metrovancouver

Greater Vancouver Water District

2020 Water Quality Annual Report

Volume 1 of 2

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EXECUTIVE SUMMARY

Source Water Quality

- In 2020, 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 early January and late September resulted in Capilano source water turbidity peaking at 7.3 Nephelometric Turbidity Unit (NTU). Even with the higher turbidity, the delivered filtered Capilano water was less than 0.1 NTU as measured by online instruments for the entire year.
- The Seymour supply was in service for the entire year. Heavy rainfall events in January resulted in Seymour source water turbidity peaking at 23 NTU. The delivered filtered Seymour water was less than 0.1 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 NTU for 7 days in 2020 and did not exceed 5 NTU throughout the year.
- The microbiological quality of the three source waters was excellent in 2020. 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.
- Results of the analyses of the source water for herbicides, pesticides, volatile organic compounds and radionuclides were all found to be below the recommended limits for these substances 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 2020. The daily average turbidity of water leaving the clearwells to enter the Greater Vancouver Water District (GVWD) transmission system was an average of 0.09 NTU in 2020.
- 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 water.
- Levels of total aluminum in filtered water were consistently below the GCDWQ operational guideline value of 0.2 mg/L for direct filtration plants using aluminum-based coagulants. The maximum value for 2020 was 0.06 mg/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.
- No *E. coli* was detected. The detection of an *E. coli* triggers a protocol which involves immediate notification to health and local government officials, re-sampling, and a thorough investigation into the possible causes.
- Bacteriological water quality was excellent in the GVWD in-system storage reservoirs. There was no *E. coli* detected in any of the associated samples.

- Bacteriological water quality was excellent in the distribution systems of the local governments. Of approximately 20,000 local government samples collected for testing in 2020, a high percentage (99.8%) were free of total coliforms, which was the same as 2019 (99.8%). No *E. coli* were detected in any of the samples taken in 2020.
- The running average levels of the Trihalomethane (THM) group of chlorine disinfection by-products detected in the delivered water in the GVWD and local government 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).

ACRONYMS

ACU	Apparent Color Unit
AO	Aesthetic Objective (characteristics such as taste, colour, appearance, temperature that are not health related)
BCDWPR	*British Columbia Drinking Water Protection Regulation*
BHT	Break Head Tank
BTEX	Benzene, Ethylbenzene, Toluene, Xylene
CALA	Canadian Association for Laboratory Accreditation
CRWPS	Capilano Raw Water Pump Station
CFE	Combined Filter Effluent
CFU	Colony Forming Units
CO_2	Carbon Dioxide
CTD	Conductivity, Temperature, Depth
CWTP	Coquitlam Water Treatment Plant
DS	Distribution System
DBP	Disinfection By-product
DOC	Dissolved Organic Carbon
DWTP	*Drinking Water Treatment Program*
DWTO	*Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*
E. coli	*Escherichia coli*
ERF	Energy Recovery Facility
EPA	Environmental Protection Agency (USA)
ESWTR	*Enhanced Surface Water Treatment Rule* (USA)
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
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Method Detection Limit
mg/L	Milligram per liter (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 Available
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
ppb	Parts per Billion (Equivalent of microgram per litre)
ppm	Parts per Million (Equivalent of microgram per litre)
RCW	Recycled Clarified Water
RWT	Raw Water Tunnel
SCADA	Supervisory Control and Data Acquisition
SCFP	Seymour Capilano Filtration Plant
TS	Transmission System
$THAA_5$	Total $Haloacetic_5$ Acids
THM	Trihalomethane
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
TWT	Treated Water Tunnel
UV_{254}	Ultraviolet Absorbance at 254 nm
WHO	World Health Organization
WQMRP	*Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members*

WATER SAMPLING AND TESTING PROGRAM

Water Type	Parameter	Frequency
Untreated, Source Water	Total coliform and *E. coli*	Daily
	Turbidity	Daily
	Giardia and *Cryptosporidium*	Monthly at Capilano and Coquitlam
	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
	Trihalomethanes, haloacetic acids	Quarterly
	Antimony, arsenic, barium, boron, cadmium, cyanide, chromium, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
	Pesticides and herbicides	Annually
	PAHs, BTEXs	Annually
	VOC	Annually
	Radioisotopes	Annually
Treated water	Total coliform and *E. coli*	Daily
	Turbidity	Daily
	Temperature	Daily
	Ammonia, colour, iron, organic carbon, pH, aluminum at SCFP	Weekly
	Aluminum, copper, sodium, total and suspended solids	Bi-Monthly
	Trihalomethanes, haloacetic acids	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
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
	Trihalomethanes, haloacetic acids, pH	Quarterly at selected sites
	PAHs, BTEXs	Semi-annually at selected sites
GVWD Reservoirs	Total coliform and *E. coli*	Weekly per site
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
Local Government Distribution System	Total coliform and *E. coli*	Weekly per site
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
	Turbidity	Weekly per site
	Trihalomethanes, haloacetic acids, pH	Quarterly at selected sites

1.0 SOURCE WATER QUALITY

The first barrier in place to protect the quality of drinking water supply is the protection of the watershed 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 also a requirement of the *Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members (WQMRP)*.

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."*

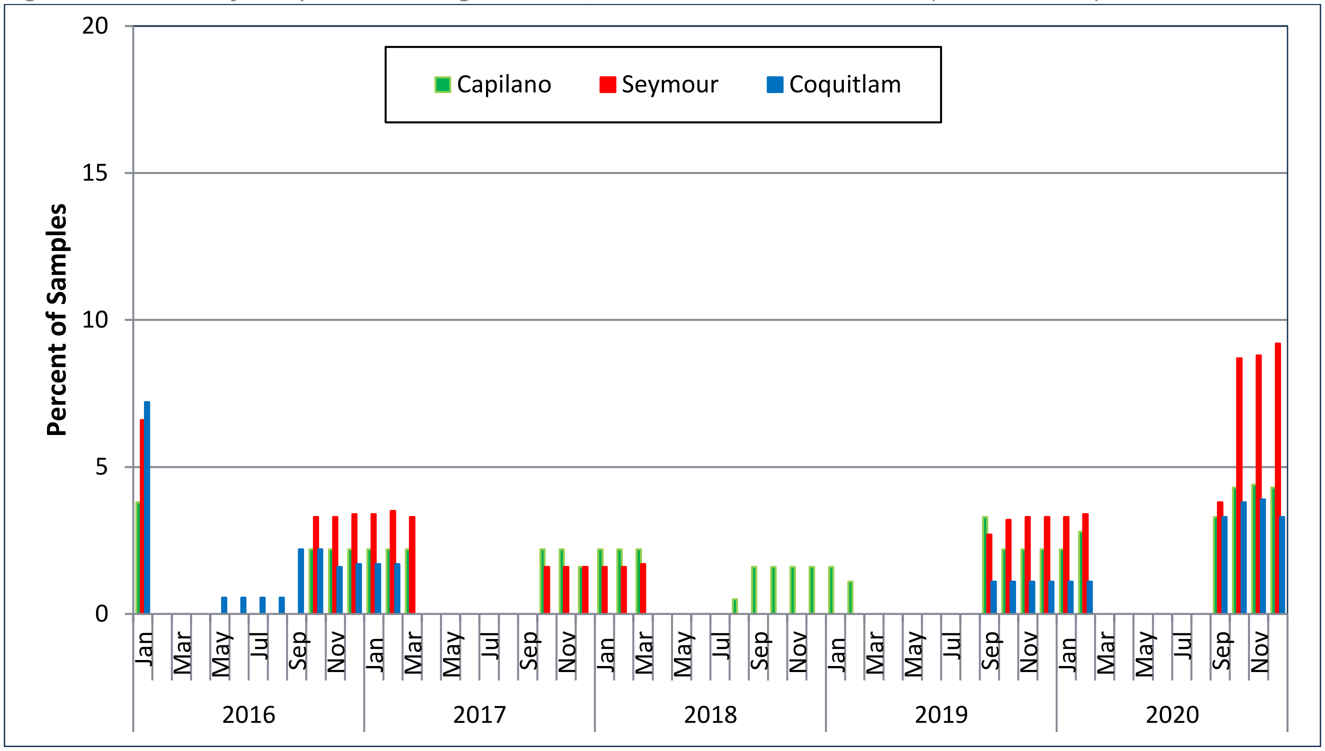
Table 1 summarizes *E. coli* data for all three GVWD water supply sources. The levels of *E. coli* for all three sources were below the 10% limit in the provincial turbidity guideline.

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

	Percent of samples (daily) in a six month period ending on the last day of the month named where *E. coli* is greater than 20/100 mL		
Month	**Capilano**	**Seymour**	**Coquitlam**
Jan	2.2	3.3	1.1
Feb	2.8	3.4	1.1
Mar	0	0	0
Apr	0	0	0
May	0	0	0
Jun	0	0	0
Jul	0	0	0
Aug	0	0	0
Sep	3.3	3.8	3.3
Oct	4.3	8.7	3.8
Nov	4.4	8.8	3.9
Dec	4.3	9.2	3.3

Figure 1 shows the results of the analysis of the source water from 2016 to 2020 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*/100mL. As was also the case in previous years, samples collected at the intakes in the fall and winter had the highest *E.coli* levels. Typically, these *E.coli* can typically 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 (2016 to 2020)



Note: Metro Vancouver has protected watersheds and therefore the source of *E.coli* is most likely originating from endemic animals in the watersheds.

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 B.C. 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 BC Centre of Disease Control Enhanced Water Testing Laboratory, to gather more information about the number and nature of cysts found in the GVWD water supplies. The program involves collecting samples from the Capilano and Coquitlam supplies upstream of disinfection.

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.

The results of the 2020 testing program are contained in the "Report to Metro Vancouver – *Giardia* and *Cryptosporidium* Annual Report January – December, 2020", which was prepared by the BC Public Health Microbiology & Reference Laboratories, Environmental Microbiology, and can be found in Appendix D. Four of twelve (33%) samples collected at Capilano and three of the twelve (25%) collected at Coquitlam were positive for *Giardia* (Table 2).

As discussed previously, Seymour samples for 2020 are all process control samples and not Seymour source water, as they were prior to 2011 (shown as N/A in the table).

Table 2: Percent of Samples Positive for Giardia

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capilano	50	75	50	18	18	50	58	33	33	33
Seymour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA	NA	NA
Coquitlam	51	50	23	8	0	17	67	8	25	25

Zero of twelve (0%) samples collected at Capilano were positive for *Cryptosporidium*, and 0 of twelve (0%) were positive at Coquitlam (Table 3). As discussed in the section on *Giardia* above, Seymour samples for 2020 are all process control samples and not Seymour source water, as they were prior to 2011 (shown as N/A in the table).

Table 3: Percent of Samples Positive of Cryptosporidium

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capilano	6	16	9	9	9	25	17	8	0	0
Seymour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA	NA	NA
Coquitlam	3	8	9	0	0	0	0	0	0	0

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

1.3. Turbidity

GVWD water sources have been susceptible to turbidity upsets due to high runoff from storms which can cause slides and stream scouring in the watersheds, 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, therefore plans were developed and implemented to filter both supplies.

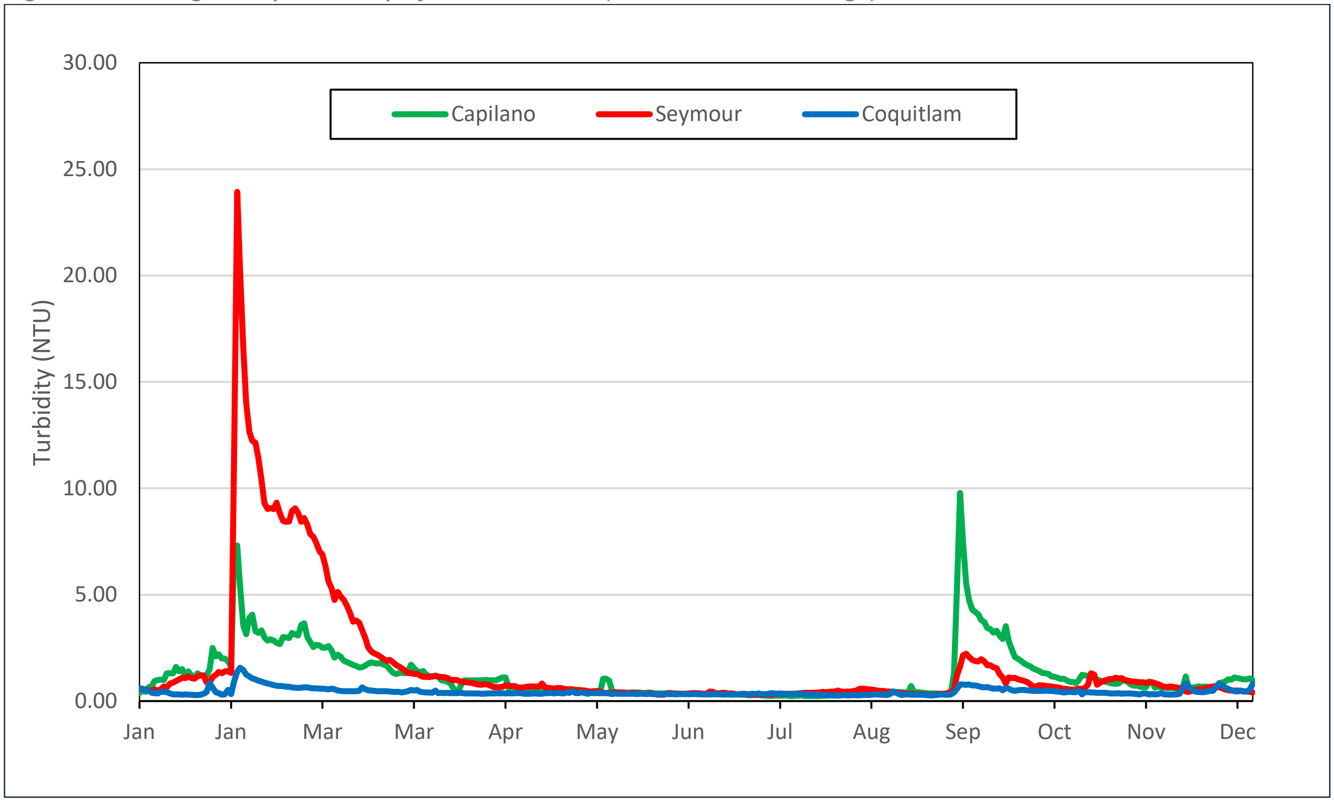
Filtration of 100% of the Seymour supply began in January 2010, and filtration and distribution of the Capilano supply through the Twin Tunnels connecting the Capilano and Seymour source supplies commenced in February 2015. Both the raw and treated water tunnels were fully operational in April 2015.

