REVIEW OF ISSUE 7.

MEASUREMENT OF SOURCE AND FINISHED WATER QUALITY

On Behalf of The Ontario Water Works Association (OWWA) and The Ontario Municipal Water Association (OMWA)

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1. Introduction

I have been asked to provide review comments on behalf of the Ontario Water Works Association (OWWA) and the Ontario Municipal Water Association (OMWA) on Issue #7 *Measurement of Source and Finished Water Quality*. In addition, and as part of the process for Part II of the Inquiry, I participated in Expert Meeting #4 – Treatment, Distribution, and Monitoring of Drinking Water on May 9-10, 2001 on behalf of OWWA/OMWA.

The subject matter relevant to Issue #7 is very closely linked to Issue #5 *Drinking Water Standards*. Drinking water standards and regulations throughout the world include specifications for monitoring frequencies, locations and methods. Also, standards and regulations include clear requirements for analytical methods, quality assurance as well as analyst and laboratory certification requirements.

Throughout this report, comments are directed primarily to Issue #7, but Issue #5 is also discussed to the extent to which overlaps exist.

2. Information Referenced in this Review of Monitoring and Analysis Issues

2.1. Walkerton Inquiry Issue Papers on Issue #7 and Issue #5

At the time of this review, there were no commissioned issue papers specifically dealing with either Issue #5 or Issue #7 posted on the Walkerton Inquiry web site (http://www.walkertoninquiry.com/part2info/commissuepapers/index.html). The Walkerton Inquiry commissioned an issue paper by Krewski *et al.* (draft March 2001) entitled *"Managing Health Risks from Drinking Water: A Background Paper for the Walkerton Inquiry".* This issue paper was to deal with Issue #1 (Management of Social Risk), Issue #3 (History of Water Pollution Outbreaks in Ontario) as well as Issue #5 and Issue #7. Issue Paper #8 *Production and Distribution of Drinking*

Water (Delcan, March 2001) includes considerable information of relevance to Issue #7 *Monitoring and Analysis of Source and Treated Drinking Water*. These two issue papers, along with other reference materials listed in Section 2.2, have been included in this review of Issue #7 Measurement of Source and Finished Water Quality.

I do not think that Issue # 7 "Measurement of source and finished water quality", has been covered in depth in the Krewski *et al.* report. Many gaps exist and these will be identified in this report. I found *Issue Paper 8: Production and Distribution of Drinking Water* an excellent overview of many monitoring and water quality issues. In fact, *Issue Paper #8* covers many topics of relevance to Issue #7 *Measurement of Source and Finished Water Quality* more thoroughly than the Krewski *et al.* report. Issue Paper #8 (Delcan, March 2001) has an excellent review of regulations and shows a good comparison table of minimum sampling and analysis frequencies required by the Ontario Drinking Water Protection Regulation. Also, Issue Paper #8 includes an excellent review of drinking water regulations in the United States, the European Union, England and Wales as well as Australia. The contaminants that must be monitored and the acceptable concentrations in each country are also presented and discussed.

2.2. Other Reference Materials included in this Review

In order to present the many issues related to Issue #7 and to a lesser extent Issue #5, I have included a number of other reference sources in this review. In addition to the Krewski *et al.* and Doyle *et al.* issue papers, I have also reviewed a number of other technical briefs, papers, regulations and standards documents. Table 1 summarizes the documents that were included in my review of water quality monitoring issues. Other references used to support my review comments are also included in the bibliography.

Table 1. Documents included in this review of Issue #7 Measurement of Source and Finished Water Quality.

Title	***Publication Date and Citation***	***Focus of Review Comments***
Ontario Drinking Water Standards	Revised January 2001 (PIBS #4065e)	• Section 4 Sampling, Analysis and Corrective Action
Regulation Made Under the Ontario Water Resources Act. Drinking Water Protection	O. Regulation 459/00 reg2000.0348.e, 34-DB/CB	• Sampling and Analysis Section, • Schedule 2 (Sampling and Analysis Requirements), • Schedule 3 Operational Parameters, • Schedule 4 (Chemical/physical Standards); • Table A (Microbiological)
Terms of Reference Engineers' Reports for Water Works	August 2000 (Revised January 2001) PIBS 4057e	• Assessment of potential for microbiological contamination • Monitoring regime
Guidelines for Canadian Drinking Water Quality	March 2001 Edition	• Section 3. Microbiological Characteristics
U.S. EPA Small Systems Regulatory Requirements Under the Safe Drinking Water Act as Amended 1996	EPA 816-R-99-0011 July 1999 Http://www.epa.gov/safewater/smallsys/ndwac/regfinal.pdf	• Small systems regulations • Case Studies: Cost Estimates of Small System Compliance
U.S. EPA National Primary Drinking Water Regulations	Http://www.epa.gov/safewater/mcl.html	• Current Drinking Water Standards

2.3. Issue #7 Measurement of Source and Finished Water Quality: Information Gaps Identified in the Krewski *et al.* Report

In January 2001, at a meeting of the Part II Parties, the Commission and its consultants, Krewski produced a status report summarizing what he said the Issue #7 report included. The paragraph in the status report for Issue #7 stated the following:

> *"Walkerton Study List #7: Current state of art in Ontario. The report examines how the presence of contaminants in drinking water (and source water) are measured, particularly microbiological contaminants. Current practices for monitoring the bacterial quality of water in Saskatchewan are described in detail and those in British Columbia referenced. A description of drinking water monitoring programs for chemical parameters in Ontario (the Drinking Water Surveillance Program) is included. Australia's efforts to develop a comprehensive water quality management system are described."*

For each of the topics mentioned in the above quotation, Table 2 summarizes my opinion on the coverage of these topics in the Krewski *et al.* issue paper.

Table 2. Coverage of topics in the Krewski *et al.* Issue Paper

Subject	**Review Comment:**
Measurement of contaminants in drinking water and source water	• Focus on microbiological contaminants • Not much on other methods, • Sampling issues not covered to any great extent. • Use of on-line monitoring for regulatory compliance not covered. • Small utility challenges for measurement of contaminants not addressed. • Sampling and monitoring focused on source and finished water, not treatment process or distribution system monitoring • No information on the standard methods used for drinking water quality monitoring for regulatory compliance (Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998) • No comment on the fact that the sample storage times specified in the Ontario Drinking Water Regulations do not meet acceptable criteria set by Standard Methods
Current practices for monitoring the bacterial quality of water in Saskatchewan	• North Battleford *Cryptosporidium* outbreak clearly indicates that "the intent rationale, responsibilities and scope of activities of agencies involved in the monitoring of bacteriological quality in Saskatchewan" is less than an ideal example • The exact circumstances triggering Precautionary Drinking Water Advisories (PDWA) and Emergency Boil Water Orders (EBWO) are not described. Also comparisons of the protocols triggering a boil water order in Saskatchewan are not compared and contrasted with protocols in Ontario or other provinces. • Saskatchewan doesn't monitor Heterotrophic Plate Count? What is "background bacterial growth"? • The number of samples collected, who collects them is not discussed • Monitoring of treatment process indicators (turbidity, chlorine residual) is not discussed • Monitoring issues and challenges in small rural municipalities are not discussed • Water quality monitoring practice in Saskatchewan or other provinces were not compared with those in Ontario (both in the past and after the Walkerton water quality incident)
Ontario Drinking Water Surveillance Program	• Very little information on this program presented. • Reader left with many questions related to the adequacy of the provincial program and how it links to or supports municipal monitoring programs required by the new regulations.

