metrovancouver

Greater Vancouver Water District

2022 Water Quality Annual Report

Volume 1 of 2

March 2023

57690220

This page has been intentionally left blank

Table of Contents

Volume 2 of 2 (58776443)
(under separate cover)

List of Tables

List of Figures

List of Appendices

ACRONYMS

ACU	Apparent Colour Unit
ALARA	As Low As Reasonably Achievable
AO	Aesthetic Objective (characteristics such as taste, colour, appearance, temperature that are not health related)
BTEX	Benzene, Ethylbenzene, Toluene, Xylene
CALA	Canadian Association for Laboratory Accreditation
CO_2	Carbon Dioxide
CWTP	Coquitlam Water Treatment Plant
DBP	Disinfection By-product
DWTO	*Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*
E. coli	*Escherichia coli*
GCDWQ	*Guidelines for Canadian Drinking Water Quality*
GVWD	Greater Vancouver Water District
HAA	Haloacetic Acid
HPC	Heterotrophic Plate Count
IFE	Individual Filter Effluent
MAC	Maximum Acceptable Concentration
mg/L	Milligram per litre (0.001 g/L)
µg/L	Microgram per litre (0.000001 g/L)
mL	Milliliter
MF	Membrane Filtration
mJ/cm^2	Millijoule per centimeter squared
MPN	Most Probable Number
N/A	Not Applicable
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic Aromatic Hydrocarbons
PFOA	Perfluorooactanoic Acid
PFOS	Perfluorooctane Sulfonate
pH	Measure of acidity or basicity of water; pH 7 is neutral
SCFP	Seymour Capilano Filtration Plant
THAA	Total Haloacetic Acids
THM	Trihalomethane
TSI	Trophic State Index
TTHM	Total Trihalomethanes
UV_{254}	Ultraviolet Absorbance at 254 nm
VOC	Volatile Organic Compounds
WQMRP	*Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members*

EXECUTIVE SUMMARY

Source Water Quality

- In 2022, the turbidity levels of the delivered water met the requirements of the *Guidelines for Canadian Drinking Water Quality* (GCDWQ).
- The Capilano supply was in service for the entire year. Heavy rainfall events in January resulted in Capilano source water turbidity peaking just over 6.5 Nephelometric Turbidity Unit (NTU). Even with the higher turbidity, the delivered filtered Capilano water was less than 0.15 NTU as measured by online instruments for the entire year.
- The Seymour supply was in service for the entire year. Heavy rainfall events in late December resulted in Seymour source water turbidity peaking at 5.4 NTU. The delivered filtered Seymour water was less than 0.15 NTU as measured by online instruments for the entire year.
- The Coquitlam supply was in service for the entire year. The unfiltered Coquitlam source water was greater than 1.0 NTU for 10 days in 2022 and did not exceed 5.0 NTU throughout the year in accordance with Greater Vancouver Water District's (GVWD) Permit to Operate.
- The microbiological quality of the three source waters was excellent in 2022. The levels of bacteria and protozoa detected were low and indicative of high quality source water.
- Coquitlam source water quality met the bacteriological requirements for avoiding filtration outlined in the turbidity section of the GCDWQ.
- Analytical results of the source water for herbicides, pesticides, volatile organic compounds and radionuclides were all found to be below the recommended limits as listed in the GCDWQ.

Water Treatment

- The Seymour Capilano Filtration Plant (SCFP) performance, as measured by the quality of the delivered water, was excellent in 2022. The daily average turbidity of water leaving the Clearwells to enter the GVWD transmission system was an average of 0.15 NTU in 2022.
- Turbidity levels for Individual Filter Effluent (IFE) met the turbidity requirements of the GCDWQ.
- Filtration consistently removed iron, colour and organics from the Capilano and Seymour source waters.
- Levels of total aluminum in filtered water were consistently below the GCDWQ operational guideline value of 0.1 mg/L for direct filtration plants using aluminum-based coagulants. The maximum value for 2022 was 0.055mg/L.
- There were no outages of ultraviolet treatment at the SCFP and the Coquitlam Water Treatment Plant (CWTP).
- The SCFP and CWTP operated the full year using sodium hypochlorite for chlorination.
- The secondary disinfection stations boosted chlorine when required.

Transmission/Distribution System Water Quality

- Bacteriological water quality was excellent in the GVWD transmission mains and in-system storage reservoirs. The number of *E. coli* detected in both GVWD and member jurisdiction drinking water samples is typically very low. More than 28,700 samples were collected and analyzed for GVWD and member jurisdiction systems in 2022, of which one sample was positive for *E. coli*.
- The running average levels of the Trihalomethane (THM) group of chlorine disinfection by-products detected in the delivered water in the GVWD and member jurisdiction systems were below the Maximum Acceptable Concentration (MAC) in the GCDWQ of 100 µg/L (0.1 mg/L). The running average levels for the Haloacetic Acid (HAA) group of chlorine disinfection by-products were below the GCDWQ Maximum Acceptable Concentration (MAC) of 80 µg/L (0.08 mg/L).

1.0 SOURCE WATER QUALITY

The first barrier in place to protect the quality of the drinking water supply is the protection of the Water Supply Area to ensure the best quality source water. Source water monitoring provides ongoing confirmation that the barrier is effective, identifies seasonal changes and provides the monitoring information necessary to adjust the level of water treatment that is in place. Regular monitoring of the water sources is a requirement of the *Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members (WQMRP)*. Refer to Appendix A for details regarding the water sampling frequency.

1.1. Bacteriological Quality of the Source Water

The bacteriological quality of the source water is an important indicator of the degree of contamination, and the treatment required to ensure a safe water supply. *The Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia* (DWTO) Section 4.3 states *"The number of E. coli in raw water does not exceed 20/100 mL (or if E. coli data are not available less than 100/100 mL of total coliform) in at least 90% of the weekly samples from the previous six months. Treatment target for all water systems is to contain no detectable E. coli or fecal coliform per 100 mL."*

Table 1 summarizes *E. coli* data for all three GVWD water supply sources. The levels of *E. coli* for all three sources were below the 10% limit in the provincial DWTO.

	Percent of samples (daily) in a six month period ending on the last day of the month named where *E. coli* greater than 20/100 mL		
Month	**Capilano**	**Seymour**	**Coquitlam**
Jan	3.8%	7.7%	3.8%
Feb	3.9%	7.8%	3.9%
Mar	0.0%	3.3%	0.6%
Apr	0.0%	0.0%	0.0%
May	0.0%	0.0%	0.0%
Jun	0.0%	0.0%	0.0%
Jul	0.0%	0.0%	0.0%
Aug	0.0%	0.0%	0.0%
Sep	0.0%	0.0%	0.0%
Oct	2.2%	1.6%	1.1%
Nov	3.3%	4.4%	1.1%
Dec	3.3%	4.5%	1.1%

Table 1: Percent of Samples in Six Continual Months with E. coli/100 mL Exceeding 20

Figure 1 shows the results of the analysis of the source water from 2019 to 2022 at all three intakes compared to the limits for source water bacterial levels in the DWTO. As in previous years, all three sources met the limit of not more than 10% exceeding 20 *E. coli*/100 mL. Also, as is typical, samples collected at the intakes in the Fall and Winter had the highest *E. coli* levels. Typically, *E. coli* can be traced back to high flow levels at the main tributaries of the supply lakes and a first flush phenomenon after a period of dry weather.

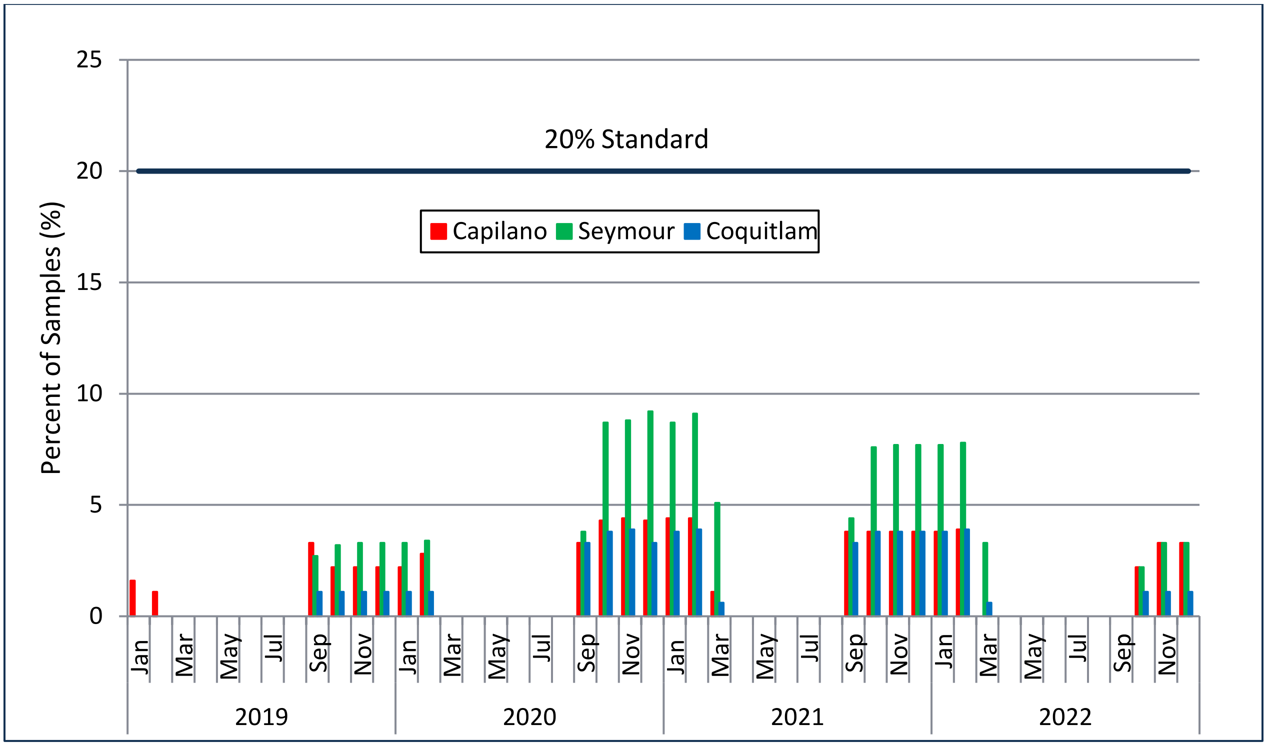


Figure 1: Percent of Samples Exceeding 20 E. coli/100 mL at all Three Sources (2019 to 2022)

Note: Metro Vancouver has protected Water Supply Areas and therefore the source of *E. coli* is most likely originating from endemic animals in the Water Supply Areas. Samples in summer have minimal *E. coli* and no detectable amounts for some sources.

1.2. Source Water Monitoring for *Giardia* and *Cryptosporidium*

Unfiltered surface water supplies have the potential of containing the protozoan pathogens *Giardia* and *Cryptosporidium*. Outbreaks of *Giardiasis* occurred in a number of locations in BC and Washington State in the late 1980s, and Metro Vancouver has been monitoring raw water for *Giardia* since 1987. Since 1992, Metro Vancouver has participated in a program with the Environmental Microbiology Laboratory of the BC Centre of Disease Control Public Health Laboratory, to gather more information about the number and nature of cysts found in the GVWD water supplies. The program has involved collecting samples from the Capilano and Coquitlam supplies upstream of disinfection; beginning in July 2022 Metro Vancouver increased monitoring to include Seymour source prior to treatment. This is in addition to the existing monitoring of recycled water at the SCFP.

At the SCFP, monitoring for *Giardia* and *Cryptosporidium* has focused on the recycled water returning to the head of the plant and this monitoring has confirmed that the procedures in place effectively control the levels of *Giardia* and *Cryptosporidium* in the recycled wash water from the filters.

Complete results of the 2022 testing program are contained in the "Metro Vancouver Detection of Waterborne *Cryptosporidium* and *Giardia* January - December, 2022 Annual Report", which was prepared by the BCCDC PHL Environmental Microbiology Laboratory, and can be found in Appendix D. Two of twelve (17%) samples collected at Capilano and one of the twelve (8%) collected at Coquitlam were positive for *Giardia* (Table 2).

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Capilano	50	18	18	50	58	33	33	33	25	17
Seymour	-	-	-	-	-	-	-	-	-	0
Coquitlam	23	8	0	17	67	8	25	25	25	8

Table 2: Percent of Samples Positive for Giardia

Zero of twelve (0%) samples collected at Capilano were positive for *Cryptosporidium*, and zero of twelve (0%) were positive at Coquitlam (Table 3). Collection of *Giardia* and *Cryptosporidium* samples from the Seymour source as initiated in August 2022. The percentages for Seymour shown on Tables 2 and 3 are for only 5 months compared to the Capilano and Coquitlam sources, which are based on 12 months.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Capilano	9	9	9	25	17	8	0	0	0	0
Seymour	-	-	-	-	-	-	-	-	-	0
Coquitlam	9	0	0	0	0	0	0	0	0	0

Table 3: Percent of Samples Positive of Cryptosporidium

Year to year fluctuations are demonstrated for *Giardia* and *Cryptosporidium* and there has always been considerable variation in the results.

1.3. Turbidity

As shown in Figure 2, GVWD water sources have been susceptible to turbidity events due to high runoff from storms, which can cause slides and stream scouring in the Water Supply Areas, or from re-suspension of sediment from the edges of the lakes during periods of low water levels. The DWTO allows a utility to be exempt from filtration if the turbidity does not exceed specific water quality parameters requirements and provided that a number of other provisions, including source water protection, and two forms of water treatment requirements are in place. Historically the turbidity levels on both the Capilano and Seymour sources would not meet these criteria, and filtration was implemented for both supplies.

Section 4.4 of the DWTO (Version 1.2, November 2012) contains the following provision for filtration exemption:

"For nonfiltered surface water to be acceptable as a drinking water source supply, average daily turbidity levels should be established through sampling at equal intervals (at least every four hours) immediately before the disinfectant is applied. Turbidity levels of around 1.0 NTU but not exceeding 5.0 NTU for more than two days in a 12-month period should be demonstrated in the absence of filtration. In addition, source water turbidity also should not show evidence of harbouring microbiological contaminants in excess of the exemption criteria."

Capilano and Seymour water is filtered so these source water criteria do not apply to the delivered water. Coquitlam, which is unfiltered, was in service for all of 2022 in accordance with the DWTO.

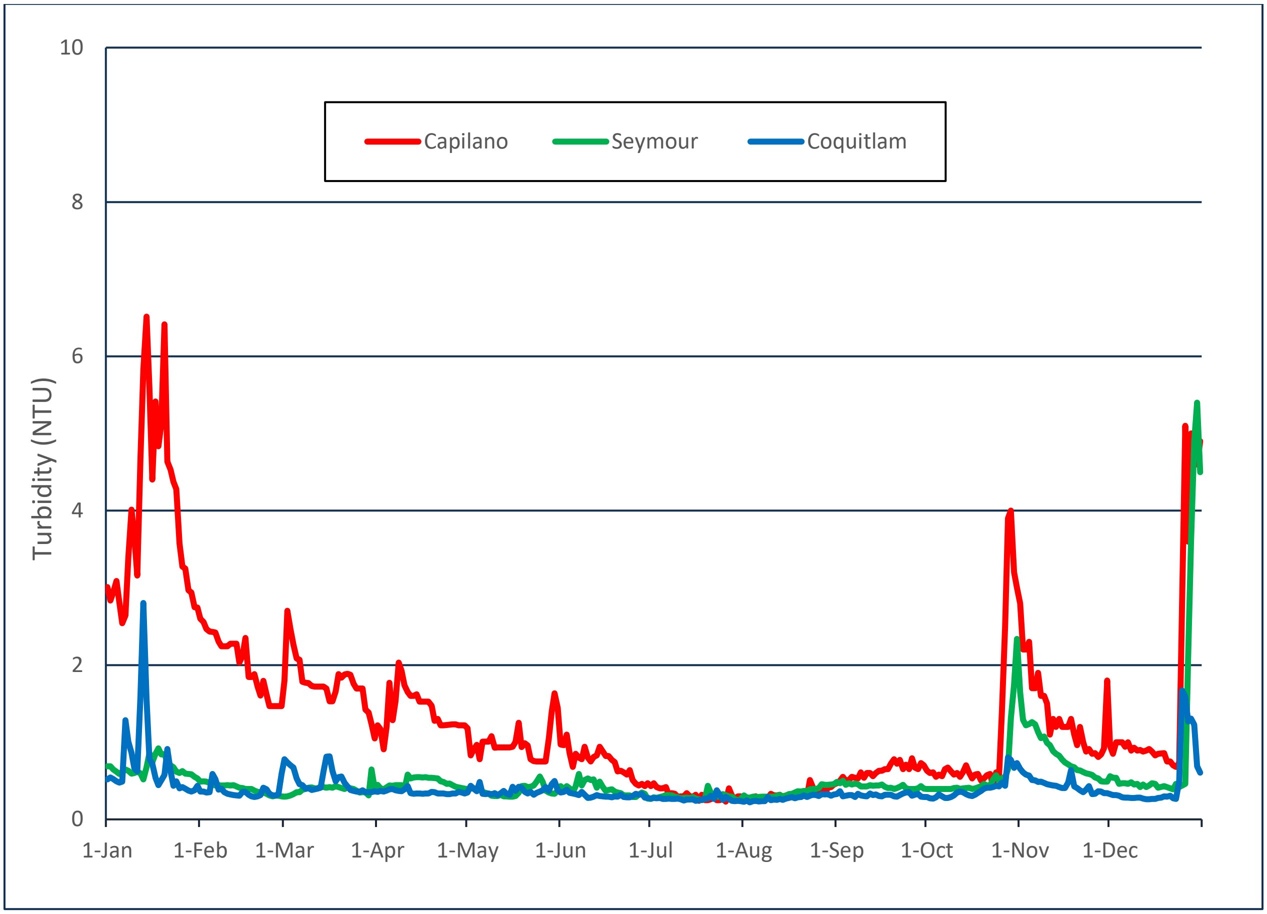


Figure 2: Average Daily Turbidity of Source Water (From In-line Readings)

1.4. Chemistry

1.4.1. Chemical and Physical Characteristics of the Source Water

The chemical and physical characteristics of the GVWD source water are summarized in Appendix B of this report; detailed analytical results are provided in Volume 2. The results from the chemical and physical analyses of the source water in 2022 were similar to those for previous years. The analysis was carried out by accredited laboratories using methods based on the current version of *Standard Methods For the Examination of Water and Wastewater*.

