Drayton Harbor Watershed Fecal Coliform Total Maximum Daily Load: Phase 1

Water Quality Study Design (Quality Assurance Project Plan)

March 2008

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Study Codes

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TMDL Study Code (Water Quality Program) is DraH01FC.

2004 303(d) Listings Addressed in this Study

Drayton Harbor (WA-01-0020)
California Creek (WA-01-1450)
Dakota Creek (WA-01-1002)

Cover photo: Drayton Harbor

Drayton Harbor Watershed
Fecal Coliform
Total Maximum Daily Load: Phase 1

Water Quality Study Design
(Quality Assurance Project Plan)

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Abstract

Sections of Drayton Harbor, Dakota Creek, and California Creek have been listed under Section 303(d) of the federal Clean Water Act for non-attainment of Washington State fecal coliform bacteria criteria. The listings in Drayton Harbor are based on sampling by the Port of Bellingham in and around the Blaine Marina from 1997-2000. The listings on Dakota and California Creeks are based on sampling done by the Northwest Indian College from 1998-2003.

The U.S. Environmental Protection Agency requires states to set priorities for cleaning up 303(d) listed waters and to establish a Total Maximum Daily Load (TMDL) for each. A TMDL entails an analysis of how much of a pollutant load a waterbody can assimilate without violating water quality standards. The *Drayton Harbor Fecal Coliform TMDL Study* will address the 303(d) listings within the harbor, as well as for California and Dakota Creeks.

This Quality Assurance (QA) Project Plan describes Phase 1 of the technical study that will monitor levels of fecal coliform bacteria in Drayton Harbor, as well as California and Dakota Creeks. It forms the basis for a bacteria TMDL.

- Phase 1 will focus on (1) collecting bacteria data from freshwater drainages within the study area and (2) investigating background bacteria levels in Semiahmoo Bay.

- Phase 2 will involve additional data collection to address marine water quality impairments.

The study will be conducted by the Washington State Department of Ecology's (Ecology) Environmental Assessment Program.

Each study conducted by Ecology must have an approved QA Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. The Phase 2 plan will be presented in an addendum. After completion of the study, a final report describing the study results from both phases will be published.

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. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of waterbodies—lakes, rivers, streams, or marine waters—that do not meet water quality standards. This list is called the 303(d) list. To develop the list, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data submitted by local, state, and federal governments; tribes; industries; and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into five categories:

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

Category 2 – Waters of concern.

Category 3 – Waters with no data available.

Category 4 – Polluted waters that do not require a TMDL because:
- 4a. – Has a TMDL approved and it's being implemented.
- 4b. – Has a pollution control plan in place that should solve the problem.
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, and culverts.

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

TMDL process overview

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each of the waterbodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. Then Ecology works with the local community to develop an overall approach to control the pollution, called the Implementation Strategy, and a monitoring plan to assess effectiveness of the water quality improvement activities. Once the TMDL has been approved by the U.S. Environmental Projection Agency (EPA), a *Water Quality Implementation Plan* must be developed within one year. This Plan identifies specific tasks, responsible parties, and timelines for achieving clean water.

Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

If the pollutant comes from a discrete source (referred to as a point source) such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from a set of diffuse sources (referred to as a nonpoint source) such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

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 loads from growth pressures is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. EPA defines the loading capacity as *the greatest amount of loading that a waterbody can receive without violating water quality standards* (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

TMDL = Loading Capacity = sum of all wasteload allocations + sum of all load allocations + margin of safety

Why is Ecology Conducting a TMDL Study in This Watershed?

Overview

Ecology is conducting a TMDL study in this watershed because there is strong evidence of bacterial contamination that is affecting beneficial uses in the area, such as shellfish harvesting and recreation. Several study-area waterbodies are included on Ecology's 303(d) list of impaired waters, including Drayton Harbor, California Creek, Dakota Creek, and a small unnamed creek that drains to Drayton Harbor between the mouth of Dakota Creek and the city of Blaine (Table 1) (Ecology, 2007a).

In 1988, Drayton Harbor was ranked as the highest priority watershed in Whatcom County for threatened beneficial uses from pollution sources. At this point in time, the majority of Drayton Harbor was approved for shellfish harvesting, except for the mouth of the harbor due to concerns about its proximity to the two marinas and the underwater sewer line. Later that year, 500 acres near the southeast end of the harbor were downgraded to *prohibited* status due to failing septic systems and livestock waste.

In 1995, another large portion of the harbor was further downgraded to prohibited, leaving only about one third of the harbor approved for harvest. In 1999, the remaining harvest area was closed due to observed water quality violations for fecal coliform bacteria.

Due to the monitoring and cleanup efforts of the community and local and state agencies, 575 acres in the central harbor were upgraded from *Prohibited* to *Conditionally Approved* status in 2004. The *Conditionally Approved* classification for shellfish harvest is based on the amount of rainfall; where, if three quarters of an inch or more of rain falls in a 24-hour period, then shellfish harvesting is closed for six days.

During the 2004-2005 prime shellfish harvesting season (October – April), harvesting was shut down due to rainfall for almost four months, over half the season (Whatcom, 2007). Further source identification and cleanup efforts are needed to restore shellfish harvesting and other beneficial uses.

The project will involve two phases of data collection and analysis.

- Phase 1 will focus on collecting freshwater bacteria data from the watershed draining to the marine waters within the study area and investigating background bacteria levels in Semiahmoo Bay.
- Phase 2 will involve additional data collection to address marine water fecal coliform impairments. Details of Phase 2 will be outlined in an addendum to the QA Project Plan.

Study area

The study area for Phase 1 of the TMDL consists of Drayton Harbor and its entire drainage area. The study area boundary also extends west into Semiahmoo Bay. Starting at Birch Bay Point, the boundary extends due north to the international border (Figure 1).

Pollutants addressed by this TMDL

This TMDL addresses fecal coliform bacteria 303(d) listings.

Impaired beneficial uses and waterbodies on Ecology's 303(d) list of impaired waters

The most sensitive beneficial use to be protected by this TMDL is shellfish harvesting in Drayton Harbor. Shellfish harvesting is threatened by high fecal coliform bacteria levels within the harbor. Other significant beneficial uses to be protected by this TMDL include primary and secondary recreation in both marine and fresh waters. That is, people coming into contact with bacteria-contaminated water through boating, fishing, wading, swimming, and other water-related activities.

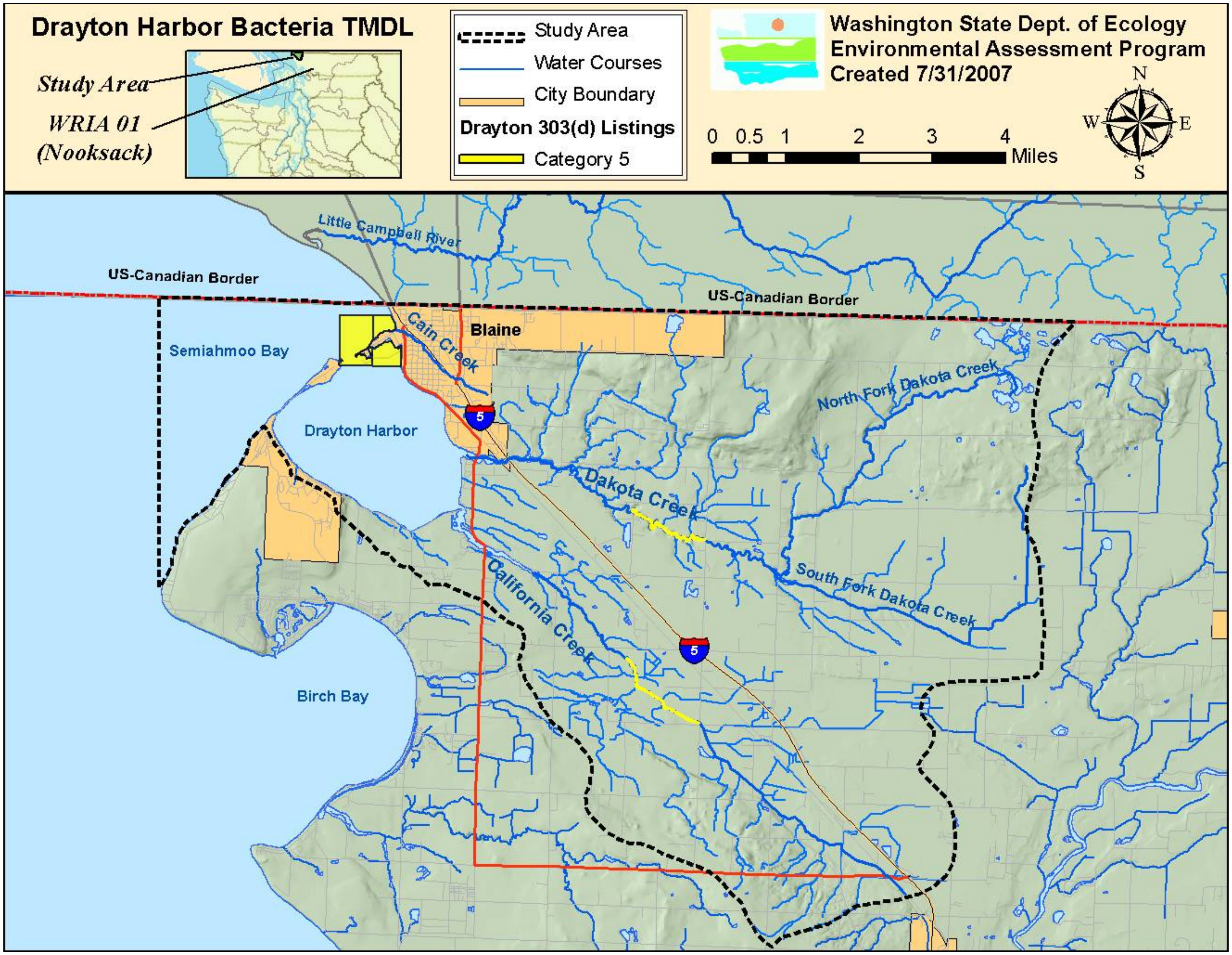

Figure 1. Study area for the *Drayton Harbor Watershed Bacteria Total Maximum Daily Load Study*

Table 1. Study area waterbodies on the 2004 303(d) list for Fecal Coliform.

Waterbody	Listing ID	Township	Range	Section	Grid Cell		
					Number	Latitude	Longitude
Drayton Harbor	39052				48122J7J6	48.995	122.765
Drayton Harbor	39048				48122J7J5	48.995	122.755
Dakota Creek	39077	40N	01E	15			
California Creek	39060	40N	01E	27			
Unnamed Creek	42507	40N	01E	6			

This watershed has other water quality issues that will be further assessed by this TMDL. In particular, the following additional Category 2 (waters of concern) listings for parameters other than fecal coliform occur in the study area. Reported violations of state water quality standards are considered Category 2 when there is either insufficient data or data collected without proper quality assurance procedures (Table 2).

Table 2. Study area waterbodies identified as Category 2 (waters of concern). Continuous data will be collected to further assess these parameters of concern during this study.

Waterbody	Parameter	Listing ID	Township	Range	Section
Dakota Creek	Dissolved oxygen	14009	40N	01E	08
Dakota Creek	Dissolved oxygen	7067	40N	02E	17
Dakota Creek	pH	14003	40N	01E	08
Dakota Creek	Temperature	13997	40N	01E	08
North Fork Dakota Creek	Dissolved oxygen	38996	40N	02E	17
South Fork Dakota Creek	Dissolved oxygen	7068	40N	02E	20
South Fork Dakota Creek	Dissolved oxygen	7069	40N	02E	19

How will the results of this study be used?

A TMDL study identifies how much pollution needs to be reduced or eliminated to achieve clean water. This is done by assessing the situation, recommending practices to reduce pollution, and establishing limits for facilities that have permits. Since the study may also identify the main sources or source areas of pollution, Ecology and local partners will use these results to figure out where to focus water quality improvement activities. Or, sometimes the study suggests areas for follow-up sampling to further pinpoint sources for cleanup actions.

Water Quality Standards and Beneficial Uses

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC) include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state.

The marine waters within Drayton Harbor are protected for the following aquatic life uses:

- *Excellent quality* for (1) salmonid and other fish migration, rearing, and spawning; (2) clam, oyster, and mussel rearing and spawning; and (3) crustaceans and other shellfish (crabs, shrimp, crayfish, and scallops) rearing and spawning.

Marine waters outside of Drayton Harbor, within Semiahmoo Bay, are protected for the following aquatic life uses:

- *Extraordinary quality* for (1) salmonid and other fish migration, rearing, and spawning; (2) clam, oyster, and mussel rearing and spawning; and (3) crustaceans and other shellfish (crabs, shrimp, crayfish, and scallops) rearing and spawning.

While aquatic life uses for marine water do not directly correlate to bacteria water quality standards, they do determine what bacteria standards apply to the fresh surface waters that drain directly into a marine waterbody.

Bacteria

Fresh waters

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In Washington State, the Department of Ecology's (Ecology) water quality standards use fecal coliform as an *indicator bacteria* for the state's freshwaters (e.g., lakes and streams). Fecal coliform in water *indicates* the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The fecal coliform criteria are set at levels that are shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Dakota, California, and the unnamed creek, as well as all other fresh surface waterbodies that drain into Drayton Harbor, are protected for the beneficial use of *primary contact recreation*.

- *Primary contact* use is intended for waters *where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing.* More to the point, however, the use is designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category: *Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/*

100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL [WAC 173-201A-200(2)(b), 2003 edition].

Cain Creek is protected for *extraordinary primary contact* recreation because it drains directly into Semiahmoo Bay, which is protected as extraordinary quality marine water.

- *Extraordinary primary contact* use 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, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL* [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures used in combination ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than allowed. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets.

The criteria for fecal coliform are based on allowing no more than the pre-determined risk of illness to humans that work or recreate in a waterbody. The criteria used in the state standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact activities. Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase the concentration above the criteria are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring fecal coliform concentrations back into compliance with the standard.

If natural levels of fecal coliform (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution. The specific level of illness rates caused by animal versus human sources has not been quantitatively determined. However, warm-blooded animals (particularly those humans manage and are thus exposed to human derived pathogens as well as those of animal origin) are a common source of serious waterborne illness for humans.

Where freshwater enters the marine environment, the marine water quality standards cannot be violated due to the freshwater inputs. In some cases, this may require more stringent targets on freshwater.

Marine waters

In marine waters, bacteria criteria are set to protect shellfish consumption and people who work and play in and on the water. In waters protected for both primary contact recreation and shellfish harvesting, the state uses fecal coliform bacteria as indicator bacteria to gauge the risk of waterborne diseases. The presence of these bacteria in the water indicates the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than is waste from cold-blooded animals.

Drayton Harbor and Semiahmoo Bay are protected for the beneficial uses of both shellfish harvesting and primary contact recreation and the criteria below apply to all marine waters within the study area.

- To protect either *shellfish harvesting or primary contact recreation* (swimming or water play): *Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% 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].

The criterion level set to protect shellfish harvesting and primary contact recreation is consistent with federal shellfish sanitation rules. Fecal coliform concentrations in our 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 criterion to protect both *shellfish harvesting* and *primary contact* uses in the state standards.

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures must be used in combination to ensure that the bacterial pollution in a waterbody will be maintained at levels that will not cause a greater 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 (summer versus winter) data sets.

Once the concentration of fecal coliform in the water reaches the numeric criterion, the state does not allow human activities that would increase the concentration above that criterion. If the criterion is exceeded, the state requires that human activities are conducted in a manner that will bring bacterial concentrations back into compliance with the standards.

If natural levels of bacteria (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution. The specific level of illness rates caused by animal versus human sources has not been quantitatively determined. However, warm-blooded animals (particularly those humans manage and are thus exposed to human derived pathogens as well as those of animal origin) are a common source of serious waterborne illness for humans.

Brackish waters

Section 173-201A-260 of the water quality standards state that: *In brackish waters of estuaries, where different criteria for the same use occurs for fresh and marine waters, the decision to use the fresh water or the marine water criteria must be selected and applied on the basis of vertically averaged daily maximum salinity, referred to below as salinity*.

(i) The fresh water criteria must be applied at any point where 95% of the salinity values are less than or equal to one part per thousand, except that the fresh water criteria for bacteria applies when the salinity is less than ten parts per thousand.

(ii) The marine water criteria must apply at all other locations where the salinity values are greater than one part per thousand, except that the marine criteria for bacteria applies when the salinity is ten parts per thousand or greater.

Salinity and conductivity data will be collected simultaneously with bacteria samples and multiple salinity surveys will be conducted at any sampling stations within brackish waters in order to determine whether or not to apply marine or fresh water criteria.

DOH Shellfish growing area standards and classifications

The Washington State Department of Health (DOH) classifies commercial shellfish beds in Washington State using the National Shellfish Sanitation Program criteria. To meet the National Shellfish Sanitation Program criteria, a commercial shellfish harvesting area must have a geometric mean value of no more than 14 most probable number (MPN)/100 mL, with an estimated 90^{th} percentile value less than 43 MPN/100 mL.

The DOH determines commercial shellfish growing area classifications for Drayton Harbor (Figure 2). The classifications are based on *sanitary surveys*, which consist of a shoreline survey to identify pollution sources; marine water bacteria sampling; an analysis of how weather, tides, and other factors affect the distribution of pollutants in the area; and an analysis of water quality data (DOH, 2007).

Based on the results of the sanitary survey, one of four classifications is given to the growing area:

- *Approved* – The growing area is approved for direct marketing of commercial harvest and does not pose a public health risk. There are no fully approved areas in Drayton Harbor.
- *Conditionally Approved* – The area is approved, but only during predictable periods. Typically, shellfish harvesting is prohibited following a rainfall event of predetermined magnitude for the length of time it takes water quality to recover from the event. For example, the conditionally approved shellfish area in central Drayton Harbor is closed for six days when precipitation of 0.75 inches or greater falls over a 24-hour period.
- *Restricted* – Restricted areas are not approved for direct commercial marketing, but due to limited pollution from non-human sources, shellfish can be relayed to an approved area for a specified amount of time to cleanse themselves before being sold commercially. There are no restricted areas in Drayton Harbor.

- *Prohibited* – In these areas pollution from fecal material or other sources poses a health risk to shellfish consumers and commercial shellfish harvest is not allowed. The majority of Drayton Harbor, as well as the portion of Semiahmoo Bay outside the harbor, are classified as prohibited.

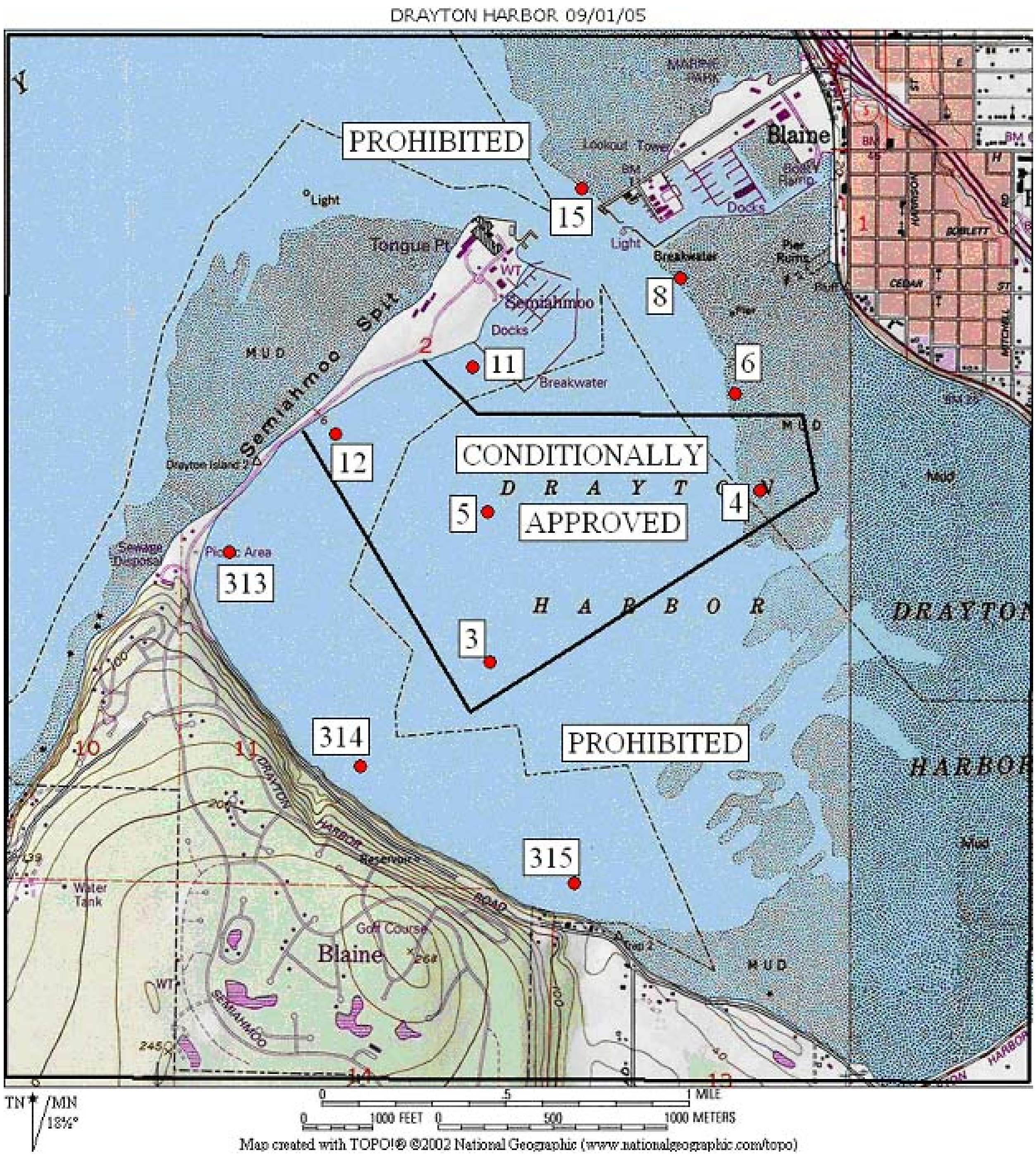

Figure 2. DOH sampling stations and shellfish growing area classifications.

Watershed Description

Drayton Harbor

Drayton Harbor is located in Whatcom County at the northwest corner of Washington State, just south of the United States-Canadian border (Figure 1). A narrow 500-foot passage at the northwest edge of the harbor connects it to Semiahmoo Bay and the Straight of Georgia (Callahan and Menzies, 2004). From the entrance to the harbor, marine water balloons out in a slightly oblong shape and spreads across approximately 1600 acres. Drayton Harbor's shallow nature results in the periodic exposure of over 900 acres of tidal mudflats, primarily within its eastern half. Historically, the harbor has been used for commercial, recreational, and tribal shellfish harvesting.

The city of Blaine borders portions of the harbor along the north and southwest shoreline. The Blaine Marina, operated by the Port of Bellingham, is located at the northern edge of the harbor entrance. The marina contains approximately 600 boat slips, including permanent moorage and 700 square feet of visitor moorage (Port of Bellingham, 2007). The marina also houses several fish processing companies and a public wharf.

To the south of the entrance to Drayton Harbor are the Semiahmoo Resort and Marina, which lie at the north end of the Semiahmoo Spit. The narrow section of the spit, southwest of the Resort at Semiahmoo, is the Semiahmoo County Park, a public access park with beach walking trails. The current Blaine Wastewater Treatment Plant (WWTP) is located southwest of the park, at the neck of the spit.

The Drayton Harbor watershed drains approximately 35,372 acres, 90% of which empties into either California or Dakota Creek (Callahan and Menzies, 2004) before entering the harbor. The watershed houses approximately 10,465 people (Callahan and Menzies, 2004) and hosts a wide variety of land uses including: (1) commercial and industrial development, (2) low density residential land, (3) commercial dairies and berry farms, (4) non-commercial hobby farms, (5) agriculture, (6) surface mining, and (7) forestland.

