Assessment of the Pineview Improvement District Drinking Water Supply: Source Water Characteristics

James Jacklin, September 2005

Introduction

In British Columbia, drinking water quality is becoming a significant public issue. We all want to have confidence in the quality of the water we consume. Its protection is also important to local purveyors, who act as our water suppliers, and to provincial government ministries responsible for water management. Within the Omineca-Peace region of B.C., our most common potable source is ground water, although many communities do make use of rivers, streams or lakes. Our basic drinking water quality is determined by a number of factors including local geology, climate and hydrology. In addition to these, human land use activities such as urbanization, agriculture and forestry, and the pollution they may cause, are becoming increasingly important influences. Environmental managers have a responsibility to control land use development so as to minimise the effects of these activities on source water quality.

The province's Drinking Water Protection Act, enacted in October, 2002, places the responsibility for drinking water quality protection with the B.C. Ministry of Health and local water purveyors. However, through the B.C. Environmental Management Act, the British Columbia Ministry of Environment (MOE) is responsible for managing and regulating activities in watersheds that have a potential to affect water quality. Accordingly, the Ministry plans to take an active role in protecting drinking water quality at its source.

Plate 1. A view of the Pineview Improvement District pump house where the raw water samples were collected.

MOE implemented a raw water quality and stream sediment monitoring program at selected communities in the Omineca-Peace region in 2002. Community sites were selected using a risk assessment process that considered:

- whether the source supply was surface water or ground water,
- the level of water treatment used,
- the population size served,
- the potential for upstream diffuse and point-source pollution,
- the availability of current, high-quality and representative data on each raw water source,
- whether past outbreaks of waterborne illness had been reported,
- the ability/willingness of local purveyors to assist with sampling.

Through this process and with available funding, a total of 18 community water supplies in the Omineca-Peace region were selected for monitoring during 2002/03, and two more were selected in 2004/05.

This brief report will summarise water quality data collected from the Pineview Improvement District raw potable water source (ground water) (Plate 1). The data are compared to current provincial drinking water quality guidelines meant to protect finished water. This comparison should identify parameters with concentrations that represent a risk to human health. It is intended that this process will lead to the identification of human activities responsible for unacceptable source water quality, and that it will assist water managers to develop measures to improve raw water quality, where needed.