1.4.2. Analysis of Water for Organic Components and Radionuclides

Analyses of the source water for a variety of organic and other compounds, including all of the compounds with a specified MAC in the *Guidelines for Canadian Drinking Water Quality* (GCDWQ), is carried out on an annual basis in accordance with the WQMRP. The results are contained in Appendix C of this report and in Volume 2. No parameters were detected above the applicable GCDWQ health based limits.

1.4.3. PFOS and PFOA

Perfluorooctane Sulfonate (PFOS) and Perfluorooactanoic Acid (PFOA) testing is conducted on source waters and the results are detailed in Table 4. Common sources of these synthetic chemicals are from consumer products and fire-fighting foam, for their water and oil repellant properties. Neither parameter was detected above the applicable health based limits at the time of the publication of this report.

Parameter	Capilano (ng/L)	Seymour (ng/L)	Coquitlam (ng/L)	MAC (ng/L)
	Jul 26	Jul 26	Jul 26	
PFOS	<0.2	<0.2	<0.2	600
PFOA	<0.2	<0.2	<0.2	200

Table 4: Monitoring of Source Waters for PFOS and PFOA

1.4.4. Limnology

The Reservoir Water Quality Monitoring Program, started in 2014, collects limnology data (physical, chemical and biological parameters) for the Capilano, Seymour and Coquitlam supply reservoirs. Reservoir monitoring information is important in proactively managing the supply reservoirs as water quality could be impacted by environmental variability and climate change. This program assists in ensuring that variation and trends in reservoir quality are scientifically tracked over time.

Water sampling of the source reservoirs and inflow rivers is conducted between April and November. Biological productivity that can influence water quality is the highest during this time of year, making it an important time for sampling and measurements. Monthly sampling of the source water is conducted and sample analysis undertaken by accredited labs. More frequent water quality measurements are compiled by arrays of scientific instruments in each reservoir.

Metro Vancouver analysis of 2022 data resulted, as in previous years, in confirmation that the three reservoirs are ultra-oligotrophic (see Table 5), which means they have low levels of available nutrients and low levels of biological production. A single value called the Trophic State Index (TSI) is used to infer time course change in water quality based on the amount of algal biomass in the water column of each reservoir. TSI values have remained consistently low since measurements began (see Figure 3), which shows low biological production. The ultra-oligotrophic classification and low TSI values are highly desirable for source drinking water supply and shows that the GVWD Water Supply Areas and reservoirs continue to supply high quality source water.

There is worldwide interest in bluegreen algae (also known as cyanobacteria) in drinking water reservoirs. These algae can produce toxins that are collectively known as microcystins. A common cyanobacterium in GVWD reservoirs is called *Merismopedia* spp., which is thought to produce these microcystins. Despite the presence of cyanobacteria, the concentration of microcystins in GVWD reservoirs remains below the level stipulated in the GCDWQ, 1.5 µg/L. This desirable condition is due to the ultra-oligotrophic status of the reservoirs. Metro Vancouver continues to monitor cyanobacteria, including *Merismopedia* spp. as well as processes in the reservoirs that control the growth of cyanobacteria and other algae. These data are routinely used to help predict changes to water quality over time related to climatic and environmental change and aid in making proactive decisions about ongoing reservoir management strategies.

Chemical Measurement	Average Value					Status of Reservoirs
	Ultra-oligotrophic status[1]	Ultra-oligotrophic status	Capilano Reservoir 2014-2022 (2022 only)	Seymour Reservoir 2014-2022 (2022 only)	Coquitlam Reservoir 2014-2022 (2022 only)	
Total Phosphorus (µg/L)	5.0	8.0	3.1 (3.1)	3.2 (3.5)	3.2 (4.0)	Ultra-oligotrophic (very high water quality)
Total Nitrogen (µg/L)	250	661	122 (105)	120 (109)	128 (121)	Ultra-oligotrophic (very high water quality)
Phytoplankton Biomass (µg/L of chlorophyll-a)	0.5	1.7	0.43 (0.68)	0.55 (0.68)	0.59 (0.85)	Ultra-oligotrophic (very high water quality)

Table 5: Comparison of Water Quality in GVWD Water Supply Sources to Standard Water Quality Classifications

[1]Wetzel, R.G. 2001 River Ecosystems. 3rd edition. Academic Press. New York.

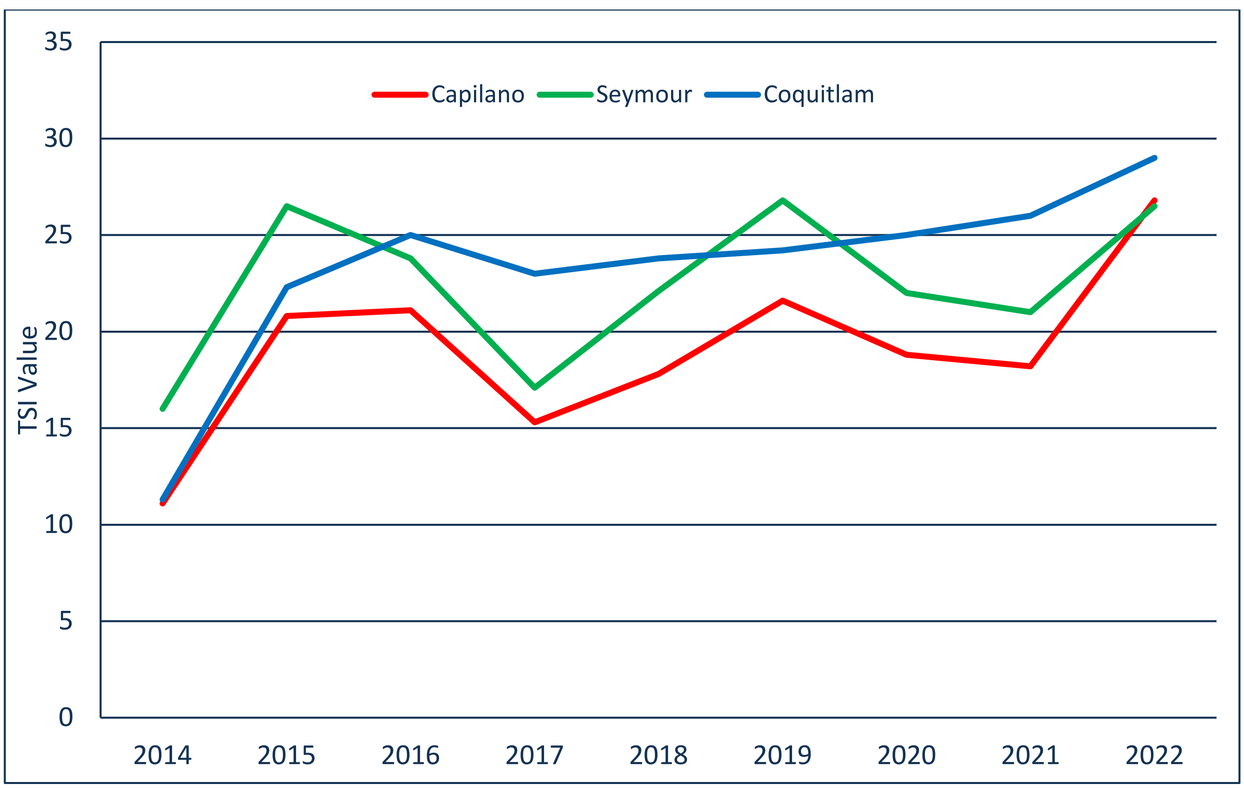


Figure 3: Trophic State Index of Source Waters

2.0 QUALITY CONTROL ASSESSMENT OF WATER TREATMENT

Primary treatment of the source water is the second barrier, following source water protection, used to assure the quality of the water supply.

Metro Vancouver filters water from the Capilano and Seymour source reservoirs at the Seymour Capilano Filtration Plant (SCFP), which is located in GVWD's Lower Seymour Conservation Reserve. Twin tunnels connect the two supply sources. Each tunnel is 3.8 metres in diameter, 7.1 kilometres long, and 160 to 640 meters below ground level, running beneath Grouse Mountain and Mount Fromme. The water from the Raw Water Tunnel is filtered and treated alongside the Seymour source water at the Seymour Capilano Filtration Plant (SCFP). Both treated sources enter the Clearwell at the SCFP for further treatment before the blended water is distributed to the region. Blended treated water returns to Capilano service area through the Treated Water Tunnel and provides high quality drinking water to the Capilano area, while the remainder is distributed through the Seymour system. This system typically supplies about two thirds of the region's drinking water.

The Coquitlam Water Treatment Plant is located north of the City of Coquitlam, and typically supplies about one third of the region's drinking water. Due to the historically low turbidity levels, the Coquitlam source water is not filtered.

Metro Vancouver operates the water supply system under the *GVWD Permit to Operate* issued jointly by Vancouver Coastal Health and Fraser Health. The permit stipulates that Metro Vancouver must meet the requirements to achieve at least a 4-log (99.99%) reduction and/or inactivation of Viruses, and at least a 3-log (99.9%) reduction and/or inactivation of *Giardia* cysts and *Cryptosporidium* oocysts. Operationally, Metro Vancouver meets the permit requirements managing the microbial risks using a combination of direct filtration, Ultraviolet (UV) light and chlorine at SCFP, and using ozone, UV light and chlorine at CWTP.

2.1. Seymour Capilano Filtration Plant

The SCFP is a chemically assisted direct filtration plant which uses polyaluminum chloride as a coagulant with polymers to improve particle removal. These substances help aggregate particles to form visible floc. The flocculated particles are removed by passing this water through a filter medium of anthracite and sand. The result is the production of filtered water, which is then exposed to UV light as the water exits each filter. The final processes are the addition of sodium hypochlorite (chlorine) and hydrated lime before the water enters the Clearwells. The West and East Clearwells are large water storage reservoirs that store and allow controlled passage of water with mixing (or blending) of the injected chlorine and hydrated lime. The Clearwells provide sufficient retention (or contact time) with chlorine to provide any further disinfection required after filtration and ultraviolet light treatment. Carbon dioxide (CO_2) in solution is added to trim pH once the desired alkalinity is reached using hydrated lime. After the Clearwells, the finished water enters the transmission system at the Seymour Treated Water Valve Chamber. The quality of the water produced has been excellent leaving the SCFP.

2.1.1. Filtration

Filtration treatment of the Capilano and Seymour water sources help improve the characteristics of the delivered water. This includes a visible decrease in colour and increase in clarity. There is a total loss of brown hue that can sometimes characterize Capilano and Seymour source waters. This improvement in colour is a result of removal of the naturally occurring parameters that cause the brown hue by the filtration process.

Suspended particles in water that cause light to scatter (turbidity) are also removed. The end product is water that is very clear. Due to the purity of the water, it may have a slight bluish tinge.

Figure 4 compares the apparent colour of SCFP filtered water and Capilano and Seymour source waters for 2022. During the fall rainfall events, the apparent colour of the Seymour source water feeding the SCFP had a reading of 44 Apparent Colour Unit (ACU). After the removal of the organic material through filtration, the colour of the filtered water delivered to the public was never greater than 6 ACU.

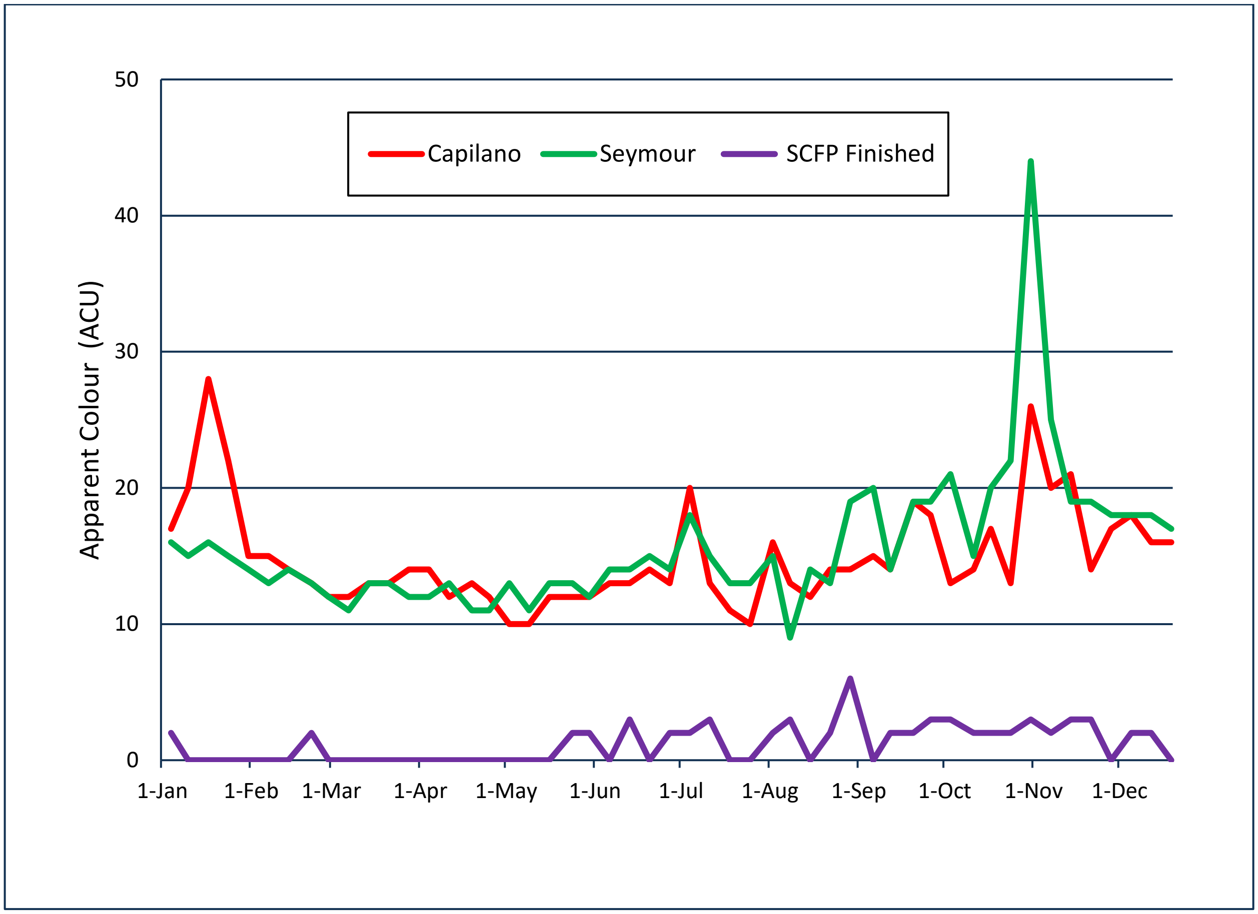


Figure 4: Apparent Colour Levels Before and After Filtration

Figure 5 compares turbidity of the two source waters that feed the SCFP to the turbidity level of the finished water. The Seymour source experienced an average daily turbidity greater than 1.0 NTU for 23 days. The Capilano source exceeded 1.0 NTU on 159 days. Since both sources are filtered at the SCFP, the maximum average daily turbidity of the delivered water was 0.28 NTU, and the average was 0.15 NTU.

