# Drayton Harbor Bacteria Total Maximum Daily Load (TMDL) Draft

*Technical Study and*
*Water Quality Improvement Plan*

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Cover photo: California Creek meets the Drayton Harbor mudflats
Photo Credit: Washington State Department of Ecology Coastal Atlas 08/05/2016



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# Drayton Harbor Bacteria
# Total Maximum Daily Load (TMDL) Draft

## Technical Study and
## Water Quality Improvement Plan

by

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# Table of Contents

Page

# List of Figures and Tables

Page

## Figures

## Tables

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# Summary

Levels of fecal bacteria observed in the Drayton Harbor watershed are above the Washington State Water Quality Standard (WQS) and the Total Maximum Daily Load (TMDL) study sets limits to address fecal bacteria pollution. This bacteria TMDL is a numerical value representing the highest pollutant load a surface water body can receive and still meet the WQS. This study quantifies the amount of pollution reduction necessary to attain the fecal coliform (FC) and *Escherichia coli* (*E. coli*) bacteria TMDLs, describes pollution sources, and has an Implementation Plan.

The TMDL comprises three primary components including the sum of the waste load allocations (WLAs) to represent point sources of pollution, load allocations (LAs) to represent nonpoint sources of pollution, and the margin of safety (MOS) to account for uncertainty. Approximately 88 percent of the watershed-wide TMDL comprises LAs, while roughly 2 percent comprises WLAs, with the remainder established as the MOS. Therefore, the TMDL indicates that reducing nonpoint sources of pollution—LAs—may provide the greatest overall benefit. However, activities that reduce localized point sources of pollution—WLAs—are also important.

Trend analysis of long-term data indicates improvement in water quality; however, pollution reductions are needed to attain the TMDL and WQS based on data from water years 2020 and 2021. Pollution reductions necessary to meet the downstream marine WQS are greater than the reductions necessary to meet the fresh water WQS. At the marine and fresh water interface, pollution reductions range from 61-99 percent, which protects the most sensitive designated use of shellfish harvesting. Pollution reductions necessary to protect fresh water contact recreation range from 0-90 percent.

Seasonal variation analysis of marine water quality data demonstrates that fecal bacteria levels observed during the wet season tend to be greater than dry season levels. Elevated fecal bacteria levels in marine waters during the wet season coincide with increased loading from fresh water tributaries to the harbor, indicated by a significant direct relationship. However, fecal bacteria concentration levels observed in fresh water do not show consistent patterns of seasonal variation. Measured rainfall shows consistent direct relationships with marine fecal bacteria concentration levels, while the relationships with fresh water bacteria levels tend to vary.

The Implementation Plan is a strategy to attain the TMDL, which describes watershed improvement activities and management that are primarily accomplished through local partner coordination and public participation. The Implementation Plan builds off the existing collaborative approach to protect and improve water quality. Grants are identified to help fund water quality improvement programs and projects. Loans are identified to provide budget relief when implementing water quality improvement activities.

# Introduction

Water quality monitoring data for Drayton Harbor and its tributaries indicate these waters experience elevated fecal indicator bacteria above the Washington State Water Quality Standards (WQS). Fecal coliform (FC), enterococci, and *Escherichia coli* (*E. coli*) bacteria are thermotolerant coliforms (APHA 2022) used in the WQS that often indicate fecal contamination from warm blooded animals has entered the water. These pathogens increase the risk of waterborne illness in humans who contact the water or consume contaminated shellfish. Nationally, pathogens are the leading cause of impairment for streams and lakes (EPA 2017), and in Washington State[1] the leading cause in marine waters.

Bacteria pollution in the Drayton Harbor watershed comes from a variety of sources, most of which are diffused, known as nonpoint sources. For example, pollution from agriculture originates from livestock waste through direct animal access to streams, runoff from pastures or manure application areas, or improper storage and handling of manure. Riparian buffers can attenuate the impacts of these sources but waterways within the Drayton Harbor watershed often lack streamside vegetation to sufficiently protect water quality. Urbanization and development also have the potential to pollute through sanitary sewer overflows and failure to follow stormwater best management practices, such as improper disposal of pet waste. Bacteria pollution can elevate concentrations above the WQS when deposited, flushed, or drained to state waters. Identifying and eliminating sources of bacteria pollution will improve water quality.

The Federal Clean Water Act (CWA) established a process to identify and clean up polluted waters. The CWA requires each state to develop and maintain WQS that protect, restore, and preserve water quality to support designated uses. The Total Maximum Daily Load (TMDL) is a numerical value representing the highest pollutant load a surface water body can receive and still meet the WQS. Any amount of pollution over the TMDL level needs to be reduced or eliminated to achieve clean water.

The primary goals of this study are to establish TMDLs and develop a plan to improve water quality to meet Washington WQS for bacteria within the Drayton Harbor watershed. These goals address current and future bacteria impairments within the watershed. The TMDL and water quality improvement plan build off recent data and efforts led by project partners and local interested parties. Field samples collected throughout the watershed form the basis of the known water quality impairments and were used to establish TMDLs. Project goals will be achieved by assessing watershed conditions and implementing pollution control recommendations that reduce fecal bacteria loading. The Drayton Harbor bacteria TMDL establishes the amount of fresh water pollution reduction necessary to meet the WQS for both fresh and marine waters.

[1] https://apps.ecology.wa.gov/approvedwqa/ApprovedPages/ApprovedSearch.aspx (Date accessed: 11/7/2023)

Coordinated efforts to reduce bacterial pollution resulted in improved water quality throughout many locations in the Drayton Harbor watershed—see Appendix D, Trend Analysis. The Drayton Harbor Shellfish Protection District was formed in 1995 to help address the downgrades and maintain safe shellfish harvesting. Pollution control led by the Whatcom Clean Water Program (WCWP)[2] reduced bacteria loading to the harbor, which allowed the opening of shellfish growing areas. Despite successful pollution controls and reductions, seasonal closures to shellfish harvesting remain. Whatcom County water quality monitoring in the Drayton Harbor watershed shows that only 14 out of 35 fresh water stations met the WQS in 2016 (Douglas 2017). Recent routine and focus area data[3] collected roughly between May 2024 and April 2025 in the Drayton Harbor watershed show 7 out of 40 fresh water stations meet water quality benchmarks. Continued pollution identification and control actions are necessary to attain the WQS where innovative solutions and public participation are key components.

This report quantifies the amount of pollution reduction necessary to attain the TMDL and WQS, identifies problematic and priority areas in the watershed, assists with unified pollution control efforts, and identifies funding opportunities to ensure the continuation of water quality improvement and protection. The Washington State Department of Ecology (Ecology), in partnership with government agencies and Tribes developed measures to control and reduce pollution sources, which primarily coordinate through the WCWP. The TMDL Implementation Plan is a strategy that identifies existing Pollution Identification and Correction (PIC) activities and provides additional information and resources to improve adaptive management. Successful project outcomes largely depend on the collective efforts of all responsible parties involved, including the public.

Monitoring and adaptive management are necessary to assess the effectiveness of water quality improvement activities. For example, monitoring information may identify problematic areas known as water quality “hot spots” that are prioritized for restoration work. These data also make it possible to conduct trend analysis or demonstrate successful restoration work. Fresh water trend analysis shows no water quality deterioration throughout the Drayton Harbor watershed. The Dakota Creek subbasin tends to show more improvement when compared to the California and Cain creek subbasins, and the shoreline catchments. Further examination of the activities that led to water quality improvements is warranted.

Marine water quality monitoring and shoreline surveys are necessary to make informed decisions on safe shellfish harvesting and characterize the relationship between upland loading and the receiving marine water quality. Since the 1990s, the number of acres reclassified from closed to approved has increased in Drayton Harbor due to water quality improvements—see Appendix A, Water Quality Issues for details. However, some areas remain closed or conditionally approved. Trend analysis of data collected over the past three decades demonstrates improvements in

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[2] https://www.whatcomcounty.us/DocumentCenter/View/41596/WhatcomCleanWaterProgram
[3] https://www.whatcomcounty.us/2608/Water-Quality-Monitoring-Results

marine water quality with no deterioration. Correlation analysis suggests that marine water quality is directly associated with upland inputs delivered by tributaries and drainages, and stormwater flushing—see Appendix D for details.

Despite these improvements, the WQS remain exceeded and significant reductions are necessary to meet them. As described in the TMDL Implementation Targets section of this report, the greatest level of pollution reduction is necessary to protect shellfish harvesting. After accounting for the observed ambient marine conditions, direct tributary inputs to the harbor near the brackish water interface require a range of 61 to 99 percent pollution reduction in FC depending on the sampling site and season. Drainages upstream of the brackish water boundary to the headwaters require pollution reductions that range from 0 to 90 percent depending on the sampling site and season.

Wet season pollution reductions tend to be greater than those of the dry season, however, this varies by sampling site. During the wet season, bacteria loads tend to be greater due to the relative increase in streamflow when compared to the dry season. Seasonal differences are most noticeable in the receiving marine water where the wet season shows greater bacteria concentrations than during the dry season. Dakota and California creeks deliver the greatest pollution loading inputs to the harbor; however, smaller discharges can deliver significant levels of bacteria pollution, as well.

# Overview

Washington State WQS and numeric criteria are designed to protect, restore, and preserve water quality with respect to designated beneficial uses. All surface waters of the state are protected by numeric or narrative criteria, designated uses, and an antidegradation policy (WAC 173-201A)[4]. Ecology is required by federal law to perform a statewide assessment of all readily available environmental data related to surface water quality every two years (Ecology 2023a). When a lake, river or stream fails to meet WQS, it is included on a list of impaired water bodies known as the 303(d) list. Information about the water quality assessment can be found at [Ecology's Water Quality Assessment & 303(d) list webpage](https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d)[5]. The assessment of data to make water quality category determinations follows Ecology's Water Quality Program Policy 1-11 (Ecology 2023a).

Section 303(d) of the CWA requires that states develop TMDLs for impaired surface waters if timely implementation of technology-based pollution controls and other required controls do not result in water bodies meeting applicable WQS. The Water Quality Assessment process in Washington State assigns 303(d) listed impairments to Category 5—see Appendix A, Clean Water Act and TMDLs. TMDL studies include a quantitative assessment of water quality problems, a description of the pollutant sources that are causing the problem(s), and load allocation (LA) and

[4] https://app.leg.wa.gov/WAC/default.aspx?cite=173-201A
[5] https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d

waste load allocation (WLA) reductions necessary to meet WQS. When a TMDL and Implementation Plan are developed for a given pollutant, the Category 5 impairment will be placed into Category 4A. Fulfilling the pollution prevention and control activities described in the Implementation Plan is expected to attain the TMDLs and meet the WQS for all water bodies in the Drayton Harbor study area.

Beginning in 2007, Phase 1 of the Drayton Harbor TMDL involved project planning and data collection and analysis to establish load reductions to meet WQS—see Appendix D. Phase 1 was updated to initiate Phase 2 using contemporaneous information shared through the WCWP partnership. Phase 2 completes this study and establishes TMDLs, investigates trends, further characterizes the relationship between fresh water bacteria loading and marine water quality, and finalizes the Implementation Plan. The TMDL and Implementation Plan build off the WCWP coordinated efforts to engage interested parties and community members to improve and protect water quality.

If the TMDLs are not met, safe shellfish harvesting will continue to be threatened by elevated FC bacteria levels within the harbor. The Washington State Department of Health (DOH) determines whether shellfish growing areas are safe for harvest[6]. The DOH annually reviews each shellfish growing area resource and explains the classification based on long-term sampling data and field observation evaluations. Temporary harvest closures may also occur based on the amount of rainfall or stream discharge, the occurrence of sanitary sewer overflows, or other relevant factors that make shellfish unsafe to consume. Appendix A details the DOH classification history and status of Drayton Harbor.

# Scope

## Drayton Harbor Watershed Study Area

Drayton Harbor is in Whatcom County at the northwest corner of Washington State, just south of the US-Canadian border (Figure 1). The study area, which includes the upland drainage and Drayton Harbor, is approximately 58.9 mi² (152.5 km²) and is part of Water Resource Inventory Area 1 (WRIA 1)—Nooksack (NHD 2001). Approximately 0.4 mi² (0.9 km²)—or 0.6 percent—of the watershed is in Canada, which is included in the loading analysis.

A narrow 500-foot entrance connects the harbor to Semiahmoo Bay and the greater Strait of Georgia. The harbor's shallow bathymetry results in approximately 60 percent exposure of the mudflat bottom during low tides (Whatcom County 2024), primarily within its eastern half. Historically, the harbor has been used for commercial, recreational, and tribal shellfish harvesting. The harbor and Semiahmoo Bay are within the usual and accustomed fishing grounds of several Tribes, including the Lummi Nation and the Nooksack Indian Tribe.

[6] https://doh.wa.gov/community-and-environment/shellfish

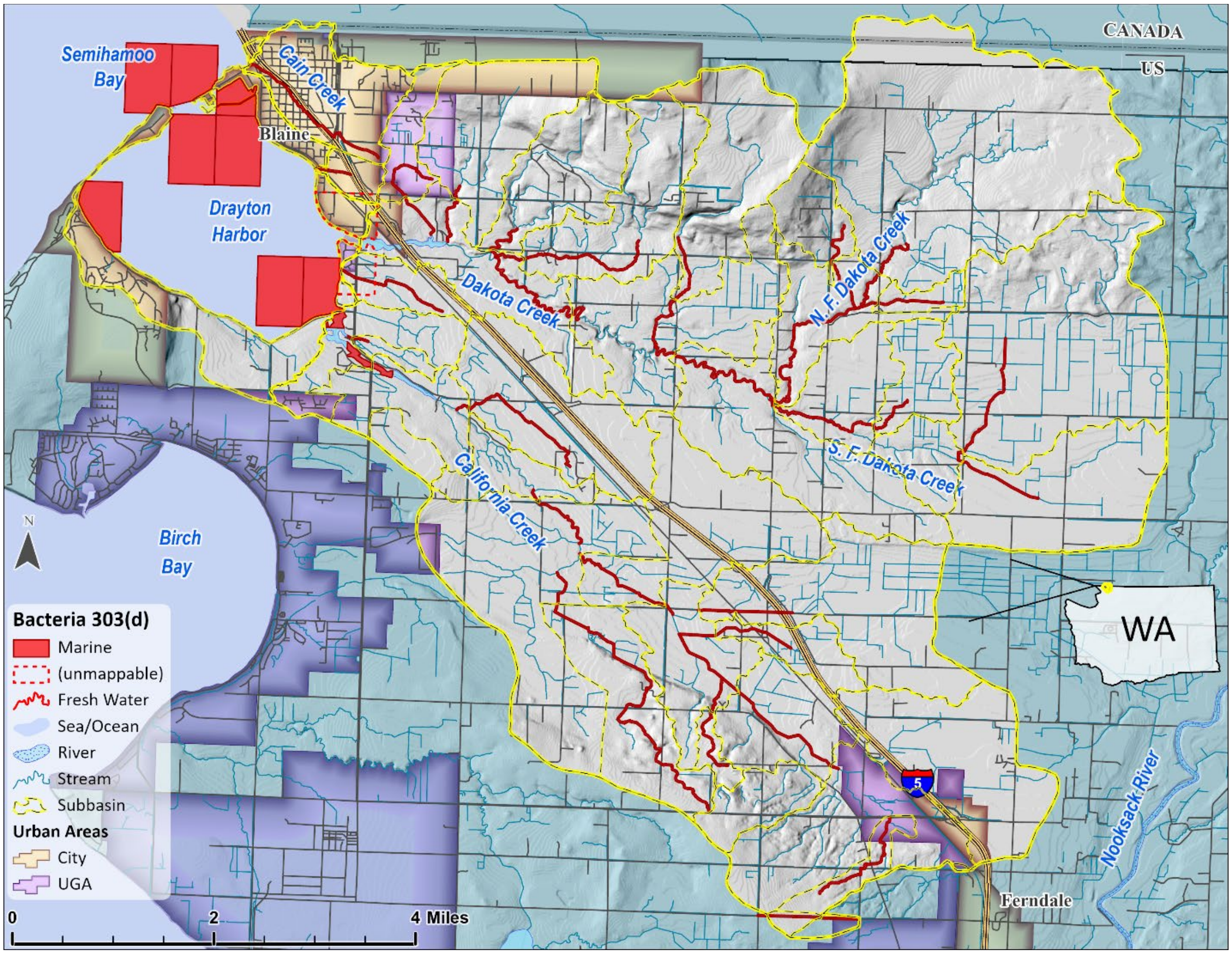


**Figure 1. Location of marine and fresh water fecal coliform bacteria impairments (303(d) list) in the Drayton Harbor TMDL study area; (unmappable): water body feature not present in the National Hydrography Dataset (NHD)**

The Port of Bellingham operates the Blaine Marina that is located at the northern edge of the harbor entrance. The marina has 629 boat slips, including permanent moorage and 800 square feet of visitor moorage[7]. The marina has several fish processing companies and a public wharf. The City of Blaine's domestic wastewater treatment plant (WWTP), known as the Lighthouse Point Water Reclamation Facility (Lighthouse Point WWTP), is located between the Blaine Marine Park and the Blaine Harbor Marina. The facility discharges treated effluent to Semiahmoo Bay and produces Class A reclaimed water—see Appendix A, Lighthouse Point Water Reclamation Facility for details. The southwest spit includes Semiahmoo County Park, which is adjacent to the Semiahmoo Resort and Marina facility with approximately 300 boat slips, including moorage.

[7] https://www.portofbellingham.com/197/About-Blaine-Harbor

Approximately 93 percent (51 mi²) of the upland watershed comprises the California and Dakota Creek subbasins, totaling 40 and 53 percent respectively (Table 1). The headwaters of these drainages originate in the eastern portion of the study area and generally flow northwest to the harbor. These watersheds mostly drain lowland areas below 100 feet to sea level with headwater elevations in the Dakota Creek subbasin reaching 542 feet and the California Creek subbasin reaching 370 feet above sea level (Dunn and Cook 2023). The Cain Creek subbasin comprises 2.3 percent (1.3 mi²) of the upland watershed area and drains to Semiahmoo Bay. The remaining shoreline area comprises 4.9 percent (2.7 mi²) of the upland watershed area and drains directly to the harbor or Semiahmoo Bay. The marine water area of the harbor totals 4 mi² based on aerial-ortho imagery at high tide. Appendix E provides further detail of each drainage that was used to develop TMDLs at the delineated catchment level.

**Table 1. Drayton Harbor TMDL study area subbasin delineations**

| Subbasin | Mi² | Acres | Km² | Hectares | Proportion of watershed area |
|---|---|---|---|---|---|
| Drayton Harbor (marine) | 4.0 | 2560 | 10.4 | 1036 | 7% |
| Upland total (fresh water) | 54.9 | 35131 | 142.2 | 14217 | 93% |
| Shoreline | 2.7 | 1731 | 7.0 | 700 | 5% |
| Dakota Creek | 28.9 | 18512 | 74.9 | 7491 | 49% |
| California Creek | 22.0 | 14065 | 56.9 | 5692 | 37% |
| Cain Creek | 1.3 | 824 | 3.3 | 333 | 2% |
| **Total:** | 58.9 | 37691 | 152.5 | 15253 | |

Data source: National Hydrography Dataset (2001), Version 2.3

Dakota Creek is the largest tributary to the harbor, followed by California Creek—see Appendix A, Watershed Hydrology. According to the Dakota Creek streamflow gage station 01Q070[8], the median discharge is 17.6 cubic feet per second (cfs) with a range of 0.3—638 cfs over the period of record from water year (WY) 2008 through 2021. California Creek does not have an active streamflow gage. The mouth of California Creek is located approximately ¾ miles to the south of the mouth of Dakota Creek.

Cain Creek flows north of the harbor through a large portion of the city of Blaine. The headwaters of Cain Creek 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 urban development and the construction of the I-5 freeway and serves as the receiving water body to several storm drainages (City of Blaine 1995).

[8] https://apps.ecology.wa.gov/ContinuousFlowAndWQ/StationDetails?sta=01Q070

The 2020 United States Census Bureau data show a resident population of roughly 20,303 people in the Drayton Harbor watershed[9]. This population count represents a slight over-estimate because census blocks were not split exactly by the watershed area perimeter. Various land cover includes high to low density development, pasture, cultivated crops, forests, shrub/scrub, and wetlands—see the Implementation Plan, Land Cover Distribution section for details. Land uses include commercial dairies, berry farms and agriculture, non-commercial hobby farms, surface mining, forestry, commercial, industrial, residential, and green spaces.

## Section 303(d)-Listed Impairments Addressed by the TMDL

Ecology is establishing FC and *E. coli* TMDLs for Drayton Harbor and its tributaries on a watershed scale. The current total number of 303(d)-listed (Category 5) bacteria impairments in the watershed is 44 (Table 2). Although these impairments are listed on the basis of FC data, this TMDL includes an *E. coli* component because the WQS have changed for fresh water—see the Uses of the Water Bodies and the Water Quality Criteria sections of this report for details. There are no 303(d) listed impairments in the study area based on *E. coli* or enterococci data. Ecology doesn't currently have available *E. coli* data to reassess the fresh water listings, however, this TMDL is written to the applicable WQS and employs the use of a bacteria translator—see the TMDL Targets, Bacteria Translator section of this report for details.

The FC and *E. coli* bacteria TMDLs established in this study incorporate a combination of water quality measurements, stream discharge measurements, and drainage area delineations at the sub-watershed (catchment) level to account for all assessment unit (AU) stream segments within the Drayton Harbor watershed—see Appendix E for details. An AU is a segment of a water body that has been evaluated for pollution to determine compliance with the WQS. Assessment units are typically delineated using the NHD reaches for fresh waters and grids for open water bodies such as lakes or marine waters.

**Table 2. Water bodies on the current (2014—2018) 303(d) list addressed by the Drayton Harbor TMDL**

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 42499 | CAIN CREEK | Fecal Coliform | 17110002000738_001_001 |
| 39058 | CALIFORNIA CREEK | Fecal Coliform | 48122J7G3_01_01 |
| 39059 | CALIFORNIA CREEK | Fecal Coliform | 48122J7F2_01_01 |
| 39060 | CALIFORNIA CREEK | Fecal Coliform | 17110002000121_001_001 |
| 72275 | CALIFORNIA CREEK | Fecal Coliform | 17110002000118_001_001 |
| 72276 | CALIFORNIA CREEK | Fecal Coliform | 17110002000123_001_001 |
| 89253 | CALIFORNIA CREEK | Fecal Coliform | 17110002000120_001_001 |
| 74145 | DAKOTA (REBEL) CREEK | Fecal Coliform | 17110002000169_001_001 |
| 39073 | DAKOTA CREEK | Fecal Coliform | 48122J7H2_01_01 |
| 39074 | DAKOTA CREEK | Fecal Coliform | 17110002000134_001_001 |

[9] https://www.census.gov/geographies/reference-files/time-series/geo/centers-population.html

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 39077 | DAKOTA CREEK | Fecal Coliform | 17110002000133_001_002 |
| 39075 | DAKOTA CREEK, N.F. | Fecal Coliform | 17110002000154_001_002 |
| 6395 | DAKOTA CREEK, S.F. | Fecal Coliform | 17110002000136_001_002 |
| 72277 | DAKOTA CREEK, S.F. | Fecal Coliform | 17110002000137_001_001 |
| 15692 | DRAYTON HARBOR | Fecal Coliform | 48122J7I6_01_01 |
| 39048 | DRAYTON HARBOR | Fecal Coliform | 48122J7J5_01_02 |
| 39052 | DRAYTON HARBOR | Fecal Coliform | 48122J7J6_01_02 |
| 53171 | DRAYTON HARBOR | Fecal Coliform | 48122J7I5_01_01 |
| 53184 | DRAYTON HARBOR | Fecal Coliform | 48122J7H8_01_02 |
| 86869 | DRAYTON HARBOR | Fecal Coliform | 48122J7G4_01_01 |
| 88161 | DRAYTON HARBOR | Fecal Coliform | 17110002000745_001_001 |
| 72280 | HAYNIE CREEK | Fecal Coliform | 17110002000163_001_002 |
| 45108 | NO NAME CREEK | Fecal Coliform | 17110002000162_001_001 |
| 39085 | STRAIT OF GEORGIA | Fecal Coliform | 48122J7J7_02_02 |
| 86863 | STRAIT OF GEORGIA | Fecal Coliform | 48122J7J6_02_02 |
| 74144 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002000168_001_001 |
| 74146 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002000178_001_001 |
| 74147 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002000390_001_001 |
| 74152 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002000837_001_001 |
| 88158 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002000864_001_001 |
| 88477 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002015789_001_001 |
| 46183 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | Fecal Coliform | 400N010E07_001 |
| 72278 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | Fecal Coliform | 17110002000159_002_003 |
| 72279 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | Fecal Coliform | 17110002000161_001_002 |
| 74157 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | Fecal Coliform | 17110002001756_001_001 |
| 74161 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | Fecal Coliform | 17110002003884_001_001 |
| 74153 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, N.F.) | Fecal Coliform | 17110002000841_001_001 |
| 74154 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, N.F.) | Fecal Coliform | 17110002000848_001_001 |
| 74155 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, S.F.) | Fecal Coliform | 17110002000850_001_001 |

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 42507 | UNNAMED CREEK (TRIB TO DRAYTON HARBOR) | Fecal Coliform | 17110002000742_001_001 |
| 46186 | UNNAMED CREEK (TRIB TO DRAYTON HARBOR) | Fecal Coliform | 400N010W01_010 |
| 88149 | UNNAMED DITCH (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002015952_001_001 |
| 88406 | UNNAMED DITCH (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110004016438_001_001 |
| 88959 | UNNAMED DITCH (TRIB TO CALIFORNIA CREEK) | Fecal Coliform | 17110002015468_001_001 |

There are 57 other 303(d) listed AUs in the watershed, but this report does not address them because they are beyond the scope of this bacteria TMDL (Table 3). The water bodies listed as impaired for a given toxin in sediment are being addressed by the Model Toxics Control Act, including the Drayton Harbor AU that is in an area commonly known as the Blaine Shipyard and the Strait of Georgia AU that is in an area commonly known as Westman Marine Inc. These AUs are in areas being investigated for sediment contamination and cleanup.

**Table 3. 303(d) listed water bodies and Assessment Unit IDs not addressed by the bacteria TMDL**

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 47732 | CAIN CREEK | DO | 17110002000738_001_001 |
| 70854 | CAIN CREEK | pH | 17110002000738_001_001 |
| 73699 | CAIN CREEK | Temperature | 17110002000738_001_001 |
| 47725 | CALIFORNIA CREEK | DO | 17110002000121_001_001 |
| 77982 | CALIFORNIA CREEK | DO | 17110002000118_001_001 |
| 73687 | CALIFORNIA CREEK | Temperature | 17110002000118_001_001 |
| 7067 | DAKOTA (REBEL) CREEK | DO | 17110002000169_001_001 |
| 47724 | DAKOTA CREEK | DO | 17110002000134_001_001 |
| 77984 | DAKOTA CREEK | DO | 17110002000133_001_002 |
| 73671 | DAKOTA CREEK | Temperature | 17110002000134_001_001 |
| 73690 | DAKOTA CREEK | Temperature | 17110002000133_001_002 |
| 38996 | DAKOTA CREEK, N.F. | DO | 17110002000154_001_002 |
| 39216 | DAKOTA CREEK, N.F. | Temperature | 17110002000154_001_002 |
| 7068 | DAKOTA CREEK, S.F. | DO | 17110002000137_001_001 |
| 7069 | DAKOTA CREEK, S.F. | DO | 17110002000136_001_002 |
| 15439 | DAKOTA CREEK, S.F. | Temperature | 17110002000136_001_002 |
| 51073 | MCALLISTER CREEK | pH | 17110002000754_001_001 |
| 51071 | NO NAME CREEK | pH | 17110002000162_001_001 |
| 81836 | SOUTH FORK DAKOTA CREEK | DO | 17110002000136_002_002 |
| 82041 | SOUTH FORK DAKOTA CREEK | DO | 17110002000867_001_001 |
| 77988 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000164_001_001 |

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 77989 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000168_001_001 |
| 77990 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000178_001_001 |
| 77991 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000390_001_001 |
| 77993 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000837_001_001 |
| 77998 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002003881_001_001 |
| 81736 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002016724_001_001 |
| 81866 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000781_001_001 |
| 81962 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002015789_001_001 |
| 82027 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110004006577_001_001 |
| 82089 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110004006382_001_001 |
| 82180 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | DO | 17110002000181_001_001 |
| 51072 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | pH | 17110002003881_001_001 |
| 80514 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | pH | 17110002000781_001_001 |
| 80538 | UNNAMED CREEK (TRIB TO CALIFORNIA CREEK) | pH | 17110002016724_001_001 |
| 77985 | UNNAMED CREEK (TRIB TO DAKOTA CREEK) | DO | 17110002000159_002_003 |
| 77996 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, S.F.) | DO | 17110002000850_001_001 |
| 81745 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, S.F.) | DO | 17110002001727_001_001 |
| 80527 | UNNAMED CREEK (TRIB TO DAKOTA CREEK, S.F.) | pH | 17110002001727_001_001 |
| 70865 | UNNAMED CREEK (TRIB TO DRAYTON HARBOR) | pH | 400N010W01_007 |
| 70866 | UNNAMED CREEK (TRIB TO DRAYTON HARBOR) | pH | 400N010W01_008 |
| 81208 | UNNAMED DITCH (TRIB TO COLONY CREEK) | DO | 17110002000397_001_001 |
| 81704 | UNNAMED DITCH (TRIB TO DAKOTA (REBEL)) | DO | 17110002016743_001_001 |

| Listing ID | Water Body Name | Pollutant | Reach Code (Assessment Unit ID) |
|---|---|---|---|
| 82116 | UNNAMED DITCH (TRIB TO DAKOTA (REBEL)) | DO | 17110002016586_001_001 |
| 80536 | UNNAMED DITCH (TRIB TO DAKOTA (REBEL)) | pH | 17110002016586_001_001 |
| 82124 | UNNAMED DITCH (TRIB TO DAKOTA CREEK, S.F.) | DO | 17110002015560_001_001 |
| 824082 | DRAYTON HARBOR | Arsenic[s] | 48122J7H3_SE |
| 824083 | DRAYTON HARBOR | Cadmium[s] | 48122J7H3_SE |
| 824084 | DRAYTON HARBOR | Chromium[s] | 48122J7H3_SE |
| 824085 | DRAYTON HARBOR | Copper[s] | 48122J7H3_SE |
| 824086 | DRAYTON HARBOR | Lead[s] | 48122J7H3_SE |
| 824087 | DRAYTON HARBOR | Mercury[s] | 48122J7H3_SE |
| 824088 | DRAYTON HARBOR | Silver[s] | 48122J7H3_SE |
| 824089 | DRAYTON HARBOR | Zinc[s] | 48122J7H3_SE |
| 819947 | STRAIT OF GEORGIA | HPAH[s] | 48122J7J6_SE |
| 819950 | STRAIT OF GEORGIA | LPAH[s] | 48122J7J6_SE |
| 819960 | STRAIT OF GEORGIA | PCBs[s] | 48122J7J6_SE |

Note:

HPAH—High Molecular Weight Polycyclic Aromatic Hydrocarbons
LPAH—Low Molecular Weight Polycyclic Aromatic Hydrocarbons
PCBs—Polychlorinated Biphenyls
[s]—Sediment

# Uses of the Water Bodies

The federal Clean Water Act requires states to designate beneficial uses, known as designated uses, for all waters. The WQS are set to protect each designated use and consist of several parts:

- Designated uses—Identify how people, aquatic communities, and wildlife use our waters,
- Numeric criteria—Amounts of specific pollutants allowed in a body of water that still protect it for the beneficial uses,
- Narrative criteria—Statements of unacceptable conditions in and on the water, and
- Antidegradation protections—Extra protection for high-quality or unique waters and existing uses.

The bacteria TMDL covering the Drayton Harbor watershed is set at a level to protect the designated uses described in the following sections (Figure 2).

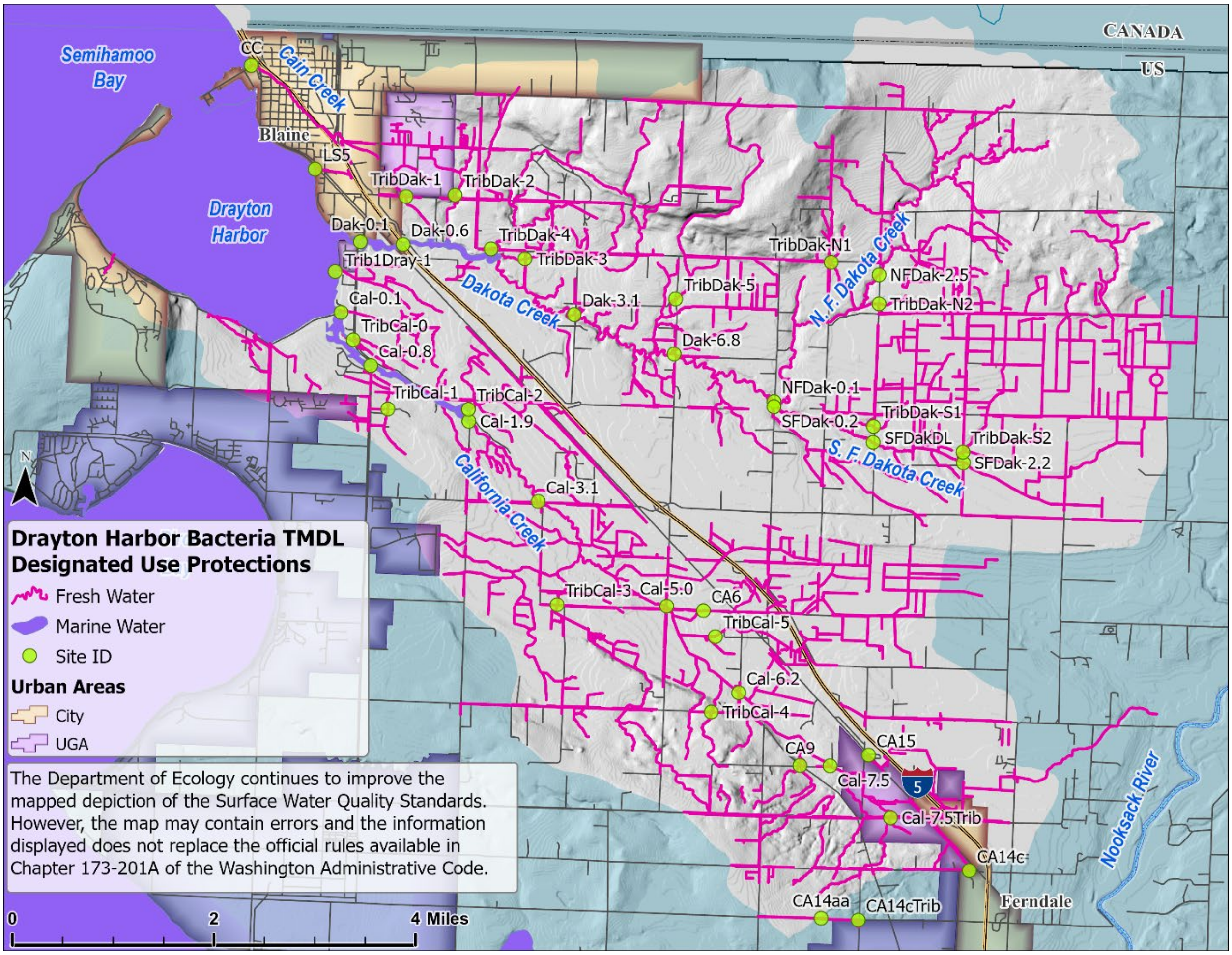


**Figure 2. Designated use areas addressed by the bacteria TMDL**

## Fresh Water Designated Uses

Designated uses assigned to fresh waters such as rivers and streams are listed in WAC 173-201A-200, WAC 173-201A-600, and WAC 173-201A-602. Specifically, the fresh water tributaries to Drayton Harbor are designated for the following relevant use:

**Recreational** – Primary contact is intended for waters where a person would have direct contact with water to the point of complete submergence 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. Bacteria criteria are based on the presence of *E. coli* organisms and expressed as colony forming units (cfu) or most probable number (MPN).

Bacteria criteria are set to protect people from waterborne illnesses who work or play in and on the water, which defines the recreational designated use. Thermotolerant bacteria such as FC or *E. coli* in water indicate the presence of waste from humans or 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 former FC criteria and current *E. coli* criteria are based on concentrations that have been shown to maintain low risk of serious intestinal illness (gastroenteritis) in people. The Dakota and California creek watersheds do not have designated swimming areas, but swimming does occur. Canoeing, kayaking, fishing, and wading also take place in these creeks.

The initial investigation of this TMDL started when the WQS used FC bacteria as the indicator for protecting fresh water contact recreation activities. In 2019, Ecology changed the WQS to use *E. coli* as the fecal bacteria indicator for fresh water. Details related to this change in the fecal indicator bacteria are presented in the Water Quality Criteria, Revised Water Quality Standard section of this report. The *E. coli* TMDLs established in this report, however, protect the fresh water primary contact recreation designated use by characterizing the relationship between FC and *E. coli*—see TMDL Targets section and Appendix D for details.

## Marine Water Designated Uses

While *E. coli* will be used to determine the attainment of recreational use in fresh water, the protection of marine water designated uses is based on the bacteria indicators Enterococci or FC depending on the specific use. Designated uses assigned to marine waters are listed in WAC 173-201A-210, WAC 173-201A-610, and WAC 173-201A-612. Drayton Harbor and the nearby marine waters are designated for the following relevant uses:

**Recreational** – Primary contact is intended for waters where a person would have direct contact with water to the point of complete submergence 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. Bacteria criteria are based on the presence of enterococci organisms and expressed as colony forming units (cfu) or most probable number (MPN).

**Shellfish harvesting** – Based on the presence of FC organisms and expressed as colony forming units (cfu) or most probable number (MPN).

Fresh waters that enter Drayton Harbor and the nearby marine waters have an impact on water quality. The WQS include the provision to protect downstream uses—"Upstream actions must be conducted in manners that meet downstream water body criteria" [WAC 173-201A-260(3)(b)]. The established bacteria TMDLs of this study are set to protect the downstream designated uses.

The most sensitive designated use protected by this TMDL is shellfish harvesting in Drayton Harbor. The sensitivity of each designated use is based on the numeric water quality criteria described in the following section. The Drayton Harbor FC TMDL establishes targets for fresh water inputs to protect the downstream designated use of shellfish harvesting. The *E. coli* TMDL in this report establishes targets to protect the downstream marine water recreational designated use because both the fresh and marine WQS provide the same level of protection, and neither is more stringent than the other when applying the primary contact recreational designated use (EPA 2012 and 2020). After TMDL goals are met, the impact of bacteria pollution from fresh water will support the recreational and shellfish harvesting designated uses in marine water.

There are no designated swimming areas in and around Drayton Harbor, however, there is access to the shorelines and marine waters. Semiahmoo Park, Blaine Marine Park, Blaine Harbor Marina, and Semiahmoo Marina all provide access to Drayton Harbor and Semiahmoo Bay. California Creek has a designated kayak launch and park near the mouth operated by the Blaine-Birch Bay Park and Recreation District 2. The Dakota Creek Kayak Launch is a City of Blaine facility that also offers public access to the harbor. A small Whatcom County Parklet along Dearborn Avenue also provides public access to the harbor shoreline and tidal flats. Designated access to the marine waters, shorelines, and tide flats increases the opportunity and frequency of recreation and shellfish harvesting.

Commercial and recreational shellfish harvesting occurs in and around the harbor and people who harvest come in close contact with these waters. Semiahmoo Park has recreational shellfish harvesting classified as prohibited year-round because it is within the closure area of the Lighthouse Point WWTP outfall. Areas directly adjacent to the Semiahmoo Marina are prohibited for recreational harvest because the beach is within the marina closure zone. Similarly, the areas directly adjacent to the Blaine Marina are prohibited for recreational harvesting and commercial harvesting due to the marina closure zone. The Drayton West Public Tidelands is classified as approved and is open for recreational harvest because water quality and shoreline conditions meet public health standards for recreational shellfish harvesting. When water quality or shoreline conditions deteriorate, these recreational and commercial areas may experience temporary or seasonal closures—see Appendix A for details about the status of commercial shellfish growing areas and the location of marine sampling stations.

# Water Quality Criteria

## Revised Water Quality Standards for Bacteria Indicators

In 2019, Ecology revised the Surface WQS for the protection of water contact recreation (Ecology 2023a). Ecology arranged a transition period that allowed FC data to be used through December 31, 2020 (Ecology 2019a). TMDLs that protect water contact recreation approved after December 31, 2020, require the use of the new bacterial indicators. To fulfill the new requirement, this Drayton Harbor bacteria TMDL and Implementation Plan is based on *E. coli* and FC standards to protect the designated uses of contact recreation and shellfish harvesting as described below.

Water quality assessments using the revised indicator(s) include the following key changes:

- New bacterial indicators for contact recreation uses,
  - Fresh water indicator – *Escherichia coli* (*E. coli)*
  - Marine water indicator – Enterococci

- Extraordinary and secondary contact recreation uses were removed from the standards,
- All waters are now protected for primary contact recreation,
- The averaging period to calculate the geometric mean for contact recreation bacterial indicators changed from 12 months to 3 months, and
- The minimum number of samples needed to calculate the geometric mean changed from 5 to 3.

Ecology develops TMDLs to show what actions need to happen to meet WQS that protect the designated uses and meet numeric criteria. TMDLs are written to the current State WQS and criteria. For example, bacteria TMDLs written to protect shellfish harvesting beneficial use are based on the FC criteria, while TMDLs written to protect fresh water contact recreation are based on *E. coli*. When approving TMDLs, the United States Environmental Protection Agency (EPA) will consider current WQS using the provisions at 40 CFR § 130.7 and national EPA guidance.

This TMDL sets pollution limits to protect the shellfish harvesting designated use—see Uses of the Water Bodies, Marine Water Designated Uses section above and Appendix D, Designated Use Protection for details. This TMDL also sets pollution limits to protect the downstream marine water contact recreation designated use. EPA (2012) suggests, where fresh waters protected for contact recreation flow into marine waters with the same designated use, the fresh water criteria are protective of downstream uses because both the fresh and marine WQS were developed using the same level of risk and illness rates for humans.

## Fresh Water Contact Recreation

The Washington State Water Quality Standards[10] (WAC 173-201A) include designated beneficial uses for specific water bodies and their associated numeric water quality criteria. Respectively, the current primary contact recreation standards in fresh water are based on *E. coli* with FC organism concentrations being the indicator prior to January 1st, 2020 [WAC173-201A-200(2)(b)]. These WQS formed the basis to set TMDL targets for the Drayton Harbor watershed.

The current applicable fresh water quality criteria for ***E. coli*** are:

1. **Geometric mean** value within an averaging 3-month period not to exceed **100 cfu/100mL**.
2. **No more than 10%** of samples (or any single sample when less than ten samples exist) exceed **320 cfu/100mL** (percent exceedance or not-to-exceed criterion) obtained within the averaging period.

WAC 173-201A-200(2)(b)(i)(B) states "**Ambient water quality samples**: When averaging bacteria sample values for comparison to the geometric mean criteria, it is preferable to average by season. The averaging period of bacteria sample data shall be ninety days or less."

The former fresh water quality criteria for FC constituted the basis for the 303(d) listing which led to the initial TMDL investigation.

[10] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

The former applicable fresh water quality criteria for **FC** are:

- **Geometric mean** criterion not to exceed **100 cfu/100mL**.
- **No more than 10%** of samples (or any single sample when less than ten samples exist) exceed **200 cfu/100mL** (percent exceedance or not-to-exceed criterion).

## Marine Water Shellfish Harvesting and Contact Recreation

The water quality criteria and fecal indicator bacteria are FC for shellfish harvesting and enterococci for primary contact recreation in marine water. As previously mentioned, this TMDL does address the shellfish harvesting designated use and the marine water contact recreation designated use.

The water quality criteria for **FC organisms** used to protect shellfish harvesting in marine waters are:

- **Geometric mean** criterion not to exceed **14 cfu/100mL**.
- **No more than 10%** of samples (or any single sample when less than ten samples exist) exceed **43 cfu/100mL** (percent exceedance or not-to-exceed criterion).

The water quality criteria for **Enterococci bacteria organisms** used to protect contact recreation in marine waters are:

- **Geometric mean** criterion not to exceed **30 cfu/100mL**.
- **No more than 10%** of samples (or any single sample when less than ten samples exist) exceed **110 cfu/100mL** (percent exceedance or not-to-exceed criterion).

## Brackish Water

Application of fresh and marine water criteria is dependent on salinity concentrations in brackish waters of estuaries. When data are available, the fresh water or marine water criterion is selected and applied based on vertically averaged daily maximum salinity, referred to as "salinity." In these cases, the method to determine what standard applies can be found in the water quality standards at WAC 173-201A-260(3)(e):

i. “The fresh water criteria must be applied at any point where ninety-five percent of the salinity values are less than or equal to one part per thousand [(ppt)], except that the fresh water criteria for bacteria applies when the salinity is less than ten [ppt]; and
ii. “The marine water criteria must apply at all other locations where the salinity values are greater than one [ppt], except that the marine criteria for bacteria applies when the salinity is ten [ppt] or greater.”

If information is not available to determine the delineation between marine and fresh water criteria for brackish waters, then the more stringent of the two criteria will apply as described in WAC 173-201A-260(3)(c):

> "Where multiple criteria for the same water quality parameter are assigned to a water body to protect different uses, the most stringent criterion for each parameter is to be applied."

In brackish waters, the 10 ppt salinity line is dynamic, changing constantly as a function of tidal movement and river flow near the fresh water and marine water interface. The approximate location of the brackish water interface between Dakota and California creeks with Drayton Harbor was delineated using the WAC 173-201A-260(3)(e) criteria. Within these segments and grids, the creeks are considered part of the Drayton Harbor estuary and are subject to the marine WQS. Therefore, the mixing of fresh and marine water above 10 ppt salinity was used to establish water quality benchmarks that are protective of shellfish harvesting.

Specific conductivity data collected during Phase 1 of the Drayton Harbor TMDL technical study demonstrates that brackish water occurs at river mile 3.1 along California and Dakota creeks—see Appendix D for details. These data also indicate that the brackish water interface between the marine water of Semiahmoo Bay and the fresh water of Cain Creek is located at the creek outlet routine sampling site. At these points along the fresh water tributaries, the FC TMDLs for marine waters are established for the purpose of protecting the downstream designated use of shellfish harvesting. All other tributaries that discharge to the harbor and brackish waters also have TMDLs that are protective of shellfish harvesting.

## Antidegradation

The federal Clean Water Act requires that Washington's WQS protect existing designated uses by establishing the maximum level of pollutants Ecology can allow in surface water. Ecology requires extra protections for water that is already cleaner than the standards. Antidegradation rules help prevent unnecessary lowering of water quality (WAC 173-201A-300). Antidegradation rules also provide a framework to identify which water is designated as an "outstanding resource" by the state. The antidegradation policy is guided by chapter 90.48 RCW, Water Pollution Control Act, chapter 90.54 RCW, Water Resources Act of 1971, and 40 CFR § 131.12. Washington State's antidegradation rules follow the federal regulations, which set three tiers of protection for surface waters:

1. **Tier I** ensures existing and designated uses are maintained and protected. This tier is applicable to all waters and sources of pollution (WAC 173-201A-310). Fully applying the water quality criteria is the focus along with correcting pollution problems using Ecology's existing regulatory and TMDL water cleanup processes. Tier I applies to the water bodies of the Drayton Harbor watershed.
2. **Tier II** is used to ensure that waters that meet a higher quality than the limits set in the standards are not degraded (WAC 173-201A-320). Waters may still be degraded if impacting water quality is necessary and in the overriding public interest.

3. **Tier III** is used when a high-quality water is designated as an outstanding resource water (WAC 173-201A-330). The water quality and uses of these waters must be maintained and protected against all sources of pollution.

## TMDL Targets

The TMDL for the Drayton Harbor watershed sets necessary limits of bacteria pollution for each 303(d) listed AU to:

- Protect primary contact recreation designated uses of fresh water,
- Protect downstream designated uses of marine water including,
    - Primary contact recreation,
    - Shellfish harvesting,
- Meet the associated WQS, and
- Account for seasonal variation.

The two designated uses are unique and treated separately in the WQS, which requires TMDLs that are specific to each designated use. Ecology developed two separate loading capacities (LCs) and TMDLs for each designated use, however, the pollution reduction strategies are related in practice. The marine shellfish harvesting designated use is more sensitive to bacteria pollution than fresh water contact recreation and will therefore require greater pollution reductions than the reductions necessary to protect contact recreation.

The FC TMDLs and pollution target reductions are established to meet the downstream designated use of shellfish harvesting based on the associated marine water criteria after accounting for the mixing of fresh water tributaries and the receiving marine waters—see Appendix D for details. The fresh water AUs that immediately discharge to marine waters require FC TMDLs and also include *E. coli* TMDLs.

All TMDL implementation activities both within and upstream of the AU catchments contribute to attaining the FC and *E. coli* TMDLs. Where AUs are assigned both FC and *E. coli* TMDLs, attaining the FC pollution target reductions is the ultimate goal because it protects the most sensitive designated use. When the FC TMDLs are achieved, it also guarantees meeting the reductions necessary to attain the *E. coli* target reductions because the level of FC pollution reduction is greater than *E. coli* to meet each WQS. In contrast where the two TMDLs are established at one sampling location, attaining the *E. coli* TMDL and pollution reduction targets does not guarantee that the applicable FC reductions are also met. The *E. coli* TMDLs and pollution target reductions are established to meet the designated use of contact recreation in fresh water.

The recommended pollution reductions, target geomean concentrations, and wasteload allocations are necessary for National Pollutant Discharge Elimination System (NPDES) permit development in watersheds that have an EPA-approved TMDL. There are several AUs in the middle and upper reaches of the watershed that have permitted entities that do not discharge directly to marine waters. These permitted entities therefore require *E. coli* WLAs to address point sources, and the adjacent nonpoint sources of pollution require *E. coli* LAs. Attaining the *E. coli* pollution target reductions is the goal to address AUs that do not discharge directly to marine water. AUs that discharge directly to marine waters, however, include both FC and *E. coli* TMDLs comprising the associated WLA and LA.

**Statistical Rollback Method**

This TMDL uses the statistical rollback method (Ott 1995) to determine target concentrations and bacteria load reductions necessary to attain the WQS. The TMDLs and target reductions are based on water quality conditions observed and modeled during water years 2020 and 2021, with few exceptions identified in the following sections. The rollback method compares monitoring data to water quality criteria, and the difference is the percentage reduction needed to meet WQS—see Appendix D, Statistical Rollback Analysis. Ecology has applied and EPA has approved the rollback method in many other bacteria TMDLs (Hood and Joy 2000, Pelletier and Seiders 2000, Joy 2004, Joy and Swanson 2005, Schneider et al. 2007, Swanson 2008, Mathieu and James 2011, Bohling and McCarthy 2020, EPA 2020, Kardouni 2023).

The rollback method uses the bacteria sample population geometric mean and the 90$^{th}$ percentile statistics to compare to the water quality criteria that is protective of designated uses. If one or both do not meet the criteria, the whole distribution is “rolled-back” to match the more restrictive of the two criteria. Load reductions based on the 90$^{th}$ percentile statistic is usually the most restrictive.

The rolled-back geometric mean (geomean) and 90$^{th}$ percentile bacteria concentration then becomes the recommended target concentration for the AU to meet WQS. The degree to which the distribution of bacteria counts is rolled-back to the target concentration represents the calculated percent reduction required to meet the bacteria WQS. The term “target” distinguishes rolled-back values from the TMDL allocations.

The 2020—2021 dataset is utilized to represent and characterize recent watershed conditions that led to the improving trends in water quality—see Appendices A and D for details. Assessing the recent conditions accounts for pollution control activities largely conducted by the WCWP, other pollution control programs, facilities under permit, and cooperative landowners and community members. The pooled two-year dataset used to establish the TMDLs includes approximately 1,050 samples collected in fresh water and 670 samples collected in marine water by boat. Pooling samples into a two-year dataset improves the statistical certainty of the TMDL calculations when compared to using only one of the two annual datasets. All water quality data used to develop the TMDLs were collected by the WCWP partnership organizations.

## Bacteria Translator

The *E. coli* concentrations predicted by the bacteria translator are used to evaluate the likelihood of exceeding *E. coli* water quality criteria and calculate *E. coli* loads, WLAs, and LAs. Briefly described below, the translator is a regression model that uses FC input data to predict *E. coli* concentrations—see Appendix D, Bacteria Translator section for details. The translated dataset was not and should not be used to determine attainment of state WQS under the formal Water Quality Assessment process (Ecology 2023a).

Fecal coliform is the historic fecal indicator bacteria used to assess the protection of contact recreation in fresh water. Fecal coliform remains the indicator to assess the protection of shellfish harvesting in marine waters. Sampling objectives have therefore relied on assessing FC bacterial pollution to Drayton Harbor, including in fresh water, while *E. coli* and enterococci have relatively been nominally sampled.

This TMDL incorporates the WQS bacterial indicator updates from FC to *E. coli*. Functioning as a translator, the regression characterizes the relationship between FC and *E. coli*. Equation 1 translates FC sample concentrations (cfu/100 mL) to *E. coli* (EC) concentration (cfu/100 mL) data points. The regression may also be used to translate FC concentrations from *E. coli* sample concentrations using Equation 2.

$$EC = 0.8870 \times (FC)^{0.9513} \quad (1)$$

$$FC = 1.1343 \times (EC)^{1.0512} \quad (2)$$

This TMDL used translated *E. coli* concentrations to:

- Calculate bacterial loading,
- Estimate the degree to which the WQS are either likely exceeded or attained,
- Calculate the TMDL and allocations,
- Determine the TMDL target concentrations and pollution reductions necessary to meet the WQS, and
- Guide pollution control implementation and monitoring efforts.

Translated FC values, however, should not be used directly to determine the attainment of the WQS in fresh water under Ecology's administration of the water quality assessment[11] (WAC 173-201A). The direct measurement of *E. coli* will be necessary to determine the attainment of WQS in fresh water, while FC or enterococci monitoring data shall remain necessary when determining the attainment of the marine WQS.

In the Drayton Harbor watershed, recent FC and *E. coli* sampling conducted by the WCWP partners include additional subset comparisons, while the inclusion of enterococci sampling is nominal. Enterococci samples are typically collected in marine waters during summer months at

[11] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

recreational beaches. Development of the bacteria translator is therefore limited to FC and *E. coli* sampling data. Due to the limited *E. coli* sampling data collected in the Drayton Harbor watershed, Ecology developed a bacteria translator using watershed data collected in the adjacent Nooksack River basin.

## TMDL Implementation Targets

Targets set for both FC and *E. coli* pollution depend on the designated use. The ultimate implementation goal is to protect the most sensitive designated use of shellfish harvesting. The FC load reductions and associated targets are established to meet the TMDL and allocations in marine waters. Similarly, *E. coli* targets are developed to address contact recreation in fresh waters upstream of the brackish zone. To estimate a corresponding (translated) *E. coli* concentration, this TMDL utilizes the bacteria translator applied to each FC datapoint. These translated *E. coli* concentrations are compared to water quality criteria for fresh water to determine the load reductions and associated targets to meet the TMDL.

The calculated FC TMDLs address the downstream most fresh water AUs that flow into Drayton Harbor. The grids representing marine water AUs did not receive TMDLs because bacteria loading calculations are not possible nor necessary. When the fresh water TMDLs are attained, the marine water AUs are protected to the degree of attaining the WQS. The entire watershed is therefore covered by a TMDL and Implementation Plan where water quality clean-up actions are expected to address all stream segments and listed AUs.

### Water Quality Results, TMDL Targets, and Percent Reductions

The water quality results and targets are presented for both FC and *E. coli* using the pooled dataset from WYs 2020 and 2021 unless otherwise specified. The FC TMDLs are established using the water quality dataset, modeled streamflow, and a combination of fresh and marine water quality criteria—see the TMDL Allocations section below for details. Similarly, the *E. coli* TMDLs are established but do not require an assessment of the marine water quality FC data. Reductions in FC are greater than those established for *E. coli* to attain the TMDL. Protection of the shellfish harvesting designated use therefore proved to be more sensitive than the contact recreation designated use. Both types of designated uses are protected when the TMDLs and targets are achieved.

### Fecal Coliform Results and Targets

Analysis of the FC data collected at 11 locations that drain directly to the harbor indicate that fresh water pollution is at a level that does not protect downstream shellfish harvesting designated use. All downstream most fresh water sampling locations did not meet the water quality criteria that protect shellfish harvesting and require load reductions to attain the FC TMDL at the (Table 4, Figures 3 and 4). The FC load reductions required to meet the WQS range from 61—99 percent during the dry season and 66—96 percent during the wet season.

The geometric mean and not-to-exceed statistical threshold value (STV) benchmarks are developed using the marine WQS and observed FC concentrations in Drayton Harbor at station 05 to account for brackish water mixing with fresh water—see Appendix A, Water Quality Issues, Marine Water for station locations. Station 05 is selected to represent background conditions for the TMDL mixing analysis—see Appendix D, Statistical Rollback Analysis, Downstream Designated Use Targets.

The mixing analysis indicates that an FC geometric mean of 20 and 19 cfu/100 mL for the dry and wet seasons respectively is protective when these concentrations are observed at the fresh water boundary. The not-to-exceed FC STV of 63 and 46 cfu/100 mL during the dry and wet seasons respectively are protective and used as benchmarks to assess the percent exceedance STV. Results that are grouped annually did not have sufficient representation for seasonal variation analysis likely due to stagnant and no flow conditions observed during the dry season. In these instances, the wet season FC mixing analysis benchmarks are applied to each annual dataset to ensure the year-round protection during both seasons.

Strong seasonal variation is not obvious because both seasons require significant reductions to attain the FC TMDLs. Fresh water geomean concentrations are greater at 4 out of 9 sites during the dry season when compared to the wet season. The 10 percent of samples not-to-exceed STV benchmark is more restrictive than the geometric mean benchmark, which incorporates brackish water mixing based on the marine WQS.

**Table 4. Water quality statistics, target percent reductions, and target concentrations (cfu/100 mL) necessary to attain the fecal coliform (FC) TMDL for marine waters (Dry = May—Sept., Wet = Oct.—Apr.)**

| Site ID | Season (n) | Geo-mean[1] | Not-to-Exceed STV | 90th Percentile[1] | Target Percent Reduction | Target Geo-mean[1] | Target 90th Percentile[1] |
|---|---|---|---|---|---|---|---|
| **Dak3.1 (DG)** | Dry (18)[a] | 48 | 50% | 100 | 65% | 17 | 35 |
| | Wet (17) | 64 | 53% | 516 | 91% | 6 | 46 |
| **TribDak1** | Dry (5) | 28 | 20% | 1774 | 96% | 1 | 63 |
| | Wet (11) | 116 | 64% | 702 | 93% | 8 | 46 |
| **TribDak2** | Dry (8) | 60 | 38% | 512 | 88% | 7 | 63 |
| | Wet (12) | 116 | 83% | 437 | 90% | 11 | 43 |
| **TribDak4** | Dry (8) | 34 | 38% | 160 | 61% | 13 | 63 |
| | Wet (11) | 84 | 64% | 786 | 94% | 5 | 46 |
| **TribDak3** | Dry (29) | 277 | 97% | 857 | 96% | 12 | 36 |
| | Wet (44) | 94 | 68% | 421 | 89% | 10 | 46 |
| **Cal 3.1** | Dry (9) | 46 | 33% | 188 | 68% | 15 | 60 |
| | Wet (11) | 92 | 55% | 1077 | 96% | 4 | 46 |
| **TribCal0[*]** | Annual (9) | 53 | 67% | 649 | 93% | 4 | 46 |
| **TribCal2** | Dry (8) | 516 | 88% | 2662 | 98% | 9 | 44 |

| Site ID | Season (n) | Geo-mean[1] | Not-to-Exceed STV | 90th Percentile[1] | Target Percent Reduction | Target Geo-mean[1] | Target 90th Percentile[1] |
|---|---|---|---|---|---|---|---|
| (CA1) | Wet (11) | 33 | 36% | 272 | 83% | 5 | 46 |
| Cain | Dry (9) | 592 | 100% | 4252 | 99% | 7 | 50 |
| (CC) | Wet (11) | 84 | 73% | 655 | 93% | 6 | 46 |
| Lift Sta. 5 | Dry (11) | 264 | 82% | 2002 | 97% | 8 | 59 |
| (LS5) | Wet (22) | 20 | 32% | 134 | 66% | 7 | 46 |
| Trib1Dray1* | Annual (18)[a] | 83 | 61% | 610 | 92% | 6 | 46 |

Note:

[1]FC cfu/100 mL

*2008 FC dataset

[a]lognormal distribution not assumed

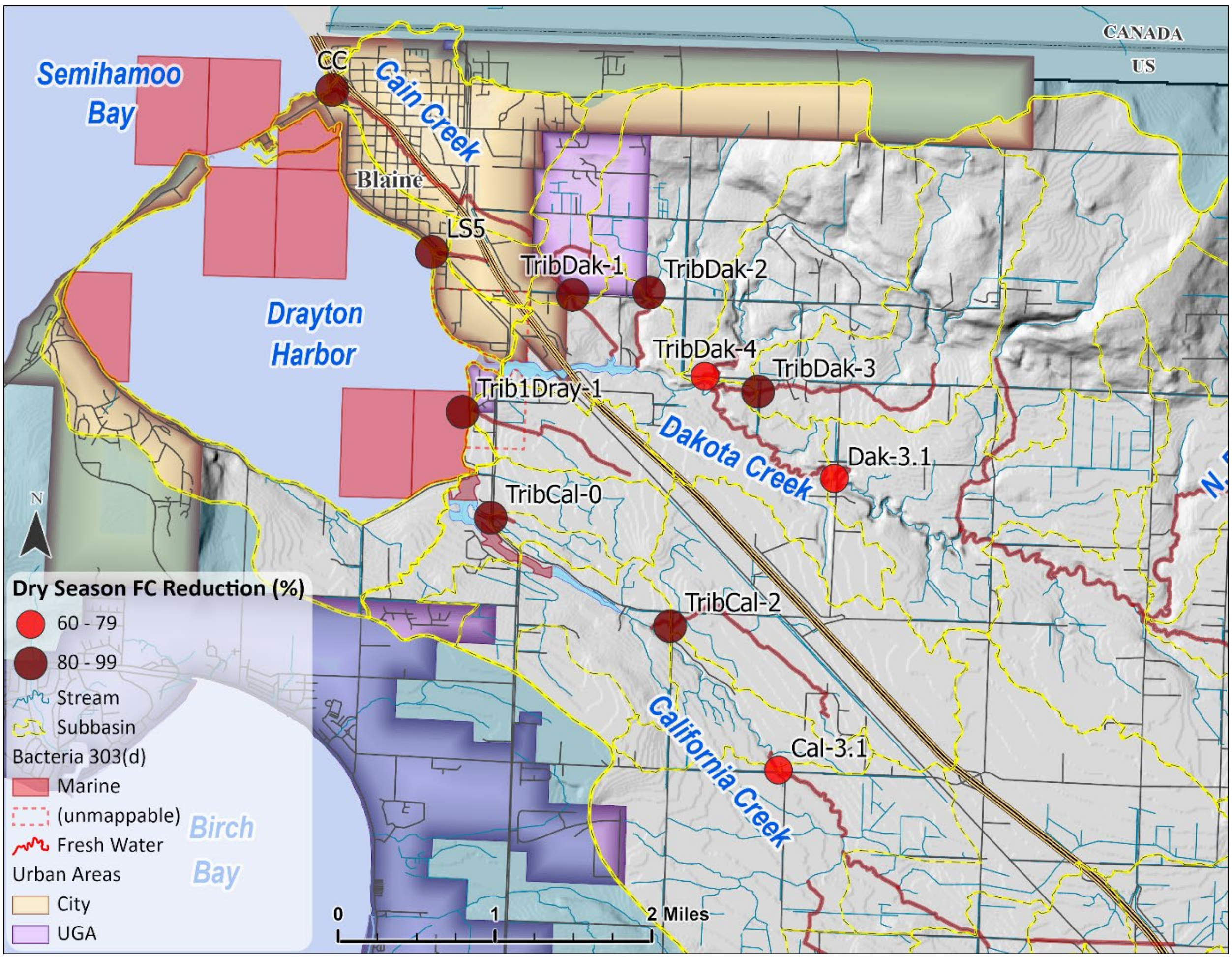


**Figure 3. Fecal coliform (FC) TMDL target reductions for dry season**

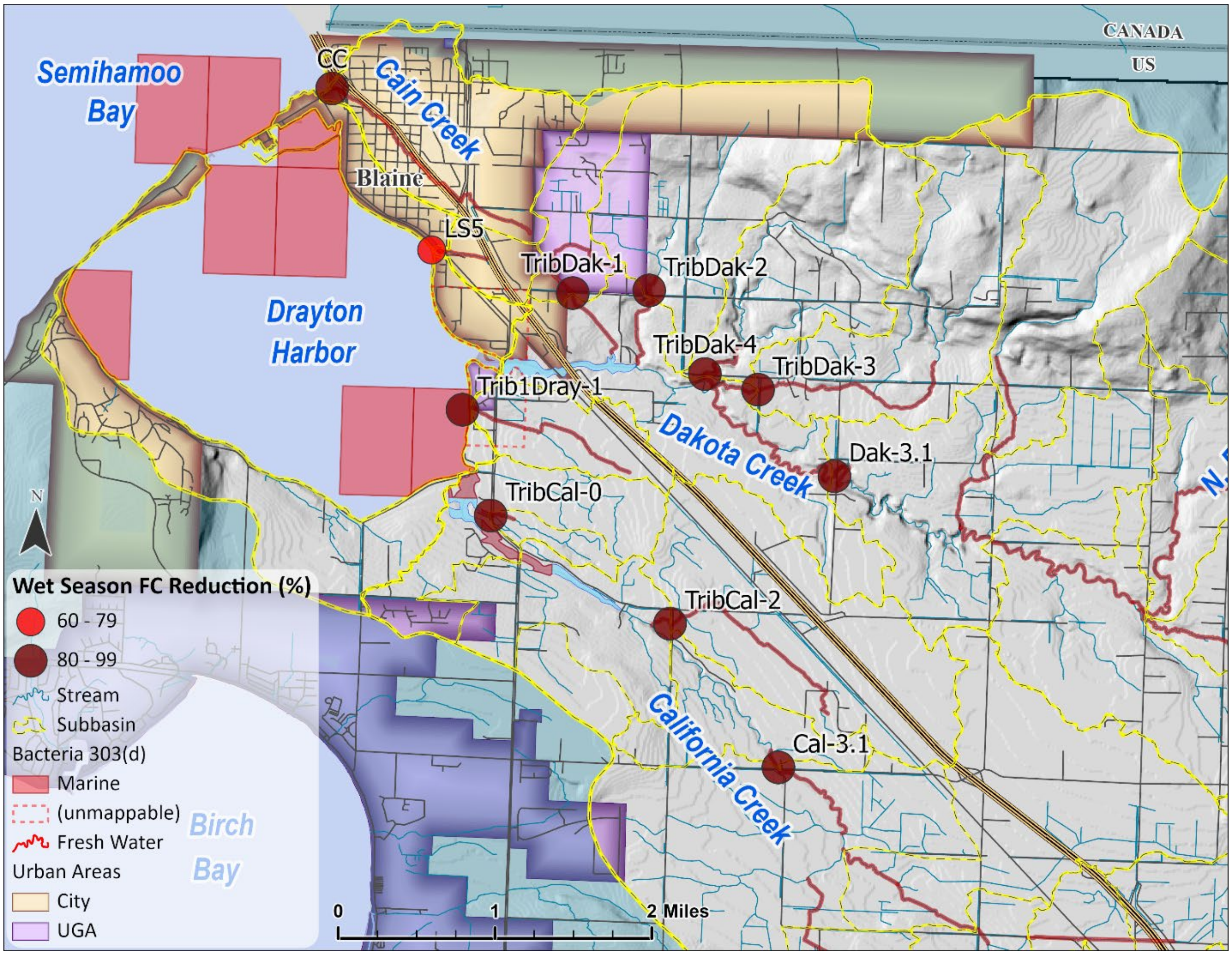

**Figure 4. Fecal coliform (FC) TMDL target reductions for wet season**

### *E. coli* Results and Targets

Analysis of the translated *E. coli* concentrations indicate that 29 out of 36 monitoring locations require reductions to attain the TMDL after accounting for seasonal variation (Table 5). Sites with less than five samples per season were analyzed annually instead of by season to improve certainty. The amount of *E. coli* load reduction expressed as a percentage range from 0—89 percent during the dry season and 0—71 percent during the wet season. Geomean concentrations are greater at 69 percent of the sites during the dry season when compared to the wet season. Similarly, when analyzing the entire period of record, differences between seasonal groups occur at 70 percent of the sites where the dry season sample population is significantly greater than that of the wet season—see Appendix D, Seasonal Variation and Critical Conditions for details. The dry and wet season maps show the bacteria reductions necessary to attain the *E. coli* TMDL (Figures 5 and 6 respectively).

**Table 5. Translated water quality statistics, target percent reductions, and target concentrations (cfu/100 mL) necessary to attain the *E. coli* TMDL in fresh water (Dry = May—Sept., Wet = Oct.—Apr.)**

| Site ID | Season (n) | Geo-mean[1] | Not-to-Exceed STV | 90th Percentile[1] | Target Percent Reduction | Target Geo-mean[1] | Target 90th Percentile[1] |
|---|---|---|---|---|---|---|---|
| **Dak3.1** | Dry (18)[a] | 35 | 0% | 72 | 0% | 35 | 72 |
| **(DG)** | Wet (17) | 46 | 12% | 338 | 5% | 44 | 320 |
| **Dak6.8** | Dry (8) | 34 | 0% | 68 | 0% | 34 | 68 |
| **(D2)** | Wet (11) | 61 | 18% | 434 | 26% | 45 | 320 |
| **TribDak1** | Dry (5) | 22 | 20% | 1082 | 70% | 7 | 320 |
| | Wet (11) | 82 | 9% | 450 | 29% | 58 | 320 |
| **TribDak2** | Dry (8) | 45 | 13% | 324 | 1% | 44 | 320 |
| | Wet (12) | 82 | 0% | 288 | 0% | 82 | 288 |
| **TribDak4** | Dry (8) | 26 | 0% | 106 | 0% | 26 | 106 |
| | Wet (11) | 60 | 9% | 505 | 37% | 38 | 320 |
| **TribDak3** | Dry (29) | 187 | 28% | 547 | 53% | 88 | 258 |
| | Wet (44) | 67 | 5% | 278 | 0% | 67 | 278 |
| **TribDak5** | Dry (8) | 49 | 13% | 239 | 0% | 49 | 239 |
| | Wet (11) | 30 | 0% | 102 | 0% | 30 | 102 |
| **NFDak01** | Dry (18) | 37 | 0% | 73 | 0% | 37 | 73 |
| **(D3)** | Wet (17)[a] | 49 | 12% | 323 | 1% | 49 | 320 |
| **NFDak2.5** | Dry (6) | 44 | 0% | 100 | 0% | 44 | 100 |
| | Wet (12) | 104 | 17% | 556 | 42% | 60 | 320 |
| **TribDakN1** | Annual (15) | 62 | 13% | 278 | 0% | 62 | 278 |
| **TribDakN2** | Dry (8) | 59 | 13% | 546 | 41% | 35 | 320 |
| | Wet (13) | 29 | 8% | 398 | 20% | 23 | 320 |
| **SFDak0.2** | Dry (14) | 22 | 0% | 84 | 0% | 22 | 84 |

| Site ID | Season (n) | Geo-mean[1] | Not-to-Exceed STV | 90th Percentile[1] | Target Percent Reduction | Target Geo-mean[1] | Target 90th Percentile[1] |
|---|---|---|---|---|---|---|---|
| **(D4)** | Wet (17) | 9 | 0% | 47 | 0% | 9 | 47 |
| **TribDakS1** | Dry (5) | 136 | 20% | 749 | 57% | 58 | 320 |
| | Wet (11) | 64 | 27% | 715 | 55% | 29 | 320 |
| **SFDakDL** | Dry (5) | 27 | 0% | 205 | 0% | 27 | 205 |
| | Wet (11)[a] | 27 | 0% | 376 | 15% | 23 | 320 |
| **SFDak2.2** | Dry (5) | 31 | 0% | 54 | 0% | 31 | 54 |
| | Wet (11) | 29 | 18% | 396 | 19% | 23 | 320 |
| **TribDakS2** | Dry (5) | 146 | 20% | 357 | 36% | 93 | 228 |
| | Wet (11) | 42 | 9% | 525 | 39% | 25 | 320 |
| **Cal 3.1** | Dry (9) | 34 | 0% | 130 | 0% | 34 | 130 |
| | Wet (11) | 65 | 9% | 683 | 53% | 30 | 320 |
| **Cal 5.0** | Dry (31)[a] | 136 | 13% | 662 | 52% | 66 | 320 |
| **(C3)** | Wet (45) | 50 | 11% | 416 | 23% | 38 | 320 |
| **Cal 6.2** | Dry (25)[a] | 137 | 24% | 765 | 58% | 57 | 320 |
| | Wet (43) | 54 | 19% | 439 | 27% | 40 | 320 |
| **Cal 7.5** | Dry (15) | 204 | 40% | 842 | 62% | 78 | 320 |
| | Wet (11) | 64 | 9% | 568 | 44% | 36 | 320 |
| **TribCal0*** | Annual (9) | 39 | 11% | 408 | 22% | 31 | 320 |
| **TribCal2** | Dry (8) | 337 | 38% | 1613 | 80% | 67 | 320 |
| **(CA1)** | Wet (11) | 24 | 0% | 181 | 0% | 24 | 181 |
| **TribCal3* (CA3)** | Annual (16) | 27 | 6% | 232 | 0% | 27 | 232 |
| **CA6** | Dry (30) | 42 | 3% | 150 | 0% | 42 | 150 |
| | Wet (51)[a] | 40 | 16% | 613 | 48% | 21 | 320 |
| **TribCal4 (CA8)** | Annual (15) | 30 | 7% | 288 | 0% | 30 | 288 |
| **CA9** | Dry (8) | 451 | 38% | 2930 | 89% | 49 | 320 |
| | Wet (11) | 87 | 9% | 685 | 53% | 40 | 320 |
| **CA14c** | Dry (9) | 207 | 33% | 1510 | 79% | 44 | 320 |
| | Wet (45)[a] | 129 | 22% | 982 | 67% | 42 | 320 |
| **CA15** | Dry (5) | 137 | 20% | 618 | 48% | 71 | 320 |
| | Wet (14) | 55 | 23% | 502 | 36% | 35 | 320 |
| **TribCal5** | Dry (7) | 71 | 14% | 343 | 7% | 66 | 320 |
| **(CA16)** | Wet (12) | 27 | 0% | 178 | 0% | 27 | 178 |
| **Cal7_5Trib** | Dry (31)[a] | 135 | 16% | 656 | 51% | 66 | 320 |
| **(GRAND4)** | Wet (45) | 50 | 11% | 416 | 23% | 38 | 320 |
| **CA14cTrib** | Dry (5) | 357 | 60% | 3121 | 90% | 37 | 320 |

| Site ID | Season (n) | Geo-mean[1] | Not-to-Exceed STV | 90th Percentile[1] | Target Percent Reduction | Target Geo-mean[1] | Target 90th Percentile[1] |
|---|---|---|---|---|---|---|---|
| **(CA14ab)** | Wet (31) | 68 | 16% | 435 | 26% | 50 | 320 |
| **CA14aa** | Annual (39) | 18 | 8% | 258 | 0% | 18 | 258 |
| **Cain** | Dry (9) | 385 | 44% | 2511 | 87% | 49 | 320 |
| **(CC)** | Wet (11) | 61 | 0% | 412 | 22% | 47 | 320 |
| **Lift Sta. 5** | Dry (11)[a] | 178 | 36% | 1228 | 74% | 46 | 320 |
| **(LS5)** | Wet (22)[a] | 16 | 0% | 91 | 0% | 16 | 91 |
| **Trib1Dray1*** | Annual (18) | 60 | 5% | 385 | 17% | 50 | 320 |

Note:

[1]translated *E. coli* cfu/100 mL

*2008 FC dataset

[a]lognormal distribution not assumed

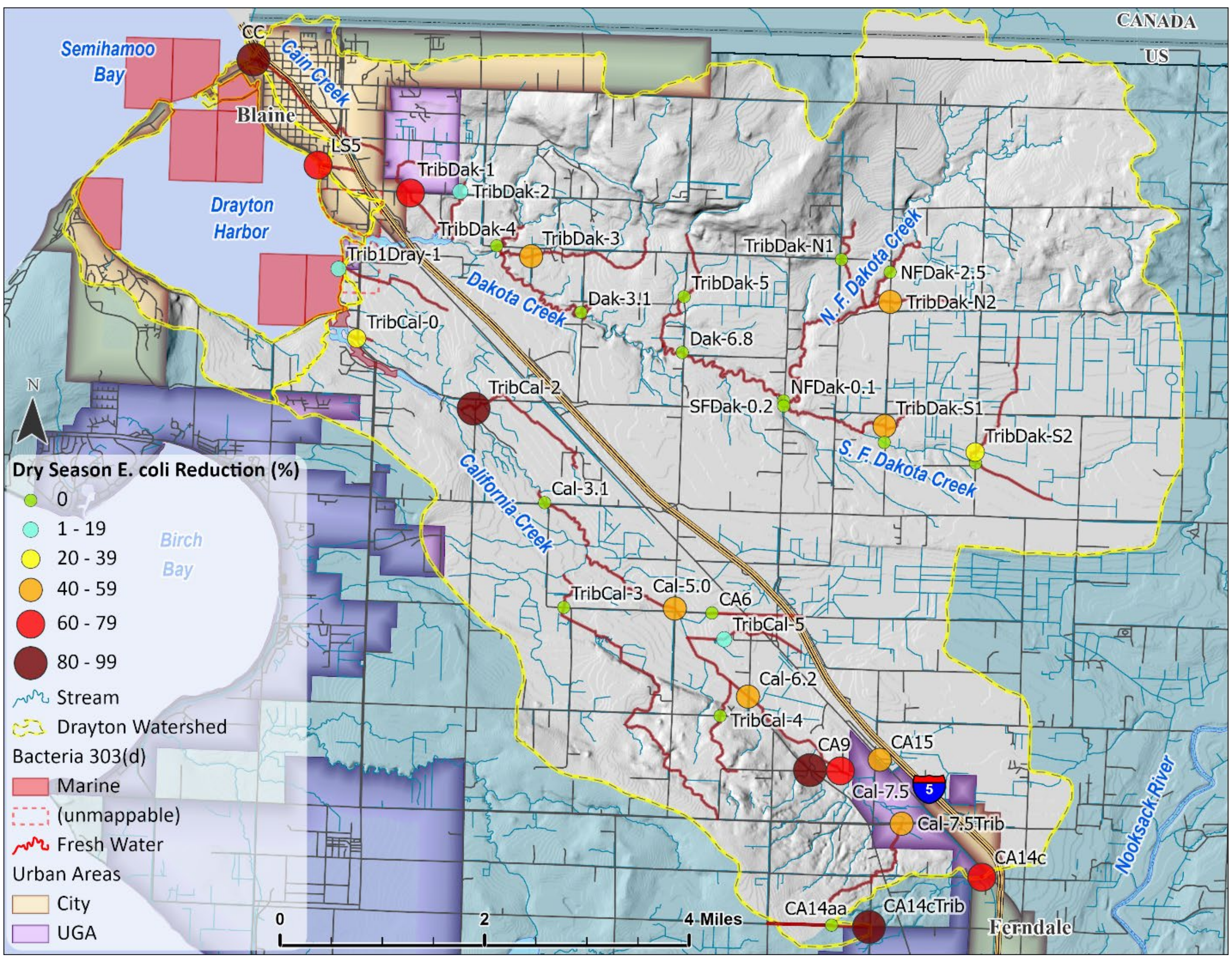


**Figure 5. *E. coli* TMDL target reductions for dry season**

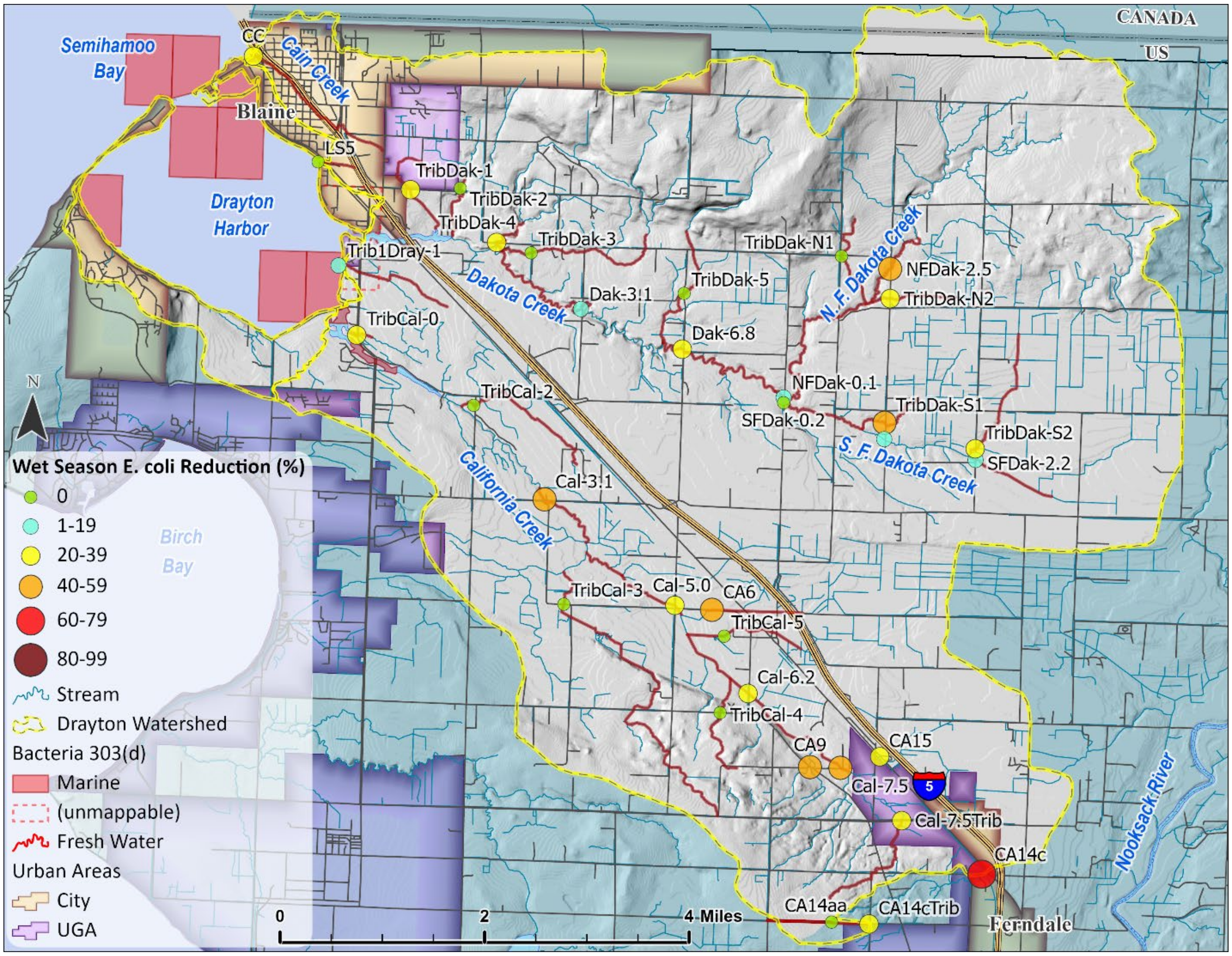


**Figure 6. *E. coli* TMDL target reductions for wet season**

To attain the *E. coli* TMDL, bacteria reductions are necessary at 28 sites to protect the primary contact recreation WQS (Table 5). Seasonal variation is apparent at 20 sites while all other locations show little to no seasonal difference in water quality. The most restrictive criterion is the 10 percent of samples not-to-exceed STV according to the rollback calculations. All sampling sites that did not receive reductions likely meet the *E. coli* water quality criteria based on translated concentration values. The geomean and 90$^{th}$ percentile are the TMDL targets to maintain when percent reductions are not necessary.

## Seasonal Variation

According to the Clean Water Act Section 303(d), the EPA recommends that TMDLs include an assessment of seasonal variation[12] (40 CFR § 130.7 (c)(1)) (EPA 1991). The Washington WQS[13] (WAC 173-201A-200) also recommends averaging by season when comparing bacteria concentrations to the geomean water quality criterion. While some discretion exists for selecting

[12] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-130
[13] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

sample averaging periods, the ability to meet water quality criteria in this TMDL was evaluated for seasonal variation—see Appendix D, Seasonal Variation and Critical Condition for details. In summary, seasonal variation is driven by differences in bacteria concentrations observed in Drayton Harbor, which is assumed to be caused by bacteria loading from fresh water sources and other nearby sources. Fresh water bacteria concentrations, however, largely do not show seasonal variability.

Seasonal targets help avoid the potentially erroneous conclusion that when TMDL targets are met based on annual averages, they are also met during all seasons of the year. If bacteria pollution sources vary significantly by season to create distinct patterns, seasonal targets are required in the TMDL to set the most protective pollution limits during the critical period of the year. The seasonal targets form the basis of the water body assimilative capacity, which is described in the TMDL Allocations section in this report. This TMDL applied the Statistical Theory of Rollback method to each dataset grouped by sampling site and season including an assessment of certainty of the rollback calculations (Ott 1995 and Appendix D—Statistical Rollback Analysis).

**Water Quality Patterns**

The TMDL and marine water quality data are grouped by wet and dry season and compared for differences between groups—Appendix D, Seasonal Variation and Critical Conditions for details. In summary:

- Bacteria loading from the fresh water tributaries to Drayton Harbor are generally greater during the wet season than during the dry season,
- In contrast, the fresh water bacteria concentrations observed during the dry season tend to be significantly greater than those observed during the wet season,
- Fresh water FC concentrations and instantaneous flux have greater variability during the wet season than that of the dry season,
- When pooling all marine monitoring station data, the seasonal FC geometric mean in Drayton Harbor is significantly lower during the dry season than that of the wet season at 3 and 11 cfu/100 mL MPN respectively,
- When pooling all marine monitoring station data, the FC $90^{th}$ percentile in Drayton Harbor is significantly lower during the dry season than that of the wet season at 10 and 81 cfu/100 mL MPN respectively, and
- The increased FC concentrations observed in Drayton Harbor during the wet season led to a Conditionally Approved shellfish harvesting closure from November 1 through January 31—Appendix A, Water Quality Issues for details.

The seasonal assessment in this TMDL incorporates the observed significant increase of FC concentrations in the harbor during the wet season, which coincides with the observed precipitation patterns and increased streamflows. In context of the TMDL targets inferred by the geometric mean and $90^{th}$ percentile values, 17 out of 32 require greater reductions during the dry season than during the wet season (Table 5). Differences in seasonal bacteria loading is therefore the likely prevailing driver of water quality in the receiving marine waters instead of fresh water bacteria concentrations alone.

## Climate Change

The effects of climate change on fecal bacteria concentrations and loading to the fresh and marine waters in the Drayton Harbor watershed are not well understood. Downscaling global climate models to regional climate models provides the resolution necessary to better understand local climate impacts (Mass et al. 2022). Certain environmental factors, however, are anticipated to deviate from historical patterns that will impact water quality. A literature review by Mauger and Vogel (2020) briefly describes certain regional impacts. In the absence of attaining the established TMDL targets, selected factors that affect the bacteria levels in the Drayton Harbor watershed include:

- Warmer air,
- Changing precipitation,
- Shifting streamflow,
- Altered sediment dynamics,
- Warming streams,
- Sea level rise, and
- Ocean warming.

Although this TMDL addresses bacteria pollution loading to the shellfish growing area in the harbor, the primary impacts on shellfish due to climate change are ocean acidification and warming (Mauger and Vogel 2020). Other important factors include precipitation event patterns that are predicted to change in duration and intensity (Salathé et al. 2014). For example, prolonged dry periods may increase in frequency causing reduced 7-day low streamflow (Dudley et al. 2020), which results in the potential risk of increased bacteria concentrations. On the other hand, heavier rain events that cause runoff could increase the risk of bacteria pollution and loading as indicated by seasonal variation assessment—see Appendix D, Seasonal Variation and Critical Conditions.

Heavy rainfall may also increase the frequency of flooding events. These flood waters can entrain fecal bacteria and pollute the water bodies in the TMDL study area. For example, pet waste and livestock waste may be picked up and flushed by increased overland flow and flood waters. Onsite sewage system (OSS) and manure lagoons may be at risk of inundation from flood waters and flush fecal bacteria to surface waters. Flooding combined with sea level rise can further increase the risk of OSS inundation along the shoreline areas of the harbor. The infiltration and inflow to the Lighthouse Point facility sanitary sewer collection system may also be further exacerbated by heavy rainfall and flooding and cause unnecessary bacteria pollution.

Climate change model ensemble forecast by the 2070s indicate that the 1-hour heavy rainfall duration at the 5-year and 25-year frequency is expected to increase by 34 and 32 percent respectively in the Drayton Harbor watershed (Mauger et al. 2021). By the 2070s, the 24-hour heavy rainfall duration at a 25-year frequency is forecasted to increase by 23 percent. This amount of rainfall is used in the current NPDES General Permit for Concentrated Animal Feeding Operations (CAFOs) where containment facilities must have capacity to hold all process wastewater, manure water, and contaminated stormwater. Seasonal patterns demonstrated by Dunn and Cook (2023) suggest that climate driven rainfall runoff through 2070 in the Drayton Harbor watershed will change as follows; spring ≈ -2 percent, summer ≈ -17 percent, fall ≈ +5 percent, and winter ≈ +3 percent. This indicates that forecasted heavy rainfall events (Mauger et al. 2021) that produce runoff will most likely occur during the fall and winter months while the spring and summer months may experience less runoff frequency.

# TMDL Allocations

The TMDL allocations in this study are expressed as loads in billions of bacteria colony forming units (cfu) per day—b.cfu/day. In summary, the TMDL limiting assimilative capacities for each 303(d) listed water body are calculated using geometric mean (geomean) of the WQS and the modeled streamflow discharge averaged by season to account for seasonal variation, while shoreline areas are addressed using the Simple Method—see Appendix E, TMDL Allocations for details.

A water body's loading capacity (LC) is the amount of a given pollutant that a water body can receive and still meet the WQS. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the WQS. The LC assigned to a particular pollution source is a wasteload allocation (WLA) or load allocation (LA). If the pollutant comes from a discrete (point) source subject to an NPDES permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the LC is called a WLA. If the pollutant comes from diffuse (nonpoint) sources not subject to an NPDES permit, such as general residential, commercial, agricultural, or forested run-off, the cumulative share of the LC is called a LA.

Assuming the stream flow and loading are proportional to the catchment area, the TMDLs are calculated using the proportion of the catchment area that drains to the identified pour point sampling location. The FC TMDL is calculated for water bodies and shoreline areas that drain directly to marine waters. In addition, the *E. coli* TMDL is calculated for each associated AU and may be applied to other upstream unlisted stream catchments that do not drain directly to marine waters. The WLAs for this TMDL were developed based on the proportional permitted area, while the LAs were developed based on the proportional area not covered by a permit.

## TMDL Formula

Once it is determined that a water body does not meet WQS, the goal of a TMDL is to provide a written, quantitative assessment of the water quality problems and of the pollutant sources that cause the problem, if known. This information is used to develop the TMDL of the water body. The TMDL provides a reference for calculating the amount of pollution reduction in terms of mass per unit time that is needed to bring a water body into compliance with the WQS. The TMDL is compared to the current amount of pollution entering the water body. If the pollutant levels are too high, the necessary reduction needed to bring a water body into compliance with the standards can be determined.

For this study, the TMDL was proportioned using the relative percent of the subbasin catchment area that contributes to the receiving AU. Following this concept, the TMDL for each AU may be determined using the relative proportion of contributing watershed area because human land use activities largely influence the amount of bacteria loading. Improving land use practices that reduce bacteria loading will lead to TMDL attainment. The relative proportion of a catchment area is expected to contribute to the same level of loading and therefore contribute similarly to the TMDL.

The TMDL must consider seasonal variations and critical conditions and include a margin of safety (MOS) that accounts for any lack of knowledge about the causes of the water quality problem. The reserve capacity for future pollutant sources is sometimes included as well. The TMDL is the sum of the wasteload allocations (WLA), the load allocations (LA), any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity (LC). The short-hand formula that describes the TMDL is:

$$TMDL = \sum WLA + \sum LA + MOS$$

This report provides the TMDLs (b.cfu/day) for both *E. coli* and FC for each 303(d) listed water body generally using the 2020 and 2021 WY pooled dataset. The FC TMDLs are established at each AU ID at the brackish water interface to protect the shellfish harvesting designated use (Table 6). Similarly, the *E. coli* TMDLs are established at each AU ID to protect the contact recreation designated use (Table 7).

Attaining the TMDLs will result in designated use protection for the entire Drayton Harbor watershed. For example, the FC TMDL of 13.8 b.cfu/day at the downstream most fresh water sampling location of Dakota Creek (Dak3.1) will be achieved at a 91 percent reduction, which equates to a target geomean of 6 FC cfu/100 mL when accounting for seasonal variability during the wet season (Tables 4 and 6).

At the AU catchment level, each TMDL includes:

- The sum of all individual WLAs to address point source pollution for each NPDES permit,
- The sum of all LAs to address nonpoint source pollution,
- The MOS to address uncertainty, and
- Seasonal components to address seasonal variation.

An explicit MOS is applied comprising 10 percent of the TMDL for each tributary subbasin and the entire watershed. The LC, WLA, LA, and MOS are described in the following sections, while the TMDL calculations are detailed in Appendix E. The TMDL seasonal variation analysis and protecting downstream designated uses are detailed in Appendix D.

**Table 6. Drayton Harbor fecal coliform TMDL summary in billions of colony forming units per day (b.cfu/day) separated by season where the Dry season is May—Sept. and the Wet season is Oct.—Apr.**

| Site ID | Season | WLA | LA | MOS | TMDL | Listing ID | AU ID |
|---|---|---|---|---|---|---|---|
| **Dak3.1** | Dry | 0 | 1.65 | 0.18 | 1.84 | 39077 | 17110002000133_001_002 |
| **(DG)** | Wet | 0 | 9.97 | 1.11 | 11.08 | 39077 | 17110002000133_001_002 |
| **TribDak1** | Dry | $9.1 \times 10^{-4}$ | 0.032 | $3.7 \times 10^{-3}$ | 0.037 | 74161 | 17110002003884_001_001 |
| | Wet | $5.5 \times 10^{-3}$ | 0.19 | 0.022 | 0.22 | 74161 | 17110002003884_001_001 |
| **TribDak2** | Dry | 0 | 0.122 | 0.014 | 0.135 | 72278 | 17110002000159_002_003 |
| | Wet | 0 | 0.73 | 0.08 | 0.82 | 72278 | 17110002000159_002_003 |
| **TribDak4** | Dry | 0 | 0.099 | 0.011 | 0.110 | 74157 | 17110002001756_001_001 |
| | Wet | 0 | 0.60 | 0.066 | 0.66 | 74157 | 17110002001756_001_001 |
| **TribDak3** | Dry | 0 | 0.12 | 0.014 | 0.14 | 72279 | 17110002000161_001_002 |
| | Wet | 0 | 0.74 | 0.083 | 0.83 | 72279 | 17110002000161_001_002 |
| **Cal 3.1** | Dry | 0.098 | 1.89 | 0.22 | 2.21 | 72275 | 17110002000118_001_001 |
| | Wet | 0.45 | 8.60 | 1.01 | 10.05 | 72275 | 17110002000118_001_001 |
| **TribCal0*** | Dry | $5.6 \times 10^{-4}$ | 0.018 | $2.0 \times 10^{-3}$ | 0.02 | 88161 | 17110002000745_001_001 |
| | Wet | $3.4 \times 10^{-4}$ | 0.107 | 0.012 | 0.119 | 88161 | 17110002000745_001_001 |
| **TribCal2*** | Dry | $4.6 \times 10^{-3}$ | 0.23 | 0.026 | 0.26 | 74144 | 17110002000168_001_001 |
| **(CA1)** | Wet | 0.021 | 1.03 | 0.12 | 1.17 | 74144 | 17110002000168_001_001 |
| **Cain** | Dry | $1.6 \times 10^{-3}$ | 0.081 | $9.2 \times 10^{-3}$ | 0.092 | 42499 | 17110002000738_001_001 |
| **(CC)** | Wet | $9.8 \times 10^{-3}$ | 0.49 | 0.055 | 0.552 | 42499 | 17110002000738_001_001 |
| **Lift Sta. 5** | Dry | $6.0 \times 10^{-4}$ | 0.013 | $1.6 \times 10^{-3}$ | 0.016 | 42507 | 17110002000742_001_001 |
| **(LS5)** | Wet | $3.6 \times 10^{-3}$ | 0.081 | $9.5 \times 10^{-3}$ | 0.095 | 42507 | 17110002000742_001_001 |
| **Trib1Dray1*** | Dry | $1.4 \times 10^{-3}$ | 0.06 | $7.0 \times 10^{-3}$ | 0.07 | 45108 | 17110002000162_001_001 |
| | Wet | $9.0 \times 10^{-3}$ | 0.38 | 0.04 | 0.43 | 45108 | 17110002000162_001_001 |

*2008 dataset

**Table 7. Drayton Harbor *E. coli* TMDL summary in billions of colony forming units per day (b.cfu/day) separated by season where the Dry season is May—Sept. and the Wet season is Oct.—Apr.**

| Site ID | Season | WLA | LA | MOS | TMDL | Listing ID | AU ID |
|---|---|---|---|---|---|---|---|
| Dak3.1 | Dry | 0 | 8.26 | 0.92 | 9.18 | 39077 | 17110002000133_001_002 |
| (DG) | Wet | 0 | 52.49 | 5.83 | 58.32 | 39077 | 17110002000133_001_002 |
| Dak6.8 | Dry | 0 | 6.81 | 0.76 | 7.57 | 39074 | 17110002000134_001_001 |
| (D2) | Wet | 0 | 43.25 | 4.81 | 48.05 | 39074 | 17110002000134_001_001 |
| TribDak1 | Dry | $4.5\times10^{-3}$ | 0.16 | 0.018 | 0.18 | 74161 | 17110002003884_001_001 |
| | Wet | 0.029 | 1.02 | 0.12 | 1.17 | 74161 | 17110002003884_001_001 |
| TribDak2 | Dry | 0 | 0.61 | 0.068 | 0.68 | 72278 | 17110002000159_002_003 |
| | Wet | 0 | 3.87 | 0.43 | 4.30 | 72278 | 17110002000159_002_003 |
| TribDak4 | Dry | 0 | 0.49 | 0.055 | 0.55 | 74157 | 17110002001756_001_001 |
| | Wet | 0 | 3.14 | 0.35 | 3.49 | 74157 | 17110002001756_001_001 |
| TribDak3 | Dry | 0 | 0.62 | 0.068 | 0.68 | 72279 | 17110002000161_001_002 |
| | Wet | 0 | 3.91 | 0.43 | 4.35 | 72279 | 17110002000161_001_002 |
| TribDak5 | Dry | 0 | 0.72 | 0.08 | 0.81 | 72280 | 17110002000163_001_002 |
| | Wet | 0 | 4.60 | 0.51 | 5.11 | 72280 | 17110002000163_001_002 |
| NFDak01 | Dry | 0 | 3.03 | 0.34 | 3.37 | 39075 | 17110002000154_001_002 |
| (D3) | Wet | 0 | 19.27 | 2.14 | 21.41 | 39075 | 17110002000154_001_002 |
| NFDak2.5 | Dry | 0 | 2.35 | 0.26 | 2.61 | 39075 | 17110002000154_001_002 |
| | Wet | 0 | 14.94 | 1.66 | 16.60 | 39075 | 17110002000154_001_002 |
| TribDakN1 | Dry | 0 | 0.21 | 0.023 | 0.23 | 74153 | 17110002000841_001_001 |
| | Wet | 0 | 1.34 | 0.15 | 1.49 | 74153 | 17110002000841_001_001 |
| TribDakN2 | Dry | 0 | 0.081 | $9.0\times10^{-3}$ | 0.09 | 74154 | 17110002000848_001_001 |
| | Wet | 0 | 0.51 | 0.057 | 0.57 | 74154 | 17110002000848_001_001 |
| SFDak0.2 | Dry | $8.0\times10^{-3}$ | 3.02 | 0.34 | 3.36 | 6395 | 17110002000136_001_002 |
| (D4) | Wet | 0.051 | 19.16 | 2.14 | 21.35 | 6395 | 17110002000136_001_002 |

| Site ID | Season | WLA | LA | MOS | TMDL | Listing ID | AU ID |
|---|---|---|---|---|---|---|---|
| TribDakS1 | Dry | 0 | 0.23 | 0.025 | 0.25 | 74155 | 17110002000850_001_001 |
| | Wet | 0 | 1.45 | 0.16 | 1.61 | 74155 | 17110002000850_001_001 |
| SFDakDL | Dry | 0 | 2.39 | 0.27 | 2.66 | | 17110002000136 |
| | Wet | 0 | 15.21 | 1.69 | 16.90 | | 17110002000136 |
| SFDak2.2 | Dry | 0 | 0.72 | 0.08 | 0.80 | 72277 | 17110002000137_001_001 |
| | Wet | 0 | 4.56 | 0.51 | 5.06 | 72277 | 17110002000137_001_001 |
| TribDakS2 | Dry | 0 | 1.58 | 0.18 | 1.75 | 74145 | 17110002000169_001_001 |
| | Wet | 0 | 10.01 | 1.11 | 11.12 | 74145 | 17110002000169_001_001 |
| Cal 3.1 | Dry | 0.18 | 5.66 | 0.65 | 6.49 | 72275 | 17110002000118_001_001 |
| | Wet | 0.88 | 27.08 | 3.11 | 31.07 | 72275 | 17110002000118_001_001 |
| | Dry | 0 | 4.11 | 0.46 | 4.56 | 89253 | 17110002000120_001_001 |
| | Wet | 0 | 19.65 | 2.18 | 21.83 | 89253 | 17110002000120_001_001 |
| Cal 5.0 | Dry | 0 | 5.95 | 0.66 | 6.61 | 39060 | 17110002000121_001_001 |
| (C3) | Wet | 0 | 28.42 | 3.16 | 31.58 | 39060 | 17110002000121_001_001 |
| Cal6.2 | Dry | 0.65 | 2.81 | 0.38 | 3.84 | 72276 | 17110002000123_001_001 |
| Cal7.5 | Wet | 3.14 | 13.39 | 1.84 | 18.37 | 72276 | 17110002000123_001_001 |
| TribCal0* | Dry | $2.9\times10^{-4}$ | 0.09 | 0.01 | 0.10 | 88161 | 17110002000745_001_001 |
| | Wet | $1.8\times10^{-3}$ | 0.56 | 0.062 | 0.62 | 88161 | 17110002000745_001_001 |
| TribCal2 | Dry | 0.023 | 1.14 | 0.13 | 1.29 | 74144 | 17110002000168_001_001 |
| (CA1) | Wet | 0.11 | 5.44 | 0.62 | 6.17 | 74144 | 17110002000168_001_001 |
| TribCal3* | Dry | 0 | 0.94 | 0.11 | 1.05 | 74146 | 17110002000178_001_001 |
| (CA3) | Wet | 0 | 5.70 | 0.63 | 6.33 | 74146 | 17110002000178_001_001 |
| CA6 | Dry | $1.7\times10^{-3}$ | 0.16 | 0.018 | 0.18 | 88959 | 17110002015468_001_001 |
| | Wet | $8.0\times10^{-3}$ | 0.78 | 0.09 | 0.88 | 88959 | 17110002015468_001_001 |
| TribCal4 | Dry | 0 | 0.10 | 0.011 | 0.11 | 74152 | 17110002000837_001_001 |
| (CA8) | Wet | 0 | 0.48 | 0.054 | 0.54 | 74152 | 17110002000837_001_001 |
| CA9 | Dry | 0 | 0.33 | 0.037 | 0.37 | | 17110002000853 |
| | Wet | 0 | 1.59 | 0.18 | 1.77 | | 17110002000853 |

| Site ID | Season | WLA | LA | MOS | TMDL | Listing ID | AU ID |
|---|---|---|---|---|---|---|---|
| CA14c | Dry | $5.0\times10^{-3}$ | 0 | $6.0\times10^{-4}$ | $6.0\times10^{-3}$ | 88149 | 17110002015952_001_001 |
| | Wet | 0.026 | 0 | $2.9\times10^{-3}$ | 0.029 | 88149 | 17110002015952_001_001 |
| CA15 | Dry | 0.17 | 1.04 | 0.13 | 1.34 | | 17110002000863 |
| | Wet | 0.80 | 4.96 | 0.64 | 6.40 | | 17110002000863 |
| TribCal5 | Dry | $4.5\times10^{-3}$ | 0.30 | 0.034 | 0.34 | 74147 | 17110002000390_001_001 |
| (CA16) | Wet | 0.022 | 1.44 | 0.16 | 1.62 | 74147 | 17110002000390_001_001 |
| Cal7_5Trib | Dry | 0.045 | 0.19 | 0.026 | 0.26 | 88158 | 17110002000864_001_001 |
| (GRAND4) | Wet | 0.22 | 0.92 | 0.13 | 1.27 | 88158 | 17110002000864_001_001 |
| CA14cTrib | Dry | 0.013 | 0.025 | $4.2\times10^{-3}$ | 0.042 | 88409 | 17110004016438_001_001 |
| (CA14ab) | Wet | 0.061 | 0.12 | 0.02 | 0.20 | 88409 | 17110004016438_001_001 |
| CA14aa | Dry | 0 | 0.045 | $5.0\times10^{-3}$ | 0.05 | 88477 | 17110002015789_001_001 |
| CA14AAW | Wet | 0 | 0.22 | 0.024 | 0.24 | 88477 | 17110002015789_001_001 |
| Cain | Dry | $8.1\times10^{-3}$ | 0.40 | 0.046 | 0.46 | 42499 | 17110002000738_001_001 |
| (CC) | Wet | 0.051 | 2.56 | 0.29 | 2.91 | 42499 | 17110002000738_001_001 |
| Lift Sta. 5 | Dry | $3.0\times10^{-3}$ | 0.067 | $7.8\times10^{-3}$ | 0.078 | 42507 | 17110002000742_001_001 |
| (LS5) | Wet | 0.019 | 0.43 | 0.05 | 0.50 | 42507 | 17110002000742_001_001 |
| Trib1Dray1* | Dry | $7.0\times10^{-3}$ | 0.31 | 0.03 | 0.35 | 45108 | 17110002000162_001_001 |
| | Wet | 0.03 | 1.46 | 0.17 | 1.66 | 45108 | 17110002000162_001_001 |

*2008 dataset

## Loading Capacity

The TMDLs for the Drayton Harbor watershed are set at the level of the LC. The LC and TMDL are typically determined for specific streamflow conditions in a mass per unit of time by calculating the mass that can be assimilated for the given discharge condition. In addition, the TMDL expressed in terms of bacterial concentrations is also allowed under the Code of Federal Regulations—40 CFR § 130.2(i)[14]. This concentration measure is useful because the WQS can be directly compared to measured concentrations in the receiving water under all streamflow conditions.

For the Drayton Harbor watershed analysis, the LC and TMDL is better stated as a set of bacteria population distributions because these concentrations generally do not consistently vary with flow. The LC and TMDL are therefore established as both a mass per unit of time—billion of bacteria colony forming units per day (b.cfu/day), and as a concentration—bacteria colony forming units per 100 mL (cfu/100 mL). The percent reduction in bacteria pollution required to attain the TMDL is also expressed to quantify the amount of pollution reduction needed to meet the WQS.

In summary, the LCs for each 303(d)-listed fresh water body in the Drayton Harbor watershed are calculated using continuous stream discharge data and the bacterial geomean water quality criterion of 100 cfu/100 mL. Similarly, the brackish water mixing areas near the downstream most fresh water locations are used to establish the FC LC using both fresh and marine water quality data resulting in a 20 cfu/100 mL geomean during the dry season and a 19 cfu/100 mL geomean during the wet season, where both geomean levels protect shellfish harvesting. Dakota Creek streamflow data from the Ecology's continuous gage station at Giles Road is used to model flow rates throughout the study area and calculate seasonal loading and instantaneous flux—see Appendices D and E for details.

In summary, the Simple Method is used to estimate bacteria contributions from stormwater runoff along the immediate shoreline of the harbor. The Simple Method establishes the FC TMDL for the shoreline areas that do not have an associated fresh water 303(d) listed AU ID. Bacteria pollution conveyed by stormwater runoff from the shoreline areas are set at a level to protect the marine water designated use of shellfish harvesting and contact recreation. The Lighthouse Point Water Reclamation Facility also received a WLA based on protective effluent limits and the maximum monthly average design rate of discharge volume.

The LC incorporates the TMDL, WLAs, and LA for the Drayton Harbor watershed and receiving marine water. The TMDL and allocations are established using information that characterizes the upland watershed areas, the shoreline areas, and permitted facilities. The established TMDL and associated pollution reduction targets are based on the conditions observed during WYs 2020 and

[14] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-130/section-130.2

2021, which includes the seasonal components. The LC is expressed in mass units per day to form the basis of the TMDL to address the associated AU impairments. All other reach code stream segments at the watershed scale that do not indicate a water quality impairment currently are also covered by the Drayton Harbor TMDLs.

## Wasteload Allocations

With some exceptions, each NPDES permittee receives WLAs as part of this TMDL (Figure 7 and Tables 8-22). The exceptions are permittees subject to the sand and gravel general permit (SGGP), and the construction stormwater general permit (CSGP). These regulated dischargers typically represent an insignificant source of bacteria pollution. The SGGP regulates discharges of process water, stormwater, and water from mine dewatering into waters of the state from sand and gravel operations, rock quarries, and similar mining operations. The SGGP also covers concrete batch operations and hot-mix asphalt operations. To protect water quality, the CSGP regulates stormwater and dewatering water discharges from construction projects with one or more acre of land disturbing activity. CSGP permittees are temporary in nature because they are active only for the duration of the construction project (EPA 2020). For purposes of attaining the Drayton Harbor TMDL goals SGGP and CSGP permitted entities shall follow permit requirements and demonstrate no pollution contributions that increase bacteria levels in the receiving water bodies.

The Drayton Harbor TMDLs include WLAs for both FC and *E. coli*. Permitted municipal and industrial stormwater point sources that discharge directly to marine waters or to AUs that directly flow to marine waters receive an individual FC and *E. coli* WLA for both the dry and wet seasons. The Lighthouse Point WWTP receives a FC WLA for effluent discharges to Semiahmoo Bay. Permitted areas that do not discharge directly to marine waters or to AUs that do not directly flow to marine waters received *E. coli* WLAs as described below.

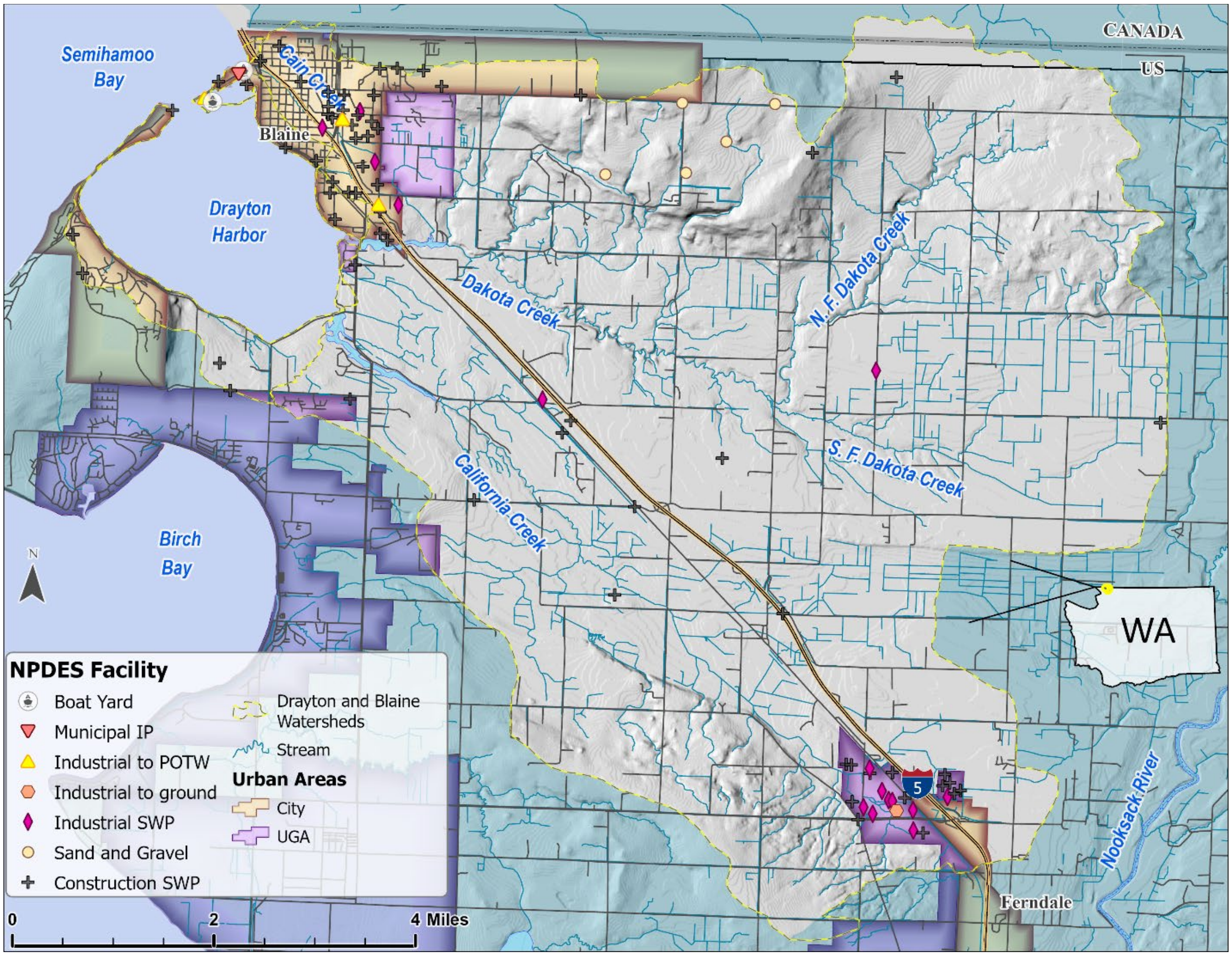


**Figure 7. National Pollutant Discharge Elimination System (NPDES) permitted facilities in the Drayton Harbor TMDL study area: individual permit (IP), publicly owned treatment works (POTW), stormwater permit (SWP)**

## Lighthouse Point WWTP WLA

The Lighthouse Point WWTP WLA is based on the 200 FC cfu/100 mL monthly geometric mean permit standard and the maximum monthly average design flow rate to outfall 001 (Table 8). Ecology's typical WWTP WLAs for FC use technology-based effluent limits as the TMDL-based limit. Modeling demonstrates that under critical conditions, the permitted discharge predicts no exceedance of the water quality criteria at the edge of the chronic mixing zone resulting in 10 FC cfu/100 mL. The FC WLA assigned to the facility includes additional conservative measures—see Appendix A, Lighthouse Point Water Reclamation Facility for details.

Without effluent data for enterococci, Ecology cannot determine whether the discharge will exceed the recreational use WQS in Drayton Harbor. Discharge monitoring for both FC and enterococci is necessary and will be proposed in the next permit version. Monthly grab sampling of enterococci occurring at the same time and effluent location as the FC sample is recommended. This dual monitoring will help inform both Ecology and the City of Blaine of the correlation between the two indicators in this treated wastewater. Ecology will use these data to assess the reasonable potential to exceed the applicable water quality criterion in the next iteration of the permit. Based on this analysis, Ecology may establish new limits for enterococci in units of concentration (cfu/100 mL) or loading rates (b.cfu/day). However, if enterococci and FC are highly correlated, an existing or revised FC limit may ensure compliance with enterococci and FC WQS.

**Table 8. Wasteload allocation for the Lighthouse Point Water Reclamation Facility NPDES permit**

| **Permittee Name** | Lighthouse Point Water Reclamation Facility |
|---|---|
| **Permit Number** | WA0022641 |
| **Permit Type** | Municipal Individual Permit |
| **Water Body Names** | Strait of Georgia |
| **Listing ID of Receiving Water** | No current 303(d) listing |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| **Outfall 001** | **Monthly Effluent Limit** |
| Dry: 11.7 FC | Dry: 200 FC |
| Wet: 11.7 FC | Wet: 200 FC |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.) |
| | Dual monitoring for fecal coliform and enterococci bacteria in effluent and use data to assess the need for enterococci permit limits |
| | Incorporate FC TMDL WLA |

## Municipal Stormwater WLAs

This TMDL assigns WLAs to discharges from Municipal Separate Storm Sewer System (MS4) infrastructure that are currently regulated under the NPDES program. Municipal stormwater discharges from unpermitted jurisdictional areas are assigned a LA. Should the unpermitted areas come under NPDES permits in the future, the associated LA will be converted to individual WLAs using methods described in Appendix E. The MS4 infrastructure currently not covered by a permit that is in the lower watershed either directly drains to Drayton Harbor or drains to adjacent tributaries to the harbor. Converting the LA to WLAs based on jurisdictional area does not affect the TMDL capacity or LC.

In the upper California Creek watershed, the both Whatcom County and the City of Ferndale are authorized to discharge municipal stormwater under the Western Washington Phase II Municipal Stormwater NPDES permit (MS4 permit)  (Table 9 and 10 respectively).

The Washington State Department of Transportation (WSDOT) is authorized to discharge stormwater under a similar permit where these areas overlap (Table 11). The area outside of the WSDOT overlap with the regulated MS4s of Whatcom County and City of Ferndale are also included in the total WLA for WSDOT. The WSDOT permitted area in the Drayton Harbor watershed covers Interstate 5, and State Routes 548, and 543.

Neither the Dakota Creek or Cain Creek watersheds currently have regulated MS4s.

The shoreline area that drains immediately to Drayton Harbor received allocations to meet the TMDL based on the estimated stormwater runoff contributions. These stormwater contributions are estimated using the Simple Method and jurisdictional area—Appendix E. The WSDOT permitted area that drains directly to the harbor includes 1.7 percent of the shoreline area. The remaining 92.7 percent of the shoreline area received a LA for FC.

The permitted stormwater discharges from Whatcom County, the City of Ferndale, and WSDOT receive individual WLAs based on permitted area (Tables 9—11). These allocations are also known as areal-based allocations. Each areal-based WLA is determined using the relative proportional area subject to permit requirements as a point source and the relative proportional area not subject to a permit as a nonpoint source.

#### City and County MS4 Permit Additional Actions

The MS4 Permit contains a range of Stormwater Management Program (SWMP) requirements that are designed to protect water quality. Ecology incorporates additional requirements based on EPA-approved TMDLs when necessary to enhance or focus stormwater management actions to address a WLA. Such additional actions are described when the MS4 Permit is renewed. The following additional actions are relevant to meeting the Whatcom County and City of Ferndale WLAs.

**Source control for existing development**, the permittee shall prioritize and inspect facilities with SIC Industry Group no. 074, 075, including NAICS Major Group 1152xx, and NAICS 325315 (composting facilities) as part of their ongoing inspection program.

For **education and outreach**, each permittee shall include public education and outreach activities that increase awareness of bacterial pollution problems and promote proper pet waste management as a best management practice (BMP) under General Awareness.

For **operations and maintenance**, each permittee shall maintain pet waste collection stations at permittee owned or operated lands that are reasonably expected to have domestic animal (dog and horse) use and the potential for pollution to stormwater.

When conducting **illicit connection/illicit discharge detection and elimination (IDDE)** field screening during normal course of business in a TMDL area, permittees shall obtain a grab sample to screen for bacteria sources when at the drainage circuit's most downstream sampling location if there is water flow. Permittees shall follow their adopted IDDE procedures to conduct source tracing efforts if bacteria levels or observations trigger a response—see IDDE guidance manual for bacteria trigger levels.

Other stormwater management activities, such as MS4 mapping, stormwater infrastructure cleaning, Stormwater Management Action Plans (SMAP), and retrofit planning may also be appropriate to leverage focus on TMDL areas of concern.

The MS4 Permit also commonly requires a TMDL-specific summary of actions with each Annual Report. Qualitative and quantitative information about the bacteria-control actions taken, including but not limited to IDDE sampling locations and results (including documenting no flow), are to be documented annually in order to inform effectiveness monitoring and adaptive management of this TMDL.

**Table 9. Wasteload allocation for the Whatcom County municipal stormwater NPDES permit**

| **Permittee Name** | Whatcom County |
|---|---|
| **Permit Number** | WAR045557 |
| **Permit Type** | Municipal separate storm sewer systems (MS4) Phase II, Western WA |
| **Water Body Name** | California Creek, Tributary to California Cr. |
| **Listing ID of Receiving Water** | 72275, 72276, 88149, 88158 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| California Creek (72275) | |
| Dry: $9.6 \times 10^{-2}$ FC | Dry: 15 FC |
| Wet: 0.44 FC | Wet: 4 FC |
| California Creek (72275) | |
| Dry: 0.15 *E. coli* | Dry: 34 *E. coli* |
| Wet: 0.74 *E. coli* | Wet: 30 *E. coli* |
| California Creek (72276) | |
| Dry: 0.43 *E. coli* | Dry: 57 *E. coli* |
| Wet: 2.1 *E. coli* | Wet: 40 *E. coli* |
| Tributary to California Cr. (88149) | |
| Dry: $4.7 \times 10^{-3}$ *E. coli* | Dry: 44 *E. coli* |
| Wet: $2.2 \times 10^{-2}$ *E. coli* | Wet: 42 *E. coli* |
| Tributary to California Cr. (88158) | |
| Dry: $4.5 \times 10^{-2}$ *E. coli* | Dry: 66 *E. coli* |
| Wet: 0.21 *E. coli* | Wet: 38 *E. coli* |
| Tributary to California Cr. (88409) | |
| Dry: $1.3 \times 10^{-2}$ *E. coli* | Dry: 37 *E. coli* |
| Wet: $6.1 \times 10^{-2}$ *E. coli* | Wet: 50 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLAs |

**Table 10. Wasteload allocation for the City of Ferndale municipal stormwater NPDES permit**

| **Permittee Name** | City of Ferndale |
|---|---|
| **Permit Number** | WAR045552 |
| **Permit Type** | Municipal separate storm sewer systems (MS4) Phase II, Western WA |
| **Water Body Name** | California Creek, Tributary to California Cr. |
| **Listing ID of Receiving Water** | 72276, 88149 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| California Creek (72276) | |
| Dry: 0.17 *E. coli* | Dry: 57 *E. coli* |

| Permittee Name | City of Ferndale |
|---|---|
| Wet: 0.82 *E. coli* | Wet: 40 *E. coli* |
| Tributary to California Cr. (88149) | |
| Dry: $7.6 \times 10^{-4}$ *E. coli* | Dry: 44 *E. coli* |
| Wet: $3.6 \times 10^{-3}$ *E. coli* | Wet: 42 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLAs |

### WSDOT MS4 Permit Additional Actions

If stormwater discharges that transport bacteria over natural background levels to listed receiving waters are found from sources within WSDOT's right-of-way and control, WSDOT will apply WSDOT Municipal Stormwater Permit best management practices (BMPs) from their Stormwater Management Program (SWMP) to eliminate the bacteria source. For run-on sources of bacteria identified by WSDOT that are from outside of WSDOT's right-of-way, WSDOT will notify Ecology and work cooperatively with Ecology, the local jurisdiction, and other parties involved for their resolution.

WSDOT will work with Ecology and local jurisdictions to identify and control potential sources of fecal bacteria pollution within the permitted right-of-way. This work may include but is not limited to site visits, data review, and coordinated problem solving.

**Table 11. Wasteload allocation for the WSDOT municipal stormwater NPDES permit**

| Permittee Name | Washington State Department of Transportation |
|---|---|
| **Permit Number** | WAR043000A |
| **Permit Type** | General stormwater permit |
| **Water Body Name** | Cain Creek, California Creek, Tributary to California Cr., Tributary to Drayton Harbor |
| **Listing ID of Receiving Water** | 39048, 39058, 39059, 42499, 42507, 45108, 46186, 53171, 72275, 72276, 74144, 74147, 88158, 88161, 88959 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| California Creek (72275) | |
| Dry: $1.8 \times 10^{-3}$ FC | Dry: 15 FC |
| Wet: $8.1 \times 10^{-3}$ FC | Wet: 4 FC |
| Tributary to California Cr. (88161) | |
| Dry: $5.6 \times 10^{-5}$ FC | Dry: 4 FC |
| Wet: $3.4 \times 10^{-4}$ FC | Wet: 4 FC |
| Tributary to California Cr. (74144) | |
| Dry: $4.0 \times 10^{-3}$ FC | Dry: 9 FC |
| Wet: $1.8 \times 10^{-2}$ FC | Wet: 5 FC |
| Cain Creek (42499) | |
| Dry: $1.4 \times 10^{-3}$ FC | Dry: 7 FC |
| Wet: $8.7 \times 10^{-3}$ FC | Wet: 6 FC |
| Tributary to Drayton Harbor (42507) | |
| Dry: $6.0 \times 10^{-4}$ FC | Dry: 8 FC |

| **Permittee Name** | Washington State Department of Transportation |
|---|---|
| Wet: 3.6 × $10^{-3}$ FC | Wet: 7 FC |
| Tributary to Drayton Harbor (45108) | |
| Dry: 1.4 × $10^{-3}$ FC | Dry: 6 FC |
| Wet: 8.6 × $10^{-3}$ FC | Wet: 6 FC |
| Stormwater to Drayton Harbor | |
| Dry: 1.2 × $10^{-2}$ FC | Dry: 20 FC |
| Wet: 3.4 × $10^{-2}$ FC | Wet: 19 FC |
| California Creek (72275) | |
| Dry: 2.9 × $10^{-2}$ *E. coli* | Dry: 34 *E. coli* |
| Wet: 0.14 *E. coli* | Wet: 30 *E. coli* |
| California Creek (72276) | |
| Dry: 2.8 × $10^{-2}$ *E. coli* | Dry: 57 *E. coli* |
| Wet: 0.14 *E. coli* | Wet: 40 *E. coli* |
| Tributary to California Cr. (88161) | |
| Dry: 2.9 × $10^{-4}$ *E. coli* | Dry: 31 *E. coli* |
| Wet: 1.8 × $10^{-3}$ *E. coli* | Wet: 31 *E. coli* |
| Tributary to California Cr. (74144) | |
| Dry: 2.0 × $10^{-2}$ *E. coli* | Dry: 67 *E. coli* |
| Wet: 9.6 × $10^{-2}$ *E. coli* | Wet: 24 *E. coli* |
| Tributary to California Cr. (88959) | |
| Dry: 1.7 × $10^{-3}$ *E. coli* | Dry: 42 *E. coli* |
| Wet: 8.3 × $10^{-3}$ *E. coli* | Wet: 21 *E. coli* |
| Tributary to California Cr. (74147) | |
| Dry: 4.5 × $10^{-3}$ *E. coli* | Dry: 66 *E. coli* |
| Wet: 2.2 × $10^{-2}$ *E. coli* | Wet: 27 *E. coli* |
| Tributary to California Cr. (88158) | |
| Dry: 8.6 × $10^{-4}$ *E. coli* | Dry: 66 *E. coli* |
| Wet: 4.1 × $10^{-3}$ *E. coli* | Wet: 38 *E. coli* |
| Cain Creek (42499) | |
| Dry: 7.2 × $10^{-3}$ *E. coli* | Dry: 49 *E. coli* |
| Wet: 4.6 × $10^{-2}$ *E. coli* | Wet: 47 *E. coli* |
| Tributary to Drayton Harbor (42507) | |
| Dry: 3.0 × $10^{-3}$ *E. coli* | Dry: 46 *E. coli* |
| Wet: 1.9 × $10^{-2}$ *E. coli* | Wet: 16 *E. coli* |
| Tributary to Drayton Harbor (45108) | |
| Dry: 6.9 × $10^{-3}$ *E. coli* | Dry: 50 *E. coli* |
| Wet: 3.3 × $10^{-2}$ *E. coli* | Wet: 50 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLAs |

## Boatyard General Permit WLA

There is one existing NPDES-permitted boatyard facility under the Boatyard General Permit (BYGP) that is assigned an areal-based WLA for its stormwater discharges. The Sundance Yacht Sales facility (formerly Blaine Marine Services LLC) is located at 199 Marine Drive in Blaine. The BYGP requires the development and implementation of a Stormwater Pollution Prevention Plan, which includes BMPs to minimize pollution impacts to the receiving marine waters.

**Table 12. Wasteload allocation for the Sundance Yacht Sales NPDES permit**

| **Permittee Name** | Sundance Yacht Sales |
|---|---|
| **Permit Number** | WAG030119 |
| **Permit Type** | Boatyard General Permit |
| **Water Body Name** | Drayton Harbor |
| **Listing ID of Receiving Water** | 15692, 39048, 39052, 53171, 53187, 86869 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $7.8 \times 10^{-4}$ FC<br>Wet: $2.2 \times 10^{-3}$ FC | Dry: 20 FC<br>Wet: 19 FC |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

## Industrial Stormwater WLAs

Multiple existing facilities authorized to discharge stormwater associated with industrial activities are assigned areal-based WLAs in this TMDL. These permitted facilities are not authorized to discharge process wastewater to a surface water body, therefore each WLA is based on the permitted area that covers stormwater discharges from the facility and infrastructure. The following facilities are currently subject to the Industrial Stormwater General Permit (ISGP):

- Justesen Industries,
- Lister Chain and Forge Incorporated,
- Silvastar Forrest Products,
- Homefire Prest Logs,
- Perry Pallet,
- Montigo Del Ray Corporation,
- Marcon Metalfab,
- Northwest Podiatric Lab Incorporated,
- Nature's Path,
- Dunkin and Bush Incorporated Buchanan Loop, and
- Beacon Battery

Refer to Tables 13-23 for permittee-specific WLAs. Under Special Condition S3 of the permit, permittees must develop and implement a Stormwater Pollution Prevention Plan, which includes BMPs to minimize pollution impacts to the receiving water bodies.

The WLAs for each facility contributes to the TMDLs of the receiving water bodies immediately downstream of each facility or discharge location. The ISGP regulates the discharge of stormwater, either directly or indirectly through a stormwater drainage system, to waters of the state. When assessing pollution control and prevention activities, bacteria sampling shall occur on an as needed basis to confirm attainment of the assigned WLA. When a receiving water body does not meet the WQS, stormwater samples shall be collected at the nearby permitted facility upon request under General Condition G12 and samples shall be collected and inspections implemented under Special Conditions S4, S5, S6, and S7.

**Table 13. Wasteload allocation for the Justesen Industries stormwater NPDES permit**

| **Permittee Name** | Justesen Industries |
|---|---|
| **Permit Number** | WAR000513 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Name** | Cain Creek |
| **Listing ID of Receiving Water** | 42499 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $1.0 \times 10^{-4}$ FC | Dry: 7 FC |
| Wet: $6.0 \times 10^{-4}$ FC | Wet: 6 FC |
| Dry: $5.0 \times 10^{-4}$ *E. coli* | Dry: 49 *E. coli* |
| Wet: $3.2 \times 10^{-3}$ *E. coli* | Wet: 47 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 14. Wasteload allocation for the Lister Chain and Forge Incorporated stormwater NPDES permit**

| **Permittee Name** | Lister Chain and Forge Incorporated |
|---|---|
| **Permit Number** | WAR008687 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | Tributary to California Creek |
| **Listing ID of Receiving Water** | 74144 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $6.4 \times 10^{-4}$ FC | Dry: 5 FC |
| Wet: $2.9 \times 10^{-3}$ FC | Wet: 5 FC |
| Dry: $3.2 \times 10^{-3}$ *E. coli* | Dry: 67 *E. coli* |
| Wet: $1.5 \times 10^{-2}$ *E. coli* | Wet: 24 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 15. Wasteload allocation for the Silvastar Forrest Products stormwater NPDES permit**

| **Permittee Name** | Silvastar Forrest Products |
|---|---|
| **Permit Number** | WAR011720 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | California Creek |
| **Listing ID of Receiving Water** | 72276 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $6.8 \times 10^{-3}$ *E. coli* | Dry: 57 *E. coli* |
| Wet: $3.2 \times 10^{-2}$ *E. coli* | Wet: 40 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 16. Wasteload allocation for the Homefire Prest Logs stormwater NPDES permit**

| | |
|---|---|
| **Permittee Name** | Homefire Prest Logs |
| **Permit Number** | WAR125508 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | California Creek |
| **Listing ID of Receiving Water** | 72276 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $3.4 \times 10^{-3}$ *E. coli* | Dry: 57 *E. coli* |
| Wet: $1.6 \times 10^{-2}$ *E. coli* | Wet: 40 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 17. Wasteload allocation for the Perry Pallet stormwater NPDES permit**

| | |
|---|---|
| **Permittee Name** | Perry Pallet |
| **Permit Number** | WAR307148 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Waterbody Names** | California Creek |
| **Listing ID of Receiving Water** | 72276 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $4.5 \times 10^{-3}$ *E. coli* | Dry: 57 *E. coli* |
| Wet: $2.2 \times 10^{-2}$ *E. coli* | Wet: 40 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 18. Wasteload allocation for the Montigo Del Rey Corporation stormwater NPDES permit**

| | |
|---|---|
| **Permittee Name** | Montigo Del Ray Corporation |
| **Permit Number** | WAR307254 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Waterbody Names** | California Creek |
| **Listing ID of Receiving Water** | 72276 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $6.6 \times 10^{-3}$ *E. coli* | Dry: 57 *E. coli* |
| Wet: $3.1 \times 10^{-2}$ *E. coli* | Wet: 40 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 19. Wasteload allocation for the Marcon Metalfab stormwater NPDES permit**

| | |
|---|---|
| **Permittee Name** | Marcon Metalfab |
| **Permit Number** | WAR310646 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | California Creek |
| **Listing ID of Receiving Water** | 72276 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $6.7 \times 10^{-3}$ *E. coli* | Dry: 57 *E. coli* |

| Permittee Name | Marcon Metalfab |
|---|---|
| Wet: $3.2 \times 10^{-2}$ *E. coli* | Wet: 40 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 20. Wasteload allocation for the Northwest Podiatric Lab Incorporated stormwater NPDES permit**

| **Permittee Name** | Northwest Podiatric Lab Incorporated |
|---|---|
| **Permit Number** | WAR301472 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | Cain Creek |
| **Listing ID of Receiving Water** | 42499 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $8.4 \times 10^{-5}$ FC | Dry: 7 FC |
| Wet: $5.1 \times 10^{-4}$ FC | Wet: 3 FC |
| Dry: $4.2 \times 10^{-4}$ *E. coli* | Dry: 49 *E. coli* |
| Wet: $2.7 \times 10^{-3}$ *E. coli* | Wet: 47 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 21. Wasteload allocation for the Nature's Path stormwater NPDES permit**

| **Permittee Name** | Nature's Path |
|---|---|
| **Permit Number** | WAR306624 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | Tributary to Dakota Creek |
| **Listing ID of Receiving Water** | 74161 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $9.1 \times 10^{-4}$ FC | Dry: 1 FC |
| Wet: $5.5 \times 10^{-3}$ FC | Wet: 8 FC |
| Dry: $4.5 \times 10^{-3}$ *E. coli* | Dry: 7 *E. coli* |
| Wet: $2.9 \times 10^{-2}$ *E. coli* | Wet: 58 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 22. Wasteload allocation for the Dunkin and Bush Incorporated Buchanan Loop stormwater NPDES permit**

| **Permittee Name** | Dunkin and Bush Incorporated Buchanan Loop |
|---|---|
| **Permit Number** | WAR127299 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Names** | Tributary to California Creek |
| **Listing ID of Receiving Water** | No current listing, site CA15 used to establish TMDL |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: 0.04 *E. coli* | Dry: 71 *E. coli* |
| Wet: 0.17 *E. coli* | Wet: 35 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

**Table 23. Wasteload allocation for the Beacon Battery stormwater NPDES permit**

| | |
|---|---|
| **Permittee Name** | Beacon Battery |
| **Permit Number** | WAR005629 |
| **Permit Type** | Industrial Stormwater General Permit |
| **Water Body Name** | South Fork Dakota Creek |
| **Listing ID of Receiving Water** | 6395 |
| **WLA (billion cfu/day)** | **Bacteria Concentration-based Limit (cfu/100 mL)** |
| Dry: $8.0 \times 10^{-3}$ *E. coli* | Dry: 22 *E. coli* |
| Wet: $5.1 \times 10^{-2}$ *E. coli* | Wet: 9 *E. coli* |
| **Other Load Limits and Requirements** | Critical Period: wet season (Oct.—Apr.)<br>Incorporate TMDL WLA |

## Load Allocations

Load allocations are allowable pollutant loads attributed to nonpoint pollution or natural background sources. The nonpoint source LAs are set in this TMDL based on the proportional area of the watershed, or subbasin, not covered by an NPDES permit (Tables 6 and 7). The LAs are established for both the FC and *E. coli* nonpoint source components of the TMDL. The LAs contribute to each specific receiving water body monitoring location within the AU, which collectively cover the Drayton Harbor watershed to account for land uses that may affect water quality.

The monitoring data used to develop this TMDL did not distinguish nonpoint sources from point sources, except for the Lighthouse Point WWTP design and technology-based effluent limits. If nonpoint sources are later mapped and segregated, success in meeting the TMDL target will still depend on effective control of stormwater runoff and all other bacteria sources. Many of the same pollution control activities that address LAs are like those used to address WLAs, however, the legal and regulatory mechanisms of enforcement may differ. Load allocations are often addressed through a variety of pollution control and prevention activities, educational programs, and other means.

Because nonpoint pollution comes from diffuse sources, all upstream activities within the drainage area have the potential to affect downstream water quality. Other potential sources of bacteria pollution in the watershed not currently under NPDES permit include urban and residential land use, failing onsite sewage systems (OSS), livestock, manure management, marina use, boat moorage, parks, recreation, or direct deposit of bacteria pollutant to the receiving water body outside of a permitted area—see the Implementation Plan for details. The allocations for such sources are expressed as LAs contingent on the source does not have a discharge permit. The same pollution reduction needed to meet the TMDLs is applied to both the WLA and LA as previously described.

## Margin of Safety

The federal Clean Water Act requires that TMDLs include a margin of safety (MOS). The MOS can be stated explicitly by setting a specific allocation as a MOS, or as an implicit MOS by using conservative assumptions in the use of data, analysis, and the effectiveness of proposed management practices. Similar to EPA (2020), an explicit ten percent MOS is allocated in each TMDL in this study to account for uncertainty. The factors that contribute to uncertainly include:

- The inherent variability and sample error associated with bacteria water quality monitoring and laboratory analysis,
- The limits of instantaneous data extrapolation to calculate daily loads,
- The modeled relationship between FC and *E. coli* using the bacteria translator, and
- The modeled stream flow conditions used to calculate each TMDL by assessment unit and season to yield daily loads.

Additionally, an implicit MOS is applied because the TMDL did not consider bacteria die-off using a natural decay rate coefficient. Although sunlight and temperature reduce bacteria survival, it is assumed that FC and *E. coli* bacteria entering the watershed will stay active and suspended in the water column to the mouth of the water body with no die-off.

# Reasonable Assurance

When establishing the Drayton Harbor bacteria TMDLs, pollution reductions are allocated among the pollutant sources—both point (WLA) and nonpoint (LA) sources— and calibrated to meet the applicable WQS. Reducing point source pollution to meet the WLAs assumes that reducing nonpoint source pollution to meet the LAs will also occur. The Drayton Harbor bacteria TMDL and Implementation Plan shows reasonable assurance that these sources shall be reduced to their allocated amount. If there is no reasonable assurance, EPA guidance indicates that the load reductions must be transferred to point sources.

Ecology believes that the PIC activities described in the Implementation Plan of this report support the resources to attain the TMDL. Ecology assumes that the implementation activities are continued and maintained to reduce bacteria pollution. Additional funding sources are identified to enhance the water cleanup process. The goal of meeting the WQS requires continued water quality monitoring that is necessary for pollution source tracking, trend analysis, adaptive management and assessing the efficacy of BMPs.

Adhering to the pollution control strategies described in the TMDL and Implementation Plan provides reasonable assurance that pollution sources are addressed through a suite of specific activities. The point sources expressed as WLAs shall be addressed by fulfilling the established regulatory permit requirements. The nonpoint sources expressed as LAs shall be addressed using similar pollution control strategies under cooperative management of these areas, which includes state and local code enforcement along with responsible public conduct. Adaptive management will provide the foundation for evolving water quality improvement strategies based on the development of new information. Documenting sufficient reasonable assurance increases the probability that regulatory and voluntary mechanisms will be applied to the level of pollution reduction identified in the TMDL to attain the WQS.

## Managing WLAs

This report describes programs and activities necessary to attain the WLAs—see the TMDL Allocations, Wasteload Allocations section, and the Implementation Plan, Point Sources of Pollution section for details. In summary, the Drayton Harbor bacteria WLAs for permitted stormwater and WWTP sources are addressed by Ecology’s NPDES permit program. Permit issuance and implementation of the permitting program, including compliance assurance actions, provides the reasonable assurance that WLAs in the TMDL will be achieved.

Each permit details specific activities to control and reduce fecal bacteria pollution to the level of meeting the WLA component of the TMDL. For example, the central means of controlling pollution discharged within the municipal stormwater infrastructure are the actions conducted under the Stormwater Management Program (SWMP). Another example is operating the Lighthouse Point facility to meet the technology based effluent limits that are well below the assigned WLA and meet the WQS.

## Managing LAs

Ongoing efforts coordinated through the WCWP led to bacteria pollution reductions in many areas of the Drayton Harbor watershed—see Appendix D, Trend Analysis for details. The WCWP primarily addresses nonpoint source pollution through voluntary measures along with providing support for regulatory actions. To address nonpoint source pollution, collaborators participate with their own funding, programs, and mandates to work toward improving and protecting water quality. The TMDL LAs along with the strategy to address them are described in the TMDL Allocations, Load Allocations section, the Implementation Plan, Nonpoint Sources of Pollution section and summarized below.

Several organizations offer farm plans or voluntary guidance to reduce or prevent nonpoint source pollution from stormwater runoff or direct deposit on agricultural lands and water ways. Farm plans and pollution prevention guidelines are generally incentive based and include elements such as education, livestock exclusion fencing, riparian buffer zones, easement programs, or safe manure management. The WCWP coordinates efforts to assist agricultural landowners in addressing potential pollution sources, where each organization that makes up the WCWP operates within the respective authority and expertise.

In urban and rural areas, stormwater program elements such as public education and outreach have essentially the same impact on all stormwater discharges regardless of whether they enter a permitted municipal stormwater system or are discharged directly to a receiving water as a nonpoint source. Other similar actions include the use of pet waste stations along with responsible public participation that equally apply to the WLAs and LAs as pollution prevention measures.

Enforcement of state law and local ordinances provide reasonable assurance that the LAs will be met. For example, Ecology is authorized under Chapter 90.48 RCW to issue enforcement actions to achieve compliance with state WQS. It is, however, the goal of all participants in the TMDL process to achieve clean water through cooperative efforts. Other codes delegate the responsibility of the Whatcom County Health and Community Services (WCHCS) to work with homeowners that have OSS to emphasize the importance of system maintenance by following a set of regulatory rules to address pollution prevention that is the responsibility of the owner—see Appendix F, Regulatory Framework for descriptions of programs and mandates that address sources of pollution.

Ecology's Environmental Reporting and Tracking System (ERTS)[15] is a statewide reporting system and coordination tool that connects local governments and state agencies when responding to an immediate pollution concern. Each reported issue is assigned a tracking number along with follow up personnel. Each organization has plans and procedures to address pollution concerns that can be coordinated through the ERTS, the WCWP, or additional correspondence.

## TMDL Calculation

The data collected at each water quality sampling station located throughout the Drayton Harbor watershed and within the harbor provides information to calculate the TMDL. The TMDL is based on the conditions of WYs 2020 and 2021 instead of 2008 conditions observed during Phase 1. The more recent dataset reflects existing watershed conditions, which accounts for the many pollution correction activities that likely improved water quality in many catchments since 2008.

The TMDL for each 303(d) listing—reach code AU—is determined using the weighted catchment drainage area and each contributing allocated source to account for the entire watershed (Tables 6 and 7, Appendix E—Table E-1). The TMDL includes a 10 percent explicit MOS calculated for each reach code AU following the precedence set by EPA (2020) for the Deschutes River bacteria TMDL. The *E. coli* LCs are calculated using the geometric mean seasonal stream discharge and meeting the geomean *E. coli* WQS criterion of 100 cfu/100 mL. The FC LCs are calculated using 20 and 19 cfu/100 mL geomeans of the dry and wet season respectively, which accounts for the mixing of fresh and marine waters and seasonal variation (Appendices D and E).

The seasonal variation assessment includes the dry season from May through September, and the wet season from October through April to identify the potential of a critical period. Accounting for seasonal variation, the amount of pollution reduction necessary to attain the TMDL is expressed as a percent reduction and geometric mean. The TMDL targets and percent reductions quantify the amount of pollution reduction necessary to achieve or be within the LC.

The TMDL represents a distribution of bacteria counts over time with a geomean that when attained will meet water quality criteria (Tables 4 and 5). The TMDLs, LCs, WLAs, and LAs are expressed in terms of mass unit-per-time loads (b.cfu/day) (Tables 6 and 7). Washington State water quality criteria for bacteria, however, are expressed as concentration such as mass-per-volume (cfu/100 mL) with 10 percent of samples not to exceed the STV. When each TMDL allocation and the MOS is summed, the underlying count distributions are combined, and the sum of the allocations will not exceed the LC. When the TMDLs are attained, it is assumed that the WLAs and LAs will be met for each AU to establish the protection of designated uses.

[15] https://ecology.wa.gov/Footer/Report-an-environmental-issue

# Implementation Plan

## Introduction

The goal is for the Drayton Harbor watershed to be at or below the TMDL, which ensures meeting the WQS. Meeting this goal allows each water body in the watershed to consistently support designated uses. The Drayton Harbor TMDL Implementation Plan describes:

- Land cover and uses,
- Water quality problems and actions necessary to address known or potential bacteria pollution loading sources,
- Organizations and means to implement bacteria pollution cleanup activities,
- Priorities and timelines to attain the TMDL or WQS,
- Technical Feasibility of attaining the TMDL,
- Funding sources for implementation activities and practices,
- Education and outreach for the community and practitioners, and
- Ways to track TMDL implementation and progress.

Watershed improvement activities and management strategies are already underway in coordination with local partners primarily through the WCWP and under existing NPDES permits. The TMDL Implementation Plan augments the approach taken by local partners with the shared goals of improving and protecting water quality. Continued and innovative implementation efforts also contribute to meeting TMDL goals.

Ecology developed this Implementation Plan with input from interested parties. It explains the roles of cleanup partners—those organizations with jurisdiction, authority, or direct responsibility for cleanup—along with the programs or other means through which they will address water quality issues. Although not an exhaustive list, the TMDL Implementation Plan includes four general types of actions including:

- Source Identification and Tracking
    - Routinely evaluate properties used to house or pasture livestock in the basin for conditions that are causing or likely to cause pollution,
    - Identify and eliminate illicit connections to the stormwater drainage system, and
    - Identify bacteria pollution sources through observation, monitoring, and evaluation.
- Source Controls
    - Implement structural and non-structural stormwater BMPs
    - Conduct stormwater system operation and maintenance procedures,
    - Investigate and repair sewer leaks and failing onsite septic systems (OSS),
    - Manage marinas and boat pump out facilities to prevent pollution,

    - Manage manure, including lagoons, liquids, solids, transport, and field application to prevent pollution, and
    - Manage domestic animal and livestock waste in a manner that prevents water pollution.
- Education and Public Outreach
    - Educate businesses, land owners and the public on bacteria pollution issues and the associated sources,
    - Educate homeowners with OSS on maintenance and service requirements,
    - Educate pet owners about proper pet waste cleanup and disposal on public and private lands, and
    - Educate operators about proper manure management including export, import, application, and setbacks.
- Water quality monitoring
    - Continue monitoring and expand efforts to address data gaps as funding allows,
    - Incorporate transitional monitoring of bacteria indicators from FC to *E. coli* in fresh water systems while balancing the requirements of PIC programs, and
    - Continue monitoring FC at locations that drain directly to the harbor to compare these contributions to the receiving marine water and TMDL targets.

While each subbasin may have varying types of pollution sources due to the mix of rural, agricultural, urban, and undeveloped areas, the implementation efforts are similar across the watershed. The methods in this plan are general in nature and combinations of practices will likely yield the best results. Water quality cleanup and protection actions are prioritized based on 1) the locations in the watershed with the highest relative pollution levels, 2) identification of potential pollution sources, and 3) the ability to work within the existing improvement programs—such as farm plans, OSS management, and stormwater NPDES permits. When determining cleanup priorities, assessing the balance between bacteria loading contributions and bacteria concentrations is not always a simple process, however, may become an important aspect to consider.

This study found that increased bacteria concentrations in marine waters demonstrate a strong direct association with bacteria loading from fresh water inputs, while the fresh water bacteria concentrations demonstrate a weak respective association. However, both the rate-based loading values and the concentration-based values are essential components of the TMDL. For added flexibility in applying water quality monitoring strategies, the Drayton Harbor bacteria TMDL is expressed in three ways to meet the WQS as follows:

- Rate-based (b.cfu/day),
- Concentration-based (cfu/100 mL), and
- Percent reduction of bacteria pollution.

These three metrics, when assessed individually or in combination, may be used to prioritize implementation activities or track progress towards meeting clean up goals.

The progress of TMDL implementation is also measured by documenting pollution control activities underway or completed coupled with field data collection and observations. To some degree, estimating the load reduction of each pollution correction activity is possible through field observation or water quality monitoring. However, quantifying the performance of management measures at the site-specific level is difficult and may be influenced by implementation at the broader scale.

For businesses and organizations that hold NPDES permits, any water cleanup activities identified in this TMDL will be re-evaluated at the time of permit reissuance and incorporated into the permit language or relevant guidance documents. Other beneficial water cleanup practices to reduce sediment transport, increase water retention, or control other pollutants may reduce bacterial loading as a secondary benefit. Site-specific innovative approaches should be considered when traditional BMPs are not an option.

The load reductions established in this TMDL will be attained when effective implementation activities are achieved throughout the watershed, which includes adaptive management as new information is obtained to inform the implementation strategy. The LA from nonpoint sources require greater reductions when compared to the WLA from point sources. This factor is due to the relative difference in watershed area that is not covered by an NPDES permit comprising the LAs, which is much larger than the permitted areas and effluent associated with the WLAs. To attain the TMDL, nonpoint source pollution management measures will therefore require a greater suite of actions applied at a broader scale when compared to point sources of pollution.

The strategy to reduce bacteria pollution includes a combination of actions designed to address the specific needs of each watershed or drainage. Implementation activities may be updated to include new projects, priorities, and approaches over time. Applying both proven methods and creative approaches to implementation is essential along with sustained activities to ensure long-term water quality protection. In summary, the comprehensive approach of tracking progress toward the TMDL study goals includes water quality monitoring, pollution reduction and prevention actions, information sharing, and cooperative management in coordination with interested parties and community members.

The TMDL Implementation Plan identifies grants and loans to help fund existing water quality improvement programs and future innovative projects, or to provide budget relief when implementing water quality improvement activities. Funding from state and local programs and the National Estuary Program (NEP) is essential for TMDL implementation and in turn, the TMDL may be utilized to leverage additional funding to increase PIC activities or incorporate adaptive management. The adaptive management process is used to assess whether the actions identified to solve the pollution problems are working. Adaptive management is also part of the annual planning efforts of the Drayton Harbor Shellfish Protection District and local PIC programs.

This TMDL and Implementation Plan also serve the function of achieving EPA's nine minimum elements for successful watershed plans (EPA 2008). These plans are required for projects that are developed and implemented with Section 319 funding at the watershed level. Because several nonpoint, or dispersed, pollution sources occur in the Drayton Harbor watershed, this report includes the nine key elements of a watershed plan:

1. Identification of the causes of impairment and pollution sources,
2. An estimate of the load reductions expected from management measures,
3. Description of the nonpoint source management measures and BMPs,
4. An estimate of the technical and financial assistance needed,
5. Information and education to be provided in the watershed,
6. Schedule for implementing needed BMPs,
7. Description of interim milestones,
8. Criteria to determine if load reductions are being met, and
9. Monitoring to evaluate effectiveness of the plan.

## Land Cover Distribution

The National Land Cover Database (NLCD) provides nationwide information on land cover at a 30 m resolution with 16 classes based on a modified Anderson Level II classification system (Wickham et al. 2021, Homer et al. 2020, Jin et al. 2019, Yang et al. 2018). When aggregating similar classes together, the NLCD shows that the land cover in the Drayton Harbor study area is primarily agricultural totaling 37 percent followed by forest and short vegetation at 26 percent, developed at 20 percent, and wetland at 17 percent (Figures 8 and 9). The total developed area is comprised of low intensity at 8.6 percent, followed by open space at 6.3 percent, medium intensity at 3.7 percent, and high intensity at 1 percent of the study area (Figure 9). The total forested area is comprised of 11.6 percent deciduous, followed by 8.3 percent mixed, and 2.8 percent evergreen. The total agricultural area is comprised of 26.8 percent pasture and 10.4 percent cultivated crop. The total wetland area is comprised of 9.4 percent woody followed by 7.5 percent herbaceous.

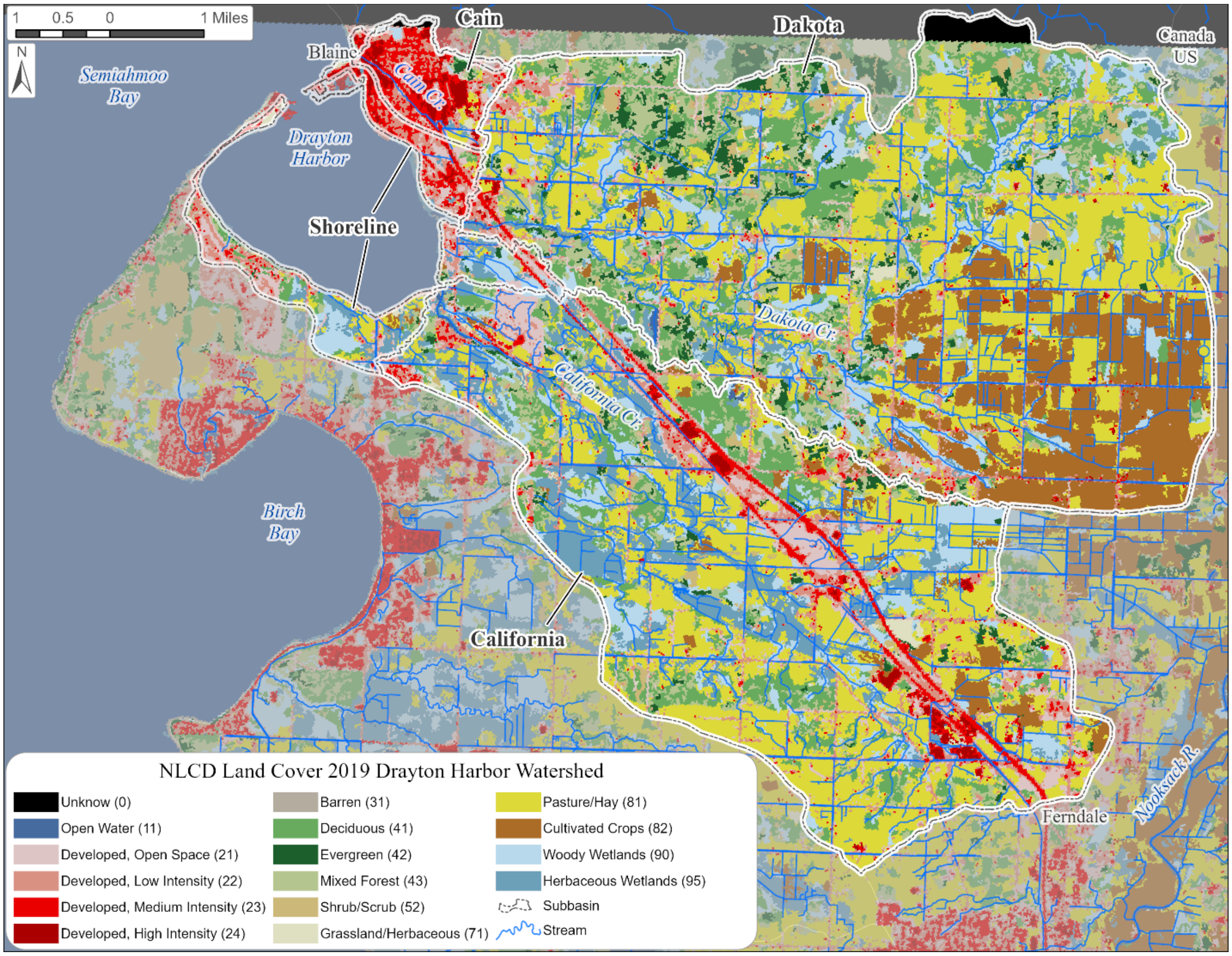


**Figure 8. NLCD 2019 land cover for the Drayton Harbor TMDL study area**

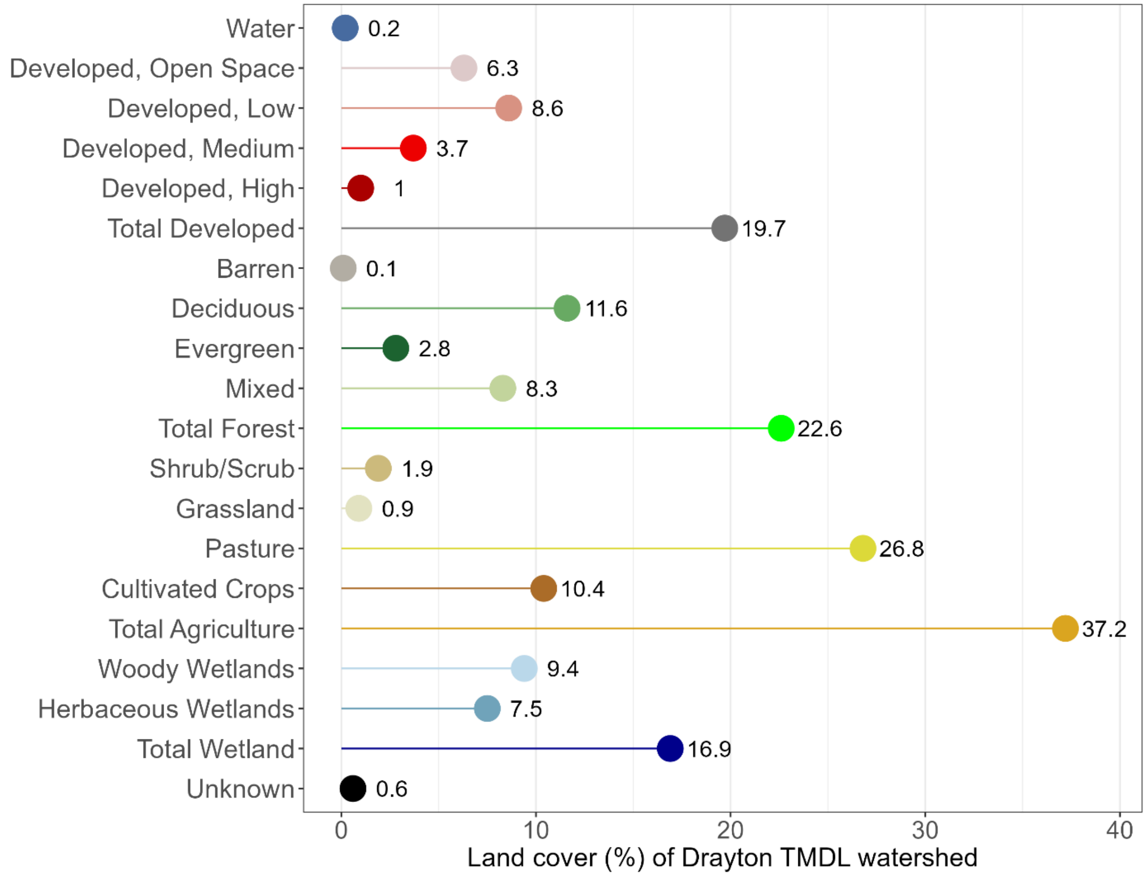


**Figure 9. NLCD 2019 by percent and categorical totals in the Drayton Harbor TMDL study area along with totals for Developed, Forest, Short Vegetation, and Wetland areas**

The dominant land cover in the eastern region of the study area is agriculture including cultivated crops and pasture/hay (Figure 9). The northern and southern areas have pasture/hay land cover with intermittent forest and wetland. Relatively, the southwestern area includes the largest amount of continuous wetland. The land cover in Blaine is primarily developed followed by areas along the I-5 corridor. The lower reaches of the Dakota and California drainages include developed land cover along with wetlands, particularly along California Creek and tributaries. The land cover adjacent to Blaine includes development, pasture/hay, and a few areas of wetland and forest.

The land cover of each subbasin in the study area is delineated (Table 24). The drainage areas of California Creek totaled 22 $mi^2$, Dakota Creek totaled 28.9 $mi^2$, and the shoreline areas totaled 2.7 $mi^2$, all of which drain directly to Drayton Harbor. The drainage area of Cain Creek totaled 1.3 $mi^2$, which drains to Semiahmoo Bay. Consolidated land cover classes were quantified as a relative percentage of each basin (Figure 10). When comparing drainages, the Dakota Creek basin had the most agriculture land cover at 44 percent followed by California at 33 percent, the shoreline drainage areas at 8 percent, and Cain at 5 percent land cover. The Cain Creek subbasin was dominated by developed land cover at 85 percent followed by the shoreline at 54 percent, California at 24 percent, and Dakota at 10 percent land cover. The Dakota Creek subbasin had the most forested land cover at 28 percent followed by California at 18 percent, the shoreline at 10 percent, and Cain at 4 percent land cover. Short vegetation land cover was similar between the Dakota and shoreline basins at 3 percent, while the California Creek basin was slightly lower at 2 percent followed by Cain at less than 1 percent. The shoreline area had a wetland land cover of 24 percent followed by California at 22 percent, Dakota at 13 percent, and finally Cain at 3 percent cover.

**Table 24. Subbasin drainage area and 2019 NLCD classification as a relative proportion (percentage) of each drainage basin along with subbasin area (mi²)**

| Aggregated Land Cover | Land Cover | Cain (%) | California (%) | Dakota (%) | Shoreline (%) | Total (mi²) |
|---|---|---|---|---|---|---|
| | Water | 0.1 | 0.3 | 0.2 | 0.5 | 0.1 |
| Developed | Developed, Open Space | 7.8 | 8.1 | 4.1 | 14.9 | 3.5 |
| | Developed, Low | 25.2 | 10.7 | 5.1 | 20.4 | 4.7 |
| | Developed, Medium | 34.6 | 4.3 | 0.9 | 14.2 | 2.0 |
| | Developed, High | 16.8 | 1.0 | 0.2 | 3.3 | 0.6 |
| | Barren | 0.1 | 0.1 | 0.0 | 1.5 | 0.1 |
| Forest | Deciduous | 0.9 | 10.3 | 13.5 | 5.4 | 6.3 |
| | Evergreen | 1.9 | 1.8 | 3.6 | 1.4 | 1.5 |
| | Mixed | 1.2 | 5.8 | 11.0 | 3.4 | 4.6 |
| Short Vegetation | Shrub/Scrub | 0.1 | 1.5 | 2.3 | 1.4 | 1.1 |
| | Grassland | 0.8 | 0.8 | 0.8 | 2.2 | 0.5 |
| | Pasture | 5.0 | 30.5 | 26.8 | 6.6 | 14.7 |
| | Cultivated Crops | 0.0 | 2.8 | 17.4 | 1.1 | 5.7 |
| Wetland | Woody Wetlands | 1.6 | 9.0 | 9.8 | 11.4 | 5.1 |
| | Herbaceous Wetlands | 1.1 | 12.9 | 3.2 | 12.3 | 4.1 |
| | Unknown | 2.8 | 0.0 | 1.1 | 0.1 | 0.4 |
| **Total subbasin area (mi²)** | | 1.3 | 22 | 28.9 | 2.7[a] | 54.9 |

[a] includes Lift station 5 (LS5) and a tributary to the harbor (Trib1Dray1) catchment areas

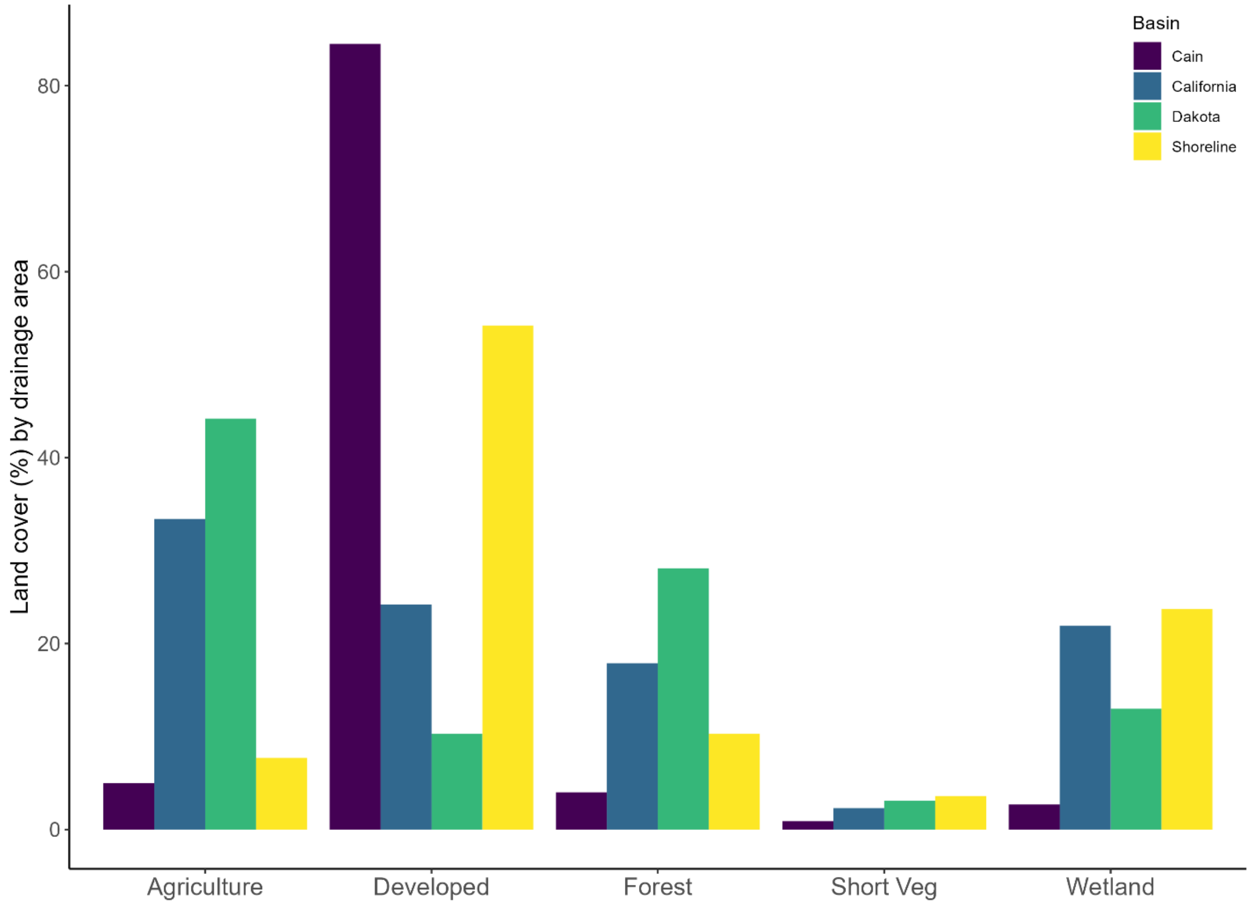


**Figure 10. Land cover from the 2019 NLCD aggregated by similar cover class and expressed as a relative proportion of each drainage subbasin**

## Hydrologic Modifications

The two major tributaries to the marine water of Drayton Harbor are California Creek and Dakota Creek. Cain Creek is the smallest contributing tributary to marine water, which flows into Semiahmoo Bay outside the harbor. The marine waters also receive fresh water inputs from the adjacent shoreline areas that do not flow through these three major tributaries. See Appendix A—Watershed Hydrology section for further details about water use.

Developed areas have impervious surfaces that change the hydrology by increasing the rate of rain runoff rather than allowing the rainwater to either infiltrate and percolate through the soils or be retained in wetlands. Increased runoff from impervious surfaces accelerates delivery to the receiving waterways that in turn increase stream velocities, sediment transport, and streambed scouring. These processes have the potential to increase bacteria transport and delivery—see Appendix D, Seasonal Variation and Critical Conditions section. The Cain Creek watershed subbasin hydrology is most affected by imperious surfaces given the high degree of development, followed by the shoreline area, the California Creek watershed subbasin, and the Dakota Creek watershed subbasin (Figure 10 and Table 24).

Maintained agricultural waterways are located along roads in much of the watershed. Many ditches also drain developed areas such as urban and residential, and pastures, fields, and forest areas to flow into roadside ditches or directly into sloughs and creeks. Irrigation withdrawals and returns also alter water courses and surface water to groundwater interactions. For example, an irrigation withdrawal or canal redistributes the amount of water that would otherwise immediately continue to flow downstream of an intake or diversion. This irrigation water is typically diverted for consumptive use.

In some cases, wetlands have long been used for agricultural production. Ongoing agriculture in these areas is exempt under state and federal wetland protection statutes. Ecology recognizes that these wetland areas may continue to be farmed under state wetland protection statutes. Even though they are in production, farmed wetlands can continue to provide important wetland functions such as waterfowl migration or overwintering areas. Use of best management practices (BMPs) and conservation practices can help enhance these functions while complementing ongoing farming operations.

Wetland mitigation and wetland compensatory mitigation also occur in the watershed with the goal of achieving no-overall-net loss in the amount (acreage) and function of Washington's remaining wetlands. Mitigation can offset or counter the adverse environmental effects that developing the land can have on wetlands, rivers, streams, lakes, and other aquatic habitats. Urban areas, residential areas, and roadways are examples of development that can occur in and adjacent to wetlands. Natural wetlands and mitigation structures can counteract the hydrological impacts of impervious surfaces by promoting water storage, which adsorbs and slowly releases water through natural hydrologic processes.

## Point Sources of Pollution

This section of the Implementation Plan begins with a summary of point sources found in the TMDL study area followed by details for each identified relevant point source. The TMDL WLAs are implemented through the administration of the NPDES permit program under the Clean Water Act section 402 to address point sources. NPDES permits are renewed every 5 years. Permit renewals following EPA’s approval of a TMDL must incorporate requirements designed to achieve the TMDL’s WLAs. Each relevant NPDES permittee is informed of the TMDL requirements and performs a suite of actions to reduce bacteria pollution in the Drayton Harbor watershed.

Point sources constitute a lesser portion of the TMDL when compared to nonpoint sources of bacteria loading. For example, the FC TMDL is established to protect shellfish harvesting where 2 percent comprise the WLAs, 88 percent comprise the LAs, and 10 percent is the MOS. The FC TMDL is established at the interface between fresh water and marine water and accounts for the shoreline areas, the Lighthouse Point Water Reclamation Facility effluent, and the upland subbasins Cain, California, and Dakota creeks. The differences between WLAs and LAs are also apparent for the *E. coli* TMDL, which comprise 1.5 percent WLAs, 88.5 percent LAs, and the 10 percent MOS. The *E. coli* TMDL protects fresh water recreation of the upland subbasins.

The TMDL target geometric mean bacteria concentrations, percent reductions, and effluent limits form the basis of the WLAs (b.cfu/day), which are developed to protect designated uses. Ultimately, the continued protection of shellfish harvesting is the most sensitive measure of attaining the TMDL that contributes to the water quality in the harbor. The reduction and prevention of point source pollution plays a role in meeting the WQS even though point sources make up a relatively minimal portion of the TMDL.

## Lighthouse Point Water Reclamation Facility

The Lighthouse Point WWTP is located on a portion of a City of Blaine park along Marine Drive (Figure 11). See Appendix A, Lighthouse Point Water Reclamation Facility section for facility details and the WLA section of the TMDL report for effluent loading limits. Full implementation of the permit requirements and meeting effluent limits will contribute to the attainment of the WLA. Operation and maintenance of the sanitary sewer infrastructure within the service area is necessary to comply with permit requirements and meet the WLA.

According to the current NPDES permit #WA0022641, the Lighthouse Point WWTP has technology-based effluent limits for FC that result in TMDL attainment and meeting the WQS as follows:

- Outfall 001 to Semiahmoo Bay,
    - FC monthly geometric mean limit = 200 cfu/100 mL, and
    - FC weekly geometric mean limit = 400 cfu/100 mL.


**Figure 11. Lighthouse Point Water Reclamation Facility location, two submarine pipes crossing the mouth of the harbor, outfall 001, and reclaimed water use area (outlined in yellow)**

## Stormwater Overview

Stormwater runoff can convey a significant source of bacterial inputs to the Drayton Harbor watershed. Stormwater is typically collected and conveyed through a system of inlets, ditches and pipes to surface waters with the intent of minimizing local flooding during rain events. Stormwater starts as precipitation that either infiltrates into the ground, flows in shallow interflow which exits into ditches or as groundwater springs, or accumulates and flows over impervious surfaces. As stormwater travels over the land surface and through stormwater infrastructure, it picks up pollutants and washes them into receiving waters. Newer stormwater systems can incorporate stormwater management BMPs that provide for stormwater infiltration, flow control and/or treatment. Illegal dumping and improper waste management practices also contribute pollutants to stormwater systems.

Paved and other impervious surfaces do not allow water to infiltrate into the ground where it can be naturally filtered and treated before entering streams or aquifers. The lack of infiltration results in excess stormwater running off developed areas. Land uses and activities in urban areas, coupled with an increase in impervious surfaces and accumulation of contaminants, often result in polluted stormwater. Stormwater systems allow pollutants to move from drainage surfaces to local waters, where pollutants are delivered quickly and in high concentrations.

When accounting for urban land uses, developed watersheds tend to have greater bacterial concentrations than watersheds with comparatively reduced amount of development (Schueler 1999). Data used to establish the TMDL from routine monitoring, stormwater sampling, and 5-in-30 sampling in Drayton Harbor corroborate with Schueler (1999)—see TMDL Targets, *E. coli* Results and Targets section (Table 5, Figures 4 and 5). Note that 5-in-30 sampling increases routine sampling frequency to 5 samples collected within a 30-day period. The developed areas in the watershed tend to have greater pollution reduction targets with some exceptions in both the California and Dakota Creek subbasins.

The Drayton Harbor watershed land cover is roughly 20 percent developed, which includes both rural and urban areas—see the Implementation Plan, Land Cover Distribution section for details. Urban areas have relatively greater developed land cover density than rural areas. For the Drayton Harbor TMDL, the urban areas include Ferndale and Blaine as well as the urban growth areas of Whatcom County including a small portion of the Birch Bay urban growth area (Figure 12). These designated urban areas have MS4s, though not all regulated at this time under NPDES, which collectively constitute 10 percent of the watershed area totaling 5.5 mi².

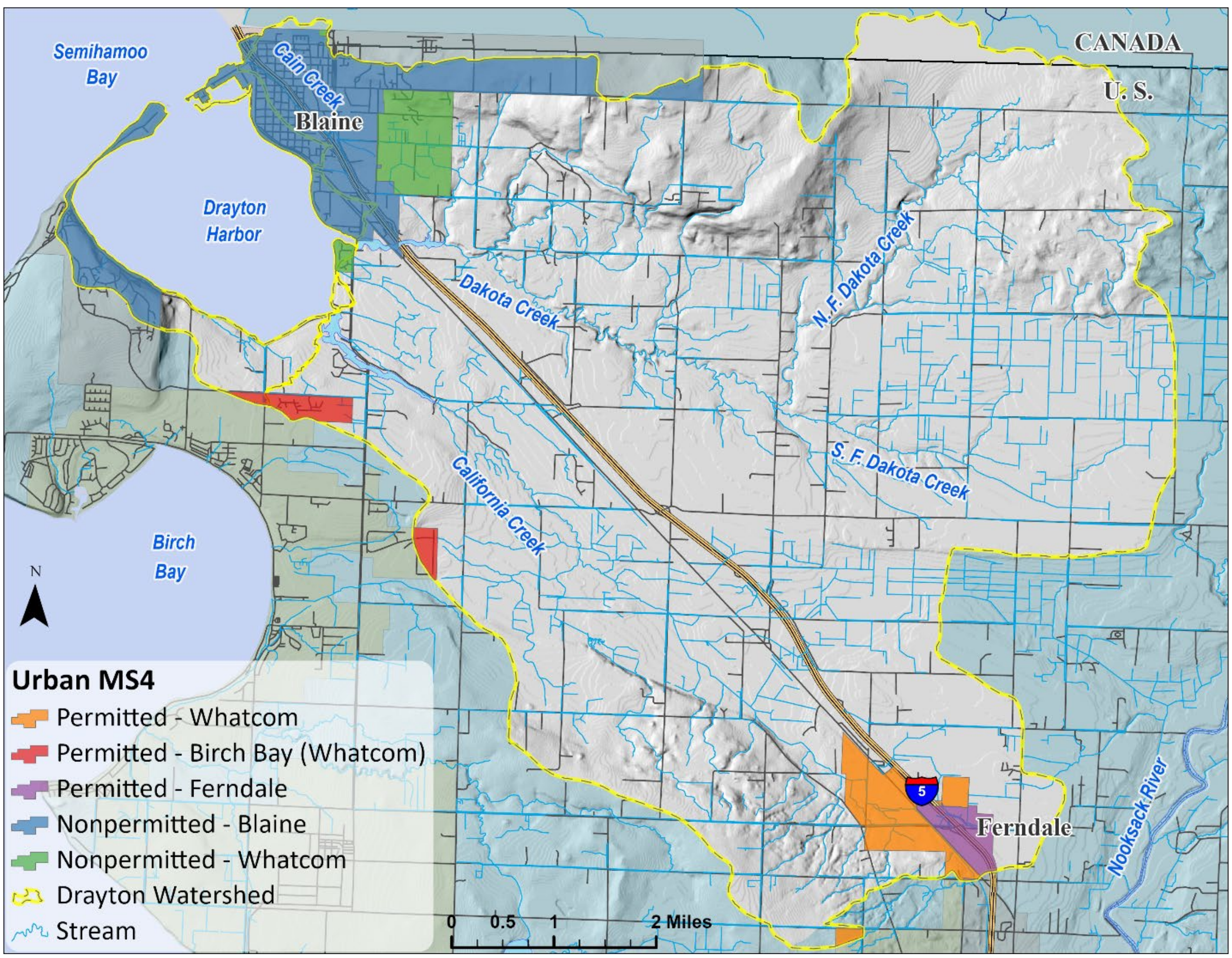


**Figure 12. Designated urban areas with municipal separate storm sewer systems including MS4 permit coverage status**

Approximately 25 percent of the urban area MS4 infrastructure within the watershed is covered by the Western Washington Phase II municipal stormwater general NPDES permit, while the remaining 75 percent of the MS4 does not have a permit. MS4s covered include the city of Ferndale and portions of Whatcom County that are adjacent to Ferndale and Birch Bay, which includes 2.5 percent of the total watershed area. Further, the WSDOT MS4 permitted infrastructure covers 0.5 percent of the watershed area, and 0.1 percent is covered by an Industrial Stormwater General Permit (ISGP) or the Boatyard General Permit. MS4s not currently covered by a municipal stormwater permit include the city of Blaine and portions of Whatcom County urban growth areas totaling 7.5 percent of the watershed area.

Bacteria can be directly deposited into waterways or transported by stormwater conveyances. Bacteria may persist outside of the originating host much longer in sediment, biofilms, and organic litter than in the water column. Therefore, sediment and organic litter entrained or mobilized by stormwater represents an important source of bacteria pollution (Clary et al. 2010, and Pachepsky and Shelton 2011). Further, naturalized bacteria populations may increase as an environmental source from biofilms, organic matter, or sediments. Clary et al. (2020) provides a review and summary of pollution sources that may originate from both point- and nonpoint sources, some of which occur the Drayton Harbor watershed:

- Municipal sanitary infrastructure,
    - Sanitary sewer overflow
    - Leaky public sewer pipes or private side sewer connections
    - Illicit sanitary connections to MS4
    - WWTP operations when inadequate or upsets
- Other sanitary,
    - Leaky septic systems (OSS or LOSS)
    - Overburdened septic systems (OSS or LOSS)
    - Encampments
    - Outhouse or porta-potties
    - Dumpsters
    - Recreation—swimmers, bathers, boaters, fishers, or trail users
    - Recreational vehicles—RVs, campers, or illegal dumping
    - Trashcans
    - Garbage trucks
- Domestic pets,
- Urban Wildlife—both naturally occurring, and human attracted,
- Miscellaneous urban—including areas that attract wildlife,
    - Landfills
    - Food processing facilities
    - Outdoor dining

    - Restaurant grease bins
    - Restaurant or bar washdown areas
    - Green waste, compost, or mulch
    - Animal-related business and facilities
- Urban non-stormwater that mobilizes deposits from sources,
    - Power washing
    - Excessive irrigation or overspray
    - Car washing
    - Pools or hot tubs
    - Inadequately managed reclaimed water or graywater
- MS4 infrastructure,
    - Illegal dumping
    - Illicit sanitary connection to MS4
    - Leaky sewer pipes
    - Biofilms and regrowth
    - Decaying plant matter
    - Litter and sediment in drainage system
- Agriculture within urban boundaries,
    - Livestock manure or storage
    - Manure spreading for fertilizer or soil amendment
    - Municipal biosolids
    - Inadequately managed reclaimed water
    - Irrigation tailwater
    - Slaughterhouse wastewater
- Natural open spaces or forested areas,
    - Wildlife
    - Grazing
    - Parks, trails, or off-leash areas, or
- Naturalized bacteria such as biofilms, decaying plant matter, sediment, or soils.

An evaluation of stormwater monitoring data from the National Stormwater Quality Database (NSQD) characterized associated pollution from specific urban land uses (Pitt et al. 2004). The mean concentrations of FC bacteria (MPN/100 mL) discharge via stormwater by land use category indicated that residential land use had the highest observed FC concentrations followed by the average of all land uses combined, then by commercial, open space, industrial, and freeways land use/land code (LULC) (Figure 13).

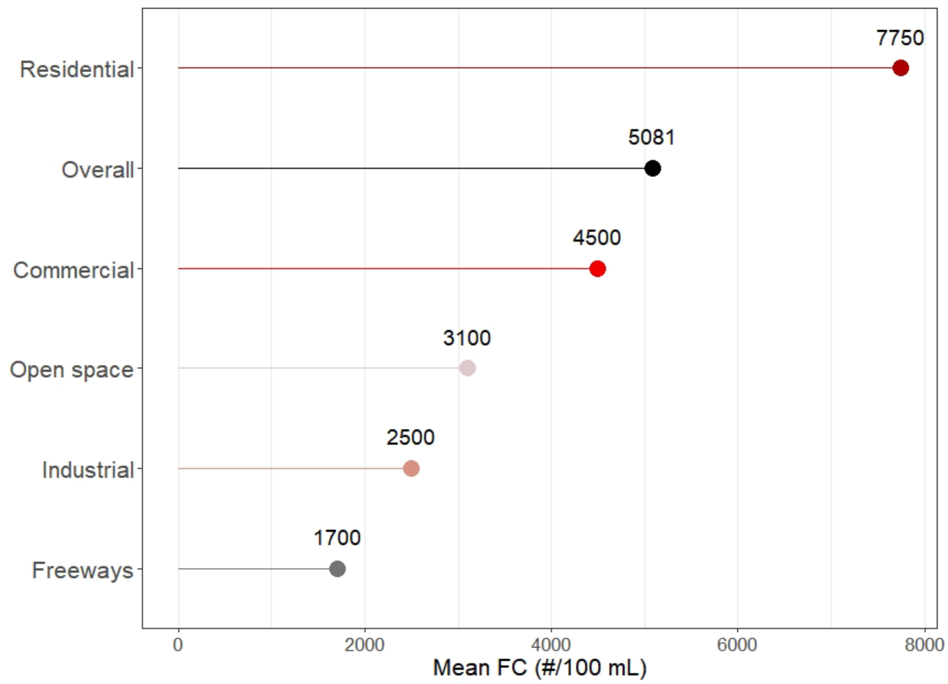


**Figure 13. Mean fecal coliform (FC) concentrations in stormwater by land use—source: Pitt et al. (2004)**

## Addressing Stormwater Point Sources

Federal regulations require certain municipalities and industry to come under NPDES stormwater permits—see the TMDL Allocations section of this report for current permits.

The regulated stormwater discharges from the City of Ferndale and portions of Whatcom County (Figure 12) flow into the upper reaches of the California Creek subbasin within the TMDL watershed boundary. The lower reaches of the California Creek subbasin include a small permitted MS4 area managed by Whatcom County.

Washington State's municipal stormwater permits contain a range requirements that constitute the Stormwater Management Program for the permitted entity. BMPs are identified in the permits and related guidance, including the Stormwater Management Manual for Western Washington, that apply to the permitted jurisdiction as well as new development and redevelopment activities, existing businesses, landowners and residents.

The City of Ferndale municipal code (13.34) establishes minimum stormwater management requirements and adopts Ecology's Stormwater Management Manual for Western Washington (13.34.030). Similarly, Whatcom County Code (Title 20.80.630 WCC) gives authority to control and regulate stormwater management activities. Through a suite of actions, both the City of Ferndale and Whatcom County ensure that stormwater systems and infrastructure minimize water quality degradation in the receiving water bodies.

The WSDOT municipal stormwater permit similarly requires a range of stormwater management best practices. It applies to discharges from WSDOT's highways, ferry terminals, rest areas, park-and-ride lots, maintenance facilities, vactor decant and street sweepings facilities, and winter chemical storage facilities. WSDOT managed areas within the Drayton Harbor watershed and TMDL boundary include the Custer Rest Area, I-5, and State Routes 543 and 548.

Eleven industries within the TMDL area are currently authorized to discharge stormwater associated with industrial activities under the ISGP. Six of these industries discharge to the upper reaches of the California Creek subbasin and two to the lower reaches. There are two industries that discharge stormwater to Cain Creek and one to a tributary to Dakota Creek. The ISGP requires permittees with discharges to water bodies listed as impaired for bacteria to comply with nonnumeric, narrative effluent limitations.

Stormwater may become contaminated by industrial activities because of contact with materials stored outside, spills and leaks from equipment or materials used onsite, contact with materials during loading, unloading or transfer from one location to another, and from airborne contaminants. Many of the potential pollutants in stormwater discharges are industry-specific but there are also significant commonalties among various industrial activities. For example, one common source of bacteria pollution to industrial stormwater discharges is from dumpsters that are not kept closed or are otherwise exposing their contents to rainwater. In addition, Standard Industrial Classification (SIC) Industry Major Group numbers 07, 24, and 26, may be more likely associated with bacteria pollutants due to agricultural production or wood product manufacturing and processing.

**Stormwater NPDES Permits**

The basic provisions of the stormwater NPDES permit programs contribute substantially to the objectives of this TMDL. When permits are fully implemented, each permittee will meet the bacteria TMDL WLAs. Permit compliance is sufficient to make progress toward WLA attainment, where adaptive management is essential as new information is obtained to address bacteria pollution.

Permit requirements specified and incorporated into Appendix 2 of the Western Washington Phase II MS4 permit for the City of Ferndale and Whatcom County will count toward WLA attainment. Where the TMDL has assigned WLAs for MS4 stormwater discharges from the permitted infrastructure, compliance with the MS4 Permit including any additional actions listed in the permit's Appendix 2 constitutes compliance with the WLAs. Similarly, permit requirements specified and incorporated into Appendix 3 of the WSDOT municipal stormwater permit count toward the WLA. Where the TMDL has assigned WLAs to WSDOT stormwater discharges, compliance with the permit including any additional actions listed in Appendix 3 of the WSDOT municipal permit constitutes compliance with the WLAs.

Following EPA approval of a TMDL, Ecology establishes any additional TMDL-related permit requirements in the next version of the permit. Permittees are encouraged to participate in development of TMDLs within their jurisdiction and continue stormwater pollution control activities and innovative approaches. For example, municipal stormwater Permittees are encouraged to identify locations within their jurisdiction that warrant the installation and use of pet waste stations and post signage to raise awareness about protecting water quality due to the hydrologic connectivity between the upland watershed and the harbor. Ecology recognizes that many Permittees are already actively planning stormwater investments and actions to address pollution and accommodate future growth in a way that minimizes impacts to receiving waters and designated uses.

Source control requires the clear identification of bacterial pollution sources. Isolating and identifying the source of bacterial pollution can be challenging when considering the many types of land use activities that interface with the MS4 and drain to a particular location. Stormwater system operation and maintenance and IDDE program implementation are common municipal stormwater source control BMPs. Particularly, bacteria sources of human origin present the highest risk to human health. These sources include failing or cross connected sewer lines, sanitary sewer overflows, failing OSS, illegal dumping, and public defecation, followed by pet waste as another substantial concern. Concentrated wildlife populations such as nesting birds or raccoon latrines may also pose a threat to water quality, however, are difficult to detect and address.

Once pollution sources have been identified in the watershed, tailored corrective and preventative measures are necessary. The MS4 permit contains requirements for following up on identified pollution sources. In addition, Whatcom County Health and Community Services (WCHCS) has the responsibility and authority to address OSS failures on private property. Cooperation within and across organizations may be necessary to comprehensively address pollution sources depending on the situation. While the most understood and effective way to reduce bacterial pollution of surface water, source control alone, however, may not be sufficient to meet ambient water quality standards (Pitt 2004, Clary et al. 2009).

Flow controls that reduce the rate of direct stormwater runoff to the receiving surface water will reduce the volume of sediment resuspension by mimicking natural hydrology. Stream sediments are the dominant reservoir for bacteria when compared to the water column (Pachepsky and Shelton 2011). Further, additional bacteria loading from upland sources is likely to increase the accumulation of bacteria in sediments that provide a suitable environment for bio-persistence. Addressing the instream sediment source of bacteria is done by addressing the upland pollutant inputs. Once bacteria are in the streambed sediment, there is no feasible way to remove it and water quality treatment BMPs specific to bacteria pollution have not been developed to do so at a consistent and predictable rate. The MS4 permit requires that new development and redevelopment implement flow control BMPs where necessary to protect streams from erosive forces from stormwater discharges.

Structures and practices that reduce flow volume through infiltration may also be effective at reducing bacteria loads to the system (Clary et al. 2020). Addressing the altered hydrology from urbanization may be used as a presumptive approach at reducing bacteria concentrations in the water column by reducing the rate of sediment resuspension. Since bacteria concentrations can be higher in the sediment than in the water column, reducing instream sediment resuspension using flow controls could lead to a decrease in bacteria concentrations in the water column. The best available science, however, is limited and currently does not demonstrate the added benefits of bacterial reductions by addressing the instream sediment source. This concept does not address the primary source of bacteria pollution.

**Stormwater Management Programs (SWMP)**
The MS4 Permit requires development and implementation of a Stormwater Management Program (SWMP) that is a set of actions and activities to fulfill permit requirements and any additional actions necessary to meet the requirements of applicable TMDLs. The SWMP is designed to reduce the discharge of pollutants from regulated MS4s to the maximum extent practicable and protect water quality.

The potential for unknown outfalls exists, where continued and additional mapping will address insufficient information. Information generated from stormwater mapping shall continue to be shared among all organizations that have municipal stormwater NPDES permits. Ecology encourages, and may enforce through NPDES permits, the fulfillment of each SWMP to prevent or reduce pollution associated with stormwater runoff. Permittees are also required to implement applicable TMDLs, complete annual program evaluation and reporting, and prepare to participate in effectiveness monitoring. Under the current permitting cycle, the MS4 Permit for the City of Ferndale and Whatcom County became effective on August 1, 2024, and expire July 31, 2029, with periodic renewals.

The WSDOT has a general permit for stormwater discharges to water bodies in areas covered by Phase I and II municipal stormwater permits and areas that have an EPA approved TMDL where the WSDOT shall be responsible for the TMDL implementation actions found in Appendix 3. The current permit for WSDOT expired in April 2024 and is administratively extended until it is reissued. Among other mandates, the current permit requires WSDOT to:

- Participate in watershed planning and TMDL development where WSDOT identifies itself as a key interested party,
- Inventory and document all known municipal separate storm sewer outfalls and structural stormwater treatment and flow control BMPs WSDOT owns, operates, or maintains, and
- Track all illicit discharges and illegal connections discovered by maintenance and construction staff and contractors and seek correction when necessary.

WSDOT has mapped all known stormwater outfalls within its permit coverage area (phase I and II) and is in the process of mapping MS4 features. WSDOT makes these mapping data available upon request.

The current permit requires WSDOT to develop and implement a SWMP that describes a suite of actions and activities to manage stormwater runoff. The SWMP includes a TMDL component to address WLAs. WSDOT updates their SWMP to reflect ongoing permit requirements and to account for changes to any existing approach when managing stormwater.

## Nonpoint Sources of Pollution

To attain the TMDL, reductions in fecal bacteria pollution is necessary at 29 out of 35 water quality sampling locations that capture a variety of land cover classifications—see TMDL Targets section for details. Nonpoint source pollution is assigned to the sum of the LAs in the TMDL. These nonpoint source components account for roughly 88 percent of the TMDL after allocating the 10 percent MOS—see TMDL Allocation section. The bulk of source control will therefore rely heavily on nonpoint source pollution prevention and corrective actions.

Wong and Pickett (2014) found that nonpoint pollution sources are widespread in Washington and cause a variety of water pollution problems. Applying best management practices (BMPs) can help reduce these pollution impacts. In summary, nonpoint source fecal bacteria pollutants are introduced into water bodies through runoff, seepage, or direct deposit.

Land use is strongly correlated to nonpoint pollution (Ecology 2023). Therefore, to manage nonpoint source pollution, implementation must focus on land use activities. Land uses that have the potential to generate sources of fecal bacteria pollution in the Drayton Harbor watershed include:

- Agriculture—livestock keeping; grazing; manure handling and applications; crop production; commercial and non-commercial,
- Recreation—marinas and boats; hiking; fishing; hunting; unsanctioned camps; pet waste,
- Urban and suburban—stormwater runoff; stormwater conveyances; sanitary sewer overflows; on-site sewage systems (OSS), and
- Wildlife.

The integrated partnership and actions of the WCWP incorporate a broad approach when addressing sources of pollution. The WCWP platform allows each agency to coordinate, share information, and act within specified areas of expertise and duty. Coordinated efforts of WCWP led to reductions in fecal bacteria pollution in fresh and marine water bodies throughout rural Whatcom County. Continued work of the WCWP along with responsible stewardship from local jurisdictions, districts, landowners, and community members are necessary to achieve clean water and prevent further degradation.

Ecology's nonpoint source program uses a combination of technical assistance, financial assistance, and regulatory tools to help community members understand and comply with state and federal water quality laws and regulations. Ecology (2023) has a management plan to address water quality impacts from nonpoint sources of pollution. This statewide management plan meets the federal Clean Water Act requirements and ensures Washington State's eligibility for Section 319 federal nonpoint source program funding.

This section describes each nonpoint pollution source in the watershed along with management solutions that prevent fecal bacteria pollution. Enacting codes and regulations along with site specific pollution prevention guidance, programs, and activities is the identified system of practice that is the most effective in achieving and maintaining the TMDL LA and WQS. Appendix F provides a brief description of codes and regulations that establish the requirements to address nonpoint source pollution, human health, and prevent environmental degradation.

## Agricultural Sources

Agricultural areas have consistently been cited as a significant source of impairment in fresh waters nationwide (Ecology 2023b). Water quality impacts from agricultural land uses that are relevant to this implementation strategy include elevated levels of fecal bacteria, suspended sediment, turbidity, and nutrients, as well as decreased levels of dissolved oxygen.

Approximately 37 percent of the Drayton Harbor watershed includes agricultural land cover (pasture and cultivated) with many of these areas used for hay, silage, and grain production. Bacterial discharge issues associated with agriculture are often directly connected to livestock operations and include: runoff containing manure from confinement areas, heavy use areas, or pastures; uncovered manure piles with inadequate containment; runoff from fields with recent manure application in the wrong place, wrong time, or at the wrong rate; direct livestock access to surface waters or seasonally flowing swales; or inadequate setbacks to surface waters. To attain the TMDL, reductions in fecal bacteria pollution to the receiving water bodies from upland agricultural lands are needed in multiple areas of the watershed.

Unrestricted access of animals to streams, riparian areas and ditches leads to manure runoff and direct discharges of manure to streams. Animals can also impact stream banks and streamside vegetation through grazing, destruction, or soil compaction, thereby reducing the filtering and infiltration capacity of the riparian area.

Dairy and other livestock operations produce manure used as a fertilizer for crops and pastures and that may be transported from one operation to another. Manure application to fields as a fertilizer can result in bacterial runoff entering waterways when applied at too high of a rate, during inappropriate times based on weather and soil conditions, when too close to streams and ditches, or on fields lacking vegetative BMPs.

## Agricultural Best Management Practices

BMPs are needed to control bacteria pollutants at their source and reduce their transport to surface waters and conduits to surface waters. While management is based on the specific needs of each property and agricultural operation, the following is a summary of recommended practices to ensure pollution sources are comprehensively addressed. Some practices listed in each summary are essentially synonymous among each topic and may be applied to address multiple management considerations.

**Riparian Buffers**

- Riparian buffers should be planted or maintained along all perennial, intermittent and ephemeral streams to reduce bacterial pollution and support meeting WQS (Ecology 2023b).
- Assessing the condition of the riparian zone is the first step to identify the need for establishing vegetation that is effective at reducing and preventing bacteria pollution.

Site Potential Tree Height Riparian Buffers

- The preferred recommendation is fully forested riparian zones along all natural streams that is one site potential tree height in width—the default width is 215 ft. The site potential tree height is the average maximum height of the tallest dominant trees for a given site class; the index tree age is 200 years, except where shorter-lived trees (such as cottonwoods) are the tallest dominant trees.

Three-Zone Riparian Buffer

- Where it is not feasible to restore full riparian habitat functions (i.e., not practicable to have a fully forested riparian management zone (RMZ) due to natural or anthropogenic factors), Ecology recommends that landowners select an alternative, three-zone buffer configuration (Table 25).

**Table 25. Western Washington RMZ options for perennial and intermittent stream reaches with riparian forest potential (Ecology 2023b)**

| Channel Width | Riparian Management Zone (RMZ) Configurations |
|---|---|
| < 5 ft | **Core zone**: ≥ 65 ft minimally managed site potential forest<br>**Inner zone**: 0-25 ft filter strip, depending on topography, soils, land use<br>**Outer zone**: 125-150 ft of agriculture implementing all applicable BMPs<br>**Total RMZ width**: ≥ 215 ft |
| 5-30 ft | **Core zone**: ≥ 80 ft minimally managed site potential forest<br>**Inner zone**: 0-25 ft filter strip, depending on topography, soils, land use<br>**Outer zone**: 110-135 ft of agriculture implementing all applicable BMPs<br>**Total RMZ width**: ≥ 215 ft |

| Channel Width | Riparian Management Zone (RMZ) Configurations |
|---|---|
| 30-150 ft | **Core zone**: ≥ 100 ft minimally managed site potential forest<br>**Inner zone**: 0-25 ft filter strip, depending on topography, soils, land use<br>**Outer zone**: 90-115 ft of agriculture implementing all applicable BMPs<br>**Total RMZ width**: ≥ 215 ft |
| > 150 ft | **Core zone**: ≥ 125 ft minimally managed site potential forest<br>**Inner zone**: 0-25 ft filter strip, depending on topography, soils, land use<br>**Outer zone**: 65-90 ft of agriculture implementing all applicable BMPs<br>**Total RMZ width**: ≥ 215 ft |

Three-Zone Riparian Buffer with Agroforestry

- Properties that are implementing agroforestry and silvopasture principals and have native trees integrated that provide supplementary stream shading and organic material inputs to streams may be eligible to use the following buffer (Table 26).

**Table 26. Western Washington RMZ options for agroforestry (Ecology 2023b)**

| Channel Width | Riparian Management Zone (RMZ) Configurations |
|---|---|
| All Channels | **Core zone**: ≥ 80 ft minimally managed site potential forest<br>**Inner zone**: 110- 135 ft agroforestry/silvopasture within native forest<br>**Outer zone**: 0-25 ft filter strip, depending on topography, soils and upland land use<br>**Total RMZ width**: ≥ 215 ft |

Additional Considerations

- TMDL implementers should give thought to the species composition and structure of riparian buffers. Only native species are recommended for planting and a mix of grasses, forbs, shrubs, and trees is recommended.
- Buffers should be actively maintained (e.g., weeded, replanted) until the riparian forest becomes self-sufficient, typically 5-10 years after planting. Buffers must remain in place in perpetuity.

A combination of factors influences the effectiveness of riparian buffers at controlling bacteria loading to receiving water bodies. In general, the following factors should be evaluated and considered when implementing RMZ buffer BMPs:

- Climate and weather,
- Geology,
- Geomorphology and topography,
- Soil properties including hydrologic groups,
- Buffer vegetation type, height, and density,
- Land use and land use intensity and practices,
- Runoff volumes, rates, and flow types, and
- Buffer size, and the area of land comprising a buffer relative to the area of land contributing surface and subsurface flow to the buffer (i.e., buffer area ratio).

**Limit Livestock Access to Streams and Streamside Areas**

- Exclude livestock from streamside areas (riparian buffers) and streams to prevent livestock from defecating in the riparian corridor and protect native riparian vegetation from grazing and trampling.
- Exclude livestock from drainage ditches and other surface water conduits.
- Well-constructed, permanent fencing is recommended because it is the most effective livestock exclusion tool.
- Use dedicated watering facilities such as tanks and troughs to provide water for livestock and stabilize areas around watering stations to prevent soil erosion.
- Locate watering facilities away from streamside areas and avoid locations likely to be saturated or with preferential flow paths to surface waters.

**Pasture and Rangeland Grazing**

The following practices are recommended to protect streamside areas, prevent the generation and discharge of pollutants to surface waters and support healthy upland pastures and rangeland.

- Protect and restore the RMZ.
- Install and maintain permanent streamside exclusion fence.
- Install and maintain off-stream water facilities.
- Stabilize heavy use area to provide a sturdy, non-eroding surface commonly used at off-stream watering facilities and sacrifice areas especially when these sites are likely to become muddy or erode. Heavy use area protection may also be used in other locations such as areas where mineral supplements are provided, supplemental feeding areas and loading corrals.
- Manage stream crossings to provide livestock or equipment access to pastures on the other side of a stream without damaging streambanks or the streambed. This practice applies to ephemeral, intermittent and perennial water courses and includes fords, bridges, or culvert-type crossings. Occasional ford crossing may be suitable for shallow, low velocity watercourses with gently sloped streambanks and a firm or stabilized streambed. Ford crossings are not suitable for high traffic areas with frequent use. Bridges or culverts should be used for high traffic situations.
- Provide emergency water access point (where applicable). An emergency access point is a location along a stream where livestock can temporarily access the stream for drinking water purposes. These locations may be needed or desired as a contingency should off-stream water equipment fail or need to be maintained or replaced. However, they must only be used under emergency situations and may not be used as alternatives to permanent off-stream water sources.

- Manage grazing to balance forage removal and plant health by adjusting the timing of grazing, stocking rates, duration of grazing and periods of rest to maximize forage utilization while promoting recovery. When properly applied, grazing management systems that incorporate timing, proper stocking rates and forage management can be a valuable tool to help livestock managers better control animal behavior and tendencies, maximize forage potential and utilization, promote pasture and rangeland health, and protect water quality.
- Use seasonal confinement areas to protect pastures and avoid forage damage.

**Animal Confinement Areas and Other Heavy Use Areas**

- Confinement areas and other heavy use area sites should be located as far away as possible from any surface water or conduit to surface water.
- Install or maintain gutters, and downspouts and divert runoff away from heavy use areas and manure storage facilities.
- Create a stabilized area that prevents erosion and runoff and supports manure collection and maintenance.
- Animal confinement areas should be situated on high level ground, not in depressional areas where water collects.
- Avoid locations near conduits to surface waters such as swales, tile lines, or other natural or artificial drainage ways that outlet to surface waters.
- Avoid areas with shallow groundwater or high leaching potential. Sites characterized by shallow soil, or a high water table, or a sandy/gravelly soil with excessive drainage and high permeability are poor or unsuitable for heavy use areas.
- Locate and design the confinement area such that it is outside the 100-year floodplain unless site restrictions require locating it within the floodplain. If located in the floodplain, protect the facility from inundation or damage from a 25-year flood event.
- Use vegetated filter strips downgradient to capture sediment and infiltrate runoff when needed.
- Conduct routine inspections especially after significant runoff events.
- Site away from seasonally saturated or flooded areas and setback from surface waters and conduits to surface waters.
- Divert clean water from the roofs of heavy uses areas and use additional BMPs to capture and treat polluted runoff.
- Collect and store accumulation manure in properly designed manure storage facilities.

**Manure Storage**

- Use a roofed/covered structure to store manure.
- Locate manure storage facilities as far from any surface water or conduit to surface water as possible.
- Install or maintain gutters and downspouts and divert clean water away from storage areas.
- Manure storage facilities should be situated on high level ground, not in depressional areas where water collects.

- Ensure manure contact with soil is reduced or eliminated. Manure should preferably be stored on a concrete pad or contained in a water-tight, leak free structure.
- Locate and design the manure storage area such that it is outside the 100-year floodplain unless site restrictions require locating it within the floodplain. If located in the floodplain, protect the facility from inundation or damage from a 25-year flood event.
- Use vegetated filter strips downgradient capture sediment and infiltrate runoff when needed.

**Manure Application and Nutrient Management**

- For pastures and hayland, make the last manure application by late summer/early fall. Specific attention should be paid to avoiding 'first flush' events, i.e., the first two rainfall events following a dry spell.
- In the spring, apply manure to hayland only when field and weather conditions are favorable. Never apply before T-SUM 200 is reached.
- Do not apply manure to saturated, frozen or snow-covered fields or when field and predicted weather conditions are likely to cause manure to runoff.
- Evaluate the 5-day weather forecast before planning any manure application.
- Apply manure at agronomic rates using soil testing and following a nutrient management plan. Apply nutrients in amounts likely to be used during the growing season and at times they are most needed.
- Adjust nutrient applications when soil sampling demonstrates that crops are not utilizing applied nutrients.
- Use a pre-sidedress nitrogen test to determine if additional nutrients are needed for corn crops before applying fertilizer or manure as fertilizer.
- Inject or incorporate manure whenever possible.
- Ensure application equipment is calibrated.
- Monitor broadcast equipment such as stationary and traveling gun sprinklers to prevent over-application and overspray to surface waters.
- Plant cover crops and relay crops to reduce erosion and runoff.

Manure management also applies to the import and export of manure from a livestock operation. Manure is considered an export when the exporting party no longer has control of how the manure is used. Transport must ensure that manure is contained and not released before reaching its destination of the receiving field, facility, or site. When imported manure is handled, stored, processed, or used as fertilizer, it is the responsibility of the recipient to ensure water bodies are not polluted, the potential to pollute does not occur, and that manure is applied at agronomic rates following the above guidelines to prevent pollution. Educational engagement about exporting, receiving, and applying manure is important and is provided in this Implementation Plan and by project partners. Continued education and opportunities to bolster this activity is recommended to ensure the WQS are met.

Note that an NPDES-permitted Concentrated Animal Feeding Operation (CAFO) is required to follow manure export protocols under Special Condition S4.O of the current permit. Regarding facilities that do not discharge under a CAFO permit, Ecology encourages manure export record keeping for operations that have a farm plan or operate under similar programs. For licensed cow dairies, manure export and import record keeping by the producer is required under Washington State Code and reported to the Washington State Department of Agriculture (WSDA) as part of the Nutrient Management Technical Services Program. Manure management and application are common practices for agricultural areas in the watershed and county-wide. Therefore, it is important to properly manage manure due to its potential as a pollution source.

#### Ecology's Clean Water Guidance for Agriculture

The Voluntary Clean Water Guidance for Agriculture[16] (CWG) is a technical resource for agricultural producers that describes Ecology's recommended BMPs to protect water quality (Ecology 2023b). It is intended to help producers meet WQS. The recommendations within the CWG are based on a robust gathering of peer-reviewed scientific research. These recommended practices provide water quality protection to a level at which a site, with the necessary BMPs, is presumed to comply with state water quality law. This provides assurances for landowners and removes uncertainty around which BMPs will be adequate to address nonpoint pollution. By transparently sharing this information and research, landowners are empowered to take action to protect water quality, be incompliance with state law, and avoid potential regulatory action from Ecology. TMDL implementers should consult the CWG when designing and implementing BMPs to address pollution sources in the Drayton Harbor TMDL area.

#### Dairy Operations with Nutrient Management Plans

Licensed grade A cow dairies must develop and implement a nutrient management plan required to meet the Dairy Nutrient Management Act under Chapter 90.64 RCW. The WSDA administers this program where one the many components address water quality protection—see Regulatory Framework section for details.

Currently, there are three licensed cow dairies in the Drayton Harbor watershed that have nutrient management plans (Figure 14). These managed dairies are generally located in the southern and eastern areas of the watershed. The upper reach of the California Creek watershed has two large dairies, and the S. F. Dakota Creek subbasin has one small dairy.

To support meeting the TMDL load reduction targets, dairy operators must:

- Ensure dairy nutrient management plans are up-to-date and based on current operations, herd size, technical standards, soil and manure sampling results.
- Implement nutrient management plans to ensure manure is applied at rates and times to prevent polluted runoff from entering surface waters.

[16] https://ecology.wa.gov/About-us/Accountability-transparency/Partnerships-committees/Voluntary-Clean-Water-Guidance-for-Agriculture-Adv

- Conduct soil sampling annually to evaluate application rates.
- Routinely sample the nutrient content of manure to ensure proper application rates.
- Update plans when soil sampling demonstrates a need to change application rates or timing, or when there are changes to dairy operations such as increases in animal numbers.
- Follow BMPs for manure application, livestock confinement, manure storage and riparian buffers.
- Apply for the applicable CAFO permit if there is a discharge from the facility or the result of a land application of manure.

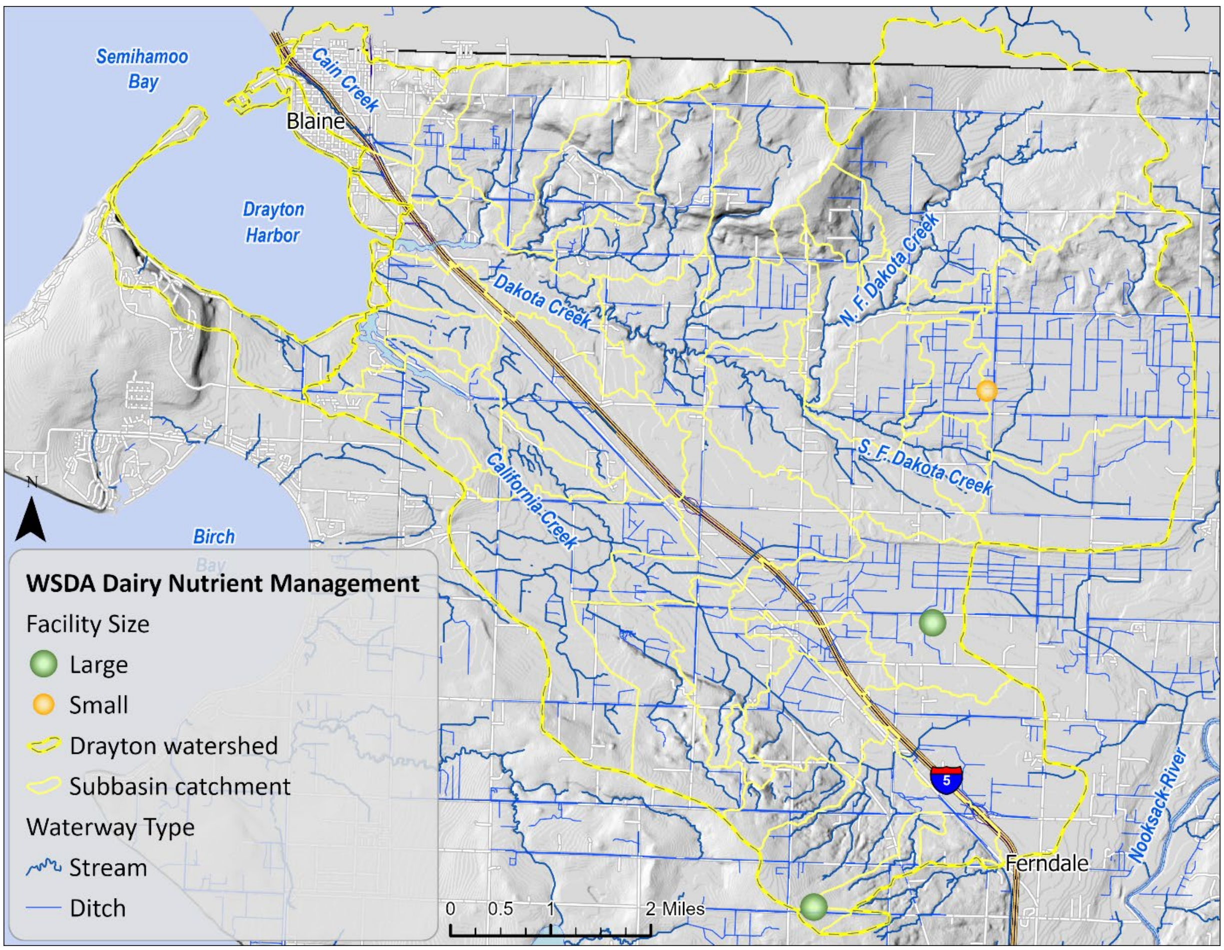


**Figure 14. Dairy Nutrient Management Program facility locations—source: WSDA (updated 9/13/24), Facility Size: For nutrient management purposes, size is determined by mature (milking + dry) animal numbers; with a dairy herd of up to 199 animals being a small, 200-699 being medium (not present in watershed), and 700 or greater being large CAFO.**

## Urban and Residential Sources

Reductions in fecal bacteria pollution to the receiving water bodies are associated with activities on the developed areas within the watershed, which include urban, residential, rural, industrial, and commercial land uses. The urban areas and urban growth areas along with MS4 infrastructures are identified in Figure 12—see the Point Sources of Pollution, Stormwater Pollution Source section. The City of Blaine and the adjacent areas of Whatcom County do not have NPDES permits covering the jurisdictional MS4 infrastructure. Unless covered by an NPDES permit, the MS4 and other land use activities in these areas represent nonpoint sources of pollution.

Rural residential areas are also located throughout the Drayton Harbor watershed. Public spaces such as parks offer recreational opportunities throughout the watershed. These rural areas and public spaces also represent nonpoint sources of pollution. Roughly 20 percent of the watershed totaling 11 square miles is developed (Table 23).

Fecal bacteria can be directly deposited into waterways or transported by stormwater that produces runoff flow or MS4 flushing. Nonpoint sources common with developed areas are unnatural populations of acclimated wildlife including racoon, deer, and possum due to access to abundant food resources in such areas including garbage, gardens, and pet food. Stormwater can carry fecal bacteria from wildlife and pet waste on the ground, surfacing wastewater from failing septic tanks, and activities such as roadside right-of-way or sidewalk cleaning. Stormwater can be a significant source of bacterial inputs to the Drayton Harbor watershed—see Appendix D, Designated Use Protection and Seasonal Variation sections for analysis details.

### Addressing Nonpoint Sources in Developed Areas

Most of the upland land cover is developed within the urban boundary of the City of Blaine and the adjacent urban growth area of Whatcom County. With some overlap, other developed areas in the Drayton Harbor watershed include the shoreline area, and the middle and upper reaches the California Creek subbasin. The bacteria pollutant loadings from the upper reaches of California Creek are partially addressed by stormwater permits. However, nonpoint sources also occur where similar pollution control strategies exercised in the permitted areas may be applied to address nonpoint source pollution. For example, the City of Blaine does not currently hold a municipal stormwater permit, however, should proactively develop and implement a Stormwater Management Program[17] to sufficiently address the ongoing bacteria pollution sources. The City of Blaine should take the lead and coordinate, when necessary, with Whatcom County and/or WSDOT to fulfill the following components:

- Map the stormwater infrastructure network and outfalls, including ditches, and stormwater treatment and flow control structures.

[17] https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Municipal-stormwater-permit-guidance

- Identify and map contributing areas to stormwater outfalls in Cain Creek, including the City of Blaine and Whatcom County's stormwater infrastructure draining to stormwater outfalls in Cain Creek, and the number of homes connected to municipal sanitary sewer versus onsite sewage systems (OSS).
- Coordinate with WCHCS to obtain OSS permits or inspection records when assessing potential pollution sources—see OSS section below. Understand OSS inspection, operation, and maintenance records, as well as information about septic system design, age, condition, and inspection frequencies.
- Utilize comprehensive stormwater planning to develop an effective stormwater management plan for the City of Blaine, including but not limited to operations and maintenance, IDDE and Source Control programs.
- Prevent sanitary sewer overflows by implementing sanitary sewer system operations and maintenance practices.

The City of Blaine should commence or increase activities for pet waste education and outreach, pet waste station installation and maintenance, and foster a partnership with local PIC Programs and the WCWP to address bacteria issues in the MS4. Engaging with the WCWP may also assist the City of Blaine in leveraging stormwater resources and experience from practitioners in the region that commonly address fecal bacteria pollution sources.

## Onsite Sewage Systems (OSS)

OSS are a potential source of fecal bacteria pollution in the Drayton Harbor TMDL watershed when they are poorly sited or designed or when property owners do not properly operate, monitor, and maintain them. Without proper maintenance, the performance, effectiveness, and life expectancy of the system may be drastically reduced. Reduced effectiveness or system failure can lead to direct discharge of high quantities of bacteria and result in a direct human health threat due to the potential presence of harmful pathogens. Illegal connections of OSS to stormwater infrastructure or piping them directly to surface waters are also potential pollution sources.