Section 4.4 of the DWTO (Version 1.1, 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 don't apply to the delivered water. Coquitlam, which is unfiltered, was in service for all of 2020 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 Source Water

The chemical and physical characteristics of the GVWD source water are summarized in Appendix A of this report; detailed analytical results are provided in Volume II. The results from the chemical and physical analyses of the source water in 2020 were similar to those for other years.

1.4.2. Herbicides, Pesticides, Volatile Organic Compounds, Radioactivity, and Uranium

Analyses of the source water for a variety of organic compounds, including all of the compounds with an specified MAC in the *Guidelines of Drinking Water Quality* (GCDWQ), is carried out on an annual basis in accordance with the WQMRP. The results are contained in Appendix B of this report and in Volume II. Uranium was the only parameter detected and it was below the applicable GCDWQ health based limits; these levels are indicative of erosion of natural deposits, meaning the contribution to total radiation exposure from our drinking water is low.

1.4.3. PFOS and PFAS

The GCDWQ have added the parameters of Perfluorooctane Sulfonate(PFOS) and Perfluorooactanoic Acid (PFAS) for testing of the source and treated waters. The results are in Appendix B of this report and in Volume II. None of the chemicals in these categories were detected. Common sources of these synthetic chemicals are from consumer products and fire-fighting foam for their water and oil repellant properties.

1.4.4. Limnology

The *Reservoir Water Quality Monitoring Program* was started in 2014 as a sampling and analysis structure for the limnology (physical, chemical, and biological parameters) of the Capilano, Seymour and Coquitlam Reservoirs. Reservoir monitoring information is important in the proactive management of the GVWD 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 primary source reservoirs and inflow rivers is conducted between April and November each year. 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 by Metro Vancouver staff and sample analysis is undertaken by accredited laboratories. Water quality measurements are compiled by arrays of scientific instruments in each reservoir.

The GVWD employs the services of a limnology consultant to review the annual program data, interpret physical, chemical, and biological conditions and examine long term trends. Results in 2020, as in previous years, confirmed the three reservoirs are ultra-oligotrophic (see Appendix C), which means they have low levels of available nutrients and low levels of biological production. This ultra-oligotrophic classification is highly desirable for source drinking water supply and shows that the GVWD watersheds and reservoirs continue to provide a high quality raw water source.

In many parts of North America there is interest in blue green algae (also known as cyanobacteria) in water reservoirs. These algae can produce toxins that are collectively known as microcystins. A common cyanobacterium in GVWD source reservoirs is called *Merismopedia* spp., which is thought to produce these microcystins.

Despite the presence of cyanobacteria, the concentration of microcystins in GVWD source reservoirs remains well below levels known to affect human health and are far below the GCDWQ. This desirable condition is due to the ultra-oligotrophic status of the reservoirs (low nutrient availability to fuel algal growth). Algae blooms have not been observed in the source water supply 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. This data is 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.

2.0 QUALITY CONTROL ASSESSMENT OF WATER TREATMENT

Water treatment is the second barrier (after source water protection) relied on to assure the quality of the water supply.

Completion of the Twin Tunnels Project in 2015 successfully concluded GVWD's regional long-range water treatment enhancement plans which spanned more than ten years. Each tunnel is 3.8 meters in diameter, 7.1 kilometers long, and 160 to 640 meters below ground level, running beneath Grouse Mountain and Mount Fromme. The water from the Raw Water Tunnel (RWT) 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 through the Treated Water Tunnel (TWT) and provides high quality drinking water to the Capilano area while the remainder is distributed through the Seymour system.

2.1. Seymour Capilano Filtration Plant

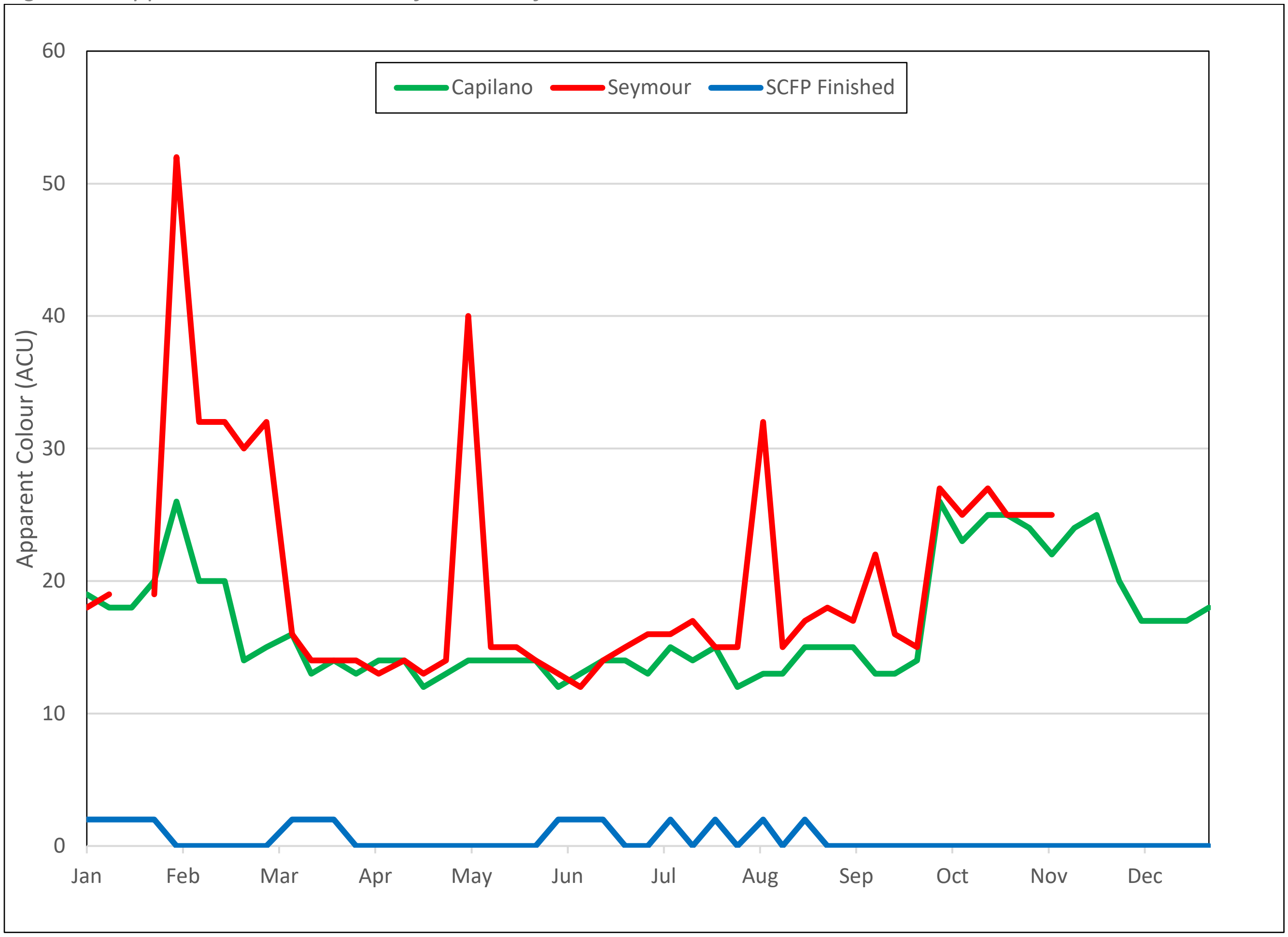
The SCFP is a chemically assisted direct filtration plant which uses poly aluminum chloride as a coagulant with polymers to improve particle removal. These substances help aggregate particles to form visible floc. The flocculated particles are removed by passing this water through a filter medium of anthracite and sand. The result is the production of filtered water which is then exposed to ultraviolet light as the water leaves each filter. Post ultraviolet filtered water has sodium hypochlorite (chlorine) and lime added 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 some mixing (or blending) of the lime and chlorine that have been added. Clearwells allow 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. After stabilization of the filtered water in the Clearwells, the finished water enters the transmission system at the Seymour Treated Water Valve Chamber. The SCFP has been operational since January 2010 and the quality of the water produced has been excellent.

2.1.1. Filtration

As a result of filtration treatment of the Capilano and Seymour water sources, there have been a number of changes to the characteristics of the delivered water. Some of these changes are visible, and some are not. The most obvious visible change in the water is the decrease in colour and increase in clarity. There is a total loss of brown hue that can sometimes characterize Capilano and Seymour waters before filtration. This improvement in colour is a result of removal of the natural components 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 3 compares the apparent colour of SCFP filtered water and Capilano and Seymour source waters for 2020. During the fall rainfall events, the apparent colour of the Seymour source water feeding the SCFP had a reading over 50 ACU. After the removal of the organic material through filtration, the colour of the filtered water delivered to the public was never greater than 2 ACU.

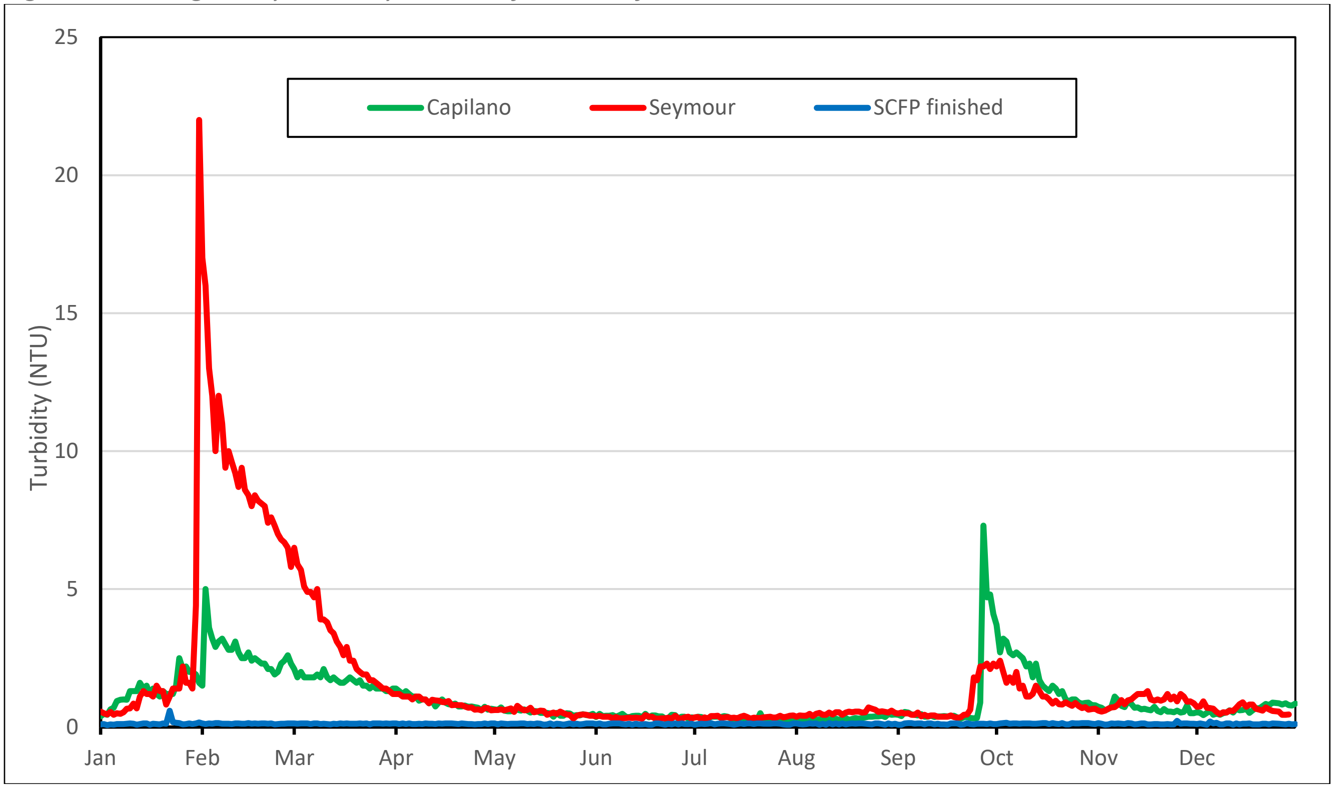
Figure 3: Apparent Colour Levels Before and After Filtration



Note: The Seymour intake sampling site was unavailable due to maintenance from November until year end.

Figure 4 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 NTU for 116 days. The Capilano source exceeded 1 NTU on 114 days. Since both sources were filtered at the SCFP, the maximum average daily turbidity of the delivered water was 0.19 NTU and the average was 0.09 NTU.

