Ministry of Community, Sport and Cultural Development

University Endowment Lands

2016 Drinking Water Quality Monitoring Report

Prepared April 2017

EXECUTIVE SUMMARY

The University Endowment Lands (UEL) implemented a Drinking Water Quality Monitoring Program in 2002. This monitoring program was developed based on the "Water Quality Monitoring and Report Plan for the GVRD and Member Municipalities" provided by the Regional Engineers Advisory Committee (REAC), the Guidelines for Canadian Drinking Water Quality (GCDWQ), and input from the Vancouver Coastal Health Authority. With this approved monitoring program in place, the UEL has collected and analyzed water quality data since 2002. This report provides an outline of the program and its water quality testing results for the year 2016.

The implementation of the Drinking Water Quality Monitoring program was a significant commitment made by the UEL to monitor the delivery of safe and high quality water. It generates valuable data for gaining an understanding of the UEL's water distribution system and for evaluating the historic performance of the system in a reliable and systematic way. Most importantly, it allows for potential health hazards to be identified and consumers' water concerns to be addressed.

The sampling analysis demonstrates that during 2016, all of the 162 samples met the standards set out in the Drinking Water Protection Act and Regulation, as well as the health standards specified in the GCDWQ.

The UEL is committed to delivering water of the highest quality, and will continue to make the necessary effort to ensure its continued success.

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1.0 INTRODUCTION

In 2002, the University Endowment Lands (UEL) implemented a Drinking Water Quality Monitoring Program to monitor the delivery of safe and high quality water. An annual Water Quality Monitoring Report is required under the program. This report is provided in fulfillment of this requirement.

During 2016, the provision of drinking water was governed by the British Columbia Drinking Water Protection Regulation (BCDWPR), pursuant to the Drinking Water Protection Act (DWA). This regulation requires drinking water suppliers in BC to:

- Develop a protocol to notify the Drinking Water Officer (DWO) of situations or conditions that render or could render the water unsuitable to drink;
- Implement a plan for collecting, shipping, and analyzing water samples in compliance with the standards set by the DWO;
- Implement a plan for reporting monitoring results to the DWO and to water users, including the preparation of an annual report.

The UEL monitors the water quality in the UEL distribution system on a weekly basis in accordance with their Drinking Water Quality Monitoring Program. There are eight sampling stations in the UEL. Six are used weekly (three locations each week alternating biweekly.) The other two stations are sampled quarterly. Appendix A shows the locations of the sampling stations. Appendix B includes a graphic summary of the test results for 2016.

This document includes a brief introduction to the UEL's water distribution system and its drinking water monitoring and testing program. The remaining parts of this document summarize the results and analyses of water samples collected in 2016 and evaluates the distribution system's performance in delivering safe drinking water.

2.0 WATER DISTRIBUTION SYSTEM

The UEL receives water from Metro Vancouver through two supply points; one located at Drummond Drive and West 6th Avenue, and the other located at Blanca Street and West 16th Avenue. Water is then supplied to the UEL's customers through its distribution system. The UEL also supplies water to the University of British Columbia (UBC) through two connection points; one located at Wesbrook Mall and University Boulevard, and one located at West 16th Avenue between Blanca Street and Wesbrook Mall. The UEL has adopted a comprehensive Operations and Maintenance (O&M) program for the water distribution system to ensure the highest quality water is delivered in sufficient quantity and pressure to its customers.

The O&M program includes an annual water main flushing program, a hydrant inspection and maintenance program, comprehensive cross connection control program and the water quality monitoring program.

There are 366 cross connection control backflow devices registered in the UEL. In 2016 350 test reports were submitted, proving the devices were tested and met the required standards. This amounts to a 96% voluntary compliance rate.

The water main flushing program is conducted annually. In 2016 it was conducted between May and June. The UEL intends to continue the water main flushing program on an annual basis going forward.

In order to improve the aesthetic quality of water and decrease iron levels in the water distribution system in 'Area C', over the years the UEL had replaced the cast iron (CI) pipe with polyvinyl chloride (PVC) pipes. In the spring of 2016 the UEL replaced the last section of existing CI with PVC pipes in 'Area C'.

3.0 TESTING AND MONITORING PROGRAM

Drinking water quality is a function of source water quality, water treatment, and water quality changes after treatment. As a result, monitoring of drinking water quality consists of three components: source water monitoring, monitoring after treatment, and monitoring in the distribution system. While Metro Vancouver carries out testing of water at the source and after treatment, the UEL's Drinking Water Quality Monitoring Program is focused on monitoring the water quality within its own water distribution system.

The monitoring and testing program consists of routine monitoring (for obtaining an accurate overview of water quality within the distribution system), and non-routine monitoring (for handling complaint and emergency situations). Monitoring involves three components: the collection of samples, the laboratory analyses of those samples and the review and analysis of the results by the UEL, Metro Vancouver, and the Vancouver Coastal Health Authority.

3.1 Routine Monitoring

The collection of water samples was completed as part of an annual contract with Caro Analytical Services. Samples were collected from sampling sites within the UEL on a regular basis and then forwarded to laboratories for various analyses. The collection, transportation, and analysis of the samples was performed in accordance with the "Standard Methods for the Examination of Water and Wastewater 22st Edition", 2012, published by the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF). All analysis was conducted by laboratories that are approved by the Canadian Association of Environmental Analytical Laboratories or an equivalent certification program for the other tests performed.

All testing parameters except vinyl chloride were analyzed by the laboratories of Metro Vancouver. Analysis of vinyl chloride, a volatile organic compound, was tested by the laboratory of Caro Analytical Services.

3.1.1 Sampling Parameters

The parameters that were analyzed are summarized in Table 1.

Table 1. Sampling Parameters

	PARAMETERS
Microbiological	Total Coliforms, Escherichia Coli, Heterotrophic Plate Count (HPC)
Chemical and Physical	Turbidity, Temperature, Free Chlorine Residual, pH, Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Zinc, Haloacetic Acids (HAAs), Trihalomethanes (THMs), Vinyl Chloride

The most relevant parameters are briefly discussed below. Further details regarding the parameters listed in the above table can be found by accessing the supporting documents of the GCDWQ through the following web site:
http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php
or by contacting Health Canada at **(613) 957-2991**.

Total Coliforms

One of the primary concerns in water quality is the growth of coliform bacteria. The presence of total coliforms indicates that treatment is inadequate or that the distribution system is experiencing regrowth or infiltration. The presence of coliforms indicates a possibility of regrowth of the bacterial in biofilms or intrusion of untreated water.

Escherichia Coli (E. coli)

E. coli is used as an indicator of microbiological safety of drinking water; if detected, enteric pathogens may also be present. E.coli monitoring is used, in conjunction with other indicators, as part of a multi-barrier approach to producing drinking water quality at an acceptable quality.

Heterotrophic Plate Counts

Heterotrophic Plate Counts (HPC) are a useful operational tool for monitoring general bacteriological water quality through the treatment process and in the distribution system. HPC results are not an indicator of water safety and should not be used as an indicator of potential adverse human health effects. Increases in HPC concentrations above baseline levels are considered undesirable but are not necessarily an indicator of water safety.

Free Chlorine Residual

Free chlorine residual provides a good indication of water quality within the distribution system. Low chlorine residual may indicate deteriorating water quality as a result of bacterial regrowth or stagnant water. Guidelines for Canadian Drinking Water Quality – Summary Table, October 2014 state free chlorine concentrations in most Canadian drinking water distributions system range from 0.04 to 2.0 mg/l.

Turbidity

Turbidity in water is caused by suspended matter, such as clay, silt, organic, and inorganic matter. Controlling turbidity is important for both health and aesthetic reasons. Bacteria, viruses, and protozoa can adhere to suspended particles in turbid water and interfere with disinfection. Excessive turbidity detracts from the appearance of treated water and has often been associated with unacceptable tastes and odours.

Disinfection Byproducts

Haloacetic acids (HAAs) and Trihalomethanes (THMs) are disinfection byproducts (DBPs) and are formed in drinking water when chlorine reacts with organic matter that is naturally present in raw water supplies. Research suggests that HAAs have an adverse impact on human health and may possibly be carcinogenic. The most common THM is chloroform which is classified as being possibly carcinogenic to humans based on limited evidence in experimental animals. DBPs are maintained as low as possible without compromising the effectiveness of disinfection.

pH

pH is used as a measure of the acidity and basicity of water. pH is monitored in a distribution system because at low values water becomes corrosive while at high levels chlorine disinfection is less effective and efficient. Health Canada guidelines state an optimal pH between 6.5 and 8.5.

Copper

Copper is used extensively in plumbing for domestic water systems. Although copper is frequently found in surface water, distributed water contains considerably more copper than the original water supply because of the dissolution of copper from copper piping. Copper can stain laundry and plumbing fixtures and cause an undesirable bitter taste in water. Copper intake at extremely high doses can result in adverse health effects.

Iron

Iron is naturally present in food and drinking water. However, there is no evidence to indicate that concentrations of iron commonly found in food or water constitute any hazard to human health. Iron can stain laundry and plumbing fixtures and cause undesirable tastes in beverages. The precipitation of excessive iron imparts an objectionable reddish-brown color to the water. Iron may also promote the growth of certain microorganisms, which can lead to the deposition of a slimy coat in piping.

Lead

Lead was used in drinking water plumbing and as solder in distribution systems. Older distribution systems may also be made from lead pipe or appurtenances. Lead is present in tap water as a result of dissolution from natural sources or from household plumbing systems. Lead is a cumulative general poison and has been classified as being potentially carcinogenic to humans. Fetuses, infants, young children and pregnant women are most susceptible to adverse health effects. In order to minimize exposure to lead introduced into drinking water from plumbing systems, it is recommended that only cold water be used, after an appropriate period of flushing to rid the system of standing water, for sampling, drinking, beverage preparation, and cooking.

Vinyl Chloride

The presence of vinyl chloride in potable water is associated mainly with the use of polyvinyl chloride (PVC) water pipes manufactured with incompletely polymerized vinyl chloride monomer. Acute exposure or chronic inhalation results in a variety of adverse effects in humans. Sufficient evidence has accumulated to implicate vinyl chloride as a human and animal carcinogen.

Zinc

Although zinc is present in surface waters at low concentrations, levels in domestic water systems can be considerably higher because of the use of zinc in plumbing materials. Water containing zinc in excessive concentrations has an undesirable astringent taste and may develop a greasy film upon boiling. Long-term ingestion of zinc in excess of the daily requirement has not shown to result in adverse effects.

3.1.2 Sampling Locations

Sampling locations are distributed in different areas within the UEL to obtain an accurate overview of water quality in the distribution system. The eight locations were strategically selected based on land use and system configuration. They include residential area supply, high-density residential area supply, institutional area supply, and water source supply. These locations are illustrated in Figure 1 in Appendix A.

Table 2. Drinking Water Sampling Sites

SITE	LOCATION	FLOW CATEGORY	SUPPLY TYPE
S-A	Drummond Dr. & W. 6th Ave.	Source	Water Source / Residential
S-B	Wycliffe Rd. & Tasmania Cres.	Low Flow	Residential
S-C*	Norma Rose Elementary	Service Connection	Institutional
S-D	Acadia Rd. & Toronto Rd.	Source	Water Source / High-Density Residential
S-E	Western Pkwy. South of Chancellor Blvd.	Medium Flow	Residential
S-F	Marine Dr. at the UEL boundary	Low Flow	Residential
S-G	Chancellor Blvd. East of Acadia	Medium Flow	Institutional
S-H*	University Hill Elementary	Service Connection	Institutional

* Sites are taps located within schools. These sites are not used for weekly sampling.