Overall, I believe that the Krewski *et al.* report is a good review of risk management issues and the development of drinking water standards and regulations. However, I do not think that Issue # 7 "Measurement of source and finished water quality", has been covered in depth in the Krewski *et al.* report for the following reasons:

- A gap analysis between state of the art practice in other countries and the current requirements for sampling and analysis in the Ontario Drinking Water Regulations has not been included,
- Little information is included on the monitoring of chemical and physical water quality indicators,
- Little or no information is included on the use of on-line monitoring, particularly as it relates to the measurement of finished water chlorine
- residual and turbidity in systems which do not have operations staff on shift 24 X 7,
- No discussion of standard methods for analysis of drinking water parameters or their limitations is included,
- No discussion is included regarding how the methods specified in Ontario's legislation compare to standard methods,
- Little discussion is included regarding the development of monitoring programs and the importance of monitoring throughout the drinking water treatment process, not just source and finished water,
- Little or no discussion is included regarding the challenges facing small utilities in conducting drinking water quality sampling, monitoring and analysis,
- Monitoring programs and sampling/analysis requirements for main repairs and replacement programs in the distribution system are not discussed at all,
- The section on Saskatchewan says that the "monitoring of bacteriological quality in Saskatchewan" will be discussed. There is no indication of the adequacy of Saskatchewan programs for source, process, finished and distribution system quality monitoring. Who conducts the analysis for rural Saskatchewan towns and how do the monitoring requirements compare to those in Ontario?

The main issues covered in this review related to Issue #7 Measurement of Source and Finished Water Quality are summarized in Table 3.

Table 3. Main issues related to Issue #7 covered in this review

Report Section	Issue
3.	**Monitoring Parameters**
3.1	Microbiological Parameters
3.2	Chemical, Physical and Operational Parameters
3.3	Turbidity Standards and Objectives
3.4	CT Concept
4.	**Laboratory Testing Methods**
4.1	Pre-analytical Phase of Testing
4.2	Analytical Phase of Testing
4.3	Post-Analytical Phase of Testing
5.	**Design of Monitoring Programs**
6.	**Monitoring Issues Related to Engineer's Reviews and Reports**
7.	**Small Systems Issues**
8.	**Issues Related to Water Quality Reports**

3. Monitoring Parameters

Many surface as well as ground water sources are subject to chemical contamination as well as microbiological contamination. Although these chemical contaminants typically are not associated with immediate symptoms such as diarrhea, contamination of water sources with pesticides, hydrocarbons, trichloroethylene and other industrial wastes are not uncommon. The use of high concentrations of chlorine and other disinfectants to meet disinfection criteria (CT) may produce undesirably high levels of disinfection by-products such at trihalomethanes and haloacetic acids.

Section 4 of the Krewski *et al.* issue paper is entitled “Measurement of Microbiological Water Quality”. The section briefly covers monitoring of other important chemical and physical parameters, but emphasizes microbiological monitoring. Most of the information presented in this section deals with the difference between pathogens and monitoring for microbiological indicator organisms. There is no section entitled *“Measurement of Chemical and Physical Water Quality”.* Issues related to water quality parameters other than microbiological parameters are discussed in a one-page sub-section entitled “Testing for Other Parameters”. To reflect a more balanced perspective, this section should have included a discussion of monitoring issues for all of the analytes in Schedule 3 Operational Parameters of the document “Regulation Made Under the Ontario Water Resources Act”, including: fluoride, color, aluminum, pH, turbidity, hardness, temperature, odor/taste, alkalinity, methane, chloramine, residual chlorine.

3.1. Microbiological Parameters.

The Krewski *et al.* report defines indicator organisms and how they are related to pathogens. The authors do a good job of emphasizing the fact that the results of monitoring for specific pathogens are not a guarantee that drinking water is safe from a health standpoint. Allen *et al.* (2000) clearly point out that pathogen monitoring is *“of little value as a pretense for public health protection”*. The amount of water tested for the presence of pathogens is insignificant compared to the amount of water produced for consumption. There are no methods of on-line monitoring of pathogens, consequently, there are delay times of up to 48 h before results for microbiological analyses are available. Simple methods are not currently available to monitor pathogens like *Giardia* and *Cryptosporidium* rapidly and frequently.

Intermittent monitoring programs for pathogens do not necessarily ensure public health and safety of the finished water because they are done on only a small fraction of the water treated. However, they can establish seasonal trends and relationships with simpler surrogate water quality tests. In Calgary, for example, monthly source water monitoring programs for *Giardia* and *Cryptosporidium* are used in combination with water quality tests for surrogate parameters (e.g., turbidity, colour, fecal coliforms, E. coli, ammonia, nitrogen) to establish normal ranges of pathogens as well as seasonal trends in source water quality. While source water pathogen monitoring can be very effective for optimizing treatment and identifying trends, monitoring methods are not yet available to allow "real-time" pathogen monitoring in either source or finished water to be used for compliance purposes.

3.2. Chemical, Physical and Operational Parameters

In addition to microbiological parameters, the Krewski *et al.* issue paper did list a number of other routine water quality parameters that are important from a regulatory standpoint and that also provide information for day-to-day system management. The Krewski *et al.* issue paper, however, gave only a small amount of information on issues surrounding the analysis of turbidity, particle counting, pH, temperature, free- and total-chlorine. Parameters conspicuously absent from Krewski's paper, but included as Operational Parameters in the "Regulation Made under the Ontario Water Resources Act" are: fluoride, color, aluminum, odour/taste, alkalinity, and methane. The paper does not provide a review of issues related to monitoring and analysis of chemical, physical and operational parameters.

In the U.S., the current Total Trihalomethane (TTHM) rule applies only to water systems serving more than 10,000 people. The rule was promulgated in 1979 and large systems have had to comply with the TTHM standard of 0.10 mg/L for almost 20 years. The Stage I Disinfectants/Disinfection Byproducts (D/DBP) rule finalized in November 1998 will eventually apply to all systems, large and small. The new TTHM standard will be 0.080 mg/L and small systems will be required to meet it. The U.S. EPA is considering a delay in the time for small systems to comply so that compliance will coincide with the Long Term I Enhanced Surface Water Treatment Rule.

According to the "*Regulations made under the Ontario Water Resources Act (August 2000),* the Maximum Acceptable Concentration for Trihalomethanes is set at 0.1 mg/L. This is in keeping with the Canadian Drinking Water Guidelines (March 2001), but not in step with the current U.S. EPA TTHM regulation of 0.08 mg/L. The Krewski *et al.* issue paper does not present any discussion about the critical issue of disinfection byproduct concentrations and does not discuss the rationale for the difference between the U.S. EPA and Ontario standards.

3.3. Turbidity Standards and Objectives

In the Ontario Drinking Water Standards (January 2001), the Maximum Acceptable Concentration for turbidity is 1.0 NTU and the Aesthetic Objective is 5.0 NTU. In the Ontario regulations, it does not appear that acceptable standards for individual filter turbidity have been set. The importance of monitoring individual filter performance using on-line turbidimeters is not discussed at all in the Krewski *et al.* issue paper. It is the understanding of OWWA/OMWA that Ontario will require turbidimeters on every filter in the new consolidated approvals to be issued under Ontario law and this is a very important step towards process optimization in treatment plants.

Health Canada (The Federal-Provincial Drinking Water Subcommittee) is currently considering a new turbidity guideline for Canada, which will likely propose lowered limits for turbidity. These may be based on regulations in the United States. The proposed US EPA Interim Enhanced surface Water Treatment Rule will lower the turbidity levels in the combined filtered effluent from 0.5 to 0.3 NTU in 95 percent of monthly samples collected at four-hour intervals (Federal Register, 1997). The maximum monthly turbidity level will also be decreased from 5 NTU to 1 NTU. As stipulated in the Interim Enhanced Surface Water Treatment Rule (IESWTR), the US EPA also regulates the effluent turbidity from individual filters and the combined filter effluent leaving the treatment plant. Furthermore, conventional and direct filtration plants must conduct continuous monitoring of turbidity for each individual filter in the plant. This requirement makes online monitoring of filter effluent turbidity a necessity in most US installations. As discussed later in this report, the Long Term 1 Enhanced Surface Water Treatment Rule (See: http://www.dep.state.pa.us/dep/deputate/watermgt/WSM/Facts/EPA-LT1ESWTR.htm) applies these turbidity requirements not only to large systems, but also to small drinking water treatment systems serving less than 10,000 people. Ontario regulations should be moving in similar direction to the US EPA regulatory trends for turbidity monitoring and regulatory compliance limits.