Figure 4: 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 (2019) 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 time less than 0.3 NTU. This is summarized in Table 4. In 2020, 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.

Table 4: Monthly Filter Effluent Turbidity Summary

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	99.99%
February	0	99.72%
March	0	99.94%
April	0	100%
May	0	100%
June	0	100%
July	0	100%
August	0	100%
September	0	99.99%
October	0	100%
November	0	100%
December	0	100%

A water treatment facility such as the SCFP should be able to produce a filter effluent that is less than 0.1 NTU. Under normal operating conditions the turbidity of the filtered water at SCFP is less than 0.09 NTU.

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

2.1.2. Ultraviolet Treatment

The effluent from each filter is treated with ultraviolet light as the water exits the filter. Ultraviolet 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, ultraviolet light is present to render any parasites that may be present as non-infectious. 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 ultraviolet light is to achieve 2-Log (99%) *Giardia* and *Cryptosporidium* inactivation is 21 mJ/cm^2.

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

Table 5 summarizes the performance of the SCFP ultraviolet system in 2020.

Table 5: Percent of Volume Meeting Ultraviolet Dosage Requirements at SCFP

Month	Percent of Monthly Volume ≥ 2-log of *Giardia* and *Cryptosporidium* Inactivation (95% of monthly volume required)
January	99.82%
February	99.89%
March	99.90%
April	99.84%
May	99.91%
June	99.95%
July	99.97%
August	99.95%
September	99.89%
October	99.92%
November	99.92%
December	99.62%

2.1.3. Chlorination

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

2.2. Coquitlam Water Treatment Plant

The Coquitlam Water Treatment Plant (CWTP) uses ozonation, ultraviolet treatment, soda ash and chlorination to treat water from the Coquitlam source.

Ozonation provides pre-treatment and helps remove micro-organisms from the water, reduces disinfection by-products and improves water clarity, which increases the efficiency of the subsequent ultraviolet process. Ozonation provides an additional 4-log virus inactivation to chlorination. Soda ash is then added for pH and alkalinity adjustment for corrosion control, followed by chlorination.

2.2.1. Ultraviolet Treatment

Ultraviolet treatment (operational since 2014) 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 (USEPA) 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 6. The USEPA standard is used because there is no Canadian standard.

Table 6: Percent of Volume Meeting Ultraviolet Dosage Requirements at CWTP

Month	Percent of Monthly Volume ≥ 3-log *Giardia* and *Cryptosporidium* Inactivation (Minimum 95% Required)
January	99.87%
February	99.88%
March	99.89%
April	99.85%
May	99.87%
June	99.85%
July	99.85%
August	99.81%
September	99.81%
October	99.90%
November	99.82%
December	99.91%

2.2.2. Chlorination

Chlorination is used for secondary disinfection at the source as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and local government distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite, which replaced the compressed chlorine gas system in 2017. Table 7 summarizes the performance of all the Coquitlam disinfection systems in 2020.

Table 7: Performance of Coquitlam Disinfection Facilities

Facility	Performance	Discussion
Ozonation	Operated 99.6% of time	Acts as a pretreatment, enhancing the removal of organics and increasing the UV Transmittance making Ultraviolet treatment more effective. Ozone outages were due to electrical or instrument maintenance, ozone outage test, or ozone generator faults.
Ultraviolet	No loss of ultraviolet in 2020. 99.86 % of volume was treated to ultraviolet specifications	UV performance met USEPA requirements. (95% of monthly volume required).
Chlorination	100% of water was chlorinated	This facility uses chlorine as a secondary disinfectant except during an outage of the ultraviolet system when it is used for primary disinfection.

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 water transmission and distribution systems to meet a target residual based on a number of factors, including source water turbidity, the amount of bacterial regrowth detected in the local government 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 8 summarizes the performance of the secondary disinfection facilities in 2020.

Table 8: Performance of Secondary Disinfection Facilities

Facility	Branch Main	Average Free Chlorine (mg/L)	Range of Free Chlorine (mg/L)	Discussion
Clayton	Whalley/Clayton	1.22	1.09-1.36	Supplied by Coquitlam water.
	Jericho/Clayton	1.24	1.11-1.38	Jericho/Clayton was out of service commencing November 3 for the Jericho Reservoir Tie-In. Will be returned to service in 2021.
Chilco/Alberni	Capilano No. 4 and 5	0.74	0.67-0.84	Supplied by SCFP water. No operational issues.
Pitt River	Haney Main No.2	1.20	0.88-1.39	Supplied by Coquitlam water. March through June, in and out of service due to replacement of pipes and instruments in various sections of the station.
	Haney Main No.3	1.24	1.00-1.38	
Newton	Surrey Hickleton Main	0.88	0.58-1.18	Primarily supplied by SCFP water. No operational issues.
Kersland	Capilano No. 4 and 5	0.89	0.83-0.96	Supplied by SCFP water. No operational issues.
Central Park	South Burnaby Main No.1	0.82	0.65-0.96	Primarily supplied by SCFP water. No operational issues.
	South Burnaby Main No.2	0.91	0.74-1.14	
Cape Horn	Coquitlam Main No.2	1.25	1.10-1.36	Supplied by Coquitlam water. No operational issues.
	Coquitlam Main No.3	1.25	1.10-1.36	
Vancouver Heights	Boundary Road Main No. 5	0.84	0.75-0.92	Supplied by SCFP water. No operational issues.

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 proposed changes in pH and alkalinity in 2021 will reduce pipe corrosion through the addition of natural minerals.

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

In the SCFP process, filtered water is dosed with hydrated lime (calcium bicarbonate) 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. Since 2015, by way of the Twin Tunnels, Capilano raw source water is transferred to the SCFP for treatment.

At the Coquitlam source, the commissioning of the CO_2 system at the CWTP began in 2019 and continued in 2020. When it is fully operational, the CO_2 system with the addition of soda ash will allow 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 Seymour Capilano and Coquitlam Water Treatment Plants was 7.7 and 7.8, respectively, during 2020, which met the aesthetic objective of the GCDWQ.

Performance of the corrosion control facilities is summarized in Table 9.

Table 9: Performance of Corrosion Control Facilities

Facility	Performance	Discussion
SCFP Corrosion Control	pH ranged from 6.9 – 9.0	The annual average pH was 7.7 and was continually monitored with online instrumentation. The pH fluctuated in March from 6.9 to 9. During this time one clearwell was being bypassed for maintenance resulting in pH fluctuations while bringing this clearwell back into service.
CWTP Corrosion Control	pH ranged from 6.8 – 9.6	The annual average pH was 7.8. On a couple of occasions in January the pH was <7.0 for a short period due to a soda ash equipment fault. In January and also in June the pH was > 9 for a short period related to testing of the soda ash system.

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

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 members. 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 distribution system itself (regrowth).

The number of *E. coli* detected in both the GVWD and the local government drinking water samples is typically very low. Out of more than 27,000 samples collected from the GVWD and local government systems analyzed in 2020, no samples were positive for *E. coli*. The detection of an *E. coli* triggers a protocol which involves immediate notification to health and local government officials, re-sampling, and a thorough investigation into the possible causes.

In the GVWD transmission system, only 27 out of the approximately 7,100 samples collected, tested positive for total coliforms. Only 38 of the approximately 20,000 samples collected from the local government distribution systems tested positive for total coliforms in 2020. The majority of the coliforms (67%) in the local government system appeared in the warmer water months of June through October.

The most likely source of these organisms can be attributed to bacterial regrowth. It should be emphasized that 99.8% of the samples in 2020 had no coliforms present, which is a good indicator of effective water treatment and good transmission/distribution system water quality.

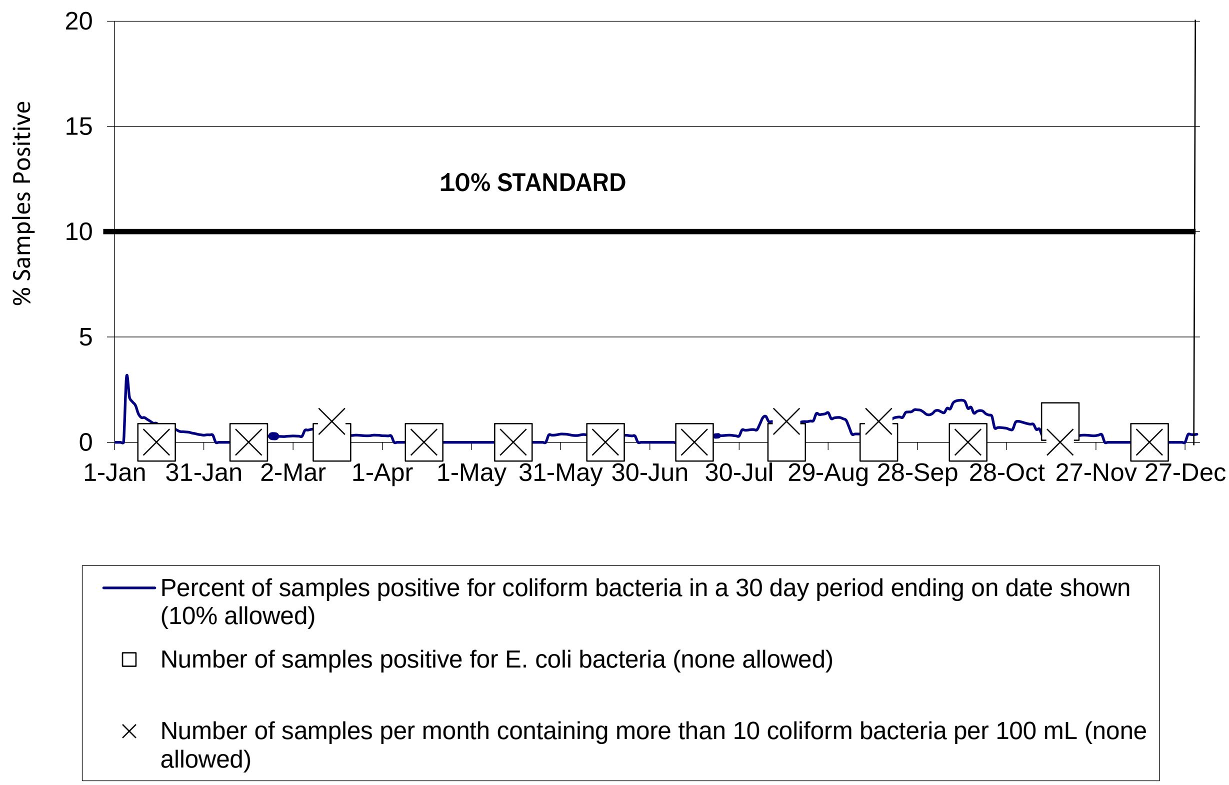
3.1. Microbiological Water Quality in the GVWD System

3.1.1. GVWD Water Mains

Water quality in water mains is monitored from the point leaving the source and throughout the transmission system. In 2020 there were approximately 5,080 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 5080 samples processed, only 21 samples tested positive for total coliforms and no samples were positive for *E. coli* bacteria. The compliance of monitoring results from GVWD transmission mains with the criteria in the BCDWPR is shown in Figure 5.

There were another 540 samples collected from stations where only chlorine residuals are measured. In addition, there are inline stations collecting data every 10-minutes after chlorination at each source, but these samples are not included in the calculations for compliance monitoring.

Figure 5: Bacteriological Quality of Water in GVWD Mains

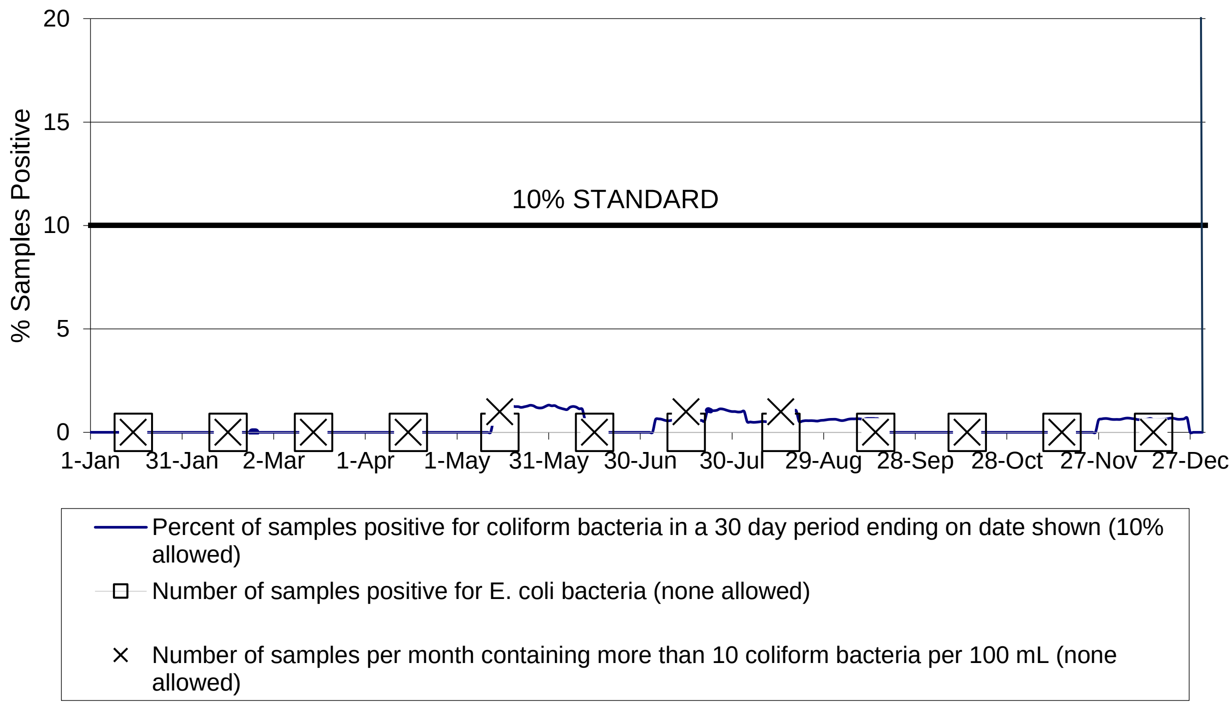


3.1.2. GVWD Reservoirs

In 2020, over 2,000 samples were collected from 21 reservoirs and tanks that are located throughout the GVWD water system. Only 6 samples were positive for total coliforms. No sample from a reservoir was positive for *E. coli*.