3.1.3 Sampling Frequency

The UEL, as a purveyor of drinking water to a population of less than 5000, is required to test at least 4 samples per month as outlined in Schedule B of the *Drinking Water Protection Regulation*. During 2016, the UEL tested more than 3 times the minimum required number of samples. Parameters that have greater effects on health were sampled and analyzed more often than those that only affect the aesthetic quality. The sampling frequency of different parameters from different sampling locations is summarized in Table 3.

Table 3. Sampling Frequency

Frequency:	**THREE SAMPLES PER WEEK**	**FOUR SAMPLES PER YEAR**	**TWO SAMPLES PER YEAR**
Parameters:	Total coliforms E. Coli HPCs Free chlorine residual Turbidity Temperature	Haloacetic Acids pH Trihalomethanes	Aluminum Arsenic Barium Boron Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Molybdenum Nickel Selenium Silver Sodium Zinc Vinyl chloride
Site Category:	Residential Areas	Residential Areas	Taps in Building

3.2 Non-routine Monitoring

A laboratory was on-call for monitoring for complaint and emergency situations. Consumer complaints were recorded so that water quality concerns could be tracked and responded to efficiently. In any emergency situation, the procedures outlined in the UEL Emergency Response Plan would be followed.

4.0 SAMPLE ANALYSIS RESULTS

A total of 162 samples were taken from the water distribution system during 2016. The sample analysis results are summarized in Table 4 below, and some of the parameters worth noting are discussed in this section. Please refer to Appendix B for detailed sample analysis results. It should be noted that the limits contained within the Guidelines for Canadian Drinking Water Quality (GCDWQ) are recommendations only and representative of best practices. These can become requirements if the Drinking Water Officer places a condition on the Operating Permit for the UEL. At present there are no such conditions placed on the UEL.

Table 4. Summary of Analysis Results

Sample Station	No. of Samples	HPC (CFU/mL)			Free Chlorine Residual (mg/L)			Turbidity (NTU)			Positive Coliform Tests	Positive E. coli Tests
		Low	Avg	High	Low	Avg	High	Low	Avg	High		
S-A	26	<2	26*	80	0.52	0.62	0.79	0.08	0.16	0.29	none	none
S-B	28	<2	8*	32	0.44	0.58	0.79	0.10	0.19	1.20	none	none
S-D	26	<2	9*	38	0.49	0.65	0.84	0.09	0.13	0.26	none	none
S-E	28	<2	3	20	0.43	0.61	0.75	0.08	0.13**	0.20	1	none
S-F	28	<2	168	3700	0.00	0.10	0.43	0.21	1.05**	5.10	none	none
S-G	26	<2	2	2	0.12	0.42	0.78	0.10	0.21**	0.45	none	none
Avg			37			0.49			0.32			
Total	162										1	0

*Metro Vancouver: HPC tests were not completed from December 24, 2016 to January 2, 2017. As a result, one sample was not tested.
**Metro Vancouver: Wrong units selected on Turbidimeter on January 5, 2016. As a result, one sample was discarded.

Total Coliforms

For total coliforms, the British Columbia Drinking Water Protection Regulation (BCDWPR) requires that (1) when there is one sample in a 30 day period, the sample contains no total coliform bacteria per 100 mL and that (2) when there is more than 1 sample in a 30 day period, at least 90% of samples have no detectable total coliform bacteria per 100 mL and no sample has more than 10 total coliform bacteria per 100 ml. Of the 162 samples tested for total coliforms, 1 sample tested positive for total coliforms. No sample had more than 10 total coliforms and at least 90% of samples taken in every 30 day period had 0 total coliform per 100mL.

E. coli

For E. coli, the BCDWPR requires that the samples contain no detectable per 100 mL. No E. coli were detected in the 162 samples analysed for microbiological criteria in 2016.

Heterotrophic Plate Count, HPC

Out of the 162 samples tested for HPC, 1 sample taken from Site S-F on October 25th exceeded the previously established GCDWQ guideline of 500 HPC colony-forming units per millilitre (CFU/mLs). The sample also had a low free chlorine concentration that may

correlate to the spike in HPC. Steady increases of HPC over time generally indicate a gradual decline in raw water quality. On October 25th an HPC count of 3700 was CFU/mLs was read at Site S-F. The results returned to acceptable levels in subsequent testing and as such the high reading may be attributed to poor sampling methods.

Turbidity

The GCDWQ recommends that to ensure effectiveness of disinfection and for good operation of the distribution system water entering the distribution system should have turbidity levels of no more than 1.0 Nephelometric Turbidity Units (NTU) to minimize the potential for interference with disinfection. Of the 162 samples tested 9 measured greater than 1.0 NTU. The corresponding disinfection readings taken at the same time were within GCDWQ limits.

Free Chlorine Residual

Two sampling sites (Sites S-F & S-G) within the UEL had readings below the free chlorine residual target of 0.2 mg/L. Site S-F had instances where free chlorine was measured below 0.04 mg/L. The location of station S-F is at an furthest end of the water distribution system, which also has low flows due to a low number of residential connections each with seasonally low water usage. These conditions increase the likelihood of stagnant water and the deterioration of chlorine residual. In 2016 a strategy was developed to improve circulation of water for site S-F. The strategy has since been implemented and the results will be available in the 2017 Water Quality Report.

Table 5 displays the percentage of samples for each station with a free chlorine residual less than 0.2 mg/L and less than 0.04 mg/L. As with HPC, low chlorine residual is merely a warning sign and not an indication of water quality problems.

Table 5. Summary of Free Chlorine Residual Results

Sample Station	Free Chlorine Residual (mg/L)	
	% of Samples <0.2 mg/L	% of Samples <0.04 mg/L
S-A	0%	0%
S-B	0%	0%
S-D	0%	0%
S-E	0%	0%
S-F	82%	39%
S-G	12%	0%

Disinfection By-products and pH

Two sample stations, sites S-E and S-B, were tested for disinfection by-product and pH. Table 6 displays the analysis results.

Table 6. Disinfection By-products and pH Analysis Results

		HAA (ppb)						THM (ppb)					
Sample Location	**Sampled date**	**Dibromoacetic Acid**	**Dichloroacetic Acid**	**Monobromoacetic Acid**	**Monochloroacetic Acid**	**Trichloroacetic Acid**	**Total Haloacetic Acid**	**Bromodichloromethane**	**Bromoform**	**Chlorodibromomethane**	**Chloroform**	**Total Trihalomethanes**	**pH**
UEL-S-B	3/1/2016	<0.5	9	<1	5	10.8	26.5	<1	<1	<1	24	25.3	7.2
UEL-S-B	5/31/2016	<0.5	9	<1	4	8.1	21.9	<1	<1	<1	20	20.3	7.2
UEL-S-B	8/30/2016	<0.5	9	<1	3	8.8	21.5	1	<1	1	26	28.0	7.4
UEL-S-B	10/18/2016	<0.5	9	<1	6	16.3	32.4	<1	<1	<1	25	27.0	7.2
Average							**25.6**					**25.2**	
UEL-S-E	3/1/2016	<0.5	11	<1	5	9.6	26.3	<1	<1	<1	24	24.9	7.1
UEL-S-E	5/31/2016	<0.5	9	<1	4	6	19.9	<1	<1	<1	22	22.0	7.2
UEL-S-E	8/30/2016	<0.5	10	<1	2	8.5	21.5	1	<1	1	27	29.0	7.4
UEL-S-E	10/18/2016	<0.5	10	<1	5	14.5	30.4	<1	<1	<1	25	27.0	7.1
Average							**24.5**					**25.7**	

Both sites S-E and S-B meet the GCDWQ requirement for the maximum acceptable concentration (MAC) for THM and HAA of 100 ppb (0.1 mg/L) and 80 ppb (0.080 mg/L) respectively. The maximum THM concentration was determined to be 28.0 (0.0280 mg/L) and 29.0 ppb (0.0290 mg/L) for sites S-B and S-E, respectively. The maximum HAA concentration was determined to be 32.4 ppb (0.0324 mg/L) for site S-B and 30.4 ppb (0.0304 mg/L) for site S-E. The pH concentrations for both sites S-B and S-E was within the GCDWQ recommended range of 6.5 to 8.5 for water treatment related objectives.

Vinyl Chloride

Vinyl chloride concentration was tested twice in 2016 with the samples taken from sites S-A and S-C on May 17th and October 25th. During sample testing, the vinyl chloride concentration was below 2 ppb (.002 mg/L), which meets the requirement from GCDWQ of less than 2 ppb (0.002 mg/L).

Metals

Two sample locations, sites S-C and S-H, were tested for total concentration of various metals in 2016. As seen in the analysis results presented below in Table 7, measured in µg/L (ppb or 0.001 mg/L) all metal levels fall below the recommended limits outlined in the GCDWQ.

Table 7. Metals Analysis Results

Sample Station		S-C		S-H		GCDWQ	
Sampled date		5/17/2016	10/25/2016	5/17/2016	10/25/2016	Health Guideline	Aesthetic Objective
Total concentration (µg/L)	Aluminum	22	38	32	57	n/a	200
	Antimony	<0.5	<0.5	<0.5	<0.5	6	n/a
	Arsenic	<0.5	<0.5	<0.5	<0.5	10	n/a
	Barium	2.5	2.8	2.1	1.7	1000	n/a
	Boron	<10	<10	<10	<10	5000	n/a
	Cadmium	<0.2	<0.2	<0.2	<0.2	5	n/a
	Calcium	2980	3300	3650	3950	n/a	n/a
	Chromium	0.26	0.14	0.22	0.24	50	n/a
	Cobalt	<0.5	<0.5	<0.5	<0.5	n/a	n/a
	Copper	17.4	12.5	3.3	2.1	n/a	≤1000
	Iron	9	36	15	42	n/a	≤300
	Lead	<0.5	<0.5	<0.5	<0.5	10	n/a
	Magnesium	144	143	124	99	n/a	n/a
	Manganese	1.4	0.9	0.6	0.9	n/a	≤50
	Mercury	<0.05	<0.05	<0.05	<0.05	1	n/a
	Molybdenum	<0.5	<0.5	<0.5	<0.5	n/a	n/a
	Nickel	<0.5	<0.5	<0.5	<0.5	n/a	n/a
	Potassium	146	231	161	193	n/a	n/a
	Selenium	<0.5	<0.5	<0.5	<0.5	50	n/a
	Silver	<0.5	<0.5	<0.5	<0.5	n/a	n/a
	Sodium	1380	1640	1410	1660	n/a	≤200,000
	Zinc	<3.0	<3.0	<3.0	<3.0	n/a	≤5000

5.0 SUMMARY

The UEL implemented a Drinking Water Quality Monitoring Program in 2002 based on the standard program adopted by Metro Vancouver member municipalities, the Guidelines for Canadian Drinking Water Quality (GCDWQ), and input from the Vancouver Coastal Health Authority. With this approved monitoring program in place, the UEL has collected and analyzed water quality data since 2002.

