2011
LUMMI NATION
WATER QUALITY ASSESSMENT REPORT
JUNE 28, 1993 TO DECEMBER 31, 2011

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EXECUTIVE SUMMARY

The goals of the Lummi Nation Surface Water Quality Monitoring Program (Program) are to:

a) Document ambient water quality and water quality trends on the Lummi Indian Reservation (Reservation);
b) Evaluate regulatory compliance of waters flowing through and onto the Reservation, including compliance with Lummi Nation Surface Water Quality Standards; and
c) Support the development and implementation of water quality regulatory programs on the Reservation.

The purpose of this report is to:

a) Present the surface water quality data collected during the calendar year 2011;
b) Compare the 2011 results to data from the period of record;
c) Present interpretations of these data with respect to the Program goals; and
d) Provide the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

The Reservation consists of approximately 38 miles of marine shoreline and 7,000 acres of tidelands. Water quality on the Reservation is complex for several reasons. It is located in the estuaries of the Lummi River and the Nooksack River where marine and fresh water interact; the water column may have varying degrees of salinity-based stratification. In addition, water can flow upstream, downstream, or be stagnant at many of the sampling sites depending on the tides and weather conditions. Upland sites become saline or dry during the summer months as the dry season progresses. Once the wet season begins during October or November, upland flow increases, diluting many of the saline monitoring sites with freshwater.

The water quality parameters measured at the monitoring sites during 2011 generally followed the trends of 2003 through 2010 with elevated bacteria levels, higher temperatures, and lower dissolved oxygen levels compared to the Lummi Nation Water Quality Standards (LWRD 2008a). Fecal coliform bacteria levels in the mainstem of the Nooksack River at the Reservation border (SW118) were improved during 2011 compared to the trends of the 2003 through 2007 period. However, data show both the geometric mean and 90th percentile fecal coliform bacteria levels increased in 2011 compared to 2010. Even with the increase in fecal coliform bacteria levels, Site SW118 achieved the Total Maximum Daily Load (TMDL) target of a geometric mean of 39 coliform forming units per 100 milliliters established for the lower Nooksack River (Ecology 2000 and 2002) and met the fecal coliform water quality standards for Class AA freshwater bodies in 2011.

The marine waters of Lummi Bay and the Sandy Point Marina continue to have relatively good quality, while the surface waters within the Lummi River and Jordan Creek watershed continue to have the poorest water quality of the sites sampled on the Reservation. Sampling of the Nooksack River indicated variable water quality with elevated fecal coliform bacteria readings during 2011 that are a cause of concern even though improvements were observed compared to the 2003 through 2007 period. The decreased levels of fecal coliform bacteria in the Nooksack River and in Portage Bay are a positive indication that the technical assistance and enforcement actions in the Nooksack River Basin are helping improve water quality. The continuing poor water quality in the Lummi River and tributaries to Lummi Bay, particularly with respect to increased fecal coliform bacteria contamination, is a major concern due to the potential for new closures of important tribal shellfish beds. The members of the Lummi Nation use these shellfish beds for ceremonial, subsistence, and commercial purposes.

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1. INTRODUCTION

The purpose of this introductory section is to present the goals of the Lummi Nation Surface and Ground Water Quality Monitoring Program (Program), identify Program staff changes during the reporting period, summarize Program improvements during 2011, and provide an outline of the report contents.

1.1. Purpose Statement

The Program was initiated in June 1993 to establish the ambient conditions of the Lummi Indian Reservation (Reservation) surface waters, which are a component of the Lummi Nation Waters. This information is used to evaluate regulatory compliance of waters flowing through and onto the Reservation including compliance with Lummi Nation Surface Water Quality Standards (LWRD 2008a); to identify and track water quality trends; and to support the development and implementation of water quality regulatory programs on the Reservation.

The purpose of this report is to describe the Lummi Nation Water Quality Program and to present the surface water quality data collected during calendar year 2011; compare the 2011 results to data from the period of record, and present interpretations of these data with respect to the Program goals. This report is also intended to provide the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

This report contains data collected pursuant to associated work plans and grant agreements between the Lummi Nation and the EPA. The data collected between January 1, 2011 and December 31, 2011 are presented in tabular form in Appendix A. These data were exported to EPA's Water Quality Exchange Network (WQX) on March 19, 2012. The data collected over the period of record is expected to be exported to WQX by December 31, 2014.

1.2. Program Staff Changes

Although the Water Resources Manager of the Lummi Water Resources Division (LWRD) of the Lummi Natural Resources Department (LNR) is responsible for the overall success of the Program, operation of the Program is delegated to the Water Resources Specialist. In the past, the Water Resources Specialist supervised a Water Resources Technician, who performed most of the water quality sampling and data entry. The Water Resources Specialist left LNR during the spring of 2005 after 12 years of service, including the initiation and development of the Program. The Water Resources Technician also resigned during the spring of 2005 after 7 years of service. These positions were filled during the spring and early summer of 2005, but both positions were again vacated during July and August 2006. The Water Resources Specialist position was refilled in October 2006 and the Water Resources Technician position was filled in February 2007. As these two staff members are the primary staff responsible for program implementation, and several months were required each time to select, hire, and train the replacements, substantially fewer water quality samples were collected during 2005, 2006, and 2007 relative to previous and subsequent years.

During the winter of 2008, a GIS/Water Resource Technician III was hired to assist with water quality sampling. Training and familiarization with the program continued during the first half of 2008. During the second half of 2008, the Program stabilized and the frequency of sampling approached the schedule described in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010). During the spring of 2008, the Water Resources Specialist position was again vacated and the position was not re-filled until October 2008. During this period, the Water Resources Technician III was promoted to Water Resource Specialist I and assigned to lead the field data collection elements of the Program. From October 2008 through October 2011, the Program consisted of a Water Resource Specialist I and a GIS/Water Resource Technician III with additional support provided by a Water Resource Specialist II, including completion of the annual Program Water Quality Assessment Reports. In early November 2011 the Water Resources Specialist II resigned and the Water Resources Specialist I became the staff member responsible for leading field collection efforts and for completion of annual Program Water Quality Assessment Reports. In December 2011 a Water Resources Technician III was hired to assist the Water Resources Specialist I and GIS/Water Resource Technician III with field data collection.

1.3. Program Improvements

When the Program was initiated in 1993, the collected data were recorded in field books and lab reports and then transcribed into computerized spreadsheets for analysis. The need to develop a database to manage the collected data was recognized by 1996, but the staff and financial resources needed to develop the database were not available. As more and more data were collected, the need to develop a database became increasingly urgent. Starting in 2005, an effort was initiated to develop improved data storage, management, and analysis capabilities. As part of this database development effort, standardized field data collection forms were also developed to ensure that all of the required data were collected and to facilitate the input of collected data into the database.

The Water Quality Monitoring Database development was largely completed during 2006 (LWRD 2011a) and was initially populated with the water quality data from 2006. Because the historic data could not be directly converted from the spreadsheets into the new database structure, a contractor was hired during 2007 and 2008 to enter all of the surface water quality data for the remainder of the period from 1993 through October 2008 into the new database. This task was completed in October 2008. LNR staff has entered all subsequent data into the database. In late October 2011, a newly developed database interface (front end) was launched that allows users to input 'real-time' data directly into the existing Water Quality Monitoring Database (back end) while the user is still on-site in the field. The new front end interface is optimized for ease-of-use on touch-screen devices and connects to the Lummi Nation servers via the 'Citrix Receiver' application using a 3G internet connection. The ability to remotely enter data into the database eliminates the need to laboriously transcribe data from field sheets at a later date, and allows some metadata (such as sample times and dates) to be automatically populated during the 'real-time' data entry process. This front-end interface, which utilizes an Apple iPad device provides significant time savings, reduces the potential for transcription errors, and makes the results available for use immediately following collection in the field. Paper data collection forms are still carried as a back-up system in case of internet connection loss or if failure of the data entry device occurs during a sampling run.

In 2010, with the addition of continuous water temperature data collection at selected sites throughout the Reservation, it was determined that the Water Quality Monitoring Database, which was not initially designed to manage continuously measured data, would not be able to store continuous monitoring datasets. During 2010, the Lummi Continuous Data Management System database (LNR 2010b) was developed to assist with data management specifically for continuous datasets and has been used to manage continuous temperature data collected from nine surface water sites throughout the Reservation in 2011.

In addition to the databases developed by LNR staff members, a data analysis tool developed by Utah State University (USU) as part of the WRIA 1 Watershed Management Project (http://wria1project.whatcomcounty.org) was available in 2006. The Lummi Water Quality Monitoring database can export data in a format compatible with the USU data analysis tool, the EPA Water Quality Exchange Network (WQX), or the Excel spreadsheet program. The Lummi Water Quality Monitoring and Lummi Continuous Data Management System databases are also able to perform limited analyses of the data. The graphical presentation in this summary report includes products that originate directly or indirectly from these two databases.

Efforts to make the Lummi Nation Water Quality Monitoring Program more accessible to the general public included the development of a LNR website during 2010. The most recent water quality assessment report from 2010, the Quality Assurance Program Plan Version 4.0, user guides for the databases, and other documents are posted on the website (http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=56).

1.4.Report Overview

This report is organized into the following sections.

- Section 1 is this introduction.
- Section 2 is a description of the Lummi Nation Waters and the Lummi Nation’s Water Resources Management Program.
- Section 3 is a description of the surface and ground water quality monitoring objectives.
- Section 4 is a description of the Lummi Nation’s surface and ground water quality assessment methods.
- Section 5 is a summary of the Lummi Nation Surface Water Quality Standards.
- Section 6 presents a comparison of the results from 2011 and the period of record to the Lummi Nation Surface Water Quality Standards and identifies trends in key water quality parameters at representative sites.
- Section 7 is a discussion of the water quality sampling results.

- Section 8 is a summary and conclusion section.
- Section 9 is a list of references cited in this report.

Appendix A presents the 2011 surface water quality data in tabular form. As noted above, these data were exported to the EPA Water Quality Exchange Network (WQX) on March 19, 2012.

2. LUMMI NATION DESCRIPTION

The purpose of this section of the report is to describe the Lummi Indian Reservation location, Lummi Nation Water Resources Management Program, and provide an overview of the Lummi Nation Waters.

2.1.Lummi Indian Reservation

The Lummi Indian Reservation (Reservation) is located in the northwest corner of Washington State (Figure 2.1). The Lummi Nation is a federally recognized Indian tribe with the Lummi Indian Business Council (LIBC) as its governing body. There are more than 4,500 enrolled members of the Lummi Nation. The Reservation is located along the western boundary of Whatcom County, Washington adjacent to Georgia Strait and Puget Sound. The Reservation includes portions of the Nooksack River and Lummi River watersheds, which drain into Bellingham Bay and Lummi Bay respectively. The Nooksack River drains a watershed of approximately 809 square miles, enters the Reservation near the mouth of the river, and discharges to Bellingham Bay (and partially to Lummi Bay during high flows). The Reservation is located approximately 8 miles west of Bellingham, 90 miles north of Seattle, and 60 miles south of Vancouver, British Columbia, Canada. The 2012 Lummi Nation Atlas reported that the total Reservation population was 2,650 people, with approximately 4,650 enrolled tribal members.

The Reservation is comprised of about 12,500 acres of upland and 7,000 acres of tidelands. Approximately 38 miles of highly productive marine shoreline surround the Reservation on all but the north and northeast borders. The Reservation includes the Nooksack River and Lummi River deltas, tidelands, forested uplands, Portage Island, and the Sandy Point Peninsula. Both the Nooksack River and Lummi River watersheds are under environmental pressures from rapid regional growth. The Lummi Nation has also entered a period of economic development under self-governance. Much of the high-density development to date has occurred along the marine shoreline. Construction of a new Tribal Administration building began during 2011 and was completed June 2013, in addition to several other new residential and municipal development projects throughout the Reservation. Growth on and near the Reservation requires that the Nation's core environmental program prioritize the development of a regulatory infrastructure that is technically sound, legally defensible, and administratively efficient. This regulatory infrastructure needs to allow for growth while protecting tribal resources and the Reservation environment. This infrastructure will support both the tribal goals and EPA's policy of tribal self-governance and recognition of sovereignty.

Lummi Indian Business Council resolutions 90-88 and 92-43 directed the Water Resources Division of the Lummi Natural Resources Department to develop a comprehensive water resources management program that ensures that the planning and development of Reservation water and land resources are safeguarded against surface and ground water degradation. Reliable information on the surface and ground water quality of the Reservation is required in order to effectively manage these resources.

The EPA and other federal agencies have previously supported the Nation's assessment of priority water resource needs and the identification of unmet needs. Environmental planning intended to protect the Nation's water resources has included the development and updating of a Wellhead Protection Program (LWRD 2011c), a Storm Water Management Program (LWRD 2011b), a Wetland Management Program (LWRD 2000), a Nonpoint Source Management Program (LWRD 2001, LWRD 2002), and Water Quality Standards for Reservation Surface Waters (LWRD 2008a). These programs are components of the Lummi Nation Comprehensive Water Resources Management Program (CWRMP). Important milestones in the program development effort include the adoption of the Lummi Nation Water Resources Protection Code (Title 17 of the Lummi Code of Laws) during January 2004, the adoption of surface water quality standards in August 2007, and the adoption of four Lummi Administrative Regulations in July 2010. The tribal water quality standards were approved by the EPA in September 2008.

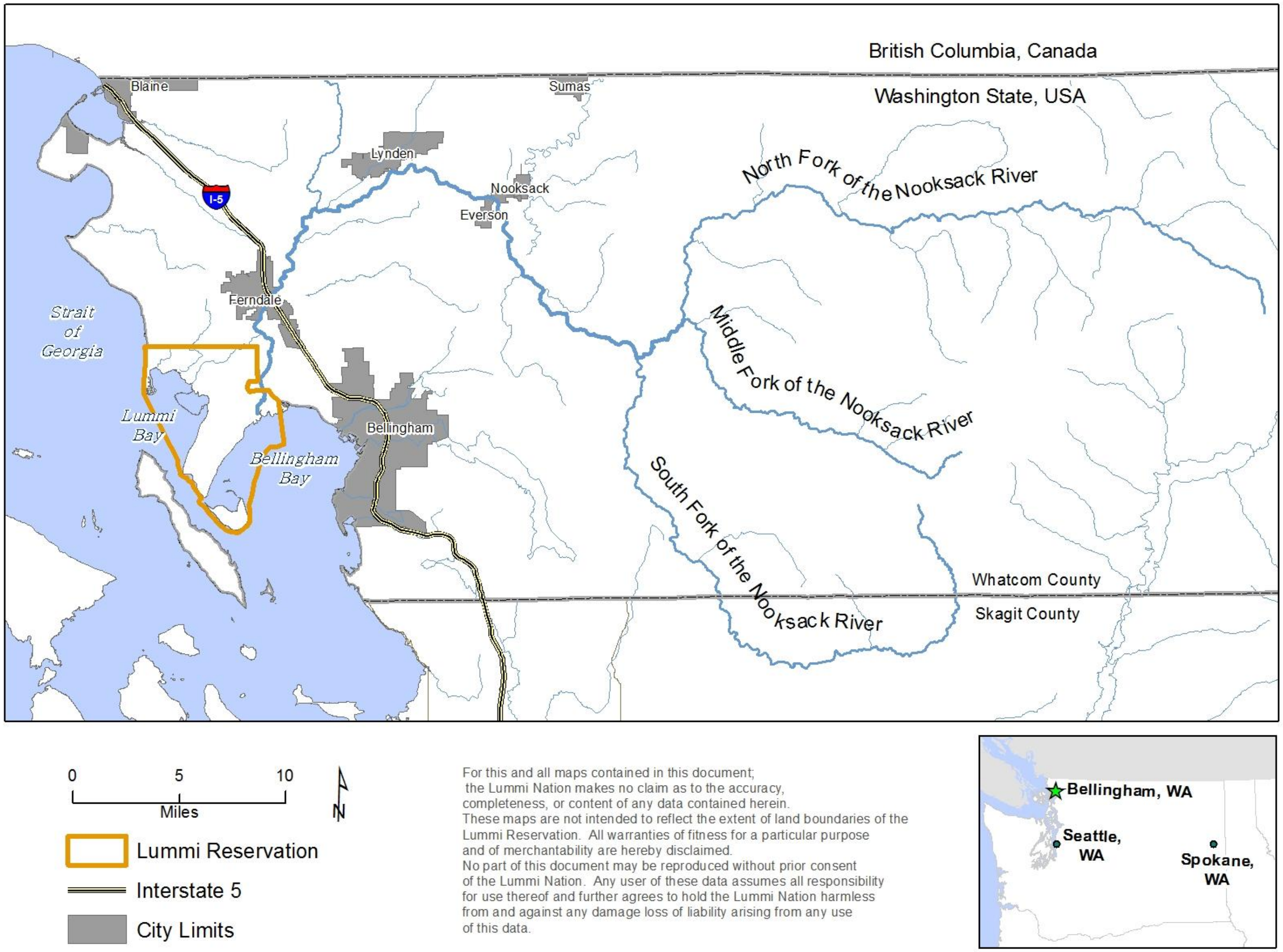

Figure 2.1 Regional Location of the Lummi Indian Reservation

2.2.Lummi Nation Waters

Lummi Nation Waters are all fresh and marine waters that originate or flow in, into, or through the Reservation, or that are stored on the Reservation, whether found on the surface of the earth or underground, and all Lummi Nation tribal reserved water rights (Lummi Code of Laws [LCL] 17.09).

2.2.1. Surface Water

The Lummi Nation is the largest fishing tribe in Puget Sound and has relied on water resources since time immemorial for ceremonial, subsistence, and commercial purposes. There are approximately 38 miles of marine shoreline surrounding most of the Reservation (except portions of the east boundary and the northern boundary). The surrounding tidelands are in the Strait of Georgia, Hale Passage, Lummi Bay, Portage Bay, and Bellingham Bay. In addition to marine waters, there are approximately 24.4 miles of rivers, streams, sloughs, and drainages on the Reservation including the multiple distributary channels of the Nooksack River delta. There are no lakes on the Reservation, but there are approximately 13 ponds. Finfish and shellfish spawn, incubate, and grow within and adjacent to Lummi Nation Waters (LNR 2010a). The Lummi Nation also operates one shellfish and two salmon hatcheries on the Reservation.

Eighteen watersheds are found on the Lummi Reservation. Reservation watersheds were delineated by the Lummi Water Resources Division as “A” through “T” (Figure 2.2) and vary in size from 134 acres up to 4,100 acres (LNR 2010c). The Nooksack River discharges to Reservation tidelands, but most of the approximately 809 square mile Nooksack River watershed is upstream of the Reservation. The 18 watersheds are aggregated into two primary drainage areas: Lummi Bay and Bellingham Bay (Figure 2.3). The Lummi Bay watershed is comprised of nine watersheds: C, H, I, K, L, O, P, Q, and R. It is noted that a portion of Watershed R discharges to Georgia Strait and that a portion of Watershed C discharges to Hale Passage. The Bellingham Bay watershed is also comprised of nine watersheds: A, B, D, E, F, G, J, S, and T. It is noted that all of Watershed A discharges to Hale Passage and that a portion of Watershed D also discharges to Hale Passage. As shown in Table 2.1, 11 of the 18 watersheds are completely within the Reservation boundary. Approximately 0.3 percent of the Nooksack River watershed (Watershed S) is on the Reservation.

There are 11 defined rivers, streams, sloughs, and drainages in the Lummi Bay and Bellingham Bay watersheds. Streams on the Reservation are classified as either Category 1 or Category 2 streams (LCL Title 17.06.080). Category 1 streams are all streams that flow year-round during years of normal rainfall or are used by juvenile or adult salmonids. Category 2 streams are all streams that are intermittent or ephemeral during years of normal rainfall and are not used by juvenile or adult salmonids. Of the eleven defined rivers, streams, sloughs, and drainages, there are six Category 1 streams and five Category 2 streams on the Reservation. All other agricultural ditches and unnamed drainages are classified as Category 2 streams. As shown in Table 2.2, there are approximately 24.4 miles of streams, rivers, sloughs, and drainages on the Reservation. Jordan Creek, Lummi River, Smuggler’s Slough, Slater Slough, Schell Creek, Onion Creek, and Seapond Creek are included in the

Lummi Bay watershed. The Bellingham Bay watershed is comprised of the Nooksack River, Kwina Slough, Lummi Shore Road streams, and Portage Island streams. Five streams, rivers, sloughs, and drainages are completely within the boundaries of the Reservation.

Prior to 1860, the Nooksack River discharged to Lummi Bay rather than to Bellingham Bay (Deardorff 1992, WSDC 1960). The river flow was redirected to Bellingham Bay at that time and currently the Lummi River only receives water from the Nooksack River when the Nooksack River flows exceed approximately 9,600 cubic feet per second (cfs). The Lummi River currently drains much of the area west of the Nooksack River in the vicinity of Ferndale, Washington. The Nooksack River drains most of western Whatcom County, including most of the forested uplands and the developed lowlands.

The Nooksack River flow is comprised of groundwater and precipitation throughout the year supplemented by glacial melt and snowmelt from Mount Baker and adjacent peaks of the Cascade Mountain range during the summer months. The Nooksack River supports several important species of salmon and other aquatic life. The Nooksack River delta is part of the Reservation and is part of an important marine wetland-estuary complex. There are water quality and water quantity challenges in the Nooksack watershed due to land development and agriculture. Whatcom County, which includes all of the lowlands in the Nooksack River watershed, had 167 dairy operations in 2005. All or portions of approximately 220 acres of tribal shellfish beds in Portage Bay were closed to commercial harvest over the November 1996 to May 2006 period due to bacterial contamination attributed to poor dairy nutrient management practices in the Nooksack River watershed (DOH 1997, Ecology 2000).