The compliance of 2020 monitoring results from GVWD reservoirs with the criteria in the BCDWPR is shown in Figure 6.

Figure 6: Bacteriological Quality of Water in GVWD 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 10 provides an overview of the status of the GVWD reservoirs from 2017 to 2020. During certain times of the year, it is not possible to cycle reservoirs as much as would be desired due to operational constraints. Despite these constraints, water quality as determined by coliform bacteria, was satisfactory in all reservoirs.

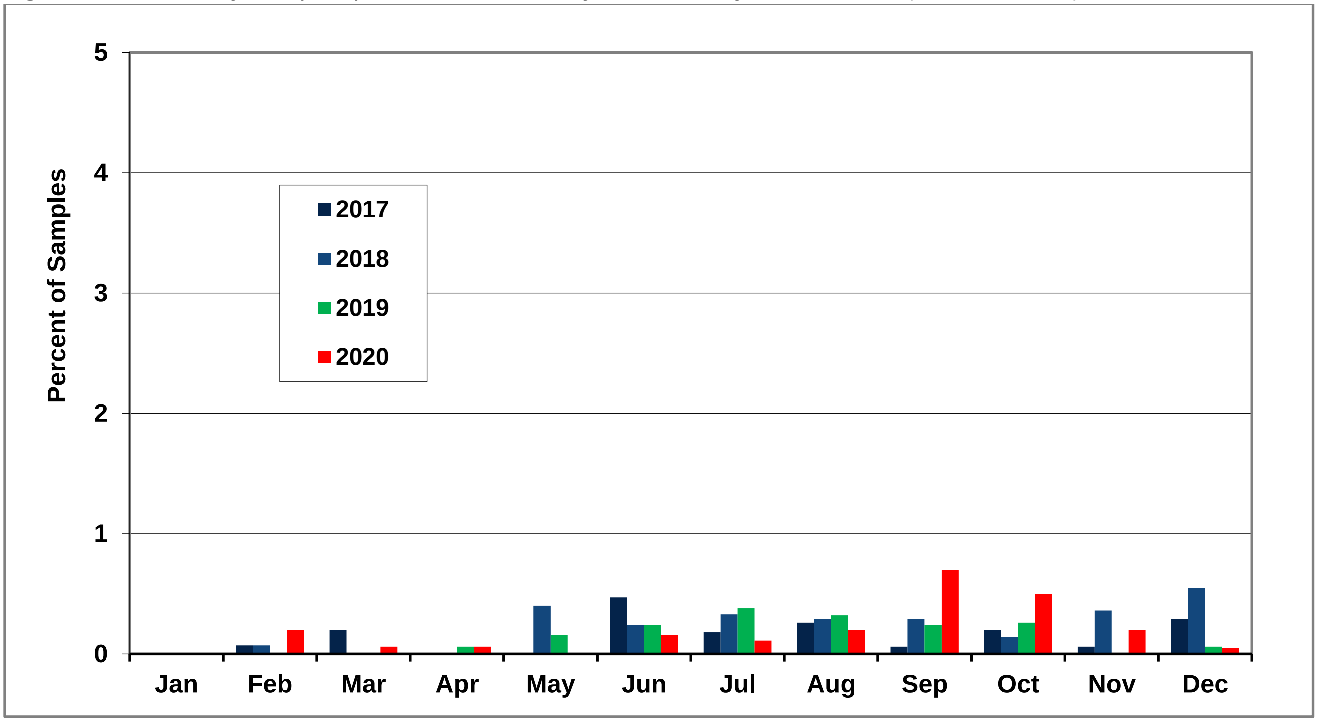
Table 10: Status of GVWD Reservoirs (2017-2020)

Reservoir (Capacity in Million Litres)	**Average Free Chlorine (mg/L)**				**Discussion**
	2017	**2018**	**2019**	**2020**	
Burnaby Mtn. Reservoir (14.1)	0.44	0.49	0.53	0.57	No operational issues
Burnaby Tank (2.4)	0.53	0.54	0.58	0.60	The tank was cleaned March 30-April 3 while remaining in service.
Cape Horn Reservoir (42.2)	0.53	0.78	0.61	0.78	No operational issues
Clayton Reservoir (22.4)	N/A	1.1	1.02	1.08	Drainage improvement project was completed in January. Cell 1 removed from service in the fall to reduce low use season storage.
Central Park Reservoir (37.0)	0.54	0.53	0.51	0.66	No operational issues
Glenmore Tanks (1.0)	0.64	0.66	0.68	0.77	No operational issues
Grandview Reservoir (14.3)	0.71	0.71	0.73	0.80	No operational issues
Greenwood Reservoir (9.2)	0.63	0.66	0.68	0.75	No operational issues
Hellings Tank (4.4)	0.45	0.47	0.48	0.54	No operational issues
Kennedy Reservoir (17.3)	0.52	0.56	0.52	0.58	No operational issues
Kersland Reservoir (78.7)	0.56	0.55	0.55	0.66	No operational issues
Little Mountain Reservoir (177.4)	0.66	0.64	0.67	0.72	No operational issues
Maple Ridge Reservoir (24.2)	0.52	0.53	0.52	0.44	New sampling kiosk installed in July.
Newton Reservoir (33.6)	0.56	0.45	0.46	0.55	No operational issues
Pebble Hill Reservoir (44.8)	0.64	0.63	0.60	0.66	Cell 1 taken out of service in the fall to reduce low use season storage.
Prospect Reservoir (4.6)	0.63	0.64	0.66	0.76	No operational issues
Sasamat Reservoir (27.6)	0.52	0.54	0.54	0.65	No operational issues
Sunnyside Reservoir (28.8)	0.65	0.58	0.47	0.73	Upgrade work on cell 1 and 2 throughout the year.
Vancouver Heights Reservoir (45.6)	0.68	0.66	0.75	0.82	No operational issues
Westburnco Reservoir (77.1)	0.50	0.58	0.58	0.64	No operational issues
Whalley Reservoir (35.7)	0.46	0.60	0.59	0.73	No operational issues

3.2. Microbiological Water Quality in Local Government Systems

For samples collected from local government systems, the percent positive per month for total coliform bacteria from 2017-2020 is shown in Figure 7.

Figure 7: Percent of Samples per Month Positive for Total Coliform Bacteria (2017 to 2020)



The percentage of samples positive for total coliform bacteria in 2020 remained relatively similar as compared to 2019.

Schedule A of the BCDWPR contains standards for the bacteriological quality of potable water in the Province. There are three components of this standard that apply to local governments:

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.

For samples from local government systems, this requirement was met in 2020 with the following exceptions:

- Two samples in June contained more than 10 total coliform bacteria.
- Three samples in September contained more than 10 total coliform bacteria.
- Two samples in October contained more than 10 total coliform bacteria.

Table 11 shows the compliance with the bacteriological standards (3 parts) in the BCDWPR for samples taken within the distribution systems of the 20 local governments that are supplied with GVWD water.

Table 11: Local Government Water Quality Compared to the Provincial Bacteriological Standards

Month	Number that met Part 1	Number that met Part 2	Number that met Part 3	Number that met all requirements
January	20	20	20	20
February	20	20	20	20
March	20	20	20	20
April	20	20	20	20
May	20	20	20	20
June	20	20	18	18
July	20	20	20	20
August	20	20	20	20
September	20	20	17	17
October	20	20	18	18
November	20	20	20	20
December	20	20	20	20

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

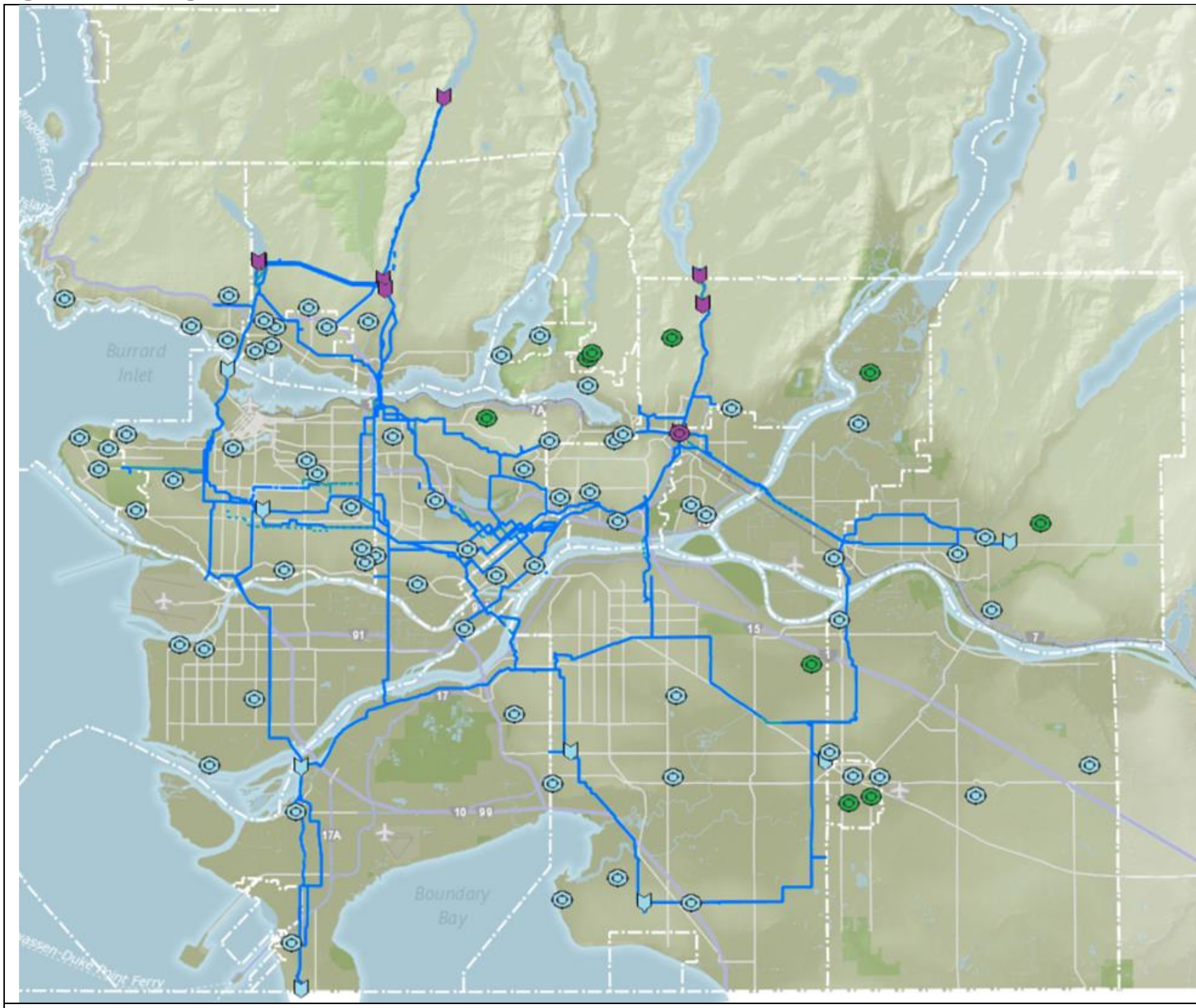
As the treated water moves through the GVWD Transmission system and into the local government distribution system infrastructure of pipes and reservoirs. Changes in water quality occur mainly due to the reaction between the chlorine in the water (added during primary and secondary disinfection) and naturally occurring organic matter in the water.

One of the most significant changes is the production of chlorinated disinfection by-products (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: The Total Trihalomethanes (TTHMs) and the Total Haloacetic Acids ($THAA_5$). 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 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 local government systems in 2020 is shown in Figure 8. All THM results from GVWD water mains and local government systems were below the MAC of 100 µg/L.

