

CITY OF RUTLAND

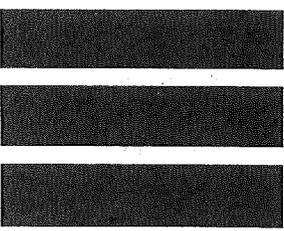
DISINFECTION BYPRODUCTS  
REDUCTION STUDY

RUTLAND, VERMONT



OTTER CREEK  
ENGINEERING

APRIL, 2012



# CITY OF RUTLAND

## DISINFECTION BYPRODUCTS REDUCTION STUDY

RUTLAND, VERMONT



April, 2012

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**Table of Contents**

**Section**

- 1.0 Introduction
- 2.0 Conclusions and Recommendations
- 3.0 Existing Water Treatment Facility and Historical DBP Data
- 4.0 Disinfection Byproduct Monitoring and Pilot Testing
- 5.0 Disinfection Byproduct Reduction Alternatives
  - 5.1 Modifications to Existing Disinfection Location
  - 5.2 Chloramination
  - 5.3 Granulated Activated Carbon (GAC)
  - 5.4 Magnetic Ion Exchange
- 6.0 Conceptual Design of Alternate Solutions for DBP Reduction
- 7.0 Estimated Project Costs of Alternative Improvements
  - 7.1 Construction Costs Estimates
  - 7.2 Project Cost Summary
  - 7.3 Annual Operating Costs
- 8.0 Potential Financing and Estimated User Costs
  - 8.1 State Drinking Water Revolving Fund for Water Supply Projects (DWSRF)
  - 8.2 Vermont Bond Bank
  - 8.3 Financing and Estimated Water Rates

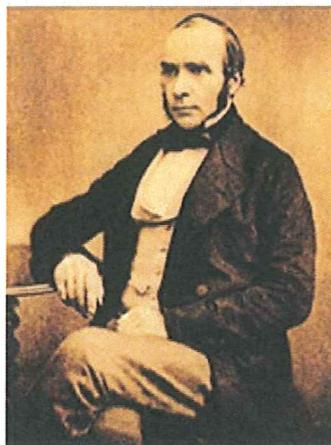
**Appendices:**

- Appendix A - Historical Total Trihalomethanes - Rutland City Water Filtration Facility
- Appendix B - Historical Total Haloacetic Acids - Rutland City Water Filtration Facility
- Appendix C - Existing Filtration Performance - UVA - DOC - SUVA
- Appendix D - GAC Pilot Filter Summary - Turbidity and UVA
- Appendix E - GAC Pilot Units - TTHM and HAA5 Sampling
- Appendix F - ORICA Pilot Report
- Appendix G - ORICA Budget Proposal

## SECTION 1.0 - INTRODUCTION

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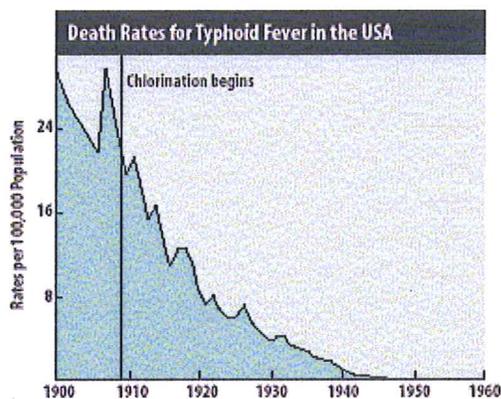
In 1835, physician and writer Oliver Wendell Holmes advised that washing hands in calcium hypochlorite prevented “midwife’s disease.” Immediately, deaths from childbirth dropped dramatically. The practice of disinfection had begun.



**John Snow**

In 1854, the British physician John Snow conducted the first known epidemiological study of a public water system, demonstrating by process of elimination that London’s Broad Street Well was the source of a Cholera outbreak. Sixteen years later, in 1860, Louis Pasteur proved that bacteria can cause disease. Shortly thereafter, the German physician Robert Kock identified the specific microorganisms responsible for Cholera and Typhoid.

To control the waterborne spread of diseases such as Cholera and Typhoid, the first continuous chlorine disinfection system was installed in Belgium in 1902. In the United States, disinfection of drinking water, using chlorine on an experimental basis, was first recorded at Louisville, Kentucky in 1896. In 1910, Newport, Rhode Island was the first New England community to add a permanent chlorination system for disinfection and, by the 1930’s, most municipal surface water supplies had chlorine disinfection facilities. Associated waterborne disease rates dropped dramatically. During 1910, Rutland City added “Bleaching Powder” for disinfection. Soon after, in 1916, gas chlorine facilities were added, following an outbreak of Typhoid Fever.



*Death Rates for Typhoid Fever in USA*

During the subsequent decades, Rutland operated gas chlorination facilities at both the Mendon Brook intake (to control algae growth in the open reservoir) at the Post Road chlorine building (to disinfect the distribution system).

As part of the Federal 1986 Safe Drinking Water Act (SDWA) amendments, water filtration was mandated nationwide for most municipal surface water supplies. In 1995, to comply with that regulation, Rutland City added a 3.6 million gallon per day (MGD) slow sand filtration facility, with sodium hypochlorite disinfection, and two 2.5 million gallon (MG) finished water storage tanks.

By the 1970's, it was discovered that chloroform and other trihalomethanes (THM's) are formed in chlorinated drinking water as chlorine reacts with natural organic matter (NOM). Some of these disinfection byproducts (DBP's) are suspected to be carcinogenic to humans, in sufficient quantity over a lifetime. In 1979, the Environmental Protection Agency (EPA) set the maximum allowable TTHM (total Trihalomethane) concentration at 100 ug/L (parts per billion).

In 1998, as part of the EPA's Stage I Disinfection Byproducts Rule, the TTHM limit was lowered to 80 ug/L and five haloacetic acids (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid, and dibromoacetic acid), referred to as HAA5, were added as regulated DBP's, as well as bromate and chlorite. Because a myriad of DBP compounds may be formed when chlorine reacts with organic matter, EPA has selected TTHM's and HAA5 as the surrogate representatives to regulate DBP's. Under EPA's Stage I rules, all sampling site results were averaged over the past four quarterly results and reported as a single running average for compliance reporting.

Under the more recent Stage II Disinfection Byproduct Rule, each sampling site is averaged and reported individually on a four quarter running average basis. This means that certain portions of a distribution system (areas with higher water age or areas with higher chlorine concentration) can be shown to have higher DBP concentrations than the overall

system average. The failure of one site to meet the regulated maximum contaminate limit (MCL) means the entire system has failed to comply with the DPB standard.

EPA's current regulated limits for DBP's are as shown on Table 1 below:

Table 1 Current EPA Regulated DBP Limits Locational Running Average (LRAA)	
DBP	Maximum Contaminate Limit (MCL), mg/l
Total THMs (TTHM)*	0.080
Haloacetic Acids (HAA5)	0.060
Bromate	0.010
Chlorite	1.0

\*Total THM's (TTHMs) represent the sum of four TTHM concentrations (chloroform, bromoform, bromodichloromethane, and dibromodichloromethane)

The City is currently in compliance with TTHM concentrations. However, Rutland City's quarterly DBP sampling results for HAA5's have shown seasonal exceedance of the MCL's, although not by a significant amount. As a result, this study was commissioned to evaluate alternative methods to reduce these DBP concentrations.

## SECTION 2.0 - CONCLUSIONS AND RECOMMENDATIONS

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### Conclusions

1. Rutland City is in violation of the Federal Stage 2 Disinfection Byproducts Rule since locational running annual averages for regulated Haloacetic acids (HAA5) in the distribution system have exceeded the 60 ug/L maximum contaminate limit (MCL) set by EPA and the State of Vermont.
2. Rutland City is not in violation of the other regulated disinfection byproduct (DBP) parameter, total trihalomethanes (TTHM). That MCL is set at 80 ug/L.
3. Both TTHM's and HAA5's are created quickly when natural organic material (NOM) in water comes in contact with free chlorine. Generally, the longer the NOM is in contact with free chlorine, the concentration of DBP's increase. This was demonstrated during the City's pilot testing.
4. Of the four treatment technologies examined during the pilot study period (split chlorination, GAC "sandwich" in the slow sand filters, chloramination and MIEX<sup>®</sup> magnetic ion exchange) only chloramination and MIEX<sup>®</sup> were determined to be capable of reliably reducing HAA5 concentrations below 60 ug/L over a long period of time with the risk of re-evaluating the technology at a later date.
5. The use of chloramines disinfection has raised some public concern, in some communities, when introduced. However, currently over 20% of the U.S. population is using drinking water with chloramines disinfection.
6. There is a significant capital (40:1) and operating cost (7:1) between the selection of the MIEX<sup>®</sup> ion exchange process and chloramines treatment. The installation of chloramines treatment being the least cost alternative

chloramines treatment could be installed at the existing water filtration facility without a building addition, exterior excavation or significant interior modifications.

7. The City has sufficient water storage volume to provide sufficient disinfection, in accordance with EPA's Surface Water Treatment Rule and Vermont's Water Supply Rule by using only monochloramine, without a free chlorine contact period.

### Recommendations

1. The City should review this report and select the treatment alternative which best meets its goals and priorities. Given the significant cost difference between the two effective technologies, it is anticipated the City will select chloramination as the preferred treatment technology.
2. If the City selects chloramination, a public notification and discussion should begin, providing water users with verifiable, scientific data on the disinfection options, the reason the City is making a change, the potential health concerns associated with all disinfection options and the costs associated with the two effective technologies recently studied. The State also has a public notification process which the City needs to follow.
3. The City should notify the Vermont Drinking Water and Groundwater Protection Division and EPA regarding its improvement intention and implementation schedule. A copy of this report should be provided to both agencies.

