# Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load

## Water Quality Improvement Report and Implementation Plan

DEPARTMENT OF
ECOLOGY
State of Washington

June 2011
Publication No. 11-10-039

## *Publication and Contact Information*

This report is available on the Department of Ecology's web site at
www.ecy.wa.gov/biblio/1110039.html

For more information contact:

Washington State Department of Ecology
Southwest Regional Office
Water Quality Program
PO Box 47600
Olympia, WA 98504-7600

Phone: 360-407-6270

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Cover photos: Left: Mouth of Uncle John Creek at Chapman Cove. Right: Chapman Cove at low tide.

## Project Codes and 1996 303(d) Water-body ID Numbers

Data for this project are available at Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, AAHM0003.

Ecology's Study Tracker Code for this study is 04-049-01-02.

TMDL Study Code (Water Quality Program) is OKHM14FC.

Water-body Numbers:
390KRD, BH46CN, ZY55KI, JZ99VQ, and MI94TV

Oakland Bay – WA-14-0110
Hammersley Inlet – WA-14-0100
Inner Shelton Harbor – WA-14-0050
Campbell Creek – WA-14-1850
Goldsborough Creek – WA-14-1600
Johns Creek – WA-14-1700
Mill Creek – WA-14-1500
Shelton Creek – WA-14-1650
Uncle John Creek – WA-14-1800

# Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load

---

# Water Quality Improvement Report and Implementation Plan

*by*

Anise Ahmed
Environmental Assessment Program

and

Lydia C. Wagner
Water Quality Program
Southwest Regional Office

Washington State Department of Ecology
Olympia, Washington 98504

*This page is purposely left blank.*

# Table of Contents

# List of Figures

# List of Tables

# Abstract

Campbell, Uncle John, Malaney, Shelton, and Goldsborough Creeks – as well as Hammersley Inlet near the mouth of Mill Creek, Upper Oakland Bay, and Inner Shelton Harbor – are listed on the 2004 Washington State 303(d) list for elevated fecal coliform bacteria.

During 2004-2006, the Squaxin Island Tribe and the Washington State Department of Ecology sampled these water bodies. The resulting data were used to develop this total maximum daily load (TMDL) report.

The report provides an evaluation of the field data collected. It also establishes load reductions in fecal coliform bacteria needed to bring the stream into compliance with Washington State water quality standards. The load reductions were determined using the *statistical rollback method* and are considered to be load allocations at the various stream segments. The *rollback* method compares monitoring data to standards, and the difference is the percent change needed to meet the standards. Only three stream segments needed reductions to meet the standards for freshwater.

In addition, the TMDL establishes load reductions to meet the primary contact and shellfish protection marine water quality standards at the mouths of all tributaries except Goldsborough and Shelton Creeks. These creeks discharge to a secondary contact marine area.

The GEMSS model was calibrated to observe bacteria population distribution in Oakland Bay and Hammersley Inlet. Modeling results show re-suspension of sediments to be a major secondary source of bacteria. High concentrations of bacteria in the upper thin layer of the sediment were observed in field samples. As sources of bacteria are controlled and sediment loads are reduced, the pool of bacteria in the sediments will decrease. This will ultimately reduce the bacteria load in the water column during periods when sediments resuspend due to wind and other factors. Various scenarios have been presented to provide managerial solutions for implementing the TMDL.

Compliance with this TMDL will be based on meeting the water quality standards.

# Acknowledgements

The authors of this report thank the following people for their contribution to this study and report:

Mason County Public Health Department

- Stephanie Kenney
- Debbie Riley

Mason County Department of Public Works

- Loretta Swanson

Oakland Bay Clean Water District Advisory Committee Representatives

- Business *(Green Diamond Resource Company, Simpson Timber Company, Enterprise Cascadia)*
- Citizens
- Education *(Washington Sea Grant, WSU Mason County Extension)*
- Mason Conservation District
- Mason County Government *(Commissioners, Public Health, Public Works, Utilities)*
- Puget Sound Partnership
- Shellfish growers *(Taylor Shellfish, Pacific Coast Shellfish Growers Association)*
- Shelton, City of
- Shelton, Port of
- Squaxin Island Tribe
- WA State Department of Health

Squaxin Island Tribe

- Tracy Farrell *(formerly)*
- John Konovsky
- Joe Puhn
- Nadine Romero *(formerly)*
- Scott Steltzner

Taylor Shellfish

- Jason Ragan

U.S. Environmental Protection Agency (EPA) dive team

- Bruce Duncan
- Lisa Macchio
- Rob Pedersen
- Rob Rau
- Chad Schulze
- Sean Sheldrake
- Tim Siwiec

Washington State Department of Ecology:

Skip Albertson
Shawna Beers
Dustin Bilhimer
Betsy Dickes
Karol Erickson
Jim Garner
Brian Grantham
Christine Hempleman
Cindy James
James Kardouni
Joan LeTourneau
Sarah Livingston
Nuri Mathieu
Kim McKee
Dylan Monahan
Brenda Nipp
Dale Norton
Sabrina Payne
Greg Pelletier
Bernard Strong
Lawrence Sullivan *(formerly)*

Debby Sargeant
Lawrence Sullivan

Washington State Department of Health

Don Melvin
Frank Meriwether

Washington State Department of Transportation

Jana Ratcliff

Watershed Council

Warren Dawes
Bill Young

*This page is purposely left blank.*

# Executive Summary

## Introduction

Oakland Bay, Hammersley Inlet, and several tributaries in the Oakland Bay watershed have fecal coliform (FC) bacteria levels higher than Washington State's allowed levels (standards) for freshwater streams. These typically harmless bacteria tend to exist along with disease-causing bacteria and viruses (for example, pathogens), so they serve to indicate the potential for pathogens in the water. Meeting the fecal coliform standards is important because it helps make our rivers and streams safer places to swim, fish, raise shellfish, boat, or enjoy other recreational activities.

The federal Clean Water Act (CWA) requires the development of a total maximum daily load (TMDL) for each of the water bodies listed on the state's 303(d) list of polluted waters. The CWA requires each state to prepare a list of all the water bodies that do not meet state water quality standards. The TMDL study identifies pollution problems in the watershed, and then specifies how much pollution reduction or elimination is needed to achieve clean water. Then Ecology, with the help of local governments, agencies, and the community, develops a plan describing actions to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities. The water quality improvement report (WQIR) consists of the TMDL study, the implementation strategy, and the implementation plan.

This report, called the *Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Water Cleanup Improvement Report and Implementation Plan*, provides details on watershed activities intended to clean up fecal coliform bacteria contamination in Oakland Bay, Hammersley Inlet, and selected tributaries. Implementation plans are a required part of the water cleanup planning process known as a total maximum daily load (TMDL). This process came about from an agreement between the Washington State Department of Ecology (Ecology) and the United States Environmental Protection Agency (EPA) in 1997. Ecology submits this report to the EPA for review and approval. The report also includes implementation commitments describing and prioritizing specific actions planned to improve water quality.

The goal of this Oakland Bay Watershed Fecal Coliform Water Cleanup Plan (more commonly referred to as the TMDL) is to reduce fecal coliform concentrations within the study area, seen in Figure 1of the TMDL, to water quality standards by 2017.

## Watershed description

Oakland Bay is located in the Water Resource Inventory Area (WRIA) 14, Kennedy-Goldsborough watershed. The watershed consists of the Oakland Bay and Hammersley Inlet basins, and numerous tributaries. Oakland Bay and Hammersley Inlet are both typical of the narrow, shallow embayments characterizing South Puget Sound. While highly productive for shellfish and salmonids, low flushing rates make these areas very sensitive to human impacts.

For over 100 years, Oakland Bay's protected waters have made it an ideal port for the city of Shelton, which has based its economy on the lumber and pulp mills dominating the waterfront. The city of Shelton operates a domestic wastewater treatment plant discharging treated sewage into Oakland Bay near Eagle Point.

Land use is primarily commercial forest, with a much smaller percentage dedicated to residential development and agriculture. Shorelines are heavily developed, both marine and lacustrine (lake), such that nearly all of the lakes are bordered with homes. Small hobby farms dominate the agricultural lands.

Shellfish, primarily manila clams; Kumamoto and Pacific oysters; and mussels, are a vital resource in Oakland Bay. The shellfish industry is a critical economic factor to the local economy and provides many full and part time jobs. Numerous commercial shellfish growers are registered with the Washington State Department of Health. There are also hundreds of recreational harvesting areas on state owned tidelands.

### Oakland Bay and tributaries

Oakland Bay is a short, narrow bay that angles abruptly northeast from its connection with Hammersley Inlet to the south. The bay ranges in width from 1000 feet to one mile and covers approximately 5.4 square miles. The surrounding hillsides are relatively low, and the head of the bay consists of extensive mudflats.

Several creeks drain into Oakland Bay: Campbell Creek, Uncle John Creek, Malaney Creek, Cranberry Creek, Deer Creek, Johns Creek, Goldsborough Creek, and Shelton Creek.

### Hammersley Inlet and tributaries

Hammersley Inlet is one of the shallowest and narrowest of all inlets in South Puget Sound. The inlet is approximately 6 miles long with an estimated surface of 2.2 square miles and a basin area of 9.4 square miles, exclusive of other watersheds. The maximum basin elevation is 200 feet at Little Timber Lake.

Mill Creek, with a drainage area of 29 square miles, is the largest tributary to Hammersley Inlet. Gosnell Creek flows out of the Black Hills feeding Lake Isabella, the source for Mill Creek. Forbes Lake, a 39-acre lake, also drains into Mill Creek.

Land use along Mill and Lower Gosnell Creeks is primarily agricultural and residential. Commercial timberlands surround Upper Gosnell Creek and Rock Creek, its largest tributary.

## TMDL targets

This TMDL sets targets in terms of the fecal coliform concentrations necessary to meet both parts of the applicable water quality standards (WQS). The two-part standard consists of a geometric mean criterion and a “no more than 10% samples exceeding” criterion. In this TMDL, Ecology established the target reductions by considering the 90th percentile of data as equivalent to “no more than 10% samples exceeding” criterion. Percent reductions reflect the estimated level of source control needed to meet water quality standards. Load and wasteload allocations for bacteria apply within the TMDL Boundary.

**Table ES-1. Load and wasteload allocations.**

| Source | Target Concentration (cfu/100 mL) | Maximum flow (cms) | Load (cfu/day) | Load reduction (percent) | Critical period/basis |
|---|---|---|---|---|---|
| **Wasteload allocations** | | | | | |
| City of Shelton Wastewater Treatment Plant (WWTP) Permit #WA0023345 | 14* (monthly average) | 0.176 (monthly) | 2.1E+09 | None* | NPDES permit limit, applicable year-round |
| Washington State Department of Transportation (WSDOT) Discharges Permit #WAR043000A | 14/43 Water Quality Standards | ** | ** | ** | *** |
| **Load allocations to meet marine criteria at mouths of tributaries** | | | | | |
| Goldsborough Creek | 14 (geomean std) | 1.985 | 2.4E+10 | 59 | May-Aug |
| Shelton Creek | 43 (90th percent std) | 0.196 | 7.3E+09 | 83 | May-Aug |
| Malaney Creek | 14 (geomean std) | 0.057 | 6.9E+08 | 78 | May-Aug |
| Campbell Creek | 14 (geomean std) | 0.082 | 9.9E+08 | 79 | May-Aug |
| Uncle John Creek | 43 (90th percent std) | 0.026 | 2.8E+09 | 93 | Annual |
| Mill Creek | 14 (geomean std) | 0.818 | 9.9E+09 | 36 | May-Aug |
| Johns Creek | 14 (geomean std) | 0.535 | 6.5E+09 | 67 | May-Aug |
| Cranberry Creek | 14 (geomean std) | 0.425 | 5.1E+09 | 72 | May-Aug |
| Deer Creek | 14 (geomean std) | 0.688 | 8.3E+09 | 71 | May-Aug |

* See Appendix J for assessment of existing limits.

** When updated, the statewide Washington State Department of Transportation (WSDOT) National Pollutant Discharge and Elimination System (NPDES) Permit for Municipal Stormwater, (WAR043000A), will identify stormwater best management practices needed to attain water quality standards at all WSDOT outfalls.

*** Ecology is developing implementation guidelines to identify appropriate action items for WSDOT discharges.

## What needs to be done in this watershed?

### General implementation actions

1. Address practices contributing bacteria to tributaries. The observed concentrations in Oakland Bay, resulting from potential sediment re-suspension, will likely continue to cause elevated levels of fecal coliform bacteria in the water column unless sources of both suspended solids and bacteria are controlled. Recommendations:
    - Control total suspended solids at all stormwater discharges to the tributaries and to the bay through best management practices (BMPs).
    - Control potential human sources, such as on-site septic systems, in the watershed.
    - Properly manage domesticated animals to limit or prevent access to waterways directly or through contact-runoff.

2. Investigate and address other ways of lowering bacteria concentrations in the sediment, including the potential role of nutrients on the survival of sediment bacteria.
3. Although the loading to the whole bay from shoreline sources may not be high, localized elevated levels may be present due to these sources. Control shoreline discharges where elevated concentrations have been identified, and continue to monitor for potential sources.

**Specific implementation actions**

1. Monitor for enterococci in Inner Shelton Harbor and compare with Washington State's standard for secondary recreation in marine waters.
2. All shoreline point sources, including Washington State Department of Transportation (WSDOT) outfalls, must implement source control BMPs and/or BMPs that reduce the volume of discharging stormwater, or otherwise perform remediation to reduce fecal coliform bacteria concentrations.
3. All potential sources of fecal coliform bacteria must implement BMPs to reduce sediment loads to the bay.
4. Eliminate all human-caused sources.

## Implementation summary

The implementation section of this report describes how fecal coliform bacteria levels will be reduced to meet water quality standards. Bacteria TMDL reductions in the Oakland Bay-Hammersley Inlet basin should be achieved by 2017.

Fecal coliform bacteria primarily enter waterways from one or more of the following sources:

- Improperly treated sewage or other illicit discharges to the watershed.
- Livestock with direct access streams or with poor manure management.
- Failing or improperly constructed septic systems.
- Pet waste.
- Wildlife.

After pollution sources are prioritized, Ecology will use adaptive management to add additional implementation activities to achieve water quality standards. Ecology will perform sampling to determine if interim targets of 50 percent of the needed reduction are achieved by 2017.

In 2007, the Oakland Bay Clean Water District was formed in response to degraded water quality at the north end of Oakland Bay. There were also concerns of degrading water quality in Chapman Cove. The goal of the district is to reduce water pollution and ensure Oakland Bay remains safe for swimming, fishing, and all activities important to the culture, heritage, and economy of the area. Next, the Oakland Bay Clean Water District Advisory Committee was formed, consisting of representatives appointed by the Mason County Board of County Commissioners. The representatives are from county, state, federal, tribal, and educational organizations, business, and private citizens. This committee has proactively identified and begun implementation activities that will benefit this water cleanup effort. They developed the Oakland Bay Action Plan, seen in

Appendix M of the TMDL, and update the plan annually.  Specific parts of their plan are included in this water cleanup plan.

## Why this matters

We usually call fecal coliform bacteria "bacteria" for short.  Human and animal waste often contains many kinds of bacteria, viruses or other pathogens that can make people sick.  When we find fecal coliform bacteria in water, we know that human or animal waste (feces or "poop") is also in the water.  Bacteria can get into our waters from untreated or partially treated discharges from wastewater treatment plants, improperly functioning septic systems, wildlife, and unknown sources.

*This page is purposely left blank.*

# What is a Total Maximum Daily Load (TMDL)

A total maximum daily load (TMDL) is a water cleanup plan that, when followed, restores water quality in a state's water body.

## Federal Clean Water Act requirements

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

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

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

| | |
|---|---|
| Category 1 | Meets standards for parameter(s) for which it has been tested. |
| Category 2 | Waters of concern. |
| Category 3 | Waters with no data available. |
| Category 4 | Polluted waters not requiring a TMDL because: |
| 4a | It has an approved TMDL in implementation. |
| 4b | It has a pollution control program in place that should solve the problem. |
| 4c | It is impaired by a non-pollutant such as low water flow, dams, or culverts. |
| Category 5 | Polluted waters requiring a TMDL – the 303(d) list. |

More information is available at Ecology's Water Quality Assessment (WQA) web site at http://www.ecy.wa.gov/programs/wq/303d/.

## TMDL process overview

The Clean Water Act requires the development of a TMDL for each water body on the 303(d) list. The TMDL process typically includes a three-fold process. The first is to conduct a water quality study. Ecology began by reviewing the list of 303(d) impaired waters in the fall of 2003. After completing the review, Oakland Bay, Hammersley Inlet, and selected tributaries were identified and selected for development of a *water quality improvement report* (WQIR). This is more commonly referred to as the TMDL, which includes the technical study and analysis and an implementation strategy to improve the water quality. It identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology submits the WQIR to the U.S. Environmental Protection Agency (EPA) for approval. Once EPA approves the plan, Ecology begins the final step and prepares a *water quality implementation plan* (WQIP). This plan describes the specific tasks, responsible parties, and timelines for achieving clean water and bringing the selected water bodies into compliance with the water quality standards. Ecology works with the local community to develop an overall approach to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities.

This report combines all these elements into one. The Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform TMDL Water Quality Improvement Report incorporates the water quality study and analysis, the WQIR, and the WQIP in one document. This is partially due to the extensive work already completed by organizations represented in the Oakland Bay Clean Water District Advisory Committee. This report represents their commitment and work toward improving the water quality in the Oakland Bay watershed.

## What part of the process are we in?

This document establishes the loading capacity and load reductions in fecal coliform bacteria at various segments of tributaries to Oakland Bay and Hammersley Inlet. The reductions are necessary to meet the water quality standards both in the tributaries as well as in the bay. The report also describes actions planned to restore water quality.

The Washington State Department of Health (DOH) downgraded the shellfish harvest status of Oakland Bay in November 2006, while the TMDL study was still in process. This triggered an aggressive cleanup response and development of a detailed cleanup plan coordinated by Mason County Public Health, Environmental Health Division, with participation of watershed residents, the Squaxin Tribe, business interests, and several local and state agencies. The Mason County Board of County Commissioners adopted the cleanup plan in September 2007. It is incorporated into this report as Appendix M, "Oakland Bay Action Plan." The TMDL study will help to guide and prioritize cleanup activities identified in the plan.

## Who should participate in this TMDL?

Nonpoint source pollutant load targets have been set in this TMDL and described in Table 14. Because nonpoint pollution comes from diffuse sources, all upstream watershed areas have the potential to affect downstream water quality. Therefore, all potential nonpoint sources in the watershed must use the appropriate best management practices to reduce impacts to water quality. The area subject to the TMDL is shown in Figure 1.

Similarly, all point source dischargers in the watershed must also comply with the TMDL.

## Elements required in a TMDL

The goal of a TMDL is to ensure that impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems, including the pollutant sources, if known, that cause the problem. A water body's *loading capacity* is the amount of a given pollutant a water body can receive and still meet water quality standards and allocates that load among the various sources.

Identifying the pollutant loading capacity for a water body is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a water body can receive without violating water quality standards" (EPA, 2001a). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

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

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

Therefore, a TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to the loading capacity.

*This page is purposely left blank.*

# Why Ecology is Conducting a TMDL Study in this Watershed

## Overview

Ecology conducted a TMDL study in this watershed because the federal Clean Water Act requires impaired water bodies be restored to meet water quality standards through a TMDL process. This process generally includes the development of two documents: 1) A water quality improvement report (WQIR), more commonly referred to as a TMDL, which includes a technical analysis. 2) A water quality implementation plan (WQIP), describing the activities needed to bring the water bodies back into compliance with the water quality standards. Ecology reviewed the list of 303(d) impaired waters in early 2003, and selected Oakland Bay, Hammersley Inlet, and selected tributaries for development of a TMDL. Work began in the fall of 2003.

Because implementation activities have already begun for this watershed, Ecology has combined all components of the TMDL process into one report. This report includes the:

- Technical Analysis
- Water Quality Improvement Report (WQIR)
- Water Quality Implementation Plan (WQIP)

## Study area

The study area for this TMDL consists of the Oakland Bay-Hammersley Inlet basins and the associated tributary sub-basins. The focus area is located in the Water Resource Inventory Area (WRIA) 14, Kennedy-Goldsborough watershed, in Mason County, Washington. See Figure 1, Oakland Bay-Hammersley Inlet and Tributaries.

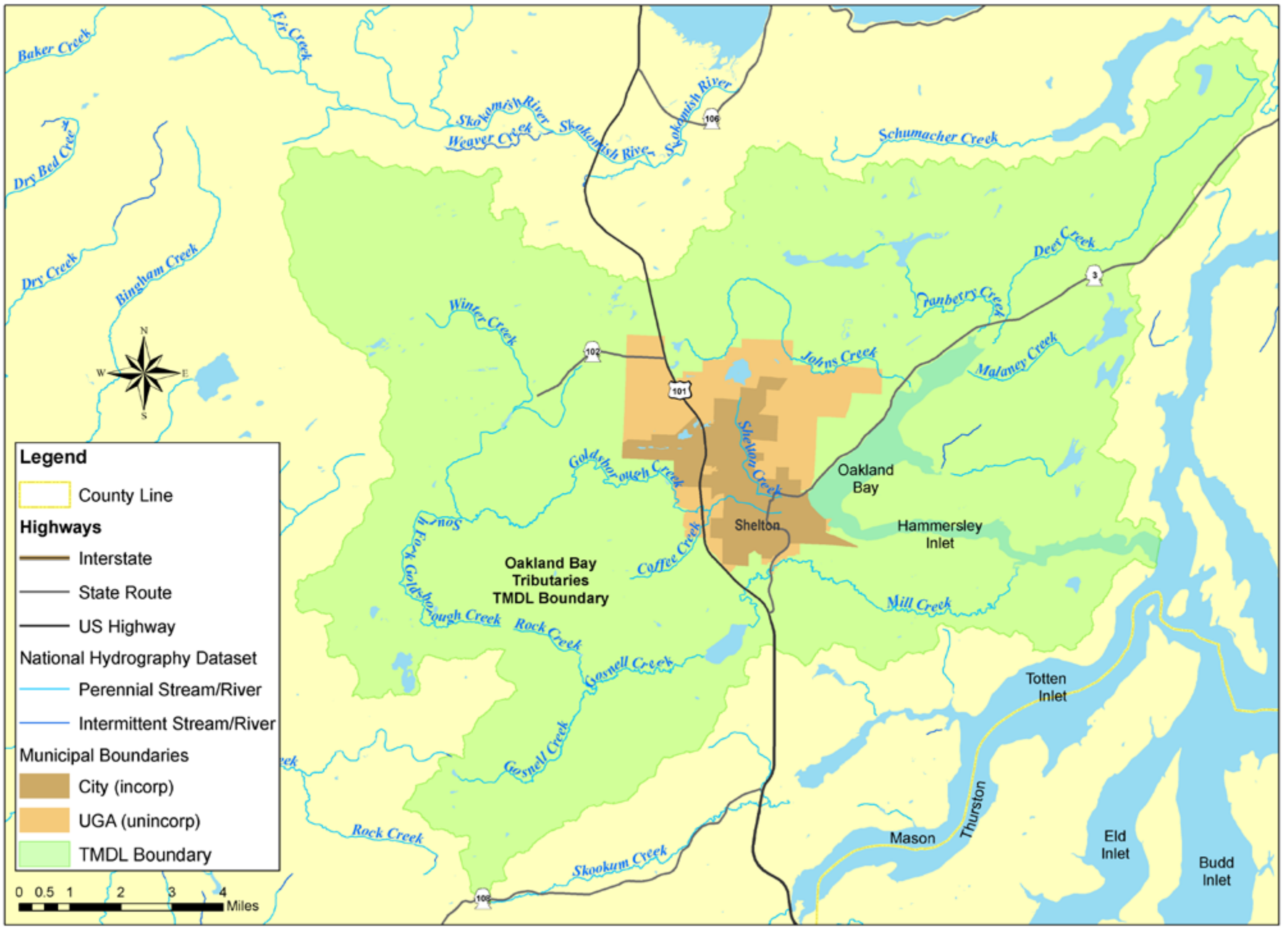



**Figure 1. Oakland Bay-Hammersley Inlet and Tributaries Study Area**

## Pollutants addressed by this TMDL

This TMDL addresses exceedances of fecal coliform (FC) bacteria standards in Oakland Bay, Hammersley Inlet, and selected tributaries. Ecology is also completing a separate TMDL to address 303(d) listings for temperature in tributaries to Oakland Bay and Hammersley Inlet.

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

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses as well as numeric and narrative water quality criteria for surface waters of the state. The numeric and narrative water quality criteria are set at levels to protect the designated beneficial uses. In other words, the criteria are set to protect the streams for the ways people use them.

The main beneficial uses to be protected by this TMDL are primary and secondary contact recreation and shellfish protection. The tributaries to Oakland Bay and Hammersley Inlet, in South

Puget Sound, that have been placed on Washington State's 2008 303(d) list of water bodies for not meeting water quality standards for FC bacteria are Uncle John, Campbell, Malaney, Shelton, and Goldsborough Creeks (Table 1). Parts of Oakland Bay and Hammersley Inlet are also on the 303(d) list for not meeting the water quality standards for FC as shown in Table 1.

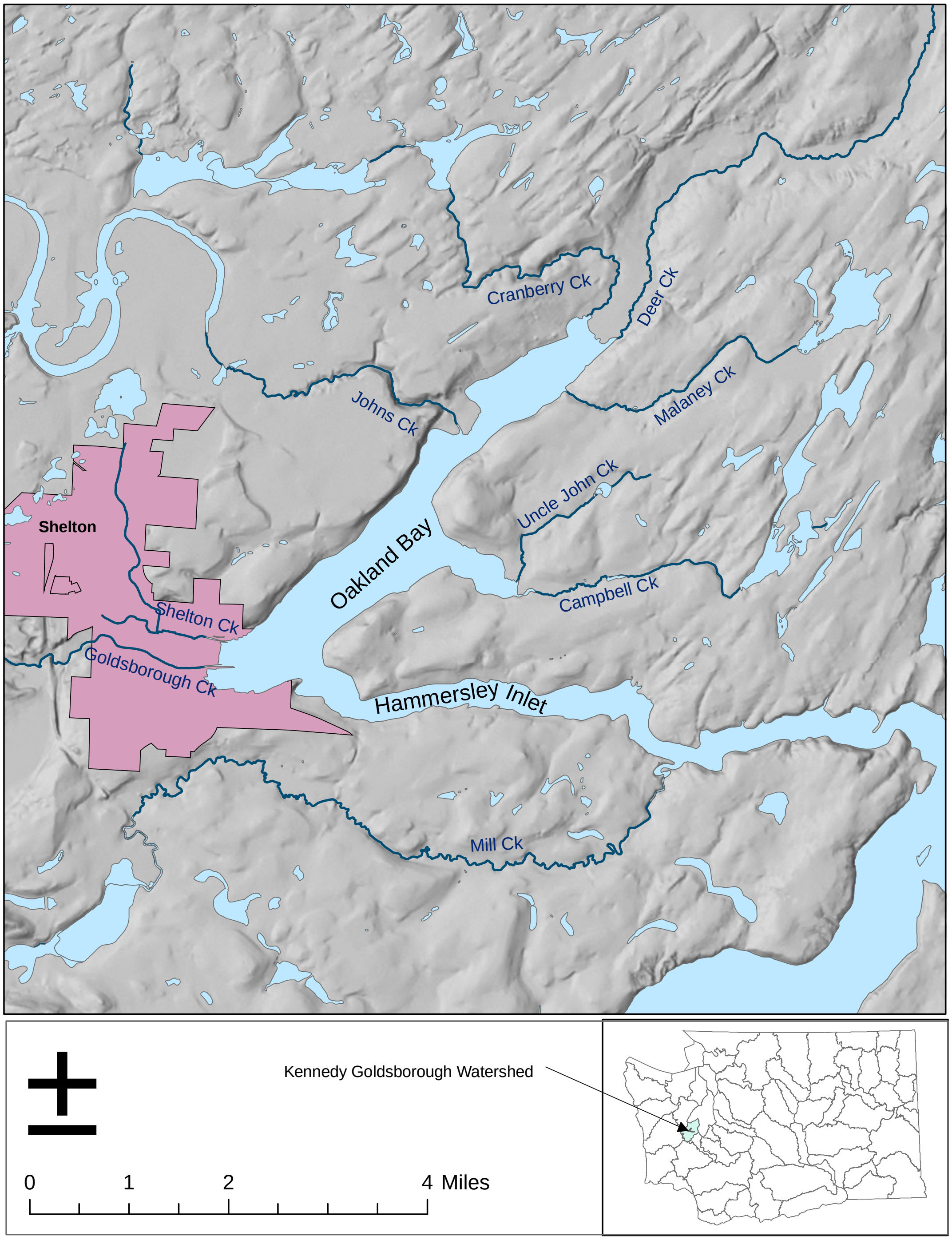



**Figure 2. Oakland Bay-Hammersley Inlet and Tributaries.**

**Table 1. Study area water bodies on the 2008 303(d) list for FC bacteria.**

| Water-body Name | Listing ID | Latitude | Longitude | |
|---|---|---|---|---|
| **Estuarine** | | | | |
| Hammersley Inlet/ mouth of Mill Creek | 39800 | 47.195 | -122.995 | |
| Hammersley Inlet | 39801* | 47.205 | 123.005 | |
| | 39803* | 47.205 | 123.015 | |
| | 39804* | 47.205 | 123.045 | |
| | 39810* | 47.195 | 122.985 | |
| | 45220* | 47.205 | 123.035 | |
| | 45915* | 47.205 | 123.035 | |
| | 53178* | 47.205 | 123.055 | |
| Oakland Bay | 39857* | 47.205 | 123.075 | |
| | 39861* | 47.245 | 123.045 | |
| | 39862* | 47.225 | 123.045 | |
| Oakland Bay (Upper) | 39872 | 47.255 | -123.025 | |
| Oakland Bay | 45159* | 47.255 | 123.015 | |
| | 45215* | 47.225 | 123.025 | |
| | 53164* | 47.225 | 123.035 | |
| Inner Shelton Harbor | 6658 | 47.205 | -123.095 | |
| **Freshwater** | | | | |
| Campbell Creek | 24239 | 20N | 3W | 14 |
| | 7596 | 20N | 3W | 13 |
| Uncle John Creek | 40618 | 20N | 3W | 14 |
| Malaney Creek | 24237 | 20N | 3W | 1 |
| Shelton Creek | 6660 | 20N | 3W | 20 |
| Goldsborough Creek | 6659 | 20N | 3W | 20 |

* These IDs were not included in the 2004 303(d) list.

This watershed has other water quality impairments. In particular, 303(d) listings for temperature occur in the study area (Table 2). Ecology will address these listings in a separate study.

**Table 2. 303(d) listings for temperature not addressed in this report.***

| Water body | Listing ID | Township | Range | Section |
|---|---|---|---|---|
| Johns Creek | 23571 | 20N | 3W | 5 |
| Cranberry Creek | 23752<br>23753<br>23754 | 21N<br>21N<br>21N | 3W<br>3W<br>3W | 36<br>34<br>27 |
| Mill Creek | 40597<br>40598<br>40599 | 20N<br>20N<br>20N | 3W<br>3W<br>3W | 35<br>30<br>31 |

* Ecology will develop the Temperature TMDL in 2011-2012.

## Why are we doing this TMDL now?

Oakland Bay and Hammersley Inlet are important aesthetic, cultural, recreational, and economic resources to Mason County and Washington State. This area has been used by the Squaxin Island Tribe since "time immemorial." European settlement of the area began during the 1800s, and commercial shellfish harvest was important by the late 1800s. Oakland Bay is currently one of the most productive commercial shellfish growing areas in the country. Recreational harvest is also popular on some beaches. In addition, both Oakland Bay and Hammersley Inlet are popular with recreational boaters and anglers.

In the late 1980s, Ecology listed freshwater creeks in this area on Washington's list of impaired water bodies, called the 303(d) List, because fecal coliform bacteria concentrations posed a potential risk of illness to recreational users. The Washington State Department of Health (DOH) listed one station at the north end of Oakland Bay as "threatened" in 2002, and noted concerns with water quality at a station in Chapman Cove in 2003 (Determan, 2007). In November 2006, DOH restricted shellfish harvest in the north end and placed Chapman Cove on the threatened list. While water quality in Chapman Cove continued to decline for awhile, it is beginning to improve.

In response to declining water quality and the downgrade in the north end in late 2006, Mason County coordinated an effort by a number of concerned groups and watershed residents to address the problems. In addition to developing Mason County's *Oakland Bay Action Plan* (adopted by the Mason County Board of County Commissioners in September 2007), these partners continue scientific investigation of sources of pollution. They also provide technical assistance and outreach to landowners to reduce sources of bacteria and build awareness and support for needed changes. This TMDL will add technical information and analysis to improve the understanding of technical issues and to help prioritize and focus implementation efforts.

*This page is purposely left blank.*

# Water Quality Standards for Bacteria and Beneficial Uses

## Freshwaters

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

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state. The beneficial use targeted for protection in this TMDL for freshwater tributaries is protection of health during primary contact recreation.

The *Primary Contact* use is intended for waters “where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing.” More to the point, however, the use is designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection.

To protect this use category: “Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL” [WAC 173-201A-200(2)(b), 2003 edition].

## Marine waters

In marine waters, bacteria criteria are set to protect shellfish consumption and people who work and play in and on the water. Ecology uses two separate bacterial indicators in the state’s marine waters. In waters protected for both primary contact recreation and shellfish harvesting, the state uses FC bacteria as indicator bacteria to gauge the risk of waterborne diseases. In water protected only for secondary contact (the designation for a part of Oakland Bay adjacent to the city of Shelton), enterococci bacteria are used as the indicator bacteria. The presence of these bacteria in the water indicates the presence of waste from humans and other warm-blooded animals.

The beneficial use targeted for protection in this TMDL for marine waters are shellfish harvesting and protection of health during primary and secondary contact recreation.

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

The criterion level set to protect shellfish harvesting and primary contact recreation is consistent with federal shellfish sanitation rules. FC concentrations in our marine waters that meet shellfish protection requirements also meet the federal recommendations for protecting people who engage in primary water contact activities. Thus, Ecology uses the same criterion to protect both "shellfish harvesting" and "primary contact" uses in the state standards.

Shellfish harvesting areas exist throughout Oakland Bay and Hammersley Inlet. Shellfish species found in Oakland Bay are shown in Table 3. The Washington State Department of Health oversees the commercial harvesting of shellfish in this watershed to protect the health of the consumers.

**Table 3. ShellfishSpecies with Known or Potential Distributions in Oakland Bay and Hammersley Inlet. (http://www.wdfw.wa.gov/fishing/shellfish)**

| Common Name | Scientific Name | Habitat/Substrate | Comments |
|---|---|---|---|
| Native Littleneck  | *Protothaca staminea* | Intertidal; firm substrate | Common; recreational and commercial harvest |
| Manila Littleneck  | *Tapes philippinarum* | Intertidal; gravel/mud/sand | Introduced commercial species |
| Butter Clam  | *Saxidomus giganteus* | Intertidal and subtidal; porous sand/shell/mud/gravel | Recreational harvest |
| Cockle  | *Clinocardium nuttallii* | Intertidal; soft sand/mud, eelgrass beds | Recreational harvest |
| Piddock  | *Zirfaea pilsbryi* | Subtidal; bores into shale, clay, or wood | Edible boring clam |
| Horse Clam  | *Tresus capax, T. nuttalli* | Subtidal; sand/shell | Abundant; recreational and small commercial harvest |
| Pacific Oyster  | *Crassostrea gigas* | Intertidal; firm substrate gravel/silt/shell, rocks and pilings; require clean substrate | Introduced commercial species |
| Olympia Oyster  | *Ostrea lurida* | Intertidal; solid rock/mud w/moderate currents | Native commercial species |

The criteria for *Secondary Contact* recreation covers activities where a person's water contact would be limited (wading or fishing for example) to the extent that bacterial infections of the eyes, ears, respiratory or digestive systems, or urogenital areas would be normally avoided. The criteria is as follows: "Enterococci organism levels must not exceed a geometric mean value of 70 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 208 colonies/100 mL" [WAC 173-201A-210(3)(b), 2003 edition].

Figure 3 shows the area of Oakland Bay designated as secondary contact recreation. This area is the Inner Shelton Harbor adjacent to the city of Shelton, and near the mouths of Shelton and Goldsborough Creeks.


**Figure 3. Oakland Bay use classification at longitude -123.0834 W.**

## Compliance with water quality standards

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

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

If natural levels of FC (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, warm-blooded animals, (particularly those managed by humans), are a common source of serious waterborne illness for humans.

# Watershed Description

Oakland Bay and Hammersley Inlet are typical of the narrow, shallow embayments that characterize South Puget Sound. While highly productive for shellfish and salmonids, low flushing rates make these areas very sensitive to human impacts.

For over 100 years, Oakland Bay's protected waters have made it an ideal port for the city of Shelton, which has based its economy on the lumber and pulp mills that dominate the waterfront. The city of Shelton operates a domestic wastewater treatment plant that discharges treated sewage into Oakland Bay near Eagle Point.

Land use is primarily commercial forest, with a much smaller percentage dedicated to residential development and agriculture. Shorelines are heavily developed, both marine and lacustrine (lake), such that nearly all of the lakes are bordered with homes. Agricultural lands are dominated by small hobby farms.

## Oakland Bay and tributaries

Oakland Bay is a short, narrow bay that angles abruptly northeast from its connection with Hammersley Inlet to the south. The bay ranges in width from 1000 feet to one mile, and covers approximately 5.4 square miles. The surrounding hillslopes are relatively low, and the head of the bay consists of extensive mudflats.

Several creeks drain into Oakland Bay:

**Campbell Creek** begins at 110-acre Phillips Lake. It also receives flow from Timber and Little Timber Lakes as it flows west into Oakland Bay at Chapman Cove, located along the east shore of Oakland Bay, near Sunset Road and Agate Loop Road. Timber Lake was created in the early 1970s by dredging wetlands and is approximately 82 acres (Taylor et al., 2000). Like many area lakes, it has been extensively developed. Much of the channel below Timber Lakes remains undeveloped and is characterized by numerous beaver ponds. Nearly the entire channel is accessible to fish. On Agate Road, Campbell Creek runs through a farm containing domestic waterfowl.

**Uncle John Creek**, with a total drainage area of only 1.4 square miles, originates in a marsh and flows into Oakland Bay via Chapman Cove near the mouth of Campbell Creek. Uncle John Creek has two forks with the east fork originating at a wetland and the west fork essentially fed by ground water. Although nearly the full length of the channel is accessible to fish, the habitat has been considerably degraded. Much of the lower channel flows through a roadside ditch, while the middle and upper reaches have been subject to livestock trampling and bank stabilization with scrap metal. Potential sources of fecal coliform (FC) bacteria are hobby farms and failing septic tanks.

**Malaney Creek**, located on the Agate peninsula, flows southwest into the upper end of Oakland Bay. The creek originates at the 230-acre Spencer Lake, which is heavily developed with residential homes that are on septic systems. Although it is only 2.9 miles long, Malaney Creek is a productive salmonid stream, flowing through forested land from Spencer Lake to its mouth. A county-owned culvert on Agate Road, which created a partial fish barrier, has been replaced. Summer flows are low, often as little as one cubic feet per second (cfs).

**Cranberry Creek** originates in a series of lakes, flowing southeast to join Oakland Bay to the northwest of Johns Creek. Cranberry and Limerick Lakes comprise the upper watershed. Lake Cranberry is a natural lake. Lake Limerick was created in 1966 by damming a wetland (Smith and Rector 1994). Steelhead and coho pass through the lake via a fish ladder, while chum use the lower channel. Juvenile sockeye have also been trapped below the dam (Squaxin Island Tribe unpublished data, 1999). Most of the land along Cranberry Creek, below Lake Limerick, is forested with a few homes on septic systems.

**Deer Creek** consists of two forks, one originating at 82-acre Lake Benson and the other at a wetland south of Lake Benson. Deer Creek drains southwest into the head of Oakland Bay. At least 150 housing tracts with septic systems surround Lake Benson (Taylor et al., 2000). Most of Deer Creek lies in forested land with the channel accessible to fish.

**Johns Creek** begins in a series of wetlands, following a low-gradient, meandering course through glacial outwash before descending through a deep canyon at a gradient of approximately two to three percent to enter Oakland Bay through a wide delta. The five-mile wetland at the headwaters is the largest in Mason County. The wetland has the largest beaver population known in the area. Some of the most productive shellfish beds in the bay are located at the mouth of Johns Creek. Most of the channel is accessible to fish.

**Goldsborough Creek** is the largest sub-drainage, comprising about 35 percent of the total area of the Oakland Bay-Hammersley Inlet watershed. The upper end is divided into north and south forks and incorporates approximately 2000 acres of lakes and wetlands. Major lakes include Hanks, Catfish, Armstrong, Goose, and Panhandle. At river mile 2.1, a diversion dam (owned by Simpson Timber Company), which was a partial barrier to steelhead, coho, and cutthroat, has since been removed (Young, 2004). The lower several miles pass through the city of Shelton and are extensively developed, channelized, and lacking any natural estuarine area. Above the city limits, the Goldsborough Creek watershed is mostly forested. Part of Shelton Creek flows are diverted to Goldsborough Creek during high winter flows.

**Shelton Creek** has its headwaters at 108-acre Island Lake to the northwest of Shelton. The lake feeds into the creek indirectly through wetlands and groundwater movement, as well as through intermittent surface flow. Shelton Springs joins the main stem approximately one mile south of the lake, although most of its flow has been diverted for Shelton's domestic water needs. An additional diversion located further downstream traps debris and limits streamflow to 55 cfs with extra flow diverted to Goldsborough Creek (Taylor et al., 2000).

Upon crossing the city limits, Shelton Creek is joined by two tributaries. The western branch, also known as City Spring Creek, originates from the Mountain View Addition. The eastern branch, know as Canyon Creek or Town Creek, originates in a marshy area north of the Capitol Hill development and flows through a steep canyon into the business district. Canyon Creek accounts for about one-third of the flow in Shelton Creek (Michaud, 1987; Taylor et al., 2000).

Shelton Creek and its tributaries have been extensively channelized. Nevertheless, the creek is used by coho, chum, and sea-run cutthroat trout. Chum may be seen spawning in the lower half mile of creek among parking lots and businesses.

## Hammersley Inlet and tributaries

Hammersley Inlet is one of the shallowest and narrowest of all inlets in South Puget Sound. The inlet is approximately six miles long with an estimated surface of 2.2 square miles and a basin area of 9.4 square miles, exclusive of other watersheds. Maximum basin elevation is 200 feet at Little Timber Lake.

Mill Creek, with a drainage area of 29 square miles, is the largest tributary to Hammersley Inlet. Gosnell Creek flows out of the Black Hills feeding Lake Isabella, which is the source for Mill Creek. Lake Isabella is approximately 200 acres with extensive wetlands at both the inlet and outlet. Mill Creek is about nine miles long and meets Hammersley Inlet east of Walker Park. Forbes Lake, a 39-acre lake about 1.5 miles west of the unincorporated area of Arcadia, also drains into Mill Creek (Taylor et al., 2000).

Along Mill and Lower Gosnell Creeks, land use is primarily agricultural and residential, while commercial timberlands surround Upper Gosnell and its largest tributary, Rock Creek.

*This page purposely left blank.*

# Sources of Fecal Coliform Pollution

Potential sources of bacteria pollution are predominantly nonpoint in nature. However, point sources also exist in the watershed.

## Nonpoint sources

Animal management practices and failing septic systems are likely major contributors of fecal coliform (FC) loads in the Oakland Bay-Hammersley Inlet watershed. The watershed is characterized predominantly by unconsolidated glacial material or compacted till. On-site sewage disposal systems function poorly in this type of soil.

The Oakland Bay Watershed Management Plan (Brown and Caldwell, 1990) identified animal management practices as likely sources of FC bacteria in Uncle John and Campbell Creeks. Michaud (1987) documented stormwater runoff contaminated by FC entering both Shelton and Goldsborough Creeks. This source of contamination has since been at least partially eliminated by improvements to Shelton's stormwater collection system, resulting in a marked decline in marine bacterial counts (Determan, 1999).

Campbell, Uncle John, Malaney, Shelton, and Goldsborough Creeks have been identified as not meeting the water quality standards for FC and contributing bacterial loading to the Oakland Bay-Hammersley Inlet watershed. Berbells (2003) identified 35 Canada Geese at the mouth of Johns Creek and 25 Canada Geese at the mouth of Campbell Creek. However, Berbells (2003) believes that wildlife is not a significant source of FC bacteria.

### Washington State Department of Transportation (WSDOT) outfalls

Currently the WSDOT is not regulated by the National Pollutant Discharge and Elimination System (NPDES) program for this watershed and is therefore considered to be a nonpoint source**.** Ecology anticipates the WSDOT discharges in Mason County and the city of Shelton will soon be regulated by the WSDOT NPDES Permit for Municipal Stormwater (Permit #WAR043000A).

The watershed is traversed by two major highways. Highway 101 crosses north-south over Mill Creek and Goldsborough Creek, near Shelton. Highway 3 crosses the watershed southwest to northeast and connects with Highway 101 near the confluence of Lake Isabella and Mill Creek, south of Shelton. Highway 3 runs along the northern shore of Oakland Bay and crosses Goldsborough, Shelton, Johns, Cranberry, and Deer Creeks.

There are many roadside storm drains along Highway 101 and Highway 3 (Figure 4) that are owned or operated by WSDOT. State and federal regulations require WSDOT to have a stormwater permit in areas covered by Phase I and Phase II of the municipal stormwater permit program. However, since neither the city of Shelton nor Mason County is currently covered under the Phase II stormwater permit, there are no WSDOT municipal stormwater permit obligations within the

TMDL boundary. When updated, the WSDOT National Pollutant Discharge and Elimination System (NPDES) Permit for Municipal Stormwater, (Permit #WAR043000A), will identify stormwater best management practices needed to attain water quality standards at all WSDOT outfalls.

The WSDOT has a statewide stormwater permit regulating stormwater discharges from state highways and related facilities contributing to discharges from separate storm sewers owned or operated by the WSDOT within the Phase I and II designated boundaries. The WSDOT's permit also covers stormwater discharges to any water body in Washington State for which there is a U.S. Environmental Protection Agency (EPA)-approved TMDL with wasteload allocations and associated implementation documents specifying actions for WSDOT stormwater discharges (applicable TMDLs listed in Appendix 3 of the WSDOT permit).

During the permit development process, the WSDOT agreed to update their Highway Runoff Manual (HRM) to equivalency with Ecology's Stormwater Manuals. This was completed in 2008. They also agreed to implement their HRM statewide. The application of the HRM statewide was formalized with an implementing agreement signed by both agencies directors.

The HRM provides project engineers and designers with technically sound stormwater management practices, equivalent to guidance provided in Ecology's stormwater management manuals, to achieve compliance with federal and state water quality regulations. It is based on best available science and results from existing federal and state laws requiring stormwater management systems to be properly designed, constructed, maintained, and operated to:

- Prevent pollution of state waters and protect water quality, including compliance with *state water quality standards.*
- Satisfy state requirements for all known available and reasonable methods of prevention, control, and treatment of wastes prior to discharge to waters of the state.
- Satisfy the federal technology-based treatment requirements under 40 CFR part 125.3.

The guidelines and criteria in the HRM also support WSDOT in its efforts to comply with the requirements of the federal Endangered Species Act (ESA).

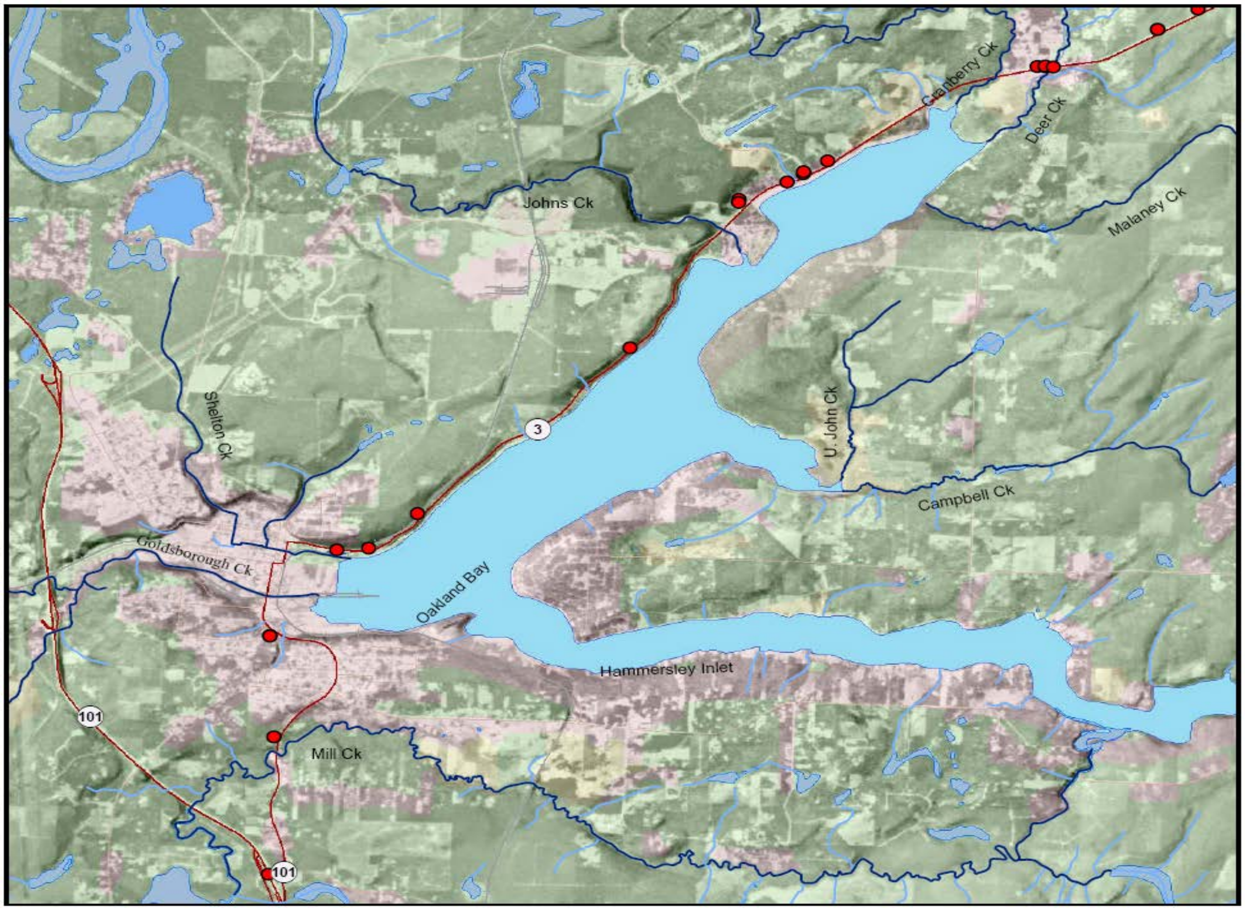



**Figure 4. WSDOT Stormwater Outfalls along Highway 101 and Highway 3.**

# Point sources

## City of Shelton Sewage Treatment Plant

The city of Shelton operates a wastewater treatment plant that discharges treated and disinfected domestic wastewater to Oakland Bay/Hammersley Inlet. The plant is located at latitude 47° 12' 28" N and longitude 123° 04' 15" W, near Eagle Point.

There are no provisions for Combined Sewer Overflows (CSOs) in the city. However, the city has a Sanitary Sewer Overflow (SSO) problem where lines surcharge and manholes overflow (Dougherty, 2004). The SSO events are reported to the Washington State Departments of Ecology and Health. In recent years, the problem has improved partly due to efforts in controlling infiltration and inflow (I & I). In the winter of 2003, only one SSO occurred during a record rainfall in October when about 6-8 manholes overflowed. Limited bacteria testing of the SSO showed high (Too Numerous to Count (TNTC)) fecal coliform bacteria counts. However, SSO flows were not monitored.

SSO events increase bacterial loads to Goldsborough Creek and stormwater drainage systems. Figure 4 shows FC concentrations in the Shelton Wastewater Treatment Plant (WWTP) effluent.

Since 1999, the WWTP has been in compliance with the effluent limitations of 200 cfu/100 mL and 400 cfu/100 mL monthly and weekly geometric means, respectively. The effluent limits were based on using chlorination as a technology for disinfection. The Washington State water quality standard for Class B marine waters (a geometric mean of 100 cfu/100 mL) are met due to a dilution factor of 1 to 94 at the edge of an approved mixing zone.

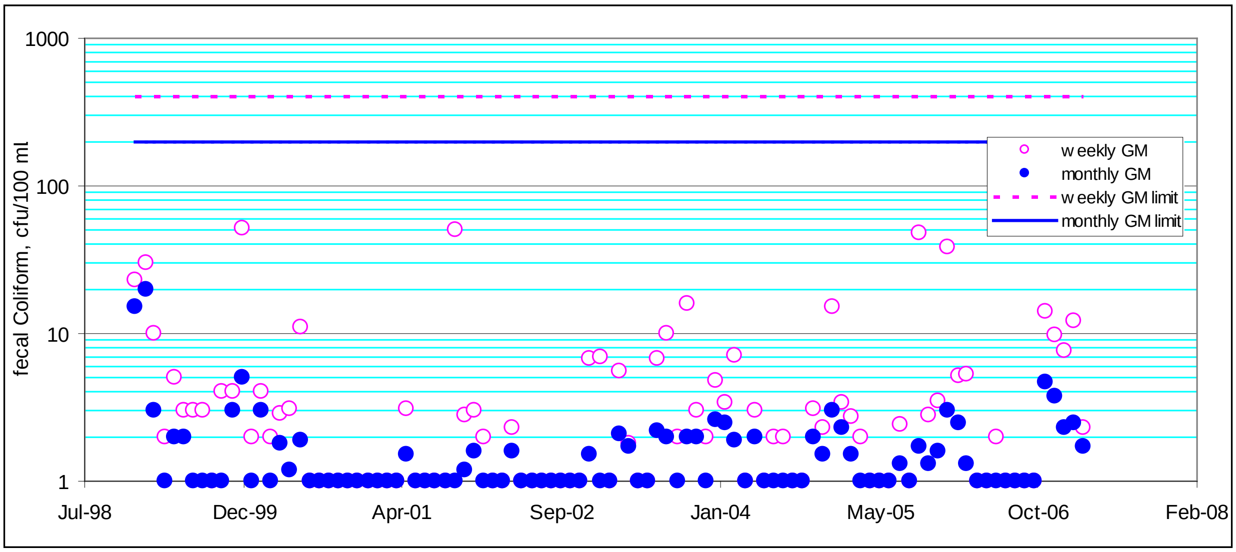



**Figure 5. FC concentrations in city of Shelton WWTP effluent (1999-2007).**

Other sources include stormwater outfalls draining the urban areas of the city of Shelton. However, Shelton does not qualify for a Phase II stormwater permit since the population is less than 10,000 people. The estimated April 2004 population was 8,695 people (www.ofm.wa.gov/pop/april1/finalapril12004popofcities.pdf ). The population of Mason County as of the 2010 Census was 60,699. This meets the *greater than 10,000 people* criteria for a Phase II stormwater permit. However, it does not meet the 1000 people per 1 square mile criteria. Thus, Mason County is also exempt from the Phase II stormwater permit.

## Permitted stormwater sources

Ecology issued several industrial stormwater permits, boatyard permits, construction stormwater permits, and sand and gravel stormwater permits for facilities in the area. These facilities are not likely sources of FC bacteria, but any discharges should meet the numeric water quality criteria if they are found to contribute to FC bacteria loading.

## Potential sources along the shoreline

A shoreline survey was conducted on September 20, 2004 to locate pipes, culverts, seepages, drainages (a large channelized seepage) and un-named tributaries. This was a dry-weather survey. Figure 6 shows the locations of these sources. There were 122 pipes/culverts, 87 drainages, 43 potential seepages, and 27 un-named tributaries located during this reconnaissance survey.

During this 2004 survey, seven samples were collected by the Squaxin Island Tribe from Chapman Cove near the mouths of Uncle John and Campbell Creeks. There were no rainfall events preceding the day or on the day of sampling. Only three of the seven samples contained coliforms above detection levels. A seepage had 600 cfu/100 mL, a pipe in a bulkhead had 380 cfu/100 mL, and an un-named tributary had 50 cfu/100 mL.

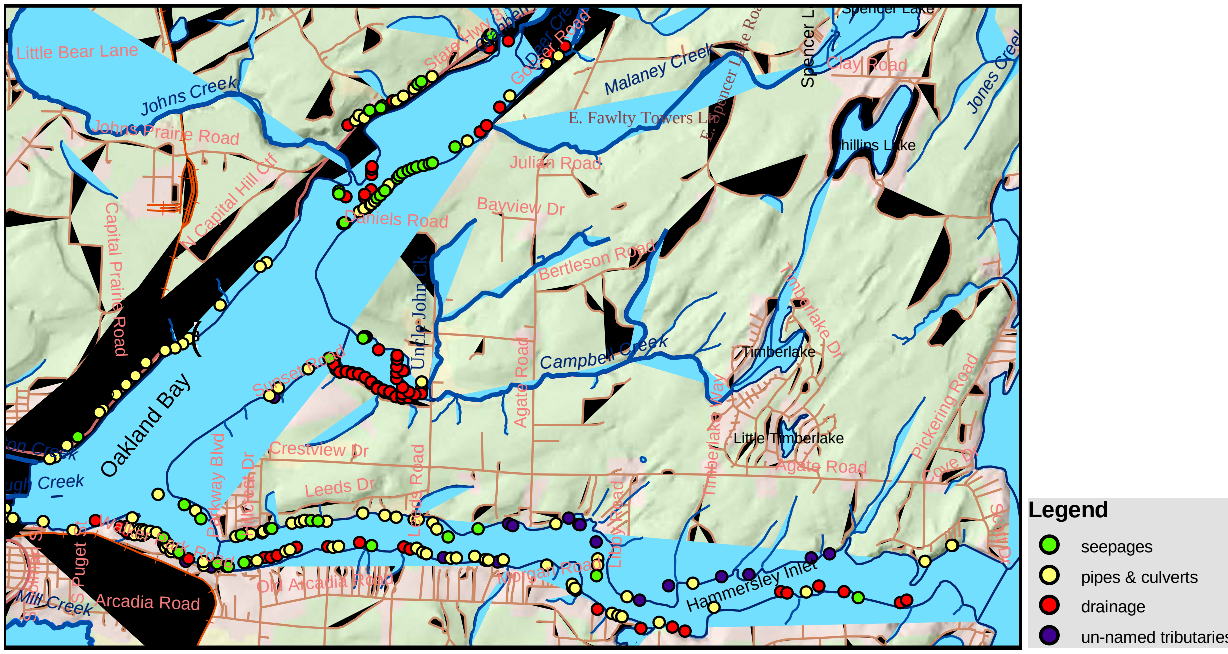



**Figure 6. Locations of seepages, pipes, culverts, drainages, and un-named tributaries.**

## Sediments

Although not directly a source, re-suspension of bacteria "trapped" in sediment has been shown to contribute bacteria in the water column. Preliminary investigations in Upper Oakland Bay showed sediments collected from the mudflats were high in FC bacteria (Konovsky, 2007).

Other studies have shown bacteria concentrations in the sediment are relatively higher than the water column and that they could potentially survive longer (Gerba and McLeod, 1976). 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).

## Microbial source identification

In early 2006, the Washington State Department of Health (DOH) data for Upper Oakland Bay (near the mouths of Cranberry and Deer Creeks) and Chapman Cove (near the mouths of Campbell and Uncle John Creeks) suggested these areas were threatened with a shellfish harvest closure. There are no point sources in these areas. The typical nonpoint sources are on-site sewage treatment systems, livestock operations, and wildlife.

In order to determine if human sources were present in these areas, a microbial sources tracking (MST) study was undertaken during 2005-06. Elevated numbers of FC were observed during the dry season (summer) in Upper Oakland Bay and during storm events in Chapman Cove. These were the periods selected for sampling. Two MST methods were used to determine sources: Bacteroides and male-specific RNA coliphage. Of the two methods, Bacteroides is a more commonly accepted MST method. The EPA analyzed the water samples for human, ruminant, and general bacteroides primers using DNA extraction and polymerase chain reaction methods. Bacteroides was chosen because it is DNA based, doesn't require a reference library for comparisons, and is ruminant and human host specific (Harris, 2007).

Five sites in Upper Oakland Bay and seven sites in Chapman Cove were selected for sample collection during this 2005-06 MST study. Upper Oakland Bay included one marine site and four freshwater sites. Chapman Cove had two marine sites and five freshwater sites.

The results of the Bacteroides MST study are as follows. The Coliphage study confirmed the Bacteroides results.

A total of 72 samples were collected in summer and 24 samples in winter. Of the 72 summer samples, 31 samples had FC bacteria in excess of 100 MPN/100 mL (Konovsky, 2007). Table 4 shows the results of the MST study combining both freshwater and marine water sites. Human markers were present in both the Upper Oakland Bay and Chapman Cove sites except for the headwaters of Chapman Cove. Bacteroides testing confirmed human sources on Uncle John Creek. Summertime human markers were more prevalent compared to the winter season. However, wintertime sample size was less than half that of summer season. In addition, human and ruminant markers were greatest at high FC concentrations.

**Table 4. Results of the MST study (November 2005 - November 2006) showing percent of samples positive for a given marker.**

| Site | Samples | Percent of samples in which a marker was present (%) | |
|---|---|---|---|
| | | Human marker | Ruminant marker |
| Upper Oakland Bay (marine and freshwater sites) | <100 MPN/100 mL | 39 | 69 |
| | >100 MPN/100 mL | 94 | 87 |
| | Winter | 20 | 50 |
| | Summer | 69 | 79 |
| Chapman Cove (marine and freshwater sites) | <100 MPN/100 mL | 19 | 35 |
| | >100 MPN/100 mL | 89 | 100 |
| | Winter | 7 | 29 |
| | Summer | 56 | 78 |

## Factors responsible for fecal coliform survival in marine environments

Several factors are responsible for bacteria die-off, including abiotic and biotic.

### Abiotic factors

**Light**

Although sunlight (ultraviolet and visible light) reduces bacteria viability (Al-Azawi, 1986), sunlight effects are restricted to shallow depths (Deller et al, 2006). Thus, surface renewal of the water column with deeper waters (for example, with wind and tidally-induced mixing) would promote greater net die-off of bacteria. The light mediated die-off was found to be enhanced in the presence of salinity (Kapuscinski and Mitchell, 1981), suggesting a synergistic effect of the combined stress factors. However, the presence of dissolved organic matter, chlorophyll, and particulate matter mitigated the effects of solar radiation (Calkins, 1982; Baker and Smith, 1982).

**Salinity**

When released into the sea, enteric bacteria are subjected to an immediate osmotic upshock. The effect of increased salinity on bacteria die-off is well established (Pike et al., 1970). Ahmed and Rountry (2007) showed a greater survivability of fecal coliform bacteria in tidally-influenced reaches of a river during storm events, primarily from increased loading and reduced salinity. Rozen and Belkin (2001) indicate enteric bacteria can counter the osmotic shock to some extent by synthesizing specific osmoprotectant molecules that tend to equalize osmotic pressure, avoiding drastic loss of water from the cytoplasm.

Conversely, enteric bacteria that were able to adapt itself to the osmotic upshock (exposed to salt water) tended to be unculturable during an osmotic downshock (exposed to freshwater). Osmotic upshock and downshock are likely to happen in coastal areas where freshwater flows into the sea, or when bacteria in sediment are re-suspended.

**pH**

Seawater pH normally ranges from 7.5 to 8.5 and is influenced by temperature, pressure, photosynthetic activity, and microorganism respiration. Within a range of pH 5 to 9 studied by Carlucci and Pramer (1960), an acidic pH was found to be most favorable for E. coli survival in seawater, and the sensitivity increased with increase in pH.

**Nutrient deprivation**

The amount of organic and inorganic nutrients in the marine environment is dramatically lower than those of laboratory media or wastewaters, and bacteria released into the marine environment need to contend with starvation conditions. However, Troussellier et al. (1998) determined that nutrient deprivation alone was not as significant compared to combined effects of nutrient deprivation and other stress factors such as salinity and light.

### Temperature

Seawater temperature is another obvious shock confronted by microorganisms. The optimal growth temperature for FC is 37° C. However, the optimum temperature for survival is not necessarily the same as for growth, with lower temperatures enhancing the stability of E. coli (Rozen and Belkin, 2001). Ahmed and Sorensen (1995) established that human pathogens (*Salmonella typhimurium, Yersinia Enterocolitica, campylobacter jejuni,* and polio virus) survived much better at 5° C compared to 22° C, 38° C, and 49° C.

### Sedimentation

Several studies focusing on the occurrence of fecal coliforms and enterococci bacteria in estuarine water and coastal sediments reveal that greater number (10 to 100 fold higher) of these organisms are found in sediments than in the water above them (Gerba and McLeod 1976; Shiaris et al., 1987). Each storm event contributes to the sediment bacteria load. Schillinger and Gannon (1985) determined that 20% of bacteria in any given storm event is attached to suspended solids.

Other processes that enhance sedimentation are adsorption, coagulation, and flocculation (EPA, 1985). In inter-tidal sediments, bacteria tend to inhabit shallow depressions on sand and silt grains. They are generally not found on particles less than 10 microns. Instead, clay sized particles tend to accumulate in bacteria biofilm which increases as the summer progresses (DeFlaun and Mayer 1983.) The settling velocity of attached bacteria is the same as the settling velocity of the material it is adsorbing to. Bai and Lung (2006) used a settling velocity of $1 \times 10^{-5}$ m/s for cohesive sediments in a tidal basin in Washington, DC. Herrera (2011) reported an almost three-fold increase in bacteria in winter season compared to baseflow conditions attached to suspended sediments in the water column.

FC die-off rates may be slower in sediment compared with water column rates due to the physical protection from predation and exclusion of light. Clays and organic matter have been shown to provide protection to E. coli from phage attack, and a physical protective mechanism has been indicated in studies of estuaries (Faust et al., 1975). A longer survival time of E. coli in sediments compared to seawater was demonstrated in several other studies, and was attributed to higher organic content in sediments (Gerba and McLeod, 1976; Hood and Ness, 1982; Van Donsel and Geldreich, 1971).

In at least one study, E. coli bacteria were shown to accumulate glycine butane (an osmoprotectant molecule) from relatively nutrient-rich sediments (Ghoul et al., 1990). Caldas et al. (1999) showed that glycine betaine is not only an osmoprotectant but also a thermoprotectant. The glycine betaine is either obtained from extracellular environment or synthesized from choline.

Bai and Lung (2006) concluded that there was a lack of available data on sediment die-off rates for FC bacteria. They used a sediment die-off rate of 0.2/day for FC for a tidal basin. This was half the dark condition die-off rate in the water column. The EPA (2001b) documented the die-off rates in stream sediments at 0.01 to 0.023 per day at 18° C.

#### Previous growth history

Rozen and Belkin (2001) noted that the ability of enteric bacteria to survive would depend on the history preceding the seawater shock. Pre-adaptation to seawater increased viability. Bacteria in the lag growth phase were more sensitive to seawater compared to those in the exponential growth or stationary phase. Exposure to environmental stress improved adaptability to seawater.

### Biotic factors

#### Grazing and competition

Various studies indicate that the main predators of bacteria in the marine environment are protozoa (Enzinger and Cooper, 1976; Davies et al., 1995; Barcina et al., 1992). Microbes also compete for nutrients, and it has been shown that E. coli is a poor competitor of nutrients under low nutrient concentrations characterizing natural seawater (Jannasch, 1968).

#### Bacteriophages

It has been shown that phages detected in seawater were active against E. coli among other enteric bacteria (Carlucci and Pramer, 1960). However, bacteriophages were effective in reducing E. coli populations only under nutrient-rich conditions, suggesting a minor role of bacteriophages under natural conditions.

#### Antibiotics and toxins

Although in-vitro studies report a reduction in enteric bacteria population due to antibiotics produced by microorganisms, there is no evidence that such effects are present in seawater (Rosenfeld and Zobell, 1947). There are also reports of a negative impact on enteric bacteria from an algal toxin (Carlucci and Pramer 1960). Impacts on enteric bacteria from heavy metal toxicity were reported by Jones (1964).

### Lumped die-off rates

Many researchers lump the overall die-off rate as a first-order decay process (Bowie et al., 1985) with a die-off ranging from 0.05/day to 4/day (Brown and Barnwell, 1987).

*This page is purposely left blank*

# Goals and Objectives

## Project goals

The goal of this project is to establish load and wasteload allocations for fecal coliform (FC) bacteria for the various point and nonpoint sources in Oakland Bay and Hammersley Inlet so the water quality standard for FC is met throughout Oakland Bay.

## Study objectives

- Characterize FC concentrations and loads at all tributary locations monitored.
- Develop a calibrated hydrodynamic model of Oakland Bay and Hammersley Inlet. This model would accurately predict observed tidal elevations, salinity profiles, and water column temperatures.
- Develop a calibrated water quality model of Oakland Bay and Hammersley Inlet. This model would accurately predict observed FC concentrations in the water column.
- Develop load allocations at the mouths of all tributaries necessary to achieve water quality standards for bacteria in Oakland Bay and Hammersley Inlet.
- Develop load allocations for bacteria at selected upstream locations in tributaries where bacterial standards are not met or where additional reductions are necessary to meet Washington State water quality standards in Oakland Bay and Hammersley Inlet.

# Field Data Collection

## Study methods for freshwaters

Ecology and the Squaxin Island Tribe undertook a study in November 2004 (Ahmed and Sullivan, 2004) to monitor fecal coliform (FC) bacteria in tributaries to Oakland Bay and Hammersley Inlet. Twenty-six freshwater sites were monitored twice a month for one year, between November 2004 and November 2005. Monitoring stations in each tributary are shown in Figures 7-9. Several of the stations initially proposed for monitoring during the development of the study (Ahmed and Sullivan, 2004) were dropped later due to unresolved accessibility issues.

Streamflows were also measured during each sampling event at stations near the mouth of each tributary. Conductivity and temperature readings were taken at each station during each sampling event.