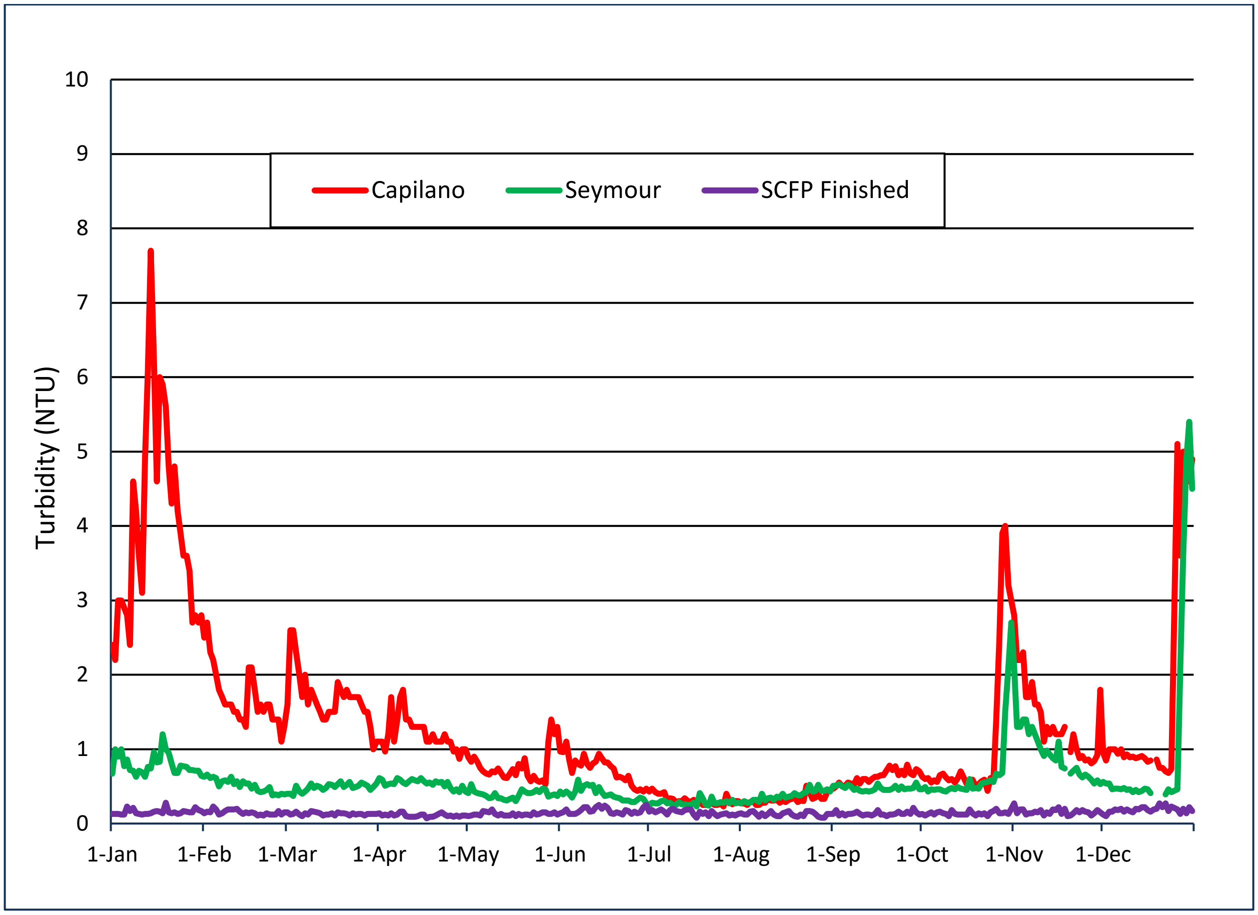


Figure 5: Average Daily Turbidity Levels Before and After Filtration

Removal of turbidity in the source water improves the aesthetic qualities of the water, but it also has the benefit of removing certain types of pathogenic microorganisms that may be present. At a minimum, properly run direct filtration plants such as the SCFP will remove up to 2.5 log (two log is a 99% reduction) of *Giardia* and *Cryptosporidium* plus 1 log of viruses. To ensure this removal, it is critical that the performance of each filter determined by the turbidity of its effluent is monitored on a continuous basis.

The GCDWQ (2020) states: "*For conventional and direct filtration, less than or equal to 0.3 nephelometric turbidity units (NTU) in at least 95% of measurements either per filter cycle or per month and never to exceed 1.0 NTU.*"

Ideally the turbidity from each filter would never exceed 0.1 NTU; however, there are rare occurrences of turbidity readings that exceed this ideal level. The turbidity performance of all 24 filters is measured by examining the percent of time that the turbidity of each Individual Filter Effluent (IFE) met the turbidity guidelines of not greater than 1.0 NTU, and at least 95% of the time less than 0.3 NTU. This is summarized in Table 6. In 2022, there were no incidents where the IFE was greater than 1.0 NTU, and the few incidences of filter turbidity readings that were greater than 0.3 NTU were well within the 95% limit.

Month	Occurrence of IFE Turbidity greater than 1.0 NTU (None Allowed)	Percent of Time IFE Turbidity was less than 0.3 NTU (Minimum 95% Required)
January	0	99.999%
February	0	100%
March	0	100%
April	0	99.999%
May	0	100%
June	0	100%
July	0	100%
August	0	100%
September	0	100%
October	0	100%
November	0	100%
December	0	99.999%

Table 6: Monthly Filter Effluent Turbidity Summary

Under normal operating conditions the average turbidity of the filtered water at SCFP was 0.15 NTU.

All water that flows through the filters immediately passes through the UV units. The intensity of the UV lamps automatically increases when there is an increase in turbidity or colour of the water exiting each filter. After UV treatment, the water is chlorinated as it enters the Clearwells, where more than one hour of contact time is provided.

2.1.2. Ultraviolet Treatment

The effluent from each filter is treated with UV light as the water exits the filter. UV treatment is effective in altering the DNA structure of *Giardia* and *Cryptosporidium* thus rendering cysts and oocysts, respectively, of these parasites, non-infectious. Other disinfectants, especially chlorine, are ineffective against *Cryptosporidium* oocysts at reasonable dosages. In the unlikely event of a breakthrough of *Cryptosporidium* oocysts, especially at the end of a filter run, UV light is present to render any parasites that may be present as non-infectious. Cysts and oocysts are not able to proliferate inside the intestines of human hosts to cause illness after a sufficient dose of ultraviolet light. The target dosage for UV light is to achieve 2-Log (99%) *Giardia* and *Cryptosporidium* inactivation.

Under normal operating conditions, two rows of lamps operating at 75% power provide sufficient UV light to meet the dosage requirement for 2-log reduction of *Giardia* and *Cryptosporidium.*

Table 7 summarizes the performance of the SCFP UV system in 2022.

Month	Percent of Monthly Volume ≥ 2-log of *Giardia* and *Cryptosporidium* Inactivation (95% of monthly volume required)
January	99.95%
February	99.97%
March	99.91%
April	99.83%
May	99.96%
June	99.94%
July	99.95%
August	99.94%
September	99.95%
October	99.97%
November	99.88%
December	99.96%

Table 7: Percent of Volume Meeting Ultraviolet Dosage Requirements at SCFP

2.1.3. Chlorination

Chlorination is used for disinfection at the source as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and member jurisdiction distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite.

2.2. Coquitlam Water Treatment Plant

The Coquitlam Water Treatment Plant (CWTP) treats the Coquitlam source water using multiple disinfection barriers, specifically, ozone, UV and chlorine, and provides corrosion control. The Coquitlam source water is not filtered. Ozone contact is achieved in a stainless steel contactor pipeline that connects the Ozonation facility with the Corrosion Control and Chlorination facility. The primary function of ozonation is to improve the transmissivity of the water for subsequent UV light treatment and oxidize organic precursors responsible for the formation of disinfection by-products (DBPs) following chlorination.

Ozone also provides disinfection capacity for *Giardia* and viruses. UV light is the primary process for inactivation of *Giardia* and *Cryptosporidium* and chlorine for viruses. Corrosion control is achieved using sodium carbonate and carbon dioxide which is added to trim the pH once the desired alkalinity is reached. After chlorination, the finished water enters the transmission system. The quality of the water produced has been excellent leaving the CWTP.

2.2.1. Ozonation

Ozone is intended as a pre-treatment, however, also provides backup for inactivation of Giardia when the UV treatment system is offline. Ozonation also provides additional virus inactivation to chlorination. The ozonation system was fully operational for 99.3% of the time in 2022. The ozone outages in 2022 were due to a combination of electrical/instrument maintenance, ozone dosing test, and ozone generator faults or power loss.

2.2.2. Ultraviolet Treatment

UV light treatment provides for primary disinfection, and achieves 3-log inactivation of chlorine-resistant micro-organisms for *Giardia* and *Cryptosporidium*. The water is directed into 8 ultraviolet units, each containing 40 ultraviolet lamps encased in protective sleeves. Ultraviolet light emitted from the lamps passes through the water. The US Environmental Protection Agency (EPA)[1] requires that the ultraviolet disinfection process results in target *Giardia* and *Cryptosporidium* inactivation in at least 95% of the treated water volume on a monthly basis, which is summarized in Table 8. The EPA performance reference is used in the absence of a Canadian standard. There was no loss of UV in 2022 and 99.88% of the water volume was treated to the above specifications.

Month	Percent of Monthly Volume ≥ 3-log *Giardia* and *Cryptosporidium* Inactivation (Minimum 95% Required)
January	99.88%
February	99.91%
March	99.89%
April	99.89%
May	99.85%
June	99.86%
July	99.88%
August	99.87%
September	99.91%
October	99.87%
November	99.83%
December	99.90%

Table 8: Percent of Volume Meeting Ultraviolet Dosage Requirements at CWTP

[1] Ultraviolet Disinfection Guidance Manual for the Final Long Term2 Enhanced Surface Water Treatment Rule, November 2006, Sec. 1.4.4.

2.2.3. Chlorination

Chlorination is used for disinfection at the source as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and member jurisdiction distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite solution. The chlorination system was fully operational 100% of the time in 2022.

2.3. Secondary Disinfection

There are 8 secondary disinfection stations operated by Metro Vancouver. The purpose of these stations is to increase the chlorine residual in the GVWD transmission and member jurisdiction distribution systems to meet a target residual based on a number of factors, including source water turbidity, the amount of bacterial regrowth detected in member jurisdiction distribution system samples and the chlorine demand in the water. The rate of chlorine decay is lower in the areas receiving filtered water from the SCFP and consequently, lower chlorine dosage levels are required to maintain desired chlorine residual levels. The target chlorine dose leaving the secondary facilities receiving SCFP water is 0.8 mg/L. These facilities frequently have an incoming chlorine residual high enough that boosting is not required. The target chlorine dose leaving the secondary facilities receiving CWTP water ranges from 1.20 to 1.50 mg/L.

Table 9 summarizes the performance of the secondary disinfection facilities in 2022.

Facility	Branch Main	Average Free Chlorine (mg/L)	Range of Free Chlorine (mg/L)	Source Water
Clayton	Whalley/Clayton	1.19	0.89-1.51	Supplied by CWTP water.
	Jericho/Clayton	1.20	0.98-1.50	
Chilco	Capilano No. 4 and No.5	0.74	0.56-0.83	Supplied by SCFP water.
Pitt River	Haney Main No.2	1.20	1.19-1.24	Supplied by CWTP water.
	Haney Main No.3	1.17	1.01-1.51	
Newton	Surrey Hickleton Main	1.08	0.51-1.39	Primarily supplied by SCFP water. Occasionally supplied by CWTP water, depending on flow demands.
Kersland	Capilano No. 4 and No.5	0.86	0.67-1.02	Supplied by SCFP water.
Central Park	South Burnaby Main No.1	0.77	0.53-0.98	Primarily supplied by SCFP water. Occasionally supplied by CWTP water, depending on flow demands.
	South Burnaby Main No.2	0.87	0.63-1.37	
Cape Horn	Coquitlam Main No.2	1.20	0.99-1.52	Supplied by CWTP water.
	Coquitlam Main No.3	1.21	0.97-1.53	
Vancouver Heights	Boundary Road Main No. 5	0.85	0.71-1.02	Supplied by SCFP water.

Table 9: Performance of Secondary Disinfection Facilities

2.4. Corrosion Control

Metro Vancouver's corrosion control program began in the 1990s, and involves several steps to reduce pipe corrosion. As part of the current *Corrosion Control Program: Copper Pipes Protection* initiative, further changes in pH and alkalinity were made in June 2021 to help reduce pipe corrosion through the addition of natural minerals. The GCDWQ established.

The untreated water from all three sources had a pH lower than the limit of the GCDWQ of pH 7.0.

In the SCFP process, filtered water is dosed with hydrated lime (calcium hydroxide) to raise its pH and alkalinity before it enters the Clearwells. To achieve the desired alkalinity, the resultant pH is trimmed using CO_2 to bring it down to target levels.

At the Coquitlam source, the commissioning of the CO_2 system at the CWTP began in 2019, and was fully operational in 2021. The CO_2 system with the addition of soda ash (sodium carbonate) allows the GVWD to meet new target pH and alkalinity values across the entire system. Similar to the SCFP, the CO_2 system is used to trim the resultant pH to desired target levels.

The average pH of the treated water leaving SCFP and CWTP was 8.6 and 8.4, respectively, during 2022.

Performance of the corrosion control facilities is summarized in Table 10.

Facility	Performance	Discussion
SCFP Corrosion Control	pH ranged from 7.3 – 9.2	The annual average pH was 8.6 and was continually monitored with online instrumentation.
CWTP Corrosion Control	pH ranged from 6.7 – 10.1	The annual average pH was 8.4. The pH was <7.0, the recommended lower limit of the GCDWQ, on January 1 for a total of 3 hours and August 2 for 2.5 hours, both times due to soda ash equipment fault. The pH never exceeded the recommended limit of 10.5 under the GCDWQ.

Table 10: Performance of Corrosion Control Facilities

The chemical and physical characteristics of the GVWD treated water are summarized in Appendix B of this report and detailed analytical results are provided in Volume 2.

3.0 TRANSMISSION/DISTRIBUTION SYSTEM WATER QUALITY

Schedule A of the *BC Drinking Water Protection Regulation* (BCDWPR) contains standards for the bacteriological quality of potable water in the Province. There are three components of this standard that apply to large utilities such as GVWD and its member jurisdictions. These are:

Part 1: No sample should be positive for *E. coli*.

Part 2: Not more than 10% of the samples in a 30-day period should be positive for total coliform bacteria when more than 1 sample is collected.

Part 3: No sample should contain more than 10 total coliform bacteria per 100 mL.

The BCDWPR does not contain any water standards other than the three limits for *E. coli* and total coliform bacteria. Information on the significance of the detection of these organisms can be found in the GCDWQ – Supporting Documents, specifically:

"E. coli is a member of the total coliform group of bacteria and is the only member that is found exclusively in the faeces of humans and other animals. Its presence in water indicates not only recent faecal contamination of the water but also the possible presence of intestinal disease-causing bacteria, viruses and protozoa."

"The presence of total coliform bacteria in water in the distribution system (but not in water leaving the treatment plant) indicates that the distribution system may be vulnerable to contamination or may simply be experiencing bacterial regrowth."

To summarize, the detection of an *E. coli* bacteria in a sample of treated water is an indication of a potentially serious risk. The detection of total coliform bacteria may indicate intrusion into the system, or it may indicate that these bacteria are growing in the system itself (regrowth).

The number of *E. coli* detected in both GVWD and member jurisdiction drinking water samples is typically very low. Out of more than 28,700 samples collected from GVWD and member jurisdiction systems analyzed in 2022, one sample was positive for *E. coli*. The detection of a positive *E. coli* sample triggers a protocol which involves immediate notification to health and member jurisdiction officials, re-sampling, and a thorough investigation into the possible causes. Three repeat samples were taken and no additional *E. coli* were found.

In the GVWD transmission system, only 12 out of the approximately 7,400 samples collected, tested positive for total coliforms. Only 20 of the approximately 21,300 samples collected from the member jurisdiction distribution systems tested positive for total coliforms in 2022. The majority of the coliforms (70%) in the member jurisdiction (and 67% in GVWD) systems appeared in the warmer water months of June through October.

The most likely source of these organisms is attributed to bacterial regrowth. It should be emphasized that 99.9% of the samples in 2022 had no coliforms present, which is a good indicator of effective water treatment and good transmission and distribution system water quality.