## SECTION 3.0 - EXISTING WATER TREATMENT FACILITY AND HISTORICAL DBP DATA

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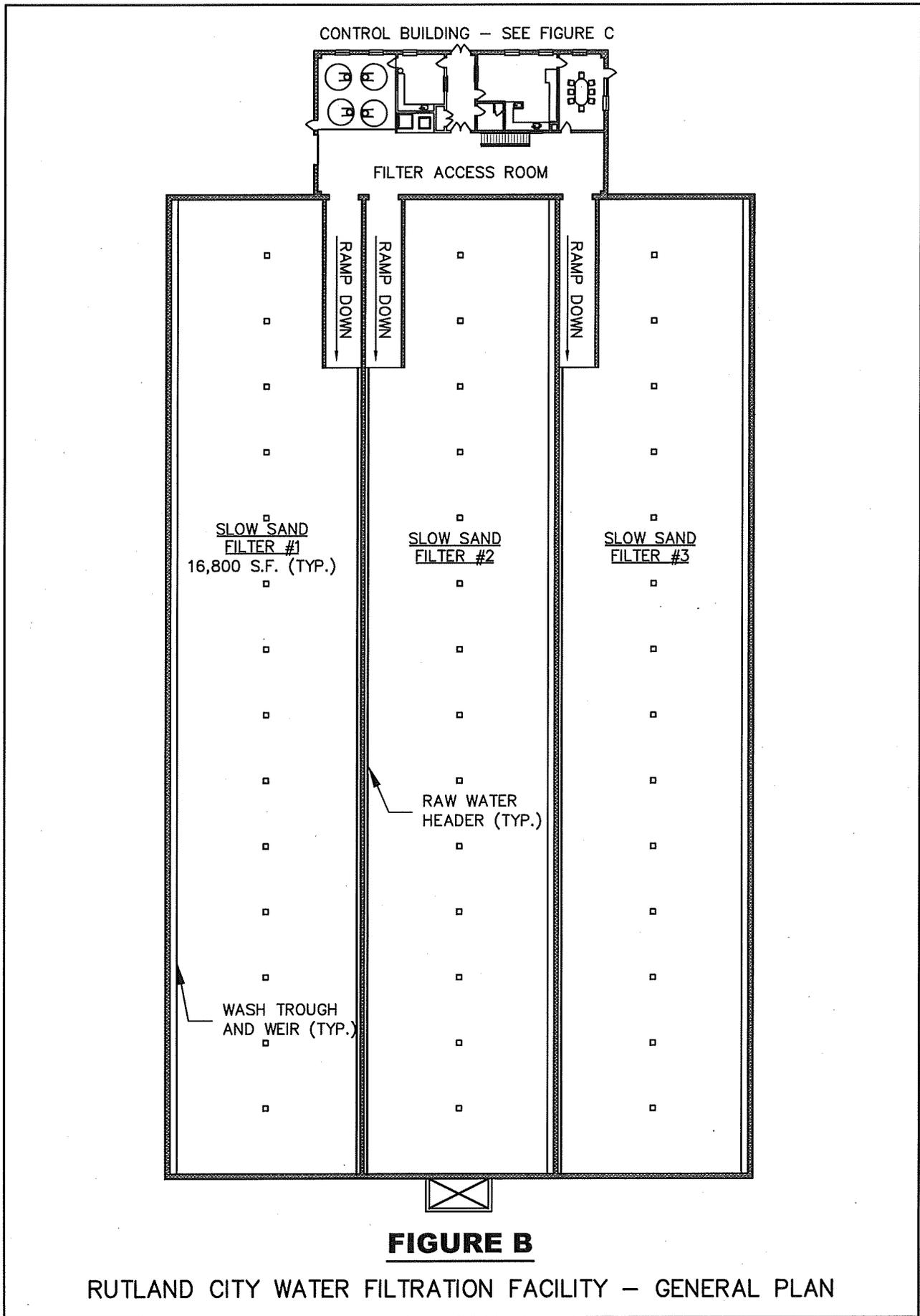
The City's water source is Mendon Brook, a steep mountain stream with variable flow and turbidity. Closing the intake during heavy rainfall events and using its 90 MG open reservoir, located between the Mendon Brook intake and the filtration facility, the City can maintain a high raw water quality and manage the intake of NOM to the filters.

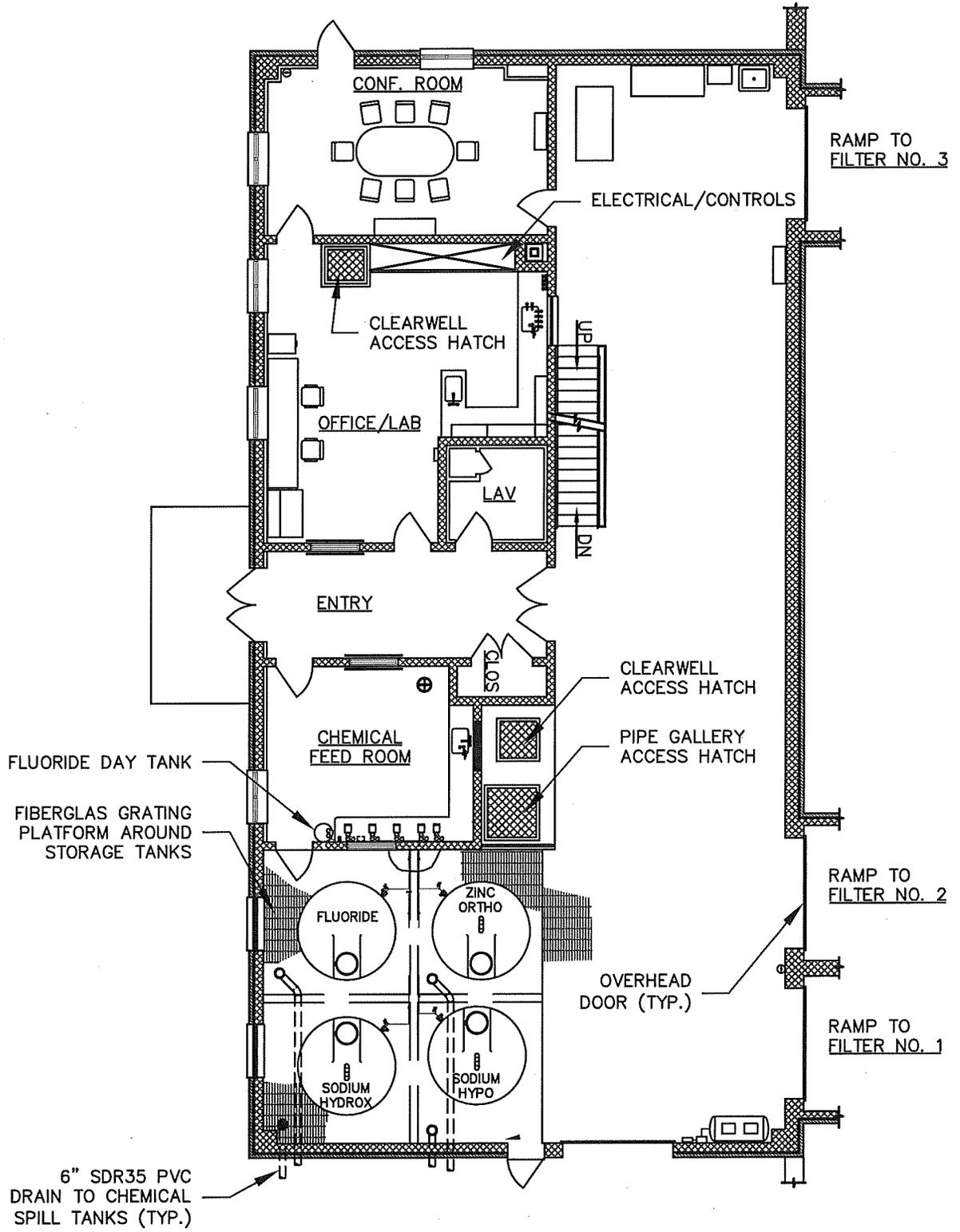
The City's slow sand water filtration facility operates entirely by gravity and has a 3.6 MGD capacity at a design filtration rate of 0.05 gallons per minute per square foot (gpm/sf). As shown in Figure B on the following page, the facility has three 56' x 300' filters, with a total filter area of 50,400 square feet (sf).

**Figure A**  
**Rutland City Water Filtration Facility**



The City adds zinc orthophosphate, hydrofluorosilic acid and sodium hypochlorite to the water, prior to finished water storage in two 2.5 MG unbaffled water storage tanks, located on the filtration facility site. With an existing average day water demand of approximately 2.5 MGD, detention in the two finished water storage tanks is approximately two days. The estimated detention time in the distribution system is an additional 24 hours.





**FIGURE C**

RUTLAND CITY WATER FILTRATION FACILITY – CONTROL BUILDING PLAN

Rutland City, to date, has not experienced exceedance of the TTHM MCL. However, the MCL for HAA5 (60 ug/L) has been exceeded on several occasions, primarily since the spring of 2006. See Appendix B.

Historical DBP sampling results from the City's distribution system are provided in Appendices A and B and summarized in Tables 2 and 3 below:

<b>Table 2</b> <b>Summary of Historical TTHM Concentrations, ug/L</b> <b>1/24/1995 to 2/7/2012</b>			
<b>Locational Running Annual Average</b>	<b>Minimum</b>	<b>Average</b>	<b>Maximum</b>
All sample sites	34	44	63
Per sample site	30	44	63
All individual samples	12	44	99
May - October samples only	12	54	99
November to April samples only	14	35	64

<b>Table 3</b> <b>Summary of Historical HAA5 Concentrations, ug/L</b> <b>1/24/1995 to 2/7/2012</b>			
<b>Locational Running Annual Average</b>	<b>Minimum</b>	<b>Average</b>	<b>Maximum</b>
All sample sites	33	57	81
Per sample site	31	57	86
All individual samples	23	56	143
May - October samples only	26	67	143
November to April samples only	23	36	71

Based on the historical (1995-2012) system sampling, the highest locational running annual average (4-quarters) has been 63 ug/L for TTHM (Ramada Inn - August 5, 2008) and 86 ug/L for HAA5 (Rutland Hospital - May 4, 2010) compared to the current MCL's of 80 ug/L and 60 ug/L, respectively.