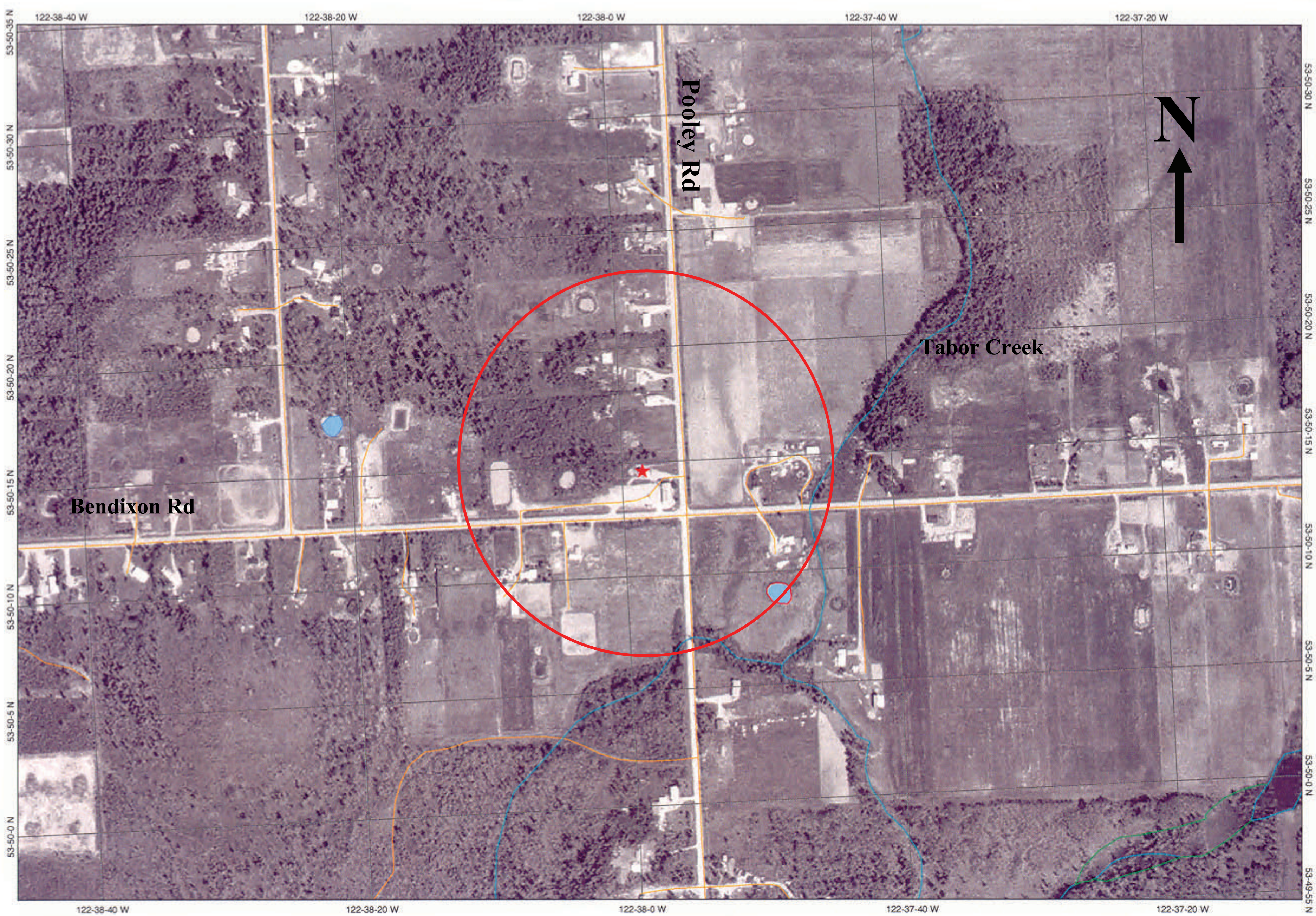

Figure 1. The location of the Pineview Improvement District water wells, as indicated by the red star. An arbitrary 300 m radius surrounds the well, indicating the zone from which contamination is most probable to occur (without doing an in-depth hydrogeological study). This 300m zone includes both agricultural and urban development.

Site Description

Watershed Overview

The Pineview Improvement District is located approximately 10 km southeast of Prince George. This area lies within the Sub-Boreal Spruce biogeoclimatic zone, which is characterized by gently rolling terrain, dense coniferous forests and extremes in the annual temperature range of -40°C to 30°C (B.C. Ministry of Forests, 1998). However, a large proportion of the land surrounding the Pineview water well has been developed for either urban, agricultural or forestry use (Figure 1).

According to Mr. Leon Lussier, a water purveyor for the Improvement District, the current withdrawal rate from the two functioning water wells is approximately 210 gallons/minute. The well log data collected during drilling indicates the lithology profiles to be dominated by clay in the upper 40 feet, followed by 150 feet of clay/till and another 100 feet of sandy till. The well depths, as indicated by the drilling logs, are 446 and 427 ft. Lithology profiles that are composed of clay and till generally have a low permeability, which should help retard the flow rate of contaminants to the ground water table. This is beneficial compared to an aquifer composed of dominantly sands and gravels, which allow materials to percolate at a much faster rate. At the time of construction, the two active wells had static water levels of 373 feet.

There are some sewage disposal permits in the Pineview Improvement District, including the local pub, the elementary school and a new proposed community sewage system (households are currently responsible for their own waste disposal, i.e. septic systems). However, none of these sources are located close to the Pineview Improvement District wells (except for nearby houses), so are not expected to affect water quality.

Drinking Water Supply & Treatment

The Pineview Improvement District draws its domestic water from a ground water supply, consisting of two wells (three wells are present, however one is not functional). The wells are situated near the pump house, beside the community hall. As measured on a GIS program, the geographic co-ordinates of the pump house are 53° 50’ 15”N/122° 37’ 59”W. From the pump station, the water is piped into a holding reservoir, and then distributed throughout the Improvement District to over 400 household connections. The District does not currently treat their source water.

Mr. Lussier has expressed some concerns regarding the source water supply, including high manganese and hardness levels, and water consumption issues.

Materials & Methods

Review of Previous Data

Historical data relevant to the Pineview Improvement District raw water supply assessment have been included in this report. The data were copied from Northern Health Authority files and are from 2002 through 2005.

