Liberty Bay Watershed
Fecal Coliform Bacteria
Total Maximum Daily Load

TMDL and
Water Quality Implementation Plan

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Cover photo: Looking across Liberty Bay at Poulsbo from a small inlet near Perry Creek.

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Abstract

Portions of Liberty Bay (Kitsap County) and several of its freshwater tributaries are listed on the Washington State Water Quality Assessment because of non-attainment of the state fecal coliform (FC) bacteria standards. The Clean Water Act requires states to establish a total maximum daily load (TMDL) for each water body assigned the highest category, Category 5 (needs a TMDL). A TMDL evaluates how much pollution a water body can accept and still meet water quality standards, and includes an implementation plan listing the actions necessary to accomplish the water quality improvement.

Twice monthly over 13 months in 2008-2009, the Washington State Department of Ecology (Ecology) measured FC bacteria concentrations, flows, and other data for the listed creeks and other freshwater sources to Liberty Bay. Exceedances of the state *Extraordinary Primary Contact Recreation* criteria for FC bacteria in freshwater were widespread. Ecology determined that reductions of seasonal FC bacteria concentration and load are necessary for all tributaries to Liberty Bay, except Sam Snyder Creek, to meet state standards and protect beneficial uses of both fresh and marine waters.

New information from the study includes the importance of Poulsbo Creek as a source of bacterial contamination. Poulsbo Creek was second only to Dogfish Creek in the estimated annual load of bacteria to Liberty Bay. The study's FC loading estimates for numerous tributaries are useful for finding and prioritizing pollution sources and focusing cleanup efforts. They will also be helpful in assessing contamination sources that could affect shellfish harvest.

Following Ecology's decision to initiate a TMDL, two grant projects were awarded during TMDL development to Kitsap Public Health District. These TMDL-related projects assisted implementation and led to improvements in several creeks; however, standards are largely still not met as of 2012. In order to meet water quality standards by 2018, additional work is required to control nonpoint sources and the four national pollutant discharge elimination system (NPDES) stormwater permittees in the watershed. The city of Poulsbo, Kitsap County, U.S. Navy, and Washington State Department of Transportation need to control sources to their municipal separate storm sewer systems (MS4s). These permittees are assigned wasteload allocations to reduce bacteria in stormwater discharges that affect sampling locations that still don't meet standards.

The TMDL identifies the actions NPDES permit holders need to take to address the wasteload allocations, and it recommends actions for local organizations to undertake to address nonpoint sources of bacteria. Ecology expects these actions will ensure that water quality standards are met throughout the watershed by 2018.

Water quality monitoring by the Kitsap Health District is continuing and biennial reviews of water quality data and implementation will be conducted to assess ongoing progress. The improvements in tributary water quality since the TMDL began are good evidence that this state/local collaboration is working and will take streams off the Category 5 (impaired) list and help in the effort to open more of Liberty Bay to shellfish harvest.

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Executive Summary

As required by the Clean Water Act for water bodies not meeting state water quality standards, the Washington State Department of Ecology (Ecology) initiated a total maximum daily load (TMDL) for fecal coliform (FC) bacteria in the Liberty Bay watershed in 2008-09.

Twice monthly monitoring of freshwater streams and outfalls indicated there were widespread exceedances of the state *Extraordinary Primary Contact* (EPC) *Recreation* standards for bacteria. Nonpoint sources of FC bacteria in the watershed include failing onsite sewage systems, pets, livestock, wildlife, and boating activities in the bay itself. Point sources of bacteria include municipal stormwater from city of Poulsbo, urbanized Kitsap County, state highways, and industrial stormwater from the Naval Base Kitsap at Keyport.

The EPC Recreation standards are concentrations of FC that apply to Liberty Bay watershed and must not be exceeded under state law. The EPC standards are a geometric mean concentration of 50 colony forming units (cfu)/100 mL, and a 90th percentile value of 100 cfu/100 mL. TMDLs measure pollutant concentrations and also estimate pollutant loads (calculated as bacteria concentrations multiplied by stream discharges). This TMDL includes load estimates and estimates of the percent reductions in loads needed to meet the concentration standards. However, in the final analysis, it is the EPC standards that the water bodies in this TMDL are required to meet.

In the study, Ecology determined critical seasons for bacteria concentration (generally highest in the dry season, June - October) and loading (generally highest in wet season, November – May). The tributaries with the highest concentrations of FC bacteria were a shoreline discharge below the Nelson Park bioswale; an outfall adjacent to an assisted living facility, an intermittent stream off Virginia Loop Road; Little Scandia Creek; and an unnamed stream between Bovela and Bay streets in Poulsbo. Ecology also determined the bacteria loading capacity of the streams and developed load and wasteload allocations that assure protection of designated beneficial uses of both fresh and marine waters.

The tributaries with the highest loads of bacteria excluding Dogfish Creek were Poulsbo, South Fork Dogfish, Big Scandia, Bjorgen, Johnson, and Little Scandia creeks. Dogfish and Daniels creeks were monitored but have a different designation [4b] on the state's Water Quality Assessment. The 4b designation is for water bodies with pollution control programs other than TMDLs being implemented to achieve water quality standards. The TMDL establishes seasonal load allocations at 25 freshwater tributary sites in the Liberty Bay watershed. Wasteload allocations are established for four NPDES stormwater permittees: city of Poulsbo, Kitsap County, Washington State Department of Transportation, and the U.S. Navy.

New information from the study includes the importance of Poulsbo Creek as a source of bacterial contamination. Poulsbo Creek was second only to Dogfish Creek in the estimated annual load of bacteria to the bay. Ecology also measured FC bacteria in discharges from six city stormwater outfalls in collaboration with the city of Poulsbo, and found moderate to high concentrations of bacteria in all of them. The study's FC loading estimates for freshwater

streams and outfalls are useful for finding and prioritizing sources and focusing cleanup efforts. Two Centennial grant projects, awarded early in the TMDL process to Kitsap Public Health District (KPHD), resulted in an early implementation approach for the TMDL and led to improvements in several creeks. KPHD has continued monitoring at many of the study's tributary locations. Ecology reviewed KPHD data for Water Year[1] (WY) 2011 to assess changes since TMDL monitoring ended. While significantly improved, most streams are still not meeting the recreational use criteria.

One of the grant projects, *Pollution Identification and Correction (PIC)*, includes outreach and education, correction of failing onsite sewage systems, boater education, assessment of marina water quality problems, and coordination with the Kitsap Conservation District to provide technical assistance to livestock owners. Also contributing to water quality improvements were (1) a second Centennial grant, the *Regional Illicit Discharge Detection and Elimination (IDDE) and Clean Runoff* stormwater implementation grant, (2) stormwater grants to city of Poulsbo: *Anderson Parkway LID and Retrofit Project* and *Caldart Avenue LID Project*, and (3) the municipal stormwater programs of Poulsbo and Kitsap County.

In order to meet water quality standards by 2018, additional work is required of the four NPDES stormwater permittees in the watershed: city of Poulsbo; Kitsap County; U.S. Navy; and Washington State Department of Transportation. These permittees are assigned wasteload allocations for bacterial pollution in their municipal stormwater systems. To address these wasteload allocations, the TMDL calls for permittees to focus their IDDE programs and optimize their operations and maintenance practices to improve stormwater discharges within the drainages upstream of TMDL monitoring sites.

The TMDL also recommends actions for local organizations to address nonpoint sources of bacteria. KPHD continues to conduct PIC projects and works to identify and correct failing on-site sewage systems. KPHD and Kitsap Conservation District will help address problems with livestock and manure management. Poulsbo and the West Sound Stormwater Outreach Group will provide pet waste awareness and conduct Mutt Mitt Programs. Water quality monitoring and PIC projects by KPHD are continuing and biennial reviews of data and implementation will be conducted to assess progress. Ecology expects these actions will ensure that water quality standards are met throughout the watershed by 2018.

Beginning in Water Year 2011, all stations in Liberty Bay monitored by Kitsap Public Health District met marine standards for bacteria. The Suquamish Tribe recently submitted a Classification Request to Washington Department of Health Shellfish Program to increase the area of Liberty Bay open to shellfish harvest. Several years of data collection and a detailed assessment of pollution sources must be accomplished in order to change a shellfish harvest classification. However, recent improvements in bay and tributary water quality suggest that local, state, and tribal efforts are having success and can be expected to help open a larger area of Liberty Bay for commercial shellfish harvest.

[1] Water Years start October 1 and end the following September 30.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. The Act requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of (1) designated uses for protection, such as cold water biota and drinking water supply, and (2) criteria, usually numeric criteria, to achieve those uses.

The Water Quality Assessment and the 303(d) List

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the Clean Water Act 303(d) list. In Washington State, this list is part of the Water Quality Assessment (WQA). Further information is available at Ecology's Water Quality Assessment website.

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, Tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The WQA divides water bodies into five categories. Those not meeting standards are given a Category 5 designation, which collectively becomes the 303(d) list.

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data or insufficient data available.

Category 4 – Polluted waters that do not require a TMDL because they:

- 4a. – Have an approved TMDL being implemented.
- 4b. – Have a pollution control program in place that should solve the problem.
- 4c. – Are impaired by a non-pollutant such as low water flow, dams, or culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

The Clean Water Act requires that a total maximum daily load (TMDL) be developed for each of the water bodies on the 303(d) list. A TMDL is a numerical value representing the highest pollutant load a surface water body can receive and still meet water quality standards. Any amount of pollution over the TMDL level needs to be reduced or eliminated to achieve clean water.

TMDL process overview

Ecology uses the 303(d) list to prioritize and initiate TMDL studies across the state. The TMDL study identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, Tribes, agencies, and the community, then develops a plan to control and reduce pollution sources and the monitoring needed to assess the effectiveness of the water quality improvement activities. Together, the study and implementation plan comprise the *water quality improvement report* (WQIR), which identifies specific tasks, responsible parties, and timelines for reducing or eliminating pollution sources and achieving clean water. After public review, comment, and revision, the WQIR is sent to the U.S. Environmental Protection Agency (EPA) for approval.

Who should participate in this TMDL?

Ecology works with state and local organizations, including government agencies, Tribes, non-profit organizations, and citizens, to review the results of the TMDL study and develop an implementation strategy that will efficiently bring the water body back to meeting state water quality standards. For this TMDL, Ecology is working with:

- City of Poulsbo
- Kitsap County Surface and Stormwater Management
- Kitsap County Department of Community Development
- Kitsap Public Health District
- Kitsap Conservation District
- Liberty Bay Foundation
- Puget Sound Restoration Fund
- Puget Sound Partnership
- Suquamish Tribe
- US Navy
- Washington State Department of Transportation
- Washington Department of Fish and Wildlife
- Washington State Department of Health

Point and nonpoint-source pollutant concentration and load targets have been set in this TMDL and are described in Tables 18-27. Because nonpoint pollution comes from diffuse sources, all upstream watershed areas have the potential to affect downstream water quality. Therefore, all potential nonpoint sources in the watershed must use the appropriate best management practices (BMPs) to reduce impacts to water quality. Nearly all creeks in the Liberty Bay and Nesika Bay watersheds (Figure 1) are subject to the TMDL. The exceptions are Thompson Creek, just east of the watershed, and Daniels and Dogfish creeks, which are designated 4b on the state Water Quality Assessment. In addition to nonpoint sources, all point source dischargers in the watershed must comply with the TMDL.

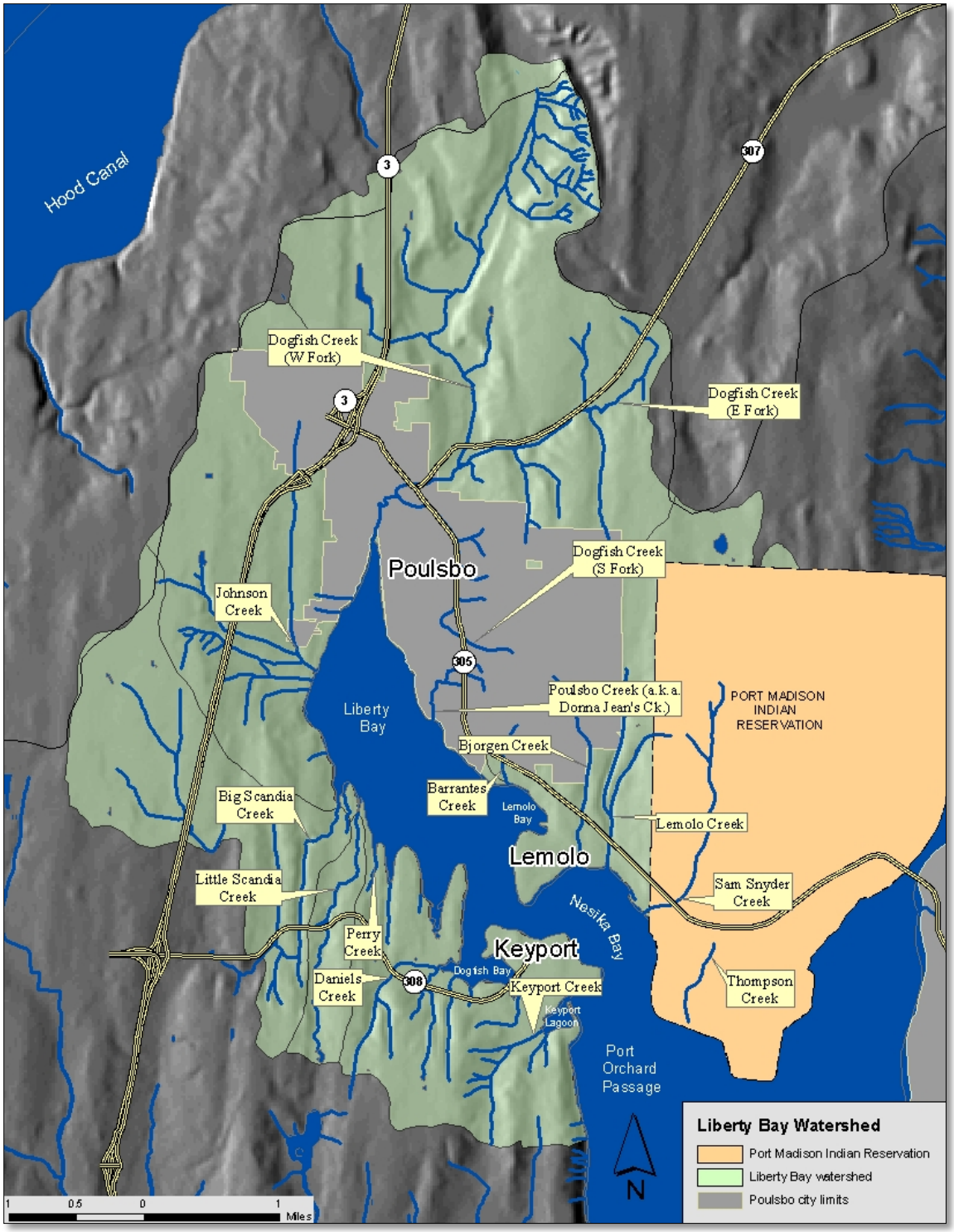


Figure 1. Liberty Bay and Nesika Bay watersheds including tributaries to Agate and Port Orchard passages.

Elements the Clean Water Act requires in a TMDL

Loading capacity, allocations, seasonal variation, margin of safety, and reserve capacity

Washington State bacteria TMDLs use a combination of loading (count-per-time units), statistical concentration targets, and percent reductions to define loading capacities. A water body's *loading capacity* is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water's loading capacity assigned to a particular source is a *wasteload* or *load* allocation. If the pollutant comes from a discrete (point) source subject to a National Pollutant Discharge Elimination System (NPDES) permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation (WLA).* If the pollutant comes from diffuse (nonpoint) sources not subject to an NPDES permit, such as residential or farm runoff, the cumulative share is called a *load allocation (LA).*

The TMDL must also consider *seasonal variations* and include a *margin of safety* that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A *reserve capacity* for future pollutant sources is sometimes included as well. Therefore, a TMDL is the sum of the WLAs and LAs, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity.

$$TMDL = LA + WLA + MOS + RC$$

where: LA = sum of all load allocations
WLA = sum of all wasteload allocations
MOS = margin of safety
RC = reserve capacity

Why Ecology Conducted a TMDL in this Watershed

Most of the freshwater streams and stormwater that drain to Liberty Bay are contaminated with fecal coliform (FC) bacteria. The bay itself has improved in recent years but still has some areas of contamination. As a result, people who use these streams and the bay for harvesting shellfish, boating, swimming, wading, and other recreational activities are risking exposure to pathogens.

The purpose of this TMDL project is to (1) determine locations and sources of FC pollution and their relative importance and (2) provide a plan for cleanup so water bodies can meet and maintain state water quality standards. The guiding document for the Liberty Bay TMDL study is the *Quality Assurance Project Plan: Liberty Bay Tributaries Fecal Coliform Bacteria TMDL* (Swanson, 2009).

Background

In 1992, Kitsap Public Health District (KPHD) conducted a monitoring study that found severe pollution in northern Liberty Bay and Dogfish Creek. In 1994, Kitsap County Surface and Stormwater Management (SSWM) was formed and one of its missions is to fund monitoring of streams and marine areas of the county in order to assess water quality and determine cleanup priorities.

From 1996 to 2001, KPHD focused a Pollution Identification and Correction (PIC) project on the Dogfish Creek basin and the city of Poulsbo. The project involved partnerships with other agencies, including the city of Poulsbo to conduct property surveys and stormwater cleanup; Ecology (grant funds); KCSSWM and the city (match funds); KPHD (monitoring and property surveys); and Kitsap Conservation District (agriculture best management practices.) The project was successful in affecting large reductions in FC bacteria in the creek and northern Liberty Bay. For more information on water quality monitoring and PIC projects in Kitsap County, visit www.kitsappublichealth.org/environment/sls.php.

Following the earlier PIC work, KPHD continued to monitor seven trend sites on tributaries to Liberty Bay as well as seven marine sites (Figure 2). KPHD data are analyzed and reported annually and used to establish a priority cleanup list. This process resulted in early cleanup projects on Daniels Creek.

In 2002, the Liberty Bay Foundation (www.libertybayfoundation.com/homepage.htm), with assistance from KPHD and funds from Ecology, sampled a large number of marine sites, and KPHD followed up and eliminated several pollution hotspots. The non-profit Puget Sound Restoration Fund (www.restorationfund.org) is also working to bring attention to the importance of clean water quality in Liberty Bay and has undertaken a project to restore the native Olympia oyster to the bay.

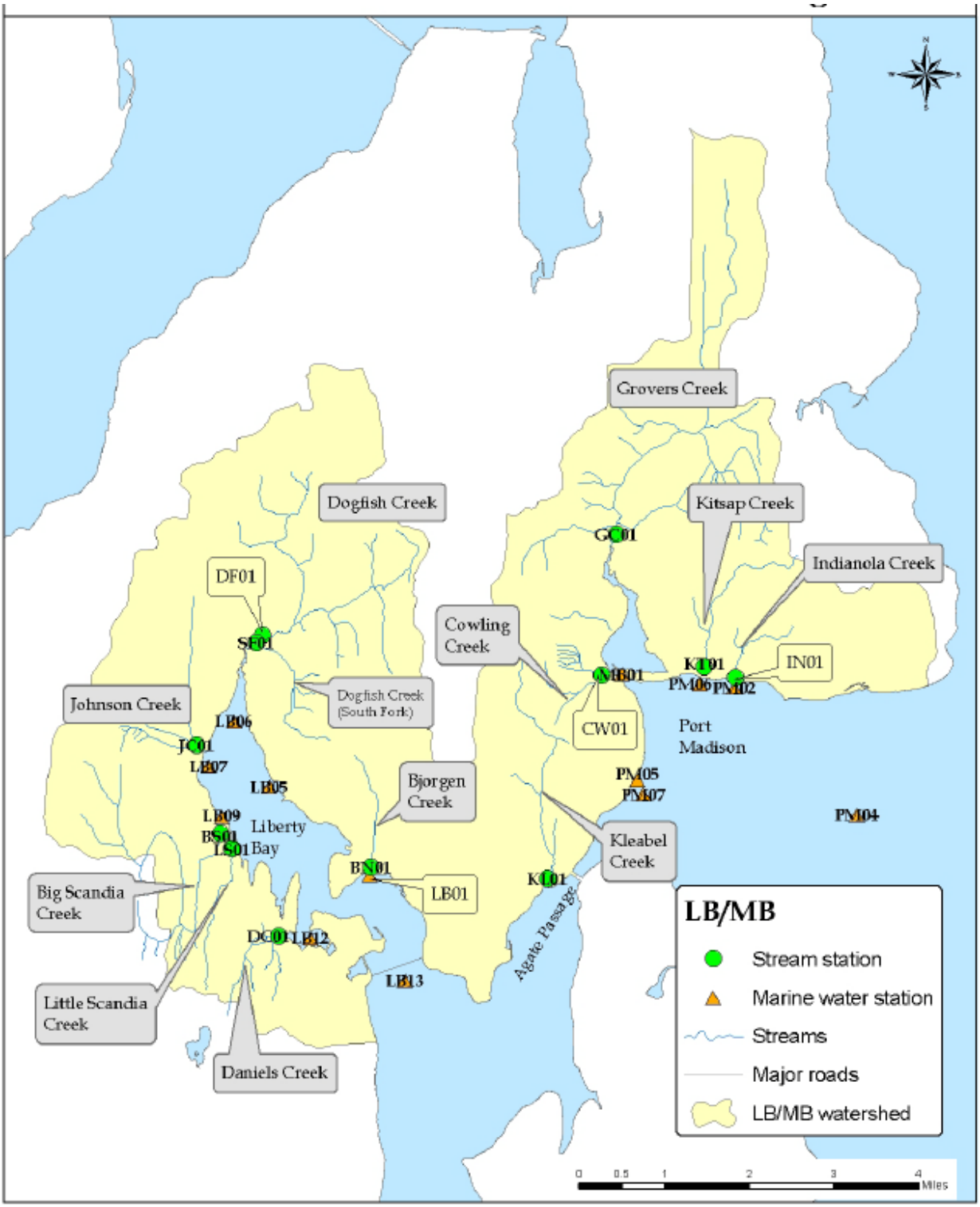


Figure 2. Kitsap Public Health District monitoring sites in Liberty Bay/Miller Bay watersheds.

Impairments addressed by this TMDL

Designated beneficial uses for protection by this TMDL include *Shellfish Harvesting* and *Primary and Secondary Contact Recreation* in Liberty Bay and its tributaries. *Primary and Secondary Contact Recreation* in both fresh and marine water include people coming into contact with water through swimming, boating, fishing, wading, and other water-related activities. Primary contact includes activities where a person would have direct contact with water to the point of complete submergence. Secondary contact includes activities where a person's water contact would be limited (e.g., wading or fishing) to the extent that bacterial infections of eyes, ears, respiratory or digestive systems would normally be avoided. Table 1 shows the Category 5 listings on the state Water Quality Assessment for FC in Liberty Bay and its tributaries, approved by EPA in 2012.

Table 1. Category 5 listings for fecal coliform located in the Liberty Bay TMDL study area.

Water Body	Listing ID	Latitude/Longitude or Township, Range, Section	Marine Grid Cell	Date (Year) of Data Supporting Listing
Liberty Bay	38687 23704 23708 23709 23707 23705 23700 45224	47.725 -122.655 47.715 -122.655 47.735 -122.655 47.745 -122.655 47.735 -122.645 47.725 -122.635 47.705 -122.625 47.745 -122.645	47122H6C5 47122H6B5 47122H6D5 47122H6E5 47122H6D4 47122H6C3 47122H6A2 47122H6E4	2009, 2005, 2002 2002, 2001 2006, 2002, 2001 2003, 2002, 2001 2003, 2002, 2001 2003, 2002, 2001 2002, 2001 2003, 2002, 2001
Johnson Creek	38663	26.0N - 01.0E - 22		2006, 2005, 2004
Big Scandia Creek	38444	26.0N - 01.0E - 27		2006, 2005, 2004, 2003
Little Scandia Creek	23692	26.0N - 01.0E - 27		2006, 2005
Lemolo Creek	23544	26.0N - 01.0E - 25		2003, 2002, 2001
Bjorgen Creek	23693 45032	26.0N - 01.0E – 25 26.0N - 01.0E - 24		2006, 2005 2002
Barrantes Creek	45535	26.0N - 01.0E - 26		2003, 2002, 2001

Kitsap County is implementing its Ecology- and EPA-approved PIC Program for Dogfish and Daniels creeks, which are currently making good progress. Dogfish Creek has eight and Daniels Creek has two Category 4b listings. Category 4b is a Water Quality Assessment designation for water bodies that do not meet state standards but have approved pollution control programs being implemented that are expected to achieve state water quality standards.

Work to clean up Dogfish and Daniels creeks began prior to the TMDL by Kitsap Public Health District (KPHD). Based on the Health District's water quality programs, Dogfish Creek was designated 4b in the 2004 Water Quality Assessment, and Daniels in the 2008 Water Quality Assessment. The Liberty Bay TMDL monitoring was initiated in 2008 and includes both creeks because of the need to understand their fecal coliform load to the bay in the context of all the other creeks monitored for the TMDL. In the event that the PIC Programs are not successful in achieving compliance with standards, the Liberty Bay Fecal Coliform TMDL will become the default pollution control plan for these streams. Other water quality impairments in the Liberty Bay watershed not addressed by this TMDL are shown in Table 2.

Table 2. Additional Category 5 listings for waters in Liberty Bay Watershed which are not addressed by this TMDL.

Water Body	Parameter	Medium	Latitude/Longitude or Township, Range, Section	Marine Grid Cell
Liberty Bay	*DO	Water	47.715 -122.625 47.725 -122.645 47.735 -122.645 47.735 -122.655	47122H6B2 47122H6C4 47122H6D4 47122H6D5
Dogfish Creek	DO	Water	26.0N - 01.0E - 14	
Dogfish Creek, East Fork	DO	Water	26.0N - 01.0E - 11	
Johnson Creek	DO	Water	26.0N - 01.0E - 22	
Big Scandia Creek	DO	Water	26.0N - 01.0E - 27	
Little Scandia Creek	DO	Water	26.0N - 01.0E - 27	
Daniels Creek	DO	Water	26.0N - 01.0E - 35	
Sam Snyder Creek	pH	Water	26.0N - 01.0E - 36	
Lemolo Creek	DO	Water	26.0N - 01.0E - 25 26.0N - 01.0E - 24	
Bjorgen Creek	DO	Water	26.0N - 01.0E - 25 26.0N - 01.0E - 24	
Barrantes Creek	DO	Water	26.0N - 01.0E - 26	

*DO – Dissolved oxygen

Water Quality Standards and Numeric Targets

Fecal coliform bacteria

Freshwater criteria

Bacteria targets in the water quality standards are set to protect people who work and play in the water from waterborne illnesses, and to protect tributaries to shellfish harvesting areas. In Washington State, surface water quality standards use fecal coliform (FC) as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). FC bacteria in water indicate the presence of waste from humans and other warm-blooded animals which is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. Ecology's selection of FC bacteria as the indicator for pathogens in surface waters is explained in *Setting Standards for the Bacteriological Quality of Washington's Surface Water Draft Discussion Paper and Literature Summary* (Hicks, 2002). The paper reviews the use of FC as an indicator bacteria and epidemiological studies of indicator bacteria in both fresh and marine waters.

The designated beneficial use of *Extraordinary Primary Contact* is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas." To protect this use category fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, and no more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value must exceed 100 colonies/100mL" [WAC 173-201A-200(2)(b), 2011 edition] (Table 3). The upper limit criterion (i.e., the level that not more than 10 percent of the samples shall exceed) has been interpreted in this TMDL as the 90th percentile of sample values.

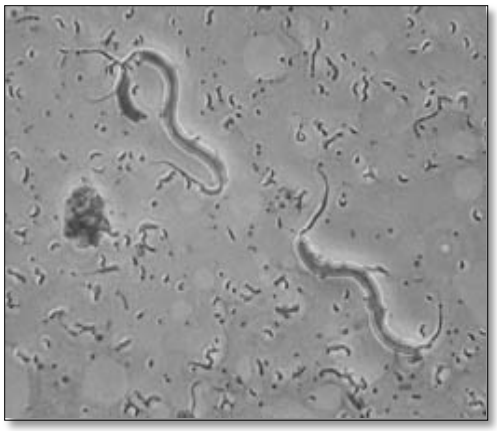
Table 3. Freshwater fecal coliform criteria.

Freshwater Criteria (Extraordinary Primary Contact)	Geometric Mean	Not more than 10 % (90th Percentile)
Freshwater tributaries to Liberty Bay	50 cfu/100 mL	100 cfu/100 mL

cfu = colony forming units

Marine water criteria

In marine waters, water quality standards for bacteria are set to protect shellfish consumption and people who work and play in and on the water. Marine water criteria apply when the salinity is ten parts per thousand or greater. Ecology uses two separate bacterial indicators in the state's marine waters:



View of fecal coliform bacteria under a microscope

- In waters protected for both *Primary Contact Recreation* and *Shellfish Harvesting*, the state uses FC bacteria as indicator bacteria to gauge the risk of waterborne diseases.
- In water protected only for *Secondary Contact Recreation*, enterococci bacteria are used as the indicator bacteria.

The presence of these bacteria in the water indicates the presence of waste from humans and other warm-blooded animals.

To protect either *Shellfish Harvesting* or *Primary Contact Recreation* (swimming or water play) in Liberty Bay: "Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL" [WAC 173-201A-210(3)(b), 2003 edition] (Table 4).

Table 4. Marine fecal coliform criteria for Liberty Bay.

Marine Criteria	Geometric Mean	Not more than 10 % (90^{th} Percentile)
Liberty Bay (*Shellfish Harvesting* & *Primary Contact Recreation*)	14 cfu/100 mL	43 cfu/100 mL

cfu = colony forming units

The criteria levels set to protect *Shellfish Harvesting* and *Primary Contact Recreation* in Liberty Bay are consistent with federal shellfish sanitation rules. FC concentrations in Washington's marine waters that meet shellfish protection requirements also meet the federal recommendations for protecting people who engage in primary water contact activities. Thus, Ecology uses the same criteria to protect both *Shellfish Harvesting* and *Primary Contact* uses in the state standards.

Compliance with criteria

Results of water samples collected randomly from one site and analyzed for bacteria typically follow a lognormal distribution, which is why the geometric mean is used for central tendency of the data set. The geometric mean is a mathematical expression of central tendency (average) of multiple sample values in a group of lognormal sample values. This average dampens the effect of extreme values that could bias an arithmetic average.

Compliance with bacteria water quality standards is based on meeting both the geometric mean criterion and the 10 percent of samples criterion. If ten or less total samples exist, then no single sample may exceed the 90th percentile. These two measures used in combination ensure that bacterial pollution in a water body will be maintained at a set level of risk to human health. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal data sets.

If FC concentrations in the water exceed the numeric criteria, human activities that would increase concentrations above the criteria need to be managed in order to allow waters to meet standards. The state, in collaboration with local governments, tribes, and watershed stakeholders, will work to ensure that human activities are conducted in a manner that will bring FC concentrations back into compliance with water quality standards.

If natural levels of FC (from wildlife, for example) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution beyond natural levels. Though the presence of bacterial contamination from wildlife is typical in most environments, there still may be a risk of human illness. For example, EPA recently published summary reports on the risk of human illnesses associated with the presence of water-borne pathogens from animals and birds (EPA, 2009, and EPA, 201l).

Changes in water quality standards

The bacteria water quality standards for the protection of contact recreation in freshwater, and contact recreation and shellfish harvesting in marine water are established in state rule, (WAC 173-201A-200(2)(b), WAC 173-201A-210(3)(b), and WAC 173-201A-20(2)(b), respectively). These standards were developed based on former U.S. Environmental Protection Agency (EPA) recommended criteria. EPA has since updated its recommended criteria (1986 & 2012) based on newer studies regarding the relationship between the incidence of human illness and bacterial pathogen indicators. Ecology has indicated in the most recent triennial review of the standards (www.ecy.wa.gov/programs/wq/swqs/triennial_review.html) that we intend to review the current bacteria standards using the most recent EPA information, including the replacement of the fecal coliform recreational use indicator with enterococci or *E. coli* bacteria.

Should the freshwater numeric criteria or indicator species for pathogens be changed in the water quality standards after this TMDL is approved, Ecology will follow implementation guidance developed as part of the Administrative Procedures Act for implementing those changes into TMDLs that are already approved or in the process of development. If newly adopted standards result in a change to the biological indicator, it is expected the guidance would include reopening of TMDLs as appropriate. (A change in pathogen indicator does not

affect a water body's beneficial uses, which are established by state rule in the water quality standards.) The beneficial uses of the water bodies in this TMDL (including marine shellfish harvest) would still need to be protected through adequately-low pathogen indicator targets for freshwaters that drain to the bay.

At this time, Ecology does not expect the indicator for the protection of shellfish harvesting to change from fecal coliform. Therefore, fecal coliform will remain as the compliance indicator in the Liberty Bay Watershed TMDL to meet downstream marine uses. Because the current freshwater fecal coliform targets are set at the more stringent recreational indicator criteria, change to another recreational use indicator may require a recalculation of fecal coliform targets in this TMDL to meet the marine shellfish harvesting use.

Watershed Description

Geographic setting

Liberty Bay and its tributaries are located in Kitsap County near the city of Poulsbo in Water Resource Inventory Area (WRIA) 15 (Figure 3). The community of Keyport is located to the south of Liberty Bay and is home to the Naval Base Kitsap, Keyport (NBK Keyport) and Naval Undersea Warfare Center, Keyport (NUWC Keyport). Other small communities surrounding Liberty Bay include Lemolo, Virginia, Pearson, and Scandia. The Port Madison Indian Reservation (Suquamish Tribe) is located in the southeastern portion of the watershed and includes Thompson Creek and upper Sam Snyder Creek.

Liberty Bay is about three miles long and three-quarters of a mile wide. The deepest point (~39 feet) is at its center. Extensive tide flats cover much of northern Liberty Bay at low tide. Circulation is enhanced by tidal movements but is somewhat limited by the enclosed shape of the bay formed by the Lemolo and Keyport peninsulas.

Nesika (Ne Si Ka) Bay connects Liberty Bay to Port Orchard Passage and is about one mile long and one half mile wide. Thompson Creek, which flows into the southern portion of Nesika Bay and northern portion of Port Orchard Passage, was not sampled in this TMDL study due to its distance from Liberty Bay. Thompson Creek is located on Port Madison Indian Reservation (Suquamish Tribe) land and is not suspected to be a significant source of FC.

The largest drainage in the watershed (4700 acres) is Dogfish Creek, forming the head of Liberty Bay at the very northern end. Other drainages include Johnson, Big Scandia, Little Scandia, Bjorgen, Daniels, Sam Snyder, Lemolo, Barrantes, Keyport, Perry, Poulsbo creeks; and several unnamed creeks (Figure 3).

The climate in Kitsap County is much like the rest of the Puget Sound basin with mild, wet winters and warm, dry summers. The Liberty Bay watershed receives about 30 to 50 inches of precipitation a year. The wettest month is usually December.

The watershed is about 22,000 acres and over 50 percent of the historically forested watershed is now developed, with approximately 17 percent of the developed area classified as impervious surface (May et al., 2005). Most of the highly developed areas are concentrated near the city of Poulsbo (population 9,200) around northern Liberty Bay and the community of Keyport on the Keyport Peninsula at the south end of Liberty Bay. Concentrated forests, rural residences, and small farms cover the rest of the watershed. Figure 4 shows categories of percent impervious surface in the watershed and locations of the TMDL sampling sites.

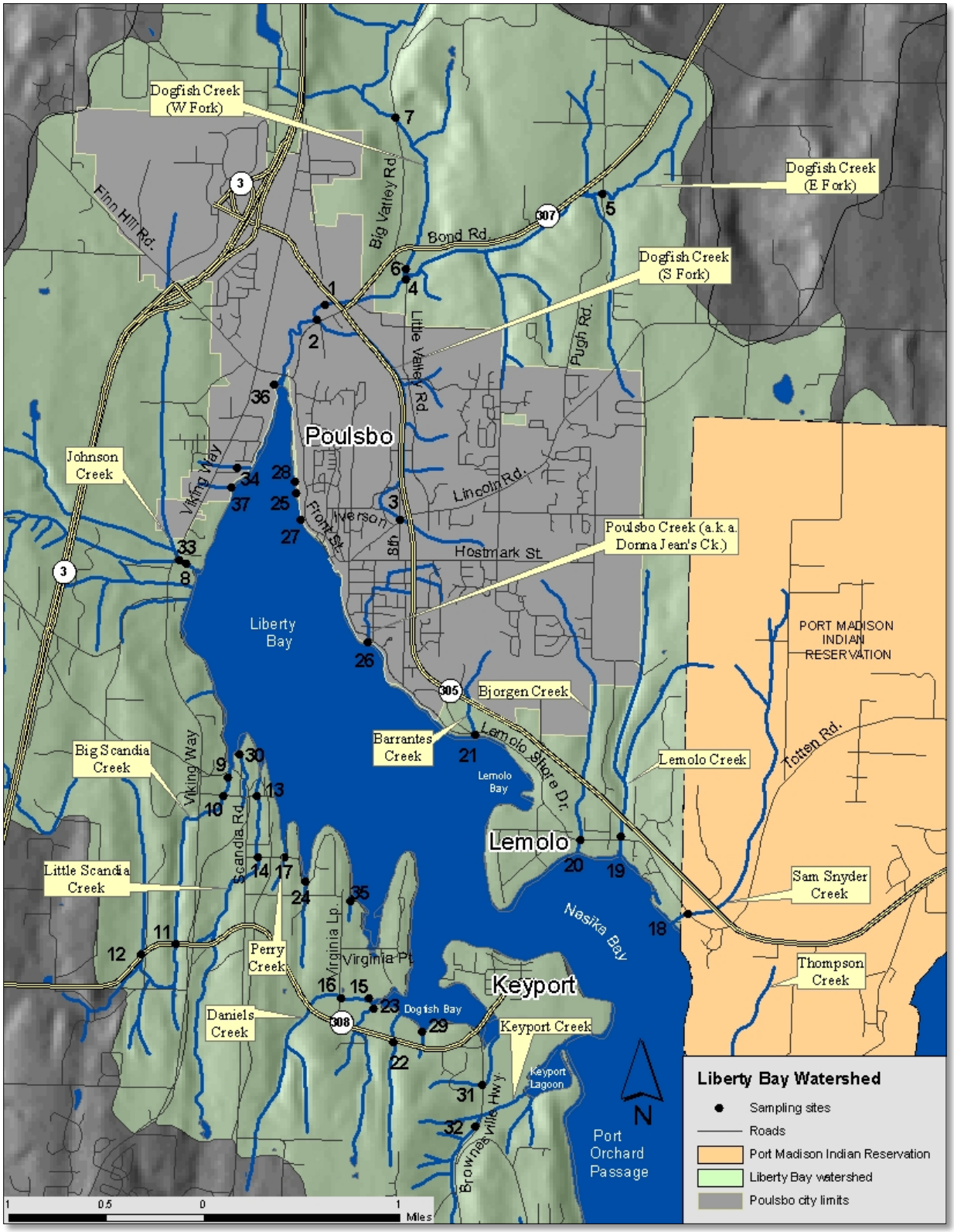


Figure 3. Liberty Bay and Nesika Bay watersheds, including TMDL sampling sites.
Numbers reference Tables 10 and 11.

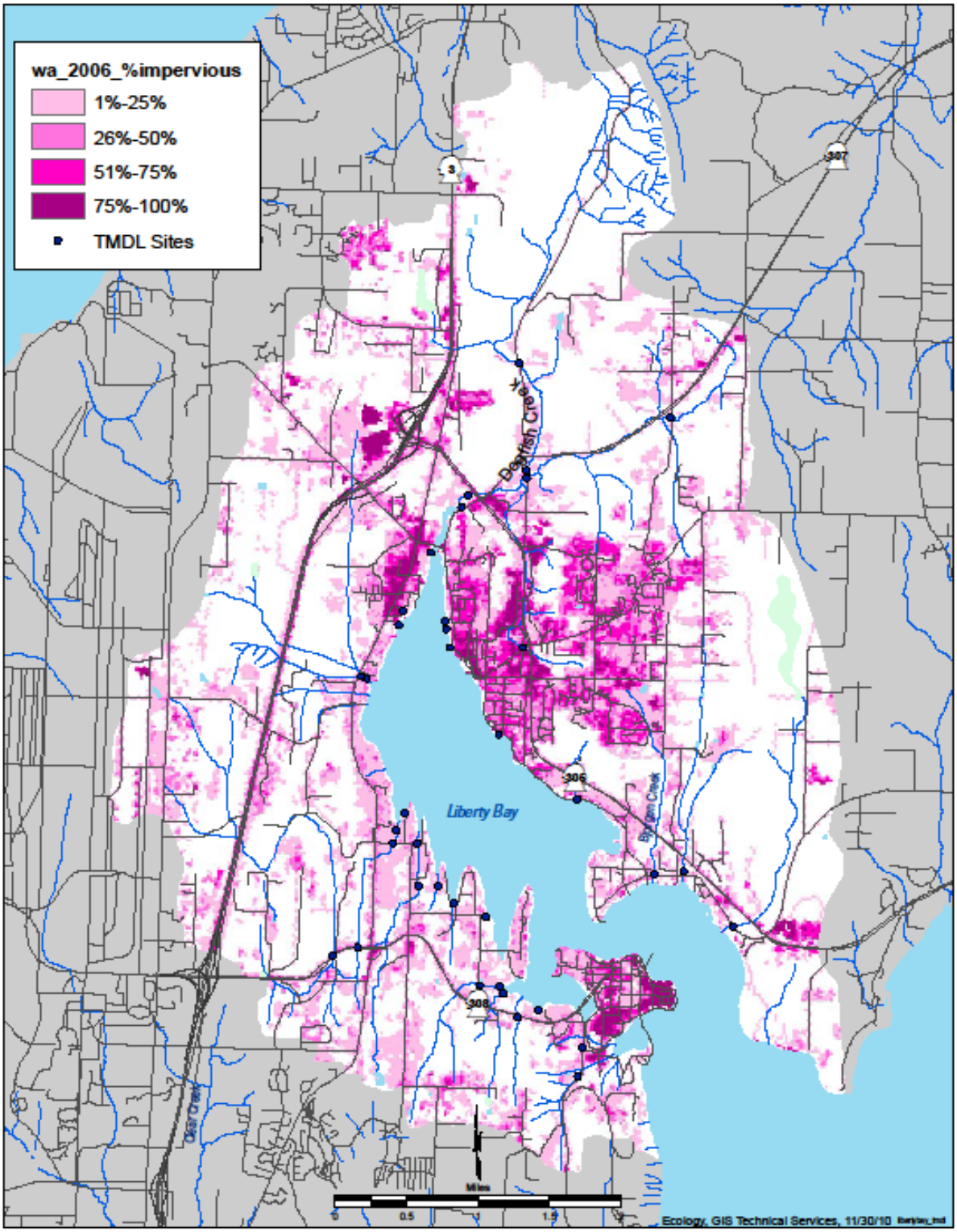


Figure 4. Categories of percent impervious surface in Liberty Bay watershed (2006) with TMDL sampling sites shown.

Table 5 shows major creeks in the watershed and their approximate lengths and their primary subbasin land-use patterns.

Table 5. Significant drainages in Liberty Bay with corresponding sizes and land-use patterns.

Subwatershed	Approximate mainstem length in miles	Primary land use
Little Scandia Creek	2	Rural-residential/agricultural
Big Scandia Creek	4	Rural-residential/agricultural
Bjorgen Creek	1.5	Suburban/rural-residential
Daniels Creek	1.5	Rural-residential/agricultural
Dogfish Creek (all major tributaries included)	8	Rural- and urban-residential/agricultural/ commercial, and light industrial
Johnson Creek (major tributaries included)	4	Rural-residential/agricultural and commercial

About 80 percent of the watershed is drained by streams, and the remaining 20 percent drains directly to marine waters via seeps, overland flow, and stormwater conveyance systems (May et al., 2005).

European settlement and subsequent development in the watershed began in the late 1800s with an influx of mostly Norwegians and Swedes who harvested timber and fish and converted forest land to farmland (May et al., 2005). The human population near Liberty Bay grew quickly throughout the 1900s, and the cumulative effects of urbanization and development have caused concerns for the health of the watershed. The Poulsbo Urban Growth Area (UGA) falls within the Liberty Bay watershed. The UGA contains stream basins including Dogfish and Johnson creeks (Forsyth, 1995).

Liberty Bay was an important shellfish harvesting area until pollution and habitat degradation took its toll in the mid to late 1900s. Coast Seafoods was the largest producer of oysters in the bay, operating until the company sold its remaining holding in 1993. An approved area for shellfish harvest is currently limited to the small bay near Lemolo. In September 2012, the Suquamish Tribe made a commercial shellfish classification request for Liberty Bay to Washington Department of Health (DOH) (R. Brooks, personal communication). In response to the request, DOH is conducting studies and evaluating marine water quality data and locations of sources of pollution to determine whether a larger harvest area could be opened.

Goals and Objectives

Project goals

The results of the 2008-09 TMDL study will help Ecology and interested parties focus efforts on prioritizing pollution sources within the Liberty Bay watershed study area. The goals of the TMDL project are to:

- Attain Washington State surface water quality standards for FC bacteria.
- Evaluate existing programs and permits that are making progress toward meeting water quality standards and identify additional actions needed to meet the standards.
- Increase public awareness on the level of FC reductions required and inform watershed residents on how they can assist with solutions.
- Manage resources to control point and nonpoint pollution.

Study objectives

Objectives of the TMDL study are:

- Collect high quality FC data.
- Identify and characterize FC concentrations and loads from all major tributaries, point sources, and drainages into Liberty Bay under various seasonal and hydrological conditions, including stormwater contributions.
- Identify relative contributions of FC loading to the bay so cleanup activities can focus on the largest sources.
- Identify FC loading capacities of streams in the study area.
- Recommend FC load and wasteload allocations to protect designated uses, including *Extraordinary Primary Contact Recreation* and *Shellfish Harvesting*.

TMDL objectives

Objectives of the Liberty Bay Fecal Coliform TMDL are to:

- Establish publically-reviewed FC load and wasteload allocations to protect beneficial uses including *Extraordinary Primary Contact Recreation* and *Shellfish Harvesting*.
- Prescribe BMPs and other corrective actions for local governments, watershed residents, and permittees to meet FC water quality standards.

- Establish a schedule for Liberty Bay water bodies to meet water quality standards for FC bacteria.
- Establish baseline water quality conditions from which to compare future conditions and identify trends.
- Periodically assess water quality monitoring results and evaluate need to adjust, accelerate, or intensify BMPs to control bacteria sources.

Information and Data from Sources Outside of Ecology

A number of other state and local entities are involved and have a vested interest in improving bacterial water quality in Liberty Bay. This section (1) summarizes these entities and the data they have collected, and (2) describes relevant source cleanup efforts within Liberty Bay and its watersheds. Recent data from these entities is also referenced in Appendix M, "*Current Water Quality.*"

Washington State Department of Health, Shellfish Program

The mission of the state Department of Health (DOH) Shellfish Program is "…to improve the health of people in Washington State by ensuring molluscan shellfish are safe to eat" (DOH, 2011a). DOH's program follows protocols established under the National Shellfish Sanitation Program (NSSP). This program prescribes methods to evaluate FC levels at marine water sampling stations to classify shellfish growing areas. DOH uses Systematic Random Sampling (SRS), which uses a minimum of the last 30 samples collected periodically for FC analysis. The targets used for analysis of samples using the SRS method are the marine criteria: the 90th percentile cannot exceed 43 cfu/100 mL, and the geometric mean cannot exceed 14 cfu/100 mL. If these criteria are exceeded in the most recent 30-sample analysis, a harvest closure is imposed and shellfish harvesting is prohibited in the area represented by that station (Lennartson, 2005).

Threatened or *Concerned* shellfish area status is generally based on water quality but may also be based on proximity to identified pollution sources. Potential bacteria pollution sources in Liberty Bay include four marinas located in the bay. DOH's sampling station #498 located northwest of Lemolo is classified as *Prohibited based on proximity to marinas*. Shellfish growing areas are designated *Threatened* when a sampling station's 90th percentile is between 30 and 43 cfu/100 mL. *Concerned* status is assigned when a water sampling station's 90th percentile is greater than 20 cfu/100 mL, but less than 30 cfu/100 mL.

DOH started sampling FC bacteria in Liberty Bay in the early 1960s and in the *Approved* (shellfish harvesting is allowed) section of Liberty Bay near Lemolo six times per year since 1988 (Figure 5). DOH uses the most probable number (MPN) method to analyze its marine water samples and count FC organisms. The MPN method uses tube fermentation procedures to estimate the FC density in water, based on probability theory. The MPN procedure indicates the presence or absence of an approximate number of FC organisms, while the membrane filtration (MF) method isolates and counts all the discrete colonies of bacteria after filtering the sample water and incubating the filter. The MPN method is most often used in marine waters because of regulatory and other reasons, and the MF method is typically used in freshwaters. Ecology used the MF method in its Liberty Bay freshwater tributary sampling.

Currently, the only approved shellfish harvest area in Liberty Bay is the area near the community of Lemolo known as Lemolo Bay (Figure 5). DOH's 2009 classification status for Lemolo Bay was "Meets standards but some concerns." In 2010, the classification status was upgraded to "Well within classification standards." (DOH, 2011b). Table 6 lists DOH sampling stations in Lemolo Bay with harvest classifications and FC data summaries. Figure 6 shows the most recent (1998-2010) twelve-year trend in FC pollution at DOH sampling station 501 in Lemolo Bay. One of DOH's samples in late 2005 had relatively high FC compared to other samples in the data record which caused the significant increase in the 90th percentile shown in Figure 6. The 90th percentile decreased significantly in 2010 when the high sample value dropped off the 30-sample data set.

Table 6. DOH's summary of shellfish growing areas; FC study results (#/100 mL) for Lemolo Bay, March 2006 to December 2010.

Station Number	Number of Samples	Range	Geometric Mean	Est. 90th Percentile	Meets Standard	Classification
498	30	1.7 - 23	2.9	7	Yes	Prohibited*
499	30	1.7 – 49	3.9	15	Yes	Approved
500	30	1.7 - 17	2.6	7	Yes	Approved
501	30	1.7 – 23	3.2	9	Yes	Approved

*Prohibited because of proximity to marinas.
SRS criteria require a minimum of 30 samples from each station.
Source: DOH; Annual Growing Area Review, 2010

Most of the western and southern parts of Liberty Bay are designated "unclassified" for shellfish harvesting. The Dogfish Creek estuary forming the north end of the bay, and the eastern portion adjacent to the city of Poulsbo, are classified as "prohibited" for shellfish harvest. In addition, a small (~2,000 feet) shoreline area on the north and east shores of the Keyport Peninsula is designated "preliminary marina closure zone." Regardless of shellfish harvest classification by DOH, the entire bay is protected in state water quality standards for the designated beneficial use of shellfish harvesting.

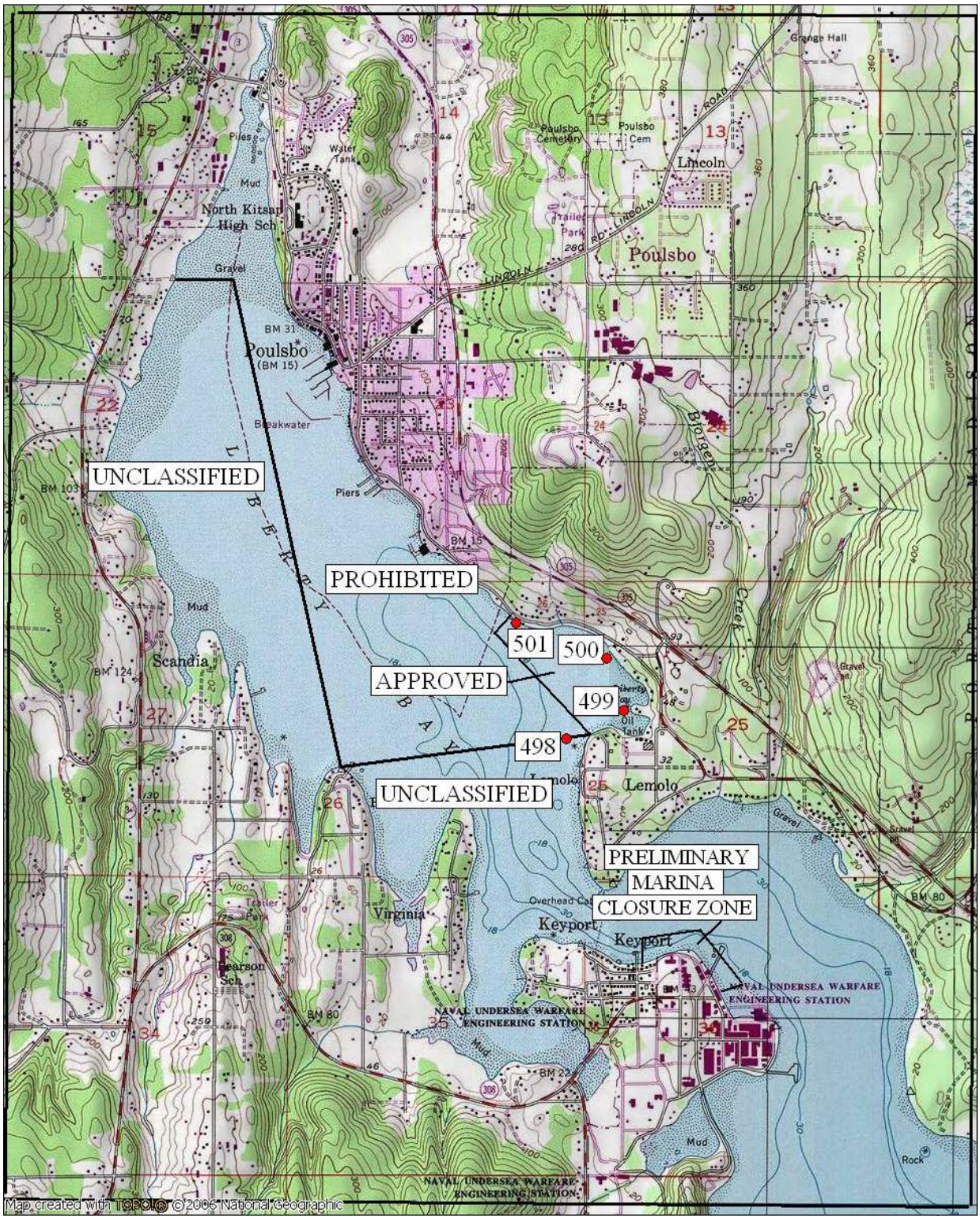


Figure 5. DOH classifications for harvesting shellfish in Liberty Bay with DOH sampling sites shown (DOH, 2011b).