Nearly all of the water bodies in the Lummi River and Nooksack River floodplains are exposed to marine influences, which include the presence of saline water, salinity-based-stratification (stratification), and upstream flow during high tide. Most of the water quality sample sites are tidally influenced (water level and/or salinity) and have variable water column profiles (e.g., stratified or well-mixed) and salinities. In addition, upland sampling sites become saline or dry during the summer months as the dry season progresses. Once the wet season begins during October or November, flow from the uplands increase, diluting many of the saline monitoring sites with freshwater.

The 1999 comprehensive wetland inventory on the Lummi Reservation (LWRD 2000) indicated that approximately 43 percent (5,432 acres) of the Reservation upland areas are either wetlands or wetland complexes (Figure 2.4). Of these Reservation wetland areas, about 60 percent are located in the floodplains of the Lummi River and Nooksack River. Wetland complexes are areas where wetlands form a highly interspersed mosaic with upland hummocks. During the 1999 wetland inventory, boundaries were drawn around the outer edges of the mosaics and the entire areas labeled as “wetland complexes”. As a result, the estimated wetland area identified in the 1999 inventory generally represents more wetland area than actually exists. All wetland boundaries mapped during the comprehensive wetland inventory are general boundaries based on soil survey mapping and interpretation of color and infrared aerial photographs with some field verification. More accurate wetland boundaries are being delineated on the ground as needed for specific activities and as part of an overall effort to improve the spatial accuracy of the wetland Geographic Information

System (GIS) database. As of 2011, approximately 217 wetlands and 2,993 acres of wetland area have been evaluated as part of the 1999 wetland inventory update (LWRD 2012).

The majority of the estuarine wetlands of the Lummi and Nooksack rivers will be protected and functionally improved through the implementation of the Lummi Nation Wetland and Habitat Mitigation Bank. The mitigation bank is being developed in phases. Implementation of Phase 1A, which encompasses most of the Nooksack River estuary, began in 2011. Enhancement measures like invasive species control and under planting with conifers will improve the ecological functions of the estuary. The mitigation bank will be protected into perpetuity through a conservation easement and used to mitigate unavoidable impacts to habitat and wetlands on the Reservation. Wetland mitigation credits will also be available for purchase within the service area of the bank (LWRD 2008b).

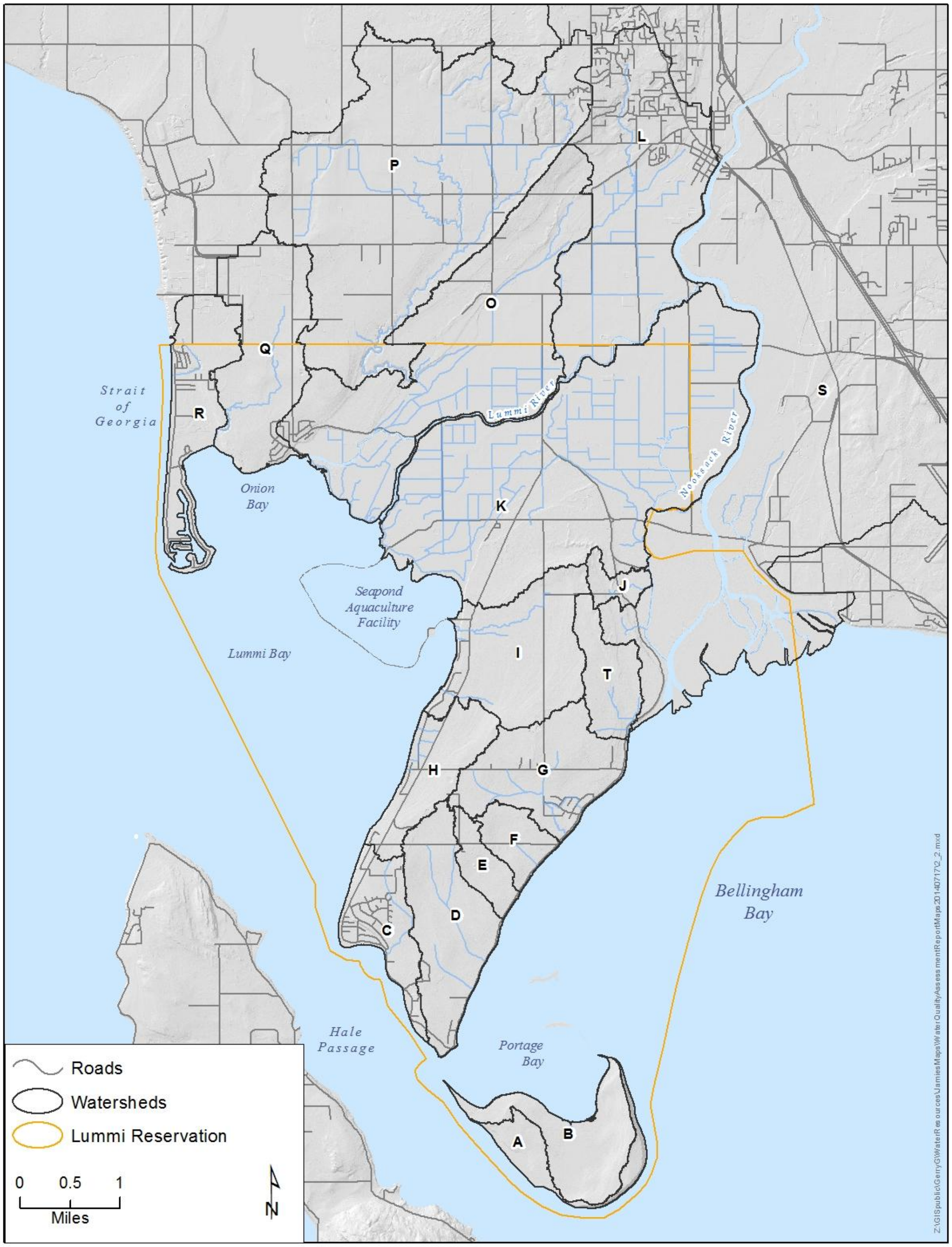

Figure 2.2 Lummi Nation Watersheds

Table 2.1 Acres of Watersheds On-Reservation and Off-Reservation

	Basin ID	Total Watershed Area (acres)	On-Reservation Watershed Area (acres)	Off-Reservation Watershed Area (acres)	On-Reservation Percent of Watershed
Lummi Bay Watershed	C	494	494	0	100
	H	549	549	0	100
	I	1,059	1,059	0	100
	K	4,091	3,354	737	82
	M	Combined with Watershed L			
	N	Combined with Watershed O			
	L	2,307	133	2,174	6
	O	2,747	1,552	1,195	57
	P	4,097	228	3,869	6
	Q	1,096	570	526	52
	R	722	531	191	74
Bellingham Bay Watershed	A	280	280	0	100
	B	617	617	0	100
	D	894	894	0	100
	E	218	218	0	100
	F	251	251	0	100
	G	883	883	0	100
	J	134	134	0	100
	S	518,033	1,296	516,737	0.3
	T	392	392	0	100

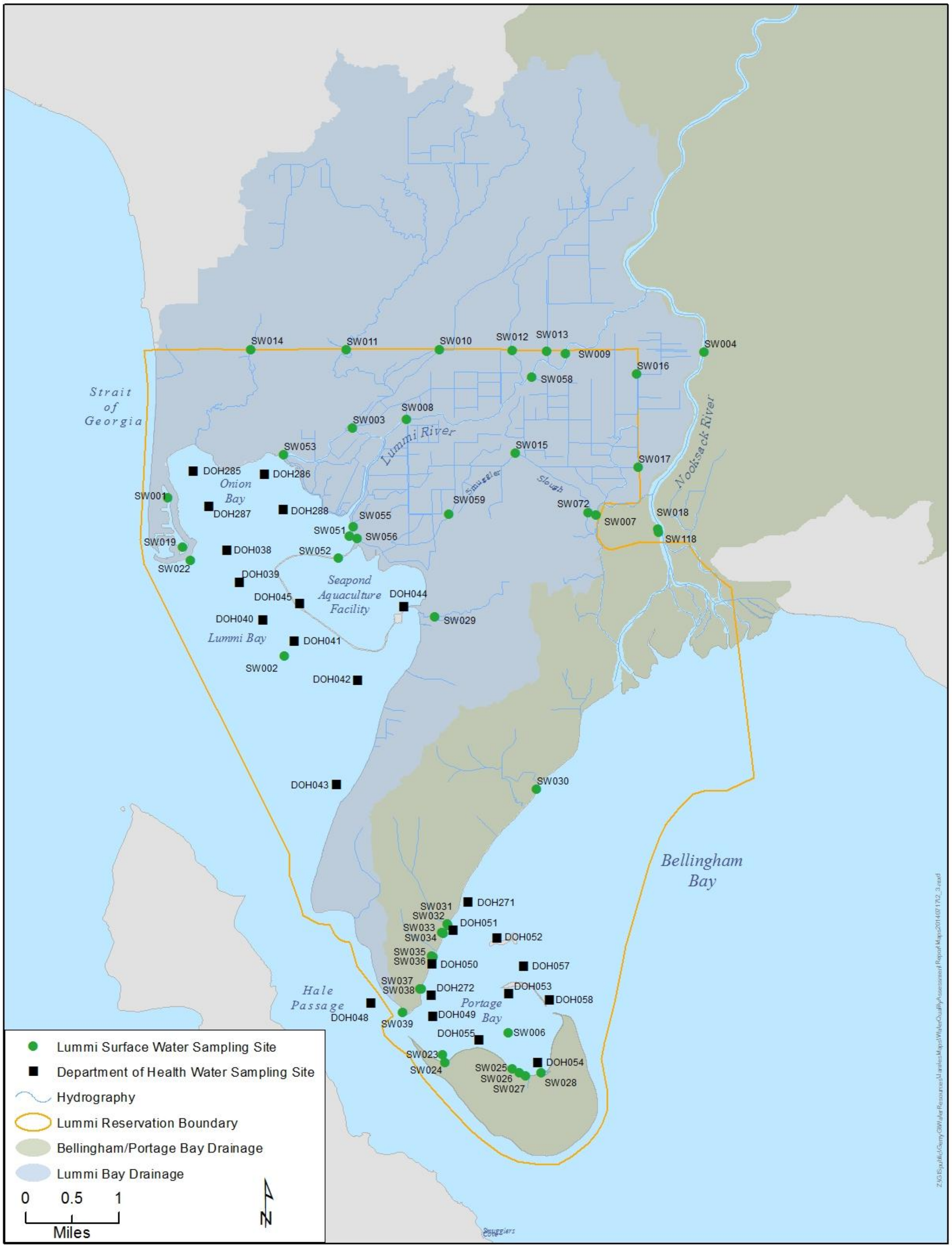

Figure 2.3 Lummi Bay and Bellingham Bay Drainage Areas

Table 2.2 River and Stream Miles On-Reservation and Off-Reservation

	River/ Stream	Stream Category	Total Stream/ River Miles	On-Reservation Stream/ River Miles	Off-Reservation Stream/ River Miles	On-Reservation Percent of Stream/ River Miles
Lummi Bay Watershed	Jordan Creek	1	6.6	2.1	4.5	32
	Lummi River	1	5.0	3.6	1.4	70
	Smuggler's Slough	1	3.9	3.9	0	100
	Slater Slough	2	1.3	1.3	0	100
	Schell Creek	1	4.1	0.4	3.7	10
	Onion Creek	2	2.2	1.8	0.4	81
	Seapond Creek	2	1.7	1.7	0	100
Bellingham Bay Watershed	Nooksack River	1	150	5.1*	144.9	3
	Kwina Slough	1	2.3	2.1	0.2	91
	Lummi Shore Road Streams	2	2.3	2.3	0	100
	Portage Island Streams	2	0.1	0.1	0	100

* Includes all distributary channel lengths in the Nooksack River delta.

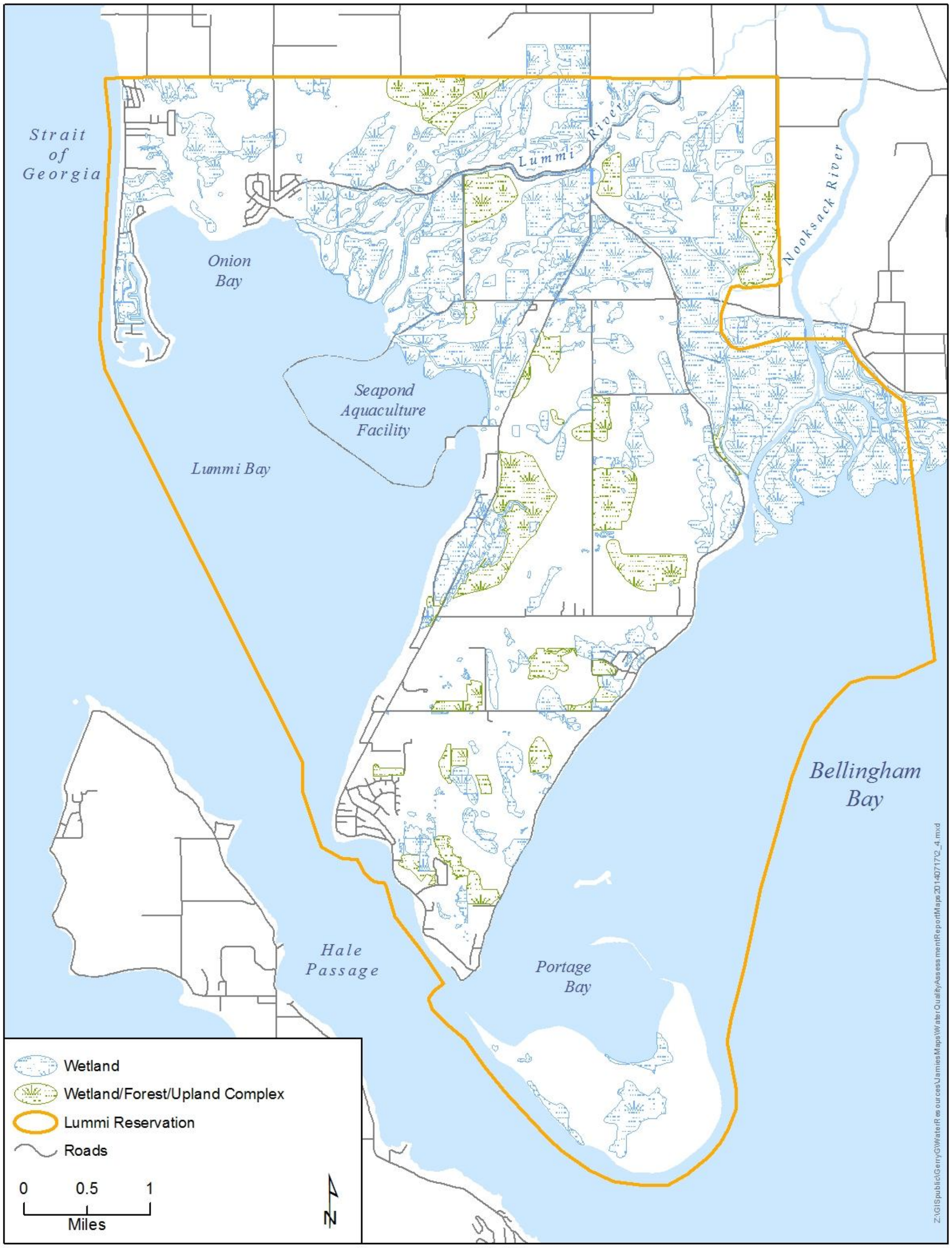

Figure 2.4 Lummi Nation Wetland Areas

2.2.2. Groundwater

Two separate potable groundwater systems occur on the Reservation. One system is located in the northern upland area. This northern system flows onto the Reservation from the north and drains to the west, south, and east (Aspect Consulting 2009). The second potable groundwater system is located in the southern upland area of the Reservation (Lummi Peninsula) and is completely contained within the Reservation boundaries (LWRD 1997, Aspect Consulting 2003). The floodplain of the Lummi and Nooksack rivers, which contains a surface aquifer that is saline (Cline 1974), separates the two potable groundwater systems (Figure 2.5). A third potable groundwater system may exist on Portage Island, but information on the water quality and the potential yield of this system is limited and inconclusive. Over 95 percent of the potable water used by Reservation residents is pumped from the Reservation aquifers. Because of the proximity to marine waters and the local geology, the aquifers on the Reservation are subject to both horizontal and vertical saltwater intrusion if wells are over-pumped (LWRD 1997).

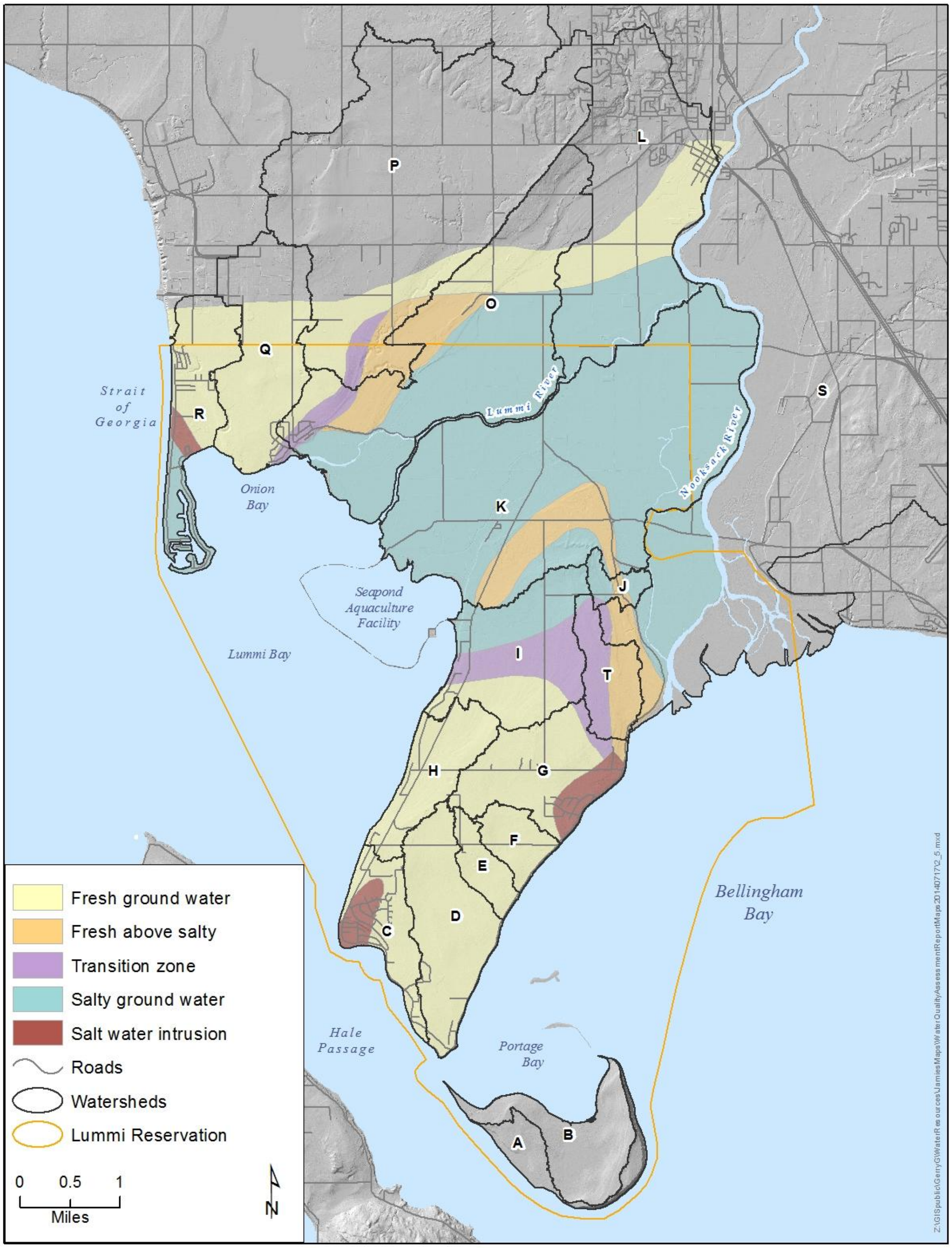

Figure 2.5 Lummi Reservation Groundwater Characteristics

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3. WATER QUALITY MONITORING OBJECTIVES

The purpose of this section is to describe the goals of the Lummi Water Resources Division (LWRD), the long-term water quality monitoring objectives, the Surface Water Quality Monitoring Program objectives, and the Groundwater Quality Monitoring Program objectives.

3.1. Lummi Water Resources Division Goals

The LWRD is responsible for protecting, restoring, and managing Lummi Nation water resources, including the Reservation shorelines, in accordance with the policies, priorities, and guidelines of the Lummi Nation. The overall goal of the LWRD is to protect the treaty rights to water of sufficient quantity and quality to support both the purposes of the Reservation as a permanent, economically viable homeland for the Lummi People, and to support a sustainable harvestable surplus of salmon and shellfish.

3.2. Long-Term Water Quality Monitoring Objectives

The Lummi Nation Surface and Ground Water Quality Monitoring Program (Program) has been ongoing since 1993. The goal of the Program is threefold: (1) to establish the baseline conditions of surface and ground waters on and flowing through and onto the Reservation, (2) to use this information to evaluate regulatory compliance of waters flowing through and onto the Reservation, and (3) to support the development and implementation of a water quality regulatory program on the Reservation.

The water quality monitoring objectives to help achieve the overall LWRD and the Program goals include:

1. Monitor surface and ground water quality at representative locations and at frequencies sufficient to establish baseline conditions of Lummi Nation Waters.
2. Monitor surface waters for compliance with the Lummi Nation surface water quality standards to support all beneficial uses, including public health and public enjoyment; the propagation, protection, and restoration of finfish, shellfish, wildlife, and their habitats; and the protection of the surface waters of the Lummi Indian Reservation as cultural, economic, and spiritual resources of the Lummi People.
3. Identify and evaluate on- and off-Reservation sources of fecal coliform bacteria contributions to shellfish harvest areas.
4. Detect and document threats to water quality and associated beneficial uses to support compliance actions.
5. Protect groundwater supplies from saltwater intrusion and groundwater mining.