Sample Collection & Analyses for the 2004/05 Water Monitoring Program

Water Quality

An experienced MOE staff member collected water samples in laboratory certified polyethylene bottles for a variety of chemical and bacterial analyses. Representative grab samples were collected from the raw water tap (Plate 2) inside the pump house (EMS site E257055).

Bottles used for general ion analyses were rinsed three times with source water prior to sample collection. Metal and bacterial bottles were not rinsed and metal samples were lab preserved. Prior to sampling the raw water tap, the source was flushed for 5 minutes in order to minimize contamination by system piping. Water samples were shipped by overnight courier in coolers with ice packs to JR Laboratories Inc. for bacteria and Maxxam Analytical Services for chemistry. Bacterial samples were analysed using membrane filtration. Metals analysis made use of ICPMS technology.

Plate 2. The water piping system inside the Pineview pump house.

Quality Assessment (QA)

To ensure accuracy and precision of data, quality assurance and control (QA/QC) procedures were incorporated into the monitoring program. This included use of rigorous sampling protocols, proper training of field staff, setting of data quality objectives and the submission of QA samples to the lab. Field QA included duplicate and blind blank samples.

Blank samples detect contamination introduced in the field and/or in the lab. A comparison of duplicate results measures the effect of combined field error, laboratory error and real between-sample variability. The blind blank and duplicate program accounted for roughly 20% of the overall chemistry and bacterial sample numbers.

Results

Review of Previous Data

Bacteriology

The NHA sampled the Pineview Improvement District for both total and fecal coliforms at four locations (9705 Sutley Road, District office-Old Cariboo Highway, General Store-Old Cariboo Highway, Pineview School-Old Cariboo Highway) throughout the water distribution system between 2002 and 2005.

Of the 53 total samples colleted, total coliforms were found above the level of detection on one date, June 23[rd,] 2004.

Water Monitoring Program (2004/05)

Quality Assessment (QA)

The field blank and duplicate results indicate that minimal field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed.

The water chemistry field blank samples that were prepared either the same day or within one day of the Pineview Improvement District collections tested positive for some parameters. The concentration of all of these parameters was below 5-fold the minimum detectable concentration, an acceptable threshold as per the lab acceptance criteria.

The water chemistry duplicate samples that were prepared either the same day or within one day of the Pineview samples had no values exceeding the lab acceptance criteria of 25% relative percent difference.

Since there were no QA exceedances during this sampling program, all data are considered to be of good quality and suitable for review.

Bacteriology

The 2004/05 bacterial data are summarised in Table 1.

Drinking water quality guidelines for *E. coli, Enterococci* and fecal coliforms are 0 CFU/100 mL for raw water supplies that undergo no treatment.

As seen in Table 1, no bacteria were detected during this sampling program. However, because the District currently uses no form of water treatment, ongoing bacterial sampling should occur to ensure no microbial contamination is entering the system.

Table 1. Results of bacterial analyses for the Pineview Improvement District source water supply. Units are CFU/100 mL.

Date	Total Coliform	*E. coli*	*Enterococci*	Fecal Coliform
Provincial Guideline	No Provincial Guideline	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL
Sep. 20/04	<1	<1	<1	<1
Dec. 7/04	<1	<1	<1	<1
Mar. 30/05	<1	<1	<1	<1
Jun. 21/05	<1	<1	<1	<1

Water Chemistry

In 2004/05, ground water samples were collected on four dates. The water samples were analysed for 15 general parameters as well as for the ICPMS low level metals package that includes 27 metals in the total form (Table 2).

Of the chemical and physical parameters tested through the duration of this study, five exceeded the provincial guidelines for raw drinking water and one was of note.

Specific Conductance (µS/cm) - The mean specific conductance was 756 µS/cm, over the recommended guideline of 700 µS/cm. High specific conductivity values indicate a high ion concentration, which can be related to the dissolved solids content of the water.

Iron, Total (mg/L) - The maximum iron concentration was 0.31 mg/L, exceeding the recommended guideline of 0.3 mg/L. However, this exceedance occurred on only one of four sample dates. The mean iron concentration was 0.15 mg/L (the high iron concentration coincided with a high turbidity value). Insoluble iron is often found in waters as colloidal material which can be difficult to remove. Additionally, iron has the tendency to colour water.