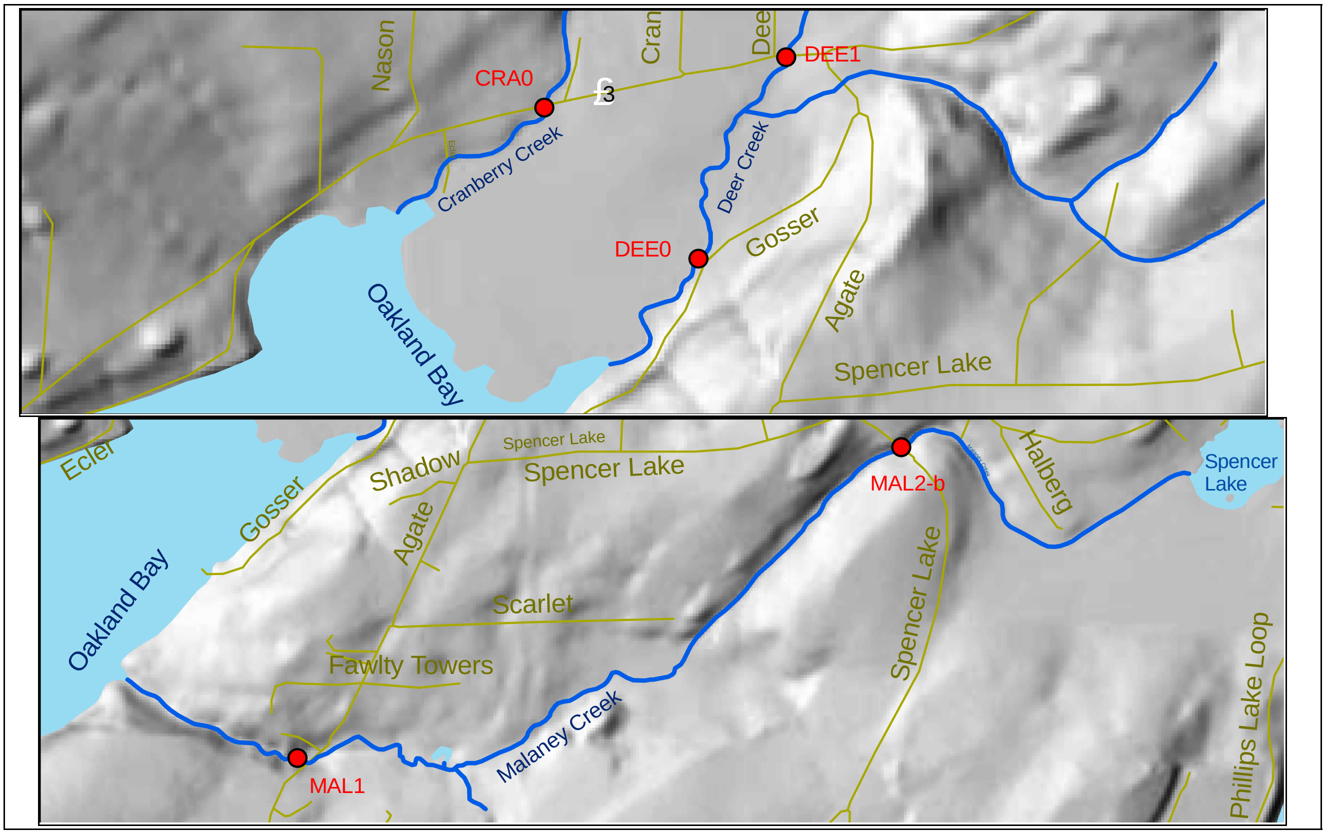



**Figure 7. Monitoring stations in Cranberry, Deer, and Malaney Creeks.**

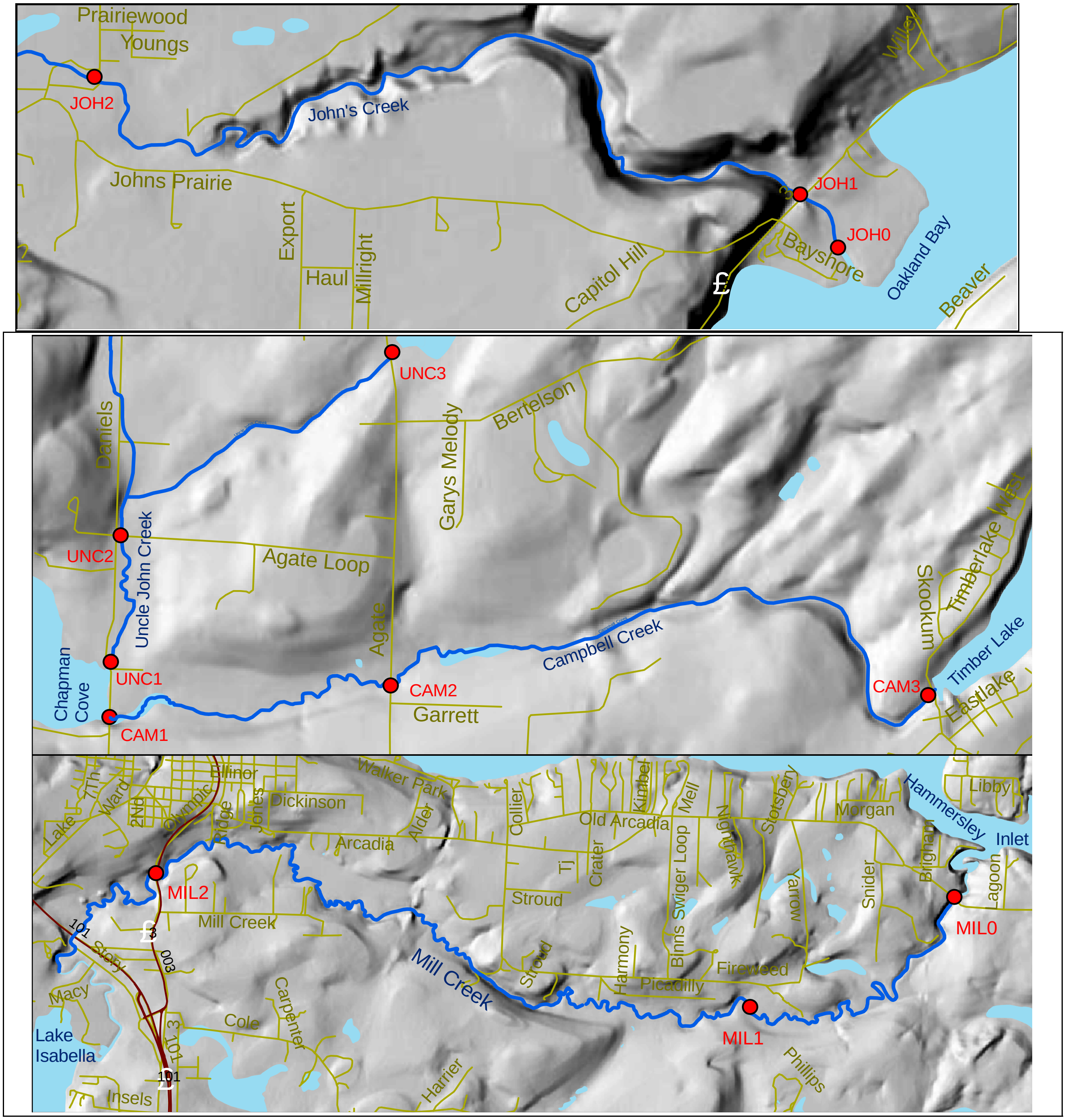



**Figure 8. Monitoring stations in Johns, Uncle John, Campbell, and Mill Creeks.**

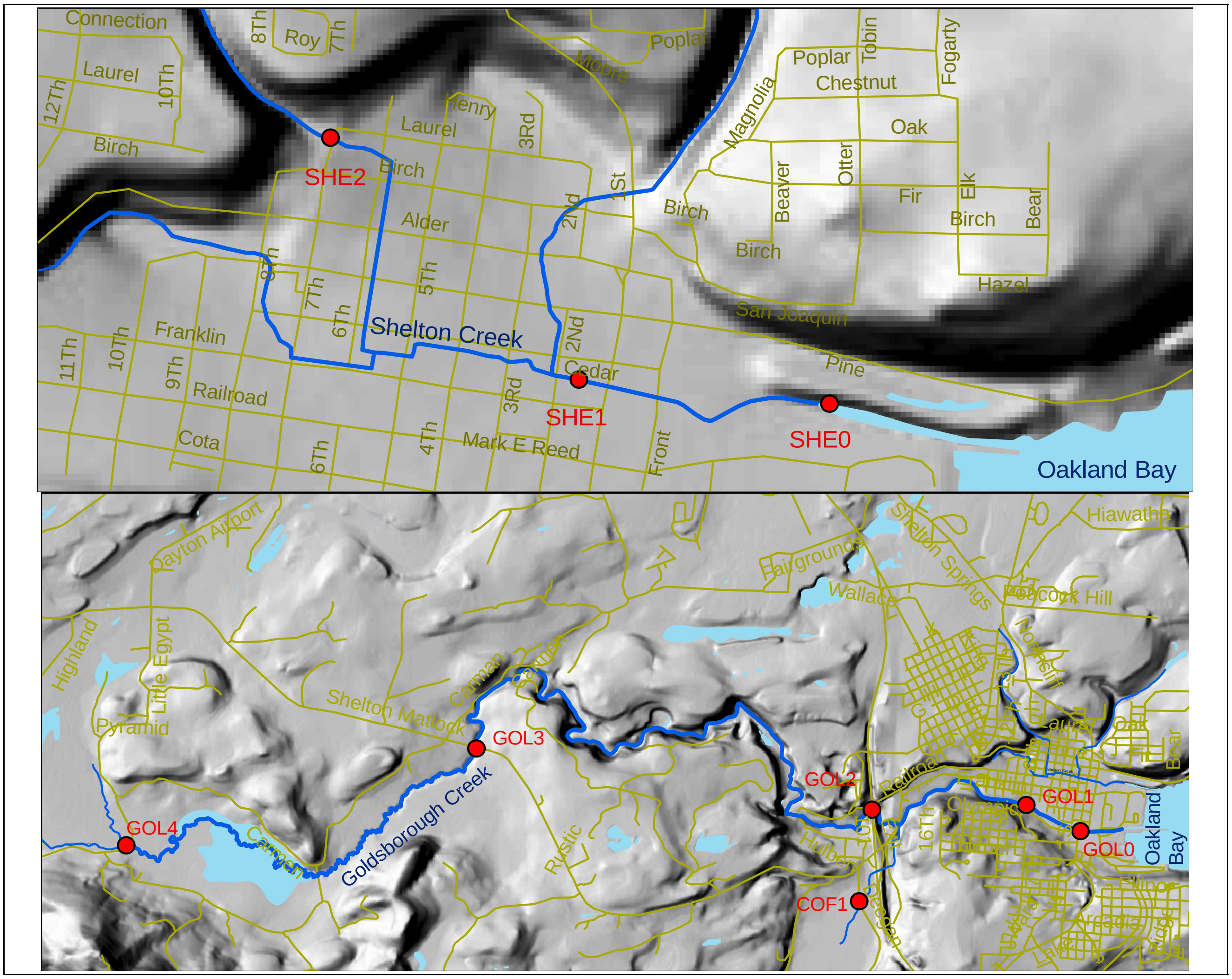



**Figure 9. Monitoring stations in Shelton and Goldsborough Creeks.**

## Study methods for marine waters

Water elevations, salinity, temperatures, and single–depth current velocity vectors were continuously measured near the mouth of Hammersley Inlet using bottom-deployed InterOcean meter, S4. Another S4 simultaneously deployed in Oakland Bay failed to work. The S4 deployed near the mouth of Hammersley Inlet collected data from January through June 2005. In addition, a bottom-mounted Acoustic Doppler Current Profile (ADCP) meter was installed in Hammersley Inlet to continuously measure vertical velocity gradients during two periods: January 13 - April 19, 2005 and October 13 - December 28, 2005. In addition, four continuous temperature devices were installed in Oakland Bay (November 2004 - January 2006) and Hammersley Inlet (Figure 10). However, data from only two stations in Hammersley Inlet were available.

The Washington State Department of Health (DOH) continued its regular monitoring of FC bacteria in Oakland Bay (once a month) and Hammersley Inlet (once every two months) using the most probable number (MPN) method. DOH stations are shown in Figure 10. Ecology also monitored for FC and salinity at selected DOH stations on scheduled DOH monitoring days.

## Study methods for shoreline surveys

Shoreline surveys were conducted to monitor FC bacteria and flows from pipes, culverts, seepages, drainages, and un-named tributaries. The first survey was conducted to establish physical locations of these sources and to estimate the number of samples that needed to be analyzed during storm events. The next surveys were planned for actual sampling of storm events. Several teams were organized to cover the approximately 30 miles of shoreline with the help of kayaks, canoes, and motor boats, or simply by walking along the water line.

## Quality assurance evaluation

All Ecology and Squaxin Island Tribe water samples were analyzed using the membrane filter (MF) method. The measurement quality objective (MQO) used by Ecology's Manchester Environmental Laboratory for fecal coliforms in laboratory duplicates was met for this project. The MQO used by Ecology's Environmental Assessment Program for field duplicates was also met for this project. Detailed analysis for the MQO is presented in Appendix C.

Continuous temperature measuring devices in the marine environment were affected by tidal action, resulting in devices day-lighting during very low tides. This potential was evaluated to validate the marine temperature measurements as shown in Appendix H.

## Study methods for sediments

Sediments were analyzed by Thurston County Environmental Laboratory using a modified 5-tube MPN method that uses a blending extraction procedure, using a buffer prior to employing the MPN method (Clark, 2007). Results were reported as MPN per 100 g dry weight.

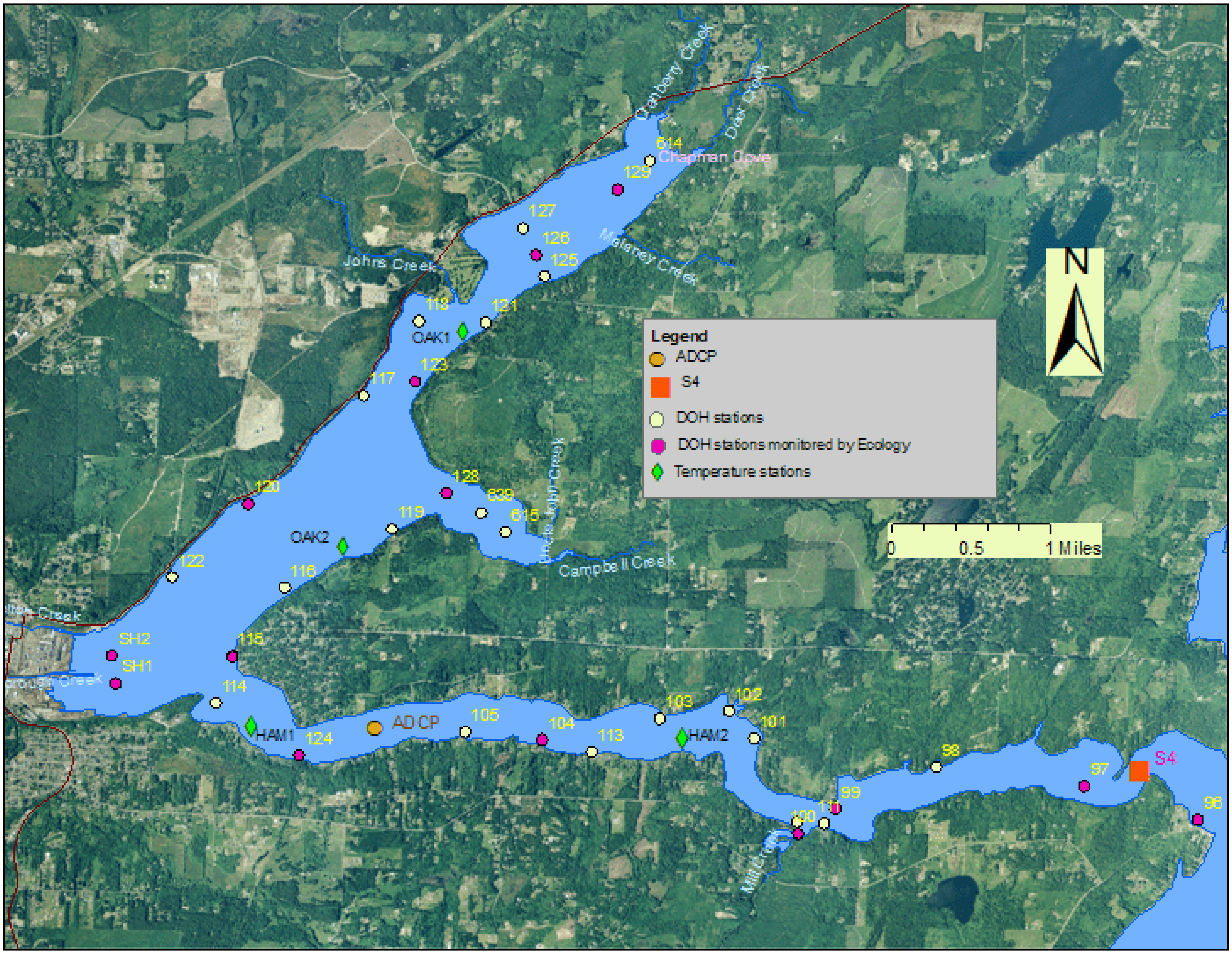



**Figure 10. Location of DOH and Ecology FC monitoring stations, ADCP current meter**

# Results and Discussion

Appendix B includes all freshwater monitoring data. Appendix D contains all tributary flow data. Appendices E and F contain seasonality and regression analysis of bacteria concentrations in the tributaries. Appendix G contains all marine monitoring data.

## Streamflow data

In addition to measured flow data presented in Appendix D, flow data were also obtained from installed gages in the following four creeks. The Squaxin Island Tribe maintains the gauges for the last three creeks.

- Goldsborough Creek (USGS gauge 12076800 near 7th Street bridge, station GOL1).
- John's Creek (two gauges: one at Highway 3 bridge at station JOH1, and the other at John's Creek Drive bridge at station JOH2).
- Mill Creek (gauge at Highway 3 bridge at station MIL2).
- Cranberry Creek (gauge at Highway 3 bridge).

The continuous flow data at Goldsborough Creek, along with the respective drainage areas, were used to develop continuous flow data for ungauged streams. The measured flows were used to calibrate these predictions. The calibrated flows are presented in Appendix D. Figure 11 shows the relative contribution of freshwater flow to Oakland Bay and Hammersley Inlet. Goldsborough Creek contributes the highest flow, while Uncle John Creek contributes the lowest.

The drainage area for Oakland Bay and Hammersley Inlet is 162.8 square miles (Taylor 2000). The drainage areas for the major tributaries – Goldsborough, Shelton, Johns, Cranberry, Deer, Malaney, Uncle John, Campbell, and Mill Creeks – account for 144.7 square miles. The remaining 18.1 square miles is along the perimeter of Oakland Bay and Hammersley Inlet. Based on drainage areas, about 11% of flow to Oakland Bay-Hammersley Inlet would come from the shoreline areas not drained by the tributaries (Figure 12).

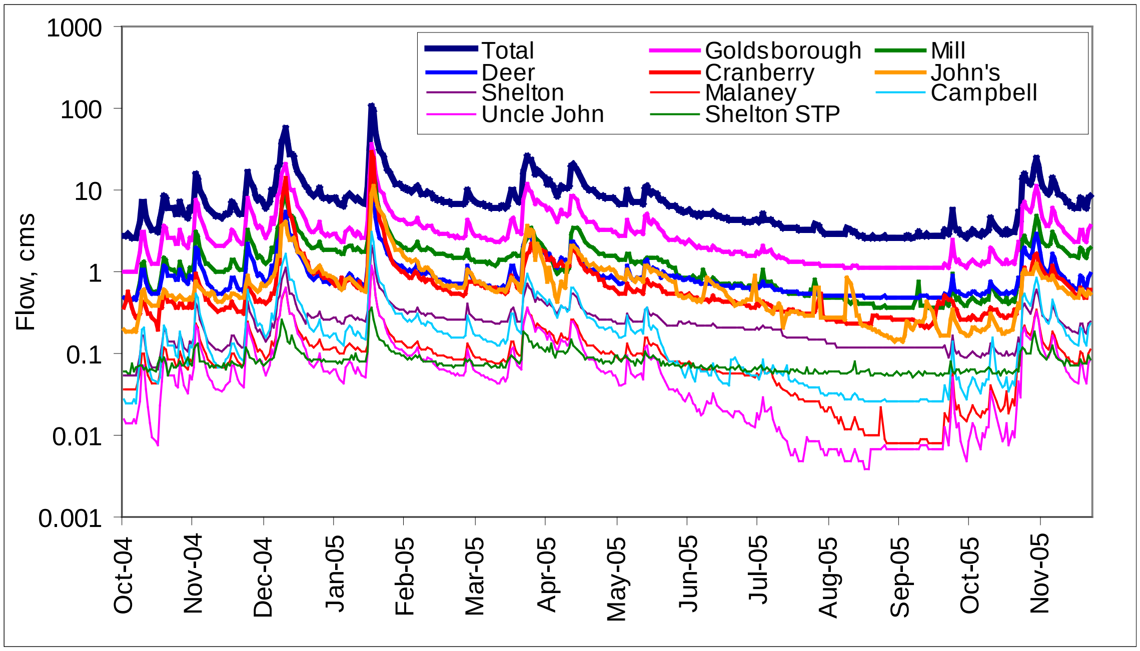



**Figure 11. Daily average flows from all tributaries to Oakland Bay and Hammersley Inlet ( 10/1/04 – 11/30/05).** STP = Sewage treatment plant.

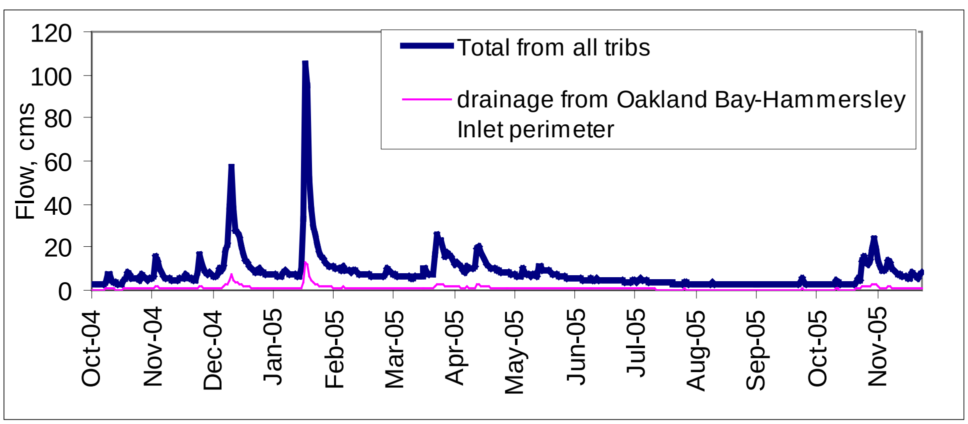



**Figure 12. Relative flows from the portion of watershed drained by all the tributaries, and flow directly contributed to the bay from areas near the perimeter ( 10/1/04 – 11/30/05).**

During the shoreline survey conducted on February 14 and 15, 2005, the total flow measured at all the shoreline pipes, un-named tributaries, culverts, seepages, and drainages was 12.8 cfs (0.363 cms). The average flow from all the major tributaries during these two days was 281.5 cfs (7.97 cms). This equates to approximately 4.5% of the total freshwater flow.

The discrepancy between flows based on drainage areas (11 percent) versus what was measured during the shoreline survey (4.5 percent) could be due to the time of measurement relative to the travel time in the streams in association with the rainfall event, and the short travel time for perimeter rainwater to drain to the bay.  The relatively crude method (bucket and stop watch) of flow measurement during the shoreline survey involves more error compared to flow measurement in the streams.

## Fecal coliform bacteria at tributary stations

Table 5 shows the annual geometric mean and 90th percentile of FC data collected at each station. Coliform concentrations were highest in Uncle John Creek compared to all freshwater stations monitored. The geometric mean freshwater quality standard for FC of 100 cfu/100 mL was met at all but one station (UNC1) on an annual basis.  Station UNC1 is at the mouth of Uncle John Creek.  Two stations in Uncle John Creek (UNC1 and UNC2) and one station in Shelton Creek (SHE1) exceeded the 90th percentile standard of 200 cfu/100 mL on an annual basis.

**Table 5.  Summary of FC data collected by the Squaxin Island Tribe and Ecology (2004-2005).**

| Station | Number of samples, n | Minimum, cfu/100 mL | Geometric mean, cfu/100 mL | Maximum, cfu/100 mL | 90th percentile, cfu/100 mL |
|---|---|---|---|---|---|
| UNC1 | 26 | 15 | 111 | 1700 | 403 |
| UNC2 | 26 | 10 | 65 | 450 | 290 |
| UNC3 | 26 | 1 | 14 | 240 | 63 |
| CAM 1 | 26 | 2 | 31 | 165 | 132 |
| CAM 2 | 26 | 1 | 23 | 380 | 131 |
| CAM 3 | 26 | 1 | 4 | 170 | 24 |
| JOH 0 | 26 | 5 | 22 | 190 | 70 |
| JOH 1 | 26 | 2 | 20 | 110 | 72 |
| JOH 2 | 26 | 6 | 29 | 160 | 82 |
| SHE 0 | 26 | 6 | 45 | 550 | 173 |
| SHE 1 | 26 | 1 | 41 | 720 | 234 |
| SHE 2 | 26 | 1 | 4 | 38 | 17 |
| GOL0 | 26 | 2 | 18 | 100 | 62 |
| GOL1 | 25 | 3 | 18 | 185 | 56 |
| GOL2 | 25 | 1 | 14 | 240 | 76 |
| GOL3 | 26 | 2 | 23 | 260 | 77 |
| GOL4 | 26 | 2 | 18 | 190 | 63 |
| COF1 | 25 | 1 | 20 | 160 | 95 |
| MIL 0 | 26 | 7 | 19 | 89 | 53 |
| MIL 1 | 26 | 1 | 24 | 130 | 95 |
| MIL 2 | 26 | 1 | 10 | 98 | 55 |
| MAL1 | 26 | 3 | 23 | 160 | 99 |
| MAL2b | 24 | 5 | 24 | 170 | 106 |
| DEE0 | 26 | 2 | 22 | 140 | 79 |
| DEE1 | 26 | 2 | 25 | 100 | 97 |
| CRA1 | 26 | 4 | 24 | 96 | 65 |

A continuous time-series of FC concentrations at tributary mouths was developed using the multiple variable log-linear regression model of Cohen et al. (1992). This is described in detail in Appendix F. The model predicts coliform concentrations as a function of flow and time of the year. Figure 13 shows the predicted and observed coliform concentrations near the mouth of Johns Creek using this model. Appendix F includes similar relationships developed for the other creeks. Appendix F also provides predictions of geometric means, 90th percentiles, and total annual loads.

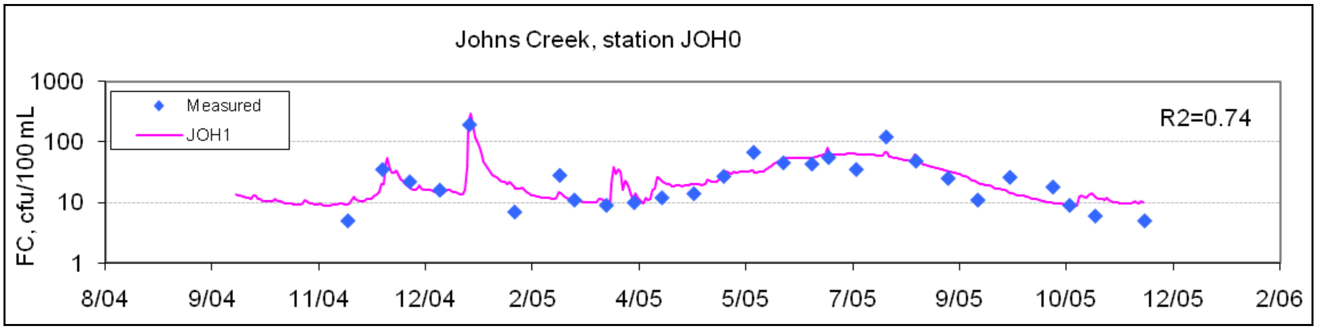



**Figure 13. Predicted and observed FC concentrations near the mouth of Johns Creek (8/04 – 2/06).**

## Fecal coliform bacteria at marine stations

Table 6 shows the annual geometric mean and 90th percentile of FC data collected at each marine station monitored by the Washington State Department of Health (DOH). The analytical method employed by DOH is the most probable number (MPN) method. The difference between the MPN method and the membrane filter (MF) method (used for fresh water) is discussed in Appendix G.

The geometric mean water quality standard for FC of 14 cfu/100 mL was met at all but one station (DOH614) on an annual basis. Station DOH614 is in Upper Oakland Bay (see Figure 10). The 90th percentile standard of 43 cfu/100 mL was exceeded at several stations on an annual basis. The highest 90th percentile concentrations were observed at two stations (DOH614 in Upper Oakland Bay and DOH615 in Chapman Cove).

**Table 6. Summary of FC data collected by the Department of Health (2004-2006).**

| Station | Number of samples, n | Minimum, MPN/100 mL | Geometric mean, MPN/100 mL | Maximum, MPN/100 mL | 90th percentile, MPN/100 mL |
|---|---|---|---|---|---|
| DOH96 | 13 | 1.7 | 2 | 11 | 5 |
| DOH97 | 13 | 1.7 | 2 | 17 | 5 |
| DOH98 | 13 | 1.7 | 2 | 11 | 5 |
| DOH99 | 13 | 1.7 | 3 | 17 | 7 |
| DOH100 | 13 | 1.7 | 10 | 350 | 83 |
| DOH101 | 13 | 1.7 | 3 | 33 | 11 |
| DOH102 | 13 | 1.7 | 3 | 64 | 14 |
| DOH103 | 13 | 1.7 | 4 | 49 | 14 |
| DOH104 | 13 | 1.7 | 3 | 49 | 10 |
| DOH105 | 13 | 1.7 | 4 | 49 | 17 |
| DOH111 | 13 | 1.7 | 3 | 49 | 13 |
| DOH112 | 13 | 1.7 | 3 | 17 | 9 |
| DOH113 | 13 | 1.7 | 3 | 23 | 11 |
| DOH114 | 29 | 1.7 | 9 | 240 | 59 |
| DOH115 | 29 | 1.7 | 6 | 49 | 27 |
| DOH116 | 29 | 1.7 | 4 | 79 | 18 |
| DOH117 | 29 | 1.7 | 4 | 43 | 12 |
| DOH118 | 29 | 1.7 | 6 | 49 | 24 |
| DOH119 | 29 | 1.7 | 4 | 110 | 25 |
| DOH120 | 29 | 1.7 | 5 | 130 | 21 |
| DOH121 | 29 | 1.7 | 5 | 170 | 21 |
| DOH122 | 29 | 1.7 | 4 | 170 | 18 |
| DOH123 | 29 | 1.7 | 4 | 350 | 17 |
| DOH124 | 29 | 1.7 | 6 | 79 | 34 |
| DOH125 | 29 | 1.7 | 4 | 130 | 17 |
| DOH126 | 28 | 1.7 | 6 | 130 | 27 |
| DOH127 | 29 | 1.7 | 5 | 240 | 32 |
| DOH128 | 29 | 1.7 | 8 | 2500 | 83 |
| DOH129 | 29 | 1.7 | 10 | 170 | 60 |
| DOH614 | 29 | 1.7 | 16 | 240 | 142 |
| DOH615 | 29 | 1.7 | 14 | 1600 | 140 |
| DOH639 | 29 | 1.7 | 8 | 920 | 64 |
| DOH662 | 25 | 1.7 | 5 | 240 | 23 |
| DOH663 | 24 | 1.7 | 4 | 79 | 17 |
| DOH668 | 25 | 1.7 | 4 | 170 | 15 |
| DOH695 | 4 | 1.7 | 3 | 17 | |

## Shoreline sampling surveys

Ecology and the Squaxin Island Tribe conducted a sampling survey on February 14 and 15, 2005, following a moderate storm event (Figure 14). Out of 122 pipes and culverts located during a reconnaissance survey (in 2004), only 33 had measurable flows for sample collection. In addition, 39 of the 87 drainages, 42 of the 43 seepages, and all (27) of the un-named tributaries, were sampled, respectively. The sampling sites are shown in Figure 14. In the reconnaissance survey of 2004, seven samples were collected under dry weather conditions. Sample locations of FC concentrations at these locations are presented in Appendix G.

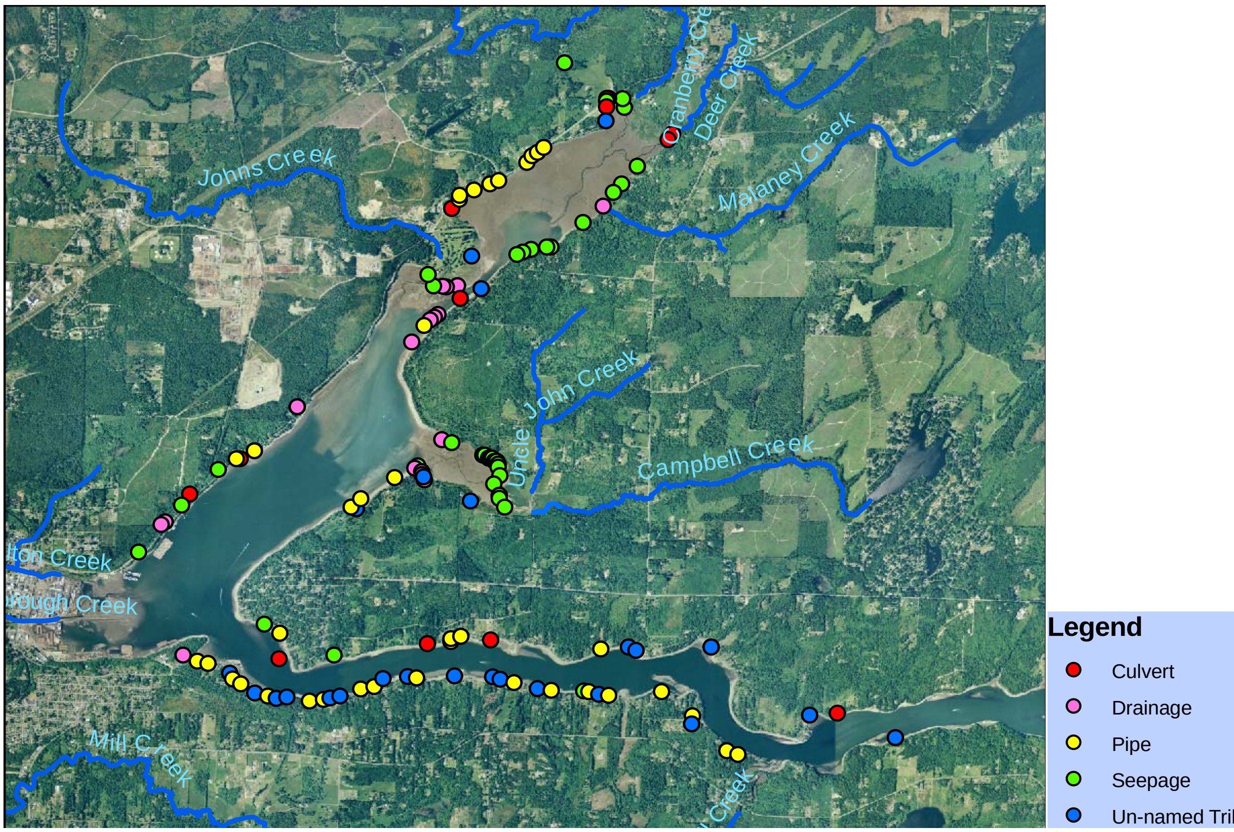



**Figure 14. Shoreline sampling Survey (February 14 and 15, 2005).**

Figure 15 shows that the sampling survey (February 14 and 15) was conducted at the end of a rainfall event. Two-tenths of an inch of rain fell on February 12, with mild rainfall on February 13 and 14.

Figure 16 shows the FC concentrations measured at all the sites. The maximum concentrations in culverts, drainages, and pipes were relatively higher compared to those in seepages and un-named tributaries. A culvert between Deer and Malaney Creeks, with an estimated flow of 0.075 cfs, had the highest coliform concentration (520 cfu/100 mL). The highest coliform concentrations (680 and 801 cfu/100 mL) in drainage discharges were observed in Hammersley Inlet (drainage near Shelton STP) and in Oakland Bay (between Daniels Road and Campbell Creek) with an estimated flow of 0.0003 cfs and 0.0038 cfs, respectively.

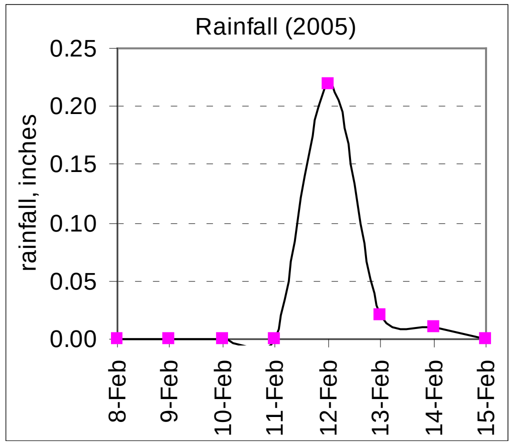



**Figure 15. Rainfall (measured at Flupsy site, Oakland Bay) preceding and during the shoreline sampling event (February 14 and 15, 2005).**

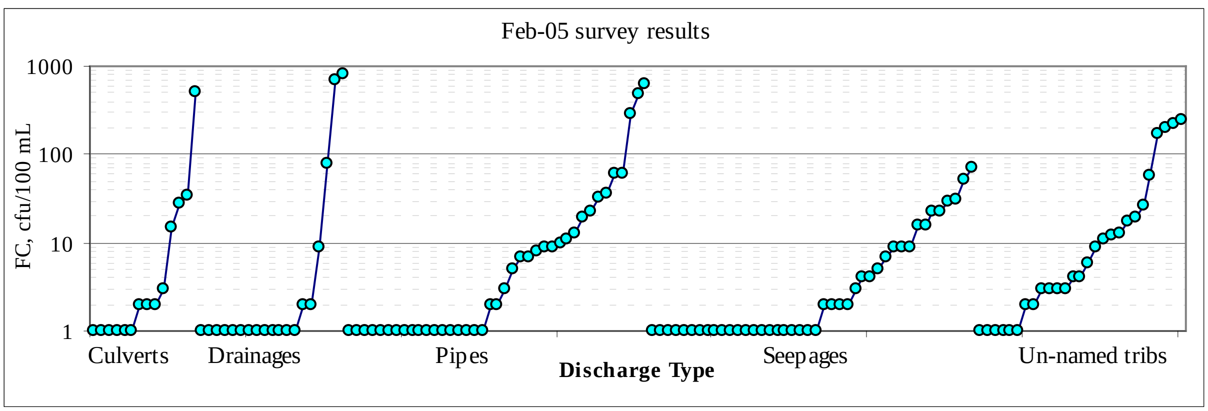



**Figure 16. FCs observed in culverts, drainages, pipes, seepages, and un-named tributaries (February 14 and 15, 2005).**

The highest (>100 cfu/100 mL) coliform concentrations in discharges from shoreline pipes were observed in Hammersley Inlet along the southern shoreline downstream of Eagle Point. The concentrations in three pipes, 6HH-P, 15HH-P, and 3HH-P, were 290, 480, and 630 cfu/100 mL, respectively. The corresponding flows were measured at 0.0177, 0.0177, and 0.0004 cfs.

The GPS readings for stations sampled along the southern shoreline of Hammersley Inlet were lost. However, the type (for example, culvert, pipe, unknown tributary) of discharge was noted. In addition, the stretch of the shoreline from beginning (latitude and longitude known) to the end of the monitoring run was known, and so were the sequence of sample numbers. A previous survey had established locations of all pipes, culverts, etc. Thus, the locations of the stations monitored along the southern Hammersley shoreline were estimated from the above information.

FC concentrations in seepages were all below 70 cfu/100 mL. The highest coliform concentrations in discharges from un-named tributaries were observed in Hammersley Inlet along the western shoreline between Eagle Point and Mill Creek. The concentration of FC at these stations, 18HH-UT and 13HH-UT, were 200 and 240 cfu/100 mL, respectively with corresponding flow of 0.0177 cfs at each station. Another un-named tributary, 7C-UT, in Upper Oakland Bay west of Cranberry Creek had a concentration of 220 cfu/100 mL with a flow of 0.0668 cfs.

The relative bacteria loadings from the shoreline sources compared to the loadings from all the tributaries is in the order of 4.5% based on data collected on February 14 and 15, 2005. However, considering only Upper Oakland Bay, the shoreline contributes about 6% compared to the loading from Cranberry and Deer Creeks, again based on February 14 and 15, 2005 data. In addition, during this period the combined shoreline contribution in Chapman Cove was less than 4.5% of the load from Campbell and Uncle John Creeks.

**Additional surveys**

The Squaxin Island Tribe conducted an intensive shoreline sampling survey of Upper Oakland Bay on November 1 and 14, 2005. Figure 17 shows the rainfall pattern during this period.

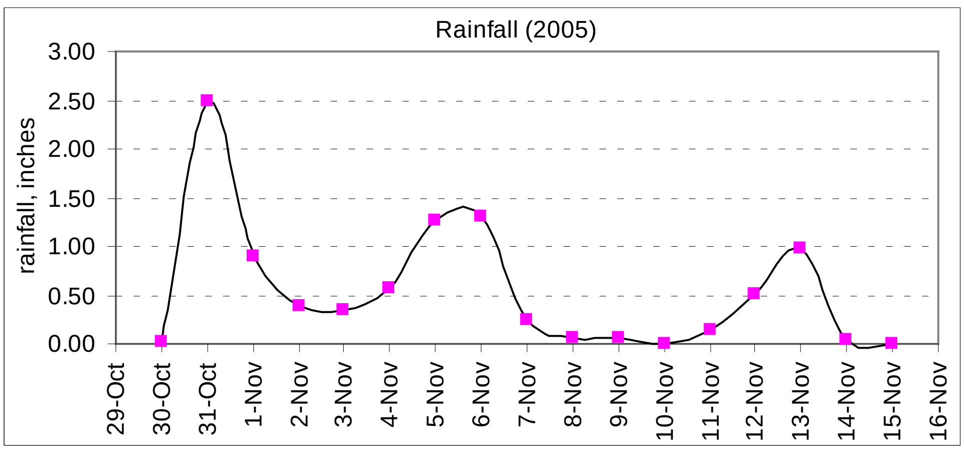



**Figure 17. Rainfall (measured at Flupsy site, Oakland Bay) preceding and during the shoreline sampling event (November 1 and 14, 2005).**

Figure 18 shows the sampling results from November 1 and 14 shoreline survey of Upper Oakland Bay. The coliform concentrations were higher during the storm event.

The Squaxin Island Tribe and Ecology conducted another intensive shoreline sampling event on February 20, 2007. This survey was limited to the Upper Oakland Bay only. Figure 19 shows the rainfall during the sampling event, and Figure 20 shows the location of stations and the associated concentrations of FCs in cfu/100 mL. Two stations adjacent to the Department of Health (DOH) station (DOH 614) were high in FC bacteria. However, other nearby stations did not have such high concentrations.

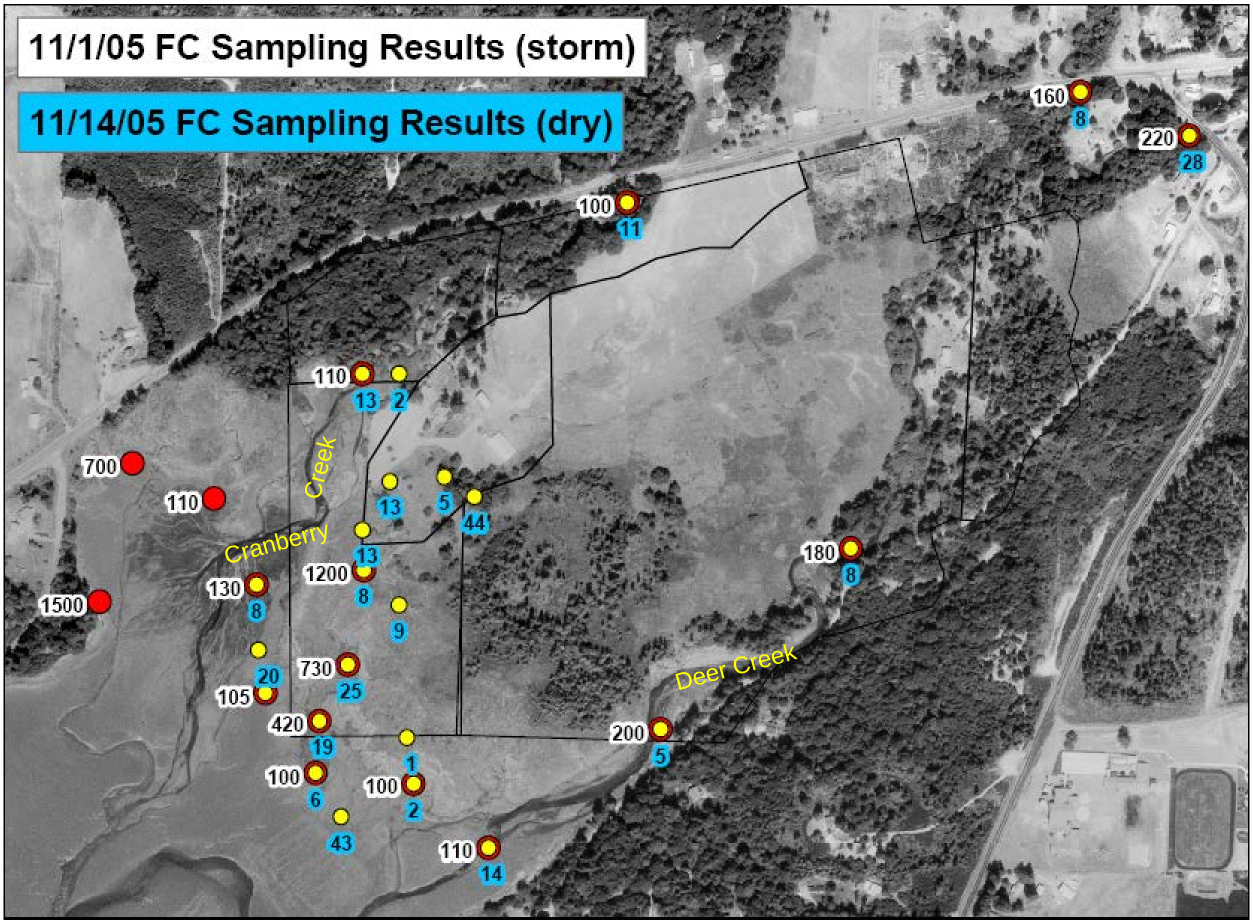



**Figure 18. Shoreline sampling survey of Upper Oakland Bay (November 1 and 14, 2005).**

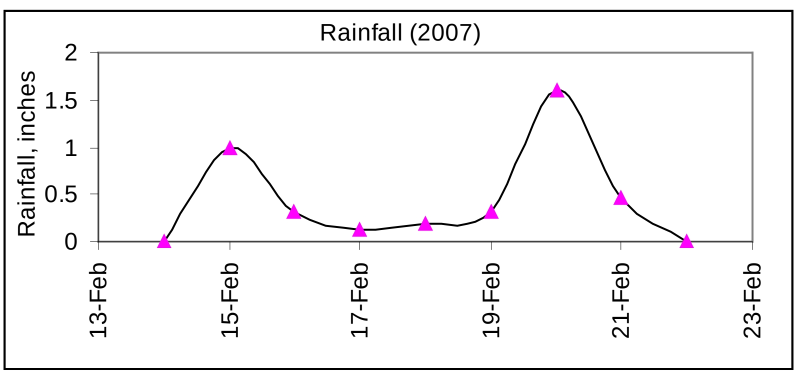



**Figure 19. Rainfall (at Flupsy site, Oakland Bay) preceding and during the shoreline sampling event (February 20, 2007).**

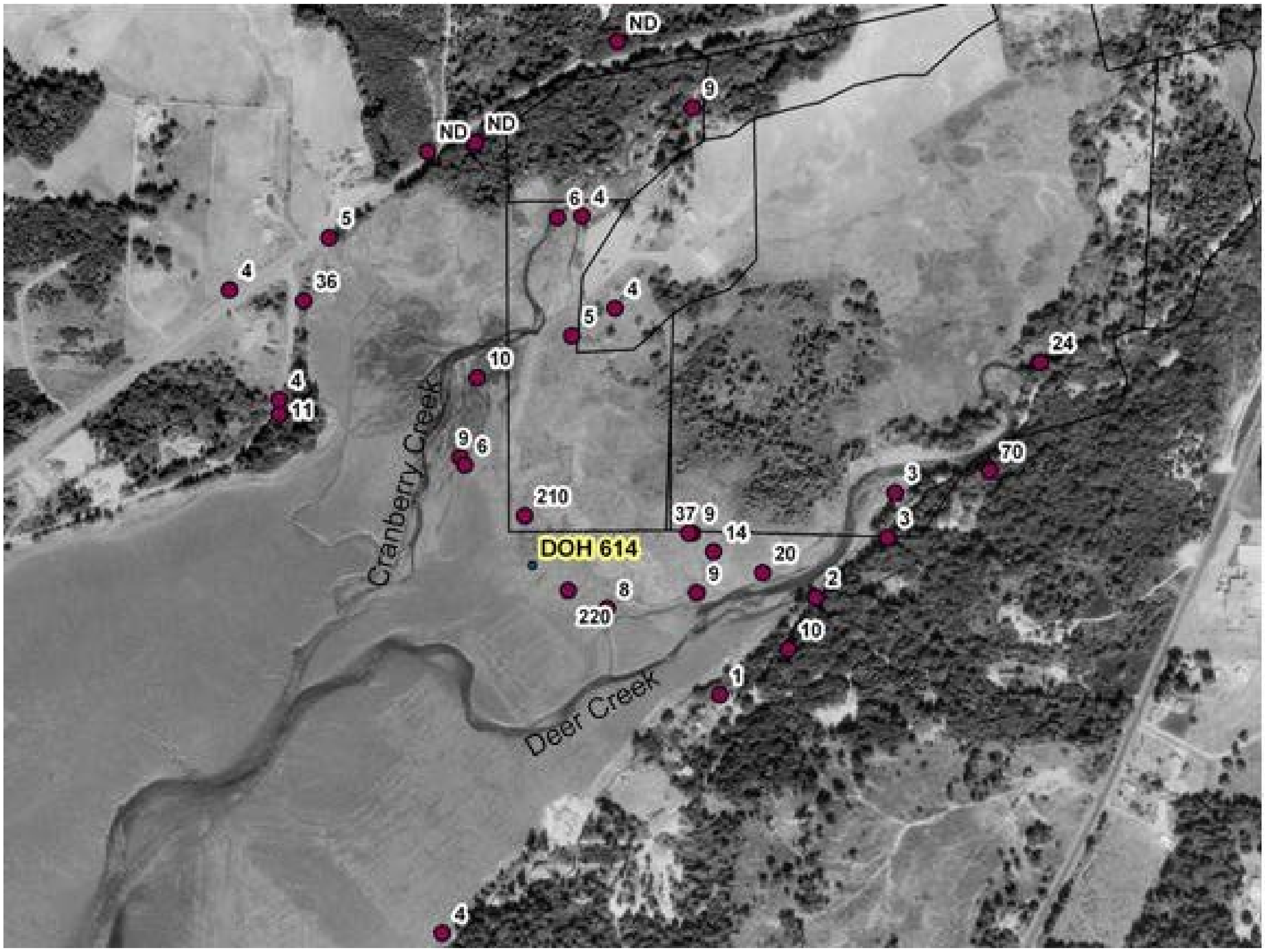



**Figure 20. Shoreline sampling survey of Upper Oakland Bay (February 20, 2007).**

The Squaxin Island Tribe and Ecology conducted shoreline sampling of Chapman Cove on March 12, 2007. Figure 21 shows the rainfall pattern during the sampling event, and Figure 22 shows the location of stations and the associated concentrations of FCs in cfu/100 mL.

Another intensive sampling was conducted along the shoreline in Upper Oakland Bay in August 2007 as shown in Figure 23.

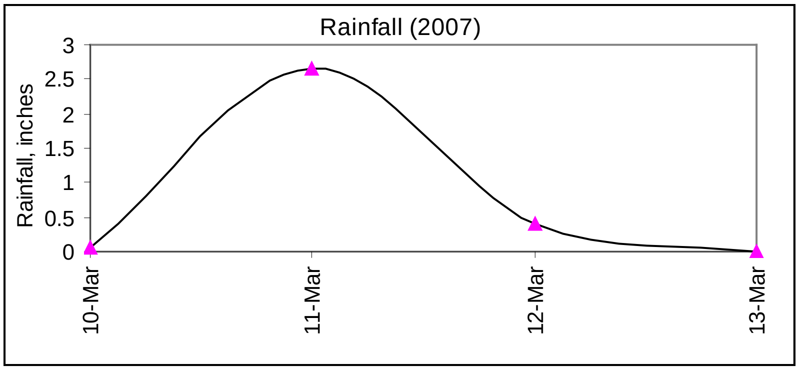



**Figure 21. Rainfall (at Flupsy site, Oakland Bay) preceding and during the shoreline sampling event (March 12, 2007).**

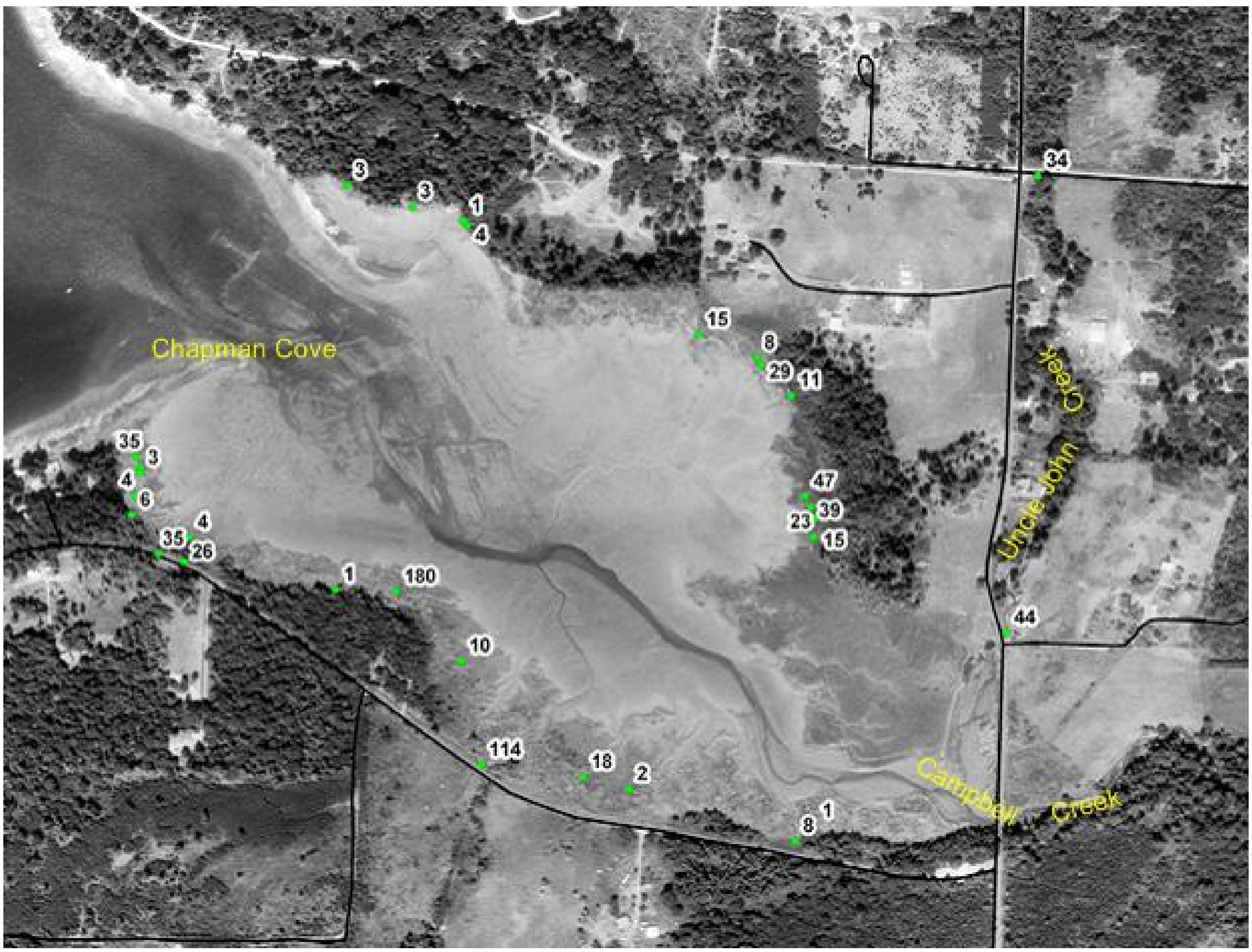



**Figure 22. Shoreline sampling survey of Chapman Cove (March 12, 2007).**

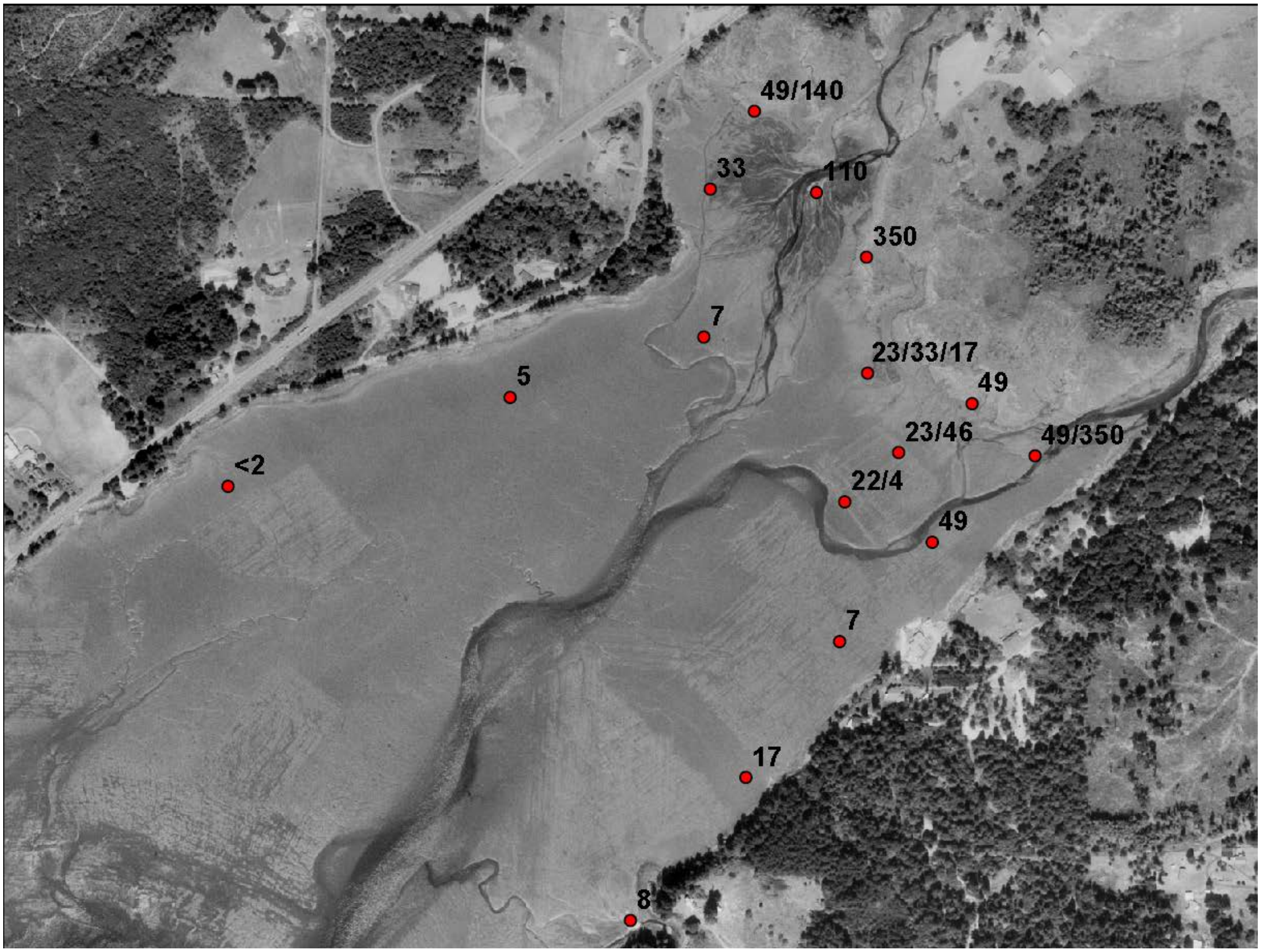



**Figure 23. Shoreline sampling survey of Upper Oakland Bay (August 2007).**

## Seasonality

FC concentrations tend to be high during storm events primarily from increased loading from the tributaries, potential bacteria resuspension from sediments, and reduced salinity.

Figure 24 shows bacteria concentrations at the mouths of all tributaries, the total flow to Oakland Bay from all the tributaries, and the rainfall at the Flupsy dock in Oakland Bay. The FC concentrations are high during storm events. During summer dry conditions, concentrations are also relatively higher. Appendix E contains plots for the individual tributaries.

Figure 25 shows the temporal variation of FC bacteria in Oakland Bay and Hammersley Inlet when all DOH stations sampled within a month were combined. The concentrations of bacteria are high in both winter and summer.

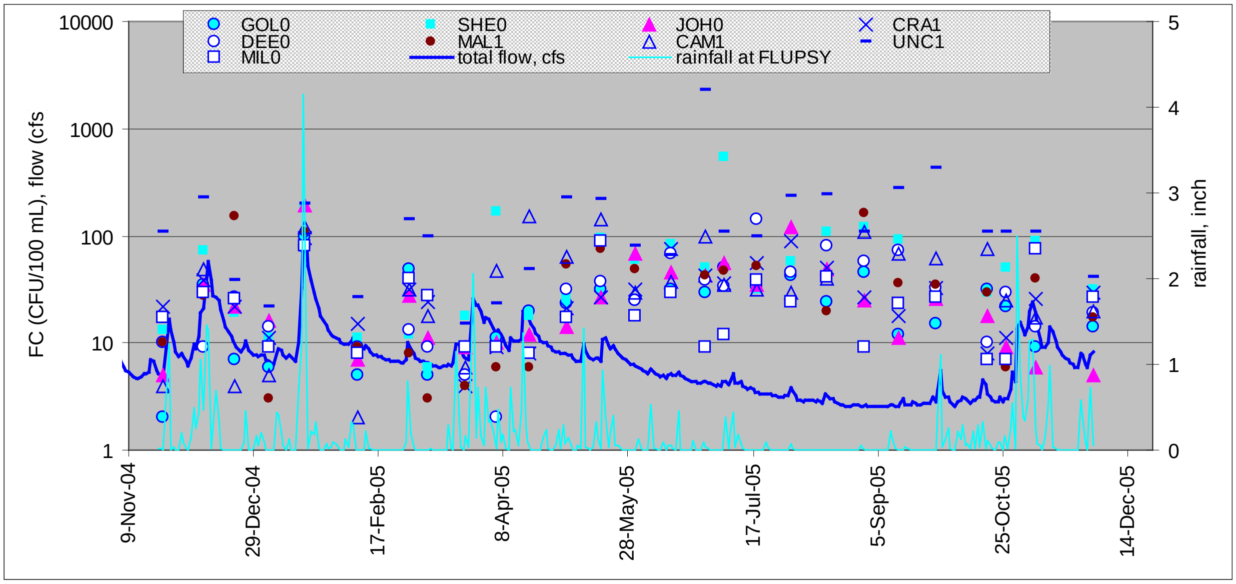



**Figure 24. FC concentrations and total tributary flows during the monitoring period (2004-2005)**

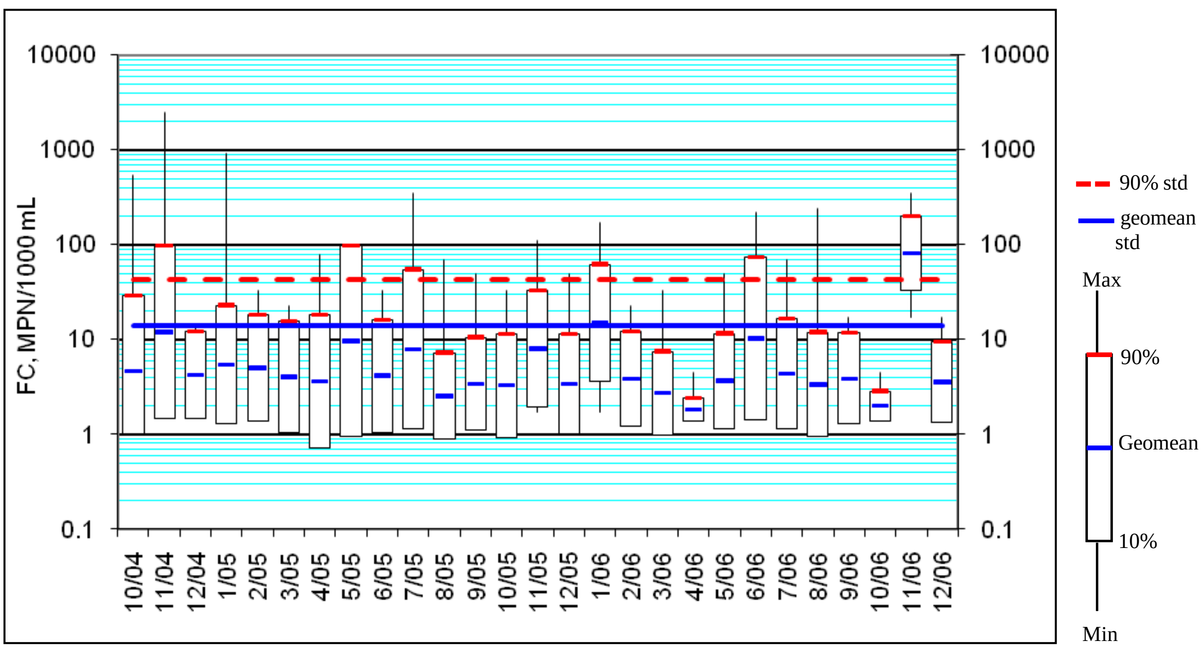



**Figure 25. Lumped temporal FC concentration for Oakland Bay-Hammersley Inlet (2004-2005).**

## Bacterial loads from tributaries

The major tributaries were sampled 27 times between November 2004 and November 2005. Figure 26 shows the relative cumulative loads at the mouths of all the tributaries to Oakland Bay-Hammersley Inlet. Goldsborough Creek, with the highest flow, also contributed the highest load on the days sampled. The loading from Johns Creek is the second highest, followed by Mill, Cranberry, and Deer Creeks.

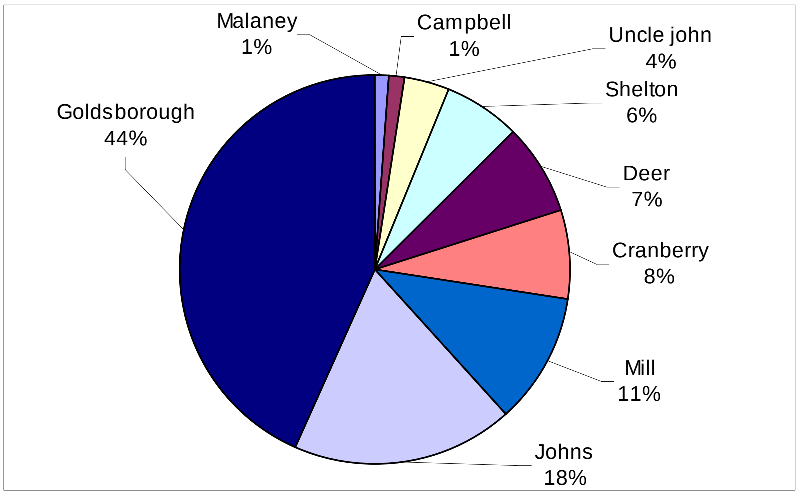



**Figure 26. Relative observed loads at the mouths of tributaries (Nov 2004-Nov 2005).**

## Bacteria concentrations in sediments

Ecology collected sediment samples in March 2006, and Thurston County Environmental Laboratory analyzed the samples for FCs. The results were reported as the most-probable-number (MPN)/100 grams (g) wet. The percent water in the sediment samples was not analyzed, except for the samples collected on March 29 when the dry weight was approximately an average of 20% of the original sample weight. The results (in MPN/100 g wet) and sample locations are presented in Figure 27. High coliform concentrations were found in Upper Oakland Bay, Chapman Cove, and near the mouth of Uncle John Creek.

As discussed earlier, bacterial die-off rates in sediments are much lower compared to the water column due to the physical protection from predation and exclusion of light (Faust et al., 1975). EPA (2001b) documented the die-off rates in stream sediments at 0.01 to 0.023 per day at 18° C. Using a first-order die-off rate and a sediment bacteria decay rate of 0.02/day, it would take approximately six months for bacteria to reduce from 500 cfu/100 g to 14 cfu/100 g given that no bacteria was added to the sediments during this period.

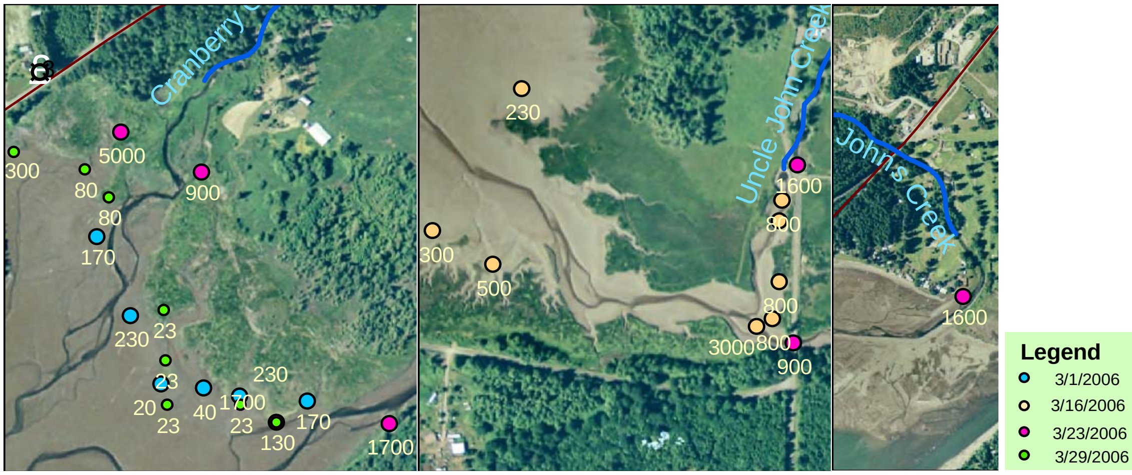



**Figure 27. Sediment FC (MPN/100 g) near mouths of Cranberry, Uncle John, and Johns Creek.**

Figure 28 shows the time in days necessary to reduce FC concentrations to 14 cfu/100 mL at the various stations sampled in March 2006, based on a sediment FC die-off rate of 0.02 cfu/100 mL. The die-off rates would be higher when sediments are re-suspended in the water column and bacteria are exposed to sunlight, higher temperature, and salinity. The overall die-off rate would depend on how much of the sediment gets resuspended, how much settles back, water column temperature, salinity, and depth (for solar radiation).

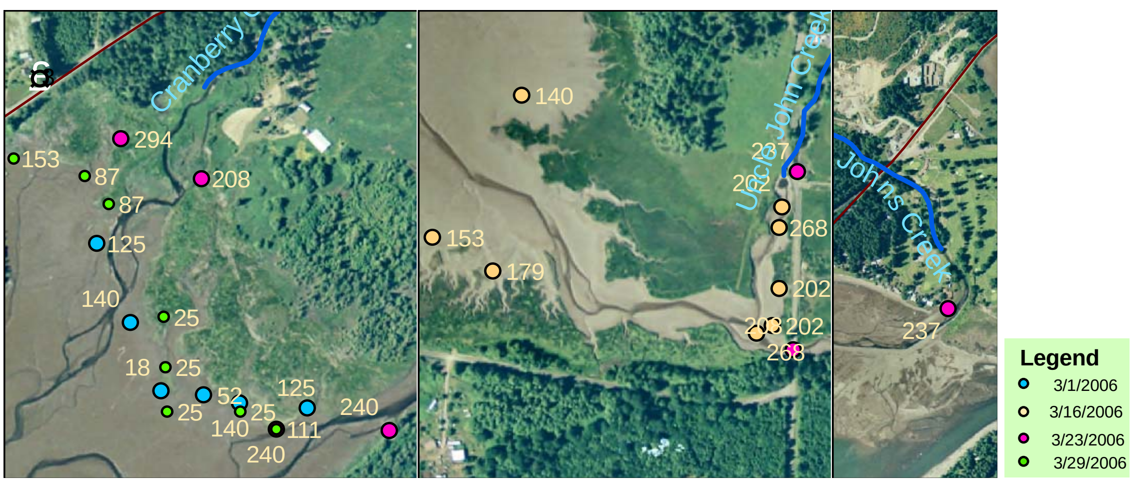



**Figure 28. Days to reduce sediment FC to 14 cfu/100 mL based on a die-off rate of 0.02 /day.**

In summer 2007, the Squaxin Island Tribe collected sediment samples from Upper Oakland Bay mudflats. Table 7 shows the concentrations in the water column and sediments at DOH station 614. As indicated in the table, the sediment concentrations are at least 10 fold higher in the sediments compared to that in the water column. These results are reported based on dry weight.

**Table 7. FCs in the water column and sediments at DOH614 (Summer 2007).**

| Date | Water cfu/100 mL | Sediment, cfu/100 g dry | | Date | Water cfu/100 mL | Sediment, cfu/100 g dry |
|---|---|---|---|---|---|---|
| 05/06/07 | -- | 69 | | 07/17/07 | 69 | -- |
| 05/07/07 | 4 | -- | | 07/17/07 | 67 | -- |
| 05/16/07 | 26 | 110 | | 07/17/07 | ND | -- |
| 05/20/07 | -- | 85 | | 07/23/07 | 27 | 213 |
| 05/21/07 | 32 | -- | | 08/01/07 | 17 | 625 |
| 05/29/07 | 5 | 215 | | 08/06/07 | ND | 888 |
| 06/05/07 | 55 | 175 | | 08/15/07 | 4 | 67 |
| 06/11/07 | 21 | 493 | | 08/20/07 | 20 | 551 |
| 06/19/07 | 8 | 223 | | 08/29/07 | 6 | 54 |
| 06/26/07 | 3 | 96 | | 09/04/07 | 35 | 85 |
| 07/09/07 | 6 | 872 | | 09/12/07 | 94 | 1316 |
| 07/17/07 | 108 | 291 | | 09/17/07 | ND | 484 |

# TMDL Analyses

## Study methods

The TMDL analysis includes the following:

1. Estimating load reductions for all tributaries necessary to meet Washington State water quality standards.
2. Developing a calibrated hydrodynamic and water quality model of Oakland Bay-Hammersley Inlet.
3. Developing load allocations for all the tributaries to Oakland Bay for shellfish protection.
4. Re-estimating load reductions for all tributaries, based on meeting the load allocations estimated from the model.