Therefore, based on the sampling results listed in Appendices A and B, it is predicted that Rutland will need to lower its DBP concentrations for at least six months of the year, in order to maintain HAA5 concentrations less than 60 ug/L.

The Vermont Water Supply Rule requires surface water source systems to provide a overall 3-log minimum removal/inactivation of Giardia and a minimum 4-log removal/inactivation of viruses. Presently, the slow sand filtration process is granted a 2-log credit towards the requirement for Giardia removal and a 2-log credit for virus removal. Therefore, an additional 1-log of Giardia inactivation and 2-log of virus inactivation is required through the disinfection process. Currently, the City achieves this through disinfection using sodium hypochlorite with sufficient contact time in the finished water storage tanks. However, due to the exceedence of the HAA5 standard in distribution sampling, the City is required to make physical and/or operational modifications in order to comply with current water quality regulations.

To evaluate existing DBP formation potential patterns, the City monitored UV Absorbance (UVA) and Dissolved Organic Carbon (DOC) from February, 2010 to October 2011. Samples were taken weekly from: 1) the Mendon Brook source, 2) raw water into the facility, prior to filtration, and 3) the filtered water clearwell. The results of this testing is shown in Appendix C.

UVA is the relative measure of the amount of light (at a wavelength of 254 nm) absorbed by water samples compared to the amount of light absorbed by a sample of pure water. Most organic compounds absorb light at the 254 nm wavelength. Pure water would be measured at 0.000 nm/m. The higher the UVA value, the more light absorbing material is in the water. Generally, the higher the UVA value, the higher the DBP potential.

DOC, dissolved organic carbon, can be described as decomposed plant and animal matter dissolved in water. Measured in mg/l, the higher the DOC value, the higher the DBP formation potential.

SUVA, Specific UV Absorbance, is an accepted calculation used to quantify the relative DBP formation potential, taking into account the DOC concentration, and is calculated as:

$$\text{SUVA} = \frac{\text{UVA nm/m}}{\text{DOC mg/l}}$$

UVA has a bias towards reactive or aromatic organic matter which has a greater tendency to form DBP's. Therefore, the higher the UVA value, compared to the total DOC, the higher potential for forming DBP's.

As shown in Appendix C, data collected during the sampling period was not consistent and individual samples are significantly variable. However, the data does show that the existing slow sand filtration process, on average, achieves a 28% UVA reduction, a 20% DOC reduction and a 10% SUVA reduction. Turbidity reduction is very significant, averaging 96%.

Prior to pilot testing of the selected alternate DBP reduction technologies, water samples were collected at the water treatment facility and held at a temperature similar to the distribution system temperature for 72 hours, the average residence time in the storage and distribution system. The purpose of this test was to determine if samples taken at the filtration facility would reasonably represent actual distribution samples. The only difference between the DBP samples taken and stored at the water filtration facility and samples collected in the distribution system would be exposure to the distribution piping system. The results of this comparative test are shown on Table 4 below:

Table 4 DBP Comparative Test		
	Regular Distribution Samples	Water Filtration Facility Samples
Date	HAA5 (ug/L)	HAA5 (ug/L)
2/3/2010	36	35
5/4/2010	82	76
8/3/2010	85	
11/2/2010	75	70

As shown above, the simulated distribution samples, taken and held at the filtration facility, do not vary significantly from the actual distribution samples.

## SECTION 5.0 - DISINFECTION BYPRODUCT REDUCTION ALTERNATIVES

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In considering potential methods of reducing DBP's, the City, in cooperation with the Vermont Drinking Water and Groundwater Protection Division, selected the following processes for evaluation:

- A. Modification to existing disinfection location.
- B. Post-filtration granulated activated carbon (GAC) absorption.
- C. Magnetic ion exchange.
- D. Chloramination.

Discussions of these treatment alternatives examined by Rutland City follow:

### 5.1 Modifications to Existing Disinfection Location

During the pilot period, the City performed a bench test to determine the potential effectiveness of adding only a trace amount of chlorine following filtration (residual of 0.3 mg/l through finished storage), then boosting the concentration to 1.1 mg/l after storage. Because of the long storage detention time at the plant site, it was theorized that DBP's might be reduced if the chlorine concentration was minimal through the 5 MG of on-site storage, then boosted for effective distribution disinfection.

Each storage tank (2.5 MG) represents one day's current average daily demand, or 24 hours of average contact time. Although the tanks are not currently piped in series, they could be modified to do so, allowing multiple split chlorination possibilities.

The results of that testing is shown on Table 5 below.

Table 5 Split Chlorination Bench Test		
Sample Description	TTHM (ug/L)	HAA5 (ug/L)
Average of 4 filtered and disinfected control samples 9/13/2011 to 10/3/2011, 3-day TTHM and HAA5.	99	58
Test #1: Filtered clearwell sample dosed with sufficient chlorine to obtain residual of 1.1 mg/l at 48 hrs. Tested for DBPs at 72 hrs.	116	67
Test #2: Filtered clearwell sample dosed with sufficient chlorine to obtain residual of 0.3 mg/l at 24 hrs., at 24 hrs Cl <sub>2</sub> boosted to 1.1 mg/l. Tested for DBP's at 72 hrs.	106	70
Test #3: Filtered clearwell sample dosed with sufficient chlorine to obtain residual of 0.3 mg/l at 48 hrs., at 48 hrs Cl <sub>2</sub> boosted to 1.1 mg/l. Tested for DBP's at 72 hrs.	116	67

This testing showed no significant reduction in DBP levels using split chlorination at the filtration facility site.

## 5.2 Chloramination

Chloramines, particularly monochloramine, have been used since 1917 in the United States for disinfection of drinking water. A textbook in this author's bookcase, "*Elements of Water Supply Engineering*," by Earle Waterman, specifically describes the chloramine disinfection process and the fact that free chlorine use can be decreased because monochloramine is less reactive with organic matter. In 1917, Denver, Colorado was the first U.S. water system to use monochloramine for disinfection.<sup>1</sup> In fact, this form of disinfection is now widely used across the country as a means to reduce distribution system DBP's. By 2002, 20% of the country's drinking water facilities used monochloramine for disinfection and by 2010, it is estimated 22% of the U.S. population (68 million people) were using water containing chloramine.<sup>2</sup> EPA estimates this will increase to 50% in the near future as more communities move to reduce DBP's. Florida and Texas currently serve more than 50% of their population with chloraminated water.<sup>2</sup> In New England alone, it is reported that 3.4 million people, in 135 communities, currently receive water with monochloramine as the disinfectant.<sup>3</sup>

As previously stated, the use of free chlorine as a disinfectant causes the formation of TTHM's and HAA5's as well as other unregulated compounds. Research has implied that these compounds may increase the risk of some cancers over a lifetime of use. Therefore, EPA currently regulates the limits of TTHM's and HAA5's in drinking water.

Chloramines, formed through the mixing of chlorine and ammonia, are weaker disinfectants than chlorine; therefore, less reactive with organic material resulting in less DBP formation. Because chloramines are more stable, they are more difficult to remove from water. Boiling, distillation, softening and reverse osmosis may not reduce chloramines enough for users who desire chlorine-free water. However, high quality granulated carbon units can effectively provide chloramine removal. Water system providers should provide notice to those with aquariums, kidney dialysis machines and others who need chlorine-free water for specific uses, prior to switching to chloramine disinfection.

The use of chloramines, specifically monochloramine, reduces the formation of TTHM's and HAA5's, but can create other, currently unregulated, compounds (such as nitrosamines, iodo-trihalomethanes and iodo-acids). These compounds, including other disinfection by-products created by chlorine-only disinfection, are currently being studied for any long-term health effects on humans.

Public concern has been expressed nationwide that chloramines disinfection may cause a myriad of health effects. However, no juried, scientific study was found that shows the risk associated with chloramination outweighs the risk of exposure to DBP's caused by free chlorine. While studies continue regarding all DBP's, regulated and unregulated, chloramination remains an EPA accepted technology for current regulatory compliance.<sup>5</sup> EPA recognizes that certain water users may have sensitivities to any disinfection chemical. However, the reported potential sensitivities are almost identical for free chlorine and chloramines, namely irritation to eyes and nose and/or stomach discomfort.<sup>6</sup> EPA is required to determine the concentration of residual disinfectant at which no adverse health effect is

likely to occur, based on exposure over a lifetime, with an adequate margin of safety (called MRDLG, maximum residual disinfectant goal). These are shown in Table 6 below.

Table 6 EPA Regulated Disinfectant Levels	
Disinfectant	MRDLG
Chloramine	4 mg/L
Chlorine	4 mg/L
Carbon Dioxide	0.8 mg/L

The commonly used limit of chloramines in municipal distribution systems is 3 mg/L.

There have been a few water systems which have reported an increase in the concentration of dissolved lead following conversion to chloramine disinfection, particularly from plumbing in older houses. Residual chlorine in a distribution system can oxidize metals such as copper and lead, forming a protective layer, decreasing solubility. However, this problem is not common, Rutland has sufficient alkalinity in its water and the City currently provides zinc orthophosphate treatment to control pipe corrosion in the distribution system.