The implementation of the Drinking Water Quality Monitoring program is a significant commitment made by the UEL to deliver safe water to its consumers. It generates valuable data for gaining an understanding of the UEL's water distribution system and for evaluating the past performance of the system in a reliable and systematic way. Most importantly, it allows for potential health hazards to be identified and consumers' water concerns to be addressed.

A Unidirectional Flushing Program is conducted annually. This helps reduce the risk of sediment, corrosion, and by-product build-up in the water mains, as well as improve water quality. Unidirectional flushing can help reduce the habitats where bacteria grows but does not address the underlying reasons for the bacterial growth or loss of disinfectant residual. The Vancouver Coastal Heath Authority has recommended that a long term strategy be developed to address these issues to maintain confidence in the distribution system. A strategy to improve the loss of disinfectant residual with improved circulation of flow has been implemented, results will be available in the 2017 Water Quality Report.

In spring, the UEL finished an infrastructure renewal project which completed the replacement of all the cast iron water mains in 'Area C' with PVC and as a result alleviating discolouration concerns. At all times the water quality met the standards set out in the Drinking Water Protection Act and Regulation, as well as the health standards specified in the GCDWGQ.

The UEL cross connection control program relies on voluntary compliance. In 2016, 96% of all the registered devices were tested and proven to be functioning as intended to protect the public water system from contamination.

The sampling analysis demonstrates that during 2016, all 162 samples taken met the standards set out in the Drinking Water Protection Act (DWA) and the BC Drinking Water Protection Regulation (BCDWPR), as well as the health standards set out the Guidelines for Canadian Drinking Water Quality (GCDWQ).

The UEL is committed to delivering water of the highest quality, and will continue to make the necessary effort to ensure its continued success.

REFERENCES

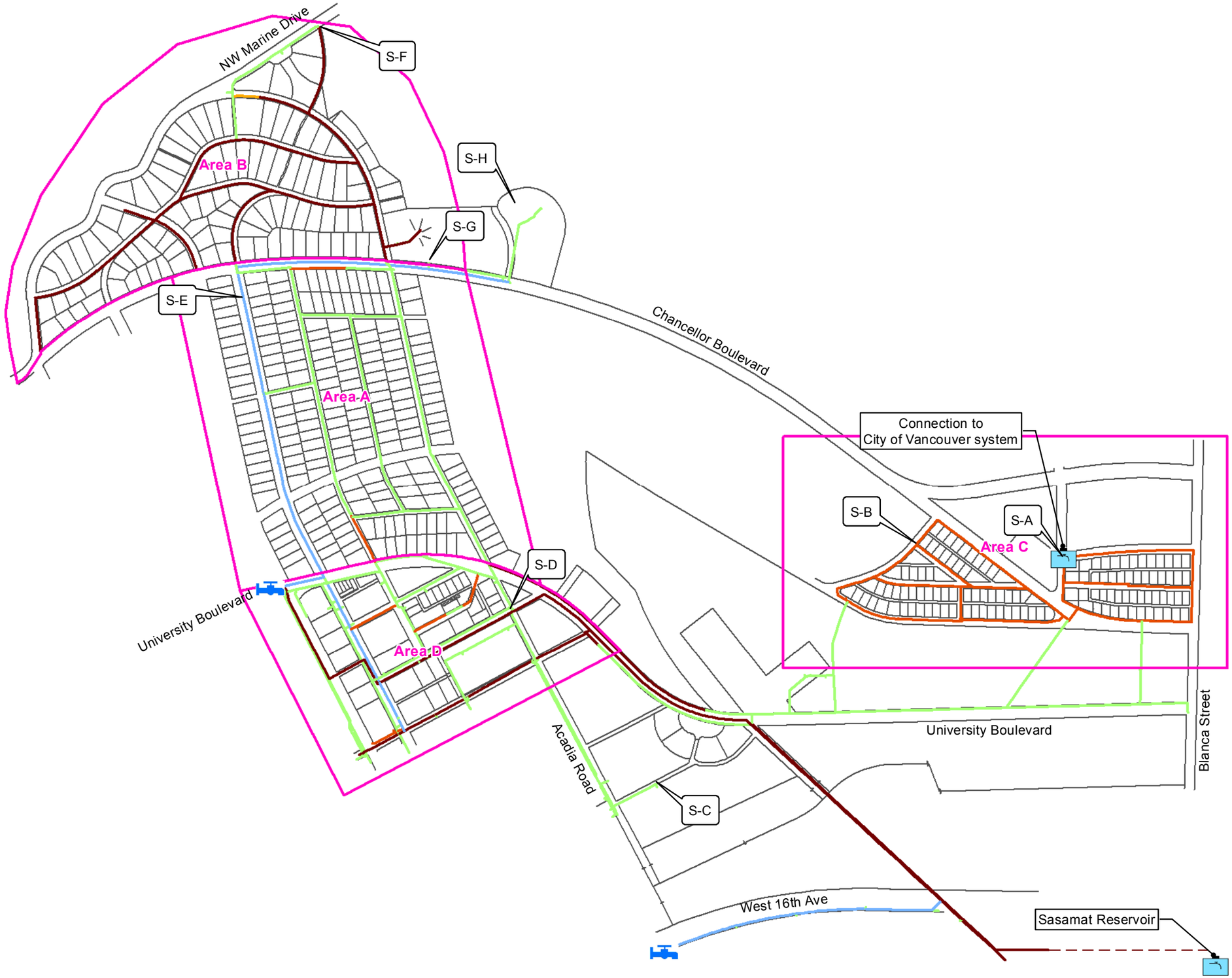
British Columbia Drinking Water Protection Regulation. *Drinking Water Protection Act* Reg. 200/2003, 2003

Guidelines for Canadian Drinking Water Quality – Health Canada, October 2014 <http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php>

Water Quality Monitoring and Reporting Plan for the GVRD and Member Municipalities, Regional Engineers Advisory Committee (REAC), May 2000

APPENDIX A

Water Sampling Sites Map



BRITISH COLUMBIA

University Endowment Lands

Ministry of Community, Sport, and Cultural Development

Legend

- UEL Water Supply
- Connection to UBC
- Area

Water Main - Material

- Asbestos Cement
- Cast Iron
- Galvanized Iron
- PVC
- Steel

AECOM

0 125 250 500 Meters

Project No.	Date
60222155	July 2016

Existing UEL Water System Sample Locations

Appendix A

APPENDIX B

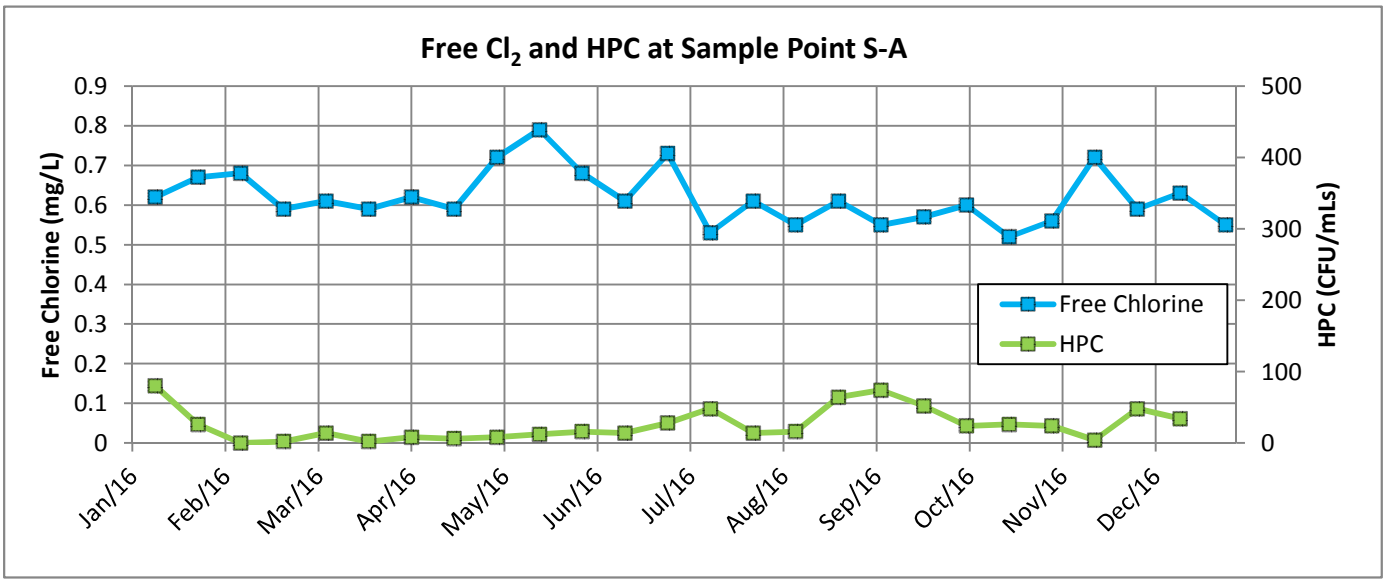
Sample Analysis Results

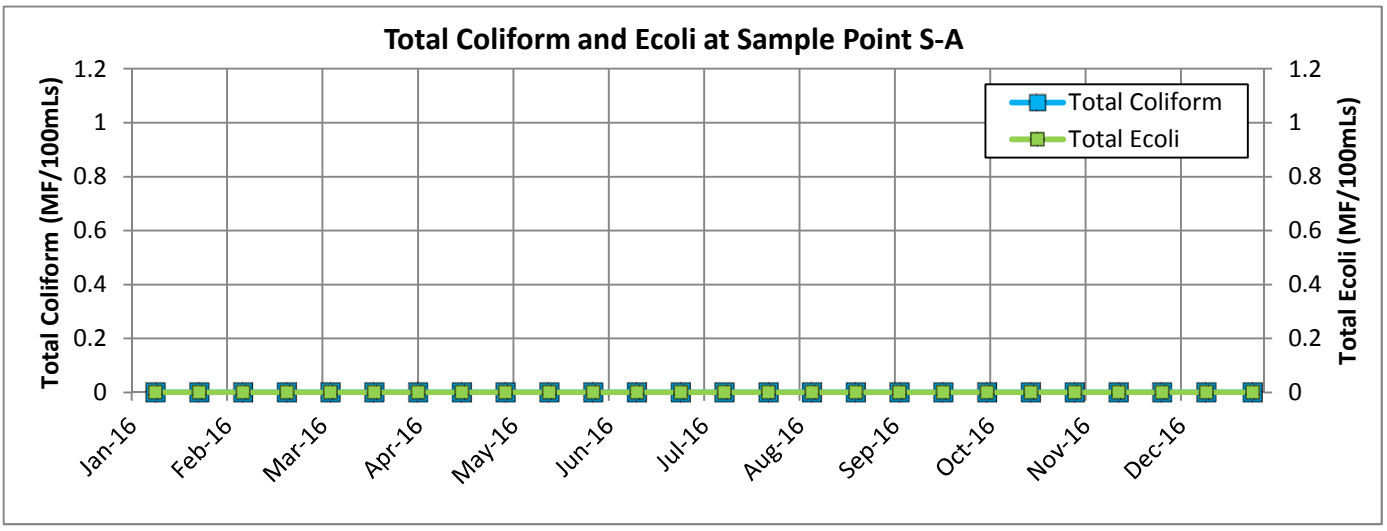
Sample Point S-A
Location: Drummond Dr. & W. 6th Ave.