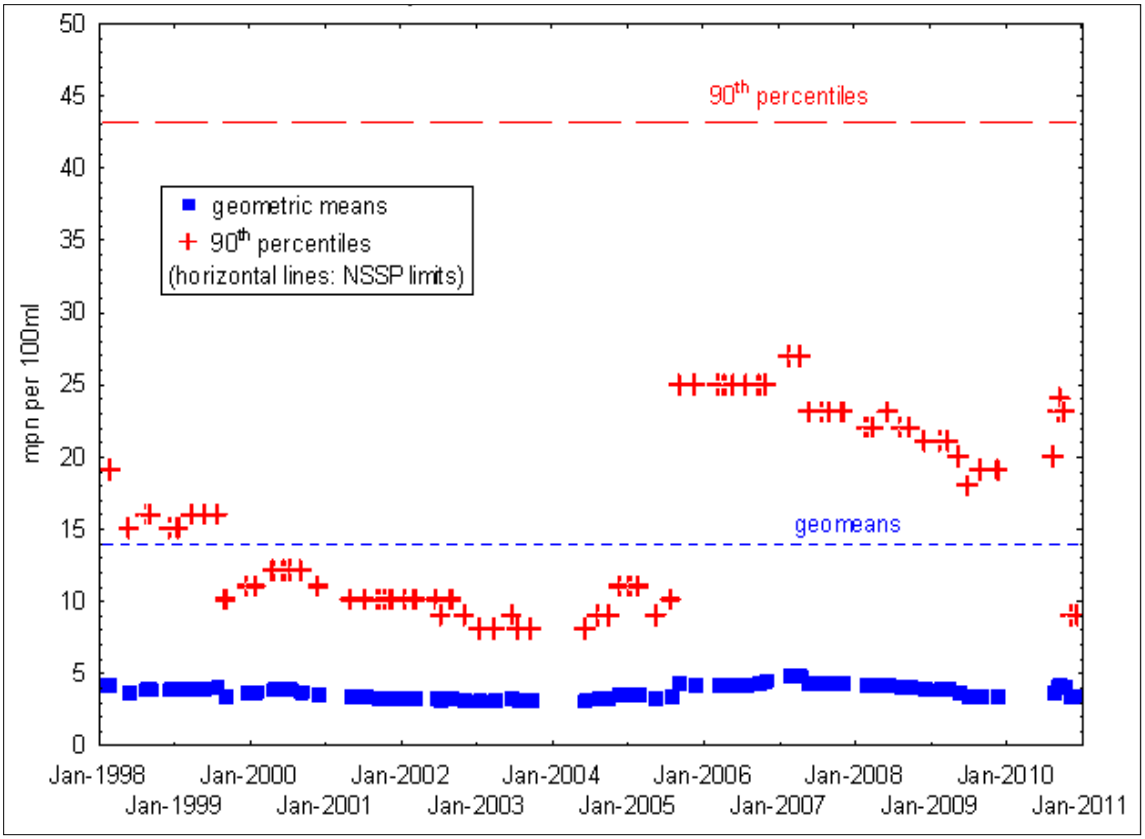


Figure 6. Recent FC trend at DOH's marine station 501-Lemolo.
MPN = most probable number.

Kitsap Public Health District

The Kitsap Public Health District (KPHD) has sampled FC in Liberty Bay and its tributaries monthly since 1996. Their purpose is to "protect public health by identifying Kitsap County surface waters impaired by bacterial contamination, prioritizing them for cleanup, and conducting pollution identification and correction projects to identify and correct sources of pollution (typically failing on-site sewage systems and animal waste)" (KPHD, 2011b). Figure 2 shows the locations of KPHD's 2011 monitoring sites in Liberty Bay and Miller Bay and their tributaries. For more information, see KPHD's 2011 Water Quality Monitoring Report (KPHD, 2011a).

Major Liberty Bay subwatersheds, their respective FC trends, and 2009-11 annual geometric mean values are listed in Table 7 based on KPHD data. Ecology calculated 90th percentiles for the same KPHD Liberty Bay stream data for water years 2009-11. Results are in Appendix K, Table K-1. *Stationary* and *Improving* are terms KPHD used in their 2011 report to describe water quality trends. KPHD used the MPN method to enumerate FC organisms in their water samples until January 2010 when they switched to the MF method.

Table 7. Significant drainages to Liberty Bay with corresponding FC trends and geometric mean values.

Data based on KPHD monthly sampling from water year[2] 2009 through water year 2011.

Subwatershed	Long-term* water quality trend	Short-term** water quality trend	2009	2010	2011
			FC geometric mean (cfu/100 mL)		
Little Scandia Creek	stationary	stationary	196	125	83
Big Scandia Creek	stationary	stationary	67	52	39
Bjorgen Creek	stationary	stationary	76	62	49
Daniels Creek	improving	stationary	67	65	49
Dogfish Creek (all tributaries included)	improving	stationary	52	54	31
Dogfish Creek, South Fork	stationary	stationary	95	97	38
Johnson Creek	improving	stationary	27	19	10

* Includes all data collected for that site since 1996.
** Includes last three years of data.

In the 2011 Water Quality Monitoring report, KPHD pointed out that Liberty Bay water quality was generally poor in many streams, but with improvements in some areas. Little Scandia Creek was the only stream in the watershed that was polluted enough to cause the Health District to advise against public contact in 2010 (KPHD, 2011a). More recently, the Health District's 2012 Water Quality Monitoring Report listed Little Scandia Creek as one of five streams in Kitsap County that had significant decreasing bacteria levels and one of three streams where public health advisories were lifted in 2012 because of improved water quality (KPHD, 2013). Continued improvement is expected as pollution reduction projects are performed by the Health District and other agencies.

KPHD also regularly samples bacteria at seven marine sites in Liberty Bay and one site in Port Orchard Passage (Figure 2). KPHD's Water Quality Monitoring Report for 2011 states, "All marine stations in this watershed passed the state FC standard in the last year. Liberty Bay marine waters as a whole are showing a significant improving trend." (KPHD, 2011a). Ecology calculated geometric means and 90th percentiles for KPHD Liberty Bay marine data for water year 2011. Results are in Appendix K, Table K-2.

From 2009-11, commercial stormwater systems were inspected throughout Kitsap County as part of the *Kitsap Regional Illicit Discharge Detection and Elimination Clean Runoff Centennial Stormwater Project*. Within the city of Poulsbo, 311 commercial properties were inspected, 109 storm water structures were determined to be deficient and received required maintenance, and 14 illicit discharges were confirmed and corrected (KPHD, 2011a).

[2] Water year = October 1st of one calendar year through September 30th of the following year.

In summer 2009, Kitsap County started the *Liberty Bay Restoration PIC Project*, which includes additional stream monitoring as well as inspecting 15 miles of shoreline and approximately 1,100 properties for pollution sources. Kitsap Public Health District's 2011 Water Quality Monitoring Report states "To date, four full shoreline inspections have been completed, and investigations of sites with high bacteria levels are in progress. Inspections have been completed on 679 properties, and 34 onsite septic system failures identified. The *Liberty Bay Marina Study* was also conducted during the summer of 2010." (KPHD, 2011).

The Health District's marine sampling station LB05 is located in the northeast portion of Liberty Bay near the Poulsbo Yacht Club marina and the outlet of Poulsbo Creek (Figure 2). KPHD has monitored station LB05 for over eight years and monthly geometric means for the years 2002-09 showed that FC concentrations were generally higher during the wet season than during dry season (Figure 7). Ecology also reviewed DOH data at nearby marine station (501), northwest of the mouth of Barrantes Creek (Figure 5). The monthly geometric means for station 501 for the years 1993 to 2009 also showed higher concentrations during wet season compared to dry season.

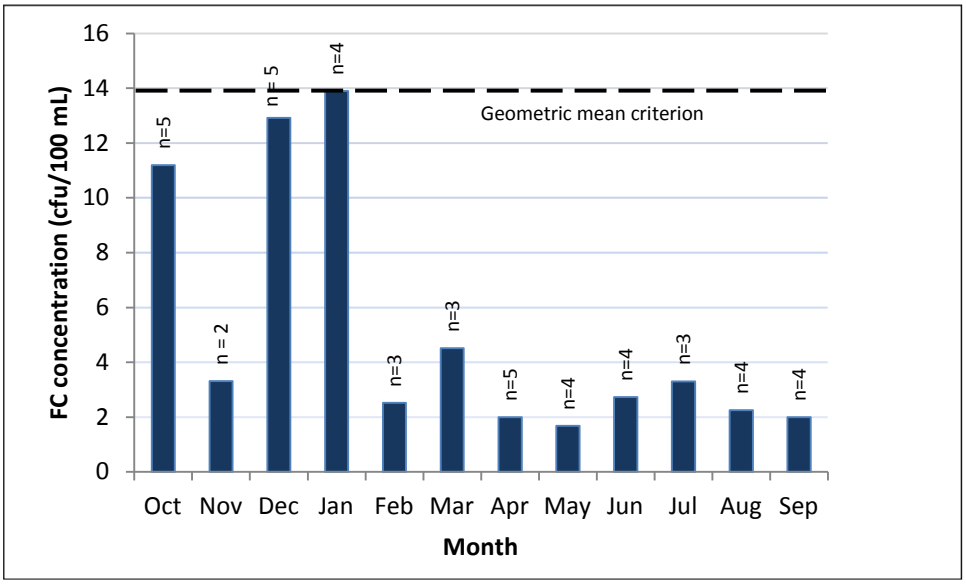


Figure 7. Monthly geomean FC concentrations at KPHD station LB05 in Liberty Bay.

Bars represent the geometric mean of KPHD samples at station LB05 (2002 to 2009). The number above each bar is the number of values used to calculate the geometric mean.

The *Liberty Bay/Miller Bay Watershed Nonpoint Source Pollution Baseline Water Quality Assessment* was released by KPHD in 1995. During the Assessment study, KPHD performed "wet condition events" FC loading analyses on Dogfish, Daniels, Big Scandia, Little Scandia, and Johnson creeks (Forsyth, 1995). Data from the two wet events showed that these creeks contributed higher FC concentrations and loading to Liberty Bay during rain and runoff events than during dry conditions. While Dogfish Creek and the Liberty Bay watershed have been altered with additional development and stormwater controls since 1995, this study confirms that runoff during wet conditions can be a major contributor of bacteria to the tributaries and bay.

Continued water quality improvements are expected in response to fecal coliform pollution source reduction projects undertaken by Kitsap Public Health District, mostly in the Dogfish Creek system, but also in Daniels Creek and other streams with KPHD pollution source control efforts. Improvements are also expected in stormwater discharges from the city of Poulsbo as the city continues to refine its stormwater management program.

Liberty Bay Nearshore Habitat Evaluation and Enhancement Project

The Lemolo Citizens Club and Liberty Bay Foundation published the *Liberty Bay Nearshore Habitat Evaluation and Enhancement Project* final report in 2005 (May et al., 2005). Among other topics, the report detailed the project's water, sediment, and biological monitoring in Liberty Bay and its tributaries. The Lemolo Citizens Club and Liberty Bay Foundation study intentionally designed marine and freshwater bacteria sampling events to occur in the wet season, unlike Ecology and Health District random periodic sampling. Wet-season FC results from 2001 to 2003 showed significant FC pollution from all creeks, stormwater outlets, and marine stations sampled. For a more comprehensive summary of FC results for this project, see the final report (May et al., 2005).

Figure 8. Liberty Bay waterfront near Poulsbo.

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Study Methods

Data collection and quality

The Quality Assurance (QA) Project Plan (Swanson, 2009) for this study describes procedures used to collect and analyze field measurements and water samples. A total of 23 fixed regularly sampled sites in the Liberty Bay watershed were sampled for FC bacteria twice monthly from August 2008 through August 2009 (Figure 2 and Table 10). Fourteen sampling sites were added to investigate possible sources of FC bacteria (Figure 2 and Table 11). Fecal coliform bacteria were analyzed in the Manchester Environmental Laboratory (MEL) located in Manchester near Port Orchard. All sampling procedures and protocols for bacteria complied with the QA Project Plan.

Flows were taken with a Marsh McBirney Flow-Mate flow meter. All procedures and protocols for flow complied with the QA Project Plan. Other parameters measured in the field included temperature and conductivity. Ecology used a Yellow Springs Instruments (YSI) temperature/conductivity multiprobe to measure temperature and conductivity.

Conductivity was not used to set TMDL targets, but was measured to ensure that Ecology sampled only freshwater at the mouths of creeks and to get a rough idea of longitudinal conductivity patterns in streams. Because use of the conductivity data was limited, there was some deviation from the QA Project Plan for conductance measurements:

- All replicates passed the field replicate quality objectives stated in the QA Project Plan, but this information was not recorded.
- Frequent instrument calibrations were deemed unnecessary. Instead, the YSI multiprobe was calibrated with certified conductivity standards at the beginning, middle, and end of the project. Because of the lack of continuous calibration data, conductivity results have been qualified as estimates.

Temperature instruments were factory calibrated and could not be calibrated in the field. Ecology compared the YSI temperature meter against a National Institute of Standards and Technology certified thermometer and found that it was within +/- 0.2 degree C. Field replicate temperature measurements were taken, but not recorded. Frequent instrument checks and replicates were deemed unnecessary to meet measurement quality objectives. Temperature results were not marked as estimates.

There were no storm events captured that met criteria for storm sampling set forth in the QA Project Plan. However, other rain events that randomly occurred during the study were used to better characterize wet conditions bacteria loading in the watershed under runoff conditions.

The QA Project Plan (Swanson, 2009) stated that Keyport Creek may be sampled if resources allowed. Ecology decided to investigate this creek due to its proximity to Nesika and Liberty bays and the possibility for fecal contamination. Investigation samples were taken in Keyport Creek during January, February, and March 2009, and Ecology began sampling on a regular basis in May 2009.

Data analysis methods

The rollback method

Ecology used the Statistical Rollback Method (Ott, 1997) to determine if FC sample distribution statistics for individual sites in the Liberty Bay watershed met water quality criteria and to set stream targets for the TMDL. The method has been applied by Ecology in other bacteria TMDL evaluations (Cusimano and Giglio, 1995; Pelletier and Seiders, 2000; Joy, 2000; Coots, 2002; Joy and Swanson, 2005; Swanson, 2008).

Ideally, at least 20 samples taken throughout the year are needed from a broad range of hydrologic conditions to determine an annual FC distribution. If sources of bacteria vary significantly by season and create distinct critical conditions, seasonal targets may be required. Fewer data provide less confidence in bacteria reduction targets, but the rollback method is robust enough to provide general targets for planning implementation measures using smaller data sets. Compliance with the most restrictive of the dual bacteria standard criteria determines the bacteria reduction needed at a stream sampling site.

The rollback method is applied as follows:

> *The geometric mean (approximate median in a log-normal distribution) and 90th percentile statistics are calculated and compared to the FC criteria. If one or both do not meet the criteria, the whole distribution is "rolled-back" to match the more restrictive of the two criteria. The 90th percentile criterion usually is the most restrictive.*

The rolled-back geometric mean or 90th percentile FC value then becomes the recommended *target* FC value for the site. The term *target* is used to distinguish these estimated numbers from the actual water quality criteria. The degree to which the distribution of FC counts is *rolled-back* to the target value represents the estimated percent of FC reduction required to meet the FC water quality criteria and *Extraordinary Primary Contact Recreation* water quality standards. For more details of the statistical rollback method, see Appendix G.

The TMDL targets for bacteria are only in place to assist water quality managers in assessing the progress toward compliance with the bacteria water quality criteria. Compliance is ultimately measured as meeting both parts of the water quality standards criteria. Any water body with FC TMDL targets is expected to (1) meet both the applicable geometric mean and "not more than 10 percent of the samples" criteria, and (2) protect designated uses for the category.

Results and Discussion

Quality assurance results

Streamflow measurements and membrane filtered FC samples met the quality criteria outlined in the Liberty Bay QA Project Plan (Swanson, 2009) and are of adequate quality to use in the TMDL analysis. Temperature and conductivity measurements (Appendix I) were not used to set TMDL allocations and, therefore, were not analyzed for quality (see Ecology Study Methods section).

Laboratory duplicates

Duplicate laboratory analysis refers to analyzing duplicate aliquots in the lab taken from a single sample container. The results for laboratory duplicates provide an estimate of lab analytical precision, including the homogeneity of the sample matrix (MEL, 2008). The measurement quality objective (MQO) used by Ecology's Manchester Environmental Laboratory (MEL) for membrane filtered bacteria duplicates is 40 percent average relative percent difference (RPD). The average RPD value for lab duplicate FC samples in the Liberty Bay watershed was 30.2 percent, thus the TMDL study met the MEL MQO for lab duplicates (Table 8).

Table 8. Duplicate laboratory sample statistics.

Parameter	Total # of samples including duplicates	Total # of samples less duplicates	Number of duplicates taken	Percent of total samples duplicated	MQO precision standard (RPD)	Average RPD	Meets MQO criteria?
FC	1011	951	60	6%	<40	30.2	Yes

Field replicates

Field replicate samples are two samples collected from the same location at the same time and submitted to MEL as blind pairs (no identification provided). Collecting field replicates is a method of looking at the precision of the entire process of sampling and analysis. Differences between the results of replicate samples can arise from variations in the sample location, collection process, sample containers, and/or analytical procedures (MEL, 2008).

The Liberty Bay QA Project Plan (Swanson, 2009) measurement quality objectives (MQOs) for analyzing precision in replicated bacteria samples requires that at least 50 percent of the samples be below a 20 percent relative standard deviation (RSD) and that at least 90 percent of the samples be below a 50 percent RSD (Mathieu, 2006). The RSD is the absolute value of the coefficient of variation for the replicated QA samples. None of the samples used to assess the MQO should have a mean concentration of 20 cfu/100 mL or less.

Ecology collected 197 FC replicates in 2008-09 for the Liberty Bay TMDL project. Of these, 161 FC samples had a mean concentration above 20 cfu/100 mL and were therefore used to assess if the MQO was met. A total of 63 percent of the replicate pairs were below 20 percent RSD and 93 percent were below 50 percent RSD. Membrane filtered FC samples met Ecology's MQO Quality Assurance (QA) precision criteria (Table 9).

Table 9. Replicate field sample statistics.

FC count	Precision Standard	Total # of samples including replicates	Number of replicates taken	Total # of samples less replicates	% total samples replicated	Average % RSD	Meets MQO criteria?
FC < or = 20 cfu/100mL	NA	250	36	214	21	30.5	NA
FC >20 cfu/100mL	at least 50% of replicate samples must be <20% RSD and 90% <50% RSD	701	161	540		19.9	Yes

Data analysis

All bacteria data collected during the 2008-09 monitoring period are shown in Appendix H: Bacteria Results, Tables H-1 to H-3. Conductivity, temperature, and flow data are shown in Appendix I: Field Results. Station locations are described in Tables 10 and 11 and numbered station locations are shown in Figure 3. Tables 10 and 11 also show annual geometric means and 90th percentiles calculated from data collected at each sampling station.

Regular sampling events were scheduled at random periodic intervals to obtain calculated values that represent general water quality conditions. Targeted or non-random sampling events may act to skew the geometric means and 90th percentiles. Therefore, special dry-period and storm-event sampling results were not included in the data used to calculate geometric means, 90th percentiles, or recommended load reductions. These results can be seen in Appendix H, Table H-3.

Data for this project are also available at Ecology's (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, TSWA0002.

Table 10. Description and summary statistics for FC bacteria (cfu/100mL) at regularly sampled sites in the Liberty Bay watershed (2008-09).

Shaded cells indicate sites where freshwater criteria were not met.

Site ID w/ stream mile	Map #	Site description	n	Min	Max	Geo-metric mean	90th percen-tile
Dogfish Creek							
15-DOG-0.6	1	Mainstem behind dental office on Bond Rd., downstream of HWY 305 crossing	26	11	390	56	218
15-SFD-0.0	2	South fork at Bond Rd. and 1st Ave., 50 ft. downstream of culvert	26	9	1000	83	447
15-SFD-1.3	3	South fork at 8th Ave. and Iverson, upstream side of culvert	26	1	640	68	467
15-EFD-0.0	4	East fork at Little Valley Rd., downstream side of culvert	26	2	890	47	405
15-EFD-1.2	5	East fork off Bond Rd. at Pugh Rd.,upstream side of culvert	26	3	300	28	151
15-WFD-0.0	6	West fork at Little Valley Rd., downstream side of culvert	26	3	1300	45	229
15-WFD-0.9	7	West fork at first Big Valley Rd. crossing near Living Waters Farm, up of culvert	26	1	510	24	188
Johnson Creek							
15-JOH-0.1	8	Mainstem south of Norfin Ln., 200ft. downstream of tributary	26	1	220	18	165
Big Scandia Creek							
15-BSC-0.0	9	Mainstem at mouth near the end of Scandia Ct. at private property. Trail to ck.	26	2	380	55	351
15-BSC-0.1	10	Mainstem at Scandia Rd, upstream side of bridge	26	2	340	48	340
15-BSC-1.1	11	Mainstem at HWY 308 between Viking Way and Cox Ave., downstream of culvert	26	1	500	28	300
15-BSC-1.6	12	Mainstem at HWY 308 just west of Cox Ave., upstream side of culvert	26	1	340	31	245
Little Scandia Creek							
15-LSC-0.1	13	Mainstem at Scandia Rd. behind church, upstream side of culvert	26	3	2600	224	1545
15-LSC-0.4	14	Mainstem at Blomster Way, upstream side of culvert	26	3	920	73	643
Daniels Creek							
15-DAN-0.0	15	Mainstem off HWY 308, near residence at 14510, upstream side of culvert	26	9	1200	102	775
15-DAN-0.2	16	Mainstem at Virgina Loop Rd., approximately 30ft. below culvert	26	1	940	40	556
Perry Creek							
15-PER-0.1	17	Mainstem at 90 deg. right turn in Thorpe Rd. upstream side of culvert	26	3	8000	102	996
Sam Snyder Creek							
15-SAM-0.1	18	Mainstem at Lemolo Shore Dr., downstream side of culvert (dry during dry season)	14	1	54	9	54
Lemolo Creek							
15-LEM-0.1	19	Mainstem at Lemolo Shore Dr. east of Delate Rd. Access from first private drive east of creek, 75 ft. upstream of culvert	26	1	960	32	448
Bjorgen Creek							
15-BJO-0.1	20	Mainstem at Lemolo Shore Dr. by market, downstream side of culvert	26	4	6700	77	1070
Barrantes Creek							
15-BAR-0.0	21	Mainstem at Lemolo Shore Dr. downstream of culvert. Sample at low tide	24	1	810	48	450
Unnamed Tributaries to Liberty Bay							
15-UNN-0.1	22	Trib. east of Daniels Ck. at Hwy 308 near "Support Our Troops" sign. 30ft.upstream of culvert	24	1	240	20	178
15-UNN-0.0	23	Trib. flowing into bay right next to Daniels Ck. mouth. Sample at low tide.	21	1	9700	60	1803

Note: Special dry-period survey and storm-event data were not included in the analysis.

Table 11. Description and summary statistics for FC bacteria (cfu/100mL) at investigation sites in the Liberty Bay watershed (2008-09).

Shaded cells indicate sites where freshwater criteria were not met.

Site ID w/ stream mile	Map #	Site description	n	Min	Max	Geo-metric mean	90th percen-tile
Investigation sites							
15-PET-0.0	24	Tributary east of Perry Ck. at Thorpe Rd. Sample at low tide above culvert. Dry during dry season.	13	3	190	43	199
15-JEA-0.0	25	South end of Legion Park, below playground. Poulsbo outfall OF-3703.	20	1	2900	84	1163
15-DON-0.0	26	Poulsbo Creek at Poulsbo Yacht Club. Poulsbo outfall OF-5304.	17	1	5200	74	1206
15-STORM-1	27	Storm drain at the south end of American Legion Park. Below the Gran Kirk, Martha and Mary, and Front St. Poulsbo outfall OF-3702.	4	160	1500	724	2714
15-STORM-2	28	North end of Legion Park, below driveway turnaround. Poulsbo outfall OF-3701.	4	32	2100	586	7202
15-UN3-0.0	29	Small, unnamed stream flowing into Dogfish Bay, east of 15-UNN-0.1.	1	27	27	-	-
15-BST-0.0	30	Small unnamed seasonal stream flowing into Liberty Bay ~300 feet east of Big Scandia Creek.	12	8	2900	134	1109
15-KE1-0.2	31	Small, unnamed ck. near Keyport Ck (1st trib. at Brownsville Hwy, traveling south).	10	1	1600	162	3156
15-KE2-0.3	32	Keyport Creek (2nd trib. at Brownsville Hwy, travelling south).	10	2	970	60	729
15-JOH-T	33	Trib. to Johnson Creek above 15-JOH-0.1, at Viking Way. Sample down of culvert.	4	1	150	9	154
15-BOV-0.0	34	Trib to Liberty Bay between Bovela St. and Bay St. Poulsbo outfall OF-3706.	10	23	900	174	799
15-LMK-0.0	35	Small, intermittent stream off Virginia Lp. Rd. NE at private property.	5	45	6000	439	6700
15-NEL-0.0	36	Nelson Park bioswale at beach. Poulsbo outfall OF-3502.	10	46	3300	714	4273
15-RET-0.0	37	Small, unnamed ck. flowing through assisted living facility property off Viking Way in Poulsbo, near Bovela St. Sample at beach. Poulsbo outfall OF-3704.	10	54	2300	461	1698

Note: Special dry-period survey and storm-event data were not included in the analysis.

Table 12 shows streams from Tables 10 and 11 in order of highest to lowest geometric mean FC concentrations. Corresponding 90th percentile statistics are also shown for each stream. Table 13 shows estimated average (arithmetic mean) annual loading to Liberty Bay for each tributary for comparison purposes. The estimated average annual loading was calculated by adding the daily loading values from each sampling event and then dividing the total by the number of sampling events.

The streams with the largest average (arithmetic mean) annual streamflows, in order of largest to smallest, were Dogfish, Johnson, Big Scandia, Bjorgen, and Poulsbo creeks. For individual streamflow values, see Appendix I: Field Results.

Table 12. Geometric mean fecal coliform data from Tables 10 and 11 in descending order.

Site ID with River Mile	Site Location Summary	Geometric Mean	Estimated 90th Percentile
15-NEL-0.0	Nelson Park bioswale at beach. Poulsbo outfall OF-3502.	714	4273
15-RET-0.0	Small, unnamed ck. flowing through assisted living facility property off Viking Way in Poulsbo, near Bovela St. Sample at beach. Poulsbo outfall OF-3704.	461	1698
15-LMK-0.0	Small intermittent stream off Virginia Loop Rd NE at private property	439	6700
15-LSC-0.1	Little Scandia Ck at Scandia Rd.	224	1545
15-BOV-0.0	Trib to Liberty Bay between Bovela St. and Bay St. Poulsbo outfall OF-3706.	174	799
15-KE1-0.2	Small unnamed ck N of Keyport Ck	162	3156
15-BST-0.0	Small unnamed seasonal ck flowing to Lib Bay ~300 ft E of Big Scandia Ck	134	1109
15-PER-0.1	Perry Ck at 90 deg. right turn in Thorpe Rd.	102	996
15-DAN-0.0	Daniels Ck off HWY 308	102	775
15-JEA-0.0	South end of Legion Park, below playground. Poulsbo outfall OF-3703.	84	1163
15-BJO-0.1	Bjorgen Ck at Lemolo Shore Dr.	77	1070
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club. Poulsbo outfall OF-5304.	74	1206
15-DOG-0.0	Dogfish Creek at mouth [3]	69	245
15-UNN-0.0	Trib to bay next to Daniels Ck mouth.	60	1803
15-KE2-0.3	Keyport Creek (southern of two creeks flowing under Brownsville Highway west of Navy facility)	60	729
15-BSC-0.0	Big Scandia Ck at Scandia Ct. at private residence	55	351
15-BAR-0.0	Barrantes Ck at Lemolo Shore Dr.	48	450
15-PET0.0	Trib E of Perry Ck at Thorpe Rd	43	199
15-LEM-0.1	Lemolo Creek at Lemolo Shore Dr.	32	448
15-UNN-0.1	Unnamed Ck E of Daniels Ck. at HWY 308	20	178
15-JOH-0.1	Johnson Ck 400 ft. south of Norfin Rd.	18	165
15-SAM-0.1	Sam Snyder Ck at Lemolo Shore Dr.	9	54

The Nelson Park bioswale near the very north end of Liberty Bay (15-NEL-0.0) had the highest geometric mean (714 cfu/100mL) of the TMDL stream sampling sites based on 10 samples taken at that site (Table 12). It should be noted that the relatively low flow in the bioswale resulted in low estimated loading to Liberty Bay (Table 13). Since the TMDL 2008-09 study, the Nelson Park outfall was sampled as part of the Liberty Bay Restoration Project in 2009-10 and the city of Poulsbo refurbished the bioswale and cleaned out sediment in all the park catch basins in 2011. The bioswale control structure was full of sediment and was also cleaned out in 2011 (Figure 9). Sampling results from the Nelson Park bioswale dramatically dropped in late 2011 following the restoration and cleaning (Jones, 2011).

Table 13 is similar to Table 12, but lists the regularly monitored sites in order of estimated highest to lowest daily loads of bacteria, rather than by highest to lowest concentrations of bacteria.

[3] 15-SFD-0.0 FC concentration data was flow-weighted and added to DOG-0.6 and called 15-DOG-0.0.

Figure 9. Nelson Park bioswale near its outlet to Liberty Bay.

Table 13. Average annual fecal coliform loading data in descending order.

Site ID with River Mile	Site Location Summary	Load (billions cfu/day)
15-DOG-0.0	Dogfish Creek at mouth [4]	33
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club. Poulsbo outfall OF-5304.	17
15-BSC-0.0	Big Scandia Ck at Scandia Ct. at private res.	7.0
15-BJO-0.1	Bjorgen Ck at Lemolo Shore Dr.	4.7
15-JOH-0.1	Johnson Ck 400 ft. south of Norfin Rd.	3.2
15-LSC-0.1	Little Scandia Ck at Scandia Rd.	2.9
15-BST-0.0	Small unnamed seasonal ck flowing to Lib Bay ~300 ft E of Big Scandia Ck	2.8
15-JEA-0.0	South end of Legion Park, below playground. Poulsbo outfall OF-3703.	2.2
15-LEM-0.1	Lemolo Creek at Lemolo Shore Dr.	1.8
15-KE1-0.2	Small unnamed ck N of Keyport Ck	1.5
15-DAN-0.0	Daniels Ck off HWY 308	1.5
15-KE2-0.3	Keyport Cr (southern of two creeks flowing under Brownsville Hwy W of Navy fac.)	1.3
15-RET-0.0	Small, unnamed ck. flowing through assisted living facility property off Viking Way in Poulsbo, near Bovela St. Sample at beach. Poulsbo outfall OF-3704.	1.1
15-PER-0.1	Perry Ck at 90 deg. right turn in Thorpe Rd.	1.0
15-NEL-0.0	Nelson Park bioswale at beach. Poulsbo outfall OF-3502.	0.93
15-UNN-0.0	Trib to bay next to Daniels Ck mouth.	0.76
15-BOV-0.0	Trib to Liberty Bay between Bovela St. and Bay St. Poulsbo outfall OF-3706.	0.61
15-LMK-0.0	Small intermittent stream off Virginia Loop Rd NE at private property	0.46
15-SAM-0.1	Sam Snyder Ck at Lemolo Shore Dr.	0.31
15-UNN-0.1	Unnamed Ck E of Daniels Ck. at HWY 308	0.20
15-BAR-0.0	Barrantes Ck at Lemolo Shore Dr.	0.18
15-PET-0.0	Trib E of Perry Ck at Thorpe Rd	0.10

[4] 15-SFD-0.0 FC concentration data was flow-weighted and added to DOG-0.6 and called 15-DOG-0.0.

Perennial streams

Figures 10 to 12 show two-sample (four samples in August) monthly averages (arithmetic mean) of FC concentrations, streamflows, and loading for perennial creeks from Table 10 that were regularly sampled. The WRIA "15-" identifier was dropped from the site IDs in the legends for these figures for simplification purposes. Figures 10 to 12 are intended for visualizing rough seasonal differences on a watershed scale. Two regularly sampled sites – Sam Snyder and Barrantes creeks – were not included since they were small and intermittent. Sam Snyder and Barrantes creeks generally flow year-round; water year 2009 was an aberration with unusually low flows. Only data from the farthest downstream regularly sampled sites were included for each stream shown in Figures 10-12. See Appendix J for detailed, stream-specific seasonal charts of flow, concentration, and loading at each creek.

To represent conditions in the Dogfish Creek watershed, SFD-0.0 flow and loading data were added to DOG-0.6 and called DOG-0.0 in Figures 10-12. SFD-0.0 is the most downstream station on South Fork Dogfish Creek, and joins the mainstem of Dogfish Creek 0.15 miles downstream of DOG-0.6. Concentration data for South Fork Dogfish Creek at SFD-0.0 were also flow-weighted and added to DOG-0.6 for total concentrations at so-called site DOG-0.0, representing the mouth of Dogfish Creek. These data were added to present the total contributions from Dogfish Creek to Liberty Bay.

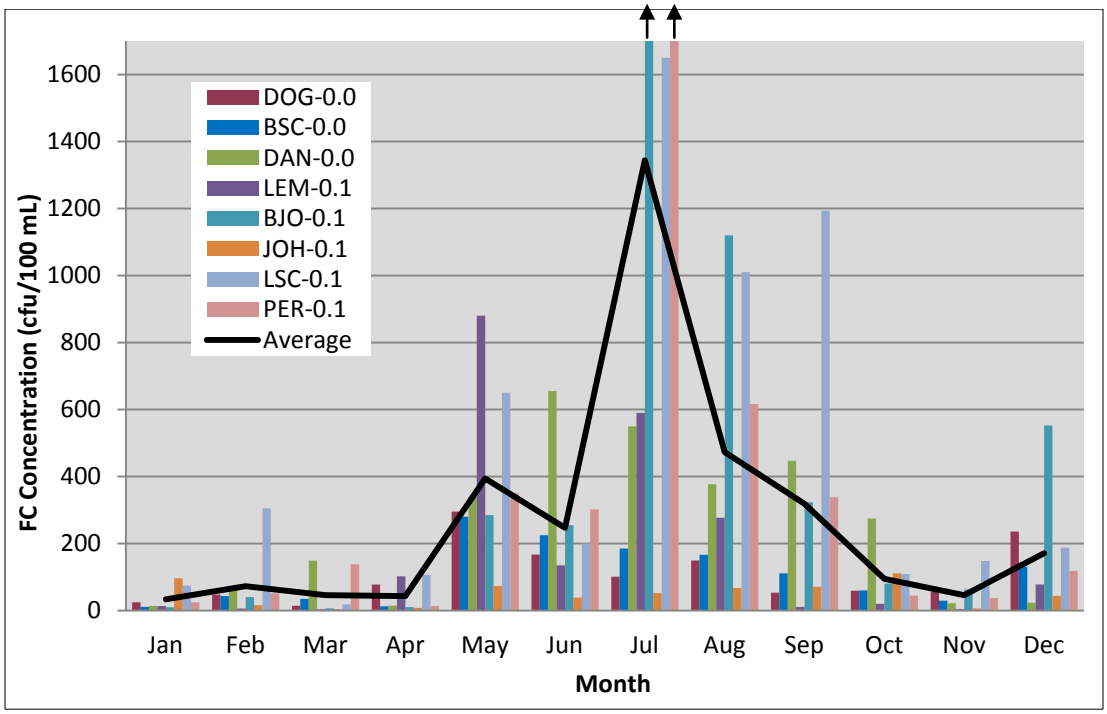

Figure 10. Two-to-four sample monthly averages of FC concentrations for perennial, regularly sampled creeks in the Liberty Bay watershed (2008-09).

Figure 10 shows that FC concentrations were generally higher in the dryer months and also elevated in May and December at some sites following rain events. The dryer months of June through October had lower flows (Figure 11), but loading was generally higher than in the

wetter months of January through April (Figure 12). In May and December, flows *and* FC concentrations were elevated, leading to higher loading during those months (Figures 11 and 12). This could have been caused by runoff and higher-than-average flows caused by rain events. See Seasonal Variation section for details. More detailed, stream-specific charts are included in Appendix J: Seasonal charts of fecal coliform concentration, flow, and loading.

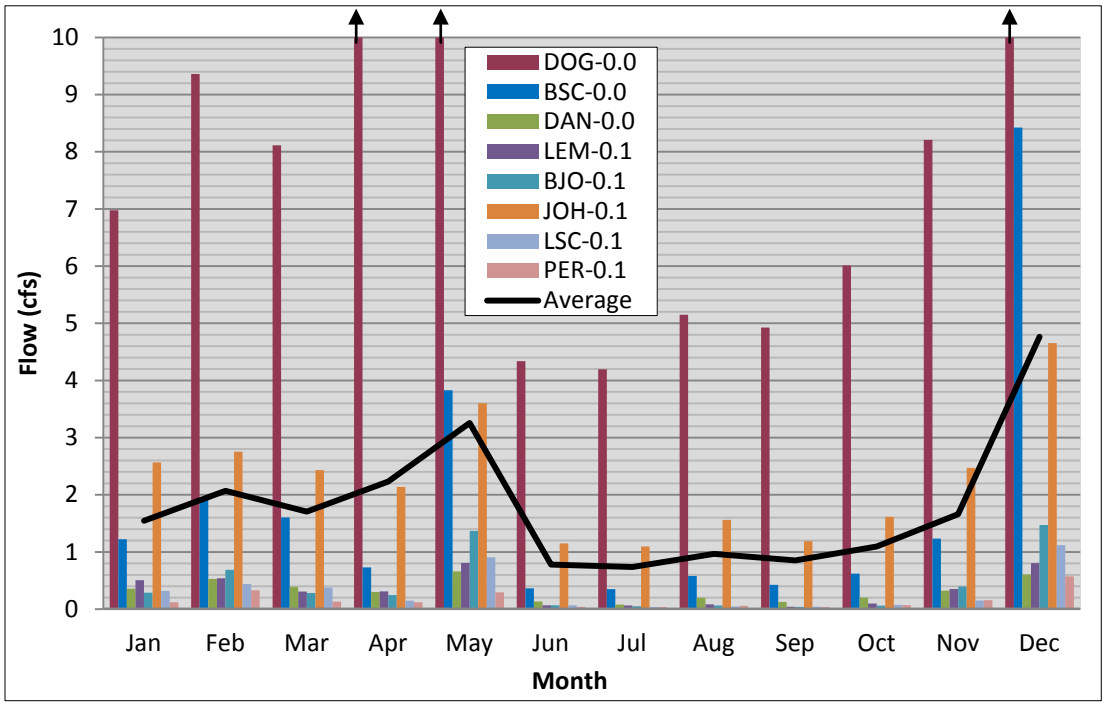

Figure 11. Two-to-four measurement monthly averages of streamflows for perennial, regularly sampled creeks in the Liberty Bay watershed (2008-09).

Dogfish Creek

The mainstem and the East and West Forks of Dogfish Creek are listed as Category 4b stream segments in Ecology's 2012 Water Quality Assessment (www.ecy.wa.gov/programs/wq/303d/WQAssessmentCats.html). Impaired water bodies are placed in Category 4b when a local, state, or federal authority is implementing a pollution control program that Ecology has determined is likely to achieve compliance with state water quality standards. South Fork Dogfish Creek has not been placed on Category 4b. Although KPHD has taken actions to improve water quality in Dogfish Creek and FC pollution has decreased as a result, the creek did not meet state water quality criteria during the TMDL study.

Ecology sampled Dogfish Creek and its major tributaries to provide supplemental data to Kitsap County and to provide seasonal FC loading data for the Liberty Bay TMDL study. Ecology did not sample mainstem Dogfish Creek below river mile (RM) 0.6 (Ecology's site DOG-0.6) because of tidal influences and because Kitsap County already had an established site at RM 0.6. South Fork Dogfish Creek was sampled at its mouth at station SFD-0.0.

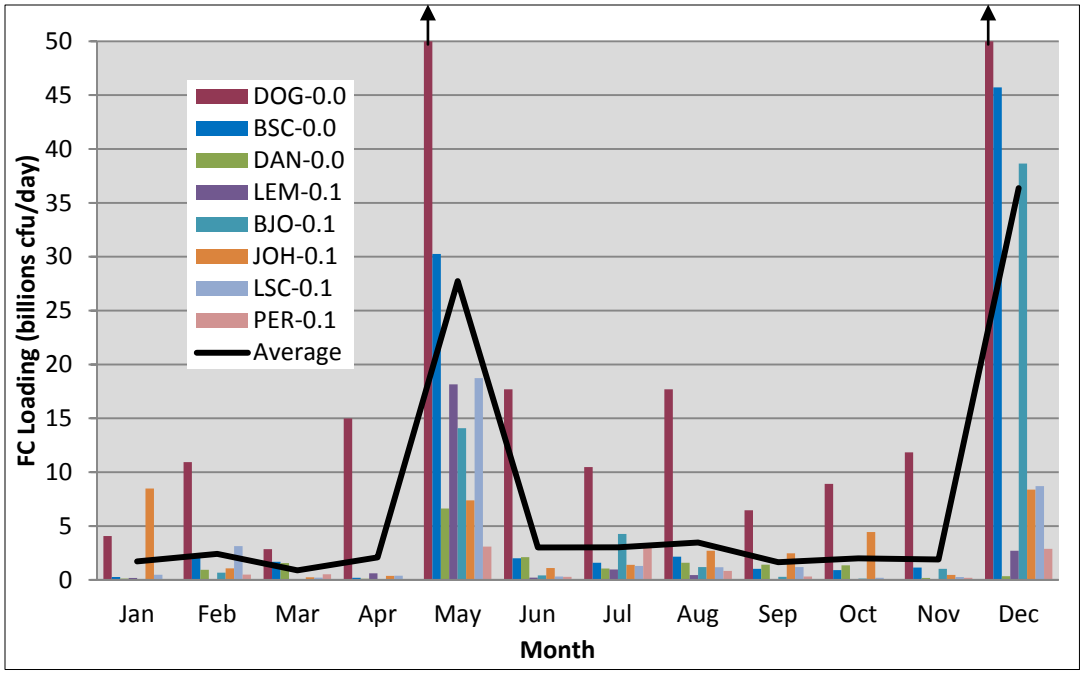

Figure 12. Two-to-four sample monthly averages of FC loading for perennial, regularly sampled creeks in the Liberty Bay watershed (2008-09).

The South Fork flows into Dogfish Creek about 0.15 miles below sampling station DOG-0.6 (Figure 2). As mentioned earlier, FC concentrations from site SFD-0.0 were flow-weighted and added to site DOG-0.6 to estimate total FC concentrations near the mouth of Dogfish Creek (DOG-0.6 + SFD-0.0 in Figure 13). Average seasonal FC concentrations near the mouth (DOG-0.6 + SFD-0.0) were relatively consistent from the dry season (Jun-Oct 2008) to the wet season (Nov 2008-May 2009) (Figure 13).

During low tide, flow at the Nelson Park bioswale site NEL-0.0 joins Dogfish Creek before entering the bay (Figure 2) but was not added to Dogfish Creek mouth (DOG-0.6 + SFD-0.0) concentrations or loads in Figures 13 and 14. At mean tide level, flow at station NEL-0.0 discharges directly into Liberty Bay near the mouth of Dogfish Creek. A small creek flowing through Fish Park enters Dogfish Creek in the tidal area below site DOG-0.6 but above station NEL-0.0. This creek (15-DOG-T) was not added to DOG-0.6 + SFD-0.0 concentrations or loads in Figures 13 and 14 because of its small size, low FC counts, and incomplete data set. It was sampled during two of the three special dry-season surveys. See Appendix H: Bacteria Results, Table H-3 for FC results at 15-DOG-T.

Seasonal variation

One objective of the Liberty Bay FC study was to find any seasonal patterns that might exist in FC concentrations or loading. Seasons were hydrologically defined as the months of the year when average flows were higher or lower than the mean annual flow. For the purposes of the Liberty Bay Watershed TMDL, seasons were divided into the low-flow months from June through October (dry season) and the high-flow months of November through May (wet season). At most sites, higher FC concentrations occurred more frequently in the dry season

than in the wet season (Appendix H, Tables H-1 and H-2). During the dry season, bacteria source and transport are most likely direct discharge, such as from leaky sewage systems, animal access, or manure disposal near the stream. During the wet season, bacteria source and transport are most likely the wash-off of pollutants deposited in the watershed.

The East and West Forks of Dogfish Creek had much higher average FC concentrations during the dry season, but the South Fork had higher concentrations during the wet season (Figure 13). This could indicate differences in land uses and bacteria sources in the subwatersheds. The South Fork flows through developed areas of Poulsbo and has a higher human and pet population density and higher percent impervious surface area. The East and West Forks are more rural and less developed than the South Fork subwatershed (Figure 3).

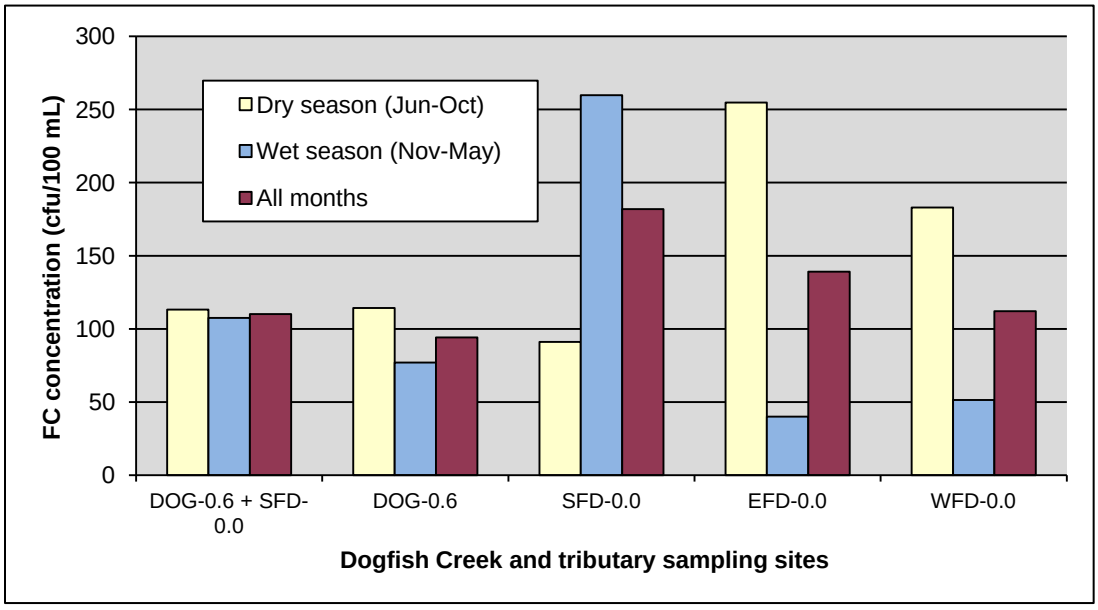

Figure 13. Average seasonal FC concentration profile of Dogfish Creek near the mouth (DOG-0.6+SFD-0.0), at river mile 0.6, and at the mouths of the South, East, and West Forks.

The East and West Forks of Dogfish Creek had fairly consistent loading from season to season (Figure 14). However at site DOG-0.6, only 0.45 miles downstream of the East and West Fork confluence and above the confluence with the South Fork, loading was more than twice as high during the wet season compared to the dry season (Figure 14). There are no known perennial tributaries here, so road runoff, drains, and/or overland flow in this reach may be contributing to wet-season loading. Further investigation is recommended in this area.

Since loading is a function of flow and concentration, higher wet season flows will cause higher loading when FC concentrations are consistent throughout the year. For example, average dry- and wet-season FC concentrations were similar at the mouth of Dogfish Creek (DOG-0.6 + SFD-0.0 in Figure 13), but dry- and wet-season loading was significantly different between the seasons and higher during the wet season (Figure 14). It is unlikely that significant loading occurs between Dogfish Creek at RM 0.6 and its mouth because there are no tributaries entering the creek in this reach, except at tributary 15-DOG-T.

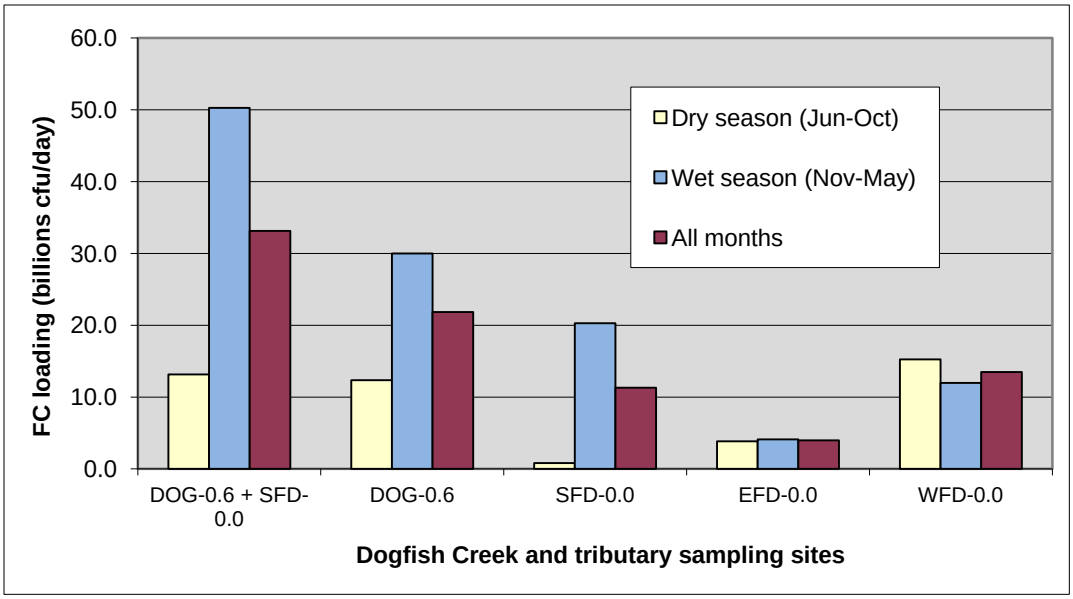

Figure 14. Average seasonal FC loading profile of Dogfish Creek near the mouth (DOG-0.6+SFD-0.0), at RM 0.6, and at the mouths of the South, East, and West Forks.

Big Scandia Creek

Overall, FC concentrations in Big Scandia Creek increased from RM 1.6 (HWY 308 near Cox Ave.) to the mouth at station BSC-0.0 (Figures 15 and 16). Average dry-season FC concentrations increased the most between RM 1.6 and RM 1.1, while the largest wet-season concentration increase occurred between RM 1.1 and RM 0.1 (Figure 16). As shown in Figure 15, the three upstream stations met the geometric mean criterion, while the mouth of Big Scandia Creek did not. All four stations exceeded the 90th percentile criterion.

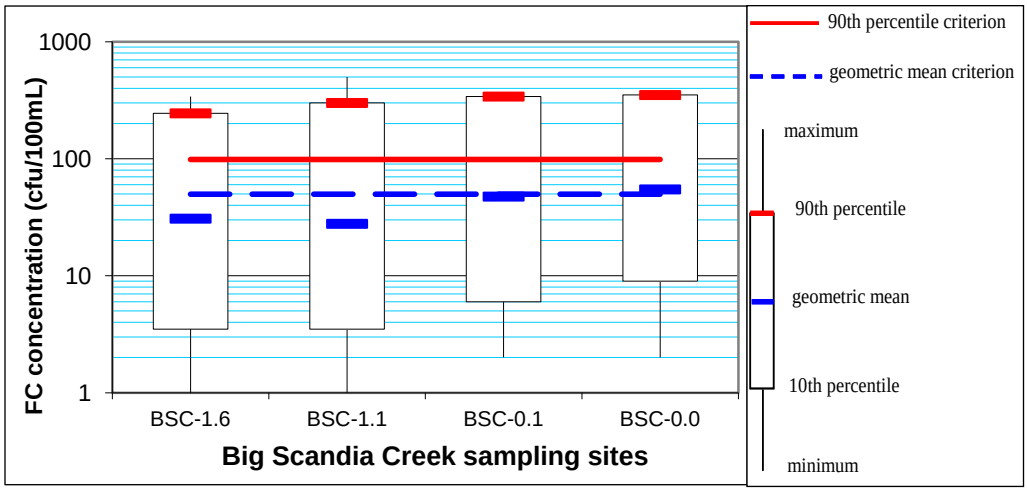

Figure 15. Longitudinal FC concentrations in Big Scandia Creek.
All sites were sampled 26 times. The y-axis is on a logarithmic scale.