Close to home, the Champlain Water District (CWD), Vermont’s largest water utility, switched from chlorine to monochloramine disinfection in 2006. CWD serves 68,000 water customers in several communities surrounding Burlington. Following CWD’s conversion to chloramines, they received 74 individual health complaints, allegedly related to the change in disinfection. Due to that public concern, CWD participated in a 2007 health assessment conducted by the U.S. Department of Health and Human Services and the Center for Disease Control and Prevention (CDC).<sup>4</sup> The CDC investigation concluded: “there do not appear to be any supportable engineering conclusions that can be made concerning a link between treatment and exposure/symptoms.” The report also noted that “CWD has measured no increase in lead levels.” Since those initial concerns, CWD reports it has received no chloramines related complaints.

Similar to all its process components, CWD continuously monitors its ammonia and chlorine feed systems, the chlorine-ammonia ratio levels, both leaving the plant and in the distribution system. Establishment of a strict quality control system has assured a stable chloramines disinfection system in compliance with the Disinfection Byproduct Rule.

Therefore, in considering the use of monochloramine for disinfection, the City should take the following into consideration:

1. Generally, monochloramine is a simple and low-cost means to provide both necessary distribution system disinfection and the required reduction of related DBP's.
2. Public notice and education is recommended prior to conversion to monochloramine. The public should be given the opportunity to address questions and be fully informed regarding the conversion to an alternate method of disinfection.
3. The conversion to monochloramine should be carefully implemented, with specific data collection and water quality monitoring, both at the treatment facility and throughout the distribution system. The installed system should be integrated into the City's SCADA system, continuously monitoring chlorine, ammonia and monochloramine levels.

During the DBP Pilot Testing period, the City performed laboratory simulation testing for reduction of DBP's using chloramines. The results of that testing is shown on Table 7 below.

**Table 7  
Chloramine Disinfection Simulation Test**

			Sample Hold Time			
			48 Hours		72 Hours	
Date	Test Description	Test Rationale	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)
11/9/2010	Sample from plant clearwell after chlorination.	Ammonia added immediately after minimum chlorine CT <sup>1</sup>			27	29
11/9/2010	Sample taken from plant valve vault immediately downstream of chlorination point. Ammonia added after 24 hrs. Hold sample in SSF's to 72 hrs.	Ammonia added as if after first storage tank, if in series			56	56
7/18/2011	Clearwell sample dosed with Cl <sub>2</sub> to achieve 1.1 mg/l residual at 48 hrs. Hold sample in SSF's to 72 hrs.	Control sample - No ammonia added			116.2	67
7/18/2011	Clearwell sample dosed with Cl <sub>2</sub> to achieve 0.3 mg/l, residual at 24 hrs. After 24 hrs., boost to 2.0 mg/l and add ammonium hydroxide at 4:1 ratio. Hold sample in SSF's to 48 hrs.	Ammonia added as if after first storage tank, if in series	85.6	51		
7/18/2011	Clearwell sample dosed with Cl <sub>2</sub> to achieve 0.3 mg/l, residual at 24 hrs. After 48 hrs., boost to 2.0 mg/l and add ammonium hydroxide at 4:1 ratio. Hold sample in SSF's to 72 hrs.	Ammonia added as if after second storage tank, if in series			92.8	60
10/31/2011	Control sample from plant clearwell before storage. No chlorine. Hold sample in SSF's to 72 hrs.	Control sample - No ammonia added			74.5	54
10/31/2011	Dosed with Cl <sub>2</sub> to 2 mg/l, for 45 minutes, then add ammonium hydroxide at 4:1 ratio. Hold sample in SSF's to 72 hrs.	Ammonia added soon after chlorine.			23.6	19

(1) Minimum CT for 1.0 log Giardia inactivation at pH = 7.5, <5°C, 2 mg/l Cl<sub>2</sub> is 45 minutes.

The results of this testing shows that the addition of sodium hypochlorite at 2.0 mg/l for only 45 minutes (the minimum required CT 1.0 log Giardia inactivation using chlorine), followed by the addition of ammonia, dramatically reduces the resultant TTHM's and HAA5's at the estimated maximum water age (72 hrs.) in the distribution system. If ammonia is added immediately following chlorine, the resultant DBP's are reduced even further. The testing confirms that the longer free chlorine is in contact with the filtered

water, prior to the addition of ammonia, the higher the resulting TTHM and HAA5 concentrations.

Therefore, as demonstrated throughout the U.S. in hundreds of water systems, the use of chloramines for maintaining distribution disinfection can significantly reduce both TTHM and HAA5 levels within EPA's current maximum contaminant limits.

### 5.3 Granulated Activated Carbon (GAC)

A concept long considered by researchers for DBP removal in slow sand filtration facilities is the "GAC sandwich."

In lieu of a separate, post-filtration, GAC contactor, a uniform layer of GAC is "sandwiched" in the filter sand profile. Sufficient sand is located over the GAC layer (12") such that the sand media develops its normal schmutzdecke for biologic treatment and the GAC is not disturbed during the filter cleaning/harrowing process. The ideal installation of a slow sand/GAC sandwich would have the effective life of the GAC (for DBP reduction) match the effective life of the filter sand, 10+ years.

To examine the effectiveness of DBP removal using GAC, Rutland city constructed three pilot units, as shown in Figure D, and operated them from December, 2010 to the present.

**Figure D**  
GAC Pilot Filter



The pilot units were set up as follows:

<u>Filter #1</u>	<u>Filter #2</u>	<u>Filter #3</u>
30" of filter sand	12" of filter sand	12" of filter sand
18" of base gravel	6" of <u>new</u> Calgon 400 GAC	6" of <u>used</u> Calgon 300 GAC
	12" of filter sand	12" of filter sand
	18" of base gravel	18" of base gravel

The used Calgon 300 GAC was obtained from the Manchester, New Hampshire water filtration facility and was considered "exhausted" by that facility and removed from their filtration process. The purpose of piloting "exhausted" GAC was to measure the DBP removal potential of GAC which had already absorbed organic compounds over a time period of many years, since the City was examining the potential of GAC being in the filter beds for, potentially, up to ten years. This test was not intended to provide data specific to long term performance of GAC in Rutland since the used GAC was imported from another facility and bed volumes, water quality, etc., would not be specific to Rutland. However, the data would provide a general comparison of DBE reduction between virgin GAC and GAC considered "exhausted," and to provide the approximate steady state DBP reduction which could be expected from exhausted GAC.

The data from these pilot units, including raw water quality data entering the Rutland filtration facility, is summarized in Appendix D. Due to the cost of TTHM and HAA5 analysis, regular turbidity and UVA were tracked as surrogate parameters for relative DBP reduction potential. TTHM and HAA5 samples were then taken from the pilot units, on a monthly basis, as reported in Appendix E.

The pilot units were erroneously operated at a high filtration rate for the first six months, from the beginning of the pilot test period to the end of May, 2011 (approximately 0.2 gpm/sf, or 4x the design filtration rate). Thereafter, the rate was reduced to 0.5 gpm/sf, Rutland's design filtration rate.

As shown on Table 8, turbidity removal rates were fairly consistent across all three filters, averaging 36% to 50% at the higher rate and 79% to 85% at the facility's design rate. However, as expected, DBP removal in the new GAC far exceeded the exhausted GAC.

	Percent Reduction @ 0.2 gpm/sf				Percent Reduction @ 0.05 gpm/sf			
	Turbidity <sup>(1)</sup>	UVA <sup>(1)</sup>	TTHM <sup>(2)</sup>	HAA5 <sup>(2)</sup>	Turbidity <sup>(1)</sup>	UVA <sup>(1)</sup>	TTHM <sup>(2)</sup>	HAA5 <sup>(2)</sup>
Filter #1 (Sand only)	36%	5%	-	-	85%	19%	-	-
Filter #2 (New GAC)	43%	53%	40%	32%	84%	67%	62%	70%
Filter #3 (Exhausted GAC)	50%	11%	10%	11%	79%	32%	36%	17%

(1) Reduction from raw water quality.

(2) Reduction from Filter #1 effluent quality.

Looking at Appendix D, the individual sampling results in each pilot unit for UVA significantly vary. Examining the average UVA reductions, the following is observed:

1. There was a slight average UVA reduction (19%) in the Pilot Filter #1 (sand only) unit, which simulated the operation of the existing slow sand filters. This reduction is verified by the UVA sampling of the full-scale operating filters shown in Appendix B.
2. There was a significant average UVA reduction of 67% in (virgin GAC). This is expected since virgin GAC is highly reactive and a high organic absorption rate is expected. This corresponded with an average TTHM reduction of 62% and average HAA5 reduction of 70%.
3. There was only a moderate average reduction of 32% in UVA in Pilot Filter #3 (exhausted GAC). This performance is within the 10-35% range predicted by Dr. Robin Collins' research at the University of New Hampshire, in his studies of biological regeneration of GAC in a

slow sand filter environment. The associated TTHM reduction was 36% and HAA5 reduction was 17%.

The City's goal with the GAC Sandwich concept would be to replace the GAC when filter sand replacement is necessary (10+ years). When exhausted, GAC was demonstrated to provide an average steady state HAA5 reduction of approximately 17% over the reduction demonstrated through the sand filters alone. Based on the UVA monitoring and HAA5 sampling from this pilot effort, it is doubtful the GAC Sandwich would be reliable to provide long-term compliance with the Stage 2 DBP limits on HAA5. The City's historical peak four-quarter, site specific, HAA5 sample (February 3, 2006) was 83 ug/L, with typical site specific running averages in the 60 to 80 ug/L range. A process intended to reliably reduce HAA5 to less than the 60 ug/L standard would need to assure at least a 30% reduction, preferably closer to 50% for a factor of safety. Based on the pilot testing, it does not appear the GAC Sandwich concept can accomplish this once the GAC becomes "exhausted" and the pilot work did not allow prediction of the number of bed volumes which would reduce GAC performance to less than acceptable levels for compliance.

