STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Prepared For:

Government of Newfoundland and Labrador
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EXECUTIVE SUMMARY

Conestoga-Rovers & Associates (CRA) was retained by the Province of Newfoundland and Labrador (Province), Department of Environment and Conservation (ENVC) to provide consulting services for the Study on Operation and Maintenance (O&M) of Drinking Water Infrastructure in Newfoundland and Labrador (Study).

The Study was completed in a phased approach under the direction of a Technical Committee (Committee) representing ENVC and Department of Municipal Affairs (DMA). Phase 1 consisted of a review of existing information and the collection of new information from a sufficient number of system operators to permit a critical evaluation of the state of O&M across the variety of size, type, and municipal structure conditions while Phase 2 consisted of the critical evaluation of the causes of drinking water issues, operator training and ability, maintenance practices, regulatory compliance, and system economics and affordability related to system design, municipal structure, population range, and geographic location. The Phase 2 focused on correlating the drinking water issues with operation and maintenance practices, economics analysis, and finally identifying challenges to providing safe drinking water with potential operation and maintenance alternatives.

The following summary statements characterize the primary findings of the Phase 2 report segregated by each major section:

E1.0 Correlation of Drinking Water Issues with Operation and Maintenance Practices

E1.1 Reasons for BWAs

The majority of communities in Newfoundland and Labrador (NL) draw water from a surface water source (lake/pond or river/stream). In particular, the larger systems rely on surface water whereas the smaller systems are a mixture of surface and ground water supply sources.

Site visits to 25 communities were completed. The site visits, in combination with basic surveys completed by water system representatives, resulted in a total of 93 surveys of specific water supply systems. The 93 communities as characterized by site visits and basic surveys provide a good representation in terms of region, governance, water source, and population for drinking water systems throughout the Province. This determination is based on the proportion of systems that are under a BWA or exceed federal guidelines for chemical drinking water quality.

Reliance upon the February 2009 period to characterize the prevalence of BWAs for public drinking water systems in NL is a reasonable strategy. The number of systems under a BWA at the time is similar to those under a BWA in January 2010. While BWAs have been issued or revoked for a number of water systems over the past year, some BWAs have been in place for up to 25 years.

The systems that are most vulnerable to BWAs are those with populations under 500 people. Another trend includes governance as LSD systems appear to be more vulnerable than municipal operations.

Factors contributing to the greatest number of BWAs are related to poor O&M practices (BWA Codes C and E), infrastructure (BWA Codes A and E), and operator training (BWA Code B).

E1.2 Issues Related To Geographic Location Eastern And Western Regions

There is a tendency for systems with very small populations (under 500) in the east and west of Newfoundland to have more BWAs in comparison to those in central Newfoundland. The percentages of communities under BWAs in the eastern and western regions (38 percent and 45 percent, respectively) are higher compared to the central region (21 percent). The reason for this finding is not clear, although it may be attributable to the relatively high proportion of LSDs in the eastern and western areas.

E1.3 Issues Related To Population Serviced

The highest number of systems and BWAs are in communities with a population under 500. Almost half of the water supply systems in NL are surface water based that serve communities with a population of less than 500. Approximately 69 percent of water supply systems in NL are in communities with less than 500 people; however, 86 percent of the current BWAs are in these communities.

As these figures indicate, there are significantly greater probabilities of BWAs for very small drinking water systems (i.e., populations less than 500 people) than for larger systems (with populations greater than 500 people).

E1.4 Issues Related To Governance

Community governance appears to have a definite impact on water system infrastructure. There is an overall greater number and percentage of BWAs occurring in LSD systems versus municipally operated systems. Eighty of 110 LSD systems have a BWA versus 72 of 277 municipally-operated systems. LSDs appear to be more vulnerable than municipalities. Less than one-third of the communities are LSDs, while LSDs represent more than 50 percent of the BWAs issued.

In terms of condition, capital investment as observed by the extent of water treatment infrastructure, and the level of operator training, were found to be lacking in LSDs when compared to municipalities.

E1.5 Issues Related To Water Source

Colour is an effective indicator of organic contamination of source water, and was used to differentiate between "secure" groundwater supplies that are not vulnerable to contamination and ground water under the direct influence (GUDI) of surface water. While this procedure has been successfully used in other jurisdictions, it is not appropriate to consider drinking water from ground water sources as better protected against BWAs than either GUDI or surface water supplies, based on the proportion of BWAs for each type of source in NL.

Specifically, for communities with less than 500 people, the percentages of BWAs as a function of water source (surface, groundwater, or combination) are very similar, such that differences of supply do not appear to contribute to, or dissociate from, BWAs.

E1.6 Water Quality Chemistry

Turbidity and colour are pervasive issues throughout NL and may warrant a Province-wide strategy. For example, high turbidity levels exist in 48 percent of NL. The two constituents of turbidity and colour are of concern because they may impact the efficiency of the disinfection process by shielding pathogens; however, increasing the chlorine dosage will increase formation of DBPs, consequently colour and turbidity indirectly contribute to health related issues.

There is a widespread lack of infrastructure to remove colloidal and dissolved matter that contributes to colour from raw water sources. Removal of turbidity generally requires one (or more) of the following filtration types: chemically assisted filtration, slow sand or diatomaceous earth filtration, or membrane filtration. ENVC data shows that of the 149 water systems with high turbidity, only 11 have filtration treatment.

Iron and manganese are aesthetic concerns and represent issues which are widespread throughout NL. Iron does not have a health related limit, but the presence of high levels of iron may lead to the staining of plumbing fixtures, laundry, and adverse taste in water. Iron may also increase the chlorine dose required to maintain a free chlorine residual. Of the 93 communities with high iron levels, only eight have some type of combined iron and manganese removal or treatment.

Low pH is a Province-wide issue where almost 75 percent of the communities in NL have recorded some pH levels below 6.5. Of these 227 which have recorded values of pH less than 6.5, only 24 have pH adjustment available. Concern with low pH exists because these levels may cause operational issues and premature aging/corrosion of the treatment and/or distribution system.

Concentrations for health related chemicals (e.g., lead, arsenic, fluoride, barium) are generally not a widespread issue. While there are individual drinking water systems with issues, the situation does not warrant a Province-wide strategy. Water systems with an elevated concentration of one of these parameters in their raw water supply should consider source relocation, added treatment infrastructure, or perhaps a PWDU (Potable Water Dispensing Unit) as potential solutions.

E1.7 Infrastructure And Equipment

Communities with more than 500 people are generally more likely to be served by a water system that has more than a single barrier capable of removing or inactivating pathogens. Approximately 70 percent of the drinking water systems rely on surface water sources; however, the infrastructure in place is not effective against surface water pathogens without filtration. The contact time is not likely long enough to remove *Giardia* and chlorination is not effective against *Cryptosporidium*.

E1.8 Operation And Maintenance

Evidence has shown that low O&M, operator effort, and poor access to spare parts correlate to high levels of BWAs; these measures were similar in all regions. Systems where chlorination systems were by-passed or disengaged (Code B BWAs) have the lowest amount of annual on-site training per operator and only one of four systems in the survey data set had an operator with on-site training; however, this does not take into consideration any instances where an operator was directed by an employer/community representative to remove disinfection equipment from service.

Water system operators in municipalities work more hours per week and devote more time to maintenance, and have more access to documentation and repair parts than water system operators in LSDs. The majority of respondents from water systems that were under a BWA due to their disinfection system being off-line for maintenance indicated that spare parts and emergency repair parts were not available. The majority of these systems also indicated that less than 10 hours of operator effort per week was focused on maintenance.

O&M practices at systems that are not under a BWA have been found to be consistently superior to facilities under a BWA.

E1.9 Training Certification

Substantial issues are evident in relation to operator training; considerable variability was noted in the number of operators who participate in some form of training for LSDs compared to municipalities. Systems are less likely to have BWAs when trained and/or certified operators are available to maintain and operate these systems. The best management practices recommend approximately 24 hours per year of operator training that would include classroom training, on-site training, and seminars that would include the Annual Clean and Safe Drinking Water Workshop and from recognized organizations. For the purposes of establishing a benchmark for the type of training, the Ontario jurisdiction was used to determine the amount of on-site training requirements as a Best Management Practice, which was set at an average of 13 hours per year. When comparing operator training based on region, governance, or population, none of these categories had an average training level of more than 2 hours per year, which is about 15 percent of the recommended level (13 hours based on Ontario regulations).

E2.0 Economics Analysis

This section of the Study relied upon the information generated in the Correlation of Drinking Water Quality Issues with Operation and Maintenance that led to developing recommendations for water treatment and distribution infrastructure upgrades necessary to treat poor quality raw water, and the O&M effort required to implement Best Management Practices (BMPs) at existing and upgraded water systems. Therefore, the intent in this section was to develop the economic analysis to upgrade the infrastructure and O&M such that public water supplies can consistently meet the water quality limits set out in the Guidelines for Canadian Drinking Water Quality (GCDWQ).

In addition, this section also described the implications of alternative funding formulae for the recommended upgrades, and reflects the current cost-sharing options for the water supplies. The cost-sharing was considered to be very important, as many smaller communities were without the necessary resources to operate and maintain their treatment and distribution systems in accordance with BMPs. As a demonstration of the issue of resource base, 65 percent of communities have populations of 500 or less people, and 89 percent have populations less than 1,500 people. Lacking economies of scale, the community structures did not have the resource base necessary to fund the initiatives necessary to bring the water supply systems to BMP level.

Finally, this section of the Study detailed the primary assessment parameters used in the economics analyses described below, based on population and source water types. Information specific to the community was used to estimate costs; for example, capital investment, O&M requirements, frequency of tasks for each process component, and operator wages.

E2.1 Focus on the 25 Communities Studied in Detail

Details provided here were described in relation to the 25 communities for which specific information was obtained through site visits. The 25 communities that were visited provided a reasonable representation of the 337 public drinking water systems in the Province based on water source, service population, and water quality. As a result, the 25 communities in the detailed survey data set were used to extrapolate the economics analysis to the 337 public drinking water systems across the Province.

Adequate water treatment infrastructure throughout the Province and for the 25 communities in the detailed survey data set was generally found to be limited. The first stage of the cost analyses involved the estimate of costs to operate the water systems based on existing infrastructure. This included, for example, the changes needed to bring the chlorination systems on line and functioning.

E2.2 Costs Based on Current Infrastructure

As a summary of the findings that used the current infrastructure:

- The annual water rates per household for 2009 as charged varied from $60 to 325 per household, with an average of approximately $200 per household.
- Assuming three persons per household, the estimated price for treated water, reflecting annualization of replacement costs and O&M of existing infrastructure in accordance with BMPs, was in the range of $61 to 1,688 per household.
- As expected, very small systems tended to have considerably larger costs per capita, due to the lack of economies of scale.

E2.3 Costs Based on Recommended Infrastructure

The second scenario of the cost analyses was based on the need to upgrade the 25 water treatment systems such that they can treat their respective sources to meet GCDWQ Standards. As a summary of the findings, assuming the recommended upgrades were adopted:

- The average price for treated water for different communities reflecting annualization of replacement, operation, and maintenance costs for BMP systems indicates a range of $0.50 to 10.96/m^3, and the annual cost per household ranges from $83 to 1,801.

The basis for the cost estimates was described to demonstrate how decisions were made for each of the 25 water supplies. Flow charts indicate the stepwise processes used to determine when, for example, filtration is needed and/or decisions on implementation of a PWDU for provision of drinking water in communities with less than 1,500 people. The basis for decisions at each of the 25 communities, and the data sources relied upon for the estimates, are included in the Study report. To evaluate the true costs to the consumer, the costs were described in terms of life cycle costs.

E2.4 Comparisons of Current Costs with Costs for Small Water Systems in Ontario

Treatment and monitoring standards were selected in order to bring the water systems into compliance with the more stringent regulations in Ontario. As a result, water rates for small communities in the Province of Ontario provided a good means of comparison to determine how the recommended upgrades to infrastructure and O&M practices would impact water rates in NL. The 2009 annual water rates per household calculated for small communities in Ontario were significantly higher than 2009 water rates in NL. The annualized infrastructure and O&M costs that were developed in this section for water systems serving 200 to 600 people were similar to the annual water rates calculated for small systems in Ontario.

E2.5 Basis for Some Understatements of Costs for Existing Water Supply Systems

While the above-indicated costs using current systems and BMP systems are higher than current costs, reasons for these differentials include:

- The current operator effort being utilized (person-hours/water supply system) was considerably less than necessary to ensure that water quality standards were met on a consistent basis.
- The costs as reported by some communities did not reflect the significant efforts being expended by volunteer workers. Sources throughout North America indicated that an average wage for water system operators is in the range of $21 to 24/h. Only one water system indicated that operators earned more than $20/h.

E2.6 Cost Savings Associated with O&M Practices

The actual useful life of water system infrastructure could not be estimated for the 25 communities in the detailed survey data set due to a lack of information regarding equipment age and current condition. The significant difference between current O&M effort and O&M of existing infrastructure in accordance with BMPs suggested that existing infrastructure will not reach its expected useful life in most cases.

In addition to BMP O&M activities, the expected useful life of water system infrastructure can be further increased by undertaking rehabilitation activities at specified intervals. Rehabilitation of existing equipment was not necessarily a cost effective option. If water treatment system owners were to develop a more proactive O&M strategy that included rehabilitation activities, one significant impact would be a decrease in capital costs and a corresponding increase in O&M costs. If limited funding is available for O&M, it is unlikely that communities would pursue rehabilitation of water treatment infrastructure to increase the expected service life.

E3.0 Challenges to Providing Safe Drinking Water

This section of the Study report concentrated on the challenges for O&M practices related to public drinking water systems in the Province.

E3.1 Challenges to Water System Management at Municipal/Local Service District Level

The following points were considered part of the responsibility of, and challenges for, both municipalities and LSDs in ensuring the GCDWQ limits are met:

- Establish appropriate local budgets to operate their water treatment systems, address debt/service ratios and collect on overdue residential taxes,
- Provide appropriate compensation for operators,
- Retain proper number of qualified operators (including Secondary Staff) so that all required O&M tasks can be completed as needed,
- Address turnover/retention of operations staff, which can partially be achieved by providing appropriate compensation for operators,
- Provide support for training and certification of all operators,
- Provide adequate tools and equipment for O&M,
- Locations of communities because, for decades, geography has been of one of the biggest challenges to the sustainability of services in the Province,
- Review outsourcing or consolidation of maintenance tasks among communities within the same general area or region.

E3.2 Challenges to Water System Management at Provincial Level

The following points were considered part of the responsibility of the Province to ensure that GCDWQ limits are met:

- Provide regulatory oversight and enforcement as the current lack of treatment regulations will likely prevent existing shortcomings in public water supply infrastructure from being addressed in a timely manner.
- Provide a new sub-code for a BWA reason (Code B4) as a designation when disinfection equipment is removed from service at the direction of a community representative.
- Provide funding for infrastructure for communities to meet the GCDWQ; if the Province establishes standards and enforces these standards for every water system, the Province would likely be required to provide adequate funding that will allow each jurisdiction to have the required components available in the first place.
- Provide policies and programs for uniformity of infrastructure, operation, and maintenance that take into account the size of the community, as well as the ability of the community to recover the cost of the treatment system, whether the community will be able to retain operators and contractors with the necessary skill level, and other socio-economic factors. The design process must ensure that the proposed infrastructure is capable of treating a site-specific raw water supply to meet GCDWQ limits, while also ideally achieving some degree of similarity with other water systems that have similar sources and service populations. Establishing a degree of uniformity between drinking water systems will allow for water system operators and management from similar systems to share troubleshooting experiences, operating strategies, and other "lessons learned" that can help make operation more efficient.
- Continue to provide training and certification of operators as the lack of regulations with respect to operator certification and training levels results in significant differences in operator training based on governance structure and service population, which emphasized the importance of the relationship between operator skill level and water quality.
- Evaluate alternative sources of cost sharing and/or funding as there will be a significant increase in the financial obligations of all levels of government and operating authorities to construct, operate, and maintain treatment and supply systems that are needed to meet the goals of full compliance with Provincial Drinking Water Standards.
- Provide public information on technical needs and policies to make the general population aware of where their water actually comes from, how (and more importantly, why) it is treated. Examples were noted where residents complained of aesthetic issues that resulted in equipment being turned off or abandoned.

E4.0 Potential Operation and Maintenance Alternatives

A variety of alternatives have been considered by public water supply management entities throughout Canada, the U.S., and the world to improve fiscal efficiencies for the O&M of drinking water treatment and distribution systems. These alternatives ranged from the conventional approach of individual water treatment systems for each community (status quo) to complete privatization with many variations between these two extremes.

The alternatives are summarized below.

E4.1 One Water System Per Community

The management structure for public drinking water systems in the Province typically follows the traditional approach where each community has its own respective water supply, treatment plant, and distribution system. Regardless of the location, type of municipal governance, minimum population, or water source for the community, a fixed minimum operating cost is required for each community.

E4.2 Regionalization

The regionalization approach involves communities within a certain geographic area combining their efforts and resources for infrastructure management that improves efficiencies through the cost-sharing of capital investment and O&M of the infrastructure, which includes the cost of an operator.

E4.3 Public-Private Partnerships

The combination of Public-Private Partnerships (PPPs) can introduce particular strengths of the private and public sectors to maximize public value for any endeavor, and in this case, particularly for public drinking water systems. The potential use of PPPs in this application can range from simple service agreements where the community retains ownership of the infrastructure while a private entity operates and maintains the infrastructure to complete infrastructure investment with O&M services by a private party for an extended period of time at which point the infrastructure is returned to the community.

The use of PPPs are often a mechanism to fill a void for communities that cannot fund the substantial financial investment required to upgrade or replace existing water treatment infrastructure, or where communities do not meet criteria for funding from higher levels of government. Some issues arise when complete control of treated water is divested to the private sector as fears of potable water being considered as a commodity for profit or as a public benefit, much in the same manner as town road networks.

A variety of PPPs are currently in use throughout the world with varying levels of success. The major categories are summarized below.

E4.3.1 Service Contracts

Service contracts are the most basic type of PPP that is currently used by most, if not all, communities. Two common examples of service contracts are the use of consultants to design and supervise construction of water treatment systems, and the use of contractors to install these systems. Service contracts are also the most straightforward of the various PPP alternatives since all management and infrastructure investment responsibility continues to remain with the community.

Service contracts clearly identify the responsibilities of the service provider, which are mandated by the community. In addition, the community continues to retain all liability associated with the water quality delivered to the end-users.

E4.3.2 Management Contracts

Management contracts are an extension of service contracts where a dedicated company or firm can provide services for a specific period of time, often one to two year terms. These contracts are common between large private sector clients and a service provider, which is typically referred to as a Standing Offer agreement. In terms of drinking water systems, a standing offer could be used for O&M services where a community and private service provider enter into an agreement with the community paying the service provider to maintain and operate the system, which includes the operator.

Management contracts allow the service provider to revise and improve operational practices that will result in a higher level of water quality. The use of management contracts continues to have communities carry the full responsibility of water quality and the service provider is guaranteed payment regardless of treated water volumes. It should be noted that management contracts could be developed on a regional basis, which would allow for a number of operators located at a central hub to operate a number of local water systems, thereby reducing the O&M cost per system.

E4.3.3 Leases

Leases are an extension of management contracts that also transfers risk to the service provider since the private sector leases the water treatment infrastructure from the community and is compensated by revenues from production volumes of treated water. Ownership of the assets continues to be that of the community, but the relationship becomes complex when new infrastructure or substantial investment is required before the term of the lease expires.

E4.3.4 Concessions

Concessions are quite similar to lease arrangements with one key exception that infrastructure investment must be covered by the service provider. Under this agreement, the private sector maintains existing infrastructure with full control of asset renewal, expansion, and O&M; however, the assets remain the property of the community.

E4.3.5 Build-Operate-Transfer

The last form of PPP is the Build-Operate-Transfer (BOT) arrangement that combines the concessions type of contract with initial infrastructure capital investment for the water treatment system specific to the community requirements, current and forecasted demands, for the term of the contract. The service provider is responsible for all financing related to initial design and construction of the water treatment system followed by the continued O&M of the infrastructure, all of which is only transferred to the community at the completion of the term of the contract.

E4.4 Privatization

Privatization is the complete transfer of ownership of the water treatment equipment to the private sector, which results in the community paying for treated water from a utility (similar to electricity). Rather than maintaining a relationship between the community and the water utility company through a contract, the community (or higher level of government) monitors the relationship through regulatory controls.

TABLE OF CONTENTS

Page

LIST OF FIGURES
(Following Text)

LIST OF TABLES
(In Text)

LIST OF TABLES
(Following Text)

LIST OF TABLES
(Following Text)

<u>LIST OF TABLES</u>
(Following Text)

LIST OF TABLES
(Following Text)

LIST OF APPENDICES

1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) was retained by the Province of Newfoundland and Labrador, Department of Environment and Conservation (ENVC) to provide consulting services for the Study on Operations and Maintenance (O&M) of Drinking Water Infrastructure in Newfoundland and Labrador (Study).

The Study was completed in a phased approach under the direction of a Technical Committee (Committee) representing the ENVC and Department of Municipal Affairs (DMA). Phase 1 of the Study focused on the collection and summarization of data obtained from communities with public water supplies, and Phase 2 focused on synthesis of the Phase 1 data into summarized observations and recommendations.

Phase 1 consisted of a review of existing information and the collection of new information from a sufficient number of system operators to permit a critical evaluation of the state of O&M across the variety of size, type, and municipal structure conditions while Phase 2 consists of the critical evaluation of the causes of drinking water issues, operator training and ability, maintenance practices, regulatory compliance, and system economics and affordability related to system design, municipal structure, population range, and geographic district.

Of the 337 communities having public drinking water systems, 65 percent serve populations of 500 or less and 89 percent serve populations of less than 1,500. This clearly provides financial challenges to the responsible management authorities in providing potable water that meets the Guidelines for Canadian Drinking Water Quality (GCDWQ) under the operation of a trained operator.

As part of the Study, data on system costs (capital and O&M) based on existing conditions was collected for comparison to system costs for two scenarios:

- O&M of existing infrastructure in accordance with Best Management Practices (BMPs)
- BMP O&M of upgraded water system infrastructure that is capable of providing treated water that complies with CDWQG limits

System funding sources and typical expenditures were assessed to determine the affordability of systems based on existing conditions and target standards.

Based on the aggregate of data considered reliable, CRA have estimated target levels for O&M budgets based on community size, affordable water rates based on community size and the cost and service life benefits of proactive O&M.

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1.1 DEFINITIONS

The framework of the economics evaluation requires that numerous terms are clearly defined for the purposes of this discussion, as noted below.

Boil Water Advisory (BWA) is typically recommended by the Medical Officer of Health with the Department of Health and Community Services (HCS) or an Environmental Health Officer with the Department of Government Services (GSC) (HCS, ENVC, and GSC 2008). BWAs are public announcements issued by the responsible authority advising the public that they should boil their drinking water prior to consumption. BWAs are generally issued as a result of a possible or confirmed microbiological contamination (Health Canada 2009).

Build-Operate-Transfer (BOT) arrangements combine concessions with the initial procurement of assets where the private partner is responsible for designing, constructing, then operating and maintaining the facilities for a long period of time, at the end of which the assets are transferred to the public sector (Canadian Council for Public Private Partnerships 2002).

Capital Works include the installation, upgrading, and replacement of major components for the water treatment or distribution infrastructure.

Community includes any incorporated town (municipality or local service district (LSD)), but excludes unincorporated towns.

Concessions are similar to leases with the additional transfer of responsibility for infrastructure investment absorbed by the private partner (Canadian Council for Public Private Partnerships 2002).

Debt-to-Service Ratio is equal to any Municipal Operating Grant received by the community plus the ratio of council debt to local revenue, based on information provided by the DMA.

Design Flows were based on standard per capita daily water consumption rates that excluded abnormally large consumers beyond residential end users, such as fish plants.

Disinfection By-Products (DBPs) chemical compounds formed by the reaction of a water disinfectant with a precursor in a water supply system (ENVC 2009a).

Distribution System is the network of pipes, valves, storage tanks, and other appurtenances that are used to distribute treated water from the discharge line of the treatment system to the end-users.

Groundwater is extracted directly from a subsurface aquifer where the overburden layer acts as an effective filter that removes microorganisms and particulate matter by straining or sorption, such that filtration generally is not required after extraction (Ministry of the Environment 2006).

Leases are an expanded version of management contracts that also transfer output risk to the private sector whereby the private sector leases infrastructure assets from government and is compensated with the revenue stream that the assets generate rather than by a fee-for-service basis (Canadian Council for Public Private Partnerships 2002).

Life Cycle Costs are used as a method for evaluating all relevant costs over time of a project that considers initial capital investment costs (purchase and installation costs), future costs (energy costs, operating costs, maintenance costs, capital replacement costs, financing costs), and any resale, salvage, or disposal cost over the life-time of the project. (US Department of Energy Guidance on Life Cycle Cost Analysis Required by Executive Order 13123, 2005).

Local Service District (LSD) established to provide limited services to communities or areas that have similar needs within a community or geographic zone; the administration of LSDs is the responsibility of five to seven elected people, known as the Local Service District Committee, when the district is originally formed.

Management Contracts extend the responsibility of the private sector into the operation and maintenance of government-owned infrastructure (Canadian Council for Public Private Partnerships 2002).

Membrane Filtration is defined as a pressure- or vacuum-driven separation process where particulate matter larger than 1 mm is rejected by an engineered barrier, primarily through a size exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test (USEPA Membrane Filtration Guidance Manual, 2003). This definition includes the following membrane processes commonly used in drinking water treatment:

• Microfiltration • Ultrafiltration	• Nanofiltration • Reverse Osmosis

Metering is the process of using a mechanical device to measure the volume of treated water discharged from the treatment system.

Operation and Maintenance includes any activity completed on a water treatment and/or distribution system following its commissioning, which provides a longer and more effective service life.

Privatization is the full divestiture of public infrastructure assets and operations to the private sector, thereby transferring all monopoly rights from government to the private sector (Canadian Council for Public Private Partnerships 2002).

Public-Private Partnership (PPP) refers to a relationship where the private business sector participates as a partner with government to deliver infrastructure or services that were traditionally provided by government alone (Canadian Council for Public Private Partnerships 2002).

Service Contracts are the simplest form of a PPP where the private sector is contracted to perform a specific service for a short period of time (Canadian Council for Public Private Partnerships 2002).

Shared Water Source refers to several communities that share the same water source, treatment system and/or a portion of the distribution system (i.e., Mount Pearl, Paradise, and CBS share a water source with St. John's). In these cases, the communities who share a water source are included in the largest centre.

Surface Water is a water source extracted from a surface water body (river, stream, lake, pond, or reservoir) for which filtration is required to remove solids typically associated with surface water sources. CRA considered the following water sources to be equivalent to a surface water source for the purpose of this report:

- Groundwater/Surface Water (GW/SW) - The consolidation of various community sources (wells and ponds for the same community) has created a third grouping having a combination of surface and groundwater; these are conservatively considered to require surface water treatment to address raw water quality issues.
- Groundwater Under the Direct Influence of Surface Water (GUDI) **-** Groundwater that receives incomplete or unreliable subsurface filtration of surface water or infiltrating precipitation, such as dug wells (Ministry of the Environment 2006). Measurable water quality parameters such as colour or turbidity are generally good indicators of surface water influence on a groundwater supply.

Treatment System includes the infrastructure (equipment or processes) located between the raw water source and the distribution system that is designed to improve water quality.

Useful Service Life refers to the estimated number of years of effective operation for a new piece of infrastructure. The useful service life of a system is typically extended with regular O&M protocols.

1.2 STUDY METHODOLOGY

The methodology used to complete the Phase 1 Study requirements included an initial review of available data and reports relevant to the systems in question, and the collection of new data through a field data collection program at selected communities. The field data collection program consisted of Site visits with interviews of water treatment operators by CRA staff, as well as the collection of data through questionnaires/surveys. The Site visits were facilitated by a prepared inspection form (detailed survey) and a shorter version (basic survey) was provided to all remaining communities with public water supplies for completion. CRA and the Committee finalized the approach to field data collection in terms of number and type of systems to inspect as well as type of data to request based on the findings of the available data review.

1.3 PROJECT BACKGROUND

1.3.1 DEFINITION OF FULL PROVINCIAL STUDY

ENVC have undertaken several studies and reports over the past number of years to investigate the overall condition of public water supplies in the Province.

Preliminary assessments indicated that a great number of the water quality issues (Boil Water Advisories (BWAs), high concentrations of Disinfection By-Products (DBPs), aesthetic, and other contaminants) in NL were being experienced in the smaller rural communities.

The DMA provides funding through capital works programs, as well as the Municipal Rural Infrastructure Fund (MRIF). Cost sharing ratios for capital improvements between the Province and communities vary from a 90/10 to 70/30 based on community population.

The first detailed assessment that reviewed all drinking water issues and possible remedial measures for deficiencies was the report entitled "Sustainable Options for the Management of Drinking Water Quality in Small Water Systems" published by the Province in March 2008.

A common conclusion derived from these assessments was that many smaller communities were without the necessary resources to operate and maintain these treatment and distribution systems even though the Province was forging ahead with efforts to upgrade the infrastructure.

- Phase 1 of this Study was undertaken to collect and consolidate various sources of information (government data, basic survey responses, and site visits with detailed surveys) on treatment systems regarding equipment, water quality, and O&M.
- Phase 2 was intended to investigate potential relationships and/or correlations that may be observed in reviewing the basic and detailed survey data that can be extrapolated to all public drinking water systems in the Province. Results of this investigation are presented in Sections 2 to 5 of this report that address the following issues:
  - correlation of drinking water issues with O&M practices
  - economics of drinking water systems including O&M practices
  - challenges to O&M of drinking water systems

1.3.2 SOURCES OF DATA

1.3.2.1 PROVINCIAL RECORDS

Published government reports used in this evaluation included:

- Sustainable Options Report for the Management of Drinking Water Quality in Small Water Systems - ENVC - March 2008)
- Best Management Practices for the Control of Disinfection By-Products in Drinking Water Systems in Newfoundland and Labrador – Draft (ENVC - January 2009)
- Boil Water Advisories for Public Water Supplies in Newfoundland and Labrador (June 10, 2009 – ENVC Website)
- Boil Water Advisories for Public Water Supplies in Newfoundland and Labrador (January 2010 – ENVC Website)
- Public Water Supplies – (ENVC Website February 2009)
- Operator Education, Training, and Certification File (ENVC internal database file)
- Boil Water Advisories for Public Water Supplies in Newfoundland and Labrador (February 2009 from ENVC website)
- Operator Education, Training, and Certification File (February 2009 from ENVC internal database)
- Potable Water Dispensing Units: Experience in NL (ENVC website)
- Atlantic Canada Guidelines for the Supply, Treatment, Storage, Distribution, and Operation of Drinking Water Supply Systems, September 2004

1.3.2.2 OTHER SOURCES

The following documents included information regarding costing, operation and maintenance of drinking water infrastructure that is not specific to drinking water systems in the Province.

- 2003 Drinking Water Infrastructure Needs Survey, Modelling the Cost of Infrastructure, USEPA, June 2006
- Department of Indian Affairs and Northern Development (DIAND) Cost Reference Manual, TID-AM-2, PWGSC, July 2004
- Water and Wastewater Asset Cost Study, Ontario Ministry of Public Infrastructure Renewal, R.J. Burnside & Associates Limited, May 2005

- Preventative Maintenance Card File for Small Public Water Systems Using Ground Water, USEPA, December 2004
- Procedure for Disinfection of Drinking Water in Ontario, Ontario MOE, June 2006
- Mechanical Engineering Reference Manual, Professional Publications, 1995.
- Drinking Water and Wastewater Handbook for Local Officials, Maryland Centre for Environmental Training and USEPA Region 3, October 2000
- Simply Hired Operator Salaries, Simply Hired Inc., February 22, 2010

  http://www.simplyhired.com/a/salary/search/q-Drinking+Water+Operator,

1.3.3.2 SITE VISITS AND SURVEYS

1.3.3.2.1 SITE VISITS

Based on available data, and in consultation with the Committee, 25 of the 364 communities in the Province with public water supply systems were selected for site inspection, in an attempt to create an optimum and representative cross-section of these systems. Criteria used for the selection of communities interviewed were based on factors including:

- System size
- Source of supply (surface or groundwater)
- Population served
- Known service issues
- Geographic district
- Type of municipal structure (Municipality or Local Service District (LSD))

A field inspection/interview format was established and the following key items were discussed:

- Infrastructure specifics including treatment components, age, past, and planned upgrades
- Service population and area, consumer demographics
- Regulatory issues
- History of drinking water issues
- Management authority

- System staff (past and projected turnover)
- Operator training, safety, maintenance practices
- Capital, operations, and maintenance costs
- Debt and annual user fees

A copy of the detailed survey is provided in Appendix A.

1.3.3.2.2 BASIC SURVEY

A shorter, basic survey was sent by e-mail or mailed to the remaining 339 communities in the Province with public water supplies to obtain additional data pertaining to the Phase 1 study requirements. The e-mail contained a link to a web site, allowing the communities to complete an on-line version of the basic survey. A copy of the basic survey is provided in Appendix B.

Communities that did not respond to the initial invitation to participate in the survey received a follow-up e-mail or telephone call in an effort to increase the response rate and assist communities in providing the required data.

1.3.3.2.3 RESPONSE TO THE SURVEY/VISITS

The basic survey was sent to 339 of 364 communities in the Province with public water supplies to obtain data pertaining to the Study; a total of 73 communities completed or partially completed survey responses that were returned, which translated to a response rate of approximately 22 percent.

While a large sampling response rate is always preferred, the response rate was somewhat higher than typically expected for this type of questionnaire and a response rate in this range provided a sound basis for extrapolation of data to the remaining supply systems.

Incorporating these 73 responses of the on-line/mail-in basic survey with the 25 communities visited and interviewed resulted in an overall response rate of more than 27 percent of the communities. It is CRA's opinion this is an acceptable rate of return to consider the information a valid representation of public water treatment systems in the Province.

1.3.3.2.4 DATA COLLECTION RESULTS

A data management system was developed using Microsoft Access for the collection, compilation, and analysis of data from various sources to undertake the Study requirements.

This allowed efficient collation and categorization of collected data, which can be organized, as necessary, to permit effective assessment of the data.

The on-line surveys completed by the communities were automatically compiled by the data management system. Surveys received by mail and/or facsimile, as well as information from the site visit interviews, were entered into the data management system by CRA personnel.

1.3.3.4 DEFICIENCIES IN CORRESPONDENCE SURVEY

The returned surveys were found to be fairly complete and provided sufficient information to allow the first level evaluation of the water system operations; however, the following discrepancies were noted:

Part A – Water Source

- Safe yields for the wells in use were not generally reported.
- Misunderstanding of the terminology for a Protected Public Water Supply Area (PPWSA) and maintaining control over one. Several responses indicated PPWSAs are in place, but also reported potential contamination from area use, both from uses allowed under current legislation and those that are banned (i.e., snowmobiling over frozen water).

Part B – Design (and Infrastructure)

- Limited information was provided on domestic consumption rates.
- Limited detail was provided regarding the extent and condition of distribution systems.
- Confusion regarding the definition of fire fighting capability and its relationship with water storage for residential/commercial consumers. Data indicated that many distribution systems included hydrants; however, system capacity was insufficient for meeting minimal fire fighting rates (4,500 L/min for 2 hours) in accordance with Underwriters' Insurance standards.

Part C – Operation & Maintenance

- Few replies provided information that problems were responded to in an appropriately and timely manner.
- Few replies provided information as to the availability and response time of suppliers, contractors, or consultants.

Part D – Reporting

- Notification protocols for Boil Water Advisories (BWAs) were misunderstood.
- Limited detail on understanding of the procedures was reported.

Part E – Operators

- Identification of the type of training required/requested was not complete from all respondents.
- Type of training completed was not completed for on-site or classroom based.
- Certification documents for the back-up operators were not frequently provided.

1.3.3.5 INFORMATION FROM SITE VISITS

Table 1.3.2.5 provides a comparison of the 25 communities that CRA personnel visited, which will be referred to as the detailed survey data set, with the 339 communities in the Province. The table shows the proportion of water systems in each of the water source and service population categories are similar for both the 25 water systems in the detailed data set and the 338 communities in the Province-wide data set, so the detailed data set provides a reasonable representation of the water systems in the Province based on water source and service population. The detailed data set and the larger basic survey data set provided an accurate representation of the public water systems in the Province based on water quality and BWAs.

As a result, CRA believes the 25 communities in the detailed data set will also provide a reasonable basis for the economic analysis contained in this report.

2.0 CORRELATION OF DRINKING WATER ISSUES WITH O&M PRACTICES

2.1 DATA ANALYSIS

2.1.1 PARAMETERS USED IN ITERATIVE REVIEW

CRA has undertaken an overview assessment of recent and present BWAs from Provincial data records included in published government reports such as "Sustainable Options Report for Drinking Water Quality (March 2008), the "Strategy for Managing Disinfection By-Products (January 2009)", "Boil Water Advisories for Public Water Supplies in Newfoundland and Labrador (2009 and 2010)", as well as other Public Water Supply documentation.

2.1.1.1 DEFINITION OF NUMBER OF COMMUNITIES

For the purposes of this assessment, a number of communities who receive their water supply from adjacent centres are included in the larger centre. In addition, original Provincial data that identified multiple supplies (more than one well, more than one pond, or combination of the two) servicing one centre were consolidated into one water source, with individual parameters consolidated as well.

Using this criterion, a total of 364 communities were 'reduced' to a total of 337; therefore, 73 mail-in or e-mail responses were reduced to 68, and a total of 98 surveys were reduced to 93.

2.1.1.2 PRIMARY PARAMETERS

An assessment of primary parameters was completed to determine whether or not any trends were obvious in these BWA events using the four primary classification parameters outlined below.

- **Region** – Divided into four ENVC management districts in the Province:
    - Eastern Newfoundland
    - Central Newfoundland
    - Western Newfoundland
    - Labrador

- **Governance** – Split according to municipal structure:
  - Municipality
  - Local Service Districts (LSDs)
- **Population** – Divided into four categories:
  - 500 persons or less
  - between 501 and 1,500 persons
  - between 1,501 and 15,000 persons
  - more than 15,000 persons

The population for these communities was classified using reported population serviced, rather than census population.

- **Water Source** – The data provided by the Province initially divided water supplies into two types:
  - Groundwater (GW)
  - Surface Water (SW)

However, CRA have determined two additional sub classifications:

Groundwater/Surface Water (GW/SW) - The consolidation of various community sources (wells and ponds for the same community) has created a third grouping having a combination of surface and groundwater; these are conservatively considered to require surface water treatment to address raw water quality issues.

Groundwater Under the Direct Influence of Surface Water (GUDI) - Many communities throughout Canada have determined their water supply, which was considered to be groundwater, are now classified as GUDI (examples include shallow (dug) wells, or deep wells located near water bodies). Water quality test parameters such as colour or turbidity are generally good indicators of surface water influence on a groundwater supply.

Permutations and combinations of these parameters (1st, 2nd, 3rd, 4th) were completed to determine whether or not there were patterns or other common characteristics under these four groupings existed.

2.1.1.3 SECONDARY PARAMETERS

As patterns or trends regarding BWAs emerged at the primary level, further assessment was undertaken to drill down into the reasons for the issuance of Boil Water Advisories.

A review was undertaken of only the locations that were experiencing BWAs based on 2009 summaries – many communities were or have been under BWAs since the 1990s.

Reasons or factors given for BWAs in ENVC documents were then classified in one of the following six categories, as identified in the ENVC "Sustainable Options Report for Drinking Water Quality (March 2008)":

- Code A - No Disinfection
- Code B – Disinfection Off-Line By Choice
- Code C – Disinfection Off-Line For Maintenance
- Code D – Potential for Adverse Water to Enter Distribution System
- Code E – Insufficient Contact Time or Free Chlorine Residual in Distribution System
- Code F – Positive Results for Microbial Parameters found in Distribution System

See attached Table 2.1.1.3, which outlines the further sub-classification under these six Codes.

A breakdown of these secondary parameters was used to classify and evaluate BWAs if there are specific O&M issues for these systems. These issues are discussed in later sections of this report.

2.1.2 EXAMINATION OF PROVINCIAL RECORDS

As stated earlier, the following documents were consolidated and used to review the public water systems of the entire Province:

- Sustainable Options Report for Drinking Water Quality (March 2008)
- Strategy for Managing Disinfection By-Products (January 2009)
- Boil Water Advisories for Public Water Supplies in Newfoundland and Labrador (2009 and 2010) from ENVC website
- Other Public Water Supply documentation from ENVC website (dated February 17, 2009)

- Operator Education Training and Certification files (February 2009 from ENVC internal database)

2.1.2.1 CORRELATION OF PRIMARY PARAMETERS

The first step involved categorizing the 337 unique communities into a possible maximum of 128 combinations (4 Regions x 2 Governances x 4 Population Groups x 4 Water Source Types) to determine the number of systems and number of those who were subject to BWAs.

The following tables were generated by changing the sort sequence of the primary parameters as follows:

- Table 2.1.2.1.1 – Boil Water Advisory Data Table - Region
- Table 2.1.2.1.2 – Boil Water Advisory Data Table - Governance
- Table 2.1.2.1.3 – Boil Water Advisory Data Table - Water Source
- Table 2.1.2.1.4 – Boil Water Advisory Data Table - Population and Governance

In each of these tables, categorization for all 337 communities was included, which incorporated the 68 communities with basic survey information collected in Phase 1, plus the 25 communities that were visited.

Many of the combinations did not have communities that fit the specific permutations (e.g., no LSDs serve communities with populations of more than 1,500 people); therefore, these were excluded from further review.

2.1.2.2 BREAKDOWN OF BOIL WATER ADVISORIES (BWAs)

Table 2.1.2.1.2 suggests a higher percentage of BWAs exists in LSD systems (80 of 110) compared to municipalities (72 of 227), and all LSD systems in the Province serve less than 500 people except for three.

Table 2.1.2.1.4 (BWAs sorted by population, then by governance) dramatically illustrates the sequence of primary parameters that consolidated the highest number of BWAs. Furthermore, another transposition of parameters of the information provided additional refinement and consolidation as shown in Table 2.1.2.1.5 (BWAs sorted by population then by water source type) that demonstrates the highest number of systems and BWAs are in communities with a population of 500 people or less whose public water supply is from surface water.

Table 2.1.2.2 (BWAs sorted by population, then by water source) further summarizes these results, from which it is concluded that:

- 69 percent of the water supply systems (232 of 337) in the Province are in communities of 500 people or less.
- 86 percent of current BWAs (130 of 152) noted in the Province are in communities of 500 people or less.
- 58 percent of the BWAs (89 of 152) noted in the Province are from surface water based systems and serve communities with 500 people or less.
- Of the systems with less than 500 people, the supply of water from ground, surface, or combined sources does not preclude any one source from having a greater or lesser percentage of BWAs (55 to 64 percent by water source).

2.1.2.3 SECONDARY PARAMETERS (REASONS FOR BWAs)

The next step in the assessment of the ENVC Records was to first categorize all 152 of the documented BWAs using the Advisory Codes from the "Sustainable Options Report for Drinking Water Quality (March 2008)", also referred to as Secondary Parameters in Section 2.1.1.3 and Table 2.1.1.3 of this report.

Table 2.1.2.3 (Reasons Contributing to BWAs) provides a breakdown of all 19 BWA Codes and Sub-Codes, firstly categorized by Region, then Governance, and then Population. The total number of 152 BWAs in 337 systems corresponds with earlier tables. It should be noted the total number of reasons listed is slightly higher as the information from 13 systems suggested multiple factors for their respective BWAs.

The total number of BWA Reasons (by each Code) is summarized at the bottom of this table. As stated in Section 2.1.1.3 of this report, the Advisory Codes will be used to classify and evaluate specific O&M issues related to those systems and will be discussed later in this report.

Two additional subtotal rows were generated across the bottom of Table 2.1.2.3. These subtotals were developed to focus on the information as it is related specifically to:

- Systems serving less than 500 people managed by LSDs

- Systems serving less than 500 people managed by Municipalities

The two lines of subtotals were noted to be statistically similar under five of the six Codes (A and C through F).

All 13 systems that were found to have their disinfection equipment "off-by-choice" (Code B) serve communities of less than 500 people.

In addition, 12 of the 13 BWAs where disinfection equipment was "off-line by choice" occurred in communities where the water system was operated by LSDs.

Further breakdown by sub-code for reasons provided show that:

- five LSD systems were turned off by the operator due to taste or other aesthetic conditions (Code B1)
- two LSD systems were turned off by the operator due to perceived health risks (Code B2)
- five LSD systems were turned off by the operator due to lack of funds to operate (Code B3)

Only one municipally-run system was turned off by the operator due to taste concerns.

Further discussion and recommendations are made later in this report.

2.1.3 SURVEY AND INSPECTION OF WATER SYSTEMS

In addition to the 25 communities visited by CRA personnel, CRA received completed surveys from an additional 68 communities. Of these 68 communities, five were cases where two communities shared a common water source and treatment system with both communities returning surveys. In these cases, the survey from the community that receives treated water was not included in the data set to avoid counting the same water system twice. If, on the other hand, a survey was received for a small community that receives treated water from another community and the community that supplies the treated water did not respond, then the survey input from the receiving community was included.

Therefore, all further references in this report for the 93 surveys and inspections include 25 systems visited and 68 that provided documentation only.

2.1.3.1 MICROBIAL WATER QUALITY

With respect to microbial water quality, ENVC provided BWA data that included factors leading to BWAs in effect for communities in the detailed survey data set (25 communities) and in the combined inspection and survey data set (93 communities) as of February 2009, which are summarized in Tables 2.1.3.1.1 and 2.1.3.1.2, respectively.

For the remainder of the report, the 93 communities that CRA visited or received surveys from will be referred to as the survey data set.

2.1.3.1.1 BWAs BY GOVERNANCE

When comparing the detailed and basic survey data sets, the proportion of BWAs in LSDs versus municipalities (63 percent and 24 percent, respectively) is slightly lower in the survey data set than in the detailed survey data set (73 percent and 35 percent), respectively. Despite the lower percentage of BWAs in LSDS, it still appears that LSDs are more vulnerable than municipalities. Less than one-third of the communities included in the survey data set are LSDs; however, LSDs represent more than 50 percent of the BWAs that were issued.

The percentage of BWAs for communities with populations of greater than or less than 500 people was lower for the basic survey data set when compared to the detailed survey data set. However, the difference increased when comparing the percentage of BWAs for communities with water systems that serve more than 500 people versus communities with water system that serve less than 500 people.

Approximately 50 percent of the very small water systems (those serving less than 500 people) in the survey data set were under a BWA, while only 16 percent of communities serving more than 500 people were under a BWA. The high BWA rates for LSDs and very small water systems are somewhat related, as LSDs generally operate very small systems. Only three LSDs with populations of more than 500 exist in the Province; one of which is included in the survey data set.

2.1.3.1.2 BWAs BY REGION

To determine whether or not geography has impacted BWAs, communities were divided according to the four ENVC regions. Labrador was determined to have the highest proportion of water systems under a BWA, although it is difficult to compare the data for Labrador with other regions due to the relatively small number of water treatment systems from Labrador in the survey data set (i.e., 6 of the 93 communities) and the geographical isolation of many Labrador communities.

The survey data set includes a similar number of communities from the Central, Eastern, and Western regions. The percentage of communities under BWAs in the Eastern and Western regions (38 percent and 45 percent, respectively) is much higher compared to the Central region (21 percent). This may be partly attributed to the relatively high proportion of LSDs in the survey data set for the Eastern and Western regions (38 percent and 34 percent of the communities from those regions, respectively) compared to the Central region (25 percent). However, it should also be noted the percentage of communities serving less than 500 people that are included in the survey data set for a given region is greater for the Central region (67 percent) compared to the Eastern and Western regions (53 percent and 62 percent, respectively).

2.1.3.1.3 <u>EXTRAPOLATION OF DETAILED SURVEY DATA SET</u>

In order to determine whether or not the survey data set provides a representative data set for microbial water quality in the Province as a whole, BWAs for the survey data set were compared to the Province-wide data set on Figure 2.1.3.1.3.1. In addition, a comparison of BWAs from the basic survey data set in comparison to the detailed survey data set is also provided on Figure 2.1.3.1.3.1.

Approximately 37 percent of communities from the survey data set were under a BWA, which is slightly less than the 45 percent of communities under BWAs on the Provincial scale. The survey data set slightly understates the BWA percentages for most region-governance-population categories when compared to the Province-wide data set. The exception is Labrador, where the percentage of communities under a BWA is greater in the survey set than in the Province-wide data set. This is likely due to the relatively small number of communities from Labrador, where only six water systems are included in the survey data set.

In general, the survey data set is considered to be representative of microbial water safety throughout the Province in terms of region, governance structure, and population. The number of BWAs for the detailed survey data set was also compared to those for the basic survey data set, as presented on Figure 2.1.3.1.2.

2.1.3.2 WATER TREATMENT INFRASTRUCTURE

Water treatment infrastructure is categorized by Region in Table 2.1.3.2.1 for the survey data set. Strong regional trends were not evident in water system infrastructure, although a higher percentage of communities in Labrador and the Central region were noted to include filtration and removal processes (i.e., coagulation and flocculation, sedimentation and filtration) that can reduce the level of colour, turbidity, and suspended solids in the raw water when operated properly. Three of the five water treatment systems in the survey data set do not have chlorination to achieve primary disinfection and are located in the Western region, which represents approximately 10 percent of communities from the survey data set located in the Western region.

Water treatment infrastructure is categorized by governance structure in Table 2.1.3.2.2. Governance structure appears to have a definite impact on water system infrastructure. Four water system serving LSDs (13 percent) have sedimentation or filtration facilities that can help remove particulate matter, while 20 of 63 municipal water systems (32 percent) have filtration or removal facilities.

Population also appears to have a significant impact on the level of water treatment provided by a community, as shown in Table 2.1.3.2.3. A smaller percentage of communities with less than 500 people have sedimentation or filtration facilities. A significant difference was apparent in the level of treatment for small (500 to 1,500 people) and medium to large (more than 1,500 people) systems. For most of the filtration and removal processes listed in the table, a higher percentage of small communities have one or both of these processes installed in comparison to medium and large communities.