Data from the WCHCS indicates there are 3,231 parcels in the Drayton Harbor watershed with suspected OSS as of June 18, 2025. Within these parcels there are 3,995 suspected OSS, which means some of the identified parcels may have multiple OSS (Figure 15). The heat map shows the density of parcels with suspected OSS weighted by the number of OSS per parcel. Suspected OSS on each parcel is defined by any of the following features: 1) a recordable OSS activity has been associated with the site, e. g., historical evaluation, 2) an active permit has been recorded without any OSS decommissioning paperwork, 3) pumping has been recorded, or 4) a suspected system like an OSS may be serving the site based on the types of structures on the parcel and the absence of a sewer connection. In some cases, partially treated sewage is pumped from the OSS to the Lighthouse Point sanitary sewer at parcels near Dearborn Ave.

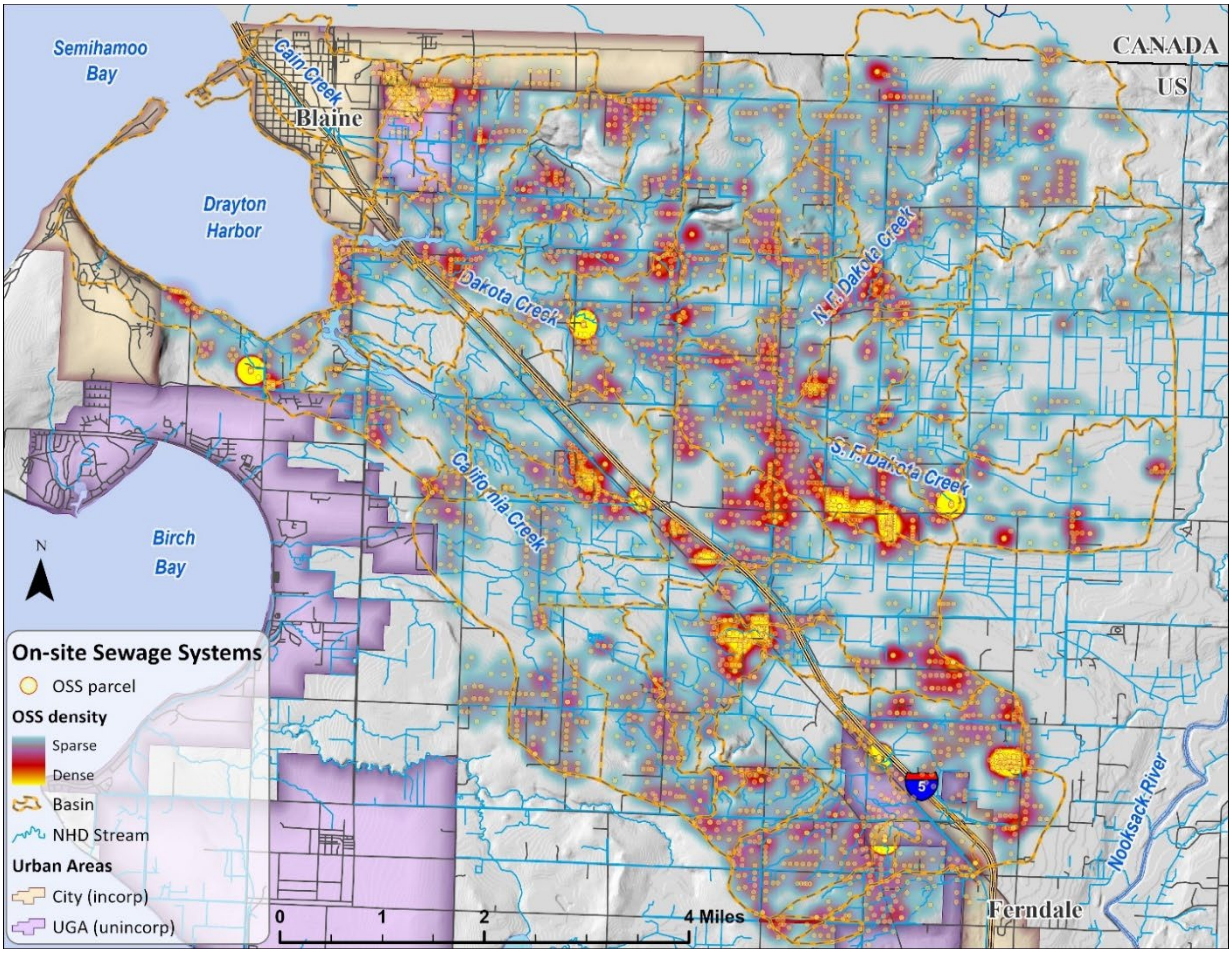


**Figure 15. Heat map of parcels with suspected onsite sewage systems (OSS) in the Drayton Harbor watershed—source: WCHCS 6/18/2025**

Parcels with OSS are mapped to illustrate potential pollution sources and to help make informed decisions when conducting bacteria source ID activities. The dry season *E. coli* TMDL target reductions for each basin sampling location are depicted to show proximity to OSS (Figure 15). The relative proximity of an OSS to a receiving water body and historical records relating to permitting and operation and maintenance records are typically considered by the WCWP partners when identifying potential pollution sources and prioritizing follow up activities. Other priorities include areas with the greatest occurrence of OSS and along the shoreline of the harbor. High OSS densities occur in the following general areas:

- East of the city of Blaine, within city limits and the urban growth area of Whatcom County that drain two tributary catchments to Dakota Creek and a small portion of the Cain Creek subbasin,
- South of the mouth of Dakota Creek along the shorelines,
- The middle reaches of California Creek, southwest of I-5,
- The upper reaches of South Fork Dakota Creek, west of I-5, and
- The upper reaches of California Creek both north of the city of Ferndale and west of I-5.

Coordination between local municipalities and WCHCS will address the OSS in the watershed when determining the feasibility and importance of connecting to each public sanitary sewer system. Structures within a serviceable distance—approximately 200 ft to municipal sewer mains—have already been connected in several instances—see the current sanitary sewer service area for the City of Ferndale[18] and the City of Blaine[19] for details. However, work will need to be completed to determine the feasibility of connecting additional OSS to each municipal sanitary sewer system within or adjacent to the service area.

The WCHCS is the local authority that typically takes the lead on the OSS regulatory oversight. In the event of OSS failure, structures within 200 ft of adequate public sanitary sewer services are required to connect to sewer, provided the connection is authorized by the sewer provider. Incentives to connect properties serviced by OSS to public sanitary sewer systems are encouraged to reduce the potential of fecal bacteria pollution.

The On-site Sewage Disposal Systems—Marine Recovery Areas (MRA) authorizes enhanced local programs to address sensitive areas—see the Regulatory Framework, Onsite Sewage Systems section for details. These Washington State OSS and MRA laws require local health jurisdictions to designate areas when OSS present added risk to public health or water quality. The Drayton Harbor watershed is entirely within the MRA and requires the WCHCS to fulfill mandatory duties as the designated local health jurisdiction. Further, the WCHCS identified both the Shoreline Management Area and MRA as sensitive areas. The mid-and lower portions of Dakota and California creeks are within the County's Shoreline Management Area.

The WCHCS's OSS Program provides regulatory oversight for septic systems throughout the county including OSS within city boundaries. Each OSS must be periodically inspected and maintained to ensure proper function. The WCHCS manages an OSS database to track mandatory maintenance and inspection schedules. Proper monitoring, correct operation and maintenance is the responsibility of the OSS owner. Homeowners in the Drayton Harbor watershed should contact WCHCS or a licensed OSS service provider for assistance if they suspect problems with their OSS or need routine inspection and maintenance.

There are no large onsite sewage system (LOSS) structures in the watershed and the nearest systems are in Point Roberts, northwest of the harbor. The LOSS are onsite sewage systems that are designed to treatment more than 3,500 gallons per day and are managed at the state level by the Washington State Department of Health.

Both community-based and individual OSS are not a problem when designed, sited, evaluated, maintained, and operated properly. Properly functioning OSS remove bacteria and some nutrients from the wastewater. Many factors can cause OSS to fail and therefore need continual operations and maintenance to treat wastewater.

[18] https://gisportal.cityofferndale.org/mapviewer/
[19] https://www.ci.blaine.wa.us/1085/Utility-Information

Signs of OSS failure include:

- Odors, surfacing sewage, wet spots, or unusually lush vegetation in the drainfield area,
- Plumbing or septic tank backups,
- Frequent high-water alarms,
- Operating levels below the discharge pipe in the septic tank,
- Slow draining fixtures, and
- Gurgling sounds in the plumbing system.

If wastewater surfaces it is possible that it could drain directly to a nearby stream, or it could be carried by stormwater runoff. Additional environmental factors such as flooding from extreme rain events, storm surges, or sea level rise increase the risk of pollution when OSS become affected. Another problem observed in some older OSS is the subsurface movement of inadequately treated wastewater through extremely porous soils. Unwanted subsurface movement of OSS discharges, however, can be difficult to detect.

All OSS owners and operators must regularly monitor and maintain their systems—see Appendix F for details on current codes and regulations. Information on OSS maintenance can be found on the Whatcom County OSS website[20]. The WCHCS helps educate OSS owners to understand when inspections are required and provides homeowner inspection training, maintenance tips, and lists of qualified OSS service providers. Evaluation of the OSS and submission of a Report of Septic System Status (ROSS) is currently required every three years for conventional gravity septic systems, and yearly for all other system types. A ROSS can be completed by qualified homeowners or licensed professionals depending on training and the OSS type. If the type of OSS is eligible for homeowner evaluation, the homeowner must complete training and maintain certification.

When a failing OSS is identified via ROSS, complaint investigation, or other means, WCHCS staff work with the property owner to ensure timely repair, replacement, or abandonment of the OSS, and may require interim measures to prevent sewage discharge. To support required evaluations and maintenance, WCHCS partners with Whatcom County Public Works to offer rebates to offset costs for evaluations, septic tank pumping, and minor repairs completed by licensed professionals. Should significant OSS repairs or replacement ever be needed, low interest loans are available through WCHCS's partnership with Craft 3—see the Cost section for details. The WCHCS will continue to lead residential and small OSS education, outreach, technical assistance, and compliance actions in this TMDL area.

## Marinas, Vessel Moorage, and Vessel Traffic

There are roughly 153,000 recreational vessels and 3,600 commercial vessels in the Puget Sound with the potential to produce roughly 50 million gallons of concentrated sewage per year from boaters[21]. Because vessels move throughout Puget Sound**,** they can especially affect sensitive resources such as shellfish growing areas, marine protected areas, aquatic reserves, and public

[20] https://www.whatcomcounty.us/891/On-Site-Sewage
[21] https://ecology.wa.gov/getattachment/4d35ed16-1fd9-4c30-b7d5-fadf1c4a9405/Infographics.pdf

beaches. Such areas can be impacted by bacteria and dissolved oxygen in sewage. Raw or partially treated sewage released from vessels into the receiving marine waters introduces high concentrations of fecal bacteria pollution.

The greater Puget Sound, including Drayton Harbor, is a no discharge zone (NDZ) where sewage, whether treated or not, may not be released—see Organizations That Implement Cleanup Activities for details. The NDZ helps to protect public health, water quality, and sensitive resources. Marinas should include NDZ signage and educational materials for boaters, which may be currently acquired from Ecology[22] at no charge to the recipient.

Within Drayton Harbor, the Blaine Harbor Marina and Semiahmoo Marina have pumpout facilities and portable solutions to handle sewage and provide a way to comply with the NDZ rule. Moorage and anchorage are options to safely secure vessels within the harbor. Marinas and moorage are in proximity to shellfish resource areas that are sensitive to pollution from discharged sewage. The use of pumpout stations and portable solutions is necessary to prevent fecal bacteria pollution. The Washington State Parks—Clean Vessel Grant Program[23] offers several services, including public outreach resources and identifies pumpout locations and facilities throughout Washington.

## Wildlife Pollution Sources

Unless wildlife populations have increased artificially or have been concentrated due to anthropogenic activities, wildlife contributions are considered natural background conditions which may be quantified in a TMDL but not assumed to be decreased. Migratory and resident birds are often seen in the upland fields or in the harbor, where seals cohabitate. Birds, elk, deer, beaver, muskrat, and other wildlife in headwater and rural valley areas are potential sources of fecal bacteria. Open fields are attractive feeding grounds for some birds whose presence can increase fecal bacteria counts in runoff. Pollution source investigations may lead to raccoon latrines, birds nesting under bridges or occupying open areas in elevated numbers, or birds and seals in the harbor. Increases in bacterial pollution have also been observed downstream of dead and decaying wildlife, but this is typically not common and often temporary.

Bird counts conducted by Whatcom County Marine Resources Committee, with follow work done by the Port of Bellingham (Hirsch Consulting Services 2007), from October 2005 to September 2006 in the commercial portion of the Blaine Harbor produced the following:

- Counts ranged from 96 (low) in November 2005 to 802 (high) in July 2006.
- Gulls were the most common bird observed followed by cormorants and then pigeons, while a lower number of Canada geese, crows, and great blue herons were also spotted.
- The greatest bird densities were observed on the breakwater surrounding Blaine Harbor along with greater densities in spring and summer months, which was primarily attributed to cormorant nesting on the rocky areas of the breakwater.

[22] https://ecology.wa.gov/ecologys-work-near-you/river-basins-groundwater/puget-sound/no-discharge-zone
[23] https://pumpoutwashington.org/

According to Washington State Fish and Wildlife surveys (Berbells 2006), marine bird and waterfowl densities are:

- In the winter, 400–1,000 birds per square kilometer throughout most of Drayton Harbor, with densities greater than 1,000 birds/ $km^2$ at the Blaine Marina and the mouth of California Creek.
- During the summer, bird densities dropped to 200–400 birds/ $km^2$ at the mouth of California Creek. In general bird densities were lower in the summer, with the exception of the mouth of Dakota Creek where concentrations remain at 400–1,000 birds/ $km^2$ and the Blaine Marina where concentrations remained above 1,000 birds/ $km^2$.

The Washington State Department of Fish and Wildlife (WDFW) identified three seal haulout sites within Drayton Harbor, one along the channels off Dakota Creek, one on the shoals and channels in central Drayton Harbor, and 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—500 (Berbells 2006). One of the seal haulouts was located adjacent to DOH station 11.

Wildlife contributions may be addressed by source control actions when sufficient information is available that illustrates an elevated pollution source. Human-caused activities that elevate bacterial pollution are, however, subject to pollution control and prevention activities to reduce or eliminate these detrimental impacts on water quality. The WDFW is the lead organization when dealing with excessive wildlife pollution that is found to be related to human-caused activities.

## Pollution Prevention Assistance

Many routine business activities can pollute stormwater runoff or groundwater. Businesses are responsible for keeping polluted runoff from their property or worksite from damaging local waterways. In 2007, Washington State Legislature established the Local Source Control (LSC) Partnership that funds interagency coordination among Ecology and local jurisdictions that participate in the voluntary program. The LSC Partnership started in the Puget Sound and Spokane watersheds and expanded the Columbia River basin. The LSC was rebranded as Pollution Prevention Assistance (PPA) in 2016. This new name was part of an effort to emphasize the benefits of the program to the public and businesses. The PPA encourages business owners and neighborhood associations to examine their land use and maintenance strategies to improve local water quality.

The PPA relies on local voluntary participation to form partnerships (Ecology 2021a). The partnership uses a unique team approach involving local, regional, and state staff with the expertise to solve pollution problems through source control. Through interagency agreements with Ecology, local jurisdictions get funding to provide free, one-on-one technical assistance to small businesses. Specialists in these jurisdictions show businesses how to manage their wastes properly and help diagnose and fix stormwater-related issues. Specialists can also offer businesses help with complicated regulatory issues.

Through the partnership, for example, WCHCS voluntarily established Specialists—formally called LSC Specialists—to assist business owners with proper waste management and to diagnose and fix stormwater-related issues. Ecology's 2016 biennium report indicated that WCHCS Specialists visited 194 businesses and found 136 issues. Since 2007, the PPA/LCS has increased from 13 to 21 local jurisdictional partnerships making a total of 7,602 visits to businesses and resolving 3,963 (85%) of the issues found (Orme 2016).

Specialists offer businesses help with complicated regulatory issues including technical assistance and education to prevent stormwater contaminants and hazardous waste from entering public waterways. Specialists can educate business owners about this bacteria TMDL, how their activities may contribute to the bacteria load, and steps they can take to reduce or prevent pollution inputs. For example, PPA Specialists helped correct runoff from leaking trash compactors that polluted nearby streams with FC bacteria from rotting organic matter (Orme 2016). Local PPA Specialists should continue to visit pet-related businesses (e.g., veterinarians, kennels, and pet stores), and other businesses identified as potential bacteria sources.

## Forest Practices Rules

The state's forest practices regulations will be relied upon to bring waters into compliance with the load allocations established in this TMDL on private and state forest lands. This strategy, referred to as the Clean Water Act Assurances, was established as a formal agreement to the 1999 Forests and Fish Report[24].

The state's forest practices rules were developed with the expectation that the stream buffers and harvest management prescriptions were stringent enough to meet state WQS for temperature and turbidity and provide protection equal to what would be required under a TMDL. As part of the 1999 agreement, new forest practices rules for roads were also established. These road construction and maintenance standards are intended to provide better control of road-related sediments, provide better stream bank stability protection, and meet current best management practices.

Forest practice rules, however, do not directly address the WQS involving shellfish harvesting or contact recreation designated uses that rely on fecal indicator bacteria. Even though Ecology is relying on the state's forest practices regulations to bring waters into compliance with the load allocations established in this TMDL on private and state forest lands, success of this TMDL project will be assessed using monitoring data from streams in the watershed.

Small portions of the watershed are managed by the Department of Natural Resources or by private landowners subject to local regulations. Although timber harvest is not a likely source of bacteria pollution, recreation or stock grazing is allowed in some areas. Livestock manure, human and pet waste represent the greatest potential sources of bacterial pollution in managed forested areas of the watershed. Concentrated wildlife populations in forests may also pose a threat to water quality.

[24] www.dnr.wa.gov/Publications/fp_rules_forestsandfish.pdf

## State Environmental Policy Act and Land Use Planning

Responsible State Environmental Policy Act (SEPA)[25] officials must consider TMDLs during SEPA and other local land use planning reviews. If the land use action under review is known to potentially impact bacteria loading as addressed by this TMDL, then the project may have a significant adverse environmental impact. State Environmental Policy Act lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives, and to document that the necessary environmental analyses have been made.

Land use planners and project managers from the City of Ferndale, City of Blaine, Whatcom County, Port of Bellingham, and WSDOT should use findings and actions prescribed in this TMDL and Implementation Plan to help prevent new land uses from violating WQS. For example, establishing future off-leash dog parks away from water bodies will reduce the potential of bacteria pollution, while planning should include installing pet waste stations in public spaces and riparian buffers.

# Organizations that Implement Cleanup Activities

A brief description of the many implementation partners is discussed below. Full implementation of this TMDL requires the participation of several groups to administer programs and work with landowners. The wide variety of water cleanup strategies include roles for federal, state, and local governments as well as nonprofits, special interest groups, and landowners. Continued funding of these ongoing programs is needed as well as additional grant and special project budgets to ensure BMPs are installed to address the full range of potential pollution sources. The inclusion of organizations that implement the TMDL is for planning purposes only. It is not meant to imply Ecology's authority over these organizations or assume their commitment to implement the TMDL unless required by an NPDES permit or other regulatory mechanism.

Public involvement is also necessary to meet the TMDL goals. Although not identified below as an organization, the public has the responsibility to ensure that bacteria pollution does not occur by engaging in several activities identified in this Implementation Plan. The public also has opportunities to provide public comment on local, state, and federal codes and planning processes that govern issues pertaining to water quality protection. For example, public comment periods are conducted for NPDES permits as part of the renewal cycle; or public comments are also part of the rulemaking process or planning process such as the development of the CWG.

## Whatcom Clean Water Program

The WCWP partnership formed in 2012 to coordinate bacteria pollution reduction work with the goal of achieving clean water and safe shellfish harvesting conditions within Whatcom County and WRIA 1, including the Drayton Harbor watershed and receiving marine waters. The WCWP works with local landowners and residents to find and fix pollution problems to maintain water quality protection measures, thus aligning with TMDL implementation.

[25] https://ecology.wa.gov/regulations-permits/SEPA-environmental-review

The WCWP coordinates pollution reduction work through water quality monitoring, data analysis, watershed evaluations, information sharing, contacting landowners, and education and outreach. The WCWP integrates several organizations by leveraging specific roles and responsibilities resulting in a systematic approach. Current program partners include:

- Whatcom County Public Works, Natural Resources Division,
- Whatcom County Health and Community Services, Environmental Health,
- Whatcom County Planning and Development Services,
- Whatcom Conservation District,
- Washington State Department of Agriculture, Nutrient Management Technical Services,
- Washington State Department of Health, Office of Environmental Health and Safety,
- Washington State Department of Ecology, Water Quality Program, and
- Additional Program Partners,
  - Tribal: Lummi Nation; Nooksack Indian Tribe,
  - State: Puget Sound Partnership; Washington State Conservation Commission,
  - Federal: Environmental Protection Agency; Natural Resources Conservation Service,
  - Cities: Ferndale and Lynden Stormwater Programs.

## U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) is jointly responsible for evaluating TMDLs in Washington State. EPA provides essential funding for technical assistance that allow states and Tribes to implement the Clean Water Act. EPA also manages the National Estuary Program (NEP), which is a non-regulatory program that addresses threats to estuaries of national significance, including Puget Sound. The NEP focuses on the protection and restoration of water quality and the ecological integrity of estuaries.

Ecology encourages EPA to continue to provide Clean Water Act section 319, NEP, and other grant funds to support nonpoint pollution-reduction projects in the Drayton Harbor watershed. Projects are carried by local interested parties and partners. For example, projects may include installing BMPs designed to eliminate fecal bacteria pollution, or local PIC programs can leverage funds to support water quality monitoring efforts and identify pollution sources. Ecology also recommends EPA's Office of Water Research section evaluate and provide guidance and funding for improvements to bacterial source identification methods or to support other innovative projects. Funding and research provided by the EPA are important to the success of TMDL implementation.

## U.S. Department of Agriculture

The United States Department of Agriculture (USDA) includes the Farm Service Agency (FSA) and Natural Resource Conservation Service (NRCS). The FSA provides oversight and implements several conservation programs, such as the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). Programs administered by the USDA are much needed to support TMDL implementation.

CREP, an alternative of CRP, pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality. CREP targets high-priority conservation issues identified by government and non-governmental organizations. Producers who qualify for the conservation programs will receive annual rental payments in exchange for not using the land for crop production or pasture during the life of the contract.

The NRCS is the USDA’s principal agency for providing conservation technical assistance to private landowners, conservation districts, Tribes, and other organizations. The NRCS provides technical assistance to land users to better address natural resource management concerns and to make sound management decisions. Programs offered through NRCS, such as the Environmental Quality Incentives Program (EQIP), provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits.

USDA organizations are largely non-regulatory; therefore, the assistance they provide is voluntary and often offers cost share to offset significant portions of the project cost. USDA staff have extensive practical experience implementing conservation programs and are often a primary contact with property owners when inquiring about conservation practices or programs. Their firsthand knowledge of watersheds and the personal relationships they’ve established with local landowners can be invaluable to reducing pollution in an economically feasible way.

## Nooksack Indian Tribe

The Nooksack Indian Tribe Natural Resources Program supports the Tribe’s mission of protecting, restoring, and managing Treaty natural resources within the Usual and Accustomed Grounds. The Natural Resources Department routinely coordinates with the WCWP on a variety of projects. Water quality monitoring is used to evaluate compliance with the WQS to support adaptive management actions that address water quality degradation.

Within the TMDL study, water quality data are collected in the Drayton Harbor watershed and along Semiahmoo Spit. Data are used to better understand the sources of pollution and develop action plans to address WQS exceedances. Key objectives are to reduce bacteria pollution loading and shellfish closure periods, while improving the ability to analyze the environmental factors that contribute to closure periods and assess water quality trends over time. Operations and outcomes of the Nooksack Natural Resources Program align with TMDL implementation.

## Washington State Department of Ecology

Ecology implements several parts of the federal Clean Water Act. Ecology’s authority to protect water quality is specified in state regulations under RCW 90.48. With this authority, Ecology coordinates and responds to environmental complaints, conducts compliance assurance activities (e.g., technical assistance, inspections, enforcement), and issues both state waste discharge and NPDES permits. Ecology shares information and coordinates with Permittees and local watershed groups, such as the WCWP, to facilitate projects that will assist TMDL implementation. Ecology provides financial assistance to local governments, Tribes, and nonprofit groups to help fund water quality improvement projects. The goals of TMDL implementation align with Ecology's enforcement of state regulations, permit requirements, and coordination efforts among project partners and interested parties.

Ecology acts as the lead agency in restoring, maintaining, and enhancing water quality collaboratively with community members, interested parties, Tribes, local governments, local governmental entities, state agencies, and federal agencies. Ecology's nonpoint source program uses a combination of public education, technical assistance, financial assistance and regulatory tools to help community members understand and comply with state and federal water quality laws and regulations that protect water quality (Figure 16).

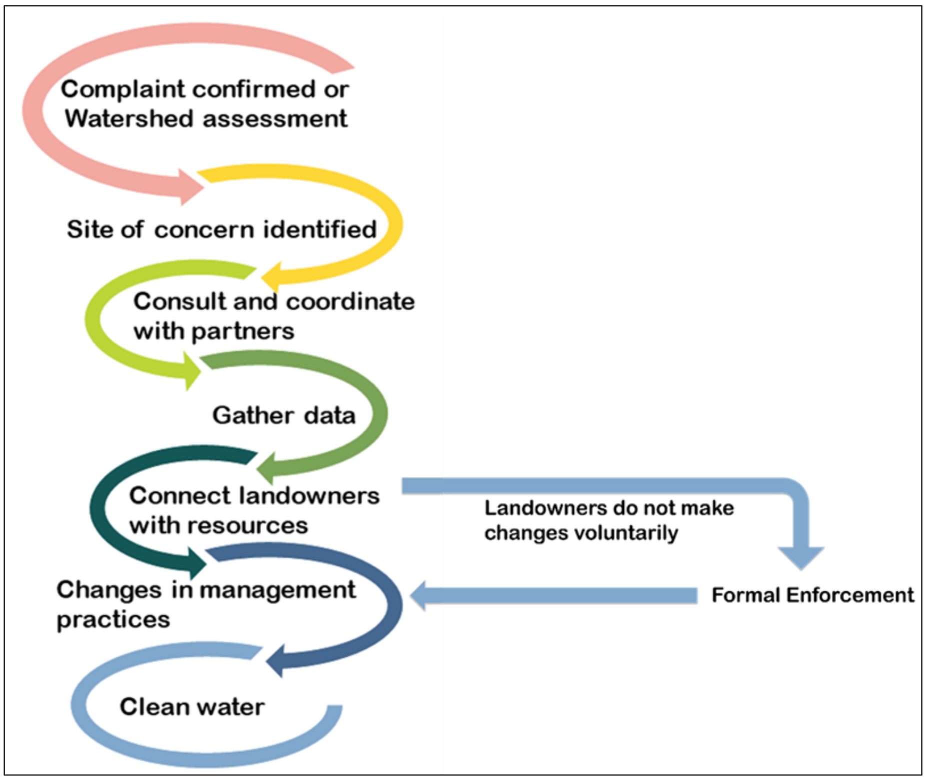


**Figure 16. Ecology's nonpoint source program flow chart**

The nonpoint source pollution plan (Ecology 2023) aims to protect public health and restore our state's waters by setting clear goals and objectives. Ecology's strategy to address nonpoint source pollution focuses on cleaning up impaired watersheds, completing watershed evaluations to identify pollution issues, and implementing suites of BMPs to address identified pollution sources and ensure compliance with the WQS.

Ecology will apply the following key principles in the implementation of this nonpoint strategy:

- Communicate clear standards and compliance expectations,
- Implement BMPs that ensure compliance with state WQS and state law,
- Implement watershed-based plans/strategies designed to meet WQS,

- Identify and correct nonpoint pollution sources in impaired watersheds,
- Be proactive in addressing pollution problems (i.e. incentives/education and outreach),
- Escalate to enforcement when education, outreach, and technical assistance fail,
- Be accountable by collecting data on watershed evaluations and tracking BMP implementation,
- Target effectiveness monitoring where implementation of BMPs has occurred,
- Promote adaptive management, and
- Develop or strengthen partnerships to achieve water quality improvement goals.

To address direct discharge to marine waters, Ecology established a Vessel Sewage No Discharge Zone[26] (NDZ) rule for Puget Sound and certain adjoining waters, which includes Drayton Harbor (Figure 17). The NDZ is a designated area of the Puget Sound where boats may not release sewage (i.e., blackwater), whether treated or not. The NDZ covers approximately 2,300 square miles of Washington waters and includes all the marine waters of Washington state inward from the line between New Dungeness Lighthouse and the Discovery Island Lighthouse to the Canadian border. Compliance with the NDZ helps protect public health, water quality, and sensitive resources. The NDZ (Chapter 173-228 WAC[27]) was adopted on April 9, 2018, after a five-year public process and approval from the EPA. The rule was effective May 10, 2018.

[26] https://ecology.wa.gov/ecologys-work-near-you/river-basins-groundwater/puget-sound/no-discharge-zone
[27] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-228

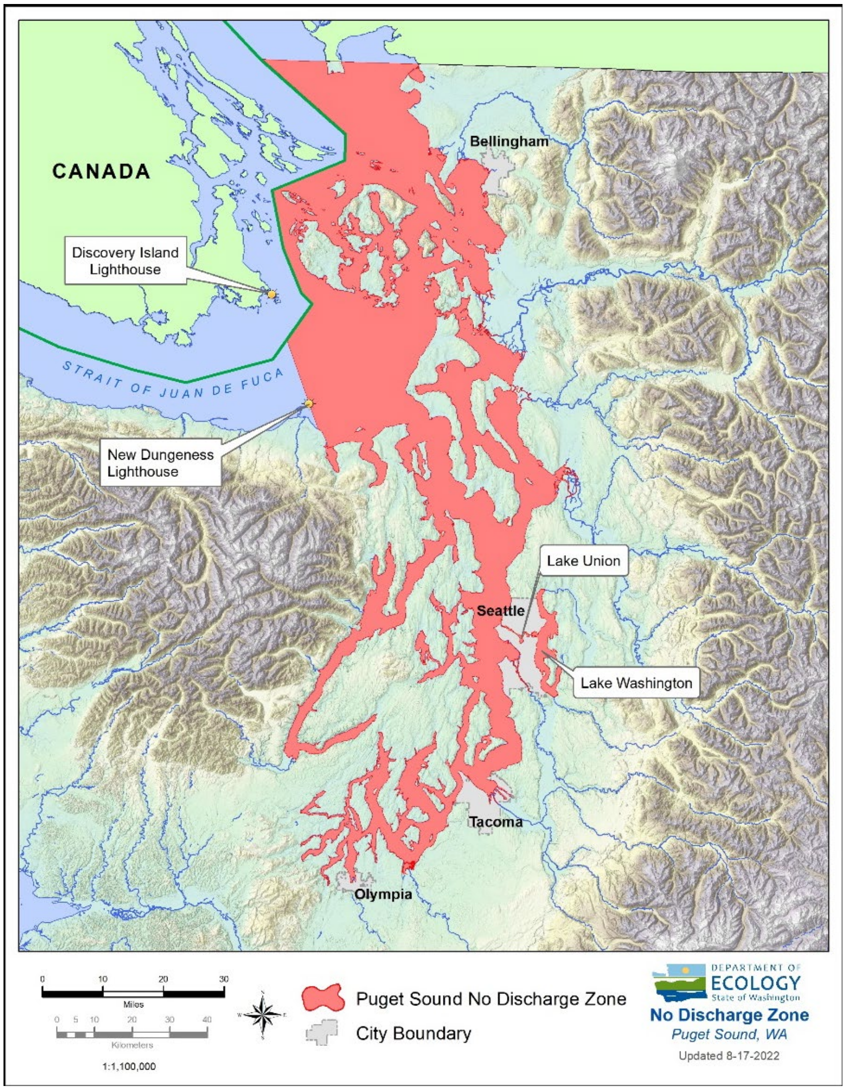


**Figure 17. Puget Sound No Discharge Zone**

Ecology's NDZ implementation approach is first focused on outreach and education and offers resources such as free NDZ signage for marinas and boat launches. Ecology also works with partners in an NDZ Enforcement Committee and NDZ Outreach and Education Committee. Ecology and the United States Coast Guard may enforce the NDZ rule by using any of the enforcement provisions in Washington's Water Pollution Control Act or other federal provisions. In addition, other federal, state, and local agencies may provide enforcement, as authorized and may be coordinated through Ecology's ERTS.

Ecology's priorities for TMDL implementation include the following objectives:

- Maintain an adequate level of staff dedicated to nonpoint pollution complaint response, and follow nonpoint guidance where water quality data point to a source of fecal bacteria pollution,

- Coordinate with WSDA and local regulatory agencies on investigation and enforcement of nonpoint pollution associated with permitted dairies,
- Coordinate and meet regularly with the WCWP for information sharing and planning,
- Provide information about funding opportunities to local organizations,
- Administer grants and loans programs,
- Assist and facilitate implementation activities leading to clean water, and
- Prepare and carry out effectiveness monitoring as resources allow to track the outcomes of implementation efforts[28].

## Washington State Department of Agriculture

Washington State Department of Agriculture (WSDA) administers the Dairy Nutrient Management Program, chapter 90.64 RCW. WSDA has water quality enforcement responsibility for dairies and, in cooperation with Ecology, Concentrated Animal Feeding Operations (CAFOs) responsibilities. WSDA conducts inspections and responds to complaints at licensed cow dairy facilities. Inspections are done on a regular schedule; routine inspections of all licensed cow dairies occur within an 18 to 26-month period. The WSDA routinely coordinates with the WCWP as project partners and supports TMDL implementation efforts.

Ecology does not have authority to require WSDA to take specific actions but encourages WSDA to consider the following:

- Continue to review water quality data as it relates to surface and ground waters potentially impacted by dairy activities such as manure applications,
- Continue the excellent support and communication with Ecology and other partners' local government in discussions of ongoing and potential nonpoint, dairy and CAFO inspections/investigations,
- Recommend and support implementation of BMPs that are protective of water quality, and
- Communicate implementation activities, funding or program opportunities, and concerns to project partners.

## Washington State Department of Health

The Washington State Department of Health (DOH) Shellfish Program coordinates and conducts the monitoring of marine water quality in shellfish growing areas—see Appendix A, Water Quality Issues for details. If water quality fails to meet National Shellfish Sanitation Program numeric criteria—geometric mean of 14 FC MPN/100mL or less and an estimated 90th percentile of 43 FC MPN/100mL or less over 30 sample datapoints—DOH will restrict or close that area to shellfish harvest.

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[28] https://ecology.wa.gov/Research-Data/Monitoring-assessment/Water-quality-improvement-effectiveness-monitoring

If the growing area was Approved or Conditionally Approved before the classification is changed to Prohibited or Restricted, it is called a classification downgrade. When a shellfish growing area's classification is downgraded due to poor water quality, the county authority must create a shellfish protection district and implement a program to find and correct the pollution source(s) that are causing water quality to decline. Whatcom County currently acts as the local Shellfish Protection District—see Drayton Harbor Shellfish Protection District in the following section.

Growing area restoration involves finding and correcting nonpoint fecal pollution sources that degrade marine water quality and cause closures of commercial and recreational shellfish beds. The DOH routinely coordinates with the WCWP as project partners with activities that support TMDL implementation. Ecology does not have authority to require specific actions, however, encourages the DOH to consider the following:

- Annually, the DOH Office of Environmental Health and Safety, Growing Area Section should provide a Drayton Harbor status report of monitoring and implementation progress,
- The DOH should continue to conduct shoreline surveys of the harbor as resources are available, or as need arises, and
- Communicate implementation activities, funding or program opportunities, and concerns to project partners.

## Washington State Department of Transportation

The WSDOT manages stormwater runoff from facilities and infrastructure under their NPDES permit. The WSDOT engages in pollution control and prevention activities or performs corrective actions by complying with permit obligations. WSDOT activities that prevent, eliminate, or reduce fecal bacteria loading supports TMDL implementation.

## Whatcom County

Whatcom County administers several department and division responsibilities that are involved in the protection and restoration of water quality and which operate under a variety codes and rules. The three primary departments are:

- Public Works – Natural Resources Division and Stormwater Division,
- Health and Community Services (WCHCS) – Environmental Health Division, identified as the Local Health Jurisdiction, and
- Planning and Development Services – Natural Resources Division.

The identified departments and divisions implement activities at a local level and provide oversight and data collection. For example, through programs such as the WCHCS's OSS Operation and Maintenance Program[29] or Public Works' Pollution Identification and Correction (PIC) Program[30], Whatcom County engages in pollution prevention measures, source identification, and

[29] https://www.whatcomcounty.us/1744/Operation-and-Maintenance-OM
[30] https://www.whatcomcounty.us/1072/Water-Quality

educational programs to reduce fecal bacteria pollution. As another example, Whatcom County created and supports local shellfish protection districts—as required by law—and has adopted shellfish recover plans for each district—see Drayton Harbor Shellfish Protection District section below. Whatcom County also leads the WCWP and coordinates closely with the partnership.

The Whatcom County PIC program identifies and addresses fecal bacteria pollution from a variety of nonpoint sources, including OSSs, farm animals, pets, sewage from boats, and stormwater runoff. Corrective actions taken may include outreach and education, technical assistance, incentives for BMPs, or enforcement of codes and regulations. Within the Drayton Harbor watershed, the water quality improvement activities conducted by Whatcom County align with TMDL implementation. Ecology encourages the county to:

- Continue to exercise local authority regarding existing laws, rules, and ordinances, and continue to update regulations over time to protect and prevent environmental degradation,
- Prioritize local implementation, outreach, and education related to fecal bacteria issues, including health and environmental effects, and
- Continue to collect and provide water quality data to inform implementation efforts, document conditions, and track changes over time.
- Implement SWMP activities in areas not currently required to have MS4 Permit coverage.

This TMDL provides a WLA for stormwater discharges from Whatcom County's permitted MS4 infrastructure within the Drayton Harbor watershed (Table 9 and Figure 12). Under this NPDES stormwater general permit, Whatcom County is required to have a stormwater management program to address stormwater discharges, infrastructure maintenance, planning, and other operations. Another component of the permit requires some degree of coordination among adjacent permittees with shared water bodies or to immediately report spills or other discharges that might cause bacterial contamination to marine waters. The next permit reissuance cycle is scheduled to occur in 2029 where additional activities will be proposed to attain the WLA—see Wasteload Allocations section for details.

## City of Ferndale

This TMDL provides a WLA for stormwater discharges from the City of Ferndale's permitted MS4 infrastructure within the Drayton Harbor watershed (Table 10 and Figure 12). Under this NPDES stormwater general permit, the City of Ferndale is required to have a stormwater management program to address stormwater discharges, infrastructure maintenance, planning, and other operations. Another component of the permit requires some degree of coordination among adjacent permittees with shared water bodies or to immediately report spills or other discharges that might cause bacterial contamination to marine waters. The next permit reissuance cycle is scheduled to occur in 2029 where additional activities will be proposed to attain the WLA—see Wasteload Allocations section for details.

The City of Ferndale is also responsible for operating the Ferndale WWTP, which is authorized to discharge treated domestic wastewater under the NPDES permit #WA0022454. Although the treated effluent from the Ferndale sewage treatment plant facility discharges to the Nooksack River, portions of the sewer service area may be within the Drayton Harbor watershed in the upper reaches of the California Creek subbasin. Under the permit, the sanitary sewer collection system requires updates, maintenance, and inspection to prevent sanitary sewer overflows.

## City of Blaine

This TMDL provides a LA for the jurisdictional area of the City of Blaine to account for nonpoint sources of pollution. The City of Blaine manages an MS4 infrastructure that is currently not covered by an NPDES permit for municipal stormwater discharges and therefore, does not have applicable NDPES permit requirements like the City of Ferndale and Whatcom County (Figure 12). Although the City of Blaine has conducted bacteria pollution source assessments, developing or following local code and MS4 infrastructure maintenance are currently the primary mechanism to control and prevent fecal bacteria pollution from the MS4 infrastructure. Additional pollution source identification will be necessary to determine the cause of elevated fecal bacteria levels observed in the Cain Creek subbasin.

The City of Blaine Public Works Department is also responsible for the operation and maintenance of the Lighthouse Point WWTP and service area infrastructure. Under the NPDES permit, the sanitary sewer collection system requires updates, maintenance, and inspection to prevent fecal bacteria contamination and pollution. The permit also regulates effluent discharge limits—see the Point Sources of Pollution, Lighthouse Point Water Reclamation Facility section for details.

## Whatcom Conservation District

The Whatcom Conservation District (CD) is a special purpose district serving Whatcom County that envisions a thriving community that protects and benefits from clean and plentiful water, productive working lands, and resilient natural habitats, including Drayton Harbor. Supporting the implementation of TMDL in Drayton Harbor furthers the Whatcom CD's mission of forming partnerships with Whatcom County residents and entities to advance resiliency and ecological processes on working lands, residential landscapes, waterways, and open spaces for current and future generations. Supporting the TMDL also aligns with the Whatcom CD's natural resource priorities of climate resiliency and preparedness, fish and wildlife habitat improvement, community stormwater and habitat improvement, and working lands productivity and conservation.

The Whatcom CD meets its mission and strategic priorities through extensive technical assistance, public outreach, research, education efforts, and cost-share programs. The Whatcom CD's volunteer Board of Supervisors develop policies, establish long-range priorities, approve annual work plans and budgets, and represent the Whatcom CD in the community. The Whatcom CD staff works with private partners, local, state and federal government agencies, agricultural and natural resource organizations, and other conservation districts. The Whatcom CD routinely coordinates with the WCWP as an integral partner.

Throughout the state, CDs provide an important connection between cooperators and government agencies to promote and implement non-regulatory technical and financial assistance programs to conserve natural resources. Ecology does not have authority to require Whatcom CD to take specific actions but encourages the CD to:

- Continue to provide technical assistance for federal, state, and local conservation programs,
- Continue to coordinate with existing agency partners to share information and further refine and focus implementation efforts based on local priorities and goals,
- Continue educational and outreach efforts, which promote conservation in all areas, and increase awareness of individual impacts and choices, and
- Continue to offer and provide landowner technical assistance and accessibility to cost-share funding programs for water quality improvement BMP implementation.

### Port of Bellingham—Blaine Harbor Marina

The Port of Bellingham operates the Blaine Harbor Marina and earned the EnviroStars and Certified Clean Marina certification. Portable pumpout carts and portable toilet dumps are offered, serviced, and maintained to empty vessel sewage tanks and reduce the threat of bacteria pollution and help boaters comply with the No Discharge Zone (NDZ) rule—Chapter 173-228 WAC[31]. The Port of Bellingham tracks and reports pumpout data. Public education and outreach activities that reduce the threat of bacterial pollution and promote proper human or pet waste management are encouraged, including emphasis on the importance of protecting marine waters and shellfish harvesting.

### Semiahmoo Marina

Semiahmoo Marina is a marina condominium association managed by a board of directors and operated by staff that earned Clean Marina certification for the facility. Portable pumpout carts and portable toilet dumps are offered, serviced, and maintained to reduce the threat of bacteria pollution and help boaters comply with the NDZ. Semiahmoo Marina is encouraged to track and report pumpout data. Public education and outreach activities that reduce the threat of bacterial pollution and promote proper human or pet waste management are encouraged, including emphasis on the importance of protecting marine waters and shellfish harvesting.

### Drayton Harbor Shellfish Protection District—Advisory Committee

Chapter 90.72 RCW[32] requires the creation of a shellfish protection district following a DOH closure or downgrade of a shellfish growing area caused by water quality issues. The Drayton Harbor Shellfish Protection District was established in 1995 in response to a growing area downgrade and is one of three districts in Whatcom County. An Advisory Committee provides recommendations to Whatcom County Council on proposed actions and operations to restore water quality in the district. These coordinated efforts continue through the PIC Program to identify and address bacteria sources to maintain year-round harvest and expand harvest to additional areas of the harbor through planning efforts.

[31] https://app.leg.wa.gov/WAC/default.aspx?cite=173-228
[32] https://app.leg.wa.gov/rcw/default.aspx?cite=90.72

In 2024, the Drayton Harbor Shellfish Protection District Advisory Committee updated the Drayton Harbor Shellfish Recovery and Protection Plan—Recovery Plan (Whatcom County 2024). Whatcom County Public Works supports the Advisory Committee. Recovery Plan activities are primarily implemented by Whatcom County. Recent updates to the Recovery Plan reflect the progress toward recovery in the harbor and prioritize activities to fully restore shellfish harvest through eight elements including program coordination, water quality monitoring, OSS and human waste, urban areas, agriculture, boats and marinas, land development, and community engagement. The Recovery Plan describes past activities that contributed to demonstrable water quality improvements and identifies emerging issues. Emerging issues include addressing population growth, climate change, inadequate infrastructure, and integrating community engagement into all elements of the Recovery Plan.

Work conducted by the Drayton Harbor Shellfish Protection District and project partners along with fulfilling the recommended activities of the Recovery Plan aligns with TMDL implementation as follows:

- Research and establish a voluntary no-anchor zone in areas of Drayton Harbor that are adjacent to shellfish growing areas and recommends the monitoring and reporting of trespass anchoring to help identify and reduce potential pollution issues.
- Protect and restore the shoreline riparian areas adjacent marine and fresh waters to establish a vegetated buffer that protects water quality. Emerging issues include encouraging new development outside of sensitive riparian and wetland areas.
- Assess the vulnerabilities of aging stormwater and sewer infrastructure while supporting connection to the Lighthouse Point sanitary sewer within the service area to reduce the number of OSS that are or may become compromised. Explore options to reduce the shellfish harvesting closure zone around the Lighthouse Point treated effluent outfall. Recommendations concerning publicly owned treatment works align with the current National Estuary Program grant for the City of Blaine—see Appendix A, Lighthouse Point Water Reclamation Facility for details.
- Enhance water quality monitoring near the entrance of Drayton Harbor and at the marina areas.
- Prioritize OSS operations and maintenance in Shoreline Management Areas and Critical Areas.

## Drayton Watershed Improvement District

The Ag Water Board of Whatcom County[33] is a nonprofit corporation organized as a partnership that provides a forum for Watershed Improvement District (WID) coordination on issues affecting agricultural landowners. There are six established WIDs in Whatcom County that cooperatively manage local watersheds to address water supply, water quality, drainage, and other water related issues. The Ag Water Board of Whatcom County represents the joint interest of the WIDs in project and policy efforts when interacting with governmental and nongovernmental organizations.

[33] https://www.agwaterboard.com/

The Drayton WID (DWID) manages the eastern portion of the Drayton Harbor watershed (Figure 18). The DWID Agriculture-Watershed Characterization and Mapping Report (2016) documents the interaction between agriculture and the watershed. This report identifies priorities used in the comprehensive planning process for agriculture and watershed enhancements. Complementary documents include the DWID Preliminary Management Plan (2017) and the DWID Agricultural and Watershed Enhancement Plan (2019). Components of the DWID action items for 2022[34] that may contribute to TMDL implementation include:

- Continue to monitor water quality and identify areas with chronic water quality violations,
- Public relations partner with Whatcom Family Farmers to dispute misinformation about farming, and
- Habitat - encourage restoration, culvert replacement, buffers, and other practices that benefit fish habitat.

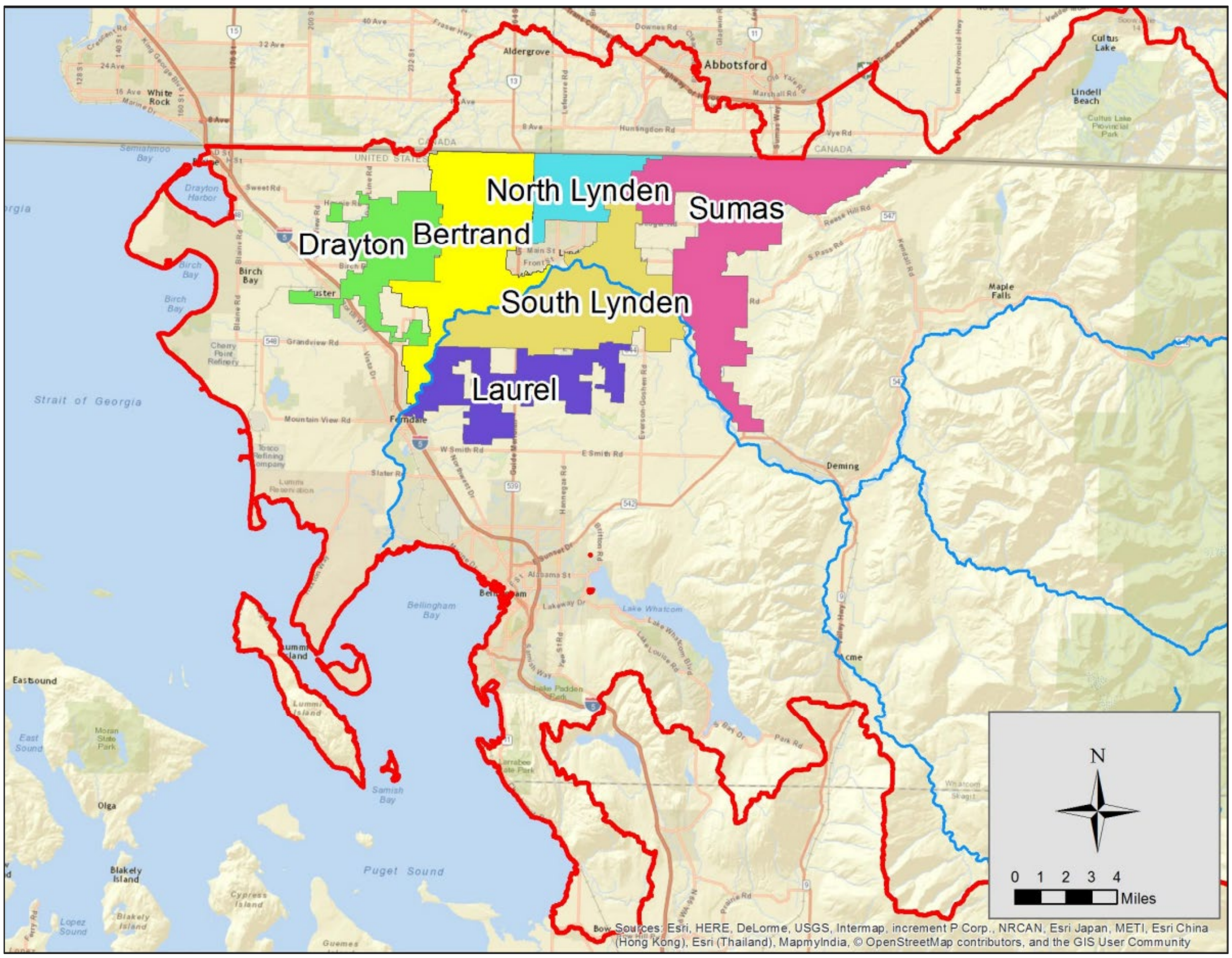


**Figure 18. Watershed Improvement Districts in WRIA 1—source: DWID (2017)**

[34] https://www.draytonwid.com/

# Priorities and Timeline

## Priority

Implementation resources and staff are limited, and it's not possible to fix all problems everywhere at once. It is therefore important to focus resources on priority areas where they can have the biggest impact. The goal is to leverage the information presented in this report and apply it at the site level in a way that addresses significant pollution sources in the most effective and efficient manner possible. Addressing water quality impacts from urban and residential areas, OSS and sewer infrastructure, agricultural areas, and boating activities are main priorities to help ensure successful implementation.

The TMDL analysis represents the water quality conditions from WYs 2020 and 2021. Based on this condition, pollution prevention activities may be prioritized in catchments where sampling location data demonstrate:

- The greatest relative geometric mean bacteria concentrations or the frequency in which the 10 percent STV is exceeded coupled with increasing levels of pollution loading, or
- The greatest relative percent reductions required to attain the TMDL and associated targets.

In addition to the TMDL-based strategy, the focus on water quality "hotspots" where elevated levels of fecal bacteria pollution occur is essential when identifying site-specific pollution sources. Prioritizing actions based on water quality hotspots is a common practice of the WCWP and can be the basis for pollution source identification and catchment evaluations. However, once a water quality hotspot is identified, it may be difficult to determine the cause due to the lack of information pertaining to the existing source(s) of pollution. Whatcom County leads planning activities to identify priority watersheds to increase efforts on gathering site-specific information and PIC activities. Utilizing the balance between TMDL targets and water quality hotspots is a key component when prioritizing watershed evaluations and pollution prevention activities.

The TMDL shows how much pollution reduction is needed and can inform a long-term strategy at the watershed scale, while water quality hotspots, identified through ongoing field work, show immediate issues to develop a short-term strategy at the catchment or site-specific scale. Addressing first-flush events through education and outreach, site preparation, farm planning, and monitoring is also an important strategy to prevent pollution and better understand the effectiveness of these practices. Combining these strategies provides a complementary approach where one prioritized activity will benefit the other. For example, successfully addressing potential pollution contributions to water quality hotspots will reduce bacteria levels to achieve short-term objectives. Each short-term accomplishment of pollution reduction eventually leads to the long-term objective of attaining the TMDLs. Continued water quality monitoring will measure the efficacy of pollution cleanup activities to guide both long-term and short-term TMDL implementation priorities.

Proximity to surface water and conveyance features such as ditches and swales are features that the WCWP typically prioritize due to the increased potential to affect water quality. PIC activities should continue to account for proximity to surface waters when prioritizing field work and technical assistance efforts. Similarly, municipalities should prioritize IDDE field screening in areas adjacent to surface waters. WCHCS is authorized to prioritize OSS management and code enforcement within the established buffer distances from surface waters. Ecology shall continue to uphold the statutory authority to act following a pollution occurrence and act proactively to prevent pollution from occurring in the first place.

In general, parcels that fall within 100 ft of surface water are considered a priority for TMDL implementation purposes. Parcels further from surface water are less likely to be significant contributors of fecal bacteria, unless drainages or infrastructure serve as a direct conduit. Ecology does not assume that all parcels close to surface water cause pollution. Only watershed evaluation work can make this determination. Direct connections to ditches or artificial drainages may provide a conduit to surface waters and thus facilitate fecal bacteria transport, even when the pollution source is further away than 100 ft from surface water.

As shown in this report, pollution reduction efforts to date have been successful at improving water quality, which led to the opening of several shellfish growing areas in the harbor. Harvesting closures and conditionally approved areas, however, still occur and 303(d) impairments remain due to excessive fecal bacteria pollution above the WQS. Continued pollution reduction activities are therefore necessary to successfully implement the TMDL and sufficiently reduce pollution to meet the marine WQS. The top priority of TMDL implementation is to maintain and bolster pollution reduction efforts led by the WCWP with cooperation from other local parties, community members, and landowners. Innovative approaches along with coordinated efforts among the WCWP and additional organizations and operators will be necessary to attain the TMDL targets and WQS.

### Fecal Coliform and *E. coli* TMDLs

Attaining the FC TMDL at the downstream most fresh water boundary with marine waters is the highest priority to protect the shellfish harvesting designated use in Drayton Harbor. Shellfish harvesting in and around the harbor is the most sensitive designated use. When the FC TMDL targets have been met, shellfish harvesting in the receiving marine waters will be protected. However, the classification of shellfish growing areas requires additional assessment that is determined by the DOH—see the Regulatory Framework and the Organizations That Implement the TMDL sections for details. When the *E. coli* TMDLs are attained, the fresh water recreation designated use is protected including that of the receiving marine waters. These assertions are based on the TMDL analysis presented in TMDL Targets section and Appendix D.

Protecting the shellfish harvesting designated use will be the greatest challenge. The FC TMDL targets range from 61 to 99 percent reduction in pollution loading. To attain these high levels of load reductions, broad scale pollution control activities must occur across a variety of land uses. Therefore, a concerted effort to address both the geographic scope and mixed land uses is necessary. This requires resources and expertise for pollution source tracking, giving technical assistance, and doing the pollution control activities necessary to eliminate each source.

One implementation priority is to increase the operational capabilities of the federal, tribal, and state entities, and the local health jurisdictions, municipalities, ports, shellfish protection districts, and agricultural operators to reduce pollution. To capitalize on increased capabilities, the local PIC Programs and WCWP partnerships offer an opportunity for all participating parties to coordinate and provides an efficient way of information sharing and project implementation. Increasing public awareness and participation in preventing fecal bacteria pollution is another priority that may be accomplished through a variety of informational campaigns and site visits. Collective efforts from all participating organizations and responsible community members to reduce fecal bacteria pollution to safe levels is necessary to attain the TMDL.

## Cain Creek Subbasin

The historical record of the Cain Creek sampling site at the mouth—site ID CC—consistently did not meet the former FC bacteria water quality criteria and did not meet the *E. coli* criteria based on this TMDL analysis (Table 5). Further, the TMDL analysis indicates that a 99 percent reduction in FC loading is necessary to protect shellfish harvesting (Table 4). Addressing the chronically elevated fecal bacteria observed in this subbasin is a priority due to the persistent bacteria pollutant inputs.

Most of the Cain Creek subbasin is within the City of Blaine jurisdiction followed by WSDOT and the Whatcom County urban growth area. The City of Blaine and the adjacent areas of Whatcom County currently do not have a stormwater permit covering MS4 discharges; therefore, all stormwater activities and programs implemented by the city and county are voluntary. Increasing efforts and activities that address urban and residential sources of pollution is the main priority for the Cain Creek subbasin.

The average fecal coliform loading during the dry season is 2.7 b.cfu/day, which is roughly equivalent to the average wet season loading even though the modeled geometric mean stream discharge during the dry season is 6 times less than the wet season at 0.19 and 1.19 cfs respectively. This seasonal loading pattern suggests a steady pollution source that may not be related to stormwater runoff or streamflow discharge. However, precipitation events have a direct association with FC concentrations in Cain Creek indicated by significant correlations where the strongest relationships occur during first flush events in the fall—see Appendix D, Seasonal Variation and Critical Conditions, Critical Condition section for analysis (Table D-14). This suggests that stormwater runoff may also flush or convey bacteria pollutants to Cain Creek.

In addition to wet weather events, water quality sampling during the dry season or dry antecedent precipitation periods also demonstrates high levels of bacteria pollution. From June through October, elevated FC bacteria concentrations occur with a maximum during August (Figure 19). This suggests a chronic source of fecal bacteria pollution that may come from inadequate maintenance of leaky sewage infrastructure, illicit cross connections, or inadequate pet waste disposal, when considering human caused sources.

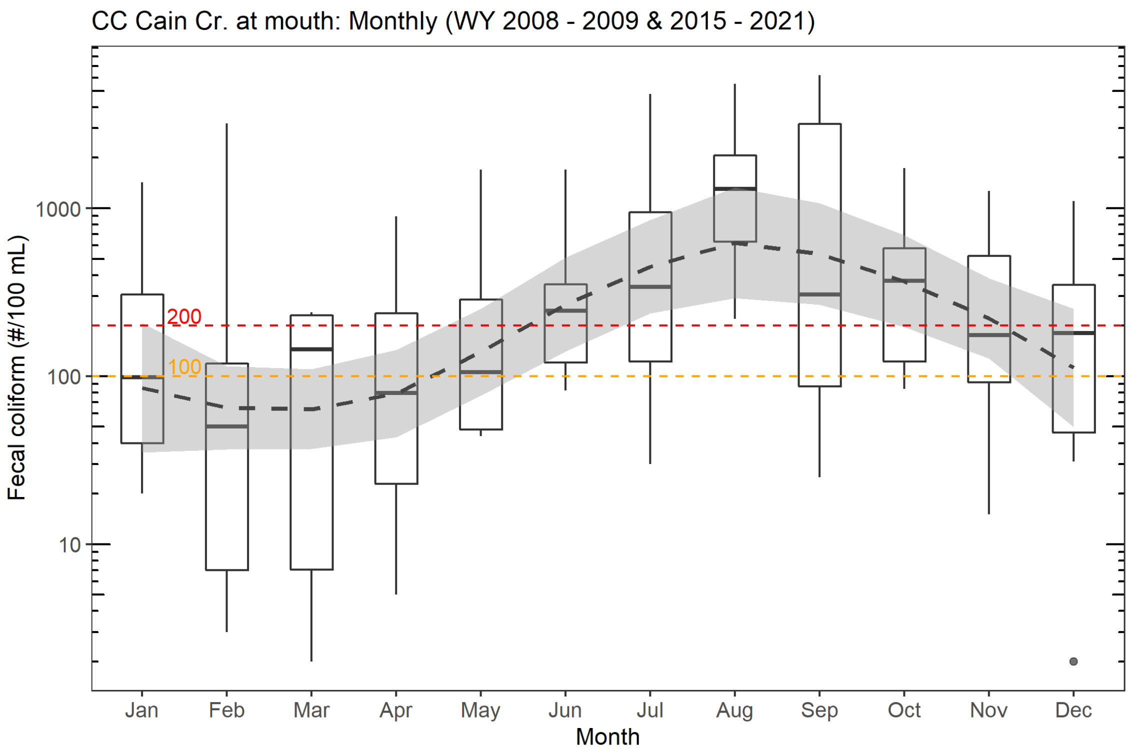


**Figure 19. Monthly fecal coliform boxplot distribution for Cain Creek at the mouth (CC) along with the former water quality criteria for recreational use**

Within the Cain Creek subbasin, fecal bacteria pollution source tracking should be led by the City of Blaine because the city manages 90 percent of the watershed. Screening the MS4 infrastructure for illicit discharges or cross-connections should be a priority. If possible, properties with OSS should connect to the Lighthouse Point WWTP services to improve waste management capabilities as a long-term strategy. Currently, the majority of OSS connection to service opportunities tend to occur in the urban growth area, which will require coordination with Whatcom County, while several urban areas of Blaine are already connected to WWTP services.

Concentrated wildlife may also be a source of pollution. Steps should be taken to ensure that conditions are not inadvertently created that cause large wildlife congregations such as areas where people feed wildlife or undue attraction from improper waste management. Despite the potential for wildlife contributions, preventing the human caused source of pollution is the greatest priority because fecal bacteria coming from human sources represent the relative greatest risk to human health. Further, correcting human sources of pollution is the most simple and efficient way to attain the TMDL, while addressing sources from wildlife is more complex.

## California Creek Subbasin

Within the California Creek subbasin at the watershed scale, attaining the FC TMDL at the sampling site at Birch-Bay Lynden Road—site ID Cal3.1—is a priority because it provides a measure to compare the most stringent protection under the shellfish harvesting designated use (Figures 2 and 3). Site Cal3.1 also represents the downstream-most fresh water location using data collected from the right-of-way access to the creek. Through tidal fluctuations, water quality monitoring downstream of Cal3.1 may be influenced by marine water where increased salinities can accelerate fecal bacteria die off. Future salinity surveys along the creek may be conducted to improve the certainty when identifying the approximate location of the fresh water and marine water interface as defined by the WQS. Therefore, flexibility is necessary to establish a representative sampling site within reasonable limits.

Fecal coliform loading during the wet season shows the greatest relative contributions to the harbor with a geometric mean loading rate of 48.6 b.cfu/day and a rate of 5.1 b.cfu/day during the dry season. As a long-term strategy, the relatively large drainage area of the California Creek subbasin creates additional challenges when addressing pollution sources due to the large geographic area along with the wide variety of land cover and land uses. The majority of land cover in the subbasin is represented by agriculture and development, which should be considered when prioritizing and implementing associated pollution prevention activities.

Fecal bacteria concentrations alone do not drive the water quality seasonal variability in the harbor—see Appendix D, Seasonal Variation and Critical Conditions for details. Over the period of record for example, California Creek at Birch Bay-Lynden Road monthly FC concentrations do not illustrate a strong seasonal effect when plotted by month (Figure 20). From May through November, the FC concentrations tend to be similar but with subtle differences in sample population distribution, while December and February through April tend to show relatively lower FC concentrations. Water quality seasonal differences in the harbor, however, are likely driven by differences in pollution loading, which may have caused the recent downgrades to the shellfish growing areas. The geometric mean wet season loading rate from California Creek is roughly 9.5 times greater than during the dry season.

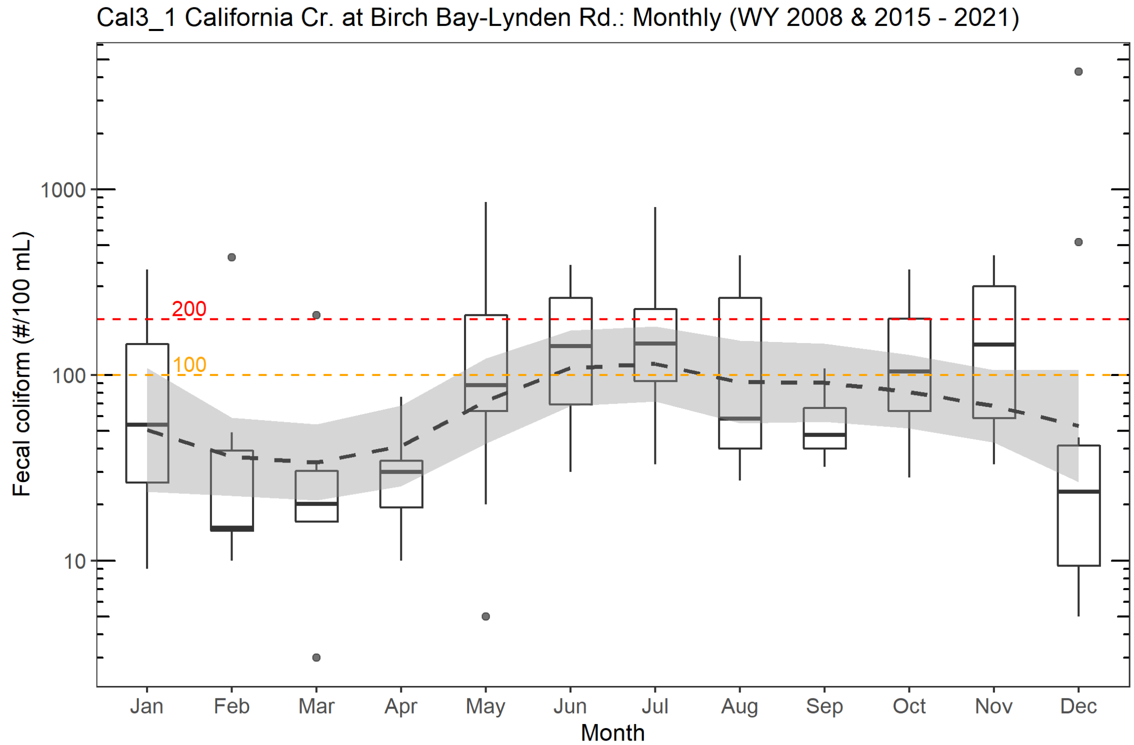


**Figure 20. Monthly fecal coliform boxplot distribution for California Creek at the mouth (Cal3.1) along with the former water quality criteria for recreational uses**

Accounting for the pollution reductions necessary to attain the *E. coli* TMDLs upstream of site Cal3.1 assists in prioritizing cleanup activities at the catchment level as a short-term priority (Figures 4 and 5). The greatest upstream reductions generally occur during the dry season. However, wet weather sampling shows a pattern of elevated bacteria levels demonstrated by WCWP data. The mainstem sites, including Cal5, Cal6.2 and Cal7.2, require significant reductions to attain the *E. coli* TMDL. Elevated fecal bacteria levels observed during the dry season may be caused by any combination of steady pollution sources from compromised OSS treatment, failing infrastructure, direct deposit, in conjunction with minimal dilution as stream discharges decrease during the dry season.

Although loading is relatively minimal when compared to the lower reaches of the mainstem, the greatest dry season reductions are required at the tributaries to California Creek at CA14cTrib—at Aldergrove Road, and CA9—at Fox Road, followed by CA14c—at Brown Road, and the mainstem of California Creek, Cal7.5—at Fox Road. Pollution concentrations observed at these locations in the upper watershed may have an indirect relationship with wet season conditions. However, first flush events can elevate pollution levels.

## Dakota Creek Subbasin

Within the Dakota Creek subbasin, attaining the FC TMDL at the sampling site at Giles Road—site ID Dak3.1—is a priority as a long-term strategy at the watershed scale because it provides a measure to compare the most stringent protection under the shellfish harvesting designated use

(Figures 2 and 3). Site Dak3.1 also represents the downstream most fresh water location using data collected from the right-of-way access to the creek. Through tidal fluctuations, water quality monitor downstream of Dak3.1 may be influenced by marine water where increased salinities can accelerate fecal bacteria die off. Future salinity surveys along the creek may be conducted to improve the certainty when identifying the approximate location of the fresh water and marine water interface as defined by the WQS. Therefore, flexibility is necessary to establish a representative sampling site within reasonable limits.

Dakota Creek fecal bacteria contributions to the harbor during the wet season have a geometric mean loading rate of 37.5 b.cfu/day and the average loading rate during the dry season is 4.4 b.cfu/day. The seasonally averaged loading rates to the harbor from Dakota Creek are less than the loading rates from California Creek. Most land cover in the subbasin is represented by agriculture, which should be considered when prioritizing and implementing associated pollution prevention activities.

Like California Creek, Dakota Creek at Giles Road monthly FC concentrations do not illustrate a strong seasonal pattern when plotted by month and are likely not the primary driver of seasonal variation observed in marine water (Figure 21). The monthly sample population distributions vary slightly throughout the year with March and April showing lower concentrations. Therefore, differences in seasonal loading are likely the primary driver of marine water quality where the geometric mean average loading during the wet season is 8.5 times greater than during the dry season.

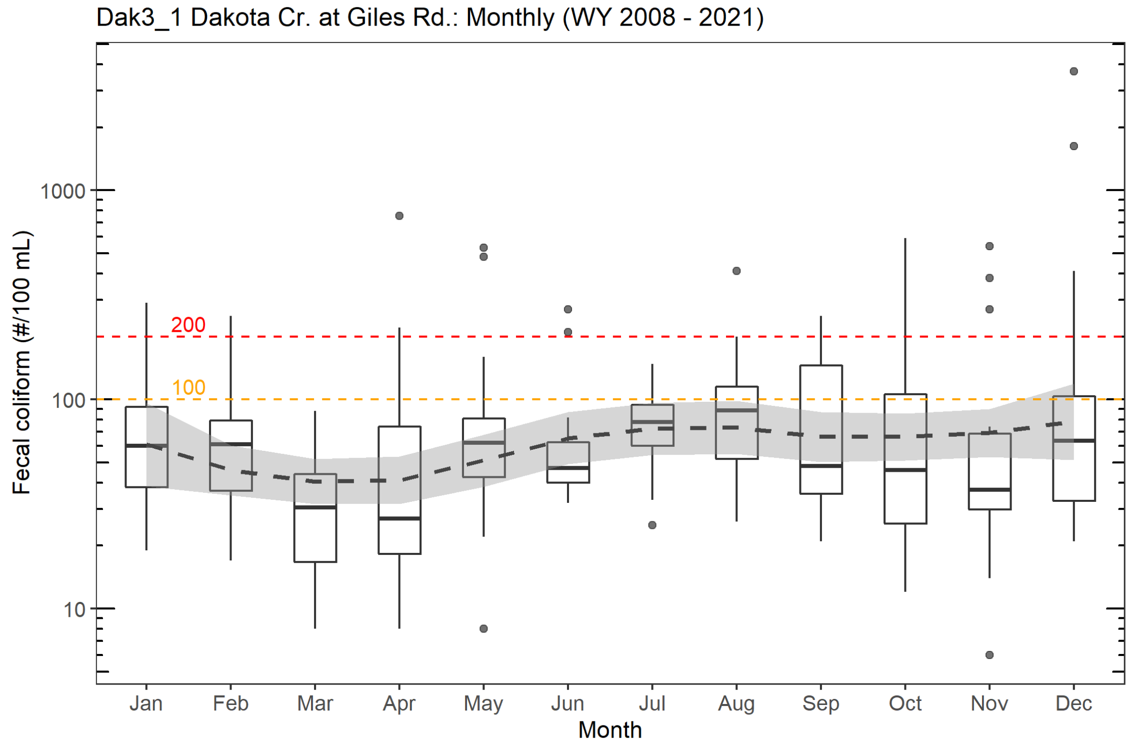


**Figure 21. Monthly fecal coliform boxplot distribution for Dakota Creek at the mouth (Dak3.1) along with the former water quality criteria for recreational use**

Examining the reductions necessary to attain the *E. coli* TMDL upstream of Dak3.1 assists in prioritizing cleanup activities at the smaller catchment level (Figures 4 and 5). The drainage area above Dak6.8 at Valley View Rd is a reasonable starting point to prioritize watershed assessments due to the pollution reductions necessary during the wet season. The lower tributaries to Dakota Creek should also be a priority due to proximity to the harbor and pollution reductions necessary depending on season. As a short-term priority, the upstream tributary to the South Fork of Dakota Creek at Delt Line Road—site ID TribDak-S1—requires relatively the greatest amount of pollution reduction to attain the *E. coli* TMDL during both the wet and dry seasons.

## Shoreline Area and Drainages

Shoreline surveys like those conducted during Phase 1 of this TMDL revealed problematic drainages with elevated fecal bacteria levels. The DOH also conducts periodic shoreline surveys and source assessments to identify problematic drainages and factors in this information when classifying shellfish growing areas. Similarly, watershed evaluations and water quality sampling conducted by other WCWP partners help identify pollution sources. However, limited water quality monitoring data exists for the shoreline drainages due to the intermittent nature of discharge from the relatively small and numerous catchments, and difficulties when accessing due to tidal cycles or extreme winds.

Once problematic drainages or seeps are identified, coordinated source tracking activities should become a short-term priority to address the pollution source(s). Mid- and long-term priorities include the continuation of shoreline surveys with an emphasis on the potential impacts from marinas. The City of Blaine and Whatcom County have integral roles in maintaining stormwater infrastructure to prevent pollution discharges. The City of Blaine is responsible for maintaining Lighthouse Point WWTP infrastructure and facility operations under permit to prevent fecal bacteria pollution from entering marine and fresh waters.

Long-term monitoring of marine waters indicates chronically elevated FC levels at station 8 and 15—see Appendix D, Analytical Framework, Seasonal Variation and Critical Conditions, Marine Water Seasonal Comparisons (D-22). Pollution sources that drive these elevated FC concentrations have yet to be identified. Without a comprehensive assessment, the possible impacts may come from the Lighthouse Point sanitation sewer infrastructure, Blaine Harbor Marina, wildlife, or sources from outside the harbor. Pollution sources from outside the harbor likely have a greater effect on station 15 when compared to all other stations due to proximity. Fresh water plumes from California Creek and Dakota Creek may also increasingly affect station 8 particularly during the wet season when prevailing winds tend to push inputs along with fecal bacteria pollution toward the northeastern region of the harbor—see Appendix A, Background, Drayton Harbor Model: Hydrodynamics and Fecal Bacteria Transport for details. In addition, the hydrodynamics at the mouth of the harbor may cause a pinch-point effect that allows fecal bacteria pollution to further concentrate in this region.

It is also important to prioritize efforts such as OSS inspections, maintenance, and service in the shoreline areas due to proximity to marine waters. Figure 15 shows that the shoreline area southwest of California Creek has several OSS within 200 ft of the harbor along with the drainage to the harbor located between California and Dakota creeks—see Nonpoint Sources of Pollution, Onsite Sewage Systems (OSS) section for details. Climate change may further cause an increased threat to OSS integrity in areas that are affected by sea level rise or flooding and increase the risk of OSS inundation causing pollution discharge.

## Timeline

Ecology anticipates that if state and local coordination proceed as expected and resources remain available, water quality data collected within the watershed will demonstrate the attainment of WQS for contact recreation and shellfish harvesting. The long-term TMDL goal is to achieve the WQS within roughly 10 years of the Implementation Plan publication date, which factors in work previously conducted by the WCWP and other actors. Within the Drayton Harbor watershed and broader Whatcom County, the WCWP operate the most prominent fecal bacteria pollution reduction program that likely led to improving trends in both fresh water and marine water quality—see Appendix D, Trend Analysis for details. However, additional work necessary to attain the TMDL or WQS will require planning, prioritization, and water quality monitoring through an iterative process.

As a short-term interim milestone, participating organizations should use the TMDL and Implementation Plan to further develop existing strategies and budgets by the end of 2026. Implementation strategy planning and activities can occur in any combination at the individual organizational level, identified partnerships, or at the WCWP level. Sufficient time will be necessary to finalize the initial implementation strategies and budgets. Participating organizations—see Organizations That Implement Cleanup Activities section—are encouraged to develop documentation procedures or databases or leverage existing processes to track implementation activities collaboratively or at the individual organizational level. Local organizations are encouraged to work together and with Ecology to build from existing efforts and develop implementation strategies.

Implementing BMPs and other pollution control activities are ongoing. For nonpoint sources, the schedule for implementing BMPs is influenced by the available resources of each participating organization, funding cycles, and the nonpoint regulatory framework. For point sources, implementation is largely driven by the NPDES permit regulations and the reissuance process. Increasing the pace of implementation efforts such as the number and frequency of site visits for OSS inspections, farm planning, watershed evaluations, or permit audits may be necessary to meet the 10-year long-term goals of the TMDL.

As a mid-term interim milestone, organizations will work with Ecology as needed to assess attainment of the TMDL or WQS, modify implementation strategies, apply for grants, report environmental concerns, request assistance, or fulfill permit requirements related to TMDL WLAs. If information is gathered during each phase of TMDL implementation, it may be used to develop follow-up actions. Documenting pollution reduction activities is an important step in understanding what has been done to address site-specific issues, what additional steps may be taken, and how changes in water quality at the watershed scale become affected. Methods used to track implementation activities may be customized at the organizational level or shared and documented.

Point source and nonpoint source pollution reduction activities are tracked using two different approaches. First, point source activity tracking is required under the relevant NPDES permit. Second, nonpoint source activities tracked outside of a permit may be a component of federal, state, or local codes, directives, or programs. Each tracking approach complements one another and may be expanded to implement the TMDL.

The NPDES permit requirements to report activities or data align with most implementation activities and shall therefore serve as one component of tracking actions and progress toward meeting the fecal bacteria TMDLs. Additional bacteria reduction actions beyond the permit reporting requirements include:

- Watershed evaluations,
- Nutrient management plan requirements,
- WCHCS OSS requirements,
- Farm plans and mitigation measures,

- PIC grant reporting requirements,
- Continued planning and data collection for FC, *E. coli*, and enterococci,
- Ecology grant reporting requirements,
- ERTS coordination and follow up,
- Stormwater management activities conducted by the City of Blaine and the urban growth areas in Whatcom County,
- Education and outreach, or
- Activities coordinated by the WCWP, which include cooperative management, strategies, goals, and objectives.

**NPDES Permits for Point Sources**

Permits shall be updated and reissued generally according to the timelines of the reissuance cycle of each permit. Updated versions of the municipal and industrial stormwater permits in the next cycle (i.e., after 2029) will include additional activities, as necessary, designed to ensure Drayton Harbor, and its tributaries meet WQS. Ecology may alternately issue Administrative Orders or conduct permit modifications after approval of the TMDL by EPA in order to put relevant requirements in place. The Lighthouse Point WWTP permit will be updated as necessary to include TMDL components and activities or facility improvements that reduce the potential for inadvertent pollution discharge. Although subject to change, the permit reissuance schedules are summarized here:

- Municipal stormwater, before December 31st, 2029,
- WSDOT municipal stormwater, before April 4th, 2029,
- Industrial stormwater, before December 31st, 2029, and
- Lighthouse Point WWTP, before next reissuance.

**Nonpoint Sources**

The TMDL implementation timeline builds upon established pollution control activities to assist in prioritization, increase efforts, provide reasonable assurance, and leverage funds. Improving and expanding pollution control actions and programs, however, is necessary where new programs or methods that address nonpoint sources of pollution may be developed based on existing and new information. As one component of the programmatic approach, Ecology will prioritize maintaining staffing levels to address the TMDL and nonpoint source pollution and provide regulatory and nonregulatory assistance.

Important short-term goals for the WCWP generally include the continuation of PIC, water quality data management, farm planning, education outreach, OSS inspections and maintenance along with documenting activities. Mid-term goals may include cyclical watershed prioritization or identifying additional activities that address outstanding issues such as the further development of stormwater management programs for urban and residential areas not covered by an MS4 permit, establishing OSS priority areas, or developing a PIC or TMDL implementation tracking system. Long-term planning may include effectiveness monitoring, water quality assessments to compare data to TMDL targets and the WQS or conduct trend analysis.

**Planning Code and TMDL Implementation**
Local planning codes for Whatcom County and the cities of Ferndale and Blaine should support TMDL implementation through current language, and future revisions to the codes could provide additional support. Long-term considerations, such as changes in zoning and land use regulations can have a significant impact on pollution loading as well. TMDL implementers may have little, if any, direct control over these processes, but they can help remind those that do of water quality considerations and advise actions most consistent with the TMDL. For planning purposes, the long-term goals of implementation align with the following cyclical review:

- Participate in the 10-year cyclical review Growth Management Act (GMA) process (RCW 36.70A.130)[35] with Whatcom County no later than December 31, 2025, and
- Participate in the 10-year cyclical review Shoreline Master Programs (SMP) process (RCW 90.58.080)[36] with Whatcom County and the cities of Blaine and Ferndale no later than June 30, 2030.

The following additional provisions, if added to the code, would provide further support to implement the TMDL:

- Additional language that refers to the TMDL as a specific watershed and recovery planning goal to be addressed in the mitigation plans.
- Prioritize monitoring and enforcement of agricultural conservation plans within the riparian areas and conveyances to surface waters in the Drayton Harbor watershed.
- Adopt Ecology's Voluntary Clean Water Guidance practices when such activities are more protective than existing plans or practices.
- Require the most current version of the Stormwater Management Manual for Western Washington for new development, redevelopment and existing businesses.
- Site future off-leash dog parks away from surface waters.

# Technical Feasibility

The proactive water quality improvement activities conducted throughout the watershed have proven effective despite the increased pressures of urban and residential development and continued agricultural land uses. This demonstrates technical feasibility in attaining the TMDL and WQS by managing land use activities to eliminate or reduce fecal bacteria pollution. The actions described in this TMDL Implementation Plan and those adopted by the collective programs and organizations that operate within the watershed provide the means necessary to improve water quality through an iterative process.

Many practices are known to be practical and technically simple to install with few exceptions. For example, it may be the case that OSS inspection and repair tends to be more complex and costly when compared to installing livestock exclusion fences. However, both sets of practices are

[35] https://app.leg.wa.gov/RCW/default.aspx?cite=36.70A.130
[36] https://app.leg.wa.gov/RCW/default.aspx?cite=90.58.080

technically feasible and have been implemented in many situations. It is therefore possible that increasing the scale and pace of TMDL implementation will be the greatest technical challenge where increased funding and staffing will be necessary. Increasing financial incentives to reduce cost barriers associated with participation in voluntary programs is a key step to increasing the scale and pace of implementation.

# Funding Sources for Implementation

The Whatcom CD, Whatcom County, WSDA, and Ecology have been proactive at reducing bacteria pollution in the Drayton Harbor watershed using existing budgets. However, additional funds may be needed to bolster efforts when examining and isolating sources of bacteria pollution.

Researching funding opportunities, developing and submitting grant applications, and managing grants when funding is secured can be a large amount of work that smaller municipalities and programs in the watershed may not be able to support financially. It is recommended that the jurisdictions that comanage the Drayton Harbor watershed explore different options to ensure access to funding sources to cover the costs of TMDL implementation. Some of these options may include supporting cooperatively a staff position that can complete all tasks related to securing and managing grant funding for actions described in this Implementation Plan.

In summary, there are several funding opportunities to initiate new water quality improvement activities or continue existing programs (Table 27). Appendix G, Funding and Cost provides additional details.

**Table 27. Summary of potential funding opportunities for water quality improvement projects**

| Sponsoring Entity | Funding Source | Funding Uses |
|---|---|---|
| Washington State Department of Ecology | Centennial Clean Water Program | Wastewater and OSS facilities, stormwater activities, nonpoint activities |
| | Clean Water Act Section 319 Program | Nonpoint activities |
| | Water Pollution Control Revolving Fund Program (CWSRF: EPA-state partnership) | Wastewater and stormwater facilities, OSS projects, nonpoint and stormwater activities |
| | Stormwater Financial Assistance Program | Stormwater facility or activity projects |
| | Community-Based Public-Private Partnerships (CBP3) | Local government and a private entity partnership to plan, deliver, or maintain public stormwater projects |

| Sponsoring Entity | Funding Source | Funding Uses |
|---|---|---|
| Washington State Recreation and Conservation Office | Salmon Recovery Funding Board | Habitat restoration, habitat assessment, monitoring, and land acquisition |
| | Farmland Preservation Grants | Conserve agricultural land to ensure lands remain available and to help to restore ecological functions |
| | Boating Facilities Program | Acquire, develop, and renovate facilities |
| | Boating Infrastructure Grant Program | Develop and renovate boating facilities and boater education |
| Washington State Parks Boating Program | Clean Vessel Act Grant Program | Recreational boating sewage disposal facilities |
| Washington State Conservation Commission | Local Conservation Districts | Deliver Shellfish Program, Natural Resource Investments, Voluntary Stewardship Program (VSP) and Conservation Reserve Enhancement Program (CREP) are delivered at the local level |
| Department of Agriculture | Conservation Reserve Program (CRP) | Long-term resource conservation of vegetative or vegetation covers on eligible farmland |
| | Conservation Reserve Enhancement Program (CREP) | Establish permanent resource by conserving native plant species and removing environmentally sensitive lands from resource production |
| | Environmental Quality Incentives Program (EQIP) | Administered by the NRCS to encourage environmental enhancements through several conservation programs |
| | Agricultural Conservation Easement Program (ACEP) | Administered by the NRCS to establish agricultural land easements for public benefits including environmental quality, historic preservation, wildlife habitat and protection of open space |
| Environmental Protection Agency | Watershed Funding | Provides tools, databases, and information on funding sources that can be used to protect watersheds |
| | National Estuary Program (NEP) | Protect and restore the Salish Sea, Puget Sound Region including upland land use that influences habitat, water quality, and stormwater runoff |
| | Climate Resilient Riparian Systems Grants | Coalition between Ecology, the Washington State Conservation Commission, and Bonneville Environmental Foundation to protect and restore riparian areas to support plants, animals, and fresh and marine waters |

# Outreach

Engagement with interested parties and public support are essential for implementation efforts to be successful at protecting water quality. Webpages, flyers, mailers, expos, and informational signs about pollution prevention help raise public awareness. Broadly, public education and outreach that stress the importance of eliminating bacterial pollution are some of the many ways to address the TMDL.

Ecology staff will work with partners to assist in the development of a well thought-out and executed public outreach strategy. Outreach should include raising awareness about the public responsibility to get involved by cleaning up after their pets, maintaining OSS, or following agricultural BMPs to prevent fecal bacteria pollution. As part of the WCWP fall strategy, outreach also targets pollution prevention before the occurrence of first flush events. Because active outreach from project partners is ongoing, implementation staff should continue to focus their outreach efforts in communicating water quality cleanup priorities by coordinating with their counterparts in other organizations.

Each organization and program that works toward achieving clean water has specialty areas for outreach, where many campaigns overlap. The WCWP is an effective platform for coordinated outreach efforts across the many organizations that implement the TMDL and other related water quality and human health programs. Ecology staff are typically not the lead in public outreach efforts outside of the TMDL development, coordinating TMDL review and the input process from project partners, applying the VCG, and providing pertinent regulatory assistance. Instead, local partners will likely take a lead role in outreach and implementation of the specific programs that they oversee. For example, the WCHCS addresses OSS maintenance and repair. Another example is the Whatcom CD outreach commonly addresses how to conduct agricultural practices that protect water quality. Increasing pet waste outreach efforts and the number of pet waste stations in the City of Blaine demonstrates an opportunity to collaborate and improve implementation efforts.

Ecology provided outreach to participating organizations during both Phase 1 and 2 of the TMDL to incorporate local knowledge and partner expertise and input. Several meetings were held for information sharing and input into TMDL development. Phase 2 of this TMDL was developed using WCWP input and shared data. Next, the draft report and Implementation Plan was made available for local party review. Once the draft was ready for public review, outreach was also given to announce the 30-day public comment period and give public webinars.

## Tracking Progress

TMDL follow-up meetings with the WCWP and other interested parties to discuss implementation activities and water quality monitoring results will take place through a variety established schedules along with additional opportunities. Workgroups will determine the optimal time and frequency of meetings. Meeting invitations shall be extended to additional organizations and committees for example, the City of Blaine or the Drayton Harbor WID, to develop pertinent implementation strategies.

Comparisons to the recommended target reductions in bacteria concentrations and trend analysis are measurable milestones to track the efficacy of implementation. Progress will be evaluated based on the goals of the implementation schedule, BMP installations, education and outreach efforts, water quality data, and the status of shellfish growing area classifications. The primary goal will be to assess how efficiently projects are being implemented and how effective they are in improving water quality conditions.

Achieving the recommended target reductions is one goal of this TMDL Implementation Plan. The Whatcom County Public Works Natural Resources Division in close cooperation with the Whatcom CD coordinates and leads data collection efforts of the WCWP to produce a publicly available interactive county-wide water quality map[37]. This voluntary mapping effort represents the best existing option to track the status of water quality and has a data dashboard component that is currently in development. Also vitally important, the DOH data and interactive map will be utilized to measure the progress of pollution reduction efforts—see Appendix A, Marine Water section for details. Determining the methods used to share water quality information in relation to TMDL cleanup implementation and progress to a broader audience including the EPA will be accomplished in coordination with Ecology and project partners. Ecology shall share the TMDL progress and adaptive management actions on their webpage or fact sheet and work with the WCWP or other interested parties to develop the content.

Participating parties are responsible for documenting their implementation activities or enforcing their legal authority within their jurisdiction under associated codes, permits, or duties. If enforcement actions are required, the issuing authority shall be responsible for follow-up on any necessary actions. Stormwater permittees shall be responsible for meeting the requirements of their permits. Restoration projects, pollution control and prevention activities, and routine maintenance shall be tracked by the responsible managing party and should include documenting the type and location of water quality improvement actions.

Restoration projects or installing BMPs should include clear language regarding responsibility for maintenance of improvement structures or other implementation activities. Ecology will work with the WCWP or other interested parties to track implementation activities occurring in the watershed. Activities that are required to be tracked and reported, for example, through National

[37] https://www.whatcomcounty.us/2618/Interactive-Water-Quality-Maps

Estuary Program funding should be referenced to reduce duplicative reporting. Tracked activities should include BMPs or projects in the watershed that reduce bacterial loading as a primary or secondary benefit. Implementation tracking efforts should be as quantitative as possible, which may include the following details:

- Document accurate location and size description of the project, including GIS based information, if available such as, total feet of fencing installed, septic systems replaced, runoff reduction BMPs installed.
- Document type of BMPs installed, project cost, and potential reductions based on BMP effectiveness estimates.
- Map and share areas of active grants or program areas with conservation partners and identity project targets in highest priority areas.
- Identify and track potential problem areas and barriers to implementation such as, locations where outreach or technical assistance was not accepted when offered.
- Document education and outreach efforts – include maps of targeted mailing areas or track survey participation and interest of landowners.

In many cases, there are specific elements of the Whatcom CD and the WSDA Dairy Nutrient Management Program activities that are protected from public disclosure due to privacy concerns. Information should only include the available project and monitoring data that is not protected by privacy rules and regulations.

As part of the water quality criteria, chronic, or long-term, conditions are measured by the geometric mean fecal bacteria concentrations, while the 10 percent STV measure the immediate, or short-term, conditions. Either criteria shall be used to track the progress of attaining the TMDL and WQS. The 90$^{th}$ percentile is used to interpret the 10 percent STV in context of the Statistical Theory of Rollback (STR)—see Appendix D, Statistical Rollback Analysis. The rollback is used to measure the level of pollution reduction necessary to attain the WQS based on the most stringent criterion. The 90$^{th}$ percentile may also indicate long-term conditions at the extreme values of the sample population when calculated over a long period of time. For example, the DOH often calculates the 90$^{th}$ percentile of 30 consecutive water quality samples to establish information used to classify the status of a shellfish growing area.

## Effectiveness Monitoring

Effectiveness monitoring uses a combination of data collection types to evaluate whether specified activities have achieved the desired effect. Effectiveness monitoring can help determine if 1) WQS and TMDLs are being met, 2) water quality improvements are linked to water cleanup activities, 3) the current implementation strategy is sufficient, and 4) progress is being made towards meeting these goals (Collyard and Onwumere 2013).

Effectiveness monitoring plans should be developed to assess the efficacy of BMPs and pollution control activities. To evaluate the effectiveness pollution control activities and the attainment of the TMDL, monitoring types may be defined to address questions as follows (Collyard and Onwumere 2013):

**Baseline**—what are the current water quality conditions?

**Status**—what is the overall condition of the watershed?

**Trends**—are conditions changing over time?

**Compliance**—are WQS or NPDES requirements being met?

**Implementation**—are BMPs or pollution control and prevention activities leading to the attainment the TMDL goals?

**Source Identification**—are additional source controls needed?

**Effectiveness**—are changes in water quality linked to pollution control activities?

Utilizing and continuing the WCWP is integral to the success of TMDL effectiveness monitoring. Depending on available resources, the WCWP is encouraged to continue or expand capabilities, while Ecology's TMDL Effectiveness Monitoring Program[38] may also be leveraged to assess water quality conditions post-TMDL implementation. Additional funding or monitoring efforts may be necessary to continue or temporarily expand efforts to investigate the causes of water quality issues.

The downstream most fresh water monitoring sites are important to monitor because these locations represent the greatest influence on marine water quality due to proximity and the information obtained may be used to characterize the upland contributions to measure the overall effectiveness of pollution control efforts. Data from these sites may also be used to determine TMDL attainment. Because California and Dakota creeks contribute the greatest loading to the harbor, monitoring at their downstream most fresh water stations should be prioritized to better understand the major drivers of marine water quality. For example, in the event minimal loading is observed from these major tributaries while water quality in the harbor remains poor, it may be possible that either more localized sources or sources from outside the harbor have a greater influence. The protection of shellfish harvesting may be determined by attaining the FC TMDL, or by the DOH Shellfish Program water quality assessment and shoreline surveys. Data collected at monitoring locations throughout the watershed may be compared to the established TMDL targets or water quality criteria to track progress.

An adaptive approach to water quality monitoring is recommended depending on each organizational program's objective. In accordance with the state WQS, either FC, *E. coli*, enterococci serve as fecal indicators of pollution depending on the water body and designated use. Ecology stopped using FC samples collected after 2020 to determine the protection of fresh water contact recreation beneficial (Ecology 2023a). For this reason, water quality monitoring to

[38] https://ecology.wa.gov/research-data/monitoring-assessment/water-quality-improvement-effectiveness-monitoring

compare to the WQS shall be done using *E. coli* data and is recommended in fresh water systems according to this implementation plan. Determining attainment of the TMDL to protect the shellfish harvesting designated use, however, is done using FC data collected in the downstream fresh water boundary with marine water, or in the harbor. Fecal coliform sampling in brackish and marine waters is recommend because of the alignment with the many sampling objectives conducted by local partners, PIC Programs, and the DOH Shellfish Program.

For paired fecal indicator bacteria analysis of fresh water that is consistent with Ecology's Ambient Program field sampling and analysis methods, it is advised to collect one sample and use the same filter for each analyte following SM9222-D for FC, and next followed by SM9222-I, which describes the transfer of the filter to analyze for *E. coli* (APHA 2022). Using the same filter for FC and *E. coli* bacteria analysis should reduce sample variability between paired datapoints. *E. coli* sampling results may be compared to the fresh water contact recreation WQS.

Enterococci sampling is also recommended in marine waters following SM9230-C to confirm the protection of contact recreation designated use in marine waters. Paired sampling or sample analysis of enterococci and FC is also recommended to better understand the relationship between each fecal indicator bacteria. Sampling to compare fecal indicator bacteria should occur in marine waters to be applied to the marine WQS. However, for research purposes, fresh water samples may also be collected.

## Adaptive Management

Natural systems are complex and dynamic. The way a system will respond to human management activities is often unknown and can only be described as probabilities or possibilities. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings. In the case of TMDLs, Ecology uses adaptive management to assess whether the actions identified as necessary to solve pollution problems are the correct ones and whether they are working. As corrective actions are implemented, the system will respond, and it will also change. Adaptive management provides information to fine-tune pollution control actions to make them more effective, and to try new strategies given the evidence that a new approach could help in achieving compliance to attain the TMDL and WSQ.

If implementation actions are effective, bacteria reductions should be achieved, and the WQS for bacteria should be met and thereby fulfill TMDL goals. Project partners will need to work together to monitor progress towards these goals and evaluate successes, obstacles, and changing needs. Implementation strategy adjustments may be necessary as new information is discovered or if the WQS are not attained. If the WQS are achieved, but wasteload and load allocations are not, the TMDL will be considered satisfied. Following the requirements of the WQA, sampling for *E. coli* will be necessary to evaluate the data with the appropriate water quality criteria (Ecology 2018 and WAC 173-201A). Either FC or *E. coli* data may be used to determine the attainment of the TMDL relative to the designated use of the water body.

Pollution prevention activities described in this Implementation Plan are based in practical and scientific knowledge. Ultimately, measuring the efficacy of the collective pollution control activities is reflected in ambient water quality data collected over time. The effectiveness of site-specific pollution control activities, however, may be assessed by sampling outfalls, ditches, or isolated stream reaches, for example, near the source of activity.

Water quality monitoring data should be assessed annually to track progress toward meeting the TMDL goals. Ecology assesses water quality data in relation to the TMDL at its discretion, or upon request from local organizations or the EPA. Ecology will use adaptive management when water monitoring data show that the TMDL targets are not being met or implementation activities are not producing the desired result. A feedback loop consisting of the following steps will be implemented (Figure 22):

**Step 1.** The activities in the water quality implementation plan are put into practice.

**Step 2.** Programs and BMPs are evaluated for technical adequacy of design, installation and/or implementation.

**Step 3.** The effectiveness of the activities is evaluated by assessing new monitoring data and comparing them to the data used to set the TMDL targets.

> **Step 3a.** If the goals and objectives are achieved, the implementation efforts are adequate as designed, installed, and maintained. Project success and accomplishments should be publicized and reported to continue project implementation and increase public support.
>
> **Step 3b.** If not, then BMPs and the implementation plan will be modified, or new actions identified. The new or modified activities are then applied as in Step 1.

Additional monitoring and evaluation may be necessary to better isolate the pollution sources so that new BMPs can be designed and implemented to address all sources of pollution to the streams. It is ultimately Ecology's responsibility to assure that implementation is being actively pursued and WQS are achieved.

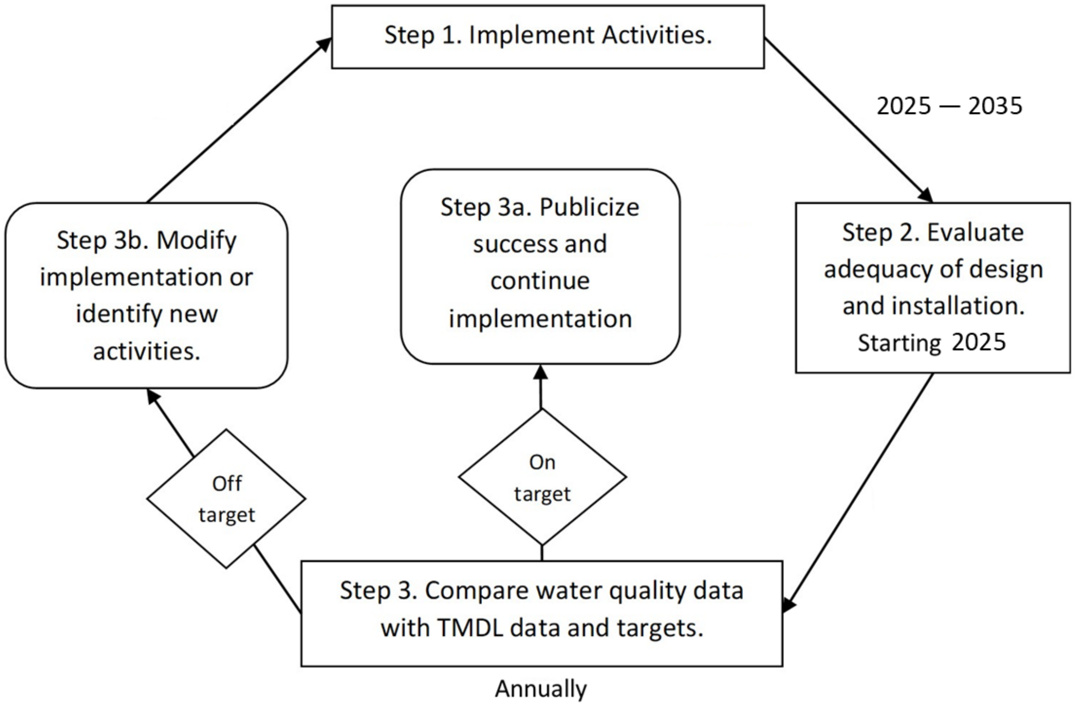


**Figure 22. Feedback loop for determining need for adaptive management where dates are estimates and may change depending on resources and implementation status**

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# Appendices

## Appendix A. Background

### Clean Water Act and TMDLs

**Federal Clean Water Act requirements**

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

**The Water Quality Assessment and the 303(d) List**

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards that are set by the state for each type of pollutant. Section 303(d) of the Clean Water Act establishes a process to identify and clean up polluted waters. In Washington State, this list is part of the Water Quality Assessment process. The Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list.

To develop the Water Quality Assessment, Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, Tribes, industries, and citizen monitoring groups. All data in this Water Quality Assessment are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The Water Quality Assessment divides water bodies into five categories. Waters with pollutants that impair beneficial uses such as for drinking, recreation, aquatic habitat, and industrial use are placed in the polluted water category (category 5) of the water quality assessment.

- **Category 1**—Meets standards for parameter(s) for which it has been tested.
- **Category 2**—Waters of concern.
- **Category 3**—Waters with no data or insufficient data available.
- **Category 4**—Polluted waters that do not require a TMDL because they:
  - **4A**—Have an approved TMDL being implemented.
  - **4B**—Have a pollution control program in place that should solve the problem.
  - **4C**—Impaired by a non-pollutant such as low water flow, dams, or culverts.
- **Category 5**—Polluted waters that require a TMDL – the 303(d) list.

Further information is available at Ecology's Water Quality Assessment website[39].

[39] https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d

**Total Maximum Daily Load (TMDL) process overview**

Ecology uses the 303(d) list to prioritize and initiate Total Maximum Daily Load (TMDL) studies across the state. The TMDL study identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local parties, develops a plan to control and reduce pollution sources as well as a monitoring plan to assess effectiveness of the water quality improvement activities. This comprises the water quality improvement report and implementation plan.

The TMDL report goes through a public comment period followed by changes and adjustments as needed. The final report is submitted to the Environmental Protection Agency (EPA) for approval and includes the TMDL, project plan, and implementation plan. After EPA approval, the TMDL water quality improvement plan is implemented and the Category 5—303(d) listing will be placed into Category 4a—has an approved TMDL. During that process, monitoring will indicate how well water quality is improving. If the water body health is not improving as expected, Ecology and local parties adjust the process, where needed. When the water body meets water quality standards, its assessment status is changed to Category 1—Meets tested standards for clean waters. Continued periodic monitoring ensures that the water body maintains state water quality standards. The biennial Water Quality Assessment process determines the most recent status of 303(d) listed water bodies.

## Future Impairment Approval Process

One goal of this TMDL is to address future impairments within the Drayton Harbor watershed study area. The TMDL and target reductions have a spatial extent that cover all Assessment Units (AUs) including current and future 303(d) listed impairments for bacteria within the study area (Figure 1). This TMDL report includes:

- A clear description of how wasteload allocations (WLA), load allocations (LA), and TMDL targets were calculated—Appendices D and E,
- A clear description of the spatial extent to which allocations and TMDL targets represent—Scope,
- A statement that the TMDL is designed to address future impairments within the TMDL study area—Appendix E, and
- A statement of the process Ecology will follow to require approval of future impairments, as follows.

Ecology works with the EPA during the Water Quality Assessment (WQA) process to make category determinations, which includes new data while covering the basis of historical determinations. When new data collected in the watershed indicate that the water body does not meet the WQS for bacteria including *E. coli*, FC, or enterococci, Ecology will first identify these impairments during the WQA review process and relate these AUs to the Drayton Harbor bacteria TMDL. Secondly, Ecology will work with EPA to review and consider the proposed Category 4A determination. Finally, Ecology will submit a letter to EPA as a formal request to acknowledge that the Drayton Harbor TMDL provides the information necessary to support moving future impaired waters into Category 4A.

Separate from the WQA approval letter, EPA will notify Ecology through an official approval letter, which will include the specific AU for the bacteria pollutant that shall move to Category 4A. The Ecology request letter and EPA's approval letter will be uploaded into the Assessment, Total Maximum Daily Load Tracking and Implementation System[40] (ATTAINS) by Ecology's TMDL program planner or EPA's TMDL coordinator. These documents will be considered "TMDL addendums" and will function as additional information for the TMDL.

## Watershed Hydrology

The following is a summary of the climate, geology, hydrology, and water uses in the Drayton Harbor watershed.

### 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˚ F below zero. The watershed is heavily influenced by precipitation, with a mean annual precipitation across the Drayton Harbor watershed basin of 45 inches (Dunn and Cook 2023). On average greater than 75 percent of the precipitation falls during the months of October to April.

### Geology and Hydrogeology

Bedrock is the regional base of the aquifer and confining geologic feature in Whatcom County. Glaciations that occurred during the Pleistocene Epoch eroded these bedrock surfaces and deposited unconsolidated glacial and interglacial sediments (Dunn and Cook 2023—literature review). Soils within the Drayton Harbor watershed were deposited by a sequence of glacial advances and retreats (Carey and Harrison 2014). These glacial deposits consist of both coarse- and fine-grained sediments. Deposits of coarse-grained glacial outwash tend to occur along the center reaches of the watershed, while the southern and northern areas include areas of fine-grained glacial outwash (Jones 1999—Plate 5). Semiahmoo Spit separates Drayton Harbor from Boundary Bay and was formed by longshore processes (Kovanen et al. 2020). Sediments tend to grade finer southward to sand and some clay layers in the Lynden area (Easterbrook 1971) on the eastern edge of the Drayton Harbor watershed.

The Sumas-Blaine aquifer is the uppermost aquifer and is the sole drinking water source for the area's rural residents (Carey 2017). The regional aquifer is unconfined and extends beyond the Drayton Harbor watershed to includes an area of about 150 $mi^2$ (Carey and Harrison 2014). The southern reaches of the California Creek subbasin, Cain Creek, and the area adjacent to Drayton Harbor are outside the aquifer.

[40] https://www.epa.gov/waterdata/attains

Groundwater within the aquifer naturally discharges to local streams in and around the Drayton Harbor watershed and to the lower reaches of the Nooksack River system. The depth to water is less than 10 feet except for a small portion of the aquifer in the east where the depth to water is generally ranges between 10 and 25 feet (Tooley and Erickson 1996). The water table will rise to around one to two feet below the surface in some areas during the wet season (Carey and Harrison 2014). A system of ditches and tile drains assist when controlling these high water table conditions and facilitate agricultural use in much of the area. During the dry season, the surface waters receive significant baseflow from the aquifer. Some upper reaches of Dakota Creek and California Creek systems originate from springs and surface runoff in upland areas.

Fluvial processes have also deposited sediments consisting of organic silts, clays, silty sands and fluvial sands and gravels (Lindsay and Bandaragoda 2013). Hale silt loam soil is found in areas of the watershed, which are part of the Lynden-Hale-Tromp grouping that overlies much of the greater Sumas-Blaine aquifer. These soils are often associated with wetlands due to their slow drainage rates and high water table[41]. Wetlands are a significant feature of the subbasin (Lindsay and Bandaragoda 2013, NLCD 2019).

**Streamflow**

The Dakota Creek streamflow gage station 01Q070[42] at river mile (RM) 3.1 is maintained and operated by Ecology. Dakota Creek is the largest tributary to Drayton Harbor followed by California Creek (Table A-1). Cain Creek is the 3rd largest tributary input in the study area; however, it discharges immediately north of the harbor to Semiahmoo Bay. Wet season streamflow is on average six to ten times greater than that of the dry season depending on the subbasin. Minimum streamflows are similar for both seasons, which is likely attributed to baseflow conditions that often occur at the start of the wet season. Conversely, the maximum streamflows observed during the wet far exceed those observed during the dry season.

**Table A-1. Streamflow summary statistics (cfs) grouped by season and modeled relationships* for water years 2008—2021**

| Creek Name | River Mile | Drainage Area ($mi^2$) | Season | Geomean | Median | Min | Max |
|---|---|---|---|---|---|---|---|
| Dakota | 3.1 | 22.2 | Dry | 4.9 | 4.3 | 0.4 | 192 |
| | | | Wet | 37.7 | 40.6 | 0.3 | 638 |
| California | 3.1 | 17.2 | Dry | 3.4 | 3.0 | 0.4 | 77 |
| | | | Wet | 19.1 | 20.4 | 0.3 | 215 |
| Cain | 0.1 | 1.3 | Dry | 0.2 | 0.2 | 0.02 | 9.6 |
| | | | Wet | 1.9 | 2.0 | 0.02 | 31.8 |

* see Equation 7

Ecology's continuous gage station on Dakota Creek (01Q070) generally provides data for daily, monthly, annual, and comparison metrics that can describe the hydrology of Drayton Harbor watershed. Streamflow gradually decreases in April until baseflows are reached in August (Figure A-1—see boxplot description in Appendix C). Baseflow conditions are followed by a

[41] USDA—Official Soil Series Descriptions https://soilseries.sc.egov.usda.gov/
[42] Ecology—Flow Monitoring https://apps.ecology.wa.gov/ContinuousFlowAndWQ/StationDetails?sta=01Q070

sharp increase through December and maintain comparatively high discharge through March. California and Cain creeks follow similar monthly discharge patterns, not depicted here. Streamflow is predicted at each fresh water sampling location using the modeled relationship with the continuous gage on Dakota Creek at Giles Road—see Appendix D, Time-series Streamflow Model and Site-specific Streamflow Model sections for details.

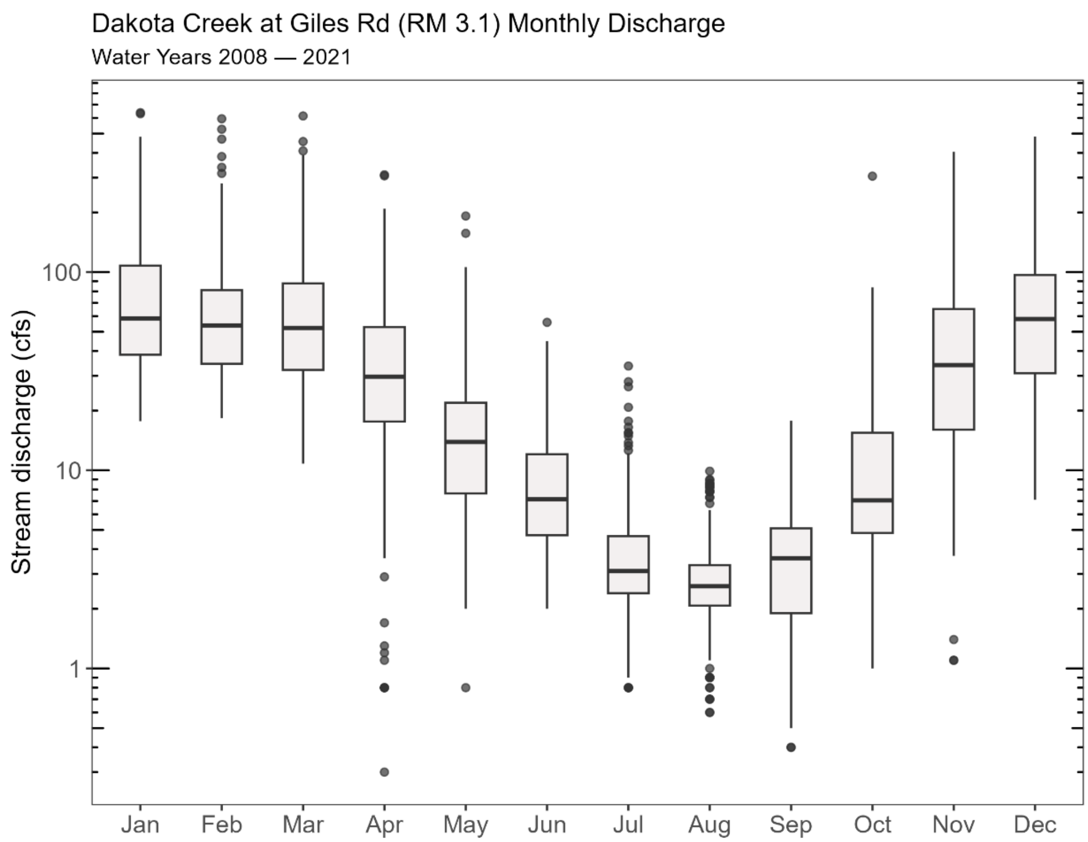


**Figure A-1. Dakota Creek streamflow discharge grouped by month, Ecology station ID 01Q070**

Streamflow from WYs 2020 and 2021 is used to calculate the LC and TMDLs (Figure A-2). Dakota Creek streamflows show a greater range of fluctuation during the wet season than that of the dry season. Fluctuations are likely driven by the seasonal differences in precipitation, frequency, duration, and intensity. Further, soils commonly become saturated with water during the wet season, which increases the potential of immediate runoff and interflow.

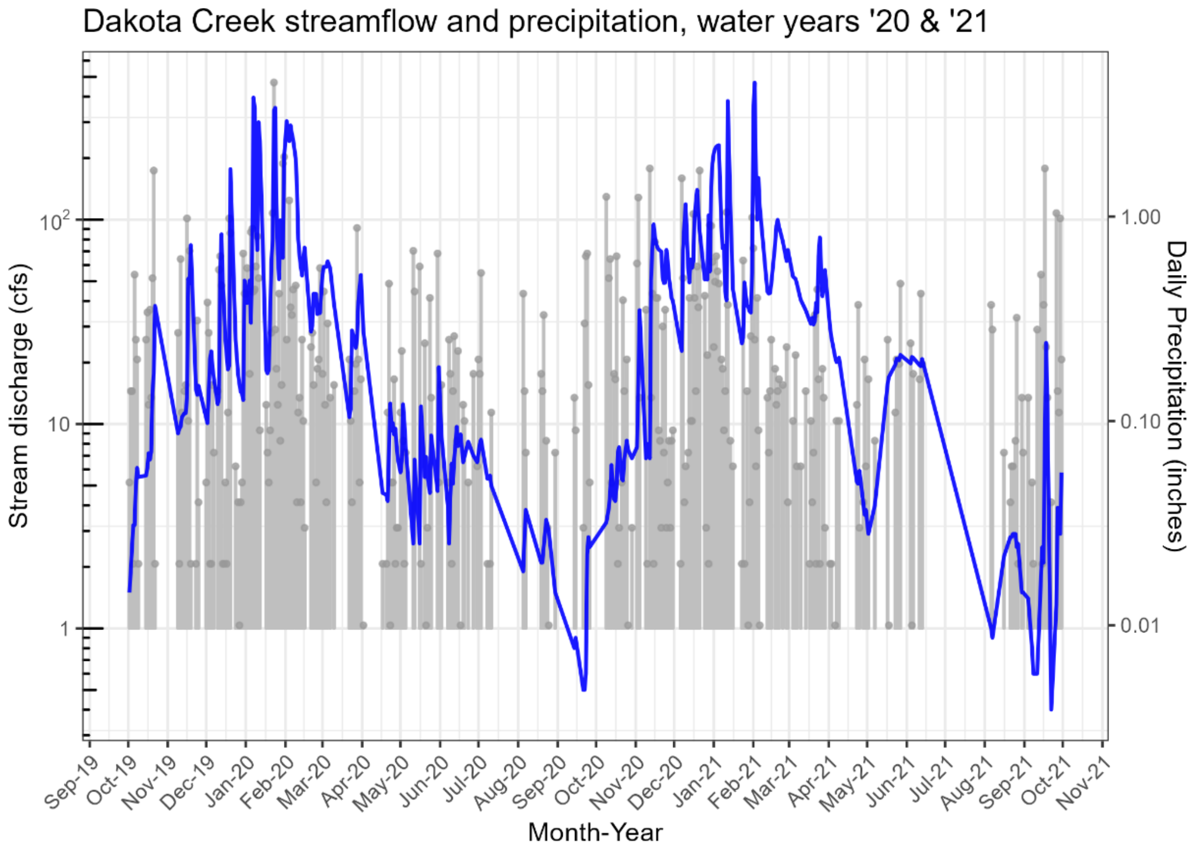


**Figure A-2. Ecology gage station ID 01Q070, Dakota Creek at Giles Rd (Dak3_1), mean daily streamflow (—), and precipitation (—·) NCDC Coop Station: 450729 for TMDL-based water years 2020 and 2021**

Streamflows observed during the WYs used to establish the TMDL are compared to the period of record that ranges from 2009 to present. The annual median discharge for WYs 2020 and 2021 ranked the lowest and 33$^{rd}$ percentiles respectively, which indicates these are relatively low flow years (Figure A-3—see boxplot description in Appendix C). Seasonal analysis shows that the wet season for WYs 2020 and 2021 ranked the lowest and 39$^{th}$ percentiles respectively, while the dry season ranked the 33$^{rd}$ and lowest based on median discharge. The TMDLs established in this report, therefore, likely represent a conservative measurement given the streamflows are collectively well below average.

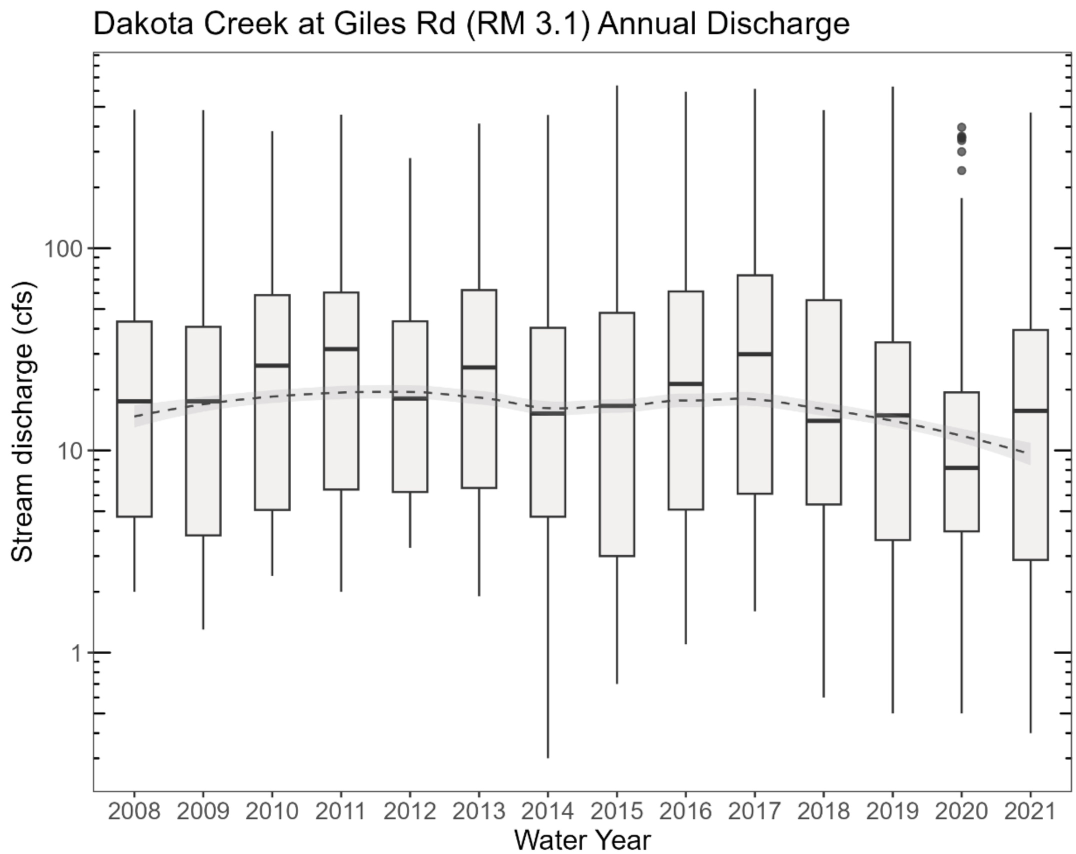


**Figure A-3. Dakota Creek streamflow discharge grouped by water year, Ecology station ID 01Q070**

**Water Uses**
Agricultural, municipal, domestic, and commercial consumptive water uses occur within the Drayton Harbor watershed. Dunn and Cook (2023) determined that in 2020, the total water use includes:

1. Irrigation = 7,000 acre feet/year
2. Municipal = 2,900 acre feet/year
3. Domestic = 545 acre feet/year
4. Commercial = 154 acre feet/year
5. Dairy = 114 acre feet/year

Irrigation makes up the greatest water use to support agricultural production followed by municipal water use to support residence and industry within the service area in Blaine, and two wholesale accounts for the Birch Bay Water and Sewer District and the Bell Bay Jackson Water Association. The City of Blaine draws water from nine nearby deep-production wells.[43]

[43] https://www.ci.blaine.wa.us/90/Public-Works

## Drayton Harbor Model: Hydrodynamics and Fecal Bacteria Transport

The EPA, Region 10 supported the development and refinements to the Salish Sea Model[44] (SSM) in collaboration with the US Department of Energy Pacific Northwest National Laboratory (PNNL) and the University of Washington Salish Sea Modeling Center. The Puget Sound Partnership teamed up with local PIC Programs in Skagit and Whatcom counties to apply the refined SSM-fecal bacteria (fb) module to selected shellfish beds through the NEP's Shellfish Strategic Initiative. The SSM-fb was developed for Drayton Harbor to better identify the major sources of fresh water loading and the effects of currents—hydrodynamics driven by tides and winds—on fresh water and pollution transport (Ni 2023).

**Setup and Objectives**

FC monitoring data were acquired from Whatcom County and DOH. Year 2020 was selected for model simulation based on the relative elevated FC concentrations observed during the winter months when compared to other years since 2014. The SSM-fb hydrodynamics simulated fresh water and fecal bacteria inputs from California, Dakota, and Cain creeks including coastal outfalls, the Lighthouse Point facility, and from Canada, the Little Campbell, Nicomekl, and Serpentine rivers. The project accomplished the following objectives:

- Develop a refined SSM for inside Drayton Harbor and around the Semiahmoo Bay and Boundary Bay areas,
- Simulate the circulation of fresh water contributions during different tidal and wind conditions,
- Conduct a model flushing rate analysis to better understand water exchange and how long a pollutant could remain in the region,
- Develop the SSM-fb to predict fecal bacteria concentrations in the harbor,
- Construct daily fecal bacteria loadings from fresh water inputs,
- Better understand the transport of fecal bacteria pollution from upland sources and interactions in marine areas, and
- Detect critical conditions that lead to elevated fecal bacteria pollution in the harbor.

**Summary of Conclusions**

The SSM-fb was able to simulate the observed FC concentrations in the harbor and successfully capture the time series salinities and currents under different tidal conditions and levels of fresh water input. The SSM-fb demonstrated that the circulation of FC pollution in the harbor varied based on environmental factors including tidal cycles and currents, the direction and speed of winds, and the amount of fresh water inputs from tributaries and coastal outfalls. California Creek and Dakota Creek are the major tributaries that dominate the fresh water plume effects on the harbor.

[44] https://ssmc-uw.org/salish-sea-modeling-center/salish-sea-model/

The amount of fresh water inputs along with tidal cycles and currents are important factors that drive the flushing rates in the harbor and the distribution of fresh water plume inputs. Flushing analysis was done to better understand the residence time and circulation of FC pollution in the harbor and how long the pollutant will remain in certain regions. Using an instantaneously introduced numeric dye concentration, harbor flushing rates were modeled under a range of tributary inputs and environmental factors that occur throughout the year to predict hydrodynamics.

High tributary input—247-353 cfs—from California and Dakota creeks coupled with spring tides result in a harbor flushing rate of approximately 24 hours. However, fresh water plumes slowed the regional flushing rate and tended to accumulate along the eastern region's nearshore. In contrast, low tributary input—0.7-2.1 cfs—show that fresh water plumes were barely noticeable while the currents, winds, and tidal cycles dominated the hydrodynamics and flushing rate of the harbor with an average of approximately 80 hours. The shoreline areas experience slower flushing rates than the average flushing rate of the harbor. The eastern region of the harbor had the slowest flushing rate likely due to the trapping of saline water and the wetting and drying process of the large intertidal zone during tidal cycles. The modeled flushing rates and patterns under varying amounts of fresh water input may indicate the likely transport location and fate of FC pollution within the harbor.

Wind direction and speed affect the modeled hydrodynamics of the harbor. Prevailing winds from the southeast tend to distribute fresh water plumes along the eastern shoreline, particularly at the mouths of the two major tributaries and northward. Northeast prevailing winds tend to distribute fresh water plumes from the two major tributaries toward the center of the harbor and along the immediate southeastern shoreline near the creek mouths. The wind effect on the harbor's modeled hydrodynamics illustrates the likely transport of FC pollution within the harbor.

Numeric dye tracers were also released from certain tributaries and sources to better understand the fate and transport of loading to the harbor. The model demonstrated that marine monitoring stations 379 and 378 were quickly affected by tracers released from California Creek and Dakota Creek respectively (Figure A-4). From these major tributaries, the tracer reached the harbor's central stations—03, 04, and 428—in approximately 15 hours and the stations near the harbor's entrance—15, 08, and 11—in approximately 40 hours. The modeled tracer circulation indicated that stations 379 and 315 were dominated by inputs from California Creek, while stations 04, 06, 08, 15, 413, and 378 along the harbor's eastern shoreline and entrance were dominated by Dakota Creek inputs. The simulated stream flow input from Dakota Creek was 30 percent greater than the California Creek input, which may partially explain the dominant impact. Further, prevailing southeast winds tended to redistribute the fresh water input tracers along the eastern coastline of the harbor. Model simulations demonstrate that all other sources such as coastal outfalls, effluent discharge from Lighthouse Point, and the fresh water inputs from Canada generated minimal or local impacts.

Using the numeric dye tracer as a proxy, model simulations indicate that fecal bacteria pollution loading from Dakota Creek likely tends to dominate DOH stations 04, 06, 08, 15, 413, and 378 (Figure A-4). Pollutant loading from California Creek likely tends to dominate DOH stations 379 and 315. Pollutant loadings from Cain Creek and the Little Campbell River likely tend to affect DOH station 15, 11, 08, 413 and primarily affect the eastern coastline of Boundary Bay. Simulated loading from the Little Campbell River is approximately 1 order of magnitude greater than loading from Cain Creek and these loadings are 1-2 orders of magnitudes less than loadings from California and Dakota creeks. Loading from the Nicomekl River and the Lighthouse Point facility likely minimally affect the water quality of the harbor.

Understanding how water moves through the marine systems and the environmental factors that affect these hydrodynamics makes it possible to simulate the fate and transport of FC bacteria pollution in the harbor. Fecal bacteria decay in marine waters was predicted using a simple kinetics model by accounting for the effects of temperature, salinity, and solar radiation. The FC concentrations in the harbor simulated by the SSM-fb were higher near the mouth of California Creek and Dakota Creek—stations 378 and 379—that are in proximity. The model simulated peak FC concentrations in the harbor during late November, December, and January, which coincides with the timing of peak tributary discharge and roughly when the DOH conditionally approved growing areas are closed for commercial harvest.

Further, reoccurring elevated FC concentrations observed during December near the entrance to Drayton Harbor may be partially driven by sources outside the harbor such as pollution loading from the Little Campbell River.

When assessing year 2020, the SSM-fb predicts FC peaks during in late November, December, and January, which is like the observed concentrations during WYs 2020 and 2021 combined (Figure D-23). The FC peaks simulated in the harbor coincide with the timing of increased stream flow discharges from California and Dakota creeks—see figure A-1 for example. However, nearby coastal outfall inputs may help explain why model simulations over-predicted FC concentrations in the harbor in a couple of instances.

The relatively high levels of FC observed on 12/9/2020 at DOH stations 08 and 15 (920 and 1600 MPN/100 mL respectively) near the inlet to the harbor may originate from sources outside the harbor. Model simulations indicate that the Little Campbell River may be a significant source under extremely high fecal bacteria pollutant concentrations when simulated at 20,000 cfu/100 mL. However, this implies that improvements to model predictions will require information from inputs at nearby shoreline monitoring stations and outside the harbor. Therefore, contributions to regional high levels of FC pollution may also originate from local shoreline drainages or sources, Cain Creek, and the Little Campbell River.

The SSM-fb model inputs from the Lighthouse Point facility were set at a FC concentration of 800 cfu/100 mL with a constant flow rate of 0.4 cfs that produces a loading flux of 7.8 b.cfu/day. For comparison, the January 2022–2024 discharge monitoring report (DMR) record of the facility shows an annual geometric mean effluent discharge rate of 0.9 cfs with a geometric mean of 1.5 FC cfu/100 mL. The DMR data produces loadings of 0.03 b.cfu/day averaged annually, which is far below the loading used in the SSM-fb and used to construct the facility permitted WLA. The WLA of 11.7 b.cfu/day for the facility was calculated using the permit limit monthly geometric mean FC bacteria concentration of 200 cfu/100 mL and the maximum monthly average design flow of 2.4 cfs. Loading parameters set for the SSM-fb are slightly less than the facility WLA but much greater than the DMR.

## Water Quality Issues

### Fresh Water

Mathieu and Sargeant (2008) provide a historical data review that describes a variety of studies from 1995 through 2007. See Appendix D for trend analysis methods and results that covers a period from 2008 through 2021 using data collected by the WCWP.

### Marine Water

The DOH Shellfish Program and the Whatcom County Public Works-Natural Resources Department monitors water quality in the harbor to determine safe shellfish harvesting conditions. The DOH utilize these data and assess shoreline and surrounding area conditions to classify shellfish growing areas. The most recent classification of commercial growing areas along with supplemental information on classifications may be found online at the DOH Growing Area Program webpage: Shellfish Growing Areas | Washington State Department of Health[45]. The image below provides an example of the interactive map and classification status with DOH FC sampling station IDs enlarged to improve readability (Figure A-4). The DOH classifies a total of 3,729 acres of growing area in and immediately outside the harbor where 833.6 acres are Approved, 742.8 acres are Conditional, and 2,152.5 are Prohibited.

[45] https://doh.wa.gov/community-and-environment/shellfish/growing-areas

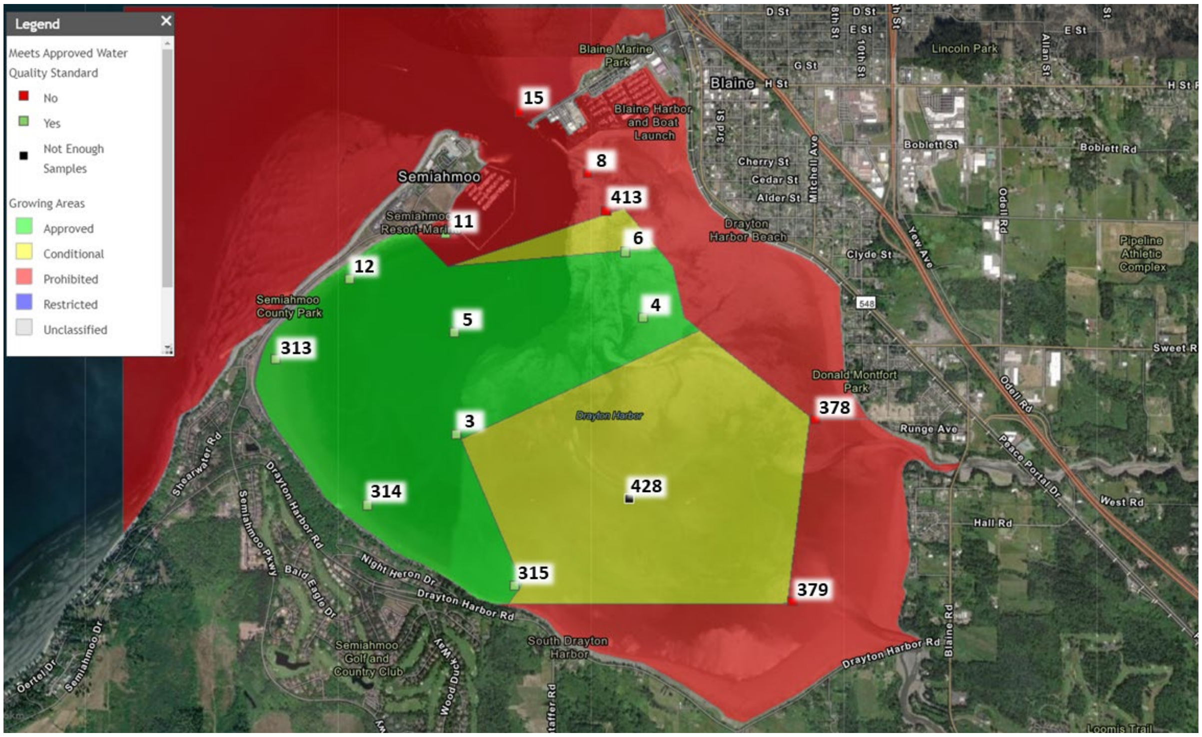


**Figure A-4 Drayton Harbor shellfish growing area classification online map—source: DOH Growing Area Program (February 2023)**

In 1988, DOH began closing the shellfish growing areas in Drayton Harbor based on a trend of deteriorating water quality. The closures ultimately resulted in the entire harbor being closed for harvest by 1999. In 2004, DOH upgraded the status of 575 acres in the central harbor from Prohibited to Conditionally Approved. In 2006, 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 a 5-day period.

In 2010, 345 acres along the harbor's southwest shoreline were upgraded to Conditionally Approved. During this classification assessment, the Conditional rainfall closure criterion was adjusted to a seasonal closure period from November 1 through end of February. Two additional portions of the harbor were upgraded to Approved for commercial harvest in 2016 and 2019. By 2016, 810 acres of shellfish beds were classified as Approved followed an upgrade in 2019, which comprised an additional 765 acres. By 2019, a total of 1,575 acres were Approved for harvest.

The annual shellfish growing area review for 2021 reclassified 695 acres from Approved to Conditionally Approved. This new Conditionally Approved area is closed annually from November 1 through January 31. During this time, an additional 450 acres were changed from Unclassified to Prohibited due to poor water quality. In 2022, 42 acres were reclassified from Approved to Conditionally Approved due to deteriorating water quality with a harvest closure from November 1 through January 31.

The southern, eastern, and northern shorelines of Drayton Harbor are currently classified as Prohibited by DOH (Figure A-25). Beyond Semiahmoo spit outside the harbor is classified as prohibited. The center of the harbor just beyond the mouth of California and Dakota creeks is classified as Conditionally Approved. The southwestern to western area of the harbor is classified as approved, which extends into the center of the harbor.

The DOH routinely evaluates shellfish growing areas using a combination of marine monitoring data, shoreline surveys, and data analysis. There are 14 active marine monitoring locations within Drayton Harbor where station 428 is the latest addition. Trends in FC data from 13 stations are evaluated using the Seasonal Kendall test—see Appendix D for trend analysis methods and additional figures and Seasonal Kendall Test results.

## Phase 1 TMDL Technical Study

Phase 1 of the TMDL was completed in 2008 as described in the Quality Assurance Project Plan (QAPP) (Mathieu and Sargeant 2008). Field data collection began on December 11, 2007, and ended December 16, 2008. The summary of Phase 1 study goals, objectives, sampling locations, and results are presented in Appendix D—Phase 1 TMDL Initiation and includes the Phase 2 analytical framework updates. When possible, the sampling location IDs include the approximate river mile on the right-hand side, that is Cal-3.1 is located at river mile 3.1 from the mouth. Phase 1 represents the initial study design and data collection of the Drayton Harbor TMDL. Data collected during Phase 1 are available through Ecology's EIM[46] using study ID NMAT0001. A summary of results and conclusions from the Phase 1 are presented here as follows:

- Fecal coliform bacteria concentrations exceed water quality standards, almost ubiquitously, throughout the entire Drayton Harbor watershed. The discharge of waste from humans and animals does not come from a few sources or "hot spots" in the watershed, but, rather, occurs systemically throughout.
- Most of the FC loading comes from the upper watersheds of Dakota and California creeks. While FC pollution occurs throughout the watershed, the greatest relative portion of that pollution comes from upstream of Bruce Road in California Creek (1-Cal-6.2) and upstream of the confluence of the north and south forks on Dakota Creek. In both upper watersheds, agriculture is the dominant land use, and all residences have OSS.
- Cain Creek greatly exceeds FC water quality standards and, under certain conditions, contributes a relatively large FC load to Semiahmoo Bay. A high amount of bacteria pollution is entering the creek between Pipeline Road (1-Cain-1.3) and from behind the Blaine Trade Center (1-Cain-0.4). Polymerase chain reaction (PCR) microbial source tracking (MST) sampling results indicated multiple human biomarkers in Cain Creek. Human sewage is therefore potentially entering the creek in this stretch.

[46] https://apps.ecology.wa.gov/eim/search/default.aspx

- Ecology conducted three surveys along the shoreline of Drayton Harbor on 1/14/2008, 5/27/2008, and 1/12/2009-1/13/2009. During the surveys, field staff collected 119 FC samples and measured discharge rates at 49 additional locations, as well as 7 routine TMDL sites located on the shore (Table D-3, site IDs: 1-Cain-0.01, 1-Cain-SD1, 1-Cal-0.1, 1-Cal-SD1, 1-Dak-0.1, 1-TribDray-1, 1-Dray-SD4). Comparison among shoreline survey sampling stations indicate that approximately 95 percent of the FC loading to the immediate receiving marine waters comes from the 7 routinely monitored TMDL sites.
- Monitoring in the Little Campbell River watershed showed high concentrations and loads of bacteria discharging to Semiahmoo Bay. Based on the model of Semiahmoo Bay (Hay and Co 2003) the larger wet-season FC loads from Little Campbell River may negatively impact FC concentrations in Drayton Harbor.
- Eight sampling events in the Blaine Harbor marina showed very high FC concentrations. including events when concentrations in the harbor were low. One or more FC sources are likely to originate from within the marina. The highest FC concentrations outside of the marina and within Drayton Harbor consistently occur at DOH station 08 and 15.
- Temperature and dissolved oxygen data exceeded the WQS in Dakota, California, and Cain creeks (Table 3), while the observed pH levels met WQS during Phase 1 data collection.
- A clear relationship between fresh water FC sources and FC concentrations in Drayton Harbor was not established. More detailed data regarding flushing, circulation patterns, and marine and fresh water mixing is required.
- Dakota, California, and Cain creeks all require large reductions in FC concentrations to meet the WQS.
- The top priority for available resources should be source identification and elimination in the Cain Creek basin (for the City of Blaine) and the upper Dakota and California Creek basins (in Whatcom County).

The goal should be to first meet the WQS by reducing FC pollution inputs to fresh and marine waters. Once that is accomplished, if FC concentrations remain above the WQS, then precisely identifying pollution sources should be further investigated. FC source identification monitoring should start in the following drainages (in order of priority):

1. Cain Creek between Pipeline Rd and behind the Blaine Trade Center. Relatively high FC loads originated in this short stream reach.
2. Wet-season sources in the North and South Forks of Dakota Creek. Over 50 percent of the FC load to Dakota Creek at Giles Rd came from the upper watershed.
3. Wet-season sources upstream of California Creek at Bruce Rd (1-Cal-6.2).
4. Unmeasured wet season sources within the tidally influenced segments of Dakota and California Creek.
5. Tributary drainages for Dakota and California Creek.
6. Direct tributary drainages to Drayton Harbor.

The summary of follow up activities to better understand the sources, fate, and transport of FC pollution are presented here along with data collection and pollution control recommendations:

- A three-dimensional FC model of Semiahmoo Bay, Drayton Harbor, and the mouths of Dakota and California creeks is needed to relate fresh water FC input loadings to high FC concentrations in the harbor.
- FC sediment sampling paired with overlying water column FC samples, in the Drayton Harbor mudflats, particularly along the banks of the tidally influenced segments of Dakota and California may gain information addressing the effects of bacteria resuspension and bio persistence on marine water quality. These sediments may serve as a reservoir and source of FC during tidal wetting and subsequent resuspension of sediments.
- Efforts should be taken to deter bird populations within the commercial area of the marina, on the east (rock portion) breakwater, and at the public wharf. Large numbers of birds and visible bird feces have been observed at all three locations.
    - A marine ornithologist should be consulted to determine the feasibility of relocating cormorant nesting habitat to a less sensitive location nearby.
    - Consideration should be given to rerouting stormwater from impervious surfaces in the marina to an onsite treatment feature or features, the new Blaine water reclamation facility, or a consolidated outfall to Semiahmoo Bay.
- Long-term monitoring should include:
    - FC samples at TMDL sampling stations, or Northwest Indian College stations at a minimum.
    - Sampling dates in the watershed should be coordinated with DOH sampling in the harbor and occur either the day before or the day of DOH sampling.
    - Ecology should reinstall the Dakota Creek continuous flow gage and equip with telemetry as a long-term WRIA 1 coastal stream station. California Creek flows could be regressed from the Dakota Creek station.
    - The combination of FC and flow in the watershed coordinated with DOH marine sampling would provide a better understanding of how FC loads from the watershed affect FC concentrations in the harbor.

## Lighthouse Point Water Reclamation Facility

The Lighthouse Point facility operation and discharge to state waters are regulated by the National Pollutant Discharge and Elimination System (NPDES) and Reclaimed Water permit number WA0022641. The facility utilizes membrane bioreactors to achieve high quality effluent. Blaine updated its general sewer plan and designed the wastewater reclamation facility with significant input from the community. Engineered facility plans were submitted in March 2006 and were approved by Ecology in May 2006 and the facility began full operation on July 19, 2010.

Recently, the City of Blaine received an EPA National Estuary Program (NEP) grant to conduct a feasibility study known as the City of Blaine Shellfish Restoration Project—DOH contract number GVL28668. The goal of this work is to improve the overall performance of the Lighthouse Point facility and infrastructure. Funding will be used to complete feasibility, design, and initial engineering work along with documentation and reporting. The project comprises the following five elements:

- Develop an outfall conceptual design to evaluate alternative diffuser configurations to improve the dilution performance of the effluent stream discharging to Semiahmoo Bay in the Strait of Georgia,
- Evaluate the existing underground 400,000-gallon influent equalization basin for leakage to determine the basin's integrity,
- Conduct a preliminary site study and design for an additional equalization basin to be sized to mitigate flooding associated with infiltration and inflow related to heavy rainfall events,
- Complete an analysis to evaluate the opportunities for redundant disinfection systems, and
- Develop a program plan to reduce infiltration and inflow to the sanitary sewer collection system and identify and prioritize related capital improvement projects.

**Collection system status**

Blaine is comprised of an east and west side, separated by the mouth of Drayton Harbor, and wastewater is generated on both sides (see Implementation Plan, Figure 11). Blaine uses two submarine force mains to transport treated and untreated wastewater from one side of the harbor to the other. The Lighthouse Point facility is in East Blaine. Piping conveys treated effluent from treatment plant facility to Semiahmoo Spit where it is either discharged from the outfall or seasonally sent to an upland golf course to be used as irrigation water.

Blaine began an infiltration and inflow (I&I) reduction project in 1998 that successfully addressed 43 illicit connections to the sanitary sewer system. In its 2017 I&I report, Blaine Public Works points out that the city's system is significantly influenced by wet weather. Excessive infiltration of 147 gallons per capita per day (gpcd) occurs, which is above EPA's allowable threshold of 120 gpcd. Further, using the highest peak daily inflow to Blaine's WWTP, the city experiences excessive inflow of 460 gpcd during significant wet weather. EPA's inflow threshold value is 275 gpcd. Blaine purchased a remote-controlled camera to systematically inspect the city's collection system. Blaine continues to smoke and dye test individual homes.

Blaine has invested in additional off-line storage for peak rain events that have contributed in the past to collection system overflows. In the past Blaine had deployed four 50,000-gallon bladder tanks during seasonal wet weather as off-line storage. These four bladder tanks (200,000 total gallons) plus the 60,000-gallon capacity of an old lift station gave the city a 260,000-gallon capacity to store wastewater for processing later. In addition to the bladder tanks, Blaine also had several tanker trucks on contract to haul wastewater around Drayton Harbor to the plant on Semiahmoo Drive. In the fall of 2006, Blaine completed installation of an off-line storage vault under Marine Drive to handle 400,000 gallons of wastewater and thereafter discontinued use of the bladder tanks.

**Authorized Beneficial Uses**

Lighthouse Point is authorized to distribute Class A reclaimed water for irrigation and water features. Currently Blaine has two contracts to sell reclaimed water seasonally, May through September. One is to Semiahmoo Golf Course and Country Club, and the second is with Gleneagle development. Lighthouse Point also seasonally uses reclaimed water for a water feature, on-site toilet flushing, and on-site irrigation in public areas adjacent to the plant. Additional infrastructure for reclaimed water distribution (purple pipe) is planned for the Blaine Marina area around Lighthouse Point.

**Applicable Regulations**

The following regulations apply to domestic wastewater NPDES permits:

- Procedures Ecology follows for issuing NPDES permits (chapter 173-220 WAC).
- Technical criteria for discharges from municipal wastewater treatment facilities (chapter 173-221 WAC).
- Water quality criteria for surface waters (chapter 173-201A WAC).
- Water quality criteria for groundwaters (chapter 173-200 WAC).
- Whole effluent toxicity testing and limits (chapter 173-205 WAC).
- Sediment management standards (chapter 173-204 WAC).
- Submission of plans and reports for construction of wastewater facilities (chapter 173-240 WAC).

These rules require any treatment facility owner/operator to obtain an NPDES permit before discharging wastewater to state waters. They also help define the basis for limits on each discharge and for requirements imposed by the permit.

In enacting the Reclaimed Water Use law, chapter 90.46 RCW[47], the Washington State Legislature found that it was in the best interest of present and future generations to encourage the use of reclaimed water in ways that protect the environment as well as the health and safety of all Washington citizens. The law directed Ecology, in coordination with the DOH, to adopt rules for reclaimed water use. Ecology adopted the Reclaimed Water Rule, chapter 173-219 WAC, in January 2018.

[47] https://app.leg.wa.gov/RCW/default.aspx?cite=90.46

**Permit Limits**
Federal and state regulations require that effluent limits in an NPDES permit must be either technology- or water quality-based.

- Technology-based limits are based upon the treatment methods available to treat specific pollutants. Technology-based limits are set by the EPA and published as a regulation, or Ecology develops the limit on a case-by-case basis (40 CFR 125.3, and chapter 173-220 WAC).
- Water quality-based limits are calculated so that the effluent will comply with the Surface Water Quality Standards (chapter 173-201A WAC), Ground Water Standards (chapter 173-200 WAC), Sediment Quality Standards (chapter 173-204 WAC), or the National Toxics Rule (40 CFR 131.36).
- Ecology must apply the most stringent of these limits to each parameter of concern. Lighthouse Point has technology-based effluent limits for FC to meet the WLA.

**Water Rights Protection**
Chapter 90.46.120 RCW states that the owner of a wastewater treatment facility producing reclaimed water under a reclaimed water permit has the exclusive rights to that water. That right is tempered, however, by chapter 90.46.130 RCW, which states that the use of reclaimed water must not impair any existing water rights downstream of any fresh water discharge points of the facilities unless compensation or mitigation is agreed upon by the holder of the affected water right. Ecology cannot issue a reclaimed water permit unless the permit applicant demonstrates compliance with water rights protection.

**Discharge to Semiahmoo Bay**
Treated and disinfected effluent flows into Semiahmoo Bay and the Strait of Georgia through a single outfall (outfall 001) on Semiahmoo Spit. The outfall is 2,460 feet long with an attached 64-foot-long diffuser, at a depth of 37 feet. The 24-inch diameter concrete outfall pipe is a bell and spigot type. Washington State Department of Health has designated a 900-foot radius shellfish closure zone around the diffuser. As standard practice, harvesting in shellfish growing areas near WWTP outfalls is classified as prohibited.

The Drayton Harbor TMDL sets the Lighthouse Point FC WLA at a level that meets the surface water quality standards at the edge of the mixing zone for discharges to outfall 001 to Semiahmoo Bay in the Georgia Strait. A mixing zone is the defined area in the receiving water surrounding the discharge port(s), where wastewater mixes with receiving water. Within mixing zones, the pollutant concentrations may exceed water quality numeric standards, so long as the discharge doesn’t interfere with designated uses of the receiving water body—for example, recreation, water supply, and aquatic life and wildlife habitat. The pollutant concentrations outside of the mixing zones must meet water quality numeric standards.

The edge of the chronic mixing zone has a 269-foot radius (538-foot diameter) around the outfall 001 diffuser. For comparison, the DOH has designated a 900-foot radius shellfish closure zone around the diffuser. Under critical conditions, the permitted effluent discharge and conservative FC WLA meets the water quality criteria at the mixing zone boundary and beyond into the DOH closure zone. For permitting purposes, the outfall mixing analysis also establishes the acute mixing zone with a 60-foot radius that only applies to aquatic life-based water quality criteria, which does not include shellfish harvesting for human health. The acute mixing zone analysis is therefore not incorporated into the FC WLA.

Ecology modeled the numbers of FC by simple mixing analysis using the technology-based limit of 400 cfu/100 mL and a dilution factor of 69 at the edge of the chronic mixing zone. Under critical conditions, modeling predicts no violation of the water quality criterion for FC with a value of 10 cfu/100 mL at the edge of the mixing zone, which includes a 5 cfu/100 mL background ambient concentration in the receiving marine water of Semiahmoo Bay.

During November 4-8, 2012, a hydrographic dye study was conducted in Semiahmoo Bay and Drayton Harbor to better understand the dilution, time of travel, and dispersion of effluent from outfall 001 (FDA 2014). The study showed that dye concentrations were 2 to 3 times greater at the surface than at depth. As a conservative measure, concentrations observed at the surface were used to determine the 1,000:1 dilution ratio between effluent and marine water. The 1,000:1 ratio is the dilution level recommended by the U.S. Food and Drug Administration (FDA) to moderate the impact of viruses from conventional WWTPs under routine operations, which is delineated just south of the entrance to the harbor.

Effluent time of travel analysis was done to quantify the time elapse before effluent reaches the nearest growing area in the harbor. The travel time for effluent to reach the harbor growing area is 24.2 hours based on the dye concentrations recorded at the surface. In the event of a Lighthouse Point facility upset, this allows over a day to close the growing area.

*WLA Calculations*

Instead of using the weekly geometric mean effluent limit of 400 FC cfu/100 mL, the WLA in units of b.cfu/day assigned to the Lighthouse Point facility is developed using the following input values to Equation 18—see Appendix E, Loading Capacity:

- The monthly geometric mean permitted effluent limit of 200 FC cfu/100 mL as a conservative measure along with,
- The maximum monthly average design flow of 2.4 cfs (1.54 MGD).

For comparison, effluent discharge rates obtained from the DMR covering 3/1/2019—12/31/2023 show a geometric mean of 1.1 cfs during the wet season and 0.7 cfs during the dry season. The associated NPDES permit incorporates the technology-based effluent limit for FC bacteria that meets the WQS outside of the chronic mixing zone. The DMR demonstrates that the facility will attain the FC WLA given the monthly geometric means are consistently near

2 cfu/100 mL and the daily maximum rarely exceed 70 cfu/100 mL, and the geometric mean average daily loading is between 0.1 and 0.012 b.cfu/day, which is well below the 11.7 b.cfu/day WLA (Figures 12 and 13). Further, the DMR data show an annual loading rate of 0.03 FC b.cfu/day, a wet season loading rate of 0.05 b.cfu/day, and a dry season loading rate of 0.02 b.cfu/day.

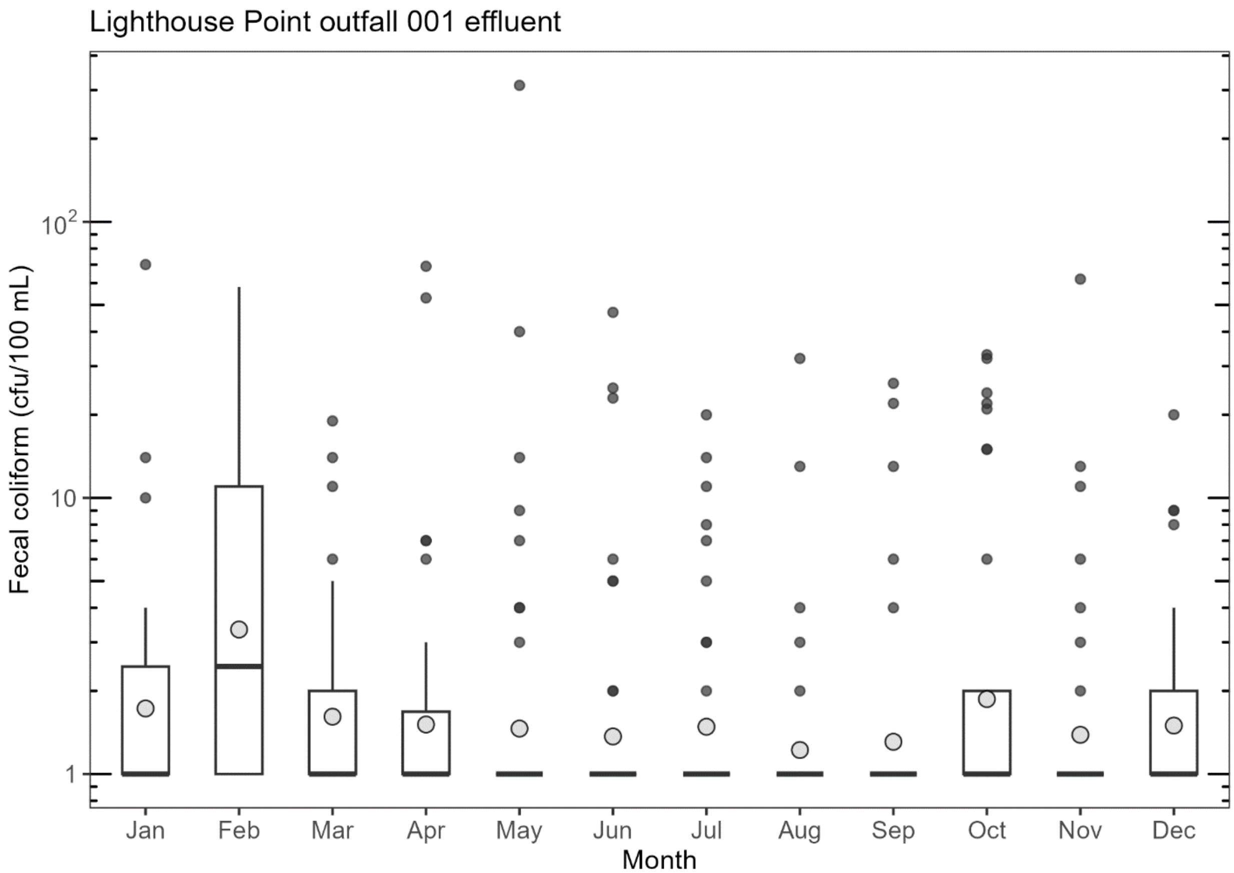


**Figure A-5. Monthly FC discharge concentrations (3/1/2019—12/31/2023) from the Lighthouse Point facility, median (—), geomean (●)**

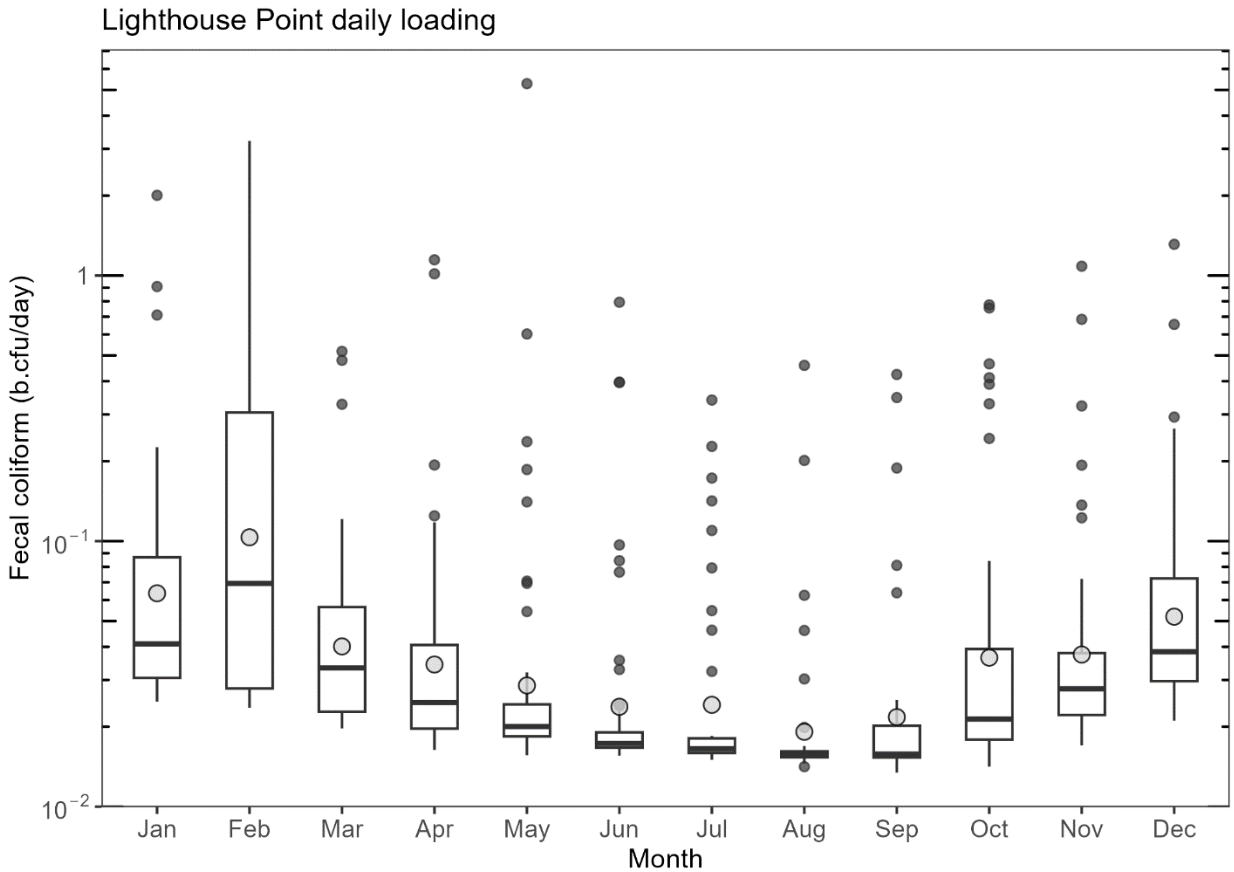


**Figure A-6. Monthly FC loading (3/1/2019—12/31/2023) from the Lighthouse Point facility, geomean (●)**

# Appendix B. Public Participation

## Public Comment

During project development, Ecology received input from the, <enter organization’s names here> and members of the public. The draft TMDL and Implementation Plan was posted on Ecology’s website and shared with the public and governmental organizations following Washington’s public participation statute requirements. Ecology held an online public presentation workshop on <Month, day, year from :00 pm to :00 pm>. The 30-day public comment period for this TMDL and Implementation Plan was from <Month, XX through XX, 2025>. Ecology sent a news release to local interested parties and to all local media and work groups in the watershed. Ecology announced the workshop using online outreach platforms through listserv and on the <enter hyperlink and include the following text: Washington State Department of Ecology’s homepage >.

Ecology welcomes and appreciates public involvement, which is integral to improving and protecting water quality in the Drayton Harbor watershed. Coordination with governmental and non-governmental organizations is essential for TMDL development and implementation. The comments on the draft TMDL and Implementation Plan are provided below along with Ecology’s response. This Comment and Response section is organized starting with those received from the members of the public and followed by those received from governmental organizations.

## Comments and Response

# Appendix C. Glossary, Acronyms, and Abbreviations

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

**Assessment Unit (AU):** A water body segment or portion of a water body segment from which data are evaluated to determine compliance with water quality standards. Assessment units are typically delineated using the NHD reaches for fresh waters and grids for open water bodies. AUs are the basis for identifying water body listings.

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

**Box and whisker plot explaination**: Presented in figures as a tool to visualize datapoint distributions. The box represents the interquartile range—$25^{th}$, $50^{th}$ (median), and $75^{th}$ percentiles. The whiskers represent the expected range under the given distribution by showing the smallest and largest values within 1.5 times beyond the interquartile range. The dots represent extreme values outside the expected range known as outliers according to these box and whisker plot specifications.

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

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

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

**Enterococci:** A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum,* and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C. Enterococci bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Enterococci are expressed as colony forming units (cfu) or most probable number (MPN) per 100 mL used to measure the protection of contact recreation designated use of the Washington State water quality standard in marine waters.

**Escherichia coli (E. coli):** A subgroup of fecal coliform, which are present in intestinal tracts and feces of warm-blooded animals, where some strains are pathogenic. *E. coli* bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. *E. coli* is expressed as colony forming units (cfu) or most probable number (MPN) per 100 mL used to measure the protection of contact recreation designated use of the Washington State water quality standard in fresh waters.

**Exceeded criteria**: Did not meet criteria.

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

**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. Fecal coliform is expressed as colony forming units (cfu) or most probable number (MPN) per 100 mL used to measure the protection of shellfish harvesting designated use of the Washington State water quality standard.

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

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

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

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

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

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

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

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

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

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

**pH**: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

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

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

**Pollution:** 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 are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate designated uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

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

**Reach**: A specific portion or segment of a stream.

**Salmonid**: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char.

**Site Potential Tree Height**: The average maximum height of the tallest dominant trees for a given site class; the index tree age is 200 years, except where shorter-lived trees (such as cottonwoods) are the tallest dominant trees.

**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 water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided. In context of water quality improvement activities, the TMDL is synonymous with a water quality or watershed cleanup plan.

**Total suspended solids (TSS)**: The suspended particulate matter in a water sample as retained by a filter.

**Turbidity**: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

**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.

**Chronic critical effluent concentration:** The maximum concentration of effluent during critical conditions at the boundary of the mixing zone assigned in accordance with WAC 173-201A-100. The boundary may be based on distance or a percentage of flow. Where no mixing zone is allowed, the chronic critical effluent concentration shall be 100 percent effluent.

**Critical condition:** When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 (see definition) flow event unless determined otherwise by the department.

**Dilution factor:** The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100.

**Riparian:** Relating to the banks along a natural course of water.

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

## Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

| | |
|---|---|
| ATTAINS | Assessment, Total Maximum Daily Load Tracking and Implementation System |
| AU | assessment unit (defines a water body segment) |
| Ave | avenue |
| b.cfu | billions of colony forming units |
| BMPs | best management practices |
| CAO | Critical Area Ordinances |
| CFR | Code of Federal Reserve |
| cfs | cubic feet per second |
| cfu | colony forming unit |
| CPAL | Conservation Program on Agricultural Lands |
| Cr | creek |
| CWG | Clean Water Guidance |
| DMR | Discharge Monitoring Report |
| DOH | Washington State Department of Health |
| Ecology | Washington State Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| ERTS | Environmental Report Tracking System |
| FDA | Food and Drug Administration |
| FOTG | Field Office Technical Guide |
| GIS | Geographic Information System |
| gpcd | gallons per capita per day |
| IP | Individual Permit |
| LA | load allocation |
| LC | loading capacity |
| MF | membrane filter |
| MGD | millions of gallons per day |

| | |
|---|---|
| MOS | margin of safety |
| MPN | most probable number |
| MS4 | municipal separate storm sewer system |
| MST | microbial source tracking |
| NF | north fork |
| NHD | National Hydrography Dataset |
| NLCD | National Land Cover Database |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resource Conservation Service |
| OSS | On-site Sewage System |
| PNNL | Pacific Northwest National Laboratory |
| POTW | publicly owned treatment works |
| PCR | polymerase chain reaction |
| QAPP | Quality Assurance Project Plan |
| RCW | Revised Code of Washington |
| Rd | road |
| RM | river mile |
| SF | south fork |
| SM | Standard Method |
| SSM | Salish Sea Model |
| SSM-fb | Salish Sea Model-fecal bacteria module |
| St | street |
| SMAP | Stormwater Management Action Plan |
| SWMP | Stormwater Management Plan |
| SWP | stormwater permit |
| TMDL | total maximum daily load |
| US | United States |
| USDA | United States Department of Agriculture |
| USFS | United States Forest Service |
| USGS | United States Geological Survey |
| WA | Washington State |
| WAC | Washington Administrative Code |
| WCHCS | Whatcom County Health and Community Services |
| WCWP | Whatcom Clean Water Program |
| WDFW | Washington Department of Fish and Wildlife |
| WLA | wasteload allocation |
| WRIA | Water Resources Inventory Area |
| WSDA | Washington State Department of Agriculture |
| WWTP | wastewater treatment plant |
| WY | water year |

## Units of Measurement

| | |
|---|---|
| °C | degrees centigrade, temperature |
| cfs | cubic feet per second, streamflow discharge |
| cfu | bacteria colony forming unit, count |
| cfu/100 mL | colony forming unit, concentration |
| b.cfu/day | billions of colony forming units per day, load or flux |
| cms | cubic meters per second, streamflow, discharge |
| °F | degrees Fahrenheit, temperature |
| ft | feet, length |
| in | inch, length |
| $km^2$ | square kilometer, area |
| m | meter, length |
| $m^2$ | square mile, area |
| mgd | million gallons per day, discharge |
| mL | milliliters, volume |
| psu | practical salinity units, concentration similar to ppt |
| ppt | parts per thousand, concentration |
| mS/cm | microsiemens per centimeter, conductivity |

# Appendix D. Analytical Framework

The goal of this TMDL study is to develop a plan to improve water quality to meet Washington WQS for bacteria within the Drayton Harbor watershed. This study is conducted in two phases. Phase 1 involved project planning and data collection to assess watershed conditions and initiate TMDL calculations (Mathieu and Sargeant 2008). Phase 2 involved drafting of the TMDL Implementation Plan, assessing long-term trends, characterizing the relationship between fresh water and marine water samples, and establishing TMDLs using contemporary information. The analytical framework used to calculate TMDLs and assess the water quality conditions include:

1. Applying fresh water designated use protection criteria,
2. Applying marine water designated use protection criteria,
3. Characterizing the relationship between the fresh and marine water quality,
4. Characterizing the relationship between fecal bacteria indicators FC and *E. coli* to develop a translator,
5. Applying the Statistical Theory of Rollback (STR) to develop load reductions,
6. Modeling streamflow hydrology to calculate instantaneous and seasonal loading,
7. Assessing seasonal variation to account for the critical period,
8. Assessing critical conditions by examining the relationship between
    a. FC concentrations and precipitation,
    b. FC concentrations in freshwater tributaries and in the harbor,
    c. FC bacteria instantaneous loading and FC concentrations in the harbor,
9. Conducting trend analysis to better understand changes in water quality over time and the effects of existing pollution control efforts, and
10. Calculating and establishing TMDLs to protect marine and fresh water designated uses.

## Approach

The growing concern over FC pollution in Drayton Harbor prompted the initiation of the bacteria TMDL study. In late 2007 Ecology began Phase 1 of the study, which included field data collection with the goals of calculating TMDLs and completing Improvement Plan (Mathieu and Sargeant 2008). Drafting the Implementation Plan was slow to develop, however, local groups organized and increased cleanup efforts under the WCWP. One of the many objectives of the program included collaborative data collection and information sharing. Since Phase 1 of the TMDL study, additional data became available through the WCWP, which became important to include in the TMDL analysis. Phase 2 of this TMDL study incorporates contemporary data from WY 2020 and 2021 and accounts for potential changes in water quality since Phase 1.

## Phase 1 TMDL Initiation

Phase 1 of the TMDL was completed in 2008 as described in the Quality Assurance Project Plan (QAPP) (Mathieu and Sargeant 2008). The Phase 1 project goal is to ensure that both impaired marine and fresh water within the study area will attain WQS by establishing TMDLs. The Phase 1 project study objectives include:

- Establish load allocations for nonpoint sources and wasteload allocations for point sources to meet the WQS and protect designated uses, including 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, and
- Identify relative contributions of FC loading to Drayton Harbor so clean-up activities can focus on the largest sources.

**Ambient Monitoring**

From December 2007 to December 2008, Ecology and Whatcom County collected bacteria and streamflow data from 34 sites throughout the watershed on 23 routine sampling events (Table D-1). The DOH collected FC samples from the harbor at 11 routine stations, as well as 3 new stations in Semiahmoo Bay that were added for the TMDL, for a total of 10 sampling events. Ecology analyzed the marine and fresh water data to determine how much the current levels of bacteria needed to be reduced to meet the WQS, both in the harbor and in the watershed. Phase 1 final sample data is available online through Ecology's Environmental Information Management System (EIM)[48], user study (NMat0001).

**Table D-1. Fresh water monitoring locations for Phase 1 of the Drayton Harbor bacteria TMDL study**

| Site ID | Description | Latitude | Longitude |
|---|---|---|---|
| Dakota Creek Watershed | | | |
| 1-TribDak-S2 | Tributary to South Fork Dakota Creek at Sunrise Rd | 48.94463 | -122.59646 |
| 1-TribDak-S1 | Tributary to South Fork Dakota Creek at Delta Line Rd | 48.94784 | -122.61629 |
| 1-SFDak-2.2 | South Fork Dakota Creek at Sunrise Rd | 48.94306 | -122.59647 |
| 1-TribDak-N2 | Tributary to North Fork Dakota Creek near Delta Line Rd | 48.96554 | -122.61708 |
| 1-NF-Dak-2.5 | North Fork Dakota Creek at Delta Line Road | 48.96971 | -122.61579 |
| 1-TribDak-N1 | Tributary to North Fork Dakota Creek at Haynie Rd | 48.97131 | -122.62618 |
| 1-NF-Dak-0.1 | North Fork Dakota Creek at Custer School Rd | 48.95107 | -122.6379 |
| 1-SF-Dak-0.2 | South Fork Dakota Creek at Custer School Rd | 48.95033 | -122.63792 |
| 1-Dak-4.9 | Dakota Creek at Valley View Rd | 48.95715 | -122.65964 |
| 1-TribDak-5 | Tributary to Dakota Creek (Haynie Creek) at Valley View Rd | 48.9652 | -122.66007 |

[48] https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

| Site ID | Description | Latitude | Longitude |
|---|---|---|---|
| 1-Dak-3.1 | Dakota Creek at Giles Street | 48.96272 | -122.68204 |
| 1-TribDak-3 | Tributary to Dakota Creek at Rogers Rd | 48.97034 | -122.69307 |
| 1-TribDak-4 | Tributary to Dakota Creek at Hoier Rd | 48.97195 | -122.70018 |
| 1-TribDak-2 | East tributary to Dakota Creek at Blaine-Lynden Rd | 48.97911 | -122.70841 |
| 1-TribDak-1 | West tributary to Dakota Creek at Blaine-Lynden Rd | 48.97915 | -122.7196 |
| 1-Dak-0.1 | The mouth of Dakota Creek at SR 548/Blaine Rd | 48.97231 | -122.72936 |
| California Creek Watershed | | | |
| 1-TribCal-4 | Tributary to California Creek at Bay Rd | 48.90633 | -122.64965 |
| 1-Cal-6.2 | California Creek at Bruce Rd | 48.90928 | -122.64406 |
| 1-TribCal-5 | Tributary to California Creek at Main St in Custer | 48.91725 | -122.64927 |
| 1-Cal-5.0 | California Creek at Valley View Rd | 48.92136 | -122.66039 |
| 1-TribCal-3 | Tributary to California Creek at Arnie Rd | 48.9211 | -122.684 |
| 1-Cal-3.1 | California Creek at Birch Bay-Lynden Rd | 48.93575 | -122.68878 |
| 1-TribCal-2 | Tributary to California Creek at Kickerville Rd | 48.94953 | -122.70449 |
| 1-TribCal-1 | Tributary to California Creek at Fleet Rd | 48.9485 | -122.72206 |
| 1-Cal-0.8 | California Creek at SR548/ Blaine Rd | 48.95468 | -122.72617 |
| 1-Cal-0.1 | The mouth of California Creek at Drayton Harbor Rd | 48.95827 | -122.73005 |
| 1-Cal-SD1 | Outfall to California Creek at its mouth | 48.96217 | -122.73289 |
| 1-TribCal-0 | Tributary to California Creek @ SR548/ Blaine Rd | 48.9623 | -122.73235 |
| Cain Creek Watershed | | | |
| 1-Cain-1.3 | Cain Creek at Pipeline Rd near airport | 48.98768 | -122.73432 |
| 1-Cain-0.4 | Cain Creek below beaver dam near Blaine Trade Center | 48.99295 | -122.74513 |
| 1-Cain-0.01 | The mouth of Cain Creek | 48.99697 | -122.75463 |
| 1-Cain-SD1 | Outfall to Semiahmoo Bay near the mouth of Cain Creek | 48.99712 | -122.75439 |
| Direct Drainages to Drayton Harbor | | | |
| 1-TribDray-1 | Tributary to harbor at Hall St & Dearborn Rd | 48.96813 | -122.73312 |
| 1-Dray-SD4 | 36" culvert to harbor east of Albert St and Peace Portal Dr | 48.98246 | -122.73935 |

**Bacteria Concentrations and Loadings**

Ecology calculated Beale's load estimates summarized by the wet and dry seasons for all sites with adequate data (Lyubchich et al. 2023, Beale 1962). These seasonal load estimates were calculated for the Dakota and California Creek basins (Figures D-1—4). Residual loads represent some combination of the unmeasured FC load and the variability associated with instantaneous bacteria sampling and analysis and instantaneous flow measurements. The Cain Creek basin did not have sufficient and reasonable data to conduct the Beale's loading analysis due to the lack of continuous flow data and unreliable relationships with gaged flow stations.

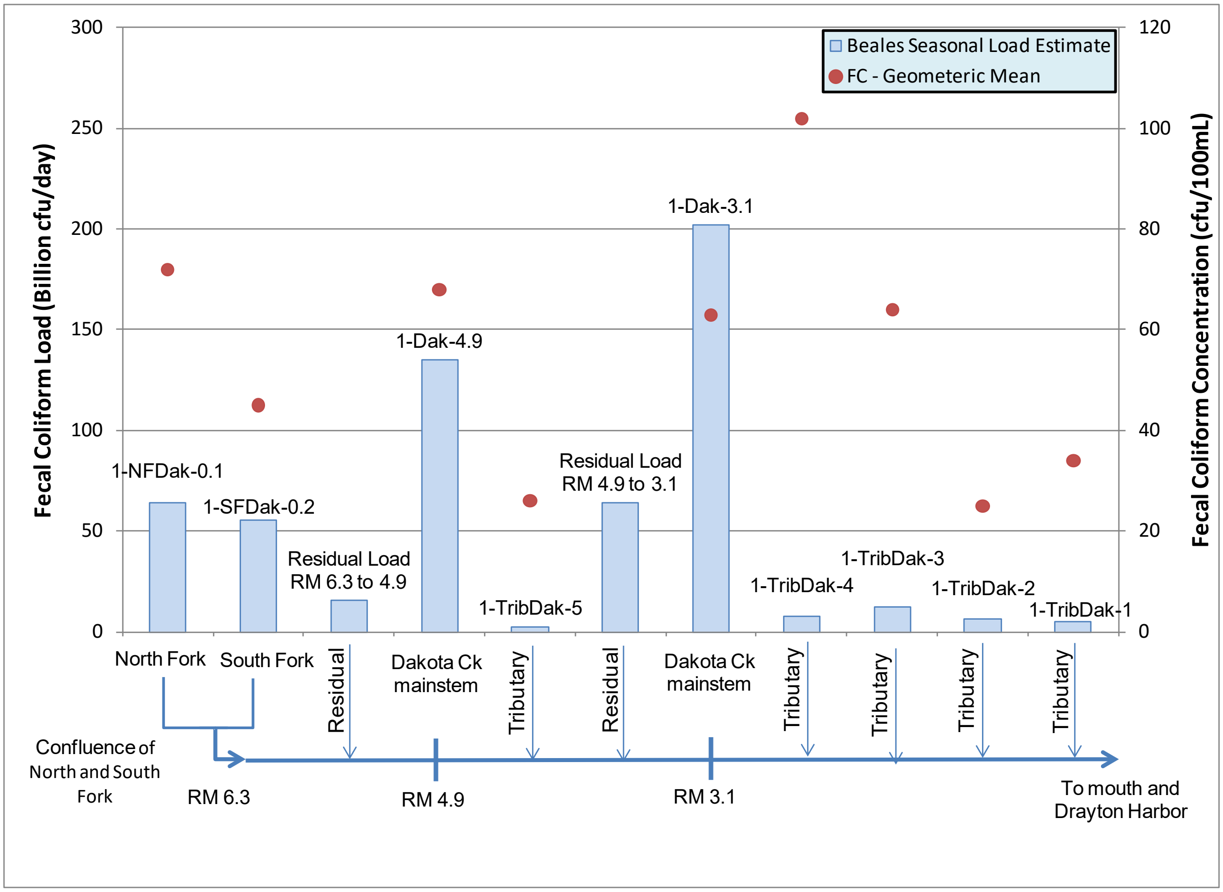


**Figure D-1. Phase 1 wet season Beale's FC loading estimates for the Dakota Creek subbasin**

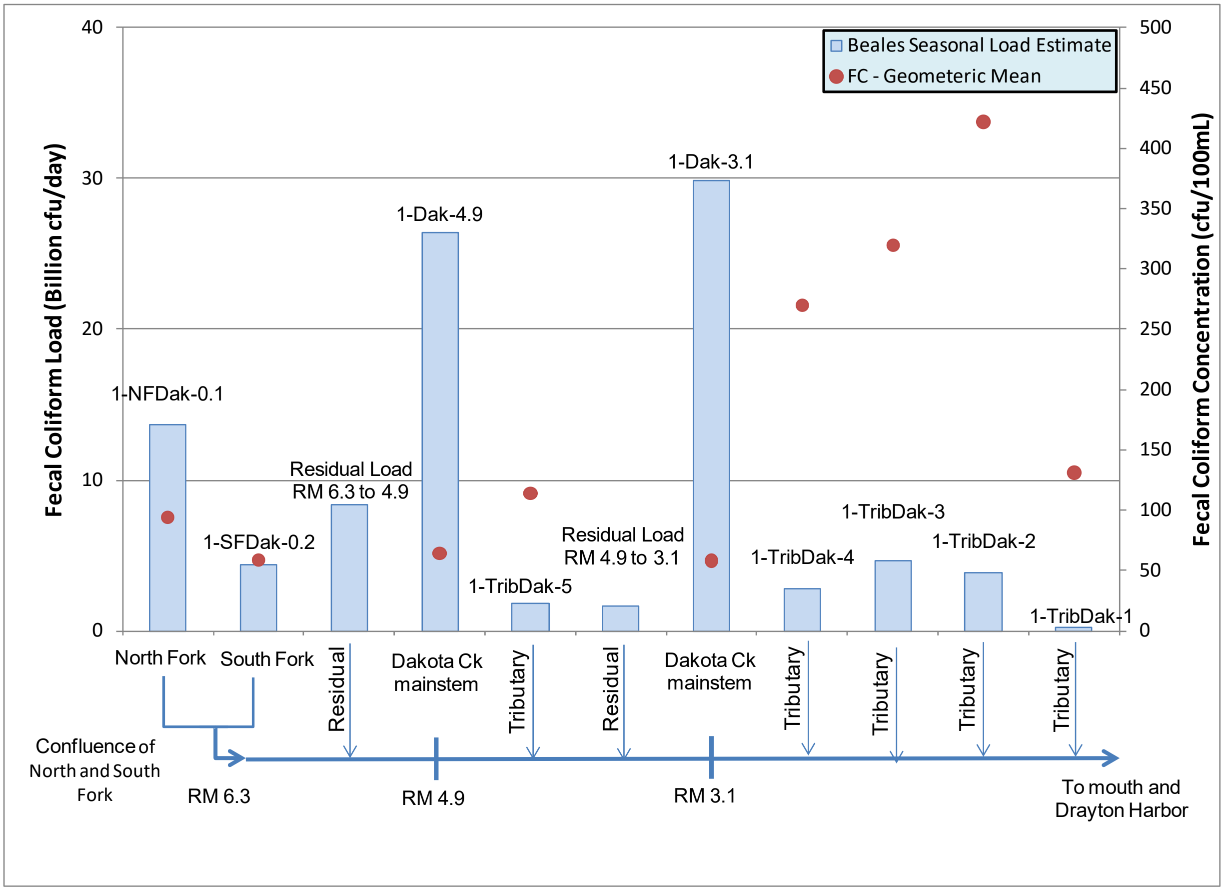


**Figure D-2. Phase 1 dry season Beale's FC loading estimates for the Dakota Creek subbasin**

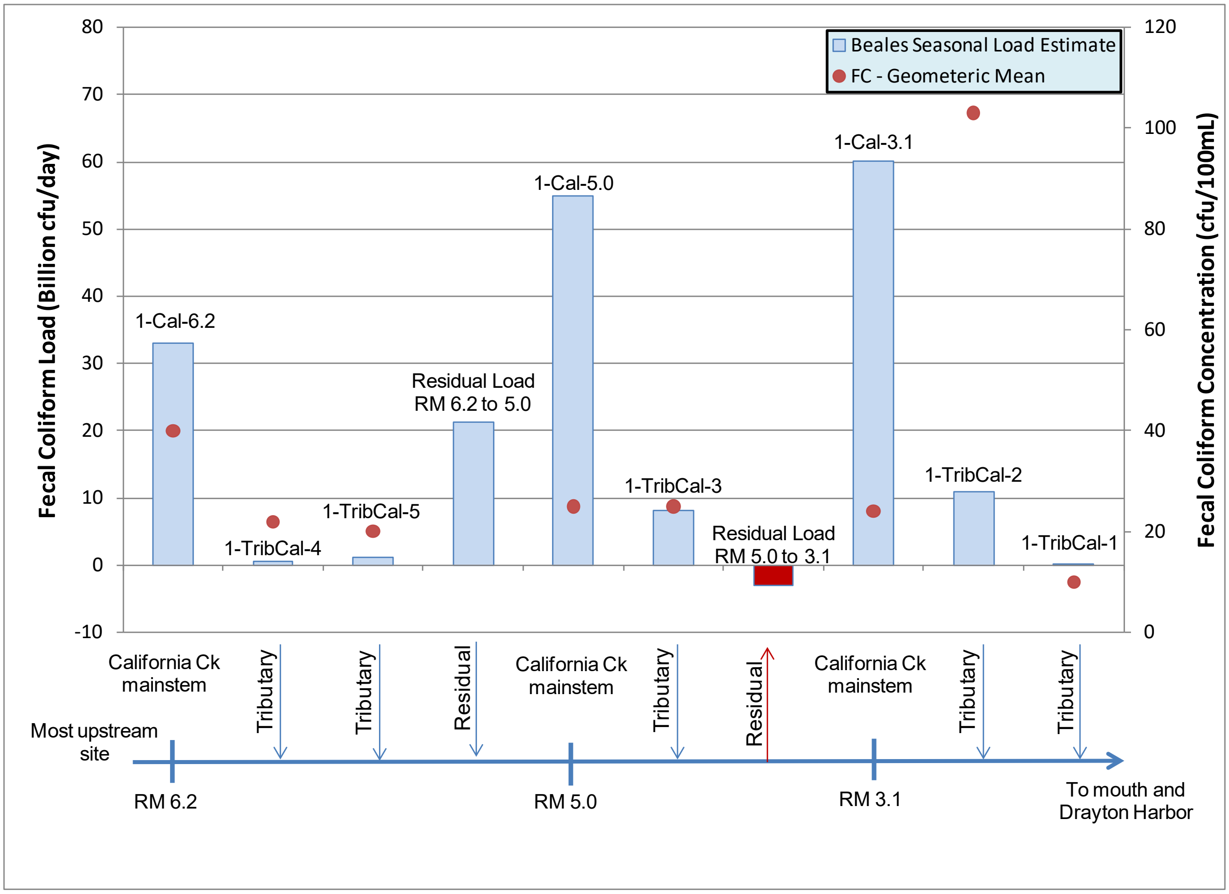


**Figure D-3. Phase 1 wet season Beale's FC loading estimates for the California Creek subbasin**

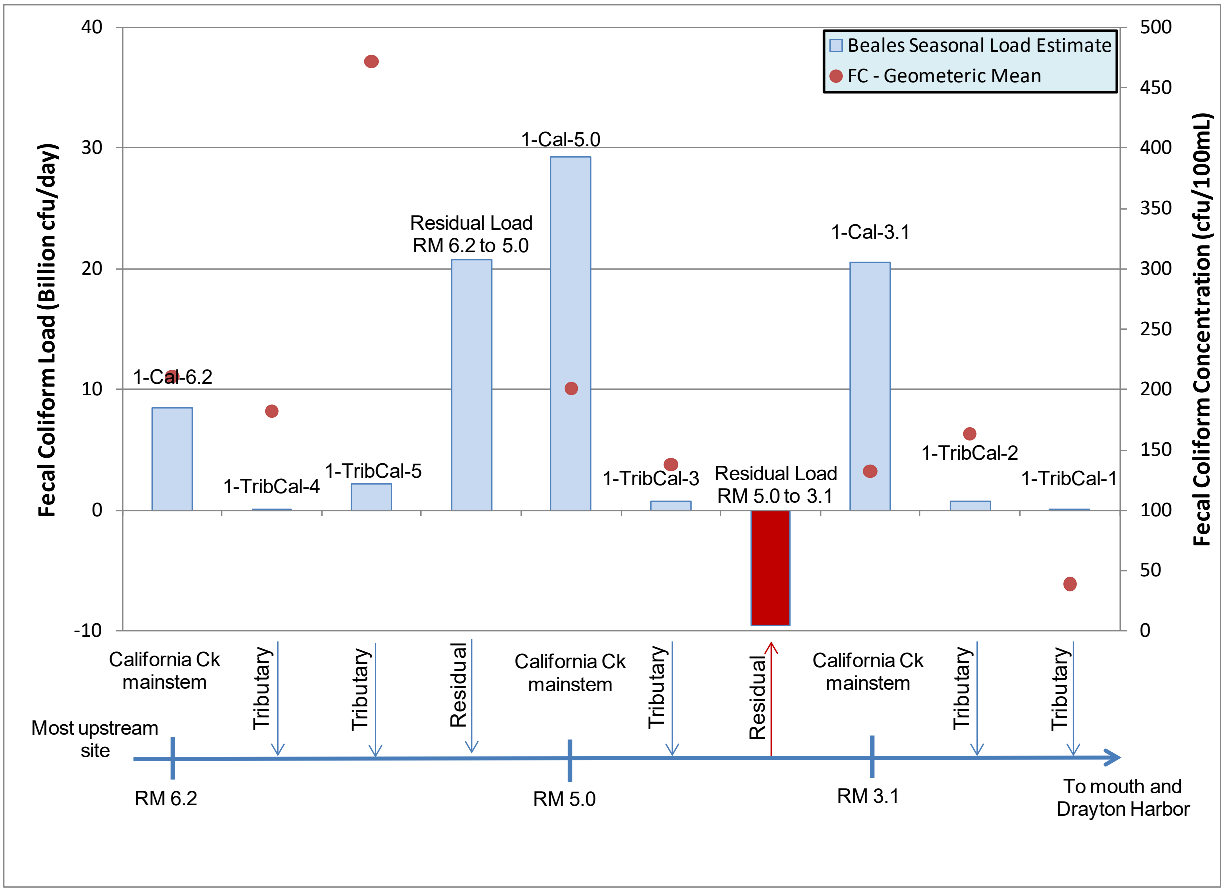


**Figure D-4. Phase 1 dry season Beale's FC loading estimates for the California Creek subbasin**

Paired Wilcoxon rank-sum tests were done to detect significant differences in FC concentrations and streamflow between upstream and downstream sampling locations (Table D-2).

**Table D-2. Phase 1 group comparisons using Wilcoxon rank-sum tests between sampling sites that bracket each designated stream reach separated by season and basin**

| Stream Reach and Season | FC (cfu/100mL) Difference[1] | P-value | Flow (cfs) Difference | P-value |
|---|---|---|---|---|
| Wet Season | | | | |
| Forks to Dak-4.9 | -10 | 0.53 | +6.59 | **0.03*** |
| Dak-4.9 to Dak-3.1 | +5 | 0.86 | +13.5 | **0.05*** |
| Dak-3.1 to Dak-0.1 | +18 | 0.21 | no data | no data |
| Cal-6.2 to Cal-5.0 | -18 | 0.11 | +14.38 | **0.00*** |
| Cal-5.0 to Cal-3.1 | -5 | 0.52 | +5.13 | **0.04*** |
| Cal-3.1 to Cal-0.8 | +6 | 0.45 | no data | no data |
| Cal-0.8 to Cal-0.1 | +24 | 0.29 | no data | no data |
| Cain-1.3 to Cain-0.4 | +276 | **0.00*** | +1.82 | **0.00*** |
| Cain-0.4 to Cain-0.1 | -6 | 0.61 | +0.62 | **0.00*** |

| Stream Reach and Season | FC (cfu/100mL) Difference[1] | P-value | Flow (cfs) Difference | P-value |
|---|---|---|---|---|
| Dry Season | | | | |
| Forks to Dak-4.9 | -22 | **0.03*** | +2.27 | **0.01*** |
| Dak-4.9 to Dak-3.1 | -6 | 0.51 | +2.84 | **0.00*** |
| Dak-3.1 to Dak-0.1 | -49 | **0.00*** | no data | no data |
| Cal-6.2 to Cal-5.0 | -9 | 0.86 | +3.31 | **0.00*** |
| Cal-5.0 to Cal-3.1 | -93 | **0.07*** | -0.48 | 0.25 |
| Cal-3.1 to Cal-0.8 | -110 | **0.00*** | no data | no data |
| Cal-0.8 to Cal-0.1 | -18 | **0.01*** | no data | no data |
| Cain-1.3 to Cain-0.4 | +269 | **0.03*** | +0.31 | **0.00*** |
| Cain-0.4 to Cain-0.1 | +70 | 0.53 | +0.08 | **0.01*** |

* Values indicate statistical significance ($p < 0.05$, $\alpha = 0.05$)

[1] Geometric mean

During the wet season in the Dakota Creek basin, flows increased significantly from the confluence of the north and south forks to river mile 4.9 (Dak-4.9) and from river mile 4.9 to 3.1 (Dak-3.1). Although the average FC load increased in both these stretches (Figures D-1 and 2), the FC concentrations did not significantly increase or decrease. This suggests that the FC concentration of the incoming flow is not drastically lower or higher than the receiving waters. Over 50 percent of the FC load originated upstream of the confluence of the north and south fork. The highest FC counts and loads occurred during the early November first flush storm event. Nonpoint source stormwater runoff or sediment resuspension upstream of Dak-3.1 are two possible sources of FC bacteria.

During the dry season in the Dakota Creek basin, FC concentrations decreased significantly within two stream reaches.

- From the confluence of the north and south forks to river mile 4.9 (Dak-5) the geometric mean decreased by 22 cfu/100mL,
    - A significant increase in flow occurred in this reach,
    - The average residual FC load was positive (increased),
    - This decrease in FC concentration suggests the incoming flow in this stretch likely had lower FC concentrations then the receiving waters, and
    - Some portion of the decrease was likely due to dilution, or FC loss from mortality, predation, settling, or UV radiation.
- From river mile 3.1 to 0.1 the geometric mean decreased by 49 cfu/100mL,
    - This decrease occurred within the tidal influence of the harbor and was likely due to some combination of the FC loss and dilution with marine water or mortality.

During the wet season in the California Creek basin, the streamflows increased significantly from Cal-6.2 to Cal-5.0 and from Cal-5.0 to Cal-3.1. However, the average FC load increased from Cal-6.2 to Cal-5.0 and decreased from Cal-5.0 to Cal-3.1 (Figures D-3 and 4), while the FC concentrations did not significantly differ. This suggests that the FC concentration of the incoming flow is not different than the receiving waters.

During the dry season in the California Creek basin, FC concentrations decreased significantly in three reaches:

- From Cal-5.0 to Cal-3.1, the geometric mean decreased by 93 cfu/100mL,
  - A significant change in flow did not occur in this reach, and
  - The decrease in FC likely represents a dry season loss rate due to mortality, predation, settling, or UV radiation.
- From Cal-3.1 to Cal-0.8 the geometric mean decreased by 110 cfu/100mL likely due to some combination of the FC loss and dilution with marine water or mortality.
- Similarly, from Cal-0.8 to Cal-0.1 the geometric mean decreased by 18 cfu/100mL, which may further illustrate the effects of marine water on bacteria survival and dilution.
- The decreases from Cal-3.1 to Cal-0.1 are within the tidal influence of the harbor and are likely due to some combination of the FC morality and dilution with marine water.

During both the wet and dry seasons in the California Creek basin, there was an average positive residual (increased) FC load from Cal-6.2 to Cal-5.0 and an average negative residual (decreased) FC load from Cal-5.0 to Cal-3.1. The FC load increase from Cal-6.2 to Cal-5.0 is likely due to the significant flow increase in this reach during both seasons. The cause of the load decrease from Cal-5.0 to Cal-3.1 is likely due to the loss rate discussed above. Over 50 percent of the FC load originated upstream of California Creek at Bruce Rd (Cal-6.2). Similar to the upper reaches in the Dakota Creek basin, the highest FC counts and loads occurred during the early November first flush storm event in the upper California Creek basin. The FC nonpoint source stormwater runoff or sediment resuspension upstream of Cal-3.1 are two possible sources of FC.

In the Cain Creek basin, there was an increase in the FC geometric mean values from river mile 1.3 downstream to river mile 0.4 near the mouth. During the wet season, approximately 50 percent of the total FC load originated within this reach with an average increase of 87.5 b.cfu/day along with a geometric mean increase of 276 cfu/100mL (Table D-3). During the dry season, over 90 percent of the total FC load originated within this reach with an average increase of 6.5 b.cfu/day along with a geometric mean increase of 269 cfu/100mL. Stormwater runoff contaminated with FC is a likely source. In addition, under little to no antecedent rainfall, the FC concentrations were above the water quality criteria, which indicates a steady source such as cross-connections, failing OSS, or illicit discharges.

**Shoreline Surveys**

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. To better assess the contribution of FC loading from these drainages, Ecology conducted 3 shoreline discharge surveys on 1/14/2008, 5/27/2008, and 1/12/2009-1/13/2009. FC samples and discharge measurements (or estimates) were collected from sites around the shoreline. During the surveys, field staff collected 119 FC samples and measured flows (when possible) at 49 new shoreline discharges, as well as 7 routine TMDL sites located on the shore (Table D-3), site IDs: 1-Cain-0.01, 1-Cain-SD1, 1-Cal-0.1, 1-Cal-SD1, 1-Dak-0.1, 1-TribDray-1, 1-Dray-SD4).

**Table D-3. Drayton Harbor Phase 1 shoreline survey sampling locations**

| Location ID | Location Description | Latitude | Longitude |
|---|---|---|---|
| 1-DrayShore-1 | 12" black plastic pipe near gate to old Drayton Harbor Rd at neck of Semiahmoo spit | 48.97664 | -122.79069 |
| 1-DrayShore-2 | 3 larger seeps; trail was re-graded and seeps installed after 5-27-08 | 48.97638 | -122.79053 |
| 1-DrayShore-3 | concrete culvert embedded in sloping bank along old Drayton Harbor Rd | 48.97603 | -122.79031 |
| 1-DrayShore-4 | 12" metal culvert sticking out of sloping bank along old Drayton Harbor Rd | 48.97467 | -122.78902 |
| 1-DrayShore-5 | 12" concrete culvert embedded in sloping bank along old Drayton Harbor Rd | 48.97323 | -122.78744 |
| 1-DrayShore-6 | 12" metal culvert sticking out of sloping bank along old Drayton Harbor Rd | 48.97219 | -122.78637 |
| 1-DrayShore-7 | Small discharge sampled on the shore along old Drayton Harbor Rd | 48.97158 | -122.78555 |
| 1-DrayShore-8 | Small upturned metal pipe sticking out of sloping bank along old Drayton Harbor Rd | 48.96996 | -122.7835 |
| 1-DrayShore-9 | 18" black plastic pipe embedded in sloping bank off old Drayton Harbor Rd | 48.96925 | -122.78297 |
| 1-DrayShore-10 | 1-DrayShore-9 channel on shoreline, within tidal influence | 48.96949 | -122.78263 |
| 1-DrayShore-11 | Black flexible pipe on shore east of Old Drayton Harbor Rd and Bald Eagle Dr | 48.96754 | -122.77882 |
| 1-DrayShore-12 | small pipe east of location: 1-DrayShore-11 | 48.96702 | -122.77738 |
| 1-DrayShore-13 | 12" white pvc pipe discharging into rock pile | 48.96658 | -122.77576 |
| 1-DrayShore-14 | small pipe east of location: 1-DrayShore-13 | 48.96599 | -122.77399 |
| 1-DrayShore-15 | Discharge on shore approximately 500 ft NE of Drayton Harbor Rd and Night Heron Dr; also sampled at 36" concrete culvert off Drayton Harbor Rd near lift station #8 | 48.96493 | -122.77161 |
| 1-DrayShore-16 | Outfall embedded in sloping bank off Drayton Harbor Rd; under vegetation | 48.96443 | -122.76967 |
| 1-DrayShore-17 | Ditch going under Drayton Harbor Rd at large field west of intersection with Shintaffer Rd | 48.9635 | -122.76646 |

| Location ID | Location Description | Latitude | Longitude |
|---|---|---|---|
| 1-DrayShore-18 | 12" metal pipe extends out from sloping bank; just west of Drayton Harbor Rd. & Shintaffer Rd. | 48.96274 | -122.76459 |
| 1-DrayShore-19 | 18" concrete culvert under Drayton Harbor Rd, at Shintaffer Rd. | 48.96251 | -122.76419 |
| 1-DrayShore-20 | Trickling pipe just east of DS-0 and intersection of Drayton Harbor & Shintaffer Rd | 48.96228 | -122.76386 |
| 1-DrayShore-21 | 18" plastic culvert under Drayton Harbor Rd | 48.96175 | -122.76261 |
| 1-DrayShore-22 | 18" metal culvert under Drayton Harbor Rd | 48.96142 | -122.76161 |
| 1-DrayShore-23 | 24"conrete culvert under Drayton Harbor Rd | 48.96101 | -122.76012 |
| 1-DrayShore-24 | 24" concrete culvert under Drayton Harbor Rd | 48.96044 | -122.75555 |
| 1-DrayShore-25 | 18" PVC pipe 0.3 miles NW of D. Harbor Rd. & Harborview Rd. | 48.95943 | -122.7536 |
| 1-DrayShore-26 | 24" culvert under Drayton Harbor Rd | 48.95852 | -122.75175 |
| 1-DrayShore-27 | 18"concrete culvert under Drayton Harbor Rd | 48.95738 | -122.74891 |
| 1-DrayShore-28 | 24" culvert under Drayton Harbor Rd. | 48.95727 | -122.74834 |
| 1-DrayShore-29 | 24" concrete culvert nr Harborview Rd | 48.95726 | -122.74788 |
| 1-DrayShore-30 | 18"concrete culvert under Drayton Harbor Rd | 48.95763 | -122.74736 |
| 1-DrayShore-31 | 18" metal culvert under Drayton Harbor Rd | 48.9579 | -122.74643 |
| 1-DrayShore-32 | Culvert under Drayton Harbor Rd, just north of KARI Radio sign | 48.95838 | -122.74518 |
| 1-DrayShore-33 | Concrete culvert under Drayton Harbor Rd; at Birch Bay visitor info sign | 48.95881 | -122.74411 |
| 1-DrayShore-34 | 18” concrete culvert under Drayton Harbor Rd | 48.9592 | -122.74291 |
| 1-DrayShore-35 | 24” concrete culvert under Drayton Harbor Rd | 48.95969 | -122.74191 |
| 1-DrayShore-36 | 24” concrete culvert under Drayton Harbor Rd | 48.96052 | -122.74012 |
| 1-Cal-0.1 | Mouth of California Creek | 48.96217 | -122.73289 |
| 1-Cal-SD1 | Storm drain at California Creek | 48.9623 | -122.73235 |
| 1-TribDray-1 | Mouth of trib to Drayton Harbor@ Hall & Dearborn | 48.96813 | -122.73312 |
| 1-Dak-0.1 | Dakota Creek @ SR 548/Blaine Rd | 48.97231 | -122.72936 |
| 1-DrayShore-37 | Small channel on north bank of Dakota Creek at the mouth, west of SR548 | 48.9727 | -122.72905 |
| 1-DrayShore-38 | 12"metal pipe sticking out of bank along shoreline | 48.97783 | -122.73893 |
| 1-DrayShore-39 | 12" black pvc pipe sticking out of bank along shoreline | 48.97837 | -122.73918 |
| 1-DrayShore-40 | 18" culvert embedded in bank | 48.98116 | -122.73932 |
| 1-Dray-SD4 | 36" culvert on harbor shoreline, due east of Peace Portal Dr and Albert St. | 48.98246 | -122.73935 |
| 1-DrayShore-41 | 36" culvert under railroad tracks due west of Madison & Peace Portal | 48.98324 | -122.74056 |
| 1-DrayShore-42 | 24" culvert at the top of the bank | 48.98544 | -122.74685 |
| 1-DrayShore-43 | Outfall south of intersection of Peace Portal Drive and Harrison | 48.98547 | -122.74686 |
| 1-DrayShore-44 | 36" metal culvert approximately 200 feet SW of Peace Portal and 4th | 48.98618 | -122.74876 |

| Location ID | Location Description | Latitude | Longitude |
|---|---|---|---|
| 1-DrayShore-45 | 12" rusty culvert embedded in bank with orange discoloration in the channel | 48.9862 | -122.74916 |
| 1-DrayShore-46 | 12" concrete culvert embedded in bank; partially filled in with gravel and silt | 48.98693 | -122.75032 |
| 1-DrayShore-47 | 36" culvert approximately 400 feet west of Peace Portal and 3rd | 48.98771 | -122.7513 |
| 1-DrayShore-48 | Culvert discharging to east end of Blaine marina near the breakwater | 48.99301 | -122.75269 |
| 1-DrayShore-49 | Small channel discharges to east end of Blaine marina next to boat ramp | 48.99365 | -122.75336 |
| 1-Cain-0.01 | Mouth of Cain Creek; 60" culvert off of Marine Dr, just north of boatyard | 48.99697 | -122.75463 |
| 1-Cain-SD1 | Storm drainage outfall to Semiahmoo Bay, just north of the mouth of Cain Creek | 48.99712 | -122.75439 |

In general, the majority of the FC instantaneous loading (flux) during the shoreline events originated from the 7 routine TMDL sites (Table D-4):

- January 14, 2008
    - 7 TMDL sites = 95.1 percent of the measured FC instantaneous load.
    - 35 non-TMDL sites sampled = less than 5 percent of the measured instantaneous load.
- May 27, 2008
    - 7 TMDL sites = 99.0 percent of the measured FC instantaneous load.
    - 26 non-TMDL sites sampled = 1 percent of the measured instantaneous load.
- January 12-13, 2008
    - 7 TMDL sites = 94.7 percent of the measured FC instantaneous load.
    - 36 non-TMDL sites sampled = less than 6 percent of the measured instantaneous load.

**Table D-4. Drayton Harbor Phase 1 shoreline survey sampling results**

| Location ID | FC (cfu/100mL) 1/14/2008 | Flow (cfs) 1/14/2008 | FC (cfu/100mL) 5/27/2008 | Flow (cfs) 5/27/2008 | FC (cfu/100mL) 12/13/2009 | Flow (cfs) 12/13/2009 |
|---|---|---|---|---|---|---|
| 1-DrayShore-1 | 490 | 0.01 | | | | |
| 1-DrayShore-2 | | | | | 21 | 0.04 |
| 1-DrayShore-3 | 9 | 0.01 | | | | |
| 1-DrayShore-4 | 75(46) | 0.04 | 180(240) | 0.01 | 2 | 0.01 |
| 1-DrayShore-5 | 34 | 0.03 | | | 54 | 0.01 |
| 1-DrayShore-6 | 28 | 0.13 | 25 | 0.01 | 4 | 0.11 |
| 1-DrayShore-7 | | | 65 | 0.01 | 6 | 0.09 |
| 1-DrayShore-8 | | | 1 | 0.01 | | |
| 1-DrayShore-9 | 28 | 3.15 | 21 | 0.01 | 51 | 0.91 |
| 1-DrayShore-10 | 220 | 1.96 | | | | |
| 1-DrayShore-11 | 1 | 0.01 | | | | |

| Location ID | FC (cfu/100mL) 1/14/2008 | Flow (cfs) 1/14/2008 | FC (cfu/100mL) 5/27/2008 | Flow (cfs) 5/27/2008 | FC (cfu/100mL) 12/13/2009 | Flow (cfs) 12/13/2009 |
|---|---|---|---|---|---|---|
| 1-DrayShore-12 | 1 | 0.01 | | | | |
| 1-DrayShore-13 | 56 | 0.82 | | | | |
| 1-DrayShore-14 | 6 | 0.01 | | | | |
| 1-DrayShore-15 | 140 | 2.92 | | | 48 | 1.46 |
| 1-DrayShore-16 | 8 | 0.82 | | | | |
| 1-DrayShore-17 | 60 | 1.79 | | | 36 | 0.44 |
| 1-DrayShore-18 | 3400 | 0.06 | 7 | 0.01 | 17 | 0.01 |
| 1-DrayShore-19 | 280(240) | 4.96 | 44 | 0.01 | 10 | 0.56 |
| 1-DrayShore-20 | 1000 | 0.02 | 110 | 0.01 | | |
| 1-DrayShore-21 | 160 | 0.3 | 590 | 0.01 | 4 | 0.1 |
| 1-DrayShore-22 | 35 | 0.2 | 11 | 0.01 | 3 | 0.04 |
| 1-DrayShore-23 | 83 | 2.46 | 560 | 0.01 | 14 | 0.56 |
| 1-DrayShore-24 | 140 | 0.3 | | | 220 | 0.04 |
| 1-DrayShore-25 | 400 | 0.28 | | | 610 | 0.02 |
| 1-DrayShore-26 | 35 | 5.18 | 270 | 0.01 | 5 | 0.96 |
| 1-DrayShore-27 | 3 | 0.48 | | | 2 | 0.01 |
| 1-DrayShore-28 | 63 | 6.75 | 41 | 0.01 | 120 | 1.56 |
| 1-DrayShore-29 | 110 | 11.54 | 2(2) | 0.03 | 6 | 1.82 |
| 1-DrayShore-30 | 51 | 3.85 | | | 1 | 0.13 |
| 1-DrayShore-31 | 8 | 0.65 | | | 1 | 0.06 |
| 1-DrayShore-32 | 1 | 0.18 | | | 1 | 0.02 |
| 1-DrayShore-33 | 41 | 0.27 | 1 | 0.01 | 1 | 0.01 |
| 1-DrayShore-34 | 110 | 0.54 | | | 5 | 0.04 |
| 1-DrayShore-35 | 22 | 0.44 | | | 6 | 0.03 |
| 1-DrayShore-36 | 27 | 0.54 | 3 | 0.01 | | |
| 1-Cal-0.1 | 230(700) | | 64(78) | | 29 | |
| 1-Cal-SD1 | 33 | 5.81 | 255 | 0.38 | 1 | 0.79 |
| 1-TribDray-1 | 230 | 15.38 | 160 | 0.02 | 31 | 1.68 |
| 1-Dak-0.1 | 380(240) | | 48(79) | | 29 | |
| 1-DrayShore-37 | | | 25 | 0.01 | | |
| 1-DrayShore-38 | | | 11 | 0.01 | 51 | 0.13 |
| 1-DrayShore-39 | | | 160(170) | 0.01 | 10 | |
| 1-DrayShore-40 | | | 26 | 0.01 | 7 | 0.07 |
| 1-Dray-SD4 | 220 | 14.47 | 180 | 0.05 | 21 | 1.51 |
| 1-DrayShore-41 | 330 | 0.69 | 7 | 0.04 | 4 | 0.94 |
| 1-DrayShore-42 | | | | | 3 | 0.01 |
| 1-DrayShore-43 | | | 1 | 0.01 | 2 | 0.06 |
| 1-DrayShore-44 | | | | | 3 | 0.01 |
| 1-DrayShore-45 | | | 3 | 0.01 | 1 | 0.01 |
| 1-DrayShore-46 | | | | | 1 | 0.01 |

| Location ID | FC (cfu/100mL) 1/14/2008 | Flow (cfs) 1/14/2008 | FC (cfu/100mL) 5/27/2008 | Flow (cfs) 5/27/2008 | FC (cfu/100mL) 12/13/2009 | Flow (cfs) 12/13/2009 |
|---|---|---|---|---|---|---|
| 1-DrayShore-47 | | | 8 | 0.01 | 5 | 0.28 |
| 1-DrayShore-48 | | | 79 | 0.02 | 1 | 0.17 |
| 1-DrayShore-49 | 64 | 0.89 | 290 | 0.01 | 7 | 0.03 |
| 1-Cain-0.01 | 1650 | 34.14 | 250(350) | 0.38 | 50 | 3.63 |
| 1-Cain-SD1 | 720 | 2.84 | 53 | 0.03 | 11 | 0.25 |

( ) field replicate

**Blaine and Semiahmoo Marina Sampling Results**

In support of the TMDL, staff from DOH and the Puget Sound Restoration Fund collected samples during two intensive FC surveys in Blaine Harbor and Semiahmoo marinas, one during a wet-season rain event on 1/14/2008 and one during dry conditions on 5/27/2008 (Figures D-5 and 6). The DOH lab analyzed the samples using the MPN method.


**Figure D-5. Blaine Harbor Marina Phase 1 sampling locations**

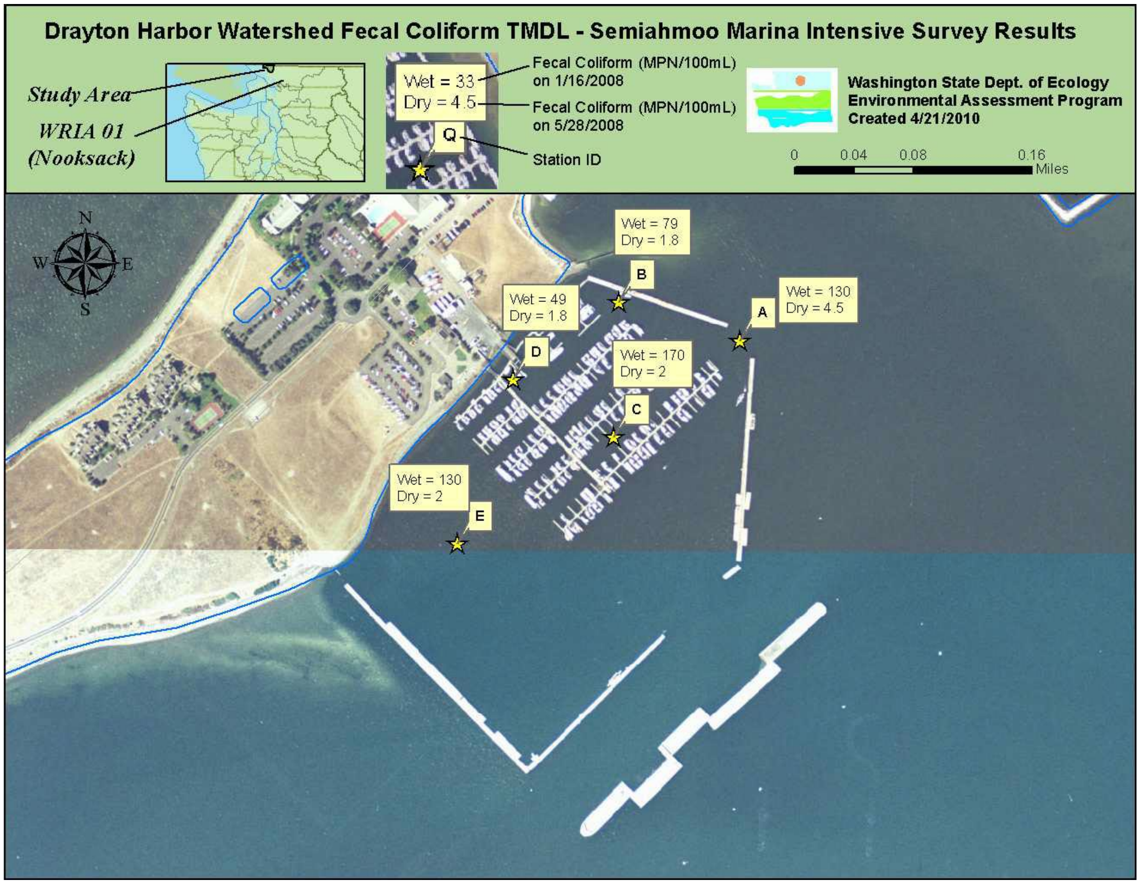


**Figure D-6. Semiahmoo Marina Phase 1 sampling locations**

During the intensive marina FC surveys:

- January 14, 2008,
  - FC contamination was present at most sites, with FC concentrations greater than 43 cfu/100mL at 13 out of 16 sites.
  - Concentrations were:
    - Highest in the commercial area of the Blaine Habor marina, ranging from 240 to 920 cfu/100mL.
    - High in the Semiahmoo Marina, ranging from 49 to 170 cfu/100mL.
    - Lowest in the recreational area of the Blaine Habor marina, ranging from 23 to 79 cfu/100mL.

- May 27, 2008
  - Only a few sites had clear FC contamination, with FC concentrations greater than 43 cfu/100mL at 6 out of 16 sites.
  - Concentrations were:
    - Again, highest in the commercial area of the Blaine Habor marina, ranging from 22 to 350 cfu/100mL.
    - Very low in the Semiahmoo Marina, ranging from below the detection limit (1.8 cfu/100mL) to 4.5 cfu/100mL.
    - Relatively low in the recreational area of the Blaine Habor marina, ranging from 4.5 to 49 cfu/100mL.

During the January 2008 survey, the source of FC contamination could have originated from either within or outside the marinas, given that FC concentrations were elevated in the harbor on the 1/16/08 DOH survey. However, concentrations were much higher in the commercial area of the Blaine Harbor marina, indicating that it may have been a source. This pattern was also evident during the May 2008 survey when counts were relatively low in both marinas except the commercial area of Blaine Harbor marina where counts were again high.

The May 2008 survey was conducted the week after Memorial Day weekend, when recreational use was elevated. While the recreational area of the Blaine marina did have relatively low counts, they were slightly elevated (49 cfu/100mL) near the public boat launch.

**Microbial Source Tracking**

EPA's Manchester Laboratory performed the *Bacteroides* host specific polymerase chain reaction (PCR) microbial source tracking (MST) analysis on a subset of samples collected during Phase 1. *Bacteroides* is a type of bacterial organism found in the gut of warm blooded animals. The host specific PCR MST analysis is capable of detecting the presence of human and ruminant specific DNA markers for *Bacteroides*. The method matches DNA strains of *Bacteroides* found in water samples with the known markers specific to human and ruminant strains of *Bacteroides*.

Ecology collected samples for MST analysis in the Blaine Harbor Marina (Figure D-5) and in a subset of fresh water sampling locations (Table D-1) from September 2008 to January 2009. Details of the MST study and standard methods are outlined in the QAPP addendum (Mathieu 2008). In summary, the field sampling and MST occurred as follows:

- Ecology collected bacteria samples during six events with the data separated by subbasin (Tables D-5—8).
  - The laboratory host specific PCR codes are provided in each table where;
    - **A** indicates that the *Bacteroides* genus marker was not detected,
    - **GB** indicates that a general *Bacteroides* marker was detected that is not host specific,
    - **H** indicates that a human *Bacteroides* marker was detected,
    - **R** indicates that a human *Bacteroides* marker was detected, and
    - **dup** indicates a laboratory duplicate.
- The DOH laboratory analyzed marine water samples for FC concentrations using the MPN standard method 9221E(a) using A-1 media.
- The Institute for Environmental Health performed ribotyping MST analysis to determine the species or source of origin of *E. coli* strains isolated from the water samples.
  - The quality control data provided by the Institute for Environmental Health was deemed insufficient to assess the usability of the data. No results are therefore presented in this report.

**Table D-5. Host specific polymerase chain reaction (PCR) microbial source tracking (MST) Phase 1 results in the Dakota Creek subbasin**

| Site | Date | FC (cfu/100mL) | Flow (cfs) | FC load (b.cfu/day) | PCR Code | Bacteroides marker |
|---|---|---|---|---|---|---|
| 1-TribDak-N2 | 9/2/2008 | 180 | 0.152 | 0.67 | A | |
| 1-NF-Dak-2.5 | 9/2/2008 | 140 | 0.109 | 0.37 | GB | |
| 1-TribDak-2 | 9/2/2008 | 2800 | 0.036 | 2.47 | H | HF134 |
| 1-TribDak-S1 | 9/2/2008 | 170 | 0.041 | 0.17 | A | |
| 1-TribDak-S2 | 9/2/2008 | 31 | 0.047 | 0.04 | A | |
| 1-TribDak-S2 | 9/21/2008 | 170 | 0.022 | 0.09 | H | HF183 |
| 1-TribDak-S1 | 9/21/2008 | 970 | 0.036 | 0.85 | A/dupGB | |
| 1-TribDak-N2 | 9/21/2008 | 490 | 0.18 | 2.16 | GB | |
| 1-NF-Dak-2.5 | 9/21/2008 | 210 | 0.056 | 0.29 | H | HF134 |
| 1-TribDak-2 | 9/22/2008 | 280 | 0.027 | 0.19 | H | HF134 |
| 1-TribDak-S2 | 10/13/2008 | 240 | 0.04 | 0.23 | GB | |
| 1-TribDak-S1 | 10/13/2008 | 23 | 0.06 | 0.03 | GB | |
| 1-TribDak-N2 | 10/13/2008 | 670 | 0.285 | 4.68 | A | |
| 1-NF-Dak-2.5 | 10/13/2008 | 3400 | 0.381 | 31.71 | GB | |
| 1-TribDak-N1 | 10/13/2008 | 980 | 0.019 | 0.46 | H | HF134 |
| 1-TribDak-2 | 10/14/2008 | 1900 | 0.183 | 8.5 | GB | |
| 1-TribDak-1 | 10/14/2008 | 400 | 0.004 | 0.04 | GB | |
| 1-TribDak-S2 | 11/4/2008 | 1400 | 5.396 | 184.9 | R | CF128 |
| 1-TribDak-S1 | 11/4/2008 | 390 | 1.077 | 10.28 | R | CF128 |
| 1-TribDak-N2 | 11/4/2008 | 3300 | 5.939 | 479.45 | R | CF128 |
| 1-NF-Dak-2.5 | 11/4/2008 | 3700 | 32.005 | 2897.09 | GB | |
| 1-TribDak-2 | 11/5/2008 | 230 | 0.952 | 5.36 | A | |
| 1-TribDak-1 | 11/5/2008 | 54 | 0.042 | 0.06 | GB | |
| 1-TribDak-S2 | 12/2/2008 | 50 | 4.696 | 5.74 | GB | |
| 1-TribDak-S1 | 12/2/2008 | 62 | 2.792 | 4.23 | GB | |
| 1-TribDak-N2 | 12/2/2008 | 67 | 2.635 | 4.32 | A | |
| 1-NF-Dak-2.5 | 12/2/2008 | 67 | 13.696 | 22.45 | A/dupGB | |
| 1-TribDak-N1 | 12/3/2008 | 170 | 1.074 | 4.46 | GB | |
| 1-TribDak-2 | 12/3/2008 | 180 | 2.112 | 9.3 | GB | |
| 1-TribDak-1 | 12/3/2008 | 84 | 0.273 | 0.56 | GB | |

EPA PCR Codes: A= Absent; GB= General Bacteroides; H= Human; R=Ruminant

**Table D-6. Host specific polymerase chain reaction (PCR) microbial source tracking (MST) Phase 1 results in the California Creek subbasin**

| Site | Date | FC (cfu/100mL) | Flow (cfs) | FC load (b.cfu/day) | PCR Code | Bacteroides marker |
|---|---|---|---|---|---|---|
| 1-TribCal-5 | 9/2/2008 | 400 | 0.07 | 0.68 | GB | |
| 1-TribCal-4 | 9/2/2008 | 240 | 0.002 | 0.01 | GB | |
| 1-TribCal-2 | 9/2/2008 | 120 | 0.026 | 0.08 | R | |
| 1-Cal-6.2 | 9/2/2008 | 180 | 0.815 | 3.59 | GB | |
| 1-TribCal-5 | 9/22/2008 | 770 | 0.031 | 0.59 | GB | |
| 1-TribCal-4 | 9/22/2008 | 170 | 0.005 | 0.02 | GB | |
| 1-TribCal-2 | 9/22/2008 | 790 | 0.015 | 0.29 | H | HF134 |
| 1-Cal-6.2 | 9/22/2008 | 140 | 0.55 | 1.88 | GB | |
| 1-Cal-5.0 | 9/22/2008 | 220 | 1.8 | 20.45 | GB | |
| 1-TribCal-5 | 10/14/2008 | 130 | 0.165 | 0.53 | A | |
| 1-TribCal-4 | 10/14/2008 | 54 | 0.014 | 0.02 | H | HF134 |
| 1-TribCal-2 | 10/14/2008 | 150 | 0.07 | 0.26 | H | HF183 |
| 1-Cal-6.2 | 10/14/2008 | 1200 | 1.055 | 30.97 | GB | |
| 1-Cal-5.0 | 10/14/2008 | 830 | 3.9 | 79.19 | GB | |
| 1-TribCal-5 | 11/4/2008 | 63 | 1.264 | 1.95 | A | |
| 1-TribCal-4 | 11/4/2008 | 410 | 0.283 | 2.84 | H | HF183 |
| 1-TribCal-3 | 11/5/2008 | 3 | 0.401 | 0.03 | A | |
| 1-TribCal-2 | 11/5/2008 | 220 | 0.454 | 2.44 | A | |
| CA14 | 11/5/2008 | 700 | n/a | n/a | R | CF183 |
| 1-TribCal-5 | 12/3/2008 | 26 | 1.15 | 0.73 | A | |
| 1-TribCal-4 | 12/3/2008 | 6 | 0.42 | 0.06 | A | |
| 1-TribCal-3 | 12/3/2008 | 24 | 3.772 | 2.21 | GB | |
| 1-TribCal-2 | 12/3/2008 | 57 | 1.78 | 2.48 | GB | |
| CA14 | 12/3/2008 | 182 | no data | no data | GB | |

EPA PCR Codes: A= Absent; GB= General Bacteroides; H= Human; R=Ruminant

**Table D-7. Host specific polymerase chain reaction (PCR) microbial source tracking (MST) Phase 1 results in the Cain Creek subbasin**

| Site | Date | FC (cfu/100mL) | Flow (cfs) | FC load (b.cfu/day) | PCR Code | Bacteroides marker |
|---|---|---|---|---|---|---|
| 1-Cain-0.01 | 9/2/2008 | 66 | 0.173 | 0.28 | GB | |
| 1-Cain-SD1 | 9/2/2008 | 76 | 0.049 | 0.09 | H | HF134 |
| 1-Cain-0.01 | 9/22/2008 | 470 | 0.111[1] | 1.276 | GB | |
| 1-Cain-SD1 | 9/22/2008 | 340 | 0.008 | 0.07 | A | |
| 1-Cain-0.01 | 10/14/2008 | 930 | 0.615 | 14 | GB | |
| 1-Cain-SD1 | 10/14/2008 | 200 | 0.009 | 0.05 | GB | |

| | | | | | |
|---|---|---|---|---|---|
| 1-Cain-0.01 | 11/5/2008 | 92 | 0.686[1] | 1.544 | GB |
| 1-Cain-SD1 | 11/5/2008 | 77 | 0.137 | 0.26 | A |
| 1-Cain-0.01 | 12/3/2008 | 300 | 2.383 | 17.49 | GB |
| 1-Cain-SD1 | 12/3/2008 | 18 | 0.471 | 0.21 | GB |

EPA PCR Codes: A= Absent; GB= General Bacteroides; H= Human; R=Ruminant
[1]Flow measured at 1-Cain-0.4 due to tidal influence at 1-Cain-0.1

**Table D-8. Host specific polymerase chain reaction (PCR) microbial source tracking (MST) Phase 1 results in the Blaine Marina**

| Site | Date | FC (MPN/100mL) | PCR Code | Bacteroides marker |
|---|---|---|---|---|
| Marina-1 | 9/2/2008 | 33 | no data | |
| Marina-1 | 9/22/2008 | 33 | no data | |
| Marina-1 | 10/14/2008 | 49 | no data | |
| Marina-1 | 11/5/2008 | 170 | no data | |
| Marina-1 | 12/3/2008 | | no data | |
| Marina-1 | 1/13/2009 | 240 | no data | |
| Marina-3 | 9/2/2008 | 33 | no data | |
| Marina-3 | 9/22/2008 | 11 | no data | |
| Marina-3 | 10/14/2008 | 170 | no data | |
| Marina-3 | 11/5/2008 | 13 | no data | |
| Marina-3 | 12/3/2008 | | no data | |
| Marina-3 | 1/13/2009 | 920 | no data | |
| Marina-D | 9/2/2008 | 11 | GB | |
| Marina-D | 9/22/2008 | 70 | HR | HF183, CF128 |
| Marina-D | 10/14/2008 | 23 | GB | |
| Marina-D | 11/5/2008 | 130 | GB | |
| Marina-D | 12/3/2008 | 49 | GB | |
| Marina-D | 1/13/2009 | 540 | no data | |
| Marina-Q | 9/2/2008 | 49 | GB | |
| Marina-Q | 9/22/2008 | 17 | A | |
| Marina-Q | 10/14/2008 | 33 | GB | |
| Marina-Q | 11/5/2008 | 240 | A | |
| Marina-Q | 12/3/2008 | 12 | GB | |
| Marina-Q | 1/13/2009 | 130 | no data | |
| Marina-R | 9/2/2008 | 33 | H | HF134 |
| Marina-R | 9/22/2008 | 70 | A | |
| Marina-R | 10/14/2008 | 920 | GB | |
| Marina-R | 11/5/2008 | 49 | GB | |
| Marina-R | 12/3/2008 | 240 | GB | |
| Marina-R | 1/13/2009 | 920 | no data | |

EPA PCR Codes: A= Absent; GB= General Bacteroides; H= Human; R=Ruminant

Microbial source tracking identified human specific markers at four sites (TribDak-2, TribDak-S2, NFDak-2.5, and TribDak-N1) during the three dry season sampling events (Table D-5). During the wet season, the microbial source tracking identified ruminant specific markers at three sites (TribDak-S2, TribDak-S1, and TribDak-N2) during the 11/4/2008 first flush storm event. Above average FC loads occurred at all three sites during this sampling event. The EPA Manchester Environmental Laboratory identified the general *Bacteroides* biomarker in 50 percent of the samples collected in the Dakota Creek basin, while *Bacteroides* was absent from 25 percent of the basin samples.

Microbial source tracking identified human specific markers at two sites, twice at TribCal-2 during the dry season and once during each season at TribCal-4 (Table D-6). These results identified ruminant specific markers once during each season:

- During the wet season at site CA14 during the 11/5/2008 first flush storm event.
- During the dry season at TribCal-2 on 9/2/2008.

Similar to the Dakota Creek basin, the EPA Manchester Environmental Laboratory identified the general *Bacteroides* biomarker in 50 percent of the samples collected in the California Creek basin, while *Bacteroides* was absent from 25 percent of the basin samples.

Microbial source tracking identified a human specific marker on one occasion at CainSD-1 during the dry season on 9/2/2008 (Table D-7). The drainage area for this site is connected to the Blaine sewer collection system. The human marker may indicate a cross-connection between the sewer and storm system. The EPA Manchester Environmental Laboratory identified the general *Bacteroides* biomarker in 70 percent of the samples collected, while *Bacteroides* was absent from 20 percent of the basin samples.

Microbial source tracking identified a human specific marker on two occasions in the Blaine Marina (Table D-8). The ruminant marker was identified on one occasion that coincided with the sample collected on 9/22/2008 at Site Marina-D.

**Multiprobe Time-series Data Collection**

Ecology conducted time-series diel monitoring for pH, DO, conductivity, and temperature at ten sites on Dakota, California, and Cain Creek using Hydrolab DataSondes®. The goal of the deployments was to collect sufficient data to make Category determinations for temperature, dissolved oxygen, or pH under the Assessment of state waters 303d - Washington State Department of Ecology[49].

**Measurement Quality Objectives**

Field sampling frequency, methods, protocols, and measurement quality objectives are described by the Mathieu and Sergeant (2008) QAPP with the follow exceptions:

[49] https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d

- Completed: 3 shoreline surveys instead of 4 to 5
    - Reason: unable to catch a dry-season storm event,
- Completed: 2 marina surveys instead of 4 to 5
    - Reason: Staff and analytical resources diverted to microbial source tracking (MST) sampling project in Blaine Marina only,
- Completed: 1 bridge survey instead of kayak survey
    - Reason: The bridge survey showed that even at a very low tide the mouths of the creeks had a high enough salinity to be considered marine water,
- Completed: 1 time-series Hydrolab multi-probe survey instead 3 surveys
    - Reason: Limited staff time and this data collection was secondary to bacteria data collection.

Comparison to the measurement quality objectives (Mathieu and Sargeant 2008) shows that out of 703 FC samples, Ecology's Manchester Environmental Laboratory (MEL) qualified 160 samples as follows:

- **95 samples** were analyzed outside of MEL's recommended 24 hour holding time. Due to transportation logistics MEL is unable to analyze samples collected before 10am the following day within 24 hours. Due to time constraints, a number of samples needed to be collected before 10 am each day. All samples qualified for holding time were analyzed within 30 hours.
- **26 samples** were greater than 150 colonies on the plate. Two or more bacteria could land in the same place during filtration; therefore the "true" values may be greater than or equal to the reported results.
- **23 samples** had background colonies on the plate. These non-motile, non-fecal colonies may interfere with the blue color produced by the fecal colonies; therefore the "true" values may be greater than or equal to the reported results.
- **14 samples** were spreader colonies on the plate. These motile, non-fecal colonies may interfere with the blue color produced by the fecal colonies; therefore the "true" values may be greater than or equal to the reported results.
- **2 samples** varied from the corresponding laboratory duplicate sample by greater than 40 percent relative percent difference (RPD).

In general, data quality met the QAPP (Mathieu and Sargeant 2008) objectives and are summarized as follows while the associated data in EIM have been assigned data qualifiers as needed.

- Multiprobe instantaneous data quality results:
    - Compared the post-calibration and side-by-side results to their respective criteria and either qualified or rejected the measurements where appropriate.
        - Temperature: 5 percent of data qualified, no data rejected.
        - Conductivity: 25 percent of data qualified, 4 percent of data rejected.
        - pH: 16 percent of data qualified, 10 percent of data rejected.
        - Dissolved Oxygen (DO): 33 percent of data qualified, 3 percent of data rejected.

- Multiprobe time-series data quality results:
  - Overall, data quality was acceptable. Some results were qualified or adjusted:
    - Qualified data due to exceedance of post-calibration criteria for:
      - Specific conductivity at five sites.
      - pH at one site.
    - Qualified dissolved oxygen data at two sites based on Winkler DO check criteria.
    - Truncated initial pH data at five sites where pH probes with low-ionic strength reference probes were deployed.
    - Removed a subset of DO data at 1-Cal-5.0 due to power failure issues.
    - Corrected DO data at three sites based on a linear regression to Winkler checks.
- Precision results.
  - Field staff collected field replicates for FC, streamflow, and Hydrolab measurements.
  - All parameters, except for FC-MPN results, met their quality objectives.
  - FC-Most probable number (MPN) results failed to meet the precision criteria outlined in the QAPP (Mathieu and Sargeant 2008). However, the MPN precision results showed less variability than those from three previously completed TMDLs (Joy 2004, Pelletier and Seiders 2000, Seiders et al. 2001), indicating that the criteria were likely too stringent and that MPN precision was within the range of variability observed during other TMDL studies.
- Manchester QA/QC results.
  - Out of 703 FC samples Ecology's Manchester Environmental Laboratory (MEL) qualified 160 samples.
  - Most of these samples (95) were qualified because they were analyzed just outside of the 24 hour holding time. All samples qualified for holding time were analyzed within 30 hours.
- Completeness results.
  - Of the 750 sampling opportunities, 47 samples were not collected because there was either no or too little flow to collect a sample. These samples were not counted against overall completeness.
  - Ecology field staff missed 10 total sampling opportunities that may have been avoidable resulting in an overall completeness percentage of 98.6 percent.

## Phase 2 TMDL Update

Data collected through the WCWP partnership are used to update the TMDLs in this report. Phase 2 builds from the data collected during Phase 1 with the common object to quantify the amount of pollution reduction necessary for all water bodies within the Drayton Harbor watershed to meet WQS including the marine waters. The Phase 2 update is done to assess the potential change in water quality since the completion of Phase 1. Laboratory analysis for FC during both the Phase 1 and 2 data collection periods follow standard method 9222D.

The data collected by the WCWP and during Phase 2 of this TMDL are instrumental for TMDL development. Uncertainty in the TMDL calculation is attributed to the variability associated with limited temporal and spatial sampling frequency and the inherent variability associated with discrete bacteria sampling and lab analysis. Discrete sampling of fecal bacteria, however, is practical by representing the most common and cost-effective approach when assessing water quality conditions. Watersheds are continuous systems that are difficult to characterize using discrete information, or sample data points. By utilizing the collective WCWP datasets, the information provided in this TMDL represents the best available assessment of the pollution reduction needed to meet the WQS.

Under Phase 2, contemporary TMDLs are established using a pooled two-year dataset from WY 2020 and 2021. Many of the sample locations from Phase 1 are incorporated in the routine monitoring efforts conducted by the WCWP. The Phase 2 TMDL incorporates these data to establish TMDLs for each AU and the Drayton Harbor watershed. Selecting a subset of the WCWP sampling locations (Table D-9 and Figure D-7) is based on data availability, which is incorporated for TMDL development and other data analysis presented in the report. The objectives accomplished during Phase 2 include:

- Following field sampling protocols and quality assurance (Ecology 2021, Douglas 2017),
- Meeting the measurement quality objectives for field replicates where 50 percent of replicate pairs are less than 20 percent relative standard deviation (RSD) with a value of 12; and 90 percent of replicate pairs are less than 50 percent RSD with a value of 39,
- Establishing TMDLs and pollution reduction targets at the watershed scale and for each fresh water 303(d) listed AU ID (Table 1) using WY 2020 and 2021 data,
- Testing the statistical differences between Phase 1 and Phase 2 FC datasets,
- Estimating daily average streamflow at each bacteria sampling location using modeled relationships with Ecology's stream-gaging stations[50] utilizing both short-term and long-term stations, and
- Characterizing the relationship between fresh water and marine water samples.

**Table D-9. WCWP sampling locations for Phase 2 of the TMDL**

| Site ID | Location | Latitude | Longitude | Alternate ID |
|---|---|---|---|---|
| Cal0.1 | California Cr at Drayton Harbor Rd. | 48.96217 | -122.73283 | C1 |
| Cal0.8 | California Cr at Blaine Rd | 48.95468 | -122.72605 | C2 |
| Cal1.9 | California Cr at Kickerville Rd | 48.94709 | -122.70438 | |
| Cal3.1 | California Cr at Birch Bay-Lynden Rd. | 48.93583 | -122.68882 | Nook-SW37 |
| Cal5.0 | California Cr at Valley View Rd | 48.92137 | -122.66023 | C3 |
| Cal6.2 | California Cr at Bruce Rd | 48.90922 | -122.64401 | Nook-SW24 |
| Cal7.5 | California Cr at Fox Rd | 48.89907 | -122.62373 | CAL7.5 |

[50] https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Flow-monitoring

| Site ID | Location | Latitude | Longitude | Alternate ID |
|---|---|---|---|---|
| TribCal-0 | Tributary to California Cr at Blaine Rd | 48.95827 | -122.73005 | |
| TribCal-1 | Tributary to California Creek at Fleet Rd | 48.94850 | -122.72206 | |
| TribCal-2 | Tributary to California Cr at Kickerville Rd | 48.94879 | -122.70453 | CA1, Nook-SW39 |
| TribCal-3 | Tributary to California Cr at Arnie Rd | 48.92111 | -122.68407 | CA3 |
| TribCal-4 | Tributary to California Cr Bay Rd | 48.90635 | -122.64987 | CA8 |
| TribCal-5 | Tributary to California Cr at Main St | 48.91720 | -122.64947 | CA16 |
| CA6 | Tributary to California Cr at Arnie Road | 48.92086 | -122.65220 | CA6 |
| CA14c | Tributary to California Cr at Brown Rd | 48.88461 | -122.59287 | |
| CA15 | Tributary to California Cr at Portal Way | 48.90077 | -122.61539 | |
| Cal7.5Trib | Tributary to California Cr at Grandview Rd | 48.89187 | -122.61031 | GRAND4 |
| CA14cTrib | Tributary to California Cr at Aldergrove Rd | 48.87712 | -122.61670 | CA14ab |
| CA9 | Tributary to California Cr at Fox Rd | 48.89903 | -122.63026 | |
| CA14aa | Tributary to California Cr at Aldergrove Rd | 48.87713 | -122.62485 | |
| CA14AAW | Tributary to California Cr at Aldergrove Rd | 48.87723 | -122.62488 | |
| CA14AC | Tributary to California Cr at Aldergrove Rd | 48.87723 | -122.62690 | |
| Dak0.1 | Dakota Cr at SR 548/Blaine Rd | 48.97237 | -122.72911 | D1 |
| Dak0.6 | Dakota Cr at I-5 bridge | 48.97213 | -122.71981 | |
| Dak3.1 | Dakota Cr at Giles Rd, Ecology gage station | 48.96279 | -122.68209 | DG, Nook-SW38 |
| Dak6.8 | Dakota Cr at Valley View Rd | 48.95752 | -122.66009 | D2 |
| SFDak-0.2 | SF Dakota Cr at Custer School Rd | 48.95035 | -122.63809 | D4 |
| SFDak-2.2 | SF Dakota Cr at Sunrise Rd | 48.94305 | -122.59652 | |
| SFDakDL | Downstream side of Delta Line Road | 48.94562 | -122.61624 | Nook-SW19 |
| NFDak-0.1 | NF Dakota Cr at Custer School Rd | 48.95110 | -122.63808 | D3 |
| NFDak2_5 | NF Dakota Cr at Delta Line Rd | 48.96966 | -122.61594 | |
| TribDak-1 | Tributary to Dakota Cr at Sweet Rd | 48.97900 | -122.71944 | |
| TribDak-2 | Tributary to Dakota Cr at Sweet Rd | 48.97941 | -122.70875 | |
| TribDak-3 | Tributary to Dakota Cr at Rogers Rd | 48.97055 | -122.69316 | |
| TribDak-4 | Tributary to Dakota Cr at Hoier Rd | 48.97186 | -122.70063 | |
| TribDak-5 | Tributary to Dakota Cr at Valley View Rd | 48.96540 | -122.66008 | |
| TribDak-N1 | Tributary to NF Dakota Cr at Haynie Rd | 48.97128 | -122.62646 | |
| TribDak-N2 | Tributary to NF Dakota Cr at Delta Line Rd | 48.96549 | -122.61580 | |
| TribDak-S1 | Tributary to SF Dakota Cr at Delta Line Rd | 48.94793 | -122.61629 | |
| TribDak-S2 | Tributary to SF Dakota Cr at Sunrise Rd | 48.94461 | -122.59668 | |
| CC | Cain Creek at mouth | 48.99721 | -122.75397 | Cain0.1 |
| LS5 | Tributary to Drayton Harbor lift station drainage | 48.98257 | -122.73940 | |
| Trib1Dray-1 | Tributary to Drayton Harbor at Dearborn Ave | 48.96797 | -122.73442 | 9-NONAME-LOW |

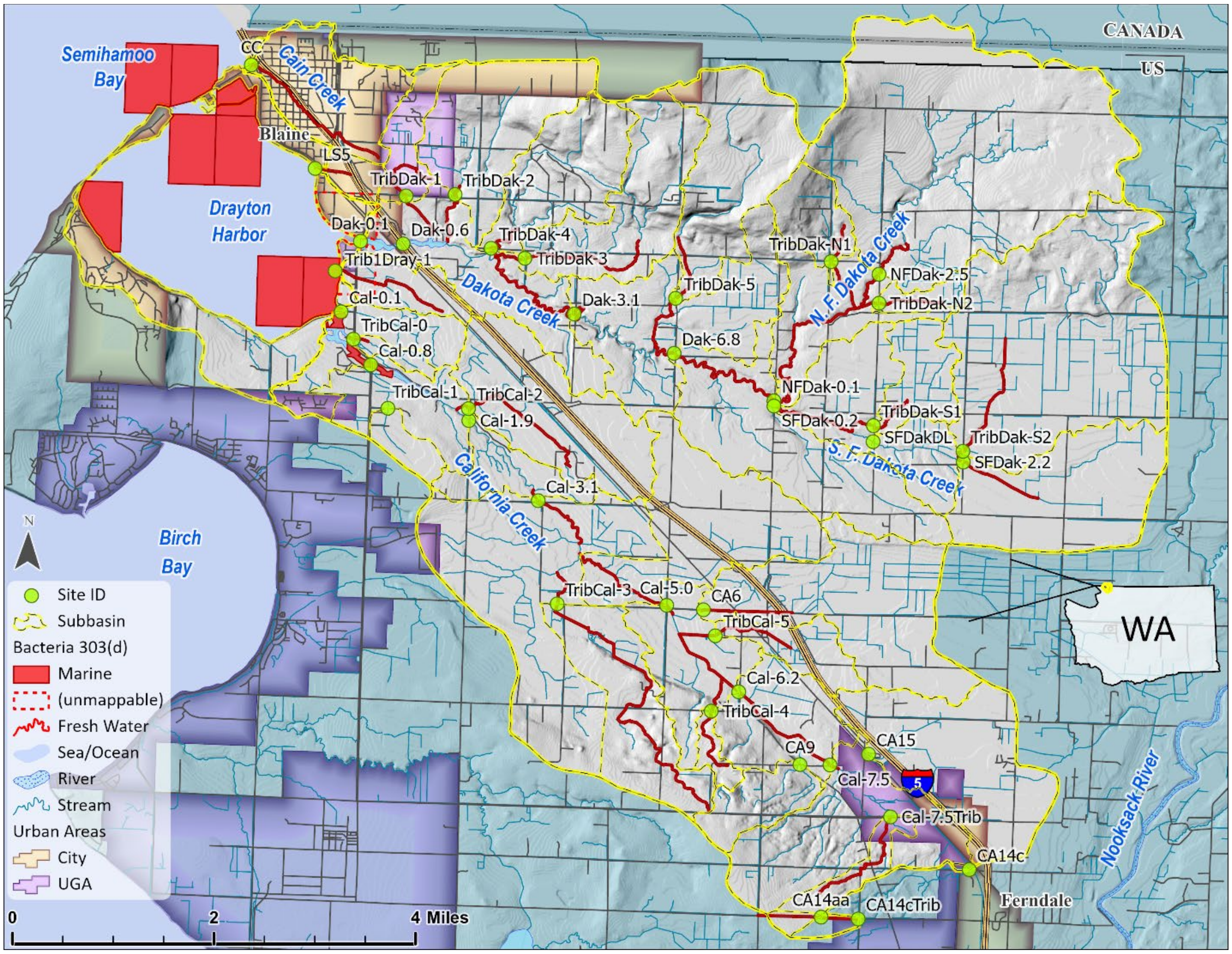


**Figure D-7. WCWP sampling location map for Phase 2 of the TMDL**

## Phase 1 and Phase 2 Dataset Comparison

Statistical significance tests (Helsel et al. 2020) between FC datasets collected during Phases 1 and 2 demonstrates whether the values in one group are frequently greater than those in the other group. The two independent datasets tested share the same FC sampling site and are distinguished by the period of data collection—Phase 1, December 2007 to December 2008, and Phase 2 the pooled WYs of 2020 and 2021.

The objective of group comparison is to assess the utility of the TMDL update using FC concentrations. When significant differences are detected, establishing TMDLs based on the contemporary Phase 2 dataset proved to be important. Further, the direction of these difference between groups may be better understood, that is one group dataset may be frequently greater or lower than the other. Note that these group comparisons do not constitute a trend analysis—see Appendix D, Trend Analysis for details.

Statistical differences between Phase 1 and Phase 2 FC datasets are assessed using the Wilcoxon rank-sum test from the R 'stats' package version 4.2.1[51] (R Core Team 2021). Comparisons using parametric methods are not applicable because several datasets aggregated by sampling location did not have normal distribution and equal variance. The nonparametric Wilcoxon rank-sum test is often incorrectly presented to compare the differences in sample population medians between two dataset groups. This test, however, examines whether the values in one group are frequently greater or lower than those in the other group at a given level of significance, $\alpha = 0.05$.

Thirty-three out of forty sampling sites had FC data from both Phase 1 and 2. Six of these sampling sites showed significant population differences including:

- Cain Cr. at the mouth (CC) where Phase 1 is greater than Phase 2 with the median of the difference between a sample from both phases of 145 cfu/100 mL,
- California Cr. at Fox Rd. (Cal-7.5) where Phase 1 is less than Phase 2 with the median of the difference between a sample from both phases of 94 cfu/100 mL,
- Tributary to California Cr. at Portal Way (CA15) where Phase 1 is less than Phase 2 with the median of the difference between a sample from both phases of 43 cfu/100 mL,
- N.F. Dakota Cr. at Custer School Rd. (NFDak-0.1) where Phase 1 is greater than Phase 2 with the median of the difference between a sample from both phases of 26 cfu/100 mL,
- S.F. Dakota Cr. at Custer School Rd. (SFDak-0.2) where Phase 1 is greater than Phase 2 with the median of the difference between a sample from both phases of 40 cfu/100 mL, and
- Tributary to N.F. Dakota Cr. at Delta Line Rd. (TribDak-N2) where Phase 1 is greater than Phase 2 with the median of the difference between a sample from both phases of 64 cfu/100 mL.

These outcomes further illustrate the importance of updating the TMDL by building off of data collected during Phase 1 and incorporating Phase 2 data. Contemporary data more importantly offer a representation of existing conditions and account for activities in the watershed that may have either improved or degraded water quality.

## Designated Use Protection

The Drayton Harbor bacteria TMDLs are established to address impairments to the designated uses of shellfish harvesting and primary contact recreation, which are caused by excessive bacteria concentrations and loading. The *E. coli* TMDLs are established using the bacteria translator—see Appendix D, Bacteria Translator for details. Addressing water quality impairments through monitoring, data analysis, and adaptive management using the TMDL Implementation Plan and NPDES permit requirements provides the foundation to protect and preserve the designated uses of the Drayton Harbor watershed. The WLAs, LAs, and MOS are incorporated using conservative assumptions. The LC accounts for the WQS because it is established using the Washington water quality criteria.

[51] https://stat.ethz.ch/R-manual/R-devel/library/stats/html/00Index.html

Establishing the protection of designated uses in both fresh and marine waters is based on meeting the WQS. The WQS includes a two-part criterion for each designated use measured by unique fecal indicator bacterium including FC, *E. coli*, and enterococci—see Uses of Water Bodies and Water Quality Criteria sections for details. The WQS criteria are the benchmarks in which the TMDLs were set to protect designated uses.

The WQS are provisioned to protect downstream designated uses—"Upstream actions must be conducted in manners that meet downstream water body criteria" [WAC 173-201A-260(3)(b)]. The TMDL for the Drayton Harbor watershed is established to protect both the fresh and marine water designated uses. The marine water designated uses included primary contact recreation and shellfish harvesting.

**Primary Contact Recreation**

The Drayton Harbor TMDL allocations set pollution limits to protect downstream estuarine and marine water primary contact recreation by following the example set in the Deschutes River TMDL (EPA 2020). The *E. coli* and enterococci fecal indicator bacteria criteria were developed using the same level of risk and illness rates for humans (EPA 2012). EPA (2012) demonstrated that the enterococci acceptable illness rate analyses were used to derive the acceptable risk level of *E. coli* in fresh water. Setting the TMDL allocations in the Drayton Harbor watershed therefore provides the same level of protection from associated pathogens in the receiving marine water. Note that states and Tribes may select either enterococci or *E. coli* for fresh waters, as adopting one indicator is sufficient, and only enterococci may be selected for marine waters (EPA 2021).

**Shellfish Harvesting**

Attaining the WQS within the tidally influenced reaches of the Dakota and California watersheds is evaluated to establish the protection of the shellfish harvesting designated use in the harbor and estuary. The method used for the Lower Skagit River FC TMDL (Pickett 1997), the Whatcom Creek FC TMDL (Kardouni 2023), and the Skagit Bay FC loading assessment (Kardouni 2012) is applied to establish a fresh water boundary target value (FC cfu/100 mL). This value is calculated using a combination of water quality data and the mixing ratio at the brackish water interface—see Appendix D, Statistical Rollback Analysis, Downstream Designated Use Targets section for details.

Since salinity in the estuary is dynamic, changing constantly as a function of tidal movement and stream flow, the fresh water boundary target value is applied downstream of RM 3.1 on Dakota and California Creeks based on Phase 1 salinity surveys (EIM[52] Study ID: NMat0001). All sampling locations along Dakota (Dak3.1) and California (Cal3.1) creeks downstream of Giles and Birch Bay-Lynden Road respectively are considered part of the Drayton Harbor estuary in relation to the bacteria WQS. These stream reaches are subject to the marine WQS for bacteria at the point where the salinity reaches 10 ppt or greater—see Water Quality Criteria section for details. Tributaries that discharge to these mainstem reaches received allocations that protect downstream designated uses in the receiving marine water.

[52] https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

All direct tributaries to the harbor assessed in the TMDL have protective FC reduction targets (Table 5). For example, the fresh water boundary target geometric mean to attain the FC TMDL for Dakota Creek is 17 and 6 cfu/100 mL for the dry and wet seasons respectively, which accounts for the brackish water interface downstream of Giles Road (RM 3.1). The target geometric mean to attain the FC TMDL for California Creek is 15 and 4 cfu/100 mL for the dry and wet seasons respectively, which accounts for the brackish water interface downstream of Birch Bay-Lynden Road (RM 3.1). These targets protect the shellfish harvesting designated use starting at the brackish water interface and extending into Drayton Harbor. Because shellfish harvesting is the most sensitive designated use, meeting the FC TMDL also ensures the protection of contact recreation in marine waters.

**Bacteria Concentration Correlations Between Fresh and Marine Waters**

Kendall's Tau correlation tests measure the strength of association between the bacteria concentrations in the fresh water tributaries and the receiving marine waters of the harbor and entrance. Even though calculations differ between each test type, the Kendall's Tau correlation test is nonparametric and similar to the Pearson's r parametric test by serving as an association test. After $\log_{10}$ transformation, the marine water bacteria dataset did not meet the normal distribution assumption to justify the use of Pearson's r; therefore, the use of the Kendall's Tau correlation test is justified.

Correlation analysis between FC concentrations covers the period from January 2008 through September 2021 and from WY 2020 through 2021 covering the Phase 2 analysis. Data from the downstream most fresh water sites were compared to the receiving marine waters data. Correlation tests include a total of 71 paired datapoints using both the same-day and lagged-by-one-day sampling events. This represents the most immediate relative conditions of both the fresh water and receiving marine waters. Correlation tests are done using the geometric mean concentration grouped separately by the fresh water tributaries and marine stations across each respective sampling environment.

Using the period of record, paired geometric mean bacteria concentrations in the fresh water tributaries to the harbor show no significant monotonic association between those of the receiving marine water. The Phase 2 period covering WYs 2020 and 2021 total 18 paired datapoints and show no significant relationship.

Same-day sampling analysis includes a subset of the 14 paired datapoints, while the pairs lagged-by-one-day comprise 57 datapoints. The same-day sampling ($n = 14$ pairs) shows no significant association between geometric means. There is, however, a significant positive association ($p < 0.05$, $\alpha = 0.05$, Tau = 0.18) between fresh water bacteria geometric mean concentrations and marine water concentrations when the marine sampling is lagged-by-one-day relative to the fresh water sampling events ($n = 57$ pairs). This analysis demonstrates a significant direct association between the observed fresh water bacteria concentrations and that of the receiving marine water of Drayton Harbor when it is sampled on the day following fresh water sampling events.

**Correlations Between Fresh Water Bacteria Loading and Marine Water Concentrations**

The instantaneous FC bacteria load, also known as flux, paired by date with the marine water quality FC concentration data for WYs 2020 and 2021 illustrates the association between fresh water loading and marine water quality during Phase 2. The dataset beginning in January 2008 through September 2021 includes some sampling locations with no delineated catchment area and are therefore not modeled for stream flow discharge that is used to calculate instantaneous loading during Phase 2.

Phase 2 correlation tests include 15 paired datapoints when both fresh and marine water sampling coincided on the same-day and when marine sampling was lagged-by-one-day relative to fresh water sampling. Both the same-day and lagged-by-one-day sampling events are combined in this analysis to provide a sufficient dataset for analysis. Instantaneous FC loads calculated near the mouth of each direct input to the harbor include the following:

- Dak3.1—Dakota Creek at Giles Road,
- Cal3.1—California Creek at Birch Bay-Lynden Road,
- CC—Cain Creek at mouth,
- TribDak1—tributary to Dakota Creek at Sweet Road,
- TribDak2—tributary to Dakota Creek at Sweet Road,
- TribDak3—tributary to Dakota Creek at Rogers Road,
- TribDak4—tributary to Dakota Creek at Hoier Road,
- TribCal2—tributary to California Creek at Kickerville Road,
- LS5—tributary to Drayton Harbor at lift station.

Note that sampling sites below Dak3.1 and Cal3.1 along the mainstems of Dakota and California are brackish and classified as marine waters under the state water quality criteria for bacteria. Daily flux was not calculated when the continuous streamflow gage on Dakota Creek did not record a daily average discharge value and therefore provided no data to model stream discharge at other locations in the watershed.

The geometric mean bacteria concentrations calculated for across the entire harbor are compared to both the geometric mean and total loading from the tributaries to measure the strength of association between marine water quality and the two fresh water loading variables. After $\log_{10}$ transformation, the pooled 2020 and 2021 WY datasets demonstrate normal distribution and equal variance using the Shapiro-Wilks and F tests respectively. Plotting the log transformed paired datapoints illustrate both a linear and monotonic relationship (figure not shown). Both the parametric Pearson’s r and nonparametric Kendall’s Tau correlation tests are conducted to measure the strength of associations.

Pearson’s r tests show a significant direct association (positive correlation) between the marine water bacteria concentrations and fresh water loading with overlapping confidence intervals ($p < 0.05$, $\alpha = 0.05$):

- Marine geometric mean bacteria concentration and total loading, $r = 0.81$
- Marine geometric mean bacteria concentration and geometric loading, $r = 0.78$

This direct association suggests that immediate and nearby fresh water loading significantly coincide with the marine water quality in the harbor. Bacteria loading from fresh water sources serve as a better indicator of marine water quality than bacteria concentrations.

The nonparametric Kendall's Tau correlation tests also show significant direct associations between fresh water FC loads and marine water FC concentrations. Reporting the Kendall's Tau statistics allows the relative comparison between the result of the bacteria concentration analysis described above and the concentration and loading analysis by using the same statistical test. The strongest direct association occurs between the geometric mean of all marine stations and sum of all loads ($p < 0.05$, $\alpha = 0.05$, Tau = 0.56), followed by the geometric mean of both metrics ($p < 0.05$, $\alpha = 0.05$, Tau = 0.47).

## Model Overview

The bacteria TMDLs established for the Drayton Harbor watershed applies four empirical model, also known as statistical models, to fill in data gaps. The Phase 2 data gaps come from limited-to-no *E. coli* sampling and no instantaneous streamflow discharge measurements taken at the time of bacteria sampling. For TMDL development, streamflow measurements are typically coupled with bacteria sampling to calculate instantaneous flux. Data gaps result from updating the Phase 1 study to Phase 2 using more recent bacteria sampling data, while streamflow models are used to fill in the data gaps due to the lack of concurrent instantaneous and continuous streamflow discharge measurements.

The four models in this TMDL include:

- The **bacteria translator** that characterizes the relationship between paired FC and *E. coli* concentrations. This model is developed to calculate (predict) *E. coli* using FC.
- The **time-series streamflow model** that calculates the average daily streamflow of California Creek using time-series data from the Dakota Creek gage station. This streamflow model is developed by characterizing the relationship between the Dakota and former California Creek gage stations.
- The **site-specific streamflow model** that combines the output of the time-series streamflow model with precipitation and catchment area to calculate streamflow at a given pour point such as a sampling site in the watershed. The site-specific streamflow model output is used to calculate bacteria loading when multiplied by the fecal bacteria concentration and conversion factor to calculate the LC. The LC is used to establish TMDLs for each impaired Assessment Unit (AU).
- The **Simple Method** is a series of equations that estimates precipitation-generated stormwater runoff from shoreline areas used to calculate the LC and TMDL—see Appendix E, TMDL Analysis, Allocations for Shoreline Areas for details.

## Bacteria Translator

This TMDL and Implementation Plan addresses the updated WQS fecal indicator bacteria from FC to *E. coli*. Beginning in 2021, the water quality criteria were updated from FC to *E. coli* as the bacterial indicator to determine the protection of the fresh water contact recreation beneficial use. For this study, the *E. coli* TMDLs require translation between the two bacteria because many samples collected in the Drayton Harbor watershed were analyzed for FC, while *E. coli* sampling was limited. Water quality monitoring for FC is justified when assessing the protection of downstream shellfish harvesting in Drayton Harbor and recognizing the long-standing former WQS that was used to assess fresh water conditions as well. Characterizing the relationship between FC and *E. coli* will accommodate future sampling efforts to estimate water quality criteria attainment or adapt to other existing EPA-approved FC TMDLs.

A Type 2 simple linear regression is used to develop the *E. coli* TMDLs for the Drayon Harbor watershed. Type 2 simple linear regression has also been applied to the Whatcom Creek bacteria TMDL (Kardouni 2023) and used to establish the continuity of long-term datasets (Cude 2005), which characterize the relationship between FC and *E. coli*. The Deschutes River multiparameter TMDL (EPA 2020) used a similar approach by applying the Deming regression to develop a bacteria translator. Other studies have applied a simple 1:1 ratio of FC-to-*E. coli* such as the Mid-Yakima River Basin Bacteria TMDL (Provence and Bohn 2020) based on $\log_{10}$ Pearson's r correlation analysis. Another way to develop a translator was done using Ordinary Least Squares (OLS) simple linear regression, which allowed EPA to characterize the bacterial relationships from a variety of environmental conditions (LimnoTech 2012).

**Data Source**

Ecology initiated *E. coli* monitoring at the beginning of WY 2019 as part of the fresh water ambient monitoring program[53], which includes paired sample analysis with FC. Samples are collected throughout the state in selected watersheds including the adjacent Nooksack River watershed (Table D-10). Ninety-three samples (n = 93) collected from 10/9/18 through 1/10/23 at five Ecology monitoring stations in the Nooksack River watershed are utilized to develop this regression. Data are available online from Ecology's Environmental Information Management System (EIM) database[54]. Following Standard Methods, Ecology uses the same filter for each fecal indicator bacteria analysis and use SM9222-D for FC followed by SM9222-I, which describes the transfer of the filter to analyze for *E. coli*[55].

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[53] https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Water-quality-monitoring

[54] https://ecology.wa.gov/research-data/data-resources/environmental-information-management-database

[55] Standard Methods for the Examination of Wastewater, America Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF), Washington, D.C., USA, 24th edition

**Table D-10. Ecology monitoring stations in the Nooksack River basin with samples used to develop the bacteria translator**

| Site ID | Location | Latitude | Longitude | Sample Count |
|---|---|---|---|---|
| 01A120 | Nooksack River at North Cedarville | 48.84167 | -122.29306 | 39 |
| 01A050 | Nooksack River at Brennan | 48.81889 | -122.58 | 41 |
| 01P070 | Tenmile Creek at Northwest Drive | 48.85417 | -122.54103 | 11 |
| 01P080 | Tenmile Creek at Barrett Road | 48.85535 | -122.53414 | 1 |
| 01U070 | Fishtrap Creek at River Road | 48.91968 | -122.48601 | 1 |

The sample data represent water quality conditions that are affected by land uses such as agriculture, industrial, residential, urban, and hobby farms. Both the Nooksack River and Drayton Harbor watersheds share similar land cover and uses; therefore, the assumption that the FC-to-*E. coli* relationship is similar for both watersheds is made. For comparison to another study, the Deschutes River TMDL (EPA 2020) incorporated paired bacteria samples collected in nearby but not adjacent watersheds that have similar land cover within the Puget Lowland ecoregion[56].

**Model Assumptions**

Functioning as a translator, the Type 2 (Model 2) simple linear regression expresses the relationship between FC and *E. coli*. Because measurement error is inherent in both types of sample methods, a Type 2 linear regression using the Least Normal Squares (Major Axis) method is justified (Legendre 2018, Helsel et al 2020). Type 2 regression should be used when the two variables in the equation are random, which applies to the circumstance where the water quality investigator has no control over either bacterial indicator. Conditional assumptions and use of the regression as a bacteria translator include:

- Bivariate normal distribution for each bacterial indicator sample population,
- Bacterial indicators are of the same unit or dimensionless, *e.g.*, log-transformed,
- Similar variance error for each bacterial indicator sample population, and
- Comparisons among observed and forecasted (translated) values are possible.

Type 2 regression is done using the 'lmodel2' package[57] (Legendre 2018), with R version 4.1.2 and the R Studio user interface. Note that the Deming or OLS regressions were not selected methods primarily due to the severe under-prediction of slope. The Deming and OLS methods over-estimate *E. coli* as the response variable, and under-estimate FC as the response variable. In addition, the OLS regression is typically appropriate when random variation is greater for the response variable (y-axis) when compared to the explanatory variable (x-axis), or when the explanatory variable is assumed to have no associated error, which is not the case in this instance where the two variables are expected to have similar error structure.

[56] https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/wa/wa_eco.pdf

[57] Model II Regression (Version 1.7-3)—https://CRAN.R-project.org/package=lmodel2

Where *E. coli* bacteria was not sampled, the bacteria translator allows the relatively robust FC dataset to be translated into *E. coli* bacteria concentrations. Given the comprehensive FC dataset used to develop the Drayton Harbor TMDLs, the translated *E. coli* values from the measured FC concentrations will reduce the uncertainty when establishing TMDL targets and load reductions.

**Model Equations and Evaluation**

The regression demonstrates a significant and predictable relationship between the two bacterial indicators. Two separate regressions are done where either *E. coli* (EC) or FC serve as the response (dependent) variable of the other. For example, when EC is designated as the response variable, FC is the explanatory variable, and these variables may be swapped (Equations 1 and 2). FC concentration (cfu/100 mL) data points are translated to *E. coli* concentration data points using Equation 1. The regression may also be used to translate FC concentrations from *E. coli* samples using Equation 2.

$$EC = 0.8870 \times (FC)^{0.9513} \quad (1)$$

$$FC = 1.1343 \times (EC)^{1.0512} \quad (2)$$

The geomeans of the datasets used to develop the translator are 25 and 19 cfu/100 mL for FC and *E. coli* respectively, with a ratio of 1:0.7 (FC:*E. coli*) (Figure D-8—see Glossary for box and whisker definition). *E. coli* bacteria are a subgroup of FC thermotolerant organisms, therefore, the respective sample geometric means and ratio support the subgroup classification. The Pearson's r correlation test demonstrates a significant positive linear relationship between FC and *E. coli* samples (r = 0.97) (Figure D-9). Model quality is measured using slope and intercept where translations made from the regression can be compared to observations. If the model slope is near 1 and the intercept near 0, then the model fits the data well. If the slope differs from 1 (45°), it measures the difference between the observed and predicted values proportional to the observed values. Note that Type 2 models do not produce coefficients of determination as one measure of model quality.

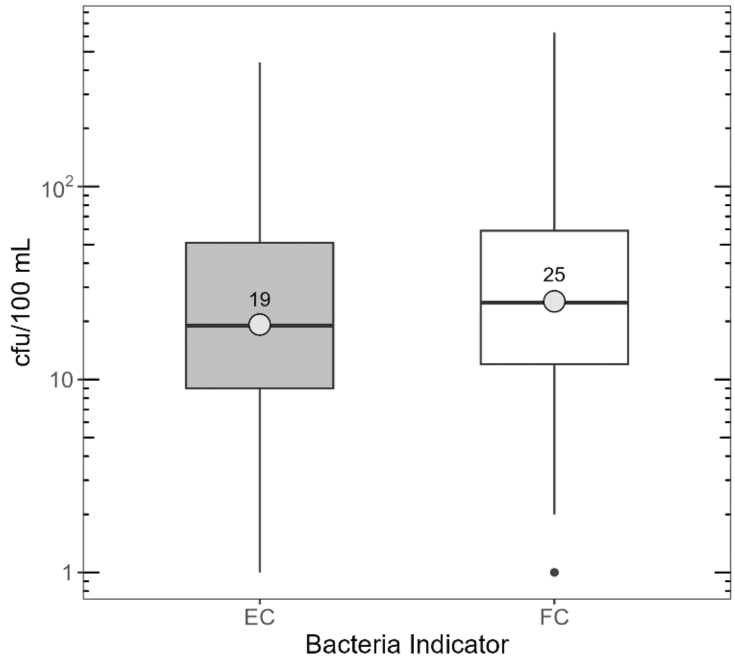



**Figure D-8. Fecal Coliform (FC) and *E. coli* (EC) $\log_{10}$ scale sample distribution collected in the Nooksack River basin with the median (—) and geometric mean (●)**

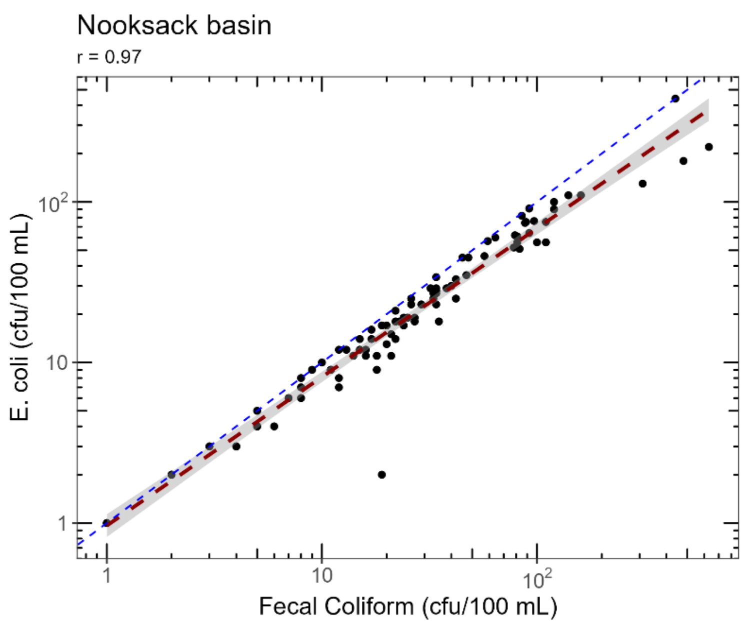



**Figure D-9. $\text{Log}_{10}$ Fecal Coliform and *E. coli* Pearson's r correlation, best fit line and 95% confidence interval (– –), observed values (●), and 1:1 ratio (---)**

The slope for the FC-to-*E. coli* bacteria translator (Equation 1) is 0.95 (43.6°) and the intercept is -0.05 (Figure D-10). The overall error of the model regression is 3.2 percent measured by the relative difference in slope. The difference in intercept is -3.7 percent, which represents the systematic difference (bias) in model performance. The slope for the *E. coli*-to-FC bacteria translator (Equation 2) is 1.05 (46.4°) and the intercept is 0.05. The overall error of the model is 3.2 percent, and the bias is 3.9 percent.

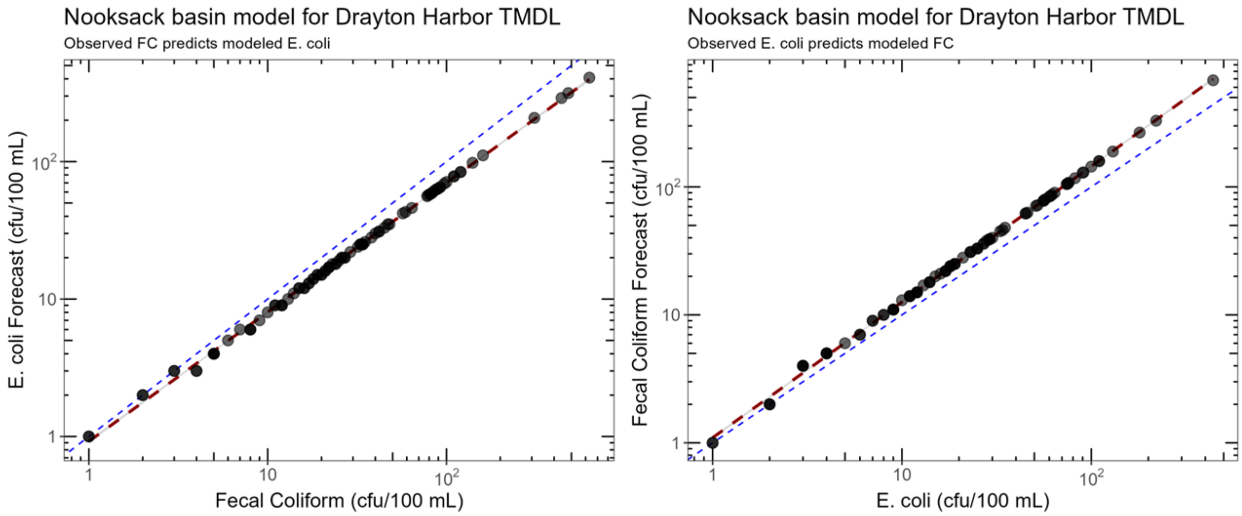



**Figure D-10. Bacteria translator regressions showing forecasted data:—regression line, --- 45° reference, • forecasted**

**Model Applicability**

The bacteria translator (Equation 1) used to establish the *E. coli* TMDLs, percent reductions, and targets may also be used for other types of water quality analysis. The -3.7 percent bias, which leads to a slight underprediction in *E. coli* justifies applying the 10 percent margin of safety (MOS) to the TMDLs. The mathematical relationship between the FC and *E. coli* bacteria groups may be applied to:

- Translate (predict or forecast) between fecal indicator bacteria,
- Bridge long-term trend analysis upon changing fecal indicator bacteria,
- Provide the basis to estimate the probability of exceeding water quality criteria,
- Illustrate relationship characteristics, and
- Lend insight into the type of bacterial pollution source, *i.e.*, vegetative or animal.

*E. coli* data forecasted from FC data establishes this TMDL and helps guide actions in the Implementation Plan to:

- Compare to the WQS for *E. coli* to estimate the likelihood of meeting the geomean and ten percent not-to-exceed STV criteria,
- Characterize seasonal variation in the watershed,
- Calculate *E. coli* loading for each water body and compare to the TMDL,
- Develop the *E. coli* TMDL rollback targets to meet WQS,
- Establish TMDL target geomean concentrations for *E. coli* that are protective of beneficial uses and guide implementation efforts,
- Establish TMDLs, and associated LCs, allocations (WLAs and LAs), and the MOS,
- Develop NPDES general permits,
- Inform TMDL effectiveness monitoring and adaptive management, and
- Gain perspective on effectiveness monitoring.

Generally, water body AUs within the Drayton Harbor watershed that do not meet Washington State Water Quality Criteria for FC will remain on the 303(d) list of impaired waters until:

- Ecology's Water Quality Assessment of new *E. coli* data indicates that standards are met for fresh water contact recreation, or
- An *E. coli* TMDL or pollution control program is activated following EPA approval.

**Model Updates**

Additional sampling data collected by project partners may be incorporated to strengthen the relationship between the two bacterial indicators, thereby informing the regressions to minimize model uncertainty. Uncertainty in the model may originate from either the number of samples or land use assumptions. Legendre (2018) suggests that the Type 2 model regression is ideally developed with a dataset of 60 or more data points to minimize model uncertainty. Datasets smaller than 60 data points may be modeled at the expense of an increasing confidence interval. The dataset for this study (n = 93) satisfies the sample number component. The comparable land cover component also satisfies representative sampling. The translator, however, may be developed at the site-specific level as well, or based on samples collected throughout the Drayton Harbor watershed. Ecology recommends using SM9222-D for FC lab analysis followed by SM9222-I for *E. coli* (APHA 2022).

## Time Series Streamflow Model

Ecology initiated data collection in 2007 during Phase 1 of this TMDL—see Appendix D, Approach. Phase 1 involved extensive bacteria sampling and streamflow measurements on a two-week cycle for over a one-year period to develop loading calculations. Two gage stations were also maintained and operated by Ecology, one on California Creek (Cal5) at Valley View Road (01R090)[58], capturing a drainage area of 10 mi$^2$, and another on Dakota Creek (Dak3.1) at Giles Road (01Q070)[59], capturing a drainage area of 22 mi$^2$. After roughly two years of data collection overlap between the two stations, the California Creek gage was decommissioned in December 2009 while the Dakota Creek gage remained in operation.

Phase 2 of this TMDL involved bacteria loading updates using data collected by the WCWP during WYs 2020 and 2021. Instantaneous streamflow required to establish the TMDL loading components, however, was not measured during the time of bacteria sampling, which represents a data gap. To address this data gap for WYs 2020 and 2021, modeled streamflow using the overlap between the California and Dakota Creek gaging stations is done. This modeled relationship is then extrapolated to each sampling location as described in the Site-Specific Streamflow Model section to calculate loadings, LCs, and TMDLs.

**Model Assumptions and Selection**

Climate, topography, wetlands, soils, land cover, and water diversions are some of the important factors that influence the hydrologic signature observed at the Dakota Creek gage. With the exception of the Cain Creek subbasin, the land cover and underlying soil texture is similar across

[58] https://apps.ecology.wa.gov/ContinuousFlowAndWQ/StationDetails?sta=01R090
[59] https://apps.ecology.wa.gov/ContinuousFlowAndWQ/StationDetails?sta=01Q070

the Drayton Harbor watershed—see the Implementation Plan Land Distribution section for details. The developed area of the Cain Creek drainage covers 85 percent of its respective subbasin. In contrast, the developed land cover in the drainage area upstream of each gage station respectively cover 8.6 and 26.5 percent of the Dakota and California subbasin.

When compared to relatively undeveloped subbasins, developed subbasins with impervious surfaces typically promote flashy runoff by limiting precipitation infiltration into the underlying soils and serves to channelize runoff. The hydrologic effects of developed impervious land cover can alter the hydrologic signature indicated by abrupt hydrographic fluctuations. Applying the time series streamflow model among subbasins with varying amounts of developed land cover is assumed to represent local hydrology based on the outcome of the model evaluation provided below.

The Cain Creek subbasin is exceptional because it does not have a gage station to form the basis of the model and has a relatively greater portion of its subbasin land cover classified as developed. Given the relative high degree of developed land cover in the Cain Creek subbasin, the modeled maximum streamflow values are assumed to be slightly lower than what would have been observed in Cain Creek. Further, an attenuated rising limb and longer lag time in response to precipitation is also possible in Dakota Creek when compared to Cain Creek. Increased runoff from the impervious surfaces in the Cain Creek subbasin is therefore assumed to produce greater daily averaged streamflows than those predicted by the model. These assumptions are not quantified in terms of streamflow units; however, outcomes lead to a conservative LC and TMDL in Cain Creek due to the assumed under-prediction of its streamflow.

In contrast to developed impervious land cover, wetlands, permeable soils, and forested areas reduce flashy runoff by slowing down the water transport processes that affect the hydrology of rivers and streams. One such effect contributes to gradual fluctuations in the hydrographic signature. The effects of developed land cover upstream of the gage stations are assumed to be buffered to some degree by many other land cover types. For example, wetlands cover 13.2 and 17.0 and forest cover 23.0 and 11.7 percent of the Dakota and California subbasins upstream of the gage stations respectively, and agriculture is the dominant land cover class at 50.8 and 42.7 percent respectively.

The effects of agriculture land cover on the hydrologic signature may vary depending on crop type, irrigation withdrawals and returns, and agricultural practices, in combination with soil texture profiles. To a lesser degree, permeable soils have a similar effect to wetlands on hydrology by increasing the interflow potential, while compact or fine-textured soils such as silts and clays have effects similar to developed surfaces that reduce the potential of infiltration.

The effects of land cover and irrigation are captured in the streamflow model error because both the Dakota and California Creek subbasins have gage station data with historical overlapping time periods. The overlapping time periods capture the simultaneous hydrologic processes of each subbasin in which the modeled relationship was constructed. Further, it is assumed that the training dataset from Phase 1 used to develop the model—described below—represents a similar modeled hydrologic relationship to be applied to the Phase 2 dataset. Model error is quantified, however, partial effects from factors such as soil texture, land cover, and irrigation are not individually isolated in the overall model error measurements.

Because the time series streamflow model incorporates the effects of land cover, soils, and wetlands equally between the Dakota and California Creek subbasins by utilizing the on-site gage stations, the hydrographic response to land cover factors is captured in the mathematical relationship between each gaged subbasin and expressed as an equation, however, irrigation withdrawals and returns are difficult to capture. The hydrographic signatures of both subbasins also respond alike to precipitation inputs given their adjacent proximity and similar topography. Above each gage station, the drainage area of Dakota Creek is roughly twice the size of the California Creek drainage area. This relative difference in drainage area is evident in the hydrographs: Dakota Creek streamflows at RM 3.1 are typically twice those of California Creek at RM 5.0 (Figure D-11).

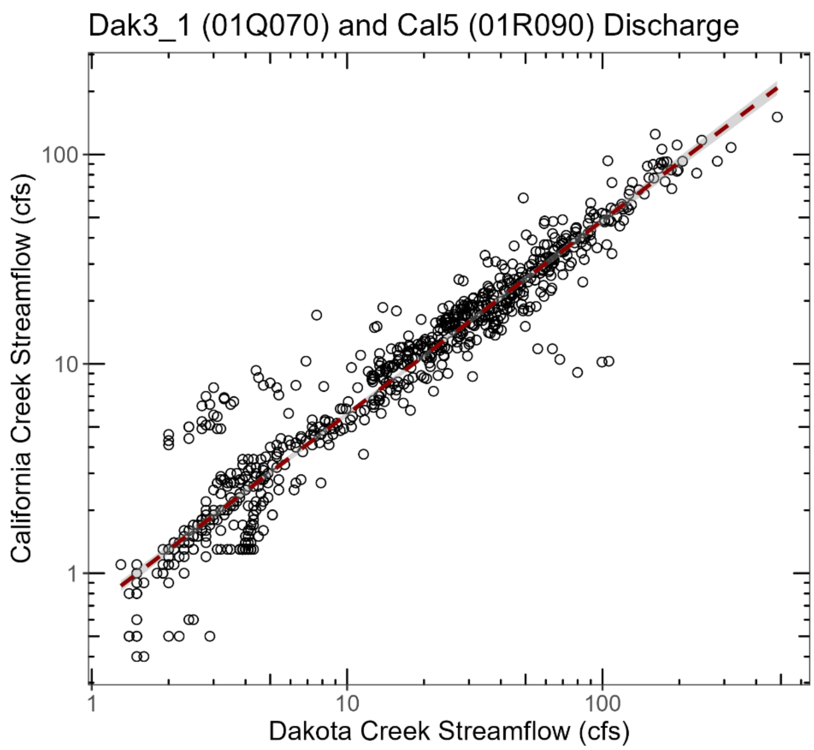



**Figure D-11. Scatter plot of the daily average time series streamflows of Dakota and California Creeks, --- best fit line, ○ observations**

Polynomial relationships are not examined between the two gage stations because the exploratory plot covering the period of record suggests that a linear relationship is present (Figure D-11). Simple linear regression using Generalized Least Squares (GLS) was selected to model the relationship between the Dakota and California gage stations. GLS is the best linear unbiased estimator and accounts for the autocorrelation structure that is typical for time series data (Zuur et al. 2007).

Ordinary Least Squares (OLS) linear regression was not applied because it includes the assumption of independent and identically distributed (~iid) data all the way through the residual error. If the residuals are not ~iid, the assumptions of the OLS regression have been violated. The typical reason that residuals are not ~iid in time series is because they are not independent and that means autocorrelation is occurring. Further, modeling time series data using OLS introduces the risk of inflated p-values and incorrect standard errors that can seriously underestimate the standard errors of the slope (Ostrom 1990).

**Model Setup**

Hydrograph data overlap between the Dakota and California Creek gage stations occurred from 11/8/2007 through 12/6/2009. The streamflow model is developed using a subset of overlapping data from 1/1/2009 through 12/6/2009. The remaining overlapping data are used to evaluate model performance.

The first step involves OLS regression to examine whether the residuals have an autoregressive (AR) structure that indicates autocorrelation. The AR structure is examined using the autocorrelation function (ACF) and partial autocorrelation function (PACF). The correlogram plots (not shown) suggest that the residuals are significantly autocorrelated thus violating the ~iid assumption. The PACF suggests a significant correlation at lag 1, while higher lags indicate no remaining significant autocorrelation. These PACF values suggested a first-order autoregressive process noted as an AR(1) model.

The AR(1) process is further examined by comparing zero-, first-, and second-order autoregressive structures and incorporating a moving average (MA) process to find the autoregressive-moving average (ARMA) model that most adequately describes the relationship between the Dakota and California Creek hydrology. Among the models examined, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) are used to select the best ARMA model. The AR(1) model is selected based on AIC and BIC scores that compared the combinations of ARMA(0,0) through ARMA(2,2) modeled structures. Further, the Durbin-Watson (D-W) test for autocorrelation of residual error in an AR(1) process confirms a significant autocorrelation ($r = 0.9$, D-W value = 0.19, $p < 0.05$, $\alpha = 0.05$).

The 'nlme' package[60] for R was used to develop the GLS streamflow model. The GLS model was trained and fit using 2009 time series data collected at both gage stations. The model validation dataset comprises gage station data collected in years 2007 and 2008. Validation indicates that this initial model shows good performance near the median value with a gradual increase in error toward the extreme values. The median discharge value of 18.3 cfs is observed at the Dakota Creek gage station for years 2007 and 2008.

[60] Linear and Nonlinear Mixed Effects Models (Version 3.1-153)—https://svn.r-project.org/R-packages/trunk/nlme/

To improve model performance near the extremes, the 2009 training dataset was separated based on the median discharge value. One model referred to as the high-flow GLS, was trained with values greater than 18.3 cfs. The other model referred to as the low-flow GLS, was trained using values less than or equal to 18.3 cfs. Separating the training dataset this way improved model performance—discussed below in the Model Evaluation section.

Equation 3 represents the high-flow GLS relationship between the two gage station datasets and incorporates the autoregressive process coefficient of $\phi = 0.56$. Equation 4 represents the low-flow GLS relationship and incorporates the autoregressive process coefficient of $\phi = 0.93$. These simple linear regression equations incorporate the AR(1) structure using GLS and are used to predict the average daily streamflow of California Creek at Valley View Road (Cal5) (01R090) for the TMDL WYs 2020 and 2021.

$$\log_{10} Q_{high} = -0.0672 + (0.8556 \times \log_{10}(Q)) \quad (3)$$

$$\log_{10} Q_{low} = -0.0477 + (0.8323 \times \log_{10}(Q)) \quad (4)$$

Where,

- $Q_{high}$ is the modeled daily average streamflow of California Creek (01R090) using values greater than 18.3 cfs from Dakota Creek (01Q070),
- $Q_{low}$ is the modeled daily average streamflow of California Creek (01R090) using values less than or equal to 18.3 cfs from Dakota Creek (01Q070), and
- Q is the daily averaged streamflow (cfs) observed at Dakota Creek (01Q070).

Equations 3 and 4 are simplified by taking the antilogarithm (inverse logarithm) to produce the simplified streamflow Equations 5 and 6. Equations 3—6 require only the raw as input, *i.e.*, the untransformed streamflow values (cfs) from Dakota Creek (01Q070).

$$Q_{high} = 0.857 \times (Q)^{0.856} \quad (5)$$

$$Q_{low} = 0.896 \times (Q)^{0.832} \quad (6)$$

**Model Evaluation**

Evaluation is done by comparing the daily average streamflows predicted by the model to the daily average streamflows recorded at the gage stations. A subset of the overlapping hydrograph data from each gage station covering 11/8/2007 through 12/31/2008 covers the model evaluation period. The model accurately predicts streamflow quartiles demonstrated by similar summary statistics for the first through third quartiles and geometric means with 95 percent confidence intervals done using nonparametric bootstrapping with the “bias corrected and accelerated” (BCa) method using the ‘confintr’ package[61] for R (Table D-11). The close agreement of summary statistics between model forecasts and observational data reduces uncertainty in the streamflow model—see Appendix E, Loading Capacity for details.

[61] Confidence Intervals (version 1.0.2)—https://cran.r-project.org/web/packages/confintr/confintr.pdf

**Table D-11. Summary statistics with 95 percent confidence intervals for the observed and predicted streamflow discharge (cfs) for the California Creek gage station (01R090) at Valley View Rd (Cal5)**

| Period and value | Minimum | 1st Quartile | Median | Geometric mean | 3rd Quartile | Maximum |
|---|---|---|---|---|---|---|
| Annual Observed | 1.3 | 2.9 ± 1.8 | 10.9 ± 2.6 | 9.2 ± 1.3 | 22.5 ± 8.0 | 151 |
| Annual Predicted | 1.6 | 3.3 ± 0.5 | 10.4 ± 3.5 | 9.8 ± 1.2 | 22.3 ± 5.5 | 169.8 |
| Wet Observed | 1.3 | 11 ± 2.7 | 18.4 ± 3.4 | 16.6 ± 1.3 | 32.8 ± 8.9 | 151 |
| Wet Predicted | 2.7 | 9.7 ± 2.7 | 16.2 ± 5.0 | 16.2 ± 1.2 | 29.76 ± 6.5 | 169.8 |
| Dry Observed | 1.3 | 1.7 ± 0.3 | 2.9 ± 1.1 | 3.3 ± 1.3 | 5.8 ± 2.8 | 21.4 |
| Dry Predicted | 1.6 | 2.7 ± 0.4 | 3.13 ± 0.5 | 4.1 ± 1.3 | 6.0 ± 3.1 | 46.3 |

The geometric means of the observed and predicted values are 16.6 and 16.2 cfs respectively during the wet season (Table D-11). The geometric means of the observed and predicted values are 3.3 and 4.1 cfs respectively during the dry season. The 95 percent confidence intervals overlap, which suggests reasonable agreement between the observed and predicted values. Equation 18 to calculate the LCs, the seasonally averaged geometric mean is the “Flow (cfs)” term predicted by the streamflow model forecast—see Appendix E. When calculating the seasonal LC, the predicted wet season geometric mean streamflow value results in a slight underestimation, while the predicted dry season geometric mean streamflow value results in an over-estimation.

The model predictions are compared to the measured observations using both the $Q_{high}$ (Equation 5) and $Q_{low}$ (Equation 6) regressions separately and when the predictions are combined under one evaluation to measure the model skill (Table D-12). Model accuracy is quantified using the root mean squared errors (RMSE). Model bias is measured by the mean error (ME). Model performance efficiency is measured by the Nash-Sutcliffe model efficiency (NSE) and index of agreement (dr).

**Table D-12. Streamflow model fitness metrics for California Creek gage station (01R090) showing the predicted relative to the observed**

| Model | RMSE (cfs) | ME (cfs) | NSE | dr | Equations |
|---|---|---|---|---|---|
| $Q_{high}$ | 10.28 | -3.06 | 0.82 | 0.82 | 5 |
| $Q_{low}$ | 1.16 | 0.16 | 0.78 | 0.80 | 6 |
| Combined Predictions | 7.37 | -1.46 | 0.89 | 0.87 | 5 and 6 |
| Wet Season | 8.26 | -3.06 | 0.88 | 0.86 | 5 and 6 |
| Dry Season | 5.50 | 1.35 | -1.13 | 0.64 | 5 and 6 |

Model accuracies measured by the RMSE are 10.28 cfs for the $Q_{high}$ (Equation 5), 1.16 cfs for the and $Q_{low}$ (Equation 6), and 7.37 cfs across the combined datasets (Table D-12 and Figure D-12). Model accuracy improves as streamflow values decrease indicated by comparing the $Q_{high}$ and wet season RMSE to the $Q_{low}$ and dry season metrics. These accuracy metrics, however, are relative to the central tendency indicated by the median and geometric means. Model bias is presented both as a value in cfs and a percentage of these values. On average, the model is slightly biased with a -1.46 cfs ME, indicating an overall under-prediction in streamflow. Model bias, however, differs by season and modeled range (Equation 5 and 6), where the wet season predictions have a negative bias while the dry season predictions have a positive bias.

Differences in drainage area may partially explain model bias. At 10 $mi^2$, the California Creek gage station at Valley View Rd measured the drainage of approximately half the area compared to the Dakota Creek station at Giles Rd, which has a drainage area of 22 $mi^2$. The positive model bias during the dry season may be explained by the increased frequency of baseflow conditions where streams with relatively smaller drainage areas tend to experience base flow conditions more frequently than streams with larger drainage areas. The relatively small drainage area contributing to the California Creek gage is a factor that will likely cause baseflow conditions to develop more rapidly and for longer periods than at the Dakota Creek gage, which reduces model skill.

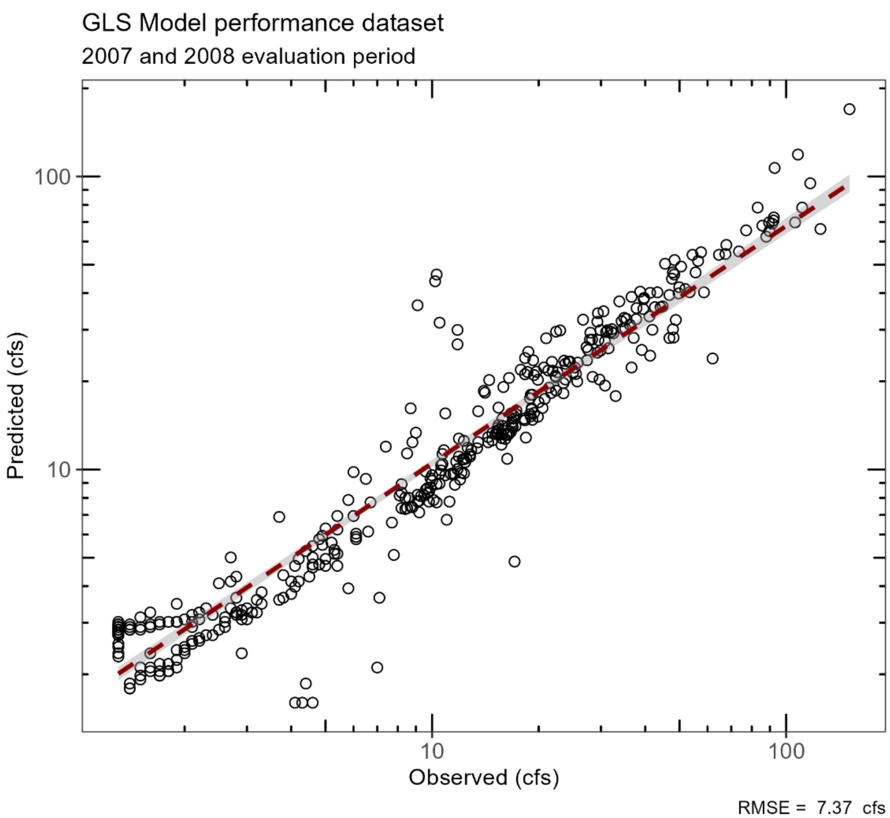



**Figure D-12. Observed and predicted daily average streamflow at the California Creek (Cal5) gage station (01R090), --- best fit line and 95% confidence interval**

Performance measured by the NSE showed that the models explained daily streamflow discharge fairly well with a value of 0.89, where a value of 1 indicates a perfect fit, 0 indicates that the model predictions are as accurate as the mean of the observed data, and negative values indicates that the observed mean is a better predictor than the model (Table D-12). The model did not perform as well during the dry season when compared to the wet season, likely due to baseflow condition explained above. Similarly, the index of agreement (dr) at 0.87 measures the degree of similarity between the observed versus predicted values, where a values of 1 demonstrates perfect agreement and 0 demonstrates no agreement.

The hydrologic signatures such as the leading edge, recession, and baseflows are generally captured by the model (Figure D-13). The model tends to under-predict the peak streamflows with exceptions during May and June 2008, which explains the dry season model bias and reduced performance. The model under-predicted peak values on 13 out of 34 occasions, where peak streamflows are illustrated as the prominent apex in the hydrograph relative to adjacent datapoints. The flow duration curve shows the most accurate model prediction values range between 2 and 30 cfs (Figure D-14). Streamflow values less than 2 cfs are over-estimated, while values greater than 30 cfs are slightly under-estimated.

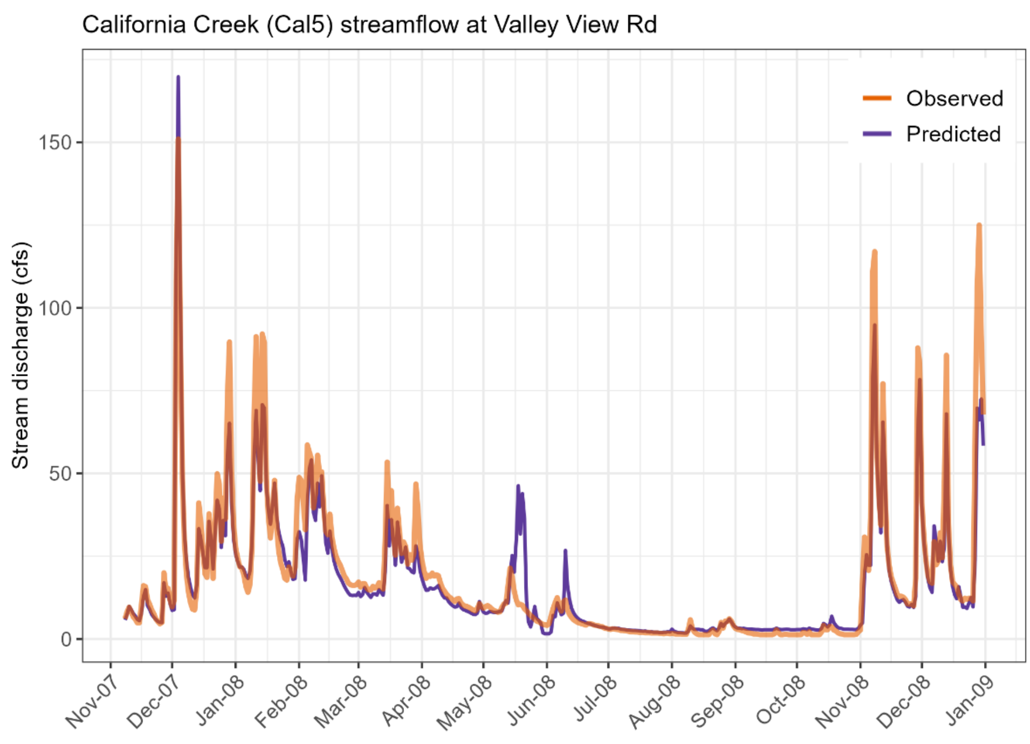



**Figure D-13. Hydrograph of observed and predicted daily average streamflow at the California Creek (Cal5) gage station (01R090)**

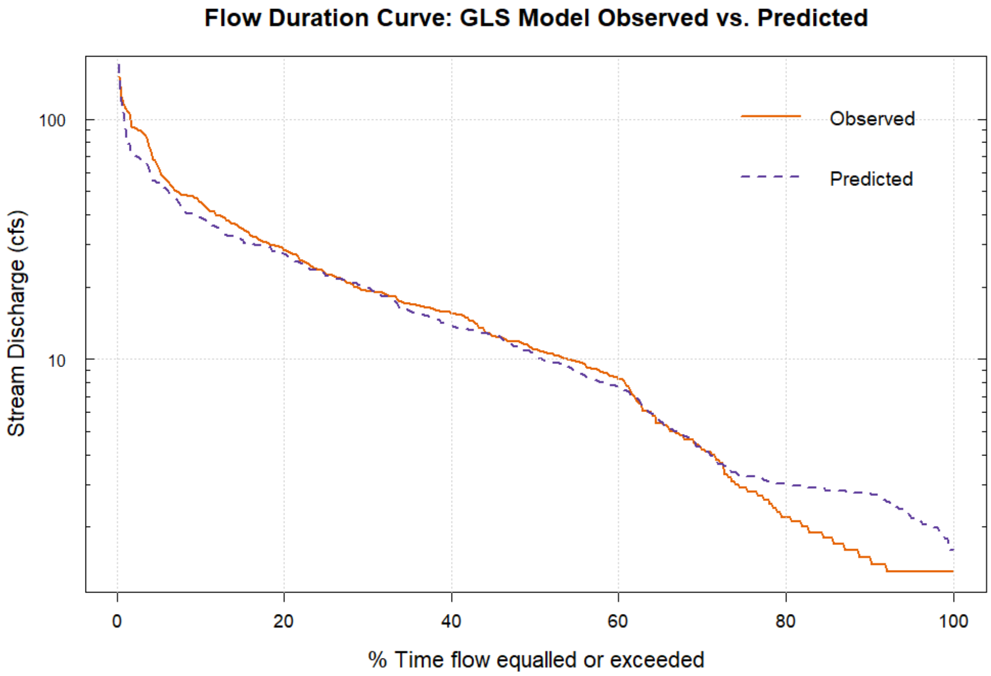



**Figure D-14. Flow duration curve of observed and predicted daily average streamflow at the California Creek (Cal5) gage station (01R090)**

## Site-specific Streamflow Model

Modeling site-specific streamflow to establish TMDLs and LCs for each assessment unit (AU) and the entire watershed is necessary because Phase 2 of this study did not include instantaneous discharge measurements as discussed earlier. To do so, the modeled relationship predicts stream discharge at each bacteria sampling location. As previously described, the initial step involves establishing the time series streamflow model to predict (forecast) the daily average streamflows of California Creek (Cal5) at Valley View Road. The next step involves modeling the relationship between the predicted streamflow values at Cal5 with the remainder of the sampling locations within the subbasin. The same procedure is done for the Dakota Creek subbasin using the observed daily average streamflow values recorded at Ecology's gage station (01Q070)—TMDL sampling location Dak3.1 at Giles Rd.

### Model Assumptions and Selection

The site-specific streamflow model is developed and applied with the assumption that there is a predictable relationship between streamflow and the localized precipitation averages from the long-term record within each subbasin drainage area. The daily mean streamflow values from the gage stations are assumed to share a predictable relationship with mean precipitation and the drainage area. It is assumed that these relationships can be characterized by model equations to accurately calculate the components of each TMDL—see Appendix E, TMDL Allocations for details. Evaluating model performance is done with the assumption that daily averaged stream discharge can be reasonably compared to instantaneous stream discharge measurements.

Selecting the site-specific streamflow model is based on a method that uses watershed area and mean precipitation to predict streamflow discharge that is calibrated to a nearby gage station (Mohamedali et al. 2011). The model functions by leveraging the relationship between the watershed area, the weighted average precipitation within this area, and the streamflow from the gaged stations. The delineated watershed areas, referred to as subbasin catchments, drain through the pour point of the given water body that is collocated at each water quality sampling site.

**Model Setup**

First, data from the Dakota Creek gage station as previously described are used to predict California Creek stream discharge. Next, the continuous streamflow record that is either modeled for California Creek (Cal5) or measured at Dakota Creek (Dak3.1) is normalized by the catchment drainage area and average annual rainfall for each of the two subbasins. Finally, the normalized streamflow is scaled by the area and average annual rainfall of the target catchment represented by the sampling location pour point (Equation 7). Each catchment area is delineated using a combination of the NHD version 2.3 catchment data, the USGS StreamStats Application[62], and the pour point location near each AU ID. Each catchment is visually inspected using GIS and manually adjusted when needed to improve delineation accuracy. Rainfall values for each catchment are calculated using the long-term "normals" Parameter-elevation Regressions on Independent Slopes Model (PRISM[63]).

$$\hat{Q} = Q_{gage} \times \frac{A_{\hat{q}}}{A_{gage}} \times \frac{P_{\hat{q}}}{P_{gage}} \qquad (7)$$

Where,

- $\hat{Q}$ is the calculated streamflow (cfs) at the pour point for the given catchment,
- $Q_{gage}$ is the streamflow (cfs) of the reference gage station that is within the shared watershed of either California Creek or Dakota Creek,
- $A_{\hat{q}}$ is the area (mi$^2$) of the catchment delineated at the pour point sampling location of the given catchment where $\hat{Q}$ is to be calculated,
- $A_{gage}$ is the area (mi$^2$) of the gaged catchment delineated at the pour point sampling location of either California Creek (Cal5) or Dakota Creek (Dak3.1),
- $P_{\hat{q}}$ is the area weighted rainfall (inches) within the given delineated catchment, and
- $P_{gage}$ is the area weighted rainfall (inches) within the delineated gaged catchments if either California Creek (Cal5) or Dakota Creek (Dak3.1).

[62] https://www.usgs.gov/streamstats

[63] PRISM Climate Group, Oregon State University, https://prism.oregonstate.edu, data created 4 Feb 2014, accessed 17 Aug 2022.

**Model Evaluation**

Evaluating the site-specific streamflow model (Equation 7) is done by comparing instantaneous discharge measurements to the modeled streamflow daily averages. The instantaneous measurements were collected during Phase 1 of the TMDL study in 2007 and 2008 at a subset of sampling stations. Phase 2 of the TMDL does not have instantaneous streamflow data, therefore, the time series model (Equations 5 and 6) is coupled with the site-specific model to hind-cast predictions of the expected daily average stream discharge during 2007 and 2008.

Comparing the difference between the modeled daily averaged streamflow at the gaged station and the instantaneous streamflow measurements includes the assumption of similar but not equal representation between the two values. For example, an instantaneous measurement falls anywhere along the 24-hour averaging period of the daily average. The daily average may differ from the instantaneous measurements; however, it is assumed to be representative of the coinciding instantaneous streamflow measurement. The effect of this assumption is not quantified by the model evaluation, rather it is identified as a potential contributor to model uncertainty.

When aggregated across all Phase 1 sampling locations, the model performance and evaluation metrics indicate a reasonable agreement between the daily averaged forecasted model predictions and instantaneous streamflow field measurements (Table D-13 and Figure D-15). Model accuracy is quantified using the root mean squared errors RMSE, bias is measured by the ME, and performance efficiency is measured by the NSE and dr. The combined annual and seasonal values of the predicted (modeled) output have a positive bias of roughly 0.7 cfs indicated by the ME. The differences in geometric means are roughly 0.4 and 0.8 cfs for the dry and wet seasons respectively, however, the 95 percent confidence intervals overlap—estimated using the bootstrap BCa method. At the watershed scale, the combined positive biases may produce an over-estimation of bacterial LC.

**Table D-13. Site-specific streamflow model performance metrics and geometric means with 95 percent confidence interval of the Phase 1 instantaneous measurements and the site-specific model predicted daily averages**

| Period | RMSE (cfs) | ME (cfs) | NSE | dr | Observed Geomean (cfs) | Predicted Geomean (cfs) |
|---|---|---|---|---|---|---|
| Annual | 4.05 | 0.68 | 0.93 | 0.88 | 0.98 ± 1.5 | 1.67 ± 1.4 |
| Dry Season | 1.75 | 0.69 | 0.75 | 0.80 | 0.31 ± 1.7 | 0.72 ± 1.5 |
| Wet Season | 5.11 | 0.67 | 0.93 | 0.88 | 2.29 ± 1.6 | 3.09 ± 1.5 |

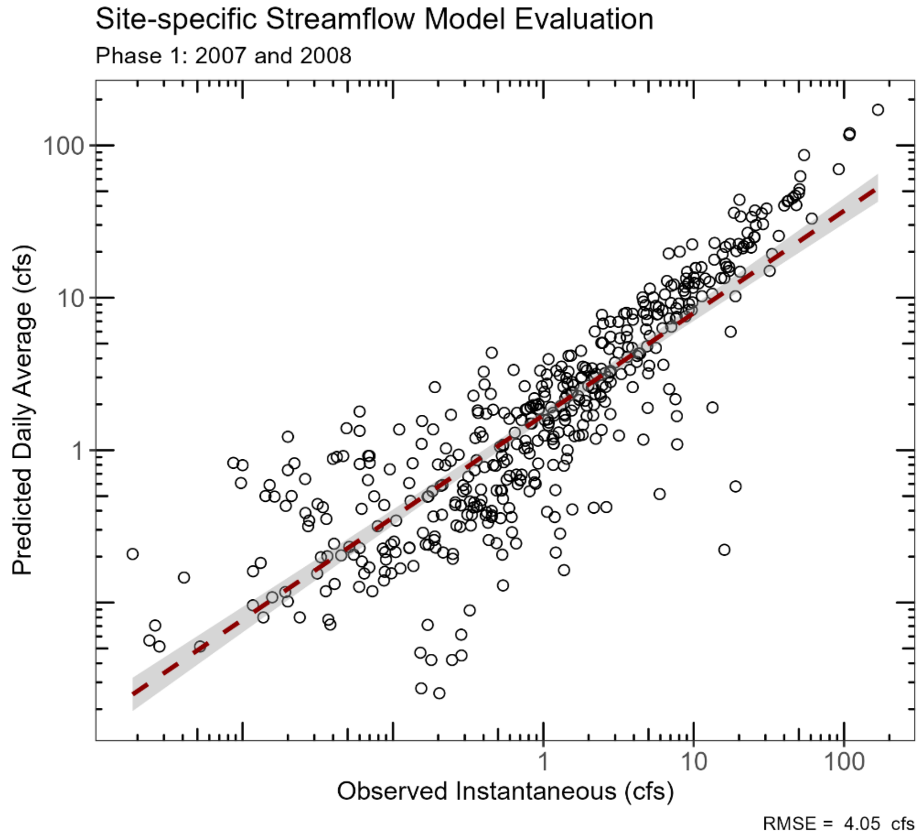



**Figure D-15. Observed instantaneous streamflow measurements from Phase 1 compared to the site-specific predicted daily average streamflow, --- best fit line and 95% confidence interval**

**Beale's Loading Estimate Comparisons**

The Beale's ratio estimator is one method used to calculate loading at sites with adequate pollutant and streamflow data (Lyubchich et al. 2023, Beale 1962). Beale's leverages the relationship between instantaneous bacteria concentrations and streamflows observed at the time of sampling. By using time series streamflow record, the Beale's method provides pollutant loading ratio estimates at the annual or seasonal level that accounts for the limitations of instantaneous bacteria sampling.

Phase 1 used the Beale's ratio estimator to calculate reach-specific seasonal loading along the major tributaries including California and Dakota creeks. While the Phase 2 TMDL update did not calculate reach-specific loading, it does compare the Beale's loading estimates with the bacteria loading and LCs calculated using the observed conditions during WYs 2020 and 2021. The method used to calculate bacteria loading, the TMDL, and the LC is described in Appendix E—Loading Capacity section.

The Beale's seasonal loading totals are used to calculate the average daily load (b.cfu/day) per season. The Beale's loading estimates are calculated using the observed bacteria concentrations and the site-specific modeled streamflow for the given sampling day to produce a daily loading ratio. The modeled time series streamflow record is used in conjunction with the instantaneous Beale's loading ratio to calculate the total loading per wet and dry season. The total seasonal loads are divided by the number of days in each season to calculate the average daily load in units of b.cfu/day.

The average daily Beale's loading rates are compared to the loading rates calculated using the seasonal geometric mean values of the bacteria concentration and streamflow (Appendix E, Equation 18) to compare each method for establishing the LC. To do so, the average daily loads are summed across all sampling locations and compared between the Beale's estimate and loading calculations using Equation 18. The daily loading estimates using the Beale's method are roughly 6 times greater than when using the annual geometric mean loading estimate at 1539 and 249 b.cfu/day respectively. Similarly, the seasonal comparisons indicate that the Beale's method produced 2.8 and 7 times greater daily loading estimates for the dry and wet season respectively when compared to using the seasonal geometric means.

When examined at the site-specific level, the Beale's estimates are greater than the estimates produced by the geometric mean method (Equation 18). While the Beale's ratio estimator is useful when calculating total loading by stream reach or pour point, it was not used to establish the TMDLs and LCs because of the risk of overestimation. Establishing the TMDLs and LCs using the seasonal geometric mean values, therefore represents a comparatively conservative measure at which the pollutant limits will not exceed the WQS.

## Seasonal Variation and Critical Conditions

For seasonal variation analysis, the Drayton Harbor bacteria TMDL defines:

- The wet season from October 1 through April 30, covering 7 months, and
- The dry season from May 1 through September 30, covering 5 months.

The bacteria concentration and daily flux values, when grouped by season, are compared for differences using the Wilcoxon rank-sum test ($p < 0.05$, $\alpha = 0.05$).

**Seasonality Summary**

The fresh water tributaries tend to experience greater bacteria concentrations during the dry season when compared to the wet season with some exceptions based on sample location. The geometric mean dry season bacteria loading, however, is less than wet season loading, which is primarily driven by the differences in the rate of stream discharge where the wet season is greater than the dry season. This difference is also reflected in seasonal LC.

The increased pollution loading rate during the wet season may drive the increase in bacteria levels observed in marine waters. The period of record for each DOH monitoring station in the harbor demonstrates a consistent pattern of significantly greater bacteria concentrations during the wet season when compared to the dry season. The TMDL therefore incorporates a seasonal component based on the seasonal variation demonstrated by marine water quality data analysis.

Storm events as critical conditions were also explored to examine the potential influence on bacteria concentrations. Critical conditions were not analyzed as a separate TMDL component because correlation tests between fresh water bacteria concentrations and precipitation did not suggest consistent strong associations. Rather, storm events captured through routine ambient sampling were incorporated into the TMDLs as data points that contribute to the seasonal geometric mean and 90th percentile calculations.

According to the critical conditions analysis, the most significant instances of increased bacteria levels tend to occur after extended dry periods particularly in the early fall followed by rain events that produce sufficient runoff. These conditions are referred to as seasonal “first flush” events. The calculated TMDLs in this study account for first flush events by incorporating these sample values into the geometric mean and percentile calculations. Streamflow rates during seasonal first flush events are also incorporated into the calculated TMDLs as data point used to calculate the seasonal streamflow geometric means.

**Precipitation Patterns**

This TMDL study defines the wet season as October 1 through April 30, and the dry season as May 1 through September 30, based on the precipitation record from the National Climate Data Center (NCDC) Coop Station: 450729[64] in Blaine, WA (Figure D-16). The mean annual precipitation total at the Blaine station for years 1903–2021 is 41 inches. For comparison, the mean annual precipitation across the Drayton Harbor watershed basin is 45 inches according to Dunn and Cook (2023).

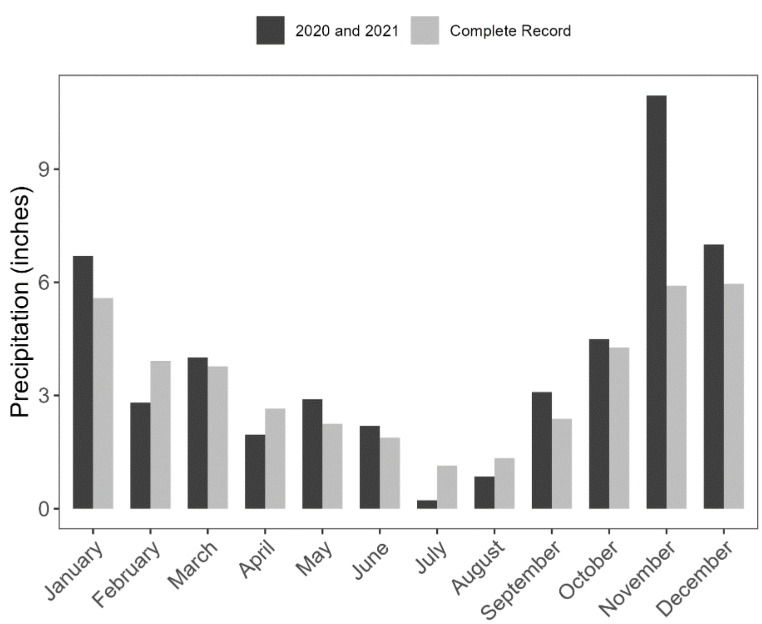



**Figure D-16. Average monthly precipitation totals measured at the Blaine (Coop Station: 450729) including the period of record (1903—2021) and TMDL analysis period (water years 2020 and 2021)**

[64] https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00450729/detail

The TMDL is established using the watershed conditions observed during WYs 2020 and 2021, which had precipitation totals of 50.5 inches (93$^{rd}$ percentile) and 44.9 inches (75$^{th}$ percentile) respectively, relative to the period of record with complete annual datasets. To exclude incomplete representation, annual datasets with less than 365 days are not included in the ranking statistics resulting in a total of 70 out of 118 years used for comparison.

To include incomplete annual datasets in the ranking analysis, the annual totals are divided by the number of observations per year to calculate the daily average total per WY. Water year 2020 has an average precipitation of 0.14 inches per day (88$^{th}$ percentile) with a dry season of 0.07 inches per day (68$^{th}$ percentile, total = 10.1 inches) and a wet season of 0.19 inches per day (83$^{rd}$ percentile, total 40.4 inches). Water year 2021 has an average precipitation of 0.12 inches per day (70$^{th}$ percentile) with a dry season of 0.07 inches per day (69$^{th}$ percentile, total = 10.1 inches) and a wet season of 0.16 inches per day (69$^{th}$ percentile, total = 34.7 inches).

The Wilcoxon rank sum test indicates a significant difference in precipitation between the dry and wet season ($p < 0.05$, $\alpha = 0.05$). Including the two-year period in which the TMDLs are based, the May through September average monthly total is 2.0 inches, which represents the dry season. The October through April period average monthly total is 5.4 inches per month, which represents the wet season.

**Fresh Water Seasonal Fecal Bacteria Concentration Comparisons**

Fresh water sampling opportunities are generally more limited during the dry season than during the wet season. Limitations include comparatively fewer months, five instead of seven respectively, and the increased tendency for a lack of streamflow or stagnant conditions during the dry season. To make use of the robust historical dataset and expand beyond the limitations of WYs 2020 and 2021, the seasonal variation analysis incorporates each fresh water sampling location's period of record up to WY 2021.

Group comparisons to examine seasonal differences in bacteria concentrations show that 27 out of 40 sites have significantly greater bacteria concentrations during the dry season than during the wet season, 8 sites are not different, 4 site have insufficient data for statistical comparison, and 1 site (Dak0.1—Dakota Cr. at SR 548/Blaine Rd.) has greater bacteria concentrations during the wet season.

The following sites show significantly greater bacteria concentrations during the dry season when compared to the wet season:

1. CA6—Tributary to California Cr at Arnie Rd,
2. CA9—Tributary to California Cr at Fox Rd,
3. CA14c—Tributary to California Cr at Brown Rd,
4. CA15—Tributary to California Cr at Portal Way,
5. Cal0.8—California Cr at Blaine Rd,

6. Cal1.9—California Cr at Kickerville Rd,
7. Cal3.1—California Cr at Birch Bay-Lynden Rd,
8. Cal5—California Cr at Valley View Rd,
9. Cal6.2—California Cr at Bruce Rd,
10. Cal7.5—California Cr at Fox Rd,
11. CC—Cain Cr at mouth,
12. Dak3.1—Dakota Cr at Giles Rd, Ecology gage station,
13. Dak6.8—Dakota Cr at Valley View Rd,
14. LS5—Tributary to Drayton Harbor lift station drainage,
15. NFDak2.5—North Fork Dakota Cr at Delta Line Rd,
16. SFDak0.2—South Fork Dakota Cr at Custer School Rd,
17. TribCal2—Tributary to California Cr at Kickerville Rd,
18. TribCal3—Tributary to California Cr at Arnie Rd,
19. TribCal4—Tributary to California Cr at Bay Rd,
20. TribCal5—Tributary to California Cr at Main St,
21. TribDak2—Tributary to Dakota Cr at Sweet Rd,
22. TribDak3—Tributary to Dakota Cr at Rogers Rd,
23. TribDak4—Tributary to Dakota Cr at Hoier Rd,
24. TribDak5—Tributary to Dakota Cr at Valley View Rd,
25. TribDakN2—Tributary to North Fork Dakota Cr at Delta Line Rd,
26. TribDakS1—Tributary to South Fork Dakota Cr at Delta Line Rd, and
27. TribDakS2—Tributary to South Fork Dakota Cr at Sunrise Rd.

The following sites show no significant seasonal difference in bacteria concentrations:

1. Cal0.1 (C1)—California Creek at Drayton Harbor Rd,
2. Cal0.8—California Creek at Blaine Rd,
3. CA14aa—Tributary to California Creek at Aldergrove Rd,
4. Dak0.6—Dakota Creek at I-5,
5. NFDak01 (D3)—North Fork Dakota Creek at Custer School Rd,
6. SFDakDL—South Fork Dakota Creek at Delta Line Rd,
7. TribDak1—Tributary to Dakota Creek at Sweet Rd, and
8. TribDakN1—Tributary to North Fork Dakota Creek at Haynie Rd.

The following sites do not have sufficient data during the dry season for seasonal difference comparisons:

1. Trib1Dray1—Tributary to Drayton Harbor at Dearborn Ave,
2. TribCal1—Tributary to California Creek at Fleet Rd, and
3. TribCal0—Tributary to California Creek at Blaine Rd.

Of the sites with no significant seasonal difference, California Creek at Drayton Harbor Road (Cal0.1) and at Blaine Road (Cal0.8), and Dakota Creek at I-5 (Dak0.6) are classified as marine waters based on applying the Phase 1 study results to the WQS for bacteria. Each sampling location arranged from downstream to upstream represents a longitudinal profile along the mainstems of Dakota and California creeks and the approximate location of each tributary between mainstem segments (Figures D-17 and 18). Bacteria concentrations in the Dakota and California creek watersheds show greater *E. coli* levels during the dry season than the wet season.

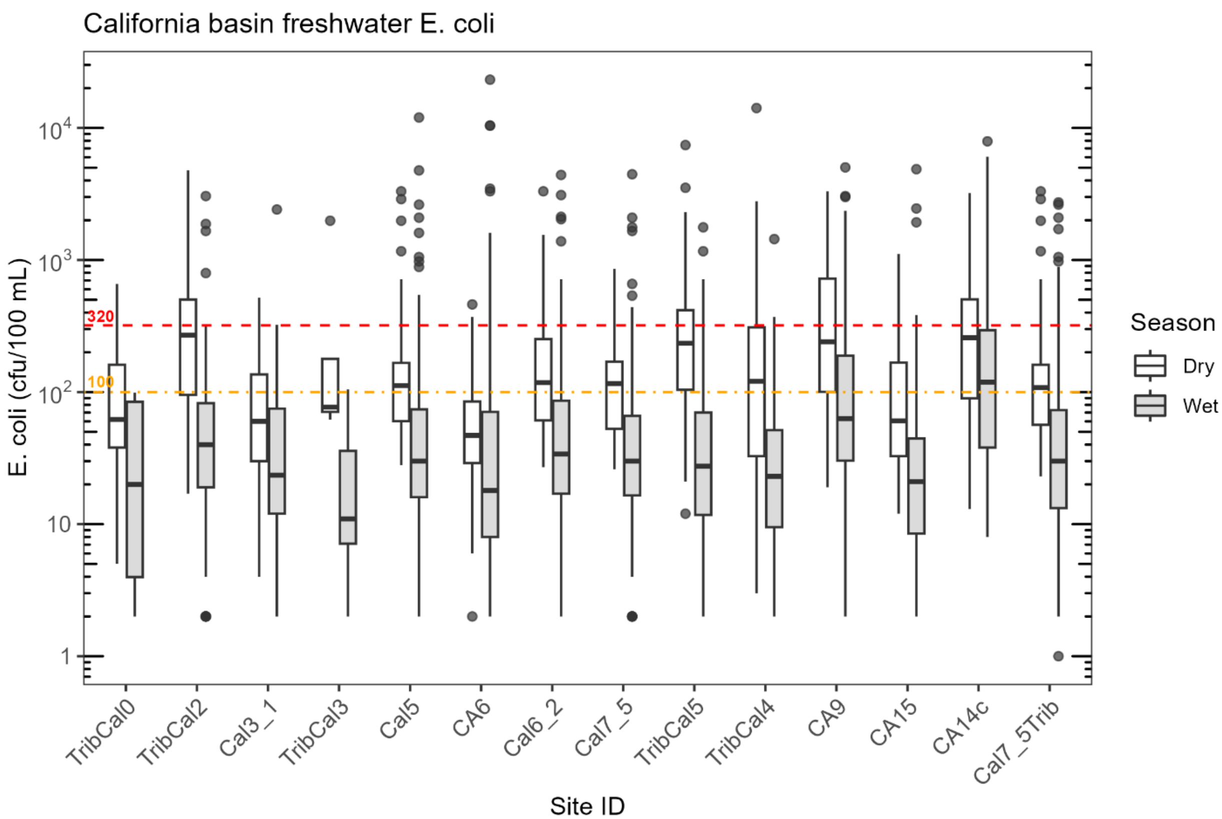



**Figure D-17. California Creek basin translated *E. coli* values at fresh water monitoring stations; median (—), and the geomean (-··-) and 10% STV (---) criteria**

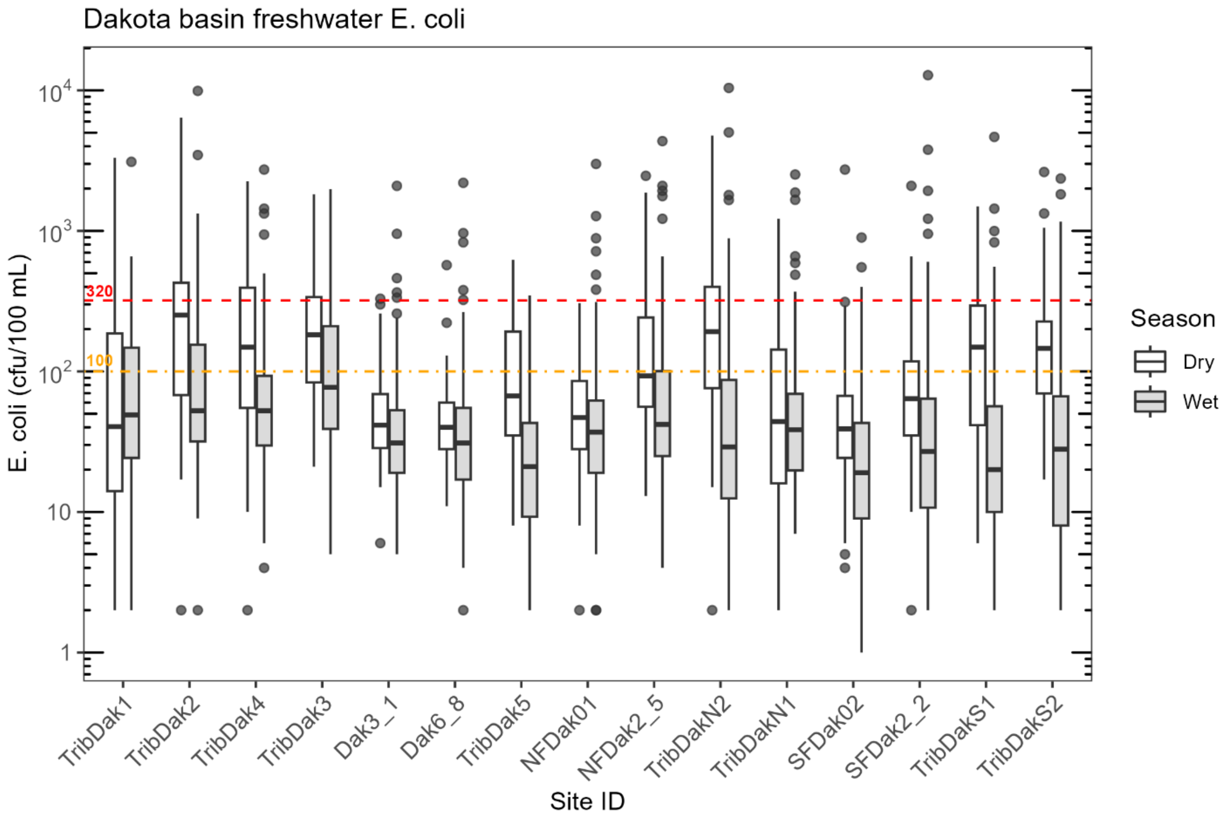



**Figure D-18. Dakota Creek basin translated *E. coli* values at fresh water monitoring stations; median (—), and the geomean (-·-) and 10% STV (---) criteria**

**Fresh Water Seasonal Bacteria Instantaneous Loading Comparisons**

For TMDL WYs 2020 and 2021, bacterial loading to the harbor is examined by comparing the sample population instantaneous flux (loading) values for each season at each fresh water tributary (Figure D-19). Note that seasonal flux comparison tests do not include the period of record for each sampling location and rather focuses on the years used to calculate the TMDL. Further, sample dates that coincide during a period where no data are available for the Dakota Creek gage station are not included because daily flux value cannot be calculated using the existing modeled streamflow relationships. The Dakota Creek gage station does not have recorded streamflow data on roughly six occasions during the wet season, which limits the flux comparison tests to available data only.

The Wilcoxon rank sum group comparison tests at the following sites indicate no significant seasonal difference in instantaneous flux to the harbor:

1. CC—Cain Creek at mouth,
2. LS5—Tributary to Drayton Harbor at lift station 5,
3. Cal3.1—California Cr at Birch Bay-Lynden Rd,
4. TribCal2—Tributary to California Cr at Kickerville Rd, and
5. TribDak3—Tributary to Dakota Cr at Rogers Rd.

The following sites show greater instantaneous bacteria flux during the wet season as follows:

1. Dak3.1—Dakota Cr at Giles Rd, Ecology gage station,
2. TribDak1—Tributary to Dakota Creek at Sweet Rd,
3. TribDak2—Tributary to Dakota Cr at Sweet Rd, and
4. TribDak4—Tributary to Dakota Cr at Hoier Rd.