Manganese, Total (µg/L) - The mean manganese concentration was 664 µg/L with a maximum of 812 µg/L, both far exceeding the aesthetic objective of 50 µg/L. Manganese can colour water and form colloidal material (a black precipitate) that can be difficult to remove. Furthermore, this black precipitate can create an unpleasant taste in the water, as well as allowing an increased growth of unwanted manganese bacteria that can form slimy layers on system piping (British Columbia Ground Water Association, 2002). Manganese is found naturally in many water

Table 2. 2004/05 sample parameters, summaries of current results and associated B.C. drinking water guidelines.

Parameter	*n*	Min.	Max.	Mean	Median	Std. Dev.	MDL	Guideline	Guideline Type
Physical									
pH	4	7.9	8.2	8.1	8.1	0.13	0.1	6.5-8.5	aesthetic objective
Colour (TCU)	4	5	5	5	5	0.0	5	≤ 15	aesthetic objective
Specific Conductance (µS/cm)	4	725	786	756	756	30.7	1	≤ 700	maximum acceptable concentration
Turbidity (NTU)	4	0.9	3.7	2.2	2.0	1.27	0.1	≤ 1	maximum acceptable concentration
Hardness Total (mg/L $CaCO_3$))	4	354	423	399	420	39.0		<200	
								> 500	normally unacceptable
Alkalinity (mg/L)	4	322	359	338	335.5	17.61	0.5		
Residue Non-Filterable (mg/L)	4	1	4	3.2	4	1.5	4		
Total Organic Carbon (mg/L)									
TOC	4	0.5	1	0.7	0.6	0.24	0.5	≤ 4	maximum, to control THM production
Anions (mg/L)									
Chloride Dissolved	4	0.6	1.2	0.9	0.9	0.29	0.5	≤ 250	aesthetic objective
Fluoride Dissolved	4	0.04	0.08	0.06	0.06	0.017	0.01		
Bromide Dissolved	4	<0.1	<0.1	<0.1	<0.1	0.00	0.1		
Nutrients (mg/L)									
Nitrate+Nitrite	4	<0.002	0.011	0.006	0.005	0.004	0.002		
Phosphorus Total	4	<0.002	0.004	0.003	0.002	0.001	0.002		
Sulphate (mg/L)									
Sulphate	4	92.5	101	97.6	98.4	3.67	0.5	≤ 500	aesthetic objective
Metals Total (µg/L)									
Aluminum-T	4	0.3	0.9	0.4	0.3	0.30	0.3		
Antimony-T	4	0.011	0.035	0.025	0.026	0.010	0.005	≤ 6	interim maximum acceptable concentration
Arsenic-T	4	0.2	0.8	0.4	0.4	0.26	0.1	≤ 25	interim maximum acceptable concentration
Barium-T	4	42.7	61.1	51.6	51.4	10.20	0.02	≤ 1000	maximum acceptable concentration
Beryllium-T	4	<0.02	<0.02	<0.02	<0.02	0.000	0.02		
Bismuth-T	4	<0.02	<0.02	<0.02	<0.02	0.000	0.02		
Cadmium-T	4	<0.01	0.03	0.02	0.01	0.010	0.01	≤ 5	maximum acceptable concentration
Calcium-T (mg/L)	4	92.1	116	107.5	111	10.68	0.05		
Chromium-T	4	0.2	0.7	0.3	0.2	0.25	0.2	≤ 50	maximum acceptable concentration
Cobalt-T	4	0.11	0.17	0.14	0.15	0.024	0.005		
Copper-T	4	0.42	1.44	0.77	0.60	0.457	0.05	≤ 1000	aesthetic objective
Iron-T (mg/L)	4	0.05	0.31	0.15	0.08	0.144	0.005	≤ 0.3	aesthetic objective
Lead-T	4	0.09	0.23	0.18	0.20	0.062	0.01	≤ 10	maximum acceptable concentration
Lithium-T	4	2.97	3.58	3.22	3.16	0.294	0.05		
Magnesium-T (mg/L)	4	30.1	33.7	32.3	32.6	1.55	0.05		
Manganese-T	4	497	812	664	674	163.0	0.008	≤ 50	aesthetic objective
Molybdenum-T	4	1.35	1.89	1.56	1.50	0.243	0.05	≤ 250	maximum acceptable concentration
Nickel-T	4	0.05	0.4	0.14	0.06	0.172	0.05		
Selenium-T	4	<0.2	<0.2	<0.2	<0.2	0.00	0.2	≤ 10	maximum acceptable concentration
Silver-T	4	<0.02	<0.02	<0.02	<0.02	0.000	0.02		
Sodium-T (mg/L)	4	20.1	22.5	21.6	22.3	1.33	0.05	≤ 200	aesthetic objective
Strontium-T	4	643	743	708	722	44.8	0.005		
Thallium-T	4	<0.002	<0.002	<0.002	<0.002	0.000	0.002	≤ 2	maximum acceptable concentration
Tin-T	4	<0.01	0.02	<0.01	<0.01	0.005	0.01		
Uranium-T	4	2.44	2.53	2.49	2.50	0.039	0.002	≤ 100	maximum acceptable concentration
Vanadium-T	4	0.06	0.10	0.08	0.08	0.021	0.06	≤ 100	maximum acceptable concentration
Zinc-T	4	2.2	96.4	30.2	11.2	44.42	0.1	≤ 5000	aesthetic objective