3.3. Surface Water Quality Monitoring Program Objectives

The Lummi Nation Nonpoint Source Assessment Report (LWRD 2001), the Lummi Nation Nonpoint Source Management Plan (LWRD 2002), and other documents developed as part of the Lummi Nation Comprehensive Water Resources Management Program (LWRD 1997, LWRD 1998, LWRD 2000) identify and locate the numerous threats to the quality of Lummi Nation Waters. These threats include both point and nonpoint sources of pollution associated with various land uses.

The purpose of the surface water quality monitoring component of the Program is to establish the baseline conditions of waters on and flowing onto the Reservation, to detect water quality problems, and to help identify the pollutant sources. Information from the Program is used to:

- Evaluate compliance of waters flowing onto and within the Reservation with water quality criteria,
- Evaluate fecal coliform bacteria contributions from on- and off-Reservation to shellfish harvest areas, and
- Support the development and implementation of a water quality regulatory program on the Reservation, including the implementation and revision of Lummi Nation Water Quality Standards.

3.4. Groundwater Quality Monitoring Program Objectives

The purpose of the groundwater quality monitoring component of the Program is to protect groundwater supplies from saltwater intrusion and groundwater mining. Groundwater resources on the Reservation are vulnerable to saltwater intrusion due to the proximity of marine waters and local geology (LWRD 1997). The majority of residential development to date has occurred along the marine shorelines of the Reservation placing the most vulnerable portion of aquifers at risk through direct pumping of groundwater near marine waters. Protection of groundwater is essential because:

- Over 95 percent of all water consumed on the Reservation comes from groundwater.
- An ample supply of good quality groundwater is needed to serve the purposes of the Reservation as a permanent and economically viable homeland for the Lummi People.

4. SURFACE AND GROUND WATER QUALITY ASSESSMENT METHODS

The purpose of this section of the report is to summarize the approach used to establish the ambient quality conditions of Reservation surface and ground water and to summarize the field data collection and laboratory analysis methodologies detailed in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010).

4.1. Overview of Surface and Ground Water Assessment Design

The LWRD employs both a fixed station network and a targeted water sampling design. The fixed station network is used for baseline water quality monitoring and includes 43 routine surface water sample sites and 27 groundwater sample sites (LWRD 2010). In addition to these 43 surface water quality sample sites, the LWRD also collects samples at 12 Washington Department of Health (DOH) sample sites within Lummi Bay. As described in Section 4.2, the DOH collects water quality samples from Portage Bay. A targeted sampling design approach is used to improve understanding of specific issues that warrant further investigation (e.g., a reported or observed manure spill, a fish or waterfowl kill near a pesticide application site, questions regarding water quality impacts of an automobile recycling facility, storm water discharge from a construction site). For a targeted design approach, sites from the fixed station monitoring network and other sites generally located both up and downstream from the identified potential pollutant source are sampled.

4.2.Surface Water Field Data Collection and Laboratory Analysis

Since 1993, the Program has grown significantly in the number of sites sampled, the parameters measured, and the ability to manage and analyze collected data. Additional sites were added in the late 1990s to better evaluate the water quality impacts of Nooksack River water on Portage Bay and to better evaluate conditions in the Lummi Bay watershed. Figure 4.1 shows the locations of the current LWRD water quality sampling sites on the Reservation and the DOH sample sites in Lummi Bay and Portage Bay. Many of the 43 sample sites are located along the Reservation border, with the majority of the contributing watershed located off-Reservation. Several intermittent streams and storm water systems are sampled as part of the Program, along with the marine waters of Lummi Bay, Portage Bay, and the Sandy Point Marina.

In consultation with the Lummi Nation and under the Shellfish Consent Decree (Order Regarding Shellfish Sanitation, *United States v. Washington [Shellfish]*, Civil Number 9213, Subproceeding 89-3, Western District of Washington, 1994), the Washington Department of Health (DOH) is responsible to the federal Food and Drug Administration (FDA) to ensure that the National Shellfish Sanitation Program (NSSP) standards for certification of shellfish growing waters are met on the Reservation. In Lummi Bay 12 sites are sampled 6 times a year to provide logistical assistance to the DOH and also to assist with the achievement of Program goals. The DOH samples 12 sites in Portage Bay 6 times a year which assists in achievement of the Program goals. The LWRD also samples Portage Bay sites during flooding conditions in the Nooksack River when Tribal harvesters are gathering shellfish.

Thirty-two (32) of the 43 Lummi sampling sites are accessible from land. As summarized in Table 4.1 and Table 4.2, the LWRD staff measure a range of water quality variables each month. During the late summer to early-winter period, “first flush” sampling is conducted at many of these sample sites at variable intervals (weekly to monthly) based upon precipitation and runoff levels during the onset of the wet season.

The remaining 11 surface water quality sample sites are accessible by boat and are located on Portage Island, in southern Portage Bay, in Lummi Bay, and in the Sandy Point Marina. These sample sites are targeted for monthly sampling, but unsafe weather conditions have historically reduced the sampling frequency. A 26 foot aluminum sampling boat was put into service during 2007 to allow for safer sampling during poor weather conditions. The DOH sites in Lummi Bay are sampled at least six times each year in coordination with the DOH.

Information from all sample runs is used to establish baseline conditions, identify trends, and to evaluate compliance with water quality criteria. Some runs serve other purposes as well, for example, to determine if sources of fecal coliform bacteria in Portage Bay are local or from the Nooksack River watershed. To make this determination, the data collected by the DOH in and around Portage Bay are analyzed in conjunction with the data collected as part of the “Lummi Shore Road” (LSR) sample run. The LSR sample run is scheduled to occur within a few hours prior to the DOH sampling of Portage Bay. At the latest, the sampling occurs concurrently with DOH sampling of Portage Bay. Similar to the LSR sample run, the data collected as part of the “Bellingham Bay Watershed First Flush” sample run aid in determining fecal coliform bacteria sources impacting the Portage Bay shellfish beds.

The data collected during the “Floodplain East” (FPE) and “Floodplain West” (FPW) sample runs are used to establish baseline conditions for waters flowing onto the Reservation and waters contributing to Lummi Bay (all within the Lummi Reservation). Similar to the LSR sample run, the data collected as part of the FPE, FPW, and Lummi Bay First Flush sample runs aid in determining fecal coliform bacteria sources that may affect the Lummi Bay shellfish beds.

The collection of water quality data along the Reservation boundary allows for compliance evaluation of waters flowing onto the Reservation by comparing the sample results with water quality criteria. The sample site selection also allows surface water quality to be evaluated along the length of the Lummi River floodplain water bodies and their tributaries. This water quality information is used to help identify pollution sources in the Lummi Bay Watershed.

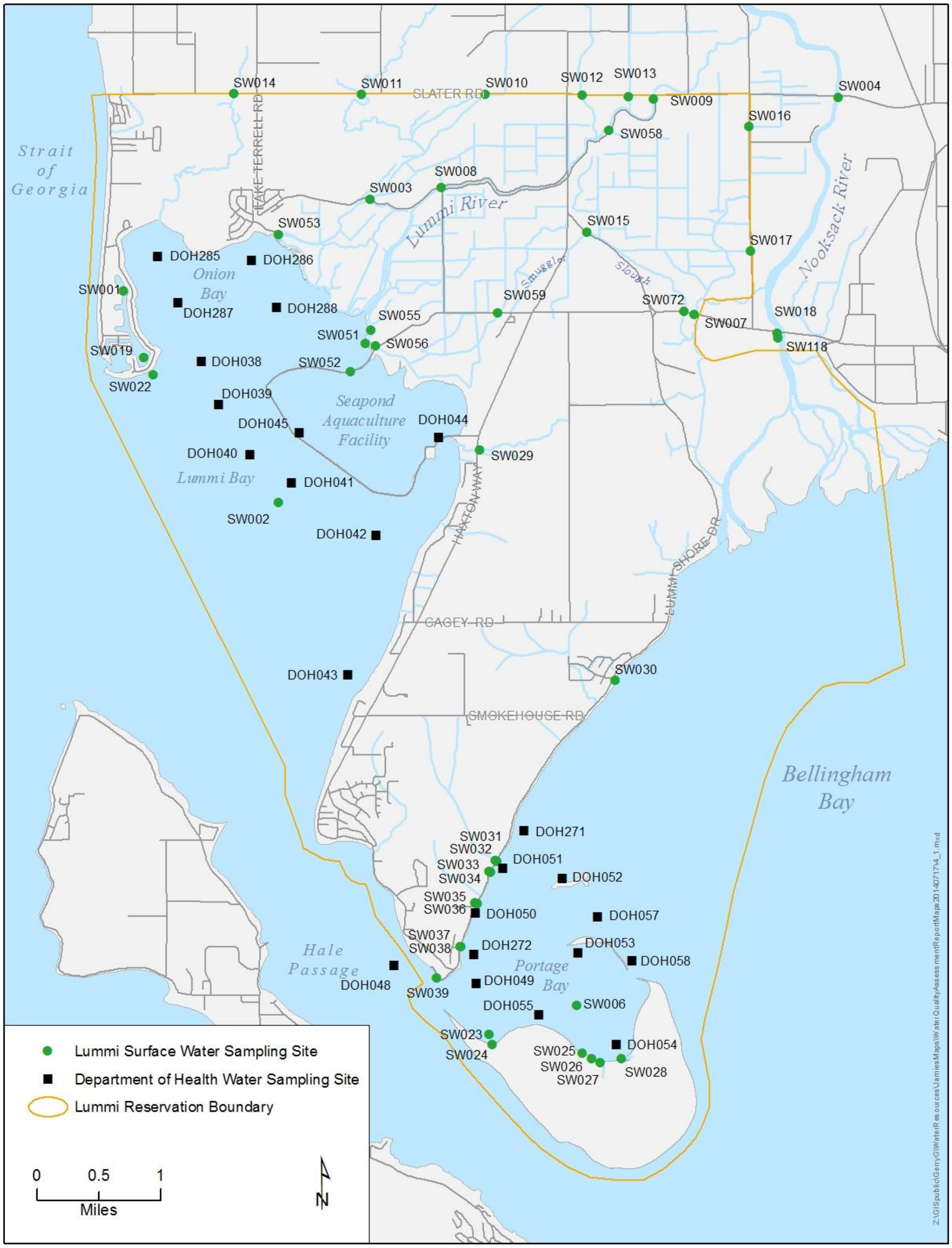

Figure 4.1 Lummi Surface Water Quality Sampling Sites and DOH Sample Sites

Data collected as part of the boat accessible sample run are used to establish baseline conditions of water quality in the Sandy Point Marina, Lummi Bay, Portage Bay, and the five Portage Island freshwater discharges to Portage Bay. These data can also help identify sources of pollution.

The "Lummi Bay DOH Support" sample run is conducted to provide information about water quality in Lummi Bay and assists in evaluating downstream impacts of elevated fecal coliform bacteria levels measured along the Reservation boundary.

The primary change in parameters measured over the Program period of record was the addition of new laboratory analyses. Bacteria sampling expanded in 2000 from often enumerating only one type of bacteria, fecal coliform or *Escherichia coli* (*E. coli*), to consistently enumerating both of these bacteria plus enterococci. In addition, starting in 1999 a suite of nutrient samples was collected approximately four times per year at five sites, and metals are sampled four times per year at two sites. When the Program was initiated in 1993, no nutrient or metal analyses were performed. At selected sites sampling is increased from the regular once-per-month to more frequent sampling during "first flush" events.

The conventional parameters measured over the Program period of record have remained constant, with the exception of pH and turbidity. The pH was not measured for many years (except at the contract laboratory for nutrient and metal samples) and, although total suspended solids are measured at the five sites that are sampled for nutrients, turbidity was not measured consistently prior to 2008. These parameters were not measured because of equipment problems coupled with the staff constraints described in Section 1.2. Starting in 2007, pH analysis was included for all sampling events, even if in some cases pH results were not obtained because of equipment malfunctions. Since March 2008, monthly turbidity measurements have been collected at the sample sites.

Table 4.1 summarizes the surface water quality monitoring sampling schedule for the following parameters measured during 2011 (see Appendix A for data): water temperature, air temperature, water depth, specific conductivity, salinity, dissolved oxygen, pH, turbidity, current flow direction, fecal coliform bacteria, *E. coli*, and enterococci. In accordance with the quality assurance plan for the laboratory, the contracted independent laboratory measures all bacteria from the same sample bottle, and fecal coliform bacteria and *E. coli* are measured from the same culture.

Table 4.2 shows the specific nutrients, metals, and hydrocarbons analyzed at independent state or federally certified laboratories. Due to the costs of analyzing water quality samples for metals and petroleum hydrocarbons, these parameters are only measured quarterly at two of the water quality monitoring sites (one freshwater site downstream from a petroleum oil refinery and one marine water site within a recreational boat marina). Similarly, due to cost considerations, nutrients are measured quarterly at only five of the surface water quality monitoring sites. Depending on the specific intent of the sampling effort, nutrients analyzed range from ammonia, nitrite+nitrate-N, and total phosphorus for "first flush" sample runs during the onset of the rainy season, to the same three parameters plus 5-day biochemical oxygen demand (BOD), Total Kjeldahl Nitrogen (TKN), orthophosphate, total phosphorous, total organic carbon, total suspended solids, total volatile suspended solids, total alkalinity, pH+temperature, sulfate, sulfide, chlorophyll *a*, iron, silicon, and pheophytin. Metals analyzed include mercury, zinc, copper, and arsenic at Site SW001 and chromium, copper, lead, and zinc at Site SW014. The Site SW001 location is near the Sandy Point Marina and the Site SW014 location is along the stream that drains from the ConocoPhillips petroleum oil refinery located along the western extent of the northern Reservation boundary. At both of these sites, petroleum hydrocarbons, pH+temperature, and total hardness are also measured. During the 2011 sampling season, nutrients, metals and hydrocarbon samples were collected for all four quarters where sample sites had flowing water. Several sites were dry or not flowing during the third quarter so water quality data were not collected at those sites.

Starting in January 2010 continuous water temperature dataloggers were deployed at 10 surface water quality sites throughout the Reservation. Water temperature is measured continuously and the measured temperature averaged and recorded at 30 minute increments at each site. The water temperature data are downloaded on a monthly basis. The collected data are used to calculate the 7-day average of the daily maximum temperature for freshwater sites and the 1-day maximum temperature for marine water sites, which allows for a direct comparison with the applicable water quality standards. Due to lost equipment, eight sites have a complete dataset and one site has seven months of data for 2011.

A major change in data collection occurred during 2011 with the addition of a custom electronic interface, which allows for real-time data entry from the field. The user's interface functions with an iPad platform, connecting to the surface and ground water database through remote network access and 3G connection. Data are field entered as they are collected, providing timely entry of data into the database and greatly improving data management. Before the user's interface was developed all data were collected on field sheets and transcribed into the database from the office. This improvement in efficiency has resulted in a significant time savings for the Program.

The quality assurance protocols identified in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010) were followed for the sample collection in 2011. The quality assurance review strategy is anticipated to be completed by December 2014 and implemented for all future surface water data collection. The data collected during 2011 are provided in Appendix A and were exported to WQX on March 19, 2012.

Table 4.1 Surface Water Quality Monitoring Sites

Run Name	Sample Sites Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Floodplain East (FPE)	15, 16, 17, 51, 52, 55, 56, 59, 72, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Floodplain West (FPW)	3, 8, 9, 10, 11, 12, 13, 14, 51, 53, 58, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Lummi Shore Road (LSR)	7, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly in coordination with the DOH sampling of Portage Bay Sites along Lummi Shore sampled from north to south or from south to north	Occasionally Site 118 is sampled at beginning and end of run if Portage Bay sampling occurs late in the morning or afternoon.
Marine Boat-Accessible (Marine)	1, 2, 6, 19, 22, 23, 24, 25, 26, 27, 28	Salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, Secchi depth, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly, as needed	Measure flow at the Portage Island sites (sites numbered 24 through 28) when channel and flow conditions are appropriate.

Table 4.1 Surface Water Quality Monitoring Sites

Run Name	Sample Sites Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Lummi Bay DOH Support	DOH 285, DOH 286, DOH 287, DOH 288, DOH 38, DOH 39, DOH 40, DOH 41, DOH 42, DOH 43, DOH 44, DOH 45	Salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, Secchi depth, water level/depth, turbidity, and general observations	Fecal coliforms	Six times annually	Washington Department of Health (DOH) provides sample bottles and bacteria enumeration. Logistical difficulties prevent DOH staff from sampling Lummi Bay: tidal window for access to marine sample sites in Portage and Lummi bays is narrow, particularly in the summer (+8.5ft MLLW tide minimum is required). LNR staff collects bacteria samples and measures other water quality for comparison with water quality standards.
Lummi Bay Watershed First Flush	11, 10, 12, 13, 9, 58, 8, 3, 53, 51, 118 Time permitting: 14, 59, 15, 16, and 17	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water level/depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	As needed based upon predicted and observed runoff during the onset of the rainy season	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Bellingham Bay Watershed First Flush	7, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 118	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water level/depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	The day following the Lummi Bay First Flush sample run	Sites along Lummi Shore Road sampled from north to south or from south to north. Site 29 samples a relatively undeveloped Lummi Peninsula upland watershed and is used as a control site representing a watershed that is minimally affected by development.

Table 4.2 Parameters Measured Quarterly at Selected Sites

Sample Site Number(s)	Group Name	Parameters	Frequency of Collection	Notes
1	Hydrocarbons	Diesel and Lube Oil range hydrocarbons	Quarterly, (depending on the year)	Sample collected in 1-L glass amber bottle. (Monday and Tuesday. Wednesday with prior lab approval)
	Metals	Arsenic, Copper, Mercury, Tin, Zinc, Hardness, and pH with the temperature of the water sample at the time of measurement	Quarterly, depending on the year	Sample collected in 1-L plastic bottle. (Monday and Tuesday. Wednesday with prior lab approval)
2, 3, 6, 9, 15	Nutrients	Alkalinity, Ammonia, Biochemical Oxygen Demand, Nitrate-N, Nitrite-N, Total Kjeldahl Nitrogen, Ortho Phosphate, Total Phosphorus, pH [with temperature at time of measurement], Total Organic Carbon, Total Suspended Solids, Total Volatile Suspended Solids, Iron, Sulfate, Chlorophyll a, Sulfide, Silicon, Pheophytin and Chemical Oxygen Demand	Quarterly, (depending on the year)	Samples collected in 4 1-L plastic bottles and 2 40-mL vials with a preservative. Nitrite and Nitrate are normally combined. (Monday and Tuesday. Wednesday with prior lab approval)
14	Hydrocarbons	Diesel and Lube Oil range hydrocarbons	Quarterly and First Flush (depending on the year)	Sample collected in 1-L glass amber bottle. (Monday and Tuesday. Wednesday with prior lab approval)
	Metals	Chromium, Copper, Lead, Zinc, Hardness and pH with the temperature of the water sample at the time of measurement	Quarterly and First Flush (depending on the year)	Sample collected in 1-L plastic bottle. (Monday and Tuesday. Wednesday with prior lab approval)

4.3.Groundwater Field Data Collection

Twenty-seven (27) groundwater sample sites (Figure 4.2) were selected for regular monitoring to characterize the two major potable aquifer systems on the Reservation. Table 4.3 lists the well sampling groups, wells in each group, well number, parameters measured, and measurement frequency. The number of wells sampled has increased over the years but the parameters measured have not changed, other than the addition of pH and salinity measurement. Wells were added to the Program as they were drilled or when access was granted to obtain better spatial resolution of aquifer conditions. Water level, pumping status, temperature, specific conductivity, pH, salinity, and chloride concentration are measured monthly or more frequently at each site. Well production is recorded from existing meters at the Lummi Water District water supply wells.

Sample sites were selected to represent aquifer-wide conditions as practicable, but the spatial representativeness of these sampling points is limited by the lack of existing groundwater wells in some parts of the Reservation – particularly along the interior of the Lummi Peninsula and the eastern part of the northwestern upland.

The primary sources of variability are seasonal changes (i.e., wet season and dry season) and pumping regimes (which are typically related to season). This variability is addressed through frequent sampling (sub-monthly to monthly), performing multiple well water level measurements during sampling at each well, and recording the pumping rate, totalizer values (if metered), and pump status of the well at the time of measurement. Water quality is generally stable in the wells.

The chloride concentration, pumping rate and amounts, and water levels of the water supply wells provide critical information about aquifer condition, pumping regimes, and the need for protective measures as these data indicate whether saltwater intrusion is occurring or if the likelihood of saltwater intrusion has increased. For wells that are not used for water supply purposes (e.g., inactive wells), water level provides information about aquifer conditions.