As a result, communities with more than 500 people are generally more likely to be served by a water treatment system that has more than one barrier capable of removing or inactivating pathogens.

The two water treatment systems in the survey data set with ultraviolet (UV) disinfection were noted to serve communities of more than 500 people. UV irradiation is capable of effectively inactivating surface water pathogens such as *Cryptosporidium* oocysts and *Giardia* cysts without forming Disinfection By-Products (DBPs).

2.1.3.3 OPERATION AND MAINTENANCE

The analysis of O&M data focuses on practices and supplies that could help address the most common contributing factors for BWAs: O&M of disinfection equipment (BWA Codes B and C) to maintain contact time (CT) and free chlorine residuals necessary to ensure that treatment standards are met (Code E). Information regarding O&M practices were recorded by CRA personnel during site visits or volunteered by communities that returned the basic survey. If the person completing the survey did not enter an answer for a particular survey question, the lack of input was noted.

Table C1 of Appendix C (Comparison of O&M practices for the survey data set sorted by Region) shows that geographic location does not appear to have much impact on O&M practices. The availability of spare parts and emergency repair parts, which help prevent Code C BWAs, was similar in all four regions. The vast majority of communities in all four regions collected free chlorine residual readings less than five times per day. Free chlorine readings can provide an indication of the effectiveness of the treatment process or the quality of water in the distribution system, depending on the sample point. Regular monitoring can help ensure that adequate CT and free chlorine residuals are maintained.

Tables summarizing O&M Practices by Region, and other tables that summarize O&M or operator training data without any strong trends are included in Appendix C.

Operator effort, measured in hours of work per week, was similar in all regions. The time devoted to maintenance activities in communities in the western region was noticeably lower than in other regions, although this may be partly due to the relatively low number of survey respondents from the western region who answered this specific question (59 percent response rate).

Figure 2.1.3.3.1 suggests that governance structure seems to have a greater impact on O&M practices than geographical location. Water treatment system operators in municipalities work more hours per week and devote more time to maintenance, collect more water samples for free chlorine analysis, and have better access to equipment documentation and repair parts than operators in LSDs. The difference in terms of operator effort is particularly significant where only one of the 14 LSDs that responded to questions regarding operator effort indicated the operator spends more than 20 hours per week on their duties as operator and more than 10 hours per week on maintenance related issues. In contrast, the majority of water treatment system operators serving municipalities spend more than 20 hours per week on their duties, and roughly half of municipal operators spend more than 10 hours per week on maintenance activities.

The population of the service area also appears to have a significant impact on O&M practices, as shown in Figure 2.1.3.3.2. The figure suggests that as the service population increases, operators spend more time working on the water treatment system and have access to more resources to help complete O&M activities. Operators in more than half of the very small communities (less than 500 people) that responded have access to O&M manuals and equipment parts, while all of the respondents from communities with more than 1,500 people indicated they have access to O&M manuals and equipment parts.

While the information received was generally complete, gaps were evident in the raw data related to the availability and skill levels of operators. A summary of the survey data set observations and deficiencies for the Treatment System Operations and Recordkeeping included:

- Generally, the level of O&M effort, response time for repairs, and satisfaction with supporting services was the same as indicated in the distribution systems section. This indicates the distribution and treatment systems are generally perceived as an inter-connected unit.
- Greater than 50 percent of respondents indicated availability of spare parts.
- The majority of respondents indicated less than 20 hours per week are spent on O&M of the systems.
- Approximately 30 percent of respondents reported a need for additional funding requirements related to operations.

2.1.3.4 OPERATOR EMPLOYMENT STATUS AND TRAINING

Certification of drinking water treatment operators is mandatory in the Province under permits-to-operate; however, a new policy is being developed by the Province that will require certified water treatment plant operators for all communities and certified water distribution operators for communities with more than 1,000 people. Two sources of data regarding operator certification were reviewed for this Study: Provincial training records, and survey responses regarding operator certification. The Provincial records data set is larger, since more than half of the communities that returned the survey did not answer questions regarding operator certification. Since the overall results for the two data sources are similar and the Provincial records are more complete, only the Provincial records will be discussed in this report. It should be noted that different levels of certification for drinking water distribution (WD1, WD2, WD3) and water treatment (WT1, WT2, WT3) systems will not be considered separately. The certification level will increase as the size and complexity of the system increases. It was assumed that operators who are certified have a certification level that is suitable for the water system they operate.

A comparison of operator certification for the survey data set by region did not demonstrate any trends. Labrador had the highest percentage of communities with a certified operator and the highest average number of certified operators per water treatment system. Labrador also had the highest percentage of systems with a backup operator, regardless of certification level, based on input from the returned surveys.

The survey responses indicate that governance structure does not have an effect on the proportion of systems served by a full-time operator; however, Table 2.1.3.2.4 (Comparison of Operator Qualifications for Survey Data Set by Governance - OETC Data) indicates that governance structure has an impact on operator certification. Only 13 percent of LSDs have a certified operator and only one operator is certified at each of the four LSDs that have a certified operator. Approximately 60 percent of municipalities have a certified operator and on average, two certified operators at each of these systems.

Figure 2.1.3.4.1 shows there are clear trends in operator status and qualifications in terms of community population. As the size of a community increases, the proportion of full-time operators increases, as does the percentage of fully or partially certified operators and the number of water treatment systems with a back-up operator. All respondents from water treatment systems serving communities with more than 500 people indicated there was a full-time lead operator, while less than 40 percent of communities with less than 500 people had a full-time operator. It should be noted the figure does not include results for one community of less than 500 people, which has a seasonal full-time operation.

ENVC recommends 24 hours of continuing education (classroom or on-site training) per year for all operators in the Guidelines for Design, Construction, and Operation (Guidelines). According to the Guidelines, classroom training seminars are occasionally held at 20 locations around the Province to minimize travel time and distance for water system operators who want to participate. On-site training is convenient for water treatment system operators who do not have time or do not receive reimbursement to travel to classroom training courses. The lack of support from employers to participate in classroom training courses was identified as an issue by a number of operators of very small water systems when CRA was completing inspections.

For comparison purposes with other Canadian jurisdictions, the Province of Ontario has a mandatory operator certification program that requires all operators of municipal water treatment systems to complete a minimum of 20 hours of training per year to maintain their certification (7 hours of classroom training and 13 hours of on-the-job or on-site training); this minimum level increases for larger systems. The operator training requirements are averaged over a three year period. Since the recommended amount of training and education per year for NL is similar to legislated levels in Ontario, the three year period used to calculate average training in Ontario was applied to operators in NL. The OETC training records provided by ENVC were current as of February 2009. As a result, only training courses completed over the course of February 2006 to February 2009 are considered in this report.

It should be noted that in the summary tables for on-site operator training, the number of operators per community and the annual average amount of training per operator are calculated considering only communities in that category (i.e., region, governance, or population) where operators have participated in on-site training in the past three years, not the overall number of survey data set communities in that category.

On-site training by category is shown in Figure 2.1.3.4.2. Overall, operators have participated in on-site training in 55 percent of the communities in the survey data set. When comparing operator training based on region, governance, or population, none of the categories had an average training level of more than 2 hours per year, which is about 15 percent of the recommended level (13 hours based on Ontario regulations).

Community governance appears to have a significant impact on the level of operator training, as shown in Table C8 (Comparison of On-Site Water System Operator Training by Governance). For the survey data set, only 28 percent of LSD operators had on-site training compared to 67 percent of municipal operators with on-site training. The amount of annual on-site training per operator was also greater for municipalities.

Population also appears to have an effect on the level of operator training, as shown in Table C9 (Comparison of On-Site Water System Operator Training by Population). While the annual average amount of training is fairly similar for very small (populations of 500 or less), small (population of 501 to 1,500), and medium to large (greater than 1,500) communities, the percentage of operators with on-site training in small and medium to large communities (75 percent and 69 percent, respectively) was noticeably higher than very small systems (44 percent). In terms of the availability of back-up operators, the number of operators being trained per community with more than 1,500 people is more than twice the number of operators being training in communities serving less than 1,500 people.

2.1.4 WATER CHEMISTRY

CRA has undertaken an additional review of water quality parameters based on information provided in the March 2008 ENVC Report, "Sustainable Options for the Management of Drinking Water Quality in Small Water Systems".

Test results for up to sixteen chemical and physical water quality indicators were provided in the above report:

- **Health** – Turbidity, Arsenic, Lead, Fluoride, Barium
- **DBPs** – Trihalomethanes (THMs), Bromodichloromethanes (BDCMs), Haloacetic acids (HAAs)
- **Aesthetics** – Colour, pH, Iron, Manganese, Copper, Chloride, Total Dissolved Solids (TDS)

The Guidelines for Canadian Drinking Water Quality (Federal-Provincial-Territorial Committee on Drinking Water, 2008) include published Maximum Acceptable Concentrations (MAC) for all relevant water quality parameters. Each MAC has been established to "safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration".

Review of Data from Provincial Documentation – Water quality test results for the sixteen parameters were available for 313 of the 337 communities identified in Provincial records available for this Study.

Table 2.1.4.1 (Summary of Water Quality Parameters for All Communities - ENVC Data) shows the number of exceedances above MAC for each parameter of the 313 communities - those under BWAs, those without BWAs, and totals for each.

Review of Data from Surveyed and Visited Locations – Water quality test results for the sixteen parameters were available for 85 of the 93 communities that were visited or provided feedback from the basic survey.

Table 2.1.4.2 (Summary of Water Quality Parameters – Surveyed and Visited Communities) shows the number of exceedances above the MAC for each parameter of the 85 surveyed or visited communities - those under BWAs, those without BWAs, and totals for each.

The results shown in these tables indicate that exceedances for eight of the sixteen parameters identified are present in more than 6 percent of the 313 communities identified.

- **Health** - Turbidity
- **DBPs** - THMs, BDCMs, HAAs
- **Aesthetics** - Colour, pH, Iron, and Manganese

The percentages of exceedances for these same parameters in the survey data set are similar. The discussion in this section is focused on these eight parameters.

The MACs for the remaining eight parameters have been exceeded in less than 6 percent of the community totals (example - copper levels in 18 of 313 communities are above the MAC), and generally require specialized equipment or processes to treat for and/or reduce the concentrations.

2.1.4.1 PARAMETERS RELATED TO HEALTH

Turbidity

As shown in Table 2.1.4.1, high turbidity levels in 149 of 313 communities (48 percent) in the Province is a significant statistic. It is coincidental this same percentage of occurrences was noted in communities with and without BWAs.

Turbidity in drinking water is a measurement of the cloudiness of the water. The presence of turbidity is usually a result of suspended or colloidal matter, such as clay, silt, organic or inorganic matter, and microorganisms); therefore, turbidity is generally higher in surface water, or GUDI water sources.

Turbid water on its own is not considered a health risk; however,

- The effectiveness of disinfection is reduced when treating turbid water
- The presence of turbidity after filtration (if present) may suggest the presence of pathogens or inadequate filtration
- Suspended matter in turbid waters may contain additional contaminants (above the 16 identified in this Study)

- Over-chlorinating of turbid waters (high in organics) may increase the potential for DBPs

Removal of turbidity generally requires one (or more) of the following filtration types:

- Chemically Assisted Filtration
- Slow Sand or Diatomaceous Earth Filtration
- Membrane Filtration, which is a technique used to separate particles from a liquid for purifying purposes.

ENVC data shows that only 11 of the 149 systems with high turbidity results have filtration, treatment.

2.1.4.2 DISINFECTION BY-PRODUCTS

Drinking water most commonly undergoes disinfection to reduce the risk of pathenogenic infection from bacteria, viruses, protozoa, etc. Chlorination has been used as primary disinfection for water treatment since the 1880s. However, scientific studies that began in the 1970s found the reaction of chlorine with certain organic materials in treated water could produce DBPs initially defined as THMs. These DBPs were also identified as cancer-causing agents and further investigations have identified some 250 DBPs.

Those most commonly included in scheduled water testing are THMs and HAAs. These have been found to be the most common classes of DBPs detected by weight basis.

Trihalomethanes

THMs are a DBP formed when chlorine reacts with naturally occurring organic matter and bromide ions found in water. These organics (humic or fulvic acids from decaying vegetation often correlated with colour of the water) are found in natural vegetation, aquifers, and agricultural run-off.

The further sub-classification of THMs has been divided into four compounds:

- Chloroform ($CHCl_3$)
- Bromodichoromethane ($CHBrC_{l2}$ or BDCMs)

- Dibromochloromethane ($CHBr_2Cl$)
- Bromoform ($CHBr_3$)

In initial studies, the presence of chloroform was used to establish the MAC for total THMs at 100 μg/L based on an annual running average of quarterly samples.

Multiple (or a combination of) factors in the presence of THMs include:

- Presence and concentration of natural organics
- Presence and concentration of bromide
- pH
- Water temperature
- Chlorine demand from inorganic compounds
- Chlorine dose
- Water residence time in the distribution system

Previous studies have identified the degree and complexity of THMs in the Province, and that methods to control the formation and/or level of THMs will first need to be examined and resolved at the source protection and treatment levels.

Regardless, suitable treatment must be operated and maintained at optimum performance to control the formation of DBPs.

<u>Haloacetic Acids</u>

HAAs are a DBP that forms when chlorine reacts with naturally occurring organic and inorganic (bromide ions) matter. The most common HAAs include:

- Monochloroacetic acid (MCA)
- Dichloroacetic acid (DCA)
- Trichloroacetic acid (TCA)
- Monobromoacetic acid (MBA)
- Dibromoacetic acid (DBA)

Standards used by the US Environmental Protection Agency (USEPA) and the GCDWQ have established the MAC for HAAs at 60 μg/L and 80 μg/L, respectively, based on an annual running average of quarterly samples.

2.1.4.3 PARAMETERS RELATED TO AESTHETICS

Aesthetic parameters are indications of conditions or the presence of substances that do not pose health risks, but are perceived by customers to suggest that water quality is unacceptable.

Typical customer complaints regarding aesthetic water quality that were identified in the survey data set include turbidity, colour, and taste. Complaints regarding taste can be due to elevated concentrations of aesthetic parameters or free chlorine.

Colour

Colour in drinking water is generally due to the high presence of metals (iron, manganese, copper) or coloured organics. These tend to occur in surface water supplies more so than groundwater as a result of potential exposure of the source water to vegetation or marshlands.

Colour due to organic compounds may also increase the potential formation of THMs.

Materials that elevate the measured level of colour may also increase turbidity, in turn reducing the effectiveness of chlorine disinfection.

pH

pH is a measurement of the acidity of any liquid or solution. The pH of most source waters is found to be within the acceptable limits of 6.5 (acidic) to 8.5 (alkaline). Generally, surface waters are found to be more acidic, or at least to have a lower pH than that of groundwater.

The pH of a domestic water supply is significant as it may affect water treatment processes, taste, and have corrosion potential.

Low pH may result in the increase of colour in drinking water due to leaching and/or metal corrosion.

High pH may increase the potential of THM formation; however, the potential for HAA formation actually decreases.

ENVC data shows that almost 75 percent of communities in NL (227 of 313) have recorded pH levels below the lower limit of 6.5; 24 of these 227 communities have pH adjustment available.

Four other communities have pH treatment. These four have test results above the minimum recommended level of 6.5, which may indicate that pH adjustment equipment serving these systems is being properly operated and maintained; however, existing equipment design limitations were not evaluated, which can be influenced by raw water alkalinity levels.

Iron

Iron is an abundant element in rocks and soils. Concentration in natural waters is dependant on many chemical processes, such as oxidation, precipitation of hydroxides, carbonites, and sulfides.

Iron does not have any direct health concerns; however, significant operational impacts may result from the presence of high levels of iron, including staining of plumbing fixtures, laundry, and adverse taste of the water. There is also the potential for the formation of iron bacteria at higher concentrations.

The percentages of communities with high iron content, distinguished by BWAs versus non-BWAs, or full Provincial data versus the survey data set were found to be at equivalent levels such that treatment for iron would not generally be enhanced (or diminished) by disinfection.

Only 8 of the 93 communities with high iron levels have some type of combined iron and manganese removal or treatment.

Manganese

Manganese is a naturally occurring element, common to both surface water and groundwater supplies. It is generally found in the same sources as iron, but usually in lower concentrations. The presence of iron and manganese can be correlated with colour issues as well.

Effects or impacts of manganese are similar to those of iron, with the additional characteristic of the potential for black discolouration of water.

The percentages of communities with manganese presence, distinguished by BWAs versus non-BWAs, or full Provincial data versus the survey data set, were found to be at similar levels such that treatment for manganese would not generally be enhanced (or diminished) by disinfection.

A total of 8 of the 76 communities with high manganese levels have some type of combined iron and manganese removal or treatment.

2.1.4.4 RELATIONSHIP BETWEEN BWAs AND PARAMETER LEVELS

Health and Aesthetic Parameters

Summary data found in Tables 2.1.4.1 and 2.1.4.2 show that relative percentages of communities with high levels of the specific health and aesthetics parameters discussed is not statistically different between communities with BWAs compared to those without.

The only exception appears to be a higher percentage of low pH results for communities without BWAs (80 percent compared to 61 percent in all communities, 83 percent versus 52 percent in the communities surveyed/visited). In addition, low pH improves the effectiveness of chlorination.

Disinfection By-Product Parameters

With respect to DBPs, Tables 2.1.4.1 and 2.1.4.2 confirm an 'expected' result that a lower percentage of THM and HAA exceedances (between 26 and 29 percent), occur in systems that have BWAs, likely due to insufficient or no chlorination.

However, the high relative percentage of TMH and HAA exceedances (66 to 73 percent) in systems without BWAs suggest over-disinfection or the presence of high levels of organics in the water supply that react with the applied rates of chlorination.

2.2 RELATIONSHIP BETWEEN O&M, INFRASTRUCTURE, AND WATER QUALITY

2.2.1 O&M AND INFRASTRUCTURE

Section 2.1.3.2 addresses water treatment infrastructure in the survey data set. The vast majority of water systems (95 percent) have chlorination equipment providing some degree of disinfection. Five of the six water systems in the survey data set that do not have chlorination equipment serve communities of 500 people or less, which suggests that very small water systems are more likely to lack basic water treatment infrastructure.

In general, the majority of water systems in the survey data set have chlorination as the only treatment process. These communities have a single process capable of inactivating pathogens. While chlorination can effectively address viruses, it is less effective with respect to surface water protozoa. Significant contact time is required for the inactivation of *Giardia* cysts, and chlorine is ineffective against *Cryptosporidium* oocysts. This is of particular concern considering the relatively high number of communities in the Province that are served by surface water sources, a mix of surface water and groundwater sources, or GUDI sources that have only chlorination.

If appropriate treatment is not in place to remove a particular contaminant or water quality parameter, O&M practices will have a limited impact on water quality. Conversely, if infrastructure is in place but proper O&M practices are not followed on a consistent basis, then performance of the treatment process will be limited.

For water systems from the detailed survey data set that have additional treatment, performance of these treatment processes was gauged by comparing water quality at these systems to relevant water quality parameters with the water quality at similar water systems that do not have that treatment process. Only water systems from the detailed survey data set were used since CRA personnel recently visited these water systems and observed water treatment equipment was in operation.

Table 2.2.1.1 (Comparison of 2007 pH Monitoring Data for Surface Water Supplies with a Service Population of More than 500) summarizes the results of pH monitoring in six communities from the survey data set. Three of the systems have pH adjustment facilities while three do not. Overall, the treated water pH for water systems without pH adjustment was outside the target range of 6.5 to 8.5 in a greater number of samples. The variation in treated water pH levels between the three water systems that have pH adjustment indicate that O&M of the equipment can have a significant impact on performance; however, existing equipment design limitations were not evaluated, which can be influenced by raw water alkalinity levels.

For the water system serving "Community C", the minimum pH of 4.02 and the range between the minimum and maximum pH results suggests the treatment equipment was off-line or was operating poorly for some period of time. In comparison, the pH adjustment system serving "Community B" appears to be relatively well operated, as the range of treated water pH results was relatively small and was consistently within the target range for the parameter.

Table 2.2.1.2 (Comparison of 2007 Treated Water Quality Monitoring Data for Surface Water Supplies with a Service Population of More than 1,500) summarizes treated water quality monitoring data for four communities from the survey data set. Two of the water systems have conventional or membrane filtration systems capable of reducing colloidal and suspended matter that cause colour and turbidity. Although the two water systems that have filtration facilities generally have effluent with lower colour levels that result in less DBP formation, results for these systems suggest that water quality could be further improved by optimizing operations.

The "Community W" water system exceeded the limits for colour and HAAs in both of the samples collected, which suggests that pre-treatment optimization is required to ensure that colloidal and dissolved organic matter is removed to minimize colour levels. The "Community X" water system consistently met limits for colour and HAAs, but exceeded the turbidity standard of 1 NTU in two of twelve samples. Conventional water treatment processes are capable of consistently achieving effluent quality of 0.3 NTU when operation has been optimized. The maximum turbidity measurement of 2.4 NTU suggests the water treatment process may be vulnerable to upset conditions.

2.2.2 O&M AND MICROBIAL WATER QUALITY

The distribution of the total number of BWAs in the six major BWA Codes is quite similar (as shown in Figure 2.2.2.1) when comparing the survey data set to the Province-wide data set. Two minor differences are that the survey data set appears to overestimate the number of BWAs caused by inadequately treated water entering the distribution system (Code D), and underestimate the proportion of BWAs caused by insufficient CT or free chlorine residual (Code E).

Despite these discrepancies, the survey data set provides a good representation of the microbial water quality on a Provincial scale, both in terms of the water treatment systems that are more likely to have a BWA, and factors that are more likely to contribute to a BWA.

When comparing the prevalence of different BWA contributing factors, Code E (Chlorine Residual or CT) contributed to the greatest proportion of BWAs for the survey and Province-wide data sets. Issues with insufficient CT or free chlorine residual in the distribution system may be due to either equipment (i.e., undersized that does not provide sufficient CT) or operational issues (i.e., not adding chlorine at a sufficient rate to meet CT requirements).

BWA Codes B and C, which are related to the O&M of disinfection equipment, contributed to 29 percent of BWAs in the survey data set. The majority of these BWAs were issued to LSDs (six of 10 BWAs) and very small water systems (eight of 10 BWAs).

This suggests that small water systems are more likely to have issues with the O&M of disinfection equipment.

However, O&M issues could be partially due to a shortfall in resources for O&M of water systems serving very small communities, or deficiencies in operator training and education, which is discussed in Section 2.1.3.4.

O&M practices for water systems that are under a BWA are compared with systems that are not under a BWA in Table 2.2.2 (Comparison of Operation and Maintenance Practices for Survey Data Set Based on Boil Water Advisory Codes). In some cases, the survey information supports the reason for the BWA being issued.

The majority of respondents from water systems that were under a BWA due to their disinfection system being off-line for maintenance (Code C) indicated that spare parts or emergency repair parts were not available. The majority of these systems also indicated that less than 10 hours of operator effort per week was focused on maintenance.

It may be concluded that if more resources were available for preventative maintenance on a consistent basis, then the amount of major reactive maintenance work that requires equipment be removed from service would be reduced.

The majority of respondents from water systems that were under a BWA due to insufficient CT or free chlorine levels in the distribution system (Code E) indicated they collect less than one sample for free chlorine analysis per day.

Increasing the sampling frequency (which would require additional operator effort) may provide additional information regarding variations in free chlorine levels as water use in the community fluctuates over the course of the day. This information would also be useful in developing variable chlorine feed procedures to maintain the free chlorine residual throughout the day, with the appropriate equipment being available and in operation. One potential solution would be to install continuous free chlorine monitoring equipment to monitor treated water entering the distribution system. Only eight of the 25 communities in the detailed survey data set had an operational chlorine residual analyzer.

Since the number of systems under each BWA Code is relatively small and the response rates for some of the relevant survey questions were not high, Figure 2.2.2.2 is included to compare the O&M practices for all surveyed systems that were under a BWA as of February 2009 to the surveyed systems that were not under a BWA at the time.

O&M practices at systems that are not under a BWA have been found to be consistently superior to facilities under a BWA.

One survey question where little difference was observed between systems (with and without a BWA) was related to typical maintenance effort. In both groups, roughly half of respondents indicated that less than 10 hours per week was dedicated to the maintenance activities for day-to-day operation of the system. Typical operator effort was greater than 20 hours per week for 72 percent of the time, while only 33 percent of systems under a BWA provided the same level of operator effort.

In the event that maintenance activities were required, operators of water systems who are more likely to have access to necessary documentation and equipment were less likely to have a system that would be under a BWA.

2.2.3 OPERATOR EMPLOYMENT STATUS, CERTIFICATION AND TRAINING, AND MICROBIAL WATER QUALITY

Similar to the survey input regarding O&M practices, response rates were low for some survey questions relevant to operator employment status (full-time, part-time, or volunteer). Figure 2.2.3.1 and Table 2.2.3.1 (Comparison of Operator Status for Survey Data Set Based on Boil Water Advisory Codes) compare the operator status for the survey data set that were under a BWA (as of February 2009) to those that were not under a BWA at the time.

The table suggests that a significant difference exists between communities that have BWAs versus those that do not. The majority of communities that are not under a BWA have a full-time operator (80 percent of respondents) and have at least one certified operator (63 percent of respondents if seasonal, full-time operators are included). Less than half of the respondents in the survey data set that are under a BWA have an operator that is full-time and fully certified. It was also noted that a higher percentage of systems not under a BWA have a secondary operator.

OETC on-site training records may be used to compare operator qualifications between systems under a BWA to those who are not. Table 2.2.3.2 (Operator Training for Systems with Boil Water Advisories Based on OETC Training Records (February 2006 to February 2009)) shows on-site training levels for the individual BWA Codes, as well as the average training level for all communities under a BWA. Many operators were noted to have about 15 percent of the minimum level of annual on-Site training.

One finding is that communities without disinfection equipment (Code A) or have chosen to remove their disinfection equipment from service (Code B) are less likely to have a trained operator. This does not take into consideration any circumstances where an operator was directed by an employer/community representative to remove the disinfection equipment from service.

If no water treatment is provided, less effort and expertise is required on the part of the operator. For communities under a Code B BWA, an operator that is untrained or has completed minimal training may be more likely to remove the disinfection system from service due to complaints of chlorine taste or the perceived health risks associated with exposure to DBPs. A well-trained operator would understand the importance of ensuring that drinking water receives adequate disinfection to inactivate pathogens that can cause acute health problems. Increasing the number of trained operators available to communities under Code B BWAs and increasing the amount of training completed by those same operators should improve the quality of water supplied to residents in those communities.

In general, communities that have a trained operator are less likely to be under a BWA. The average number of operators per community is also greater for communities without a BWA. Having more trained operators at each community or within groups of communities should result in more consistent operation of water treatment systems, which would translate to a greater degree of confidence in drinking water quality.

3.0 ECONOMICS ANALYSIS

3.1 PARAMETERS USED IN ECONOMIC ANALYSIS

A review of four primary assessment parameters was completed for the information presented in the Phase 2 report on the Correlation of Drinking Water Quality Issues with O&M Practices to determine whether or not any trends were obvious in comparing the drinking water systems as noted below. The results of the review and basis for evaluation of this report are outlined below.

- **Region** – This was not considered as a parameter of importance as the initial assessment of the four ENVC regions (Eastern, Central, Western, and Labrador) indicated similar results pertaining to the economics of drinking water O&M. The only relevant information related to Region is increased cost associated with initial capital investment for shipping to, and construction, in remote communities, which is site-specific, not region specific. Additional site-specific parameters include adverse climate conditions and limitations in contractor/consultant availability due to accessibility.
- **Governance** – Split according to municipal structure for Municipality or LSDs. This parameter was only assessed in relation to budgets, water/sewer rates, and operator salaries. The municipal structure does not influence the type of drinking water infrastructure required as this is primarily dependent on source water quality.
- **Population** – Divided into two categories based on the service population rather than the 2006 census data:
    - 500 people or less
    - more than 500 people
- **Water Source** – The data provided by the Province initially divided water supplies into two types:
    - Groundwater (GW)
    - Surface Water (SW), including GUDI and communities that use both GW and SW sources (GW/SW)

For the economic analysis related to costing of capital investment and O&M requirements, only population and water source were considered.

3.2 EXISTING CONDITIONS

3.2.1 OVERVIEW OF EXISTING INFRASTRUCTURE

The following points provide generalized statements on CRA's findings related to the 25 locations included in the detailed data set.

3.2.1.1 PRIMARY DISINFECTION

Water treatment infrastructure throughout the Province, and for the 25 communities in the detailed data set, is generally limited. Most water systems use chlorination to provide primary and secondary disinfection, but water does not generally undergo additional treatment prior to distribution. Chlorination is the only form of treatment at 18 of the 25 water systems in the detailed data set. Although all systems in the detailed data set have chlorination equipment, four water systems are under a BWA because the existing chlorination system has been removed from service, the equipment requires maintenance, or there is no operator to operate and maintain the equipment (Code A and C BWAs).

3.2.1.2 ADDITIONAL TREATMENT

Generally, larger water systems are more likely to have some form of treatment in addition to disinfection: Four of the 5 water systems in the detailed data set that have pH adjustment serve populations of greater than 500, and both of the water systems with advanced filtration processes capable of removing surface water pathogens (i.e., conventional treatment or membrane filtration) serve communities with populations of greater than 1,500.

3.2.1.3 SYSTEM STORAGE

Only 7 of the 25 communities in the detailed data set have storage facilities, which were either buried or installed at ground level (i.e., standpipes). Communities with water storage facilities need to complete the necessary internal and external O&M activities to ensure that water quality does not degrade in storage facilities due to stagnation of treated water or contamination entering the storage facility.

3.2.1.4 SYSTEM DISTRIBUTION

Eighteen of the 25 water systems in the detailed data set have flush valves or fire hydrants in their distribution systems. These appurtenances allow for water system operators to flush the distribution system, which is a key maintenance activity in maintaining distribution system water quality.

3.2.1.5 MONITORING

With respect to water quality and quantity monitoring equipment, information was only available for flow meters and residual chlorine analyzers. Continuous chlorine analyzers are used to ensure the quality of water leaving the treatment plant consistently meets treatment standards with respect to chlorine contact time and residual chlorine concentration. Only 7 of the 25 detailed data set water systems had operational continuous chlorine monitoring equipment at the time of CRA's site visit.

Ideally, water systems with additional treatment, such as pH adjustment or advanced filtration and removal processes, should have the continuous monitoring equipment necessary to ensure those processes are meeting treatment standards. No information was available regarding pH or turbidity monitoring equipment for the 25 water systems; therefore, CRA assumed that relevant continuous monitoring equipment is installed at any water system that currently has additional treatment.

Eighteen of the 25 water systems have some degree of flow metering. The ability to track variations in water demand can influence operating decisions, and can provide evidence of leaks in the distribution system.

3.2.1.6 OVERALL

Water systems are categorized by the water treatment, distribution, and storage infrastructure listed in Table 3.2.1.6. These categories will be used to determine the O&M effort required to properly operate the 25 water systems in the detailed data set based on existing infrastructure.

3.2.2 O&M FOLLOWING BEST MANAGEMENT PRACTICES

This section describes the steps taken and background used to develop the estimated efforts and costs for Best Management Practices of the 25 water systems as currently configured. O&M tasks were identified based on the USEPA Preventative Maintenance Card File for Small Public Water Systems Using Groundwater (USEPA Card File). Since this document is specific to groundwater sources, O&M activities for water treatment processes generally associated with surface water sources were added to supplement the task list.

3.2.2.1 CALCULATION OF CONSUMABLES AS PART OF O&M

Water treatment chemicals are required for the following existing treatment processes: primary disinfection (calcium hypochlorite powder, chlorine gas, or sodium hypochlorite solution), pH adjustment (i.e., sodium hydroxide solution), coagulation (i.e., aluminum sulphate solution), and flocculation (i.e., cationic polymer).

Feed rates for all water treatment chemicals were calculated based on the average daily demand for the community. The average daily demand for six of the communities in the detailed data set was included in the ENVC report Best Management Practices for the Control of Disinfection By-Products in Newfoundland and Labrador (Control of Disinfection By-Products). For the remaining 19 communities in the detailed data set, the average daily demand was estimated based on a per capita water use rate of 450 L/d. This value is based on the average daily per capita water demand of 270 to 450 L that is used in the Province of Ontario when flow records are not available.

Unit supply costs for water treatment chemicals were obtained from East-Chem Inc., a local supplier in the St. John's, NL area. The unit costs for water treatment chemicals are included in Appendix D.

3.2.2.2 CALCULATION OF O&M EFFORT TO MEET BEST MANAGEMENT PRACTICES

In addition to identifying O&M tasks, the USEPA Card File provides recommended frequencies (i.e., daily, weekly, quarterly, annually) for various tasks. CRA estimated the amount of operator effort to complete each task to develop an annualized O&M effort for the water system.

Total effort was annualized based on frequency of tasks for various combinations of supply, treatment, and distribution infrastructure (i.e., groundwater, surface water, systems without filtration, membrane filtration, conventional treatment, disinfection, treated water storage, distribution system with flushing, distribution system without flushing, monitoring and reporting, building/site maintenance). Total effort was also calculated per process component, based on the sum of all tasks applicable to that component.

Templates were then used to calculate expected total hourly effort to operate and maintain each of the 25 systems (see Appendix E).

Operator costs were then calculated adding lump sum hours for annual training, vacation and sick leave, all multiplied by an average wage level (excluding benefits, etc.).

3.2.2.3 CALCULATION OF THIRD PARTY CONTRACTORS

It is unlikely a small water system operator would have the process-specific expertise or equipment to complete all of the seasonal, annual, or less frequent maintenance activities included in the USEPA Card File. As a result, a third party contractor would be required to perform such maintenance activities, including calibration of equipment and instrumentation, and inspection and replacement of internal parts. Contractor effort was estimated on a per day basis, and includes a travel allowance.

The total annual O&M costs for the 25 communities, using best management practices, in the detailed survey data set based on operator effort, chemical consumption, and contractor effort for the detailed data set are included in Table 3.2.2.3.

3.2.3 DEVELOPMENT OF REPLACEMENT COSTS FOR EXISTING INFRASTRUCTURE

Replacement costs for supply wells, surface water intakes, and pump stations were not calculated because CRA is not recommending that any of the communities in the detailed data set consider relocating their source. Such site-specific recommendations are beyond the scope of this Study.

For the most part, replacement costs for existing water treatment and storage infrastructure were estimated based on cost curves developed for the Ontario Ministry of Public Infrastructure Renewal (MPIR) in a 2004 report.

The replacement cost for the Potable Water Dispensing Unit (PWDU) serving the community of Howley was based on the capital cost listed in a presentation developed by the Water Resources Management Division of ENVC. The presentation is available from the website for the Government of Newfoundland and Labrador.

The cost curves and their respective regression equations estimate the replacement cost for a piece of infrastructure based on its design flow rate or design capacity. The maximum day demand for a water system was used as the design flow rate. The maximum day demand for a given system was calculated based on an assumed per capita daily water demand of 450 L, and a maximum day factor which is estimated based on the population served by the water system.

Original cost curves were in 2004 dollars. The Bank of Canada inflation calculator was used to adjust the costs to 2009 dollars, using a multiplier of 1.0892.

The original cost curves were based on projects that were completed outside of the Greater Toronto Area (GTA). A regional multiplier of 1.06 was used to account for a slight increase in capital costs for projects performed in the GTA. A second regional multiplier of 1.078 was used to represent increased costs associated with utilities projects in St. John's compared to Toronto. It was assumed the cost of equipment, materials, and labour in St. John's would provide a reasonable estimate of these costs throughout the Province.

Due to a lack of information regarding the distribution system infrastructure for the communities in the detailed data set, replacement costs for raw water transmission and treated water distribution systems were generally estimated based on pipe length, and to a lesser degree, pipe diameter and material of construction.

Replacement costs for monitoring and distribution system equipment were based on unit capital costs listed in a 2003 report by the U.S. Environmental Protection Agency (USEPA). These costs were adjusted to reflect the 2003 exchange rate, as well as inflation and the increased cost of equipment to St. John's, NL.

The replacement cost for the building housing the water treatment plant was estimated based on replacement cost of the treatment infrastructure inside the building. A multiplier of 1.24 was applied to the replacement cost of all treatment infrastructure, with an additional multiplier of 1.1 for buildings with slow sand filtration systems.

Infrastructure replacement costs are summarized in Table 3.2.3.

3.3 RECOMMENDED UPGRADES TO INFRASTRUCTURE

3.3.1 OVERVIEW OF RECOMMENDED INFRASTRUCTURE

The infrastructure upgrades recommended for the 25 detailed data set communities were selected based on community size, existing infrastructure, source water quality, and the type of source. For source water quality, if a parameter exceeded its Guideline for Canadian Drinking Water Quality (GCDWQ) limit in more than one sample during the 2008 monitoring year, treatment equipment was selected to address that parameter.

3.3.1.2 POTABLE WATER STORAGE

Storage facilities are generally designed to have sufficient capacity to meet elevated water demand during peak flow periods, emergency flow requirements during short periods when the water system is not in operation, and in some cases, will also have the necessary storage capacity to provide chlorine contact time prior to distribution and storage for firefighting purposes. The storage capacity design equation from the Atlantic Canada Guidelines for the Supply, Treatment, Storage, Distribution, and Operation of Drinking Water Systems is shown below.

$$S = F + CT + A + B$$

where:

S: Total storage capacity (m^3)
F: Fire flow storage (m^3)
CT: Storage to meet contact time requirements (m^3)
A: Peak balancing requirements (m^3), equal to 25 percent of the maximum day demand
B: Emergency storage (m^3), equal to 15 percent of the average day demand

This report does not consider the effect that fire flow will have on the capacity of water system infrastructure. As a result, the "F" term is removed from the equation.

Due to a lack of information regarding the location of the storage tank for some systems, the "CT" term is also removed from the equation.

The capacity of storage facilities was available for four of the seven communities that currently have storage facilities. Of those four systems, three have sufficient capacity to meet peak balancing and emergency storage requirements. For the remaining three storage facilities, CRA assumed that existing storage facilities have sufficient capacity for peak balancing and emergency storage.

If the recommended storage infrastructure is installed, each community will have sufficient storage volume to meet peak balancing requirements. As a result, new water treatment infrastructure can be sized according to the maximum day demand for the water system, instead of having to meet the peak hour demand.

3.3.1.3 pH ADJUSTMENT

Low raw water pH, which is a problem throughout the Province, can increase distribution system corrosion; however, three of the 25 detailed data set systems exceeded the GCDWQ upper limit of 8.5 for pH. All three of these systems have a groundwater or GUDI supply. The flow chart for selecting acid or caustic pH adjustment equipment is included on Figure 3.3.1.3.

3.3.1.4 FILTRATION

Filtration was not required for the four groundwater systems in the detailed data set based on their water quality. Filtration equipment for surface water systems was selected for a given community; which was dependant on the raw water quality and the population served in that community. It was assumed that small water systems (i.e., serving less than 1,500 people) would be less likely to have the resources to hire and retain the skilled personnel required to operate and maintain more complex treatment processes that are generally used to treat raw water with high colour or high turbidity, such as direct filtration or membrane filtration. As a result, small water systems are eligible for installation of a central PWDU if the water supply has high colour. The flowchart for selecting filtration equipment is included on Figure 3.3.1.4.

3.3.1.5 CHLORINATION

It was assumed that new chlorination equipment was required for any water system that does not have existing chlorination equipment, currently uses a calcium hypochlorite "powder" chlorination system, or is under a Code A or C BWA. The flowchart for selecting chlorination equipment is included on Figure 3.3.1.5.

3.3.1.6 WATER TREATMENT FACILITIES

It was assumed a new water treatment building would be required to house new advanced filtration equipment or a PWDU. If the only new treatment infrastructure is chemical addition equipment for pH adjustment or chlorination, it was assumed the new equipment could be housed within the existing building.

3.3.1.7 PWDUs

Although a PWDU will provide the community with potable water for consumption, it was assumed that a community with a PWDU would continue to operate the pH adjustment (if necessary) and chlorination equipment to prevent excessive corrosion or bio-film formation in the distribution system.

3.3.1.8 SUMMARY OF RECOMMENDED INFRASTRUCTURE UPGRADES

Water systems were categorized based on the water treatment, distribution, and storage infrastructure listed in Table 3.3.1.8. These categories were used to determine O&M effort required to properly operate the 25 water systems in the detailed data set based on existing infrastructure.

3.3.2 O&M FOLLOWING BEST MANAGEMENT PRACTICES

This section describes the steps taken and background used to develop the estimated efforts and costs for Best Management Practices of the 25 water systems upgraded to meet Provincial/Federal water quality standards.

3.3.2.1 CALCULATION OF OPERATIONAL EFFORT TO MEET BEST MANAGEMENT PRACTICES

Task lists and operator effort estimates were developed based on the USEPA Card File for processes and infrastructure associated with groundwater systems. Since most water systems in the detailed data set provided chlorination as the only form of treatment, O&M task lists were not required for many other processes. Since CRA is assuming that additional treatment infrastructure be installed to treat GUDI, combined groundwater/surface water, and surface water supplies, task lists were developed for the additional treatment processes. The total effort for O&M of the upgraded facility was calculated per process component (existing and new), including supply, filtration, disinfection, distribution, monitoring and reporting, building and site maintenance activities.

Templates were then used to estimate total hourly effort to operate and maintain each of the upgraded 25 systems (see Appendix E).

Operator costs were then calculated adding lump sum hours for annual training, vacation and sick leave, all multiplied by an average wage level (excluding benefits, etc.).

3.3.2.2 CALCULATION OF CONSUMABLES USED AS PART OF O&M

Water treatment chemicals are required for the following treatment processes: primary disinfection (chlorine gas or sodium hypochlorite solution), pH adjustment (high-grade hydrochloric acid or sodium hydroxide solution), coagulation (i.e., aluminum sulphate solution), and flocculation (i.e., cationic polymer).

Feed rates for all water treatment chemicals were calculated using the same average day demands and unit costs described in Section 3.2.2 for existing conditions.

3.3.2.3 CALCULATION OF THIRD PARTY CONTRACTORS

Given that CRA is assuming additional treatment infrastructure be installed as part of this scenario, it is even less likely that small water system operator would have the process-specific expertise or equipment to complete all of the seasonal, annual, and other less frequent maintenance activities. As a result, a third party contractor would be required to perform such maintenance activities, including calibration of equipment and instrumentation, and inspection and replacement of internal parts. Contractor effort was estimated on a per day basis, and includes a travel allowance.

The total annual O&M costs for the 25 communities in the detailed data set based on operator effort, chemical consumption, and contractor effort for the detailed survey data set are included in Table 3.3.2.3.

3.3.3 DEVELOPMENT OF CAPITAL COSTS FOR INFRASTRUCTURE (NEW AND REPLACEMENT)

3.3.3.1 PROPOSED INFRASTRUCTURE

Similar to the replacement costs for existing infrastructure, capital costs for the new water treatment and storage infrastructure were estimated based on the cost curves and respective regression equations in the MPIR report. The same assumptions and multipliers were used for the calculation of capital costs for new equipment as for replacement costs of existing equipment, with the addition of a multiplier of 0.75 that was applied to all new equipment and construction.

Capital costs for the 25 water systems are summarized in Table 3.3.3.1.

3.3.3.2 ABOVEGROUND STORAGE FACILITIES

A capital cost for aboveground storage facilities (i.e., stand pipes) was developed for all water systems that do not have sufficient storage volume, which is included under the distribution infrastructure.

3.3.3.3 pH ADJUSTMENT EQUIPMENT

Capital cost estimates for chemical addition equipment for caustic or acid addition were developed for water systems that fell below or exceeded the GCDWQ pH range of 6.5 to 8.5.

3.3.3.4 FILTRATION

Capital cost estimates were developed for the alternative treatment processes (i.e., a combination of media and cartridge filtration, slow sand filtration, direct filtration, membrane filtration) selected from the applicable flow chart. Proper O&M of these systems will provide GUDI and surface water systems with a barrier to surface water pathogens. In Ontario, all surface water and GUDI supplies require a filtration process that is capable of removing cryptosporidium and/or Giardia cysts. This is especially important for water systems that use chlorination to provide primary disinfection, as chlorine does not inactivate cryptosporidium.

3.3.3.5 MECHANICAL WASTE HANDLING

In addition to the cost of filtration facilities, capital cost for mechanical waste handling facilities was developed for any community that will have a filtration process that produces a backwash or other liquid waste stream.

3.3.3.6 CHLORINATION

It was assumed that new chlorination equipment would use a 12 percent (by weight) sodium hypochlorite solution, to eliminate safety issues associated with chlorine gas.

3.3.3.7 MONITORING AND DISTRIBUTION SYSTEM EQUIPMENT

Capital costs for monitoring and distribution system equipment were based on the same unit capital costs listed in the 2003 USEPA report that were used to develop the unit replacement costs. Continuous chlorine monitoring equipment and flow meters are added to the capital cost estimates for water systems that do not currently have this equipment to improve monitoring capabilities. Continuous pH monitoring equipment was added to the capital costs for any communities where pH adjustment is recommended. Continuous raw and treated water turbidity monitoring units were added to the capital costs for communities that use surface water or GUDI wells as their source. Distribution system hydrants were included for any water system where they are not currently installed.

3.3.3.8 PWDUs

Since no cost curves were available for PWDUs, the capital costs for new PWDUs were estimated based on the capital costs for the five existing PWDU pilot plants in the Province. For the five existing systems, there appeared to be a trend in capital cost of the system per capita with respect to service population. The regression equation for the curve is shown on Figure 3.3.3.8.

3.4 REALISTIC SYSTEM COSTS

3.4.1 LIFE CYCLE COSTS

In order to evaluate the true costs of constructing, owning, operating, and maintaining public water systems for the consumer, municipality, and Province, it is necessary to incorporate life cycle costs.

These costs include purchasing new equipment to replace old equipment, as well as the purchase of recommended infrastructure to upgrade systems to meet Federal/Provincial water quality standards.

3.4.2 INFRASTRUCTURE COSTS

As discussed in Sections 3.2 and 3.3 of this Report, capital costs for new infrastructure and estimated replacement values of existing infrastructure were derived from previous studies (component by component) using regression analysis to determine costs of infrastructure as a function of system capacity or production. These can be found in Table 3.2.3 (existing infrastructure) and Table 3.3.3.1 (recommended infrastructure).

3.4.3 ANNUALIZATION OF COSTS (EXISTING/UPGRADED)

Replacement costs for existing infrastructure and recommended infrastructure are given in 2009 Canadian dollars. In order to account for the increase in cost of replacing infrastructure between 2009 and the end of the useful service life for the infrastructure, CRA estimated an average inflation rate of 1.75 percent based on the core Consumer Price Index (Core CPI) from February 1995 to February 2009. The increase in capital cost of infrastructure due to inflation was partly based on the expected useful service life of the infrastructure. Although different pieces of treatment equipment have different expected useful service lives, for the purpose of this report, CRA used an estimated useful service life of 30 years (n = 30 years) for all water treatment equipment. This value was based on the average of the expected useful service lives for all existing or recommended water treatment infrastructure for the 25 communities in the detailed survey data set. An effective annual interest rate of 5 percent was selected for the 30 year service life based on the expected return rate for long-term bonds from the Bank of Canada. Based on the above information, the 9th edition of the Mechanical Engineering Reference Manual indicated that a multiplier of 0.0151 could be used to convert a future infrastructure capital cost for a water system to an annualized cost over the 30 year lifetime.

$$A = \frac{F * i}{(1+i)^n - 1}$$

where:

A: Annual Payments
F: Future Infrastructure Costs
i: Annual Interest Rate
n: Estimated Useful Service Life

The annualized infrastructure replacement costs and O&M costs for the 25 communities in the detailed data set are shown in Tables 3.4.3.1 (existing infrastructure) and 3.4.3.2 (recommended infrastructure). It should be noted that Tables 3.4.3.1 and 3.4.3.2 account for the division of the infrastructure replacement costs between the community and the Province. This arrangement is discussed further in Section 3.5.2.

The tables are organized such that water systems are grouped according to service population and water supply. The tables show that although the annualized costs for both O&M and capital costs generally increase as population increases, the annual cost per household generally decreases as the population increases. These annualized costs should be the basis for setting residential water rates, if the water system is intended to recover O&M and capital costs.

3.4.4 LIFE CYCLE FOR EQUIPMENT REPLACEMENT VS. REHABILITATION

External studies have been undertaken to investigate the cost effectiveness of completing additional rehabilitation (above prescribed maintenance according to manufacturer recommendations for each of the components), in order to extend the useful service life of specific equipment.

These studies provide example annual maintenance costs and periodic rehabilitation costs as a function of the initial purchase price, an example being:

- annual maintenance cost equal to 5 percent of the replacement cost
- an expected product life 30 years, assuming the recommended maintenance activities are completed
- rehabilitation costs equal to 10 percent of the replacement cost every 20 years
- an extended product life 60 years, assuming that both maintenance and rehabilitation activities are completed.

Table 3.4.4 shows examples of life extension costs the various primary and secondary treatment components in a water supply system, based on the historical percentages of the initial costs. For this table, CRA have standardized the initial purchase price at $100,000 for each component, allowing adjustment to reflect alternative costs.

Based on the percentage costs for the suggested rehabilitation schedules compared to the life extension of the specified product, it appears there is overall savings (capital and rehabilitation and maintenance) to be gained from rehabilitation efforts on chlorination and pH adjustment equipment. However, little or no overall savings appear to exist for rehabilitation works for filtration equipment.

It followed that when comparing the distribution of costs between capital, O&M for maintenance only, and rehabilitation scenarios, that as the annualized O&M and rehabilitation costs increased for a given piece of equipment, the annualized capital cost will decrease. This may become an issue if capital/infrastructure investments are funded by one level of government while the O&M and rehabilitation costs are funded by a different level of government, as the proportionality of this cost sharing changes.