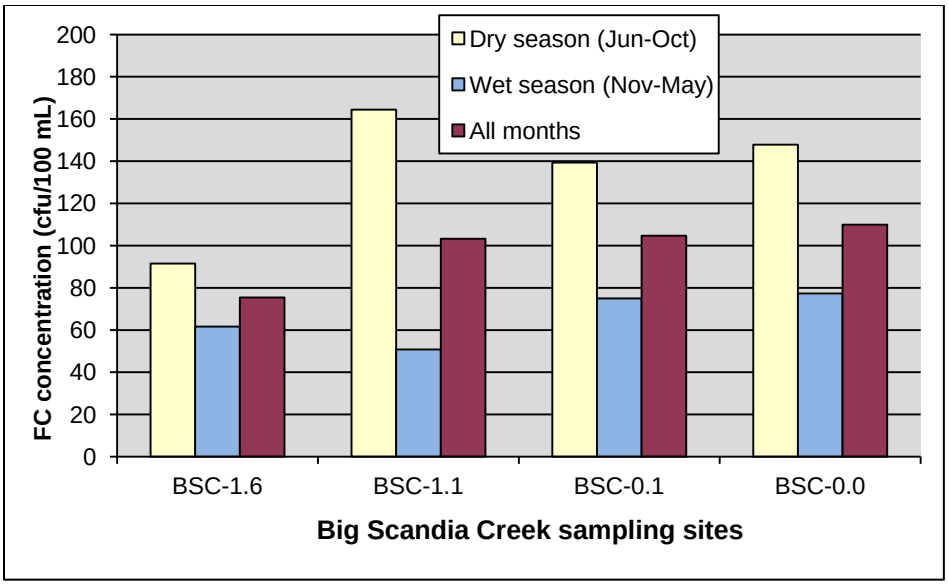

Figure 16. Average seasonal longitudinal FC concentration profile of Big Scandia Creek.

FC loading to Liberty Bay from Big Scandia Creek increased during the wet season, even though dry season concentrations were higher (Figures 16 and 18). The largest increase in loading along the length of Big Scandia Creek occurred between RM 1.1 and RM 0.1 during the wet season (Figure 18). This area also warrants further pollution source investigation.

Figure 17. Big Scandia Creek at NW Scandia Road.

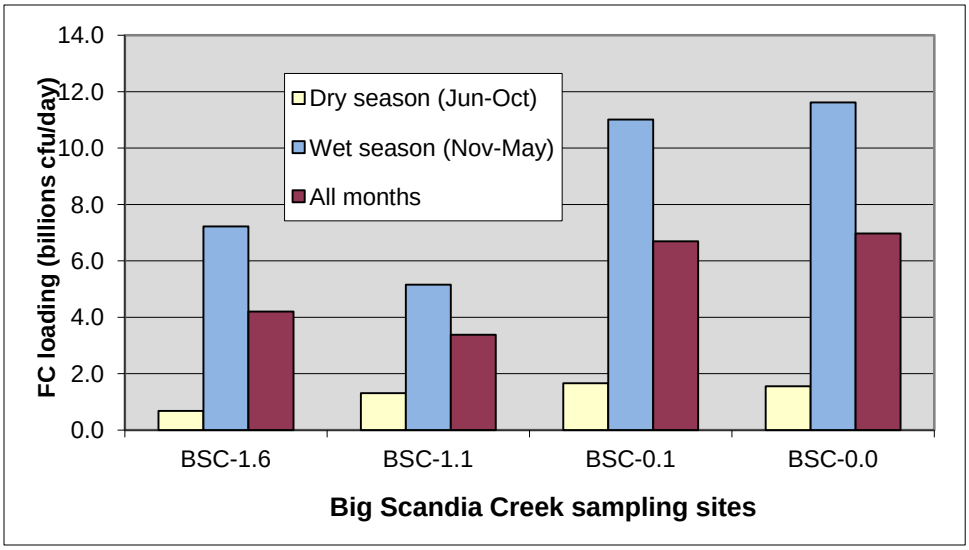

Figure 18. Average seasonal longitudinal FC loading profile of Big Scandia Creek.

Little Scandia and Daniels Creeks

Bacteria concentrations and loading in Little Scandia and Daniels creeks increased from the upstream sites to the downstream sites at or near the mouths (Figures 19-21).

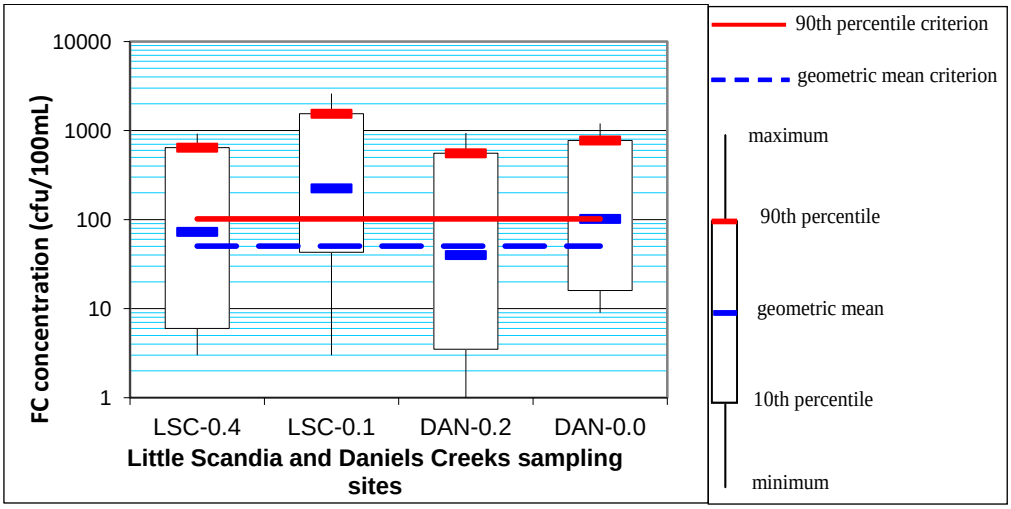

Figure 19. Longitudinal FC concentrations in Little Scandia and Daniels creeks.
All sites were sampled 26 times. The y-axis is on a logarithmic scale.

Little Scandia Creek FC data showed an increase in loading to Liberty Bay during the wet season, even though concentrations were higher in the dry season (Figures 20 and 21). Since the TMDL study, Kitsap Public Health District reports that Little Scandia Creek is one of five streams in Kitsap County with the most improved FC levels (KPHD, 2013).

Daniels Creek at RM 0.2 (DAN-0.2) had higher concentrations and loading during the dry season than during the wet season (Figures 20 and 21). Daniels Creek had higher dry-

season concentrations at the mouth (DAN-0.0), but only slightly higher dry-season loading (Figure 21).

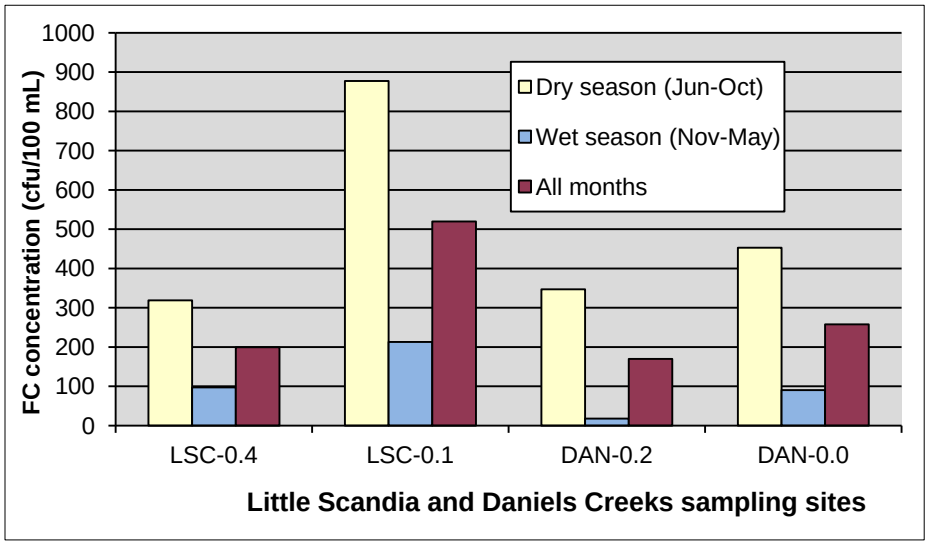

Figure 20. Average seasonal longitudinal FC concentration profile of Little Scandia and Daniels creeks.

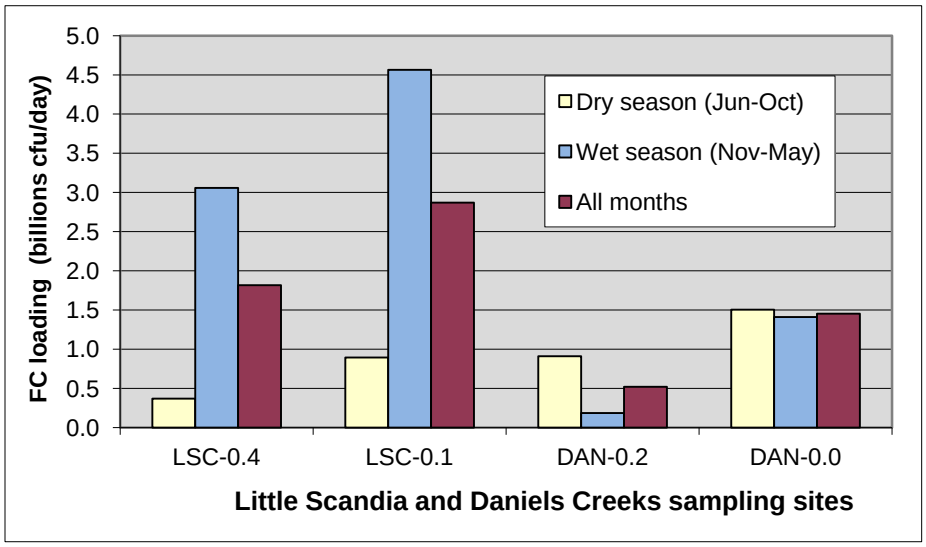

Figure 21. Average seasonal longitudinal FC loading profile of Little Scandia and Daniels creeks.

Storm (rain-event) monitoring

The purpose of storm monitoring was to better characterize potential sources of FC loading to tributaries and Liberty Bay during runoff events. Loads are instructive for (1) identifying changes in FC source intensity between sites along a stream or between seasons at a site and (2) evaluating impacts on marine waters. Historical Liberty Bay and statewide data show that higher FC loading occurs during rain events. Even when freshwater FC concentrations meet criteria, loading may be high enough to affect bay water quality.

For the purposes of the TMDL, rainfall events need to meet certain criteria to qualify as a storm event. A qualified storm event was defined in the TMDL QA Project Plan (QAPP) as a minimum 0.3 inches of rainfall in a 24-hour period preceded by no more than trace rainfall in the previous 24 hours. This amount was considered sufficient to cause runoff from impervious surfaces in the watershed and raise creek levels (based on previous sampling in similar watersheds).

As discharge from streams and storm drains increases, freshwater is more rapidly distributed above the denser marine waters of the bay. This limits vertical mixing in the bay and slows down dilution. Consequently, bacteria die-off due to saline conditions is slower in the bay during the wet season relative to the dry season. Ultraviolet light from the sun, which can kill exposed FC bacteria, is also less intense during the wet season. As a result, even slightly elevated wet-season bacteria concentrations from streams (over the marine criterion of 43 cfu/100 mL) have the potential to affect FC concentrations in the bay, especially if mixing is not complete and a freshwater surface lens develops.

Unfortunately, due to storm timing and laboratory limitations on accepting unscheduled storm samples, no rain events sampled during the TMDL study met QAPP storm-event criteria. However, some significant rain events occurred during regular sampling that enabled Ecology to better characterize conditions that affected Liberty Bay stream FC concentrations and loading. Table 14 shows daily rainfall during sampling and one, two, and three days prior to the day of sampling. The highlighted rows in Table 14 show times when rainfall conditions were conducive to raising stream FC concentrations and loading through overland wash-off processes.

Precipitation during the 2008-09 TMDL study data collection was below average. Rainfall for water year 2009 at the Kitsap Public Utilities District (KPUD) Office (Finn Hill Road, near the head of Liberty Bay) totaled 27.7 inches. This was the lowest rainfall on record for the past 20 years at that location. From 1991 to 2011, the median annual precipitation was 41.1 inches, while the maximum was 62.2 inches (1999) and the minimum 27.7 inches (2009). Even though there was unusually low rainfall during the TMDL study, overall target reductions and allocations based on the study data are considered proportionally accurate for the purposes of this TMDL.

Table 14. Rainfall totals before and during regular FC sampling in the Liberty Bay watershed.

Highlighted rows are sampling dates with higher than normal (for that time of year) streamflow in Liberty Bay streams (based on Dogfish Ck flow) and prior rain and runoff that may have been conducive to raising FC levels throughout the watershed. See also Table 15.

KWAPOULS6 weather station (Central Market, Poulsbo)								
			Rainfall (inches)					
Sampling date	Day of sampling rainfall (inches)	Day of sampling rainfall (time)	1 day prior	2 days prior	3 days prior	Last day it rained	Last day it rained 0.20 inches or more	Dogfish Ck mouth flow (cfs)
8/12/2008	0		0	0	0.10	see left	weeks before sampling (July had a total of only 0.48" of rain)	5.1
8/26/2008	0.01	no significant rain	0.36	0.30	0	see left	see left	7.4
9/10/2008	0		0	0	0	8/31/08, .08	8/25/08, .36	4.8
9/24/2008	0.06	all day	0.06	0.02	0.01	see left	8/25/08, .36	5.1
10/8/2008	0		0	0.20	0	see left	see left	6.3
10/22/2008	0		0.01	0.06	0	see left	10/13/08, .33	5.8
10/29/2008	0		0	0	0	10/21/08, .01	10/13/08, .33	5.5
11/11/2008	0.24	most between 3-6 AM and 5-8 PM	0	0.05	0.56	see left	day of sampling	11
11/24/2008	0.01	no significant rain	0	0	0.19	see left	11/11/2008, .24	5.7
12/10/2008	0		0.12	0	0.05	see left	11/11/2008, .24	6.6
12/29/2008	0.20	8-12 AM with most between 9-10 AM	0.09	0.02	0.08	see left	day of sampling	34
1/14/2009	0		0.13	0.03	0.01	see left	1/7/2009, .87	8.2
1/28/2009	0		0	0	0	1/24/2009, .04	1/7/2009, .87	5.8
2/11/2009	0		0.31	0.39	0	see left	see left	9.6
2/25/2009	0.06	830 AM - 1 PM	0.38	0.23	0.17	see left	see left	9.1
3/11/2009	0		0	0	0.02	see left	3/2/2009, .20	7.8
3/24/2009	0.11	4-6 PM (after sampling)	0.01	0.45	0	see left	see left	8.4
4/8/2009	0		0	0	0	4/4/09, .01 and 4/3/09, .14	4/2/09, .69	21
4/29/2009	0.09	3-5 AM	0.24	0	0.23	see left	see left	6.7
5/6/2009	0		0.22	0.77	0.39	see left	see left	19
5/20/2009	0		0.38	0.36	0	see left	see left	10
6/9/2009	0		0	0	0	5/19/09, .38	see left	4.3
6/17/2009	0		0	0	0	5/19/09, .38	see left	4.4
7/8/2009	0		0	0	0	6/24/09, .02	6/19/09, .24	4.3
7/22/2009	0		0	0	0	7/13/09, .08	6/19/09, .24	4.1
8/12/2009	0.01	no significant rain	0.13	0.04	0	see left	6/19/09, .24	4.1
8/19/2009	0		0	0	0	8/14/2009, .01	8/13/09, .23	4.2
9/1/2009	0.01	no significant rain	0	0	0.01	see left	8/13/09, .23	4.1
10/12/2009	0		0	0	0	10/02/09, .20	10/02/09, .20	4.2

Table 15 provides more detail on the highlighted rows in Table 14, including the outcome of each rain event.

Table 15. Discussion of highlighted rows in Table 14.

Date	Why high FC was expected	Outcome
8/26/2008	Preceding dry period, then 0.66" of rain in prior two days	Dogfish, Big Scandia, and Johnson creeks had higher than average dry-season flows and loading. Smaller, flashier creeks were generally unaffected.
11/11/2008	Rainfall before sampling, high flows	No obvious signs of high FC in streams were found.
12/29/2009	Rainfall prior to sampling (0.20"), high flows	High FC concentration and loading.
5/6/2009	1.38" of rain fell in prior 3 days but not on day of sampling. High flows. Possible land-use changes (e.g., manure spreading, pet walking)	High FC concentration and loading.
5/20/2009	0.74" of rain fell in prior 2 days but not on day of sampling. High flows. Possible land-use changes (e.g., manure spreading, pet walking)	High FC concentration and loading.

Stormwater outfalls

Within the city of Poulsbo there are 19 stormwater outfalls that drain directly to Liberty Bay. Ecology sampled several major residential and commercial outfalls within city limits that flow to the bay using information from city of Poulsbo regarding land-use type and sizes of subbasin drainages (Funk, 2008) (Table 16).

Figure 22. Nelson Park bioswale outfall to Liberty Bay.

Outfalls at sites 15-STORM-1 and 15-STORM-2 only flowed during times of runoff, unlike the other TMDL sites in Table 16, which also receive groundwater inputs and flow year-round. Ecology sampled the STORM-1 and 2 outfalls during four regularly scheduled sampling events when runoff was occurring. The geometric mean of the four samples taken at STORM-1 was 724 cfu/100 mL and the geometric mean of the four samples at STORM-2 was 586 cfu/100 mL. Both outfalls are part of the city of Poulsbo's municipal separate storm sewer system (MS4), and drain mostly parking lots, roof tops, and streets near downtown Poulsbo. FC concentrations and flows for all six outfalls listed in Table 16 are shown in Table 11 and Appendices H: Bacteria Results, and I: Field Results.

Table 16. City of Poulsbo stormwater outfalls sampled when flowing by Ecology (2008-09).
Map numbers refer to Figure 2.

Name of outfall (City of Poulsbo)	Ecology TMDL site and map #	Location	Land use	Approx. Latitude	Approx. Longitude
OF-3706	15-BOV-0.0 Map # 34	Trib between Bovela and Bay Streets	Commercial	47.74026	-122.65497
OF-3502	15-NEL-0.0 Map # 36	Nelson Park Bioswale	Residential, commercial	47.74613	-122.65296
OF-3703	15-JEA-0.0 Map # 25	South end of Legion Park, below playground	Residential	47.73816	-122.64998
OF-3702	15-STORM-1 Map # 27	Below the Gran Kirk, Martha and Mary, and Front Street	Commercial, parking lot/road	47.73701	-122.64974
OF-3701	15-STORM-2 Map # 28	North end of Legion Park, below driveway turnaround	Commercial, Road	47.73455	-122.64753
OF-5304 (Poulsbo Creek)	15-DON-0.0 Map # 26	6th Ave. NE and Fjord Dr.	Residential, Highway	47.72728	-122.64178

The first five stormwater outfalls listed in Table 16 have asterisks '*' on tables in the TMDL Analysis section to indicate the different way in which water quality standards apply to these outfalls compared to tributary stream sites. While Poulsbo Creek is included in the Table 16 list of Poulsbo stormwater outfalls, it is treated as a stream tributary to Liberty Bay for the purposes of the TMDL.

Comparison of FC loading to Liberty Bay during dry vs. wet seasons

Ecology performed three dry-season, low-flow surveys on October 29, 2008[5], August 19, 2009, and October 22, 2009 to better understand baseline FC loading to the bay when runoff was not

[5] During the October 29, 2008 survey, Ecology did not sample sites 15-RET-0.0, 15-BOV-0.0, 15-DON-0.0, 15-NEL-0.0, and 15-KE1-0.2. To calculate a more accurate estimate of total FC loading to the bay, flows and FC results from these sites were estimated and added to results from sampled sites. Estimated load from unsampled

occurring. This involved sampling FC and measuring or estimating streamflow at all freshwater discharges to the bay on the same day. Ecology collected samples and measurements at or near stream mouths and measured conductivity at each sampling site to ensure that only freshwater was sampled. Total FC loading to the bay from all overland flow varied between sampling events. Estimated daily loads are shown in Table 17. Survey sampling locations and FC results are included in Appendix H: Bacteria results, Table H-3.

Table 17. Comparison of flow and estimated daily FC loading to Liberty Bay in dry and wet seasons.

Date	Total overland flow to bay (cubic feet/second)	Total estimated FC load to bay per day (billions of FC)
Dry-season estimates based on sampling events		
10/29/2008	8.6	21.6
8/19/2009	6.2	38.4
10/22/2009	6.5	12.5
Average	7.1	24.2
Wet-season estimates (average for Nov-May)[6]		
Average	21.7	116.0

For comparison, average overland flow to the bay during dry season was estimated at 7.1 cubic feet per second (cfs) and average flow during wet season was 21.7 cfs. Average loading during dry season sampling was 24.2 billion FC organisms per day (B cfu/day) while wet-season (Nov-May) estimated loading at the same sites sampled during the dry-season sampling averaged 116 B cfu/day to the bay. Overall, wet-season loading of FC to the bay is higher than dry-season loading, even though wet season concentrations were generally lower.

sites on Oct 29 was 3.8 billion FC bacteria per day. The estimate was the arithmetic average of all 2008-09 TMDL FC results from each site. Added to the 17.8 billion FC bacteria from sampled sites, the estimated total Oct 29 load is 21.6 billion FC organisms per day.

[6] The wet season daily FC loading and flow estimates in Table 17 were derived in three steps.

1. Calculating the daily load for each November through May sampling event for each of the streams sampled during the three dry season surveys.
2. Averaging daily loads from step 1 above to get an average daily load for each stream.
3. Adding average daily loads from all streams together to get total loading to the bay during Nov through May wet season.

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TMDL Analysis

Analytical framework

Bacteria concentration targets for creeks flowing to Liberty Bay were based on an analysis of TMDL data collected in 2008-2009. Excel® spreadsheets were used to evaluate the data, including statistical analyses and plots.

The statistical rollback method (Ott, 1997) was used to establish FC reduction targets for streams and stream segments in the Liberty Bay watershed. The rollback method simply compares monitoring data to standards, and the difference is the percent change needed to meet the standards. See Data Analysis Methods section for more details.

Loading capacity

EPA recommends that all TMDLs and associated load allocations and wasteload allocations be expressed in terms of daily time increments. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards. TMDLs must continue to be established at a level necessary to attain and maintain the applicable water quality standards, account for seasonal variations, and include a margin of safety. [7]

Washington State bacteria TMDLs use a combination of loading (counts per day), statistical concentration targets, and percent reductions to define loading capacities. However, the statistical concentration targets serve as a surrogate measure that is more appropriate for comparison with standards, compliance, and implementation. This is because count-per-time units (loads) do not adequately define periods of FC criteria violations.

Bacteria sources are quite variable and different sources can cause water quality violations under different conditions (e.g., poor dilution of contaminated sources during low-streamflow conditions or increased source loading during runoff events). Comparisons of loads along a stream, or between seasons at a site, can be instructive for identifying changes in FC source intensity, and for evaluating impacts on marine waters. However, concentrations and percent reductions are most practical for identifying trends and tracking implementation progress.

The statistical concentration targets are referenced in the Washington State FC criteria and provide a better measure of the loading capacity during the dry and wet seasons. The Liberty Bay watershed bacteria loading capacities are the applicable two statistics in the state FC criteria (i.e., the geometric mean and the value not to be exceeded by more than 10 percent of the samples) as applied to targets calculated to ensure freshwater FC levels are protective of marine waters. The 90th percentile value of samples is used in TMDL evaluations for the latter

[7] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/dailyloadsguidance.cfm

criterion statistic. The TMDL loading capacity targets (target capacities) in the following tables are either the criteria or statistics that estimate the reductions necessary to meet the criteria.

The percent reduction values in Tables 18-25 indicate the relative degree the water body is out of compliance with criteria (i.e., how far it is over its capacity to receive FC source loads and still provide protection of the designated beneficial uses). Sites representing reaches or tributaries currently meeting water quality standards have a FC reduction value of 0 percent. Sites that require aggressive reductions in FC sources have a high percentage reduction value, while sites with minor problems have a low percentage reduction value.

The loading capacity and statistical target values are based on seasons, and the tables include the seasonal capacities to provide water quality managers with a sense of when FC sources are violating criteria. Seasonal targets also help avoid the potentially erroneous conclusion that when FC targets are met during one season of the year, they are assumed to be met throughout the entire year.

Compliance with standards

Dry-season (June through October) and wet-season (November through May) FC target reductions were calculated at each sampling site where four or more samples were taken (Tables 18 through 21). If streams were not flowing during the dry season, no target reduction values were assigned. With the exception of Sam Snyder Creek during wet season, all creeks and tributaries sampled during the 2008-09 Liberty Bay FC TMDL study exceeded the 90th percentile criteria. Many creeks and tributaries also exceeded the geometric mean criterion.

At most stream sampling sites, the highest FC concentrations occurred during the dry season. One notable exception is South Fork Dogfish Creek, which had significantly higher FC concentrations during the wet season. Dry-season FC concentration reductions ranged from 50 percent (South Fork Dogfish Creek) to 98 percent (Nelson Park bioswale outfall and an unnamed stream next to Daniels Creek) in order to meet the 90th percentile criterion (Tables 18 and 19). Several sites need wet- and dry-season FC reductions of over 90 percent to meet state water quality criteria (Tables 18 through 21).

Table 18. Dry-season FC reductions and target concentrations for regularly sampled Liberty Bay tributaries.

Site ID with River Mile	Site Location Summary	No. of Samples	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	FC Reduction	FC Target Capacity (cfu/100mL)	
						Geo-mean	90th percentile
Dogfish Creek							
15-DOG-0.6	Dogfish off Bond Rd. at dental office	12	93	214	53 %	43	100
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave	12	62	200	50 %	31	100
15-SFD-1.3	South Fork at 8th Ave. and Iverson	12	102	210	52 %	48	100
15-EFD-0.0	East Fork at Little Valley Rd.	12	159	560	82 %	28	100
15-EFD-1.2	East Fork at Pugh Rd.	12	45	206	51 %	22	100
15-WFD-0.0	West Fork at Little Valley Rd.	12	81	362	72 %	22	100
15-WFD-0.9	West Fork at Big Valley Rd.	12	60	239	58 %	25	100
Johnson Creek							
15-JOH-0.1	400 ft. south of Norfin Rd.	12	36	232	57 %	15	100
Big Scandia Creek							
15-BSC-0.0	Scandia Ct. at private res.	12	111	366	73 %	30	100
15-BSC-0.1	Scandia Rd.	12	99	318	69 %	31	100
15-BSC-1.1	HWY 308, between Viking and Cox	12	69	554	82 %	13	100
15-BSC-1.6	HWY 308, west of Cox Ave.	12	67	221	55 %	30	100
Little Scandia Creek							
15-LSC-0.1	Scandia Rd.	12	523	2232	96 %	23	100
15-LSC-0.4	Blomster Way	12	217	820	88 %	26	100
Daniels Creek							
15-DAN-0.0	Off HWY 308	12	343	1060	91 %	32	100
15-DAN-0.2	Virginia Loop Rd.	12	241	805	88 %	30	100
Perry Creek							
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	12	256	2375	96 %	11	100
Sam Snyder Creek							
15-SAM-0.1	Lemolo Shore Dr.	0	no flow during dry season / no reductions necessary				
Lemolo Creek							
15-LEM-0.1	Lemolo Shore Dr.	12	63	597	83 %	11	100
Bjorgen Creek							
15-BJO-0.1	Lemolo Shore Dr.	12	276	2098	95 %	13	100
Barrantes Creek							
15-BAR-0.0	Lemolo Shore Dr.	10	180	688	85 %	26	100
Unnamed Tributaries to Liberty Bay							
15-UNN-0.1	East of Daniels Ck. at HWY 308	10	80	305	67 %	26	100
15-UNN-0.0	Trib. flowing into bay next to Daniels	7	578	5266	98 %	11	100

Dry-season FC reductions for flowing investigation sites where more than four samples were collected ranged from 76 percent to 98 percent. The largest investigation stream with the highest dry-season loading to Liberty Bay, Poulsbo Creek (15-DON-0.0), needs a 91 percent reduction in dry-season FC to meet state criteria (Table 19). As discussed under the previous Data Analysis section, some of the 98% reduction needed at Nelson Park bioswale (15-NEL-0.0) was achieved by city of Poulsbo's Nelson Park catch basin cleaning that occurred in 2011.

Table 19. Dry-season FC reductions and target concentrations for investigation sites in Liberty Bay tributaries.

Site ID with River Mile	Site Location Summary	Number of Samples	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	FC Reduction	FC Target Capacity (cfu/100mL)	
						Geo-mean	90th percentile
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	1	no significant flow during dry season				
15-JEA-0.0*	American Legion Park outfall	6	125	422	76 %	30	100
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club	6	302	1114	91 %	27	100
15-BST-0.0	~300 ft. east of Big Scandia Ck.	0	no flow during dry season				
15-KE1-0.2	Brownsville HWY	6	552	2656	96 %	21	100
15-KE2-0.3	Brownsville HWY	6	209	748	87 %	28	100
15-BOV-0.0*	Outfall betw. Bovela Lane and Bay St.	6	365	828	88 %	44	100
15-LMK-0.0	Off Virginia Loop Rd. at private residence	1	no significant flow during dry season				
15-NEL-0.0*	Nelson Park bioswale on beach	6	1061	4271	98 %	25	100
15-RET-0.0*	Outfall off Viking at assisted living facility	6	344	1381	93 %	25	100

* - FC targets for Poulsbo stormwater outfalls are for informational purposes only.

Wet-season FC concentration reductions ranging from 0 percent (several streams) to 99 percent (unnamed stream off of Virginia Loop Rd.) are necessary to meet the 90th percentile criterion (Tables 20 and 21).

Table 20. Wet-season FC reductions and target concentrations for regularly sampled Liberty Bay tributaries.

Site ID with River Mile	Site Location Summary	Number of Samples	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	FC Reduction	FC Target Capacity (cfu/100mL)	
						Geo-mean	90th percentile
Dogfish Creek							
15-DOG-0.6	Dogfish off Bond Rd. at dental office	14	36	161	38%	22	100
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave.	14	106	798	87 %	13	100
15-SFD-1.3	South Fork at 8th Ave. and Iverson	14	48	584	83 %	8	100
15-EFD-0.0	East Fork at Little Valley Rd.	14	17	105	5 %	16	100
15-EFD-1.2	East Fork at Pugh Rd.	14	19	103	3 %	19	100
15-WFD-0.0	West Fork at Little Valley Rd.	14	27	121	17 %	22	100
15-WFD-0.9	West Fork at Big Valley Rd.	14	11	85	0 %	NA	NA
Johnson Creek							
15-JOH-0.1	400 ft. south of Norfin Rd.	14	10	97	0 %	NA	NA
Big Scandia Creek							
15-BSC-0.0	Scandia Ct. at private res.	14	30	221	55 %	13	100
15-BSC-0.1	Scandia Rd.	14	25	226	56 %	11	100
15-BSC-1.1	HWY 308, between Viking and Cox	14	13	116	13 %	11	100
15-BSC-1.6	HWY 308, west of Cox Ave.	14	16	160	37 %	10	100
Little Scandia Creek							
15-LSC-0.1	Scandia Rd.	14	109	680	85 %	16	100
15-LSC-0.4	Blomster Way	14	29	226	56 %	13	100
Daniels Creek							
15-DAN-0.0	Off HWY 308	14	36	185	46 %	19	100
15-DAN-0.2	Virginia Loop Rd.	14	9	50	0 %	NA	NA
Perry Creek							
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	14	46	293	66 %	16	100
Sam Snyder Creek							
15-SAM-0.1	Lemolo Shore Dr.	14	9	54	0 %	NA	NA
Lemolo Creek							
15-LEM-0.1	Lemolo Shore Dr.	14	18	297	66 %	6	100
Bjorgen Creek							
15-BJO-0.1	Lemolo Shore Dr.	14	26	255	61 %	10	100
Barrantes Creek							
15-BAR-0.0	Lemolo Shore Dr.	14	19	134	25 %	14	100
Unnamed Tributaries to Liberty Bay							
15-UNN-0.1	East of Daniels Ck. at HWY 308	14	7	43	0 %	NA	NA
15-UNN-0.0	Trib. flowing into bay next to Daniels	14	19	371	73 %	5	100

Wet-season FC reductions for investigation sites where more than four samples were collected ranged from 0 to 99 percent. The largest investigation stream with the highest wet-season loading to Liberty Bay, Poulsbo Creek (15-DON-0.0), needs an 84 percent reduction in wet-season FC to meet state criteria (Table 21).

Table 21. Wet-season FC reductions and target concentrations for investigation sites in Liberty Bay tributaries.

Site ID with River Mile	Site Location Summary	Number of Samples	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	FC Reduction	FC Target Capacity (cfu/100mL)	
						Geo-mean	90th percentile
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	12	40	195	49 %	21	100
15-JEA-0.0*	American Legion Park outfall	14	71	1512	93 %	5	100
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club	11	34	644	84 %	5	100
15-BST-0.0	~300 ft. east of Big Scandia Ck.	12	134	1109	91 %	12	100
15-KE1-0.2	Brownsville HWY	4	26	611	84 %	4	100
15-KE2-0.3	Brownsville HWY	4	9	54	0 %	NA	NA
15-BOV-0.0*	Outfall betw. Bovela Lane and Bay St.	4	57	182	45 %	31	100
15-LMK-0.0	Off Virginia Loop Rd. at private residence	4	565	11743	99 %	5	100
15-NEL-0.0*	Nelson Park bioswale on beach	4	395	3762	97 %	10	100
15-RET-0.0*	Outfall off Viking at assisted living facility	4	714	2120	95 %	34	100

* - FC targets for Poulsbo stormwater outfalls are for informational purposes only.

Annual loading

Figure 23 shows each tributary's percent of the total estimated average (arithmetic mean) annual FC loading to Liberty Bay during the 2008-09 TMDL study. Tributaries sampled fewer than five times and stormwater not associated with streams are not included in the figure. Loading to the bay may also occur from other less obvious sources such as shoreline seeps, failing onsite sewage systems, and boats, but these sources were not directly sampled and thus were not included in this figure.

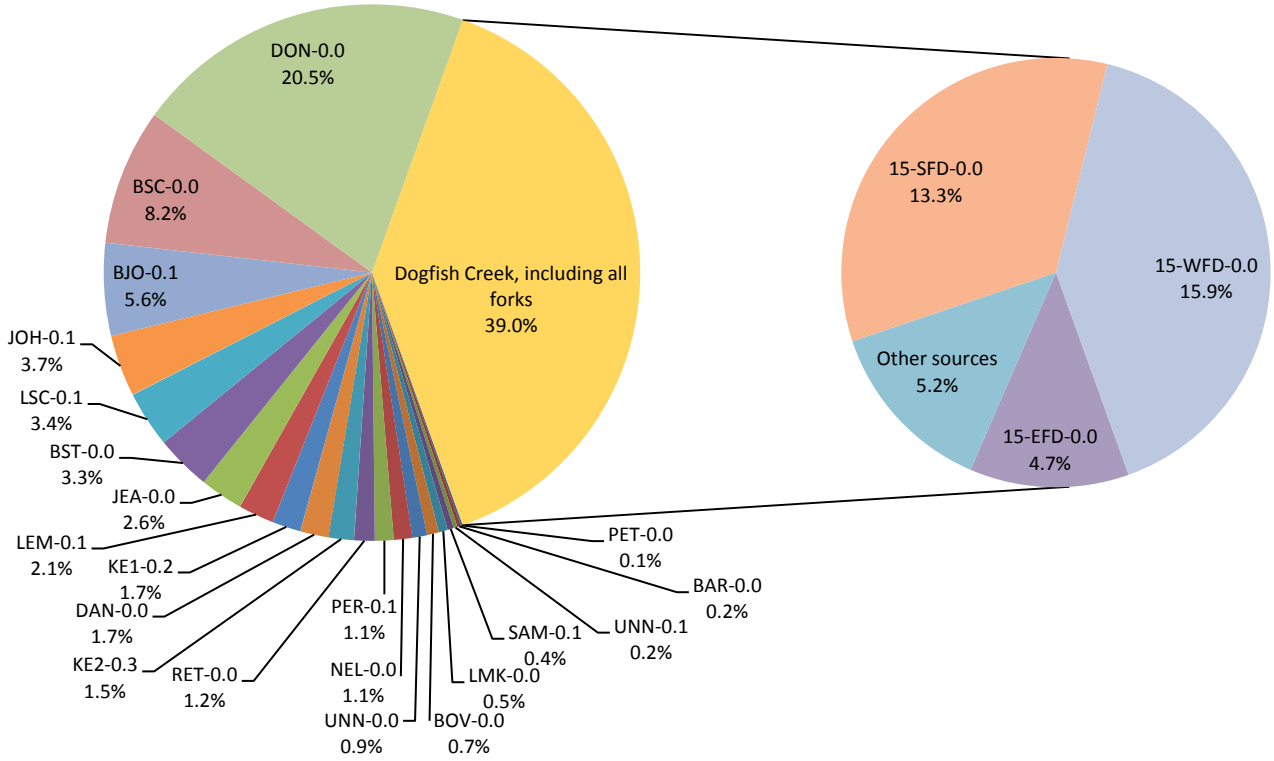

Figure 23. Estimated average annual load from tributaries to Liberty Bay (2008-09), shown as percent of total load. *Left: All freshwater flows including total Dogfish Creek contribution, Right: Dogfish Creek load broken down by tributary.*

Figure 23 shows that Dogfish Creek and its tributaries were the largest estimated bacteria loading source (39%) to the bay during the TMDL study. The Dogfish Creek loading estimate is further broken down in the secondary pie chart showing relative loading from the South Fork, West Fork, and East Forks of Dogfish Creek, and "other sources". The second largest estimated tributary load to Liberty Bay was Poulsbo Creek (20.5%) at Poulsbo Yacht Club (DON-0.0). Other significant FC loading sources were Big Scandia (8.2%), Bjorgen (5.6%), Johnson (3.7%), and Little Scandia (3.4%) creeks.

Load allocations

Load allocations are allowable pollutant loads attributed to nonpoint pollution or natural background sources. Load allocations (LAs) in the Liberty Bay FC TMDL are associated with specific monitoring locations and apply to the land uses and activities in the area that drains to, and influences, water quality at the location. LAs are addressed through a variety of best management practices (BMPs), educational programs, and other means. Point sources in each drainage that may contribute the TMDL pollutant in their discharge are assigned wasteload allocations (WLAs).

Most stormwater in urbanized areas is conveyed through drainage systems called municipal separate storm sewer systems (MS4s) and is covered under the NPDES municipal stormwater general permit. There may be some existing stormwater sources of bacteria in the watershed that are not currently under NPDES permit. The allocations for such sources are expressed in the TMDL as the "load allocation" contingent on the source remaining unpermitted. However, this part of the load allocation could at some future time be deemed a "wasteload allocation" if the stormwater discharge from the source is required to obtain NPDES permit coverage.

Both point and nonpoint sources are assumed to contribute to bacteria loads within jurisdictions with NPDES stormwater permits. If data are not available to distinguish between point-source and nonpoint-source contributions, then the same percent reduction needed to meet FC target concentrations is applied to both point- and nonpoint discharges. Therefore, the percent reductions in Tables 22-25 apply to both point and nonpoint sources that may be affecting the TMDL monitoring locations.

Tables 22-25 show dry- and wet-season load estimates from all TMDL sites sampled more than four times and TMDL load allocations based on calculated target reductions needed to meet the 50/100 FC standards. The difference between current dry and wet season loads and the loads at each site that would allow standards to be achieved is the target FC reduction. Load allocations and subsequent reductions were calculated using the rollback method and by applying the 90^{th} percentile criterion to each site, Appendix G: Statistical theory of rollback. Certain statistical assumptions are used in setting geometric means and 90^{th} percentiles for post-correction stream quality. Ultimately, it is the 50/100 FC standards that need to be met at each site in order to achieve the TMDL.

Sampling sites in Tables 22 and 24 that have asterisks (*) are associated with Category 4b creeks. Load allocations and target FC reductions for sites with asterisks (*) in Tables 22 and 24 are for informational purposes only. Compliance with standards at these sites will be evaluated during the next state Water Quality Assessment. Outfall sites with asterisks (*) in Tables 23, 25, 26, and 27 are given load, wasteload, and target reductions for loading comparison and informational purposes only.

Table 22. Dry-season FC load allocations and reductions for regularly sampled sites in the Liberty Bay watershed.

Target reductions are advisory only. Sites with an asterisk (*) are Category 4b waters.

Site ID with River Mile	Site Location Summary	Current Dry-season Load (billions cfu/day)	Load Allocation (billions cfu/day)	Target FC Reduction
Dogfish Creek				
15-DOG-0.6*	Dogfish off Bond Rd. at dental office	12	5.8	53 %
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave.	0.81	0.40	50 %
15-SFD-1.3	South Fork at 8th Ave. and Iverson	0.77	0.37	52 %
15-EFD-0.0*	East Fork at Little Valley Rd.	3.8	0.68	82 %
15-EFD-1.2*	East Fork at Pugh Rd.	0.78	0.38	51 %
15-WFD-0.0*	West Fork at Little Valley Rd.	15	4.2	72 %
15-WFD-0.9*	West Fork at Big Valley Rd.	7.4	3.1	58 %
Johnson Creek				
15-JOH-0.1	400 ft. south of Norfin Rd.	2.5	1.1	57 %
Big Scandia Creek				
15-BSC-0.0	Scandia Ct. at private res.	1.6	0.42	73 %
15-BSC-0.1	Scandia Rd.	1.7	0.52	69 %
15-BSC-1.1	HWY 308, between Viking and Cox	1.3	0.24	82 %
15-BSC-1.6	HWY 308, west of Cox Ave.	0.68	0.31	55 %
Little Scandia Creek				
15-LSC-0.1	Scandia Rd.	0.90	0.04	96 %
15-LSC-0.4	Blomster Way	0.37	0.05	88 %
Daniels Creek				
15-DAN-0.0*	Off HWY 308	1.5	0.14	91 %
15-DAN-0.2*	Virginia Loop Rd.	0.91	0.11	88 %
Perry Creek				
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	0.87	0.04	96 %
Sam Snyder Creek				
15-SAM-0.1	Lemolo Shore Dr.	No flow during dry season		
Lemolo Creek				
15-LEM-0.1	Lemolo Shore Dr.	0.32	0.05	83 %
Bjorgen Creek				
15-BJO-0.1	Lemolo Shore Dr.	1.2	0.06	95 %
Barrantes Creek				
15-BAR-0.0	Lemolo Shore Dr.	0.09	0.01	85 %
Unnamed Tributaries to Liberty Bay				
15-UNN-0.1	East of Daniels Ck. at HWY 308	0.37	0.12	67 %
15-UNN-0.0	Trib. flowing into bay next to Daniels	0.80	0.02	98 %

Table 23. Dry-season FC load reductions for investigation sampling sites.
Target reductions are advisory only. Sites with fewer than four samples are not included.

Site ID with River Mile	Site Location Summary	Current Dry-season Load (billions cfu/day)	Load Allocation (billions cfu/day)	Target FC Reduction
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	No flow during dry season		
15-JEA-0.0*	American Legion Park outfall	0.04	0.01	76 %
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club	2.2	0.20	91 %
15-BST-0.0	~300 ft. east of Big Scandia Ck.	No flow during dry season		
15-KE1-0.2	Brownsville HWY	0.60	0.02	96 %
15-KE2-0.3	Brownsville HWY	2.0	0.26	87 %
15-BOV-0.0*	Outfall between Bovela Lane and Bay Street	0.55	0.07	88 %
15-LMK-0.0	Off Virginia Loop Rd. at private res.	No flow during dry season		
15-NEL-0.0*	Nelson Park bioswale on beach	0.66	0.02	98 %
15-RET-0.0*	Outfall off Viking at assisted living facility	0.13	0.01	93 %

* - Allocations and targets for Poulsbo stormwater outfalls are for informational purposes only.

Wet season load allocations (LAs) are typically higher than dry season allocations because of higher wet season flows. An exception is the Nelson Park bioswale, which only had a slight difference between dry season LA (0.02 billion cfu/day) and wet season LA (0.04 billion cfu/day). Dry season target FC reductions at most sites are higher than wet season targets because of the dilution effect of higher wet season flows. An exception to this higher dry season reduction is South Fork Dogfish Creek (15-SFD-0.0), which had higher wet season target reduction (87%) than for dry season (50%). This could be because the South Fork drains portions of residential and commercial Poulsbo along state highway 305 and runoff may be washing off additional sources during wet season. Higher wet season target reductions suggest that wet season runoff may be including more far-field pollution sources and source investigation should include the entire subwatershed and not just near-stream sources.

Table 24. Wet-season tributary FC load reductions for regularly sampled sites.

Sites with an asterisk (*) are Category 4b waters. Target reductions are advisory only.

Site ID with River Mile	Site Location Summary	Current Wet-season Load (billions cfu/day)	Load Allocation (billions cfu/day)	Target FC Reduction
Dogfish Creek				
15-DOG-0.6*	Dogfish off Bond Rd. at dental office	30	19	38 %
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave.	20	2.5	87 %
15-SFD-1.3	South Fork at 8th Ave. and Iverson	3.1	0.52	83 %
15-EFD-0.0*	East Fork at Little Valley Rd.	4.1	3.9	5 %
15-EFD-1.2*	East Fork at Pugh Rd.	3.1	3.0	3 %
15-WFD-0.0*	West Fork at Little Valley Rd.	12	9.9	17 %
15-WFD-0.9*	West Fork at Big Valley Rd.	6.3	NA	0 %
Johnson Creek				
15-JOH-0.1	400 ft. south of Norfin Rd.	3.8	NA	0 %
Big Scandia Creek				
15-BSC-0.0	Scandia Ct. at private res.	12	5.2	55 %
15-BSC-0.1	Scandia Rd.	11	4.9	56 %
15-BSC-1.1	HWY 308, between Viking and Cox	5.2	4.5	13 %
15-BSC-1.6	HWY 308, west of Cox Ave.	7.2	4.5	37 %
Little Scandia Creek				
15-LSC-0.1	Scandia Rd.	0.89	0.13	85 %
15-LSC-0.4	Blomster Way	0.37	0.16	56 %
Daniels Creek				
15-DAN-0.0*	Off HWY 308	1.4	0.76	46 %
15-DAN-0.2*	Virginia Loop Rd.	0.19	NA	0 %
Perry Creek				
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	1.0	0.36	66 %
Sam Snyder Creek				
15-SAM-0.1	Lemolo Shore Dr.	0.31	NA	0 %
Lemolo Creek				
15-LEM-0.1	Lemolo Shore Dr.	3.1	1.06	66 %
Bjorgen Creek				
15-BJO-0.1	Lemolo Shore Dr.	7.8	3.04	61 %
Barrantes Creek				
15-BAR-0.0	Lemolo Shore Dr.	0.24	0.18	25 %
Unnamed Tributaries to Liberty Bay				
15-UNN-0.1	East of Daniels Ck. at HWY 308	0.08	NA	0 %
15-UNN-0.0	Trib. flowing into bay next to Daniels	0.74	0.20	73 %

Table 25. Wet-season FC load reductions at investigation sampling sites.
Target reductions are advisory only. Sites with fewer than four samples were not included.

Site ID with River Mile	Site Location Summary	Current Wet-season Load (billions cfu/day)	Load Allocation (billions cfu/day)	Target FC Reduction
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	0.10	0.05	49 %
15-JEA-0.0*	American Legion Park outfall	3.1	0.22	93 %
15-DON-0.0	Poulsbo Ck. at Poulsbo Yacht Club	26	4.1	84 %
15-BST-0.0	~300 ft. east of Big Scandia Ck.	2.8	0.26	91 %
15-KE1-0.2	Brownsville HWY	3.0	0.49	84 %
15-KE2-0.3	Brownsville HWY	0.27	NA	0 %
15-BOV-0.0*	Between Bovela Lane and Bay St.	0.70	0.38	45 %
15-LMK-0.0	Off Virginia Lp. Rd. at private res.	0.57	0.01	99 %
15-NEL-0.0*	Nelson Park bioswale on beach	1.4	0.04	97 %
15-RET-0.0*	Off Viking at assisted living facility	2.5	0.12	95 %

* - Allocations and targets for Poulsbo stormwater outfalls are for informational purposes only.

Wasteload allocations

Wasteload allocations (WLAs) are used in TMDLs to require that water quality standards are met and to assign responsibility for implementation to point sources (jurisdictions and facilities with NPDES permits). The permittee or source type is assigned a WLA if the TMDL determines that the permittee has the potential to discharge the parameter of concern at concentrations that contribute to exceedances in the receiving waters.

The WLA must be expressed in numeric form in the TMDL. Washington State's municipal stormwater permits do not include numeric permit limits. EPA guidance for TMDLs states that municipal stormwater WLAs may be addressed in a jurisdiction's NPDES stormwater permit by BMPs that are expected to reduce the discharge of the parameter of concern, in lieu of a numeric limit (Wayland and Hanlon, 2002). The BMPs specified in this TMDL have been identified based on our best current understanding of the practices that will lead to water quality improvement. As this TMDL project continues to be implemented, it is expected that these BMPs could be revised if necessary through the adaptive management process.

Point sources that discharge to Liberty Bay include:

- Municipalities with NPDES Phase II permit coverage that discharge stormwater from an MS4. The city of Poulsbo and the urbanized area of Kitsap County adjacent to Poulsbo are covered under the Phase II permit (Figure 24).
- U.S. Naval Base Kitsap at Keyport is covered under an EPA NPDES Stormwater Multi-Sector General Permit for Industrial Activities, permit number WAR05BA6F. The permit is managed by Naval Base Kitsap Bangor.

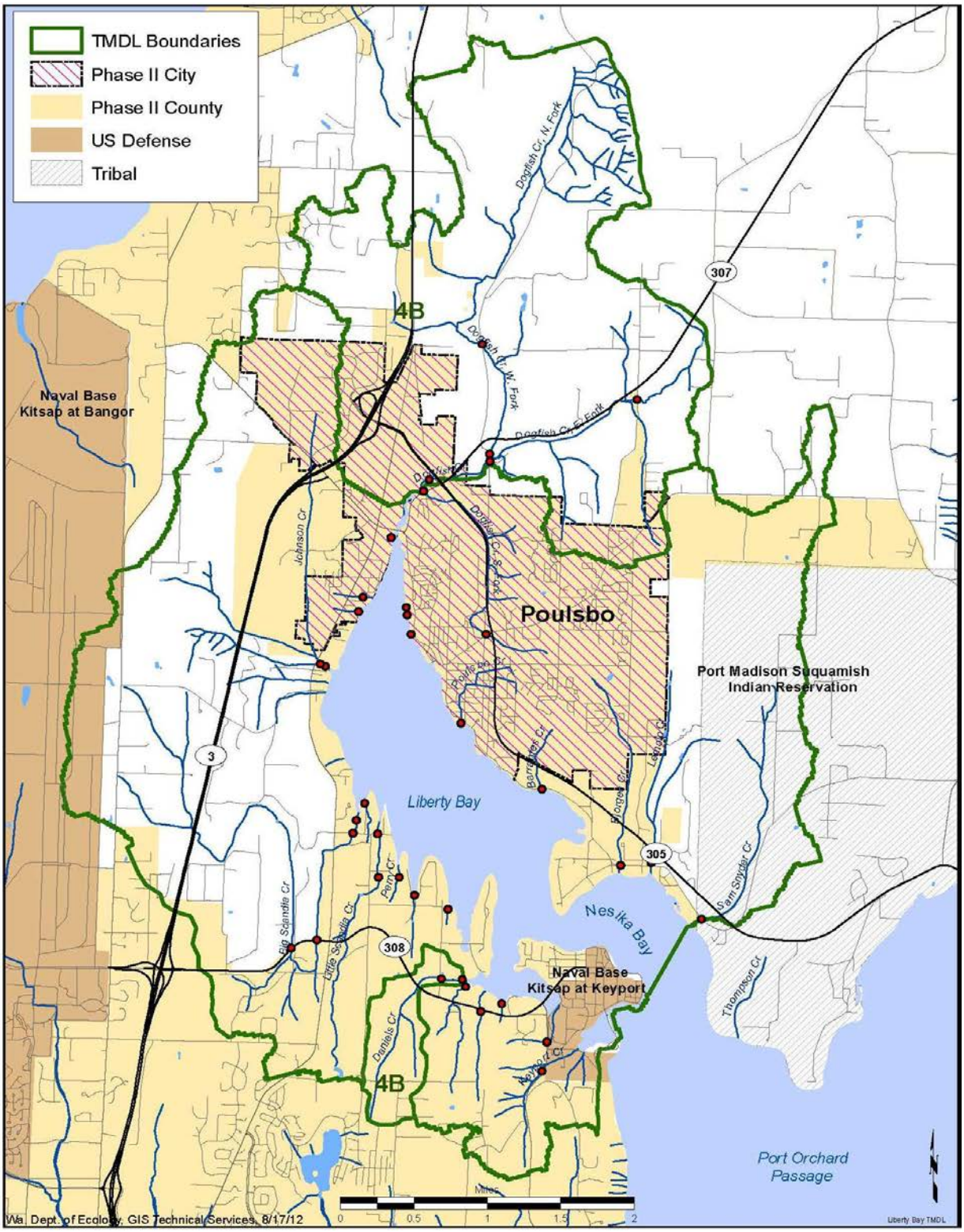

Figure 24. Areas of Liberty Bay watershed with Phase II NPDES stormwater permits.

- Washington State Department of Transportation (WSDOT) has an Ecology NPDES permit for stormwater discharges from state highways. Portions of SR3, SR305, SR307, and SR308 are shown in Figure 24 along with the Phase II jurisdictions they cross. WSDOT's permit coverage area consists of state highway drainage systems in areas covered by Phase II municipal stormwater permits.
- There are no municipal wastewater treatment facilities discharging to Liberty Bay. The Central Kitsap Wastewater Treatment Plant (WWTP) at Brownsville serves most of Poulsbo; the U.S. Navy facilities at Bangor and Keyport; the community of Keyport; and other communities in central Kitsap and discharges to Port Orchard Passage southwest of Liberty Bay. Central Kitsap WWTP operates under individual NPDES municipal wastewater permit WA-003052-0.