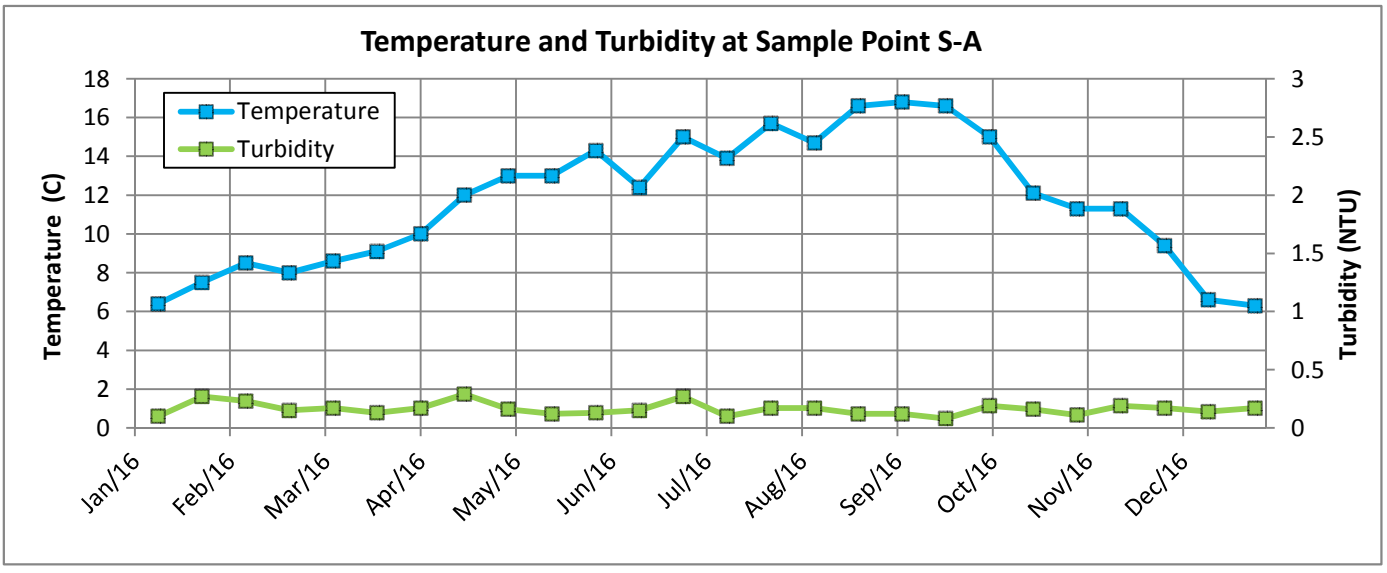
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
12-Jan-16	0.62	<1	80	6.4	<1	0.1
26-Jan-16	0.67	<1	26	7.5	<1	0.27
9-Feb-16	0.68	<1	<2	8.5	<1	0.23
23-Feb-16	0.59	<1	2	8.0	<1	0.15
8-Mar-16	0.61	<1	14	8.6	<1	0.17
22-Mar-16	0.59	<1	2	9.1	<1	0.13
5-Apr-16	0.62	<1	8	10.0	<1	0.17
19-Apr-16	0.59	<1	6	12.0	<1	0.29
3-May-16	0.72	<1	8	13.0	<1	0.16
17-May-16	0.79	<1	12	13.0	<1	0.12
31-May-16	0.68	<1	16	14.3	<1	0.13
14-Jun-16	0.61	<1	14	12.4	<1	0.15
28-Jun-16	0.73	<1	28	15.0	<1	0.27
12-Jul-16	0.53	<1	48	13.9	<1	0.1
26-Jul-16	0.61	<1	14	15.7	<1	0.17
9-Aug-16	0.55	<1	16	14.7	<1	0.17
23-Aug-16	0.61	<1	64	16.6	<1	0.12
6-Sep-16	0.55	<1	74	16.8	<1	0.12
20-Sep-16	0.57	<1	52	16.6	<1	0.08
4-Oct-16	0.6	<1	24	15.0	<1	0.19
18-Oct-16	0.52	<1	26	12.1	<1	0.16
1-Nov-16	0.56	<1	24	11.3	<1	0.11
15-Nov-16	0.72	<1	4	11.3	<1	0.19
29-Nov-16	0.59	<1	48	9.4	<1	0.17
13-Dec-16	0.63	<1	34	6.6	<1	0.14
28-Dec-16	0.55	<1	NA*	6.3	<1	0.17

Min	0.52	<1	<2	6.3	<1	0.08
Average	0.62	<1	26	11.7	<1	0.16
Max	0.79	<1	80	16.8	<1	0.29
Count	26	26	25	26	26	26

*Metro Vancouver: No HPC's were done from Dec 24th to Jan 2nd.


Free Cl2 and HPC at Sample Point S-A
Free Chlorine (mg/L)
HPC (CFU/mLs)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
400
300
200
100
0
Free Chlorine
HPC
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-A
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
1.2
1
0.8
0.6
0.4
0.2
0
Total Coliform
Total Ecoli
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16

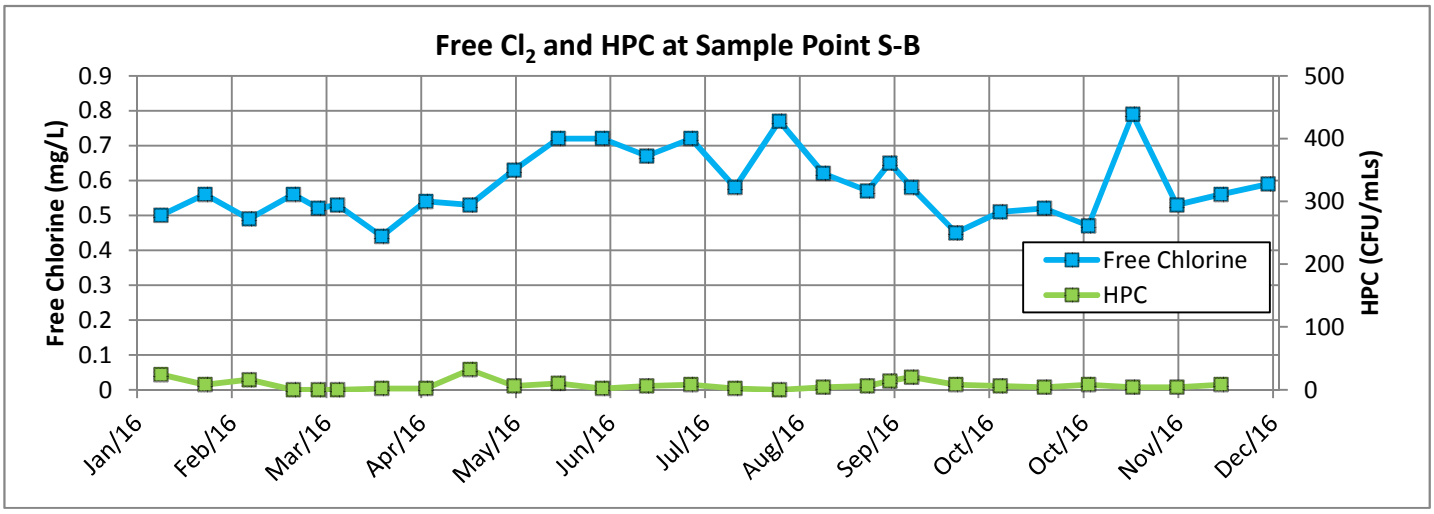

Temperature and Turbidity at Sample Point S-A
Temperature (C)
Turbidity (NTU)
18
16
14
12
10
8
6
4
2
0
3
2.5
2
1.5
1
0.5
0
Temperature
Turbidity
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16

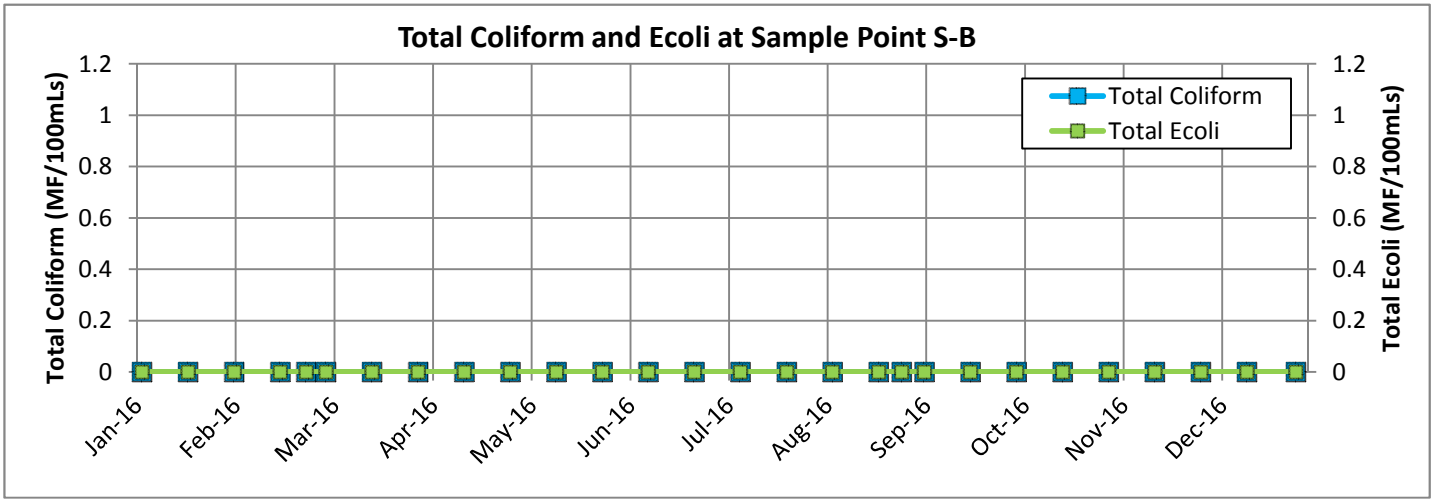
Sample Point S-B
Location Wycliff Road & Tasmania Crescent