Dakota Creek

The Dakota Creek watershed accounts for about 52% of the Drayton Harbor drainage area and empties into the harbor near the southeastern boundary of the city of Blaine. The upper watershed is dominated by agriculture and commercial dairy farms, which are concentrated between the North and South Forks of Dakota Creek. Wetlands are also located throughout the upper watershed with several riparian planting projects recently completed by the Whatcom County Conservation District. The middle and lower portions of the watershed are characterized primarily by: (1) partially forested, low-density residential areas and (2) small, non-commercial farms.

California Creek

The drainage area of California Creek makes up 38% of the watershed and is similar to that of Dakota Creek. With the upper half consisting primarily of dairy farms and agriculture, the lower portion is sparsely populated with residences and hobby farms. The mouth of California Creek is located approximately ¾ of a mile to the southeast of the mouth of Dakota Creek.

Cain Creek

Cain Creek drains a large portion of the city of Blaine, north of the harbor. The headwaters begin in a minimally developed wetland area just south of the Blaine Airport and drain into the main channel which parallels the I-5 freeway through town. The creek discharges to Semiahmoo Bay due west of the intersection of Peace Portal and Marine Drive, approximately ⅓ of a mile south of the international border with Canada. The creek has been heavily impacted by the development of Blaine and the construction of the I-5 freeway and serves as receiving waters to a number of storm drainages (City of Blaine, 1995).

Climate

The climate of the Drayton Harbor watershed is characterized by mild maritime weather, influenced by prevailing southwest winds from the Pacific Ocean and Puget Sound. Occasionally, the prevailing wind shifts to a northeasterly wind which brings brisk cold weather in the winter and hot dry weather in the summer. These cold episodes can drop temperatures to below 0˚ F with a wind-chill of 50 below zero (City of Blaine, 1995).

The watershed is heavily influenced by precipitation, receiving approximately 40 inches a year. On average greater than 75% of the precipitation falls during the months of October to April (WRRC, 2007)(Table 3 and Figure 3).

Table 3. Monthly average climate data for the city of Blaine. Period of Record: June 1, 1948 to December 31, 2006. Washington Regional Climate Center.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (F)	42.4	47.0	51.0	56.8	63.3	68.3	72.1	71.9	66.5	57.4	48.8	43.4	57.4
Average Minimum Temperature (F)	31.3	33.5	35.4	39.1	44.3	49.3	51.7	51.6	47.2	41.8	36.6	32.9	41.2
Average Total Precipitation (in.)	5.51	4.06	3.52	2.78	2.27	1.92	1.27	1.50	2.04	3.89	5.99	5.91	40.67
Average Total Snow Fall (in.)	5.4	2.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.4	13.8

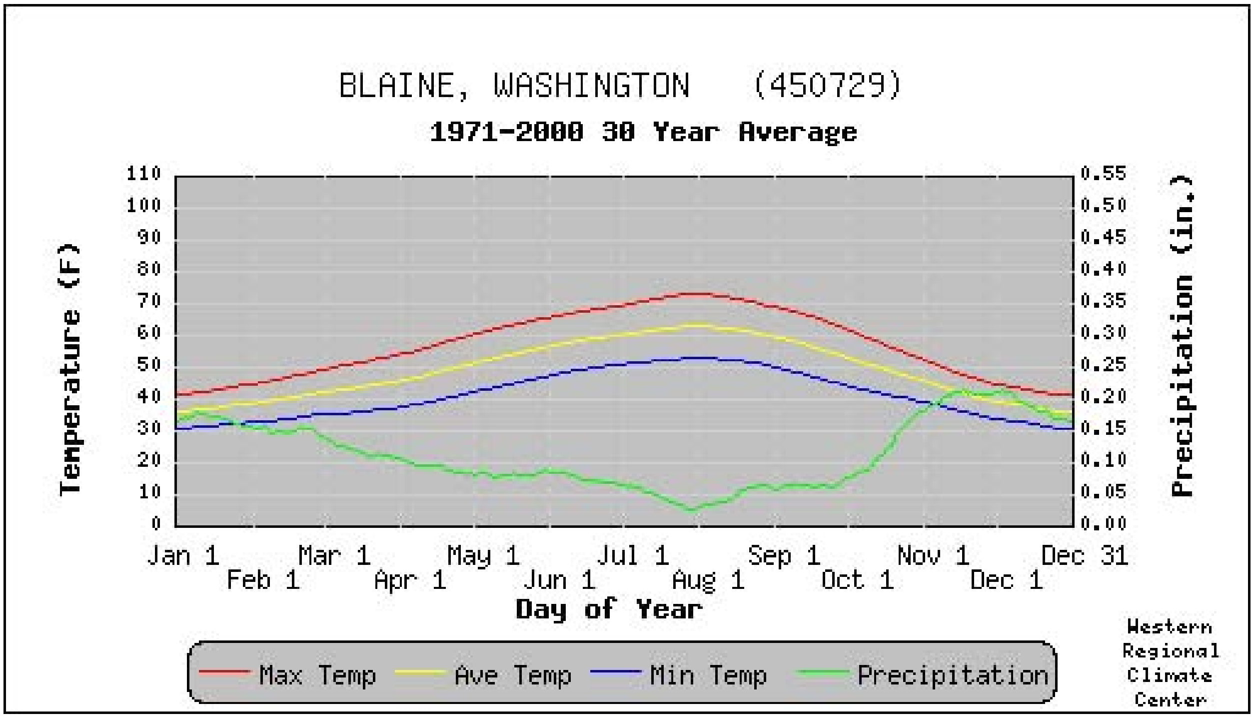

Figure 3. Data is smoothed using a 29-day running average of daily values. Washington Regional Climate Center.

Geology

The geology of the area was primarily influenced by the repeated advance and retreat of glacial ice sheets from Canada. When the Vashon Drift retreated, the lowlands of the Drayton Harbor watershed were covered by the sea. Both the glacial ice and the sea deposited sediments. Since then, stream erosion and deposition have shaped the landscape (City of Blaine, 1995).

Hydrology

Drayton Harbor Watershed Contributions:

- Dakota Creek Watershed: 52%
- California Creek Watershed: 38%
- Other drainages to Harbor: 10%

Ecology's Stream Hydrology Unit maintains two instantaneous staff gages in the watershed: one each on Dakota and California Creeks. A rating curve has been developed for Dakota Creek (Ecology, 2007b), which shows that flows are highest November through January and then steadily decline until July and August (Figure 4). Flows remain low in September and October despite an increase in rainfall in October. The large jump from 14 cubic feet per second (cfs) in October to 92 cfs in November correlates to the increase in precipitation from an average of 3.89 inches in October to an average of 5.99 inches in November.

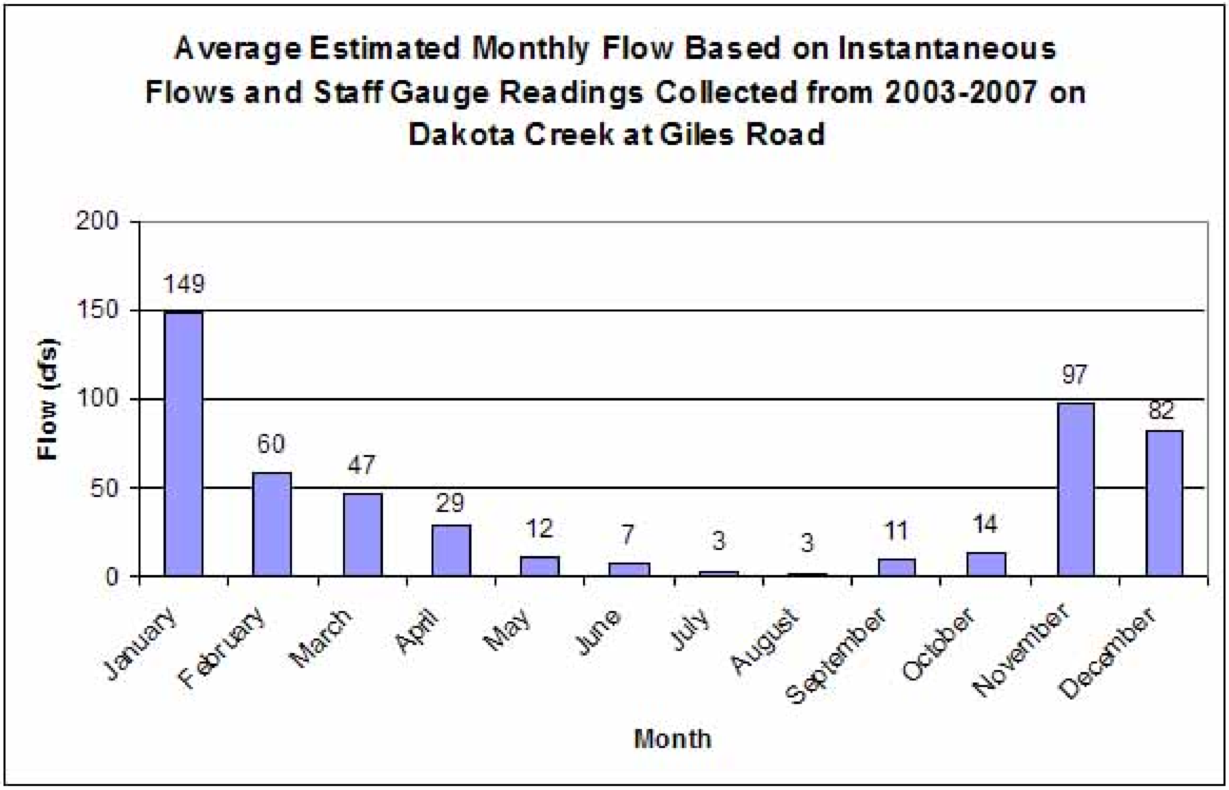

Figure 4. Average monthly flows for Dakota Creek at Giles Road.

Potential sources of contamination

A wide variety of point and nonpoint pollution sources, as well as background and wildlife sources, are present in the Drayton Harbor watershed (Figure 5).

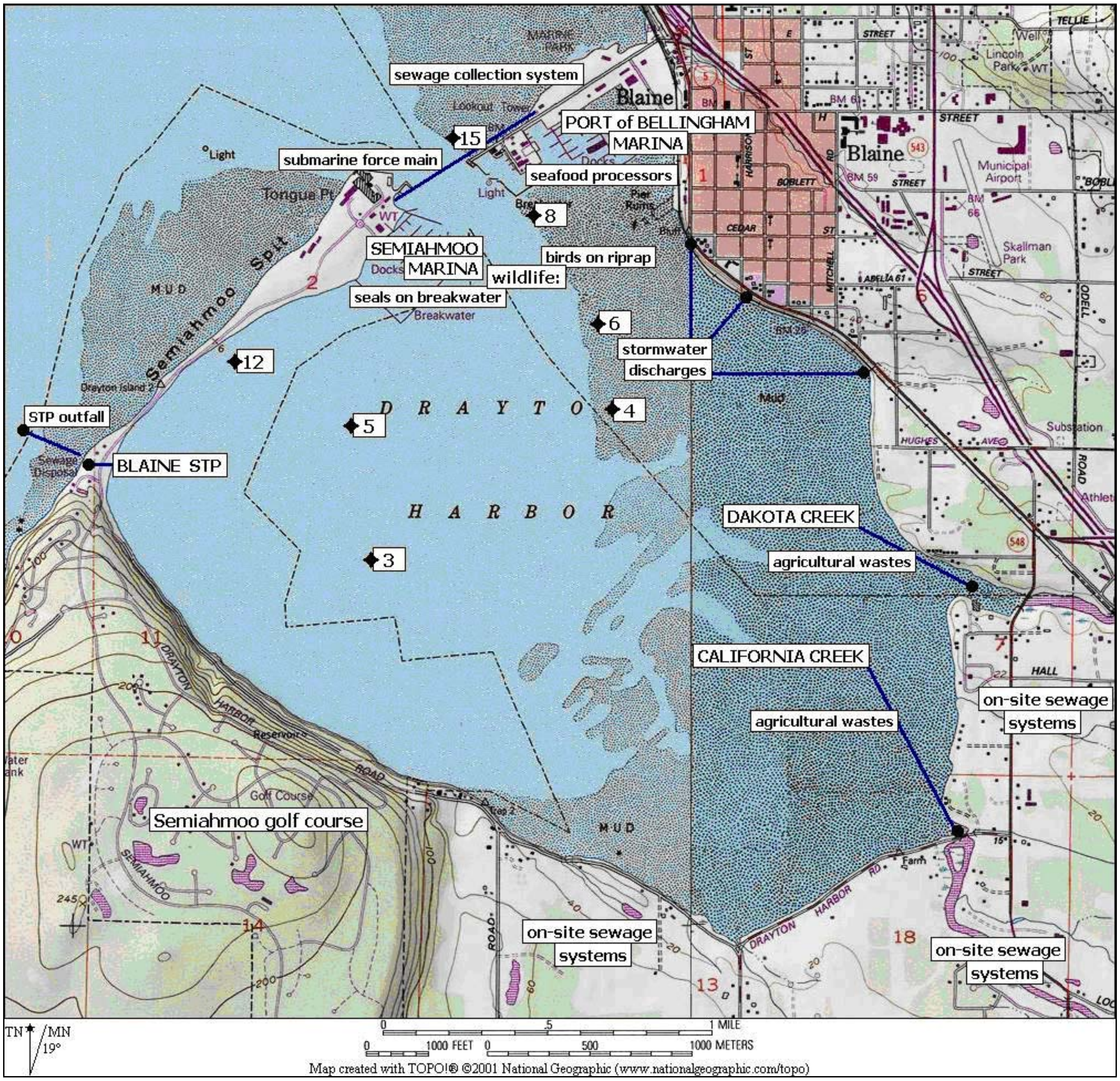

Figure 5. Potential sources to Drayton Harbor (Lennartson, 2004).

Permit holders

Fecal coliform (FC) bacteria can be present in a wide variety of municipal and industrial wastewater and stormwater sources. No method is 100% effective at removing FC all of the time, hence FC bacteria can enter the receiving waters from these sources. Fecal coliform bacteria and potential contaminants from industrial and municipal sources are regulated by various National Pollutant Discharge Elimination System (NPDES) and general permits from Ecology.

Most homes within the city of Blaine and its Urban Growth Area discharge sewage to the Blaine WWTP collection system. Wastewater is treated biologically in rotating contactors, followed by secondary clarification, and then post-treatment chlorine disinfection. Treated and disinfected wastewater is discharged into Semiahmoo Bay approximately ½ mile from the shore, via a submerged diffuser (Hoyle-Dodson, 1997). The plant holds an individual wastewater permit, which is regulated by Ecology.

Construction plans have recently been approved for the new City of Blaine Lighthouse Point Water Reclamation Facility (WRF). The new facility will have increased capacity for wet weather events and future growth, including membrane bioreactor (MBR) technology, and will eventually replace the existing WWTP. The new WRF will be located along Marine Drive near the Blaine Marina. The outfall for the new facility will remain the same, but the sewage main that runs beneath the mouth of Drayton Harbor will carry treated effluent (Adolfson, 2006).

The watershed currently has 11 active dairies with 7,029 mature dairy animals (Pentzer, 2007), several commercial livestock operations, and numerous small non-commercial farms. Most are non-permitted facilities; however, all Class A dairies are required to operate in accordance with the state Dairy Nutrient Management Act, and they are inspected periodically by the Washington State Department of Agriculture (WSDA). New Concentrated Animal Feeding Operations (CAFO) regulations are under development and will be administered by Ecology.

The Washington State Department of Transportation (WSDOT) highways and facilities within the Phase I, Phase II, and applicable TMDL areas are covered under a NPDES stormwater discharge permit. Within these areas, the WSDOT is required to focus implementation of its stormwater management program (SWMP), including water quality monitoring and field investigations of illicit discharges into its conveyances. WSDOT shall report the findings of its investigations and the actions taken to implement its SWMP in the annual report. For the rest of the state not directly covered by the permit, WSDOT will implement it’s Ecology approved Highway Runoff Manual and Ecology approved Stormwater Management Program as its default stormwater control program. Within the Blaine Road study area, WSDOT controls state highway 548 and Interstate 5.

The Blaine marina has several seafood processors. The processors have combined to form a consortium and no longer discharge to Blaine WWTP but to a separate outfall at the mouth of Drayton Harbor. The seafood processors are regulated by Ecology through an industrial state waste discharge permit (Henderson, 2007).

Both marinas operate vessel marine sanitation device pump-out stations, which discharge to the Blaine WWTP.

Wildlife and background sources

Migratory and other birds are often seen in fields and in the harbor itself. Birds, elk, deer, beaver, muskrat, and other wildlife in headwater and rural valley areas are potential sources of FC bacteria. Open fields are attractive feeding grounds for some birds whose presence can increase FC counts in runoff.

Bird counts conducted by the Port of Bellingham from October 2005 to September 2006 in the commercial portion of the Blaine Harbor Marina ranged from 96 in November 2005 to 802 in July 2006. Gulls were the most common bird observed followed by cormorants and then pigeons. A small number of Canada geese, crows, and great blue herons were also spotted. The highest bird densities were observed on the breakwater surrounding Blaine Harbor and higher densities in spring and summer months were attributed to cormorant nesting on the rock portion of the breakwater (Hirsch, 2007).

According to the Washington State Department of Fish and Wildlife surveys, marine bird and waterfowl densities are:

- 400 – 1,000 birds per square kilometer throughout most of Drayton Harbor in the winter, with densities greater than 1,000 birds/ km^2 at the Blaine Marina and the mouth of California Creek.

- Above 1,000 birds/ km^2 at the marina, dropping to 200 – 400 birds/ km^2 at California Creek during the summer. Bird densities are generally lower in the summer, except at the mouth of Dakota Creek where concentrations remain at 400 – 1,000 birds/ km^2 (Berbells, 2006).

The Washington State Department of Fish and Wildlife has identified three seal haulout sites within Drayton Harbor: (1) one along the channels off Dakota Creek, (2) one on the shoals and channels in central Drayton Harbor, and (3) one on the floats at Semiahmoo Marina. Quantities at these haulout sites are less than 100, except for at the Semiahmoo Marina, which is estimated at 100 to 500 (Berbells, 2006).

Usually these sources are dispersed and do not elevate FC counts over state criteria. Sometimes birds and animals are locally concentrated and can cause elevated counts. Concentrated bird and wildlife presence in the watershed will be noted during sampling surveys.

Nonpoint sources

Agriculture

Nonpoint sources and practices are dispersed and not readily controlled by discharge permits. Several types of potential nonpoint sources are present in the study area. Range and pastured livestock with direct access to streams can be a source of FC contamination. Poor livestock or pet manure management on non-commercial farms is another source.

Fecal coliform bacteria from nonpoint sources are transported to surface water by direct and indirect means. Manure that is spread over fields during certain times of the year can enter streams via surface runoff or fluctuating water levels. Often livestock have direct access to water. Manure is deposited in the riparian area of the access points where fluctuating water levels, surface runoff, or constant trampling can bring the manure into the water. Swales, sub-surface drains, and flooding through pastures and near homes can carry FC bacteria from sources to waterways.

The Whatcom Conservation District recently conducted a livestock windshield survey and identified approximately 233 animal-holding sites in the Drayton Harbor watershed as follows: 136 horse sites; 79 cattle sites; and less than ten sites each of sheep, goat, llama/alpaca, and swine (Berbells, 2006).

On-site septic systems

Malfunctioning or antiquated on-site septic systems (OSS) can seep FC bacteria into waterways.

In 1997-98, Whatcom County Health Department inspections identified 54 failing systems out of 252 OSS systems inspected. The inspections were conducted within priority drainage areas of Drayton Harbor identified as having elevated bacteria counts by a Western Washington University study. Of the 54 systems that failed, all but one has been repaired (DHSPD, 2007).

During a 2006 shoreline survey, DOH evaluated OSS systems along the Drayton Harbor shoreline and found that the majority of the systems were older, gravity-fed systems. Eight developed parcels were identified as potential sources of pollution; however, none of these systems were found to be impacting the harbor (Berbells, 2006).

Recreation

Recreational opportunities in the Drayton Harbor watershed include boating, fishing, golfing, and waterskiing. A public boat launch is available at the Blaine Marina. Two public parks, Semiahmoo County Park and Blaine Marine Park, provide shoreline access and walking/hiking trails. The Semiahmoo Company operates a major resort and marina at the tip of the Semiahmoo Spit, as well as a private golf course southeast of the spit. Three other courses exist in the watershed: one in the Dakota watershed and two in the California Creek watershed. Water skiers are occasionally seen in Drayton Harbor in the summer. Borderline Sports and Waterskiing owns and operates Borderline Lake, a man-made lake in the Dakota Creek watershed (Peterson, 1995).

Other nonpoint sources

Road runoff, pet waste, and other nonpoint sources can add FC bacteria to the waters flowing to Drayton Harbor.

Historical Data Review

Freshwater bacteria data

Northwest Indian College 1998-2007

Since 1998, Northwest Indian College (NWIC) has collected monthly FC samples on 11 sites within the study area of the TMDL. The NWIC sites include: 5 on Dakota Creek, 3 on California Creek, the mouth of an unnamed creek on the 303(d) list, the mouth of Cain Creek, and an outfall that discharges to Cain Creek at its mouth. Appendix A of this report includes an analysis of 1999-2007 NWIC FC data. A map of the NWIC sampling sites is also included Appendix A. The analysis of NWIC data includes:

- Trend analysis of the NWIC stations.
- Monthly geometric mean and 90th percentile statistics.
- A comparison of FC levels for select periods.

Summary findings include:

- The most frequent violation of freshwater water quality standards occurred during the dry season. All sites, except for the mouth of California Creek, violated the 90th percentile criterion during this period, while three of ten stations violated the geometric mean criterion.
- For the wet season analysis, only two stations, Cain Creek at the mouth and the outfall at Cain Creek, violated water quality criteria. However, several stations were close to exceeding the 90th percentile criterion. The outfall exceeded the 90th percentile criterion, while Cain Creek at the mouth exceeded both criteria.
- The mouths of Dakota and California Creeks were below the freshwater water quality standards, but exceeded the geometric mean and 90th percentile criteria during both the wet and dry season when compared to marine water quality standards. Preliminary salinity surveys suggest that these stations will most likely be compared to marine criteria.

Marine bacteria data

Port of Bellingham/ Hirsch Consulting

The Port of Bellingham (Port) began monitoring water quality in the Blaine Harbor marina in 1997 to establish base-line data prior to expanding the marina. In August 2000, monitoring began in accordance with a 10-year monitoring plan. Fecal coliform monitoring occurs on a monthly monitoring basis during years 1, 2, 5, and 10; with summer-only monitoring during the off years. A 2007 report (TEC Inc, Hirsch Consulting Services) summarized 2005-06 results. Report conclusions were as follows:

- 2006 FC results for all sample stations within the marina failed the water quality standard.
- Visual inspection of historical FC data graphs shows levels reached a peak in fall of 1999 and then dropped until summer/fall of 2001, when they began to climb again to current levels.
- In 2006, breakwater areas represented 69% of the total bird count and included glaucous-winged gulls, cormorant, and pigeons.

Washington State Department of Health (DOH)

DOH collects monthly or bimonthly marine data in Drayton Harbor for FC bacteria, temperature, and salinity. There are 11 monitoring sites in Drayton Harbor. Appendix B of this report includes an analysis of 1999-2007 DOH fecal coliform data. A map of the DOH sampling sites is also included in Appendix B. The analysis of DOH data includes:

- Trend analysis of the marine stations.
- Monthly geometric mean and 90th percentile statistics.
- A comparison of FC levels for select periods.
- A comparison of FC levels in ebb-versus-flood conditions.
- A comparison of FC levels and precipitation.