3.1. Microbiological Water Quality in the GVWD System

3.1.1. GVWD Water Mains

Water quality in GVWD water mains is monitored from the point leaving the source and throughout the transmission system. In 2022, there were approximately 4,000 samples collected and tested for the presence of indicator bacteria. The percentage of samples from the GVWD water mains that were positive for total coliform bacteria was very low, well below the 10% standard. Of the approximately 4,000 samples processed, 10 samples tested positive for total coliforms and no samples were positive for *E. coli* bacteria. The compliance of monitoring results from GVWD water mains with BCDWPR criteria is shown in Figure 6.

There were another 436 samples collected from stations where only chlorine residuals are measured. In addition, there are inline stations collecting chlorine data every 10-minutes after chlorination at each source, but these samples are not included in the calculations for compliance monitoring.

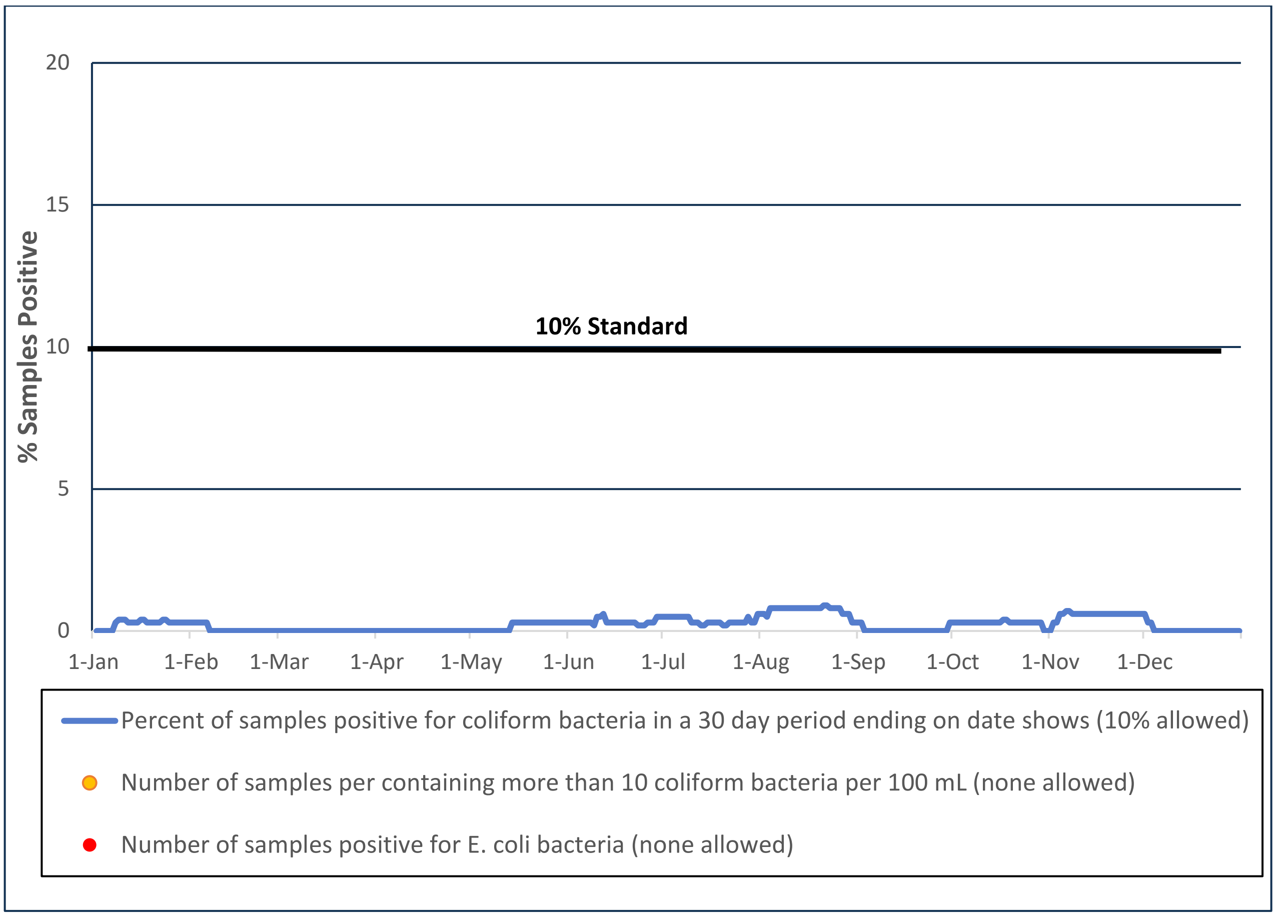


Figure 6: Bacteriological Quality of Water in GVWD Water Mains

3.1.2. GVWD In-System Reservoirs

In 2022, over 2,000 samples were collected from reservoirs that are located throughout the GVWD water system. Only 1 sample was positive for total coliforms. No sample from a reservoir was positive for *E. coli*.

The compliance of 2022 monitoring results from GVWD reservoirs with the criteria in the BCDWPR is shown in Figure 7.

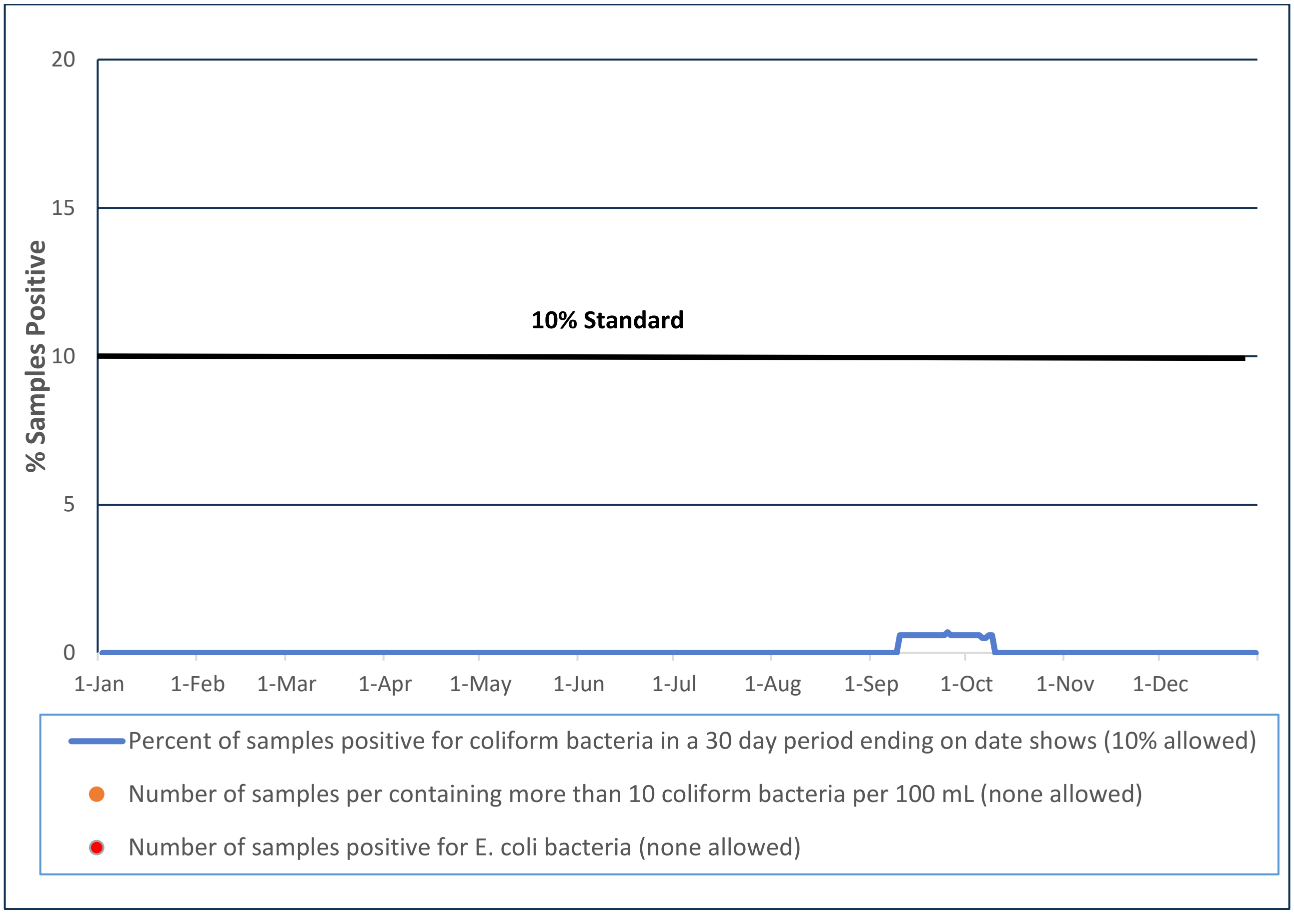


Figure 7: Bacteriological Quality of Water in GVWD In-System Reservoirs

Reservoir water quality is optimized by the use of secondary disinfection coupled with an active reservoir exercising program that includes a minimum of weekly monitoring of chlorine residuals and bacteriology results, which can result in changes to filling levels, if necessary.

Table 11 provides an overview of the status of the GVWD reservoirs from 2019 to 2022. During certain times of the year, it is not possible to cycle reservoirs as often as desired due to operational constraints. Despite these constraints, water quality as determined by coliform bacteria was satisfactory in all reservoirs.

Reservoir (Capacity in Million Litres)					Discussion
	2019	2020	2021	2022	
Burnaby Mountain Reservoir (13.2)	0.53	0.57	0.53	0.49	No operational issues
Burnaby Tank (2.3)	0.58	0.60	0.57	0.56	No operational issues
Cape Horn Reservoir (40.0)	0.61	0.78	0.71	0.78	No operational issues
Central Park Reservoir (35.0)	0.51	0.66	0.54	0.56	No operational issues
Clayton Reservoir (21.6)	1.02	1.08	1.1	1.05	To maintain water quality due to seasonal low demand, the cells of this reservoir are periodically removed from service. Cell 1 was in service Jan 1 - Nov 15 Cell 2 was in service March 16 - Dec 31
Glenmore Tanks (1.0)	0.68	0.77	0.73	0.67	No operational issues
Grandview Reservoir (13.5)	0.73	0.80	0.85	0.84	No operational issues
Greenwood Reservoir (8.8)	0.68	0.75	0.70	0.68	No operational issues
Hellings Tank (4.3)	0.48	0.54	0.56	0.52	No operational issues
Jericho Reservoir (20.0)	-	-	1.10	0.92	Cell 1 in service for entire year . Cell 2 not yet commissioned. Construction delays in 2022, anticipate completion in 2023.
Kennedy Reservoir (16.3)	0.52	0.58	0.65	0.60	No operational issues
Kersland Reservoir (73.7)	0.55	0.66	0.65	0.61	Following the completion of upgrades that were begun in Oct 2021, Cell No.1 was disinfected and returned to service in May. No operational issues with other cell.
Little Mountain Reservoir (171.0)	0.67	0.72	0.69	0.66	No operational issues
Maple Ridge Reservoir (20.0)	0.52	0.44	0.46	0.43	Reservoir was cleaned by divers in December.
Newton Reservoir (32.0)	0.46	0.55	0.44	0.64	Cell 2 was out of service beginning in March for inspection and preparatory work, it was then disinfected and returned to service on April 27. In October, the cell was once again removed from service for work on a new outlet structure. Work continued in 2023. During the fall outage, cell 1 operated at a lower level for worker safety in cell 2.
Pebble Hill Reservoir (42.2)	0.60	0.66	0.54	0.61	Cells 1 and 2 are being seismically upgraded. Work on Cell 1 that began in Fall 2021 continued in the spring until the cell was needed to meet the seasonal demands; after demand dropped, both Cells 1 & 2 were isolated and drained. Cell 1 was out of service Jan 1 - May 19. Oct 16 - Dec 31. Cell 2 was out of service Oct 16 - Dec 31.
Prospect Reservoir (4.4)	0.66	0.76	0.73	0.69	No operational issues
Sasamat Reservoir (26.0)	0.54	0.65	0.62	0.61	No operational issues

Reservoir (Capacity in Million Litres)	2019	2020	2021	2022	Discussion
Sunnyside Reservoir (22.7)	0.47	0.73	0.85	0.78	No operational issues
Vancouver Heights Reservoir (43.0)	0.75	0.82	0.78	0.71	No operational issues
Westburnco Reservoir (73.0)	0.58	0.64	0.60	0.65	No operational issues
Whalley Reservoir (33.4)	0.59	0.73	0.71	0.65	The reservoir was cleaned, disinfected and returned to service in April.

Table 11: Status of GVWD Reservoirs (2019-2022)

3.2. Microbiological Water Quality in Member Jurisdiction Systems

For samples collected from member jurisdiction systems, the percent positive per month for total coliform bacteria from 2019-2022 is shown in Figure 8.

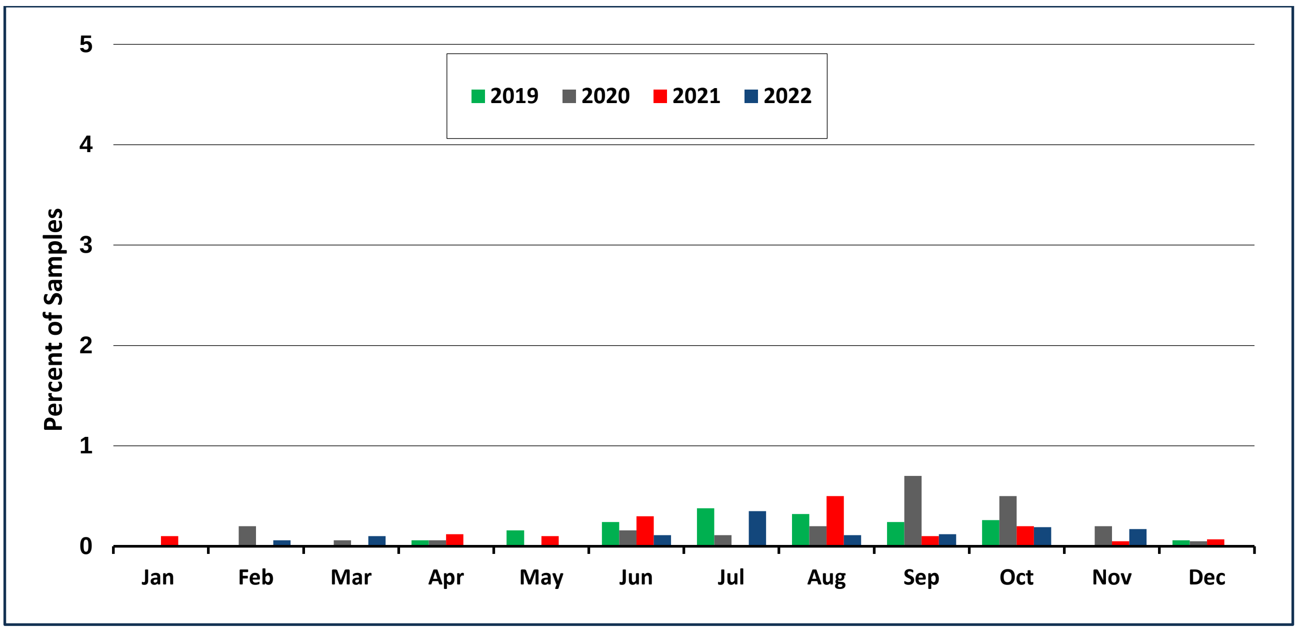


Figure 8: Percent of Samples per Month Positive for Total Coliform Bacteria (2019 to 2022)

The percentage of samples positive for total coliform bacteria in 2022 remained relatively similar as compared to 2021.

For Part 1 of the BCDWPR, no sample should be positive for *E. coli*. A single sample in July from member jurisdiction systems was positive *E. coli.* All subsequent samples taken over the following 3 days were negative.

For Part 3 no sample should contain more than 10 total coliform bacteria per 100 mL. For samples from member jurisdiction systems, this requirement was met in 2022 with the following exceptions:

- One sample in April contained more than 10 total coliform bacteria.

One sample in July contained more than 10 total coliform bacteria.

Table 12 shows the compliance with the bacteriological standards (3 parts) in the BCDWPR for samples taken within the distribution systems of the 21 member jurisdictions that are supplied with GVWD water.