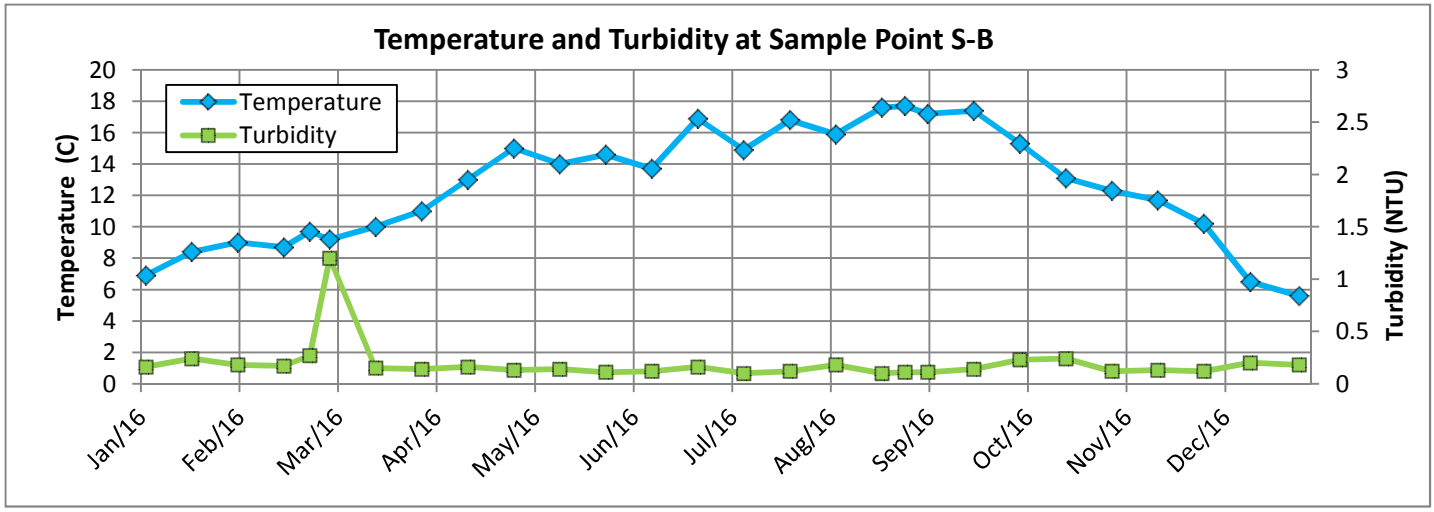
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
12-Jan-16	0.5	<1	24	6.9	<1	0.16
26-Jan-16	0.56	<1	8	8.4	<1	0.24
9-Feb-16	0.49	<1	16	9	<1	0.18
23-Feb-16	0.56	<1	<2	8.7	<1	0.17
2-Mar-16	0.52	<1	<2	9.7	<1	0.27
8-Mar-16	0.53	<1	<2	9.2	<1	1.2
22-Mar-16	0.44	<1	2	10	<1	0.15
5-Apr-16	0.54	<1	2	11	<1	0.14
19-Apr-16	0.53	<1	32	13	<1	0.16
3-May-16	0.63	<1	6	15	<1	0.13
17-May-16	0.72	<1	10	14	<1	0.14
31-May-16	0.72	<1	2	14.6	<1	0.11
14-Jun-16	0.67	<1	6	13.7	<1	0.12
28-Jun-16	0.72	<1	8	16.9	<1	0.16
12-Jul-16	0.58	<1	2	14.9	<1	0.1
26-Jul-16	0.77	<1	<2	16.8	<1	0.12
9-Aug-16	0.62	<1	4	15.9	<1	0.18
23-Aug-16	0.57	<1	6	17.6	<1	0.1
30-Aug-16	0.65	<1	14	17.7	<1	0.11
6-Sep-16	0.58	<1	20	17.2	<1	0.11
20-Sep-16	0.45	<1	8	17.4	<1	0.14
4-Oct-16	0.51	<1	6	15.3	<1	0.23
18-Oct-16	0.52	<1	4	13.1	<1	0.24
1-Nov-16	0.47	<1	8	12.3	<1	0.12
15-Nov-16	0.79	<1	4	11.7	<1	0.13
29-Nov-16	0.53	<1	4	10.2	<1	0.12
13-Dec-16	0.56	<1	8	6.5	<1	0.2
28-Dec-16	0.59	<1	NA*	5.6	<1	0.18

Min	0.44	<1	<2	5.6	<1	0.10
Average	0.58	<1	8	12.6	<1	0.19
Max	0.79	<1	32	17.7	<1	1.20
Count	28	28	27	28	28	28

*Metro Vancouver: No HPC's were done from Dec 24th to Jan 2nd.


Free Cl_2 and HPC at Sample Point S-B
Free Chlorine (mg/L)
HPC (CFU/mLs)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
400
300
200
100
0
Free Chlorine
HPC
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-B
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
1.2
1
0.8
0.6
0.4
0.2
0
Total Coliform
Total Ecoli
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16

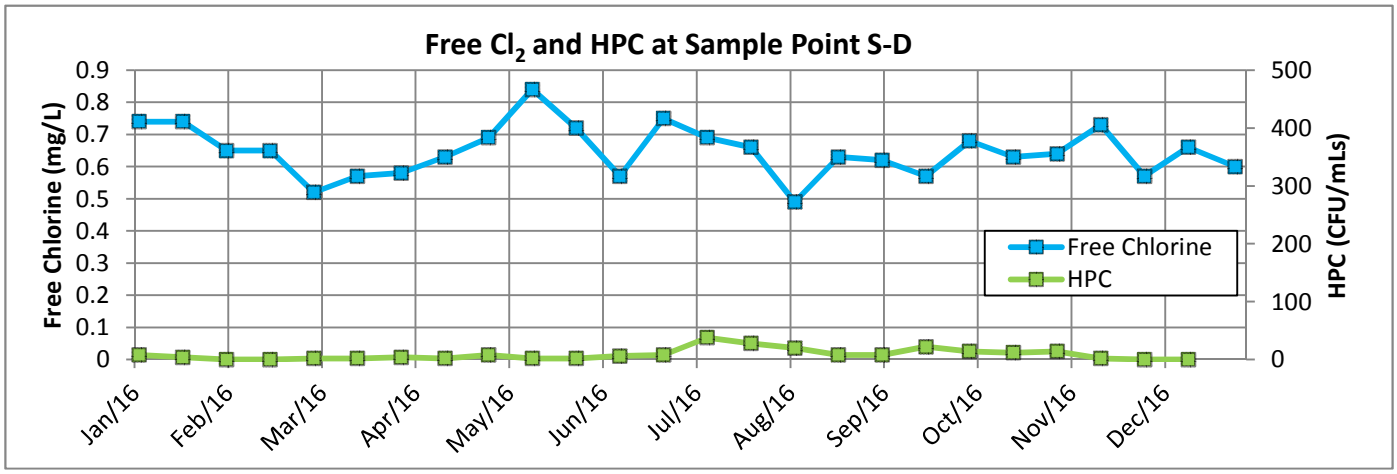

Temperature and Turbidity at Sample Point S-B
Temperature (C)
Turbidity (NTU)
20
18
16
14
12
10
8
6
4
2
0
3
2.5
2
1.5
1
0.5
0
Temperature
Turbidity
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16

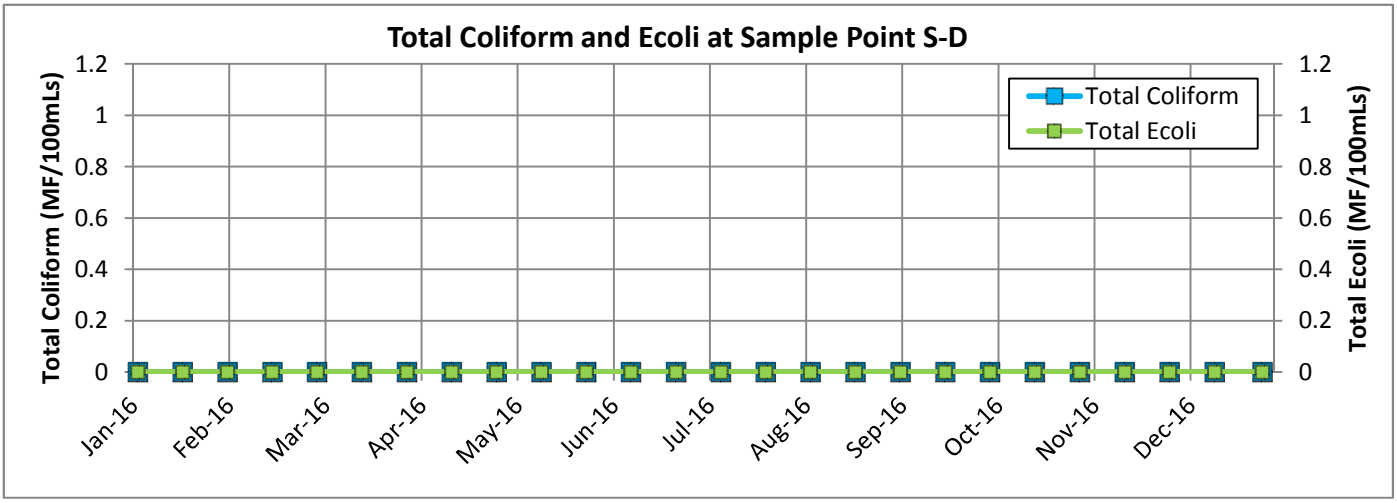
Sample Point S-D
Location: Acadia Rd. & Toronto Rd.

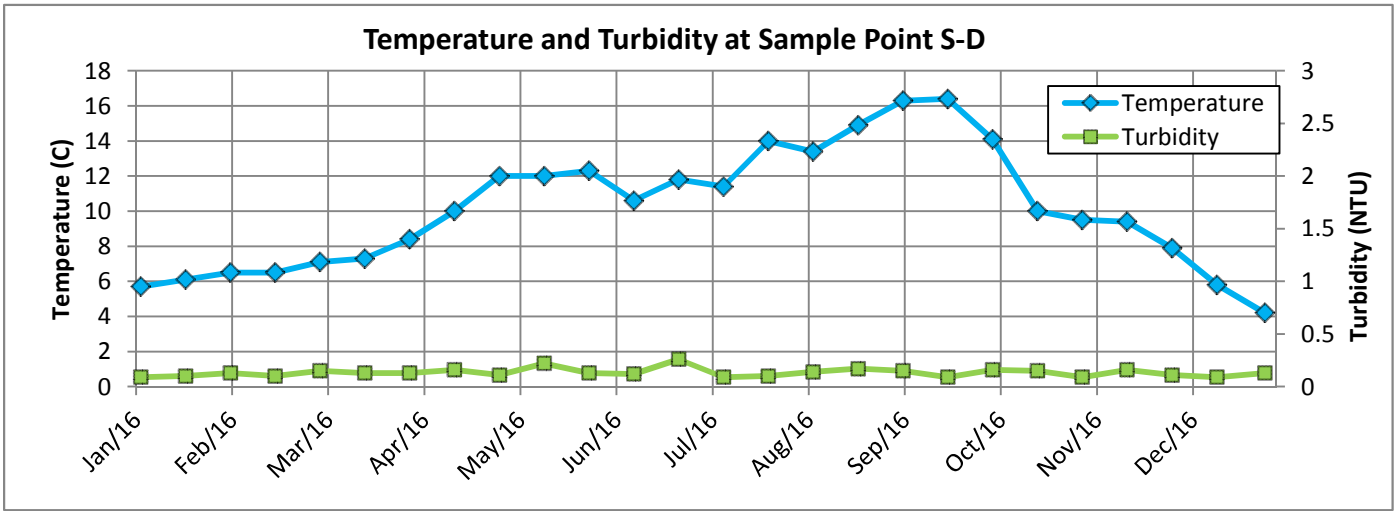
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
12-Jan-16	0.74	<1	8	5.7	<1	0.09
26-Jan-16	0.74	<1	4	6.1	<1	0.1
9-Feb-16	0.65	<1	<2	6.5	<1	0.13
23-Feb-16	0.65	<1	<2	6.5	<1	0.1
8-Mar-16	0.52	<1	2	7.1	<1	0.15
22-Mar-16	0.57	<1	2	7.3	<1	0.13
5-Apr-16	0.58	<1	4	8.4	<1	0.13
19-Apr-16	0.63	<1	2	10	<1	0.16
3-May-16	0.69	<1	8	12	<1	0.11
17-May-16	0.84	<1	2	12	<1	0.22
31-May-16	0.72	<1	2	12.3	<1	0.13
14-Jun-16	0.57	<1	6	10.6	<1	0.12
28-Jun-16	0.75	<1	8	11.8	<1	0.26
12-Jul-16	0.69	<1	38	11.4	<1	0.09
26-Jul-16	0.66	<1	28	14	<1	0.1
9-Aug-16	0.49	<1	20	13.4	<1	0.14
23-Aug-16	0.63	<1	8	14.9	<1	0.17
6-Sep-16	0.62	<1	8	16.3	<1	0.15
20-Sep-16	0.57	<1	22	16.4	<1	0.09
4-Oct-16	0.68	<1	14	14.1	<1	0.16
18-Oct-16	0.63	<1	12	10	<1	0.15
1-Nov-16	0.64	<1	14	9.5	<1	0.09
15-Nov-16	0.73	<1	2	9.4	<1	0.16
29-Nov-16	0.57	<1	<2	7.9	<1	0.11
13-Dec-16	0.66	<1	<2	5.8	<1	0.09
28-Dec-16	0.6	<1	NA*	4.2	<1	0.13