Figure 8: Average Total Trihalomethane Levels



2020 Average GVWD TTHM = 22 µg/L
2020 Average Local Governments TTHM = 31 µg/L

Total Trihalomethane Levels for GVWD Sites

- >= 0 AND < 20
- >= 20 AND < 40
- >= 40 AND < 60
- >= 60 AND < 80
- >= 80 AND < 100
- >= 100

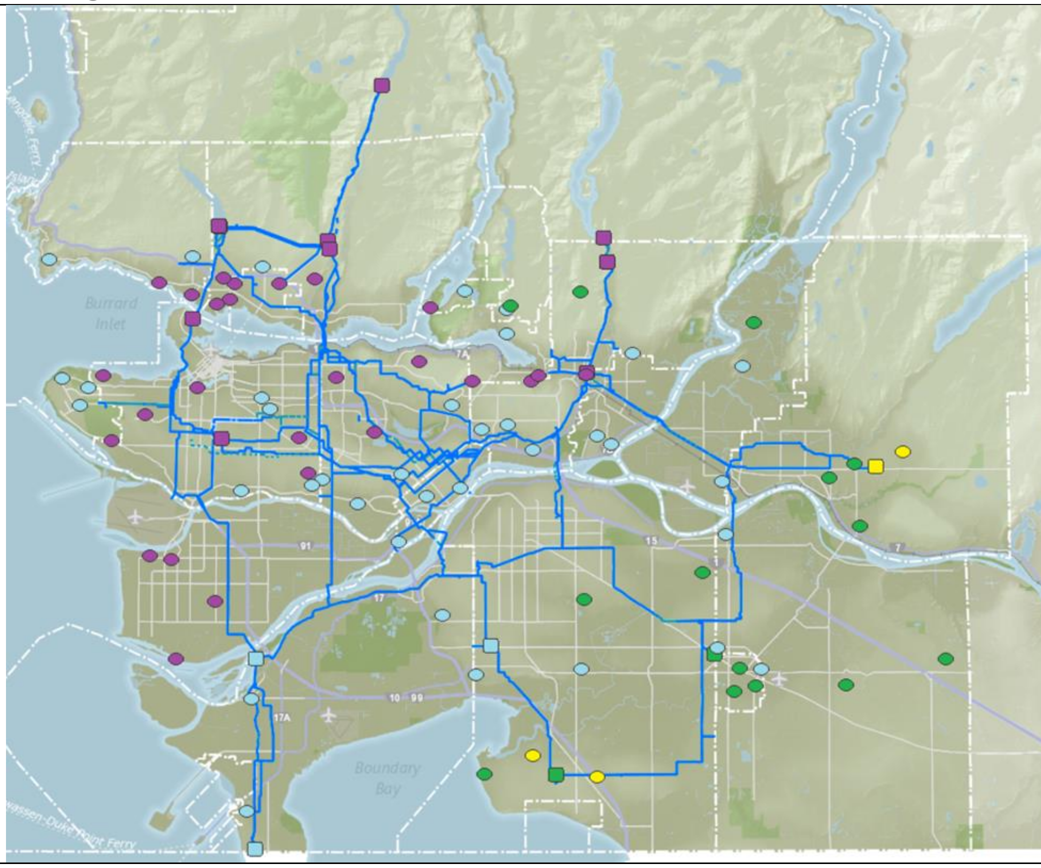
Total Trihalomethane Levels for Local Government Sites

- >= 0 AND < 20
- >= 20 AND < 40
- >= 40 AND < 60
- >= 60 AND < 80
- >= 80 AND < 100
- >= 100

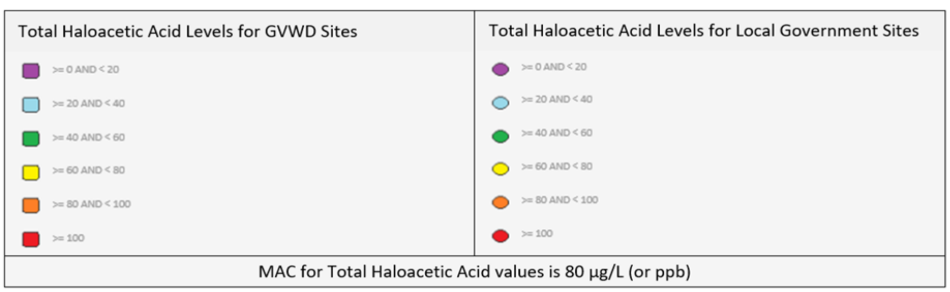
MAC for Total Trihalomethane values is 100 µg/L (or ppb)

The other group of disinfection by-products of interest is the Total Haloacetic Acid ($THAA_5$) group. Comparison of $THAA_5$ in the GVWD and local government systems in 2020 is shown in Figure 9. In 2020, eight locations had a single quarterly sample with $THAA5$ readings above 80 µg/L. The MAC is calculated on a locational yearly running average based on quarterly samples and despite the higher single readings, no location exceeded the yearly 80 µg/L MAC.

Figure 9: Average Total Haloacetic Acid Levels



2020 Average GVWD THAA = 24 µg/L
2020 Average Local Governments THAA = 30 µg/L



4.0 QUALITY CONTROL/QUALITY ASSURANCE

In 1994, as required by a new BC Ministry of Health program, the bacteriology section of the GVWD Laboratory received approval from the Provincial Medical Health Officer to perform bacteriological analysis of potable 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 have carried out an inspection of the GVWD Laboratory facilities at the Lake City Operations Centre in February 2019 as part of the process leading up to approval of the laboratory by the Provincial Health Officer. The next inspection is scheduled for 2022.

In addition to the approval process discussed above, the GVWD Laboratory is accredited by the Canadian Association for Laboratory Accreditation (CALA) for the analysis of parameters for which the laboratory has requested certification. The GVWD Laboratory has been inspected by representatives from CALA bi-annually since 1995.

Accreditation for the laboratory from the Standards Council of Canada was first received early in 1996 and continued until the middle of 2005, when accreditation was granted by CALA directly.

The most recent on-site audit took place in November 2019, and CALA issued accreditation approval in February 2020. The next CALA inspection will take place in the fall of 2021.

APPENDIX A — CHEMICAL AND PHYSICAL ANALYSIS SUMMARIES

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metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Physical and Chemical Analysis of Water Supply

2020 – Capilano Water System

	Untreated	Treated		Canadian Guideline		
Parameter	**Average**	**Average**	**Range**	**Days Exceeded**	**Limit**	**Reason Established**
Alkalinity as CaCO3 (mg/L)	2.9	10	5.8-12		none	
Aluminum Dissolved (µg/L)	81	29	20-48		none	
Aluminum Total (µg/L)	143	29	18-58		none	
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	Health
Barium Total (µg/L)	2.7	2.9	2.1-3.6	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	1160	4180	2460-4640		none	
Carbon Organic - Dissolved (mg/L)	1.9	0.7	0.4-1.0		none	
Carbon Organic - Total (mg/L)	1.9	0.7	0.5-1.0		none	
Chlorate (mg/L)	<0.01	0.02	0.02-0.03	0	1	Health
Chloride (mg/L)	<0.5	2.5	2.0-3.2	0	≤250	Aesthetic
Chromium Total (µg/L)	<0.07	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	17	<2	<2-2		none	
Color - True (TCU)	12	<1	<1-1	0	≤15	Aesthetic
Conductivity (µmhos/cm)	10	32	22-37		none	
Copper Total (µg/L)	3.1	<0.5	<0.5	0	≤1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as CaCO3 (mg/L)	3.6	11.1	6.7-12.3		none	
Iron Dissolved (µg/L)	34	<5	<5-8		none	
Iron Total (µg/L)	91	<5	<5-14	0	≤300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	167	171	122-200		none	
Manganese Dissolved (µg/L)	3.8	1.7	0.9-3.7		none	
Manganese Total (µg/L)	5.1	2.9	1.9-5.2	0	≤120	Health
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.07	0.06	0.03-0.12	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	7.4	7.2-7.7	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<5-<10		none	
Potassium Total (µg/L)	159	170	153-200		none	
Residue Total (mg/L)	18	28	23-32		none	
Residue Total Dissolved (mg/L)	10	20	20-30	0	≤500	Aesthetic
Residue Total Fixed (mg/L)	8	20	14-24		none	
Residue Total Volatile (mg/L)	10	8	6-11		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO2 (mg/L)	3.4	3.4	2.5-3.9		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	595	1580	1290-1800	0	≤200000	Aesthetic
Sulphate (mg/L)	0.7	1	0.7-1.4	0	≤500	Aesthetic
Turbidity (NTU)	1	0.12	0.08-0.21		none	
Turbidity IFE (NTU)	-	-	-	0	≤ 1.0	Health
UV Absorbance 254 nm (Abs/cm)	0.08	0.011	0.008-0.021		none	
Zinc Total (µg/L)	<3	<3	<3	0	≤5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from the intake prior to the raw water tunnel, treated water is from a single site in the GVWD distribution system after the treated water tunnel and before the breakhead tank. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Capilano Source was operational for 365 days in 2020.
[1]Treated turbidity guideline and the number of exceedances applies to Individual Filter Effluent readings; measured in events and not days.

Physical and Chemical Analysis of Water Supply

2020 – Seymour Water System

Parameter	Untreated Average	Treated Average	Treated Range	Canadian Guideline Days Exceeded	Canadian Guideline Limit	Canadian Guideline Reason Established
Alkalinity as CaCO3 (mg/L)	3.6	10	5.9-12		none	
Aluminum Dissolved (µg/L)	70	30	19-57		none	
Aluminum Total (µg/L)	199	29	18-66		none	
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	Health
Barium Total (µg/L)	3.7	3	2.1-3.5	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	1670	4210	2420-4820		none	
Carbon Organic - Dissolved (mg/L)	1.7	0.7	0.5-1.0		none	
Carbon Organic - Total (mg/L)	1.7	0.7	0.5-1.0		none	
Chlorate (mg/L)	<0.01	0.02	0.02-0.03	0	1	Health
Chloride (mg/L)	<0.5	2.5	2.0-3.2	0	≤250	Aesthetic
Chromium Total (µg/L)	0.06	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	19	<2	<2-2		none	
Color - True (TCU)	12	<1	<1-1	0	≤15	Aesthetic
Conductivity (µmhos/cm)	13	32	22-36		none	
Copper Total (µg/L)	19.9	<0.5	<0.5-0.7	0	≤1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as CaCO3 (mg/L)	4.9	11.2	6.6-12.9		none	
Iron Dissolved (µg/L)	80	<5	<5-7		none	
Iron Total (µg/L)	214	<6	<5-11	0	≤300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	182	173	121-204		none	
Manganese Dissolved (µg/L)	5.5	3.9	2.4-7.8		none	
Manganese Total (µg/L)	11.4	4.6	3.4-8.4	0	≤120	Health
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.06	0.06	0.03-0.12	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	7.4	7.2-7.6	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<5-<10		none	
Potassium Total (µg/L)	188	175	142-203		none	
Residue Total (mg/L)	20	25	23-27		none	
Residue Total Dissolved (mg/L)	10	20	10-20	0	≤500	Aesthetic
Residue Total Fixed (mg/L)	12	17	14-20		none	
Residue Total Volatile (mg/L)	9	8	5-11		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO2 (mg/L)	3.4	3.3	2.5-3.9		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	571	1580	1300-1810	0	≤200000	Aesthetic
Sulphate (mg/L)	1.2	1	0.7-1.4	0	≤500	Aesthetic
Turbidity (NTU)	1.6	0.12	0.07-0.59		none	
Turbidity IFE (NTU)	-	-	-	0	≤ 1.0	Health
UV Absorbance 254 nm (Abs/cm)	0.074	0.011	0.008-0.016		none	
Zinc Total (µg/L)	<3	<3	<3	0	≤5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from a sample site prior to coagulation, treated water is from a sample site downstream of the SCFP clearwell. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Seymour Source was operational for 365 days in 2020.

[1]Treated turbidity guideline and the number of exceedances applies to Individual Filter Effluent readings; measured in events and not days.

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Physical and Chemical Analysis of Water Supply

2020 – Coquitlam Water System

Parameter	Untreated Average	Treated Average	Treated Range	Canadian Guideline Days Exceeded	Canadian Guideline Limit	Canadian Guideline Reason Established
Alkalinity as CaCO3 (mg/L)	2	8.6	7.5-11		none	
Aluminum Dissolved (µg/L)	63	62	59-66		none	
Aluminum Total (µg/L)	100	96	77-166		none	
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	Health
Barium Total (µg/L)	2.4	2.3	2.1-2.5	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	837	834	799-873		none	
Carbon Organic - Dissolved (mg/L)	1.6	1.5	0.2-2.1		none	
Carbon Organic - Total (mg/L)	1.8	1.5	1.3-2.1		none	
Chlorate (mg/L)	<0.01	0.06	0.04-0.08	0	1	Health
Chloride (mg/L)	<0.5	2.2	1.8-2.5	0	≤250	Aesthetic
Chromium Total (µg/L)	<0.05	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	14	<2	<2-3		none	
Color - True (TCU)	10	<1	<1-1	0	≤15	Aesthetic
Conductivity (µmhos/cm)	8	27	25-33		none	
Copper Total (µg/L)	4.2	<0.5	<0.5	0	≤1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as CaCO3 (mg/L)	2.5	2.5	2.3-2.6		none	
Iron Dissolved (µg/L)	21	23	15-43		none	
Iron Total (µg/L)	52	52	35-97	0	≤300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	98	97	84-109		none	
Manganese Dissolved (µg/L)	4.1	2.3	1.5-3.0		none	
Manganese Total (µg/L)	4.6	3.2	2.4-4.6	0	≤120	Health
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.07	0.07	0.04-0.09	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.3	7.6	7.1-8.1	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<5-<10		none	
Potassium Total (µg/L)	113	114	106-122		none	
Residue Total (mg/L)	14	26	21-30		none	
Residue Total Dissolved (mg/L)	10	20	8-30	0	≤500	Aesthetic
Residue Total Fixed (mg/L)	7	16	11-22		none	
Residue Total Volatile (mg/L)	7	10	7-12		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO2 (mg/L)	2.6	2.6	2.4-2.9		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	470	5100	4640-5650	0	≤200000	Aesthetic
Sulphate (mg/L)	0.5	<0.6	<0.5-0.6	0	≤500	Aesthetic
Turbidity (NTU)	0.49	0.42	0.19-1.4		none	
UV 254 - Apparent (Abs/cm)	0.073	0.023	0.014-0.059		none	
UV Absorbance 254 nm (Abs/cm)	0.067	0.019	0.015-0.024		none	
Zinc Total (µg/L)	<3	<3	<3	0	≤5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from the intake prior to treatment, treated water is from a single site in the GVWD distribution system downstream of CWTP. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Recommended turbidity guidelines applies to finished treated water from an un-filtered source. Coquitlam source was operational for 365 days in 2020.