## Estimating load reductions for tributaries based on freshwater criteria

An initial FC load reduction for the tributaries was estimated based on data collected by the Squaxin Island Tribe (SIT) from 2001-2004, and by Ecology and the SIT from 2004-2005. Both annual and seasonal geometric means and 90th percentiles of FC concentrations were evaluated.

### Goldsborough Creek

The 303(d) list includes Goldsborough Creek based on six data points for FC bacteria collected in the winter of 1987-1988 (Michaud, 1987). The samples were collected close to the mouth of the creek, below the industrial stormwater outfall. In the same study, the creek was in compliance with the water quality standards upstream of this station.

Current data (2001-2005) shows that all the stations monitored comply with the state freshwater FC standard (geometric mean of 100 cfu/100 mL and 90th percentile of 200 cfu/100 mL) whether the data are combined or evaluated on a seasonal basis. However, reductions in fecal coliforms in Goldsborough Creek may be required based on meeting the marine FC standards at the mouth of the creek. This is discussed in the next section.

Figure 29 shows only the worst case among the various scenarios evaluated (combined 2001-2005, combined 2004-2005, seasonal September-April, and May-August). The May-August period was the most critical. Station GOL0 (near the mouth at Highway 3 or N 1st Street bridge) is located at approximately river mile 0.5. Michaud (1987) found a city storm drain and two industrial storm drains downstream of this location, and found elevated FC concentrations at the city drain and downstream of the outfalls. Meeting water quality standards at these outfalls would potentially bring the lower 0.5 miles of Goldsborough Creek into compliance with the water quality standards.

The locations of monitoring stations described in Figure 29 are shown on the map in Figure 9.

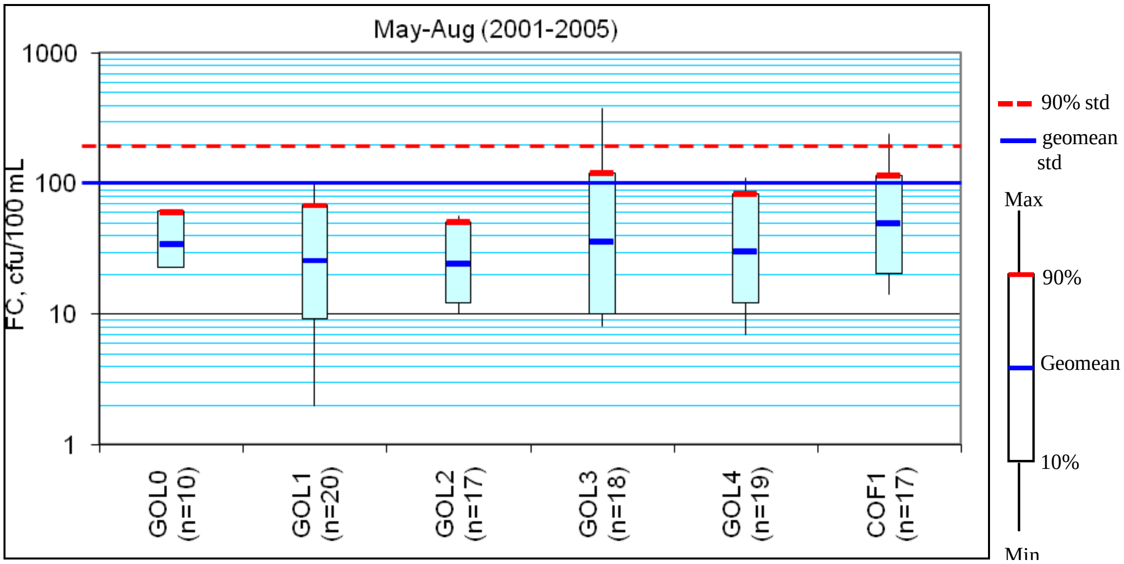



**Figure 29. Seasonal FC evaluation for Goldsborough Creek (May-August, 2001-2005).**

## Shelton Creek

Shelton Creek was listed on the 303(d) list of water bodies as not meeting the state standard for FC bacteria based on data gathered by Michaud (1987) at river mile 0.2 (below the BNSF railway and east of Front Street). During the 2004-2005 monitoring period, Shelton Creek was monitored both upstream (station SHE1 at Dairy Queen near N 1st Street) and near the mouth of the creek (station SHE0) as well as at station SHE2 (on 7th Street between Laurel and Birch Streets; see Figure 9). Current data shows that the May-August period is most critical, as shown in Figure 30.

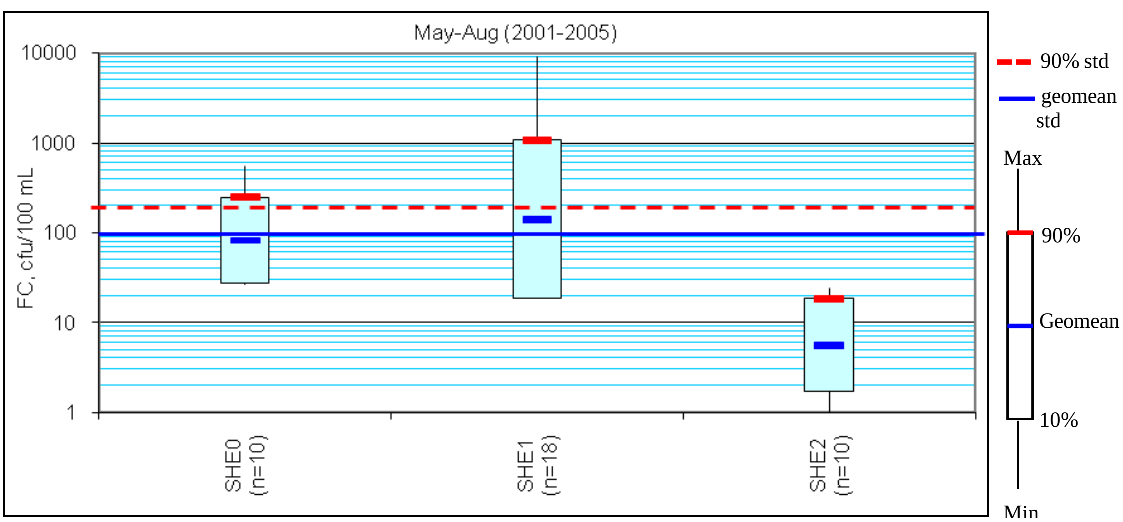



**Figure 30. Seasonal FC evaluation for Shelton Creek (May-August 2001-2005).**

Load reductions are deemed necessary at stations SHE1 and SHE0 to bring these stations into compliance with state standards for FC. Table 8 shows the necessary load reductions based on either meeting the geometric mean or 90th percentile freshwater standard, whichever is more restrictive. Additional reductions may be necessary to meet marine water quality standards for FC at the mouth of the creek as discussed in the next section.

**Table 8. Load reductions for Shelton Creek based on freshwater criteria (May-August, 2001-2005).**

| Station | Geometric mean (cfu/100 mL) | 90th percentile | Load reduction (percent) |
|---|---|---|---|
| SHE0 | 83 | 249 | 20 |
| SHE1 | 142 | 1068 | 81 |

## Malaney Creek

Malaney Creek was included in the 303(d) list of water bodies as not meeting state FC standards based on limited data (six data points) collected by the Squaxin Island Tribe at the Agate Road culvert in 2002. The current data evaluation includes data collected between 2001 and 2005. Seasonal geometric means and 90th percentiles were more critical compared to those on an annual basis. Figure 31 shows the geometric means and 90th percentiles during May-August (2001-2005). The expanded data set shows that Malaney Creek is in compliance with the state standards for FC bacteria for freshwater. However, additional reductions in FC bacteria may be necessary to meet the marine water quality standards at the mouth of the creek. This is discussed in the next section.

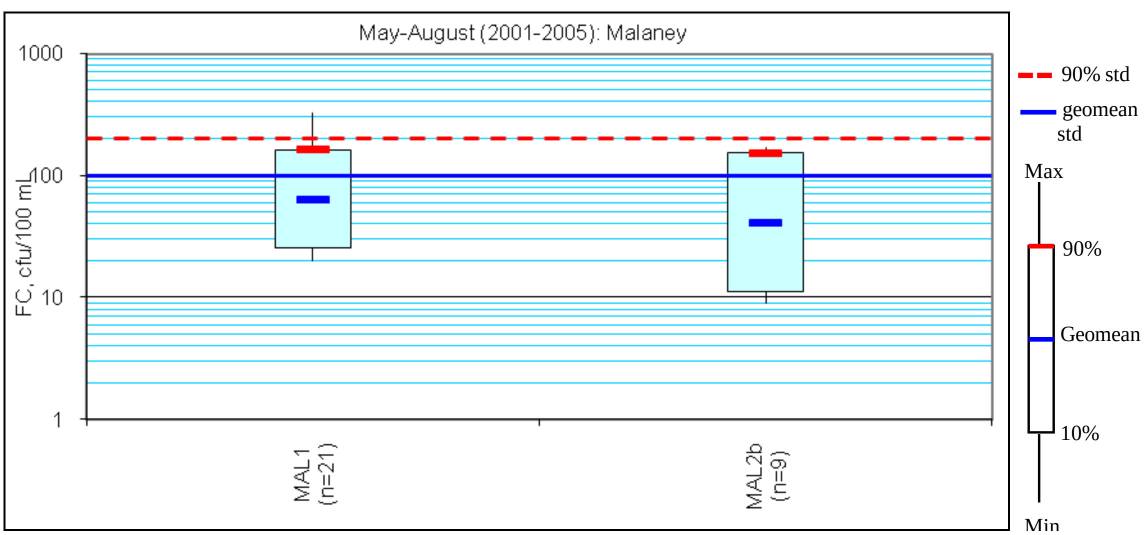



**Figure 31. Seasonal FC evaluation for Malaney Creek (May-August, 2001-2005).**

## Campbell Creek

Campbell Creek station CAM2 (just below Agate Road culvert) was included on the 303(d) list for not meeting FC standard based on four data points collected by the Squaxin Island Tribe in 2002. Brown and Caldwell (1990) also collected samples in 1988 upstream of this culvert and found exceedances of the water quality standard. The current data evaluation includes data collected between 2001 and 2005. Seasonal geometric means and 90th percentiles were more critical compared to those on an annual basis. Figure 32 shows the geometric means and 90th percentiles during May-August (2001-2005). The expanded data set shows that Campbell Creek is in compliance with the state standards at all stations except CAM2 at the Agate Road culvert.

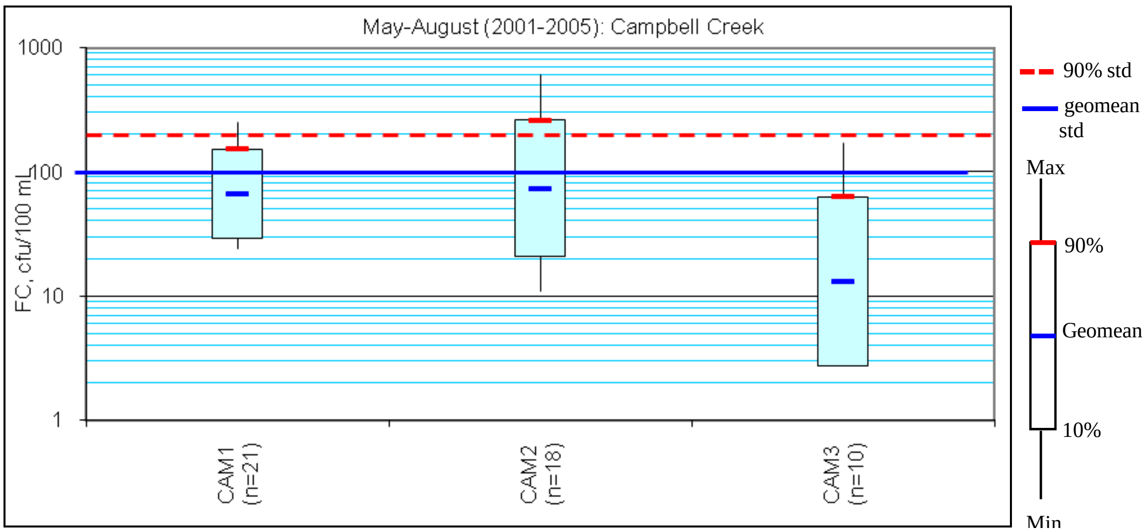



**Figure 32. Seasonal FC evaluation for Campbell Creek (May-August, 2001-2005).**

Load reductions are deemed necessary at station CAM2 to bring it into compliance with state standards for FC. Table 9 shows the necessary load reductions based on either meeting the geometric mean or 90th percentile freshwater standard, whichever is more restrictive. However, additional reductions may be necessary to meet the marine water quality standards at the mouth of the creek. This is discussed in the next section.

**Table 9. Load reductions for Campbell Creek based on freshwater criteria (May - August 2001-2005).**

| Station | Geometric mean (cfu/100 mL) | 90th percentile | Load reduction (percent) |
|---|---|---|---|
| CAM2 | 73 | 260 | 23 |

## Uncle John Creek

Uncle John Creek was included on the 303(d) list for not meeting the FC standard based on 1988 data collected by Brown and Caldwell (1990). These data were collected between the Agate Loop Road and the mouth of the creek (see Figure 8). Data gathered between 2001 and 2005 were evaluated both on an annual and seasonal basis to establish any load reduction requirements. Since all scenarios evaluated need a load reduction, they are all presented in Figure 33.

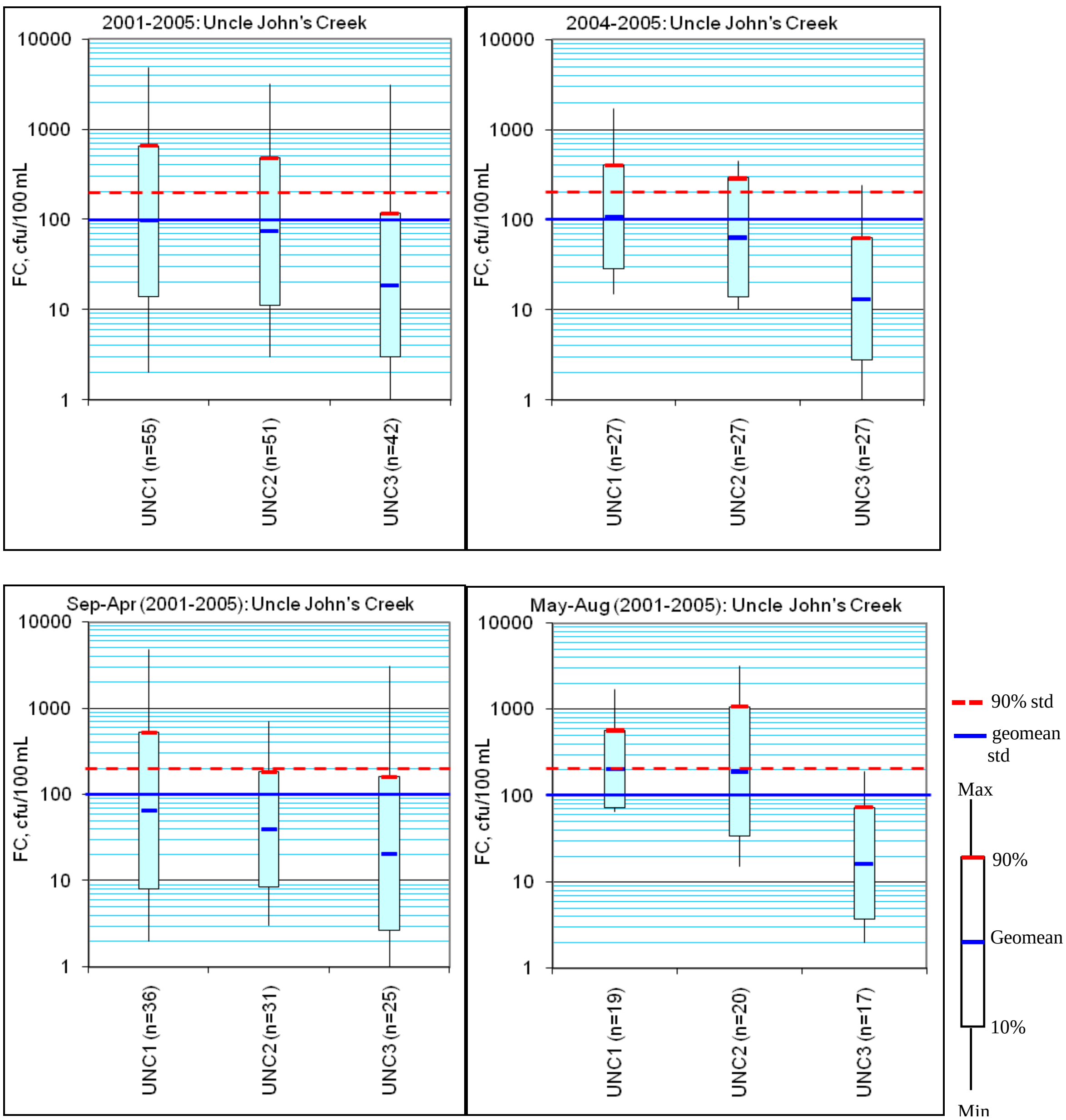



**Figure 33. Seasonal and annual FC evaluations for Uncle John Creek (2001-2005).**

Table 10 shows the necessary load reductions based on either meeting the geometric mean or 90th percentile freshwater standard, whichever is more restrictive. All scenarios were evaluated, and the one with the highest load reduction (2001-2005 data) was selected as shown in Table 10. It should be noted that additional reductions may be necessary to meet the marine water quality standards for fecal coliform at the mouth of the creek. This is discussed in the next section.

**Table 10. Load reductions for Uncle John Creek (2001-2005) based on freshwater criteria**

| Station | Basis | Geometric mean | 90th percentile | Load reduction (%) |
|---|---|---|---|---|
| UNC1 | Annual | 96 | 655 | **69** |
| | Sept-Apr | 65 | 523 | 62 |
| | May-Aug | 204 | 568 | 65 |
| UNC2 | Annual | 74 | 481 | 58 |
| | Sept-Apr | 40 | 184 | ----- |
| | May-Aug | 192 | 1068 | **81** |

Bold = limiting reduction

## Deer, Cranberry, Johns, and Mill creeks

These creeks are not included on the 303(d) list. However, data collected between 2001 and 2005 were evaluated to determine if any reductions are needed. The data were evaluated both on an annual and seasonal basis. The scenario that presented the highest observed geometric mean and/or 90th percentile concentration is shown in Figure 34. The water quality standard is being met at the designated stations in each creek. However, reductions in existing FC concentrations may be necessary to meet the water quality standards for FC at the mouths of these tributaries, as discussed in the next section.

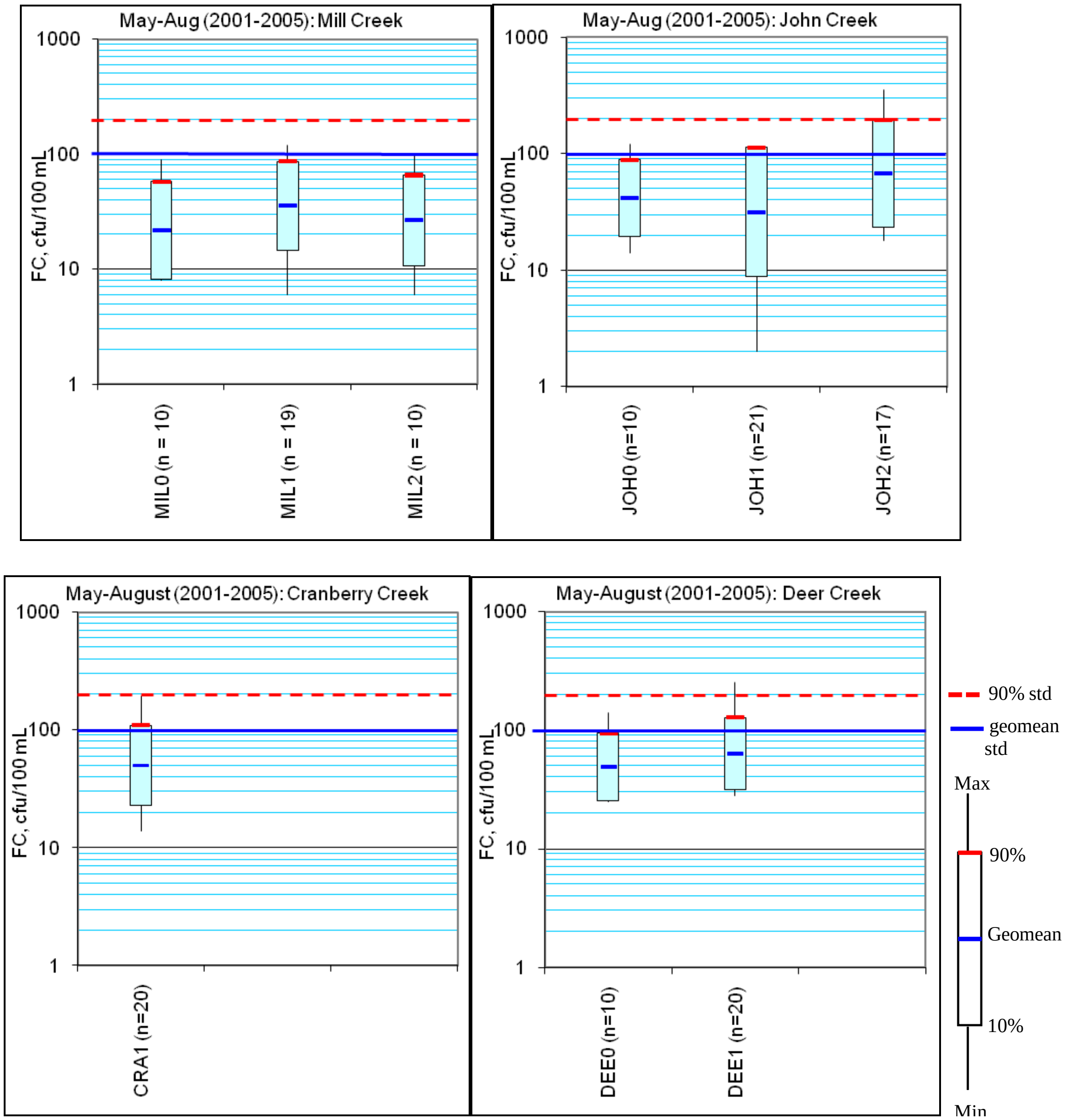



**Figure 34. Seasonal FC evaluations for the non-303(d) listed creeks (2001-2005).**

## Estimating load reductions for tributary mouths based on marine criteria

In brackish waters of estuaries, WAC 173-201A-260 (3) (e) (ii) requires the marine FC criteria be applied where the vertically averaged salinity is greater than 10 ppt during high tide (period of maximum salinity influence). The marine water quality criteria are a geometric mean of 14 cfu/100 mL and a 90th percentile value of 43 cfu/100 mL. Longitudinal salinity profiles toward the mouths of the creeks were measured at high tide (November 17 and 18, 2005) to establish the uppermost location where the marine standards should apply. Figure 35 shows the data along and near the mouths of each respective creek. The location near the mouth of the tributary where the vertical average salinity is 10 ppt will vary depending on the tidal stage. This location will move upstream during high tide and further into the bay during low tides. However, the delineation between marine and freshwater criteria remains static at the uppermost location in which the average salinity is 10 ppt.

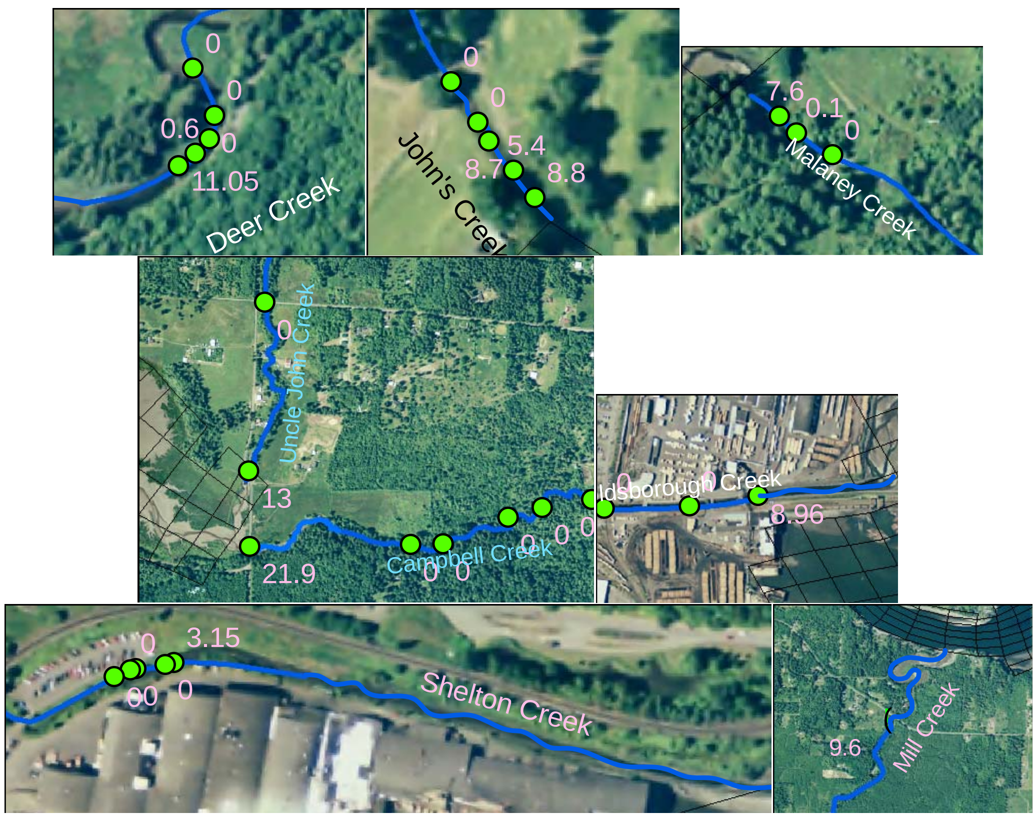



**Figure 35. Average vertical salinity near the mouths of major tributaries in Oakland Bay.**

Although WAC 173-201A-400 allows mixing zones to be used for compliance with water quality standards following application of “all known available and reasonable methods of prevention, control and treatment” or “best management practices” for nonpoint sources, establishing a mixing zone within the dynamics of a tidal mudflat is complicated and difficult to define spatially. Therefore, a simple approach was taken. For each creek, a location near the mouth was defined close to the measured average vertical salinity of 10 ppt, and the marine FC standard was applied here.

The load reductions are based on meeting the marine criteria at or near the mouth are shown in Table 11 for the critical season discussed in the previous section. These stations are near the mouth but close to and upstream of locations where vertically average salinity is 10 ppt. No die off is assumed between these two locations. The load reductions based on marine criteria also apply to Shelton and Goldsborough creeks, even though Inner Shelton Harbor; to which these creeks discharge, have an enterococci marine water quality standard of 70 and 208 cfu/100 mL for the geometric mean and 90th percentile, respectively. A secondary reason is at low tides these creeks discharge very close to the boundary (see Figure 3) where marine criteria for FC of 14 and 43 cfu/100 mL (geometric mean and 90th percentile, respectively) apply.

**Table 11. Load reductions at the mouth of the tributaries based on marine criteria.**

| Station | Period | Geometric mean (cfu/100 mL) | 90th percentile (cfu/100 mL) | Load reduction (percent) |
|---|---|---|---|---|
| GOL0 | May-Aug | 34 | 61 | 59 |
| SHE0 | May-Aug | 83 | 249 | 83 |
| MAL1 | May-Aug | 64 | 162 | 78 |
| CAM1 | May-Aug | 67 | 152 | 79 |
| UNC1 | Annual | 96 | 655 | 93 |
| MIL0 | May-Aug | 22 | 58 | 36 |
| JOH0 | May-Aug | 42 | 88 | 67 |
| CRA1 | May-Aug | 50 | 110 | 72 |
| DEE0 | May-Aug | 49 | 95 | 71 |

An obvious question is how far upstream the freshwater criteria would need to be met for the marine criteria to be met near the mouth (assuming no additional sources in the intervening reach). The FC die-off rates in freshwater have been cited as varying from 0.5 to 3.5 per day (Lung, 2001). The time of travel necessary for reducing a geometric mean of 100 cfu/100 mL to 14 cfu/100 mL is 2.2 days based on a die-off rate of two per day and first-order decay rate equation:

$$N_t=N_0e^{-kt}$$

Where:

$N_0$ = initial coliform concentration, cfu/100 mL
$N_t$ = concentration of coliform at any time t, cfu/100 mL
k = die-off rate, 1/day
t = time in days = $1/k *Ln(N_0-N_t)$

All of the tributaries except Goldsborough Creek are relatively small, and sufficient travel times do not exist, even at low flows, to provide the needed reductions in FC populations for the mouths of the tributaries to meet marine standards. Therefore, the load reductions will be set as targets for the mouths of the tributaries.

In Inner Shelton Harbor, the water quality standard is based on enterococci, which was not measured during field monitoring of this project. However, the water quality standard for both the freshwater tributaries draining into Inner Shelton Harbor, and marine waters beyond the harbor, are in terms of FC bacteria. It will be assumed that meeting the most stringent FC standard at the harbor boundary will also ensure meeting of the inner harbor standard. There is no evidence that the enterococci standard is not being met in the harbor. However, follow-up monitoring of enterococci is recommended in Inner Shelton Harbor during the implementation phase of this TMDL.

## Hydrodynamic calibration and verification of GEMSS model

A three-dimensional model of Oakland Bay was used to study how the tributary loadings and loadings from the sediment affect the bacteria levels in Oakland Bay. Ecology developed a three-dimensional model of Oakland Bay using the Generalized Environmental Modeling System for Surface waters (GEMSS) model. GEMSS is an integrated system of three-dimensional hydrodynamic and transport models embedded in a geographic information and environmental data system (GIS).

The GEMSS software uses Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport (GLLVHT) as the main kernel, which is a state-of-the-art, three-dimensional numerical model that computes time-varying velocities, water surface elevations, and water quality constituent concentrations in rivers, lakes, reservoirs, estuaries, and coastal water bodies. The computations are done on a horizontal and vertical grid that represents the water body bounded by its water surface, shoreline, and bottom. The water surface elevations are computed simultaneously with the velocity components. The water quality constituent concentrations are computed from the velocity components and elevations. Included in the computations are boundary condition formulations for friction, wind shear, turbulence, inflow, outflow, surface heat exchange, and water quality kinetics.

The GLLVHT model has been peer reviewed and published (Edinger and Buchak, 1995; Edinger, et al., 1994 and 1997). The fundamental computations are an extension of the well known longitudinal-vertical transport model (GLLVHT) that was developed by J. E. Edinger Associates, Inc. beginning in 1974 and summarized in Buchak and Edinger (1984). This model forms the hydrodynamic and transport basis of the Corps of Engineers' Water Quality Model CE-QUAL-W2 (U. S. Army Corps of Engineers Waterways Experiment Station, Environmental and Hydraulics Laboratories, 1986). GEMSS uses the z-coordinate system which deals with drying in shallow areas by completely eliminating associated surface layers in succession.

The hydrodynamic calibration of the model entails the following:

- Develop a 3-D grid model.
- Populate the 3-D grid with bathymetry.
- Establish boundary conditions for the model.
    - Tributary and point source inflows, temperature, and salinity.
    - Evaluation of diffused shoreline sources.
    - Establishing the forcing functions at the outermost boundary (for example, the mouth of the Hammersley Inlet).

- o Generating a meteorological data file for input to the model.
- Calibrate to tidal elevations and observed temperatures within Oakland Bay-Hammersley Inlet.
- Calibrate to observed current velocities.

## Three-dimensional grid of Oakland Bay-Hammersley Inlet

The grid generator *gridgen* within GEMSS was used to generate grids on a shoreline GIS map of Oakland Bay-Hammersley Inlet. The grid was later updated by ERM (2007) to provide higher resolution and orthogonality. The number of vertical layers within each grid-cell was a function of cell depth (for example, more layers in deeper cells).

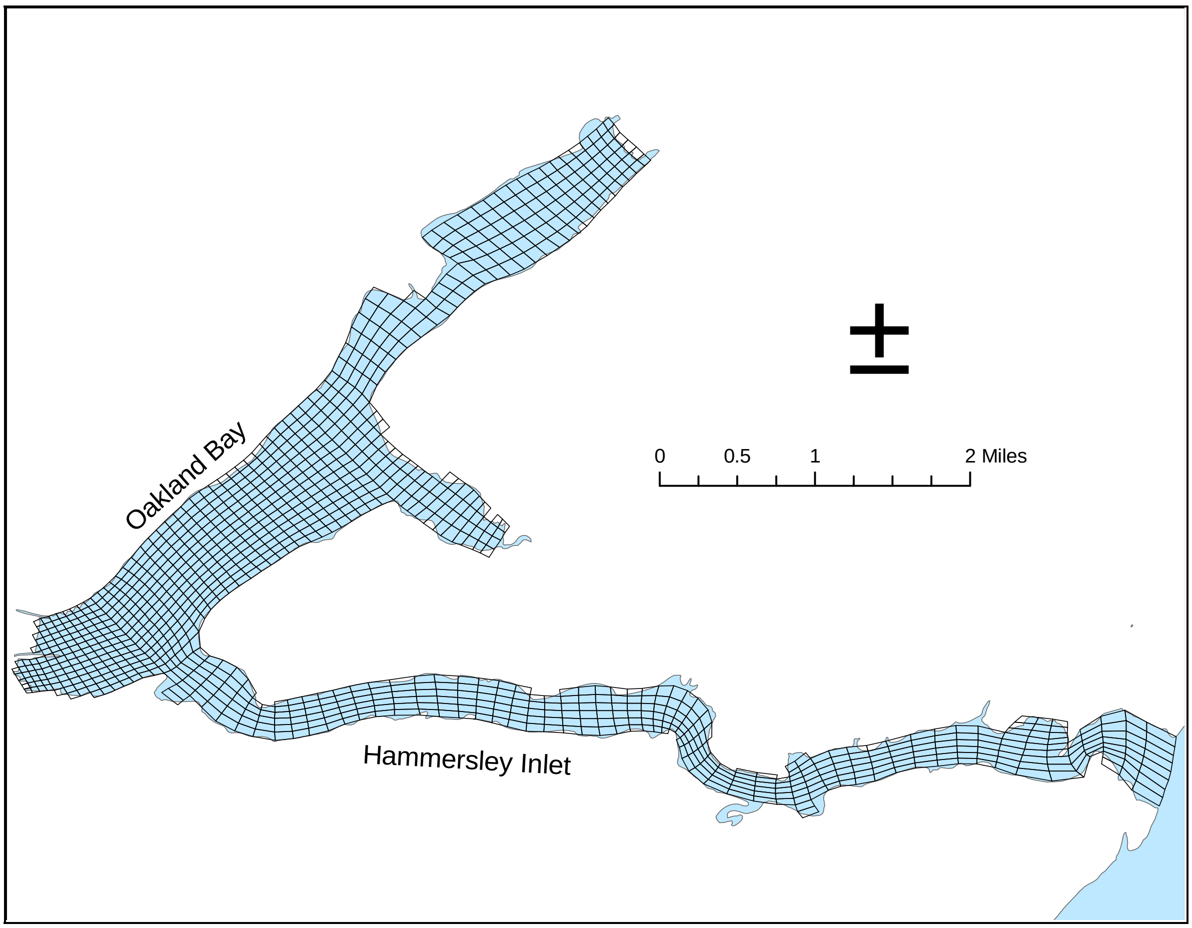



**Figure 36. Oakland Bay-Hammersley Inlet model grid.**

## Bathymetry

The Oakland Bay-Hammersley Inlet bathymetry is based on the Puget Sound Digital Elevation Model (PSDEM) developed by David Finlayson in 2005. This coverage was originally developed in Washington State Plane North (feet) NAD83, with the vertical datum of NAVD88 (www.ocean.washington.edu/data/pugetsound/psdem2005.html). It was later re-projected by Ecology to Washington State Plane South (feet) NAD83 HARN.

Depths were kept in feet. To convert depths in feet to meters, first the ArcGIS Extension tool 3D Analyst was used to generate an attribute table by converting the existing floating point grid to an integer grid. Once the table was generated, all elevations were multiplied by 0.3048 to convert from feet to meters and then by -1 to convert depths to elevations. Negative elevations are below the vertical NAVD88 datum, and the positive values are above the NAVD88 datum. Each elevation represents a grid size of 10 m x 10 m.

The resulting grid was clipped by a buffered shoreline shape file of Oakland Bay and Hammersley Inlet. This was used in the GEMSS model to establish bathymetry for each GEMSS grid cell. The uniform elevations for each GEMSS grid cell was calculated from the bathymetry grids through a smoothing technique within the GEMSS software.

## Tidal elevations

Tidal elevations at the various locations in Oakland Bay and Hammersley Inlet were obtained from the Puget Sound Tide Channel Model (PSTCM) which was originally developed by Lavelle et al. (1988) and subsequently updated by Mofjeld et al. (2002) to include the full suite of standard tidal constituents. A stand-alone Python version of the updated PSTCM, "*pstide.py*" was developed by David Finlayson in 2004 (http://david.p.finlayson.googlepages.com/pugetsoundtides). *Pstides.py* was used to estimate time-series of tidal elevations at specific segments within Oakland Bay and Hammersley Inlet.

Figure 37 shows the segments also established by David Finlayson in 2004 (http://david.p.finlayson.googlepages.com/segment_map.pdf ).

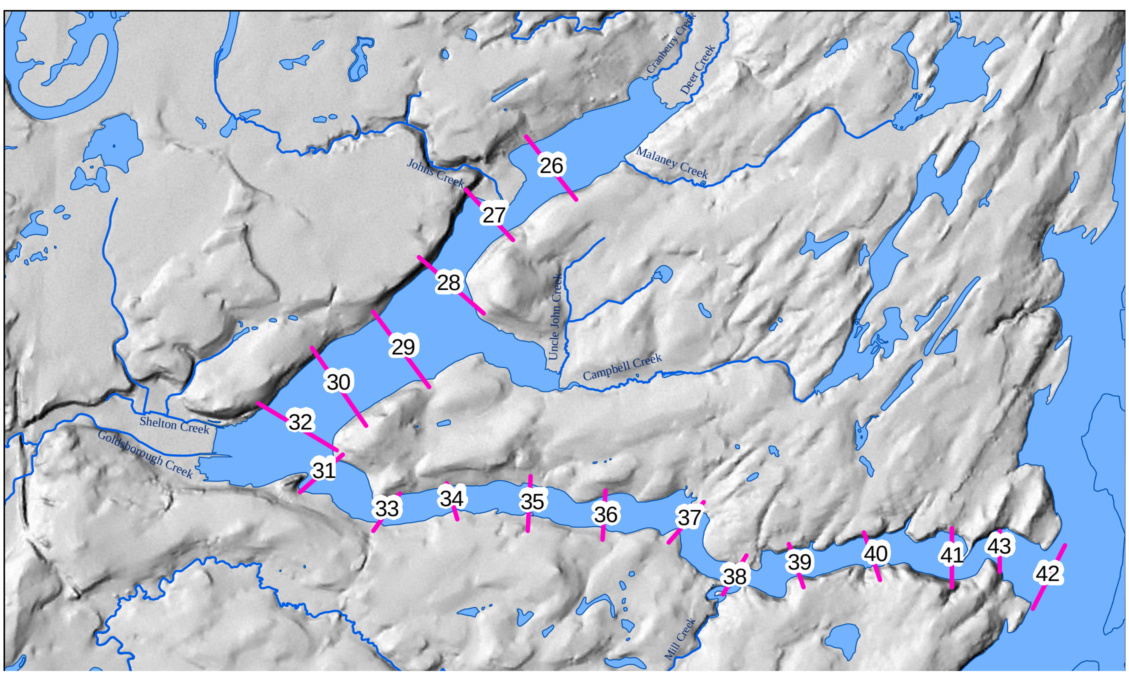



**Figure 37. *Pstide.py* segments where tidal elevation data were available.**

*Pstide.py* predicts tidal elevations based on the local mean low low water (MLLW) (for example, at the segment locations). Positive elevations are above the local MLLW, and negative elevations are below the local MLLW. In order to make both the bathymetry and tidal elevations to reference the same vertical datum, the predicted tidal elevations (based on local MLLW) were converted to NAVD88 using the *VDatum -- Southern Puget Sound, Washington - version 2* software (March 2006) provided by NOAA (http://nauticalcharts.noaa.gov/csdl/vdatum_projectsWA.htm). The latitude and longitude entered into *VDatum* was midpoint of each *Pstide.py* segments. The NAVD88 was found to be approximately 1 meter above the local MLLW (i.e., 0 MLLW = -1 m NAVD88).

The converted tidal elevation (NAVD88) time-series data were then used in GEMSS. Again, positive elevations are above the datum, and negative elevations below the datum.

To gain more confidence in the tidal elevations predicted by *pstides*, actual tidal elevations measured in 2003 at Libby Point (Albertson, 2004) were compared with *pstide* predictions as shown in Figure 38. Libby Point is between *pstide* segments 38 and 39 (Figure 37).

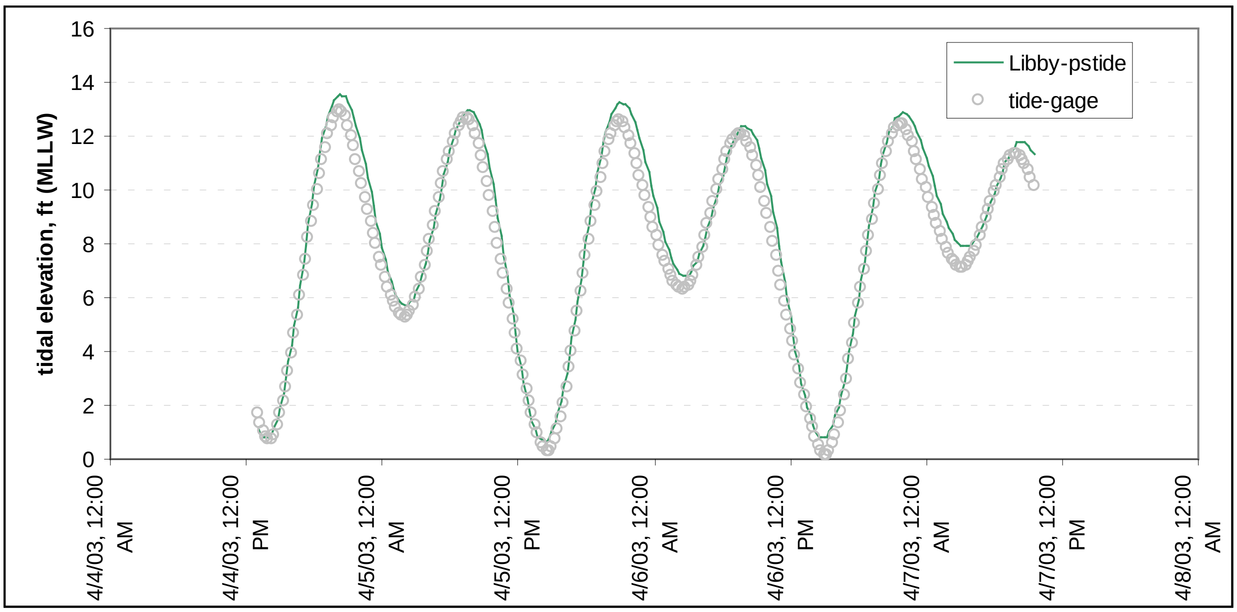



**Figure 38. *Pstide* and actual tidal elevations at Libby Point (2003).**

## Boundary conditions

Flow and temperature data gathered for the tributaries in 2004-2006 were discussed earlier under *Results and Discussion* (also see Appendix D). Grab samples were also taken for conductivity and temperature twice a month at the mouths of all the tributaries (Appendix B). These data were used as boundary condition for hydrodynamic calibration of the GEMSS model. A single point source to the bay is the city of Shelton WWTP discharge near Eagle Point. Flow and temperature data were obtained from the facility's monthly "discharge monitoring reports" (DMRs). For the mouth of Hammersley Inlet, the boundary conditions were the tidal elevation at *pstide* segment number 42, and temperature and salinity data collected by InterOcean™ device S4 near the boundary (Appendix G).

The meteorological data (wind speed and direction, cloud cover, dew point, atmospheric pressure) were obtained from Shelton's Sanderson Field. Rainfall data were obtained from the rainfall gauge at Taylor Shellfish's Flupsy dock.

At the outer boundary (mouth of Hammersley Inlet), temperature and salinity data were only available from January through June, due to malfunction of the instrument (InterOcean™ device S4). To generate temperature and salinity data for the whole year (2005), the following procedure was followed:

### Additional temperature data at the boundary

To obtain temperature data at the open boundary for the rest of the year (for example, June through December), existing data at the open boundary were correlated with those measured at station HAM2 (see Figure 10) in Inner Hammersley Inlet. Figure 39 shows the correlation between temperatures measured at station HAM2 and those at the open boundary at station S4. For locations of these stations, see Figure 10. Using the relationship shown in Figure 39, temperature data for station S4 were generated between June and December 2005.

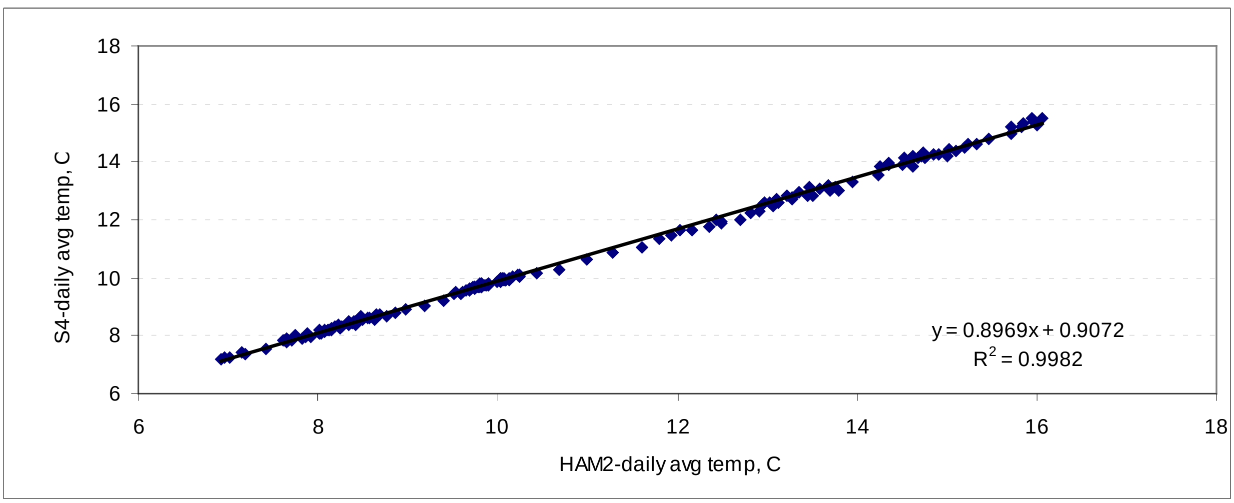



**Figure 39. Correlation between temperatures measured at station HAM2 and station S4.**

### Additional salinity data at the boundary

A constant average salinity of 27 ppt was assumed at the open boundary at the mouth of Hammersley Inlet. Continuous data collected at station S4, near the mouth, from January through April 2005 formed the basis of this assumption.

## Calibration and verification of tidal elevations

Calibration to tidal elevations was achieved through modification of the grid, changes to bottom friction, and wind drag coefficient. *Pstide* segment 36 was used for model calibration, and segments 29 and 27 (see Figure 37) were used for model verification. Figure 40 shows the calibration and verification plots.

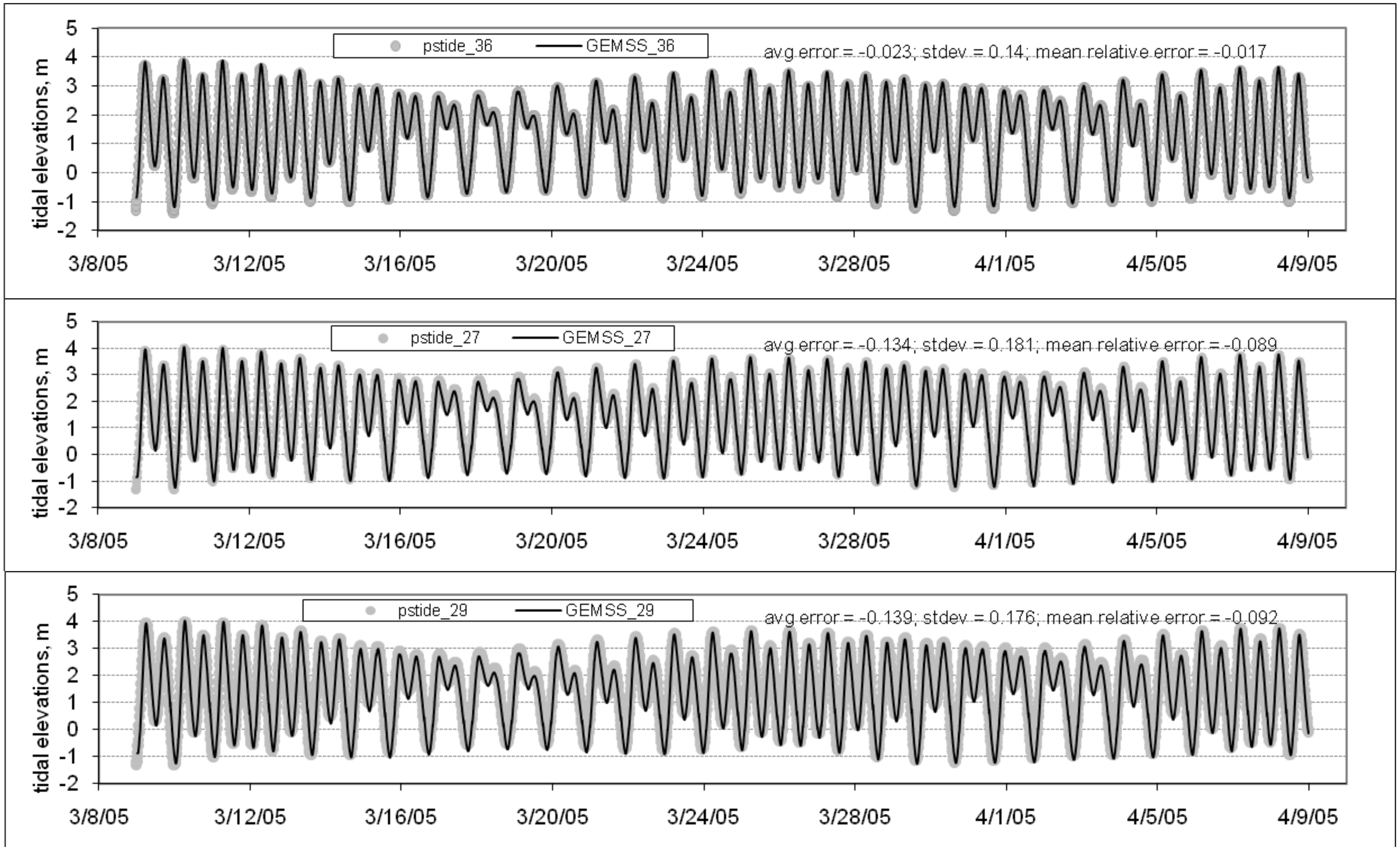



**Figure 40. Tidal calibration (segment 36) and verification (segments 27 and 29).**

## Calibration and verification to observed temperatures

Two of the four stations where continuous temperatures were measured were affected by instrument exposure during low tides and could not be used for temperature calibration (Appendix H). These two stations were OAK1 and OAK2 (see Figure 10). In order to calibrate model predictions to the observed temperatures, the wind speed function of the surface-heat-exchange tab and the scaling factors within the meteorological sub-tab of the control file were varied until a good fit was obtained. Heat transfer at the air-water interface is governed by solar radiation, longwave radiation, evaporation, condensation, and convection/conduction. Air temperature, dewpoint, and wind speed influence heat flux processes. Six wind speed functions were evaluated, and the wind speed function that gave the best calibration was that of Brady, Graves, and Geyer.

Station HAM2 was used for calibration, and HAM1 was used for model verification (Figure 10).

Figure 41 and Figure 42 show temperature calibration and verification of the GEMSS model. Table 12 shows the error analysis for temperature calibration and verification.

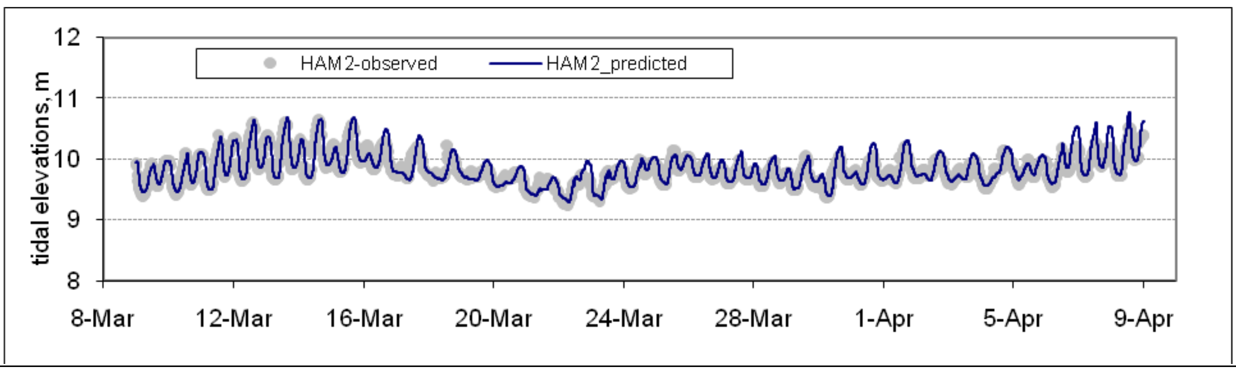



**Figure 41. GEMSS calibration of temperatures at station HAM2 (March-April, 2005).**

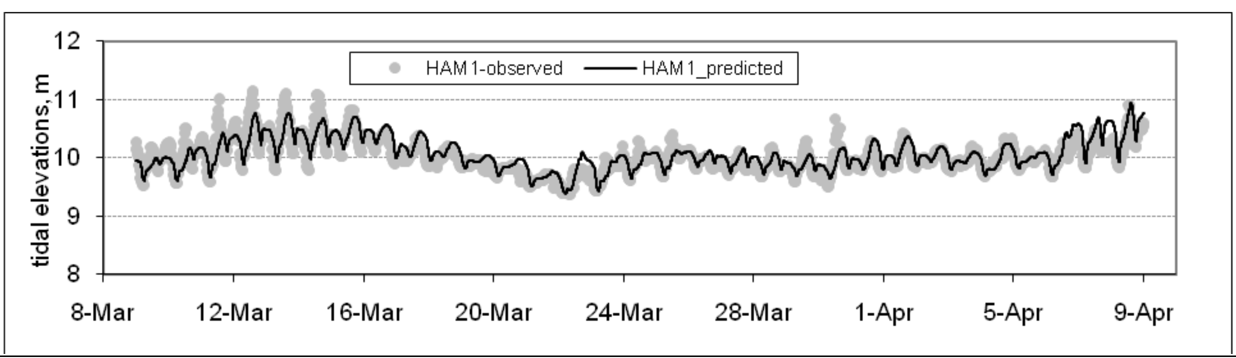



**Figure 42. GEMSS verification of temperatures at station HAM1 (March-April, 2005).**

**Table 12. Error analysis of temperature calibration and verification.**

| Error analysis | HAM2 | HAM1 |
|---|---|---|
| Root mean square error | 0.12 | 0.17 |

Temperature simulations for the whole year (2005) at stations HAM2 and HAM1 are included in Appendix I.

## Calibration to observed currents

An Acoustic Doppler Current Profiler (ADCP) was deployed at the headwaters of Hammersley Inlet. The ADCP was deployed in a “hole” within the model grid (i,j=31,23). In addition, the ADCP failed to capture the currents near the water surface due to error in programming of the instrument. Therefore, data within the “hole” in the bathymetry as well as that near the surface could not be used. The rest of the data had to be used carefully since bottom velocities are always near zero and truncation of data does not reduce the artificial bottom velocities to zero. Because of this error, the observed velocities were slightly higher as shown in Figure 43. However, there is good agreement in phase.

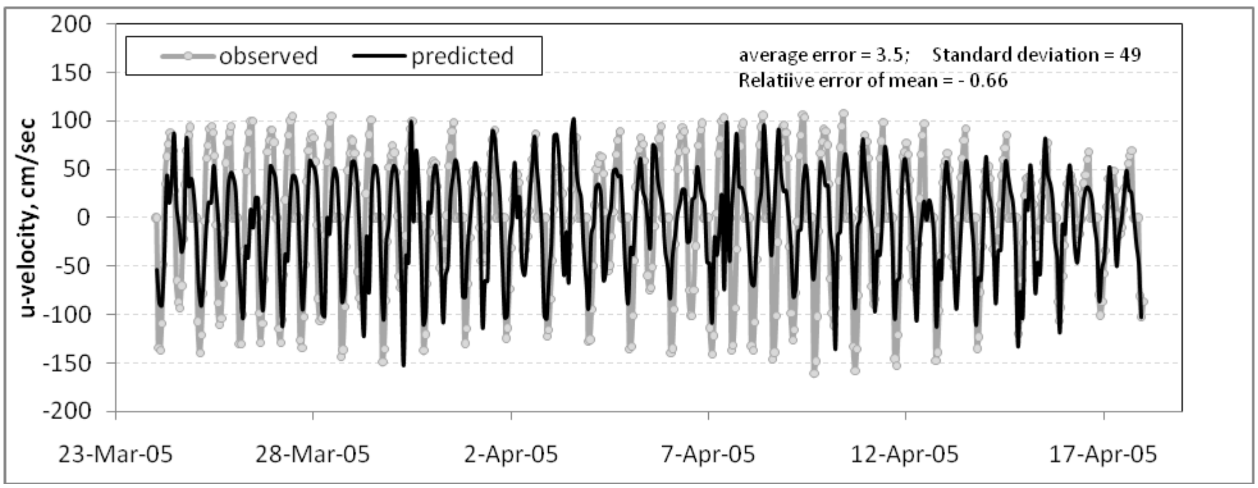



**Figure 43. Observed (ADCP) and model predicted current velocities at grid (31, 23) near the headwaters of Hammersley Inlet.**

# Water quality calibration and verification of the GEMSS model

## Units for fecal coliform bacteria

Since shellfish harvesting restrictions and shellfish harvesting area closures and classifications are based on the most-probable-number (MPN) method of FC enumeration, all modeling input for FCs would be in terms of MPN. Since all the freshwater FC concentrations were based on the membrane filter (MF) method, a MPN to MF method ratio was developed (Appendix G) based on data gathered during field monitoring.

## Bacterial die-off

The bacteria loss rate from the water column can be represented as follows (Chapra, 1997):

$$K_t = K_{fresh} + K_{salt} + K_{solar}$$

Where

$K_t$ = total loss rate (d-1)

$K_{fresh}$ = freshwater loss rate (d-1)

$K_{salt}$ = saltwater loss rate (d-1)

$K_{solar}$ = loss rate due to solar radiation (d-1)

An extension of the above formulation also includes loss due to predation and settling. However, these terms will be assumed to be included in the above formulation with gross assumptions of the individual decay rates. Some formulations include after-growth and re-suspension (EPA, 2001b). After-growth or re-growth will be assumed to be also included in the above formulation. Re-suspension will be dealt with separately during modeling of FC bacteria in Oakland Bay.

**Base mortality rate**

The freshwater and salinity loss rates are sometimes lumped together and labeled as base mortality rate (Mancini, 1978; Thomann and Mueller, 1987):

$$K_b = K_{fresh} + K_{salt} = (K_{fresh} + 0.006 P_s) 1.07^{T-20}$$

Where

$K_b$ = base mortality rate (d-1)

$K_{fresh}$ = freshwater loss rate (d-1) at 20 °C = 0.8 (Chapra, 1997), but variable

$K_{salt}$ = saltwater loss rate (d-1) at 20 °C = $0.006 P_s$

$P_s$ = percent seawater = $\frac{S_{station}}{S_{sea}} x100$

$S_{station}$ = salinity at monitoring station
$S_{sea}$ = assumed seawater salinity, usually 30 to 35 ppt
$1.07^{T-20}$ = temperature correction for base mortality for any temperature
T = temperature, °C

**Loss Due to Sunlight**

The die-off rate due to light inactivation is given by the following equation:

$$K_{solar} = \alpha \left( \frac{I}{k_e z} \right) \left[ 1 - e^{-k_e z} \right]$$

Where
$K_{solar}$ = loss rate due to solar radiation (d-1)
$\alpha$ = proportionality constant = 1 (Thomann and Mueller, 1987)
z = depth, m
I = surface light energy (ly/hr)
$k_e$ = extinction coefficient (m-1), a function of suspended solids and color of the water
= 1.8/Sd or 0.55 TSS (Di Torro et al., 1981)
Sd = secchi depth, m
TSS = total suspended solids, mg/L

**First-order die-off rate**

Bacterial die-off rate is also modeled as a first-order decay rate (Bowie et al., 1985) as shown below:

$$N_t = N_o e^{-kt}$$

Where
$N_t$ = number of bacteria at any time t
$N_o$ = original number of bacteria to start with
k = overall die-off rate at temperature T = $k_{20} 1.07^{(T-20)}$
Reported decay rates span about two orders of magnitude and typically range from 0.04 to 4 per day (Bowie et al., 1985) as a first-order rate constant. Pelletier and Seiders (2000) estimated $k_{20}$ at 0.4 per day in the Grays Harbor FC TMDL study as a best fit to the model predictions.

**Bacterial die-off rate used in the GEMSS model**

The salinity and temperature of surface water varied significantly during the 2004-2006 period as measured at the various DOH stations and shown in Figure 44.

Temperature at the DOH stations varied from 5 to 20°C, and salinity varied from 0 to 30 psu. Therefore the base mortality rate inclusive of salinity impacts as well as die-off rates due to sunlight seems appropriate for evaluating the die-off rates for coliform bacteria in Oakland Bay.

The first-order die-off rate employing a single overall decay rate was not used in the GEMSS model.

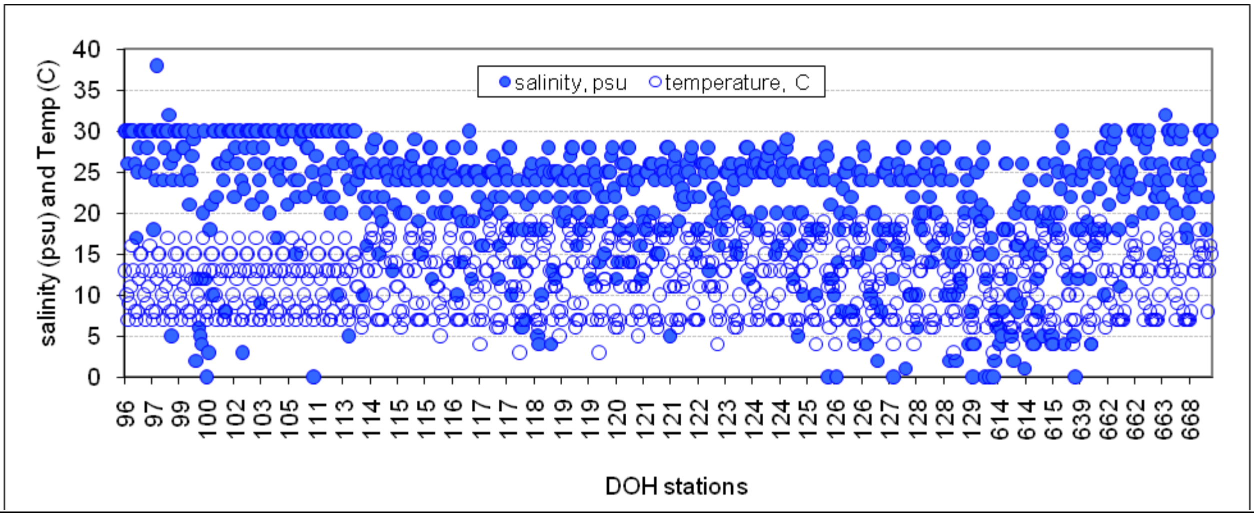



**Figure 44. Variation of salinity at the various DOH stations in Oakland Bay (2004-2006).**

## Effect of wind and wind direction

Ufnar et al. (2006) studied the effects of wind and wind direction on elevated levels of FC bacteria in the Mississippi Sound and found that wind direction and high bacteria counts were correlated. They found that high bacteria counts were most likely when the winds are out of the west or southwest at most stations monitored. Smith et al. (1999) found elevated levels of E. coli at stations in the downwind directions at wind speeds of 10 knots (11.5 mph) or higher.

A similar analysis was conducted for Oakland Bay by Konovsky (2007) who correlated DOH bacteria data for station 614 (near the mouths of Cranberry and Deer Creeks) with wind speed and direction. Konovsky concluded that south-westerly winds greater than 5 mph correlated well with elevated levels of FC (Table 13). Oakland Bay is almost perfectly oriented in the southwest-northeast direction which is the predominant direction of both winds and tidal action. It is likely that the southwesterly winds at a certain magnitude create enough shear velocities to resuspend the soft top layer of the sediments. Konovsky (2007) showed that FC exists only in the top centimeter of sediment.

**Table 13. Effect of wind on FC bacteria in northern Oakland Bay (adopted from Konovsky, 2007). DOH 614 Mean FC Level Matrix (DOH data May 02 - June 06)**

| Wind Speed | Wind Direction (cfu/100 mL) | |
|---|---|---|
| | SW1/4 (180-270°) | Other |
| <5 mph | 7 (n=22) | 20 (n=11) |
| ≥ 5 mph | 73 (n=27) | 14 (n=5) |

Using multiple liner regression analysis, an equation was developed for FCs and wind, wind-direction, and time of year for DOH station 614. This is shown as follows:

$$Log\left[\frac{FC}{K_{se}}\right] = \beta_0 + \beta_1 \text{LogV} + \beta_2 \text{LogV}^2 + \beta_3 \text{LogD} + \beta_4 \text{LogD}^2 + \beta_5 \sin[2\pi \text{T}] + \beta_6 \cos[2\pi \text{T}] + \beta_7 \sin[4\pi \text{T}] + \beta_8 \cos[4\pi \text{T}]\}$$

Where

V = wind speed
D = wind direction
T = time of year
$K_{se}$ = smearing coefficient as defined by Duan (1983)
$\beta$ = regression constants

Figure 45 shows that the wind regression equation described above does a fairly good job at predicting the observed FC concentrations. With a zero die-off rate and no sediment bacterial fluxes, GEMSS predicts concentrations that are much below the observed data. The observed summer concentrations are almost ten times the predicted values at station DOH614. Thus, it seems that there are other sources of bacteria that contribute much larger loads compared to the tributaries. As was shown earlier, sediments can contain FC concentrations that are ten times the concentrations in the water column. Wind induced re-suspension of sediments may be responsible for high observed FC concentrations in the bay.

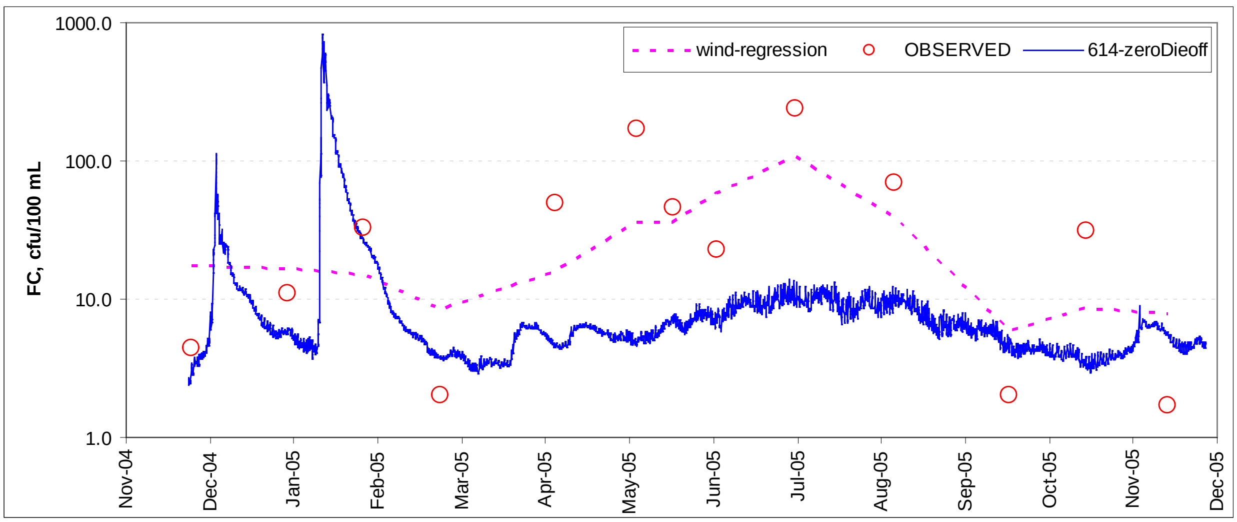



**Figure 45. FC predictions using GEMSS and using a multiple regression equation with wind speed, direction, and time of year at station DOH614.**

## Sediment re-suspended bacteria and model calibration

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. 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).

Jeng et al. (2005) found that the levels of FCs in sediments increased significantly following a given storm event and that bacteria survival increased by at least seven days. 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.

Jeng et al. (2005) also found in their study that approximately 20% of the FC load in a storm event would be attached to suspended particles, with an average settling velocity of 0.33 meters per hour with 95% of the solids being greater than 5 µm. The concentrations of FC in the water column would be reduced at the rate of 0.06 per hour due to sedimentation. Herrera (2011) reported that in Deer Creek 68% and 17% of the bacteria were attached to suspended sediments during winter and base flow conditions, respectively.

The previous analysis with prediction 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. A previous version of GEMSS did not have a sediment re-suspension module. With a grant from Ecology, Environmental Resource Management (ERM) added a sediment re-suspension module to GEMSS as per the procedures of Stapleton (2007). This module included a sediment layer thickness, sediment resuspension velocity, sediment coliform concentration, and sediment decay rate. These variables were varied within the model recommended values. The sediment average area-wide coliform concentration that gave the best calibration was 0.3 cfu/g, as shown in Figure 46.

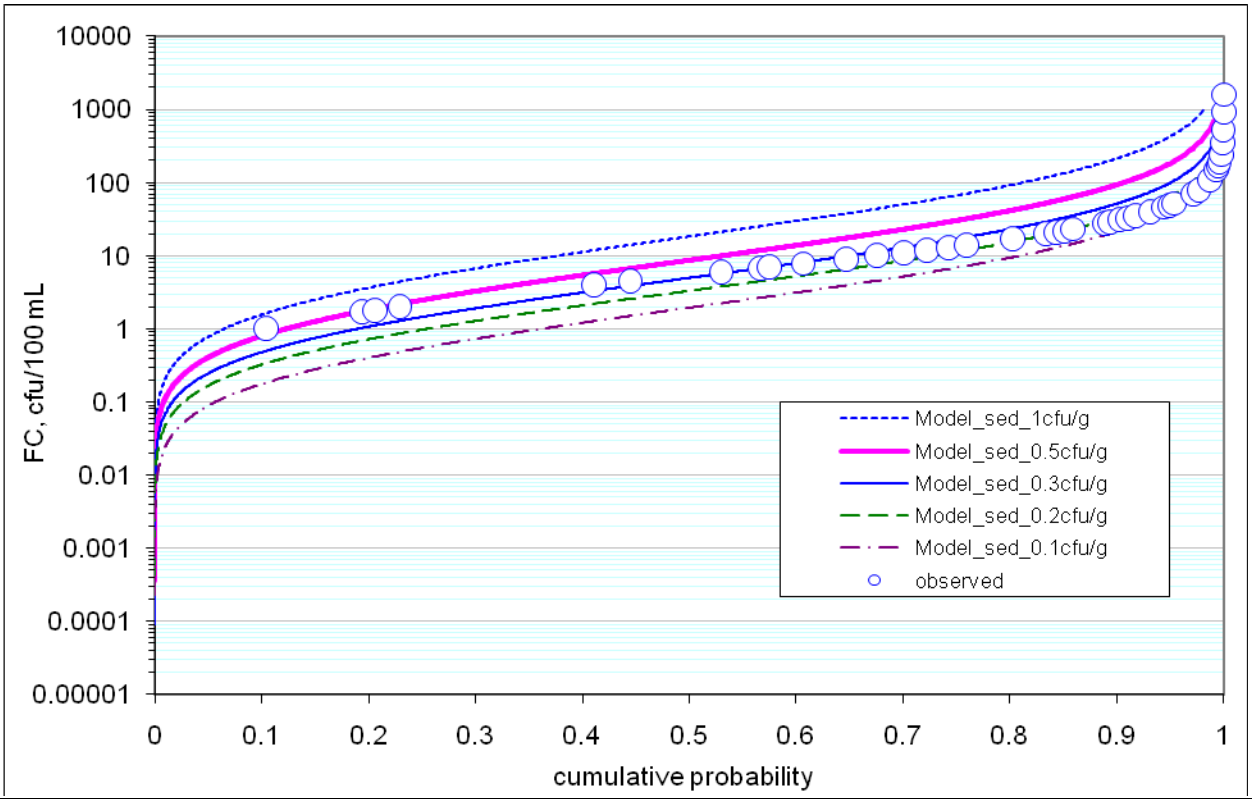



**Figure 46. Model calibration to observed bacteria population (all DOH stations) in Oakland Bay-Hammersley Inlet (2004-2005).**

As previously discussed, the shoreline loading was estimated as 4.5% of the total loading from the tributaries. To accommodate this and other unknown loading, the tributary loading was increased by 4.5 percent. Figure 47 shows the cumulative probability distribution of FC with existing tributary loads as well as with an additional 4.5% load. The geometric mean and 90th percentile concentrations under the two scenarios are essentially the same. This indicates that the sediment load likely plays a major role in bacterial concentrations in the bay.

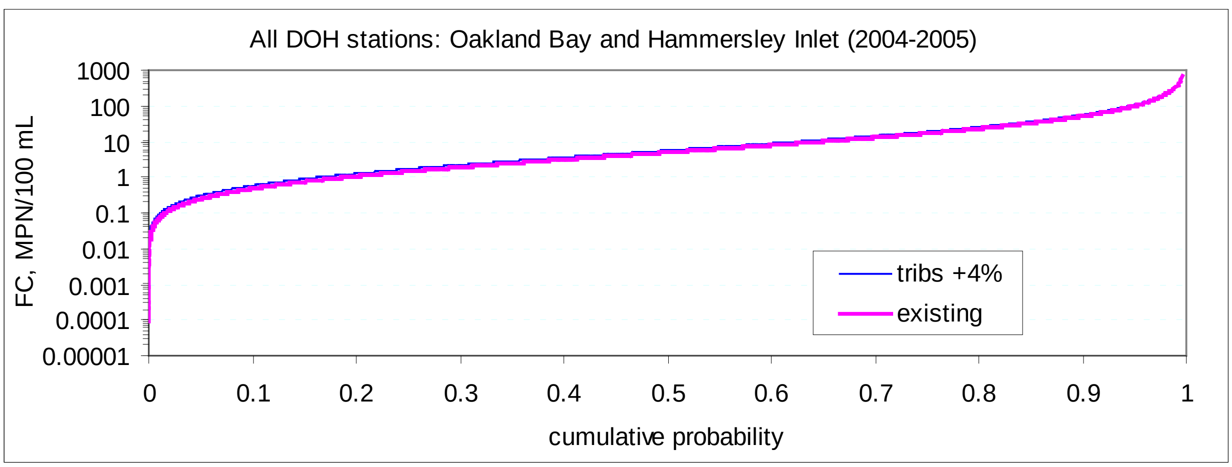



**Figure 47. Effects on bacteria populations of increasing tributary load by 4.5%.**

Four stations were evaluated for model calibration: DOH614, DOH128, SHE1, and DOH112. These are shown in Figure 48.

## Reduction scenarios

To provide a management tool for evaluating source control and its impact on bacterial populations in Oakland Bay, various source reduction levels were evaluated. In developing the scenarios, it was assumed that any level of bacteria reduction in the tributary loads will bring about a similar reduction in the sediment bacteria re-suspension load.

The impact of the reduction levels on bacteria concentrations at key DOH stations (DOH614, DOH128) are shown in Figure 49 and Figure 50. It will take between 50% to 70% reduction in bacteria concentrations at all sources to bring the 90th percentile concentrations to within the water quality standard at DOH station 614. The geometric mean concentration will be well within the water quality standard at these reduction levels. A 10% to 30% reduction in all sources would be sufficient to lower the bacteria concentrations at station DOH128 to within water quality standards.

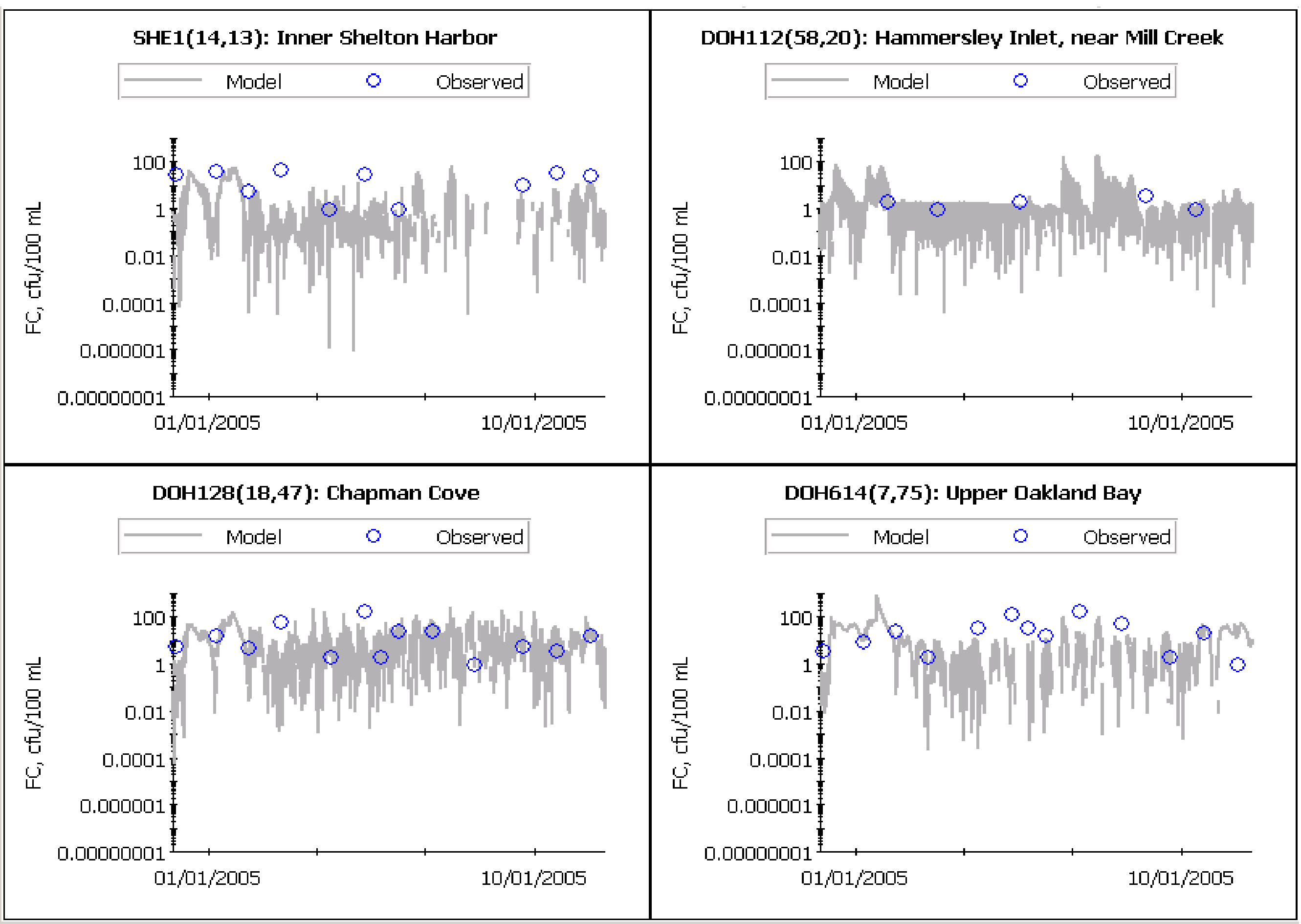



**Figure 48. Predicted and observed FC concentrations at selected stations in Oakland Bay and Hammersley Inlet.**

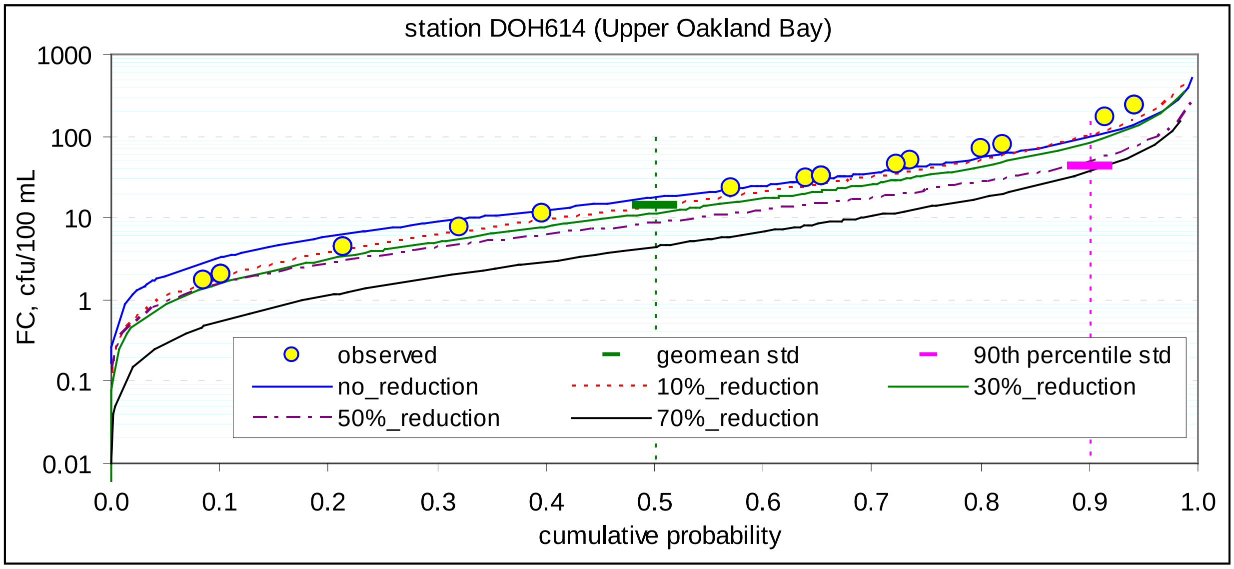



**Figure 49. Concentrations of FC bacteria at station DOH614 under various scenarios.**

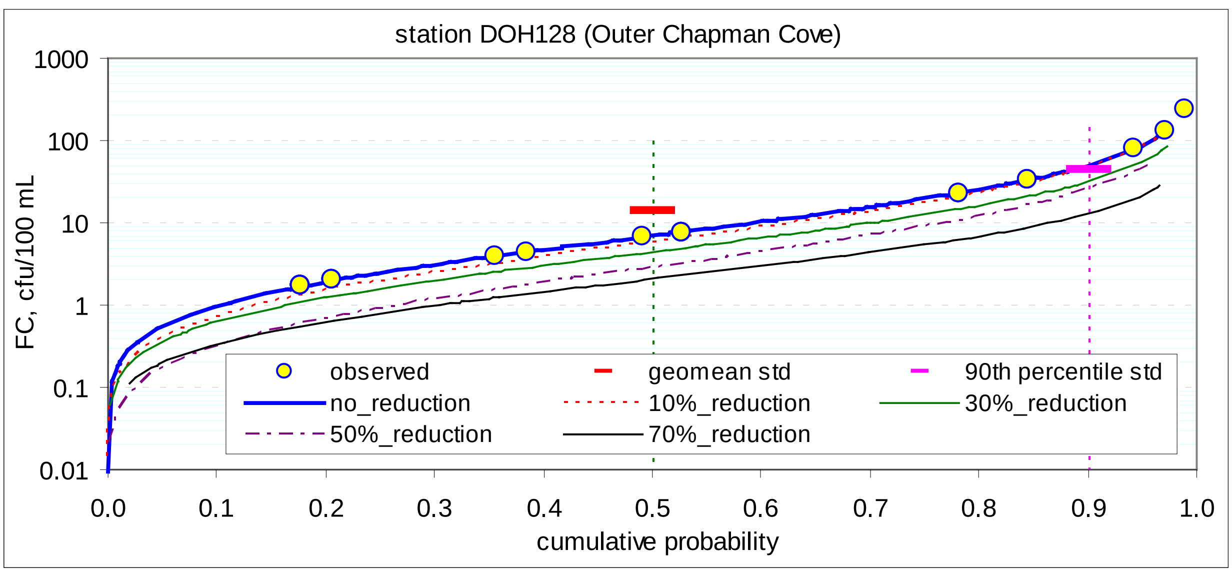



**Figure 50. Concentrations of FC bacteria at station DOH128 under various scenarios.**

## Loading capacity

The loading capacity is the maximum load that can be assimilated by the receiving water without violating Washington State water quality standards under critical conditions. Loading capacity is therefore the water quality criterion multiplied by critical flow. The loading capacity at any location will thus be met at any flow and volume conditions, as long as the water quality criterion is met.

**Loading capacity for tributaries**

Figure 51 shows the loading capacities for FC at the mouths of the tributaries under various flow scenarios for meeting the 90th percentile water quality criteria (200 cfu/100 mL). The lowest loading capacity is during late summer/early fall when the flow is the lowest. The perimeter load is based on a total watershed drainage area of 162.8 $mi^2$ and major tributary drainage area of 144.7 $mi^2$. This equates to tributaries comprising approximately 90% of watershed load to the bay. The rest is coming from perimeter sources. However, the loading from the tributaries is higher (in excess of 96 percent) since the shoreline survey indicated a much lower contribution by the diffused perimeter sources. This loading evaluation does not account for direct point sources to the bay.

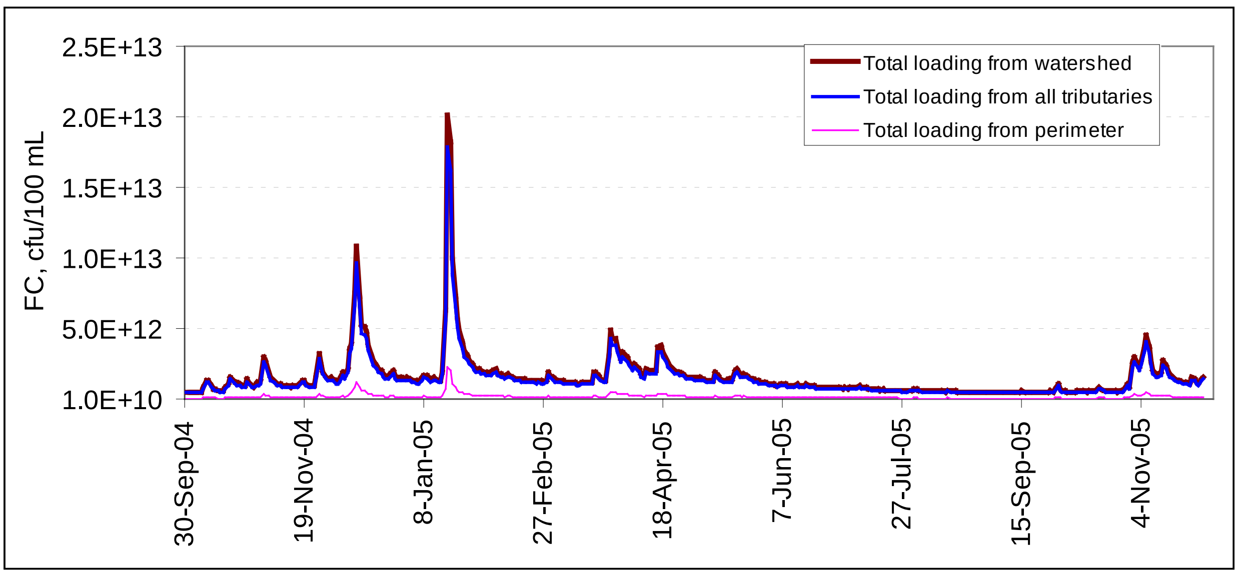



**Figure 51. Loading capacity for tributaries and diffused sources based on meeting the 90th percentile freshwater criteria.**

Because of the applicability of marine standards at the mouths of all tributaries in this study, the loading capacity at the mouths of all tributaries, with the exception of Goldsborough and Shelton Creeks, is based on the marine standards. Figure 52 shows the loading capacities for FC at the mouths of the tributaries under various flow scenarios for meeting the 90th percentile marine water quality criteria (43 cfu/100 mL).

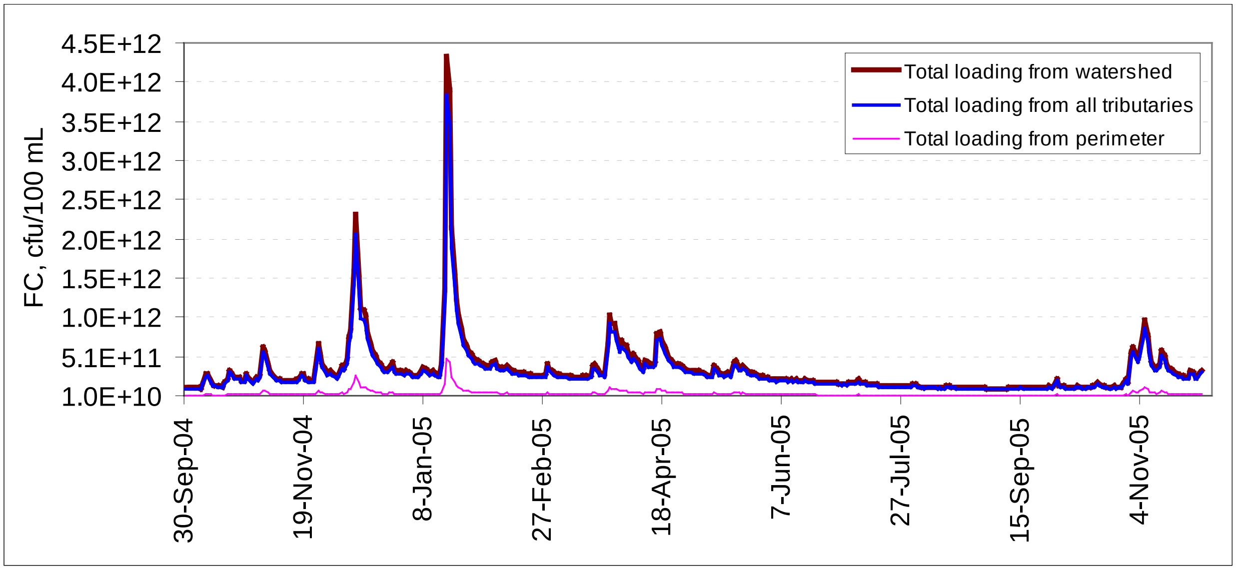



**Figure 52. Loading capacity goals for tributaries and diffused sources based on meeting the 90th percentile marine criteria.**

## Loading capacity for Inner Shelton Harbor

The loading capacity for Inner Shelton Harbor should be based on meeting the enterococci standard of a geometric mean of 70 cfu/100 mL and a 90th percentile of 208 cfu/100 mL. However, no measurements were made for the enterococci within the harbor. Monitoring for enterococci is recommended during the implementation phase of this TMDL. It should be noted that the listing of Inner Shelton Harbor was for FC bacteria based on (1) FC data collected in 1988, and (2) comparison with the older FC criteria of 100 cfu/100 mL and 200 cfu/100 mL geometric mean and 90th percentile concentrations for secondary contact recreation uses.

The marine criteria for primary contact recreation and shellfish protection (14 cfu/100 mL and 43 cfu/100 mL geometric mean and 90th percentile concentrations) must be met at the boundary of secondary and primary contact recreation areas at the mouth of Inner Shelton Harbor (see Figure 3). At low tides, the mouths of Shelton and Goldsborough Creeks are close to this boundary. Therefore, it seems prudent to apply the more stringent primary contact marine standards at the mouths of these creeks.

## Loading capacity for Oakland Bay and Hammersley Inlet

The loading capacity for Oakland Bay and Hammersley Inlet is based on meeting the marine standard at all locations. However, under the current condition, the FC concentration in the sediment is sufficiently high to cause exceedances of the marine criteria through sediment resuspension. This condition is aggravated during significant storm events and windy low-flow conditions. Although the loading during storm events will be minimized through the implementation of best management practices (BMPs) to meet water quality standards at the mouths of the tributaries, the wind-induced re-suspension of sediments will continue to cause elevated levels of bacteria in the water column. This can only be minimized through a systematic reduction in the bacteria pool in the sediments through natural die-off and minimizing additional sediment loads.

The loading capacity for the Oakland Bay-Hammersley Inlet is basically a goal to achieve zero loading of coliform bacteria from anthropogenic sources. This can be done primarily through source control to reduce bacteria and suspended solids loading to the tributaries.

## Load and wasteload allocations

Load reductions may be in terms of concentration, or load, or both. For Oakland Bay and its tributaries, the TMDL for FC is expressed in terms of FC concentrations as allowed under Federal Regulations [40 CFR 130.2(I)] as “other appropriate measures”. The concentration measure is appropriate since the water quality standard can be directly compared to measured concentrations in the receiving water under all flow scenarios. The “load reductions” show what is necessary to achieve the water quality standard. However, loads at specific locations along the river and at the mouths of tributaries have been established to provide a relative comparison of contributions of FC. Specific load reductions and loadings are shown in Table 14. The loadings are based on average flows in the critical period indicated.

Stormwater bacteria load allocations are imbedded in the load allocations for streams in which they discharge. Load allocations for stormwater discharging directly to Oakland Bay are imbedded in the load allocation for the perimeter of the bay. Based on an average perimeter flow of 0.6 cms for the May-August period, the load allocation would be $2.2 \times 10^9$ cfu/day based on meeting the 90th percentile marine criteria.

All shoreline point sources, including Washington State Department of Transportation (WSDOT) outfalls, must implement source control BMPs and/or BMPs to reduce the volume of discharging stormwater, or otherwise reduce fecal coliform bacteria concentrations. The load allocations for all outfalls are the tiered marine water quality standards. Suspended solids should be reduced as per available and reasonable technology.

All tributaries must meet the marine water quality standards at the mouth of the creeks during all seasons. The discharge of sediments from each tributary shall be minimized.

**Table 14. Load and wasteload allocations.**

| Source | Target Concentration (cfu/100 mL) | Maximum flow (cms) | Load (cfu/day) | Load reduction (percent) | Critical period/basis |
|---|---|---|---|---|---|
| **Wasteload allocations** | | | | | |
| City of Shelton Wastewater Treatment Plant (WWTP) Permit #WA0023345 | 14* (monthly average limit) | 0.176 (monthly) | 2.1E+09 | None* | NPDES permit limit, applicable year-round |
| Washington State Department of Transportation (WSDOT) Discharges Permit #WAR043000A | 14/43 water quality standards | ** | ** | ** | *** |
| **Load allocations to meet marine criteria at mouths of tributaries** | | | | | |
| Goldsborough Creek | 14 (geomean std) | 1.985 | 2.4E+10 | 59 | May-Aug |
| Shelton Creek | 43 (90th percent std) | 0.196 | 7.3E+09 | 83 | May-Aug |
| Malaney Creek | 14 (geomean std) | 0.057 | 6.9E+08 | 78 | May-Aug |
| Campbell Creek | 14 (geomean std) | 0.082 | 9.9E+08 | 79 | May-Aug |
| Uncle John Creek | 43 (90th percent std) | 0.026 | 2.8E+09 | 93 | Annual |
| Mill Creek | 14 (geomean std) | 0.818 | 9.9E+09 | 36 | May-Aug |
| Johns Creek | 14 (geomean std) | 0.535 | 6.5E+09 | 67 | May-Aug |
| Cranberry Creek | 14 (geomean std) | 0.425 | 5.1E+09 | 72 | May-Aug |
| Deer Creek | 14 (geomean std) | 0.688 | 8.3E+09 | 71 | May-Aug |

* See Appendix J for assessment of existing limits.

** When updated, the statewide Washington State Department of Transportation (WSDOT) National Pollutant Discharge and Elimination System (NPDES) Permit for Municipal Stormwater, (WAR043000A), will identify stormwater best management practices needed to attain water quality standards at all WSDOT outfalls.

*** Ecology is developing implementation guidelines to identify appropriate action items for WSDOT discharges.

# Conclusions and recommendations

## General

1. Practices contributing bacteria to tributaries should be addressed. The observed concentrations in Oakland Bay, resulting from potential sediment re-suspension, will likely continue to cause elevated levels of FC in the water column unless sources of both suspended solids and bacteria are controlled: It is therefore recommended that:
   a. Total suspended solids should be controlled at all stormwater discharges to the tributaries and to the bay through best management practices (BMPs).
   b. Potential human sources, such as recreation, as a rule should be investigated and controlled in the watershed.
   c. Domesticated animals should be managed to limit access to waterways either directly or through contact-runoff.
2. Investigate and address other ways of lowering bacteria concentrations in the sediment, including the potential role of nutrients on survival of sediment bacteria.

3. Although the loading to the whole bay from shoreline sources may not be high, localized elevated levels may be present due to these sources. Control shoreline discharges where elevated concentrations have been identified, and continue to monitor for potential sources.

**Specific**

1. Monitor for enterococci in Inner Shelton Harbor and compare with Washington State's standard for secondary recreation in marine waters.
2. All shoreline point sources, including Washington State Department of Transportation (WSDOT) outfalls, must implement source control BMPs and/or BMPs that reduce the volume of discharging stormwater, or otherwise perform remediation to reduce fecal coliform bacteria concentrations. When updated, the statewide WSDOT National Pollutant Discharge and Elimination System (NPDES) Permit for Municipal Stormwater, (WAR043000A), will identify stormwater best management practices needed to attain water quality standards at all WSDOT outfalls.
3. All potential sources of FC bacteria must implement BMPs to reduce sediment loads to the bay.
4. All human-caused sources must be eliminated.

## Seasonal variation

The concentration of fecal coliform bacteria are high in both winter and summer. As previously noted in this report, load reductions were established in most cases for the May-August period rather than an annual basis. BMPs applied year round to achieve these reductions would provide for an added margin of safety.

## Allocation for future growth

Future point and nonpoint sources may be allowed as long as (1) the water quality standards are met either at the end-of-pipe or at the edge of any applicable mixing zone, and (2) there is no reasonable potential to add bacteria to sediments.

## Margin of safety

The margin of safety is implicit in the assumptions made in the modeling exercise. The model used the lower range of die-off rates for temperature, salinity, solar radiation, and sediment die-off rates, as published in the literature. When evaluating the impact of shoreline loads, excess loading was assumed compared to observed shoreline loading. Load reductions were established, in most cases, for the May-August period rather than on an annual basis. BMPs applied year-round to achieve these reductions would provide for added margin of safety.

.

# Reasonable Assurance

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources) in the water body. For the Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform TMDL Water Quality Improvement Report both point and nonpoint sources exist. Water cleanup plans, commonly referred to as TMDLs, must show "reasonable assurance" these sources will be reduced to their allocated amount. Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure the goals of this water clean-up plan are met.

Ecology believes the implementation plan activities identified in this report already support this water cleanup plan and add to the assurance fecal coliform bacteria for Oakland Bay, Hammersley Inlet, and selected tributaries, will meet criteria provided by Washington State water quality standards. This assumes the activities are continued and maintained.

The purpose of the Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform TMDL Water Quality Improvement Report is to provide information on resources and activities which will result in the waters of the basin meeting the state's water quality standards. There is considerable interest and local involvement toward resolving the water quality problems in the watershed. Numerous organizations and agencies are already engaged in stream restoration and source correction actions that will help resolve the fecal coliform problem. The following rationale helps provide reasonable assurance that the Oakland Bay, Hammersley Inlet, and selected tributaries nonpoint source TMDL goals will meet water quality standards by 2017.

## Legal authorities

**Table 15. Legal authorities**

| Organization | Statutory Authority | Comments |
|---|---|---|
| Mason Conservation District | Chapter 89.08 RCW, Conservation Districts | Administers programs to conserve the natural resources of Mason County. |
| Mason County Public Health Department, Environmental Health Division (EHD) | Chapter 246-272A WAC, On-site Sewage Systems | Regulates on-site septic systems in the watershed |
| Mason County Public Works | Mason County Stormwater and Surface Water Utility Ordinance 80-08<br>Mason County Stormwater Management Ordinance 81-08 | The Stormwater Program is managed through the Mason County Public Works Department. |
| Squaxin Island Tribe | Legal Authority - 1854 Treaty of Medicine Creek | |
| Washington State Department of Ecology | Chapter 90.48, Water Pollution Control Act; Federal Clean Water Act | Establishes water quality standards, coordinates water cleanup projects (TMDLs), and enforces water quality regulations. |

| Organization | Statutory Authority | Comments |
|---|---|---|
| Washington State Department of Health | Chapter 43.70 RCW | The mission of the Office of Shellfish and Water Protection is to improve the health of people in Washington State by ensuring shellfish are safe for eating, beaches are safe for swimming, and on-site sewage and reclaimed water systems are managed properly. |
| Washington State Department of Transportation | Chapter 90.48, Water Pollution Control Act; Federal Clean Water Act | |

## Technical assistance

**Table 16. Example of technical assistance.**

| Lead Entity | Activity | Comments |
|---|---|---|
| Mason County Public Health, Environmental Health Division | Septic System Retrofit Rebate Program | $200 rebate to Oakland Bay Clean Water District homeowners to retrofit their existing septic system with septic take risers, effluent filters, or both. |

## Grants/Loans

**Table 17. Examples of grants/loans funded for the work in the watershed.**

| Recipient | Project Title | Comments |
|---|---|---|
| Mason County Public Health | Onsite Septic System Discovery & Pollution Abatement | Grant #G1000278 |
| Squaxin Island Tribe | Oakland Bay Sa-Heh-Wa-Mish Stewardship Initiative (EPA West Coast Estuaries Initiative Grant) | This is a broad-based community action coalition. Goal is to assist private landowners in the implementation of best management practices to limit contributions of pathogens and bacteria. |
| Mason Conservation District | Oakland Bay Riparian Area Assessment | Grant #G0700294: Project to identify areas and extent of riparian degradation along 303(d) listed freshwater tributaries to Oakland Bay. One result from this grant was available cost-share funds to help with planting projects and fencing projects along streams and creeks. |
| Mason County | Oakland Bay Local Government Stormwater Grant | Grant #G0800202; Establish a program to improve and prevent future water downgrades with a new efficient and cost-effective treatment to improve and protect the water quality in Oakland Bay. |
| WSU Mason County Extension Office | Puget Sound Starts Here Campaign | Funding provided by the Puget Sound Partnership. This block grant was used for messaging and media coverage in 2009-2010. |
| WSU Mason County Extension Office | Mason County Pet Waste Stations | Funding provided by the Puget Sound Partnership. This block grant was used for identifying potential locations to install pet waste stations; and the supplies needed to build and install them. |

## Education/Outreach

**Table 18. Examples of education and outreach efforts in the watershed.**

| Lead Entity | Activity | Schedule/Comments |
|---|---|---|
| WSU Mason County Extension Office | Pioneer Elementary and Evergreen School Environmental Camp Classes | 2008, 2009, 2010, and 2011 |
| WSU Mason County Extension Office | Mason County (Area) Fair – Water Quality Display | 2008, 2009, and 2010 |
| WSU Mason County Extension Office | Low Impact Development - Realtor Workshop | October 27, 2008 |
| WSU Mason County Extension Office | On-site Septic System Operation & Maintenance Workshops | September 17, 2008, January 26, 2009, December 16, 2009, and January 12, 2010. There have been six workshops per year conducted by the WSU Mason County Extension Office and Mason County Public Health. |
| Mason Conservation District | Newsletter article, *"Tips for Managing Stormwater at Home"* | Winter 2009 |
| WSU Mason County Extension Office | Rain Gardens – How to Build Your Own | March and December 2009 and September 2010. |
| Mason Conservation District | Rain Garden and Stormwater Management Workshop | March 29, 2009 |
| WSU Mason County Extension Office | Shoreline Living Workshop | April 26, 2009, and December 3, 2009. They also held additional courses targeted to realtor education. |
| Mason Conservation District | Managing Stormwater in Your Backyard Workshop | June 2, 2009, and October 1, 2009 |
| Mason Conservation District | Low Impact Development Tour | June 9, 2009 |
| WSU Mason County Extension Office | Stormwater in Your Backyard Videoconference | September 15, 2009 |
| WSU Mason County Extension Office | Developed two Low Impact Development Brochures | 2009: One targeted to the public and the other specific to project done for the new Mason County Public Works facility. |
| WSU Mason County Extension Office | Developed Low Impact Development Fact Sheet, "Protecting our Waters" | 2009 |
| Mason Conservation District & WSU Mason County Extension Office | Earth Day on Oakland Bay | April 18, 2010, and April 30, 2011: Information from local resource agencies; riparian restoration project; on-site workshops; "Puget Sound Starts Here" information; and other activities related to natural resources. |
| Mason Conservation District | Brochure: Stormwater Management Guidelines | |
| WSU Mason County Extension Office | Shoreline Management Workshop – for Realtors | May 2010 and 2011 |
| WSU Mason County Extension Office | KMAS Radio Station – Garden Gate Radio Spots | Twelve annually |
| Mason Conservation District | Mason County Scoop the Poop Campaign | www.masoncd.org/scoopthepoop.html |
| Mason Conservation District | Small Farms Program | www.masoncd.org/small_farms.html |

## Riparian restoration/Low impact development

**Table 19. Examples of riparian restoration and low impact development activities.**

| Lead Entity | Activity | Comments |
|---|---|---|
| Mason Conservation District | Impervious concrete parking are installed at Turning Pointe | Completed 2008 |
| Mason Conservation District | Rain Garden installed at Pioneer School | Completed 2010 |
| Mason Conservation District | Twin Rivers Ranch Riparian Restoration Project | Work began Fall 2010 with completion expected Spring 2011. Project partially funded through Ecology's Coastal Protection Fund, Grant #G110008. |
| WSU Mason County Extension Office | Rain garden installed at Harmony Hill | Completed 2008 |
| WSU Mason County Extension Office | Rain garden installed at WSU Mason County Extension Office | Completed 2010 |

# Implementation Plan

## Introduction

This *implementation plan* describes the necessary actions to improve water quality. It expands on the recommendations made from the technical study portion of this report. It describes the roles and authorities of cleanup partners (the organizations with jurisdiction, authority, or direct responsibility for cleanup) and the programs or other means through which they will address these water quality issues.

Typically, Ecology produces an *implementation strategy*, which is submitted with the technical analysis to the U.S. Environmental Protection Agency (EPA) for approval of the water quality improvement report (more commonly referred to as the TMDL). Then, following EPA's approval, Ecology and the interested and responsible parties develop a *water quality implementation plan* (WQIP). However, this *implementation plan* will serve as both the *implementation strategy* and the *implementation plan*.

This plan describes how fecal coliform bacteria levels will be reduced to meet water quality standards. It specifies the actions needed and planned to improve water quality and achieve water quality standards. Bacteria TMDL reductions in Oakland Bay, Hammersley Inlet, and the selected tributaries should be achieved by 2017.

## Summary of actions

Fecal coliform bacteria primarily enter waterways from one or more of the following sources:

- Improperly treated sewage or other illicit discharges to the watershed.
- Livestock with direct access to streams or with poor manure management.
- Failing or improperly constructed septic systems.
- Pet waste.
- Wildlife.

The most effective means of addressing these sources is prevention. If these sources are managed and maintained properly, bacteria can be prevented from entering waterways both directly and through runoff.

The follow section describes addressing the sources listed earlier in more detail.

## Activities to address pollution sources

### Fecal coliform from failing or improperly constructed on-site septic systems

Septic systems can fail and lead to pollutants entering waterways. Untreated or partially treated sewage can accumulate on the ground's surface and flow into streams. Improperly treated sewage can also leach pollutants into the ground water, which can travel to nearby streams.

To combat failing septic systems, homeowners should be educated about the proper maintenance and inspection of septic systems. This education should include the negative effects of garbage disposals and what should and should not be disposed of through in-home drains to septic systems. Recognizing signs of on-site septic system failure is a critical and important step toward proper maintenance. When available, provide incentives such as retrofit rebates for risers or effluent filters, and coupons to reduce cost for professional inspections and septic pumping.

Sub-reaches of the streams with consistent year-round loading should be further investigated for failing or improperly constructed septic systems. If failing or straight pipe (direct discharge without treatment to a ditch or stream) septic systems are found, they will need to be repaired or replaced under proper permitting regulations.

### Fecal coliform from animals (livestock and wildlife)

When livestock or wildlife congregate along streams, they deposit fecal matter, trample vegetation, and break up the soil. When the vegetation is removed and the soil is loosened, it increases erosion and removes any filtering effect for the deposited fecal matter. To address these issues, riparian fencing and off-stream watering should be installed in areas with livestock to ensure the stream corridor is protected. In areas without livestock, riparian vegetation should be planted, enhanced, or maintained to discourage wildlife congregation and filter polluted runoff.

### Fecal coliform from stormwater (including pet waste)

Many best management practices (BMPs) exist to reduce runoff that can transport bacteria to streams via stormwater. Mason County, the city of Shelton, and the Washington State Department of Transportation (WSDOT) should inventory stormwater outfalls to determine where stormwater may be delivering pollutants to streams, and work to prevent delivery of unnatural levels of fecal coliform to their stormwater conveyance systems. Because bacteria loading is sometimes correlated with total suspended solids (mainly sediments), the inventory should include assessing potential sediment discharges. Efforts to prevent sources and reduce fecal coliform contributions should include the use of BMPs, pollution prevention measures such as Illicit Discharge Detection and Elimination (IDDE) programs, increased public education, and other methods.

An important source of bacteria in stormwater can be pet waste left on the ground. Local governments should have pet waste ordinances in place to require citizens to pick up and properly dispose of pet waste. Educating the local residents about this practice is an important and critical step to take to reduce bacteria in stormwater. Make educational material available at veterinary offices, kennels, pet stores, or other places associated with animals kept as pets. Where possible, install pet waste stations, including disposal bags and trashcans, throughout the watershed to encourage proper disposal of pet waste.

## Implementation actions, goals, and schedules from participating organizations

This section describes actions identified by the various participating organizations already involved in the watershed and this water quality cleanup effort. The actions taken will work toward addressing the issues identified in the technical analysis of this report. The entities are listed alphabetically after Ecology.

Improving water quality is a dynamic process. The implementing organizations represented in the following tables will meet at least annually to monitor progress, evaluate successes, identify areas which need improvement, and adjust action items in the tables as needed. This is all part of the Adaptive Management process which is described in more detail later in this report.

### Washington State Department of Ecology (Ecology)

Ecology has the responsibility by delegated authority from the EPA to establish water quality standards, coordinate water cleanup projects (commonly referred to as TMDLs), and enforce water quality regulations. In addition to this regulatory role, Ecology gives grants and loans to local governments, tribes, and conservation districts, for water quality projects. Projects supporting water cleanup plans have a higher priority for funding.

Statutory authorities: Chapter 90.48 RCW, Water Pollution Control Act, and Federal Clean Water Act.

**Table 20. Summary for Ecology implementation actions.**

| Action | Comments |
|---|---|
| Oversee and track the implementation of the Oakland Bay Fecal Coliform TMDL. The focus is to ensure implementation is on schedule and pollution sources are being addressed. | This is an ongoing activity. |
| Refer nonpoint sources of pollution to the Mason Conservation District or Mason County Environmental Health Department, to receive technical and financial assistance to correct the pollution problem. If necessary, Ecology will use its authority under Revised Code of Washington (RCW) 90.48 to enforce water quality regulations. | This is an ongoing activity. |
| Administer the NPDES permit for the Shelton Wastewater Treatment Plant (WWTP). This permit reflects permit limits and actions to prevent impairment of water quality standards from WWTP discharges. | This is an ongoing activity. |
| Provide funding opportunities through its competitive water quality grants and loan funding cycle, to projects addressing the goals of this TMDL and rank high enough to receive funding. The Ecology TMDL lead will provide feedback on grant | This is an ongoing activity. |

| Action | Comments |
|---|---|
| applications prior to their submission to help applicants refine their scope of work to develop the best project that has the highest likelihood of receiving funding. | |
| Investigate and respond to water quality complaints involving land uses in critical areas. | This is an ongoing activity.. Respond as needed within two working days of a complaint. |
| Respond to animal feeding operations or pasture-based water quality complaints. | Ecology will work with the WA State Department of Agriculture and the Mason Conservation District as appropriate. |
| Provide technical assistance for stormwater program and TMDL-related activities. | This is an ongoing activity. |
| Effectiveness monitoring to ensure state water quality standards are being met. Prepare report. | Start date not identified at this time. |

More information about the Department of Ecology is available at www.ecy.wa.gov.

## Mason Conservation District

The Mason Conservation District (MCD) is a non-regulatory organization assisting land owners and managers in implementing conservation practices. The MCD educates landowners about water quality problems and steps they can take to help reduce pollutants reaching the streams. They provide technical assistance, outreach, and education to county residents related to developing and implementing farm conservation plans. They also provide assistance for the design and installation of best management practices (BMPs). Ecology normally refers farmers who have received a Notice of Correction to the MCD for assistance. The MCD assists with conservation planning and provides technical and cost-share assistance to landowners. They receive annual base operational funding from the Washington Conservation Commission.

Statutory authority: Chapter 89.08 RCW, Conservation Districts.

**Table 21. Summary for Mason Conservation District (MCD) implementation actions.**

| Action | Comments |
|---|---|
| Assist with implementation actions. | This is an ongoing activity. |
| Farm Conservation Plans: Work with farmers to develop plans identifying best management practices. | This is an ongoing activity. |
| Respond to pasture-based water quality complaints. | The MCD will respond to referrals within 48 hours of receipt of agency (Ecology or WSDA) notice or landowner request. |
| Prepare and implement riparian restoration project for Oakland Bay Park. | Phase 2 site preparation completed in 2010. Planting to finish in Fall 2011. |
| Prepare and implement plan for a rain garden at the Port of Shelton Oakland Bay Marina. | Rain garden installed September 2009. |
| Develop incentives for (1) natural shoreline protection, including reduction of existing hard armoring; and (2) shoreline riparian and other buffer enhancement with native plantings. | MCD held four native plant workshops in 2009-2010. Developed two brochures on native plants for shoreline/streamside landowners and distributed them in January 2010. Completed 26 restoration planting plans since 2008. Implementation is ongoing. |

| Action | Comments |
|---|---|
| Provide technical assistance regarding best management practices (BMPs) for the Small Parcel Stormwater Site Plan requirements. Develop informational brochures and conduct workshops. | Provided technical assistance to 51 landowners between 2008 - 2010. Coordinated effort with the Mason County Departments of Community Development and Public Works Stormwater Program. |
| Livestock and Poultry Operations: Provide education and outreach to all watershed area livestock and poultry operations through targeted mailings and public meetings. | This is an ongoing activity. In December 2009, they identified all sites with livestock and poultry. Conducted a series of three compost workshops in 2010. |
| Develop and implement phased riparian restoration along Malaney Creek in Oakland Bay Park. | Coordinated effort with Capitol Land Trust and Mason County Public Utilities District #3. Phase 1 and 2 completed March 2010. Phase 1 planning completed October 2008 and Phase 2 planning completed February 2010. |
| Work with local landowners to identify fecal coliform sources. Provide technical assistance for removal of sources. | This is an ongoing activity. |

More information about the Mason Conservation District is available at www.masoncd.org.

## Mason County Department of Community Development

The Mason County Department of Community Development (DCD) consists of the Building Department, Planning Department, and Fire Marshall's Office. They are responsible for assisting with property acquisitions into conservancy; responding to water quality complaints involving land use in critical areas; and developing small parcel stormwater site plan requirements.

More information about the DCD is available at www.co.mason.wa.us/community_dev/index.php.

## Mason County Department of Public Works

Mason County developed and adopted a Countywide Stormwater Management Plan, consistent with required stormwater responsibilities, the Puget Sound Action Agenda, and potential future Phase II NPDES Municipal stormwater permit requirements. Stormwater is a problem associated with land use and development. Common issues are the potential presence of pollutants such as pesticides, fertilizers, petroleum products, and animal wastes. Land use and development can also increase the volume and duration of peak stormwater runoff. Stormwater pollution can cause or contribute to the closure of shellfish beds, swimming beaches, and other restrictions on the public use of waterbodies within Mason County.

The Countywide Stormwater Management Plan (SWMP) includes various strategies to protect, enhance, and restore Mason County's waterbodies. Implementation is carried out as funding is available (primarily through grants) by an interdepartmental County team, currently led by Mason County Department of Public Works. Mason County will often contract out or coordinate work through partnerships with the Mason Conservation District, WSU Mason County Extension Office, and the Squaxin and Skokomish Tribes. Some stormwater strategies from the SWMP include public education and involvement, water quality monitoring, low impact retrofit projects, and stormwater regulations for new development.

In June 2008, Mason County adopted Ordinance Number 81-08, (Stormwater Management Ordinance), which states how new development and redevelopment will manage stormwater. The 2005 edition of the Department of Ecology's Stormwater Management Manual was adopted as part of this ordinance and geographic application has been gradually phased in over time. The 2005 Manual will apply countywide by June 2012.

Also in June 2008, Mason County adopted Ordinance Number 80-08, forming a Stormwater and Surface Water Utility whose purpose includes, but is not limited to, improving water quality in all local streams and waterbodies. Their goal is to mediate conflicts between pressures created by development and the need to conserve Mason County's natural environment. The ordinance also defines department roles and responsibilities for managing stormwater. The identified lead for overall program management and administration is Mason County Utilities and Waste Management. The County is currently investigating long-term funding options since utility rates were not established at the time the Utility was formed.

More information about Mason County's Stormwater Management Program is available at www.co.mason.wa.us/stormwater/index.php.

## Mason County Public Health Department, Environmental Health Division

The Mason County Public Health (PH) Department, Environmental Health Division (EHD), protects and preserves the environment and promotes healthy lifestyles through education and community partnerships to make a positive difference in the health of Mason County residents and visitors. The mission of the EHD is to serve the residents of Mason County under the direction and guidance of the Mason County Board of Health. This is done by conducting activities designed to protect public health through control of key environmental factors, including but not limited to drinking water, solid waste, food, sewage, vectors, and chemical/physical hazards. Where the scope of these activities is limited by resources or jurisdictional boundaries, the EHD cooperates and coordinates, where appropriate, with other public and private agencies. The EHD works closely with the DCD on permits and other issues.

The 2007 Washington State Legislature strengthened regulations (WAC 246-272A) for on-site septic systems (OSS). Mason County Environmental Health Department adopted the state code and its developing procedures to implement the new requirements. The requirements include generating a written plan to guide development and management activities for all OSS. This plan must describe educational efforts regarding the operation and maintenance (O&M) of all types of systems. It also includes how the department will remind and encourage homeowners to complete required O&M inspections.

For most OSS, homeowners will be required to have the system components and property inspected to determine functionality, maintenance needs, and compliance with regulations and permits at least once every three years.

The Mason County Public Health Department, Environmental Health Division, emphasizes areas previously identified as having high bacteria loading along the Oakland Bay watershed in their education and outreach. They already have materials available online, including information about the Mason County Operations and Maintenance Program, "Septic Systems User's Manual", "On-site Sewage and Disposal System Operations and Maintenance Report," and "Septic Sense" brochure.

Statutory authority: WAC 246-272A, On-site Sewage Systems

**Table 22. Summary for Mason County PH Department, EHD implementation actions.**

| Action | Comments |
|---|---|
| On-site septic systems: Conduct and track investigations of on-site septic systems (OSS) based on complaints or unsatisfactory maintenance reports. Use results for voluntary compliance or code enforcement. | This is an ongoing activity. |
| Scan on-site septic systems (OSS) records. First priority are shoreline and stream parcels. Update Mason County PH database with the type, age, and indicate whether the system is less than 100 ft. to surface water. | This is an ongoing activity. |
| Operation & Maintenance (O&M): Continue to contact property owner notifications, monitoring, recording, and follow-up for all on-site sanitary systems. | This is an ongoing activity.. Routine notification. Record responses in O&M database. |
| On-site Septic Sanitary Surveys: Conduct on-site septic sanitary surveys for marine shoreline, stream, and upland areas. Segment streams with excessive fecal coliform levels. Use results for voluntary compliance or code enforcement. | This is an ongoing activity.. Sample 1/3 of the Oakland Bay Clean Water District shoreline yearly. |
| On-site septic systems: Upgrade components of existing on-site septic systems. Obtain funding for 100 systems in the Oakland Bay area for upgrades to make O&M easier. Publicly promote the septic system upgrades until the 100 upgrades are completed. | Coordinated effort with the Mason Conservation District and WSU Mason County Extension Office. Work began July 2008. Estimate completion by July 2012. Completed 49/100 upgrades by September 2009. |
| Environmental Complaint Response: Dye trace systems as needed based on sanitary survey results, complaint investigation results, or unsatisfactory maintenance records. | This is an ongoing activity.. Prioritize work according to department policy for sanitary surveys and complaints. |
| Freshwater sampling for pollution identification. Review quarterly number and location of samples taken. | This is an ongoing activity.. Coordinate with the Squaxin Island Tribe and the WA State Department of Health. |
| Facilitate regular meetings of the Oakland Bay Clean Water District Advisory Committee. Coordinate tasks through regular meetings and revise the Oakland Bay Action Plan Strategy annually. | Meetings currently scheduled on the first Wednesdays of January, March, May, July, September, and November. Additional meetings scheduled as needed. |
| Updated Mason County Sanitary Code, Chapter 6.76 On-site Sewage Regulations, to improve enforcement capabilities. | Subsection 6.76.130, Enforcement, updated April 7, 2009. |

More information about the Mason County Public Health Department is available at www.co.mason.wa.us/health/envhealth/index.php.

## Puget Sound Partnership

The Puget Sound Partnership (PSP) is a community effort of citizens, governments, tribes, scientists and businesses working together to restore and protect Puget Sound. Governor

Gregoire and the state legislature charged the PSP with creating an action agenda which will lead to a healthier Puget Sound. This action agenda prioritizes cleanup and improvement projects, coordinates with federal, state, tribal, and private resources, ensuring all work cooperatively. The PSP base their decisions on science, and focus on actions having the biggest impact and holding people and organizations accountable for their actions. The primary goal is to make Puget Sound healthy again. They will provide technical assistance to local governments and other partners in support of water cleanup activities.

More information about the Puget Sound Partnership is available at www.psp.wa.gov.

## Shelton, City of

The city of Shelton (Shelton) includes 6.11 square miles and 8,735 residents. It is the last city in Washington to have a Mayor/Commission form of government. It is located 35 miles northwest of Olympia on the shores of Oakland Bay at the southern tip of Puget Sound. Water quality issues fall under the jurisdiction of Shelton's Public Works Department. They are responsible for engineering; public works construction projects; and maintenance and operation of the water, stormwater, and sewer systems; streets; traffic signals; garbage and recycling; city equipment and municipal buildings and facilities.

**Table 23. Summary for the city of Shelton implementation actions.**

| Action | Comments |
|---|---|
| Education and Outreach: Encourage watershed residents to use water wisely. | This is an ongoing activity. |
| Wastewater treatment plant: Follow the NPDES permit requirements including operational best management practices (BMPs) to prevent discharge of bacterial pollutants. | This is an ongoing activity. |
| Stormwater control and management: Proactively implement NPDES Phase 2 requirements to improve stormwater control and management. | This is an ongoing activity. |
| Reduce infiltration and inflow to the Shelton Wastewater Treatment Plant (WWTP). | Sewer line replacement is ongoing. Complete construction of WWTP upgrade expected by 2012. |
| Riparian planting project near Highway 3, connected to mouth of Shelton Creek. | This is an ongoing activity. |
| Source identification: Conduct monthly stream sampling of Goldsborough and Shelton streams. Test to confirm Shelton sewer basin work has controlled infiltration and exfiltration. Identify other sources and reduce stream pollution. | Completed. Report posted on Friends of Oakland Bay website at http://www.co.mason.wa.us/oakland_bay/. |
| Work with local landowners to identify fecal coliform sources. Provide technical assistance for removal of sources. | This is an ongoing activity. |
| Wastewater Treatment Plant upgrade | Targeting completion in 2012 of the following to benefit shellfish production and enable the WA Department of Health to reduce shellfish harvest closures: add a basin for nitrogen treatment; new slack-tide storage tank; extend the discharge effluent diffuser by 96 feet; and new ultra-violet disinfection treatment. |

More information about the city of Shelton is available at www.ci.shelton.wa.us.

## Shelton, Port of

The port of Shelton comprises a marina, industrial park, and airport. Oakland Bay Marina is located in the harbor of Shelton and is a facility for long term and day use. This includes the ability to launch recreational boaters into Hammersley Inlet, which leads into Oakland Bay, connecting it to Puget Sound. Oakland Bay Marina is a participant of Clean Marina Washington, implementing best management practices (BMPs) to reduce pollution at the source.

More information about the Port of Shelton is available at www.portofshelton.com

## Squaxin Island Tribe

The Squaxin Island Tribe (SIT) is known as the “People of the Water”. Tribal members historically resided in the seven inlets of southern Puget Sound. Now the tribal headquarters and trade center are located in Mason County, six miles south of Shelton, in Kamilche at Little Skookum Inlet.

The SIT is a historic steward and a conscientious co-manager and protector of natural resources, working in cooperation with numerous federal, state and county government agencies and organization. The SIT participates in natural resources enhancement and protection programs with the Northwest Indian Fisheries Commission, the Puget Sound Partnership, the Washington Department of Fish and Wildlife, and other groups and agencies to ensure that today’s decisions provide for a healthy future.

**Table 24. Summary for the Squaxin Island Tribe implementation actions.**

| Action | Comments |
|---|---|
| Freshwater sampling to identify emerging pollution issues. Review results semi-annually and make recommendations to Mason County and Washington State Department of Health of streams needing further investigation. | Ongoing. Coordinate with the WA State Department of Health and Mason County Public Health Department, Environmental Health Division. |
| Sediment investigation: Investigate sediment as a secondary source of bacterial pollution. | This is an ongoing activity. |
| Seek federal funding to support protection and restoration activities in the Oakland Bay watershed. | This is an ongoing activity. |

More information about the Squaxin Island Tribe is available at www.squaxinisland.org.

## United States Environmental Protection Agency (EPA)

The United States Environmental Protection Agency (EPA) is responsible for implementation of the federal Clean Water Act. EPA approves total maximum daily load (TMDL) water quality improvement reports (also referred to as water cleanup plans). EPA provides water-quality related loan and grant funding opportunities. Region 10 of the EPA oversees the Pacific Northwest, which consists of Alaska, Idaho, Oregon, Washington, and Native Tribes.

More information about the EPA Region 10 is available at www.epa.gov/Region10.

## Washington State Department of Agriculture (WSDA)

The Washington State Department of Agriculture (WSDA) serves the people of Washington by supporting the agricultural community and promoting consumer and environmental protection.

The major goals of the WSDA are:

- Protect and reduce the risk to public health by ensuring the safety of the state's food supply.
- Ensure the safe and legal distribution, use, and disposal of pesticides and fertilizers in Washington.
- Protect Washington State's natural resources, agricultural industry, and the public from selected plant and animal pests and diseases.
- Facilitate the movement of Washington agricultural products in domestic and international markets.

They coordinate with the Washington State Department of Ecology to respond and investigate non-dairy livestock complaints. In Mason County, these typically address animal feeding operations or pasture-based water quality concerns. Most often, the issue gets referred to the Mason Conservation District if there is no immediate impact or potential for impact to waters of the state.

More information about the Washington State Department of Agriculture is available at www.agr.wa.gov.

## Washington State Department of Health (DOH)

The Washington State Department of Health (DOH), under authority of Chapter 43.70 RCW, monitors marine water quality in commercial shellfish growing areas of the state, including the Oakland Bay watershed, for harvest sustainability. Classifications for shellfish growing areas for commercial harvest are: approved, conditionally approved, restricted, or prohibited.

In the past, DOH has downgraded commercial shellfish classification in areas of Oakland Bay because fecal coliform levels were higher than public health-based water quality standards. Currently, no sampling stations are in "threatened" status and there are several stations of concern due to elevated bacteria levels. DOH continues to monitor water quality in the Oakland Bay watershed at least 12 times per year.

DOH is responsible for protecting public health by promoting the safe treatment and disposal of domestic and other non-industrial wastewater in areas not served by municipal wastewater treatment. DOH can provide assistance to local health jurisdictions for residential on-site wastewater issues on large on-site sewage plan reviews (Chapter 246.272B WAC). Chapter 246-272A WAC establishes minimum on-site requirements.

Statutory authority: Chapter 43.70 RCW.

**Table 25. Summary for the DOH implementation actions.**

| Action | Comments |
|---|---|
| Freshwater sampling for pollution identification. Review quarterly number and location of samples taken. Develop Fact Sheet on trends in fecal coliform levels, number of "hot spots" identified, investigations started, analysis, and recommendations. | Ongoing. Coordinate with the Squaxin Island Tribe and Mason County Public Health Department, Environmental Health Division. |
| Marine Sampling: Determine if non-point identification and remediation have improved marine water quality in Oakland Bay enough to reopen or keep open portions of the bay for shellfish harvesting. | Sampling is conducted 12 times per year. Sampling began at the north end of Oakland Bay summer 2009. |

More information about the Washington State Department of Health is available at www.doh.wa.gov.

## Washington State Department of Transportation (WSDOT)

WSDOT stormwater was not sampled during the TMDL study. Therefore, there is no water quality data indicating WSDOT stormwater is a source of fecal coliform. However, Highways 3 and 101 are within the study area. It is reasonable to assume WSDOT stormwater may convey fecal coliform in areas where adjacent land uses are a recognized source of this bacteria. While the WSDOT can be the source of bacteria in some locations, there is a greater likelihood the source of fecal coliform bacteria at a WSDOT outfall (if measured) comes from adjacent private property via natural drainage, an illicit discharge, or an illegal connection.

Statutory authorities: Chapter 90.48 RCW, Water Pollution Control Act, and Federal Clean Water Act.

**Table 26. Summary for the WSDOT implementation actions.**

| Action | Comments |
|---|---|
| Inventory highway discharge locations along State Route 3 (SR3) into Oakland Bay, at SR3 stream crossings, and at US Highway 101 stream crossings within WSDOT's right-of-way and inside the Oakland Bay TMDL boundary. The inventory will include the conveyance system directly draining to the discharge point. | Completion to be determined based on when the TMDL is added to their NPDES Municipal Permit. |
| Implement source identification for fecal coliform and illicit discharge detection and elimination (IDDE) during discharge inventory. | Completion to be determined based on when the TMDL is added to their NPDES Municipal Permit. |
| If discharges transporting bacteria are found, apply best management practices from the Stormwater Management Program Plan (SWMPP) or perform remediation to correct bacteria discharges. | As needed based on discharge inventory and source identification findings. |
| After the IDDE Program is developed, give a presentation on how it will work to the Oakland Bay Clean Water District Advisory Committee. | Completed November 2009 |

More information about the Washington State Department of Transportation is available at www.wsdot.wa.gov.

## Washington State University (WSU) Mason County Extension

The Washington State University (WSU) Mason County Extension is an educational resource to Mason County residents. Their Water Quality Programs provide research based information and educational programs. These are designed to promote responsible land and water stewardship to protect aquifers, streams, rivers, wetlands, marine waters and the resources these waterbodies provide. Specific activities they develop include septic workshops, educational publications, maintain Friends of Oakland Bay website, Low Impact and Stormwater programs, realtor education, write and submit newspaper articles and radio spots on water quality issues, and provide outreach at local public events.

**Table 27. Summary for WSU Mason County Extension Office implementation actions.**

| Action | Comments |
| --- | --- |
| Develop educational materials and public involvement plan regarding water quality in Oakland Bay. | This is an ongoing activity. |
| Develop Rain Garden educational materials and assist with project management. | This is an ongoing activity. |
| Provide realtor education classes to help real estate professionals understand water resources issues relating to homeowners and property development. | This is an ongoing activity. |
| Provide On-Site Septic System education in partnership with Mason County Public Health. | This is an ongoing activity. Workshops provided 4-6 times per year. |
| Develop and provide resources on Shoreline Living and the Shore Stewards program. | This is an ongoing activity. |
| Provide information on water quality issues such as Low Impact Development, composting, riparian restoration, and stormwater management. | This is an ongoing activity. |
| Provide water quality materials at local events, for example, the Mason Area Fair and Oysterfest. | This is an ongoing activity. |
| Develop and submit articles on water quality issues to local media (newspaper and radio). | This is an ongoing issue. |

More information about the Washington State University Mason County Extension is available at http://county.wsu.edu/mason/.

## Oakland Bay Clean Water District Advisory Committee

In addition to the activities previously listed, participating organizations of the Oakland Bay Clean Water District Advisory Committee (OBCWDAC) identified and committed to other activities benefiting this water cleanup effort. Appendix M provides the complete Oakland Bay Action Plan, prepared August 16, 2007.

This committee came together in 2007 after the Oakland Bay Clean Water District was formed in response to degraded water quality at the north end of Oakland Bay. The goal of the district is to reduce water pollution and ensure that Oakland Bay remain safe for swimming, fishing, and all activities important to the culture, heritage and economy of the area. The OBCWDAC consists of representatives appointed by the Mason County Board of County Commissioners including:

- Business
- Citizens
- Education (Washington Sea Grant, WSU Mason Extension)
- Mason County Government (Commissioners, Public Health, Public Works, Utilities)
- Mason Conservation District
- Shellfish growers
- Shelton, City of
- Shelton, Port of
- Squaxin Island Tribe
- Washington State agencies (Ecology, Health, Puget Sound Partnership)

**Table 28. Summary for the OBCWDAC implementation actions. Highlights other actions by the Oakland Bay Clean Water District Advisory Committee.**

| Action | Comments |
|---|---|
| Develop new educational materials and a public involvement plan regarding water quality in Oakland Bay that uses the principles of social marketing. | Coordinated effort by the Oakland Bay Education Subcommittee. |
| Low Impact Development (LID): Identify and implement projects such as rain gardens and pervious concrete pavements. | In 2008, a project to install pervious concrete pavement within the city limits of Shelton was completed. In 2010, a rain garden was completely installed at Pioneer School. |
| Pet Waste Control Strategy: Develop a strategy to increase public awareness, response, and compliance with local pet waste disposal regulations. | Target completion date of the Dog Waste Program is June 2011. Coordinated effort by the Oakland Bay Education Subcommittee. |
| Mycoremediation: Conduct research on the use of mycoremediation to reduce fecal coliform levels. | Coordinated effort between the Squaxin Island Tribe, Fungi Perfecti, Mason Conservation District, and the Mason County Public Works, Public Health, and Utilities & Waste Management Departments. Research is underway at the Allyn WWTP. Research was completed June 2009. Pilot project began February 2011. Results expected June 2011. |
| Land acquisitions for preservation and riparian restoration: Identify land and funding to acquire property in the 1) Johns Lake, Bayshore Golf Course, Sunset Bluffs, Eagle Point (pending), Twin Rivers Ranch (completed); and 2) Shoreline and creek frontage along Johns Creek, Coffee Creek, Hammersley Inlet, Goldsborough Creek, and Eastern Oakland Bay. | Coordinated effort with Cascade Land Conservancy, Capitol Land Trust, Mason Conservation District, City of Shelton, Port of Shelton, Mason County Department of Community Development, Squaxin Island Tribe, and others. |

| Action | Comments |
| --- | --- |
| Stream Source Identification: Identify and reduce stream pollution for the Goldsborough and Shelton streams. | Coordinated effort between the City of Shelton and Mason County Public Health, Environmental Health Division. |
| Update Critical Areas Ordinance to improve the function of Goldsborough and Shelton Creeks. | City of Shelton |
| Update Mason County Stormwater Ordinance #81-08, specifically addressing Oakland Bay. | Mason County Utilities & Waste Management adopted the updates to this ordinance on June 17, 2008. |
| On-site septic systems: Implement cost-share program for risers and low interest loans for homeowners to repair or replace on-site septic systems. | The U.S. Environmental Protection Agency provided funding for this program to the Squaxin Island Tribe (SIT) through a West Coast Estuaries (WEI) Grant. Working with the SIT, Mason County Public Health coordinated outreach for this program with the Mason Conservation District, WSU Mason County Extension Office, Enterprise Cascadia, and others. |
| Friends of Oakland Bay website: Established and maintained to announce public workshops, local restoration and cleanup efforts, provide educational material, and local outreach. Website link: http://www.co.mason.wa.us/oakland_bay/. | Coordinated effort led by the Mason Conservation District, WSU Mason County Extension Office, and Mason County Public Health. |
| Individual accountability: Pick up pet waste, dispose properly, and obey local regulations. Use water wisely. Reduce stormwater volumes from private property. Use best management practices for livestock, poultry operations, or hobby farms. Install rain gardens or consider low impact development techniques. | Citizens |

More information about the Oakland Bay Clean Water District is available at http://www.co.mason.wa.us/oakland_bay/index.php.

## What is the schedule for achieving water quality standards?

The target reductions in fecal coliform bacteria for the tributaries listed in this TMDL study area should be achieved by 2017. The targets are described in terms of concentrations and/or loads, as well as implemented cleanup actions. Partners will work together to monitor progress toward these goals; evaluate success, challenges, and changing needs; and adjust the water cleanup strategy as needed. Significant implementation to reduce and control fecal coliform bacteria is already occurring or planned in this watershed. It is important to remember that in order to maintain compliance with the standards and achieve success at the remaining sites, no location should receive additional inputs of fecal coliform bacteria.

While Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the Oakland Bay, Hammersley, Inlet, and Selected Tributaries TMDL process to achieve clean water through voluntary control actions.

It is ultimately Ecology's responsibility to assure water quality cleanup is actively pursued and water quality standards are achieved. Compliance with this TMDL is based on meeting the two-part fecal coliform bacteria standards. If the targets (percent reductions) are not met, but the water quality standards are met, the purpose of this TMDL will be satisfied.

## Performance measures and targets

A monitoring program for evaluating progress is an important component of any implementation plan. Monitoring is needed to keep track of what activities have been done, measure the success or failure of actions, and evaluate if water quality standards are achieved. Monitoring should continue after attaining the water quality standards to ensure implementation measures are effective and standards continue to be met.

Monitoring is required midway through the implementation progress to see if interim goals are being met. Ecology will conduct interim monitoring when enough implementation actions have been completed to anticipate achieving a 50 percent reduction in fecal coliform bacteria. Ecology will monitor the progress of implementation and resulting in-stream fecal coliform bacteria concentrations. Ecology will use this information to make sure the Oakland Bay watershed and its tributaries are on track for meeting the 2017 schedule.

Implementation actions will be tracked through adaptive management meetings beginning in 2013. Tracking will help identify and determine:

- What activities were performed and where did they occur?
- Did the actions work and could they be applied elsewhere?
- What practices should be considered for adaptive management?
- Were there resource limitations or other factors preventing some actions from occurring?
- Was this implementation plan adequate to meet water quality standards?

## Effectiveness monitoring plan

Effectiveness monitoring is needed to determine if interim targets and overall water quality standards goals are met. This is usually started five years after implementation activities are completed or underway. Ecology's Environmental Assessment Program usually conducts effectiveness monitoring for TMDLs.

The Ecology Water Cleanup Plan (TMDL) Coordinator will recommend monitoring schedules and locations based on this report and completed implementation. The coordinator will use the results of monitoring by Ecology and others to determine if this plan is working as written. If sufficient progress is not made the coordinator will begin adaptive management.

Before any water quality monitoring begins, a quality assurance project plan (QAPP) is prepared. The QAPP should follow Ecology guidelines (Lombard and Kirchmer, 2004), paying particular attention to consistency in sampling and analytical methods. The "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies" is available online at http://www.ecy.wa.gov/pubs/0403030.pdf. Separate QAPPs should be developed for the implementation and effectiveness monitoring efforts since they generally have different monitoring objectives.

## Adaptive management

Natural systems are complex and dynamic. The way a system responds to human management activities is often unknown. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches based on scientific findings.

In the case of TMDLs, Ecology uses adaptive management to assess whether the identified needed actions to solve the identified pollution problems are the correct ones and whether they are working. As we implement these actions, the system will respond and change. Adaptive management allows us to adjust our implementation efforts to make them more effective, and to try new strategies if we have evidence a new approach could help us to achieve compliance.

The Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform TMDL Water Quality Improvement Report will use an adaptive management approach to ensure the progress and overall success of this plan. It calls for evaluating the effectiveness of best management practices (BMPs) in causing Oakland Bay, Hammersley Inlet, and the selected tributaries to attain water quality standards after five years of implementation activities. Following the successful implementation of BMPs and adequate sampling to represent all climatological, hydrological, and land use characteristics, a reassessment of compliance with water quality standards can be made. When water quality criteria for fecal coliform bacteria are met, the objectives of this water cleanup plan are met and no further reductions or additional BMPs are needed.

TMDL reductions should be achieved by 2017. Adaptive management will be applied if effectiveness monitoring does not show significant improvement toward meeting the assigned percent reductions.

Ecology will use adaptive management when water monitoring data show 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:

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

Step 2. Programs and best management practices (BMPs) are evaluated for adequacy of design and installation.

Step 3. The effectiveness of the activities is evaluated by assessing new monitoring data and comparing it 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 may be necessary to better isolate the bacteria sources so new BMPs can be designed and implemented to address all sources of bacteria to the tributaries. Adaptive management meetings begin in 2013 with Ecology and partners to discuss progress and redirect unsuccessful implementation.

**SEPA/Planning**

Consider TMDLs during State Environmental Policy Act (SEPA) and other local land use planning reviews. If the land use action under review is known to potentially impact fecal coliform bacteria as addressed by this TMDL, then the project may have a significant adverse environmental impact. SEPA lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives and to document the necessary environmental analyses have been made. Land-use planners and project managers should consider findings and actions in this TMDL to help prevent new land uses from violating water quality standards. Ecology recently published a focus sheet on how TMDLs play a role in SEPA impact analysis, threshold determinations, and mitigation. The focus sheet is available at http://www.ecy.wa.gov/biblio/0806008.html. Additionally, the TMDL should be considered in the issuance of land use permits by local authorities.}

## Potential funding sources

Financial assistance for water cleanup activities is available through various federal and state agencies; local government sources, including conservation districts; and selected public and not-for-profit sources. Ecology's Centennial Clean Water Fund, Section 319, and State Water Pollution Control Revolving Fund grants and loans can provide funding to help implement this TMDL. In addition to Ecology's funding programs, there are many other funding sources available for watershed planning and implementation, point and nonpoint source pollution management, fish and wildlife habitat enhancement, stream restoration, and water quality education. Public sources of funding include federal and state government programs, which can offer financial as well as technical assistance. Private sources of funding include private foundations, which most often fund nonprofit organizations with tax-exempt status. Forming partnerships with other government agencies, nonprofit organizations, and private businesses can often be the most effective approach to maximize funding opportunities. Some of the most commonly accessed funding sources for TMDL implementation efforts are shown in Table 20 and are described afterward.

**Table 29. Possible funding sources to support TMDL implementation.**

| | |
|---|---|
| **Enterprise Cascadia Septic Loan** | |
| **For more information contact:** | **Funding Source** |
| 360-427-2875 or www.sbpac.com | Enterprise Cascadia |
| **Mason Conservation District (MCD)** | |
| **For more information contact:** | **Funding Source** |
| 360-427-9436 or www.masoncd.org | Washington State Conservation Commission (WCC) |
| **Puget Sound Partnership** | |
| **For more information contact:** | **Funding Source** |
| Toll-free: 800-54-SOUND or 360-725-5444; www.psp.wa.gov | Public Involvement and Education Grants |
| **United States Department of Agriculture (USDA)** | |
| **For more information contact:** | **Funding Source** |
| Farm Service Agency (FSA) www.fsa.usda.gov/FSA | Conservation Reserve Enhancement Program (CREP) |
| Olympia Service Center and Rural Development Office 360-704-7740; www.nrcs.usda/gov/programs/CRP | Conservation Reserve Program (CRP) |
| Olympia Service Center and Rural Development Office 360-704-7740; www.nrcs.usda.gov/programs/EWP | Emergency Watershed Protection (EWP) |
| Olympia Area Office (serving Mason County)<br>1835 Black Lake Blvd. SW, Suite C<br>Olympia, WA 98512-5716<br>360-704-7760;<br>www.rurdev.usda.gov/rhs/sfh/brief_repairloan.htm | Rural Housing Repair and Rehabilitation Program |
| **For more information contact:** | **Funding Source** |
| Olympia Service Center and Rural Development Office 360-704-7740; www.nrcs.usda.gov/programs/WHIP | Wildlife Habitat Incentive Program (WHIP) |
| **United States Environmental Protection Agency (U.S. EPA), Region 10** | |
| **For more information contact:** | **Funding Source** |
| www.yosemite.epa.gov/r10/ecocomm.nsf/webpage/Funding+and+Resources | Watershed Funding and Resources |
| **Washington State Department of Ecology (Ecology)** | |
| **For more information contact:** | **Funding Source** |
| www.ecy.wa.gov/programs/wq/funding/funding.html | Centennial Clean Water Grant Program |
| | Federal Clean Water Act Section 319 Nonpoint Source Fund |
| | Washington State Water Pollution Control Revolving Loan Fund |
| **Washington State Department of Natural Resources (DNR)** | |
| **For more information contact:** | **Funding Source** |
| Small Forest Landowner Office 360-902-1400; E-mail: sflo@dnr.wa.gov | Forestry Riparian Easement Program (FREP) |
| Forest Practices Division 360-902-1427; www.dnr.wa.gov | Riparian Open Space Program (ROSP) |
| **Washington State Recreation and Conservation Office** | |
| **For more information contact:** | **Funding Source** |
| 360-902-3000; www.rco.wa.gov/srfb/board/board.htm | Salmon Recovery Funding Board (SRFB) |
| **Washington State Recreation and Conservation Office** | |
| **For more information contact:** | **Funding Source** |
| 360-902-3000; www.rco.wa.gov/srfb/board/board.htm | Salmon Recovery Funding Board (SRFB) |

The programs of each of the involved organizations have some base funding for implementing and monitoring costs. However, base funding is not adequate to meet the needs.

**Centennial Clean Water Fund/Clean Water Act Section 319 Nonpoint Source Fund/Washington State Water Pollution Control Revolving Loan Fund**. These three funding sources are managed by the Washington State Department of Ecology through one combined application program. Funds are available to public entities and some not-for-profit organizations (Section 319 only) as grants or low-interest loans. Grants require a 25 percent local match and they may be used for education/outreach, technical assistance, specific water quality projects, or as seed money to establish various kinds of water quality related programs or program components. Recipients cannot use grant monies for capital improvements to private property without an easement being given; but riparian fencing, riparian re-vegetation, and alternative stock water projects can be eligible for funding consideration.

Low-interest loans are available to public entities for all the above uses. They have also been used as "pass-through money" to provide low-interest loans to homeowners for septic system repair or agricultural best management practice implementation. Loan money can also be used for a wide range of improvements to private property.

**Conservation Reserve Enhancement Program (CREP)**. This federal program provides incentives to restore and improve salmon and steelhead habitat on private land. This is a voluntary program to establish forested buffers along streams where streamside habitat is a significant limiting factor for salmonids. In addition to providing habitat, the buffers improve water quality and increase stream stability. Land enrolled in CREP is removed from production and grazing under 10-15 year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments. The annual payments can equal twice the weighted average soil rental rate (incentive is 110 percent in areas designated by the Growth Management Act). The Pierce County Conservation District administers this program in conjunction with the U.S. Department of Agriculture, Natural Resource Conservation Service.

**Conservation Reserve Program (CRP).** This is a voluntary program that offers annual rental payments, incentive payments for certain activities, and cost-share assistance to establish approved cover on eligible cropland. Assistance is available in an amount equal to not more than 50 percent of the participant's costs in establishing approved practices; contract duration is between 10-15 years. The Pierce County Conservation District administers this program in conjunction with the U.S. Department of Agriculture, Natural Resource Conservation Service.

**Emergency Watershed Protection.** The U.S Department of Agriculture, Natural Resource Conservation Service (NRCS) may purchase land vulnerable to flooding or easements on floodplain lands and the right to conduct restoration activities, in exchange for limited future use by the landowner.

**Enterprise Cascadia**. This is an FDIC-insured commercial bank helping businesses adopt sustainable practices and contribute to the long-term health of their local communities. Sustainability means creating a healthy environment, vibrant communities, and a strong economy that will thrive for many generations. Enterprise Cascadia entered the natural resources arena by providing loan-funding opportunities for repair or replacement of individual on-site septic systems.

**Environmental Quality Incentives Program (EQIP).** The U.S Department of Agriculture, Natural Resource Conservation Service program provides technical assistance, cost share payments, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm. This funding source proves 75 percent cost-share but allows 90 percent if a producer is a limited resource or beginning farmer or rancher. Program funding is divided up between livestock-related practices (60%) and crop land needs (40%). Contracts are for one to ten years.

**Forestry Riparian Easement Program.** The Washington State Department of Natural Resources provides funding through its Small Forest Landowner Office to protect wildlife habitat. The intent of the program is to help small forest landowners keep their land in forestry. The Forestry Riparian Easement Program partially compensates landowners for not cutting or removing qualifying timber under a 50-year easement. The landowner still owns property and retains full access, but has "leased" the trees and their associated riparian function to the state.

**Riparian Open Space Program.** The Washington State Department of Natural Resources (DNR) provides funding for the acquisition (through purchase or donation) of lands within unconfined avulsing channel migration zones (CMZs). The DNR may acquire the fee interest of the CMZ land or a permanent conservation easement over such lands.

**Rural Housing Repair and Rehabilitation Program.** Authorized by Section 504 of the Housing Act of 1949, 7 CFR Part 3550, the U. S. Department of Agriculture provides grant and loan funding to low-income rural residents who own and occupy a dwelling in need of repairs. Funds are available for repairs to improve or modernize a home or to remove health and safety hazards. One percent loans are given for up to 20 years.

**Salmon Recovery Funding Board.** In 1999, the Washington State Legislature created the Salmon Recovery Funding Board (SRFB) composed of five citizens appointed by the Governor and five state agency directors. The board provides grant funds to protect or restore salmon habitat through habitat protection, land acquisition, and habitat assessments. It also supports restoration projects and related programs and activities that produce sustainable and measurable benefits for fish and their habitat. It works closely with local watershed groups known as lead entities. SRFB has helped finance over 500 projects.

**Washington Conservation Commission**. The Washington State Conservation Commission (WCC) works in conjunction with local conservation districts to provide grant funding for various environmental programs and needs. Annual appropriations are used by the conservation districts to address priority projects.

**Wetland Reserve Program.** The U.S Department of Agriculture (USDA), Natural Resource Conservation Service, provides incentives to individual landowners to enhance wetlands in exchange for retiring agricultural lands that are marginal in terms of production.

## Summary of public involvement methods

Ecology communicated with the public in several ways during the development of this Water Quality Improvement Report. Beginning in 2005, Ecology staff worked with local organizations represented on the Oakland Bay Clean Water District Advisory Committee. The committee held public open house meetings in October 2007, 2008, and 2009 to provide education and outreach opportunities to the watershed residents. Ecology staff presented an overview of the technical findings at the 2007 and 2008 meetings.

Multiple organizations are responsible for participating in actions to address the water quality problems indentified in this water cleanup plan. Discussions and implementation activity updates occurred during routine Oakland Bay Clean Water District Advisory Committee meetings. Additionally, each organization was invited to participate in the development of the language drafted to describe their role.

Ecology held a public comment period from May 9, 2011, through June 8, 2011, on this report to discuss the study and process for developing this water cleanup plan. A public meeting was held on May 16, 2011, at Mason County Public Works, 100 W. Public Works Dr., Shelton, Washington. Comments from ten individuals or organizations were received during the comment period. The comments and Ecology's responses are in Appendix K.

*This page is purposely left blank.*

# References

Ahmed, A. U. and D. L. Sorensen, 1995. Kinetics of Pathogen Destruction During Storage of Dewatered Biosolids. Water and Environment Research. Vol 69, No. 2, pp 143.

Ahmed, A. and L. Sullivan, 2004. Quality Assurance Project Plan: Fecal Coliform Bacteria TMDL for Oakland Bay-Hammersley Inlet and Tributaries. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-111. www.ecy.wa.gov/biblio/0403111.html

Ahmed, A. and D. Rountry, 2007. Willapa River Fecal Coliform Bacteria Total Maximum Daily Load: Water Quality Improvement Report. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-021. www.ecy.wa.gov/biblio/0703021.html

Al-Azawi, S.K.A., 1986. Bacteriological Analysis of Stored Aerobic Sewage Cake. Agricultural Wastes 16:77-87.

Albertson, S.L., 2004. Oakland Bay Study: A dye and modeling study in an enclosed estuary with high degree of refluxing. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-020. www.ecy.wa.gov/biblio/0403020.html

Bagley, S.T. and R. Seidler, 1977. Significance of Fecal Coliform-Positive Klebsiella. Applied and Environmental Microbiology. May 1977. Vol. 33, No. 5, p. 1141-1148.

Bai, S. and W. Lung, 2006. Three-Dimensional Modeling of Fecal Coliform in the Tidal Basin and Washington Channel, Washington DC. Journal of Environmental Science and Health Part A. 41:11327-1346.

Baker, K.S. and R.C. Smith, 1982. Spectral irradiance penetration in natural waters. In: The Role of Solar Ultraviolet radiation in Marine Ecosystems (Calkins, J., Ed.). pp. 233-246. Plenum, New York.

Barcina, I., J.M. Gonzales, J. Iriberri, and L. Egea, 1992. Role of protozoa in the regulation of enteric bacteria populations in seawater. Marine Microbial Food Webs 5:179–188.

Berbells, S., 2003. 2003 Shoreline survey of the Oakland Bay Shellfish Growing Area. Washington State Department of Health, Olympia, WA.

Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, and S.A. Gherini, 1985. Rates Constants and Kinetics Formulations in Surface Water Quality Modeling (Second Edition). EPA/600/3-85/040. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. Athens, GA.

Brown, L. C. and T. O. Barnwell, 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS. EPA/600/3-87/007. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. Athens, Georgia.

Brown and Caldwell Consultants, 1990. Oakland Bay Watershed Management Plan. Final Report. December 1990.

Buchak, E.M. and J.E. Edinger, 1984. Generalized, Longitudinal-Vertical Hydrodynamics and Transport: Development, Programming, and Applications. Prepared for U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss. Contract No. DACW39-84-M-1636. Prepared by J.E. Edinger Associates, Wayne, PA. Document No. 84-18-R. June.

Caldas T., Demont-Caulet N., Ghazi A. Richarme G., 1999. Thermoprotection by glycine betaine and choline. Microbiology 145, 2543-2548.

Calkins, J., 1982. A method for the estimation of the penetration of biologically injurious solar ultraviolet radiation into natural waters. In: The Role of Solar Ultraviolet Radiation in Marine Ecosystems (Calkins, J., Ed.). pp. 274-261. Plenum, New York.

Carlucci, A.F. and D. Pramer, 1960. An evaluation of factors effecting the survival of Escherichia coli in seawater II: salinity, pH, and nutrients. Appl. Environ. Microbiol. 8, 247-250.

Chapra, S.C., 1997. Surface Water Quality Modeling. McGraw-Hill Publishers.

Clark, M., 2007. Personal communications. Thurston County Environmental Laboratory. Olympia, WA.

Cohn, T.A., D.L. Caulder, E.J. Gilroy, L.D. Zynjuk, and R.M. Summers, 1992. The validity of a simple statistical model for estimating fluvial constituent loads: an empirical study involving nutrient loads entering Chesapeake Bay. Water Resources Research 28(9):2353-2363.

Craig, D.L., H.J. Fallowfield, and N.J. Cromar, 2002. Enumeration of fecal coliforms from recreational coastal sites: Evaluation of techniques for the separation of bacteria from sediments. Journal of Applied Microbiology 93:557-565.

Davenport, C.V., E. B. Sparrow, and R. C. Gordon, 1976. Fecal indicator bacteria persistence under natural conditions in an ice-covered river. Appl. Environ. Microbiol. October 1976; 32(4): 527–536.

Davies, C.M., J.A.H. Long, M. Donald, N.J. Ashbolt, 1995. Survival of Fecal Microorganisms in Marine and Freshwater Sediments. Appl. Environ. Microbiol., Vol 61, No. 5, p. 1888–1896.

De Flaun, M.F. and L.M. Mayer. 1983. Relationships between bacteria and grain surfaces in intertidal sediments. Limnol. Oceanogr. 28(5) 873-881.

Deller, S., F. Mascher, S. Platzer, F.F. Reinthaler, E. Marth. 2006. Effect of solar radiation on survival of indicator bacteria in bathing waters. Cent Eur J Publ Health. 14(3) 133-137.

Determan, T., 1999. Trends in Fecal Coliform Pollution in Eleven Puget Sound Embayments. Report for the Puget Sound Ambient Monitoring Program. Office of Shellfish Programs, Washington State Department of Health, Olympia, WA.

Determan, T., 2007. Atlas of Fecal Coliform Pollution in Puget Sound: Year 2005. A Report for the Puget Sound Assessment and Monitoring Program. Office of Shellfish and Water Protection. Washington State Department of Health, Olympia, WA.

Di Torro, D.M., O'Conner, D.J., Thomann, R.V., and St. John, J.P., 1981. Analysis of the fate of chemicals in receiving waters. Phase I. Chemical Manuf. Assoc., Washington, D.C. Prepared by HydroQual Inc., Mahwah, NJ.

Dougherty, D., 2004. Personnel communication, Ecology NPDES Permit Writer, Southwest Region Water Quality Program, Washington State Department of Ecology, Olympia, WA.

Duan, N., 1983. Smearing estimate: A nonparametric retransformation method. Journal of the American Statistical Association 78(383):605-610.

Edinger, J.E. and E.M. Buchak, 1995. Numerical Intermediate and Far Field Dilution Modeling Journal Water, Air and Soil Pollution 83: 147-160,1995. Kluwer Academic Publishers, The Netherlands.

Edinger, J.E., E.M. Buchak, and M.D. McGurk, 1994. Analyzing Larval Distributions Using Hydrodynamic and Transport Modelling. Estuarine and Coastal Modeling III. American Society of Civil Engineers, New York.

Edinger J.E., J.Wu, and E.M. Buchak, 1997. Hydrodynamic and Hydrothermal Analyses of the Once-Through Cooling Water System at Hudson Generating Station. Prepared for Public Service Electric and Gas (PSE&G). Prepared by J.E. Edinger Associates, Inc., June 1997.

Enzinger, E.M., and R.C. Cooper, 1976. Role of Bacteria and Protozoa in the Removal of Escherichia Coli from Estuarine Waters. Appl. Environ. Microbiol. 31:758-763.

EPA, 1985. Rates, constants, and kinetics formulations in surface water quality modeling (second edition). U.S. Environmental Protection Agency. EPA/600/3-85/040.

EPA, 2001a. Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations. U.S. Environmental Protection Agency. www.epa.gov/owow/tmdl/overviewfs.html

EPA, 2001b. Protocols for Developing Pathogen TMDLs. First Edition. Office of Water. U.S. Environmental Protection Agency. www.epa.gov/owow/tmdl/techsupp.html

ERM, 2007. GEMSS setup for Oakland Bay. Memorandum. Environmental Resource Management, May 9, 2007.

Faust, M.A., A.E. Aotaky, and M.T. Hargadon, 1975. Effect of physical parameters on the in situ survival of Escherichia coli in an estuarine environment. Applied Microbiology. 30(5)800-806.

Gerba, C.P. and J.S. McLeod, 1976. Effect of sediments on the survival of Escherichia coli in marine waters. Applied and Environmental Microbiology 32(1):114-120.

Ghoul M., T. Bernard, and M. Cormier, 1990. Evidence that Escherichia coli accumulates glycine betaine from marine sediments. Appl. Environ. Microbiol. 56(2): 551-554.

Harris, S., 2007. Microbial Source Tracking: Lessons Learned. Paper presented at the 2007 Bacteria/Microbe EPA Region 10 Conference in Tacoma, WA. May 14-15, 2007.

Herrera Environmental Consultants. 2011. Oakland Bay Sediment Bacteria Study. Prepared for the Squaxin Island Tribe.

Hood M.A. and G.E. Ness, 1982. Survival of Vibrio cholerae and Escherichia coli in estuarine waters and sediments. Appl. Environ. Microbiol. 43(3): 578–584.

Jannasch, H.W., 1968. Competitive elimination of Enterobacteriaceae from seawater. Appl. Microbiol. 16, 1616-1618.

Jeng, H.C., A.J. England, and H.B. Bradford, 2005. Indicator organisms associated with stormwater suspended particles and estuarine sediment. Journal of Environmental Science and Health. 40:779-791.

Jones, G.E., 1964. Effect of Chelating Agents on the Growth of Escherichia Coli in Seawater. J. Bacteriol. 87: 484-499.

Kapuscinski, R.B. and R. Mitchell, 1981. Solar radiation induces sublethal injury in Escherichia coli in seawater. Appl. Environ. Microbiol. 41, 670-674.

Koch, R.W. and G.M. Smillie, 1986. Bias in hydrologic prediction using log-transformed regression models. Water Resources Bulletin 22:717-723.

Konovsky, J., 2007. Tracking bacteria Sources in Oakland Bay. Paper presented at the 2007 Bacteria/Microbe EPA Region 10 Conference in Tacoma. May 14-15, 2007.

Lavelle, J.W., H.O. Mofjeld, et al., 1988. A multiply-connected channel model of tides and tidal currents in Puget Sound, Washington and a comparison with updated observations. Seattle, WA, Pacific Marine Environmental Laboratory: 103.

Loutit, M.W. and G. Lewis, 1985. Fecal bacteria from sewage effluents in sediments around an ocean outfall. New Zealand Journal of Marine and Freshwater Research 19: 179-185.

Lung, W., 2001. Water Quality Modeling for Wasteload Allocations and TMDLs. Publishers John Wiley and Sons, Inc., New York, NY.

Mancini, J.L., 1978. Numerical Estimates of Coliform Mortality Rates Under Various Conditions. J. Water Poll. Control Fed. 50(11).

Mathieu, N., 2006. Replicate precision for 12 TMDL studies and recommendations for precision measurement quality objectives for water quality parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. www.ecy.wa.gov/biblio/0603044.html

Michaud, J., 1987. Sources Affecting Bacteria Quality in Oakland Bay. Final report. Washington State Department of Ecology, Olympia, WA. Publication No. 87-e26. www.ecy.wa.gov/biblio/87e26.html

Mofjeld, H.O., A.J. Venturato, et al. 2002. Tidal datum distributions in Puget Sound, Washington, based on a tide model. Seattle, WA, NOAA/Pacific Marine Environmental Laboratory: 39.

Obiri-Danso, K. and K. Jones, 2000. Intertidal sediments as reservoirs for hippurate negative campylobacters, Salmonella, and fecal indicators in three EU recognized bathing waters in Northwest England.

Pelletier. G. and K. Seiders, 2000. Grays Harbor Fecal Coliform Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 00-03-020 www.ecy.wa.gov/biblio/0003020.html

Pike, E.B., A.H.L. Gameson, and D. J. Gould, 1970. Mortality of Coliform Bacteria in Seawater Samples in the Dark. Rev. Int. Oceanogr. Med. 18/19:97-107.

Rosenfeld, W.D. and C.E. Zobell, 1947. Antibiotics production by marine microorganisms. J. Bacteriol. 54, 393-398

Rozen, Y. and S. Belkin, 2001. Survival of enteric bacteria in seawater. Federation of European Microbiological Societies. Microbiological reviews 25 (2001), 513-529.

Schillinger, J.E. and J.J. Gannon, 1985. Bacterial adsorption to and suspended particles in urban stormwater. J. WPCF 1985 57(5) 384-389.

Sherer, B.M., J.R. Miner, J.A. Moore, and J.C. Buckhouse, 1992. Indicator bacteria survival in stream sediments. Journal of Environmental Quality. 21:591-595.

Shiaris M. P., A.C. Rex, G.W. Pettibone, K. Keay, P. McManus, M. A. Rex, J. Ebersole, and E. Gallagher, 1987. Distribution of indicator bacteria and Vibrio parahaemolyticus in sewage-polluted intertidal sediments. Appl. Environ. Microbiol. **53**(8):1756–1761.

Smith, K. A. and J. Rector, 1994. Water Quality Assessments of Selected Lakes Within Washington State. Washington State Department of Ecology, Olympia, WA. Publication No. 97-307. www.ecy.wa.gov/biblio/97307.html

Smith, P., C. Carroll, B. Wilkins, P. Johnson, S. Nic Gabhainn, and L.P. Smith, 1999. The effect of wind speed and direction on the distribution of sewage-associated bacteria. Letter in Applied Microbiology 28: 184-188.

Squaxin Island Tribe, 1999. 1999 Squaxin Island Smolt Trapping Data. Squaxin Island Tribe, Shelton, WA.

Stapleton, C.M., 2007. Fate and transport of particles in estuaries. Numerical modeling for bathing water enterococci estimation in the Severn estuary. UK Environment Agency, Bristol, UK. March 2007.

Stephenson, G.R. and R.C. Rychert, 1982. Bottom sediment: a reservoir of Escherichia coli in rangeland streams. Journal of Range Management. 35(1)119-123.

Taylor, K., Moreland, T., and M. Stevie, 2000. Oakland Bay-Hammersley Inlet Watershed Assessment. Squaxin Island Tribe, Shelton, WA.

Thomann, R.V. and J.A. Mueller, 1987. Principles of Surface Water Quality Modeling and Control. Harper and Row, New York, NY.

Thomas, R.B., 1985. Estimating total suspended sediment yield with probability sampling. Water Resources Research 21:1381.

Troussellier M., J.L. Bonnefont, C. Courties, A. Derrien, E. Dupray, M. Gauthier, M. Gourmelon, F. Joux, P. Lebaron, Y. Martin, and M. Pommepuy, 1998. Responses of enteric bacteria to environmental stresses in seawater. Oceanologica Acta, Volume 21, Number 6, pp. 965-981(17).

Ufnar, D., J.A. Ufnar, R.D. Ellender, D. Rebarchik, and G. Stone, 2006. Influence of coastal processes on high fecal coliform counts in the Mississippi Sound. Journal of Coastal Research 22(6): 1515-1526.

U.S. Army Engineer Waterways Experiment Station, Environmental and Hydraulics Laboratories, 1986. CE-QUAL-W2: A Numerical Two-Dimensional, Laterally Averaged Model of Hydrodynamics and Water Quality; User's Manual, Instruction Report E-86-5, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss. NTIS No. AD A172 930.

Van Donsel, D.J. and E.E. Geldreich, 1971. Relationships of Salmonellae to fecal coliforms in bottom sediments. Water Research 5, 1079-1087.

Weiskel, P.K., B.L. Howes, and G.R. Heufelder, 1996. Coliform contamination of a coastal embayment: sources and transport pathways. Environmental Science and Technology. 30(6)1872-1881.

Young, B., 2004. Personal communication. Oakland Bay Watershed Council, Shelton, WA.

*This page is purposely left blank.*

# Appendices

*This page purposely left blank.*

# Appendix A.  Glossary, acronyms, and abbreviations

## Glossary

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

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

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

**Designated uses:** Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each 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.

**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 twenty-four hours at 44.5 plus or minus 0.2 degrees Celsius. FC are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

**Geometric mean:** A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

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

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

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

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

**Nonpoint source:** Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the 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.

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

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

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

**Point source:** Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

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

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

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt.

Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**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 (WLAs) for point sources, (2) the load allocations (LAs) for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

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

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

## Acronyms and Abbreviations

| | |
|---|---|
| ADCP | Acoustic Doppler Current Profile meter |
| cfs | cubic feet per second |
| cms | cubic meters per second |
| CTD | conductivity, temperature, and depth |
| DOH | Washington State Department of Health |
| DOT | Washington State Department of Transportation |
| Ecology | Washington State Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| GEMSS | Generalized Environmental Modeling System |
| GM | geometric mean |
| MF | membrane filter |
| MLLW | mean low low water |
| NHD | National Hydrography Dataset |
| psu | practical salinity units |
| STP | sewage treatment plant |
| TSS | total suspended solids |
| WAC | Washington Administrative Code |
| WWTP | wastewater treatment plant |

*This page purposely left blank.*

# Appendix B.  Freshwater monitoring data

**Table B-1.  Locations of freshwater monitoring stations (2004-2005).**

| Station | Description | Latitude | Longitude |
|---|---|---|---|
| UNC1 | Culvert at mouth of Uncle John Creek on Agate Loop Road | 47.223628 | -123.028760 |
| UNC2 | Culvert at the corner of Agate Loop Road and Daniels Road | 47.228687 | -123.028434 |
| UNC3 | Culvert below wetland on Agate Road | 47.236323 | -123.013152 |
| CAM1 | Bridge at Agate Loop Road at mouth of Campbell Creek | 47.221432 | -123.028737 |
| CAM2 | Culvert on Agate Road | 47.223046 | -123.012612 |
| CAM3 | Culvert at Timberlake West Drive, below Timber Lake | 47.223329 | -122.981673 |
| JOH0 | Bridge off of Bayshore Drive near mouth of Johns Creek | 47.246149 | -123.043039 |
| JOH1 | Highway 3 bridge | 47.248229 | -123.045322 |
| JOH 2 | Bridge on Johns Creek Drive | 47.252024 | -123.086176 |
| SHE0 | Near mouth, off of Highway 3 over railroad | 47.213855 | -123.094860 |
| SHE1 | At Dairy Queen | 47.214111 | -123.100629 |
| SHE2 | On North 7th St between W. Birch and Laurel Streets | 47.217827 | -123.106524 |
| GOL0 | On N 1st St/Highway 3 bridge | 47.209144 | -123.100606 |
| GOL1 | 7th St bridge | 47.211417 | -123.107961 |
| GOL2 | Hwy 101 bridge at flow gauge | 47.210511 | -123.128594 |
| GOL3 | On W. Shelton-Matlock Road, near W. Carmen Road | 47.215006 | -123.181752 |
| GOL4 | Bridge on West Little Egypt Road | 47.204875 | -123.228132 |
| COF1 | Off of West Deegan Road | 47.201944 | -123.129872 |
| MIL0 | Arcadia Road bridge | 47.193274 | -122.997847 |
| MIL1 | Off of dirt road from Binns Swiger Loop | 47.183004 | -123.023224 |
| MIL2 | Highway 3 bridge | 47.193132 | -123.099024 |
| MAL1 | Culvert on Agate Road | 47.249046 | -123.011675 |
| MAL2b | Culvert at East Spencer Lake Road | 47.259630 | -122.984193 |
| DEE0 | Gosser Road turnout, off of Agate Road | 47.261647 | -123.006818 |
| DEE1 | Highway 3 bridge | 47.265893 | -123.004383 |
| CRA1 | Highway 3 bridge, near mouth | 47.264689 | -123.011579 |

**Table B-2. Conductivity data (µS) at all freshwater stations (2004-2005).**

| Date | UNC1 | UNC2 | UNC3 | CAM1 | CAM2 | CAM3 | JOH0 | JOH1 | JOH 2 | SHE0 | SHE1 | SHE2 | GOL0 | GOL1 | GOL2 | GOL3 | GOL4 | COF1 | MIL0 | MIL1 | MIL2 | MAL1 | MAL2b | DEE0 | DEE1 | CRA1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11/22/2004 | 386 | 69 | 70 | 348 | 67 | 55 | 94 | 94 | 77 | 205 | 126 | 106 | 114 | 110 | 89 | 75 | 80 | 102 | 116 | 98 | 91 | 79 | 59 | 96 | 87 | 95 |
| 12/8/2004 | 100 | 46 | 56 | 397 | 56 | 46 | 66 | 66 | 58 | 90 | 92 | 86 | 72 | 69 | 60 | 53 | 60 | 75 | 75 | 71 | 68 | 58 | 40 | 964 | 65 | 67 |
| 12/21/2004 | 186 | 48 | 49 | 24 | 54 | 53 | 70 | 63 | 64 | 149 | 113 | 100 | 94 | 90 | 77 | 66 | 76 | 80 | 74 | 60 | 67 | 44 | 39 | 79 | 68 | 53 |
| 1/4/2005 | 201 | 51 | 50 | 32900 | 57 | 46 | 64 | 65 | 62 | 294 | 103 | 85 | 97 | 92 | 77 | 64 | 70 | 80 | | | 64 | 50 | 37 | 76 | 68 | 54 |
| 1/18/2005 | 6 | | 38 | 74 | | 54 | 48 | | 44 | 98 | | 77 | 38 | 38 | 36 | 32 | 34 | 41 | 172 | | 66 | | 30 | 44 | | |
| 2/8/2005 | 556 | 45 | 42 | 11090 | 49 | 42 | 59 | 58 | 57 | 100 | 98 | 78 | 84 | 83 | 71 | 58 | 64 | 72 | 82 | 65 | 62 | 46 | 35 | 83 | 63 | 44 |
| 3/1/2005 | 266 | | 56 | 684 | | 50 | 71 | | 69 | 250 | | 92 | 96 | 93 | 81 | 68 | 72 | 84 | | | 10 | | 5 | 107 | | 55 |
| 3/8/2005 | 740 | 53 | 49 | 6370 | 55 | 42 | 63 | 62 | 61 | 190 | 103 | 79 | 97 | 96 | 79 | 64 | 66 | 81 | 99 | 71 | 50 | 56 | 37 | 97 | 72 | 48 |
| 3/23/2005 | 299 | 56 | 57 | 320 | 58 | 50 | 73 | 72 | 71 | 240 | 119 | 94 | 106 | 100 | 84 | 71 | 76 | 71 | 117 | 85 | 82 | 58 | 40 | 92 | 77 | 58 |
| 4/5/2005 | 36 | 124 | 33 | 257 | 41 | 39 | 52 | 52 | 50 | 140 | 88 | 75 | 67 | 66 | 56 | 49 | 57 | 64 | 62 | 60 | 59 | 37 | 30 | 57 | 53 | 40 |
| 4/18/2005 | 82 | 43 | 42 | 155 | 48 | 49 | 65 | 65 | 61 | 148 | 106 | 90 | 72 | 72 | 3 | 56 | 81 | 82 | 72 | 70 | 71 | 50 | 48 | 69 | 65 | 48 |
| 5/3/2005 | 456 | 48 | 42 | 776 | 55 | 45 | 58 | 57 | 57 | 163 | 93 | 74 | 84 | 83 | | 56 | 59 | 75 | 60 | 80 | 60 | 45 | 35 | 75 | 65 | 44 |
| 5/17/2005 | 196 | 60 | 54 | 303 | 57 | 17 | 72 | 13 | 16 | 149 | 117 | 99 | 108 | 106 | 91 | 74 | 74 | 107 | 77 | 81 | 77 | 62 | 49 | 85 | 80 | 58 |
| 5/31/2005 | 936 | 67 | 54 | 940 | 76 | 92 | 74 | 73 | 74 | 240 | 121 | 98 | 116 | 114 | 94 | 76 | 78 | 101 | 116 | 84 | 81 | 70 | 52 | 97 | 85 | 60 |
| 6/14/2005 | 1098 | 60 | 46 | 986 | 65 | 53 | 60 | 60 | 62 | 155 | 106 | 80 | 100 | 100 | 82 | 64 | 64 | 85 | 96 | 71 | 69 | 64 | 45 | 76 | 70 | 50 |
| 6/27/2005 | 260 | 79 | 64 | 804 | 71 | 55 | 78 | 77 | 81 | 207 | 131 | 100 | 125 | 121 | 104 | 84 | 81 | 109 | 127 | 92 | 83 | 82 | 60 | 101 | 89 | 64 |
| 7/5/2005 | 1710 | 72 | 56 | 1224 | 76 | 61 | 67 | 68 | 71 | 155 | 119 | 88 | 125 | 120 | 97 | 73 | 72 | 98 | 113 | 82 | 79 | 73 | 52 | 83 | 79 | 58 |
| 7/18/2005 | 1540 | 83 | 68 | 627 | 73 | 65 | 80 | 81 | 84 | 189 | 134 | 102 | 139 | 138 | 111 | 86 | 85 | 115 | 159 | 97 | 93 | 84 | 62 | 104 | 90 | 68 |
| 8/1/2005 | 2840 | 80 | 62 | 1660 | 80 | 63 | 71 | 69 | 75 | 169 | 117 | 88 | 129 | 125 | 99 | 76 | 76 | 98 | 120 | 90 | 70 | 79 | 54 | 89 | 81 | 62 |
| 8/15/2005 | 1500 | 93 | 71 | 1653 | 94 | 69 | 65 | 81 | 83 | 156 | 136 | 105 | 121 | 146 | 114 | 90 | 87 | 117 | 169 | 103 | 93 | 92 | ---- | 81 | 95 | 74 |
| 8/30/2005 | 2680 | 84 | 65 | 1640 | 85 | 62 | 72 | 73 | 78 | 171 | 121 | 94 | 136 | 133 | 105 | 80 | 79 | 104 | 112 | 77 | | 83 | 56 | 92 | 85 | 68 |
| 9/13/2005 | 1995 | 96 | 77 | 1432 | 94 | 76 | 84 | 83 | 87 | 191 | 135 | 107 | 150 | 149 | 114 | 89 | 89 | 117 | 170 | 106 | 104 | 96 | 78 | 101 | 95 | 79 |
| 9/28/2005 | 1763 | 98 | 77 | 1296 | 95 | 82 | 83 | 82 | 87 | 184 | 134 | 107 | 147 | 146 | 108 | 84 | 92 | 112 | 151 | 108 | 106 | 94 | | 99 | 93 | 68 |
| 10/18/2005 | 2270 | 78 | 70 | 2060 | 62 | 54 | 76 | 76 | 74 | 342 | 120 | 96 | 110 | 109 | 88 | 77 | 100 | 78 | 172 | 95 | 91 | 85 | 58 | 105 | 84 | 67 |
| 10/26/2005 | 730 | 69 | 60 | 555 | 65 | 48 | 63 | 64 | 61 | 139 | 95 | 79 | 91 | 95 | 75 | 65 | 63 | 86 | 116 | 81 | 80 | 70 | 50 | 73 | 67 | 57 |
| 11/7/2005 | 23700 | 49 | 52 | 196 | 51 | 51 | 57 | 57 | 52 | 208 | 99 | 93 | 58 | 56 | 49 | 45 | 62 | 70 | 82 | 87 | 83 | 50 | 42 | 82 | 59 | 57 |
| 11/30/2005 | 162 | 55 | 61 | 661 | 66 | 60 | 76 | 75 | 71 | 170 | 119 | 101 | 92 | 91 | 78 | 68 | 77 | 85 | 93 | 84 | 83 | 65 | 48 | 85 | 79 | 68 |

**Table B-3. Temperature data (C) at all freshwater stations (2004-2005).**

| Date | UNC1 | UNC2 | UNC3 | CAM2 | CAM3 | JOH0 | JOH1 | JOH 2 | SHE0 | SHE1 | SHE2 | GOL0 | GOL0 | GOL1 | GOL2 | GOL3 | GOL4 | COF1 | MIL0 | MIL1 | MIL2 | MAL1 | MAL2b | DEE0 | DEE1 | CRA1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11/22/2004 | 6.8 | 6.6 | 6.4 | 7.4 | 7.5 | 8.7 | 7.4 | 7.8 | 7.1 | 9.2 | 8.9 | 10.6 | 7.2 | 7 | 7.3 | 6.5 | 8.2 | 6.3 | 6.7 | 7.2 | 7.8 | 6.7 | 5.2 | 6.4 | 6.9 | 8.2 |
| 12/8/2004 | 6.41 | 6.35 | 5.1 | 6.54 | 6.5 | 6.6 | 6.78 | 6.73 | 6.06 | 8.35 | 8.53 | 10 | 6.5 | 6.36 | 6.26 | 5.93 | 7.06 | 5.9 | 6.75 | 6.82 | 6.69 | 6.05 | 4.76 | 6.5 | 6.5 | 6.77 |
| 12/21/2004 | 5.8 | 5.75 | 5.9 | 7.1 | 6.05 | 6.8 | 6.9 | 6.97 | 6.4 | 8.8 | 9 | 10.2 | 6.7 | 6.8 | 6.5 | 6.1 | 7.2 | 5.6 | 6.5 | 6.33 | 6.9 | 5.39 | 5.2 | 6.1 | 6.08 | 6.42 |
| 1/4/2005 | 1.96 | 1.94 | 3.29 | 4.64 | 2.85 | 4.09 | 3.69 | 3.77 | 2.62 | 6.46 | 6.34 | 8.75 | 3.52 | 3.12 | 2.97 | 2.30 | 4.42 | 1.39 | | | 3.43 | 1.71 | 1.06 | 2.70 | 2.93 | 3.24 |
| 1/18/2005 | 6.8 | | 5.2 | 6.8 | | 3.7 | 6.9 | | 6.5 | 7.9 | | 10 | 7.2 | 7.1 | 7.1 | 7.1 | 7.4 | 7.3 | 3.3 | | 4.9 | | 6.3 | 6.5 | | |
| 2/8/2005 | 4.34 | 3.88 | 4.58 | 5.11 | 4.53 | 6 | 5.78 | 5.47 | 4.53 | 7.83 | 7.05 | 9.06 | 5.44 | 5.28 | 5.2 | 4.38 | 5.44 | 3.6 | 5.42 | 5.57 | 5.85 | 3.55 | 3.04 | 4.53 | 4.63 | 5.49 |
| 3/1/2005 | 8 | | 8.9 | 8 | | 9 | 8.9 | | 9.2 | 10 | 8.5 | 10.3 | 8.5 | 7.8 | 8.1 | 7.4 | 9.2 | 6.6 | | | 8.3 | | 6.9 | 8.5 | | 8.4 |
| 3/8/2005 | 9.23 | 8.75 | 10.4 | 9.38 | 8.7 | 10.8 | 9.74 | 9.25 | 9.53 | 10.5 | 9.57 | 10.3 | 9.96 | 9.87 | 9.41 | 9.32 | 8.27 | 8.32 | | | | 8.84 | 8.01 | 9.22 | 8.85 | 9.04 |
| 3/23/2005 | 8.3 | 7.6 | 11.8 | 8.1 | 8.6 | 10.7 | 8 | 7.7 | 10.6 | 9 | 9.9 | 10.4 | 8.6 | 8.8 | 8.6 | 7.4 | 9.6 | 10.6 | 7.7 | 8 | 8.7 | 8.9 | 8.7 | 8 | 7.3 | 8.5 |
| 4/5/2005 | 7.56 | 7.65 | 9.21 | 8.38 | 8.51 | 10.2 | 8.48 | 8.27 | 8.19 | 9.07 | 8.33 | 9.47 | 7.81 | 7.74 | 7.55 | 7.14 | 7.33 | 6.67 | | | | 7.84 | 7.86 | 7.75 | 7.59 | 8.99 |
| 4/18/2005 | 8.9 | 9.1 | 10.8 | 9.4 | 9.6 | 11.7 | 9.5 | 10.1 | 11.4 | 9.4 | 9.7 | 10.8 | 8.7 | 9.4 | 9.3 | 8.7 | 9.1 | 9.1 | 9.7 | 9.7 | 9.8 | 9.4 | 9.5 | 9.1 | 9.7 | 7:12 |
| 5/3/2005 | 12.1 | 11.9 | 15.3 | 12 | 11.6 | 15.1 | 11.5 | 11.5 | 12.5 | 10.5 | 10.1 | 10 | 11.4 | 11.5 | | 11.4 | 9.93 | 11.2 | | | | 12.7 | 13.3 | 11.6 | 11.6 | 13.26 |
| 5/17/2005 | 13.4 | 13.1 | 15.8 | 13.9 | 14.1 | 47.2 | 12.5 | 72.2 | 72.1 | 11.1 | 11.3 | 11.2 | 12.5 | 12.4 | 14.3 | 13.1 | 12.6 | 13.6 | 15 | 16.2 | 17.1 | 13.6 | 15 | 12.5 | 13 | 15 |
| 5/31/2005 | 13.9 | 13.3 | 16.1 | 13.7 | 13 | 14.6 | 12.5 | 12.9 | 15.1 | 11.2 | 11.4 | 11.5 | 12.4 | 13.3 | 14.2 | 13 | 12.3 | 13.9 | 15.4 | 16.4 | 17.1 | 14.1 | 15.2 | 12.7 | 13 | 15.5 |
| 6/14/2005 | 12 | 11.5 | 16.2 | 12.4 | 11.9 | 15.4 | 11.6 | 11.9 | 13.3 | 10.5 | 10.9 | 11.3 | 12.4 | 12.5 | 12.9 | 12.4 | 10.9 | 11.6 | 14.7 | 15.3 | 16.7 | 13.3 | 13.1 | 11.7 | 11.9 | 14.09 |
| 6/27/2005 | 15.2 | 14 | 18.7 | 16.2 | 15.3 | 20.5 | 13.8 | 13.6 | 15 | 12.3 | 11.3 | 11.4 | 13.9 | 14 | 14.3 | 13.5 | 12.6 | 13.6 | 17.6 | 16.5 | 17.6 | 15.2 | 15.3 | 14.3 | 13.2 | 16.5 |
| 7/5/2005 | 18.7 | 14.9 | 19.4 | 17.7 | 14.7 | 17.4 | 15.1 | 14.3 | 16 | 13.7 | 11.6 | 11.7 | 13.5 | 15.1 | 14.3 | 15.6 | 12.4 | 13.6 | 19 | 18.9 | 19.7 | 16.6 | 16.2 | 14.9 | 14.3 | 16.58 |
| 7/18/2005 | 19.2 | 15.2 | 21.5 | 17.7 | 16.6 | 23.4 | 13.9 | 16.1 | 18 | 12.8 | 11.7 | 12 | 13.8 | 13.9 | 17.9 | 16.4 | 15.1 | 15.4 | 17.8 | 18.1 | 19.5 | 17.2 | 18 | 14.8 | 14.3 | 18.6 |
| 8/1/2005 | 17.2 | 14.4 | 19.3 | 16 | 13.6 | 19.1 | 13.4 | 12.9 | 14.4 | 13.5 | 12.1 | 11.1 | 13.1 | 13.2 | 13.9 | 15.3 | 12.1 | 12.6 | | | | 15.3 | 15.5 | 13.8 | 13.3 | 15.31 |
| 8/15/2005 | 12:00 | 15.9 | 21.1 | 16.2 | 15.3 | 21.3 | 14.2 | 15.7 | 17.7 | 12.8 | 13.7 | 13.4 | 13.9 | 16.5 | 17.8 | 17 | 15.6 | 16.4 | 18.4 | 21.2 | 20.6 | 17.6 | ---- | 14.5 | 15.7 | 17.9 |
| 8/30/2005 | 16.7 | 14.8 | 17.5 | 15.6 | 13.8 | 18.6 | 13.5 | 13.3 | 14.5 | 12.6 | 11.9 | 13.2 | 13.4 | 13.5 | 13.6 | 15 | 12.3 | 13.1 | | | | 15.7 | 13.9 | 13.7 | 13.4 | 15.07 |
| 9/13/2005 | 13 | 11.7 | 14.7 | 11.6 | 11.3 | 16.4 | 11.2 | 12.1 | 13.1 | 10.9 | 11.6 | 14.1 | 11.2 | 12.3 | 12.9 | 12.9 | 11.7 | 11.4 | 13.2 | 14.9 | 16.5 | 12.3 | 11.2 | 10.9 | 11.3 | 12.8 |
| 9/28/2005 | 11.7 | 10.1 | 13.2 | 10.6 | 9.5 | 14.7 | 10 | 10.9 | 12 | 10.2 | 11 | 13.9 | 9.9 | 11.3 | 11.7 | 11.5 | 11.5 | 10.8 | 11.7 | 12.4 | 14.4 | 10.9 | | 9.7 | 10 | 13.6 |
| 10/18/2005 | 13.8 | 12.8 | 13.4 | 13.5 | 13.2 | 14.5 | 12.8 | 12.4 | 12.9 | 12.4 | 11.7 | 12.6 | 12.6 | 12.7 | 12.1 | 11.3 | 12.5 | 12.2 | 14.3 | 14.5 | 15.2 | 12.9 | 12.5 | 12.1 | 11.7 | 13.21 |
| 10/26/2005 | 10.7 | 10.2 | 10.9 | 10.1 | 9.9 | 13 | 10.2 | 10.4 | 10.7 | 9.9 | 9.9 | 11.5 | 9.7 | 10.1 | 10.3 | 10.2 | 9.8 | 10 | 11 | 11.6 | 12.7 | 10.3 | 9.8 | 9.7 | 9.8 | 11.2 |
| 11/7/2005 | 7.98 | 7.09 | 6.37 | 7.42 | 7.95 | 9.41 | 6.87 | 6.9 | 6.52 | 8.94 | 8.13 | 10.8 | 7.47 | 7.38 | 7.39 | 7.2 | 7.77 | 6.59 | 8.8 | 9 | 9.2 | 6.55 | 5.92 | 6.49 | 6.5 | 8.51 |
| 11/30/2005 | 5.4 | 5.3 | 4.3 | 5.7 | 5.5 | 6.6 | 5.7 | 5.8 | 4.3 | 8.6 | 7.6 | 9.7 | 5.1 | 4.9 | 4.8 | 4.3 | 6 | 8.8 | 4.9 | 5 | 5.5 | 4.9 | 3.6 | 5 | 5 | 6 |

**Table B-4. FC data (cfu/100 mL) at all freshwater stations (2004-2005).**

| Date | UNC 1 | UNC 2 | UNC 3 | CAM 1 | CAM 2 | CAM 3 | JOH0 | JOH1 | JOH 2 | SHE 0 | SHE 1 | SHE 2 | GOL 0 | GOL 1 | GOL 2 | GOL 3 | GOL 4 | COF 1 | MIL0 | MIL1 | MIL2 | MAL 1 | MAL 2b | DEE 0 | DEE 1 | CRA 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11/22/2004 | 110 | 54 | 29 | 4 | 36 | 1 | 5 | 2 | 6 | 13 | 10 | 2 | 2 | 7 | 4 | 8 | 5 | 6 | 17 | 10 | 8 | 9 | 6 | 10 | 17 | 24 |
| 12/8/2004 | 225 | 370 | 12 | 49 | 170 | 3 | 35 | 46 | 42 | 73 | 250 | 3 | 35 | | | 30 | 31 | | 29 | 42 | 12 | 28 | 24 | 9 | 65 | 38 |
| 12/21/2004 | 39 | 13 | 8 | 5 | 6 | 2 | 22 | 5 | 15 | 19 | 20 | 4 | 7 | 12 | 4 | 9 | 2 | 39 | 26 | 30 | 8 | 150 | 90 | 27 | 17 | 22 |
| 1/4/2005 | 22 | 18 | 42 | 5 | 2 | 1 | 16 | 11 | 17 | 11 | 12 | 1 | 6 | 10 | 1 | 14 | 16 | 1 | 9 | 17 | 7 | 3 | 14 | 11 | 63 | 11 |
| 1/18/2005 | 200 | 150 | 240 | 120 | 88 | 6 | 190 | 100 | 160 | 180 | 250 | 38 | 100 | 185 | 240 | 130 | 48 | 160 | 80 | 130 | 54 | 110 | 130 | 77 | 86 | 96 |
| 2/8/2005 | 27 | 28 | 36 | 2 | 4 | 1 | 7 | 10 | 9 | 11 | 7 | 1 | 5 | 3 | 1 | 5 | 11 | 42 | 8 | 13 | 3 | 9 | 24 | 9 | 16 | 15 |
| 3/1/2005 | 140 | 49 | 2 | 31 | 49 | 1 | 27 | 28 | 59 | 12 | 29 | 1 | 49 | 59 | 77 | 110 | 31 | 44 | 40 | 28 | 1 | 8 | 29 | 13 | 12 | 31 |
| 3/8/2005 | 100 | 10 | 2 | 18 | 8 | 1 | 11 | 16 | 14 | 6 | 1 | 1 | 5 | 5 | 1 | 31 | 190 | 6 | 28 | 1 | 1 | 3 | 8 | 9 | 4 | 24 |
| 3/23/2005 | 15 | 14 | 20 | 6 | 1 | 1 | 8 | 11 | 9 | 18 | 15 | 7 | 3 | 5 | 5 | 9 | 4 | 6 | 9 | 11 | 1 | 4 | 5 | 5 | 4 | 4 |
| 4/5/2005 | 23 | 290 | 10 | 47 | 8 | 1 | 10 | 4 | 11 | 170 | 110 | 4 | 11 | 7 | 18 | 2 | 9 | 10 | 9 | 5 | 1 | 6 | 6 | 2 | 2 | 9 |
| 4/18/2005 | 48 | 14 | 24 | 165 | 6 | 1 | 12 | 9 | 15 | 18 | 12 | 1 | 20 | 14 | 7 | 16 | 5 | 8 | 8 | 9 | 3 | 8 | 8 | 8 | 20 | 8 |
| 5/3/2005 | 230 | 180 | 14 | 64 | 28 | 27 | 14 | 16 | 49 | 27 | 29 | 1 | 23 | 18 | 15 | 29 | 32 | 65 | 17 | 27 | 6 | 53 | 60 | 32 | 80 | 21 |
| 5/17/2005 | 220 | 450 | 190 | 140 | 68 | 5 | 27 | 36 | 22 | 140 | 60 | 6 | 32 | 21 | 15 | 37 | 7 | 45 | 89 | 120 | 38 | 98 | 45 | 37 | 35 | 27 |
| 5/31/2005 | 80 | 15 | 17 | 29 | 52 | 170 | 67 | 46 | 29 | 69 | 47 | 4 | 25 | 13 | 12 | 25 | 17 | 25 | 18 | 49 | 21 | 47 | 13 | 25 | 42 | 32 |
| 6/14/2005 | 66 | 22 | 21 | 37 | 11 | 9 | 45 | 80 | 57 | 84 | 28 | 3 | 32 | 36 | 56 | 23 | 11 | 43 | 29 | 29 | 39 | 29 | 14 | 69 | 45 | 74 |
| 6/27/2005 | 1700 | 110 | 13 | 92 | 94 | 3 | 48 | 110 | 49 | 52 | 42 | 14 | 33 | 19 | 19 | 29 | 24 | 33 | 8 | 24 | 25 | 43 | 95 | 39 | 29 | 37 |
| 7/5/2005 | 110 | 400 | 8 | 35 | 30 | 4 | 55 | 57 | 67 | 550 | 720 | 24 | 51 | 43 | 47 | 260 | 23 | 30 | 12 | 36 | 21 | 47 | 80 | 34 | 48 | 36 |
| 7/18/2005 | 100 | 60 | 10 | 31 | 52 | 26 | 35 | 19 | 25 | 32 | 36 | 4 | 34 | 25 | 26 | 17 | 34 | 28 | 38 | 94 | 22 | 52 | 63 | 140 | 100 | 55 |
| 8/1/2005 | 250 | 92 | 7 | 29 | 38 | 31 | 120 | 88 | 88 | 57 | 220 | 3 | 43 | 35 | 53 | 21 | 67 | 85 | 24 | 47 | 20 | 23 | 170 | 46 | 80 | 88 |
| 8/15/2005 | 240 | 230 | 20 | 38 | 37 | 12 | 48 | 35 | 40 | 110 | 84 | 13 | 25 | 39 | 25 | 20 | 23 | 36 | 41 | 84 | 98 | 20 | | 80 | 71 | 51 |
| 8/30/2005 | 110 | 260 | 3 | 110 | 380 | 6 | 25 | 27 | 120 | 120 | 270 | 8 | 60 | 20 | 21 | 21 | 57 | 48 | 8 | 22 | 39 | 160 | 9 | 57 | 80 | 27 |

| Date | UNC1 | UNC2 | UNC3 | CAM1 | CAM2 | CAM3 | JOH0 | JOH1 | JOH2 | SHE0 | SHE1 | SHE2 | GOL0 | GOL1 | GOL2 | GOL3 | GOL4 | COF1 | MIL0 | MIL1 | MIL2 | MAL1 | MAL2b | DEE0 | DEE1 | CRA1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/13/2005 | 310 | 80 | 17 | 67 | 22 | 10 | 11 | 10 | 52 | 92 | 39 | 11 | 12 | 13 | 10 | 19 | 21 | 18 | 23 | 7 | 10 | 36 | 150 | 73 | 43 | 18 |
| 9/28/2005 | 440 | 69 | 17 | 61 | 13 | 12 | 18 | 28 | 23 | 31 | 33 | 14 | 10 | 30 | 10 | 27 | 15 | 29 | 27 | 21 | 25 | 35 | | 27 | 21 | 33 |
| 10/18/2005 | 110 | 23 | 9 | 76 | 69 | 11 | 18 | 10 | 24 | 29 | 21 | 13 | 32 | 28 | 46 | 44 | 40 | 35 | 7 | 19 | 6 | 29 | 6 | 10 | 14 | 8 |
| 10/26/2005 | 110 | 52 | 1 | 25 | 10 | 1 | 9 | 6 | 34 | 51 | 55 | 1 | 22 | 10 | 11 | 23 | 7 | 1 | 7 | 19 | 5 | 6 | 6 | 31 | 11 | 11 |
| 11/7/2005 | 110 | 110 | 26 | 17 | 26 | 3 | 6 | 14 | 23 | 88 | 92 | 13 | 9 | 37 | 23 | 23 | 29 | 11 | 75 | 100 | 46 | 40 | 29 | 14 | 6 | 26 |
| 11/30/2005 | 41 | 32 | 4 | 20 | 36 | 1 | 5 | 7 | 20 | 35 | 39 | 1 | 14 | 17 | 15 | 17 | 11 | 15 | 27 | 31 | 9 | 17 | 20 | 19 | 8 | 29 |

*This page is purposely left blank.*

# Appendix C. Evaluation of measurement quality objective for fecal coliform bacteria data gathered in 2004-2005

In addition to the 671 freshwater samples collected for FC analysis, 109 quality assurance (QA) samples were collected during this project. The QA samples were field duplicates. The measurement quality objective (MQO) (Mathieu, 2006) for QA samples requires that the mean FC concentration of the QA samples be 20 cfu/100 mL or greater. Of the 131 QA samples, only 60 had a mean FC concentration greater than 20 cfu/100 mL.

The recommended MQO for QA samples (Ecology, 2006) is to have 50% of the QA samples below a 20% relative standard deviation (RSD), and 90% of the samples below a RSD of 50%. The RSD is defined as the percent standard deviation divided by the mean, or as the percent coefficient of variation for the duplicate QA samples. None of the samples used to assess the MQO should have a mean concentration of 20 cfu/100 mL or less.

Figure C-1 shows the plot for the QA results for samples with a mean concentration of more than 20 cfu/100 mL. The samples met the MQO prescribed for the QA samples.

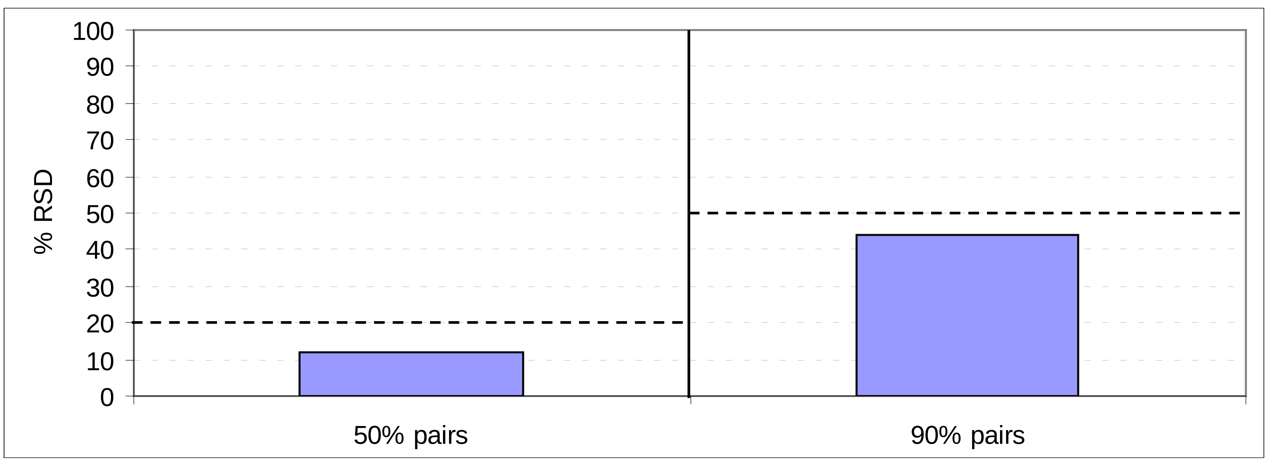



**Figure C-1. Percent RSD for QA samples (cfu/100 mL > 20) in tributaries to Oakland Bay and Hammersley Inlet (2004-2005).**

*This page is purposely left blank.*

# Appendix D. Tributary flow data

There are nine named tributaries to Oakland Bay-Hammersley Inlet watershed. These are listed in Table D-1 along with their drainage area, mean annual precipitation, and the respective area averaged flow as obtained from StreamStats (http://water.usgs.gov/osw/streamstats/Washington.html, see Figure D-1). The flows are peak flows at the indicated recurrence interval in years.

**Table D-1. Tributaries to the Oakland Bay-Hammersley Inlet Watershed.**

| Stream name | Drainage area, $mi^2$ | Mean annual precipitation, inches | Area averaged peak flows, cfs | | | | | Location of mouth of stream | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Q2 | Q10 | Q25 | Q50 | Q100 | latitude | longitude |
| Goldsborough | 60.94* | 85.2 | 2820 | 5000 | 6140 | 7210 | 8110 | 47.2093 | -123.096 |
| Shelton | 2.92 | 69.1 | 138 | 253 | 314 | 371 | 418 | 47.2133 | -123.091 |
| Johns | 10.3 | 73.6 | 459 | 833 | 1030 | 1220 | 1370 | 47.2462 | -123.043 |
| Cranberry | 14 | 70.5 | 563 | 1020 | 1260 | 1480 | 1670 | 47.2619 | -123.016 |
| Deer | 14.7 | 60.9 | 471 | 843 | 1040 | 1220 | 1370 | 47.2581 | -123.012 |
| Malaney | 4.29 | 58.2 | 149 | 269 | 333 | 392 | 441 | 47.2513 | -123.02 |
| Uncle John | 1.8 | 59.6 | 72.2 | 132 | 163 | 193 | 217 | 47.2228 | -123.029 |
| Campbell | 4.01 | 57.5 | 138 | 249 | 308 | 363 | 408 | 47.2215 | -123.028 |
| Mill | 29.7 | 65.3 | 969 | 1730 | 2130 | 2500 | 2810 | 47.1884 | -123.001 |

* the drainage area for USGS gauge located 1 Km above the mouth is 54.9 $mi^2$

Drainage area = 60.9 mi $^2$

Goldsborough Creek


Drainage area = 2.92 mi $^2$

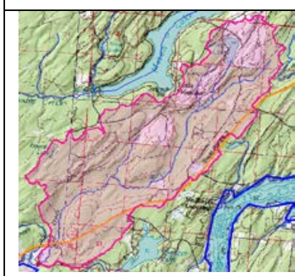
Shelton Creek

Drainage area = 10.3 mi $^2$

Johns Creek

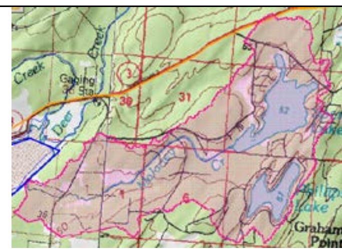
Drainage area = 14 mi $^2$

Cranberry Creek



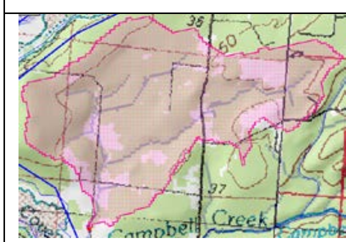
Drainage area = 14.7 mi $^2$

Deer Creek



Drainage area = 4.29 mi $^2$

Malaney Creek

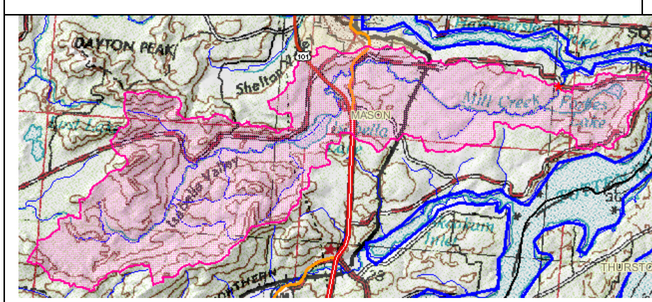



Drainage area = 1.8 mi $^2$

Uncle John Creek

Drainage area = 4 mi $^2$

Campbell Creek




Drainage area = 29.7 mi $^2$

Mill Creek

**Figure D-1. Drainage areas as delineated by StreamStats.**

Table D-2 shows the flow measured at the designated location. Where continuous gages were available, flows were not measured.

**Table D-2. Measured flow data (cfs) at selected freshwater stations (2004-2005).**

| Date | CAM2 | DEE1 | JOH1 | MAL1 | MIL1 | SHE1 | UNC2 |
|---|---|---|---|---|---|---|---|
| 11/22/2004 | 12.86 | 19.38 | 14.65 | 2.24 | 46.47 | 6.51 | 3.72 |
| 12/8/2004 | 9.21 | 38.21 | 25.74 | 5.99 | 82.82 | 8.50 | 4.89 |
| 12/21/2004 | 6.32 | 34.96 | 39.69 | 5.12 | 96.53 | 9.84 | 2.36 |
| 1/4/2005 | 5.94 | 33.58 | 31.85 | 4.95 | 65.70 | 9.37 | 1.14 |
| 1/18/2005 | 107.50 | 100.98 | 323.17 | 39.10 | - | 36.90 | 30.96 |
| 2/8/2005 | 7.78 | 42.80 | 43.42 | 5.26 | 82.82 | 10.67 | 2.34 |
| 3/1/2005 | - | - | 36.60 | - | 50.76 | - | 3.53 |
| 3/8/2005 | 4.05 | 29.17 | 34.13 | 2.69 | 48.11 | 8.39 | 1.40 |
| 3/23/2005 | 8.97 | 35.65 | 28.38 | 4.61 | 58.39 | 8.70 | 2.83 |
| 4/5/2005 | 13.72 | 53.04 | 48.70 | 8.85 | 32.37 | 10.03 | 3.98 |
| 4/18/2005 | 25.88 | 39.40 | | 6.53 | 134.31 | 14.81 | 8.15 |
| 5/3/2005 | 3.21 | 34.90 | 36.99 | 5.37 | 57.86 | 7.97 | 1.40 |
| 5/17/2005 | 10.22 | 34.50 | 27.43 | 5.36 | 46.47 | 11.79 | 3.12 |
| 5/31/2005 | 2.66 | 27.81 | 27.05 | 2.51 | 36.13 | 8.21 | 0.98 |
| 6/14/2005 | 1.57 | 25.01 | 29.26 | 1.56 | 41.25 | 7.20 | 0.44 |
| 6/27/2005 | 4.05 | 22.62 | 13.60 | 1.86 | 24.73 | 7.48 | 0.53 |
| 7/5/2005 | 2.05 | 26.41 | 30.90 | 2.15 | 43.56 | 7.60 | 0.75 |
| 7/18/2005 | 3.29 | 19.50 | 7.21 | 1.22 | 22.66 | 6.54 | 0.31 |
| 8/1/2005 | 0.99 | 18.92 | 22.17 | 1.05 | 31.25 | 5.45 | 0.19 |
| 8/15/2005 | 1.03 | 18.15 | 29.55 | 0.50 | 15.50 | 3.96 | 0.27 |
| 8/30/2005 | 0.90 | 16.33 | 5.04 | 0.96 | 11.98 | 3.95 | 0.21 |
| 9/13/2005 | 1.02 | 18.81 | 6.61 | 0.25 | 29.24 | 4.53 | 0.24 |
| 9/28/2005 | 1.01 | 16.70 | 5.60 | 0.25 | 15.27 | 3.91 | 0.23 |
| 10/18/2005 | 6.68 | 22.41 | 6.31 | 0.93 | 15.32 | 3.72 | 0.30 |
| 10/26/2005 | 1.74 | 21.34 | 6.57 | 1.94 | 15.35 | 3.46 | 0.24 |
| 11/7/2005 | 17.56 | 52.86 | 40.03 | 7.05 | 152.03 | 8.41 | 5.18 |
| 11/30/2005 | 5.53 | 28.90 | 18.91 | 4.11 | 71.02 | 9.98 | 4.03 |

Creeks that have continuous recording flow gages are Goldsborough, Cranberry, Johns, and Mill Creeks.

- **Goldsborough Creek** has a USGS gauge (12076800) located near the 7th Street bridge, approximately 1 Km from the mouth of the creek. This is the monitoring station GOL1. The USGS gauge was installed in October 2004. Funding for the gauge was provided by the Squaxin Island Tribe.
- Flow gages in **Cranberry**, **John,** and **Mill creeks** are maintained by the Squaxin Island Tribe and are all located near bridges on Highway 3 (stations CRAN1, JOH1, and MIL2, respectively). An additional gauge on Johns Creek is located at station JOH2, at Johns Creek Drive. The Highway 3 gauge (JOH1) on Johns Creek was operational in June 2005.

The flow data at the Goldsborough Creek and Cranberry Creek gages were used directly as input data (Oct 2004 through Nov 2005) for the Oakland Bay-Hammersley Inlet hydrodynamic model. These flow gages are near the mouth of the creeks.

For Johns Creek, the time-series flow data at station JOH1 were used with missing data extrapolated from a relationship between measured flow at JOH1 and gauge flow at JOH2.

Time-series data near the mouth of Mill Creek (station MIL1) were generated using relationships between measured flow at MIL1 and gauge data at MIL2 and comparison with gauge flow data for Goldsborough Creek.

Figure D-2 shows the gauge flow in the four streams at stations GOL1, CRAN1, JOH2, and MIL2.

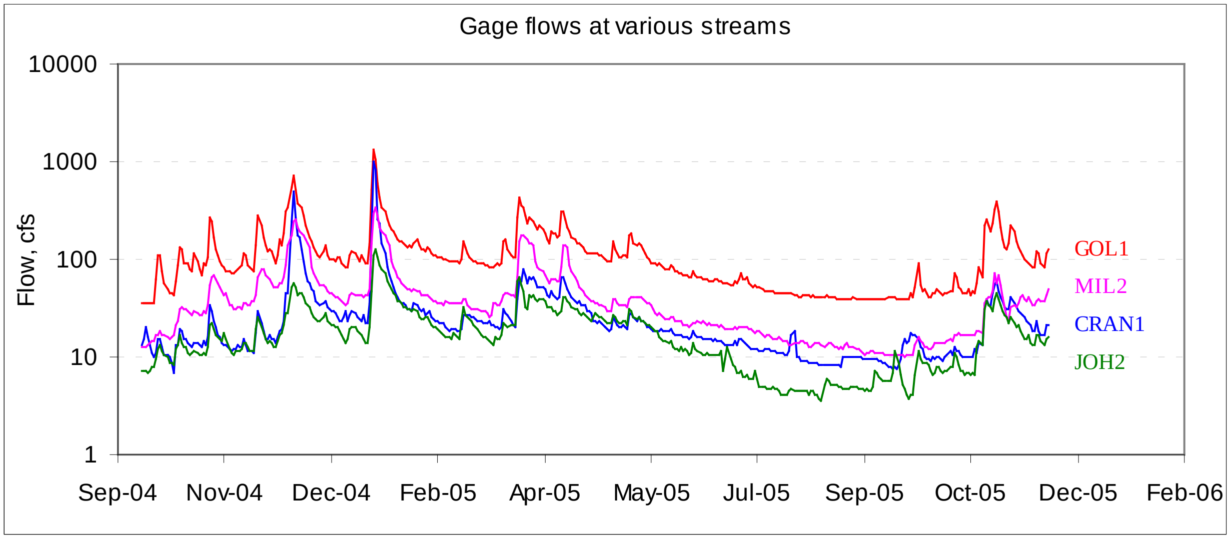



**Figure D-2. Gauge flows at selected streams.**

## Johns Creek

Johns Creek has a long-term flow gauge at station JOH2, located at the Johns Creek Drive bridge, almost three miles upstream of the mouth. JOH1 is located at the Highway 3 bridge and closer to the mouth of the creek, approximately 0.3 miles from mouth. The flow gauge at JOH1 was installed in June 2005. Flow was measured at this gauging station since October 2004. The measured flow at JOH1 was used in conjunction with gauge flow at JOH2 and its relationship with available gauge-flow data at JOH1 to generate continuous flow data for station JOH1. Some adjustments were made to calibrate to measured flows at JOH1. Figure D-3 shows the time-series flow data at station JOH1.

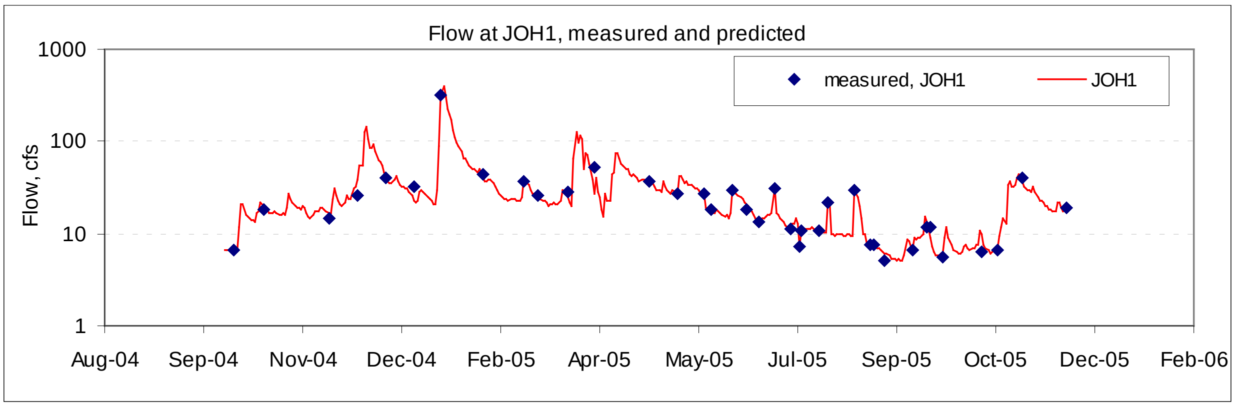



**Figure D-3. Predicted flows near the mouth of Johns Creek.**

## Mill Creek

Mill Creek has a gauge at the Highway 3 bridge at station MIL2. However this is in excess of eight miles from the mouth. Station MIL1 is closer to the mouth (approximately two miles) and was used to establish flows for Mill Creek. Flow measurements were made at MIL1 approximately once every two weeks between October 2004 and November 2005.

First, time-series flow data were generated for MIL1 based on the relationship between measured flows at MIL1 and corresponding gauge flows at MIL2. However, the predicted flows at MIL1 were overestimated for baseflows and underestimated for higher flows. Also, smaller peak flows resulting from downstream tributaries, and lakes were underestimated. The predicted flows based on the time-series flow at the MIL2 gauge, and the relationship between measured flows, were adjusted to calibrate to observed flows. Figure D-4 shows the time-series data for station MIL1.

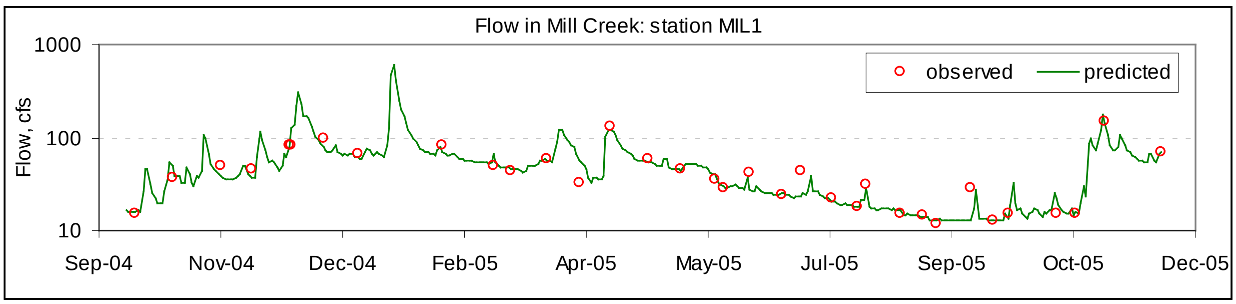



**Figure D-4. Predicted flows near the mouth of Mill Creek**

## Shelton, Deer, Malaney, Uncle John, and Campbell Creeks

Shelton, Deer, Malaney, Uncle John, and Campbell Creeks do not have any flow gages. The time- series flow data from Goldsborough Creek were used to estimate flows based on either a ratio of the drainage areas or the difference between observed flows. The drainage areas were obtained from StreamStats (http://water.usgs.gov/osw/streamstats/Washington.html, see Figure D-1). The baseflows were generally overestimated and therefore adjusted to calibrate to the observed flows. Figure D-5 shows the predicted and observed flows in these creeks for October 2004 through November 2005.

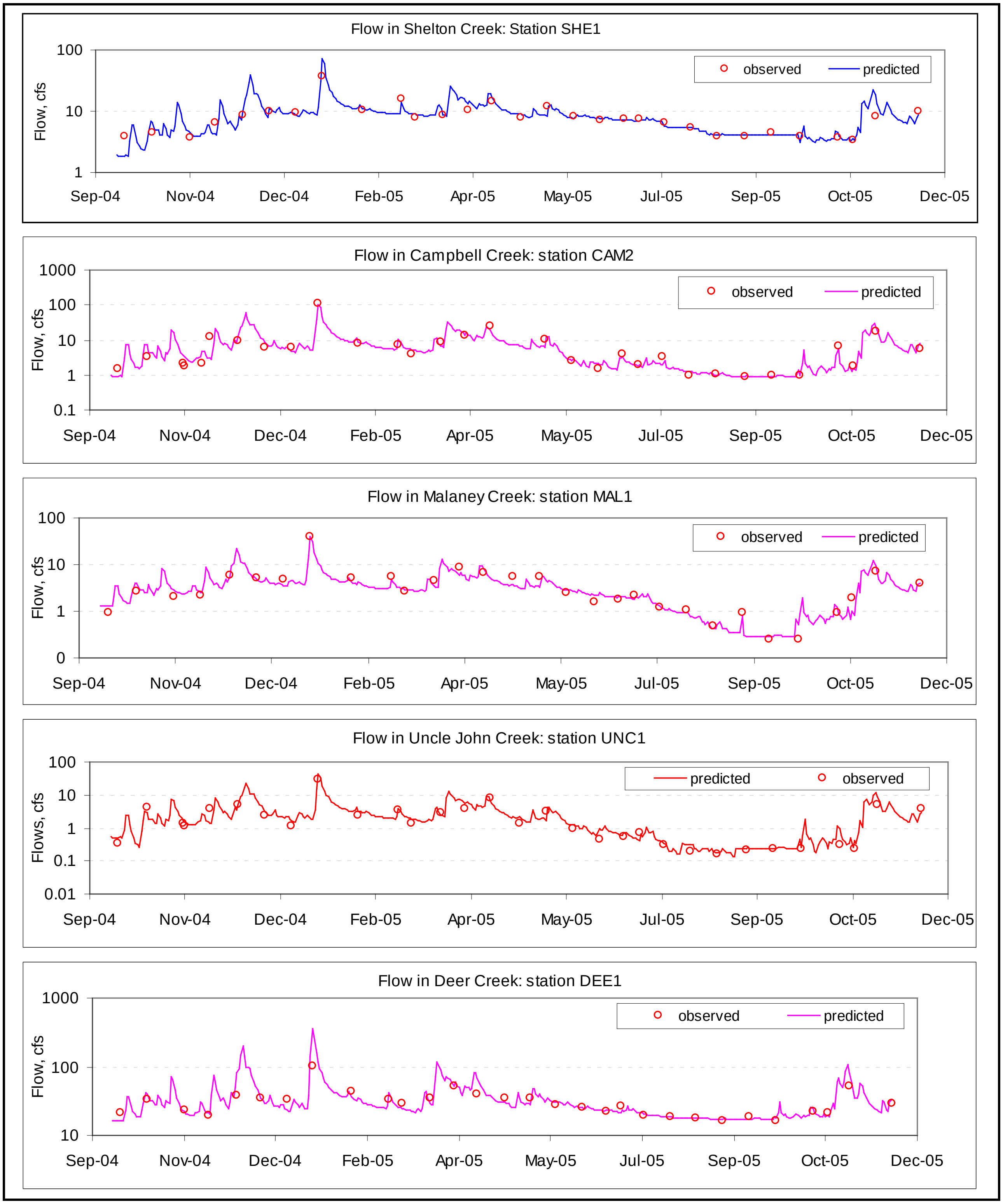



**Figure D-5. Predicted and observed flows in Shelton, Deer, Malaney, Uncle John, and Campbell Creeks**

*This page purposely left blank.*

# Appendix E. Seasonality of tributary bacteria concentrations

Figures E-1, E-2, and E-3 show the variation of bacteria concentrations near the mouth of all tributaries during the 2004-2005 monitoring period. The rainfall data were obtained from the Flupsy site in Oakland Bay. In the absence of rain, concentrations were generally higher during summer compared to the winter season. High rainfall events were associated with relatively high bacteria concentrations.

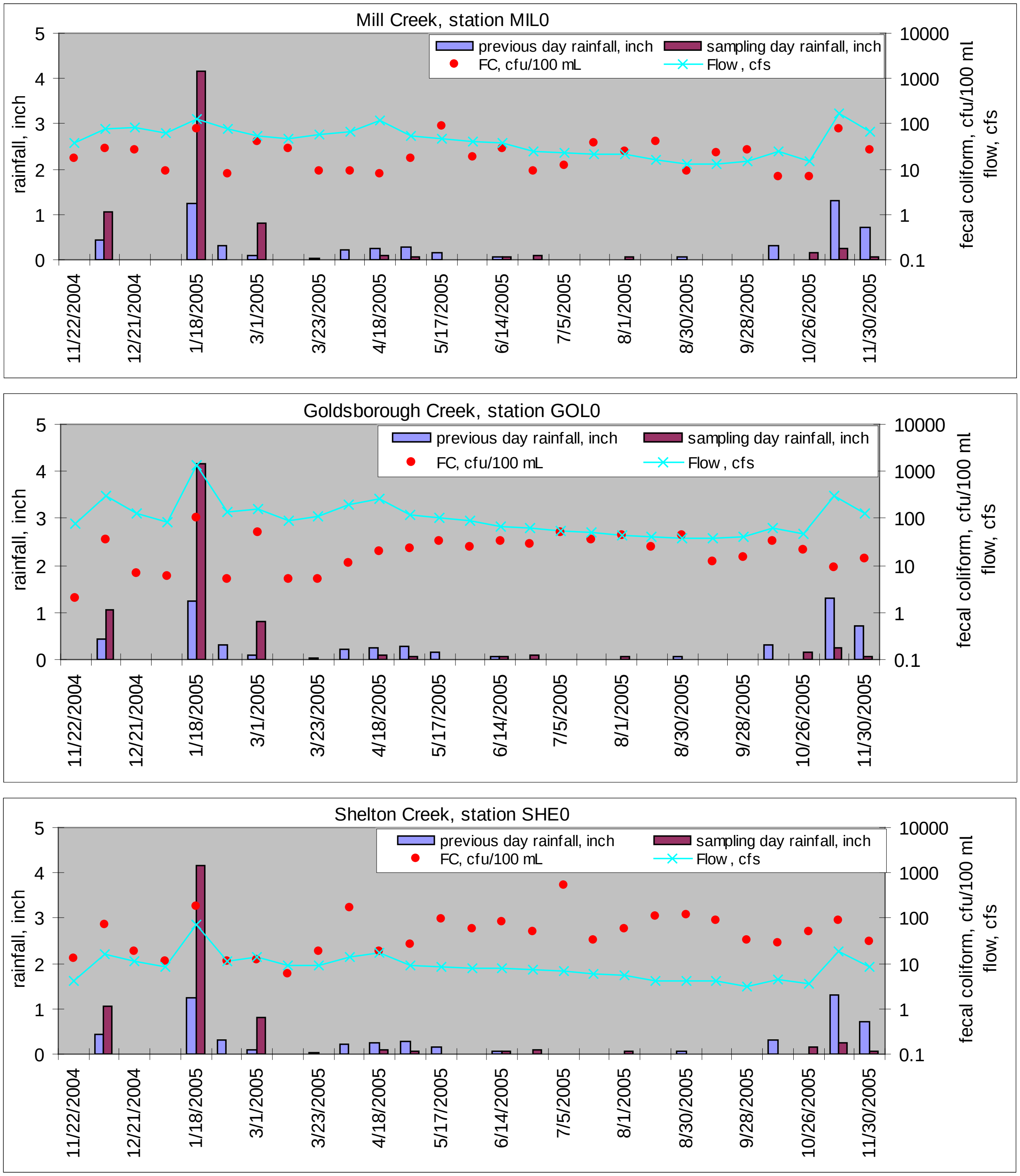
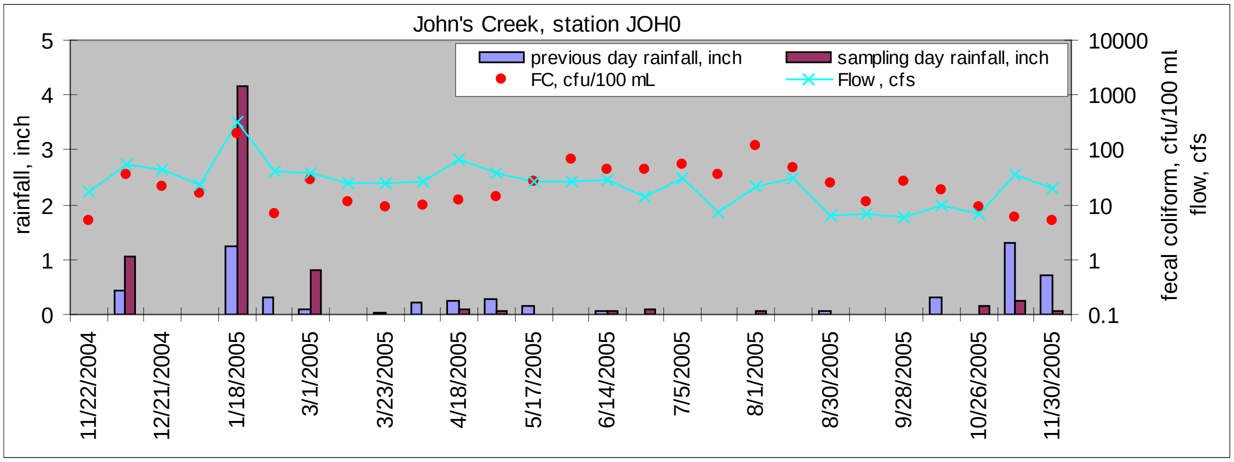
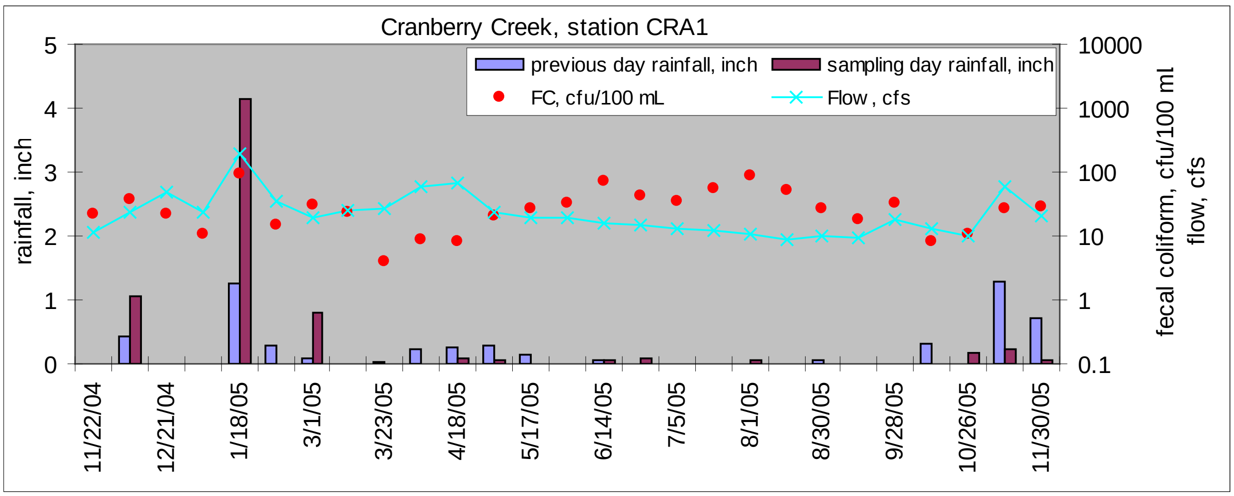



**Figure E-1. Bacteria concentrations at the mouths of Mill, Goldsborough, and Shelton Creeks.**



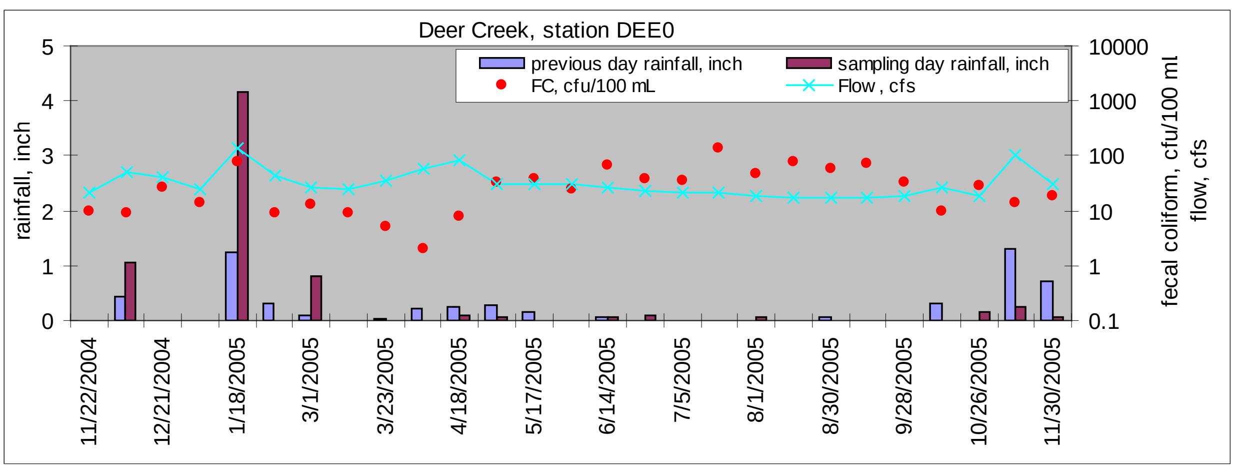




**Figure E-2. Bacteria concentrations at the mouths of Johns, Cranberry, and Deer Creeks.**

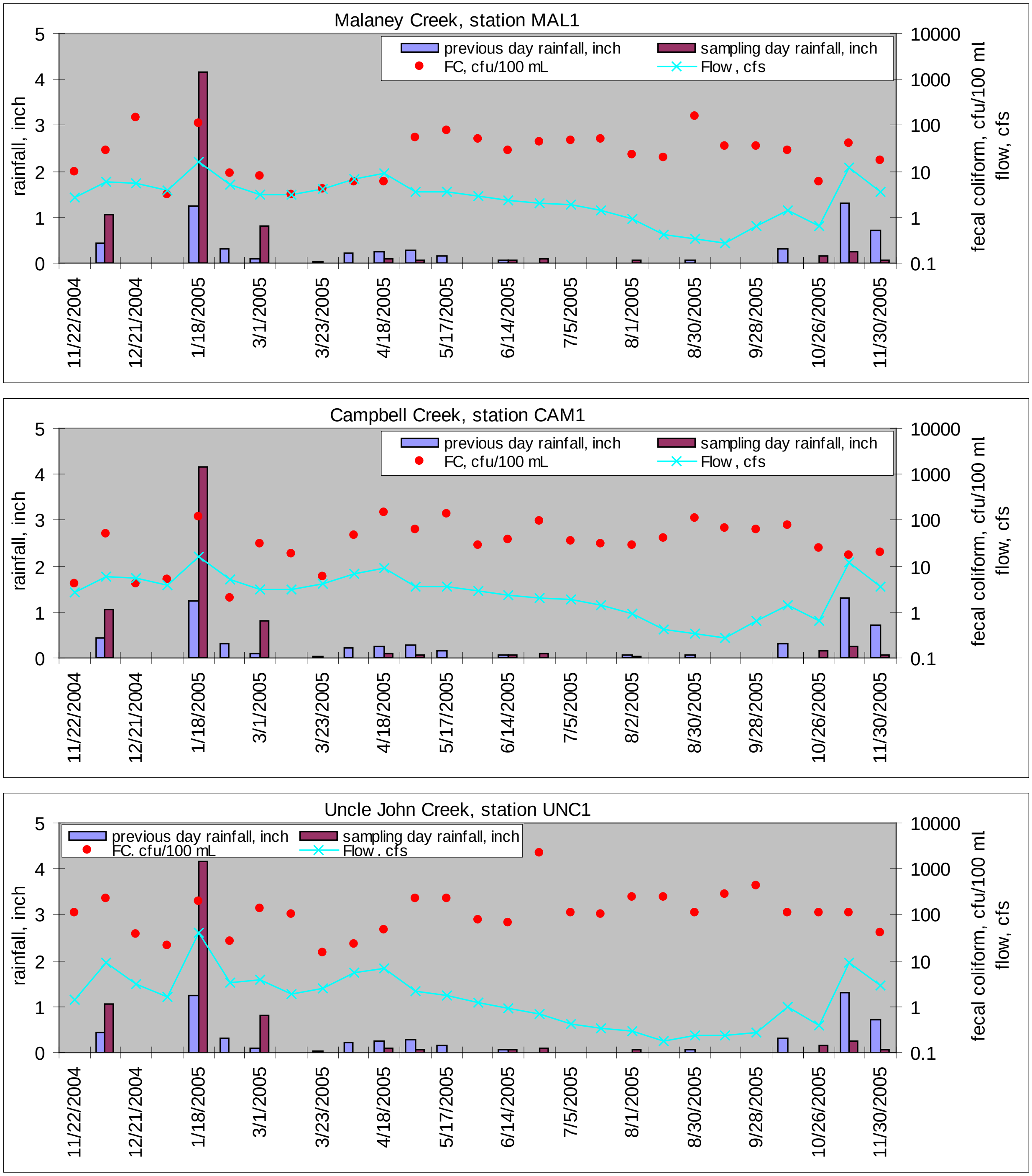



**Figure E-3. Bacteria concentrations at the mouths of Malaney, Campbell, and Uncle John Creeks.**

*This page purposely left blank.*

# Appendix F. Multiple regression analysis for predicting fecal coliform loads in tributaries

Pelletier and Seiders (2000) successfully used the log-linear regression model of Cohn et al. (1992) to accurately represent fluvial loads of FC bacteria to Gray's Harbor. The log-linear regression model is of the type shown below. The model contains a constant, linear, and quadratic fit to the logarithm of flow, and sinusoidal (Fourier) functions to remove the effect of annual seasonality.

$$Log[FC] = \beta_0 + \beta_1 Log[Q] + \beta_2 (Log[Q])2 + \beta_3 \sin[2\pi T] + \beta_4 \cos[2\pi T] + \beta_5 \sin[4\pi T] + \beta_6 \cos[4\pi T] + \varepsilon$$

where: Log[FC] = logarithm of fecal coliform (number of organisms per 100 ml)
Log[Q] = logarithm of flow (cubic meters per second)
T = time measured in years
ε = error term assumed to be independent and normally distributed with a mean of zero
β-terms = parameters of the model estimated through multiple regression

Although Pelletier and Seiders (2000) found the terms $\beta_2$, $\beta_5$, and $\beta_6$ to be statistically insignificant, they actually improved predictions for FC for the tributaries to Oakland Bay and Hammersley Inlet.

The regression model is used, in conjunction with the record of daily flows, to predict daily loading of FC bacteria. However, to do this, the logarithm of FC must be retransformed into real units of FC concentration. This creates an error and must be corrected through a *smearing estimate* (Duan, 1983), a non-parametric, re-transformation function appropriate for non-normal error distributions to correct the re-transformed predicted concentrations for potential biases that can otherwise occur due to log-transformation. This method has been recommended by Thomas (1985) and Koch and Smillie (1986), and successfully used by Pelletier and Seiders (2000). The predictive form of the regression equation is:

$$FC = K_{se}\ 10(\beta0 + \beta1\ Log[Q] + \beta2\ (Log[Q])2 + \beta3 \sin[2\pi T] + \beta4 \cos[2\pi T] + \beta5 \sin[4\pi T] + \beta6 \cos[4\pi T])$$

Where: $K_{se}$ = *smearing estimate* = mean value of the antilogs of the regression residuals.

The resulting regression equations for the tributaries to Oakland Bay-Hammersley Inlet are presented in Table F-1. The predicted daily loads were estimated as the product of daily flow and estimated daily concentrations. Annual loads were estimated as the sum of estimated daily loads. Figures F-1 shows a comparison of predicted and observed loads of FC from all the tributaries to Oakland Bay-Hammersley Inlet. Figures F-2 and F-3 show the regression estimates of daily FC concentrations in comparison with observed FC in tributaries to Oakland Bay-Hammersley Inlet.

The potential bias of predicted versus observed total loads, integrated over all sampling days, will be tested using the t-test method described by Cohn et al. (1992). The predicted loads were found to be not significantly different from the observed loads.

**Table F-1. Summary of multiple regression results for prediction of FC concentrations in tributaries as a function of flow (Cohn et al., 1992).**

| Tributary (Creek) | Station | Regression coefficients from multiple regression analysis using SYSTAT* | | | | | | | | Squared multiple R | Adjusted squared multiple R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Smearing bias correction factor | β0 | β1 | β2 | β3 | β4 | β5 | β6 | | |
| Goldsborough | GOL0 | 1.116 | 1.213 | -0.645 | 0.899 | -0.128 | -0.408 | -0.077 | 0.071 | 0.70 | 0.60 |
| Shelton | SHE0 | 1.095 | 2.259 | 1.502 | 0.520 | -0.413 | -0.422 | -0.074 | -0.009 | 0.77 | 0.69 |
| Johns | JOH0 | 1.119 | 1.343 | 0.602 | 0.517 | -0.094 | -0.343 | 0.114 | 0.187 | 0.74 | 0.66 |
| Cranberry | CRA1 | 1.120 | 1.369 | 0.222 | 0.441 | -0.105 | -0.165 | 0.063 | 0.260 | 0.59 | 0.47 |
| Deer | DEE0 | 1.126 | 1.070 | -1.040 | 3.578 | -0.032 | -0.190 | -0.021 | 0.246 | 0.73 | 0.65 |
| Malaney | MAL1 | 1.404 | 2.623 | 2.194 | 0.816 | -0.224 | -0.319 | -0.123 | 0.245 | 0.48 | 0.32 |
| Campbell | CAM1 | 1.357 | 2.839 | 2.404 | 0.922 | -0.017 | -0.452 | -0.151 | -0.130 | 0.50 | 0.35 |
| Uncle John | UNC1 | 1.251 | 2.494 | 1.018 | 0.402 | -0.168 | -0.166 | -0.070 | -0.078 | 0.40 | 0.21 |
| Mill | MIL0 | 1.167 | 1.231 | 0.965 | -0.264 | -0.324 | -0.169 | 0.188 | 0.038 | 0.33 | 0.12 |

* Model: LFC = β0 + β1(LFLO) + β2(LFLOSQ) + β3(SIN_YF)+ β4(COS_YF)+ β5(SIN2_YF) + β6(COS2_YF)
Regression coefficients: β0, β1, β2, β3, β4, β5, β6
LFC = log10 of fecal coliform concentration in colony forming units per 100 mL
LFLO = log10 of flow in cubic meters per second
LFLOWSQ = log10 of square of flow in cubic meters per second
SIN_YF = Sin (2*π*T)
COS_YF = Cos (2*π*T)
SIN2_YF = Sin (4*π*T)
COS2_YF = Cos (4*π*T)
T = time in years

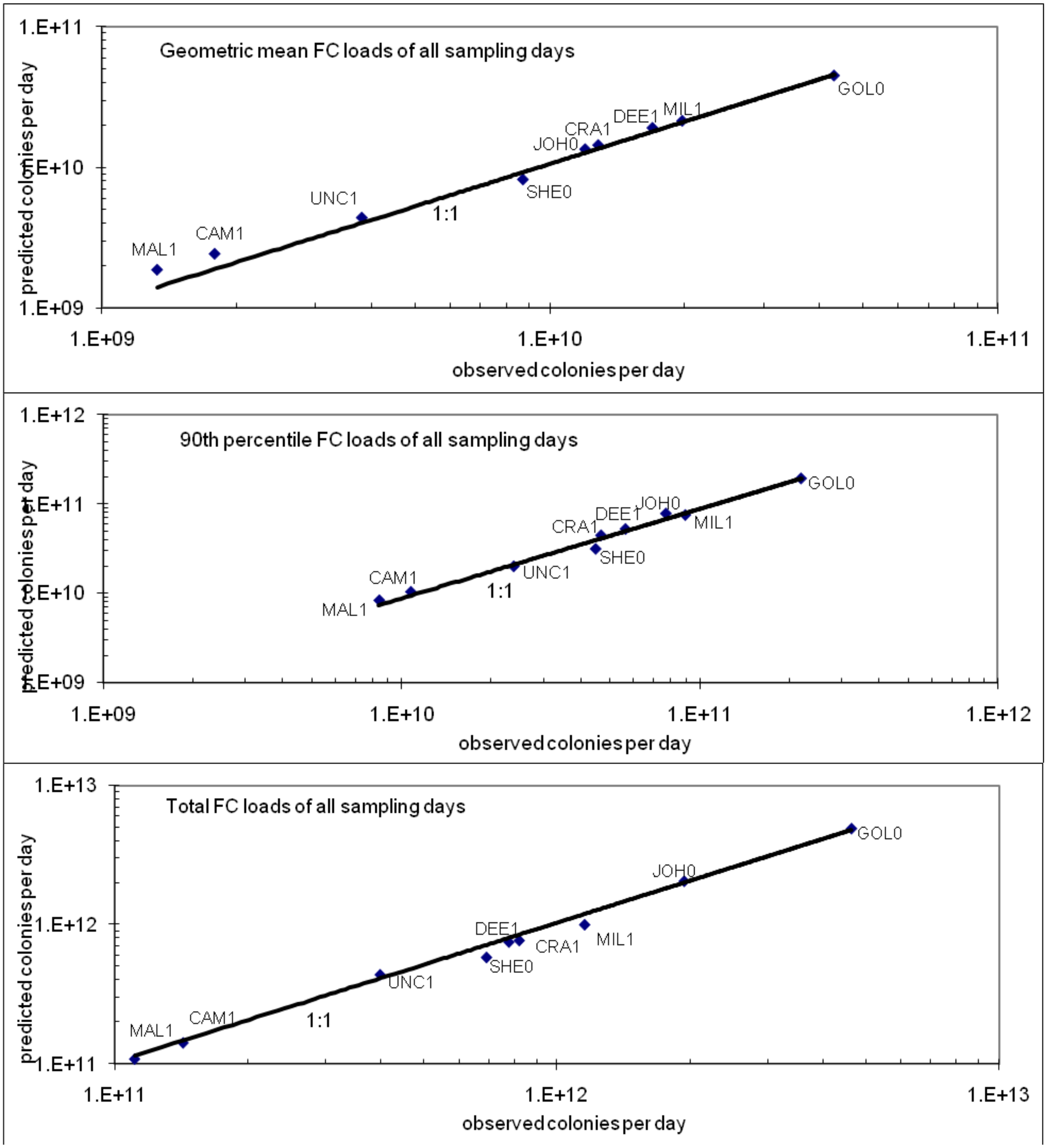



**Figure F-1. Comparison of observed and predicted geometric mean, 90th percentile, and total loads of FC from tributaries to Oakland Bay-Hammersley Inlet during 11/22/04-11/30/05.**
*Data labels indicate sampling stations at tributary mouths.*

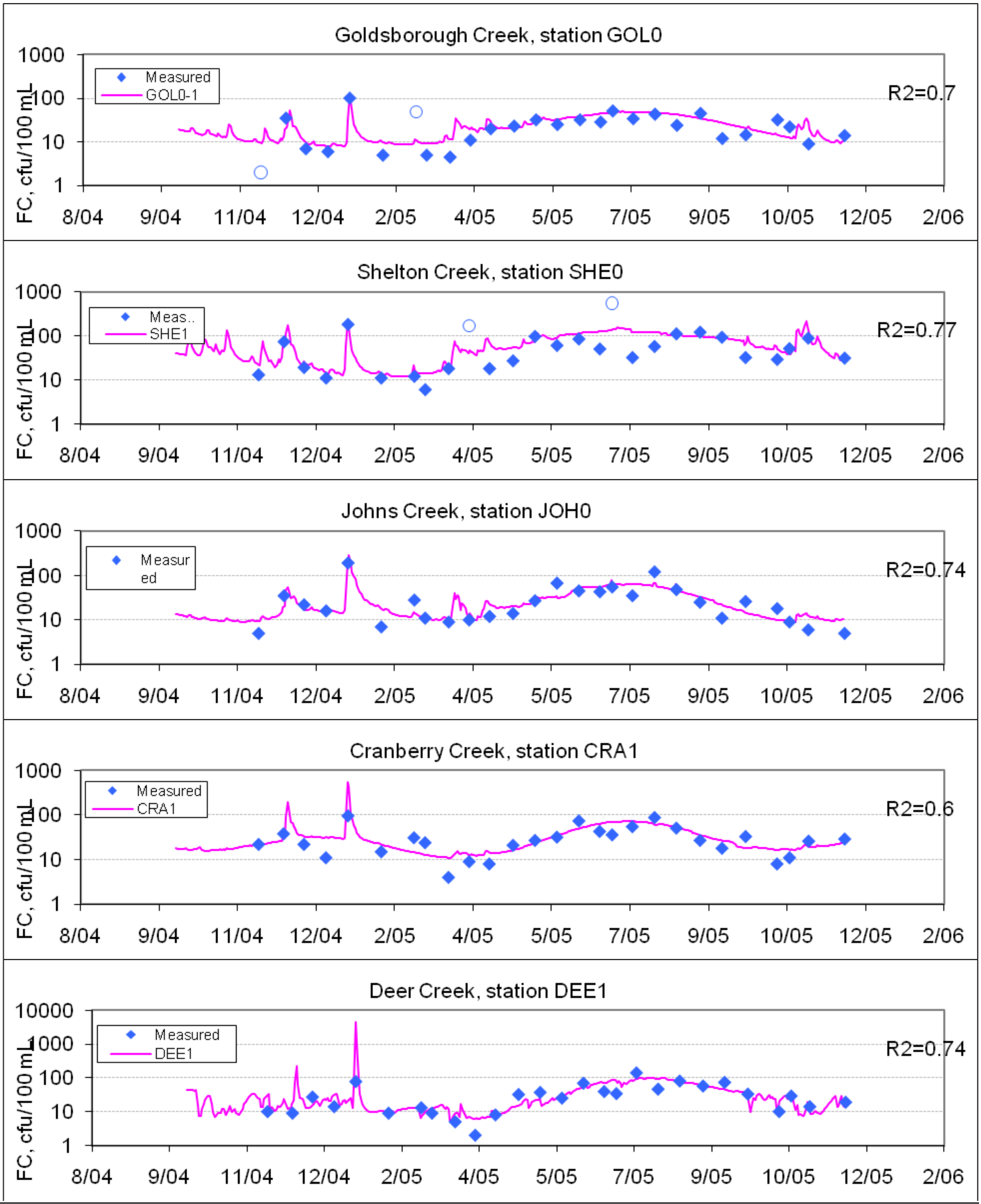



**Figure F-2. Predicted and observed FC concentrations at the mouths of Goldsborough, Shelton, Johns, Cranberry, and Deer Creeks from 11/22/04 – 11/30/05.**

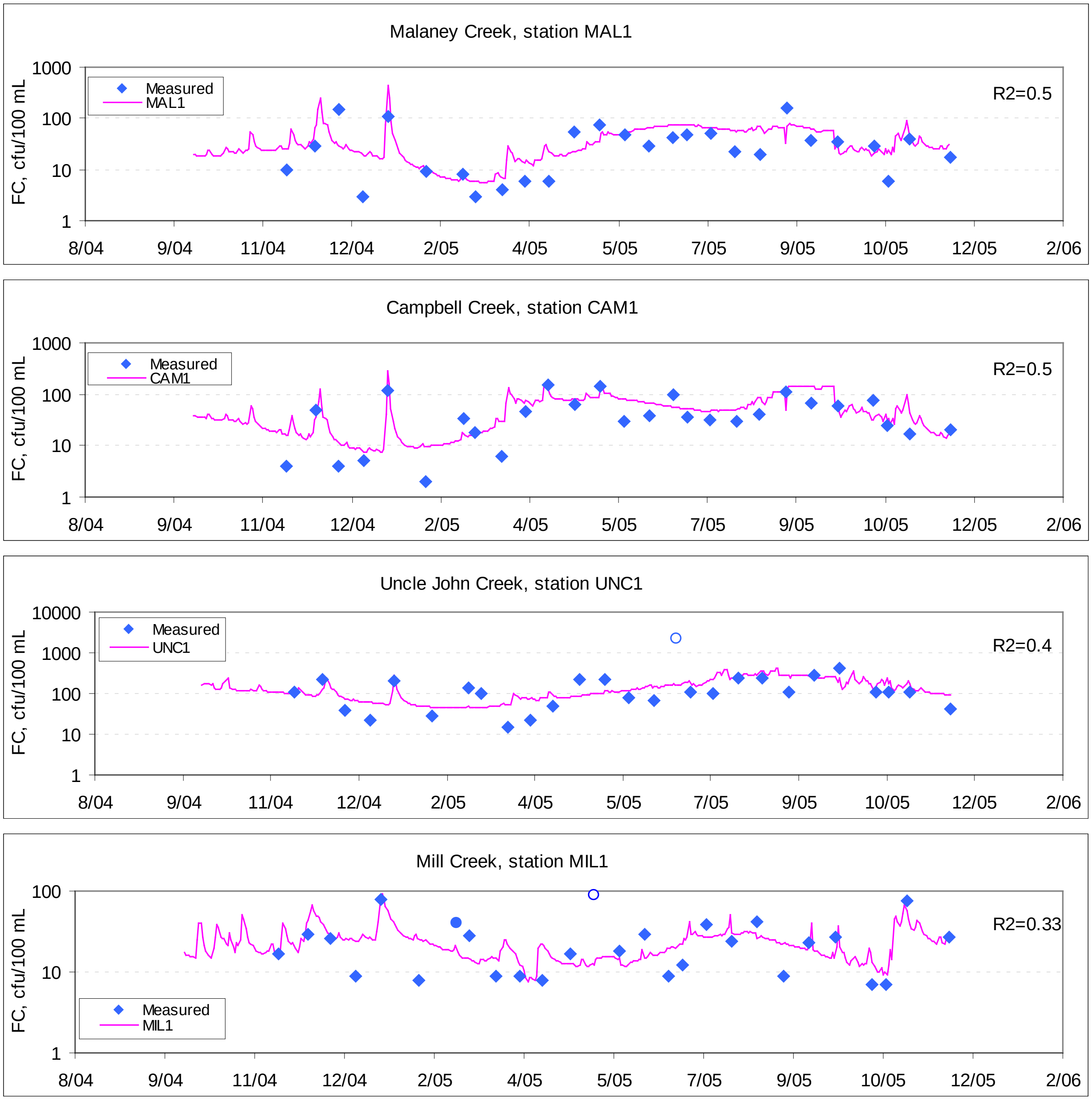



**Figure F-3. Predicted and observed FC concentrations at the mouths of Malaney, Campbell, Uncle John, and Mill creeks from 11/22/04 – 11/30/05.**

*This page purposely left blank.*

# Appendix G. Marine water monitoring data

## Most probable number (MPN) and membrane filter (MF) methods

In Oakland Bay, Washington State Department of Health (DOH) monitors fecal coliform (FC) bacteria at 19 locations, and in Hammersley Inlet at 12 stations. These stations are either monitored monthly, once every two months, or once a week depending on the location of the station and the degree of FC pollution.

The analytical method for FC bacteria used by DOH is the "most probable number" or MPN method. Davenport et al. (1976) found that heat shock was a major factor in suppression of the FC counts on the membrane filters at 44.5° C and that this could be minimized with extended incubation at 35° C before exposure to the higher temperature. Therefore, the MF method has a slightly negative bias compared to the MPN method. This negative bias was reflected in the data from Oakland Bay as shown in Figure G-1. Data prior to February 2005 were not used, as they were not true duplicates, rather two separate samples collected from the same location.

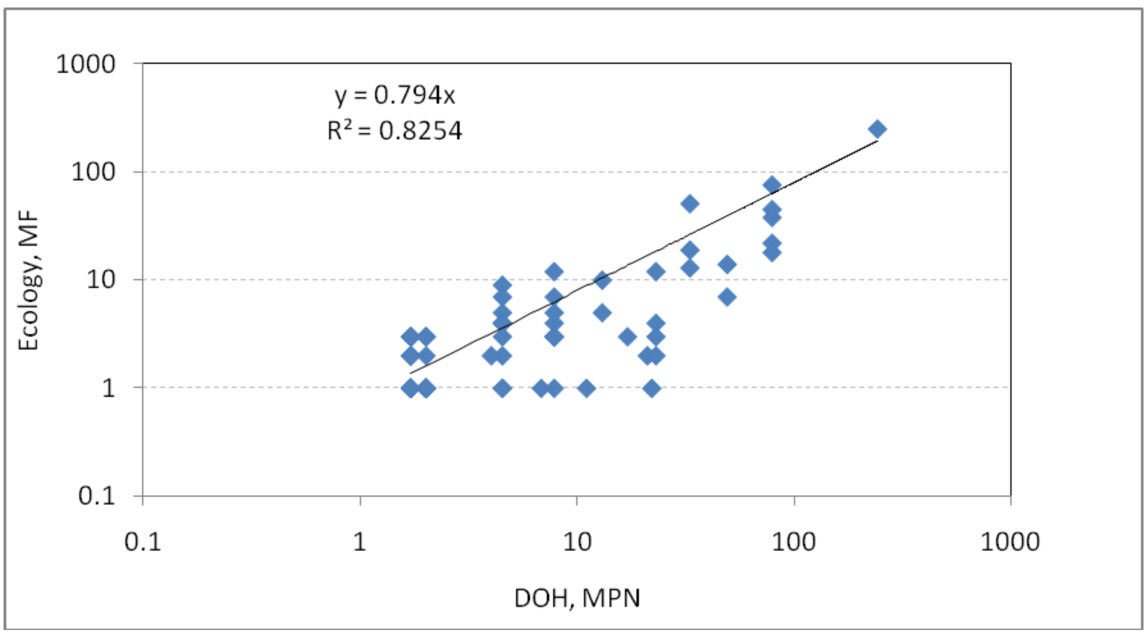



**Figure G-1. Comparison of MF and MPN methods (cfu/100 mL) for split samples collected in Oakland Bay (February 2005-January 2006).**

The negative bias of the MF method is also reflected in the FC standard used by the National Shellfish Sanitation Program (NSSP) when classifying shellfish growing areas (www.cfsan.fda.gov/~ear/nss2or04.html).

> *The fecal coliform geometric mean (MPN or MF) shall not exceed 14 /100 mL and no more than 10 percent of samples shall exceed*
>
> *a) 43 MPN per 100 ml for a five tube decimal dilution test; or*
> *b) 31 CFU per 100 ml for a MF test.*

DOH uses the MPN method for fecal coliform laboratory analyses, while Ecology may use either the MF or MPN method, although the MF method is more routinely used. This TMDL will be based on the MPN method. All MF fecal coliform data near the mouths of the tributaries will be converted to MPN concentrations based on relationship between MF and MPN concentrations developed in Figure G-1.

## Klebsiella

The FC group includes mainly *Escherichia* (*E. coli*). However, FC-positive *Klebsiella* also shows up as part of the cfu/100 mL fecal coliform counts in a MF or MPN method result. These *Klebsiella* species are routinely isolated from nutrient-rich industrial effluents, such as pulp and paper mill wastes, textile finishing plant effluents, sugarcane wastes, fresh vegetables, wood products, and natural receiving waters (Bagley and Seidler, 1977).

In Oakland Bay, four samples were collected by DOH and Mason County and analyzed for both FC and *Klebsiella.* Data are presented in Table G-1, and the sampling locations are shown in Figure G-2. The *Klebsiella* counts were low. Although these are limited data, this study will be limited to FC load allocations only because (1) broader conclusions cannot be drawn on the fraction of *Klebsiella* in Oakland Bay or the variability thereof, and (2) U.S. Food and Drug Administration and DOH do not distinguish between FC and FC-positive *Klebsiella*.

**Table G-1. FC and Klebsiella counts in samples from Oakland Bay.**

| Date | Location | FC (cfu/100 mL) | Klebsiella (percent) |
|---|---|---|---|
| 12/28/2005 | 614 | 37 | 8 |
| 12/28/2005 | 002 | 10 | 0 |
| 12/28/2005 | 31 | 63 | 0 |
| 12/28/2005 | 001 | 44 | 0 |

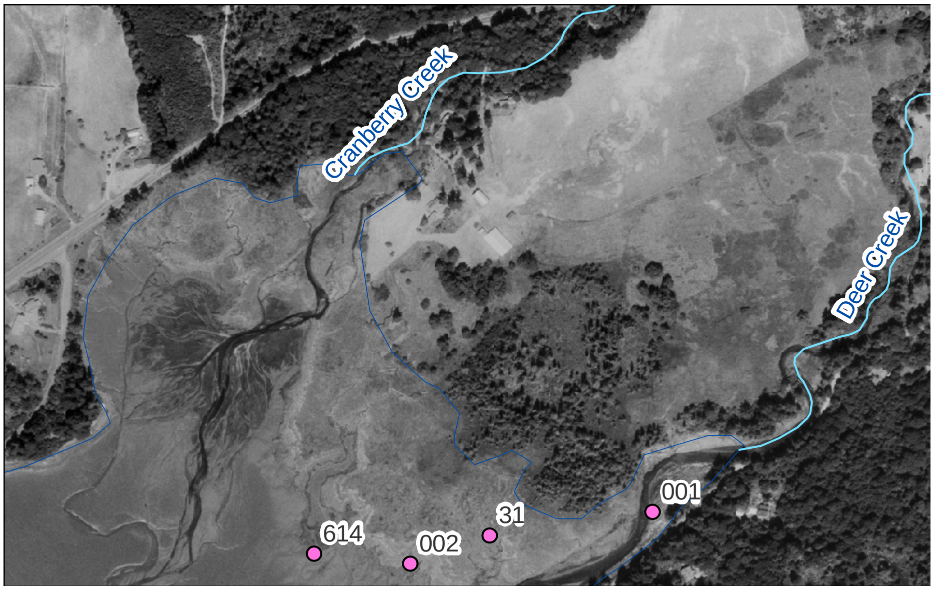



**Figure G-2. Locations where FC/Klebsiella samples were taken.**

## Fecal coliform bacteria

Tables G-2, G-3, and G-4 show monitoring data for FC bacteria gathered by DOH at their monthly stations in Oakland Bay, and once every two months in Hammersley Inlet, respectively. DOH uses the MPN method to enumerate coliforms from marine water samples.

**Table G-2 FC data (MPN/100 mL) in Oakland Bay stations monitored by DOH.**

| Date | DOH 114 | DOH 115 | DOH 116 | DOH 117 | DOH 118 | DOH 119 | DOH 120 | DOH 121 | DOH 122 | DOH 123 | DOH 124 | DOH 125 | DOH 126 | DOH 127 | DOH 128 | DOH 129 | DOH 614 | DOH 615 | DOH 639 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/13/04 | 2 | 1.7 | 2 | 2 | 1.7 | 1.7 | 4.5 | 1.7 | 1.7 | 2 | 4.5 | 4.5 | 7.8 | 49 | 1.7 | 2 | 2 | 13 | 1.7 |
| 11/2/04 | 22 | 11 | 2 | 23 | 46 | 110 | 23 | 17 | 23 | 33 | 49 | 130 | 70 | 130 | 2500 | 79 | 130 | 240 | 540 |
| 11/18/04 | 23 | 33 | 17 | 4 | 13 | 49 | 13 | 33 | 11 | 11 | 2 | 4.5 | | 4.5 | 23 | 7.8 | 4.5 | 13 | 49 |
| 12/2/04 | 2 | 23 | 2 | 4 | 2 | 1.7 | 13 | 2 | 4.5 | 2 | 6.8 | 2 | 1.7 | 4 | 7.8 | 7.8 | 4.5 | 7.8 | 2 |
| 1/5/05 | 7.8 | 2 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 2 | 4.5 | 4.5 | 7.8 | 1.8 | 6.8 | 7.8 | 23 | 7.8 | 11 | 4.5 | 7.8 |
| 2/1/05 | 11 | 33 | 7.8 | 2 | 2 | 4.5 | 4.5 | 2 | 1.7 | 2 | 2 | 17 | 4.5 | 2 | 6.8 | 1.7 | 33 | 7.8 | 4.5 |
| 3/1/05 | 7.8 | 2 | 1.7 | 2 | 4.5 | 1.7 | 1.7 | 4.5 | 7.8 | 2 | 7.8 | 4.5 | 17 | 7.8 | 79 | 7.8 | 2 | 49 | 23 |
| 4/11/05 | 1.7 | 1.7 | 1.7 | 1.7 | 4.5 | 2 | 1.7 | 1.7 | 7.8 | 1.7 | 1.7 | 2 | 1.7 | 4.5 | 2 | 2 | 49 | 79 | 14 |
| 5/10/05 | 240 | 23 | 1.7 | 17 | 49 | 110 | 79 | 170 | 170 | 4.5 | 49 | 4.5 | 79 | 240 | 240 | 79 | 170 | 1600 | 920 |
| 5/23/05 | 1.7 | 2 | 2 | 17 | 4.5 | 2 | 7.8 | 11 | 1.8 | 7.8 | 1.8 | 17 | 11 | 23 | 2 | 33 | 46 | 14 | 4.5 |
| 6/8/05 | 1.8 | 2 | 2 | 2 | 2 | 1.7 | 1.7 | 4.5 | 2 | 2 | 4.5 | 7.8 | 7.8 | 1.8 | 33 | 33 | 23 | 13 | 17 |
| 7/6/05 | 6.8 | 13 | 7.8 | 4.5 | 7.8 | 6.8 | 1.7 | 1.7 | 4.5 | 4.5 | 6.8 | 2 | 7.8 | 1.7 | 33 | 14 | 240 | 350 | 13 |
| 8/10/05 | 1.8 | 4.5 | 2 | 4.5 | 2 | 1.7 | 2 | 17 | 1.7 | 2 | 1.7 | 2 | 2 | 2 | 1.7 | 13 | 70 | 1.7 | 1.7 |
| 9/20/05 | 1.7 | 1.7 | 1.7 | 2 | 4.5 | 7.8 | 1.7 | 6.8 | 2 | 4.5 | 2 | 2 | 4.5 | 1.7 | 7.8 | 49 | 2 | 7.8 | 11 |
| 10/18/05 | 13 | 2 | 2 | 1.7 | 7.8 | 22 | 4.5 | 2 | 1.7 | 2 | 4 | 2 | 7.8 | 1.7 | 4.5 | 23 | 31 | 23 | 13 |
| 11/16/05 | 110 | 2 | 11 | 2 | 7.8 | 6.8 | 7.8 | 7.8 | 1.7 | 11 | 21 | 6.8 | 4.5 | 4 | 23 | 22 | 1.7 | 23 | 33 |
| 12/13/05 | 33 | 49 | 33 | 2 | 2 | 4.5 | 4.5 | 4.5 | 7.8 | 2 | 17 | 1.7 | 4 | 1.7 | 1.7 | 4.5 | 7.8 | 11 | 2 |
| 1/3/06 | 79 | 7.8 | 6.8 | 11 | 11 | 4.5 | 13 | 7.8 | 7.8 | 23 | 79 | 9.3 | 1.7 | 13 | 7.8 | 2 | 2 | 11 | 11 |

| Date | DOH 114 | DOH 115 | DOH 116 | DOH 117 | DOH 118 | DOH 119 | DOH 120 | DOH 121 | DOH 122 | DOH 123 | DOH 124 | DOH 125 | DOH 126 | DOH 127 | DOH 128 | DOH 129 | DOH 614 | DOH 615 | DOH 639 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/15/06 | 23 | 13 | 1.7 | 2 | 11 | 1.7 | 1.7 | 1.7 | 6.8 | 2 | 13 | 1.7 | 1.7 | 4 | 1.7 | 2 | 4.5 | 4.5 | 4.5 |
| 3/7/06 | 7.8 | 7.8 | 33 | 1.7 | 2 | 1.7 | 2 | 2 | 4 | 2 | 4.5 | 4.5 | 2 | 2 | 1.7 | 4 | 33 | 13 | 1.8 |
| 4/18/06 | 1.7 | 2 | 1.7 | 1.7 | 1.7 | 2 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 2 | 1.7 | 4.5 | 1.7 | 1.8 | 1.7 | 1.7 | 2 |
| 5/16/06 | 2 | 2 | 2 | 17 | 49 | 1.7 | 2 | 1.8 | 1.7 | 2 | 4.5 | 13 | 2 | 4.5 | 2 | 4.5 | 33 | 2 | 1.7 |
| 6/13/06 | 110 | 33 | 17 | 1.7 | 4.5 | 2 | 7.8 | 4.5 | 2 | 1.7 | 79 | 2 | 13 | 2 | 4 | 49 | 79 | 220 | 11 |
| 7/17/06 | 4.5 | 2 | 13 | 1.7 | 7.8 | 1.7 | 7.8 | 4.5 | 1.7 | 2 | 4 | 2 | 2 | 7.8 | 1.7 | 70 | 33 | 2 | 1.7 |
| 8/9/06 | 4.5 | 4 | 4.5 | 1.7 | 6.8 | 2 | 1.7 | 4.5 | 1.7 | 4.5 | 1.7 | 2 | 7.8 | 2 | 1.7 | 22 | 240 | 7.8 | 2 |
| 9/13/06 | 6.8 | 13 | 1.7 | 1.7 | 1.7 | 1.7 | 4.5 | 1.8 | 1.7 | 1.7 | 2 | 2 | 7.8 | 1.7 | 1.7 | 4.5 | 11 | 1.7 | 2 |
| 10/12/06 | 2 | 1.7 | 1.7 | 1.7 | 2 | 1.7 | 2 | 2 | 2 | 1.7 | 1.7 | 4.5 | 2 | 2 | 1.7 | 1.7 | 4.5 | 1.7 | 1.7 |
| 11/8/06 | 49 | 46 | 79 | 43 | 49 | 70 | 130 | 46 | 46 | 350 | 79 | 49 | 130 | 64 | 130 | 170 | 240 | 110 | 33 |
| 12/6/06 | 17 | 1.7 | 1.7 | 4.5 | 13 | 2 | 4.5 | 2 | 6.8 | 2 | 6.8 | 1.7 | 2 | 1.7 | 7.8 | 4.5 | 2 | 4.5 | 4.5 |

**Table G-3. FC data (MPN/100 mL) in Hammersley Inlet stations monitored by DOH.**

| Date | DOH96 | DOH97 | DOH98 | DOH99 | DOH100 | DOH101 | DOH102 | DOH103 | DOH104 | DOH105 | DOH111 | DOH112 | DOH113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19-Oct-04 | 11 | 2 | 2 | 2 | 350 | 11 | 7.8 | 4.5 | 7.8 | 2 | 2 | 17 | 2 |
| 16-Nov-04 | 1.7 | 1.7 | 1.7 | 4 | 7.8 | 1.8 | 1.7 | 1.7 | 1.7 | 2 | 6.8 | 1.7 | 4.5 |
| 26-Jan-05 | 1.7 | 1.7 | 2 | 2 | 7.8 | 4 | 6.8 | 17 | 4.5 | 4.5 | 2 | 2 | 13 |
| 8-Mar-05 | 2 | 1.7 | 1.7 | 1.7 | 4 | 1.7 | 2 | 1.7 | 1.7 | 23 | 1.7 | 1.7 | 1.7 |
| 17-May-05 | 2 | 1.7 | 1.7 | 2 | 13 | 1.8 | 1.7 | 2 | 1.7 | 1.7 | 1.7 | 2 | 2 |
| 30-Aug-05 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 2 | 1.7 | 1.8 | 1.7 | 4.5 | 1.7 |
| 11-Oct-05 | 2 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 2 | 1.7 | 2 | 1.7 | 1.7 | 1.7 |
| 7-Dec-05 | 1.7 | 1.7 | 1.7 | 1.7 | 4.5 | 1.7 | 2 | 1.7 | 1.7 | 2 | 2 | 1.7 | 2 |
| 10-Jan-06 | 4.5 | 4.5 | 7.8 | 17 | 170 | 33 | 64 | 49 | 49 | 49 | 49 | 6.8 | 23 |
| 28-Mar-06 | 1.7 | 1.7 | 1.7 | 2 | 2 | 1.7 | 1.7 | 1.7 | 2 | 2 | 1.7 | 1.7 | 1.7 |
| 23-May-06 | 2 | 2 | 1.7 | 7.8 | 17 | 2 | 2 | 4.5 | 2 | 2 | 6.8 | 4.5 | 4.5 |
| 15-Aug-06 | 1.7 | 2 | 2 | 2 | 17 | 6.8 | 1.7 | 4 | 1.7 | 2 | 2 | 1.8 | 2 |
| 19-Sep-06 | 4.5 | 17 | 11 | 1.8 | 11 | 4 | 11 | 4.5 | 2 | 17 | 11 | 13 | 13 |

**Table G-4. FC data (MPN/100 mL) in Hammersley Inlet stations monitored by DOH.**

| Date | DOH662 | DOH663 | DOH668 | DOH695 |
|---|---|---|---|---|
| 19-Oct-04 | 7.8 | 2 | 2 | 1.7 |
| 16-Nov-04 | 240 | 2 | 2 | 2 |
| 26-Jan-05 | 13 | 8 | 1.7 | 1.8 |
| 8-Mar-05 | 2 | 2 | 7.8 | 17 |
| 17-May-05 | 4.5 | 8 | 1.7 | |
| 30-Aug-05 | 1.7 | 2 | 1.7 | |
| 11-Oct-05 | 1.8 | 2 | 2 | |
| 7-Dec-05 | 4.5 | 2 | 1.7 | |
| 13-Dec-05 | 2 | 2 | 4.5 | |
| 3-Jan-06 | 7.8 | 17 | 17 | |
| 10-Jan-06 | 49 | 49 | 23 | |
| 15-Feb-06 | 2 | 13 | 7.8 | |
| 7-Mar-06 | 1.7 | 2 | 4 | |
| 28-Mar-06 | 1.7 | 2 | 1.7 | |
| 18-Apr-06 | 1.7 | 2 | 1.7 | |
| 16-May-06 | 7.8 | 2 | 1.7 | |
| 23-May-06 | 4 | 8 | 1.7 | |

| 13-Jun-06 | 13 | 8 | 11 | |
|---|---|---|---|---|
| Date | DOH662 | DOH663 | DOH668 | DOH695 |
| 17-Jul-06 | 6.8 | 2 | 6.8 | |
| 9-Aug-06 | 2 | 5 | 1.7 | |
| 15-Aug-06 | 2 | 5 | 1.7 | |
| 13-Sep-06 | 1.7 | 2 | 2 | |
| 19-Sep-06 | 4 | | 2 | |
| 12-Oct-06 | 1.7 | 2 | 2 | |
| 8-Nov-06 | 17 | 79 | 170 | |

Ecology also gathered FC data in marine water samples using the MF technique. Sampling was done at selected DOH monitoring locations as shown in Table G-5. Each sample collected at these stations was split between DOH and Ecology for MPN and MF analysis, respectively.

**Table G-5. FC data (cfu/100 mL) collected by Ecology using the membrane filter (MF) method.**

| Oakland Bay | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | SH1 | SH2 | DOH129 | DOH128 | DOH126 | DOH124 | DOH123 | DOH120 | DOH115 |
| 02-Nov-04 | 110 | 150 | 23 | 130 | 22 | 29 | 32 | 14 | 11 |
| 02-Dec-04 | 31 | 11 | 2 | 8 | 5 | 1 | 5 | 2 | 3 |
| 05-Jan-05 | 40 | 21 | 2 | 4 | 9 | 1 | 2 | 15 | 2 |
| 01-Feb-05 | 6 | 9 | 3 | 1 | 9 | 1 | 1 | 5 | 13 |
| 01-Mar-05 | 52 | 190 | 3 | 22 | 3 | 12 | 1 | 1 | 1 |
| 11-Apr-05 | 1 | 20 | 1 | 1 | 2 | 2 | 1 | 3 | 1 |
| 10-May-05 | 33 | 530 | 45 | 250 | 38 | 14 | 7 | 76 | 12 |
| 08-Jun-05 | 1 | 17 | 19 | 51 | 3 | 4 | 1 | 2 | 3 |
| 20-Sep-05 | 12 | 7 | 7 | 1 | 1 | 1 | 4 | 1 | 1 |
| 18-Oct-05 | 35 | 10 | 4 | 4 | 7 | 2 | 3 | 2 | 2 |
| 16-Nov-05 | 28 | 29 | 1 | 3 | 3 | 2 | 1 | 4 | 1 |
| 03-Jan-06 | 21 | 31 | 3 | 3 | 3 | 18 | 2 | 5 | 5 |

| Lower Hammersley Inlet | | | | | |
|---|---|---|---|---|---|
| Date | DOH96 | DOH97 | DOH99 | DOH100 | DOH104 |
| 25-Jan-05 | 1 | 1 | 1 | 5 | 3 |
| 17-May-05 | 1 | 1 | 1 | 10 | 1 |
| 11-Oct-05 | 1 | 1 | 2 | 1 | 1 |
| 07-Dec-05 | 1 | 1 | 3 | 1 | 1 |

## First Shoreline survey for fecal coliform September 20, 2004

First survey, September 20, 2004: This survey was done to locate shoreline sources. There was no rain during or before the day of survey. Seven samples were collected by the Squaxin Island Tribe near the Chapman Cove area. The data are shown in Table G-6. Sample location photos are shown in Figure G-3.

**Table G-6. FC Concentrations and station locations during September 20, 2004 survey.**

| Photo ID (see Figure G-3) | Latitude | Longitude | Station description | Type | FC, cfu/ 100 mL |
|---|---|---|---|---|---|
| 1 | 47.224240 | -123.041930 | Collection site #1. Estuary cut. | drainage | 600 |
| 2 | 47.221750 | -123.032960 | The new ditch<br>(Sample #2, marine sample) | drainage | <10 |
| 3 | 47.222060 | -123.030230 | Field drainage, associated with dike.<br>(Sample #3, marine; at confluence of Uncle John's Cr.) | drainage | <10 |
| 4 | 47.222330 | -123.031160 | Channel that cuts into field<br>(Sample #4, marine). | drainage | <10 |
| 5 | 47.225840 | -123.032920 | Lagoon complex, next to house.<br>(Sample #5, fw) | drainage | <10 |
| 6 | 47.221260 | -123.052340 | Hood Canal Land Trust. Sun 4<br>(Sample #6, fw) | creek | 50 |
| 7 | 47.224490 | -123.047020 | Dual pipes.<br>(Sample #7) | pipe | 380 |

fw = freshwater

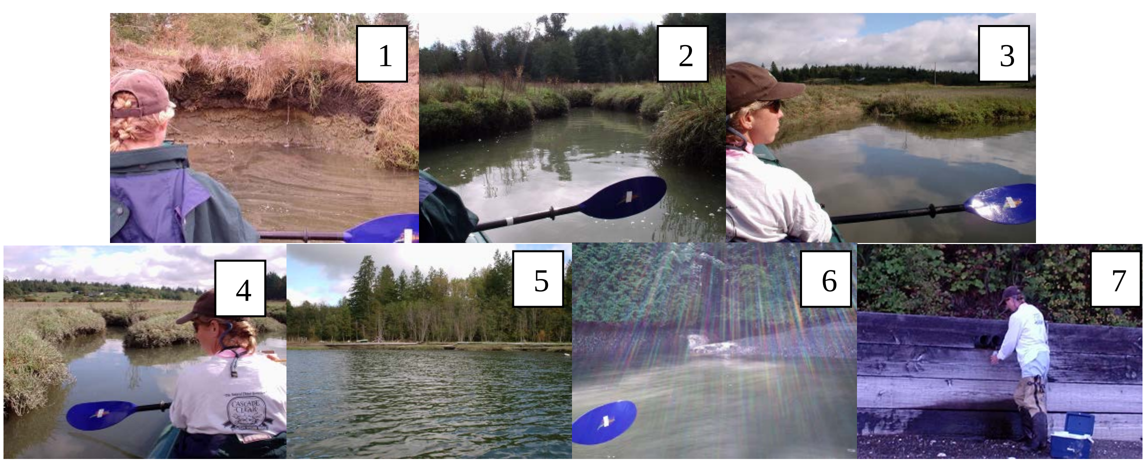



**Figure G-3. Photos of locations where samples were collected during September 20, 2004 survey.**

## Conductivity and temperature profiles

At each of the Ecology/DOH marine sampling locations, a vertical profile was measured for temperature and conductivity using a Seabird CTD profiler. However, of the 96 or so profiles taken, only five were able to be retrieved from the instrument (Table G-7).

**Table G-7. CTD data for selected marine stations.**

| Station | Date | Time | Depth, m | Temp, C | Cond, S/m | Salinity, psu |
|---|---|---|---|---|---|---|
| SH2 | 2-Nov-04 | 10:05 AM | 0.5 | 11.3 | 2.6 | 21.7 |
| | | | 1 | 11.7 | 3.1 | 26.4 |
| | | | 1.5 | 11.8 | 3.2 | 27.9 |
| | | | 2 | 11.9 | 3.3 | 28.2 |
| | | | 2.5 | 11.9 | 3.3 | 28.2 |
| | | | 3 | 11.9 | 3.3 | 28.3 |
| | | | 3.5 | 11.9 | 3.3 | 28.3 |
| | | | 4 | 11.9 | 3.3 | 28.3 |
| SH2 | 5-Jan-05 | 10:15 AM | 0.5 | 6.4 | 2.3 | 22.6 |
| | | | 1 | 7.0 | 2.6 | 24.6 |
| | | | 1.5 | 7.2 | 2.7 | 25.8 |
| | | | 2 | 7.2 | 2.7 | 25.8 |
| | | | 2.5 | 7.3 | 2.7 | 25.8 |
| | | | 3 | 7.3 | 2.7 | 25.8 |
| SH2 | 2-Dec-04 | 10:00 AM | 0.5 | 9.1 | 2.2 | 20.0 |
| | | | 1 | 9.5 | 3.0 | 27.0 |
| | | | 1.5 | 9.7 | 3.0 | 27.3 |
| | | | 2 | 9.7 | 3.1 | 27.6 |
| | | | 2.5 | 9.7 | 3.1 | 27.7 |
| | | | 3 | 9.8 | 3.1 | 27.8 |
| | | | 3.5 | 9.8 | 3.1 | 27.8 |
| | | | 4 | 9.8 | 3.1 | 27.9 |
| | | | 5 | 9.8 | 3.1 | 27.9 |
| | | | 5.5 | 9.8 | 3.1 | 27.9 |
| DOH96 | 11-Oct-05 | 12:25 PM | 0.5 | 14.5 | 2.5 | 19.4 |
| | | | 1 | 14.4 | 4.0 | 32.6 |
| | | | 1.5 | 14.4 | 3.6 | 29.5 |
| | | | 2 | 14.4 | 3.6 | 29.5 |
| | | | 2.5 | 14.4 | 3.6 | 29.5 |
| | | | 3 | 14.4 | 3.6 | 29.5 |
| | | | 3.5 | 14.4 | 3.6 | 29.5 |
| | | | 4 | 14.4 | 3.6 | 29.5 |
| | | | 4.5 | 14.4 | 3.6 | 29.5 |
| | | | 5 | 14.4 | 3.6 | 29.5 |
| | | | 5.5 | 14.3 | 3.6 | 29.5 |
| | | | 6 | 14.3 | 3.6 | 29.5 |
| | | | 6.5 | 14.3 | 3.6 | 29.5 |
| DOH128 | 20-Sep-05 | 9:00 AM | 0.5 | 16.5 | 3.0 | 23.0 |
| | | | 1 | 16.5 | 3.7 | 28.2 |
| | | | 1.5 | 16.6 | 3.6 | 27.8 |
| | | | 2 | 16.6 | 3.7 | 28.2 |
| | | | 2.5 | 16.7 | 3.7 | 28.4 |
| | | | 3 | 16.7 | 3.7 | 28.5 |
| | | | 3.5 | 16.7 | 3.7 | 28.5 |
| | | | 4 | 16.7 | 3.7 | 28.5 |

## Continuous marine temperature measurements at selected locations

Of the four locations (two in Oakland Bay and two in Hammersley Inlet) where a continuous temperature measurement device was deployed, only the two stations in Hammersley Inlet were able to record viable temperature data. The other two devices were routinely exposed to air due to miscalculation of tidal elevations during deployment. This is discussed in detail in Appendix H. Figure G-4 shows the continuous temperature data gathered in the two Hammersley stations, HAM1 and HAM2. HAM1 was deployed east of Eagle Point along the southern shoreline of Hammersley Inlet at latitude 47.20528 N and longitude -123.0675 W. HAM2 was deployed just west of Mill Creek along the southern shoreline of Hammersley Inlet at latitude 47.158035 N and longitude -124.435975 W.

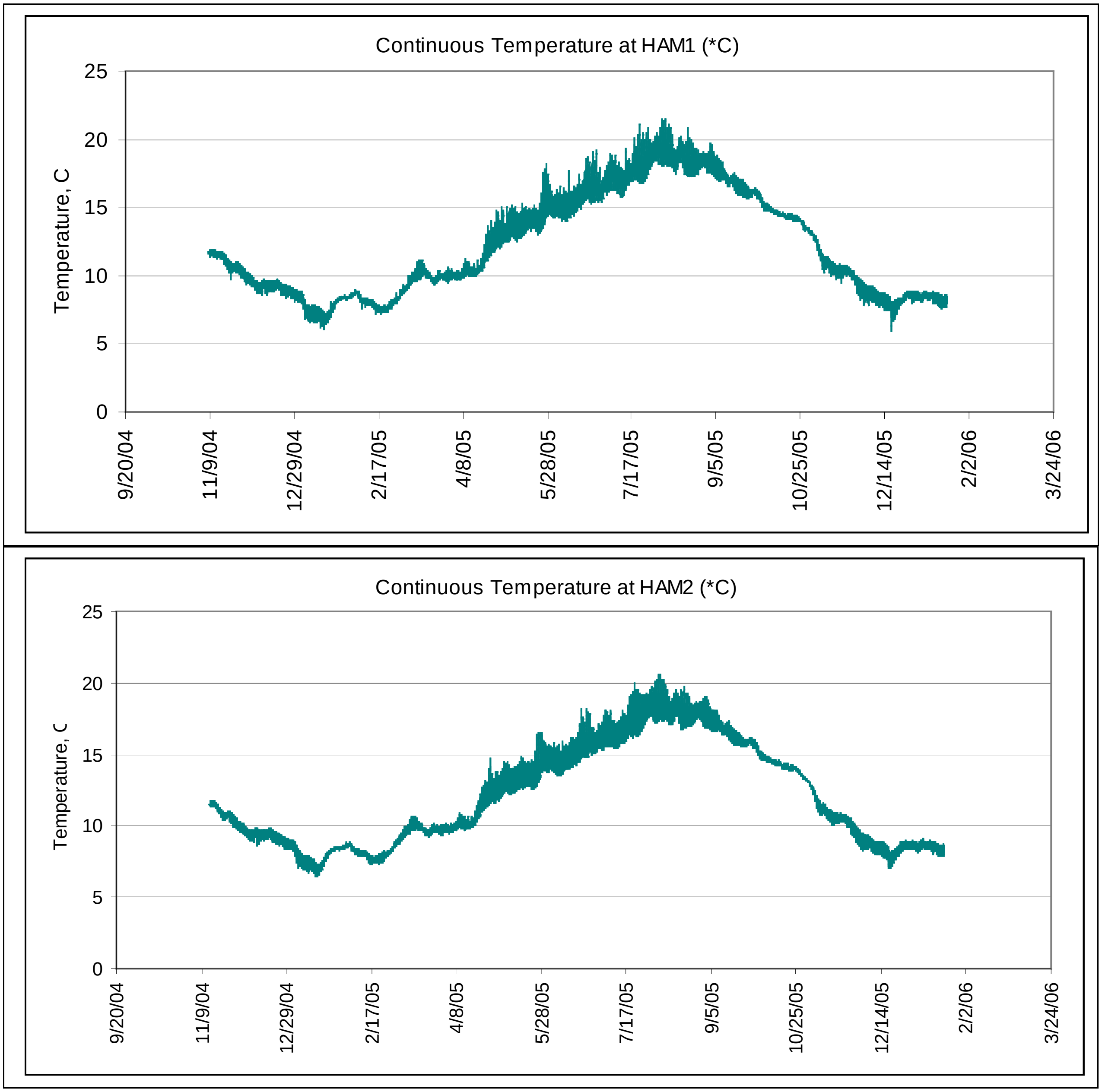



**Figure G-4. Continuous temperature measured at two marine stations.**

## Continuous temperature, salinity, and current measurements

InterOcean device S4s were deployed in Oakland Bay and Hammersley Inlet in January 2005 to gather continuous temperature, salinity, and currents. No data were retrieved from the Oakland Bay deployment due to battery failure. The Hammersley Inlet deployment was successful, but the battery failed toward the end of June 2005. The S4 in Hammersley Inlet was deployed about 2.6 feet from the bottom at latitude 47.20233 N and longitude -122.9483 N.

Figure G-5 shows the S4 before deployment and upon retrieval. Figure G-6 shows the continuous temperature and salinity data gathered by the device and rainfall during the deployment period. Temperature data were available until June. However, salinity data beyond April were erroneous, apparently due to fouling up of the probe. The current data were available but could not be used due to some errors in the current directions recorded by the device.


**Figure G-5. InterOcean S4 device before deployment (left) and upon retrieval (right).**

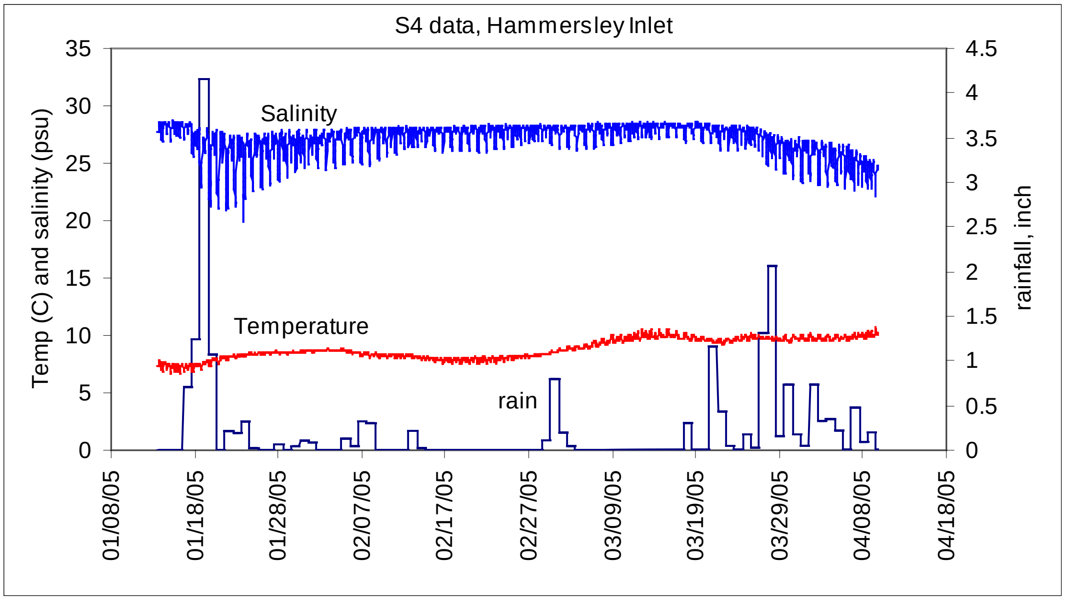



**Figure G-6. Salinity and temperature data gathered by S4 near the mouth of Hammersley Inlet.**

## Continuous current measurements in the water column

An Acoustic Doppler Current Profiler (ADCP) was deployed near the junction of Oakland Bay and Hammersley Inlet (latitude 47.20587 N and longitude -123.0505667 W) to continuously measure current velocities and directions at regular depths within the water column. Figure G-7 shows the ADCP setup for deployment. Due to leakage, one of the lenses exploded. The data gathered were very limited.