Min	0.49	<1	<2	4.2	<1	0.09
Average	0.65	<1	9	10.1	<1	0.13
Max	0.84	<1	38	16.4	<1	0.26
Count	26	26	25	26	26	26

*Metro Vancouver: No HPC's were done from Dec 24th to Jan 2nd.


Free Cl2 and HPC at Sample Point S-D
Free Chlorine (mg/L)
HPC (CFU/mLs)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
400
300
200
100
0
Free Chlorine
HPC
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-D
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
1.2
1
0.8
0.6
0.4
0.2
0
Total Coliform
Total Ecoli
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16

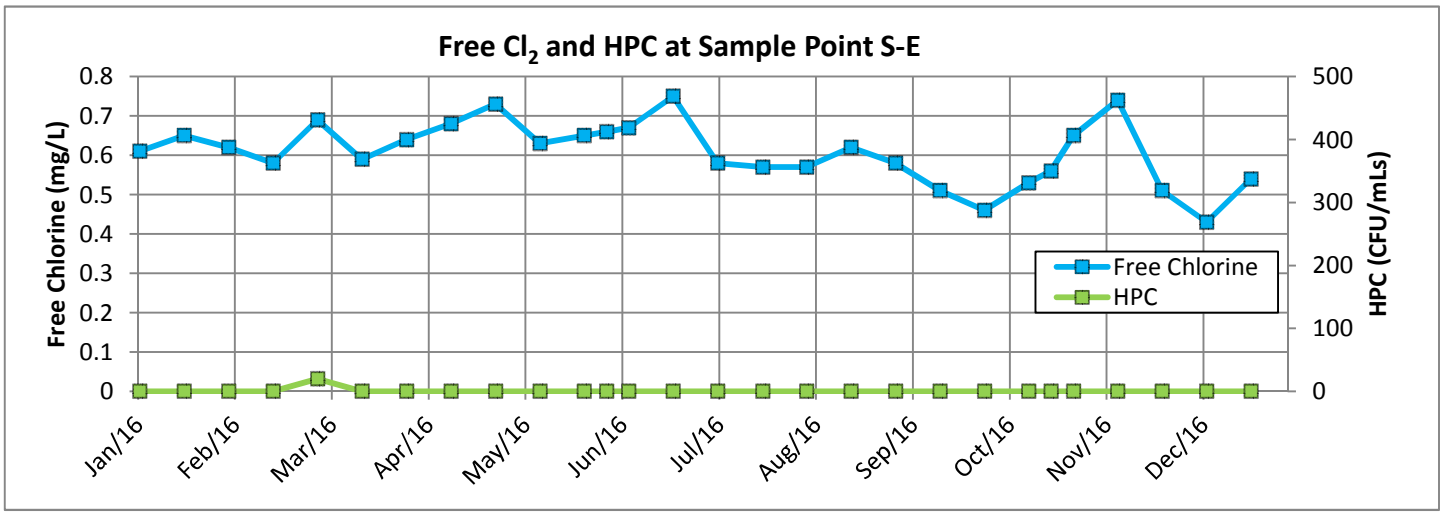

Temperature and Turbidity at Sample Point S-D
Temperature (C)
Turbidity (NTU)
18
16
14
12
10
8
6
4
2
0
3
2.5
2
1.5
1
0.5
0
Temperature
Turbidity
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16

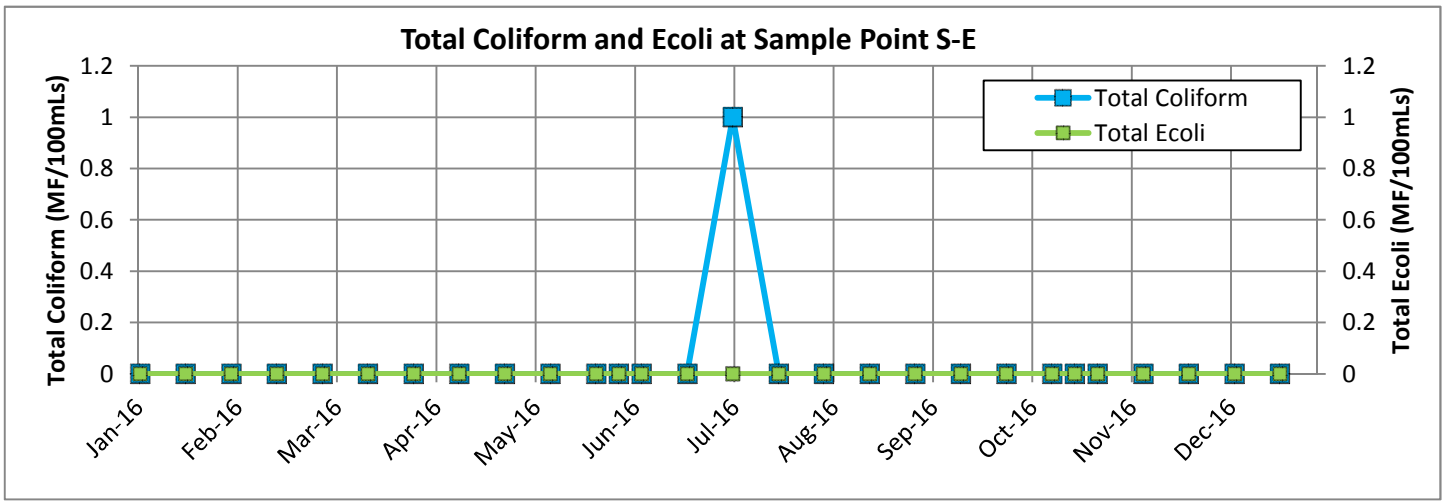
Sample Point S-E
Location: Western Pkwy. S. of Chancellor Blvd.

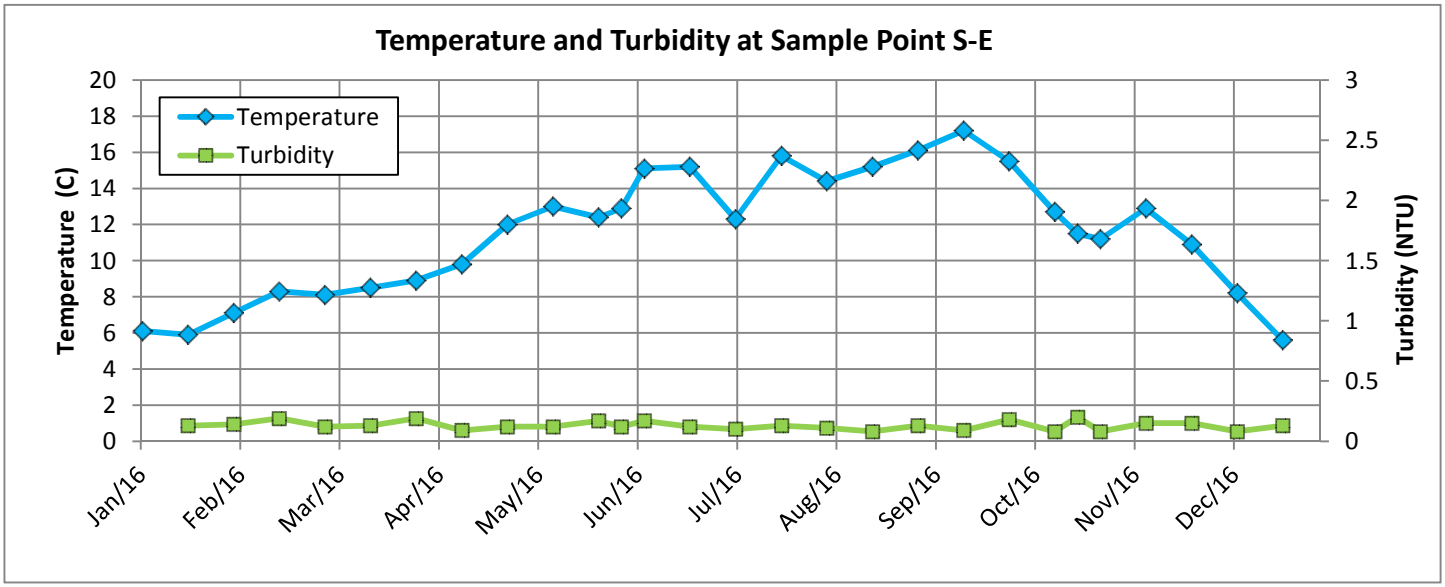
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
5-Jan-16	0.61	<1	<2	6.1	<1	LA**
19-Jan-16	0.65	<1	<2	5.9	<1	0.13
2-Feb-16	0.62	<1	<2	7.1	<1	0.14
16-Feb-16	0.58	<1	<2	8.3	<1	0.19
1-Mar-16	0.69	<1	20	8.1	<1	0.12
15-Mar-16	0.59	<1	<2	8.5	<1	0.13
29-Mar-16	0.64	<1	<2	8.9	<1	0.19
12-Apr-16	0.68	<1	<2	9.8	<1	0.09
26-Apr-16	0.73	<1	<2	12	<1	0.12
10-May-16	0.63	<1	<2	13	<1	0.12
24-May-16	0.65	<1	<2	12.4	<1	0.17
31-May-16	0.66	<1	<2	12.9	<1	0.12
7-Jun-16	0.67	<1	<2	15.1	<1	0.17
21-Jun-16	0.75	<1	<2	15.2	<1	0.12
5-Jul-16	0.58	<1	<2	12.3	1	0.1
19-Jul-16	0.57	<1	<2	15.8	<1	0.13
2-Aug-16	0.57	<1	<2	14.4	<1	0.11
16-Aug-16	0.62	<1	<2	15.2	<1	0.08
30-Aug-16	0.58	<1	<2	16.1	<1	0.13
13-Sep-16	0.51	<1	<2	17.2	<1	0.09
27-Sep-16	0.46	<1	<2	15.5	<1	0.18
11-Oct-16	0.53	<1	<2	12.7	<1	0.08
18-Oct-16	0.56	<1	<2	11.5	<1	0.2
25-Oct-16	0.65	<1	<2	11.2	<1	0.08
8-Nov-16	0.74	<1	<2	12.9	<1	0.15
22-Nov-16	0.51	<1	<2	10.9	<1	0.15
6-Dec-16	0.43	<1	<2	8.2	<1	0.08
20-Dec-16	0.54	<1	<2	5.6	<1	0.13