supplies originating from the weathering and dissolution of natural rocks and minerals, with anthropogenic sources including industrial effluents, fertilizers, gasoline (manganese is an additive), as well as many other sources.

Turbidity (NTU) - The mean and maximum turbidity levels were 2.2 and 3.7 NTU, respectively, both exceeding the provincial guideline of 1 NTU for raw potable water. Turbidity is a measure of the suspended particulate matter in the water, including silt, organic material and/or micro-organisms, that interfere with the passage of light. Turbidity can increase the available surface area of solids upon which bacteria grow. Additionally, high turbidity can interfere with disinfection and can be aesthetically unpleasant.

Sodium, Total (mg/L) - The mean sodium concentration was 21.6 mg/L, well below the recommended drinking water guideline of 200 mg/L; however, just above the 20 mg/L alert level for people on sodium restricted diets. Natural sources of sodium include the weathering of salt deposits and contact of water with igneous rock. Anthropogenic sources include road salts, sewage and industrial effluents and the use of sodium products in corrosion control and water softening products (Health Canada, 1992).

Hardness, Total (mg/L $CaCO_3$) - Water hardness, which can often be a problem in ground water supplies, had a mean concentration of 399 mg/L $CaCO_3$. This is considered very hard (>180 mg/L $CaCO_3$) and above the optimum range of 60-120 mg/L $CaCO_3$ for a drinking water supply. This hardness is mainly due to the presence of calcium and magnesium in the water. Hard water can reduce the toxicity of some metals, but can also leave scale deposits on piping (RIC, 1998). Some anthropogenic sources that contribute to water hardness include mining and industrial effluents (not likely applicable to Pineview Improvement District). High hardness values also occur naturally in areas where there is an abundance of calcium and magnesium bearing rocks and minerals.

The data from 2004/05 indicates that most chemical and physical parameters in the Pineview water supply have a low concentration compared to drinking water guidelines. There do however appear to be potential issues regarding specific conductivity, turbidity, iron, manganese, water hardness and sodium levels.

Conclusions & Recommendations

Review of the Pineview Improvement District ground water data indicates a source water supply with some undesirable characteristics. Specifically, the high manganese, hardness, sodium and turbidity levels exceed their respective drinking water guideline. Because the District currently uses no water treatment, these parameters may lead to other problems throughout the distribution system. Examples of this include: high hardness levels leaving scale deposits on system piping and being aesthetically unpleasant; high manganese levels forming a black precipitate that can be aesthetically unpleasant and can also form a slimy layer of manganese bacteria on system piping (manganese bacteria are non pathogenic); elevated turbidity levels can be aesthetically unpleasant as well as acting as a nutrient source (if in an organic form) to unwanted micro-organisms.

Based on a lack of hydrogeological information regarding the wells, a 300m radius has been arbitrarily assigned as the source from which contamination is most likely (Mike Wei, Senior Hydrogeologist, B.C. Environment, p.c.). Since the wells are over 400 ft deep and the lithology profile is dominated by clays, the aquifer probably has a low permeability and should be more buffered against land use activities compared to a ground composed of sands and gravels. However, it would still useful to have a site assessment done in the area of the well to ensure no detrimental land use activities are occurring.

Because the Pineview water supply currently uses no form of microbial water treatment (i.e. disinfection), it is recommended that periodic bacterial samples be collected to ensure that levels do not exceed recommended drinking water guidelines of 0 CFU/100 mL.

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