Month	Number that met Part 1	Number that met Part 2	Number that met Part 3	Number that met all requirements
January	21	21	21	21
February	21	21	21	21
March	21	21	21	21
April	21	21	20	20
May	21	21	21	21
June	21	21	21	21
July	20	21	20	20
August	21	21	21	21
September	21	21	21	21
October	21	21	21	21
November	21	21	21	21
December	21	21	21	21

Table 12: Member Jurisdiction Water Quality Compared to the Provincial Bacteriological Standards

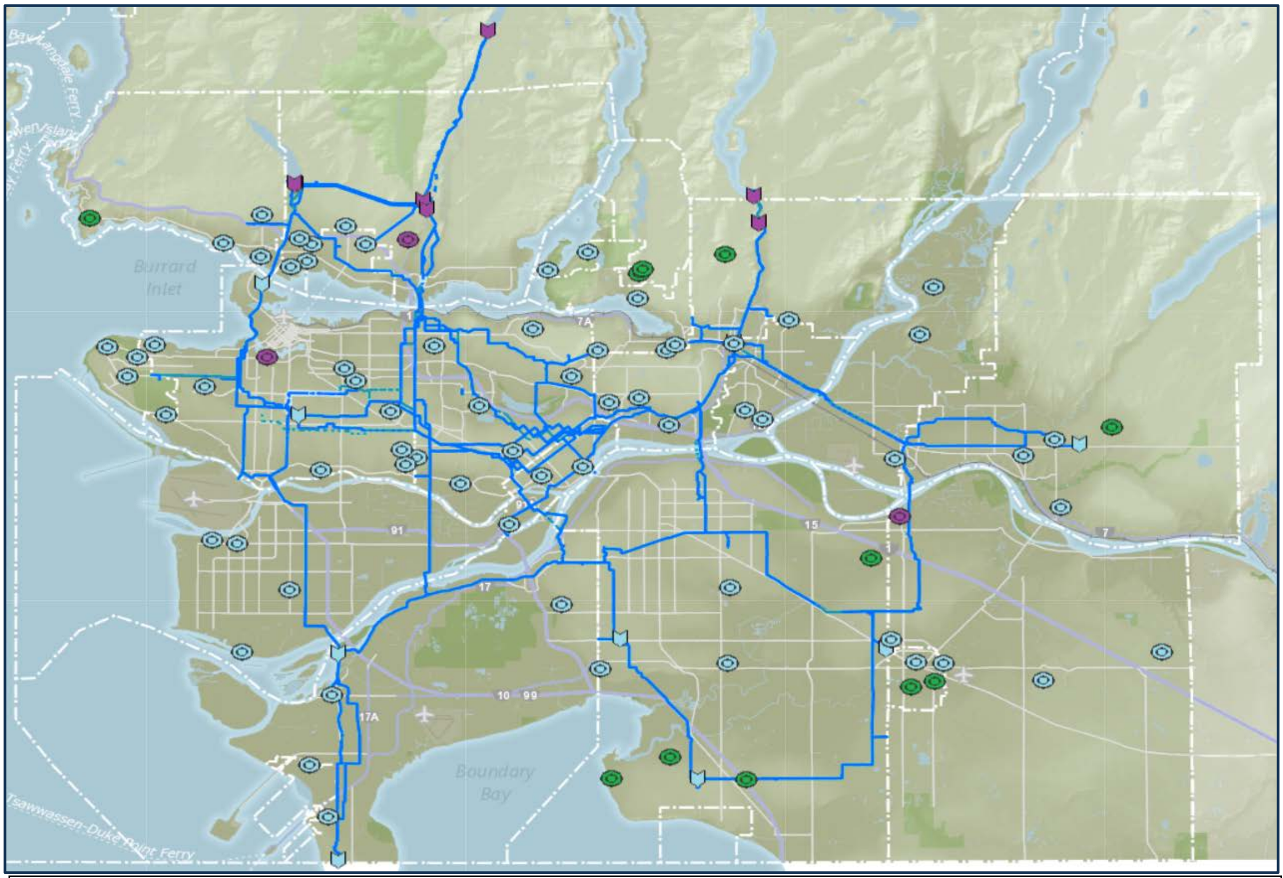
3.3. Disinfection By-Products in the Transmission/Distribution Systems

As the treated water moves through the GVWD Transmission system and into the member jurisdiction distribution system's infrastructure of water mains and reservoirs, changes in water quality occur. This is mainly due to the reaction between the chlorine in the water (added during primary and secondary disinfection) with naturally occurring organic matter in the water.

One of the most significant changes is the production of chlorinated DBPs. DBPs is a term used to describe a group of organic and inorganic compounds formed during water disinfection.

Reactions between dissolved natural organic matter and chlorine can lead to the formation of a variety of halogenated DBPs. There are two major groups of chlorinated DBPs: Total Trihalomethanes (TTHMs) and Total Haloacetic Acids (THAA). Factors that affect DBP formation include: amount of chlorine added to water, reaction time, concentration and characteristics of dissolved organic materials (precursors), water temperature, and water pH. In general, DBPs continue to form as long as chlorine and reactive DBP precursors are present in the water.

The Maximum Acceptable Concentration (MAC) in the GCDWQ for TTHMs is a locational yearly running average of 100 µg/L (0.1 mg/L) based on quarterly samples. A comparison of TTHM levels in the GVWD and member jurisdiction systems in 2022 is shown in Figure 9. All THM results from GVWD water mains and member jurisdiction systems were below the MAC of 100 µg/L.



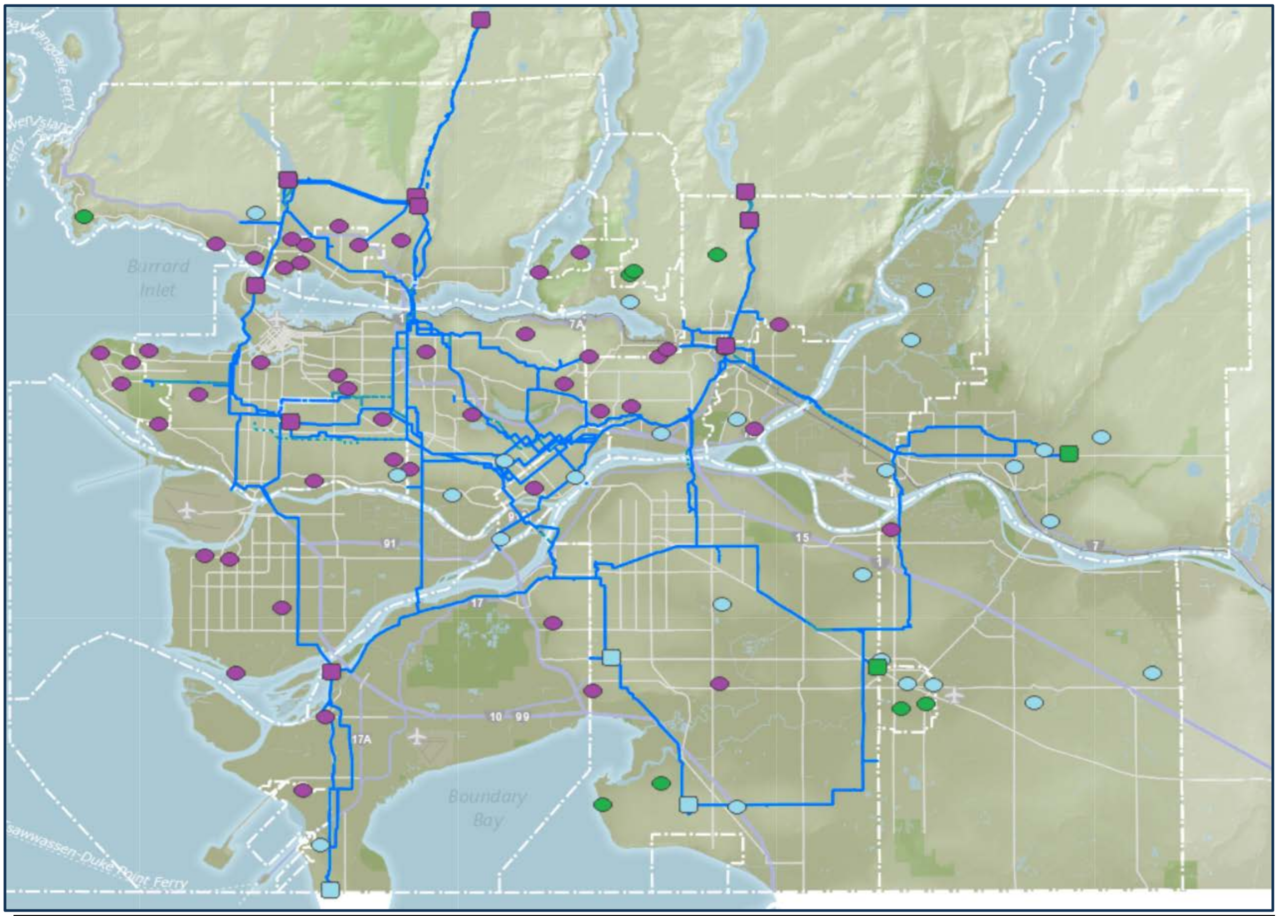
2022 Average GVWD TTHM = 23 µg/L
2022 Average Member Jurisdictions TTHM = 30 µg/L

Total Trihalomethane Levels - GVWD	Total Trihalomethane Levels - Member Jurisdiction
>= 0 AND < 20	>= 0 AND < 20
>= 20 AND < 40	>= 20 AND < 40
>= 40 AND < 60	>= 40 AND < 60
>= 60 AND < 80	>= 60 AND < 80
>= 80 AND < 100	>= 80 AND < 100
>= 100	>= 100

MAC for Total Trihalomethane values is 100 µg/L

Figure 9: Average Total Trihalomethane Levels

The other group of disinfection by-products of interest is the Total Haloacetic Acid (THAA) group. Comparison of THAA in the GVWD and member jurisdiction systems in 2022 is shown in Figure 10. In 2022, all HAA results from GVWD water mains and member jurisdiction systems were below the MAC of 80 µg/L.



2022 Average GVWD THAA = 19 µg/L
2022 Average Member Jurisdictions THAA = 23 µg/L

Total Haloacetic Acid Levels - GVWD	Total Haloacetic Acid Levels - Member Jurisdiction
>= 0 AND < 20	>= 0 AND < 20
>= 20 AND < 40	>= 20 AND < 40
>= 40 AND < 60	>= 40 AND < 60
>= 60 AND < 80	>= 60 AND < 80
>= 80 AND < 100	>= 80 AND < 100
>= 100	>= 100

MAC for Total Haloacetic Acid values is 80 µg/L

Figure 10: Average Total Haloacetic Acid Levels

4.0 QUALITY CONTROL/QUALITY ASSURANCE

Since 1994, the Metro Vancouver Microbiology Laboratory has participated in the BC Centre for Disease Control Public Health Laboratory Enhanced Water Quality Assurance Program and has been approved by the Provincial Medical Health Officer to perform microbiological analysis of drinking water as required in the BCDWPR. An ongoing requirement of this approval is successful participation in the provincial Clinical Microbiology Proficiency Testing Program, or its equivalent. Representatives of the Approval Committee for Bacteriology Laboratories carried out an inspection of the Metro Vancouver Microbiology Laboratory at the Lake City Operations Centre in September 2022 as part of the process leading up to approval of the laboratory by the Provincial Health Officer. The next inspection is planned for 2025.

In addition to the approval process discussed above, the Metro Vancouver Laboratories are accredited by the Canadian Association for Laboratory Accreditation (CALA) for the analysis of specific parameters to the ISO/IEC 17025 *General requirements for the competence of testing and calibrations laboratories* international standard.

Representatives from CALA have assessed the Metro Vancouver Laboratories bi-annually since 1995. The most recent on-site audit took place in September 2021, and the Metro Vancouver Laboratories have been granted accreditation until 2024. The next CALA assessment will take place in the fall of 2023. The Scope of Accreditation is available on the CALA website – www.cala.ca.

APPENDIX A — WATER SAMPLING FREQUENCY

This page has been intentionally left blank.

Water Type	Parameter	Frequency
Untreated, Source Water	Total coliform and *E. coli*	Daily
	HPC	Daily
	Turbidity	Daily
	Giardia and *Cryptosporidium*	Monthly at Capilano, and Coquitlam. Seymour began in July 2022.
	Ammonia, colour, iron, organic carbon, pH	Weekly
	Alkalinity, chloride, calcium, hardness, magnesium, manganese, nitrate, potassium, phosphate, sulphate	Monthly
	Aluminum, copper, sodium, total and suspended solids	Bi-monthly
	THMs, HAAs	Quarterly
	Antimony, arsenic, barium, boron, cadmium, cyanide, chromium, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
	Pesticides and herbicides	Annually
	PAHs, BTEX	Annually
	VOCs	Annually
	Radionuclides	Annually
Treated water	Total coliform and *E. coli*	Daily
	Turbidity	Daily
	Temperature	Daily
	pH	Daily
	Ammonia, colour, iron, organic carbon, aluminum at SCFP only	Weekly
	Aluminum, copper, sodium, total and suspended solids	Bi-Monthly
	THMs, HAAs	Quarterly at selected sites
	Antimony, arsenic, barium, boron, cadmium, cyanide, chromium, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
GVWD Water Mains	Total coliform and *E. coli*	Weekly per site
	HPC	Weekly per site
	Free chlorine	Weekly per site
	THMs, HAAs, pH	Quarterly at selected sites
	PAHs, BTEX	Semi-annually at selected sites
GVWD Reservoirs	Total coliform and *E. coli*	Weekly per site
	HPC	Weekly per site
	Free chlorine	Weekly per site
	Turbidity	Weekly per site
Member Jurisdiction Distribution Systems	Total coliform and *E. coli*	Weekly per site
	HPC	Weekly per site
	Free chlorine	Weekly per site
	Turbidity	Weekly per site
	THMs, HAAs, pH	Quarterly at selected sites

APPENDIX B — CHEMICAL AND PHYSICAL ANALYSIS SUMMARIES

This page has been intentionally left blank.

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Physical and Chemical Analysis of Water Supply

2022 – Capilano Water System

	Untreated[1]	Treated[1]		Canadian Guideline		
Parameter	**Average**	**Average**	**Range**	**Days Exceeded**	**Limit[2]**	**Reason Established**
Alkalinity as $CaCO_3$ (mg/L)	3.0	22	18-25	N/A	None	N/A
Aluminum Dissolved (µg/L)	59	26	20-35	N/A	None	N/A
Aluminum Total (µg/L)	126	29	18-51	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10 (ALARA)	Health
Barium Total (µg/L)	2.4	2.8	2.5-3.5	0	2,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10	N/A	None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	7	Health
Calcium Total (µg/L)	1,200	8,430	7,560-9,280	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.5	0.6	0.4-0.9	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.5	0.6	0.4-0.9	N/A	None	N/A
Chlorate (µg/L)	<10	25	16-41	0	1000	Health
Chloride (mg/L)	<0.5	2.3	2.1-2.9	0	≤ 250	Aesthetic
Chromium Total (µg/L)	<0.08	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	15	<3	<2-14	N/A	None	N/A
Colour - True (TCU)	10	<1	<1-1	0	≤ 15	Aesthetic
Conductivity (µmhos/cm)	10	49	43-54	N/A	None	N/A
Copper Total (µg/L)	1.4	<0.5	<0.5	0/0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins - Microcystin - LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1.1	10.4	9.5-12	0	80 (ALARA)	Health
Hardness as $CaCO_3$ (mg/L)	3.7	22.0	20.3-24.0	N/A	None	N/A
Iron Dissolved (µg/L)	51	<5	<5-9	N/A	None	N/A
Iron Total (µg/L)	154	<9	<5-64	0	≤ 300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5 (ALARA)	Health
Magnesium Total (µg/L)	176	208	181-256	N/A	None	N/A
Manganese Dissolved (µg/L)	7.4	2.8	0.9-5.0	N/A	None	N/A
Manganese Total (µg/L)	8.9	6.0	2.4-10.6	0/0	120/20	Health/Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.08	0.07	0.02-0.17	0	10	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	8.0	7.8-8.4	0	7.0-10.5	None
Phenol (mg/L)	<0.005	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	148	172	135-228	N/A	None	N/A
Residue Total (mg/L)	15	34	31-36	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	10	30	30-40	0	≤ 500	Aesthetic
Residue Total Fixed (mg/L)	9	27	25-30	N/A	None	N/A
Residue Total Volatile (mg/L)	6	7	5-9	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO_2 (mg/L)	3.2	3.3	2.8-3.6	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	591	1,570	1,380-1,820	0	≤ 200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	18	16-20	0	100	Health
Turbidity (NTU)	1.3	0.15	0.07-1.2	N/A	None[3]	N/A
Uranium Total (µg/L)	0.0302	N/A	N/A	0	50	Health
UV Absorbance 254 nm (Abs/cm)	0.062	0.010	0.008-0.013	N/A	None	N/A
Zinc Total (µg/L)	<3	<3	<3-5	0	≤ 5,000	Aesthetic

[1]*Untreated water is sampled from the source intake. Treated water is sampled prior to entering the Capilano transmission system.*

[2]*Limits are taken from the Guidelines for Canadian Drinking Water Quality summary table (September 2022).*

[3]*GCDWQ recommends that water entering the distribution system have turbidity levels of 1.0 NTU or less.*

