

Cé rapport contient des information importantes concernant votre eau potable. Veuillez traduire, ou parlez avec quelqu' un qui peut le comprendre.

System Description

The Cana Well system was established in the early 1950's by a co-operative formed by homeowners living on Marian Crescent, Rochdale Crescent, and Cana Blvd. The system was operated privately by the co-operative, then by the Ministry of the Environment (MOE), until operation was assumed by the former Township of Pittsburgh. When the township amalgamated with the city of Kingston and Kingston Township in 1998, operation of the system passed into the care of Utilities Kingston.



Staff from the Utilities Kingston Treatment Group operate the treatment system. The distribution system is maintained by the Utilities' Underground Infrastructure Department.

The water is supplied from a 150mm steel cased drilled well. Sodium hypochlorite is injected into the system after the pressure tank for disinfection.

The water then passes through detention tanks that allow time for the chlorine to be in contact with the water and achieve disinfection before it enters the distribution system.

The distribution system was also originally installed by the co-operative, and was constructed from a variety of materials which were available to the co-operative at the time of construction.

Treatment Plant staff attend the well on a daily basis to make system checks, take bacteriological samples, and to test chlorine residuals in both the treated water and in the distribution system. All Operators are certified by the MOE. ❖

Ontario's Drinking Water Regulations

This report has been prepared in response to Operation Clean Water, an initiative of Ontario's Ministry of the Environment to ensure high quality drinking water for the residents of Ontario. The new regulations put into law what was formerly the Ontario Drinking Water Objectives (ODWO), and sets requirements for public waterworks with regard to sampling and testing, levels of treatment, licensing of staff, and notification of authorities and the public about water quality.

Further information on the Drinking Water Regulations can be found on the Ministry of the Environment web site at www.ene.gov.on.ca

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Water Quality and Sampling

Sampling requirements for a waterworks are specified by the new Ontario Drinking Water Regulations (ODWR) as well as any Certificates of Approval (COA) issued for the specific waterworks. Since there are no sampling requirements outlined in the COA, sampling follows the schedule for groundwater supplies as listed in schedule 2 of the ODWR.

What is in your water?

Some parameters may be present in source water before it is treated. Here is a description of the various groups of parameters.

Microbiological parameters such as bacteria may come from wastewater treatment plants, livestock operations, septic systems and wildlife. Microbiological quality is the most important aspect of drinking water quality because of its association with dangerous water-borne diseases which can strike quickly.

Inorganic parameters such as salts and metals can be naturally occurring or as a result of urban storm runoff, industrial or domestic wastewater discharges, mining or agriculture. Some may be the result of the treatment and distribution of water (for example, lead from solder in plumbing and fixtures).

Organic parameters can be naturally occurring, but most organics of concern are synthetic. They originate from industrial discharges, urban storm runoff and other sources. Included in this group are pesticides that originate from both rural and urban areas. Some may originate from treatment of drinking water (for example, chlorination byproducts such as trihalomethanes). Volatile organics such as solvents and certain industrial chemicals are often the result of vehicle emissions or industrial discharges.

DEFINITIONS & TERMS

° C - degrees Celsius

° F - degrees Fahrenheit

kg - kilogram

l - litre

m - meter

m³ - cubic meter, 1 m³ = 1000 litres.

TCU - True Colour Units

CaCO₃ - Calcium carbonate

mg - milligram

psi - pounds per square inch

mg/l - Milligrams per litre. This is a measure of the concentration of a parameter in water, also called parts per million. (PPM)

ug/l - Micrograms per litre. This is a measure of the concentration of a parameter in water, also called parts per billion.

ng/l - Nanograms per litre. This is a measure of the concentration of a parameter in water, also called parts per trillion.

NTU - Nephelometric Turbidity Units - A measure of the amount of particles in water.

MAC - Maximum Acceptable Concentration. This is a health-related drinking water standard established for contaminants having known or suspected adverse health effects when above a certain concentration. The length of time the MAC can be exceeded without injury to health will depend on the nature and concentration of the parameter.

IMAC - Interim Maximum Acceptable Concentration. This is a health related drinking water standard established for contaminants when there are insufficient toxicological data to establish a MAC with reasonable certainty, or when it is not practical to establish a MAC at the desired level.