There is no discussion in the Krewski *et al.* issue paper of the discrepancy between the new Ontario Drinking Water Standards and the U.S. EPA turbidity standards. Utilities serving less than 10,000 people were given more time to meet the regulations in the United States, but eventually all will have to comply. I have not been able to find any papers or references that indicate that there will be more time provided to small systems in Ontario to meet new regulations. This would have been an important discussion, but it was not included in the Krewski *et al.* issue paper.

3.4. CT Concept

In order to produce the highest quality drinking water, utilities must carefully balance disinfection doses to ensure the drinking water produced is free of pathogens and contains the lowest possible concentrations of disinfection byproducts. The effectiveness of a certain dosage of disinfectant depends on: 1) the quality of the water to which the disinfectant is added (i.e., particulate and organic matter in turbid water may react with disinfectants to reduce the effective dose), 2) water temperature and, 3) the amount of time the disinfectant is in contact with the water before it reaches the consumer.

Many utilities use a mathematical calculation called CT (Disinfectant Concentration X Time) to optimize the disinfectant dose in their treatment plants. Issue Paper #8 *Production and Distribution of Drinking Water* has an excellent explanation of CT concept and the importance of well controlled disinfection practices. The Krewski *et al.* issue paper does not include any discussion of the CT concept of disinfection and the importance of gathering data to ensure that CT criteria are met.

Unfortunately, the monitoring issues related to CT have been addressed in neither Issue Paper #8 *Production Distribution of Drinking Water* nor in the Krewski *et al.* issue paper.

Calculation of CT requires monitoring throughout the treatment process for disinfectant residual, water temperature, and process disinfectant contact time (varies with flow or production rate changes). Large drinking water utilities often automate CT calculations and display the CT values on their process computer. This documents and ensures continuously optimized disinfection. All drinking water utilities in Ontario should be encouraged to collect the data to do CT calculations at least seasonally, to ensure that adequate disinfection doses have been added to kill pathogens without needless production of disinfection byproducts.

4. Laboratory Testing Methods

The Krewski *et al.* issue paper (draft March 2001) divides laboratory test methods into three phases: Pre-analytical, Analytical and Post-analytical. My review comments in the section that follows are also divided into these three categories.

Throughout the issue paper, Krewski *et al.* refer to “laboratory test methods” and there is no mention or distinction between on-line monitors and batch sample analysis.

Also, the focus of the Krewski *et al.* issue paper is on sending samples away to an accredited laboratory and the report does not address the major issues surrounding maintenance and operation of on-line instruments or quality assurance related to batch tests done on-site.

4.1. Pre-analytical Phase of Testing

4.1.1. Sampling Procedures

On p. 89, of the Krewski *et al.* issue paper, the authors emphasize the importance of sampling procedures. Krewski *et al.* do not go into detail on the important issues related to sampling, however, and these are fundamental causes of the water quality incident in Walkerton.

4.1.2. Sampling Requirements, Chain of Custody and other Sampling Issues

The information obtained from any monitoring program is only as reliable as the samples that are collected. The quality of monitoring information can be seriously compromised if samples are not collected using consistent standard operating procedures and following a well-planned monitoring program.

In the Krewski *et al.* issue paper, Section 4.6 Drinking Water Monitoring in Ontario and Saskatchewan, the statement is made:

"Under the new Ontario Drinking Water Protection Regulation of August 2000, sampling requirements for water works have become mandatory."

One of the important issues related to sampling that is not addressed in the Krewski *et al.* issue paper is the issue of "chain of custody" in sample collection. Who collects, who transports, who analyzes, and who records results from samples? The Krewski *et al.* issue paper does not discuss the monitoring regime required by Ontario Ministry of Environment Engineers Reports or the need for Standard Operating Procedures (SOPs) clearly outlining how to collect samples, who should collect them, and the "chain of custody" from collection through analysis to the reporting of the results.

In many small rural Alberta water treatment systems, treatment plant operators or technicians collect samples in the treatment plant itself, but staff not associated with the treatment plant operation (or contract employees) collect distribution system samples. The people responsible for sampling in the treatment plant process train are typically not the same people who collect the distribution system microbiological samples and transport them to the provincial laboratory. Sample collection procedures are important issues and SOPs must be in place in order to increase confidence in test results and minimize the opportunity for sample tampering or miss-representation.

4.1.3. Ontario's Drinking Water Surveillance Program: Using Existing Trend Information to Optimize New Sampling Programs

Krewski *et al.* describe the Ontario Ministry of the Environment "Drinking Water Surveillance Program" briefly. There was only a cursory review of this subject in the issue paper. The authors say that in the Drinking Water Surveillance Program:

"samples are taken of the source water, the treated water entering the distribution system and water from at least one location within the distribution system that is representative of the water at the consumer's tap."

The data collected from the Surveillance Program was never intended to be for compliance purposes. The database is, however, a valuable resource and well worth some investment of time and resources to ensure the data is "mined" to extract useful water quality trending information. It is unclear whether the data collected from the surveillance program have ever been compared against data bases collected by individual utilities over the same time period.

Krewski *et al.* make the observation that:

"in 1997, 145 municipal water works were being monitored representing 88% of the population served by municipal water.

Further, the authors say that:

"waterworks using surface water sources are sampled more frequently than "true" groundwater sources because of the often more variable quality."

"Annually, one sample of the raw and treated water collected from each water works in the program is screened for the complete spectrum of organic chemicals."

The frequency of monitoring by utilities, the role of the provincial surveillance program, and how the two programs interrelate or support each other are important issues relevant to the Walkerton case and these subjects are not addressed in depth by the Krewski *et al.* report. It would be worthwhile to review the data collected in the provincial program and compare the results to those from existing utility databases and results that will be collected through the new monitoring programs legislated by the new Ontario Drinking Water Regulations. Surveillance data review may help identify the number of utilities facing critical challenges in meeting the new regulations and standards.

4.1.4. Definition of Groundwater Under the Direct Influence of Surface Water

In the documents I reviewed, I was not able to find a clear definition of the criteria used to categorize groundwater as "groundwater under the direct influence of surface water". It will be important for the Government of Ontario to work with stakeholders to clearly define criteria for "Ground Water Under the

Direct Influence of Surface Water". Clearly defined indicators for making a determination in this matter are needed, such as variations in turbidity or color with rainfall or runoff events, presence of Coliform bacteria or E. coli or presence of nitrates. Information gathered through Ontario's Drinking Water Surveillance Program may be a useful long-term database that may help identify key indicators of surface water intrusion. Because of the significant difference in treatment requirements for groundwater and groundwater under the direct influence of surface water, drinking water utilities are looking for clear direction and guidance on this issue.

4.1.5. Number of Samples Collected

A Technical Brief (August 2000) on *"New sampling requirements for waterworks"* gives information on the number of samples that must be analyzed for bacterial parameters in distribution systems. According to the Technical Brief:

"Weekly samples of a water system's raw water source and samples taken at all points where the treated water enters the distribution system are now required for E. Coli/fecal coliforms and total coliforms.

For systems serving 100,000 people or fewer, a minimum of eight samples must be taken per month in the distribution system, increasing by one per 1,000 people served.

For systems serving more than 100,000 people, a minimum of 100 samples must be taken monthly, increasing by one per 1,000 population.

According to Schedule 2 of the Regulation, systems serving 100,000 people or fewer must take at least one sample per week in the distribution system. System serving more than 100,000 people are required to take at least three samples each week.

The frequency, location and rationale for microbiological, chemical and physical monitoring in the distribution system are very important issues to ensure quality water reaches consumers in their homes. The Krewski *et al.* issue paper did not discuss or critique the numbers of samples proposed in the Ontario regulations nor did they compare the sample numbers with regulations in other provinces or the United States.