Physical and Chemical Analysis of Water Supply

2022 – Seymour Water System

Parameter	Untreated[1] Average	Treated[1] Average	Treated[1] Range	Canadian Guideline Days Exceeded	Canadian Guideline Limit[2]	Canadian Guideline Reason Established
Alkalinity as $CaCO_3$ (mg/L)	3.6	22	18-24	N/A	None	N/A
Aluminum Dissolved (µg/L)	48	25	19-34	N/A	None	N/A
Aluminum Total (µg/L)	87	30	18-55	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10 (ALARA)	Health
Barium Total (µg/L)	2.9	2.8	2.5-3.5	0	1,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10	N/A	None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	1,620	8,450	7,520-9,240	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.3	0.6	0.5-1.0	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.4	0.6	0.4-1.0	N/A	None	N/A
Chlorate (µg/L)	<10	23	13-40	0	1000	Health
Chloride (mg/L)	<0.5	2.3	2.1-2.9	0	≤250	Aesthetic
Chromium Total (µg/L)	<0.06	<0.06	<0.05-0.07	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	14	<2	<2-6	N/A	None	N/A
Colour - True (TCU)	9	<1	<1-1	0	≤15	Aesthetic
Conductivity (µmhos/cm)	12	49	43-53	N/A	None	N/A
Copper Total (µg/L)	22.3	<2	<0.5-5.5	0/0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins - Microcystin - LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1.1	11.7	7.8-19	0	80 (ALARA)	Health
Hardness as $CaCO_3$ (mg/L)	4.7	21.9	19.5-23.9	N/A	None	N/A
Iron Dissolved (µg/L)	74	<5	<5-7	N/A	None	N/A
Iron Total (µg/L)	168	<9	<5-22	0	≤300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5 (ALARA)	Health
Magnesium Total (µg/L)	153	210	180-266	N/A	None	N/A
Manganese Dissolved (µg/L)	5.6	3.5	1.1-6.1	N/A	None	N/A
Manganese Total (µg/L)	8.8	6.5	2.7-12.8	0	≤50	Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.06	0.07	0.02-0.17	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	8.0	7.7-8.3	0	7.0-10.5	None
Phenol (mg/L)	<0.005	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	156	170	137-226	N/A	None	N/A
Residue Total (mg/L)	16	34	31-36	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	10	30	30-40	0	≤500	Aesthetic
Residue Total Fixed (mg/L)	9	27	25-30	N/A	None	N/A
Residue Total Volatile (mg/L)	6	7	5-8	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO_2 (mg/L)	3.2	3.3	2.8-3.6	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	558	1,550	1,390-1,810	0	≤200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	16	16-17	0	100	Health
Turbidity (NTU)	0.58	0.15	0.07-0.28	N/A	None[3]	N/A
Uranium Total (µg/L)	0.0198	N/A	N/A	0	50	Health
UV Absorbance 254 nm (Abs/cm)	0.058	0.010	0.008-0.015	N/A	None	N/A
Zinc Total (µg/L)	<5	<3	<3-3	0	≤5,000	Aesthetic

[1]Untreated water is sampled prior to the SCFP. Treated water is sampled prior to entering the Seymour transmission system.

[2]Limits are taken from the Guidelines for Canadian Drinking Water Quality summary table (September 2022).

[3]GCDWQ recommends that water entering the distribution system have turbidity levels of 1.0 NTU or less.

Physical and Chemical Analysis of Water Supply

2022 – Coquitlam Water System

	Untreated[1]	Treated[1]		Canadian Guideline		
Parameter	**Average**	**Average**	**Range**	**Days Exceeded**	**Limit[2]**	**Reason Established**
Alkalinity as $CaCO_3$ (mg/L)	1.9	21	20-26	N/A	**None**	N/A
Aluminum Dissolved (µg/L)	59	68	51-85	N/A	None	N/A
Aluminum Total (µg/L)	81	83	61-106	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10[1]	Health
Barium Total (µg/L)	2.6	2.4	1.7-3.6	0	1,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10		None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	807	911	706-2,300	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.5	1.4	1.1-2.0	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.6	1.4	1.2-2.1	N/A	None	N/A
Chlorate (µg/L)	<10	52	32-85	0	1,000	Health
Chloride (mg/L)	<0.5	2.1	1.9-2.3	0	≤250	Aesthetic
Chromium Total (µg/L)	<0.06	<0.05	<0.05-0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	12	<3	<2-8	N/A	None	N/A
Colour - True (TCU)	9	<1	<1-6	0	≤15	Aesthetic
Conductivity (µmhos/cm)	8	45	40-53	N/A	None	N/A
Copper Total (µg/L)	4.4	<0.5	<0.5	0/0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins - Microcystin - LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1.1	7.4	4.2-12	0	80[1]	Health
Hardness as $CaCO_3$ (mg/L)	2.4	2.7	2.1-6.2	N/A	None	N/A
Iron Dissolved (µg/L)	18	19	12-35	N/A	None	N/A
Iron Total (µg/L)	48	49	25-76	0	≤300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5[1]	Health
Magnesium Total (µg/L)	93	94	77-110	N/A	None	N/A
Manganese Dissolved (µg/L)	3.9	2.7	1.6-3.7	N/A	None	N/A
Manganese Total (µg/L)	4.4	3.6	2.0-4.8	0	≤50	Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.07	0.08	0.04-0.11	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.3	8.2	7.6-8.9	0		None
Phenol (mg/L)	<0.005	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	147	144	102-234	N/A	None	N/A
Residue Total (mg/L)	12	35	33-37	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	9	30	30	0	≤500	Aesthetic
Residue Total Fixed (mg/L)	6	23	20-24	N/A	None	N/A
Residue Total Volatile (mg/L)	6	12	9-14	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO_2 (mg/L)	2.4	2.4	2.2-2.5	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	448	10,300	9,000-11,100	0	≤200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	8	6-12	0	100	Health
Turbidity (NTU)	<0.4	0.36	0.13-4.5	N/A	None[3]	N/A
Uranium Total (µg/L)	0.0491	N/A	N/A	0	50	Health
UV 254 - Apparent (Abs/cm)	0.065	0.023	0.016-0.057	N/A	None	N/A
UV Absorbance 254 nm (Abs/cm)	0.059	0.020	0.013-0.050	N/A	None	N/A
Zinc Total (µg/L)	<3	<3	<3-5	0	≤5,000	Aesthetic

[1]Untreated water is sampled from the source intake. Treated water is sampled prior to entering the Coquitlam transmission system.

[2]Limits are taken from the Guidelines for Canadian Drinking Water Quality summary table (September 2022).

[3]GCDWQ recommends that water entering the distribution system have turbidity levels of 1.0 NTU or less.

APPENDIX C — ANALYSIS OF WATER FOR ORGANIC COMPONENTS AND RADIONUCLIDES

This page has been intentionally left blank.

Analysis of Source Waters for Herbicides, Pesticides, and other Organic Compounds

Parameter	Capilano (µg/L)	Seymour (µg/L)	Coquitlam (µg/L)	MAC (µg/L)	AO (µg/L)
	Jul 26	Jul 26	Jul 26		
Herbicides					
2,4-D	<1.0	<1.0	<1.0	100	None
Bromoxynil	<0.50	<0.50	<0.50	30	None
Dicamba	<1.0	<1.0	<1.0	110	None
Diclofop-methyl	<0.90	<0.90	<0.90	None	None
Diquat	<7.0	<7.0	<7.0	50	None
Diuron	<10	<10	<10	None	None
Glyphosate	<10	<10	<10	280	None
MCPA	<10	<10	<10	350	None
Metribuzin (Sencor)	<5.0	<5.0	<5.0	80	None
Paraquat	<1.0	<1.0	<1.0	None	None
Picloram	<5.0	<5.0	<5.0	None	None
Pesticides					
Atrazine	<0.50	<0.50	<0.50	5	None
Carbaryl	<5.0	<5.0	<5.0	None	None
Carbofuran	<5.0	<5.0	<5.0	None	None
Chlorpyrifos (Dursban)	<1.0	<1.0	<1.0	90	None
Diazinon	<1.0	<1.0	<1.0	None	None
Dimethoate	<2.5	<2.5	<2.5	20	None
Guthion (Azinphos-methyl)	<2.0	<2.0	<2.0	None	None
Malathion	<5.0	<5.0	<5.0	190	None
Metolachlor	<0.50	<0.50	<0.50	None	None
Phorate (Thimet)	<0.50	<0.50	<0.50	None	None
Simazine	<1.0	<1.0	<1.0	None	None
Terbufos	<0.50	<0.50	<0.50	None	None
Trifluralin	<1.0	<1.0	<1.0	None	None
Other Organic Compounds					
Phenolics					
2,3,4,6-tetrachlorophenol	<0.50	<0.50	<0.50	None	None
2,4,6-trichlorophenol	<0.50	<0.50	<0.50	5	≤2
2,4-dichlorophenol	<0.25	<0.25	<0.25	None	None
Pentachlorophenol	<0.50	<0.50	<0.50	60	≤30

Analysis of Source Waters for Herbicides, Pesticides, and other Organic Compounds Con't.

Parameter	Capilano (µg/L)	Seymour (µg/L)	Coquitlam (µg/L)	MAC (µg/L)	AO (µg/L)
	Jul 26	Jul 26	Jul 26		
Volatile Organics					
1,1-dichloroethene	<0.50	<0.50	<0.50	14	None
1,2-dichlorobenzene	<0.50	<0.50	<0.50	None	None
1,2-dichloroethane	<0.50	<0.50	<0.50	5	None
1,4-dichlorobenzene	<0.50	<0.50	<0.50	5	≤1
Benzene	<0.40	<0.40	<0.40	5	None
Carbon tetrachloride	<0.50	<0.50	<0.50	2	None
Chlorobenzene	<0.50	<0.50	<0.50	None	None
Dibromomethane	<0.90	<0.90	<0.90	None	None
Dichloromethane	<2.0	<2.0	<2.0	50	None
Ethylbenzene	<0.40	<0.40	<0.40	140	1.6
Methyl-tert-butylether (MTBE)	<4.0	<4.0	<4.0	None	≤15
Tetrachloroethene	<0.50	<0.50	<0.50	10	N/A
Toluene	<0.40	<0.40	<0.40	60	24
Trichloroethene	<0.50	<0.50	<0.50	5	None
Vinyl chloride	<0.50	<0.50	<0.50	2 (ALARA)	None
m & p-Xylene	<0.40	<0.40	<0.40	None	None
o-Xylene	<0.40	<0.40	<0.40	None	None
Xylenes (Total)	<0.40	<0.40	<0.40	90	20
Miscellaneous					
Nitrilotriacetic Acid : Nitrilotriacetic acid (NTA) (mg/L)	<0.050	<0.050	<0.050	0.4 mg/L	None
N-Nitrosodimethylamine (NDMA) (ng/L)	<2.2	<2.2	<2.1	40 ng/L	None

Monitoring of Selected GVWD Water Mains for BTEX

Parameter	Maple Ridge Main (µg/L)		Barnston Island Main at Willoughby Pump Station (µg/L)		Jericho Clayton Main (µg/L)		South Burnaby Main No. 2 (µg/L)		MAC (µg/L)	AO (µg/L)
	May 16	Dec 1	May 17	Dec 8	May 17	Dec 1	May 17	Nov 29		
Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5	None
Ethyl Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	140	1.6
Toluene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	60	24
m & p-Xylene	<1	<1	<1	<1	<1	<1	<1	<1	None	None
o-Xylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	None	None
Total Xylenes	<1	1	<1	1	<1	1	<1	1	90	20
Total BTEX	<1	2	1	1	<1	2	<1	1	None	None

Analysis of Source Water for PAHs

Parameter	Capilano (µg/L)			Seymour (µg/L)			Coquitlam (µg/L)		
	May 16	Jul 26	Nov 29	May 16	Jul 26	Nov 28	May 16	Jul 26	Dec 1
1-Methylnaphthalene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acenaphthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)pyrene[1]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(k)fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenz(a,h)anthracene	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Fluoranthene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fluorene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-cd)pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenanthrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Pyrene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Quinoline	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Total PAHs	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

[1]Benzo(a)pyrene is the only PAH compound that has a GCDWQ limit. Maximum Acceptable Concentration of Benzo(a)pyrene is 0.04 µg/L.

Analysis of Selected GVWD Mains for PAHs

Parameters	Coquitlam Main No. 2 (µg/L)		Westburnco Reservoir (µg/L)		Barnston Island Main (µg/L)		Annacis Main No. 4 (µg/L)		Whalley - Kennedy Link Main (µg/L)		Haney Main No. 2 (µg/L)		36 Ave. Main (µg/L)	
	May 16	Nov 30	May 17	Dec 1	May 17	Dec 1	May 16	Nov 29	May 17	Dec 6	May 16	Dec 1	May 17	Dec 2
1-Methylnaphthalene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acenaphthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benz[a]anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo[a]pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo[b+j]fluoranthene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo[g,h,i]perylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo[k]fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenz[a,h]anthracene	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Fluoranthene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fluorene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno[1,2,3-c,d]pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenanthrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Pyrene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Quinoline	<0.020	<0.020	<0.020	0.028	<0.020	<0.020	<0.020	<0.020	0.021	<0.020	0.023	<0.020	<0.020	<0.020
Total PAHs	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

[1]Benzo(a)pyrene is the only PAH compound that has a GCDWQ limit. Maximum Acceptable Concentration of Benzo(a)pyrene is 0.04 µg/L.

Analysis of Source Water for Radionuclides

Parameter	Capilano (Bq/L)	Seymour (Bq/L)	Coquitlam (Bq/L)	MAC (Bq/L)
	Jul 26	Jul 26	Jul 26	
Gross Alpha	<0.10	<0.10	<0.10	0.5
Gross Beta	<0.10	<0.10	<0.10	1
Cesium-134	<1	<1	<1	None
Cesium-137	<1	<1	<1	10
Iodine-131	<1	<1	<1	6
Lead-210	<0.10	<0.10	<0.10	0.2
Manganese-54	<1	<1	<1	None
Radium 226	<0.010	<0.010	<0.010	0.5
Radon-222	<10	<10	<10	None
Strontium-90	<0.10	<0.10	<0.10	7
Tritium	<20	<20	<20	7,000
Zinc-65	<1	<1	<1	None

APPENDIX D — METRO VANCOUVER DETECTION OF WATERBORNE *CRYPTOSPORIDIUM* AND *GIARDIA* JANUARY - DECEMBER 2022 ANNUAL REPORT

This page has been intentionally left blank

Metro Vancouver
Detection of Waterborne *Cryptosporidium* and *Giardia*

January - December, 2022
Annual Report

February 2023

Dr. Natalie Prystajecky, Program Head
Christine Tchao, Team Lead
Tracy Chan, Technical Coordinator
Angela Kong, Technical Coordinator
Jenny Jeong, Technical Coordinator

Environmental Microbiology
BCCDC Public Health Laboratory
Provincial Health Services Authority

Metro Vancouver
Detection of Waterborne *Cryptosporidium and Giardia*
January - December 2022 Annual Report

Purpose

To detect and quantify *Cryptosporidium* oocysts and *Giardia* cysts from Metro Vancouver reservoirs (Capilano, Coquitlam and Seymour), as well as from the Recycled Clarified Water (RCW) from Seymour-Capilano Filtration Plant (SCFP).

Introduction

Cryptosporidium and *Giardia* species are parasites that infect the intestinal tracts of a wide range of warm-blooded animals. In humans, infection with *Cryptosporidium* species or *Giardia lamblia* can cause gastroenteritis. Since *Cryptosporidium* oocysts and *Giardia* cysts are resistant to chlorination, they are of great concern for drinking water purveyors (1-3). On behalf of Metro Vancouver, the Environmental Microbiology Laboratory at BCCDC Public Health Laboratory (BCCDC PHL) examined the source water of Capilano, Coquitlam and Seymour reservoirs, as well as Recycled Clarified Water (RCW) at the Seymour-Capilano Filtration Plant (SCFP) for the presence of *Cryptosporidium* oocysts and *Giardia* cysts. All sample collection, testing, analysis and reporting occurred on a monthly basis using a validated method.

Methods

The Environmental Microbiology Laboratory at BCCDC PHL follows the United States Environmental Protection Agency (USEPA) Method 1623.1: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA (4) for the detection of oocysts and cysts in water. As stated by Method 1623.1, the performance is based on the method applicable for the quantification of *Cryptosporidium* and *Giardia* in aqueous matrices. It requires the filtration of a large volume of water and immunomagnetic separation (IMS) to concentrate and purify the oocysts and cysts from sample material captured. After the IMS purification, immunofluorescence microscopy was performed to identify and enumerate oocysts and cysts. 4’-6-diamidino-2-phenylindole staining (DAPI) and differential interference contrast microscopy (DIC) are used to confirm internal structures of the cysts and oocysts.