Parameter - A substance that we sample and analyze for in the water.

QUESTIONS AND ANSWERS

Q. What parameters must be tested for?

A. The regulation outlines exactly what needs to be tested. The regulation may be found on the ministry's Web site at www.ene.on.ca.

Q. How often must the water be tested?

A. Requirements for frequency of testing for waterworks vary depending on the number of people served by the waterworks. Owners/operators of waterworks should check the regulation to find out how often they are required to test. The regulation may be found on the ministry's Website at www.ene.gov.on.ca.

Q. What is an AO (aesthetic objective) exceedance?

A. Parameters with aesthetic objectives are those which do not directly affect the safety of the

water. Typically these parameters may cause unpleasant effects, such as a taste or colour. The residents are aware that historically there have been aesthetic concerns with the well water, and many have taken measures to address some of those concerns. Utilities Kingston has recently drilled a test well and is currently conducting tests to determine what options are available to improve water quality.

Vulnerable Populations

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as those who may have cancer and are undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers.

The water from the Cana well contains an elevated level of sodium (on average approximately 80 mg/l), which when above 20 mg/l requires notification of both residents and the local Medical Officer of Health. This information is relevant only to those who may be on a sodium restricted diet. Consumption of sodium in excess of 10 grams per day by normal adults does not result in any apparent adverse health effects and sodium intake from water accounts for only a small fraction of daily intake. Sodium occurs naturally in the earth's crust and is not considered to be toxic. The aesthetic objective for sodium is 200 mg/l.

Did We Exceed the Standards?

There was one exceedance for a health-related parameter listed in the Ontario Drinking Water Standards for this reporting period. On July 7 the on-line analyzer indicated an alarm for turbidity – a measure of particles in water. An operator was dispatched to check the station and the alarm was verified. Excessively high system demand was exceeding the well capacity which resulted in air being picked up by the pump. The air bubbles passing through the well-house piping disturbed some iron sediment which is created when chlorine is added to iron-rich well water. The turbidity was above the MAC for less than one hour.

Summary of Results

The data presented in the tables below lists the results of testing that was done to meet the regulations, as well as some additional testing that was carried out. Our interpretation of these results is that acceptable quality water which is safe to drink was produced by this well during this reporting period. To review this information yourself, look in the exceedance column to determine if there are any parameters to be concerned about. Then compare the result to the MAC/IMAC or AO/OG value. At that point you should investigate the particular parameters' potential health or aesthetic effects, and then, considering your own health situation, decide if there is cause for concern. Contact us at the numbers listed on page one if you have any questions, or talk to your doctor if you have specific health concerns.

Water quality results for this quarter are listed in the tables below.

Microbiological Parameters	MAC or IMAC	AO or OG	Number of Samples	Number of Positive Results	Sampling Dates	Range	Exceedance?	Typical Source of Contaminant
Plant Effluent Total Coliform (counts/100ml)	*		36	0	7/3/02 - 9/30/02	N/A	No	Indicates possible presence of fecal matter.
Plant Effluent Escherichia coliform (counts/100ml)	*		36	0	7/3/02 - 9/30/02	N/A	No	Definite indicator of fecal contamination.
Plant Effluent Heterotrophic plate count (counts/ml)	>500		35	0	7/3/02 - 9/30/02	N/A	No	Indicator of Deteriorating water quality.

* Indicator of adverse water quality if detected.

Microbiological Parameters	MAC or IMAC	AO or OG	Number of Samples	Number of Positive Results	Sampling Dates	Range	Exceedance?	Typical Source of Contaminant
Distribution System Total Coliform (counts/100ml)	*		49	0	7/3/02 - 9/30/02	N/A	No	Indicates possible presence of fecal matter.
Distribution System Escherichia coliform (counts/100ml)	*		49	0	7/3/02 - 9/30/02	N/A	No	Definite indicator of fecal contamination.
Distribution System Heterotrophic plate count (counts/ml)	>500		37	0	7/3/02 - 9/30/02	N/A	No	Indicator of Deteriorating water quality.