Some Ecology bacteria TMDLs that address the problem of contaminated freshwaters draining to marine waters with the 14/43 standard establish stream FC targets that are lower than the existing freshwater standard in order to protect the bay. Examples of TMDLs with more protective freshwater standards to protect marine waters are Sinclair and Dyes Inlets Fecal Coliform TMDL (Ecology, 2011) and Samish Bay Watershed Fecal Coliform TMDL (Ecology, 2009). Because the freshwater streams in the Liberty Bay Watershed TMDL are already assigned the more protective Extraordinary Primary Contact 50/100 standard, the existing standard for tributaries was judged sufficiently protective of marine waters and shellfish areas. As a result, for this TMDL the freshwater EPC standards (50/100) are retained as the freshwater targets.

Table 26 lists the sites monitored during the 2008-09 TMDL study that were sampled more than four times and that require reductions in FC concentrations to meet state water quality standards. The percent reductions (WLAs and LAs) are calculated separately for wet and dry seasons. Where NPDES Municipal Stormwater Permittees are noted, the corresponding percent reductions at each site represent the WLAs assigned to the relevant NPDES permittees. Mass loading estimates associated with each MS4 jurisdiction's portion of the load reduction at each site are given in Table 27 and Appendix E: Wasteload allocation summary tables.

In summary, the TMDL study determined the target capacity at each site in wet and dry seasons (Tables 18 to 21), and defined the target statistics that will enable the site to reach the 50/100 standards during implementation. The difference between the current concentration statistics and the targets set using the rollback method is the percent reduction needed.

In addition, the TMDL study determined current average daily load (concentration times flow) at each site in wet and dry seasons (Tables 22 to 25). Applying the percent reductions from Tables 18 to 21 to these average daily loads yields the loading capacity for each site and season. Finally, the percent reductions are expressed as WLAs assigned to NPDES stormwater permittees (Tables 26 and 27).

Table 26. Seasonal wasteload allocations (percent FC reductions) for NPDES stormwater permittees.
The 50/100 standards are the targets to be met. Shaded cells indicate permittee with primary responsibility.[8]

Site ID w/ River Mile	Water Body and Site Location	Wasteload Allocation		NPDES Municipal Stormwater Permittee			
		Dry-season % reduction	Wet-season % reduction	Poulsbo	Kitsap Co.	WSDOT	US Navy
15-DOG-0.6	Dogfish Creek off Bond Rd. at dental office	***Category 4b***		X	***must meet 50/100 FC standards***		
15-SFD-0.0	South Fork Dogfish Creek at Bond Rd. and 1st Ave.	50 %	87 %	X		HWY 305	
15-SFD-1.3	South Fork Dogfish Creek at 8th Ave. and Iverson	52 %	83 %	X		HWY 305	
15-EFD-0.0	East Fork Dogfish Creek at Little Valley Rd.	***Category 4b and must meet 50/100 FC standards***					
15-EFD-1.2	East Fork Dogfish Creek at Pugh Rd.						
15-WFD-0.0	West Fork Dogfish Creek at Little Valley Rd.	***Category 4b and must meet 50/100 FC standards***					
15-WFD-0.9	West Fork Dogfish Creek at Big Valley Rd.						
15-JOH-0.1	Johnson Creek 400 ft. south of Norfin Rd.	57 %	0 %	X	X	SR 3	
15-BSC-0.0	Big Scandia Creek at Scandia Ct. at private res.	73 %	55 %		X	SR 3	
15-BSC-0.1	Big Scandia Creek at Scandia Rd.	69 %	56 %		X	HWY 308	
15-BSC-1.1	Big Scandia Ck at HWY 308, between Viking and Cox	82 %	13 %		X	HWY 308	
15-BSC-1.6	Big Scandia Creek at HWY 308, west of Cox Ave.	55 %	37 %		X	SR 3, HWY 308	
15-LSC-0.1	Little Scandia Creek at Scandia Rd.	96 %	85 %		X	HWY 308	
15-LSC-0.4	Little Scandia Creek at Blomster Way	88 %	56 %		X	HWY 308	
15-DAN-0.0	Daniels Creek off HWY 308	***Category 4b and must meet 50/100 FC standards***					
15-DAN-0.2	Daniels Creek at Virginia Loop Rd.						
15-PER-0.1	Perry Creek at 90 deg. right turn in Thorpe Rd.	96 %	66 %		X		
15-LEM-0.1	Lemolo Creek at Lemolo Shore Dr.	83 %	66 %	X	X	HWY 305	
15-BJO-0.1	Bjorgen Creek at Lemolo Shore Dr.	95 %	61 %	X	X	HWY 305	
15-BAR-0.0	Barrantes Creek at Lemolo Shore Dr.	85 %	25 %	X	X	HWY 305	
15-UNN-0.1	Small stream east of Daniels Creek at HWY 308	67 %	0 %		X	HWY 308	
15-UNN-0.0	Small stream flowing into bay next to Daniels Creek	98 %	73 %		X	HWY 308	
15-PET-0.0	Small stream east of Perry Creek at Thorpe Rd.	0 %[9]	49 %		X		
15-JEA-0.0*	Outfall at American Legion Park	76 %	93 %	X			
15-DON-0.0	Poulsbo Creek at Poulsbo Yacht Club	91 %	84 %	X		HWY 305	
15-BST-0.0	Small stream ~300 ft. east of Big Scandia Creek	0 %[9]	91 %		X		
15-KE1-0.2	Small stream at Brownsville HWY	96 %	0 %[9]		X		X
15-KE2-0.3	Keyport Creek off Brownsville HWY	87 %	0 %[9]		X		X
15-BOV-0.0*	Small stream between Bovela St. and Bay St.	88 %	0 %[9]	X			
15-LMK-0.0	Small stream off Virginia Loop Rd at private residence	0 %[9]	99 %		X		
15-NEL-0.0*	Discharge from Nelson Park bioswale on beach	98 %	97 %	X			
15-RET-0.0*	Small stream off Viking at assisted living facility	93 %	95 %	X			

* - WLAs for Poulsbo stormwater outfalls are for informational purposes only.

[8] City of Poulsbo and Kitsap County share responsibility for Lemolo, Bjorgen, and Barrantes Creeks because sources of pollution are not well understood in relation to jurisdictional boundary.

[9] WLA set at 0% because stream was dry during dry season or insufficient wet season data.

Using seasonal loading capacity estimates, wasteload allocations are assigned to NPDES Stormwater Permittees in mass loading terms (i.e., billions FC colonies/day) in Table 27.

Table 27. Seasonal wasteload allocations in mass loading terms for NPDES stormwater permittees.

Site ID w/River Mile	Water Body and Site Location	Loading Capacity		Municipal Stormwater Permittee WLAs - billion FC cfu/100mL			
		Seasonal Loading capacity billion FC cfu/100mL	Critical season	Poulsbo	Kitsap Co.	WSDOT	US Navy
15-SFD-0.0	South Fork Dogfish Creek	2.5	wet	1.2		1.2	
15-JOH-0.1	Johnson Creek	1.1	dry	0.4	0.4	0.3	
15-BSC-0.0	Big Scandia Creek	0.42	dry		0.2	0.2	
15-LSC-0.1	Little Scandia Creek	0.04	dry		0.02	0.02	
15-PER-0.1	Perry Creek	0.04	dry		0.04		
15-LEM-0.1	Lemolo Creek	0.05	dry	0.02	0.02	0.01	
15-BJO-0.1	Bjorgen Creek	0.06	dry	0.02	0.02	0.01	
15-BAR-0.0	Barrantes Creek	0.01	dry	0.004	0.004	0.002	
15-UNN-0.1	Small stream E of Daniels Cr	0.12	dry		0.1	0.02	
15-UNN-0.0	Small Cr. next to Daniels Cr	0.02	dry		0.016	0.004	
15-PET-0.0	Small stream E of Perry Cr	0.05	wet		0.05		
15-JEA-0.0*	Outfall at American Legion Park	0.22	wet	0.2			
15-DON-0.0	Poulsbo Creek	0.2	dry	0.15		0.05	
15-BST-0.0	Small Cr. ~300' E of Big Scandia Cr	0.26	wet		0.2		
15-KE1-0.2	Small stream @ Brownsville HWY	0.02	dry		0.01		0.01
15-KE2-0.3	Keyport Creek	0.26	dry		0.16		0.1
15-BOV-0.0*	Small stream (outfall) betw. Bovela Lane & Bay Street	0.07	dry	0.07			
15-LMK-0.0	Small stream off Virginia Loop Rd	0.01	wet		0.01		
15-NEL-0.0*	Nelson Park bioswale outfall	0.02	dry	0.02			
15-RET-0.0*	Small stream (outfall) off Viking at Retirement facility	0.12	wet	0.12			

* - WLAs for Poulsbo stormwater outfalls are for informational purposes only.

Critical season wasteload allocations were assigned to municipal stormwater permittees based on general relative land areas draining to each sampling site. Seasonal geometric mean concentration targets and daily mass loading limits during the critical season are summarized for each NPDES municipal stormwater permittee in Appendix E: Wasteload allocation summary tables.

Margin of Safety

The federal Clean Water Act requires that TMDLs be established with margins of safety (MOS). The MOS accounts for uncertainty about pollutant loading and water body response, and uncertainty in available data and the unknown effectiveness of the water quality controls that are put in place. The MOS can be stated explicitly (e.g., a specific portion of the load capacity is set aside for the MOS). But implicit expressions of the MOS are also allowed, such as conservative assumptions in the use of data, application of models, and the effectiveness of proposed management practices.

Implicit MOS elements were applied to analyses to provide a large MOS for the Liberty Bay Watershed FC TMDL evaluation. The recommended FC reductions and allocations are conservatively set to ensure targets will result in achieving water quality standards in order to protect human health and designated beneficial uses.

The following are conservative assumptions that contribute to the Liberty Bay MOS:

- In most cases, the statistical rollback method was applied to FC concentration data for the season, and the resultant recommended TMDL target annual FC load reductions are more protective than would be required under the listed numeric standards for Washington State *Extraordinary Primary Contact* and *Primary Contact Recreation* uses.

- The rollback method conservatively assumes that the variance of the pre-management data will be equivalent to the post-management sample population variance. As pollution sources are managed, the occurrence of high FC values is likely to be less frequent, reducing the variance and 90th percentile of the post-management condition. The assumption of consistent variance adds to the MOS in that higher variances result in more protective targets than will be needed as pollution source correction progresses.

- The simple mass balance calculations and subsequent derivation of target values in freshwater assumed no FC die-off. Dilution and die-off of FC in freshwater after mixing with marine water also was not included in the analysis. Assuming bacteria levels are persistent and there is no natural attenuation adds to the MOS.

- Targets set in this TMDL were based on limited numbers of bacteria samples. These small sample sets are often highly variable and subsequent rollback calculations often result in more protective reduction targets than larger sample populations.

- Ecology uses a statistical formula based on the variability of the sample sets to calculate estimated 90^{th} percentile values. This method results in a theoretical characteristic of the sample population and can produce 90^{th} percentiles that are higher than any of the actual individual sample values.

- Recommended load allocations were set downstream from suspected nonpoint sources. The reduction or elimination of FC at upstream sources will likely bring downstream sites closer to compliance with water quality criteria. The downstream sites add assurance that any other FC nonpoint (diffuse) sources will be identified and reduced.

Reasonable Assurance

Reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources) in the water body when establishing a TMDL. TMDLs (and related implementation plans) must show "reasonable assurance" that nonpoint sources will be reduced to their allocated amount, so it is not necessary to put the entire burden for pollution reduction on point sources. Education, outreach, technical and financial assistance, permit administration, and enforcement will be used to ensure that the goals of this TMDL are met.

For the Liberty Bay Watershed Fecal Coliform Bacteria TMDL, both point and nonpoint sources exist. Ecology believes that the nonpoint programs, activities, and authorities in the following list, have already begun implementation of this TMDL. These nonpoint programs provide assurance that FC bacteria in the tributaries and marine waters of Liberty Bay will meet the Washington State water quality standards by 2018. This assumes the following described activities are continued, maintained, and adaptively managed.

- Kitsap Public Health District (KPHD) has made substantial progress through Centennial Grant-funded Pollution Identification and Correction (PIC) projects for the Dogfish Creek watershed and the Liberty Bay watershed. KPHD is authorized to require repair or replacement of failing onsite sewage systems in accordance with Kitsap County Board of Health Ordinance 2008-01, Onsite Sewage System and General Sewage Sanitation Regulations, May 1, 2008. Funding assistance in the form of low-interest loans for on-site system repair and replacement is available through non-profit organizations such as Craft3.

- If landowners with livestock fail to work voluntarily with the Kitsap Conservation District to eliminate impacts to surface water from livestock manure management problems, KPHD can require compliance with Kitsap County Board of Health Ordinance 2004-02, Solid Waste Regulations.

- KPHD is authorized to require compliance with Kitsap County Board of Health Ordinance 1999-13, Marina Sewage Regulations, which prohibits discharge of sewage into marine waters from floating structures and requires marina owners and operators to provide marina sewage disposal facilities or services. The US Coast Guard also enforces regulations requiring Marine Safety Devices (MSDs) for vessels with installed toilets.

- Daniels and Dogfish creeks were placed in Category 4b by Ecology because of early KPHD PIC projects. Category 4b is a designation for waters for which a local government agency or organization is implementing a pollution control program that is expected to achieve compliance with state water quality standards. Water quality in both streams has improved considerably since early PIC projects and Category 4b designation, but the streams are not yet meeting standards (KPHD, 2011a). The KPHD PIC program initiated with this TMDL in 2009 continues to succeed in locating and correcting numerous failing onsite systems throughout the watershed and water quality continues to improve.

- Public education and involvement elements of municipal stormwater programs typically reach all populations in MS4 jurisdictions, including those involved in land uses whose drainages do not involve MS4s. This raising of public awareness of water quality and

BMPs should help improve the quality of stormwater which is considered a potential conveyance of nonpoint source pollution by virtue of its being outside MS4 systems.

While Ecology is authorized under Chapter 90.48 RCW to impose requirements or issue enforcement actions to achieve compliance with Washington State water quality standards, it is the goal of all participants in the Liberty Bay Watershed TMDL process to achieve clean water through cooperative efforts.

Implementation Plan

Introduction

The TMDL implementation plan describes what will be done to improve water quality in the Liberty Bay watershed so that water quality standards will be met by 2018. It explains the roles and authorities of cleanup partners (organizations with jurisdiction, authority, or direct responsibility for cleanup), along with programs or other means through which they will address these water quality issues.

The plan builds on existing local government programs and identifies a set of prioritized actions based on the TMDL analysis and recent water quality data. It reviews the programs already in place, identifies missing pieces and high priority sites to be addressed, and points to strategies and funding that can assist in enabling local surface waters to meet standards. It raises the issue of future population growth in the watershed and identifies local actions that can help prevent growth-related water quality degradation.

The plan identifies the water quality monitoring needed to track the effectiveness of current programs and recommends additional actions needed to achieve the TMDL. Finally, it describes the adaptive management process that will be used to adjust priorities and actions during the next five years. It is intended to be flexible, leaving some decision-making to local entities, and it recognizes the adaptive management and prioritization processes already working throughout the watershed.

The TMDL monitoring program resulted in a list of 25 sites assigned load and wasteload allocations because they did not meet standards in 2008-2009 (Table 26). Because the Liberty Bay PIC project and other local programs jump-started implementation starting in 2009, Ecology considered more recent WY2011 data collected by KPHD (Appendix M) to develop two levels of priority for addressing the load and wasteload allocations.

Recent KPHD marine data (Figure 25) indicate that Liberty Bay is currently meeting standards at several sites. However, bacteria statistics for Dogfish Creek estuary and the west side of the bay are at a tenuous point in relation to the standards. Continued progress is needed to ensure these sites continue to comply with the standards.

Priority locations for follow-up

Kitsap Health's WY 2011 PIC project data for Liberty Bay watershed streams and outfalls (Appendix M) were reviewed to see whether water quality had improved substantially since the TMDL study. The review was used to separate locations with WLAs (Table 26) into two priority levels for follow-up. Estimated annual loadings from these streams and outfalls to Liberty Bay in 2008-2009 were also considered in establishing priorities (Table 13).

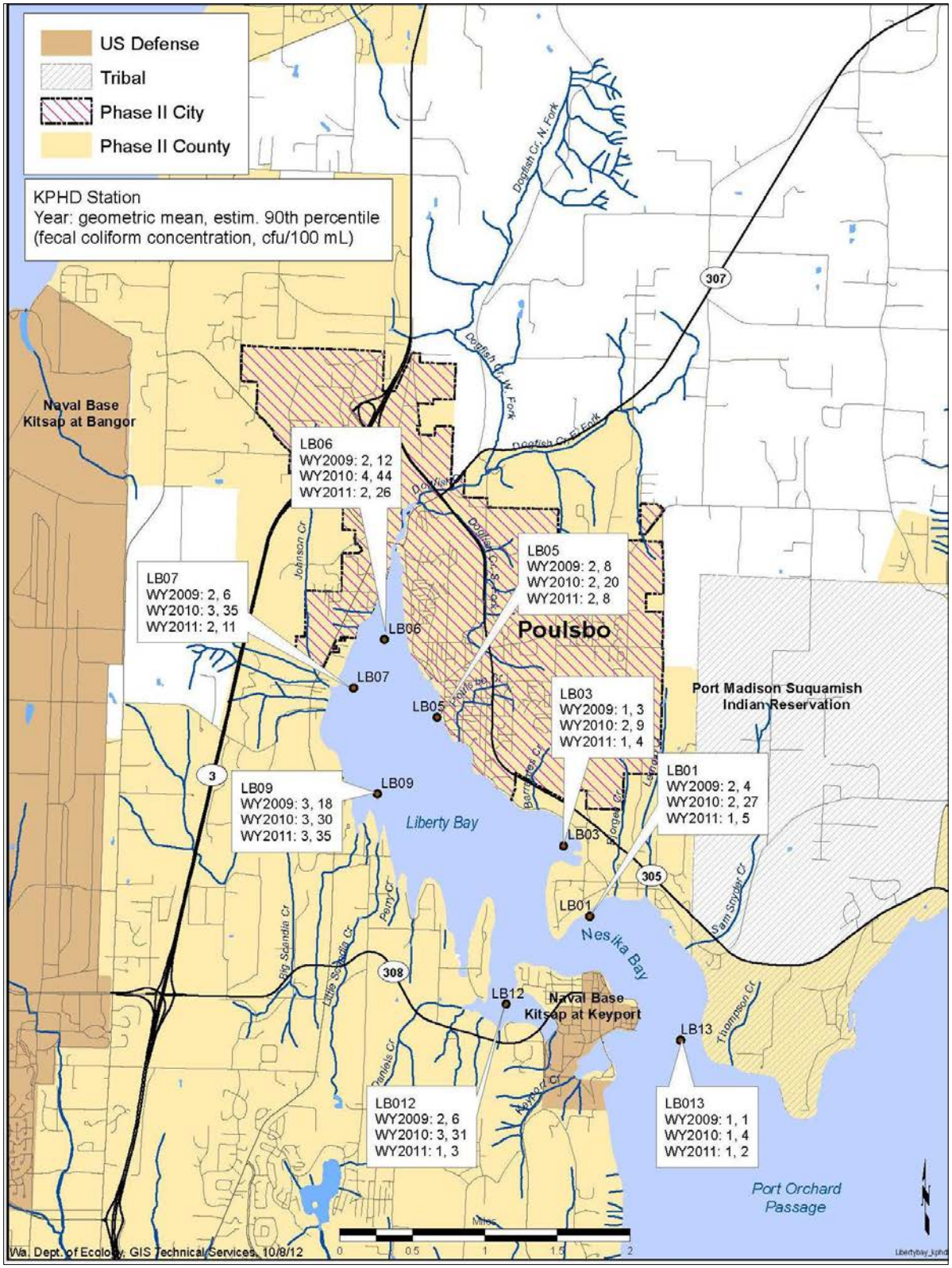

Figure 25. Recent KPHD fecal coliform statistics for Liberty Bay marine sites.

Higher priority streams for cleanup (based on potential for nearshore impacts and relatively high FC concentrations): South Fork Dogfish; Dogfish; Poulsbo; Bjorgen; Big Scandia, Little Scandia; Lemolo; unnamed seasonal stream just east of Big Scandia (Ecology site BST); and the outfall next to the assisted living facility (Ecology site RET).

Lower priority streams for cleanup: Perry Creek; Keyport creeks 1 and 2 (Ecology sites KE1-0.2 and KE2-0.3); Barrantes Creek; outfall below Nelson Park bioswale; tributary east of Perry Creek (Ecology site PET); Sam Snyder Creek; tributary between Bovela and Bay streets (Poulsbo outfall OF-3706); and freshwater investigation sites UNN0.0, UNN0.1, LMK, and JEA. Some of these streams are in less-developed parts of the watershed and could be affected by future development (tributary east of Perry; Lemolo; Keyport creeks 1 and 2; Perry; Sam Snyder; and Barrantes creeks).

The nine higher priority streams were selected based on their relatively high estimated loading to Liberty Bay in 2008-2009. All high priority streams discharged more than one billion bacteria per day, based on annual averages (Table 13). These streams also did not meet the 50/100 freshwater bacteria criteria during the TMDL study.

Based on the appendices K and M comparison of WY2011 data with the 2008-09 TMDL study data, several streams have improved significantly:

- Johnson, Big Scandia, Poulsbo, and Little Scandia creeks – dry season.
- South Fork Dogfish, Poulsbo, Little Scandia, and two Big Scandia sites – wet season.

However, some sites have not improved or have gotten worse:

- South Fork Dogfish, Bjorgen, upstream site on Little Scandia, and Lemolo - dry season.
- Lemolo, Barrantes, two sites on Big Scandia, and Perry creeks - wet season.

The two levels of priority for follow-up are intended to allow jurisdictions that are assigned several locations with WLAs to initially focus on higher priority areas.

Sources of fecal coliform bacteria

Sources contributing to nearshore areas of Liberty Bay and creeks may include:

- Failing onsite sewage systems along creeks or marine shorelines.
- Human waste from recreational vessels and liveaboards, if boaters are not following best management practices.
- Livestock and pet waste and manure spreading, if not managed properly.
- Bacteria-contaminated municipal stormwater from commercial or residential areas.
- Municipal wastewater collection systems, if not maintained properly.
- Watersheds with higher percent impervious areas. City of Poulsbo and urbanized Kitsap County are expected to grow significantly over the next few years. Proactive plans should be put in place to allow development without increasing pollution.

Nonpoint programs and actions to reduce bacteria

This section describes the nonpoint programs that will address the six types of FC bacteria sources listed previously. Government agencies, tribes, non-profit organizations, and citizen groups are described that have regulatory authority, influence, information, resources, or other involvement that will assist in implementing the Liberty Bay Watershed TMDL. For each agency, current programs that address *nonpoint sources* of bacteria are listed, followed by specific implementation activities that should be undertaken to address LAs in Table 26. All implementation actions are summarized in Table 29. The actions and an implementation schedule are provided in Appendix F: Schedule of implementation actions.

Onsite sewage systems - Kitsap Public Health District (KPHD) and others

KPHD has authority under county ordinance to assess penalties on owners of failing onsite systems and has developed the Pollution Identification and Correction (PIC) program to monitor surface waters, inform the community, and locate and ensure correction of failing systems. It is the responsibility of homeowners and businesses to ensure onsite sewage systems are properly operated and maintained. If these systems fail, they may pollute nearby surface waters. Sewage typically contains pathogenic bacteria and viruses that can make people sick.

With funding from Kitsap County Surface and Stormwater Management, KPHD manages a program throughout the county to reduce fecal coliform pollution along marine shorelines and in streams and lakes. KPHD started a Liberty Bay PIC project at about the time the TMDL monitoring was completed, using a Centennial Grant administered by Ecology. The project is funded through 2014, and elements and accomplishments of the project are described in Figure 26. The project includes monitoring to identify fecal pollution sources and follow-up investigations to correct the sources.

Finding failing onsite systems is critical, but the high cost of repair and replacement can be an obstacle to getting onsite corrections completed. Having a low-cost local loan funding program for repair has made a difference in many counties in Washington State. In Kitsap County Craft3, formerly known as Enterprise Cascadia, a nonprofit organization based in Seattle and Shelton, Washington (http://craft3.org/Borrow/SepticLoans) has been a key partner in making low-interest loans available for onsite system repair and replacement.

In some neighborhoods served for decades by onsite sewage systems, soil conditions in combination with increasing housing density may mean these individual systems do not provide sufficient treatment to protect surface waters from loading by nutrients and bacteria. Although some areas of Poulsbo are not yet connected to sewer, it does not appear that any of these are causing water quality problems because of unsuitable soils for onsite system drainfields.

Liberty Bay Watershed Restoration:
A Kitsap Public Health District PIC Project

Kitsap Public Health District (KPHD) was awarded a Centennial Clean Water Grant for a Pollution Identification and Correction (PIC) project. A PIC project follows an established protocol (KPHD 2003) and includes monitoring of freshwater streams, shoreline seeps, and stormwater outfalls. When elevated bacteria concentrations are detected, KPHD investigates further to locate and eliminate or reduce the sources. Follow-up investigations may segment a stream to locate sources or use charcoal packets that pick up optical brighteners from laundry detergents. The project is funded through 2014.

Besides monitoring, a PIC includes:

- Water quality outreach. At community meetings, explaining the water quality problems and ways to prevent fecal coliform pollution.
- Onsite system education and inspections. Conducting door to door surveys to educate households on proper septic maintenance, provide a copy of the "as-built" record for the homeowner's system, ask permission to inspect the system and, if no one is home, leaving explanatory brochures.
- Technical assistance to livestock owners. Kitsap Conservation District is funded under the grant to provide education and cost-share funds for livestock owners who need to implement Best Management Practices.
- Boater education. Information about water quality has been provided to boaters at a Liberty Bay-area marina, and a follow up survey conducted afterward, to assess changes in understanding. Hour-use meters were installed at the marina pumpout station to collect data on usage.
- Enforcement—KPHD has authority to enforce implementation through its solid waste ordinance.

As of September 2012:

- Five of the larger streams monitored by KPHD have significantly improved, based on trend analysis. One upstream site on Big Scandia Creek met standards in both wet and dry seasons of WY2011.
- All eight marine stations monitored by KPHD met standards in WY2009 and 2011, and all but one met standards in 2010 (Figure 21).
- 792 onsite systems were inspected; 42 failures were identified; 29 repairs completed; and 13 repairs are in process.
- Shoreline "hot spots" continue to be investigated; currently, the sources for 14 hot spots remain unidentified and investigations are continuing.
- Kitsap Conservation District has reduced the percentage of High and Medium High Priority sites (sites with evidence pollution is occurring) in the Liberty Bay watershed from 22 percent in 2010 to seven percent in 2012. The approach includes education, implementation of farm plans, and installation of best management practices.

Figure 26. Liberty Bay Watershed Pollution Identification and Correction Project.

Pet waste - City of Poulsbo and others

In rural areas, pets may be a nonpoint source of fecal coliform bacteria to surface waters. When left on the ground, the waste and bacteria are easily washed into streams, lakes, and bays, including shellfish beds. If picked up and disposed of properly, this source can be reduced effectively. In urban areas, the number of pets and consequent amount of pet waste can increase significantly. Addressing pet waste is a significant element of pollution control in permitted stormwater systems (see Municipal Stormwater section).

Figure 27. Mutt Mitt station providing baggies for pet waste pick-up at Lions Park near Poulsbo Yacht Club.

Poulsbo is one of six cities that joined with Kitsap County to form the West Sound Stormwater Outreach Group (WSSOG). The purpose of WSSOG is to provide a mechanism for the members to pool resources for the development, implementation, and funding of education and outreach programs to the public on numerous stormwater pollution prevention topics. As part of the development and implementation of its various programs, WSSOG conducts research and follow-up on the effectiveness of the programs on public awareness and behaviors. WSSOG public awareness campaigns involve advertisements on television, in theaters and buses; direct mailers, print and online ads, and utility bill inserts; and Puget Sound Starts Here promotions in local restaurants, bars, and coffee shops. An Ecology Stormwater Grant of Regional or Statewide Significance (GROSS grant) has provided funding to support research, message development, advertising strategy testing, and evaluation for the increased promotion of the regional Water Pollution Reporting Hotline.

Among the topics addressed by the WSSOG group is that of increasing public awareness about the effects of pet waste on surface waters. One of the ways this is accomplished is through the Mutt Mitt Program. The program provides Mutt Mitt stations and a starter set of bags to

community sponsors, such as homeowner associations, desiring to install stations in their shared open spaces areas. In addition, the local jurisdictions provide Mutt Mitt stations in their parks. The West Sound Mutt Mitt Program has grown from 100 stations in 2009 to 300 stations in 2012. An increasing number of these stations (27 as of early 2013) are located in Liberty Bay watershed.

Recreational and live aboard boater waste – KPHD and others

Liberty Bay is a valued recreational destination and resource for boaters. Vessels tie up at public and private docks along the shoreline, use slips at marinas, and visit from neighboring waters. During Poulsbo's Viking Fest in May, other summer holidays, and during summer weekends, hundreds of boats visit the bay.

Marinas on Liberty Bay include:

- Port of Keyport, at 1954 Grandview, about 25 slips
- Poulsbo Yacht Club at 18129 Fjord Dr NE, 152 slips
- Liberty Bay Marina at 17791 Fjord Dr NE, 135 slips plus linear moorage
- Port of Poulsbo at 18809 Front Street NE, more than 100 slips

Figure 28. Boats moored in Liberty Bay.

Marine water quality at marinas is frequently poorer than the quality of more open waters away from boats and people. In 2011, KPHD found bacteria concentrations inside three Liberty Bay marinas were higher than outside the marinas (KPHD, 2011). The poor water quality inside marinas is a factor that the Washington Department of Health (DOH) is required to consider as it designates classifications of marine water bodies for shellfish harvest under the National Shellfish Sanitation Program.

Regulations related to management of human waste on vessels and at marinas include:

- Coast Guard regulations requiring Marine Safety Devices (MSDs) for vessels with installed toilets. www.uscg.mil/hq/cg5/cg5213/msd.asp
- Kitsap County Board of Health Ordinance 1999-13, *Marina Sewage Regulations*, requires boatyards, marinas, and yacht clubs to provide and maintain service for proper waste management.
- Vessel General Permit. EPA is expected to issue the final Vessel General Permit on March 15, 2013 with permit effective date at the end of 2013. Information about the Vessel General Permit and the Small Vessel General Permit is available at: http://cfpub2.epa.gov/npdes/home.cfm?program_id=350. WA guidance on EPA's Vessel General Permit and vessels in general: www.ecy.wa.gov/programs/wq/permits/VGP/index.html

Ecology is working with DOH and a number of other agencies on a proposal to the U.S. Environmental Protection Agency to designate Puget Sound a "*No Discharge Zone*." A no discharge zone (NDZ) is an area in which both treated and untreated sewage discharges from vessels are prohibited. Within NDZ boundaries, vessel operators are required to retain their sewage discharges onboard for disposal at sea (beyond three miles from shore) or onshore at a pump-out facility. The geographic scope of a Puget Sound *No Discharge Zone* has not been determined but could include Liberty Bay. More information on a Puget Sound *No Discharge Zone* is at: www.ecy.wa.gov/programs/wq/nonpoint/CleanBoating/nodischargezone.html.

As part of its enforcement of the *Marina Sewage Regulations*, KPHD responds to complaints about illicit greywater or sewage discharge from marine vessels. The ordinance depends in part on boater awareness and motivation to use available pumpout stations. To track pumpout station usage, KPHD is monitoring usage at several Kitsap-area marinas. Two Centennial Grant projects (Liberty Bay PIC and Sinclair Inlet Restoration) are funding the program, which will test the effectiveness of different methods to increase awareness and use of pumpouts.

KPHD actions needed to ensure the TMDL project sites meet state water quality standards for bacteria in five years (by 2018) are:

- Continue to locate and ensure correction of bacteria sources at all regularly-monitored and investigation TMDL project sites through the Liberty Bay PIC project, which addresses bacteria from failing onsite systems, illicit discharges to storm systems, and livestock waste sources.
- Continue enforcement and education activities related to marina operations and boater behavior in Liberty Bay.
- Continue to implement the public outreach and education efforts that address fecal coliform pollution in the Liberty Bay watershed.

Kitsap Conservation District

Livestock and manure management

Property owners in rural and urbanized areas of Kitsap County and in Poulsbo may keep livestock such as cows or goats, pigs, chickens, ducks, horses and other domestic livestock as a source of food or as pets. It is the responsibility of property owners to make sure they manage land and livestock to ensure that downstream waters are not degraded. Kitsap Conservation District (KCD) educates landowners on ways to protect surface water in addition to providing farm planning and financial assistance programs to increase production and conserve soil (Figure 29).

Figure 29. Trampling of stream bank by livestock contaminates surface water with bacteria and sediment.

Kitsap Conservation District (www.kitsapcd.org) is a non-regulatory, legal subdivision of state government that administers programs to conserve natural resources. KCD works with agricultural and other private landowners to reduce soil erosion and impacts to water quality.

As a partner in KPHD's Pollution Identification and Correction projects, KCD offers technical assistance to landowners whose farm or livestock practices may be affecting water quality. For some practices, KCD can offer cost-share funds to landowners.

KCD provides technical assistance on:

- Farm planning.
- Pasture management and livestock and manure management.
- Soil conservation; stream bank protection and restoration.
- Wildlife habitat enhancement.
- Rain gardens for stormwater infiltration.

- Woodland maintenance and enhancement.
- Native plant sales and planting recommendations.

Pollution related to growth and development

The Liberty Bay watershed is expected to experience significant population increase in the coming years. The city of Poulsbo is expected to increase in population by 59 percent, from 9,300 in 2008 to 14,800 by 2025 (city of Poulsbo, 2009). Kitsap County population county-wide is expected to increase by 43 percent, from 231,000 in 2006 to 331,000 in 2025 (Kitsap County Department of Community Development, 2006). The developed infrastructure associated with housing and commercial areas typically results in water quality degradation. In a literature survey, Glasoe and Christy (2005) observed that moderate levels of development in the range of 10 to 25 percent impervious cover typically correlate with degraded aquatic habitats, including shellfish growing areas.

Population increases are unavoidable and in fact are encouraged in urban areas by the Growth Management Act. Liberty Bay watershed is located within the UGA where such growth is encouraged. Since increases in population and percent impervious area could be associated with water quality degradation and shellfish closures, local governments should use all available tools to plan development in ways that protect water quality.

The way infrastructure is built can be modified to include Low Impact Development (LID) or other stormwater management approaches that minimize the increase in percent impervious area. The Phase II stormwater permit scheduled to take effect in August 2013 requires the city of Poulsbo and urbanized Kitsap County to implement LID at applicable developments approved starting in 2017. Kitsap County has already implemented language indicating LID is the preferred approach to development. Poulsbo may consider strengthening its current language "encouraging" implementation of LID prior to the permit requirement taking effect.

Retrofitting existing impervious areas to manage stormwater on site is a way to reduce impervious area and reduce or eliminate current stormwater impacts. Kitsap County and the city of Poulsbo are implementing retrofit projects, and the city has some projects currently underway. To avoid growth that would result in future water quality degradation, Ecology recommends:

- Local planning agencies should develop incentives for small developments (those not triggering MS4 thresholds) to be designed to retain all stormwater on site through site design, installation of rain gardens, and other approaches.
- Local planning agencies should develop tools for identifying areas within the Liberty Bay watershed that have different sensitivity to development, i.e., that pose greater or lesser risk of degrading surface water quality if developed.

Suquamish Tribe

The Suquamish Tribe is a signatory to the 1855 Treaty of Point Elliott and is a co-manager of fishery resources within the Tribe's usual and accustomed fishing area (U & A). Liberty Bay is

situated within the Tribe's U & A and some fish and shellfish resources within the watershed are reserved to the Suquamish under the Treaty.

The Lemolo area is currently the only area of Liberty Bay designated by state Department of Health as "Approved" for commercial shellfish harvest (Figure 5). The Suquamish Tribe is a partner in the TMDL project and has assisted in the development of TMDL goals. As part of the TMDL project, Suquamish Tribe plans to continue its collaborative work with KPHD, DOH, Ecology, and others to evaluate whether water quality and other conditions in Liberty Bay result in upgrades in the Commercial Shellfish Growing Area Classification from Prohibited or Unclassified to Approved.

Craft3 (formerly, Enterprise Cascadia)

Craft3 is a non-profit community development financial institution promoting economic opportunity and a healthy environment in urban and rural communities of Oregon and Washington (www.craft3.org). Formerly called ShoreBank Enterprise Cascadia, the non-profit organization continues one of its principal environmental programs: to provide loans for homeowners along Hood Canal, Kitsap County, and other parts of Puget Sound to repair and replace failing onsite sewage systems.

Craft3 currently manages the Hood Canal Regional Septic Loan component of the program, which serves onsite sewage system owners in Jefferson, Kitsap, and Mason Counties. The non-profit is continuing to seek capital for a permanently sustainable on-site system loan program.

SEPA reviews by city and county planning agencies

Planners need to consider TMDLs during state Environmental Policy Act (SEPA) and other local land use planning reviews. If the land use action under review is known to potentially increase discharges of bacteria to surface waters, then the project may have a significant adverse environmental impact. SEPA lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives and to document that the necessary environmental analyses have been done prior to permitting. Land use planners and project managers should consider findings and actions in this TMDL to help prevent new land uses from contributing to exceedances of water quality standards. Guidance for using TMDLs in SEPA impact analysis, threshold determinations, and mitigation can be found on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/0806008.html. Additionally, the TMDL should be considered by local authorities in the issuance of land use permits.

Washington Department of Ecology

Ecology is responsible for overseeing and documenting implementation of the Liberty Bay Watershed Fecal Coliform TMDL. Once EPA approves a TMDL, Ecology is responsible for advocating and supporting implementation actions and periodically assessing progress in meeting water quality standards. Ecology will work with local organizations to develop projects and programs to meet the targets of the TMDL.

Ecology has regulatory oversight of the NPDES wastewater and stormwater permits cited in the TMDL, and will work to ensure that WLAs are incorporated as appropriate into these permits so the required bacteria loading reductions will occur. Ecology will communicate with EPA federal permit managers to ensure that requirements for federal facilities include TMDL wasteload allocations and are carried out.

Ecology will periodically review results of local and state water quality monitoring to assess progress, and will work to adaptively manage the TMDL to assure its effective implementation. Ecology will continue to support and manage grant and loan programs that assist in developing programs and projects to help reduce fecal coliform in the watershed, and will work with stakeholders to de-list water body segments that meet water quality standards. In addition, Ecology has the responsibility to ensure compliance with state water quality regulations under RCW 90.48.080.

Washington State Department of Health (DOH)

The DOH Office of Shellfish and Water Protection has authority to establish classifications of marine waters for commercial shellfish harvest, according to regulations of the National Shellfish Sanitation Program (NSSP). To establish classifications, the DOH Shellfish Growing Area Program conducts marine water quality monitoring, conducts shoreline sanitary surveys, and evaluates the potential for point sources to affect water quality and shellfish harvest areas. Growing area classifications determine whether or not shellfish in the area can be harvested for human consumption. Commercial harvest is not allowed in areas that are not classified.

In addition to evaluating available marine water quality data and stream FC concentrations and loads, NSSP regulations require that DOH also consider other potential point sources including marinas and private docks with recreational vessels, and evaluate the magnitude and seasonality of these potential sources in relation to marine water circulation and dilution by tidal action. The Lemolo area is currently the only area of Liberty Bay designated “Approved” for commercial shellfish harvest by DOH (Figure 5). However, in September 2012, the Suquamish Tribe submitted a shellfish harvest request for additional areas of Liberty Bay.

Washington State Department of Natural Resources (DNR)

Washington State Department of Natural Resources (DNR) manages over 2.6 million acres of state-owned aquatic lands and leases aquatic lands, including leases to some marinas. DNR’s non-regulatory Aquatic Resources Program manages the leases and does not issue permits. When the Aquatic Resources Program authorizes a project, the parties involved sign a legal contract that documents the terms and conditions of the use, such as insurance requirements and rent (if applicable). Included in DNR’s responsibilities is the protection of the environmental quality of state aquatic lands.

On Liberty Bay, DNR leases aquatic land to two marinas (Poulsbo Yacht Club Marina and Liberty Bay Marina). Two other marinas (Port of Poulsbo--Figure 30--and Port of Keyport) lease state aquatic land through DNR’s ports program. Under the program, ports are eligible for

a Port Management Agreement which defines general responsibilities for both the Port and DNR. If the port controls uplands that abut the state-owned aquatic lands, the port still follows all applicable local, state and federal laws. Where a port does not have upland control, the Ports Program administers other agreements that include Commercial Leases, Material Sales Agreements, Easements and Rights of Entry.

Ecology encourages DNR to assist, as resources allow, with the TMDL implementation and its goal of increasing beneficial uses, both those related to recreation and shellfish harvest.

U.S. EPA

U.S Environmental Protection Agency Region X (EPA) has approval authority for Washington state TMDLs and will review the Liberty Bay Watershed TMDL to make sure it meets the requirements of the Clean Water Act. EPA also administers the NPDES program for federal facilities in Washington, including the Multi-Sector Industrial Stormwater Permit that provides coverage for Naval Base Kitsap Keyport. EPA will review the TMDL recommendations for Navy actions and determine whether they should be reflected in a future issuance of the Navy's permit.

Figure 30. Department of Health vessel departs Port of Poulsbo marina after sampling Liberty Bay.

Independents and non-profit organizations

Fecal coliform bacteria could be more effectively reduced if the general public was more aware of the risks to human health, recreational uses, and shellfish harvest from behaviors that introduce pollution to surface waters. Education and outreach that help change behaviors to

best management practices (BMPs) are needed to address proper management of pet waste, livestock manures, onsite sewage systems, and food waste left to attract wildlife.

Innovative strategies may be needed to engage and persuade people to modify behaviors. Partners in the TMDL project are encouraged to develop innovative ways to reach various audiences. Underwater video documenting trash disposal in marine waters may inspire recreational boaters and those on liveaboards to better protect the waters they use. An example is the work of a Kitsap-area scuba diver and film producer, which can be viewed online at www.stillhopeproductions.com/.

Clean Marina Washington

Clean Marina Washington was created in 2005 under an expansion of the EnviroStars program, which provides incentives for businesses to reduce and better manage their hazardous waste. Clean Marina Washington is an incentive-based certification program in which marinas assess their operations and implement improvements to better protect the environment. When marinas reach the qualification standards of Clean Marina Washington they earn the EnviroStar designation. Best management practices advocated by Clean Marina can be reviewed at: www.cleanmarinawashington.org/CleanMarinaBMPs.pdf

Puget Sound Restoration Fund

In 2007, Puget Sound Restoration Fund (PSRF), www.restorationfund.org), a nonprofit organization, selected Liberty Bay as a location to reestablish the native Olympia oyster, in part because this native oyster was found growing wild in the bay. This ongoing project is expected to increase the public's interest and action to protect water quality and aquatic life supported by Liberty Bay.

WSU/Kitsap Beach Watchers

Kitsap County Beach Watchers Program is a partnership of WSU Extension and Washington Sea Grant, and is one of nine WSU Extension Beach Watcher Programs in the Puget Sound area. The program trains volunteers who provide education, outreach, and mentoring to local citizens about shoreline protection and aquatic life along shorelines. Volunteers collect data on marine plants and animals, measure shore topography, evaluate water quality, talk with the public, conduct tours and classes, and perform valuable services such as removing invasive weeds from fragile estuaries. Ecology asks WSU/Kitsap Beach Watchers to look for opportunities to educate Liberty Bay watershed residents and visitors about ways to protect water quality through festivals, beach cleanups, and other events.

Kitsap Stream Stewards

The Kitsap Stream Stewardship Program is a partnership between WSU Kitsap Extension, Washington Sea Grant, and Kitsap County SSWM. Volunteers receive training that prepares them to work on upland and stream riparian restoration projects and assist in educating the public about the importance of healthy riparian ecosystems.

Point sources: NPDES permit elements that address bacteria

Jurisdictions with NPDES permits in the Liberty Bay watershed include the urbanized areas of unincorporated Kitsap County (Phase II Municipal General Stormwater Permit) and the city of Poulsbo (same Phase II permit), shown in Figure 24. The Washington State Department of Transportation (WSDOT) is covered by an individual NPDES and State Waste Discharge Permit for Municipal Stormwater; a handful of construction and industrial sites are covered under state stormwater permits; and the Naval Base Kitsap at Keyport is covered by an EPA Multi-Sector General Industrial Stormwater Permit (Appendix D).

Municipal stormwater

The city of Poulsbo and the Urban Growth Area of Kitsap County adjacent to Poulsbo are covered under the Western Washington Phase II NPDES municipal general stormwater permit. These areas cover most of the northern and eastern portions of Liberty Bay Watershed including significant shoreline area (Figure 24). WSDOT is covered under an individual statewide municipal stormwater permit, modified in 2012. The WSDOT permit covers stormwater discharges from state roadway drainages, including state roads within the Liberty Bay watershed.

Figure 31. Vactor Truck used to clean out stormwater catch basins.

The 2013-18 Phase II NPDES General Municipal Stormwater Permit includes elements that are expected to effectively reduce bacteria in stormwater. These elements include implementing the inspection and maintenance schedule of the Permittee's *Municipal Operations and Maintenance Program*. Table 28 lists stormwater permit components that will assist in implementing this TMDL. These permit elements need to be implemented with special consideration of potential bacteria sources contributing to MS4s and must be applied in the geographic priority areas of the TMDL.

Table 28. Major program components of stormwater program required by proposed 2013 Ecology Phase II Western Washington NPDES Municipal Stormwater Permit[10]. *Note: S5, S5A, and S5A C1 through C5 refer to sections of the permit*

S5 Program Component	Phase II permit requirements	Key elements to be completed under permit	Possible focused actions
A. Stormwater Management Plan	Tracking costs, actions and activities. Establish coordination among permittees as possible.	Under way	
C.1 Public Education and Outreach	Implement education program. Measure understanding, adoption of behavior change. Adjust program as necessary.	Continue to implement education and outreach program. ** Measure understanding and adoption of targeted behavior in one targeted audience in one subject area.	Education program targeting specific source of FC bacteria (e.g., pet waste management and disposal, dumpster/trash compactor maintenance)
C. 1 Public Education and Outreach	Encourage voluntary stewardship.	Provide opportunities for activities such as storm drain marking, education	Discuss w Poulsbo and County
C.2 Public Involvement	Stormwater Management Plan (SWMP) and annual reports are available to the public and posted on website.	Create ongoing opportunities for public input.	Request input on education priorities, stewardship opportunities, field screening priorities
C.3 Illicit Discharge Detection and Elimination (IDDE)	Maintain public hotline to report spills and illicit discharges. Update IDDE codes & regulations to prohibit non-stormwater discharges, establish compliance strategy. Maintain MS4 map, including outfalls to receiving waters. Conduct field screening. IDDE and general staff training. Maintain recordkeeping if needed.	Maintain MS4 map. Conduct field screening of storm system (40 % by 2017 and ongoing). Characterize, trace, and eliminate illicit discharges to MS4. Educate public, educate staff.	Target specific portions of MS4 in TMDL area for field screening: OF-3701, OF-3702, & OF-5304.
C.4 Control Runoff from Construction Sites in New Development & Redevelopment (generally, disturbing ≥ 1 acre)	Make Notices of Intent for construction, industrial stormwater permits available. Recordkeeping (inspections, maintenance, enforcement). Adopt regulations, continue to implement program for runoff control, site plan review, inspection, enforcement, Low Impact Development (LID). Update Operations & Maintenance regulations for post-construction BMPs & facilities, as needed. Staff training.	Implement program for runoff control, site plan review, inspection, enforcement, LID, etc. at applicable sites. 80 % inspection rate.	
C.5 Municipal Pollution Prevention, Operation and Maintenance	Implement Stormwater Pollution Prevention Plan (SWPPP), inspection & maintenance schedule, maintenance procedures for permittee lands and properties. Staff training.	Inspect & maintain key facilities, BMPs, and catch basins. Fully implement policies, procedures, & practices to reduce stormwater runoff from permittee properties, including parks & rights-of-way (e.g., trash and pet waste management).	As appropriate: special actions re: fertilizer application, trash and pet waste management, system/conveyance maintenance/cleaning

[10] Other permit elements listed below this table. This is guidance only – see the permit for additional detail and related requirements.

Notes to Table 28: Other significant elements of the Western Washington Phase II Municipal Stormwater NPDES permit

See the permit for additional detail and related requirements.

S1 Application for coverage

All operators or owners of small MS4s that meet the criteria for a regulated small MS4 or operators of small MS4s designated by Ecology as "significant contributors" per S1.B.3 must obtain coverage under the permit.

Jurisdictions applying as Co-Permittees submit a joint NOI. Co-Permittees can end or amend agreements at any time.

S4.F Response to violations of water quality standards

Notification and possible corrective actions may occur at any time.

S7 Compliance with total maximum daily load (TMDL) requirements

Jurisdictions comply with applicable TMDL requirements listed in Appendix 2 with individual timelines. Report on activities annually.

S8 Monitoring

Monitoring conducted under S8B. or C. may also be used to support/inform TMDL actions.

S9 Reporting

Keep all records related to permit and SWMP for at least five years. On an annual basis, report for previous calendar year using annual report forms in Appendix 3. Notify of changes in jurisdictional boundary with annual report.

G3 Notification of spill

Report to Ecology within 24 hours a spill into or from the MS4, which could constitute a threat to human health, welfare or the environment.

G14 General Permit Modification and Revocation

The Phase II municipal stormwater permit may be modified, revoked and reissued, or terminated in accordance with the provisions of WAC 173-226-230.

G20 Non-compliance notification
Notify Ecology with 30 days of awareness of permit non-compliance.

Urban areas and highway systems have high percentages of total impervious area, causing fewer places for stormwater to soak into the ground (infiltrate). Soils can be effective at reducing or eliminating FC through the infiltration process. In addition, bacteria in water tend to associate with particulate matter, so storm sewers that collect street and parking lot sediments may temporarily "capture" bacteria and hold them in reserve only to release them again during high-flow events.

How the 2013 Phase II municipal stormwater permit addresses bacteria

The Phase II municipal stormwater permit does not specifically mention FC bacteria. Some elements, however, if implemented with bacteria in mind can work well to reduce bacteria in stormwater (Table 28):

- C.1 – *Public education and outreach*. The municipalities in the Liberty Bay watershed have worked together in the Kitsap Peninsula Clean Runoff Collaborative on a public education program that includes messages on proper disposal of pet waste. Local stewardship activities may foster public awareness or improve pet waste management.
- C.3 – *Illicit discharge detection and elimination (IDDE).* This program can be used to investigate sources of FC discharging into the municipal stormwater system and eliminate them. A municipality can focus its IDDE program on high priority areas such as those water bodies or areas identified in this TMDL as needing FC reduction. Notifications from the spills hotline, called "Kitsap 1", or knowledge of areas of known septic failure or cross-connections may inform priorities.
- C.4 – *Controlling runoff from new and redevelopment*. This element includes a provision that municipalities must incorporate Low Impact Development (LID) approaches into site development planning, as appropriate. By reducing the stormwater that leaves a site, LID reduces the occurrence and impact of high-flow, pollution-carrying storm events. Incorporating LID into new development is essentially "bacteria-neutral" in avoiding the addition of *new* sources of bacteria-carrying stormwater. Incorporating LID into redevelopment helps address current, ongoing sources of bacteria-carrying stormwater.
- C.5 – *MS4 maintenance practices*. A municipality can increase the frequency of storm vault cleaning and other practices needed to reduce drain clogging and flooding that can disperse pollutants carried by stormwater into surface waters. Municipalities can also target additional resources to high-priority water bodies within their jurisdictions.

Effective approaches for reducing bacteria in stormwater

This information for Phase II NPDES municipal stormwater permittees also may be useful for U.S. Naval facilities and Washington Department of Transportation.

There are four main ways to reduce bacteria input to surface waters from stormwater systems:

- Infiltration
- Pollution prevention/source control
- Improved operations and maintenance
- Treatment

Infiltration. Since stormwater is a transporter of bacteria, approaches that enhance stormwater infiltration also decrease the discharge of bacteria to surface waters. These approaches include LID retrofit projects to contain stormwater onsite; adding rain gardens and green roofs; and directing roof runoff to landscaped areas rather than street drains. Similarly, street runoff can be captured in bioswales rather than discharged to municipal separate storm sewer systems (MS4s).

Municipalities can encourage stormwater infiltration by implementing LID BMPs or the LID performance standard in accordance with Appendix 1 of the 2013 Phase II municipal stormwater permit. An example of this is the city of Poulsbo's Anderson Parkway LID and Retrofit Project (Figure 32). Municipal Permittees can also:

- Adopt other policies that encourage reduced impervious areas and wider use of LID in development. One approach, already adopted by Kitsap County Surface and Stormwater Management and the city of Poulsbo, assesses stormwater fees based on impervious area.
- Educate citizens and developers on the value of infiltrating stormwater and reducing impervious area.
- Implement municipal projects that showcase and highlight infiltration BMPs and practices, including LID.

Figure 32. Newly-constructed Anderson Parkway bioretention cell with immature plantings.

Pollution prevention/source control. The Public Education (S5.C.1), IDDE (C5.C.3), and Municipal Operations and Maintenance (S5.C.5) elements of the Phase II permit can help reduce bacteria that enter the MS4, by addressing:

- Pet waste, through public education and providing pet waste bag stations in public parks.
- Wildlife waste from rodents and birds, by making sure multi-family and commercial property owners address food litter around dumpsters and trash compactors.

- Failing on-site systems or cross-connected sanitary sewers that discharge improperly to the MS4, through IDDE programs.
- Manure-composting facilities, stables, kennels, pet stores, and other businesses with potential animal waste. These facilities should be inventoried and targeted with specific education (e.g., via IDDE related activities and inspections) to ensure they are not contributing FC to stormwater.

Improved operations and maintenance. A municipality can reduce bacteria inputs to the MS4 by adjusting the frequency of storm system maintenance and street sweeping and conveyance/vault cleanout, to limit resuspension of bacteria, sediment buildup, and prevent flooding.

Treatment. Ecology's Stormwater Manual (2012) Volume IV includes some stormwater treatment options but none specifically targeting bacteria. www.ecy.wa.gov/programs/wq/stormwater/wwstormwatermanual/2012draft/2012draftSWMMWW.html#Draft_SWMMWW_Documents

Infiltration is a passive means of treatment using either existing soil on site or amended soils and substrate enhanced to ensure effective collection and treatment. Although costly and not appropriate for most locations, ozone or ultraviolet disinfection can be used to treat stormwater with bacteria (e.g., Fowler and Rasmus, 2005).

Construction site stormwater

Construction sites that disturb one or more acres and drain to surface waters are required to obtain coverage under Ecology's NPDES Construction Stormwater General Permit. When an operator (permittee) applies for permit coverage for a construction project that discharges stormwater to an impaired water body, Ecology requires the permittee to submit a form, "Construction Stormwater General Permit Proposed New Discharge to an Impaired Water Body" and an addendum to the Stormwater Pollution Prevention Plan (SWPPP). The SWPPP addendum includes implemented BMPs that prevent a discharge that will cause or contribute to a violation of water quality standards. Operators/Permittees are required to submit additional information regarding locations, contaminants, and concentrations, and the BMPs to control the off-site discharges of soil/groundwater contaminants. There are currently seven sites in the Liberty Bay watershed covered under the permit (Appendix D: Facilities with NPDES permits).

Construction sites can potentially contribute FC bacteria to surface water if not managed properly. The following are potential sources of bacteria and recommended practices to prevent degradation of surface waters:

- Old septic system tank or drainfield – avoid digging or ditching that could convey untreated waste to surface waters.
- Dumpster maintenance and worker food waste – proper disposal to avoid attracting birds, rodents, and other wildlife.
- Portable toilets – place well away from surface water bodies and ensure service on a proper maintenance schedule (Figure 33).
- Manure used in landscaping – make sure it is composted and not "hot".

Figure 33. Portable toilets at construction sites need proper maintenance and location away from surface waters.

Industrial stormwater

Industrial facilities (with specific Standard Industrial Codes [SIC]) are required to obtain coverage under Ecology's NPDES Industrial Stormwater General Permit. The permit, modified in 2012, requires FC sampling but has a non-numeric FC limit in the form of BMPs. www.ecy.wa.gov/programs/wq/stormwater/industrial/permitdocs/iswgpfinal051612.pdf

The bacteria-related BMPs to be incorporated in the facility's SWPPP and implemented are:

- Use all known, available and reasonable methods to prevent rodents, birds, and other animals from feeding/nesting/roosting at the facility.
- Perform at least one annual dry weather inspection of the stormwater system to identify and eliminate sanitary sewer cross-connections.
- Install structural source control BMPs to address on-site activities and sources that could cause bacterial contamination (e.g., dumpsters, compost piles, food waste, animal products, etc.).
- Implement operational source control BMPs to prevent bacterial contamination from any known sources of fecal coliform bacteria (e.g., animal waste, etc.).
- Additional bacteria-related sampling and/or BMPs, if ordered by Ecology on a case-by-case basis.

Two facilities in the Liberty Bay watershed have coverage under the state Industrial Stormwater permit (Appendix D). In addition, the Naval Base Kitsap at Keyport has federal coverage under the NPDES Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity.

Municipal wastewater

Wastewater treatment for most residents of Poulsbo, for county residents near Lemolo, for Naval Base Kitsap – Keyport, and for the village of Keyport, is provided by the Central Kitsap Wastewater Treatment facility in Brownsville. This facility operates under an individual state NPDES permit and is located outside the watershed. Treated discharge from Central Kitsap WWT plant goes to Port Orchard Passage, also outside the Liberty Bay watershed. No analysis or requirements from this TMDL apply to treated effluent discharged by the Central Kitsap treatment facility.

Parts of the sewage collection system that serve the Central Kitsap facility run through utility corridors within the Liberty Bay watershed and are operated and maintained by different jurisdictions – city of Poulsbo; Kitsap County; and Naval Base Kitsap at Keyport. Because sewage collection systems need to be operated and maintained responsibly and if in disrepair can be a source of bacteria and other pollutants to the environment, Ecology recommends that the city, county, and U.S. Navy verify they are following BMPs outlined in industry guidance, *Core Attributes of Effectively Managed Wastewater Collection Systems* (APWA et al., 2010).

- The sewage collection system within the city of Poulsbo is the responsibility of Poulsbo Public Works Department.
- Southeastward from the Poulsbo city boundary, the collection system runs through Kitsap County at Lemolo, crosses under Liberty Bay to Naval Base Kitsap at Keyport and runs south to the Brownsville treatment plant. This section of the system is operated and maintained by Kitsap County Public Works.
- Within the property boundaries of Naval Base Kitsap at Keyport (Figure 24), the Navy is responsible for the collection system.
- In addition, sewage collected at Naval Base Kitsap at Bangor (west of the Liberty Bay watershed) is piped through a utility corridor through county jurisdiction on the south side of the watershed, along SR 308 to Central Kitsap at Brownsville. This section of the system is operated and maintained by Kitsap County Public Works.

Organizations with responsibilities under permits

This section describes the facilities in the Liberty Bay watershed with federal or state permits to discharge to surface water. Permit provisions that can help ensure that these facilities do not contribute FC bacteria to surface waters were described in the previous section. Additional actions that should be taken by these facilities to prevent bacteria pollution are described in this section and summarized in the Implementation Summary Table 29.

Naval Undersea Warfare Center and Base Kitsap at Keyport

The Naval Undersea Warfare Center (NUWC) and Naval Base Kitsap at Keyport (NBKK) are covered under a federally-administered EPA NPDES Multi-Sector General Permit for stormwater discharges associated with industrial activity www.epa.gov/npdes/pubs/msgp2008_parts1-7.pdf. The permit requires that facilities document they have checked for the presence of non-stormwater discharges and that all unauthorized discharges have been eliminated (Section 5.1.3.4). Also,

Section 7.2 of the permit requires an annual report that includes results of comprehensive site inspections and any corrective actions.

Naval facilities have a SWPPP that includes practices and measures to minimize and control pollutants in stormwater discharges and establishes a schedule for implementing these practices (NBKK, 2009). The SWPPP is supported by a pollution prevention team working to develop, implement, and maintain the plan. The plan describes the existing stormwater system, water quality monitoring results, and an overview of related water and materials management plans. The plan was developed based on fieldwork to verify and map drains and discharge points and investigate sources of illicit discharges. Although quarterly monitoring of Navy facility outfalls was completed in the first two years of permit coverage, the list of parameters to be measured does not include FC bacteria (Section 5.3.2).

Ecology's TMDL findings, and inspections of the Keyport facility in conjunction with KPHD and EPA, lead to two recommendations. These recommendations are expected to become permit requirements in the next reissuance of the Navy's stormwater permit.

- In September 2009, a joint inspection of Navy outfalls by EPA, Ecology, and KPHD resulted in finding an illicit connection that was ultimately traced to a naval base residence. (The Navy fixed the illicit connection in 2012). *The Navy should conduct annual dry weather inspections of outfalls, and analyze for FC if flow is observed. Any measurement of FC ≥ 200 cfu/100 mL should be confirmed in follow up monitoring, and if confirmed then source investigation should proceed. Corrections should be made as soon as possible, not to exceed two years after initiating an investigation.*

- During the TMDL study, two creeks near Keyport (KE1-0.2 and KE1-0.3) exceeded water quality standards at Brownsville Highway, just prior to entering Navy property. These creeks discharge to two different brackish water lagoons on Navy property. These creeks are expected to be listed as impaired waters in the next Water Quality Assessment. Ecology and Navy staff inspected the streams in June 2012 to look for potential discharges from base facilities. One outfall to the northern stream system was identified; it serves the visitor parking lot at the Pass and ID entrance to the base. (Since this outfall conveys municipal stormwater, it is not covered by the EPA permit.)

***Ecology recommends**: The Navy monitor the streams just upstream of where they discharge to the brackish lagoons (below any wetlands or other potential sources of FC). Ideally, the monitoring will be scheduled to coincide with Kitsap County monitoring of the streams at Brownsville Highway. FC monitoring should be conducted twice monthly for a minimum of 12 continuous months to capture any seasonality in bacteria concentrations. (If twice monthly sampling is not feasible, then once monthly may suffice but would make statistical comparisons more difficult.) The Navy should follow Kitsap County's Ecology-approved bacteria sampling procedures or similar protocol. Duplicate field samples should be collected at a rate of one duplicate per 10 samples and data quality should be assessed at the end of the sampling period.*

If the average of the 12 or more FC sample concentrations taken on Navy property shows a statistically significant increase compared with corresponding upstream sites monitored by the

county, source investigation should proceed. If the average of the FC sample concentrations is not significantly different than that for the corresponding upstream site, no action will be required.

City of Poulsbo

The city of Poulsbo's Stormwater Division of the Public Works Department maintains the city's stormwater collection and conveyance system. The natural drainage system consists of the Dogfish, Lemolo, Johnson, and Bjorgen Creek basins, as well as several other basins that discharge directly to Liberty Bay. The collection and conveyance system consists of approximately 19 miles of pipe, 4 miles of open drainage ditches, over 2,000 catch basins, and 51 discharge points.

As of this writing, the city of Poulsbo is understood to be in compliance with the Phase II NPDES municipal stormwater permit and has implemented the required stormwater program components (Table 28). Additional strengthening of the city's stormwater program has come through several Ecology grants including a Centennial Stormwater Implementation Grant to KPHD to provide training to Kitsap-area municipalities in the Regional IDDE Clean Runoff Project (Figure 34). Under this grant, Poulsbo was assisted with:

- Dry weather screening conducted annually for three years at 15 Poulsbo stormwater outfalls.
- Pollution prevention/source control. Inspections of catch basins on commercial properties resulted in improved maintenance, correction of pollution sources, and education of property owners about the link between stormwater and receiving water quality.

In addition, Poulsbo has been successful in obtaining Ecology grants for several LID retrofit projects that are reducing effective impervious area: the Caldart Avenue Stormwater LID Project; the Anderson Parkway LID Retrofit Project; the Old Town LID Retrofit Project; and the Central Business District Stormwater Retrofit Project. The Anderson Parkway Project was completed in April 2013. The project encompassed removing existing pavements, installing bioretention cells, Filterra stormwater treatment units, and associated stormwater drainage structures. The location of the Anderson Parkway project is important in that it is immediately adjacent to Liberty Bay in downtown Poulsbo (HDPA, 2013).

The actions Poulsbo is required to undertake to address the WLAs in Tables 26 and 27 are:

- Focus IDDE efforts on parts of the MS4 upstream of Liberty Bay sampling sites with LAs/WLAs.
- Optimize frequency of operations and maintenance (O & M) inspections of MS4 infrastructure upstream of Liberty Bay monitoring sites with LAs/WLAs.
- Include a focus on Liberty Bay watershed pollution sources as part of stormwater public outreach and education. Key topics may include pet waste education and management. Stormwater education of business owners could include improved maintenance of trash compactors and dumpsters to prevent food waste from becoming an attraction for wildlife.

KPHD Regional Illicit Discharge Detection and Elimination (IDDE) Clean Runoff Project

In 2008, KPHD was awarded a Centennial Stormwater Implementation grant to provide technical assistance to the cities of Poulsbo, Bainbridge Island, Bremerton, Port Orchard, and unincorporated Kitsap County. Using interlocal agreements with partnering agencies, KPHD passed through funding to assist in completing stormwater system mapping; refining Illicit Discharge Detection and Elimination (IDDE) inspection procedures; conducting dry weather outfall screening[1]; and conducting inspections of commercial properties with drainage to municipal storm systems. The project was completed in 2012 and accomplished (in all the municipalities, not just those on Liberty Bay):

- 1252 commercial property inspections, including education of owners about water quality;
- 222 IDDE investigations resulting from complaints and commercial property inspections;
- Confirmation of 155 illicit discharges, out of the 222 investigations;
- Removal of 113 illicit discharges, out of the 155 confirmed.

The main pollution problems identified during the IDDE project were: (1) excess sediment buildup in catch basins, and (2) inadequate solid waste management at food establishments, creating attractions for urban wildlife.

[1]Under the Regional IDDE project, KPHD helped city of Poulsbo conduct yearly dry weather screening of 15 municipal outfalls. The screening used measurements of *E. coli* rather than fecal coliform bacteria, however, these tests are usually highly correlated in urban areas.

Figure 34. Kitsap Public Health District's Centennial Regional IDDE Clean Runoff Project

Additional actions necessary for Poulsbo to implement this TMDL are:

- Explore opportunities in the Liberty Bay watershed to encourage citizen stewardship of the environment, using events such as boating festivals and beach or park cleanups.
- Inventory and educate businesses/land uses that have potential to discharge FC bacteria, including restaurants or facilities that dispose of food waste in outdoor trash containers.
- Because of the potential for growth in this watershed, the city may consider strengthening its language to "encourage" LID prior to the Phase II (2013) stormwater permit requirement to require LID in 2016.
- Because of the potential for growth in this watershed, the city should develop incentives for small development projects (those not triggering MS4 thresholds) to retain stormwater on site.

- Also to address growth, the city planning department should identify areas with high potential to contribute bacteria and sediment to nearby surface waters and provide incentives for avoiding development in those areas or for eliminating impacts to surface waters.

Kitsap County

About half the Liberty Bay watershed that is in unincorporated Kitsap County is covered by the Phase II NPDES municipal stormwater permit (Figure 24). As of this writing, Kitsap County is understood to be in compliance with its NPDES municipal stormwater permit and has implemented the required stormwater program components (Table 28). Kitsap County has accomplished the following:

- By February 2011, it had conducted dry weather screening at all its stormwater outfalls in the Liberty Bay watershed. This is in accordance with the 2007 Phase II stormwater permit, which required jurisdictions to screen three water bodies by 2011 and one annually thereafter. In the 2013-2018 permit, this requirement is modified to focus on screening a percentage of the MS4.
- Semiannually, it conducted operations and maintenance (O & M) inspections on all catch basins. Over the past several years, it has developed a priority list of catch basins that require more frequent maintenance, and these are maintained on a specific frequency. There are an unknown number of high priority catch basins in the Liberty Bay watershed.

The actions Kitsap County needs to take to address the WLAs in Tables 26 and 27 are:

- Focus IDDE efforts on parts of the MS4 upstream of Liberty Bay sites with WLAs.
- Optimize frequency of O & M inspections of MS4 infrastructure upstream of Liberty Bay sites with WLAs.
- Focus on Liberty Bay watershed pollution sources as part of its public outreach and education on stormwater pollution. Key topics may include pet waste education and management; education of business owners could include management of trash compactors and dumpsters to prevent food waste from becoming an attraction for wildlife.

Additional actions by Kitsap County necessary to implement this TMDL are:

- Continue to provide funding for KPHD nonpoint pollution programs.
- Inventory businesses/land uses that have potential to discharge FC bacteria, including restaurants or facilities that dispose of food waste in outdoor trash containers.
- Explore opportunities in the Liberty Bay watershed to encourage citizen stewardship of the environment, using events such as boating festivals and beach or park cleanups.
- Because of the potential for growth in this watershed, County Department of Community Development should develop incentives for small development projects (those not triggering MS4 thresholds) to retain stormwater on site.
- Also to address growth in a way that minimizes water pollution, the county planning department should identify areas with high potential to contribute bacteria to nearby surface waters and provide incentives for avoiding development in those areas or for eliminating impacts to surface waters.

Discharge of stormwater runoff to waters of the state from state highway municipal storm systems is authorized by Ecology under the NPDES municipal general stormwater permit. The permit can be reviewed at: www.ecy.wa.gov/programs/wq/stormwater/municipal/wsdot.html.

Washington State Department of Transportation (WSDOT) facilities with MS4s include highways, bridges, maintenance facilities, ferry terminals, weigh stations, and rest stops. The Clean Water Act requires the permit to effectively prohibit non-stormwater discharges to storm sewers that discharge to surface waters, and apply controls to reduce the discharge of pollutants to the maximum extent practicable (MEP) (CWA, paragraph 402 (p) (3)). The permit does not directly regulate discharges from agricultural runoff, irrigation return flows, process and non-process wastewaters from industrial activities, and stormwater runoff from areas served by combined sewer systems. These types of discharges may be regulated by other local or state requirements if they discharge to MS4s.

The Liberty Bay Watershed TMDL study did not directly monitor state highway discharges. The TMDL assigns WLAs to WSDOT where state highway stormwater discharges may introduce FC bacteria into impaired receiving waters. These locations (Table 26) include SR3 crossing of Johnson Creek; SR308 crossings of Big Scandia and Little Scandia creeks and two small tributaries east of Daniels Creek; also SR305 crossings of South Fork Dogfish, Poulsbo, Lemolo, Bjorgen, and Barrantes creeks (Figure 3). As required under the WSDOT NPDES municipal stormwater permit, WSDOT will implement its Stormwater Management Program Plan (SMPP) in areas covered by Phase II municipal stormwater permits.

Through implementation of the SMPP, WSDOT has committed to coordinate maintenance, IDDE, mapping, and reporting with local governments (i.e., cities and counties), tribes and other local organizations in areas where highway and MS4 runoff combine, and permit implementation responsibilities overlap. Section S4.F. of the WSDOT permit provides assurance that WSDOT will respond promptly if WSDOT, local authorities, or Ecology determines there is a potential discharge of concern from WSDOT facilities to waters of the state, including those locations in the Liberty Bay watershed assigned WLAs.

Implementation summary

Table 29 lists TMDL implementation actions assigned to Liberty Bay watershed jurisdictions and organizations.

Table 29. Implementation actions and programs, by source.
Onsite sewage systems that have failed or need repair

Organization	Action	Date
KPHD	Continue implementing Pollution Identification and Correction projects for creeks and shoreline areas not meeting water quality standards	Ongoing
Kitsap County	Continue funding KPHD trend monitoring of Liberty Bay streams & bay	Ongoing
Craft3 (nonprofit org.)	Develop sustainable loan program for repair and replacement of onsite sewage systems in Kitsap County	Ongoing

Recreational and live aboard boater waste

Organization	Action	Date
KPHD	Complete marina pumpout survey and education project for Liberty Bay and develop recommendations for increasing boater compliance with pumpout requirement.	2014 (grant completion date)
KPHD and other implementing agencies	Implement recommendations for increasing boater use of pumpout stations and protect water quality of Liberty Bay.	By 2017
Department of Natural Resources	Work with city/county authorities to ensure no derelict vessels or illegal liveaboards that could harbor activities contributing to poor water quality.	By 2018

Municipal stormwater

Organization	Action	Date
City of Poulsbo and Kitsap County Phase II permit area in the watershed	Look for opportunities to incorporate LID (or other stormwater management approaches to reduce discharge of bacteria to surface waters) in retrofit and redevelopment projects.	Following TMDL approval
	Address locations with WLAs (Table 26) by targeting implementation of NPDES stormwater management program. • Focus IDDE efforts on MS4 areas upstream of sites with WLAs; • Optimize frequency of O & M inspections of MS4 infrastructure upstream of sites with WLAs.	Effective with permit reissuance or modification - as appropriate
	Allocate resources for monitoring sites in Tables 29 and 30	Following TMDL approval
	Include focus on Liberty Bay FC pollution sources as part of public outreach and education on stormwater pollution	Following TMDL approval
	Explore opportunities in Liberty Bay watershed to encourage citizen stewardship of the aquatic environment	Following TMDL approval
	Inventory businesses/land uses that could discharge FC bacteria, including facilities that dispose of food waste in outdoor trash containers. Educate about impacts of polluted stormwater.	Following TMDL approval
City, County govt.	Planners develop incentives for small development projects to retain stormwater on site	Following TMDL approval
City, County govt.	Planners identify areas of watershed that pose higher risk for water quality degradation if developed.	Following TMDL approval
WSDOT	Implement WSDOT Municipal Stormwater Permit in the Phase II coverage areas of this watershed, for SR3, SR305, SR307, and SR308.	Ongoing

Industrial stormwater

Organization	Action	Date
Naval Base Kitsap at Keyport	Conduct annual dry weather inspections of outfalls, and analyze for FC if flow is observed.	Following TMDL approval
	Monitor streams (Keyport 1 and Keyport 2) just upstream of where the streams discharge to the lagoons, In coordination with Kitsap County monitoring of same streams upstream of Brownsville Highway.	Following TMDL approval. Monitor monthly for 1 year.

Municipal stormwater outside Phase II municipal permit coverage

Organization	Action	Date
Kitsap County Department of Community Development	For areas outside municipal stormwater Phase II permit coverage, KCDCD is encouraged to require applicable developments to manage stormwater in accordance with Low Impact Development principles and practices. Develop incentives for incorporating LID into small parcel developments and redevelopment projects.	Ongoing
Kitsap County Surface and Stormwater Management	Encourage citizen stewardship of water resources at festivals, beach cleanups. Educate citizens and business owners about Liberty Bay FC pollution sources during stormwater pollution outreach. Educate those responsible for pet waste, trash compactors and dumpsters.	Following TMDL approval

Municipal sewage

Organization	Action	Date
Responsible operating agency (City; County)	Follow BMPs for collection systems in APWA et al. (2010)	Ongoing

Livestock waste

Organization	Action	Date
KCD	Update livestock inventory for Liberty Bay watershed	2015
	Continue to provide technical assistance and cost share for livestock owners in the Liberty Bay watershed, through the KPHD PIC	Ongoing

TMDL oversight

Organization	Action	Date
Ecology	Organize biennial review of water quality and implementation activities with local government and Suquamish Tribe partners. Report out whether on track to meet standards by 2018 and specify additional actions to ensure meeting standards.	2015, 2017
Ecology	Assessment of NPDES permittee compliance	Ongoing
Ecology	Work with stakeholders to de-list waters that meet water quality standards	Ongoing
EPA	Review Ecology TMDL submittal	Summer 2013
EPA	Assessment of NPDES permittee compliance (NBK Keyport)	Ongoing

Schedule for meeting water quality standards

The TMDL project and implementation plan are expected to result in Liberty Bay tributaries and the bay meeting water quality standards in 2018.

Measuring Progress toward Goals

The implementation plan is a list of actions and programs to be undertaken by residents and organizations within the Liberty Bay watershed. Resources need to be allocated to ensure that marine waters and tributary creeks will meet water quality standards by 2018.

To track progress, Ecology will assist local organizations in a biennial review of water quality monitoring data and status reports from organizations responsible for achieving bacteria reductions. See the Adaptive Management section. If some water bodies are not on schedule to meet standards in 2018, then additional monitoring may be needed to identify sources and meet targets on schedule. It may also be helpful to assign local targets to specific sub-areas.

Performance measures and targets (Monitoring Plan)

The following monitoring is needed to implement the TMDL and document progress, and resources need to be allocated to support these:

- State Department of Health (DOH) Office of Shellfish Protection will continue monitoring in Liberty Bay in support of safe shellfish harvest.
- Kitsap Public Health District (KPHD) will continue its current ambient monitoring of freshwater tributaries and marine waters of Liberty Bay.
- Naval Base Kitsap – Keyport will coordinate monitoring of Keyport creeks 1 and 2 with Kitsap County/KPHD to make sure the Navy is not contributing to FC impairment of these streams.

Meeting the Extraordinary Primary Contact 50/100 criteria for freshwater tributaries (Tables 30 and 31) to Liberty Bay is the goal of the TMDL project, as well as meeting marine criteria in the bay. Dogfish and Daniels creeks are not included in Table 30 because these creeks have been designated 4b and are being addressed by Kitsap County's PIC program, which is expected to bring the streams into compliance with state water quality standards.

Table 30. Ongoing stream (freshwater) monitoring & bacteria targets.

Station Description	Responsible Organization	Ecology Station ID	Start Date[11]	TMDL Targets	
				GM	90th %ile
South Fork Dogfish	City of Poulsbo	SFD-0.0	2014	50	100
Poulsbo Creek	City of Poulsbo	DON-0.0	2014	50	100
Big Scandia	Kitsap County	BSC-0.0	2014	50	100
Bjorgen	Poulsbo/Kitsap Co	BJO-0.1	2014	50	100
Johnson	Kitsap County	JOH-0.1	2014	50	100
Little Scandia	Kitsap County	LSC-0.1	2014	50	100

[11] Water quality monitoring to begin following EPA approval of TMDL

Performance measure TMDL targets are tabulated in Table 31 for investigation sites used during the TMDL study. Of the sites listed in Table 31, four are city of Poulsbo stormwater outfalls. Targets for these stormwater outfalls are listed for informational purposes only, and for comparison with other tributaries and inputs to Liberty Bay.

TMDL progress will also be monitored by tracking implementation actions. Appendix F: Schedule of Implementation Actions, is a schedule and list of implementation activities for each organization listed in *Organizations - Roles, Programs, Actions* section of this report.

Table 31. Investigation site (freshwater) monitoring & bacteria targets.

Station Description	Responsible Organization	Ecology Station ID	Start Date[12]	TMDL Targets	
				GM	90th %ile
Poulsbo outfall* OF-3703	City of Poulsbo	JEA-0.0*	2014	50	100
Unnamed trib near Big Scandia	Kitsap County	BST-0.0	2014	50	100
Unnamed trib next to Daniels	Kitsap County	UNN-0.0	2014	50	100
Barrantes	Poulsbo/Kitsap Co	BAR-0.0	2014	50	100
Perry	Kitsap County	PER-0.1	2014	50	100
Lemolo	Poulsbo/Kitsap Co	LEM-0.1	2014	50	100
Unnamed Creek at Thorpe Rd.	Kitsap County	PET-0.0/THR01**	2014	50	100
Trib near Keyport Creek (Keyport #1)	Kitsap County US Navy	KE1-0.2/KE01**	2014	50	100
Keyport Creek (Keyport #2)	Kitsap County US Navy	KE2-0.3/KE02**	2014	50	100
Bovela Ln. outfall* OF-3706	City of Poulsbo	BOV-0.0*	2014	50	100
Creek off Virginia Loop Rd	Kitsap County	LMK-0.0	2014	50	100
Outfall OF-3502*	City of Poulsbo	NEL-0.0*	2014	50	100
Outfall OF-3704*	City of Poulsbo	RET-0.0*	2014	50	100

* - TMDL targets for Poulsbo stormwater outfalls are for informational purposes only.

** - Kitsap County Station ID

[12] Water quality monitoring to start following EPA approval of TMDL.

Effectiveness monitoring

Effectiveness monitoring is conducted to determine whether the interim targets and water quality standards have been met after implementation is well under way. Typically, Ecology considers effectiveness monitoring for TMDLs when five or even ten years have elapsed following approval by EPA. There is Clean Water Act requirements for effectiveness monitoring that include review of what has occurred under implementation. Before deciding to conduct an effectiveness monitoring project, Ecology usually considers whether there is evidence that implementation has occurred and that water quality improvement has occurred.

Ecology will partner with local organizations and the Suquamish Tribe to develop the quality assurance project plan for any proposed effectiveness monitoring project. This will ensure that the project will meet Ecology requirements and that local monitoring resources, if available, are considered for inclusion in any Ecology data collection effort.

Figure 35. Ecology measured bacteria in stormwater from local outfalls.

In lieu of an effectiveness monitoring project to assess the effectiveness of the TMDL, Ecology may rely on data from existing monitoring programs such as routine sampling by KPHD of Liberty Bay and Liberty Bay tributaries.

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Adaptive Management

An adaptive approach will be used to adjust the implementation plan in response to changing circumstances and new water quality data. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings. In the case of TMDLs, Ecology uses adaptive management to assess whether the actions implemented to solve the identified pollution problems are the correct ones and whether they are working. As these actions take effect, the system will respond, and change. Adaptive management allows us to fine-tune our actions to make them more effective, and to try new strategies if we have evidence that a new approach could help us improve water quality.

Liberty Bay Watershed TMDL targets are described in terms of target geometric mean concentrations, target 90th percentile concentrations, percent reductions in concentrations, mass loading allocations, and implementation activities. A key measure of TMDL progress will be the number of stream tributaries to Liberty Bay meeting water quality standards. Partners will work together to monitor progress towards these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the implementation strategy as needed. Additional monitoring may be necessary to better isolate bacteria sources and identify needed BMPs so that new BMPs and restoration projects can be designed and implemented to improve long term stream quality.

Ecology will use adaptive management when water monitoring data show that the TMDL targets are not being met or implementation activities are not producing the desired result. To track progress, Ecology will assist local organizations in a biennial review of water quality data and status reports from organizations responsible for achieving bacteria reductions. An open meeting format will be used to encourage information sharing. Ecology encourages local jurisdictions to assess progress in meeting wasteload allocations and provide data to Ecology related to compliance with FC targets at specific locations.

The first biennial review for this TMDL will be conducted in 2015 and will include:

- A meeting involving local governments, Suquamish Tribe, KPHD and other organizations.
- Review of recent water quality data (DOH and KPHD) to assess progress.
- Review of implementation actions and their degree of completion and identification of new implementation actions, if needed.
- Status of 303(d) listing/de-listing effort.
- A report summarizing progress and identifying any additional actions needed to ensure meeting standards by 2018.

If water quality standards are achieved in any Liberty Bay watershed water bodies, but individual wasteload and load allocations have not been met, the TMDL will still be considered achieved based on attainment of the standards.

If the implementation actions (Table 29) are completed, but water bodies still do not meet standards, then implementation actions will be modified and/or increased in consultation with appropriate local agencies and organizations. Water quality monitoring will be used to assess progress in achieving water quality standards (see *Performance Measures and Targets [Monitoring Plan]* section).

Based on current implementation in the Liberty Bay watershed and additional requirements of the TMDL, it is expected that fecal coliform bacteria levels will be reduced and water quality standards will be met by 2018. It is ultimately Ecology's responsibility to ensure that cleanup is being actively pursued and water quality standards are achieved.

Potential Funding Sources

Financial assistance for water quality improvement activities is available through Ecology's grant and loan programs, state salmon recovery, Kitsap Conservation District cost-share programs, Kitsap County programs and other sources (Table 32). Ecology will work with stakeholders to identify funding sources and prepare appropriate scopes of work to help implement this TMDL.

Table 32. Potential funding sources for TMDL Implementation.

Sponsor	Fund	Uses
Department of Ecology, Water Quality Program	Centennial Clean Water Fund, Section 319, and State Revolving Fund www.ecy.wa.gov/programs/wq/funding	Facilities and water pollution control-related activities; implementation, design, acquisition, construction, and improvement of water pollution control. Priorities include: implementing water quality plans (TMDLs); keeping pollution out of streams and aquifers; modernizing aging wastewater treatment facilities; reclaiming and reusing wastewater.
County Conservation District	Federal Conservation Reserve Enhancement Program (CREP) www.kitsapcd.org/	Conservation easements; cost-share for implementing agricultural/riparian best management practices (BMPs).
Craft3	Currently developing new funding strategy. www.craft3.org	Non-profit organization makes low-interest loans in Kitsap, Mason and Jefferson counties for repair of individual onsite sewer systems.
Department of Ecology, SEA	Coastal Protection Fund	Limited grants for on-the-ground projects funded by penalty monies collected by the Water Quality Program.
State Recreation and Conservation Funding Board	Recreation and Conservation Office www.rco.wa.gov/rcfb/grants.asp	Provides grants for habitat restoration, land acquisition and habitat assessment. Current grant programs include: Aquatic Lands Enhancement Account Land and Water Conservation Fund Washington Wildlife Recreation Program
Natural Resources Conservation Service	Emergency Watershed Protection www.nrcs.usda.gov/programs/ewp/index.html	NRCS purchases land vulnerable to flooding to ease flooding impacts.
Natural Resources Conservation Service	Wetland Reserve Program www.wa.nrcs.usda.gov/programs/wrp/wrp.html	Landowners may receive incentives to enhance wetlands in exchange for retiring marginal agricultural land.
Natural Resources Conservation Service	EQIP (Environmental Quality Incentive Program) www.nrcs.usda.gov/programs/eqip/	Provides technical assistance, cost share, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm. Contracts last five to ten years.
Natural Resources Conservation Service	AWEP (Agriculture Water Enhancement Program) www.nrcs.usda.gov/programs/AWEP/	Offers financial and technical assistance to help farmers and ranchers carry out water enhancement activities that conserve ground and surface water and improve water quality on agricultural lands such as cropland, pasture, grassland and rangeland.
Naval Base Kitsap at Keyport and Bangor	Federal Dept of Defense budget process	Funding to meet environmental compliance requirements and fleet readiness

Ecology funding opportunities

Centennial/SRF/319 Fund

These three funding sources are managed by Ecology through one combined application program. Centennial and 319 funds are grants and the State Revolving Fund (SRF) is a low interest loan program and each is available to public entities. Grants require a 25 % match and may be used to provide education/outreach, technical assistance, for specific water quality projects, or as seed money to establish various kinds of water quality related programs or program components.

At the time of this report, grant funds are available for riparian fencing, riparian re-vegetation, and alternative stock watering methods to assist riparian restoration. Funds are generally not available for making capital improvements to private property. However, eligibility rules can change so one should check at the beginning of each grant cycle.

Low-interest loans are available to public entities for all the above uses, and have also been used as "pass-through" to provide low-interest loans to homeowners for agricultural best management practices. Ecology's grant and loan cycle kicks off in September of each year with public meetings held throughout the state. See Ecology's webpage for more information on Ecology financial assistance opportunities as well as other funding sources.
www.ecy.wa.gov/programs/wq/funding/funding.html

Coastal Protection Fund

Since July 1998, water quality penalties issued under Chapter 90.48 RCW have been deposited into a sub-account of the Coastal Protection Fund. A portion of this fund is made available to regional Ecology offices to support on-the-ground environmental restoration and enhancement projects. Local governments, tribes, and state agencies must propose projects through Ecology staff. Projects seeking to reduce bacterial pollution are encouraged. Contact an Ecology Water Cleanup specialist to investigate fund availability and to determine if your project is a good candidate.

Additional stormwater projects funding

In addition to sources of water quality improvement funding listed in Table 32, funding provided by the state legislature for municipal stormwater projects and programs is expected to assist in implementing the Liberty Bay TMDL. Stormwater retrofit, and Low Impact Development (LID) projects recently conducted by city of Poulsbo with this funding assistance include Caldart Avenue Stormwater LID Project, Anderson Parkway LID Project, Old Town LID Retrofit Project, and the Central Business District Stormwater Retrofit Project. Future availability of special appropriation stormwater grant funding is uncertain.

Summary of Public Involvement Methods

Ecology engaged the public in several ways in the TMDL process to address bacteria problems in the Liberty Bay watershed. A number of methods were used to involve local and state agencies, tribes, nonprofit organizations, and the general public in the Liberty Bay Watershed FC TMDL. In the fall of 2007, Ecology consulted with Kitsap Public Health District (KPHD) about the value of doing a Liberty Bay Watershed Fecal Coliform TMDL. This idea was supported and subsequently KPHD submitted a proposal for Ecology Centennial Grant funding for the Liberty Bay PIC project, which was awarded funding beginning in July 2009.

Ecology shared a draft version of the quality assurance project plan with local organizations in 2008 and coordinated with KPHD and the city of Poulsbo on selection of monitoring sites. As much as possible, Ecology's downstream sites on major streams were the same as KPHD trend station locations. The city of Poulsbo requested monitoring of six city outfalls during the TMDL monitoring program.

Ecology made a presentation on the TMDL to the Poulsbo City Council in April 2008 and conducted local meetings on the technical report findings in May 2011 and January 2012. A preliminary version of the implementation plan was shared with local organizations in December 2012. Comments received have been addressed in this document and responded to by letter. A meeting with local government agencies, Suquamish Tribe, and EPA to review aspects of the TMDL and elements of the implementation plan was held in Poulsbo February 11, 2013.

Ecology maintained a Liberty Bay TMDL website throughout TMDL development. It provided updated Ecology water quality data during the study and periodically provides information about partner activities in the watershed. Access at: www.ecy.wa.gov/programs/wq/tmdl/LibertyBay/

The public comment period on the draft TMDL was held from March 15 to April 15, 2013. The public meeting on the draft TMDL was held at the Poulsbo Fire Department Community Room on March 21, 2013. The public meeting and public comment period for the TMDL report were advertised on Ecology's TMDL website and a display ad was published in the Kitsap Sun on March 10, 16, and 17, 2013 (Appendix B).

Printed copies of the TMDL report were made available starting March 15, 2013 at:

- www.ecy.wa.gov/programs/wq/tmdl/LibertyBay/
- Libraries:
  - Poulsbo, 700 NE Lincoln Road
  - Silverdale, 3450 NW Carlton Street
  - Kingston Community Center, 11212 State Hwy 104
- Ecology's Northwest Regional Office in Bellevue, 3190 160th Ave SE.

Copies of the Draft TMDL were mailed to over twelve stakeholder groups and a link to the web document was emailed to 40 people.

Public comments were received at the public meeting on March 21 and by mail and email through the end of the comment period on April 15, 2013. Comments resulted in numerous changes in the TMDL and responses to comments are summarized in Appendix C: Response to public comments.

Figure 36. Poulsbo Creek, a perennial stream that discharges via an outfall to Liberty Bay, is piped in some areas of Poulsbo and open in others.

Conclusions

The following conclusions were derived from the 2008-2009 Liberty bay Watershed TMDL study and associated analyses:

- Fecal coliform (FC) pollution is widespread in the Liberty Bay watershed but is on an improving trend in some places. According to the TMDL study data, all streams flowing into Liberty Bay (except Sam Snyder Creek) need significant wet-season and/or dry-season FC reductions to meet state freshwater criteria.

- This TMDL establishes seasonal load allocations, target concentrations, and percent reductions at 25 stream and tributary sites in the Liberty Bay watershed (Tables 22-25). Wet and dry season wasteload allocations are set at 20 stream sites for four NPDES stormwater permittees: city of Poulsbo, Kitsap County, Washington State Department of Transportation, and the U.S. Navy. Streams that were flowing during the dry season have dry season target percent reductions ranging from 50% to 98%. Wet season reductions range from 0% to 99% (Table 26).

- At most sites, the highest FC concentrations occurred during the dry season (June through October). An exception is South Fork Dogfish Creek, which drains Poulsbo commercial areas along SR 305 and had significantly higher FC concentrations during the wet season.

- Average FC loading to Liberty Bay from tributary streams was higher in the wet season (November through May) than in the dry season. However, dry-season loading is higher if the May and December high loading rain events are removed from the 2008-09 data set.

- Stream and bay sampling data suggest that stormwater entering Liberty Bay degrades its water quality, especially during the wet season. The Kitsap Public Health District (KPHD) marine data from the area between downtown Poulsbo and Lemolo Bay show higher FC concentrations during October through January, when storm events are more likely to affect water quality in the bay.

- Existing Phase II municipal stormwater permit elements can help reduce bacteria in stormwater, though bacteria are not a focus of the permit. These elements include Public Education and Outreach, Illicit Discharge Detection and Elimination, controlling runoff from new and redevelopment, and MS4 maintenance practices.

- Wet season loading more than doubled in Dogfish Creek between the confluence of East and West Forks and sampling site DOG-0.6 which is about 0.45 miles downstream. Further investigation of potential sources in this reach is warranted.

- Wet season loading also increased significantly in Big Scandia Creek between sites BSC-1.1 and BSC-0.1. This area also warrants further pollution source investigation.

- Sampling sites below the Nelson Park bioswale, the assisted living facility, and off Virginia Loop Rd had some of the highest FC concentrations in the watershed during the study.

However, because of relatively low flow at these sites, their impact on the bay is likely less than that of larger streams such as Dogfish, Poulsbo, and Big Scandia.

- There were no rain events sampled during the TMDL study that met the QAPP-defined storm event criteria. However, significant rain events occurred during regular sampling that enabled Ecology to better characterize Liberty Bay stream FC concentrations and loading during runoff conditions.

- Funding for TMDL implementation projects is available through Ecology's Centennial Clean Water Fund, State 319 Fund, and Coastal Protection Fund; NRCS and County Conservation District Funding programs; Department of Defense funding for Navy environmental compliance at Keyport; nonprofits such as Craft3 for low-interest loans to repair and replace individual onsite sewer systems; and various other funding sources.

Review of water year 2011 water quality data and the progress of current source identification and control programs suggest:

- Current source identification programs and permit requirements are making significant progress toward cleaning up bacteria sources in Liberty Bay watershed. With one more year of funding remaining in the KPHD Liberty Bay pollution identification and correction (PIC) project and with continued outreach and education, as well as with this TMDL's added requirements for NPDES stormwater permittees, Ecology expects that water quality standards will be met in five years, in 2018.

Recommendations

Based on the 2008-09 TMDL study and KPHD WY2011 data, Ecology recommends the following:

- KPHD should continue implementing the Liberty Bay PIC project, which has resulted in water quality improvements throughout the watershed and is funded for one more year.

- KPHD should continue monitoring the Liberty Bay watershed, to show where water quality is improving and to indicate the effectiveness of cleanup activities.

- Kitsap County Surface and Stormwater Management (SSWM) should continue its fee-based program to fund water quality monitoring and improvement projects.

- Municipal stormwater permittees should implement certain permit elements such as Public Education and Outreach, Illicit Discharge Detection and Elimination, controlling runoff from new and redevelopment, and MS4 maintenance with potential for bacterial pollution and remediating bacterial pollution in mind.

- Ecology will work with local organizations and the Suquamish Tribe to schedule a biennial review of water quality in 2015. The group's findings will be reported in a document that summarizes water quality results, implementation completed, and changes in implementation actions (adaptive management) needed to meet water quality standards in 2018.

- Local organizations should focus first on the higher priority sites with wasteload allocations: South Fork Dogfish; Poulsbo (Figure 28); Dogfish Creek between confluence of East and West Forks and sampling site DOG-0.6 during wet season; Big Scandia Creek between RM 1.1 and 0.1 during wet season; Little Scandia; Bjorgen; Lemolo creeks; and the tributary east of Big Scandia Creek (BST).

- After addressing the higher priority sites, local organizations should then focus on lower priority sites with wasteload allocations: Barrantes; Perry; stream east of Perry (PET); Keyport creeks 1 and 2 (KE1-0.2 and KE2-0.3); discharge below Nelson Park bioswale; small unnamed tributaries UNN0.0 and UNN0.1; stream off Virginia Loop Rd (LMK); and Sam Snyder Creek.

- Poulsbo should focus on cleaning up stormwater outfalls which were found to contribute to Liberty Bay bacteria loading such as the outfall stream next to the assisted living facility (RET); the stream (outfall) between Bovela Lane and Bay streets (BOV); and the Nelson Park bioswale outfall near the mouth of Dogfish Creek.

- KPHD should consider measuring or calculating streamflows during sampling on three of the larger streams – Dogfish (has flow gage maintained by Kitsap Public Utility District), South Fork Dogfish, and Big Scandia creeks. This will enable trend analysis, support future monitoring to gage progress, and allow for upstream to downstream loading comparisons.

- Poulsbo and Kitsap County should develop incentives for small development projects (those under MS4 thresholds) to design for stormwater retention on site.

- Poulsbo and Kitsap County should identify areas that pose high risk to water quality if developed, and adopt ordinances or design incentives to develop away from such areas or use other measures to prevent such areas from becoming sources of pollution.

- The Navy should conduct annual dry weather screening of shoreline outfalls. See recommendation in the "Organizations with responsibilities under permits" section.

- The Navy should monitor two streams (Keyport 1 and 2) just upstream of where they discharge to the brackish lagoons (below any wetlands or other potential sources of FC). Sampling should be scheduled to coincide with Kitsap County monitoring of streams at Brownsville Highway. See monitoring recommendation in the "Organizations with responsibilities under permits" section.

- Liberty Bay watershed already has a community of people who care about their watershed and water quality. Residents and visitors to Liberty Bay watershed should continue to participate in water quality forums and projects, report pollution spills or illegal use of storm drains, keep animals out of streams, use Mutt Mitts when walking their pets, and participate in stream and beach restoration or other events that raise water quality awareness and stewardship.

References

APWA, ASCE, NACWA and WEF, 2010. Core Attributes of Effectively Managed Wastewater Collection Systems. July 2010. Published by American Public Works Association, American Society of Civil Engineers, National Association of Clean Water Agencies and Water Environment Federation, 34 pp.

Center for Watershed Protection and Robert Pitt, 2004. Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessment. October 2004. University of Alabama, Tuscaloosa, AL.

City of Poulsbo, 2009. City of Poulsbo Comprehensive Plan. Adopted by City Council, 2009. www.cityofpoulsbo.com/planning/documents/chapter_7.pdf

City of Poulsbo, 2012. Operation and Maintenance Manual for Private Drainage Facilities, City of Poulsbo, July 2012.

Coots, R., 2002. Colville River FC Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 02-03-036. https://fortress.wa.gov/ecy/publications/SummaryPages/0203036.html

Cusimano, R. and D. Giglio, 1995. Salmon Creek Nonpoint Source Pollution TMDL. Washington State Department of Ecology, Olympia, WA. Publication No. 95-355. https://fortress.wa.gov/ecy/publications/SummaryPages/95355.html.

DOH, 2011a. Washington State Department of Health, Office of Shellfish and Water Protection; Home Page. www.doh.wa.gov/ehp/sf/default.htm.

DOH, 2011b. Washington State Department of Health, Office of Shellfish and Water Protection: Annual Growing Area Review. www.doh.wa.gov/ehp/sf/Pubs/gareports/lemolo.pdf.

Ecology, 2009. Samish Bay Watershed Fecal Coliform Bacteria Total Maximum Daily Load: Volume 2 – TMDL and Water Quality Implementation Plan. August 2009. https://fortress.wa.gov/ecy/publications/SummaryPages/0910019.html.

Ecology, 2011. Sinclair and Dyes Inlets Fecal Coliform Bacteria Total Maximum Daily Load: TMDL and Water Quality Implementation Plan. April 2012. https://fortress.wa.gov/ecy/publications/SummaryPages/111051.html.

EPA, 2008. Multi-Sector General Permit for Industrial Stormwater Discharges. www.epa.gov/npdes/pubs/msgp2008_parts1-7.pdf

EPA, 2009. Review of zoonotic pathogens in ambient waters. EPA 822-R-09-002. U.S. Environmental Protection Agency, Office of Water, Health and Ecological Criteria Division. February 2009.

EPA, 2011. Report of the expert's scientific workshop on potential human health risks from exposure to fecal contamination from avian and other wildlife sources in recreational waters. December 2011. US Environmental Protection Agency, Office of Water, Office of Research and Development. Nov.2011 conference at Emory Conference Center, Atlanta, GA. http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/avian_report.pdf

Forsyth, S., 1995. Liberty Bay/Miller Bay Watershed Nonpoint Source Pollution Baseline Water Quality Assessment. Bremerton-Kitsap Public Health District, Environmental Health Division, Water Quality Program, Bremerton, WA.

Fowler, B., and J. Rasmus, 2005. Seaside solution: Ozone treatment of stormwater in Dana Point, California. Civil Engineering, Dec. 2005, pp. 44-49.

Funk, A., 2008. Personal communication. November 2008. Senior Engineering Technician. City of Poulsbo Public Works, Poulsbo, WA.

Glasoe, S., and A. Christy. 2005. Literature review and analysis of coastal urbanization and microbial contamination of shellfish areas. Proceedings of the 2005 Puget Sound-Georgia Basin Research Conference. http://depts.washington.edu/uwconf/2005psbg/2005proceedings/papers/P2_GLASO.pdf.

HDPA, 2013. *HDPA Insider*, Historic Downtown Poulsbo Association newsletter, February 2013, 4 pp.

Hicks, M., 2002. Setting Standards for the Bacteriological Quality of Washington's Surface Water Draft Discussion Paper and Literature Summary. Washington State Department of Ecology, Olympia, WA. Publication No. 00-10-072. https://fortress.wa.gov/ecy/publications/SummaryPages/0010072.html.

Jones, K., 2011. Nelson Park Outfall Report, by Kimberly Jones, Environmental Health Specialist, Kitsap Public Health District, Pollution Identification and Correction Program, Nov 2, 2011, 10 pp.

Joy, J., 2000. Lower Nooksack River Basin Bacteria Total Maximum Daily Load Evaluation. Washington State Department of Ecology, Olympia, WA. Publication No. 00-03-006. https://fortress.wa.gov/ecy/publications/SummaryPages/0003006.html.

Joy, J. and T. Swanson, 2005. Walla Walla River Basin FC Bacteria Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 05-03-041. https://fortress.wa.gov/ecy/publications/SummaryPages/0503041.html.

Kitsap County Department of Community Development, 2006. Kitsap County Comprehensive Plan. Adopted by Kitsap County Commissioners, 2006. www.kitsapgov.com/dcd/community_plan/comp_plan/comprehensive_plan_current.htm

KPHD, 2003. Manual of Protocol: FC Bacteria Pollution Identification and Correction Projects. Kitsap Public Health District, Bremerton, WA. November 2003.

KPHD, 2011. Liberty Bay Marina Study. Unpublished report, Kitsap Public Health District, Bremerton, WA. August 2011. 10 pp.

KPHD, 2011a. 2011 Water Quality Monitoring Report. Kitsap Public Health District. Bremerton, WA. www.kitsappublichealth.org/environment/files/reports/2011_Intro.pdf

KPHD, 2011b. KPHD environment and water quality webpage. Kitsap Public Health District, Bremerton, WA. www.kitsappublichealth.org/environment/sls.php.

KPHD, 2013. 2012 Water Quality Monitoring Report. Kitsap Public Health District. Bremerton, WA.

Lennartson, D., 2005. Personal communication, June-November, 2005. Public Health Advisor, Office of Food, Safety, and Shellfish Programs. Division of Environmental Health, Washington State Department of Health, Olympia, WA.

Mathieu, N., 2006. Replicate Precision for Twelve Total Maximum Daily Load (TMDL) Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. https://fortress.wa.gov/ecy/publications/SummaryPages/0603044.html.

May, C., K. Byrne-Barrantes, and L. Barrantes, 2005. Liberty Bay Nearshore Habitat Evaluation and Enhancement Project. Prepared for the Lemolo Citizens Club and Liberty Bay Foundation, Poulsbo, WA.

MEL, 2008. Manchester Environmental Laboratory Lab Users Manual, Ninth Edition. Washington State Department of Ecology, Manchester, WA.

NBKK, 2009. Stormwater Pollution Prevention Plan: Naval Base Kitsap Keyport, May 2009. Prepared by Naval Facilities Engineering Command, Silverdale, WA. 365 pp.

Ott, W., 1997. Environmental Statistics and Data Analysis. Lewis Publishers, New York, NY.

Pelletier, G. and K. Seiders, 2000. Grays Harbor FC Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 00-03-020. https://fortress.wa.gov/ecy/publications/SummaryPages/0003020.html.

Sargeant, D., W.R. Kammin, and S. Collyard, 2011. Review and Critique of Current Microbial Source Tracking (MST) Techniques, Washington State Department of Ecology Environmental Assessment Program, Publication No. 11-03-038, 66 pp.

Sargeant, D., and J. Lowe, 2012. Focus on Microbial Source Tracking (MST), Department of Ecology Environmental Assessment Program, Publication Number 12-03-010, Feb 2012, 5 pp.

Swanson, T., 2008. Samish Bay FC Bacteria Total Maximum Daily Load: Volume 1. Water Quality Study Findings. Washington State Department of Ecology, Olympia, WA. Publication No. 08-03-029. https://fortress.wa.gov/ecy/publications/SummaryPages/0803029.html.

Swanson, T., 2009. Quality Assurance Project Plan: Liberty Bay Tributaries FC Bacteria TMDL. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-102. https://fortress.wa.gov/ecy/publications/SummaryPages/0903102.html.

WAC 173-201A., 2011. Water Quality Standards for Surface Waters in the State of Washington. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html#wq.

Wayland, R.H., and J.A. Hanlon, 2002. Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water and NPDES Permit Requirements Based on those WLAs. U.S. Environmental Protection Agency, Office of Water, Memorandum to Water Directors U.S. EPA Regions 1-10, Washington, D.C. November 22, 2002. 6 pp.

Appendices

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Appendix A: Glossary, acronyms, and abbreviations

Glossary

Aliquot: Portion of a sample.

Best management practices (BMPs): Physical, structural, or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Enterococci: A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum*, and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Exceeded criteria: Did not meet criteria.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. FC bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100mL).

Geometric mean: A mathematical expression of the central tendency (average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either:

1) taking the nth root of a product of n factors, or
2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing and revising permits, as well as imposing and enforcing pretreatment requirements, under the Clean Water Act. The NPDES permit program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to, atmospheric deposition; surface water runoff from agricultural lands; urban areas; or forest lands; subsurface or underground sources; or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II stormwater permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reach: A specific portion or segment of a stream.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Surrogate measures: To provide more meaningful and measurable pollutant loading targets, EPA regulations [40 CFR 130.2(i)] allow other appropriate measures, or surrogate measures in a TMDL. The Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program (EPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

> *When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.*

Total maximum daily load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Water year: 12-month period from October 1, for any given year, through September 30 of the following year.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) List: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which designated uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited water bodies (ocean waters, estuaries, lakes, and streams) that fall short of state surface water quality standards, and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10 percent of the data exists and below which 90 percent of the data exists.