Raw water samples were collected by the Metro Vancouver at specific sampling sites at the reservoirs and filtration plants on the scheduled date each month. A desired volume of samples were filtered in the field using Pall Life Science Envirochek HV filters. After collection and filtration, the Envirochek HV filters were transported to the Environmental Microbiology Laboratory at BCCDC PHL, where they were processed and analysed within 96 hours. Positive and negative controls were included for the entire process to assess the performance of the method. Matrix spike testing was also performed at scheduled collection periods, annually for baseline assessment.

Results & Discussions

In 2022, 41 sample filters (excluding matrix spikes) were examined in total. These include:

- 12 Envirochek HV filters from Capilano reservoir
- 12 Envirochek HV filters from Coquitlam reservoir
- 12 Envirochek HV filters from SCFP-RCW
- 5 Envirocheck HV filters from Seymour reservoir

Table 1 and Figures 1-3 show the summary of all results. Detailed results per collection site can be found in Tables A1-A4 in Appendix A.

	Capilano Reservoir		Coquilam Reservoir		Seymour Capilano Filtration Plant – Recycled Clarified Water		Seymour Reservoir	
# of Filter Tested	12		12		12		5	
Average volume (L) Filtered per Month	48.3		49.6		279.9		39.2	
Average Detection Limit (oo)cysts per 100 L	<2.0		<2.0		0.66		2.69	
	Cryptosporidium	*Giardia*	*Cryptosporidium*	*Giardia*	*Cryptosporidium*	*Giardia*	*Cryptosporidium*	*Giardia*
# Positive Filters	0	2	0	1	0	0	0	0
% Positive Filters	0%	17%	0%	8%	0%	0%	0%	0%
Max Count (oo)cysts per 100 L	0	2	0	2	0	0	0	0

Table 1. Metro Vancouver Filter Result Summary in 2022

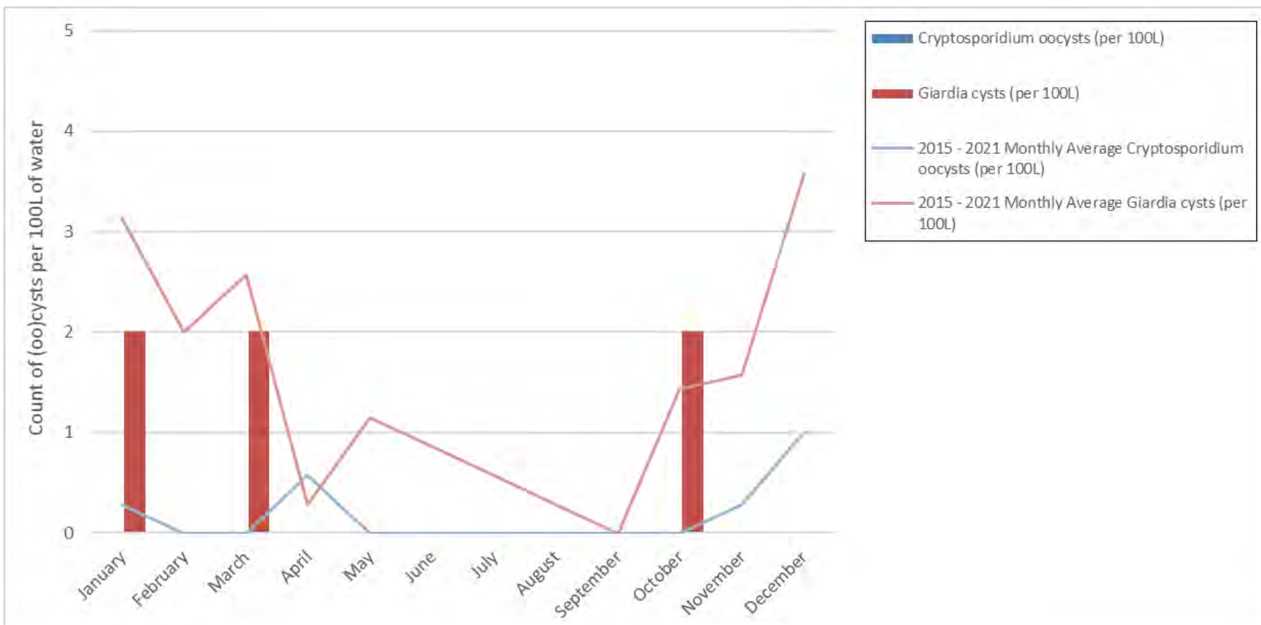


Figure 1. Capilano Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 202

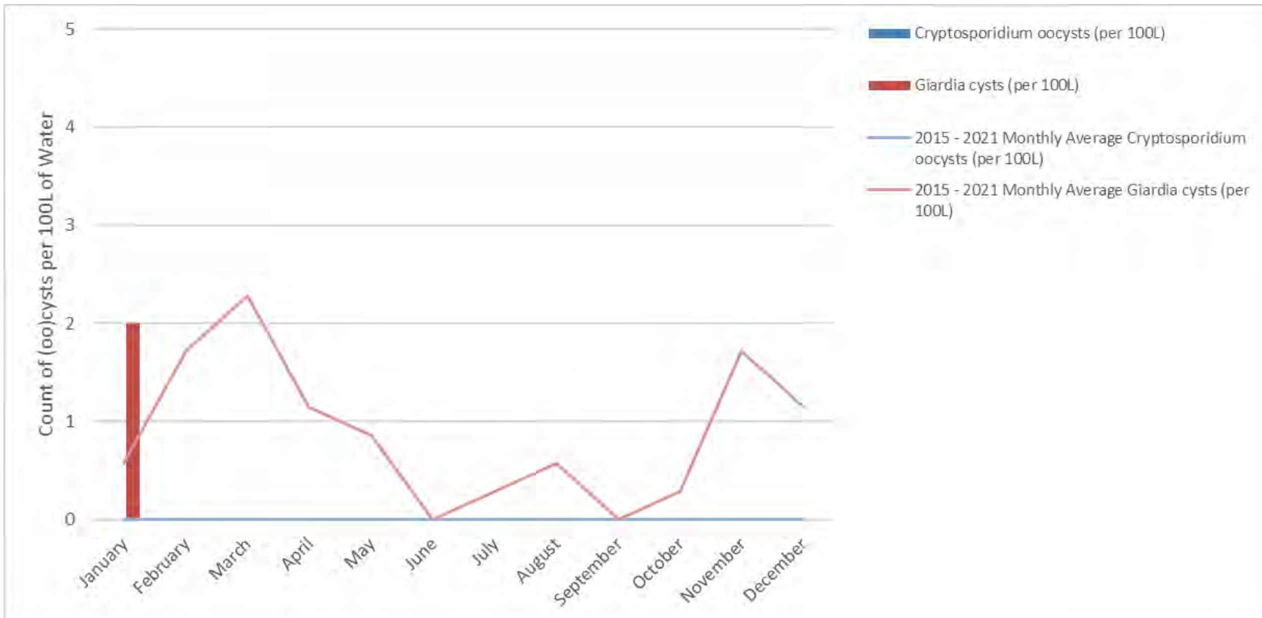


Figure 2: Coquitlam Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2022

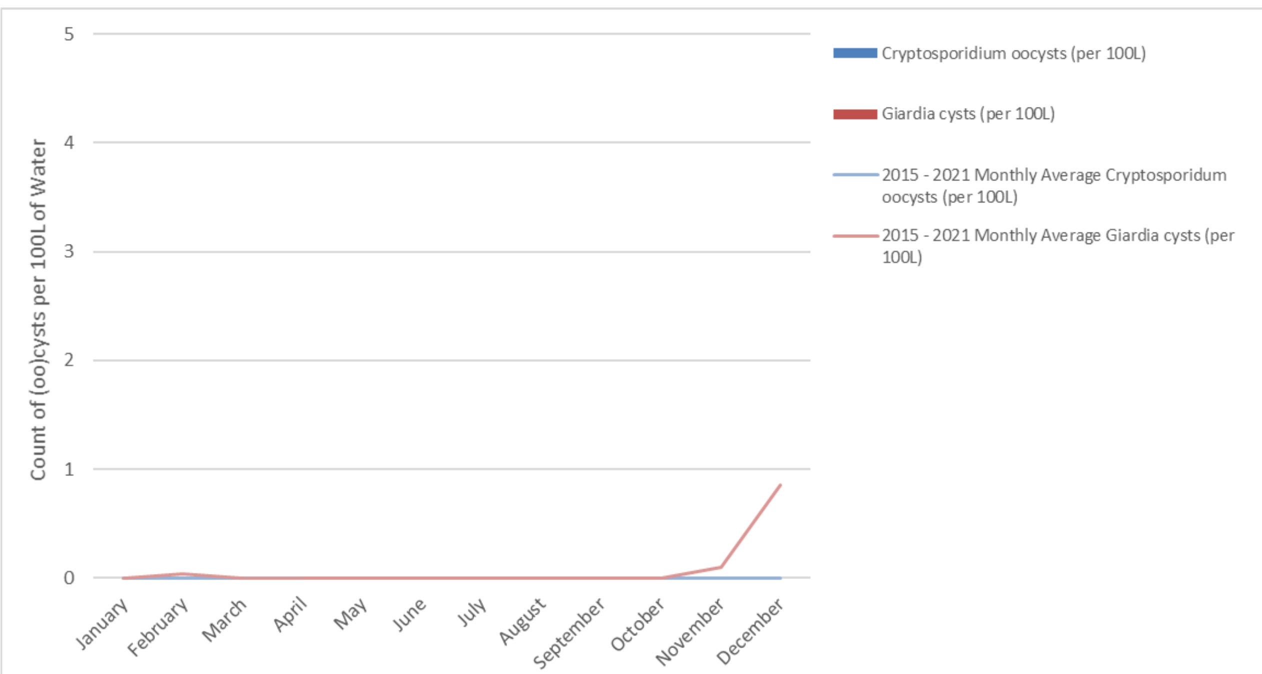


Figure 3: Seymour Capilano Filtration Plant - Recycled Clarified Water *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2022

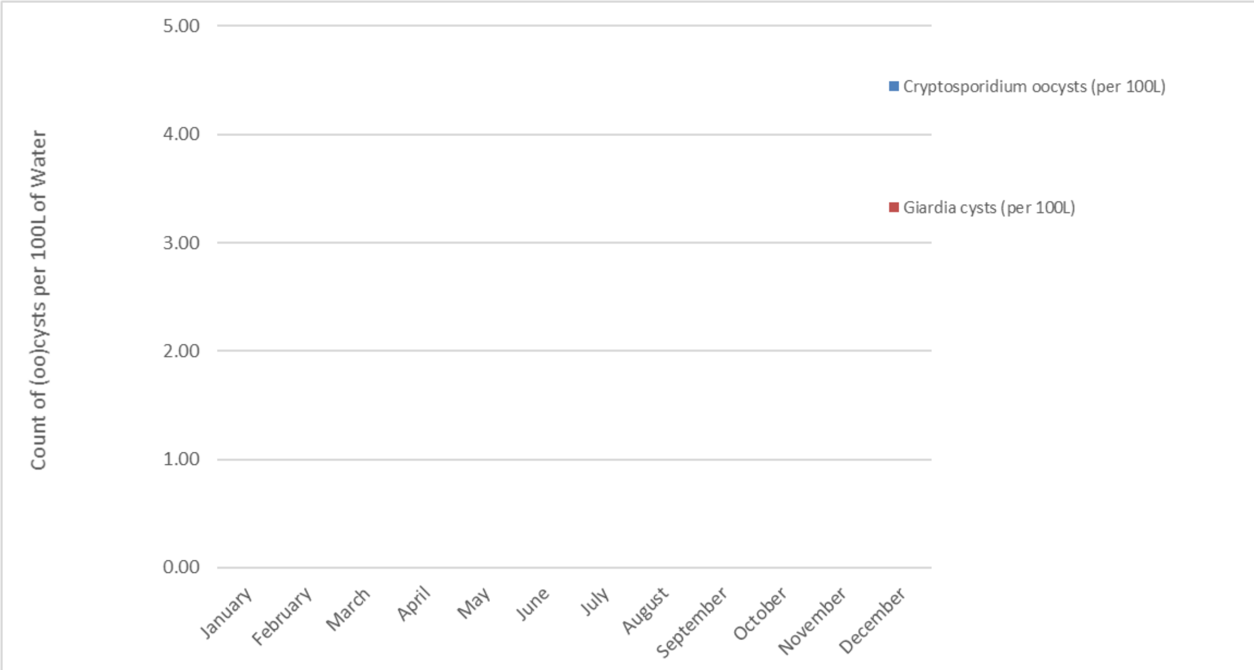


Figure 4: Seymour Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2022

Overall, similar trends were observed for both *Cryptosporidium* and *Giardia* in 2022, in comparison to historical data in 2015-2021. Testing for Seymour reservoir started in July 2022, therefore there is no historical data for comparison. There were no detections of *Cryptosporidium* or *Giardia* at this site in 2022.

DAPI staining is used as part of the confirmation of the internal structure of *Cryptosporidium* oocysts and *Giardia* cysts. DIC microscopy is used primarily for *Cryptosporidium* oocyst and *Giardia* cyst confirmation but it can also serve as an indicator of oocysts/cysts cytoplasm and cell wall integrity. While no median body (or axoneme) was observed for all *Giardia* cysts detected, the cytoplasm was observed indicating that the cysts were not empty and could be viable.

Summary of morphological results are listed in Tables 2 and 3. Detailed results for staining by IFA, DAPI and internal morphology, as determined through DIC microscopy, for every identified cyst and oocyst were recorded in Tables A5-A12 in Appendix A.

Site	Count of oocysts	DAPI -	DAPI +		DIC		
		Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, sporozoites
Capilano	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%	0.0%
Coquitlam	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%	0.0%
SCFP-RCW	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%	0.0%
Seymour	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%	0.0%

Table 2. 2022 Summary of morphological results for *Cryptosporidium* oocysts observed under fluorescence microscope

Site	Count of cysts	DAPI -	DAPI +		DIC				
		Light blue internal staining, no distinct	Intense blue internal staining	Nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Cysts with internal structure		
							Nuclei	Median Body	Axoneme
Capilano	2	1	1	0	0	2	0	0	0
		50.0%	50.0%		0.0%	100.0%		0.0%	0.0%
Coquitlam	1	0	0	3	0	0	1	0	0
		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%
SCFP-RCW	0	0	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%
Seymour	0	0	0	0	0	0	0	0	0
		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%

Table 3: 2022 Summary of morphological results for *Giardia* cysts observed under fluorescence microscope

DAPI staining is used as an indicator of nuclei integrity by staining the DNA. It can also approximate oocysts/cysts integrity; the absence of nuclei is indicative of an aged, damaged or non-infective cell. A number of oocysts and cysts observed across all sites had no visible nuclei indicating that they were aged and likely subjected to environmental degradation (Table 4). However, they were likely in previous infective state.

Number of Nuclei per (oo)cyst	0*	1	2	3	4	Total # of (oo)cysts
***Cryptosporidium* oocysts**						
Capilano	0	0	0	0	0	0
Coquitlam	0	0	0	0	0	0
SCFP-RCW	0	0	0	0	0	0
***Giardia* cysts**						
Capilano	2	0	0	0	0	2
Coquitlam	0	0	0	1	0	1
SCFP-RCW	0	0	0	0	0	0

Table 4: 2022 Number of nuclei in each *Cryptosporidium* oocysts and *Giardia* cysts. *DAPI negative or only intense blue internal staining.

Due to the variations of water chemistry and organic matters between geographical area and temporally within each sampling sites, a matrix spike is performed annually to provide recovery rate estimation from each site. The results of the matrix spike recovery (2007-2022) are compiled in Table 5. Matrix recovery rates fluctuate from year-to-year, even within each site. This variation is not uncommon for the test and has been noted in USEPA's Method 1623.1.

Matrix testing in 2022 was completed in both summer and winter on two separate sampling events at each site. 50L were provided from each site and the percentage recovery for *Cryptosporidium* oocysts and *Giardia* cysts and were noted in Table 5. One of the carboys containing 10L of matrix water from Capilano reservoir leaked in transit and was not used in testing; therefore the Capilano 2022 Fall/Winter matrix testing was performed with only 40L of water.