3.5 FINANCES

Drinking water infrastructure costs are comprised of the installation, operation, and maintenance of various components that transport raw source water through to a treatment facility, which is then distributed to end users. Initial infrastructure construction requires capital funding while the day-to-day O&M requires funding from the community that uses the treated water. This section reviews the various financial information collected from the detailed survey data set during Phase 1 of the Study.

Issues such as total annual budgets, O&M budgets, water and sewer rates, debt-service ratios, residential water tax arrears, and operator hourly wages are discussed. In addition, the financial framework associated with the initial capital investment and the inherent O&M costs associated with ensuring the infrastructure continues to operate as originally designed for the intended useful service life.

3.5.1 CURRENT FINANCIAL ASSESSMENT

3.5.1.1 2009 COMMUNITY BUDGETS

Budgets from 2009 for the 25 communities were reviewed and the raw data (shown in Table 3.5.1.1.1) was sorted by governance, population, and water source as shown in

Table 3.5.1.1.2, Table 3.5.1.1.3, and Table 3.5.1.1.4, respectively. The 2009 community budget data summary is included in Table 3.5.1.1.5 from which the following was noted:

- LSDs had lower overall budgets compared to municipalities. The majority of LSDs (88 percent) had an overall budget of less than $50,000 compared to municipalities, where 47 percent of detailed survey data set systems had an overall budget of $100,000 - $500,000.
- Communities with smaller populations had smaller budgets. Almost half (44 percent) of very small population centres with less than 500 people reported overall budgets of less than $50,000 while population centres with more than 500 people (56 percent) reported an overall budget of more than $1,000,000.
- There was a substantial difference between budgets for groundwater and non-groundwater supplies. The majority of communities with groundwater sources (75 percent) had an overall budget of less than $50,000 whereas one-third of communities with surface water sources had an overall budget of $100,000 - $500,000. Groundwater sources typically served communities of less than 500 people in NL; however, it was noted that communities with surface water sources had a wide range of budgets.
- LSDs with a population of less than 500 people and a groundwater source had substantially lower overall budgets than municipalities with a population of more than 500 people and a surface water source.

Table 3.5.1.1.5: Community 2009 Budget Data Summary

Sort Parameters		*Community Overall Budgets[1]*				
		<50	***50 -100***	***100 -500***	***500 -1,000***	***>1,000***
Governance	**LSD**	88%	12%			
	MUN		6%	47%	18%	29%
Population	**0 - 500**	44%	12%	38%	6%	
	>500			22%	22%	56%
Water Source	**GW**	75%	25%			
	SW	19%	10%	33%	14%	24%

1. Based on 2009 budgets received from DMA; ranges in thousands of dollars.

3.5.1.2 2009 O&M BUDGETS

Budgets from 2009 for the 25 communities were reviewed with particular attention to O&M allocations; the raw data are presented with summary information sorted by governance, population, and water source in Tables 3.5.1.1.1, 3.5.1.1.2, 3.5.1.1.3, and 3.5.1.1.4, respectively. The community 2009 O&M budget data summary is included in Table 3.5.1.2 from which the following was noted:

- LSDs have lower O&M budgets compared to municipalities. The majority of LSDs (88 percent) have an O&M budget of less than $10,000 whereas the majority of municipalities (52 percent) have an O&M budget of $10,000 - $50,000.
- Communities with smaller populations have smaller O&M budgets compared to larger communities. The majority of very small population centres (63 percent) have an O&M budget of less than $10,000 whereas all population centres with more than 500 people have O&M budgets of more than $10,000 with the many (45 percent) in the $10,000 to $50,000 range.
- There is a substantial difference between budgets for the two water sources as all four communities with groundwater sources have O&M budgets of less than $10,000 whereas a large number of communities (48 percent) with surface water sources have an O&M budget of $10,000 - $50,000 (48 percent). However, it is noted that communities with surface water sources have a wide range of budgets.
- LSDs with a population of less than 500 people and a groundwater source have substantially lower O&M budgets compared to municipalities with more than 500 people and a surface water source.

Table 3.5.1.2: Community 2009 O&M Budget Data Summary

Sort Parameters		*Community O&M Budgets[1]*				
		<10	***10 - 50***	***50 -100***	***100 -500***	***>500***
Governance	**LSD**	88%	12%			
	MUN	18%	52%	6%	18%	6%
Population	**0 - 500**	63%	37%			
	>500		45%	11%	33%	11%
Water Source	**GW**	100%				
	SW	28%	48%	5%	14%	5%

1. Based on 2009 budgets received from DMA; ranges in thousands of dollars.

3.5.1.3 2009 WATER AND SEWER RATES

Current water and sewer rates with segregated water rates for the 25 communities were reviewed; the raw data are presented with summary information sorted by governance, population, and water source in Tables 3.5.1.3.1, 3.5.1.3.2, 3.5.1.3.3, and Table 3.5.1.3.4, respectively. The water and sewer rates data summary is included in Table 3.5.1.3.5 from which the following was noted:

- Combined water and sewer rates were not provided by the eight LSDs, two of the 17 municipalities, or by any communities with a groundwater source.
- Water rates were provided by all 25 communities.
- The majority of LSDs (63 percent) have a water rate of $100 - $200/year whereas the majority of municipalities (65 percent) have a water rate of $200 - $300/year.
- There is not a substantial difference between the rates for the two population sizes. The majority of very small population centres (67 percent) and communities with populations of more than 500 people (56 percent) have a combined water and sewer rate of $300 - $400 per residential connection per year; however, the majority of very small population centres (50 percent) and communities with populations of more than 500 people (56 percent) have a water rate of $200 - $300 per residential connection per year.
- There is a difference between the rates for the two water sources, as the majority of the groundwater sources (75 percent) have a water rate of $100 - $200/year while the majority of the surface water sources (57 percent) have a water rate of $200 - $300/year.
- Governance, population, or water source does not affect the combined water and sewer rates, as the majority (56 percent to 67 percent) of each of the three has a rate of $300 -$400/year.

Table 3.5.1.3.5: Community 2009 Water and Sewer Rates Data Summary

Sort Parameters		*Water and Sewer Rates ($/year)*			*Water Rates ($/year)*[1]			
		200-300	***300-400***	***400-500***	***<100***	***100-200***	***200-300***	***300-400***
Governance	**LSD**				12%	63%	25%	
	MUN	20%	60%	20%		29%	65%	6%
Population	**0 - 500**		67%	33%	6%	38%	50%	6%
	>500	33%	56%	11%		44%	56%	
Water Source	**GW**					75%	25%	
	SW	20%	60%	20%	5%	33%	57%	5%

1. Based on 2009 rates received from DMA.

3.5.1.4 OUTSTANDING RESIDENTIAL TAXES AND DEBT/SERVICE RATIO

Outstanding residential taxes and debt/service ratios for the 25 communities were reviewed; the raw data is presented with summary information sorted by governance, population, and water source in Tables 3.5.1.4.1, 3.5.1.4.2, 3.5.1.4.3, and Table 3.5.1.4.4, respectively. The outstanding residential taxes and debt/service ratio data summary is included in Table 3.5.1.4.5 from which the following was noted:

- The majority of municipalities (80 percent) were noted to have outstanding residential taxes of less than 10 percent while the majority of LSDs (86 percent) were noted as less than 30 percent. Some LSDs (14 percent) were noted to have outstanding residential taxes of more than 50 percent, while no municipalities reported more than 30 percent of households with outstanding residential taxes.
- Little difference was noted in the amount of outstanding residential taxes between population centres of very small communities compared to small communities or larger except some very small communities (7 percent) reported residential tax arrears of more than 50 percent.
- All communities with surface water sources were noted to have less than 30 percent of households with outstanding residential taxes with the majority (79 percent) with arrears of less than 10 percent. Communities with groundwater sources reported the majority (66 percent) having outstanding residential taxes and the remaining one-third having more than 50 percent of households in arrears.
- The majority of LSDs (75 percent) reported a debt to service ratio of less 30 percent with one-quarter having a debt to service ratio of more than 50 percent. A greater

proportion of municipalities (87 percent) reported a debt to service ratio of less than 30 percent while only some (13 percent) reported a debt to service ratio of more than 30 percent.

- The majority of very small communities (82 percent) reported a debt to service ratio of less than 30 percent with some (18 percent) having a debt to service ratio of more than 30 percent. A substantial number of small communities and larger (83 percent) indicated having a debt to service ratio of less than 30 percent with some (12 percent) having a higher ratio.
- All communities with groundwater reported a debt to service ratio of less than 30 percent; however, the majority of communities with surface water sources (82 percent) have a debt to service ratio of less than 30 percent while the some (18 percent) reported a debt to service ratio of more than 30 percent.

Table 3.5.1.4.5: Community 2009 Outstanding Residential Taxes and Debt/Service Ratio Data Summary

Sort Parameters		*Outstanding Residential Taxes[1]*			*Debt/Service Ratio[2]*			
		<10	*10-30*	*>50*	*<10*	*10-30*	*30-50*	*>50*
Governance	**LSD**	57%	29%	14%	50%	25%		25%
	MUN	80%	20%		7%	80%	13%	
Population	**0 - 500**	79%	14%	7%	18%	64%	9%	9%
	>500	63%	37%		12.5%	75%	12.5%	
Water Source	**GW**	33%	33%	33%	50%	50%		
	SW	79%	21%		12%	70%	12%	6%

1. Based on information collected during the Site visits.
2. Based on information received from DMA for 2009.

3.5.1.5 COMMUNITY 2009 OPERATOR WAGES AND EMPLOYMENT STATUS

Operator hourly wages from 2009 and employment status information were reviewed from the detailed data set information collected from the 25 communities; the raw data is presented with summary information sorted by governance, population, and water supply in Tables 3.5.1.5.1, 3.5.1.5.2, 3.5.1.5.3, and 3.5.1.5.4. The operator wages and employment status summary data table is presented as Table 3.5.1.5.5 from which the following was noted:

- Operator wages showed that LSDs were mostly volunteers with one response at less than $10/hour while municipalities mostly paid at $10-$15/hour or more.
- Very small communities (less than 500 people) had all operator wages at $10-$15/hour with about one-third as volunteer operators while small population centres or larger (more than 500 people) had all operators paid at $10-$15/hour or more with no volunteer operators.
- Communities with groundwater sources showed all operator wages at less than $10-$15/hour while surface water sources had about one-quarter as volunteer operators with a majority at more than $10/hour.
- Employment status for LSDs was mostly volunteer operators while municipalities were mostly full-time operators.
- Very small communities had mostly volunteer operators while small population centres or larger had part-time or full-time operators with no volunteers.
- Communities with surface water sources had dramatically more volunteer or full-time operators with few part-time operators.

Table 3.5.1.5.5: Community 2009 Operator Wages and Effort Data Summary

Sort Parameters		*Operator Wages[1] ($/hr)*					*Employment Status[1]*		
		0	***1-10***	***10-15***	***15-20***	***>20***	***V***	***PT***	***FT***
Governance	**LSD**	31%	4%				31%	11%	11%
	MUN	4%		48%	9%	4%	4%	7%	86%
Population	**0 - 500**	35%	4%	30%			35%	9%	
	>500			18%	9%	4%		26%	30%
Water Source	**GW**	9%	4%	4%			9%	4%	4%
	SW	26%		44%	9%	4%	26%	4%	53%

1. Based on information collected during the Site visits.

3.5.2 CAPITAL FUNDING FOR DRINKING WATER INFRASTRUCTURE

Capital funding is available to communities (Municipalities and LSDs) through a variety of federal and provincial sources; however, a cost-sharing formula is usually attached with several conditions, one of which typically includes the community providing a share of the capital cost. Capital funding is limited to the installation of new infrastructure or replacement of major components. The following funding sources are available for communities to invest in drinking water infrastructure development:

- Canada-Newfoundland and Labrador Municipal Infrastructure Fund (MRIF)
- Government of Canada Building Canada Fund (BCF), which includes the Gas Tax Fund (GTF)
- Government of Newfoundland and Labrador Annual Municipal Capital Works Program through DMA
- Government of Newfoundland and Labrador Multi-Year Municipal Capital Works Program through DMA

The Federal Government funding programs apply to communities with less than 100,000 people (which applies to all NL communities) and typically requires a one-third equal commitment from the three levels of government (federal, provincial, and municipal); however, the Province has committed to minimizing municipal contributions from communities of less than 3,000 people to 10 percent. Cost sharing ratios set by the Province are 90:10, 80:20, and 70:30 based on community populations of less than 3,000, 3,000 to 7,000, and more than 7,000 people, respectively.

In some cases, communities can qualify for the GTF, which will cover their required 10 percent obligation to receive the remainder of the funding for infrastructure development.

Another provincial requirement for communities to qualify for capital works funding relates to the debt to service ratio, which must be less than 30 percent. This requirement was not considered when estimating the Province's share of the capital costs for new water treatment infrastructure.

3.5.3 CURRENT VS. FUTURE O&M BUDGETS

Limited information was available from the communities and DMA regarding specific expenses associated with the O&M of drinking water systems. In most cases, the information was consolidated into a single budget line item for entry into the Municipal Information Management System (MIMS). Therefore, current O&M budgets that specifically relate to drinking water infrastructure cannot be assessed with any degree of accuracy.

O&M budgets are directly influenced by such factors as:

- Location
- Population

- Type, size, and age of treatment equipment
- Type, size, and age of distribution network
- O&M tasks and frequency
- Operator wages
- Quantity of consumables
- Water tax arrears
- Debt/service ratio

In smaller communities with paid operators, wages can be a substantial portion of the O&M budget.

The Drinking Water Handbook for Local Officials (Drinking Water Handbook) includes a formula used to allocate for emergency repairs. The budget should be based on the average spent over the last five years for emergency repairs, plus 10 percent, plus 100 percent of the cost of replacing the most expensive capital item, such as a well, main pumping station, elevated storage tank, or filter.

3.5.3.1 CURRENT VS. FUTURE WATER RATES

The average current water rate for the 25 communities from the detailed data set is $207 per residential service, with the vast majority of communities having a water rate in the range of $100 to $300 per year for a residential service. Regardless of the number of people in a community, a minimum level of service is required to maintain and operate drinking water infrastructure.

Based on the Annual O&M costs and infrastructure replacement costs calculated in Table 3.4.3.1, CRA calculated annual water rates per household to operate and maintain existing infrastructure in accordance with BMPs. In 2009, water rates for the 25 communities in the detailed survey data set are compared with the BMP rates calculated by CRA in Table 3.5.3.1.1. For the most part, the BMP water rates are greater than current water rates for these communities. The difference between the rates is particularly significant for very small water systems serving less than 200 people. The BMP water rates are relatively similar to existing water rates for communities serving between 600 and 1,700 people. For communities with a service population of greater than 1,700 people, the BMP rates are less than the current water rates.

In order to provide an additional point of comparison, CRA contacted a number of municipal clients in the Province of Ontario to compare water rates between the two jurisdictions. CRA's estimates of capital costs for water treatment infrastructure upgrades and O&M effort associated with monitoring activities are based on the level of treatment and monitoring required in the Province of Ontario, so water rates for communities in Ontario should be similar to the water rates that CRA has calculated based on annual O&M budgets and amortized infrastructure costs. Although information regarding water rates is often made available to the public via the internet, generic names have been assigned to the communities and the respective counties that they are located in, in order to maintain confidentiality.

The basis for calculating water rates for small and medium-sized communities in County A is shown in Table 3.5.3.1.2. A representative from County A indicated that these rates are sufficient to achieve cost recovery. County A considers small and medium sized water systems to serve populations of less than 2,600. The majority of water systems in the Province of Newfoundland and Labrador are within this population range.

The basis for calculating water rates for two specific communities in County B is included in Table 3.5.3.1.3. A representative of County B indicated that the water rates for Community Y and Z are being increased to "move towards" cost recovery. Community Y has a population of 8,000, which is greater than most communities in Newfoundland. However, it should be noted that there a number of very small water stand-alone water systems located nearby Community Y that are operated by Community Y and use the same equation to calculate their water rates.

In 2009, annual water rates for these communities are estimated in Table 3.5.3.1.4. To estimate the annual water rate per dwelling for metered water systems, CRA assumed the average residential household is serviced by a 20 mm service connection, and has 3 residents that use 450 L/d of water per capita. The range of annual water rate per household was from $611 for unmetered small water systems in County A, to $937 for Community Z in County B. These are similar to the water rates that CRA calculated for communities with a service population in the range of 200 to 600 people based on annual O&M and infrastructure replacement costs.

Estimates of operator effort and O&M costs that are developed on a per task basis, such as the BMP O&M estimates developed for this report, appear to overestimate O&M costs for very small (i.e., serving less than 200 people) water systems and underestimate O&M costs for larger water systems. It is difficult to account for the complexity of larger systems in task lists. Larger systems are also more likely to have additional raw water supply infrastructure (i.e., multiple intakes or reservoirs) and treated water distribution system infrastructure (i.e., chlorine and pressure booster stations) and appurtenances. There was insufficient information to determine whether this additional distribution system infrastructure was installed for each of the 25 communities in the detailed survey data set. As a result, the BMP O&M task lists do not include this equipment. For larger water systems, a comprehensive list of water system infrastructure would be needed in order to calculate the O&M effort required to follow BMPs.

3.5.3.2 CURRENT VS. FUTURE OPERATOR WAGE SCALE

Current operator wages range from no cost to the community (volunteers) to one respondent who is earning more than $20/hour. Although water treatment plant operator wages or salaries are generally not available to the public, several US sources were identified that provide wages and annual salary data.

A US nation-wide employment job database (Simply Hired) tracks average salaries for most job opportunities, including drinking water system operators. Data as of February 2010 indicated that average operator salaries are $42,000 and when converted to Canadian dollars using the exchange rate for February 22, 2010 ($0.9597 Canadian), the resulting average annual salary is $43,800. This is equivalent to an average hourly wage of $21/h.

A representative for County B provided CRA with wages for operators of the water systems serving communities Y and Z. Wages for water system operators in County B were in the range of $21 to 24/h, which agrees with the wage calculated for U.S. water system operators.

3.5.4 O&M FUNDING SOURCES

O&M funding sources are currently limited to municipal budget allocations, which are derived by any municipal revenues such as taxes. High debt to service ratios result in more municipal revenues being committed to pay down accrued interest on previous loans, which diminishes the amount of funds that can be allocated to O&M activities related to all municipal infrastructure.

At present, the Province provides little to no funding assistance to municipalities related to O&M other than small subsidies to assist communities in having their operators attend training sessions and/or limited emergency funding to address urgent and small repair issues (i.e. pump failure & beyond repair).

3.6 SUMMARY

This summary relates to the economic analysis section of the Study that details issues of water quality and considers information regarding treatment infrastructure, O&M practices, and operator training to identify factors contributing to BWAs. Issues relied upon to determine the types of treatment needed are, for example, highly influenced by the water source type (groundwater, surface water, groundwater under direct influence of surface water). The implications of these issues were described in Section 2.

The intent of this Section of the report is to recommend water treatment and distribution infrastructure upgrades necessary to treat poor quality raw water, and the O&M effort required to implement BMPs at existing and upgraded water systems. Hence, the intent in this report is to develop the economic analysis to upgrade the infrastructure and O&M such that public water supplies can consistently meet the water quality limits set out in the Guidelines for Canadian Drinking Water Quality (GCDWQ).

This section also describes the implications of alternative funding formulae for the recommended upgrades, and reflects the current cost-sharing options for the water supplies. The cost-sharing is considered to be very important, as many smaller communities are without the necessary resources to operate and maintain their treatment and distribution systems in accordance with BMPs. As a demonstration of the issue of resource base, 65 percent of communities have populations of 500 or less, and 89 percent have populations less than 1500. Lacking economies of scale, the community structures do not have the resource base necessary to fund the initiatives necessary to bring the water supply systems to BMP level.

This section details the primary assessment parameters utilized in the economic analyses described herein, based on population and source water types. Information specific to the community is utilized to estimate costs; for example, capital investment, O&M requirements, frequency of tasks for each process component, and operator wages.

(a) Focus on the 25 Communities Studied in Detail

Specific details provided herein are described in relation to the 25 communities for which specific information was obtained through site visits. The 25 communities that were visited provide a reasonable representation of the

337 public drinking water systems in the province based on water source, service population, and water quality. As a result, the 25 communities in the detailed data set can be used to extrapolate the economic analysis to the 337 public drinking water systems across the Province.

As detailed within the text, adequate water treatment infrastructure throughout the Province and for the 25 communities in the detailed data set is generally limited. The first stage of the cost analyses involves the estimate of costs to operate the water systems based on existing infrastructure. This includes, for example, the changes needed to bring the chlorination systems on line and functioning.

(b) Costs Based on Current Infrastructure

As a summary of the findings using the current infrastructure:

- the annual water rates per household for 2009 as charged varied from $60 to 325 per household, with an average of approximately $200 per household.
- Assuming three persons per household, the estimated price for treated water, reflecting annualization of replacement costs and O&M of existing infrastructure in accordance with BMPs, was in the range of $61 to 1,688 per household.
- as expected, very small systems tend to have considerably larger costs per capita, due to the lack of economies of scale.

(c) Costs Based on Recommended Infrastructure

The second scenario of the cost analyses is based on the need to upgrade the 25 water treatment systems such that they can treat their respective sources to meet GCDWQ Standards. As a summary of the findings, assuming the recommended upgrades are adopted:

- the average price for treated water for different communities reflecting annualization of replacement, operation, and maintenance costs for BMP systems indicates a range of $0.50 to 10.96/m^3, and the annual cost per household ranges from $83 to 1,801.

The detailed rationale for the cost estimates is described within the text.

The basis for the cost estimates is described to demonstrate how decisions were made for each of the 25 water supplies. Flow charts indicate the stepwise processes used to determine when, for example, filtration is needed and/or decisions on implementation of a Potable Water Dispensing Unit (PWDU) for provision of drinking water for communities of less than 1,500 people. The bases for decisions at each of the 25 communities, and the data sources relied upon for the estimates, are provided.

To evaluate the true costs to the consumer, the costs are described in terms of life cycle costs.

(d) Comparisons of Current Costs with Costs for Small Water Systems in Ontario

Treatment and monitoring standards were selected in order to bring the water systems into compliance with the more stringent regulations in Ontario. As a result, water rates for small communities in the Province of Ontario provide a good means of comparison to determine how the recommended upgrades to infrastructure and O&M practices would impact water rates in Newfoundland and Labrador. The 2009 annual water rates per household that were calculated for small communities in Ontario are significantly higher than 2009 water rates in Newfoundland and Labrador. The annualized infrastructure and O&M costs that are developed in this report for water systems serving 200 to 600 people are similar to the annual water rates calculated for small systems in Ontario.

(e) Basis for Some Understatements of Costs for Existing Water Supply Systems

While the above-indicated costs using current systems and BMP systems are higher than current costs, reasons for these differentials include:

- the current operator effort being utilized (person-hours/water supply system) is considerably less than necessary to ensure that water quality standards are met on a consistent basis.
- the costs as reported by some communities do not reflect the significant efforts being expended by volunteer workers. Sources throughout North America indicate that an average wage for water system operators is in the range of $21 to 24/h. Only one water system indicated that operators earn more than $20/h.

(f) Cost Savings Associated with O&M Practices

The actual useful life of water system infrastructure could not be estimated for the 25 communities in the detailed survey data set due to a lack of information regarding equipment age and current condition. The significant difference between current O&M effort and O&M of existing infrastructure in accordance with BMPs suggests that existing infrastructure will not reach its expected useful life in most cases.

In addition to BMP O&M activities, the expected useful life of water system infrastructure can be further increased by undertaking rehabilitation activities at specified intervals. Rehabilitation of existing equipment is not necessarily a cost effective option. If a water system was to develop a more proactive O&M strategy that included rehabilitation activities, one significant impact would be a decrease in capital costs and a corresponding increase in O&M costs. If limited funding is available for O&M, it is unlikely that communities would pursue rehabilitation of water treatment infrastructure in order to increase the expected service life.

Section 4 of this report summarizes the challenges specific to BMP O&M of drinking water systems in the Province. Section 5 will provide potential O&M alternatives.

4.0 CHALLENGES TO PROVIDING SAFE DRINKING WATER

4.1 POSITIVE ASPECTS OF CURRENT PROVINCIAL AND LOCAL PROGRAMS

In general, the Province has taken a number of steps to address the many challenges facing very small water systems, which represent the majority of the water systems in the Province. Existing programs focus on challenges associated with drinking water system infrastructure and operator training.

The Province-wide infrastructure funding program, where the Province covers 70 to 90 percent of drinking water infrastructure costs, helps to address problems caused by the relatively small tax base and the lack of economy of scale that can make it difficult for small communities to invest in infrastructure. Without this cost sharing, the annualized replacement cost associated with most water treatment infrastructure would make household water rates unaffordable in most communities.

The Province implemented a pilot study whereby Potable Water Dispensing Units (PWDUs) were installed on an adhoc basis in five small communities; however, PWDUs are now being installed as part of a more defined program under the Rural Drinking Water Safety Initiative. Investigating innovative solutions to shortcomings in existing drinking water infrastructure indicates that the Province is willing to take an active role in identifying cost-effective solutions to the drinking water quality issues facing small communities.

OETC training records for the on-site training program were previously summarized for communities in the basic survey data set. The innovative Mobile Training Unit program developed by the Province has been adapted by other jurisdictions (i.e., the Mobile Unit and On-site Hands-on Training Program offered through the Walkerton Clean Water Centre in Ontario) to provide remote communities in other parts of Canada with hands-on training that is relevant to their water system.

4.2 CHALLENGES TO MEET PROVINCIAL WATER QUALITY OBJECTIVES

The following sections discuss the challenges identified in meeting the water quality objectives, for those who are locally responsible for the production and provision of safe drinking water in each community of the Province.

4.2.1 INFRASTRUCTURE

Well designed, properly operated drinking water infrastructure is necessary to ensure that residents are supplied with high quality drinking water that consistently meets GCDWQ limits. The Province recently updated the Guidelines for Design, Construction and Operation of Water and Sewerage Systems (NL Guidelines) in 2005, which provides guidance with respect to the design of different components of drinking water infrastructure. However, there are no legislated treatment requirements for public water systems in the province.

4.2.1.1 WATER TREATMENT

- Disinfection Equipment:
  - Some communities in the Province lack the most basic water treatment infrastructure. As of February 2009, there were 26 communities under a Code A BWA (No disinfection), which represents 17 percent of BWAs in the Province. Twenty-four of the communities under a Code A BWA have a service population of less than 500 people.
  - LSDs and very small water systems have a relatively low level of investment in treatment infrastructure, and as a result, most water systems serving LSDs or very small systems have, at most, one barrier to drinking water contamination. Ideally, drinking water systems should have multiple barriers capable of removing pathogens. This is especially true for surface water sources and GUDI sources that do not receive adequate subsurface filtration to protect the water supply.
- Advanced Treatment for Removal of Pathogens:
  - Despite the fact that the majority of communities in the Province use surface water as their supply, the majority of communities perform chlorination only prior to distribution. Chlorination is not an effective means of inactivating pathogens associated with surface water, such as *Cryptosporidium* oocysts and *Giardia* cysts.
- Advanced Treatment to Prevent DBP Formation:
  - Of the 313 communities served by public water systems in the Province, GCDWQ limits for colour and turbidity were exceeded in 233 and 149 communities, respectively.
  - The proportion of communities in the Province that exceed the GCDWQ standards for colour and turbidity are similar for communities under a BWA and

those that are not. Although there is less likely to be an acute health risk associated with a community water supply if that community is not under a BWA, a greater proportion of communities that are not under a BWA exceed GCDWQ limits for DBPs such as THMs and HAAs. As a result, communities that are not under a BWA have not necessarily eliminated concerns with respect to health-related parameters (i.e., DBPs) or the aesthetic and operational parameters (i.e., colour and turbidity) that contribute to their formation.

- pH Adjustment:
  - Approximately 75 percent of communities in NL (227 of 313) have recorded pH levels below the lower GCDWQ limit of 6.5. Approximately 10 percent of communities that have pH levels below the lower limit have equipment capable of adjusting the pH.

4.2.1.2 WATER TREATMENT DESIGN

- Poor Design of Existing Disinfection Equipment:
  - As of February 2009, 63 communities were under a Code E BWA (insufficient CT or free chlorine residual), which represents 41 percent of BWAs in the Province. Fifty-six of the communities under a Code E BWA have less than 500 people. There are numerous potential causes for a Code E BWA, one such cause being poor design of water treatment system equipment, such that CT requirements cannot be met during periods of peak demand due to the capacity of the chlorination system or a lack of contact time.

4.2.1.3 WATER QUALITY MONITORING AND MAINTENANCE EQUIPMENT

In addition to the lack of advanced water treatment infrastructure in the Province, data made available by the Province or collected during site visits also demonstrated that issues with respect to water quality monitoring and maintenance equipment can have a significant impact on the operation of the water system.

- Free Chlorine Monitoring:
  - For the detailed survey data set, 17 of 25 communities indicated that they did not have a continuous chlorine analyzer. A lack of continuous monitoring equipment increases the level of operator effort associated with daily monitoring tasks.

- Systems without continuous monitoring are less likely to be aware of periods of low raw water quality or poor treatment performance, which can result in insufficiently treated water entering the distribution system.

- Raw and Treated Water Flow Monitoring:
  - Detailed survey data also indicated that 7 of the 25 communities did not have flow meters. The ability to track changes in water demand on a daily and seasonal basis can influence operating decisions and procedures, as well as provide evidence of distribution system leaks.

- Distribution System Appurtenances:
  - Eighteen of the communities in the detailed data set have flush valves or fire hydrants in the distribution system. These distribution system appurtenances allow for the operator to flush the distribution system at a regular interval, which is a key maintenance activity with respect to distribution system water quality.

4.2.1.4 DISTRIBUTION SYSTEM DESIGN AND CONFIGURATION

The "branched" distribution system configuration, which typically consists of a number of separate service lines connected to a long transmission watermain, results in a number of dead ends. Stagnation of water can occur near dead ends during periods of low use, resulting in decay of the free chlorine residual.

- Design Issues With Existing Distribution Infrastructure:
  - As of February 2009, 63 communities were under a Code E BWA (insufficient CT or free chlorine residual), which represents 41 percent of BWAs in the Province. Fifty-six of the communities under a Code E BWA had less than 500 people. As noted in Section 4.2.2.1, there are numerous potential causes for a Code E BWA, including poor design of the water distribution system.
  - Very small communities in the Province typically have a "branched" distribution system configuration. As a result, it is especially important that systems with this configuration have the necessary tools, distribution system appurtenances (i.e., valves, hydrants) and procedures in place to allow for regular (i.e., semi-annual) flushing of the distribution system.

- Replacement of Existing Infrastructure:
  - When distribution water mains are in need of replacement at the end of their useful life, consideration should be given to pipe diameter and construction material, as well as the location of valves, hydrants, and other distribution

system appurtenances to optimize hydraulic retention time and water pressure while minimizing the potential for bio-film growth. The potential for "looping" dead ends in the distribution system to form a grid and reduce stagnation should also be evaluated.

4.2.2 OPERATIONS

The absence of capable water treatment, monitoring, and maintenance infrastructure can limit the quality of water that a given water system supplies. However, infrastructure alone is not sufficient to ensure that the water system supplies safe drinking water. Consistent, diligent operation of existing infrastructure is required to ensure that water quality is optimized based on the existing water system infrastructure.

Treated water quality data for communities in the detailed survey data set that have similar sources and service populations, but different treatment infrastructure (i.e., systems with pH adjustment vs. systems without pH adjustment, systems with advanced filtration vs. systems without filtration) were previously compared. This comparison showed that while communities with additional treatment equipment generally had better water quality, the water quality in these communities did not necessarily meet GCDWQ standards on a regular basis.

4.2.2.1 OPERATOR EFFORT

On average, operator effort in communities that are under a BWA is at a lower level than in communities that are not under a BWA, which is supported by the following observations regarding maintenance and monitoring efforts:

- Maintenance Effort:
  - Based on the information collected during site visits and from surveys returned by communities, the communities that were under a Code C BWA (Disinfection off-line due to maintenance) tended to have minimal maintenance effort (i.e., <10 h/week). If more effort and resources were focused on preventative maintenance of key water system processes (i.e., barriers to contamination), the need for reactive maintenance of these processes would decrease. If reactive maintenance is required on a less frequent basis, then water systems would be less likely to be under a Code C BWA due to their disinfection equipment being removed from service.

- Monitoring Effort:
  - As of February 2009, 63 communities were under a Code E BWA (insufficient CT or free chlorine residual), which represents 41 percent of BWAs in the Province. The majority of water systems under a Code E BWA collect less than one measurement for chlorine residual in the distribution system per day. Regular monitoring activities can represent a significant portion of operator effort, particularly for very small water systems.
- Additional Responsibilities for Water System Operators:
  - Water system operators often perform other Public Works roles within the community. These additional responsibilities outside of the Water Treatment Plant were identified as a factor that limited the amount of effort the operator could devote to the water system by operators in 3 of the 25 communities in the detailed survey data set.

4.2.2.2 <u>SIGNIFICANT ROLE OF OPERATORS</u>

Operator training is important not only to provide operators with instruction regarding specific processes and procedures, but also to help operators understand the importance of their role to protecting drinking water quality and public health.

- Impact of Operator Education on Water Quality:
  - As of February 2009, there were 13 communities under a Code B BWAs (Disinfection off-line by choice) in the Province, which represents 9 percent of all BWAs. Twelve of the communities under a Code B BWA were LSDs; all 13 communities have a service population of less than 500. Of the four communities in the combined survey data set that were under a Code B BWA, only one had certified operators, and the average level of training received by operators at that system was lower than for water systems under any other BWA Code, or water systems that were not under a BWA. These results suggest that operators in very small communities have received less training and education, which can result in a reduced understanding of the importance of disinfection and treatment to protect drinking water safety.

4.2.2.3 DEVELOPMENT OF MANUALS AND OPERATING PROCEDURES

Access to relevant water system documentation, such as equipment O&M manuals and Standard Operating Procedures (SOPs) developed specifically for the community, provides operators with consistent procedures to address maintenance needs and emergency situations as they arise.

- Availability of SOPs at Very Small Water Systems:
  - Of the 25 communities in the detailed survey data set, operators from 13 communities indicated that SOPs had not been prepared for their water system. Of the communities with SOPs, 11 had a service population of less than 500 people. SOPs ensure that operators consistently follow the same Best Practices when performing maintenance activities, and that maintenance activities are completed at the necessary intervals.

4.2.2.4 BASIC O&M EQUIPMENT

- Availability of Spare Parts and Emergency Repair Parts:
  - As of February 2009, there were 25 communities under a Code C BWA (Disinfection off-line due to maintenance) in the Province, which represents 16 percent of all BWAs. Nineteen of the communities under a Code C BWA have a service population of less than 500. This indicates very small water systems are less likely to have access to parts for repair, or may not be able to afford hiring external contractors to perform work that water system operators do not have the tools or training to perform.

4.3 CHALLENGES TO WATER SYSTEM MANAGEMENT

The following sections discuss the challenges identified for the parties mandated with providing the required resources for those responsible for the day-to-day operation of each public water system in the Province.

4.3.1 MUNICIPALITY/LOCAL SERVICE DISTRICT LEVEL

The following points were considered part of the responsibility of, and challenges for, both municipalities and LSDs in ensuring the GCDWQ limits are met:

- Establish Appropriate Local Budgets:
  - As previously identified in Section 3, the detailed survey data set of 25 communities showed that all but one of the systems operated within LSDs (all less than 500 people) budget less than $7,500 annually to operate their water systems.
  - A number of very small and small communities in the Province currently have debt/service ratios near to 30 percent. Many have also been unable to collect on all residential taxes that are due.
  - Both of these factors make it difficult for residents in these communities to afford the full (and independent) cost of the level of service and reliability that many people inside and outside Newfoundland and Labrador take for granted.
  - As a minimum, additional review of cost sharing and current grant distribution policies should be undertaken.
- Provide Appropriate Compensation for Operators:
  - As previously identified in Section 3, the detailed survey data set of 25 communities showed that all but one of the systems operated within LSDs (all less than 500 people) use volunteer operators.
  - For communities in the detailed survey data set with paid operators, wages were in the range of $10 to 15/h for most of the communities with a service population of less than 1,500, and were greater than $15 for systems with a service population of greater than 1,500. There was only one community where the operators earned greater than $20/h.
  - Based on records for water system operator wages in the U.S. (converted to 2009 Canadian dollars) and correspondence with small municipalities in Ontario, water system operator wages are generally in the range of $20 to 25/h.
  - In order to provide a standard or uniform level of compensation throughout the province for all water systems, it would be necessary to increase many of the community water budgets, likely well beyond the ability of residents to support this standardization.
- Retain proper number of Qualified Operators (including Secondary Staff):
  - The recommended work tasks and levels of effort identified in earlier reports show that most all communities would require, or are near to requiring, the

equivalent of one operator for their system, in order to undertake independent operation of their supply and treatment system.

- In addition (as is similar to the configuration of most treatment and supply equipment or components within each system), it is necessary to provide a level of redundancy with respect to operations staff in the event that the primary operator is not available.
- The number of operators being trained per community with more than 1,500 people is more than twice the number of operators being trained in communities serving less than 1,500 people. More effort will be required to target smaller communities for operator training.
- One suggestion may be to provide an overlap or sharing of resources between adjacent communities, regardless of governance.

- Address Turnover/Retention of Operations Staff:
  - One of the concerns identified by ENVC as part of the initial commissioning of this report was the ability of both municipalities and LSDs to retain current staff. Studies have shown that the efforts of employers in most any field or occupation group to locate, hire, and train new persons in most any employment are a significant (and generally irrecoverable) cost to the employer.
  - The discrepancies between operator wages for small and medium-to-large communities within the Province, in addition to the difference between average operator wages in the Province and wages in other jurisdictions, present significant challenges for small water systems in terms of retaining operators.

- Provide Support for Training and Certification of all Operators:
  - It should be noted that operators in three of the detailed survey data set communities indicated they did not receive sufficient support from their employer to attend off-site "classroom" training courses. All three of these communities were under BWAs at the time.
  - A significant component of providing the necessary skills for staff to properly operate and maintain these systems is the need for continued and ongoing training.
  - It is necessary to ensure those assigned the day-to-day responsibility of ensuring each community is able to provide safe drinking water are not only at the required level of qualification, but are also current on new technologies, operation strategies, as well as regulatory requirements, independent of the financial obligations of those in governance, to do so. Certification is currently required for operators of water treatment plants; however, ENVC is in the

process of drafting a policy that would require certification of water treatment system operators for communities with a population of more than 1,000 people.

- Provide Tools and Equipment for Operation and Maintenance:
  - It is necessary to ensure that front line staff is provided with appropriate tools or instruments to complete their daily, weekly, and other periodic tasks.
  - Operators from six communities in the detailed survey data set indicated that their employer did not provide them with the relevant tools to complete O&M tasks. Of those six communities, five were under a BWA at the time.
- Locations of Communities:
  - For decades, geography has been of one of the biggest challenges to the sustainability of services in the Province of Newfoundland and Labrador.
- Review Outsourcing or Consolidation of Maintenance Tasks among communities with the same general area or region:
  - Operators at a number of communities in the detailed survey data set indicated they had difficultly finding qualified contractors to perform less frequent maintenance tasks.

4.3.2 PROVINCIAL LEVEL

The following points were considered part of the responsibility of the Province of Newfoundland and Labrador in ensuring that GCDWQ limits are met:

- Provide Regulatory Oversight and Enforcement:
  - The lack of treatment regulations will likely prevent existing shortcomings in public water supply infrastructure from being addressed in a timely manner. These existing shortcomings pose a number of challenges for public water supplies in the Province.
  - It is recommended the Province shall establish (by legislation if required) regulations that define the water quality standards to be met at all times, by all sizes and types of water supply systems. The Province must also have the authority to impose fines or other actions to ensure that every effort is made by the local water operators to meet these water quality standards.
- Provide Funding for Infrastructure for communities to meet the GCDWQ:
  - It would be suggested that if the Province establishes standards and enforces these standards for every water system, the Province would be required to

provide adequate funding that will allow each jurisdiction to have the required components available in the first place.

- A higher percentage of BWAs exist in LSD systems (80 of 110) compared to municipalities (72 of 227), and all LSD systems in the Province (except three) serve less than 500 people. In addition, almost 60 percent of the BWAs (89 of 152) noted in the Province are from surface water sources and serve less than 500 people. The sheer logistics of addressing such a high number of communities with BWAs will require substantial effort on a province wide level to consistently decrease the number of BWAs.
- Some survey respondents reported lengthy and complicated application processes to secure capital or emergency funding. Improving the funding application process so that small communities with volunteers can better submit the required information.

• Provide Policies and Programs for Uniformity of Infrastructure, Operation and Maintenance:

- In 2005, ENVC released an updated version of the NL Design Guidelines, updating the 1980 version of the document. In addition to these guidelines, the design process needs to take into account the size of the community, as well as the ability of the community to recover the cost of the treatment system, whether the community will be able to retain operators and contractors with the necessary skill level, and other socioeconomic factors. The design process must ensure that the proposed infrastructure is capable of treating a site-specific raw water supply to meet GCDWQ limits, while also ideally achieving some degree of similarity with other water systems that have similar sources and service populations. Establishing a degree of uniformity between drinking water systems will allow for water system operators and management from similar systems to share troubleshooting experiences, operating strategies, and other "lessons learned" that can help make operation more efficient.
- These specifications would ensure that water systems of similar supply, size, and configuration throughout the province will be operated and maintained at a consistent level of care and responsibility.

• Provide Training and Certification of Operators:

- At the time of this report, certification of water system operators is a voluntary process. ENVC recommends a minimum 24 hours of "continuing education" training per year for all water system operators (ENVC 2005).
- The lack of regulations with respect to operator certification and training levels results in significant differences in operator training based on governance

structure and service population, which emphasize the importance of the relationship between operator skill level and water quality. In general, communities that are not under a BWA are more likely to have certified operators, are more likely to make use of on-site training programs, and have a greater number of operators participating in on-site training. Water system operators in communities serving more than 500 people are more likely to be certified, and more likely to receive on-site training.

- In addition to the Mobile Training Units that provide on-site training, educational seminars are regularly held at 20 locations throughout the Province. These "classroom" training seminars are offered throughout the Province to minimize travel time and distance for operators.
- Despite the availability of both educational seminars and on-site training throughout the Province, the average amount of operator training per year is an order of magnitude below the recommended level when water systems are categorized based on region, governance, or service population.
- As identified in an earlier section, it is necessary to ensure that all local operators are at their proper level of certification, as well as familiar with new technologies, operation strategies, and regulatory requirements.
- It is recommended the Province expand, enhance and standardize content of, frequency of, and financial support for these programs.

• Evaluate Alternative Sources of Cost Sharing and/or Funding:
  - There will be a significant increase in the financial obligations of all levels of government and operating authorities in order to construct, operate, and maintain treatment and supply systems that are needed to meet the goals of full compliance with Provincial Drinking Water Standards.
  - A great number of small and very small communities are under financial strain to meet all of their present obligations, including those outside of water supply.
  - It may be necessary to re-evaluate current funding formula for provincial contributions to infrastructure.
  - It would also be suggested that in order to ensure that infrastructure funding does <u>not</u> fall into general revenue for these municipalities, stricter checks and balances must be put into place and enforced by the province.

• Provide Public Information on Technical Needs and Policies:
  - Additional efforts must be made on an on-going basis to make the general population aware of where their water actually comes from, how (and more importantly, why) it is treated. Examples were noted where residents

complained of aesthetic issues that resulted in equipment being turned off or abandoned.

- Further information must be conveyed to identify the public's obligations and responsibilities in maintaining source water quality.

4.4 CHALLENGES IDENTIFIED IN OTHER JURISDICTIONS

Many of the issues that were identified with respect to water system infrastructure, O&M practices, operator training, and drinking water management at both the local and provincial level have been faced by other jurisdictions in the past. In order to provide some insight into the impact that these issues have had on drinking water quality and public health in other jurisdictions and recommendations that have been implemented to address these issues, CRA has prepared a case study based on the circumstances surrounding the waterborne disease outbreak that occurred in Walkerton, Ontario, in May 2000. The case study is included as Appendix F.

5.0 POTENTIAL O&M ALTERNATIVES

Previous studies and investigations completed by ENVC over the last 10 years have focused primarily on raw and treated water quality, which has provided much needed data to elevate the assessment of province-wide water quality issues to the extent addressed in this Study. Different departments within the Government of Newfoundland and Labrador are currently involved with the management of water quality in the Province:

- ENVC manages Protected Public Water Supply areas, including Wellhead Protected Water Supply areas
- ENVC and DMA play a role in water treatment system approvals before funding allocation is finalized
- DMA injects funding through municipal infrastructure investment and other limited funding programs such as Municipal Operating Grants, or emergency funding
- Government Services (GSC) and ENVC collect bacterial and chemical water samples for analysis (occasionally, the local operator or third parties are contracted to collect samples for specific study purposes)
- Department of Health and Community Services (HCS) are responsible for advising communities to issue BWAs when bacterial water samples exceed the GCDWQ
- ENVC manages the analytical data, most of which is publicly available on their website
- DMA and ENVC combine efforts to provide training and certification opportunities to water treatment operators and community government officials

In addition to the provincial government level of water quality management, local governments (and in some cases, regional authorities) are also involved as follows:

- Determining annual operating budgets for revenues (i.e., water tax and/or mil rates) and expenses related to O&M (including operator wages, contractors, suppliers, and/or consultants)
- Municipal planning that includes funding applications for infrastructure investment by the federal or provincial governments
- Protection of public drinking water sources
- Training, certification, and retention of operators (with some financial assistance available for training by DMA)
- Regular O&M of treatment and distribution systems

- Issuance and communication of BWAs to the community when advised by HCS of bacterial exceedances
- Release of BWAs upon confirmation from HCS.

Before alternatives are considered for their potential in supporting O&M activities related to drinking water quality, levels of responsibility, accountability, and liability must first be fully defined and transparent to all stakeholders. Moving from the conventional arrangement of local government management for O&M to regionalization, PPPs, or privatization should ensure full participation of the stakeholders, including the general public, to lay out legislative requirements, policies, guidelines, and fact-based targets for performance related to each alternative (Bakker and Cameron, 2002). These are global governance issues at the province level that should start with a clearly defined authority between the Province, local government or regional management by communities, and any third parties through PPPs or privatization (Nowlan and Bakker, 2007).

A variety of alternatives have been considered by public water supply management entities throughout Canada and the U.S. to improve fiscal efficiencies for the O&M of drinking water treatment and distribution systems. These alternatives ranged from the conventional approach of individual water treatment systems for each community (status quo) to complete privatization with many variations between these two extremes.

5.1 PUBLIC/GOVERNMENT

The standard approach to management of public water supplies in the Province has been one public water supply for each community, managed by the respective community; however, some exceptions exist where neighbouring communities have banded together and developed a regional approach, either a regional system or a regional operator. In both management scenarios, the municipal level of government, whether individually or regionally, is directly responsible for the O&M of their respective drinking water systems.

Typically, the responsibility to operate and maintain water treatment systems rests entirely at the municipal level; therefore, operator wages (whenever volunteers are not involved), equipment repairs, disinfection supplies, and other associated expenses are necessary expenditures in municipal operating budgets. For communities with less than 1,500 people, the wages of an operator combined with other necessary expenses for

O&M of a water treatment system can create a heavy financial burden on the community's annual operating budget.

5.1.1 ONE WATER SYSTEM PER COMMUNITY (i.e., STATUS QUO)

The management structure for public drinking water systems in the Province follow the traditional approach where each community has its own respective water supply, treatment plant, and distribution system. Regardless of the location, type of municipal governance, minimum population, or water source for the community, a fixed minimum operating cost is required for each community. Variations in the level of operating costs are directly related to operator wages, operator employment status (volunteer, part-time, or full-time seasonal), level of treatment (filtration, disinfection, etc.), and even the types of disinfection (chlorination through powder, liquid, or gas).

5.1.2 REGIONALIZATION

Regionalization is not a new concept for the Government of Newfoundland and Labrador as the first goal identified in the DMA 2008-09 to 2010-11 Strategic Plan is "*…to increase regional co-operative initiatives and assess regional service delivery opportunities throughout the Province*" (Department of Municipal Affairs 2009). To support this goal, DMA created a support network in its department under a Director of Regional Co-operation. One initiative that evolved from the regionalization concept is the Integrated Community Strategic Plan (ICSP) approach to regionalized planning. Completion of an ICSP is a mandatory requirement to receive Gas Tax Funding (GTF) from the federal government for any municipal projects.

Three alternatives are available for communities to complete an ICSP (Department of Municipal Affairs 2009), which are:

- **Municipal Plan ICSP**, which is the most costly and in-depth document that would provide the plan with legislative authority.
- **Stand Alone ICSP**, which can be a costly option; however, this type of plan still allows the community to have complete control over the plan's goals and objectives.
- **Collaborative ICSP**, which is the most cost-effective option where a community can develop a regional ICSP for a five year period in partnership with any other nearby municipality, LSD, or unincorporated communities that would share common goals with an allowance for individual goals where collaboration is impractical.

The collaborative ICSP introduces all types of communities to a regionalized approach for infrastructure management that demonstrates improved efficiencies through the cost-sharing of capital investment and O&M of the infrastructure.

Some areas of the Province previously identified a regionalized approach for public drinking water as a mutually beneficial arrangement (i.e., St. John's and surrounding communities, Grand Falls-Windsor and surrounding communities). This approach has a proven track record in the Province that can benefit each participating community within the region.

5.1.3 DRINKING WATER QUALITY MANAGEMENT

Historically, drinking water legislation and management has focused on treatment and end-of-pipe monitoring. More recently, the effectiveness of this approach in preventing waterborne disease outbreaks has come into question. Depending on laboratory analysis of water samples to determine whether drinking water contains pathogens that could have an adverse impact on human health results in health risks being identified after they have occurred. The microbiological indicator parameters that are typically analyzed may not accurately represent the concentration of all waterborne pathogens that have the potential to enter the water supply for a particular water supply. In addition, due to the costs associated with analysis, the frequency and location of sampling in the distribution system is not necessarily sufficient to identify contamination of drinking water after treatment but prior to reaching the consumer.