Acronyms and abbreviations

a.k.a.	Also known as
APWA	American Public Works Association
BMPs	Best management practices
cfs	Cubic feet per second
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	U.S. Environmental Protection Agency
FC	Fecal coliform bacteria
HDPA	Historic Downtown Poulsbo Association
IDDE	Illicit Discharge Detection and Elimination
KCD	Kitsap Conservation District
KPHD	Kitsap Public Health District
LA	Load allocation
LID	Low impact development

MEL	Manchester Environmental Laboratory
MF	Membrane filtration
MPN	Most probable number
MQO	Measurement Quality Objective
MS4	Municipal separate storm sewer systems
n	Number
NPDES	National Pollutant Discharge Elimination System
NSSP	National Shellfish Sanitation Program
PIC	Pollution identification and correction
QA	Quality assurance
RM	River mile
RPD	Relative percent deviation
RSD	Relative standard deviation
SRS	Systematic Random Sampling
SWPPP	Storm Water Pollution Prevention Plan
SSWM	Kitsap County Surface and Stormwater Management
TMDL	Total maximum daily load (water cleanup plan)
U & A	Usual and accustomed fishing area
UGA	Urban growth area
USFS	United States Forest Service
USGS	United States Geological Survey
vs.	Versus
WDFW	Washington Department of Fish and Wildlife
WLA	Wasteload allocation
WQA	Water quality assessment
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WSSOW	West Sound Stormwater Outreach Group
WWTP	Wastewater treatment plant

Units of measurement

cfs	cubic feet per second
cfu	colony forming unit
ft	feet
g	gram, a unit of mass
m	meter
mL	milliliters

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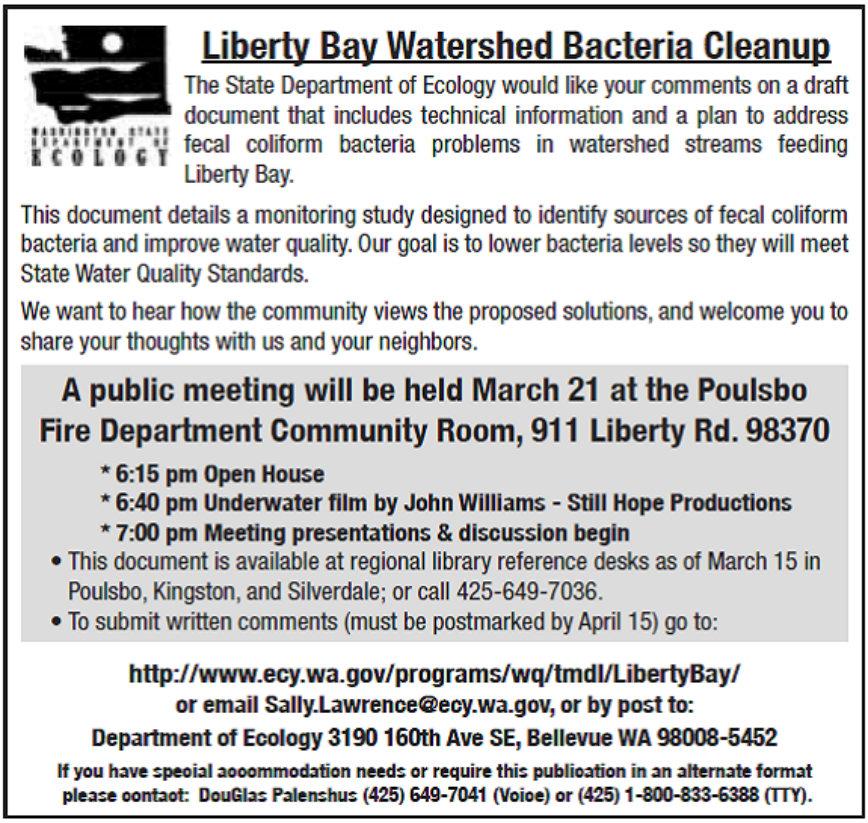
Appendix B: Record of public participation

Ecology consulted with Kitsap Public Health District (KPHD) about the value of doing a TMDL in fall 2007, prior to initiating the TMDL, and received support for the project. Ecology provided a copy of the draft quality assurance project plan (QAPP) to KCSSWM and other local organizations during QAPP development. Ecology coordinated with both city of Poulsbo and KPHD regarding sampling locations and, at city of Poulsbo request, sampled storm discharges from six city outfalls. Ecology consulted with Suquamish Tribe in 2012 regarding the potential for increasing beneficial uses in the watershed through implementation of the TMDL.

Ecology held several meetings with local organizations, governments, and the Suquamish Tribe as the TMDL was being developed:

- April 2008 Presentation to Poulsbo Mayor and City Council.
- May 2011 Introductory TMDL meeting, including monitoring results.
- January 2012 Second TMDL meeting, including monitoring results and technical report.
- February 2013 Review meeting on the preliminary draft TMDL and Implementation Plan.
- A public meeting on the draft TMDL was held in Poulsbo on March 21, 2013 and the following ad was run in *The Kitsap Sun* on the 10th, 16th, and 17th of March 2013.



Liberty Bay Watershed Bacteria Cleanup

The State Department of Ecology would like your comments on a draft document that includes technical information and a plan to address fecal coliform bacteria problems in watershed streams feeding Liberty Bay.

This document details a monitoring study designed to identify sources of fecal coliform bacteria and improve water quality. Our goal is to lower bacteria levels so they will meet State Water Quality Standards.

We want to hear how the community views the proposed solutions, and welcome you to share your thoughts with us and your neighbors.

A public meeting will be held March 21 at the Poulsbo Fire Department Community Room, 911 Liberty Rd. 98370

*** 6:15 pm Open House**
*** 6:40 pm Underwater film by John Williams - Still Hope Productions**
*** 7:00 pm Meeting presentations & discussion begin**

- This document is available at regional library reference desks as of March 15 in Poulsbo, Kingston, and Silverdale; or call 425-649-7036.
- To submit written comments (must be postmarked by April 15) go to:

http://www.ecy.wa.gov/programs/wq/tmdl/LibertyBay/
or email Sally.Lawrence@ecy.wa.gov, or by post to:
Department of Ecology 3190 160th Ave SE, Bellevue WA 98008-5452

If you have special accommodation needs or require this publication in an alternate format please contact: Douglas Palenshus (425) 649-7041 (Voice) or (425) 1-800-833-6388 (TTY).

- The public comment period on the Draft TMDL ran from March 15, 2013 to April 15, 2013 and several comment letters and emails were received.

The Ecology website also included announcements of the public comment period on the draft TMDL and of the March 21, 2013 evening public meeting held at the Poulsbo Fire Department Community Room. The website included links to the draft document and to a general information document: "Focus on Liberty Bay Watershed." The latter and a link to the draft TMDL document were included in email messages sent to a list of about 40 people. About a dozen printed copies of the draft TMDL were sent by U.S. Postal Service. Email messages included announcements of the draft TMDL document's electronic availability on-line, and of printed copies at local libraries in Kingston, Poulsbo, and Silverdale; as well as announcements of the comment period and the public meeting.

The March 21 public meeting included an open house followed by an underwater film presentation *(by filmmaker John Williams—Still Hope Productions)*; presentations by government officials; facilitated interactive questions, answers, and comments among attendees; and additional informal dialogue after the meeting adjourned. About 37 people were in attendance.

Reminders of the public review comment period were sent to the meeting attendees and the mail list during the first week of April.

Appendix C: Response to public comments

Summary of comments and responses

Ecology received the following summarized comments during the public comment period for the draft Liberty Bay Watershed Bacteria TMDL report. Comments regarding factual inaccuracies, improved wording, or those that clarify policy positions by other government agencies have been directly incorporated into the text of the final report. All other comments are summarized below.

1. **Comment:** Extraordinary Primary Contact" is too onerous a standard for Liberty Bay tributaries. We have concerns about the appropriateness of the Extraordinary Primary Contact designation for freshwater. We believe classifying these streams as "extraordinary" water is unrealistic for an area that has been designated by the state for urbanization and creates a conflict with the designated urban growth objectives.

   Response: Most of the state's waters have been assigned their uses through the general classification system. Under that system, waters that exist in special areas such as national parks, national forests, and wilderness areas are assumed to be capable of providing extraordinary protection for their uses. As well, waters that drain to extraordinary quality fresh or marine waters or to downstream lakes are assigned the uses and criteria of those downstream waters to ensure that the downstream waters are able to meet their criteria for use protection. In many cases, it is the need to protect downstream uses and criteria that determine the assignment of more protective criteria to upstream waters.

   The "Extraordinary Primary Contact" use was designated for Liberty Bay and many other Puget Sound and coastal waters in 1967. Since the promulgation of the Clean Water Act, all uses designated or attained since 1975 must be protected, maintained, and restored. A review of current designations or degradation from previous designations is not allowable unless it can be shown through a Use Attainability Analysis that the current use is unattainable and a lesser attainable use should be assigned. Ecology believes that the numeric criteria of the current indicator for Extraordinary Primary Contact use is what is of most concern rather than the specific use designation for Liberty Bay. A change in the pollutant indicator and associated numeric criteria may be a more effective approach to address the burden of meeting the water quality standards than the development of a UAA. Language was added to the TMDL report in response to this and other similar comments.

2. **Comment:** Suggest re-evaluating the Extraordinary Primary Contact standard applied to Liberty Bay tributaries. The less stringent Primary Contact standard has been found to be protective of shellfish harvesting and public health in Dyes Inlet. We question whether this very onerous EPC standard is achievable in a developing watershed like Liberty Bay.

   ***Response*:** See response to Comment #1. Review of current designations or degradation from previous designation is not allowable unless it can be shown through a Use Attainability Analysis that the current use is unattainable and a lesser attainable use should be assigned.

3. **Comment:** Now that Liberty Bay is in conformance with fecal limits, it appears a waste of taxpayer money to proceed with the TMDL program for that water body. I strongly suggest the TMDL efforts be terminated. This is in recognition that the major reason for the TMDL in the first place was to bring fecal contamination down to levels that would allow shellfish harvesting. This objective has been achieved and activities to allow harvesting are underway.

   Response: The Liberty Bay Watershed TMDL includes the tributaries to the bay as well as the bay itself. Recent sampling by Kitsap Pubic Health shows the bay may be meeting standards. Other than a small area near Lemolo, Liberty Bay is largely closed for shellfish harvesting. Efforts are currently underway to verify that a larger area of the bay can be opened for shellfish harvest. The TMDL demonstrated that water quality in the bay is affected by stream input and most of the tributaries to Liberty Bay are still not meeting standards.

   Standards for both freshwater recreational and downstream marine shellfish harvesting uses must be met. These currently are both maintained through the same indicator, fecal coliform. As described in WAC 173-201A-260(3)(c), where multiple criteria for the same water quality parameter are assigned to a water body to protect different uses, the most protective criterion for each parameter is to be applied. The freshwater recreational use criteria must remain even if a less protective target would be sufficient to meet the marine shellfish harvesting criteria standards. Implementation efforts must continue until all standards are met.

4. **Comment:** Omit Figure 6 (now Figure 7) and the associated discussion. What is the purpose of discussing data that meets the standard but happens to show a spike (but is still well within the standard)?

   ***Response*:** The purpose of Figure 7 showing monthly fecal coliform geomeans at Liberty Bay marine station LB05 for data collected during 2002-09 is to illustrate seasonal differences in bay water quality. The graph shows October, December, and January were the months with the highest FC concentrations at the site. This correlates with high wet season loading in Liberty Bay tributaries found during the TMDL study, especially in Dogfish, Big Scandia, and Bjorgen creeks.

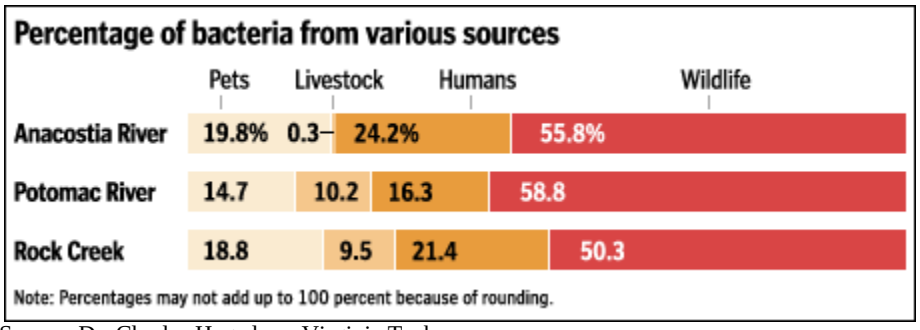
5. **Comment:** We question whether this TMDL is warranted given that 1) Majority of data supporting the 303(d) listings is over ten years old and 2). Current data, collected by local jurisdictions, shows attainment of FC standards in Liberty Bay and improving trends in the tributaries.

   ***Response*:** Following EPA guidance, Ecology maintains 303(d) listings regardless of data age until a TMDL is completed or newer data showing compliance with standards are assessed and no longer show exceedances of the numeric criteria. This TMDL also includes recreation use impairment determinations in freshwater tributaries to Liberty Bay. Shellfish harvesting criteria are only one basis for the TMDL. See reference to WAC 173-201A-

260(3)(c) in Response #3 above. Improving trends in Liberty Bay tributaries make it likely that streams will meet water quality standards by 2018.

6. **Comment:** If the TMDL program must still to be applied to the freshwater creeks, it is strongly recommended that DNA/RNA testing be accomplished to determine the actual sources of the fecal pollution. As the following chart suggests, over half of the fecals found in urban environments originate from wildlife and less than a quarter from human sources. While such testing involves additional expense, these costs are more than compensated for by being able to scientifically target and prioritize the actual sources needing cleanup — resulting in not wasting money on a non-scientific scattergun approach.

Fecal Coliform Sources in Three Urbanized Rivers



Source: Dr. Charles Hagedorn, Virginia Tech

***Response*:** Thank you for your comment. Ecology has been aware of microbial source tracking (MST) methods for many years. Ecology recently conducted a review and critique of MST techniques which cites the source of your graphs Dr. Hagedorn (Sargeant, et al., 2011). The charts you provide are not indicative of the percentages of sources of FC contamination in samples. Rather, they are percentages of identifiable isolates in the samples. The opportunity to misinterpret MST results is one of its major drawbacks. Even if wildlife were responsible for over 50% of FC contamination in a sample, it would not alleviate responsibility to control human-related sources. In addition, some wildlife sources such as lawns attracting birds, and unkempt dumpster areas attracting birds and rodents, are human-related and controllable sources.

Ecology's greatest concern about all current MST techniques is the quality of the data, especially considering the expense of MST studies (Sargeant, et al., 2011). Quality control (QC) sampling to assess precision and accuracy of results is not typically included in the majority of MST studies. In most cases, FC sources can be found by investigations using standard water sampling techniques and 'bracketing' with stations along the polluted stream reaches. If regular water sampling and bacterial count analyses do not get us to successful results in the Liberty Bay Watershed TMDL, it is conceivable that MST may be used in the future.

Sargeant, D., W.R. Kammin, and S. Collyard, 2011. Review and Critique of Current Microbial Source Tracking (MST) Techniques, Washington State Department of Ecology Environmental Assessment Program, Publication No. 12-03-010, 66 pp.

Sargeant, D., and J. Lowe, 2012. Focus on Microbial Source Tracking (MST), Department of Ecology Environmental Assessment Program, Publication No. 12-03-010, Feb 2012, 5 pp.

7. **Comment:** Suggest adding the following sentence, "Compliance with a Permittee's TMDL specified actions included in the NPDES Municipal Permit constitute compliance with the assigned Wasteload Allocations."

   ***Response*:** It would be inappropriate to put this sentence into a TMDL. A Permittee's TMDL specified actions are placed into a NPDES Municipal Permit only after the TMDL is completed and approved by EPA. It is possible that some of the actions specified in the TMDL would not be appropriate for inclusion into the permit, but would still be required of the permittee by the TMDL. In that situation, the sentence proposed would be incorrect.

8. **Comment:** During the TMDL, no marine samples were collected by Ecology for the study. However, Kitsap Public Health District collected marine data. The statement, "Portions of Liberty Bay … are listed for non-attainment of standards," is inaccurate.

   ***Response*:** Ecology relied on KPHD and DOH Shellfish Area monitoring for marine data in Liberty Bay. Even if water bodies meet water quality standards at any particular time, they may remain listed for non-attainment of standards until newer data are assessed and the list is revised. Ecology will work with local government on maintaining a more current and accurate 303(d) list.

9. **Comment:** In lieu of finalizing this TMDL, we suggest these water bodies be moved to Category 4b and evaluated at a later date to determine if the local, ongoing efforts to address FC pollution in the watershed will result in attainment of standards.

   ***Response*:** The water bodies subject to this TMDL cannot be moved to 4b because no project is currently being implemented that is designed to address all the specific listings. Also, the TMDL identified sources of pollution other than Kitsap County creeks, so it is not reasonable to expect that cleaning up the streams will address the entire problem.

Appendix D: Facilities in watershed with state or federal NPDES permits

Table D-1. Facilities in Liberty Bay watershed with state or federal NPDES permits.

Facility Name	Permit Number	Permit Type	Location
Naval Base Kitsap at Keyport	EPA WAR05BA6F	Federal Multi-Sector General Industrial SW[13] Permit	NBK Keyport
Washington Dept of Transportation	WAR043000A	Municipal SW Phase II Western WA GP[14]	State highways in Poulsbo and urbanized Kitsap County
Kitsap County	WAR045546	Municipal SW Phase II Western WA GP	Urbanized Kitsap County
Poulsbo City	WAR045537	Municipal SW Phase II Western WA GP	Poulsbo
Keyport Undersea Charter & Salvage	WAG030073	Boatyard GP	Keyport
Kitsap Transit North Base Parking	WAR011509	Industrial SW GP	Poulsbo
Yank A Part Auto Wrecking	WAR012109	Industrial SW GP	Poulsbo
Avondale Glen	WAR009992	Construction SW GP	Poulsbo
Chateau Ridge PUD	WAR007086	Construction SW GP	Poulsbo
Clear Creek Estates	WAR009991	Construction SW GP	Poulsbo
First Western SR3 SR305 Interchange	WAR004650	Construction SW GP	Poulsbo
Olhava Property	WAR004675	Construction SW GP	Poulsbo
Poulsbo Place Ii	WAR125018	Construction SW GP	Poulsbo
Urdahl Meadows PUD	WAR124586	Construction SW GP	Poulsbo

[13] SW = Stormwater
[14] GP = General Permit

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Appendix E: Wasteload allocation summary tables

Name of Phase I or II Permittee:	**Poulsbo Phase II Stormwater**
Municipal NPDES IP: **WAR045537**	FS ID: **3382**
Liberty Bay Watershed Bacteria TMDL	**Approved: 2013**

	Fecal coliform bacteria (FC)
Receiving water SWQS	Extraordinary Primary Contact Geometric mean = 50 FC cfu/100 mL; 90th percentile = 100 FC cfu/100 mL
Loading Capacity for Receiving Water (stream mile) billions cfu/day – critical season	SF Dogfish Creek–(0.0) 2.5 - wet; Johnson Creek–(0.1) 1.1 - dry; Bjorgen Creek–(0.1) 0.06 - dry; Barrantes Creek–(0.0) 0.01 - dry; American Legion Park outfall–(0.0) 0.22 - wet; Poulsbo Creek-(0.0) 0.2 - dry; Bovela outfall-(0.0) 0.07 - dry; Nelson Park outfall-(0.0) 0.02 - dry; Viking Assisted Living-(0.0) 0.12 - wet
Current permit limits	2012 Phase II Western Washington Municipal Stormwater Permit requires discharges to comply with Washington State Surface Water Standards
Implementation Actions prescribed	• Implementation of stormwater BMPs to control, reduce, or eliminate stormwater discharges during critical period: Incorporate LID or other stormwater management approaches to reduce discharges of bacteria to surface waters in retrofit and redevelopment projects. • Focus IDDE on MS4 areas upstream of WLA sites. • Focus public outreach and education on Liberty Bay pollution sources. • Allocate resources for monitoring sites in Tables 29 and 30. • Inventory businesses /land uses that could discharge FC bacteria and enforce BMPs to control sources.
TMDL Reporting Requirements	Include in annual report TMDL-related actions such as illicit connections corrected, onsite systems repaired, etc.
Other Comments	Geomean limits based on current sample population characteristics. Dry season = June-Oct; Wet season = Nov – May. WLAs at '*' outfalls for informational purposes only.

Individual Wasteload Allocations apply to stormwater discharges at the following locations:

WLA Location	**Geomean concentration limit to meet WLA** (cfu/100mL)**:** **Dry**	**Wet**	**Wasteload Allocation and Critical Period** FC cfu/day	season	**Measurement Reduction goal**
15-SFD-0.0	31	13	1.2×10^9	wet	50% dry, 87% wet
15-JOH-0.1	15	NA	4.0×10^8	dry	57% dry season
15-LEM-0.1	11	6	2.0×10^7	dry	83% dry, 66% wet
15-BJO-0.1	13	10	2.0×10^7	dry	95% dry, 61% wet
15-BAR-0.0	26	14	4.0×10^6	dry	85% dry, 25% wet
15-JEA-0.0*	30	5	2.0×10^8	wet	76% dry, 93% wet
15-DON-0.0	27	5	1.5×10^8	dry	91% dry, 84% wet
15-BOV-0.0*	44	31	7.0×10^7	dry	88% dry, 45% wet
15-NEL-0.0*	25	10	2.0×10^7	dry	98% dry, 97% wet
15-RET-0.0*	25	34	1.2×10^8	wet	93% dry, 95% wet

Name of Phase I or II Permittee: **Kitsap County Phase II Stormwater**	
Municipal NPDES IP: **WAR045546**	FS ID: **62721174**
Liberty Bay Watershed Bacteria TMDL	**Approved: 2013**

	Fecal coliform bacteria
Receiving water SWQS	Extraordinary Primary Contact Geometric mean = 50; 90th percentile = 100 cfu/100 mL fecal coliform
Loading Capacity for Receiving Water (stream mile) billions cfu/day – critical season	Johnson Creek–(0.1) 1.1 - dry; Big Scandia Creek-(0.0) 0.42 - dry Little Scandia Cr–(0.1) 0.04 - dry; Perry Creek-(0.1) 0.04 - dry Lemolo Creek–(0.1) 0.05 - dry; Bjorgen Creek–(0.1) 0.06 - dry Barrantes Creek–(0.0) 0.01 - dry; Unnamed Creek–(0.1) 0.12 - dry Unnamed Creek-(0.0) 0.02 – dry; Small stream PET–(0.0) 0.05 - wet Small Stream BST-(0.0) 0.26 – wet; Small stream @ Brnsville Hwy KE1–(0.2) 0.02 – dry Keyport Creek KE2–(0.3) 0.26 – dry; Small stream off Virginia Loop Rd LMK-(0.0) 0.01 - wet
Current permit limits	2012 Phase II Western Washington Municipal Stormwater Permit requires discharges to comply with Washington State Surface Water Standards
Implementation Actions prescribed	• Implementation of stormwater BMPs to control, reduce, or eliminate stormwater discharges during critical period: Incorporate LID or other stormwater management approaches to reduce discharges of bacteria to surface waters in retrofit and redevelopment projects. • Continue funding KPHD trend monitoring of Liberty Bay streams & bay. • Focus IDDE on MS4 areas upstream of high priority WLA sites (pg 71). • Focus public outreach and education on Liberty Bay pollution sources. • Allocate resources for monitoring sites in Tables 29 and 30. • Inventory businesses /land uses that could discharge FC bacteria and enforce BMPs to control sources.
TMDL Reporting Requirements	Include in annual report TMDL-related actions such as illicit connections corrected, onsite systems repaired, etc.
Other Comments	Geomean limits based on current sample population characteristics.

Individual Wasteload Allocations apply to stormwater discharges at the following locations:

WLA Location	Geomean concentration limit to meet WLA (cfu/100mL): Dry	Wet	Wasteload Allocation and Critical Period (FC cfu/day)		Measurement Reduction goal	
15-JOH-0.1	15	NA	4.0×10^8	dry	57% dry season	
15-BSC-0.0	30	13	2.0×10^8	dry	73% dry,	55% wet
15-LSC-0.1	23	16	2.0×10^7	dry	96% dry,	85% wet
15-PER-0.1	11	16	4.0×10^7	dry	96% dry,	66% wet
15-LEM-0.1	11	6	2.0×10^7	dry	83% dry,	66% wet
15-BJO-0.1	13	10	2.0×10^7	dry	95% dry,	61% wet
15-BAR-0.1	26	14	4.0×10^6	dry	85% dry,	25% wet
15-UNN-0.1	26	NA	1.0×10^8	dry	67% dry,	NA
15-UNN-0.0	11	5	1.6×10^7	dry	98% dry,	73% wet
15-PET-0.0	NA	21	5.0×10^7	wet	NA ,	49% wet
15-BST-0.0	NA	12	2.0×10^8	wet	NA ,	91% wet
15-KE1-0.2	21	4	1.0×10^7	dry	96% dry,	84% wet
15-KE2-0.3	28	NA	1.6×10^8	dry	87% dry,	NA
15-LMK-0.0	NA	5	1.0×10^7	wet	NA ,	99% wet

Name of Phase I or II Permittee: **WSDOT Phase II Stormwater**	
Municipal NPDES IP: **WAR043000A**	FS ID: **61164417**
Liberty Bay Watershed Bacteria TMDL	**Approved: 2013**

	Fecal coliform bacteria
Receiving water SWQS	Extraordinary Primary Contact Geometric mean = 50; 90th percentile = 100 cfu/100 mL fecal coliform
Loading Capacity for Receiving Water body (stream mile) billions cfu/day – critical season	SF Dogfish Creek–(0.0) 2.5 - wet Big Scandia Creek-(0.0) 0.42 – dry Lemolo Creek-(0.1) 0.05 – dry Barrantes Creek–(0.0) 0.01 - dry Unnamed Creek-(0.0) 0.02 – dry Poulsbo Creek-(0.0) 0.2 - dry Johnson Creek–(0.1) 1.1 - dry Little Scandia Cr–(0.1) 0.04 - dry Bjorgen Creek–(0.1) 0.06 - dry Unnamed Creek–(0.1) 0.12 - dry
Current permit limits	2012 Phase II Western Washington Municipal Stormwater Permit requires discharges to comply with Washington State Surface Water Standards
Implementation Actions prescribed	Implementation of stormwater BMPs to control, reduce, or eliminate stormwater discharges during critical period: Implement WSDOT Municipal Stormwater Permit in Liberty Bay Watershed Phase II Areas for SR 3, SR 305, SR 307, & SR 308. (Table 29)
TMDL Reporting Requirements	Include in annual report TMDL-related actions such as illicit connections corrected, onsite systems repaired, etc.
Other Comments	Geomean limits based on current sample population characteristics.

Individual Wasteload Allocations apply to stormwater discharges at the following locations:

WLA Location	Geomean concentration limit to meet WLA (cfu/100mL): Dry	Wet	Wasteload Allocation and Critical Period (FC cfu/day)		Measurement Reduction goal	
15-SFD-0.0	31	13	1.2×10^9	wet	50% dry,	87% wet
15-JOH-0.1	15	NA	3.0×10^8	dry	57% dry season	
15-BSC-0.0	30	13	2.0×10^8	dry	73% dry,	55% wet
15-LSC-0.1	23	16	2.0×10^7	dry	96% dry,	85% wet
15-LEM-0.1	11	16	1.0×10^7	dry	83% dry,	66% wet
15-BJO-0.1	13	10	1.0×10^7	dry	95% dry,	61% wet
15-BAR-0.0	26	14	2.0×10^6	dry	85% dry,	25% wet
15-UNN-0.1	26	NA	2.0×10^7	dry	67% dry,	NA
15-UNN-0.0	11	5	4.0×10^6	dry	98% dry,	73% wet
15-DON-0.0	27	5	5.0×10^7	dry	91% dry,	84% wet

Name of Phase I or II Permittee: **US Navy Multi-Sector General Permit for Stormwater**	
Municipal NPDES IP: **WAR05BA6F**	FS ID: **157**
Liberty Bay Watershed Bacteria TMDL	**Approved: 2013**

	Fecal coliform bacteria
Receiving water SWQS	Extraordinary Primary Contact Geometric mean = 50; 90th percentile = 100 cfu/100 mL fecal coliform
Loading Capacity for Receiving Water body (stream mile) billions cfu/day – critical season	Small stream @ Brownsville Hwy; KE1–(0.2) 0.02 – dry Keyport Creek off Brownsville Hwy; KE2–(0.3) 0.26 – dry
Current permit limits (include last permit revision date)	NA - last permit revision September 29, 2008 permit expires September 29, 2013
Implementation Actions prescribed	Implementation of stormwater BMPs to control, reduce, or eliminate stormwater discharges during critical period: • Conduct annual dry weather inspections of outfalls and analyze for FC if flow is observed. (Table 29) • Monitor Keyport Creek and unnamed stream KE1 above (upstream of) lagoons (pg 91).
TMDL Reporting Requirements	Include in annual report TMDL-related actions such as monitoring results, illicit connections corrected, onsite systems repaired, etc.
Other Comments	Geomean limits based on current sample population characteristics.

Individual Wasteload Allocations apply to stormwater discharges at the following locations:

WLA Location	Geomean concentration limit to meet WLA (cfu/100mL): Dry	Wet	Wasteload Allocation and Critical Period (FC cfu/day)	Measurement Reduction goal
15-KE1-0.2	21	4	1.0×10^7 dry	96% dry, 84% wet
15-KE2-0.3	28	NA	1.0×10^8 dry	87% dry, NA

Appendix F: Schedule of implementation actions

Table F-1. Schedule of implementation actions.

Source	Organization	Implementation Actions	Potential Concern	Performance Measure	
				What	When
Onsite Septic Systems	Kitsap Public Health District	Continue implementing Pollution Identification and Correction project for priority creeks and shoreline areas	Fecal coliform pollution from onsite system malfunction or failure	Complete PIC project	2014
Onsite Septic Systems	Craft3 (nonprofit organization)	Develop secure funding for sustainable loan programs for onsite repair/replacement	Fecal coliform pollution from onsite system malfunction or failure	Funds obtained	Fall 2015
Waste from boaters	Kitsap Public Health District	Complete marina pumpout survey and draft recommendations	Improper disposal of human waste	Draft report with recommendations	2014
Waste from boaters	Kitsap Public Health District	Implement recommendations (above) for increasing boater use of pumpout stations	Improper disposal of human waste	Implement new educational or regulatory approaches	2017
Waste from boaters	DNR, City of Poulsbo & Kitsap County	Work with city and county authorities to ensure there are no derelict vessels or illegal liveaboards that could harbor activities contributing to poor water quality.	Prevent improper disposal from unregistered vessels.	No derelict vessels; no illegal liveaboards	2018
Stormwater with fecal coliform pollution	Phase II NPDES municipal permittees (City of Poulsbo and Kitsap County)	To address current WQ impairments, look for opportunities to incorporate LID into retrofit and redevelopment[15] projects. To prevent future degradation of water quality, require applicable new development to incorporate LID BMPs or other stormwater management techniques that minimize the discharge of bacteria to surface waters.	Piped stormwater systems from urban areas with high % impervious surface typically have high fecal coliform concentrations in discharges.	Local development permits, as reported in Phase II NPDES stormwater annual report	Effective with permit reissuance or modification

[15] If the use of LID BMPs in redevelopment projects is not otherwise addressed by the reissued Phase II permit.

Source	Organization	Implementation Actions	Potential Concern	Performance Measure	
				What	When
		Address locations with WLAs (Table 26) via geographic focus of IDDE and Operations & Maintenance programs	Fecal coliform bacteria conveyed by stormwater	Phase II NPDES stormwater annual report	Yearly following TMDL approval
		Work together to ensure monitoring continues at sites in Tables 29 and 30	Assess compliance with water quality standards	KPHD monitoring data available to Ecology	Yearly
Stormwater with fecal coliform pollution	Phase II NPDES municipal permittees (City of Poulsbo and Kitsap County)	Include focus on Liberty Bay FC pollution sources as part of public outreach & education on stormwater pollution	Fecal coliform bacteria conveyed by stormwater	Phase II NPDES stormwater annual report	Yearly following TMDL approval
		Explore opportunities in Liberty Bay watershed to encourage citizen stewardship of aquatic environment	Fecal coliform bacteria conveyed by stormwater	Phase II NPDES stormwater annual report	Yearly following TMDL approval
		Inventory businesses/land uses that could discharge FC bacteria; educate owners on impacts of polluted stormwater to local waters	Fecal coliform bacteria conveyed by stormwater	Phase II NPDES stormwater annual report	Yearly following TMDL approval
		Planners develop incentives for small development projects to retain stormwater on site	Prevent future degradation from development	Biennial TMDL implementation review	2015, 2017, etc…
		Planners identify areas of watershed that pose high risk to water quality if developed. Develop incentives to develop in lower risk locations	Prevent future degradation from development	Biennial TMDL implementation review	2015, 2017, etc…
Stormwater with fecal coliform pollution	WSDOT	Implement WSDOT Municipal Stormwater permit in the Phase II coverage areas of watershed, for SR3, SR305, SR308	Fecal coliform bacteria conveyed by stormwater	Biennial TMDL implementation review	2015, 2017, etc.
Stormwater with fecal coliform pollution	Naval Base Kitsap at Keyport	Conduct annual dry weather inspections of outfalls & analyze for FC if flow observed	Fecal coliform bacteria conveyed by stormwater	Biennial TMDL implementation review	2015, 2017, etc.

Source	Organization	Implementation Actions	Potential Concern	Performance Measure	
				What	When
Stormwater with fecal coliform pollution	Naval Base Kitsap at Keyport	Monitor streams Keyport 1 and 2 just upstream of discharges to lagoons, in coordination with Kitsap County monitoring upstream of Brownsville Highway	Fecal coliform bacteria conveyed by stormwater	Minimum one year monthly monitoring until standards met	2015
Stormwater with fecal coliform pollution	Kitsap County Dept of Community Development	Outside Phase II area, require applicable developments to implement LID or other approaches to manage stormwater on site	Fecal coliform bacteria conveyed by stormwater	Biennial TMDL implementation review	2015, 2017, etc.
Municipal sewage	Responsible operating agency (Poulsbo; Kitsap County)	Follow BMPS for collection systems in APWA et al. (2010)	Prevent sewage pollution from inadequate O & M of sewage collection systems	Ongoing	2018
Animal waste	Kitsap Conservation District	Update livestock inventory	Biennial TMDL implementation review	Every 2 years	2015, 2017, etc.
		Continue technical assistance and cost share for livestock owners in watershed	Prevent FC pollution from animal waste	Biennial TMDL implementation review	2015, 2017, etc.

Appendix G: Statistical theory of rollback

Statistical theory of rollback

The statistical rollback method proposed by Ott (1995) describes a way to use a numeric distribution of a water quality parameter to estimate the distribution after abatement processes are applied to sources. The method relies on basic dispersion and dilution assumptions and their effect on the distribution of a chemical or a bacterial population at a monitoring site downstream from a source. It then provides a statistical estimate of the new population after a chosen reduction factor is applied to the existing pollutant source. In the case of the TMDL, compliance with the most restrictive of the dual FC criteria will determine the reduction factor needed.

As with many water quality parameters, FC counts collected over time at an individual site usually follow a lognormal distribution. That is, over the course of sampling for a year, or multiple years, most of the counts are relatively low, but a few are much higher. When monthly FC data are plotted on a logarithmic-probability graph (the open diamonds in Figure G-1), they appear to form a nearly straight line.

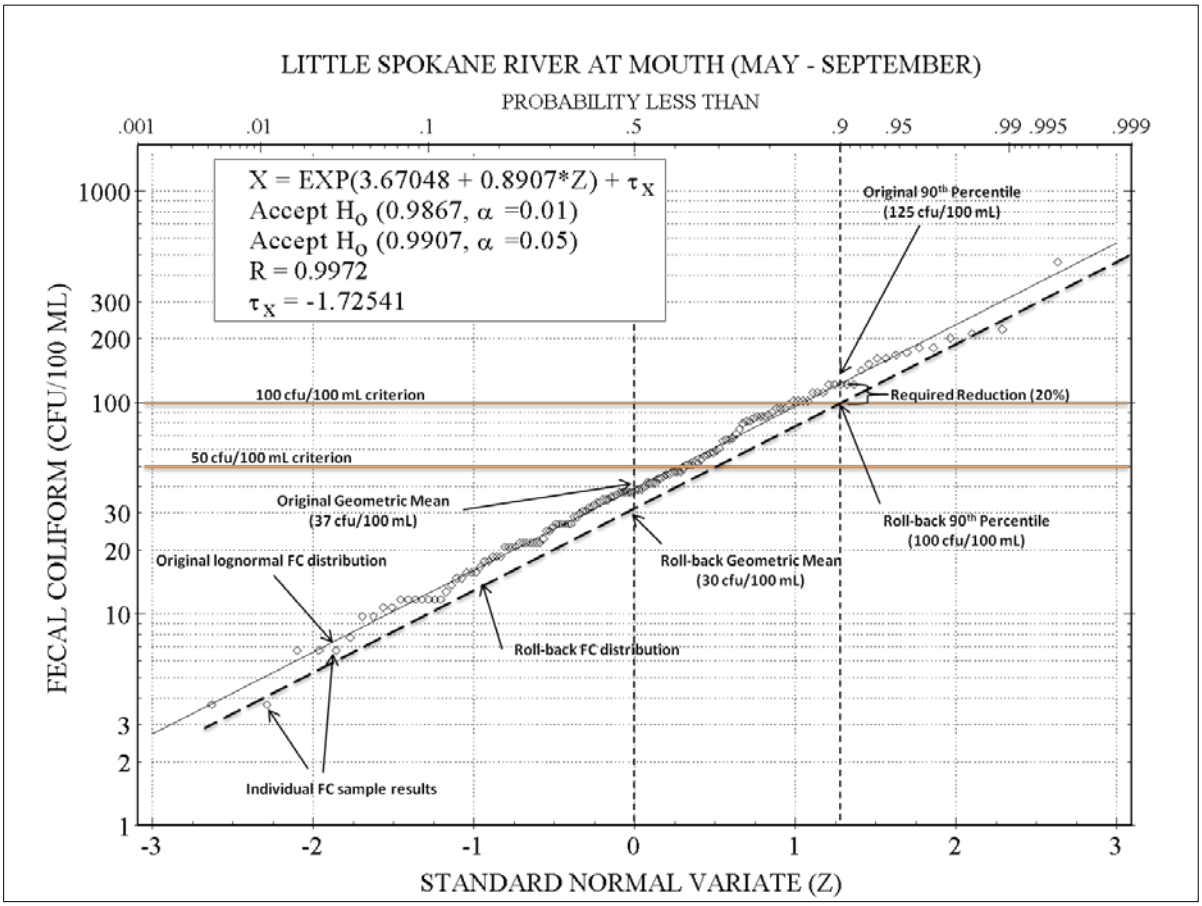

Figure G-1. Graphical depiction of the statistical rollback method for fecal coliform (FC) targets.

The 50th percentile (an estimate of the geometric mean) and the 90th percentile (a representation of the level over which 10% of the samples lie) can be located along a line plotted from an equation estimating the original monthly FC data distribution.

In Figure G-1, these numbers are 37 cfu/100 mL and 125 cfu/100 mL, respectively. Using the statistical rollback method, the 90th percentile value is then reduced to 100 cfu/100 mL (*extraordinary primary contact recreation* 90th percentile criterion), since 37 cfu/100 mL meets the geometric mean criterion. The new distribution is plotted parallel to the original. The estimate of the geometric mean for this new distribution, located at the 50th percentile, is 30 cfu/ 100 mL. The result is a geometric mean target of a sample distribution that would likely have less than 10% of its samples over 100 cfu/100 mL. A 20% FC reduction is required from combined sources to meet this target distribution from the simple calculation:

$$(125 - 100) / 125 = 0.2 * 100 = 20\%.$$

The following is a summary of the major theorems and corollaries for the Statistical Theory of Rollback (STR) from *Environmental Statistics and Data Analysis* by Ott (1995).

1. If Q = the concentration of a contaminant at a source, and D = the dilution-diffusion factor, and X = the concentration of the contaminant at the monitoring site, then X = Q*D.
2. Successive random dilution and diffusion of a contaminant Q in the environment often result in a lognormal distribution of the contaminant X at a distant monitoring site.
3. The coefficient of variation (CV) of Q is the same before and after applying a "rollback" (i.e., the CV in the post-control state will be the same as the CV in the pre-control state). The rollback factor = r, a reduction factor expressed as a decimal (a 70% reduction would be a rollback factor of 0.3). The random variable Q represents a pre-control source output state, and rQ represents the post-control state.
4. If D remains consistent in the pre-control and post-control states (long-term hydrological and climatic conditions remain unchanged), then CV(Q)*CV(D)=CV(X), and CV(X) will be the same before and after the rollback is applied.
5. If X is multiplied by the rollback factor, then the variance in the post-control state will be multiplied by r^2, and the post-control standard deviation will be multiplied by r.
6. If X is multiplied by the rollback factor, the quantiles of the concentration distribution will be scaled geometrically.
7. If any random variable is multiplied by r, then its expected value and standard deviation also will be multiplied by r, and its CV will be unchanged. (Ott uses "expected value" for the mean.)

Statistical formulae for deriving percentile values

The 90th percentile value for a population can be derived in several ways. The set of FC counts collected at a site were subjected to a statistically-based formula (Zar, 1984). The estimated 90th percentile is calculated by:

(a) Calculating the arithmetic mean and standard deviation of the sample result logarithms (base 10);

(b) Multiplying the standard deviation in (a) by 1.28;
(c) Adding the product from (b) to the arithmetic mean;
(d) Taking the antilog (base 10) of the results in (c) to get the estimated 90th percentile.

The 90^{th} percentile derived using this formula assumes a lognormal distribution of the FC data. Several sites were checked to verify lognormal distributions. The variability in the data is expressed by the standard deviation, and with some data sets it is possible to calculate a 90^{th} percentile greater than any of the measured data.

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Appendix H: Bacteria results

Table H-1. Fecal coliform (colony forming units per 100 mL) at regularly sampled stations (fixed-network sites) in the Liberty Bay watershed.

Yellow and orange highlighted values do not meet Washington State surface water quality criteria. Map numbers reference Figure 2.
Dashes denote no sample taken. For site descriptions, see Table 10.

Site ID w/ stream mile	Map #	Aug 12	Aug 26	Sept 10	Sept 24	Oct 8	Oct 22	Nov 11	Nov 24	Dec 10	Dec 29	Jan 14	Jan 28	Feb 11	Feb 25	Mar 11	Mar 24	Apr 8	Apr 29	May 6	May 20	Jun 9	Jun 17	July 8	July 22	Aug 12	Sept 1	n	Min	Max	Geo-metric mean	90th percen-tile
Dogfish Creek																																
15-DOG-0.6	1	65	110	43	66	88	32	63	52	21	390	17	19	24	31	12	15	13	11	280	130	250	92	120	84	330	92	26	11	390	56	218
15-SFD-0.0	2	360	120	26	31	84	12	65	9	290	540	31	180	190	280	18	32	11	1000	830	160	54	140	51	130	54	31	26	9	1000	83	447
15-SFD-1.3	3	61	72	170	71	140	46	41	8	330	340	29	66	130	170	3	6	1	140	640	130	110	380	96	69	92	140	26	1	640	68	467
15-EFD-0.0	4	180	80	51	34	220	92	51	4	10	68	5	2	30	15	30	5	18	3	180	140	890	110	180	240	830	150	26	2	890	47	405
15-EFD-1.2	5	60	67	16	29	9	4	3	12	51	130	9	5	51	7	4	10	31	14	170	75	61	61	120	56	300	120	26	3	300	28	151
15-WFD-0.0	6	75	180	110	31	18	18	43	45	23	270	9	14	10	33	10	25	3	44	51	140	74	40	80	120	1300	150	26	3	1300	45	229
15-WFD-0.9	7	57	80	19	28	13	18	37	30	17	170	4	1	4	6	6	8	1	7	35	140	60	510	180	170	62	71	26	1	510	24	188
Johnson Creek																																
15-JOH-0.1	8	8	120	4	140	220	2	11	1	1	87	190	3	15	17	6	2	1	15	120	27	24	53	47	57	74	69	26	1	220	18	165
Big Scandia Creek																																
15-BSC-0.0	9	180	110	14	40	80	40	56	3	31	230	5	17	44	43	13	56	2	23	380	180	240	210	200	170	210	280	26	2	380	55	351
15-BSC-0.1	10	79	110	36	35	88	20	6	2	44	260	9	6	24	56	80	52	2	9	250	250	340	200	88	86	290	300	26	2	340	48	340
15-BSC-1.1	11	35	110	6	10	28	7	11	2	1	55	14	5	12	110	9	5	4	3	340	140	200	400	77	320	500	280	26	1	500	28	300
15-BSC-1.6	12	84	72	32	31	88	7	3	9	1	340	14	40	11	41	24	4	2	4	170	200	74	110	75	150	290	85	26	1	340	31	245
Little Scandia Creek																																
15-LSC-0.1	13	1600	660	410	670	77	140	46	250	55	320	40	110	340	270	3	34	120	92	920	380	160	240	700	2600	770	2500	26	3	2600	224	1545
15-LSC-0.4	14	920	150	260	640	180	160	41	3	6	100	6	99	28	67	4	9	15	40	760	180	120	17	680	220	300	180	26	3	920	73	643
Daniels Creek																																
15-DAN-0.0	15	590	62	540	450	450	100	29	15	23	23	17	10	20	120	18	280	20	9	550	130	110	1200	500	600	480	350	26	9	1200	102	775
15-DAN-0.2	16	420	92	940	200	80	65	10	44	18	51	2	8	1	6	1	5	7	6	62	30	96	670	390	520	550	140	26	1	940	40	556
Perry Creek																																
15-PER-0.1	17	530	550	69	77	80	9	71	3	17	220	23	26	29	74	77	200	20	7	500	200	84	520	310	8000	770	870	26	3	8000	102	996
Sam Snyder Creek																																
15-SAM-0.1	18	-	-	-	-	-	-	20	3	13	54	1	1	22	21	3	6	2	47	32	24	-	-	-	-	-	-	14	1	54	9	54
Lemolo Creek																																
15-LEM-0.1	19	84	77	3	7	18	22	2	6	5	150	21	6	7	5	1	6	14	190	960	800	120	150	280	900	670	23	26	1	960	32	448
Bjorgen Creek																																
15-BJO-0.1	20	3000	140	49	190	140	21	120	6	5	1100	14	6	27	53	6	7	4	17	490	80	280	230	6700	240	220	730	26	4	6700	77	1070
Barrantes Creek																																
15-BAR-0.0	21	450	190	810	190	270	20	110	13	3	90	4	27	8	11	12	1	24	62	240	48	51	170	210	270	-	-	24	1	810	48	450
Unnamed Tributaries to Liberty Bay																																
15-UNN-0.1	22	29	40	-	-	29	15	100	3	4	110	14	1	11	8	4	7	1	7	9	6	83	240	84	230	230	230	24	1	240	20	178
15-UNN-0.0	23	-	-	-	-	-	77	180	63	330	180	10	3	9	39	2	1	1	1	420	150	270	240	180	3300	750	9700	21	1	9700	60	1803

Table H-2. Fecal coliform (colony forming units per 100 mL) at investigation and dry-period survey sites in the Liberty Bay watershed.

Yellow and orange highlighted values do not meet Washington State surface water quality criteria. Dashes denote no sample taken.
For site descriptions, see Table 11.

Site ID w/ stream mile	Map #	Aug 12	Aug 26	Sept 10	Sept 24	Oct 8	Oct 22	Nov 11	Nov 24	Dec 10	Dec 29	Jan 14	Jan 28	Feb 11	Feb 25	Mar 11	Mar 24	Apr 8	Apr 29	May 6	May 20	Jun 9	Jun 17	July 8	July 22	Aug 12	Sept 1	n	Min	Max	Geo-metric mean	90th percen-tile
Investigatory sites																																
15-PET-0.0	24	-	-	-	-	-	89	-	-	160	110	8	86	26	190	3	64	22	21	57	59	-	-	-	-	-	-	13	3	190	43	199
15-JEA-0.0	25	-	-	-	-	-	-	150	75	82	1300	3	220	69	1000	1	7	6	34	2900	370	200	49	52	200	530	69	20	1	2900	84	1163
15-DON-0.0	26	-	-	-	-	-	-	-	-	-	370	11	1	21	140	8	13	14	12	5200	71	92	840	710	180	700	110	17	1	5200	74	1206
15-STORM-1	27	-	-	-	-	-	-	1500	-	-	880	-	-	-	160	-	-	-	-	1300	-	-	-	-	-	-	-	4	160	1500	724	2714
15-STORM-2	28	-	-	-	-	-	-	-	-	-	1100	-	-	32	2100	-	-	-	-	1600	-	-	-	-	-	-	-	4	32	2100	586	7202
15-UN3-0.0	29	-	-	-	-	-	-	-	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	27	27	-	-
15-BST-0.0	30	-	-	-	-	-	-	-	-	760	200	60	11	110	230	88	8	130	100	2900	510	-	-	-	-	-	-	12	8	2900	134	1109
15-KE1-0.2	31	-	-	-	-	-	-	-	-	-	-	23	-	-	51	-	1	-	-	-	380	640	1600	610	930	50	970	10	1	1600	162	3156
15-KE2-0.3	32	-	-	-	-	-	-	-	-	-	-	2	-	-	6	-	10	-	-	-	57	55	160	160	970	430	140	10	2	970	60	729
15-JOH-T	33	-	-	-	-	-	-	-	-	3	150	-	-	-	-	-	-	-	1	17	-	-	-	-	-	-	-	4	1	150	9	154
15-BOV-0.0	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	100	31	150	660	200	250	200	900	400	10	23	900	174	799
15-LMK-0.0	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	6000	2900	130	160	-	-	-	-	-	5	45	6000	439	6700
15-NEL-0.0	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3200	280	590	46	760	870	1700	160	3300	2400	10	46	3300	714	4273
15-RET-0.0	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	310	520	2300	700	330	54	320	290	1300	770	10	54	2300	461	1698

Table H-3. Fecal coliform (colony forming units per 100 mL) at dry-period survey sites in the Liberty Bay watershed.

Yellow highlighted values do not meet Washington State surface water quality criterion. Dashes denote no sample taken. Site descriptions are included.