Figure 4.2 Groundwater Quality Monitoring Sample Sites

Table 4.3 Groundwater Quality Monitoring Wells

Well Group	Wells	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
Domestic	R. Jefferson	112	Water level	Monthly
	K. Charles	74	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Berg	143	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Bewley	164	Water level	Monthly
	M. Egawa	189	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	J. Finkbonner	109	Chloride, temperature, specific conductivity, pH, salinity, water level infrequently	Monthly
	T. Teeter	413	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Skolrood	101	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
Potable Public Water Supply Wells	Balch	115	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Horizon	58	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley Way (Kinley 1)	59	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley 2	409	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley 3	421	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Mackenzie 2	129	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Northwest Well 2 (NW2)	418	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	West Shore	146	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Gooseberry Point 4	419	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Gooseberry Point 5	420	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed

Table 4.3 Groundwater Quality Monitoring Wells

Well Group	Wells	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
Monitoring Wells	Hopkins	111	Water level, datalogger upload	Monthly
	Cultee	56	Water level, datalogger upload	Monthly
	Revey	127	Water level, datalogger upload	Monthly
	Mackenzie 1	128	Water level, datalogger upload	Monthly
	Mackenzie 3	405	Water level, datalogger upload	Monthly
	Mackenzie 4	422	Water level	Monthly
	Pierre	66	Water level, datalogger upload	Monthly
	Northwest Well 1 (NW1)	417	Water level, datalogger upload	Monthly
Other Wells	Johnson	145	Water level, datalogger upload, water use, chloride, temperature, specific conductivity, pH, salinity, tank level, and discharge from manifold in tank Flow rate and totalizer at all meters except M. Finkbonner (Nau) and Greg Finkbonner meters every visit to Johnson well. The latter two meters are measured monthly	Weekly or more frequently for water quality, water level, and water use
	Northwest Well 3 (NW3)	441	Water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed

5. LUMMI NATION SURFACE WATER QUALITY STANDARDS

The purpose of this section of the report is to summarize the Lummi Nation Surface Water Quality Standards (LWRD 2008a). The Water Quality Standards (WQS) for Surface Waters of the Lummi Indian Reservation were adopted by the Lummi Nation in August 2007 and approved by the EPA on September 30, 2008. The standards are summarized in Table 5.1. Figure 5.1 shows the surface waters of the Lummi Nation, water body classifications for the surface waters, and the current sampling locations.

Because of the Reservation location in the Nooksack River and Lummi River estuaries, many Reservation water bodies are seasonally brackish. This temporal and spatial variability creates uncertainty regarding whether or not marine or fresh water standards apply. To remove this uncertainty, the approach taken in developing the water quality standards for the surface waters of the Reservation was to identify specific geographic locations as the demarcation between fresh and marine waters. These locations are depicted in Figure 5.1. A line between Fish Point and Treaty Rock separates freshwater and marine water in the Nooksack River Delta. The location where the water body flows under Hillaire Road separates the freshwater and marine water in the Lummi River Delta, which corresponds with sample site SW008 shown on Figure 5.1.

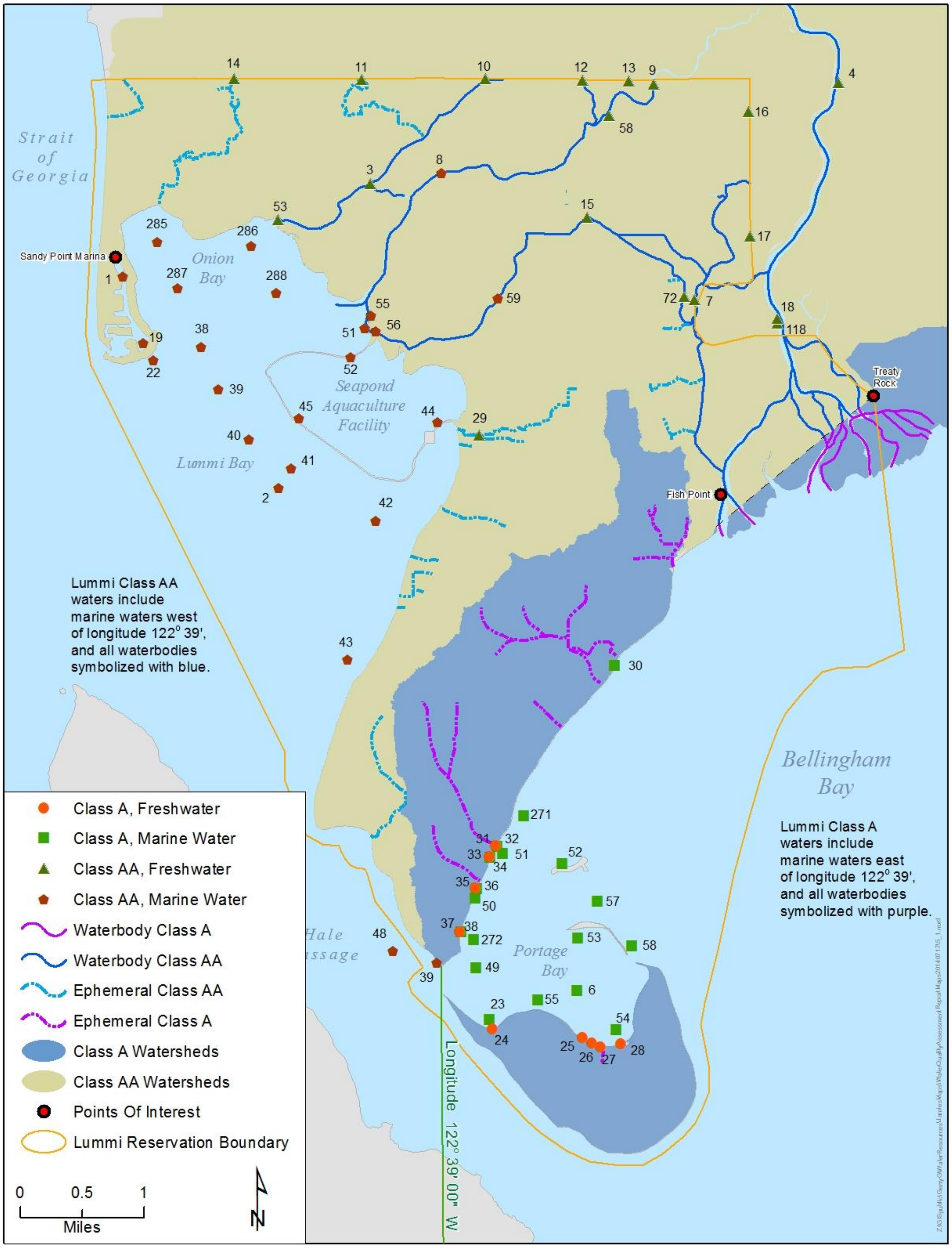

Figure 5.1 Classification of Lummi Nation Waters and Current Sampling Locations

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

	Surface Water Classes of the Lummi Indian Reservation			
Parameter	**Class AA Extraordinary**	**Class A Excellent**	**Class B Good**	**Lake Class**
General Characteristics	Uniformly exceeds the requirements for all or substantially all uses	Meets or exceeds the requirements for all or substantially all uses	Meets or exceeds the requirements for most uses	Meets or exceeds the requirements for all or substantially all uses

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation Class AA Extraordinary	Class A Excellent	Class B Good	Lake Class
Characteristic Uses	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing, spawning, and harvesting. **(D)** Wildlife habitat. **(E)** Recreation (extraordinary primary contact, primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing, spawning, and harvesting. **(D)** Wildlife habitat. **(E)** Recreation (primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing and spawning. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing and spawning. **(D)** Wildlife habitat. **(E)** Recreation (secondary contact, sport fishing, boating, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam and mussel rearing and spawning. Crayfish rearing and spawning. **(D)** Wildlife habitat. **(E)** Recreation (extraordinary primary contact, primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Freshwater Fecal Coliform Bacteria Geometric Mean Density	Shall both not exceed 50 colonies/100 ml AND not exceed 100 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 100 colonies/100 ml AND not exceed 200 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 200 colonies/100 ml AND not exceed 400 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 50 colonies/100 ml AND not exceed 100 colonies/100 ml in more than 10% of the samples obtained for calculation purposes
Marine Water Fecal Coliform Bacteria Geometric Mean Density	Shall both not exceed 14 colonies/100 ml AND not exceed 43 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 14 colonies/100 ml AND not exceed 43 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 100 colonies/100 ml AND not exceed 200 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	N/A
Freshwater Enterococci	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 78 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml
Marine Water Enterococci	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 104 colonies/100 ml	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 104 colonies/100 ml	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 158 colonies/100 ml	N/A

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Freshwater Dissolved Oxygen Concentration	The seven-day mean minimum shall both not be less than 11.0 mg/l AND not have a spatial median intergravel dissolved oxygen concentration below 8.0 mg/l. If minimum spatial median intergravel dissolved, oxygen is 8.0 mg/l or greater, the minimum dissolved oxygen criterion is 9.0 mg/l. Where barometric pressure and temperature preclude attainment of criteria, dissolved oxygen must not be less than 95% of saturation.	Shall not be less than 8.0 mg/l. Where barometric pressure and temperature preclude attainment of criteria, dissolved oxygen must not be less than 90% of saturation.	Shall not be less than 6.5 mg/l.	No measurable decrease from natural conditions
Marine Water Dissolved Oxygen Concentration	Shall exceed a 1-day minimum daily concentration of 7.0 mg/l	Shall exceed a 1-day minimum daily concentration of 6.0 mg/l	Shall exceed a 1-day minimum daily concentration of 5.0 mg/l	N/A
Freshwater Temperature	Shall not exceed a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summertime spawning, temperature shall not exceed a 7DADM temperature of 13.0°C.	Shall not exceed a 7DADM temperature of 17.5°C.	Shall not exceed a 7DADM temperature of 17.5°C.	No measurable increase from natural conditions
Marine Water Temperature	Shall not exceed a 1-day maximum temperature of 13.0°C	Shall not exceed a 1-day maximum temperature of 16.0°C	Shall not exceed a 1-day maximum temperature of 19.0°C	N/A

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Freshwater pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	No measurable change from natural conditions
Marine Water pH	7.0 – 8.5	7.0 – 8.5	7.0 – 8.5	N/A
Turbidity	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 10% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 10% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 20% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity
Toxic, Radioactive, Or Deleterious Material Concentrations	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chromic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.
Aesthetic Values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species

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6. SURFACE WATER QUALITY SAMPLE RESULTS AND REGULATORY COMPLIANCE

Water quality sample results for 2011 and for the period of record through 2010 were compared with the applicable water quality standards associated with each sample site. Maximum and minimum water quality sample results are depicted as vertical bars in the graphs presented in this section of the report. Water quality standard values are presented as horizontal lines on the graphs where standard values apply for a particular parameter. Sample site identification codes, corresponding to the sample site locations shown in Figure 4.1 and Figure 4.2 and listed in Table 4.1 and Table 4.3, are presented along the X-axis. The number of observations/sample results is shown just above the X-axis next to the respective bar. Turbidity results are depicted differently because turbidity water quality standards are expressed as relative to the background turbidity level, which is dependent on a number of factors including flow, time of year, and sediment load. The turbidity sample results are averaged to characterize the relative turbidity levels at each sample site. Although there are currently no applicable water quality standards, the sample results for total suspended solids (a measure of turbidity), phosphorus, and total nitrogen are also summarized.

The water quality sample results for 2011 were then used to generate water quality maps for select parameters to illustrate how frequently a sample site achieved the associated water quality standard. In the case of bacteria, the water quality maps indicate how frequently and whether the standard was fully or partially achieved during 2011.

6.1.Water Quality Results

The use of bar graphs to present the sample program results allows:

- The various sites within a specific water body classification to be compared to each other;
- The sample results to be compared with the applicable water quality standards;
- The sample results from 2011 to be compared with the sample results over the period of record through 2010.

However, the bar graphs do not allow for a presentation of seasonal variations or trends as the data are for the entire reporting period for the site rather than over time. In addition, because the bar graphs for water temperature, dissolved oxygen, and pH show the maximum and minimum of the measured values, a single measurement above or below a water quality criteria/threshold suggests that the standards are not achieved at the site even though a single sample result may be an anomaly.

To address these limitations, the bar graphs for the various parameters are supplemented with graphs and box-and-whisker plots from a representative sample site from the same water body classification to depict seasonal variations and trends over the period of record. Also, the continuous water temperature data from nine sites were used to calculate the 7-day average of the daily maximum for freshwater sample sites and the 1-day maximum temperature for marine water sample sites, which allows for a direct comparison with the applicable water quality standards and was used to depict the seasonal change in water temperature during 2011.

The selected representative freshwater sample sites are along the Lummi River and the Nooksack River. The continuous water temperature sites are along the Lummi River, Jordan Creek, Smuggler's Slough, and Schell Creek. The Lummi River and Nooksack River are the two largest freshwater bodies that discharge to marine waters on the Reservation. All of the water bodies originate off-Reservation except Smuggler's Slough and are classified as Class AA waters. Because all of the Class A freshwater bodies are ephemeral streams that are seasonally dry, have low discharges when they have flow during the rainy season, and have been shown to have minimal or no measurable impact on the water quality of the receiving marine waters (LWRD 1999, LWRD 2006a, LWRD 2006b), a Class A freshwater body was not selected as a representative site or continuous water temperature monitoring site. As a result, the representative freshwater site associated with the Class A marine water site is a Class AA site located along the Nooksack River (Site SW018/SW118). The representative sample sites used to depict seasonal variations and trends are the following:

- Class AA Freshwater: Site SW009 (Lummi River at Slater Road)
- Class AA Marine Water: Site SW002 (Lummi Bay)
- Class AA Freshwater: Site SW118 (Nooksack River below Marine Drive – formerly Site SW018[1]).
- Class A Marine water: Site SW030 (Bellingham Bay between the Nooksack River Delta and Portage Bay)

6.2.Water Quality Maps

Water quality maps were generated from the 2011 water quality data for water temperature, dissolved oxygen, and pH to illustrate whether a sample site achieved the associated water quality standard 100% of the time sampled, greater than or equal to 75% of the time sampled, or less than 75% of the time sampled. In the case of fecal coliform bacteria and enterococcus bacteria the water quality maps indicate whether the associated water quality standard was fully or partially achieved 100% of the time sampled, fully or partially achieved greater than or equal to 75% of the time sampled or fully or partially achieved less than 75% of the time sampled during 2011.

6.3. Fecal Coliform Bacteria Results

Bacteria sampling is routinely conducted at each of the surface water quality sampling locations. Pursuant to the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010), the collected samples are transported on ice to a contracted analytical laboratory the day of collection and tested for fecal coliform bacteria, *E. coli*, and enterococcus. Water from one sample bottle is used for

[1]Sample Site SW018 was moved approximately 200 feet downstream along the west bank of the Nooksack River during 2008 to ensure safe access to the sampling location. The new sample site location was assigned the identifier Site SW118 but the samples at this site are from essentially the same water that was sampled at the discontinued Site SW018.

each of the tests, and fecal coliform bacteria and *E. coli* are enumerated from the same growth plates.

To allow comparison to the applicable water quality standards, the bar graphs for the bacteria types depict the geometric mean and 90th percentile for fecal coliform bacteria and *E. coli* and the geometric mean and maximum value for enterococcus bacteria for each site. As summarized in Table 5.1, the water quality standards for enterococcus bacteria set maximum bacteria counts. If sample results show a higher count than the applicable water quality standard, the water quality standard is not met and the characteristic uses of the water body are not supported.

6.3.1. Class AA Waters

The Class AA freshwater standards for fecal coliform bacteria are a geometric mean not to exceed 50 colony forming units (cfu) per 100 milliliters (ml) <u>and</u> a 90th percentile standard of 100 cfu/100 ml (from the values used to calculate the geometric mean). As shown in Figure 6.1, 5 of 16 Class AA freshwater sites sampled during 2011 achieved both the geometric mean and 90th percentile standard, which includes Site SW118 (Nooksack River). As shown in Figure 6.3, 5 of the 11 Class AA freshwater sample sites that did not achieve both the geometric mean and 90th percentile standard achieved at least part of the water quality standard during 2011. However, as only part of the standard was met the water quality standard for fecal coliform bacteria was not achieved at those sites. Sample Site SW004 is shown in Figure 6.1 to have met the 90th percentile standard in 2011; however, this result reflects the laboratory findings from one sample. The single sample collected did not meet the standard for geometric mean. As shown in Figure 6.2, the geometric mean was below the standard at 10 of the 17 sites over the period of record. However, because the 90th percentile criterion was exceeded at all of the sites, the water quality standard for fecal coliform bacteria was not achieved at any of the Class AA freshwater sites for the period of record. The site with the highest 90th percentile during 2011 was Site SW003 (northern Lummi River distributary channel) and the highest geometric mean was Site SW011 along Jordan Creek at Slater Road (the northern Reservation boundary). Sample sites along the northern Reservation boundary (i.e., SW009, SW010, SW011, SW012, SW013, and SW014) have some of the highest fecal coliform bacteria geometric means and 90th percentiles over the period of record. Sample Site SW029, which drains a forested area west of Chief Martin Road, also experienced periodic high fecal coliform bacteria counts. All of these water bodies discharge to Lummi Bay where important shellfish beds are located.

Site SW118 is located along the Nooksack River where it flows onto the Reservation. High bacteria densities at this site would represent a threat to the shellfish beds within and adjacent to Portage Bay and to the people who consume shellfish from these areas. The geometric mean for SW118, based on the most recent 30 sampling events during 2011, was 23 cfu/100 ml. This geometric mean is lower than the Lummi Nation fecal coliform bacteria geometric mean standard of 50 cfu/100 ml, and the Total Maximum Daily Load (TMDL) target of 39 cfu/100 ml established for the lower Nooksack River (Ecology 2000, 2002). The TMDL was established by the Washington Department of Ecology (Ecology) to be protective of the shellfish beds within and adjacent to Portage Bay and to protect the health of people who consume shellfish from these waters. The 90th percentile value at SW118, based on the most recent 30 samples collected at this site during 2011, was 84 cfu/100 ml, which meets the standard. Unlike in 2007 through 2009 the water quality standard at Site SW118 has been achieved for the past two years and the designated uses supported.

The Class AA marine water quality standards for fecal coliform bacteria are more stringent than for Class AA freshwater and include a geometric mean not to exceed 14 cfu/100 ml and a 90th percentile (from the values used to calculate the geometric mean) standard of 43 cfu/100 ml. As shown in Figure 6.4, 18 of the 24 sample sites met these criteria during 2011. As shown in Figure 6.3, of the 6 sites that did not achieve both the geometric mean and 90th percentile standard, 3 of those sites partially achieved the water quality standard during 2011. However, as discussed previously as only part of the standard was met the water quality standard for fecal coliform bacteria was not achieved at those sites. As shown in Figure 6.5, 17 of the 18 sites that met the criteria in 2011 also met the criteria for the period of record through 2010. Sample Site SW039 met the fecal coliform bacteria criteria for 2011; it did not achieve the standard for the period of record.

As shown in Figure 6.6, the fecal coliform bacteria sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009 on the Lummi River along the northern Reservation boundary) have been consistently above the geometric mean and the 90th percentile criteria over the period of record. In contrast, as shown in Figure 6.7, the fecal coliform bacteria sample results for the representative Class AA marine water site (SW002 in Lummi Bay) have been consistently below the geometric mean and 90th percentile criteria over the period of record.