#### 5.4 Ion Exchange (MIEX®)

As part of the City's DBP reduction pilot project, consideration was given to a proprietary magnetized ion exchange process developed by Orica Watercare, Inc. The MIEX® (Magnetic Ion Exchange) resin used by Orica attracts negatively charged organic acids which then are continuously withdrawn from the contact tank, regenerated with sodium chloride or sodium bicarbonate and then fed back into the contact tank. Testing and installations of the MIEX® process at other facilities showed significant DBP reduction.

From August 8 to October 5, 2011, Orica Watercare operated a 10 gpm mobile pilot unit at the Rutland Water Filtration Facility. See Figures E and F. During this period, samples for turbidity, color, pH, DOC, heterotrophic plate count (HPC), TTHM's and HAA5's were analyzed for comparison of the MIEX® process to the existing slow sand

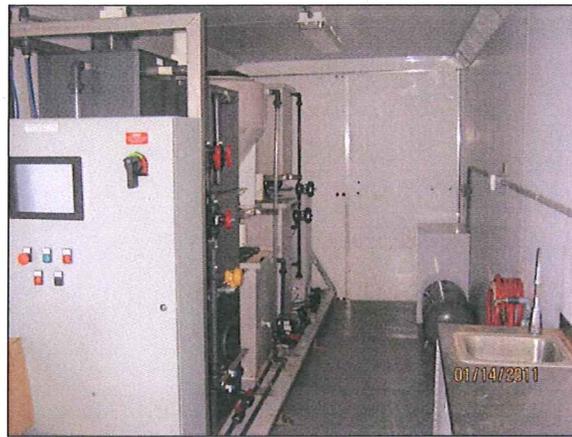
filtration process (alone) and the GAC Sandwich pilot units being tested at the facility. The complete pilot report by Orca Watercare is included as Appendix F.

The MIEX<sup>®</sup> pilot unit was located so as to treat water from the open reservoir, prior to the City’s slow sand filters. Samples were taken and analyzed for pH, UVA, DOC, turbidity, color, TTHM and HAA5 formation.

**Figure E**  
**MIEX<sup>®</sup> Pilot Unit**



*MIEX<sup>®</sup> Pilot Unit*

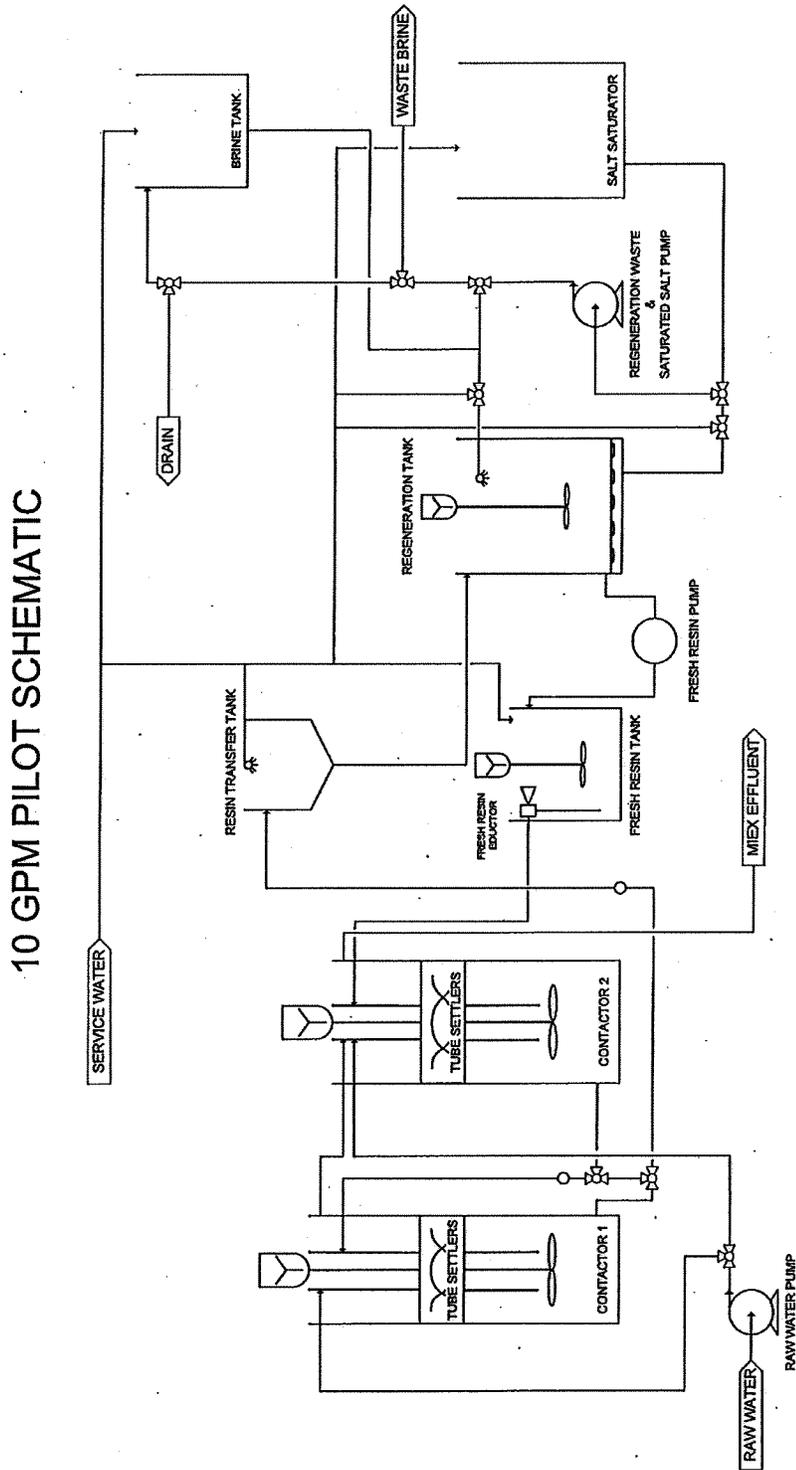


*MIEX<sup>®</sup> Pilot Unit*

Table 9 below summarizes the DBP reduction demonstrated by the MIEX<sup>®</sup> Pilot Unit.

Table 9 MIEX <sup>®</sup> DBP Reduction Summary						
Date	Free Cl <sub>2</sub> Residual (mg/L)	DOC (mg/L)	TTHM 3 Day ug/L	HAA5 3 Day ug/L	% Reduction TTHM	% Reduction HAA5
Plant Control Samples						
9/13/11	1.54	1.7	90.7	59	-	-
9/16/11	1.34	1.7	102.1	59	-	-
9/29/11	1.19	1.9	106.6	58	-	-
10/3/11	1.11	1.9	97.7	57	-	-
AVG	1.30	1.8	99.3	58	-	-
MIEX <sup>®</sup> Pretreated Treated Samples						
9/13/11	1.36	0.5	15.1	12	83%	80%
9/16/11	1.14	<0.5	22.5	17	78%	71%
9/29/11	1.19	1.0	18.4	9	83%	84%
10/3/11	1.26	1.3	32.0	24	67%	58%
AVG	1.24	0.83	22.0	16	78%	72%

Figure F  
10 GPM MIEX® Pilot Schematic



From the MIEX<sup>®</sup> piloting data summarized on Table 8, it is concluded the MIEX<sup>®</sup> process can reduce HAA5's by 60-80%. Therefore, in theory, the MIEX<sup>®</sup> process should be capable of reducing the City's HAA5 concentrations to 20-25 ug/L, allowing a significant margin between that presumptive result and the regulatory MCL of 60 ug/L.

As a secondary benefit of reducing DOC, the City would be able to lower its chlorine dosage since the finished water chlorine demand would be reduced.

As detailed in Appendix F, the Orica Watercare Final Pilot Test Report, the MIEX<sup>®</sup> process was shown to be very effective at removing DOC and DBP's. DOC removal averaged 61%. UVA removal averaged 82%. Further reduction of both DOC and UVA through the subsequent slow sand process was minimal. Color reduction, through the MIEX<sup>®</sup> process, averaged 69%, from 11 Cobalt Units (CU) to 3 CU. The slow sand filtration process further reduced color to 1 CU.

The MIEX<sup>®</sup> process itself had no significant effect on turbidity. This would be expected, since the MIEX<sup>®</sup> process is designed to allow small, non-organic suspended particles to flow through the contact unit, while the process retains the larger resin. However, the subsequent slow sand filters reduced overall turbidity by 96%.

Regarding DBP reduction, the MIEX<sup>®</sup> process was shown to be very successful. Average 3-day TTHM concentrations were reduced from 99 ug/L to 22 ug/L and average 3-day HAA5 concentrations were reduced from 58 ug/L to 16 ug/L, both well under the current EPA limits.

Table 10 below, summarizes the piloting of the MIEX<sup>®</sup> process.

	Raw Water	MIEX®	MIEX® followed by Slow Sand Filtration
UVA	0.072	0.013	0.012
DOC, mg/l	2.37	0.85	0.93
True Color, CU	11	3	1
pH	7.63	7.48	7.39
Turbidity, NTU	3.00	2.98	0.112
3-day TTHM, ug/L	99.3	22.0	*
3-day HAA5, ug/L	58	16	*

\*Not measured. However, since the slow sand process did not show an additional reduction in DOC, further DBP reduction is not anticipated.

### Projected Effectiveness of Studied DBP Reduction Methods

Tables 11 and 12 below compares the DBP reduction related to the alternatives considered in this recent pilot testing effort.

Sampling Period	<u>Slow Sand Only</u> <sup>(1)</sup>		<u>GAC Sandwich (Virgin GAC)</u>		<u>GAC Sandwich (Exhausted GAC)</u>		<u>Chloramines</u>		<u>MIEX®</u>	
	6/22/11 to 10/6/11	# of Samples	6/22/11 to 10/6/11	# of Samples	6/22/11 to 10/6/11	# of Samples	10/31/11	# of Samples	9/13/11 to 10/3/11	# of Samples
Average, Clearwell			-		-		74.5	1	99.3	4
Average, Treated	92.7	6	21.45	4	48.2	4	23.6	1	22.0	4
% reduction from slow sand only			76.9%		51.2%		74.5%		76.3%	

(1) Includes both operating filters (clearwell) and Pilot Unit #1 (sand only).