The need to shift the focus of drinking water management from treated water monitoring to the assessment and management of risks from the supply through to the consumer has been identified by the World Health Organization (WHO). The 3rd edition of the WHO Guidelines for Drinking-Water Quality, which were published in 2006, outlines a Framework for safe drinking water (Framework). One of the key aspects of the WHO Framework is the preparation of a site-specific Water Safety Plan (WSP), which addresses water system assessment and design, operational monitoring of control measures, and management plans and procedures for small water systems (WHO 2006).

The Guidelines recognize that it may not be feasible for small water systems to develop their own supply-specific WSPs. As a result, the Guidelines suggest that the local regulatory authority develop a generic WSP template that can be edited and expanded as necessary to incorporate supply-specific information for small water (WHO 2006). Such documents have been developed in Australia (Community Water Planner) and New Zealand (Small Water Supplies: Preparing a Public Health Risk Management Plan).

Health Canada is currently developing a generic risk assessment tool for small drinking water systems based on the Australian and WHO approach; the Province is involved in its development.

Since small water systems (i.e., serving communities of less than 1,500) in Newfoundland and Labrador appear to be at greatest risk in terms of water quality, this section will focus on jurisdictions that have developed guidelines documents specifically for small drinking water systems.

5.1.3.1 AUSTRALIA

The current edition of the Australian Drinking Water Guidelines (ADWG) was endorsed by the National Health and Medical Research Council (NHMRC) in April 2003. In developing the current edition of the ADWG, the focus of the document shifted to emphasize preventative action, and to provide a comprehensive risk management approach to drinking water quality management from source to tap (Sinclair and Rizak 2004).

The Framework for Management of Drinking Water Quality (Framework) developed in the ADWG is divided into 12 elements that are intended to address all elements of water system O&M on a day-to-day and a long-term scale. The Framework incorporates elements of the Hazard Analysis and Critical Control Point (HACCP) approach, ISO 9001 (Quality Management), and AS/NZS 4360 (Joint Australian/New Zealand Standard for Risk Management) (NHMRC 2004).

The ADWG is a federal guideline document, not an enforceable piece of legislation. The Framework was designed to be flexible, not exhaustive, such that each state can implement it in a way that suits their regulatory regime (Hrudey et al, 2006). This flexibility also allows the quality management principles of the Framework to be applied to all water systems, regardless of size or complexity (Rizak et al, 2003).

Chapter 4 of the ADWG specifically addresses the application of the Framework to small water systems. It recognizes that it may not be practical for a small water system serving less than 1,000 people to meet all of the requirements of the Framework (NHMRC 2004). The Community Water Planner (Planner) was developed primarily for use by operators and agencies responsible for water supplies that serve less than 1,000 people. The Planner includes a CD-ROM that develops a Drinking Water Management Plan Outline (Outline) based on water system information input by the user. The Outline includes a process schematic for the drinking water system based on the user input, and identifies potential hazards and risks associated with the relevant water system components, as well as potential preventative measures that can be implemented to address the risks. The Outline also includes recommendations regarding performance and verification monitoring activities for the system. The Outline is compliant with the requirements of the Framework, but does not address each aspect of the Framework directly (NHMRC 2005).

5.1.3.2 NEW ZEALAND

The Health (Drinking Water) Amendment Act 2007 (Act) was enacted in 2007 to protect public health by improving the quality of drinking water supplied to communities. Previously, most operating activities associated with water supplies were voluntary. The main duties under the Act are to take all practical steps to comply with the Drinking Water Standards for New Zealand 2005 (DWSNZ), and to implement a Public Health Risk Management Plan (PHRMP) (Ministry of Health 2010).

There is no specific procedure that the water supplier must follow when developing a PHRMP. However, the Ministry of Health (MOH) did prepare a "Framework on How to Prepare and Develop Public Health Risk Management Plans" (Framework) as a guidance document. The MOH also prepared Public Health Risk Management Plan Guides (Guides), which address each component of the water system (i.e., source, treatment processes, storage, and distribution). The Guides include tables listing potential events associated with each component of the water system. The term "event" is used based on the premise that small water system operators would be more likely to relate to a concrete incident than the more hypothetical term, "hazard" (Hrudey et al, 2006). The Guides also identify the likely cause of the event, preventative measures that can be implemented to reduce or eliminate the impact of the event, monitoring activities or "checks" associated with each of the preventative measures, and corrective actions to re-establish control if the checks indicate that the preventative measure has failed.

The revised DWSNZ, which consists of water quality standards and compliance criteria, came into effect on December 31, 2005. The goal of the DWSNZ is to reduce the reliance on water quality monitoring as a means of ensuring compliance. The DWSNZ specifically addresses small water supplies that serve less than 500 people. Small water supplies that are subject to the Act can demonstrate compliance with the DWSNZ by either implementing a PHRMP and demonstrating that risks to public health are being managed properly (these communities are referred to as "participating supplies"), or by meeting the requirements for removal of microbiological, chemical, and radiological parameters set out in the DWSNZ (these communities are referred to as "standard supplies") (MOH 2005a).

The guidance document "Small Drinking-Water Supplies: Preparing a Public Health Risk Management Plan" (Small Supplies) was developed to assist small water system owners and operators in implementing a PHRMP. The Small Supplies document is essentially a condensed version of the Framework document that addresses existing system barriers, potential hazards and preventative measures, monitoring requirements and corrective actions. However, it does not include an explicit risk assessment procedure (MOH 2005b).

5.2 PUBLIC-PRIVATE PARTNERSHIPS

The combination of PPPs can introduce particular strengths of the private and public sectors to maximize public value for any endeavor, and in this case, particularly for public drinking water systems. The potential use of PPPs in this application can range from simple service agreements where the community retains ownership of the infrastructure while a private entity operates and maintains the infrastructure to complete infrastructure investment with O&M services by a private party for an extended period of time at which point the infrastructure is returned to the community.

The Canadian Council for Public-Private Partnerships (CCPPP) commissioned a nation-wide survey in 2004, 2005, and 2006 to measure and track public opinion about the involvement of the private sector in partnering with the government to provide public assets and services, one of which related specifically to water treatment facilities (Alberta Department of Infrastructure 2003). In particular, the Atlantic provinces consistently showed approximately 60 percent in favour of private operation of water treatment facilities.

The Province of Alberta have been successfully using the PPP model since 2003 as it was glaringly obvious that government funding alone could not match the ever-increasing demand for public funds to address basic municipal infrastructure requests (Alberta Department of Infrastructure 2003). The Alberta PPP model draws on the private sector to develop innovative solutions and financing to respond to needs that the Alberta government cannot address. The exact type of PPP arrangement is determined in conjunction with the type of project, financing requirements, and service period.

The use of PPPs are often a mechanism to fill a void for communities that cannot fund the substantial financial investment required to upgrade or replace existing water treatment infrastructure, or where communities do not meet criteria for funding from higher levels of government. Some issues arise when complete control of treated water is divested to the private sector as fears of potable water being considered as a commodity for profit or as a public benefit, much in the same manner as town road networks (Canadian Council for Public Private Partnerships 2006).

Regardless of the type of PPP being considered, a number of guidelines should be developed before selecting the specific PPP arrangement that would best suit each community or region. These guidelines include the following (Alberta Department of Infrastructure 2003):

- Review of available PPP models should take into consideration the advantages and disadvantages of each model before settling on a particular PPP arrangement
- Identify and quantify any efficiencies that would be lost or gained under the various PPP alternatives under consideration using a cost-benefit analysis
- Dedicate a group to whose only responsibility is to manage the development of the PPP process
- Educate the local governments or regional entities that they will always remain accountable to some degree for water quality delivered to the consumers since they retain ownership of the infrastructure
- Ensure that advice to local governments or regional entities from advisors, consultants, and/or managers is impartial to avoid any potential for conflict of interest
- Involve the general public (specifically those in the community where a PPP is likely to develop) to incorporate constructive feedback into an agreement, which would should involve the private sector partner; then make the agreement available to the public

5.2.1 SERVICE CONTRACTS

Service contracts are the most basic type of PPP that is currently used by most, if not all, communities. Two common examples of service contracts are the use of consultants to design and supervise construction of water treatment systems, and the use of contractors to install these systems. Service contracts are also the most straightforward of the various PPP alternatives since all management and infrastructure investment responsibility continues to remain with the community.

The use of specialized expertise to address specific treatment system requirements that cannot be resolved with existing operators would be contracted on an as-needed basis rather than a standing offer arrangement. A tendering process can further improve the cost-effectiveness of this approach.

Service contracts clearly identify the responsibilities of the service provider, which are mandated by the community. In addition, the community continues to retain all liability associated with the water quality delivered to the end-users.

5.2.2 MANAGEMENT CONTRACTS

Management contracts are an extension of service contracts where a dedicated company or firm can provide services for a specific period of time, often one to two year terms. These contracts are common between large private sector clients and a service provider, which is typically referred to as a Standing Offer agreement. In terms of drinking water systems, a standing offer could be used for O&M services where a community and private service provider enter into an agreement with the community paying the service provider to maintain and operate the system, which includes the operator.

The use of a management contract is known to currently be in place at one community in the Province and numerous other management contracts throughout Canada are gaining more favour in other provinces such as Ontario, Alberta, and Saskatchewan (CCPPP 2002).

Management contracts allow the service provider to revise and improve operational practices that will result in a higher level of water quality. The use of management contracts continues to have communities carry the full responsibility of water quality and the service provider is guaranteed payment regardless of treated water volumes. It should be noted that management contracts could be developed on a regional basis, which would allow for a number of operators located at a central hub to operate a number of local water systems, thereby reducing the O&M cost per system.

5.2.3 LEASES

Leases are an extension of management contracts that also transfers risk to the service provider since the private sector leases the water treatment infrastructure from the community and is compensated by revenues from production volumes of treated water. Ownership of the assets continues to be that of the community, but the relationship becomes complex when new infrastructure or substantial investment is required before the term of the lease expires.

This PPP alternative would prove a difficult arrangement to manage as all communities in the Province are currently charged a flat rate for water taxes; therefore, regular annual reviews of revenues from water taxes would be necessary to ensure the service provider and community are both obtaining equitable benefits from the contractual agreement.

5.2.4 CONCESSIONS

Concessions are quite similar to lease arrangements with one key exception that infrastructure investment must be covered by the service provider. Under this agreement, the private sector maintains existing infrastructure with full control of asset renewal, expansion, and O&M; however, the assets remain the property of the community.

This alternative shifts the full focus of the private sector to balance revenues with efficient management of the water treatment system without compromising water quality. Concession contracts would require substantially longer service periods to allow the private sector partner to recover any infrastructure investments during the life of the agreement.

5.2.5 BUILD-OPERATE-TRANSFER

The last form of PPP is the Build-Operate-Transfer (BOT) arrangement that combines the concessions type of contract with initial infrastructure capital investment for the water treatment system specific to the community requirements, current and forecasted demands, for the term of the contract. The service provider is responsible for all financing related to initial design and construction of the water treatment system followed by the continued O&M of the infrastructure, all of which is only transferred to the community at the completion of the term of the contract.

The BOT contract arrangement allows full flexibility of the service provider to obtain the best possible financing for initial construction and take all necessary steps to maximize efficiencies during the O&M stage of the contract. As with concession contracts, longer service agreements would be required to ensure the private sector partner can recover the large capital investment at the start of the term.

5.3 PRIVATIZATION

Privatization is the complete transfer of ownership of the water treatment equipment to the private sector, which results in the community paying for treated water from a utility (similar to electricity). Rather than maintaining a relationship between the community and the water utility company through a contract, the community (or higher level of government) monitors the relationship through regulatory controls.

Although large capital investment requirements are shifted to the private sector, the regulatory framework for such an arrangement would first have to be created in co-operation with the private sector and the public to ensure the investor receives a fair and adequate return on their investment, but not at the expense of a heavy financial burden to the community or its taxpayers.

Failure to establish a fair and equitable regulatory framework to protect the private investor, the community, and the public before a privatization arrangement is developed will likely lead to lengthy litigation while the public are left to battle water supply and quality issues, as was the case during the 1990s in England and Wales (Bakker 2003).

6.0 CONCLUSIONS

6.1 REASONS FOR BWAs

The following summary statements are intended to characterize the primary findings of drinking water quality issues and their correlation to O&M practices. The text of the report provides the supporting basis and specifics for these summary statements.

The majority of communities in Newfoundland and Labrador draw water from a surface water source (lake/pond or river/stream). In particular, the larger systems rely on surface water whereas the smaller systems are a mixture of surface and ground water supply sources.

Site visits to 25 communities were completed. The site visits, in combination with a review of the basic surveys completed by water system representatives, resulted in a total of 93 surveys of specific water supply systems. The 93 communities as characterized by site visits and surveys provide a good representation of the microbial and chemical water quality at drinking water systems throughout the Province of Newfoundland and Labrador. This determination is based on the proportion of systems that are under a BWA or exceed federal guidelines for chemical drinking water quality.

Reliance upon the February 2009 period to characterize the prevalence of BWAs for public drinking water systems in Newfoundland and Labrador is a reasonable strategy. The number of systems under a BWA at that time is similar to the number under a BWA in January 2010. While BWAs have been issued or revoked for a number of water systems over the past year, some BWAs have been in place for up to 25 years.

The systems that are most vulnerable to BWAs are those with populations under 500 people. Another trend is governance as LSD systems appear to be more vulnerable than municipal operations.

The factors contributing to the greatest number of BWAs are related to poor O&M practices (BWA Codes C and E), infrastructure (BWA Codes A and E), and operator training (BWA Code B).

6.1.1 ISSUES RELATED TO GEOGRAPHIC LOCATION EASTERN AND WESTERN REGIONS

There is a slight tendency for systems with very small populations (under 500) in the east and west of Newfoundland to have more BWAs in comparison to those in central Newfoundland, although the reason for this finding is not clear.

6.1.2 ISSUES RELATED TO POPULATION SERVICED

Almost half of the water treatment systems in Newfoundland and Labrador are surface water based that serve communities with a population of less than 500. Approximately 69 percent of water treatment systems in Newfoundland and Labrador are in communities of with less than 500 people; however, 86 percent of the current BWAs are in these communities.

As these figures indicate, there are significantly greater probabilities of BWAs for very small drinking water systems (i.e., populations less than 500 people) than for larger systems (with populations greater than 500 people).

6.1.3 ISSUES RELATED TO GOVERNANCE

There is an overall greater number and percentage of BWAs occurring in LSD systems versus municipally-operated systems.

In terms of condition, capital investment as observed by the extent of water treatment infrastructure, as well as level of operator training, were found to be lower in LSDs when compared to municipalities.

In addition, a sub-Code does not currently exist for the removal of disinfection equipment by an operator when directed by a community representative; therefore, a new sub-Code should be considered to reflect this condition, which is not directly related to operator training or knowledge.

6.1.4 ISSUES RELATED TO WATER SOURCE

Colour is a good indicator of organic contamination of source water, and was used to differentiate between "secure" groundwater supplies that are not vulnerable to contamination and ground water under the direct influence (GUDI) of surface water.

However, it is not appropriate to consider drinking water from ground water sources as better protected against BWAs than either GUDI or surface water supplies, based on the proportion of BWAs for each type of source.

In fact, for communities with less than 500 people, the percentages of BWAs as a function of water source (surface, groundwater, or combination) are very similar, such that differences of supply do not appear to contribute to, or dissociate from, BWAs.

6.2 WATER QUALITY CHEMISTRY

Turbidity and colour are pervasive issues throughout Newfoundland and Labrador and may warrant a Province-wide strategy. These two constituents are of concern because they may impact the efficiency of the disinfection process by shielding pathogens. Increasing the chlorine dosage to limit the effect of turbidity and colour will increase formation of DBPs. Consequently, colour and turbidity indirectly contribute to health-related issues.

A widespread lack of infrastructure to remove colloidal and dissolved matter that contributes to colour from raw water sources is evident. Removal of turbidity generally requires one (or more) of the following filtration types: chemically assisted filtration, slow sand or diatomaceous earth filtration, or membrane filtration. ENVC data shows that only 11 of the 149 water systems with high turbidity have filtration treatment.

Iron and manganese are aesthetic concerns and are widespread throughout Newfoundland and Labrador. Iron does not have a health-related limit, but the presence of high levels of iron can lead to the staining of plumbing fixtures, laundry, and adverse taste in water. Iron may also increase the chlorine dose required to maintain a free chlorine residual.

Low pH is a Province-wide issue. Concern with low pH exists because these levels may cause operational issues and premature aging/corrosion of the treatment and/or distribution system. Evaluated pH also influences other treatment processes by reducing the effectiveness of filtration and chlorination.

Concentrations for health-related chemicals (e.g., lead, arsenic, fluoride, barium) are generally not a widespread issue. While there are individual drinking water systems with issues, the situation does not warrant a Province-wide strategy. Water systems with an elevated concentration of one of these parameters in their raw water supply should consider source relocation, added treatment infrastructure, or perhaps a PWDU (Potable Water Dispensing Unit) as potential solutions.

6.3 INFRASTRUCTURE AND EQUIPMENT

Approximately 70 percent of the drinking water systems rely on surface water sources; however, the infrastructure in place is not effective against surface water pathogens without filtration. The contact time is not likely long enough to remove *Giardia* and chlorination is not effective against *Cryptosporidium*.

6.4 OPERATION AND MAINTENANCE

Evidence has shown that low O&M, operator effort, and poor access to spare parts results in a higher probability of BWAs. Communities where chlorination systems were bypassed or disengaged (Code B BWAs) have the lowest amount of annual on-site training per operator; only one of four systems (in the survey data set) that were manually turned off had an operator with on-site training.

6.5 TRAINING AND CERTIFICATION

Substantial issues are evident in relation to operator training; considerable variability was noted in the number of operators for LSDs compared to municipalities. Systems are less likely to have BWAs when trained and/or certified operators are available to maintain and operate these systems.

It should also be noted the average operator has about 15 percent of the minimum BMP of 13 hours of annual on-Site training, which is a substantial portion of the required 20 hours of annual training.

7.0 RECOMMENDATIONS

7.1 MANAGEMENT ALTERNATIVES

Potential management alternatives range from the conventional approach of one water treatment system per community to complete privatization of the process where a community pays for potable drinking water, usually based on metered consumption at some agreed point in the treatment or distribution system. Each alternative must be carefully assessed for the community or area and its specific needs before selecting the optimal alternative. For each of the alternatives, the following factors should be considered during the assessment process:

- For the one water treatment system per community scenario, a more detailed financial assessment is recommended to determine the minimum population base and minimum water tax rates required to sustain an individual water treatment and distribution system for a given community.
- For the consolidation of public services through regionalization, further study is recommended for communities with BWAs to identify potential neighbouring communities that could supply a higher quality source of drinking water. This approach will need to consider the capital costs associated with the transmission main, and treatment system upgrades required to meet the increase in water demand.
- For the formation Public-Private Partnerships (PPPs), a complete network of legislation and guidelines would need to be developed. This option requires further investigation to gauge the level of interest from the Province, local governments, and especially the general public.
- For privatization of drinking water systems, a very detailed network of legislation, guidelines, and contracts would be need to be developed before the sale of any public assets to a private company. Testing the waters of acceptability for privatization with the general public should be considered, possibly in conjunction with evaluating the PPP alternative.

7.2 LOCAL GOVERNMENT

In order to address the challenges CRA identified during the assessment of drinking water system operations in Newfoundland and in Walkerton at the time of the outbreak, the following recommendations were developed for the local government:

- Establish appropriate local budgets
- Provide improved compensation for operators
- Retain required number of certified operators to ensure consistent operation
- Provide support for operators to participate in provincial training programs
- Provide necessary tools and equipment for operators to perform necessary O&M tasks
- Review existing maintenance and service contracts

7.3 PROVINCIAL GOVERNMENT

In order to address the challenges CRA identified during the assessment of drinking water system infrastructure and operations in Newfoundland and in Ontario at the time of the Walkerton outbreak, the following recommendations were developed for the provincial government:

- Provide consistent regulatory oversight and enforcement
- Establish binding regulations for treatment and monitoring infrastructure based on water source and service population
- Prioritize infrastructure funding to target communities that do not currently meet GCDWQ limits
- Investigate the implementation of a quality management approach to ensuring drinking water safety as a means of better incorporating system-specific challenges and minimizing reliance on end-of-pipe compliance monitoring
- Establish provincial standards or best management practice guidelines for O&M
- Provide a new sub-code for a BWA reason (Code B4) as a designation when disinfection equipment is removed from service at the direction of a community representative.
- Evaluate cost sharing or funding alternatives for O&M
- Move towards binding operator training and certification standards
- Expand water system operator training programs to focus on preventative maintenance activities, and help operators develop Standard Operating Procedures for these activities
- Develop guidelines for operator compensation that reflect operator certification levels and the community service population

- Update design guidelines to consider service population and community socioeconomic conditions
- Provide "plain language" versions of technical and policy documents to the public
- Continue to seek out innovative and non-conventional approaches to address public drinking water quality issues (such as PWDUs), specifically related to equipment/system design and subsequent O&M.

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Figure 2.1.3.1.3.1
Boil Water Advisory Breakdown
Survey and Province-wide Data Sets
(ENVC Data February 2009)

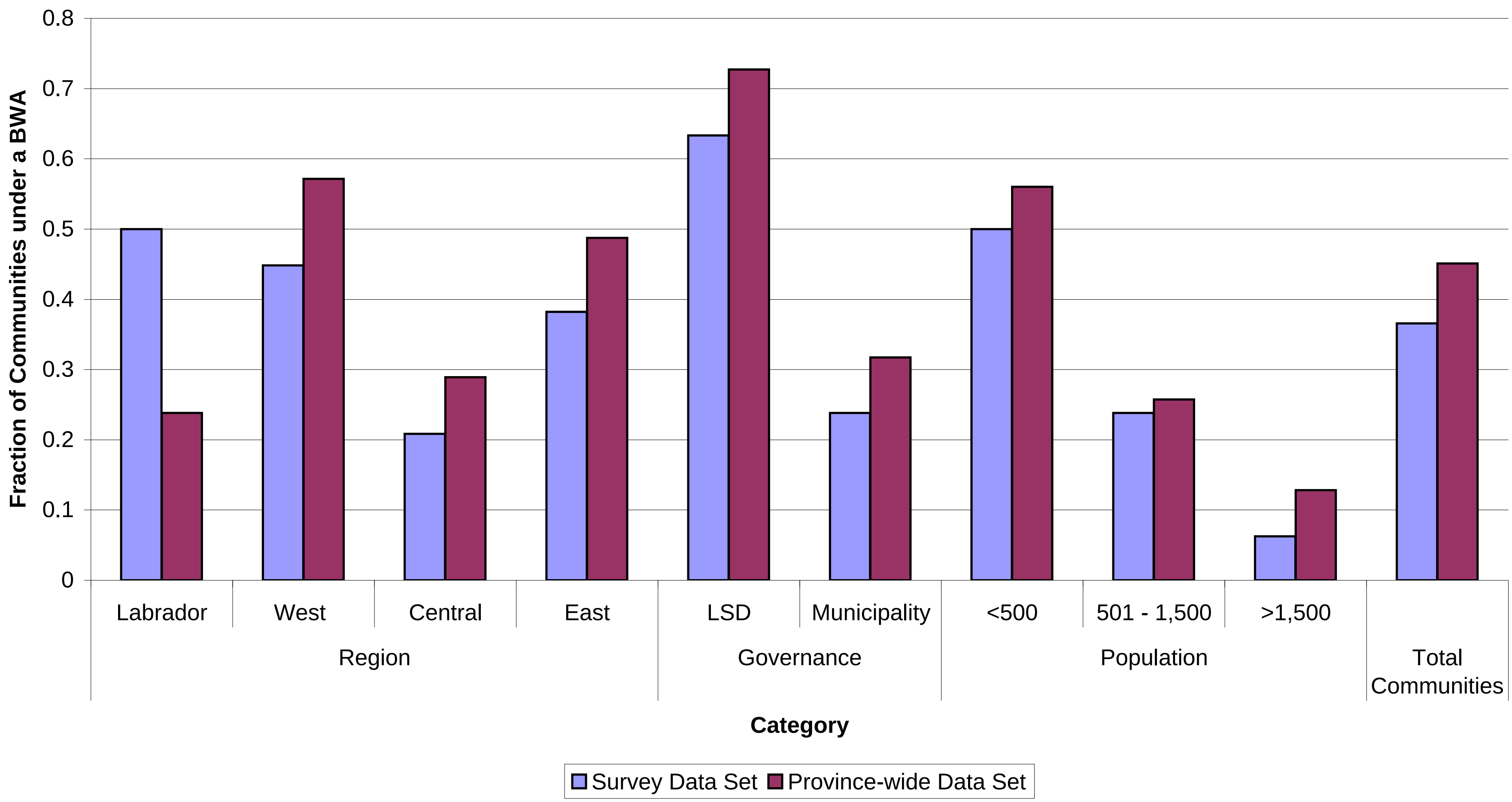


Figure 2.1.3.1.3.2
Boil Water Advisory Breakdown for Inspection and Survey Data Sets
(ENVC Data February 2009)

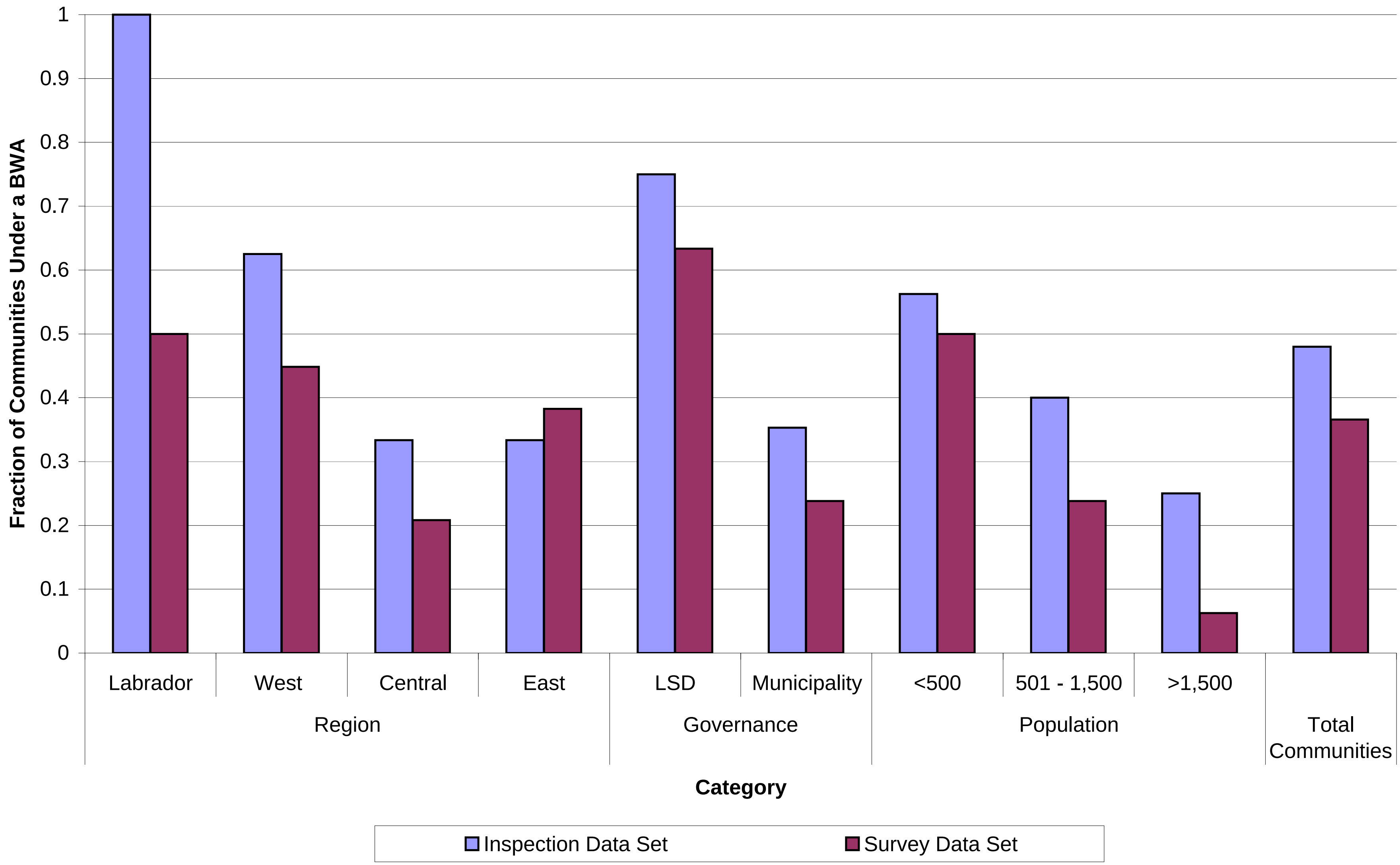


Figure 2.1.3.3.1
Comparison of Operator Effort Based on Governance
Survey Data Set

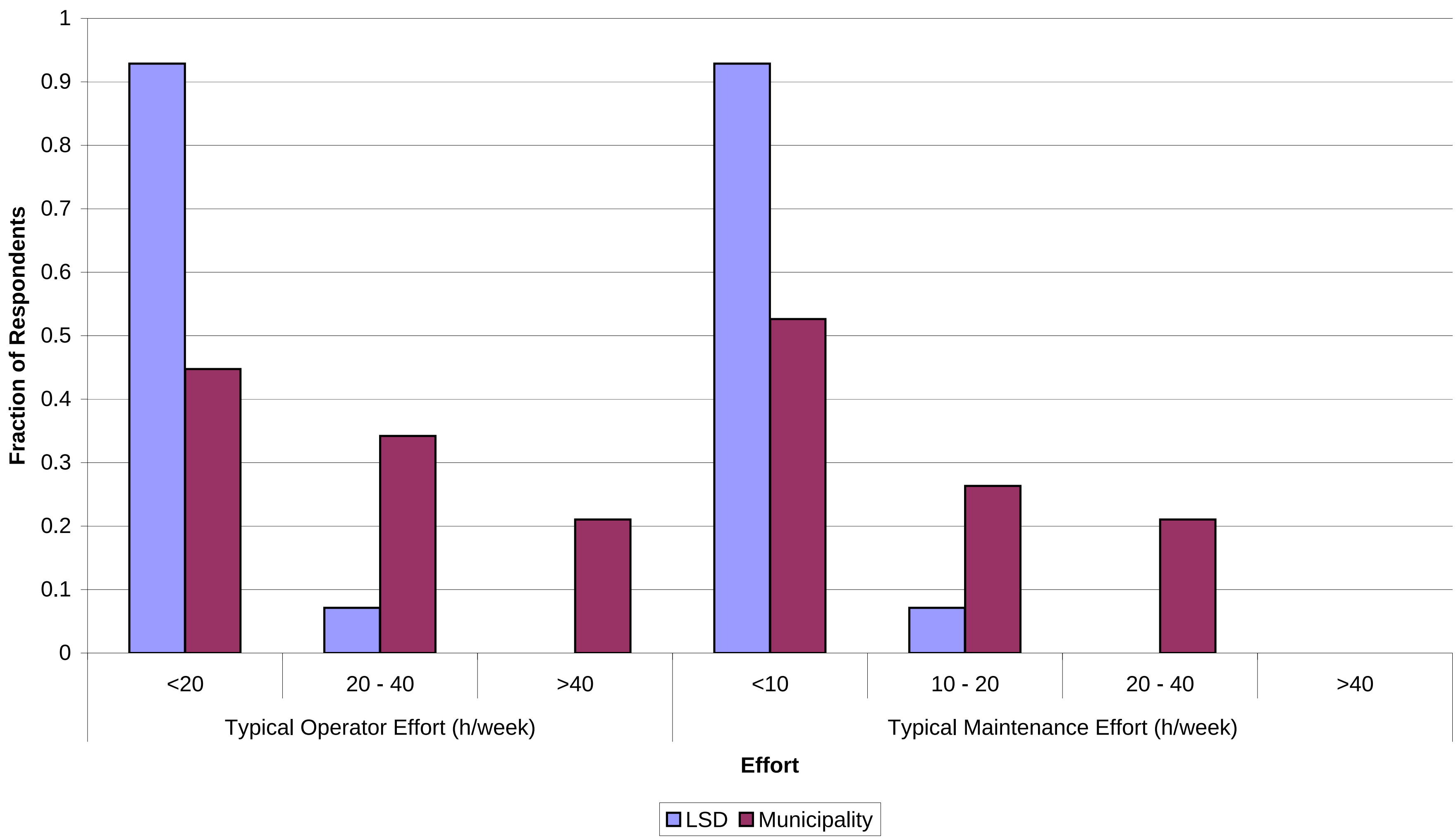


Figure 2.1.3.3.2
Comparison of Operator Effort Based on Population Size
Survey Data Set

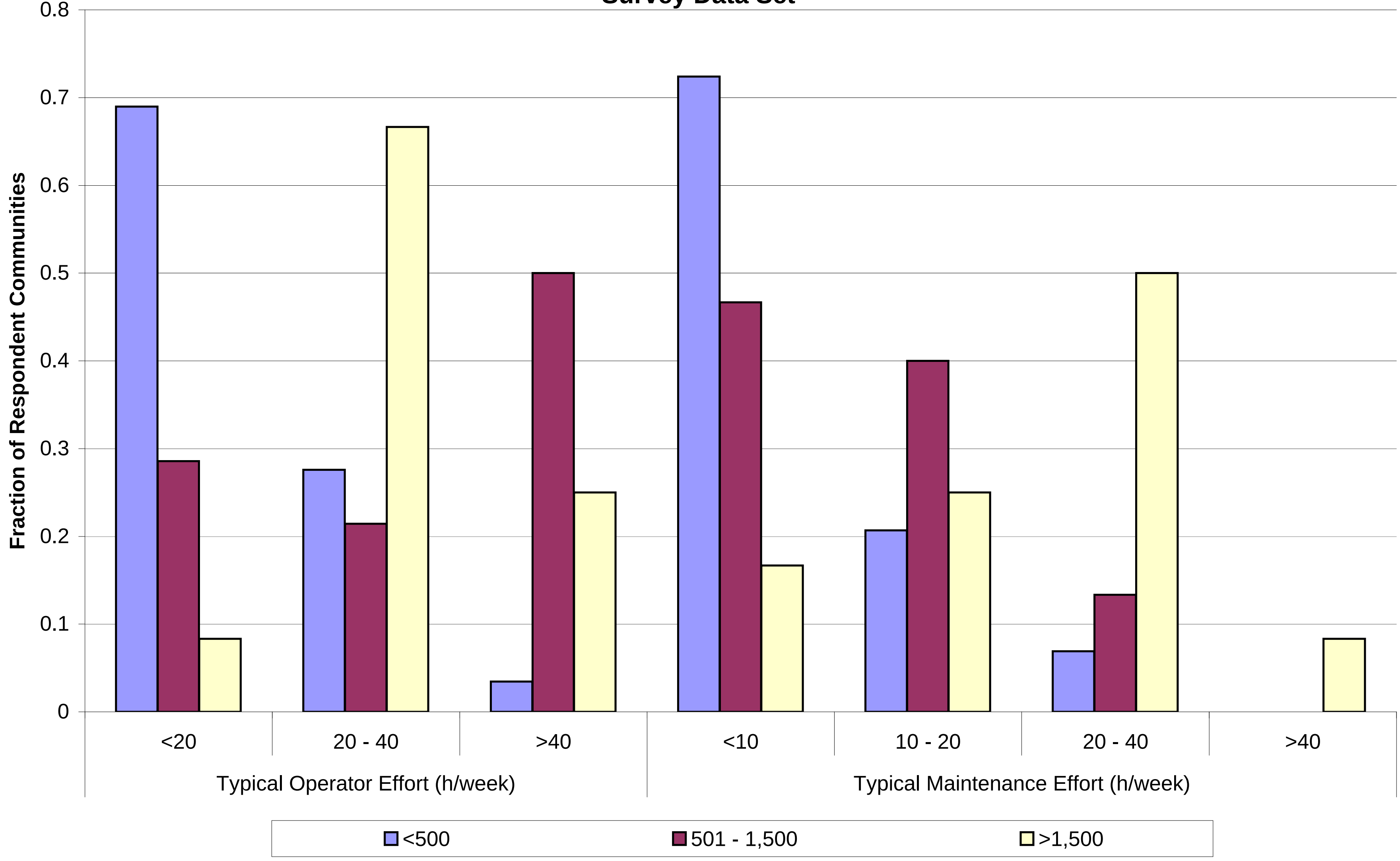


Figure 2.1.3.4.1
Comparison of Operator Status By Community Population
Survey Data Set

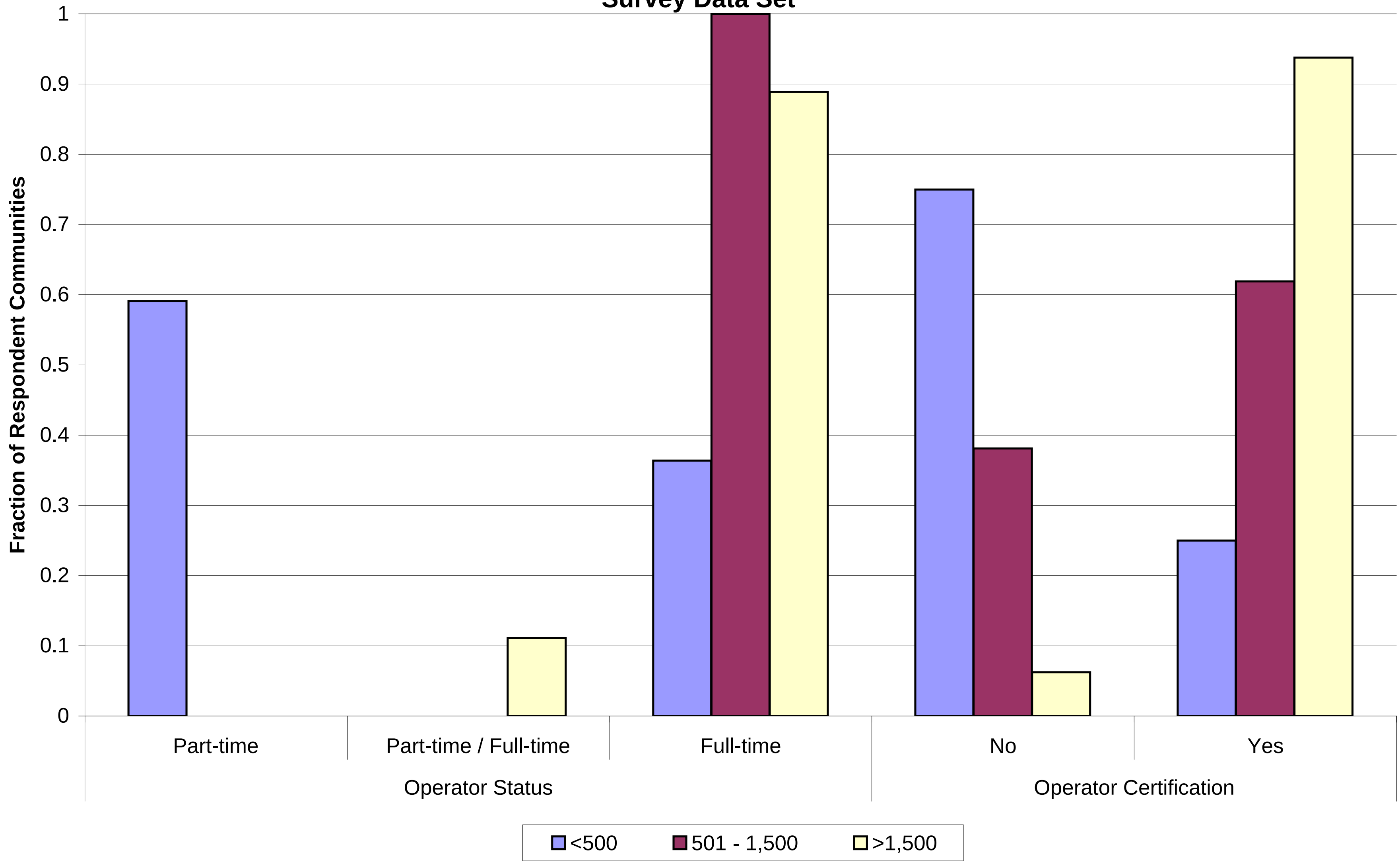


Figure 2.1.3.4.2
Comparing Levels of On-Site Training
By Region, Governance and Population
Survey Data Set

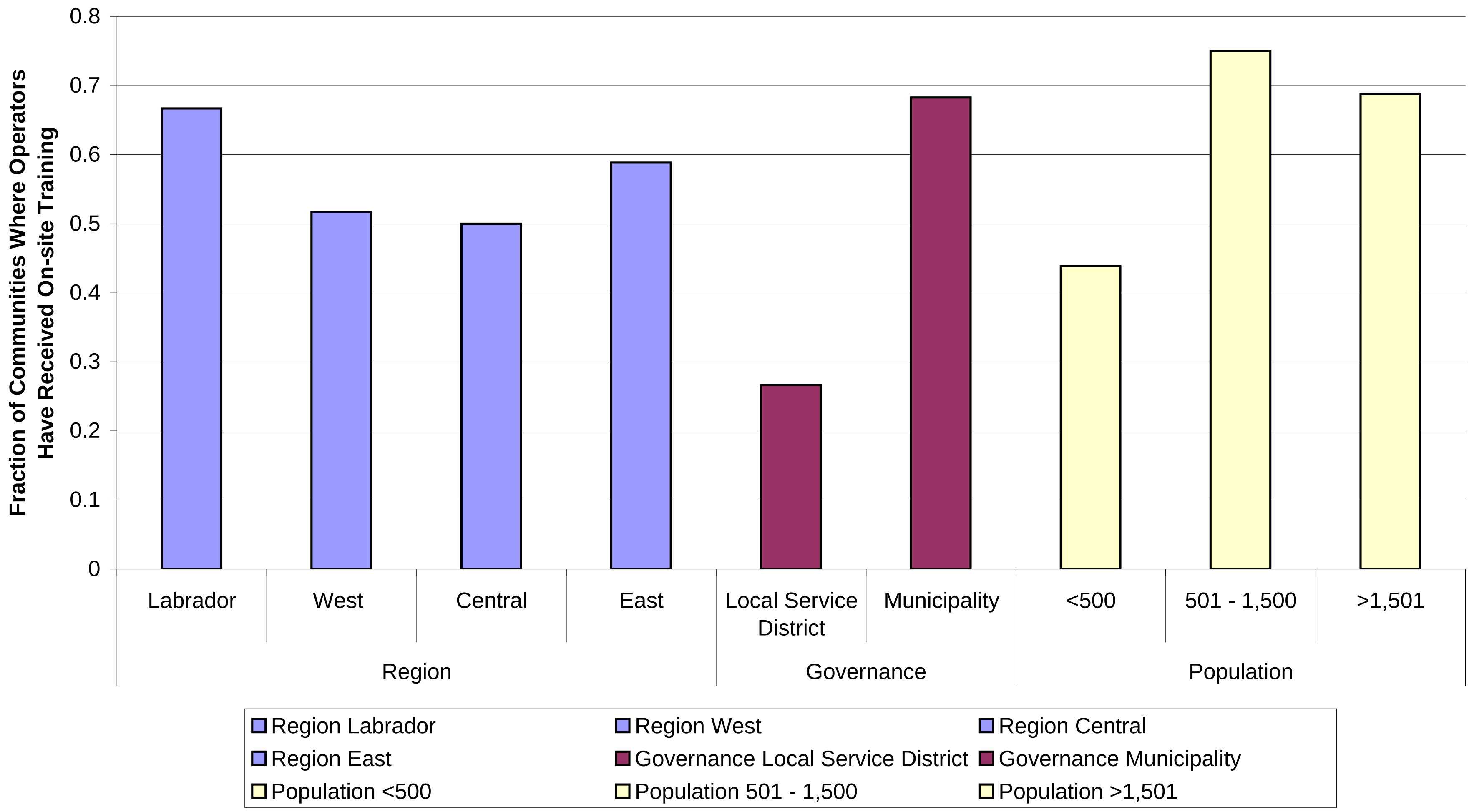


Figure 2.2.2.1
Comparison of Boil Water Advisory Codes
Survey Data Set and Province-wide Data
(ENVC Data February 2009)

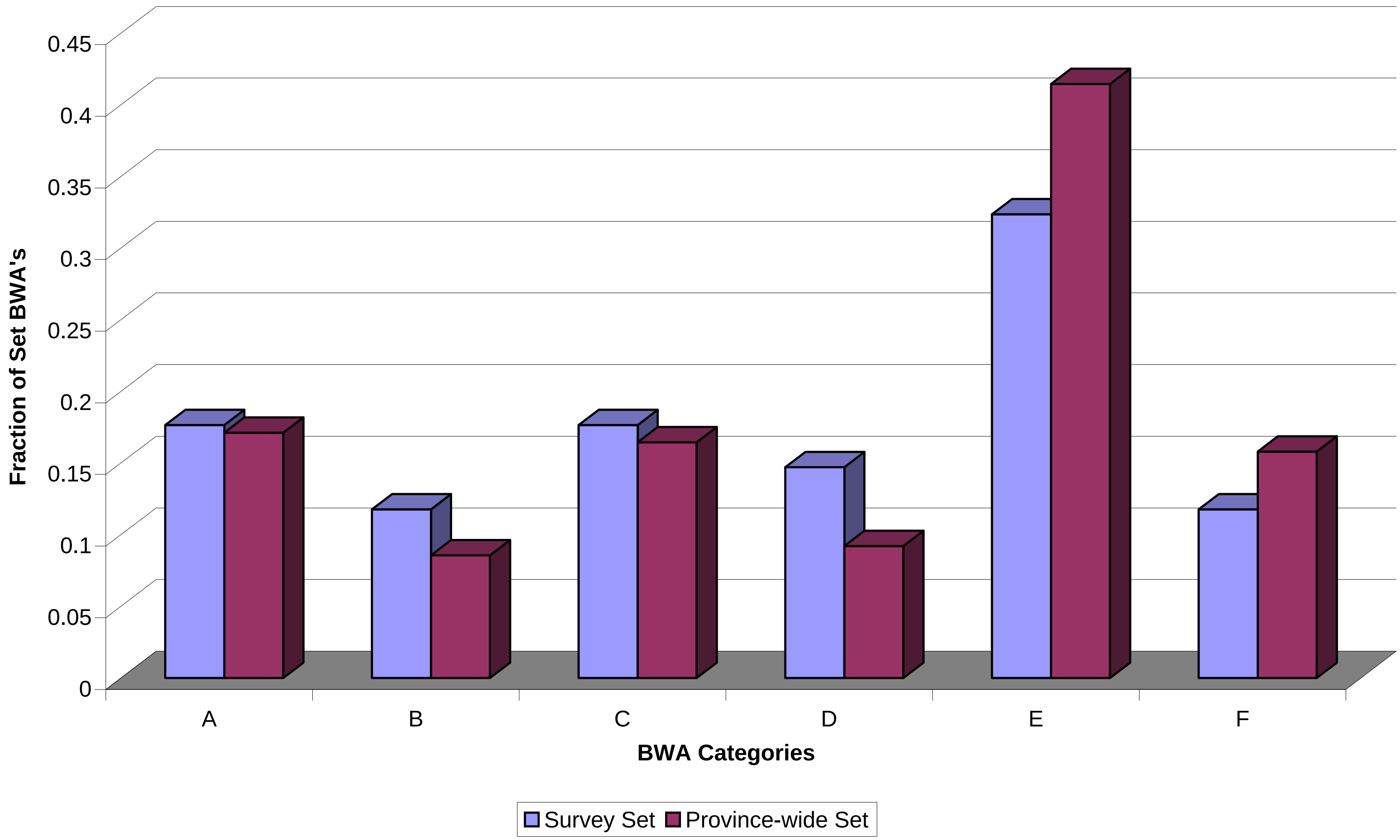


Figure 2.2.2.2
Comparison of Resources for Operations and Maintenance Activities
Survey Data Set