Year	Capilano		Coquitlam		SCFP - Recycled Clarified Water		Seymour	
	Cryptosporidium % Recovery	*Giardia* % Recovery	*Cryptosporidium* % Recovery	*Giardia* % Recovery	*Cryptosporidium* % Recovery	*Giardia* % Recovery	*Cryptosporidium* % Recovery	*Giardia* % Recovery
2007	27.6%	37.4%	28.0%	54.0%	not collected		not collected	
2008	25.0%	55.0%	28.0%	39.0%	not collected		not collected	
2009	10.0%	40.0%	16.0%	37.0%	not collected		not collected	
2010	28.0%	43.0%	26.0%	49.0%	17.0%	13.0%	not collected	
2011	27.0%	44.0%	22.0%	47.0%	1.0%	0.0%	not collected	
2012	38.4%	76.5%	35.0%	49.0%	7.0%	13.7%	not collected	
2013	22.4%	59.4%	16.3%	64.4%	6.1%	14.9%	not collected	
2014	not collected		55.0%	39.4%	18.0%	14.1%	not collected	
2015	26.3%	40.4%	2.0%	60.6%	9.1%	26.5%	not collected	
2016	35.4%	47.5%	22.2%	50.5%	9.1%	14.0%	not collected	
2017	20.2%	38.4%	22.2%	21.2%	0.0%	2.0%	not collected	
2018	43.4%	75.8%	17.1%	59.6%	1.0%	11.1%	not collected	
2019	0.0%	43.0%	1.0%	55.0%	0.0%	4.1%	not collected	
2020	5.1%	37.4%	8.1%	59.8%	0.0%	4.0%	not collected	
2021 June	2.0%	53.0%	0.0%	35.0%	5.1%	38.0%	not collected	
2021 November	11.1%	52.0%	15.2%	80.0%	0.0%	8.0%	not collected	
2022 Summer	12.1%	17.0%	4.0%	13.0%	0.0%	11.0%	0.0%	19.0%
2022 Fall/Winter	0.0%	12.2%	5.1%	49.0%	1.0%	36.7%	not collected	

Table 5: Matrix Results from 2007 - 2022

Summary

In brief, we reported:

1. Overall, a low but consistent positivity rate was observed across all sites, except for Seymour reservoir, for both *Cryptosporidium* oocysts and *Giardia* cysts. Seymour reservoir is a new site this year and more data will be required for any trend analysis.

2. *Cryptosporidium* oocysts were not detected the following sites: Capilano reservoir, Coquitlam reservoir, SCFP-RCW and Seymour reservoir.

3. *Giardia* cysts were detected in filters from Capilano and Coquitlam reservoirs but not from SCFP-RCW or Seymour reservoir. 17% of all filters received from Capilano were positive for *Giardia*, and 8% of all filters received from Coquitlam were positive for *Giardia*, and there were no *Giardia* cysts detected for SCFP-RCW or Seymour reservoir.

4. The highest concentration of *Giardia* cysts detected in 2022 was 2 cysts per 100 L from Capilano reservoir in January and October, as well as from Coquitlam reservoir in January.

5. Most of the *Giardia* cysts detected showed evidence of environmental degradation, based on microscopic examination. .

6. Matrix recovery for *Cryptosporidium* oocyst continued to be low, which is consistent with previous years. The additional matrix collection in the summer did not confirm suspected seasonality variabilities for this year. Further summer matrix collections are recommended to continue this investigation.

These *semi-quantitative* data (reported oocyst and cyst levels) should be interpreted in the context of, and with the understanding that the current standard laboratory method, USEPA Method 1623.1, used for detecting and analysing parasites in water matrices has its limitations, with variable recovery rates depending on the water matrix and environmental conditions.

Acknowledgements

The BCCDC Public Health Laboratory thanks Metro Vancouver for their ongoing support of this program and other related projects. In particular, the assistance of Larry Chow, Vila Goh, Eileen Butler, Melody Sato, and Rick Zolkiewski of the Metro Vancouver, Water Quality Department are greatly appreciated.

References

1. Haas CN, Aturaliye D. Semi-quantitative characterization of electroporation-assisted disinfection processes for inactivation of *Giardia* and *Cryptosporidium*. 1999. Journal of Applied Microbiology. 88:899-905.

2. Hoff JC. Inactivation of microbial agents by chemical disinfectants. 1986. Publication EPA/600/2-86/067. U.S. Environmental Protection Agency, Cincinnati, Ohio.

3. Korich DG, Mead JR, Madore MS, et al. Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocysts viability. 1990. Applied and Environmental Microbiology. 56(5):1423-1428.

4. U.S. Environmental Protection Agency. Method 1623.1: *Cryptosporidium* and *Giardia* in water by filtration/IMS/FA. 2012. Publication EPA-816-R-12-001. U.S. Environmental Protection Agency Office of Water, Washington, D.C.

5. Atherholt TB, LeChevallier MW, Norton WD, and Rosen JS. Effect of rainfall on Giardia and Crypto. 1998. Journal of American Water Works Association. 90(9): 66-80.

Appendix A

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	*Cryptosporidium* oocysts (per 100L)	*Giardia* cysts (per 100L)	2015 - 2021 Monthly Average	
								Cryptosporidium oocysts (per 100L)	*Giardia* cysts (per 100L)
8224	Capilano Reservoir	January	January 17, 2022	50	<2.0	0	2	0.3	3.1
8229	Capilano Reservoir	February	Febuary 14, 2023	50	<2.0	0	0	0.0	2.0
8234	Capilano Reservoir	March	March 21, 2022	50	<2.0	0	0	0.0	2.6
8239	Capilano Reservoir	April	April 11, 2022	50	<2.0	0	0	0.6	0.3
8249	Capilano Reservoir	May	May 16, 2022	50	<2.0	0	0	0.0	1.1
8254	Capilano Reservoir	June	June 20, 2022	50	<2.0	0	0	0.0	0.9
8262	Capilano Reservoir	July	July 18, 2022	50	<2.0	0	0	0.0	0.6
8270	Capilano Reservoir	August	August 22, 2022	50	<2.0	0	0	0.0	0.3
8278	Capilano Reservoir	September	September 26, 2022	30	<3.3	0	0	0.0	0.0
8293	Capilano Reservoir	October	October 31, 2022	50	<2.0	0	2	0.0	1.4
8300	Capilano Reservoir	November	November 21, 2022	50	<2.0	0	0	0.3	1.6
8307	Capilano Reservoir	December	December 12, 2022	50	<2.0	0	0	1.0	3.6
			2022 Average	48.3	<2.0	0	0.3		

Table A1. Capilano Reservoir Monthly Filter Results in 2022

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	*Cryptosporidium* oocysts (per 100L)	*Giardia* cysts (per 100L)	2015 - 2021 Monthly Average	
								Cryptosporidium oocysts (per 100L)	*Giardia* cysts (per 100L)
8225	Coquitlam Reservoir	January	January 17, 2022	50	<2.0	0	2	0.0	0.6
8230	Coquitlam Reservoir	February	Febuary 14, 2024	50	<2.0	0	0	0.0	1.7
8235	Coquitlam Reservoir	March	March 21, 2022	50	<2.0	0	0	0.0	2.3
8240	Coquitlam Reservoir	April	April 11, 2022	50	<2.0	0	0	0.0	1.1
8250	Coquitlam Reservoir	May	May 16, 2022	50	<2.0	0	0	0.0	0.9
8255	Coquitlam Reservoir	June	June 20, 2022	50	<2.0	0	0	0.0	0.0
8263	Coquitlam Reservoir	July	July 18, 2022	50	<2.0	0	0	0.0	0.3
8271	Coquitlam Reservoir	August	August 22, 2022	50	<2.0	0	0	0.0	0.6
8279	Coquitlam Reservoir	September	September 26, 2022	45	<2.2	0	0	0.0	0.0
8294	Coquitlam Reservoir	October	October 31, 2022	50	<2.0	0	0	0.0	0.3
8301	Coquitlam Reservoir	November	November 21, 2022	50	<2.0	0	0	0.0	1.7
8308	Coquitlam Reservoir	December	December 12, 2022	50	<2.0	0	0	0.0	1.1
			2022 Average	49.6	<2.0	0	0		

Table A2. Coquitlam Reservoir Monthly Filter Results in 2022

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	*Cryptosporidium* oocysts (per 100L)	*Giardia* cysts (per 100L)	2015 - 2021 Monthly Average	
								Cryptosporidium oocysts (per 100L)	*Giardia* cysts (per 100L)
8226	SCFP - Recycled Clarified Water	January	January 18, 2022	898	0.111	0	0	0.0	0.0
8231	SCFP - Recycled Clarified Water	February	Febuary 15, 2022	319.7	<0.31	0	0	0.0	0.0
8236	SCFP - Recycled Clarified Water	March	March 22, 2022	168.5	<0.59	0	0	0.0	0.0
8241	SCFP - Recycled Clarified Water	April	April 12, 2022	343.7	<0.29	0	0	0.0	0.0
8251	SCFP - Recycled Clarified Water	May	May 17, 2022	259.8	<0.38	0	0	0.0	0.0
8256	SCFP - Recycled Clarified Water	June	June 21, 2022	327.5	<0.31	0	0	0.0	0.0
8264	SCFP - Recycled Clarified Water	July	July 19, 2022	91.1	<1.1	0	0	0.0	0.0
8273	SCFP - Recycled Clarified Water	August	August 24, 2022	59	<1.7	0	0	0.0	0.0
8281	SCFP - Recycled Clarified Water	September	September 27, 2022	102.5	<0.97	0	0	0.0	0.0
8285	SCFP - Recycled Clarified Water	October	October 18, 2022	50	<1.53	0	0	0.0	0.0
8303	SCFP - Recycled Clarified Water	November	November 22, 2022	207.1	<0.48	0	0	0.0	0.1
8310	SCFP - Recycled Clarified Water	December	December 13, 2022	531.9	<0.19	0	0	0.0	0.9
			2022 Average	279.9	0.66	0	0		

Table A3. Seymour Capilano Filtration Plant - Recycled Clarified Water (SCFP-RCW) Monthly Filter Results in 2022

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	*Cryptosporidium* oocysts (per 100L)	*Giardia* cysts (per 100L)
n/a	Seymour Reservoir	January	not sampled				
n/a	Seymour Reservoir	February	not sampled				
n/a	Seymour Reservoir	March	not sampled				
n/a	Seymour Reservoir	April	not sampled				
n/a	Seymour Reservoir	May	not sampled				
n/a	Seymour Reservoir	June	not sampled				
8265	Seymour Reservoir	July	July 18, 2022	50	<2.0	0	0
8272	Seymour Reservoir	August	August 22, 2022	36	<2.0	0	0
8280	Seymour Reservoir	September	September 26, 2022	30	<3.3	0	0
n/a	Seymour Reservoir	October		not sampled			
8302	Seymour Reservoir	November	November 21, 2022	30	<3.33	0	0
8309	Seymour Reservoir	December	December 12, 2022	50	<2.0	0	0
			2022 Average	39.2	2.69	0	0

Table A4. Seymour Reservoir Monthly Filter Results in 2022

			Cryptosporidium									
			Cryptosporidium			DAPI -	DAPI +		DIC			
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8224	Capilano Reservoir	January 16, 2022	0								
8229	Capilano Reservoir	February 13, 2022	0								
8234	Capilano Reservoir	March 20, 2022	0								
8239	Capilano Reservoir	April 10, 2022	0								
8249	Capilano Reservoir	May 15, 2022	0								
8254	Capilano Reservoir	June 19, 2022	0								
8262	Capilano Reservoir	July 17, 2022	0								
8270	Capilano Reservoir	August 21, 2022	0								
8278	Capilano Reservoir	September 25, 2022	0								
8293	Capilano Reservoir	October 30, 2022	0								
8300	Capilano Reservoir	November 20, 2022	0								
8307	Capilano Reservoir	December 11, 2022	0								

Table A5. Capilano Reservoir Slide Examination Results - *Cryptosporidium* 2022

			Cryptosporidium									
			Cryptosporidium			DAPI -	DAPI +		DIC			
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8225	Coquitlam Reservoir	January 16, 2022	0								
8230	Coquitlam Reservoir	February 13, 2022	0								
8235	Coquitlam Reservoir	March 20, 2022	0								
8240	Coquitlam Reservoir	April 10, 2022	0								
8250	Coquitlam Reservoir	May 15, 2022	0								
8255	Coquitlam Reservoir	June 19, 2022	0								
8263	Coquitlam Reservoir	July 17, 2022	0								
8271	Coquitlam Reservoir	August 21, 2022	0								
8279	Coquitlam Reservoir	September 25, 2022	0								
8294	Coquitlam Reservoir	October 30, 2022	0								
8301	Coquitlam Reservoir	November 20, 2022	0								
8308	Coquitlam Reservoir	December 11, 2022	0								

Table A6. Coquitlam Reservoir Slide Examination Results - *Cryptosporidium* 2022

			Cryptosporidium									
			Cryptosporidium			DAPI -	DAPI +		DIC			
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8226	SCFP - Recycled Clarified Water	January 18, 2022	0								
8231	SCFP - Recycled Clarified Water	February 15, 2022	0								
8236	SCFP - Recycled Clarified Water	March 22, 2022	0								
8241	SCFP - Recycled Clarified Water	April 12, 2022	0								
8251	SCFP - Recycled Clarified Water	May 17, 2022	0								
8256	SCFP - Recycled Clarified Water	June 21, 2022	0								
8264	SCFP - Recycled Clarified Water	July 19, 2022	0								
8273	SCFP - Recycled Clarified Water	August 24, 2022	0								
8281	SCFP - Recycled Clarified Water	September 26, 2022	0								
8285	SCFP - Recycled Clarified Water	October 18, 2022	0								
8303	SCFP - Recycled Clarified Water	November 22, 2022	0								
8310	SCFP - Recycled Clarified Water	December 13, 2022	0								

Table A7. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Cryptosporidium* 2022

			Cryptosporidium								
			Cryptosporidium			DAPI -	DAPI +		DIC		
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8265	Seymour Reservoir	July 17, 2022	0								
8272	Seymour Reservoir	August 21, 2022	0								
8280	Seymour Reservoir	September 25, 2022	0								
8302	Seymour Reservoir	November 20, 2022	0								
8309	Seymour Reservoir	December 11, 2022	0								

Table A8. Seymour Reservoir Slide Examination Results - *Cryptosporidium* 2022

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
8224	Capilano Reservoir	January 16, 2022	#1	Oval	14x10	P				P			
8229	Capilano Reservoir	February 13, 2022	0										
8234	Capilano Reservoir	March 20, 2022	0										
8239	Capilano Reservoir	April 10, 2022	0										
8249	Capilano Reservoir	May 15, 2022	0										
8254	Capilano Reservoir	June 19, 2022	0										
8262	Capilano Reservoir	July 17, 2022	0										
8270	Capilano Reservoir	August 21, 2022	0										
8278	Capilano Reservoir	September 25, 2022	0										
8293	Capilano Reservoir	October 30, 2022	#1	oval	14x7		P			P			
8300	Capilano Reservoir	November 20, 2022	0										
8307	Capilano Reservoir	December 11, 2022	0										

Table A9. Capilano Reservoir Slide Examination Results - *Giardia* 2022 (P = present)

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
8225	Coquitlam Reservoir	January 16, 2022	#1	Oval	11x8			3			1		
8230	Coquitlam Reservoir	February 13, 2022	0										
8235	Coquitlam Reservoir	March 20, 2022	0										
8240	Coquitlam Reservoir	April 10, 2022	0										
8250	Coquitlam Reservoir	May 15, 2022	0										
8255	Coquitlam Reservoir	June 19, 2022	0										
8263	Coquitlam Reservoir	July 17, 2022	0										
8271	Coquitlam Reservoir	August 21, 2022	0										
8279	Coquitlam Reservoir	September 25, 2022	0										
8294	Coquitlam Reservoir	October 30, 2022	0										
8301	Coquitlam Reservoir	November 20, 2022	0										
8308	Coquitlam Reservoir	December 11, 2022	0										

Table A10. Coquitlam Reservoir Slide Examination Results - *Giardia* 2022 (P = present)

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
8226	SCFP - Recycled Clarified Water	January 18, 2022	0										
8231	SCFP - Recycled Clarified Water	February 15, 2022	0										
8236	SCFP - Recycled Clarified Water	March 22, 2022	0										
8241	SCFP - Recycled Clarified Water	April 12, 2022	0										
8251	SCFP - Recycled Clarified Water	May 17, 2022	0										
8256	SCFP - Recycled Clarified Water	June 21, 2022	0										
8264	SCFP - Recycled Clarified Water	July 19, 2022	0										
8273	SCFP - Recycled Clarified Water	August 24, 2022	0										
8281	SCFP - Recycled Clarified Water	September 26, 2022	0										
8285	SCFP - Recycled Clarified Water	October 18, 2022	0										
8303	SCFP - Recycled Clarified Water	November 22, 2022	0										
8310	SCFP - Recycled Clarified Water	December 13, 2022	0										

Table A11. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Giardia* 2022

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
8265	Seymour Reservoir	July 17, 2022	0										
8272	Seymour Reservoir	August 21, 2022	0										
8280	Seymour Reservoir	September 25, 2022	0										
8302	Seymour Reservoir	November 20, 2022	0										
8309	Seymour Reservoir	December 11, 2022	0										

Table A12. Seymour Reservoir Slide Examination Results - *Giardia* 2022

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION