EXHIBIT L. WATER QUALITY MONITORING REPORT
LAKE WHATCOM NORTH SHORE ON-SITE SEWAGE SYSTEM LEACHATE DETECTION PROJECT
(Herrera, July 10, 2017)
And
NORTH SHORE ON-SITE SEPTIC SYSTEM PHOSPHORUS LOADING ANALYSIS
(Herrera, June 21, 2018)

WATER QUALITY MONITORING REPORT

LAKE WHATCOM NORTH SHORE ON-SITE SEWAGE SYSTEM LEACHATE DETECTION PROJECT

Prepared for
Lake Whatcom Water & Sewer District

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA

WATER QUALITY MONITORING REPORT

LAKE WHATCOM NORTH SHORE ON-SITE SEWAGE SYSTEM LEACHATE DETECTION PROJECT

Prepared for
Lake Whatcom Water & Sewer District
1220 Lakeway Drive
Bellingham, Washington 98229

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

July 10, 2017

CONTENTS

APPENDICES

TABLES

FIGURES

LAKE WHATCOM WATER & SEWER DISTRICT

1220 Lakeway Drive
Bellingham, WA, 98229

(360) 734-9224
Fax 738-8250

PREFACE

Lake Whatcom Water and Sewer District (District) was formed in the 1960's for the primary purpose of reducing pollution entering Lake Whatcom from individual onsite sewage septic systems in the urbanized and growing Sudden Valley and Geneva communities. The District's public sewer system now serves the equivalent of 4,308 single family residences located in the Lake Whatcom watershed. By means of a network of sewer mains and pump stations an average of 0.78 million gallons of wastewater is collected and sent to the City of Bellingham's wastewater treatment plant every day. For nearly 50-years the District has worked with the State of Washington and other local governments to protect and improve Lake Whatcom water quality, which is the drinking water source for a population of nearly 100,000 people. The District's mission statement has long included the protection of Lake Whatcom water quality.

In furtherance of the District's mission to protect lake water quality, the District commissioned this study to investigate potential impacts from onsite septic systems at the end of Northshore Road where there is currently no public sewer system. The District contracted with Herrera Environmental Consultants to test lake water quality over a period of time using various state of the art scientific methods along 2.5 miles of shoreline starting at Agate Bay and ending at Whatcom County's Lake Whatcom Park. On this stretch there are 97 existing homes with the potential for development of around 30 more. Wastewater from these lots could result in as much as 22,000 gallons per day (8 million gallons annually) that is treated and dispersed by individual onsite sewage septic system drain fields located close to the lakeshore.

The District was concerned that wastewater percolating through soils from individual drain fields near the lakeshore may be carrying fecal coliform, phosphorus, and other chemicals to ground water that flows into the lake. The results of this study give credence to these concerns. DNA testing of the water samples positively identified fecal coliform entering the lake came from not just animals but also humans. The study made no attempt to quantify or perform a loading analysis, but proves that human feces are entering Lake Whatcom from several sources along Northshore Road.

The results of this study may support extending public sewer and eliminating septic systems near the lake. The District plans to coordinate with various Whatcom County departments and Washington State Department of Ecology to review all potential solutions to this problem, including the potential for extending public sewer to the end of Northshore Road.

Lake Whatcom Water and Sewer District
Board of Commissioners

EXECUTIVE SUMMARY

To protect the high quality water supply from Lake Whatcom, the Lake Whatcom Water and Sewer District investigated the area along approximately 2.3 miles of North Shore Road that includes approximately 97 homes currently served by on-site septic systems . A water quality monitoring study was developed to determine if septic systems along North Shore Road are contaminating Lake Whatcom, either by soil seepage or surfacing failure.

Herrera Environmental Consultants prepared a plan that considered various microbiological, chemical, biochemical, and molecular techniques for detecting septic system effluent in drainage from the study area and in the lake. The study design included monitoring of select field and laboratory parameters during three wet weather events in the winter of 2017, when septic system contamination would most likely be observed due to saturated soils and a high water table. Water quality monitoring was conducted in the lake near the shoreline and in discharges to the lake that drain only properties in the study area. Therefore, any discharge shown to be contaminated by septic system effluent is contaminating the lake from septic systems located within the study area.

The study was conducted, as planned, by boat during a large rain event on January 19 (2.20 inches in 48 hours), a moderate rain event on March 15 (0.87 inch in 48 hours), and a large rain event on March 29 (1.86 inches in 48 hours), 2017. The lake level rose 1.9 feet between January 19 and March 15, and another 0.7 foot by March 29, 2017.

For each rain event, field measurements were taken continuously in the lake and in all the observed surface water discharges to the lake, proceeding in a northwest direction along the shoreline from the control site (undeveloped forest) and then through the study area. Water samples were collected from select lake and surface water discharge locations where optical brighteners from laundry detergent were detected at greater than approximately 50 percent above the background measured at the lake control stations. During each event, a total of up to 18 samples were collected at lake control stations (undeveloped shoreline to southeast for background), lake impact stations (distant from drainage discharges in study area), discharge stations (draining only the study area), and one on-site sewage station (source confirmation). The samples were analyzed for microbiological parameters (fecal coliform bacteria and E. coli) for all three events, and for two different DNA biomarkers of human-specific fecal bacteria and chemistry parameters (total phosphorus, chloride, and bromide) for the second and third events only.

Study results showed that many septic systems in the study area are a likely source of contamination to Lake Whatcom. The DNA biomarkers of human-specific bacteria were found at moderate to high concentrations at 6 of the 13 sampled discharge stations and at 1 of the 4 sampled lake stations located along the 2.3-mile-long shoreline. At one discharge station,

human biomarker concentrations were high for both wet weather sampling events and were present at levels similar to those measured in septic tank samples.

Discharge and lake samples contaminated by human biomarkers from septic system effluent also contained elevated levels of optical brighteners, fecal coliform bacteria, and total phosphorus. The elevated concentrations of optical brighteners indicate the presence of laundry detergents from septic system effluent. Fecal coliform bacteria and total phosphorus concentrations in the contaminated samples exceeded Washington State surface water quality standards, indicating impacts on public health and the lake environment, respectively. Both fecal coliform bacteria and total phosphorus positively correlated with optical brighteners, providing additional evidence that septic systems are a significant source of the observed contamination.

Fecal coliform bacteria and total phosphorus concentrations were several orders of magnitude higher in septic tank samples than in lake samples, indicating that the lake was contaminated by diffuse seepage from septic system drain fields rather than overland flow from failed systems. The numerous and diffuse septic system sources present in the study area would be difficult to locate and control for protection of public health and the environment. Connecting homes in the study area to a sanitary sewer would prevent the ongoing contamination of Lake Whatcom from septic systems in the area.

1. INTRODUCTION

Lake Whatcom is the surface water supply for the Lake Whatcom Water and Sewer District (LWWSD) that currently serves a population of nearly 10,000 people from a water treatment plant located in Sudden Valley. Lake Whatcom is also the drinking water source for a number of residences that draw directly from the lake as well as the City of Bellingham, which serves a population of nearly 100,000.

The US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) determined that the water quality of Lake Whatcom has become polluted to the point where action must be taken. The Lake Whatcom Watershed Total Phosphorus and Bacteria TMDL (total maximum daily load) Water Quality Improvement Plan (Ecology 2016) addresses elevated amounts of fecal coliform bacteria and phosphorus, which causes excessive growth of algae and low dissolved oxygen levels. Sources contributing to the high phosphorus and bacteria levels may include failed on-site septic systems (OSS). The TMDL Water Quality Improvement Plan primarily relies on stormwater treatment to reduce phosphorus loadings to the lake, and only addresses OSS inputs through existing OSS regulations and permitting.

The City of Bellingham and Whatcom County each have a program to sample and analyze water quality of certain areas of Lake Whatcom and incoming streams. The LWWSD is a partner with the City of Bellingham and Whatcom County through inter-local agreements. However, there currently are no known efforts to sample and analyze the North Shore area of Lake Whatcom to investigate possible impacts from OSS leaching into the lake.

The LWWSD has concerns that OSS along the North Shore of Lake Whatcom may be contributing to phosphorus and fecal coliform bacteria pollution problems, as well as adding pharmaceutical and other manmade compounds to the lake. The leachate of OSS drain fields contain high levels of phosphorus and fecal bacteria. Leachate also contains man-made compounds found in most detergents called optical brighteners. These compounds may be detectible and useful as an indicator of leachate entering the lake.

The LWWSD evaluated OSS maintenance records showing recent OSS problems and a lack of regulatory compliance, and recommended conducting a water quality study to document impacts to Lake Whatcom by OSS in the North Shore Road area (Wilson 2015). Subsequent to a concentrated effort by the Whatcom County Health Department; 90 properties became current on their OSS inspections as of August 2016.

A water quality monitoring study was developed to determine if septic systems along North Shore are contaminating Lake Whatcom, either by soil seepage or surfacing failure. A quality assurance project plan (QAPP) was prepared that considered various microbiological, chemical, biochemical, and molecular techniques for detecting septic system effluent in drainage from the study area and in the lake (Herrera 2016). The study design included monitoring of select field

and laboratory parameters during three wet weather events in the winter of 2017, when septic system contamination would be most likely observed due to saturated soils and a high water table. Water quality monitoring was conducted in the lake near the shoreline and in discharges to the lake. All 20 discharges in the study area drained only properties in the study area. Thus, any discharge shown to be contaminated by septic system effluent is contaminating the lake from a septic system located within the study area.

This report is organized into the following sections:

- Methods
- Results and Discussion
- Conclusions

2. METHODS

Field and analytical methods used are discussed below. Additional information regarding project background, experimental design, and sampling methods can be found in the *Lake Whatcom North Shore OSS Quality Assurance Project Plan* (QAPP) (Herrera 2016).

Water quality monitoring was conducted from a motorized inflatable boat during three wet weather events that included continuous field measurements along the lake shore within a control site and the project site (Figure 1), and the collection of water samples from four different types of sample stations:

1. **Lake Control Station**: Lake water adjacent to an undeveloped lake shoreline located southeast of the project site in the control site

2. **Lake Impact Station**: Lake water adjacent to the lake shoreline in the project site that is distant from and not directly affected by discharge of local drainages

3. **Discharge Station**: Drainage water discharging to the lake from local pipes and ditches in the project site

4. **OSS Station**: OSS source water collected from one septic tank located in the project site

The wet weather events analyzed 48-hour rainfall totals (for sampling date and previous day) with 2.20 inches of rainfall on January 19 (Event 1), 0.87 inches on March 15 (Event 2), and 1.86 inches on March 29 (Event 3), 2017, as shown in Table 1. These rainfall amounts are for a rain gauge located at a lake shore residence in the project site and are slightly higher than those measured at a nearby rain gauge operated by the City of Bellingham. Thus, samples were collected during two large storm events (Events 1 and 3) and one moderate storm event (Event 2). The QAPP objective of sampling after a minimum of 0.5 inches of rain in 24 hours was not quite met for Event 2.

Table 1. Rainfall Amounts and Lake Levels for Sampling Events.

	Sampling Event 1 1/19/2017	Sampling Event 2 3/15/2017	Sampling Event 3 3/29/2017
City 24-hour rainfall previous day (inches)[a]	0.98	0.33	0.59
City 24-hour rainfall sampling day (inches)[a]	1.05	0.42	1.10
City Total 48-hour rainfall (inches)[a]	2.03	0.75	1.69
Lake Shore 48-hour rainfall (inches)[b]	2.20	0.87	1.86
Daily Average Lake Elevation (feet MSL)	312.0	313.9	314.6

[a] Rainfall data from the City of Bellingham's North Shore MET rain gage.

[b] Rainfall data from Weather Underground station SWABELL105 located at a lake shore residence in the project site.

The lake level rose 1.9 feet between sampling on January 19 (Event 1) and March 15 (Event 2), and another 0.7 feet on March 29 (Event 3) (see Table 1). The shallow water table adjacent to the lake likely rose a similar amount and may have increased the potential for OSS contamination of the lake with each event.

For each event, field measurements were measured continuously in the lake and all of the observed surface water discharges to the lake, proceeding in a northwest direction along the shoreline from the control site (undeveloped forest) and then through the project site (see Figure 1). Photographic documentation is included in Appendix A.

A calibrated YSI ProDSS multimeter was used to measure and log positon, temperature, dissolved oxygen (DO), pH, and conductivity. A Turner Cyclops-7 fluorometer, configured at a wavelength for optical brighteners (OB) and calibrated for a low detection limit (0.6 µg/L), was used to log data in relative fluorescence units (RFU). The meter probes were zip tied together and deployed at a depth of about 6 inches in the lake while the boat was slowly maneuvered as close to shore as possible; the boat was typically beached for deployment of the probes directly in discharges.

The OB fluorometer method has the advantage of detecting human wastewater inputs in real-time and by logging data continuously, which is particularly useful for pinpointing OSS inputs. However, other studies have reported no correlation between fluorometer and fecal coliform bacteria results. High concentrations of naturally-produced humic acids and contamination by petroleum hydrocarbons may interfere with OB analyses, but those interferences are not expected to be a substantial in Lake Whatcom. The Cyclops 7 probe with the DataBank display/logger, stainless steel sensor, and 5 meter cable was recommended for this OSS detection study because of its high sensitivity, low detection limit, low interference, and ease of use for measuring OB concentrations at an unlimited number of locations along the lake shore (Herrera 2016).

Water samples were collected from select lake and surface water discharge locations exhibiting fluorescence greater than approximately 50 percent above background measured at the lake control stations. During each event, a total of up to 18 samples were collected from up to 3 lake control stations, 3 lake impact stations, 14 discharge stations, and 1 on-site sewage (OSS) station (see Figure 1). All of the lake impact stations were located beyond the influence of a discharge and represent impacts from groundwater seepage or other non-point sources. Nearly all of the 20 discharges located along the 2.3 mile shoreline exceeded the fluorescence criterion for sampling and some discharges were not sampled because they were not observed or had previously exhibited low fecal coliform concentrations. Table 2 summarizes the sample analyses performed for each event.

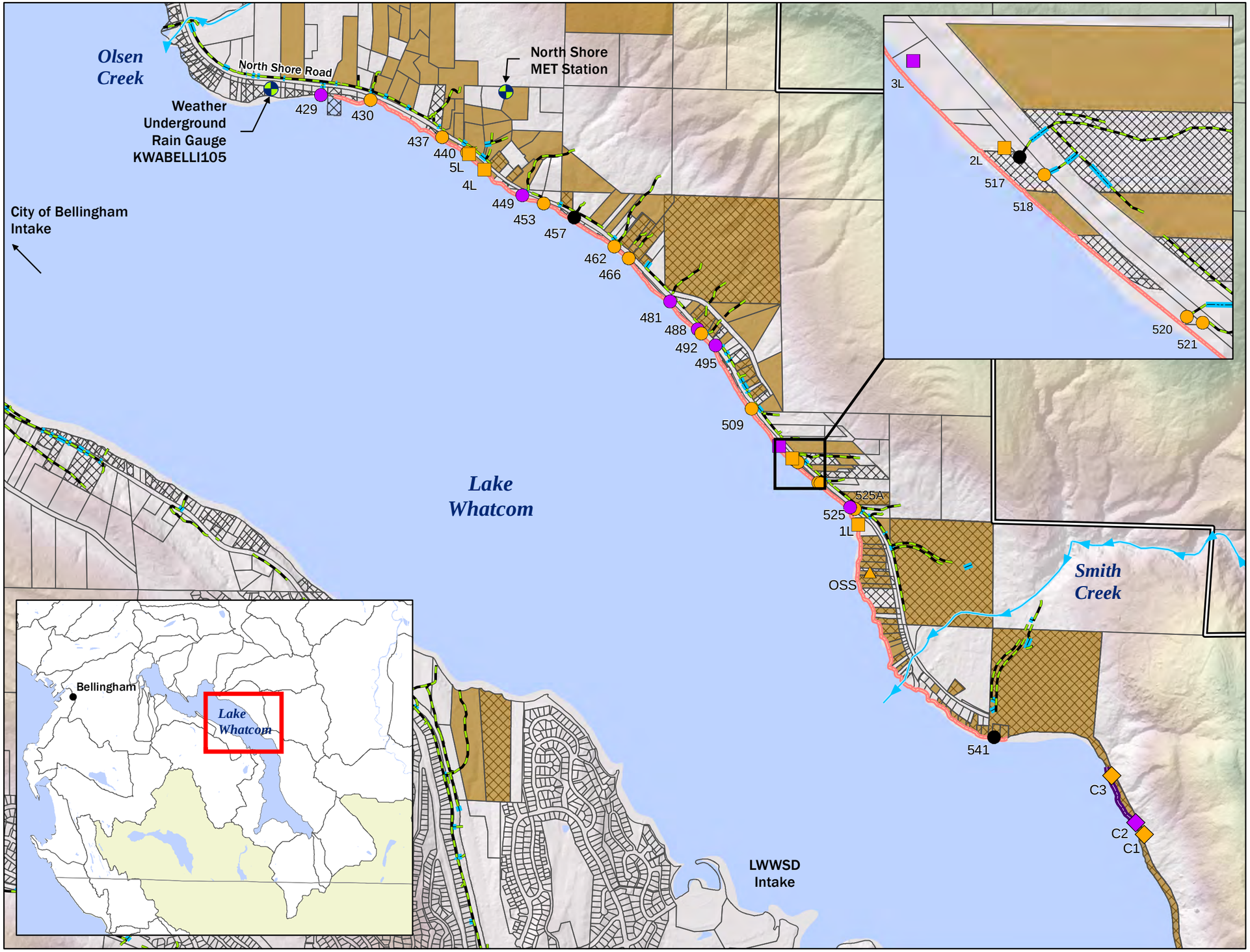


Figure 1.
Sample Stations
Lake Whatcom North Shore Road
OSS Detection Project.

Legend

- Rain Gauge/Weather Station
- Stream
- Open drain
- Culvert
- Project site survey area
- Control site survey area
- Parcel boundary
- Lake
- Septic system permit
- Water Right Application/ Claim/Permit or Improved
- LWWSD boundary

Sample Station Type

- Discharge
- Lake Control
- Lake Impact
- OSS Source

Sample Analysis Type

- Field/Fecals/MST
- Field/Fecals
- No analyses

0 625 1,250 2,500 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet
ESRI Basemap (2017)

K:\Projects\Y2016\16-06326-000\Project\GIS_Working\Sampling_Station_Figure.mxd (6/5/2017)

Table 2. Sample Analyses Performed for Each Sampling Event.				
Station ID	Station Description	Sample Analyses		
		Event 1	Event 2	Event 3
Lake Control				
C1	Next to undeveloped shoreline SE of site	F, B	F, B, L	F, B, L
C2	Next to undeveloped shoreline SE of site	F, B	–	–
C3	Next to undeveloped shoreline SE of site	F, B	F, B, L	F, B
Lake Impact				
1L	Next to shoreline S of Discharge 525	–	–	F, B, L
2L	Next to shoreline at Discharge 517	–	F, B, L	–
3L	Next to shoreline NW of Discharge 517	F, B	–	–
4L	Next to shoreline SE of Discharge 440	–	F, B, L	–
5L	Next to shoreline at Discharge 440	–	F, B, L	–
Discharge				
429	8-inch corrugated HDPE	–	–	F, B
430	Twin 12- and 8-inch corrugated HDPE	F[a], B	F, B, L	F, B, L
437	Open channel	F[a], B	F, B, L	F, B, L
440	Open channel	F[a], B	–	F, B, L
449	Open channel	F[a], B	F, B	F, B, L
453	24-inch corrugated HDPE	–	F, B	F, B, L
462	36-inch corrugated HDPE	F[a], B	F, B, L	F, B, L
466	36-inch concrete	F[a], B	F, B, L	F, B, L
481	36-inch concrete	F, B	F	F
488	36-inch corrugated HDPE	F, B	F	F
492	Open channel	F, B	F, B, L	F, B
495	36-inch concrete	F, B	F	–
509	36-inch concrete	F, B	F, B	F, B, L
518	36-inch concrete	–	F, B, L	F, B, L
520	Open channel	–	F, B, L	F, B, L
521	36-inch concrete	F, B	F	F, B, L
525	24-inch concrete	–	F, B, L	F, B, L
525A	Open channel	F, B	–	–
Septic Tank				
OSS	3201 North ~~s~~Shore Road	–	F, B, L	F, B, L

[a] Optical brighteners not measured with field parameters due to fluorometer malfunction.

F = Field parameters (temperature, dissolved oxygen, pH, conductivity, turbidity, optical brighteners).

B = Bacteria parameters (fecal coliform bacteria and *E. coli*).

L = Laboratory analysis of chemistry (total phosphorus, chloride, and bromide) and Bacteroidetes (*B. dorei* and EPA developed assay).

Water samples were collected by pumping water with a peristaltic pump from 0.25-inch tubing attached to the instrument probe assembly. New tubing was used for each event and purged for several minutes prior to the collection of each sample. Sterile technique was employed, the

control samples were collected first, and the OSS sample was collected last. Sample containers provided by the laboratories were filled as designed for the following laboratory analyses:

- Microbiological: fecal coliform bacteria and *E. coli* by LabCor, Inc. using Standard Method 9222D (membrane filtration).

- Chemistry: total phosphorus, chloride, and bromide by Analytical Resources, Inc. using Standard Method 4500-P E (persulfate/ascorbic acid) and EPA Method 300.0 (ion chromatography).

- Microbial Source Tracking (MST): Bacteroidetes human gene biomarkers 1 (*B. dorei*) and 2 (EPA developed assay) by Source Molecular Corporation using digital quantitative polymerase chain reaction (digital qPCR).

Analysis of water samples for fecal coliform bacteria was recommended for this OSS detection study to assess potential effects of OSS on fecal coliform bacteria loading to Lake Whatcom and assist with TMDL implementation. Although fecal coliform bacteria concentrations in the lake may not be directly related to OSS inputs, due to an abundance of non-human fecal sources, unusually high concentrations may be used as one line of evidence for OSS impacts to human health.

Total dissolved phosphorus analysis of water samples was originally recommended for this OSS study because of the importance of phosphorus loading from OSS to the lake, and because measuring only dissolved fractions of phosphorus would reduce variation in concentrations of total phosphorus caused by wave suspension of near shore sediment (Herrera 2016). However, total phosphorus was analyzed because it directly relates to the TMDL (Ecology 2016) and ongoing monitoring at Lake Whatcom. In addition, suspension of lake sediment along the shoreline appeared to be minor and analysis of only soluble phosphorus would have excluded phosphorus from OSS contamination that had precipitated or adsorbed to particles in discharge waters.

Chloride and bromide analyses were recommended for this OSS study as an additional indicator of possible OSS contamination of the lake. Chloride concentrations are elevated in sewage due to large amounts of salt in human waste and chloride moves conservatively (no adsorption or degradation) in ground and surface waters. Chloride (Cl) to bromide (Br) ratios have been used successfully to detect OSS contamination of ground waters because this ratio accounts for natural variation of these constituents in the salt content of rainfall and groundwater. The USGS (Katz et al. 2011) conducted a nationwide study of 1,848 wells and found that the Cl/Br ratio was useful as a screening tool for identifying potential impacts of OSS on shallow wells. However, bromide analysis may not be necessary because background salt concentrations are not likely to vary in the lake or shallow groundwater within the study area.

The *B. dorei* and EPA Developed Assay methods are designed around the principle that fecal Bacteroidales-like bacteria are found in large quantities in feces of warm-blooded animals. Furthermore, certain strains have been shown to be associated only with humans. False positives from non-human sources have never been observed for the *B. dorei* method and have been

observed only on rare occasions for the EPA method (Source Molecular, personal communication). As such, these bacterial strains can be used as indicators of human fecal contamination. MST results were weighted based on the following criteria with respect to the extent of human fecal contamination (Cao et. al. 2013):

- The frequency of samples that are positive for human MST markers was of primary importance
- The magnitude of and consistency between human-associated markers was of secondary importance
- General fecal indicator bacteria received the least weight.

For each event, all 17 or 18 samples were analyzed for the microbiological parameters and results were reported within 48 hours. For Events 2 and 3, 15 of the lake control and other samples exhibiting elevated fecal coliform concentrations were analyzed for the chemistry and MST parameters.

3. RESULTS AND DISCUSSION

Summary statistics for samples are presented in Table 3. Laboratory reports and data quality review worksheets and are presented in Appendix B. The sample results database is included in Appendix C.

Data quality review results are summarized first in this section. Monitoring results are then presented and discussed separately for field parameters (temperature, DO, pH, conductivity, and OB), chemistry (total phosphorus, chloride, and bromide), bacteria (fecal coliform and *E. coli*), and Bacteroidetes. This section concludes with results and discussion of the correlation analysis performed on the collected data.

3.1. DATA QUALITY REVIEW

Field and laboratory procedures followed the project QAPP (Herrera 2016) with the following exceptions:

- Optical brightener data are missing for approximately half of the site during Event 1 due to water damage to the fluorometer.
- Chemistry analyses were performed by Analytical Resources, Inc. instead of the Institute for Environmental Health that was specified in the QAPP.
- Total phosphorus was analyzed instead of total dissolved phosphorus.
- Reported laboratory detection limits for total phosphorus (0.008 milligrams per liter [mg/L]) and bromide (0.100 mg/L) were slightly elevated from the QAPP objectives (0.005 mg/L and 0.05 mg/L, respectively).

All continuous field parameter data were reviewed to remove data logged while probes were out of the water. Identified data were deleted from the database

Laboratory data were verified and validated to ensure that all data were consistent, correct, and complete, and that all required quality control information was provided. Values associated with minor quality control problems were considered estimates and assigned *J* qualifiers. Estimated values were used for evaluation purposes. The following laboratory quality control elements were reviewed for each sampling event:

- Completeness
- Methodology

Table 3. Summary Statistics for Samples Collected.

Parameter	Discharge Stations			Lake Impact Stations			Lake Control Stations			OSS Station		
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Temperature (°C)	5.2	8.9	7.4	6.8	7.7	7.2	6.3	6.7	6.7	7.8	9.1	8.5
Dissolved oxygen (mg/L)	10.5	12.2	11.7	11.1	11.7	11.3	10.4	11.8	11.4	**0.30**	**0.61**	**0.46**
pH (std. units)	**6.3**	7.4	7.1	6.9	7.4	7.1	7.2	7.5	7.3	6.9	7.0	6.9
Conductivity (µS/cm)	0.2	115.6	59.0	56.6	64.8	60.9	50.7	58.1	57.3	944	963	660
Turbidity (FNU)	0.9	67.2	8.2	0.4	3.0	1.7	0.2	0.6	0.3	26.8	32.3	29.6
Optical brighteners (RFUB)	51.0	297	189	61.7	227.7	81.2	8.2	45.5	43.4	632	686	660
Total phosphorus (mg/L)	0.014	**0.218**	**0.054**	0.012	**0.030**	**0.021**	<0.008	<0.008	<0.008	**10.2**	**10.3**	**10.3**
Chloride (mg/L)	1.15	3.47	2.08	2.56	3.05	2.61	2.59	2.68	2.68	46.8	48.1	47.5
Bromide (mg/L)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.001
Fecal coliform (CFU/100 mL)	2	800	36/**192**[a]	<5	46	10/31[a]	<2	<5	3/5[a]	1,500,000	4,080,000	**2,470,000/ 3,820,000**[a]
E. coli (CFU/100 mL)	2	342	28/**156**[a]	<5	42	10/29[a]	<2	<5	3/5[a]	1,500,000	4,080,000	**2,470,000/ 3,820,000**[a]
Fecal coliform/*E. coli* ratio	0.1	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
B. dorei (copies/100 mL)	0	21,700	8.4[b]	0	60	3.7[b]	0	<3	1.4[b]	1,030	1,460	1,230[b]
B. EPA (copies/100 mL)	0	9,960	4.6[b]	0	0	0	0	0	0	55,000	141,000	88,100[b]

[a] Geometric mean/90th percentile calculated for coliform bacteria.

[b] Geometric mean calculated for Bacteroidetes DNA.

Bold values exceed following surface water standards (WAC 173-201A): Temperature >16°C, DO <9.5 mg/L, pH <6.5, >8.5, Total phosphorus >0.020 mg/L, Bacteria geometric mean >0 cfu/100 mL or 90th percentile >100 cfu/100 mL.

°C = degrees Celsius

mg/L = milligrams per liter

µS/cm = microsiemens per centimeter

FNU = formazin nephelometric units

RFUB = relative fluorescence units, blank corrected

CFU/100 mL = colony forming units per 100 milliliters; Copies/100 mL = copies per 100 milliliters

< = not detected above the associated reporting limit

- Holding times
- Blanks
- Control Standards
- Matrix spikes
- Laboratory duplicates
- Fecal coliform bacteria enumeration

Based on the data validation, all reported results were considered acceptable for use as reported with the following exceptions:

- Several fecal coliform bacteria and *E. coli* results were qualified as estimated due to plate counts outside the ideal range of 20 to 60.
- The total phosphorus result for the sample collected from Station 4L during the second event was qualified as estimated (flagged *J*) due to method blank contamination.

3.2. FIELD PARAMETERS

Sample summary statistics for temperature, DO, pH, conductivity, and OB are presented in Table 3. Continuous field parameter data are presented on Figures 2 through 7.

As shown on Figure 2, continuous temperature measurements for Events 2 and 3 indicate a general increase in lake temperature along the shoreline moving away (northwest) from the control site, and the discharge points exhibited higher water temperature than the lake. For Event 1, however, temperature was generally consistent along the lake shoreline and discharge water temperatures were lower than the lake. This was due to snow and ice being present in the area during sampling for Event 1 in January. Temperature measurements ranged from 5.2 to 8.9 degrees Celsius (°C) at the discharge stations, 6.8 to 7.7°C at the lake impact stations, 6.3 to 6.7°C at the lake control stations, and 7.8 to 9.1°C at the OSS station (Table 3). Thus, the OSS samples were only a couple of degrees warmer than the lake and discharge waters. All temperature measurements met the surface water standard of less than 16°C (WAC 173-201A).

DO levels in the lake increased with each of the sampling events (Figure 3), likely due to increasing algae productivity. DO levels also slightly increased with distance along the shoreline from the control area for all three events. The DO results ranged from 10.5 to 12.2 mg/L at the discharge stations, 11.1 to 11.7 mg/L at the lake impact stations, 10.4 to 11.8 mg/L at the lake control stations, and 0.3 to 0.6 mg/L at the OSS station (Table 3). The lake and discharge samples were essentially saturated with oxygen, while essentially no oxygen was present in the OSS samples.

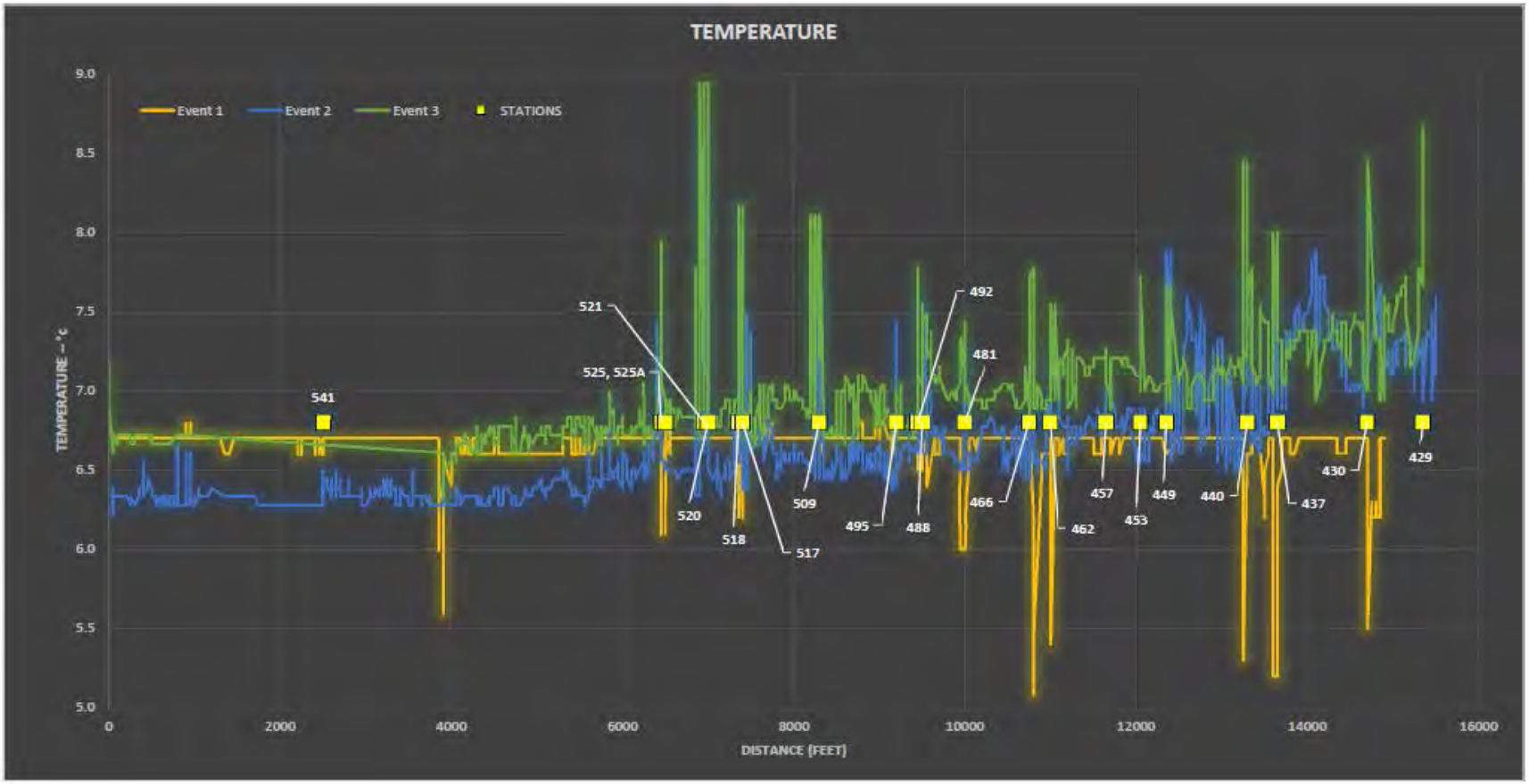


Figure 2. Water Temperature (°C) Along Lake Whatcom Shoreline Extending from Control Area.

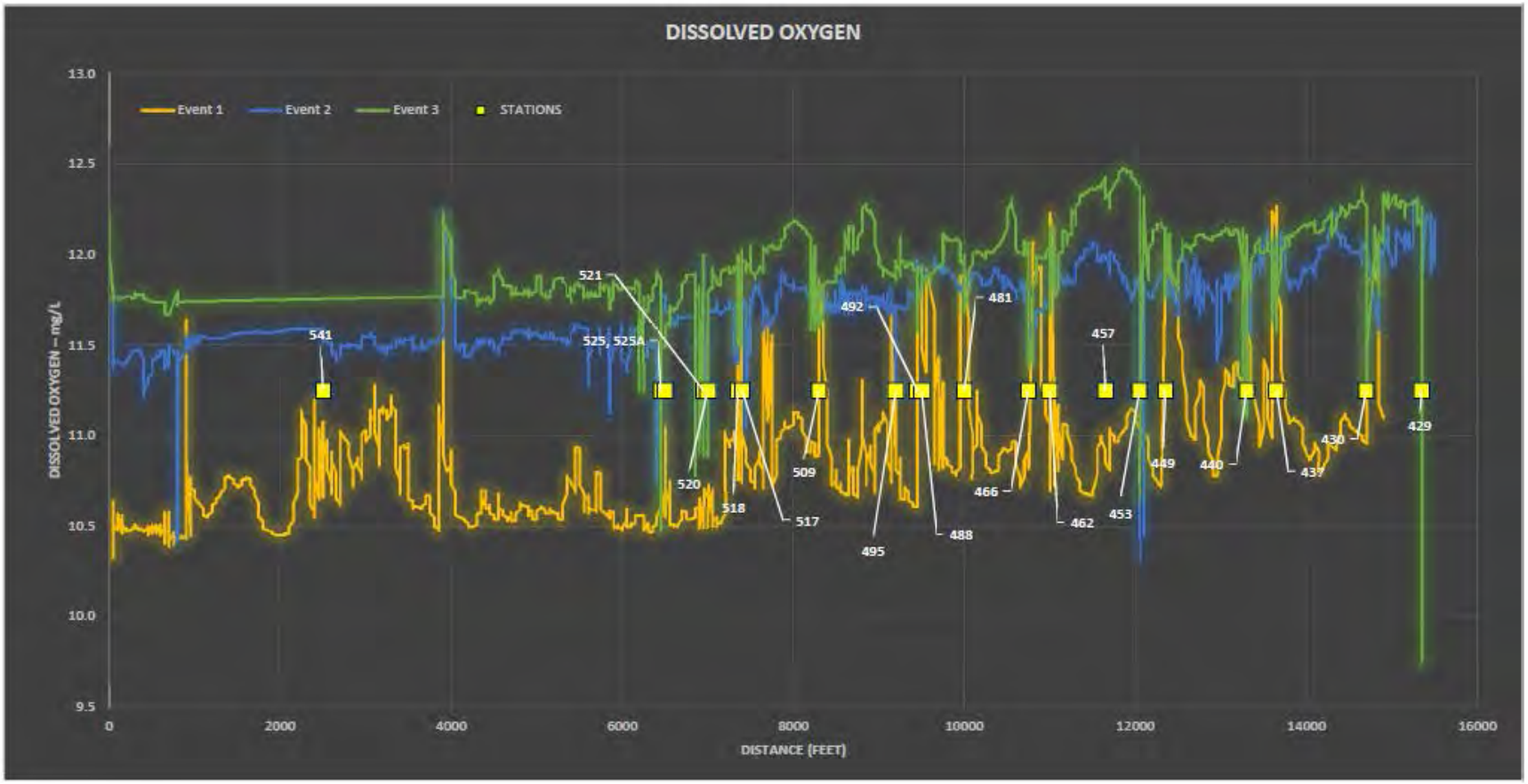


Figure 3. Dissolved Oxygen (mg/L) Along Lake Whatcom Shoreline Extending from Control Area.

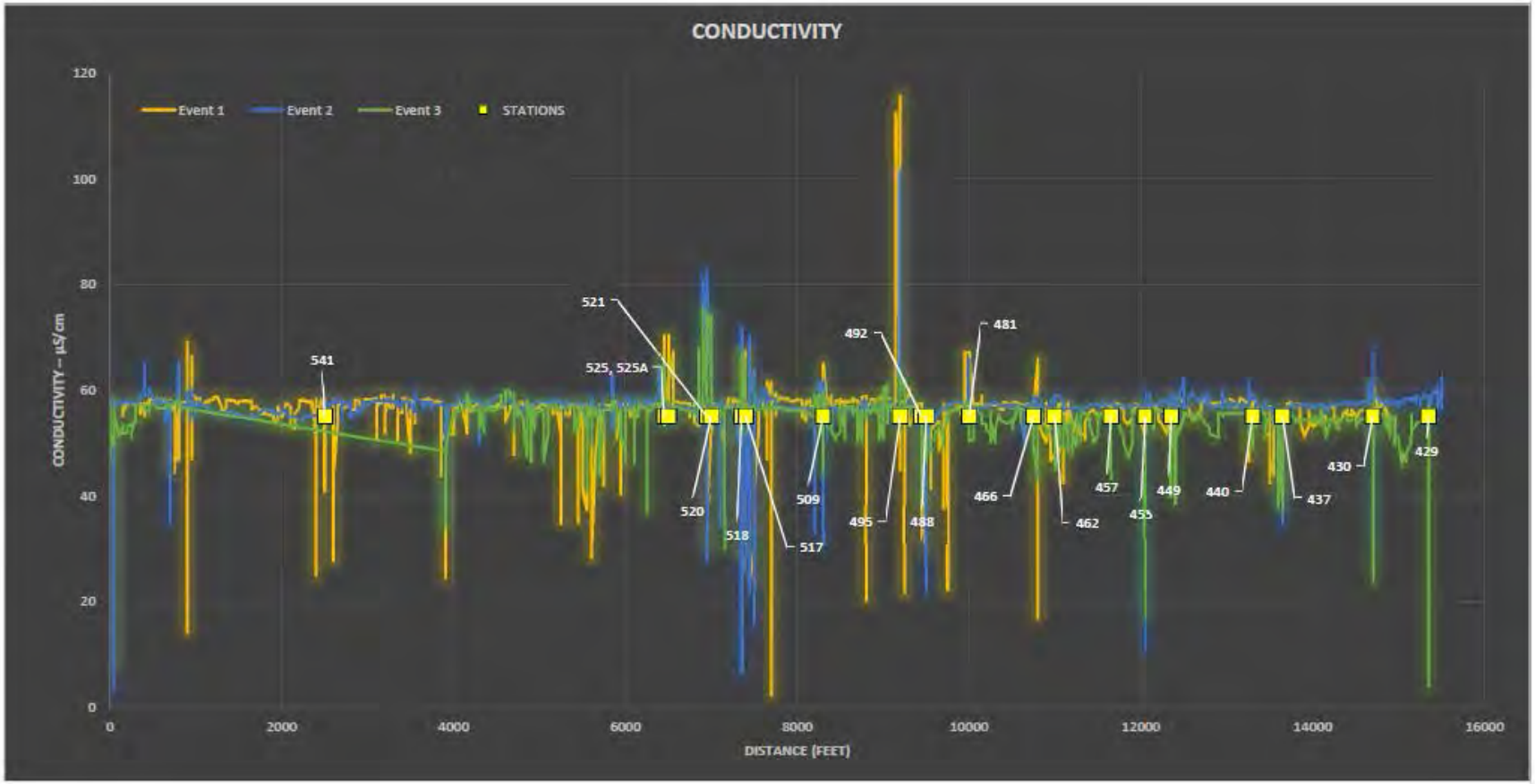


Figure 4. Conductivity (µS/cm) Along Lake Whatcom Shoreline Extending from Control Area.

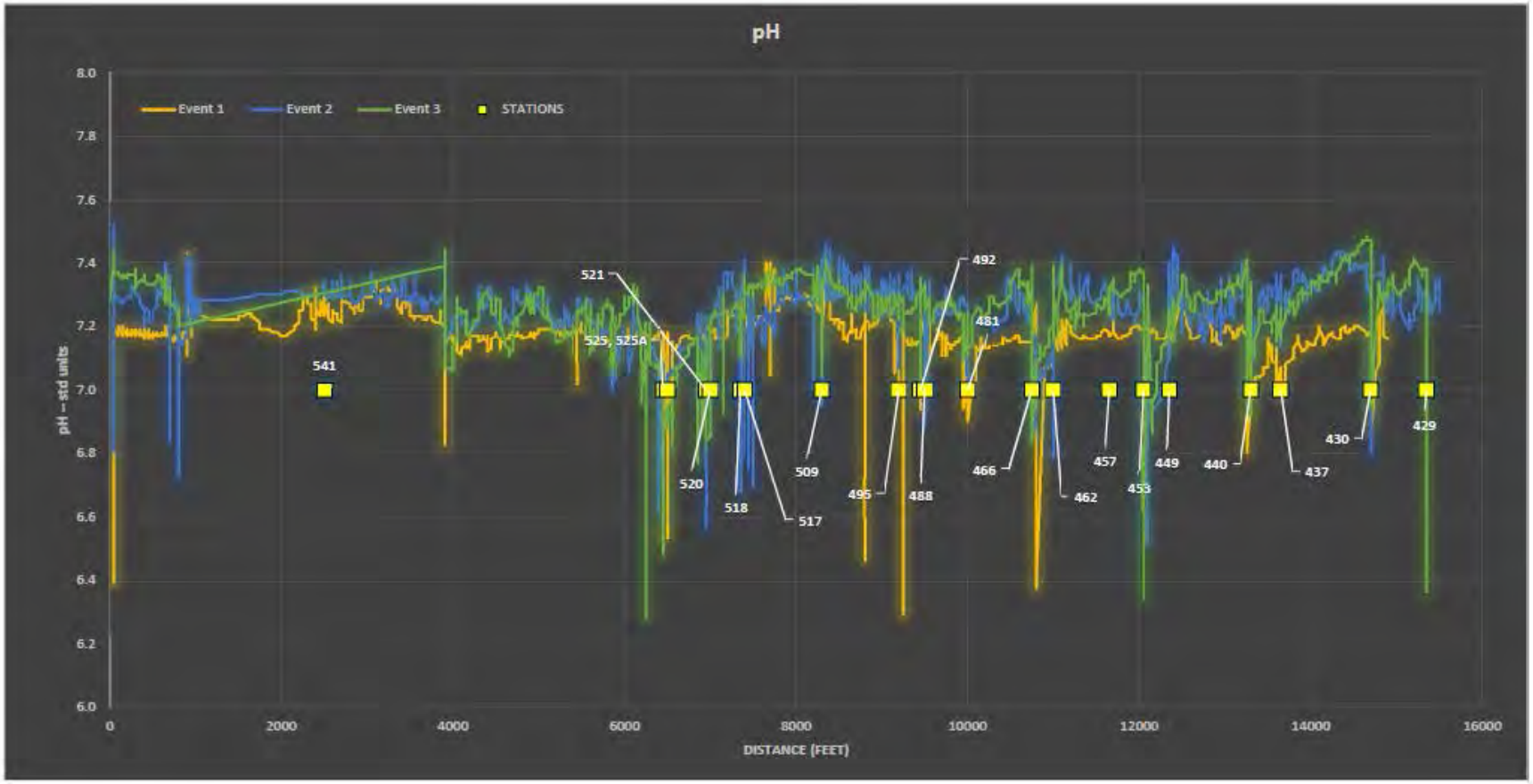


Figure 5. Continuous pH Along Lake Whatcom Shoreline Extending from Control Area.

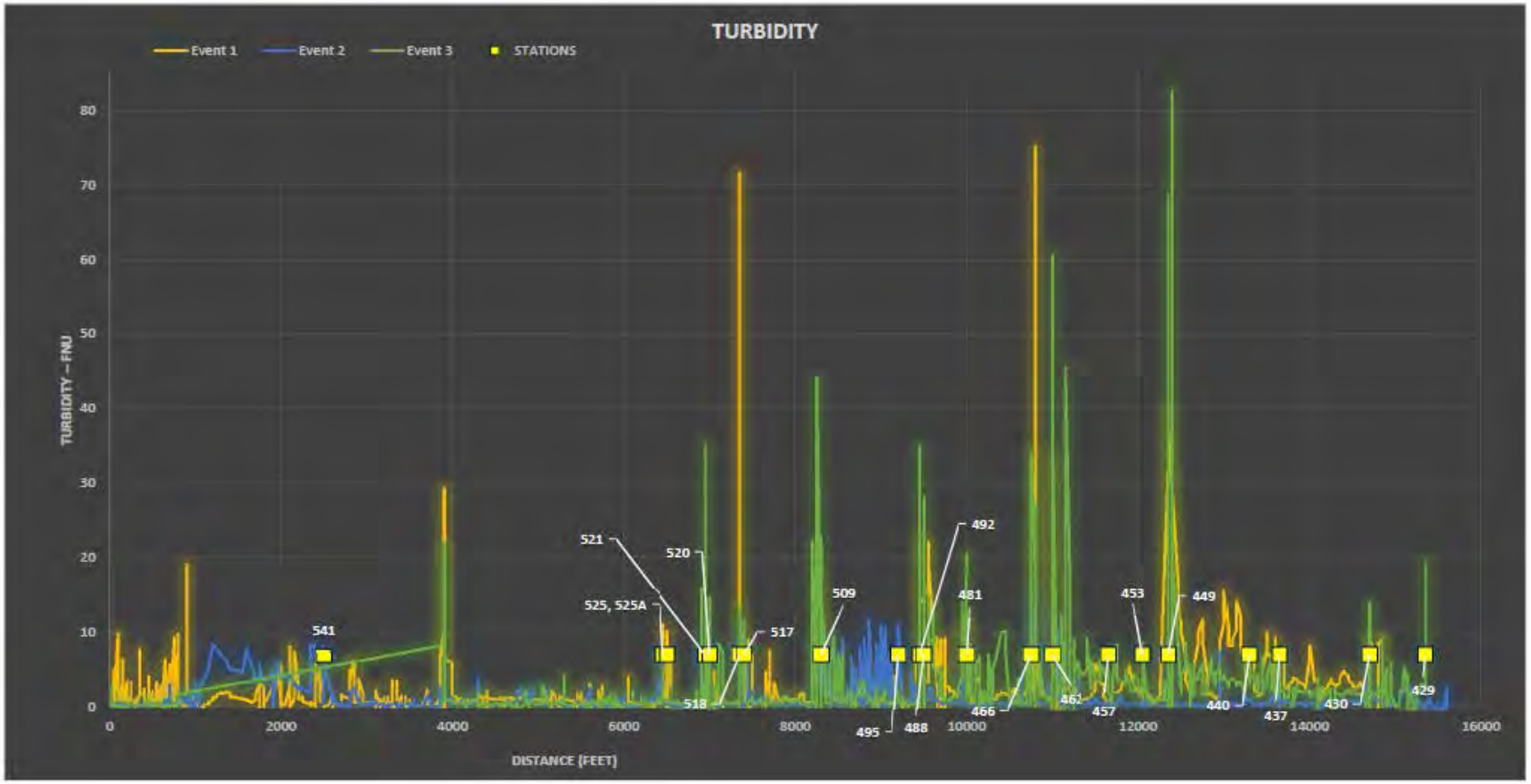


Figure 6. Turbidity (FNU) Along Lake Whatcom Shoreline Extending from Control Area.

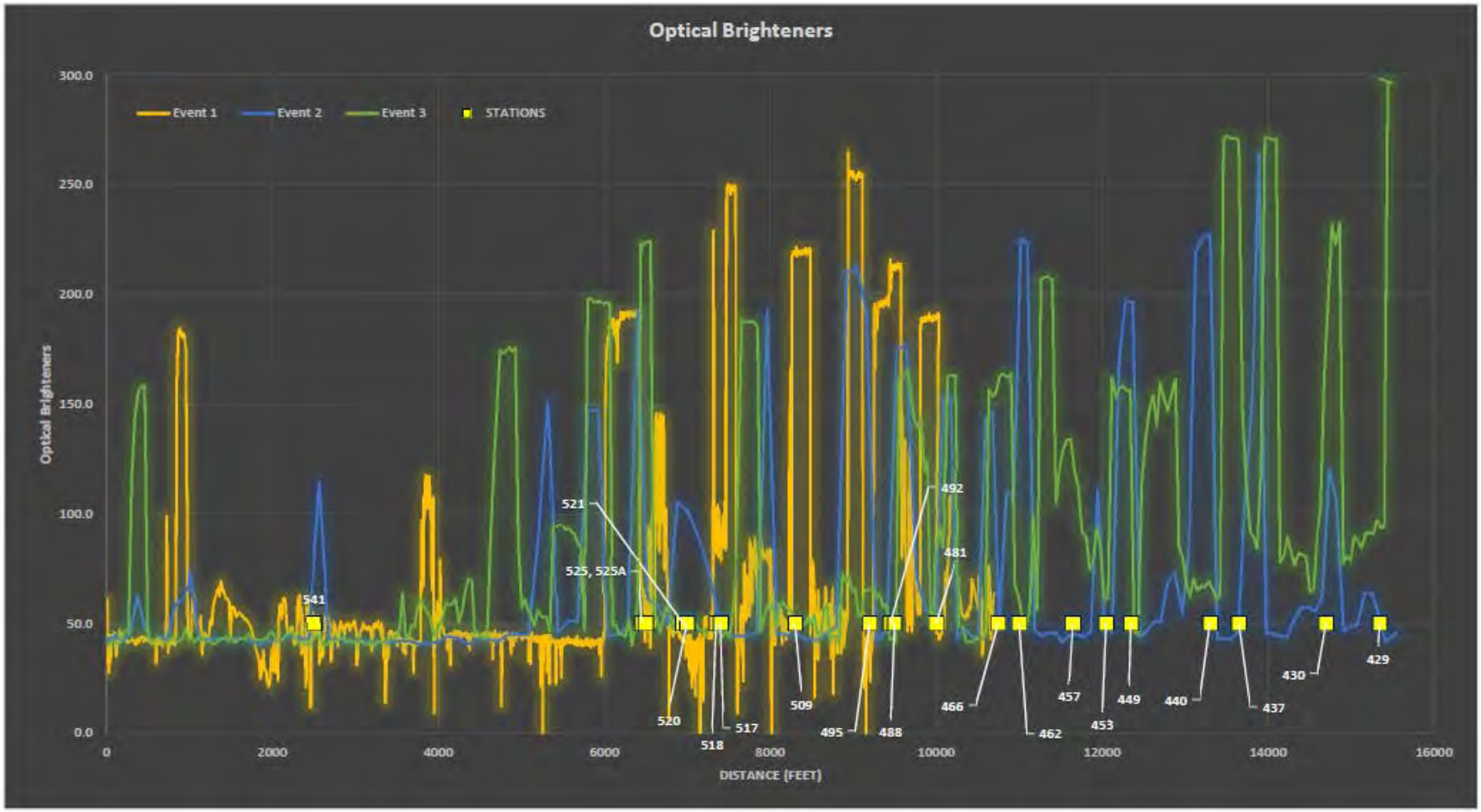


Figure 7. Optical Brightener (RFUB) Along Lake Whatcom Shoreline Extending from Control Area.

In general, conductivity was similar between all three sampling events and remained consistent in the lake with distance along the shoreline (Figure 4). Conductivity often decreased briefly in the lake at and between discharges, while some discharges exhibited high conductivity compared to the lake. As shown in Table 3, conductivity ranged from 0.2 to 115.6 microsiemens per centimeter (µS/cm) at the discharge stations, 56.6 to 64.8 µS/cm at the lake impact stations, 50.7 to 58.1 µS/cm at the lake control stations, and 944 to 963 µS/cm at the OSS stations. Discharge station 429 had the unusually low conductivity value of 0.2 µS/cm. The median conductivity was approximately 11 times higher in the OSS samples than the lake impact or discharge samples.

Continuous pH measurements were generally consistent with distance along the shoreline from the control area for all three events (Figure 5). The pH of discharge water was lower than the lake water at all discharge points for all three events. The pH results ranged from 6.3 to 7.4 at the discharge stations, 6.9 to 7.4 at the lake impact stations, 7.2 to 7.5 at the lake control stations, and 6.9 to 7.0 at the OSS station. The low pH results at discharge sample locations 429 (6.27) and 453 (6.43) during the third sampling event did not meet the surface water standard of greater than 6.5 and less than 8.5.

Continuous turbidity was consistently low in the lake except in the vicinity of some turbid discharges (Figure 6). Turbidity results ranged from 0.9 to 67 formazin nephelometric units (FNU) at the discharge stations, 0.4 to 3.0 FNU at the lake impact stations, 0.2 to 0.6 FNU at the lake control stations, and 27 to 32 FNU at the OSS station.

OB values in the lake frequently increased from baseline either in the vicinity of or distant from discharges, and slightly increased with distance along the shoreline from the control area for Event 3 (Figure 7). The OB values ranged from 51 to 297 relative fluorescence units—blank corrected (RFUB) at the discharge stations, 62 to 228 RFUB at the lake impact stations, 8.2 to 46 RFUB at the lake control stations, and 632 to 686 RFUB at the OSS station. Median OB values increased from the lake control stations (43 RFUB) by a factor of 2 at the lake impact stations (81 RFUB), a factor of 4 at the discharge stations (189 RFUB), and a factor of 15 at the OSS station (660 RFUB).

3.3. CHEMISTRY

Sample summary statistics for total phosphorus, chloride, and bromide are presented in Table 3. Results for all sample locations are presented in Appendix C.

Total phosphorus was not detected above the laboratory reporting limit (0.008 mg/L) in any of the lake control samples. Median total phosphorus concentrations increased from the lake impact stations (0.021 mg/L), to the discharge stations (0.054 mg/L), and to a very high concentration at the OSS station (10.3 mg/L). High concentrations, defined as exceeding the Washington State action value of 0.020 mg/L for Puget Sound lowland lakes (WAC 173-201A), were observed at 12 of the 13 discharge stations and at 2 of the 4 lake impact stations.

The median chloride concentration was similar for lake impact stations (2.61 mg/L) and lake control station (2.68 mg/L), and slightly lower for the discharge stations (2.08 mg/L). The median chloride concentration at the OSS station (47.5 mg/L) was 18 times higher than the lake stations.

Bromide was not detected above the reporting limit in any sample. Therefore, chloride/bromide ratios were not calculated.

3.4. Bacteria Indicators

Sample summary statistics for fecal coliform and *E. coli* are presented in Table 3. Results for all sample locations are presented in Appendix C.

Geometric mean concentrations of fecal coliform bacteria increased from the lake control stations (<3 CFU/100 mL), to the lake impact stations (10 CFU/100 mL), to the discharge stations (36 CFU/100 mL), and to a very high concentration at the OSS station (2.5 million CFU/100 mL) (see Table 2).

Fecal coliform bacteria results are summarized for each station location in Figure 8. High concentrations, defined as exceeding the Washington State surface water standard of 100 CFU/100 mL for a single sample, were observed on one or more occasion at eight discharge stations and no lake stations. Thus, primary contact recreation in the vicinity of these discharges should be avoided to protect public health. Furthermore, consumption of untreated lake waters containing any detectable concentrations of fecal coliform bacteria should be avoided to protect public health.

Fecal coliform bacteria concentrations were typically equivalent to E. coli concentrations, suggesting that the samples did not include many positive testing organisms that are not of fecal origin. Considering the high levels observed at the OSS station and that fecal coliform concentrations commonly exceed 1,000 CFU/100 mL in stormwater runoff (e.g., event mean concentration of 7,750 most probable number [MPN]/100 mL for stormwater draining residential development; Shaver et al. 2007), none of the observed lake or discharge results exhibited high enough fecal coliform bacteria concentrations to strongly indicate contamination from septic system effluent.

3.5. Bacteroidetes

Geometric mean concentrations of Bacteroidetes human biomarkers (including both *B. dorei* and EPA methods) did not exceed the limit of quantitation at the lake control and impact stations (<3 copies/100 mL for both methods), increased at the discharge stations (8.4 and 4.6 copies/100 mL, respectively), and were much higher at the OSS station (1,230 and 88,100 copies/100 mL, respectively) (see Table 3).

Bacteroidetes human biomarker results are summarized for each station in Figure 9. High concentrations, defined as greater than 100 times the quantitation limit of 3 copies/100 mL, were observed on one or more occasion at two discharge locations and no lake locations.

Moderate concentrations (3 to 300 copies/100 mL) were observed at four discharge stations and one lake station (located near a discharge with a moderate concentration). Moderate to high concentrations of human biomarkers are considered proof that the samples were contaminated by septic system effluent. False positives from non-human sources have never been observed for the *B. dorei* method and have been observed only on rare occasions for the EPA method (Source Molecular personal communication). Thus, septic system contamination was definitely observed at seven locations in the 2.3-mile study area.

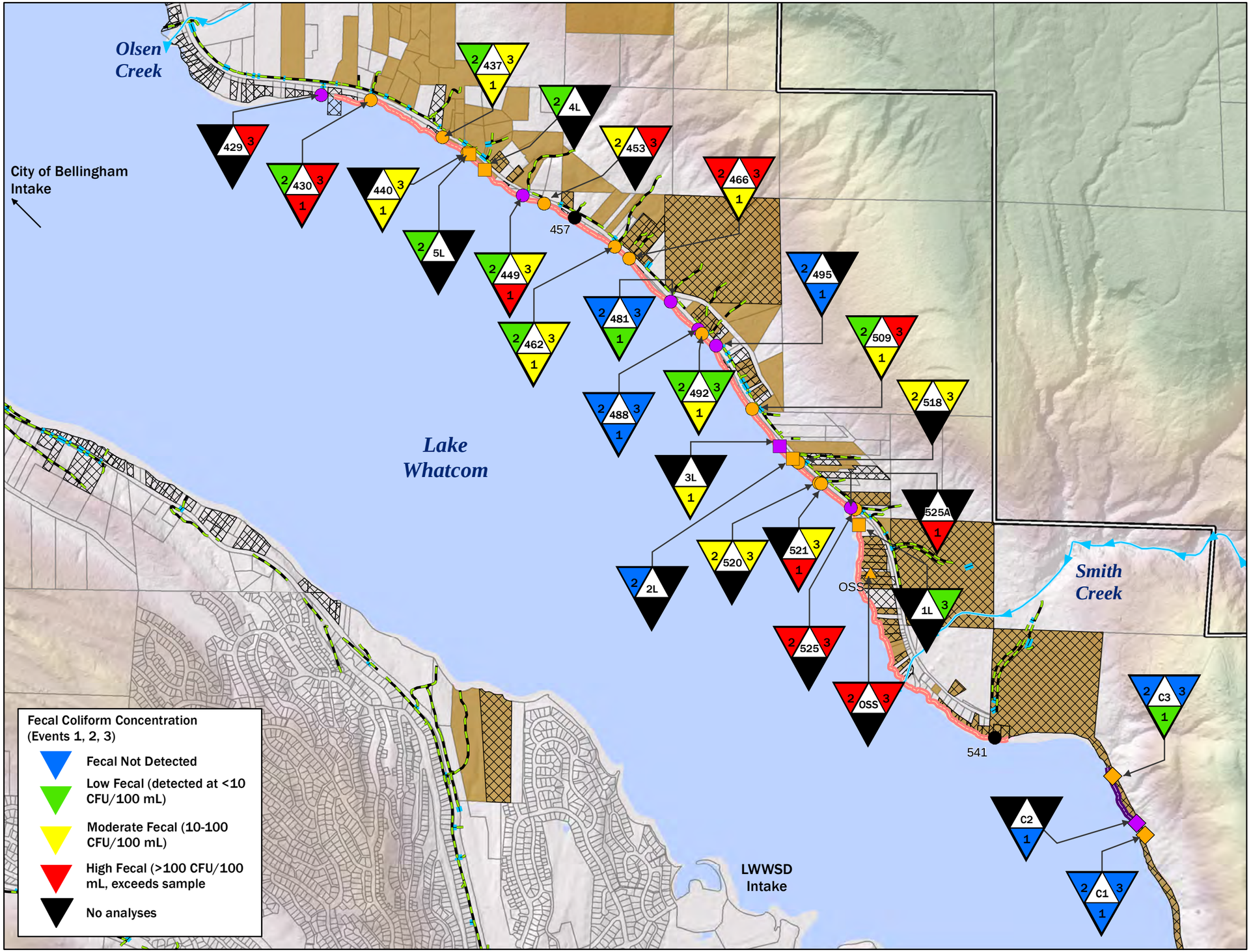
Discharge 520 (see Figure 9) exhibited the most conclusive evidence of septic system contamination because both samples collected at this discharge contained high concentrations of both biomarkers that were similar to concentrations observed in the OSS sample. Interestingly, fecal coliform bacteria concentrations were not exceptionally high (62 and 100 CFU/100 mL) in either sample from Discharge 520. Higher fecal coliform bacteria concentrations would be expected if this discharge was contaminated by a septic system that was undergoing a surfacing failure and draining directly into the discharge drainage. The moderate to high concentrations of human Bacteroidetes DNA without exceptionally high fecal coliform bacteria concentrations at this and the other sampled stations suggest that those drainage and lake waters were contaminated by seepage of septic system effluent through soils, which may have retained fecal coliform bacteria cells and passed Bacteroidetes DNA.

3.6. Correlation Analysis

Non-parametric correlation analysis (Spearman's rho) was performed on the results to determine which monitoring parameters were good predictors of fecal and phosphorus contamination. The lake and discharge sample data were tested both separately and combined for significant parameter correlations. Results of this analysis are presented in Table 4.

None of the field, chemical, or microbiological parameters analyzed for this study were good predictors of human fecal contamination in the lake or discharge samples. Neither human biomarker correlated to fecal coliform or *E. coli*, suggesting that fecal coliform bacteria also originate from animals and are not good indicators of human fecal contamination within the project area. The two human biomarkers were significantly ($\alpha = 0.05$) correlated with each other among the discharge samples, but not strongly (rho = 0.46). Significant but rather weak correlations (rho < 0.6) were observed in the discharge samples for *B. dorei* with temperature (positive) and for the EPA method with dissolved oxygen (negative), pH (negative), and chloride (positive).

Figure 8.
Fecal Bacteria Results
(Fecal Coliform Concentration)
Lake Whatcom North Shore
OSS Detection.



Legend

- Stream
- Open drain
- Culvert
- Project site survey area
- Control site survey area
- Water Right Application/ Claim/Permit or Improved Parcel without Water Right
- Septic system permit
- LWWSD boundary
- Parcel boundary
- Lake

Sample Station Type

- Discharge
- Lake Control
- Lake Impact
- OSS Source

Sample Analysis Type

- Field/Fecals/MST
- Field/Fecals
- No analyses

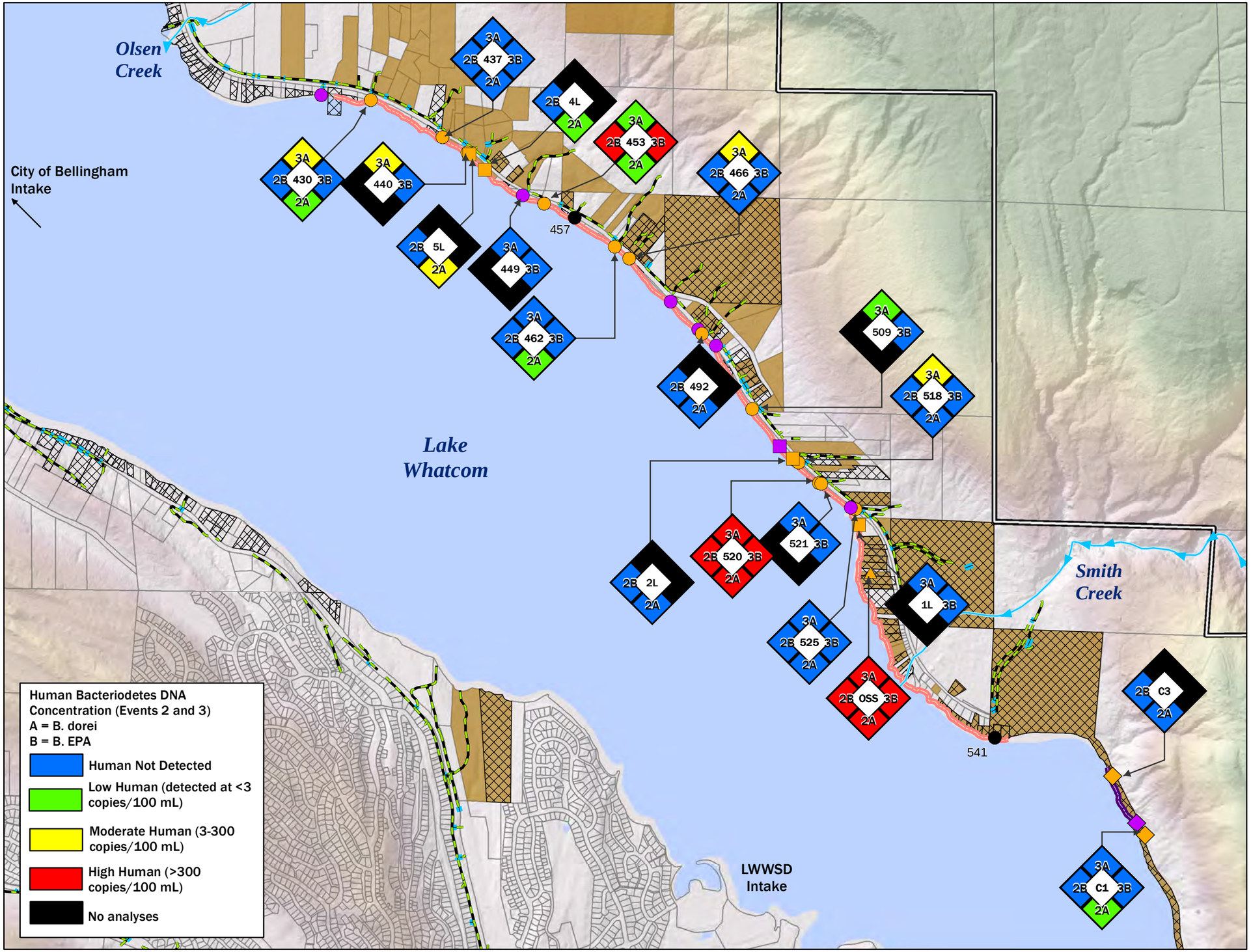
0 687.5 1,375 2,750 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet
ESRI Basemap (2017)

K:\Projects\Y2016\16-06326-000\Project\GIS_Working\Fecal_Figure.mxd (5/17/2017)

Figure 9.
Fecal Bacteria Results (Human Bacteriodetes DNA Concentration) Lake Whatcom North Shore OSS Detection.



Legend

- Stream
- Open drain
- Culvert
- Project site survey area
- Control site survey area
- Water Right Application/ Claim/Permit or Improved Parcel without Water Right
- Septic system permit
- LWWSD boundary
- Parcel boundary
- Lake

Sample Station Type

- Discharge
- Lake Control
- Lake Impact
- OSS Source

Sample Analysis Type

- Field/Fecals/MST
- Field/Fecals
- No analyses

0 687.5 1,375 2,750 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet
ESRI Basemap (2017)

K:\Projects\Y2016\16-06326-000\Project\GIS_Working\Human_Figure.mxd (5/18/2017)

Table 4. Spearman Rank Order Correlation Coefficients for the Lake Whatcom North Shore Road OSS Detection Project.												
Variable	**Temp. (°C)**	**DO (mg/L)**	**pH (std. units)**	**Sp. Cond (uS/cm)**	**OB (RFUB)**	**Total P (mg/L)**	**Chloride (mg/L)**	**Fecal coliform (CFU/100mL)**	**E. coli (CFU/100mL)**	**B. dorei (copies/100mL)**	**B. EPA (copies/100mL)**	**B. dorei+B. EPA (copies/100 ml)**
All Sites except OSS												
Temperature (°C)	1.00	-0.31	0.00	-0.03	0.41	0.70	-0.29	0.12	0.09	0.50	0.19	0.43
Dissolved Oxygen (mg/L)	-0.31	1.00	0.37	-0.30	0.26	0.10	-0.45	-0.04	-0.05	-0.20	-0.51	-0.32
pH (standard units)	0.00	0.37	1.00	-0.14	-0.16	-0.14	-0.18	-0.52	-0.55	-0.12	-0.47	-0.25
Specific Conductance (uS/cm)	-0.03	-0.30	-0.14	1.00	0.02	-0.15	0.62	0.12	0.06	0.28	0.25	0.26
Optical Brighteners (RFUB)	0.41	0.26	-0.16	0.02	1.00	0.70	-0.53	0.38	0.38	0.30	-0.05	0.23
Total Phosphorus (mg/L)	0.70	0.10	-0.14	-0.15	0.70	1.00	-0.59	0.61	0.57	0.36	0.05	0.30
Chloride (mg/L)	-0.29	-0.45	-0.18	0.62	-0.53	-0.59	1.00	-0.20	-0.29	0.22	0.42	0.27
Fecal coliform (CFU/100mL)	0.12	-0.04	-0.52	0.12	0.38	0.61	-0.20	1.00	0.97	0.31	0.31	0.35
E. coli (CFU/100mL)	0.09	-0.05	-0.55	0.06	0.38	0.57	-0.29	0.97	1.00	0.17	0.18	0.22
B. dorei (copies/100mL)	0.50	-0.20	-0.12	0.28	0.30	0.36	0.22	0.31	0.17	1.00	0.43	0.96
B. EPA (copies/100mL)	0.19	-0.51	-0.47	0.25	-0.05	0.05	0.42	0.31	0.18	0.43	1.00	0.64
B. dorei + B. EPA (copies/100 ml)	0.43	-0.32	-0.25	0.26	0.23	0.30	0.27	0.35	0.22	0.96	0.64	1.00
Discharge Sites Only												
Temperature (°C)	1.00	-0.48	0.15	-0.07	0.19	0.46	-0.14	0.06	-0.01	0.54	0.10	0.41
Dissolved Oxygen (mg/L)	-0.48	1.00	0.51	-0.37	0.15	0.20	-0.53	-0.29	-0.31	-0.22	-0.53	-0.36
pH (standard units)	0.15	0.51	1.00	-0.12	0.16	0.18	-0.43	-0.48	-0.53	-0.05	-0.49	-0.22
Specific Conductance (uS/cm)	-0.07	-0.37	-0.12	1.00	-0.08	-0.24	0.72	0.06	-0.03	0.36	0.31	0.35
Optical Brighteners (RFUB)	0.19	0.15	0.16	-0.08	1.00	0.47	-0.58	-0.04	-0.05	0.16	-0.28	0.02
Total Phosphorus (mg/L)	0.46	0.20	0.18	-0.24	0.47	1.00	-0.53	0.31	0.27	0.34	-0.14	0.21
Chloride (mg/L)	-0.14	-0.53	-0.43	0.72	-0.58	-0.53	1.00	0.13	0.00	0.25	0.55	0.36
Fecal coliform (CFU/100mL)	0.06	-0.29	-0.48	0.06	-0.04	0.31	0.13	1.00	0.94	0.32	0.20	0.33
E. coli (CFU/100mL)	-0.01	-0.31	-0.53	-0.03	-0.05	0.27	0.00	0.94	1.00	0.11	0.06	0.13
B. dorei (copies/100mL)	0.54	-0.22	-0.05	0.36	0.16	0.34	0.25	0.32	0.11	1.00	0.46	0.94
B. EPA (copies/100mL)	0.10	-0.53	-0.49	0.31	-0.28	-0.14	0.55	0.20	0.06	0.46	1.00	0.71
B. dorei + B. EPA (copies/100 ml)	0.41	-0.36	-0.22	0.35	0.02	0.21	0.36	0.33	0.13	0.94	0.71	1.00
Lake Sites Only												
Temperature (°C)	1.00	-0.14	-0.83	0.56	0.74	0.96	0.03	0.49	0.49	0.43	0.00	0.43
Dissolved Oxygen (mg/L)	-0.14	1.00	0.45	-0.06	0.19	-0.48	-0.05	0.11	0.11	0.00	0.00	0.00
pH (standard units)	-0.83	0.45	1.00	-0.25	-0.46	-0.67	0.36	-0.29	-0.29	0.09	0.00	0.09
Specific Conductance (uS/cm)	0.56	-0.06	-0.25	1.00	0.71	0.63	0.44	0.49	0.49	0.36	0.00	0.36
Optical Brighteners (RFUB)	0.74	0.19	-0.46	0.71	1.00	0.93	0.22	0.77	0.77	0.42	0.00	0.42
Total Phosphorus (mg/L)	0.96	-0.48	-0.67	0.63	0.93	1.00	0.17	0.58	0.58	0.56	0.00	0.56
Chloride (mg/L)	0.03	-0.05	0.36	0.44	0.22	0.17	1.00	0.15	0.15	0.73	0.00	0.73
Fecal coliform (CFU/100mL)	0.49	0.11	-0.29	0.49	0.77	0.58	0.15	1.00	1.00	0.37	0.00	0.37
E. coli (CFU/100mL)	0.49	0.11	-0.29	0.49	0.77	0.58	0.15	1.00	1.00	0.37	0.00	0.37
B. dorei (copies/100mL)	0.43	0.00	0.09	0.36	0.42	0.56	0.73	0.37	0.37	1.00	0.00	1.00
B. EPA (copies/100mL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
B. dorei + B. EPA (copies/100 ml)	0.43	0.00	0.09	0.36	0.42	0.56	0.73	0.37	0.37	1.00	0.00	1.00

Red values are significant correlations at $p<0.05$

Fecal coliform and *E. coli* were significantly and strongly correlated (rho = 0.77) with optical brighteners in the lake samples (see Table 4). Optical brighteners did not correlate with fecal bacteria in the discharge samples, likely due to false positive fluorescence from varied amounts and types of dissolved organic carbon in the discharge samples. Relationships of fecal coliform bacteria with optical brighteners are shown separately for the lake and discharge samples in Figure 10.