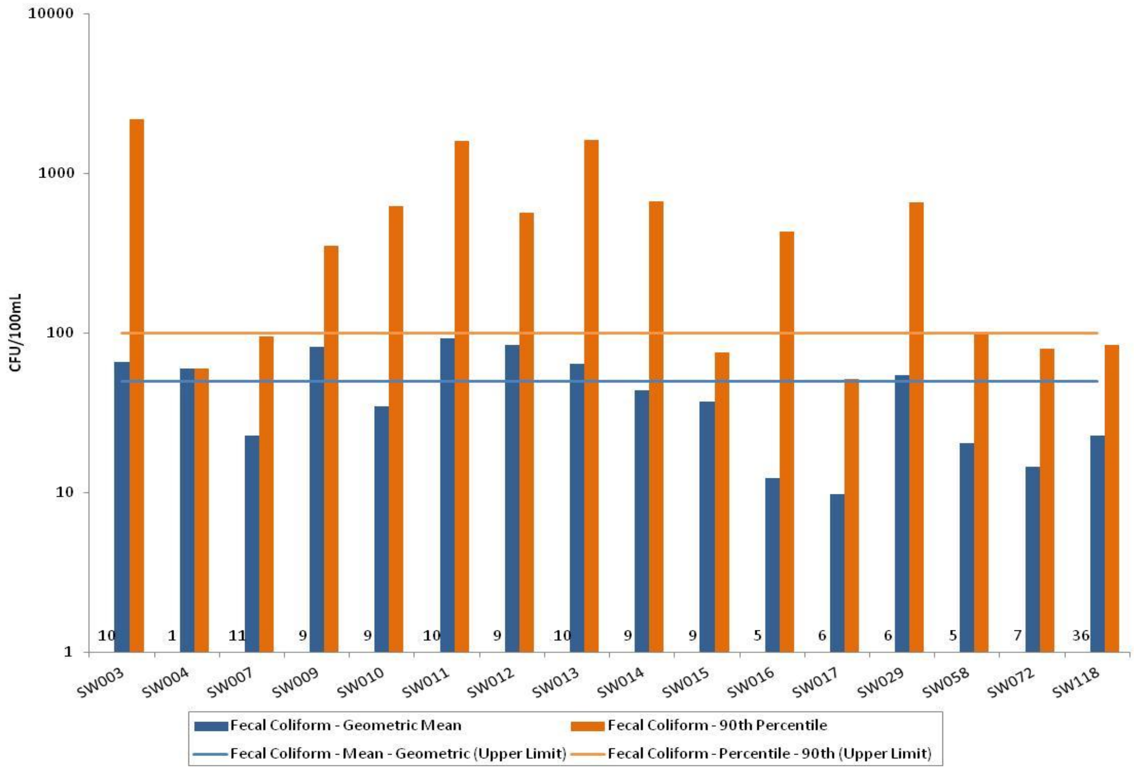

Figure 6.1 Class AA Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2011

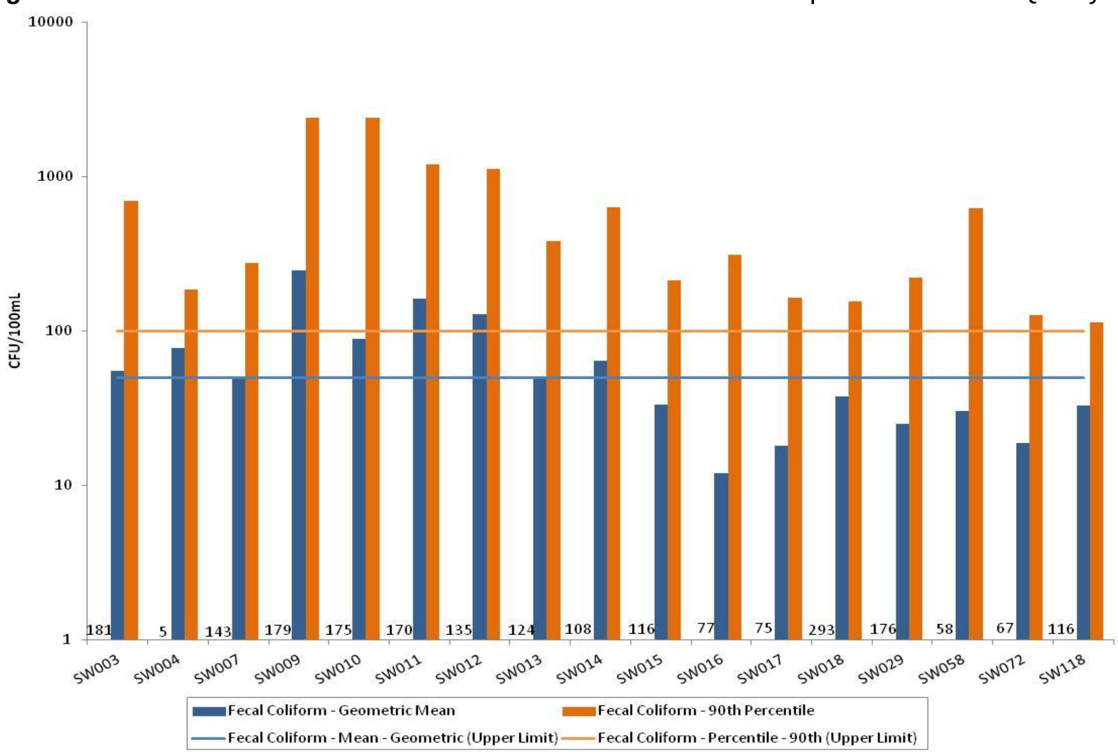

Figure 6.2 Class AA Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

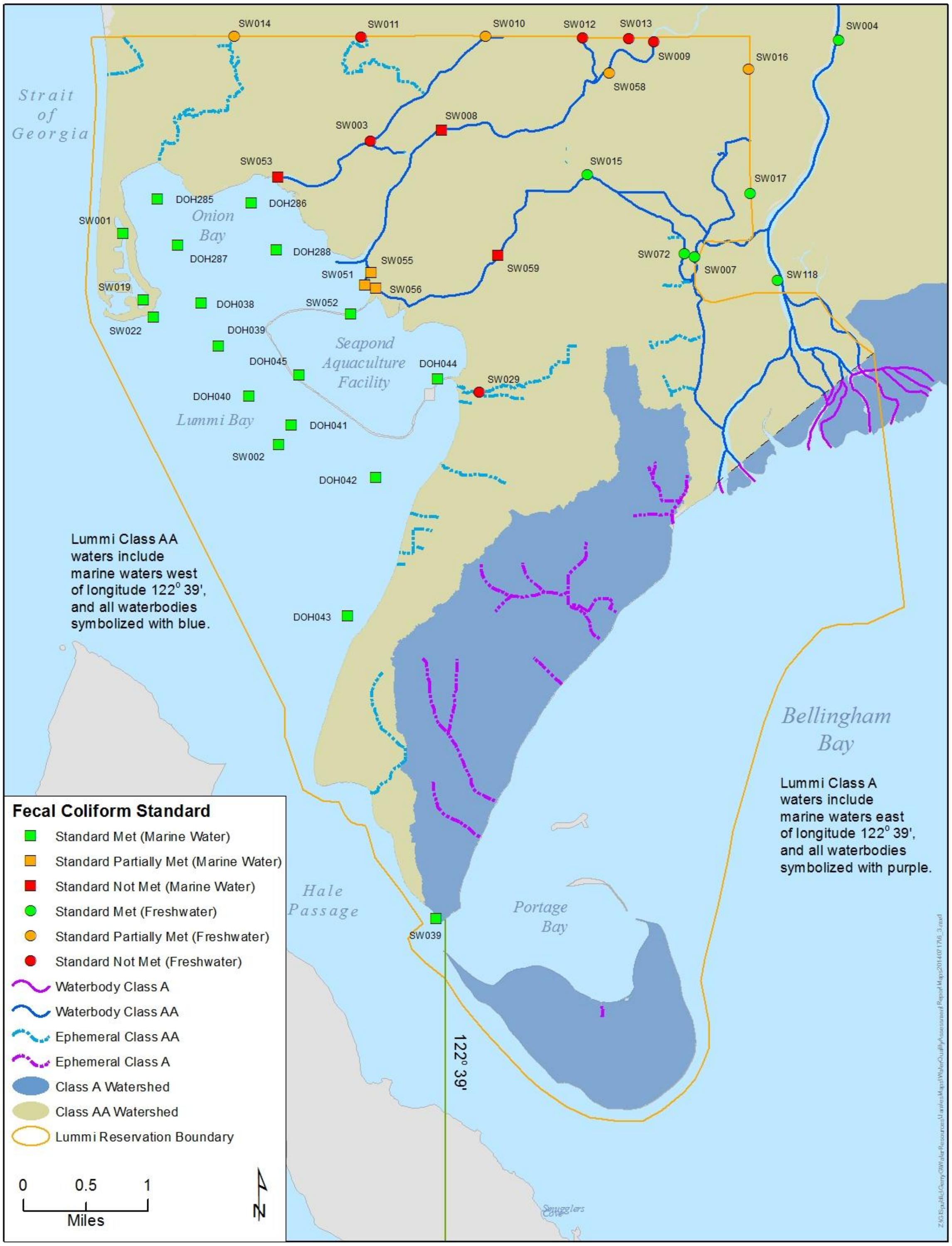

Figure 6.3 Class AA Freshwater and Marine Water Fecal Coliform Compliance with Water Quality Standards: 2011

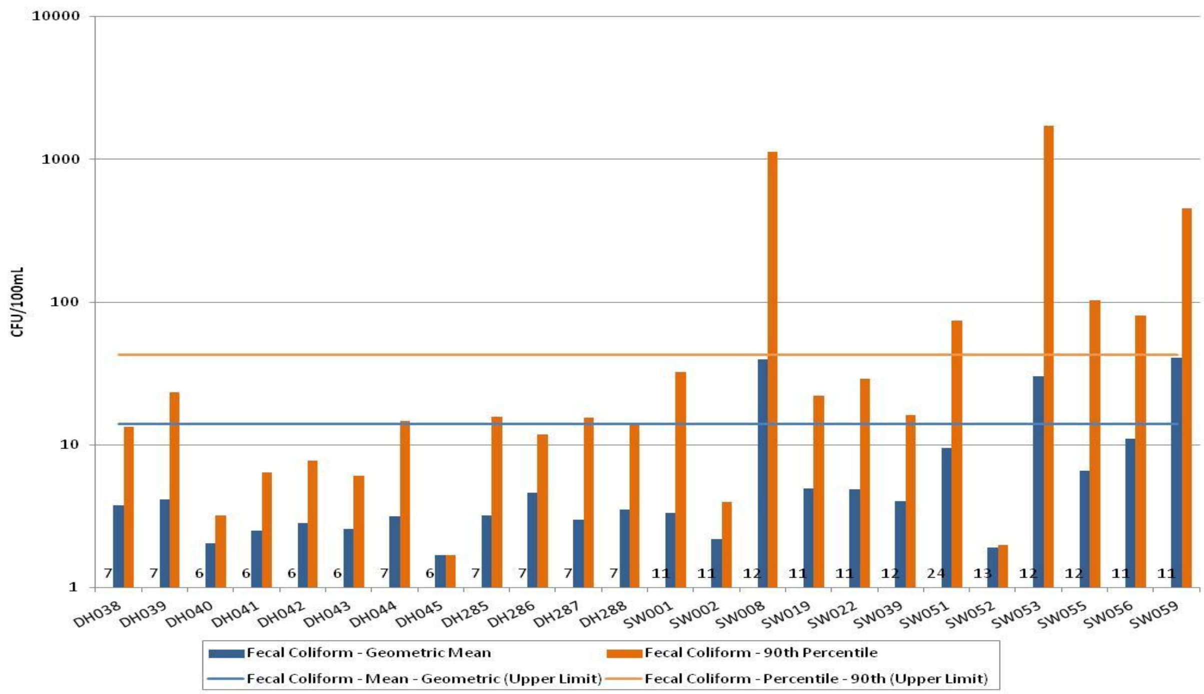

Figure 6.4 Class AA Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2011

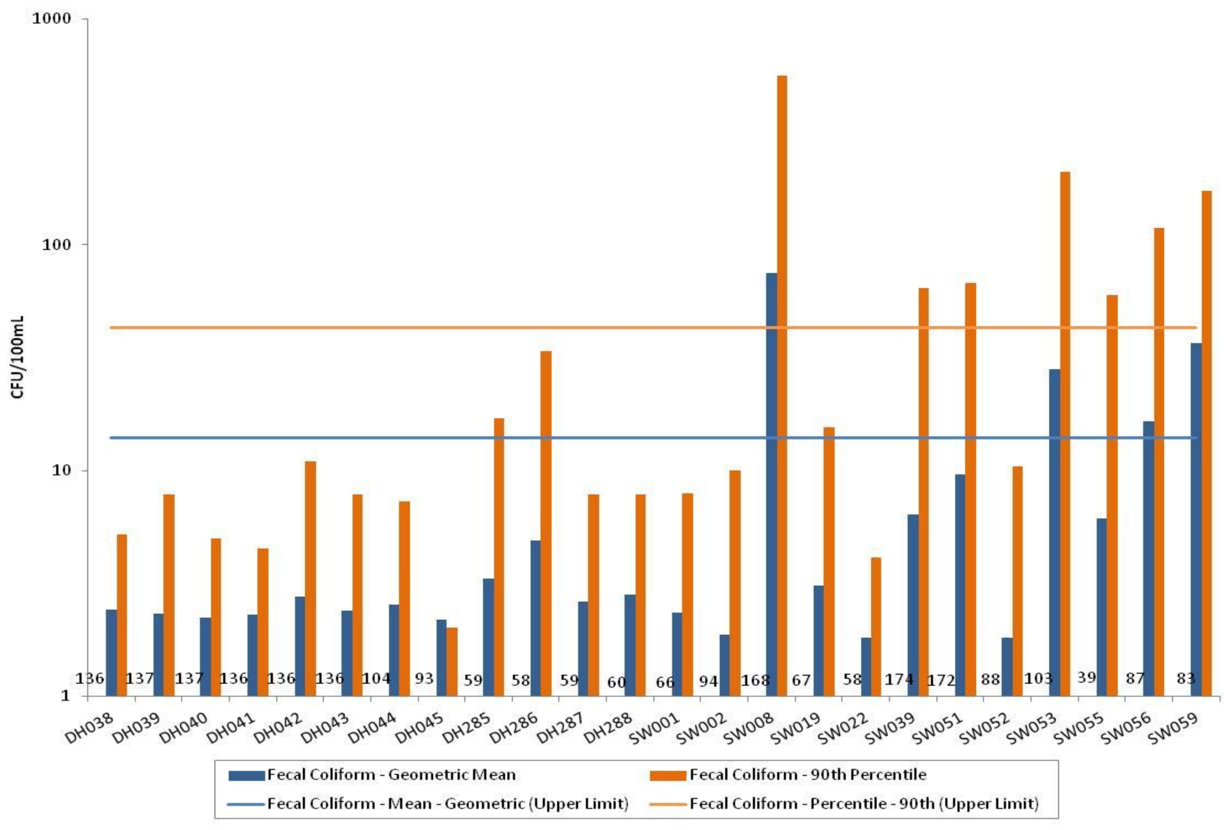

Figure 6.5 Class AA Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

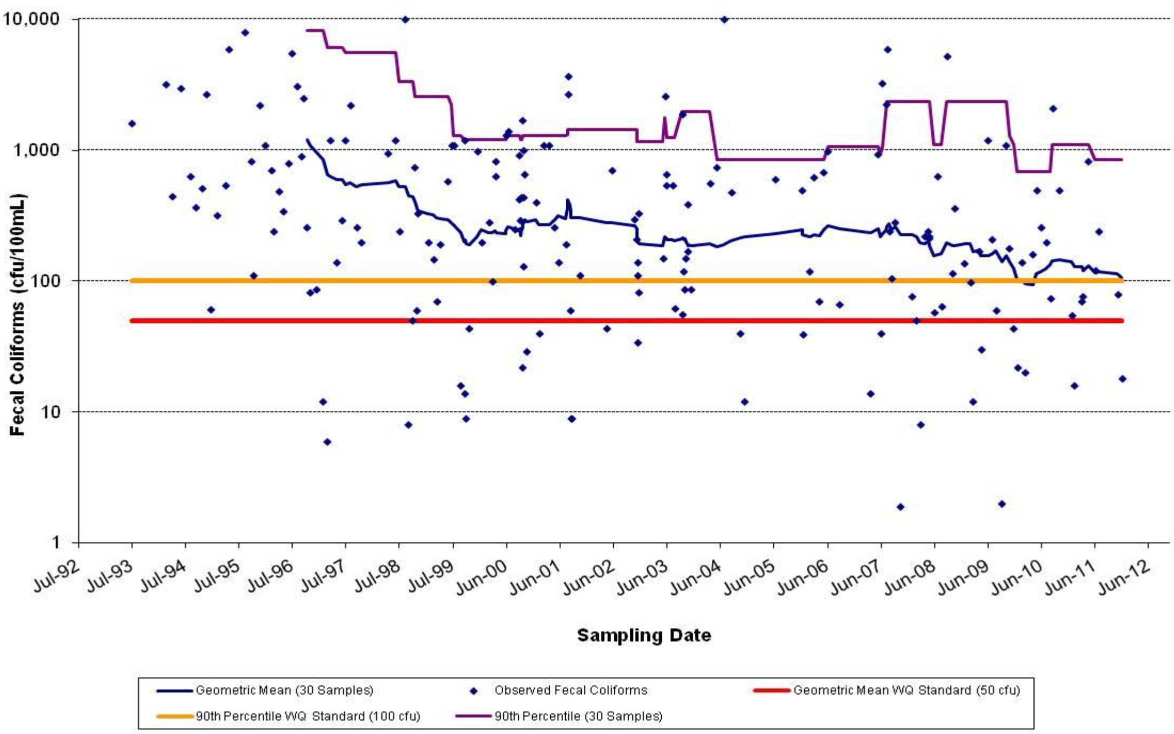

Figure 6.6 Class AA Freshwater Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW009

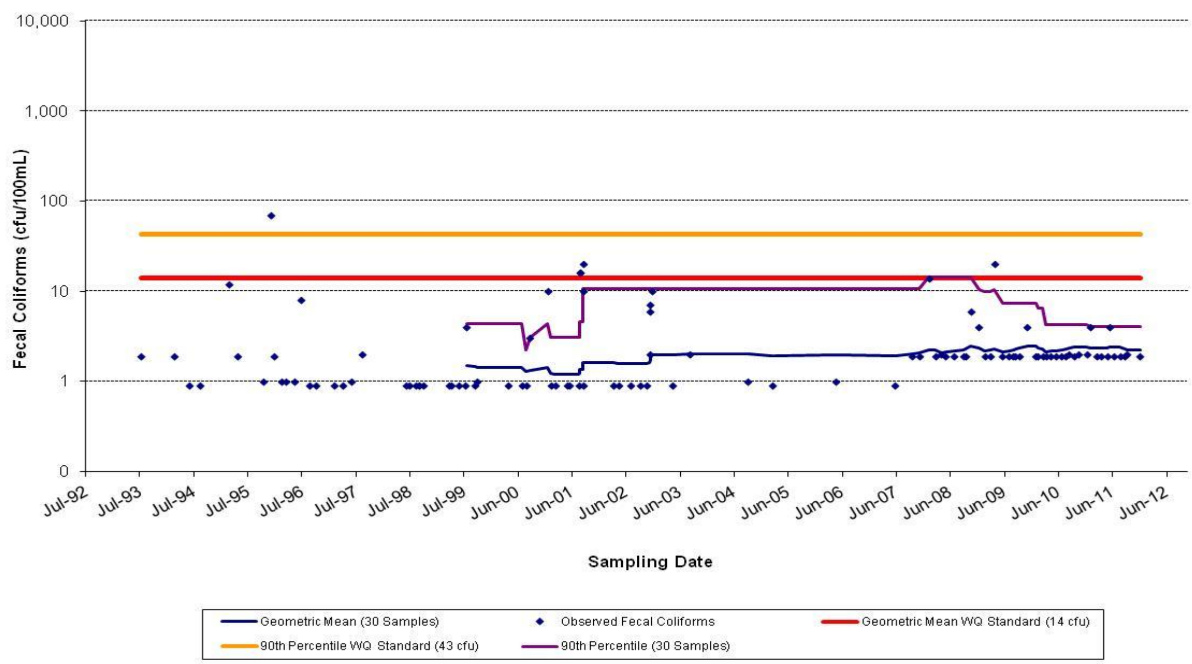

Figure 6.7 Class AA Marine Water Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW002

6.3.2. Class A Waters

The Class A freshwater standard for fecal coliform bacteria are a geometric mean not to exceed 100 cfu/100 ml and a 90th percentile (from the values used to calculate the geometric mean) not to exceed 200 cfu/100 ml. Although sites SW027, SW031, SW033, SW035, and SW037 are shown in Figure 6.8 to have met the standard for geometric mean during 2011, as shown in Figure 6.10 only one of the Class A freshwater sites, Site SW031, met both the geometric mean and the 90th percentile standard. As shown in Figure 6.9, the geometric mean was below the standard at all 9 Class A freshwater sample sites for the period of record through 2010, but the 90th percentile values were above the standard at all the sites, except Site SW031, which drains a forested wetland along Lummi Shore Road. The sites with the highest geometric mean and 90th percentile are located on Portage Island (SW024, SW025, SW026, SW027, and SW028) with an additional site on the south end of Lummi Shore Road (SW037). Although elevated fecal coliform bacteria levels have been sampled at the Class A freshwater sites, as noted above, the water bodies are seasonally dry and have low discharges during the rainy season. The results from an intensive sampling effort in the adjacent area along the Lummi Peninsula suggest that discharge from these sites have minimal or no measurable impact on the water quality of the receiving marine waters (LWRD 1999, LWRD 2006a, LWRD 2006b).

The Class A marine water quality standards for fecal coliform bacteria are more stringent than for Class A freshwater quality standards and include a geometric mean not to exceed 14 cfu/100 ml and a 90th percentile (from the values used to calculate the geometric mean) not to exceed 43 cfu/100 ml. As shown in Figure 6.11, the standards were met at 12 of the 18 sample sites during 2011. As shown in Figure 6.10, of the 6 sample sites that did not achieve the water quality standard, all 6 sites achieved a portion of the standard during 2011. However, because both the geometric mean and 90th percentile criterion were exceeded, the water quality standard for fecal coliform bacteria was not achieved at those sites. As shown in Figure 6.12, 9 of the 18 sites met the criteria for the period of record and all 18 sites had geometric means below the standard for the period of record.

Figure 6.13 depicts the 30 sample running geometric mean and 90th percentile of fecal coliform bacteria at the mainstem of the Nooksack River just below the Marine Drive Bridge (SW018/SW118). Site SW018/SW118 is the representative Class AA freshwater site that contributes to a Class A marine water site. As shown in Figure 6.13, from 1998 through 2003 there is a general trend of decreasing fecal coliform bacteria densities. During late 2003 through 2004, fecal coliform bacteria densities increased and exceeded both the Lummi Nation Water Quality Standards (WQS) for Class AA freshwater and the TMDL target (Ecology 2000, 2002). Fecal coliform bacteria levels dropped below the Lummi Nation WQS and the TMDL target during late 2005 through early 2007. During this period, there also was reduced sampling due to staff changes. The fecal coliform bacteria geometric mean decreased to below the TMDL Target in 2008 and 2009 however there continued to be periodic samples with high fecal coliform bacteria levels in the Nooksack River. Consequently, the fecal coliform bacteria levels were not meeting the 90th percentile standard in 2008 or 2009. During 2010 and 2011 water quality improved and Site SW018/SW118 was lower than the Lummi Nation fecal coliform bacteria geometric mean standard of 50 cfu/100 ml, the Total Maximum Daily Load (TMDL) target of 39 cfu/100 ml established for the lower Nooksack River (Ecology 2000, 2002), and the 90th Percentile standard of 100 cfu/100 ml. The water quality standard at Site SW118 was achieved during 2011 and the designated uses supported.

Figure 6.14 depicts the 30 sample running geometric mean and 90th percentile of fecal coliform bacteria for Site SW030 in Bellingham Bay between the Nooksack River Delta and Portage Bay. The fecal coliform bacteria sample results for this representative Class A marine water site have been similar to the results from SW018/SW118 over the period of record. During 1998 through 2003, there was a general trend of decreasing fecal coliform bacteria density. Similar to the Nooksack River site (SW018/SW118), fecal coliform bacteria levels at the Bellingham Bay near shore site (SW030) increased from 2004 to 2009 and began to improve in 2010. Sample Site SW030 met the geometric mean standard during 2011, but the 90 percentile value was above the standard. The decreasing trend of fecal coliform bacteria in the Nooksack River and Bellingham Bay is a sign of improving water quality in the Nooksack River watershed and Bellingham Bay after several years of high bacteria densities.