* Indicator of adverse water quality if detected

Parameters Related to Microbiological Quality	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Range	Exceedance?	Typical Source of Contaminant
Turbidity (NTU)	1		Continuous	Continuous	7/1/02 - 9/30/02	0.31 - 1.28	Yes	Turbidity is a measure of particles in water.
Free chlorine - Plant effluent (mg/l)	-		Continuous	Continuous	7/1/02 - 9/30/02	1.52 - 3.8	N/A	See below
Free chlorine - Distribution system (mg/l)	-		61	61	7/3/02 - 9/30/02	0.06 - 2.11	N/A	Recommended level of at least 0.20 mg/l in distribution system to maintain microbiological quality. Min. level of 0.05 mg/l

Table B - Volatile Organics (ug/l)	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result *	Exceedance?	Typical Source of Contaminant
Benzene (ug/l)	5		1	0	7/3/02	<0.5	No	Discharge from plastics manufacturing, leaking fuel tanks
Carbon tetrachloride (ug/l)	5		1	0	7/3/02	<0.2	No	Discharge from chemical plants and other industrial activities
1,2-dichlorobenzene (ug/l)	200		1	0	7/3/02	<0.1	No	Discharge from industrial chemical factories
1,4-dichlorobenzene (ug/l)	5		1	0	7/3/02	<0.2	No	Discharge from industrial chemical factories
1,2-dichloroethane (ug/l)	5		1	0	7/3/02	<0.1	No	Discharge from industrial chemical factories
1,1-dichloroethene (ug/l)	14		1	0	7/3/02	<0.1	No	Discharge from industrial chemical factories
Dichloromethane (ug/l)	50		1	0	7/3/02	<3.0	No	Discharge from pharmaceutical and chemical factories; insecticide
Ethylbenzene (ug/l)	24		1	0	7/3/02	<0.5	No	Discharge from petroleum refineries; industrial chemical factories
Monochlorobenzene (ug/l)	80		1	0	7/3/02	<0.2	No	Discharge from industrial and agricultural chemical factories and dry cleaning facilities
Tetrachloroethylene (ug/l)	30		1	0	7/3/02	<0.2	No	Leaching from PVC pipes; discharge from factories, dry cleaners and auto shops (metal degreaser)
Toluene (ug/l)	24		1	0	7/3/02	<0.5	No	Discharge from petroleum and chemical factories, leaking fuel tanks
Trihalomethanes: Plant Effluent Annual average (ug/l)	100		4	4	11/8/01 - 7/3/02	3.5	No	By-product of chlorination
Bromodichloromethane: Plant Effluent (ug/l)			4	4	11/8/01 - 7/3/02	1.0	N/A	By-product of chlorination
Bromoform: Plant Effluent (ug/l)			4	3	11/8/01 - 7/3/02	0.6	N/A	By-product of chlorination
Chloroform: Plant Effluent (ug/l)			4	4	11/8/01 - 7/3/02	0.8	N/A	By-product of chlorination

Table B - Volatile Organics (ug/l)	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result *	Exceedance?	Typical Source of Contaminant
Dibromochloromethane: Plant Effluent (ug/l)			4	3	11/8/01 - 7/3/02	1.2	N/A	By-product of chlorination
Trihalomethanes: Distribution System Annual Average (ug/l)	100		4	4	11/8/01 - 7/3/02	28.2	No	By-product of chlorination
Bromodichloromethane: Distribution System(ug/l)			4	4	11/8/01 - 7/3/02	8.8	N/A	By-product of chlorination
Bromoform: Distribution System(ug/l)			4	3	11/8/01 - 7/3/02	3.4	N/A	By-product of chlorination
Chloroform: Distribution System(ug/l)			4	4	11/8/01 - 7/3/02	4.1	N/A	By-product of chlorination
Dibromochloromethane: Distribution System (ug/l)			4	4	11/8/01 - 7/3/02	11.83	N/A	By-product of chlorination
Trichloroethylene (ug/l)	50		1	0	7/3/02	<0.1	No	Discharge from metal degreasing sites and other factories
Chloroethene (Vinyl chloride) (ug/l)	2		1	0	7/3/02	<0.3	No	Leaching from PVC pipes; discharge from plastics factories
Xylenes (ug/l)	300		1	0	7/3/02	<2.0	No	Discharge from petroleum and chemical factories; fuel solvent

* The MAC for THMs is based on a running annual average. The numbers listed are average results for data from the last 4 quarters.