Min	0.43	<1	<2	5.6	<1	0.08
Average	0.61	<1	3	11.5	<1	0.13
Max	0.75	<1	20	17.2	1	0.20
Count	28	28	28	28	28	27

**Incorrect UNITS selected on Turbidimeter


Free Cl2 and HPC at Sample Point S-E
Free Chlorine (mg/L)
HPC (CFU/mLs)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
400
300
200
100
0
Free Chlorine
HPC
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-E
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
1.2
1
0.8
0.6
0.4
0.2
0
Total Coliform
Total Ecoli
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16

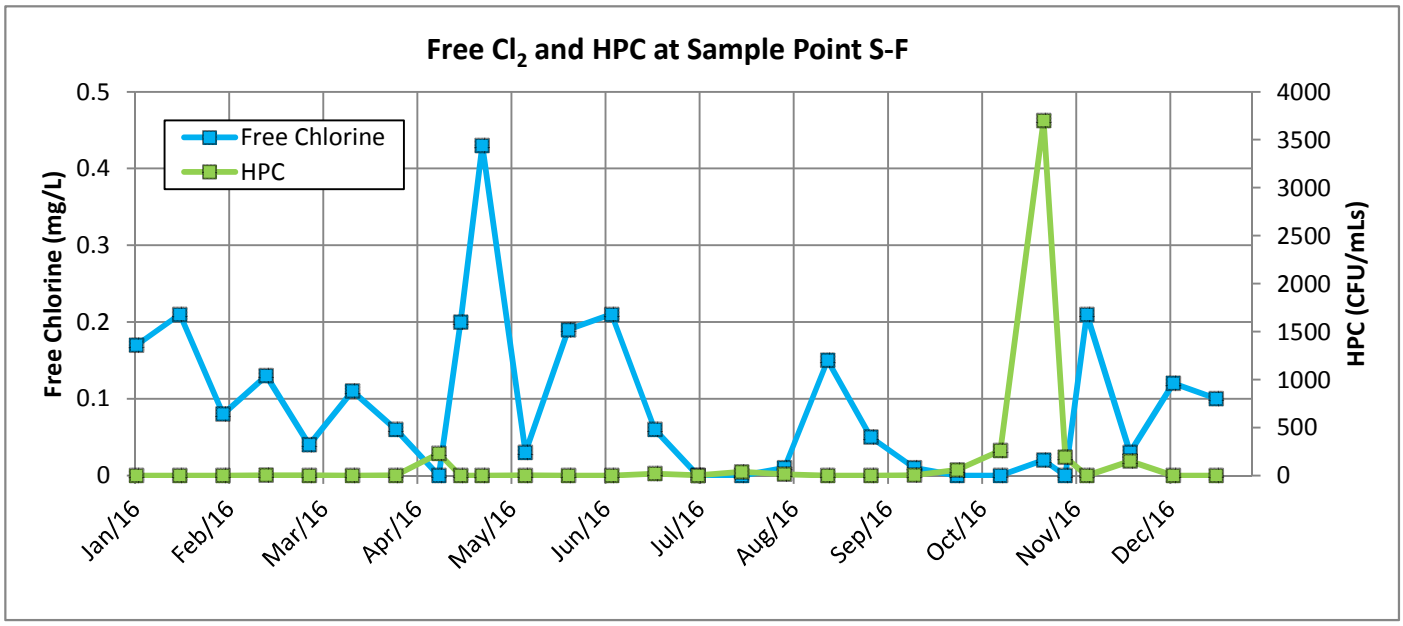

Temperature and Turbidity at Sample Point S-E
Temperature (C)
Turbidity (NTU)
20
18
16
14
12
10
8
6
4
2
0
3
2.5
2
1.5
1
0.5
0
Temperature
Turbidity
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16

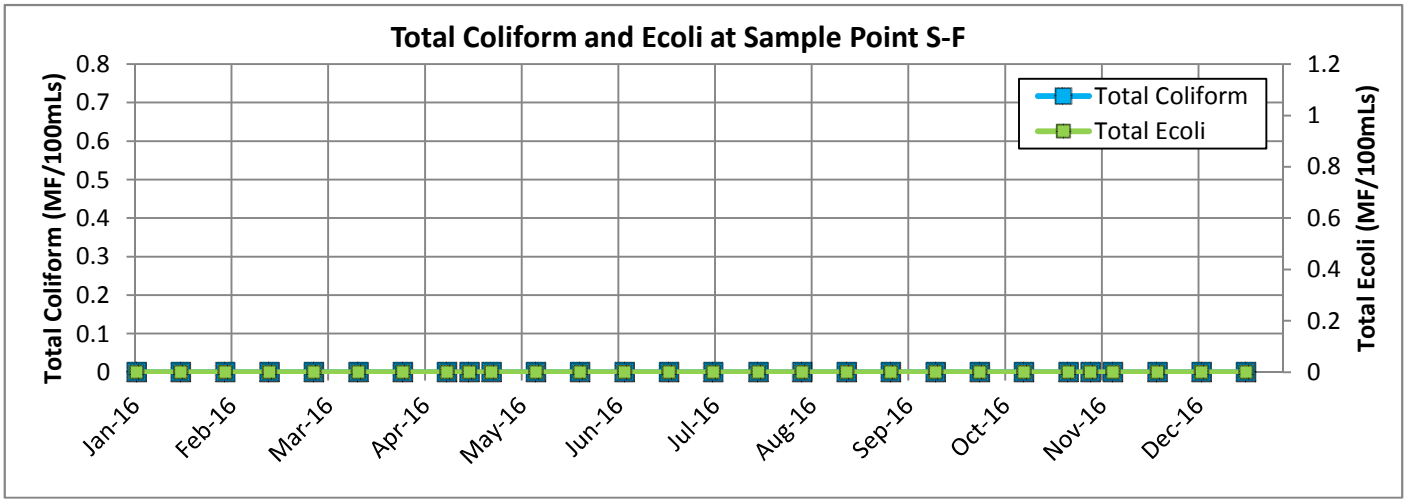
Sample Point S-F
Location: Marine Drive at UEL Boundary

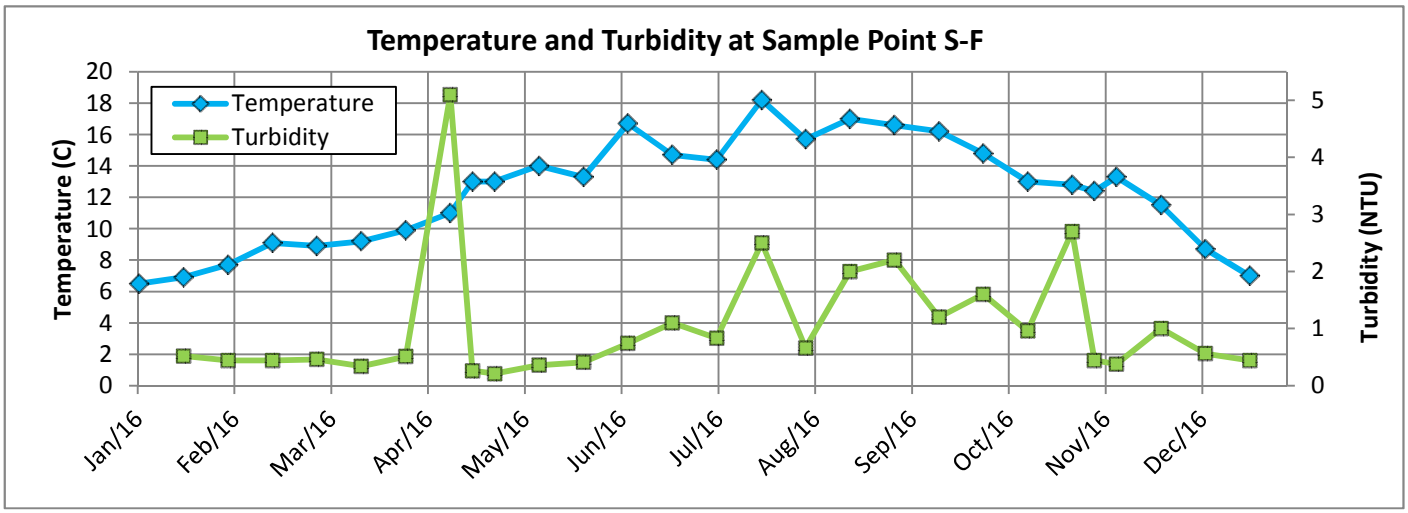
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
5-Jan-16	0.17	<1	<2	6.5	<1	LA**
19-Jan-16	0.21	<1	<2	6.9	<1	0.52
2-Feb-16	0.08	<1	<2	7.7	<1	0.44
16-Feb-16	0.13	<1	4	9.1	<1	0.44
1-Mar-16	0.04	<1	2	8.9	<1	0.46
15-Mar-16	0.11	<1	<2	9.2	<1	0.34
29-Mar-16	0.06	<1	2	9.9	<1	0.51
12-Apr-16	<0.04	<1	230	11	<1	5.1
19-Apr-16	0.2	<1	<2	13	<1	0.26
26-Apr-16	0.43	<1	<2	13	<1	0.21
10-May-16	0.03	<1	2	14	<1	0.36
24-May-16	0.19	<1	<2	13.3	<1	0.41
7-Jun-16	0.21	<1	<2	16.7	<1	0.74
21-Jun-16	0.06	<1	20	14.7	<1	1.1
5-Jul-16	0	<1	2	14.4	<1	0.83
19-Jul-16	<0.02	<1	38	18.2	<1	2.5
2-Aug-16	0.01	<1	14	15.7	<1	0.66
16-Aug-16	0.15	<1	<2	17	<1	2
30-Aug-16	0.05	<1	<2	16.6	<1	2.2
13-Sep-16	0.01	<1	4	16.2	<1	1.2
27-Sep-16	0	<1	58	14.8	<1	1.6
11-Oct-16	0	<1	260	13	<1	0.96
25-Oct-16	0.02	<1	3700	12.8	<1	2.7
1-Nov-16	0	<1	190	12.4	<1	0.44
8-Nov-16	0.21	<1	<2	13.3	<1	0.38
22-Nov-16	0.03	<1	150	11.5	<1	1
6-Dec-16	0.12	<1	<2	8.7	<1	0.56
20-Dec-16	0.1	<1	<2	7	<1	0.44

Min	0.00	<1	<2	6.5	<1	0.21
Average	0.10	<1	168	12.3	<1	1.05
Max	0.43	<1	3700	18.2	<1	5.10
Count	28	28	28	28	28	27