The number of samples of distribution system water quality required by the Ontario Drinking Water Regulations are greater than those specified in the Canadian Drinking Water Guidelines. This is a very proactive and important move for the protection of public health. Ontario requires 8 samples per month up to 5,000 population, then 1 per thousand population. Canadian Guidelines (1996) require only 4 samples per month up to 5,000 population and then 1 per thousand population after that. For large cities, the numbers of samples specified in the Canadian guidelines and Ontario regulations are almost the same. The Ontario regulations also require at least one sample to be collected each week, while the Canadian guidelines don't specify the time requirement. The Ontario regulations will ensure that utilities do not collect all of their distribution system water quality samples on one day of the month.

The questions that must be answered after a considerable set of data from a large number of municipalities has been collected are:

- Are the numbers of samples collected really adequate to characterize a distribution system?
- What data has been collected to show that one sample taken per week adequately characterizes the water quality sent to as many as 100,000 people?
- For populations of over 100,000 people, is collection of three samples in a week really sufficient to understand and preserve water quality in a complex distribution system network?

I think that drinking water consumers in municipalities serving up to 100,000 people would question the effectiveness of a distribution system sampling program that could see as few as ONE sample being collected in any given week.

In Calgary, 287 compliance samples are collected each month from the city's distribution system. Currently, the City of Calgary's population is approximately 850,000 people. According to the Canadian Guidelines and the Provincial "License to Operate", Calgary Waterworks is required to collect a minimum of 166 samples per month in the distribution system. Calgary Waterworks has voluntarily chosen to collect almost double the number of samples required. The utility operates two water treatment plants and a complex distribution system. According to the rationale in the ***Coliform Monitoring Plan*** developed by the utility (see Appendix I for the Table of Contents of Calgary's monitoring plan), the distribution system could not be adequately characterized by collecting the minimum number of samples prescribed.

According to the Ontario Ministry of the Environment Technical Brief (August 2000) on *"New sampling requirements for waterworks"*:

"Twenty-five percent of the distribution system samples must be analyzed for heterotrophic plate count."[1]

The Krewski *et al*. issue paper focused to a large extent on the use of indicator organisms to identify pathogens. No mention was made or discussion presented concerning the Ontario Drinking Water Regulations requirement to

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[1] The Regulation states "Only 25 percent of each batch of the above samples (i.e., distribution system samples) needs to be analyzed for Heterotrophic Plate Count or background colonies on a total coliform membrane filter analysis."

analyze Heterotrophic Plate Count in only 25% of samples collected. Why do only twenty-five percent of the distribution system samples require Heterotrophic Plate Count analysis? Also, the results obtained by counting the number of background colonies on a total coliform membrane filter analysis may give similar trends but are not necessarily the same as those from an actual Heterotrophic Plate Count analysis.

The E. coli, fecal and total coliform tests will provide very little information about the distribution system, because typically none of these organisms will be detected. So, most of the results will be reported as "Non-detect" and not give any indication of distribution system bacterial populations. The data will not be useful for statistical analysis of trends, neural network modeling of distribution system water quality or any mathematical assessment of data. Mathematical models require numbers, not the words "non-detect". Even though Heterotrophic Plate Count is a non-specific indicator and the numbers are not associated with fecal contamination, they can be a good tracking tool for distribution system integrity.

In Calgary, the current Alberta Environment Approval for the operation of the water treatment plants (October 1999) specifies Heterotrophic Plate Count as one of the bacterial indicators that requires a specific response:

"When coliform bacteria are present in any sample of treated water, or if a sample contains confluent growth with either more than 500 HPC colonies per millilitre, or more than 200 background colonies on a total coliform membrane filter, the approval holder shall ensure that the following actions are taken:

- *the sample is analyzed for fecal coliform or E. coli*
- *repeat samples are collected*
- *the cause of the coliform(s) or colonies presence is investigated and corrected.*

In Edmonton (L. Gammie, Ph.D., EPCOR Water Services, personal communication), HPC monitoring is used to get an overall picture of water quality in the distribution system. In Edmonton, HPC numbers are typically <10 HPC/mL and flushing will be initiated if more than 50 HPC/mL are detected.

Results of any microbial tests, including HPC, should always be reported as a number not simply as “presence/absence”.

4.1.6. Review of Ontario Drinking Water Standards

I requested review comments from Dr. Martin Allen (American Waterworks Research Foundation, Denver) on the new Ontario Regulations and the quote below summarizes Dr. Allen’s remarks related to the microbial monitoring requirements in the new regulations:

“The new Ontario regulations do not reflect the current science that Total Coliforms have no public health significance in drinking water. Their presence indicates undesirable water quality, but there is no health significance unless the coliforms include E. coli. If the focus of the regulations is on public health protection, then Ontario regulations must specify that E. coli always be tested rather than Total Coliforms alone. Public health advisories should never be issued merely on the basis of Total Coliform data.

There are specific Standard Method commercial tests (Colilert) that can provide E. coli data in 18-24 h and all labs should be using these tests now. Ontario still allows the use of a non-standard Membrane Filtration methods for Total Coliforms. The Membrane Filtration method is inferior to the Colilert Test and requires up to 72 h to confirm Total Coliforms.

Further, the new methods of E. coli speciation are so simple and foolproof that all public water utilities should be allowed and encouraged to do their own daily testing. It is hard to understand why the new regulations focus on Total Coliforms and also require that utilities be certified or send their bacterial samples to a provincial or *commercial lab. This adds unnecessary delay time to getting results back and also could introduce errors as a result of shipping, storage time, or other impacts of analytical delays.*

Regarding Heterotrophic Plate Count and its role as an adverse public health indicator -- IT IS NOT. There is no clinical basis that HPCs in drinking water pose any health risk. Also, HPC populations must be determined when using Membrane Filtration method for detection of Total Coliforms, because high HPC counts can interfere with the results. This is another strong reason why HPC populations should be determined with Colilert Test methods (or equivalent) rather than Membrane Filtration.

Fecal coliforms are not the same as E. coli and for a number of reasons well published in the scientific literature, fecal coliforms should be dropped from both drinking water and wastewater regulations."

4.1.7. Sampling procedures during main replacements, main breaks and repairs

It seems very strange that the Krewski *et al.* report does not discuss the issue of sampling and analysis or procedures related to disruptions in distribution system integrity. Section 4.2 Measurement of Source and Finished Drinking Water seems to focus on microbiological contamination of source water and finished water, but does not raise the issues related to distribution system integrity.

Fecal bacteria, including *E. coli* could enter any water supply after a main repair, replacement or other disruption in the water distribution network. The American Waterworks Association has published disinfection and sampling/analysis guidelines for the installation and replacement of water mains (Haas *et al.* 1998). A survey in the Haas *et al*. report showed that bacteriological tests are rarely conducted after main repair or replacement operations.

Standard Operating Procedures describing flushing, chlorination procedures and sampling/analysis are a must during any distribution system main disruption. If Standard Operating Procedures do not already exist, the Government of Ontario should work with the appropriate stakeholders to develop standard procedures for flushing, chlorinating, sampling and analysis during any distribution system main disruption and ensure that adequate training is provided for same.

4.1.8. **Importance of Storage and Transport Issues**

An Ontario Ministry of the Environment Technical Brief entitled "Water sampling and testing for microbiological parameters" (November 2000), indicates that:

"Samples for microbiological analysis should be analyzed within 48 hours, to ensure the most reliable results. Samples that have not been refrigerated must be analyzed within four hours of sample collection."

These specifications for holding time do not agree with those specified in *Standard Methods (1999).* According to *Standard Methods*:

"Holding Time and Temperature

General – Start microbiological analysis of water samples as soon as possible after collection to avoid unpredictable changes in the microbial population. For most accurate results, ice samples during transport to the laboratory, if they cannot be processed within 1 h after collection. If the results may be used in legal action, employ special means (rapid transport, express mail, courier service, etc.) to deliver the samples to the laboratory within the specified time limits and maintain chain of custody. Follow the guidelines and requirements given below for specific water types.