Summary findings include:

- Since 1999, there has been some improvement in fecal coliform levels at DOH station 15.
- For DOH stations 3 - 6, 12, and 313-315, higher FC levels are seen during the November through February period.
- Stations 8 and 15 have the highest fecal coliform levels of any of the stations in Drayton Harbor. No clear, monthly FC pattern is present for these stations.
- For stations 5 and 12, higher FC levels are seen on the flood tide. At stations 11 and 15, higher fecal coliform levels are seen on the ebb tide.

DOH produces an Annual Growing Area Review for each growing area. For the 2006 Drayton Harbor review (Melvin, 2007), the area met standards with some *concerns*. Stations of *concern* are those stations where there are some concerns with the sanitary conditions in the growing area. A station goes into concerned status when the annual analysis of the previous 30 samples shows a 90th percentile FC value between 20 and 30 cfu. When the 90th percentile falls between 30 and 40, the station is classified as *threatened*. Numerous actual and potential pollution sources were identified during the June 2006 shoreline survey (summarized below). Sources noted included: (1) FC from Dakota, California, and Cain Creeks and (2) stormwater culverts and drainages near Blaine.

Puget Sound Restoration Fund

Whatcom County Public Works Department contracted with the Puget Sound Restoration Fund (PSRF) to conduct a wet-weather marine sampling program in Drayton Harbor. The purpose of the sampling was to determine whether the harvest closure threshold (0.75" of rain in a 24-hour period) could be adjusted upward. Eight sample events were conducted from March 2006 - May 2007. Samples were obtained up to 5 days after a 0.50 – 1.00" rain event.

The limited sample results showed that stations 4 and 15 exhibited the strongest correlation between rainfall and FC concentration. The study results did not support an upward adjustment of the rainfall level for harvest closure but confirm that following a rain event of < 0.75" in a 24-hour period, water quality is acceptable for shellfish harvest (PSRF, 2007).

Shoreline/stormwater surveys

Washington State Department of Health (DOH) - 2006

DOH recently evaluated 41 discharge points and 27 developed parcels along eight miles of Drayton Harbor shoreline. A site map, as well as descriptions and coordinates, for the shoreline discharges can be found in Appendix D. DOH collected fecal coliform samples and measured or estimated flow (where possible) at 20 sites in spring 2006. Flows ranged from less than 1 gallon per minute (gpm) to 237 gpm. Five sites had fecal coliform concentrations greater than 100 cfu/100 mL (Table 4). All five sites are concentrated within a ¾ mile stretch of Drayton Harbor Road along the south harbor shoreline (Berbells, 2006).

Table 4. DOH shoreline sites with fecal coliform concentrations greater than 100 cfu/100 mL.

Site #	Date	Flow (gpm)	FC/100 ml	Approx. FC/Day
01	3/29/06	<5	220	4.79×10^7
	4/20/06	5 *(estimated)*	>2,400	6.81×10^8
03	4/20/06	23	240	3.01×10^8
05	4/5/06	<5	130	2.83×10^7
12	4/20/06	<5	110	2.40×10^7
36	3/29/06	15 *(estimated)*	110	2.99×10^7

Drayton Harbor Community Shoreline WQ Sampling Program - 2001

In 2001, The Puget Sound Restoration Fund collected FC samples and flow measurements from ten shoreline drainages to Drayton Harbor. A site map and descriptions are located in Appendix E. Community volunteers were trained by DOH staff and the Blaine WWTP laboratory analyzed the samples. Sample results are summarized in Table 5 (Menzies, 2002).

Results of the study showed:

- Every drainage violated freshwater standards on at least one occasion.
- The flushing event captured on August 22, 2001, produced the highest concentrations at all sites and the greatest loading at all-but-one site. Flushing events after prolonged dry periods have a severe impact to the harbor.
- Sites 2, 3, 5, and 6 were found to be the highest priority, given the frequency of concentrations greater than 100 cfu/100 mL.

Table 5. Results for Drayton Harbor Community Shoreline Water Quality Sampling Program (Table from: Berbells, 2006). Fecal Coliform Results, FC/100 mL.

Site	DOH Site	7/24/2001	8/22/2001	9/12/2001	10/23/2001	11/13/2001	12/12/2001	Geomean
1		1,070	1,531	100	58	27	70	162
2	23	4,433[a]	2,800	600	254	40[a]	1,160	667
3	24	1,520[a]	6,100	--	600	247	3,000	1327
4	30	800[a]	11,200	1,300	88	100[a]	80	449
5	31	--	12,000	181	40	80*	144	251
6		--	49,000	<100	139	85	380	685
8	22	28	270	<100	44	40	65	61
9	21	196	16,000	<100	246	53	20[a]	241
10		--	2,000	--	82	2[a]	29[a]	56
11	20	16	630	<100	29	35	74	60

[a] Number estimated by the Blaine STP Laboratory.
* Due to initial lab error on November 13, 2001, this site was re-sampled on November 15, 2001.

Western Washington University - Cykler, Haggerty, and Matthews, 1995

In response to January 1995 shellfish closures by the DOH, Western Washington University conducted a three-part fecal contamination study in Drayton Harbor. The study consisted of: (1) oyster tissue bacteria sampling in the Blaine Marina area, (2) bacteria sampling and flow measurements at stormwater outfalls and tributaries to Drayton Harbor, and (3) a dye test of the sewer line across the mouth of the harbor.

The study concluded that bacteria contamination was much higher at oyster tissue sites within the marina and that commercial fish processing appeared to be the greatest source of contamination. In the shoreline sampling surveys, sites were sampled six times during July 1995, including two *flush* rain events where prolonged dry conditions were followed by short storm events. Out of a total 30 sites, water quality standards were violated at all-but-one sampling site. No dye was detected when testing the sewer line (Cykler et al, 1995).

Based on the results of the shoreline survey, 18 of the 30 sites were determined to be high priority sites. Whatcom County later conducted OSS inspections in the drainage areas of these high priority sites and identified and repaired 53 failing septic systems.

Drogue/circulation studies

Washington State Department of Health - 2005

Staff from the Washington State Department of Health (DOH), the Food and Drug Administration (FDA) and Nooksack Tribe conducted a dye and drogue study at the Blaine WWTP outfall in June 2005. The study was conducted during adverse tidal conditions. The study confirmed that effluent from the Blaine WWTP enters Drayton Harbor within a single major flood tide cycle. Minimum dye dilutions monitored in the study indicate that a dilution of at least 300:1 was achieved within the 300-yard minimum size shellfish closure zone around the WWTP outfall (Meriwether and Kinney, 2006).

Washington State Department of Health - 2003

DOH staff conducted a dye and drogue study in Drayton Harbor on July 14, 2003, to determine if pollution at DOH Station 8 received sufficient dilution to not present a shellfish water quality concern at DOH Stations 4 and 6. Results of the dye dilutions during the study indicate that dilution of the DOH Station 8 waters was rapid and substantial during the middle and latter portions of the flood tide. The drogue pathways indicated that water from DOH Station 8 can pass directly through the area of DOH Station 6 just after the incoming water is starting to cover the adjacent mudflats. Given the high levels of pollution at DOH Station 8, DOH recommends that no shellfish be harvested from the area of Station 6. Shellfish harvest from the Drayton Harbor Community Oyster Farm in the area of DOH Station 4 is possible if certain other criteria are satisfied.

Hays and Company Consultants - 2003

In 2003, Hays and Company Consultants developed, calibrated, and ran a three-dimensional bacteria model of Boundary Bay, Semiahmoo Bay, and Drayton Harbor in both the United States and Canada. The model was primarily based on FC and flow data from 2001 for six major inputs: (1) Serpentine River, (2) Nicomekl River, (3) Little Campbell River, (4) Dakota Creek, (5) California Creek, and (6) Blaine WWTP.

The study concluded that Little Campbell River had the greatest potential impact, followed by Dakota Creek and the Serpentine River. It also suggested more data was needed for inputs in future modeling efforts (Hay and Co., 2003).

Puget Sound Restoration Fund/ Department of Health - 2002-03

Blaine Harbor/Mouth of Drayton Harbor Drogue Studies

The Puget Sound Restoration Fund (PSRF) under contract with Whatcom County Health worked closely with DOH to conduct a series of circulation studies to better understand movement of water in the commercial portion of Blaine Harbor (Puget Sound Restoration Fund, 2003). Drogues were set to capture current at various depths: 21 inches, 3, 10, and 21 feet. The drogues were released about two hours before and after high slack tide capturing both ebb and flood tides. Sampling occurred on the following dates: March 20, 21, 22, and April 17, 2002.

During the later ebbing tide, the surface drogues (21" and 3') did not exit Blaine Harbor. On one occasion, the 10' drogue would have exited the Harbor but was caught by its surface float. Drogues deployed at the center of the entrance to Drayton Harbor at the start of flood tide moved into the Harbor in a south-to-southwesterly path. This suggests that pollution, which originates inside of Blaine Harbor and exits with the ebb tide, can re-enter Blaine Harbor in short order (Puget Sound Restoration Fund, 2003).

The series of drogue releases showed that there is little if any exchange of surface water from Blaine Harbor to surrounding waters during the ebb tide, but some exchange of deeper water may occur. Also, fecal coliform contaminated water from inside of Blaine Harbor likely does not impact DOH stations 3, 4, 6, and 12 (Puget Sound Restoration Fund, 2003).

Three additional drogue studies were done by PSRF on August 29 and September 9-10, 2002. Results of these studies were similar to results described above. It is unlikely that DOH stations 4 and 6 in the commercial growing area are influenced by surface water quality at DOH stations 8 and 15, or any of the sites within Blaine Harbor. Again, none of the drogue floats placed in Blaine Harbor left the harbor area.

Microbial source tracking studies

Herrera Environmental Consultants - 1998

In 1998, the City of Blaine contracted with Herrera Environmental Consultants to conduct a microbial source tracking (MST) project on Drayton Harbor. The goal of the project was to identify the specific source species contributing bacterial pollution to Drayton Harbor.

Herrera sampled four marine sites and three freshwater sites (Cain and Dakota Creeks and Portal Way drain) using genetic fingerprinting deoxyribonucleic acid ribotyping. Samples were collected for fecal coliform bacteria as well as *E. coli* for the MST study. High numbers of fecal coliform were found during rainfall runoff conditions. Results of the MST study did not give an adequate picture of possible sources present in the watershed. Approximately 53-71% of the ribotypes obtained could not be matched to a source.

When conducting a MST study that requires matching source types from a library, it is important to have a very large library that has catalogued a variety of sources. During the period when this MST study was done, it is likely the library was not large enough to provide a complete view of sources in the watershed. False negatives are a problem with MST studies due to the difficulty and expense of conducting enough sampling to adequately address all pollution event conditions.

Sources found in Cain Creek included cat, dog, duck/goose, and gull. Portal Drain sources included cat, dog, and duck/goose. In the Dakota Creek watershed, there were human, cow, horse, and duck/goose sources. There were not many sources matched to the marine stations except fish, cow, horse, duck/goose, seal, gull, pigeon waste. Oyster meats were also tested and again the match rate was low; sources matched included cow, duck/goose, seal, and gull.

Puget Sound Restoration Fund/ Hirsch Consulting Services - 2006

In 2006, Puget Sound Restoration Fund commissioned Hirsch Consulting Services to conduct another microbial source tracking (MST) study in the Drayton Harbor watershed. Hirsch Consulting developed a monitoring plan (Hirsch Consulting Services, 2006) and started MST sampling in 2006-2007. For this MST project, two indicators were used: *Bacteroides* was the primary indicator and DNA Ribotyping was used for a subset of samples to corroborate *Bacteroides* results and to further distinguish possible sources. Five sites on California Creek were included in the study and eight marine sites in Drayton Harbor. The results of this study are due at the end of December 2007.

Critical periods and areas

Based on analysis of the historical data, there are several critical periods and areas where fecal coliform levels are elevated. Elements of the TMDL study will be designed to address these issues, including:

- For most of the marine stations within Drayton Harbor, bacteria counts are elevated from November to February. The highest counts occurred at DOH stations 8 (near the breakwater and entrance of Blaine Marina) and 15 (near the entrance to the harbor and Blaine Marina in Semiahmoo Bay). At these two sites, there was no seasonal pattern to the high fecal coliform levels.
    - Ecology will increase sampling frequency from November to February to obtain 10 events during this period. Multiple shoreline surveys will also be targeted within this critical season.

- Freshwater bacteria concentrations from Dakota, California, and Cain Creek are most critical from May to September. During this period, the 90th percentile criterion is most frequently violated suggesting infrequent events, such as flushing events, are the main cause of bacteria pollution.

    - Ecology will increase sampling frequency to obtain 10 events during this period as well, and multiple shoreline surveys and storm events will also be targeted within this critical season.

- Shoreline discharge surveys identified bacteria sources from both the stormwater system of central Blaine and discharges along the southern shoreline. Prolonged dry periods followed by *flushing* storm events resulted in very high bacteria counts.
    - Flushing storm event and shoreline surveys will be targeted in both wet and dry critical periods. Replicate samples will be taken at previously identified high priority shoreline discharges.

- Water quality violations occurred at all sites sampled within the Blaine Marina in 2006.
    - Transects within both marinas will be sampled during shoreline surveys to determine concentrations within the marinas relative to other sources entering the harbor.

Project Goal and Study Objectives

Project goal

The goal of the overall TMDL project is to ensure that both impaired marine and freshwater within the study area will attain water quality standards.

Phase 1 objectives

Objectives of Phase 1 of the proposed study are as follows:

- Establish load allocations for nonpoint sources and wasteload allocations for point sources to meet water quality standards and protect beneficial uses, including primary contact recreation and shellfish harvesting.
- Identify and characterize FC bacteria concentrations and loads from all significant tributaries, point sources, and drainages into Drayton Harbor under various seasonal or hydrological conditions, including stormwater contributions.
- Identify location of sources of FC to Dakota, California, and Cain Creeks.
- Identify relative contributions of FC loading to Drayton Harbor so clean-up activities can focus on the largest sources.

Study Design – Phase 1

Overview

The study objectives will be met through characterizing annual and seasonal FC bacteria loads for all significant surface waters draining to Drayton Harbor and Semiahmoo Bay within the study area. Fecal coliform concentrations will be monitored at the mouths of all tributaries, point sources, significant drainage/discharges, and three locations within Semiahmoo Bay over a 13-month period. When possible, flow will be measured at all sites at the time of sampling.

The freshwater component of the TMDL Study will use a fixed-network of sites sampled from December 2007 to December 2008 (Table 6). Fixed-network sites will be sampled once every 2-3 weeks, with one sampling event coinciding with the Washington State Department of Health (DOH) sampling every month and other events scheduled as necessary to get the desired number of total events per season (Table 6).

DOH currently samples 11 stations within Drayton Harbor on a monthly basis. An additional three sites will be added to the DOH sampling run in Semiahmoo Bay to help identify background fecal coliform concentrations. Ecology will coordinate with the DOH and sample in the watershed on the same day as bay sampling occurs. If the sample run cannot be completed in one day, then the lower watershed will be sampled on the same day as the DOH run and the upper sites on California and Dakota Creeks will be sampled the day before the marine sampling.

TMDL allocations at all freshwater sites will be set based on measured data (no modeling will be used). The roll-back method (Ott, 1995) will be used to determine how much (in terms of percentage) that FC concentrations need to be reduced at each sampling site.

Sampling of shoreline discharges and sites within the two marinas will occur 4-5 times throughout the course of the project (Table 6).

Instantaneous FC loads will be estimated at each site using the best available streamflow data. Loads estimated at individual sites and within reaches will be compared to adjacent loads to characterize potential areas of excessive FC loading or areas of FC losses.

Practical constraints, such as staff availability, weather/road conditions, and safety concerns may limit the ability of project staff to collect the number of samples or sample events outlined in the QA Project Plan.

Table 6. Proposed temporal distribution of fixed-network sites, synoptic shoreline, and DOH bay sampling surveys.

Survey Type	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fixed-network sites	2	2	2	1	1	2	2	2	2	2	1	2	1
Marine sampling (DOH/PSRF)	1	1	1	1	1	1	1	1	1	1	1	1	1
Shoreline/storm sampling	1	1	*					1	1	*		1	

* If a shoreline survey storm event is not captured in December or January, then it may be sampled in February. Likewise, a dry season storm event may be sampled in September if necessary.

Details

Fixed-network sampling

Data from the fixed-network sampling will provide FC data sets to meet the following needs:

- Provide an estimate of the annual and seasonal geometric mean and 90th percentile statistics FC counts. The schedule should provide at least 10 samples per site during the dry season (May – September) and 10 samples per site during the more intense months of the wet season (November – February). Sites will also be sampled once a month during the shoulder season months of March, April, and October.
- Provide reach-specific FC load and concentration comparisons in Dakota, California, and Cain Creeks: (1) to define areas of increased FC loading (e.g., malfunctioning on-site systems, livestock, wildlife, or manure spreading) or (2) FC decreases (e.g., settling with sediment, die-off, dilution, or diversion). With accurate streamflow monitoring, tributary and source loads also can be estimated.
- Identify if certain land uses affect instream changes in FC loads.

The fixed-network sites will be sampled from December 2007 to December 2008 (Table 6). The locations of the fixed-network water quality stations are listed in Tables 7-8. Stations were selected based on historical site locations and FC results. The freshwater sampling component will consist of 32 fixed-network sites. Stations within the California Creek watershed will be sampled by Whatcom County. All other stations will be sampled by Ecology field staff.

Fecal coliform bacteria are sensitive to saltwater and die-off rates change when entering estuarine waters. Monitoring of stations under tidal influence will occur during ebb tide so fecal coliform samples reflect the freshest input possible. Salinity will be checked to determine if stream water is sampled.

Sites may be added or removed from the sampling plan depending upon access and new information provided during the QA Project Plan review, field observations, and preliminary data analysis.

Department of Ecology - Whatcom County sampling coordination

Field measurement and sampling responsibilities will be shared by Ecology and Whatcom County. All samples will be analyzed by Manchester Environmental Laboratory (MEL). The comparability section presented later in this document outlines the measures that will be taken to ensure consistency between Ecology and Whatcom County.

Prior to each fixed network sampling run, Ecology will prepare coolers, sample containers, tags, lab processing paperwork, and other sampling equipment as necessary for both Ecology and Whatcom County. Ecology will also simultaneously calibrate three Hydrolab multi-probes: one for each sampling team and one back-up. Whatcom County will collect measurements and samples at each site using Ecology's Hydrolab and containers. Both sample teams will meet at the end of the day and Whatcom County will transfer their samples and equipment to Ecology.

Ecology will sample sites in the Dakota and Cain Creek drainage areas as well as two direct drainages to Drayton Harbor (Table 7). Whatcom County will sample sites within the California Creek watershed (Table 8).

Table 7. Fixed-network sites in the Drayton Harbor Watershed.

Site ID	Road Crossing or Access
Dakota Creek Watershed	
1-Dak-0.1	Dakota Cr at SR 548 bridge crossing
1-Dak-3.1	Dakota Cr at Giles Street bridge crossing
1-Dak-6.8	Dakota Cr at Valley View Rd bridge crossing
1-NF-Dak-0.1	NF Dakota Cr at Custer School Rd
1-NF-Dak-2.5	NF Dakota Cr at Delta Line Road
1-SF-Dak-0.2	SF Dakota Cr at Custer School Rd
1-TribDak-1	Trib to Dakota Cr at Blaine-Lynden Rd nr Odell St; joins Dakota at RM 0.9
1-TribDak-2	Trib to Dakota Cr at Blaine-Lynden Rd nr Harvey Rd; joins Dakota at RM 1.1
1-TribDak-3	Trib to Dakota Cr at Rogers Road; joins TribDak-4 and then Dakota at RM 1.7
1-TribDak-4	Trib to Dakota Cr at Hoier Road; joins TribDak-3 and then Dakota at RM 1.7
1-TribDak-5	Trib to Dakota Cr at Valley View Rd north of McGee; joins Dakota at RM 2.8
1-TribDak-Giles	Outlet to Giles Pond at W. 88 St.
1-TribDak-NF1	Trib to NF Dakota Creek at Haynie Rd; joins NF Dakota at RM 2.0
1-TribDak-NF2	Trib to NF Dakota Creek at Delta Line Rd; joins NF Dakota at RM 2.1
1-Dak-SD1	Surface ditch that drains to Dakota Creek near mouth
Cain Creek Watershed	
1-Cain-1.3	Cain Cr at Pipeline Road south of Airport
1-Cain-0.4	Cain Cr at H Street and Harrison Ave.
1-Cain-0.01	Cain Cr at mouth; west of Marine Dr.
1-Cain-SD1	Storm drainage outfall to Cain Cr near mouth
Direct Inputs to Drayton Harbor or Semiahmoo Bay	
1-TribDray-1	Mouth of trib to Drayton Harbor at Hall & Dearborn
1-Dray-SD4	Albert Street drainage swale (36" by 42" concrete pipe)

Trib – tributary; RM – river mile

Table 8. Fixed-network sites in the Drayton Harbor watershed.

Site ID	Road Crossing or Access
California Creek Watershed	
1-Cal-0.1	California Cr at Drayton Harbor Rd.
1-Cal-0.8	California Cr at SR548/ Blaine Rd.
1-Cal-3.1	California Cr at Birch Bay-Lynden Rd.
1-Cal-5.0	California Cr at Valley View Rd
1-Cal-6.2	California Cr at Bruce Rd
1-Cal-SD1	Storm drainage outfall to California Creek near mouth
1-TribCal-1	Trib to California Cr at Fleet Rd; joins California Cr.
1-TribCal-2	Trib to California Cr at Kickerville Rd; joins California Cr.
1-TribCal-3	Trib to California Cr at Arnie Rd west of Ham Rd
1-TribCal-4	Trib to California Cr at Bay road just west of Bruce Rd.
1-TribCal-5	Trib to California Cr at dead end of Main Street in Custer

Trib – tributary; RM – river mile

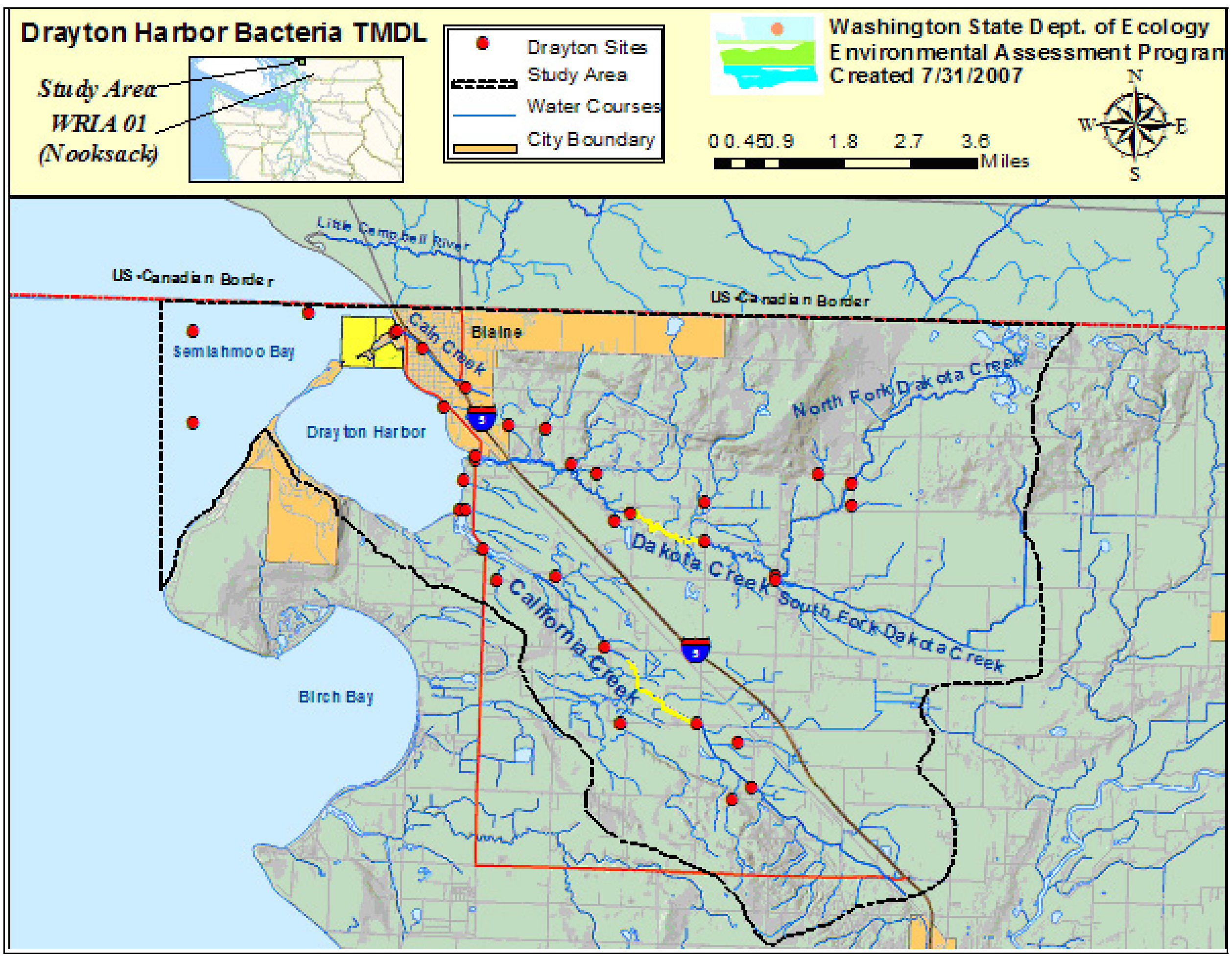

Figure 6. Drayton Harbor Watershed Fecal Coliform TMDL sampling locations.