**Figure G-7. ADCP before deployment (left), after retrieval (middle), and close up of exploded lens (right).**

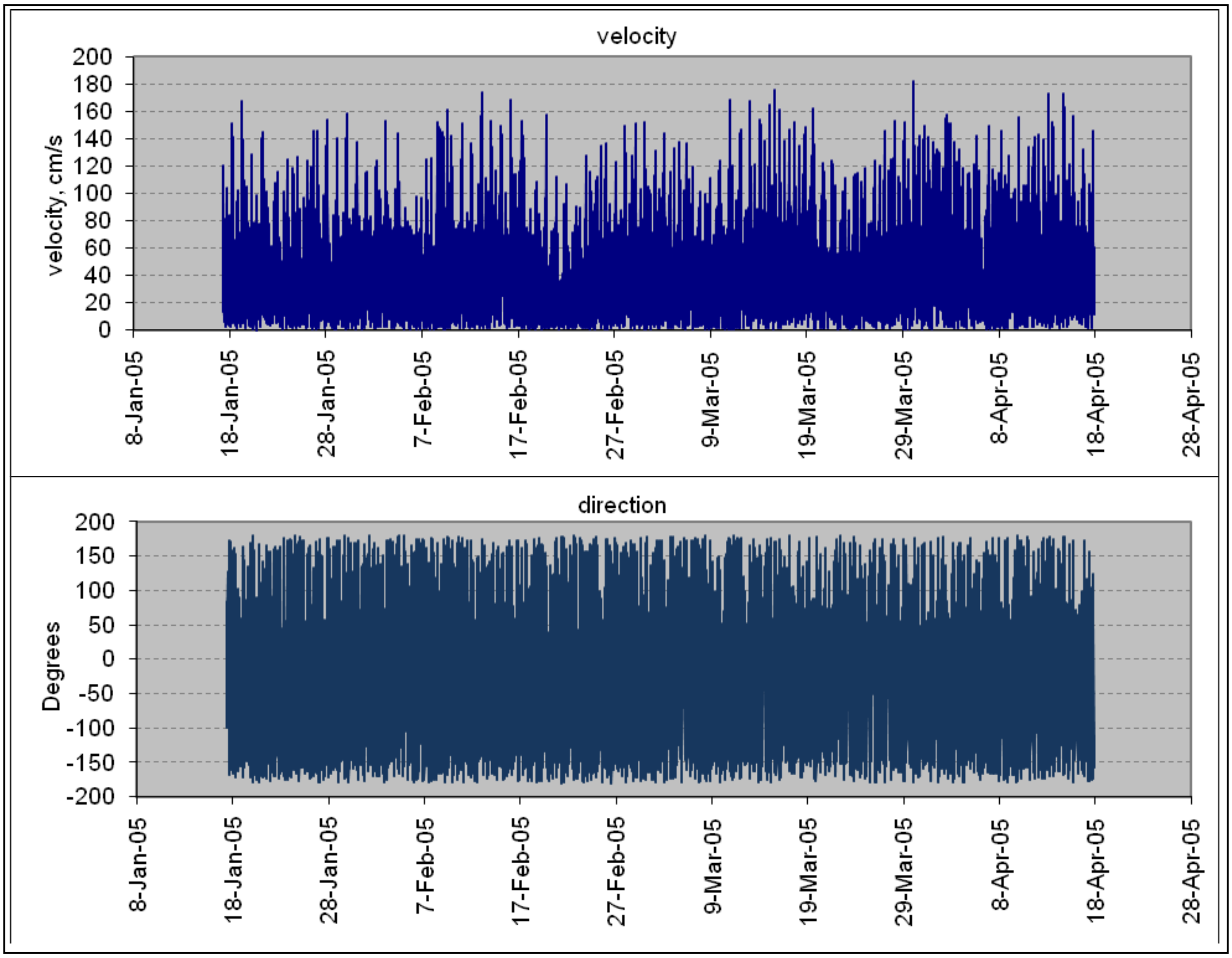



**Figure G-8. Daily vertical current velocities and directions measured with an ADCP.**

# Appendix H.  Validation of marine temperature data

The temperature devices in marine waters were suspended at a fixed elevation above the bottom.  To obtain the elevation of the device with respect to NAVD88, the device height above the bottom was subtracted from the bathymetry elevation discussed earlier.  In the GEMSS time-varying data generator (TVDG), only two options are available: depth of measurement relative to water surface or to MLLW.  For modeling purposes, the NAVD88 was used instead of MLLW.  This worked because all elevations, including tidal elevations, were referenced to NAVD88.

## Station OAK1

Station OAK1 is located in the narrows near the mouth of Johns Creek at latitude 47.24273 and longitude -123.04006.  This location is between *pstide* station 27 and 26 as shown in Figure H-1.


**Figure H-1.  Location of station OAK1 in Upper Oakland Bay.**

The station depth was obtained from a 30’ x 30’ grid of a Puget Sound digital elevation model developed by David Finlayson in 2005 (www.ocean.washington.edu/data/pugetsound/psdem2005.html).  The depth of the station is 0.001 m NAVD88.  The device was deployed at 1.5 ft (0.4572 m) above the bottom on November 8, 2004 at 11:00 am.  The device was programmed to start recording on October 27, but the deployment was delayed due to scheduling conflicts.  Similarly, the last reading was taken on January 19, 2006 in the afternoon.  Thus all data prior to November 10, 2004 and after December 31, 2005 were deleted.

Tidal elevations with respect to the device were generated based on available bathymetry data and tidal elevations from *pstide* with positive heights above the device and negative heights below the device, as shown in Figure H-2.  Figure H-3 shows a time-series plot of tidal elevations above the device and temperature.

Tides at the OAK1 site exposed the device frequently throughout the deployment period. As a result, the continuous temperature data are not wholly representative of the water temperatures. Because removing the data that are not representative of water temperature would be tedious and cumbersome and would create "holes" in the continuous data, it is recommended that these temperature data not be used.

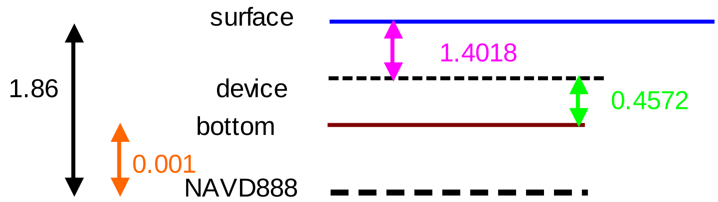
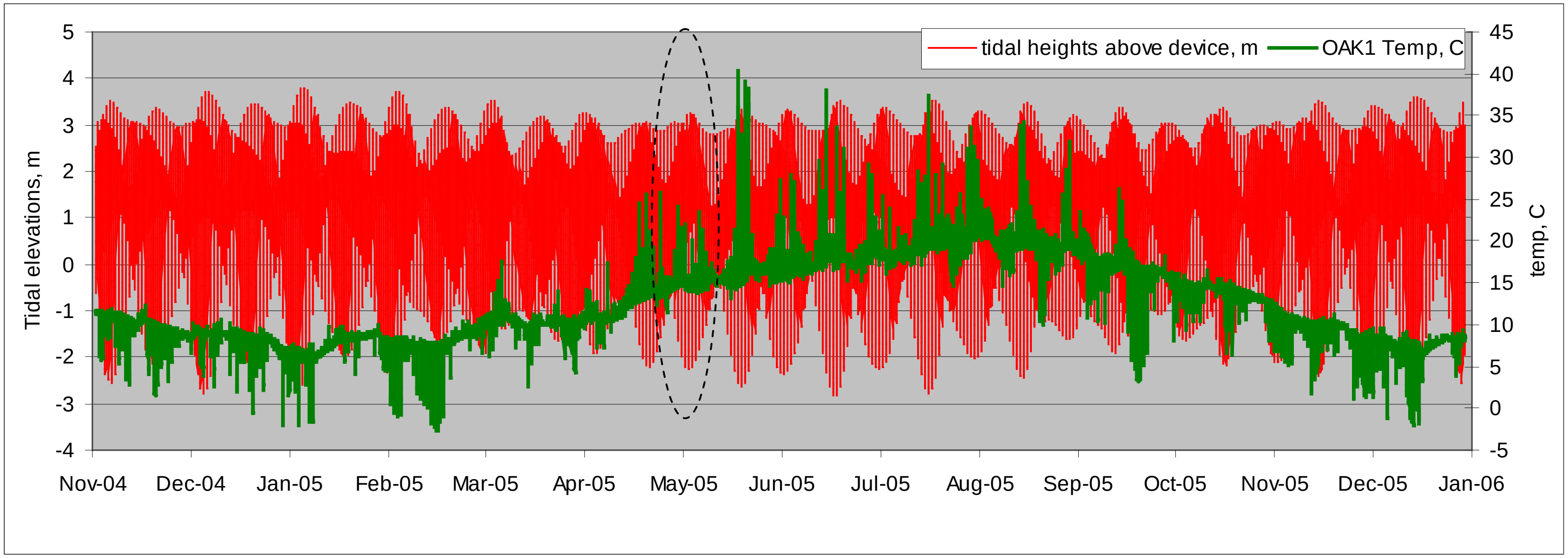



**Figure H-2. Example of how tidal elevations above the device were estimated, November 10, 2004, 2:30 p.m.**



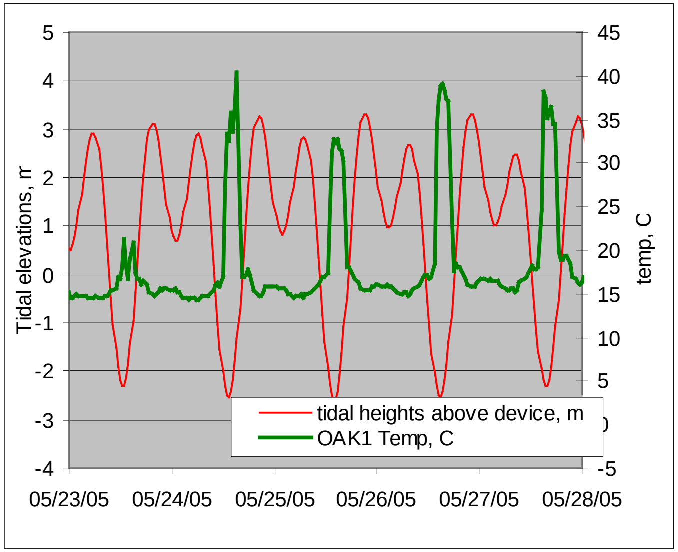




**Figure H-3. Tidal elevations at OAK1 and measured temperature data.**

## Station OAK2

Station OAK2 is located along the eastern shore of Oakland Bay south of the mouth of Chapman Cove, at latitude 47.22183 and longitude -123.05561. This location is between *pstide* stations 30 and 29 as shown in Figure H-4.

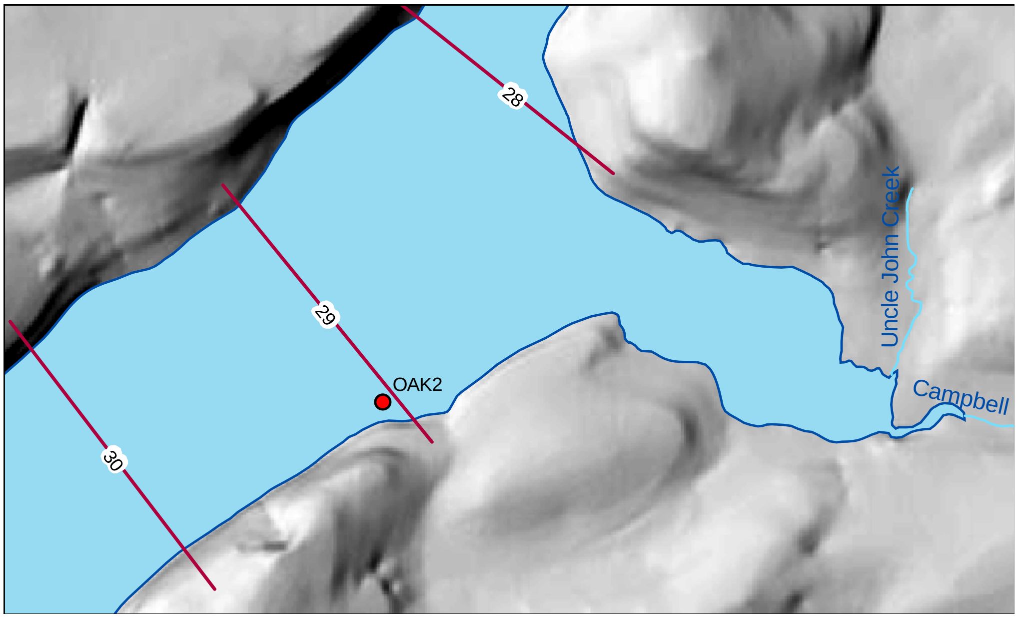



**Figure H-4. Location of station OAK1 in Upper Oakland Bay.**

The station depth was obtained from a 30' x 30' grid of a Puget Sound digital elevation model developed by David Finlayson in 2005 at the University of Washington (www.ocean.washington.edu/data/pugetsound/psdem2005.html). The station depth is -1.523m NAVD88. The device was deployed at 5 ft (1.524 m, OAK2A)) and 1.5 ft (0.4572 m, OAK2B) above the bottom on November 8, 2004 at 11:40 am. The device was programmed to start recording on October 27, but the deployment was delayed due to scheduling conflicts. Similarly, the last reading was taken on January 19, 2006 in the afternoon. Thus all data prior to November 10, 2004 and after December 31, 2005 were deleted. Tidal elevations with respect to the device elevation OAK2A and OAK2B were generated based on available bathymetry data and tidal elevations from *pstide*, with positive heights above the device and negative heights below the device.

Figure H-5 shows a time-series plot of tidal elevations above the device and the associated temperature. Tidal changes at both OAK2A and OAK2B exposed the device frequently throughout the deployment period. As a result, the continuous temperature data are not wholly representative of the water temperatures. It is recommended that these temperature data not be used because (1) removing data that are not representative of water temperature would be tedious and cumbersome and would create "holes" in the continuous data, and (2) the cutoff tidal elevation where water is just above the device is at best an estimate due to bathymetry smoothing in GEMSS.

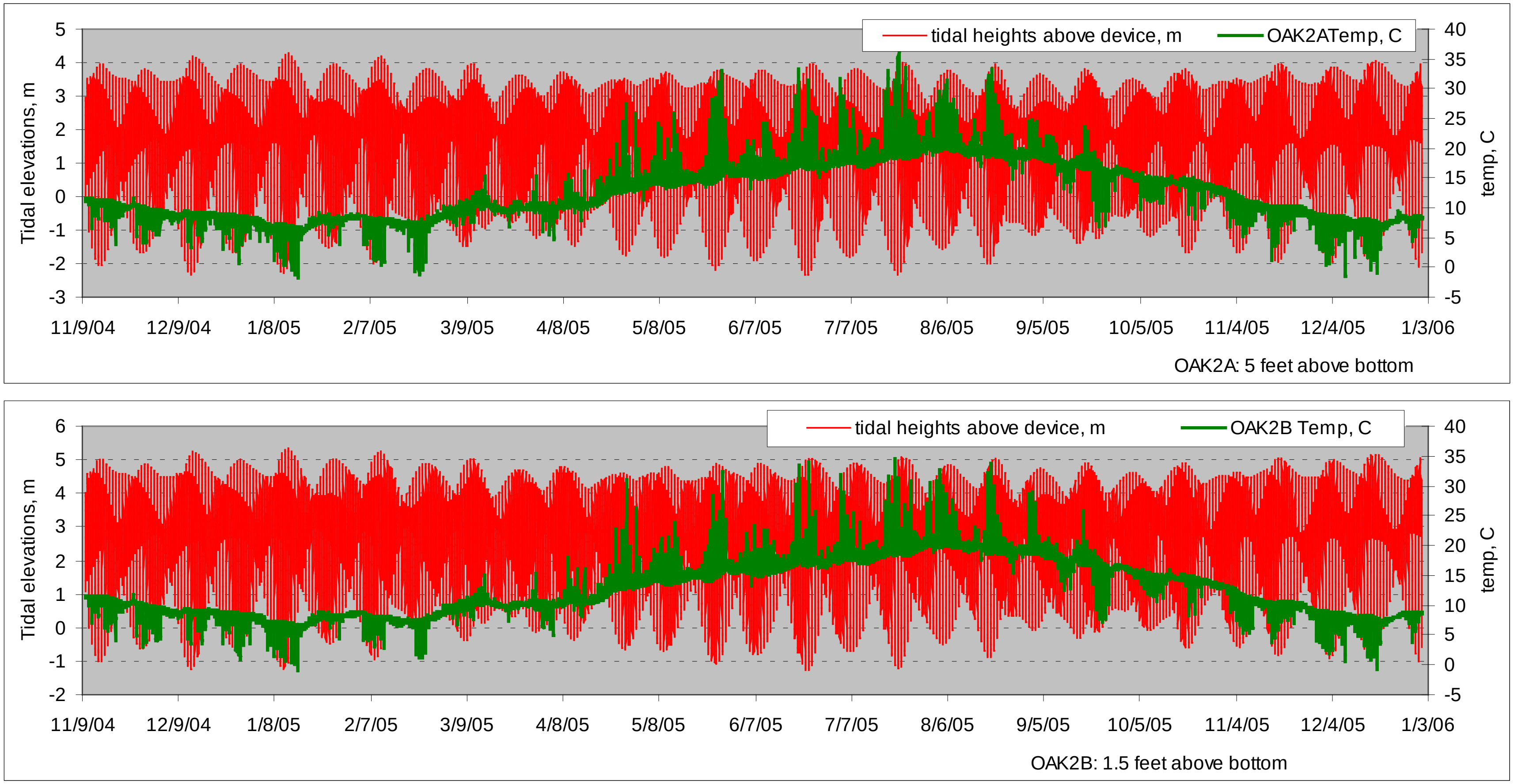



**Figure H-5. Tidal elevations above the temperature devices at OAK2 and respective measured temperature data.**

*This page is purposely left blank.*

# Appendix I.  Temperature predictions at stations HAM2 and HAM1 (2004-2005)

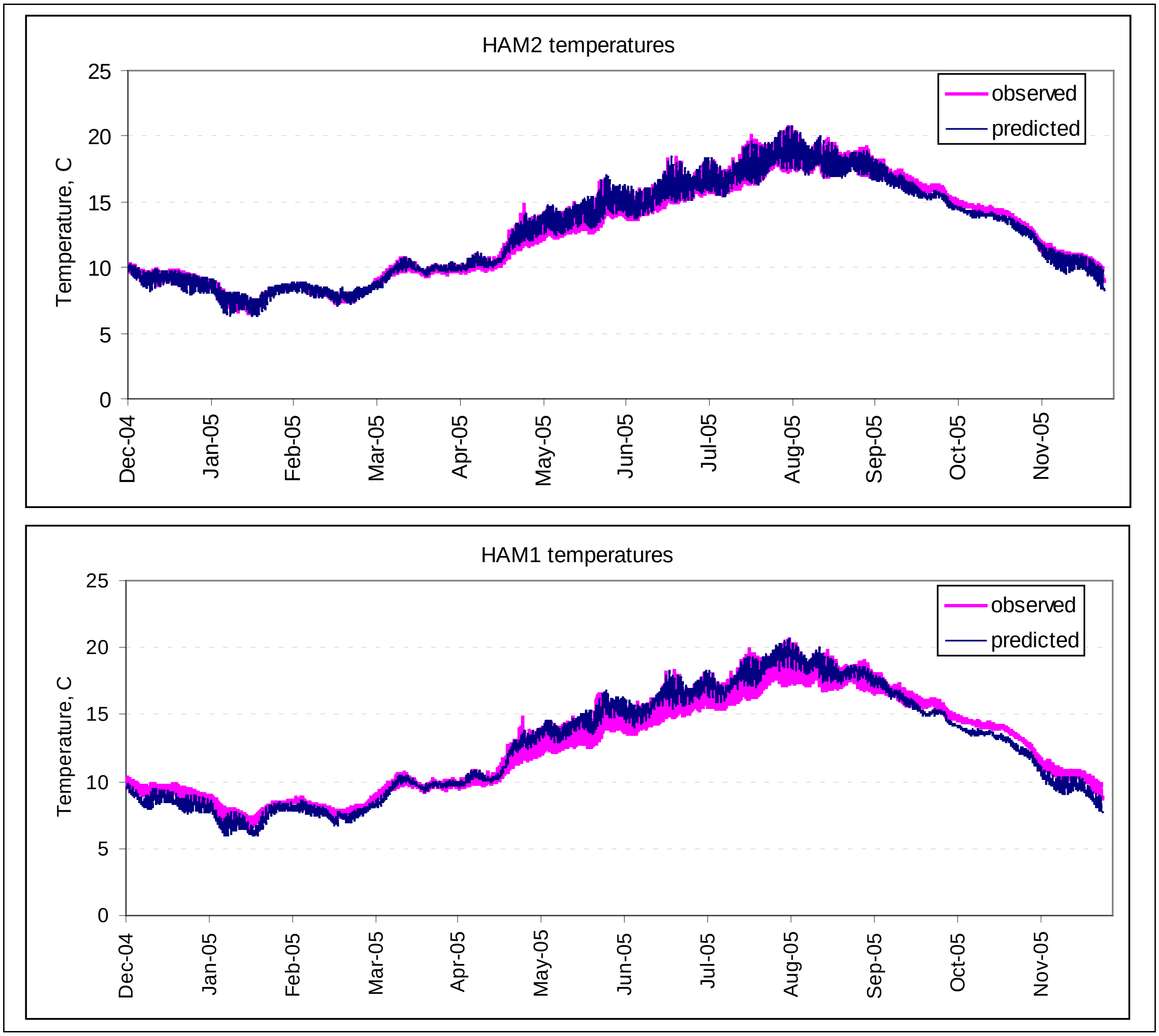



**Figure I-1.  Predicted and observed temperatures at stations HAM2 and HAM1 (Dec 2004-Nov 2005).**

**Table I-1.**

| Predicted-Observed Errors | HAM2 | HAM1 |
|---|---|---|
| ME (mean error) | -0.18 | -0.31 |
| RMSE (root mean square error) | 0.549 | 0.54 |

*This page is purposely left blank.*

# Appendix J. Assessment of city of Shelton Wastewater Treatment Plant effluent limit on fecal coliform

The city of Shelton WWTP's NPDES permit contains effluent limitations on FC bacteria. These are a monthly average of 200 cfu/100 mL and a weekly average of 400 cfu/100 mL. A dilution factor of 94 is applied at the edge of an applicable mixing zone. An EFDC model was previously used (Albertson, 2004) to establish no violation of the water quality standard with these technology-based limitations. Albertson's study also recommended that at higher future flows the diffuser configuration be modified and/or effluent held back during slack tide.

The following are currently under construction and the City anticipates being on-line by the end of 2011: an ultra-violet disinfection system, a modified diffuser configuration, and a storage tank for holding back effluent during slack tide.

The area around Shelton's WWTP outfall is *not* on the 303(d) list. The background concentration as measured at Ecology's long-term marine station OAK004 (Figure J-1) above Eagle's Point in Oakland Bay for 2002-2004 was a geometric mean of 1 cfu/100 mL and a 90th percentile of 3 cfu/100 mL.

The closest DOH station is DOH114 (Figure J-1) adjacent to the outfall. Using data from 2004-2006 (n=67), the geometric mean and 90th percentile FC concentrations at station DOH114 were 5 cfu/100 mL and 30 cfu/100 mL, respectively. Using station DOH114 for background FC concentrations, and using a volumetric dilution factor of 94, the predicted concentrations at the edge of the mixing zone, with existing FC effluent limitations, are as follows:

$$FC_{mix} = \frac{FCe_{ff} + FC_{amb}(DF - 1)}{DF}$$

Where,

$FC_{mix}$ = FC concentration at the edge of the mixing zone
$FC_{eff}$ = FC concentration in the effluent
$FC_{amb}$ = FC concentration in the ambient water
DF = dilution factor

| DF | $FC_{eff}$ | $FC_{amb}$ | $FC_{mix}$ |
|---|---|---|---|
| 94 | 200 | 5 | 7 |
| 94 | 400 | 30 | 34 |

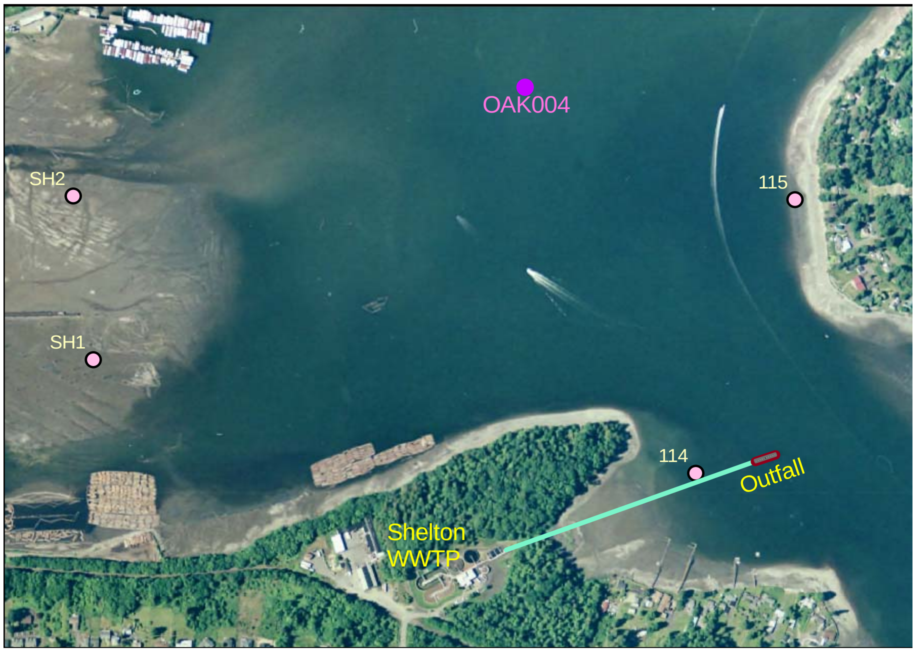



**Figure J-1. Shelton WWTP outfall and location of DOH station 114 and Ecology station OAK004.**

Therefore, with the existing effluent limitation, and available dilution factor and ambient concentrations, the concentrations at the edge of the mixing zone meet the water quality standards. Therefore, the wasteload allocation would be the existing technology-based limitation. The facility is also meeting a “bench mark” (performance-based) effluent concentration of roughly 14 cfu/100 mL and 45 cfu/100 mL, monthly and weekly averages, respectively. In addition, an ultra-violet disinfection system is currently under construction to enhance the treatment as well as provide consistency in reducing effluent FC concentrations.

# Appendix K.  Record of public participation

## Introduction:

This section provides a record of the public outreach which occurred prior to and during the comment period for the draft Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan.

## Public meeting

Ecology held a public meeting on Monday, May 16, 2011, at Mason County Public Works, 100 W. Public Works Dr., Shelton, Washington.  An overview of the plan was presented to 13 attendees.  See Appendix L for copies of the presentation slides.

## Outreach and announcements

Ecology held a 30-day public comment period for this report from May 9, 2011, through June 8, 2011.

A news release was sent to the local media (newspaper and radio) in the Oakland Bay watershed. Ecology placed one paid advertisement in the Shelton-Mason County Journal, published on May 5, 2011.  *(Note:  A second display ad announcing the public meeting was submitted to the Shelton-Mason County Journal, for publication on May 12.  Unfortunately, due to an unknown error, the display ad was not published.)*

Ecology, the Mason Conservation District, and the Washington State University (WSU) Mason County Extension Office provided additional outreach through e-mails on May 9, 11, 12, and 31, 2011.  The Oakland Bay Clean Water District Friends of Oakland Bay posted information about the public comment period and meeting on their website at http://www.co.mason.wa.us/oakland_bay/index.php.  The Mason County Daily News posted the announcements on their website at http://www.masoncountydailynews.com.

Paper copies of the draft plan were available at the following locations:

Shelton Timberland Library
710 W. Alder St.
Shelton, WA 98584

Mason County Public Health
415 North 6th St.
Shelton, WA 98584

Department of Ecology
Southwest Regional Office
300 Desmond Dr. SE
Lacey, WA 98503

An online version of the plan was available at www.ecy.wa.gov/biblio/1110039.html.

## Summary of comments and responses

The following are the comments received during the public comment period, and Ecology's responses. Lengthy comments received by letter or e-mail are reprinted in their entirety at the end of this Appendix. Only the parts of the comments addressing the cleanup plan itself (which was the subject of the public comment period) are listed with the responses. Cleanup actions must occur within the context of existing regulations. Comments made regarding changes to the state water quality standards or other regulations need to be addressed through other processes.

| City of Shelton (COS) |
|---|

*Steve Goins, City of Shelton, sent the following comments in a letter dated June 8, 2011. (See full letter following all comments and responses in this Appendix.)*

**COS Comment 1**: "Pages 7 and 8: Text indicates tributaries have been placed on 2004 303d list for water bodies for not meeting water quality standards for FC bacteria, while Table 1 on page 8 indicates the year to be 2008. Comment – confirm date."

**COS Response 1**: *Comment noted. Text revised for consistent reference to the 2008 303(d) list.*

**COS Comment 2**: "Page 8 and 9: The City is interested in the scope and timing of future studies and other work related to the referenced 303d listings for temperature. Comment – please confirm the year which listings for these water bodies occurred, and keep City informed on this matter."

**COS Response 2**: *Comment noted. Notations added to Tables 1 and 2.*

**COS Comment 3**: "Page 11, 4$^{th}$ paragraph: Comment – 200/colonies mL should read 200 colonies/100 mL."

**COS Response 3**: *Comment noted. Text corrected as indicated.*

**COS Comment 4**: "Page 91: Table 23 does not fully summarize implementation actions being taken as part of the Wastewater Treatment Plant upgrade and expansion to be completed by 2012. Comment – recommend adding row(s) in table indicating specific Wastewater Treatment Plant upgrades to be completed in 2012, including; adding a basin for nitrogen treatment, a new slack-tide storage tank, extending the discharge effluent diffuser by 96 feet, new ultra-violet disinfection treatment, all to benefit shellfish production and enabling DOH to reduce the Shellfish Harvest 'closure are'".

**COS Response 4**: *Comment noted. Row and suggested text added.*

**COS Comment 5**: "Page 97: Page numbering in the Footer adds an A 'Page A-97'; appears this should have waited until Page 115.

**COS Response 5**: *Comment noted. Pagination corrected.*

**COS Comment 6**: "Page K-165: Should be Page J-165 & Page J-166."

**COS Response 6**: *Comment noted. Page numbers corrected.*

**COS Comment 7**: "Appendix J 'Assessment of City of Shelton Wastewater Treatment Plan effluent limit on fecal coliform', paragraph 2 is a bit misleading. This section contains reference to a 'new' NPDES permit for the plant, which I believe won't actually be issued until the upgrades are finished. It also states that this permit contains 'benchmark effluent limits'. I believe that it would be correct to state that these benchmarks are being discussed for the new permit **when** issued but not that they are currently in place (or that they will ultimately be imposed). The current NPDES permit effluent limitation benchmarks for FC are 14 cfu/100 ml monthly average, and 45 cfu/100 ml weekly average."

**COS Response 7**: *Comment noted. Appendix J updated to include the current status and conditions of this permit.*

## Jules Michel (JM)

*Jules Michel sent the following comments by e-mail on June 8, 2011. (See the complete e-mail following all comments and responses in this Appendix.)*

**JM Comment 1**: "Consideration should be given to narrowing the area focused on. Inclusion of Hammersley Inlet in the Oakland Bay effort greatly expands the area being studied and diffuses the limited resources available for both this study as well as support for the numerous other areas of Puget Sound (e.g., Mills Creek drainage area is 20% of the total noted in Figure D-1, page D-128). While there are occasional monitoring spots which show higher Fcoli readings in Hammersley Inlet, none are to the level found in Oakland Bay. Further, Hammersley Inlet's waters are flushed far more effectively than those of Oakland Bay, primarily due to a combination of the prevailing winds and Oakland Bay's being at the end of the estuary. This flushing quickly dissipates any temporary increases which may be found (see DOH's Hammersley Inlet water 2010 quality report: http://www.doh.wa.gov/ehp/sf/Pubs/gareports/hammersley.pdf. 2011 results to date indicate levels well within safety concerns.) Additional significance is also found when consideration is given to where the productive tidelands are: Oakland Bay."

**JM Response 1**: *Comments noted. Please see the section on Adaptive Management. Ecology uses this process to adjust implementation efforts if those already tried are not achieving the TMDL targets and the impaired water bodies are still not meeting water quality* *standards. During this process, Ecology may identify specific areas where there is a need for water quality monitoring or cleanup actions.*

**JM Comment 2:** "Pages 11 and 12 set the water quality levels of Fcoli for fresh water and a far lower one for salt water. Each strives to provide safety with the former (100colonies/100ml) being human contact and the second (14colonies/100ml) for the production of shellfish. While both are important, the second sets a substantially lower bar to get under in order to ensure tidelands remain productive. In order to achieve this level, immense resources are focused on minimizing the impacts from various sources, whether at the state, county or tribal level. Resources needed from private sources are also increased through septic upgrades, fences, or alternative forms of yard care. Focus of these resources on achieving this level allows shellfish production to occur, increasing revenues, and thereby the value of the tidelands certified for shellfish production. Consideration should be given to both increasing the assessed value of these tidelands to better reflect their true value, as uplands do, and a fee tied to production in order to generate revenues to help pay for this. So doing is an equitable means of helping to defray the costs by those who benefit the most from this."

**JM Response 2**: *Comments noted. Ecology develops a TMDL within the context of existing programs, regulations, or authorities. The issues raised are outside this TMDL process. Your suggestion to create alternative funding sources to finance cleanup work is commendable. Ecology encourages you to bring these ideas for consideration at the local government level. More information on Mason County Government is available at http://www.co.mason.wa.us.*

**JM Comment 3:** "Page 14 notes the important issue of Fcoli sources and makes the point that sources from wildlife and humans has not been quantified. At issue is whether focusing on human sources will, in fact, achieve the far more stringent marine water levels. Large populations of seal and upland populations of deer and other warm blooded mammals, including occasional Orcas. Yet based on page 14, it does not appear there is a clear understanding what the sources are. Added to the problem is the unknown source in the sediments, discussed on page 23. While it may be Fcoli is from upland human sources, it may be the past history of Oakland Bay has created a "soup" of chemicals in which Fcoli bacteria reproduce. Consideration should be given to focusing the initial effort on determining what percentage is coming from wild versus human and whether production or storage only is occurring in the sediments in order to determine whether eliminating human sources will, in fact, result in the levels being sought. It may be relaying shellfish to cleaner waters is more effective."

**JM Response 3***: Comments noted. The TMDL process is used to identify and prevent pollution sources by prioritizing the actions which are expected to bring the best results. Because Ecology believes humans and livestock are the most likely sources, these are the primary targets of the TMDL. There are already known and common strategies available to control these sources. If, after using these strategies, the water quality still does not meet state* *water quality standards, the adaptive management process will look for other sources or control strategies. TMDLs do not generally identify actions to manage wildlife.*

**JM Comment 4:** "Consideration should be given to an economic analysis on what gains have been achieved at what expense to date for the incremental improvement of tideland production for shellfish, and what future gains will be gained from those future expenses. Opportunities to apply funds in areas in need of clean water programs, such as that recently proposed for North Bay or the southern portion of Hoods Canal may result in greater economic returns from the limited dollars available."

**JM Response 4**: *Comments noted. Issues raised are outside this TMDL process. Ecology's mandate is to identify actions to result in the currently impaired water bodies meeting state water quality standards so the designated beneficial uses of the affected water is improved and maintained.*

## Mason Conservation District (MCD)

*Stephanie Bishop provided the following comments.*

*(All comments refer to Table 21 on page 88.)*

**MCD Comment 1:** *(Row 2)* "We also help with implementation if we have the resources to do so."

**MCD Comment 2:** *(Row 4)* Correct "Spring 2011" to "Fall 2011".

**MCD Comment 3:** *(Row 5)* Correct date from "2010" to "September 2009".

**MCD Comment 4:** *(Row 7)* Change "…to 15 landowners" to "…51 landowners between 2008-2010."

**MCD Comment 5:** *(Row 7)* Include reference to the Mason County Stormwater Program.

**MCD Comment 6:** *(Row 8)* Add sentence, "A series of three compost workshops were held in 2010."

**MCD Comment 7:** *(Row 9)* Delete last three sentences. Replace with the following ones. "Phase 1 and 2 were completed 3/2010. Phase 1 planning was completed 10/08, and Phase 2 planning was completed 2/2010."

**MCD Comment 8:** *(Row 10)* Add sentence, "This is an ongoing activity."

**MCD Response 1-8**: *Comments noted. Ecology considered all suggestions. Most were accepted and incorporated into the referenced sections.*

**Mason County Public Health (MCPH), Environmental Health Division**

*Stephanie Kenney provided the following comments.*

**MCPH Comment 1**: *(Page 9, second paragraph, last sentence)* "Water Quality has improved recently. Other areas of this document contain more recent information, for example the sediment study. Why not a sentence about the recent improvements at the north end of Chapman Cove."

**MCPH Response 1**: *Comment noted. Revised text to state the water quality in Chapman Cove is beginning to improve.*

**MCPH Comment 2**: *(Page 19, Nonpoint sources, first paragraph)* "Mandatory Septic system operation and maintenance reporting requirements plus tracking software has been in place since 2008 to track septic system health and regularity of maintenance."

**MCPH Response 2**: *Comment noted. Ecology acknowledges work already done by the MCPH and appreciates your efforts. These actions are included in the implementation plan section of this report.*

**MCPH Comment 3**: *(Page 19, Nonpoint sources, second paragraph)* "The CD has worked with land owners in the Oakland Bay area to modify animal management practices."

**MCPH Response 3***: Comment noted. Ecology acknowledges work already done by the Mason CD and appreciates their efforts. These actions are included in the implementation plan section of this report.*

**MCPH Comment 4**: *(Page 33, Streamflow data, first paragraph)* "This is repeated below.

**MCPH Response 4**: *Comment noted. First paragraph deleted.*

**MCPH Comment 5**: *(Page 43, Figure 20)* "Wrong date"

**MCPH Response 5**: *Comment noted. Date corrected to March 12, 2007.*

**MCPH Comment 6**: *(Page 49)* "Some of the load reductions are in fairly natural areas, such as Campbell Creek and some of the load reductions are very high, such as 81% on Uncle John's Creek. UCJ has improved WQ these days. Still, seems likely that some of these clean up goals will never be reached."

**MCPH Response 6***: Comments noted. The load reductions were based upon observed data without any regard to the origin of the bacteria (whether natural or anthropogenic). If during the implementation phase all anthropogenic sources are controlled, and it is concluded the remaining bacteria are due to natural conditions, then the natural conditions would become the criteria. WAC 173-201A-260 (1)(a) recognizes that portions of many* *water bodies cannot meet the assigned criteria due to the natural conditions of the water body and that when a water body does not meet its assigned criteria due to natural climatic or landscape attributes, the natural conditions constitute the water quality criteria.*

**MCPH Comment 7**: *(Page 72, Reduction scenarios, last paragraph)* "FC is low in Deer Creek (the major source of loading to this area. Cranberry's interaction should be insignificant according to flow studies.) Hard to imagine how this great of a reduction could be achieved."

**MCPH Response 7**: *Comments noted. See MCPH Response 6.*

**MCPH Comment 8**: *(Page 76, second paragraph)* "Is the assumption in the loading reduction goals that they can only be achieved by zero anthropogenic loading or is zero anth. Loading a separate goal?"

**MCPH Response 8**: *Comments noted. See MCPH Response 6.*

**MCPH Comment 9**: *(Page 76, second paragraph, last sentence)* "Will TSS goals be set by Ecology?"

**MCPH Response 9**: *Comment noted. The technical analysis in this TMDL recognizes bacteria do get adsorbed to suspended particles that can be transported during storm events to Oakland Bay, potentially becoming part of the sediment bacteria load. A recommendation for reducing total suspended solids (TSS) in stormwater discharges is included in this TMDL to address such loadings to the bay. A TSS goal would be assessed on a case-by-case basis through applying "all known available and reasonable methods of treatment' (AKART) under the NPDES permitting program.*

**MCPH Comment 10**: *(Page 88, Table 21, first row)* "WSU is lead on this task."

**MCPH Response 10**: *Comment noted. Removed this row was removed Table 21 and added it to the new WSU Mason County Extension Office Table.*

**MCPH Comment 11**: *(Page 88 Table 21, third row)* "Doesn't the state take animal feeding operations complaints and the CD takes the pasture based complaints? I never work on these myself, so I could easily be confused."

**MCPH Response 11**: *Comment noted. Ecology revised Table 21 by deleting the reference to animal feeding operations. Yes, the state Departments of Ecology and Agriculture are responsible for the oversight of animal feeding operations. Ecology often refers complaints to the Mason Conservation District for them to provide technical assistance.*

**MCPH Comment 12**: *(Page 89, Mason County Department of Community Development)* "Tasks missing – 1) Assist with property acquisitions into conservancy. 2) Respond to WQ complaints that involve land use in critical areas. 3) developed small parcel storm water site plan requirements."

**MCPH Response 12**: *Comments noted. Revised DCD section and added tasks provided.*

**MCPH Comment 13**: *(Page 90, Table 22)* "Other actions that could be added 1) Hold regular meetings of Oakland Bay Clean Water District Advisory Committee, coordinate tasks through regular meetings and revise the Oakland Bay Action Plan Strategy yearly. 2) Scan OSS records, first priority shoreline and stream parcels, update public health database with type, age and note systems <100 ft to surface water. 3) Updated of On-site Septic System code resulting in improved enforcement policies."

**MCPH Response 13**: *Comments noted. Table 22 revised to incorporate these action items.*

**MCPH Comment 14**: *(Page 90, Table 22, sixth row)* "Not sure where this task came from. What does Ecology have in mind for us to do specifically? This type of activity would be done as part of a septic system sanitary survey, or in response to a complaint, but not normally at any other time. This task can be included with the On-site Septic Sanitary Survey task if you would like to retain in."

**MCPH Response 14**: *Comments noted. Ecology agrees the septic system sanitary surveys captures these activities. Therefore, we updated Table 22 and deleted this row.*

**MCPH Comment 15**: *(Page 94, Oakland Bay Clean Water District Advisory Committee, bulleted list)* "Puget Sound Partnership should be included."

**MCPH Response 15**: *Comment noted. Thank you for pointing out this oversight. This section was revised to include the Puget Sound Partnership under "Washington State agencies".*

**MCPH Comment 16**: *(Page 95, Table 27, fourth row)* They provided additional information for the comments column. This included adding the "Squaxin Island Tribe", research completed in "6/09", reference to pilot project beginning "2/11", and results expected "6/11".

**MCPH Response 16**: *Comments noted. Revised Table 27 to include these additional details. Debbie Riley sent the following comments by e-mail on June 7, 2011. (See the complete e-mail following all comments and responses in this Appendix.)*

**MCPH Comment 17.a**: "Page 12 of the draft 'Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan' states: 'The water quality criteria for Shellfish Harvesting or Primary Contact Recreation (swimming or water play) is as follows: Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more that 10%

of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL'. Although this is a re-statement of WAC 173-201A-210(3)(b), 2003 edition, it may be an unrealistic/unreachable goal for this TMDL and for all of Oakland Bay. Our goal, like everyone else's, is to maintain current good water quality in the areas that exhibit good values and to improve water quality in areas with samples that do not meet the strict standards of the FDA for human consumption of shellfish. We want all of Oakland Bay re-opened to shellfish harvest."

**MCPH Response 17.a:** *Comments noted. Based upon what we have found about natural and human influences in the areas up gradient of marine waters, water quality standards should be attainable through employing best management practices (BMPs) and adopting a management strategy focused on a heightened awareness of human bacterial inputs. Human bacterial inputs are manageable through voluntary cooperation and commitment.*

**MCPH Comment 17.b:** "Is this area of 'shellfish harvesting and/or primary contact' in the marine water as determined by salinity? Is it in the mixing zone at the mouth of the tributary? Is it a measurable distance up the stream that is under tidal influence? I ask because fresh and marine standards are so different and depending on how the TMDL defines where the criteria is to be met, outcomes may be radically different. Interpretations I have received from very knowledgeable professionals over the years has given me different answers leaving me unsure as to where the measurement is to be taken. As I drive along the Bay during the winter I witness the fresh water influence as evidenced by a thick layer of ice (fresh water) extending some distance out into the Bay itself. The lack of a definition is problematic to me. I have expressed this concern at various meetings as far back as the original sampling. I have yet to receive a satisfying answer; but your comment period allows me one more chance to voice my concerns and possibly get an answer that makes sense to me."

**MCPH Response 17.b:** *Comments noted. The bacterial limits used as the basis of this TMDL are those currently developed by the state and approved by the U.S. Environmental Protection Agency. The procedures for applying freshwater and marine water state water quality standards are described in WAC 173-201A-260(3). These procedures were used in the development of this TMDL. During the recent public triennial review of the water quality standards, Ecology heard there was a need for further guidance for delineating between marine and fresh waters in the standards. In response to these comments, Ecology is currently developing guidance and sampling procedures for making these delineations and these will be available later this year on Ecology's water quality standards web page at http://www.ecy.wa.gov/programs/wq/swqs/index.html.*

**MCPH Comment 17.c**: "The other thing that jumped out at me was in the chart on Page A-100 Funding sources. The first entry says 'Enterprise Cascadia Septic Loan' but in the contact information section ‘ShoreBank’ still appears. Please remove the words ‘ShoreBank’ and leave ‘Enterprise Cascadia’."

**MCPH Response 17.c:** *Comment noted. Text corrected and "ShoreBank" removed.*

| Squaxin Island Tribe (SIT) |
| --- |

*John Konovsky, Squaxin Island Tribe, sent the following comments in a May 25, 2011 letter. (See the complete letter following all comments and responses in this Appendix.)*

**SIT Comment 1.a:** "On behalf of the Squaxin Island Tribe, I am writing to comment on the May 2011 Draft Oakland Bay and Hammersley Inlet Fecal Coliform Bacteria TMDL Water Quality Improvement Report and Implementation Plan. As you well know, Oakland Bay hosts shellfish resources of national and Tribal significance. About 40% of the manila clams produced in the entire county come from Oakland Bay. The shellfish value exceeds $10 million, and over 200 Tribal members make at least part of their living there. Oakland Bay and its natural resources are central to the culture and history of the Squaxin Island Tribe and from our viewpoint, must be protected to the maximum extent possible."

**SIT Response 1.a:** *Comments noted. No revisions to document needed.*

**SIT Comment 1.b:** "After reviewing the report, the Tribe is concerned that the measures proposed are not protective enough to sustain our right to harvest shellfish reserved in the 1854 Medicine Creek Treaty. The bottom line is that we request that the Department of Ecology adopt the marine water quality standard at the mouths of all tributaries as the primary target, not a secondary target. A more stringent target than the freshwater alternative is the only way to overcome the unique challenges the bay presents to water quality and shellfish harvest.

The Tribe's standard for evaluating the report is that it has to be protective enough to sustain the opportunity to harvest shellfish in perpetuity. Oakland Bay has three strikes against it that endanger that objective."

**SIT Response 1.b:** *Comments noted. The marine water quality criteria are currently applicable at the mouths of tributaries flowing to the Puget Sound. The current standards effectively apply marine criteria in most of the tidally influenced portion of a tributary. Ecology is currently developing guidance on the delineation of marine and fresh waters, which will provide more information on this matter. Also see MCPH Response 17.b.*

**SIT Comment 1.c:** "First, in the same way that South Puget Sound is somewhat isolated from the rest of Puget Sound by the Tacoma Narrows, Oakland Bay is somewhat isolated from South Puget Sound by Hammersley Inlet. Oakland Bay is the terminal estuary of a terminal estuary resulting in extremely long residence times leading to very poor water quality. In fact, the Marine Water Quality Index under development by the Department of Ecology identified

Oakland Bay as having the lowest water quality index score in the entire Puget Sound monitoring network. That coupled with a significant decline since 1999 calls for application of more stringent water quality targets."

**SIT Response 1.c:** *Comments noted. Ecology agrees Oakland Bay is a unique and sensitive marine area. We share Tribal concerns regarding the threat of human activities on water quality conditions. Concern for Oakland Bay water quality was the basis for engaging in this TMDL effort. Water quality targets are based on meeting the water quality criteria associated with the designated uses of Oakland Bay and its freshwater tributaries. The development and modification of water quality criteria must be achieved through the water quality standards rule process. For more information on water quality standards development, see Ecology's water quality standards web page at http://www.ecy.wa.gov/programs/wq/swqs/index.html.*

**SIT Comment 1.d:** "Second, Oakland Bay sediments host a reservoir of pathogens that re-suspend into the water column with sufficient shear stress from wind and wave action. Oakland Bay is not unique in this regard, but its perfect southwest-northeast geographic orientation significantly exacerbates the problem. The strongest winds come from the southwest and blow up a five mile long fetch stirring up the sediments at the upper end of the bay. This has led to water quality violations and a shellfish harvest downgrade. Oakland Bay is much more vulnerable to pathogen-laden sediment than most shellfish growing areas."

**SIT Response 1.d:** *Comments noted. Ecology agrees with the Tribal observation on physical and atmospheric conditions in Oakland Bay. More investigation of bacterial resuspension and sediment bacterial relationships is warranted and would greatly enhance our understanding of environmental conditions in the bay. Ecology believes reductions in fecal coliform bacteria, as well as associated pathogens, will be achieved by implementing the TMDL measures.*

**SIT Comment 1.e:** "Third, not much needs to be belabored about population growth, other than to acknowledge the obvious—it is coming to the Oakland Bay Watershed, and will significantly increase anthropogenic stresses in an extremely susceptible location."

**SIT Response 1.e:** *Comments noted. Ecology agrees.*

**SIT Comment 1.f:** "The combination of all three of these water quality challenges makes Oakland Bay unique. To overcome them will require non-standard solutions. Only with an enhanced target, will fecal coliform concentrations in the marine waters remain below the 14/43 shellfish harvest standard. Our primary request is to increase the margin of safety by adopting the 14/43 shellfish harvest standard at the mouths of all tributaries as the primary target. The bacteria roll-backs for upstream reductions should be set to achieve that target. With long residence times and large bacteria reserves, no other solution seems likely to protect marine waters."

**SIT Response 1.f:** *Comments noted. Please see MCPH Response 17.b. Ecology will work with other stakeholder groups in the project area to adapt implementation actions to meet the TMDL goal for attaining the water quality standards in both marine and freshwaters. Ecology recognizes in the future this will likely require more stringent targets in the upland freshwaters.*

**SIT Comment 1.g:** "With a more stringent water quality target in place, the next weakest link for Oakland Bay is the Department of Transportation. I have participated in the Clean Water District from the start, and have found Transportation's participation very sporadic. Improving their actions and infrastructure are a big part of the solution. State Highway 3 runs along the entire northern shoreline of Oakland Bay. It contributes significant stormwater runoff that must be addressed to protect shellfish harvest. Somehow getting them more involved is a key implementation action."

**SIT Response 1.g:** *Comments noted. Ecology is actively working with the Washington State Department of Transportation (WSDOT) on issues related to their NPDES and State Waste Discharge Permit for Municipal Stormwater. In recent years, the WSDOT has increased their involvement to identify and address stormwater related to the state roadways they manage. Ecology will continue to work with the WSDOT regarding the actions identified in this TMDL.*

**SIT Comment 1.h:** "On a cautionary note, a previous water quality crisis occurred in the late 1980's. It inspired the development of the 1990 Oakland Bay Watershed Management Plan. What is striking is that the remediation actions suggested in 1990 are very similar to draft implementation plan. Not much has changed other than a better understanding of how pathogens on sediment influence water quality. The Tribe hopes that the current improvement report will not languish like the 1990 version."

**SIT Response 1.h:** *Comments noted. No response to this document is needed.*

**SIT Comment 1.i:** "This new report must be implemented to the greatest extent possible and the monitoring program proposed carried out with vigor. We must know with certainty whether a 50% reduction in bacteria loads has been achieved by 2015 with 100% by 2017. If not, there must be consequences, likely both adaptive management and enforcement actions."

**SIT Response 1.i:** *Comments noted. During the adaptive management process Ecology and the responsible partners will work together to identify areas not meeting the TMDL targets. At that time we will work together to find potential pollutant sources and additional implementation actions to meet those goals.*

**SIT Comment 1.j:** "Since the tumultuous days when harvest downgrades were proposed in 2005-06, the Clean Water District has come together to make progress. However, backsliding can be surprisingly quick. Remember that in January 2005, all of Oakland Bay was taken off the Department of Health's list of threatened shellfish growing areas for the first time in years. But by September 2005, we were facing serious harvest downgrades.  Degradation can happen very fast and its prevention requires continuous, ongoing diligence and requisite financial support."

**SIT Response 1.j:** *Comments noted.  No response needed.*

**SIT Comment 1.k:** "  Finally, I have included in an appendix some technical comments about the report.  If you have any questions, please feel free to contact me."

**SIT Response 1.k:** *See SIT Comments 2.a through 2.m.*

**SIT Comment 1.l:** "In closing and on behalf of the Tribe, I want to thank both you and Anise Ahmed for all the hard work you have put into this process and product.  I know each of you has put in extraordinary effort and I want to thank you for your diligence and persistence.  The Department of Ecology and the Squaxin Island Tribe were partners in the collection of the data necessary to write this report, and I look forward to that continued cooperation."

**SIT Response 1.l:** *Comment noted.  No response needed.*

*Referencing the Appendix – detailed comments, from the May 25, 2011 letter previously mentioned:*

**SIT Comment 2.a**:  "Page 6, Figure 1—why is Oakland Bay and Hammersley Inlet outside the TMDL boundary?"

**SIT Response 2.a**:  *Comment noted.  An incorrect map was used.  Figure 1 replaced with the correct graphic.*

**SIT Comment 2.b**: "Page 16, Deer Creek—actually has two forks that form the headwaters, one from Benson and one from a wetland to the south of Benson."

**SIT Response 2.b**:  *Comment noted.  Text corrected appropriately*.

**SIT Comment 2.c**: "Page 16, Johns Creek—sentence "Some of the most productive shellfish beds in the bay begin in a series of wetlands…." makes no sense."

**SIT Response 2.c**:  *Comment noted.  Text revised to provide clarity.*

**SIT Comment 2.d**: "Page 24, Table 4—need to clarify that meaning of "percent" is absence/presence."

**SIT Response 2.d**:  *Comment noted.  Table revised to provide clarity.*

**SIT Comment 2.e**: "Page 25, Sedimentation—please revise relationship between sediment size and bacteria attachment based on DeFlaun & Mayer 1983.  It is the only study I am aware of that directly researched the relationship."

**SIT Response 2.e**: *Comment noted. Text revised as appropriate.*

**SIT Comment 2.f**: "Could also add Ecology and Squaxin data from Deer Creek that suggests ~2/3 of FC are sediment-attached in during winter storm events, while only ~1/3 are attached during summer low flows?"

**SIT Response 2.f**: *Comment noted. Text revised based on SIT Comment 2.e.*

**SIT Comment 2.g**: "Page 39—"Eagles Point" = "Eagle Point""

**SIT Response 2.g**: *Comment noted. Text corrected.*

**SIT Comment 2.h**: "Page 57—Marine standard should be met at mouth of all tributaries as a primary target."

**SIT Response 2.h**: *Comment noted. The marine waters criteria is the standard to meet. To improve clarity, Table 11 was revised by removing the reference to "secondary".*

**SIT Comment 2.i**: "Page 68, last paragraph—FC exist only in the top centimeter of sediment"

**SIT Response 2.i**: *Comment noted. Text revised to provide more clarity.*

**SIT Comment 2.j**: "Page 70—could also add Ecology and Squaxin data from Deer Creek that suggests ~2/3 of FC are sediment-attached in during winter storm events, while only ~1/3 are attached during summer low flows."

**SIT Response 2.j**: *Comment noted. Text revised to provide more clarity.*

**SIT Comment 2.k**: "Page 76, last paragraph—meeting marine water quality standards at tributary mouths should be primary goal."

**SIT Response 2.k**: *Comment noted. Meeting the more stringent marine standards is the goal for water quality protection. To provide clarity, the last sentence of the referenced paragraph was removed. In addition, Ecology modified Table 14 (and the corresponding Table ES-1) and removed the rows addressing "load allocations to meet freshwater criteria in the tributaries".*

**SIT Comment 2.l**: "Page 81, Table 15—add Squaxin Island Tribe and the legal authority is the 1854 Treaty of Medicine Creek."

**SIT Response 2.l**: *Comment noted. Table 15 revised as suggested.*

**SIT Comment 2.m**: "Page 86—should include a plan for enforcement of septic regs if voluntary compliance fails to correct the pollution."

**SIT Response 2.m**: *Comment noted. Mason County Public Health is responsible for enforcing the Mason County Sanitary Code. They updated Chapter 6.76, On-site Sewage Regulations, to improve their enforcement capabilities. Please refer to Mason County's website at* www.co.mason.wa.us/health/envhealth/septic/index.php *for more information.*

*John Konovsky, SIT, sent the following comments by e-mail on June 3, 2011:*

**SIT Comment 3**: "Require DOT implement the following actions:

1. Map all stormwater outfalls associated with HWY 3.
2. Monitor water quality at all stormwater outfalls monthly for at least one year and continue monitoring at least quarterly thereafter.
3. Implement best management practices at any outfall that fails the 14/43 fecal coliform bacteria standard for shellfish harvest or the total suspended solids target recommended in the TMDL. Continue to monitor monthly and improve management of these outfalls until 12 consecutive samples meet FC and TSS targets, then monitor quarterly.
4. Consider the option of contracting with the local health department to carry out the monitoring."

**SIT Response 3:** *Comments noted. Table 26, Summary for the WSDOT implementation actions, states they have already planned to inventory all highway discharge locations along State Route 3 into Oakland Bay. Ecology will share the other suggestions with the WSDOT and will encourage their consideration.*

## U.S. Environmental Protection Agency (EPA)

*Laurie Mann, EPA, sent the following comments in a letter by e-mail on June 8, 2011. (See complete e-mail and letter following all comments and responses in this Appendix. She did not send a hard copy of the letter.)*

**EPA Comment 1:** "Stormwater Sources. The EPA developed a Memorandum in 2002 ('Establishing TMDL Wasteload Allocations for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs') that clarifies existing EPA regulatory requirements for establishing wasteload allocations (WLA) for stormwater in TMDLs. In this Memorandum, it is explained that WLAs and LA are to be expressed in numeric form in the TMDL, and that EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system. The Memorandum also explains that because storm water discharges are highly variable in frequency and duration and are not easily characterized, that the NPDES permits will typically express these WLAs as BMPs.

The draft TMDL states that DOT stormwater discharges are regulated by the NPDES program, and are therefore 'point sources.' In recent conversations with Department of Ecology staff, however, I have learned that DOTs discharges may not in fact be currently regulated by the NPDES program. Regardless of DOT's NPDES status, it is appropriate for Ecology to designate an allocation for DOT in the TMDL because DOT discharges do contribute pollutant loadings to the watershed. Moreover, EPA supports the inclusion of implementation recommendations for DOT stormwater regardless of DOT's permitting status.

The City of Shelton stormwater is not currently regulated by the NPDES program, and has not received a WLA in the draft TMDL. Allocations for unregulated stormwater are discussed on page 76, however, and appear to be equivalent to the marine water quality standards. This information could be added to Table 14 (e.g. unregulated stormwater) in order to clearly indicate that stormwater sources have been considered by Ecology in this analyses, and to facilitate the development of NPDES permits, if they are needed in the future."

**EPA Response 1:** *Comments noted. We concur with EPA's statement that determining numerical WLAs or LAs is difficult because stormwater discharges are highly variable in frequency and duration and are not easily characterized. Ecology will condition future applicable NPDES permits with implementation actions (best management practices) identified in this TMDL. Table 14 (and the corresponding table ES-1) were modified to specify the target concentration for WSDOT. Since Mason County and the city of Shelton are not currently regulated by the NPDES program, the discharges are considered nonpoint sources and are addressed using best management practices. Ecology modified the Section addressing "Sources of Fecal Coliform Pollution" and moved the WSDOT references from "Point Sources" to "Nonpoint Sources".*

**EPA Comment 2:** "Tributaries. In order to meet marine water quality standards in Oakland Bay and Hammersley Inlet, the TMDL study indicates that the tributaries need to meet the marine water quality standards at the tributary mouths (e.g. discussion on pages 56-7). A statement on page 76 contradicts this finding: 'All tributaries must meet the freshwater water quality standards at the mouth of creeks during all seasons….meeting the marine standards will be a secondary goal.' I suggest that the statement on page 76 (and the associated LAs in Table 14) be clarified so that the reductions needed in order to achieve water quality in Oakland Bay and Hammersley Inlet are clearly understood. In Table 14, for example, it's important to know which of the reductions are needed in order to achieve water quality standards in Oakland Bay (e.g. 23% or 79% reduction in Campbell Creek?)."

**EPA Response 2:** *Comments noted. Text on pages 56, 57, and 76 revised to provide clarity. Please see SIT Comment 2.k.*

## WA State Department of Agriculture (WSDA)

*Virginia Prest, WSDA, sent the following comment by e-mail on May 31, 2011.*

**WSDA Comment 1**: *(Page 92, Washington State Department of Agriculture)* "There are no dairies in Mason County so WSDA is not a major player in the landscape." Correct last paragraph to read: "They coordinate with the Washington State Department of Ecology to respond and investigate non-dairy livestock complaints. In Mason County, these typically address animal feeding operations or pasture-based water quality concerns."

**WSDA Response 1**: *Comment noted. Text revised as stated to provide clarity.*

| **WA State Department of Transportation (WSDOT)** |
|---|

*Kenneth M. Stone, WSDOT, sent the following comments in a letter dated June 8, 2011. (See the complete letter following all comments and responses in this Appendix.)*

**WSDOT Comment 1**: *(Page xvii, Table ES-1 and page 77, Table 14 (Load and wasteload allocations table)* "WSDOT's wasteload allocations in the table states "analysis pending," however, no such analysis was mentioned in the rest of the document. To be consistent with regulations and guidelines used to establish TMDLs, we feel it is Ecology's responsibility to characterize the sources of pollution and assign numeric waste load allocations (WLAs) only when there is credible, site specific data/information indicating that WDOT facilities are a meaningful source or contributor of the pollutant of concern. In the absence of site specific stormwater outfall data, a numeric WLA assigned to WSDOT is presumptuous and without just cause.

If WSDOT is known or suspected to be a source or contributor of the parameter(s) of concern in a TMDL, Ecology should include WSDOT stormwater in the TMDL study. If scientifically credible data reveals via statistical inference that WSDOT is a meaningful source, a numeric WLA should be calculated.

If WSDOT is known to be a source or contributor at a specific location but site specific data is not available, we expect that assigned WLAs would take the form of specific actions (e.g., inventory discharge locations, IDDE, or the installation of BMPs) rather than numeric WLAs.

Otherwise, in instances where WSDOT is not known or suspected to be a significant source or contributor, or site specific data reveals such, WSDOT should not be assigned a WLA. In the event new data or other actionable information should later reveal that WSDOT is a significant source or contributor, it would be appropriate to assign WSDOT actions under the TMDL via the adaptive management process."

**WSDOT Response 1**: *Comments noted. Determining stormwater allocations based upon the variability of stormwater data is challenging. (Also see EPA Response 1.) In the absence of a numeric wasteload allocation or a numeric or narrative load allocation, the default* *would be zero discharge.  Stormwater best management practices need to be implemented to address stormwater bacterial sources, regardless of whether or not an allocation is given.*

**WSDOT Comment 2:** *(Page 3, last paragraph and equation)* "Suggest revising the equation to be consistent with the previous sentence, 'TMDL ≤ Loading Capacity = Sum of all wasteload allocations + sum of all load allocations + margin of safety + reserve capacity (if any).'"

**WSDOT Response 2**: *Comment noted.  Paragraph revised and equation deleted.*

**WSDOT Comment 3***: (Page 11, fourth paragraph, page 12, first paragraph, and page 13, first paragraph)* "Suggest adding clarification after each citation of the water quality standards that the 90th percentile value is being used in place of the second part of the standard – 'no more than 10 percent of samples may exceed…'"

**WSDOT Response 3**: *Comment noted.  The 90th percentile value was not meant to replace, but used as statistically equivalent to, the second part of the standard.  The 90th percentile value was deemed more appropriate in developing the TMDL targets using statistical analysis and modeling.  For compliance to water quality standards, the two-part standards would still need to be met.*

**WSDOT Comment 4**: *(Page 14, first sentence)* "Suggest the following revision for clarity, 'Compliance is based on meeting both the geometric mean criterion and the 90th percentile limit.'"

**WSDOT Response 4**: *Comment noted.  See WSDOT Response 3.*

**WSDOT Comment 5**: *(Page 21, first paragraph)* "Suggest the following revisions for clarity: 'There are many roadside storm drains along Highway 101 and Highway 3 (Figure 5) that ~~belong to~~ are owned or operated by the WSDOT.  State and federal regulations require the WSDOT to have a stormwater permit in areas covered by Phase I and Phase II of the municipal stormwater permit program.  However, since neither the city of Shelton nor Mason County are covered under the Phase II stormwater permit there are no WSDOT municipal stormwater permit obligations within the TMDL boundary.'"

**WSDOT Response 5**: *Comments noted.  Text revised to provide more clarity.  See WSDOT Response 1.*

**WSDOT Comment 6**: *(Page 76, fourth paragraph)* "Suggest the following revision: 'All shoreline point sources, including Washington State Department of Transportation (WSDOT) outfalls, must implement source control BMPs and/or BMPs that reduce the volume of discharging stormwater, or otherwise reduce fecal coliform bacteria concentrations.' The revision is suggested because Ecology does not have any approved BMPs in the Stormwater Management Manual to reduce fecal coliform bacteria.  Further, this revision would make the sentence consistent with pages xviii and 78, where the same statement is made."

**WSDOT Response 6**: *Comments noted. Text revised to provide consistency.*

**WSDOT Comment 7**: *(Page 93, last paragraph)* "Suggest the following revisions for consistency and clarity: 'WSDOT stormwater was not sampled during the TMDL study. Therefore, there is no water quality data indicating WSDOT stormwater is a source of fecal coliform. However, Highways 3 and 101 are within the study area, so it is reasonable to assume that WSDOT stormwater may convey fecal coliform in areas were [sic] adjacent land uses are a recognized source of this bacteria. While WSDOT can be the source of bacteria in some locations, there is greater likelihood that the source of fecal coliform bacteria at a WSDOT outfall (if measured) comes from adjacent private property via natural drainage, an illicit discharge, or an illegal connection."

**WSDOT Response 7**: *Comments noted. Text revised to provide clarity.*

**WSDOT Comment 8**: *(Page 94, Table 26, first row)* "Suggest the following revisions for clarity: 'Inventory highway discharge locations along State Route 3 (SR3) into Oakland Bay, at SR3 stream crossings, and at US Highway 101 stream crossings within WSDOT's right-of-way and inside the Oakland Bay TMDL boundary. The Inventory will include the conveyance system directly draining to the discharge point.'"

**WSDOT Response 8**: *Comments noted. Text revised to provide clarity.*

**WSDOT Comment 9**: *(Page A-97, third paragraph, second sentence)* "Suggest using 'geometric mean and 90th percentile value' instead of 'two-part' standards since this is the first time this term is used in the document and 90th percentile is being used in place of Part II of the standard."

**WSDOT Response 9**: *Comment noted. See WSDOT Response 3.*

**WSDOT Comment 10**: *(Page A-97, fifth paragraph, second sentence)* "Suggest revising this sentence to be consistent with page xviii, which provides a 2015 timeline for sampling to determine if the 50 percent reduction target is achieved."

**WSDOT Response 10**: *Comment noted. The correct year is 2017 and text revised throughout the report to correct inconsistencies.*

**WSDOT Comment 11**: *(Page M-184, third bullet)* "Suggest the following revisions for consistency with Table 26, 'Washington State Department of Transportation will inventory highway discharge points along SR 3 and US 101 within the TMDL boundary, implement source identification and IDDE, and perform remediation if discharges transporting bacteria are found.'"

**WSDOT Response 11**: *Comment noted. The document this comment refers to is Appendix M, Oakland Bay Action Plan. Mason County Public Health prepared this document so*

*Ecology cannot change the contents. It is referenced in this report because of the direct connection to work done by organizations in the Oakland Bay Clean Water District Advisory Committee. As noted in WSDOT Response 8, we revised Table 26 to improve clarity.*

**WSDOT Comment 12**: "WSDOT has not performed a QA/QC check on the water quality or flow data presented in this report, nor have we re-computed the math behind derived values, and reserve the right to make corrections if errors are found at a later date."

**WSDOT Response 12**: *Comment noted. In any scientific study, the principal investigator is the appropriate person to conduct a QA/QC check, given that project specific knowledge is necessary for a thorough data quality evaluation. Ecology welcomes reviewers to help identify potential errors; however, the report review process is the appropriate time to raise any questions about the adequacy of the QA/QC data and analysis in the report. To date, WSDOT has had the opportunity to raise questions or concerns about data quality in three separate review stages of this report: 1) advisory group review of technical sections, 2) advisory group review of full report with implementation strategy, and 3) public comment period. Ecology feels this was a more than adequate amount of opportunity and reserves the right to respond to comments outside the review period to whatever extent we deem appropriate given the specific comments and circumstances at that time.*

## Washington State University (WSU) Mason County Extension Office

*Emily Sanford and Robert Simmons provided the following comments.*

**WSU Comment 1** *(page xv - referencing Watershed Description)*: "Probably worth mentioning the related economic contributions of the shellfish industry to the local economy as well (historic and current)."

**WSU Response 1:** *Comment noted. Text revised.*

**WSU Comment 2** *(page xvii - referencing General Implementation Actions, section 1, bullet 2)*: "Why recreation? Should OSS be mentioned here as well?"

**WSU Response 2:** *Comment noted. Text revised.*

**WSU Comment 3** *(page xviii - referencing Specific Implementation Actions, item 4):* "Is this realistic? Minimize…sounds dramatic! ☺"

**WSU Response 3:** *Comment noted. Text revised to say "Eliminate or significantly reduce all human-caused sources."*

**WSU Comment 4** *(page xviii – referencing Implementation Summary, third paragraph):* "Haven't they already been determined? Do you mean ranked or prioritized? See page 42 MST study."

**WSU Response 4:** *Comment noted. Text revised and "determined" replaced with "prioritized".*

**WSU Comment 5** *(page xviii – referencing Implementation Summary, fourth paragraph):* "Also Chapman Cove was in danger of downgrade."

**WSU Response 5:** *Comment noted. Text revised to include this statement.*

**WSU Comment 6** *(page 85 – last paragraph)*: "Even a properly maintained one can fail."

**WSU Response 6:** *Comment noted. Text revised by deleting "improperly maintained".*

**WSU Comment 7** *(page 86 – second paragraph):* "What about including something along the lines of…'Incentives should when possible be made available to residents to encourage system maintenance. These may include but are not limited to retrofit rebates for risers or effluent filters and coupons for maintenance and pumping. Recognizing the signs of failure for an on-site system is an important step toward their maintenance.'"

**WSU Response 7:** *Comment noted. Text revised.*

**WSU Comment 8** *(page 86 – last paragraph)*: "Where possible pet waste stations with bags and trash cans should be strategically placed throughout the watershed to encourage this behavior everywhere possible. Education materials should be made available throughout the watershed at appropriate places include [sic ] vet clinics, kennels, etc."

**WSU Response 8:** *Comment noted. Text revised by incorporating suggested references to pet waste stations and availability of educational material.*

**WSU Comment 9** *(page 89 – referencing Mason County Department of Community Development)*: "I believe this ordinance is in place… see www.co.mason.wa.us/stormwater/index.php. *Should this be under Mason County Public Works?*"

**WSU Response 9:** *Comment noted. Entire section revised.*

**WSU Comment 10** *(page 96 – Table 27, on-site septic systems)*: "While important and it probably needs its own space in the table, Shorebank is not affiliated with the retrofit rebate program…this is made possible by the WEI grant with MCPH the lead on it as a subcontractor to Squaxin Tribe."