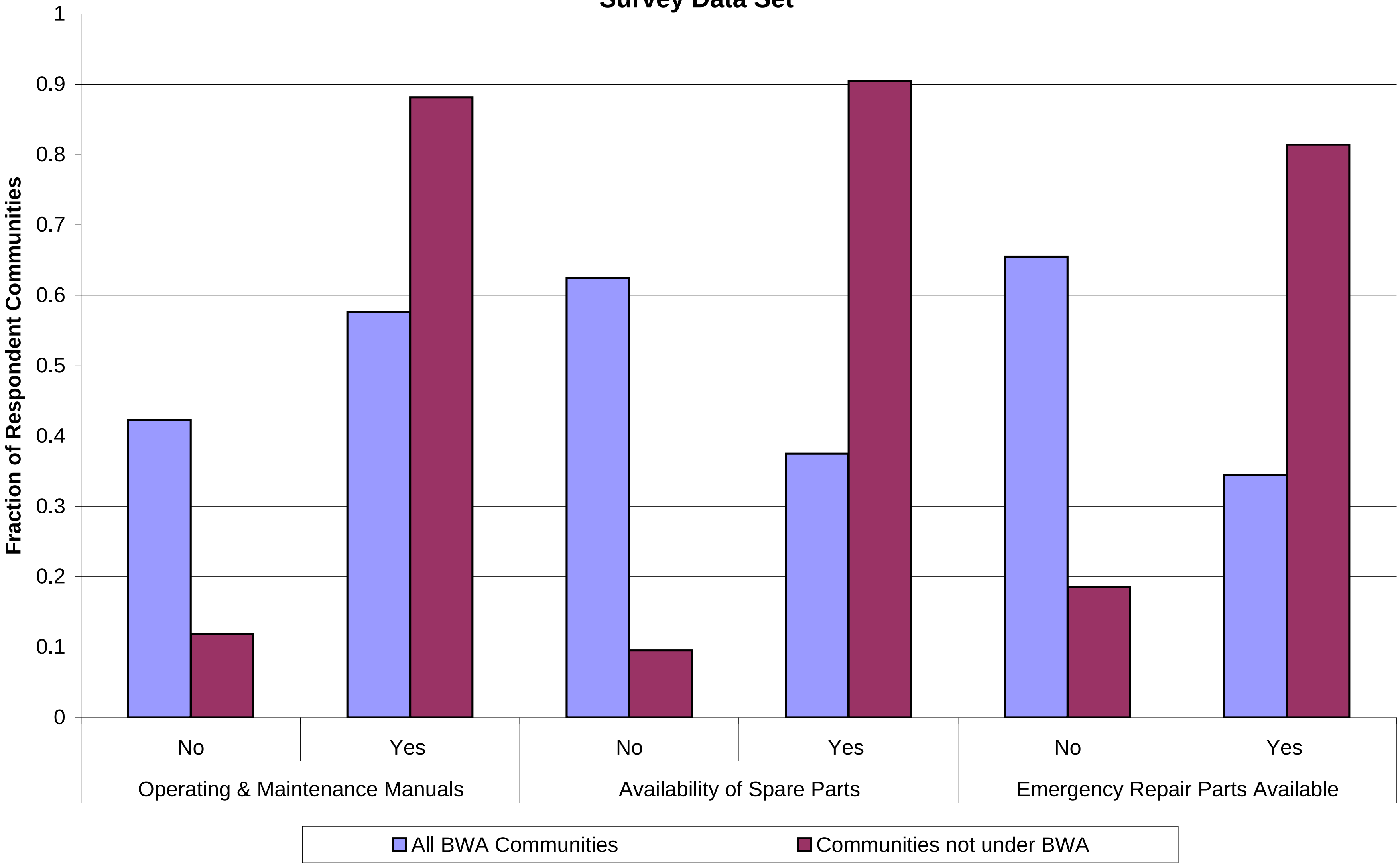
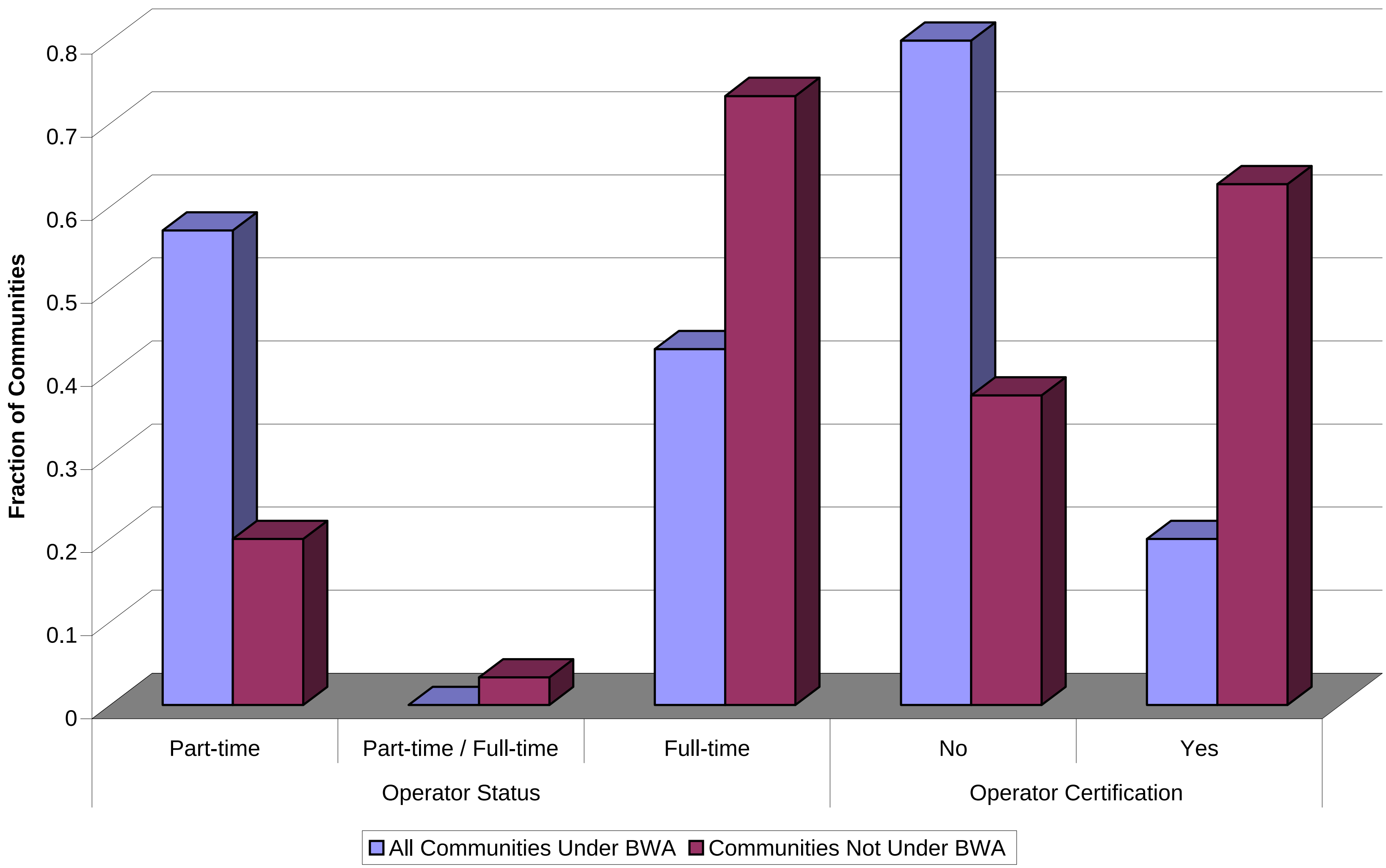
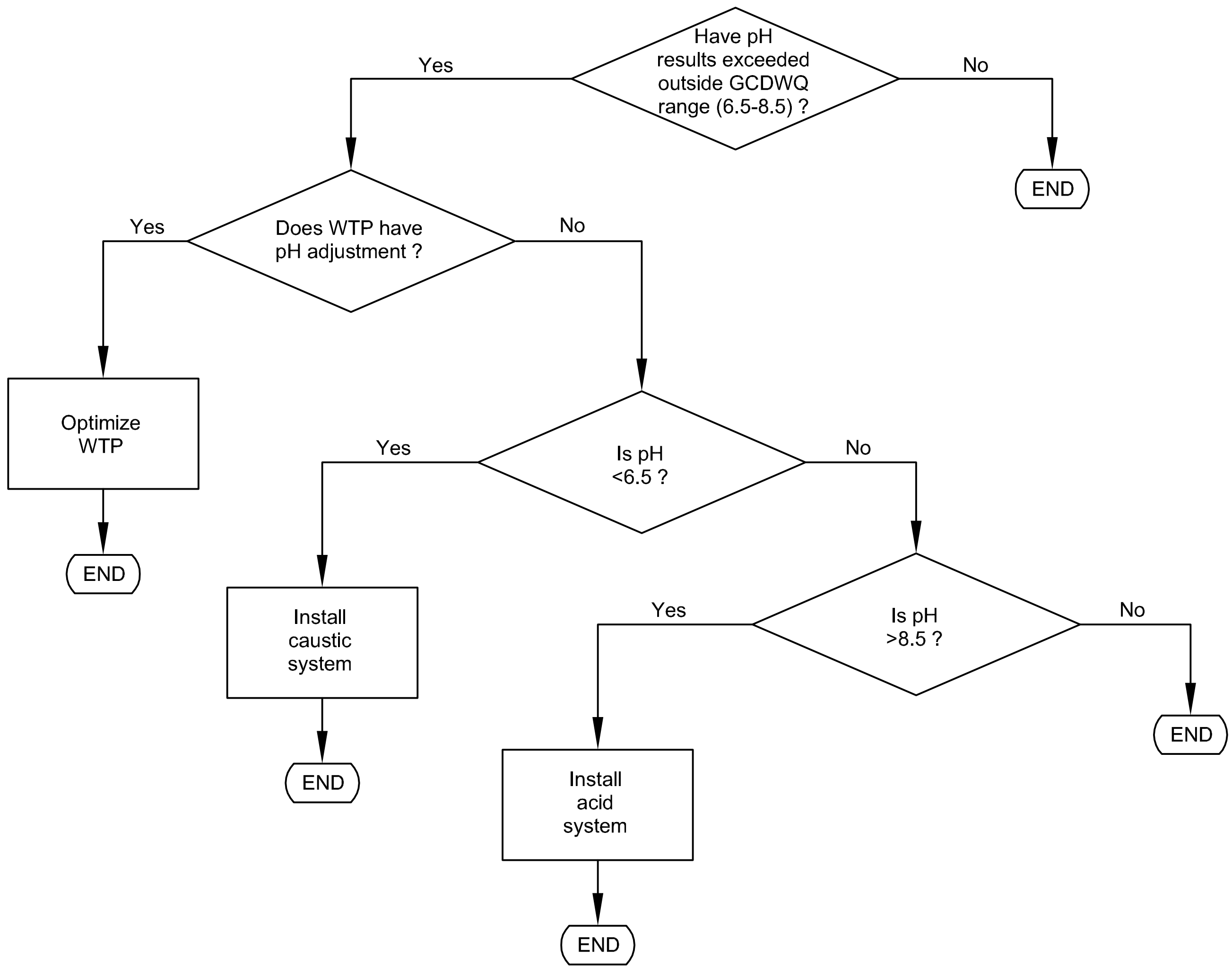


Figure 2.2.3.1
Comparison of Operator Status Based on Boil Water Advisory Code
Survey Data Set





WTP : WATER TREATMENT PLANT

figure 3.3.1.3

FLOW CHART FOR pH ADJUSTMENT
ECONOMIC ANALYSIS OF DRINKING WATER
INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR
Government of Newfoundland and Labrador

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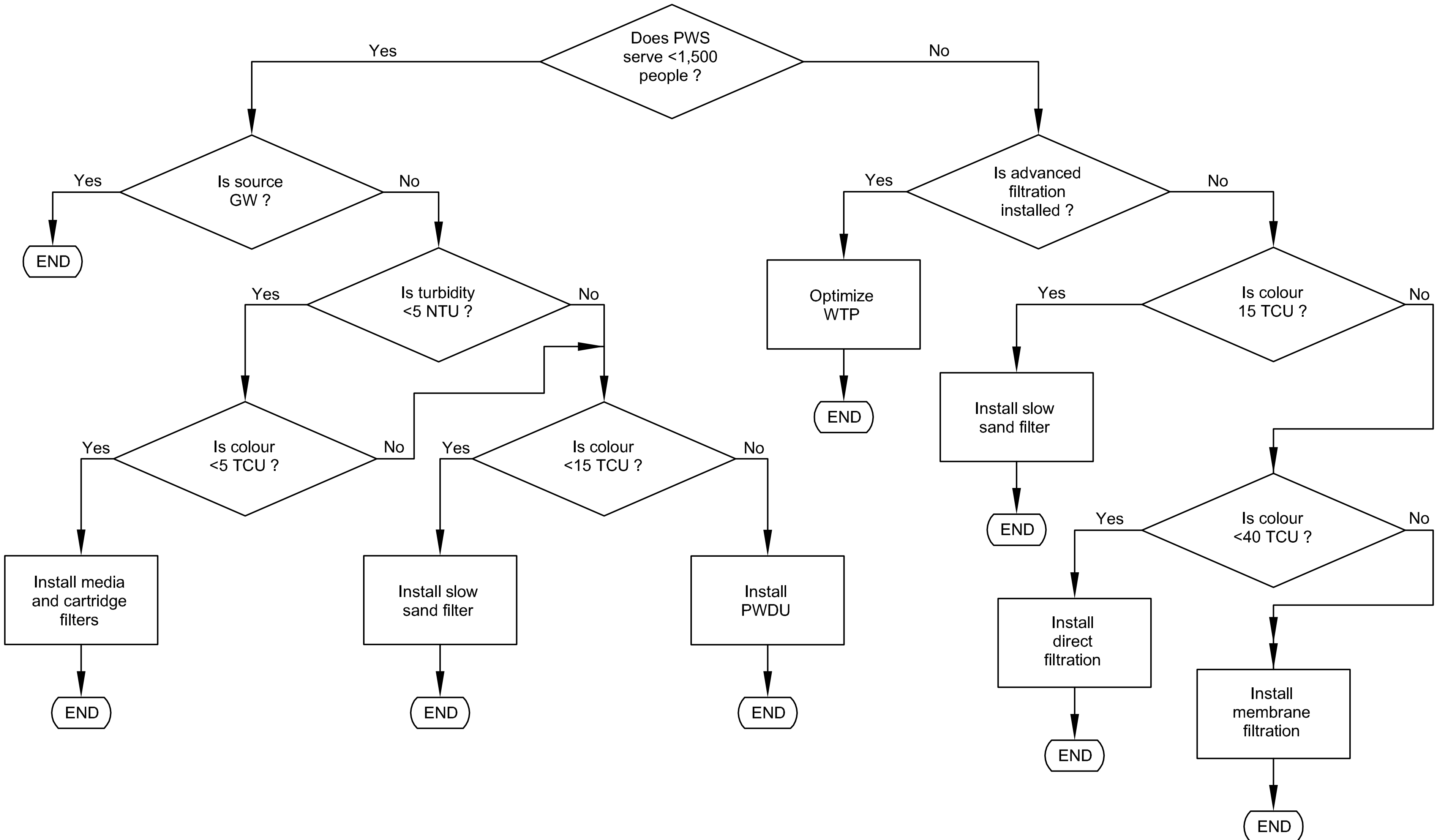
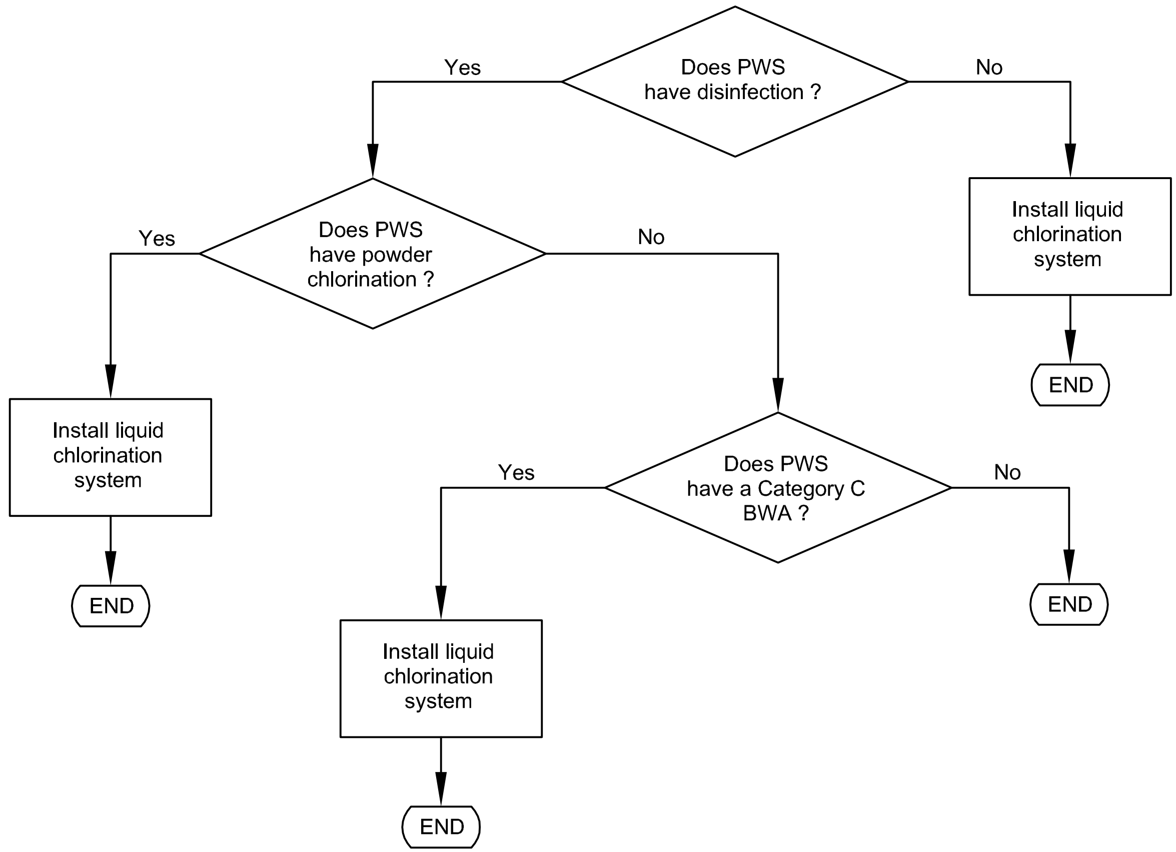
55425-00(005)GN-WA002 FEB 19/2010



GW : GROUNDWATER
PWS : PUBLIC WATER SAFETY
PWDU : POTABLE WATER DISPENSING UNIT

figure 3.3.1.4
FLOW CHART FOR FILTRATION INFRASTRUCTURE
ECONOMIC ANALYSIS OF DRINKING WATER
INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR
Government of Newfoundland and Labrador

55425-00(005)GN-WA003 FEB 19/2010



BWA : BOIL WATER ADVISORY
PWS : PUBLIC WATER SUPPLY

figure 3.3.1.5

FLOW CHART FOR CHLORINATION INFRASTRUCTURE
ECONOMIC ANALYSIS OF DRINKING WATER
INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR
Government of Newfoundland and Labrador

Figure 3.3.3.8
PWDU Capital Cost as a Function of Service Population
Capital Cost Adjusted to 2009 CND

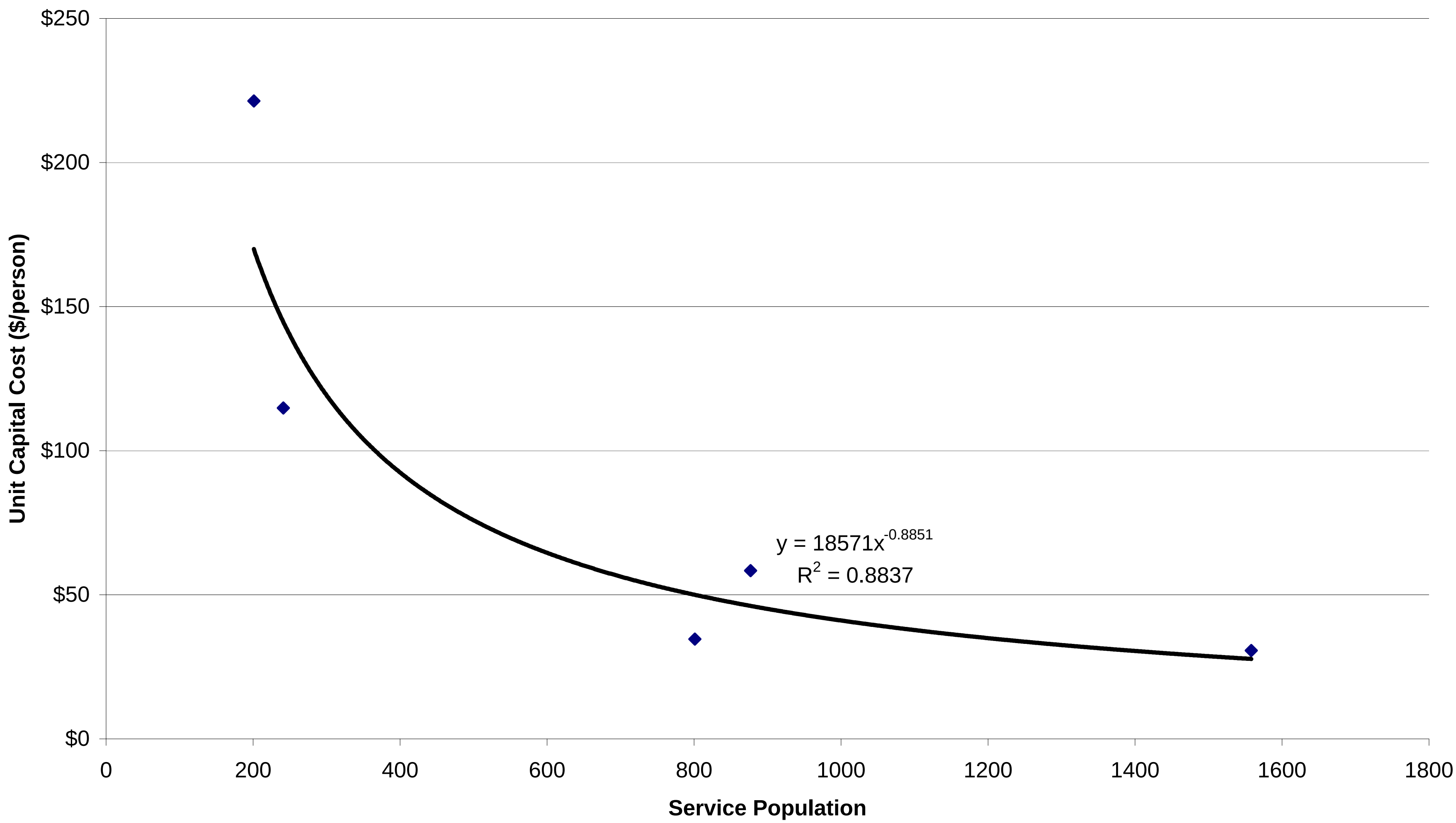


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TABLE 1.3.2.5

**COMPARISON OF COMMUNITIES
IN THE DETAILED SURVEY DATA SET TO PROVINCE-WIDE DATA
BASED ON SOURCE & SERVICE POPULATION
STUDY ON O&M OF DRINKING WATER
INFRATRUCTURE IN NL**

		Detailed Survey Data Set		*Province-wide Data Set*	
Source	*Service Population*	*# of Communities in Data Set*	*% of Communities in Data Set*	*# of Communities in Data Set*	*% of Communities in Data Set*
GW	-	4	16.0%	51	15.1%
GUDI,	<500	12	48.0%	192	56.8%
GW/SW,	501 - 1,500	5	20.0%	61	18.0%
SW	>1,500	4	16.0%	34	10.1%
	Total	**25**	**-**	**338**	**-**

TABLE 2.1.1.3

**REASONS FOR ISSUING BOIL WATER ADVISORIES
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR**

Standard Reasons for Issuing Boil Water Advisories	
Water supply has no disinfection system	A
Chlorination system is turned off by operator due to taste or other aesthetic considerations.	B1
Chlorination system is turned off by operator due to perceived health risks.	B2
Chlorination system is turned off by operator due to lack of funds to operate.	B3
Disinfection system is off due to maintenance or mechanical failure.	C1
Disinfection system is off due to lack of chlorine or other disinfectant.	C2
Water distribution system is undergoing maintenance or repairs.	D1
A cross connection is discovered in the distribution system.	D2
Inadequately treated water was introduced into the system due to fireflows, flushing operations, minor power outage or other pressure loss.	D3
Water entering the distribution system or facility, after a minimum 20 minute contact time (CT) does not have a free chlorine residual of at least 0.3 mg/l or equivalent CT value.	E1
No free chlorine residual detected in the water distribution system.	E2
Insufficient residual disinfectant in water system primarily disinfected by means other than chlorination.	E3
Total coliform count is more than 10 counts per 100 ml (This code now applies to PRIVATE wells only)	F1
Total coliform or Escherichia coli (E. coli) detected AND repeat samples can not be taken, as required.	F2
Total coliforms detected and confirmed in repeat sample.	F3
E.coli detected in an initial sample(s) is considered extensive and the water system has other known problems.	F4
E.coli detected and confirmed in repeat sample.	F5
Viruses detected (e.g., Hepatitis A, Norwalk).	F6
Protozoa detected (e.g., Giardia, Cryptosporidium).	F7
Water supply system integrity compromised due to disaster (e.g. contamination of water source from flooding, gross contamination, major power failure, etc.).	G
Waterborne disease outbreak in the community.	H

TABLE 2.1.2.1.1

BOIL WATER ADVISORY DATA TABLE - BY REGION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Region	*Governance*	*Population*	*Water Source*	*Number of Communities*[1]	*Number of BWAs*
East	MUN	0 - 500	*GW*	***12***	***5***
East	MUN	0 - 500	*GUDI*	***2***	***1***
East	MUN	0 - 500	*GW/SW*	***4***	***2***
East	MUN	0 - 500	*SW*	***27***	***11***
East	MUN	501 - 1,500	*GW*	***1***	***1***
East	MUN	501 - 1,500	*GW/SW*	***1***	***1***
East	MUN	501 - 1,500	*SW*	***17***	***4***
East	MUN	1,501 - 15,000	*GW*	***2***	***1***
East	MUN	1,501 - 15,000	*GW/SW*	***1***	***0***
East	MUN	1,501 - 15,000	*SW*	***12***	***0***
East	MUN	> 15,000	*GW/SW*	***1***	***0***
East	LSD	0 - 500	*GW*	***14***	***10***
East	LSD	0 - 500	*GUDI*	***6***	***6***
East	LSD	0 - 500	*GW/SW*	***4***	***3***
East	LSD	0 - 500	*SW*	***15***	***12***
East	LSD	501 - 1,500	*GW/SW*	***1***	***1***
East	LSD	501 - 1,500	*SW*	***1***	***1***
Central	MUN	0 - 500	*GUDI*	***2***	***0***
Central	MUN	0 - 500	*GW/SW*	***2***	***0***
Central	MUN	0 - 500	*SW*	***26***	***11***
Central	MUN	501 - 1,500	*GW*	***2***	***0***
Central	MUN	501 - 1,500	*SW*	***18***	***1***
Central	MUN	1,501 - 15,000	*GW/SW*	***1***	***0***
Central	MUN	1,501 - 15,000	*SW*	***8***	***0***
Central	LSD	0 - 500	*GW*	***2***	***1***
Central	LSD	0 - 500	*GUDI*	***1***	***0***
Central	LSD	0 - 500	*GW/SW*	***1***	***1***
Central	LSD	0 - 500	*SW*	***20***	***10***
West	MUN	0 - 500	*GW*	***1***	***1***
West	MUN	0 - 500	*SW*	***37***	***19***
West	MUN	501 - 1,500	*GW*	***1***	***0***
West	MUN	501 - 1,500	*GW/SW*	***4***	***1***
West	MUN	501 - 1,500	*SW*	***15***	***5***
West	MUN	1,501 - 15,000	*GW*	***3***	***1***
West	MUN	1,501 - 15,000	*SW*	***7***	***3***
West	MUN	> 15,000	*SW*	***1***	***0***
West	LSD	0 - 500	*GW*	***11***	***6***
West	LSD	0 - 500	*GUDI*	***3***	***3***
West	LSD	0 - 500	*GW/SW*	***2***	***1***
West	LSD	0 - 500	*SW*	***26***	***23***
West	LSD	501 - 1,500	*GW*	***1***	***1***
Labrador	MUN	0 - 500	*GW*	***1***	***0***
Labrador	MUN	0 - 500	*GUDI*	***1***	***1***
Labrador	MUN	0 - 500	*SW*	***10***	***2***
Labrador	MUN	501 - 1,500	*SW*	***4***	***1***
Labrador	MUN	1,501 - 15,000	*GW*	***1***	***0***
Labrador	MUN	1,501 - 15,000	*SW*	***2***	***0***
Labrador	LSD	0 - 500	*SW*	***2***	***1***
TOTALS				***337***	***152***

TABLE 2.1.2.1.2

BOIL WATER ADVISORY DATA TABLE - BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Governance	*Population*	*Water Source*	*Region*	*Number of Communities*[1]	*Number of BWAs*
MUN	0 - 500	*GW*	*East*	***12***	***5***
MUN	0 - 500	*GW*	*West*	***1***	***1***
MUN	0 - 500	*GW*	*Labrador*	***1***	***0***
MUN	0 - 500	*GUDI*	*East*	***2***	***1***
MUN	0 - 500	*GUDI*	*Central*	***2***	***0***
MUN	0 - 500	*GUDI*	*Labrador*	***1***	***1***
MUN	0 - 500	*GW/SW*	*East*	***4***	***2***
MUN	0 - 500	*GW/SW*	*Central*	***2***	***0***
MUN	0 - 500	*SW*	*East*	***27***	***11***
MUN	0 - 500	*SW*	*Central*	***26***	***11***
MUN	0 - 500	*SW*	*West*	***37***	***19***
MUN	0 - 500	*SW*	*Labrador*	***10***	***2***
MUN	501 - 1,500	*GW*	*East*	***1***	***1***
MUN	501 - 1,500	*GW*	*Central*	***2***	***0***
MUN	501 - 1,500	*GW*	*West*	***1***	***0***
MUN	501 - 1,500	*GW/SW*	*East*	***1***	***1***
MUN	501 - 1,500	*GW/SW*	*West*	***4***	***1***
MUN	501 - 1,500	*SW*	*East*	***17***	***4***
MUN	501 - 1,500	*SW*	*Central*	***18***	***1***
MUN	501 - 1,500	*SW*	*West*	***15***	***5***
MUN	501 - 1,500	*SW*	*Labrador*	***4***	***1***
MUN	1,501 - 15,000	*GW*	*East*	***2***	***1***
MUN	1,501 - 15,000	*GW*	*West*	***3***	***1***
MUN	1,501 - 15,000	*GW*	*Labrador*	***1***	***0***
MUN	1,501 - 15,000	*GW/SW*	*East*	***1***	***0***
MUN	1,501 - 15,000	*GW/SW*	*Central*	***1***	***0***
MUN	1,501 - 15,000	*SW*	*East*	***12***	***0***
MUN	1,501 - 15,000	*SW*	*Central*	***8***	***0***
MUN	1,501 - 15,000	*SW*	*West*	***7***	***3***
MUN	1,501 - 15,000	*SW*	*Labrador*	***2***	***0***
MUN	> 15,000	*GW/SW*	*East*	***1***	***0***
MUN	> 15,000	*SW*	*West*	***1***	***0***
LSD	0 - 500	*GW*	*East*	***14***	***10***
LSD	0 - 500	*GW*	*Central*	***2***	***1***
LSD	0 - 500	*GW*	*West*	***11***	***6***
LSD	0 - 500	*GUDI*	*East*	***6***	***6***
LSD	0 - 500	*GUDI*	*Central*	***1***	***0***
LSD	0 - 500	*GUDI*	*West*	***3***	***3***
LSD	0 - 500	*GW/SW*	*East*	***4***	***3***
LSD	0 - 500	*GW/SW*	*Central*	***1***	***1***
LSD	0 - 500	*GW/SW*	*West*	***2***	***1***
LSD	0 - 500	*SW*	*East*	***15***	***12***
LSD	0 - 500	*SW*	*Central*	***20***	***10***
LSD	0 - 500	*SW*	*West*	***26***	***23***
LSD	0 - 500	*SW*	*Labrador*	***2***	***1***
LSD	501 - 1,500	*GW*	*West*	***1***	***1***
LSD	501 - 1,500	*GW/SW*	*East*	***1***	***1***
LSD	501 - 1,500	*SW*	*East*	***1***	***1***
			TOTALS	***337***	***152***

TABLE 2.1.2.1.3

**BOIL WATER ADVISORY DATA TABLE - BY WATER SOURCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR**

Water Source	*Population*	*Governance*	*Region*	*Number of Communities* [1]	*Number of BWAs*
GW	0 - 500	MUN	*East*	***12***	***5***
GW	0 - 500	MUN	*West*	***1***	***1***
GW	0 - 500	MUN	*Labrador*	***1***	***0***
GW	0 - 500	LSD	*East*	***14***	***10***
GW	0 - 500	LSD	*Central*	***2***	***1***
GW	0 - 500	LSD	*West*	***11***	***6***
GW	501 - 1,500	MUN	*East*	***1***	***1***
GW	501 - 1,500	MUN	*Central*	***2***	***0***
GW	501 - 1,500	MUN	*West*	***1***	***0***
GW	501 - 1,500	LSD	*West*	***1***	***1***
GW	1,501 - 15,000	MUN	*East*	***2***	***1***
GW	1,501 - 15,000	MUN	*West*	***3***	***1***
GW	1,501 - 15,000	MUN	*Labrador*	***1***	***0***
GUDI	0 - 500	MUN	*East*	***2***	***1***
GUDI	0 - 500	MUN	*Central*	***2***	***0***
GUDI	0 - 500	MUN	*Labrador*	***1***	***1***
GUDI	0 - 500	LSD	*East*	***6***	***6***
GUDI	0 - 500	LSD	*Central*	***1***	***0***
GUDI	0 - 500	LSD	*West*	***3***	***3***
GW/SW	0 - 500	MUN	*East*	***4***	***2***
GW/SW	0 - 500	MUN	*Central*	***2***	***0***
GW/SW	0 - 500	LSD	*East*	***4***	***3***
GW/SW	0 - 500	LSD	*Central*	***1***	***1***
GW/SW	0 - 500	LSD	*West*	***2***	***1***
GW/SW	501 - 1,500	MUN	*East*	***1***	***1***
GW/SW	501 - 1,500	MUN	*West*	***4***	***1***
GW/SW	501 - 1,500	LSD	*East*	***1***	***1***
GW/SW	1,501 - 15,000	MUN	*East*	***1***	***0***
GW/SW	1,501 - 15,000	MUN	*Central*	***1***	***0***
GW/SW	> 15,000	MUN	*East*	***1***	***0***
SW	0 - 500	MUN	*East*	***27***	***11***
SW	0 - 500	MUN	*Central*	***26***	***11***
SW	0 - 500	MUN	*West*	***37***	***19***
SW	0 - 500	MUN	*Labrador*	***10***	***2***
SW	0 - 500	LSD	*East*	***15***	***12***
SW	0 - 500	LSD	*Central*	***20***	***10***
SW	0 - 500	LSD	*West*	***26***	***23***
SW	0 - 500	LSD	*Labrador*	***2***	***1***
SW	501 - 1,500	MUN	*East*	***17***	***4***
SW	501 - 1,500	MUN	*Central*	***18***	***1***
SW	501 - 1,500	MUN	*West*	***15***	***5***
SW	501 - 1,500	MUN	*Labrador*	***4***	***1***
SW	501 - 1,500	LSD	*East*	***1***	***1***
SW	1,501 - 15,000	MUN	*East*	***12***	***0***
SW	1,501 - 15,000	MUN	*Central*	***8***	***0***
SW	1,501 - 15,000	MUN	*West*	***7***	***3***
SW	1,501 - 15,000	MUN	*Labrador*	***2***	***0***
SW	> 15,000	MUN	*West*	***1***	***0***
			TOTALS	***337***	***152***

TABLE 2.1.2.1.4

BOIL WATER ADVISORY DATA TABLE - BY POPULATION AND GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Population	*Governance*	*Water Source*	*Region*	*Number of Communities*[1]	*Number of BWAs*
0 - 500	MUN	*GW*	*East*	***12***	***5***
0 - 500	MUN	*GW*	*West*	***1***	***1***
0 - 500	MUN	*GW*	*Labrador*	***1***	***0***
0 - 500	MUN	*GUDI*	*East*	***2***	***1***
0 - 500	MUN	*GUDI*	*Central*	***2***	***0***
0 - 500	MUN	*GUDI*	*Labrador*	***1***	***1***
0 - 500	MUN	*GW/SW*	*East*	***4***	***2***
0 - 500	MUN	*GW/SW*	*Central*	***2***	***0***
0 - 500	MUN	*SW*	*East*	***27***	***11***
0 - 500	MUN	*SW*	*Central*	***26***	***11***
0 - 500	MUN	*SW*	*West*	***37***	***19***
0 - 500	MUN	*SW*	*Labrador*	***10***	***2***
0 - 500	LSD	*GW*	*East*	***14***	***10***
0 - 500	LSD	*GW*	*Central*	***2***	***1***
0 - 500	LSD	*GW*	*West*	***11***	***6***
0 - 500	LSD	*GUDI*	*East*	***6***	***6***
0 - 500	LSD	*GUDI*	*Central*	***1***	***0***
0 - 500	LSD	*GUDI*	*West*	***3***	***3***
0 - 500	LSD	*GW/SW*	*East*	***4***	***3***
0 - 500	LSD	*GW/SW*	*Central*	***1***	***1***
0 - 500	LSD	*GW/SW*	*West*	***2***	***1***
0 - 500	LSD	*SW*	*East*	***15***	***12***
0 - 500	LSD	*SW*	*Central*	***20***	***10***
0 - 500	LSD	*SW*	*West*	***26***	***23***
0 - 500	LSD	*SW*	*Labrador*	***2***	***1***
501 - 1,500	MUN	*GW*	*East*	***1***	***1***
501 - 1,500	MUN	*GW*	*Central*	***2***	***0***
501 - 1,500	MUN	*GW*	*West*	***1***	***0***
501 - 1,500	MUN	*GW/SW*	*East*	***1***	***1***
501 - 1,500	MUN	*GW/SW*	*West*	***4***	***1***
501 - 1,500	MUN	*SW*	*East*	***17***	***4***
501 - 1,500	MUN	*SW*	*Central*	***18***	***1***
501 - 1,500	MUN	*SW*	*West*	***15***	***5***
501 - 1,500	MUN	*SW*	*Labrador*	***4***	***1***
501 - 1,500	LSD	*GW*	*West*	***1***	***1***
501 - 1,500	LSD	*GW/SW*	*East*	***1***	***1***
501 - 1,500	LSD	*SW*	*East*	***1***	***1***
1,501 - 15,000	MUN	*GW*	*East*	***2***	***1***
1,501 - 15,000	MUN	*GW*	*West*	***3***	***1***
1,501 - 15,000	MUN	*GW*	*Labrador*	***1***	***0***
1,501 - 15,000	MUN	*GW/SW*	*East*	***1***	***0***
1,501 - 15,000	MUN	*GW/SW*	*Central*	***1***	***0***
1,501 - 15,000	MUN	*SW*	*East*	***12***	***0***
1,501 - 15,000	MUN	*SW*	*Central*	***8***	***0***
1,501 - 15,000	MUN	*SW*	*West*	***7***	***3***
1,501 - 15,000	MUN	*SW*	*Labrador*	***2***	***0***
> 15,000	MUN	*GW/SW*	*East*	***1***	***0***
> 15,000	MUN	*SW*	*West*	***1***	***0***
			TOTALS	***337***	***152***

TABLE 2.1.2.1.5

BOIL WATER ADVISORY DATA TABLE - BY POPULATION AND WATER SOURCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Population	*Water Source*	*Governance*	*Region*	*Number of Communities* [1]	*Number of BWAs*
0 - 500	*GW*	MUN	*East*	***12***	***5***
0 - 500	*GW*	MUN	*West*	***1***	***1***
0 - 500	*GW*	MUN	*Labrador*	***1***	***0***
0 - 500	*GW*	LSD	*East*	***14***	***10***
0 - 500	*GW*	LSD	*Central*	***2***	***1***
0 - 500	*GW*	LSD	*West*	***11***	***6***
0 - 500	*GUDI*	MUN	*East*	***2***	***1***
0 - 500	*GUDI*	MUN	*Central*	***2***	***0***
0 - 500	*GUDI*	MUN	*Labrador*	***1***	***1***
0 - 500	*GUDI*	LSD	*East*	***6***	***6***
0 - 500	*GUDI*	LSD	*Central*	***1***	***0***
0 - 500	*GUDI*	LSD	*West*	***3***	***3***
0 - 500	*GW/SW*	MUN	*East*	***4***	***2***
0 - 500	*GW/SW*	MUN	*Central*	***2***	***0***
0 - 500	*GW/SW*	LSD	*East*	***4***	***3***
0 - 500	*GW/SW*	LSD	*Central*	***1***	***1***
0 - 500	*GW/SW*	LSD	*West*	***2***	***1***
0 - 500	*SW*	MUN	*East*	***27***	***11***
0 - 500	*SW*	MUN	*Central*	***26***	***11***
0 - 500	*SW*	MUN	*West*	***37***	***19***
0 - 500	*SW*	MUN	*Labrador*	***10***	***2***
0 - 500	*SW*	LSD	*East*	***15***	***12***
0 - 500	*SW*	LSD	*Central*	***20***	***10***
0 - 500	*SW*	LSD	*West*	***26***	***23***
0 - 500	*SW*	LSD	*Labrador*	***2***	***1***
501 - 1,500	*GW*	MUN	*East*	***1***	***1***
501 - 1,500	*GW*	MUN	*Central*	***2***	***0***
501 - 1,500	*GW*	MUN	*West*	***1***	***0***
501 - 1,500	*GW*	LSD	*West*	***1***	***1***
501 - 1,500	*GW/SW*	MUN	*East*	***1***	***1***
501 - 1,500	*GW/SW*	MUN	*West*	***4***	***1***
501 - 1,500	*GW/SW*	LSD	*East*	***1***	***1***
501 - 1,500	*SW*	MUN	*East*	***17***	***4***
501 - 1,500	*SW*	MUN	*Central*	***18***	***1***
501 - 1,500	*SW*	MUN	*West*	***15***	***5***
501 - 1,500	*SW*	MUN	*Labrador*	***4***	***1***
501 - 1,500	*SW*	LSD	*East*	***1***	***1***
1,501 - 15,000	*GW*	MUN	*East*	***2***	***1***
1,501 - 15,000	*GW*	MUN	*West*	***3***	***1***
1,501 - 15,000	*GW*	MUN	*Labrador*	***1***	***0***
1,501 - 15,000	*GW/SW*	MUN	*East*	***1***	***0***
1,501 - 15,000	*GW/SW*	MUN	*Central*	***1***	***0***
1,501 - 15,000	*SW*	MUN	*East*	***12***	***0***
1,501 - 15,000	*SW*	MUN	*Central*	***8***	***0***
1,501 - 15,000	*SW*	MUN	*West*	***7***	***3***
1,501 - 15,000	*SW*	MUN	*Labrador*	***2***	***0***
> 15,000	*GW/SW*	MUN	*East*	***1***	***0***
> 15,000	*SW*	MUN	*West*	***1***	***0***
			TOTALS	***337***	***152***

TABLE 2.1.2.2

SUMMARY OF BOIL WATER ADVISORIES BY POPULATION AND WATER SOURCE
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Population	*Water Source*	*Total Systems* [1]	*BWA*	*pct*	*Survey* [2]	*BWA*	*pct*	*Site Visits* [3]	*BWA*	*pct*
0 - 500	*GW*	*41*	*23*	*56%*	*14*	*11*	*79%*	*5*	*4*	*80%*
	GUDI or GW/SW	*28*	*18*	*64%*	*5*	*3*	*60%*	*3*	*2*	*67%*
	SW	***163***	***89***	*55%*	*35*	*18*	*51%*	*7*	*5*	*71%*
		232	***130***	***56%***	***54***	***32***	***59%***	***15***	***11***	***73%***
	pct of provincial total	***69%***	***86%***	***--***	***56%***	***58%***	***--***	***60%***	***69%***	***--***
501 - 1,500	*GW*	*5*	*2*	*40%*	5	*1*	*20%*	1	*0*	*0%*
	GW/SW	*6*	*3*	*50%*	3	*2*	*67%*	0	*0*	*--*
	SW	*55*	*12*	*22%*	17	*12*	*71%*	6	*5*	*83%*
		66	***17***	***26%***	***25***	***15***	***60%***	***7***	***5***	***71%***
	pct of provincial total	***20%***	***11%***	***--***	***26%***	***27%***	***--***	***28%***	***31%***	***--***
1,501 - 15,000	*GW*	*6*	*2*	*33%*	2	*1*	*50%*	0	*0*	*--*
	GW/SW	*2*	*0*	*0%*	0	*0*	*--*	0	*0*	*--*
	SW	*29*	*3*	*10%*	14	*6*	*43%*	3	*0*	*--*
		37	***5***	***14%***	***16***	***7***	***44%***	***3***	***0***	***--***
	pct of provincial total	***11%***	***3%***	***--***	***16%***	***13%***	***--***	***12%***	***0%***	***--***
> 15,000	*GW/SW*	***2***	***0***	***0%***	**2**	***1***	***50%***	**0**	***0***	***--***
	pct of provincial total	***1%***	***0%***	***--***	***2%***	***2%***	***--***	***0%***	***0%***	***--***
	PROVINCIAL TOTAL	***337***	***152***	***46%***	***97***	***55***	***57%***	***25***	***16***	***64%***

Notes:

1. Based on the 337 communities with public water supply systems (one or more supplies)
2. Based on the 97 survey responses, including the communities visited
3. Based on the 25 communities visited

TABLE 2.1.2.3

REASONS CONTRIBUTING TO BOIL WATER ADVISORIES
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

						*Boil Water Advisory Codes**																		
Region	*Governance*	*Population*	*# of Systems*	*Systems with BWAs*	*Reasons Listed*	*No disinfection*	*Disinfection off-line by choice*			*Disinfection off-line for maintenance*		*Potential for inadequately treated water to enter distribution system*			*Insufficient CT or free chlorine residual in distribution system*			*Distribution of samples positive for microbiological parameters*						
						A	*B1*	*B2*	*B3*	*C1*	*C2*	*D1*	*D2*	*D3*	*E1*	*E2*	*E3*	*F1*	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*
Labrador	LSD	<500	2	1	1		1																	
	MUN	<500	12	3	3	1				1						1								
		501 - 1,500	4	1	1									1										
		1,501 - 15,000	3	0	0																			
West	LSD	<500	42	33	**37**	6	2		3	2					2	13		**1**	**4**	2	1	**1**		
		501 - 1,500	1	1	1					1														
	MUN	<500	38	20	20	2				3		2			5	7			1					
		501 - 1,500	20	6	6	1				2		1				2								
		1,501 - 15,000	10	4	4							3			1									
		>15,000	1	0	0																			
Central	LSD	<500	24	12	12	3		1		3					1	1			1	2				
	MUN	<500	30	11	**12**	2				3					3			**1**	1	2				
		501 - 1,500	20	1	1									1										
		1,501 - 15,000	9	0	0																			
East	LSD	<500	39	31	**34**	5	2	1	2	5				3	9	3	**2**			**2**				
		501 - 1,500	2	2	2					1					1									
	MUN	<500	45	19	**22**	5	1			2		1			7	2				**4**				
		501 - 1,500	19	6	**7**	1				2		1			1	1				**1**				
		1,501 - 15,000	15	1	**2**								1		**1**									
		>15,000	1	0	0																			
Total			337	152	165	26	6	2	5	25	0	8	1	5	31	30	2	2	7	13	1	1	0	0
			337	**152**	**165**	**26**	**13**			**25**		**14**			**63**			**24**						

Sub-Total	**LSD**	**< 500**	107	77	84	14	5	2	5	10	0	0	0	3	12	17	2	1	5	6	1	1	0	0
			107	**77**	**84**	**14**	**12**			**10**		**3**			**31**			**14**						
Sub-Total	**Municipal**	**< 500**	125	53	57	10	1	0	0	9	0	3	0	0	15	10	0	1	2	6	0	0	0	0
			125	**53**	**57**	**10**	**1**			**9**		**3**			**25**			**9**						

*- one water system received a BWA due to multiple contributing factors, so that community is counted in the total for both BWA Categories E and F

TABLE 2.1.3.1.1

COMPARISON OF BWA CONTRIBUTING FACTORS
DETAILED SURVEY DATA SET
(ENVC DATA - FEBRUARY 2009)
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

Region	Government Structure	Population	# of Communities Visited	# of BWA's	*Boil Water Advisory Codes**					
					A *No disinfection*	**B** *Disinfection off-line by choice*	**C** *Disinfection off-line for maintenance*	**D** *Potential for inadequately treated water to enter distribution system*	**E** *Insufficient CT or free chlorine residual in distribution system*	**F** *Distribution samples positive for microbiological parameters*
Labrador	Municipal	<500	1	1	1					
		501 - 1,500	1	1				1		
West	LSD	<500	2	2			2			
		501 - 1,500	0	-						
	Municipal	<500	4	2			1		1	2
		501 - 1,500	1	0						
		1,501 - 15,000	1	1				1		
Central	LSD	<500	2	1						1
	Municipal	<500	2	0						
		501 - 1,500	1	1				1		
		1,501 - 15,000	1	0						
East	LSD	<500	4	3				1	2	
		501 - 1,500	0	-						
	Municipal	<500	1	0						
		501 - 1,500	2	0						
		1,501 - 15,000	2	0						
Total			25	12	1	0	3	4	3	3

**- a BWA can be issued for more than one reason, so the total number of BWA's may not equal the total number of reasons for BWA's*

TABLE 2.1.3.1.2

COMPARISON OF BWA CONTRIBUTING FACTORS
SURVEY DATA SET
(ENVC DATA FEBRUARY 2009)
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

					Boil Water Advisory Codes*																	
					No disinfection	Disinfection off-line by choice			Disinfection off-line for maintenance		Potential for inadequately treated water to enter distribution system			Insufficient CT or free chlorine residual in distribution system			Distribution of samples positive for microbiological parameters					
Region	**Governance**	**Population**	**# of Systems in Survey**	**# of BWA's**	**A**	**B1**	**B2**	**B3**	**C1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Labrador	LSD	<500	1	1		1																
	Municipal	<500	3	1	1																	
		501 - 1,500	1	1									1									
		1,501 - 15,000	1	0																		
West	LSD	<500	9	6	2				2					1	1							
		501 - 1,500	1	1					1													
	Municipal	<500	9	4					2					1	1		1			1		
		501 - 1,500	5	1	1																	
		1,501 - 15,000	4	1							1											
		>15,000	1	0																		
Central	LSD	<500	6	2	1												1					
	Municipal	<500	10	2										1				1				
		501 - 1,500	5	1									1									
		1,501 - 15,000	3	0																		
East	LSD	<500	13	9				2					2	5								
	Municipal	<500	5	3	1	1								1								
		501 - 1,500	9	1					1													
		1,501 - 15,000	7	0																		
Total			93	34	6	2	0	2	6	0	1	0	4	9	2	0	2	1	0	1	0	0

*- one water system received a BWA due to multiple contributing factors, so that community is counted in the total for both BWA Categories E and F

TABLE 2.1.3.2.1

SUMMARY OF WATER TREATMENT INFRASTRUCTURE FOR SURVEY DATA SET BY REGION STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