The following sites do not have sufficient data during the dry season for comparison tests:

1. Trib1Dray1—Tributary to Drayton Harbor at Dearborn Ave,
2. TribCal0—Tributary to California Cr at Blaine Rd, and

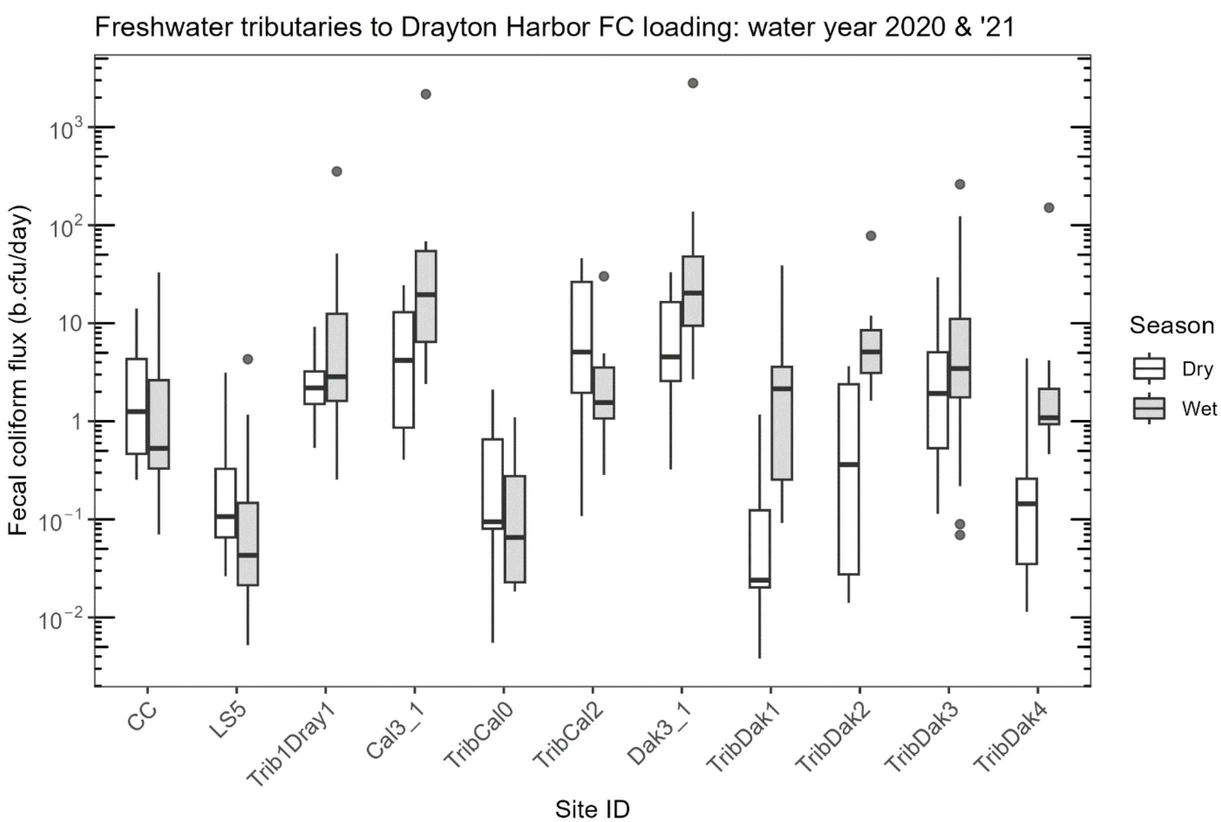



**Figure D-19. Seasonal FC loading flux (instantaneous loading) from fresh water tributaries to Drayton Harbor grouped by sampling site**

Combining all tributary flux values together that discharge to the harbor, the group comparison tests show a significant difference in seasonal bacterial loading with a geometric mean flux of 1.0 billion cfu/day (b.cfu/day) during the dry season and 2.5 b.cfu/day during the wet season. The tributary inputs combined are estimated at 0.9 b.cfu/day greater on average during the wet season than that of the dry season according to the Hodges-Lehmann difference estimate (Figure D-20).

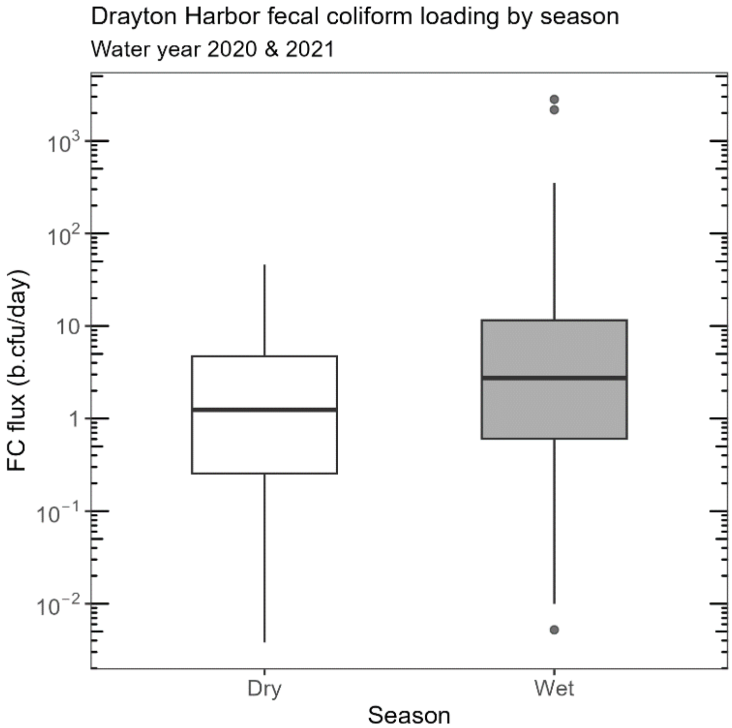



**Figure D-20. Seasonal fecal coliform (FC) loading flux from fresh water tributaries to Drayton Harbor**

### Marine Water Seasonal FC Concentration Comparisons

When aggregated, the FC levels in the harbor are greater during the wet season than during the dry season for WYs 2020 and 2021 (Figure D-21). Comparison tests indicate a significant difference between sample populations when grouped by season, with a Hodges-Lehmann difference estimate of 9 MPN/100 ml. When analyzed by station during WYs 2020 and 2021, seasonal differences are observed at all stations except for stations 15, 314, 378, and 413 (Figure A-4—DOH marine water quality stations map). However, all stations show a significant seasonal difference except for station 413 when analyzed using the entire period of record for each station (Figure D-22).

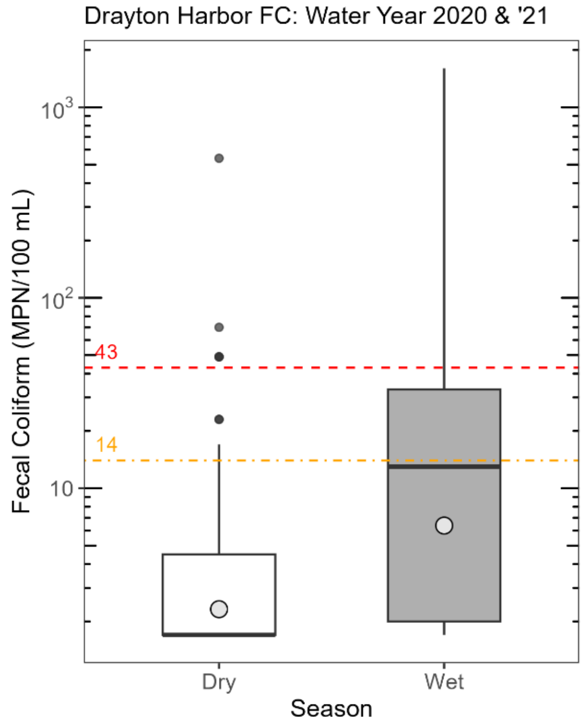



**Figure D-21. Bacteria levels observed in Drayton Harbor aggregating all monitoring stations during the TMDL period; median (—), geomean (●), and the geomean (-·-) and 10% STV (---) criteria**

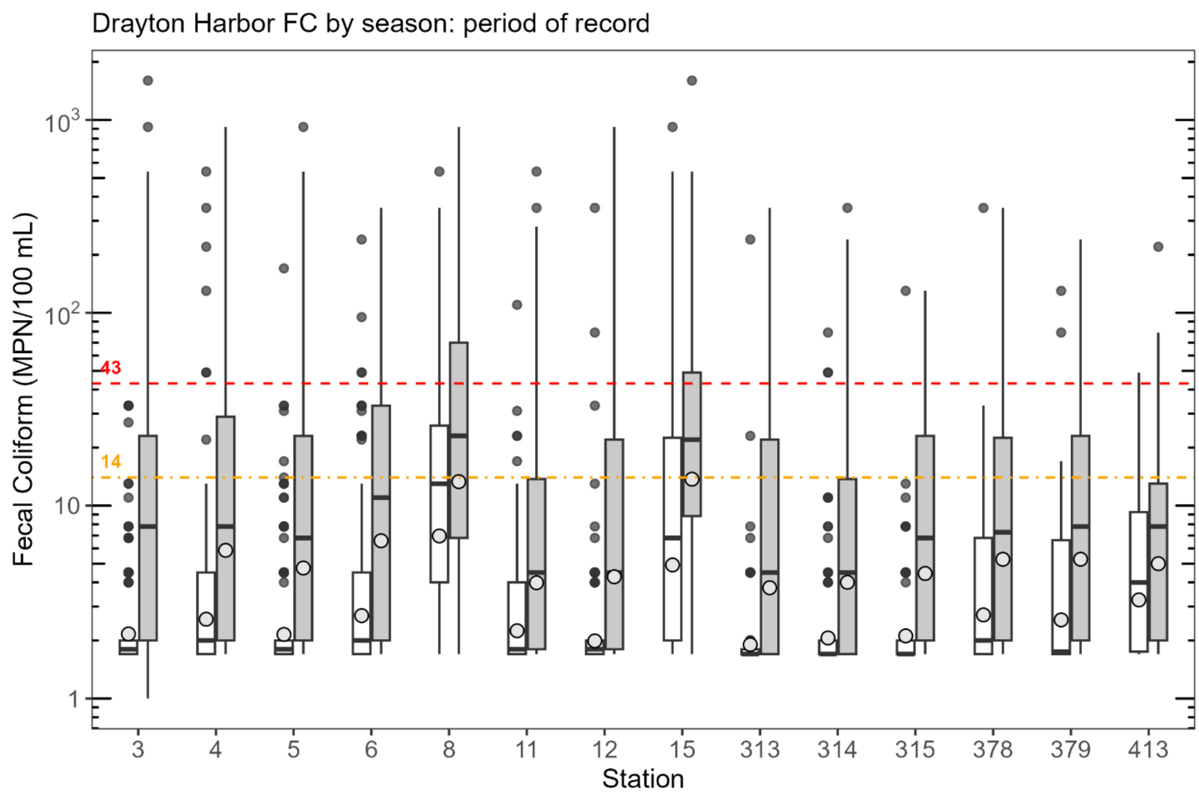



**Figure D-22. Drayton Harbor bacteria for each monitoring station's period of record; median (—), geomean (●), and the geomean (-·-) and 10% STV (---) criteria**

Using WYs 2020 and 2021, the distribution of FC datapoints illustrate the differences and similarities among months (Figure D-23). Bacteria concentrations in Drayton Harbor gradually increase beginning in September and peak by December, followed by a gradual decline through April. From April through August, the bacteria levels tend to meet the marine water quality criteria for shellfish harvesting. This monthly variation aligns closely with significant differences observed between the wet and dry seasons. Note that the entire dataset from 1991 through 2022 follows a similar pattern not depicted here.

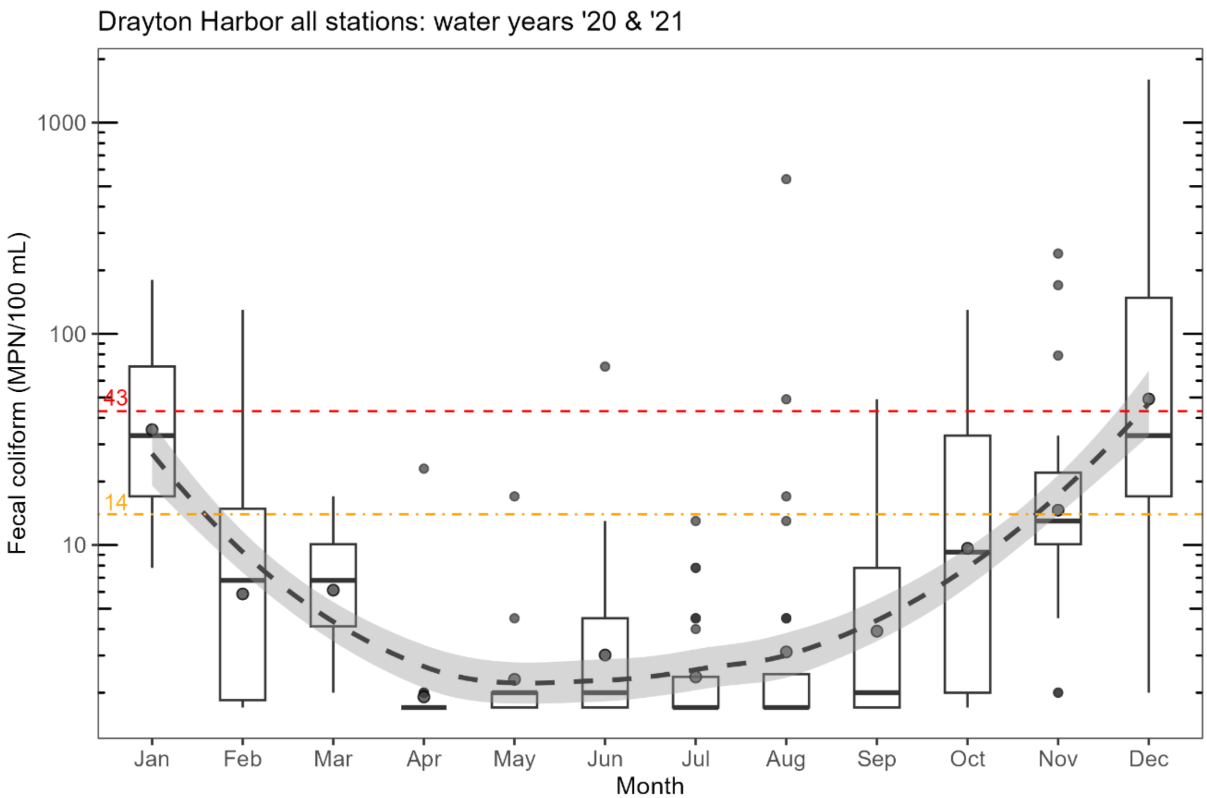



**Figure D-23. Drayton Harbor bacteria aggregating all monitoring stations during the TMDL period and grouped by month; median (—), geomean (●), and the geomean (---) and 10% STV (---) criteria**

## Critical Conditions

Paule-Mercado et al. (2015) demonstrated that runoff from agricultural, mixed with construction sites and urban land uses contain high fecal indicator bacteria concentrations. Stormwater runoff to the receiving waters represents a potential critical condition that can elevate bacteria levels during either the wet or dry season. Bacteria can be directly deposited into waterways or transported by stormwater that produces runoff or hydrologic flushing and resuspension of sediment (Pachepsky and Shelton 2011). The amount and duration of stormwater runoff is driven by the amount of precipitation inputs.

Stormwater runoff and flushing that occurs after long antecedent dry periods can produce elevated bacteria levels in the Drayton Harbor watershed. These conditions are known as “first flush” events beginning in September and may extend through November depending on weather conditions. Stormwater can carry bacteria from pet waste on the ground, surfacing wastewater from failing septic tanks, manure associated with livestock operations, manure associated with agricultural applications, businesses that manufacture or supply compost, or activities such as right-of-way and sidewalk cleaning. When enough stormwater runoff enters receiving water ways, it also increases stream velocity that resuspends sediment where bacteria may persist outside of the originating host. A summary of literature covering bacteria survival outside the host—also known as bio-persistence—and sediment resuspension is presented later in the following section.

To analyze the Drayton Harbor watershed potential for critical conditions, the strength of association between bacteria concentrations and precipitation accumulation in a given period is measured using Kendall's Tau correlation tests for two general types of events. For one type of event, precipitation totals are binned relative to the day of water quality sampling resulting in 12 fixed factors. These fixed factors include the 24-, 48-, and 72-hour periods at certain levels of precipitation accumulation including the; 1) period total, 2) period total greater than 0.2 inches, 3) period total greater than 0.5 inches, and 4) period total greater than 1 inch. For the other type of event, the first flush period is assessed, which includes precipitation accumulation totals at the 24-, 48-, and 72-hour period levels at any point from September through November. The dataset used for analysis leverages long-term conditions beginning in November 2007, which marks the initial fresh water sampling event in Phase 1 of the TMDL and ends in December 2021.

The fresh and brackish water bacteria associations with precipitation show that 24 out of 39 sampling sites have significant correlations in at least one category of the 12 fixed factors and first flush period (Table D-14). A total of 19 sites have positive correlations, 7 sites have negative correlations, and 2 sites have both positive and negative correlations depending on the precipitation fixed factor. Of the fixed factors, the 72- and 48-hour precipitation events most frequently have a direct relationship with bacteria concentrations indicated by positive correlations. Note that not all sampling events are equally represented, therefore, each site and event combination may not have enough data to conclude significance. Sampling events that are not captured are indicated in the correlation tables as no data.

**Table D-14. Kendall's Tau correlation values between bacteria concentrations and precipitation events in fresh and brackish waters**

| Site ID | Precipitation Event | 24 hr | 24 hr 0.2 in | 24 hr 0.5 in | 24 hr 1 in | 48 hr | 48 hr 0.2 in | 48 hr 0.5 in | 48 hr 1 in | 72 hr | 72 hr 0.2 in | 72 hr 0.5 in | 72 hr 1 in |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CA14aa | Total | **0.24** | 0.03 | -0.05 | 0.04 | **0.33** | -0.06 | -0.07 | -0.01 | **0.28** | **0.87** | -0.14 | -0.07 |
| CA14aa | First flush | **0.50** | — | — | — | **0.67** | — | — | — | **0.54** | — | — | — |
| CA14c | Total | 0.09 | -0.16 | -0.10 | 0.03 | **0.17** | **0.59** | -0.11 | -0.02 | **0.14** | -0.33 | -0.03 | -0.13 |
| CA14c | First flush | 0.16 | — | — | — | 0.17 | — | — | — | 0.08 | — | — | — |
| CA14cTrib | Total | 0.05 | 0.06 | -0.07 | -0.01 | **0.16** | -0.02 | -0.08 | -0.02 | **0.13** | 0.49 | -0.15 | -0.05 |
| CA14cTrib | First flush | 0.24 | — | — | — | **0.49** | — | — | — | **0.37** | — | — | — |
| CA15 | Total | 0.00 | -0.12 | -0.04 | 0.08 | 0.05 | -0.33 | -0.20 | 0.07 | 0.06 | 0.49 | 0.55 | 0.07 |
| CA15 | First flush | 0.06 | — | — | — | 0.09 | — | — | — | 0.15 | — | — | — |
| CA6 | Total | -0.03 | -0.06 | -0.10 | 0.02 | 0.05 | -0.05 | -0.16 | 0.01 | 0.04 | -0.03 | -0.33 | -0.31 |
| CA6 | First flush | -0.05 | — | — | — | 0.15 | — | — | — | 0.12 | — | — | — |
| CA9 | Total | 0.01 | **-0.29** | -0.15 | 0.05 | 0.05 | 0.00 | -0.26 | -0.02 | -0.04 | -0.03 | 0.14 | -0.30 |
| CA9 | First flush | 0.25 | — | — | — | **0.33** | — | — | — | 0.13 | — | — | — |
| Cal01* | Total | **0.13** | 0.03 | 0.01 | 0.02 | **0.24** | **0.58** | -0.07 | 0.04 | **0.27** | 0.33 | 0.10 | -0.01 |
| Cal01* | First flush | 0.09 | — | — | — | **0.28** | — | — | — | **0.33** | — | — | — |
| Cal1_9* | Total | 0.05 | -0.01 | -0.04 | 0.07 | 0.08 | 0.60 | 0.06 | 0.08 | 0.08 | 0.33 | **0.65** | 0.21 |
| Cal1_9* | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| Cal3_1 | Total | 0.02 | -0.10 | -0.09 | -0.01 | 0.11 | 0.20 | -0.16 | -0.13 | **0.15** | 0.33 | 0.10 | -0.21 |
| Cal3_1 | First flush | -0.05 | — | — | — | **0.36** | — | — | — | **0.44** | — | — | — |
| Cal5 | Total | 0.00 | 0.02 | -0.07 | 0.02 | 0.08 | 0.42 | -0.11 | 0.06 | 0.07 | 0.33 | -0.10 | -0.13 |
| Cal5 | First flush | 0.01 | — | — | — | **0.23** | — | — | — | **0.23** | — | — | — |
| Cal6_2 | Total | 0.03 | 0.02 | -0.04 | 0.05 | **0.11** | 0.38 | -0.14 | 0.07 | 0.08 | 0.33 | -0.13 | -0.15 |
| Cal6_2 | First flush | 0.21 | — | — | — | **0.38** | — | — | — | **0.28** | — | — | — |
| Cal7_5 | Total | -0.01 | -0.01 | -0.03 | 0.08 | 0.04 | 0.40 | -0.09 | 0.09 | 0.03 | 0.33 | 0.21 | 0.01 |
| Cal7_5 | First flush | 0.10 | — | — | — | 0.23 | — | — | — | 0.22 | — | — | — |
| Cal7_5Trib | Total | 0.04 | -0.05 | -0.06 | 0.00 | **0.14** | 0.20 | -0.17 | -0.08 | **0.12** | 0.40 | -0.30 | -0.20 |
| Cal7_5Trib | First flush | 0.13 | — | — | — | **0.33** | — | — | — | **0.36** | — | — | — |
| CC | Total | **0.20** | 0.05 | -0.03 | 0.13 | **0.27** | 0.33 | -0.13 | 0.09 | **0.20** | 0.40 | 0.15 | 0.22 |
| CC | First flush | **0.44** | — | — | — | **0.51** | — | — | — | **0.42** | — | — | — |
| Dak01* | Total | **0.24** | -0.04 | 0.17 | **0.17** | **0.27** | **0.61** | 0.04 | 0.18 | **0.27** | 1.00 | 0.16 | 0.06 |
| Dak01* | First flush | 0.17 | — | — | — | **0.24** | — | — | — | **0.22** | — | — | — |

| Site ID | Precipitation Event | 24 hr | 24 hr 0.2 in | 24 hr 0.5 in | 24 hr 1 in | 48 hr | 48 hr 0.2 in | 48 hr 0.5 in | 48 hr 1 in | 72 hr | 72 hr 0.2 in | 72 hr 0.5 in | 72 hr 1 in |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dak06* | Total | **0.17** | -0.17 | -0.11 | 0.05 | **0.29** | 0.33 | -0.20 | 0.08 | **0.26** | 1.00 | 0.05 | -0.18 |
| Dak06* | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| Dak3_1 | Total | 0.02 | -0.06 | -0.11 | 0.01 | **0.12** | 0.73 | -0.21 | -0.07 | **0.11** | 1.00 | -0.06 | -0.33 |
| Dak3_1 | First flush | 0.04 | — | — | — | **0.26** | — | — | — | **0.26** | — | — | — |
| Dak6_8 | Total | 0.04 | -0.09 | -0.15 | -0.04 | **0.15** | 0.00 | -0.26 | -0.13 | **0.15** | 1.00 | 0.21 | -0.31 |
| Dak6_8 | First flush | 0.05 | — | — | — | 0.20 | — | — | — | 0.21 | — | — | — |
| LS5 | Total | 0.09 | 0.03 | — | — | 0.22 | -0.35 | -0.29 | -0.20 | 0.18 | -0.09 | -0.17 | -0.33 |
| LS5 | First flush | -0.11 | — | — | — | -0.2 | — | — | — | -0.25 | — | — | — |
| NFDak01 | Total | 0.06 | -0.22 | -0.16 | -0.01 | **0.18** | 0.00 | -0.23 | -0.06 | **0.13** | -0.28 | -0.11 | -0.26 |
| NFDak01 | First flush | 0.05 | — | — | — | 0.19 | — | — | — | 0.13 | — | — | — |
| NFDak2_5 | Total | 0.01 | -0.05 | -0.10 | 0.00 | 0.07 | 0.20 | -0.16 | -0.01 | 0.03 | -0.28 | 0.14 | -0.13 |
| NFDak2_5 | First flush | 0.04 | — | — | — | 0.14 | — | — | — | 0.09 | — | — | — |
| SFDak02 | Total | 0.04 | -0.19 | -0.16 | 0.01 | **0.12** | 0.30 | -0.25 | -0.07 | 0.08 | -0.28 | -0.28 | **-0.41** |
| SFDak02 | First flush | 0.09 | — | — | — | 0.06 | — | — | — | -0.02 | — | — | — |
| SFDak2_2 | Total | 0.05 | 0.01 | -0.04 | 0.11 | 0.10 | -0.41 | -0.06 | 0.09 | 0.08 | -0.28 | 0.47 | 0.16 |
| SFDak2_2 | First flush | 0.15 | — | — | — | **0.26** | — | — | — | 0.18 | — | — | — |
| SFDakDL | Total | **0.31** | -0.43 | -0.22 | 0.06 | **0.42** | -0.33 | -0.34 | 0.01 | **0.30** | -0.28 | 0.25 | -0.23 |
| SFDakDL | First flush | **0.55** | — | — | — | **0.55** | — | — | — | 0.31 | — | — | — |
| Trib1Dray1 | Total | 0.21 | — | — | 0.08 | 0.19 | — | — | 0.14 | 0.16 | — | — | 0.11 |
| Trib1Dray1 | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| TribCal0 | Total | 0.47 | — | 0.55 | 0.36 | 0.37 | — | — | 0.18 | **0.65** | — | — | 0.82 |
| TribCal0 | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| TribCal1 | Total | -0.24 | 1.00 | -0.74 | **-0.72** | -0.01 | -0.33 | -0.33 | -0.55 | 0.24 | -0.28 | 0.82 | -0.82 |
| TribCal1 | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| TribCal2 | Total | -0.06 | -0.19 | -0.05 | 0.05 | -0.07 | -0.07 | 0.00 | 0.02 | **-0.12** | -0.28 | 0.28 | 0.20 |
| TribCal2 | First flush | -0.05 | — | — | — | 0.05 | — | — | — | 0.10 | — | — | — |
| TribCal3 | Total | 0.16 | -0.19 | 0.74 | 0.21 | -0.11 | — | — | 0.55 | -0.08 | -0.28 | 0.28 | 0.82 |
| TribCal3 | First flush | — | — | — | — | — | — | — | — | — | — | — | — |
| TribCal4 | Total | 0.07 | -0.08 | 0.00 | 0.08 | 0.10 | — | -0.11 | 0.07 | 0.08 | -0.28 | 0.28 | -0.01 |
| TribCal4 | First flush | — | — | — | — | 0.20 | — | — | — | 0.27 | — | — | — |
| TribCal5 | Total | **-0.14** | 0.03 | -0.07 | 0.01 | -0.09 | -0.20 | 0.01 | 0.03 | **-0.13** | -0.28 | 0.06 | -0.16 |

| Site ID | Precipitation Event | 24 hr | 24 hr 0.2 in | 24 hr 0.5 in | 24 hr 1 in | 48 hr | 48 hr 0.2 in | 48 hr 0.5 in | 48 hr 1 in | 72 hr | 72 hr 0.2 in | 72 hr 0.5 in | 72 hr 1 in |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TribCal5 | First flush | -0.10 | — | — | — | 0.08 | — | — | — | 0.02 | — | — | — |
| TribDak1 | Total | 0.13 | -0.15 | -0.15 | -0.01 | **0.21** | -0.40 | **-0.32** | -0.09 | **0.23** | -0.28 | -0.20 | **-0.49** |
| TribDak1 | First flush | 0.07 | — | — | — | 0.18 | — | — | — | 0.22 | — | — | — |
| TribDak2 | Total | -0.05 | -0.04 | -0.05 | 0.03 | -0.03 | — | -0.18 | 0.01 | -0.06 | -0.28 | -0.17 | -0.30 |
| TribDak2 | First flush | 0.11 | — | — | — | **0.24** | — | — | — | 0.21 | — | — | — |
| TribDak3 | Total | 0.02 | **-0.22** | — | — | 0.018 | -0.02 | -0.17 | -0.02 | -0.03 | 0.072 | -0.01 | -0.16 |
| TribDak3 | First flush | 0.01 | — | — | — | 0.13 | — | — | — | 0.11 | — | — | — |
| TribDak4 | Total | 0.05 | 0.01 | 0.04 | 0.14 | 0.03 | — | -0.08 | 0.12 | 0.00 | — | -0.06 | -0.21 |
| TribDak4 | First flush | 0.15 | — | — | — | 0.21 | — | — | — | 0.21 | — | — | — |
| TribDak5 | Total | -0.03 | -0.04 | 0.00 | 0.13 | -0.06 | — | -0.04 | 0.14 | **-0.11** | -0.28 | 0.50 | 0.21 |
| TribDak5 | First flush | 0.08 | — | — | — | 0.08 | — | — | — | 0.05 | — | — | — |
| TribDakN1 | Total | 0.12 | -0.01 | 0.01 | 0.04 | **0.20** | — | 0.00 | 0.08 | **0.19** | -0.28 | 0.08 | -0.12 |
| TribDakN1 | First flush | 0.27 | — | — | — | 0.28 | — | — | — | **0.36** | — | — | — |
| TribDakN2 | Total | -0.07 | 0.01 | -0.08 | 0.03 | -0.02 | 0.33 | -0.05 | 0.02 | -0.05 | -0.28 | 0.25 | 0.04 |
| TribDakN2 | First flush | -0.01 | — | — | — | 0.06 | — | — | — | 0.08 | — | — | — |
| TribDakS1 | Total | -0.02 | -0.09 | -0.08 | 0.01 | 0.03 | -0.30 | -0.13 | 0.00 | 0.00 | -0.28 | 0.25 | -0.07 |
| TribDakS1 | First flush | 0.05 | — | — | — | 0.15 | — | — | — | 0.15 | — | — | — |
| TribDakS2 | Total | -0.03 | -0.12 | -0.09 | 0.02 | 0.03 | -0.33 | -0.14 | -0.02 | 0.03 | -0.28 | 0.36 | -0.16 |
| TribDakS2 | First flush | 0.18 | — | — | — | **0.31** | — | — | — | **0.38** | — | — | — |

**Bold** values are significant ($p < 0.05$, $\alpha = 0.05$)**;** * brackish water; —no data

At the DOH marine stations, positive correlations between FC concentrations and precipitation are common at all stations except for station 428, which does not have enough data to test for significance (Table D-15). There are no negative correlations between precipitation and marine FC concentrations. The cumulative 72-hour precipitation shows the strongest positive correlation, followed by the 48- and 24-hour periods. Precipitation events with accumulation thresholds that are greater than 0.2, 0.5, and 1 inches, do not show significant correlations likely due to limited data for these thresholds. Station 15 shows the strongest association between bacteria and precipitation followed by stations 4 and 5, while stations 378 and 379 show the weakest association.

**Table D-15. Kendall's Tau correlation values between bacteria concentrations and precipitation events in marine water**

| Station | Precipitation Event | 24 hr | 24 hr 0.2 in | 24 hr 0.5 in | 24 hr 1 in | 48 hr | 48 hr 0.2 in | 48 hr 0.5 in | 48 hr 1 in | 72 hr | 72 hr 0.2 in | 72 hr 0.5 in | 72 hr 1 in |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Total | **0.14** | 0.13 | 0.08 | 0.03 | **0.25** | 0.15 | 0.03 | -0.01 | **0.30** | — | 0.33 | 0.15 |
| 3 | First flush | -0.08 | — | — | — | 0.11 | — | — | — | 0.19 | — | — | — |
| 4 | Total | **0.14** | 0.16 | 0.02 | 0.00 | **0.27** | 0.12 | 0.04 | 0.00 | **0.32** | — | 0.33 | 0.03 |
| 4 | First flush | 0.20 | — | — | — | **0.25** | — | — | — | **0.34** | — | — | — |
| 5 | Total | **0.14** | 0.15 | -0.01 | 0.00 | **0.28** | 0.38 | -0.03 | -0.05 | **0.31** | — | 0.33 | -0.14 |
| 5 | First flush | 0.04 | — | — | — | **0.27** | — | — | — | **0.32** | — | — | — |
| 6 | Total | **0.19** | 0.06 | -0.01 | 0.06 | **0.25** | -0.22 | 0.05 | 0.05 | **0.28** | — | — | 0.08 |
| 6 | First flush | 0.21 | — | — | — | **0.26** | — | — | — | **0.28** | — | — | — |
| 8 | Total | **0.18** | -0.02 | 0.12 | 0.11 | **0.21** | -0.04 | 0.12 | 0.13 | **0.24** | — | — | 0.16 |
| 8 | First flush | 0.21 | — | — | — | **0.30** | — | — | — | **0.29** | — | — | — |
| 11 | Total | 0.10 | 0.18 | 0.02 | -0.02 | **0.22** | 0.42 | 0.03 | -0.03 | **0.29** | — | 0.82 | -0.07 |
| 11 | First flush | 0.10 | — | — | — | **0.28** | — | — | — | **0.30** | — | — | — |
| 12 | Total | 0.11 | -0.01 | -0.01 | -0.01 | **0.23** | 0.31 | -0.04 | -0.07 | **0.30** | — | — | 0.13 |
| 12 | First flush | -0.07 | — | — | — | 0.15 | — | — | — | 0.19 | — | — | — |
| 15 | Total | **0.13** | -0.09 | 0.02 | 0.07 | **0.18** | -0.04 | 0.10 | 0.09 | **0.19** | — | — | 0.22 |
| 15 | First flush | **0.34** | — | — | — | **0.35** | — | — | — | **0.35** | — | — | — |
| 313 | Total | 0.09 | -0.01 | 0.02 | 0.00 | **0.15** | 0.16 | -0.07 | -0.08 | **0.24** | — | 0.33 | 0.08 |
| 313 | First flush | 0.01 | — | — | — | 0.17 | — | — | — | **0.26** | — | — | — |
| 314 | Total | **0.13** | 0.02 | 0.01 | 0.01 | **0.25** | 0.27 | -0.07 | -0.06 | **0.31** | — | — | 0.09 |
| 314 | First flush | -0.09 | — | — | — | 0.10 | — | — | — | 0.19 | — | — | — |
| 315 | Total | **0.15** | 0.03 | 0.11 | 0.05 | **0.24** | 0.22 | 0.05 | 0.01 | **0.31** | — | 0.33 | 0.06 |
| 315 | First flush | 0.02 | — | — | — | 0.19 | — | — | — | **0.28** | — | — | — |
| 378 | Total | 0.06 | 0.09 | -0.08 | -0.14 | **0.16** | -0.07 | -0.10 | -0.17 | **0.28** | — | 0.33 | 0.00 |
| 378 | First flush | -0.08 | — | — | — | 0.06 | — | — | — | 0.12 | — | — | — |
| 379 | Total | 0.07 | 0.08 | -0.04 | -0.05 | **0.16** | -0.28 | -0.08 | -0.12 | **0.27** | — | 0.33 | -0.03 |
| 379 | First flush | -0.01 | — | — | — | 0.07 | — | — | — | 0.18 | — | — | — |
| 413 | Total | 0.19 | 0.28 | 0.10 | 0.22 | **0.24** | -0.82 | 0.28 | 0.23 | **0.29** | — | 0.33 | 0.39 |
| 413 | First flush | 0.33 | — | — | — | 0.28 | — | — | — | 0.23 | — | — | — |

**Bold** values are significant ($p < 0.05$, $\alpha = 0.05$);—no data

The first flush correlation analysis shows a direct relationship between precipitation and fresh water bacteria data at 17 out of 38 sampling sites. The 48- and 72-hour accumulation periods have the greatest number of significant correlations while the 24-hour period has the strongest measure of association indicated by increasing Tau values above zero. Similarly, first flush to the receiving marine waters indicate that bacteria concentrations directly relate to precipitation at 8 out of 14 stations. This analysis is limited to the 24-, 48-, and 72-hour precipitation accumulation because all other accumulation thresholds do not have sufficient data for analysis.

The Drayton Harbor marine data are also grouped by flood and ebb tide categories to examine the potential for an associated critical condition. The Wilcoxon rank-sum test indicates no difference in bacteria concentrations under flood and ebb tides. This comparison is done using all monitoring stations aggregated across the harbor.

**Sediment Resuspended Bacteria**

Although *E. coli* pollution initially occurs from runoff or direct deposition, these bacteria may also persist outside of the originating host much longer in sediment, biofilms, and organic litter than in the water column (Pachepsky and Shelton 2011). The bottom sediments may act as a reservoir of previously deposited bacteria (Stephenson and Rychert 1982, Weiskel et al. 1996, Craig et al. 2002, Obiri-Danso and Jones 2000). Certain factors and conditions resuspend bacteria in both the fresh and marine water systems. For example, in marine water systems, winds and currents have been shown to be responsible for bacteria resuspension from sediments and transport in the water column (Loutit and Lewis 1985, Smith et al. 1999, Ufnar et al. 2006).

Sediment resuspension as a secondary bacteria source contributes to FC concentrations observed in the water column. Wagner and Ahmed (2011) demonstrated that the sediment load likely plays a major role in bacterial concentrations in Oakland Bay, which has an EPA approved TMDL for bacteria. Loading analysis of FC in the water column suggests that the bacteria loads coming from the tributaries alone cannot fully account for the observed concentrations in the water column. Therefore, the observed concentrations in Oakland Bay, resulting from potential sediment resuspension, will likely continue to cause elevated levels of FC bacteria in the water column unless sources of both suspended solids and bacteria are controlled. The Oakland Bay bacteria TMDL also recommended an investigation of nutrients' potential role on the survival of sediment bacteria.

Solids in the water column can also act as a surface for microbial attachment that prolongs bio-persistence. Sherer et al. (1992) found that the survival rates of bacteria in sediment may be longer than 30 days compared with only several days in the water column. Therefore, sediment and organic litter resuspended and mobilized by stormwater flushing represents an important source of water-borne bacteria pollution along with runoff (Clary et al. 2020, and Pachepsky and Shelton 2011). Further, naturalized bacteria populations outside of the originating host may increase under conducive environmental conditions even with no additional loading to the waterway.

The resuspension of bacteria in the stream sediment under increased stream velocities due to runoff, wind action, or tidal current represents a condition that is not measured by water column sampling alone. Matson et al. (1978) and later, Yagow and Shanholtz (1998) developed a conceptual model of in-channel processes for *E. coli*. Stream discharge and velocity increase during initial runoff, which scours bacteria from the stream channel and bed. Increased bacteria levels in the water column come from both the runoff and resuspended sediments in the stream channel, while stream bed sediment concentrations decrease. After peak discharge, the water column bacteria levels decrease at a faster rate than stream discharge, which can lead to downstream deposition of sediment-bound bacteria.

Concentrations of FC in sediment may be higher than in the overlying water due to slower bacteria die-off rates and the settling of bacteria to the bottom. Jeng et al. (2005) found that the levels of FCs in sediment increased significantly following a given storm event and that bacteria survival increased by at least seven days. Around 10 to 28 percent of FC, and 8 to 12 percent of *E. coli* sampled in urban stormwater was attached to suspended sediment. The concentrations of FC in the water column would be reduced at the rate of 0.06 per hour due to sedimentation. However, estimates of partitioning free-floating bacteria from suspended particles vary greatly between studies (Clary et al. 2020). Assessing the fate and transport of both free-floating and sediment-bound bacteria is typically done using models.

Bacteria populations in the Drayton Harbor watershed experience these sediment related phenomena. The variety of environmental conditions such as precipitation, stormwater runoff, hydrography, seasonality, and harbor characteristics including bathometry, salinity, wind, currents, and tide cycles affect the transport and fate of bacteria in the watershed. These environment conditions coupled with land cover and land uses cause difficulty when attributing nonpoint source bacteria pollution to a particular source.

Although the established TMDLs for the Drayton Harbor watershed represent a protective measure, environmental factors confound bacteria source identification. Further, bacteria associated with sediment transport and bio-persistence are not quantified. These dynamic sensitivities illustrate the importance of effective bacteria source control.

## Statistical Rollback Analysis

The Statistical Theory of Rollback (STR) (Ott 1995) is used to calculate FC reduction targets for the Drayton Harbor watershed to protect designated uses in both fresh and marine waters. The STR compares monitoring data to the numeric water quality criteria, and the difference is the percentage change needed to meet the WQS. The rollback method has been applied by Ecology in many other bacteria TMDL studies (Hood and Joy 2000, Pelletier and Seiders 2000, Joy 2004, Joy and Swanson 2005, Schneider et al. 2007, Swanson 2008, Mathieu and James 2011, Bohling and McCarthy 2020, EPA 2020, Kardouni 2023).

Ideally, at least 20 bacteria observations per site taken throughout the year are needed from a broad range of hydrologic conditions to determine the sample population distribution. Fewer data provide less confidence when determining bacteria reductions. The rollback method, however, is robust enough to determine and compare the observed loading to the TMDL LC, and to calculate percent reductions and the associated geomean sampling targets for planning implementation actions using smaller datasets that follow normal distribution. If seasonal variation in bacteria pollution is observed, then seasonal TMDLs and reductions may be required, which was applied to the bacteria TMDLs within the Drayton Harbor watershed.

The 90$^{th}$ percentile is a statistical distribution measure that determines the value for which 90 percent of the data points are less than, and 10 percent are greater. Similar to the 90$^{th}$ percentile, the no more than 10 percent water quality criterion, or statistical threshold value (STV), measures of the proportion of samples as a percentage that are above the STV, where 90 percent of the sample distribution should be under the STV to meet the water quality criterion. While like the no more than 10 percent criterion STV, the 90$^{th}$ percentile provides a numeric value in terms of a concentration instead of a percentage. That is, the 90$^{th}$ percentile threshold is expressed as a concentration based on bacteria colony forming units (cfu) per 100 mL (cfu/100 mL), while the percent exceedance STV criterion is expressed as a percentage of samples above a particular bacteria concentration.

The pollution threshold set for the 90$^{th}$ percentile is based on the no more than 10 percent criterion STV. For example, as described in the Water Quality Criteria section of this TMDL report, the STV for *E. coli* is 10 percent of samples not to exceed 320 cfu/100 mL. The STV of 320 cfu/100 mL is used as the 90$^{th}$ percentile pollution threshold value to be compared to the 90$^{th}$ percentile statistic of the sample population dataset. When the 90$^{th}$ percentile of the dataset is greater than the given STV, pollution reductions are necessary to meet the WQS. In this example, the 90$^{th}$ percentile and percent not-to-exceed STV are related to one another, however, they are not interchangeable because the 90$^{th}$ percentile is not used to determine compliance with the WQS. Rather, the no more than 10 percent STV criterion is compared to the WQS.

Target reductions are estimates generally based on the water quality criteria for FC—see the 'Water Quality Criteria' section of this report or WAC 173-201A[65] for details. Attaining the most restrictive of the dual bacteria water quality criteria—*i.e.*, the geometric mean or 10 percent exceedance STV portions—is used to estimate the pollution reduction needed at each stream sampling site. The 90$^{th}$ percentile of the sample population distribution is used to express the 10 percent exceedance STV as a concentration.

[65] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

The STV is also applied to determine the designated use protection for marine waters, however, modified based on the background FC concentration in the harbor combined with the marine WQS. The FC target values represent the bacteria levels in the tributaries to Drayton Harbor that meet marine standards when the mixture of fresh and marine water reach 10 ppt salinity (Kardouni 2012 and 2023, Pickett 1997). After accounting for the mixing of fresh and marine water, the 90$^{th}$ percentile STV for FC is 63 cfu/100 mL during the dry season with a geomean of 20 cfu/100 mL, and the 90$^{th}$ percentile STV is 46 cfu/100 mL with a geomean of 19 cfu/100 mL during the wet season. These calculated marine standard target values are used to establish the FC TMDL and target reductions downstream at the fresh-water-marine-water interface to address the protection of shellfish harvesting—see Downstream Designated Use Targets in this Appendix.

**Descriptive Statistics**

The geometric mean is the $n$'$^{th}$-root of the product of all $n$ observations. The bacteria geometric mean $\bar{x}_G$ is calculated using Equation 8 where $x$ is the sample concentration (cfu/100 mL) and $n$ is the sample population count:

$$\bar{x}_G = \sqrt[n]{x_1 x_2 \ldots x_n} \qquad (8)$$

Equation 9 is used to calculate the bacteria 90$^{th}$ percentile $\left(\bar{x}_{90^{th}}\right)$, where μ is the mean of the $\log_{10}$ data, $\sigma$ is the standard deviation of the $\log_{10}$ transformed data, and the 90$^{th}$ percentile standardized normal score is 1.282:

$$\bar{x}_{90^{th}} = 10^{(\mu_{log_{10}}+1.282\sigma_{log_{10}})} \qquad (9)$$

**Statistical Theory of Rollback**

The STR (Ott 1995) involves the calculation of the geometric mean (approximate median in a log-normal distribution) and 90$^{th}$ percentile statistics, which were compared to the two-part *E. coli* water quality criteria—100 and 320 cfu/100 mL (Equations 10 and 11 respectively). If one or both do not meet the criteria, the whole distribution is "rolled-back" to match the more restrictive of the two criteria. After applying the STR method to calculate the final rollback, the 90$^{th}$ percentile criterion is usually the most restrictive (Equation 11). The rolled-back geometric mean or 90$^{th}$ percentile bacteria value then becomes the recommended target bacteria value for the site to meet the TMDL limits. The STR calculates the FC reductions needed to protect the downstream designated use of shellfish harvesting as described in the following section. This method establishes FC reductions at the fresh and marine water interface in brackish waters of Drayton Harbor.

The initial step in the STR method calculates the reduction needed to meet the fresh water contact recreation WQS using the geometric mean of *E. coli* at 100 cfu/100 mL (Equation 10) and STV of 320 cfu/100 mL (Equation 11) and select the greater of the two outputs.

$$Geomean\ Reduction\ (log_{10}) = \left[\frac{\mu_{log_{10}}(E.coli) - log_{10}(100)}{\mu_{log_{10}}(E.coli)}\right] \qquad (10)$$

$$90^{th}\ Reduction\ (log_{10}) = \left[\frac{\bar{x}_{90^{th}}(log_{10}(E.coli)) - log_{10}(320)}{\bar{x}_{90^{th}}(log_{10}(E.coli))}\right] \qquad (11)$$

Next, the greater of the two reductions from Equations 10 and 11 in terms of the $\log_{10}$ the geomean and 90th percentile, is used to calculate the $\log_{10}$ rollback for both terms. The $\log_{10}$ greatest reduction is used in Equation 12 to calculate the $\log_{10}$ FC rollback target mean:

$$Target\ Mean(log_{10}) = \mu_{log10}(E.coli) - \left(\mu_{log10}(E.coli) \times Greatest\ Reduction\right) \qquad (12)$$

The rollback $Target\ Mean(log_{10})$ output and standard deviation $`\sigma_{(Target\ Mean(log_{10}))}$ is used in Equation 13 to calculate the $Target\ 90^{th}(log_{10})$:

$$Target\ 90^{th}(log_{10}) = Target\ Mean(log_{10}) + \left(1.2816 \times `\sigma_{(Target\ Mean(log_{10}))}\right) \qquad (13)$$

Finally, the values from Equations 12 and 13 are back-transformed to the original units of bacteria cfu/100 mL to determine the greatest percent reduction for the final rollback. The greatest percent reduction from either the STR geomean or 90th percentile is used to calculate the final rollback using Equations 14 and 15:

$$STR\ Geomean\ Reduction\ (\%) = \left[\frac{\bar{x}_G - Target\ (`\bar{x}_G)}{\bar{x}_G}\right] \times 100 \qquad (14)$$

$$STR\ 90^{th}\ Reduction\ (\%) = \left[\frac{\bar{x}_{90^{th}} - Target\ (`\bar{x}_{90^{th}})}{\bar{x}_{90^{th}}}\right] \times 100 \qquad (15)$$

Where $\bar{x}_G$ and $\bar{x}_{90^{th}}$ are the calculated FC concentrations before rollback, and the $`\bar{x}_G$ and $`\bar{x}_{90^{th}}$ are the concentrations after rollback.

In summary, the major theorems and corollaries for the STR from Environmental Statistics and Data Analysis by Ott (1995) is as follows:

1. If $Q =$ the concentration of a contaminant at a source, and $D =$ the dilution-diffusion factor, and $x =$ the concentration of the contaminant at the monitoring site, then $x = Q \times D$.

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

**Downstream Designated Use Targets**

The STR is also applied to address downstream designated use of shellfish harvesting while accounting for fresh and marine water mixing at 10 ppt salinity. Equations 10 through 15 are used to calculate the FC target reductions at each tributary when the fresh and marine water mixture reaches 10 ppt salinity in accordance with WAC 173-201A-260(3)(e). Ambient marine water conditions are used to establish water quality benchmarks that do not allow an exceedance of the WQS that forms the basis of the TMDL targets and LC.

Ideally, ambient marine conditions are represented by observations away from fresh water inputs, the shoreline areas, and outside of the harbor. Phase 1 of the TMDL study included three sampling locations in Semiahmoo Bay collected in 2008 and 2009, while Phase 2 did not. As an alternative to represent WYs 2020 and 2021 for the FC TMDL development, station 05 is used to represent ambient marine water quality because it is in a relatively deep area and away from the shoreline areas, while being near the harbor entrance. Salinity and FC data were collected by the Washington State Department of Health Shellfish Program and Whatcom County in Drayton Harbor during shellfish growing areas sampling events for WY 2020 and 2021. Data collected in harbor represents the most comprehensive dataset available to establish the FC TMDL.

Equations 16 and 17 calculate are used to calculate protective water quality target benchmarks to meet the marine shellfish harvest criteria and account for ambient conditions in the harbor. Using WYs 2020 and 2021 for station 05 to represent ambient conditions, the STR target reduction for FC meets the geomean of 19 cfu/100 mL and the STV of 46 cfu/100 mL during the wet season. The STR target reduction during the dry season meets the geomean of 20 cfu/100 mL and the STV of 63 cfu/100 mL. For comparison, data collected outside the harbor during Phase 1 to represent ambient conditions, the STR target reductions would have been similar at 18 cfu/100 mL geomean and 46 cfu/100 mL STV during the wet season; and 21 cfu/100 mL geomean and 67 cfu/100 mL STV during the dry season.

Following the STR method, the more restrictive of the two targets—geomean or STV—forms the basis of the maximum amount of FC reduction necessary to attain the TMDL.

$$Target_{GM} = \frac{WQS_{GM} - (Salinity_{MW} \times FC_{GM})}{Salinity_{FW}} \tag{16}$$

$$Target_{STV} = \frac{WQS_{STV} - \left(Salinity_{MW} \times FC_{90^{th}}\right)}{Salinity_{FW}} \tag{17}$$

Where,

$Target_{GM}$ (cfu/100 mL) is the protective geomean concentration in the brackish mixing zone,

$Target_{STV}$ (cfu/100 mL) is the protective 90$^{th}$ percentile concentration in the brackish mixing zone,

$WQS_{GM}$ (cfu/100 mL) is the geomean criterion of 14 for marine waters,

$WQS_{STV}$ (cfu/100 mL) is the STV criterion of 43 for marine waters,

$Salinity_{MW}$ is the mixed marine water portion at 10 ppt salinity where the value of 36.8% was calculated for the dry season and 35.5% for the wet season,

$Salinity_{FW}$ is the mixed fresh water portion at 10 ppt salinity where the value of 63.2% was calculated for the dry season and 64.5% for the wet season,

$FC_{GM}$ is a value of either 3 or 5 MPN/100 mL geomean FC concentrations representing the background marine water quality separated by the dry and wet season respectively,

$FC_{90}{}^{th}$ is the value of either 9 or 38 MPN/100 mL 90$^{th}$ percentile fecal coliform concentrations representing background marine water quality separated by the dry and wet season, respectively.

Median salinity values that quantify the contribution of marine water mixing with fresh water incorporate the pooled 2020 and 2021 two-year dataset. The median salinity at station 05 is 27 ppt, or practical salinity units, during the dry season and 28 ppt during the wet season, which determine the $Salinity_{MW}$ term. Note that practical salinity units and ppt are very similar and either unit of measurement may be reasonably applied in the WQS. According to Phase 1 data, the fresh water inputs had 0.14 ppt salinity based on the specific conductance data. Fresh water salinity values are calculated following the Intergovernmental Oceanographic Commission (IOC) (2010) guidelines.

For TMDL development during WYs 2020 and 2021, the FC values representing ambient (existing) marine concentrations are calculated by season using the pooled two-year dataset at station 05 to represent the $FC_{GM}$ and $FC_{90}{}^{th}$ terms in Equations 16 and 17 respectively. During the wet season, station 05 has a geomean FC concentration of 5 MPN/100 mL and a 90$^{th}$ percentile of 38 MPN/100 mL. During the dry season, station 05 has a geomean FC concentration of 3 MPN/100 mL and a 90$^{th}$ percentile of 9 MPN/100 mL. Because the FC TMDLs are set to protect downstream water quality, the ambient FC levels in the receiving marine water directly influence the amount of pollution the harbor can sustain and still meet the WQS.

The 90$^{th}$ percentile ambient conditions in the harbor have the greatest influence on the final FC TMDL targets when compared to the ambient geometric mean. The greater ambient FC levels in the harbor during the wet season require greater pollution reductions from fresh water sources when compared to that of the dry season. According to this mixing analysis, the marine water conditions during the wet season has far less capacity to assimilate additional pollutant loading than during the dry season, which is illustrated by these ambient concentrations and differences in seasonal target reductions. Even after considering the effects of seasonal variation, the amount of FC pollution reduction necessary to protect the shellfish growing areas is substantial during both the wet and dry seasons according to this TMDL analysis.

**Rollback Target Concentrations and Percent Reductions**

The term “target” is used to distinguish these estimated numbers from the actual water quality criteria. The degree to which the distribution of bacteria counts is rolled-back (rollback factor, to the target value represents the estimated percent of bacteria reduction required to meet the WQS, and TMDL limits. The bacteria targets are used to assist water quality managers in assessing the progress toward compliance with the bacteria water quality criteria. Compliance is ultimately measured as meeting both parts of the water quality standards criteria.

The rollback method assumes log-normal distribution for each sample site population. Both the Shapiro-Wilk test and visual inspection of the plotted data are used to check the assumption of log-normal distribution. The Shapiro-Wilk test tends to be stringent while visual inspection allows this hypothesis test outcome to be relaxed. The roll-back best estimate is provided in cases where the Shapiro-Wilk test does not infer log-normal distribution identified in Tables 4 and 5 and reported in the following figures (Figures D-24—66). Visual inspection of these data plots allows for a qualitative judgement of population distribution.

The statistical rollback analyses incorporate the FC dataset from WYs 2020—2021 where each FC datapoint is translated to *E. coli* bacteria (Equation 1). The two-year pooled dataset provided a large enough sample size to adequately characterize the watershed and offer sufficient certainty to the roll-back analysis. The sample populations ranged from 4 to 46 samples per site when separated by wet and dry season. The wet season typically has more sample data points than the dry season. Seasonal estimates determine TMDL limits and target reductions. Starting from the downstream most TMDL calculation and organized by subbasin, Figures D-24—D-66 from the statistical rollback analysis include:

- Reduction in FC bacteria to meet the TMDLs accounting for seasonal variation and the mixing of fresh and marine waters at all locations that discharge directly to marine water,
- Reductions in *E. coli* bacteria to meet the TMDLs while accounting for seasonal variation,
- Current water quality conditions represented by data points, 90$^{th}$ percentile, and geometric mean per season (orange),
- Target values for the 90$^{th}$ percentile and target geometric mean to attain the TMDL (blue),
- Reductions needed to attain the TMDL (green), and
- Shapiro-Wilk Test p-value for normal distribution assessment, α = 0.05

*Dakota Creek Subbasin Roll-back Targets*

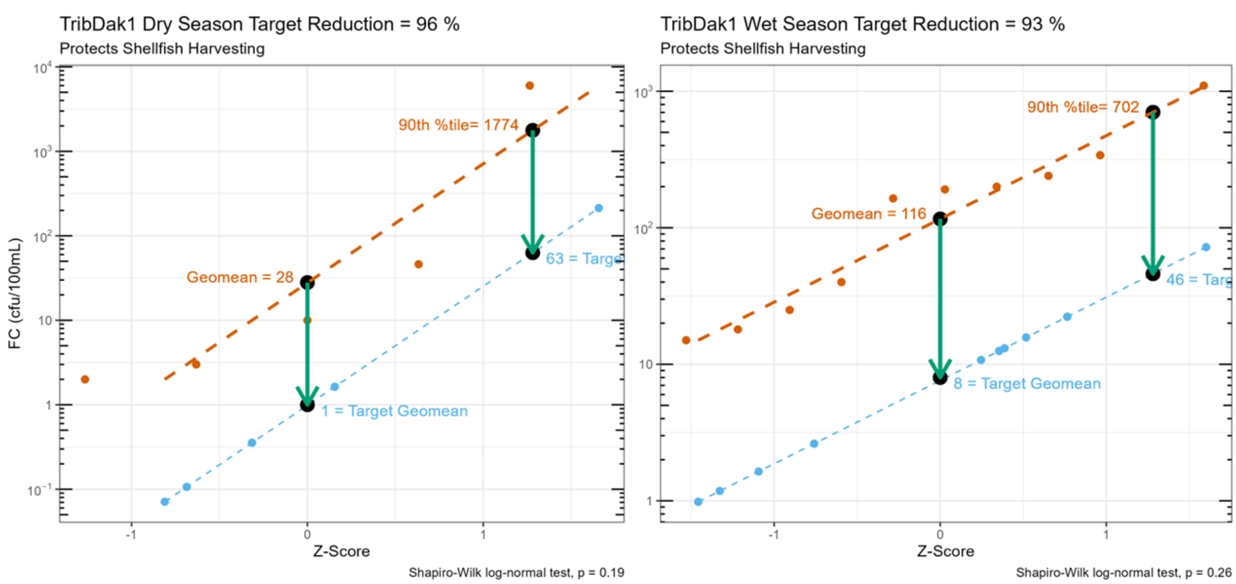



**Figure D-24. Tributary to Dakota Creek (TribDak1) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

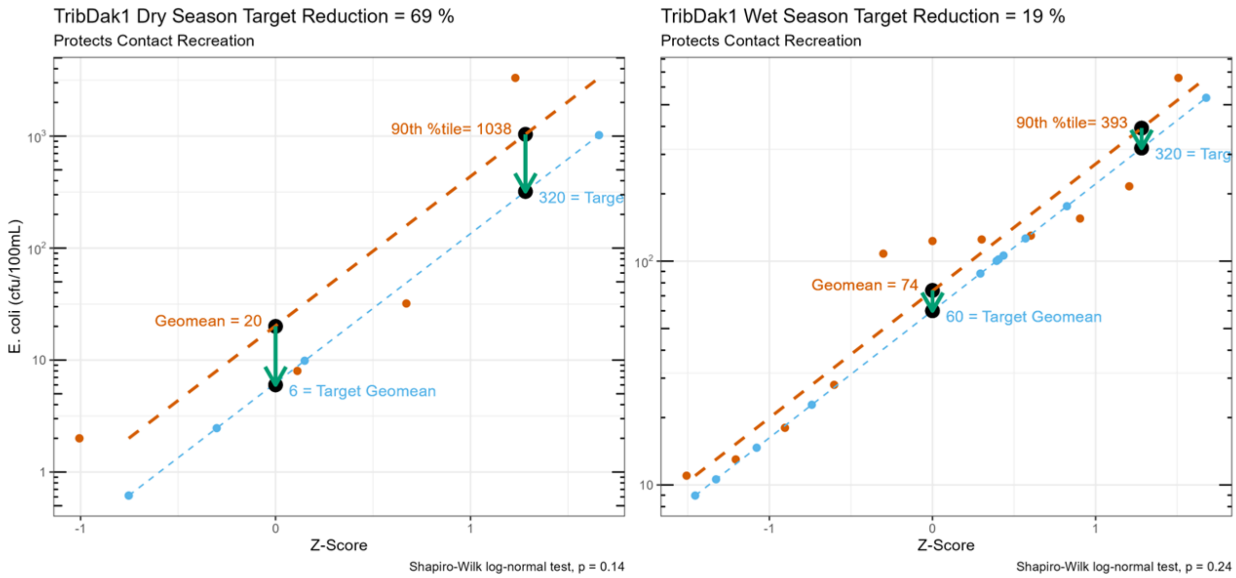



**Figure D-25. Tributary to Dakota Creek (TribDak1) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

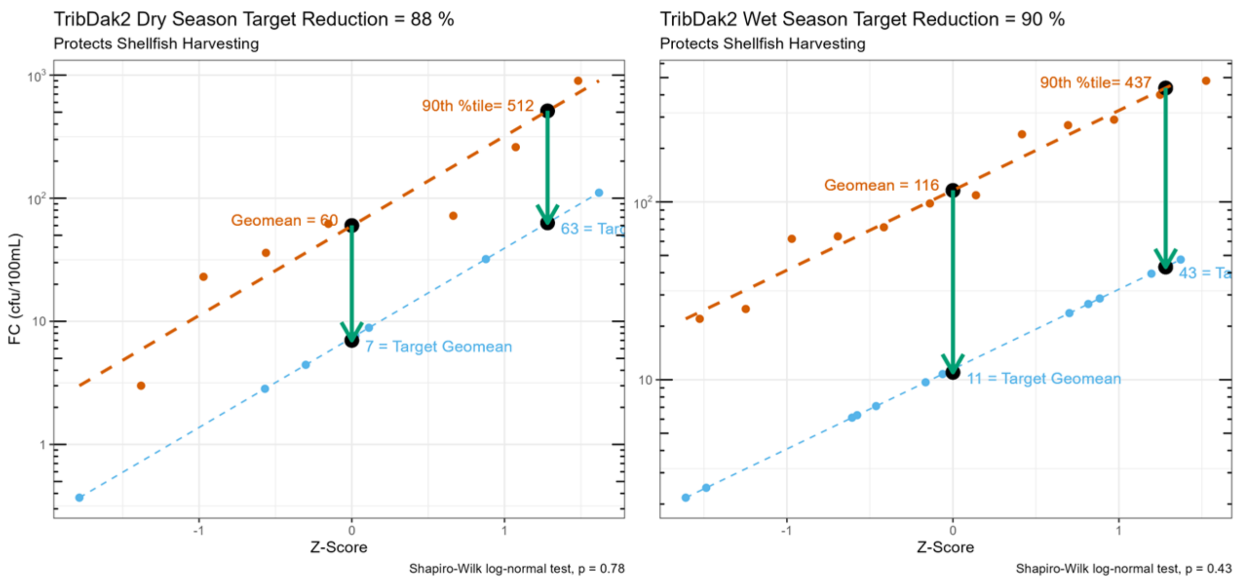



**Figure D-26. Tributary to Dakota Creek (TribDak2) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

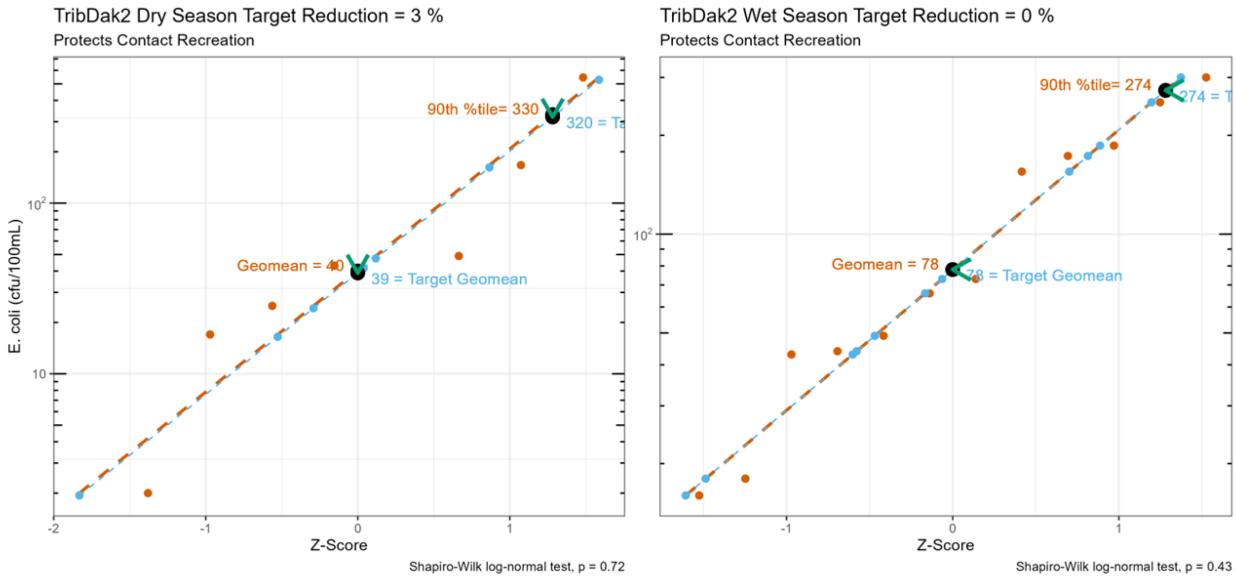



**Figure D-27. Tributary to Dakota Creek (TribDak2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

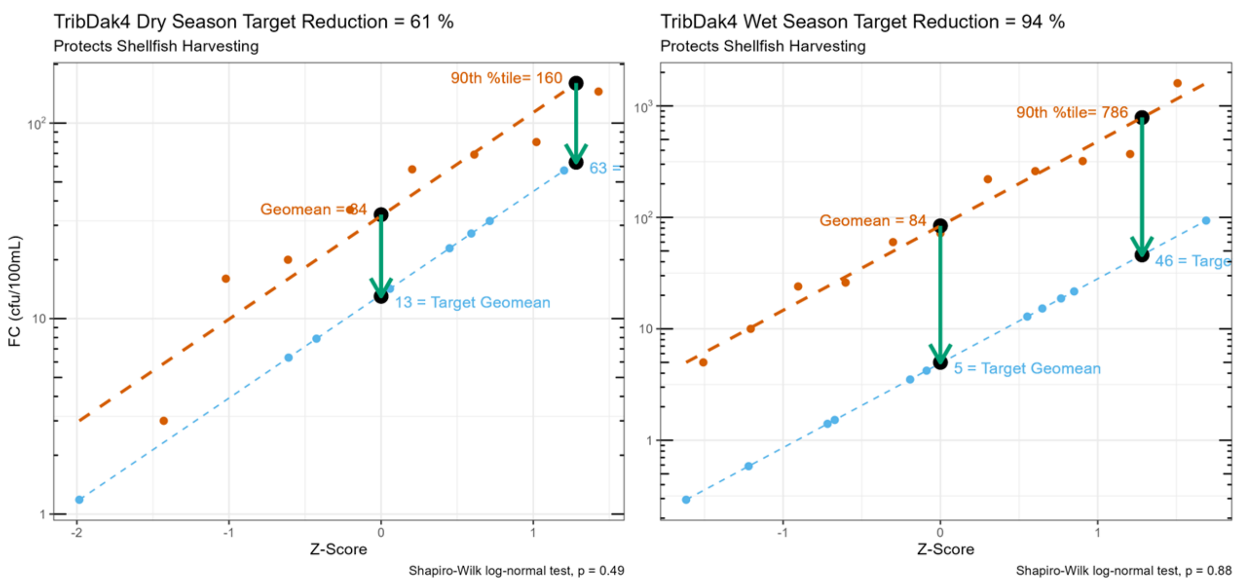



**Figure D-28. Tributary to Dakota Creek (TribDak4) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

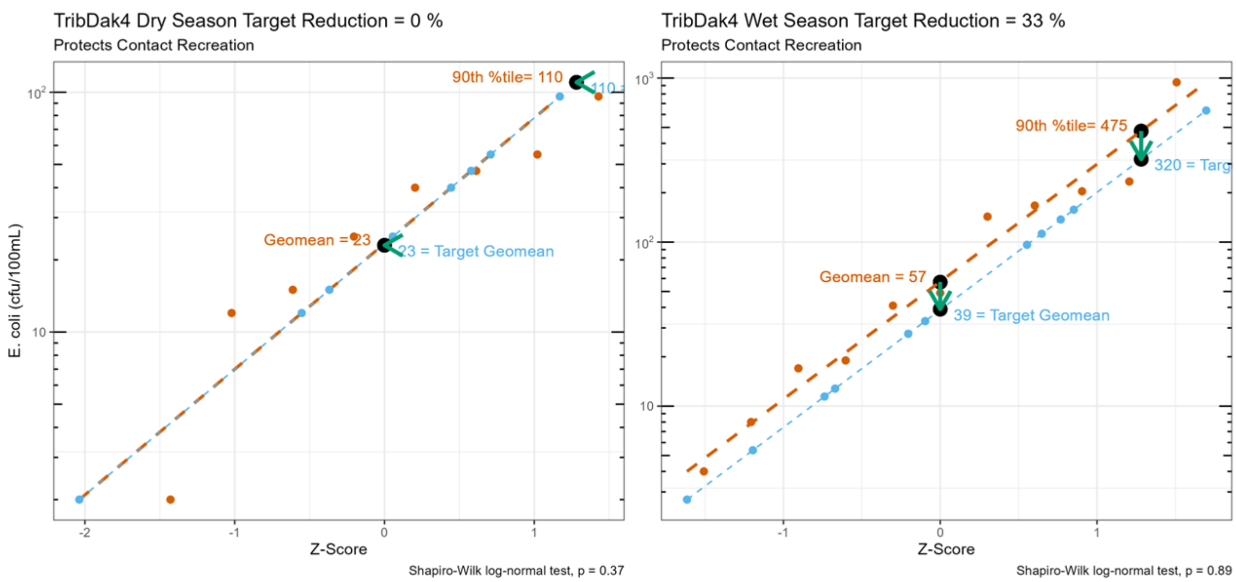



**Figure D-29. Tributary to Dakota Creek (TribDak4) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

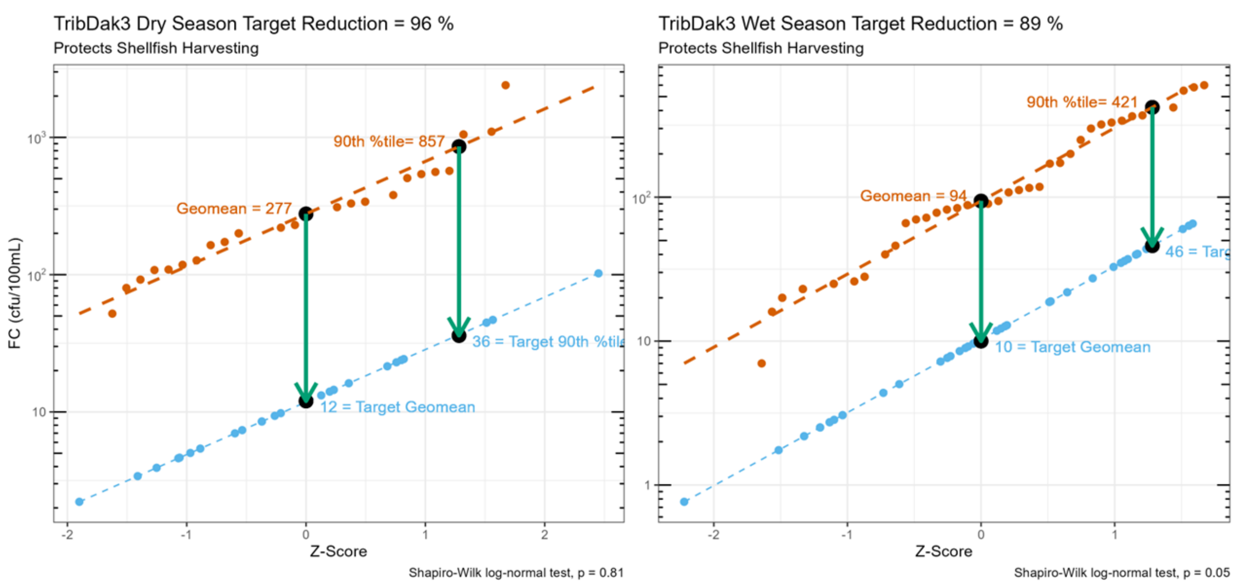



**Figure D-30. Tributary to Dakota Creek (TribDak3) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

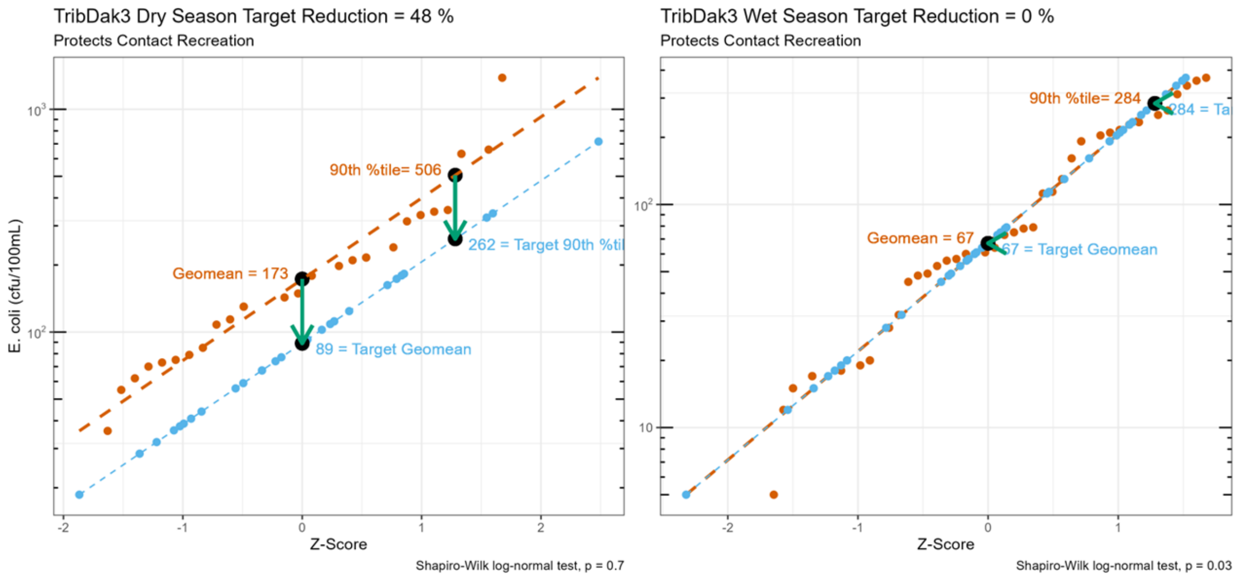



**Figure D-31. Tributary to Dakota Creek (TribDak3) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

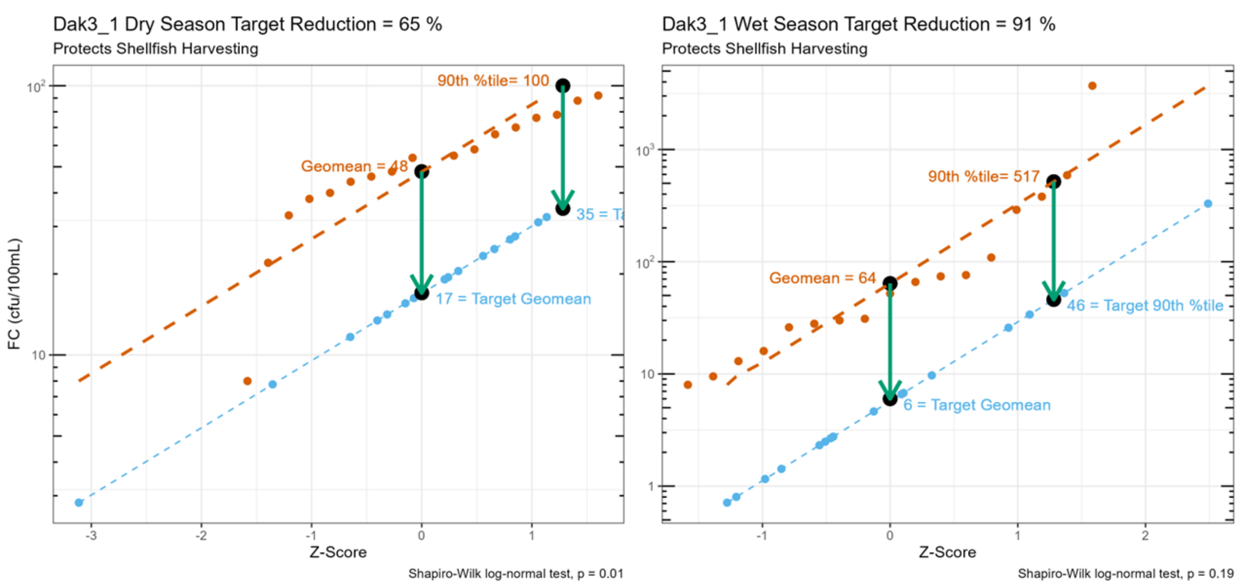



**Figure D-32. Dakota Creek (Dak3_1) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

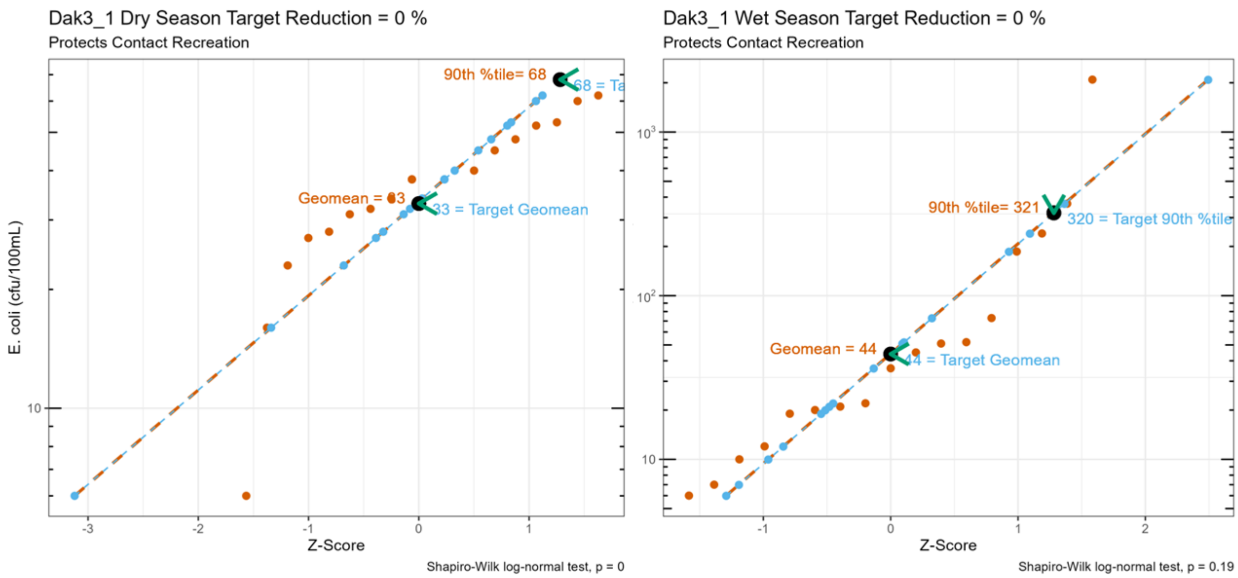



**Figure D-33. Dakota Creek (Dak3_1) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

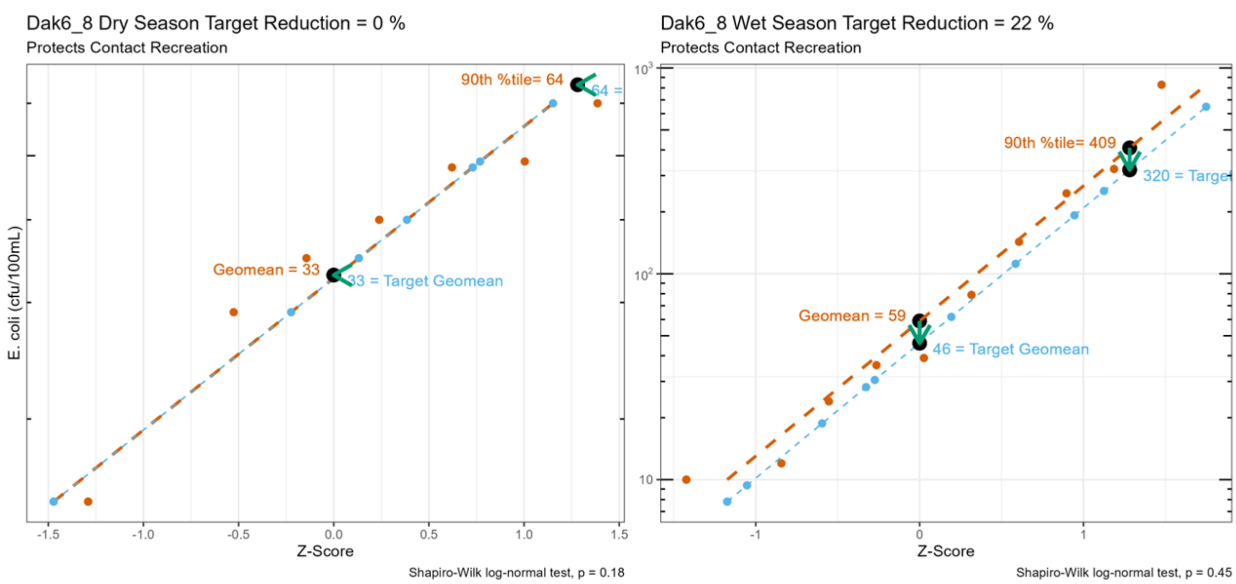



**Figure D-34. Dakota Creek (Dak6_8) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

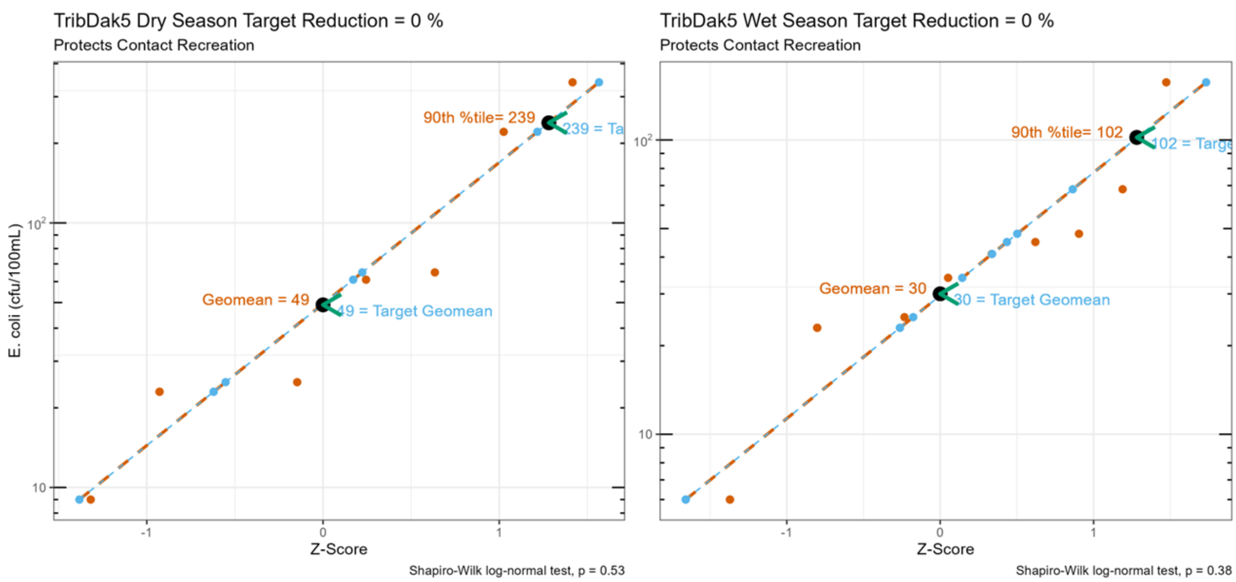



**Figure D-35. Tributary to Dakota Creek (TribDak5) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

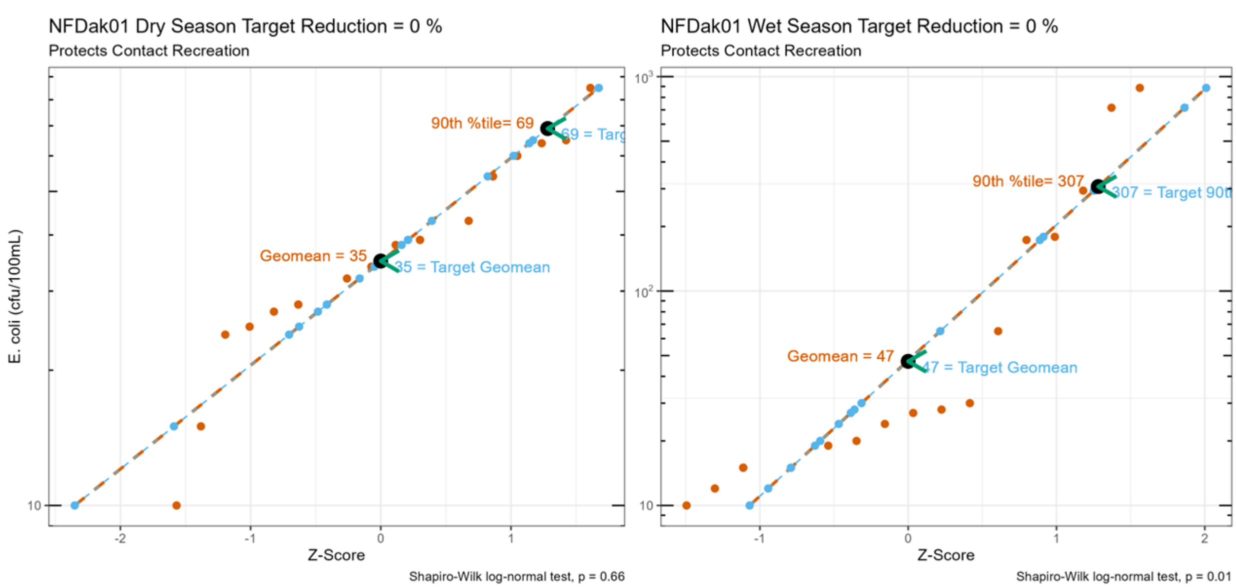



**Figure D-36. North Fork Dakota Creek (NFDak01) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

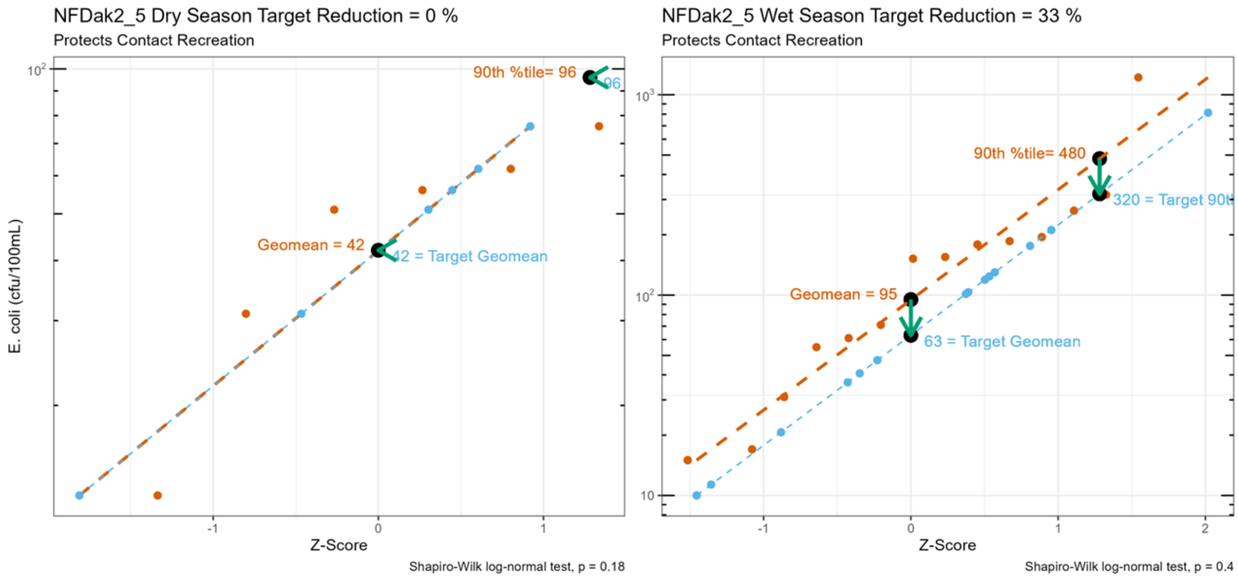



**Figure D-37. North Fork Dakota Creek (NFDak2_5) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

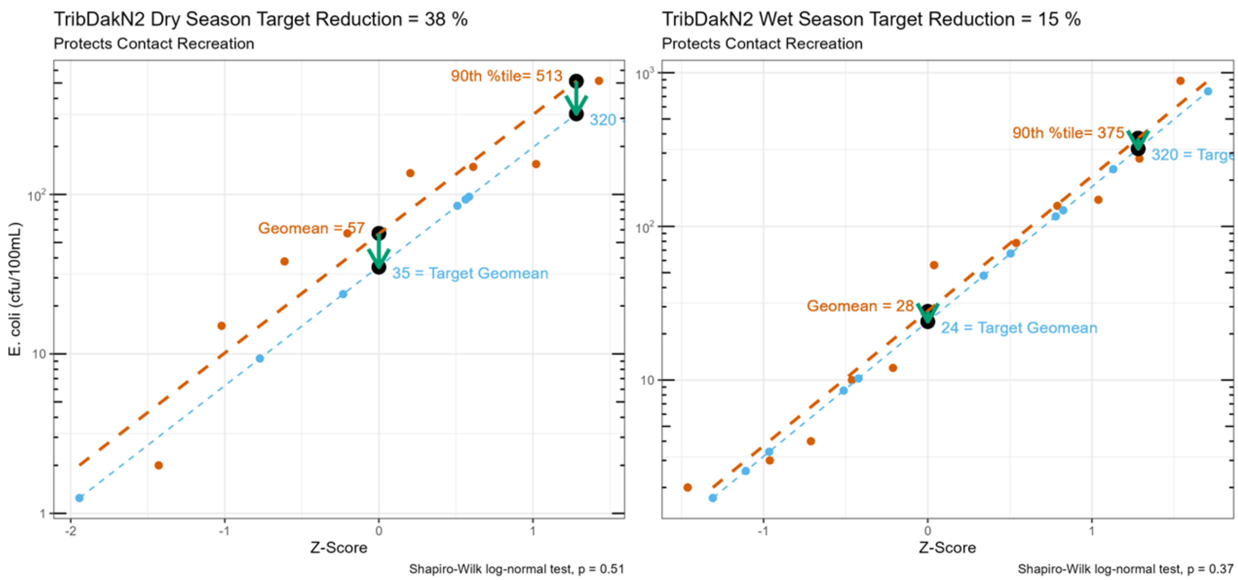



**Figure D-38. Tributary to North Fork Dakota Creek (TribDakN2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

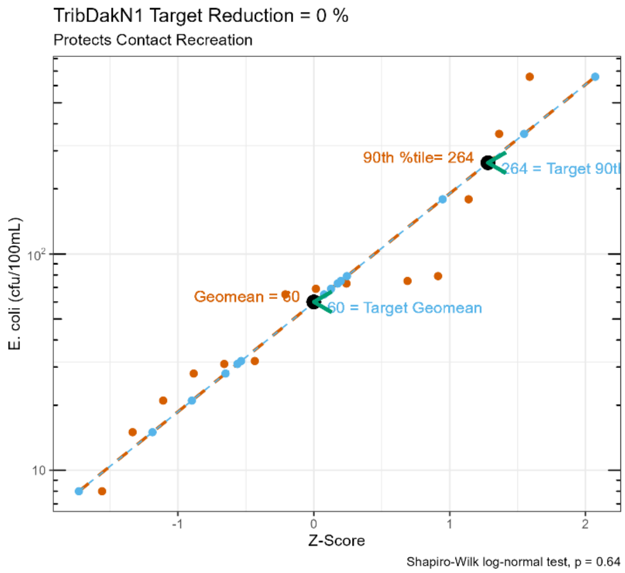



**Figure D-39. Tributary to North Fork Dakota Creek (TribDakN1) *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

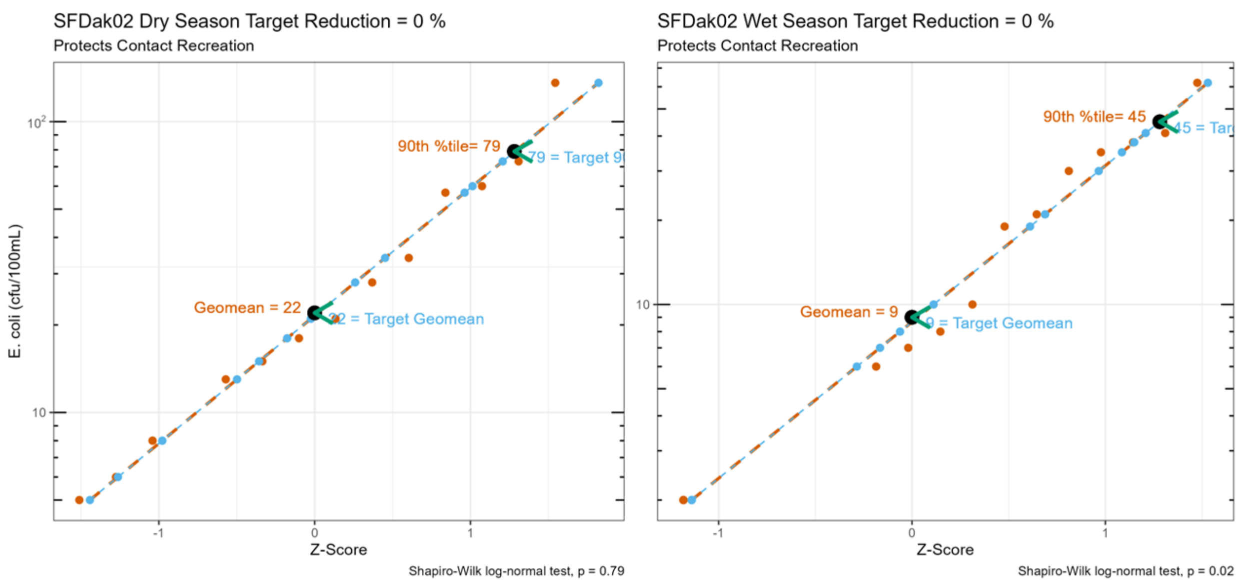



**Figure D-40. South Fork Dakota Creek (SFDak02) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

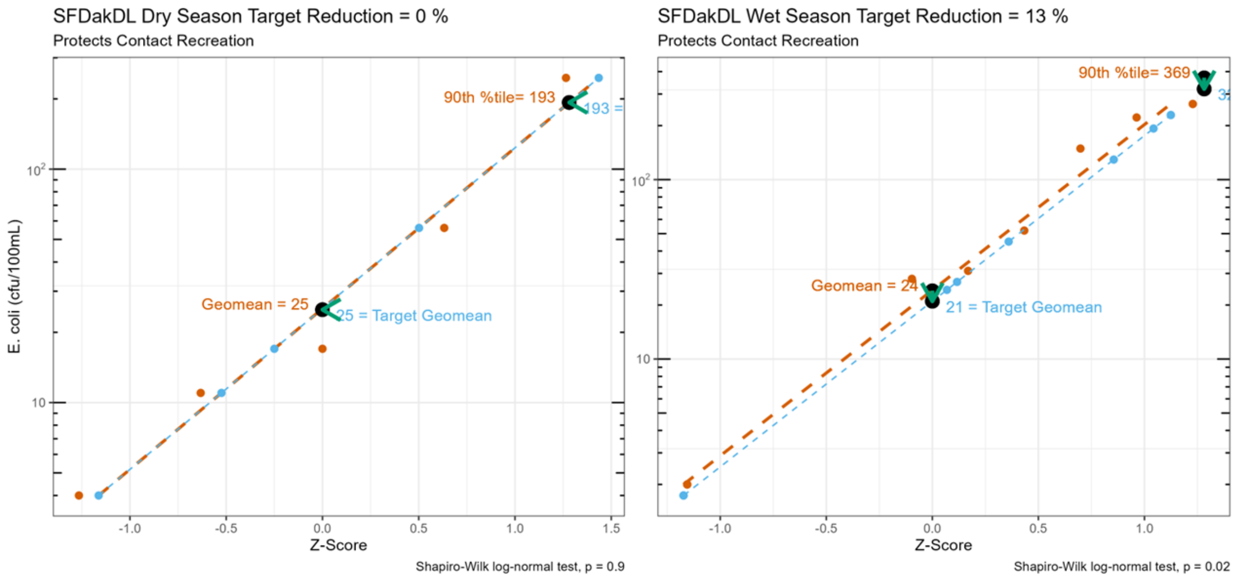



**Figure D-41. South Fork Dakota Creek (SFDakDL) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

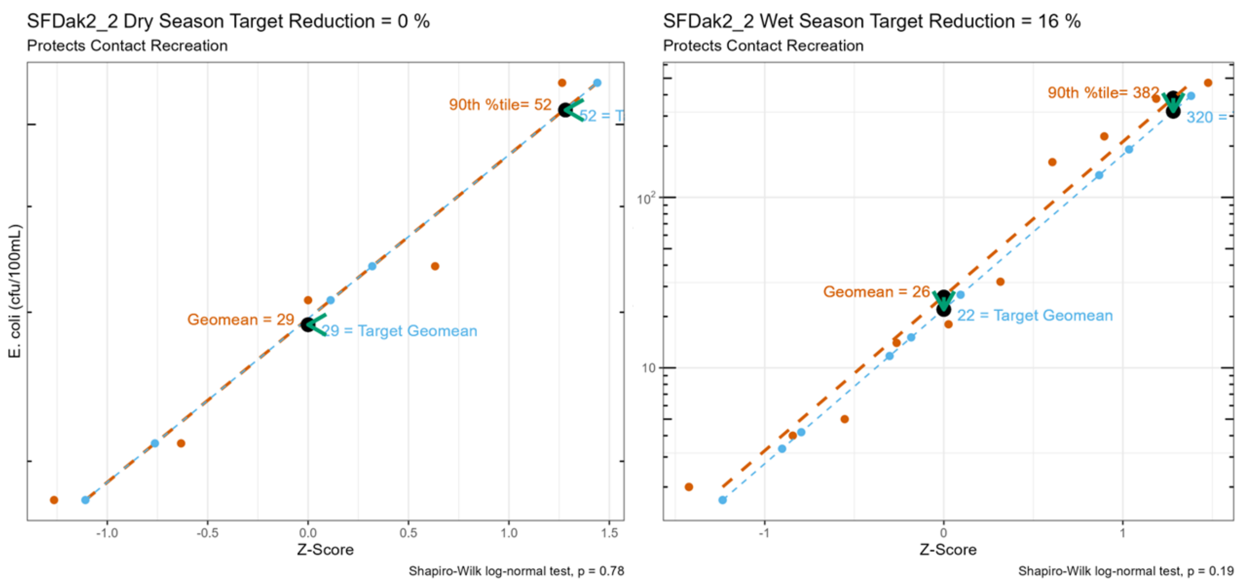



**Figure D-42. South Fork Dakota Creek (SFDak2_2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

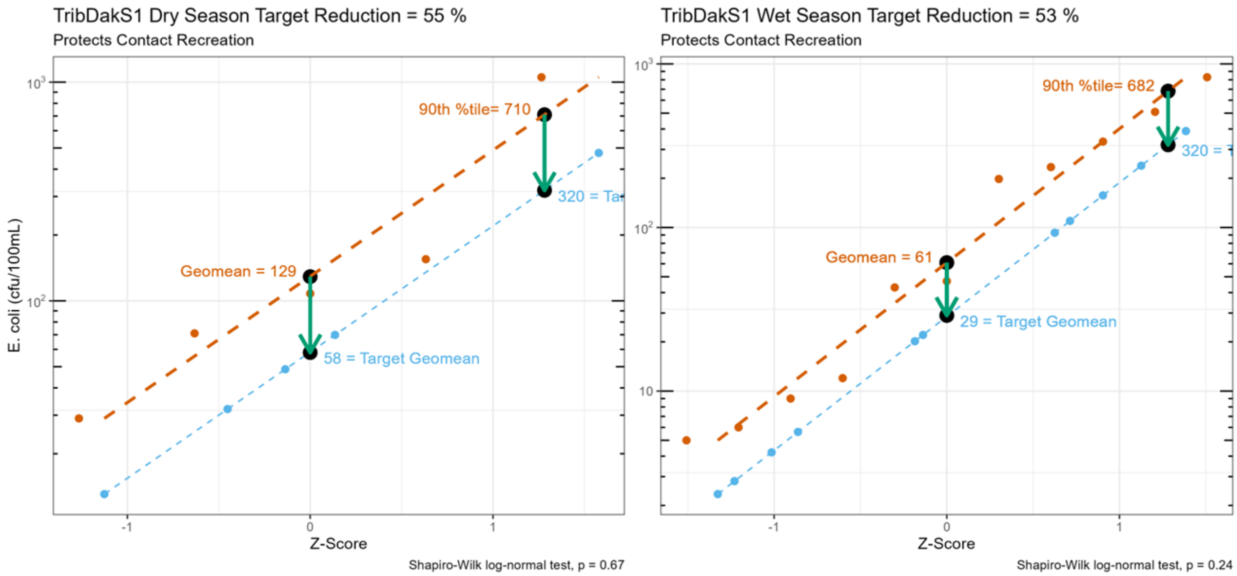



**Figure D-43. Tributary to South Fork Dakota Creek (TribDakS1) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

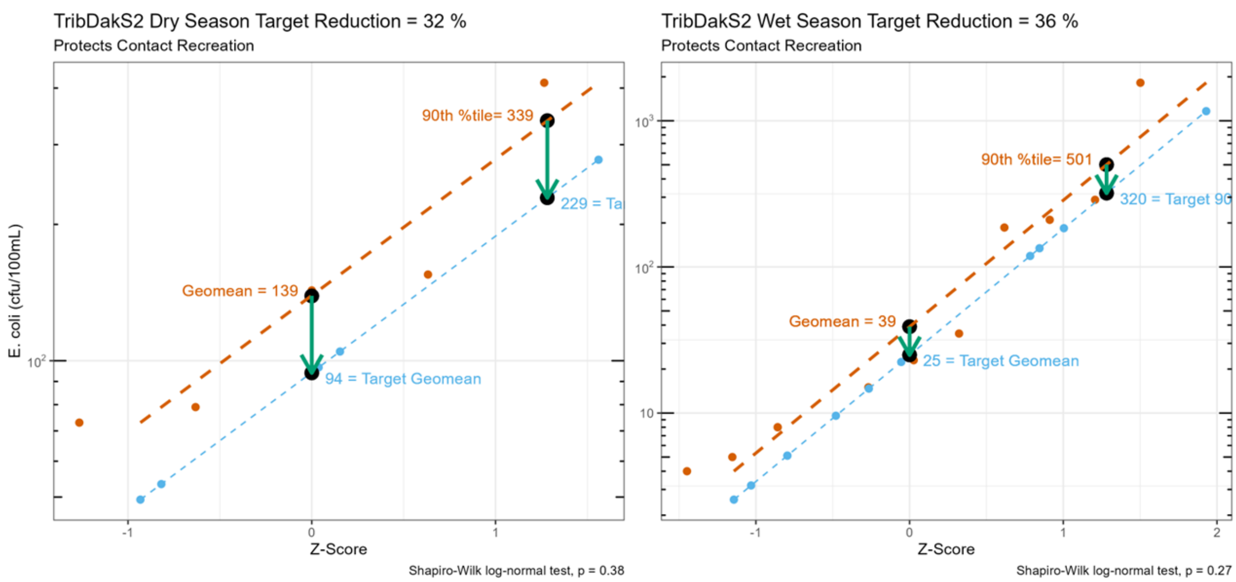



**Figure D-44. Tributary to South Fork Dakota Creek (TribDakS2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

## *California Creek Subbasin Roll-back Targets*

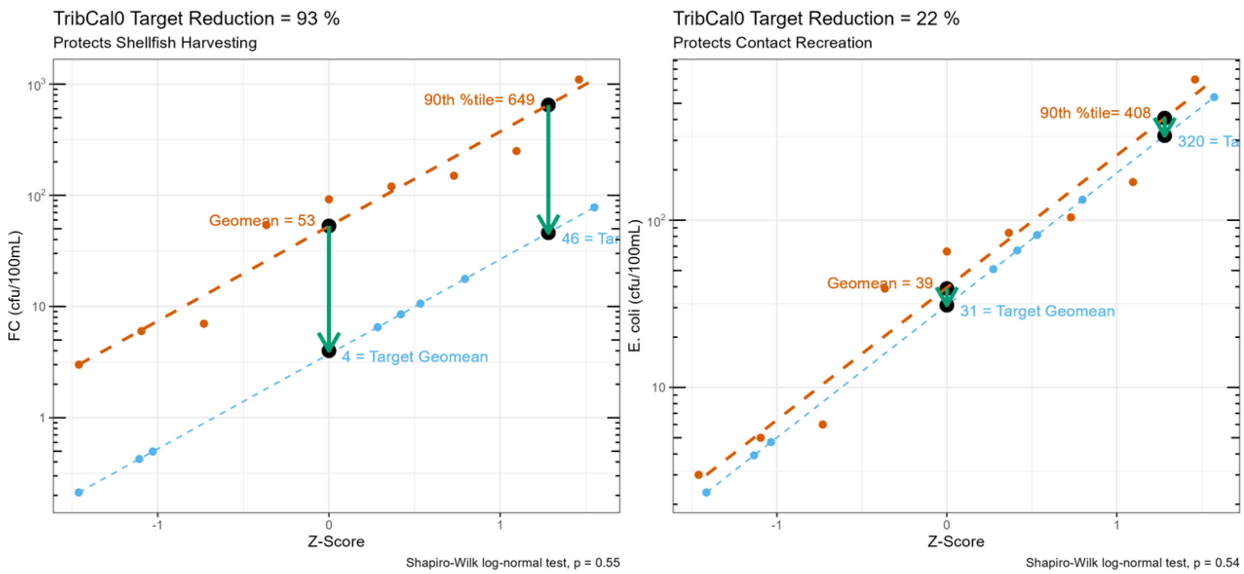



**Figure D-45. Tributary to California Creek (TribCal0) fecal coliform (FC) and *E. coli* TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for 2008**