APPENDIX B — ANALYSIS OF WATER FOR ORGANIC/INORGANIC COMPONENTS AND RADIONUCLIDES

Analysis of Source Waters for Herbicides, Pesticides, Volatile Organic Compounds and Uranium

	Units	Date Sampled	MAC	AO	Capilano	Seymour	Coquitlam
Atrazine	µg/L	27-Oct-20	5		<0.50	<0.50	<0.50
Azinphos-Methyl	µg/L	27-Oct-20	20		<1.0	<1.0	<1.0
Benzene	µg/L	11-Dec-20	5		<0.50	<0.50	<0.50
Benzo(a)pyrene	µg/L	16-Jun-20	0.04		<0.0050	<0.0050	<0.0050
Bromoxynil	µg/L	27-Oct-20	5		<0.50	<0.50	<0.50
Carbaryl	µg/L	27-Oct-20	90		<5.0	<5.0	<5.0
Carbofuran	µg/L	27-Oct-20	90		<5.0	<5.0	<5.0
Carbon Tetrachloride	µg/L	11-Dec-20	2		<0.50	<0.50	<0.50
Cyanobacterial toxins—Microcystin-LR	µg/L	Apr–Nov-20	1.5		<0.20	<0.20	<0.20
Chlorpyrifos	µg/L	27-Oct-20	90		<2.0	<2.0	<2.0
Diazinon	µg/L	27-Oct-20	20		<2.0	<2.0	<2.0
Dicamba	µg/L	27-Oct-20	120		<1.0	<1.0	<1.0
Dichlofop-Methyl	µg/L	27-Oct-20	9		<0.90	<0.90	<0.90
Dichlorobenzene, 1,2-	µg/L	11-Dec-20	200	≤ 3	<0.50	<0.50	<0.50
Dichlorobenzene, 1,4-	µg/L	11-Dec-20	5	≤ 1	<0.50	<0.50	<0.50
Dichloroethane, 1,2-	µg/L	11-Dec-20	5		<0.50	<0.50	<0.50
Dichloroethylene, 1,1-	µg/L	11-Dec-20	14		<0.50	<0.50	<0.50
Dichloromethane	µg/L	11-Dec-20	50		<1.0	<1.0	<1.0
Dichlorophenol, 2,4-	µg/L	27-Oct-20	900	≤ 0.3	<0.33	<0.10	<0.10
Dichlorophenoxyacetic acid, 2,4-(2,4-D)	µg/L	27-Oct-20	100		<1.0	<1.0	<1.0
Dimethoate	µg/L	27-Oct-20	20		<2.0	<2.0	<2.0
Diquat	µg/L	27-Oct-20	70		<7.0	<7.0	<7.0
Diuron	µg/L	27-Oct-20	150		<10.0	<10.0	<10.0
Ethylbenzene	µg/L	11-Dec-20	140	≤ 1.6	<0.5	<0.5	<0.5
Glyphosate	µg/L	27-Oct-20	280		<10.0	<10.0	<10.0
Malathion	µg/L	27-Oct-20	190		<2.0	<2.0	<2.0
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	µg/L	27-Oct-20	100		<2.0	<2.0	<2.0
Methyl t-butyl ether (MTBE)	µg/L	11-Dec-20	None	≤ 15	<0.50	<0.50	<0.50
Metolachlor	µg/L	27-Oct-20	50		<5.0	<5.0	<5.0
Metribuzin	µg/L	27-Oct-20	80		<5.0	<5.0	<5.0
Monochlorobenzene	µg/L	11-Dec-20	80	≤ 30	<0.50	<0.50	<0.50
N-Nitroso dimethylamine (NDMA)	µg/L	27-Oct-20	0.04		<0.0021	<0.0021	<0.0021
Nitrilotriacetic Acid (NTA)	µg/L	27-Oct-20	400		<50.0	<50.0	380
Paraquat (as Dichloride)	µg/L	27-Oct-20	10		<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	27-Oct-20	60	≤30	<0.33	<0.10	<0.10

	Units	Date Sampled	MAC	AO	Capilano	Seymour	Coquitlam
Phorate	µg/L	27-Oct-20	2		<1.0	<1.0	<1.0
Picloram	µg/L	27-Oct-20	190		<5.0	<5.0	<5.0
Simazine	µg/L	27-Oct-20	10		<2.0	<2.0	<2.0
Terbufos	µg/L	27-Oct-20	1		<1.0	<1.0	<1.0
Tetrachloroethylene	µg/L	11-Dec-20	10		<0.50	<0.50	<0.50
Tetrachlorophenol, 2,3,4,6-	µg/L	27-Oct-20	100	≤ 1	<0.33	<0.10	<0.10
Toluene	µg/L	11-Dec-20	60	24	<0.50	<0.50	<0.50
Trichloroethylene	µg/L	11-Dec-20	5		<0.50	<0.50	<0.50
Trichlorophenol, 2,4,6-	µg/L	27-Oct-20	5	≤ 2	<0.33	<0.10	<0.10
Trifluralin	µg/L	27-Oct-20	45		<5.0	<5.0	<5.0
Uranium (Total)	µg/L	27-Oct-20	20		0.0298	0.0231	0.0489
Vinyl Chloride	µg/L	11-Dec-20	2		<1.0	<1.0	<1.0
Xylene (Total)	µg/L	11-Dec-20	90	≤ 20	<1.0	<1.0	<1.0

Monitoring of Selected GVWD Water Mains for BTEXs

Parameters	Units	MAC	AO	Maple Ridge Main at Reservoir		Barnston Island Main at Willoughby PS		Jericho-Clayton Main		South Burnaby Main #2	
				15-Jun	23-Nov-	17-Jun	25-Nov	17-Jun	25-Nov	18-Jun	25-Nov
Benzene	µg/L	5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	µg/L	140	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/L	60	24	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylenes Total)	µg/L	90	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Analysis of Source Water for PAH's

Parameters	Units	Capilano		Seymour		Coquitlam	
		16-Jun	24-Nov	16-Jun	24-Nov	16-Jun	24-Nov
Acenaphthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Acenaphthylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Acridine	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)anthracene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)pyrene[1]	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b+j)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(b+j+k)fluoranthene	µg/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Benzo(g,h,i)perylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(k)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chrysene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Dibenzo(a,h)anthracene	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Fluorene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Indeno(1,2,3-c,d)pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 1-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 2-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Naphthalene	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phenanthrene	µg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Quinoline	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Analysis of Selected GVWD Mains for PAHs

Parameters	Units	Coquitlam Main #2	Westburnco Reservoir		Barnston Island		Queensborough		Whalley Kennedy Link Main		Haney Main #2		36th Ave Main
		16-Jun	25-Nov	17-Jun	25-Nov	18-Jun	24-Nov	16-Jun	23-Nov	15-Jun	23-Nov	17-Jun	26-Nov
Acenaphthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Acenaphthylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Acridine	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	µg/L	<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)anthracene	µg/L	<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[1]	µg/L	<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	µg/L	<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(b+j+k)fluoranthene	µg/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Benzo(g,h,i)perylene	µg/L	<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(k)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chrysene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Dibenzo(a,h)anthracene	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Fluorene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010
Indeno(1,2,3-c,d)pyrene	µg/L	<0.010	<0.010	<0.010	<0.000	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 1-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 2-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Naphthalene	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phenanthrene	µg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Quinoline	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

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

Monitoring of Source Waters for PFOS and PFOA [1]

Parameters	Units	MAC	Capilano	Seymour	Coquitlam
PFOS	ng/L	600	<0.765	<0.756	<0.757
PFOA	ng/L	200	<0.765	<0.756	<0.757

ANALYTE	Capilano	Seymour	Coquitlam
PFBA	<3.06	<3.03	<3.03
PFPeA	<1.53	<1.51	<1.51
PFHxA	<0.765	<0.756	<0.757
PFHpA	<0.765	<0.756	<0.757
PFOA	<0.765	<0.756	<0.757
PFNA	<0.765	<0.756	<0.757
PFDA	<0.765	<0.756	<0.757
PFUnA	<0.765	<0.756	<0.757
PFDoA	<0.765	<0.756	<0.757
PFTrDA	<0.765	<0.756	<0.757
PFTeDA	<0.765	<0.756	<0.757
PFBS	<0.765	<0.756	<0.757
PFPeS	<0.765	<0.756	<0.757
PFHxS	<0.765	<0.756	<0.757
PFHpS	<0.765	<0.756	<0.757
PFOS	<0.765	<0.756	<0.757
PFNS	<0.765	<0.756	<0.757
PFDS	<0.765	<0.756	<0.757
PFDoS	<0.765	<0.756	<0.757
4:2 FTS	<3.06	<3.03	<3.03
6:2 FTS	<2.75	<2.72	<2.73
8:2 FTS	<3.06	<3.03	<3.03
PFOSA	<0.765	<0.756	<0.757
N-MeFOSA	<0.88	<0.87	<0.871
N-EtFOSA	<1.91	<1.89	<1.89
MeFOSAA	<0.765	<0.756	<0.757
EtFOSAA	<0.765	<0.756	<0.757
N-MeFOSE	<7.65	<7.56	<7.57
N-EtFOSE	<5.74	<5.67	<5.68
HFPO-DA	<2.91	<2.87	<2.88
ADONA	<3.06	<3.03	<3.03
9Cl-PF3ONS	<3.06	<3.03	<3.03
11Cl-PF3OUdS	<3.06	<3.03	<3.03

[1]Samples analyzed on April 27th.

Analysis of Source Water for Radioactivity

Radioactivity	Units	Date Sampled	MAC[1]	Capilano	Seymour	Coquitlam
				Activity	Activity	Activity
Gross Alpha	Bq/L	06-Oct-20	<0.5	<0.10	<0.10	<0.10
Gross Beta	Bq/L	06-Oct-20	<1.0	<0.10	<0.10	<0.10
Cobalt-60	Bq/L	06-Oct-20	2	<1	<1	<1
Cesium-134	Bq/L	06-Oct-20	7	<1	<1	<1
Cesium-137	Bq/L	06-Oct-20	10	<1	<1	<1
Iodine-131	Bq/L	06-Oct-20	6	<1	<1	<1
Lead-210	Bq/L	06-Oct-20	0.2	<0.10	<0.10	<0.10
Radium-226	Bq/L	06-Oct-20	0.5	<1.0	<1.0	<1.0
Radon-222	Bq/L	06-Oct-20	None	16	<10	<10
Strontium-90	Bq/L	06-Oct-20	5	<0.10	<0.10	<0.10
Tritium (H-3)	Bq/L	06-Oct-20	7000	<20	<20	<20
Radon-222 Repeat[1]	Bq/L	15-Dec-20	None	<10	<10	<10

[1]The October 6, 2020 Radon-222 result for the Capilano Source was unusual. A repeat of the test was done with a sample taken on December 15, 2020.

APPENDIX C — ANALYSIS OF SOURCE WATERS FOR THE RESERVOIR MONITORING PROGRAM

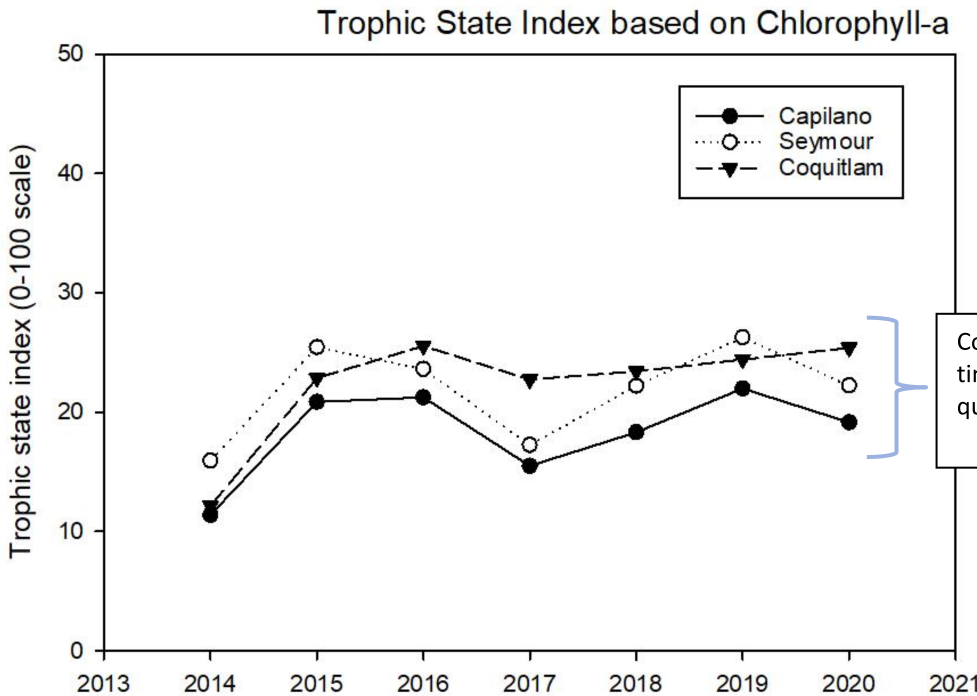
Comparison of Water Quality in Metro Vancouver Reservoirs to Standard Water Quality Classifications

Chemical measurement[2]	Average value[3]					Status of Reservoirs
	Ultra-oligotrophic status defined in the scientific literature[1]	Oligotrophic status defined in the scientific literature[1]	Capilano Reservoir 2014 – 2020 (2020 only in brackets)	Seymour Reservoir 2014 – 2020 (2020 only in brackets)	Coquitlam Reservoir 2014 – 2020 (2020 only in brackets)	
Total phosphorus (parts per billion)	5	8.0	3.0 (3.0)	3.0 (3.0)	2.0 (2.0)	Ultraoligotrophic (very high water quality)
Total Nitrogen (parts per billion)	250	661	126 (118)	130 (116)	129 (119)	Ultraoligotrophic (very high water quality)
Phytoplankton biomass (parts per billion of chlorophyll-a)	0.5	1.7	0.42 (0.39)	0.56 (0.49)	0.53 (0.64)	Ultraoligotrophic (very high water quality)

[1]e.g. Wetzel, R.G. 2001 River Ecosystems. 3rd edition. Academic Press. New York.
Ultraoligotrophic means very low nutrient content and very low biological production: very high water quality
Oligotrophic means low nutrient content and low biological production (low risk of algal blooms): high water quality
[2]Chemical measurements are defined as follows:

- Phosphorus and nitrogen are nutrients that primarily control the growth of algae, including cyanobacteria.
- Phytoplankton biomass includes cells of all algae and cyanobacteria species in a reservoir.