Table 12  
3-Day HAA5 Summary of all Treatment Alternatives

Sampling Period	<u>Slow Sand Only</u> <sup>(1)</sup>		<u>GAC Sandwich (Virgin GAC)</u>		<u>GAC Sandwich (Exhausted GAC)</u>		<u>Chloramines</u>		<u>MIEX</u> <sup>®</sup>	
	6/22/11 to 10/6/11	# of Samples	6/22/11 to 10/6/11	# of Samples	6/22/11 to 10/6/11	# of Samples	10/31/11	# of Samples	9/13/11 to 10/3/11	# of Samples
Average, Clearwell			-				54		58.3	
Average, Treated	60.3	6	18.75	4	49.5		19		15.5	
% reduction from slow sand only	-		68.9%		17.9%		64.8%		73.4%	

(1) Includes samples from both the operating filters (clearwell) and the Pilot Unit #1 (sand only).

1. History of Chloramine Use, American Water Works Association, [www.drinktap.org](http://www.drinktap.org)
2. Trends and Effects of Chloramine in Drinking Water, Cang Li, Ph.D., Water Conditioning and Purification, October, 2011.
3. Letter dated March 11, 2008 to Senators Douglas Racine and Ed Flanagan from New England Water Works Association.
4. Report from Leslie Hausman, RN, MPH, EIS Officer, et al to Douglas H. Hamilton, MD, Ph.D. dated January 16, 2008, Department of Public Health and Human Services, Centers for Disease Control and Prevention.
5. "The Effectiveness of Disinfectant Residuals in the Distribution System," Environmental Protection Agency, Office of Ground Water and Drinking Water.
6. Basic Information About Disinfectants in Drinking Water: Chloramine, Chlorine and Chlorine Dioxide," Environmental Protection Agency, <http://water.epa.gov/drink/contaminants/basicinformation/disinfectants.cfm>

## SECTION 6.0 - CONCEPTUAL DESIGN OF ALTERNATE SOLUTIONS FOR DBP REDUCTION

Based on the piloting data, there are two alternative processes which could reliably provide reduction of Rutland City's DBP's, most specifically HAA5, in accordance with the Stage 2 Disinfection Byproducts Rule. These are chloramination and the magnetic ion exchange (MIEX®) process.

A description of how each of these processes could be adapted to the existing Rutland City Water Filtration Facilities is provided below.

### Chloramination

A chloramination system for Rutland would involve the addition of equipment for adding liquid ammonium sulphate (LAS) to the filtered water after injection of sodium hypochlorite (which the City already uses for disinfection).

One approach would have the City achieve a full 1-log Giardia inactivation using chlorine, for primary disinfection, then add LAS for chloramine secondary disinfection. To achieve a full 1-log of Giardia inactivation of primary disinfection, using chlorine, a CT=90 would be required. At 1.5 mg/l Cl<sub>2</sub> and a flow rate of 3.6 MGD (2500 gpm), a minimum contact volume of 150,000 gallons would be required. This would be difficult to achieve at the Rutland City facility without construction of a fully baffled contact tank, a very long contact pipe or modification of one of the existing storage tanks and remote injection of the LAS. More importantly, as shown in the chloramine simulation testing, the longer free chlorine is in contact with the filtered water, the greater the resultant DBP's.

Alternatively, because the City has considerable finished water storage, both primary and secondary disinfection could be accomplished using monochloramine without any significant free chlorine contact period. This would be physically easy to construct and would reduce the initial DBP formation caused by a prolonged free chlorine contact time. Chlorine

would be added first, closely followed by a corresponding dosage of LAS, at a controlled 4:1 - 4.5:1 chlorite to NH<sub>3</sub> ratio.

AWWA's "Guidance Manual for Compliance with Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources (1991) provides the CT values for Giardia and Virus inactivation using chloramines as shown in Tables 13 and 14:

Table 13 CT Values for Giardia Cyst Inactivation using Chloramines					
	Temperature (°C) (mg·min/L)				
Inactivation	5	10	15	20	25
0.5-log	365	310	250	185	125
1-log	735	615	500	370	250
1.5-log	1,100	930	750	550	375
2-log	1,470	1,230	1,000	735	500
2.5-log	1,830	1,540	1,250	915	625
3-log	2,200	1,850	1,500	1,100	750

Source: AWWA, 1991

Values shown in this table are based on a pH range between 6 and 9.

Table 14 CT Values for Virus Inactivation using Chloramines					
	Temperature (°C) (mg·min/L)				
Inactivation	5	10	15	20	25
2-log	857	643	428	321	214
3-log	1,423	1,067	712	534	356
4-log	1,988	1,491	994	746	497

Source: AWWA, 1991

Assuming a monochloramine dosage of 3 mg/l, a minimum required contact volume in an un baffled water tank would equal 2.38 MG at Rutland's design average daily demand of 3.6 MGD. This volume is calculated as follows:

$$\frac{857^{(1)}}{3 \text{ mg/l} \times 2500 \text{ gpm}} \times 0.3^{(2)} = 2.35 \text{ MG}$$

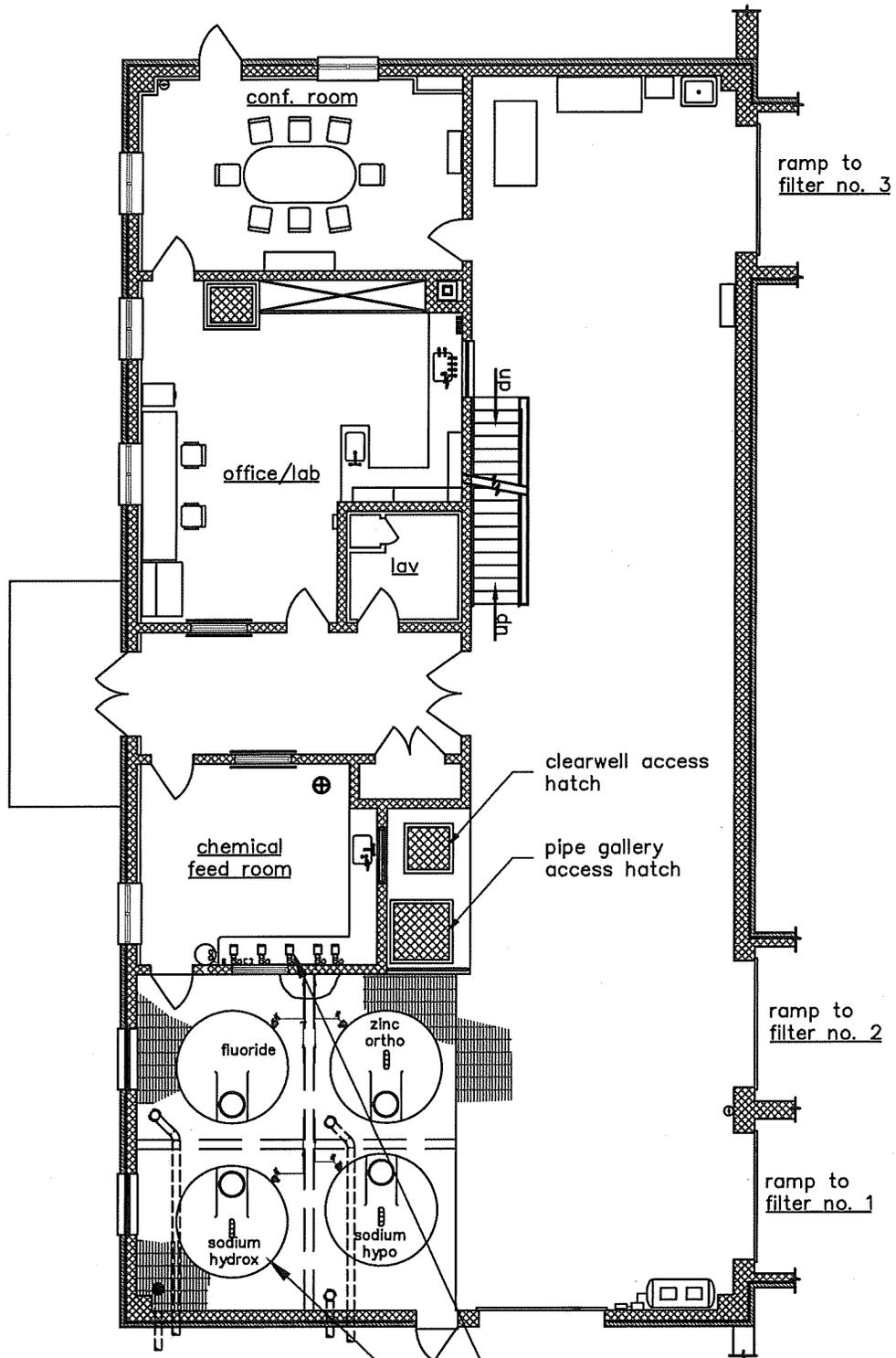
(1) CT for 2-log virus inactivation, 5°C

(2) Baffling factor for un baffled tank

The City has two 2.5 MG finished water storage tanks, currently operated in parallel, not in series. However, either tank, individually, can meet the required chloramine CT

without taking into account the additional available contact volume in the two transmission mains prior to the first customer.

With such an installation, the conversion to chloramines would be relatively simple, as schematically shown below in Figures G and H on the following pages.