**WSU Response 10:** *Comment noted. Revised Table 27.*

**WSU Comment 11** *(page 97, Monitoring Progress, last bullet)*: "I think this section needs more detail – specific actions by who…etc."

**WSU Response 11:** *Comment noted. No changes were made to this section. The purpose of the adaptive management meetings is to identify details. At these meetings, Ecology will work with the participating stakeholders to discuss and document issues such as action items completed, their success or failure, challenges, limitations, new actions or ideas to address continued concerns, and potential monitoring requirements.*

**WSU Comment 12** *(page 82 – Table 17, Grants/Loans)*: Requested we add rows referencing two grants from the Puget Sound Partnership. 1) "Puget Sound Starts Here grant to the Mason Conservation District in 2010 for Pet Waste Stations, etc." 2) "WSU Extension Block Grant for Puget Sound Starts Here for messaging, media campaign in 2009-10".

**WSU Response 12:** *Comment noted. Table 17 updated and information added.*

**WSU Comment 13** *(page 83 – Table 18, Education/Outreach, Row 1)*: Requested we add text, "There have been six workshops per year by WSU and MCPH."

**WSU Response 13:** *Comment noted. Table 18 updated and information added.*

**WSU Comment 14** *(page 83 – Table 18, Education/Outreach, Row 6)*: Requested we add text, "plus additional shoreline realtor ed courses".

**WSU Response 14:** *Comment noted. Table 18 updated and information added.*

**WSU Comment 15** *(page 94, Implementation Plan):* Requested we add a table specific to the WSU Mason County Extension Office. "Under Implementation we need to have a section like this outlining what WSU can do, including septic workshops, publications, website, LID and Stormwater programs, realtor education."

**WSU Response 15**: *Comment noted. Ecology added Table 27, Summary for WSU Mason County Extension Office implementation actions.*

"Building A Stronger Community TOGETHER"

June 8, 2011

Ms. Lydia Wagner
PO Box 47775
Olympia, WA 98504-7775

Dear Ms. Lydia Wagner:

**Subject: Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report (WQIR) and Water Quality Improvement Plan (WQIP)**

The City of Shelton offers the following comments on the subject Report and Plan:

Pages 7 and 8: Text indicates tributaries have been placed on 2004 303d list for water bodies for not meeting water quality standards for FC bacteria, while Table 1 on page 8 indicates the year to be 2008. Comment - confirm date.

Page 8 and 9: The City is interested in the scope and timing of future studies and other work related to the referenced 303d listings for temperature. Comment – please confirm the year which listings for these water bodies occurred, and keep City informed on this matter.

Page 11, 4th paragraph: Comment – 200/colonies mL should read 200 colonies/100mL

Page 91: Table 23 does not fully summarize implementation actions being taken as part of the Wastewater Treatment Plant upgrade and expansion to be completed by 2012. Comment – recommend adding row(s) in table indicating specific Wastewater Treatment Plant upgrades to be completed in 2012, including; adding a basin for nitrogen treatment, a new slack-tide storage tank, extending the discharge effluent diffuser by 96 feet, new ultra-violet disinfection treatment, all to benefit shellfish production and enabling DOH to reduce the Shellfish Harvest "closure area".

Page 97: Page numbering in the Footer adds an **A** "Page A-97"; appears this should have waited until Page 115.

Page K-165: Should be Page J-165 & Page J-166.

Appendix J "Assessment of City of Shelton Wastewater Treatment Plant effluent limit on fecal coliform", paragraph 2 is a bit misleading. This section contains reference to a "new" NPDES permit for the plant, which I believe won't actually be issued until the upgrades are finished. It also states that this permit

525 W. Cota St. • Shelton, WA 98584
(360) 426-4491 •FAX (360) 426-1338 • E-Mail: cityhall@ci.shelton.wa.us
Web Site: www.ci.shelton.wa.us

contains "benchmark effluent limits". I believe that it would be correct to state that these benchmarks are being discussed for the new permit **when** issued but not that they are currently in place (or that they will ultimately be imposed). The current NPDES permit effluent limitation benchmarks for FC bacteria are 14 cfu/100 ml monthly average, and 45 cfu/100 ml weekly average

The City is very interested in participating in efforts to improve water quality in Oakland Bay, and it is our hope to remain partners with Ecology and others to achieve this objective. I can be reached at (360) 432-5136, or by email, Steveg@ci.shelton.wa.us.

Cordially,

Steve Goins
Director of Community and Economic Development and Public Works Administration and Services

Cc: The Honorable Mayor Tarrant
The Honorable Commissioner Byrne
The Honorable Commissioner Pannell
Dave O'Leary, City Administrator

Washington State
Department of Transportation
Paula J. Hammond, P.E.
Secretary of Transportation

Transportation Building
310 Maple Park Avenue S.E.
P.O. Box 47300
Olympia, WA 98504-7300

360-705-7000
TTY: 1-800-833-6388
www.wsdot.wa.gov

June 8, 2011

Ms. Lydia C. Wagner
WA Department of Ecology
Southwest Regional Office
PO Box 47775
Olympia, WA 98504-7775

RE: WSDOT Review Comments for Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan Draft

Dear Ms. Wagner:

The Washington State Department of Transportation (WSDOT) Environmental Services Office has reviewed the Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan Draft – May 2011 (Washington State Department of Ecology Publication No. 11-10-039). We appreciate the opportunity to provide comment on this TMDL document.

First and foremost, WSDOT is committed to working collaboratively with Ecology and others to address the fecal coliform contributions of state highways to Oakland Bay, Hammersley Inlet, and tributaries in the Oakland Bay watershed, as they may exist.

We would like to provide the following specific comments, which include the page number and wording in question/of concern:

1) Page xvii, Table ES-1 and page 77, Table 14 (Load and wasteload allocations table):

   Comment: WSDOT's wasteload allocation in the table states "analysis pending," however, no such analysis was mentioned in the rest of the document. To be consistent with regulations and guidelines used to establish TMDLs, we feel it is Ecology's responsibility to characterize the sources of pollution and assign numeric waste load allocations (WLAs) only when there is credible, site specific data/information indicating that WSDOT facilities are a meaningful source or contributor of the pollutant of concern. In the absence of site specific stormwater outfall data, a numeric WLA assigned to WSDOT is presumptuous and without just cause.

If WSDOT is known or suspected to be a source or contributor of the parameter(s) of concern in a TMDL, Ecology should include WSDOT stormwater in the TMDL study. If scientifically credible data reveals via statistical inference that WSDOT is a meaningful source, a numeric WLA should be calculated.

If WSDOT is known to be a source or contributor at a specific location but site specific data is not available, we expect that assigned WLAs would take the form of specific actions (e.g., inventory discharge locations, IDDE, or the installation of BMPs) rather than numeric WLAs.

Otherwise, in instances where WSDOT is not known or suspected to be a significant source or contributor, or site specific data reveals such, WSDOT should not be assigned a WLA. In the event new data or other actionable information should later reveal that WSDOT is a significant source or contributor, it would be appropriate to assign WSDOT actions under the TMDL via the adaptive management process.

2) Page 3, last paragraph and equation: "Therefore, a TMDL is the sum of the wasteload and load allocations, and any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity. TMDL = Loading Capacity = Sum of all wasteload allocations + sum of all load allocations + margin of safety."

   Comment: Suggest revising the equation to be consistent with the previous sentence, "TMDL ≤ Loading Capacity = Sum of all wasteload allocations + sum of all load allocations + margin of safety + reserve capacity (if any)."

3) Page 11, fourth paragraph; page 12, first paragraph; and page 13, first paragraph:

   Comment: Suggest adding clarification after each citation of the water quality standards that the $90^{th}$ percentile value is being used in place of the second part of the standard – "no more than 10 percent of samples may exceed…"

4) Page 14, first sentence: "Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than 10 total samples) limit."

   Comment: Suggest the following revision for clarity, "Compliance is based on meeting both the geometric mean criterion and the $90^{th}$ percentile limit."

5) Page 21, first paragraph: "There are many roadside storm drains along Highway 101 and Highway 3 (Figure 5) that belong to the WSDOT. State and federal regulations require the WSDOT to have a stormwater permit in areas covered by Phase I and Phase II of the municipal stormwater permit program, however neither the city of Shelton nor Mason County are covered under the Phase II stormwater permit."

   Comment: Suggest the following revisions for clarity: "There are many roadside storm drains along Highway 101 and Highway 3 (Figure 5) that ~~belong to~~ are owned or operated by the WSDOT. State and federal regulations require the WSDOT to have a stormwater permit in areas covered by Phase I and Phase II of the municipal stormwater permit program. However, since neither the city of Shelton nor Mason County are covered under the Phase II stormwater permit there are no WSDOT municipal stormwater permit obligations within the TMDL boundary."

6) Page 76, fourth paragraph: "All shoreline point sources, including WSDOT outfalls, must implement BMPs to reduce suspended solids and bacteria."

Comment: Suggest the following revision: "All shoreline point sources, including Washington State Department of Transportation (WSDOT) outfalls, must implement source control BMPs and/or BMPs that reduce the volume of discharging stormwater, or otherwise reduce fecal coliform bacteria concentrations." The revision is suggested because Ecology does not have any approved BMPs in the Stormwater Management Manual to reduce fecal coliform bacteria. Further, this revision would make the sentence consistent with pages xviii and 78, where the same statement is made.

7) Page 93, last paragraph: "Ecology did not directly measure stormwater outfalls from WSDOT during the TMDL study. Therefore, there is no water quality data indicating WSDOT stormwater is a source of fecal coliform. However, WSDOT Highway 3 is within the study area and has the potential to discharge stormwater to the study area that could contribute fecal coliform."

Comment: Suggest the following revisions for consistency and clarity: "WSDOT stormwater was not sampled during the TMDL study. Therefore, there is no water quality data indicating WSDOT stormwater is a source of fecal coliform. However, Highways 3 and 101 are within the study area, so it is reasonable to assume that WSDOT stormwater may convey fecal coliform in areas were adjacent land uses are a recognized source of this bacteria. While WSDOT can be the source of bacteria in some locations, there is greater likelihood that the source of fecal coliform bacteria at a WSDOT outfall (if measured) comes from adjacent private property via natural drainage, an illicit discharge, or an illegal connection."

8) Page 94, Table 26, first row: Action: "Inventory highway discharge locations along State Route 3 (SR3) into Oakland Bay, at SR3 stream crossings, and at US Highway 101 stream crossings within the Oakland Bay TMDL boundary. The Inventory will include the conveyance system directly draining to the discharge point."

Comment: Suggest the following revisions for clarity: "Inventory highway discharge locations along State Route 3 (SR3) into Oakland Bay, at SR3 stream crossings, and at US Highway 101 stream crossings within WSDOT's right-of-way and inside the

Oakland Bay TMDL boundary. The Inventory will include the conveyance system directly draining to the discharge point."

9) Page A-97, third paragraph, second sentence: "Compliance with this TMDL is based on meeting the two-part fecal coliform bacteria standards."

 <u>Comment</u>: Suggest using "geometric mean and 90th percentile value" instead of "two-part" standards since this is the first time this term is used in the document and 90th percentile is being used in place of Part II of the standard.

10) Page A-97, fifth paragraph, second sentence: "Ecology will conduct interim monitoring when enough implementation actions have been completed to anticipate achieving a 50 percent reduction in fecal coliform bacteria."

 <u>Comment</u>: Suggest revising this sentence to be consistent with page xviii, which provides a 2015 timeline for sampling to determine if the 50 percent reduction target is achieved.

11) Page M-184, third bullet: "Washington State Department of Transportation will reduce bacterial conveyance from Highway 3 storm water discharges."

 <u>Comment:</u> Suggest the following revisions for consistency with Table 26, "Washington State Department of Transportation will inventory highway discharge points along SR 3 and US 101 within the TMDL boundary, implement source identification and IDDE, and perform remediation if discharges transporting bacteria are found."

Other Comments:

- WSDOT has not performed a QA/QC check on the water quality or flow data presented in this report, nor have we re-computed the math behind derived values, and reserve the right to make corrections if errors are found at a later date.

Thank you for considering our comments. If you have questions or wish to discuss, please contact WSDOT's TMDL Lead, Jana Ratcliff, at 360-570-6649 (office), 360-701-6353 (cell), or ratclij@wsdot.wa.gov.

Sincerely,

Richard [signature]

for Kenneth M. Stone
Resource Programs Branch Manager
Environmental Services Office
KMS:jr

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
WATER AND WATERSHEDS

June 8, 2011

Lydia Wagner
Water Quality Program
Southwest Regional Office
Washington State Department of Ecology
Olympia, WA 98504

Dear Ms Wagner:

Thank you for providing the EPA an opportunity to comment on the draft Oakland Bay & Hammersley Inlet TMDL. The technical analysis performed by Ecology during development of the TMDL is well thought-out and is clearly explained in the TMDL. Just as importantly, the integration of implementation issues throughout the document indicates a thorough understanding of the sources, and will assist the watershed stakeholders in implementing water quality improvements.

I have a few comments on the draft TMDL, as follows:

1. Stormwater Sources. The EPA developed a Memorandum in 2002 ("Establishing TMDL Wasteload Allocations for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs") that clarifies existing EPA regulatory requirements for establishing wasteload allocations (WLA) for stormwater in TMDLs. In this Memorandum, it is explained that WLAs and LA are to be expressed in numeric form in the TMDL, and that EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system. The Memorandum also explains that because storm water discharges are highly variable in frequency and duration and are not easily characterized, that the NPDES permits will typically express these WLAs as BMPs.

   The draft TMDL states that DOT stormwater discharges are regulated by the NPDES program, and are therefore "point sources." In recent conversations with Department of Ecology staff, however, I have learned that DOTs discharges may not in fact be currently regulated by the NPDES program. Regardless of DOT's NPDES status, it is appropriate for Ecology to designate an *allocation* for DOT in the TMDL because DOT discharges do contribute pollutant loadings to the watershed. Moreover, EPA supports the inclusion of implementation recommendations for DOT stormwater regardless of DOT's permitting status.

   The City of Shelton stormwater is not currently regulated by the NPDES program, and has not received a WLA in the draft TMDL. Allocations for unregulated stormwater are discussed on page 76, however, and appear to be equivalent to the marine water quality standards. This information could be added to Table 14 (e.g. unregulated stormwater) in order to clearly indicate that stormwater sources have been considered by Ecology in this analysis, and to facilitate the development of NPDES permits, if they are needed in the future.

2. Tributaries. In order to meet marine water quality standards in Oakland Bay and Hammersley Inlet, the TMDL study indicates that the tributaries need to meet the marine water quality standards at the tributary mouths (e.g. discussion on pages 56-7). A statement on page 76 contradicts this finding: "All tributaries must meet the freshwater water quality standards at the mouth of creeks during all seasons….meeting the marine standards will be a secondary goal." I suggest that the statement on page 76 (and the associated LAs in Table 14) be clarified so that the reductions needed in order to achieve water quality in Oakland Bay and Hammersley Inlet are clearly understood. In Table 14, for example, it's important to know which of the reductions are needed in order to achieve water quality standards in Oakland Bay (e.g. 23% or 79% reduction in Campbell Creek?).

If you have any questions about these comments, please don't hesitate to call me at 206-553-1583.

Sincerely,

/s/

Laurie Mann
Environmental Engineer
TMDL Program

Printed on Recycled Paper

**Wagner, Lydia (ECY)**

| | |
|---|---|
| **From:** | JJNM@aol.com |
| **Sent:** | Wednesday, June 08, 2011 4:06 PM |
| **To:** | Wagner, Lydia (ECY) |
| **Subject:** | Oakland Bay Fcoli TMDL Comments |

Thank you for the opportunity to provide these limited comments on the Department of Ecology's "Oakland Bay Water Cleanup Plan". Strides taken towards ensuring this unique body of water is healthy will be appreciated for generations to come.

1. Consideration should be given to narrowing the area focused on. Inclusion of Hammersley Inlet in the Oakland Bay effort greatly expands the area being studied and diffuses the limited resources available for both this study as well as support for the numerous other areas of Puget Sound (e.g., Mills Creek drainage area is 20% of the total noted in Figure D-1, page D-128). While there are occasional monitoring spots which show higher Fcoli readings in Hammersley Inlet, none are to the level found in Oakland Bay. Further, Hammersley Inlet's waters are flushed far more effectively than those of Oakland Bay, primarily due to a combination of the prevailing winds and Oakland Bay's being at the end of the estuary. This flushing quickly dissipates any temporary increases which may be found (see DOH's Hammersley Inlet water 2010 quality report: http://www.doh.wa.gov/ehp/sf/Pubs/gareports/hammersley.pdf. 2011 results to date indicate levels well within safety concerns.) Additional significance is also found when consideration is given to where the productive tidelands are: Oakland Bay.

2. Pages 11 and 12 set the water quality levels of Fcoli for fresh water and a far lower one for salt water. Each strives to provide safety with the former (100colonies/100ml) being human contact and the second (14colonies/100ml) for the production of shellfish. While both are important, the second sets a substantially lower bar to get under in order to ensure tidelands remain productive. In order to achieve this level, immense resources are focused on minimizing the impacts from various sources, whether at the state, county or tribal level. Resources needed from private sources are also increased through septic upgrades, fences, or alternative forms of yard care. Focus of these resources on achieving this level allows shellfish production to occur, increasing revenues, and thereby the value of the tidelands certified for shellfish production. Consideration should be given to both increasing the assessed value of these tidelands to better reflect their true value, as uplands do, and a fee tied to production in order to generate revenues to help pay for this. So doing is an equitable means of helping to defray the costs by those who benefit the most from this.

3. Page 14 notes the important issue of Fcoli sources and makes the point that sources from wildlife and humans has not been quantified. At issue is whether focusing on human sources will, in fact, achieve the far more stringent marine water levels. Large populations of seal and upland populations of deer and other warm blooded mammals, including occasional Orcas. Yet based on page 14, it does not appear there is a clear understanding what the sources are. Added to the problem is the unknown source in the sediments, discussed on page 23. While it may be Fcoli is from upland human sources, it may be the past history of Oakland Bay has created a "soup" of chemicals in which Fcoli bacteria reproduce. Consideration should be given to focusing the initial effort on determining what percentage is coming from wild versus human and whether production or storage only is occurring in the sediments in order to determine whether eliminating human sources will, in fact, result in the levels being sought. It may be relaying shellfish to cleaner waters is more effective.

4. Consideration should be given to an economic analysis on what gains have been achieved at what expense to date for the incremental improvement of tideland production for shellfish, and what future gains will be gained from those future expenses. Opportunities to apply funds in areas in need of clean water programs, such as that recently proposed for North Bay or the southern portion of Hoods Canal may result in greater economic returns from the limited dollars available.

Thank you for considering these comments. As mentioned earlier, Oakland Bay has become a far healthier body of water from the efforts of a diverse group of people. The improvement found in this body of water has benefited many, including future generations.

Jules Michel

**Wagner, Lydia (ECY)**

**From:** Debbie Riley [Dlr@co.mason.wa.us]
**Sent:** Tuesday, June 07, 2011 11:13 AM
**To:** Wagner, Lydia (ECY)
**Subject:** Comments on Oakland Bay plan

Lydia,
First, thank you for a very professional product in the Draft Water Quality Improvement Report. Mason County Public Health appreciates the efforts that have gone into the report and finds huge value in having the information about this very complex system compiled into an easy to use format. Mason County's official comments will come from Stephanie Kenny, our lead on the project, but I have a comment that is very important to me.

Page 12 of the draft "Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan" states: "The water quality criteria for Shellfish Harvesting or Primary Contact Recreation (swimming or water play) is as follows: "Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more that 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL". Although this is a re-statement of WAC 173-201A-210(3)(b), 2003 edition, it may be an unrealistic/unreachable goal for this TMDL and for all of Oakland Bay. Our goal, like everyone else's, is to maintain current good water quality in the areas that exhibit good values and to improve water quality in areas with samples that do not meet the strict standards of the FDA for human consumption of shellfish. We want all of Oakland Bay re-opened to shellfish harvest.

Is this area of "shellfish harvesting and/or primary contact" in the marine water as determined by salinity? Is it in the mixing zone at the mouth of the tributary? Is it a measurable distance up the stream that is under tidal influence? I ask because fresh and marine standards are so different and depending on how the TMDL defines where the criteria is to be met, outcomes may be radically different. Interpretations I have received from very knowledgeable professionals over the years has given me different answers leaving me unsure as to where the measurement is to be taken. As I drive along the Bay during the winter I witness the fresh water influence as evidenced by a thick layer of ice (fresh water) extending some distance out into the Bay itself. The lack of a definition is problematic to me. I have expressed this concern at various meetings as far back as the original sampling. I have yet to receive a satisfying answer; but your comment period allows me one more chance to voice my concerns and possibly get an answer that makes sense to me.

The other thing that jumped out at me was in the chart on Page A-100 - Funding sources. The first entry says "Enterprise Cascadia Septic Loan" but in the contact information section "ShoreBank" still appears. Please remove the words "ShoreBank" and leave "Enterprise Cascadia" .

Thank you again for all of your efforts as part of the Oakland Bay Clean Water Advisory Committee and on compiling this report. Coming in on the middle of a project cannot be easy, but you dived right in and became a valuable partner. You represented the Department of Ecology well.
Debbie

Debbie Riley, RS
Environmental Health Manager
Mason County Public Health
PO Box 1666
Shelton, WA 98584

(360) 427-9670 ext 358
FAX (360) 427-8442
DLR@co.mason.wa.us

SQUAXIN ISLAND TRIBE

25 May 2011

Lydia Wagner
Water Quality Program—SWRO
Department of Ecology
POB 47775
Olympia, WA 98504-7775

Dear Ms Wagner,

On behalf of the Squaxin Island Tribe, I am writing to comment on the May 2011 Draft Oakland Bay and Hammersley Inlet Fecal Coliform Bacteria TMDL Water Quality Improvement Report and Implementation Plan. As you well know, Oakland Bay hosts shellfish resources of national and Tribal significance. About 40% of the manila clams produced in the entire county come from Oakland Bay. The shellfish value exceeds $10 million, and over 200 Tribal members make at least part of their living there. Oakland Bay and its natural resources are central to the culture and history of the Squaxin Island Tribe and from our viewpoint, must be protected to the maximum extent possible.

After reviewing the report, the Tribe is concerned that the measures proposed are not protective enough to sustain our right to harvest shellfish reserved in the 1854 Medicine Creek Treaty. The bottom line is that we request that the Department of Ecology adopt the marine water quality standard at the mouths of all tributaries as the primary target, not a secondary target. A more stringent target than the freshwater alternative is the only way to overcome the unique challenges the bay presents to water quality and shellfish harvest.

The Tribe's standard for evaluating the report is that it has to be protective enough to sustain the opportunity to harvest shellfish in perpetuity. Oakland Bay has three strikes against it that endanger that objective.

First, in the same way that South Puget Sound is somewhat isolated from the rest of Puget Sound by the Tacoma Narrows, Oakland Bay is somewhat isolated from South Puget Sound by Hammersley Inlet. Oakland Bay is the terminal estuary of a terminal estuary resulting in extremely long residence times leading to very poor water quality. In fact, the Marine Water Quality Index under development by the Department of Ecology identified Oakland Bay as having the lowest water quality index score in the entire Puget Sound monitoring network. That coupled with a significant decline since 1999 calls for application of more stringent water quality targets.

Natural Resources Department / 2952 S.E. Old Olympic Hwy. / Shelton, WA 98584
Fax (360) 426-3971 / Phone (360) 426-9781

Second, Oakland Bay sediments host a reservoir of pathogens that re-suspend into the water column with sufficient shear stress from wind and wave action. Oakland Bay is not unique in this regard, but its perfect southwest-northeast geographic orientation significantly exacerbates the problem. The strongest winds come from the southwest and blow up a five mile long fetch stirring up the sediments at the upper end of the bay. This has led to water quality violations and a shellfish harvest downgrade. Oakland Bay is much more vulnerable to pathogen-laden sediment than most shellfish growing areas.

Third, not much needs to be belabored about population growth, other than to acknowledge the obvious—it is coming to the Oakland Bay Watershed, and will significantly increase anthropogenic stresses in an extremely susceptible location.

The combination of all three of these water quality challenges makes Oakland Bay unique. To overcome them will require non-standard solutions. Only with an enhanced target, will fecal coliform concentrations in the marine waters remain below the 14/43 shellfish harvest standard. Our primary request is to increase the margin of safety by adopting the 14/43 shellfish harvest standard at the mouths of all tributaries as the primary target. The bacteria roll-backs for upstream reductions should be set to achieve that target. With long residence times and large bacteria reserves, no other solution seems likely to protect marine waters.

With a more stringent water quality target in place, the next weakest link for Oakland Bay is the Department of Transportation. I have participated in the Clean Water District from the start, and have found Transportation's participation very sporadic. Improving their actions and infrastructure are a big part of the solution. State Highway 3 runs along the entire northern shoreline of Oakland Bay. It contributes significant stormwater runoff that must be addressed to protect shellfish harvest. Somehow getting them more involved is a key implementation action.

On a cautionary note, a previous water quality crisis occurred in the late 1980's. It inspired the development of the 1990 Oakland Bay Watershed Management Plan. What is striking is that the remediation actions suggested in 1990 are very similar to draft implementation plan. Not much has changed other than a better understanding of how pathogens on sediment influence water quality. The Tribe hopes that the current improvement report will not languish like the 1990 version.

This new report must be implemented to the greatest extent possible and the monitoring program proposed carried out with vigor. We must know with certainty whether a 50% reduction in bacteria loads has been achieved by 2015 with 100% by 2017. If not, there must be consequences, likely both adaptive management and enforcement actions.

Since the tumultuous days when harvest downgrades were proposed in 2005-06, the Clean Water District has come together to make progress. However, backsliding can be surprisingly quick. Remember that in January 2005, all of Oakland Bay was taken off the Department of Health's list of threatened shellfish growing areas for the first time in years. But by September

2005, we were facing serious harvest downgrades. Degradation can happen very fast and its prevention requires continuous, ongoing diligence and requisite financial support.

Finally, I have included in an appendix some technical comments about the report. If you have any questions, please feel free to contact me.

In closing and on behalf of the Tribe, I want to thank both you and Anise Ahmed for all the hard work you have put into this process and product. I know each of you has put in extraordinary effort and I want to thank you for your diligence and persistence. The Department of Ecology and the Squaxin Island Tribe were partners in the collection of the data necessary to write this report, and I look forward to that continued cooperation.

Sincerely,

John Konovsky, Environmental Program Manager

CC: Andy Whitener, SIT NR Director
Jeff Dickison, SIT Assistant NR Director
Laurie Mann, EPA
Bill Taylor, Taylor Shellfish Farms
Steve Bloomfield, PCSGA

APPENDIX—detailed comments

Page 6, Figure 1—why is Oakland Bay and Hammersley Inlet outside the TMDL boundary?

Page 16, Deer Creek—actually has two forks that form the headwaters, one from Benson and one from a wetland to the south of Benson.

Page 16, Johns Creek—sentence "Some of the most productive shellfish beds in the bay begin in a series of wetlands...." makes no sense.

Page 24, Table 4—need to clarify that meaning of "percent" is absence/presence.

Page 25, Sedimentation—please revise relationship between sediment size and bacteria attachment based on DeFlaun & Mayer 1983. It is the only study I am aware of that directly researched the relationship.

Could also add Ecology and Squaxin data from Deer Creek that suggests ~2/3 of FC are sediment-attached in during winter storm events, while only ~1/3 are attached during summer low flows?

Page 39—"Eagles Point" = "Eagle Point"

Page 57—Marine standard should be met at mouth of all tributaries as a primary target.

Page 68, last paragraph—FC exist only in the top centimeter of sediment

Page 70—could also add Ecology and Squaxin data from Deer Creek that suggests ~2/3 of FC are sediment-attached in during winter storm events, while only ~1/3 are attached during summer low flows.

Page 76, last paragraph—meeting marine water quality standards at tributary mouths should be primary goal.

Page 81, Table 15—add Squaxin Island Tribe and the legal authority is the 1854 Treaty of Medicine Creek.

Page 86—should include a plan for enforcement of septic regs if voluntary compliance fails to correct the pollution.

# Appendix L. Public Involvement Materials

WASHINGTON STATE DEPARTMENT OF ECOLOGY

## Public Meeting on the Draft Oakland Bay Water Quality Improvement and Implementation Plan

The Department of Ecology (Ecology), Water Quality Program, is holding a public meeting to provide information about the draft **Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan.** The plan identifies problem areas and implementation activities to clean up unhealthy waters in the Oakland Bay watershed.

The draft plan is currently available for review. We welcome and encourage your comments on this draft plan during the public comment period of May 9 through June 8, 2011.

**Public Meeting**
**May 16, 2011**

Mason County Public Works
100 W. Public Works Dr.
Shelton, WA 98584

5:00 p.m. – Meeting Opens
5:30 p.m. – Ecology presentation

**Public comment period**
**May 9 – June 8, 2011**

The draft Plan is available for review at:

Shelton Timberland Library
710 W. Alder St.
Shelton, WA 98584

Mason County Public Health
415 North 6th St.
Shelton, WA 98584

Department of Ecology
Southwest Regional Office
300 Desmond Dr. SE
Lacey, WA 98503

Please send comments by June 8, 2011, to Lydia Wagner, Department of Ecology, PO Box 47775, Olympia, WA 98504-7775, or by e-mail at lydia.wagner@ecy.wa.gov.

For more information, please contact Lydia Wagner, Water Cleanup Plan Coordinator, by phone at 360-407-6329, or e-mail at lydia.wagner@ecy.wa.gov.

DEPARTMENT OF
ECOLOGY
State of Washington

# Comments requested on the Draft Oakland Bay Water Quality Improvement and Implementation Plan

There are too many fecal coliform bacteria in Oakland Bay, Hammersley Inlet, and selected tributaries located in the Kennedy/Goldsborough watershed. During 2004-2006, the Squaxin Island Tribe and the Washington State Department of Ecology (Ecology) collected water quality data for these waterbodies. This was done in response to impairment listings on the 303(d) list. Ecology has analyzed the data and made recommendations to reduce fecal coliform pollution in these areas.

Ecology, Mason County Government, Squaxin Island Tribe, City of Shelton, Port of Shelton, WSU Mason Extension, Mason Conservation District, shellfish industry and local business, and other partners associated with the Oakland Bay Clean Water District, have been working on a water quality improvement and implementation plan to clean up unhealthy waters in the Oakland Bay watershed. The plan identifies problem areas and implementation activities for the various partners. Numerous activities are currently in process or already completed.

**Public comment period**
**May 9 – June 8, 2011**

The draft Plan is available for review at:

Shelton Timberland Library
710 W. Alder St.
Shelton, WA 98584

Mason County Public Health
415 North 6th St.
Shelton, WA 98584

Department of Ecology
Southwest Regional Office
300 Desmond Dr. SE
Lacey, WA 98503

Please send comments by June 8, 2011, to Lydia Wagner, Department of Ecology, PO Box 47775, Olympia, WA 98504-7775, or by e-mail at lydia.wagner@ecy.wa.gov.

The draft **Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan** is now available for your review. We welcome and encourage your comments on this draft plan during the public comment period May 9 through June 8, 2011.

For more information, please contact Lydia Wagner, Water Cleanup Plan Coordinator, by phone at 360-407-6329, or e-mail at lydia.wagner@ecy.wa.gov.

## Oakland Bay Fecal Coliform TMDL Public Meeting
## Attendance Sheet

| Full Name | Representing | Mailing Address | Phone | E-mail |
|---|---|---|---|---|
| Patricia A. Jerrells | Private Citizen | 320 SE Nighthawk Place, Shelton, WA 98584 | 360-426-1725 | trisha7of9@hotmail.com |
| Jerry Lingle | Mason County Commissioner | Commissioner's Office, 411 N. 5th St., Shelton, WA 98584 | 360-427-9670, ext. 419 | JerryL@co.mason.wa.gov |
| Terry Hull | Enterprise Cascadia | 221 W. Railroad Ave., Shelton, WA 98584 | 360-427-2875 | THULL@SBPAC.com |
| Terri Thompson | Citizen | 201 E. Paint Brush Lane, Shelton, WA 98584 | 360-898-5428 | mwtat@hctc.com |
| Deb Soper | Citizen | 31 E. Springwood, Shelton, WA 98584 | 360-432-1220 | jomomi@yahoo.com |
| Jennifer Hopper | Taylor Shellfish | 130 SE Lynch Rd., Shelton, WA 98584 | 360-481-2417 | jenniferh@taylorshellfish.com |
| Bob Simmons | WSU Mason Extension | 303 N. 4th St., Shelton, WA 98584 | 360-427-9670, ext. 690 | simmons@wsu.edu |
| Jane Roush | Citizen | 2335 Washington, Shelton, WA 98584 | 360-426-7389 | moneybags07@q.com |
| Loretta Swanson | Mason County Public Works | 100 W. Public Works Dr., Shelton, WA 98584 | 360-427-9670, ext. 769 | lorettas@co.mason.wa.us |
| Will Durham | Citizen | 2406 E. Walker Park Rd., Shelton, WA 98584 | 360-427-7713 | wilsondurham@gmail.com |
| Darren Wagner | Mason County Public Works | 100 W. Public Works Dr., Shelton, WA 98584 | 360-427-9670, ext. 381 | DarrenW@co.mason.wa.us |

Contact:
Lydia C. Wagner, 360-407-6329, Lydia.Wagner@ecy.wa.gov

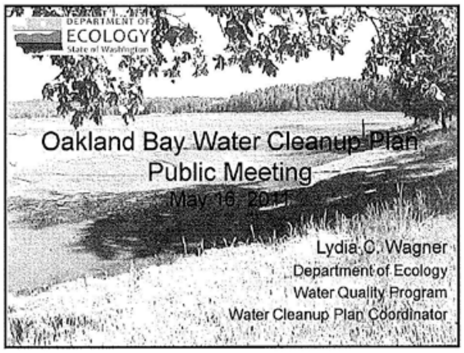
May 16, 2011

## Oakland Bay Fecal Coliform TMDL Public Meeting
## Attendance Sheet

| Full Name | Representing | Mailing Address | Phone | E-mail |
|---|---|---|---|---|
| Stephanie Kenney | Mason County Public Health | PO Box 1666, Shelton, WA 98584 | 360-427-9670, ext. 581 | Smk@co.mason.wa.us |
| Sally Toteff | Dept. of Ecology | PO Box 47775, Olympia, WA 98504-7775 | 360-407-6307 | Sally.Toteff@ecy.wa.gov |
| Lydia Wagner | Dept. of Ecology | PO Box 47775, Olympia, WA 98504-7775 | 360-407-6329 | Lydia.Wagner@ecy.wa.gov |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Contact:
Lydia C. Wagner, 360-407-6329, Lydia.Wagner@ecy.wa.gov

May 16, 2011




"Oakland Bay, Hammersley Inlet, and Selected Tributaries Fecal Coliform Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan"


Uncle John Creek at mouth


Chapman Cove at mouth of Uncle John Creek

## *What is the Oakland Bay Fecal Coliform TMDL?*

**Technical Study**
Identifying problem
Identifying locations
*It's the science piece!*

**Water Quality Improvement Report**
What do we need to work on?
Where are the problem areas?

**Water Quality Implementation Plan**
What actions are needed?
Who will do them?

## *Where can I find copies?*

**Shelton locations:**

**Shelton Timberland Regional Library**
710 W. Alder St.
Shelton, WA 98584

**Mason County Public Health**
415 North 6th St.
Shelton, WA 98584

DEPARTMENT OF ECOLOGY State of Washington

**Department of Ecology Southwest Regional Office**
300 Desmond Dr. SE
Lacey, WA 98503

**New!**
It is now posted on **Ecology's website at**
http://www.ecy.wa.gov/biblio/1110039.html

## *What is a TMDL?*

A Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

It's also a watershed plan to control or cleanup pollution.

## *Why do we develop TMDLs?*

The Federal Clean Water Act (CWA) requires states to set water quality standards for surface waters to protect public and environmental health.

These standards protect water for beneficial uses such as: drinking water, recreation, fishing, aquatic habitat, irrigation, and livestock.

## Why do we develop TMDLs?

The Department of Ecology is the agency required to clean up water bodies to meet these standards.

It is required by the **Clean Water Act** and a **Lawsuit Settlement.**

## How does Ecology do it?

The Department of Ecology cannot accomplish this task alone. We develop partnerships with organizations who have a common goal to improve the water quality.

*So who are the partners Ecology has worked with to improve Oakland Bay? Let me show you...*

## Oakland Bay Partners

Local Citizens

Washington State University

WSDA

Green Diamond Resource Company

Sea Grant Washington

Health

Port of Shelton

Department of Ecology State of Washington

Taylor Shellfish Farms

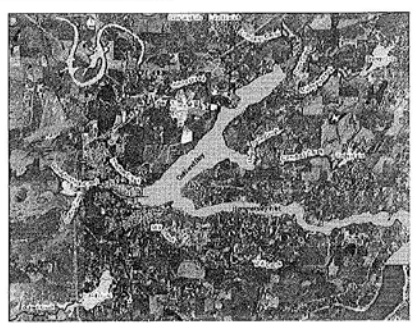
Puget Sound Partnership

## Parts of a TMDL

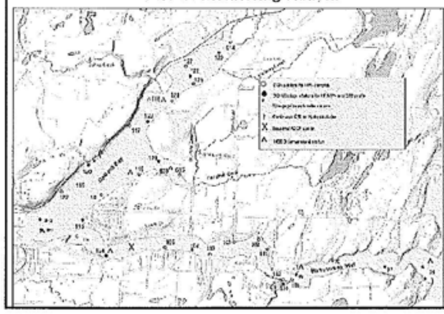
- Water sampling to verify the impairment or get more information
- Data analysis and mathematical modeling
- Set allocations (limits) for pollution sources
- Implementation strategy
- Effectiveness monitoring

## Water Quality Based Approach

Water Quality Standards (WQS) → Identify waters not meeting WQS 303(d) list → Prioritize the list → Develop water cleanup plans (TMDLs) → Implement cleanup actions → Effectiveness monitoring → Water Quality Standards (WQS)



Marine monitoring stations



## Data Analysis & Mathematical Modeling

Determines how much of the pollutant the water body can accept and **still** meet water quality standards.

- This amount is the **Total Maximum Daily Load.**
- The **sources** of the pollutants are determined.
- A **model** is designed to determine how much pollutant needs to be reduced from various sources.
- **Allocations** are assigned to these sources.

## *Goal of the Oakland Bay TMDL*

The Department of Ecology, Environmental Assessment and Water Quality Programs, working with other partners, have created a draft plan to reduce the amount of fecal coliform bacteria in Oakland Bay, Hammersley Inlet, and Selected Tributaries.

Efforts are already underway to implement this plan to clean up and improve the water quality in these waterbodies.

**Example of Data from the Draft Report**

Microbial Source Identification (Nov 2005 – Nov 2006)

using human ruminant and general bacteroides primers (conducted by EPA)

| Site | Samples | Human (percent) | Ruminant (percent) |
|---|---|---|---|
| **Upper Oakland Bay** (marine & freshwater sites) | FC <100 MPN/100 mL | 39 | 69 |
| | FC >100 MPN/100 mL | 94 | 87 |
| | Winter | 20 | 50 |
| | Summer | 69 | 79 |
| **Chapman Cove** (marine & freshwater sites) | FC <100 MPN/100 mL | 19 | 35 |
| | FC >100 MPN/100 mL | 89 | 100 |
| | Winter | 7 | 29 |
| | Summer | 56 | 78 |

**Example of Data from the Draft Report**

### Oakland Bay TMDL Approach

Be able to predict the concentrations observed at WA State Dept. of Health stations.

Establish target reductions at the tributary mouths

- Meet freshwater standards at the mouths
- Marine standards within the bay

**Example of Data from the Draft Report**

### Oakland Bay TMDL Report Conclusions

Meet marine standards at the mouths of all creeks and outfalls discharging directly to the bay.

Eliminate all human sources, particularly areas established by the MST study.

Implement BMPs to reduce fecal coliform bacteria and sediments at all potential sources; including DOT outfalls.

Monitor for enterococci in the Inner Shelton Harbor to evaluate 303(d) listing.

MST: Microbial Source Tracking
BMPs: Best Management Practices
DOT: WA State Dept. of Transportation

3

## Allocations

Waste Load Allocations (WLA) - are allocations for **point** sources of pollution

- End of pipe discharge
- Usually from a facility such as a wastewater treatment plant or a factory

## Allocations
(continued)

Load Allocations (LA) - allocations from **nonpoint** sources of pollution

- They come from diverse sources
- The exact source not easily determined

Examples: Failing septic systems, pet waste, pasture runoff

## 2008 Water Quality Assessment


www.ecy.wa.gov/programs/wq/303d/2008/index.html


## Implementation Actions

- Continue water quality monitoring
- Low impact development projects
- Riparian restoration projects
- Seek funding
- On-site septic system workshops
- Technical assistance with best management practices
- Investigate & respond to water quality complaints
- Develop educational materials
- Land acquisitions for preservation
- Maintain pet waste stations
- On-site septic sanitary surveys
- Look for potential sources of fecal coliform bacteria

## Fecal Coliform

***What are they?***

A group of bacteria found in the feces *(poop)* of warm-blooded animals. This includes people, livestock, pets, and wildlife.

## Sources of Fecal Coliform

- Pet waste
- On-site septic systems (failing)
- Livestock waste (poor management)
- Sanitary practices from recreational activities

## *What happens when fecal coliform levels are too high?*

**Health Impacts:** *You can get sick!* Illness causing viruses and bacteria can cause upset stomach, diarrhea, ear infections, and rashes.

You can get exposure to these bacteria by skin contact, drinking water, or eating contaminated fish and shellfish.

If we find these bacteria, we might also find more serious disease-causing bacteria and longer-lived viruses.

## *What happens when fecal coliform levels are too high?*

**Shellfish:** They can concentrate fecal coliform and bacteria from the water around them.

**Overgrowth of Plants:** They can deplete oxygen in the water which is needed by fish, affect pH of the water, create odor problems, interfere with recreational activities, affect property values.

## *How can **you** help reduce fecal coliform contamination?*

**Pet Waste**
✓Pick it up
✓Bag it
✓Put it in the trash

**On-site septic systems**
✓Keep them working properly
✓Identify and fix problems
✓Get routine inspections

**Livestock**
✓Manage them to keep them away from direct access to a stream or lake.
✓Cover manure piles to protect them from rain and surface run-off.

## *What is included in the report?*

Technical Study
Identifying problem
Identifying locations
*It's the science piece!*

Water Quality Improvement Report
What do we need to work on?
Where are the problem areas?

Water Quality Implementation Plan
What actions are needed?
Who will do them?

## Public Comment Period

- Started May 9 and goes through June 8, 2011
- Display ads published in the Shelton/Mason County Journal
- Information provided to KMAS Radio and posted on MasonCountyDailyNews.com
- Posted on Ecology's website. *(Pending)*
- E-mail Distribution Lists
- Public meeting in Shelton

DEPARTMENT OF ECOLOGY

## Draft Copies Available

**Shelton locations:**

**Shelton Timberland Regional Library**
710 W. Alder St.
Shelton, WA 98584

**Mason County Public Health**
415 North 6th St.
Shelton, WA 98584

DEPARTMENT OF ECOLOGY State of Washington

**Department of Ecology Southwest Regional Office**
300 Desmond Dr. SE
Lacey, WA 98503

**New!**
It is now posted on
**Ecology's website** at
http://www.ecy.wa.gov/biblio/1110039.html

## *What next?*

✓Comments accepted through June 8, 2011
✓Response to comments prepared
✓Oakland Bay Fecal Coliform TMDL completed
✓Submitted to EPA by June 30, 2011

- Starting soon! Continue work on the Oakland Bay Temperature TMDL

DEPARTMENT OF ECOLOGY State of Washington

## For more information…

DEPARTMENT OF ECOLOGY State of Washington

Lydia C. Wagner
Department of Ecology
Water Quality Program
Southwest Regional Office
P.O. Box 47775
Olympia, WA 98504-7775
Office: 360-407-6329
E-mail: Lydia.Wagner@ecy.wa.gov

E-mail Me


DEPARTMENT OF ECOLOGY State of Washington

# Appendix M.  Oakland Bay Action Plan

# Oakland Bay Action Plan

A committee of citizens, business representatives and staff from city, county, state and tribal government is launching a broad-based, community plan in order to:

- Reduce water pollution.
- Ensure the county's waters remain safe for swimming, fishing and all activities important to the culture, heritage and economy of the area.

August 16, 2007

Prepared by Stephanie Kenny
Environmental Health Specialist
Mason County Public Health
360-427-9670
smk@co.mason.wa.us

This document is also available online:  www.co.mason.wa.us

# Table of Contents

# A. Purpose of the Action Plan

## Background

In November 2006, the Washington State Department of Health restricted the north end of Oakland Bay for shellfish harvesting. The Restricted classification means that direct harvest of shellfish is not allowed. Shellfish must be moved to an Approved or Conditionally Approved area to cleanse and become safe for human consumption before it is harvested. One shellfish grower is currently affected by this restriction.

All other areas of Oakland Bay remain in an unchanged status – either Conditionally Approved or Prohibited for shellfish harvest at this time, though the Chapman Cove area is very close to receiving a downgrade.

Because the ends of inlets tend to be more sensitive to water quality pollution than other areas, this reclassification of the end of Oakland Bay could be an indicator of overall water quality problems that will eventually affect many other growers and citizens who use the bay.

Oakland Bay is a unique area with many uses and needs that must be carefully balanced in order to preserve natural resources, aesthetics and tradition while providing for growth, recreation and employment opportunities. Degraded water quality in the area indicates not just a loss of shellfish revenue and jobs but an impaired environment, lost recreational opportunities and, overall, a loss to the culture and heritage of the community.

**Who is involved?**

In compliance with RCW 90.72.045 Mason County developed this action plan as a response to the November 2006 closure so that the County and its citizens could provide leadership in improving the water quality of Oakland Bay. Mason County took the lead in creating this plan. However, it is a coordinated multi-strategy plan that is a collaboration of all who are affected by the Oakland Bay downgrade.

These parties include:

- The citizens of Mason County
- Mason Conservation District Mason County Shellfish Growers
- Squaxin Island Tribe
- United States Environmental Protection Agency
- Washington State Department of Health
- Washington State Department of Ecology
- Washington State Department of Agriculture
- Puget Sound Partnership
- Mason Conservation District
- City of Shelton
- Washington State University Mason County Extension
- University of Washington Sea Grant Program., University of Washington

The Oakland Bay Action Plan represents our understanding of the work that must be done and who will be responsible. While the document establishes the initial framework of the plan, we expect to expand and adapt it to the needs of the county throughout the course of the project.

***Legal Notice:*** *If any portion of this plan is found, for any reason, to be invalid or unconstitutional by any court of law, those portions will be considered a separate provision of the plan and will not affect the validity of the rest of the plan.*

# B. Background information and history

## Description of the Oakland Bay Watershed

**Physical Description:** Oakland Bay is a small, relatively broad and shallow estuary approximately four miles long and ¾ of a mile wide with water depths averaging 10-35 feet. A large area of the foreshore is exposed to air at low tides. This inter-tidal zone is predominately mud flats with narrow deeper channels. Due to the restrictive nature of Hammersley Inlet, the long narrow waterway linking the bay to the Puget Sound Basin, the water in Oakland Bay has high refluxing, low flushing and high retention rates. There are nine major creeks: Deer, Cranberry, Campbell, Johns, Uncle John, Malaney, Shelton, Mill and Goldsborough. The drainages of these creeks, together with the shoreline drainage have been used to define the Oakland Bay Action Plan Focus Area. See Figure M-1. For detailed information about the watershed the Kennedy-Goldsborough Watershed (WRIA 14) Phase II Level 1 Assessment (Golder, 2003) is a recommended source.

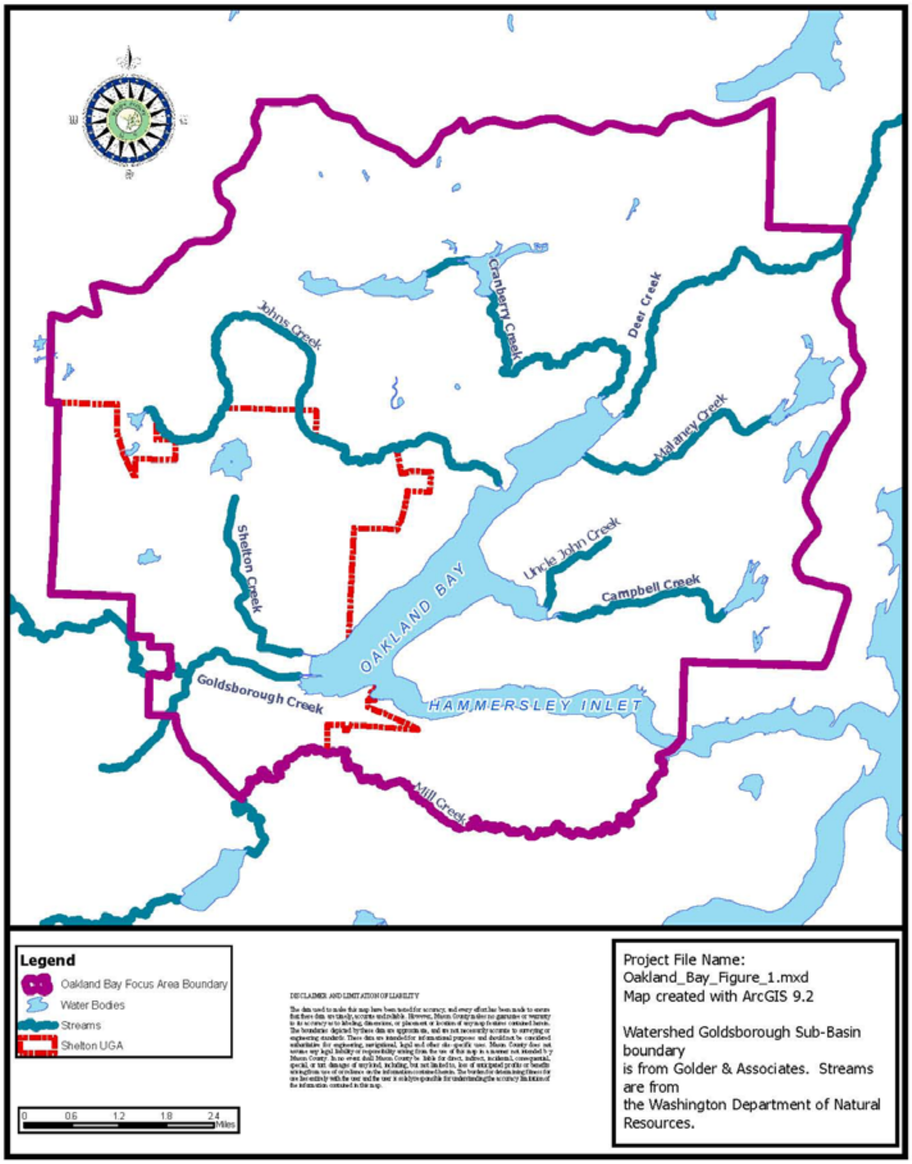



**Figure M-1. Oakland Bay Focus Area**

**Squaxin Island Tribal Involvement**: The area is home to modern Squaxin Island Tribe members, who are descended from maritime people who lived and prospered along the shores of Oakland Bay for thousands of years. Squaxin leaders signed the Medicine Creek Treaty with the U.S. Government in 1854, reserving the right to hunt, gather and fish at all usual and accustomed places including Oakland Bay. As a result, Tribal scientists now co-manage natural resources in Oakland Bay with the State of Washington. The federal government also maintains a trust responsibility for Tribal interests in Oakland Bay.

**Growth and development expectations:** Development on the shoreline and upland areas of Oakland Bay is gradually expanding. Most development in the area is residential with some industry and commercial activity, especially along the west and south sides of the bay. In most of the area on-site sewage systems treat residential waste. The Shelton Wastewater Treatment Plant serves all residences and commercial establishments within its service area along the south end of the bay. About 102 agricultural activities with potential to impact the growing area are located in the watershed (Berbells, 2003). One marina is located in the watershed.

## History of shellfish harvesting and water quality issues in the Oakland Bay Shellfish Growing Area

*The Oakland Bay Growing Area, as delineated by Washington State Department of Health, is located to the northeast of a straight line, drawn from approximately 0.2 miles northeast of Munson Point. See Figure M-2.*

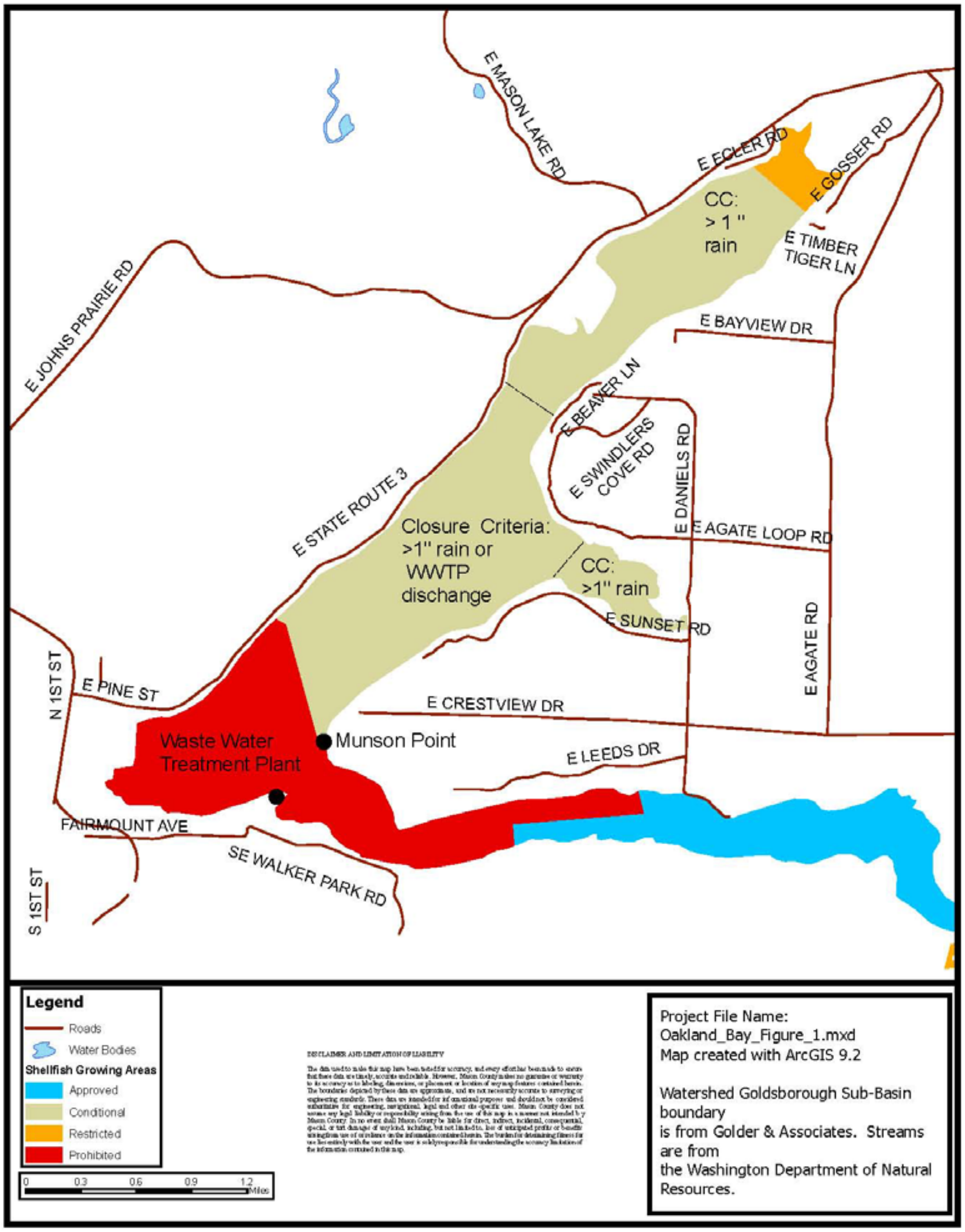



**Figure M-2. Oakland Bay Growing Area**

Currently, Oakland Bay is one of the most productive commercial shellfish growing areas in the country. Much of the nation's manila clam harvest is grown here, as well as high-value oysters. Approximately three million pounds of clams and 1.8 million pounds of oysters are harvested yearly. There are 21 shellfish growers in Oakland Bay in addition to the Squaxin Island Tribe. Some of the public and private beaches in the area support recreational shellfish harvesting. Approximately 2000 recreational harvesting licenses are obtained for the area each year.

**Timeline**

1880s: Oyster production becomes a valuable local commodity (Deegan, 1960)

1927: A pulp and paper mill starts operation on the Shelton waterfront. The pulping process produces sulfite liquor, a waste product that is released into the nearby water body.

1930: Oyster growers sue the mill owners for damages to their harvest. Improved industrial practices eventually lead to recovery of the harvest.

1955: Oakland Bay is approved for commercial shellfish harvest through Washington State Department of Health. At this time, Oakland Bay is probably classified as conditionally approved due to sewer impacts, but sewer improvements are later made.

*1957: The pulp and paper mill closes.* This is the beginning of significant environmental recovery for the area.

1978: Chapman Cove and northward is classified as approved; the rest is prohibited from shellfish harvesting.

1986: Washington Department of Health changes its classifications methods. The upper portion of the bay receives a classification change to conditional approval. The prohibited line for sewer may have been moved southward at this time.

1987: The Washington Department of Health downgrades 820 acres of shellfish beds in southern Oakland Bay from Conditionally Approved to Restricted after finding fecal coliform bacteria. *This leads to a surge of activities to identify, prevent and eliminate sources of shellfish bed contamination. The Oakland Bay Watershed Management Plan is developed with local, state and tribal participation. A number of grants are funded to both make capital improvements and educate the area residents. Over the next several years, the recommendations of that plan are partly carried out, but there are still major barriers to full implementation, including lack of staff time, money and citizen response.*

1989: The Washington Department of Health reverses its downgrade after improvements are made. (See *Measuring Results Project*, July 1993). *In the end, some of the funding did result in lasting capacity, but because long-term and consistent funding is not provided, many of the water quality improvement efforts ended.*

*2006: Fifty-five acres at the north end of the bay are downgraded to Restricted by Washington State Department of Health.* In addition, Chapman Cove was listed as threatened.

*2007: Current Status of Oakland Bay.* Oakland Bay has approximately 1434 acres classified as Conditionally Approved**.** Fifty- five acres at the north end of the bay are classified as Restricted. In addition, 774 acres to the south are classified as Prohibited due to Shelton Wastewater Treatment Plant discharge. Rainfall of one inch or more in 24 hours triggers a five-day shellfish harvesting closure throughout the Conditionally Approved area. A discharge of inadequately treated or raw sewage into the bay by Shelton Wastewater Treatment Plant would trigger a five-day closure of the central portion of the bay. The Shelton Wastewater Treatment Plant will be upgraded by 2010 in order to protect and improve the health of the bay.

## Previous Efforts to Prevent Water Quality Degradation in Oakland Bay

Many water quality improvements have been undertaken in the Oakland Bay watershed over the years, including:

- Improved industrial waste management.
- A number of upgrades to the Shelton Wastewater Treatment Plant.
- More stringent storm water requirements.
- Sanitary surveys.
- Repairs of on-site sewage systems.

All of these steps helped to preserve the health of Oakland Bay in the past. These same measures need to be reassessed for their value to our new action plan.

## Current Oakland Bay water quality research and improvement efforts

Typical non-point sources of pollution in the Oakland Bay area include on-site sewage systems, storm water, livestock, pets, and wildlife. Here are some of the current efforts underway to pinpoint pollution sources and develop clean-up plans:

**Squaxin Island Tribe and Mason County Public Health:** Routine and intensive water quality sampling in the area.

**Mason County Public Health:** Sanitary surveys and dye testing of on-site systems in the north Oakland Bay and Chapman Cove areas.

**Washington State Department of Health and Squaxin Island Tribe:** Circulation studies in north Oakland Bay and added interim sampling stations.

**United States Environmental Protection Agency, Washington State Department of Health and Squaxin Island Tribe:** A microbial source tracking study in the area.

**Washington State Department of Ecology:** Extensive water quality sampling study to develop a pollution clean-up plan for Oakland Bay and Hammersley Inlet.

**Mason Conservation District:** Has written conservation plans, provided technical and financial assistance to landowners for installation of Best Management Practices to reduce pollutants from entering Oakland Bay. Best Management Practices have been monitored by Mason Conservation District to determine effectiveness.

**Washington State University Mason County Extension:** Public education and involvement programs. Mason Conservation District and Mason County Public Health also conduct educational programs both independently and in partnership with each other and WSU.

**Washington Sea Grant Program, University of Washington:** Several educational programs offered to area residents.

**City of Shelton and Mason County Utilities and Public Works:** The city and county are working together to decrease sources of pollution and will jointly implement a plan to reduce pollution (NPDES 2). City of Shelton also has a Goldsborough Creek source reduction project.

**Grass-roots citizen and business efforts in Mason County:** Many community members have, on their own initiative, taken measures to improve water quality on their private property:

- Some community members have performed operation and maintenance on their septic systems to check that the systems are functioning appropriately.
- Others have adopted new landscaping practices to prevent polluted storm water runoff.
- Several agricultural producers have made changes on their properties to protect both their private land and the water quality in greater Oakland Bay.

These grass-roots efforts demonstrate the stewardship ethic among Oakland Bay Watershed residents that we must continue to recognize and nurture. Citizens who take the initiative are at the leading edge of protecting the Oakland Bay community, its economy, and its water quality.

## C. Our ten-point strategy for improving the water quality in Oakland Bay:

**Goal:** To take immediate steps, through the Oakland Bay Action Plan Strategy to:

- Reduce water pollution.
- Meet state and federal water quality standards.
- Ensure that water quality improvements are maintained.

### 1. Identify accountable government agencies, create an action plan and establish performance measures.

Since the fall of 2005, a number of key stakeholders have come together to coordinate a response to the threatened shellfish downgrade in the north end of Oakland Bay. Those efforts have included intensive sampling, outreach, and investigation of problem areas.

In the wake of the November 2006 downgrade, the Washington State Department of Health convened an initial core response group meeting on February 13, 2007, which included these representatives:

- Washington State Department of Health
- Puget Sound Action Team
- Washington State Department of Ecology
- Squaxin Island Tribe
- Mason County
- Mason Conservation District
- Washington State University Mason County Extension
- Washington Sea Grant Program, University of Washington
- Local shellfish growers

With Mason County Board of County Commissioners acting as the lead, this group, along with additional stakeholders, will continue to work together to develop and carry out a response to the downgrade. Recognizing the need for rapid and defined action, the core response group will develop a strategy that will:

- Identify immediate and long-term actions.
- Provide performance measures.
- Identify objectives.
- Provide target dates and an overall timeline.

Once the strategy is developed, the Oakland Bay Action Plan Committee will:

- Designate, through the Mason County On-Site Septic System Plan, an Oakland Bay marine protection area.
- Provide the community and all other stakeholders with regular updates of work related to the plan.

## 2. Identify the Oakland Bay Focus Area boundaries, set up a governing structure and a way to fund its work

Mason County Board of County Commissioners is required by state law (RCW 90.72) to establish a shellfish protection district and program to correct the pollution that led to the Department of Health's water quality downgrade. An additional goal of the plan is to prevent future downgrades.

On May 15, 2007, the Mason County Board of County Commissioners adopted the Oakland Bay Focus Area and defined its boundaries. The Action Plan Committee now will develop a system of governance that agrees on the governing principles, determines the voting structure, and establishes methods of addressing performance deficiencies. A variety of funding options such as sales tax, public health money, and private funding are being identified.

**To achieve these goals:**

- The Oakland Bay Focus Area was created.
- A system of governance will be adopted.
- A financial strategy will be developed.
- Feasibility of septic or sewer districts will be assessed.

## 3. Develop community and private partnerships, involve all citizens, and create a plan for evaluating our success.

We believe that we can bring about lasting change if we involve more local citizens and businesses, as well as other stakeholders. We will schedule public outreach meetings and invite comment on this plan. We will create educational activities in the communities that will raise awareness of water quality problems and increase the community's engagement in solving them.

**To achieve these goals:**

- Area landowners have been invited to be part of the Action Plan Committee.
- An Oakland Bay Action Plan open house will be held to provide the public with a chance to learn about the draft action plan. Educational displays, opportunities for interactions with educators, presentations and reading materials will be provided
- After the Action Plan is finalized periodic additional open houses will held to educate and update the community on progress.

## 4. Monitor Oakland Bay water quality, survey its shorelines and upland areas, and conduct research.

The Oakland Bay Action Plan is both a short-term project that responds to the immediate problems affecting the shellfish growing area and a long-term plan to maintain water quality in Oakland Bay.

**To achieve these goals:**

- Washington State Department of Health will increase to 30-35 a year the number of fresh and marine samples taken in order to rapidly assess any changes in water quality.
- Mason County Public Health will conduct regular shoreline and on-site system sanitary surveys and segment streams within the Oakland Bay watershed. These surveys will help target further investigations and corrective actions.
- Mason County Public Health will increase its efforts in septic operations and maintenance, both in regulatory and educational capacities.
- Squaxin Island Tribe will continue to sample major streams, investigate the role of sediment as an incubator of bacteria in marine water, and use a Geographical Information System (GIS) to analyze all the data collected.
- The Squaxin Island Tribe will conduct an additional Upper Oakland Bay Circulation study.
- The need for special studies will be researched when warranted.
- Washington State Department of Ecology using this Action Plan as a foundation, will create a longer-term plan for restoring impaired tributaries and the Bay itself to water quality standards. Implementation of the two plans will be integrated. Ecology will conduct future monitoring of fresh and salt water. to track progress toward water quality goals.
- The U.S. Environmental Protection Agency will conduct a Phase II Microbial Source Tracking study.

## 5. Identify and establish strategies to correct agricultural sources of water contamination.

To control new pollution sources, the Mason County Department of Community Development will require any application for a new agricultural building permit to go through the conservation planning process with Mason Conservation District or Mason County Environmental Permit process. They will also respond to water quality complaints that involve land use in critical areas.

Washington State Departments of Ecology (ECY) and Agriculture (AG) will coordinate their investigations of agricultural water quality complaints. If landowner's agricultural management practices threaten water quality, ECY and AG will refer the landowner to Mason Conservation

District. The Mason Conservation District staff will consult with landowners to identify existing and potential threats to water quality and available solutions through their conservation planning process. If there is an immediate threat to water quality, or the landowner is unwilling to work with Mason Conservation District or does not adopt practices to remove the threat to water quality, Departments of Ecology and
Agriculture will take appropriate enforcement actions.

Contact the Ecology/ Agriculture Complaint line by calling: (360) 407-6300.

**To achieve these goals:**

- Mason Conservation District will continue to provide technical help to agricultural landowners.
- Citizens applying for agricultural building permits will be required to go through a Mason Conservation District Conservation Plan or Mason Environmental Permit process.
- Mason Conservation District will seek funding for an Anaerobic Digester in the watershed.
- Washington Departments of Ecology and Agriculture will respond to animal feeding operation or pasture-based water quality complaints.
- Mason County Department of Community Development will respond to water quality complaints that involve land use in critical areas.

## 6. Identify and establish strategies to correct on-site sewage system water contamination sources

**Mailing campaign.** Mason County Public Health staff will research and target existing septic systems that are not being serviced, then create a mailing campaign to educate residents about how to properly operate and maintain them. Mason County Public Health is using its Operation and Maintenance database mapping technology to generate both a visual and tabular inventory of the properties within the Oakland Bay Focus Area. This database will generate GIS maps of the project area that will show developed lots with documented septic systems -- as well as developed lots with undocumented sewage disposal. Mason County Public Health will follow up with surface water sampling of properties without a maintenance report if needed.

**Shoreline and stream sampling** will complement the Operation and Maintenance program by helping to detect on-site sewage system sources of pollution that are not observed during service inspections. If sampling indicates a need, an on-site sanitary survey will be conducted. During sanitary surveys, Mason County Public Health staff members interview residents about wastewater generation, construction or land-disturbing activities on the property, and other activities that may affect the septic system.

**On-site evaluations and testing.** During on-site surveys, staff member also walk the property with residents to identify system components, evaluate the general state of the system area, and educate the residents on the proper use and maintenance of the septic system. If the situation warrants and the residents are willing, Mason County Public Health staff can also introduce a dye into the system to test for system failure. The dye can be detected in marine or fresh water by means of charcoal filter bags. The county will direct property owners with failing systems to a low-interest loan program so they may repair and upgrade their systems. Enforcement will be used if needed.

**Code changes.** Mason County Public Health will be adopting code changes as part of their new On-site Sewage System Plan. It also will periodically assess the need upgrade treatment standards and promote upgrades of existing on-site sewage systems.

**To achieve these goals:**

- Mason County Public Health will:
  - Conduct parcel research.
  - Conduct regular, on-site system sanitary surveys along the shoreline.
  - Develop a risk-based timeline for responding to maintenance report problems other than failures (which are responded to under the complaint timeline).
  - Dye trace as needed, with follow-up sampling and referral to enforcement, if necessary.
  - Conduct regular Operation and Maintenance program notification, monitoring, recording and follow-up for all on-site systems.
  - Update On-Site System Enforcement Codes.
- Puget Sound Partnership and others will help to periodically assess the feasibility of, and need for, nitrogen/phosphorus removal.
- Washington Sea Grant and partners will promote the upgrading of components in existing on-site systems to improve operation & maintenance.

## 7. Identify and establish strategies to correct other potential, non-point water quality contamination sources such as pet waste and wildlife.

**To achieve these goals:**

- Mason County and the City of Shelton and partners will establish a pet waste control program and install pet waste stations in area parks.

## 8. Identify land use and growth management policies that will protect, preserve and restore Oakland Bay's water quality.

Well-planned growth is essential to improving water quality and protecting the health of Oakland Bay.

**To achieve these goals:**

- Mason County Departments of Public Health, Community Development, Utilities and Public Works will, as needed, review and implement ongoing policies supported by oversight and enforcement.
- Property acquisition into conservancy will be sought.
- Mason County Department of Community Development will:
  - Develop incentives for natural shoreline protection.
  - Require small parcel storm water site plans.
  - Evaluate the need for special overlay protection within the closure area.

- Mason County Departments of Utilities and Public Works, and the City of Shelton will develop a cooperative city and county storm water plan.
- Mason County Public Works will improve storm water code enforcement.
- Washington State Department of Transportation will reduce bacterial conveyance from Highway 3 storm water discharges.
- City of Shelton will improve the function of Goldsborough Creek through Critical Area Ordinance changes and special projects.
- City of Shelton will implement NPDES 2 requirements.
- Mason County storm water ordinance will include low-impact development standards.

## 9. Establish enforcement elements for the plan

Enforcement tasks are part of many objectives in this plan. Mason County Public Health will take the following steps to contribute to the success of this plan:

- Develop a non-point ordinance.
- Update its Environmental Health Enforcement Policy and Procedures.
- Review the Oakland Bay Action Plan to make sure it is consistent with the Administrative Plan required under RCW.70.118.030.

## 10. Create a system for evaluating the success of the plan.

The Oakland Bay Action Plan must establish goals that can be measured in order to track progress toward the objectives. If we are not accomplishing our goals or achieving our objectives, we will re-evaluate and make changes.

**To achieve these goals:**

- The Oakland Bay Action Plan Committee will establish goals we can measure to see if our efforts are working.
- Measure progress regularly and evaluate if goals and objectives are being met.
- Review and revise the Action Plan if the goals and objectives are not reached.

## Attachment 1. National Water Quality Standards for Shellfish harvesting

To be approved for commercial shellfish growing under the National Shellfish Sanitation Program (NSSP) standards, a station must have a fecal coliform geometric mean not greater than 14 organisms/100mL, and an estimate of the 90th percentile not greater than 43 organisms/100 mL. Alternative NSSP standards are applied to stations in the central area of the bay because they are potentially influenced by Shelton Wastewater Treatment Plant. These stations must have a fecal coliform geometric mean not greater than 14 organisms/100mL, and no more than 10% of the samples greater than 43 organisms/100 mL.

Fecal coliform bacteria, a subset of coliform bacteria, are found in the feces of all warm-blooded animals including humans, livestock, other mammals, and birds. Although most fecal coliform bacteria do not cause disease, they are commonly used as an indicator of microbial contamination of water. Filter-feeding shellfish retain fecal coliform bacteria and other microorganisms, which do not harm the shellfish themselves but can cause disease in humans who eat the shellfish. Water-borne pathogens can also infect people by pathways other than shellfish consumption, such as recreational contact with the water.