Fecal coliform and *E. coli* were significantly correlated with pH (weakly negative at rho = -0.47) in the discharge samples, but not in the lake samples. Combining the lake and discharge data showed a significant correlation of both fecal indicators with total phosphorus (rho = 0.6)

Total phosphorus was significantly correlated with optical brighteners and temperature with much higher coefficients in the lake samples (rho = 0.93 and 0.96, respectively) than the discharge samples (rho = 0.47 and 0.46). Relationships of total phosphorus with optical brighteners are shown separately for the lake and discharge samples in Figure 11. The discharge samples also exhibited a significant but weakly negative relationship between total phosphorus and chloride (rho = -0.53).

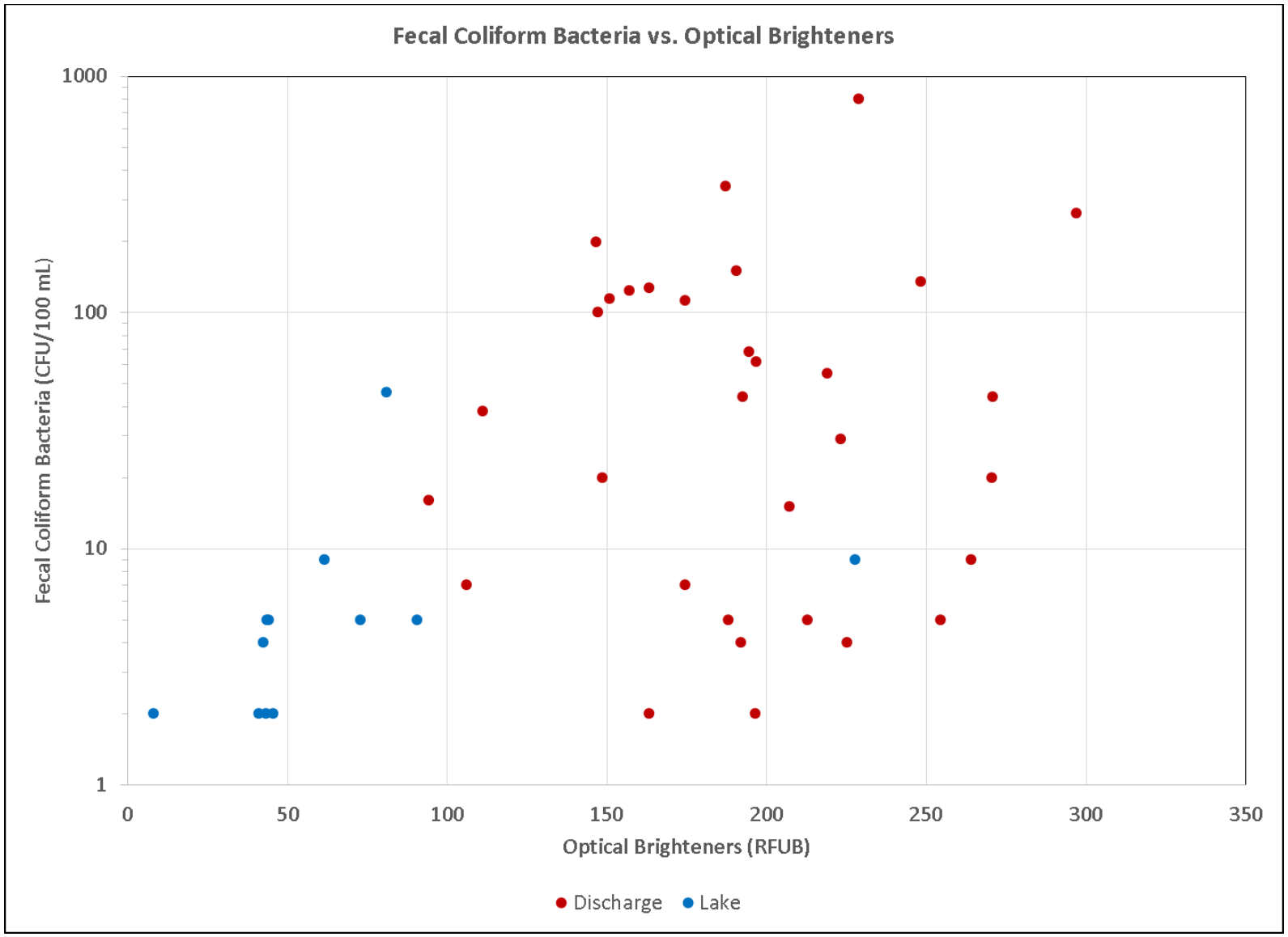


Figure 10. Fecal Coliform Bacteria Versus Optical Brighteners.

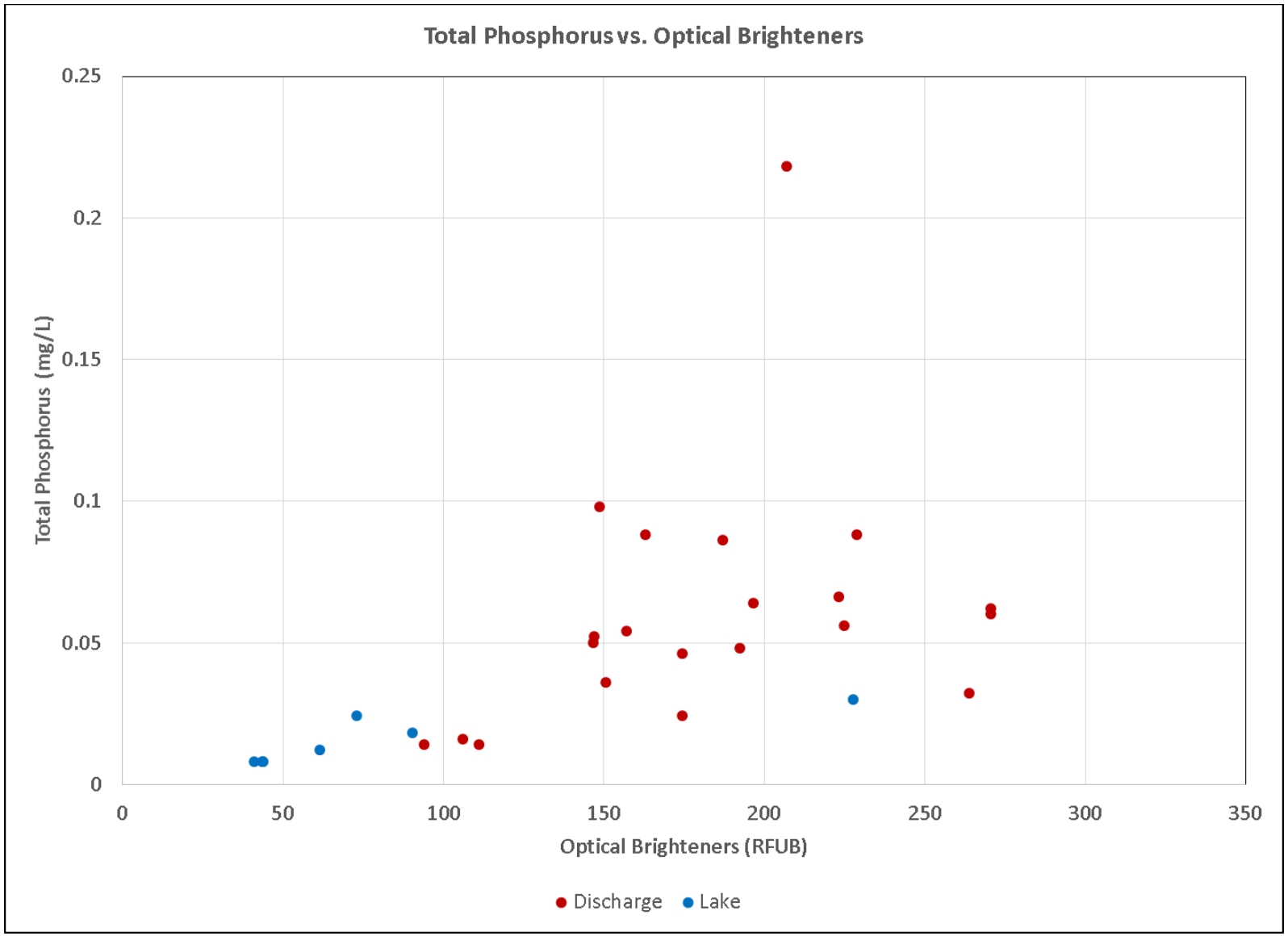


Figure 11. Total Phosphorus Versus Optical Brighteners.

4. CONCLUSIONS

Study results showed that many septic systems in the study area are a likely source of contamination to Lake Whatcom. The two molecular DNA biomarkers of human-specific bacteria were found at moderate to high concentrations of either biomarker at 6 of the 13 sampled discharge stations and at 1 of the 4 sampled lake stations located along the 2.3-mile-long shoreline. At one discharge station, biomarker concentrations were high for both wet weather sampling events and were present at levels similar to those measured in septic tank samples.

Discharge and lake samples contaminated by human biomarkers from septic system effluent also contained elevated levels of optical brighteners, fecal coliform bacteria, and total phosphorus. The elevated concentrations of optical brighteners indicate the presence of laundry detergents from septic system effluent. Fecal coliform bacteria and total phosphorus concentrations exceeded Washington State surface water quality standards, indicating impacts on public health and the lake environment, respectively. Both fecal coliform bacteria and total phosphorus positively correlated with optical brighteners, providing additional evidence that septic systems are a significant source of the observed contamination.

Fecal coliform bacteria and total phosphorus concentrations were several orders of magnitude higher in septic tank samples, indicating that the lake was contaminated by diffuse seepage from septic system drain fields rather than overland flow from failed systems. The numerous and diffuse septic system sources present in the study area would be difficult to locate and control for protection of public health and the environment. Connecting homes in the study area to a sanitary sewer would prevent the ongoing contamination of Lake Whatcom from septic systems in the area.

5. REFERENCES

Cao, Yiping, C. Hagedorn, O.C. Shanks, D. Wang, J. Ervin, J.F. Griffith, B.A. Layton, C.D. McGee, T.E. Riedel, and S.B. Weisberg. 2013. Towards Establishing a Human Fecal Contamination Index in Microbial Source Tracking. International Journal of Environmental Science and Engineering Research. Vol 4(3):46–58.

Ecology. 2016. Lake Whatcom Watershed Total Phosphorus and Bacteria Total Maximum Daily Loads: Volume 2. Water Quality Improvement Report and Implementation Strategy. Publication Number 13 10 012. Washington State Department of Ecology, Water Quality Program, Bellingham, Washington. Originally published in 2014; revised February 2016.

Herrera. 2016. Water Quality Monitoring and Quality Assurance Project Plan, Lake Whatcom North Shore On-Site Sewage System Leachate Detection Project. Prepared for Lake Whatcom Water and Sewer District by Herrera Environmental Consultants, Inc., Seattle, Washington. December.

Katz, B.G., S.M. Eberts, and L.J. Kauffman. 2011. Using Cl/Br Ratios and Other Indicators to Assess Potential Impacts on Groundwater Quality from Septic Systems: A Review and Examples from Principal Aquifers in the United States. US Geological Survey. Journal of Hydrology 397 (2011): 151–166.

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley, 2007. Fundamentals of Urban Runoff Management, Technical and Institutional Issues. North American Lake Management, Madison, Wisconsin.

Wilson. 2015. Northshore System Extension Preliminary Investigation. Prepared by Wilson Engineering, LLC. November 19, 2015.

APPENDIX A

Photographic Documentation

Water Quality Monitoring Report—Lake Whatcom North Shore OSS Leachate Detection Project Photographic Log

LAKE CONTROL STATION

Station C1, Event 3.

Smith Creek, Event 2.

Smith Creek, Event 3.

Smith Creek, Event 3.

Lake Impact Stations

Station 1L, Event 3.

Station 2L, Event 2.

Station 4L, Event 2.

Station 4L, Event 2.

Station 5L, Event 2.

LAKE DISCHARGE STATIONS

Station 429, Event 3.

Station 430, Event 1.

Station 430, Event 2.

Station 430, Event 3.

Station 437, Event 1.

Station 437, Event 2.

Station 437, Event 2.

Station 437, Event 3.

Station 440, Event 3.

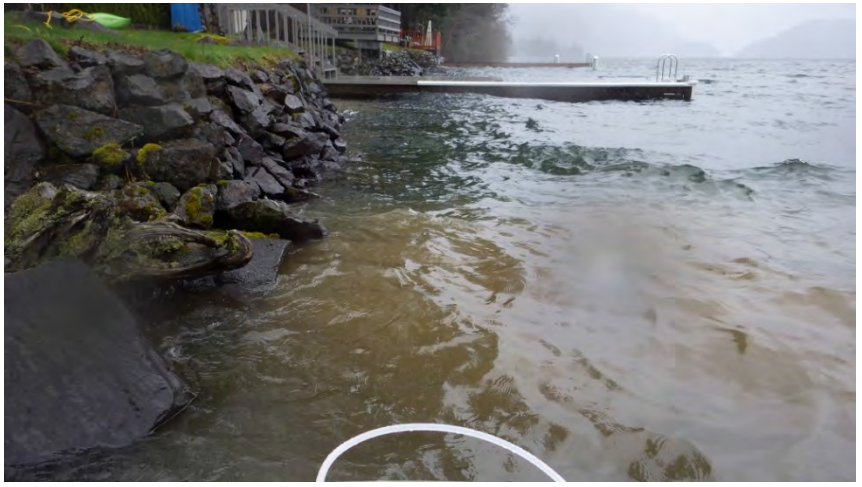
Station 449, Event 1.

	
Station 449, Event 2.	**Station 449, Event 3.**
	
Station 453, Event 2.	**Station 453, Event 2.**

Station 462, Event 2.

Station 462, Event 3.

Station 466, Event 2.



Station 466, Event 3.

Station 481, Event 1.

Station 481, Event 2.

Station 481, Event 3.

Station 488, Event 3.

Station 488, Event 2.

Station 492, Event 1.

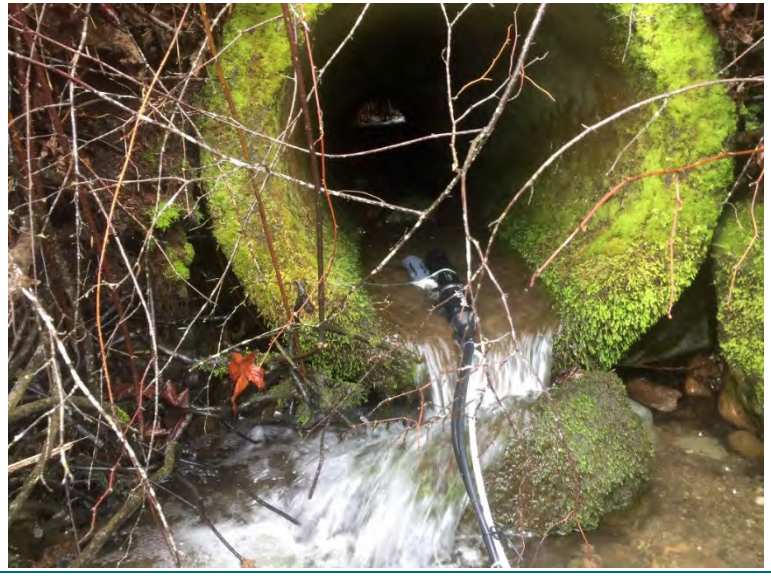
Station 492, Event 2.

Station 492, Event 2.

Station 492, Event 3.

Station 495, Event 2.

Station 509, Event 2.

	
Station 509, Event 2.	**Station 509, Event 3.**
	
Station 518, Event 2.	**Station 518, Event 3.**

Station 520, Event 2.

Station 520, Event 3.

Station 521, Event 2.

Station 521, Event 3.

Station 525, Event 2.

Station 525, Event 2.

Station 525, Event 3.

Station 525A, Event 1.

Station 525A, Event 2.

APPENDIX B

Laboratory Data Reports

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Analysis Report Cover

Final Report

A Professional Service Corporation in the Northwest

Phone: (206) 781-0155
http://www.labcor.net

Job Number: 170061 **SEA**

Report Number: 170061R02

Report Date: 1/23/2017

Client: Herrera Environmental Consultants, Inc

Address: 2200 Sixth Avenue
Suite 1100
Seattle, WA 98121

Project Name: Whatcom OSS Detection

Project No.:

PO Number:

PWS ID:

Reference No.:

Enclosed please find results for samples submitted to our laboratory. A list of samples and analyses follows:

Lab/Cor Sample #	Client Sample # and Description	Analysis	Analysis Notes	Date Received:
170061 - S1	C1 - Lake; Aliquots 50ml & 5ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S2	C2 - Lake; Aliquots 50ml & 5ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S3	C3 - Lake; Aliquots 50ml & 5ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S4	1D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S5	2D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S6	3L - Lake; Aliquots 50ml & 5ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S7	4D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S8	5D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S9	6D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S10	7D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S11	8D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S12	9D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S13	10D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S14	11D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S15	12D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S16	13D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S17	14D - Stormwater; Aliquots 20ml & 2ml	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S18	MB1 - Method Blank #1	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S19	MB2 - Method Blank #2	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S20	MB3 - Method Blank #3	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017
170061 - S21	MB4 - Method Blank #4	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		1/20/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

Job Number: 170061 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom OSS Detection

Report Number: 170061R02
Report Date: 1/23/2017

170061 - S22	Neg - Negative Control	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU	1/20/2017
170061 - S23	Pos - Positive Control	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU	1/20/2017

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

The presence of Fecal Coliform and E. coli from waters and/or environmental sources are tested using the following standard methods:

SM9222 D&G1c1:
Qualitative and Quantitative analysis of Fecal Coliforms and E. coli using a Membrane Filtration procedure begins with selecting a volume of sample that will yield optimal colony counts. Several aliquots are filtered onto sterile, gridded, 0.1um MCE filters. The filters are then placed onto a culture dish containing fecal coliform selective medium. The samples are then incubated in a water bath at 44.5 ± 0.2 ℃ for 24 ± 2 hours.

Upon completion of incubation, positive fecal coliform colonies will produce various shades of blue while negative non-fecal coliform colonies will produce a gray to cream colored colony. Fecal Coliform densities are then calculated and reported as CFU/ 100ml.

After completion of the fecal coliform enumeration, the gridded filter is removed from the fecal coliform selective medium and transferred to a nutrient agar substrate containing 4-methylumbelliferyl-b-d-glucuronide (MUG). The samples are then incubated at 35 ± 0.5 ℃ for 4 hours. The sample is placed beneath a 365nm ultraviolet lamp to determine the presence of Escherichia coli. A colony producing a blue fluorescence around the periphery is diagnostic for the presence of E. coli.

Disclaimer

The results reported relate only to the samples tested or analyzed; the laboratory is not responsible for data collected by personnel who are not affiliated with the laboratory. Results reported in both structures/cm3 and structures/mm2 are dependent on the sample volume and area. These parameters are measured and recorded by non-laboratory personnel and are not covered by the laboratory's accreditation. Interpretation of these results is the sole responsibility of the client.

If further clarification of these results is needed, please call us. Thank you for allowing the staff at Lab/Cor, Inc. the opportunity to provide you with the analytical services.

Sincerely,

Derk Wipprecht
Laboratory Supervisor

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170061 **SEA**

Report Number: 170061R02

Client: Herrera Environmental Consultants, Inc

Date Received: 1/20/2017

Project Name: Whatcom OSS Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S1	C1 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	<2	CFU/ 100ml	0 - 7.4	1/19/2017	9:26 AM	DW 1/21/2017
S1	C1 - Lake; Aliquots 50ml & 5ml	**E. COLI**	<2	CFU/ 100ml	0 - 7.4	1/19/2017	9:26 AM	DW 1/21/2017
S1	C1 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:26 AM	DW 1/21/2017
S1	C1 - Lake; Aliquots 50ml & 5ml	**E. COLI**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:26 AM	DW 1/21/2017
S2	C2 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	<2	CFU/ 100ml	0 - 7.4	1/19/2017	9:32 AM	DW 1/21/2017
S2	C2 - Lake; Aliquots 50ml & 5ml	**E. COLI**	<2	CFU/ 100ml	0 - 7.4	1/19/2017	9:32 AM	DW 1/21/2017
S2	C2 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:32 AM	DW 1/21/2017
S2	C2 - Lake; Aliquots 50ml & 5ml	**E. COLI**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:32 AM	DW 1/21/2017
S3	C3 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	4	CFU/ 100ml	0.4 - 14.4	1/19/2017	9:40 AM	DW 1/21/2017
S3	C3 - Lake; Aliquots 50ml & 5ml	**E. COLI**	4	CFU/ 100ml	0.4 - 14.4	1/19/2017	9:40 AM	DW 1/21/2017
S3	C3 - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:40 AM	DW 1/21/2017
S3	C3 - Lake; Aliquots 50ml & 5ml	**E. COLI**	<20	CFU/ 100ml	0 - 74	1/19/2017	9:40 AM	DW 1/21/2017
S4	1D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	150	CFU/ 100ml	122.6 - 177.4	1/19/2017	11:00 AM	DW 1/21/2017
S4	1D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	145	CFU/ 100ml	118.1 - 171.9	1/19/2017	11:00 AM	DW 1/21/2017
S4	1D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	350	CFU/ 100ml	140 - 720	1/19/2017	11:00 AM	DW 1/21/2017
S4	1D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	300	CFU/ 100ml	110 - 655	1/19/2017	11:00 AM	DW 1/21/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170061 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom OSS Detection

Report Number: 170061R02
Date Received: 1/20/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S5	2D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	135	CFU/ 100ml	109 - 161	1/19/2017	11:32 AM	DW 1/21/2017
S5	2D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	105	CFU/ 100ml	82.1 - 127.9	1/19/2017	11:32 AM	DW 1/21/2017
S5	2D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	100	CFU/ 100ml	10 - 360	1/19/2017	11:32 AM	DW 1/21/2017
S5	2D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	100	CFU/ 100ml	10 - 360	1/19/2017	11:32 AM	DW 1/21/2017
S6	3L - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	46	CFU/ 100ml	36.4 - 55.6	1/19/2017	11:44 AM	DW 1/21/2017
S6	3L - Lake; Aliquots 50ml & 5ml	**E. COLI**	42	CFU/ 100ml	32.8 - 51.2	1/19/2017	11:44 AM	DW 1/21/2017
S6	3L - Lake; Aliquots 50ml & 5ml	**FECAL COLIFORM**	100	CFU/ 100ml	32 - 234	1/19/2017	11:44 AM	DW 1/21/2017
S6	3L - Lake; Aliquots 50ml & 5ml	**E. COLI**	60	CFU/ 100ml	12 - 176	1/19/2017	11:44 AM	DW 1/21/2017
S7	4D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	50	CFU/ 100ml	23.5 - 92	1/19/2017	11:58 AM	DW 1/21/2017
S7	4D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	25	CFU/ 100ml	8 - 58.5	1/19/2017	11:58 AM	DW 1/21/2017
S7	4D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	100	CFU/ 100ml	10 - 360	1/19/2017	11:58 AM	DW 1/21/2017
S7	4D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	50	CFU/ 100ml	5 - 280	1/19/2017	11:58 AM	DW 1/21/2017
S8	5D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<5	CFU/ 100ml	0 - 18.5	1/19/2017	12:17 PM	DW 1/21/2017
S8	5D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<5	CFU/ 100ml	0 - 18.5	1/19/2017	12:17 PM	DW 1/21/2017
S8	5D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:17 PM	DW 1/21/2017
S8	5D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:17 PM	DW 1/21/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170061 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom OSS Detection

Report Number: 170061R02
Date Received: 1/20/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S9	6D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	75	CFU/ 100ml	42 - 124	1/19/2017	12:27 PM	DW 1/21/2017
S9	6D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	60	CFU/ 100ml	31 - 105	1/19/2017	12:27 PM	DW 1/21/2017
S9	6D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:27 PM	DW 1/21/2017
S9	6D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:27 PM	DW 1/21/2017
S10	7D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<5	CFU/ 100ml	0 - 18.5	1/19/2017	12:34 PM	DW 1/21/2017
S10	7D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<5	CFU/ 100ml	0 - 18.5	1/19/2017	12:34 PM	DW 1/21/2017
S10	7D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:34 PM	DW 1/21/2017
S10	7D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:34 PM	DW 1/21/2017
S11	8D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	5	CFU/ 100ml	0.5 - 28	1/19/2017	12:45 PM	DW 1/21/2017
S11	8D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	5	CFU/ 100ml	0.5 - 28	1/19/2017	12:45 PM	DW 1/21/2017
S11	8D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:45 PM	DW 1/21/2017
S11	8D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	12:45 PM	DW 1/21/2017
S12	9D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	80	CFU/ 100ml	46 - 130	1/19/2017	1:07 PM	DW 1/21/2017
S12	9D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	75	CFU/ 100ml	42 - 124	1/19/2017	1:07 PM	DW 1/21/2017
S12	9D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:07 PM	DW 1/21/2017
S12	9D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:07 PM	DW 1/21/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170061 **SEA**

Report Number: 170061R02

Client: Herrera Environmental Consultants, Inc

Date Received: 1/20/2017

Project Name: Whatcom OSS Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S13	10D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	90	CFU/ 100ml	53.5 - 142	1/19/2017	1:16 PM	DW 1/21/2017
S13	10D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	70	CFU/ 100ml	38.5 - 117.5	1/19/2017	1:16 PM	DW 1/21/2017
S13	10D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:16 PM	DW 1/21/2017
S13	10D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:16 PM	DW 1/21/2017
S14	11D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	210	CFU/ 100ml	177.6 - 242.4	1/19/2017	1:29 PM	DW 1/21/2017
S14	11D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	180	CFU/ 100ml	150 - 210	1/19/2017	1:29 PM	DW 1/21/2017
S14	11D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:29 PM	DW 1/21/2017
S14	11D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:29 PM	DW 1/21/2017
S15	12D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	45	CFU/ 100ml	20 - 85.5	1/19/2017	1:39 PM	DW 1/21/2017
S15	12D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	25	CFU/ 100ml	8 - 58.5	1/19/2017	1:39 PM	DW 1/21/2017
S15	12D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	100	CFU/ 100ml	10 - 360	1/19/2017	1:39 PM	DW 1/21/2017
S15	12D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	100	CFU/ 100ml	10 - 360	1/19/2017	1:39 PM	DW 1/21/2017
S16	13D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	20	CFU/ 100ml	5 - 51	1/19/2017	1:44 PM	DW 1/21/2017
S16	13D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	15	CFU/ 100ml	3 - 44	1/19/2017	1:44 PM	DW 1/21/2017
S16	13D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:44 PM	DW 1/21/2017
S16	13D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	<50	CFU/ 100ml	0 - 185	1/19/2017	1:44 PM	DW 1/21/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170061 **SEA**

Report Number: 170061R02

Client: Herrera Environmental Consultants, Inc

Date Received: 1/20/2017

Project Name: Whatcom OSS Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S17	14D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	125	CFU/ 100ml	100 - 150	1/19/2017	1:53 PM	DW 1/21/2017
S17	14D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	100	CFU/ 100ml	77.6 - 122.4	1/19/2017	1:53 PM	DW 1/21/2017
S17	14D - Stormwater; Aliquots 20ml & 2ml	**FECAL COLIFORM**	50	CFU/ 100ml	5 - 280	1/19/2017	1:53 PM	DW 1/21/2017
S17	14D - Stormwater; Aliquots 20ml & 2ml	**E. COLI**	50	CFU/ 100ml	5 - 280	1/19/2017	1:53 PM	DW 1/21/2017

Reviewed by:

x

Derk Wipprecht
Laboratory Supervisor

Fecal Analysis Bench Sheet

FECAL COUNTS

pg 1 of 2

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check 8m 11/26/17	Start Date/Time:	End Date/Time:
170061-01	50	Ø	< 2	✓	1/20/17 11:00	1/21/17 11:00
	5	Ø	< 20			
-02	50	Ø	< 20 2	✓		
	5	Ø	< 20			
-03	50	2	4 J	4J		
	5	Ø	< 20			
-04	20	30	150	✓		
	2	7	350			
-05	20	27	135	✓		
	2	2	100			
-06	50	23	46	✓		
	5	5	100			
-07	20	10	50	55 J		
	2	2	100			
-08	20	Ø	< 5	✓		
	2	Ø	< 50			
-09	20	15	75	68 J		
	2	Ø	< 50			
-10	20	Ø	< 5	✓		
	2	Ø	< 50			
-11	20	1	5	5J		
	2	Ø	< 50			
-12	20	16	80	73 J		
	2	Ø	< 50			
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

Density: use if only one count is within ideal range **(20-60 colonies)**

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,SampleFiltered} \times 100$$

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Fecal Analysis Bench Sheet

FECAL COUNTS

12 2 & 2

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check 8m 11/28/17	Start Date/Time:	End Date/Time:
170061-13	20	18	90	82 J	1/20/17	1/21/17
	2	Ø	< 50		11:00	11:00
-14	20	42	210	190 J		
	2	Ø	< 50			
-15	20	9	45	50 J		
	2	2	100			
-16	20	4	20	18 J		
	2	Ø	< 50			
-17	20	25	125	✓		
	2	1	50			
MB # 1	100	Ø	< 1			
		Ø				
MB # 2	100	Ø	< 1			
		Ø				
MB # 3	100	Ø	< 1			
		Ø				
MB #4	100	Ø	< 1			
		Ø				
Lab Duplicate						
Negative Control	100	Ø	< 1			
Positive Control	100	231	231			

Calculation of Results

Density: use if only one count is within ideal range **(20-60 colonies)**

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,Sample Filtered} \times 100$$

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\,filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Fecal Analysis Bench Sheet

E. coli counts

pg 1 of 2

Sample ID	Volume (mL)	Colonies counted	Result (~~CFU~~ CFU/100 mL)	Herrera Check 8/11/2017	Start Date/Time:	End Date/Time:
170061-01	50	0	< 2	✓	1/21/17	1/21/17
	5	0	< 20		11:00	12:00
-02	50	0	< 2	✓		
	5	0	< 20			
-03	50	2	4	4J		
	5	0	< 20			
-04	20	29	145	✓		
	2	6	300			
-05	20	21	105	✓		
	2	2	100			
-06	50	21	42	✓		
	5	3	60			
-07	20	5	25	27J		
	2	1	50			
-08	20	0	< 5	✓		
	2	0	< 50			
-09	20	12	60	55J		
	2	0	< 50			
-10	20	0	< 5	✓		
	2	0	< 50			
-11	20	1	5	5J		
	2	0	< 50			
-12	20	15	75	68J		
	2	0	< 50			
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

Density: use if only one count is within ideal range **(20-60 colonies)**

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,SampleFiltered} \times 100$$

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 or if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Fecal Analysis Bench Sheet

E. COLI COUNTS

pg 1 & 2

Sample ID	Volume (mL)	Colonies counted	Result ~~(CFU~~ (CFU/100 mL)	Herrera Check spc 112417	Start Date/Time:	End Date/Time:
170061-13	20	14	70	64J	1/21/17 11:00	1/21/17 12:00
	2	Ø	< 50			
-14	20	36	180	✓		
	2	Ø	< 50			
-15	20	5	25	32J		
	2	2	100			
-16	20	3	15	14J		
	2	Ø	< 50			
-17	20	20	100	✓		
	2	1	50			
MB #1	100	Ø	< 1			
MB #2	100	Ø	< 1			
MB #3	100	Ø	< 1			
MB #4	100	Ø	< 1			
Lab Duplicate						
Negative Control	100	Ø	< 1			
Positive Control	100	231	231			

Calculation of Results

Density: use if only one count is within ideal range **(20-60 colonies)**

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,Sample Filtered} \times 100$$

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Bacterial Chain of Custody Record

170061

Lab/Cor, Inc
7619 6th Ave NW
Seattle, WA 98117

Office (206) 781-0155
Fax (206) 789-8424

mail@labcor.net
www.labcor.net

Client: Herrera Environmental Consultants
Address: 2200 Sixth Ave, Suite 1100
City, State, Zip: Seattle, WA 98121
Contact: Rob Zisette
Phone: 206-787-8262 Fax:
Email: rzisette@herrerainc.com
Other Info:

Analytical Protocol:
- ___ E. coli P/A
- X E. coli / Coliform MPN
- ___ E. coli / Fecal Coliform
- ___ Heterotrophic Bacteria
- ___ Bacterial ID
- ___ MPA Analysis
- ___ Cryptosporidium
- ___ Giardia
- ___ Turbidity
- ___ Microbial Limit Test
- ___ Other

Turnaround Time:
- ___ 7 days
- ___ 5 days
- ___ 3 days
- ___ 48 hours
- ___ 24 hours*
- Standard

(Not all TATs are available for all analysis types)

Project Name: Whatcom OSS Detection **Project Number:** **P.O. Number:**

Sample Number	Sample Description (* See filter volume note)	Sample Type: Water	Swab	Air	Other	Sample Date	Sample Time: On	Off	Total	Flow Rate (lpm): Start	End	Avg	Total Volume
C1	Lake	X				1/19/17	0926						100mL
C2	Lake						0932						
C3	Lake						0940						
1D	Stormwater						1100						
2D	Stormwater						1132						
3L	Lake						1144						
4D	Stormwater						1158						
5D							1217						
6D							1227						
7D							1234						

(To be completed by lab): **Receipt Temperature** 4 °C **Receipt Condition** good

Internal Lab Use Only:
Prelim Released:
By: ☐ Fax ☐ Phone ☐ E-mail ☐ Verbal
Final Results Released:
By: ☐ Fax ☐ Phone ☐ E-mail
Hardcopy / Invoice Mailed:
Reviewed By:

By signing below you are agreeing to comply with Lab/Cor's Requests, Tenders and Contracts.

Relinquished by: Date: 1/20/16 Time: 0830
Received by: 1/20/17 Date: 1/20/17 Time: 0830
Relinquished by: Date: Time:
Received by: Date: Time:

* *Call ahead for TATs of 24hrs or less*

Bacterial Chain of Custody Record

170061

Lab/Cor, Inc
7619 6th Ave NW
Seattle, WA 98117

Office (206) 781-0155
Fax (206) 789-8424

mail@labcor.net
www.labcor.net

Client: Herrera Environmental Consultants
Address:
City, State, Zip:
Contact: Rob Zisette
Phone: **Fax:**
Email:
Other Info:

Analytical Protocol:
- ___ E. coli P/A
- ___ E. coli / Coliform MPN
- ___ E. coli / Fecal Coliform
- ___ Heterotrophic Bacteria
- ___ Bacterial ID
- ___ MPA Analysis
- ___ Cryptosporidium
- ___ Giardia
- ___ Turbidity
- ___ Microbial Limit Test
- ___ Other

Turnaround Time:
- ___ 7 days
- ___ 5 days
- ___ 3 days
- ___ 48 hours
- ___ 24 hours*

(Not all TATs are available for all analysis types)

Project Name: Whatcom OSS Detection **Project Number:** **P.O. Number:**

Sample Number	Sample Description	Sample Type				Sample Date	Sample Time			Flow Rate (lpm)			Total Volume
	* See filter volume note	Water	Swab	Air	Other		~~On~~	~~Off~~	~~Total~~	Start	End	Avg	
8D	Stormwater	X				1/19/17	1245						100mL
9D							1307						
10D							1316						
11D							1329						
12D							1339						
13D							1344						
14D							1353						
*	Filter Lake at 50mL and		5mL										
	Filter Stormwater at 20mL and		2mL										

(To be completed by lab): **Receipt Temperature** 4° °C **Receipt Condition** good

Internal Lab Use Only:
Prelim Released: By: ☐ Fax ☐ Phone ☐ E-mail ☐ Verbal
Final Results Released: By: ☐ Fax ☐ Phone ☐ E-mail
Hardcopy / Invoice Mailed:
Reviewed By:

By signing below you are agreeing to comply with Lab/Cor's Requests, Tenders and Contracts. ** Call ahead for TATs of 24hrs or less*

Relinquished by: [signature] Date: 1/20/16 Time: 0830
Received by: [signature] Date: 1/20/17 Time: 0830
Relinquished by: Date: Time:
Received by: Date: Time:

Data Quality Assurance Worksheet

By G. Catarra

Project Name/No./Client: Lake Whatcom / 16-06326-000 / LWWSD. Date 1/26/2017 Page 1 of 1

Laboratory/Parameters: LabCor, Inc. / fecal bacteria and E. coli Checked: initials

Sample Date/Sample ID: 1/19/2017 / 17 samples date

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (hours)		Total Holding Times (days)		Method Blanks Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal[1]	Reported	Goal[1]	
Fecal coliform	OK / SM9222D	NA	**NA**	1	**≤1**	≤2 2	NA	**NA**	NA	**NA**	NA	**≤ 35**	NA	**NA**	C3, 4D,6D,8D-13D "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
E. coli	OK / SM9222D	NA	**NA**	1	**≤1**	≤2 2	NA	**NA**	NA	**NA**	NA	**≤ 35**	NA	**NA**	C3, 4D, 6D, 8D-10D, 12D, 13D "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
						3									

[1] If the sample or duplicate value is less than five times the reporting limit, the difference is calculated rather than the relative percent difference (RPD). The QA goal is a difference <2 times the detection limit instead of the number indicated in the goal column.

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit.

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Analysis Report Cover

Final Report

A Professional Service Corporation in the Northwest

Phone: (206) 781-0155
http://www.labcor.net

Job Number: 170242 **SEA**

Report Number: 170242R02

Report Date: 3/17/2017

Client: Herrera Environmental Consultants, Inc

Address: 2200 Sixth Avenue
Suite 1100
Seattle, WA 98121

Project Name: Whatcom Septic Detection

Project No.: 16-06326-000

PO Number: 16-06326 R2

PWS ID:

Reference No.:

Enclosed please find results for samples submitted to our laboratory. A list of samples and analyses follows:

Lab/Cor Sample #	Client Sample # and Description	Analysis	Analysis Notes	Date Received:
170242 - S1	C1 - Control - Lake	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S2	C2 - Control - Lake	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S3	1D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S4	2D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S5	3D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S6	4L - Lake Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S7	5D (DUP) - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S8	6D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S9	7D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S10	8D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S11	9D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S12	10D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S13	11L - Lake Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S14	12L - Lake Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S15	13D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S16	14D - Discharge Water	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S17	OSS - Raw Sewage (High Level)	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S18	18 - Method Blank 1	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S19	19 - Method Blank 2	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S20	20 - Negative Control	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017
170242 - S21	21 - Positive Control	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/16/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

Job Number: 170242 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom Septic Detection

Report Number: 170242R02
Report Date: 3/17/2017

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

The presence of Fecal Coliform and E. coli from waters and/or environmental sources are tested using the following standard methods:

SM9222 D&G1c1:
Qualitative and Quantitative analysis of Fecal Coliforms and E. coli using a Membrane Filtration procedure begins with selecting a volume of sample that will yield optimal colony counts. Several aliquots are filtered onto sterile, gridded, 0.1um MCE filters. The filters are then placed onto a culture dish containing fecal coliform selective medium. The samples are then incubated in a water bath at 44.5 ± 0.2 ℃ for 24 ± 2 hours.