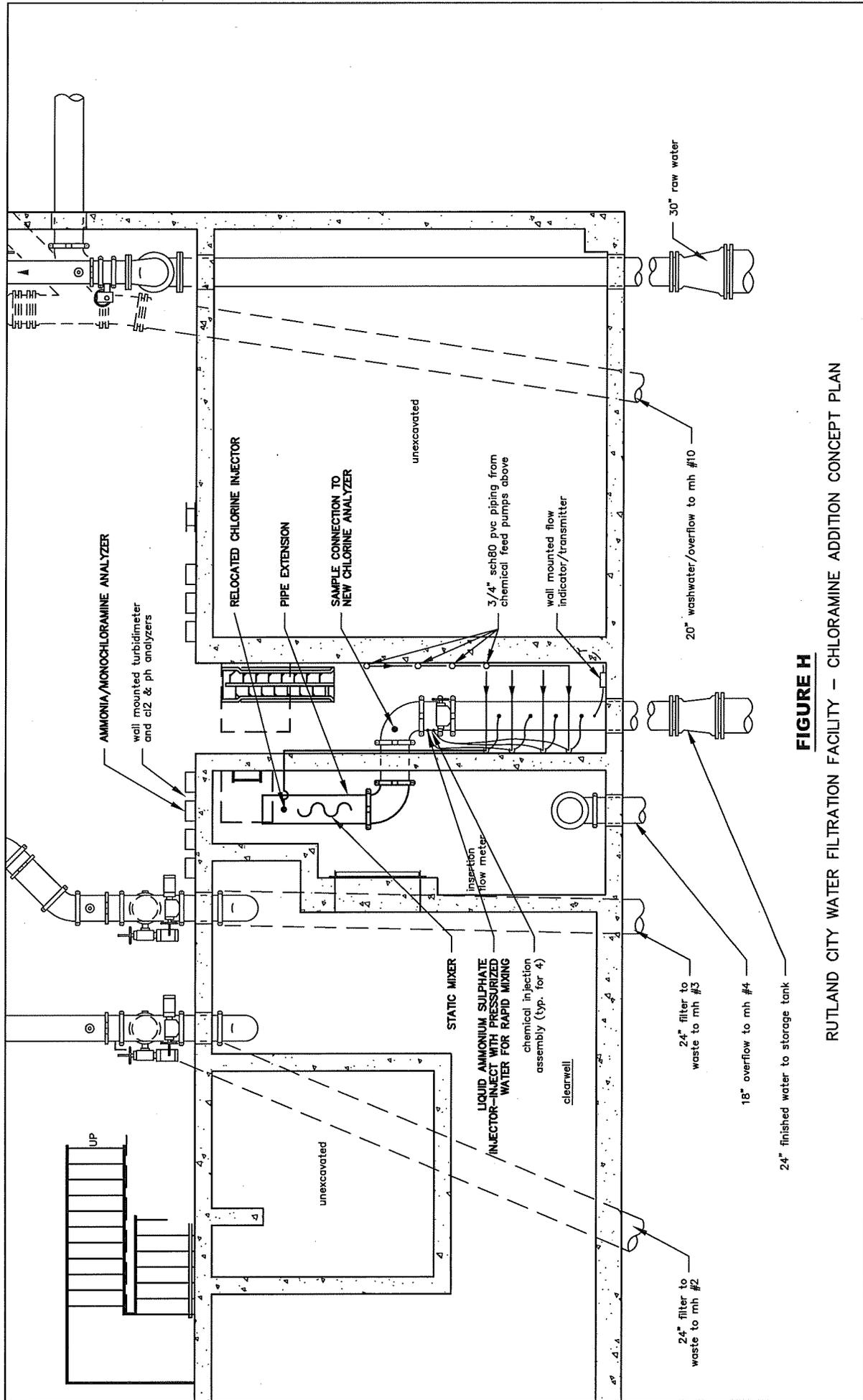


USE SPARE CHEMICAL FEED PUMP FOR LIQUID AMMONIUM SULPHATE

REPLACE EXISTING 4,200 GALLON TANK WITH 3,500 FLAT BOTTOM HDPE LIQUID AMMONIUM SULPHATE TANK

**FIGURE G**

CHLORAMINE ADDITION CONCEPT PLAN – FIRST FLOOR LEVEL



**FIGURE H**  
 RUTLAND CITY WATER FILTRATION FACILITY – CHLORAMINE ADDITION CONCEPT PLAN

Such an installation could be made without any building modifications. In fact, a chemical storage tank location is already provided (originally intended for the addition of sodium hydroxide) with piping to a flow-paced chemical feed pump in the chemical feed room. With the addition of an ammonia/chloramine analyzer and a total/free chlorine analyzer, and some modifications to the City's SCADA system, chloramine disinfection could be added very simply within the existing facility.

### Magnetic Ion-Exchange (MIEX®)

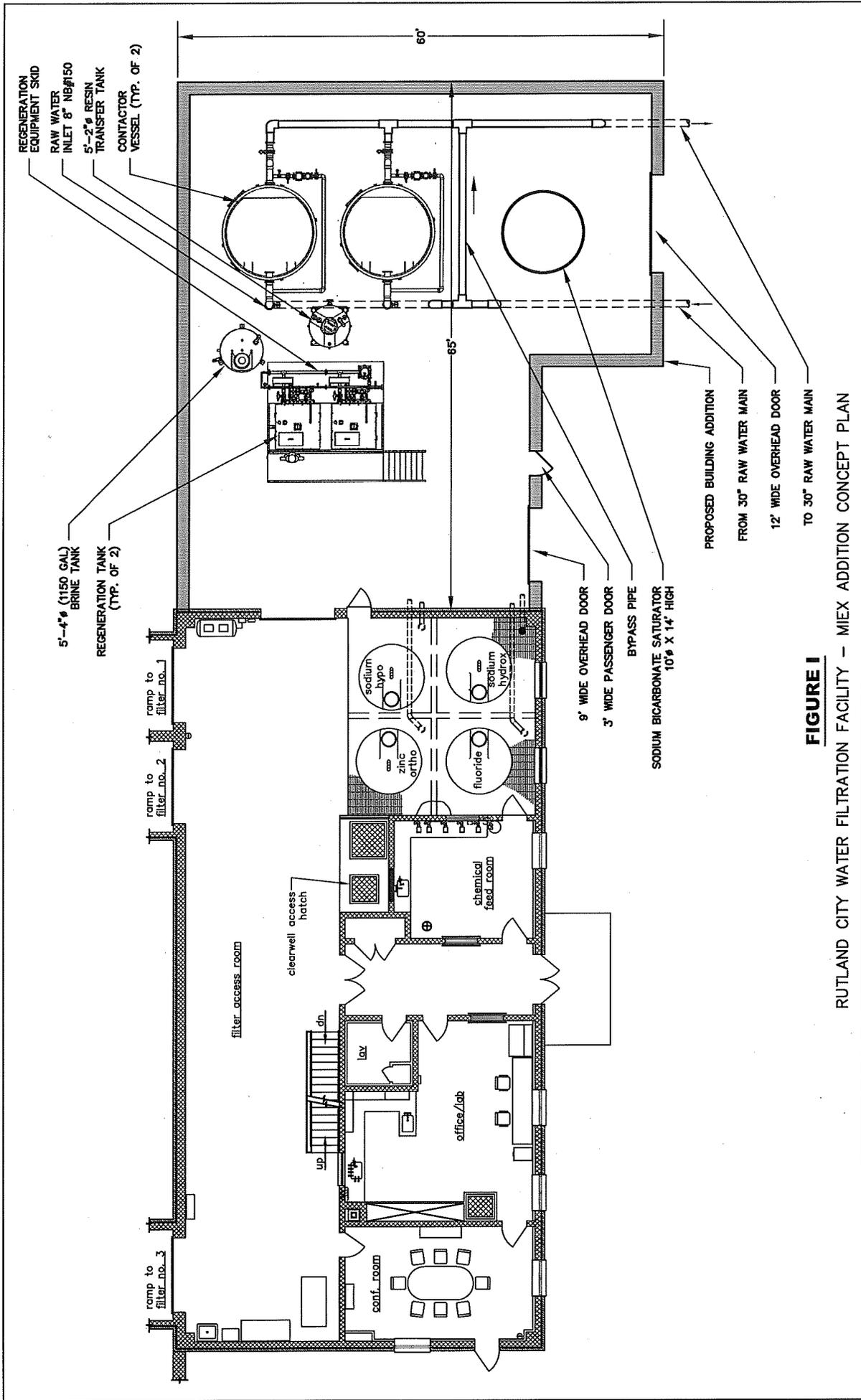
The City's pilot study demonstrated that MIEX® would significantly reduce DBP's in the City's finished water. Specifically, the Pilot Study showed a reduction in HAA5 concentrations by at least 50%.

Based on the City's historical locational running annual averages for HAA5, the highest concentration to date has been 83 ug/L, which would have required only a 28% reduction to achieve compliance. Therefore, a MIEX® installation could conceivably be sized less than the facility's filtration capacity, providing treatment of only a portion of the incoming flow.

Rutland City's filtration capacity is 3.6 MGD. A cost-saving approach would be to size a MIEX® installation for 1.8 MGD, 50% of the plant's capacity, allowing Rutland to meet the current HAA5 MCL limitation at a reduced capital cost for the new process equipment.

With a current Average Daily Demand of 2.5 MGD, such a 50% installation would allow bypassing of 1.25 MGD, reducing MIEX® operating costs.

A MIEX® installation at the Rutland slow sand facility could be installed as generally illustrated in Figure I on the following page:



**FIGURE I**

RUTLAND CITY WATER FILTRATION FACILITY - MIEX ADDITION CONCEPT PLAN

A complete MIEX<sup>®</sup> installation, as previously described, would require the following equipment:

1. 8,000 gallon sodium bicarbonate saturator tank (approximately 10' x 14' high) with loading/feeding equipment.
2. MIEX<sup>®</sup> package treatment unit including:
  - a. Two 13,500 gallon (11' dia x 19 ft high) contactor tanks.
  - b. Two resin regeneration vessels (4' dia x 9 ft high) with associated pumps, piping and equipment.
  - c. 750 gallon resin transfer tank with support stand.
  - d. 8,000 gallon sodium bicarbonate tank, mixer, pump and associated equipment.
  - e. Virgin resin feed system.
  - f. 2,000 gallon reused brine tank with pump and associated equipment.
  - g. Compressed air supply (should be able to use existing City compressor).
  - h. MIEX<sup>®</sup> control system and panel(s).
3. 3,500 sf building addition.
4. Connection to/from existing 30" plant raw water main.
5. Pressure control valve and control system (to allow bypassing of 50% of flow).
6. Integration of MIEX<sup>®</sup> system into existing SCADA system.
7. On-site waste disposal of sodium bicarbonate brine waste (approximately 1,000 gpd).