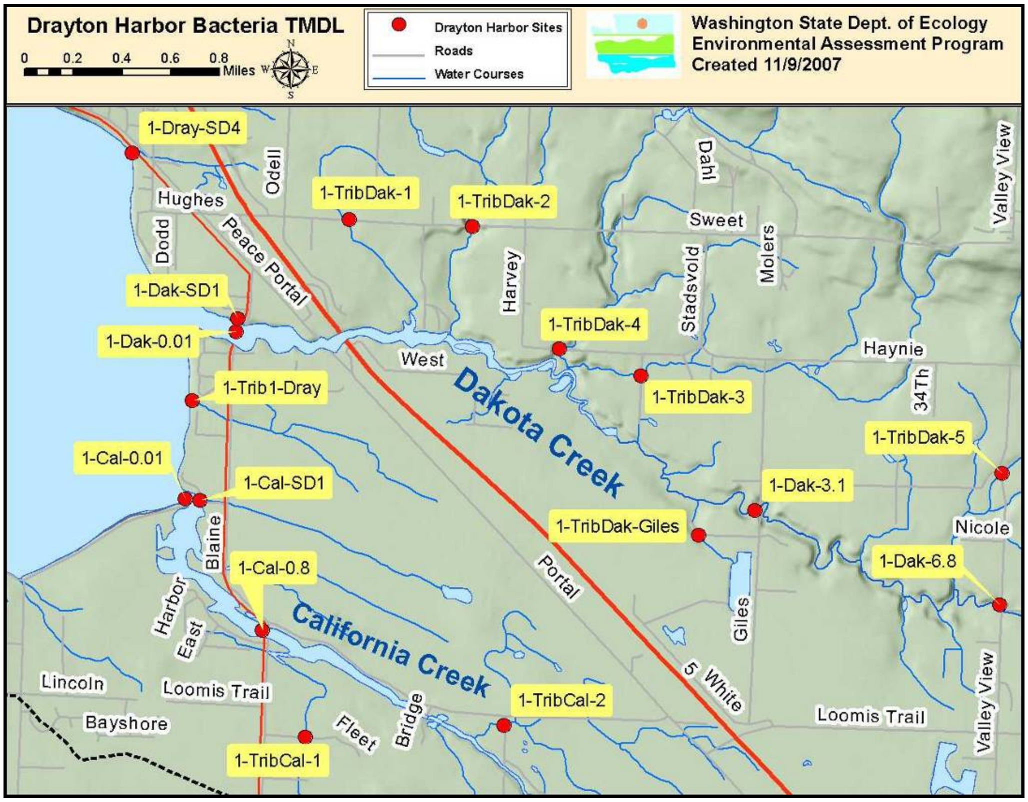

Figure 7. Sampling locations in Lower Dakota and California Creeks drainage areas.

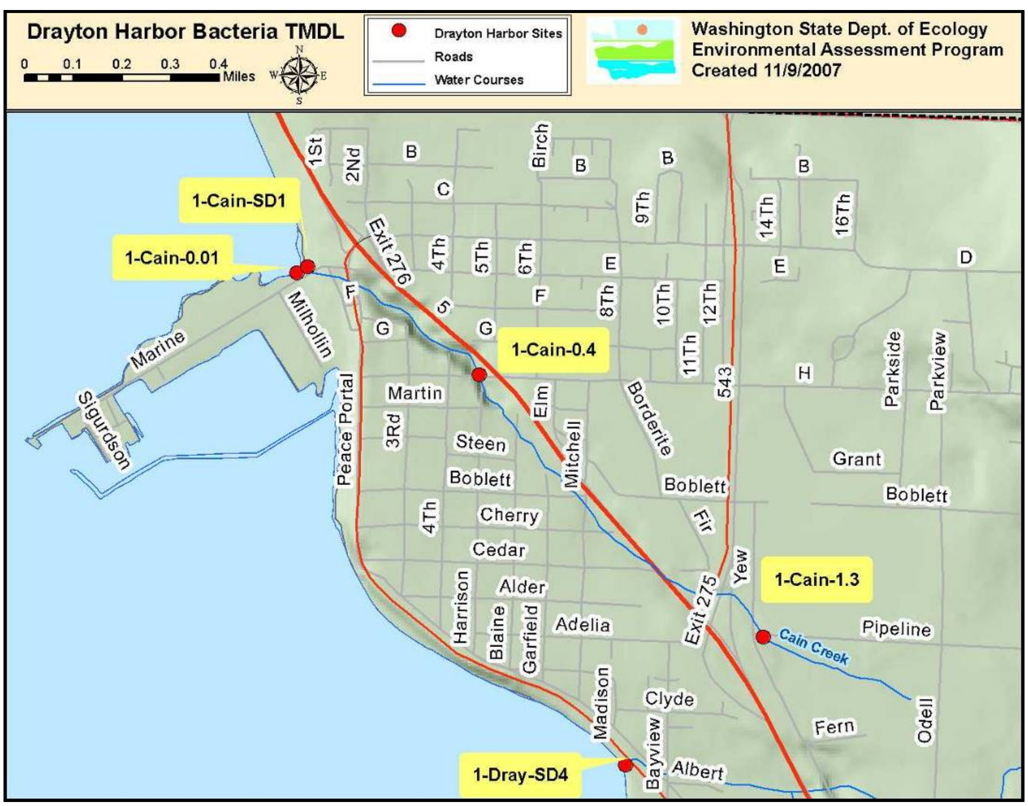

Figure 8. Cain Creek sampling locations.

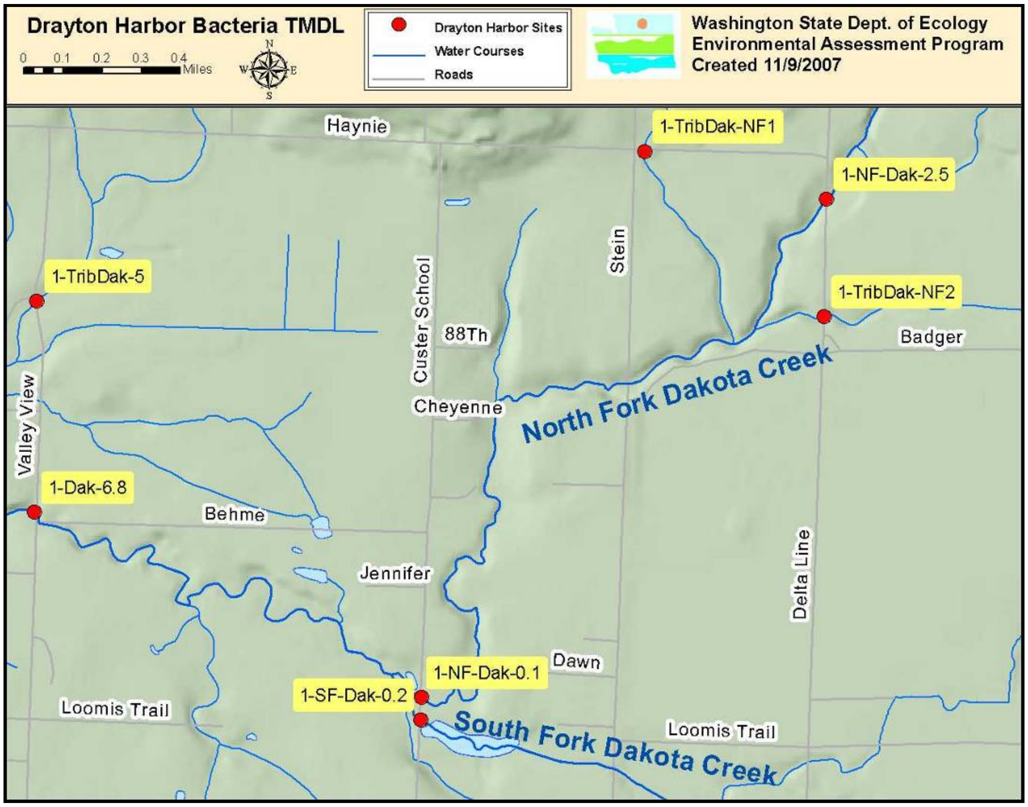

Figure 9. Upper Dakota Creek sampling locations.

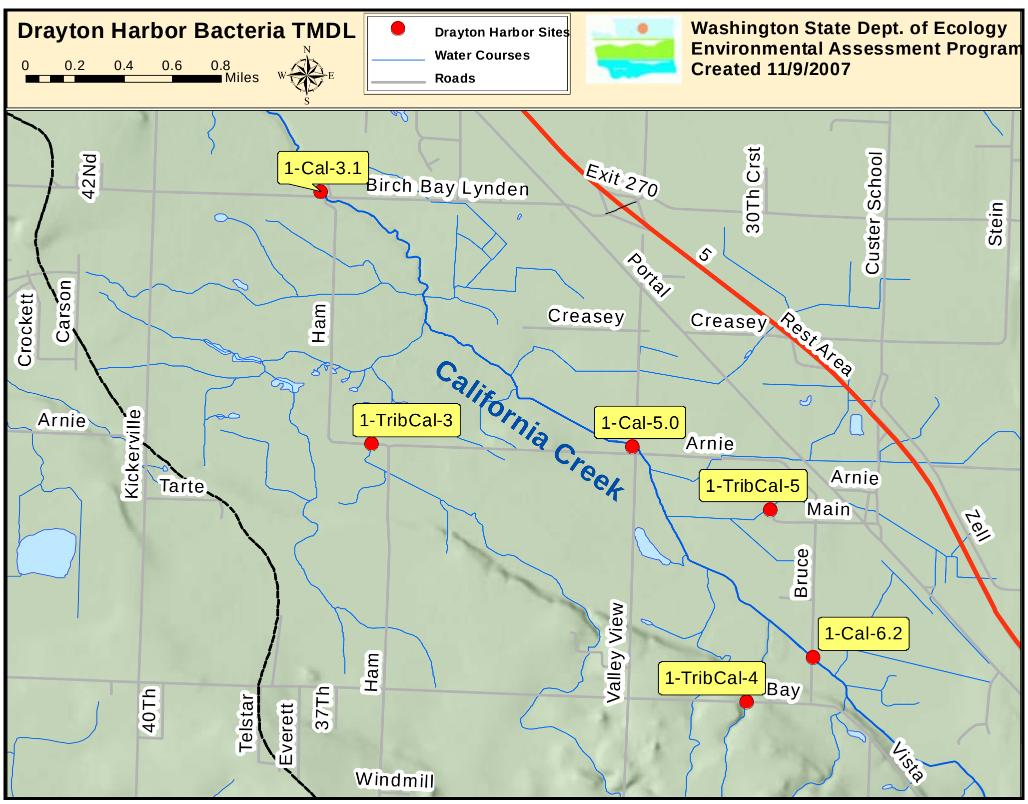

Figure 10. Upper California Creek sampling locations.

DOH marine sampling

DOH and the Drayton Harbor Shellfish Protection District will continue to collect monthly bacteria samples at 11 stations in Drayton Harbor and will begin sampling 3 stations in Semiahmoo Bay (Table 9). Stations 3-5 and 12 are classified *Conditionally Approved* for shellfish harvest. Stations 6, 8, 11, and 15 are classified as *Prohibited* and stations 313-315 are currently *Unclassified*.

Table 9. Marine sites within the TMDL study area sampled by DOH.

Site ID	Site Description
DOH Station 3	Drayton Harbor (DH) at south corner of conditionally approved shellfish area
DOH Station 4	DH at east corner of conditionally approved shellfish area
DOH Station 5	DH near center of conditionally approved shellfish area
DOH Station 6	DH north of DOH #4, outside conditionally approved shellfish area
DOH Station 8	DH approximately 1000 ft SE of entrance to Blaine Marina
DOH Station 11	DH just SW of Semiahmoo Marina breakwater
DOH Station 12	DH at west corner of conditionally approved shellfish area
DOH Station 15	DH approximately 1000 ft NW of entrance to Blaine Marina
DOH Station 313	DH near picnic area at neck of Semiahmoo Bay; currently unclassified area
DOH Station 314	DH southwest of conditionally approved area; currently unclassified area
DOH Station 315	DH southeast of conditionally approved area; currently unclassified area
Semiah-NW	Semiahmoo Bay at northwest corner of the TMDL study area boundary
Semiah-Tower	Semiahmoo Bay near the international border tower
Semiah-WWTP	Semiahmoo Bay west of WWTP outfall

Shoreline and marina transect sampling

In addition to the larger tributaries, the Drayton Harbor shoreline has numerous small drainage/discharge points including stormwater outfalls, unnamed tributaries, and other drainage features. In order to better assess the contribution of FC loading from these drainages, Ecology will conduct 4-5 shoreline discharge surveys. Fecal coliform samples will be collected and flow will be measured or estimated at each measurable discharge site. The shoreline surveys will be coupled with sampling within the Semiahmoo and Blaine marinas.

Within each marina, bacteria samples will be collected at key locations and along transects during the shoreline surveys. Samples will be collected by boat or kayak and will follow Ecology kayak safety protocols (Appendix C).

The goal will be to conduct two shoreline surveys each during both the wet and dry season. Within each season, one survey will be targeted during normal runoff conditions and another during a stormwater runoff event. An additional survey will be conducted during November or December 2008 to compare between the two wet seasons and provide more sampling opportunities (Table 6).

Discharge measurements

Continuous streamflow data will be obtained from two stream gaging stations:

- Dakota Creek at Giles Road (Ecology, Stream Hydrology Unit).
- California Creek at Valley View Road (Ecology, Stream Hydrology Unit).

In wadeable conditions, flow measurements will be taken by measuring cross-sectional area and velocity using a Marsh McBirney Flowmate, wading rod, and tagline. At sites that are unwadeable during certain flow regimes, Ecology will develop discharge rating curves based on stage. Stage measurements will be collected in lieu of flow measurements in these conditions during routine sampling. Ecology will attempt to measure flows from bridges at or near maximum stage at these stations to assist in developing an accurate rating curve.

At some stations, particularly during shoreline surveys, flow measurements may be taken using culvert or timed-volume calculation methods.

Storm monitoring

The purpose of storm monitoring is to better characterize potential sources of FC loading to Drayton Harbor. Storm sampling will occur throughout the course of the project. If sufficient rain and runoff do not occur during this timeframe, the schedule maybe extended. Runoff from areas by range, agriculture, and residential areas will be targeted and bracketed by sites where possible.

Timing may vary with the timing of the storm. For example, if a strong storm occurs in the early morning hours of Day 1, sites could be sampled in the morning and afternoon of Day 1. However, if the storm occurs in the afternoon or evening hours, half the samples may be collected on Day 1 and the other half on Day 2.

The goal will be to sample at least five events. The stormwater sampling sites will include all fixed network sites plus significant outfalls under NPDES Phase II permits. Stormwater NPDES permits are required to have corresponding wasteload allocations set in TMDL studies. Therefore, this study must determine wasteload allocations for each permit holder, including jurisdictions covered by Municipal Stormwater General Permits.

The fixed-network sites will be divided into two sets of sampling sites, based on stormwater drainage characteristics, and subjected to separate storm event criteria. Multiple storm events will most likely be captured during scheduled sampling runs. Additional storm events will be targeted as needed. Storm event criteria may be altered after the initial wet season based on field observations and data review.

For the Cain Creek watershed and the two direct drainages to Drayton Harbor, a storm event will be defined as a minimum of 0.15 inches of rainfall within a 24-hour period. In addition, sampling must begin within 12 hours of the onset of rainfall. Preferably, there will be no more than a trace amount of rainfall (<0.05") in the preceding 24-hour period. However, due to the heavy frequency of rainfall in the winter months, some storm events may be captured with more than 0.05" of rainfall in the preceding 24 hours. These criteria are designed to capture stormwater at sites where the drainage areas are relatively small, have higher percentages of impervious surfaces, and stormwater moves quickly through the system. The goal will be to begin sampling (1) at or near the onset of what looks to be significant rainfall and (2) while rainfall is occurring.

For the Dakota and California Creek watersheds, a storm event will be defined as a minimum of 0.75 inches within a 72-hour period preceding sampling. In these larger drainage systems with less impervious surface, soils often must first become saturated for runoff to occur and it may take several days for stormwater to make its way from the upper watershed to the harbor.

Streamflow will be measured or estimated using stage and rating curves or relationships with other monitoring locations when grab samples are collected. Daily rainfall data will be obtained from the Blaine WWTP and an Ecology rain gage at the mouth of Bertrand Creek.

After regular monitoring has commenced and land use characterized more thoroughly, adjustments to the storm monitoring schedule and site locations may be necessary. Any major adjustments will be addressed through an addendum to the QA Project Plan and sent to the appropriate parties. The ability to quickly and safely access some sites and obtain a representative sample will be a challenge. Permission to sample runoff at some locations is still required.

Special studies

Dakota and California Creeks salinity surveys

Vertical salinity surveys will be conducted by kayak on multiple occasions during a range of tidal conditions to determine whether to apply freshwater or marine water quality criteria at stations within the tidal influence.

Continuous dissolved oxygen, pH, conductivity, and temperature data surveys

Continuous diel monitoring for pH, DO, conductivity, and temperature will be conducted at several sites with Hydrolab DataSondes®. Hydrolabs will be deployed at key sites throughout the Dakota and California Creek watersheds. Sites will be based on Category 2 listings and existing water quality data.

Hydrolabs will be deployed for a 1-2 week period on three deployments: (1) one in late fall/early winter, (2) one during spring, and (3) one during summer.

Study Design – Phase 2

Overview

The goal of Phase 2 will be to collect data to address marine FC 303(d) listings and problems within Drayton Harbor and Semiahmoo Bay. Freshwater data and shoreline surveys collected during Phase I will also be used to assist in data analysis for Phase II. The details of the Phase 2 study design will be presented as an addendum to the QA Project Plan.

Sampling and Measurement Procedures

Field sampling and measurement protocols will follow Standard Operating Procedures (SOP) developed for the Environmental Assessment Program's Directed Studies Unit (EAP-DSU). Grab samples will be collected directly into pre-cleaned containers supplied by MEL and described in the MEL User's Manual (2005). Sample parameters, containers, volumes, preservation requirements, and holding times are listed in Table 10. Bacteria samples for laboratory analysis will be stored on ice and delivered to MEL within 24 hours of collection via Horizon Air and Ecology courier.

Grab samples will be collected using the EAP-DSU SOPs for bacteria (Mathieu, 2006a) and grab sampling (Joy, 2006). Twenty percent of FC samples, and 10% of all other parameters, will be duplicated in the field in a side-by-side manner to assess field and lab variability. Samples will be collected in the thalweg and just under the water's surface.

Table 10. Containers, preservation requirements, and holding times for samples collected during the Drayton Harbor Watershed FC TMDL (MEL, 2005).

Parameter	Sample Matrix	Container	Preservative	Holding Time
Fecal coliform	Surface water, WWTP effluent, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours

Field measurements will be taken at all freshwater sampling sites and will include conductivity, temperature, pH, and dissolved oxygen (DO) using a calibrated Hydrolab MiniSonde® following the EAP-DSU Hydrolab SOPs (Swanson, 2007). DO will also be collected and analyzed using the Winkler titration method (Mathieu, 2006b).

Estimation of instantaneous flow measurements will follow the EA Program-DSU protocol (Sullivan, 2006). Continuous flow gages will be installed by Ecology's Watershed Technical Support Unit and will follow the protocols manual (Butkus, 2005). Volumes will be calculated from continuous stage height records and rating curves developed during the project. Stage height will be measured by a pressure transducer and recorded by a data logger every 15 minutes. All data loggers will be downloaded monthly. Staff gages may be installed at other selected sites. During the field surveys, streamflow will be measured at selected stations and staff gage readings will be recorded. A flow rating curve will be developed for sites with a staff gage.

Data Quality Objectives

Measurement quality objectives state the level of acceptable error in the measurement process. Precision is a measure of the variability in the results of replicate measurements due to random error (Lombard and Kirchmer, 2004). This random error includes error inherently associated with field sampling and laboratory analysis. Field and laboratory errors are minimized by adhering to strict protocols for sampling and analysis. Precision for replicates will be expressed as percent relative standard deviation (%RSD).

Microbiological and analytical methods, precision targets, and method resolution or reporting limits are listed in Table 11. The reporting limits of the methods listed in the table meet the expected range of results and the required level of sensitivity to meet project objectives. The laboratory's measurement quality objectives are documented in the MEL Lab Users Manual (MEL, 2005).

Table 11. Targets for precision and reporting limits for the measurement systems.

Analysis	Method/Equipment	Field Replicate MQO	Lab Duplicate MQO	Reporting Limits and Resolution
Field Measurements				
Discharge Volume	Marsh McBirney Flow-Mate Flowmeter	10% RSD	n/a	0.01 ft/s
Water Temperature[1]	Hydrolab MiniSonde®	+/- 0.2° C	n/a	0.01° C
Specific Conductivity	Hydrolab MiniSonde®	10% RSD	n/a	0.1 umhos/cm
pH	Hydrolab MiniSonde®	10% RSD	n/a	1 to 14 SU
Dissolved Oxygen	Hydrolab MiniSonde® (Clark cell)	10% RSD	n/a	0.1 - 15 mg/L
Dissolved Oxygen[1]	SM4500OC	+/- 0.2 mg/L	n/a	0.1 mg/L
Laboratory Analyses				
Fecal Coliform – MPN	MPN 9221 E2	50% of replicate pairs < 20% RSD 90% of replicate pairs <50% RSD[2]	40% RPD	1.8 MPN/100 mL
Fecal Coliform – MF	SM 9222D	50% of replicate pairs < 20% RSD 90% of replicate pairs <50% RSD[2]	40% RPD	1 cfu/100 mL

[1] as units of measurement, not percentages.
[2] replicate results with a mean of less than or equal to 20 cfu/100 mL will be evaluated separately.
SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA et al., 1998).
EPA = EPA Method Code.