Drinking Water for compliance purposes: Preferably, hold samples at <10^{o}C during transit to the laboratory. Analyze samples on day of receipt whenever possible and refrigerate overnight if arrival is too late for processing on same day. DO NOT EXCEED 30 H HOLDING TIME FROM COLLECTION TO ANALYSIS FOR COLIFORM BACTERIA. DO NOT EXCEED 8 H HOLDING TIME FOR HETEROTROPHIC PLATE COUNTS.

There appears to be a significant deviation from *Standard Methods* (1999) specifications in the Ontario Ministry of the Environment's Technical Brief. A storage time of 48 h could result in significantly increased rates of false positives as well as increased counts in all bacteriological tests. Further, the delay time between the sample collection and analysis has a serious negative impact on response time. Was the impact of 48-h storage on test results determined scientifically before these storage times were approved? It is recommended that the 48-h storage time be revised to the accepted Standard Method.

In the Krewski *et al.* report, I believe that the reader is left with the impression that sampling, transport and storage conditions are more important for microbiological testing than for any other testing. Also, the reader is left with the impression that all water quality parameters lend themselves to taking a batch sample and transporting/shipping the sample to a laboratory for analysis. I disagree with the statement on p. 88 that:

"Turbidity is essentially a physical rather than a biological parameter and is relatively stable. Therefore, the time between sampling and testing, and conditions of transport are less critical than for microbiological tests."

Turbidity and particle counting measurements are both time-sensitive and storage-sensitive. Chlorine residual must also be analyzed immediately and, therefore, samples cannot be stored or sent to an external laboratory for analysis. Table 4 summarizes the sample storage requirements for turbidity, particle counting and chlorine residual presented in *Standard Methods (1998).*

The Ontario Government should ensure that standard methods are adopted for turbidity, particle counting and chlorine residual measurements.

Table 4. Sample storage requirements specified in Standard Methods (1998).

Analytical Parameter	**Acceptable Sample Storage**
Turbidity	Determine turbidity as soon as possible after the sample is taken. For best results, measure turbidity immediately without altering the original sample conditions such as temperature or pH.
Particle Counting	Minimize time between sampling and analysis: if at all possible, make measurements immediately after sampling.
Chlorine Residual	Chlorine in aqueous solution is not stable, and the chlorine content of samples, particularly weak solutions, will decrease rapidly. Start chlorine determinations immediately after sampling. Do not store samples to be analyzed for chlorine.

4.1.9. Sampling Locations

Section 4 “Sampling, analysis and Corrective Action” of the new Ontario Drinking Water Standards (January 2001) lists a number of reasons for monitoring and analysis of source water, the treatment process and finished water. The regulations state that water monitoring can be used to “monitor treatment efficiency and operating parameters”. This would imply that analysis of some water quality parameters would be required throughout the water treatment process. Yet, only three basic locations at which waterworks should be sampled are listed: raw water, treated water entering the distribution system, and distributed water. There is no mention of requiring treatment plants to monitor sites throughout the treatment process.

The selection of sampling sites and the frequency of sampling in the treatment train may be addressed in the Ontario Ministry of the Environment Engineers' Reports for Water Works (August 2000), but this topic is not discussed in the Krewski *et al.* issue paper. As such, I have recommended enhancements to the water works review process to ensure the treatment train is adequately monitored (see Section 5 Design of Monitoring Programs).

4.2. Analytical Phase of Testing

Generally, the analytical phase section of the Krewski *et al.* report focuses on analysis of batch samples by accredited laboratories. There is no mention of on-site analysis by operators or technicians or about the importance of on-line monitoring and simple field tests for surveillance.

4.2.1. Use of On-line Instruments for Regulatory Compliance

Ontario Ministry of the Environment Technical Brief (August 2000b) lists a number of water quality parameters that can be analyzed on-site at the water treatment plant or in the distribution system. Table 5 divides these parameters into two categories: those that are commonly monitored on-line and those that are monitored using batch or laboratory analysis.

Table 5. Parameters which can be tested on-site at waterworks using either on-line or batch procedures.

On-line Analysis	***Batch Sample Analysis***
• Fluoride • Turbidity • Temperature • Chloramine • Residual Chlorine	• Aluminum • Alkalinity • Colour • Fluoride • PH • Hardness • Odour/taste • Methane

The use of on-line instrumentation for process optimization, process control as well as regulatory compliance has not been addressed in the Krewski report. On p. 89, the report states that:

"it is important that turbidity meters are designed and calibrated to measure in the appropriate range with the desired degree of accuracy. "

The report does not mention that turbidity can be measured with either on-line or batch instruments.

Historically, many utilities have relied on bench instrument measurements to make decisions about plant operations. Today, on-line instruments are increasingly replacing these measurements. A recent survey of on-line monitoring practices for US utilities (Frey 2001) indicated that only 84% of these facilities use on-line instruments. Also, more than 75% of the drinking water utilities operate on-line analyzers for such water quality parameters as chlorine and turbidity. Approximately half of the utilities also use on-line sensors for pH measurements, and 20% apply online sensors for general water quality parameters such as conductivity, temperature, and dissolved oxygen.

In North America, utilities exhibit mixed attitudes about the relative quality of bench and on-line measurements. The majority of water quality compliance monitoring in North America is performed using bench or laboratory techniques, though this is slowly changing. The degree to which the bench or laboratory measures are used for purposes perceived to have high data quality requirements (i.e., regulatory compliance) indicates the perception that these measurements are more reliable than those produced by on-line monitors.

In contrast, European utilities rely predominantly on their on-line measurements for operational decisions, control of plant processes as well as compliance reporting. This trend for European utilities coincides with the industry trend towards higher levels of automation in plant operations than that typified in North American utilities.

Drinking water utilities in Canada still rely predominantly on bench measurements for important operational or regulatory activities, transitions to online monitoring results should be executed in a prudent and methodical manner. Table 6 presents a summary of drinking water regulations in the United States where on-line monitoring data would be suitable for compliance reporting.

Table 6. Drinking Water Regulations in the United States where on-line monitoring results could be used to generate compliance reports.

Regulation	**Parameter**	**Degree of Online Monitoring**
Interim and Long-term 1 Enhanced Surface Water Treatment Rules	• Combined Filter Effluent Turbidity • Individual Filter Effluent Turbidity • Finished Water Chlorine Residual	• Nearly All Filter Plants • All Filter Plants • Nearly All Plants
Stage 1 Disinfectants/Disinfection By-Products Rule	• Distribution System Chlorine Residual	• Some Utilities with Remote Monitoring Stations
Inorganic Contaminants	Fluoride	• Some Plants
Lead and Copper Rule	• PH • Alkalinity • Phosphate	• Many Plants • Few Plants • Few Plants
Filter Backwash Rule	• Recycle Flow rate	• Few Affected Plants

The new *Ontario Drinking Water Standards* and *the Regulation Made Under the Ontario Water Resources* Act do not specify online monitors however, utilities must ensure that disinfection is provided at all times. The only way to ensure that disinfection dosing equipment is functioning continuously is with automatic monitors that shut-down at no or low disinfectant dosages. I would suggest, however, that Ontario has an opportunity to encourage water utilities to install and use online monitoring systems, particularly in small systems where treatment operations are often unmanned for long periods. Ontario should also consider accepting online monitoring data for regulatory compliance rather than specifying the use of batch or composite samples.

To get accurate data from online monitors, appropriate quality assurance programs, calibrations, maintenance, cleaning etc. all must be prescribed. Many small systems may chose to purchase online monitors for continuous monitoring of remote or unmanned locations, however, specific operational guidance and minimum requirements must be in place to ensure that the results obtained are meaningful. Also, because online instruments have a lot more water going through them continuously, the possibility of fouling, deposits, or flow disruptions is much higher than batch analysis.