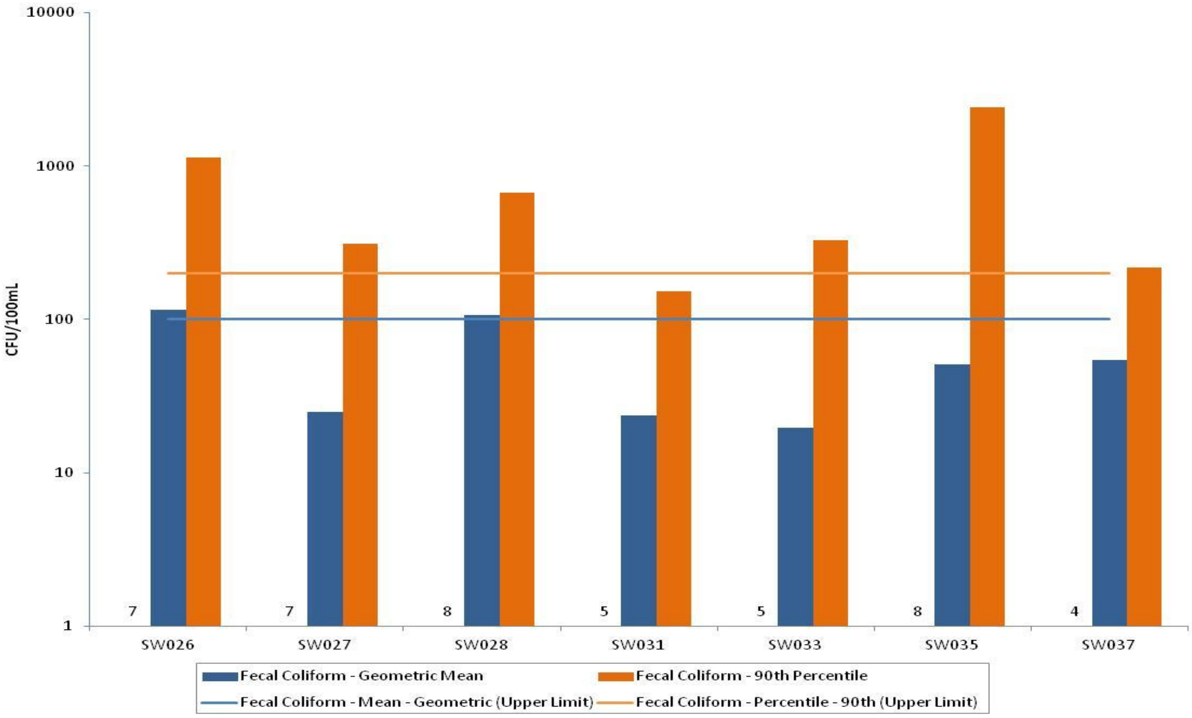

Figure 6.8 Class A Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2011

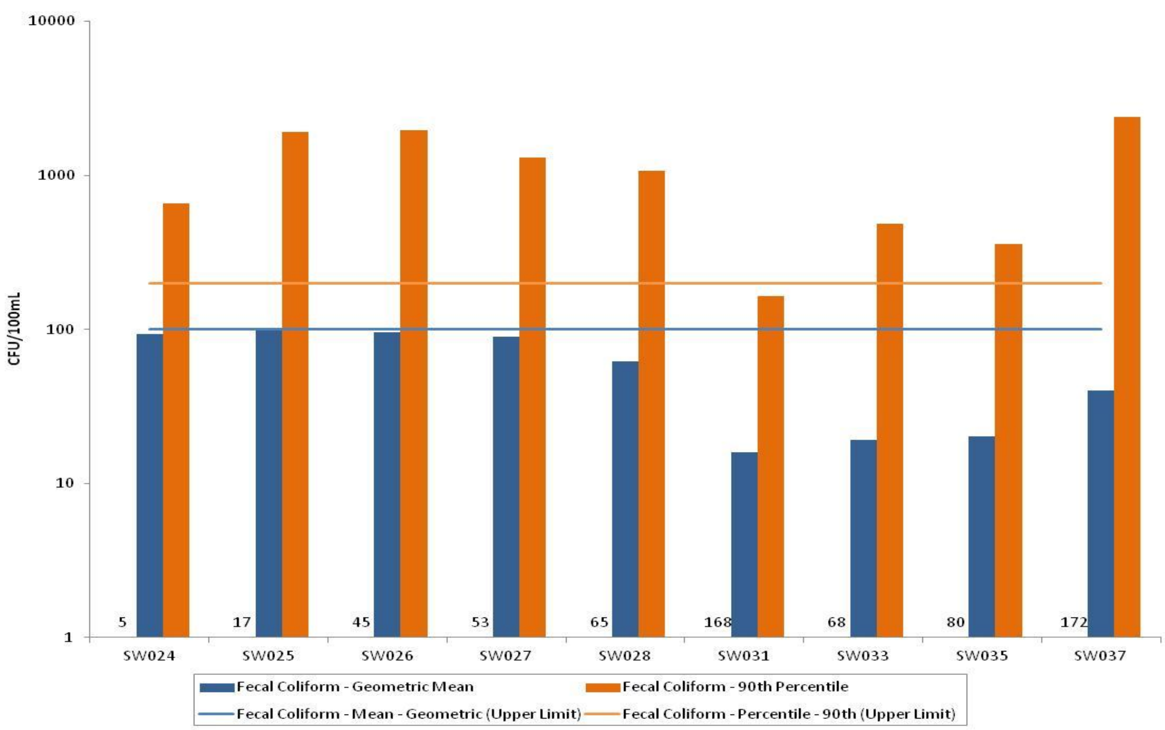

Figure 6.9 Class A Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

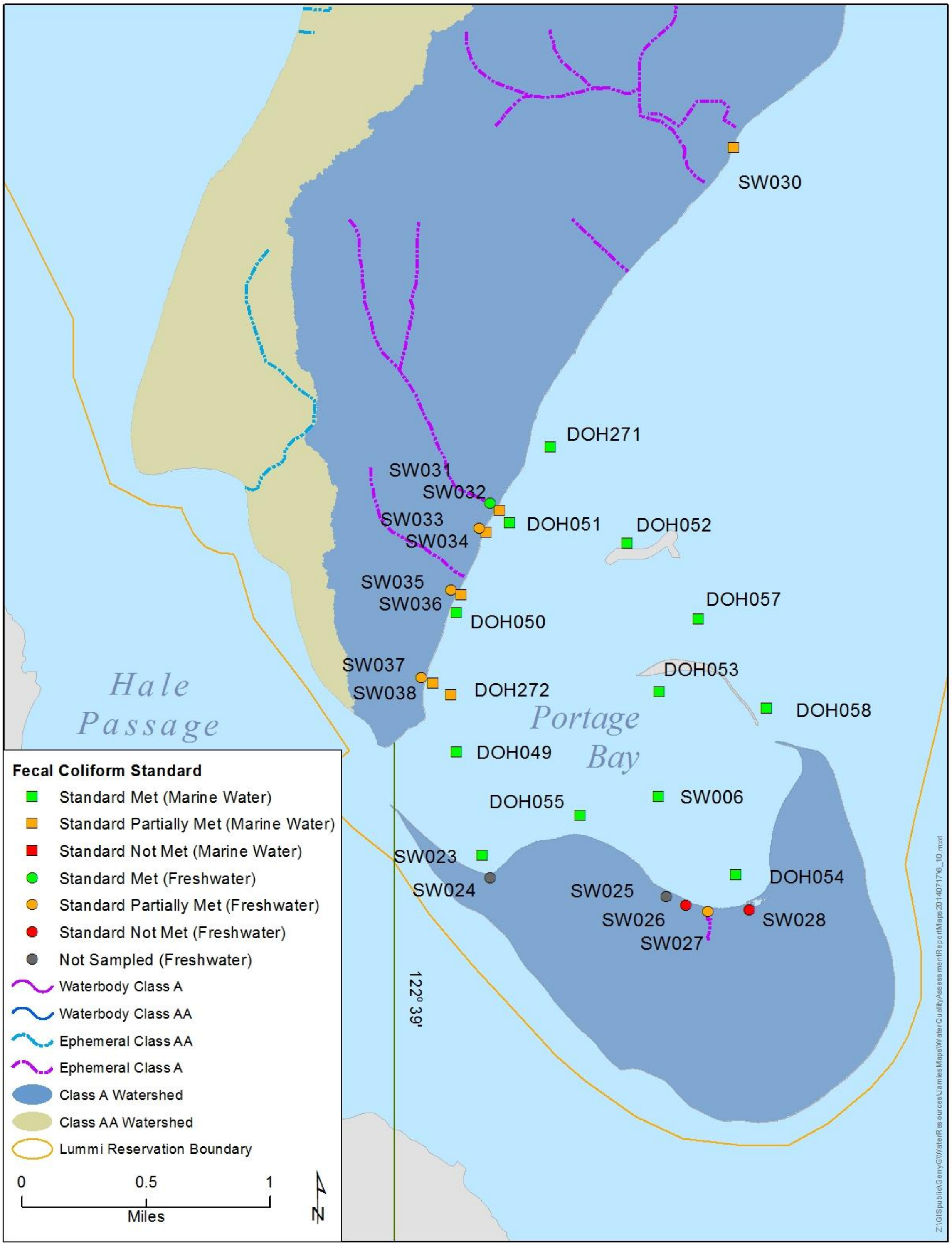

Figure 6.10 Class A Freshwater and Marine Water Fecal Coliform Compliance with Water Quality Standards: 2011

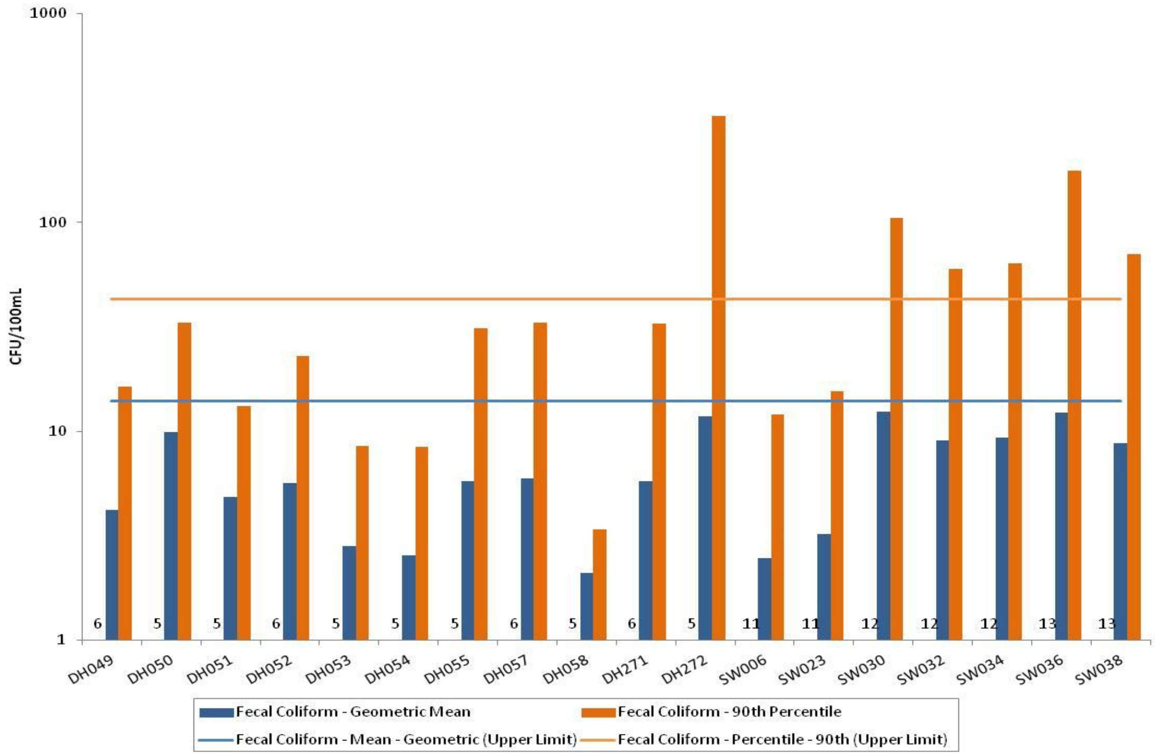

Figure 6.11 Class A Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2011

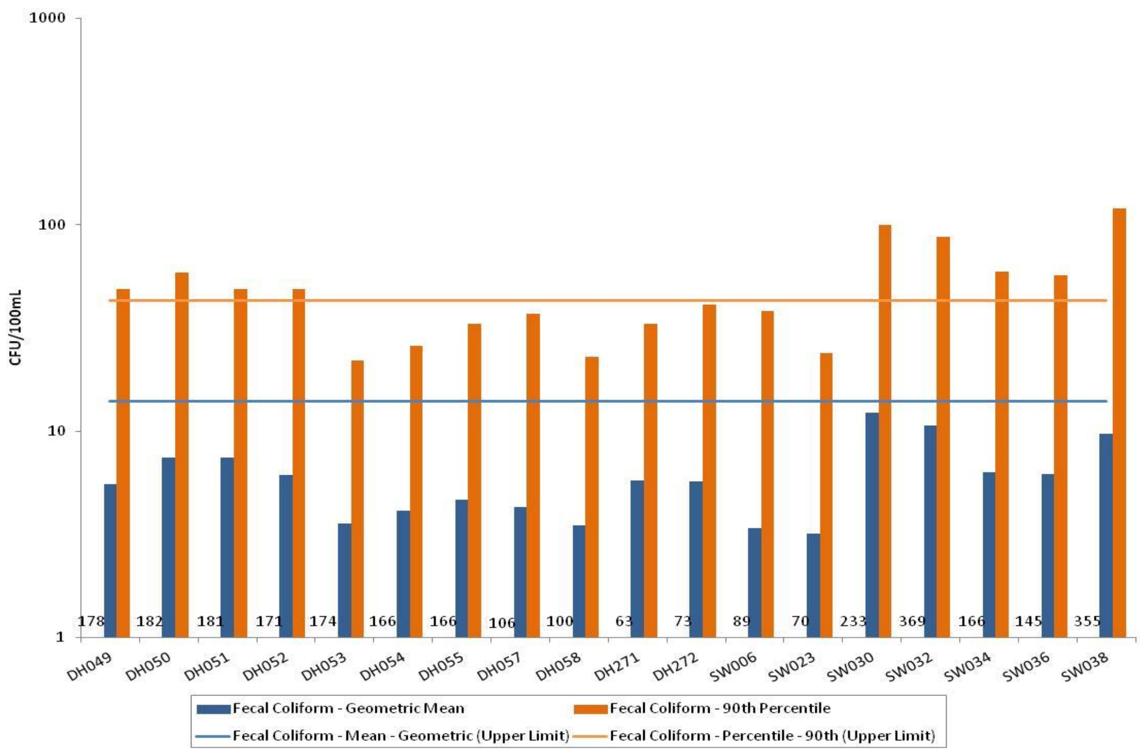

Figure 6.12 Class A Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

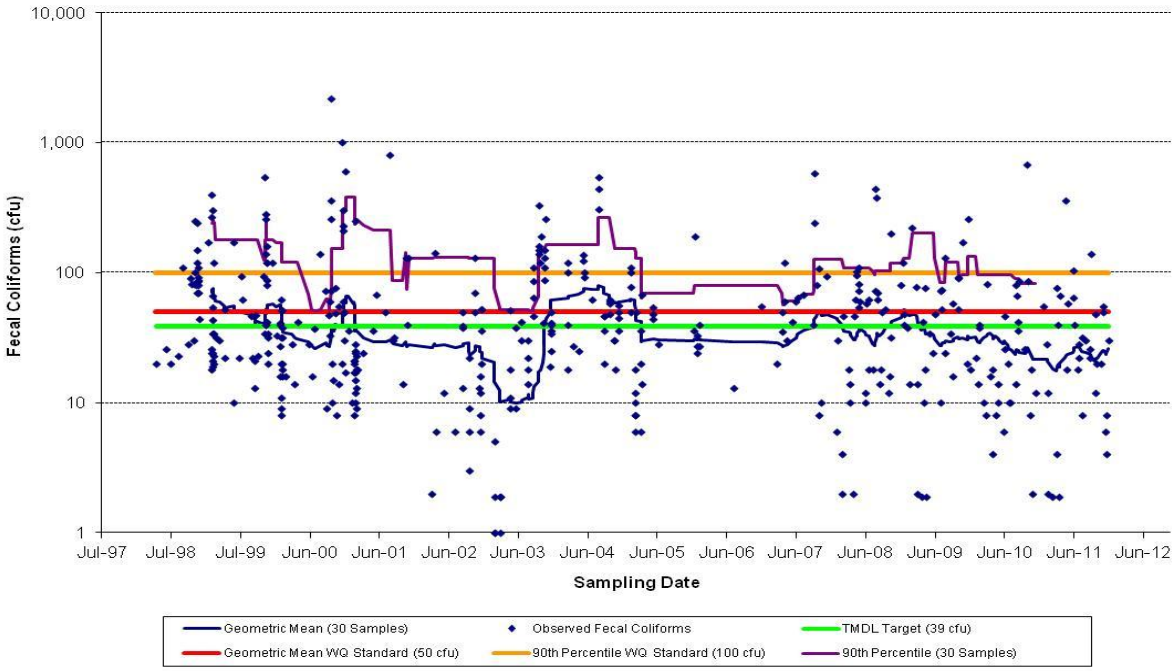

Figure 6.13 Class AA Freshwater Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW018/SW118 (Nooksack River)

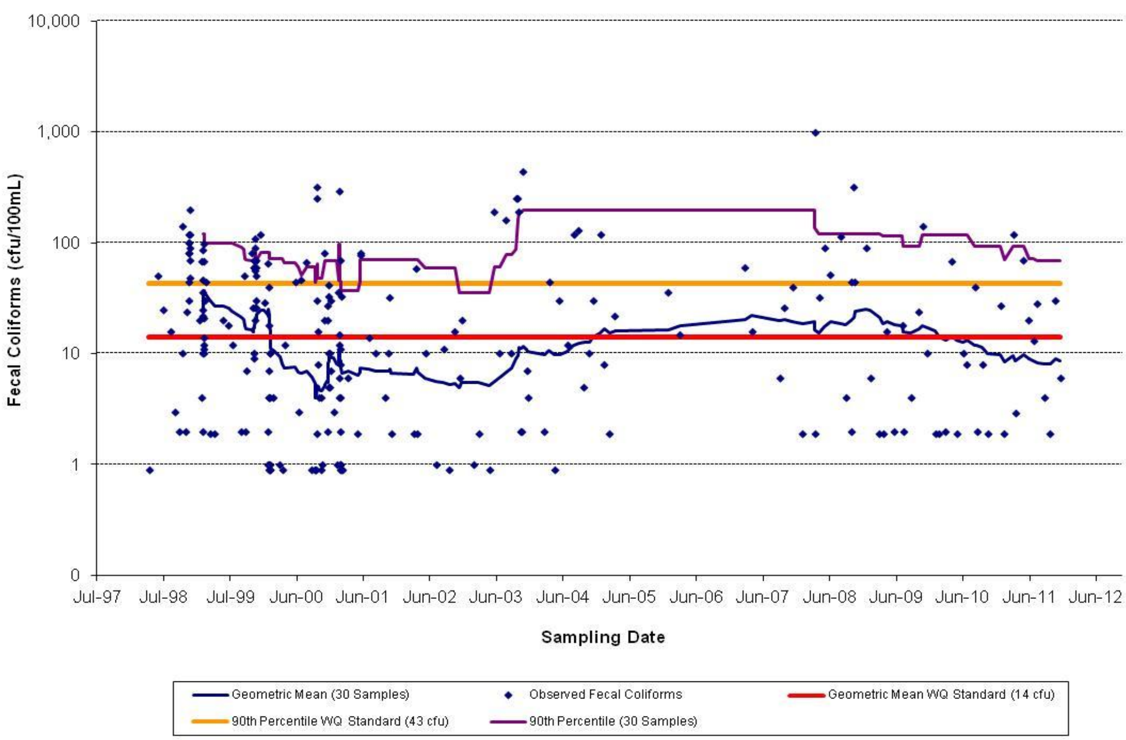

Figure 6.14 Class A Marine Water Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW030

6.4. Enterococcus Results

As described in Section 6.1, collected water quality samples are transported on ice to a contracted analytical laboratory the day of collection and tested for fecal coliform bacteria, *E.coli*, and enterococcus. Water from one sample bottle is used for each of the tests; fecal coliform bacteria and *E. coli* are enumerated from the same growth plates.

6.4.1. Class AA Waters

The Class AA freshwater standards for enterococcus bacteria are a geometric mean not to exceed 33 cfu/100 ml <u>and</u> not exceed a single sample maximum allowable density of 61 cfu/100 ml. As shown in Figure 6.15 the geometric mean was below the standard at 6 of the 16 sample sites during 2011. However as shown in Figure 6.17 both the geometric mean and the single sample maximum allowable density was only achieved at one of the 16 sites sampled during 2011. Site SW004 is one of the two sites that met the maximum allowable density in 2011; however, this result reflects the laboratory findings from a single sample. As shown in Figure 6.16, the geometric mean was below the standard at 7 of the 17 sample sites (data were included for discontinued Nooksack River site SW018) for the period of record through 2010. However, because the single maximum allowable density criterion was exceeded at all 17 sites, the water quality standard for enterococcus was not achieved at any of the Class AA freshwater sample sites for the period of record. The site with the highest geometric mean and single sample density percentile was Site SW009 located on the Lummi River at the Reservation boundary. Additional sites along the northern Reservation boundary (SW010, SW011, SW012, SW013, SW014, and SW017) had high geometric mean and single sample maximum allowable density values. Sample sites SW003 and SW058 are downstream from these sites along the boundary and also experienced high enterococcus counts.