The targets for analytical precision of laboratory analyses in Table 11 are based on historical performance by MEL for environmental samples taken around the state by the Watershed Ecology Section (Mathieu, 2005).

Hydrolabs will be calibrated before each run and post checked afterwards using conductivity/pH buffer solutions and the air saturation calibration method for DO. Table 12 contains the data quality objectives for post-check values.

Table 12. Data quality criteria for Hydrolab post-checks.

Parameter	Units	Accept	Qualify	Reject
pH	std. units	< or = ± 0.25	> ± 0.25 and < or = ± 0.5	> ± 0.5
Conductivity*	µS/cm	< or = ± 5%	> ± 5% and < or = ± 15%	> ± 15%
Dissolved Oxygen**	% saturation	< or = ± 5%	> ± 5% and < or = ± 10%	> ± 10%

* Criteria expressed as a percentage of readings; for example, buffer = 100.2 µS/cm and Hydrolab = 98.7 µS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%.
**When Winkler data is available, it will be used to evaluate acceptability of data in lieu of % saturation criteria.

Bias is defined as the difference between the population mean and the true value of the parameter being measured (Lombard and Kirchmer, 2004). Bias is also a component of data accuracy; however, bias from the true value is very difficult to determine for this set of parameters. Calibration standards for microbiological analyses are not available. Bias in field measurements will be minimized by strictly following sampling and handling protocols.

Representative sampling

The study was designed to have enough sampling sites and sufficient sampling frequency to adequately characterize fecal coliform spatial and temporal patterns in the watershed. Fecal coliform values are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard procedures and collecting quality control samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the parameter value. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time. Laboratory and field errors are further expanded by estimate errors in seasonal loading calculations and modeling estimates.

Comparability

The DOH enumerates fecal coliform bacteria using the MPN method. Ecology typically uses the MF method. Ecology will collect MPN samples at the mouths of Dakota and California Creek and will collect ten 500 mL samples during shoreline surveys, which MEL will then analyze using both methods to assess method and result comparability for the project. Results will be compared using simple linear correlation to test if a significant relationship exists and how well correlated the methods' results are. Splitting samples with the DOH may also occur to further ensure all data is comparable.

Whatcom County will follow Ecology's standard fecal coliform sampling and field measurement protocols (see Sampling and Measurement Procedures section) for all sampling and measurements collected for the TMDL. Ecology and Whatcom County will start and end each sampling run at the same site, where replicate samples, Hydrolab measurements, Winkler DOs, and flow measurements will be collected to assess comparability between Ecology and Whatcom County. Field training of Ecology protocols will be provided to Whatcom County, as needed.

Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard, et al., 2004). The goal for the Drayton Harbor Watershed TMDL is to correctly collect and analyze 100% of the fecal coliform samples for all sites, plus 100% of the storm event samples. However, problems occasionally arise during sample collection that cannot be controlled which can interfere with this goal. Examples of these problems include flooding, inadequate rain for storm sampling, site access problems, or sample container shortages. A lower limit of five samples per season per site will be required for comparison to state criteria, which should easily be met with the current sampling design. WAC 173-201A states:

When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period…and [the period of averaging] should have sample collection dates well distributed throughout the reporting period.

Investigatory samples may be collected at sites not included in this QA Project Plan; or, if necessary, a site may be added to further characterize fecal coliform problems in an area. Such sampling that does not meet the lower limit criteria of five samples per season (wet or dry) per site will still be useful for source location identification, recommendations, or other analyses but not used to set load or wasteload allocations.

Quality Control

Total variation for field sampling and laboratory analysis will be assessed by collecting replicate samples. Bacteria samples tend to have a high relative standard deviation between replicates compared to other water quality parameters. Bacteria sample precision will be assessed by collecting replicates for approximately 20% of samples in each survey. MEL routinely duplicates sample analyses in the laboratory to determine laboratory precision. The difference between field variability and laboratory variability is an estimate of the sample field variability.

All samples will be analyzed at MEL. The laboratory's measurement quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2005). MEL will follow standard quality control procedures (MEL, 2005). Field sampling and measurements will follow quality control protocols described in their individual SOPs. If any of these quality control procedures are not met, the associated results may be qualified by MEL or the project manager and used with caution, or not used at all.

Standard Methods (APHA, AWWA, and WEF, 1998) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for non-potable water tested for compliance purposes. MEL has a maximum holding time for microbiological samples of 24 hours (MEL, 2005). Standard Methods (APHA, AWWA, and WEF, 1998) recommends a holding time of less than 30 hours for drinking water samples and less than 24 hours for other types of water tested when compliance is not an issue. Microbiological samples analyzed beyond the 24-hour holding time are qualified with a *J* qualifier code, indicating the sample result is an estimate.

To identify any problems with holding times, two comparison studies were conducted during the Yakima Area Creeks TMDL (Mathieu, 2005). A total of 20 FC samples were collected in 500 mL bottles and each split into two 250 mL bottles. The samples were driven to MEL within 6 hours. One set of the split samples was analyzed upon delivery. The other set was stored overnight and analyzed the next day. Both sets were analyzed using the MF method. Replicates were compared to the Measurement Quality Objectives in Table 12.

The combined precision results between the different holding times yielded a mean RSD of 19%. This is comparable to the 23% mean RSD between field replicates for twelve EA Program TMDL studies using the MF method (Mathieu, 2006c), suggesting that a longer (i.e., 24 hour) holding time has little effect on FC results processed by MEL. Samples with longer holding times did not show a significant trend towards higher or lower FC counts compared to the samples analyzed within 6-8 hours.

Data Management Procedures

Field measurement data will be entered into a field book with waterproof paper in the field and then entered into EXCEL® spreadsheets (Microsoft, 2003) as soon as practical after returning from the field. This database will be used for preliminary analysis and to create a table to upload data into Ecology's Environmental Information Management (EIM) System.

Sample results received from MEL by Ecology's Laboratory Information Management System (LIMS) will be loaded into EIM, exported, and added to a cumulative spreadsheet for laboratory results. This spreadsheet will be used to informally review and analyze data during the course of the project.

An EIM user study (NMat0001) has been created for this TMDL study and all monitoring data will be available via the internet. The web address for this geospatial database is: http://apps.ecy.wa.gov/eimreporting/Downlods.htm. All data will be uploaded to EIM by the EIM data engineer.

All spreadsheet files, paper field notes, and Geographic Information System (GIS) products created as part of the data analysis will be kept with the project data files. Data that does not meet acceptability requirements will be separated from data files used for analysis.

Audits and Reports

The project manager will be responsible for submitting quarterly reports and the final technical study report to the Water Quality Program TMDL coordinator for this project, according to the project schedule. The project field lead will be responsible for completing the bacteria section of the quarterly report.

Data Verification and Validation

Laboratory data will be verified by MEL and validated by an EAP project staff member. Field measurement data will be verified by a project staff member and validated by a different staff member.

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL Users Manual (MEL, 2005). Lab results will be checked for missing or improbable data. Variability in lab duplicates will be quantified using the procedures outlined in the MEL Users Manual (MEL, 2005). Any estimated results will be qualified and their use restricted appropriately. A standard case narrative of laboratory Quality Assurance/Quality Control results will be sent to the project manager for each set of samples.

Field notebooks will be checked for missing or improbable measurements before leaving each site. The EXCEL® Workbook file containing field data will be labeled *Draft* until data verification and validity is completed. Data entry will be checked by the field assistant against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled *Final*.

As soon as FC data are verified by MEL, the laboratory microbiologist will notify the field lead by e-mail or by phone of FC results greater than 200 cfu/100 mL. The field lead will then notify the Bellingham Field Office (BFO) Client Staff Contact and Water Quality Section Manager by e-mail of these elevated counts in accordance with EA Program Policy 1-03. The TMDL coordinator will notify local authorities or permit managers as appropriate. This notification process typically happens within a week of collecting the samples.

Data received from LIMS will be checked for omissions against the *Request for Analysis* forms by the field lead. Data can be in EXCEL® spreadsheets (Microsoft, 2001) or downloaded tables from EIM. These tables and spreadsheets will be located in a file labeled *Draft* until data validity is completed. Field replicate sample results will be compared to quality objectives in Table 12. Data requiring additional qualifiers will be reviewed by the project manager. After data validity and data entry tasks are completed, all field, laboratory, and flow data will be entered into a file labeled *Final*, and then into the EIM system. EIM data will be independently reviewed by another EA Program field assistant for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken.

At the end of the field collection phase of the study, the data will be compiled in a data summary. Quarterly progress reports will be available every 3 months throughout the 12 month data collection period of the project.

Data Quality (Usability Assessment)

The bacteria field lead will verify that all measurement and data quality objectives have been met for each monitoring station. If the objectives have not been met (such as percent RSD for bacteria replicates exceeds the MQO or a Hydrolab was recording bad data), then the field lead and project manager will decide how to qualify the data and how it should be used in the analysis or whether it should be rejected.

Fecal coliform values reported as non-detect values will not be used in the data quality assessment process; for example, a percent RSD value will not be calculated for a replicate pair with two non-detect values.

The data quality assessment process will be documented in individual project data files and summarized in the final report.

Data Quality Analysis and Use

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution of transformed data. Streamflow data will be frequently reviewed during the field data survey season to check longitudinal water balances. Fecal coliform mass balance calculations will be performed on a reach basis. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, and regressions) will be made using the Water Quality/Hydrology Graphics/Analysis System (Aroner, 2007) and EXCEL® (Microsoft, 2001) software.

Data will be applied to several TMDL methods of evaluation. The statistical rollback method (Ott, 1995) will be applied to FC data distributions to determine target count reductions along key reaches of each waterbody during critical conditions. At least 10 data points will be collected for each critical season to develop reduction targets during this season. Fewer data will provide less confidence in FC reduction targets, but the rollback method is robust enough to provide general targets for planning implementation measures.

Project Organization

The organization, roles, and responsibilities of Ecology staff are as follows:

- *Nuri Mathieu, Project Manager, QA Project Plan Author, Field Lead, and EIM Data Engineer, Directed Studies Unit, Environmental Assessment (EA) Program, Western Operations Section.* Responsible for overall project management. Defines project objectives, scope, and study design. Co-author of the QA Project Plan. Responsible for development of bacteria TMDLs and writing the technical report. Manages the data collection program. Coordinates and conducts field surveys. Responsible for data collection, entering project data into the EIM system, and data quality review.

- *Debby Sargeant, QA Project Plan Author, Directed Studies Unit, EA Program, Western Operations Section.*
  Responsible for analyzing marine historical data and approving sampling design and methods.

- *Steve Hood, Overall TMDL Project Lead, Bellingham Field Office.*
  Acts as point of contact between Ecology technical study staff and interested parties. Responsible for coordinating information exchange, forming technical advisory group, and organizing meetings. Supports, reviews, and comments on QA Project Plan and technical report. Is responsible for implementing, planning, and preparing TMDL document for submittal to EPA.

- *Richard Grout, Manager, Bellingham Field Office.*
  Client for this project. Responsible for approving TMDL submittal to EPA.

- *Bob Cusimano, Section Manager, EA Program, Western Operations Section.*
  Responsible for approving project QA Project Plan and final TMDL report.

- *George Onwumere, Unit Supervisor, Directed Studies Unit, EA Program, Western Operations Section.*
  Responsible for reviewing and approving project QA Project Plan, staffing plan, final TMDL report, and technical study budget.

- *Stuart Magoon, Leon Weiks, Nancy Jensen, and Nancy Rosenbower, EA Program, Manchester Environmental Laboratory.*
  Provides laboratory staff and resources, sample processing, analytical results, laboratory contract services, and QA/QC data. Responsible for reviewing sections of the QA Project Plan relating to laboratory analysis.

- *Chuck Springer, Watershed Technical Support Unit, EA Program, Statewide Coordination Section.*
  Responsible for the deployment and maintenance of continuous flow loggers and staff

gauges. Responsible for producing records of hourly flow data at select sites for the study period.

- *Bill Kammin, Ecology Quality Assurance Officer.*
  Responsible for reviewing all agency QA Project Plans and quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of projects.

Project Schedule

EIM data entry, quarterly progress reports, and the final data analysis report will be completed according to the schedule outlined in Table 13. The schedule may be revised based on changes to sampling schedule or staff workload, if necessary.

Table 13. Project schedule and report authors.

Environmental Information System (EIM) Data Set	
EIM Data Engineer	Nuri Mathieu
EIM User Study ID	NMAT0001
EIM Study Name	Phase 1: Drayton Harbor Watershed Fecal Coliform TMDL
EIM Completion Due	December 2009
Quarterly Reports	
Author Lead	Nuri Mathieu
Schedule	
1st Quarter Report	April 2008
2nd Quarter Report	July 2008
3rd Quarter Report	October 2008
4th Quarter Report	January 2009
Phase I - Final Report	
Author Lead	Nuri Mathieu
Schedule	
Draft Due to Supervisor	December 2009
Draft Due to Client/Peer Reviewer	January 2010
Draft Due to External Reviewer	March 2010
Final Report Due	July 2010
Phase II - Final Report	
Author	Nuri Mathieu
Project Schedule will be included in the Phase II addendum to QA Project Plan	

Laboratory Budget

The estimated laboratory budget and lab sample load in Table 14 is based on the proposed schedule in Table 6. Since all months have more than one survey that occur on different weeks, monthly and weekly laboratory sample loads should not overload the microbiological units at MEL. The greatest uncertainty in the laboratory load and cost estimate is with the shoreline survey sampling events. Efforts will be made to keep the submitted number of samples within the estimate, however, because the number of active shoreline sites will vary based on weather conditions. This is an estimate only.

Table 14. An estimate of the monthly, fiscal year, and total analytical cost[5] for the *Drayton Harbor Watershed Fecal Coliform TMDL* project.

Month	Membrane Filter MF	Most Probable # MPN	Cost
December-DOH	672	195	
December-Extra	672	195	
January-DOH	672	195	
January-Extra	672	195	
February-DOH	672	195	
February-Extra	672	195	
March-DOH	672	195	
April-DOH	672	195	
May-DOH	1,344	195	
June-DOH	1,344	195	
QA (total for FY08)	1,218	351	
Totals FY08	8,064	2,301	10,365
July	1,472	430	
August	1,472	430	
September	1,472	430	
October	1,472	430	
November	1,472	430	
December	1,472	430	
QA (Total for FY09)	736	430	
Totals FY09	9,568	3,010	12,578
Shoreline Survey	FCMF sites	FC-MPN sites	
Winter-dry FY08	630	390	1,020
Winter-storm FY08	630	390	1,020
Special Tidal Studies			2,500
QA FY08	252	156	408
Summer-dry FY09	690	430	1,120
Summer-storm FY09	690	430	1,120
Winter-dry/storm FY09	690	430	1,120
QA FY09	414	258	672
Totals			
FY08			15,313
FY09			16,610
Project Total			$ 31,923

[5] Costs include a 50% discount for Manchester Environmental Laboratory

References

Adolfson, 2006. Environmental Assessment: City of Blaine Lighthouse Point Water Reclamation Facility. Prepared for City of Blaine by Adolfson Associates, Inc. Seattle, WA.

APHA, AWWA, and WEF, 1998. Standard Methods for the Examination of Water and Wastewater 20th Edition. American Public Health Association, Washington, D.C.

Aroner, E.R., 2007. WQHYDRO: Water Quality/Hydrology Graphics/Analysis System. Portland, OR.

Berbells, Scott, 2006. 2006 Shoreline Survey of Drayton Harbor Shellfish Growing Area. Washington State Department of Health. Olympia, WA.

Butkus, S., 2005. Quality Assurance Monitoring Plan: Streamflow Gaging Network. Washington State Department of Ecology, Olympia, WA. Publication No. 05-03-204. www.ecy.wa.gov/biblio/0503204.html

Callahan, Katie and Geoff Menzies, 2004. Summary Report: Tracking Reports and Projects of Potential Pollution Sources in the Drayton Harbor Watershed 1991 – 2003. Whatcom County Public Works and Drayton Harbor Shellfish Protection District.

City of Blaine, 1995. Stormwater Management Plan for the City of Blaine. Prepared by Economic and Engineering Services, Inc. Olympia, WA.

Cykler, J., M. Haggerty, and R. Matthews, 1995. Fecal Coliform Contamination Study of Drayton Harbor. Western Washington University – Geology Department and Institute for Watershed Studies, Bellingham, WA.

DHSPD, 2007. Drayton Harbor Projects: On-site Septic System Projects. Drayton Harbor Shellfish Protection District. Marine Resources of Whatcom County. http://whatcomshellfish.wsu.edu/Drayton/septic.htm

DOH, 2007. Growing Area Classification Program. Washington State Department of Health. www.doh.wa.gov/ehp/sf/grow.htm#approved

Ecology, 2007a. 2004 Water Quality Assessment (Final) – Category 5 Listings. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/wq/303d/2002/2004_documents/list_by_category-cat5.html

Ecology, 2007b. Stream Flow Monitoring Station: Dakota Cr. at Giles Rd. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=01Q070

Hay and Co., 2003. Semiahmoo Circulation Study Technical Report. Hay and Company Consultants, Inc. Vancouver, B.C. Canada.

Henderson, Mark, 2007. Fact Sheer for NPDES Permit WA-002264-1: Blaine Wastewater Treatment Plant. Washington State Department of Ecology. Bellingham, WA.

Herrera Environmental Consultants, Inc., 1998. Baseline Monitoring Plan for Fecal Coliform Bacteria Source Tracking. Prepared for City of Blaine, Public Works Department, Blaine, WA. by Herrera Environmental Consultants, Inc. Seattle, WA.

Hirsch Consulting Services, 2006. California Creek and Drayton Harbor Microbial Source Tracking Pilot Study Monitoring Plan. Prepared for Puget Sound Restoration Fund, Ferndale, WA. by Hirsch Consulting Services. Lummi Island, WA.

Hirsch, Julie, 2007. 2006 Blaine Harbor Water Quality Monitoring Summary and Recommendations, Port of Bellingham, Washington. TEC Inc. and Hirsch Consulting Services. Lummi Island, WA.

Hoyle-Dodson, Guy, 1997. City of Blaine Wastewater Treatment Plant Class II Inspection. Washington State Department of Ecology, Olympia, WA. Publication No. 97-333. www.ecy.wa.gov/biblio/97333.html

Joy, Joe, 2006. Standard Operating Procedure for Manually Obtaining Surface Water Samples. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_ManuallyObtainingSurfaceWaterSamples.pdf

Lennartson, Don, 2004. Sanitary Survey of Drayton Harbor. Washington State Department of Health - Office of Shellfish and Water Protection. Tumwater, WA.

Lombard, Stewart and Cliff Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030. www.ecy.wa.gov/biblio/0403030.html

Mathieu, Nuri, 2005. Yakima Area Creeks Fecal Coliform TMDL Quarterly Progress Report #3 (July 2005 through September 2005). Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Mathieu, Nuri, 2006a. Standard Operating Procedure for Sampling Bacteria in Water – Provisional. Washington State Department of Ecology, Olympia, WA.

Mathieu, Nuri, 2006b. Standard Operating Procedure for Measuring Dissolved Oxygen in Surface Water. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_MeasuringDO_v1.1_72507.pdf

Mathieu, Nuri, 2006c. 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. www.ecy.wa.gov/biblio/0603044.html

MEL, 2005. Manchester Environmental Laboratory Lab User's Manual, Eighth Edition. Washington State Department of Ecology. Manchester, WA.

Melvin, Don, 2007. Drayton Harbor 2006 Annual Growing Area Review. Washington State Department of Health - Office of Shellfish and Water Protection. Tumwater, WA.

Menzies, Geoff, 2002. Drayton Harbor Community Shoreline Water Quality Sampling Program. Submitted to Whatcom Country Water Resources Division - Shellfish Protection Program by the Puget Sound Restoration Fund.

Meriwether, F., 2003. Washington State Department of Health, Office of Shellfish and Water Protection, Memorandum to the Drayton Harbor Growing Area File Dated September 25, 2003. Subject: Dye and Drogue Study in Drayton Harbor. Washington State Department of Health, Office of Shellfish and Water Protection. Olympia, WA.

Meriwether, F. and S. Kinney, 2006. Washington State Department of Health, Office of Shellfish and Water Protection, Memorandum to the Drayton Harbor Growing Area File Dated December 8, 2006. Subject: Blaine WWTP Drogue and Dye Study. Washington State Department of Health, Office of Shellfish and Water Protection. Olympia, WA.

Microsoft, 2001. Microsoft Office XP Professional, Version 10.0. Microsoft Corporation.

Ott, W., 1995. Environmental Statistics and Data Analysis. Lewis Publishers. New York, N.Y.

Peterson, Becky, 1995. Drayton Harbor Watershed Management Plan. Whatcom County Council of Governments. Bellingham, WA.

Port of Bellingham, 2007. Blaine Harbor. Port of Bellingham. www.portofbellingham.com/blaine_harbor_home_page.php

Puget Sound Restoration Fund, 2007. Drayton Harbor Marine Wet Weather Sampling Project Final Report. Whatcom County Public Works – Stormwater Division. Bellingham, WA.

Sullivan, Lawrence, 2006. Standard Operating Procedures for Estimating Streamflow – Provisional. Washington State Department of Ecology, Olympia, WA.

Swanson, Trevor, 2007. Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_Hydrolab_v1_0.pdf

WAC 173-201A. 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

WRCC, 2007. Blaine, Washington (450729). Washington Regional Climate Center. www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa0729

Appendices

Appendix A. Analysis of Northwest Indian College Data from January 1999 - July 2007

Since 1998, Northwest Indian College (NWIC) has collected monthly fecal coliform samples on 11 sites (Figure A-1) within the study area of the Total Maximum Daily Load (TMDL). The NWIC sites include: 5 on Dakota Creek, 3 on California Creek, the mouth of an unnamed creek on the 303(d) list (LS5 site), the mouth of Cain Creek, and an outfall that discharges to Cain Creek at its mouth. Not enough data was available for the LS5 site to calculate summary statistics or test for trends.