I agree with the conclusion in Issue Paper 8: Production and Distribution of Drinking Water (Doyle *et al. 2001*):

"The population of southwestern Ontario, while large, is quite disperse. Many of the waterworks in this area are small; 157 facilities that serve less than 1,000 people are located here. While the trend in many parts of North America is to merge several treatment and distribution systems to improve quality and supply, a large number of small individual systems remain in southwestern Ontario. This may present greater challenges to monitoring and promotion of uniform water quality for the population."

I believe there is an information gap here. It will be important for Ontario to review the role of online monitoring for regulatory compliance as well as to consider a “water quality network” approach to monitoring for small systems, particularly in remote locations. Ontario Ministry of the Environment may want to consider reviewing possible options to overcome monitoring challenges in remote locations by considering the use of online networks, telemetry to central monitoring stations or other technologies that would ensure continuous water quality monitoring while minimizing manpower requirements.

4.2.2. Use of Simple Field Test Kits for Chlorine Residual, Turbidity and other basic indicators

The use of simple test kits for monitoring drinking water quality in the field is not discussed in the Krewski *et al.* issue paper. The Ontario Government should review the benefits and potential applications of simple field tests, particularly for small systems and distribution system monitoring.

4.3. Post-Analytical Phase of Testing

The Krewski et al. issue paper devotes less than a quarter of a page of text to the important issue of records management and the use of monitoring information for process improvement or compliance. These issues would be addressed in a comprehensive monitoring plan, as described in Section 5 below.

5. Design of Monitoring Programs

Monitoring program design is a very important consideration in Issue #7 Measurement of Source and Finished Water Quality. Monitoring programs must be developed to address compliance monitoring requirements, process optimization requirements as well as response monitoring. Program design will be a challenge, particularly for small utilities in Ontario.

In Europe, the European Commission has established strict Raw Water Quality Directives as well as requirements for river basin characterization and monitoring and establishment of protected areas. Issues related to source water protection and monitoring would need to be investigated and taken into account in a well-designed monitoring program. The concept of different levels of monitoring requirements based on source water quality should be considered in Ontario.

Section 4.3 of the Krewski *et al.* issue report deals with the design of monitoring programs only briefly. A thorough review of important considerations in the design of monitoring programs in drinking water utilities has not been included. The issues of plant treatment monitoring, plant optimization monitoring and stable control have also not been addressed by the Krewski *et al,* report.

5.1. Program Elements

A good program monitors water quality from start to finish, including source, treatment plant process, finished as well as distribution system water. Some important elements of a monitoring program are:

1) Sampling Sites
   a) Number of samples and their locations, including:
      - Rationale for site selection and relevance to system operational variables
      - Evaluation of seasonal impacts on frequency and types of samples collected (i.e., monitoring for pesticides during known application periods)
2) Division of sampling activities into categories and description of the interrelationship of the programs:
   a) Compliance monitoring
   b) Treatment plant process control monitoring
   c) Response monitoring (e.g., monitoring related to algal blooms in reservoirs, maintenance activities or disruptions in plant processes or distribution system repairs)

   d) Special process characterization and optimization monitoring
   e) Source water characterization (e.g., watershed monitoring well above source water intakes to identify point sources of pollutants)

3) Standard Operating Procedures for the methods used
4) Quality Assurance Program (including instrument maintenance)
5) Training Program
6) Definition of water quality compliance and “in-house” action limits
   a) Clear rationale for response limits
7) Data Evaluation
   a) Clear process for reviewing long-term water quality trending

The monitoring program should include a cost benefit analysis to justify the sites selected and the sampling frequency. Many utilities voluntarily choose to collect more than the number of samples than the regulatory requirement. The benefits are high customer confidence and satisfaction, strong working relationships and trust between the utility and the regulatory agencies, timely identification and response to water quality issues and cost savings on treatment chemicals and process maintenance.

5.2. Example of a Monitoring Plan

In Alberta, as a condition of Section 9.2.3.1 in the *Standards and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems* (Alberta Environment, 1996), drinking water utilities are required to prepare a <u>*Coliform Monitoring Plan*</u>. The plan outlines the details of a water utility’s microbiological monitoring program as well as its regulatory compliance and treatment plant process control monitoring programs. The <u>*Coliform Monitoring Plan*</u> appears to be similar to the “recommendations for a monitoring regime” that is required by the Ontario Ministry of the Environment Engineers’ Reports for Waterworks.

The City of Calgary has developed a detailed ***Coliform Monitoring Plan*** (Strilchuk, 2000). The Table of Contents for the City of Calgary ***Coliform Monitoring Plan*** has been included as Appendix 1 of this report. The City of Calgary's ***Coliform Monitoring Plan*** distinguishes between compliance monitoring and response monitoring. It also includes details of sampling sites and frequencies, the rationale for the sampling sites, collection methods and field analyses.

5.3. Training and Instrument Maintenance

Training, instrument installation and maintenance, the creation of Standard Operating Procedures under the umbrella of a comprehensive monitoring program have also all not been covered in the Krewski *et al.* issue paper.

Training of operators and technicians at the treatment plant is an important issue that is not discussed by Krewski *et al.* Most utilities rely on continuous, on-line monitors for control of disinfection processes and monitoring turbidity. In small utilities, instrument set up, maintenance and calibration are all serious challenges. According to the Ministry of the Environment Technical Brief on staff licensing (August 2000), anyone who performs analytical tests for regulated parameters must hold a Class I, II, III or IV water treatment or water distribution operator's license or be licensed as a water quality analyst. It will be important for the Ontario Government to consider the need to include training related to analysis and instrument maintenance criteria in the requirements.

6. Monitoring Issues Related to Engineer's Reviews and Reports

The Ontario Ministry of the Environment Terms of Reference for Engineers' Reports for Waterworks (August 2000) describes the requirements of the engineering review of water treatment facilities. These engineering reviews and reports are an excellent step towards ensuring high quality treatment processes and consistent drinking water quality. A number of possible future focus changes and additions to the scope of work in Engineers' Reports are presented in the following section.

6.1. Balancing Microbial Disinfection and Disinfection Byproduct Formation

The "Terms of Reference" state:

"The principal objectives of the review and Report are to assess the potential for microbiological contamination of the water works and to identify operational and physical improvements necessary to mitigate this potential utilizing multiple barrier concepts."

The "Terms of Reference" statement tend to emphasize microbiological contamination issues more than chemical or physical contamination. I think it is very important that utilities be encouraged to take a balanced approach to drinking water treatment, to ensure all water quality issues are addressed. The principal objectives of the engineering reviews and reports quoted above would be more balanced if the phrase "potential for microbiological contamination" were replace with "assess the disinfection and overall treatment efficacy". A balance between disinfection, chemical and microbial quality will ensure that high levels of disinfection byproducts are not the inadvertent consequence of an over-emphasis on microbial issues.

I think an engineering review of a treatment works should be broadly focused on disinfection efficacy rather than narrowly targeted to microbiological contaminants (see section on CT Concept).

6.2. Comprehensive Monitoring Program Review and Assessment

The Terms of Reference for Engineers' Reports also requires:

- *Assessment of operational procedures and recommendations*
- *Assessment of existing physical works and recommendations*
- *Recommendations for a monitoring regime for entire water works system to ensure compliance with the Ontario Drinking Water Standards and the Regulation*

The engineering consultants hired to prepare recommendations for a monitoring regime should also review existing monitoring capabilities, training programs, quality control, data validation and instrument maintenance programs. The report could then include a review of the "state of readiness" of the utility to undertake the recommended monitoring regime. This assessment would also include cost and time estimates for a utility to achieve compliance.