Site ID w/ stream mile	Map #	Site Description	Oct 29, 2008	Aug 19, 2009	Oct 12, 2009
Dry season synoptic survey					
15-LEM-0.0	-	Lemolo Ck. mouth	47	-	190
15-LEM-0.1	19	Lemolo Ck. at Lemolo Shore Dr. east of Delate Rd. Access from first private drive east of creek, 75 ft. upstream of culvert	-	62	-
15-BJO-0.0	-	Bjorgen Ck. mouth	260	-	180
15-BJO-0.1	20	Bjorgen Ck. at Lemolo Shore Dr. by market, downstream side of culvert	-	470	-
15-BAR-0.0	21	Barrantes Ck. at Lemolo Shore Dr. downstream of culvert on beach	43	-	-
15-DOG-0.0	-	Dogfish Ck. at mouth, above site 15-NEL-0.0	40	190	44
15-DOG-T	-	small stream flowing through Fish Park. Enters Dogfish Ck. in the tidal area below site 15-DOG-0.6, but above site 15-NEL-0.0	2	-	20
15-JOH-0.0	-	Johnson Ck. mouth	9	480	31
15-BSC-0.0	9	Big Scandia Ck. mouth	51	100	100
15-LSC-0.0	-	Little Scandia mouth	5600	-	360
15-LSC-0.1	13	Little Scandia Ck. at Scandia Rd. behind church, upstream side of culvert	-	970	-
15-PER-0.0	-	Perry Ck. mouth	100	-	360
15-PER-0.1	17	Perry Ck. at 90 deg. right turn in Thorpe Rd. upstream side of culvert	-	290	-
15-DAN-0.0	15	Daniels Ck. mouth	220	340	1100
15-UN1-0.0	-	15-UNN-0.1 mouth	470	-	200
15-UNN-0.1	22	Trib. east of Daniels Ck. at Hwy 308 near “Support Our Troops” sign. 30ft.upstream of culvert	-	120	15
15-UNN-0.0	23	Trib. flowing into bay south of and next to Daniels Ck. mouth.	26	340	-
15-UN3-0.0	29	Small, unnamed stream flowing into Dogfish Bay, east of station 15-UNN-0.1	71	-	-
15-JEA-0.0	25	South end of Legion Park, below playground. Poulsbo outfall OF-3703.	8	46	33
15-BOV-0.0	34	Trib to Liberty Bay between Bovela St. and Bay St. Poulsbo outfall OF-3706.	-	2500	250
15-NEL-0.0	36	Nelson Park bioswale at beach. Poulsbo outfall OF-3502.	-	620	1800
15-DON-0.0	26	Poulsbo Creek at Poulsbo Yacht Club. Poulsbo outfall OF-5304.	-	100	20
15-RET-0.0	37	Small, unnamed ck. flowing through assisted living facility property off Viking Way in Poulsbo, near Bovela St. Sample at beach. Poulsbo outfall OF-3704.	-	1700	830
15-KE1-0.2	31	Small, unnamed ck. near Keyport Ck (1st trib. at Brownsville Hwy, traveling south)	-	-	310
15-KE2-0.3	32	Keyport Creek (2nd trib. at Brownsville Hwy, travelling south)	-	-	9

Appendix I: Field results

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-BAR-0.0	8/12/2008	10:05	14.2	271	0.01	estimate
15-BAR-0.0	8/26/2008	11:00	13.6	223	0.03	
15-BAR-0.0	9/10/2008	11:10	13.6	515	0.01	
15-BAR-0.0	9/24/2008	10:45	12.5	182	0.01	
15-BAR-0.0	10/8/2008	8:45	10.9	157	0.03	estimate
15-BAR-0.0	10/22/2008	10:05	9.2	217	0.02	
15-BAR-0.0	10/29/2008	11:15			0.02	estimate
15-BAR-0.0	11/11/2008	11:45	10.0	174	0.09	
15-BAR-0.0	11/24/2008	10:30	7.3	211	0.04	
15-BAR-0.0	12/10/2008	10:30	8.4	215	0.06	estimate
15-BAR-0.0	12/29/2008	12:25	4.7	119	0.45	
15-BAR-0.0	1/14/2009	11:05	6.9	235	0.09	
15-BAR-0.0	1/28/2009	13:10	4.8	130	0.08	estimate
15-BAR-0.0	2/11/2009	13:35	5.0	133	0.13	
15-BAR-0.0	2/25/2009	13:10	6.6	137	0.12	
15-BAR-0.0	3/11/2009	11:30	4.1	132	0.05	
15-BAR-0.0	3/24/2009	12:25	6.9	123	0.10	
15-BAR-0.0	4/8/2009	12:45	8.7	154	0.07	
15-BAR-0.0	4/29/2009	11:50	9.6	209	0.03	
15-BAR-0.0	5/6/2009	13:40	10.0	145	0.30	
15-BAR-0.0	5/20/2009	12:25	10.3	174	0.10	estimate
15-BAR-0.0	6/9/2009	13:50	13.0	408	0.01	
15-BAR-0.0	6/17/2009	9:55	13.2	456	0.01	
15-BAR-0.0	7/8/2009	13:14	13.9	1690	0.01	
15-BAR-0.0	7/22/2009	13:50	17.4	2900	0.01	
15-BJO-0.0	10/29/2008	12:15			0.06	estimate
15-BJO-0.0	10/12/2009	8:30	7.0	460	0.04	estimate
15-BJO-0.1	8/12/2008	10:00	13.8	203	0.04	estimate
15-BJO-0.1	8/26/2008	10:35	13.8	177	0.11	
15-BJO-0.1	9/10/2008	10:50	12.5	198	0.04	
15-BJO-0.1	9/24/2008	10:35	11.5	149	0.03	
15-BJO-0.1	10/8/2008	9:30	10.0	148	0.06	
15-BJO-0.1	10/22/2008	10:40	7.6	118	0.07	
15-BJO-0.1	11/11/2008	12:40	9.9	141	0.70	
15-BJO-0.1	11/24/2008	11:09	5.8	198	0.09	
15-BJO-0.1	12/10/2008	10:55	7.6	218	0.09	
15-BJO-0.1	12/29/2008	16:00	4.0	56.4	2.9	
15-BJO-0.1	1/14/2009	10:20	6.6	104	0.33	
15-BJO-0.1	1/28/2009	13:40	3.5	122	0.25	estimate
15-BJO-0.1	2/11/2009	15:05	4.2	82	0.70	
15-BJO-0.1	2/25/2009	13:55	6.6	98.0	0.67	
15-BJO-0.1	3/11/2009	13:55	3.5	114	0.17	
15-BJO-0.1	3/24/2009	13:00	7.0	98.3	0.39	
15-BJO-0.1	4/8/2009	13:55	9.3	111	0.28	
15-BJO-0.1	4/29/2009	11:10	9.4	187	0.21	
15-BJO-0.1	5/6/2009	13:50	10.4	116	2.3	
15-BJO-0.1	5/20/2009	13:00	11.2	123	0.48	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-BJO-0.1	6/9/2009	14:05	15.4	206	0.06	
15-BJO-0.1	6/17/2009	14:00	15.1	186	0.07	
15-BJO-0.1	7/8/2009	13:31	13.8	202	0.05	estimate
15-BJO-0.1	7/22/2009	14:15	16.5	212	0.05	
15-BJO-0.1	8/12/2009	13:30	14.2	317	0.04	
15-BJO-0.1	8/19/2009	16:25	18.0	220	0.04	estimate
15-BJO-0.1	9/1/2009	12:45	14.4	211	0.04	
15-BOV-0.0	4/8/2009	16:10	10.1	163	0.07	estimate
15-BOV-0.0	4/29/2009	14:00	11.9	215	0.08	estimate
15-BOV-0.0	5/6/2009	11:25	13.2	87.5	0.92	
15-BOV-0.0	5/20/2009	14:00	12.7	198	0.50	estimate
15-BOV-0.0	6/9/2009	12:15	16.3	247	0.11	estimate
15-BOV-0.0	6/17/2009	13:10	16.6	246	0.05	estimate
15-BOV-0.0	7/8/2009	11:54	16.3	245	0.04	estimate
15-BOV-0.0	7/22/2009	12:10	17.8	234	0.03	
15-BOV-0.0	8/12/2009	12:35	18.7	192	0.03	estimate
15-BOV-0.0	8/19/2009	13:10	19.3	239	0.03	
15-BOV-0.0	9/1/2009	11:05	17.3	250	0.03	estimate
15-BOV-0.0	10/12/2009	10:55	8.2	238	0.03	estimate
15-BSC-0.0	8/12/2008	12:05	14.7	144	0.55	
15-BSC-0.0	8/26/2008	14:10	13.7	140	0.85	
15-BSC-0.0	9/10/2008	15:35	13.2	143	0.41	
15-BSC-0.0	9/24/2008	16:20	11.6	110	0.50	
15-BSC-0.0	10/8/2008	13:25	10.4	107	0.62	
15-BSC-0.0	10/22/2008	13:55	8.1	150	0.62	estimate
15-BSC-0.0	10/29/2008	12:40			0.55	
15-BSC-0.0	11/11/2008	15:55	9.9	137	1.6	
15-BSC-0.0	11/24/2008	14:30	6.2	148	0.85	
15-BSC-0.0	12/10/2008	13:25	7.6	148	0.80	
15-BSC-0.0	12/29/2008	14:30	3.8	88	16.1	
15-BSC-0.0	1/14/2009	14:50	6.7	78.1	1.6	
15-BSC-0.0	1/28/2009	12:25	3.5	83.0	0.85	
15-BSC-0.0	2/11/2009	10:45	3.5	85.2	1.8	
15-BSC-0.0	2/25/2009	15:20	6.7	80.6	2.0	
15-BSC-0.0	3/11/2009	12:35	3.6	82.0	0.99	
15-BSC-0.0	3/24/2009	15:40	7.9	77.7	2.2	
15-BSC-0.0	4/8/2009	16:35	9.8	92.9	0.85	
15-BSC-0.0	4/29/2009	14:50	10.8	139	0.61	
15-BSC-0.0	5/6/2009	16:45	10.0	104	5.4	
15-BSC-0.0	5/20/2009	14:25	10.9	107	2.3	
15-BSC-0.0	6/9/2009	15:55	14.5	149	0.36	
15-BSC-0.0	6/17/2009	12:15	14.0	150	0.37	
15-BSC-0.0	7/8/2009	15:05	13.9	149	0.34	
15-BSC-0.0	7/22/2009	16:00	16.0	154	0.36	
15-BSC-0.0	8/12/2009	12:00	15.2	153	0.34	
15-BSC-0.0	8/19/2009	13:55	16.7	167	0.36	
15-BSC-0.0	9/1/2009	15:40	14.0	151	0.36	
15-BSC-0.0	10/12/2009	8:50	6.4	2250	0.61	
15-BSC-0.1	8/12/2008	12:20	13.8	144	0.53	estimate
15-BSC-0.1	8/26/2008	13:50	13.3	140	0.97	
15-BSC-0.1	9/10/2008	15:10	12.8	143	0.54	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-BSC-0.1	9/24/2008	16:00	11.5	109	0.53	
15-BSC-0.1	10/8/2008	13:05	10.2	104	0.66	
15-BSC-0.1	10/22/2008	13:30	7.8	150	0.66	
15-BSC-0.1	11/11/2008	15:40	9.9	135	1.8	
15-BSC-0.1	11/24/2008	14:15	6.0	135	0.89	
15-BSC-0.1	12/10/2008	13:15	7.6	146	0.89	estimate
15-BSC-0.1	12/29/2008	15:25	3.7	88	15.3	
15-BSC-0.1	1/14/2009	16:30	6.5	77.1	1.8	
15-BSC-0.1	1/28/2009	12:30	3.3	81.5	0.89	
15-BSC-0.1	2/11/2009	10:40	3.3	80.6	1.8	
15-BSC-0.1	2/25/2009	15:15	6.7	81.3	2.0	
15-BSC-0.1	3/11/2009	12:40	3.0	77.9	1.0	
15-BSC-0.1	3/24/2009	15:30	7.7	77.1	1.9	
15-BSC-0.1	4/8/2009	16:25	9.7	92.5	0.89	
15-BSC-0.1	4/29/2009	14:40	10.5	139	0.67	
15-BSC-0.1	5/6/2009	16:35	10.0	103	5.2	
15-BSC-0.1	5/20/2009	14:20	10.8	106	2.2	
15-BSC-0.1	6/9/2009	15:50	14.6	147	0.43	
15-BSC-0.1	6/17/2009	12:25	13.6	150	0.44	
15-BSC-0.1	7/8/2009	14:59	13.5	150	0.41	
15-BSC-0.1	7/22/2009	15:55	15.7	151	0.43	
15-BSC-0.1	8/12/2009	12:10	14.7	153	0.41	
15-BSC-0.1	9/1/2009	15:30	13.8	151	0.43	
15-BSC-1.1	8/12/2008	12:50	13.5	139	0.46	estimate
15-BSC-1.1	8/26/2008	16:20	13.2	136	0.76	
15-BSC-1.1	9/10/2008	16:50	12.5	139	0.32	
15-BSC-1.1	9/24/2008	17:25	11.2	106	0.46	
15-BSC-1.1	10/8/2008	14:40	10.1	103	0.47	estimate
15-BSC-1.1	10/22/2008	15:30	8.2	146	0.49	
15-BSC-1.1	11/11/2008	17:25	9.9	132	1.4	
15-BSC-1.1	11/24/2008	15:10	6.3	141	0.73	
15-BSC-1.1	12/10/2008	14:10	7.7	141	0.68	
15-BSC-1.1	12/29/2008	15:10	3.9	78	14.1	
15-BSC-1.1	1/14/2009	16:55	6.5	74.2	1.6	
15-BSC-1.1	1/28/2009	15:00	4.4	81.8	0.72	
15-BSC-1.1	2/11/2009	17:30	4.4	76.6	1.6	
15-BSC-1.1	2/25/2009	16:05	6.6	78.4	1.7	
15-BSC-1.1	3/11/2009	12:55	4.0	78.2	0.85	
15-BSC-1.1	3/24/2009	17:25	7.4	73.0	1.7	
15-BSC-1.1	4/8/2009	17:50	9.1	88.0	0.72	
15-BSC-1.1	4/29/2009	16:15	10.5	133	0.52	
15-BSC-1.1	5/6/2009	17:10	9.9	97.8	4.7	
15-BSC-1.1	5/20/2009	15:40	10.4	98.0	2.0	
15-BSC-1.1	6/9/2009	16:30	13.5	145	0.29	
15-BSC-1.1	6/17/2009	15:50	13.4	146	0.30	
15-BSC-1.1	7/8/2009	15:42	13.0	145	0.28	
15-BSC-1.1	7/22/2009	16:20	15.0	145	0.29	
15-BSC-1.1	8/12/2009	14:50	14.6	147	0.28	
15-BSC-1.1	9/1/2009	16:10	13.3	145	0.29	
15-BSC-1.6	8/12/2008	12:40	12.4	136	0.41	
15-BSC-1.6	8/26/2008	16:00	12.8	133	0.58	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-BSC-1.6	9/10/2008	16:30	12.1	136	0.26	
15-BSC-1.6	9/24/2008	17:10	11.1	104	0.40	
15-BSC-1.6	10/8/2008	14:35	10.1	99	0.44	
15-BSC-1.6	10/22/2008	15:00	8.3	141	0.44	estimate
15-BSC-1.6	11/11/2008	17:20	9.8	125	1.0	
15-BSC-1.6	11/24/2008	14:55	6.7	135	0.64	
15-BSC-1.6	12/10/2008	13:55	7.7	88	0.59	
15-BSC-1.6	12/29/2008	15:05	3.8	69	9.3	
15-BSC-1.6	1/14/2009	16:45	6.6	60.7	1.1	
15-BSC-1.6	1/28/2009	14:50	4.8	78.7	0.58	
15-BSC-1.6	2/11/2009	17:20	4.7	71.7	1.1	
15-BSC-1.6	2/25/2009	16:00	6.9	73.4	1.2	
15-BSC-1.6	3/11/2009	12:50	3.8	73.3	0.67	
15-BSC-1.6	3/24/2009	17:10	7.6	67.0	1.3	
15-BSC-1.6	4/8/2009	17:45	9.5	83.7	0.58	
15-BSC-1.6	4/29/2009	16:20	10.9	128	0.45	
15-BSC-1.6	5/6/2009	17:15	9.7	90.0	3.2	
15-BSC-1.6	5/20/2009	15:45	10.3	91.5	1.4	
15-BSC-1.6	6/9/2009	16:40	13.2	141	0.25	
15-BSC-1.6	6/17/2009	16:00	12.6	142	0.26	
15-BSC-1.6	7/8/2009	15:46	12.4	136	0.23	
15-BSC-1.6	7/22/2009	16:35	14.0	141	0.25	
15-BSC-1.6	8/12/2009	14:55	13.5	142	0.23	
15-BSC-1.6	9/1/2009	16:15	12.8	141	0.25	
15-BST-0.0	12/10/2008	10:05	7.2	2670	0.03	estimate
15-BST-0.0	12/29/2008	13:20	3.4	275	0.99	
15-BST-0.0	1/14/2009	14:40	6.7	552	0.17	
15-BST-0.0	1/28/2009	12:20	3.2	838	0.15	estimate
15-BST-0.0	2/11/2009	10:50	3.1	800	0.17	
15-BST-0.0	2/25/2009	12:00	6.8	586	0.22	
15-BST-0.0	3/11/2009	12:30	3.6	755	0.07	
15-BST-0.0	3/24/2009	11:50	7.0	184	0.22	
15-BST-0.0	4/8/2009	11:40	9.7	1010	0.06	
15-BST-0.0	4/29/2009	14:45	12.7	950	0.05	
15-BST-0.0	5/6/2009	11:15	11.2	600	0.32	
15-BST-0.0	5/20/2009	11:35	12.6	199	0.26	
15-DAN-0.0	8/12/2008	13:40	15.1	201	0.21	estimate
15-DAN-0.0	8/26/2008	17:00	13.7	190	0.27	
15-DAN-0.0	9/10/2008	17:50	13.9	202	0.10	
15-DAN-0.0	9/24/2008	17:50	11.9	151	0.21	
15-DAN-0.0	10/8/2008	15:25	10.9	140	0.20	
15-DAN-0.0	10/22/2008	9:30	7.5	133	0.20	
15-DAN-0.0	10/29/2008	11:45			0.18	estimate
15-DAN-0.0	11/11/2008	17:00	10.1	186	0.34	
15-DAN-0.0	11/24/2008	15:50	7.0	195	0.31	
15-DAN-0.0	12/10/2008	14:30	8.5	197	0.23	
15-DAN-0.0	12/29/2008	10:10	3.8	156	0.98	
15-DAN-0.0	1/14/2009	15:20	6.8	115	0.36	
15-DAN-0.0	1/28/2009	11:45	4.0	115	0.36	
15-DAN-0.0	2/11/2009	12:10	4.4	111	0.51	
15-DAN-0.0	2/25/2009	11:20	6.8	114	0.55	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-DAN-0.0	3/11/2009	10:00	3.0	110	0.35	
15-DAN-0.0	3/24/2009	17:45	7.8	119	0.43	
15-DAN-0.0	4/8/2009	17:30	9.6	131	0.33	
15-DAN-0.0	4/29/2009	16:00	11.3	191	0.27	
15-DAN-0.0	5/6/2009	10:45	9.5	165	0.87	
15-DAN-0.0	5/20/2009	15:05	11.3	172	0.45	
15-DAN-0.0	6/9/2009	11:35	14.2	210	0.14	
15-DAN-0.0	6/17/2009	10:50	13.5	212	0.13	
15-DAN-0.0	7/8/2009	11:11	13.4	206	0.10	
15-DAN-0.0	7/22/2009	11:00	14.6	215	0.06	
15-DAN-0.0	8/12/2009	11:25	14.8	203	0.11	
15-DAN-0.0	8/19/2009	14:50	18.0	214	0.07	
15-DAN-0.0	9/1/2009	10:15	13.7	221	0.07	estimate
15-DAN-0.0	10/12/2009	11:15	7.3	219	0.10	
15-DAN-0.2	8/12/2008	13:00	14.4	195	0.17	estimate
15-DAN-0.2	8/26/2008	16:50	13.4	185	0.21	
15-DAN-0.2	9/10/2008	17:30	13.5	198	0.08	
15-DAN-0.2	9/24/2008	17:40	11.7	145	0.17	
15-DAN-0.2	10/8/2008	15:05	10.6	135	0.19	
15-DAN-0.2	10/22/2008	9:45	7.7	194	0.17	
15-DAN-0.2	11/11/2008	16:50	10.0	174	0.25	
15-DAN-0.2	11/24/2008	16:05	6.9	185	0.23	
15-DAN-0.2	12/10/2008	14:35	8.3	186	0.24	
15-DAN-0.2	12/29/2008	10:20	3.7	144	0.61	
15-DAN-0.2	1/14/2009	15:50	6.6	107	0.28	
15-DAN-0.2	1/28/2009	11:50	3.9	108	0.26	
15-DAN-0.2	2/11/2009	12:30	4.1	99.3	0.35	
15-DAN-0.2	2/25/2009	11:30	6.7	106	0.37	
15-DAN-0.2	3/11/2009	10:20	3.0	103	0.26	
15-DAN-0.2	3/24/2009	17:40	7.5	112	0.27	
15-DAN-0.2	4/8/2009	17:20	9.0	123	0.24	
15-DAN-0.2	4/29/2009	16:05	10.6	181	0.21	
15-DAN-0.2	5/6/2009	10:50	9.3	149	0.62	
15-DAN-0.2	5/20/2009	15:00	10.6	159	0.31	
15-DAN-0.2	6/9/2009	11:40	13.5	204	0.14	
15-DAN-0.2	6/17/2009	11:40	13.4	205	0.13	
15-DAN-0.2	7/8/2009	11:15	13.4	207	0.08	estimate
15-DAN-0.2	7/22/2009	11:30	14.4	209	0.05	estimate
15-DAN-0.2	8/12/2009	11:30	14.6	216	0.09	estimate
15-DAN-0.2	9/1/2009	16:30	13.8	215	0.05	estimate
15-DOG-0.0	10/29/2008	14:30			5.5	estimate
15-DOG-0.0	8/19/2009	12:50	17.5	1220	4.2	
15-DOG-0.0	10/12/2009	10:25	6.8	257	4.2	
15-DOG-0.6	8/12/2008	11:15	11.6	154	4.8	estimate
15-DOG-0.6	8/26/2008	13:00	11.9	156	6.6	
15-DOG-0.6	9/10/2008	13:30	11.2	154	4.6	
15-DOG-0.6	9/24/2008	13:45	10.4	117	4.8	
15-DOG-0.6	10/8/2008	12:00	9.6	117	5.9	
15-DOG-0.6	10/22/2008	12:25	7.9	166	5.3	
15-DOG-0.6	11/11/2008	14:30	9.6	163	8.7	
15-DOG-0.6	11/24/2008	13:25	6.7	164	5.4	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-DOG-0.6	12/10/2008	12:15	7.9	165	6.0	estimate
15-DOG-0.6	12/29/2008	16:40	4.0	82	26	estimate
15-DOG-0.6	1/14/2009	12:45	7.1	97.6	7.2	
15-DOG-0.6	1/28/2009	14:30	5.5	98.2	5.3	
15-DOG-0.6	2/11/2009	16:30	5.3	93	8.9	
15-DOG-0.6	2/25/2009	14:55	7.3	99.5	8.1	
15-DOG-0.6	3/11/2009	15:05	4.9	94.8	7.4	
15-DOG-0.6	3/24/2009	14:15	7.9	98.0	7.8	
15-DOG-0.6	4/8/2009	15:15	10.1	90.2	21	
15-DOG-0.6	4/29/2009	13:20	10.4	156	5.8	
15-DOG-0.6	5/6/2009	15:45	9.9	135	13	
15-DOG-0.6	5/20/2009	13:45	10.3	141	8.7	
15-DOG-0.6	6/9/2009	15:25	12.8	171	4.0	
15-DOG-0.6	6/17/2009	15:20	12.1	160	4.0	
15-DOG-0.6	7/8/2009	14:37	11.9	163	4.0	
15-DOG-0.6	7/22/2009	15:20	13.1	163	3.9	
15-DOG-0.6	8/12/2009	14:25	12.7	166	3.9	
15-DOG-0.6	9/1/2009	14:55	11.8	165	3.8	
15-DOG-T	10/29/2008	14:35			0.06	estimate
15-DOG-T	10/12/2009	10:20	7.8	188	0.02	estimate
15-DON-0.0	12/29/2008	12:40	6.4	400	2.4	
15-DON-0.0	1/14/2009	13:35	9.4	472	0.29	
15-DON-0.0	1/28/2009	13:05	8.8	430	0.27	
15-DON-0.0	2/11/2009	13:20	8.9	515	0.40	
15-DON-0.0	2/25/2009	13:00	8.5	510	0.35	
15-DON-0.0	3/11/2009	11:20	8.2	1120	0.23	
15-DON-0.0	3/24/2009	12:10	9.7	370	0.30	
15-DON-0.0	4/8/2009	12:30	10.5	553	0.29	
15-DON-0.0	4/29/2009	12:05	13.0	525	0.29	
15-DON-0.0	5/6/2009	13:30	12.9	171	2.0	
15-DON-0.0	5/20/2009	12:15	13.4	440	0.33	
15-DON-0.0	6/9/2009	13:35	17.8	1230	0.24	
15-DON-0.0	6/17/2009	9:45	14.5	1030	0.22	
15-DON-0.0	7/8/2009	13:07	15.5	1500	0.20	estimate
15-DON-0.0	7/22/2009	13:40	17.4	910	0.20	estimate
15-DON-0.0	8/12/2009	13:10	17.1	740	0.19	estimate
15-DON-0.0	8/19/2009	11:50	17.5	975	0.18	
15-DON-0.0	9/1/2009	12:20	15.2	510	0.18	estimate
15-DON-0.0	10/12/2009	10:00	10.7	429	0.17	estimate
15-EFD-0.0	8/12/2008	11:00	13.1	160	0.81	estimate
15-EFD-0.0	8/26/2008	12:25	11.2	154	1.4	estimate
15-EFD-0.0	9/10/2008	13:00	10.3	153	0.70	estimate
15-EFD-0.0	9/24/2008	13:15	10.6	121	0.81	estimate
15-EFD-0.0	10/8/2008	11:35	9.8	121	1.2	
15-EFD-0.0	10/22/2008	12:15	7.2	171	1.2	
15-EFD-0.0	11/11/2008	14:05	9.6	164	2.1	
15-EFD-0.0	11/24/2008	12:40	5.6	171	1.3	
15-EFD-0.0	12/10/2008	11:50	7.4	174	1.4	
15-EFD-0.0	12/29/2008	16:30	3.5	78	10.5	
15-EFD-0.0	1/14/2009	12:15	6.8	93.0	2.1	
15-EFD-0.0	1/28/2009	14:15	4.0	95.5	1.2	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-EFD-0.0	2/11/2009	16:10	4.1	88.4	2.4	
15-EFD-0.0	2/25/2009	14:45	6.8	96.3	1.9	
15-EFD-0.0	3/11/2009	14:55	3.6	90.4	2.6	
15-EFD-0.0	3/24/2009	14:05	7.4	88.4	2.1	
15-EFD-0.0	4/8/2009	14:40	10.3	83.7	17.2	
15-EFD-0.0	4/29/2009	13:10	10.5	155	0.79	
15-EFD-0.0	5/6/2009	15:25	10.0	119	4.6	
15-EFD-0.0	5/20/2009	13:20	10.2	128	1.1	
15-EFD-0.0	6/9/2009	14:45	13.9	165	0.46	
15-EFD-0.0	6/17/2009	14:50	13.5	163	0.46	
15-EFD-0.0	7/8/2009	13:59	13.1	169	0.50	
15-EFD-0.0	7/22/2009	14:45	15.2	171	0.46	
15-EFD-0.0	8/12/2009	14:00	14.8	178	0.50	
15-EFD-0.0	9/1/2009	13:45	13.4	175	0.59	
15-EFD-1.2	8/12/2008	10:45	12.0	140	0.55	estimate
15-EFD-1.2	8/26/2008	11:40	12.0	148	0.88	
15-EFD-1.2	9/10/2008	11:50	10.6	140	0.45	
15-EFD-1.2	9/24/2008	11:30	10.3	106	0.55	
15-EFD-1.2	10/8/2008	10:10	8.5	108	0.85	
15-EFD-1.2	10/22/2008	11:20	6.1	156	0.65	
15-EFD-1.2	11/11/2008	13:25	9.3	157	1.4	
15-EFD-1.2	11/24/2008	12:00	4.5	157	0.81	
15-EFD-1.2	12/10/2008	11:20	7.2	158	0.85	
15-EFD-1.2	12/29/2008	16:20	3.1	71	6.1	
15-EFD-1.2	1/14/2009	11:40	6.6	86.2	1.3	
15-EFD-1.2	1/28/2009	14:00	3.8	87.2	0.76	
15-EFD-1.2	2/11/2009	15:35	5.0	86	1.4	
15-EFD-1.2	2/25/2009	14:35	7.1	88.5	1.1	
15-EFD-1.2	3/11/2009	14:30	4.8	83.5	1.6	
15-EFD-1.2	3/24/2009	13:50	7.3	82.2	1.3	
15-EFD-1.2	4/8/2009	14:25	10.5	87.3	9.9	
15-EFD-1.2	4/29/2009	12:55	10.9	145	0.52	
15-EFD-1.2	5/6/2009	15:00	10.4	113	2.6	
15-EFD-1.2	5/20/2009	13:30	12.2	122	0.71	
15-EFD-1.2	6/9/2009	15:05	15.1	142	0.33	
15-EFD-1.2	6/17/2009	15:00	14.0	145	0.33	
15-EFD-1.2	7/8/2009	14:17	13.0	146	0.36	
15-EFD-1.2	7/22/2009	15:00	14.6	147	0.33	
15-EFD-1.2	8/12/2009	14:10	14.1	155	0.36	
15-EFD-1.2	9/1/2009	14:25	12.9	151	0.41	
15-JEA-0.0	10/29/2008	13:50			0.02	estimate
15-JEA-0.0	11/11/2008	11:15			0.03	estimate
15-JEA-0.0	11/24/2008	10:10	10.1	840	0.01	
15-JEA-0.0	12/10/2008	10:20	10.5	480	0.02	estimate
15-JEA-0.0	12/29/2008	11:40	6.0	153	0.25	estimate
15-JEA-0.0	1/14/2009	13:50	9.2	541	0.05	
15-JEA-0.0	1/28/2009	12:50	8.4	2170	0.05	
15-JEA-0.0	2/11/2009	14:00	7.5	250	0.13	estimate
15-JEA-0.0	2/25/2009	12:30	7.9	144	0.10	estimate
15-JEA-0.0	3/11/2009	11:00	7.1	420	0.02	
15-JEA-0.0	3/24/2009	12:05	9.0	380	0.10	estimate

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-JEA-0.0	4/8/2009	12:15	9.8	570	0.02	
15-JEA-0.0	4/29/2009	12:25	10.6	1000	0.02	
15-JEA-0.0	5/6/2009	12:50	12.5	110	0.45	
15-JEA-0.0	5/20/2009	12:05	11.6	398	0.08	estimate
15-JEA-0.0	6/9/2009	13:20	13.7	925	0.01	
15-JEA-0.0	6/17/2009	9:30	13.7	700	0.01	estimate
15-JEA-0.0	7/8/2009	12:48	14.3	655	0.01	
15-JEA-0.0	7/22/2009	13:25	16.4	1100	0.01	estimate
15-JEA-0.0	8/12/2009	13:00	16.2	465	0.01	estimate
15-JEA-0.0	8/19/2009	12:25	16.2	720	0.01	
15-JEA-0.0	9/1/2009	12:10	15.7	920	0.01	estimate
15-JEA-0.0	10/12/2009	10:15	11.1	1500	0.01	
15-JOH-0.0	10/29/2008	13:15			1.5	estimate
15-JOH-0.0	8/19/2009	15:45	13.1	161	1.1	
15-JOH-0.0	10/12/2009	9:05	7.3	254	1.1	
15-JOH-0.1	8/12/2008	11:30	11.5	136	1.6	estimate
15-JOH-0.1	8/26/2008	13:35	12.4	123	2.0	
15-JOH-0.1	9/10/2008	14:35	11.2	136	0.93	
15-JOH-0.1	9/24/2008	15:10	10.5	102	1.6	
15-JOH-0.1	10/8/2008	12:45	9.9	99.3	1.6	
15-JOH-0.1	10/22/2008	12:45	8.6	142	1.6	estimate
15-JOH-0.1	11/11/2008	15:20	9.9	120	3.3	
15-JOH-0.1	11/24/2008	13:50	7.2	137	1.6	
15-JOH-0.1	12/10/2008	13:00	8.3	141	1.5	
15-JOH-0.1	12/29/2008	11:00	4.2	134	7.8	
15-JOH-0.1	1/14/2009	17:10	7.0	91.6	3.6	
15-JOH-0.1	1/28/2009	11:15	4.9	87.0	1.5	
15-JOH-0.1	2/11/2009	17:10	5.1	94.7	2.9	
15-JOH-0.1	2/25/2009	15:10	6.9	92.1	2.6	
15-JOH-0.1	3/11/2009	13:05	4.5	82.6	2.4	
15-JOH-0.1	3/24/2009	14:45	7.8	83.6	2.5	
15-JOH-0.1	4/8/2009	16:20	8.8	89.5	2.4	
15-JOH-0.1	4/29/2009	14:25	10.1	131	1.8	
15-JOH-0.1	5/6/2009	16:20	10.1	106	4.4	
15-JOH-0.1	5/20/2009	14:10	10.6	150	2.8	
15-JOH-0.1	6/9/2009	15:35	12.3	146	1.1	
15-JOH-0.1	6/17/2009	12:55	11.8	147	1.2	
15-JOH-0.1	7/8/2009	14:50	11.7	146	1.1	
15-JOH-0.1	7/22/2009	15:40	12.7	150	1.1	
15-JOH-0.1	8/12/2009	12:15	12.3	151	1.1	
15-JOH-0.1	9/1/2009	15:20	11.7	151	1.0	
15-JOH-T	12/10/2008	12:40			0.30	
15-JOH-T	12/29/2008	11:05			0.50	estimate
15-JOH-T	3/24/2009	14:50	7.5	65.6	0.83	
15-JOH-T	4/29/2009	14:30	9.9	141	0.50	
15-JOH-T	5/6/2009	16:25	9.5	108	1.0	
15-JOH-T	6/17/2009	12:55			0.24	
15-KE1-0.2	1/14/2009	15:35			0.17	estimate
15-KE1-0.2	2/25/2009	15:50	7.5	131	0.15	estimate
15-KE1-0.2	3/24/2009	18:00			0.15	estimate
15-KE1-0.2	5/20/2009	15:20			0.20	estimate

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-KE1-0.2	6/9/2009	10:50	14.5	226	0.04	estimate
15-KE1-0.2	6/17/2009	11:30	15.1	229	0.03	estimate
15-KE1-0.2	7/8/2009	10:37	14.0	160	0.02	estimate
15-KE1-0.2	7/22/2009	10:30	15.2	152	0.01	estimate
15-KE1-0.2	8/12/2009	11:00	15.9	240	0.01	estimate
15-KE1-0.2	9/1/2009	9:50	14.7	244	0.01	estimate
15-KE1-0.2	10/12/2009	11:35	8.9	226	0.01	estimate
15-KE2-0.3	1/14/2009	15:40			0.45	estimate
15-KE2-0.3	2/25/2009	15:45	7.2	116	0.75	estimate
15-KE2-0.3	3/24/2009	18:05			0.45	estimate
15-KE2-0.3	5/20/2009	15:25			0.60	estimate
15-KE2-0.3	6/9/2009	11:10	12.0	155	0.31	
15-KE2-0.3	6/17/2009	11:35	12.3	185	0.25	estimate
15-KE2-0.3	7/8/2009	10:43	11.9	186	0.25	estimate
15-KE2-0.3	7/22/2009	10:35	12.8	188	0.25	estimate
15-KE2-0.3	8/12/2009	11:10	13.1	190	0.25	estimate
15-KE2-0.3	9/1/2009	9:45	12.5	173	0.25	estimate
15-KE2-0.3	10/12/2009	11:45	8.0	192	0.31	
15-LEM-0.0	10/29/2008	12:10			0.09	estimate
15-LEM-0.0	10/12/2009	8:35	7.2	730	0.05	estimate
15-LEM-0.1	8/12/2008	9:20	11.8	405	0.04	estimate
15-LEM-0.1	8/26/2008	10:25	12.9	205	0.16	
15-LEM-0.1	9/10/2008	10:30	11.3	364	0.04	
15-LEM-0.1	9/24/2008	10:15	11.1	207	0.03	
15-LEM-0.1	10/8/2008	9:15	9.6	182	0.09	
15-LEM-0.1	10/22/2008	10:30	7.5	256	0.10	
15-LEM-0.1	11/11/2008	12:15	9.6	203	0.55	
15-LEM-0.1	11/24/2008	10:55	5.7	232	0.15	
15-LEM-0.1	12/10/2008	10:50	7.7	235	0.15	estimate
15-LEM-0.1	12/29/2008	15:50	3.3	86	1.5	
15-LEM-0.1	1/14/2009	10:50	6.6	106	0.56	
15-LEM-0.1	1/28/2009	13:35	3.8	118	0.45	estimate
15-LEM-0.1	2/11/2009	14:50	3.8	106	0.54	
15-LEM-0.1	2/25/2009	13:30	6.6	113	0.54	
15-LEM-0.1	3/11/2009	13:30	4.0	123	0.18	
15-LEM-0.1	3/24/2009	13:15	7.2	115	0.43	
15-LEM-0.1	4/8/2009	13:20	8.9	125	0.39	
15-LEM-0.1	4/29/2009	11:25	9.3	202	0.23	
15-LEM-0.1	5/6/2009	14:10	10.1	155	1.1	
15-LEM-0.1	5/20/2009	12:40	10.6	171	0.47	
15-LEM-0.1	6/9/2009	14:20	14.0	271	0.08	
15-LEM-0.1	6/17/2009	14:20	13.9	261	0.05	
15-LEM-0.1	7/8/2009	13:24	12.7	269	0.06	estimate
15-LEM-0.1	7/22/2009	14:05	14.3	451	0.07	
15-LEM-0.1	8/12/2009	13:20	15.8	218	0.06	
15-LEM-0.1	8/19/2009	17:30	14.8	458	0.05	estimate
15-LEM-0.1	9/1/2009	13:00	12.5	477	0.05	
15-LMK-0.0	4/8/2009	17:05	9.8	100	0.05	estimate
15-LMK-0.0	4/29/2009	15:40			0.01	estimate
15-LMK-0.0	5/6/2009	11:00	9.7	147	0.01	estimate
15-LMK-0.0	5/20/2009	14:50	11.2	153	0.01	estimate

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-LMK-0.0	6/9/2009	11:45	13.3	147	0.01	estimate
15-LSC-0.0	10/29/2008	12:50			0.06	
15-LSC-0.0	10/12/2009	8:10	5.7	6500	0.02	estimate
15-LSC-0.1	8/12/2008	12:25	14.5	188	0.05	estimate
15-LSC-0.1	8/26/2008	14:40	14.1	178	0.05	estimate
15-LSC-0.1	9/10/2008	16:10	13.8	187	0.04	estimate
15-LSC-0.1	9/24/2008	16:30	12.0	147	0.05	estimate
15-LSC-0.1	10/8/2008	13:45	10.5	139	0.08	
15-LSC-0.1	10/22/2008	14:05	8.1	195	0.07	
15-LSC-0.1	11/11/2008	16:05	10.1	170	0.26	
15-LSC-0.1	11/24/2008	14:40	6.2	204	0.04	estimate
15-LSC-0.1	12/10/2008	13:30	7.6	190	0.03	estimate
15-LSC-0.1	12/29/2008	15:20	3.6	83	2.2	
15-LSC-0.1	1/14/2009	16:15	6.6	92.2	0.43	
15-LSC-0.1	1/28/2009	12:15	3.1	94.8	0.20	
15-LSC-0.1	2/11/2009	11:10	3.2	92.5	0.27	
15-LSC-0.1	2/25/2009	15:25	7.2	89.3	0.61	
15-LSC-0.1	3/11/2009	12:10	3.7	90.1	0.26	
15-LSC-0.1	3/24/2009	16:00	9.1	99.9	0.50	
15-LSC-0.1	4/8/2009	16:40	11.1	112	0.15	estimate
15-LSC-0.1	4/29/2009	15:05	12.5	163	0.15	
15-LSC-0.1	5/6/2009	16:55	10.8	111	1.5	
15-LSC-0.1	5/20/2009	14:30	12.1	139	0.26	
15-LSC-0.1	6/9/2009	16:05	16.0	189	0.09	estimate
15-LSC-0.1	6/17/2009	12:10	14.5	191	0.05	estimate
15-LSC-0.1	7/8/2009	15:12	14.1	195	0.04	estimate
15-LSC-0.1	7/22/2009	16:05	16.6	199	0.03	estimate
15-LSC-0.1	8/12/2009	11:55	15.4	208	0.04	estimate
15-LSC-0.1	8/19/2009	17:55			0.03	
15-LSC-0.1	9/1/2009	15:50	14.5	206	0.04	estimate
15-LSC-0.4	8/12/2008	12:30	13.7	195	0.05	estimate
15-LSC-0.4	8/26/2008	15:00	13.6	185	0.04	
15-LSC-0.4	9/10/2008	16:15	13.4	194	0.04	
15-LSC-0.4	9/24/2008	16:40	12.0	151	0.05	
15-LSC-0.4	10/8/2008	14:05	10.7	142	0.07	
15-LSC-0.4	10/22/2008	14:15	8.9	170	0.06	estimate
15-LSC-0.4	11/11/2008	16:15	10.0	167	0.42	
15-LSC-0.4	11/24/2008	14:45	7.2	198	0.04	estimate
15-LSC-0.4	12/10/2008	13:35	8.1	190	0.03	estimate
15-LSC-0.4	12/29/2008	15:15	3.5	85	2.4	
15-LSC-0.4	1/14/2009	16:10	6.5	91.7	0.53	
15-LSC-0.4	1/28/2009	12:10	3.8	96.8	0.30	
15-LSC-0.4	2/11/2009	11:20	3.7	93.5	0.43	
15-LSC-0.4	2/25/2009	15:30	6.7	88.5	0.71	
15-LSC-0.4	3/11/2009	12:05	3.9	91.2	0.40	
15-LSC-0.4	3/24/2009	16:15	8.2	97.4	0.56	
15-LSC-0.4	4/8/2009	16:50	9.8	108	0.20	estimate
15-LSC-0.4	4/29/2009	15:15	11.1	164	0.20	
15-LSC-0.4	5/6/2009	17:00	10.4	111	1.7	
15-LSC-0.4	5/20/2009	14:35	10.7	141	0.42	
15-LSC-0.4	6/9/2009	16:15	14.5	198	0.09	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-LSC-0.4	6/17/2009	11:55	13.2	143	0.05	
15-LSC-0.4	7/8/2009	15:18	13.4	206	0.04	estimate
15-LSC-0.4	7/22/2009	16:15	15.6	209	0.03	estimate
15-LSC-0.4	8/12/2009	11:48	13.6	214	0.04	estimate
15-LSC-0.4	9/1/2009	16:00	13.9	214	0.04	
15-NEL-0.0	4/8/2009	12:05			0.06	estimate
15-NEL-0.0	4/29/2009	13:40	11.6	147	0.01	estimate
15-NEL-0.0	5/6/2009	12:35	12.5	70.3	0.04	
15-NEL-0.0	5/20/2009	11:55	11.8	180	0.03	estimate
15-NEL-0.0	6/9/2009	13:05	14.4	222	0.01	estimate
15-NEL-0.0	6/17/2009	9:15	14.3	215	0.01	estimate
15-NEL-0.0	7/8/2009	12:34	14.4	212	0.02	estimate
15-NEL-0.0	7/22/2009	13:10	15.8	170	0.03	estimate
15-NEL-0.0	8/12/2009	12:45	15.5	221	0.01	estimate
15-NEL-0.0	8/19/2009	12:55	16.5	240	0.01	estimate
15-NEL-0.0	9/1/2009	11:55	15.6	222	0.03	estimate
15-NEL-0.0	10/12/2009	10:40	10.8	225	0.02	estimate
15-PER-0.0	10/29/2008	13:05			0.07	
15-PER-0.0	10/12/2009	8:00	5.8	3750	0.04	estimate
15-PER-0.1	8/12/2008	13:15	14.2	177	0.03	estimate
15-PER-0.1	8/26/2008	15:25	13.7	162	0.10	
15-PER-0.1	9/10/2008	17:15	13.5	172	0.03	
15-PER-0.1	9/24/2008	16:50	11.9	134	0.03	
15-PER-0.1	10/8/2008	14:15	10.6	127	0.07	
15-PER-0.1	10/22/2008	14:40	8.6	173	0.08	
15-PER-0.1	11/11/2008	16:30	10.1	153	0.22	
15-PER-0.1	11/24/2008	16:15	6.7	167	0.09	estimate
15-PER-0.1	12/10/2008	14:55	8.0	169	0.09	
15-PER-0.1	12/29/2008	10:40	3.6	77	1.1	
15-PER-0.1	1/14/2009	14:25	6.8	94.4	0.15	
15-PER-0.1	1/28/2009	12:05	3.5	93.4	0.09	estimate
15-PER-0.1	2/11/2009	11:45	3.6	86.5	0.18	
15-PER-0.1	2/25/2009	11:50	6.4	88.5	0.48	
15-PER-0.1	3/11/2009	10:30	2.6	89.5	0.09	
15-PER-0.1	3/24/2009	16:30	8.0	95.4	0.18	
15-PER-0.1	4/8/2009	11:25	8.4	107	0.14	
15-PER-0.1	4/29/2009	15:30	11.1	161	0.10	
15-PER-0.1	5/6/2009	11:10	9.5	129	0.45	
15-PER-0.1	5/20/2009	14:40	11.1	142	0.14	
15-PER-0.1	6/9/2009	11:55	13.0	178	0.04	
15-PER-0.1	6/17/2009	11:45	13.5	180	0.04	
15-PER-0.1	7/8/2009	11:33	13.0	183	0.04	
15-PER-0.1	7/22/2009	11:40	14.2	185	0.03	estimate
15-PER-0.1	8/12/2009	11:40	14.7	191	0.04	
15-PER-0.1	8/19/2009	18:05			0.03	
15-PER-0.1	9/1/2009	10:40	13.7	186	0.04	
15-PET-0.0	10/22/2008	9:40	6.2	8460	0.01	
15-PET-0.0	12/10/2008	9:55	7.6	4900	0.05	
15-PET-0.0	12/29/2008	15:00	2.8	68	0.26	
15-PET-0.0	1/14/2009	14:15	6.7	1110	0.06	
15-PET-0.0	1/28/2009	11:55	3.9	1290	0.06	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-PET-0.0	2/11/2009	11:35	4.0	860	0.09	
15-PET-0.0	2/25/2009	11:45	7.0	1490	0.10	
15-PET-0.0	3/11/2009	10:25	2.0	1220	0.05	
15-PET-0.0	3/24/2009	11:40	7.5	950	0.08	
15-PET-0.0	4/8/2009	11:10	9.5	1500	0.04	
15-PET-0.0	4/29/2009	15:20	13.0	1860	0.04	
15-PET-0.0	5/6/2009	11:05	10.7	1300	0.17	
15-PET-0.0	5/20/2009	11:25	13.1	1420	0.07	
15-RET-0.0	4/8/2009	11:50	9.4	161	0.06	
15-RET-0.0	4/29/2009	14:05	13.2	170	0.02	estimate
15-RET-0.0	5/6/2009	11:20	11.3	124	0.14	
15-RET-0.0	5/20/2009	11:45	12.1	182	0.07	estimate
15-RET-0.0	6/9/2009	12:10	16.4	210	0.01	estimate
15-RET-0.0	6/17/2009	10:10	16.1	200	0.01	estimate
15-RET-0.0	7/8/2009	11:47	15.6	195	0.01	estimate
15-RET-0.0	7/22/2009	12:00	17.7	205	0.01	estimate
15-RET-0.0	8/12/2009	12:25	17.7	208	0.01	estimate
15-RET-0.0	8/19/2009	13:25	18.4	213	0.01	estimate
15-RET-0.0	9/1/2009	11:00	15.0	208	0.01	estimate
15-RET-0.0	10/12/2009	10:50	8.1	201	0.01	estimate
15-SAM-0.1	11/11/2008	12:00	9.3	83	1.2	
15-SAM-0.1	11/24/2008	10:45	5.4	77.0	0.14	
15-SAM-0.1	12/10/2008	10:40	7.3	70.6	0.06	estimate
15-SAM-0.1	12/29/2008	15:40	1.5	30.6	0.02	estimate
15-SAM-0.1	1/14/2009	10:35	5.5	30.5	1.5	
15-SAM-0.1	1/28/2009	13:25	2.5	30.0	0.22	
15-SAM-0.1	2/11/2009	14:30	2.5	21.5	0.98	
15-SAM-0.1	2/25/2009	13:25	5.8	28.6	0.77	
15-SAM-0.1	3/11/2009	13:20	1.9	25.7	0.24	
15-SAM-0.1	3/24/2009	13:25	5.8	26.1	1.1	
15-SAM-0.1	4/8/2009	13:05	7.9	28.5	0.62	
15-SAM-0.1	4/29/2009	11:40	8.4	45.4	0.08	
15-SAM-0.1	5/6/2009	14:25	9.7	38.5	2.6	
15-SAM-0.1	5/20/2009	12:30	10.0	41.4	0.77	
15-SFD-0.0	8/12/2008	11:20	15.1	230	0.29	estimate
15-SFD-0.0	8/26/2008	13:20	14.9	164	0.77	
15-SFD-0.0	9/10/2008	13:45	13.5	229	0.22	
15-SFD-0.0	9/24/2008	14:35	12.3	164	0.29	
15-SFD-0.0	10/8/2008	12:25	11.2	156	0.40	
15-SFD-0.0	10/22/2008	12:35	8.5	223	0.43	
15-SFD-0.0	11/11/2008	14:45	10.5	174	2.0	
15-SFD-0.0	11/24/2008	13:35	6.4	240	0.27	
15-SFD-0.0	12/10/2008	12:20	8.1	218	0.60	
15-SFD-0.0	12/29/2008	16:45	4.5	120	8.3	
15-SFD-0.0	1/14/2009	13:00	7.3	152	1.0	
15-SFD-0.0	1/28/2009	14:40	4.5	150	0.43	
15-SFD-0.0	2/11/2009	16:45	5.5	127	0.78	
15-SFD-0.0	2/25/2009	15:00	7.4	119	0.99	
15-SFD-0.0	3/11/2009	15:20	4.0	141	0.43	
15-SFD-0.0	3/24/2009	14:25	8.0	137	0.60	
15-SFD-0.0	4/8/2009	15:40	9.8	156	0.51	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-SFD-0.0	4/29/2009	13:25	11.7	194	0.88	
15-SFD-0.0	5/6/2009	16:00	12.0	113	6.1	
15-SFD-0.0	5/20/2009	13:50	12.3	170	1.4	
15-SFD-0.0	6/9/2009	15:30	15.2	236	0.27	
15-SFD-0.0	6/17/2009	15:25	15.0	237	0.43	
15-SFD-0.0	7/8/2009	14:41	14.0	205	0.27	
15-SFD-0.0	7/22/2009	15:25	16.6	234	0.27	
15-SFD-0.0	8/12/2009	14:30	16.0	225	0.20	
15-SFD-0.0	9/1/2009	15:00	14.6	229	0.27	
15-SFD-1.3	8/12/2008	10:35	12.5	194	0.22	estimate
15-SFD-1.3	8/26/2008	11:10	12.6	175	0.32	
15-SFD-1.3	9/10/2008	11:35	11.9	195	0.26	
15-SFD-1.3	9/24/2008	11:00	11.3	147	0.22	
15-SFD-1.3	10/8/2008	9:50	10.1	139	0.28	
15-SFD-1.3	10/22/2008	11:00	9.1	199	0.27	
15-SFD-1.3	11/11/2008	13:00	10.3	143	0.54	
15-SFD-1.3	11/24/2008	11:40	8.3	197	0.25	
15-SFD-1.3	12/10/2008	11:10	9.4	196	0.30	
15-SFD-1.3	12/29/2008	16:10	4.9	76	1.7	
15-SFD-1.3	1/14/2009	11:20	8.2	123	0.39	
15-SFD-1.3	1/28/2009	13:50	7.4	132	0.27	
15-SFD-1.3	2/11/2009	15:25	6.7	107	0.34	
15-SFD-1.3	2/25/2009	14:20	8.1	161	0.37	
15-SFD-1.3	3/11/2009	14:10	7.2	128	0.27	
15-SFD-1.3	3/24/2009	13:40	9.1	125	0.30	
15-SFD-1.3	4/8/2009	14:10	10.2	136	0.29	
15-SFD-1.3	4/29/2009	12:45	11.5	189	0.31	
15-SFD-1.3	5/6/2009	14:45	11.2	103	1.3	
15-SFD-1.3	5/20/2009	13:15	11.8	173	0.45	
15-SFD-1.3	6/9/2009	14:40	14.3	202	0.25	
15-SFD-1.3	6/17/2009	14:40	13.2	197	0.27	
15-SFD-1.3	7/8/2009	13:49	12.6	199	0.22	
15-SFD-1.3	7/22/2009	14:35	14.1	202	0.25	
15-SFD-1.3	8/12/2009	13:50	13.4	203	0.23	
15-SFD-1.3	9/1/2009	13:20	12.6	205	0.25	
15-STORM-1	11/11/2008	11:20			0.05	estimate
15-STORM-1	12/29/2008	11:45		66	0.04	estimate
15-STORM-1	2/25/2009	12:40	7.5	45	0.01	estimate
15-STORM-1	5/6/2009	13:00	13.9	121	0.15	
15-STORM-2	12/29/2008	11:55		47	0.08	estimate
15-STORM-2	2/11/2009	14:05	6.1	89.7	0.01	estimate
15-STORM-2	2/25/2009	12:35	7.4	59.0	0.04	estimate
15-STORM-2	5/6/2009	12:45	13.1	50.3	0.25	
15-UN1-0.0	10/29/2008	11:30			0.12	estimate
15-UN1-0.0	10/12/2009	7:40			0.11	estimate
15-UN3-0.0	10/29/2008	11:55			0.01	estimate
15-UN3-0.0	11/24/2008	15:35	7.6	163	0.01	estimate
15-UNN-0.0	10/22/2008	9:20	7.4	179	0.06	
15-UNN-0.0	10/29/2008	11:40			0.05	estimate
15-UNN-0.0	11/11/2008	11:00	9.6	332	0.16	
15-UNN-0.0	11/24/2008	9:45	5.6	360	0.06	

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-UNN-0.0	12/10/2008	9:40	7.4	402	0.06	
15-UNN-0.0	12/29/2008	13:10	3.7	164	0.75	
15-UNN-0.0	1/14/2009	15:15	6.7	188	0.11	
15-UNN-0.0	1/28/2009	11:40	3.5	425	0.05	
15-UNN-0.0	2/11/2009	12:05	3.9	260	0.14	
15-UNN-0.0	2/25/2009	11:14	6.3	178	0.07	
15-UNN-0.0	3/11/2009	9:55	2.3	271	0.09	
15-UNN-0.0	3/24/2009	11:24	6.5	192	0.17	
15-UNN-0.0	4/8/2009	10:55	7.8	258	0.11	
15-UNN-0.0	4/29/2009	15:55	10.9	300	0.11	
15-UNN-0.0	5/6/2009	10:40	9.3	223	0.49	
15-UNN-0.0	5/20/2009	11:20	10.2	227	0.16	
15-UNN-0.0	6/9/2009	11:25	13.7	700	0.04	
15-UNN-0.0	6/17/2009	11:00			0.04	
15-UNN-0.0	7/8/2009	11:03	11.6	795	0.02	
15-UNN-0.0	7/22/2009	11:15	15.5	2620	0.03	
15-UNN-0.0	8/12/2009	11:18	15.0	455	0.01	
15-UNN-0.0	8/19/2009	14:40	18.5	1920	0.01	estimate
15-UNN-0.0	9/1/2009	10:10	14.1	900	0.01	estimate
15-UNN-0.1	8/12/2008	13:55	12.0	176	0.12	estimate
15-UNN-0.1	8/26/2008	17:10	11.6	174	0.12	
15-UNN-0.1	10/8/2008	15:50			0.12	estimate
15-UNN-0.1	10/22/2008	16:15	9.3	180	0.12	
15-UNN-0.1	11/11/2008	17:10	9.7	177	0.17	
15-UNN-0.1	11/24/2008	15:45	7.8	180	0.15	
15-UNN-0.1	12/10/2008	14:15	8.8	181	0.13	
15-UNN-0.1	12/29/2008	14:50	5.4	84	0.15	
15-UNN-0.1	1/14/2009	15:25	7.5	117	0.16	
15-UNN-0.1	1/28/2009	11:35	5.9	115	0.14	
15-UNN-0.1	2/11/2009	12:20	5.9	114	0.11	
15-UNN-0.1	2/25/2009	15:40	7.4	118	0.13	
15-UNN-0.1	3/11/2009	10:10	4.7	110	0.14	
15-UNN-0.1	3/24/2009	17:50	8.3	121	0.14	
15-UNN-0.1	4/8/2009	17:35	9.1	125	0.13	
15-UNN-0.1	4/29/2009	15:45	10.1	180	0.15	
15-UNN-0.1	5/6/2009	10:30	9.2	167	0.13	
15-UNN-0.1	5/20/2009	15:15	10.1	173	0.13	
15-UNN-0.1	6/9/2009	11:15	11.4	180	0.12	
15-UNN-0.1	6/17/2009	11:15	11.2	182	0.13	
15-UNN-0.1	7/8/2009	10:49	11.1	183	0.13	
15-UNN-0.1	7/22/2009	10:40	11.6	183	0.13	estimate
15-UNN-0.1	8/12/2009	11:15	11.8	168	0.12	estimate
15-UNN-0.1	8/19/2009	18:00			0.12	
15-UNN-0.1	9/1/2009	10:00	11.2	186	0.12	estimate
15-UNN-0.1	10/12/2009	11:25			0.12	estimate
15-WFD-0.0	8/12/2008	11:05	10.7	152	3.5	estimate
15-WFD-0.0	8/26/2008	12:40	12.6	160	5.2	
15-WFD-0.0	9/10/2008	12:40	12.1	160	3.8	
15-WFD-0.0	9/24/2008	13:10	10.2	116	3.5	
15-WFD-0.0	10/8/2008	11:45	9.2	114	4.6	
15-WFD-0.0	10/22/2008	12:20	7.9	163	4.0	estimate

Site	Date	Time	Temperature (deg C)	Conductivity (umhos/cm)*	Flow (cfs)	Flow comments
15-WFD-0.0	11/11/2008	13:55	9.5	158	6.6	
15-WFD-0.0	11/24/2008	13:00	6.9	160	4.2	
15-WFD-0.0	12/10/2008	11:55	8.0	160	4.5	
15-WFD-0.0	12/29/2008	16:35	4.1	79	15.3	
15-WFD-0.0	1/14/2009	12:25	7.2	95.9	4.9	
15-WFD-0.0	1/28/2009	14:20	6.1	98.1	4.1	
15-WFD-0.0	2/11/2009	16:15	5.9	94	6.4	
15-WFD-0.0	2/25/2009	14:50	7.3	98.3	6.0	
15-WFD-0.0	3/11/2009	15:00	9.8	95.8	5.5	
15-WFD-0.0	3/24/2009	14:10	7.9	101	5.8	
15-WFD-0.0	4/8/2009	14:45	8.9	105	5.0	
15-WFD-0.0	4/29/2009	13:15	10.1	155	4.4	
15-WFD-0.0	5/6/2009	15:30	9.7	144	8.3	estimate
15-WFD-0.0	5/20/2009	13:25	10.2	147	6.6	
15-WFD-0.0	6/9/2009	14:50	11.9	160	3.2	
15-WFD-0.0	6/17/2009	14:55	11.4	160	3.2	
15-WFD-0.0	7/8/2009	14:00	11.2	161	3.2	
15-WFD-0.0	7/22/2009	14:50	12.1	161	3.1	
15-WFD-0.0	8/12/2009	14:05	11.8	162	3.1	
15-WFD-0.0	9/1/2009	14:00	11.1	163	3.1	
15-WFD-0.9	8/12/2008	10:55	10.7	152	3.5	estimate
15-WFD-0.9	8/26/2008	12:10	11.2	155	4.7	
15-WFD-0.9	9/10/2008	12:15	10.5	153	3.3	
15-WFD-0.9	9/24/2008	11:50	10.1	107	3.5	
15-WFD-0.9	10/8/2008	10:35	9.3	113	4.6	
15-WFD-0.9	10/22/2008	11:40	8.4	160	3.7	
15-WFD-0.9	11/11/2008	13:35	9.4	160	3.3	
15-WFD-0.9	11/24/2008	12:25	7.2	155	2.7	
15-WFD-0.9	12/10/2008	11:35	8.2	159	2.5	
15-WFD-0.9	12/29/2008	16:25	4.2	82	12.8	
15-WFD-0.9	1/14/2009	11:55	7.3	96.7	4.0	
15-WFD-0.9	1/28/2009	14:10	6.4	98.6	2.8	
15-WFD-0.9	2/11/2009	15:45	6.2	94.6	5.2	
15-WFD-0.9	2/25/2009	14:40	7.5	98.8	4.9	
15-WFD-0.9	3/11/2009	14:45	6.1	96.3	4.5	
15-WFD-0.9	3/24/2009	14:00	8.2	101	4.7	
15-WFD-0.9	4/8/2009	14:30	8.9	104	4.1	
15-WFD-0.9	4/29/2009	13:05	10.2	155	3.6	
15-WFD-0.9	5/6/2009	15:15	9.7	146	7.5	
15-WFD-0.9	5/20/2009	13:40	10.4	148	5.2	
15-WFD-0.9	6/9/2009	15:15	11.6	158	2.6	
15-WFD-0.9	6/17/2009	15:10	10.8	160	2.6	
15-WFD-0.9	7/8/2009	14:26	10.8	160	2.6	
15-WFD-0.9	7/22/2009	15:10	11.6	160	2.6	
15-WFD-0.9	8/12/2009	14:15	11.4	162	2.6	
15-WFD-0.9	9/1/2009	14:30	10.8	163	2.6	

*All conductivity values are estimates.