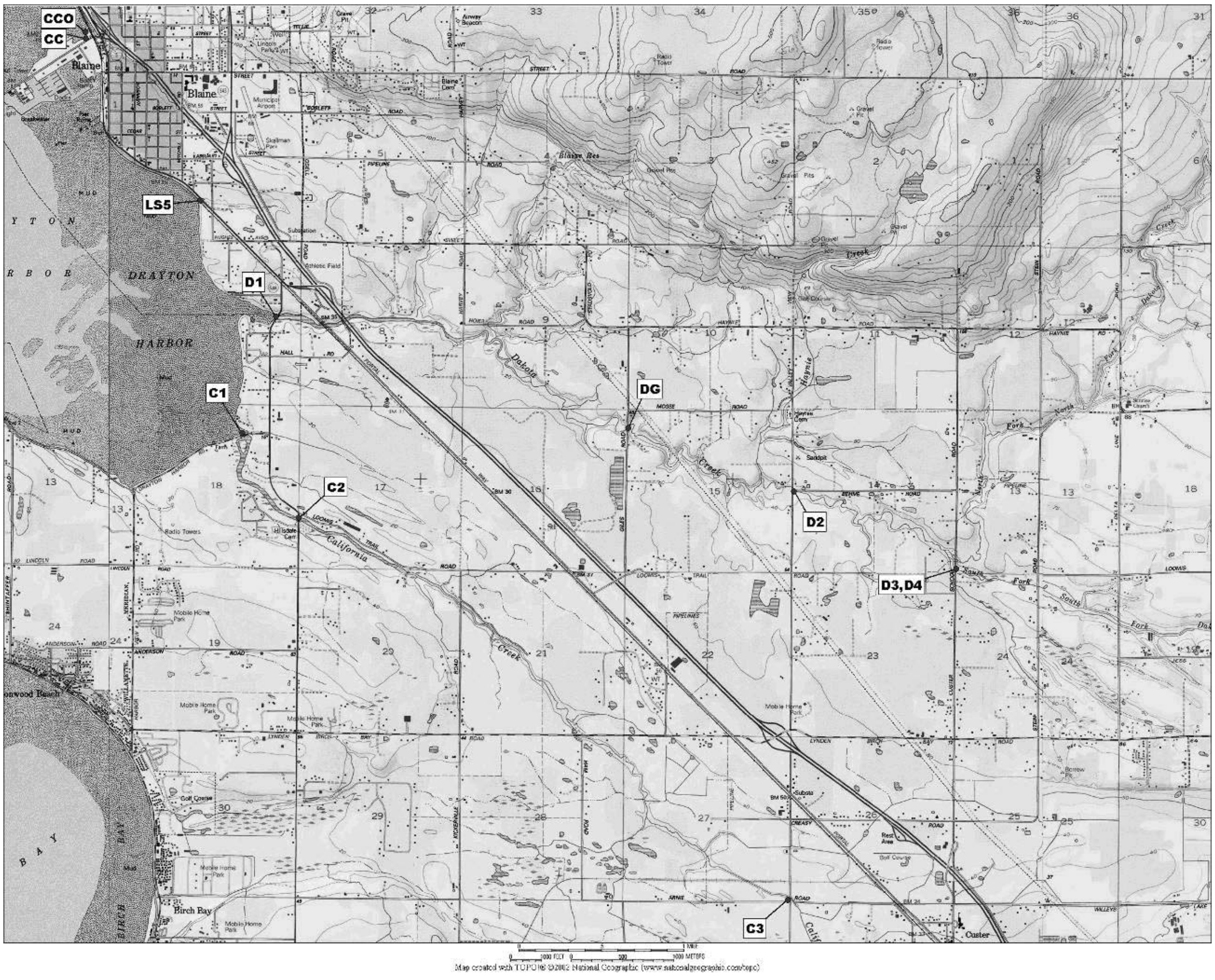

Figure A-1. NWIC freshwater monitoring stations (Berbells, 2006).

Data obtained from NWIC staff was compiled and organized using Excel® spreadsheet software (Microsoft Corporation, 2001). Statistical analyses and plots were made using Excel® software. WQHYDRO software (Aroner, 2007) was used to conduct trend analysis. A two-tailed, non-parametric Seasonal-Kendall trend test was used to test for trends.

Fecal Coliform trend analysis

Seasonal-Kendall trend analysis was conducted for all stations, except LS5. Results are presented in Table A-1. For Table A-1 trends from 1999 to the present were determined, for Table A-2 data from 2003 through the present were analyzed.

Six of the ten freshwater sites on California and Dakota Creeks show improving fecal coliform levels (significantly decreasing trends) for the 1999-2007 period (Table 1). The two heavily marine influenced sites, the mouths of Dakota and California Creeks, showed no trend; while the outfall at Cain Creek and South Fork Dakota Creek at the mouth had insignificant decreases in concentrations.

Interestingly, the trend analysis of the 2003-2007 data showed significant increases in fecal coliform levels at six of the ten sites (Table A-2). The remaining 4 sites showed either an insignificant increase or no change at all.

Table A-1. Seasonal-Kendall fecal coliform trend analysis results for NWIC stations. Period tested: January 1999 - July 2007.

NWIC Site	Seasonal Sen Slope	P value (2 tail)	Have fecal coliform levels changed significantly?
NWIC-C1	0	0.817	No
NWIC-C2	-4.84 (9.67%)	0.050	Yes at 95% CL
NWIC-C3	-5.73 (7.16%)	0.007	Yes at 99% CL
NWIC-D1	0	0.99	No
NWIC-DG	-7.73 (15.47%)	0.001	Yes at 99% CL
NWIC-D2	-4.00 (10.00%)	0.147	Yes at 80% CL
NWIC-D3	-5.06 (10.11%)	0.026	Yes at 95% CL
NWIC-D4	-1.43 (4.77%)	0.205	No
NWIC-CC	-18.98 (15.82%)	0.016	Yes at 95% CL
NWIC-CCO	-5.02 (4.56%)	0.366	No

CL – confidence level

Table A-2. Seasonal-Kendall fecal coliform trend analysis results for NWIC stations. Period tested: January 2003 - July 2007.

DOH Site	Seasonal Sen Slope	P value (2 tail)	Have fecal coliform levels changed significantly?
NWIC-C1	+5.88 (11.77%)	0.330	No
NWIC-C2	0	0.773	No
NWIC-C3	+10.00 (25.01%)	0.001	Yes at 99% CL
NWIC-D1	+12.52 (20.87%)	0.024	Yes at 95% CL
NWIC-DG	0	0.779	No
NWIC-D2	+9.66 (32.21%)	0.003	Yes at 99% CL
NWIC-D3	+9.68 (24.20%)	0.037	Yes at 95% CL
NWIC-D4	+5.03 (25.13%)	0.005	Yes at 99% CL
NWIC-CC	+3.96 (4.40%)	0.509	No
NWIC-CCO	+15.07 (18.84%)	0.063	Yes at 90% CL

CL – confidence level

Summary Statistics

Summary statistics were calculated for each station using the 1999 through 2007 data set. Based on the majority of decreasing trends, the data was split into two time periods: 1999-2002 and 2003-2007. Box plots were developed for the dry season (May to September) and the wet season (October to April) for both time periods (Figures A-2 through A-6). Geometric mean and 90th percentile statistics were compared to state water quality standards for each site.

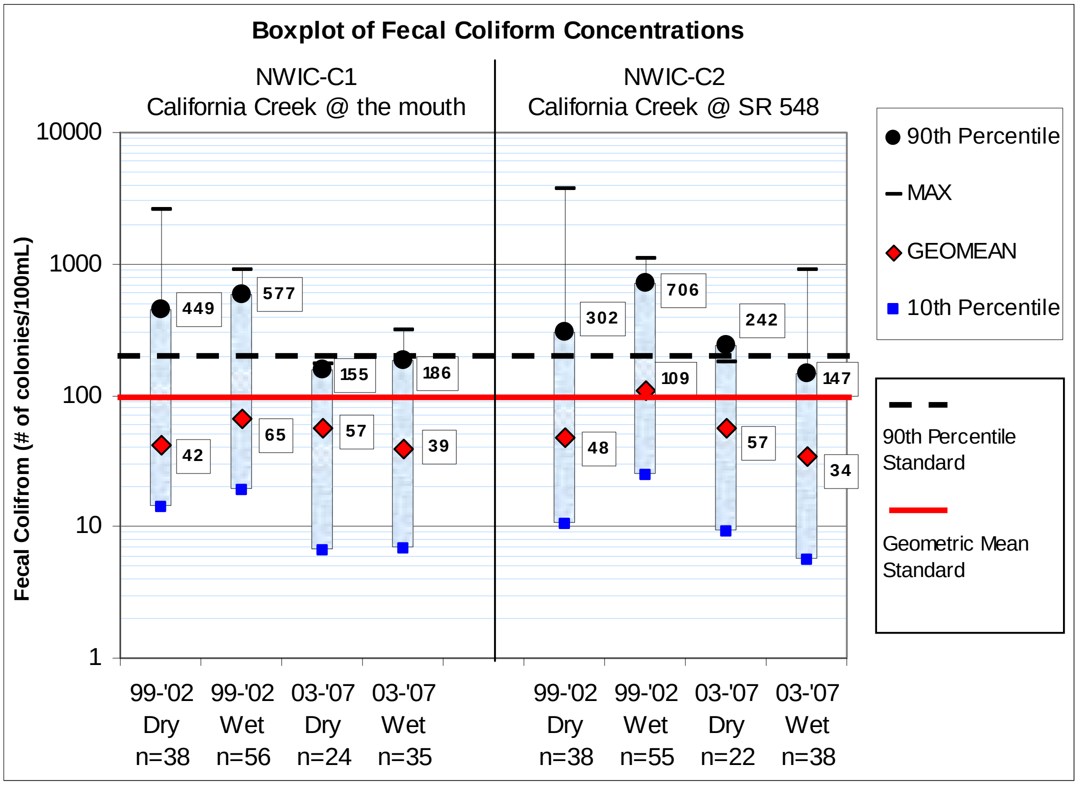

Figure A-2. Geometric means and 90th percentiles at NWIC-C1 & NWIC-C2 split into the wet and dry seasons for 1999 to 2002 and 2003 to 2007.

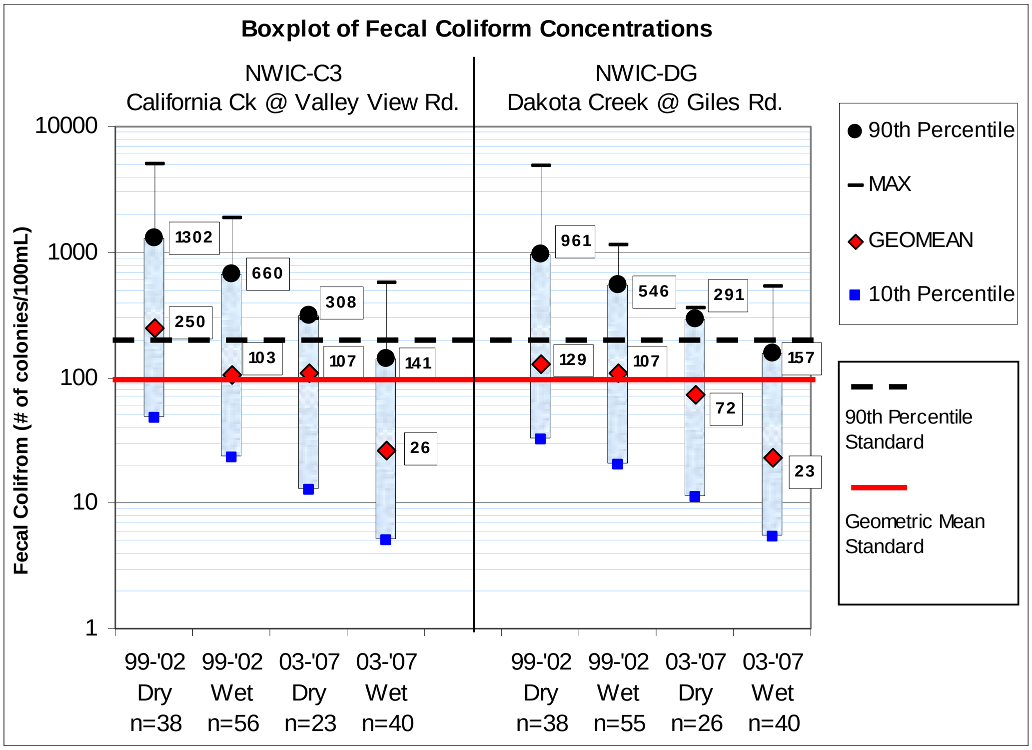

Figure A-3. Geometric means and 90th percentiles at NWIC-C3 & NWIC-DG split into the wet and dry seasons for 1999 to 2002 and 2003 to 2007.

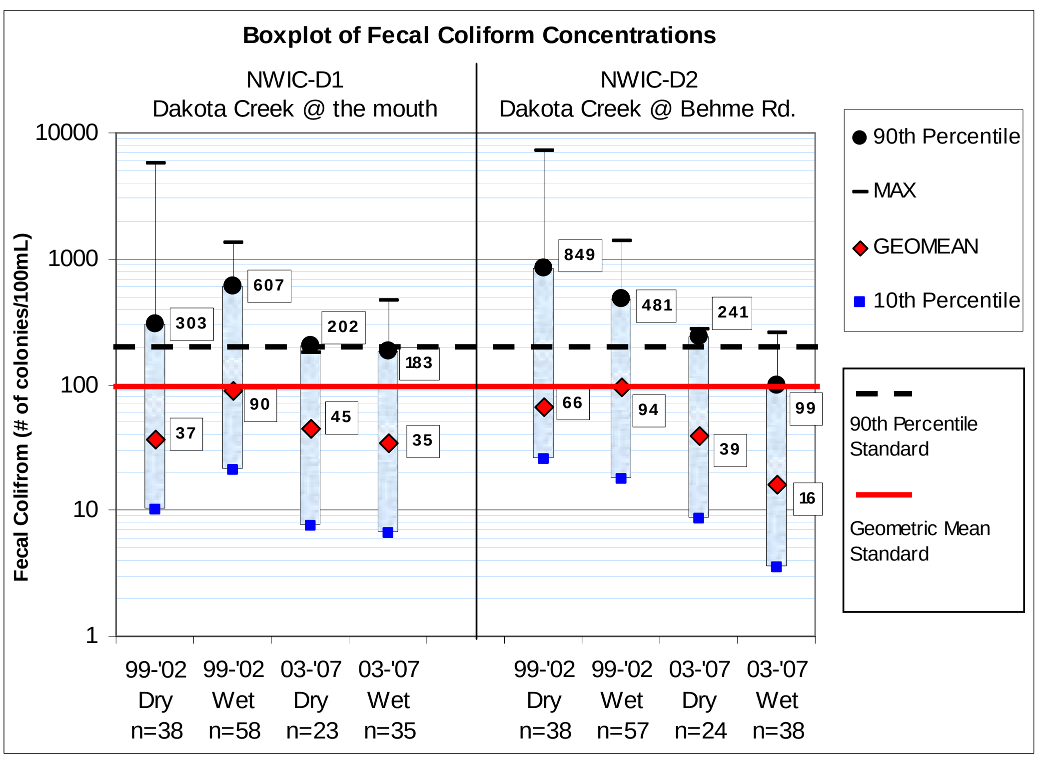

Figure A-4. Geometric means and 90th percentiles at NWIC-D1 & NWIC-D2 split into the wet and dry seasons for 1999 to 2002 and 2003 to 2007.

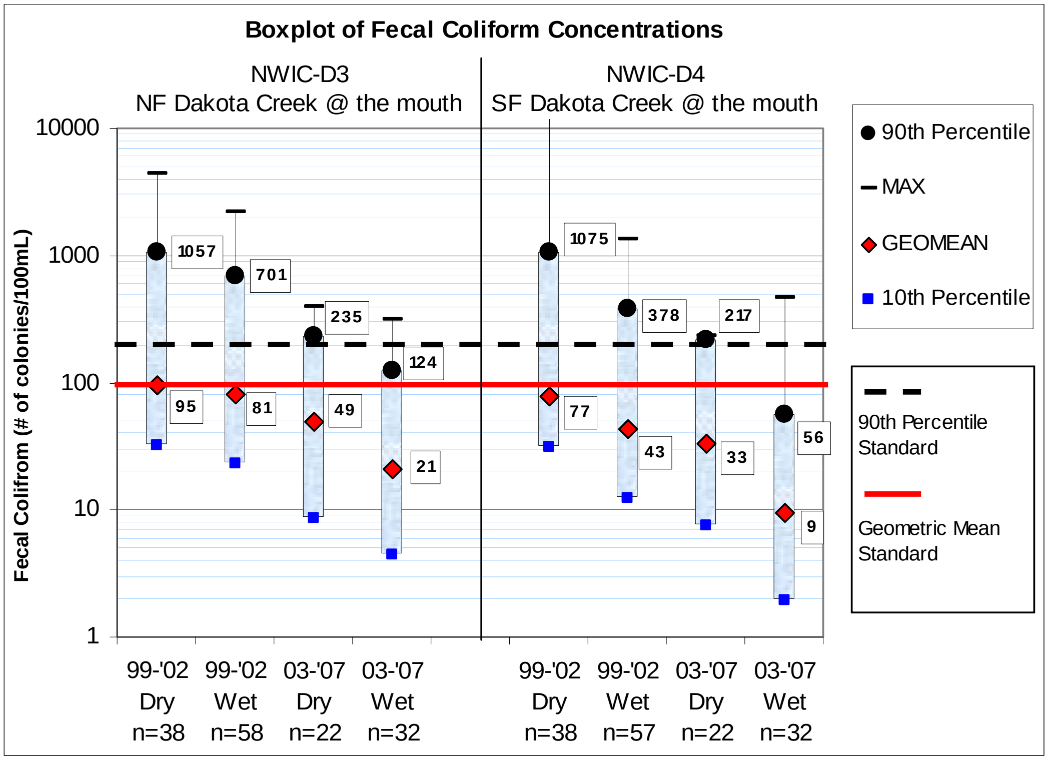

Figure A-5. Geometric means and 90th percentiles at NWIC-D3 & NWIC-D4 split into the wet and dry seasons for 1999 to 2002 and 2003 to 2007.

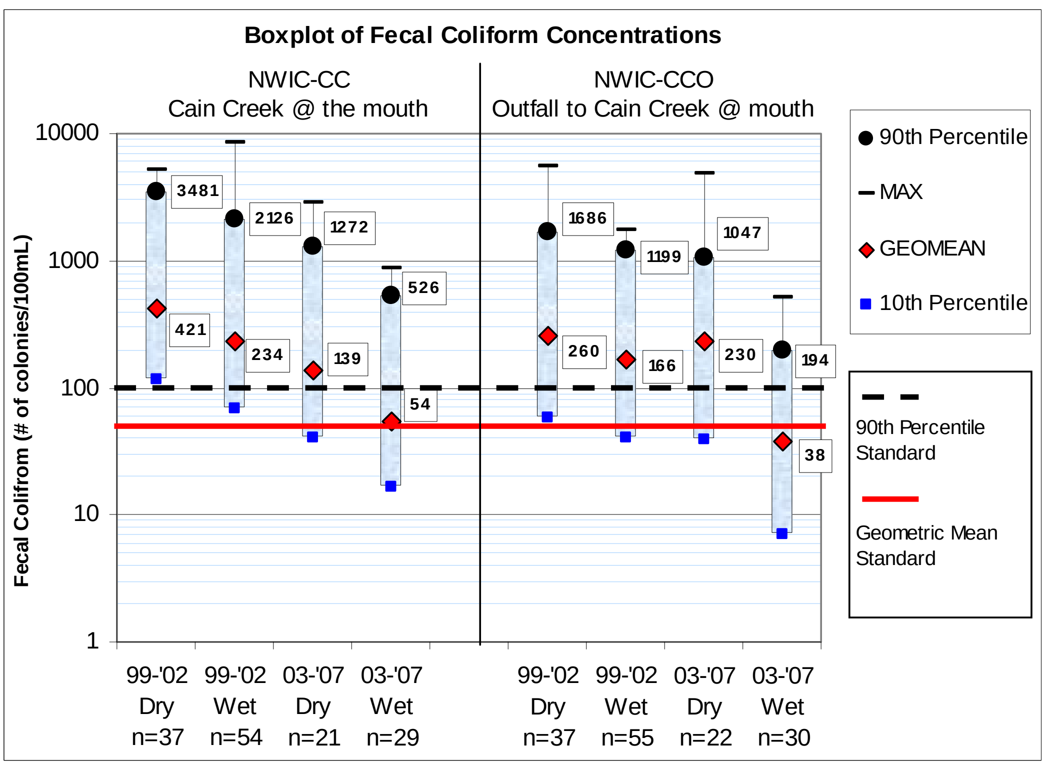

Figure A-6. Geometric means and 90th percentiles at NWIC-CC & NWIC-CCO split into the wet and dry seasons for 1999 to 2002 and 2003 to 2007.

Appendix B. Analysis of Department of Health Data from January 1999 - September 2007

The Washington State Department of Health (DOH) collects monthly or bimonthly marine data in Drayton Harbor for fecal coliform bacteria, temperature, and salinity. The DOH stations are shown in Figure B-1. Stations 3-5 and station 12 are classified *Conditionally Approved* for shellfish harvest. The harvest condition is: if rainfall is ≥ 0.75 inches in a 24-hour period, the area is closed to shellfish harvest for 6 days. Stations 6, 8, 11, and 15 are classified as *Prohibited*; commercial shellfish harvest is not allowed in these areas. Stations 313-315 are classified *Unclassified;* there is an interest in shellfish harvest in this area, but the requirements to classify the area have not been completed.

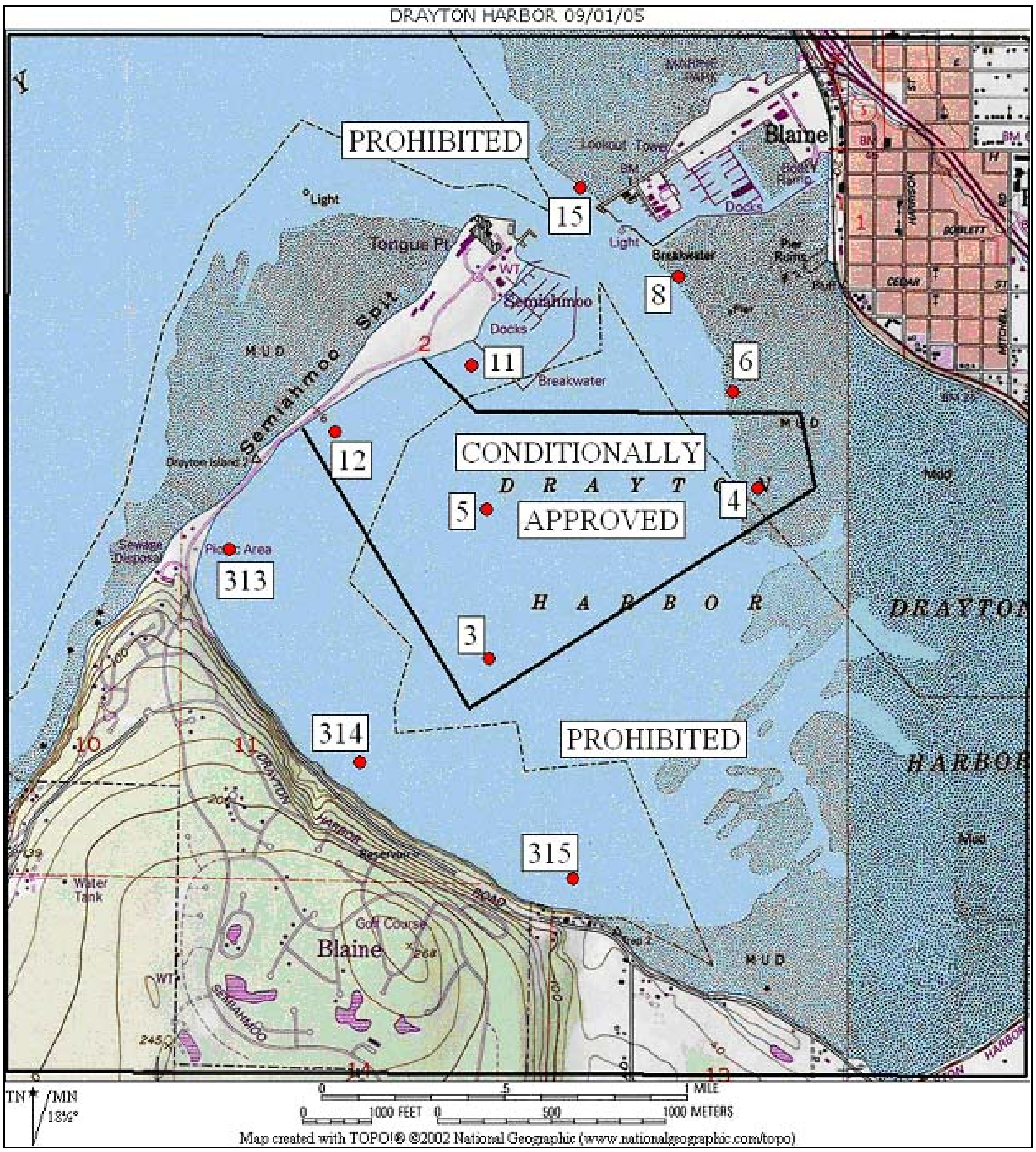

Figure B-1. Drayton Harbor DOH marine shellfish monitoring stations.