Table C - Inorganic Parameters	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result	Exceedance?	Typical Source of Contaminant
Arsenic (ug/l)	25		0	0		N/A	No	Naturally occurring in surface waters / mine drainage
Barium (ug/l)	1000		0	0		N/A	No	Erosion of natural deposits. Discharge from metal refineries, oil drilling wastes.
Boron (ug/l)	5000		0	0		N/A	No	Erosion of natural deposits, industrial waste effluents.
Cadmium (ug/l)	5		0	0		N/A	No	Industrial discharge
Chromium (ug/l)	50		0	0		N/A	No	Industrial residues
Copper (ug/l)	1000		0	0		N/A	No	Domestic plumbing (Aesthetic objective)
Iron (ug/l)		300	5	5	7/23/02 - 9/16/02	480	AO Exceedance	Leaching from natural deposits and plumbing materials, industrial wastes. (Aesthetic objective)
Lead (ug/l) Treated Water	10		0	0		N/A	No	Leaching from domestic plumbing materials
Lead (ug/l) Distribution system	10		0	0		N/A	No	Internal corrosion of household plumbing, erosion of natural deposits.
Manganese (ug/l)		50	5	5	7/23/02 - 9/16/02	80	AO Exceedance	Erosion of natural deposits.
Mercury (ug/l)	0.1		0	0		N/A	No	Erosion of natural deposits, industrial discharges.
Nitrogen, Nitrite (mg/l)	1		2	0	7/3/02 - 8/6/02	<0.1	No	Runoff from fertilizer use, erosion of natural deposits
Nitrate (mg/l)	10		2	0	7/3/02 - 8/6/02	<0.1	No	A natural component of water at this level.
Selenium (ug/l)	10		0	0		N/A	No	Discharge from refineries, mines, chemical manufacture
Uranium (ug/l)	20		0	0		N/A	No	Erosion of natural deposits.

Table D - Pesticides & PCB (ug/l)	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result	Exceedance?	Typical Source of Contaminant
Alachlor (Lasso) (ug/l)	5		1	0	7/3/02	<0.5	No	Agricultural herbicide
Aldicarb (ug/l)	9		1	0	7/3/02	<6	No	Agricultural insecticide
Aldrin+dielddrin (ug/l)	0.7		1	0	7/3/02	<0.05	No	Residue from banned insecticide
Atrazine (ug/l)	5		1	0	7/3/02	<1	No	Agricultural herbicide
Azinphos-methyl (Guthion) (ug/l)	20		1	0	7/3/02	<2	No	Insecticide
Bendiocarb (ug/l)	40		1	0	7/3/02	<5	No	Insecticide