In part VIII Assessment of Operational Procedures, the Terms of Reference also specifically state that the Engineer shall:

"….review and document the current state of the Operations Manual available to the Owner and Operating Authority of the water works to determine if the manual:

- *Exists*
- *Is current*
- *Contains all relevant requirements of the applicable Ministry of the Environment's "Model Conditions for Certificates of approval", and*
- *Contains adequate requirements respecting operation, maintenance (including calibration) of equipment utilized for flow measurement and automated analysis of water samples.*

The Engineers' Report does not appear to require actual physical inspection of monitoring equipment, but rather calls simply for a review of the Operations Manual. The section in the Engineering Terms of Reference entitled "Description of the Supply/Treatment /Storage Works does not mention that on-line monitors (e.g., flow, level, pressure, turbidity, chlorine residual) will be physically inspected to ensure that they have been installed correctly and are in good running order. The assessment of existing physical works should include an assessment of the on-line instrumentation, their installation, maintenance and operation.

6.3. Monitoring of Distribution System Water Quality During Disruptions

The importance of monitoring chlorine residual, turbidity as well as bacterial quality indicators during main replacement or after main repairs was discussed in section 4.17 of this report. Currently, there is no mention in the Engineers' Report Terms of Reference of a review of main replacement programs, main repair procedures (including chlorination practices and sampling strategies to ensure microbiological quality is maintained following new main installations or main repairs).

In the future, it would be very beneficial to include a review of standard operating procedures in the distribution system in Engineers' Report Terms of Reference.

7. Small Systems Issues

The Krewski *et al.* issue paper includes a thorough description of the development of standards and regulations in Canada, the United States and Australia. Section 5 focuses on how values are set for microbial, chemical and physical water quality parameters. Neither the Krewski *et al.* nor Doyle *et al.* issue papers discuss the process used in the United States and other countries to define "large systems" or "small systems". Also, the process of gradually implementing the regulations to allow "small systems" more time to comply is not presented.

7.1. Definition of Small Systems in Ontario

Ontario's new Drinking Water Protection Regulation applies to "large waterworks". According to an Ontario Ministry of the Environment discussion paper entitled *"Protecting drinking water for small waterworks in Ontario"* (August 9, 2000) the definitions of "large waterworks" and "small waterworks" are as follows:

> *Large Waterworks: The Drinking Water Protection Regulation currently applies to all waterworks that:*

- *Use more than 50,000 litres of water on any day or have the capacity to supply 250,000 or more litres of water per day. This would include municipalities, large hospitals, resorts, large restaurants; or*
- *Systems that serve six or more residences. This would include everything from small private systems to large municipal systems serving hundreds of thousands of people.*

Small Waterworks: Small waterworks provide less than 50,000 litres on any given day, do not have the capacity to supply 250,000 litres per day, and serve five or fewer residences. This would include a broad range of establishments (such as gas stations, motels, etc) that use wells or surface water sources such as lakes and rivers for their water supply.

At the end of the discussion paper entitled "Protecting drinking water for small waterworks in Ontario" (August 2000), questions were posed on what regulations should be imposed on small systems currently not include under the new drinking water regulations. Questions were posed on the following topics:

- sampling and testing,
- minimum level of treatment,
- keeping the public informed
- notifying authorities about water quality

There did not appear to be anywhere to comment on the definitions of "large" and "small" waterworks used in the Ontario Drinking Water Regulations.

Ontario's definitions of large and small waterworks are very different from those currently used by the U.S. EPA. Clearly, there are municipal systems included in Ontario's definition of large waterworks that will have considerably more difficulty meeting the requirements of Ontario's Drinking Water Protection Regulation than municipal systems run by large cities such as Toronto, Ottawa or Hamilton. I was not able to find any reference that indicated there would be a gradual implementation of the regulations or that utilities in relatively small communities would have more time to achieve compliance than large municipal systems.

7.2. Definition of Small Systems in the United States

In the United States, small systems are defined as those utilities serving less than 10,000 people. Small systems were given more time to make improvements and get ready to meet regulations before these regulations were enforced. In the United States, there is a great deal of information available to small systems to help explain the regulations as well as present case studies of the cost of small system compliance, such as:

- http://www.dep.state.pa.us/dep/deputate/watermgt/WSM/Facts/EPA-LT1ESWTR.htm;
- http://www.epa.gov/safewater/smallsys.html;
- http://www.epa.gov/safewater/smallsys/ndwac/regfinal.pdf

The proposed new U.S. EPA Long Term 1 Enhanced Surface Water Treatment Rule applies to public water systems using surface water or ground water under the direct influence of surface water that serve less than 10,000 people. Effective 2004, small systems in the United States will be required to meet the same turbidity requirements that have been enforced for large and medium systems since 1998:

> *<u>Combined Filter Effluent Turbidity</u>*
>
> *Conventional and direct filtration plants must comply with the new standard of 0.3 NTU in place of the current 0.5 NTU (95% of the readings per month would have to be less than 0.3 NTU). The maximum instantaneous turbidity level would be lowered to 1 NTU to replace the current level of 5 NTU.*
>
> *<u>Individual Filter Effluent Turbidity</u>*

> *Conventional and direct filtration plants must continually monitor turbidity on each filter effluent. Turbidity levels need to be recorded at least every 15 minutes. When certain individual turbidity levels are exceeded (this would not be a violation), follow-up action would be required with assistance from your state drinking water program to resolve the exceedance and improve filter operation (not completing the flow-up actions would be a violation).*

The U.S. EPA (http://www.dep.state.pa.us/dep/deputate/watermgt/WSM/Facts/EPA-LT1ESWTR.htm) will require systems serving between 3,300 and 10,000 populations to meet the same requirements as large systems. However, two other categories being considered are systems less than 3,300 population, but with more than 2-3 filters and then those with less than 2-3 filters.

7.3. Impact of Regulations on Small Systems

The U.S. EPA spent a considerable amount of time and effort evaluating the impact of new rules on small systems and getting input from these utilities. It was recognized that small systems would need more time to meet the new regulations. A similar effort will be required in Ontario to define the readiness of small systems to meet more stringent water quality requirements and monitoring requirements.

As part of the development process for the U.S. EPA's Long Term I Enhanced Surface Water Treatment Rule, EPA spent a considerable amount of time and effort on evaluating the impact of any rule on small systems. They asked for feedback on issues like:

- What subcategories dividing small systems should be established and how should the regulatory requirements differ among the categories?
- What would be the impact of changing the monitoring requirements on individual filters from every 30 minutes to 15 minutes?

- Should filter redundancy be required for any system with only one filter? If not, how can a single filter be repaired (media, underdrains, etc.) if a problem arises during operations?
- Should systems with just 2-3 filters be allowed to continuously monitor just combined filter turbidity and not individual filters?
- Should filter turbidity alarms be required for systems where the operator is away during part of the time the plant is operating?
- Should the proposed rules apply to slow sand and diatomaceous earth plants?
- Are there other small systems issues that EPA should consider?

Perhaps most importantly, the U.S. EPA asked what kind of technical assistance would be most beneficial to small surface and “groundwater under the influence of surface water” systems. The U.S. EPA also recognized that small systems face data gathering, record keeping and reporting issues under the proposed new regulations. Further issues facing small utilities are issues surrounding instrument installation, maintenance to ensure reliable operation.

7.4. Regulatory Compliance Challenges for Small Systems in Ontario

According to Allen *et al.* (2000), more than 75% of Canada’s public water systems serve communities with populations under 10,000. These relatively small systems may not have the in-house expertise or laboratory facilities to monitor for pathogens routinely or even occasionally.

Also, the proper installation, use and maintenance of on-line monitoring equipment for process control (e.g., flow, level, pressure, turbidity, chlorine residual) present significant challenges to small systems. Instrument failures are not always identified immediately nor can they be immediately addressed. If on-line turbidimeters at a small, remote water utility fail and the utility does not have expertise on-site to fix it, it may be some time before a technician arrives at the plant to repair the instrumentation.

If regulations and licenses to operate the treatment plants do not specifically set out requirements to the contrary, the same person in a small water utility is often responsible for:

- collecting the samples,
- conducting tests at the treatment plant,
- sending samples away to laboratories for analysis,
- maintaining and operating on-line instrumentation continuously monitoring water treatment plant operating parameters, and
- recording the results.