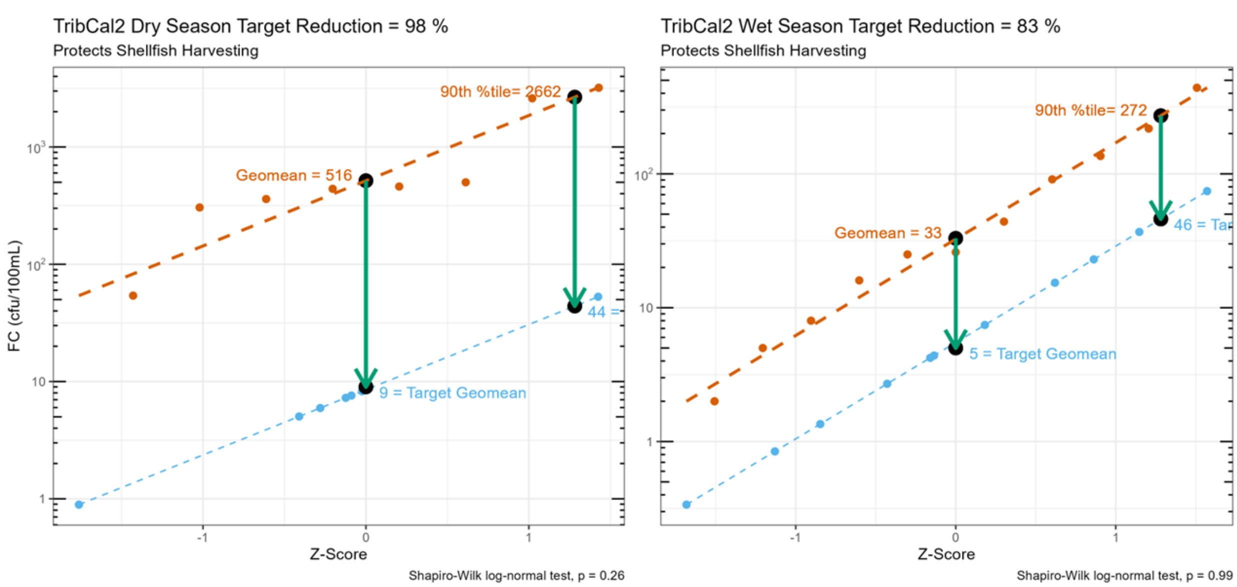



**Figure D-46. Tributary to California Creek (TribCal2) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

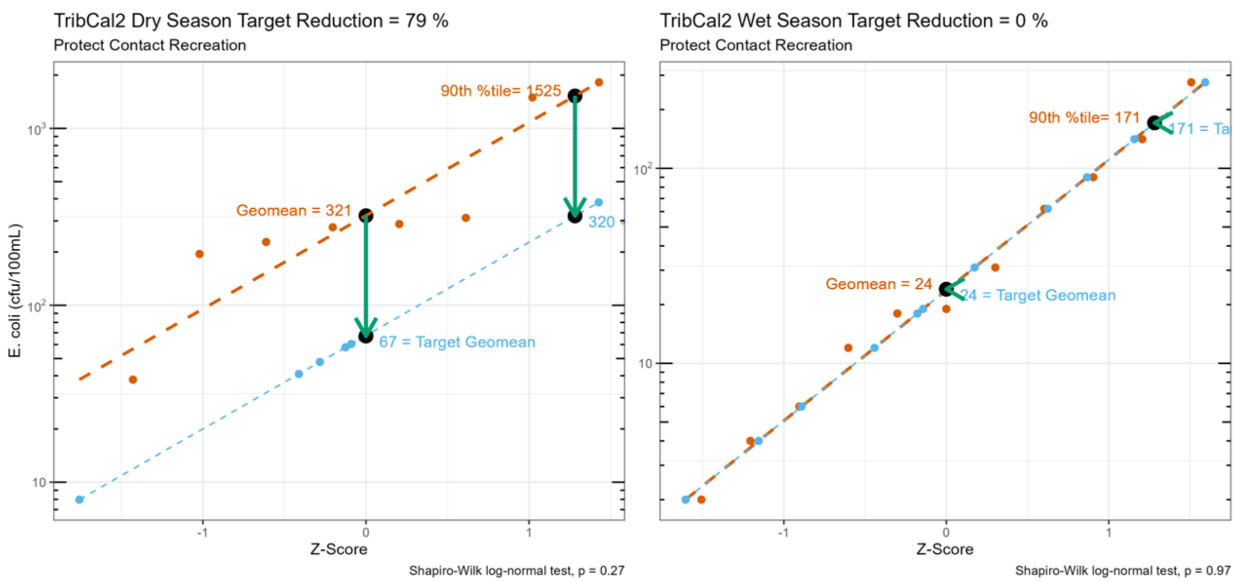



**Figure D-47. Tributary to California Creek (TribCal2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

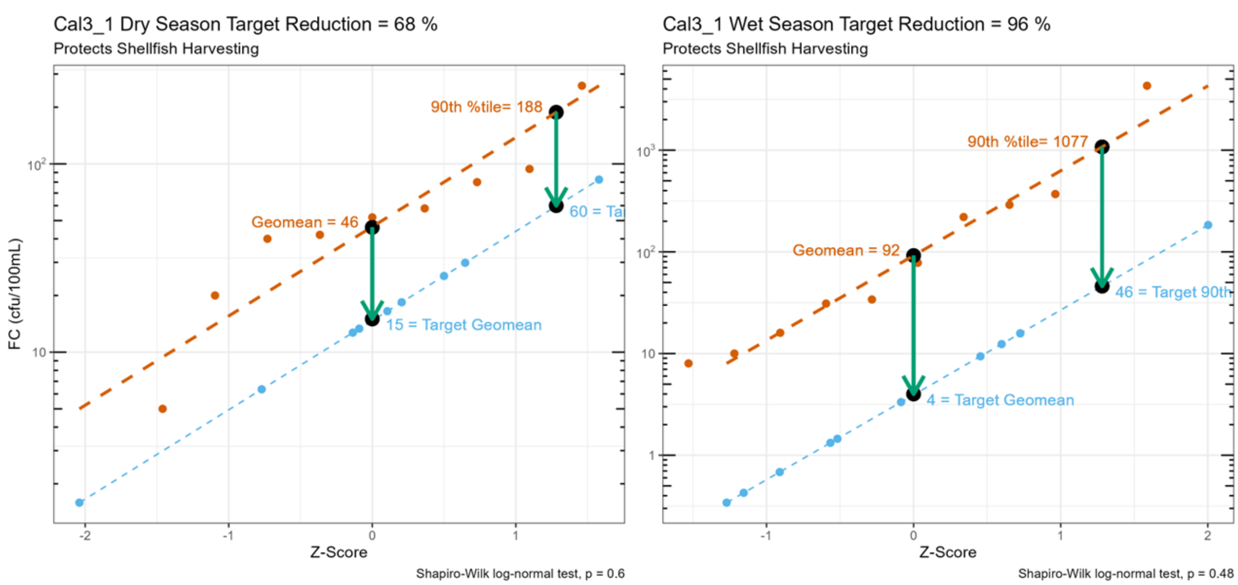



**Figure D-48. California Creek (Cal3_1) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

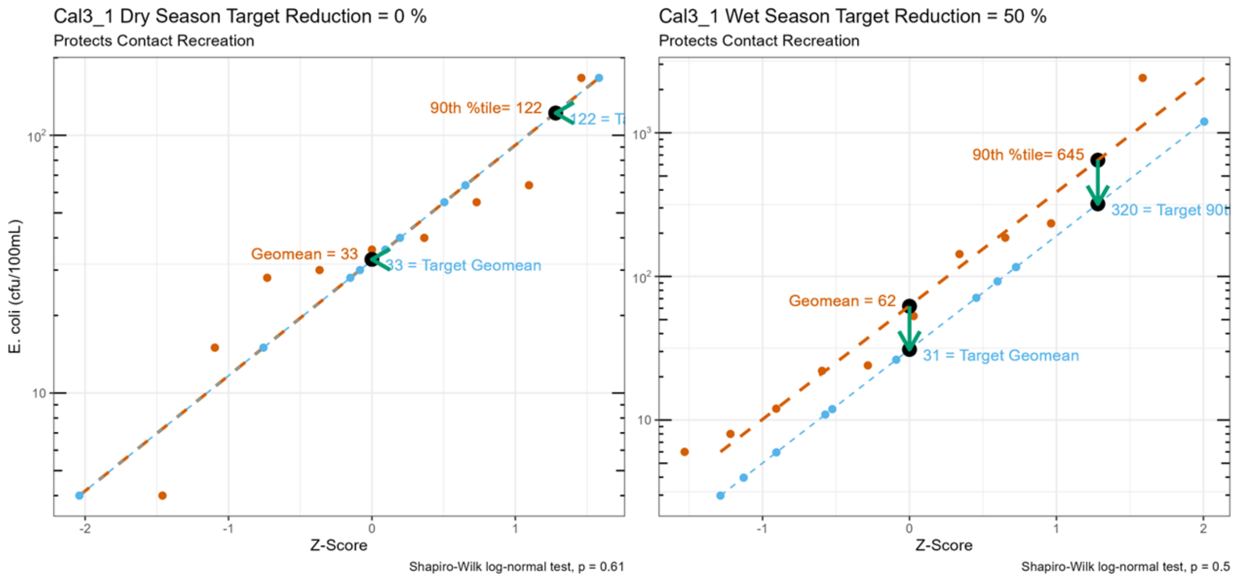



**Figure D-49. California Creek (Cal3_1) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

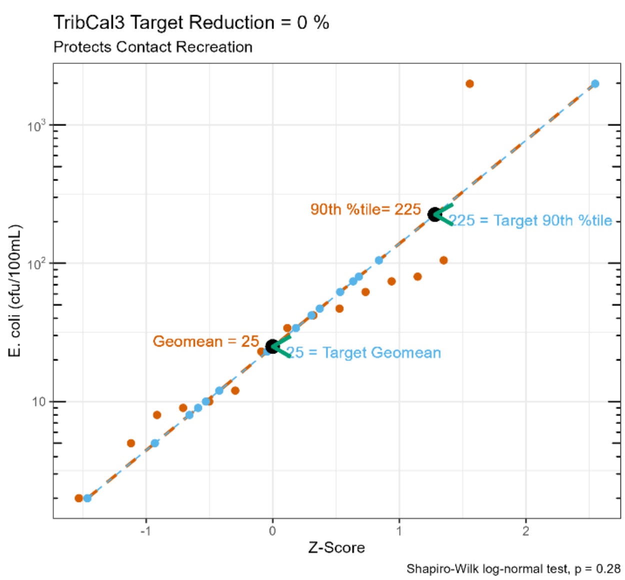



**Figure D-50. Tributary to California Creek (TribCal3) *E. coli* TMDL targets using the statistical rollback method for 2008**

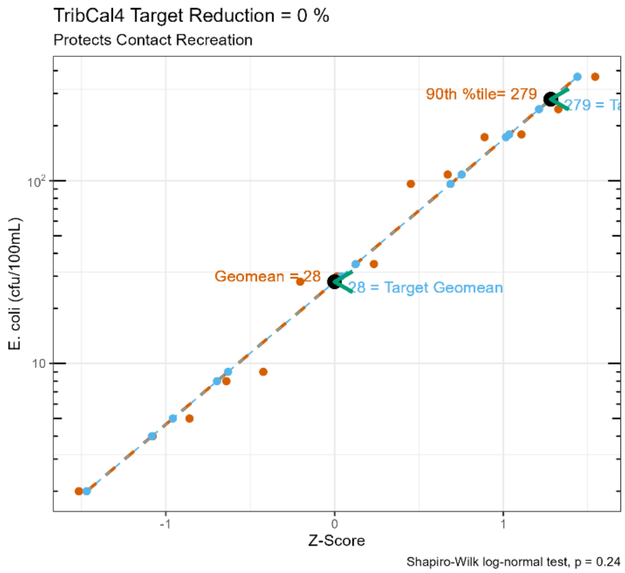



**Figure D-51. Tributary to California Creek (TribCal4) *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

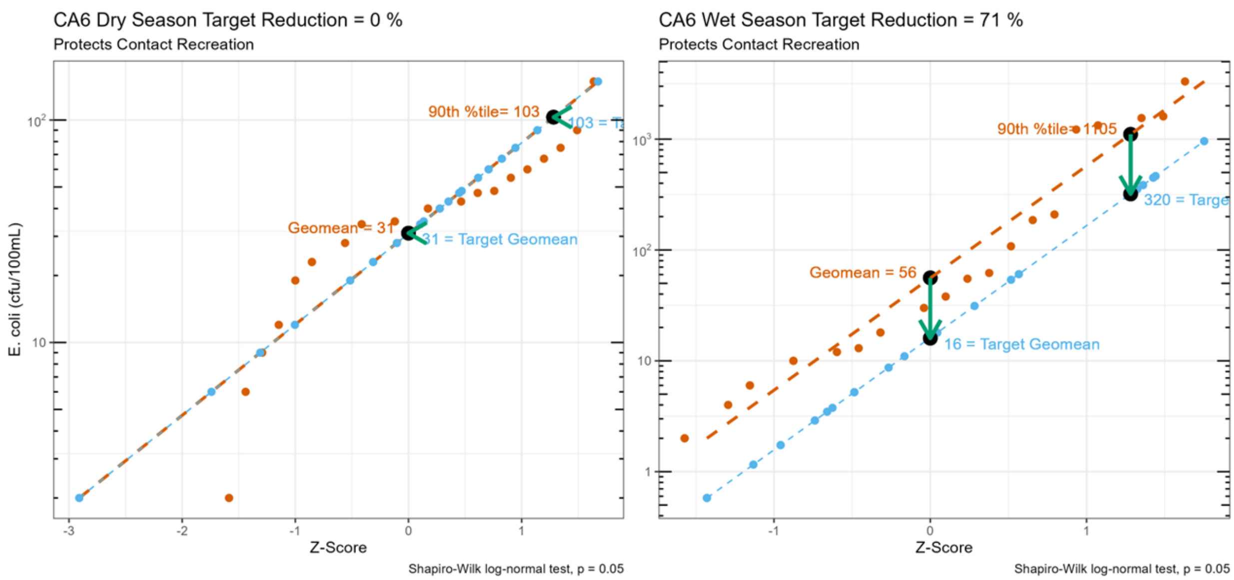



**Figure D-52. Tributary to California Creek (CA6) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

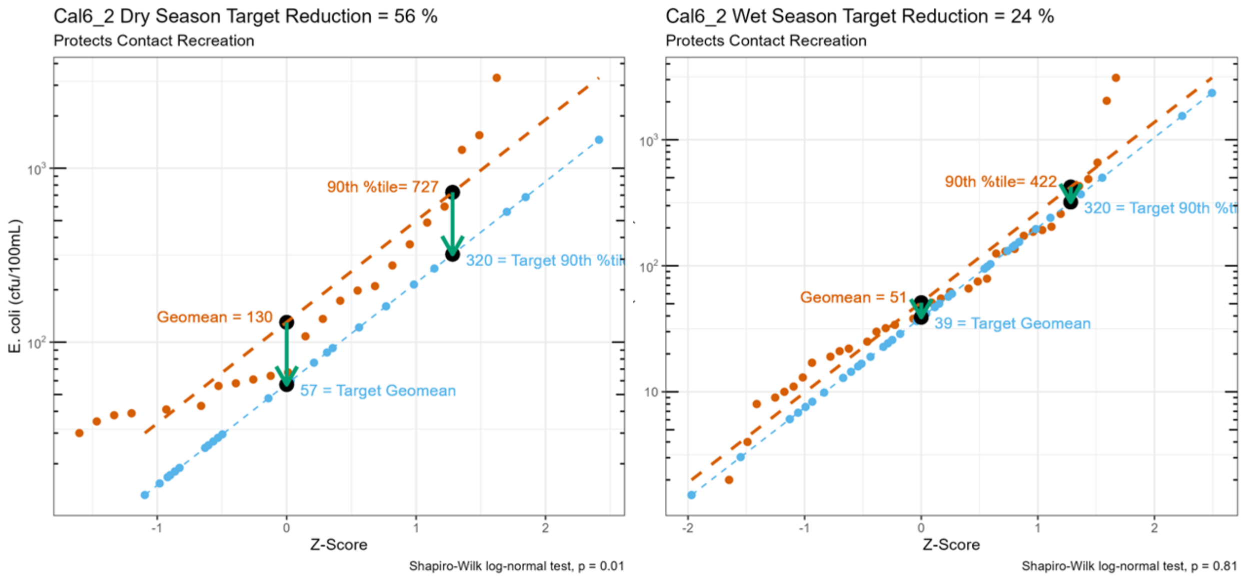



**Figure D-53. California Creek (Cal6_2) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

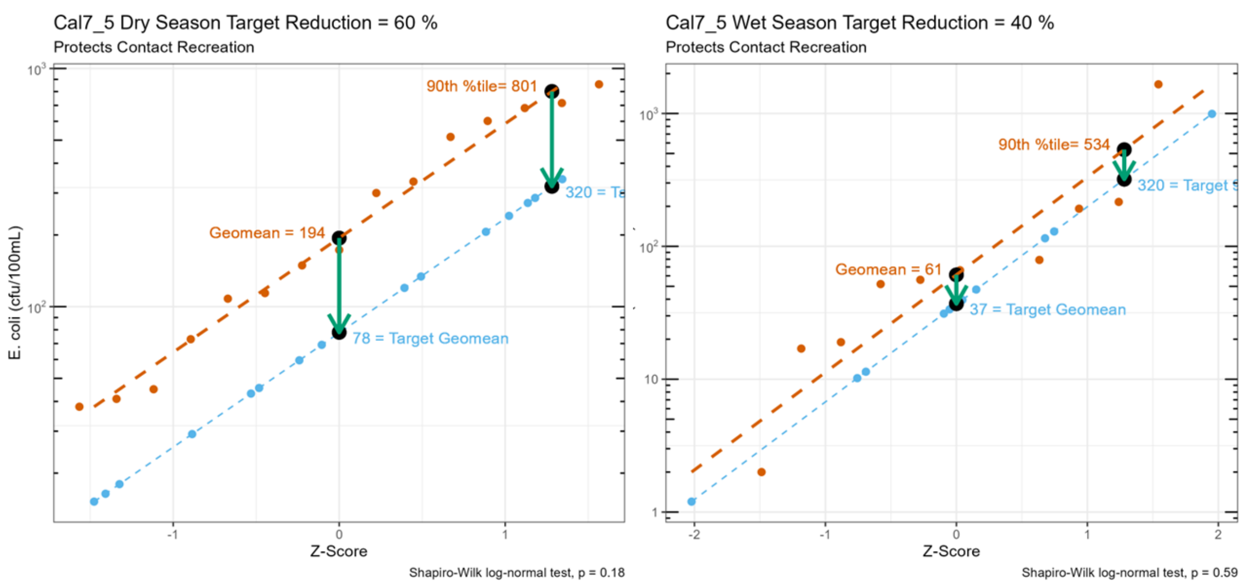



**Figure D-54. California Creek (Cal7_5) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

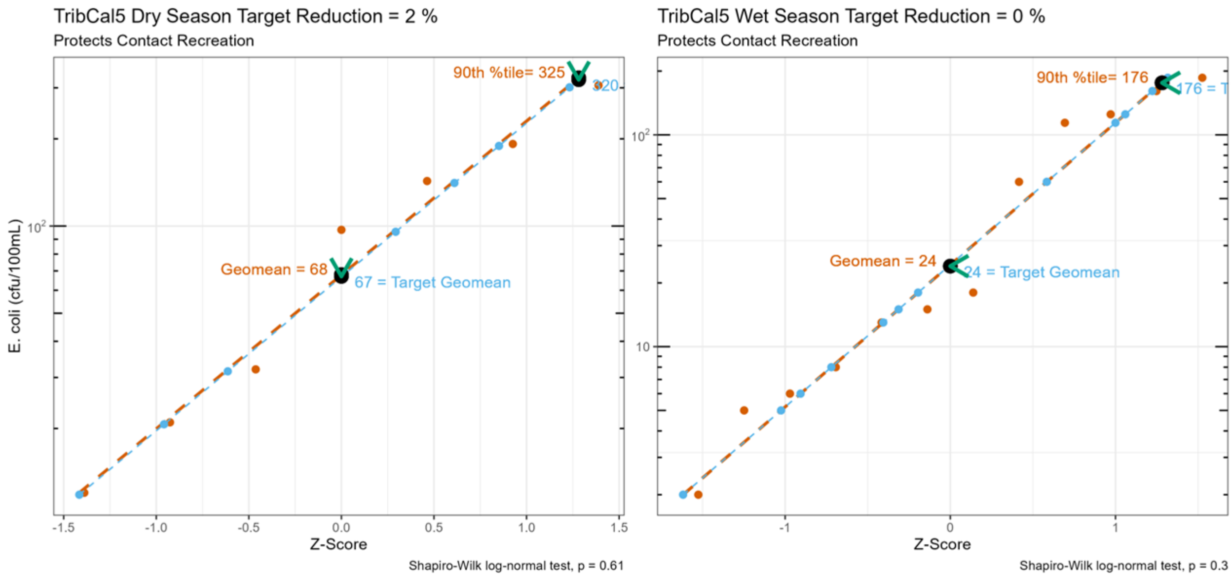



**Figure D-55. Tributary to California Creek (TribCal5) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

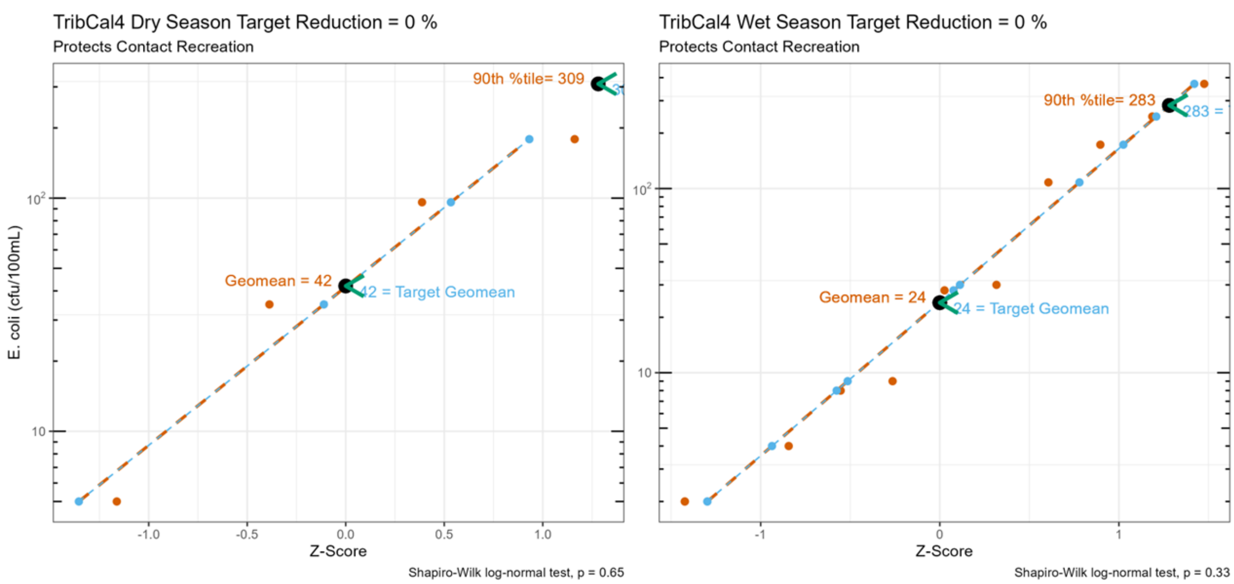



**Figure D-56. Tributary to California Creek (TribCal4) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

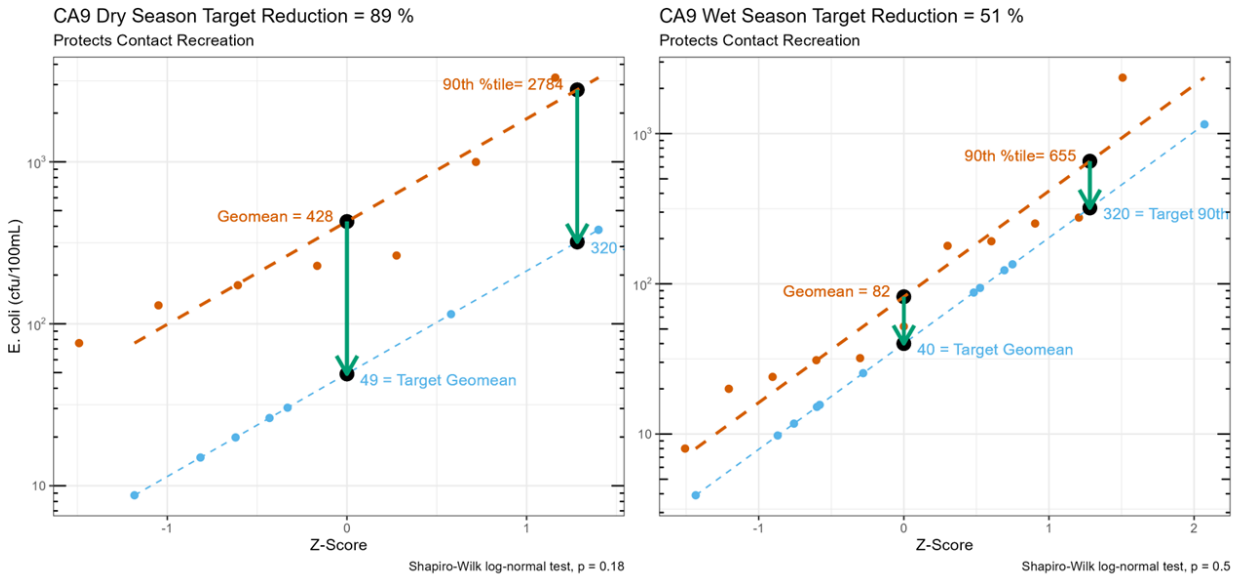



**Figure D-57. Tributary to California Creek (CA9) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

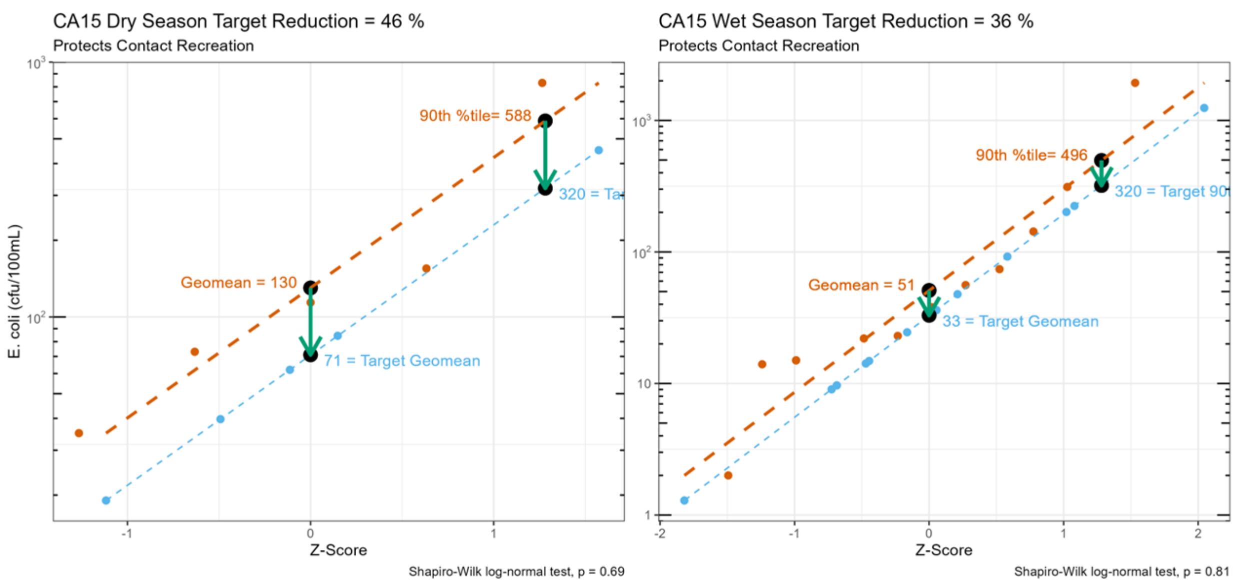



**Figure D-58. Tributary to California Creek (CA15) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

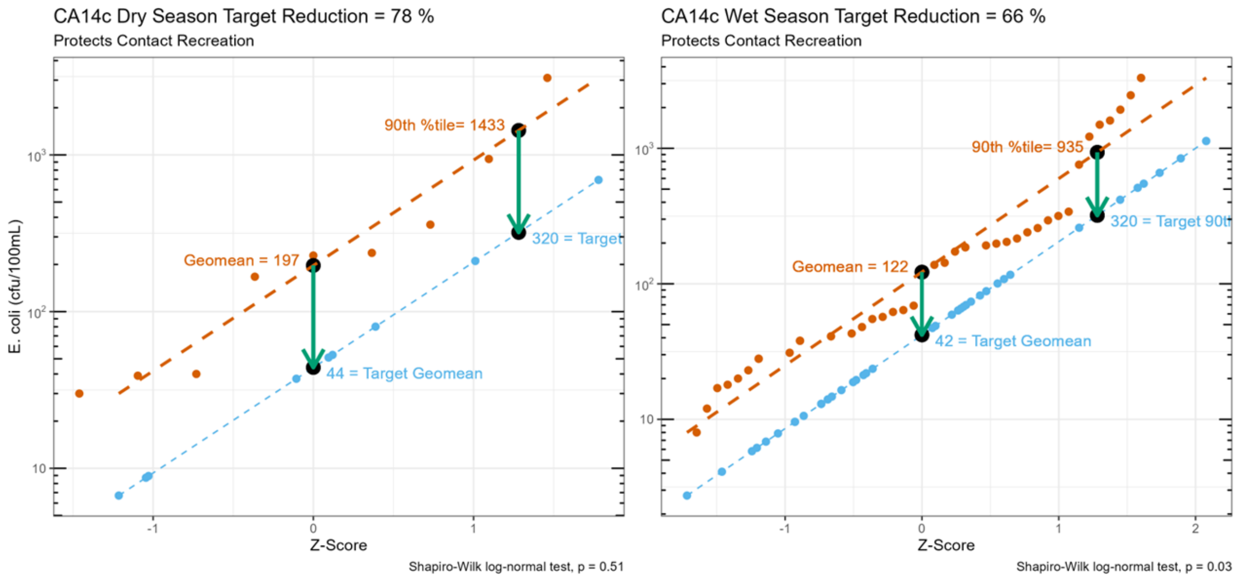



**Figure D-59. Tributary to California Creek (CA14c) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

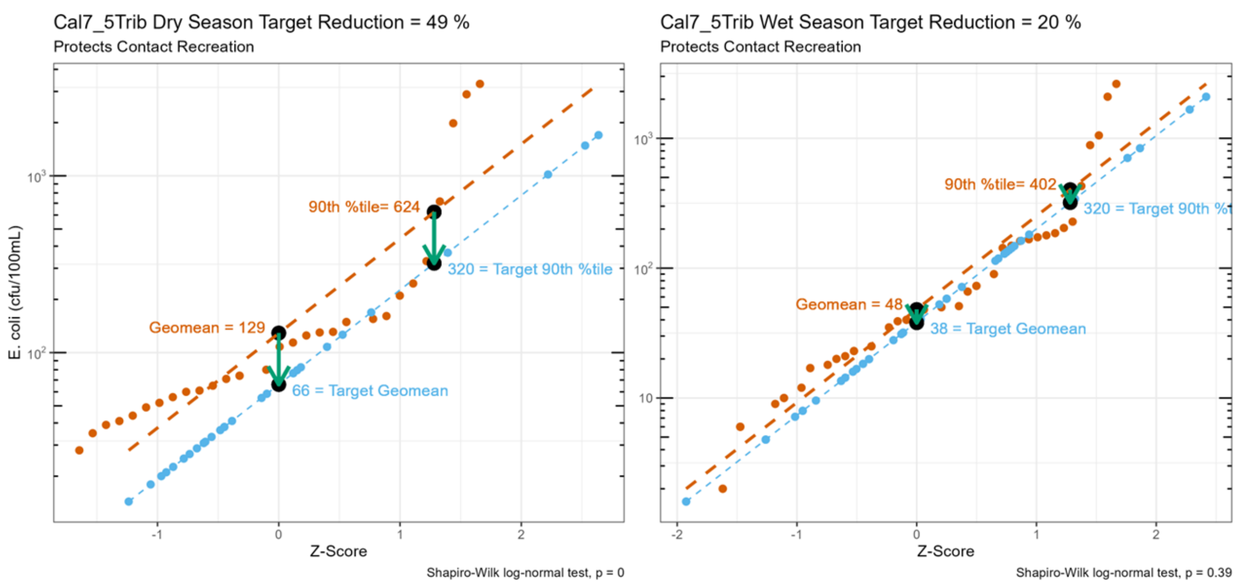



**Figure D-60. Tributary to California Creek (Cal7_5Trib) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

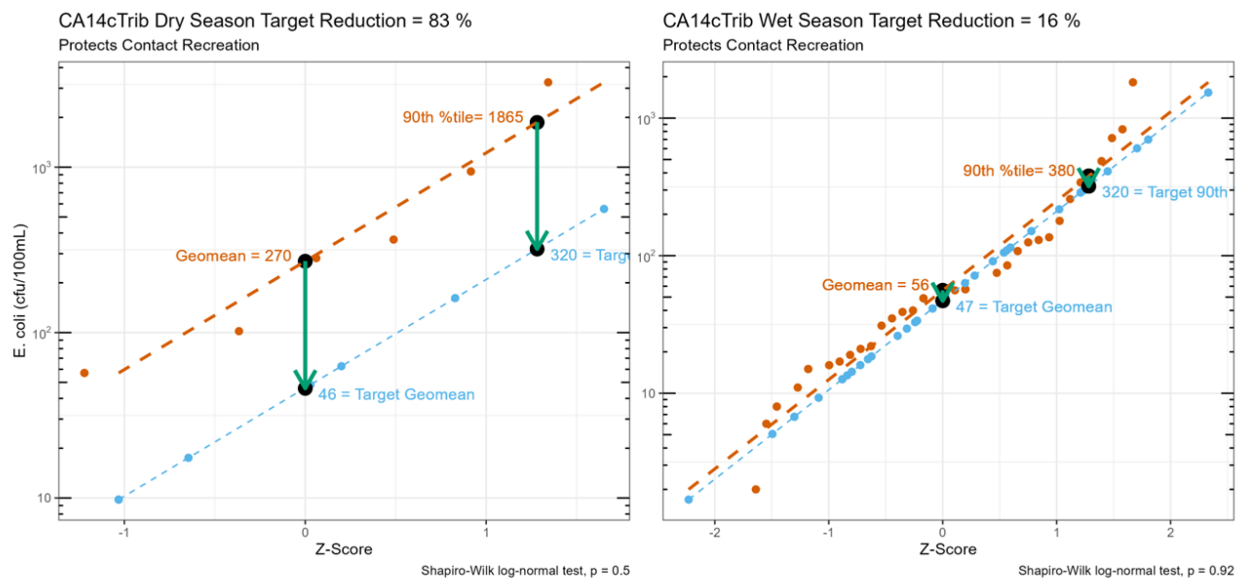



**Figure D-61. Tributary to California Creek (CA14cTrib) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

*Small Tributaries to Drayton Harbor and Semiahmoo Bay*

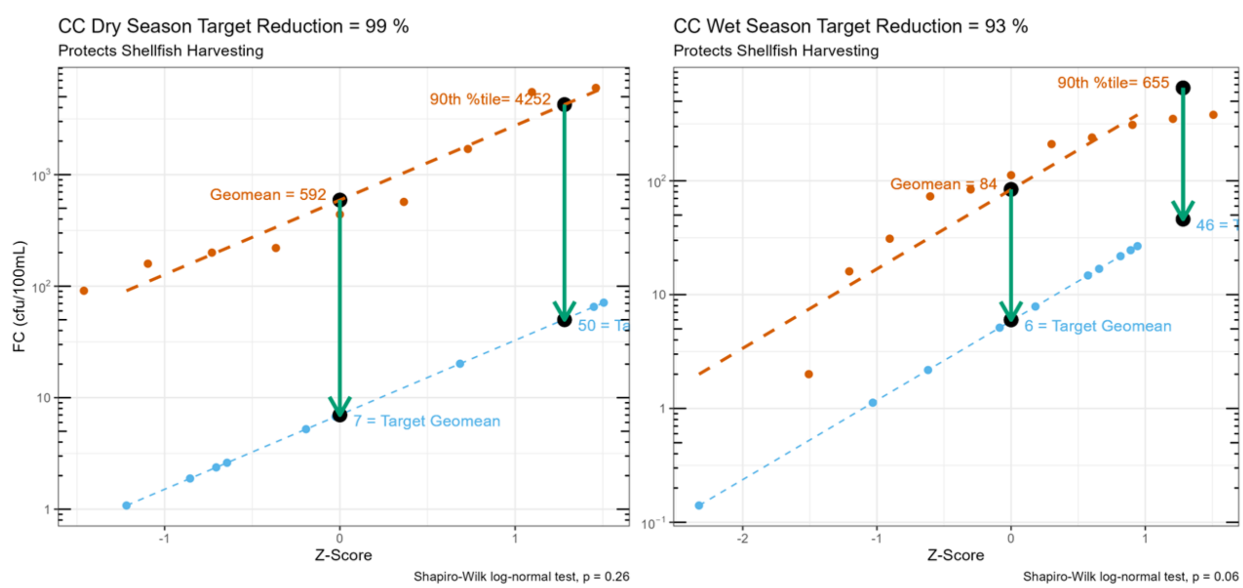



**Figure D-62. Cain Creek (CC) seasonal fecal coliform (FC) TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

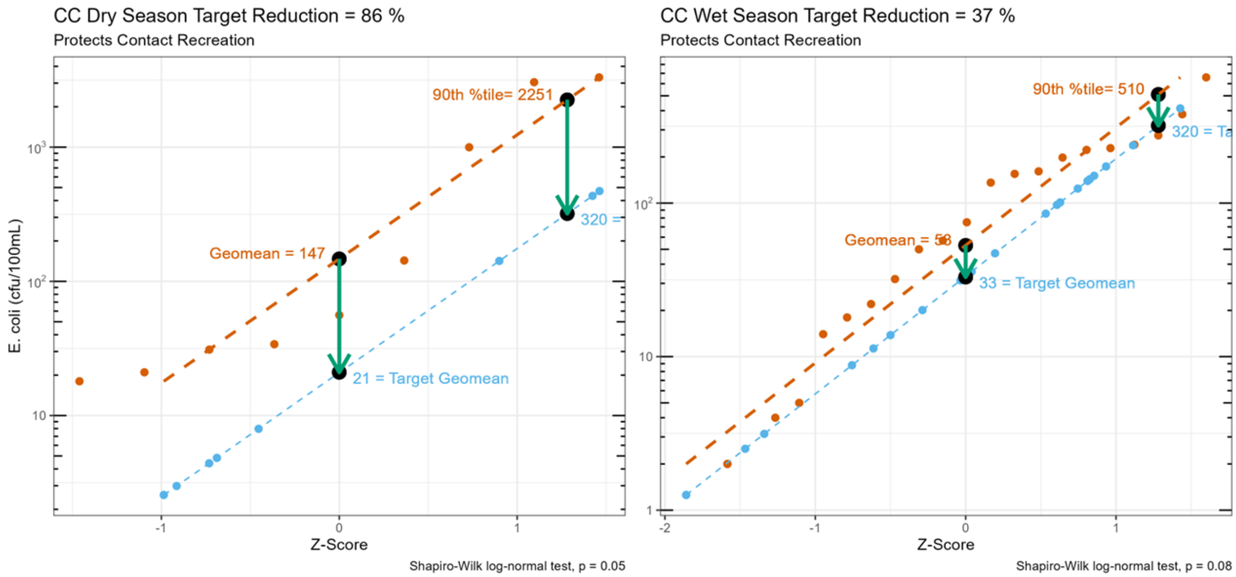



**Figure D-63. Cain Creek (CC) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

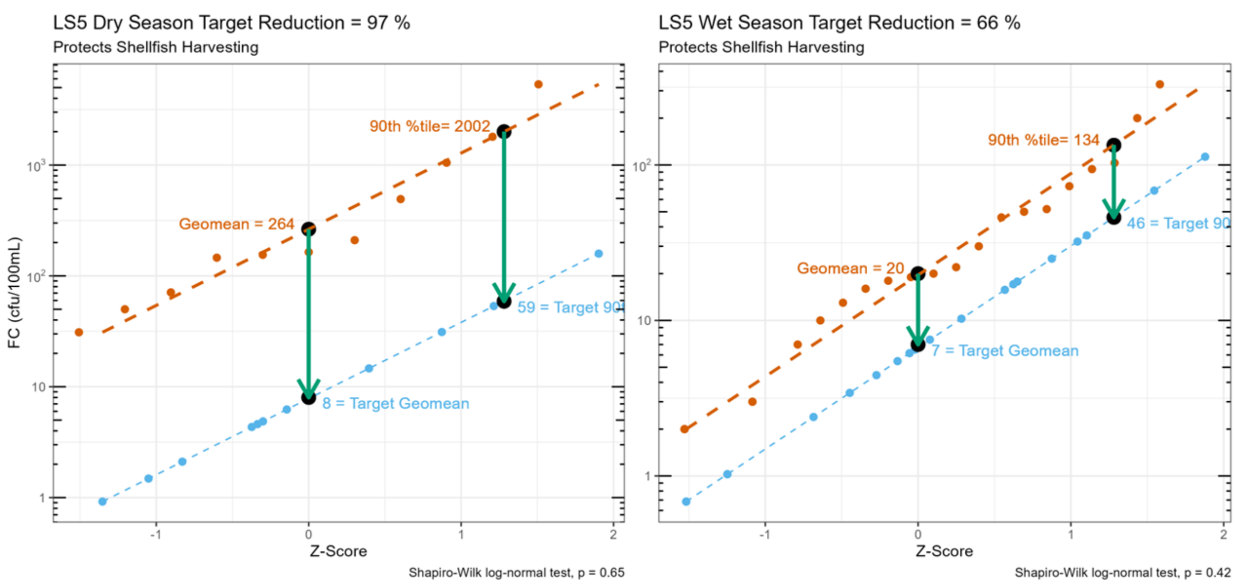



**Figure D-64. Lift station drainage (LS5) seasonal fecal coliform TMDL targets using the statistical rollback method accounting for mixing between fresh and marine waters for water years 2020—2021**

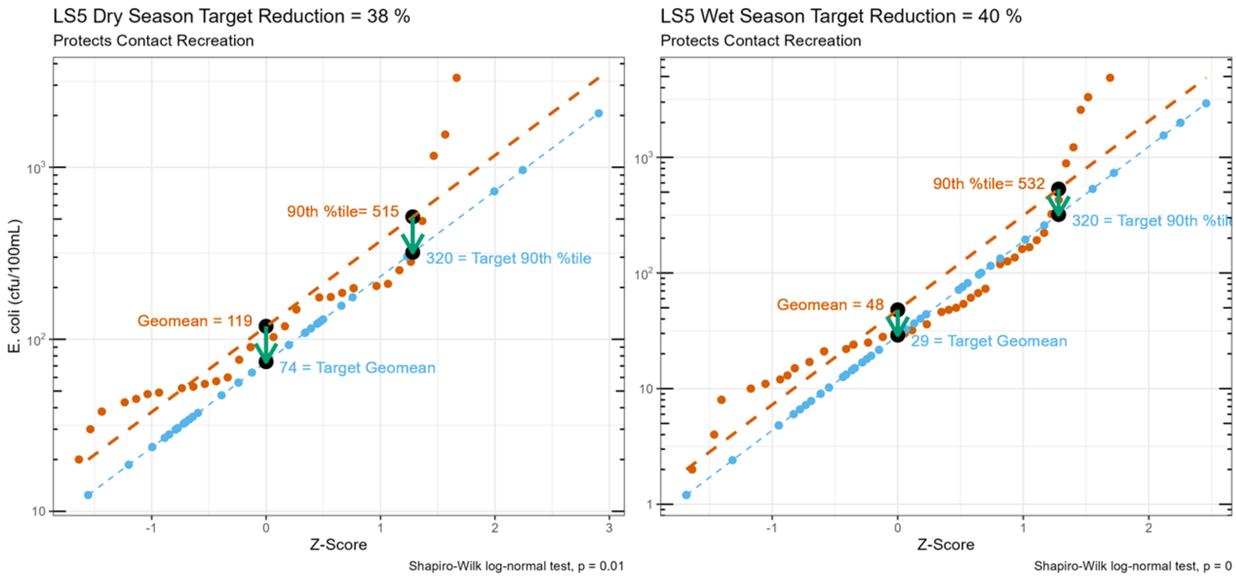



**Figure D-65. Lift station drainage (LS5) seasonal *E. coli* TMDL targets using the statistical rollback method for water years 2020—2021**

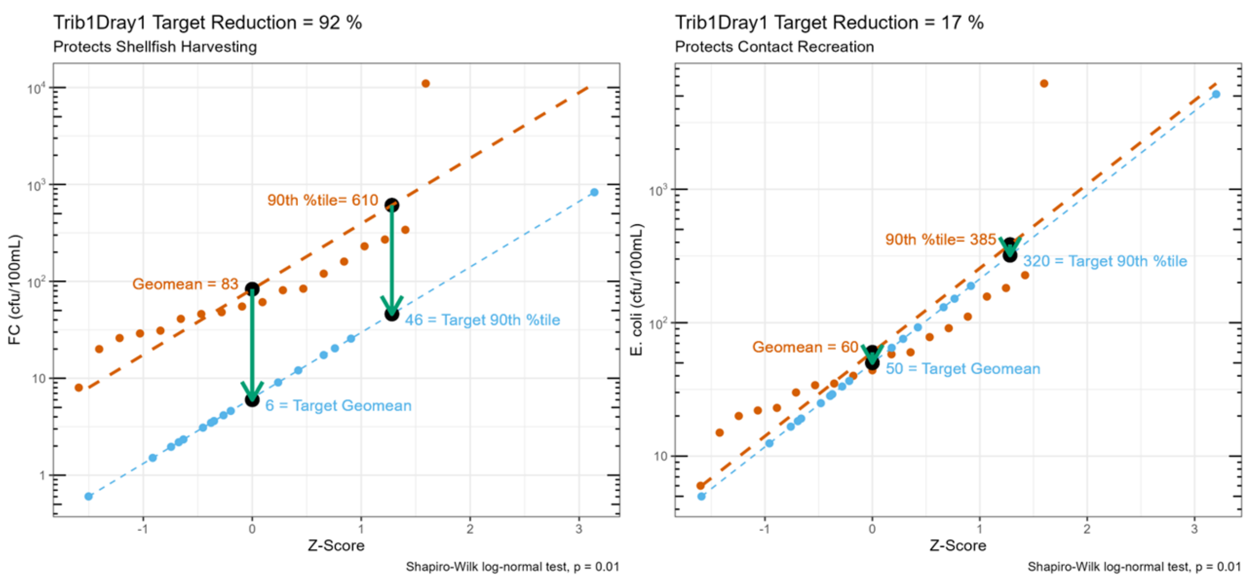



**Figure D-66. Tributary to Drayton Harbor (Trib1Dray1) bacteria TMDL targets using the statistical rollback method for water years 2020—2021**

## Trend Analysis

The Seasonal Kendall Trend (SK) test is one approach applied to water quality data collected over several years at roughly consistent intervals (Meals et al. 2011). The SK tests for monotonic trends when the data are expected to change in the same direction—increasing or decreasing—for one or more seasons, such as months (Hirsch et al. 1982, Gilbert 1987, Helsel and Hirsch 2002). The SK test accounts for seasonal variation, which implies that the data may have different distributions for different seasons of the year. This trend test calculates the probability of a relationship between FC and time, while compensating for seasonal variability by only comparing sample results from the same month.

The SK test is practical when all trends for each season share the same direction, which is tested using the heterogeneous chi-squared statistic. The SK test does not quantify trends within segments of the period of record, rather it accounts for the trend over the entire period of record. The SK tests are performed on marine and fresh water data using the 'EnvStats'—Package for Environmental Statistics, Including US EPA Guidance (Version 2.7.0)[66] for R software.

**Fresh Water Trends**

The dataset for each sampling station's period of record contributes to the trend analysis. Starting in 2008, samples were collected approximately once a month to yield 36 sites with sufficient data. Some sites included the 5-in-30 sampling objective of the WCWP, which are incorporated into the trend analysis. The 5-in-30 sampling increases monthly sampling frequency to roughly 5 samples equally spaced in a 30-day period to improve temporal resolution.

The SK tests confirm that 15 sites have strong downward trends in FC levels, which indicates a significant water quality improvement ($p < 0.05$, $\alpha = 0.05$), 3 sites have weak downward trends ($p < 0.1$, $\alpha = 0.1$), and the remaining 18 sites show no trend (Table D-16). There are no sites that have an increasing trend in bacteria concentrations, which indicates no water quality degradation over the analyzed period. There are three sampling sites with no trend results due to an insufficient period of record. The SK test is inconclusive at three sites indicated by the heterogeneous chi-squared test, which suggests seasonal trends in both directions being positive and negative. The SK test is not suitable when trends occur in two different directions within the same month, season, or event. In summary, the SK tests show significant improving trends at the following sites:

- **TribCal2**—Tributary to California Cr at Kickerville Rd,
- **TribCal5**—Tributary to California Cr at Main St,
- **CA14c**—Tributary to California Cr at Brown Rd (upstream side box culvert),
- **CA9**—Tributary to California Cr at Fox Rd (upstream side of cross culvert),

[66] https://cran.r-project.org/web/packages/EnvStats/EnvStats.pdf

- **Dak06**—Dakota Cr at I-5 bridge,
- **D2**—Dakota Cr at Valley View Rd,
- **D4**—SF Dakota Cr at Custer School Rd, downstream of bridge,
- **SFDak2_2**—SF Dakota Cr Sunrise Rd,
- **D3**—NF Dakota Cr at Custer School Rd, upstream of bridge,
- **TribDak2**—Tributary to Dakota Cr at Sweet Rd,
- **TribDak3—**Tributary to Dakota Cr at Rogers Rd,
- **TribDak4—**Tributary to Dakota Cr at Hoier Rd,
- **TribDak5—**Tributary to Dakota Cr at Valley View Rd,
- **TribDakN2**—Triburtary to NF Dakota Cr at Delta Line Rd, and
- **CC**—Cain Cr at mouth.

All other sampling sites showed no significant trend (α = 0.05), while two sites showed signficanly weak improving trends (α = 0.1) including NFDak2_5—NF Dakota Cr at Delta Line Rd, and TribDak1—Tributary to Dakota Cr at Sweet Rd.

**Table D-16. Seasonal Kendall Test statistics for FC at the Drayton Harbor watershed fresh water monitoring sites from the given start date through water year 2021**

| Site ID | Tau (τ) | Theil-Sen Slope | Intercept | Chi-Squared ($\chi^2$) | Z | Change (%) | Start Date | Latitude | Longitude |
|---|---|---|---|---|---|---|---|---|---|
| Cal01 | -0.05 | -0.39 | 834 | 8.02 | -1.15 | -5.4 | 2008 | -122.7328 | 48.9622 |
| Cal08 | -0.08 | -1.00 | 1779 | 10.15 | -1.32 | -14 | 2008 | -122.7261 | 48.9547 |
| Cal1_9 | -0.08 | -0.87 | 810 | 8.95 | -1.18 | -10.5 | 2009 | -122.7044 | 48.9471 |
| Cal3_1 | -0.17 | -2.09 | 3730 | 13.24 | -1.76** | -29.3 | 2008 | -122.6888 | 48.9358 |
| Cal5 | 0.03 | 0.33 | -1815 | 13.37 | 0.57 | 4.7 | 2008 | -122.6602 | 48.9214 |
| Cal6_2 | -0.01 | -0.33 | 1462 | 11.18 | -0.43 | -4.7 | 2008 | -122.6440 | 48.9092 |
| Cal7_5 | 0.00 | -0.08 | 62 | 11.87 | -0.14 | -1.1 | 2009 | -122.6237 | 48.8991 |
| TribCal0 | - | - | - | - | - | - | 2008 | -122.7301 | 48.9583 |
| TribCal1 | - | - | - | - | - | - | 2008 | -122.7221 | 48.9485 |
| TribCal2 | -0.17 | -4.00 | 6401 | 17.99 | -2.96* | -52 | 2008 | -122.7045 | 48.9488 |
| TribCal4 | 0.00 | 0.00 | -536 | 13.77 | -0.16 | 0 | 2008 | -122.6499 | 48.9064 |
| TribCal5 | -0.19 | -3.33 | 4517 | 12.31 | -3.1* | -40 | 2008 | -122.6495 | 48.9172 |
| TribCal3 | - | - | - | - | - | - | 2008 | -122.6841 | 48.9211 |
| CA6 | -0.03 | -0.53 | 945 | 13.18 | -0.78 | -6.9 | 2008 | -122.6522 | 48.9209 |
| CA9 | -0.15 | -4.65 | 13502 | 7.75 | -2.13* | -60.5 | 2008 | -122.6303 | 48.8990 |
| CA14c | -0.14 | -8.17 | 14677 | 3.25 | -2.5* | -106.2 | 2008 | -122.5929 | 48.8846 |
| CA14aa | - | - | - | - | - | - | 2015 | -122.6249 | 48.87713 |
| CA14cTrib | -0.09 | -4.00 | 82835 | 21.50 | -0.64 | -24 | 2015 | -122.6167 | 48.8771 |
| CA15 | 0.23 | 2.50 | -5710 | 20.77~ | 3.32 | 32.5 | 2008 | -122.6154 | 48.9008 |
| Cal7_5Trib | 0.09 | 2.40 | -4535 | 11.66 | **1.84**** | 19.2 | 2015 | -122.6103 | 48.8919 |
| Dak01 | -0.08 | -0.69 | 1287 | 22.62~ | -1.73 | -9.7 | 2008 | -122.7291 | 48.9724 |
| Dak06 | -0.21 | -3.00 | 4893 | 11.09 | -2.93* | -33 | 2010 | -122.7198 | 48.9721 |
| Dak3_1 | -0.05 | -0.57 | 2254 | 6.52 | -0.90 | -8 | 2008 | -122.6821 | 48.9628 |
| Dak6_8 | -0.13 | -1.75 | 2656 | 6.68 | -2.08* | -22.8 | 2008 | -122.6601 | 48.9575 |
| SFDak02 | -0.22 | -2.70 | 3810 | 12.03 | -4.12* | -35.1 | 2008 | -122.6381 | 48.9504 |
| SFDakDL | -0.25 | -11.00 | 42729 | 11.68 | -1.79** | -77 | 2014 | -122.6162 | 48.9456 |
| SFDak2_2 | -0.17 | -2.20 | 6360 | 5.08 | -2.6* | -28.6 | 2008 | -122.5965 | 48.9431 |
| NFDak01 | -0.14 | -2.25 | 3803 | 11.06 | -2.69* | -29.2 | 2008 | -122.6381 | 48.9511 |
| NFDak2_5 | -0.12 | -2.11 | 4948 | 12.46 | -1.88** | -29.6 | 2008 | -122.6159 | 48.9697 |
| TribDak1 | -0.11 | -2.53 | 2762 | 8.05 | -1.85** | -32.9 | 2008 | -122.7194 | 48.9790 |
| TribDak2 | -0.27 | -10.42 | 21278 | 9.29 | -4.55* | -135.4 | 2008 | -122.7088 | 48.9794 |
| TribDak3 | -0.20 | -8.33 | 16931 | 12.14 | -3.87* | -108.3 | 2008 | -122.6932 | 48.9706 |
| TribDak4 | -0.19 | -6.67 | 16135 | 10.41 | -3.2* | -86.7 | 2008 | -122.7006 | 48.9719 |
| TribDak5 | -0.17 | -1.60 | 3870 | 6.10 | -2.92* | -20.8 | 2008 | -122.6601 | 48.9654 |
| TribDakN1 | -0.05 | -1.00 | 3158 | 7.63 | -0.9 | -14 | 2008 | -122.6265 | 48.9713 |
| TribDakN2 | -0.14 | -3.17 | 7447 | 11.44 | -2.29* | -44.3 | 2008 | -122.6158 | 48.9655 |
| TribDakS1 | -0.10 | -1.73 | 6532 | 12.02 | -1.51 | -22.5 | 2008 | -122.6163 | 48.9479 |
| TribDakS2 | -0.03 | -0.80 | 835 | 8.16 | -0.70 | -10.4 | 2008 | -122.5967 | 48.9446 |
| Trib1Dray1 | - | - | - | - | - | - | 2003 | -122.7344 | 48.9680 |
| LS5 | 0.05 | 2.50 | -6495 | 9.28 | 1.41 | 2.5 | 2015 | -122.7394 | 48.9826 |
| CC | -0.19 | -9.54 | 17355 | 7.71 | -2.16* | -133.5 | 2008 | -122.7540 | 48.9972 |

* indicates statistical significance ($p < 0.05$, $\alpha = 0.05$) of a strong trend
** indicates statistical significance ($0.05 < p < 0.1$, $\alpha = 0.1$) of a weak trend
~ non-conclusive due to heterogeneous trends ($p < 0.05$, $\alpha = 0.05$)
- insufficient dataset

TribDak2—tributary to Dakota Creek at Sweet Rd shows the greatest improvement followed by CC—Cain Creek at the mouth as shown by the Theil-Sen estimator of the regression slope, which is used to calculate the percent change over the period of record. TribDak3—tributary to Dakota Creek at Rogers Rd and CA14c—tributary to California Creek at Brown Rd also show a relatively high degree of improvement. Despite the observed improving trends, these sampling locations require TMDLs to attain the WQS.

The SK test show a decrease in FC concentrations in the Dakota Creek basin at 12 out of 18 sites, while the California Creek basin shows 5 out of 15 sites with decreasing trends, which indicates improving water quality (Figure D-67 and 68). No trend and a modest improving trend are indicated at Dakota Creek at Giles Rd (Dak3_1) and California Creek at Birch Bay-Lynden Rd (Cal3_1) respectively. These two locations represent the farthest downstream fresh water sites before entering the receiving brackish marine water. All other sampling locations along the mainstem of California Creek do not show significant FC reductions, while 4 out of 7 tributary sites show improving water quality (Figure D-67). Two Dakota Creek mainstem sites (Dak6_8) at Valley View Road and (Dak06) at I-5 show reductions in FC. Both the north and south forks of Dakota Creek (NFDak01 and SFDak02) and the upstream sampling locations (NFDak2_5 and SFDak2_2) show significant FC reductions (Figure D-68). Ten out of fourteen tributary sites to Dakota Creek and the north and south forks show improving water quality.

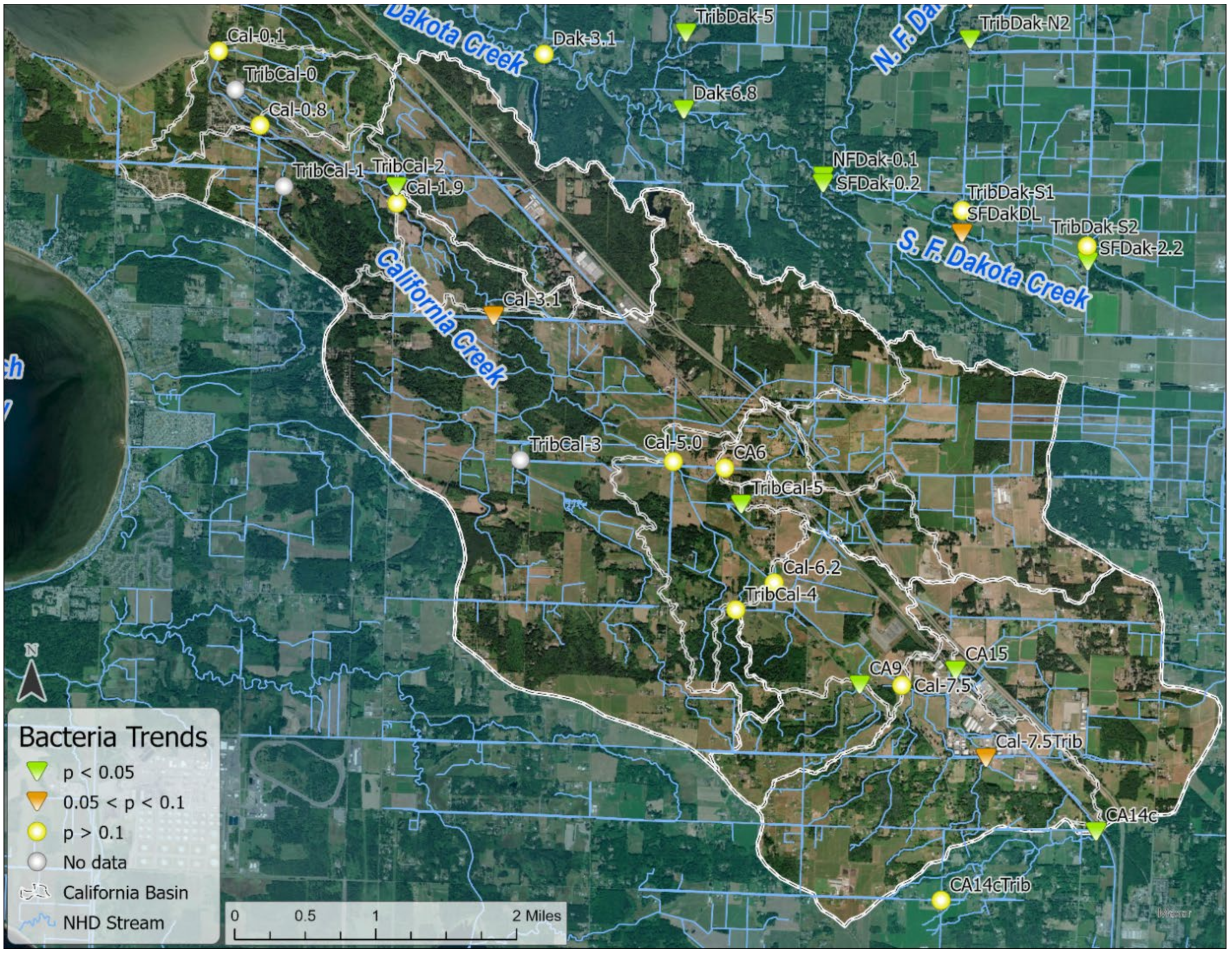


**Figure D-67. Seasonal Kendall bacteria trends in the California Creek basin where $p < 0.05$ = strong improving trend indication, $0.05 < p < 0.1$ = weak trend indication, $p > 0.1$ = no trend indication**

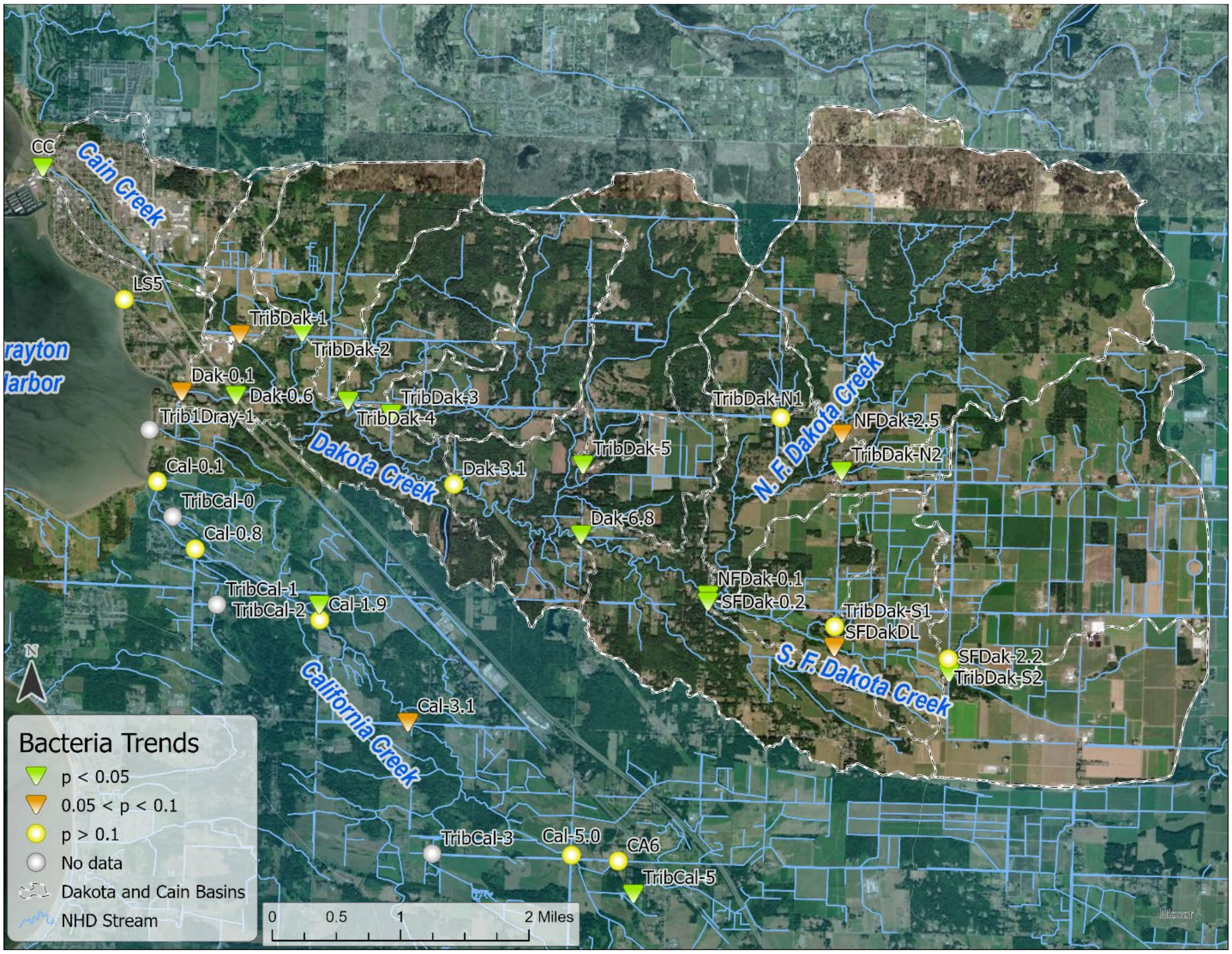



**Figure D-68. Seasonal Kendall bacteria trends in the Dakota and Cain Creek basins where p < 0.05 = strong improving trend indication, 0.05 < p < 0.1 = weak trend indication, p > 0.1 = not trend indication**

### Marine water Trends

In summary, the SK test indicates an overall significant improving trend in FC levels when aggregating across the harbor ($\tau$ = -0.16, slope = -0.005, intercept = 13.9, $\chi^2$ = 29.1, Z = -14.0, percent change = -1.5 $yr^{-1}$). When examined by station, the SK tests show that 11 of 14 DOH marine station are significantly improving in FC concentrations showed by negative Z-scores (Table D-17 and Figure D-69). The Theil-Sen slope and percent change express the level of change over the period of record from the start date shown in Table D-17 through December 2022. The start date represents the year in which data collection began that was equally distributed among the seasons. Note the different periods of record among stations:

- Stations 03, 04, 05, 06, 08, 11, and 12 = 31 years,
- Station 15 = 29 years,
- Stations 313, 314, and 315 = 17 years,
- Stations 378 and 379 = 10 years,
- Station 413 = 6 years, and
- Station 428 = 1.5 years—not analyzed due to an insufficient period of record.

The SK tests are also done to account for the differences in the period of record among stations and based on the limiting record from stations 378 and 379 (2012—2022). The SK tests for each station using data from 2012—2022 show a marginal significant trend for station 05 ($p = 0.06$, $\alpha = 0.1$), and a significant trend for station 06 ($p = 0.005$, $\alpha = 0.05$). All other stations do not show a significant trend from 2012—2022. Therefore, FC concentrations at 12 of the 14 DOH monitoring stations are neither significantly improving nor degrading over the past 11 years according to the SK tests.

Excluding station 428 (Figure A-1), stations 378, 379, and 413 are the most recently added monitoring locations with enough data for the SK test (Table D-17 and Figure D-69). Station 379 has heterogeneous trends indicated by the Chi-squared test statistic. Not shown in Table D-17, there is a significant upward trend for samples collected during October and a significant downward trend during August, thus producing a heterogenous trend at station 379. The SK test is therefore inconclusive for station 379.

**Table D-17. Seasonal Kendall Test statistics for FC at the DOH Drayton Harbor marine sampling stations from the given start date through calendar year 2022**

| Station | Tau (τ) | Theil-Sen Slope | Intercept | Chi-Squared ($\chi^2$) | Z | Change (%) | Start Date | Latitude | Longitude |
|---|---|---|---|---|---|---|---|---|---|
| Sta03 | -0.2 | -0.005 | 20.4 | 8.56 | -4.93* | -1.5 | 1991 | 48.97413 | -122.77287 |
| Sta04 | -0.15 | -0.004 | 19.4 | 5.49 | -4.07* | -1.5 | 1991 | 48.98077 | -122.75662 |
| Sta05 | -0.18 | -0.004 | 11.4 | 3.29 | -4.78* | -1.2 | 1991 | 48.97994 | -122.77302 |
| Sta06 | -0.14 | -0.005 | 4.25 | 7.01 | -3.65* | -1.6 | 1991 | 48.98453 | -122.75818 |
| Sta08 | -0.15 | -0.29 | 760.5 | 9.03 | -3.65* | -8.9 | 1991 | 48.98902 | -122.76144 |
| Sta11 | -0.21 | -0.004 | 11.2 | 5.32 | -4.52* | -1.3 | 1991 | 48.98560 | -122.77380 |
| Sta12 | -0.21 | -0.004 | 6.5 | 7.00 | -5.5* | -1.2 | 1991 | 48.98296 | -122.78213 |
| Sta15 | -0.09 | -0.007 | 65.6 | 8.69 | -2.18* | -2.1 | 1993 | 48.99253 | -122.76738 |
| Sta313 | -0.11 | 0 | 1.75 | 13.98 | -2.52* | 0 | 2005 | 48.97840 | -122.78860 |
| Sta314 | -0.13 | 0 | 1.9 | 10.16 | -2.65* | 0 | 2005 | 48.97010 | -122.78060 |
| Sta315 | -0.22 | 0 | 5.7 | 7.65 | -4.66* | 0 | 2005 | 48.96552 | -122.76781 |
| Sta378 | -0.07 | 0 | 48.0 | 12.88 | -0.97 | 0 | 2012 | 48.97496 | -122.74167 |
| Sta379 | -0.04 | 0 | 4.4 | 9.84 | -0.57 | 0 | 2012 | 48.96463 | -122.74364 |
| Sta413 | 0.04 | 0 | 1.70 | 5.43 | 0.13 | 0 | 2017 | 48.98690 | -122.75996 |

***** Statistical significance ($p < 0.05$, $\alpha = 0.05$)


**Figure D-69. Fecal coliform (FC) concentration trends at the DOH marine monitoring stations in Drayton Harbor where p < 0.05 = strong improving trend indication, 0.05 < p < 0.1 = weak trend indication**

The annual geometric mean (geomean) is calculated for Drayton Harbor as a whole using all DOH station data and plotted over time (Figure D-70). The geomean box plots shows the distribution of geometric means as data points to compare to the 14 MPN/100 mL geomean water quality criterion. The annual geomeans represent long term chronic water quality for the given period.

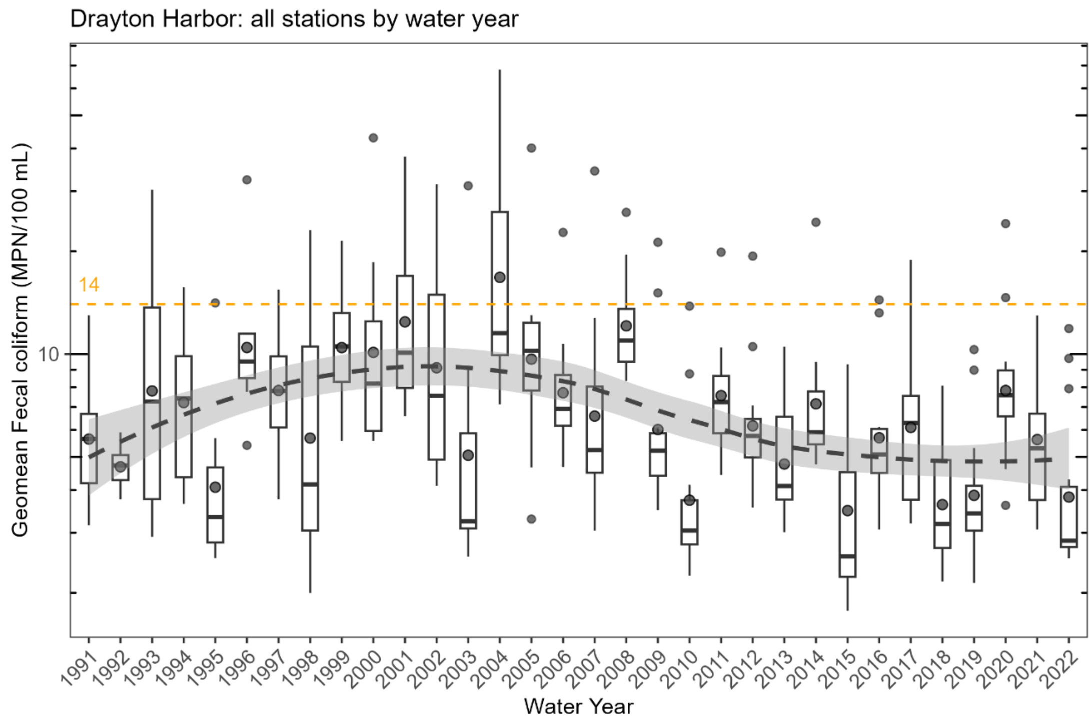



**Figure D-70. FC geomean distribution across Drayton Harbor with median (—), mean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) criterion**

To compare the period of record to the WYs used to establish the TMDL, 2020 and 2021 rank in the 73rd and 27th percentiles respectively according to the geometric mean aggregated across all stations. Water year 2004 has the highest geometric mean followed by 2001 and 2008. The lowest geometric means occur during WYs 2015, 2018, and 2010. Drayton Harbor as a whole seems to experience a relative rise in FC starting in 1997 and peaks in 2004. Starting around 2005 the collective FC levels seem to decline until 2020 when a sharp increase occurs then seems to level decline in the proceeding two years.

The distribution of annual geometric means illustrate chronic levels of FC to provide context for trend analysis. For example, a monitoring station may show a significant improving trend but still remain above the geomean water quality criterion. Or, a station may meet the water quality criterion but show no trend. Stations 08 and 15 consitently have an annual geometric mean above 14 MPN/100 mL (Figure D-71). Stations 04 and 06 exceed the geomean criterion during one and two WYs respectively. Stations 05, 11, 12, 313, 314, 315, 378, 379, 413 do not exceed the geomean criterion for each station’s period of record. Note, these observations do not include the 10% STV above 43 cfu/100 mL criterion.

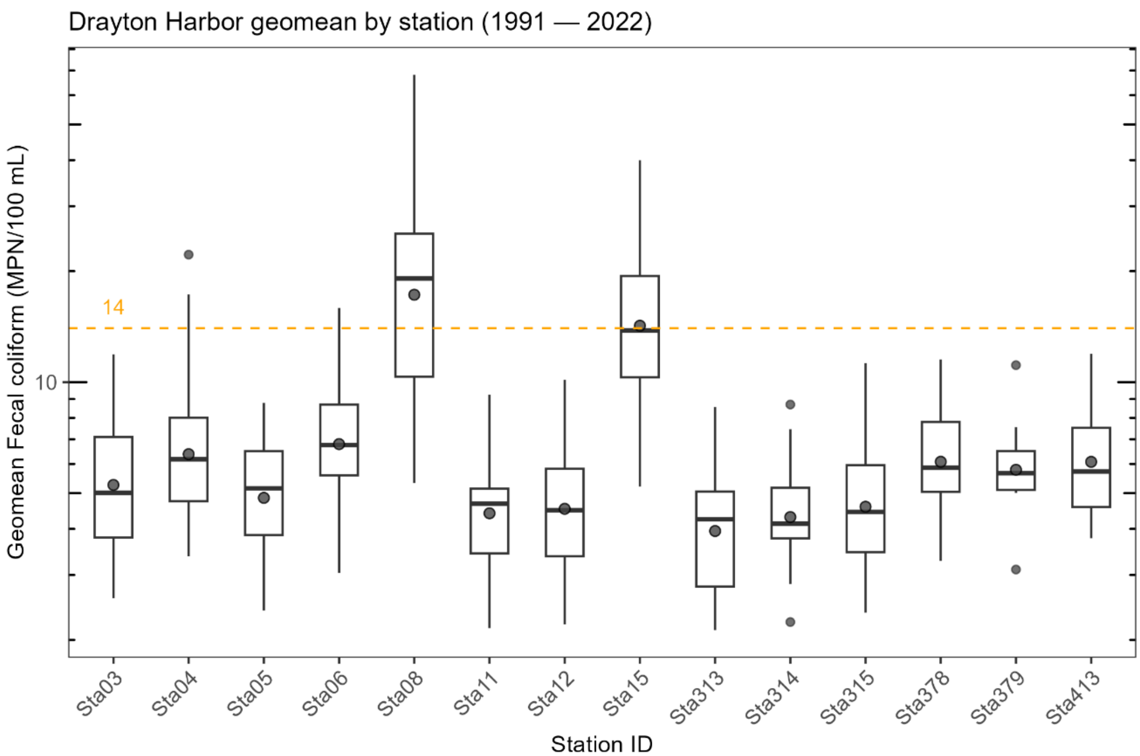



**Figure D-71. FC geomean boxplot distributions for all DOH station's respective period of record with median (—), mean (●), and the geomean (---) criterion**

The 43 MPN/100 mL STV criterion does not apply to the geomean, rather it represents accute conditions using single sample comparisons. The 90$^{th}$ percentile values for each station is plotted to compare a concentration to the percent not-to-exceed STV (Figure D-72). The 43 MPN/100 mL criterion is exceeded during all WYs except for 2018 based on the annual 90$^{th}$ percentile value. Stations 15 and 08 consistently show greater 90$^{th}$ percentiles than the remaining stations, however, each station exceeds the 43 MPN/100 mL criterion when assessed by WY (Figure D-73). Note the 90$^{th}$ percentile and STV are not interchangeable—see the TMDL Targets section. The 90$^{th}$ percentile, however, is used to assess shellfish growing area conditions by the DOH Shellfish Program.

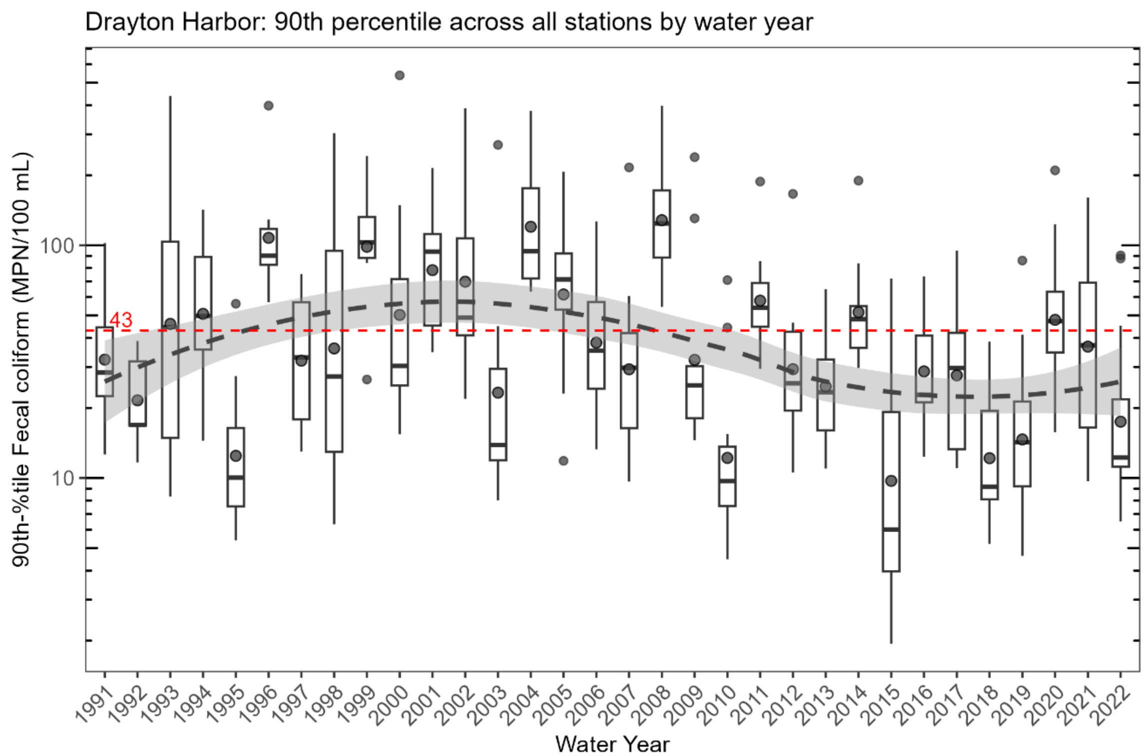



**Figure D-72. FC 90th percentile distribution across Drayton Harbor with median (—), mean (●), loess smoothing and 95% confidence interval (---), and the STV (---) criterion**

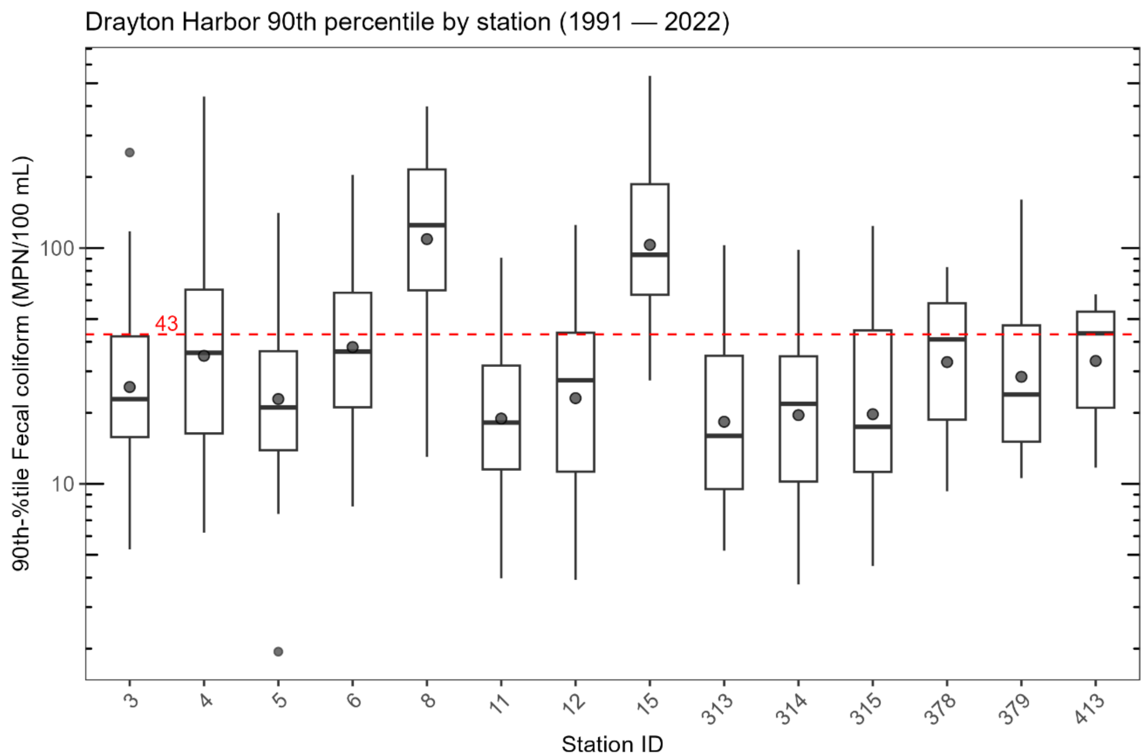
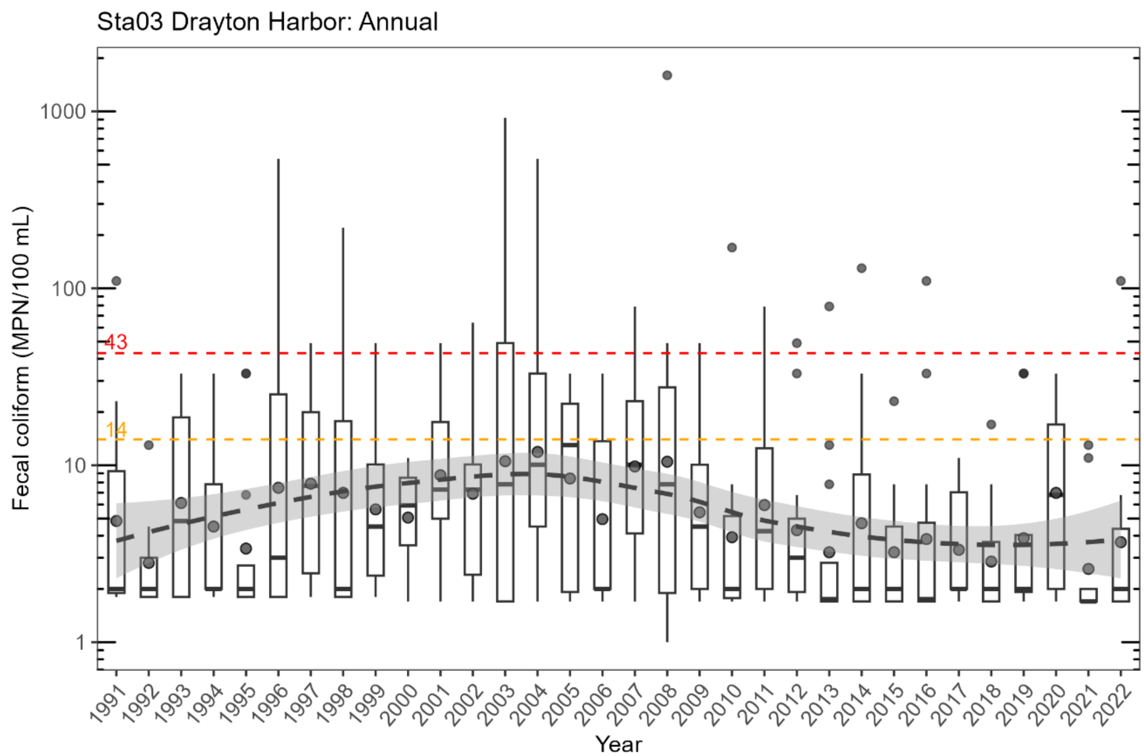



**Figure D-73. FC geomean boxplot distributions for all DOH station's respective period of record with median (—), mean (●), and the STV (---) criterion**

The annual FC distributions at each station illustrate concentrations over time, which generally decrease as shown by the SK tests, eventhough interannual variablility occurs (Figures D-74—87). The monthly distributions illustrate the times of the year with relatively low or high levels of FC for the period of record and identifies the months of the year when FC levels are either likely above or below the WQS. In general, the dry season months (May—September) experienced lower FC concentrations when compared to the wet season (October—April). Stations 15, 378, and 379, however, show subtle exceptions where some dry season months on average exceed wet season months. The geometric mean values can be visually compared to the 14 cfu/100 mL water quality criterion to better understand the conditions at each station. Similary, the single-sample concentrations offer a comparison to the 43 cfu/100 mL STV.



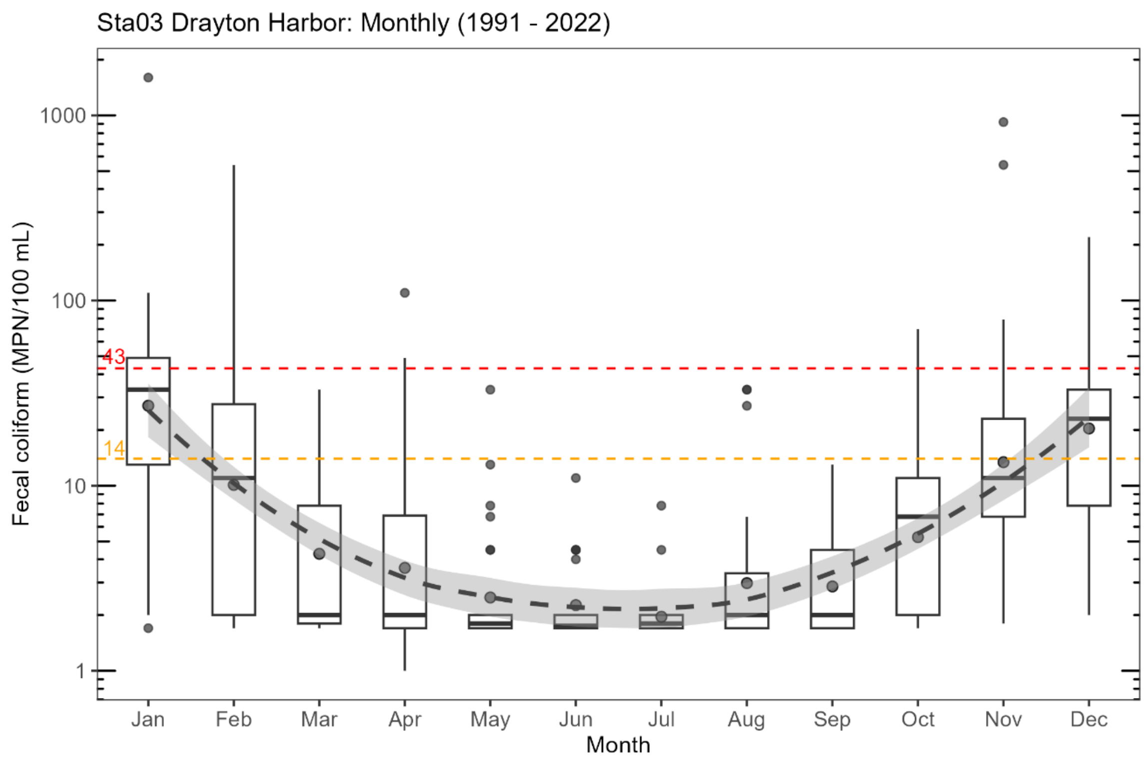




**Figure D-74. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 03 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**

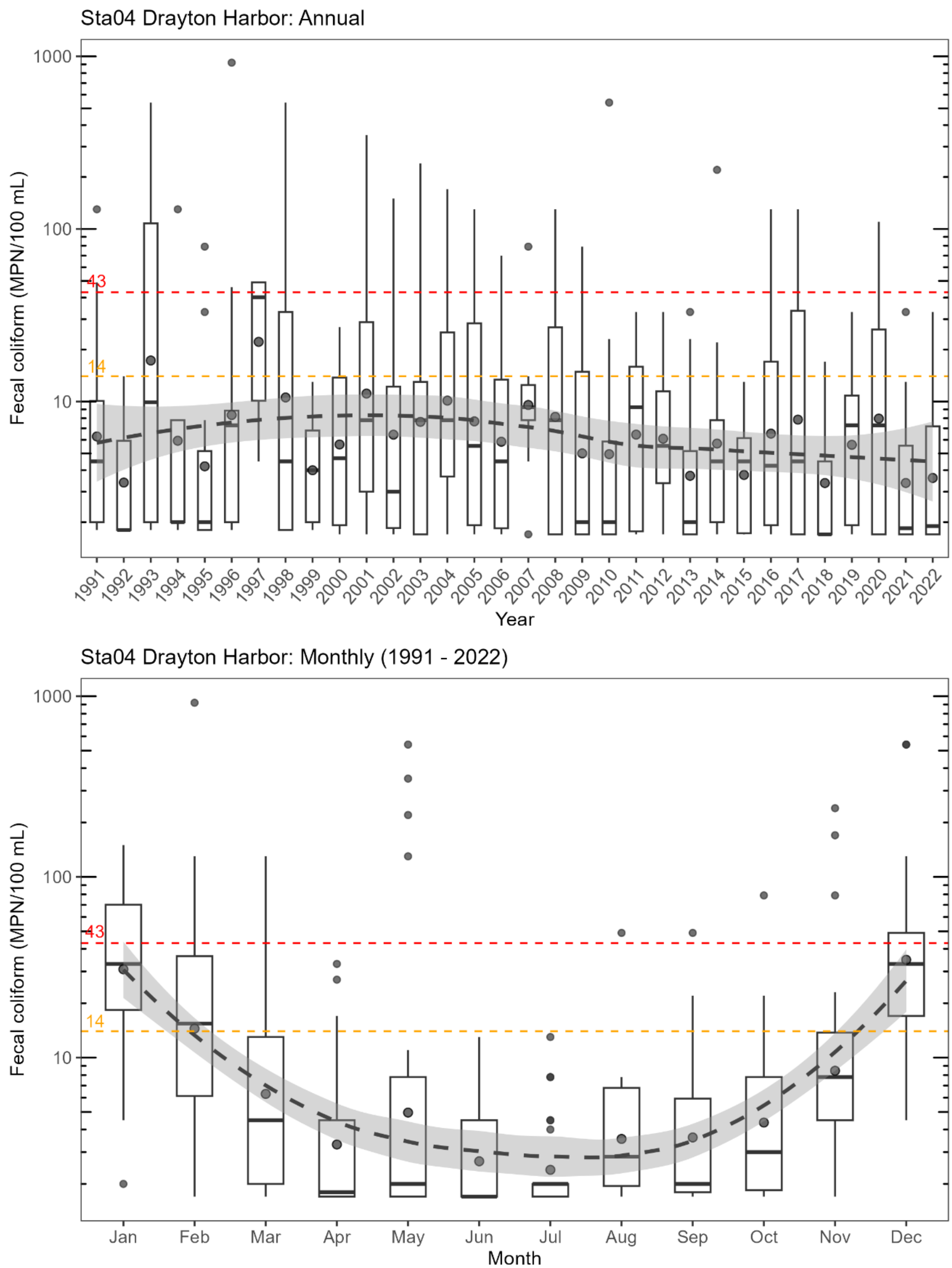



**Figure D-75. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 04 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**

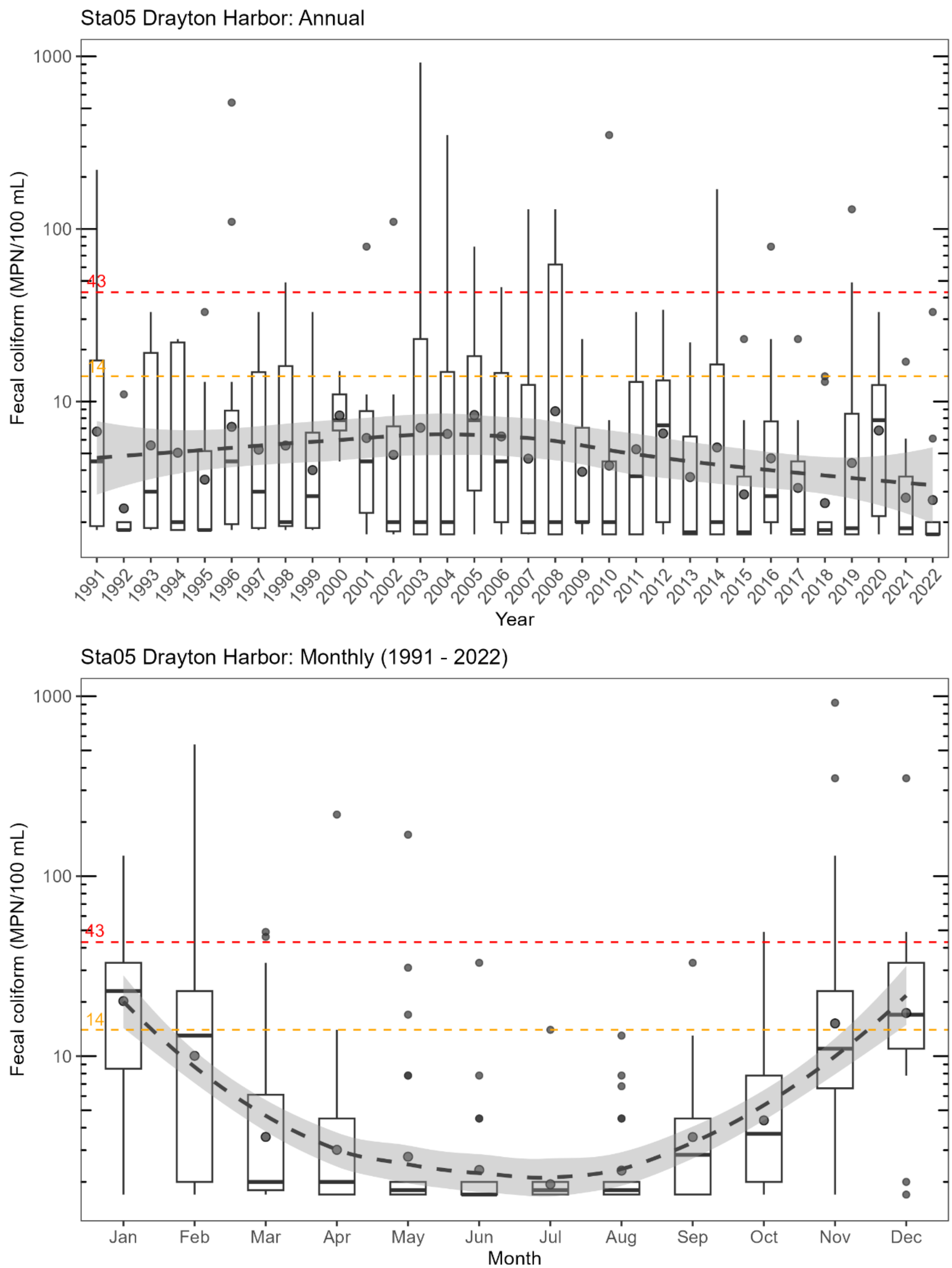
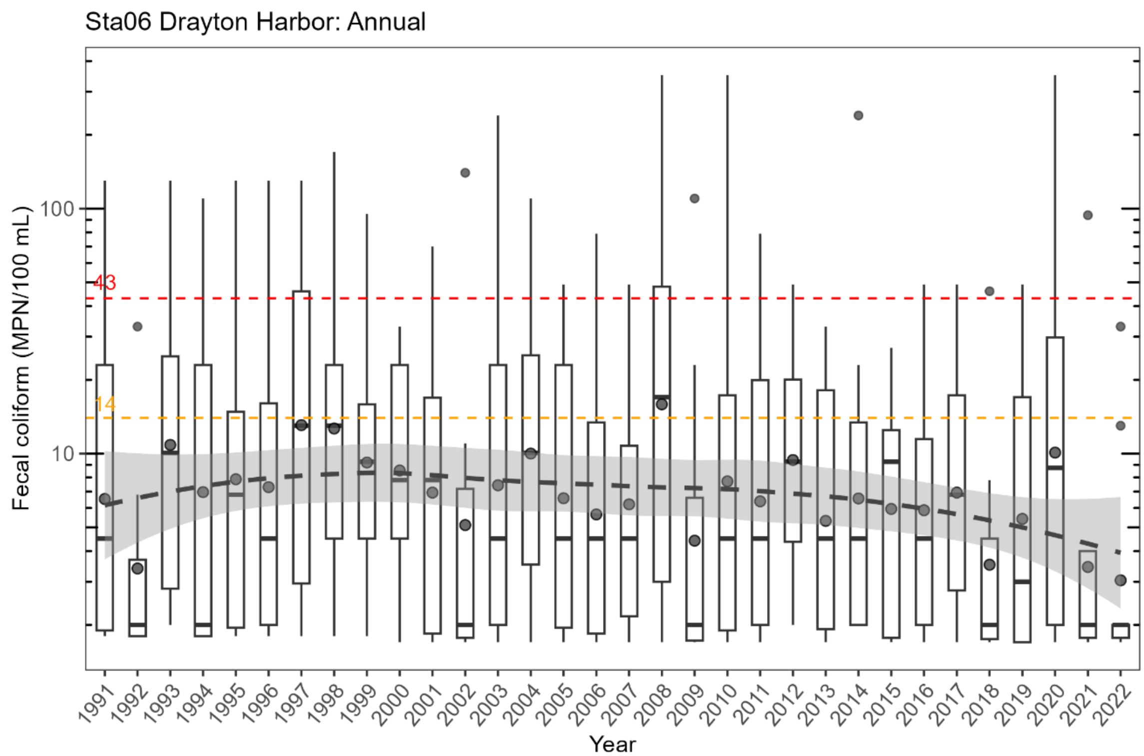



**Figure D-76. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 05 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



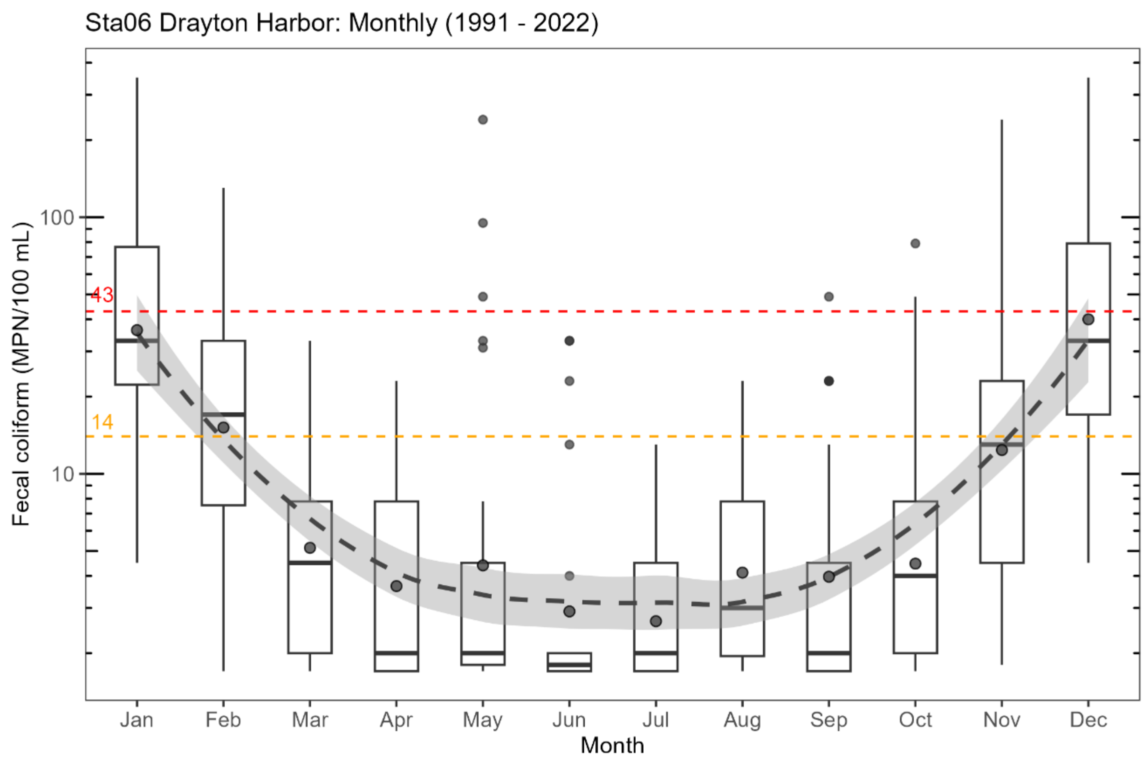
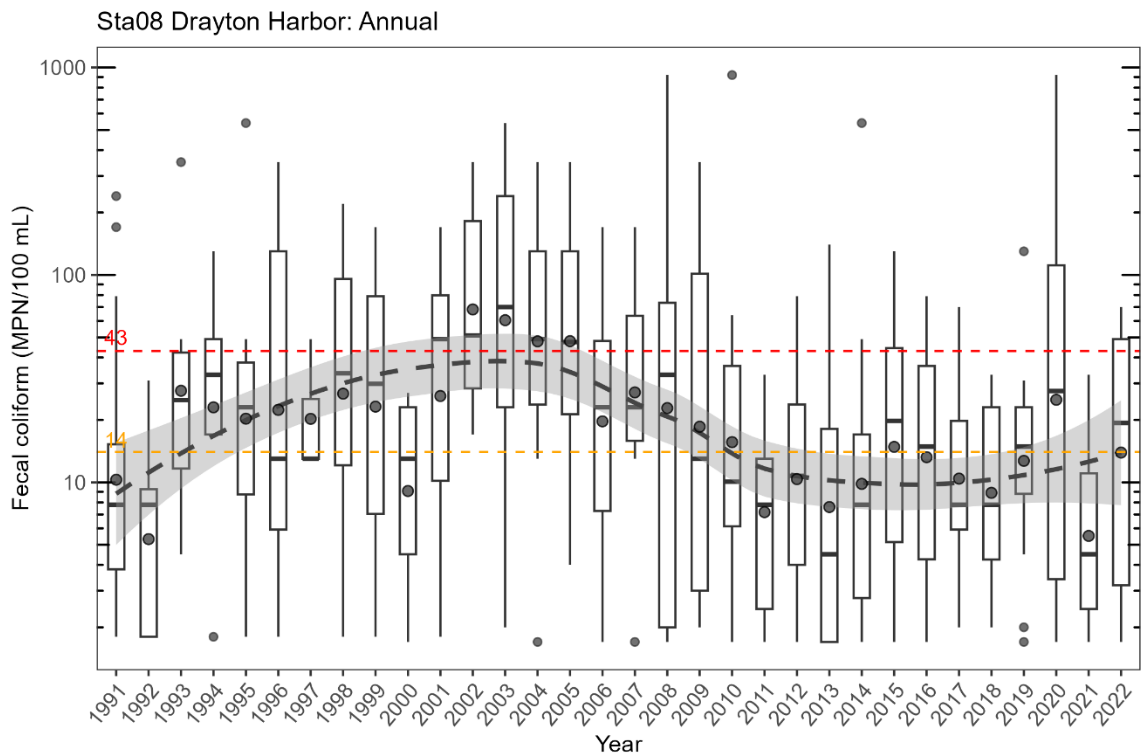




**Figure D-77. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 06 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



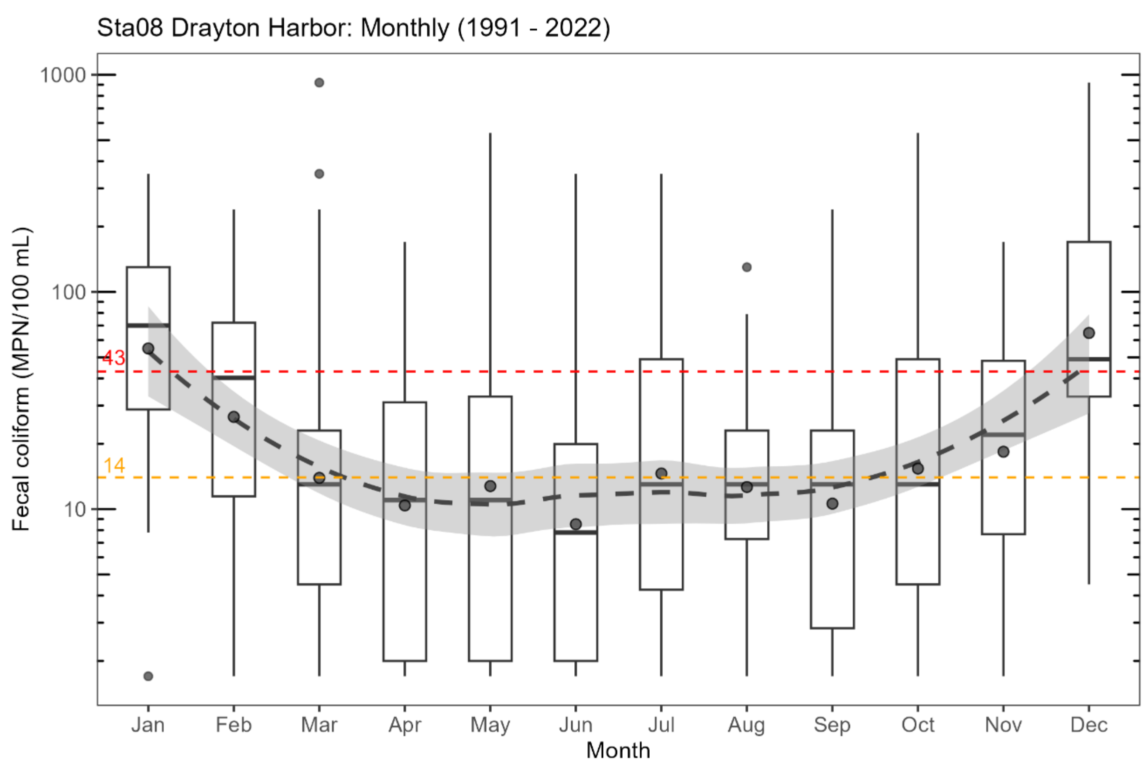
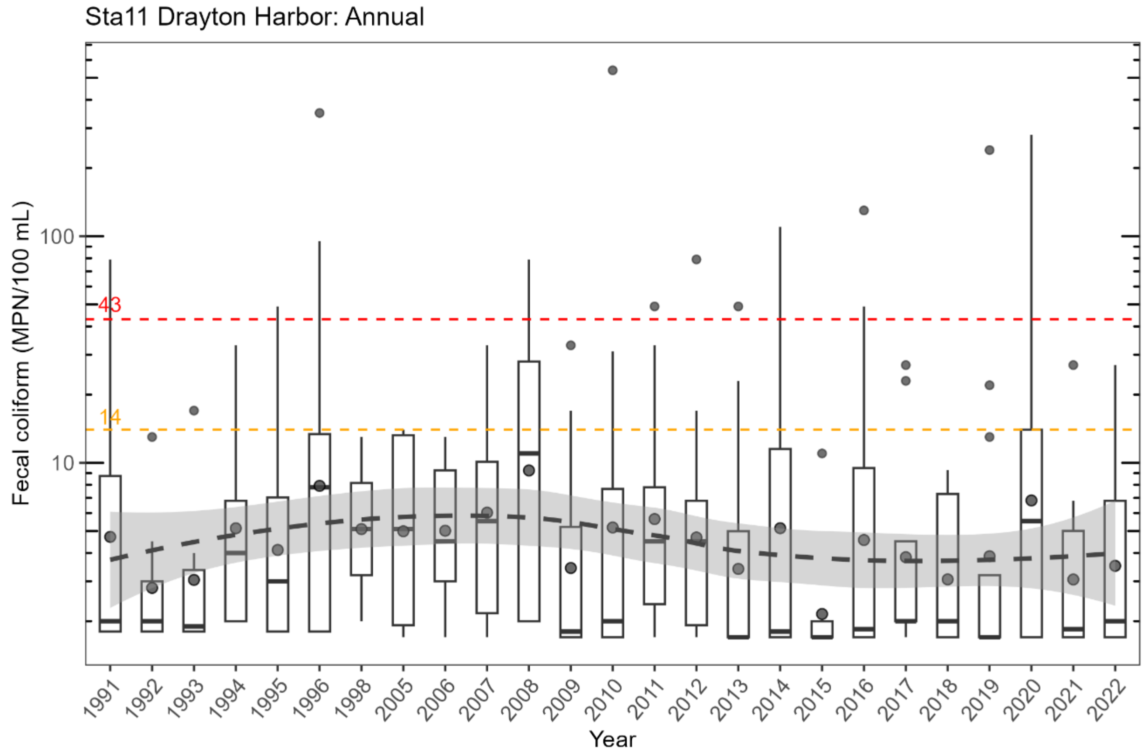




**Figure D-78. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 08 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



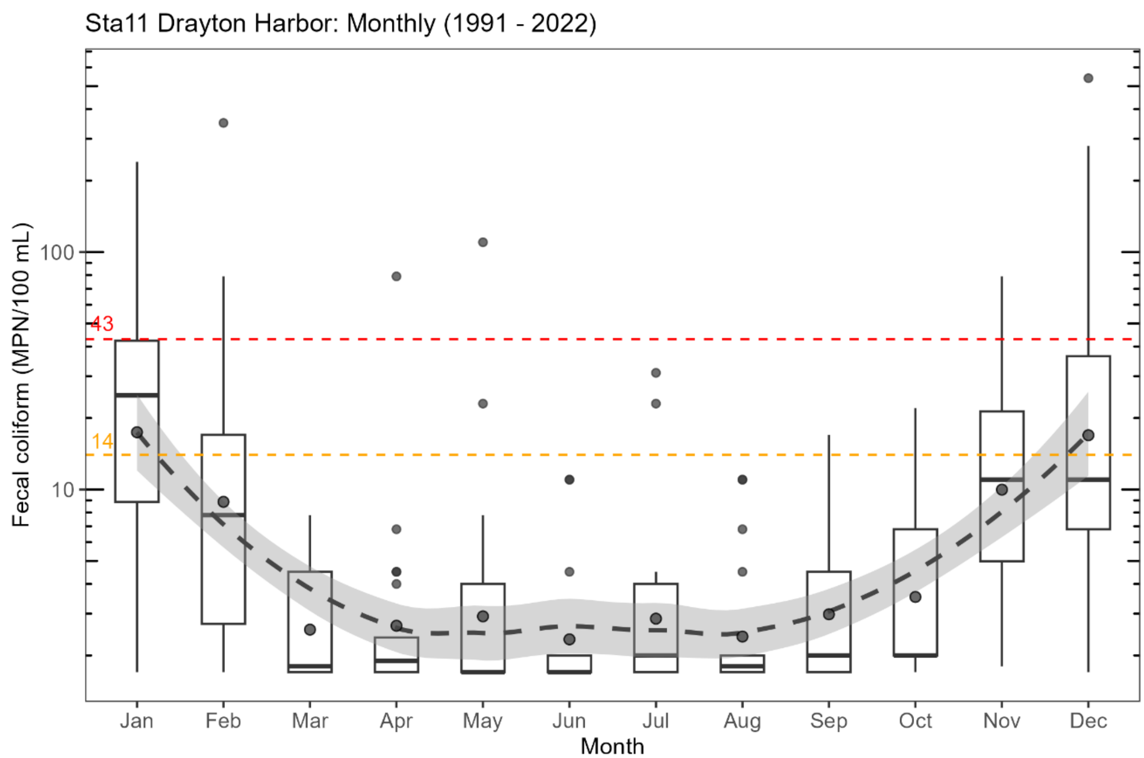




**Figure D-79. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 11 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**