Data from 1999 through the present is available for Stations 3-6, 8, 12, and 15. For Station 11, monitoring data is available from September 2005 through the present. For stations 313-315, data is available from August 2004 to the present. The data set analyzed includes all data, including when the bay is closed due to rainfall. In addition, a special rainfall study was conducted on the following dates: March 14, April 10, September 21, October 16, November 8, 2006 and January 25, March 27, and May 22, 2007. This data was analyzed with the rest of the data set. This biases the data analysis from 2003 to the present slightly because there are more rain events.

Data was obtained from DOH shellfish staff and compiled and organized using Excel® spreadsheet software (Microsoft Corporation, 2001). Statistical analyses and plots were made using Excel® software. WQHYDRO software (Aroner, 2007) was used to conduct trend analysis. A two-tailed, non-parametric Seasonal-Kendall trend test was used to test for trends.

Fecal Coliform trend analysis

Seasonal-Kendall trend analysis was conducted for all the marine stations. Results are presented in Tables B-1 and B-2. For Table B-1, trends from 1999 to the present were determined, for Table B-2 data from 2003 through the present were analyzed. This was done to be consistent with the freshwater trend analysis on the tributaries.

There is moderate evidence that fecal coliform levels at stations 15 are improving using both the 1999 - present data set (p=0.17) and the 2003 - present data set (p=0.13). Other stations showed no detectable change in fecal coliform levels.

While there is not much change in fecal coliform levels in the harbor, it is interesting to note that some of the freshwater sites on California and Dakota Creeks show improving fecal coliform levels for the 1999 - 2007 period. Six-of-ten sites on California and Dakota Creeks showed a decreasing trend in fecal coliform levels. The two sites near the mouths of California and Dakota Creeks showed no significant change in bacteria levels.

Table B-1. Seasonal-Kendall Fecal coliform trend analysis results for Drayton Harbor DOH shellfish stations. Period tested February 1999 - September 2007.

DOH Site	Seasonal Sen Slope	P value (2 tail)	Have fecal coliform levels changed significantly?
Station 3	0.00	0.582	No
Station 4	0.00	0.869	No
Station 5	0.00	0.864	No
Station 6	0.00	0.582	No
Station 8	0.00	0.793	No
Station 11	+ 0.15 (3.4%)	0.558	No
Station 12	0.00	0.811	No
Station 15	- 0.66 (3.0%)	0.165	Yes at 80% CL
Station 313	0.00	0.567	No
Station 314	+ 0.17 (3.9%)	0.216	No
Station 315	-3.04 (39.0%)	0.200	No

CL – confidence level

Table B-2. Seasonal-Kendall fecal coliform trend analysis results for Drayton Harbor DOH shellfish stations. Period tested January 2003- September 2007.

DOH Site	Seasonal Sen Slope	P value (2 tail)	Have fecal coliform levels changed significantly?
Station 3	0.00	0.096	Yes at 90% CL
Station 4	0.00	0.316	No
Station 5	0.00	0.729	No
Station 6	0.00	0.798	No
Station 8	- 2.99 (6.1%)	0.250	No
Station 11	+ 0.54 (12.1%)	0.444	No
Station 12	0.00	0.656	No
Station 15	- 2.05 (9.3%)	0.126	Yes at 80% CL
Station 313	0.00	0.499	No
Station 314	+ 0.14	0.239	No
Station 315	-2.90 (37.2%)	0.300	No

CL – confidence level

Summary Statistics

Summary statistics were calculated for each station using the 1999 through 2007 data set. The results for the *Conditionally Approved* stations (stations 3, 4, 5, and 12) are presented in Figures B-2 – B-5. For all four stations, higher bacteria levels are seen during the November through February period. This could be because more rain events were captured during this period than in other months.

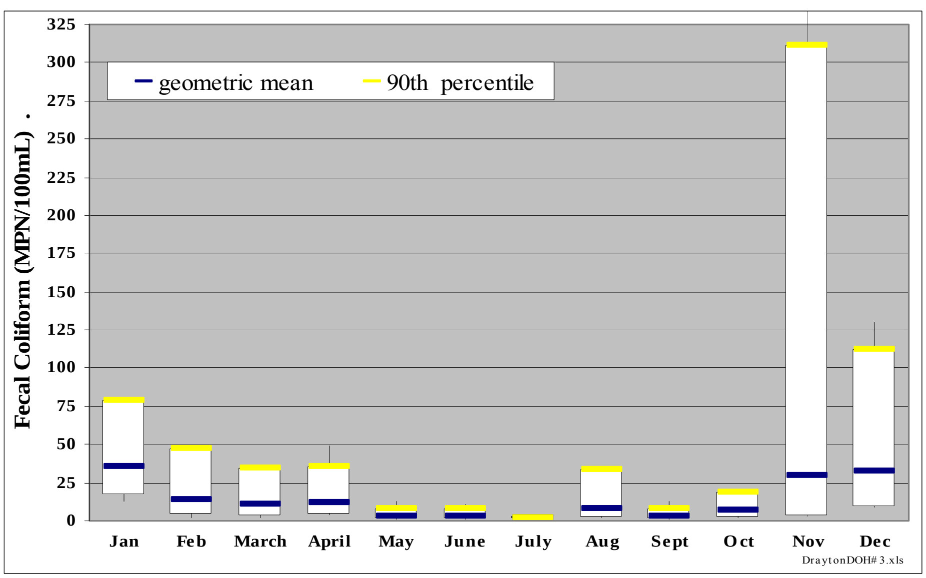

Figure B-2. DOH Station 3 monthly fecal coliform statistics for 1999 – September 2007.

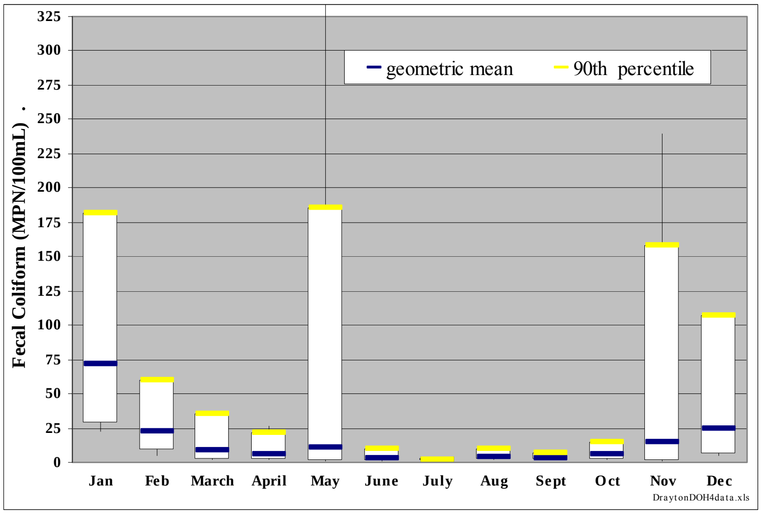

Figure B-3. DOH Station 4 monthly fecal coliform statistics for 1999 – September 2007.

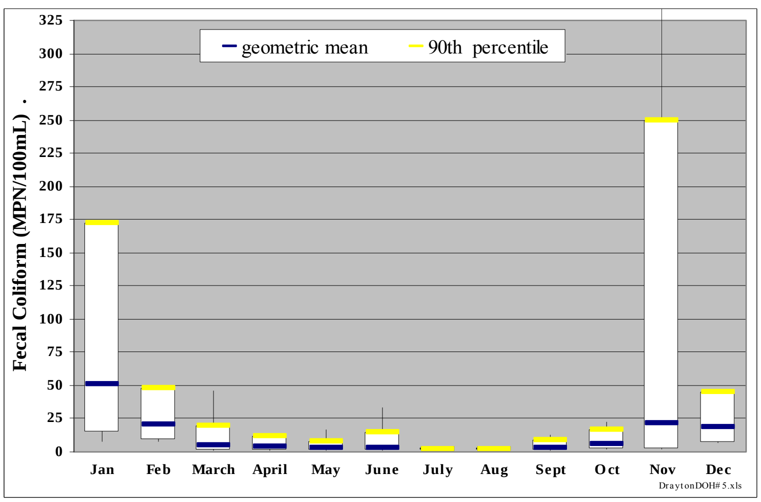

Figure B-4. DOH Station 5 monthly fecal coliform statistics for 1999 – September 2007.

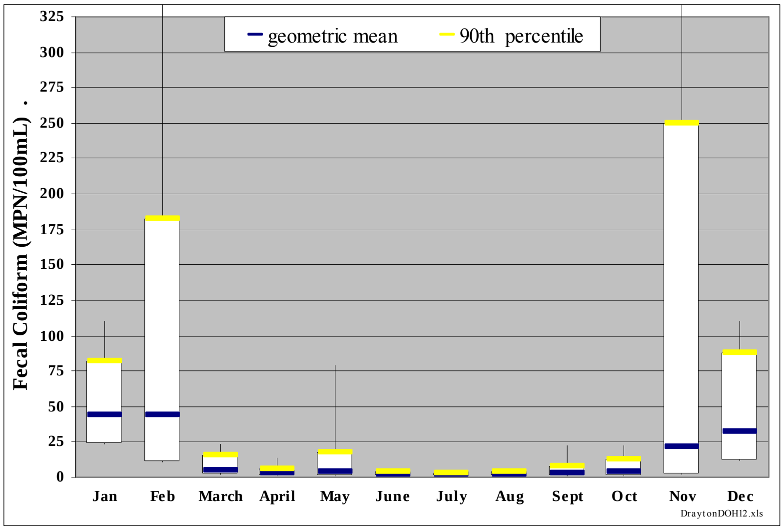

Figure B-5. DOH Station 12 monthly fecal coliform statistics for 1999 – September 2007.

Figure B-6 presents statistical summaries for the *Conditionally Approved* stations. Data summaries include data from 1999 - 2007, 2003 - 2007, and a 1999 - 2007 flood and ebb comparison of fecal coliform data. Station 4 showed higher levels of fecal coliform during the ebb tide, while stations 3, 5, and 12 showed higher levels during a flood tide. Because the harbor is shallow, DOH sampling usually occurs near high slack tide so data does not represent maximum ebb or flood tide events.

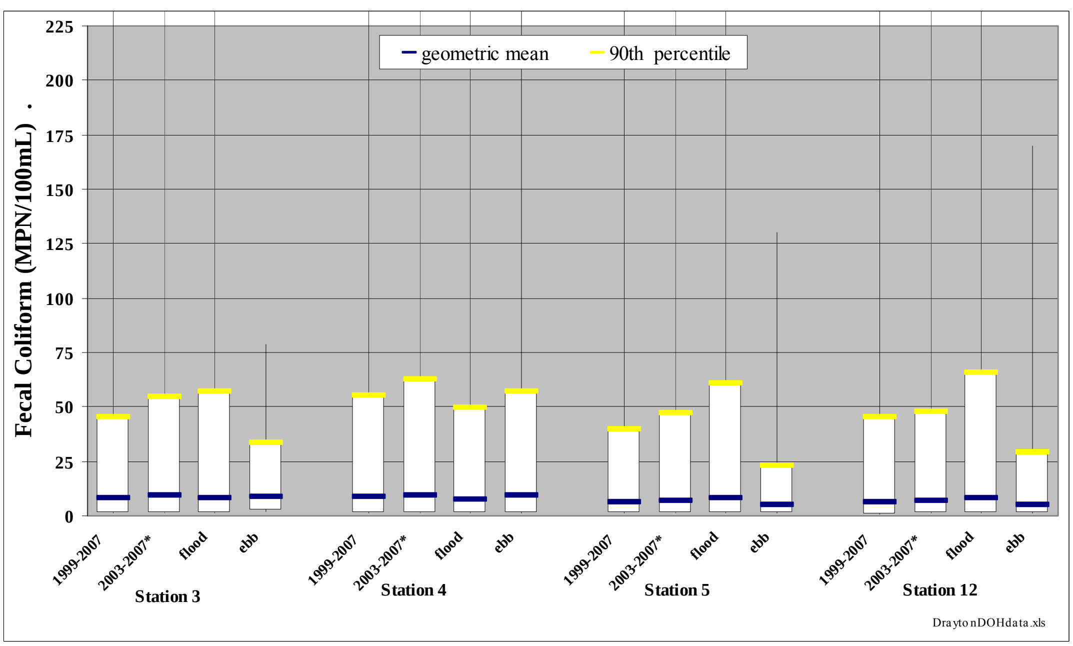

Figure B-6. Comparison of fecal coliform statistics during the ebb and flood at DOH Stations 3, 4, 5, and 12.

The results for the northernmost *Prohibited* stations are presented below in Figures B-7 – B-9. The northernmost sites include stations 6, 8, and 15 (adjacent to the city of Blaine) and station 11 (adjacent to the Semiahmoo Marina). Monthly results for station 11 are not presented due to the small size of the data set; data collection did not begin at this site until late 2005. Results for station 11 (n=31) are generally very good with only one high value (350 MPN/100 mL) seen on January 25, 2007. For the remainder of the data set, all values were below 34 MPN/100 mL.

Station 6 shows a similar pattern as the *Conditionally Approved* stations with increasing fecal coliform levels seen from November to February. Stations 8 and 15 have the highest fecal coliform levels of all the stations. Bacteria levels vary between months, and no clear pattern is evident.

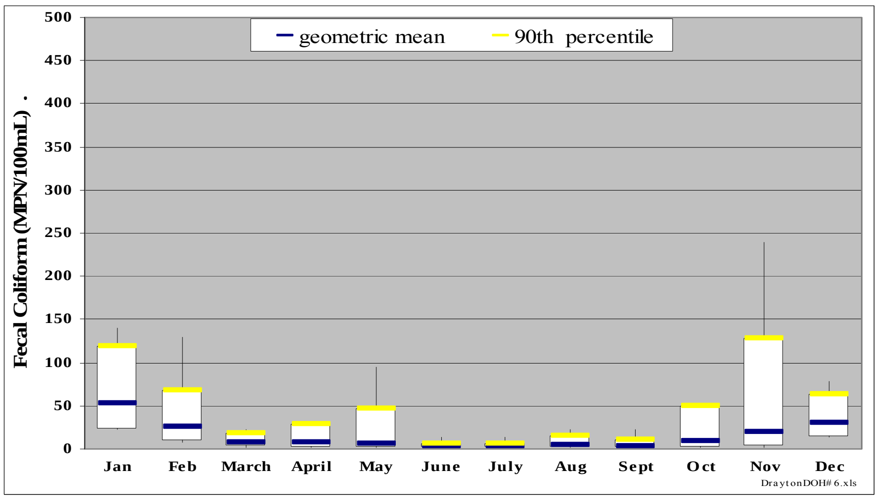

Figure B-7. DOH Station 6 monthly fecal coliform statistics for 1999 – September 2007

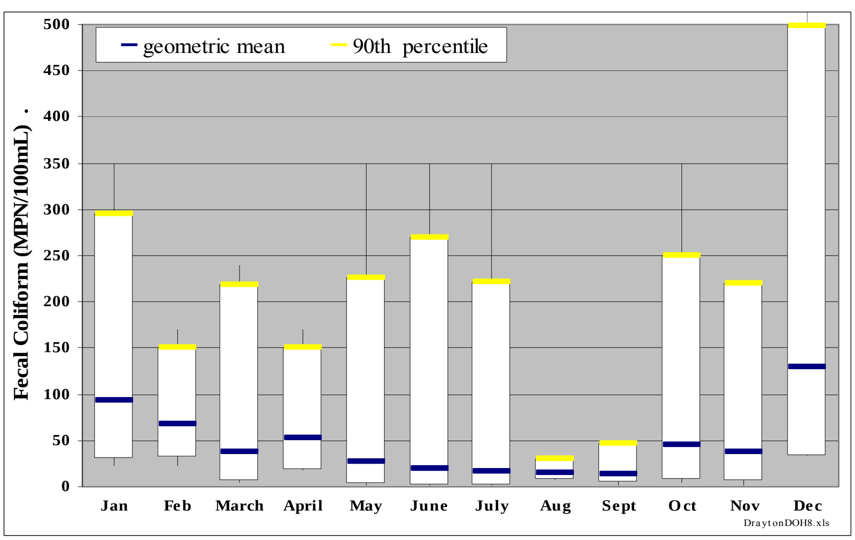

Figure B-8. DOH Station 8 monthly fecal coliform statistics for 1999 – September 2007

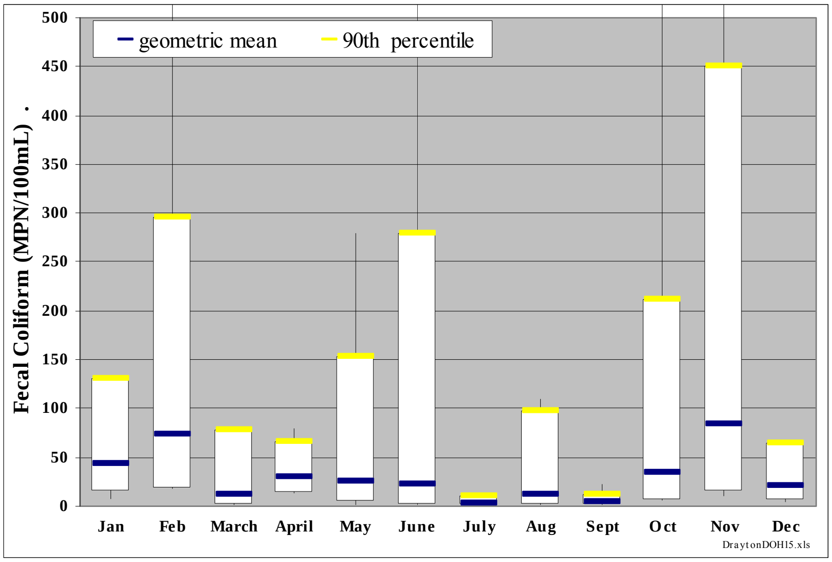

Figure B-9. DOH Station 15 monthly fecal coliform statistics for 1999 -September 2007.

Figure B-10 presents statistical summaries for *Prohibited* stations 6, 8, 15, and 11. Data summaries include data from 1999-2007, 2003-2007, and a 1999-2007 flood and ebb comparison of fecal coliform data. Stations 15 and 11 showed higher levels of fecal coliform during ebb tide, while stations 6 and 8 showed no clear pattern.

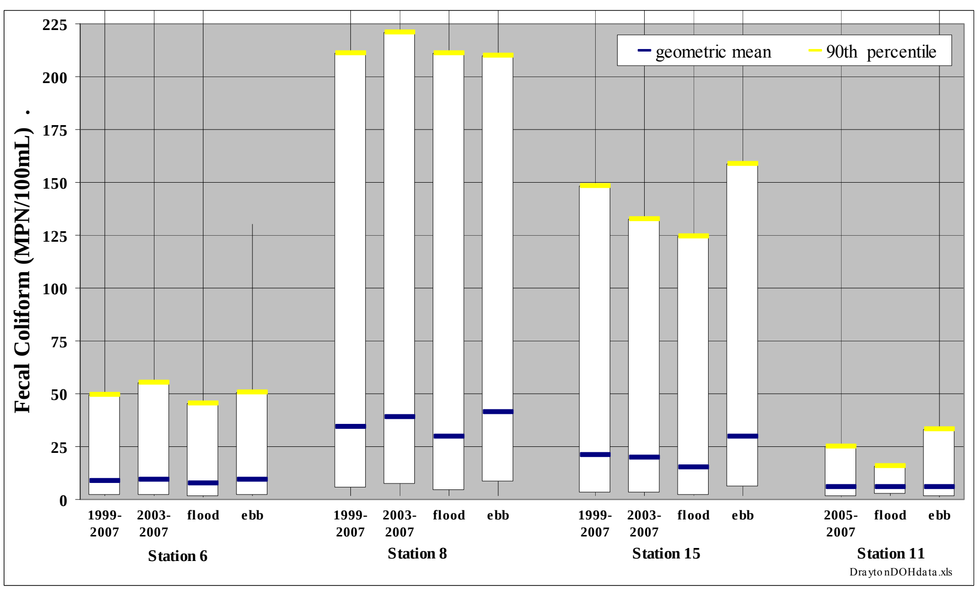

Figure B-10. Comparison of fecal coliform statistics during the ebb and flood at DOH Stations 6, 8, 15, and 11.

The results for the southwestern *Unclassified* stations 313 - 315 are presented below in Figures B-11 – B-13. Because they are relatively new stations, there is less monthly data for stations 313-315 (n=3-5) than the other DOH stations. Because the standard deviation is used to calculate the estimated 90th percentile, a lower sample size with a lot of variance in fecal coliform levels will produce a high 90th percentile estimate. Stations 313-315 show a similar pattern as the *Conditionally Approved* stations with increasing fecal coliform levels seen from November to February.

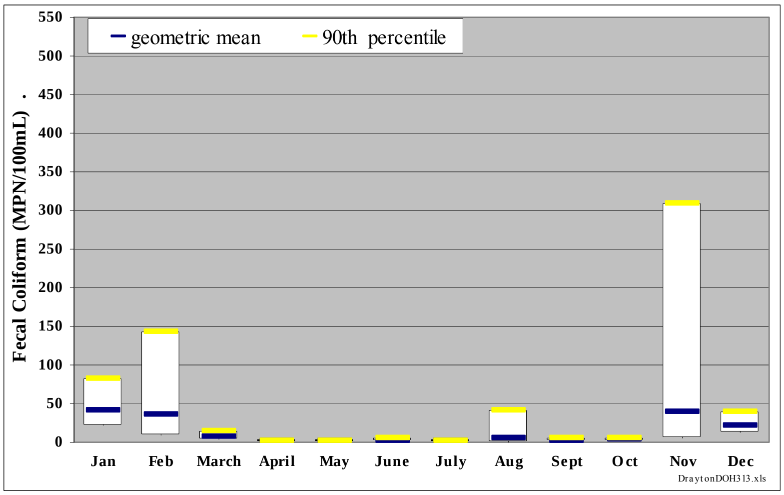

Figure B-11. Station 313 monthly fecal coliform statistics for August 2004 - September 2007.

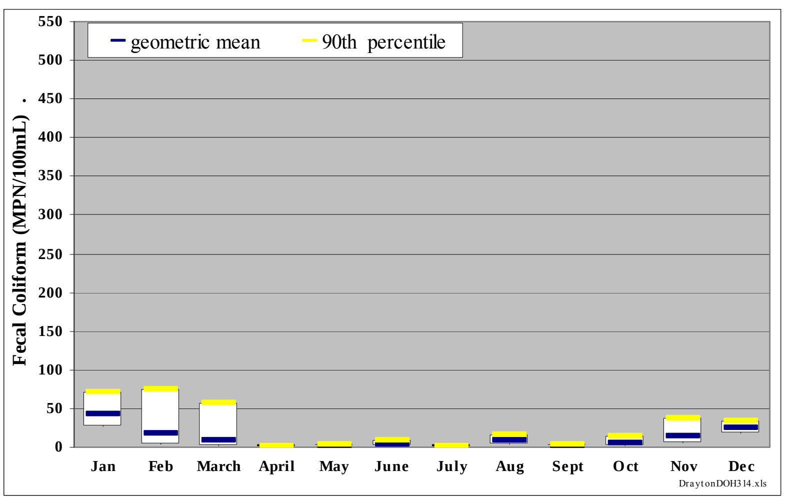

Figure B-12. Station 314 monthly fecal coliform statistics for August 2004 - September 2007.