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Appendix J: Seasonal charts of fecal coliform concentration, flow and loading

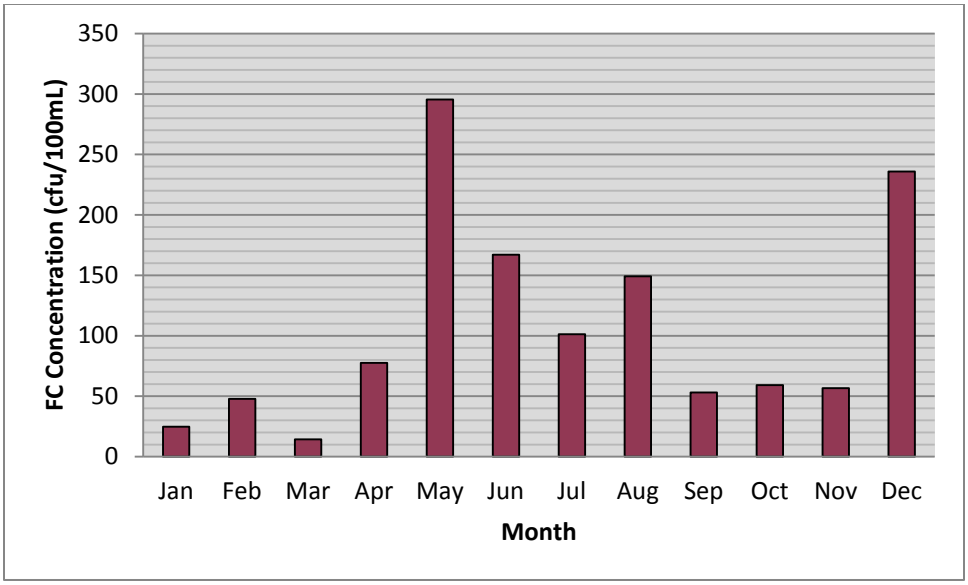

Figure J-1. Dogfish Creek at mouth (15-DOG-0.6 + 15-SFD-0.0) monthly FC concentrations.

Bars represent two-sample arithmetic means.

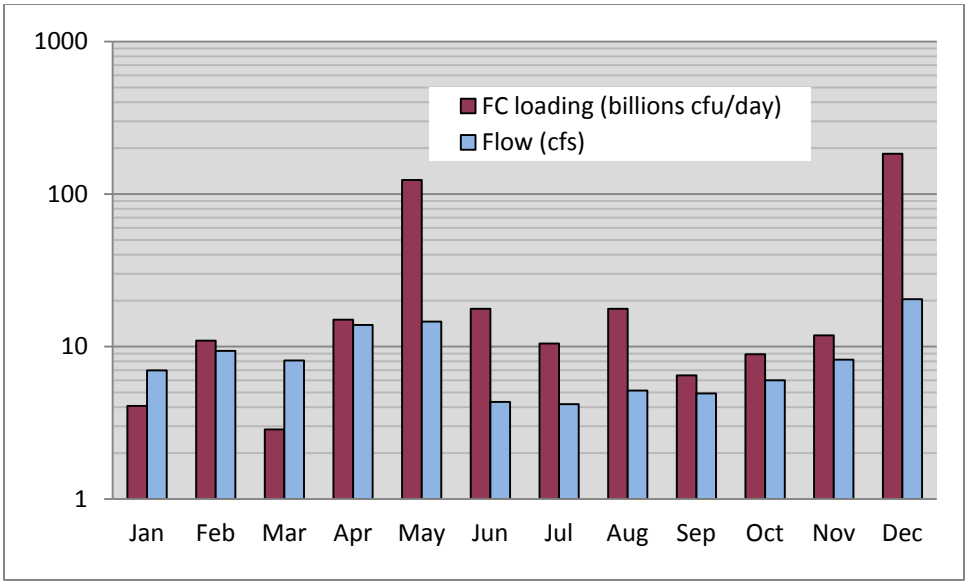

Figure J-2. Dogfish Creek at mouth (15-DOG-0.6 + 15-SFD-0.0) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

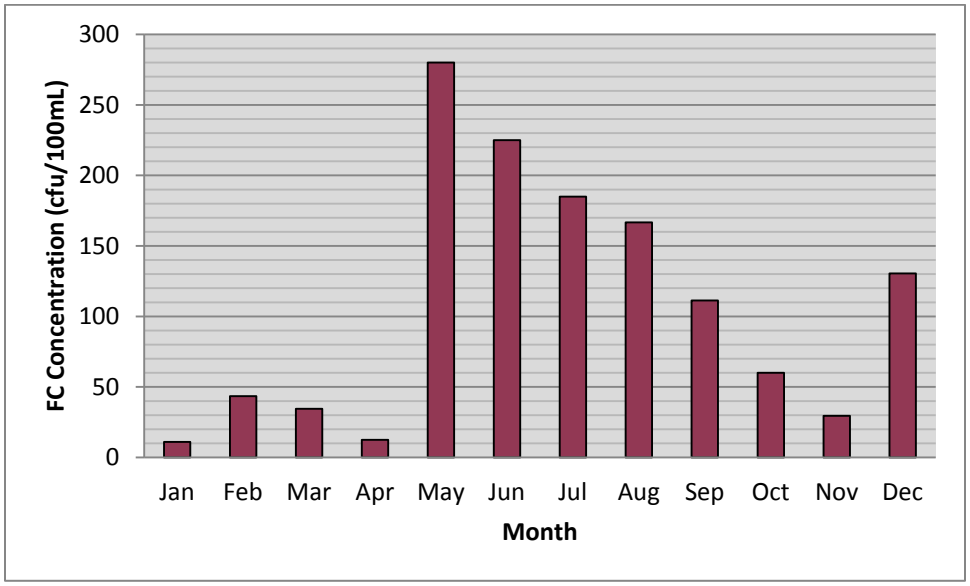

Figure J-3. Big Scandia Creek at mouth (15-BSC-0.0) monthly FC concentrations.
Bars represent two-sample arithmetic means.

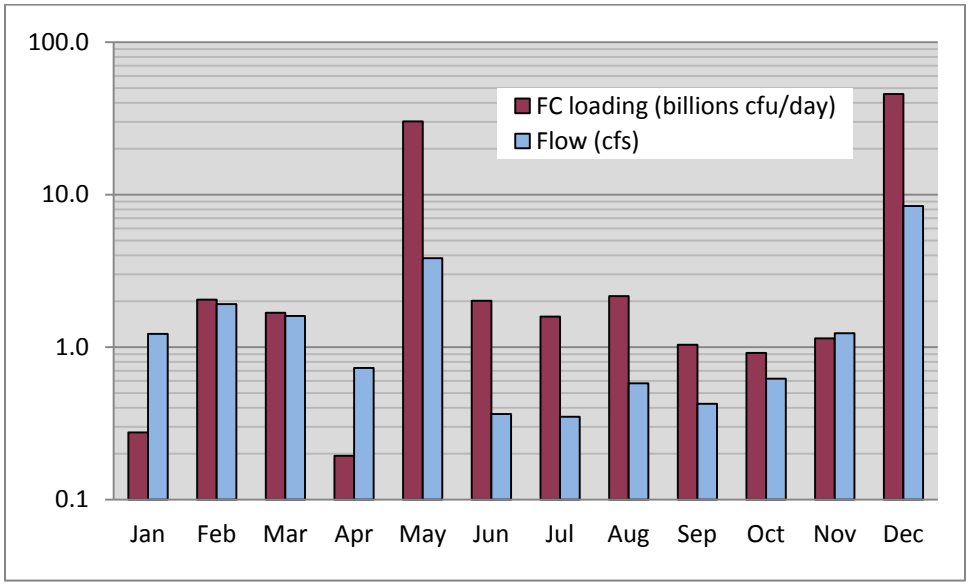

Figure J-4. Big Scandia Creek at mouth (15-BSC-0.0) monthly FC loading and flow.
Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

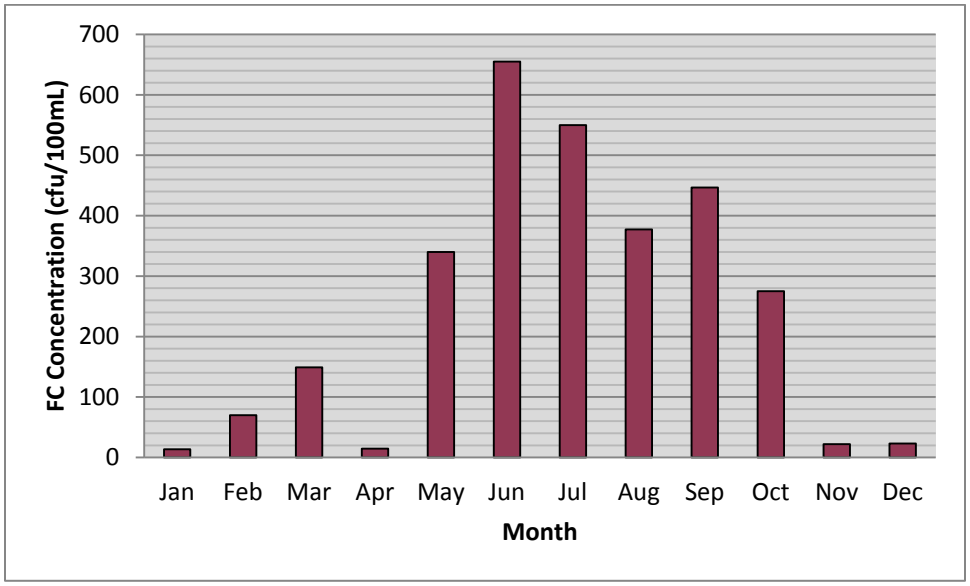

Figure J-5. Daniels Creek at mouth (15-DAN-0.0) monthly FC concentrations.
Bars represent two-sample arithmetic means.

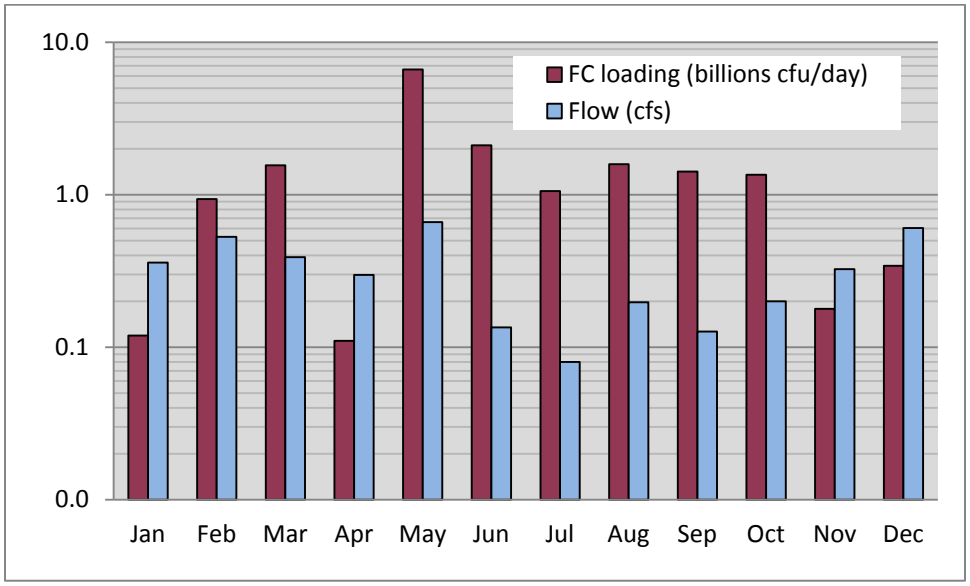

Figure J-6. Daniels Creek at mouth (15-DAN-0.0) monthly FC loading and flow.
Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

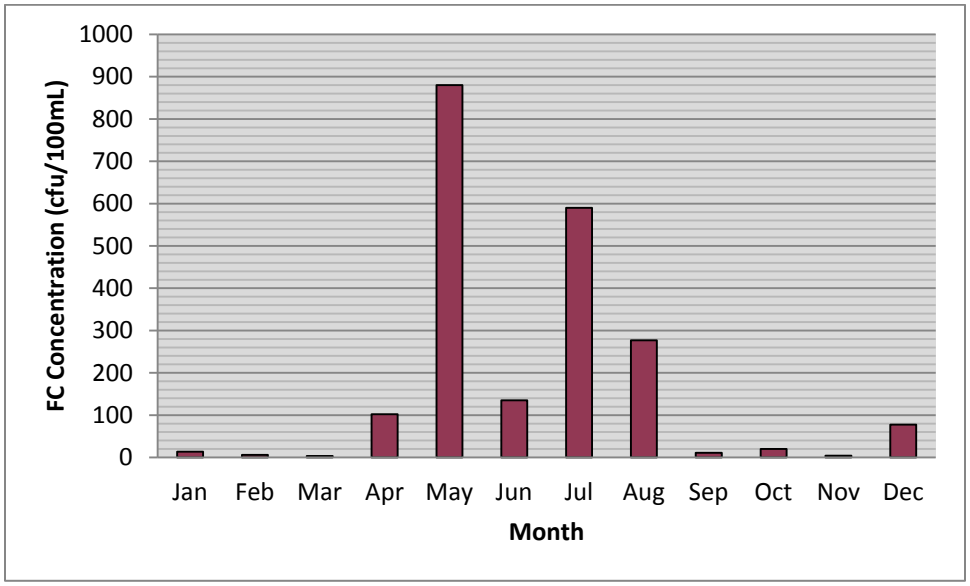

Figure J-7. Lemolo Creek near mouth (15-LEM-0.1) monthly FC concentrations.

Bars represent two-sample arithmetic means.

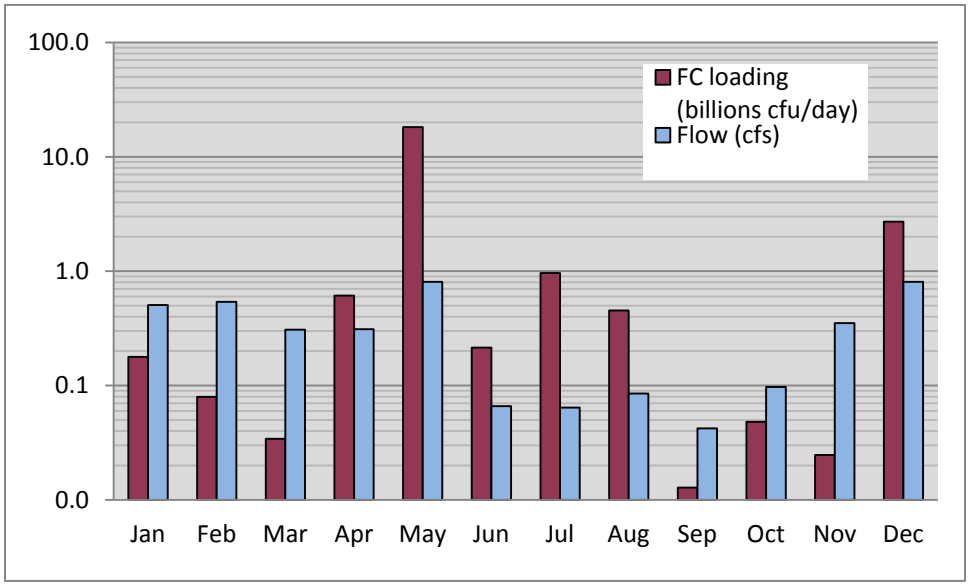

Figure J-8. Lemolo Creek near mouth (15-LEM-0.1) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

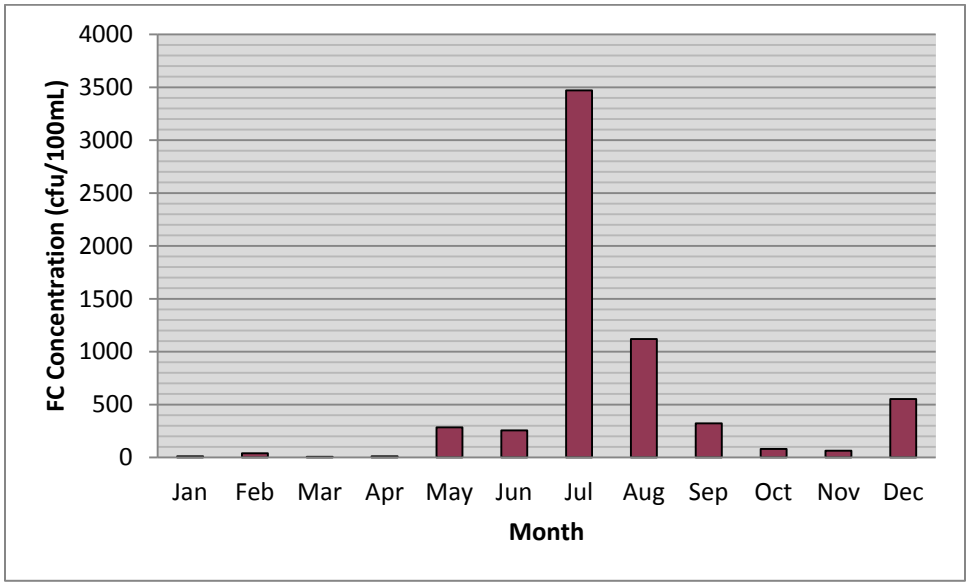

Figure J-9. Bjorgen Creek near mouth (15-BJO-0.1) monthly FC concentrations.

Bars represent two-sample arithmetic means.

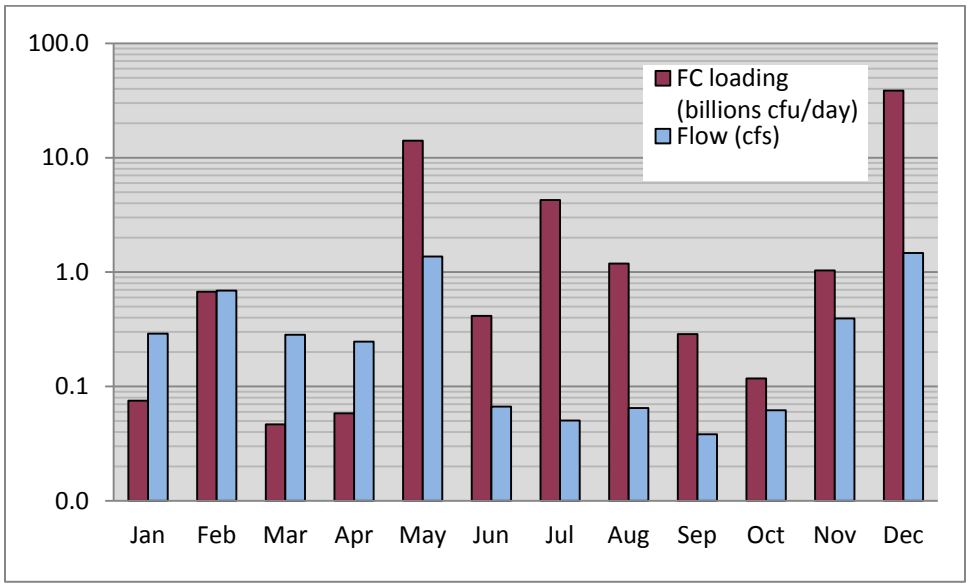

Figure J-10. Bjorgen Creek near mouth (15-BJO-0.1) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

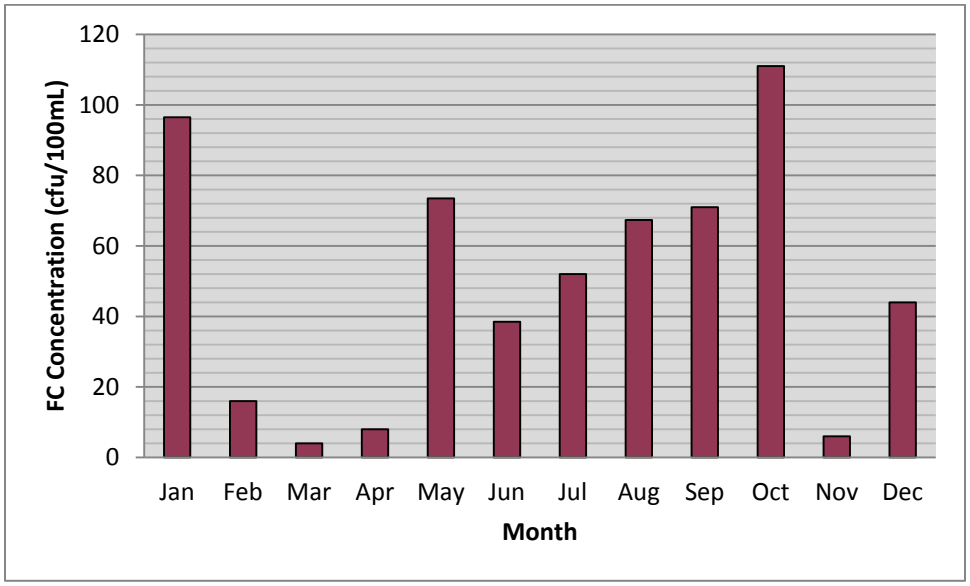

Figure J-11. Johnson Creek near mouth (15-JOH-0.1) monthly FC concentrations.

Bars represent two-sample arithmetic means.

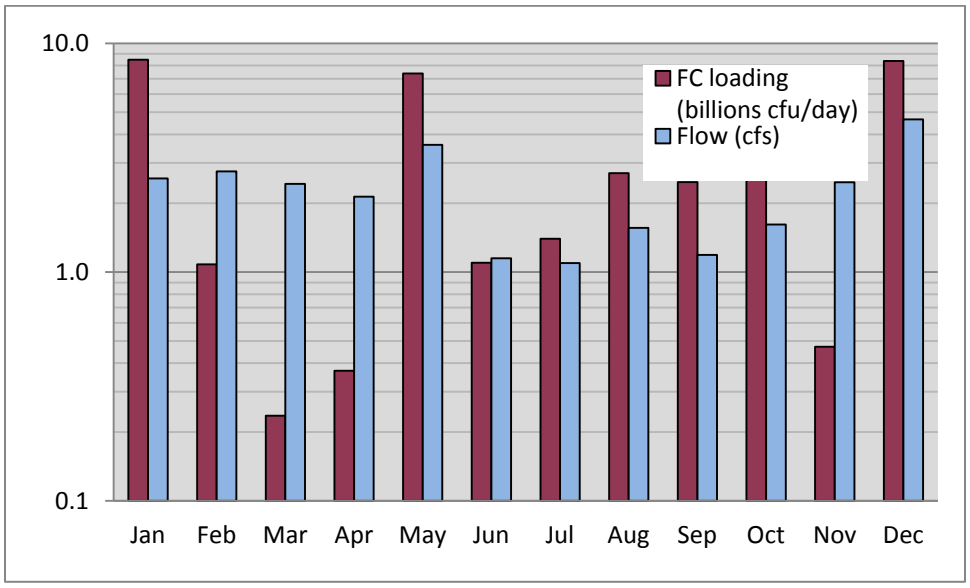

Figure J-12. Johnson Creek near mouth (15-JOH-0.1) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

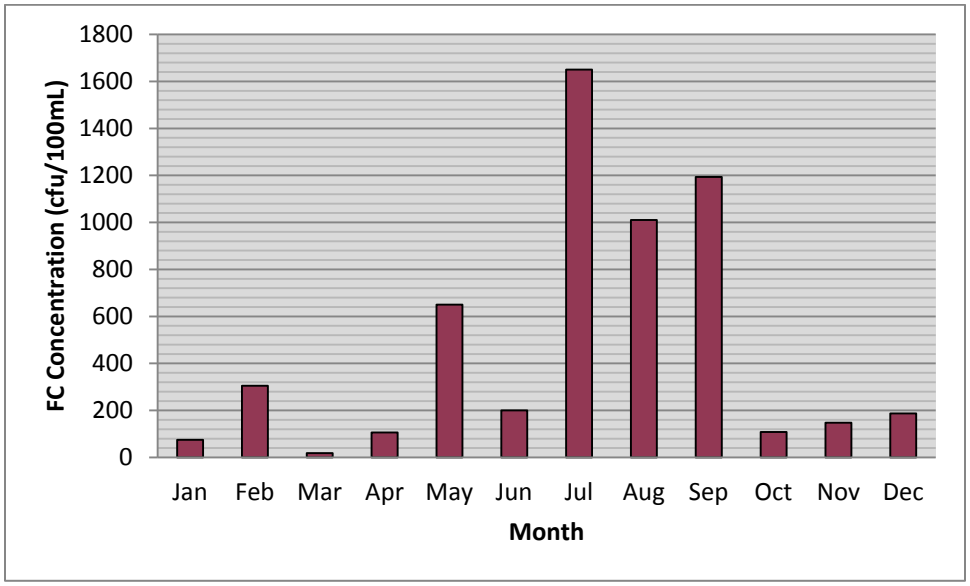

Figure J-13. Little Scandia Creek near mouth (15-LSC-0.1) monthly FC concentrations.

Bars represent two-sample arithmetic means.

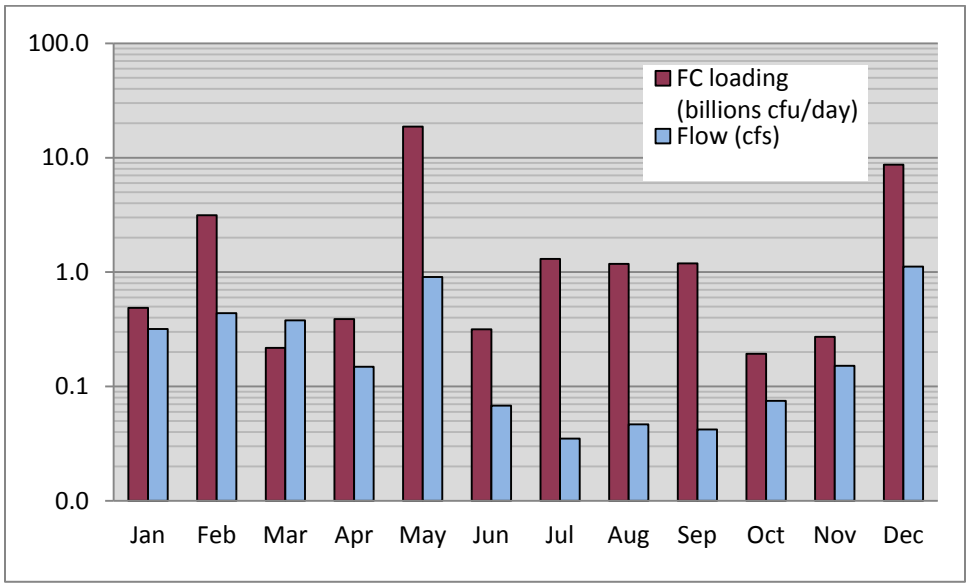

Figure J-14. Little Scandia Creek near mouth (15-LSC-0.1) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

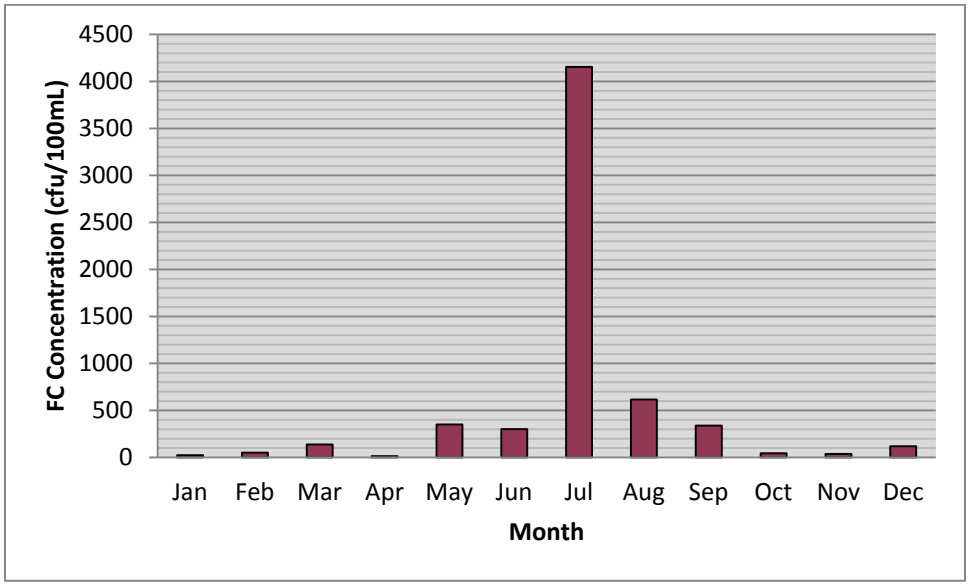

Figure J-15. Perry Creek near mouth (15-PER-0.1) monthly FC concentrations.

Bars represent two-sample arithmetic means.

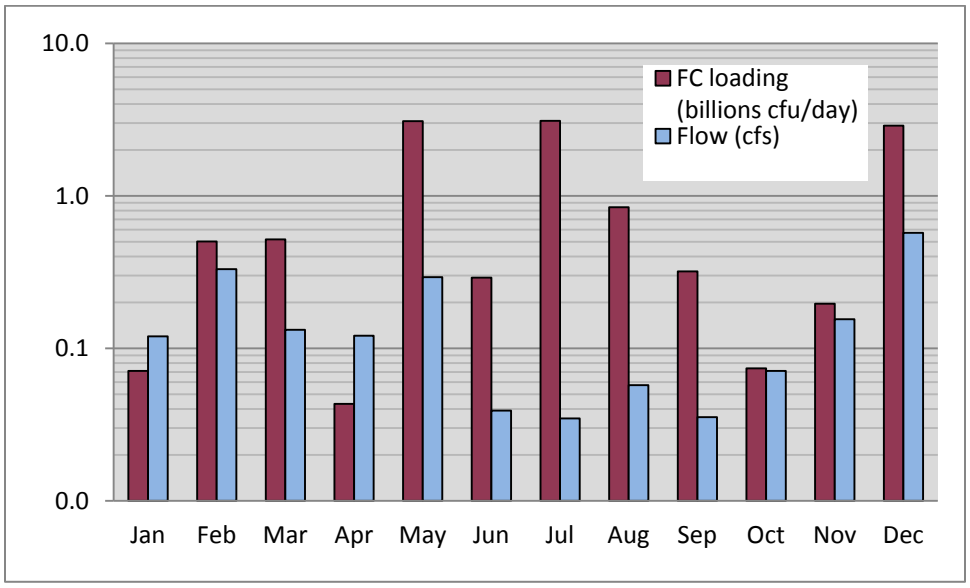

Figure J-16. Perry Creek near mouth (15-PER-0.1) monthly FC loading and flow.

Bars represent two-sample (FC) and two-measurement (flow) arithmetic means.

Appendix K: Summary statistics for Liberty Bay watershed fecal coliform data collected by KPHD.

Table K-1. Estimated 90th percentiles for KPHD stream FC data from Table 8.
Statistics were calculated by Ecology.

Subwatershed	2009 Est. 90th percentile (cfu/100 mL)	2010 Est. 90th percentile (cfu/100 mL)	2011 Est. 90th percentile (cfu/100 mL)
Little Scandia Creek	1920	1482	590
Big Scandia Creek	421	160	167
Bjorgen Creek	1081	486	510
Daniels Creek	654	199	339
Dogfish Creek (all tributaries included)	313	219	161
Dogfish Creek, South Fork	483	330	348
Johnson Creek	136	71	44

Table K-2. Geometric means and 90th percentiles of KPHD marine data from eight stations in Liberty Bay (WY 2011[16]).
Statistics were calculated by Ecology.

KPHD Liberty Bay station ID/name	Number of samples collected	Geometric mean (cfu/100 mL)	Estimated 90th percentile (cfu/100 mL)
LB01	12	1	5
LB03	12	1	4
LB05	12	2	8
LB06	12	3	25
LB07	12	2	10
LB09	12	3	31
LB12	12	1	3
LB13	12	1	2

[16] October 2010 through September 2011

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Appendix L: State and federal grants assisting the Liberty Bay Tributaries Fecal Coliform TMDL

L-1. State grants that implement the Liberty Bay Watershed Bacteria TMDL.

Grant number & total amount	Funding Source	Date (to be) completed	Recipient	Title and Purpose
G0500008 $250,000	Centennial	2008	Kitsap Conservation District	Kitsap water quality improvement project: Farm inventory for high priority Kitsap Creeks (including Daniels and Big Scandia)
G1000301 $666,666a	Centennial	June 2014	Kitsap Public Health District	Liberty Bay watershed restoration
G0700270 $263,000	Stormwater LID & Retrofit	January 2011	City of Poulsbo	Caldart Ave. Stormwater LID Project
G1100150 $360,730a	Stormwater LID & Retrofit	March 2014	City of Poulsbo	Anderson Parkway LID Project
G1100272 $246,945	Stormwater LID & Retrofit	2014	Kitsap County	Poulsbo RC & HHW LID Project
G1100275 $368,450	Stormwater LID & Retrofit	2014	City of Poulsbo	Old Town Poulsbo LID Retrofit
G0800588 $794,697a	Centennial Stormwater Implementation	2012	Kitsap Public Health District	Kitsap Regional IDDE Clean Runoff Project (interlocal agreements with 5 municipalities)

[a] Includes 25 percent local match

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Appendix M: Current water quality

Current water quality

At the request of participants in the Liberty Bay TMDL, Ecology reviewed available recent water quality data collected since the end of the TMDL study in 2009. The review does not alter the load and wasteload allocations established by the TMDL, but provides a basis for recommending priority locations for more current follow-up investigations (see Recommendations).

The following data sets were reviewed:

- Kitsap Public Health District (KPHD) freshwater and marine monitoring (www.kitsappublichealth.org/environment/files/reports/2011_Intro.pdf)
- KPHD monitoring data from the Centennial Grant-funded Pollution Identification and Correction (PIC) project, *Liberty Bay Restoration Project G1000301*.
- Washington Department of Health (DOH) growing area annual report for Lemolo: www.doh.wa.gov/CommunityandEnvironment/Shellfish/GrowingAreas/AnnualReports.aspx

Marine water quality

KPHD. Eight marine sites monitored by KPHD are meeting or close to meeting the strict 14/43 marine standards -- all sites met standards in WYs 2009 and 2011. In WY2010, one site (LB06 in Dogfish Creek estuary) barely failed to meet standards (Figure 2). (Ecology does not monitor marine water quality in Liberty Bay, so no comparison is possible with current KPHD data.)

DOH. DOH monitors four sites in Lemolo area of Liberty Bay. Table M-1 provides the results for the most recent year reported (2011). The classifications shown in Figure 4 have not changed.

Because DOH has received a classification request for a larger area of Liberty Bay, there could be a change in Liberty Bay shellfish classification in the future. The National Shellfish Sanitation Program requires DOH to evaluate water quality for a minimum of 30 samples, which can take more than two years. Not only do the data need to meet strict criteria, but also the potential for point sources of contamination (such as stormwater outfalls and marinas) to impact shellfish areas must be evaluated.

Table M-1. DOH's summary of shellfish growing areas; FC study results (cfu/100 mL) for Lemolo Bay, February 2007 to December 2011.

Station Number	Classification	Number of Samples	Range	Geometric Mean	Est. 90th Percentile	Meets Standard
498	Prohibited*	30	1.7 - 23	2.9	7	Yes
499	Approved	30	1.7 – 49	3.5	14	Yes
500	Approved	30	1.7 - 17	2.6	7	Yes
501	Approved	30	1.7 – 23	3.1	9	Yes

*Prohibited because of pollutions concerns other than FC
SRS criteria require a minimum of 30 samples from each station
Source: DOH; Annual Growing Area Review, 2011

Review of recent KPHD water quality data

Dry-season regularly-monitored sites (Table M-2). Of the 15 TMDL sites assigned dry-season WLAs and LAs, three are now meeting standards in the dry season. Five sites have improved significantly, two have fecal coliform concentrations similar to the TMDL, two have gotten worse, and two require current data.

Priorities for follow up are South Fork Dogfish Creek, an urban stream in Poulsbo with currently-poorer dry-season water quality than during the 2008-09 TMDL sampling period; Little Scandia Creek, which has seen some improvement but still exhibits some of the highest fecal coliform geometric means in the watershed; and Bjorgen Creek, which has high values and has not improved.

Figure M-1 illustrates the color coding used to assess progress in Tables M-2 to M-5, which compare TMDL seasonal bacteria results with KPHD WY2011 seasonal bacteria results.

Color code for TMDL statistics

	4b – no WLA
	Meets standard – no WLA
	Assigned WLA in TMDL

Color code for WY2011 comparison

	4b – no WLA
	Meets standard – no WLA
	WLA: Does not meet standard, but WQ has improved since TMDL
	WLA: Does not meet standard; minimal change since TMDL
	WLA: Does not meet standard – WQ worse than during TMDL
	WLA: No current data

Figure M-1. Color codes for comparing TMDL and recent water quality in Tables M-2 to M-5.

Table M-2. Dry-season FC statistics for regularly-sampled TMDL sites compared with WY2011 KPHD data.

Site ID with River Mile	TMDL Site	n [17]	TMDL GM [18]	TMDL 90th [9]	n	KPHD WY2011 GM [9]	KPHD WY2011 90th [9]	KPHD Site Name
Dogfish Creek								
15-DOG-0.6	Dogfish off Bond Rd. at dental office	12	93	214	5	83	153	DF01
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave.	12	62	200	5	123	650	SF01
15-SFD-1.3	South Fork at 8th Ave. and Iverson	12	102	210				SF0219
15-EFD-0.0	East Fork at Little Valley Rd.	12	159	560	5	90	560	ED01
15-EFD-1.2	East Fork at Pugh Rd.	12	45	206				ED02?
15-WFD-0.0	West Fork at Little Valley Rd.	12	81	362	5	40	66	WD01
15-WFD-0.9	West Fork at Big Valley Rd.	12	60	239				WD04?
Johnson Creek								
15-JOH-0.1	400 ft. south of Norfin Rd.	12	36	232	5	15	101	JC01
Big Scandia Creek								
15-BSC-0.0	Scandia Ct. at private res.	12	111	366	5	61	119	BS01
15-BSC-0.1	Scandia Rd.	12	99	318	5	86	209	BS01A
15-BSC-1.1	HWY 308, between Viking and Cox	12	69	554	5	39	251	BS02
15-BSC-1.6	HWY 308, west of Cox Ave.	12	67	221	5	27	88	BS03
Little Scandia Creek								
15-LSC-0.1	Scandia Rd.	12	523	2232	5	335	1716	LS01
15-LSC-0.4	Blomster Way	12	217	820	5	217	692	LS01B
Daniels Creek								
15-DAN-0.0	Off HWY 308	12	343	1060	5	95	254	DC01
15-DAN-0.2	Virginia Loop Rd.	12	241	805	5	96	318	DC01A
Perry Creek								
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	12	256	2375	5	37	81	PER01
Sam Snyder Creek								
15-SAM-0.1	Lemolo Shore Dr.	0	no flow during dry season / no reductions necessary					SAM01 [20]
Lemolo Creek								
15-LEM-0.1	Lemolo Shore Dr.	12	63	597	5	121	331	LEM01
Bjorgen Creek								
15-BJO-0.1	Lemolo Shore Dr.	12	276	2098	5	289	445	BN01
Barrantes Creek								
15-BAR-0.0	Lemolo Shore Dr.	10	180	688	5	36	100	BAR01
Unnamed Tributaries to Liberty Bay								
15-UNN-0.1	East of Daniels Ck. at HWY 308	10	80	305	5	124	424	UNN01
15-UNN-0.0	Trib. flowing into bay next to Daniels	7	578	5266				21

[17] n = number of samples
[18] Statistics are geometric mean (GM) and estimated 90th percentile values. Units are bacteria concentrations (cfu/100 mL)
[19] SF02 is about 500 ft downstream of TMDL site and may be affected by other influences. Data needed.
[20] KPHD data for WY2011: year round GM = 31. Data needed to evaluate by season.
[21] Under PIC, KPHD did not sample.

Dry-season investigation sites (Table M-3). Of seven TMDL investigation sites assigned WLAs and LAs, one has improved significantly (Poulsbo Creek, added to KPHD's monthly monitoring and has been segmented upstream to locate sources). Five still being investigated through KPHD's PIC program; see footnotes. The Nelson Park bioswale has been re-sodded by city of Poulsbo; follow-up data needed.

Wet-season regularly-monitored sites (Table M-4). Of the 13 TMDL sites assigned WLAs and LAs for the wet season, two are now meeting standards. Four sites have improved, one has concentrations similar to those in the TMDL, five are worse, and three require current data.

Although wet-season FC concentrations are generally lower than dry season, there are still challenges to meeting standards. Priority is to continue the improvements in SF Dogfish and Little Scandia (because of priority in dry season) and continue follow up on Perry (it has highest geomean and estimated 90th percentile of regularly-monitored sites with WLAs and LAs).

Table M-3. Dry-season FC statistics for TMDL investigation sites compared w/ WY2011 KPHD data.

Site ID with River Mile	TMDL Site Description	n [22]	TMDL GM [23]	TMDL 90th [21]	n	KPHD WY2011 GM [21]	KPHD WY2011 90th [21]	KPHD Site Name
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	1	no significant flow during dry season					THR01 [24]
15-JEA-0.0	S end of Legion Park, blw playground. Poulsbo outfall OF-3703.	6	125	422				[25]
15-DON-0.0	Poulsbo Ck. at Poulsbo Yacht Club. Poulsbo outfall OF-5304	6	302	1114	5	71	194	PB01 [26]
15-BST-0.0	~300 ft. east of Big Scandia Ck.	0	no flow during dry season					
15-KE1-0.2	Brownsville HWY	6	552	2656				[27]
15-KE2-0.3	Keyport Creek at Brownsville HWY	6	209	748				KE02 [28]
15-BOV-0.0	Between Bovela St. and Bay St. Poulsbo outfall OF-3706	6	365	828				[29]
15-LMK-0.0	Off Virginia Lp. Rd. at private res.	1	no significant flow during dry season					
15-NEL-0.0	Nelson Park bioswale on beach. Poulsbo outfall OF-3502	6	1061	4271				[30]
15-RET-0.0	Off Viking at assisted living facility. City of Poulsbo outfall OF-3704.	6	344	1381				[31]

[22] n = number of samples
[23] Statistics are geometric mean (GM) and estimated 90th percentile values. Units are bacteria concentrations (cfu/100 mL)
[24] PIC station THR01: need to check data, may be meeting standards.
[25] Under PIC, KPHD is working cooperatively with city of Poulsbo to determine stream origin and follow up.
[26] Under PIC, KPHD has established station PB01 at the mouth (monitored monthly) and has segmented the creek with four upstream monitoring sites to locate and correct sources.
[27] Under PIC, KPHD is sampling next to sewage collection lift station at Brownsville Highway. Need data.
[28] Under PIC, tentative info – this location monitored one year and met standards
[29] Under PIC, KPHD and city of Poulsbo are investigating this location and related LBB9 hot spot on beach.
[30] City of Poulsbo responded to TMDL and PIC data and has re-sodded the bioswale to correct the source. Data needed.
[31] Under PIC, KPHD is investigating and must address technical challenge of dye testing various components of multistory assisted living center. Related beach site investigation at LBB8.

Table M-4. Wet-season bacteria statistics for regularly-sampled TMDL sites compared with WY2011 KPHD[32] data.

Site ID with River Mile	TMDL Site	n[33]	TMDL GM[34]	TMDL 90th [27]	n	KPHD WY2011 GM[27]	KPHD WY2011 90th [27]	KPHD Site Name
Dogfish Creek								
15-DOG-0.6	Dogfish off Bond Rd. at dental office	14	36	161	7	14	130	DF01
15-SFD-0.0	South Fork at Bond Rd. and 1st Ave.	14	106	798	7	21	127	SF01
15-SFD-1.3	South Fork at 8th Ave. and Iverson	14	48	584				SF02[35]
15-EFD-0.0	East Fork at Little Valley Rd.	14	17	105	7	10	49	ED01
15-EFD-1.2	East Fork at Pugh Rd.	14	19	103	7			ED02?
15-WFD-0.0	West Fork at Little Valley Rd.	14	27	121	7	14	84	WD01
15-WFD-0.9	West Fork at Big Valley Rd.	14	11	85	7			WD04?
Johnson Creek								
15-JOH-0.1	400 ft. south of Norfin Rd.	14	10	97	7	10	33	JC01
Big Scandia Creek								
15-BSC-0.0	Scandia Ct. at private res.	14	30	221	7	24	121	BS01
15-BSC-0.1	Scandia Rd.	14	25	226	7	32	242	BS01A
15-BSC-1.1	HWY 308, between Viking and Cox	14	13	116	7	28	208	BS02
15-BSC-1.6	HWY 308, west of Cox Ave.	14	16	160	7	20	94	BS03
Little Scandia Creek								
15-LSC-0.1	Scandia Rd.	14	109	680	7	38	197	LS01
15-LSC-0.4	Blomster Way	14	29	226	7	28	129	LS01B
Daniels Creek								
15-DAN-0.0	Off HWY 308	14	36	185	7	24	185	DC01
15-DAN-0.2	Virginia Loop Rd.	14	9	50	7	8	23	DC01A
Perry Creek								
15-PER-0.1	At 90 deg. right turn in Thorpe Rd.	14	46	293	7	63	507	PER01
Sam Snyder Creek								
15-SAM-0.1	Lemolo Shore Dr.	14	9	54	7			[36]
Lemolo Creek								
15-LEM-0.1	Lemolo Shore Dr.	14	18	297	7	27	209	LEM01
Bjorgen Creek								
15-BJO-0.1	Lemolo Shore Dr.	14	26	255	7	14	79	BN01
Barrantes Creek								
15-BAR-0.0	Lemolo Shore Dr.	14	19	134	7	45	139	BAR01
Unnamed Tributaries to Liberty Bay								
15-UNN-0.1	East of Daniels Ck. at HWY 308	14	7	43	7	12	116	UNN01
15-UNN-0.0	Trib. flowing into bay next to Daniels	14	19	371	7			[37]

[32] See Z:\.....\SlawerenceLibertyStreamsandMarine.xls
[33] n = number of samples
[34] Statistics are geometric mean (GM) and estimated 90th percentile values. Units are bacteria concentrations (cfu/100 mL)
[35] SF02 is about 500 ft downstream of TMDL site and may be affected by other influences. Data needed.
[36] Under PIC, WY2011 GMV (year round) was 31. Need monthly data to calculate seasonal stats.
[37] Under PIC, KPHD did not sample.

Wet-season investigation sites (Table M-5). Of the nine TMDL investigation sites assigned WLAs and LAs, one (Poulsbo Creek) is meeting standards in the wet season. All nine sites are being followed up through KPHD's PIC program; see footnotes to the table.

Table M-5. Wet-season bacteria statistics for TMDL investigation sites compared with WY2011 KPHD data.

Site ID with River Mile	TMDL Site	n[38]	TMDL GM[39]	TMDL 90th [39]	n	KPHD WY2011 GM[39]	KPHD WY2011 90th [39]	KPHD Site Name
15-PET-0.0	East of Perry Ck. at Thorpe Rd.	12	40	195				THR01[40]
15-JEA-0.0	South end of Legion Park, below playground. Poulsbo outfall OF-3703.	14	71	1512				[41]
15-DON-0.0	Poulsbo Ck. at Poulsbo Yacht Club. City of Poulsbo outfall OF-5304	11	34	644	3	13	57	PB01[42]
15-BST-0.0	~300 ft. east of Big Scandia Ck.	12	134	1109				[43]
15-KE1-0.2	Brownsville HWY	4	26	611				[44]
15-KE2-0.3	Keyport Creek at Brownsville HWY	4	9	54				KE02[45]
15-BOV-0.0	Between Bovela St. and Bay St. City of Poulsbo outfall OF-3706	4	57	182				[46]
15-LMK-0.0	Off Virginia Lp. Rd. at private res.	4	565	11743				[47]
15-NEL-0.0	Nelson Park bioswale on beach. City of Poulsbo outfall OF-3704	4	395	3762				[48]
15-RET-0.0	Off Viking at assisted living facility. City of Poulsbo outfall OF-3704.	4	714	2120				[49]

[38] n = number of samples
[39] Statistics are geometric mean (GM) and estimated 90th percentile values. Units are bacteria concentrations (cfu/100 mL). Note that while geometric means for datasets with fewer than 5 samples are calculated here for informational purposes, 5 or more samples are required to calculate a geometric mean for comparison with bacteria standards.
[40] PIC station THR01: need to check data, may be meeting standards.
[41] Under PIC, KPHD is working cooperatively with city of Poulsbo to determine stream origin and follow up. KPHD IDDE monitoring was low in 2009 (range 130 to 230) and high in 2010 (range 80 to >2000).
[42] Under PIC, KPHD has established station PB01 at the mouth (monitored monthly) and has segmented the creek with four upstream monitoring sites to locate and correct sources. Because only 3 wet season values available for WY2011, determination of compliance not complete.
[43] KPHD does not sample at this location.
[44] Under PIC, KPHD samples next to sewage collection lift station at Brownsville Highway. Need data.
[45] Under PIC, tentative info – this location monitored one year and met standards
[46] Under PIC, KPHD and City of Poulsbo are investigating this location and related LBB9 hot spot on beach.
[47] Is KPHD sampling at this location?
[48] City of Poulsbo responded to TMDL and PIC data and has re-sodded the bioswale to correct the source. Any data?
[49] Under PIC, KPHD is investigating and must address technical challenge of dye testing various components of multistory assisted living center. Related beach site investigation at LBB8.