	# of Water Systems With Treatment				
Treatment Processes	*Labrador*	*West*	*Central*	*East*	*Total*
pH Adjustment	2	1	4	7	14
Taste & Odour	0	0	1	1	2
Coagulation / Flocculation	1	1	1	1	4
Softening	1	1	1	2	5
Clarification	0	0	0	1	1
Sedimentation	1	1	4	3	9
Filtration	2	6	8	4	20
Fluoridation	1	0	1	1	3
UV	0	2	0	0	2
Arsenic Removal	0	0	0	1	1
PWDU	0	1	0	1	2
Chlorination	6	26	23	33	88
No Disinfection	0	3	1	1	5
Total # of Communities	**6**	**29**	**24**	**34**	**93**

TABLE 2.1.3.2.2

SUMMARY OF WATER TREATMENT INFRASTRUCTURE FOR SURVEY DATA SET BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

	# of Water Systems With Treatment		
Treatment Processes	*LSD*	*Municipality*	*Total*
pH Adjustment	0	14	14
Taste & Odour	0	2	2
Coagulation / Flocculation	0	4	4
Softening	0	5	5
Clarification	0	1	1
Sedimentation	2	7	9
Filtration	2	18	20
Fluoridation	1	1	3
UV	1	1	2
Arsenic Removal	0	1	1
PWDU	0	2	2
Chlorination	28	59	88
No Disinfection	2	3	5
Total # of Communities	30	63	93

TABLE 2.1.3.2.3

SUMMARY OF WATER TREATMENT INFRASTRUCTURE FOR SURVEY DATA SET BY POPULATION
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

	# of Water Systems With Treatment			
Treatment Processes	*<500*	*500 - 1,500*	*>1,500*	*Total*
pH Adjustment	1	5	8	14
Taste & Odour	0	0	2	2
Coagulation / Flocculation	1	0	3	4
Softening	1	3	1	5
Clarification	0	1	0	1
Sedimentation	4	3	2	9
Filtration	7	8	5	20
Fluoridation	1	0	2	3
UV	0	1	1	2
Arsenic Removal	0	1	0	1
PWDU	1	1	0	2
Chlorination	52	20	16	88
No Disinfection	4	1	0	5
Total # of Communities	56	21	16	93

TABLE 2.1.3.2.4

**COMPARISON OF OPERATOR QUALIFICATIONS FOR SURVEY DATA SET BY GOVERNANCE
OETC DATA
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR**

Governance	*# of Communities in Survey*	*# of Communities That Currently Have Certified Operators*	*% of Communities That Currently Have Certified Operators*	*# of Certified Operators Per Community*
LSD	30	4	13.3%	1.0
Municipality	63	38	60.3%	2.3
Survey Data Set	93	42	45.2%	2.2

TABLE 2.1.4.1

SUMMARY OF WATER QUALITY PARAMETERS - ALL COMMUNITIES (ENVC DATA) STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

		*Communities with BWA **		*Communities w/o BWA **		*Total Communities*	
		126		*187*		*313*	
PARAMETER	***Allowable***	*Exceedences*	*Percent*	*Exceedences*	*Percent*	*Exceedences*	*Percent*
THM	> 100 ug/L	**37**	29.4%	**123**	65.8%	**160**	51.1%
BDCM	> 16 ug/L	**9**	7.1%	**32**	17.1%	**41**	13.1%
HAA	> 60 ug/L	**33**	26.2%	**136**	72.7%	**169**	54.0%
Turbidity	> 1.0 NTU	**60**	47.62%	**89**	47.59%	**149**	47.60%
Arsenic	>0.01 mg/L	**1**	0.8%	**7**	3.7%	**8**	2.6%
Lead	> 0.01 mg/L	**4**	3.2%	**9**	4.8%	**13**	4.2%
Fluoride	> 1.5 mg/L	**0**	0.0%	**1**	0.5%	**1**	0.3%
Barium	> 1.0 mg/L	**0**	0.0%	**0**	0.0%	**0**	0.0%
Colour	> 15 TCU	**94**	74.6%	**139**	74.3%	**233**	74.4%
Low pH **	< 6.5	**77**	61.1%	**150**	80.2%	**227**	72.5%
High pH	> 8.5	**6**	4.8%	**5**	2.7%	**11**	3.5%
Iron	> 0.3 mg/L	**42**	33.3%	**51**	27.3%	**93**	29.7%
Manganese	> 0.05 mg/L	**26**	20.6%	**50**	26.7%	**76**	24.3%
Copper	> 1.0 mg/L	**5**	4.0%	**13**	7.0%	**18**	5.8%
Chloride	> 250 mg/L	**1**	0.8%	**3**	1.6%	**4**	1.3%
TDS	> 500 mg/L	**2**	1.6%	**5**	2.7%	**7**	2.2%

Water Quality data from "SUSTAINABLE OPTIONS FOR DRINKING WATER QUALITY REPORT" - March 2008

** Some communities have multiple sources - wells, lakes, rivers, or combinations thereof*

*** Low pH is considered to be influenced by Acid Rain*

TABLE 2.1.4.2

SUMMARY OF WATER QUALITY PARAMETERS - SURVEYED AND VISITED COMMUNITIES STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

PARAMETER	*Allowable*	*Surveyed & Visited Communities with BWA **		*Surveyed and Visited Communities w/o BWA **		*Surveyed and Visited Communities - TOTAL*	
		27		*58*		*85*	
		Exceedences	*Percent*	*Exceedences*	*Percent*	*Exceedences*	*Percent*
THM	> 100 ug/L	**10**	37.0%	**39**	67.2%	**49**	57.6%
BDCM	> 16 ug/L	**2**	7.4%	**11**	19.0%	**13**	15.3%
HAA	> 60 ug/L	**8**	29.6%	**43**	74.1%	**51**	60.0%
Turbidity	> 1.0 NTU	**14**	51.9%	**25**	43.1%	**39**	45.9%
Arsenic	>0.01 mg/L	**1**	3.7%	**3**	5.2%	**4**	4.7%
Lead	> 0.01 mg/L	**0**	0.0%	**2**	3.4%	**2**	2.4%
Fluoride	> 1.5 mg/L	**0**	0.0%	**0**	0.0%	**0**	0.0%
Barium	> 1.0 mg/L	**0**	0.0%	**0**	0.0%	**0**	0.0%
Colour	> 15 TCU	**19**	70.4%	**43**	74.1%	**62**	72.9%
Low pH **	< 6.5	**14**	51.9%	**48**	82.8%	**62**	72.9%
High pH	> 8.5	**3**	11.1%	**1**	1.7%	**4**	4.7%
Iron	> 0.3 mg/L	**8**	29.6%	**13**	22.4%	**21**	24.7%
Manganese	> 0.05 mg/L	**5**	18.5%	**15**	25.9%	**20**	23.5%
Copper	> 1.0 mg/L	**1**	3.7%	**5**	8.6%	**6**	7.1%
Chloride	> 250 mg/L	**0**	0.0%	**0**	0.0%	**0**	0.0%
TDS	> 500 mg/L	**1**	3.7%	**0**	0.0%	**1**	1.2%

Water Quality data from "SUSTAINABLE OPTIONS FOR DRINKING WATER QUALITY REPORT" - March 2008

** Some communities have multiple sources - wells, lakes, rivers, or combinations thereof*

*** Low pH is considered to be influenced by Acid Rain*

TABLE 2.1.4.3

SUMMARY OF WATER QUALITY PARAMETERS - WATER SOURCES
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

PARAMETER	*Allowable*	*Sources with BWA **		*Sources w/o BWA **		*All Sources **	
		202		*245*		*437*	
		Exceedences	*Percent*	*Exceedences*	*Percent*	*Exceedences*	*Percent*
THM	> 100 ug/L	**37**	18.3%	**149**	60.8%	**186**	42.6%
BDCM	> 16 ug/L	**10**	5.0%	**36**	14.7%	**46**	10.5%
HAA	> 60 ug/L	**31**	15.3%	**167**	68.2%	**198**	45.3%
Turbidity	> 1.0 NTU	**78**	38.6%	**116**	47.3%	**194**	44.4%
Arsenic	>0.01 mg/L	**8**	4.0%	**9**	3.7%	**17**	3.9%
Lead	> 0.01 mg/L	**5**	2.5%	**9**	3.7%	**14**	3.2%
Fluoride	> 1.5 mg/L	**0**	0.0%	**1**	0.4%	**1**	0.2%
Barium	> 1.0 mg/L	**0**	0.0%	**1**	0.4%	**1**	0.2%
Colour	> 15 TCU	**103**	51.0%	**168**	68.6%	**271**	62.0%
Low pH **	< 6.5	**79**	39.1%	**184**	75.1%	**263**	60.2%
High pH	> 8.5	**10**	5.0%	**7**	2.9%	**17**	3.9%
Iron	> 0.3 mg/L	**49**	24.3%	**58**	23.7%	**107**	24.5%
Manganese	> 0.05 mg/L	**45**	22.3%	**61**	24.9%	**106**	24.3%
Copper	> 1.0 mg/L	**4**	2.0%	**14**	5.7%	**18**	4.1%
Chloride	> 250 mg/L	**1**	0.5%	**3**	1.2%	**4**	0.9%
TDS	> 500 mg/L	**2**	1.0%	**8**	3.3%	**10**	2.3%

Water Quality data from "SUSTAINABLE OPTIONS FOR DRINKING WATER QUALITY REPORT" - March 2008
** Some communities have multiple sources - wells, lakes, rivers, or combinations thereof*
*** Low pH is considered to be influenced by Acid Rain*

TABLE 2.2.1.1

COMPARISON OF 2007 pH MONITORING DATA
SURFACE WATER SUPPLIES WITH SERVICE POPULATION >500
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

			2007 pH Results			
pH Adjustment?	*Community*	*Service Population*	*# of Samples*	*# of Exceedances*	*Minimum*	*Maximum*
Y	Community A	552	4	3	5.6	6.51
	Community B	976	6	0	6.52	7.19
	Community C	1669	7	3	4.02	7.17
	Total		17	6		
N	Community D	529	6	5	5.86	6.93
	Community E	747	4	0	7.1	7.81
	Community F	1003	6	6	4.2	6.36
	Total		16	11		

TABLE 2.2.1.2

COMPARISON OF 2007 TREATED WATER QUALITY MONITORING DATA
SURFACE WATER SUPPLIES WITH SERVICE POPULATION >1,500
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

			Colour (GCDWQ = 15 TCU)				*Turbidity (GCDWQ = 1 NTU)*				*THM's (GCDWQ = 100 μg/L)*		*HAA's (GCDWQ = 80 μg/L)*	
Community	*Service Population*	*Filtration Process*	*# of Samples*	*# of Exceedances*	*Minimum*	*Maximum*	*# of Samples*	*# of Exceedances*	*Minimum*	*Maximum*	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Community W	3133	Ultrafiltration	2	2	17	19	2	0	0.4	0.5	96.5	194	124	165
Community X	13340	Screening, c/f/s/f	12	0	0	3	12	2	0.2	2.4	36.5	114	46	74
		Total	14	2			14	2						
Community Y	1669	-	7	3	7	42	7	1	0.4	1.3	45.5	482	-	-
Community Z	5436	-	6	6	17	37	6	0	0.4	1	68.3	205	100	240
		Total	13	9			13	1						

TABLE 2.2.2

**COMPARISON OF OPERATION AND MAINTENANCE PRACTICES
FOR SURVEY DATA SET BASED ON BWA CODES
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR**

	BWA Code	*A*	*B*	*C*	*D*	*E*	*F*		
Contributing Factor	*Survey Input*	*No disinfection*	*Disinfection off-line by choice*	*Disinfection off-line for maintenance*	*Potential for inadequately treated water to enter distribution system*	*Insufficient CT or free chlorine residual in distribution system*	*Distribution of samples positive for microbiological parameters*	*All BWA's*	*No BWA*
Frequency of Cl Testing (samples/day)	No input	6	4	3	1	5	1	20	15
	< 1 /day	0	0	2	1	4	1	8	18
	1 - 5/day	0	0	1	2	2	1	6	21
	6 - 10/day	0	0	0	0	0	0	0	3
	>10/day	0	0	0	1	0	0	1	2
Typical Operator Effort (h/week)	No input	5	3	1	0	5	0	14	24
	<20	1	1	3	3	5	1	14	11
	20 - 40	0	0	1	1	1	2	5	15
	>40	0	0	1	1	0	0	2	9
Typical Maintenance Effort (h/week)	No input	5	3	1	1	6	0	16	21
	<10	1	1	4	1	2	1	10	20
	10 - 20	0	0	1	1	2	1	5	10
	20 - 40	0	0	0	2	1	1	4	7
	>40	0	0	0	0	0	0	0	1
Operating & Maintenance Manuals	No input	4	1	1	0	3	0	9	17
	No	2	3	2	2	1	1	11	5
	Yes	0	0	3	3	7	2	15	37
Availability of Spare Parts	No input	5	1	1	0	4	0	11	17
	No	1	3	3	2	3	3	15	4
	Yes	0	0	2	3	4	0	9	38
Emergency Repair Parts Available	No input	2	1	1	0	2	0	6	16
	No	2	3	3	3	6	2	19	8
	Yes	2	0	2	2	3	1	10	35
	# of Survey Communities	**6**	**4**	**6**	**5**	**11**	**3**	**35**	**59**

TABLE 2.2.3.1

**COMPARISON OF OPERATOR STATUS
FOR SURVEY DATA SET BASED ON BWA CODES
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR**

		A	B	C	D	E	F		
		No disinfection	*Disinfection off-line by choice*	*Disinfection off-line for maintenance*	*Potential for inadequately treated water to enter distribution system*	*Insufficient CT or free chlorine residual in distribution system*	*Distribution samples positive for microbiological parameters*	*All BWA's*	*No BWA*
Operator Status	No input	5	3	2	2	9	0	21	29
	Part-time	1	1	2	1	2	1	8	6
	Part-time / Full-time	0	0	0	0	0	0	0	1
	Full-time	0	0	2	2	0	2	6	22
	Seasonal	0	0	0	0	0	0	0	1
Operator Certification	No	5	4	4	3	9	3	28	22
	Yes	1	0	2	2	2	0	7	37
Back-up Operator	No input	5	3	2	0	5	0	15	20
	No	0	0	3	1	4	2	10	16
	Yes	1	1	1	4	2	1	10	23
	# of Survey Communities	**6**	**4**	**6**	**5**	**11**	**3**	**34**	**59**

TABLE 2.2.3.2

OPERATOR TRAINING FOR SYSTEMS WITH BWAs
BASED ON OETC TRAINING RECORDS, FEBRUARY 2006 - FEBRUARY 2009
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

BWA Category	*Contributing Factor*	*# of Survey Communities**	*# of Communities With Trained Operators*	*% of Survey Communities With Trained Operators*	*# of Operators Receiving On-site Training Per Community*	*Annual Average Hours On-site Training per Operator (h/yr)*
A	No disinfection	6	1	16.7%	4.0	1.0
B	Disinfection off-line by choice	4	1	25.0%	3.0	0.6
C	Disinfection off-line for maintenance	6	4	66.7%	1.8	1.7
D	Potential for inadequately treated water to enter distribution system	5	2	40.0%	2.0	1.2
E	Insufficient CT or free chlorine residual in distribution system	11	3	27.3%	1.7	0.9
F	Distribution of samples positive for microbiological parameters	3	3	100.0%	2.7	1.1
-	All BWA's	35	14	40.0%	2.1	1.2
-	No BWA	59	38	64.4%	3.4	1.4

**- one water system received a BWA due to multiple contributing factors, so that community is counted in the total for both BWA Categories E and F*

TABLE 3.2.1.6

SUMMARY OF EXISTING
WATER TREATMENT AND DISTRIBUTION INFRASTRUCTURE
DETAILED SURVEY DATA SET
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NL

Disinfection	*pH Adjustment*	*Filtration*	*Waste Handling*	*Storage*	*Distribution Flushing*	*# of Communities*
Chlorination (20)	Yes (4)	none (3)	-	none	Yes	3
		Conventional treatment (1)	Yes	Yes	Yes	1
	none (16)	none (15)	-	none (11)	none	5
					Yes	6
				Yes (4)	Yes	4
		Membrane filtration (1)	Yes	none	Yes	1
Category A or C Boil Water Advisory (4)	none (3)	none (3)	-	Yes (1)	Yes	1
			-	none (2)	none	2
	Yes (1)	none	-	none	Yes	1
PWDU (1)	none (1)	-	-	Yes	Yes	1

TABLE 3.2.2.3

**OPERATION AND MAINTENANCE OF EXISTING WATER SYSTEMS
USING BEST MANAGEMENT PRACTICES
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR**

Community	*Population*	*Water Source*	*System Components*	*Operation and Maintenance*				*O&M Total (Annual)*
				Effort (hrs)	*Effort ($)*	*Consumables*	*Sub Contracts*	
A	136	GW		2244	$ 33,660	$ -	$ 20,000	**$ 53,660**
B	138	GW		2262	$ 33,930	$ 950	$ 26,000	**$ 60,880**
C	183	GW		2262	$ 33,930	$ 1,260	$ 26,000	**$ 61,190**
D	248	GW		2108	$ 31,620	$ -	$ 20,000	**$ 51,620**
E	110	GUDI		2262	$ 33,930	$ 757	$ 26,000	**$ 60,687**
F	140	GUDI		2074	$ 31,110	$ -	$ 20,000	**$ 51,110**
G	164	GUDI		2262	$ 33,930	$ 1,129	$ 26,000	**$ 61,059**
H	125	GW/SW		2244	$ 33,660	$ -	$ 20,000	**$ 53,660**
I	133	SW		2262	$ 33,930	$ 916	$ 26,000	**$ 60,846**
J	188	SW		2318	$ 34,770	$ 3,439	$ 26,000	**$ 64,209**
K	203	SW		2318	$ 34,770	$ 1,420	$ 26,000	**$ 62,190**
L	241	SW	PWDU rest of system	250 2032	$ 3,750 $ 30,480	 $ 1,659	$ 5,000 $ 20,000	**$ 60,889**
M	309	SW		2318	$ 34,770	$ 2,655	$ 26,000	**$ 63,425**
N	315	SW		2278	$ 34,170	$ 2,169	$ 26,000	**$ 62,339**
O	376	SW		2278	$ 34,170	$ 3,038	$ 26,000	**$ 63,208**
P	499	GUDI		2278	$ 34,170	$ 3,436	$ 26,000	**$ 63,606**
Q	529	SW		2278	$ 34,170	$ 8,109	$ 26,000	**$ 68,279**
R	552	SW		2284	$ 34,260	$ 18,589	$ 28,000	**$ 80,849**
S	747	SW		2318	$ 34,770	$ 6,417	$ 26,000	**$ 67,187**
T	976	SW		2284	$ 34,260	$ 15,588	$ 28,000	**$ 77,848**
U	1003	SW		2278	$ 34,170	$ 20,790	$ 26,000	**$ 80,960**
V	1669	SW		2284	$ 34,260	$ 18,714	$ 28,000	**$ 80,974**
W	3133	SW		2442	$ 36,630	$ 26,915	$ 30,000	**$ 93,545**
X	5436	SW		2278	$ 34,170	$ 46,699	$ 26,000	**$ 106,869**
Y	13340	SW		2494	$ 37,410	$ 132,081	$ 32,000	**$ 201,491**

TABLE 3.2.3

REPLACEMENT COSTS FOR EXISTING INFRASTRUCTURE
DETAILED SURVEY DATA SET
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NL

Community Name	*Region (Env)*	*Governance*	*Population Serviced*	*Water Source*	*Infrastructure Replacement Costs - 2009 CND*					
					Treatment incl. PWDUs	*Water Treatment Plant*	*Water Quality Monitoring Equipment*	*Storage Facilities*	*Distribution System Hydrants*	*Total Cost*
U	E	MUN	1003	SW	$60,806	$100,533	$29,164		$148,715	$339,217
K	C	MUN	203	SW	$22,626	$37,409	$22,993	$367,332	$33,799	$484,159
O	W	MUN	376	SW	$29,205	$48,286	$22,993		$54,078	$154,563
B	E	LSD	138	GW	$20,033	$33,121				$53,154
R	L	MUN	552	SW	$108,459	$179,319	$22,993		$81,117	$391,888
G	E	LSD	164	GUDI	$21,078	$34,849	$45,986			$101,913
P	C	MUN	499	GUDI	$29,252	$48,363	$29,164		$74,357	$181,136
Q	E	MUN	529	SW	$44,172	$73,031	$29,164		$81,117	$227,484
N	C	LSD	315	SW	$25,545	$42,235			$47,318	$115,099
Y	C	MUN	13340	SW	$5,832,783	$9,643,535	$750,667	$539,456	$2,000,890	$18,767,331
L	W	MUN	241	SW	$60,508	$98,552	$22,993	$266,287	$33,799	$482,139
I	E	LSD	133	SW	$19,817	$32,763				$52,580
X	E	MUN	5436	SW	$82,064	$135,679	$22,993		$817,931	$1,058,667
A	W	LSD	136	GW	$19,947	$32,979				$52,926
E	C	LSD	110	GUDI	$18,739	$30,981	$6,170			$55,891
J	E	MUN	188	SW	$21,943	$36,279	$22,993	$246,684	$27,039	$354,938
C	E	LSD	183	GW	$21,769	$35,992				$57,762
W	W	MUN	3133	SW	$2,808,213	$4,642,912	$39,717		$473,183	$7,964,025
S	W	MUN	747	SW	$34,995	$57,858	$22,993	$558,326	$114,916	$789,088
V	E	MUN	1669	SW	$138,552	$229,072	$29,164		$250,111	$646,898
D	W	MUN	248	GW	$23,808	$39,363	$22,993	$268,655	$40,559	$395,378
H	W	LSD	125	GW/SW	$19,458	$32,170	$6,170			$57,798
M	W	MUN	309	SW	$25,401	$41,997	$22,993	$483,884	$47,318	$621,593
T	C	MUN	976	SW	$154,230	$254,994	$34,490		$148,715	$592,429
F	L	MUN	140	GUDI	$326,992	$540,626	$22,993		$20,279	$910,890

TABLE 3.3.1.8

**SUMMARY OF RECOMMENDED
WATER TREATMENT AND DISTRIBUTION INFRASTRUCTURE UPGRADES
DETAILED SURVEY DATA SET
STUDY ON O&M OF DRINKING WATER
INFRASTRUCTURE IN NL**

Disinfection	*pH Adjustment*	*Filtration*	*Waste Handling*	*Storage*	*Distribution Flushing*	*# of Communities*
Chlorination (25)	Yes (18)	Conventional treatment (1)	Yes	Yes	Yes	1
		Direct filtration (1)	Yes	Yes	Yes	1
		Media & cartridge filter (1)	Yes	Yes	Yes	1
		Membrane filtration (1)	Yes	Yes	Yes	1
		Slow sand filtration (1)	No	Yes	Yes	1
		PWDU (11)	No	Yes	Yes	11
		None (2)	-	Yes	Yes	2
	None (7)	Membrane filtration (1)	Yes	Yes	Yes	1
		PWDU (4)	No	Yes	Yes	4
		None (2)	-	Yes	Yes	2

TABLE 3.3.2.3

**OPERATION AND MAINTENANCE OF UPGRADED WATER SYSTEMS
USING BEST MANAGEMENT PRACTICES
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR**

Community	*Population*	*Water Source*	*System Components*	*Operation and Maintenance*				*O&M Total (Annual)*
				Effort (hrs)	*Effort ($)*	*Consumables*	*Sub Contracts*	
A	136	GW	complete	2324	$ 34,860	$ 3,248	$ 28,000	**$ 66,108**
B	138	GW	complete	2318	$ 34,770	$ 3,256	$ 26,000	**$ 64,026**
C	183	GW	complete	2324	$ 34,860	$ 3,854	$ 28,000	**$ 66,714**
D	248	GW	complete	2318	$ 34,770	$ 4,564	$ 26,000	**$ 65,334**
E	110	GUDI	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 2,867	$ 5,000 $ 21,000	**$ 63,532**
F	125	GW/SW	PWDU rest of system	250 2055	$ 3,750 $ 30,825	 $ 3,076	$ 5,000 $ 19,000	**$ 61,651**
G	133	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 3,333	$ 5,000 $ 21,000	**$ 63,998**
H	140	GUDI	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 3,284	$ 5,000 $ 21,000	**$ 63,949**
I	164	GUDI	complete	2449	$ 36,735	$ 3,618	$ 32,000	**$ 72,353**
J	188	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 3,924	$ 5,000 $ 21,000	**$ 64,589**
K	203	SW	PWDU rest of system	250 2055	$ 3,750 $ 30,825	 $ 4,131	$ 5,000 $ 19,000	**$ 62,706**
L	241	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 4,500	$ 5,000 $ 21,000	**$ 65,165**
M	309	SW	PWDU rest of system	250 2055	$ 3,750 $ 30,825	 $ 652	$ 5,000 $ 19,000	**$ 59,227**
N	315	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 5,258	$ 5,000 $ 21,000	**$ 65,923**
O	376	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 6,885	$ 5,000 $ 21,000	**$ 67,550**
P	499	GUDI	complete	2494	$ 37,410	$ 6,855	$ 32,000	**$ 76,265**
Q	529	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 15,392	$ 5,000 $ 21,000	**$ 76,057**
R	552	SW	PWDU rest of system	250 2061	$ 3,750 $ 30,915	 $ 13,462	$ 5,000 $ 21,000	**$ 74,127**
S	747	SW	PWDU rest of system	250 2055	$ 3,750 $ 30,825	 $ 1,220	$ 5,000 $ 19,000	**$ 59,795**
T	976	SW	PWDU rest of system	300 2061	$ 4,500 $ 30,915	 $ 2,989	$ 5,000 $ 21,000	**$ 64,404**
U	1003	SW	PWDU rest of system	300 2061	$ 4,500 $ 30,915	 $ 14,067	$ 5,000 $ 21,000	**$ 75,482**
V	1669	SW	complete	2489	$ 37,335	$ 25,359	$ 32,000	**$ 94,694**
W	3133	SW	complete	2483	$ 37,245	$ 27,209	$ 32,000	**$ 96,454**
X	5436	SW	complete	2494	$ 37,410	$ 61,608	$ 32,000	**$ 131,018**
Y	13340	SW	complete	2494	$ 37,410	$ 146,213	$ 32,000	**$ 215,623**

TABLE 3.3.3.1

CAPITAL COSTS FOR RECOMMENDED INFRASTRUCTURE UPGRADES AND EXISTING INFRASTRUCTURE TO REMAIN
DETAILED SURVEY DATA SET
STUDY ON O&M OF DRINKING WATER
INFRASTRUCTURE IN NL

Community	LGP #	Region (Env)	Governance	Population Serviced	Water Source	*Infrastructure Capital Costs - 2009 CND*						Replacement Cost of Remaining Infrastructure
						Treatment Infrastructure incl. PWDU	WTP Building	Monitoring Equipment	Distribution Infrastructure	Engineering and Construction	Total	
U	110	E	MUN	1003	SW	$131,274	$182,314	$225,814	$511,816	$209,004	$1,260,222	$339,217
K	610	C	MUN	203	SW	$39,056	$54,241	$79,217	$0	$12,693	$185,208	$484,159
O	740	W	MUN	376	SW	$75,044	$104,222	$103,056	$248,053	$105,007	$635,382	$154,563
B	845	E	LSD	138	GW	$0		$106,296	$184,735	$54,713	$345,743	$53,154
R	970	L	MUN	552	SW	$74,421	$103,355	$146,768	$346,477	$136,792	$807,814	$351,079
G	1365	E	LSD	164	GUDI	$224,095	$336,321	$83,396	$199,289	$130,498	$973,599	$101,913
P	1490	C	MUN	499	GUDI	$201,100		$103,227	$250,824	$146,875	$702,026	$181,136
Q	1580	E	MUN	529	SW	$99,724	$138,497	$159,763	$373,737	$153,875	$925,595	$227,484
N	1770	C	LSD	315	SW	$69,003	$95,832	$124,186	$217,031	$92,961	$599,013	$115,099
Y	1960	C	MUN	13340	SW	$0		$0	$986,973	$320,766	$1,307,740	$18,767,331
L	2370	W	MUN	241	SW	$25,254	$35,073	$82,724	$0	$8,208	$151,258	$482,139
I	3035	E	LSD	133	SW	$57,407	$79,726	$86,541	$182,858	$72,760	$479,291	$52,580
X	3155	E	MUN	5436	SW	$1,215,064	$1,687,481	$323,346	$697,764	$621,669	$4,545,324	$1,058,667
A	3170	W	LSD	136	GW	$35,333		$88,750	$183,990	$65,954	$374,026	$32,979
E	3055	C	LSD	110	GUDI	$55,214	$76,681	$82,782	$168,092	$69,024	$451,792	$55,891
J	3435	E	MUN	188	SW	$78,176	$108,571	$76,789	$0	$25,407	$288,944	$332,995
C	3585	E	LSD	183	GW	$22,774		$95,171	$205,341	$67,036	$390,322	$57,762
W	3685	W	MUN	3133	SW	$0		$222,362	$532,856	$173,178	$928,396	$7,964,025
S	3975	W	MUN	747	SW	$45,363	$63,000	$124,627	$0	$14,743	$247,733	$789,088
V	4015	E	MUN	1669	SW	$1,580,120	$2,194,470	$183,703	$426,738	$652,229	$5,037,259	$646,898
D	4095	W	MUN	248	GW	$17,856		$85,192	$0	$5,803	$108,851	$371,570
H	4655	W	LSD	125	GW/SW	$51,533	$71,569	$93,909	$179,754	$69,842	$466,607	$38,341
M	4475	W	MUN	309	SW	$40,988	$56,924	$89,175	$0	$13,321	$200,408	$621,593
T	4975	C	MUN	976	SW	$46,778	$64,966	$202,780	$461,602	$165,224	$941,350	$592,429
F	5310	L	MUN	140	GUDI	$52,512	$72,929	$70,353	$169,085	$72,019	$436,898	$890,772

TABLE 3.4.3.1

ANNUALIZATION OF REPLACEMENT, OPERATION, AND MAINTENANCE COSTS - CURRENT SYSTEMS
PER HOUSEHOLD AND PER CUBIC METRE TREATED
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

Community	*Population*	*Estimated # of Dwellings*	*Municipal Share of Infrastructure Funding*	*Water Source*	*Current Replacement Value of Existing*	*Future Replacement Value of Existing*	*Annualized Future Replacement Cost*	*Annual O&M (Table 3.2.1)*	*Annual O&M + Replacement Cost*	*Annual Cost per household*	*Price per m^3 treated*
A	136	45	0.1	GW	$ 52,926	$ 88,916	$ 80	**$ 53,660**	$ 53,740	$ 1,194	$7.27
B	138	46	0.1	GW	$ 53,154	$ 89,299	$ 80	**$ 60,880**	$ 60,960	$ 1,325	$8.07
C	183	61	0.1	GW	$ 57,762	$ 97,040	$ 87	**$ 61,190**	$ 61,277	$ 1,005	$6.12
D	248	82	0.1	GW	$ 395,378	$ 664,235	$ 597	**$ 51,620**	$ 52,217	$ 637	$3.88
E	110	36	0.1	GUDI	$ 55,891	$ 93,896	$ 84	**$ 60,687**	$ 60,772	$ 1,688	$10.28
F	140	46	0.1	GUDI	$ 910,890	$ 1,530,295	$ 1,375	**$ 51,110**	$ 52,485	$ 1,141	$6.95
G	164	54	0.1	GUDI	$ 101,913	$ 171,214	$ 154	**$ 61,059**	$ 61,213	$ 1,134	$6.90
H	125	41	0.1	GW/SW	$ 57,798	$ 97,101	$ 87	**$ 53,660**	$ 53,747	$ 1,311	$7.98
I	133	44	0.1	SW	$ 52,580	$ 88,334	$ 79	**$ 60,846**	$ 60,925	$ 1,385	$8.43
J	188	62	0.1	SW	$ 354,938	$ 596,296	$ 536	**$ 64,209**	$ 64,744	$ 1,044	$6.36
K	203	67	0.1	SW	$ 484,159	$ 813,387	$ 731	**$ 62,190**	$ 62,921	$ 939	$5.72
L	241	80	0.1	SW	$ 428,139	$ 719,274	$ 646	**$ 8,750**	$ 9,396	$ 117	$0.72
M	309	103	0.1	SW	$ 621,593	$ 1,044,277	$ 939	**$ 63,425**	$ 64,363	$ 625	$3.80
N	315	105	0.1	SW	$ 115,099	$ 193,366	$ 174	**$ 62,339**	$ 62,513	$ 595	$3.62
O	376	125	0.1	SW	$ 154,563	$ 259,666	$ 233	**$ 63,208**	$ 63,441	$ 508	$3.09
P	499	166	0.1	GUDI	$ 181,136	$ 304,309	$ 274	**$ 63,606**	$ 63,879	$ 385	$2.34
Q	529	176	0.1	SW	$ 227,484	$ 382,173	$ 344	**$ 68,279**	$ 68,623	$ 390	$2.37
R	552	184	0.1	SW	$ 391,888	$ 658,373	$ 592	**$ 80,849**	$ 81,440	$ 443	$2.69
S	747	249	0.1	SW	$ 789,088	$ 1,325,667	$ 1,192	**$ 67,187**	$ 68,379	$ 275	$1.67
T	976	325	0.1	SW	$ 592,429	$ 995,280	$ 895	**$ 77,848**	$ 78,743	$ 242	$1.48
U	1003	334	0.1	SW	$ 339,217	$ 569,885	$ 512	**$ 80,960**	$ 81,472	$ 244	$1.49
V	1669	556	0.1	SW	$ 646,898	$ 1,086,789	$ 977	**$ 80,974**	$ 81,951	$ 147	$0.90
W	3133	1044	0.2	SW	$ 7,964,025	$ 13,379,562	$ 24,051	**$ 93,545**	$ 117,596	$ 113	$0.69
X	5436	1812	0.2	SW	$ 1,058,667	$ 1,778,560	$ 3,197	**$ 106,869**	$ 110,067	$ 61	$0.37
Y	13340	4446	0.3	SW	$ 18,767,331	$ 31,529,116	$ 85,016	**$ 201,491**	$ 286,507	$ 64	$0.39

TABLE 3.4.3.2

**ANNUALIZATION OF REPLACEMENT, OPERATION, AND MAINTENANCE COSTS - UPGRADED SYSTEMS
PER HOUSEHOLD AND PER CUBIC METRE TREATED
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR**

Community	*Population*	*Estimated # of Dwellings*	*Municipal Share of Infrastructure Funding*	*Water Source*	*Current Cost of Capital Improvements*	*Current Replacement Value of Existing*	*Future Cost of Capital + Existing*	*Annualized Future Infrastructure Cost*	*Annual O&M (Table 4.2.1)*	*Annual O&M + Replacement Cost*	*Annual Cost per household*	*Price per m^3 treated*
A	136	45	10%	GW	$ 394,953	$ 32,979	$ 718,927	**$ 1,086**	**$ 66,108**	$ 67,194	$ 1,493	$9.09
B	138	46	10%	GW	$ 418,574	$ 53,154	$ 792,504	**$ 1,197**	**$ 64,026**	$ 65,223	$ 1,418	$8.63
C	183	61	10%	GW	$ 401,578	$ 57,762	$ 771,690	**$ 1,165**	**$ 66,714**	$ 67,879	$ 1,113	$6.77
D	248	82	10%	GW	$ 120,115	$ 371,570	$ 826,030	**$ 1,247**	**$ 65,334**	$ 66,581	$ 812	$4.94
E	110	36	10%	GUDI	$ 456,274	$ 55,891	$ 860,436	**$ 1,299**	**$ 63,532**	$ 64,831	$ 1,801	$10.96
F	125	41	10%	GW/SW	$ 462,552	$ 38,341	$ 841,499	**$ 1,271**	**$ 61,651**	$ 62,922	$ 1,535	$9.34
G	133	44	10%	SW	$ 485,024	$ 52,580	$ 903,174	**$ 1,364**	**$ 63,998**	$ 65,362	$ 1,486	$9.04
H	140	46	10%	GUDI	$ 433,152	$ 890,772	$ 2,224,193	**$ 3,359**	**$ 63,949**	$ 67,308	$ 1,463	$8.91
I	164	54	10%	GUDI	$ 1,295,664	$ 101,913	$ 2,347,929	**$ 3,545**	**$ 72,353**	$ 75,899	$ 1,406	$8.56
J	188	62	10%	SW	$ 271,744	$ 332,995	$ 1,015,962	**$ 1,534**	**$ 64,589**	$ 66,123	$ 1,066	$6.49
K	203	67	10%	SW	$ 179,916	$ 484,159	$ 1,115,647	**$ 1,685**	**$ 62,706**	$ 64,391	$ 961	$5.85
L	241	80	10%	SW	$ 185,715	$ 482,139	$ 1,121,995	**$ 1,694**	**$ 65,165**	$ 66,859	$ 836	$5.09
M	309	103	10%	SW	$ 201,830	$ 621,593	$ 1,383,350	**$ 2,089**	**$ 59,227**	$ 61,316	$ 595	$3.62
N	315	105	10%	SW	$ 582,390	$ 115,099	$ 1,171,782	**$ 1,769**	**$ 65,923**	$ 67,692	$ 645	$3.93
O	376	125	10%	SW	$ 676,350	$ 154,563	$ 1,395,935	**$ 2,108**	**$ 67,550**	$ 69,658	$ 557	$3.39
P	499	166	10%	GUDI	$ 1,150,207	$ 181,136	$ 2,236,657	**$ 3,377**	**$ 76,265**	$ 79,642	$ 480	$2.92
Q	529	176	10%	SW	$ 893,185	$ 227,484	$ 1,882,724	**$ 2,843**	**$ 76,057**	$ 78,900	$ 448	$2.73
R	552	184	10%	SW	$ 783,627	$ 351,079	$ 1,906,305	**$ 2,879**	**$ 74,127**	$ 77,005	$ 419	$2.55
S	747	249	10%	SW	$ 258,397	$ 789,088	$ 1,759,775	**$ 2,657**	**$ 59,795**	$ 62,452	$ 251	$1.53
T	976	325	10%	SW	$ 942,895	$ 592,429	$ 2,579,344	**$ 3,895**	**$ 64,404**	$ 68,299	$ 210	$1.28
U	1003	334	10%	SW	$ 1,229,041	$ 339,217	$ 2,634,674	**$ 3,978**	**$ 75,482**	$ 79,460	$ 238	$1.45
V	1669	556	10%	SW	$ 4,538,924	$ 646,898	$ 8,712,181	**$ 13,155**	**$ 94,694**	$ 107,849	$ 194	$1.18
W	3133	1044	20%	SW	$ 946,340	$ 7,964,025	$ 14,969,413	**$ 45,208**	**$ 96,454**	$ 141,662	$ 136	$0.83
X	5436	1812	20%	SW	$ 4,174,615	$ 1,058,667	$ 8,791,914	**$ 26,552**	**$ 131,018**	$ 157,570	$ 87	$0.53
Y	13340	4446	30%	SW	$ 1,307,740	$ 18,767,331	$ 33,726,119	**$ 152,779**	**$ 215,623**	$ 368,402	$ 83	$0.50

TABLE 3.4.4

COMPARISON OF LIFE CYCLE COSTS
MAINTENANCE ONLY vs ADDITIONAL REHABILITATION
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

	Chlorination			*pH Treatment*		
PURCHASE			**$ 100,000**			**$ 100,000**
Annual Maintenance		12.0%	$ 12,000		12.0%	$ 12,000
Rehab 1		12 years	10.0%		10 years	10%
Rehab 2						
Normal Life		**12 years**			**10 years**	
Extended Life		**25 years**			**20 years**	
		No Rehab	**Rehab**		**No Rehab**	**Rehab**
5 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
10 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
	Rehab		$ 10,000	Rehab		$ 10,000
	New	**$ 100,000**		**New**	**$ 100,000**	
15 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
20 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
				New	**$ 100,000**	**$ 100,000**
25 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
	New	**$ 100,000**	**$ 100,000**			
30 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
				Rehab		$ 10,000
				New	**$ 100,000**	
35 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
	Rehab		$ 10,000			
	New	**$ 100,000**				
40 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
				New	**$ 100,000**	**$ 100,000**
45 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
50 years	Maint	$ 60,000	$ 60,000	Maint	$ 60,000	$ 60,000
				Rehab		$ 10,000
	New	**$ 100,000**	**$ 100,000**	**New**	**$ 100,000**	
55 years				Maint	$ 60,000	$ 60,000
60 years				Maint	$ 60,000	$ 60,000
				New	**$ 100,000**	**$ 100,000**
65 years						
70 years						
75 years						
		No Rehab	**Rehab**		**No Rehab**	**Rehab**
Capital		$ 400,000	$ 200,000		$ 600,000	$ 300,000
Rehab		$ -	$ 20,000		$ -	$ 30,000
Maintenance		$ 600,000	$ 600,000		$ 720,000	$ 720,000
TOTAL		**$ 1,000,000**	**$ 820,000**		**$ 1,320,000**	**$ 1,050,000**
years		**50**	**50**		**60**	**60**
Annualized Capital		$ 8,000.00	$ 4,000.00		$ 10,000.00	$ 5,000.00
(on the dollar)		$ 0.080	$ 0.040		$ 0.10	$ 0.05
Annualized Rehab		$ -	$ 400.00		$ -	$ 500.00
Annualized Maintenance		$ 12,000.00	$ 12,000.00		$ 12,000.00	$ 12,000.00
(on the dollar)		$ 0.120	$ 0.124		$ 0.120	$ 0.125

TABLE 3.4.4

COMPARISON OF LIFE CYCLE COSTS
MAINTENANCE ONLY vs ADDITIONAL REHABILITATION
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER
INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

		Cartridge Filtration			*Slow Sand Filtration*			*Direct Filtration*	
PURCHASE			**$ 100,000**			**$ 100,000**			**$ 100,000**
Annual Maintenance		6.7%	$ 6,667		1.3%	$ 1,333		1.3%	$ 1,333
Rehab 1		5 years	15%		10 years	5%		10 years	5%
Rehab 2		10 years	25%		20 years	8%		20 years	10%
Normal Life		**15 years**			**50 years**			**50 years**	
Extended Life		**30 years**			**75 years**			**75 years**	
		No Rehab	**Rehab**		**No Rehab**	**Rehab**		**No Rehab**	**Rehab**
5 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
10 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 40,000	Rehab		$ 5,000	Rehab		$ 5,000
15 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
	New	**$ 100,000**							
20 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 40,000	Rehab		$ 13,000	Rehab		$ 15,000
25 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
30 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
				Rehab		$ 5,000	Rehab		$ 5,000
	New	**$ 100,000**	**$ 100,000**						
35 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
40 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 40,000	Rehab		$ 13,000	Rehab		$ 15,000
45 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
	New	**$ 100,000**							
50 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 40,000	Rehab		$ 5,000	Rehab		$ 5,000
				New	**$ 100,000**		**New**	**$ 100,000**	
55 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
	Rehab		$ 15,000						
60 years	Maint	$ 33,334	$ 33,334	Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
				Rehab		$ 13,000	Rehab		$ 15,000
	New	**$ 100,000**	**$ 100,000**						
65 years				Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
70 years				Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
				Rehab		$ 5,000	Rehab		$ 5,000
75 years				Maint	$ 6,667	$ 6,667	Maint	$ 6,667	$ 6,667
				New	***$ 50,000***	**$ 100,000**	New	***$ 50,000***	**$ 100,000**

	Cartridge **No Rehab**	Cartridge **Rehab**	Slow Sand **No Rehab**	Slow Sand **Rehab**	Direct **No Rehab**	Direct **Rehab**
Capital	$ 400,000	$ 200,000	$ 150,000	$ 100,000	$ 150,000	$ 100,000
Rehab	$ -	$ 250,000	$ -	$ 59,000	$ -	$ 65,000
Maintenance	$ 400,002	$ 400,002	$ 99,998	$ 99,998	$ 99,998	$ 99,998
TOTAL	**$ 800,002**	**$ 850,002**	**$ 249,998**	**$ 258,998**	**$ 249,998**	**$ 264,998**
years	**60**	**60**	**75**	**75**	**75**	**75**
Annualized Capital	$ 6,666.67	$ 3,333.33	$ 2,000.00	$ 1,333.33	$ 2,000.00	$ 1,333.33
(on the dollar)	$ 0.07	$ 0.03	$ 0.02	$ 0.01	$ 0.02	$ 0.01
Annualized Rehab	$ -	$ 4,166.67	$ -	$ 786.67	$ -	$ 866.67
Annualized Maintenance	$ 6,666.70	$ 6,666.70	$ 1,333.30	$ 1,333.30	$ 1,333.30	$ 1,333.30
(on the dollar)	$ 0.067	$ 0.108	$ 0.013	$ 0.021	$ 0.013	$ 0.022

TABLE 3.4.4

COMPARISON OF LIFE CYCLE COSTS
MAINTENANCE ONLY vs ADDITIONAL REHABILITATION
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

	Membrane Filtration			*Backwash*		
PURCHASE			**$ 100,000**			**$ 100,000**
Annual Maintenance		7.5%	$ 7,500		2.0%	$ 2,000
Rehab 1		5 years	10%		15 years	8%
Rehab 2		10 years	25%		+ 10 years	5%
Normal Life		**25 years**			**20 years**	
Extended Life		**50 years**			**30 years**	
		No Rehab	**Rehab**		**No Rehab**	**Rehab**
5 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 10,000			
10 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 35,000			
15 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 10,000	Rehab		$ 8,000
20 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 35,000			
				New	**$ 100,000**	
25 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 10,000	Rehab		$ 13,000
	New	**$ 100,000**				
30 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 35,000			
				New		**$ 100,000**
35 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 10,000			
40 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 35,000			
				New	**$ 100,000**	
45 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	Rehab		$ 10,000	Rehab		$ 8,000
50 years	Maint	$ 37,500	$ 37,500	Maint	$ 10,000	$ 10,000
	New	**$ 100,000**	**$ 100,000**			
55 years				Maint	$ 10,000	$ 10,000
				Rehab		$ 13,000
60 years				Maint	$ 10,000	$ 10,000
				New	**$ 100,000**	**$ 100,000**
65 years						
70 years						
75 years						
		No Rehab	**Rehab**		**No Rehab**	**Rehab**
Capital		$ 200,000	$ 100,000		$ 300,000	$ 200,000
Rehab		$ -	$ 190,000		$ -	$ 42,000
Maintenance		$ 375,000	$ 375,000		$ 120,000	$ 120,000
TOTAL		**$ 575,000**	**$ 665,000**		**$ 420,000**	**$ 362,000**
years		**50**	**50**		**60**	**60**
Annualized Capital		$ 4,000.00	$ 2,000.00		$ 5,000.00	$ 3,333.33
(on the dollar)		$ 0.04	$ 0.02		$ 0.05	$ 0.03
Annualized Rehab		$ -	$ 3,800.00		$ -	$ 700.00
Annualized Maintenance		$ 7,500.00	$ 7,500.00		$ 2,000.00	$ 2,000.00
(on the dollar)		$ 0.075	$ 0.113		$ 0.020	$ 0.027

TABLE 3.5.1.1.1

SUMMARY OF COMMUNITY & O&M BUDGETS
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance		Population		Source	Comm. Visited	Community Budgets (Thousands)					Community O&M Budgets (Thousands)				
						<50	50 - 100	100 - 500	500 - 1000	>1000	<10	10 - 50	50 - 100	100 - 500	>500
LSD	8	0 - 500	8	GW	3	3					3				
				SW	5	4	1				4	1			
MUN	17	0 - 500	8	GW	1			1			1				
				SW	7		1	5	1		2	5			
		>500	9	SW	9			2	2	5		4	1	3	1
Totals					25	7	2	8	3	5	10	10	1	3	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.1.2

COMMUNITY & O&M BUDGETS - SORTED BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance	*Population*	*Source*	*Comm. Visited*	*Community Budgets (Thousands)*					*Community O&M Budgets (Thousands)*				
				<50	*50 - 100*	*100 - 500*	*500 - 1000*	*>1000*	*<10*	*10 - 50*	*50 - 100*	*100 - 500*	*>500*
LSD	0 - 500	GW	3	3					3				
LSD	0 - 500	SW	*5*	4	1				4	1			
MUN	0 - 500	GW	1			1			1				
MUN	0 - 500	SW	7		1	5	1		2	5			
MUN	>500	SW	9			2	2	5		4	1	3	1
TOTALS			25	7	2	8	3	5	10	10	1	3	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.1.3

COMMUNITY & O&M BUDGETS - SORTED BY POPULATION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Population	*Source*	*Governance*	*Comm. Visited*	*Community Budgets (Thousands)*					*Community O&M Budgets (Thousands)*				
				<50	*50 - 100*	*100 - 500*	*500 - 1000*	*>1000*	*<10*	*10 - 50*	*50 - 100*	*100 - 500*	*>500*
0 - 500	GW	LSD	3	3					3				
0 - 500	GW	MUN	1			1			1				
0 - 500	SW	LSD	5	4	1				4	1			
0 - 500	SW	MUN	7		1	5	1		2	5			
>500	SW	MUN	9			2	2	5		4	1	3	1
TOTALS			25	7	2	8	3	5	10	10	1	3	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.1.4

COMMUNITY & O&M BUDGETS - SORTED BY WATER SOURCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Source	*Population*	*Governance*	*Comm. Visited*	*Community Budgets (Thousands)*					*Community O&M Budgets (Thousands)*				
				<50	*50 - 100*	*100 - 500*	*500 - 1000*	*>1000*	*<10*	*10 - 50*	*50 - 100*	*100 - 500*	*>500*
GW	0 - 500	LSD	3	3					3				
GW	0 - 500	MUN	1			1			1				
SW	0 - 500	LSD	5	4	1				4	1			
SW	0 - 500	MUN	7		1	5	1		2	5			
SW	>500	MUN	9			2	2	5		4	1	3	1
TOTALS			25	7	2	8	3	5	10	10	1	3	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.3.1

SUMMARY OF WATER AND SEWER RATES DATA
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance		Population		Source	Comm. Visited	Water & Sewer Rate ($/year)				Water Rate ($/year)			
						<200	200 - 300	300 - 400	400 - 500	<100	100 - 200	200 - 300	300 - 400
LSD	8	0 - 500	8	GW	3						3		
				SW	5					1	2	2	
MUN	17	0 - 500	8	GW	1							1	
				SW	7			4	2		1	5	1
		>500	9	SW	9		3	5	1		4	5	
Totals					25	0	3	9	3	1	10	13	1

NOTES: Based on the 25 communities visited, and their 2009 budgets.
SW also includes GUDI and SW/GW.
LSD's have only a water rate. No combined water and sewer rate.