The Class AA marine water standards for enterococcus are a geometric mean not to exceed 35 cfu/100 ml <u>and</u> not exceed a single sample maximum allowable density of 104 cfu/100 ml. As shown in Figure 6.18, only 6 of the 12 sample sites met these criteria during 2011. As shown in Figure 6.17, of the 6 sample sites that did not meet both the geometric mean and the single sample maximum allowable density, 4 of those sites achieved part of the standard. However as both the geometric mean and single sample maximum allowable density was only achieved at 6 of the 12 sample sites the water quality standard was not achieved at the remaining 6 Class AA marine water sites during 2011. All sample results at Sites SW002 and SW052 had values too low for the laboratory to detect (10 cfu/100ml) for enterococcus during 2011. As shown in Figure 6.19, sites SW001, SW002, and SW022 met the criteria for the period of record. The site with the highest geometric mean and single sample maximum density value was Site SW053, located in Lummi Bay at the northern Lummi River distributary channel tidegate. Site SW053 is downstream from Site SW003 and Sites SW010 and SW011 along the northern Reservation boundary all of which have not achieved the water quality standard for enterococcus during the period of record.

As summarized in Table 6.1, the relation between fecal coliform bacteria and enterococcus bacteria varies by site and there is generally a poor relationship between the two types of bacteria. The best relationships, defined by the highest coefficient of determination (r^2) and slope of the best-fit line close to 1 was Sites SW003 (northern Lummi River distributary channel) and SW053 (Lummi Bay at northern Lummi River distributary channel tidegate). At Sites SW003 and SW053, as fecal colifom bacteria values increased, enterococcus values increased. Because fecal coliform bacteria occur in human feces, but can also be present in animal feces, soil, and submerged wood and in other places outside the human body, and enterococcus are typically a more human-specific subgroup within the larger fecal coliform bacteria group, the very good relationship at these sites suggests that the source of fecal coliform bacteria is from human waste. The findings at Site SW003 and SW053 suggest a potential source of human waste in watershed "O" where these sites are located (Figure 2.2).

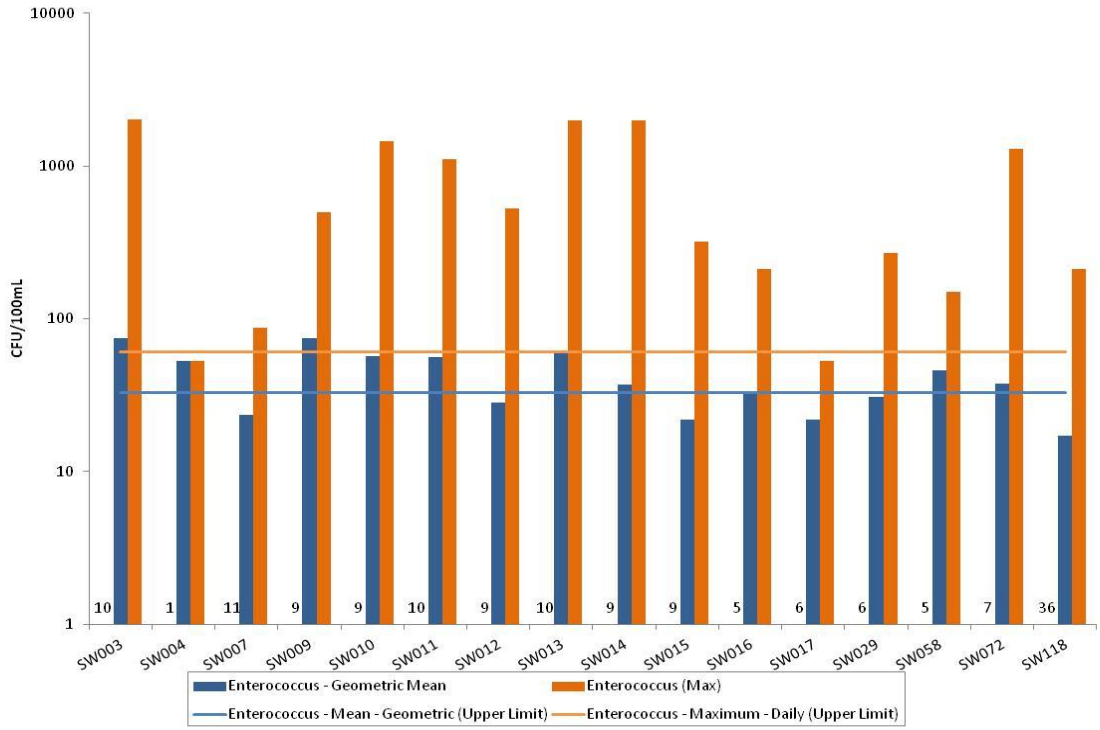

Figure 6.15 Class AA Freshwater Enterococcus Bacteria Results Compared with Water Quality Standards: 2011

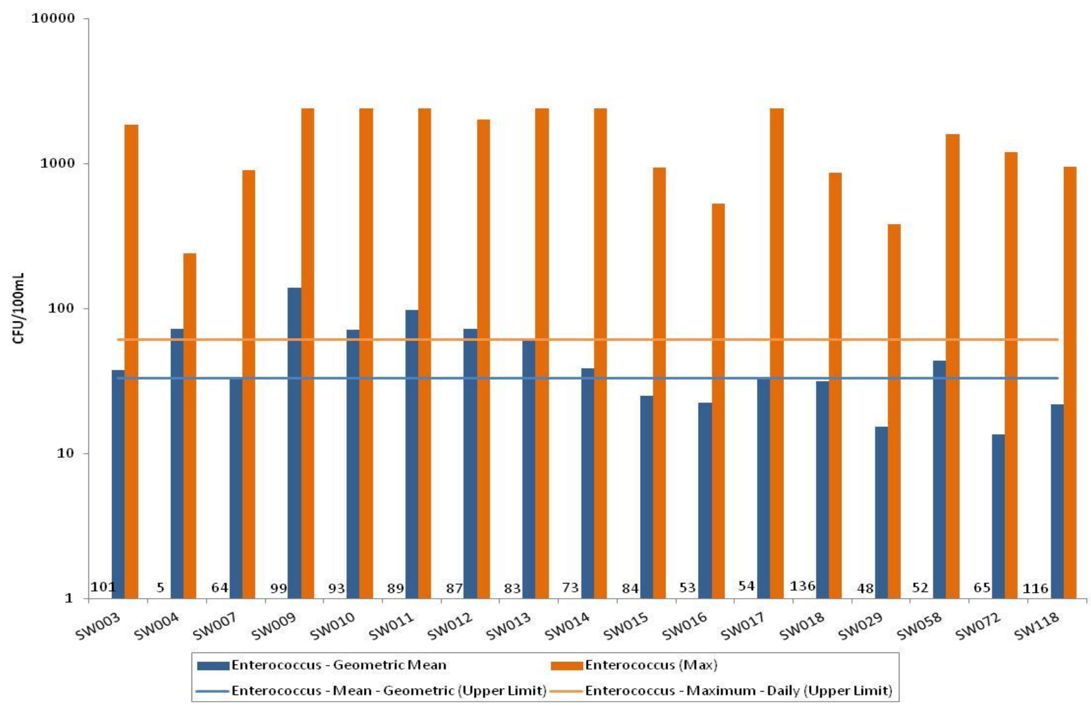

Figure 6.16 Class AA Freshwater Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

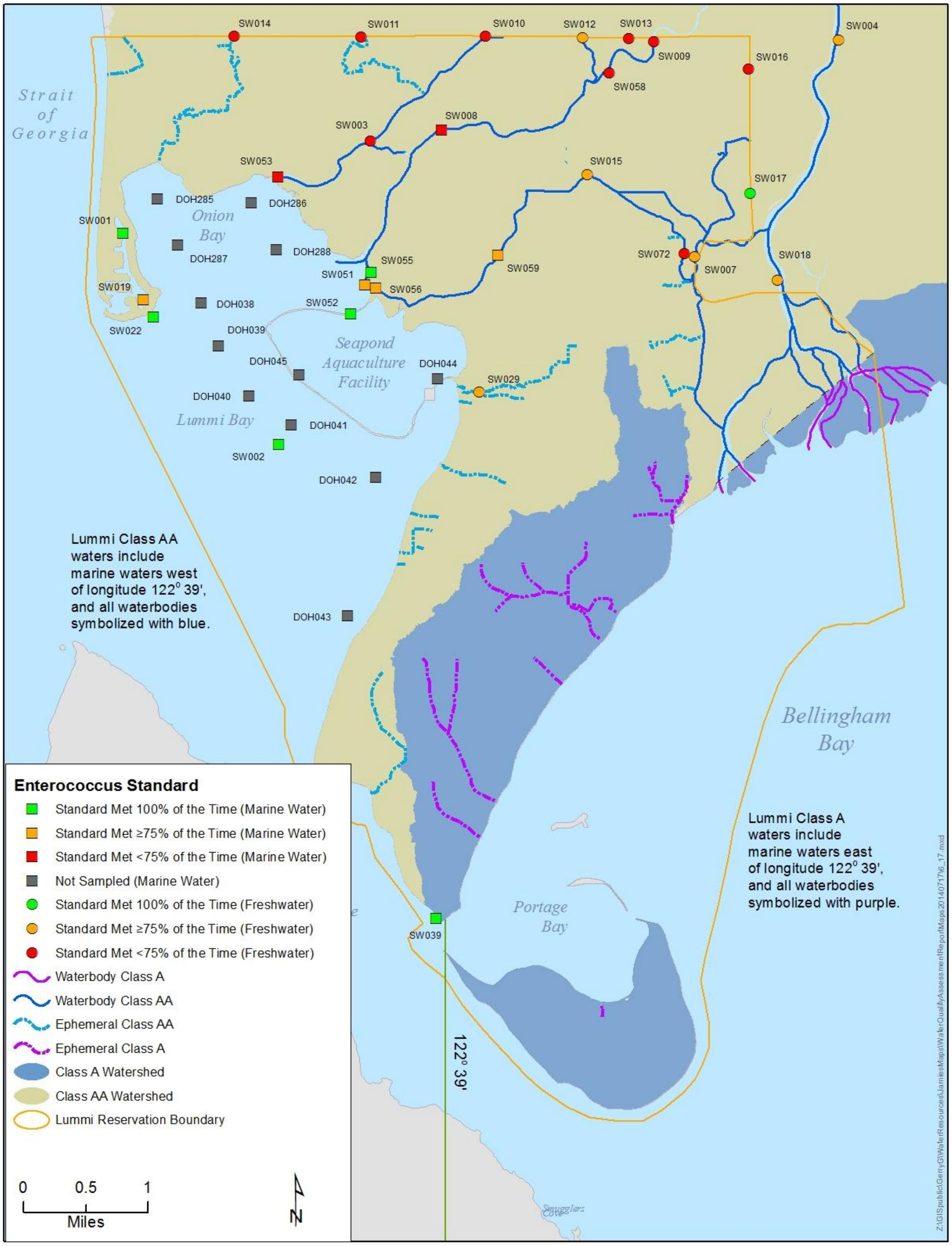

Figure 6.17 Class AA Freshwater and Marine Water Enterococcus Compliance with Water Quality Standards: 2011

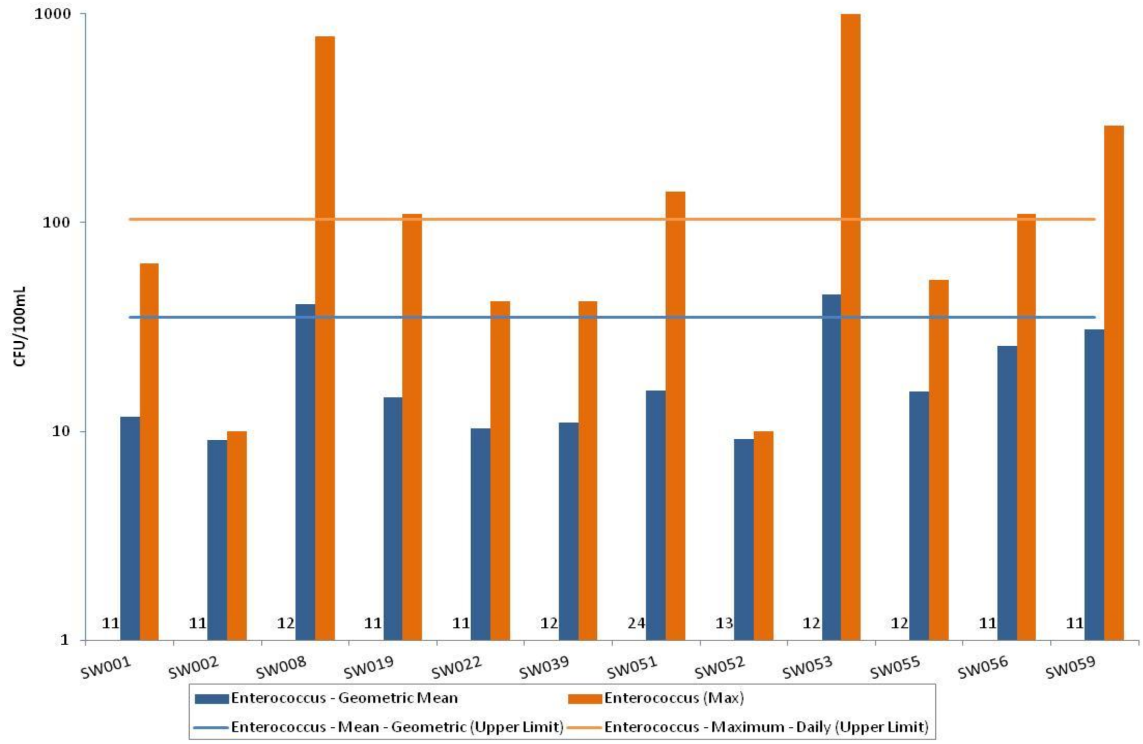

Figure 6.18 Class AA Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: 2011

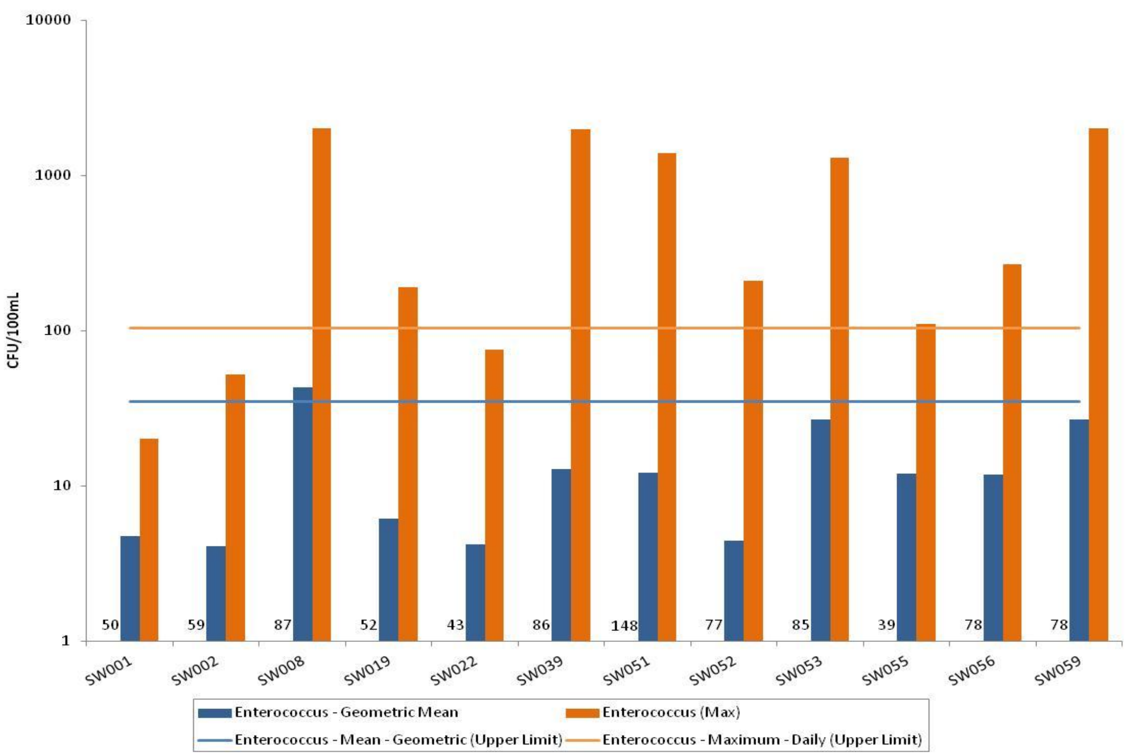

Figure 6.19 Class AA Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

Table 6.1 Relation Between Fecal Coliform and Enterococcus Bacteria – Class AA Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	111	0.76	35.84	0.69
SW007	75	0.95	16.68	0.46
SW009	108	1.29	53.31	0.41
SW010	102	0.79	17.10	0.58
SW011	99	1.29	73.10	0.37
SW012	96	2.15	-13.20	0.62
SW013	92	0.14	96.41	0.10
SW014	82	0.41	141.56	0.27
SW015	93	0.61	53.77	0.23
SW016	57	0.33	23.37	0.11
SW017	60	0.77	-22.61	0.53
SW029	54	1.06	47.17	0.29
SW058	57	0.62	136.60	0.11
SW072	71	0.09	39.74	0.10
SW118	156	0.76	26.60	0.60
Marine Water				
SW001	61	0.51	-0.38	0.59
SW002	70	0.24	1.57	0.14
SW008	99	1.87	16.09	0.51
SW019	63	0.17	3.53	0.24
SW022	54	0.55	-0.61	0.64
SW039	99	0.02	11.16	0.05
SW051	171	0.08	29.81	0.01
SW052	90	0.14	2.43	0.14
SW053	96	0.74	2.22	0.71
SW055	51	0.85	6.27	0.13
SW056	89	0.82	33.37	0.05
SW059	89	0.69	41.53	0.61

6.4.2. *Class A Waters*

The Class A freshwater standards for enterococcus bacteria include a geometric mean not to exceed 33 cfu/100 ml and not to exceed a single sample maximum allowable density of 61 cfu per 100 ml. As shown in Figure 6.20, the geometric mean was below the standard at sample sites SW026, SW028, SW031, and SW033. However as shown in Figure 6.22 the water quality standard was not achieved at any of the 7 Class A freshwater sites sampled during 2011 as none of the sites achieved both the geometric mean and the single sample maximum allowable density. As shown in Figure 6.21, the geometric mean was below the standard at eight of the nine sample sites for the period of record through 2010. However, because the single sample criteria were exceeded at eight of the nine sites, the water quality standard for enterococcus was only achieved at Site SW024 for the period of record. It is noted that there were only two samples for Site SW024. The site with the highest geometric mean and single sample values both during 2011 and over the period of record is Site SW037, which is located along Hermosa Beach, a developed portion of the Lummi Peninsula.

The Class A marine water quality standards for enterococcus are a geometric mean not to exceed 35 cfu/100 ml and not to exceed a single sample maximum allowable density of 104 cfu/100 ml. As shown in Figure 6.23, the water quality standard was achieved at 5 of the 7 sites sampled during 2011. As shown in Figure 6.22 the remaining 2 sites sampled achieved part of the water quality standard, however, as both the geometric mean and the single sample maximum allowable density were not achieved neither Site SW036 nor Site SW038 met the water quality standard during 2011. As shown in Figure 6.24, the geometric mean was lower than the standard at all sample sites but both criteria were not achieved for any of the sites for the period of record due to the exceedence of the single sample maximum density criteria.

As summarized in Table 6.2, the relation between fecal coliform bacteria and enterococcus bacteria varies by site and there is a generally poor relationship between the two types of bacteria. The best relationships, as defined by the highest coefficient of determination (r^2) and the slope of the best-fit line closest to 1, are Site SW036 and Site SW037 (along Lummi Peninsula/Portage Bay shoreline). The relationship between fecal coliform bacteria and enterococcus bacteria at Site SW036 and Site SW037 is very good, as fecal coliform bacteria values increased enterococcus values increased. As described in section 6.2.1, a positive correlation between fecal coliform and enterococcus indicates that the source of fecal coliform at Site SW036 and Site SW037 is from human waste.