Table D - Pesticides & PCB (ug/l)	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result	Exceedance?	Typical Source of Contaminant
Bromoxynil (ug/l)	5		1	0	7/3/02	<0.5	No	Agricultural herbicide
Carbaryl (ug/l)	90		1	0	7/3/02	<5	No	Agricultural/Forestry/ Household insecticide
Carbofuran (ug/l)	90		1	0	7/3/02	<2	No	Agricultural insecticide
Chlordane (Total) (ug/l)	7		1	0	7/3/02	<0.6	No	Residue from banned insecticide
Chlorpyrifos (Dursban) (ug/l)	90		1	0	7/3/02	<1	No	Agricultural/ Household insecticide
Cyanazine (Bladex) (ug/l)	10		1	0	7/3/02	<1	No	Agricultural/ Residential herbicide
Diazinon (ug/l)	20		1	0	7/3/02	<2	No	Agricultural/ Livestock Operation/ Residential insecticide
Dicamba (ug/l)	120		1	0	7/3/02	<10	No	Agricultural herbicide
2,4-dichlorophenol (ug/l)	900		1	0	7/3/02	<0.2	No	Industrial contamination/ reaction with chlorine
DDT (ug/l)	30		1	0	7/3/02	<1	No	Residue from banned insecticide
2,4-dichloro-phenoxyacetic acid (2,4-D) (ug/l)	100		1	0	7/3/02	<10	No	Agricultural/ Residential herbicide
Diclofop-methyl (ug/l)	9		1	0	7/3/02	<0.9	No	Agricultural herbicide
Dimethoate (ug/l)	20		1	0	7/3/02	<2	No	Agricultural/ Livestock Operation/ Forestry insecticide
Dinoseb (ug/l)	10		1	0	7/3/02	<1	No	Herbicide residue
Diquat (ug/l)	70		1	0	7/3/02	<5	No	Agricultural/ Aquatic herbicide
Diuron (ug/l)	150		1	0	7/3/02	<10	No	Agricultural/ Industrial/ herbicide
Glyphosate (ug/l)	280		1	0	7/3/02	<25	No	Agricultural/Forestry/ Household herbicide
Heptachlor+heptachlor epoxide (ug/l)	3		1	0	7/3/02	<0.1	No	Residue from banned insecticide
Lindane (Total) (g-BHC Hexachloro-cyclohexane) (ug/l)	4		1	0	7/3/02	<0.1	No	Agricultural/ Pharmaceutical insecticide
Malathion (ug/l)	190		1	0	7/3/02	<10	No	Fruit & Vegetable / pest control insecticide
Methoxychlor (ug/l)	900		1	0	7/3/02	<10	No	Agricultural/ Livestock Operation/ Residential insecticide
Metolachlor (ug/l)	50		1	0	7/3/02	<5	No	Agricultural herbicide
Metribuzin (Sencor) (ug/l)	80		1	0	7/3/02	<5	No	Agricultural herbicide
Paraquat (ug/l)	10		1	0	7/3/02	<1	No	Agricultural/ Aquatic herbicide
Parathion (ug/l)	50		1	0	7/3/02	<5	No	Agricultural insecticide
Pentachlorophenol (ug/l)	60		1	0	7/3/02	<0.2	No	Pesticide/ wood preservative residue
Phorate (Thimet) (ug/l)	2		1	0	7/3/02	<0.5	No	Agricultural insecticide
Picloram (ug/l)	190		1	0	7/3/02	<10	No	Industrial herbicide
PCB; total (ug/l)	3		1	0	7/3/02	<0.3	No	Residue from various industrial uses
Prometryne (ug/l)	1		1	0	7/3/02	<0.2	No	Agricultural herbicide
Simazine (ug/l)	10		1	0	7/3/02	<1	No	Agricultural herbicide or its residue
Temephos (ug/l)	280		1	0	7/3/02	<25	No	Insecticide for Mosquito/Blackfly control
Terbufos (ug/l)	1		1	0	7/3/02	<0.7	No	Agricultural insecticide
2,3,4,6-tetra-chlorophenol (ug/l)	100		1	0	7/3/02	<0.1	No	Wood preservative
Triallate (ug/l)	230		1	0	7/3/02	<20	No	Agricultural herbicide
2,4,6-trichlorophenol (ug/l)	5		1	0	7/3/02	<0.2	No	Pesticide manufacturing
Trifluralin (ug/l)	45		1	0	7/3/02	<1	No	Agricultural herbicide
2,4,5-trichloro-phenoxyacetic acid (2,4,5-T) (ug/l)	280		1	0	7/3/02	<22	No	Industrial herbicide residue