**Incorrect UNITS selected on Turbidimeter


Free Cl2 and HPC at Sample Point S-F
Free Chlorine
HPC
Free Chlorine (mg/L)
HPC (CFU/mLs)
0.5
0.4
0.3
0.2
0.1
0
4000
3500
3000
2500
2000
1500
1000
500
0
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-F
Total Coliform
Total Ecoli
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.2
1
0.8
0.6
0.4
0.2
0
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16

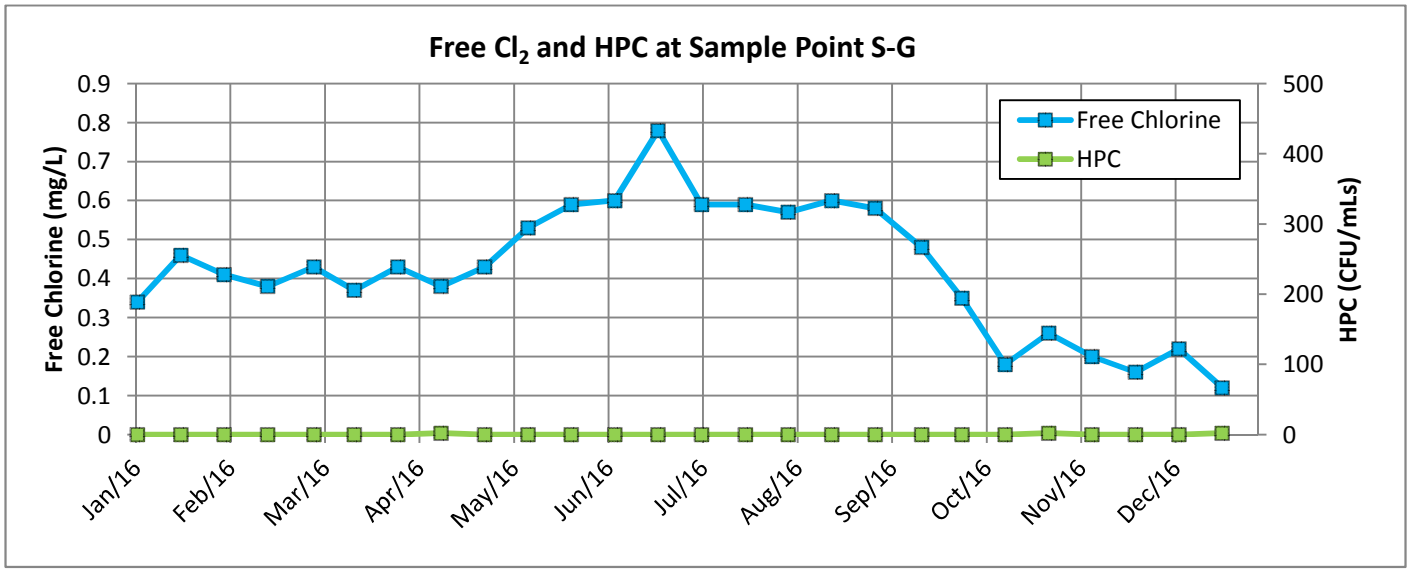

Temperature and Turbidity at Sample Point S-F
Temperature
Turbidity
Temperature (C)
Turbidity (NTU)
20
18
16
14
12
10
8
6
4
2
0
5
4
3
2
1
0
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16

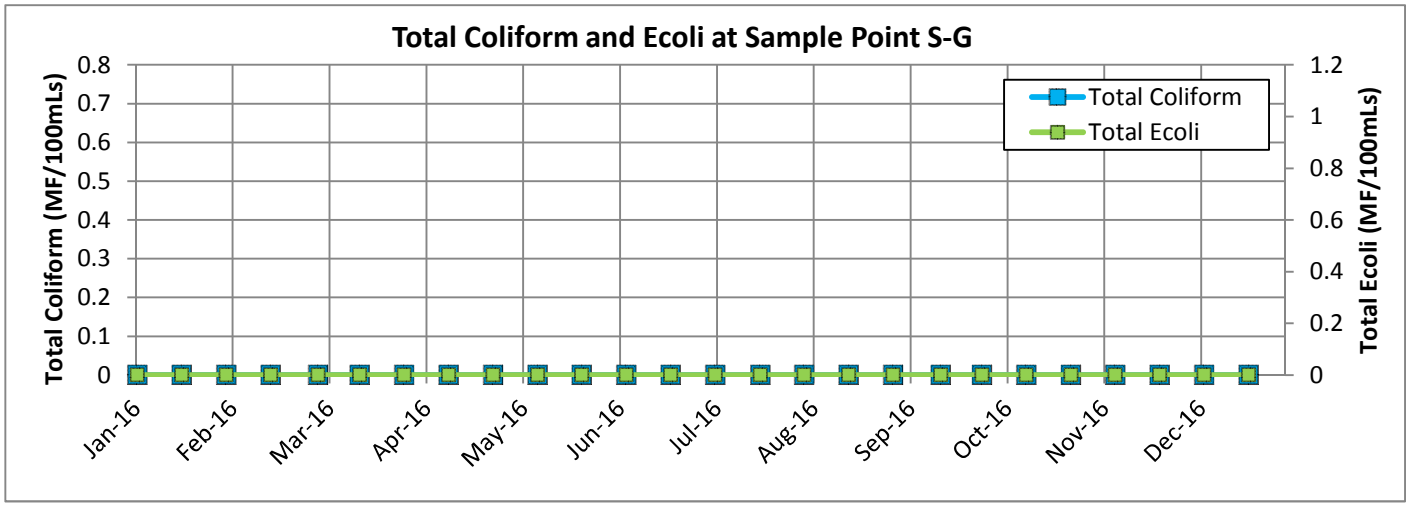
Sample Point S-G
Location: Chancellor Blvd. East of Acadia

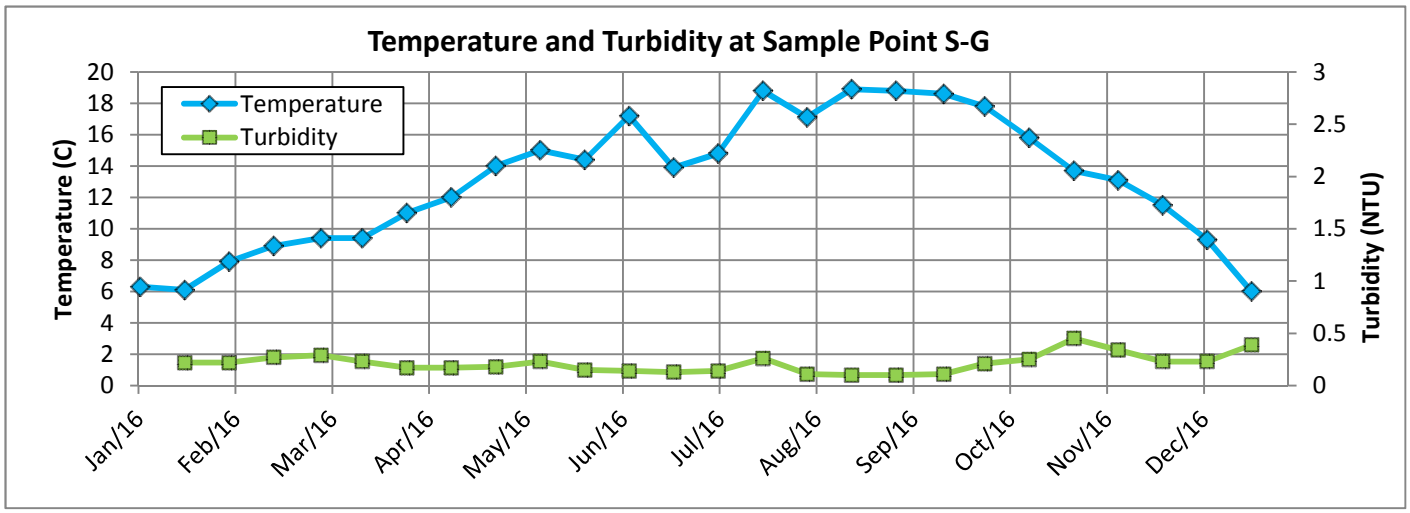
Sampled Date	Chlorine Free (mg/L)	Ecoli (MF/100mLs)	HPC (CFU/mls)	Temp (°C)	Total Coliform (MF/100mLs)	Turbidity (NTU)
5-Jan-16	0.34	<1	<2	6.3	<1	LA**
19-Jan-16	0.46	<1	<2	6.1	<1	0.22
2-Feb-16	0.41	<1	<2	7.9	<1	0.22
16-Feb-16	0.38	<1	<2	8.9	<1	0.27
2-Mar-16	0.43	<1	<2	9.4	<1	0.29
15-Mar-16	0.37	<1	<2	9.4	<1	0.23
29-Mar-16	0.43	<1	<2	11	<1	0.17
12-Apr-16	0.38	<1	2	12	<1	0.17
26-Apr-16	0.43	<1	<2	14	<1	0.18
10-May-16	0.53	<1	<2	15	<1	0.23
24-May-16	0.59	<1	<2	14.4	<1	0.15
7-Jun-16	0.6	<1	<2	17.2	<1	0.14
21-Jun-16	0.78	<1	<2	13.9	<1	0.13
5-Jul-16	0.59	<1	<2	14.8	<1	0.14
19-Jul-16	0.59	<1	<2	18.8	<1	0.26
2-Aug-16	0.57	<1	<2	17.1	<1	0.11
16-Aug-16	0.6	<1	<2	18.9	<1	0.1
30-Aug-16	0.58	<1	<2	18.8	<1	0.1
14-Sep-16	0.48	<1	<2	18.6	<1	0.11
27-Sep-16	0.35	<1	<2	17.8	<1	0.21
11-Oct-16	0.18	<1	<2	15.8	<1	0.25
25-Oct-16	0.26	<1	2	13.7	<1	0.45
8-Nov-16	0.2	<1	<2	13.1	<1	0.34
22-Nov-16	0.16	<1	<2	11.5	<1	0.23
6-Dec-16	0.22	<1	<2	9.3	<1	0.23
20-Dec-16	0.12	<1	2	6	<1	0.39

Min	0.12	<1	<2	6.0	<1	0.10
Average	0.42	<1	2	13.1	<1	0.21
Max	0.78	<1	2	18.9	<1	0.45
Count	26	26	26	26	26	25

**Incorrect UNITS selected on Turbidimeter


Free Cl2 and HPC at Sample Point S-G
Free Chlorine (mg/L)
HPC (CFU/mLs)
Free Chlorine
HPC
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
400
300
200
100
0
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16


Total Coliform and Ecoli at Sample Point S-G
Total Coliform (MF/100mLs)
Total Ecoli (MF/100mLs)
Total Coliform
Total Ecoli
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.2
1
0.8
0.6
0.4
0.2
0
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16


Temperature and Turbidity at Sample Point S-G
Temperature (C)
Turbidity (NTU)
Temperature
Turbidity
20
18
16
14
12
10
8
6
4
2
0
3
2.5
2
1.5
1
0.5
0
Jan/16
Feb/16
Mar/16
Apr/16
May/16
Jun/16
Jul/16
Aug/16
Sep/16
Oct/16
Nov/16
Dec/16