TABLE 3.5.1.3.2

**WATER AND SEWER RATES - SORTED BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL**

Governance	*Population*	*Source*	*Comm. Visited*	*Water & Sewer Rate ($/year)*				*Water Rate ($/year)*			
				<200	*200 - 300*	*300 - 400*	*400 - 500*	*<100*	*100 - 200*	*200 - 300*	*300 - 400*
LSD	0 - 500	GW	3						3		
LSD	0 - 500	SW	5					1	2	2	
MUN	0 - 500	GW	1							1	
MUN	0 - 500	SW	7			4	2		1	5	1
MUN	>500	SW	9		3	5	1		4	5	
TOTALS			25	0	3	9	3	1	10	13	1

NOTES: Based on the 25 communities visited, and their 2009 budgets.
SW also includes GUDI and SW/GW.
LSD's have only a water rate. No combined water and sewer rate.

TABLE 3.5.1.3.3

WATER AND SEWER RATES - SORTED BY POPULATION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Population	*Source*	*Governance*	*Comm. Visited*	*Water & Sewer Rate ($/year)*				*Water Rate ($/year)*			
				<200	*200 - 300*	*300 - 400*	*400 - 500*	*<100*	*100 - 200*	*200 - 300*	*300 - 400*
0 - 500	GW	LSD	3						3		
0 - 500	GW	MUN	1							1	
0 - 500	SW	LSD	5					1	2	2	
0 - 500	SW	MUN	7			4	2		1	5	1
>500	SW	MUN	9		3	5	1		4	5	
TOTALS			25	0	3	9	3	1	10	13	1

NOTES: Based on the 25 communities visited, and their 2009 budgets.
SW also includes GUDI and SW/GW.
LSD's have only a water rate. No combined water and sewer rate.

TABLE 3.5.1.3.4

WATER AND SEWER RATES - SORTED BY WATER SOURCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

	Population	*Governance*	*Comm. Visited*	*Water & Sewer Rate ($/year)*				*Water Rate ($/year)*			
				<200	*200 - 300*	*300 - 400*	*400 - 500*	*<100*	*100 - 200*	*200 - 300*	*300 - 400*
GW	0 - 500	LSD	3						3		
GW	0 - 500	MUN	1							1	
SW	0 - 500	LSD	5					1	2	2	
SW	0 - 500	MUN	7			4	2		1	5	1
SW	>500	MUN	9		3	5	1		4	5	
TOTALS			25	0	3	9	3	1	10	13	1

NOTES: Based on the 25 communities visited, and their 2009 budgets.
SW also includes GUDI and SW/GW.
LSD's have only a water rate. No combined water and sewer rate.

TABLE 3.5.1.4.1

SUMMARY OF OUTSTANDING RESIDENTIAL TAXES & COMMUNITY DEBT/SERVICE RATIO
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance		*Population*		*Source*	*Comm. Visited*	*Outstanding Residential Taxes (%)*				*Debt/Service Ratio (%)*			
						<10	***10 - 30***	***30 - 50***	***>50***	***<10***	***10 - 30***	***30 - 50***	***>50***
LSD	8	0 - 500	8	GW	3		1		1	1			
				SW	5	4	1			1	1		1
MUN	17	0 - 500	8	GW	1	1					1		
				SW	7	6					5	1	
		>500	9	SW	9	5	3			1	6	1	
Totals					25	16	5	0	1	3	13	2	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.4.2

SUMMARY OF OUTSTANDING RESIDENTIAL TAXES & COMMUNITY DEBT/SERVICE RATIO - GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance	*Population*	*Source*	*Comm. Visited*	*Outstanding Residential Taxes (%)*				*Debt/Service Ratio (%)*			
				<10	*10 - 30*	*30 - 50*	*>50*	*<10*	*10 - 30*	*30 - 50*	*>50*
LSD	0 - 500	GW	3		1		1	1			
LSD	0 - 500	SW	5	4	1			1	1		1
MUN	0 - 500	GW	1	1					1		
MUN	0 - 500	SW	7	6					5	1	
MUN	>500	SW	9	5	3			1	6	1	
TOTALS			25	16	5	0	1	3	13	2	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.4.3

SUMMARY OF OUTSTANDING RESIDENTIAL TAXES & COMMUNITY DEBT/SERVICE RATIO - POPULATION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Population	*Source*	*Governance*	*Comm. Visited*	*Outstanding Residential Taxes (%)*				*Debt/Service Ratio (%)*			
				<10	*10 - 30*	*30 - 50*	*>50*	*<10*	*10 - 30*	*30 - 50*	*>50*
0 - 500	GW	LSD	3		1		1	1			
0 - 500	GW	MUN	1	1					1		
0 - 500	SW	LSD	5	4	1			1	1		1
0 - 500	SW	MUN	7	6					5	1	
>500	SW	MUN	9	5	3			1	6	1	
TOTALS			25	16	5	0	1	3	13	2	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.4.4

SUMMARY OF OUSTANDING RESIDENTIAL TAXES & COMMUNITY DEBT/SERVICE RATIO - WATER SUPPLY
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Source	*Population*	*Governance*	*Comm. Visited*	*Outstanding Residential Taxes (%)*				*Debt/Service Ratio (%)*			
				<10	*10 - 30*	*30 - 50*	*>50*	*<10*	*10 - 30*	*30 - 50*	*>50*
GW	0 - 500	LSD	3		1		1	1			
GW	0 - 500	MUN	1	1					1		
SW	0 - 500	LSD	5	4	1			1	1		1
SW	0 - 500	MUN	7	6					5	1	
SW	>500	MUN	9	5	3			1	6	1	
TOTALS			25	16	5	0	1	3	13	2	1

NOTES: Based on the 25 communities visited, and their 2009 budgets
SW also includes GUDI and SW/GW

TABLE 3.5.1.5.1

SUMMARY OF OPERATOR WAGES AND EMPLOYMENT STATUS
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance		*Population*		*Water Source*[1]	*Comm.*[2] *Visited*	*Operator Wages ($/hour)*					*Employment Status*		
						$0[3]	*$1 - $10*	*$10 - $15*	*$15 - $20*	*>$20*	*FT*	*PT*	*V*
MUN	17	0 - 500	8	SW	7	1		6			5	1	1
		>500	9	SW	9			4	2	1	7		
LSD	8	0 - 500	8	GW	4	2	1	1			1	1	2
				SW	5	5							5
TOTALS					25	8	1	11	2	1	13	2	8

NOTES: 1. SW also includes GUDI and SW/GW
2. Based on the 25 visited communities with detailed survey information
3. Salary of $0 represents volunteers
4. Two communities did not provide responses for these queries.

TABLE 3.5.1.5.2

SUMMARY OF OPERATOR WAGES AND EMPLOYMENT STATUS - SORTED BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Governance	*Population*	*Water Source*	*Survey Pop.*	*Operator Wages ($/hour)*					*Employment Status*		
				$0	*$1 - $10*	*$10 - $15*	*$15 - $20*	*>$20*	*FT*	*PT*	*V*
LSD	0 - 500	GW	3	2	1					1	2
LSD	0 - 500	SW	5	5							5
MUN	>500	SW	9			4	2	1	7		
MUN	0 - 500	GW	1			1			1		
MUN	0 - 500	SW	7	1		6			5	1	1
TOTALS			25	8	1	11	2	1	13	2	8

NOTES: Based on the 25 communities visited
SW also includes GUDI and SW/GW

TABLE 3.5.1.5.3

SUMMARY OF OPERATOR WAGES AND EMPLOYMENT STATUS - SORTED BY POPULATION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Population	*Water Source*	*Governance*	*Survey Pop.*	*Operator Wages ($/hour)*					*Employment Status*		
				$0	***$1 - $10***	***$10 - $15***	***$15 - $20***	***>$20***	***FT***	***PT***	***V***
>500	SW	MUN	9			4	2	1	7		
0 - 500	GW	LSD	3	2	1					1	2
0 - 500	GW	MUN	1			1			1		
0 - 500	SW	LSD	5	5							5
0 - 500	SW	MUN	7	1		6			5	1	1
TOTALS			25	8	1	11	2	1	13	2	8

NOTES: Based on the 25 communities visited
SW also includes GUDI and SW/GW

TABLE 3.5.1.5.4

SUMMARY OF OPERATOR WAGES AND EMPLOYMENT STATUS - SORTED BY SUPPLY
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN NL

Water Source	*Population*	*Governance*	*Survey Pop.*	*Operator Wages ($/hour)*					*Employment Status*			*O&M Effort (Hr/Week)*			
				$0	*$1 - $10*	*$10 - $15*	*$15 - $20*	*>$20*	*FT*	*PT*	*V*	*<10*	*10 - 20*	*20 - 40*	*>40*
GW	0 - 500	LSD	3	2	1					1	2	2	1		
GW	0 - 500	MUN	1			1			1			1			
SW	>500	MUN	9			4	2	1	7			3	3	1	1
SW	0 - 500	LSD	5	5							5	5			
SW	0 - 500	MUN	7	1		6			5	1	1	4	1	1	
TOTALS			25	8	1	11	2	1	13	2	8	15	5	2	1

NOTES: Based on the 25 communities visited
SW also includes GUDI and SW/GW

TABLE 3.5.3.1.1

COMPARISON OF ANNUAL HOUSEHOLD WATER RATES
CURRENT RATES VS. RATES BASED ON BEST MANAGEMENT PRACTICES
STUDY ON OPERATION AND MATINENANCE OF DRINKING WATER
INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Community	*Status*	*Population Serviced*	*Water Source*	*Current Boil Water Advisory*	*Annual Water Rates 2009* *per household*	*Annual Cost* *per household*
A	LSD	136	GW	Yes	$ 300	$ 1,194
B	LSD	138	GW	No	$ 120	$ 1,325
C	LSD	183	GW	Yes	$ 180	$ 1,005
D	MUN	248	GW	Yes	$ 240	$ 637
E	LSD	110	GUDI	No	$ 200	$ 1,688
F	LSD	125	GW/SW	Yes	$ 132	$ 1,141
G	LSD	133	SW	Yes	$ 60	$ 1,134
H	MUN	140	GUDI	Yes	$ 325	$ 1,311
I	LSD	164	GUDI	Yes	$ 120	$ 1,385
J	MUN	188	SW	No	$ 252	$ 1,044
K	MUN	203	SW	No	$ 276	$ 939
L	MUN	241	SW	Yes	$ 220	$ 117
M	MUN	309	SW	No	$ 185	$ 625
N	LSD	315	SW	Yes	$ 204	$ 595
O	MUN	376	SW	No	$ 240	$ 508
P	MUN	499	GUDI	No	$ 210	$ 385
Q	MUN	529	SW	No	$ 180	$ 390
R	MUN	552	SW	Yes	$ 210	$ 443
S	MUN	747	SW	No	$ 280	$ 275
T	MUN	976	SW	Yes	$ 300	$ 242
U	MUN	1003	SW	No	$ 192	$ 244
V	MUN	1669	SW	No	$ 139	$ 147
W	MUN	3133	SW	Yes	$ 230	$ 113
X	MUN	5436	SW	No	$ 228	$ 61
Y	MUN	13340	SW	No	$ 150	$ 64

* Rate to operate plant based on 100% of O&M costs, plus infrastructure as per Provincial Funding Ratios (Department of Municipal Affairs)

TABLE 3.5.3.1.2

SUMMARY OF 2009 WATER RATES CALCULATIONS
COUNTY A, ONTARIO
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

	Community	*Units*	*Unmetered Small Water Systems*	*Medium Water Systems*
Water System Background	Population range	-	180 - 946	770 - 2,595
	C of A Capacity	(m3/d)	389 - 1,296	916 - 4,744
	Water Supply	-	GW	GW, GUDI
2009 Water Rates	Reg 170 Upgrade	$/yr	$5	-
	Program	$/m3	-	0.07
	Service Charge[1]	$/mo	-	19.20 - 179.18
	Flat Rate	$/yr	$586	$444
	Initial Metered Rate	$/m3	-	$0.66
	Cut-off for Initial Rate	m3	-	34
	Excess Metered Rate	$/m3	-	$0.76

1- range for water meters from 20 to 150 mm

TABLE 3.5.3.1.3

SUMMARY OF 2009 WATER RATE CALCULATIONS
COUNTY B, ONTARIO
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE
IN NEWFOUNDLAND AND LABRADOR

	Community	*Community Y*[1]	*Community Z*
Water System Background	Population Serviced	8,132	800
	WTP Capacity (m3/d)	18,242	1,024
	Water Supply	GW, SW	GW
2009 Water Rates	Contribution to Meter ($/yr)	$104	
	Operating Flat Rate[2] ($/month)	$25 - 979.50	$31
	Metered Rate ($/m3)	$0.55	$0.95

1- population served and WTP capacity include 3 small satellite community systems serving less than 70 people

2- range for 20 to 150 mm service connection

TABLE 3.5.3.1.4

SUMMARY OF 2009 WATER RATES
SMALL WATER SYSTEMS IN COUNTY A AND COUNTY B, ONTARIO
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NL

		County A Medium Water Systems	*County B*	
			Community Y[1]	*Community Z*
Assumptions	Service connection (mm)	20	20	20
	Residents per dwelling	3	3	3
	Per Capita Water Demand (L/person.d)	450	450	450
2009 Water Rate Calculation	Service charge ($/mo)	$19.20	$25.00	$31.00
	Monthly water use (m3/mo)	40.5	40.5	40.5
	Initial metered fee ($/mo)	$26.28	$22.28	$38.48
	Surcharge metered fee ($/mo)	$5.40	-	-
	Consumption charge ($/mo)	$31.68	$22.28	$38.48
	Monthly bill ($/mo)	$50.88	$47.28	$69.48
	Annual water rate ($/yr)	$611	$671	$937

APPENDIX A

DETAILED SURVEY

STUDY ON THE OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

DETAILED SURVEY Date of submission ________________________

The information collected from this confidential survey will assist the Department of Environment and Conservation, Water Resources Management Division and the Department of Municipal Affairs through the efforts of Conestoga-Rovers & Associates. This survey will be used to determine the best approach to reducing significant drinking water issues in the Province related to Operation and Maintenance that include a variety of factors such as population, location, system size and type, capital and maintenance expenses compared to available municipal budget funds, operator training and availability, among others.

We have created a list of survey questions to help us assess these issues and we would appreciate your co-operation by submitting your completed survey. Please check all that apply to your community.

Please complete and return by July 18, 2009.

Once completed, please fax to Jamie Hunt at 709-364-5368, **OR**

Please call 709-364-5353 if you have any questions or complete the survey on-line by following these steps:

- Open your internet browser (Internet Explorer, Firefox, etc.)
- Type in the following web address: http://survey.nlwaterinfrastructurestudy.ca

Name of Community:
Address: ________________________
____
Phone # ________________________
Fax # ________________________
e-mail ________________________

Questionnaire Respondent:
Name:________________________________
Position:______________________________
Years with Town/LSD:_________________

Community Status: Town ___ LSD _____

Population Serviced: 0 to 500 __; 501 to 1,500 __; 1501 to 15,000 __ ; greater than 15,000 ___

Have Town officials (Mayor, Manager, Councilors, Town Clerk, Administrator, Operators, etc.) been in contact related to water quality issues over the last 12 months with:

Department of Municipal Affairs: Yes: No:

Department of Environment and Conservation: Yes: No:
(Water Resources Management Division)

PART A: WATER SOURCE

1) Water Source: (Check all that apply) Lake/Pond: River/Stream: Groundwater Well: Other:

2) Water Supply/Source Name(s):___________________________

3) Permit to Operate Water Distribution #: _________ Complying with Permit? Yes: No:

4) How does water reach the treatment system/plant? Gravity: Pumped:

5) Have there been any reported shortages of water? Yes: No:

   If yes, Frequency: ____
   Reason(s): ____
   ____

6) Is the water source area designated as a Protected Public Water Supply Area (including Wellhead Protected Water Supply Areas)?
   Yes: No:

8) Does the quality of the water source vary? Yes: No:

   If yes, describe: ____
   ____
   ____

9) Surface Water (Pond/Lake/River/Stream)

   a) Are there any identifiable sources of contaminants affecting the quality of drinking water?
      Yes: No:
      If yes, describe: ____
      ____
      ____

   b) Description of water intake: ____
      (location, water depth, etc.) ____
      ____

10) Groundwater

   a) Number of municipal wells: _______

   b) Are pitless adapters installed on the wells? Yes: No:

   c) Are there any problems with municipal wells? Yes: No:

      How often, describe: ____
      ____
      ____

d) Well construction Number Drilled: Number Surface (Dug):

e) What is the rated safe yield for each well:
____
____
____

PART B: DESIGN

1) What year was the water treatment system/plant constructed? ____________________

2) Have there been any upgrades to the treatment system/plant? ____________________

a) Year:________________ Description of upgrade:_________________________

3) Permit to Operate Water Treatment #: _________ Complying with Permit? Yes: No:

4) What is the Rated Design Capacity: ________ (L/s)

5) Is the water metered at the water treatment system/plant? Yes: No:

a) What is the Average Daily Flow of the water treatment system/plant? ________ (L/day)

b) What is the Peak Daily Flow of the water treatment system/plant? ________ (L/day)

6) What is the water consumption rate? ________ (L/person/day)

7) Operating Pressures

a) At the water treatment system/plant discharge: ____________ (psi)

b) Highest pressures in the distribution system: ____________ (psi)

c) Lowest pressures in the distribution system: ____________ (psi)

8) Does the current water demand in the community meet or exceed the design capacity?

Yes: No:

Explain: ____
____
____

9) Is there one or more large volume demands on your water supply? Yes: No:

a) If so, is it seasonal (i.e. fish plant)? Yes: No:

10) a) Is there a Water Storage System/Tank? Yes: No:

b) Where is the Water Storage System/Tank located? Water Treatment Plant:
Off-Site (away from plant):

Description: ____

____

____

c) What is the capacity of the Water Storage System/Tank(s)? ______________ (L)

d) Is there a provision in the Water Storage System/Tank for fire flow? Yes: No: N/A:

e) Does the volume of the Water Storage System/Tank meet or exceed the current water demands for the community?

Yes: No: N/A:

If no, explain: ____

____

____

11) a) Is there a pump for fire protection? Yes: No:

Fuel: Electric: Other:

b) Is the pump certified by a regulatory Agency (i.e. NFA, CSA) Yes: No: N/A

c) Is the pump supplied with emergency power back-up? Yes: No: N/A

12) What type of tank is used for water storage? In-Ground:
Water Storage Tower:

If In-Ground, Gravity fed: Pumped:

a) If Pumped:

i) What are the rated pump capacities? ____________________

13) What is the power supply to run the water treatment system/plant? Fuel: Electric: Other:

14) Back-up Power Supply

a) Is there a generator to supply back-up power to the water treatment system/plant?

Yes: Fuel: Other:

No:

b) Is there a generator to supply back-up power to the distribution system, including booster stations?

Yes: Fuel: Other:

No: N/A:

15) Is there a designated Office/Filing Area in the community for drinking water system information?

Yes: No:

a) Is there a designated workshop area for drinking water system operation and maintenance?

Yes: No:

b) Are there appropriate tools in the workshop to perform basic maintenance? Yes: No:

16) Distribution Lines (These will be available with pull-down menus on-line)

Phase #	Year Started	Year Completed	Type of Materials	Length (metres)	Diameter Range (mm)	Ground Cover (> 1.8 m)
						Y N
						Y N
						Y N
						Y N
						Y N
						Y N
						Y N

Use the following choices for above:

Type of Materials	Lengths in Metres	Diameter Ranges
Cast Iron	0-500	50-100
Ductile Iron	500-2,500	100-200
Asbestos Cement	2,500-5,000	200-300
Low Density PE	5,000-10,000	300-450
High Density PE	> 10,000	> 450
PVC		
Other (state type)		

17) Number of dead-ends in the distribution system _______

18) Do you have a cross-connections control program? Yes: No:
(Connections to prevent back-siphoning or back-pressure into the town water mains)

19) Are there high risk public facilities supplied from the water treatment plant such as:

Daycare Facility Yes: No: Hospital Yes: No: Seniors Home: Yes: No:

School (K-12) Yes: No: Other ________________________________ Yes: No:

20) Main Type of Disinfection: Chlorination: Chloramination Ultraviolet:
(First system to disinfect water as
it enters treatment building/ structure) None: Ozonation: Other:

21) Secondary Disinfection: Chlorination: Chloramination Other:
(Second system to disinfect water as
as it leaves treatment building/ structure) None:

22) Distribution Line Disinfection: Chlorination: Chloramination Ultraviolet:
(After treatment building,

i.e. Booster System) None Ozonation: Other:

23) Does your water treatment system include any of the following processes or treatments?

Coagulation	Yes:	No:	Flocculation	Yes:	No:	Sedimentation	Yes:	No:
Softening	Yes:	No:	Fluoridation	Yes:	No:	Upflow Clarifier	Yes:	No:

pH Adjustment	Yes:	No:	Dissolved Air Flotation	Yes:	No:
Taste & Odour Control	Yes:	No:	Stripping	Yes:	No:
Arsenic Removal	Yes:	No:			

Filtration	Yes:	No:	Media Type	Anthracite Coal	Yes:	No:
				Sand	Yes:	No:
				Granular Activated Carbon	Yes:	No:
				Green Sand	Yes:	No:
				Other: __________________	Yes:	No:

Membrane Filtration	Yes:	No:	Type	Microfiltration	Yes:	No:
				Nanofiltration	Yes:	No:
				Reverse Osmosis	Yes:	No:
				Ultrafiltration	Yes:	No:

PART C: OPERATION & MAINTENANCE

1) Disinfection

a) Is there disinfection equipment installed as part of your water treatment system/plant?

Yes: No:

List type of disinfection equipment: ____
____

b) Is the disinfection equipment working? Yes: No: N/A:

If no, explain: ____
____

2) a) Is there sufficient disinfecting agent available? Yes: No: N/A:

b) Has the disinfecting agent expired? Yes: No: N/A:

3) a) Is there a Chlorine Residual Analyzer? Yes: No:

b) Is the Chlorine Residual Analyzer calibrated regularly? Yes: No: N/A:

4) a) How often are Chlorine residuals in the treated water checked at the water treatment system/plant? ____

b) How often are Chlorine residuals checked in the distribution lines? ____________

Locations? ____

c) Current free Chlorine residual in Water Treatment Plant reservoir: __________ mg/L

5) What other chemicals are used in the water treatment process?

____
____
____
____

a) Are the chemicals properly stored in accordance with manufacturer's instructions?

Yes: No: N/A:

b) Are the chemicals effective in the treatment process? Yes: No: N/A:

c) Is a sufficient supply of the listed chemicals for treatment readily available?

Yes: No: N/A:

6) Are there operating and maintenance manuals for the treatment equipment, pumps, etc. readily available?

Yes: No:

If no, where are they located? ______________________________________
____

Are the manuals current with any upgrades at the facility? Yes: No:

7) Do you have spare parts, consumables, maintenance kits, etc.? Yes: No:

8) Are emergency repair parts readily available to keep the system operational in an emergency situation (such as back-up pumps)?

Yes: No:

Parts kept on site: ____
____

9) Emergency Repairs

a) How many emergency repairs have been completed in the last 2 years? ________

b) What types of repairs were completed? ______________________________________

10) Complaints regarding water quality

a) What types of complaints have been received and how often?

____ ________
____ ________
____ ________

b) What is the range of response times to these complaints? _______________

11) Have there been any service disruptions (plant or distribution) in the past 2 years?

Yes: No:

If yes, explain cause: ____
____
____

12) a) Is there a distribution line flushing program?: Yes: No:

When was the date of the last flushing? ______/______/______

b) Is there a fire hydrant maintenance program? Yes: No:

c) Are there regular fire pump tests? Yes: No: N/A:

If yes, how often: _______________

When was the date of the last test? ______/______/______

d) Do you carry out fire flow capacity checks at fire hydrants? Yes: No:

When was the date of the last check? ______/______/______

e) Do you have an annual valve operating/maintenance program? Yes: No:

13) Do you have a surface water intake cleaning program? Yes: No: N/A:

14) Do you have a water storage tank cleaning program? Yes: No: N/A:

15) a) Do you have difficulty with obtaining qualified contractors? Yes: No:

b) What is the average response time of the Technicians/Trades People? ___________

c) Are you satisfied with their response time? Yes: No:

d) What is the average response time of the Consultant? ___________

e) Are you satisfied with their response time? Yes: No:

f) What is the average response time of Suppliers? ___________

g) Are you satisfied with their response time? Yes: No:

16) Do you have the resources to prepare and maintain up-to-date water treatment system/plant documentation such as As-Built drawings, Process diagrams, Operations Manuals, Log Books, Lab Results, etc.?

Yes: No:

17) Can you easily locate the As-Built drawings for:

Water Treatment System/Plant:	Yes:	No:	
Distribution System:	Yes:	No:	
Water Storage Tank:	Yes:	No:	N/A:

18) Are there any re-occurring operational problems? Yes: No:

If yes, explain: ______________________________
____
____

19) Does the water treatment facility, water source area, and/or water storage tank have adequate security to prevent unauthorized entry?

Yes: No:

PART D: REPORTING

1) Does the Operator(s) keep a record of their daily activities? Yes: No:
(flows, chlorine residuals, maintenance activities, etc.)

2) Does the Operator(s) keep a detailed record of the following?

Surface water intake screen cleaning	Yes:	No:	N/A:
Water treatment system/plant equipment cleaning	Yes:	No:	
Water storage tank cleaning	Yes:	No:	N/A:
Fire Hydrant flushing	Yes:	No:	
Water treatment system/plant chlorine residuals	Yes:	No:	
Distribution system chlorine residuals and sample locations	Yes:	No:	
Emergency Repairs	Yes:	No:	

3) Have there been any Boil Water Advisories issued in the past 2 years? Yes: No:

If yes, Notification Protocols: ______________________________
(GSC to Town) ______________________________

Notification Protocols: ______________________________
(Town to Residents) ______________________________

4) Release of Boil Water Advisories

Notification Protocols: ______________________________

(Town to Residents) ______________________________

5) Is testing of any chemical properties of the treated water conducted by the Town?

Yes: No:

List Parameters and Frequency of Testing? ______________________
____
____
____

6) What water quality problems are you most concerned with in your community?

____
____
____
____

PART E: OPERATORS

1) Do you have difficulty with the availability of qualified Operators? Yes: No:

2) How many new/replacement Operators have you hired in the last five years? ________

3) Have the Operator(s) been in contact about water quality issues over the last 12 months with:

Department of Municipal Affairs: Yes: No:

Department of Environment and Conservation: Yes: No:
(Water Resources Management Division)

4)

	Years of Experience	Training/ Certification	Full Time/ Part Time	Paid/ Volunteer
a)	_______	______________	_________	__________
b)	_______	______________	_________	__________
c)	_______	______________	_________	__________

5) Operator Hours

a) What are the typical hours of work for an Operator? Per Day ______Per Week ________

b) How many hours are spent on work/maintenance related to the water treatment system/plant and distribution system, etc.?

Per Day ______Per Week ________

6) What is the typical hourly salary for an Operator? ____________

7) Have the Operator(s) received training to operate and maintain the water treatment system/plant and distribution system equipment by contractors, equipment suppliers, or through job shadowing?

Operator A Yes: No: When: __________ By Who: ______________
Operator B Yes: No: When: __________ By Who: ______________

Operator C Yes: No: When: ____________ By Who: __________________

8) Are the Operator(s) familiar with calibrating and maintaining the disinfection equipment?

Operator A Yes: No: N/A:
Operator B Yes: No: N/A:
Operator C Yes: No: N/A:

9) Do the Operator(s) feel they require additional training to operate the water treatment system/plant and distribution system?

Operator A Yes: No: N/A:
Operator B Yes: No: N/A:
Operator C Yes: No: N/A:

10) Is any training recommended? Yes: No:

Recommendation(s): ____
____
____

11) Operator Incidents/Injuries

a) Have there been any incidents or injuries while operating and maintaining the water treatment system/plant or water distribution system that resulted in lost time?
Yes: No:

If yes, what type of incident/injury? ____

12) Are there any limitations with Operator training? Yes: No: N/A:

a) Travel costs? Yes: No: N/A:

b) No replacement while on training? Yes: No: N/A:

c) Unwilling/no interest to attend? Yes: No: N/A:

d) Other: ____

13) a) Is there only one Operator? Yes: No: N/A:

b) Does anyone replace the Operator while on vacation, training, or sick? Yes: No: N/A:

If yes, who? ____
____
____

What training has this person received?
____
____
____

PART F: FINANCIAL

1) What are the average annual household water tax rates over the last 5 years? __________

2) What percentage of your residential water tax base is outstanding for more than one year? _____

3) What is the average operation and maintenance allocation in your annual budget for your water treatment system/plant and distribution system over the last 5 years?

   ____

4) Have you requested and/or received capital works funding in the last 5 years for:

	Requested		Received	
Water Treatment System/Plant	Yes:	No:	Yes:	No:
Distribution System	Yes:	No:	Yes:	No:
Water Storage Tank	Yes:	No:	Yes:	No:

5) Have you requested and/or received operation and maintenance assistance related to your water treatment system/plant in the last 5 years for:

   Requested Yes: No: Received Yes: No:

6) Have you requested and/or received operation and maintenance assistance related to your water distribution system in the last 5 years for:

   Requested Yes: No: Received Yes: No:

SECTION G: SYSTEM DEFICIENCIES

Please provide any additional comments regarding problems that you are currently having with your water treatment system/plant, water storage tank, and/or distribution system.

____

____

____

____

____

____

____

____

____

SECTION H: RECOMMENDATIONS

Do you have any recommendations on how the Department of Environment and Conservation, Water Resources Management Division and/or Department of Municipal Affairs can assist you with improvements to operation or maintenance issues related to your water treatment system/plant, water storage system/tank, and/or distribution system?

____

____

____

____

____

____

____

____

____________________________ ____________________________

Signature Date

APPENDIX B

BASIC SURVEY

STUDY ON THE OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

BASIC SURVEY Date of submission ______________________________

The information collected from this confidential survey will assist the Department of Environment and Conservation, Water Resources Management Division and the Department of Municipal Affairs through the efforts of Conestoga-Rovers & Associates. This survey will be used to determine the best approach to reducing significant drinking water issues in the Province related to Operation and Maintenance that include a variety of factors such as population, location, system size and type, capital and maintenance expenses compared to available municipal budget funds, operator training and availability, among others.

We have created a list of survey questions to help us assess these issues and we would appreciate your co-operation by submitting your completed survey. Please check all that apply to your community.

Please complete and return by June 30, 2009 by faxing to Jamie Hunt at 709-364-5368, **OR** **c**omplete the survey on-line by following these steps:

- Open your internet browser (Internet Explorer, Firefox, etc.)
- Type in the following web address: http://survey.nlwaterinfrastructurestudy.ca

If you have any questions regarding the survey, please call 709-364-5353.

The first 25 to reply to this survey will receive a small non-monetary gift from CRA.

Name of Community:
Address: __________________________
____
Phone # __________________________
Fax # __________________________
e-mail __________________________

Questionnaire Respondent:
Name:__________________________________
Position:________________________________
Years with Town/LSD:__________________

Community Status: Town ___ LSD _____

Population Serviced: 0 to 500 __; 501 to 1,500 __; 1501 to 15,000 __ ; greater than 15,000 ___

PART A: WATER SOURCE

1) Water Source: Lake/Pond: River/Stream:
(Check all that apply) Groundwater Well: Other:

2) How does water reach the treatment system/plant? Gravity: Pumped:

3) Have there been any reported shortages of water? Yes: No:

4) Is the water source area designated as a Protected Public Water Supply Area (including Wellhead Protected Water Supply Areas)?
Yes: No:

5) Surface Water (Pond/Lake/River/Stream)

   a) Are there any identifiable sources of contaminants affecting the quality of drinking water?
   Yes: No:

   b) Description of water intake: ____
   ____
   ____

6) Groundwater

   a) Number of municipal wells: ________

   b) What is the rated safe yield for each well:
   ____
   ____
   ____

PART B: DESIGN

1) What year was the water treatment system/plant constructed? ____________________

2) Have there been any upgrades to the treatment system/plant? ____________________

   a) Year:________________ Description of upgrade:__________________________

3) What is the Rated Design Capacity: ________ (L/s)

4) Is the water metered at the water treatment system/plant? Yes: No:

   a) What is the Average Daily Flow of the water treatment system/plant? ________ (L/day)

   b) What is the Peak Daily Flow of the water treatment system/plant? ________ (L/day)

5) Operating Pressures

   a) Highest pressures in the distribution system: ____________ (psi)

   b) Lowest pressures in the distribution system: ____________ (psi)

6) Is there one or more large volume demands on your water supply? Yes: No:

a) If so, is it seasonal (i.e. fish plant)? Yes: No:

7) a) Is there a Water Storage System/Tank? Yes: No:

b) Is there a provision in the Water Storage System/Tank for fire flow? Yes: No: N/A:

8) a) Is there a pump for fire protection? Yes: No:

Fuel: Electric: Other:

b) Is the pump supplied with emergency power back-up? Yes: No: N/A

9) Is there a designated Office/Filing Area in the community for drinking water system information?

Yes: No:

a) Is there a designated workshop area for drinking water system operation and maintenance?

Yes: No:

b) Are there appropriate tools in the workshop to perform basic maintenance? Yes: No:

10) Distribution Lines (These will be available with pull-down menus on-line)

Phase #	Year Started	Year Completed	Type of Materials	Length (metres)	Diameter Range (mm)	Ground Cover (> 1.8 m)
						Y N
						Y N
						Y N
						Y N
						Y N
						Y N
						Y N

Use the following choices for above:

Type of Materials	Lengths in Metres	Diameter Ranges
Cast Iron	0-500	50-100
Ductile Iron	500-2,500	100-200
Asbestos Cement	2,500-5,000	200-300
Low Density PE	5,000-10,000	300-450
High Density PE	> 10,000	> 450
PVC		
Other (state type)		

11) Do you have a cross-connections control program? Yes: No:
(Connections to prevent back-siphoning and/or backpressure into the town water mains)

12) Main Type of Disinfection: Chlorination: Chloramination Ultraviolet:
(First system to disinfect water as it enters treatment building/ structure) None Ozonation: Other:

13) Secondary Disinfection: Chlorination: Chloramination Other:
(Second system to disinfect water as as it leaves treatment building/ structure) None

14) Does your water treatment system include any of the following processes or treatments?

Coagulation	Yes:	No:	Flocculation	Yes:	No:	Sedimentation	Yes:	No:
Softening	Yes:	No:	Fluoridation	Yes:	No:	Upflow Clarifier	Yes:	No:
Filtration	Yes:	No:	Stripping	Yes:	No:	pH Adjustment	Yes:	No:
Membrane Filtration	Yes:	No:				Dissolved Air Flotation	Yes:	No:
Taste & Odour Control	Yes:	No:				Arsenic Removal	Yes:	No:

PART C: OPERATION & MAINTENANCE

1) Disinfection

a) Is there disinfection equipment installed as part of your water treatment system/plant?

Yes: No:

b) Is the disinfection equipment working? Yes: No: N/A:

2) Is there a Chlorine Residual Analyzer? Yes: No:

3) a) How often are Chlorine residuals in the treated water checked at the water treatment system/plant?
____

b) How often are Chlorine residuals checked in the distribution lines? _________

Locations? ____

4) Are there operating and maintenance manuals for the treatment equipment, pumps, etc. readily available?

Yes: No:

5) Do you have spare parts, consumables, maintenance kits, etc.? Yes: No:

6) Are emergency repair parts readily available to keep the system operational in an emergency situation (such as back-up pumps)?

Yes: No:

7) Emergency Repairs

a) How many emergency repairs have been completed in the last 2 years? __________

b) What types of repairs were completed? ______________________________

8) Complaints regarding water quality

a) What types of complaints have been received and how often?

______________________________ __________
______________________________ __________
______________________________ __________

b) What is the range of response times to these complaints? ____________

9) Have there been any service disruptions (plant or distribution) in the past 2 years?

Yes: No:

10) Do you have a regular system cleaning program? Yes: No:
(includes treatment system/plant and distribution system)

11) a) Do you have difficulty with obtaining qualified contractors? Yes: No:

b) What is the average response time of the Technicians/Trades People? ________

c) Are you satisfied with their response time? Yes: No:

d) What is the average response time of the Consultant? ________

e) Are you satisfied with their response time? Yes: No:

f) What is the average response time of Suppliers? ________

g) Are you satisfied with their response time? Yes: No:

12) Are there any re-occurring operational problems? Yes: No:

If yes, explain: ______________________________
____
____

PART D: REPORTING

1) Does the Operator keep a record of their daily activities? Yes: No:
(flows, chlorine residuals, maintenance activities, etc.)

2) Have there been any Boil Water Advisories issued in the past 2 years? Yes: No:

3) What water quality problems are you most concerned with in your community?

____
____
____
____

PART E: OPERATORS

1) Do you have difficulty with the availability of qualified Operators? Yes: No:

2) How many new/replacement Operators have you hired in the last five years? ____________

3)

	Years of Experience	Training/ Certification	Full Time/ Part Time	Paid/ Volunteer
a)	_______	________________	___________	_____________
b)	_______	________________	___________	_____________
c)	_______	________________	___________	_____________

4) Operator Hours

a) What are the typical hours of work for an Operator? Per Day ______Per Week ________

b) How many hours are spent on work/maintenance related to the water treatment system/plant and distribution system, etc.?
Per Day ______Per Week ________

5) What is the typical hourly salary for an Operator? _______________

6) Have the Operator(s) received training to operate and maintain the water treatment system/plant and distribution system equipment by contractors, equipment suppliers, or through job shadowing?

Operator A Yes: No:
Operator B Yes: No:
Operator C Yes: No:

7) Are the Operator(s) familiar with calibrating and maintaining the disinfection equipment?

Operator A Yes: No: N/A:
Operator B Yes: No: N/A:
Operator C Yes: No: N/A:

8) Are there any limitations with Operator training? Yes: No: N/A:

a) Travel costs? Yes: No: N/A:

b) No replacement while on training? Yes: No: N/A:

c) Unwilling/no interest to attend? Yes: No: N/A:

d) Other: ____

9) a) Is there only one Operator? Yes: No: N/A:

b) Does anyone replace the Operator while on vacation, training, or sick? Yes: No: N/A:

Does this person have the same training as the Operator? Yes: No: N/A:

PART F: FINANCIAL

1) What are the average annual household water tax rates over the last 5 years? ________________

2) What percentage of your residential water tax base is outstanding for more than one year? _____

3) What is the average operation and maintenance allocation in your annual budget for your water treatment system/plant and distribution system over the last 5 years?

   ____

4) Have you requested and/or received capital works funding in the last 5 years for:

	Requested		Received	
Water Treatment System/Plant	Yes:	No:	Yes:	No:
Distribution System	Yes:	No:	Yes:	No:
Water Storage Tank	Yes:	No:	Yes:	No:

5) Have you requested and/or received operation and maintenance assistance related to your water treatment system/plant and/or distribution system in the last 5 years for:

   Requested Yes: No: Received Yes: No:

SECTION G: SYSTEM DEFICIENCIES

Please provide any additional comments regarding problems that you are currently having with your water treatment system/plant, water storage tank, and/or distribution system.

SECTION H: RECOMMENDATIONS

Do you have any recommendations on how the Department of Environment and Conservation, Water Resources Management Division and/or Department of Municipal Affairs can assist you with improvements to operation or maintenance issues related to your water treatment system/plant, water storage system/tank, and/or distribution system?

Signature

Date

APPENDIX C

SUMMARY TABLES FOR OPERATIONS AND MAINTENANCE,
OPERATOR TRAINING AND QUALIFICATIONS
SURVEY DATA SET

TABLE C1

COMPARISON OF OPERATION AND MAINTENANCE PRACTICES
FOR SURVEY DATA SET
BASED ON REGION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

		Region			
Contributing Factor	*Survey Input*	*Labrador*	*West*	*Central*	*East*
Frequency of Cl Testing (samples/day)	No input	3	14	8	10
	< 1 /day	1	7	7	9
	1 - 5/day	1	7	9	11
	6 - 10/day	1	1	0	1
	>10/day	0	0	0	3
Typical Operator Effort (h/week)	No input	2	12	9	15
	<20	1	9	6	9
	20 - 40	2	5	6	6
	>40	1	3	3	4
Typical Maintenance Effort (h/week)	No input	2	12	9	14
	<10	2	7	7	14
	10 - 20	0	7	5	3
	20 - 40	2	3	2	3
	>40	0	0	1	0
Operating & Maintenance Manuals	No input	1	9	6	10
	No	2	3	1	10
	Yes	3	17	17	14
Availability of Spare Parts	No input	2	9	7	10
	No	1	5	5	7
	Yes	3	15	12	17
Emergency Repair Parts Available	No input	1	8	5	8
	No	2	9	7	8
	Yes	3	12	12	18
	# of Survey Communities	6	29	24	34

TABLE C2

COMPARISON OF OPERATION AND MAINTENANCE PRACTICES
FOR SURVEY DATA SET
BASED ON GOVERANCE
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

		Governance	
Contributing Factor	*Survey Input*	*LSD*	*Municipality*
Frequency of Cl Testing (samples/day)	No input	12	26
	< 1 /day	10	15
	1 - 5/day	6	3
	6 - 10/day	0	18
	>10/day	2	1
Typical Operator Effort (h/week)	No input	16	25
	<20	13	17
	20 - 40	1	13
	>40	0	8
Typical Maintenance Effort (h/week)	No input	16	25
	<10	13	20
	10 - 20	1	10
	20 - 40	0	8
	>40	0	0
Operating & Maintenance Manuals	No input	6	20
	No	12	9
	Yes	12	34
Availability of Spare Parts	No input	8	20
	No	9	10
	Yes	13	33
Emergency Repair Parts Available	No input	5	16
	No	14	17
	Yes	11	30
	# of Survey Communities	**30**	**63**

TABLE C3

**COMPARISON OF OPERATION AND MAINTENANCE PRACTICES
FOR SURVEY DATA SET
BASED ON POPULATION
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR**

		Population		
Contributing Factor	***Survey Input***	***<500***	***501 - 1,500***	***>1,500***
Frequency of Cl Testing (samples/day)	No input	23	9	3
	< 1 /day	16	6	2
	1 - 5/day	15	6	7
	6 - 10/day	0	0	3
	>10/day	2	0	1
Typical Operator Effort (h/week)	No input	27	7	4
	<20	20	4	1
	20 - 40	8	3	8
	>40	1	7	3
Typical Maintenance Effort (h/week)	No input	27	6	4
	<10	21	7	2
	10 - 20	6	6	3
	20 - 40	2	2	6
	>40	0	0	1
Operating & Maintenance Manuals	No input	14	7	5
	No	15	1	0
	Yes	27	13	11
Availability of Spare Parts	No input	17	6	5
	No	15	3	0
	Yes	24	12	11
Emergency Repair Parts Available	No input	12	7	3
	No	21	5	0
	Yes	23	9	13
	# of Survey Communities	**56**	**21**	**16**

TABLE C4

COMPARISON OF OPERATOR STATUS AND QUALIFICATIONS BY REGION STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

		Region			
Survey Question	*Survey Input*	*Labrador*	*West*	*Central*	*East*
Operator Status	No input	3	14	12	21
	Part-time	1	4	4	4
	Part-time / Full-time	0	0	0	1
	Full-time	2	11	8	7
	Seasonal	0	0	0	1
Operator Certification	No	3	17	13	18
	Yes	3	12	11	16
Back-up Operator	No input	3	11	6	15
	No	0	10	6	9
	Yes	3	8	12	10
	# of Survey Communities	**6**	**29**	**24**	**34**

TABLE C5

COMPARISON OF OPERATOR STATUS AND QUALIFICATIONS BY GOVERNANCE
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Survey Question	*Survey Input*	*LSD*	*Municipality*
Operator Status	No input	21	29
	Part-time	2	6
	Part-time / Full-time	0	1
	Full-time	7	26
	Seasonal	0	1
Operator Certification	No	26	25
	Yes	4	38
Back-up Operator	No input	13	22
	No	6	19
	Yes	11	22
	# of Survey Communities	30	63

TABLE C6

COMPARISON OF OPERATOR STATUS AND QUALIFICATIONS BY POPULATION STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

		Population		
Survey Question	***Survey Input***	***<500***	***501 - 1,500***	***>1,500***
Operator Status	No input	34	9	7
	Part-time	13	0	0
	Part-time / Full-time	0	0	1
	Full-time	8	12	8
	Seasonal	1	0	0
Operator Certification	No	42	8	1
	Yes	14	13	15
Back-up Operator	No input	23	8	4
	No	16	5	4
	Yes	17	8	8
	# of Survey Communities	56	21	16

TABLE C7

COMPARISON OF ON-SITE WATER SYSTEM OPERATOR TRAINING BY REGION
FEBRUARY 2006 - FEBRUARY 2009 TRAINING RECORDS
STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Region	*# of Communities in Survey*	*# of Communities With Trained Operators*	*% of Communities With Trained Operators*	*# of Operators Receiving On-Site Training Per Region*	*# of Operators Receiving On-site Training Per Community*	*Average Hours of On-site Training Per Operator*
Labrador	6	4	66.7%	9	2.3	1.8
West	29	15	51.7%	36	2.4	1.5
Central	24	12	50.0%	42	3.5	1.2
East	34	20	58.8%	73	3.7	1.3

TABLE C8

COMPARISON OF ON-SITE WATER SYSTEM OPERATOR TRAINING
BY GOVERNANCE
FEBRUARY 2006 - FEBRUARY 2009 TRAINING RECORDS
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Governance	*# of Communities in Survey*	*# of Communities With Trained Operators*	*% of Communities With Trained Operators*	*# of Operators Receiving On-site Training Per Community*	*Average Hours of On-site Training Per Operator*
LSD	30	8	26.7%	3.5	1.0
Municipality	63	43	68.3%	3.1	1.4

TABLE C9

COMPARISON OF ON-SITE WATER SYSTEM OPERATOR TRAINING BY COMMUNITY POPULATION FEBRUARY 2006 - FEBRUARY 2009 TRAINING RECORDS STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Population	*# of Communities in Survey*	*# of Communities With Trained Operators*	*% of Communities With Trained Operators*	*# of Operators Receiving On-site Training Per Community*	*Average Hours of On-site Training Per Operator*
<500	57	25	43.9%	2.4	1.3
501 - 1,500	20	15	75.0%	2.5	1.5
>1,501	16	11	68.8%	5.7	1.2

TABLE C10

COMPARISON OF OPERATOR QUALIFICATIONS BY REGION
OETC DATA
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

Region	*# of Communities in Survey*	*# of Communities That Currently Have Certified Operators*	*% of Communities That Currently Have Certified Operators*	*# of Certified Operators Per Community*
Labrador	6	3	50.0%	2.7
West	29	12	41.4%	2.5
Central	24	11	45.8%	2.0
East	34	16	47.1%	1.9
Survey Total	93	42	45.2%	2.2

TABLE C11

COMPARISON OF OPERATOR QUALIFICATIONS BY POPULATION OETC DATA STUDY ON OPERATION AND MAINTENANCE OF DRINKING WATER INFRASTRUCTURE IN NEWFOUNDLAND AND LABRADOR

Population	*# of Communities in Survey*	*# of Communities That Currently Have Certified Operators*	*% of Communities That Currently Have Certified Operators*	*# of Certified Operators Per Community*
<500	56	14	25.0%	1.0
501 - 1,500	21	13	61.9%	1.1
>1,500	16	15	93.8%	4.2
Survey Data Set	93	42	45.2%	2.2

TABLE C12

COMPARISON OF OPERATOR QUALIFICATIONS
BY BWA CATEGORY
OETC DATA
STUDY ON OPERATION AND MAINTENANCE OF
DRINKING WATER INFRASTRUCTURE IN
NEWFOUNDLAND AND LABRADOR

BWA Category	*Contributing Factors*	*# of Communities in Survey**	*# of Communities That Currently Have Certified Operators*	*% of Communities That Currently Have Certified Operators*	*# of Certified Operators Per Community*
A	No disinfection	6	1	16.7%	1.0
B	Disinfection off-line by choice	4	0	0.0%	-
C	Disinfection off-line for maintenance	6	2	33.3%	1.0
D	Potential for inadequately treated water to enter distribution system	5	2	40.0%	2.0
E	Insufficient CT or free chlorine residual in distribution system	11	2	18.2%	1.0
F	Distribution of samples positive for microbiological parameters	3	0	0.0%	-
-	All BWA's	34	7	20.6%	1.3
-	No BWA	59	37	62.7%	2.2

**- one water system received a BWA due to multiple contributing factors, so that community is counted in the total for both BWA Categories E and F*

APPENDIX D

UNIT COSTS FOR WATER TREATMENT CHEMICALS – ST. JOHN'S

EAST-CHEM INC.
90 CLYDE AVE.
DONOVAN'S
INDUSTRIAL PARK

FAX
COVER SHEET

PHONE: (709) 747-3777 **FAX: (709) 747-5306**

TO:	Brian Luffman
COMPANY:	Conestoga-Rovers
FAX #	(709)364-5368
PHONE #	

FROM:	Lloyd Roberts	
SUBJECT:	Chemical pricing	
DATE:	Feb 11,2010	
TOTAL NO. Of PAGES (Including Cover):		1

MESSAGE

Hi Brian,

Reference your request here are the current prices on the products that you requested.
Please use them for estimating purposes, since they are subject to change over time and with quantities purchased at one time.