[3]Values are averages from all water depths during April through November of all years. Values in brackets are average values only from 2020.



Consistently low TSI values over time show sustained high water quality

APPENDIX D — REPORT TO METRO VANCOUVER ON *GIARDIA* AND *CRYPTOSPORIDIUM* STUDY

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

January - December, 2020
Annual Report

January 2021

Dr. Natalie Prystajecky, Program Head
Christine Tchao, Team Lead
Tracy Chan, Technical Coordinator
Daisy Yu, Technical Coordinator

Environmental Microbiology
BCCDC Public Health Laboratory
Provincial Health Services Authority

Metro Vancouver
Detection of Waterborne *Giardia* and *Cryptosporidium*
January - December, 2020 Annual Report

Purpose

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

Introduction

Giardia and *Cryptosporidium* species are parasites that infect the intestinal tracts of a wide range of warm-blooded animals. In humans, infection with *Giardia lamblia* or *Cryptosporidium* species can cause gastroenteritis. As the cyst and oocyst forms of *Giardia* and *Cryptosporidium* 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 and Coquitlam reservoirs, as well as Recycled Clarified Water (RCW) at the Seymour Capilano Filtration Plant (SCFP) for the presence of *Giardia* cysts and *Cryptosporidium* oocysts. 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 quantitation 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 staff at specific sampling sites at the reservoirs and filtration plants. Samples were filtered in the field using Pall Life Science Envirochek HV filters. After collection, filters were then transported to the Environmental Microbiology Laboratory at BCCDC PHL by Metro Vancouver staff, where they were processed and analysed within 96 hours. Negative and positive 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 2020, a total of 36 filters were examined (excluding matrix spikes). These included:

- 12 Envirochek filters from the Capilano reservoir
- 12 Envirochek filters from the Coquitlam reservoir
- 12 Envirochek filters from SCFP-RCW

The summary of our findings are presented in Figures 1 - 3 and Tables 1 - 5. An average of 50.0L of raw water was filtered for both the Capilano and Coquitlam reservoirs per month. The average detection limit for Capilano and Coquitlam were <2.0 (oo)cysts per 100L for both reservoirs. The average volume of water filtered and detection limit for SCFP-RCW was 604.2L and <0.41(oo)cysts per 100L, respectively (Appendix A, Tables A1-A3).

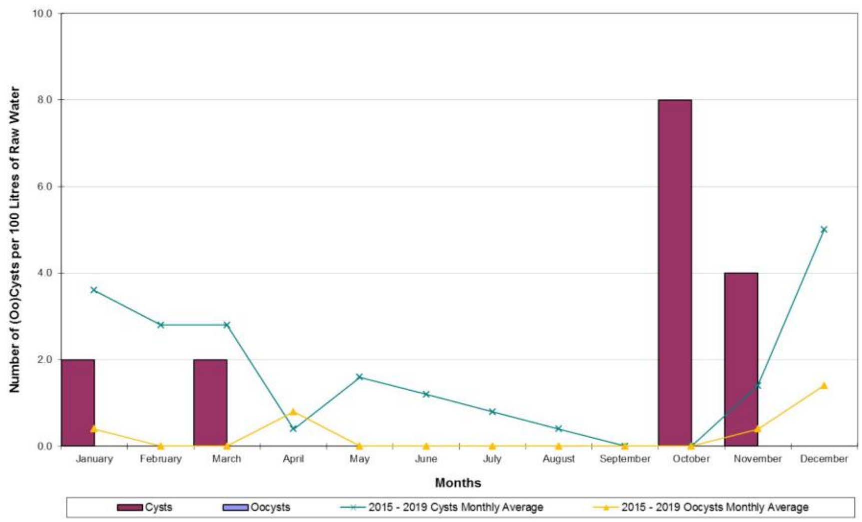

Figure 1: 2020 Capilano Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water

3

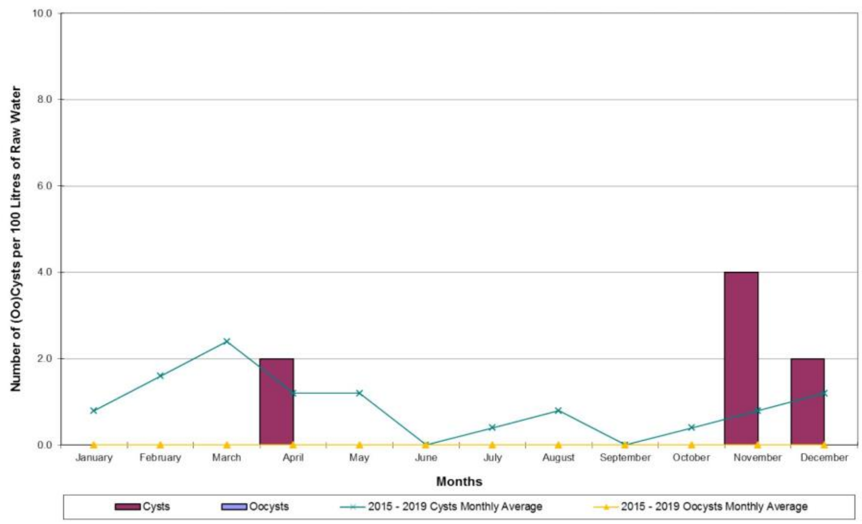

Figure 2: 2020 Coquitlam Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water

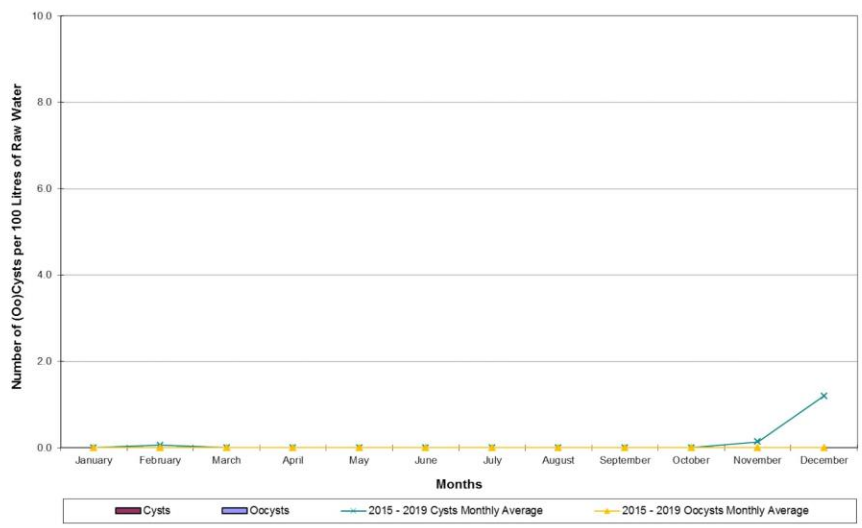

Figure 3: 2020 Seymour Capilano Filtration Plant – Recycled Clarified Water *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water

Overall, similar trends were observed for both *Cryptosporidium* and *Giardia* in 2020, in comparison to historical data.

	Capilano Reservoir	Coquitlam Reservoir	SCFP - RCW
Number of Water Filter Tested	12	12	12
% Filters – *Giardia* Positive	33.3%	25.0%	0.0%
% Filters – *Cryptosporidium* Positive	0.0%	0.0%	0.0%

Table 1: 2020 *Giardia* and *Cryptosporidium* Percent Positives for Metro Vancouver Water Filters

Sampling Sites	# of Water Filters Tested	Average Detection Limit (oo)cysts/ 100 L	Max Detection (oo)cysts/ 100L	Min Detection (oo)cysts/ 100L	# of *Giardia* Positive Filters	Max # of *Giardia* cysts/ 100L	# of *Crypto* Positive Filters	Max # of *Crypto* oocysts/ 100L
All Sites	36	<1.47	5.0	1.5	2.3	4.0	0.0	0.0
Capilano Reservoir	12	<2.0	8	2	4	8	0	0
Coquitlam Reservoir	12	<2.0	2	2	3	4	0	0
SCFP - RCW	12	<0.41	NPD*	0.41	0	0	0	0

*NDP = No Parasites Detected

Table 2: 2020 *Giardia* Cyst and *Cryptosporidium* Oocyst Concentrations for Positive Water Filters

Results for staining by IFA, DAPI and internal morphology, as determined through DIC microscopy, for every identified cyst and oocyst were recorded and summarized in Tables A4 – A9 in the Appendix A.

DAPI staining is used as part of the confirmation of the internal structure of *Giardia* cysts and *Cryptosporidium* oocysts; it is used as an indicator of nuclei integrity by staining the DNA. It can also approximate cysts/oocysts integrity; the absence of nuclei is indicative of an aged, damaged or non-infective cell. A number of cysts (Table 3, 5) and oocysts (Table 4, 5) observed across all sites had no visible nuclei indicating that they were aged and likely subjected to environmental degradation. However, they were likely in previous infective state.

Likewise, DIC microscopy is used primarily for *Giardia* cyst and *Cryptosporidium* oocyst confirmation but it can also serve as an indicator of cysts/oocysts 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.

Site	Total number of cysts	DAPI -	DAPI +		D.I.C.				
							Cysts with internal structure		
		Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Nuclei stained sky blue	Empty cysts (no cytoplasm)	Cysts with amorphous structure	Nuclei	Median body	Axoneme
Capilano	8	7 (87.5%)	0 (0.0%)	1 (14.3%)	0 (0.0%)	8 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Coquitlam	4	2 (50.0%)	0 (0.0%)	2 (50.0%)	0 (0.0%)	4 (100.0%)	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 (0.0%)	0 (0.0%)

Table 3: 2020 Summary of morphological results for *Giardia* cysts observed under fluorescence microscope

Site	Total number of oocysts	DAPI -	DAPI +		D.I.C.		
		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
							Number of sporozoites
Capilano	0	0 (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 (0.0%)
SCFP-RCW	0	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 4: 2020 Summary of morphological results for *Cryptosporidium* oocysts observed under fluorescence microscope

Number of Nuclei	*Giardia* Cysts			*Cryptosporidium* Oocysts		
	Capilano	Coquitlam	SCFP-RCW	Capilano	Coquitlam	SCFP-RCW
0*	7 (87.5%)	2 (50.0%)	-	-	-	-
1	-	-	-	-	-	-
2	1 (12.5%)	-	-	-	-	-
3	-	2 (50.0%)	-	-	-	-
4	-	-	-	-	-	-
Total # of (oo)cysts	8	4	0	0	0	0

* DAPI negative or only intense blue internal staining of cytoplasm.

Table 5: 2020 Comparisons of number of nuclei in each *Giardia* cysts and *Cryptosporidium* Oocysts between different sites

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 (2007-2020) are compiled in Table 6. 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 2020 was successful on a single sampling event at each site. 50L were filtered from each site and the percentage recovery for *Giardia* cysts and *Cryptosporidium* oocysts were noted.

Year	Capilano		Coquitlam		SCFP-RCW	
	Cysts	Oocysts	Cysts	Oocysts	Cysts	Oocysts
2007	37.4%	27.6%	54.0%	28.0%	-	-
2008	55.0%	25.0%	39.0%	28.0%	-	-
2009	40.0%	10.0%	37.0%	16.0%	-	-
2010	43.0%	28.0%	49.0%	26.0%	13.0%	17.0%
2011	44.0%	27.0%	47.0%	22.0%	0.0%	1.0%
2012	76.5%	38.4%	49.0%	35.0%	13.7%	7.0%
2013	59.4%	22.4%	64.4%	16.3%	14.9%	6.12%
2014	-	-	39.4%	55.0%	14.1%	18.0%
2015	40.4%	26.3%	60.6%	2.0%	26.5%	9.1%
2016	47.5%	35.4%	50.5%	22.2%	14.0%	9.1%
2017	38.4%	20.2%	21.2%	22.2%	2.0%	0.0%
2018	75.8%	43.4%	59.6%	17.1%	11.1%	1.0%
2019	43.0%	0.0%	55.0%	1.0%	4.1%	0.0%
2020	37.4%	5.1%	59.8%	8.1%	4.0%	0.0%

- No matrix sample collected

Table 6: Matrix water results from 2007 - 2020

Summary

In brief, we reported that:

1. Overall, a steady positivity rate was observed across all sites for both cysts and oocysts.
2. *Giardia* cysts were detected in filters from Capilano and Coquitlam but not from SCFP-RCW. 33.3% of all filters received from Capilano were positive for *Giardia*, and 25% of all filters received from Coquitlam were positive for *Giardia*, and there were no *Giardia* cysts detected for SCFP-RCW.
3. *Cryptosporidium* oocysts were not detected in Capilano reservoir, Coquitlam reservoir and SCFP-RCW.
4. The highest concentration of *Giardia* cysts detected in 2020 was from Capilano reservoir in January (6 cysts per 100 L).
5. Most of the *Giardia* cysts detected showed evidence of environmental degradation.
6. Matrix recovery for *Cryptosporidium* oocyst continued to be low, which is consistent with previous years. Performing an additional matrix collection to understand the effects of matrix spike recovery when collected in a different season (i.e. spring/ summer) is recommended.