Upon completion of incubation, positive fecal coliform colonies will produce various shades of blue while negative non-fecal coliform colonies will produce a gray to cream colored colony. Fecal Coliform densities are then calculated and reported as CFU/ 100ml.

After completion of the fecal coliform enumeration, the gridded filter is removed from the fecal coliform selective medium and transferred to a nutrient agar substrate containing 4-methylumbelliferyl-b-d-glucuronide (MUG). The samples are then incubated at 35 ± 0.5 ℃ for 4 hours. The sample is placed beneath a 365nm ultraviolet lamp to determine the presence of Escherichia coli. A colony producing a blue fluorescence around the periphery is diagnostic for the presence of E. coli.

Disclaimer

The results reported relate only to the samples tested or analyzed; the laboratory is not responsible for data collected by personnel who are not affiliated with the laboratory. Results reported in both structures/cm3 and structures/mm2 are dependent on the sample volume and area. These parameters are measured and recorded by non-laboratory personnel and are not covered by the laboratory's accreditation. Interpretation of these results is the sole responsibility of the client.

If further clarification of these results is needed, please call us. Thank you for allowing the staff at Lab/Cor, Inc. the opportunity to provide you with the analytical services.

Sincerely,

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**

Report Number: 170242R02

Client: Herrera Environmental Consultants, Inc

Date Received: 3/16/2017

Project Name: Whatcom Septic Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S1	C1 - Control - Lake	**FECAL COLIFORM**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	9:41 AM	AT 3/17/2017
S1	C1 - Control - Lake	**E. COLI**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	9:41 AM	AT 3/17/2017
S1	C1 - Control - Lake	**FECAL COLIFORM**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	9:41 AM	AT 3/17/2017
S1	C1 - Control - Lake	**E. COLI**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	9:41 AM	AT 3/17/2017
S2	C2 - Control - Lake	**FECAL COLIFORM**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	9:50 AM	AT 3/17/2017
S2	C2 - Control - Lake	**E. COLI**	<50	CFU/ 100ml (2mL)	0 - 185	3/15/2017	9:50 AM	AT 3/17/2017
S2	C2 - Control - Lake	**FECAL COLIFORM**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	9:50 AM	AT 3/17/2017
S2	C2 - Control - Lake	**E. COLI**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	9:50 AM	AT 3/17/2017
S3	1D - Discharge Water	**FECAL COLIFORM**	80	CFU/ 100ml (5ml)	20 - 204	3/15/2017	10:50 AM	AT 3/17/2017
S3	1D - Discharge Water	**E. COLI**	80	CFU/ 100ml (5ml)	20 - 204	3/15/2017	10:50 AM	AT 3/17/2017
S3	1D - Discharge Water	**FECAL COLIFORM**	114	CFU/ 100ml (50ml)	98.9 - 129.1	3/15/2017	10:50 AM	AT 3/17/2017
S3	1D - Discharge Water	**E. COLI**	114	CFU/ 100ml (50ml)	98.9 - 129.1	3/15/2017	10:50 AM	AT 3/17/2017
S4	2D - Discharge Water	**FECAL COLIFORM**	120	CFU/ 100ml (5ml)	44 - 262	3/15/2017	11:05 AM	AT 3/17/2017
S4	2D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	11:05 AM	AT 3/17/2017
S4	2D - Discharge Water	**FECAL COLIFORM**	100	CFU/ 100ml (50ml)	85.9 - 114.1	3/15/2017	11:05 AM	AT 3/17/2017
S4	2D - Discharge Water	**E. COLI**	8	CFU/ 100ml (50ml)	2 - 20.4	3/15/2017	11:05 AM	AT 3/17/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom Septic Detection

Report Number: 170242R02
Date Received: 3/16/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S5	3D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	11:20 AM	AT 3/17/2017
S5	3D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	11:20 AM	AT 3/17/2017
S5	3D - Discharge Water	**FECAL COLIFORM**	44	CFU/ 100ml (50ml)	34.6 - 53.4	3/15/2017	11:20 AM	AT 3/17/2017
S5	3D - Discharge Water	**E. COLI**	14	CFU/ 100ml (50ml)	5.6 - 28.8	3/15/2017	11:20 AM	AT 3/17/2017
S6	4L - Lake Water	**FECAL COLIFORM**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	11:35 AM	AT 3/17/2017
S6	4L - Lake Water	**E. COLI**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	11:35 AM	AT 3/17/2017
S6	4L - Lake Water	**FECAL COLIFORM**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	11:35 AM	AT 3/17/2017
S6	4L - Lake Water	**E. COLI**	<5	CFU/ 100ml (20ml)	0 - 18.5	3/15/2017	11:35 AM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**FECAL COLIFORM**	20	CFU/ 100ml (5ml)	2 - 112	3/15/2017	12:15 PM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**E. COLI**	20	CFU/ 100ml (5ml)	2 - 112	3/15/2017	12:15 PM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**FECAL COLIFORM**	<4	CFU/ 100ml (25ml)	0 - 14.8	3/15/2017	12:15 PM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**E. COLI**	<4	CFU/ 100ml (25ml)	0 - 14.8	3/15/2017	12:15 PM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**FECAL COLIFORM**	2	CFU/ 100ml (50ml)	0.2 - 11.2	3/15/2017	12:15 PM	AT 3/17/2017
S7	5D (DUP) - Discharge Water	**E. COLI**	2	CFU/ 100ml (50ml)	0.2 - 11.2	3/15/2017	12:15 PM	AT 3/17/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Whatcom Septic Detection

Report Number: 170242R02
Date Received: 3/16/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S8	6D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	12:26 PM	AT 3/17/2017
S8	6D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	12:26 PM	AT 3/17/2017
S8	6D - Discharge Water	**FECAL COLIFORM**	8	CFU/ 100ml (50ml)	2 - 20.4	3/15/2017	12:26 PM	AT 3/17/2017
S8	6D - Discharge Water	**E. COLI**	8	CFU/ 100ml (50ml)	2 - 20.4	3/15/2017	12:26 PM	AT 3/17/2017
S9	7D - Discharge Water	**FECAL COLIFORM**	340	CFU/ 100ml (5ml)	198 - 544	3/15/2017	12:51 PM	AT 3/17/2017
S9	7D - Discharge Water	**E. COLI**	320	CFU/ 100ml (5ml)	184 - 520	3/15/2017	12:51 PM	AT 3/17/2017
S9	7D - Discharge Water	**FECAL COLIFORM**	184	CFU/ 100ml (50ml)	164.8 - 203.2	3/15/2017	12:51 PM	AT 3/17/2017
S9	7D - Discharge Water	**E. COLI**	178	CFU/ 100ml (50ml)	159.1 - 196.9	3/15/2017	12:51 PM	AT 3/17/2017
S10	8D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	1:03 PM	AT 3/17/2017
S10	8D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	1:03 PM	AT 3/17/2017
S10	8D - Discharge Water	**FECAL COLIFORM**	4	CFU/ 100ml (50ml)	0.4 - 14.4	3/15/2017	1:03 PM	AT 3/17/2017
S10	8D - Discharge Water	**E. COLI**	4	CFU/ 100ml (50ml)	0.4 - 14.4	3/15/2017	1:03 PM	AT 3/17/2017
S11	9D - Discharge Water	**FECAL COLIFORM**	40	CFU/ 100ml (5ml)	4 - 144	3/15/2017	1:18 PM	AT 3/17/2017
S11	9D - Discharge Water	**E. COLI**	40	CFU/ 100ml (5ml)	4 - 144	3/15/2017	1:18 PM	AT 3/17/2017
S11	9D - Discharge Water	**FECAL COLIFORM**	38	CFU/ 100ml (50ml)	23 - 59.2	3/15/2017	1:18 PM	AT 3/17/2017
S11	9D - Discharge Water	**E. COLI**	38	CFU/ 100ml (50ml)	23 - 59.2	3/15/2017	1:18 PM	AT 3/17/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**

Report Number: 170242R02

Client: Herrera Environmental Consultants, Inc

Date Received: 3/16/2017

Project Name: Whatcom Septic Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S12	10D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	1:35 PM	AT 3/17/2017
S12	10D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	1:35 PM	AT 3/17/2017
S12	10D - Discharge Water	**FECAL COLIFORM**	2	CFU/ 100ml (50ml)	0.2 - 11.2	3/15/2017	1:35 PM	AT 3/17/2017
S12	10D - Discharge Water	**E. COLI**	2	CFU/ 100ml (50ml)	0.2 - 11.2	3/15/2017	1:35 PM	AT 3/17/2017
S13	11L - Lake Water	**FECAL COLIFORM**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	1:56 PM	AT 3/17/2017
S13	11L - Lake Water	**E. COLI**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	1:56 PM	AT 3/17/2017
S13	11L - Lake Water	**FECAL COLIFORM**	5	CFU/ 100ml (20ml)	0.5 - 28	3/15/2017	1:56 PM	AT 3/17/2017
S13	11L - Lake Water	**E. COLI**	5	CFU/ 100ml (20ml)	0.5 - 28	3/15/2017	1:56 PM	AT 3/17/2017
S14	12L - Lake Water	**FECAL COLIFORM**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	2:09 PM	AT 3/17/2017
S14	12L - Lake Water	**E. COLI**	<50	CFU/ 100ml (2ml)	0 - 185	3/15/2017	2:09 PM	AT 3/17/2017
S14	12L - Lake Water	**FECAL COLIFORM**	10	CFU/ 100ml (20ml)	1 - 36	3/15/2017	2:09 PM	AT 3/17/2017
S14	12L - Lake Water	**E. COLI**	10	CFU/ 100ml (20ml)	1 - 36	3/15/2017	2:09 PM	AT 3/17/2017
S15	13D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	2:20 PM	AT 3/17/2017
S15	13D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	2:20 PM	AT 3/17/2017
S15	13D - Discharge Water	**FECAL COLIFORM**	10	CFU/ 100ml (50ml)	3.2 - 23.4	3/15/2017	2:20 PM	AT 3/17/2017
S15	13D - Discharge Water	**E. COLI**	10	CFU/ 100ml (50ml)	3.2 - 23.4	3/15/2017	2:20 PM	AT 3/17/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**

Report Number: 170242R02

Client: Herrera Environmental Consultants, Inc

Date Received: 3/16/2017

Project Name: Whatcom Septic Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S16	14D - Discharge Water	**FECAL COLIFORM**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	2:40 PM	AT 3/17/2017
S16	14D - Discharge Water	**E. COLI**	<20	CFU/ 100ml (5ml)	0 - 74	3/15/2017	2:40 PM	AT 3/17/2017
S16	14D - Discharge Water	**FECAL COLIFORM**	8	CFU/ 100ml (50ml)	2 - 20.4	3/15/2017	2:40 PM	AT 3/17/2017
S16	14D - Discharge Water	**E. COLI**	8	CFU/ 100ml (50ml)	2 - 20.4	3/15/2017	2:40 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**FECAL COLIFORM**	1500000	CFU/ 100ml (0.01ml)	1377525.5 - 1622474.5	3/15/2017	3:50 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**E. COLI**	1500000	CFU/ 100ml (0.01ml)	1377525.5 - 1622474.5	3/15/2017	3:50 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**FECAL COLIFORM**	880000	CFU/ 100ml (0.1ml)	850335.2 - 909664.8	3/15/2017	3:50 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**E. COLI**	880000	CFU/ 100ml (0.1ml)	850335.2 - 909664.8	3/15/2017	3:50 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**FECAL COLIFORM**	TNTC	CFU/ 100ml (1.0ml)		3/15/2017	3:50 PM	AT 3/17/2017
S17	OSS - Raw Sewage (High Level)	**E. COLI**	TNTC	CFU/ 100ml (1.0ml		3/15/2017	3:50 PM	AT 3/17/2017
S18	18 - Method Blank 1	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017
S18	18 - Method Blank 1	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017
S19	19 - Method Blank 2	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017
S19	19 - Method Blank 2	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017
S20	20 - Negative Control	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017
S20	20 - Negative Control	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/15/2017	10:00 AM	AT 3/17/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170242 **SEA**

Report Number: 170242R02

Client: Herrera Environmental Consultants, Inc

Date Received: 3/16/2017

Project Name: Whatcom Septic Detection

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S21	21 - Positive Control	**FECAL COLIFORM**	27	CFU/ 100ml	21.8 - 32.2	3/15/2017	10:00 AM	AT 3/17/2017
S21	21 - Positive Control	**E. COLI**	27	CFU/ 100ml	21.8 - 32.2	3/15/2017	10:00 AM	AT 3/17/2017

Reviewed by:

Fecal Analysis Bench Sheet

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time: 3/16/17 11:30AM	End Date/Time: 3/17/17 11:30AM
170242-01	2	0	0	<5		
	20	0	0			
170242-02	2	0	0	<5		
	20	0	0			
170242-03	5	4	80			
	50	57	114			
170242-04	5	6	120			
	50	50	100			
170242-05	5	0	0			
	50	22	44			
170242-06	2	0	0	<5		
	20	0	0			
170242-07	5	1	20	> 4J see 3/22/17		
	50	~~8~~ 1	0			
170242-08	5	0	0	> 7J see 3/22/17		
	50	4	8			
170242-09	5	17	340	> 198J see 3/22/17		
	50	92	184			
170242-10	5	0	0	> 4J see 3/22/17		
	50	2	4			
170242-11	5	2	40	> 38J see 3/22/17		
	50	19	38			
170242-12	5	0	0	> 2J see 3/22/17		
	50	1	2			
Lab Duplicate	~~10~~ (25)	0	0			
Negative Control	100	0	0			
Positive Control	100	27	27			

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Fecal Analysis Bench Sheet

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time: 3/16/17 11:30AM	End Date/Time: 3/17/17 11:30AM
170242-13	2	0	0	> 5J 3/22/17		
	20	1	5			
170242-14	2	0	0	> 9J 3/22/17		
	20	2	10			
170242-15	5	0	0	> 9J 3/22/17		
	50	5	10			
170242-16	5	0	0	> 7J 3/22/17		
	50	4	8			
170242-17	0.01	150	1500000	J 3/22/17		
	0.1	880	880000			
170242-17	1.0	TNTC	TNTC			
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170242-01	2	0	<50		3/16/17 9:30AM	3/17/17 11:30AM
	20	0	<5			
170242-02	2	0	<50			
	20	0	<5			
170242-03	5	4	80			
	50	57	114			
170242-04	5	0	<20			
	50	4	8	7J		
170242-05	5	0	<20			
	50	7	14	13J		
170242-06	2	0	<50			
	20	0	<5			
170242-07	5	1	20			
	50	1	2	4J		
170242-08	5	0	<20			
	50	4	8	7J		
170242-09	5	16	320			
	50	89	178	191J		
170242-10	5	0	<20			
	50	2	4	4J		
170242-11	5	2	40			
	50	19	38	38J		
170242-12	5	0	<20			
	50	1	2	2J		
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170242-13	2	0	<50		3/16/17 11:30AM	3/17/17 11:30AM
	20	1	5	5J gpc		
170242-14	2	0	<50			
	20	2	10	9J gpc		
170242-15	5	0	<20			
	50	5	10	9J gpc		
170242-16	5	0	<20			
	50	4	8	7J gpc		
170242-17	0.01	150	1500000 J	gpc		
	0.1	880	880000			
170242-17	1.0	TNTC				
Lab Duplicate-57	25	0				
Negative Control	100	0				
Positive Control	100	27				

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,SampleFiltered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\,filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

170242

Page 1 of 2

Bacterial Chain of Custody Record

Lab/Cor, Inc
7619 6th Ave NW
Seattle, WA 98117

Office (206) 781-0155
Fax (206) 789-8424

mail@labcor.net
www.labcor.net

Client: Herrera
Address: 2200 6th Ave
City, State, Zip: Seattle, WA 98121
Contact: Rob Zisette
Phone: 206 787 8262 Fax:
Email: ~~to~~ rzisette@herreratnc.com
Other Info:

Analytical Protocol:
- ___ E. coli P/A
- ___ E. coli / Coliform MPN
- X E. coli / Fecal Coliform
- ___ Heterotrophic Bacteria
- ___ Bacterial ID
- ___ MPA Analysis
- ___ Cryptosporidium
- ___ Giardia
- ___ Turbidity
- ___ Microbial Limit Test
- ___ Other

Turnaround Time:
- ___ 7 days
- ___ 5 days
- ___ 3 days
- ___ 48 hours
- X 24 hours*

(Not all TATs are available for all analysis types)

Project Name: Whatcom Septic Detection **Project Number:** 16-06326-000 **P.O. Number:** 16-06326 RZ

Sample Number	Sample Description	Sample Type: Water	Swab	Air	Other	Sample Date	Sample Time: On	Off	Total	Flow Rate (lpm): Start	End	Avg	Dilution ~~Total~~ Volume	
C1	Control - lake	X				3/15/17	0941						2,20mL	1
C2	Control - lake	↓				↓	0950						2,20mL	2
1D	Discharge water						1050						5,50mL	3
2D	↓						1105						↓	4
3D							1120							5
4L	Lake water						1135						2,20mL	6
5D	Discharge water						1215						5,50mL	7
6D	↓						1226						↓	8
7D							1251							9
8D		↓				↓	1303							10

dup → 5D

(To be completed by lab): **Receipt Temperature** 2.6 °C **Receipt Condition** Good

Internal Lab Use Only:
Prelim Released: By ☐ Fax ☐ Phone ☐ E-mail ☐ Verbal
Final Results Released: By ☐ Fax ☐ Phone ☐ E-mail
Hardcopy / Invoice Mailed:
Reviewed By:

By signing below you are agreeing to comply with Lab/Cor's Requests, Tenders and Contracts.

* *Call ahead for TATs of 24hrs or less*

Relinquished by: [signature] Date: 3/16/17 Time: 0825
Received by: [signature] Date: 3/16/17 Time: 0830
Relinquished by: Date: Time:
Received by: Date: Time:

170242

Page 2 of 2

Bacterial Chain of Custody Record

Lab/Cor, Inc
7619 6th Ave NW
Seattle, WA 98117

Office (206) 781-0155
Fax (206) 789-8424

mail@labcor.net
www.labcor.net

Client: Herrera
Address:
City, State, Zip:
Contact:
Phone: **Fax:**
Email:
Other Info:

Analytical Protocol:
- ___ E. coli P/A
- ___ E. coli / Coliform MPN
- X E. coli / Fecal Coliform
- ___ Heterotrophic Bacteria
- ___ Bacterial ID
- ___ MPA Analysis
- ___ Cryptosporidium
- ___ Giardia
- ___ Turbidity
- ___ Microbial Limit Test
- ___ Other ___

Turnaround Time:
- ___ 7 days
- ___ 5 days
- ___ 3 days
- ___ 48 hours
- X 24 hours*

(Not all TATs are available for all analysis types)

Project Name: **Project Number:** **P.O. Number:**

Sample Number	Sample Description	Sample Type				Sample Date	Sample Time			Flow Rate (lpm)			Dilution ~~Total~~ Volumes
		Water	Swab	Air	Other		On	Off	Total	Start	End	Avg	
9D	Discharge Water	X				3/15/17	1318						~~5~~,50 mL
10D	↓	↓				↓	1335						5,50 mL
11L	Lake Water						~~1409~~	1356					~~2~~,20 mL
12L	↓						~~1420~~	1409					2,20 mL
13D	Discharge Water						1420						5,50 mL
14D	↓						1440						5,50 mL
OSS	Raw Sewage (high level)	↓				↓	1550						0.1,1 mL

(To be completed by lab): **Receipt Temperature** 2.6 °C **Receipt Condition** Good

Internal Lab Use Only:
Prelim Released: By ☐ Fax ☐ Phone ☐ E-mail ☐ Verbal
Final Results Released: By ☐ Fax ☐ Phone ☐ E-mail
Hardcopy / Invoice Mailed:
Reviewed By:

By signing below you are agreeing to comply with Lab/Cor's Requests, Tenders and Contracts.

** Call ahead for TATs of 24hrs or less*

Relinquished by: Date: 3/16/17 Time: 0825
Received by: Date: 3/16/17 Time: 0830

Relinquished by: Date: Time:
Received by: Date: Time:

Analytical Resources, Incorporated
Analytical Chemists and Consultants

01 April 2017

Rob Zisette
Herrera Environmental Consultants
2200 6th Avenue, Suite 1100
Seattle, WA 98121

RE: Lake Whatcom North Shore Testing

Please find enclosed sample receipt documentation and analytical results for samples from the project referenced above.

Sample analyses were performed according to ARI's Quality Assurance Plan and any provided project specific Quality Assurance Plan. Each analytical section of this report has been approved and reviewed by an analytical peer, the appropriate Laboratory Supervisor or qualified substitute, and a technical reviewer.

Should you have any questions or problems, please feel free to contact us at your convenience.

Associated Work Order(s)	Associated SDG ID(s)
17C0308	N/A

Mark Harris
Digitally signed by Mark Harris
DN: c=US, st=Washington, l=Tukwila, o=Analytical Resources, Inc., ou=Client Services, cn=Mark Harris, email=markh@arilabs.com
Date: 2017.04.01 09:14:02 -07'00'

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed in the enclose Narrative. ARI, an accredited laboratory, certifies that the report results for which ARI is accredited meets all the reqirements of the accrediting body. A list of certified analyses, accreditations, and expiration dates is included in this report.

Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his/her designee, as verified by the following signature.

Analytical Resources, Inc.

Mark Harris, Project Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

ACCREDITED IN ACCORDANCE WITH nelac
Cert# 100006

PJLA Testing
Accreditation # 66169

Chain of Custody Record & Laboratory Analysis Request

ARI Assigned Number: 17C0308	Turn-around Requested: Std.
ARI Client Company: Herrera	Phone: 206 441 9080
Client Contact: Rob Zisette	
Client Project Name: Lake Whatcom	
Client Project #: 16-032 6326-000	Samplers: GC/RZ

Page: 1	of 2
Date: 3/16/17	Ice Present?
No. of Coolers: 1	Cooler Temps:

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)
www.arilabs.com

Sample ID	Date	Time	Matrix	No. Containers	Chloride/ bromide by ICP	~~Total dissolved~~ phosphorus	Total Phosphorus						Notes/Comments
C1	3/15/17	~~1318~~ 0941	W	1	X	X							Hold analyses until we receive bacteria results. Of the 17 samples will not be analyzed.
C2		~~1335~~ 0950			X	X							
1D		~~1356~~ 1050			X	X							
2D		~~1409~~ 1105			X	X							
3D		~~1420~~ 1120			X	X							
4L		~~1440~~ 1135			X	X							
5D		~~1550~~ 1215			X	X							
6D		1226			X	X							
7D		1251			X	X							
8D	↓	1303	↓	↓	X	X							

Comments/Special Instructions	Relinquished by:	Received by:	Relinquished by:	Received by:
~~Total dissolved~~ Phosphorus – needs to be ~~filtered~~ prior to digestion	(Signature) GSCat	(Signature) Paul Mark	(Signature)	(Signature)
	Printed Name: Gina Catarra	Printed Name: Paul Mark	Printed Name:	Printed Name:
	Company: Herrera	Company: ARI	Company:	Company:
	Date & Time: 3/16/17 1505	Date & Time: 3/16/2017 1505	Date & Time:	Date & Time:

Chain of Custody Record & Laboratory Analysis Request

ARI Assigned Number: 17C0308	Turn-around Requested: Std
ARI Client Company: Herrera	Phone:
Client Contact: Rob Zisette	
Client Project Name: Lake Whatcom	
Client Project #: 16-06326-000	Samplers: GC/RZ

Page: 2 of 2	
Date:	Ice Present?
No. of Coolers:	Cooler Temps:

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)
www.arilabs.com

Sample ID	Date	Time	Matrix	No. Containers	Chloride/ Bromide by ICP	~~Total dissolved~~ Phosphorus	Total phosphorus						Notes/Comments
9D	3/15/17	1318	W	1	X	X							Hold analyses until bacteria results received. 15 of the 17 samples will be analyzed.
10D		1335			X	X							
11L		1356			X	X							
12L		1409			X	X							
13D		1420			X	X							
14D		1440			X	X							
OSS		1550	*		X	X							

Comments/Special Instructions
*- Septic system Sample
~~Total dissolved~~ phos - needs to be ~~filtered prior to digestion~~

Relinquished by: (Signature)	Received by: (Signature)	Relinquished by: (Signature)	Received by: (Signature)
Printed Name: Gina Catarra	Printed Name: Paul Mark	Printed Name:	Printed Name:
Company: Herrera	Company: ARI	Company:	Company:
Date & Time: 3/16/17 1505	Date & Time: 3/16/2017 1505	Date & Time:	Date & Time:

Limits of Liability: *ARI will perform all requested services in accordance with appropriate methodology following ARI Standard Operating Procedures and the ARI Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the Invoiced amount for said services. The acceptance by the client of a proposal for services by ARI release ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the Client.*

Sample Retention Policy: All samples submitted to ARI will be appropriately discarded no sooner than 90 days after receipt or 60 days after submission of hardcopy data, whichever is longer, unless alternate retention schedules have been established by work-order or contract.

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: Herrera

Project Name: Lake Whatcom

COC No(s): _____ NA

Delivered by: Fed-Ex UPS Courier (Hand Delivered) Other: _____

Assigned ARI Job No: 17C0308

Tracking No: _____ (NA)

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of to cooler?	YES	(NO)
Were custody papers included with the cooler?	(YES)	NO
Were custody papers properly filled out (ink, signed, etc.)	(YES)	NO

Temperature of Cooler(s) (°C) (recommended 2.0-6.0 °C for chemistry) 4.2

Time: _____

If cooler temperature is out of compliance fill out form 00070F

Temp Gun ID#: D85276

Cooler Accepted by: PM Date: 3/16/2017 Time: 1505

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	(NO)
What kind of packing material was used? ... Bubble Wrap (Wet Ice) Gel Packs Baggies Foam Block Paper Other: _____			
Was sufficient ice used (if appropriate)?	NA	(YES)	NO
Were all bottles sealed in individual plastic bags?		YES	(NO)
Did all bottles arrive in good condition (unbroken)?		(YES)	NO
Were all bottle labels complete and legible?		(YES)	NO
Did the number of containers listed on COC match with the number of containers received?		(YES)	NO
Did all bottle labels and tags agree with custody papers?		YES	(NO)
Were all bottles used correct for the requested analyses?		(YES)	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs)...	(NA)	YES	NO
Were all VOC vials free of air bubbles?	(NA)	YES	NO
Was sufficient amount of sample sent in each bottle?		(YES)	NO
Date VOC Trip Blank was made at ARI	(NA)		

Was Sample Split by ARI : (NA) YES Date/Time: _____ Equipment: _____ Split by: _____

Samples Logged by: ~~M~~ B.H. Date: 3/21/17 Time: 9:00

B.H. 3/21/17 ** *Notify Project Manager of discrepancies or concerns* **

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC
11D	11L		

Additional Notes, Discrepancies, & Resolutions:

For sample 6D the sampling date on bottle was 3/15/14, COC date was 3/15/17.

By: B.H. Date: 3/21/17

Small Air Bubbles <2mm	Peabubbles 2-4 mm	LARGE Air Bubbles >4 mm
• • •	• • •	• • •

Small → "sm" (< 2 mm)

Peabubbles → "pb" (2 to < 4 mm)

Large → "lg" (4 to < 6 mm)

Headspace → "hs" (> 6 mm)

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
C1	17C0308-01	Water	15-Mar-2017 09:41	16-Mar-2017 15:05
C2	17C0308-02	Water	15-Mar-2017 09:50	16-Mar-2017 15:05
1D	17C0308-03	Water	15-Mar-2017 10:50	16-Mar-2017 15:05
2D	17C0308-04	Water	15-Mar-2017 11:05	16-Mar-2017 15:05
3D	17C0308-05	Water	15-Mar-2017 11:20	16-Mar-2017 15:05
4L	17C0308-06	Water	15-Mar-2017 11:35	16-Mar-2017 15:05
6D	17C0308-07	Water	15-Mar-2017 12:26	16-Mar-2017 15:05
7D	17C0308-08	Water	15-Mar-2017 12:51	16-Mar-2017 15:05
8D	17C0308-09	Water	15-Mar-2017 13:03	16-Mar-2017 15:05
9D	17C0308-10	Water	15-Mar-2017 13:18	16-Mar-2017 15:05
11L	17C0308-11	Water	15-Mar-2017 13:56	16-Mar-2017 15:05
12L	17C0308-12	Water	15-Mar-2017 14:09	16-Mar-2017 15:05
13D	17C0308-13	Water	15-Mar-2017 14:20	16-Mar-2017 15:05
14D	17C0308-14	Water	15-Mar-2017 14:40	16-Mar-2017 15:05
OSS	17C0308-15	Water	15-Mar-2017 15:50	16-Mar-2017 15:05
5D	17C0308-16	Water	15-Mar-2017 12:15	16-Mar-2017 15:05
10D	17C0308-17	Water	15-Mar-2017 13:35	16-Mar-2017 15:05

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Case Narrative

Client: Herrera Environmental Consultants
Project: Lake Whatcom North Shore Testing
Workorder: 17C0308

Sample receipt

17 samples were received 16-Mar-2017 15:05 under ARI work order 17C0308. For details regarding sample receipt, please refer to the Cooler Receipt Form. 15 samples were analyzed for anions and total phosphorous as requested.

Wet Chemistry

These samples were prepared and analyzed within the recommended holding times.

All initial and continuing calibrations were within method requirements.

A small amount of phosphorous was detected in the method blank (MB) associated with the 3/30/17 analyses of samples '11L' and 'OSS'. Since the concentration of total phosphorous measured in sample 'OSS' was substantially greater than the amount found in the MB, the contribution to the result from laboratory contamination should be considered negligible. The concentration of total phosphorous measured in sample '11L' was comparable to that found in the MB. Since the source of the contamination is uncertain, and repeated analyses have yielded similar results, no corrective actions were taken. This sample can be re-prepared and re-analyzed upon request. No other target compounds were detected in the MBs.

The percent recoveries for all compounds were within acceptable QC limits for the LCSs.

Matrix spikes (MSs) were prepared and analyzed in conjunction with sample 'C1'. The percent recoveries were within acceptable QC limits for the MSs.

Matrix duplicates (MDs) were prepared and analyzed in conjunction with sample 'C1'. The RPD for total phosphorous was high following the analysis of the MD. Since the percent recovery for total phosphorous was within acceptable QC limits for the the corresponding LCS, it was concluded that a lack of sample homogeneity was the cause of the high RPD. No corrective actions were taken. The RPDs for both anions were within acceptable QC limits for the MD.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

C1

17C0308-01 (Water)
Sampled: 03/15/2017 09:41

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 20:10

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.68**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:31

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	ND	mg-P/L	U

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

C2

17C0308-02 (Water)
Sampled: 03/15/2017 09:50

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 21:53

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.68**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:33

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	ND	mg-P/L	U

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

1D

17C0308-03 (Water)
Sampled: 03/15/2017 10:50

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 22:13

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.63**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:33

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0360**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

2D

17C0308-04 (Water)
Sampled: 03/15/2017 11:05

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 22:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**3.47**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:33

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0520**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

3D

17C0308-05 (Water)

Sampled: 03/15/2017 11:20

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 22:55

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.16**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0480**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

4L

17C0308-06 (Water)

Sampled: 03/15/2017 11:35

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 23:14

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.59**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0180**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

6D

17C0308-07 (Water)

Sampled: 03/15/2017 12:26

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 23:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.15**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0240**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

7D

17C0308-08 (Water)

Sampled: 03/15/2017 12:51

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/21/2017 23:53

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.41**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:35

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0500**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

8D

17C0308-09 (Water)
Sampled: 03/15/2017 13:03

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 00:13

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.08**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:36

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0560**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

9D

17C0308-10 (Water)
Sampled: 03/15/2017 13:18

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 01:14

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.82**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:37

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0140**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

11L

17C0308-11 (Water)

Sampled: 03/15/2017 13:56

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 01:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.63**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFC0762 Sample Size: 25 mL
Prepared: 03/29/2017 18:21 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/30/2017 15:57

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0240**	mg-P/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

12L

17C0308-12 (Water)
Sampled: 03/15/2017 14:09

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 01:54

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**3.05**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:37

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0300**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

13D

17C0308-13 (Water)
Sampled: 03/15/2017 14:20

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 02:14

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.96**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:38

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0320**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

14D

17C0308-14 (Water)
Sampled: 03/15/2017 14:40

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 02:34

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.70**	mg/L	

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFC0652 Sample Size: 25 mL
Prepared: 03/25/2017 10:38 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/27/2017 13:38

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0160**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

OSS

17C0308-15 (Water)

Sampled: 03/15/2017 15:50

Wet Chemistry

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFC0546 Sample Size: 5 mL
Prepared: 03/21/2017 13:21 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX2100 Analyzed: 03/22/2017 02:55

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFC0762 Sample Size: 25 mL
Prepared: 03/29/2017 18:21 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 03/30/2017 16:00

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	50	0.400	**10.3**	mg-P/L	D, B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

OSS

17C0308-15RE1 (Water)

Sampled: 03/15/2017 15:50

Wet Chemistry

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFC0546	Sample Size: 5 mL
	Prepared: 03/21/2017 13:21	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX2100 | Analyzed: 03/22/2017 12:17

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	10	1.00	**46.8**	mg/L	D

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Wet Chemistry - Quality Control

Batch BFC0546 - No Prep Wet Chem

Instrument: DX2100

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFC0546-BLK1)			Prepared: 21-Mar-2017 Analyzed: 21-Mar-2017 19:30							
Bromide	ND	0.100	mg/L							U
Chloride	ND	0.100	mg/L							U
LCS (BFC0546-BS1)			Prepared: 21-Mar-2017 Analyzed: 21-Mar-2017 19:50							
Bromide	2.97	0.100	mg/L	3.00		98.8 %	75-125			
Chloride	3.02	0.100	mg/L	3.00		101 %	75-125			
Duplicate (BFC0546-DUP1)	**Source: 17C0308-01**		Prepared: 21-Mar-2017 Analyzed: 21-Mar-2017 21:12							
Bromide	ND	0.100	mg/L		ND					U
Chloride	2.67	0.100	mg/L		2.68			0.23	20	
Matrix Spike (BFC0546-MS1)	**Source: 17C0308-01**		Prepared: 21-Mar-2017 Analyzed: 21-Mar-2017 21:32							
Bromide	1.89	0.100	mg/L	2.00	ND	94.4 %	75-125			
Chloride	4.70	0.100	mg/L	2.00	2.68	101 %	75-125			

Recovery limits for target analytes in MS/MSD QC samples are advisory only.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Wet Chemistry - Quality Control

Batch BFC0652 - SM 4500-P B-5 Persulfate

Instrument: UV1800-2

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFC0652-BLK1)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:30							
Total Phosphorus	ND	0.00800	mg-P/L							U
DL (BFC0652-BLK2)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:35							
Total Phosphorus	ND	0.00800	mg-P/L							U
DL (BFC0652-BLK3)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:39							
Total Phosphorus	ND	0.00800	mg-P/L							U
LCS (BFC0652-BS1)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:30							
Total Phosphorus	0.298	0.00800	mg-P/L	0.300		99.3 %	90-110			
DL (BFC0652-BS2)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:35							
Total Phosphorus	0.298	0.00800	mg-P/L	0.300		99.3 %	90-110			
DL (BFC0652-BS3)			Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:39							
Total Phosphorus	0.298	0.00800	mg-P/L	0.300		99.3 %	90-110			
Duplicate (BFC0652-DUP1)		**Source: 17C0308-01**	Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:32							
Total Phosphorus	ND	0.00800	mg-P/L		ND					U
Matrix Spike (BFC0652-MS1)		**Source: 17C0308-01**	Prepared: 25-Mar-2017 Analyzed: 27-Mar-2017 13:32							
Total Phosphorus	0.198	0.00800	mg-P/L	0.200	ND	96.1 %	75-125			

Recovery limits for target analytes in MS/MSD QC samples are advisory only.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Wet Chemistry - Quality Control

Batch BFC0762 - SM 4500-P B-4 Strong Acid

Instrument: UV1800-2

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFC0762-BLK1)			Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 15:52							
Total Phosphorus	ND	0.00800	mg-P/L							U
DL (BFC0762-BLK2)			Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 16:02							
Total Phosphorus	0.0100	0.00800	mg-P/L							*
LCS (BFC0762-BS1)			Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 15:53							
Total Phosphorus	0.320	0.00800	mg-P/L	0.300		107 %	90-110			B
DL (BFC0762-BS2)			Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 16:02							
Total Phosphorus	0.328	0.00800	mg-P/L	0.300		109 %	90-110			B
Duplicate (BFC0762-DUP1)	**Source: 17C0308-11**		Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 15:59							
Total Phosphorus	0.0300	0.00800	mg-P/L		0.0240			22.20	20	L, B
Matrix Spike (BFC0762-MS1)	**Source: 17C0308-11**		Prepared: 29-Mar-2017 Analyzed: 30-Mar-2017 15:59							
Total Phosphorus	1.93	0.0400	mg-P/L	2.00	0.0240	95.4 %	75-125			D, B

Recovery limits for target analytes in MS/MSD QC samples are advisory only.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Certified Analyses included in this Report

Analyte	Certifications
EPA 300.0 in Water	
Bromide	DoD-ELAP,WADOE,NELAP
Chloride	DoD-ELAP,WADOE,WA-DW,NELAP
SM 4500-P E-99 in Water	
Total Phosphorus	WADOE,NELAP

Code	Description	Number	Expires
ADEC	Alaska Dept of Environmental Conservation	UST-033	05/06/2017
CALAP	California Department of Public Health CAELAP	2748	02/28/2018
DoD-ELAP	DoD-Environmental Laboratory Accreditation Program	66169	03/30/2017
NELAP	ORELAP - Oregon Laboratory Accreditation Program	WA100006	05/11/2017
WADOE	WA Dept of Ecology	C558	06/30/2017
WA-DW	Ecology - Drinking Water	C558	06/30/2017

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	01-Apr-2017 09:12

Notes and Definitions

*	Flagged value is not within established control limits.
B	This analyte was detected in the method blank.
D	The reported value is from a dilution
L	Analyte concentration is <=5 times the reporting limit and the replicate control limit defaults to +/- RL instead of 20% RPD
U	This analyte is not detected above the applicable reporting or detection limit.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
[2C]	Indicates this result was quantified on the second column on a dual column analysis.