Sodium Hydroxide 50%, 205/L drum ------------------- $ 3.20/L

Sodium Hypochlorite 12% 205/L drum ---------------- $ 1.31/L
" " " 15/L case --------------- $ 1.50/L

Chlorine Gas 68Kg Cyl ---------------- $ 4.00/Kg

Liquid Alum 205/L drum-------------- $ 1.05/Kg

Polymer 20 Kg Pail-------------- $ 16.40/Kg

Lloyd Roberts
Eastchem (NL) Inc
(709)747-3777

APPENDIX E

ANNUALIZATION OF REPLACEMENT

TABLE E1

EFFORT SUMMARY BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

	SOURCE W/O FILTRATION		*CARTRIDGE FILTRATION*		*SLOW SAND FILTRATION*		*DIRECT FILTRATION*		*MEMBRANE FILTRATION*	
	Annualized Effort *Effort (hrs)*	***Cost @ $15 / hr***	***Annualized Effort*** *Effort (hrs)*	***Cost @ $15 / hr***	***Annualized Effort*** *Effort (hrs)*	***Cost @ $15 / hr***	***Annualized Effort*** *Effort (hrs)*	***Cost @ $15 / hr***	***Annualized Effort*** *Effort (hrs)*	***Cost @ $15 / hr***
Raw Supply	***335***	$ 5,017.50	***317***	$ 4,747.50	***317***	$ 4,747.50	***317***	$ 4,747.50	***317***	$ 4,747.50
Filtration	***0***	$ -	***187***	$ 2,808.75	***136***	$ 2,043.75	***187***	$ 2,808.75	***182***	$ 2,733.75
Disinfection	***246***	$ 3,682.50	***246***	$ 3,682.50	***246***	$ 3,682.50	***246***	$ 3,682.50	***246***	$ 3,682.50
+ monthly bac-t sampling	***192***	$ 2,880.00	***192***	$ 2,880.00	***192***	$ 2,880.00	***192***	$ 2,880.00	***192***	$ 2,880.00
Other Treatment	***46***	$ 685.50	***46***	$ 685.50	***46***	$ 685.50	***46***	$ 685.50	***46***	$ 685.50
Pumping / Station Capacity	***349***	$ 5,235.00	***349***	$ 5,235.00	***349***	$ 5,235.00	***349***	$ 5,235.00	***349***	$ 5,235.00
Distribution	***411***	$ 6,165.00	***411***	$ 6,165.00	***411***	$ 6,165.00	***411***	$ 6,165.00	***411***	$ 6,165.00
Storage	***0***	$ -	***41***	$ 607.50	***41***	$ 607.50	***41***	$ 607.50	***41***	$ 607.50
Building/Other	***566***	$ 8,493.00	***566***	$ 8,493.00	***566***	$ 8,493.00	***566***	$ 8,493.00	***566***	$ 8,493.00
Sub-total (hours)	**2144**	**$ 32,158.50**	**2354**	**$ 35,304.75**	**2303**	**$ 34,539.75**	**2354**	**$ 35,304.75**	**2349**	**$ 35,229.75**
Provincial Training - minimum (w/o travel)	20	$ 300.00	20	$ 300.00	20	$ 300.00	20	$ 300.00	20	$ 300.00
vacation	80	$ 1,200.00	80	$ 1,200.00	80	$ 1,200.00	80	$ 1,200.00	80	$ 1,200.00
illness	40	$ 600.00	40	$ 600.00	40	$ 600.00	40	$ 600.00	40	$ 600.00
	2284	**$ 34,258.50**	**2494**	**$ 37,404.75**	**2443**	**$ 36,639.75**	**2494**	**$ 37,404.75**	**2489**	**$ 37,329.75**

TABLE E2

EFFORT SUMMARY BY FREQUENCY - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

	SOURCE W/O FILTRATION		*CARTRIDGE FILTRATION*		*SLOW SAND FILTRATION*		*DIRECT FILTRATION*		*MEMBRANE FILTRATION*	
	Required	*Effort (hrs)*	*Required*	*Effort (hrs)*	*Required*	*Effort (hrs)*	*Required*	*Effort (hrs)*	*Required*	*Effort (hrs)*
		annual		**annual**		**annual**		**annual**		**annual**
Summary of Daily Tasks (365 days)	3.7	1332	4.0	1460	4.0	1460	4.0	1460	4.0	1460
Summary of Weekly Tasks	4.8	247	5.0	260	5.0	260	5.0	260	5.0	260
Summary of Monthly Tasks	14	166	18	211	13	154	18	214	17	208
+ Monthly Bac-T Sampling	16	192	16	192	16	192	16	192	16	192
Summary of Semi Annual Tasks	13	26	15	30	15	30	15	30	15	30
Summary of Annual Tasks										
total of seasonal items	109	109	113	113	113	113	113	113	113	113
once a year	29	29	53	53	53	53	53	53	51	51
Summary of 5 Year Tasks (days)	22	35	22	35	22	35	22	35	22	35
Sub-total (hours)		**2144**		**2354**		**2303**		**2357**		**2349**
Provincial Training - minimum (w/o travel)		20		20		20		20		20
vacation		80		80		80		80		80
illness		40		40		40		40		40
		2284		**2494**		**2443**		**2497**		**2489**

TABLE E3

OPERATION AND MAINTENANCE EFFORTS - BY TREATMENT PROCESS

Raw Supply

Daily	Inspect source pumps, motors and controls
Daily	Record source pump running times and cycle starts
Weekly	Record pumping rates for each well or source water pump
Monthly	Check source pumps - bearing temperature while in operation
Monthly	Inspect well heads
Monthly	Check and record static and pumping levels of each well
Six Months	check source pump power cable connections and tighten as necessary
July	Contact an electrician to check running amperage on each source pump
December	Contact an electrician to check running amperage on each well pump
Annual	Source pumps - Check bearing, stator and other sensors as applicable
Annual	Source pumps - Megger test winding insulation
Annual	Source pumps - Check direction of pump rotation
Annual	Source pumps - Check impeller condition
Annual	clean intake pipeline (swab)
Annual	inspect intake structure (damage + zebra mussels)
5 Years	Dismantle and clean the source pump and all parts
5 Years	Replace bearings on source pump
5 Years	Replace O rings on source pump
5 Years	Replace rubber seals on source pump

Filtration

Daily	Check and record filter influent and effluent turbidity
Weekly	Check filter backpressure
Monthly	Manual backwash (as required)
Monthly	Flush backwash water line
Monthly	Check backwash pumps - bearing temperature while in operation
Monthly	Check cartridge filters for discoloration / backpressure
Monthly	Exercise inlet and outlet control valves
Monthly	inspect and lubricate backwash and surface wash pumps
Monthly	Inspect the surface wash equipment (where applicable)
Monthly	Inspect air scour / blower
Six Months	Filter Vessels - visual inspection for corrosion
March	Backwash Water Waste Handling

TABLE E3

OPERATION AND MAINTENANCE EFFORTS - BY TREATMENT PROCESS

Filtration (continued)

June	Backwash Water Waste Handling
September	Backwash Water Waste Handling
December	Backwash Water Waste Handling
Annual	Shutdown filter
Annual	check media uniformity
Annual	check depth(s) of media layer(s)
Annual	inspect underdrain system
Annual	dewater and clean sedimentation tanks, floc tanks and clearwells

Disinfection

Daily	Inspect chemical feed pumps
Daily	Check and record chlorine residual at the point of application
Daily	Check chlorine quantity (liquid/gas) and record amount used
Weekly	Inspect chlorine testing equipment
Weekly	Take appropriate weekly water quality samples
Monthly	Check chemical pumps - bearing temperature while in operation
Monthly	Order Consumables (chemicals) / Accept Delivery and Changeout
January	Overhaul chemical feed pumps (O rings, check valves and diaphragms)
January	Inspect and clean chemical feed lines and solution tanks
January	Calibrate chemical feed pumps after overhaul
April	Inspect and clean chemical feed lines and solution tanks
April	Calibrate chemical feed pumps
July	Inspect and clean chemical feed lines and solution tanks
July	Calibrate chemical feed pumps
October	Inspect and clean chemical feed lines and solution tanks
October	Calibrate chemical feed pumps

Other Treatment

Daily	Check and Record ph readings (Pre- and Post-)
Monthly	Check pH pumps - bearing temperature while in operation
Monthly	Check pH Mixer
Six Months	inspect mixers

TABLE E3

OPERATION AND MAINTENANCE EFFORTS - BY TREATMENT PROCESS

Pumping / Station Capacity

Daily	Inspect booster pumps
Daily	Check water meter readings and record water production
Daily	Record booster pump running times and cycle starts
Weekly	Record pumping rates for each booster pump
Monthly	Check booster pumps - bearing temperature while in operation
Six Months	check booster pumppower cable connections and tighten as necessary
January	Operate all valves inside treatment and pump house
February	Operate all valves inside treatment and pump house
August	Operate all valves inside treatment and pump house
Annual	Booster pumps - Check bearing, stator and other sensors as applicable
Annual	Booster pumps - Megger test winding insulation
Annual	Booster pumps - Check direction of pump rotation
Annual	Booster pumps - Check impeller condition
5 Years	Dismantle and clean the booster pump and all parts
5 Years	Replace bearings on booster pump
5 Years	Replace O rings on booster pump
5 Years	Replace rubber seals on booster pumps

Distribution

Daily	Check and record chlorine residual in the distribution system
March	Exercise half of all mainline valves (distribution system)
June	Flush the distribution system and exercise/check all fire hydrant valves
September	Exercise mainline valves that were not exercised in March (distribution system)

Storage

Daily	Check and record water levels in storage tanks
May	Inspect storage tanks for defect and sanitary deficiencies
May	Clean storage tanks if necessary

TABLE E3

OPERATION AND MAINTENANCE EFFORTS - BY TREATMENT PROCESS

Building/Other

Daily	Investigate customer complaints
Daily	Complete daily security check (pump house, wells)
Daily	Inspect heater operations (winter months)
Daily	Check instrumentation for proper signal input/output
Weekly	Conduct weekly security check (plumbing, sump pumps, station alarms, backup power, fencing and gates)
Weekly	Clean pumphouse and grounds. Make sure fire hydrants are accessible
Weekly	Check inventory of all consumables
Monthly	Read all customer meters and compare against total water production for the month
Monthly	Lubricate locks
Monthly	Check condition and function of controllers
Monthly	Check spare parts inventory
Monthly	Read electric meter at pump house and record
Monthly	Check on-site insturmentation readings against lab results
Monthly	Record pump operating hours and all maintenance performed
Monthly	Complete and Submit monthly reports
Six Months	calibrate instrumentation
Six Months	lubricate rising stems valves and slide gates
Six Months	lubricate motor bearings of all continuous operating fans
January	Begin Safety Equipment Repair Log. Maintain log continuously throughout year
January	Review emergency response plans
February	Inspect chemical safety equipment and repair or replace as needed
March	Inspect, clean and repair control panels in treatment and pump house
June	Undertake preventative maintenance on treatment and pump house building
September	Inspect, clean and repair control panels in treatment and pump house
September	Prepare system for winter operation *
September	Clean and test building heaters
October	Prepare system for winter operation *
November	Prepare system for winter operation *

TABLE E3

OPERATION AND MAINTENANCE EFFORTS - BY TREATMENT PROCESS

Building/Other (cont'd)

Annual	Lube service for all pumps, compressors, mixers, valves and other plant equipment.
Annual	Check damper motors
Annual	Check overloads
Annual	Check pipe supports
Annual	dewater, inspect, clean and disinfect storage tank
Annual	inspect chemical feed, flow and level control systems
Annual	Confirm submittal of annual reports
5 Years	Touch up paint as required
5 Years	All pumps - Check pump lifting hardware

TABLE E4

OPERATION AND MAINTENANCE EFFORTS - BY FREQUENCY OF TASKS

Daily	Inspect chemical feed pumps
	Inspect source pumps, motors and controls
	Inspect booster pumps
	Investigate customer complaints
	Complete daily security check (pump house, wells)
	Inspect heater operations (winter months)
	Check instrumentation for proper signal input/output
	Check and record filter influent and effluent turbidity
	Check and record chlorine residual at the point of application
	Check and Record ph readings (Pre- and Post-)
	Check water meter readings and record water production
	Check chlorine quantity (liquid/gas) and record amount used
	Check and record water levels in storage tanks
	Record source pump running times and cycle starts
	Record booster pump running times and cycle starts
	Check and record chlorine residual in the distribution system
Weekly	Inspect chlorine testing equipment
	Take appropriate weekly water quality samples
	Conduct weekly security check (plumbing, sump pumps, station alarms, backup power, fencing and gates)
	Clean pumphouse and grounds. Make sure fire hydrants are accessible
	Check filter backpressure
	Check inventory of all consumables
	Record pumping rates for each well or source water pump
	Record pumping rates for each booster pump

TABLE E4

OPERATION AND MAINTENANCE EFFORTS - BY FREQUENCY OF TASKS

Monthly	Read all customer meters and compare against total water production for the month
	Check all pumps - bearing temperature while in operation
	Check pH Mixer
	Inspect well heads
	Lubricate locks
	Check condition and function of controllers
	Check spare parts inventory
	Check cartridge filters for discoloration / backpressure
	Manual backwash (as required)
	Flush backwash water line
	Exercise inlet and outlet control valves
	inspect and lubricate backwash and surface wash pumps
	Inspect the surface wash equipment (where applicable)
	Inspect air scour / blower
	Order Consumables (chemicals) / Accept Delivery and Changeout
	Read electric meter at pump house and record
	Check on-site insturmentation readings against lab results
	Check and record static and pumping levels of each well
	Record pump operating hours and all maintenance performed
	Complete and Submit monthly reports
Six Months	check power cable connections and tighten as necessary
	calibrate instrumentation
	inspect mixers
	lubricate rising stems valves and slide gates
	lubricate motor bearings of all continuous operating fans
	Filter Vessels - visual inspection for corrosion

TABLE E4

OPERATION AND MAINTENANCE EFFORTS - BY FREQUENCY OF TASKS

January	Overhaul chemical feed pumps (O rings, check valves and diaphragms)
	Inspect and clean chemical feed lines and solution tanks
	Calibrate chemical feed pumps after overhaul
	Operate all valves inside treatment and pump house
	Begin Safety Equipment Repair Log. Maintain log continuously throughout year
	Review emergency response plans
February	Inspect chemical safety equipment and repair or replace as needed
	Operate all valves inside treatment and pump house
March	Inspect, clean and repair control panels in treatment and pump house
	Backwash Water Waste Handling
	Exercise half of all mainline valves (distribution system)
April	Inspect and clean chemical feed lines and solution tanks
	Calibrate chemical feed pumps
May	Inspect storage tanks for defect and sanitary deficiencies
	Clean storage tanks if necessary
June	Flush the distribution system and exercise/check all fire hydrant valves
	Backwash Water Waste Handling
	Undertake preventative maintenance on treatment and pump house building
July	Inspect and clean chemical feed lines and solution tanks
	Calibrate chemical feed pumps
	Contact an electrician to check running amperage on each source pump
August	Operate all valves inside treatment and pump house

TABLE E4

OPERATION AND MAINTENANCE EFFORTS - BY FREQUENCY OF TASKS

September	Exercise mainline valves that were not exercised in March (distribution system)
	Inspect, clean and repair control panels in treatment and pump house
	Prepare system for winter operation *
	Backwash Water Waste Handling
	Clean and test building heaters
October	Inspect and clean chemical feed lines and solution tanks
	Calibrate chemical feed pumps
	Prepare system for winter operation *
November	Prepare system for winter operation *
December	Backwash Water Waste Handling
	Contact an electrician to check running amperage on each well pump
Annual	All pumps - Check bearing, stator and other sensors as applicable
	All pumps - Megger test winding insulation
	All pumps - Check direction of pump rotation
	All pumps - Check impeller condition
	Lube service for all pumps, compressors, mixers, valves and other plant equipment.
	Check damper motors
	Check overloads
	Check pipe supports
	dewater, inspect, clean and disinfect storage tank
	inspect chemical feed, flow and level control systems
	Confirm submittal of annual reports
	clean intake pipeline (swab)
	inspect intake structure (damage + zebra mussels)
	Shutdown filter
	check media uniformity
	check depth(s) of media layer(s)
	inspect underdrain system
	dewater and clean sedimentation tanks, floc tanks and clearwells

TABLE E4

OPERATION AND MAINTENANCE EFFORTS - BY FREQUENCY OF TASKS

5 Years	Dismantle and clean the entire pump and all parts
	Replace bearings
	Replace O rings
	Replace rubber seals
	Touch up paint as required
	All pumps - Check pump lifting hardware
10 Years	check for exfiltration or pipe damage
	replace filter canisters / vessels
	replace / upgrade media (as required)
	overhaul filter valves and backwash pumps

TABLE E5

EFFORT SUMMARY AND TASK DETAIL - BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

Frequency	Task	Esitmated Effort per task per unit (hrs)	SOURCE W/O FILTRATION				CARTRIDGE FILTRATION				SLOW SAND FILTRATION				DIRECT FILTRATION				MEMBRANE FILTRATION				SUPPLIER OR CONTRACTOR			
			Required	units	Effort (hrs)	Annualized Effort	Required	units	Effort (hrs)	Annualized Effort	Required	units	Effort (hrs)	Annualized Effort	Required	units	Effort (hrs)	Annualized Effort	Required	units	Effort (hrs)	Annualized Effort	Required	units	***ON-SITE Unit Effort (days)	TOTAL EFFORT (DAYS)
	SYSTEM EQUIPMENT																									
	No of Source Pumps			*2*				*2*				*2*				*2*				*2*				*2*		
	No of Chemical Pumps			*2*				*2*				*2*				*2*				*2*				*0*		
	No. of Backwash Pumps			*0*				*2*				*0*				*2*				*2*				*0*		
	No of Booster Pumps			*2*				*2*				*2*				*2*				*2*				*2*		
	pH System pumps			*2*				*2*				*2*				*2*				*2*				*0*		
	storage tanks			*0*				*1*				*1*				*1*				*1*				*1*		
	flushing			*1*				*1*				*1*				*1*				*1*				*1*		
1	**Raw Supply**		*335*			$ 5,017.50	*317*			$ 4,747.50	*317*			$ 4,747.50	*317*			$ 4,747.50	*317*			$ 4,747.50	*12*		**$**	**12,100.00**
2	**Filtration**		*0*			$ -	*187*			$ 2,808.75	*136*			$ 2,043.75	*187*			$ 2,808.75	*182*			$ 2,733.75	*0*		**$**	**-**
3	**Disinfection**		*246*			$ 3,682.50	*246*			$ 3,682.50	*246*			$ 3,682.50	*246*			$ 3,682.50	*246*			$ 3,682.50	*0*		**$**	**-**
	+ monthly bac-t sampling		*192*			$ 2,880.00	*192*			$ 2,880.00	*192*			$ 2,880.00	*192*			$ 2,880.00	*192*			$ 2,880.00			**$**	**-**
4	**Other Treatment**		*46*			$ 685.50	*46*			$ 685.50	*46*			$ 685.50	*46*			$ 685.50	*46*			$ 685.50	*0*		**$**	**-**
5	**Pumping / Station Capacity**		*349*			$ 5,235.00	*349*			$ 5,235.00	*349*			$ 5,235.00	*349*			$ 5,235.00	*349*			$ 5,235.00	*4*		**$**	**4,300.00**
6	**Distribution**		*411*			$ 6,165.00	*411*			$ 6,165.00	*411*			$ 6,165.00	*411*			$ 6,165.00	*411*			$ 6,165.00	*0*		**$**	**-**
7	**Storage**		*0*			$ -	*41*			$ 607.50	*41*			$ 607.50	*41*			$ 607.50	*41*			$ 607.50	*0*		**$**	**-**
8	**Building/Other**		*566*			$ 8,493.00	*566*			$ 8,493.00	*566*			$ 8,493.00	*566*			$ 8,493.00	*566*			$ 8,493.00	*3*		**$**	**3,000.00**
	Sub-total (hours)		**2144**			**$ 32,158.50**	**2354**			**$ 35,304.75**	**2303**			**$ 34,539.75**	**2354**			**$ 35,304.75**	**2349**			**$ 35,229.75**	**19**		**$**	**19,400.00**
	Provincial Training - minimum (w/o travel)		20			$ 300.00	20			$ 300.00	20			$ 300.00	20			$ 300.00	20			$ 300.00				
	vacation		80			$ 1,200.00	80			$ 1,200.00	80			$ 1,200.00	80			$ 1,200.00	80			$ 1,200.00				
	illness		40			$ 600.00	40			$ 600.00	40			$ 600.00	40			$ 600.00	40			$ 600.00				
			2284			**$ 34,258.50**	**2494**			**$ 37,404.75**	**2443**			**$ 36,639.75**	**2494**			**$ 37,404.75**	**2489**			**$ 37,329.75**				

TABLE E5

EFFORT SUMMARY AND TASK DETAIL - BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

			SOURCE W/O FILTRATION				CARTRIDGE FILTRATION				SLOW SAND FILTRATION				DIRECT FILTRATION				MEMBRANE FILTRATION				SUPPLIER OR CONTRACTOR			
Frequency	*Task*	*Esitmated Effort per task per unit (hrs)*	*Required*	*units*	*Effort (hrs)*	*Annualized Effort*	*Required*	*units*	*Effort (hrs)*	*Annualized Effort*	*Required*	*units*	*Effort (hrs)*	*Annualized Effort*	*Required*	*units*	*Effort (hrs)*	*Annualized Effort*	*Required*	*units*	*Effort (hrs)*	*Annualized Effort*	*Required*	*units*	****ON-SITE Unit Effort (days)*	*TOTAL EFFORT (DAYS)*
	Raw Supply																									
Daily	Inspect source pumps, motors and controls	0.25	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5				0
Daily	Record source pump running times and cycle starts	0.1	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73				0
Weekly	Record pumping rates for each well or source water pump	0.25	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26				0
Monthly	Check source pumps - bearing temperature while in operation	0.25	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6				0
Monthly	Inspect well heads	0.5	Y	2	1	12		2	0	0		2	0	0		2	0	0		2	0	0				0
Monthly	Check and record static and pumping levels of each well	0.5	Y	2	1	12			0	0			0	0			0	0			0	0				0
Six Months	check source pump power cable connections and tighten as necessary	1	Y	2	2	4	Y	2	2	4	Y	2	2	4	Y	2	2	4	Y	2	2	4				0
July	Contact an electrician to check running amperage on each source pump	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	1	2
December	Contact an electrician to check running amperage on each well pump	0.25	Y	2	0.25	0.5	Y	2	0.25	0.5	Y	2	0.25	0.5	Y	2	0.25	0.5	Y	2	0.25	0.5	Y	1	1	1
Annual	Source pumps - Check bearing, stator and other sensors as applicable	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
Annual	Source pumps - Megger test winding insulation	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
Annual	Source pumps - Check direction of pump rotation	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5		2		0
Annual	Source pumps - Check impeller condition	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
Annual	clean intake pipeline (swab)	4			0	0	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y	1	1	1
Annual	inspect intake structure (damage + zebra mussels)	2			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y	1	1	1
5 Years	Dismantle and clean the source pump and all parts	16	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	8	3.2
5 Years	Replace bearings on source pump	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.8
5 Years	Replace O rings on source pump	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.8
5 Years	Replace rubber seals on source pump	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.8
						334.5				**316.5**				**316.5**				**316.5**				**316.5**				**12.1**
	Filtration																									
Daily	***Check and record filter influent and effluent turbidity***	**0.25**			0	0	Y		0.25	91.25	Y		0.25	91.25	Y		0.25	91.25	Y		0.25	91.25				0
Weekly	***Check filter backpressure***	**0.25**			0	0	Y		0.25	13	Y		0.25	13	Y		0.25	13	Y		0.25	13				0
Monthly	***Manual backwash (as required)***	**2**			0	0	Y		2	24			0	0	Y		2	24	Y		2	24				0
Monthly	***Flush backwash water line***	**1**			0	0	Y		1	12			0	0	Y		1	12	Y		1	12				0
Monthly	Check backwash pumps - bearing temperature while in operation	0.25			0	0	Y	2	0.5	6	Y	0	0	0	Y	2	0.5	6	Y	2	0.5	6				0
Monthly	***Check cartridge filters for discoloration / backpressure***	**0.25**			0	0	Y		0.25	3			0	0			0	0			0	0				0
Monthly	***Exercise inlet and outlet control valves***	**0.25**			0	0	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3				0
Monthly	***inspect and lubricate backwash and surface wash pumps***	**0.25**			0	0	Y	2	0.5	6			0	0	Y	2	0.5	6	Y	2	0.5	6				0
Monthly	***Inspect the surface wash equipment (where applicable)***	**0.25**			0	0	Y		0.25	3	Y		0.25	3	Y		0.25	3			0	0				0
Monthly	***Inspect air scour / blower***	**0.25**			0	0			0	0			0	0	Y		0.25	3	Y		0.25	3				0
Six Months	***Filter Vessels - visual inspection for corrosion***	**1**			0	0	Y		1	2	Y		1	2	Y		1	2	Y		1	2				0
March	Backwash Water Waste Handling	2			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
June	Backwash Water Waste Handling	2			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
September	Backwash Water Waste Handling	2			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
December	Backwash Water Waste Handling	2			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0

TABLE E5

EFFORT SUMMARY AND TASK DETAIL - BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

Frequency	Task	Esitmated Effort per task per unit (hrs)	SOURCE W/O FILTRATION				CARTRIDGE FILTRATION				SLOW SAND FILTRATION				DIRECT FILTRATION				MEMBRANE FILTRATION				SUPPLIER OR CONTRACTOR			
			Required	units	Effort (hrs)	Annualizted Effort	Required	units	Effort (hrs)	Annualizted Effort	Required	units	Effort (hrs)	Annualizted Effort	Required	units	Effort (hrs)	Annualizted Effort	Required	units	Effort (hrs)	Annualizted Effort	Required	units	***ON-SITE Unit Effort (days)	TOTAL EFFORT (DAYS)
	Filtration (continued)																									0
Annual	***Shutdown filter***	**2**			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y	0	0.5	0
Annual	***check media uniformity***	**2**			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y	0	0.5	0
Annual	***check depth(s) of media layer(s)***	**2**			0	0	Y		2	2	Y		2	2	Y		2	2			0	0	Y	0	0.5	0
Annual	***inspect underdrain system***	**2**			0	0	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y	0	0.5	0
Annual	***dewater and clean sedimentation tanks, floc tanks and clearwells***	**8**			0	0	Y		8	8	Y		8	8	Y		8	8	Y		8	8				0
						0				**187.25**				**136.25**				**187.25**				**182.25**				**0**
	Disinfection																									
Daily	Inspect chemical feed pumps	0.1	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5				0
Daily	Check and record chlorine residual at the point of application	0.1	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5				0
Daily	Check chlorine quantity (liquid/gas) and record amount used	0.1	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5				0
Weekly	Inspect chlorine testing equipment	1	Y		1	52	Y		1	52	Y		1	52	Y		1	52	Y		1	52				0
Weekly	Take appropriate weekly water quality samples	1	Y		1	52	Y		1	52	Y		1	52	Y		1	52	Y		1	52				0
Monthly	Check chemical pumps - bearing temperature while in operation	0.25	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6				0
Monthly	Order Consumables (chemicals) / Accept Delivery and Changeout	1	Y		1	12	Y		1	12	Y		1	12	Y		1	12	Y		1	12				0
January	Overhaul chemical feed pumps (O rings, check valves and diaphragms)	1	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	0	0.5	0
January	Inspect and clean chemical feed lines and solution tanks	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5				0
January	Calibrate chemical feed pumps after overhaul	2	Y	2	4	4	Y	2	4	4	Y	2	4	4	Y	2	4	4	Y	2	4	4	Y	0	0.25	0
April	Inspect and clean chemical feed lines and solution tanks	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5				0
April	Calibrate chemical feed pumps	1	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	0	0.5	0
July	Inspect and clean chemical feed lines and solution tanks	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5				0
July	Calibrate chemical feed pumps	1	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	0	0.5	0
October	Inspect and clean chemical feed lines and solution tanks	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5	Y		0.5	0.5				0
October	Calibrate chemical feed pumps	1	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	2	2	2	Y	0	0.5	0
						245.5				**245.5**				**245.5**				**245.5**				**245.5**				**0**
	Other Treatment																									
Daily	Check and Record ph readings (Pre- and Post-)	0.1	Y	1	0.1	36.5	Y	1	0.1	36.5	Y	1	0.1	36.5	Y	1	0.1	36.5	Y	1	0.1	36.5				0
Monthly	Check pH pumps - bearing temperature while in operation	0.25	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6				0
Monthly	Check pH Mixer	0.1	Y	1	0.1	1.2	Y	1	0.1	1.2	Y	1	0.1	1.2	Y	1	0.1	1.2	Y	1	0.1	1.2				0
Six Months	inspect mixers	1	Y	1	1	2	Y	1	1	2	Y	1	1	2	Y	1	1	2	Y	1	1	2				0
						45.7				**45.7**				**45.7**				**45.7**				**45.7**				

TABLE E5

EFFORT SUMMARY AND TASK DETAIL - BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

			SOURCE W/O FILTRATION				CARTRIDGE FILTRATION				SLOW SAND FILTRATION				DIRECT FILTRATION				MEMBRANE FILTRATION				SUPPLIER OR CONTRACTOR			
Frequency	*Task*	*Esitmated Effort per task per unit (hrs)*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	****ON-SITE Unit Effort (days)*	*TOTAL EFFORT (DAYS)*
	Pumping / Station Capacity																									
Daily	Inspect booster pumps	0.25	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5	Y	2	0.5	182.5				0
Daily	Check water meter readings and record water production	0.1	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5				0
Daily	Record booster pump running times and cycle starts	0.1	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73	Y	2	0.2	73				0
Weekly	Record pumping rates for each booster pump	0.25	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26	Y	2	0.5	26				0
Monthly	Check booster pumps - bearing temperature while in operation	0.25	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6	Y	2	0.5	6				0
Six Months	check booster pumppower cable connections and tighten as necessary	1	Y	2	2	4	Y	2	2	4	Y	2	2	4	Y	2	2	4	Y	2	2	4				0
January	Operate all valves inside treatment and pump house	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1				0
February	Operate all valves inside treatment and pump house	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1				0
August	Operate all valves inside treatment and pump house	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1	Y		1	1				0
Annual	Booster pumps - Check bearing, stator and other sensors as applicable	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
Annual	Booster pumps - Megger test winding insulation	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
Annual	Booster pumps - Check direction of pump rotation	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5		2		0
Annual	Booster pumps - Check impeller condition	0.25	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.5	0.5	Y	2	0.25	0.5
5 Years	Dismantle and clean the booster pump and all parts	16	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	32	6.4	Y	2	8	1.6
5 Years	Replace bearings on booster pump	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.4
5 Years	Replace O rings on booster pump	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.4
5 Years	Replace rubber seals on booster pumps	8	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	16	3.2	Y	2	2	0.4
						349				**349**				**349**				**349**				**349**				**4.3**
	Distribution																									
Daily	Check and record chlorine residual in the distribution system	1	Y		1	365	Y		1	365	Y		1	365	Y		1	365	Y		1	365				0
March	Exercise half of all mainline valves (distribution system)	0.5	Y	20	10	10	Y	20	10	10	Y	20	10	10	Y	20	10	10	Y	20	10	10				0
June	Flush the distribution system and exercise/check all fire hydrant valves	16	Y	1	16	16	Y	1	16	16	Y	1	16	16	Y	1	16	16	Y	1	16	16				0
September	Exercise mainline valves that were not exercised in March (distribution system)	1	Y	20	20	20	Y	20	20	20	Y	20	20	20	Y	20	20	20	Y	20	20	20				0
						411				**411**				**411**				**411**				**411**				
	Storage																									
Daily	Check and record water levels in storage tanks	0.1	Y	0	0	0	Y	1	0.1	36.5	Y	1	0.1	36.5	Y	1	0.1	36.5	Y	1	0.1	36.5				0
May	Inspect storage tanks for defect and sanitary deficiencies	2	Y	0	0	0	Y	1	2	2	Y	1	2	2	Y	1	2	2	Y	1	2	2				0
May	Clean storage tanks if necessary	2	Y	0	0	0	Y	1	2	2	Y	1	2	2	Y	1	2	2	Y	1	2	2				0
						0				**40.5**				**40.5**				**40.5**				**40.5**				
	Building/Other																									
Daily	Investigate customer complaints	0.25	Y		0.25	91.25	Y		0.25	91.25	Y		0.25	91.25	Y		0.25	91.25	Y		0.25	91.25				0
Daily	Complete daily security check (pump house, wells)	0.2	Y		0.2	73	Y		0.2	73	Y		0.2	73	Y		0.2	73	Y		0.2	73				0
Daily	Inspect heater operations (winter months)	0.1	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5	Y		0.1	36.5				0
Daily	Check instrumentation for proper signal input/output	0.2	Y		0.2	73	Y		0.2	73	Y		0.2	73	Y		0.2	73	Y		0.2	73				0

TABLE E5

EFFORT SUMMARY AND TASK DETAIL - BY PROCESS - OPERATION AND MAINTENANCE OF WATER SYSTEMS - AS PER USEPA GUIDELINES

			SOURCE W/O FILTRATION				CARTRIDGE FILTRATION				SLOW SAND FILTRATION				DIRECT FILTRATION				MEMBRANE FILTRATION				SUPPLIER OR CONTRACTOR			
Frequency	*Task*	*Esitmated Effort per task per unit (hrs)*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	*Effort (hrs)*	*Annualizted Effort*	*Required*	*units*	****ON-SITE Unit Effort (days)*	*TOTAL EFFORT (DAYS)*
	Building/Other (Continued)																									0
Weekly	Conduct weekly security check (plumbing, sump pumps, station alarms, backup power, fencing and gates)	0.5	Y		0.5	26	Y		0.5	26	Y		0.5	26	Y		0.5	26	Y		0.5	26				0
Weekly	Clean pumphouse and grounds. Make sure fire hydrants are accessible	1	Y		1	52	Y		1	52	Y		1	52	Y		1	52	Y		1	52				0
Weekly	Check inventory of all consumables	0.25	Y		0.25	13	Y		0.25	13	Y		0.25	13	Y		0.25	13	Y		0.25	13				0
Monthly	*Read all customer meters and compare against total water production for the month*	2	Y		2	24	Y		2	24	Y		2	24	Y		2	24	Y		2	24				0
Monthly	Lubricate locks	0.25	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3				0
Monthly	Check condition and function of controllers	1	Y		1	12	Y		1	12	Y		1	12	Y		1	12	Y		1	12				0
Monthly	Check spare parts inventory	0.5	Y		0.5	6	Y		0.5	6	Y		0.5	6	Y		0.5	6	Y		0.5	6				0
Monthly	Read electric meter at pump house and record	0.25	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3				0
Monthly	Check on-site insturmentation readings against lab results	0.5	Y		0.5	6	Y		0.5	6	Y		0.5	6	Y		0.5	6	Y		0.5	6				0
Monthly	Record pump operating hours and all maintenance performed	0.25	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3	Y		0.25	3				0
Monthly	Complete and Submit monthly reports	4	Y		4	48	Y		4	48	Y		4	48	Y		4	48	Y		4	48				0
Six Months	calibrate instrumentation	4	Y		4	8	Y		4	8	Y		4	8	Y		4	8	Y		4	8	Y	1	1	1
Six Months	lubricate rising stems valves and slide gates	2	Y		2	4	Y		2	4	Y		2	4	Y		2	4	Y		2	4				0
Six Months	lubricate motor bearings of all continuous operating fans	2	Y		2	4	Y		2	4	Y		2	4	Y		2	4	Y		2	4				0
January	Begin Safety Equipment Repair Log. Maintain log continuously throughout year	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
January	Review emergency response plans	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
February	Inspect chemical safety equipment and repair or replace as needed	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
March	Inspect, clean and repair control panels in treatment and pump house	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y	1	1	1
June	Undertake preventative maintenance on treatment and pump house building	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8				0
September	Inspect, clean and repair control panels in treatment and pump house	16	Y		16	16	Y		16	16	Y		16	16	Y		16	16	Y		16	16				0
September	Prepare system for winter operation *	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
September	Clean and test building heaters	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
October	Prepare system for winter operation *	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
November	Prepare system for winter operation *	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
Annual	Lube service for all pumps, compressors, mixers, valves and other plant equipment.	0.25	Y	4	1	1	Y	4	1	1	Y	4	1	1	Y	4	1	1	Y	4	1	1	Y	4	0.25	1
Annual	Check damper motors	0.25	Y		0.25	0.25	Y		0.25	0.25	Y		0.25	0.25	Y		0.25	0.25	Y		0.25	0.25				0
Annual	Check overloads	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
Annual	Check pipe supports	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2	Y		2	2				0
Annual	dewater, inspect, clean and disinfect storage tank	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8				0
Annual	inspect chemical feed, flow and level control systems	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8	Y		8	8	Y	0	1	0
Annual	Confirm submittal of annual reports	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4	Y		4	4				0
5 Years	Touch up paint as required	8	Y		8	1.6	Y		8	1.6	Y		8	1.6	Y		8	1.6	Y		8	1.6				0
5 Years	All pumps - Check pump lifting hardware	8	Y		8	1.6	Y		8	1.6	Y		8	1.6	Y		8	1.6	Y		8	1.6				0
						566.2				**566.2**				**566.2**				**566.2**				**566.2**				**3**

APPENDIX F

HISTORICAL CASE STUDY – WALKERTON, ONTARIO

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HISTORICAL CASE STUDY – WALKERTON, ONTARIO

Over the course of the Phase 2 of this project, CRA personnel have noticed a number of similarities between the current situation with respect to the public drinking water supply in Newfoundland and Labrador and the circumstances in Ontario in May 2000, at the time of the waterborne disease outbreak in Walkerton, Ontario. Some of these similarities are based on the regulatory climate, others are based on observations and data that were collected regarding the operation of public water supplies in the Province of Newfoundland and Labrador.

1.0 BACKGROUND

The community of Walkerton is located in rural Bruce County, Ontario. At the time of the outbreak, the population of Walkerton was approximately 4,800 people (Hrudey and Hrudey, 2004).

At the time of the outbreak, the Walkerton municipal drinking water system had three drilled water supply wells, Wells No. 5, No. 6, and No. 7. Each well was completed in an unconfined fractured bedrock aquifer (O'Connor, 2002a). Well No. 5 was completed at a shallow depth of 15 metres (m) compared to Well No. 6 (72.2 m) and Well No. 7 (76.2 m) (Hrudey and Hrudey, 2004). Each well was outfitted with a separate chlorination system to achieve primary disinfection prior to the treated water reaching the first user. Historical construction documents and MOE inspection records for Well No. 5 suggested that the aquifer the well was completed in was Groundwater Under the Influence of Surface Water (GUDI), although there is no indication that the Walkerton Public Utilities Commission (PUC) personnel who operated the system or more recent MOE inspectors were aware of the vulnerability of the well (O'Connor, 2002a).

According to the Walkerton Inquiry, the accumulated rainfall for the Walkerton area over the period of May 8 to 12, 2000 was 134 millimetres (mm), which was equivalent to a 60-year storm event for this area in the month of May (O'Connor, 2002a). Flooding occurred in the town and in the area of Well No. 5. On May 9, 2000, the water supply was switched from Well No. 7, which was in operation despite not having a functioning chlorination system at that time, to Wells No. 5 and No. 6. Well No. 5 operated continuously and was the primary water source from May 10 until the afternoon of May 15, with the exception of a period of approximately 16 hours between the evening of May 12 and the afternoon of May 13 when it was shut down. Over this period, the contamination that caused the outbreak is believed to have entered the aquifer supplying Well No. 5. The well was located near a cattle farm, and manure was land applied within 100 m of the well in the weeks prior to the outbreak. Bacterial contaminants associated with the manure are likely to have entered the aquifer via conduits through the thin overburden layer, such as fence posts on the farm property or improperly abandoned water supply wells (O'Connor, 2002a).

Walkerton Public Utilities Commission (PUC) staff recorded free chlorine residual concentrations of 0.75 milligrams per Litre (mg/L) for treated water from Well No. 5 on May 13 and 14. It is unlikely that the recorded numbers were accurate, as PUC staff often falsified records with respect to free chlorine levels, and testimony from experts during the Walkerton Inquiry who estimated that the initial chlorine dose at Well No. 5 was likely in the range of 0.4 to 0.44 mg/L (O'Connor, 2002a). On May 15, PUC staff collected several water samples, a number of which may have been labeled with the incorrect sampling location, and shipped them to a private laboratory for analysis of microbiological parameters. On May 17, the PUC was notified that the majority of these samples were positive for both *Escherichia coli* (*E. coli*) and total coliform bacteria. PUC staff withheld these results from the Ontario Ministry of the Environment (MOE) and Bruce-Grey-Owen Sound Health Unit (PHU) staff until May 22, 2000 (O'Connor, 2002a).

Due to exposure to Campylobacter and E. coli O157:H7 present in the Walkerton water system in May 2000, approximately 2,321 people became ill, 27 people developed Hemolytic Uremic Syndrome (HUS), and 7 people died (O'Connor, 2002a).

2.0 COMPARISON WITH ISSUES IN NEWFOUNDLAND

2.1 REGULATORY CLIMATE

At the time of the outbreak, municipal water systems in the Province of Ontario were required to apply for a Certificate of Approval (C of A) from the MOE when constructing new water system infrastructure, such as a well. If a C of A was issued, the Minister could set out specific operating conditions as part of the C of A. Over time, the MOE developed standard language with respect to operating conditions, adopting the requirements of new guidelines and standards as they were implemented. One such standard was the 1994 Ontario Drinking Water Objectives (ODWO), which required continuous chlorine and turbidity monitoring of GUDI wells. The MOE did not have a policy of reviewing existing C of A's to determine whether they should be revised based on recent changes in guidelines or best practices (O'Connor, 2002a).

Under the Water Resources Act (Newfoundland), Chapter W-4.01, Part II, Section 37 indicates that plans, specifications, and an engineer's report must be submitted to the Minister prior to construction of new water works or modification of existing water works. The Minister may place terms and conditions on the permit as needed (Department of Environment and Conservation, 2009b). Under Section 49, Subsection 2, the Minister may add or amend a condition in the event that was not reasonably foreseeable at the time of the application has occurred or may occur (Department of Environment and Conservation, 2009b). Based on this language, the Minister could amend existing permits for water works to include more stringent treatment or monitoring requirements as best management practices for drinking water systems have improved with time. However, there is no indication that such a program for amending permits for public water systems is in place.

At the time of the outbreak, treatment and monitoring requirements for municipal water systems in Ontario were set out in the aforementioned ODWO and Bulletin 65-W-4, "Chlorination of Potable Water Supplies." Both of these documents were considered to be guidelines or policies, not legally binding regulations (O'Connor, 2002a).

Similarly, the Department of Environment and Conservation (ENVC) has set out guidelines for water quality monitoring and reporting requirements for public water supplies as part of a policy directive, and has set out standards for disinfection, water quality monitoring, corrective actions and reporting for public water supplies. Binding regulations do not appear to have been developed for treatment or monitoring.

At the time of the outbreak, certification of water operators was mandatory for municipal water systems (O'Connor, 2002a). However, experienced water system operators, such as the General Manager and Foreman of the Walkerton PUC, could receive certification through a "grandfather" clause without participating in any specific training courses or completing an exam (O'Connor, 2002a). There were annual training requirements for water system operators, although Walkerton PUC personnel did not necessarily complete the required level of training on an annual basis.

Operator certification is a voluntary process at this time in Newfoundland (ENVC, 2005). However, the situation is similar in the sense that operators do not need to pass an exam prior to operating a public water system, and do not need to complete a minimum amount of training per year in order to maintain their position.

2.2 OPERATION OF PUBLIC WATER SYSTEMS

At the time of the outbreak, Walkerton PUC personnel recorded daily free chlorine levels for the water supply wells that were in service on that day (O'Connor, 2002a). The treated water sampling frequency was not specified in the Chlorination Bulletin, but was agreed upon between the MOE and the Walkerton PUC in 1979, at the time that Well No. 5 was brought into service. Based on testimony given by the Walkerton PUC at the Inquiry, treated water samples were rarely collected from the wells. Instead, Walkerton PUC falsified entries for free chlorine levels, typically recording a concentration in the 0.5 to 0.75 mg/L range (O'Connor, 2002a). These values were used because the minimum acceptable concentration was 0.5 mg/L after 30 minutes of contact time under the Chlorination Bulletin (Ministry of the Environment, 1987).

In the data collected by the basic and detailed surveys, none of the participating water systems shared information regarding the falsification of free chlorine records. However, a number of communities indicated that they collected free chlorine readings on a less than daily basis. The frequency of free chlorine monitoring was lowest for water systems serving LSDs and very small (i.e., service population of less than 500) communities. Roughly half of the communities serving less than 1,500 people that responded to the survey question regarding the frequency of free chlorine monitoring indicated that samples were collected on a less than daily basis. Although the sampling frequency improved for medium and large water systems (i.e., service population of greater than 1,500), 2 of the 13 systems (15 percent) indicated that they monitored free chlorine levels on a less than daily basis.

Walkerton PUC personnel knowingly set the chlorine dosage so that the initial concentration was in the range of 0.3 to 0.5 mg/L, which is below the guideline limit of 0.5 mg/L after 30 minutes of contact time that is listed in the Chlorination Bulletin (O'Connor, 2002a). This decision was informed partly by the belief of PUC personnel that the water from the supply wells was safe, and did not require disinfection. Walkerton PUC personnel also indicated that residents complained about the aesthetic quality of the water due to the chlorine levels (O'Connor, 2002a). The limited training received by Walkerton PUC personnel likely contributed to their decision to reduce the chlorine dose based on the above factors.

As of February 2009, 13 communities in the Province of Newfoundland were under a Category B Boil Water Advisory (BWA). A Category B BWA indicates that the chlorination system has purposely been removed from service due to aesthetic concerns, concerns regarding health risks associated with Disinfection By-products (DBPs), or because the community does not have funds to operate the system. As indicated in Section 2.3.2.5, water system operators in communities that are under a Category B BWA are not typically certified, and generally have participated in minimal on-site training. The lack of education and training of these operators may contribute to their decision to remove chlorination equipment from service.

3.0 SUMMARY OF APPLICABLE RECOMMENDATIONS FROM THE REPORT OF THE WALKERTON INQUIRY

Justice O'Connor identified many of the recommendations listed in the report based on Best Management Practices that had been implemented in other jurisdictions at the time of the Inquiry (O'Connor, 2002b). Therefore, some of these recommendations have been in effect in other jurisdictions for greater than 10 years.

3.1 RECOMMENDATIONS THAT HAVE BEEN ADDRESSED

Some of the recommendations have already been implemented in the Province of Newfoundland, to some extent. These recommendations include:

- Develop a source water protection program that includes the protection of surface water intake and wellhead areas.
- Develop a drinking water operator training curriculum that is accessible to, and has content that is relevant to, operators in small and remote communities (O'Connor, 2002b).

3.2 RECOMMENDATIONS REGARDING STANDARDS

The Walkerton Inquiry includes recommendations regarding standards and equipment for water treatment and monitoring. Specific recommendations included:

- Develop legally binding drinking water quality standards for the Province.
- Develop binding regulations regarding treatment, monitoring, and reporting for non-municipal or non-residential drinking water systems that serve designated facilities (i.e., children's camps, day nurseries, health care facilities, schools, etc.) and public facilities (i.e., campgrounds, restaurants, other facilities that supply the public with drinking water).
- Upgrade monitoring equipment at municipal water treatment plants to include continuous monitoring equipment with alarms that signal when GCDWQ or Provincial water quality limits have been exceeded.
- Amend regulations to specify requirements for drinking water sampling procedures at facilities where samples are not collected by ENVC personnel.
- Develop alternative means of providing microbiological testing for communities where samples cannot be delivered to a laboratory within the specified holding time due to remoteness (O'Connor, 2002b).

3.3 RECOMMENDATIONS REGARDING LOCAL GOVERNANCE

The Walkerton Inquiry includes recommendations regarding the role of the local government in ensuring a safe drinking water supply. One recommendation is that municipalities raise adequate resources and develop individual financial plans to achieve full cost recovery (O'Connor, 2002b).

It should be noted that the structure of local government for some communities in Newfoundland (i.e., Local Service Districts) may be different from Ontario. As a result, these recommendations may need to be modified for implementation in communities with limited resources.

3.4 RECOMMENDATIONS REGARDING QUALITY MANAGEMENT

The Walkerton Inquiry recommends that municipalities adopt a quality management approach to supplying drinking water (O'Connor, 2002b). The quality management standard set out for municipal water systems in Ontario in the Drinking water quality management standard may be too onerous for small municipalities in Newfoundland to complete. Drinking water quality management guides that have been developed in other jurisdictions (i.e., Australia and New Zealand) for small water systems could be used as a reference when developing guidance documents specific to small water systems in Newfoundland.

3.5 RECOMMENDATIONS REGARDING OPERATOR TRAINING

The actions of Walkerton PUC personnel prior to and during the May 2000 outbreak demonstrated that the operators did not have sufficient training or understanding of the importance of their role in delivering safe drinking water. As a result, the following recommendations were made:

- Require all drinking water operators to complete a mandatory entry level training course.
- Require all municipal water system operators to be certified based on completion of a mandatory exam (O'Connor, 2002b).

3.6 RECOMMENDATIONS REGARDING PROVINCIAL GOVERNMENT

The Walkerton Inquiry included recommendations intended to improve the way that the provincial government fulfilled its role with respect to drinking water oversight in the Province of Ontario. Specific recommendations included:

- Create drinking water policies that implement the Multiple Barrier Approach to drinking water safety, and a Safe Drinking Water Act.
- Ensure programs related to drinking water safety are adequately funded (O'Connor, 2002b).

3.7 RECOMMENDATIONS REGARDING SMALL WATER SYSTEMS

The Walkerton Inquiry recognized that small communities and non-municipal systems may not have sufficient resources to invest in the recommended upgrades to water system operations and management practices. As a result, the following recommendations were made:

- Allow small systems to apply for variances from treatment requirements under the Act, such that variance would be allowed based on the results of a site-specific risk assessment
- Refuse to approve water systems that are not economically viable (O'Connor, 2002b)

For greater detail on these recommendations, interested parties are encouraged to refer to Part II of the Report of the Walkerton Inquiry: A Strategy for Safe Drinking Water.