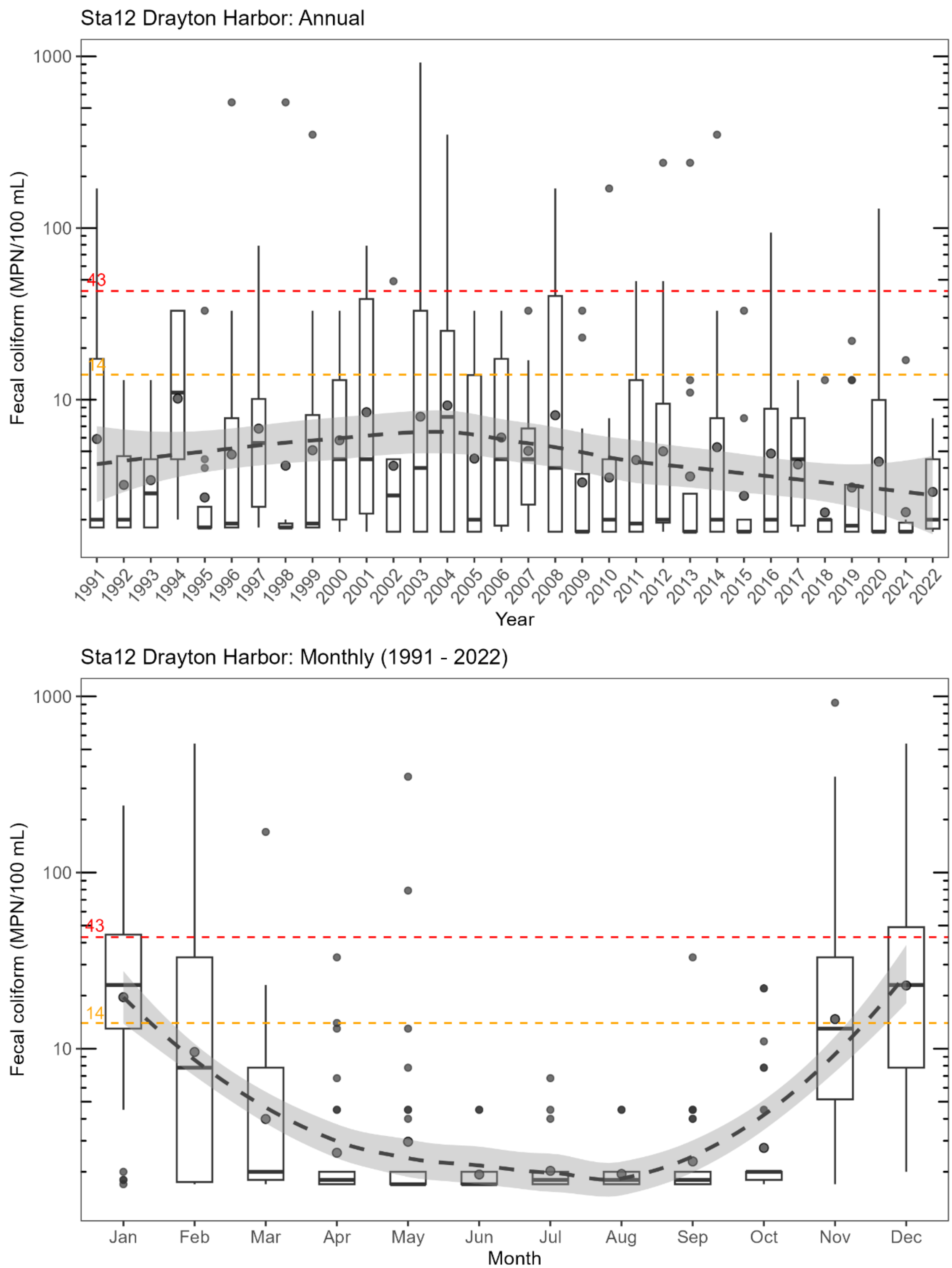
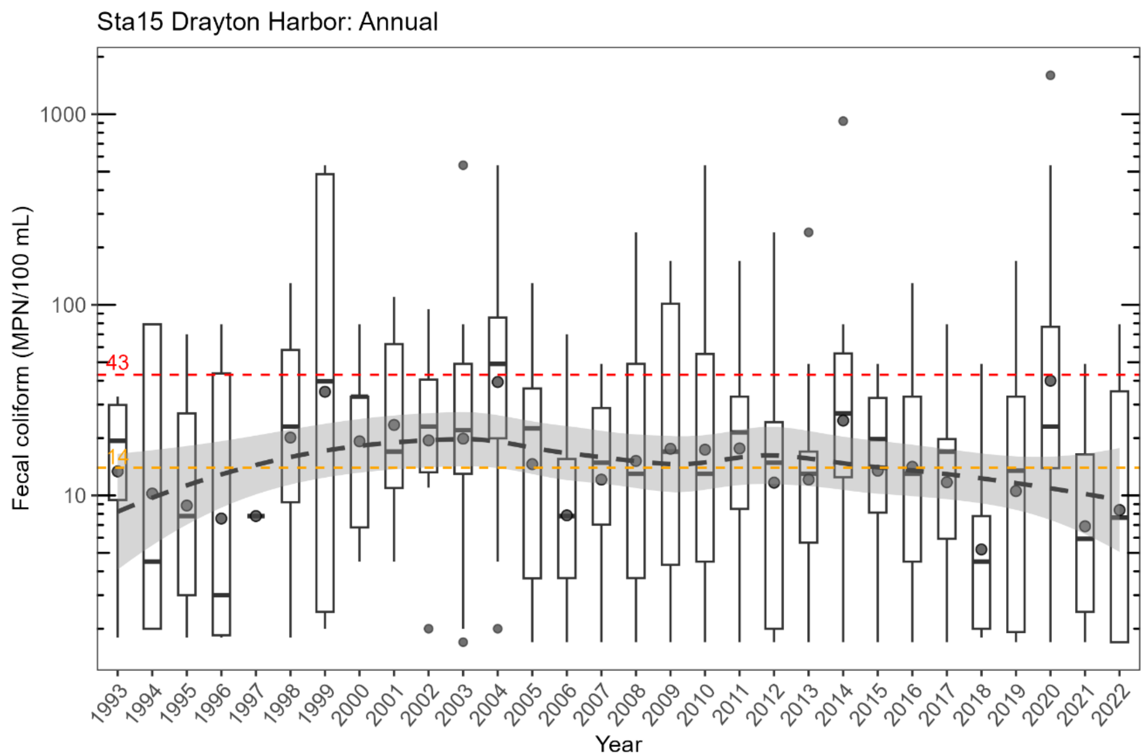



**Figure D-80. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 12 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



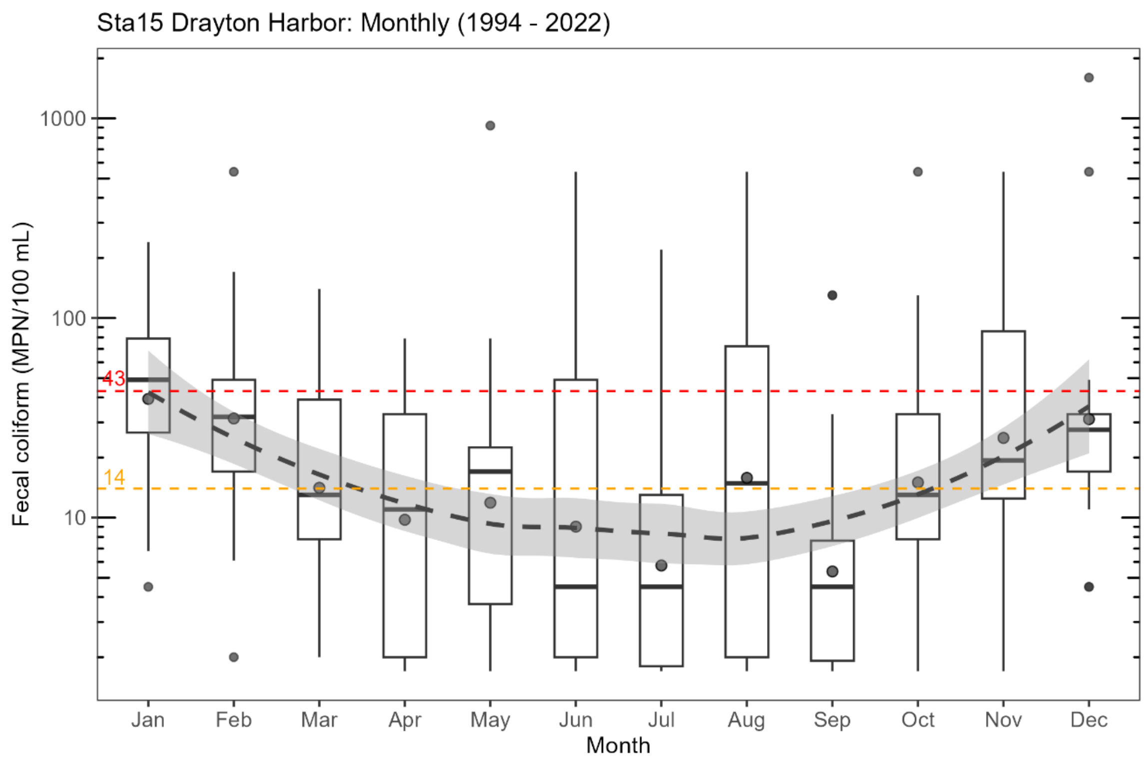




**Figure D-81. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 15 with median (—), geomean (♦), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**

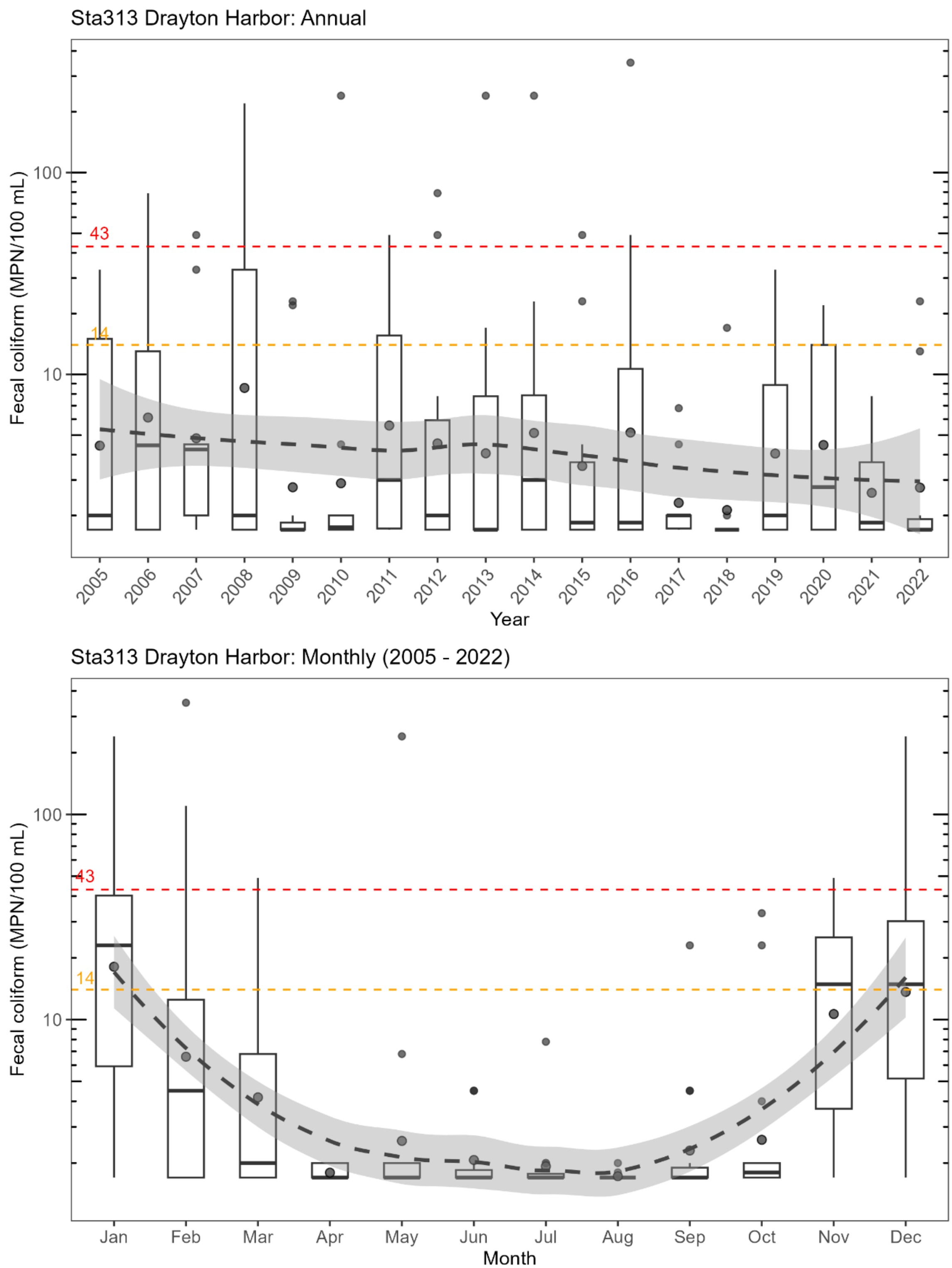
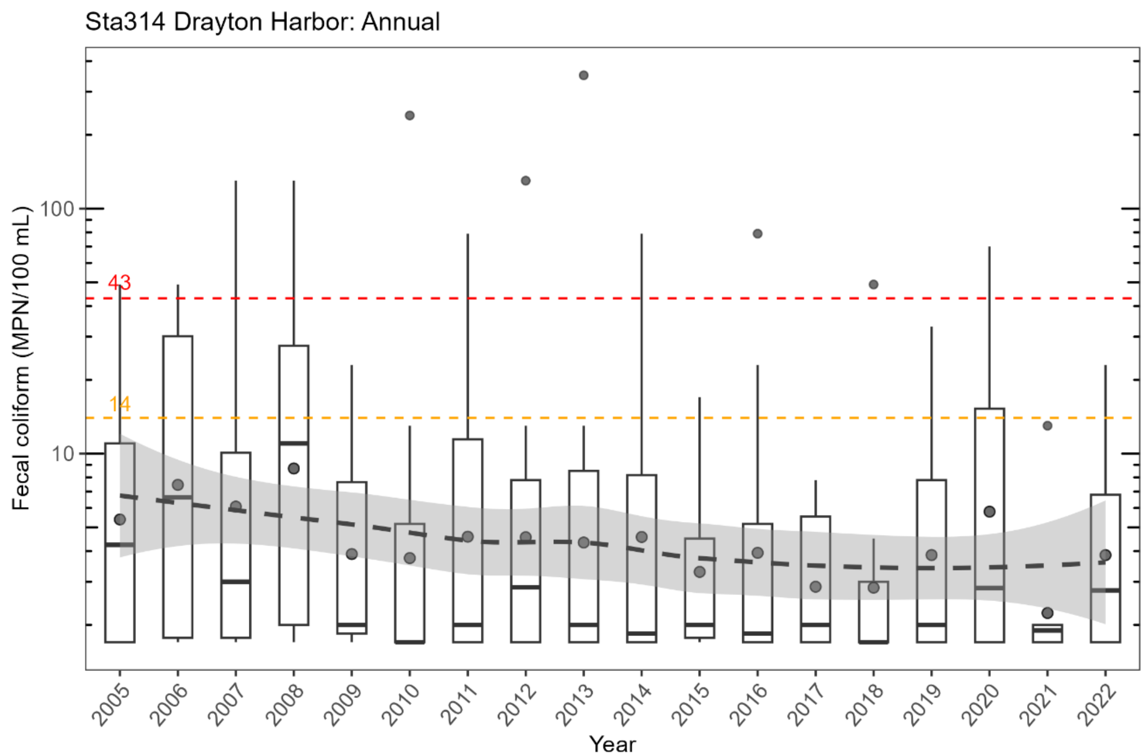



**Figure D-82. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 313 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



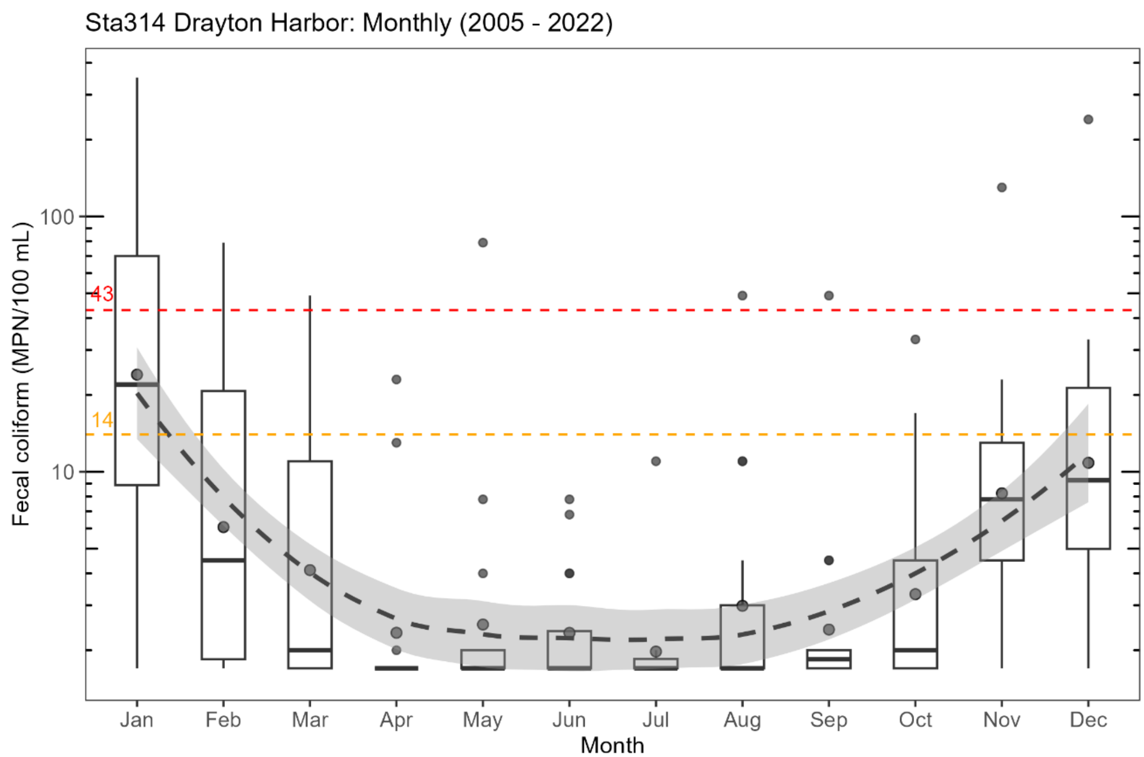
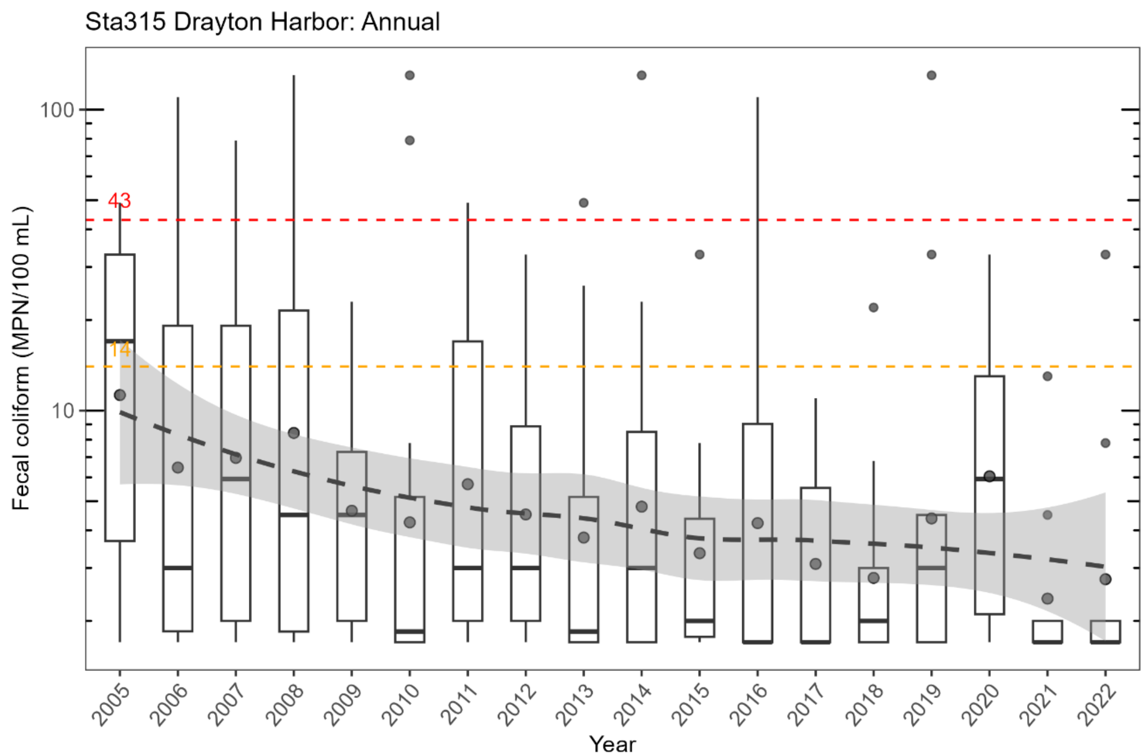




**Figure D-83. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 314 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



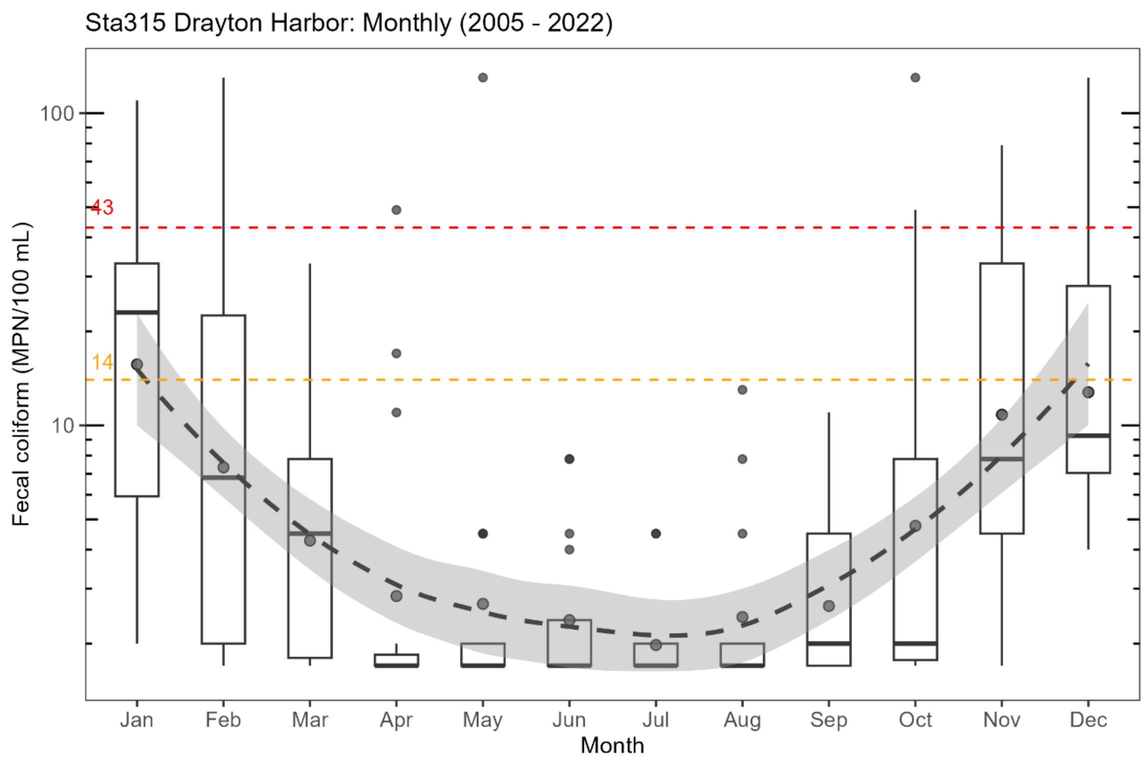
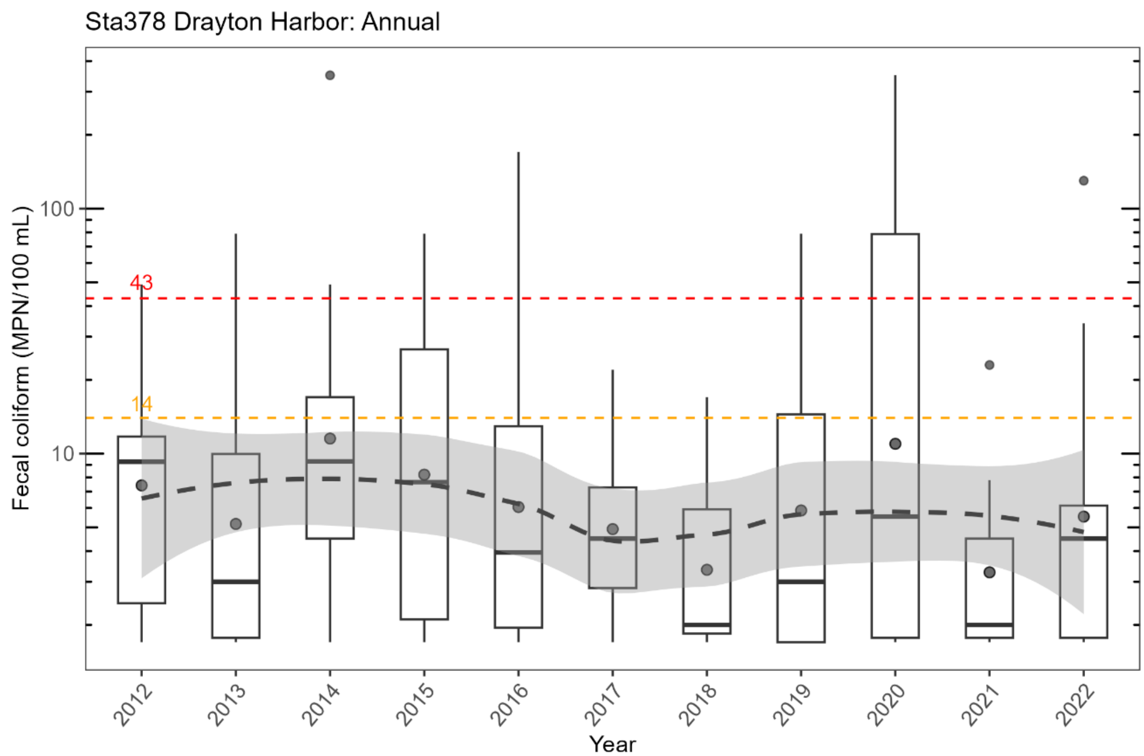




**Figure D-84. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 315 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



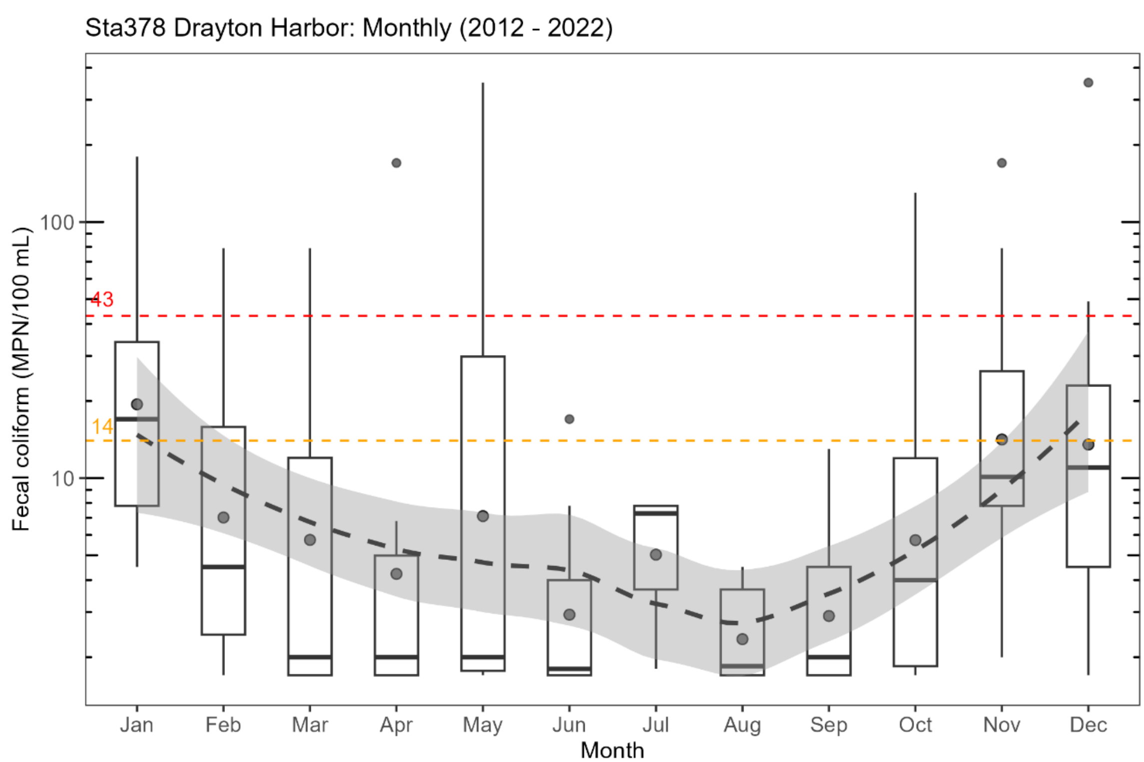
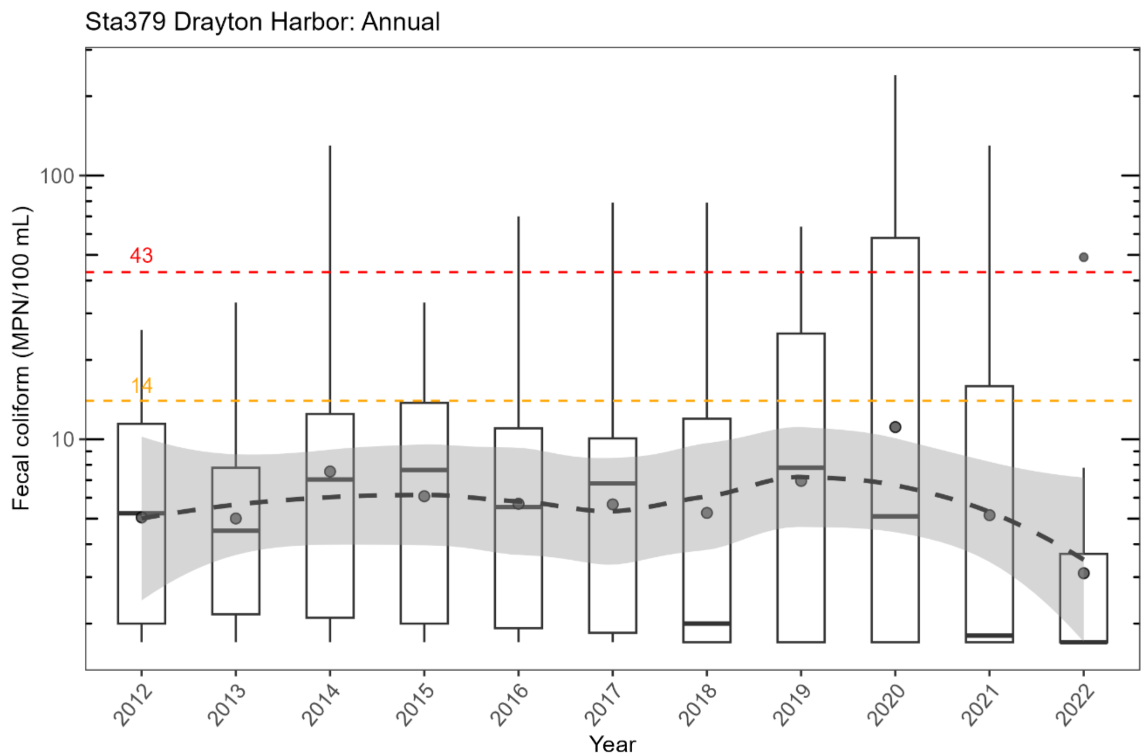




**Figure D-85. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 378 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



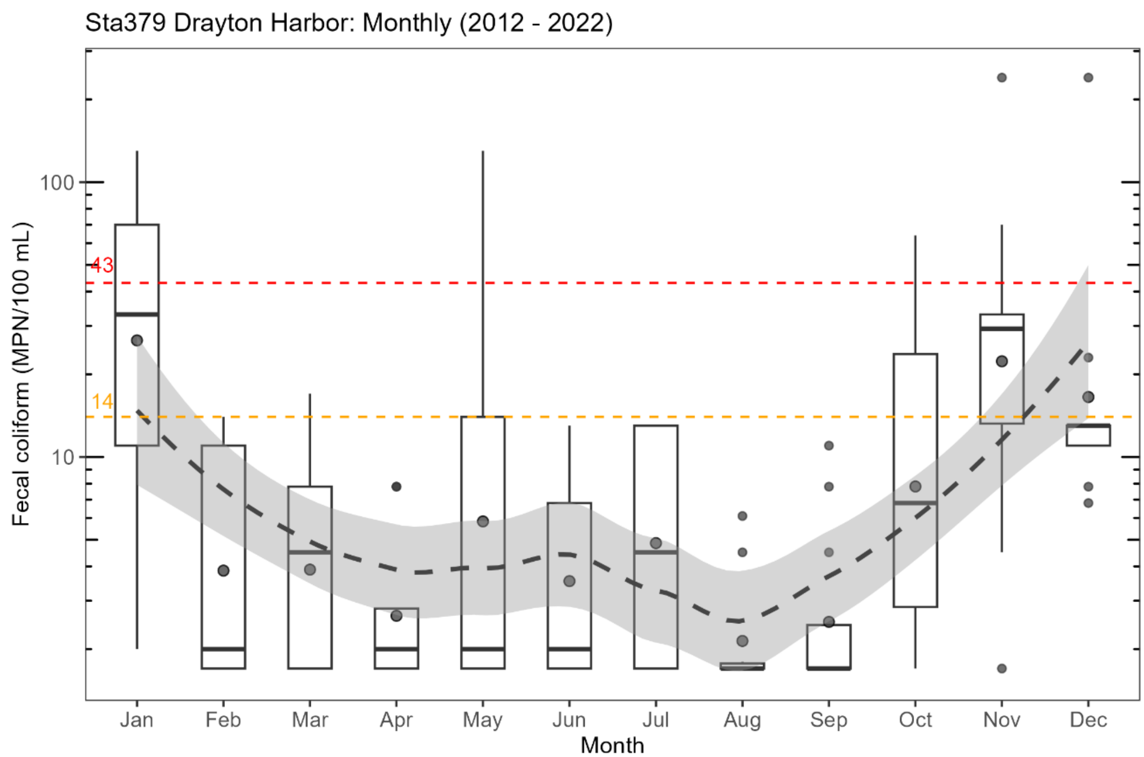
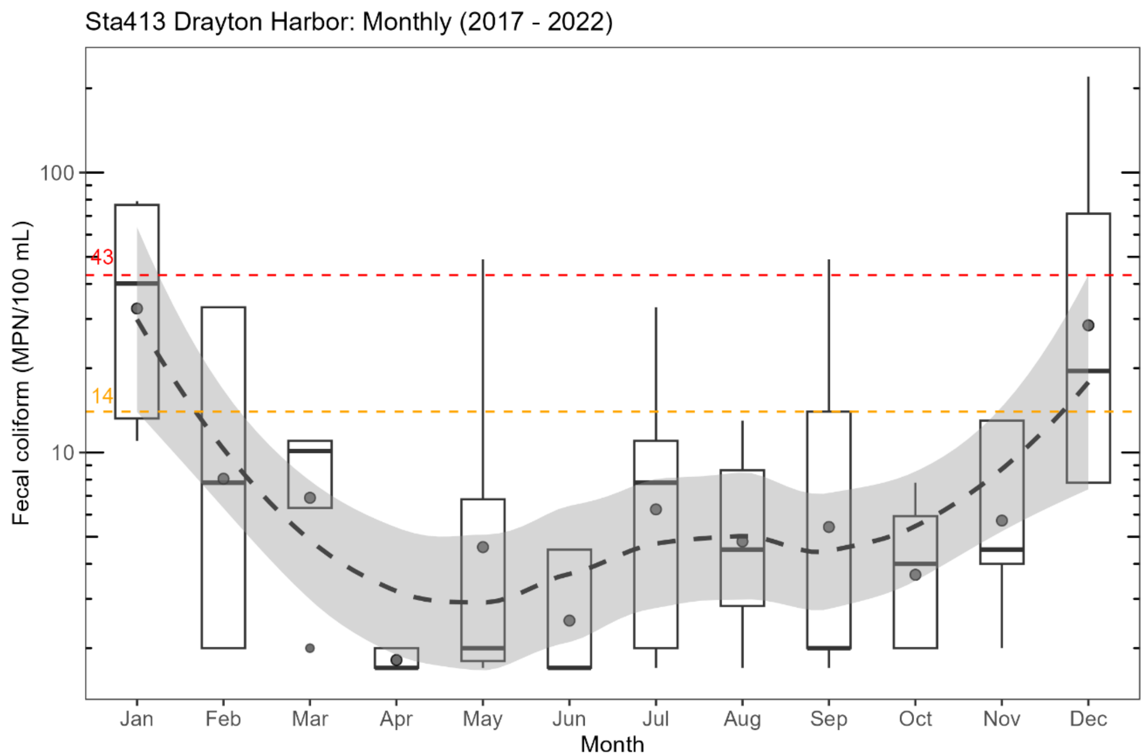




**Figure D-86. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 379 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**



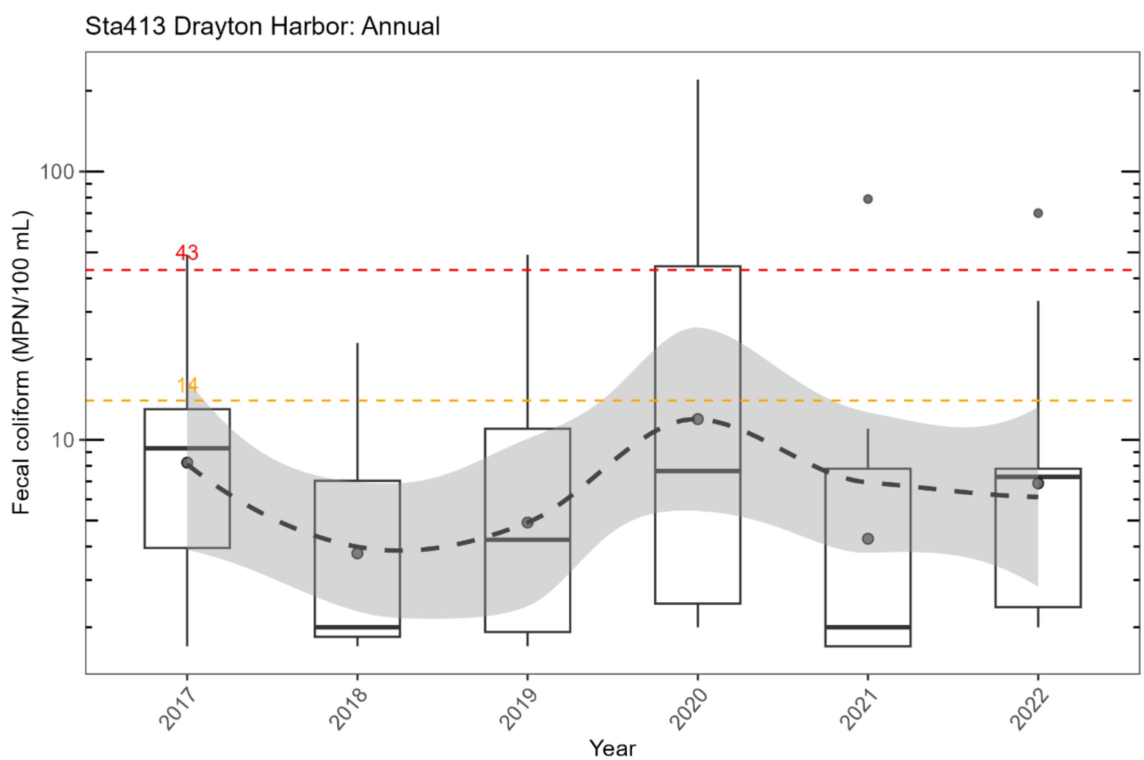




**Figure D-87. Annual (top) and monthly (bottom) FC boxplot distributions for DOH station 413 with median (—), geomean (●), loess smoothing and 95% confidence interval (---), and the geomean (---) and 10% STV (---) criteria**

# Appendix E. TMDL Analysis

## Loading Capacity

Two LCs and TMDLs are established to protect designated uses; one for shellfish harvesting using the FC water quality criteria, and the other for contact recreation using the *E. coli* water quality criteria, see the TMDL Allocations Section—Tables 6 and 7. The FC LC is calculated for the shoreline areas and incorporates both parts of the technology-based effluent limits of the Lighthouse Point Water Reclamation Facility. After incorporating the dilution factor of the mixing zone, this effluent limit meets the marine water quality criteria. Meeting the WLA of the Lighthouse Point Water Reclamation Facility will not result in an exceedance of the TMDL and LC.

The bacteria LCs are calculated for the mainstem of Cain, California, and Dakota creeks, and all other direct tributaries to Drayton Harbor. The LCs are calculated by subbasin and catchment, and therefore, established for each AU ID to account for each contributing NHD catchment throughout the entire watershed study area. Both the FC and *E. coli* LCs are established within the TMDL footprint, which is defined as the basin-wide drainage and human activities that occur within the Drayton Harbor watershed.

Establishing the bacteria TMDLs at or below the associated LCs addresses each Category 5—303(d) listed impairment (AU ID) and each tributary to the harbor for a basin-wide implementation approach. Information collected at the local, state, and federal levels is leveraged to calculate the LCs and characterize potential pollution sources. The bacteria translator (Equation 1) converts individual FC concentrations to *E. coli* concentrations to establish LCs and assess TMDL attainment. The TMDLs and reductions necessary to meet WQS are based on the pooled 2020 and 2021 WY datasets and expressed as mass per unit time (b.cfu/day), percent load reductions, and water quality targets. Establishing the TMDL for the shoreline areas accounts for immediate inputs to Drayton Harbor that do not pass through a tributary input with an associated TMDL.

Loading is also examined using the Beale's ratio estimator during the wet and dry seasons (Beale 1962)—see Appendix D, Beale's Loading Estimate Comparison. The first step involves calculating the Beale's ratio using the observed bacteria concentration and stream discharge at the time of sampling. This ratio is applied to all other days when sampling did not occur to calculate the total bacteria load by season. The daily load is calculated by dividing the total Beale's seasonal load by the number of days in each season.

Although the Beale's ratio method is useful when estimating loads outside of each sampling event, this method did not form the basis to calculate the LC. Rather, Beale's uses bacteria sampling data instead of the two-part water quality criteria, which remain static across all streamflows. For comparison, the Beale's loading in the Drayton Harbor study area is similar to that of the estimated loading when using the $90^{th}$ percentile value of the bacteria sample population and the geometric mean streamflow value. This similarity, however, depends on the season and is not a fair comparison because the 90$^{th}$ percentile is not used to develop the Beale's ratio. On the other hand, the Beale's loading estimates are far greater than the loading derived when using the geometric mean value of the bacteria sample population and the geometric mean streamflow value. This illustrates the use of a conservative TMDL based on the geometric mean values rather than the Beale's estimates.

Establishing the LC and TMDL based on the geometric mean water quality criterion is an additional conservative measure when compared to the 90$^{th}$ percentile STV. The geometric mean criterion is used to calculate the LC rather than the STV criterion that is estimated by the 90$^{th}$ percentile value to obtain a bacterial concentration. Basing the LC off the 90$^{th}$ percentile would result in an over estimation of the TMDL because it would chronically exceed the geometric mean criterion. Basing the LC on the geometric mean criterion, however, will not result in an exceedance of either of the two-part criteria. To ultimately attain the TMDL, the STR accounts for each water quality criterion and selects the most conservative, which is measured by the amount of the percent reduction (rollback) necessary to meet the WQS—see Appendix D, Statistical Rollback Analysis for details.

After calculating the FC and *E. coli* seasonal loading, the TMDL for each AU ID stream segment, also known as a catchment, is determined based on the delineated contributing catchment area as described below in the following sections. All contributing stream segments with unique AU IDs are accounted for when establishing each TMDL. If a future Water Quality Assessment concludes that a new stream segment AU ID does not meet the bacteria WQS, in accordance with federal regulations at 40 CFR § 130.7, Ecology will coordinate with EPA to make the correct Category determination—see Appendix A, Clean Water Act and TMDLs and Future Impairment Approval Process.

The following methods, tables, and equations are useful to establish the TMDL for any future bacteria impairment based on the WY conditions of 2020 and 2021. These methods are consistent with the methods used to establish the TMDLs in this report. In the event a future 303(d) listing is warranted, the TMDLs and LCs will not change. By design, the redistribution of the WLAs and LAs to account for future changes among pollution sources will not result in excessive bacteria loading above these established TMDLs. Adhering to these TMDL calculation methodologies to address all current and future AU IDs protects designated uses and helps guide pollution prevention and control activities throughout the watershed.

**Loading Calculation**

Calculating bacteria loads require the measurement of streamflow, or effluent discharge, and bacteria concentrations for either FC or *E. coli*. Selecting which fecal bacteria indicator to apply depends on the receiving water body, either marine or fresh water and their interface. The hydrological water balance for the Drayton Harbor watershed is developed using time series streamflow data from the Dakota Creek gage station and simulated hydrographs for all other catchments—see Appendix D. The methods applied in this study to address *E. coli*, also fills in the data gaps by quantifying the *E. coli* loads, LCs, and TMDLs for each catchment. The FC load, LC, and TMDL are further established at the fresh and marine water interface by accounting for the downstream designated use based on the WQS and criteria. The loads, LCs, and TMDLs are presented by wet and dry season.

The following equation calculates the LC and TMDL used to assess the attainment of the FC or *E. coli* TMDLs:

$$Load\ \left(\frac{cfu}{day}\right) = \ Bacteria\ \left(\frac{cfu}{100mL}\right) \times Flow\ (cfs) \times Conversion\ Factor\ (2.447 * 10^7) \qquad (18)$$

Equation 18 calculates the LC (cfu/day), where the bacteria concentration is the *E. coli* geometric mean criterion of 100 (cfu/100 mL) and streamflow discharge is the geometric mean averaged by season. Equation 18 also calculates the FC LC at fresh and marine water interface by using the geometric mean concentrations of 19 and 20 (cfu/100 mL) averaged by the wet and dry seasons, respectively and the seasonally geometric mean average streamflow discharge—see Appendix D, Protecting Downstream Designated Uses. Dakota Creek streamflow data, for WYs 2020—2021 from Ecology's gage station at Giles Road, is used to calculate the mainstem loads and the loads for each catchment through modeling—see Appendix D, Model Overview. Finally, each TMDL, LC, WLA, and LA are all expressed as billion cfu per day (b.cfu/day)—total number divided by one billion ($10^9$)—to effectively show very large bacterial load numbers.

The resulting LC represents the observed conditions, such as seasonal loading, at each fresh water sampling location using data collected during WYs 2020 and 2021. The geometric mean streamflow is averaged by season for each catchment using outputs from both the time series and site-specific models. The bacteria concentrations measured at each sampling location are averaged by season using the geometric mean value. These seasonally averaged geometric mean streamflow values and geometric mean bacteria concentrations are multiplied along with the conversion factor to calculate the seasonal loading, which is expressed as a daily load.

Equation 18 may also be used to calculate instantaneous loading, which is also known as flux, using the measured bacteria concentration and average daily streamflow discharge observed at the time of sampling, or effluent-based loading from measured "end-of-pipe" discharges. Either the measured instantaneous discharge or the average daily streamflow values, often calculated using gage station data, may be used to quantify bacteria loading.

## TMDL Allocations

The process used to delineate each catchment subbasin is described in Appendix D—Site-specific Streamflow Model. The site-specific streamflow model is one component used to establish each LC. The TMDL allocations for each impaired Category 5 reach code—AU stream segment is presented in Tables 6 and 7. For AUs with no overlapping water quality sampling locations, the TMDL targets immediately downstream will be applied to these upstream AUs. Currently, listing ID 89253 (AU ID 17110002000120_001_001) is the only stream reach that does not have an overlapping sampling site where the TMDL is established. For listing ID 89253, the TMDL is developed using data collected at the immediate downstream site on California Creek at Birch Bay-Lynden Rd (Cal3.1) (Table 7).

An area-weighted calculation is used to determine the LC for each AU ID, which includes the WLA and LA components of the TMDL. The area-weighted allocations, which are relative to each delineated watershed subbasin area, incorporate areal loadings that are proportional to both the NPDES stormwater permitted area to assign WLAs, and the non-permitted areas to assign LAs (Figures E-1 and 2). The TMDL calculated at each sampling location is therefore weighted to each contributing reach code AU ID based on the proportion of catchment area. To calculate the TMDL, these catchments represent the AU ID for which the LC is established. It is important to note that a subbasin in terms of hydrology may include one or more AU catchment that contributes to the LC.

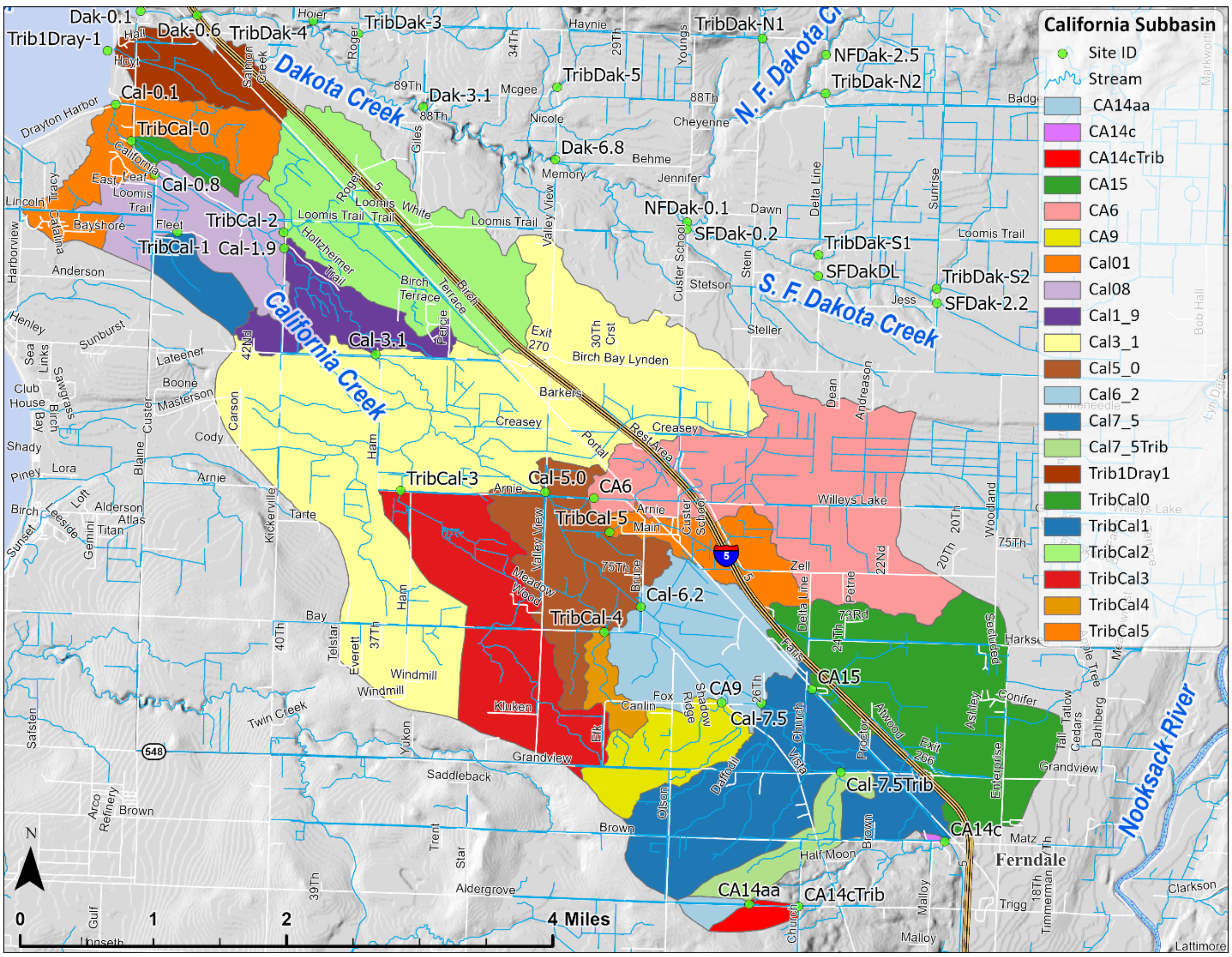



Figure E-1. California watershed subbasin areas used to establish each LC and TMDL

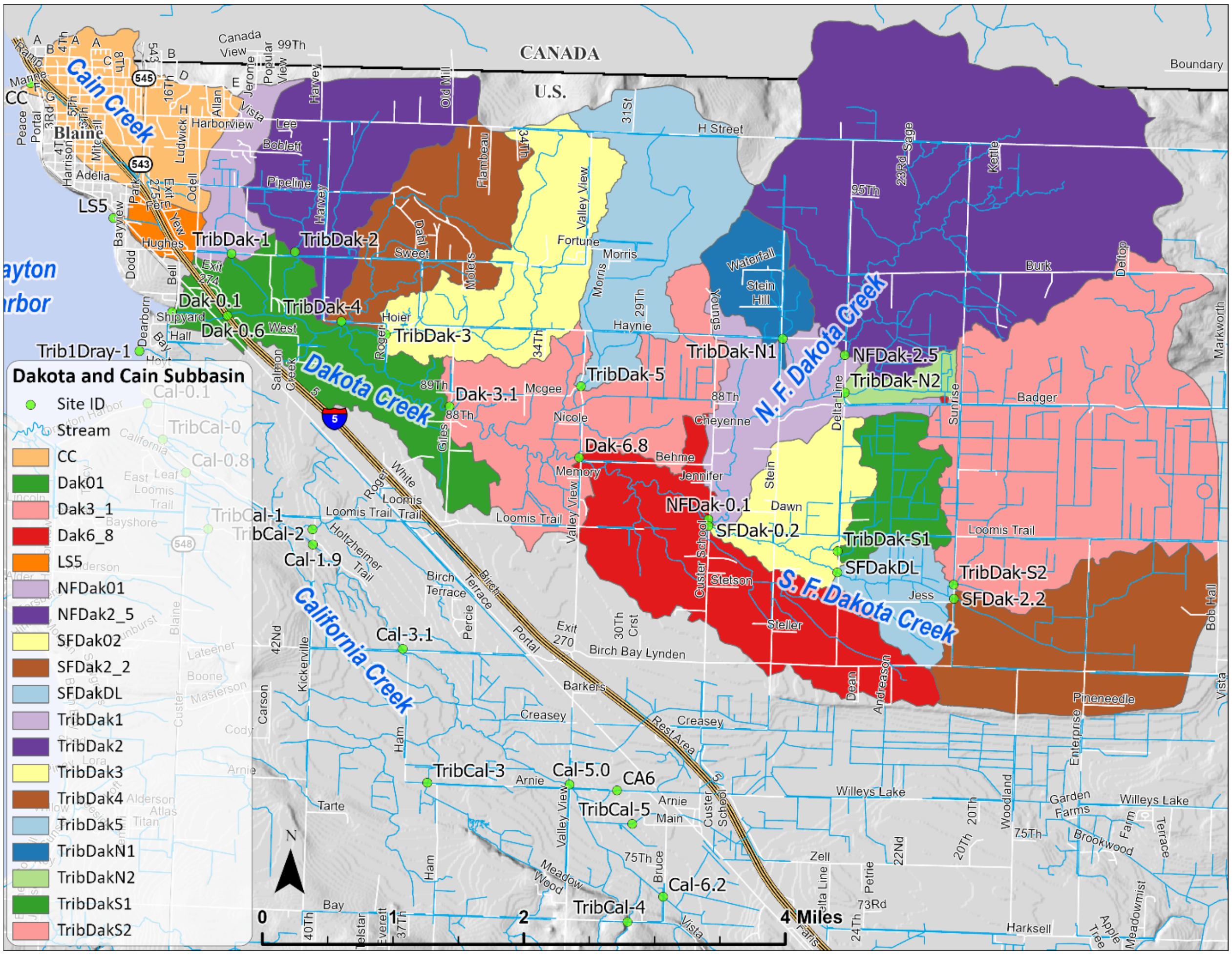



**Figure E-2. Dakota and Cain watershed subbasin areas used to establish each LC and TMDL**

Each TMDL and allocation accounts for the drainage catchment that is associated with the immediate receiving AU ID and area that receives either a WLA or LA (Table E-1). For example, the sampling location at California Creek (Cal3.1)—Birch Bay-Lynden Road has TMDLs established for AU IDs 17110002000118_001_001 and 17110002000120_001_001 (Table 7). The TMDL is calculated using data collected at this sampling location and is proportional to each AU ID immediate drainage area catchment. AU ID 17110002000118_001_001 has 63 acres covered by an NDPES permit that receives a WLA, while the remaining 1,931 acres are not covered by a permit that receives the LA. AU ID 17110002000120_001_001 does not have a permitted discharge and therefore receives a LA covering 1,401 acres for its TMDL and no WLA is applied.

The site-specific data used to establish each TMDL accounts for both the immediate catchment and all upstream contributions because bacteria and streamflow moves from upstream to downstream. This mass-balance approach assumes no bacteria pollutant attenuation from natural processes, for example, from die-off or settling. The TMDLs established for upstream and tributary contributions are similarly site specific based on localized sampling data. Each TMDL meets the purpose of:

1. Collectively maintaining the downstream fresh water and marine water WQS,
2. Individually attaining the pollution limits for each AU ID,
3. Setting pollution limits at or below the LC, and
4. Addresses Drayton Harbor at the watershed scale.

**Table E-1. Drayton Harbor watershed subbasin areas, TMDL catchments, and associated allocation areas**

| Site ID (pour point) | WLA (Acres) | LA (Acres) | TMDL Catchment (Acres) | Subbasin Total (Acres) | TMDL Contribution Catchment Area (%) | Listing ID | AU ID Catchment |
|---|---|---|---|---|---|---|---|
| **Dak3.1** | 0 | 1351 | 1351 | 14211 | 100 | 39077 | 17110002000133_001_002 |
| **Dak6.8** | 0 | 1443 | 1443 | 11702 | 100 | 39074 | 17110002000134_001_001 |
| **TribDak1** | 8.7 | 309 | 317 | 317 | 100 | 74161 | 17110002003884_001_001 |
| **TribDak2** | 0 | 1076 | 1076 | 1076 | 100 | 72278 | 17110002000159_002_003 |
| **TribDak4** | 0 | 842 | 842 | 842 | 100 | 74157 | 17110002001756_001_001 |
| **TribDak3** | 0 | 1046 | 1046 | 1046 | 100 | 72279 | 17110002000161_001_002 |
| **TribDak5** | 0 | 1158 | 1158 | 1158 | 100 | 72280 | 17110002000163_001_002 |
| **NFDak01** | 0 | 697 | 697 | 4913 | 100 | 39075 | 17110002000154_001_002 |
| **NFDak2.5** | 0 | 3719 | 3719 | 3719 | 100 | 39075 | 17110002000154_001_002 |
| **TribDakN1** | 0 | 357 | 357 | 357 | 100 | 74153 | 17110002000841_001_001 |
| **TribDakN2** | 0 | 140 | 140 | 140 | 100 | 74154 | 17110002000848_001_001 |
| **SFDak0.2** | 2.0 | 750 | 752 | 5346 | 100 | 6395 | 17110002000136_001_002 |
| **TribDakS1** | 0 | 409 | 409 | 409 | 100 | 74155 | 17110002000850_001_001 |
| **SFDakDL** | 0 | 166 | 166 | 4186 | 100 | | 17110002000136 |
| **SFDak2.2** | 0 | 1309 | 1309 | 1309 | 100 | 72277 | 17110002000137_001_001 |
| **TribDakS2** | 0 | 2711 | 2711 | 2711 | 100 | 74145 | 17110002000169_001_001 |
| **Cal 3.1** | 63 | 1931 | 1994 | 11035 | 59 | 72275 | 17110002000118_001_001 |
| **Cal 3.1** | 0 | 1401 | 1401 | 9041 | 41 | 89253 | 17110002000120_001_001 |
| **Cal 5.0** | 1.8 | 730 | 732 | 6667 | 100 | 39060 | 17110002000121_001_001 |
| **Cal6.2** | 679 | 2895 | 3574 | 3947 | 100 | 72276 | 17110002000123_001_001 |
| **TribCal0** | 0.3 | 92 | 92 | 92 | 100 | 88161 | 17110002000745_001_001 |
| **TribCal2** | 25 | 1211 | 1235 | 1235 | 100 | 74144 | 17110002000168_001_001 |
| **TribCal3** | 0 | 972 | 972 | 972 | 100 | 74146 | 17110002000178_001_001 |
| **CA6** | 65 | 1474 | 1539 | 1539 | 100 | 88959 | 17110002015468_001_001 |
| **TribCal4** | 0 | 113 | 113 | 113 | 100 | 74152 | 17110002000837_001_001 |
| **CA9** | 0 | 375 | 375 | 375 | 100 | | 17110002000853 |

| Site ID (pour point) | WLA (Acres) | LA (Acres) | TMDL Catchment (Acres) | Subbasin Total (Acres) | TMDL Contribution Catchment Area (%) | Listing ID | AU ID Catchment |
|---|---|---|---|---|---|---|---|
| **CA14c** | 5.9 | 0 | 5.9 | 5.9 | 100 | 88149 | 17110002015952_001_001 |
| **CA15** | 191 | 1189 | 1380 | 1380 | 100 | | 17110002000863 |
| **TribCal5** | 5.0 | 332 | 337 | 337 | 100 | 74147 | 17110002000390_001_001 |
| **Cal7_5Trib** | 53 | 225 | 278 | 278 | 100 | 88158 | 17110002000864_001_001 |
| **CA14cTrib** | 15 | 30 | 45 | 45 | 100 | 88409 | 17110004016438_001_001 |
| **CA14aa** | 0 | 51 | 51 | 51 | 100 | 88477 | 17110002015789_001_001 |
| **Cain** | 16 | 807 | 824 | 824 | 100 | 42499 | 17110002000738_001_001 |
| **Lift Sta. 5** | 6.0 | 135 | 141 | 141 | 100 | 42507 | 17110002000742_001_001 |
| **Trib1Dray1** | 7.4 | 327 | 334 | 334 | 100 | 45108 | 17110002000162_001_001 |

The values in Table E-1 are used to allocate the components of each TMDL, which include the affected point and nonpoint source areas within each identified catchment. These TMDL allocations are converted to proportions as percentages that are relative to each catchment area. The TMDL components are distributed to each pollution source as WLAs or LAs after accounting for the 10 percent MOS. Equation 19 shows the interim step to establish the LC using the proportional contributing catchment area to the reach code AU after accounting for the MOS.

$$LC_{AU} = AU_A \times (TMDL - MOS) \qquad (19)$$

Where:

$LC_{AU}$ is the bacterial loading capacity (b.cfu/day) for the reach code assessment unit (AU),

$AU_A$ is the proportional contributing catchment area as a percentage of the reach code AU delineated between the downstream most pour point of the given AU to the next upstream AU pour point,

TMDL is the total maximum daily load of bacteria (b.cfu/day) established using data collected at the downstream most sampling location, which is at or below the $LC_{AU}$, and

MOS is the margin of safety (b.cfu/day) comprised of 10 percent of the TMDL.

Once the $LC_{AU}$ is calculated, the final $TMDL_{AU}$ for the given AU is calculated by accounting for the proportional contributions from the WLAs, LAs, and the MOS (Equation 20). The sum of all $TMDL_{AU}$ calculated for a given AU is equal to the TMDL for the 303(d) listed water body.

$$TMDL_{AU} = LC_{AU}(WLA_A + LA_A) + MOS_{AU} \qquad (20)$$

Where:

$TMDL_{AU}$ is the bacterial total maximum daily load (b.cfu/day) for the AU,

$LC_{AU}$ is the loading capacity (b.cfu/day) of the AU from Equation 19,

$WLA_A$ is the proportional areal contribution (%) from point sources within the AU catchment after accounting for all applicable effluent based WLA contributions,

$LA_A$ is the proportional areal contribution (%) from nonpoint sources within the AU catchment, and

$MOS_{AU}$ is the margin of safety (b.cfu/day) that is standardized by the $AU_A$, which is calculated using the TMDL and the 10 percent MOS:

Both point sources and nonpoint sources are assumed to contribute equal amounts of bacteria pollution per unit area (acre). Water quality sampling data used to establish the bacteria LCs and TMDLs did not separate the permitted stormwater infrastructure's interface with ambient streamflow discharge or direct pollution deposit. The WLAs and LAs, however, are apportioned to determine the contribution from each pollutant source and assigned an allocation type. Areal WLAs and LAs are assigned based on whether the area is covered by an NPDES permit plus the permitted entity's jurisdictional area for WLAs when applicable. The WLA applied to the Lighthouse Point facility, however, is isolated from ambient loading given the WLA is effluent based. Both the FC and *E. coli* TMDL are made up of the contributing WLA and LA for each watershed and 303(d) listed AU, while the MOS is 10 percent of the total TMDL. Each TMDL is established at a level that does not exceed the LC.

**Converting Between Allocation Types**

The weighted WLAs and LAs are calculated using the concept of areal loading and applies to both stream segment AU IDs and unmappable AU IDs. The watershed areas not under permit received a LA, while all other remaining permitted areas received a WLA. In the event an area becomes permitted, the LA shall be retired and given a WLA that is proportional to the permitted area. This conversion will result in an equal transfer of allocations, while resulting in no change to the TMDL cap and LC.

Each unit area of the watershed is assumed to contribute the same quantity of the pollutant and the same quantity of water as other units of area regardless of allocation type—WLA or LA. The WLAs and LAs for the Drayton Harbor watershed and are calculated using Equations 21 and 22 respectively.

$$WLA_{AU} = (LC_{AU} - MOS_{AU}) \times A_{WLA} \qquad (21)$$

$$LA_{AU} = (LC_{AU} - MOS_{AU}) \times A_{LA} \qquad (22)$$

Where:

$WLA_{AU}$ is the sum of all wasteload allocations (b.cfu/day), that contribute to the immediate downstream assessment unit (AU),

$LA_{AU}$ is the load allocation (b.cfu/day) that contribute to the immediate downstream AU,

$LC_{AU}$ is the loading capacity (b.cfu/day) of the AU,

$MOS_{AU}$ is the margin of safety (b.cfu/day) of the AU, and

$A_{WLA}$ or $A_{LA}$ is the proportional area (%) of the allocations relative to the specific AU catchment area, which collectively sum to 1.

In the future, if an area of land is converted to a use that requires coverage under an NPDES permit, the associated LA shall be retired and an equal WLA shall be available to the permitted point source, which would not require TMDL resubmittal and associated approval.

> "If any sources currently assigned load allocations are later determined to be point sources requiring NPDES permits, the portion of the load allocations applied to those sources are to be treated as wasteload allocations for purposes of determining appropriate water quality-based effluent limitations pursuant to 40 CFR 122.44(d)(1)."[67]

Equation 23 calculates the unit area allocation conversions for area-based allocations that are typically associated with newly permitted stormwater areas:

$$Unit\ Area\ Allocation\ \left(\frac{b.cfu}{day \times acre}\right) = LA\ or\ WLA\ \left(\frac{b.cfu}{day}\right) \div Area\ (acre) \qquad (23)$$

[67]EPA, 2015. Helpful Practices for Addressing Point Sources and Implementing TMDLs in NPDES Permits https://www.epa.gov/sites/default/files/2018-04/documents/tmdls-npdes_permits_helpful_practices_final_6_30_15.pdf

The unit area allocation, LA or WLA, and area is relative to the sum of the TMDL for each receiving water body for which the LC was calculated. To illustrate this conversion, the following example is given using Equation 23 and the values provided in Table 6 and E-1. If a 12-acre area within the catchment that contributes to the Cain Creek sampling location (AU ID 17110002000738_001_001, listing 42499) is required to obtain an NPDES permit, the unit area conversion from a LA to a WLA for FC during the wet season is calculated as follows:

$$5.95 \times 10^{-4} \left(\frac{b.cfu}{day \times acre}\right) = 0.49 \left(\frac{b.cfu}{day}\right) \div 824\ (acre)$$

$$7.13 \times 10^{-3} \left(\frac{b.cfu}{day}\right) = 5.95 \times 10^{-4} \left(\frac{b.cfu}{day \times acre}\right) \times 12\ (acre)$$

Following this example, the LA—0.49 b.cfu/day—for the Cain Creek catchment subbasin and associated AU ID is adjusted by subtracting the new WLA—$7.13 \times 10^{-3}$ b.cfu/day resulting in a new LA equal to 0.48 b.cfu/day after rounding. The total WLA is adjusted by adding newly assigned contribution as a permitted component to the TMDL. The resulting TMDL only differs by the distribution of allocations, while the total LC and TMDL remain unaffected.

As NPDES permits are written or revised to implement the TMDL, they are conditioned to attain the FC or *E. coli* WLAs. By meeting the target geometric means in the ambient receiving water bodies, it is assumed the percentage reduction allocations will have been met. Bacteria sampling either immediately downstream from the AU, or within the AU will confirm that the WQS are met, while sampling permitted effluent will assess the performance of the facility.

The WLAs and LAs established in the Drayton Harbor watershed are inherent in the WQS geometric mean to meet the TMDL, which is based on the STR using the most stringent of the two-part water quality criteria. Target geometric means, percent reductions, and loadings are presented to guide water quality practitioners under clean up and pollution prevention efforts such as NPDES development and other control strategies such as the PIC program.

**Allocations for Shoreline Areas**

Stormwater runoff contribution from the Drayton Harbor shoreline area that do not pass through a fresh water tributary with an established TMDL received WLAs and LAs. When data are limited, the Simple Method (Schueler 1987) uses empirical relationships between watershed characteristics and pollutant loading and assumes that physical characteristics of land units are homogeneous to simplify physical representation. The amount of rainfall runoff is assumed to be a function of impervious land cover. This TMDL assumes that impervious land cover is equal to the classification of “developed” using the NLCD (Table 24).

The Simple Method applies to the shoreline area that drains directly into Drayton Harbor and does not have an associated streamflow-based TMDL (Figure 8). The Simple Method incorporates the water quality criteria to protect the most sensitive use of shellfish harvesting to form the basis for the TMDL. Seasonal precipitation totals that produce runoff are also components to calculate pollutant loading for the given drainage area. The Simple Method estimates refer to storm-event-derived loads, which are calculated by the wet and dry season (Equation 24). These seasonal estimates are further broken down into daily loading estimates to establish the TMDL for the shoreline area.

$$L = (1.03 \times 10^{-3}) \times R \times C \times A \qquad (24)$$

Where,

L = FC bacteria loading (b.cfu/season)
$1.03 \times 10^{-3}$ = unit conversion factor
R = seasonal runoff (inches)
C = protective water quality criteria (FC cfu/100 mL)
A = drainage area (acres)

$$R = P \times P_j \times R_v \qquad (25)$$

Where,

R = seasonal runoff (inches)
P = seasonal precipitation total (inches)
$P_j$ = fraction of annual rainfall events that produce runoff
$R_v$ = runoff coefficient ($0.05 + 0.9 \times Ia$)
Ia = impervious fraction of land cover (0.542), which is the sum of the percent developed area of the Shoreline land cover (Table 24)

The Simple Method requires certain constants and land cover values, where:

- Area is calculated using GIS, land cover is from the NLCD (2019), and jurisdictional area is from Ecology's GIS database[68] (Table E-2).
- Runoff (R) for the dry season is 4.23 inches, and the wet season is 17.33 inches using Equation 25, which was calculated using the following values.
  - The impervious fraction, Ia = 0.542, represents the developed areas of the NLCD for the shoreline area and is used to calculate the runoff coefficient ($R_v$).
  - $P_j$ = 0.85 and is a constant of that is the fraction of annual rainfall events that produce runoff. This constant is consistent with other regional TMDL studies that have used the Simple Method (Svrjcek 2006, Lee 2008, Bohling and McCarthy 2020).
  - Precipitation totals (P) 9.25 inches during the dry season and 37.92 inches during the wet season using data obtained from the NCDC Coop Station: 450729 in Blaine, WA. Precipitation totals from were averaged using WYs 2020 and 2021 that coincide with the established TMDLs in this study.
  - The runoff coefficient $R_v$ = 0.538.

[68] https://ecology.wa.gov/research-data/data-resources/geographic-information-systems-gis

- Finally, the FC TMDL allocations are calculated using Equation 19 and distributed by season among the designated shoreline areas where (Table E-2):
    - WLAs are assigned to stormwater discharges from the permitted areas for the WSDOT infrastructure and the Sundance Yacht Sale boatyard,
    - LA is assigned to the Whatcom County and City of Blaine areas that do not operate under a stormwater permit.
- The bacteria concentration value of C = 19 and 20 FC cfu/100 mL for the wet and dry season respectively is set to achieve compliance with the Washington State water quality geometric mean criterion when accounting for the mixing of fresh water and marine water—see Appendix D.
- The total loading estimates (L) per season are divided by the number of days per season where, dry = 153 days and wet = 212 days to estimate the daily load (b.cfu/day).

**Table E-2. Fecal coliform TMDL allocations for the Drayton Harbor shoreline areas using the Simple Method**

| Designated Area and Allocation Type | A (acres) | Dry Allocation (b.cfu/day) | Wet Allocation (b.cfu/day) |
|---|---|---|---|
| Blaine Urban Area (LA) | 582.38 | 0.33 | 0.93 |
| Whatcom Urban Growth Area (LA) | 21.20 | $1.2\times10^{-2}$ | $3.4\times10^{-2}$ |
| Non-Urban Growth Area (LA) | 552.76 | 0.31 | 0.88 |
| WSDOT (WLA) | 21.42 | $1.2\times10^{-2}$ | $3.4\times10^{-2}$ |
| Sundance Yacht (WLA) | 1.37 | $7.8\times10^{-4}$ | $2.2\times10^{-3}$ |

# Appendix F. Regulatory Framework

The regulatory framework identified supports TMDL implementation activities in the Drayton Harbor watershed. Regulations develop and establish programs and mechanisms to prevent pollution and maintain the protection of water quality. The following is a summary, therefore, additional requirements and regulations in greater detail may also apply including local codes and enforcement.

## Clean Water Act

**Section 319**

In 1987, Congress amended Section 319 to the Clean Water Act to address nonpoint sources of pollution. Section 319 required states to develop assessment reports that describe the states' nonpoint source pollution problems and establish management programs to address these problems. A federal grant program was created to provide funding to Tribes, territories, and states to develop nonpoint source management programs. Washington State developed a program and plan as the approach to addressing water quality impacts from nonpoint sources of pollution (Ecology 2023). This statewide management plan meets Clean Water Act section 319 requirements and ensures Washington State's eligibility for Section 319 funding.

**National Pollutant Discharge Elimination System (NPDES)**

NPDES permits are a requirement of the federal Clean Water Act. The EPA delegated Ecology the authority to write these federal permits as part of the NPDES delegation program[69]. Managing wastewater and stormwater is important to protect surface and groundwater to maintain designated uses and achieve the WQS. Using a system of water quality permits, Ecology manages when, where, and how treated wastewater and stormwater enters the environment. The types of NPDES permits that currently apply in the Drayton Harbor watershed are general permits and individual permits—see TMDL Allocations, Wasteload Allocations for details. The general permit allows a unified approach to regulating similar facilities or industries and can simplify the permitting process. This has the potential to save the facility or industry and Ecology time and resources. Individual NPDES permits apply to municipalities and industries discharging wastewater to surface water. Individual permits are written for one specific entity where discharge characteristics are variable and do not fit a general permit category.

## National Estuary Program

The National Estuary Program (NEP) was established under the 1987 CWA amendments as a program to "restore and maintain the chemical, physical, and biological integrity of the estuary, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish, and wildlife, and recreational activities in the estuary, and assure that the designated uses of the estuary are protected".

[69] https://www.epa.gov/npdes/npdes-state-program-information

The NEP is designed to encourage local communities to take responsibility for managing their own estuaries. Each NEP is made up of representatives from federal, state, and local government agencies responsible for managing the estuary's resources, as well as members of the community such as community members, business leaders, educators, and researchers. These interested parties work together to identify problems in the estuary, develop specific actions to address those problems, and create and implement a formal management plan to restore and protect the estuary.

## Farm Bill

The 2018 Farm Bill was enacted on December 20, 2018. The Farm Bill continues to fund many conservation programs that can benefit agricultural producers and forest landowners along with the environment. The U.S. Department of Agriculture (USDA) administers the suite of agricultural conservation programs through two primary agencies—the Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA).

In 2010 Ecology, the NRCS, The Washington State Conservation Commission, Northwest Indian Fisheries Commission, WSDA and the EPA met for a year to better understand the federal NRCS programs, how they are implemented and whether they are designed to meet Washington's WQS. These are important and valuable programs to get conservation activities on the ground.

While these federal funding programs and their associated practices are important for getting conservation on the ground, Ecology found that they are not designed to achieve each of our state's Clean Water Act approved WQS. This gap between the federal programs and Washington's need to ensure BMPs are designed to meet our state's WQS emphasized the need for Ecology to develop BMPs that will fully meet state WQS. The Voluntary Clean Water Guidance for Agriculture (Ecology 2023b) addresses this gap and is briefly described in this TMDL implementation plan.

## Water Pollution Control Act

The Water Pollution Control Act—Chapter 90.48 RCW[70]—is the principal state law governing water quality. It provides the primary authority to regulate nonpoint source pollution, achieve compliance with the state WQS, and require the implementation of BMPs to address nonpoint source pollution. Other state and local authorities can also provide authority to address nonpoint source pollution. In addition to the Water Pollution Control Act, this section describes other state laws and associated regulations—the Forest Practices Rules, the Dairy Nutrient Management Act, and On-Site Sewage Systems Regulations—that provide enforcement authority to address nonpoint sources of pollution.

[70] https://app.leg.wa.gov/rcw/default.aspx?cite=90.48

Under the Washington State Water Pollution Control Act, Ecology is given the jurisdiction "to control and prevent the pollution of… waters of the state of Washington."[71] Pollution is broadly defined in RCW 90.48.020 and includes the contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. Under state law, it does not matter whether the pollution comes from a point or nonpoint sources, all pollution of state waters is subject to Ecology's authority to control and prevent pollution.

The Water Pollution Control Act makes it unlawful for any person to "cause, permit or suffer to be thrown, run, drained, allowed to seep or otherwise discharged … any organic or inorganic matter that shall cause or tend to cause pollution of" waters of the state.[72] Any person who violates or creates a substantial potential to violate the provisions of Chapter 90.48 RCW is subject to an enforcement order from Ecology pursuant to RCW 90.48.120. Ecology is authorized to "issue such order or directive as it deems appropriate under the circumstances[.]"[73]

It is worth noting that while RCW 90.48.120 gives Ecology the authority to act in response to NPS pollution, the statute also gives Ecology the authority to act based on a "substantial potential" to pollute state waters via either a point or nonpoint pollution source. Consequently, Ecology not only has authority to act following a NPS pollution occurrence (i.e. there was a discharge) but has specific statutory authority to proactively prevent nonpoint sources of pollution from occurring in the first place. Ecology's Nonpoint Program utilizes this authority to identify nonpoint pollution based upon site conditions.

## Dairy Nutrient Management Act

The Dairy Nutrient Management Act—Chapter 90.64 RCW[74]—is administered by the Washington State Department of Agriculture (WSDA) and requires all grade "A" licensed dairies under Chapter 15.36 RCW to:

- Register with the WSDA.
- Develop a nutrient management plan that describes how manure and process wastewater will be managed including collection, storage and utilization. The nutrient management plan must be approved within six months of licensing and certified within twenty-four months of licensing by their local conservation district.
- Prevent discharges to waters of the state.
- Maintain land applications records demonstrating agronomic use of all nutrients.

Chapter 90.64.026 required the Washington State Conservation Commission to develop a document that clearly describes the elements that a dairy nutrient management plan must contain to gain local conservation district approval by November 1, 1998. In addition, Washington State Conservation Commission may authorize other methods and technologies than Natural Resources Conservation Service (NRCS) if they meet specific standards—see RCW 90.64.026(3).

[71] See RCW 90.48.030.
[72] See RCW 90.48.080.
[73] See RCW 90.48.120.
[74] https://app.leg.wa.gov/rcw/default.aspx?cite=90.64

The nutrient management plan development process is completed by the dairy producer in consultation with a local conservation district, the NRCS, or a private planner. Each nutrient management plan incorporates a process to assess how the number of animals affect the nutrient inventory, surface and ground water risk(s), manure and process wastewater collection systems, conveyance and storage needs, crop production and history, and land application acreage needs. The nutrient management plan process identifies the producer's goals, resource risk(s), and BMPs to protect each resource.

## Onsite Sewage Systems

Onsite Sewage Systems (OSS) are regulated by 246-272A WAC[75] covering small OSS and 246-272B WAC[76] covering large OSS (LOSS). There are no LOSS in the watershed, while OSS are present (Figure 15). The state OSS rule is adopted by the State Board of Health and administered by the State Department of Health. Local codes must be consistent with, and at least as stringent as the state laws. Local Health Jurisdictions work with local boards of health to adopt and administer the local codes. The State Department of Health may take enforcement action if a Local Health Jurisdiction fails to regulate OSS in compliance with state law. The Department of Ecology also has authority to take enforcement actions under the Water Pollution Control Act if there is a discharge to state waters.

Small OSS, also known as septic systems, treat domestic sewage from private residences, restaurants, and other small-scale developments. They are used extensively statewide in rural and suburban infill settings and regulated under Chapter 43.20 RCW[77], Chapter 70.05 RCW[78], and Chapter 70.118A RCW[79] (marine recovery area statute). Fulfilling the RCW at the local level is accomplished by the WCHCS through County Code—Chapter 24.05[80], to protect the public by minimizing the potential for public exposure to OSS discharges and limit discharges to state waters through a suite of administrative duties and regulatory codes.

The state OSS and marine recovery area (MRA) laws require Local Health Jurisdictions to designate areas where OSSs present added risk to public health or water quality. Areas adjacent to Puget Sound that have pollution problems linked to OSS may be designated as MRAs. The entire Drayton Harbor watershed is a designated MRA. Consistent with the state OSS rule, Chapter 70.118A RCW requires Local Health Jurisdictions to adopt management plans and implement enhanced programs in these areas to protect public health and Puget Sound water quality. As part of the enhanced programs in MRAs, Local Health Jurisdictions are required to:

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75 https://app.leg.wa.gov/wac/default.aspx?cite=246-272A
76 https://app.leg.wa.gov/WAC/default.aspx?cite=246-272B
77 https://app.leg.wa.gov/rcw/default.aspx?cite=43.20
78 https://app.leg.wa.gov/rcw/default.aspx?cite=70.05
79 https://app.leg.wa.gov/rcw/dispo.aspx?Cite=70.118A
80 https://www.codepublishing.com/WA/WhatcomCounty/html/WhatcomCounty24/WhatcomCounty2405.html

- Inventory and manage the inspection process of all OSS,
- Identify failing systems and ensure they are either repaired or replaced, and
- Develop and maintain electronic data systems capable of sharing OSS information with other regulators.

The state OSS rule complements this with the following management plan requirements from WAC 246-272A-0015 for Puget Sound counties:

- Progressively inventory all systems,
- Identify high-risk areas and designate MRAs,
- Develop and tailor operation and maintenance (O&M) requirements to these areas,
- Facilitate education of owners on their O&M responsibilities,
- Remind and encourage system owners to inspect their systems,
- Maintain records of O&M activities,
- Find failing systems and enforce system owner requirements,
- Assure coordination with local comprehensive plans, and
- Assess the capacity of the Local Health Jurisdictions to adequately fund the program.

## Shellfish Protection

Shellfish Protection Districts—Chapter 90.72 RCW[81]—encourages, and in some cases, requires counties to establish shellfish protection districts and programs to curb the loss of productive shellfish beds caused by nonpoint sources of pollution, such as stormwater runoff, failing on-site sewage systems, and runoff from farm animal wastes.

## Managing Shorelines and Growth Development

The Shoreline Management Act and Growth Management Act are the two primary state statutes related to land use planning. They share some commonalities, but are separate statutes with different purposes, jurisdictions, and requirements.

### Shoreline Management Act (SMA)

The overarching goal of the Shoreline Management Act (SMA)—Chapter 90.58 RCW[82]—is, "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." Under the SMA, each city and county with "shorelines of the state" must prepare and adopt a shoreline master program (SMP) that is based on state laws and rules, but is tailored to the specific geographic, economic, and environmental needs of the community. The local SMP is essentially a shoreline-specific combined comprehensive plan, zoning ordinance, and development permit system.

[81] https://app.leg.wa.gov/rcw/default.aspx?cite=90.72
[82] https://app.leg.wa.gov/rcw/default.aspx?cite=90.58

The SMA establishes a balance of authority and partnership between local and state government. Towns, cities, and counties are the primary regulators. Ecology acts primarily in a support and review capacity. Each SMP and any amendments are effective only after Ecology approval. In reviewing and approving each SMP, Ecology is limited to a decision on whether the proposed changes are consistent with the policy and provisions of the SMA and the SMP guidelines.

Ecology provides technical assistance to local governments. Ecology also provides funding in the form of grants. Finally, Ecology is also required to review certain kinds of permits, e.g. conditional use and variance permits, for compliance with the law and must review local shoreline master programs to ensure they also comply. Local governments may modify (amend) master programs to reflect changing local circumstances, new information, or improved shoreline management approaches.

**Growth Management Act (GMA)**

The Growth Management Act (GMA)—Chapter 36.70A RCW[83] and 36.70B RCW[84]— addresses development and environmental protection in both designated Urban Areas (UA) and Urban Growth Areas (UGA). The GMA requires that each Washington city and county establish a public participation program and procedures for amendments, updates, and revisions of comprehensive plans and development regulations. These areas are allowed to develop, however, must incorporate proactive plans for careful growth.

Environmental protection is one of the many mandates of the GMA where jurisdictions must consider reducing the detrimental impacts of urban growth on water quality. For example, natural area preservation, stormwater BMPs, retrofits, and low impact development (LID) should be implemented in order protect water quality. In addition to GMA protections, the Critical Area Ordinances for city and county jurisdictions are also enacted to protect natural systems, including wetlands, frequently flooded areas, fish and wildlife habitat conservation areas, geologically hazardous areas, and aquifer recharge areas.

The Voluntary Stewardship Program (VSP) was passed in 2011 as an amendment to the GMA. Its goals are to protect and enhance critical areas, maintain and improve the long-term viability of agriculture, and reduce the conversion of farmland to other uses. To accomplish these goals the VSP relies primarily on incentives and voluntary stewardship practices. Counties that opt into the VSP are responsible for designating a local watershed group that will develop a watershed plan that describes how critical areas on agricultural lands will be protected and enhanced.

[83] https://app.leg.wa.gov/rcw/default.aspx?cite=36.70a

[84] https://app.leg.wa.gov/rcw/default.aspx?cite=36.70b

## Forest Practices

The Forest Practices Rules establish protection standards for forest activities such as timber harvest, pre-commercial thinning, road construction and maintenance, fertilization, forest chemical application, required reforestation, and specific riparian and wetland protection measures—Title 222 WAC[85]. They give direction on how to implement the Forest Practices Act—Chapter 76.09 RCW[86]—and the Stewardship of Non-industrial Forests and Woodlands—Chapter 76.13 RCW[87]. The rules are designed to protect public resources, such as water quality and fish habitat while maintaining a viable timber industry. They are under constant review through an adaptive management program.

[85] https://app.leg.wa.gov/wac/default.aspx?cite=222
[86] https://app.leg.wa.gov/rcw/default.aspx?cite=76.09
[87] https://apps.leg.wa.gov/RCW/default.aspx?cite=76.13

# Appendix G. Funding and Costs

## Coordinated Investment

Ecology will look to support coordinated investment strategies that help meet the goals of the nonpoint source pollution plan (Ecology 2023). Ecology's goal is to support coordinated investments targeting projects that implement TMDLs and other restoration plans, while also solving multiple environmental problems in an efficient way. Where possible, Ecology works to leverage multiple sources of funding and fund projects that meet water quality, salmon and shellfish goals. Ecology supports efforts that include multiple parcels in a watershed and maximize opportunities to secure continuous BMP implementation over longer stretches of streams and rivers. Key coordinated investment principles include:

- Focusing on the implementation of BMPs and projects that ensure compliance with state WQS at the parcel level,
- Supporting projects communicating clear standards and compliance expectations,
- Supporting the implementation of TMDLs and other restoration plans,
- Supporting projects that provide multiple environmental benefits—water quality, salmon and shellfish goals,
- Focusing on outcomes and accountability through collecting specific BMP implementation data, and
- Maximizing opportunities to secure continuous BMP implementation over longer stretches of streams and rivers.

## Ecology Funding Sources

Ecology encourages the use of funding opportunities by applying for state-run grants and loans. Funding opportunities offered through Ecology include the Centennial Clean Water Fund, Section 319, State Revolving Fund, and Stormwater Grants. Ecology grant and loan officers are available for consultation throughout the application process. The Drayton Harbor TMDL and Implementation Plan helps leverage funding for successful acceptance of the sought grant or loan. Ecology's Grant and Loan Program[88] webpage provides the information needed for the application process. Ecology also offers application workshops.

Ecology's Water Quality Combined Funding Program[89] is an integrated funding program for projects that improve and protect water quality throughout the state using state and federal funding sources. Ecology awards grants and loans on a competitive basis to eligible applicants for high-priority water quality projects. Ecology provides technical assistance and an annual guidance document (Ecology 2019b) to Combined Funding Program applicants. Allocated funds support

[88] https://ecology.wa.gov/About-us/Payments-contracts-grants/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

[89] https://ecology.wa.gov/About-us/Payments-contracts-grants/Grants-loans/Find-a-grant-or-loan/Water-Quality-Combined-Funding-Program

local communities by helping them upgrade sewage treatment systems, manage polluted stormwater runoff, and complete a variety of other projects to prevent and clean up pollution. More than $100 million of our combined funding is for new projects that will help support Puget Sound recovery. These projects are a high priority, as they help improve water quality and create a healthy habitat for the endangered Southern Resident Orca, salmon, and the food web they rely on. State financial managers calculate that 11 direct and indirect jobs are created in Washington for every $1 million spent on building clean water infrastructure.

The Final List[90] presents the offered distribution of funding for the State Fiscal Year 2024 (SFY24) Funding Cycle (Ecology 2023c). The Final List also discusses the goals and objectives for meeting water quality priorities and state and federal funding requirements. There are four major funding programs under the Water Quality Combined Funding Program with an annual funding cycle. The Final List describes how Ecology intends to use and administer the four major funding sources from 1) the Centennial Clean Water Program (Centennial), 2) the federal Clean Water Act (CWA) Section 319 Program (Section 319), 3) the Stormwater Financial Assistance Program (SFAP), and 4) the Washington State Water Pollution Control Revolving Fund, nationally referred to as the Clean Water State Revolving Fund (CWSRF). The Final List also serves as the Intended Use Plan (IUP) required by the federal EPA for providing information on how Ecology will administer the CWSRF. Due to the integrated nature of the funding programs, Ecology publishes one combined document.

**Centennial Clean Water Program**

The Centennial Clean Water Program (Centennial) is a state funding program established by the State Legislature in 1986. The Centennial provides grants to eligible public bodies for wastewater facility preconstruction, construction in qualified hardship communities, and for nonpoint source pollution control activity projects. Nonpoint source pollution control projects include:

- Stream restoration and buffers,
- Water quality-focused agricultural best management practices (BMPs),
- Onsite sewage system (OSS) repair and replacement,
- Stormwater activities, and
- TMDL support.

**Section 319**

Congress established Section 319 as part of the CWA amendments of 1987 to address nonpoint sources of water pollution. Based on Congressional appropriations, EPA offers an annual grant to Washington State to implement Washington's Water Quality Management Plan to Control Nonpoint Sources of Pollution. The grant from EPA requires a 40 percent state match. Ecology provides this match by awarding Centennial grants to nonpoint source pollution control projects. Section 319 provides grants for a variety of projects such as:

[90] https://apps.ecology.wa.gov/publications/summarypages/2310018.html

- Stream restoration and buffers
- Water quality focused agricultural BMPs
- TMDL support.

Projects that implement BMPs are required to collect and report data that estimate load reductions of nitrogen, phosphorus, and sediments. Ecology must report the reductions to EPA annually. Eligible applicants include public bodies and not-for-profit groups. There are no specific state laws or rules for Section 319, but Ecology uses a combination of federal laws, rules, and guidelines and the Centennial law and rule to govern the program.

**Clean Water State Revolving Fund**

The Clean Water State Revolving Fund (CWSRF) is a low-interest rate loan program established by Congress under Title VI of the CWA Amendments of 1987 to fund water quality related projects. The CWSRF provides funds for a broad range of facility and activity projects, including:

- Planning, design, and construction of wastewater facilities, stormwater facilities, and large onsite sewage systems (OSS)
- Planning and implementation of nonpoint source pollution control activities
- Planning and implementation of estuary conservation and management activities
- Onsite sewage system repair and replacement programs
- TMDL support.

Ecology also uses CWSRF to provide special funding for financially challenged (hardship) communities and for projects or portions of projects that meet one or more of EPA's criteria for green project reserve.

**Stormwater Financial Assistance Program**

The Stormwater Financial Assistance Program (SFAP) is a state grant program established through legislative appropriation. The SFAP funds facilities and activities that have been proven effective at reducing adverse water quality impacts from existing urban infrastructure and development built before the start of the MS4 permits. Cities, counties, and ports are eligible for SFAP grants per Chapter 173-323 WAC. In addition, Ecology must implement the program in accordance with any conditions in the SFAP funding appropriation. Funding for the SFAP may come from various state sources that in the past included Model Toxics Control Act (MTCA) and State Building Construction Account. Recent updates to the MTCA statute established the MTCA Stormwater Account that addresses the funding of the SFAP.

Other stormwater grants administered by Ecology include the **Grants of Regional or Statewide Significance** and **Stormwater Capacity Grants.** Grants of Regional or Statewide Significance (GROSS) are competitive grants that assist Phase I and Phase II NPDES permittees in completing projects that will benefit multiple permit holders. Stormwater Capacity Grants are non-competitive and awarded to Phase I and Phase II NPDES municipal permittees for activities and equipment necessary for permit implementation. Ecology formed a Stormwater Financial Assistance Stakeholder group that developed guidelines for program implementation. Total funding available to each eligible recipient is $50,000. Ports, universities, school or drainage districts, state agencies covered by municipal stormwater permits, or other secondary permittees are not eligible to directly receive this funding.

**Community-Based Public-Private Partnerships**

Ecology's funding sources include the Community-Based Public-Private Partnerships (CBP3), which are partnerships between a local government and a private entity to collaboratively plan, deliver, or maintain public stormwater projects. These partnerships are intended to achieve community benefits beyond stormwater improvements and permit compliance through performance-based contracts and alternative procurement.

Stormwater CBP3 projects can vary greatly, ranging from a municipality installing green infrastructure on private land, to contracting to design/build a project on public land, to a single contract to deliver and maintain a multi-year program that achieves MS4 permit requirements. The goal is to make Stormwater CBP3 and performance-based contracts more accessible to all communities, including smaller and underserved communities.

## Pollution Identification and Correction (PIC) Programs

To promote PIC programs, the state Departments of Health and Ecology have offered federally funded grants to county governments, local health jurisdictions, and tribal governments adjacent to Puget Sound to establish or enhance PIC programs. The goal of these grants is to launch new and improved existing PIC programs that can eventually be sustainable in the long term by integrating planning across local water quality programs, interests, and concerns. An effective program will have the following components:

- A defined process for engaging polluters to reduce or eliminate pathogen and nutrient pollution caused by OSSs, farm animal waste, pet waste, boat sewage, and stormwater. The capacity to address diverse sources may be accomplished through partnerships,
- An on-going assessment and monitoring program to identify and prioritize problem areas for correction. A monitoring program should include both targeted monitoring to identify pollution sources and monitoring to assess effectiveness of control efforts to ensure that waters stay clean. Assessments from other programs can be used to identify and prioritize water quality problems, for instance the Washington State Water Quality Assessment,
- Corrective action work which includes outreach and education, technical assistance, and incentives, such as cost share for the installation of best management practices. The program includes enforcement as a backstop when other methods don't fix the problem,
- A sustainable funding source, and
- PIC programs should use the Voluntary Clean Water Guidance for Agriculture.

While PIC programs are administered at the local level, Ecology will continue to take an active role in supporting these programs because our nonpoint strategy shares the objectives of identifying and addressing water pollution issues. Additionally, Ecology provides the regulatory enforcement backstop for counties to help implement the agriculture-related components of their programs. Specifically, as EPA pushed for NEP funding to be focused on local PIC programs, there was an acknowledgement that it would take some local programs time to have a complete and sustainable program similar to Kitsap County's program[91]. Ecology was asked to provide enforcement backup until those local programs developed their own comprehensive enforcement programs that address all sources of nonpoint pollution.

## Climate Resilient Riparian Systems Grants

The EPA awarded Ecology funds to develop a grant program and facilitate subawards of these funds toward improving the climate resiliency of riparian systems in Puget Sound. Ecology is working in partnership with riparian restoration and protection experts to start a new Climate Resilient Riparian Systems Lead grant program[92]. The program is a coalition between Ecology, the Washington State Conservation Commission, and Bonneville Environmental Foundation. The goal of the program is to promote programs that catalyze sustainable, effective, reach-scale riparian restoration and permanent protection in Puget Sound.

The Climate Resilient Riparian Systems Lead program focuses on protecting and restoring riparian areas that have been damaged or are struggling to support the plants, animals, and waters of Puget Sound. It also aims to maintain and learn from pristine riparian systems. The new program will support riparian restoration programs that work with communities and landowners to improve the overall function of river and stream riparian systems.

## Implementation Costs

The estimated implementation costs presented here are based on the East Fork Lewis River Restoration Plan (Rostorfer 2021) and the Padilla Bay bacteria TMDL Implementation Plan (Bohling and McCarthy 2020) covering similar land use and pollution prevention methods. These two reports also incorporate data pertaining to the installation and cost of the listed practices internally from Ecology TMDL implementation specialists. Unless otherwise stated, cost estimates do not include staff time for related outreach work and overhead. The costs listed below may change over time due to inflation.

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[91] https://apps.ecology.wa.gov/publications/SummaryPages/1710011.html

[92] https://ecology.wa.gov/about-us/payments-contracts-grants/grants-loans/find-a-grant-or-loan/climate-resilient-riparian

**NRCS Labor Costs and Estimate Tools**
Cost estimate tools from USDA NRCS[93] should be used to develop accurate and detailed budgets for agricultural projects in the Drayton Harbor watershed. NRCS provides detailed payment schedules and information for the Environmental Quality Invective's Program, Conservation Stewardship Program, Agricultural Conservation Easement Program, and Regional Conservation Partnership Program. These tools estimate costs for labor, mobilization, excavation, and implementation of a wide range of agricultural BMPs. These resources are Washington specific and are updated each fiscal year between October and December.

When developing projects, project sponsors should use the most recent cost estimates from NRCS during budget development. NRCS also has a fence cost estimate tool for wire or electric fence that is available to estimate costs to implement fencing on pasture and rangelands. In addition, NRCS provides the Conservation Practice Physical Effects matrix for use by field planners to understand the economic costs and benefits of each conservation practice.

**Conservation Planning on Agricultural Lands**
Before landowners can benefit from public grant funding to implement agricultural BMPs, conservation planning for water quality BMP implementation is sometimes necessary to support project planning and implementation. For example, USDA NRCS now requires comprehensive nutrient management plans for every property that installs BMPs that affect manure, including manure storage, composting facilities, heavy use areas, and wastewater storage. These plans can cost $3,000 to $6,000 dollars to complete. The estimated cost to complete a conservation plan specific to water quality BMP implementation is approximately $6,375 dollars per plan. This number is based off the assumption that one conservation plan will take approximately 85 hours to complete, at an hourly composite rate of $75 dollars.

**Site Visits and Technical Assistance on Agricultural Lands**
To support implementation of agricultural BMPs, initial site visits and technical assistance are often needed to help landowners with their water quality and natural resource challenges. The estimated cost to complete a site visit and technical assistance letter is approximately $2,250 dollars per property. This number is based off the assumption that one site visit and technical assistance letter will take approximately 30 hours to complete, at an hourly composite rate of $75 dollars.

**Livestock Exclusion Fencing**
Fencing should be designed using the NRCS guidelines found in the FOTG. Specific fencing types and styles are recommended based on the observed or anticipated type of livestock and site conditions. The cost of the fencing will depend on style and materials used. Based on information collected by the USDA Extension service guidance[94], costs (including labor and materials) range between $5-7 per foot for woven wire, barbed wire, and electric fencing. To account for the

[93] https://www.nrcs.usda.gov/resources/guides-and-instructions/conservation-practice-benefit-cost-templates
[94] https://www.extension.iastate.edu/agdm/livestock/pdf/b1-75.pdf

increased cost of materials and labor since 2012, as well as Ecology implementation specialist input, $7-10 per foot may be used as the typical cost for fencing projects across the state. Specific projects may require additional elements (high tensile materials, additional height fencing) which may exceed the $10 per foot budget estimate.

**Heavy Use Protection**

Heavy use protection is used to stabilize a ground surface that is frequently and intensively used by people, animals, or vehicles. While not specifically used to reduce bacteria loading, the installation of heavy use protection areas reduces onsite erosion and therefore limits bacterial transport. To reduce the negative water quality impact of heavy use areas, landowners should locate them as far away as possible from water bodies or water courses.

In some cases, this may require relocating the heavily used area rather than armoring an area that is already in use. Preferred practices would limit impervious surfaces, such as concrete pads, used for protections. Gravels and stabilizing materials (such as geotextile fabric) are the preferred option when feasible, based on NRCS heavy use protection guidance[95].

Based on NRCS FOTG guides and scenarios for heavy use protection practices (NRCS practice code 561), average practices range between 2,500-4,000 square feet, but actual size should be developed based on the number of animal units and other site-specific information. Heavy use protection scenarios used to estimate typical costs place each practice cost between $10,000 and $16,000.

**Manure Management**

Manure management is a broad description of several categories described in the Agricultural Sources section in Implementation Plan, ranging from onsite manure storage to timing and application rates based on individual farm conservation plans. Properly designed manure storage facilities are part of manure management and are useful in reducing bacterial loading.

Several programs are available to address manure and nutrients within the Drayton Harbor watershed, such as the WSDA Dairy Nutrient Management Program and nutrient management farm planning through the Whatcom CD or Whatcom County Planning and Development CPAL. Manure transfers such as imports or exports is another management strategy lead by the Whatcom CD, which includes a manure link program to coordinate among interested parties. Manure Transfer Agreements are required for export. The costs to operate and maintain these existing programs were not quantified in this TMDL implementation plan.

Knowledge of site-specific criteria and conditions is required to estimate the associated costs of manure management practices. Manure collection and storage needs are influenced by species, manure handling, grazing, confinement, etc. For example, a structure consisting of a simple 3 bin structure with 8'x 8' bins could cost as much as $10,000. This would store the waste for two horses for 6 months in a typical scenario. Adding a roof to the storage structure could add an additional $6,000-$10,000. Based on NRCS design criteria and site scenarios, Ecology will assume a cost between $10,000 and $15,000 per structure.

[95] https://efotg.sc.egov.usda.gov/references/public/MO/561HeavyUseAreaProtection.pdf

Other costs to consider include the creation of additional lagoons, expansion or upgrades to existing lagoons (if feasible), and costs associated with the de-commissioning of old lagoons. Dairy lagoons must meet specifications as defined by NRCS. Estimated costs to replace lagoons are highly variable based on capacity, site conditions, engineering, and constructions costs. For example, a recent lagoon project in neighboring Skagit County that included a steel tank was estimated at $950,000 for 2.6 million gallons. This does not include permitting, soil sampling or preloading costs, nor pump or piping to make effective. Costs vary significantly depending on earthen or steel tank or concrete tank, soil loading capacity, preload requirements, availability of clay lining material for earthen structures, availability of contractors, and other factors.

**Stormwater Control**

Stormwater control covers many land uses and may involve manure management as noted above or IDDE in the case of MS4s. In this analysis it refers to control of all stormwaters not managed in a regulated storm sewer system. Controlling runoff is essential in improving water quality in the Drayton Harbor TMDL project area. Stormwater is the combined rain and snow melt that runs off of rooftops, paved streets, highways, parking lots, agricultural land into storm drains or nearby surface waters.

Gutters, downspouts ($7-9 per linear foot) and outlet piping ($20 per linear foot) may be necessary to upgrade existing livestock facilities. The additional plumbing would direct water away from potential sources of pollution during rain events. Cost sharing for gutters, downspouts, and outlet piping, may be available through federal, state, or local cost share programs. The NRCS offers guidance under practice 651 in the FOTG. A conservative estimate of 20 percent of sites identified would benefit from additional gutters and downspouts.

Similarly, installing roofing on existing storage structures is an excellent way to prevent bacteria leaks, which can result in contamination of surface waters. However, based on the variability of the structures in terms of size and length of downspouts and gutters, need for a roof, and other necessary equipment to protect water quality, additional information should be collected based on site visits and priority locations.

**Stock Watering Facilities**

Watering facilities are designed to provide alternative locations for livestock to get water while protecting streams from livestock damage and fecal contamination. This BMP is recommended on sites where it appears that animals have direct access to the watercourse as a primary drinking source. It can also be used near other vulnerable surface waters where water quality is an issue.

Due to animals congregating near the watering facilities, this practice often includes heavy use protection BMPs near the watering location. The resulting heavy use protection costs are described in the heavy use protection section above and not duplicated here. Based on NRCS site scenarios and cost share program guidelines, the estimated cost is approximately $2,500-$4,000 per facility.

**Riparian Vegetative Buffers or Filter Strips**

Ecology's Water Quality Combined Funding Program estimated that the average cost to complete riparian restoration is approximately $15,500 per acre, based on 33 previously funded grant agreements across the state from State Fiscal Years 2016 to 2019. Cost per acre varies based on specific site conditions and project scale. Costs range from approximately $3,500 to $35,000, depending on extent of invasive species control, ease of access, plant stock quality, and if maintenance is included in the budget. Typically, larger scale projects have a lower cost per acre.

Buffer width is variable depending on the type and goal of the implementation project, ranging from simple filter strips to full forested buffers within the riparian management zone. The recommended forested buffer width is variable across each tributary, ranging from 35' to 125', depending on the site location within the tributary catchment. Due to this variety of practices, prices range from $500-$2,000 per acre. This cost includes site preparation, plant materials, plant protectors, and planting labor.

**Onsite Sewage Systems (OSS)**

OSS maintenance, upgrades, or replacements are another set of key practices to reduce potential bacterial loading within the Drayton Harbor watershed. Serving as the local health jurisdiction, the WCHCS has a robust, proactive septic inspection and education program. WCHCS systematically contacts landowners and ensures inspections of OSS on a one to three-year cycle, depending on the type of system.

The ongoing cost to maintain this program is not accounted for within the budget estimate. A routine inspection costs between $100-$300 and the cost of OSS pumping services depends on the amount removed and the size of the OSS treatment tanks with an estimate of $500 per service. WCHCS and nonprofit lender Craft 3 are working together to offer homeowners affordable septic system financing with the Clean Water Loan. This program seeks to minimize the economic impact of replacing a septic system when repair or replacement costs average between $10,000 and $20,000 per unit. When OSS are located near POTW infrastructure, the option to connect to the municipal sewer line may cost up to $19,000.

**Pet Waste Management**

Pet waste disposal is identified as a BMP that may be increased or expanded within the Drayton Harbor TMDL area to reduce and prevent pollution. Increasing maintenance frequency or including additional stations in existing public spaces, as well as areas that may be developed in the future. Installation of new stations can cost $250-$500 dollars per station, with anticipated additional costs for supplies and site maintenance.

**Site Identification**

Site inspections or site visits are important tools to identify, document, and reduce nonpoint source pollution. In general, Ecology staff identify sites with nonpoint sources of pollution in one of two ways:

- Observing sites from public access points during watershed evaluations, or
- Responding to complaints from community members or referrals from other entities.

The basic difference in these two approaches is whether staff are proactively surveying impaired watersheds to identify nonpoint sources of pollution or are reacting to information provided by complainants or other partners. Ecology staff will continue to support site identification efforts through existing budgeted resources and positions.

**Partner Site Inspection**

Partner site inspections refer to additional site inspections related to the WCWP operated by the various local, state, tribal, or federal entities. These partnership programs are key to identifying, documenting, and reducing nonpoint source pollution. These programs operate under existing budget sources under the various entities conducting the inspections. No additional funding is included in the estimate.

**Education and Outreach**

Outreach and education programs to create community awareness of local pollution issues and motivate community members to adopt BMPs should be tailored to the specific needs of that community. The WCWP is the most unified approach for collective messaging. Although uniform, targeted message delivery from each implementing partner is ideal, it is not always possible. Organizations the make up the WCWP each have specialty areas of focus to develop education and outreach methods and materials. Some of these areas to overlap and materials are often referenced to each specialist in the area of expertise—see Organizations That Implement Cleanup Activities.