Source Molecular
Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Preliminary Interpretation of Human Fecal Pollution ID™ Results

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by Droplet Digital Polymerase Chain Reaction (ddPCR) DNA analytical technology

Submitter: Herrera Environmental Consultants
Date Received: March 17, 2017
Report Generated: March 22, 2017

SM #	Client #	Approximate Contribution of Human Fecal Pollution in Water Sample	Comment
SM-7C17001	C1	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C17002	C2	Not Detected	2 Human fecal biomarkers not detected
SM-7C17003	1D	Not Detected	2 Human fecal biomarkers not detected
SM-7C17004	2D	**Moderate Concentration**	Moderate levels of human fecal biomarker(s)
SM-7C17005	3D	Not Detected	2 Human fecal biomarkers not detected
SM-7C17006	4L	Not Detected	2 Human fecal biomarkers not detected
SM-7C17008	6D	Not Detected	2 Human fecal biomarkers not detected
SM-7C17009	7D	Not Detected	2 Human fecal biomarkers not detected
SM-7C17010	8D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C17011	9D	**Low Concentration**	Low levels of 2 Human fecal biomarkers
SM-7C17013	11L	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C17014	12L	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C17015	13D	Not Detected	2 Human fecal biomarkers not detected
SM-7C17016	14D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C17017	OSS	**Moderate Concentration**	Moderate levels of human fecal biomarker(s)

Source Molecular
Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Human Fecal Pollution ID™ Quantification

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by Droplet Digital Polymerase Chain Reaction (ddPCR) DNA analytical technology

Submitter: Herrera Environmental Consultants
Date Received: March 17, 2017
Report Generated: March 22, 2017

SM #	Client #	Analysis Requested	Target	Marker Quantified (copies/100 ml)	DNA Analytical Results
SM-7C17001	C1	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C17002	C2	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17003	1D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17004	2D	Human Bacteroidetes ID 1	Dorei	1.74E+04	**Present**
SM-7C17005	3D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17006	4L	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17008	6D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17009	7D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17010	8D	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C17011	9D	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C17013	11L	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C17014	12L	Human Bacteroidetes ID 1	Dorei	6.00E+01	**Present**
SM-7C17015	13D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C17016	14D	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C17017	OSS	Human Bacteroidetes ID 1	Dorei	1.03E+03	**Present**
SM-7C17018	C1	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17019	C2	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17020	1D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17021	2D	Human Bacteroidetes ID 2	EPA	1.45E+03	**Present**
SM-7C17022	3D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17023	4L	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17025	6D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17026	7D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17027	8D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17028	9D	Human Bacteroidetes ID 2	EPA	4.05E+03	**Present**
SM-7C17030	11L	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17031	12L	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17032	13D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17033	14D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C17034	OSS	Human Bacteroidetes ID 2	EPA	5.50E+04	**Present**

ND: Not Detected
<LOQ: Detected below level of quantification

Laboratory Comments

Submitter: Herrera Environmental Consultants

Report Generated: March 22, 2017

Negative Results

In sample(s) classified as negative, the human-associated Bacteroidetes gene biomarker(s) was either not detected in test replicates, one replicate was detected at a concentration below 3 copies/copies/20µL and the other was not, or one replicate was detected at a concentration above 3 copies/copies/20µL and the other was not after repeated analysis. It is important to note that a negative result does not mean that the sample does not definitely have human fecal contamination. Only repeated sampling (both during wet and dry sampling events) will enable you to draw more definitive conclusions as to the contributor(s) of fecal pollution.

In order to strengthen the result, a negative sample should be analyzed further for human fecal contamination with other DNA analytical tests. A list of human fecal ID tests can be found at **www.sourcemolecular.com/human**.

Positive Results

In sample(s) classified as positive, the human-associated Bacteroidetes gene biomarker(s) was detected in both test replicates suggesting that human fecal contamination is present in the water sample(s). The biomarker(s) serve as an indicator of the targeted fecal pollution, but the presence of the biomarker does not signify conclusively the presence of that form of fecal pollution. Only repeated sampling (both during wet and dry sampling events) will enable you to draw more definitive conclusions as to the contributor(s) of fecal pollution.

Detected Not Quantified (DNQ) Results

In sample(s) classified as detected not quantified (DNQ), the human-associated Bacteroidetes biomarker was detected in both test replicates but in low, non-quantifiable quantities. This result indicates that fecal indicators associated with human were present in the sample(s) but in low concentrations.

Human Fecal Reference Samples

The client is encouraged to submit samples from the surrounding wastewater facilities and/or septic systems in order to gain a better understanding of the concentration of the human-associated fecal Bacteroidetes genetic marker as well as the concentration of the general fecal Bacteroidetes genetic marker in the geographic region of interest. A more precise interpretation would be available to the client with the submittal of such baseline samples.

Result Interpretations

Quantitative results are reported along with interpretations. Interpretations are given as "negative", “trace”, "low concentration", "moderate concentration", or "high concentration" based on the concentration of the genetic markers found in the water samples.

Additional Testing

A portion of all samples has been frozen and will be archived for 3 months. The client is encouraged to perform additional tests on the sample(s) for other hosts suspected of contributing to the fecal contamination. A list of available tests can be found at **www.sourcemolecular.com/tests**

DNA Analytical Method Explanation

All reagents, chemicals, and apparatuses were verified and inspected beforehand to ensure that no false negatives or positives could be generated. In that regard, positive and negative controls were run to attest the integrity of the analysis. All inspections and controls tested negative for possible extraneous contaminants.

Each submitted water sample was filtered through 0.45-micron membrane filters. Each filter was placed in a separate, sterile 2ml disposable tube containing a unique mix of beads and lysis buffer. The sample was homogenized and the DNA extracted and purified.

Sample DNA was amplified and analyzed with a Bio-Rad QX200 Droplet Digital PCR System (Bio-Rad Laboratories, Inc.). Samples were processed in duplicate in a 20µL reaction containing DNA extract, forward primer, reverse primer, probe (as appropriate) and an optimized buffer solution. Absolute quantification was achieved by software Poisson Distribution Analysis.

For quality control purposes, a positive control consisting of genomic or synthetic DNA, and three negative controls consisting of PCR-grade water were run alongside the sample(s) to monitor for any false negatives or false positives.

Human Bacteroidetes ID™ Species*: B. dorei*

The **Human Bacteroidetes ID™ Species*: B. dorei*** service targets the species *Bacteroides dorei*. *B. dorei* is an anaerobe that is frequently shed from the gastrointestinal tract and isolated from human feces worldwide. It is a newly discovered species that is widely distributed in the USA.[1,2] The human-associated marker DNA sequence is located on the 16S rRNA gene of *B. dorei*.[3] The marker is the microbial source tracking (MST) marker of choice for detecting human fecal pollution due to its exceptional sensitivity and specificity. Internal validations have been conducted on hundreds of sewage, septage, human and animal host fecal samples collected from throughout the U.S and archived in the Source Molecular fecal bank. The marker has also been evaluated in both inland and coastal waters. A recent, comprehensive, multi-laboratory MST method evaluation study, exploring the performance of current MST methods, concluded the *B. dorei* PCR assay to be the top performing human-associated assay amongst those tested. The success and consistency of this marker in numerous studies around the world[1,3,4] makes the **Human Bacteroidetes ID™ Species*: B. dorei*** service the primary service for identifying human fecal pollution at Source Molecular.

Fecal *Bacteroidetes* are considered for several reasons an interesting alternative to more traditional indicator organisms such as *E. coli* and *Enterococci*.[5] Since they are strict anaerobes, they are indicative of recent fecal contamination when found in water systems. This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

The Human Bacteroidetes ID™ service is designed around the principle that fecal *Bacteroidetes* are found in large quantities in feces of warm-blooded animals.[3,5,6,7,8] Furthermore, certain strains of *Bacteroidetes* have been found to be associated with humans.[3,6] As such, these bacterial strains can be used as indicators of human fecal contamination.

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the unique B. dorei DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the B. dorei DNA sequence, then billions of copies of the DNA fragment will be available, detected and quantified.

To strengthen the validity of the results, additional tests targeting other high-ranking, human-associated *Bacteroidetes* species should be performed, such as
Human Bacteroidetes ID™ Species*: B. stercoris*,
Human Bacteroidetes ID™ Species*: B. fragilis,* and
Human Bacteroidetes ID™ Species*: B. thetaiotaomicron*.

[1]Boehm, A., Fuhrman, J., Mrse, R., Grant, S. **Tiered approach for identification of a human fecal pollution source at a recreational beach: case study at Avalon Bay, Catalina Island, California**. Environ Sci Technol. 2003 37**:** 673–680.
[2]Bakir, M., Sakamoto, M., Kitahara, M., Matsumoto, M., Benno, Y. **Bacteroides dorei sp. nov., isolated from human faeces**. Int. J. Syst. Evol. Microbiol. 2006 56: 1639–1641.
[3] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA.** Appl. Environ. Microbiol. 2000b 66: 4571-4574.
[4]Ahmed, w., Masters, N., Toze, S. **Consistency in the host specificity and host sensitivity of the Bacteroides HF183 marker for sewage pollution tracking. Lett. Appl. Microbiol. 2012 55: 283-289.**
[5] Scott, T., Rose, J., Jenkins, T., Farrah, S., Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[6] Bernhard, A., Field, K. **Identification of nonpoint sources of fecal pollution in coastal waters by using host-specific 16S ribosomal DNA genetic markers from fecal anaerobes.** Appl. Environ. Microbiol. 2000a 66: 1587-1594.
[7] Fogarty, L., Voytek, M. **A Comparison of Bacteroides-Prevotella 16S rRNA Genetic Markers for Fecal Samples from Different Animal**

Human Bacteroidetes ID™: EPA Developed Assay

The **Human Bacteroidetes ID™: EPA Developed Assay** service targets a functional gene biomarker in *Bacteroidales*-like anaerobic bacteria that is present in high concentrations in the human gut. The U.S Environmental Protection Agency (U.S. EPA) was the first to target the biomarker using Polymerase Chain Reaction (PCR) technology in order to detect ground and surface waters impacted by human fecal pollution.[1] Since it's development, the assay has been used succesfully around the U.S to identify fecal pollution originating from human sources, such as sewage and septage wastewaters.

The U.S. EPA Developed assay has been shown to be highly associated with human fecal pollution. It has successfully been validated in multiple nationwide studies using at least 300 individual reference fecal material from 22 different animal species known to commonly contaminate environmental waters.[1,2] A reported 99.2% specificity to human fecal material makes this one of the leading assays to confirm the presence of fecal contamination that is of human origin.[1] The *Bacteroidales*-like bacteria is widely distributed. It was detected in 100% of hundreds of sewage and human reference fecal samples collected from more than 20 human populations, making it highly sensitive. Internal validations have also been conducted on hundreds of wastewater, human and animal host fecal samples archived in the Source Molecular fecal bank.

Fecal anaerobic bacteria are considered for several reasons an interesting alternative to more traditional fecal indicator organisms such as *E. coli* and *Enterococci*.[3] Since they are strict anaerobes, they are indicative of recent fecal contamination when found in water systems.[3] This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

The **Human Bacteroidetes ID™: EPA Developed Assay** service is designed around the principle that fecal *Bacteroidales*-like bacteria are found in large quantities in feces of warm-blooded animals.[4,5] Furthermore, certain strains have been shown to be associated with humans.[4,5] As such, these bacterial strains can be used as indicators of human fecal contamination. An advantage of the Human Bacteroidetes ID™ service is that the entire portion of water sampled is filtered to concentrate bacteria. As such, this method avoids the randomness effect of culturing and selecting bacterial isolates. This is an advantage for highly contaminated water systems with potential multiple sources of fecal contamination.

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the unique B. dorei DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the B. dorei DNA sequence, then billions of copies of the DNA fragment will be available, detected and quantified.

To strengthen the validity of the results, additional tests targeting other high-ranking, human-associated *Bacteroidetes* species should be performed, such as
Human Bacteroidetes ID™ Species*: B. dorei*,
Human Bacteroidetes ID™ Species*: B. fragilis,* and
Human Bacteroidetes ID™ Species*: B. stercoris*

[1] Shanks, O., Kelty, C., Sivaganesan, M., Varma, M. and Haugland, R. **Quantitative PCR for Genetic Markers of Human Fecal Pollution**. Appl. Environ. Microbiol. 2009 75: 5507-5513.
[2] Layton, B., Cao, Y., Ebentier, D., Hanley, K., Ballesté, E., Brandão, J., *et al*. **Performance of Human Fecal Anaerobe-Associated PCR-Based Assays in a Multi-Laboratory Method Evaluation Study.** Water Research. 2013 In Press.
[3] Scott, T., Rose, J., Jenkins, T., Farrah, S. and Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[4] Bernhard, A., Field, K. **Identification of nonpoint sources of fecal pollution in coastal waters by using host-specific 16S ribosomal DNA genetic markers from fecal anaerobes.** Appl. Environ. Microbiol. 2000a 66: 1587-1594.
[5] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA**. Appl. Environ. Microbiol. 2000b 66: 4571-4574.

Data Quality Assurance Worksheet

By G. Catarra

Project Name/No./Client: Lake Whatcom / 16-06326-000 / LWWSD. Date 1/26/2017 Page 1 of 1

Laboratory/Parameters: LabCor, Inc. / fecal bacteria and E. coli; ARI / TP, Cl/Br; Source Molecular / MST Checked: initials

Sample Date/Sample ID: 3/15/2017 / 17 samples date

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (hours)		Total Holding Times (days)		Method Blanks Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal	Reported	Goal[1]	
Fecal coliform	OK / SM9222D	NA	**NA**	1	**≤1**	≤1.0 / 2 CFU /100ML	NA	**NA**	NA	**NA**	5D NC	**≤ 35**	NA	**NA**	STATIONS 5-14, OSS "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
E. coli	OK / SM9222D	NA	**NA**	1	**≤1**	≤1.0 / 2	NA	**NA**	NA	**NA**	5D NC	**≤ 35**	NA	**NA**	STATION 2-3, 5-14, OSS "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
Total Phosphorus	OK / EPA 365.1	NA	**NA**	12	**≤28**	≤8.0 – 10 / 8.0 µg/L	95-96	**±20**	99-109	**±10**	NC, D = 6	**≤ 20**	NA	**NA**	11L "J" DUE TO MB CONTAMINATION.
Chloride	OK / EPA 300.0	NA	**≤12**	6	**≤28**	≤0.1 / 0.1 mg/L	101	**±20**	101	**±10**	2.7	**≤ 20**	NA	**NA**	NONE
Bromide	OK / EPA 300.0	NA	**NA**	6	**≤28**	≤0.1 / 0.1 mg/L	94	**±20**	99	**±10**	NC	**≤ 20**	NA	**NA**	NONE
B. Dorei	OK / Digital qPCR		**≤48**		**NA**	≤0.01 / 3	NA	**NA**	NA	**NA**	NA	**≤ 30 cov**	NA	**NA**	NONE
EPA Assay	OK / Digital qPCR		**≤48**		**NA**	≤0.05 / 3	NA	**NA**	NA	**NA**	NA	**≤ 30 cov**	NA	**NA**	NONE

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit; NS – field duplicate not sampled.

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Analysis Report Cover

Final Report

A Professional Service Corporation in the Northwest

Phone: (206) 781-0155
http://www.labcor.net

Job Number: 170293 **SEA**

Report Number: 170293R01

Report Date: 3/31/2017

Client: Herrera Environmental Consultants, Inc

Address: 2200 Sixth Avenue
Suite 1100
Seattle, WA 98121

Project Name: Lake Whatcom North Shore Water Testing

Project No.: 16-06326-000

PO Number:

PWS ID:

Reference No.:

Enclosed please find results for samples submitted to our laboratory. A list of samples and analyses follows:

Lab/Cor Sample #	Client Sample # and Description	Analysis	Analysis Notes	Date Received:
170293 - S1	C1 - Control - Lake, WA Water ID#: 11919819	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S2	C2 - Control - Lake, WA Water ID#: 11919820	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S3	1L - Lake Water, WA Water ID#: 11919821	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S4	2D - Discharge Water, WA Water ID#: 11919822	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S5	3D - Discharge Water, WA Water ID#: 11919823	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S6	4D - Discharge Water, WA Water ID#: 11919824	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S7	5D - Discharge Water, WA Water ID#: 11919825	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S8	6D - Discharge Water, WA Water ID#: 11919826	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S9	7D - Discharge Water, WA Water ID#: 11919827	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S10	8D - Discharge Water, WA Water ID#: 11919828	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S11	9D - Discharge Water, WA Water ID#: 11919829	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S12	10D - Discharge Water, WA Water ID#: 11919830	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S13	11D - Discharge Water, WA Water ID#: 11919831	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S14	12D - Discharge Water, WA Water ID#: 11919832	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S15	13D - Discharge Water, WA Water ID#: 11919833	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S16	14D - Discharge Water, WA Water ID#: 11919834	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU	High Confluent Growth Present	3/30/2017
170293 - S17	0SS - (Raw Sewage), WA Water ID#: 11919835	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S18	15D - Discharge Water, WA Water ID#: 11919836	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S19	NEGCTRL - , WA Water ID#: 11919837	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S20	POSCTRL - , WA Water ID#: 11919838	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017
170293 - S21	Blank - Run #1, WA Water ID#: 11919839	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU		3/30/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

Job Number: 170293 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Lake Whatcom North Shore Water Testing

Report Number: 170293R01
Report Date: 3/31/2017

170293 - S22	Blank - After Run #10, WA Water ID#: 11919840	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU	3/30/2017
170293 - S23	Blank - Final Run, WA Water ID#: 11919841	SM 9222D G1c1- Fecal Coliform/ E.coli - CFU	3/30/2017

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

The presence of Fecal Coliform and E. coli from waters and/or environmental sources are tested using the following standard methods:

SM9222 D&G1c1:
Qualitative and Quantitative analysis of Fecal Coliforms and E. coli using a Membrane Filtration procedure begins with selecting a volume of sample that will yield optimal colony counts. Several aliquots are filtered onto sterile, gridded, 0.1um MCE filters. The filters are then placed onto a culture dish containing fecal coliform selective medium. The samples are then incubated in a water bath at 44.5 ± 0.2 ℃ for 24 ± 2 hours.

Upon completion of incubation, positive fecal coliform colonies will produce various shades of blue while negative non-fecal coliform colonies will produce a gray to cream colored colony. Fecal Coliform densities are then calculated and reported as CFU/ 100ml.

After completion of the fecal coliform enumeration, the gridded filter is removed from the fecal coliform selective medium and transferred to a nutrient agar substrate containing 4-methylumbelliferyl-b-d-glucuronide (MUG). The samples are then incubated at 35 ± 0.5 ℃ for 4 hours. The sample is placed beneath a 365nm ultraviolet lamp to determine the presence of Escherichia coli. A colony producing a blue fluorescence around the periphery is diagnostic for the presence of E. coli.

Disclaimer

The results reported relate only to the samples tested or analyzed; the laboratory is not responsible for data collected by personnel who are not affiliated with the laboratory. Results reported in both structures/cm3 and structures/mm2 are dependent on the sample volume and area. These parameters are measured and recorded by non-laboratory personnel and are not covered by the laboratory's accreditation. Interpretation of these results is the sole responsibility of the client.

If further clarification of these results is needed, please call us. Thank you for allowing the staff at Lab/Cor, Inc. the opportunity to provide you with the analytical services.

Sincerely,

x _____

Ashley Tonge
Technician/Analyst

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**

Report Number: 170293R01

Client: Herrera Environmental Consultants, Inc

Date Received: 3/30/2017

Project Name: Lake Whatcom North Shore Water Testing

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S1	C1 - Control - Lake, WA Water ID#: 11919819	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:01 AM	AT 3/31/2017
S1	C1 - Control - Lake, WA Water ID#: 11919819	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:01 AM	AT 3/31/2017
S1	C1 - Control - Lake, WA Water ID#: 11919819	**FECAL COLIFORM**	<2	CFU/ 100ml (50mL)	0 - 7.4	3/29/2017	10:01 AM	AT 3/31/2017
S1	C1 - Control - Lake, WA Water ID#: 11919819	**E. COLI**	<2	CFU/ 100ml (50mL)	0 - 7.4	3/29/2017	10:01 AM	AT 3/31/2017
S2	C2 - Control - Lake, WA Water ID#: 11919820	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:12 AM	AT 3/31/2017
S2	C2 - Control - Lake, WA Water ID#: 11919820	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:12 AM	AT 3/31/2017
S2	C2 - Control - Lake, WA Water ID#: 11919820	**FECAL COLIFORM**	<2	CFU/ 100ml (50mL)	0 - 7.4	3/29/2017	10:12 AM	AT 3/31/2017
S2	C2 - Control - Lake, WA Water ID#: 11919820	**E. COLI**	<2	CFU/ 100ml (50mL)	0 - 7.4	3/29/2017	10:12 AM	AT 3/31/2017
S3	1L - Lake Water, WA Water ID#: 11919821	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:56 AM	AT 3/31/2017
S3	1L - Lake Water, WA Water ID#: 11919821	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	10:56 AM	AT 3/31/2017
S3	1L - Lake Water, WA Water ID#: 11919821	**FECAL COLIFORM**	10	CFU/ 100ml (50mL)	3.2 - 23.4	3/29/2017	10:56 AM	AT 3/31/2017
S3	1L - Lake Water, WA Water ID#: 11919821	**E. COLI**	10	CFU/ 100ml (50mL)	3.2 - 23.4	3/29/2017	10:56 AM	AT 3/31/2017
S4	2D - Discharge Water, WA Water ID#: 11919822	**FECAL COLIFORM**	80	CFU/ 100ml (5mL)	20 - 204	3/29/2017	11:08 AM	AT 3/31/2017
S4	2D - Discharge Water, WA Water ID#: 11919822	**E. COLI**	80	CFU/ 100ml (5mL)	20 - 204	3/29/2017	11:08 AM	AT 3/31/2017
S4	2D - Discharge Water, WA Water ID#: 11919822	**FECAL COLIFORM**	112	CFU/ 100ml (50mL)	97 - 127	3/29/2017	11:08 AM	AT 3/31/2017
S4	2D - Discharge Water, WA Water ID#: 11919822	**E. COLI**	112	CFU/ 100ml (50mL)	97 - 127	3/29/2017	11:08 AM	AT 3/31/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**

Report Number: 170293R01

Client: Herrera Environmental Consultants, Inc

Date Received: 3/30/2017

Project Name: Lake Whatcom North Shore Water Testing

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S5	3D - Discharge Water, WA Water ID#: 11919823	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	11:21 AM	AT 3/31/2017
S5	3D - Discharge Water, WA Water ID#: 11919823	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	11:21 AM	AT 3/31/2017
S5	3D - Discharge Water, WA Water ID#: 11919823	**FECAL COLIFORM**	18	CFU/ 100ml (50mL)	8 - 34.2	3/29/2017	11:21 AM	AT 3/31/2017
S5	3D - Discharge Water, WA Water ID#: 11919823	**E. COLI**	18	CFU/ 100ml (50mL)	8 - 34.2	3/29/2017	11:21 AM	AT 3/31/2017
S6	4D - Discharge Water, WA Water ID#: 11919824	**FECAL COLIFORM**	160	CFU/ 100ml (5mL)	68 - 316	3/29/2017	11:36 AM	AT 3/31/2017
S6	4D - Discharge Water, WA Water ID#: 11919824	**E. COLI**	160	CFU/ 100ml (5mL)	68 - 316	3/29/2017	11:36 AM	AT 3/31/2017
S6	4D - Discharge Water, WA Water ID#: 11919824	**FECAL COLIFORM**	62	CFU/ 100ml (50mL)	50.9 - 73.1	3/29/2017	11:36 AM	AT 3/31/2017
S6	4D - Discharge Water, WA Water ID#: 11919824	**E. COLI**	62	CFU/ 100ml (50mL)	50.9 - 73.1	3/29/2017	11:36 AM	AT 3/31/2017
S7	5D - Discharge Water, WA Water ID#: 11919825	**FECAL COLIFORM**	40	CFU/ 100ml (5mL)	4 - 144	3/29/2017	11:50 AM	AT 3/31/2017
S7	5D - Discharge Water, WA Water ID#: 11919825	**E. COLI**	40	CFU/ 100ml (5mL)	4 - 144	3/29/2017	11:50 AM	AT 3/31/2017
S7	5D - Discharge Water, WA Water ID#: 11919825	**FECAL COLIFORM**	28	CFU/ 100ml (50mL)	15.4 - 47	3/29/2017	11:50 AM	AT 3/31/2017
S7	5D - Discharge Water, WA Water ID#: 11919825	**E. COLI**	28	CFU/ 100ml (50mL)	15.4 - 47	3/29/2017	11:50 AM	AT 3/31/2017
S8	6D - Discharge Water, WA Water ID#: 11919826	**FECAL COLIFORM**	360	CFU/ 100ml (5mL)	214 - 568	3/29/2017	12:10 PM	AT 3/31/2017
S8	6D - Discharge Water, WA Water ID#: 11919826	**E. COLI**	360	CFU/ 100ml (5mL)	214 - 568	3/29/2017	12:10 PM	AT 3/31/2017
S8	6D - Discharge Water, WA Water ID#: 11919826	**FECAL COLIFORM**	340	CFU/ 100ml (50mL)	313.9 - 366.1	3/29/2017	12:10 PM	AT 3/31/2017
S8	6D - Discharge Water, WA Water ID#: 11919826	**E. COLI**	340	CFU/ 100ml (50mL)	313.9 - 366.1	3/29/2017	12:10 PM	AT 3/31/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Lake Whatcom North Shore Water Testing

Report Number: 170293R01
Date Received: 3/30/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S9	7D - Discharge Water, WA Water ID#: 11919827	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	12:33 PM	AT 3/31/2017
S9	7D - Discharge Water, WA Water ID#: 11919827	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	12:33 PM	AT 3/31/2017
S9	7D - Discharge Water, WA Water ID#: 11919827	**FECAL COLIFORM**	2	CFU/ 100ml (50mL)	0.2 - 11.2	3/29/2017	12:33 PM	AT 3/31/2017
S9	7D - Discharge Water, WA Water ID#: 11919827	**E. COLI**	2	CFU/ 100ml (50mL)	0.2 - 11.2	3/29/2017	12:33 PM	AT 3/31/2017
S10	8D - Discharge Water, WA Water ID#: 11919828	**FECAL COLIFORM**	120	CFU/ 100ml (5mL)	44 - 262	3/29/2017	12:55 PM	AT 3/31/2017
S10	8D - Discharge Water, WA Water ID#: 11919828	**E. COLI**	120	CFU/ 100ml (5mL)	44 - 262	3/29/2017	12:55 PM	AT 3/31/2017
S10	8D - Discharge Water, WA Water ID#: 11919828	**FECAL COLIFORM**	128	CFU/ 100ml (50mL)	112 - 144	3/29/2017	12:55 PM	AT 3/31/2017
S10	8D - Discharge Water, WA Water ID#: 11919828	**E. COLI**	122	CFU/ 100ml (50mL)	106.4 - 137.6	3/29/2017	12:55 PM	AT 3/31/2017
S11	9D - Discharge Water, WA Water ID#: 11919829	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	1:05 PM	AT 3/31/2017
S11	9D - Discharge Water, WA Water ID#: 11919829	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	1:05 PM	AT 3/31/2017
S11	9D - Discharge Water, WA Water ID#: 11919829	**FECAL COLIFORM**	16	CFU/ 100ml (50mL)	6.8 - 31.6	3/29/2017	1:05 PM	AT 3/31/2017
S11	9D - Discharge Water, WA Water ID#: 11919829	**E. COLI**	12	CFU/ 100ml (50mL)	4.4 - 26.2	3/29/2017	1:05 PM	AT 3/31/2017
S12	10D - Discharge Water, WA Water ID#: 11919830	**FECAL COLIFORM**	140	CFU/ 100ml (5mL)	56 - 288	3/29/2017	1:25 PM	AT 3/31/2017
S12	10D - Discharge Water, WA Water ID#: 11919830	**E. COLI**	140	CFU/ 100ml (5mL)	56 - 288	3/29/2017	1:25 PM	AT 3/31/2017
S12	10D - Discharge Water, WA Water ID#: 11919830	**FECAL COLIFORM**	122	CFU/ 100ml (50mL)	106.4 - 137.6	3/29/2017	1:25 PM	AT 3/31/2017
S12	10D - Discharge Water, WA Water ID#: 11919830	**E. COLI**	110	CFU/ 100ml (50mL)	95.2 - 124.8	3/29/2017	1:25 PM	AT 3/31/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**

Report Number: 170293R01

Client: Herrera Environmental Consultants, Inc

Date Received: 3/30/2017

Project Name: Lake Whatcom North Shore Water Testing

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S13	11D - Discharge Water, WA Water ID#: 11919831	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	1:39 PM	AT 3/31/2017
S13	11D - Discharge Water, WA Water ID#: 11919831	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	1:39 PM	AT 3/31/2017
S13	11D - Discharge Water, WA Water ID#: 11919831	**FECAL COLIFORM**	22	CFU/ 100ml (50mL)	10.8 - 39.4	3/29/2017	1:39 PM	AT 3/31/2017
S13	11D - Discharge Water, WA Water ID#: 11919831	**E. COLI**	20	CFU/ 100ml (50mL)	9.4 - 36.8	3/29/2017	1:39 PM	AT 3/31/2017
S14	12D - Discharge Water, WA Water ID#: 11919832	**FECAL COLIFORM**	40	CFU/ 100ml (5mL)	4 - 144	3/29/2017	1:57 PM	AT 3/31/2017
S14	12D - Discharge Water, WA Water ID#: 11919832	**E. COLI**	40	CFU/ 100ml (5mL)	4 - 144	3/29/2017	1:57 PM	AT 3/31/2017
S14	12D - Discharge Water, WA Water ID#: 11919832	**FECAL COLIFORM**	44	CFU/ 100ml (50mL)	34.6 - 53.4	3/29/2017	1:57 PM	AT 3/31/2017
S14	12D - Discharge Water, WA Water ID#: 11919832	**E. COLI**	44	CFU/ 100ml (50mL)	34.6 - 53.4	3/29/2017	1:57 PM	AT 3/31/2017
S15	13D - Discharge Water, WA Water ID#: 11919833	**FECAL COLIFORM**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	2:12 PM	AT 3/31/2017
S15	13D - Discharge Water, WA Water ID#: 11919833	**E. COLI**	<20	CFU/ 100ml (5mL)	0 - 74	3/29/2017	2:12 PM	AT 3/31/2017
S15	13D - Discharge Water, WA Water ID#: 11919833	**FECAL COLIFORM**	22	CFU/ 100ml (50mL)	10.8 - 39.4	3/29/2017	2:12 PM	AT 3/31/2017
S15	13D - Discharge Water, WA Water ID#: 11919833	**E. COLI**	22	CFU/ 100ml (50mL)	10.8 - 39.4	3/29/2017	2:12 PM	AT 3/31/2017
S16	14D - Discharge Water, WA Water ID#: 11919834	**FECAL COLIFORM**	800	CFU/ 100ml (5mL)	673.5 - 926.5	3/29/2017	2:28 PM	AT 3/31/2017
S16	14D - Discharge Water, WA Water ID#: 11919834	**E. COLI**	200	CFU/ 100ml (5mL)	94 - 368	3/29/2017	2:28 PM	AT 3/31/2017
S16	14D - Discharge Water, WA Water ID#: 11919834	**FECAL COLIFORM**	164	CFU/ 100ml (50mL)	145.9 - 182.1	3/29/2017	2:28 PM	AT 3/31/2017
S16	14D - Discharge Water, WA Water ID#: 11919834	**E. COLI**	82	CFU/ 100ml (50mL)	69.2 - 94.8	3/29/2017	2:28 PM	AT 3/31/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Lake Whatcom North Shore Water Testing

Report Number: 170293R01
Date Received: 3/30/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst
S17	0SS - (Raw Sewage), WA Water ID#: 11919835	**FECAL COLIFORM**	4080000	CFU/ 100ml (0.01mL)	3878009.9 - 4281990.1	3/29/2017	3:41 PM	AT 3/31/2017
S17	0SS - (Raw Sewage), WA Water ID#: 11919835	**E. COLI**	4080000	CFU/ 100ml (0.01mL)	3878009.9 - 4281990.1	3/29/2017	3:41 PM	AT 3/31/2017
S18	15D - Discharge Water, WA Water ID#: 11919836	**FECAL COLIFORM**	280	CFU/ 100ml (5mL)	154 - 470	3/29/2017	2:47 PM	AT 3/31/2017
S18	15D - Discharge Water, WA Water ID#: 11919836	**E. COLI**	280	CFU/ 100ml (5mL)	154 - 470	3/29/2017	2:47 PM	AT 3/31/2017
S18	15D - Discharge Water, WA Water ID#: 11919836	**FECAL COLIFORM**	260	CFU/ 100ml (50mL)	237.2 - 282.8	3/29/2017	2:47 PM	AT 3/31/2017
S18	15D - Discharge Water, WA Water ID#: 11919836	**E. COLI**	258	CFU/ 100ml (50mL)	235.3 - 280.7	3/29/2017	2:47 PM	AT 3/31/2017
S19	NEGCTRL - , WA Water ID#: 11919837	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S19	NEGCTRL - , WA Water ID#: 11919837	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S20	POSCTRL - , WA Water ID#: 11919838	**FECAL COLIFORM**	25	CFU/ 100ml	20 - 30	3/30/2017	8:00 AM	AT 3/31/2017
S20	POSCTRL - , WA Water ID#: 11919838	**E. COLI**	25	CFU/ 100ml	20 - 30	3/30/2017	8:00 AM	AT 3/31/2017
S21	Blank - Run #1, WA Water ID#: 11919839	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S21	Blank - Run #1, WA Water ID#: 11919839	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S22	Blank - After Run #10, WA Water ID#: 11919840	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S22	Blank - After Run #10, WA Water ID#: 11919840	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S23	Blank - Final Run, WA Water ID#: 11919841	**FECAL COLIFORM**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017
S23	Blank - Final Run, WA Water ID#: 11919841	**E. COLI**	<1	CFU/ 100ml	0 - 3.7	3/30/2017	8:00 AM	AT 3/31/2017

Lab/Cor, Inc.
7619 6th Ave NW
Seattle, WA 98117

Final Report

Phone: (206) 781-0155
http://www.labcor.net

A Professional Service Corporation in the Northwest

SM 9222D G1c1- Fecal Coliform/ E.coli - CFU

Job Number: 170293 **SEA**
Client: Herrera Environmental Consultants, Inc
Project Name: Lake Whatcom North Shore Water Testing

Report Number: 170293R01
Date Received: 3/30/2017

Lab/Cor Sample No.	Client Sample	Analyte Type	Analysis Result	UOM	95% Confidence Interval	Sample Date	Sample Time	Analyst

Reviewed by:

x _____

Ashley Tonge
Technician/Analyst

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170293-01	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	0	<2		3/30 10:00AM	3/31 10:00AM
170293-02	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	0	<2		3/30 10:00AM	3/31 10:00AM
170293-03	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	5	10	9J	3/30 10:00AM	3/31 10:00AM
170293-04	5	4	80		3/30 10:00AM	3/31 10:00AM
	50	56	112		3/30 10:00AM	3/31 10:00AM
170293-05	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	9	18	16J	3/30 10:00AM	3/31 10:00AM
170293-06	5	8	160		3/30 10:00AM	3/31 10:00AM
	50	31	62		3/30 10:00AM	3/31 10:00AM
170293-07	5	2	40		3/30 10:00AM	3/31 10:00AM
	50	14	28	29J	3/30 10:00AM	3/31 10:00AM
170293-08	5	18	360		3/30 10:00AM	3/31 10:00AM
	50	170	340	342J	3/30 10:00AM	3/31 10:00AM
170293-09	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	1	2	2J	3/30 10:00AM	3/31 10:00AM
170293-10	5	6	120		3/30 10:00AM	3/31 10:00AM
	50	64	128	127J	3/30 10:00AM	3/31 10:00AM
170293-11	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	8	16	15J	3/30 10:00AM	3/31 10:00AM
170293-12	5	7	140		3/30 10:00AM	3/31 10:00AM
	50	61	122	124J	3/30 10:00AM	3/31 10:00AM
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170293-13	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	11	22	20J 8	3/30 10:00AM	3/31 10:00AM
170293-14	5	2	40		3/30 10:00AM	3/31 10:00AM
	50	22	44		3/30 10:00AM	3/31 10:00AM
170293-15	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	11	22	20J 8	3/30 10:00AM	3/31 10:00AM
170293-16	5	40	800		3/30 10:00AM	3/31 10:00AM
	50	82	164		3/30 10:00AM	3/31 10:00AM
170293-17	.01	408	> 4080000	spc	3/30 10:00AM	3/31 10:00AM
					3/30 10:00AM	3/31 10:00AM
170293-18	5	14	280		3/30 10:00AM	3/31 10:00AM
	50	130	260	26J 8	3/30 10:00AM	3/31 10:00AM
Lab Duplicate						
Negative Control	100	0	0			
Positive Control	100	25	25			

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170293-13	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	10	20	18 J sz	3/30 10:00AM	3/31 10:00AM
170293-14	5	2	40		3/30 10:00AM	3/31 10:00AM
	50	22	44		3/30 10:00AM	3/31 10:00AM
170293-15	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	11	22	20J sz	3/30 10:00AM	3/31 10:00AM
170293-16	5	10	200		3/30 10:00AM	3/31 10:00AM
	50	41	82		3/30 10:00AM	3/31 10:00AM
170293-17	.01	408	>4080000	sz	3/30 10:00AM	3/31 10:00AM
					3/30 10:00AM	3/31 10:00AM
170293-18	5	14	280		3/30 10:00AM	3/31 10:00AM
	50	129	258	260 J sz	3/30 10:00AM	3/31 10:00AM
Lab Duplicate						
Negative Control	100	0	0			
Positive Control	100	25	25			

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\,counted}{mL\,Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\,counted}{\sum mL\,sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

Sample ID	Volume (mL)	Colonies counted	Result (CPN/100 mL)	Herrera Check	Start Date/Time:	End Date/Time:
170293-01	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	0	<2		3/30 10:00AM	3/31 10:00AM
170293-02	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	0	<2		3/30 10:00AM	3/31 10:00AM
170293-03	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	5	10	9J SR	3/30 10:00AM	3/31 10:00AM
170293-04	5	4	80		3/30 10:00AM	3/31 10:00AM
	50	56	112		3/30 10:00AM	3/31 10:00AM
170293-05	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	9	18	16J SR	3/30 10:00AM	3/31 10:00AM
170293-06	5	8	160		3/30 10:00AM	3/31 10:00AM
	50	31	62		3/30 10:00AM	3/31 10:00AM
170293-07	5	2	40		3/30 10:00AM	3/31 10:00AM
	50	14	28	29J SR	3/30 10:00AM	3/31 10:00AM
170293-08	5	18	360		3/30 10:00AM	3/31 10:00AM
	50	170	340	342J SR	3/30 10:00AM	3/31 10:00AM
170293-09	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	1	2	2J SR	3/30 10:00AM	3/31 10:00AM
170293-10	5	6	120		3/30 10:00AM	3/31 10:00AM
	50	61	122	122J SR	3/30 10:00AM	3/31 10:00AM
170293-11	5	0	<20		3/30 10:00AM	3/31 10:00AM
	50	6	12	11J SR	3/30 10:00AM	3/31 10:00AM
170293-12	5	7	140		3/30 10:00AM	3/31 10:00AM
	50	55	110		3/30 10:00AM	3/31 10:00AM
Lab Duplicate						
Negative Control						
Positive Control						

Calculation of Results

$$\frac{Colonies}{100\,mL} = \frac{Colonies\ counted}{mL\ Sample Filtered} \times 100$$

Density: use if only one count is within ideal range **(20-60 colonies)**

Average Density: use if all counts are outside of ideal range (20-60 colonies) excluding counts greater than 200 **or** if more than one count is within ideal range

$$\frac{Colonies}{100\,mL} = \frac{\sum Colonies\ counted}{\sum mL\ sample\ filtered} \times 100$$

If all >200 colonies calculate density of value closest to 200 and add greater than to result (e.g. >1000)

HERRERA
2200 Sixth Avenue | Suite 1100
Seattle, Washington | 98121
p 206 441 9080 | f 206 441 9108
PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA
WINTHROP, WA | GUANGZHOU, CHINA

Chain of Custody Record

170293

Project Name:	Project Number:	Client:
Lake Whatcom North Shore Water Testing	16-06326-000	LWWD
Report To:		**Copy To:**
Rob Zisette		
Sampled By:		**Delivery Method:**
R. Zisette, G. Catarra		Hand delivered
Laboratory:	**Requested Completion Date:**	**Total No. of Containers:**
LabCorp	24 hrs	18

Lab Use:

Dilution vol

Sample ID / Description	Date	Time	Sample Type (see codes)	Preserv-ative? (Y/N)	Matrix (see codes)	Number of Containers	Analyses Requested: Fecal coliform bacteria	Analyses Requested: E. Coli	Lab ID No.
C1 / Control - lake 5,50mL	3/29/17	1001	G	N	SW	1	X	X	
C2 / ↓	3/29/17	1012	G	N	SW	1	X	X	
1L / Lake water	3/29/17	1056	G	N	SW	1	X	X	
2D / Discharge water	3/29/17	1108	G	N	SW	1	X	X	
3D	3/29/17	1121	G	N	SW	1	X	X	
4D	3/29/17	1136	G	N	SW	1	X	X	
5D	3/29/17	1150	G	N	SW	1	X	X	
6D	3/29/17	1210	G	N	SW	1	X	X	
7D	3/29/17	1233	G	N	SW	1	X	X	
8D	3/29/17	1255	G	N	SW	1	X	X	
9D	3/29/17	1305	G	N	SW	1	X	X	

Comments/Special Instructions:

Condition: Good Temp: 4.6°C

Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time
Rob Zisette/Herrera	RZ	3/30/17 0800	Ashley Tonge	AT	3/30/17 8AM
Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time

Sample Type: G=Grab C=Composite

Matrix Codes: A=Air GW=Groundwater SE=Sediment SO=Soil SW=Surface Water W=Water (blanks) M=Material O=Other (specify)

HERRERA
2200 Sixth Avenue | Suite 1100
Seattle, Washington | 98121
p 206 441 9080 | f 206 441 9108
PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA
WINTHROP, WA | GUANGZHOU, CHINA

Chain of Custody Record

170293

Project Name:	Project Number:	Client:
Lake Whatcom North Shore Water Testing	16-06326-000	LWWD
Report To:		Copy To:
Rob Zisette		
Sampled By:		Delivery Method:
R. Zisette, G. Catarra		Hand delivered
Laboratory:	Requested Completion Date:	Total No. of Containers:
LabCorp	24 hours	18

Lab Use: Dil vol.