See Appendix F for a detailed description of the MIEX<sup>®</sup> equipment list.

### 7.1 Construction Costs Estimates

Based on the previously described alternative improvements for DBP reduction, preliminary opinions of construction costs have been prepared. Table 14 details construction cost estimates for the addition of chloramination. Table 15 details the estimated costs associated with the addition of the MIEX<sup>®</sup> process.

### 7.2 Project Cost Summary

Beyond actual construction costs, project expenses also include survey, design, and permitting assistance, as well as bid and construction phase engineering services.

- a. **Technical Services** - For this phase of engineering study, the estimated construction cost are used to estimate technical fees during design, bid and construction phases of the project. Based on the Agency of Natural Resource's formula for eligible engineering fees. In our experience, subject to the nature of the project, we have found that this fee curve is a useful and reasonably accurate tool for estimating fees when the project is not yet sufficiently defined to prepare an actual level of effort fee estimate.
- b. **Other Project Related Expenses** - In addition to technical fees, projects of this nature typically incur some costs for legal and/or accounting services, short term financing costs, and/or costs related to public notification and/or bond votes.
- c. **Contingency** - Given the early phase of this project it is prudent to include a contingency in the overall budget to account for variability on construction, material, and equipment pricing, and unanticipated design considerations. A contingency of 15% of estimated construction cost is typically included in the budget at this phase of a project. This percentage may be reduced as the project design progresses.

- d. **Land Acquisition** - No land acquisition is anticipated to be required for this project.

### 7.3 Annual Operating Costs

The estimated annual operating cost increase related to chloramines disinfection is approximately \$15,000 per year.

The estimated annual operating cost increase related to the MIEX<sup>®</sup> process is estimated at \$0.12/1,000 gallons treated, assuming current power and resin costs, and salt used for regeneration. At 1.25 MGD, this equates to \$150/day, or \$54,750 per year. Rutland would use sodium bicarbonate in order to dispose of the waste on site. The concept of on-site disposal of brine waste has not been reviewed or approved by the Agency of Natural Resources. However, on-site disposal is used in Maine. The use of sodium bicarbonate would increase the operating cost by approximately \$100/day, to \$91,250. Estimated additional labor requirements would result in a total estimated increase in operating costs of approximately \$100,000.

**Table 15**  
**Estimated Project Cost of Chloramination Addition**

Description	Total Quantity	Unit Cost	Unit	Total Cost
Liquid Ammonium Sulphate Tank and Feed System	1	\$15,000	L.S.	\$15,000
Chloramine Analyzer and Chlorine Analyzer	1	\$25,000	L.S.	\$25,000
Electrical / Plumbing Modifications	1	\$ 5,000	L.S.	\$ 5,000
Modification to Existing SCADA	1	\$ 5,000	EA.	\$ 5,000
Miscellaneous Improvements	1	\$ 5,000	EA.	\$ 5,000
<b>Subtotal - Construction</b>				<b>\$ 55,000</b>
Construction Contingency, (15%)				\$ 8,250
<b>TOTAL ESTIMATED CONSTRUCTION COST</b>				<b>\$ 63,250</b>
<b>Other Project Costs</b>				
Final Design				\$ 8,000
Public Education, Hearings				\$ 10,000
Construction Phase Services, Start-up				\$ 5,000
<b>TOTAL ESTIMATED PROJECT COSTS</b>				<b>\$ 86,250</b>

**Table 16**  
**Estimated Project Cost of MIEX® Addition**

Description	Total Quantity	Unit Cost	Unit	Total Cost
Sitework, Exterior Piping	1	\$ 50,000	L.S.	\$ 50,000
Building Addition, 45' x 60'	3,500	\$175	S.F.	\$612,500
1.8 MGD MIEX® Package Process Equipment	1	\$1,460,000	L.S.	\$1,460,000
Mechanical, Piping, Heat, Ventilation	1	\$ 150,000	L.S.	\$ 150,000
Electrical Installation	1	\$ 150,000	L.S.	\$ 150,000
On-site Disposal System	1	\$ 50,000	L.S.	\$ 50,000
SCADA Integration	1	\$ 5,000	L.S.	\$ 5,000
First Year's Resin Use	1	\$ 43,000	L.S.	\$ 43,000
<b>Subtotal - Construction</b>				<b>\$2,520,000</b>
Construction Contingency, (15%)				\$ 378,075
<b>TOTAL ESTIMATED CONSTRUCTION COST</b>				<b>\$2,898,575</b>
<b>Technical, Admin, Legal, Financial</b>				
Final Design				\$ 150,000
Bid / Construction Phase Services				\$ 250,000
<b>TOTAL ESTIMATED PROJECT COSTS</b>				<b>\$3,298,575</b>

Funding for the publicly owned community water projects in Vermont, for a community over 10,000 in population, is generally only available from:

- **The Vermont Agency of Natural Resources:** Drinking Water State Revolving Loan.
- **Vermont Bond Bank:** loans.

A goal of any water system improvement project is to make the necessary improvements at the lowest resultant cost to the user without compromising quality and longevity. These two funding sources are described in detail below. Table 16 summarizes the potential funding.

### 8.1 State Drinking Water Revolving Fund for Water Supply Projects (DWSRF)

- a. **Funding Priority List** - For a project to be eligible for DWSRF funding, it must be placed upon the Water Supply Project Priority List. Projects are ranked to ensure that the most critical needs receive first consideration in awarding available dollars. Projects are funded based on their priority and ability to proceed. If a project is not ready to proceed, it must reapply for the next year's funding. In general, DWSRF funding is limited to improvements to existing water systems and can not be used to create new water systems.
- b. **Planning Assistance** - Planning for most water improvement projects requires investments in engineering and hydrogeological services before actual construction of any improvements. To help offset the "front end" burden on the local municipality, the State can provide a DWSRF planning loan. DWSRF planning loans are not grants; they are 0% interest loans that must be paid back within 5 years or when the project goes to construction, whichever comes first. Planning advances are typically available for preliminary studies, hydro geological services, final design, surveys, and the development of plans,

specifications and bid documents. Such funding has been utilized for this preliminary study may be used for final design, if the project proceeds.

- c. **DWSRF Funding for Construction** - There is one State funding program, administered by the Agency of Natural Resources, Water Supply Division. DWSRF is available for construction of water system improvements for both public and private community water systems. This fund provides low interest loans for all project costs associated with a water system improvement project. Interest rates vary between 0 and 3% for a 20 years term. Disadvantaged communities (local 2012 MHI below \$59,755) are eligible for interest rates as low as -3% with a 30 year term. Interest rates are set in an attempt to keep the total annual cost of water at approximately 1% of the system's median household income, if possible.

Rutland City's median household income from the 2000 census was \$30,478. Increasing this figure by 4% per year (from the year 2002) as required by DWSRF guidelines, yields an estimated 2012 MHI of \$45,115 resulting in a DWSRF funding goal of \$451 per residence (total annual water cost). For perspective, this is roughly the current average annual cost of municipal water in Vermont.

**Since the adjusted 2012 MHI for the City is below the 2012 limit of \$59,755 for "disadvantaged" status, the City is eligible for up to a 30 year term loan and/or an interest rate as low as -3%, in order to maintain, as closely as possible, a \$451 average annual residential water cost.**

A Rutland City water user using 225 gpd currently pays \$440 per year for water, indicating that the City should be eligible for a DWSRF loan interest rate close to -3% for a project which will increase the average cost of water to over \$451 per year.

## 8.2 Vermont Bond Bank

Financing for municipal infrastructure projects is available from the Vermont Bond Bank. The term for water projects is 30 years and the interest rate is fixed at the time of the bond sale.

## 8.3 Financing and Estimated Water Rates

Because of the low interest rate available through the Drinking Water State Revolving Fund, it is recommended that Rutland City pursue funding of the project through that State program. In addition, because of the necessity of the proposed improvement, to meet Federal drinking water contaminant standards, the City should rank very high on the State's funding priority list.

	State DWSRF	Vermont Municipal Bond Bank
Total Estimated Project Cost	\$ 86,250	\$ 86,250
Loan Amount	\$ 86,250	\$ 86,250
Estimated Interest Rate / Term	0% - 20 yrs.	4% - 30 yrs.
Annual Bond Payment	\$ 4,062	\$ 4,699
Annual Operating Cost	\$15,000	\$15,000
Estimated Annual Increase in Water Bill per 100 CF <sup>(1)</sup>	\$ 0.029	\$ 0.032
% Increase in Current Rate	0.9%	1.0%

(1) Calculated by Rutland City.

	State DWSRF	Vermont Municipal Bond Bank
Total Estimated Project Cost	\$ 3,298,575	\$ 3,298,575
Loan Amount	\$ 3,298,575	\$ 3,298,575
Estimated Interest Rate / Term	-3% - 20 yrs.	4% - 30 yrs.
Annual Bond Payment	\$ 117,956	\$ 184,056
Annual Operating Cost	\$ 100,000	\$ 100,000
Estimated Annual Increase in Water Bill per 100 CF <sup>(1)</sup>	\$ 0.30	\$ 0.39
% Increase in Current Rate	9.2%	11.9%

(1) Calculated by Rutland City.