Ideally, different persons would be assigned to collect samples in the distribution system and in the treatment plant. Those that collect the samples would also not be the same persons that analyze and record the results. This approach provides significant protection of the water quality surveillance program, but would be a challenge for many small systems. The feasibility and cost implications of this approach should be explored in Ontario.

Lastly, small systems whose finished water does not meet the new Ontario standards and regulatory requirements may have difficulty bringing their treatment facilities and monitoring equipment up to the required standards immediately. The Ontario Government should consider whether more lenient time frames are required to ensure that small systems can realistically achieve compliance. Also, fines and penalties are not effective as small systems simply cannot achieve compliance for legitimate reasons. The Ontario Government should identify the most critical small systems challenges and work with stakeholders to develop mechanisms that will overcome these challenges and result in compliance.

8. Water Quality Reports

The Ontario Ministry of the Environment requires that waterworks owners produce and make readily available a free, quarterly report for the people to whom they supply drinking water. The report must provide basic system and water source information, outline the measures taken to comply with the regulation and summarize water-testing results. First reports were to have been received by the Ministry of the Environment, and made available to the public no later than October 30, 2000. Waterworks that serve more than 10,000 people are also required to post their reports on the Internet. The information included in a water quality report could potentially have a major impact on public risk perception. Krewski *et al.* discuss the difference between risk assessment, risk management and public risk perception. However, no mention is made of what information should be in water quality reports, how successful water quality reports have been in keeping citizens informed, the impacts of water quality reports on risk perception or the kind of information that should be provided to citizens.

Water quality reports have been required in the United States for several years. It would have been useful if the Krewski *et al.* report had included information on the public perception of these reports and their impact on public understanding of water quality issues. In Ontario, it is important to determine public perception of the value of the reports:

- Do members of the public read and understand water quality reports?
- How can they be improved to make them a better communications tool?

9. Conclusions

The Krewski *et al.* report is a good review of risk management issues and the development of drinking water standards and regulations. However, I do not think that Issue # 7 "Measurement of source and finished water quality", has been covered in depth in the Krewski *et al.* report. As a result, a number of critical information gaps may exist in the information available to the Commission. These issues have been reviewed and discussed in this report.

In Ontario there is great opportunity to move from voluntary guidelines to enforceable drinking water quality standards along with monitoring regulations. Standards, in combination with regulations defining monitoring requirements will significantly improve the safety and quality of drinking water for consumers. Although Walkerton was a microbial contamination issue, potential for contamination resulting from chemical, physical or microbiological water quality parameters must all be addressed in a balanced way in the Ontario Drinking Water Quality Standards. Further, it is important to ensure that all utilities are supported in their efforts to achieve compliance with the new regulations.

Sampling requirements in the new Ontario regulations meet or exceed the Canadian guidelines, an excellent step toward protection of public health. A review of laboratory accessibility and sample storage/transportation issues would be of benefit to remote Ontario water utilities. Samples sent to laboratories located far away from the utility may introduce unacceptable delay times in return of results. Water could be consumed for more than three days prior to results becoming available to the utility. Use of simple field test kits on a regular basis would go a long way towards identifying problems quickly and ensuring prompt response to correct the situation.

Monitoring program design is a very important issue for all water utilities in Ontario. Currently, Engineers' Reports address some of the aspects of a monitoring program, however, there is an opportunity for the Ontario Government to provide more guidance to utilities. Based on the types of water utilities in Ontario, the Government of Ontario could take a leadership role in monitoring program design to ensure consistency. Without assistance, small systems will have difficulty developing a comprehensive monitoring plan. Several tiers of monitoring could be developed, from Level I monitoring covering only essential requirements through to Level 3 or 5 describing the elements of an "best practice" monitoring program.

Small systems in Ontario will face the greatest water quality monitoring challenges in the future. The use of online monitoring for basic water quality indicators such as turbidity and disinfectant residual provides a significant amount of assurance that water of acceptable quality is being produced continuously. However, online instrumentation requires maintenance, calibration and proper operation in order to collect reliable data. Serious consideration must be given to the definitions of small systems and the phasing of regulatory requirements to allow small systems more time to comply. Also, the issue of groundwater under the direct influence of surface water impacts primarily small systems. A clear definition of the defining factors for "ground water under the direct influence of surface water" would be a great benefit to many small systems.

10. Recommendations

In light of the findings and conclusions of the above review on Issue #7 matters, the OWWA/OMWA urge the Commission to recommend adoption of the following measures by the Ontario Government regarding measurement of source and finished water quality:

1) Conduct a gap analysis for monitoring and analysis requirements, including consideration of the roles of on-site analysis, contract/provincial laboratories, as well as the use of test kits and online monitoring. Consider monitoring requirements for distribution system integrity, source water protection and optimizing treatment processes (e.g., disinfection/contact time).

2) The Government of Ontario should evaluate the criteria used to define small systems. The impacts of the regulations and standards on small systems and their ability to comply should also be evaluated. The Government of Ontario should consider whether small systems need more time to comply with new regulations.

3) The Government of Ontario should investigate whether the number of samples collected is adequate to characterize a distribution system and the quality of the

water reaching consumers in that system. The factors that should be considered include:

a) whether one sample per week is adequate protection for the population served,

b) When water utilities collect the samples (i.e. are samples evenly spread throughout the month or is a utility that serves up to 100,000 people choosing to take one sample per week for three weeks of a month and the remainder in the fourth week)

c) How many water utilities have voluntarily increased the number of samples taken and at what cost? What benefits have been attained from extra sampling and are costs offset?

d) What level of monitoring does the public expect and are they prepared to pay a premium for additional monitoring?

e) Are there differences between surface water and groundwater systems, small systems and large systems?

f) The analysis should assess what types of tests are required in distribution systems and question the rationale of testing only 25% of the samples for Heterotrophic Plate Count.

4) The Ontario Government should expand Section 13 of Ontario Regulation 459/00 regarding the water works reviews in the manner suggested by the OWWA/OMWA in this Review. In particular, the province should focus on:

a) Development and implementation of a monitoring program that includes plant process control requirements as well as distribution system requirements

b) A review of the "state of readiness" of the utility to undertake the recommended plant process control and distribution system monitoring program should be completed, including a physical inspection of existing online instrumentation, a review of their installation, maintenance and operation.

c) A review of standard operating procedures for flushing, main replacement programs, main repair procedures, including chlorination practices and sampling strategies should be included in the water works review.

d) Development and implementation of a monitoring program that distinguishes between compliance monitoring, process optimization monitoring and response monitoring. It should include details of sampling sites and frequencies, the rationale for the sampling sites, collection methods and field analyses.

e) Development and implementation of a monitoring program that includes "chain of custody" protocols. The protocols should consider the feasibility of requiring that staff not associated with the treatment plant process be responsible for collection of distribution system samples.

f) Consider implementing monitoring program reforms in the next 18 months to three years

5) The Government of Ontario should work with appropriate stakeholders to develop the above noted "chain of custody" protocols for drinking water sampling and "standard operating procedures" for flushing, chlorination, sampling/analysis during any distribution system main disruption, etc. The sampling protocols and standard operating procedures will need to address field test kit and online monitoring requirements, as well as training, installation and maintenance requirements. In addition, consideration must be given to issues and challenges relating to small systems.

6) The Government of Ontario should ensure the Ministry of the Environment's testing methods comply with standard methods (i.e., 48-h storage time for microbial tests be revised to the accepted Standard Methods) and ensure that standard methods for monitoring turbidity, disinfection residual and other regulated parameters.

7) The Government of Ontario should consider the value of seasonal source water monitoring programs for *Giardia* and *Cryptosporidium,* except in cases where clear evidence exists that the source water is not at risk from contamination by these pathogens.

8) The Government of Ontario should work with stakeholders to clearly define criteria for “Ground Water Under the Direct Influence of Surface Water”.

9) The Government of Ontario should review whether the public is reading the water quality reports, and if not, how they should be improved.

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