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, and Melody Sato 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

	Water Filter #	Site Location	Sampling Date	Month	Detection Limit (per 100L)	No. of Cysts per 100L	No. of Oocysts per 100L	Volume of Water Filtered (L)	2015 - 2019 Monthly Average	
									No. of Cysts per 100L	No. of Oocysts per 100L
1	8075	Capilano Reservoir	January 12, 2020	January	<2.0	2.0	0.0	50.0	3.6	0.4
2	8080	Capilano Reservoir	February 9, 2020	February	<2.0	0.0	0.0	50.0	2.8	0.0
3	8085	Capilano Reservoir	March 15, 2020	March	<2.0	2.0	0.0	50.0	2.8	0.0
4	8090	Capilano Reservoir	April 19, 2020	April	<2.0	0.0	0.0	50.0	0.4	0.8
5	8095	Capilano Reservoir	May 10, 2020	May	<2.0	0.0	0.0	50.0	1.6	0.0
6	8100	Capilano Reservoir	June 14, 2020	June	<2.0	0.0	0.0	50.0	1.2	0.0
7	8111	Capilano Reservoir	July 19, 2020	July	<2.0	0.0	0.0	50.0	0.8	0.0
8	8116	Capilano Reservoir	August 16, 2020	August	<2.0	0.0	0.0	50.0	0.4	0.0
9	8121	Capilano Reservoir	September 20, 2020	September	<2.0	0.0	0.0	50.0	0.0	0.0
10	8126	Capilano Reservoir	October 18, 2020	October	<2.0	8.0	0.0	50.0	0.0	0.0
11	8136	Capilano Reservoir	November 15, 2020	November	<2.0	4.0	0.0	50.0	1.4	0.4
12	8144	Capilano Reservoir	December 13, 2020	December	<2.0	0.0	0.0	50.0	5.0	1.4
				Averages	<2.0	1.3	0.0	50.0		

Table A1: 2020 Metro Vancouver Capilano Reservoir Monthly Filter Results

	Water Filter #	Site Location	Sampling Date	Month	Detection Limit (per 100L)	No. of Cysts per 100L	No. of Oocysts per 100L	Volume of Water Filtered (L)	2015 - 2019 Monthly Average	
									No. of Cysts per 100L	No. of Oocysts per 100L
1	8076	Coquitlam Reservoir	January 12, 2020	January	<2.0	0.0	0.0	50.0	0.8	0.0
2	8081	Coquitlam Reservoir	February 9, 2020	February	<2.0	0.0	0.0	50.0	1.6	0.0
3	8086	Coquitlam Reservoir	March 15, 2020	March	<2.0	0.0	0.0	50.0	2.4	0.0
4	8091	Coquitlam Reservoir	April 19, 2020	April	<2.0	2.0	0.0	50.0	1.2	0.0
5	8096	Coquitlam Reservoir	May 10, 2020	May	<2.0	0.0	0.0	50.0	1.2	0.0
6	8101	Coquitlam Reservoir	June 14, 2020	June	<2.0	0.0	0.0	50.0	0.0	0.0
7	8112	Coquitlam Reservoir	July 19, 2020	July	<2.0	0.0	0.0	50.0	0.4	0.0
8	8117	Coquitlam Reservoir	August 16, 2020	August	<2.0	0.0	0.0	50.0	0.8	0.0
9	8122	Coquitlam Reservoir	September 20, 2020	September	<2.0	0.0	0.0	50.0	0.0	0.0
10	8127	Coquitlam Reservoir	October 18, 2020	October	<2.0	0.0	0.0	50.0	0.4	0.0
11	8137	Coquitlam Reservoir	November 15, 2020	November	<2.0	4.0	0.0	50.0	0.8	0.0
12	8145	Coquitlam Reservoir	December 13, 2020	December	<2.0	2.0	0.0	50.0	1.2	0.0
				Averages	<2.0	0.7	0.0	50.0		

Table A2: 2020 Metro Vancouver Coquitlam Reservoir Monthly Filter Results

	Water Filter #	Site Location	Sampling Date	Month	Detection Limit (per 100L)	No. of Cysts per 100L	No. of Oocysts per 100L	Volume of Water Filtered (L)	2015 - 2019 Monthly Average	
									No. of Cysts per 100L	No. of Oocysts per 100L
1	8077	SCFP - Recycled Clarified Water	January 12, 2020	January	<0.07	0.0	0.0	1460.1	0.0	0.0
2	8082	SCFP - Recycled Clarified Water	February 11, 2020	February	<0.19	0.0	0.0	525.3	0.1	0.0
3	8087	SCFP - Recycled Clarified Water	March 17, 2020	March	<0.36	0.0	0.0	280.4	0.0	0.0
4	8092	SCFP - Recycled Clarified Water	April 21, 2020	April	<1.6	0.0	0.0	63.9	0.0	0.0
5	8097	SCFP - Recycled Clarified Water	May 12, 2020	May	<0.6	0.0	0.0	177.0	0.0	0.0
6	8102	SCFP - Recycled Clarified Water	June 16, 2020	June	<0.04	0.0	0.0	2608.3	0.0	0.0
7	8113	SCFP - Recycled Clarified Water	July 21, 2020	July	<0.29	0.0	0.0	350.4	0.0	0.0
8	8118	SCFP - Recycled Clarified Water	August 18, 2020	August	<0.17	0.0	0.0	580.3	0.0	0.0
9	8123	SCFP - Recycled Clarified Water	September 22, 2020	September	<0.3	0.0	0.0	338.0	0.0	0.0
10	8128	SCFP - Recycled Clarified Water	October 20, 2020	October	<0.2	0.0	0.0	499.0	0.0	0.0
11	8138	SCFP - Recycled Clarified Water	November 17, 2020	November	<0.64	0.0	0.0	155.3	0.1	0.0
12	8146	SCFP - Recycled Clarified Water	December 15, 2020	December	<0.47	0.0	0.0	212.5	1.2	0.0
				Averages	<0.41	0.0	0.0	604.2		

Table A3: 2020 Metro Vancouver Seymour Capilano Filtration Plant – Recycled Clarified Water (SCFP-RCW) Monthly Filter Results

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			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
8075	Capilano Reservoir	January 12, 2020	1	Oval	14x7	P				P			
8080	Capilano Reservoir	February 9, 2020	0										
8085	Capilano Reservoir	March 15, 2020	1	Oval	15x10	P				P			
8090	Capilano Reservoir	April 19, 2020	0										
8095	Capilano Reservoir	May 10, 2020	0										
8100	Capilano Reservoir	June 14, 2020	0										
8111	Capilano Reservoir	July 19, 2020	0										
8116	Capilano Reservoir	August 16, 2020	0										
8121	Capilano Reservoir	September 20, 2020	0										
8126	Capilano Reservoir	October 18, 2020	1	Oval	10x7	P				P			
8126	Capilano Reservoir	October 18, 2020	2	Oval	10x7	P				P			
8126	Capilano Reservoir	October 18, 2020	3	Oval	11x10	P				P			
8126	Capilano Reservoir	October 18, 2020	4	Oval	11x10	P				P			
8136	Capilano Reservoir	November 15, 2020	1	Oval	11x10	P				P			
8136	Capilano Reservoir	November 15, 2020	2	Oval	12x10			2		P			
8144	Capilano Reservoir	December 13, 2020	0										

P = Present

Table A4: 2020 Metro Vancouver Capilano Reservoir Slide Examination *Giardia* Results

			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
8076	Coquitlam Reservoir	January 12, 2020	0										
8081	Coquitlam Reservoir	February 9, 2020	0										
8086	Coquitlam Reservoir	March 15, 2020	0										
8091	Coquitlam Reservoir	April 19, 2020	1	Oval	13x7			3		P			
8096	Coquitlam Reservoir	May 10, 2020	0										
8101	Coquitlam Reservoir	June 14, 2020	0										
8112	Coquitlam Reservoir	July 19, 2020	0										
8117	Coquitlam Reservoir	August 16, 2020	0										
8122	Coquitlam Reservoir	September 20, 2020	0										
8127	Coquitlam Reservoir	October 18, 2020	0										
8137	Coquitlam Reservoir	November 15, 2020	1	Oval	15x10	P				P			
8137	Coquitlam Reservoir	November 15, 2020	2	Oval	14x9			3		P			
8145	Coquitlam Reservoir	December 13, 2020	1	Oval	18x6	P				P			

P = Present

Table A5: 2020 Metro Vancouver Coquitlam Reservoir Slide Examination *Giardia* Results

			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
8077	SCFP - Recycled Clarified Water	January 12, 2020	0										
8082	SCFP - Recycled Clarified Water	February 11, 2020	0										
8087	SCFP - Recycled Clarified Water	March 17, 2020	0										
8092	SCFP - Recycled Clarified Water	April 21, 2020	0										
8097	SCFP - Recycled Clarified Water	May 12, 2020	0										
8102	SCFP - Recycled Clarified Water	June 16, 2020	0										
8113	SCFP - Recycled Clarified Water	July 21, 2020	0										
8118	SCFP - Recycled Clarified Water	August 18, 2020	0										
8123	SCFP - Recycled Clarified Water	September 22, 2020	0										
8128	SCFP - Recycled Clarified Water	October 20, 2020	0										
8138	SCFP - Recycled Clarified Water	November 17, 2020	0										
8146	SCFP - Recycled Clarified Water	December 15, 2020	0										

P=Present

Table A6: 2020 Metro Vancouver Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination *Giardia* Results

			Cryptosporidium								
			Cryptosporidium			DAPI -	DAPI +		DIC		
Lab #	Site name	Date sampled	Object located by FA2	Shape (oval or round)2	Size L x W (µm)2	Light blue internal staining, no distinct nuclei, green rim2	Intense blue internal staining2	Number of nuclei stained sky blue2	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8075	Capilano Reservoir	January 12, 2020	0								
8080	Capilano Reservoir	February 9, 2020	0								
8085	Capilano Reservoir	March 15, 2020	0								
8090	Capilano Reservoir	April 19, 2020	0								
8095	Capilano Reservoir	May 10, 2020	0								
8100	Capilano Reservoir	June 14, 2020	0								
8111	Capilano Reservoir	July 19, 2020	0								
8116	Capilano Reservoir	August 16, 2020	0								
8121	Capilano Reservoir	September 20, 2020	0								
8126	Capilano Reservoir	October 18, 2020	0								
8136	Capilano Reservoir	November 15, 2020	0								
8144	Capilano Reservoir	December 13, 2020	0								

Table A7: 2020 Metro Vancouver Capilano Reservoir Slide Examination *Cryptosporidium* Results

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			Cryptosporidium									
			Cryptosporidium			DAPI -	DAPI +		DIC			
Lab #	Site name	Date sampled	Object located by FA2	Shape (oval or round)2	Size L x W (µm)2	Light blue internal staining, no distinct nuclei, green rim2	Intense blue internal staining2	Number of nuclei stained sky blue2	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites	
8076	Coquitlam Reservoir	January 12, 2020	0									
8081	Coquitlam Reservoir	February 9, 2020	0									
8086	Coquitlam Reservoir	March 15, 2020	0									
8091	Coquitlam Reservoir	April 19, 2020	0									
8096	Coquitlam Reservoir	May 10, 2020	0									
8101	Coquitlam Reservoir	June 14, 2020	0									
8112	Coquitlam Reservoir	July 19, 2020	0									
8117	Coquitlam Reservoir	August 16, 2020	0									
8122	Coquitlam Reservoir	September 20, 2020	0									
8127	Coquitlam Reservoir	October 18, 2020	0									
8137	Coquitlam Reservoir	November 15, 2020	0									
8145	Coquitlam Reservoir	December 13, 2020	0									

Table A8: 2020 Metro Vancouver Coquitlam Reservoir Slide Examination *Cryptosporidium* Results

			Cryptosporidium									
			Cryptosporidium			DAPI -	DAPI +		DIC			
Lab #	Site name	Date sampled	Object located by FA2	Shape (oval or round)2	Size L x W (µm)2	Light blue internal staining, no distinct nuclei, green rim2	Intense blue internal staining2	Number of nuclei stained sky blue2	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites	
8077	SCFP - Recycled Clarified Water	January 12, 2020	0									
8082	SCFP - Recycled Clarified Water	February 11, 2020	0									
8087	SCFP - Recycled Clarified Water	March 17, 2020	0									
8092	SCFP - Recycled Clarified Water	April 21, 2020	0									
8097	SCFP - Recycled Clarified Water	May 12, 2020	0									
8102	SCFP - Recycled Clarified Water	June 16, 2020	0									
8113	SCFP - Recycled Clarified Water	July 21, 2020	0									
8118	SCFP - Recycled Clarified Water	August 18, 2020	0									
8123	SCFP - Recycled Clarified Water	September 22, 2020	0									
8128	SCFP - Recycled Clarified Water	October 20, 2020	0									
8138	SCFP - Recycled Clarified Water	November 17, 2020	0									
8146	SCFP - Recycled Clarified Water	December 15, 2020	0									

Table A9: 2020 Metro Vancouver Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination *Cryptosporidium* Results