Chemical/ Physical Parameters Non Health Related	MAC or IMAC	AO or OG	Number of Samples	Number of Detectable Results	Sampling Dates	Max. Result	Exceedance?	Parameter Description
Alkalinity (mg/l as CaCO ₃)		500	0	0		N/A	No	A measure of the resistance of the water to the effects of acids. Expressed as calcium carbonate.
Aluminum (ug/l)		100	0	0		N/A	No	May be naturally present or a residual from the coagulation process.
Ammonia N (mg/l)			0	0		N/A	No	Occurs naturally from organic nitrogen containing compounds.
Benzo(a)pyrene (ug/l)	0.01		0	0		N/A	No	Formed from the incomplete burning of organic matter.
Calcium (mg/l)			0	0		N/A	No	Naturally occurring.
Chloride (mg/l)		250	0	0		N/A	No	A common naturally occurring non-toxic material that may produce a salty taste in water.
Colour (TCU)		5	2	1	7/3/02 - 8/6/02	5.00	No	Typically the result of organic or inorganic matter in ground waters.
Conductivity (Us/cm)			0	0		N/A	No	A measure of ability of water to carry an electric current due to the presence of ions.
Cyanide (mg/l)	0.2		0	0		N/A	No	Industrial discharge
Dioxin and Furan (pg/l)	15		0	0		N/A	No	Formed in very small amounts in combustion processes
Dissolved Organic Carbon (mg/l)		5	0	0		N/A	No	High DOC is an indicator of potential chlorination by-product problems.
Fluoride (mg/l)	1.5		0	0		N/A	No	Added to prevent tooth decay, but may be naturally occurring.
Gross Alpha (Bq/l)			0	0		N/A	No	Decay of natural deposits.
Gross Beta (Bq/l)			0	0		N/A	No	Decay of natural deposits.
Hardness (mg/l)		100	2	2	7/3/02 - 8/6/02	547	AO Exceedance	Naturally occurring from dissolved calcium and magnesium.
Nitrilotriacetic acid -NTA (ug/l)	400		0	0		N/A	No	Used in laundry detergents.
Nitrosodimethylamine - NDMA (ug/l)	0.009		0	0		N/A	No	Rarely used industrially but has been used as an antioxidant, and an additive for lubricants
Orthophosphate (mg/l)			0	0		N/A	No	From agricultural runoff or as a result of residential use.
pH	8.5		0	0		N/A	No	An indicator of the acidity of water.
Silica (mg/l)			0	0		N/A	No	Naturally occurring.
Sodium (mg/l)		200	5	5	7/3/02 - 8/6/02	102.0	No	Occurs naturally in the earth's crust.
Sulphate (mg/l)		500	0	0		N/A	No	An inorganic constituent that may cause tastes at high levels.
Tritium (Bq/l)	7000		0	0		N/A	No	Decay of Natural & man made deposits.
Total Kjeldahl Nitrogen (mg/l)			0	0		N/A	No	Indicator of organic contamination or the potential for taste and odour problems.
Zinc (ug/l)	5000		0	0		N/A	No	An inorganic constituent that may cause tastes.

Symbols used above may include: (N/A) - Not Applicable; (N/D, <) - Not Detected or, less than the value shown - this typically means the parameter was below detectable levels.

Where testing is not required on a quarterly basis, some of the levels shown above may be results from a previous quarter. The most recent results are typically shown. The table immediately above (Chemical/physical parameters non health related) lists some of the sampling done for the quarter which is above and beyond that required in the regulations.

As indicated by a recent survey, most of the residents served by this system maintain an in-home treatment system to address some of the aesthetic concerns presented by this water supply. Utilities Kingston is taking steps to address these concerns also, and will be replacing much of the old distribution system piping, as well as investigating a new source well.

Exceedances this quarter included three for aesthetic objectives for Iron, Manganese, and Hardness. This means there may be some effect from the parameter that you may find inconvenient. For hardness this typically means more soap may be required to form suds or lather, or some scaling may appear on fixtures or in kettles. There is no health effect associated with this. For Iron and Manganese an aesthetic exceedance typically means some staining may occur. The exceedances mentioned in the tables above for turbidity were resulting from excessive flows in the distribution system caused by high customer demand or system maintenance. Turbidity is a measure of the amount of particulates in water, and can potentially affect the ability of the disinfectant to kill bacteria. Typically, in the Cana distribution system, turbidity is caused by a reaction between the chlorine disinfectant and dissolved iron from the well water. This forms a precipitate that can be disturbed by abnormally high flows in the distribution system piping.

What was done to meet the regulations?

During this quarter there were three instances during sample collection where chlorine residuals were found to be less than the recommended level of 0.20 mg/l of free chlorine, although still above the minimum level of 0.05 mg/l. In each case, all associated bacteriological sampling found no contamination, and the system was flushed until a greater than 0.20 mg/l free chlorine residual was obtained.