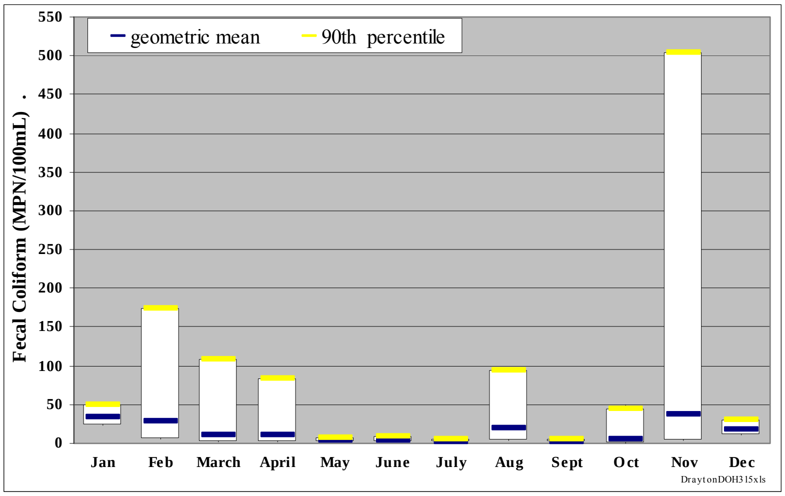

Figure B-13. Station 315 monthly fecal coliform statistics for August 2004 - September 2007.

Figure B-14 presents statistical summaries for the *Unclassified* stations 313-315. Data summaries include data from August 2004 through September 2007, and a 2004-2007 flood and ebb comparison of fecal coliform data. There was no clear pattern between ebb and flood tides for the *Unclassified* stations.

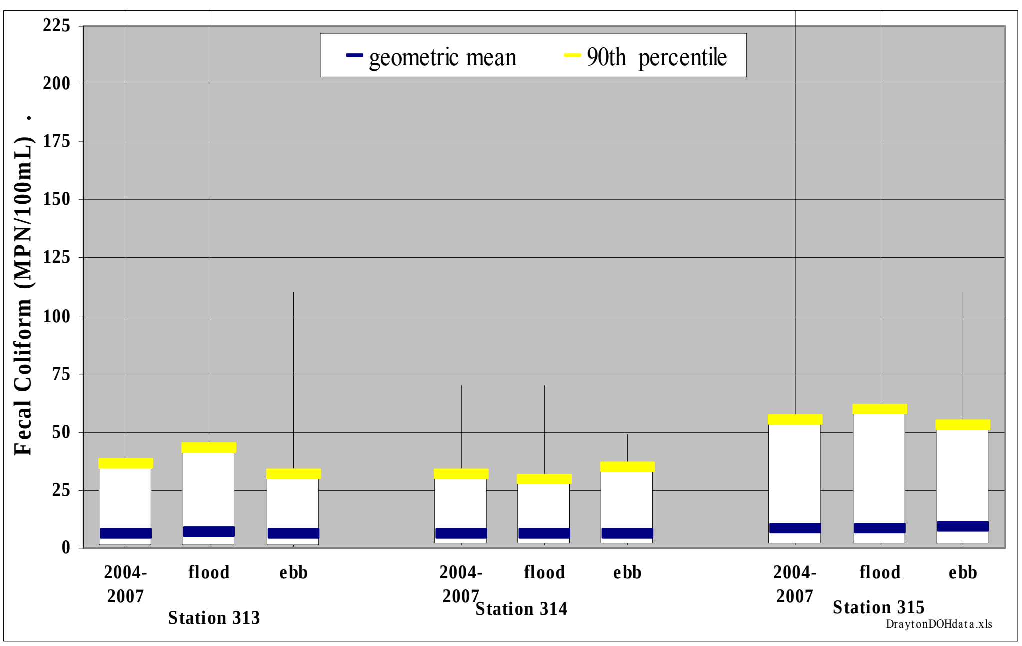

Figure B-14. Comparison of fecal coliform statistics during the ebb and flood at DOH Stations 313-315.

Comparison of precipitation and fecal coliform levels

To determine if there is a relationship between rainfall and fecal coliform levels, the two were compared using simple linear regression techniques. Fecal coliform values were log-transformed and were compared to rainfall for:

- the day of sampling.
- previous 24-hour rainfall (midnight-midnight).
- previous 48-hour rainfall.
- previous 72-hour rainfall.

Table B-3 presents the r^2 for the regression results. The r^2 ranges from 0.00 to 1.00 with 1.00 being the strongest relationship and 0.00 being no relationship. There were no strong or moderately strong relationships with previous rainfall and fecal coliform. For most sites, there was a weak relationship with previous 72-hour rainfall and fecal coliform. At DOH sites 8, 11, and 314 there was no relationship between rainfall and fecal coliform levels.

Table B-3. The r^2 regression relationship between fecal coliform levels and precipitation. A weak relationship between fecal coliform and the previous 72-hour rainfall is evident for most stations, with the exception of stations 8, 11, and 314, where no relationship is seen with rainfall.

Station	Day of Rainfall	Previous 24-hour rainfall	Previous 48-hour rainfall	Previous 72-hour rainfall
Conditionally Approved Stations				
Station 3	0.00	0.02	0.17	0.25
Station 4	0.00	0.02	0.15	0.21
Station 5	0.03	0.03	0.18	0.27
Station 12	0.08	0.03	0.15	0.25
Prohibited				
Station 6	0.02	0.08	0.20	0.31
Station 8	0.01	0.01	0.04	0.03
Station 11	0.03	0.01	0.00	0.06
Unclassified				
Station 313	0.06	0.04	0.21	0.27
Station 314	0.05	0.01	0.05	0.08
Station 315	0.00	0.01	0.15	0.13

Summary

Summary findings include:

- Since 1999, there has been some improvement in fecal coliform levels at DOH station 15.
- For the *Conditionally Approved* and *Unclassified* stations and station 6, higher fecal coliform levels are seen during the November through February period.
- Stations 8 and 15 in the *Prohibited* area have the highest fecal coliform levels in Drayton Harbor. No clear monthly fecal coliform pattern is present for these stations.
- For *Conditionally Approved* stations 5 and 12, higher fecal coliform levels are seen on the flood tide, while at *Prohibited* stations 11 and 15 higher fecal coliform levels are seen on the ebb tide.

Appendix C. Operating Kayaks for Field Work

Purpose

To ensure that kayaks owned or leased by Ecology are operated according to Ecology policy, *Operating Ecology Boats* (page 87, 88) and the boat manufacturer's specification, to prevent personal injury and loss/damage to expensive field sampling equipment.

Application

For Environmental Assessment (EA) Program staff operating kayaks owned or leased by Ecology. Kayaks will only be used if all other sampling options have been exhausted and supervisor and safety committee permission has been obtained.

Requirements

1. EA Program kayak operators must brief the crew on board the boat on all safety related items to comply with all provisions in the *EA Boating Plan* (page 85 and 86) and Ecology policy, *Operating Ecology Boats* (page 87 and 88).

2. Check weather and tidal conditions or flow discharge conditions before launching.

3. Wear life jacket at all times when in the kayak.

4. Use a minimum of two staff for field work using a kayak.

5. Use a type of kayak that is very stable, with good primary stability.

6. Equip each kayak with the following safety items: bailing device such as a manually operated bilge bump; flotation bags, a paddle float; and a dry bag containing a cell phone or radio, flares, and a first aid kit.

7. If stability is a concern while sampling, two kayaks should raft side by side with a paddle placed over the fore deck of both boats. One kayaker holds both boats in the side by side position using the paddle while the other kayaker conducts the sampling.

8. Kayak operators need a minimum of 100 hours experience in kayak operation.

Appendix D. DOH Shoreline Surveys Map and Descriptions

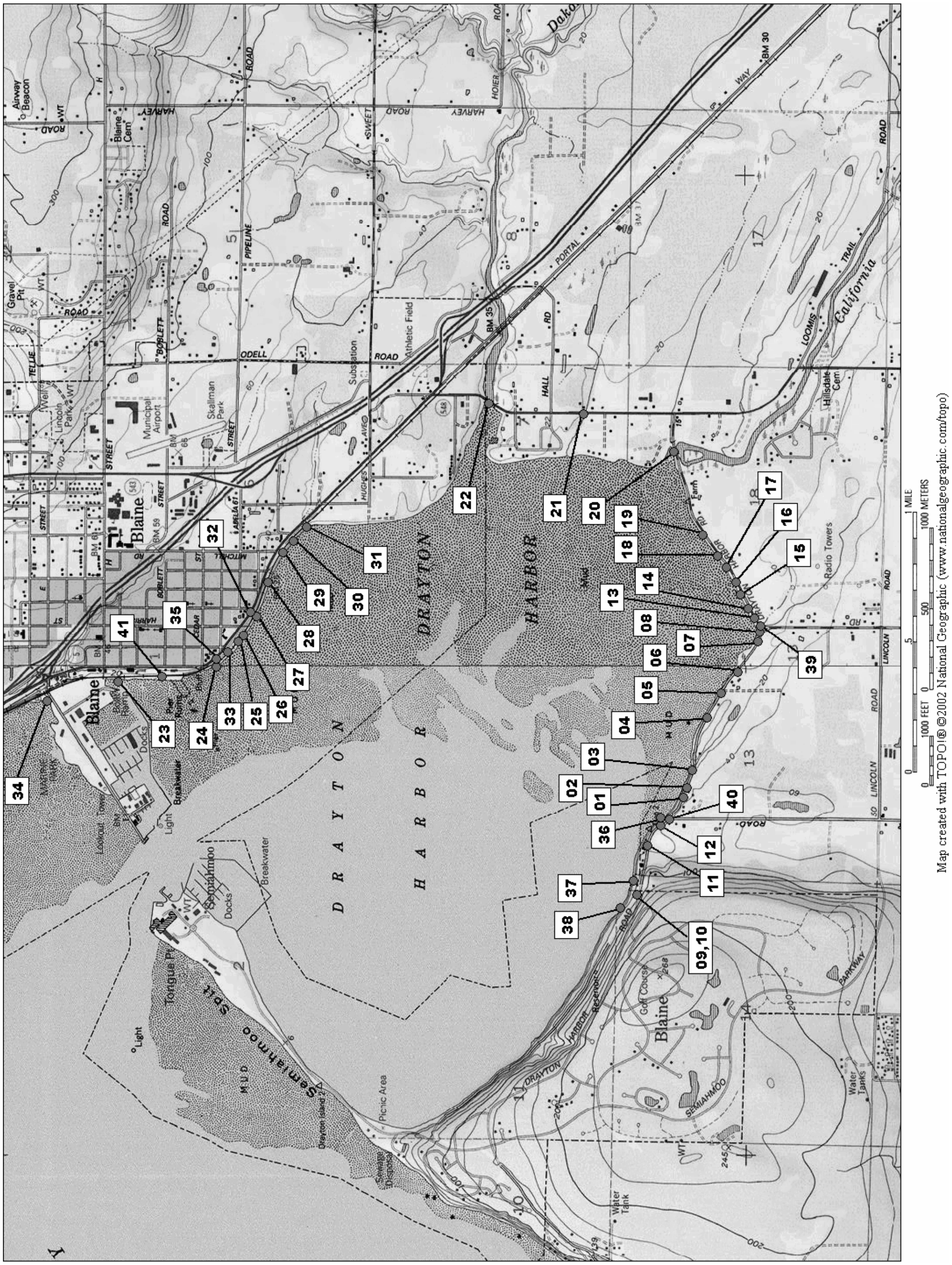

Figure D-1. Map of DOH shoreline survey sampling locations.

Table D-1. Coordinates and descriptions for DOH shoreline survey sampling locations.

Site #	Location	Comments
1	Lat. *N 46.96156°* Long. *W 122.76238°*	18" plastic culvert under Drayton Harbor Road. Discharging <5 gpm during evaluation.
2	Lat. *N 48.96140°* Long. *W 122.76163°*	18" metal culvert under Drayton Harbor Road. Discharging <5 gpm during evaluation.
3	Lat. *N 48.96101°* Long. *W 122.76012°*	Culvert under Drayton Harbor Road. Discharging 10-15 gpm during evaluation.
4	Lat. *N 48.96026°* Long. *W 122.75563°*	12" concrete culvert under Drayton Harbor Road. Discharging <5 gpm during evaluation.
5	Lat. *N 48.95943°* Long. *W 122.75360°*	18" plastic culvert (smooth finish) under Drayton Harbor Road. Discharging approximately 1 gpm during evaluation.
6	Lat. *N 48.95852°* Long. *W 122.75175°*	24" concrete culvert under Drayton Harbor Road. Discharging approximately 30 gpm during evaluation.
7	Lat. *N 48.95739°* Long. *W 122.74922°*	18" concrete culvert under Drayton Harbor Road. Discharging 5-10 gpm during evaluation.
8	Lat. *N 48.95727°* Long. *W 122.74830°*	24" concrete culvert under Drayton Harbor Road, discharging approximately 50 gpm during evaluation. Drainageway runs along east side of Harborview Road. (site is located south of Site 39).
9	Lat. *N 48.96412°* Long. *W 122.77074°*	12" concrete culvert under Drayton Harbor Road. Small discharge during evaluation.
10	Lat. *N 48.96414°* Long. *W 122.77058°*	6" green plastic pipe under Drayton Harbor Road. No discharge during evaluation.
11	Lat. *N 48.96352°* Long. *W 122.76648°*	12" concrete culvert under Drayton Harbor Road. Discharging approximately 10 gpm during evaluation.
12	Lat. *N 48.96276°* Long. *W 122.76480°*	18" concrete culvert under Drayton Harbor Road. No discharge during evaluation.
13	Lat. *N 48.95757°* Long. *W 122.74728°*	18" concrete culvert under Drayton Harbor Road. Discharging <5 gpm during evaluation.
14	Lat. *N 48.95789°* Long. *W 122.74634°*	18" metal culvert under Drayton Harbor Road.
15	Lat. *N 48.95832°* Long. *W 122.74507°*	Culvert under Drayton Harbor Road.
16	Lat. *N 48.95863°* Long. *W 122.74417°*	Concrete culvert under Drayton Harbor Road.
17	Lat. *N 48.95915°* Long. *W 122.74284°*	18" concrete culvert under Drayton Harbor Road.
18	Lat. *N 48.95964°* Long. *W 122.74187°*	24" concrete culvert under Drayton Harbor Road.
19	Lat. *N 48.96050°* Long. *W 122.74004°*	24" concrete culvert under Drayton Harbor Road.
20	Lat. *N 48.96206°* Long. *W 122.73312°*	California Creek
21	Lat. *N 48.96716°* Long. *W 122.72989°*	Culvert under Blaine Road. Discharging approximately 30 gpm during evaluation.
22	Lat. *N 48.97217°* Long. *W 122.72924°*	Dakota Creek
23	Lat. *N 48.99311°* Long. *W 122.75264°*	Concrete culvert discharging 10-15 gpm during evaluation.

Site #	Location	Comments
24	Lat. *N 48.98771°* Long. *W 122.75126°*	36" metal culvert under railroad tracks. Discharge to culvert is from upland just east of culvert, through Site 35. Discharging 10-15 gpm during evaluation.
25	Lat. *N 48.98632°* Long. *W 122.74919°*	8" steel culvert discharging approximately 5 gpm to shoreline. Unknown flow origin.
26	Lat. *N 48.98618°* Long. *W 122.74885°*	36" metal stormwater culvert under railroad tracks. Flow to culvert is from northwest and southeast direction along northeast side of railroad tracks with small flow from upland.
27	Lat. *N 48.98544°* Long. *W 122.74689°*	24" metal culvert under railroad tracks, discharging approximately 5 gpm during evaluation. Flow to culvert is from Site 32, just northwest of culvert.
28	Lat. *N 48.98478°* Long. *W 122.74414°*	18" plastic culvert slip fit into 36" concrete culvert and grouted with cement. Small flow through concrete portion of culvert. Culvert runs under railroad tracks and discharge is from upland area.
29	Lat. *N 48.98386°* Long. *W 122.74153°*	24" metal culvert under railroad tracks. Slight discharge during evaluation, flow from upland along southwest side of main road.
30	Lat. *N 48.98336°* Long. *W 122.74057°*	36" metal culvert under railroad tracks. Discharging 20-30 gpm during evaluation. Majority of flow is from northwest along the northeast side of the railroad tracks, small flow from upland.
31	Lat. *N 48.98259°* Long. *W 122.73944°*	36" concrete culvert discharging 25-30 gpm during evaluation.
32	Lat. *N 48.98557°* Long. *W 122.74680°*	18" plastic culvert under road. Discharge to growing area through Site 27.
33	Lat. *N 48.98698°* Long. *W 122.75009°*	18" concrete culvert under railroad tracks. Stormwater flow from northwest and southeast along northeast side of railroad tracks. Some discharge from upland.
34	Lat. *N 48.99712°* Long. *W 122.75413°*	Upland drainageway, discharging during evaluation. Discharge outside of Drayton Harbor.
35	Lat. *N 48.98765°* Long. *W 122.75076°*	24" plastic culvert with freefall discharge, discharging during evaluation. 18" metal culvert underneath, no discharge. Discharges to shoreline through Site 24.
36	Lat. *N 48.96254°* Long. *W 122.76411°*	Discharge at shoreline. Discharge from Site 40.
37	Lat. *N 48.96433°* Long. *W 122.76949°*	Discharge at shoreline.
38	Lat. *N 48.96502°* Long. *W 122.77184°*	Discharge at shoreline.
39	Lat. *N 48.95726°* Long. *W 122.74788°*	24" concrete culvert discharging to shoreline from upland area, approximately 100 gpm during evaluation. (site is located north of Site 08.
40	Lat. *N 48.96240°* Long. *W 122.76430°*	18" metal culvert under road. Discharging during evaluation, discharges to shoreline at Site 36.
41	Lat. *N 48.99712°* Long. *W 122.75413°*	18" metal culvert along upland side of railroad tracks. Culvert runs north to south along side to tracks, discharging approximately 5 gpm during evaluation. Discharge flows to north, unknown location of discharge to marine shoreline, may be through Site 23.

Appendix E. Puget Sound Restoration Fund Volunteer (PSRF) Shoreline Surveys Map and Descriptions

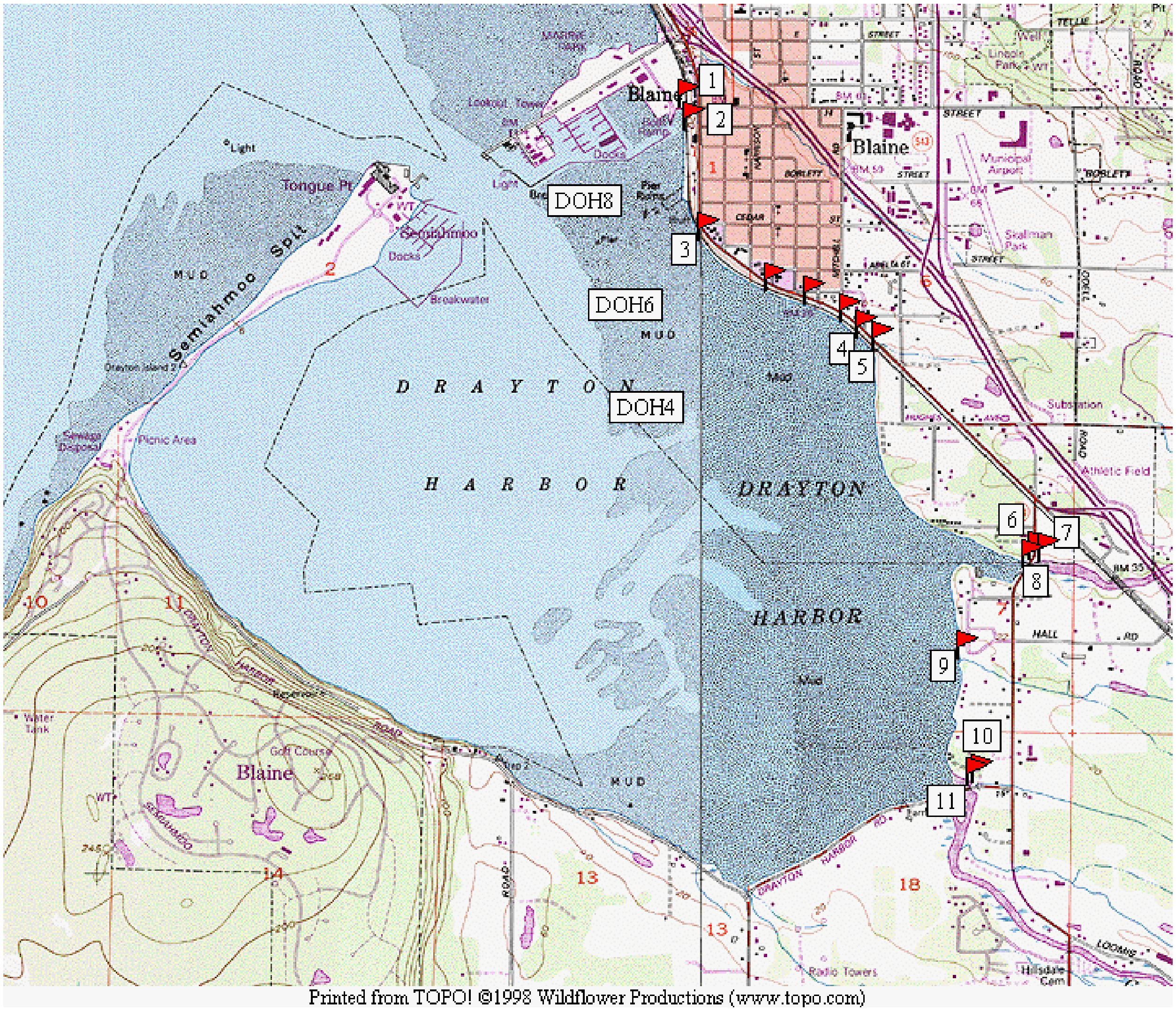

Figure E-1. Map of PSRF volunteer shoreline survey sampling locations.

Table E-1. Coordinates and descriptions for PSRF volunteer shoreline survey sampling locations.

Sample Site #	Location and Description
1	Small surface stream in mudflat east of the boat ramp
2	Small surface stream due east of the eastern end of the Blaine Harbor breakwater (48.99306 / 122.75294)
3	36” black drain pipe near Peace Portal and 4th (48.98774 / 122.75134) (Possibly Cykler and Haggerty site 1)
4	30” by 36” concrete pipe across from “Psychic Palm Reader” (Cykler, Haggerty site 6) (48.98324 / 122.74056)
5	36” by 42” concrete pipe across from Nikki’s Restaurant (Cykler, Haggerty site 3) (48.98261 / 122.73915)
6	Surface ditch on West side of Blaine Rd drains into Dakota Creek (Cykler, Haggerty site 9A)
7	Surface ditch on East side of Blaine Rd drains into Dakota Creek (Cykler, Haggerty site 9B)
8	Mouth of Dakota Creek
9	Mouth of “No Name Creek” 20 m south of hall Rd and Dearborn (Cykler, Haggerty site 10) (48.96819 / 122.73340)
10	Concrete storm drain immediately north of California Creek Bridge
11	Mouth of California Creek

Appendix F. Glossary and Acronyms

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

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.

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

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. Fecal coliform 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/100 mL).

Geometric mean: A mathematical expression of the central tendency (an 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 waters' 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 waterbody 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 waterbody.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES 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 NPDES 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.

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

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 5 acres of land.

Pollution: Such 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 is 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.

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.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody 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.

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.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report. Those used infrequently are not included.

cfs	Cubic feet per second
DH	Drayton Harbor
DO	Dissolved oxygen
DOH	Washington State Department of Health
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management system
EPA	U.S. Environmental Protection Agency
FC	Fecal coliform
FY	Fiscal year
gpm	Gallons per minute
MEL	Manchester Environmental Laboratory
MPN	Most probable number
NPDES	National Pollutant Discharge Elimination System
OSS	On-site septic systems
PSRF	Puget Sound Restoration Fund
QA	Quality assurance
RSD	Relative standard deviation
SOP	Standard operating procedure
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WWTP	Wastewater treatment plant