Sample ID / Desc.	Date	Time	Sample Type (see codes)	Preserv-ative? (Y/N)	Matrix (see codes)	Number of Containers	Analyses Requested: Fecal coliform bacteria	Analyses Requested: E. Coli	Lab ID No.
10 D / Discharge water 5,50 mL	3/29/17	1325	G	N	SW	1	X	X	
11 D	3/29/17	1339	G	N	SW	1	X	X	
12 D	3/29/17	1357	G	N	SW	1	X	X	
13 D	3/29/17	1412	G	N	SW	1	X	X	
14 D	3/29/17	1428	G	N	SW	1	X	X	
OSS / (Raw sewage) 0.01 mL	3/29/17	1541	G	N	O	1	X	X	
15D / Discharge water 5,50mL	3/29/17	1447	G	N	SW	1	X	X	

Comments/Special Instructions:

Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time
M Zisette / Herrera	Rob Zisette	3/30/17 0800	Ashley Tonge	A Tonge	3/30/17 8AM
Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time

Sample Type: G=Grab C=Composite

Matrix Codes: A=Air GW=Groundwater SE=Sediment SO=Soil SW=Surface Water W=Water (blanks) M=Material O=Other (specify)

Analytical Resources, Incorporated
Analytical Chemists and Consultants

24 April 2017

Rob Zisette
Herrera Environmental Consultants
2200 6th Avenue, Suite 1100
Seattle, WA 98121

RE: Lake Whatcom North Shore Testing

Please find enclosed sample receipt documentation and analytical results for samples from the project referenced above.

Sample analyses were performed according to ARI's Quality Assurance Plan and any provided project specific Quality Assurance Plan. Each analytical section of this report has been approved and reviewed by an analytical peer, the appropriate Laboratory Supervisor or qualified substitute, and a technical reviewer.

Should you have any questions or problems, please feel free to contact us at your convenience.

Associated Work Order(s)	Associated SDG ID(s)
17C0454	N/A

Mark Harris

Digitally signed by Mark Harris
DN: c=US, st=Washington, l=Tukwila, o=Analytical Resources, Inc., ou=Client Services, cn=Mark Harris, email=markh@arilabs.com
Date: 2017.04.24 12:16:18 -07'00'

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed in the enclose Narrative. ARI, an accredited laboratory, certifies that the report results for which ARI is accredited meets all the reqirements of the accrediting body. A list of certified analyses, accreditations, and expiration dates is included in this report.

Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his/her designee, as verified by the following signature.

Analytical Resources, Inc.

Mark Harris, Project Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

ACCREDITED IN ACCORDANCE WITH nelac
Cert# 100006

PJLA Testing
Accreditation # 66169

Chain of Custody Record & Laboratory Analysis Request

ARI Assigned Number: 17C0454	Turn-around Requested: Std.	Page: 1 of 2	
ARI Client Company: Herrera	Phone: 2067878262	Date: 3/29/17	Ice Present?
Client Contact: Rob Zisette		No. of Coolers: 1	Cooler Temps:
Client Project Name: Lake Whatcom North Shore Water Testing			
Client Project #: 16-06326-000	Samplers: R. Zisette, G. Catarra		

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)
www.arilabs.com

Sample ID	Date	Time	Matrix	No. Containers	Analysis Requested: Total Phosph.	Analysis Requested: Bromide/Chloride	Notes/Comments
C1	3/29/17	1001	W	2/spc	X	X	X - hold analyses pending bacteria results.
C2		1012					
1L		1056					
2D		1108					
3D		1121					
4D		1136					
5D		1150					
6D		1210					
7D		1233					
8D		1255					

Comments/Special Instructions	Relinquished by: (Signature)	Received by: (Signature)	Relinquished by: (Signature)	Received by: (Signature)
	Printed Name: Gina Catarra	Printed Name: Brithney Hall	Printed Name:	Printed Name:
	Company: Herrera	Company: ARI	Company:	Company:
	Date & Time: 3/30/17 1331	Date & Time: 3/30/17 13:31	Date & Time:	Date & Time:

Chain of Custody Record & Laboratory Analysis Request

ARI Assigned Number: 17C0454	Turn-around Requested: std	Page: 2 of 2	
ARI Client Company: Herrera	Phone: 2067878262	Date: 3/29/17	Ice Present?
Client Contact: Rob Zisette		No. of Coolers:	Cooler Temps:
Client Project Name: Lake Whatcom North Shore Water Testing			
Client Project #: 16-06326-000	Samplers: R. Zisette, G. Catarra		

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)
www.arilabs.com

Sample ID	Date	Time	Matrix	No. Containers	Analysis Requested: Total Phosphorus	Analysis Requested: Bromide/Chloride	Notes/Comments
9D	3/29/17	1305	W	2	⊗	⊗	⊗ - hold analyses pending bacteria results.
10D		1325					
11D		1339					
12D		1357					
13D		1412					
14D		1428					
OSS	↓	1541	↓	↓	↓	↓	

Comments/Special Instructions	Relinquished by: (Signature)	Received by: (Signature)	Relinquished by: (Signature)	Received by: (Signature)
	GS Cat	Brittney Hall		
	Printed Name: Gina Catarra	Printed Name: Brittney Hall	Printed Name:	Printed Name:
	Company: Herrera	Company: ARI	Company:	Company:
	Date & Time: 3/30/17 1331	Date & Time: 3/30/17 13:31	Date & Time:	Date & Time:

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: Herrera

Project Name: Lake Whatcom

COC No(s): _____ NA

Delivered by: Fed-Ex UPS Courier (Hand Delivered) Other: _____

Assigned ARI Job No: 17C0454

Tracking No: _____ (NA)

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of to cooler?	YES	(NO)
Were custody papers included with the cooler?	(YES)	NO
Were custody papers properly filled out (ink, signed, etc.)	(YES)	NO

Temperature of Cooler(s) (°C) (recommended 2.0-6.0 °C for chemistry) 3.6

Time: 13:31

If cooler temperature is out of compliance fill out form 00070F

Temp Gun ID#: D0052760

Cooler Accepted by: B.H. Date: 3/30/17 Time: 13:31

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	(NO)
What kind of packing material was used? ...	Bubble Wrap (Wet Ice) Gel Packs Baggies Foam Block Paper Other:		
Was sufficient ice used (if appropriate)?	NA	(YES)	NO
Were all bottles sealed in individual plastic bags?		YES	(NO)
Did all bottles arrive in good condition (unbroken)?		(YES)	NO
Were all bottle labels complete and legible?		YES	(NO)
Did the number of containers listed on COC match with the number of containers received?		(YES)	NO
Did all bottle labels and tags agree with custody papers?		YES	(NO)
Were all bottles used correct for the requested analyses?		(YES)	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs)...	NA	(YES)	NO
Were all VOC vials free of air bubbles?	(NA)	YES	NO
Was sufficient amount of sample sent in each bottle?		(YES)	NO
Date VOC Trip Blank was made at ARI	(NA)		

Was Sample Split by ARI : (NA) YES Date/Time: _____ Equipment: _____ Split by: _____

Samples Logged by: B.H. Date: 3/31/17 Time: 6:56

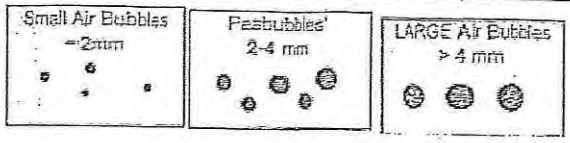
*** Notify Project Manager of discrepancies or concerns ***

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Additional Notes, Discrepancies, & Resolutions:

Most labels were completely smeared and illegible. I identified those samples by the number written on their lids.

By: B.H. Date: 3/31/17



Small → "sm" (< 2 mm)

Peabubbles → "pb" (2 to < 4 mm)

Large → "lg" (4 to < 6 mm)

Headspace → "hs" (> 6 mm)

WORK ORDER

17C0454

Client: Herrera Environmental Consultants | **Project Manager:** Mark Harris

Project: Lake Whatcom North Shore Testing | **Project Number:** [none]

Preservation Confirmation

Container ID	Container Type	pH
17C0454-01 A	Small OJ, 500 mL	
17C0454-01 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-02 A	Small OJ, 500 mL	
17C0454-02 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-03 A	Small OJ, 500 mL	
17C0454-03 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-04 A	Small OJ, 500 mL	
17C0454-04 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-05 A	Small OJ, 500 mL	
17C0454-05 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-06 A	Small OJ, 500 mL	
17C0454-06 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-07 A	Small OJ, 500 mL	
17C0454-07 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-08 A	Small OJ, 500 mL	
17C0454-08 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-09 A	Small OJ, 500 mL	
17C0454-09 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-10 A	Small OJ, 500 mL	
17C0454-10 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-11 A	Small OJ, 500 mL	
17C0454-11 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-12 A	Small OJ, 500 mL	
17C0454-12 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-13 A	Small OJ, 500 mL	
17C0454-13 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-14 A	Small OJ, 500 mL	
17C0454-14 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-15 A	Small OJ, 500 mL	
17C0454-15 B	Small OJ, 500 mL, 9N H2SO4	<2 Pass
17C0454-16 A	Small OJ, 500 mL	

B.H. — Reviewed By

3/31/17 — Date

WORK ORDER

17C0454

Client: Herrera Environmental Consultants **Project Manager: Mark Harris**

Project: Lake Whatcom North Shore Testing **Project Number: [none]**

17C0454-16 B	Small OJ, 500 mL, 9N H2SO4	L2 Pass
17C0454-17 A	Small OJ, 500 mL	
17C0454-17 B	Small OJ, 500 mL, 9N H2SO4	L2 Pass

B.H.
Preservation Confirmed By

3/31/17
Date

B.H.
Reviewed By

3/31/17
Date

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
C1	17C0454-01	Water	29-Mar-2017 10:01	30-Mar-2017 13:31
C2	17C0454-02	Water	29-Mar-2017 10:12	30-Mar-2017 13:31
1L	17C0454-03	Water	29-Mar-2017 10:56	30-Mar-2017 13:31
2D	17C0454-04	Water	29-Mar-2017 11:08	30-Mar-2017 13:31
3D	17C0454-05	Water	29-Mar-2017 11:21	30-Mar-2017 13:31
4D	17C0454-06	Water	29-Mar-2017 11:36	30-Mar-2017 13:31
5D	17C0454-07	Water	29-Mar-2017 11:50	30-Mar-2017 13:31
6D	17C0454-08	Water	29-Mar-2017 12:10	30-Mar-2017 13:31
7D	17C0454-09	Water	29-Mar-2017 12:33	30-Mar-2017 13:31
8D	17C0454-10	Water	29-Mar-2017 12:55	30-Mar-2017 13:31
9D	17C0454-11	Water	29-Mar-2017 13:05	30-Mar-2017 13:31
10D	17C0454-12	Water	29-Mar-2017 13:25	30-Mar-2017 13:31
11D	17C0454-13	Water	29-Mar-2017 13:39	30-Mar-2017 13:31
12D	17C0454-14	Water	29-Mar-2017 13:57	30-Mar-2017 13:31
13D	17C0454-15	Water	29-Mar-2017 14:12	30-Mar-2017 13:31
14D	17C0454-16	Water	29-Mar-2017 14:28	30-Mar-2017 13:31
OSS	17C0454-17	Water	29-Mar-2017 15:41	30-Mar-2017 13:31

4611 S. 134th Place, Suite 100 • Tukwila, WA 98168 • Ph: (206) 695-6200 • Fax: (206) 695-6202

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Case Narrative

Client: Herrera Environmental Consultants
Project: Lake Whatcom North Shore Testing
Workorder: 17C0454

Sample receipt

The samples listed on the preceding page were received 30-Mar-2017 13:31 under ARI work order 17C0454. For details regarding sample receipt, please refer to the Cooler Receipt Form.

Wet Chemistry

These samples were prepared and analyzed within the recommended holding times.

All initial and continuing calibrations were within method requirements.

A small amount of chloride was detected in the method blank (MB) associated with these samples. Choride was detected in all samples associated with this MB. Since the concentrations of chloride measured in the samples were significantly greater than the amount found in the blank, no corrective actions were taken.

A small amount of total phosphorous was detected in the MB associated with these samples . Total phosphorous was detected in all samples associated with this MB. All samples that contained total phosphorous at concentrations that were less than 10x the amount found in the MB were re-prepared and re-analyzed. Total phosphorous was not detected in the re-analyses of the MBs. The results for the re-analyses only have been submitted for these samples. No other target compounds were detected in the MBs above the LOQs.

The percent recoveries for all compounds were within acceptable QC limits for the LCSs.

A matrix spike (MS) was prepared and analyzed for bromide and chloride in conjunction with sample 'C1'. The percent recoveries for both anions were within acceptable QC limits for the MS.

A matrix duplicate (MD) was prepared and analyzed for bromide and chloride in conjunction with sample 'C1'. The RPDs for both anions were within acceptable QC limits for the MD.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

C1

17C0454-01 (Water)
Sampled: 03/29/2017 10:01

Wet Chemistry

2.00

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 14:09

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.59**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

C1

17C0454-01RE1 (Water)
Sampled: 03/29/2017 10:01

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFD0538 Sample Size: 25 mL
Prepared: 04/21/2017 13:02 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/22/2017 15:00

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	ND	mg-P/L	U

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

1L

17C0454-03 (Water)
Sampled: 03/29/2017 10:56

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 15:16

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.56**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

1L

17C0454-03RE1 (Water)
Sampled: 03/29/2017 10:56

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0538	Sample Size: 25 mL
	Prepared: 04/21/2017 13:02	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/22/2017 15:00

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0120**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

2D

17C0454-04 (Water)
Sampled: 03/29/2017 11:08

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 15:33

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.30**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

2D

17C0454-04RE1 (Water)
Sampled: 03/29/2017 11:08

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:47

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0460**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

3D

17C0454-05 (Water)
Sampled: 03/29/2017 11:21

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 15:50

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.66**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

3D

17C0454-05RE1 (Water)
Sampled: 03/29/2017 11:21

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0538	Sample Size: 25 mL
	Prepared: 04/21/2017 13:02	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/22/2017 15:01

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0140**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

4D

17C0454-06 (Water)
Sampled: 03/29/2017 11:36

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 17:00

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**3.10**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

4D

17C0454-06RE1 (Water)
Sampled: 03/29/2017 11:36

Sample Preparation: Preparation Method: SM 4500-P B-5 Persulfate
Preparation Batch: BFD0422 Sample Size: 25 mL
Prepared: 04/18/2017 10:45 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/19/2017 13:48

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0640**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

5D

17C0454-07 (Water)
Sampled: 03/29/2017 11:50

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 17:16

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.77**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

5D

17C0454-07RE1 (Water)
Sampled: 03/29/2017 11:50

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:48

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0660**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

6D

17C0454-08 (Water)
Sampled: 03/29/2017 12:10

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 17:33

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.42**	mg/L	B

Wet Chemistry

6.00

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFD0198 Sample Size: 25 mL
Prepared: 04/15/2017 12:20 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/17/2017 16:37

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0860**	mg-P/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

8D

17C0454-10 (Water)
Sampled: 03/29/2017 12:55

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 17:50

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.87**	mg/L	B

Wet Chemistry

6.00

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFD0198 Sample Size: 25 mL
Prepared: 04/15/2017 12:20 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/17/2017 16:38

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0880**	mg-P/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

9D

17C0454-11 (Water)
Sampled: 03/29/2017 13:05

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 18:07

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.46**	mg/L	B

Wet Chemistry

6.00

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFD0198 Sample Size: 25 mL
Prepared: 04/15/2017 12:20 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/17/2017 16:39

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.218**	mg-P/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

10D

17C0454-12 (Water)
Sampled: 03/29/2017 13:25

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 18:23

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**2.17**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

10D

17C0454-12RE1 (Water)
Sampled: 03/29/2017 13:25

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:49

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0540**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

11D

17C0454-13 (Water)
Sampled: 03/29/2017 13:39

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 18:40

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.71**	mg/L	B

Wet Chemistry

6.00

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFD0198 Sample Size: 25 mL
Prepared: 04/15/2017 12:20 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/17/2017 16:40

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0980**	mg-P/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

12D

17C0454-14 (Water)
Sampled: 03/29/2017 13:57

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 18:57

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.80**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

12D

17C0454-14RE1 (Water)
Sampled: 03/29/2017 13:57

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:50

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0620**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

13D

17C0454-15 (Water)
Sampled: 03/29/2017 14:12

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 19:14

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.38**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

13D

17C0454-15RE1 (Water)
Sampled: 03/29/2017 14:12

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:50

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0600**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

14D

17C0454-16 (Water)
Sampled: 03/29/2017 14:28

Sample Preparation:	Preparation Method: No Prep Wet Chem	
	Preparation Batch: BFD0124	Sample Size: 5 mL
	Prepared: 04/06/2017 08:52	Final Volume: 5 mL

Analytical Method: EPA 300.0 | Instrument: DX500 | Analyzed: 04/13/2017 19:31

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	1	0.100	**1.78**	mg/L	B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

14D

17C0454-16RE1 (Water)
Sampled: 03/29/2017 14:28

Sample Preparation:	Preparation Method: SM 4500-P B-5 Persulfate	
	Preparation Batch: BFD0422	Sample Size: 25 mL
	Prepared: 04/18/2017 10:45	Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 | Instrument: UV1800-2 | Analyzed: 04/19/2017 13:50

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	1	0.00800	**0.0880**	mg-P/L	

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

OSS

17C0454-17 (Water)

Sampled: 03/29/2017 15:41

Sample Preparation: Preparation Method: No Prep Wet Chem
Preparation Batch: BFD0124 Sample Size: 5 mL
Prepared: 04/06/2017 08:52 Final Volume: 5 mL

Analytical Method: EPA 300.0 Instrument: DX500 Analyzed: 04/13/2017 20:21

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	10	1.00	ND	mg/L	U

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	10	1.00	**48.1**	mg/L	B, D

Wet Chemistry

6.00

Sample Preparation: Preparation Method: SM 4500-P B-4 Strong Acid
Preparation Batch: BFD0198 Sample Size: 25 mL
Prepared: 04/15/2017 12:20 Final Volume: 50 mL

Analytical Method: SM 4500-P E-99 Instrument: UV1800-2 Analyzed: 04/17/2017 16:43

Analyte	CAS Number	Dilution	Reporting Limit	Result	Units	Notes
Total Phosphorus	7723-14-0	20	0.160	**10.2**	mg-P/L	B, D

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Wet Chemistry - Quality Control

Batch BFD0124 - No Prep Wet Chem

Instrument: DX500

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFD0124-BLK1)			Prepared: 06-Apr-2017 Analyzed: 13-Apr-2017 13:32							
Bromide	ND	0.100	mg/L							U
Chloride	0.103	0.100	mg/L							*
Blank (BFD0124-BLK2)			Prepared: 06-Apr-2017 Analyzed: 13-Apr-2017 14:26							
Bromide	ND	0.100	mg/L							U
Chloride	ND	0.100	mg/L							U
LCS (BFD0124-BS1)			Prepared: 06-Apr-2017 Analyzed: 13-Apr-2017 13:49							
Bromide	3.03	0.100	mg/L	3.00		101 %	75-125			
Chloride	2.94	0.100	mg/L	3.00		97.8 %	75-125			B
Duplicate (BFD0124-DUP1)	**Source: 17C0454-01**		Prepared: 06-Apr-2017 Analyzed: 13-Apr-2017 14:43							
Bromide	ND	0.100	mg/L		ND					U
Chloride	2.59	0.100	mg/L		2.59			0.23	20	B
Matrix Spike (BFD0124-MS1)	**Source: 17C0454-01**		Prepared: 06-Apr-2017 Analyzed: 13-Apr-2017 15:00							
Bromide	1.94	0.100	mg/L	2.00	ND	96.8 %	75-125			
Chloride	4.76	0.100	mg/L	2.00	2.59	109 %	75-125			B

Recovery limits for target analytes in MS/MSD QC samples are advisory only.

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Wet Chemistry - Quality Control

Batch BFD0198 - SM 4500-P B-4 Strong Acid

Instrument: UV1800-2

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFD0198-BLK1)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:11							
Total Phosphorus	0.0100	0.00800	mg-P/L							*
Blank (BFD0198-BLK2)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:36							
Total Phosphorus	0.0100	0.00800	mg-P/L							*
DL (BFD0198-BLK3)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:44							
Total Phosphorus	0.00800	0.00800	mg-P/L							*
Blank (BFD0198-BLK4)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:47							
Total Phosphorus	0.0100	0.00800	mg-P/L							*
LCS (BFD0198-BS1)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:11							
Total Phosphorus	0.304	0.00800	mg-P/L	0.300		101 %	90-110			B
DL (BFD0198-BS2)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:37							
Total Phosphorus	0.300	0.00800	mg-P/L	0.300		100 %	90-110			B
DL (BFD0198-BS3)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:45							
Total Phosphorus	0.304	0.00800	mg-P/L	0.300		101 %	90-110			B
LCS (BFD0198-BS4)			Prepared: 15-Apr-2017 Analyzed: 17-Apr-2017 16:48							
Total Phosphorus	0.304	0.00800	mg-P/L	0.300		101 %	90-110			B

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Wet Chemistry - Quality Control

Batch BFD0422 - SM 4500-P B-5 Persulfate

Instrument: UV1800-2

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFD0422-BLK1)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 13:33							
Total Phosphorus	ND	0.00800	mg-P/L							U
Blank (BFD0422-BLK2)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 13:52							
Total Phosphorus	ND	0.00800	mg-P/L							U
DL (BFD0422-BLK3)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 14:00							
Total Phosphorus	ND	0.00800	mg-P/L							U
Blank (BFD0422-BLK4)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 14:01							
Total Phosphorus	ND	0.00800	mg-P/L							U
LCS (BFD0422-BS1)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 13:33							
Total Phosphorus	0.294	0.00800	mg-P/L	0.300		98.0 %	90-110			
DL (BFD0422-BS2)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 13:52							
Total Phosphorus	0.296	0.00800	mg-P/L	0.300		98.7 %	90-110			
DL (BFD0422-BS3)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 14:00							
Total Phosphorus	0.294	0.00800	mg-P/L	0.300		98.0 %	90-110			
LCS (BFD0422-BS4)			Prepared: 18-Apr-2017 Analyzed: 19-Apr-2017 14:02							
Total Phosphorus	0.296	0.00800	mg-P/L	0.300		98.7 %	90-110			

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Wet Chemistry - Quality Control

Batch BFD0538 - SM 4500-P B-5 Persulfate

Instrument: UV1800-2

QC Sample/Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BFD0538-BLK1)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 14:30							
Total Phosphorus	ND	0.00800	mg-P/L							U
Blank (BFD0538-BLK2)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:04							
Total Phosphorus	ND	0.00800	mg-P/L							U
DL (BFD0538-BLK3)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:12							
Total Phosphorus	ND	0.00800	mg-P/L							U
Blank (BFD0538-BLK4)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:14							
Total Phosphorus	ND	0.00800	mg-P/L							U
LCS (BFD0538-BS1)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 14:31							
Total Phosphorus	0.296	0.00800	mg-P/L	0.300		98.7 %	90-110			
DL (BFD0538-BS2)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:05							
Total Phosphorus	0.296	0.00800	mg-P/L	0.300		98.7 %	90-110			
DL (BFD0538-BS3)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:13							
Total Phosphorus	0.298	0.00800	mg-P/L	0.300		99.3 %	90-110			
LCS (BFD0538-BS4)			Prepared: 21-Apr-2017 Analyzed: 22-Apr-2017 15:15							
Total Phosphorus	0.296	0.00800	mg-P/L	0.300		98.7 %	90-110			

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Certified Analyses included in this Report

Analyte	Certifications
EPA 300.0 in Water	
Bromide	DoD-ELAP,WADOE,NELAP
Chloride	DoD-ELAP,WADOE,WA-DW,NELAP
SM 4500-P E-99 in Water	
Total Phosphorus	WADOE,NELAP

Code	Description	Number	Expires
ADEC	Alaska Dept of Environmental Conservation	UST-033	05/06/2017
CALAP	California Department of Public Health CAELAP	2748	02/28/2018
DoD-ELAP	DoD-Environmental Laboratory Accreditation Program	66169	03/30/2017
NELAP	ORELAP - Oregon Laboratory Accreditation Program	WA100006	05/11/2017
WADOE	WA Dept of Ecology	C558	06/30/2017
WA-DW	Ecology - Drinking Water	C558	06/30/2017

Herrera Environmental Consultants	Project: Lake Whatcom North Shore Testing	
2200 6th Avenue, Suite 1100	Project Number: 16-06326-000	**Reported:**
Seattle, WA 98121	Project Manager: Rob Zisette	24-Apr-2017 12:15

Notes and Definitions

*	Flagged value is not within established control limits.
B	This analyte was detected in the method blank.
D	The reported value is from a dilution
U	This analyte is not detected above the applicable reporting or detection limit.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
[2C]	Indicates this result was quantified on the second column on a dual column analysis.

Source Molecular
Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Preliminary Interpretation of Human Fecal Pollution ID™ Results

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by Droplet Digital Polymerase Chain Reaction (ddPCR) DNA analytical technology

Submitter: Herrera Environmental Consultants
Date Received: March 31, 2017
Report Generated: April 7, 2017

SM #	Client #	Approximate Contribution of Human Fecal Pollution in Water Sample	Comment
SM-7C31005	C1	Not Detected	Human fecal biomarkers not detected
SM-7C31007	1L	Not Detected	Human fecal biomarkers not detected
SM-7C31008	2D	Not Detected	Human fecal biomarkers not detected
SM-7C31009	3D	Not Detected	Human fecal biomarkers not detected
SM-7C31010	4D	**Moderate Concentration**	Moderate levels of Human fecal biomarker(s)
SM-7C31011	5D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C31012	6D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C31014	8D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C31015	9D	Not Detected	Human fecal biomarkers not detected
SM-7C31016	10D	**Low Concentration**	Low levels of 2 Human fecal biomarkers
SM-7C31017	11D	Not Detected	Human fecal biomarkers not detected
SM-7C31018	12D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C31019	13D	Not Detected	Human fecal biomarkers not detected
SM-7C31020	14D	**Low Concentration**	Low levels of 1 Human fecal biomarker
SM-7C31021	OSS (Raw Sewage)	**High Concentration**	High levels of Human fecal biomarker(s)

Source Molecular
Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Human Fecal Pollution ID™ Quantification

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by Droplet Digital Polymerase Chain Reaction (ddPCR) DNA analytical technology

Submitter: Herrera Environmental Consultants
Date Received: March 31, 2017
Report Generated: April 7, 2017

SM #	Client #	Analysis Requested	Target	Marker Quantified (copies/100 ml)	DNA Analytical Results
SM-7C31005	C1	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31007	1L	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31008	2D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31009	3D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31010	4D	Human Bacteroidetes ID 1	Dorei	2.17E+04	**Present**
SM-7C31011	5D	Human Bacteroidetes ID 1	Dorei	1.12E+02	**Present**
SM-7C31012	6D	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C31014	8D	Human Bacteroidetes ID 1	Dorei	8.70E+01	**Present**
SM-7C31015	9D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31016	10D	Human Bacteroidetes ID 1	Dorei	<LOQ	**Present**
SM-7C31017	11D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31018	12D	Human Bacteroidetes ID 1	Dorei	1.07E+02	**Present**
SM-7C31019	13D	Human Bacteroidetes ID 1	Dorei	ND	Absent
SM-7C31020	14D	Human Bacteroidetes ID 1	Dorei	2.78E+02	**Present**
SM-7C31021	OSS (Raw Sewage)	Human Bacteroidetes ID 1	Dorei	1.46E+03	**Present**
SM-7C31022	C1	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31024	1L	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31025	2D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31026	3D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31027	4D	Human Bacteroidetes ID 2	EPA	1.61E+03	**Present**
SM-7C31028	5D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31029	6D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31031	8D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31032	9D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31033	10D	Human Bacteroidetes ID 2	EPA	9.96E+03	**Present**
SM-7C31034	11D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31035	12D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31036	13D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31037	14D	Human Bacteroidetes ID 2	EPA	ND	Absent
SM-7C31038	OSS (Raw Sewage)	Human Bacteroidetes ID 2	EPA	1.41E+05	**Present**

ND: Not Detected
<LOQ: Detected below level of quantification

Laboratory Comments

Submitter: Herrera Environmental Consultants

Report Generated: April 7, 2017

Negative Results

In sample(s) classified as negative, the human-associated Bacteroidetes gene biomarker(s) was either not detected in test replicates, one replicate was detected at a concentration below 3 copies/copies/20µL and the other was not, or one replicate was detected at a concentration above 3 copies/copies/20µL and the other was not after repeated analysis. It is important to note that a negative result does not mean that the sample does not definitely have human fecal contamination. Only repeated sampling (both during wet and dry sampling events) will enable you to draw more definitive conclusions as to the contributor(s) of fecal pollution.

In order to strengthen the result, a negative sample should be analyzed further for human fecal contamination with other DNA analytical tests. A list of human fecal ID tests can be found at **www.sourcemolecular.com/human**.

Positive Results

In sample(s) classified as positive, the human-associated Bacteroidetes gene biomarker(s) was detected in both test replicates suggesting that human fecal contamination is present in the water sample(s). The biomarker(s) serve as an indicator of the targeted fecal pollution, but the presence of the biomarker does not signify conclusively the presence of that form of fecal pollution. Only repeated sampling (both during wet and dry sampling events) will enable you to draw more definitive conclusions as to the contributor(s) of fecal pollution.

Detected Not Quantified (DNQ) Results

In sample(s) classified as detected not quantified (DNQ), the human-associated Bacteroidetes biomarker was detected in both test replicates but in low, non-quantifiable quantities. This result indicates that fecal indicators associated with human were present in the sample(s) but in low concentrations.

Human Fecal Reference Samples

The client is encouraged to submit samples from the surrounding wastewater facilities and/or septic systems in order to gain a better understanding of the concentration of the human-associated fecal Bacteroidetes genetic marker as well as the concentration of the general fecal Bacteroidetes genetic marker in the geographic region of interest. A more precise interpretation would be available to the client with the submittal of such baseline samples.

Result Interpretations

Quantitative results are reported along with interpretations. Interpretations are given as "negative", “trace”, "low concentration", "moderate concentration", or "high concentration" based on the concentration of the genetic markers found in the water samples.

Additional Testing

A portion of all samples has been frozen and will be archived for 3 months. The client is encouraged to perform additional tests on the sample(s) for other hosts suspected of contributing to the fecal contamination. A list of available tests can be found at **www.sourcemolecular.com/tests**

DNA Analytical Method Explanation

All reagents, chemicals, and apparatuses were verified and inspected beforehand to ensure that no false negatives or positives could be generated. In that regard, positive and negative controls were run to attest the integrity of the analysis. All inspections and controls tested negative for possible extraneous contaminants.

Each submitted water sample was filtered through 0.45-micron membrane filters. Each filter was placed in a separate, sterile 2ml disposable tube containing a unique mix of beads and lysis buffer. The sample was homogenized and the DNA extracted and purified.

Sample DNA was amplified and analyzed with a Bio-Rad QX200 Droplet Digital PCR System (Bio-Rad Laboratories, Inc.). Samples were processed in duplicate in a 20µL reaction containing DNA extract, forward primer, reverse primer, probe (as appropriate) and an optimized buffer solution. Absolute quantification was achieved by software Poisson Distribution Analysis.

For quality control purposes, a positive control consisting of genomic or synthetic DNA, and three negative controls consisting of PCR-grade water were run alongside the sample(s) to monitor for any false negatives or false positives.

Human Bacteroidetes ID™ Species*: B. dorei*

The **Human Bacteroidetes ID™ Species*: B. dorei*** service targets the species *Bacteroides dorei*. *B. dorei* is an anaerobe that is frequently shed from the gastrointestinal tract and isolated from human feces worldwide. It is a newly discovered species that is widely distributed in the USA.[1,2] The human-associated marker DNA sequence is located on the 16S rRNA gene of *B. dorei*.[3] The marker is the microbial source tracking (MST) marker of choice for detecting human fecal pollution due to its exceptional sensitivity and specificity. Internal validations have been conducted on hundreds of sewage, septage, human and animal host fecal samples collected from throughout the U.S and archived in the Source Molecular fecal bank. The marker has also been evaluated in both inland and coastal waters. A recent, comprehensive, multi-laboratory MST method evaluation study, exploring the performance of current MST methods, concluded the *B. dorei* PCR assay to be the top performing human-associated assay amongst those tested. The success and consistency of this marker in numerous studies around the world[1,3,4] makes the **Human Bacteroidetes ID™ Species*: B. dorei*** service the primary service for identifying human fecal pollution at Source Molecular.

Fecal *Bacteroidetes* are considered for several reasons an interesting alternative to more traditional indicator organisms such as *E. coli* and *Enterococci*.[5] Since they are strict anaerobes, they are indicative of recent fecal contamination when found in water systems. This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

The Human Bacteroidetes ID™ service is designed around the principle that fecal *Bacteroidetes* are found in large quantities in feces of warm-blooded animals.[3,5,6,7,8] Furthermore, certain strains of *Bacteroidetes* have been found to be associated with humans.[3,6] As such, these bacterial strains can be used as indicators of human fecal contamination.

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the unique B. dorei DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the B. dorei DNA sequence, then billions of copies of the DNA fragment will be available, detected and quantified.

To strengthen the validity of the results, additional tests targeting other high-ranking, human-associated *Bacteroidetes* species should be performed, such as
Human Bacteroidetes ID™ Species*: B. stercoris*,
Human Bacteroidetes ID™ Species*: B. fragilis,* and
Human Bacteroidetes ID™ Species*: B. thetaiotaomicron*.

[1]Boehm, A., Fuhrman, J., Mrse, R., Grant, S. **Tiered approach for identification of a human fecal pollution source at a recreational beach: case study at Avalon Bay, Catalina Island, California**. Environ Sci Technol. 2003 37**:** 673–680.
[2]Bakir, M., Sakamoto, M., Kitahara, M., Matsumoto, M., Benno, Y. **Bacteroides dorei sp. nov., isolated from human faeces**. Int. J. Syst. Evol. Microbiol. 2006 56: 1639–1641.
[3] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA.** Appl. Environ. Microbiol. 2000b 66: 4571-4574.
[4]Ahmed, w., Masters, N., Toze, S. **Consistency in the host specificity and host sensitivity of the Bacteroides HF183 marker for sewage pollution tracking. Lett. Appl. Microbiol. 2012 55: 283-289.**
[5] Scott, T., Rose, J., Jenkins, T., Farrah, S., Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[6] Bernhard, A., Field, K. **Identification of nonpoint sources of fecal pollution in coastal waters by using host-specific 16S ribosomal DNA genetic markers from fecal anaerobes.** Appl. Environ. Microbiol. 2000a 66: 1587-1594.
[7] Fogarty, L., Voytek, M. **A Comparison of Bacteroides-Prevotella 16S rRNA Genetic Markers for Fecal Samples from Different Animal**

Human Bacteroidetes ID™: EPA Developed Assay

The **Human Bacteroidetes ID™: EPA Developed Assay** service targets a functional gene biomarker in *Bacteroidales*-like anaerobic bacteria that is present in high concentrations in the human gut. The U.S Environmental Protection Agency (U.S. EPA) was the first to target the biomarker using Polymerase Chain Reaction (PCR) technology in order to detect ground and surface waters impacted by human fecal pollution.[1] Since it's development, the assay has been used succesfully around the U.S to identify fecal pollution originating from human sources, such as sewage and septage wastewaters.

The U.S. EPA Developed assay has been shown to be highly associated with human fecal pollution. It has successfully been validated in multiple nationwide studies using at least 300 individual reference fecal material from 22 different animal species known to commonly contaminate environmental waters.[1,2] A reported 99.2% specificity to human fecal material makes this one of the leading assays to confirm the presence of fecal contamination that is of human origin.[1] The *Bacteroidales*-like bacteria is widely distributed. It was detected in 100% of hundreds of sewage and human reference fecal samples collected from more than 20 human populations, making it highly sensitive. Internal validations have also been conducted on hundreds of wastewater, human and animal host fecal samples archived in the Source Molecular fecal bank.

Fecal anaerobic bacteria are considered for several reasons an interesting alternative to more traditional fecal indicator organisms such as *E. coli* and *Enterococci*.[3] Since they are strict anaerobes, they are indicative of recent fecal contamination when found in water systems.[3] This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

The **Human Bacteroidetes ID™: EPA Developed Assay** service is designed around the principle that fecal *Bacteroidales*-like bacteria are found in large quantities in feces of warm-blooded animals.[4,5] Furthermore, certain strains have been shown to be associated with humans.[4,5] As such, these bacterial strains can be used as indicators of human fecal contamination. An advantage of the Human Bacteroidetes ID™ service is that the entire portion of water sampled is filtered to concentrate bacteria. As such, this method avoids the randomness effect of culturing and selecting bacterial isolates. This is an advantage for highly contaminated water systems with potential multiple sources of fecal contamination.

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the unique B. dorei DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the B. dorei DNA sequence, then billions of copies of the DNA fragment will be available, detected and quantified.

To strengthen the validity of the results, additional tests targeting other high-ranking, human-associated *Bacteroidetes* species should be performed, such as
Human Bacteroidetes ID™ Species*: B. dorei*,
Human Bacteroidetes ID™ Species*: B. fragilis,* and
Human Bacteroidetes ID™ Species*: B. stercoris*

[1] Shanks, O., Kelty, C., Sivaganesan, M., Varma, M. and Haugland, R. **Quantitative PCR for Genetic Markers of Human Fecal Pollution**. Appl. Environ. Microbiol. 2009 75: 5507-5513.
[2] Layton, B., Cao, Y., Ebentier, D., Hanley, K., Ballesté, E., Brandão, J., *et al*. **Performance of Human Fecal Anaerobe-Associated PCR-Based Assays in a Multi-Laboratory Method Evaluation Study.** Water Research. 2013 In Press.
[3] Scott, T., Rose, J., Jenkins, T., Farrah, S. and Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[4] Bernhard, A., Field, K. **Identification of nonpoint sources of fecal pollution in coastal waters by using host-specific 16S ribosomal DNA genetic markers from fecal anaerobes.** Appl. Environ. Microbiol. 2000a 66: 1587-1594.
[5] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA**. Appl. Environ. Microbiol. 2000b 66: 4571-4574.

Data Quality Assurance Worksheet

By G. Catarra

Project Name/No./Client: Lake Whatcom / 16-06326-000 / LWWSD. Date 4/3/2017 Page 1 of 1

Laboratory/Parameters: LabCor, Inc. / fecal bacteria and E. coli; ARI / TP, Cl/Br; Source Molecular / MST Checked: initials

Sample Date/Sample ID: 3/29/2017 / 18 samples date

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (hours)		Total Holding Times (days)		Method Blanks Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal	Reported	Goal[1]	
Fecal coliform	OK / SM9222D	NA	**NA**	1	**≤1**	≤1.0 2 CFU /100ML	NA	**NA**	NA	**NA**	NA	**≤ 35**	NA	**NA**	STATIONS 1, 3, 5-11, 13, 15 "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
E. coli	OK / SM9222D	NA	**NA**	1	**≤1**	≤1.0 2	NA	**NA**	NA	**NA**	NA	**≤ 35**	NA	**NA**	STATIONS 1, 3, 5-9, 11, 13, 15 "J" DUE TO PLATE COUNTS. RESULTS CALCULATED PER METHOD.
Total Phosphorus	OK / EPA 365.1	NA	**NA**	19-24	**≤28**	≤8.0 – 10 8.0 µg/L	NA	**±20**	98-101	**±10**	NA	**≤ 20**	NA	**NA**	NO FLAG FOR MB, SAMPLES <10X MB WERE REPREPPED AND REANALYZED.
Chloride	OK / EPA 300.0	NA	**≤12**	16	**≤28**	0.103 0.1 mg/L	109	**±20**	98	**±10**	0.23	**≤ 20**	NA	**NA**	NO FLAG FOR MB, ALL SAMPLES >10X MB.
Bromide	OK / EPA 300.0	NA	**NA**	16	**≤28**	≤0.1 0.1 mg/L	97	**±20**	101	**±10**	NC	**≤ 20**	NA	**NA**	NONE
B. Dorei	OK / Digital qPCR	<48	**≤48**	NA	**NA**	≤0.01 3	NA	**NA**	NA	**NA**	NA	**≤ 30 cov**	NA	**NA**	NONE
EPA Assay	OK / Digital qPCR	<48	**≤48**	NA	**NA**	≤0.05 3	NA	**NA**	NA	**NA**	NA	**≤ 30 cov**	NA	**NA**	NONE

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit; NS – field duplicate not sampled.

APPENDIX C

Sample Results Database

Database for Lake Whatcom North Shore On-site Sewage System Detection Project

Station	Station Type	Sample ID	Event	Date	Time	Lat (°)	Long (°)	Temp (°C)	DO (mg/L)	pH	Sp Cond (uS/cm)	Turbidity (FNU)	OB (RFUB)	Fecal coliform (CFU/100mL)		E coli (CFU/100mL)		EC/FC Ratio	B dorei (copies/100mL)		B EPA (copies/100mL)		Bacteroidetes Lab Category	Total P (mg/L)		Chloride (mg/L)		Bromide (mg/L)		Sample Analysis Code
OSS	Septage	OSS	2	3/15/2017	15:50	48.73255	-122.31705	7.8	0.30	6.96	963	26.81	632.9	1500000	J	1500000	J	1.0	1030		55000		Moderate	10.3		46.8		0.100	U	All parameters
OSS	Septage	OSS	3	3/29/2017	15:41	48.73254	-122.31709	9.1	0.61	6.91	943.8	32.3	686.0	4080000	>	4080000	>	1.00	1460		141000		High	10.2		48.1		0.100	U	All parameters
1L	Lake	1L	3	3/29/2017	10:56	48.73429	-122.31767	6.9	11.31	6.92	56.6	0.58	61.7	9	J	9	J	1.00	0	ND	0	ND	Not detected	0.012		2.56		0.100	U	All parameters
2L	Lake	4L	2	3/15/2017	11:35	48.73649	-122.32124	7.2	11.14	7.08	64.8	2.95	90.51	5	U	5	U	1.0	0	ND	0	ND	Not detected	0.018		2.59		0.100	U	All parameters
3L	Lake	3L	1	1/19/2017	11:44	48.7369	-122.32196	6.8	11.59	7.39	60.9	2.7	81.17	46		42		0.9												Field + Fecals
4L	Lake	11L	2	3/15/2017	13:56	48.74635	-122.33769	7.2	11.67	7.16	59.7	0.43	73.0	5	J	5	J	1.0	3	<	0	ND	Low	0.024	J	2.63		0.100	U	All parameters
5L	Lake	12L	2	3/15/2017	14:09	48.74685	-122.33852	7.7	11.16	7.08	61.4	1.71	227.7	9	J	9	J	1.0	60		0	ND	Low	0.030		3.05		0.100	U	All parameters
C1	Lake	C1	1	1/19/2017	9:26	48.72298	-122.30225	6.7	10.42	7.20	50.7	0.3	8.16	2	U	2	U	1.0												Field + Fecals
C1	Lake	C1	2	3/15/2017	9:41	48.72372	-122.30253	6.3	11.55	7.46	57.3	0.41	43.64	5	U	5	U	1.0	3	<	0	ND	Low	0.008	U	2.68		0.100	U	All parameters
C1	Lake	C1	3	3/29/2017	10:01	48.72375	-122.30257	6.6	11.77	7.41	56.7	0.6	41.1	2	U	2	U	1.00	0	ND	0	ND	Not detected	0.008	U	2.59		0.100	U	All parameters
C2	Lake	C2	1	1/19/2017	9:32	48.72408	-122.30284	6.7	10.60	7.21	57.7	0.2	43.43	2	U	2	U	1.0												Field + Fecals
C3	Lake	C3	1	1/19/2017	9:40	48.72568	-122.30415	6.7	10.60	7.20	58.1	0.2	42.4	4	J	4	J	1.0												Field + Fecals
C3	Lake	C2	2	3/15/2017	9:50	48.72564	-122.30418	6.3	11.43	7.39	57.6	0.44	44.03	5	U	5	U	1.0	0	ND	0	ND	Not detected	0.008	U	2.68		0.100	U	All parameters
C3	Lake	C2	3	3/29/2017	10:12	48.72568	-122.30408	6.7	11.67	7.31	57.1	0.25	45.5	2	U	2	U	1.00												Field + Fecals
429	Discharge	15D	3	3/29/2017	14:47	48.74885	-122.34624	8.9	11.47	6.27	0.2	25.6	297	262	J	260	J	0.99								`				Field + Fecals
430	Discharge	14D	1	1/19/2017	13:53	48.74865	-122.34364	5.5	11.85	6.94	61.3	9.1		125		100		0.8												Field + Fecals
430	Discharge	14D	2	3/15/2017	14:40	48.74866	-122.34368	7.2	11.99	7.33	60.3	1.26	106.1	7	J	7	J	1.0	3	<	0	ND	Low	0.016		2.70		0.100	U	All parameters
430	Discharge	14D	3	3/29/2017	14:28	48.74871	-122.34364	8.4	11.47	7.00	57.0	11.4	229	800		82		0.10	278		0	ND	Low	0.088		1.78	J	0.100	U	All parameters
437	Discharge	13D	1	1/19/2017	13:44	48.74736	-122.33991	5.2	12.17	7.05	41.4	6.4		18	J	14	J	0.8												Field + Fecals
437	Discharge	13D	2	3/15/2017	14:20	48.74743	-122.3399	7.6	11.82	7.29	45.6	5.68	264.1	9	J	9	J	1.0	0	ND	0	ND	Not detected	0.032		1.96		0.100	U	All parameters
437	Discharge	13D	3	3/29/2017	14:12	48.74738	-122.33993	8.0	11.64	7.18	37.7	7.7	270.7	20	J	20	J	1.00	0	ND	0	ND	Not detected	0.060		1.38		0.100	U	All parameters
440	Discharge	12D	1	1/19/2017	13:39	48.7469	-122.3386	5.3	11.88	6.85	53.5	3.6		50	J	32	J	0.6												Field + Fecals
440	Discharge	12D	3	3/29/2017	13:57	48.7469	-122.33854	8.4	11.14	7.04	49.1	5.11	270.8	44		44		1.00	107		0	ND	Low	0.062		1.80		0.100	U	All parameters
449	Discharge	11D	1	1/19/2017	13:29	48.74545	-122.33574	6.6	11.97	7.17	58.8	34.7		190	J	180		0.9												Field + Fecals
449	Discharge	10D	2	3/15/2017	13:35	48.74546	-122.33574	7.9	11.87	7.37	59.2	6.63	196.5	2	J	2	J	1.0												Field + Fecals
449	Discharge	11D	3	3/29/2017	13:39	48.74547	-122.33577	7.6	11.89	7.20	48.6	67.15	148.7	20	J	18	J	0.90	0	ND	0	ND	Not detected	0.098		1.71		0.100	U	All parameters
453	Discharge	9D	2	3/15/2017	13:18	48.74528	-122.33444	6.9	10.48	6.60	59.3	1.38	111.2	38	J	38	J	1.0	3	<	4050		Low	0.014		2.82		0.100	U	All parameters
453	Discharge	10D	3	3/29/2017	13:25	48.7453	-122.33442	7.6	10.75	6.43	51.4	6.52	157.2	124	J	110		0.89	3	<	9960		Low	0.054		2.17		0.100	U	All parameters
462	Discharge	10D	1	1/19/2017	13:16	48.74376	-122.33084	5.4	12.21	7.13	57.7	29.7		82	J	64	J	0.8												Field + Fecals
462	Discharge	8D	2	3/15/2017	13:03	48.74375	-122.33079	7.2	11.94	7.33	59.2	10.17	225.1	4	J	4	J	1.0	3	<	0	ND	Low	0.056		2.08		0.100	U	All parameters
462	Discharge	9D	3	3/29/2017	13:05	48.74385	-122.33078	7.6	11.77	7.26	49.4	39.41	207.1	15	J	11	J	0.73	0	ND	0	ND	Not detected	0.218		1.46		0.100	U	All parameters
466	Discharge	9D	1	1/19/2017	13:07	48.74336	-122.33008	5.4	11.91	6.84	58.1	6.8		73	J	68	J	0.9												Field + Fecals
466	Discharge	7D	2	3/15/2017	12:51	48.74335	-122.33005	6.8	11.47	6.96	58.6	14.41	146.8	198	J	191	J	1.0	0	ND	0	ND	Not detected	0.050		2.41		0.100	U	All parameters
466	Discharge	8D	3	3/29/2017	12:55	48.74333	-122.33004	7.7	11.39	6.94	50.7	17.83	163.2	127	J	122	J	0.96	87		0	ND	Low	0.088		1.87		0.100	U	All parameters
481	Discharge	8D	1	1/19/2017	12:45	48.74184	-122.32775	6.0	11.88	6.90	67.2	10.9	188.03	5	J	5	J	1.0												Field + Fecals
481	Discharge	1-8D	2	3/15/2017	12:43	48.74184	-122.32772	7.3	11.72	7.02	65.8	3.7	154																	Field only
481	Discharge	1-8D	3	3/29/2017	12:45	48.74184	-122.32774	7.4	11.85	7.11	57.7	17.0	160																	Field only
488	Discharge	7D	1	1/19/2017	12:34	48.74094	-122.32648	6.4	11.92	7.09	52.5	18.6	212.8	5	U	5	U	1.0												Field + Fecals
488	Discharge	1-7D	2	3/15/2017	12:35	48.74089	-122.32634	7.5	11.88	7.21	49.1	8.1	177																	Field only
488	Discharge	1-7D	3	3/29/2017	12:41	48.74098	-122.32636	7.4	11.87	7.25	48.6	15.4	140																	Field only
492	Discharge	6D	1	1/19/2017	12:27	48.74084	-122.32623	6.5	11.92	7.18	41.3	14.1	194.52	68	J	55	J	0.8												Field + Fecals
492	Discharge	6D	2	3/15/2017	12:26	48.74082	-122.32623	7.6	11.89	7.22	40.3	2.31	174.6	7	J	7	J	1.0	0	ND	0	ND	Not detected	0.024		1.15		0.100	U	All parameters
492	Discharge	7D	3	3/29/2017	12:33	48.74081	-122.32622	7.8	11.74	7.20	38.9	13.81	163.2	2	J	2	J	1.00												Field + Fecals
495	Discharge	5D	1	1/19/2017	12:17	48.74035	-122.3254	6.5	11.07	7.00	115.6	3.6	254.56	5	U	5	U	1.0												Field + Fecals
495	Discharge	1-5D	2	3/15/2017	12:07	48.74028	-122.32543	7.4	11.28	7.12	102.0	2.1	212																	Field only
509	Discharge	4D	1	1/19/2017	11:58	48.73824	-122.32341	6.6	11.84	7.21	65.1	15.8	219.16	55	J	27	J	0.5												Field + Fecals
509	Discharge	5D	2	3/15/2017	12:15	48.73822	-122.32336	7.8	11.75	7.38	61.8	7.58	191.9	4	J	4	J	1.0												Field + Fecals
509	Discharge	6D	3	3/29/2017	12:10	48.73803	-122.32349	8.1	11.59	7.27	59.1	22.21	187.1	342	J	342	J	1.00	3	<	0	ND	Low	0.086		1.42		0.100	U	All parameters
518	Discharge	3D	2	3/15/2017	11:20	48.73634	-122.32094	8.2	11.64	7.24	71.8	8.5	192.5	44		13	J	0.3	0	ND	0	ND	Not detected	0.048		2.16		0.100	U	All parameters
518	Discharge	5D	3	3/29/2017	11:50	48.73637	-122.32088	8.2	11.51	7.25	66.7	15.3	223.4	29	J	29	J	1.00	112		0	ND	Low	0.066		1.77		0.100	U	All parameters
520	Discharge	2D	2	3/15/2017	11:05	48.73556	-122.31964	8.7	11.09	7.05	81.9	4.36	147.2	100		7	J	0.1	17400		1450		Moderate	0.052		3.47		0.100	U	All parameters
520	Discharge	4D	3	3/29/2017	11:36	48.73561	-122.31953	8.9	10.92	6.87	75.3	8.26	196.8	62		62		1.00	21700		1610		Moderate	0.064		3.10		0.100	U	All parameters
521	Discharge	2D	1	1/19/2017	11:32	48.73633	-122.32094	6.2	11.91	7.24	67.4	10.8	248.34	135		105		0.8												Field + Fecals
521	Discharge	1-2D	2	3/15/2017	11:02	48.73558	-122.31968	6.9	11.35	7.19	61.4	0.9	51.0																	Field only
521	Discharge	3D	3	3/29/2017	11:21	48.73546	-122.31934	7.6	10.83	6.80	66.2	1.57	94.2	16	J	16	J	1.00	0	ND	0	ND	Not detected	0.014		2.66		0.100	U	All parameters
525	Discharge	1D	2	3/15/2017	10:50	48.73466	-122.31799	7.4	10.74	6.62	64.4	3.84	150.8	114		114		1.0	0	ND	0	ND	Not detected	0.036		2.63		0.100	U	All parameters
525	Discharge	2D	3	3/29/2017	11:08	48.73478	-122.31793	7.9	10.62	6.56	64.9	5.06	174.5	112		112		1.00	0	ND	0	ND	Not detected	0.046		2.30		0.100	U	All parameters
525A	Discharge	1D	1	1/19/2017	11:00	48.73471	-122.31801	6.1	10.59	6.55	70.4	5.8	190.63	150		145		1.0												Field + Fecals

HERRERA

TECHNICAL MEMORANDUM

Date: June 21, 2018

To: Bill Hunter, Lake Whatcom Water and Sewer District

From: Rob Zisette, Herrera Environmental Consultants

Subject: North Shore On-Site Septic System Phosphorus Loading Analysis

INTRODUCTION

Herrera Environmental Consultants (Herrera) recently conducted a water quality study for the Lake Whatcom Water and Sewer District that identified contamination of the lake with phosphorus and fecal coliform bacteria from on-site septic systems (OSS) in the North Shore subbasin of Lake Whatcom (Herrera 2017a). The study findings were presented to the Lake Whatcom Data and Information Management Team on September 14, 2017, and to the Whatcom County staff on October 31, 2017.

A draft memorandum was prepared on January 25, 2018 to address comments by the Whatcom County Health Department on the study report and a request by the Lake Whatcom Water and Sewer District to estimate phosphorus loading from OSS in the study area. This final memorandum was prepared to address comments on the draft memorandum and the study report by Whatcom County Public Works (WCPW) (Erika Douglas and Gary Stoyka), Washington Department of Ecology (Steve Hood), and City of Bellingham (Peg Wendling). Attached are responses by Herrera to each of these comments. Also attached is the study database updated to include discharge measurement data used for this phosphorus loading analysis.

STUDY REPORT COMMENT RESPONSES

The Whatcom County Health Department (WCHD) acknowledged that the study report provides useful information (Wolpers 2017). Based on the report findings, WCHD has prioritized operation and maintenance of OSS in the North Shore subbasin. During the winter of 2017–2018, WCHD is contacting property owners, surveying properties, inspecting OSS components, and performing drain field dye tests. Failing OSS will be replaced with a system designed by a licensed OSS designer to meet current OSS regulations.

2200 Sixth Avenue | Suite 1100 | Seattle, Washington | 98121 | p 206 441 9080 | f 206 441 9108
PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA | BELLINGHAM, WA

The problem with this approach is that it primarily addresses failing OSS that result in direct discharge of effluent to surface drainages. An exception is that OSS inspections have identified non-surfacing discharges between septic tanks and drainfields. The study results and the poor soil conditions discussed below clearly indicate that OSS effluent is being transported through saturated soils to drainages or the lake by OSS that are not considered to be failing. The fate and transport of phosphorus through saturated soils from septic tank effluent has been well documented in many other studies, and is diagrammed in Figure 1 from a recent review of those studies (Lusk et al. 2017).

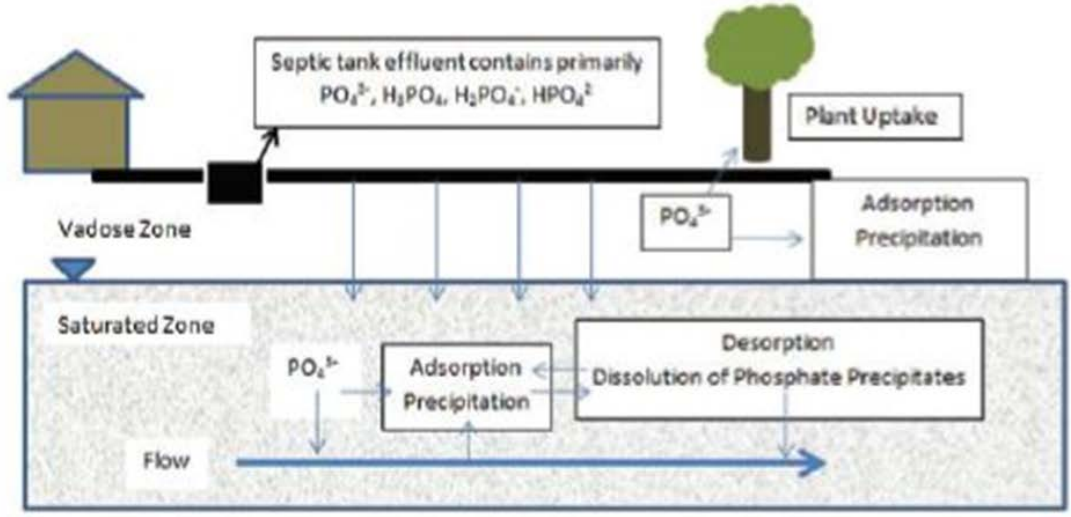


Figure 1. Fate and Transport of Phosphorus in Septic System Effluent.

WCHD commented that the study results did not appear to substantiate the report conclusions because the following factors were not considered:

1. Control stations along areas that are currently served by sewer
2. Potential upland sources from discharge samples
3. Lake Whatcom is not on Ecology's 303(d) list for fecal bacteria
4. Phosphorus contribution to surface water quality is *de minimus*. Phosphorus is typically immobilized within the first 2 or 3 feet of soil below the drain field.

Responses to these comments are provided separately in the following sections.

Control Stations

The purpose of control stations is to provide monitoring locations that are not impacted by human fecal sources and serve as background conditions in the lake. Control stations were appropriately located along a shoreline that has no development or potential input from human fecal sources. Locating additional monitoring stations along a developed shoreline with sewers

would be a reasonable addition for comparison to stations in the developed shoreline with OSS. However, a sewered shoreline would not serve as a good experimental control for this study because the control should represent an area not impacted by human sources to verify parameter detection limits, and drainage from a sewered area may be impacted by human sources due to unknown cross-connections of the drainage system with sanitary sewers.

If the study is repeated again in the future to evaluate effectiveness of WCHD efforts to control failing OSS in the North Shore Road area, then a sewered area should be monitored in addition to the control stations to evaluate potential impacts of sewered areas on human fecal sources to the lake.

Upland Sources

Potential upland sources of human fecal matter were considered in the study design. There are no OSS located upland from the sampled drainages that would not be connected to sewers. The potential for direct deposit of fecal matter by humans in the study area was recognized in the study report as another potential source of human sources in the collected samples. Homeless persons and recreationalists (e.g., hikers) exhibiting unsanitary practices are examples of potential non-septic sources of human fecal bacteria in surface water drainage from the area. However, an apparent lack of homeless persons and recreationalists in the study area during the cold winter sampling period suggests there was a low probability that detected human sources originated from direct deposit of human fecal matter. In addition, direct deposits of fecal matter by humans is typically on soils that have adsorption capacity and not directly into surface water drainages.

Fecal Bacteria Listing

The study report did not state that Lake Whatcom is on Ecology's 303(d) list of impaired waters for fecal coliform bacteria. Contamination of the lake with fecal coliform bacteria is a significant concern to lake users and water utilities regardless of whether it is currently considered to be impaired by high bacteria concentrations.

Soil Immobilization of Phosphorus

The Soil Conservation Service assessment of shoreline soils around Lake Whatcom indicates that virtually all soils have severe limitations for septic systems (Carlson 2011). The soils are characterized as having a shallow depth (3 feet or less) to bedrock, hard pan, or water table, and are subject to seasonal flooding. These conditions promote phosphorus migration downgradient through soils from OSS drain fields to shallow groundwater that seeps into drainages or the lake. Many of the old OSS in the study area do not meet current WCHD regulations for the minimum vertical distance through soil or minimum horizontal distance to surface waters to allow for adequate immobilization of OSS phosphorus in soils.

The transport of phosphorus from septic systems to surface drainages and Lake Whatcom (see Figure 1) is enhanced by the following conditions present in the North Shore Road area:

- Old septic systems discharging effluent and saturating soils with phosphorus for decades
- Septic systems located close to the lake or a surface drainage, reducing the potential for continued adsorption before reaching the lake or a surface drainage
- An area that receives a high amount of rainfall, frequent soil saturation, and shallow depths to groundwater
- Relatively shallow soils overlying bedrock, which prevents downward flow of contaminated groundwater.
- A steep slope that increases the rate of gravity flow through saturated soils.

PHOSPHORUS LOADING METHODS

The annual total phosphorus (TP) loading to Lake Whatcom from all surface drainage in the North Shore subbasin was estimated to be 181.6 kilograms (kg) or 400 pounds (lbs) by the *Lake Whatcom Watershed Total Phosphorus and Bacteria Total Maximum Daily Loads* (TMDLs) (existing conditions scenario in Table 6 of Ecology 2016). This estimate was based on a Hydrological Simulation Program-Fortran (HSPF) model of land cover and hydrologic conditions present in 2003. The TMDLs are based on loadings in 2003 because loadings vary each year with precipitation and 2003 was a normal precipitation year. TP loadings are estimated by multiplying an average TP concentration for each land cover type to the annual runoff volume from each land cover area.

Herrera estimated the septic system contribution to the North Shore TP loading estimate using flow rates, TP concentrations, and human fecal bacteria deoxyribonucleic acid (DNA) concentrations measured in drainage samples collected in March 2017 for the North Shore OSS leachate detection project. The selected TP loading analysis method was to correct the TP concentration for OSS contaminated discharges to the TP concentration typically observed in uncontaminated discharges, and then compare flow-weighted average TP concentrations in all monitored drainages under existing and OSS corrected conditions. The percent change in TP concentration from existing to OSS corrected conditions was then applied to the 2003 TP loading estimate to calculate the TP loading to Lake Whatcom from septic system leachate in the North Shore subbasin. Flow-weighted average concentrations were used because loadings are directly related to flow and the discharges exhibited a wide range of flow rates, ranging from approximately 0.08 to 10 cubic feet per second (cfs).

The first step in the TP loading analysis was to separate discharge locations into contaminated and uncontaminated discharges based on human fecal bacteria DNA concentrations. Discharges with human Bacteroidetes (either B. dorei or B. EPA markers) detected above the detection limit

of 3 copies per 100 milliliters (copies/100 mL) were considered to be contaminated by OSS leachate. Discharges with no detected human Bacteroidetes were considered to be uncontaminated by OSS leachate. Results for single samples from three discharges (430, 462, and 509) did not fit into either group and were excluded from the analysis because one human Bacteroidetes marker (B. dorei) was detected below the detection limit and the other human Bacteroidetes marker (B. EPA) was not detected in samples from these discharges. Thus, it is not clear whether these three samples were contaminated with OSS or not. In addition, one sample collected on March 29 from discharge 462 was removed from the OSS uncontaminated group because it was an outlier with an unusually high TP concentration of 218 micrograms per liter (µg/L), compared to a value of 56 µg/L for the sample collected on March 15 from discharge 462 and a range of 14 to 98 µg/L for all other samples. The two March events were similar hydrologically and neither sample from discharge 462 exhibited high fecal bacteria or human Bacteroidetes marker concentrations. Thus, the sample collected on March 29 may have been contaminated from an unusual high phosphorus source (e.g., direct application of phosphorus fertilizer), rather than OSS or a natural phosphorus source (e.g., phosphorus release from an anoxic wetland). In total, the contaminated group included six discharge locations, and the uncontaminated group included seven discharge locations.

Average flow rates and flow-weighted average TP concentrations were then calculated for each discharge sampled more than once in the contaminated and uncontaminated groups. The flow-weighted average TP concentration was calculated for each discharge location rather than each sample to not bias for discharges sampled twice over those sampled once.

The flow-weighted TP concentrations for discharges in each group were tested to verify that the groups are significantly different. A non-parametric, one-tailed Mann-Whitney U test was used to show that the groups are significantly different ($p = 0.069$) at an alpha level of 0.10. Thus, there is a 90 percent probability that the median value for the OSS contaminated discharges (64 µg/L) is significantly different than the median value for the uncontaminated discharges (48 µg/L).

The overall existing flow-weighted average TP concentration was then calculated for all discharges to represent all drainage from the North Shore subbasin. The existing flow-weighted average TP concentration for each OSS contaminated discharge was corrected for OSS contamination by reducing it to the median value for the uncontaminated discharges (48 µg/L). Reduction of the OSS-contaminated TP concentration to an OSS-corrected value was performed to estimate the typical reduction in TP loading expected if OSS contamination is removed. The existing TP concentration was not reduced for one of the six OSS contaminated discharges because the measured TP concentration was less than the median value for the uncontaminated discharges.

PHOSPHORUS LOADING RESULTS AND REMOVAL COSTS

The TP loading analysis results are presented in Table 1. Correcting TP concentrations for OSS contamination reduced the flow-weighted average TP concentration for discharges from the North Shore subbasin by 10 percent from 77 to 69 µg/L. Applying this percentage to the annual TP loading of 400 pounds/year (using 2003 as a typical year) estimated by the TMDL study for the subbasin results in an annual TP loading of 40 pounds/year from OSS in the subbasin. This amount is considered to be underestimated because it does not account for TP loading from OSS that seep directly into the lake, which was detected by the OSS leachate detection study at some, but likely not all, locations in the lake. The estimated 40 pounds/year from discharges was increased by 25 percent to 50 pounds/year to account for direct seepage into the lake. The 25 percent increase is reasonable because approximately 30 percent of the OSS in the subbasin are located between the lake and North Shore Road where leachate would likely not drain to discharges draining the road ditches.

The annual phosphorus loading rate of 50 pounds/year is similar to the 55 pounds/year from 92 OSS located in shallow soils (3 feet or less) within 150 feet of Lake Whatcom that was estimated for the cost/benefit analysis of phosphorus loading reduction methods (Carlson 2011). The cost/benefit analysis method assumed a TP loading to the lake of 0.6 pounds/year for each of the 92 OSS based on 0.8 pound TP/person/year reaching the drainfield, three persons per house for a total of 2.4 pound TP/OSS/year, and 25 percent of the drainfield TP loading reaching the lake. Agreement among results from both methods suggests that the TP loading method developed from drainage monitoring data collected for this study provides a reasonable estimate of TP loading from OSS in the North Shore subbasin.

The cost of reducing TP loading to Lake Whatcom from the North Shore subbasin was estimated for stormwater treatment and sewer extension. Herrera (2017b) recently evaluated the cost, benefit, and feasibility of stormwater treatment for reducing TP loading to Lake Whatcom. A total of 29 stormwater treatment projects were identified that ranked highest by a combined score for cost, benefit, and feasibility. Eight of those projects are located on North Shore Road and include six media filter drains, one biofiltration swale, and one Stormfilter® device with Phosphosorb® media (Table 2).

The cost per pound of TP removed by these projects ranges from $9,000 to $292,000, and the average project cost of all eight projects is $26,000/pound. These costs include design and construction, but not long-term maintenance of the stormwater treatment facilities. To account for long-term maintenance, 10 percent was added to the median stormwater treatment cost, resulting in a total cost of $29,000/pound of TP removal by stormwater treatment.

Table 1. Flow-weighted Total Phosphorus Concentrations in Onsite Septic System Contaminated and Uncontaminated Discharges in North Shore Subbasin.

Discharge Station	Event No.	B. dorei (copies/100 mL)	B. EPA (copies/100 mL)	Total P (mg/L)	Flow (cfs)	Flow-Weighted Mean TP (ug/L)	Mean Flow (cfs)	OSS Corrected Flow-Weighted Mean TP (ug/L)[a]
Uncontaminated Discharges								
525	2	0	0	0.036	0.35	-	-	-
525	3	0	0	0.046	0.35	-	-	-
525	Mean					41	0.35	41
521	3	0	0	0.014	0.08	14	0.08	14
518	2	0	0	0.048	0.42	48	0.42	48
492	2	0	0	0.024	0.75	24	0.75	24
466	2	0	0	0.050	2.5	50	2.50	50
449	3	0	0	0.098	10	98	10.00	98
437	2	0	0	0.032	0.45	-	-	-
437	3	0	0	0.060	1.5	-	-	-
437	Mean					54	0.98	54
Uncontaminated Median						**48**	-	**48**
Contaminated Discharges								
520	2	17,400	1,450	0.052	0.15	-	-	-
520	3	21,700	1,610	0.064	0.38	-	-	-
520	Mean					61	0.26	48
518	3	112	0	0.066	0.38	66	0.38	48
466	3	87	0	0.088	3.3	88	3.30	48
453	2	3	4,050	0.014	0.60	-	-	-
453	3	3	9,960	0.054	0.80	-	-	-
453	Mean					37	0.70	37
440	3	107	0	0.062	3.00	62	3.00	48
430	3	278	0	0.088	0.50	88	0.50	48
Contaminated Median						**64**	-	**48**
All Discharges Overall								
Flow-weighted Mean						**77**	-	**69**
Percent Reduction from Existing to OSS Corrected TP Concentration								**10%**
Possibly Contaminated Discharges Not Used								
509	3	3	0	0.086	0.25	-	-	-
462	2	3	0	0.056	0.73	-	-	-
430	2	3	0	0.016	0.50	-	-	-
Outlier Discharge Not Used								
462	3	0	0	0.218	2.2	-	-	-

[a] Corrected for OSS contamination by reduced the existing TP concentration for a contaminated discharge to 48 µg/L, which represents the median TP concentration of all uncontaminated discharges if the measured TP concentration of a contaminated discharge is greater than 48 µg/L.

Table 2. Proposed Stormwater Projects for North Shore Road.

Project Rank	Project Name	Proposed Solution	Estimated Project Cost	Total Phosphorus Removed (pounds/year)	Cost per Pound of Phosphorus Removed ($/pound/year)
1	East side of Northshore at Edgewater Lane	1,000-linear-foot Media Filter Drain	$320,000	12.23	$26,000
2	North Lake Whatcom Park	Bioretention	$450,000	5.91	$76,000
4	Northshore East of Olsen Creek	275-linear-foot Media Filter Drain	$83,000	5.27	$16,000
5	Northshore West of Olsen Creek	350-linear-foot Media Filter Drain	$105,000	5.08	$21,000
10	Northshore Road at Eagleridge	650-linear-foot Media Filter Drain	$195,000	2.48	$79,000
11	Eagleridge Pond at Northshore	Stormfilter with Phosphosorb	$277,000	31.87	$9,000
28	3303 Northshore Road	550-linear-foot Media Filter Drain	$165,000	1.22	$136,000
29	Northshore Drive at Eagleridge	200-linear-foot Media Filter Drain	$60,000	0.21	$292,000
Total	All Projects	All Solutions	$1,655,000	64.27	26,000

Source: Herrera 2017b.

Wilson Engineering recently estimated the cost of extending the sewer to connect 100 OSS in the North Shore subbasin. The total design and construction cost ranges from $3 to $6 million depending on the sewer extension approach (Melanie Mankamyer, personal communication: e-mail to Rob Zisette, January 17, 2018). Applying this range of cost to 50 pounds/year of TP removal equates a range of $60,000 to $120,000/pound of TP removal by sewer extension. Thus, the cost for TP removal by sewer extension is estimated to be at least twice the cost of stormwater treatment.

The phosphorus TMDL implementation plan is to reduce phosphorus loading from 400 to 193 pounds/year (87 percent rollback scenario) for the North Shore subbasin (Ecology 2016). Thus, the eight highest-ranked stormwater treatment projects for the North Shore subbasin would only remove 64 of the required 207 pounds/year, and achieve only 30 percent of the goal. Additional removal by stormwater treatment would likely cost more than $29,000/pound of TP removed, and the phosphorus reduction goal may not be achievable without the sewer extension. The sewer extension evaluation should evaluate all feasible alternatives for meeting the TMDL goal for the North Shore subbasin, and should also account for the additional benefits of removing OSS phosphorus and other wastewater contaminants that currently seep directly into the lake.

REFERENCES

Carlson, A. 2011. Benefit and Cost of Phosphorus-Reducing Activities in the Lake Whatcom Watershed. Technical memorandum prepared for the City of Bellingham by Amy Carlson, PE, CH2M Hill, Bellevue, Washington. December 15.

Ecology. 2016. Lake Whatcom Watershed Total Phosphorus and Bacteria Total Maximum Daily Loads, Volume 2. Water Quality Improvement Report and Implementation Strategy. Publication No. 13-10-012. Washington Department of Ecology, Olympia, Washington. Revised February.

Herrera. 2017a. Water Quality Monitoring Report, Lake Whatcom North Shore On-Site Sewage System Leachate Detection Project. Prepared for Lake Whatcom Water and Sewer District by Herrera Environmental Consultants, Inc., Seattle, Washington. July 10.

Herrera. 2017b. Lake Whatcom Comprehensive Plan: Stormwater Capital Program Update, Whatcom County, Washington. Prepared for Whatcom County Public Works by Herrera Environmental Consultants, Inc., Seattle, Washington. September 25.

Lusk, M.G., G. Toor, Y. Yang, S. Mechtensimer, M. De, and T. Obreza. (2017). A Review of the Fate and Transport of Nitrogen, Phosphorus, Pathogens, and Trace Organic Chemicals in Septic Systems. Critical Reviews in Environmental Science and Technology. 47. 455-541.

ATTACHMENT A

Comment Responses

Responses to Comments on North Shore On-Site Septic System Study Report and Phosphorus Loading Analysis Technical Memorandum

Comment Source	Comment	Response
County - General Comments on Report	Study Design Recommendation: Include a stretch of shoreline with homes serviced by a sewer as an additional control site. It appears that the goal of this project is to determine if a public sewer system would be a better option than individual septic systems for sewage treatment at lakeshore residences in the Lake Whatcom watershed.	The project goal was to determine if septic systems are contaminating the lake. Monitoring the shoreline of a sewered area may provide useful information for estimating potential reductions in contamination by sewering the study area, but characteristics of the sewered areas likely vary widely and may not represent those planned for the study area. We will recommend including a sewered area for future monitoring.
County - General Comments on Report	Study Design Recommendation: Clearly establish prior to the outset of the project which criteria will be used for selecting a site for monitoring (e.g. during first sample run, elevated OB levels observed in lake near this discharge site). The QAPP indicates criteria will be established following survey of the control site and the report references optical brightener levels.	The QAPP specified that OB would be used to select sampling sites based on background levels observed at the lake control sites. The exact OB threshold over background was not specified in the QAPP because this method had not been previously used. The same threshold determined for the first monitoring event was used for the following two monitoring events.
County - General Comments on Report	Study Design Recommendation: Suggest sampling all lake sites throughout the duration of the project. In particular, it is unclear why the lake project area station with the highest fecal coliform bacteria level in Event 1 was not sampled during the following sampling events. It appears that all five lake project area stations were only sampled once while two of the three control lake stations were sampled during all sampling events.	We agree that all lake and discharge stations should be monitoring during all events to better evaluate the entire study area. The project goal and sampling design was to sample worst case conditions, and the project budget did not allow an unlimited the number of samples. We will recommend more samples for future monitoring now that the large number of contaminated lake and discharge sites are known.
County - General Comments on Report	Study Design Recommendation: Suggest establishing sampling stations during first sample run and then consistently sampling these stations throughout the duration of the project. Additional stations may be established during later sampling runs based upon higher optical brightener levels.	We agree as noted above.
County - General Comments on Report	Results Question: Are there similar studies of optical brighteners that could provide ranges of levels typically found in lakes, creeks, and other discharges?	Yes there are, but most of them that we are aware of used a different meter with higher detection limits. We are not aware of any studies in this region and comparison to results for other regions may not be valid due to differences in background OB concentrations.
County - General Comments on Report	Results Question: DOE publication 11-03-038 indicates optical brighteners should be evaluated with other fecal indicators to evaluate public health risk. A wastewater treatment plant's effluent can have optical brighteners regardless of its effectiveness in removing pathogens. Based upon this, which sites have a public health risk?	OB data were not and should not be used to evaluate public health risk. In this study, OB data correlated with fecal coliform data, which is useful and compelling, but not strong enough to use OB as a surrogate for fecal coliform or pathogen concentrations.
County - General Comments on Report	Results Recommendation: Suggest measuring optical brightener levels at a minimum at each discharge site with each sampling run.	We measured OB at every discharge site that we could find during each sampling run.
County - General Comments on Report	Results Question: Are there other similar studies that could be reviewed to provide context for the levels of biomarkers found and the high, moderate, and low categories?	Yes there are comprehensive interlaboratory comparison studies that recommend how to rank biomarker results. The Cao et al 2013 study cited in the report formed the basis for the rankings made in this study.
County - General Comments on Report	Results Question: Are these human biomarkers the same biomarkers used by the EPA in the Tillamook and Nooksack studies?	We do not know and could investigate that if you provide us with reports of the other studies. It is likely that the EPA human marker quantified by Source Molecular for in this study is very similar to the human marker used by EPA in the other studies, but it may have been improved upon if those studies are old.
County - General Comments on Report	Discussion and Conclusions Comment: There seem to be conflicting statements in the results and discussion section. Under Section 3.4 Bacteria Indicators, it is stated that "none of the observed lake or discharge results exhibited high enough fecal coliform bacteria concentrations to strongly indicate contamination from septic system effluent". In Section 3.5 Bacteriodetes, the report indicates "moderate to high concentrations of human biomarkers are considered proof that the samples were contaminated by septic system effluent". This is explained as likely being associated with seepage of septic system effluent through soils rather than a direct discharge to surface waters. It would be valuable to have reference materials for this concept.	We agree that additional research on fecal coliform and Bacteroidetes fate and transport should be conducted to validated this possible explanation of why high Bacteroidetes concentrations are observed where low fecal coliform concentrations are observed. A possible explanation is that only living fecal coliforms are measured, while Bacteroidetes DNA analyses includes dead bacteria that may persist longer than living fecal coliforms. We will recommend addtional research on this topic for future monitoring.
County - General Comments on Report	Discussion and Conclusions Comment: The final conclusion of the report is "connecting homes in the study area to a sanitary sewer would prevent the ongoing contamination of Lake Whatcom from septic systems in the area". One site (520) had a consistent (two sample) pattern of the presence of both human DNA biomarkers and one site (453) had the presence of one of the human biomarkers in both samples. The other discharge sites did not show consistent patterns or moderate to high biomarker levels. One control lake site had the presence of low level of human biomarkers in one sample.	We do not see a conflict with the patterns observed and the conclusion drawn.

Responses to Comments on North Shore On-Site Septic System Study Report and Phosphorus Loading Analysis Technical Memorandum

Comment Source	Comment	Response
Memo Page 1, Pgh 3 (Douglas)	Without the work completed to evaluate septic systems in this area, it isn't clear if the referenced bacteriodes and TP results may be affected by effluent transported through soils, a failing system with a surface discharge, or other source. It was agreed at the meeting this fall that it would be helpful to analyze water samples again after systems were evaluated.	We agree that it would be helpful to conduct additional monitoring to determine if septic system evaluation reduces contamination from septic systems. Study methods would need to be modified to identify the specific means of septic system effluent transport to the lake.
Memo Page 2, Pgh 3 (Stoyka)	This does not make sense. The point of the study is to make a case that connection to sewer will result in water quality improvements, but this is saying that sewer connection will not lead to any water quality improvements b/c of cross connections, etc.	The project goal was to determine if septic systems are contaminating the lake, not to prove that sewers would prevent contamination. Monitoring the shoreline of a sewered area may provide useful information for estimating potential reductions in contamination by sewering the study area, but characteristics of sewered areas likely vary widely and may not represent those planned for the study area. We will recommend including a sewered area for future monitoring.
Memo Page 2, Pgh 4 (Stoyka)	Recreationalists can be a significant source of fecal in some areas and the land above these homes is a County park with trails.	We agree that may be the case in the summer, but discussions with residents indicated that is not the case in January when the ground was covered in snow and in March when it rained almost every day. We will recommend monitoring of recreationalist inputs for future monitoring.
Memo Page 3, Pgh 1 (Stoyka)	this is still within the depth range that would provide full treatment.	Possibly, but P removal likely depends more on the type of soil, amont of sewage loading, age of the drainfield, the amount/rate of rain, and the depth of the water table.
Memo Page 4, Pgh 3 (Stoyka)	I can't figure out where these numbers are coming from.	We will include all raw data and calculations in the revised memo.
Memo Page 4, Pgh 4 (Stoyka)	Why would you reduce the contaminated discharge to the uncontaminated concentration.	We will clarify that the P concentrations in contaminated discharges were reduced to uncontaminated background concentrations to determined the difference between contaminated and uncontaminated for estimating the potential reduction in P loading if OSS contamination is removed.
Memo Page 4, Pgh 5 (Stoyka)	Where does this 50 lbs/yr come from?	10 lbs/yr was added to the estimate of 40 lbs/year for only discharges to account for direct seepage of P from OSS to the lake that was not included in discharge loading estimate.
Memo Page 5, Table 1 (Stoyka)	These numbers do not appear to be correct and do not reflect the averages from the above columns.	We will review the calculations and include all data in the revised memo.
Memo Page 6, Table 2 (Douglas)	These stormwater projects together would remove an estimated 64 pounds of phosphorus per year for a cost of $1,655,000. This is an average cost of about $26,000 per pound of TP removal by stormwater projects. Both sewer and stormwater facilities require ongoing maintenance and the associated costs.	This is a reasonable way to estimate stormwater costs and we will revise the cost analysis to evaluate average cost based on implementationof all planned projects.
Hood - Memo Data Review Comments	1 – In reviewing data, there are no field book notes or other indication to line up Sample ID to Station. It is not possible to verify that the correct analyses are line up with the station. For a random example, sample 9D represents station 453 on one date and station 462 on another date.	As described in the QAPP and report, each sample ID was identified sequentially as samples were collected rather being uniquely associated with the same station ID because the prior lake and discharge sample locations were not known at the time of sampling. The station ID was assigned to each sample ID upon completion of sampling by GIS mapping of the logged GPS location recorded in field notes to determine the lake or discharge station ID for each sample ID.
Hood - Memo Data Review Comments	2 – The COC lists sample ID 10D and 5D but there is no data phosphorus, or chloride for 3/15/2017 sampling event and no explanation for the lack of analysis.	We reviewed the data again for any data entry errors and none were identified. As described in the QAPP and report, some of the samples exhibiting low fecal bacteria concentrations were not analyzed for the chemical and molecular parameters because there was a project budget limit of up to 15 samples per event for analysis of all laboratory parameters. Samples 10D and 5D collected on 3/15/17 are two of the samples analyzed for fecal bacteria and not other parameters due to the budget limitation.

Responses to Comments on North Shore On-Site Septic System Study Report and Phosphorus Loading Analysis Technical Memorandum

Comment Source	Comment	Response
Hood - Memo Data Review Comments	3 – Handling of outliers is not consistent. Denis Helsel advises, "Treat outliers like children -- correct them when needed but never throw them out.' (See https://practicalstats.teachable.com/p/applied-environmental-statistics-1) we should investigate outliers and provide a rationale for any correction. Station 462 sampled on 3/29/2017was eliminated from non-contaminated group because it was an outlier (not 238 but 218 a minor error). The Lab QC was OK. One possible explanation is that the discharge may contain runoff from a wetland during times the water table is very high. The SCS soil map shows a couple of "wet spots" in the shoreline between Smith and Olsen Creeks. Wetlands often have high levels of phosphorus. In addition, wetlands often discharge intermittently. Note that March 2017 was wet, with nearly twice-normal rainfall spread throughout the month. January was mild January and February was normal. The single largest value may be a valid background value demonstrating what happens when wetlands discharge. Likewise, there are unexplored outliners in the bacterioidetes results. Station 520 has B. dorei levels that are an order of magnitude higher than OSS septage, yet FC and E. coli results are quite modest.	We removed the outlier TP value from the flow-weighted average TP concentration for uncontaminated discharges because it a statistical outlier (greater than 2 times all other values) and clearly does not represent an uncontaminated discharge. Wetland discharge of low oxygen waters is a possible high P source at that location, but it seems that this natural source would also have been observed in the sample collected 2 weeks previously from Station 462 or at another locations within the study area. There are other possible causes of the TP outlier, which include a direct application of a phosphorus fertilizer, or soil slumping and erosion caused by the extended wet period and high flow conditions. The bacteroidetes data were only used in the loading analysis to identify if a discharge was OSS contaminated. They were not used to calculate flow-weighted P loadings and removal of the high B. dorei value at station 520 as an outlier would not have changed its designation as contaminated because of the high concentration of B. EPA at that same station.
Hood - Memo Data Review Comments	4 – I cannot find the discharge flows used to calculate the flow weighted means in the 7-12-2017 study, so I cannot verify volume weighted averages for all events. However, when going through the data to verify that the numbers reported were reasonable I found that three of the "contaminated" group used the max value and all were on the second March date. Two of those stations are also in the uncontaminated group using the early March Date. See comment #7 below on the significance of grouping by date of sample.	We calculated discharge data from field notes and entered it into the database after the report was written because it was needed when we were asked to conduct the P loading analysis. We will include all discharge data in the revised memo.
Hood - Memo Data Review Comments	5- At the end of "7-12-17-Final-North-Shore-Herrera-Report", there is a table with all of the data. It would be helpful to understand the difference between less than DL and ND for the bacteroidetes data. One is in the Low "Bacteroidetes Lab Category" and the other is in Non detect. Does less than three represent presence?	Detected below the DL and not detected are distinctions commonly used for trace organics data. Less than 3 means that it was positively detected below the estimated quantitation limit of 3, and that was considered to be a low concentration. Not detected values are considered to not be present in the sample.
Hood - Memo Data Review Comments	6 – Lack of a sewered control area fails to test effectiveness of providing sewers. The extrapolation that contaminated events would mimic uncontaminated events is unsupported because no sites that have sewer were tested.	The project goal was to determine if septic systems are contaminating the lake, not to prove that sewers would prevent contamination. Monitoring the shoreline of a sewered area may provide useful information for estimating potential reductions in contamination by sewering the study area, but characteristics of the sewered areas likely vary widely and extrapolation of sewered area results to the study area may not be relevant. However, it is clear from all reviewers that future monitoring should include monitoring of a sewered area for evaluating potential effects of a sewer extension. We will recommend including a sewered area for future monitoring.
Hood - Memo Data Review Comments	7 – Date of sample seems to be a more significant factor determining phosphorus than contaminated vs. uncontaminated groups identified. The paper claims that the groups are valid at alpha 10%. However, date is significant in defining the groups. 75% of the contaminated group is samples from the second date but only 44% of the uncontaminated group is from samples on the second date. The paper examine the significance of date of sample. A one sided Mann-Whitney test for all discharge sites based on date indicates that that date of sample is significant at alpha = 1% (p = 0.00224, with station 462 and p=0.00319 without station 462) chance that the location shift is equal to zero. This test is significant even at alpha = 1% so the significance of the groups may be more influenced by date. Also note that the date. Below is a box plot of TP for the two days from Discharge Stations. Two stations in the "Uncontaminated" group have sample results for both dates. The TP results on first sample date are 46% and 22% less than the second sample date. This is greater than the reduction estimated by providing sewers.	We recognize that the data vary by sampling event and that is not unique to this study. Collecting grab samples at different points on the hydrograph during different types of storms inherently results in data that varies by sampling event. Finding greater differences between sampling events does not negate statistical differences observed in other data pairings. It is important to recognize that the study was not designed to estimate P loadings from septic systems. P loading is difficult to estimate accurately because of the high variance of P concentrations in drainage. Accurate P loadings would require many more samples collected with automatic samplers, continuous flow meters over at least a 1-year period, and a model to predict P concentrations during unsampled periods of flow. Research has shown that even with a high level of effort, the uncertanty in P loading estimates can exceed 50 percent. Accurate P loadings from septic systems would require additional upstream stations and should also include shallow groundwater well testing.

Responses to Comments on North Shore On-Site Septic System Study Report and Phosphorus Loading Analysis Technical Memorandum

Comment Source	Comment	Response
Hood -Memo Method Comments	8– While the text correctly makes the case that weighted averages should be used it appears that arithmetic averages may have been used. As noted in 4 above I could not recalculate flow weighted TP concentrations for all events. However, weighted averages for the contaminated group are smaller than the reported flow weighted concentration and the weighted average for the uncontaminated group are higher than the reported concentration. The calculations below use the data from table 1. It is unclear when there are two events, if the reported flow is the average or the sum. In the calculations below "Flow.wt" is the concentration times the reported flow. In the column "TFlow?.wt", the weights are the doubled flow. Using the either of the weighted average uncontaminated flow as a target achievable for the contaminated events would only mean a reduction in 25% of the events. If we use the TotalFlow weights and make a similar calculation the contaminated group would drop from 58.4 µg/L to 56.1 µg/L a mere 4% reduction.	We will present all data and calculations, and review those calculations for the final memo.
Hood -Memo Method Comments	9 – Assuming the bottom of table 1 is correct, some area (undefined in the report) contributes 77 µg/L phosphorus, and when sewered the discharge would be 69 µg/L it is important to note that forest covers over half the watershed. Since there seems to be a balance between contaminated and uncontaminated sites, providing sewers will improve only about half of the developed area. It does not seem reasonable to apply a 10% reduction across the watershed. Based on this data, providing sewers would improve only a quarter of the watershed.	The 10 percent reduction to the entire watershed is reasonable because 77 and 69 are flow-weighted values for all discharges measured in the watershed under two different scenarios.
Hood -Memo Method Comments	10 – High flows at the extreme end of the distributions provide a large influence on the weighted means. We should ask if we have a representative sample.	The samples are representative of high flow conditions. We don't know if P concentrations are lower during lower flows, or if the flow- weighting of specific discharges would substantially change during lower flows. There is indication from the one discharge sampled in the North Shore basin for the Phase 2 P loading study (site NS1 referenced in a comment below) that it does have lower P concentrations during the smaller storms sampled for that study. We will add that data comparison and a discussion of representative storms to the final memo. However, we have often seen higher P concentrations during base flow than storm flow in drainages where the groundwater P concentrations are high and runoff dilutes the drainage P concentrations, which may be the case for septic contaminated drainages in the study area.
Hood -Memo Method Comments	11 – There does not seem to be any discussion on how much of the developed area may be increasing TP in discharges.	Samples were not collected upstream of the developed area to determine how development may have affected P loading from non-OSS sources. We recognize that development increases P loading from sources other than OSS and those sources were assumed equavalent in all discharges for this analysis, with the exception of the one outlier removed.
Hood -Memo Method Comments	12 – The multiplier for ground water discharge to the lake does not address that	The multiplier for groundwater discharge is intended to only represent OSS P loading and it would not be appropriate to increase the multiplier for non-OSS loading from development.
Hood - Memo Proposed Solution Comments	12- In dismissing the ability of the OSS maintenance program to address failures that discharge to ground, there is an error in the last paragraph of page 1. I know of at least one case where an OSS inspection identified a failure that was not surfacing. In this case, the septic tank was leaking and septage was going to ground without reaching the drain field. The observation of draw down can capture system problems between the septic tank and the drain field that do not result in surface discharges.	We will revise the statement to clarify that the OSS maintenance program occasionally corrects failures that do not surface.
Hood - Memo Proposed Solution Comments	13- There seems to be a balance between sites identified as contaminated and not contaminated. This would indicated that we are applying a solution to all that may be only necessary for some. A $6MM project should have several alternatives evaluated. We must evaluate more than one alternative, to ensure, we select a cost effective solution. Alternative to consider would be: Include measures to evaluate groundwater separation in the inspection to capture systems that are not functional but do not meet current criteria for drain fields. Require rebuilding failed systems. Alternative such as STEP systems that would reduce the infrastructure cost, so only failed systems need connect.	We agree that there are several alternatives to consider besides maintaining septics and extending the sewer.

Responses to Comments on North Shore On-Site Septic System Study Report and Phosphorus Loading Analysis Technical Memorandum

Comment Source	Comment	Response
Hood - Memo Proposed Solution Comments	14 – To the extent that the results from contaminated groundwater, a greater understanding of groundwater will be required to estimate the benefits. If there is a deep contamination of the groundwater, the contaminated groundwater may continue to flow into the lake for many years.	We agree that a greater understanding of groundwater contamination and P movement towards the lake would be valuable for assessing OSS impacts on the lake.

ATTACHMENT B

Updated Database

Lake Whatcom North Shore On-Site Sewage System Leachate Detection Project Database

Station	Station Type	Sample ID	Event	Date	Time	Lat (°)	Long (°)	Temp (°C)	DO (mg/L)	pH	Sp Cond (uS/cm)	Turbidity (FNU)	OB (RFUB)
OSS	Septage	OSS	2	3/15/2017	15:50	48.73255	-122.31705	7.8	0.30	6.96	963	26.8	633
OSS	Septage	OSS	3	3/29/2017	15:41	48.73254	-122.31709	9.1	0.61	6.91	943.8	32.3	686
C1	Lake	C1	1	1/19/2017	9:26	48.72298	-122.30225	6.7	10.42	7.20	50.7	0.3	8
C1	Lake	C1	2	3/15/2017	9:41	48.72372	-122.30253	6.3	11.55	7.46	57.3	0.4	44
C1	Lake	C1	3	3/29/2017	10:01	48.72375	-122.30257	6.6	11.77	7.41	56.7	0.6	41
C2	Lake	C2	1	1/19/2017	9:32	48.72408	-122.30284	6.7	10.60	7.21	57.7	0.2	43
C3	Lake	C3	1	1/19/2017	9:40	48.72568	-122.30415	6.7	10.60	7.20	58.1	0.2	42
C3	Lake	C2	2	3/15/2017	9:50	48.72564	-122.30418	6.3	11.43	7.39	57.6	0.4	44
C3	Lake	C2	3	3/29/2017	10:12	48.72568	-122.30408	6.7	11.67	7.31	57.1	0.3	46
1L	Lake	1L	3	42823	0.4556	48.73429	-122.31767	6.9	11.31	6.92	56.6	0.6	62
2L	Lake	4L	2	42809	0.4826	48.73649	-122.32124	7.2	11.14	7.08	64.8	3.0	91
3L	Lake	3L	1	42754	0.4889	48.7369	-122.32196	6.8	11.59	7.39	60.9	2.7	81
4L	Lake	11L	2	42809	0.5806	48.74635	-122.33769	7.2	11.67	7.16	59.7	0.4	73
5L	Lake	12L	2	3/15/2017	14:09	48.74685	-122.33852	7.7	11.16	7.08	61.4	1.7	228
525A	Discharge	1D	1	1/19/2017	11:00	48.73471	-122.31801	6.1	10.59	6.55	70.4	5.8	191
525	Discharge	1D	2	3/15/2017	10:50	48.73466	-122.31799	7.4	10.74	6.62	64.4	3.8	151
525	Discharge	2D	3	3/29/2017	11:08	48.73478	-122.31793	7.9	10.62	6.56	64.9	5.1	175
521	Discharge	2D	1	1/19/2017	11:32	48.73633	-122.32094	6.2	11.91	7.24	67.4	10.8	248
521	Discharge	1-2D	2	3/15/2017	11:02	48.73558	-122.31968	6.9	11.35	7.19	61.4	0.9	51
521	Discharge	3D	3	3/29/2017	11:21	48.73546	-122.31934	7.6	10.83	6.80	66.2	1.6	94
520	Discharge	2D	2	3/15/2017	11:05	48.73556	-122.31964	8.7	11.09	7.05	81.9	4.4	147
520	Discharge	4D	3	3/29/2017	11:36	48.73561	-122.31953	8.9	10.92	6.87	75.3	8.3	197
518	Discharge	3D	2	3/15/2017	11:20	48.73634	-122.32094	8.2	11.64	7.24	71.8	8.5	193
518	Discharge	5D	3	3/29/2017	11:50	48.73637	-122.32088	8.2	11.51	7.25	66.7	15.3	223
509	Discharge	4D	1	1/19/2017	11:58	48.73824	-122.32341	6.6	11.84	7.21	65.1	15.8	219
509	Discharge	5D	2	3/15/2017	12:15	48.73822	-122.32336	7.8	11.75	7.38	61.8	7.6	192
509	Discharge	6D	3	3/29/2017	12:10	48.73803	-122.32349	8.1	11.59	7.27	59.1	22.2	187
495	Discharge	5D	1	1/19/2017	12:17	48.74035	-122.3254	6.5	11.07	7.00	115.6	3.6	255
495	Discharge	1-5D	2	3/15/2017	12:07	48.74028	-122.32543	7.4	11.28	7.12	102.0	2.1	212
492	Discharge	6D	1	1/19/2017	12:27	48.74084	-122.32623	6.5	11.92	7.18	41.3	14.1	195
492	Discharge	6D	2	3/15/2017	12:26	48.74082	-122.32623	7.6	11.89	7.22	40.3	2.3	175
492	Discharge	7D	3	3/29/2017	12:33	48.74081	-122.32622	7.8	11.74	7.20	38.9	13.8	163
488	Discharge	7D	1	1/19/2017	12:34	48.74094	-122.32648	6.4	11.92	7.09	52.5	18.6	213
488	Discharge	1-7D	2	3/15/2017	12:35	48.74089	-122.32634	7.5	11.88	7.21	49.1	8.1	177
488	Discharge	1-7D	3	3/29/2017	12:41	48.74098	-122.32636	7.4	11.87	7.25	48.6	15.4	140
481	Discharge	8D	1	1/19/2017	12:45	48.74184	-122.32775	6.0	11.88	6.90	67.2	10.9	188
481	Discharge	1-8D	2	3/15/2017	12:43	48.74184	-122.32772	7.3	11.72	7.02	65.8	3.7	154
481	Discharge	1-8D	3	3/29/2017	12:45	48.74184	-122.32774	7.4	11.85	7.11	57.7	17.0	160
466	Discharge	9D	1	1/19/2017	13:07	48.74336	-122.33008	5.4	11.91	6.84	58.1	6.8	
466	Discharge	7D	2	3/15/2017	12:51	48.74335	-122.33005	6.8	11.47	6.96	58.6	14.4	147
466	Discharge	8D	3	3/29/2017	12:55	48.74333	-122.33004	7.7	11.39	6.94	50.7	17.8	163
462	Discharge	10D	1	1/19/2017	13:16	48.74376	-122.33084	5.4	12.21	7.13	57.7	29.7	
462	Discharge	8D	2	3/15/2017	13:03	48.74375	-122.33079	7.2	11.94	7.33	59.2	10.2	225
462	Discharge	9D	3	3/29/2017	13:05	48.74385	-122.33078	7.6	11.77	7.26	49.4	39.4	207
453	Discharge	9D	2	3/15/2017	13:18	48.74528	-122.33444	6.9	10.48	6.60	59.3	1.4	111
453	Discharge	10D	3	3/29/2017	13:25	48.7453	-122.33442	7.6	10.75	6.43	51.4	6.5	157
449	Discharge	11D	1	1/19/2017	13:29	48.74545	-122.33574	6.6	11.97	7.17	58.8	34.7	
449	Discharge	10D	2	3/15/2017	13:35	48.74546	-122.33574	7.9	11.87	7.37	59.2	6.6	197
449	Discharge	11D	3	3/29/2017	13:39	48.74547	-122.33577	7.6	11.89	7.20	48.6	67.2	149
440	Discharge	12D	1	1/19/2017	13:39	48.7469	-122.3386	5.3	11.88	6.85	53.5	3.6	
440	Discharge	12D	3	3/29/2017	13:57	48.7469	-122.33854	8.4	11.14	7.04	49.1	5.1	271
437	Discharge	13D	1	1/19/2017	13:44	48.74736	-122.33991	5.2	12.17	7.05	41.4	6.4	
437	Discharge	13D	2	3/15/2017	14:20	48.74743	-122.3399	7.6	11.82	7.29	45.6	5.7	264
437	Discharge	13D	3	3/29/2017	14:12	48.74738	-122.33993	8.0	11.64	7.18	37.7	7.7	271
430	Discharge	14D	1	1/19/2017	13:53	48.74865	-122.34364	5.5	11.85	6.94	61.3	9.1	
430	Discharge	14D	2	3/15/2017	14:40	48.74866	-122.34368	7.2	11.99	7.33	60.3	1.3	106
430	Discharge	14D	3	3/29/2017	14:28	48.74871	-122.34364	8.4	11.47	7.00	57.0	11.4	229
429	Discharge	15D	3	3/29/2017	14:47	48.74885	-122.34624	8.9	11.47	6.27	0.2	25.6	297

ND = not detected, < = detected at less that practical quantitation limit

U = undetected at reporting limit, J = estimated value based on data quality review

Lake Whatcom North Shore On-Site Sewage System Leachate Detection Project Database

Station	Fecal coliform (CFU/100mL)		E coli (CFU/100mL)		EC/FC Ratio	B dorei (copies/100mL)		B EPA (copies/100mL)		Lab Category	Total P (mg/L)		Chloride (mg/L)		Bromide (mg/L)	
OSS	1500000	J	1500000	J	1.0	1030		55000		Moderate	10.3		46.8		0.10	U
OSS	4080000	>	4080000	>	1.00	1460		141000		High	10.2		48.1		0.10	U
C1	2	U	2	U	1.0											
C1	5	U	5	U	1.0	3	<	0	ND	Low	0.008	U	2.68		0.10	U
C1	2	U	2	U	1.00	0	ND	0	ND	Not detected	0.008	U	2.59		0.10	U
C2	2	U	2	U	1.0											
C3	4	J	4	J	1.0											
C3	5	U	5	U	1.0	0	ND	0	ND	Not detected	0.008	U	2.68		0.10	U
C3	2	U	2	U	1.00											
1L	9	J	9	J	1	0	ND	0	ND	Not detected	0.012		2.56		0.10	U
2L	5	U	5	U	1	0	ND	0	ND	Not detected	0.018		2.59		0.10	U
3L	46		42		0.913											
4L	5	J	5	J	1	3	<	0	ND	Low	0.024	J	2.63		0.10	U
5L	9	J	9	J	1.0	60		0	ND	Low	0.030		3.05		0.10	U
525A	150		145		1.0											
525	114		114		1.0	0	ND	0	ND	Not detected	0.036		2.63		0.10	U
525	112		112		1.00	0	ND	0	ND	Not detected	0.046		2.30		0.10	U
521	135		105		0.8											
521																
521	16	J	16	J	1.00	0	ND	0	ND	Not detected	0.014		2.66		0.10	U
520	100		7	J	0.1	17400		1450		Moderate	0.052		3.47		0.10	U
520	62		62		1.00	21700		1610		Moderate	0.064		3.10		0.10	U
518	44		13	J	0.3	0	ND	0	ND	Not detected	0.048		2.16		0.10	U
518	29	J	29	J	1.00	112		0	ND	Low	0.066		1.77		0.10	U
509	55	J	27	J	0.5											
509	4	J	4	J	1.0											
509	342	J	342	J	1.00	3	<	0	ND	Low	0.086		1.42		0.10	U
495	5	U	5	U	1.0											
495																
492	68	J	55	J	0.8											
492	7	J	7	J	1.0	0	ND	0	ND	Not detected	0.024		1.15		0.10	U
492	2	J	2	J	1.00											
488	5	U	5	U	1.0											
488																
488																
481	5	J	5	J	1.0											
481																
481																
466	73	J	68	J	0.9											
466	198	J	191	J	1.0	0	ND	0	ND	Not detected	0.050		2.41		0.10	U
466	127	J	122	J	0.96	87		0	ND	Low	0.088		1.87		0.10	U
462	82	J	64	J	0.8											
462	4	J	4	J	1.0	3	<	0	ND	Low	0.056		2.08		0.10	U
462	15	J	11	J	0.73	0	ND	0	ND	Not detected	0.218		1.46		0.10	U
453	38	J	38	J	1.0	3	<	4050		Low	0.014		2.82		0.10	U
453	124	J	110		0.89	3	<	9960		Low	0.054		2.17		0.10	U
449	190	J	180		0.9											
449	2	J	2	J	1.0											
449	20	J	18	J	0.90	0	ND	0	ND	Not detected	0.098		1.71		0.10	U
440	50	J	32	J	0.6											
440	44		44		1.00	107		0	ND	Low	0.062		1.80		0.10	U
437	18	J	14	J	0.8											
437	9	J	9	J	1.0	0	ND	0	ND	Not detected	0.032		1.96		0.10	U
437	20	J	20	J	1.00	0	ND	0	ND	Not detected	0.060		1.38		0.10	U
430	125		100		0.8											
430	7	J	7	J	1.0	3	<	0	ND	Low	0.016		2.70		0.10	U
430	800		82		0.10	278		0	ND	Low	0.088		1.78	J	0.10	U
429	262	J	260	J	0.99								`			

Lake Whatcom North Shore On-Site Sewage System Leachate Detection Project Database

Station	Sample Analysis Code	Depth (ft)	Width (ft)	Area (ft2)	Velocity (fps)	Flow (cfs)		Flow Data Source
OSS	All parameters							
OSS	All parameters							
C1	Field a0 Fecals							
C1	All parameters							
C1	All parameters							
C2	Field a0 Fecals							
C3	Field a0 Fecals							
C3	All parameters							
C3	Field a0 Fecals							
1L	All parameters							
2L	All parameters							
3L	Field a0 Fecals							
4L	All parameters							
5L	All parameters							
525A	Field a0 Fecals	0.15	1.50	0.23	2.0	0.45		photo
525	All parameters	0.33		24" pipe	1.0	0.35		notes
525	All parameters	0.33		24" pipe	1.0	0.35		notes
521	Field a0 Fecals	0.25		36" pipe	0.1	0.04		notes
521	Field only			36" pipe	0.0	0.00		notes
521	All parameters	0.50		36" pipe	0.1	0.08		notes
520	All parameters	0.29	1.00	0.29	0.5	0.15		notes
520	All parameters	0.25	1.00	0.25	1.5	0.38		notes
518	All parameters	0.21		36" pipe	2.0	0.42		notes/photo
518	All parameters	0.25		36" pipe	1.5	0.38		notes/photo
509	Field a0 Fecals			36" pipe		0.25	J	other events
509	Field a0 Fecals	0.13		36" pipe	2.0	0.25		notes/photo
509	All parameters	0.17		36" pipe	1.5	0.25		notes/photo
495	Field a0 Fecals					0.05	J	other event
495	Field only					0.05		photo
492	Field a0 Fecals	0.25	1.50	0.38	4.0	1.5		photo
492	All parameters	0.25	1.50	0.38	2.0	0.75		notes/photo
492	Field a0 Fecals	0.25	1.50	0.38	2.0	0.75		notes/photo
488	Field a0 Fecals					0.75	J	other events
488	Field only	0.17	2.00	0.33	1.5	0.50		notes/photo
488	Field only	0.25	2.00	0.50	1.5	0.75		notes
481	Field a0 Fecals	0.21		36" pipe	3.0	0.65		photo
481	Field only	0.17		36" pipe	2.0	0.35		photo
481	Field only			36" pipe		0.35	J	other events
466	Field a0 Fecals			36" pipe		3.0	J	other events
466	All parameters	1.67		36" pipe	0.5	2.5		notes/photo
466	All parameters	2.67		36" pipe	0.5	3.3		notes/photo
462	Field a0 Fecals					2.0	J	other events
462	All parameters	0.17	2.20	0.37	2.0	0.7		notes/photo
462	All parameters	0.50	2.20	1.10	2.0	2.2		notes/photo
453	All parameters	0.83		24" pipe	0.5	0.6		notes/photo
453	All parameters	1.67		24" pipe	0.3	0.8		notes
449	Field a0 Fecals					10		photo
449	Field a0 Fecals	0.50	2.20	1.10	6.0	6.6		notes/photo
449	All parameters	0.67	3.00	2.00	5.0	10		notes
440	Field a0 Fecals					3.0	J	other event
440	All parameters	1.50	8.00	12.00	0.25	3.0		notes/photo
437	Field a0 Fecals	0.10	2.50	0.25	3.0	0.75		photo
437	All parameters	0.10	1.50	0.15	3.0	0.45		notes/photo
437	All parameters	0.10	5.00	0.50	3.0	1.5		notes/photo
430	Field a0 Fecals	.15/.1		8"/12" pipe	5/3	0.5		photo
430	All parameters					0.5		photo
430	All parameters					0.5		photo
429	Field a0 Fecals	0.05	0.50	0.03	1.5	0.04		photo