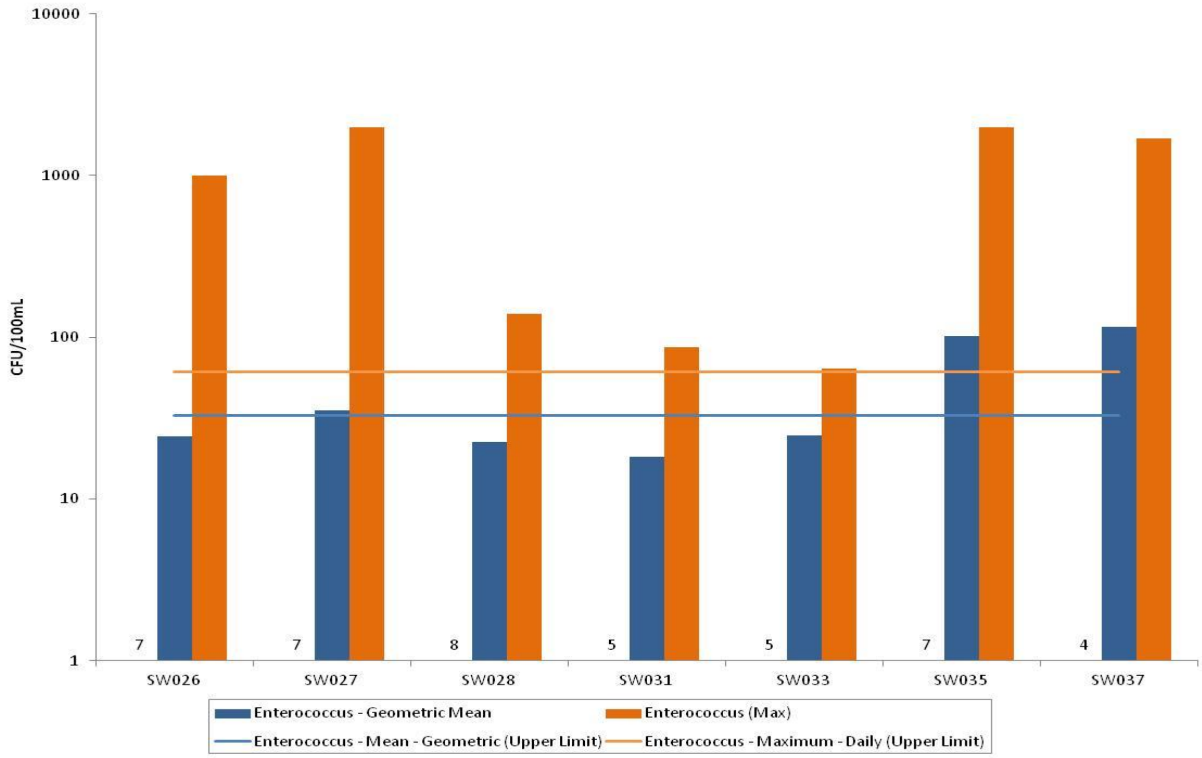

Figure 6.20 Class A Freshwater Enterococcus Results Compared with Water Quality Standards: 2011

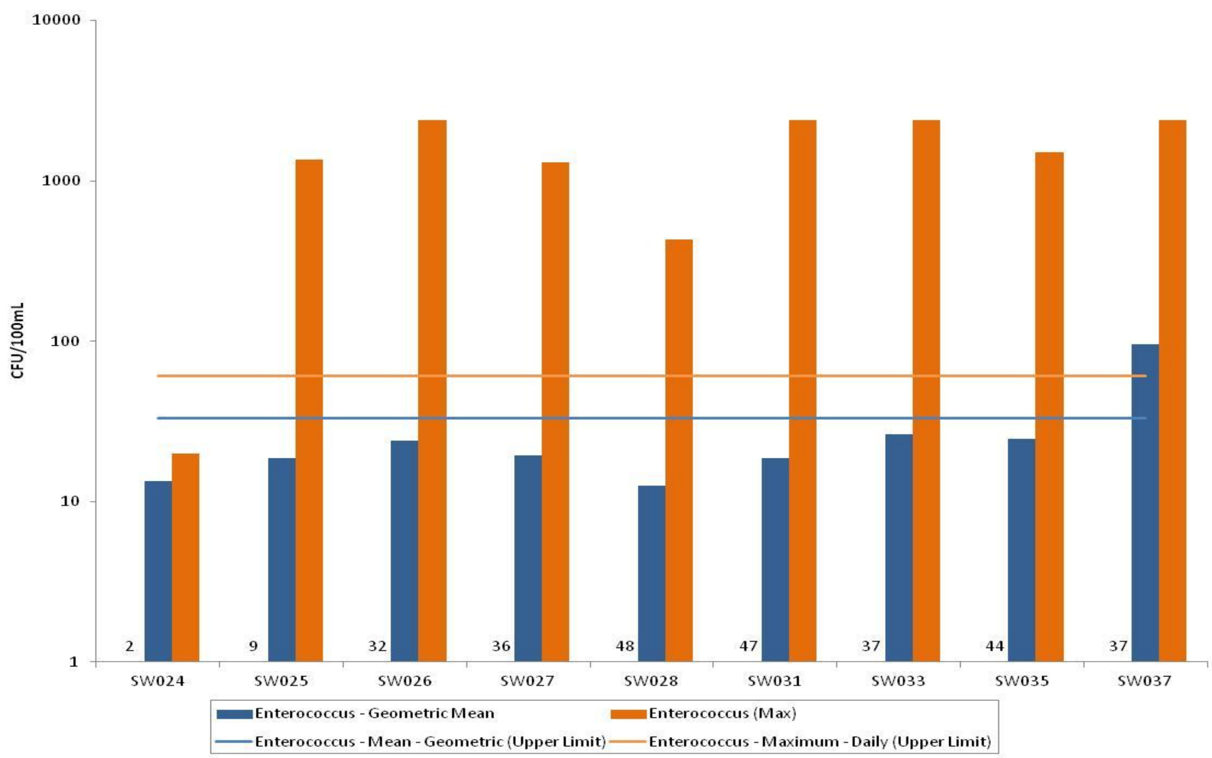

Figure 6.21 Class A Freshwater Enterococcus Results Compared with Water Quality Standards: Period of Record through 2010

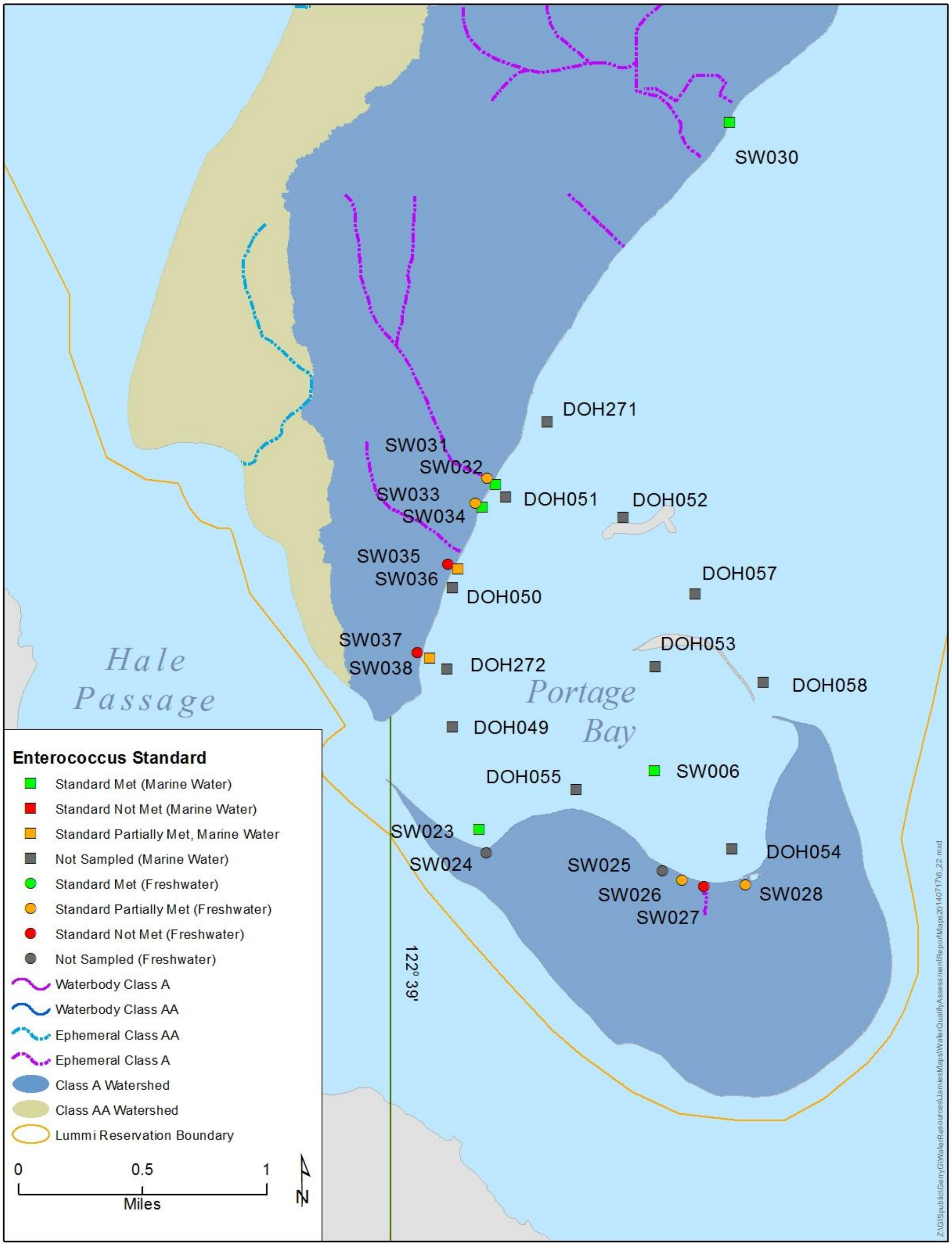

Figure 6.22 Class A Freshwater and Marine Water Enterococcus Compliance with Water Quality Standards: 2011

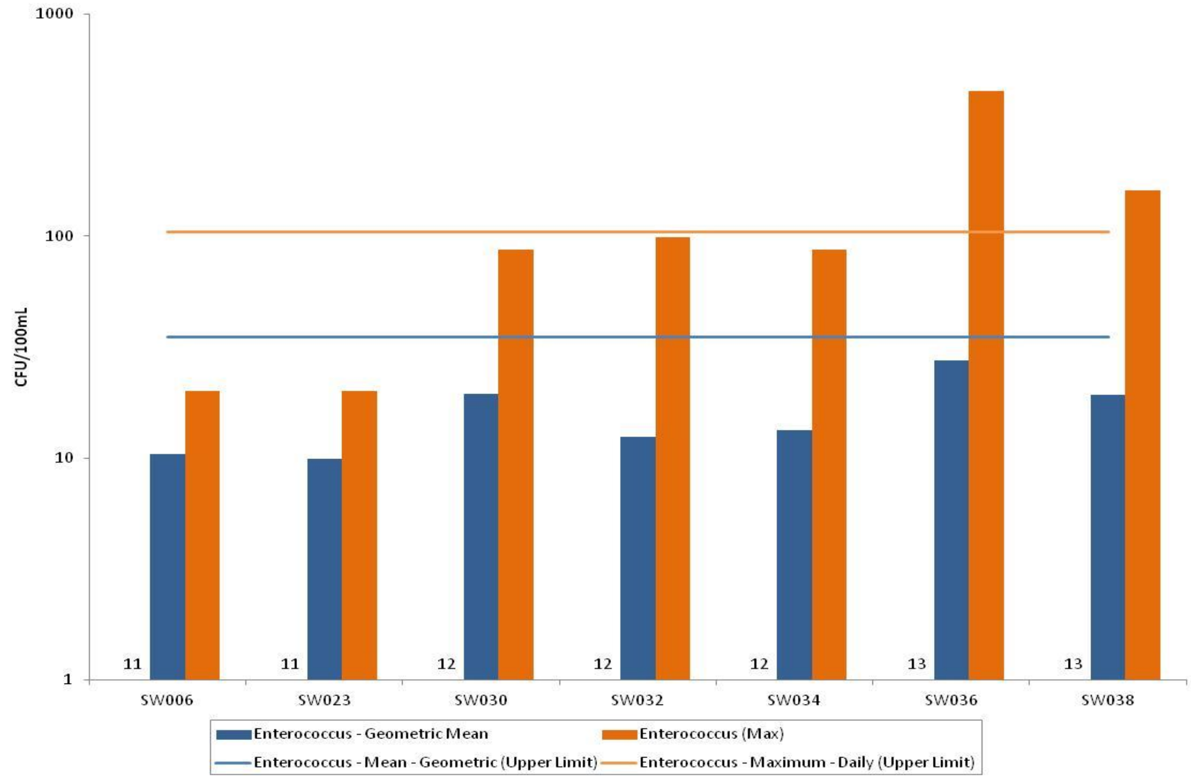

Figure 6.23 Class A Marine Water Enterococcus Results Compared with Water Quality Standards: 2011

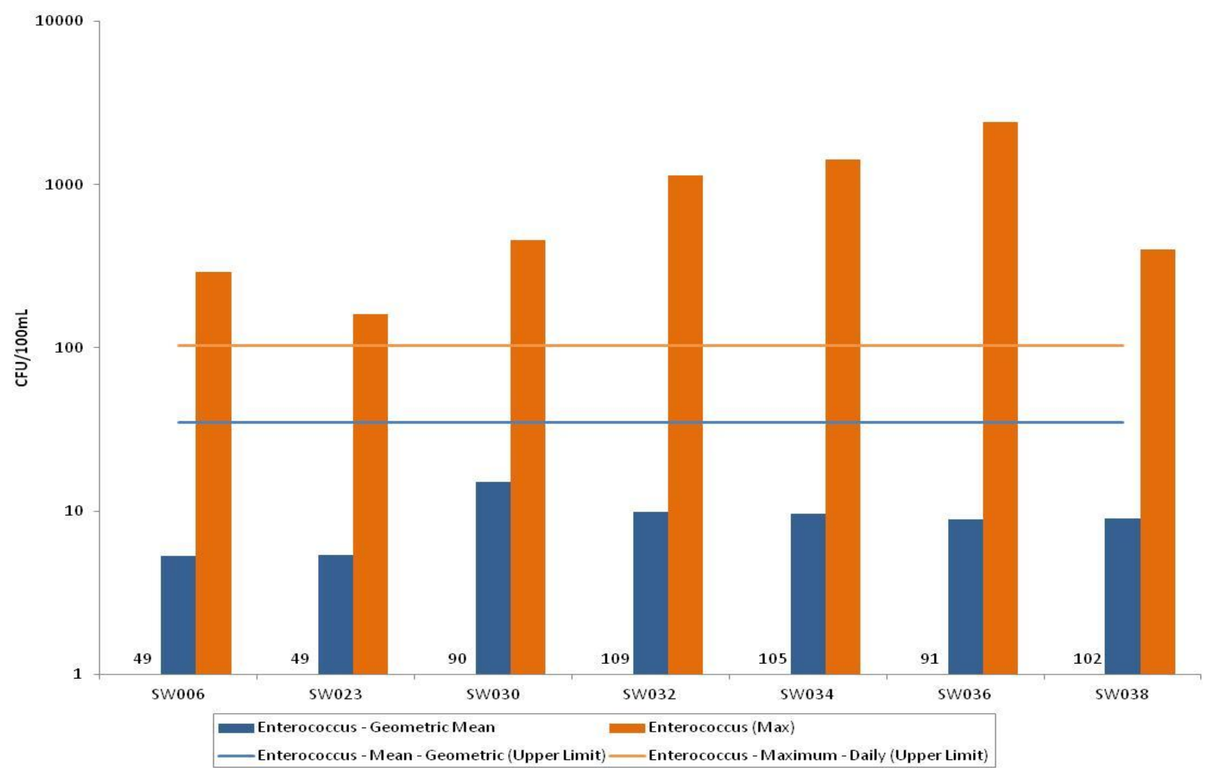

Figure 6.24 Class A Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2010

Table 6.2 Relation Between Fecal Coliform and Enterococcus Bacteria – Class A Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW025	9	1.21	139.48	0.75
SW026	39	3.43	394.47	0.46
SW027	43	0.27	308.03	0.01
SW028	56	11.05	-106.85	0.61
SW031	52	0.47	11.70	0.70
SW033	42	0.14	98.82	0.61
SW035	49	1.19	-31.59	0.66
SW037	41	2.67	-646.44	0.96
Marine Water				
SW006	60	0.22	3.65	0.34
SW023	60	0.65	0.38	0.71
SW030	104	0.54	31.88	0.09
SW032	121	0.55	5.91	0.69
SW034	117	0.41	6.42	0.56
SW036	104	1.09	-9.27	0.99
SW038	114	0.34	6.38	0.55

6.5. Escherichia coli Results

As described in Section 6.1, collected water quality samples are transported on ice to a contracted analytical laboratory the day of collection and water from one sample bottle is used for each of the tests for bacteria; fecal coliform bacteria and *Escherichia coli* (*E. coli*) are enumerated from the same growth plates.

Escherichia coli (*E. coli*) is a type of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. The Lummi Nation did not establish a water quality standard for *E. coli*, primarily because fecal coliform bacteria is the criterion used to classify commercial shellfish beds in the federal Food and Drug Administration (FDA) National Shellfish Sanitation Program (NSSP). Although there is currently not an adopted water quality standard for *E. coli*, the Program samples for *E. coli* since the EPA recommends *E. coli* as the best indicator of health risk from water contact in recreational waters and because an *E. coli* standard might be adopted in the future.

6.5.1. Class AA Waters

As summarized in Table 6.3, the fecal coliform bacteria results are generally highly correlated (coefficients of determination greater than 0.90 and slope of the best-fit line close to 1) with the *E. coli* results. The generally high correlations are not surprising since *E. coli* is a species in the fecal coliform bacteria group. The high correlation indicates that the measured fecal coliform bacteria levels are from fecal material from humans and other warm-blooded animals rather than from other bacteria types that are not necessarily fecal in origin (e.g., *Klebsiella*). Although still highly correlated with a coefficient of determination greater than 0.60, the correlation between fecal coliform bacteria and *E. coli* at sample sites SW002 and SW007 are lower and the deviation from a 1:1 slope of a best fit line is notably greater than for the majority of the other sites. Freshwater sample Sites SW003, SW010, SW014, SW017 and marine water sample Sites SW052, SW053, and SW056 had perfect correlation between fecal coliform bacteria and *E. coli* indicating that the *E. coli* are likely to be from bacteria types that are fecal in origin.

The high correlation is reflected in similar trends of fecal coliform bacteria and *E. coli* densities at the majority of sample sites. As shown in Figure 6.25 and Figure 6.26, the Class AA freshwater sites with the highest geometric mean and 90th percentile values were sites SW003, SW009, SW010, SW011, and SW012 along the northern Lummi River distributary channel and northern Reservation boundary. As shown in Figure 6.27 and Figure 6.28, the Class AA marine sites with the highest geometric mean and 90^{th} percentile values were sites SW008, SW053, SW056, and SW059. Sample Site SW008 is downstream from Site SW009 on the Lummi River but is classified as a marine water site. Although the *E. coli* density at Site SW053 is high, it is lower than the respective upstream Site SW003.

Table 6.3 Relation Between Fecal Coliform Bacteria and *E. coli* – Class AA Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	149	1.00	1.62	1.00
SW007	113	0.99	15.25	0.78
SW009	147	1.00	17.01	0.99
SW010	149	1.00	7.74	1.00
SW011	141	1.02	7.00	0.99
SW012	135	0.99	23.52	0.99
SW013	134	0.99	5.50	0.99
SW014	117	1.00	4.87	1.00
SW015	124	0.99	2.52	0.99
SW016	81	0.99	9.01	0.96
SW017	81	1.00	1.65	1.00
SW029	179	1.00	3.27	0.99
SW058	63	1.05	24.35	0.92
SW072	71	0.97	2.99	0.92
SW118	156	1.04	1.65	0.89
Marine Water				
SW001	62	0.98	0.43	0.83
SW002	85	0.96	0.61	0.63
SW008	138	1.01	4.39	0.99
SW019	77	0.98	0.69	0.83
SW022	68	0.99	0.15	0.99
SW039	185	1.00	1.00	0.99
SW051	195	1.10	-0.93	0.98
SW052	101	1.00	0.05	1.00
SW053	115	1.00	2.48	1.00
SW055	51	0.99	1.38	0.97
SW056	97	1.00	0.64	1.00
SW059	93	0.99	3.86	0.99

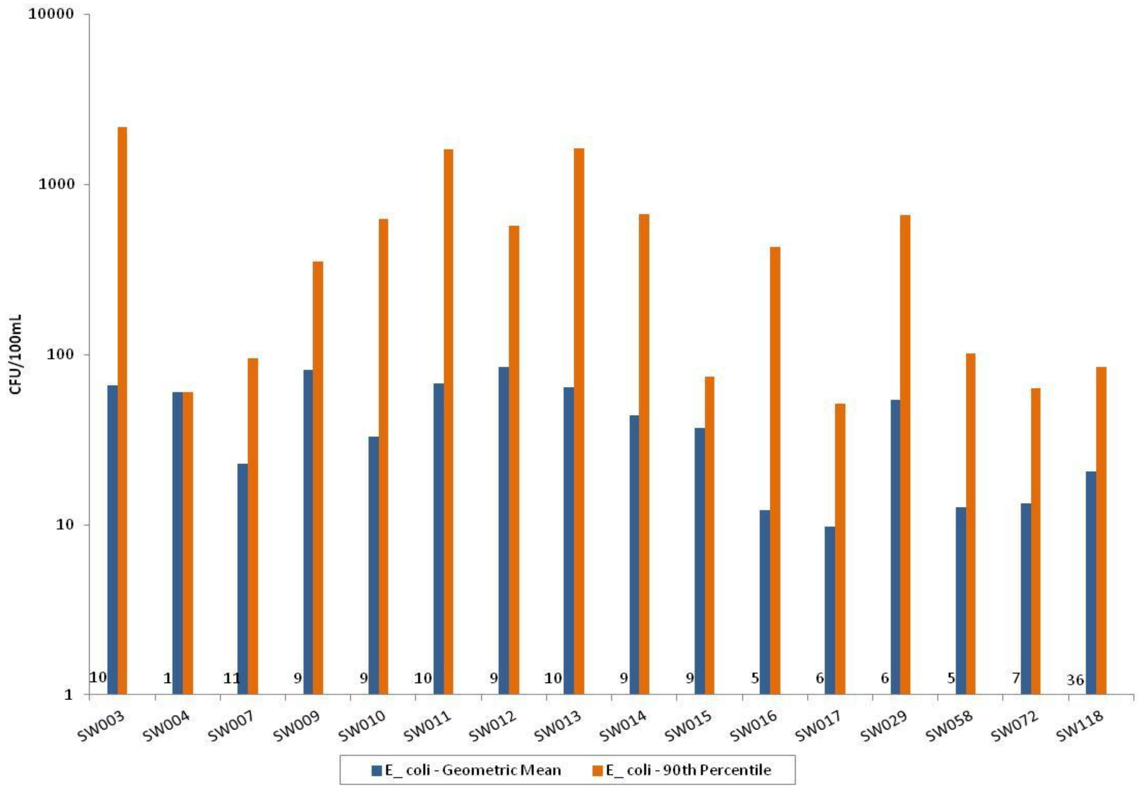

Figure 6.25 Class AA Freshwater *E.coli* Results: 2011

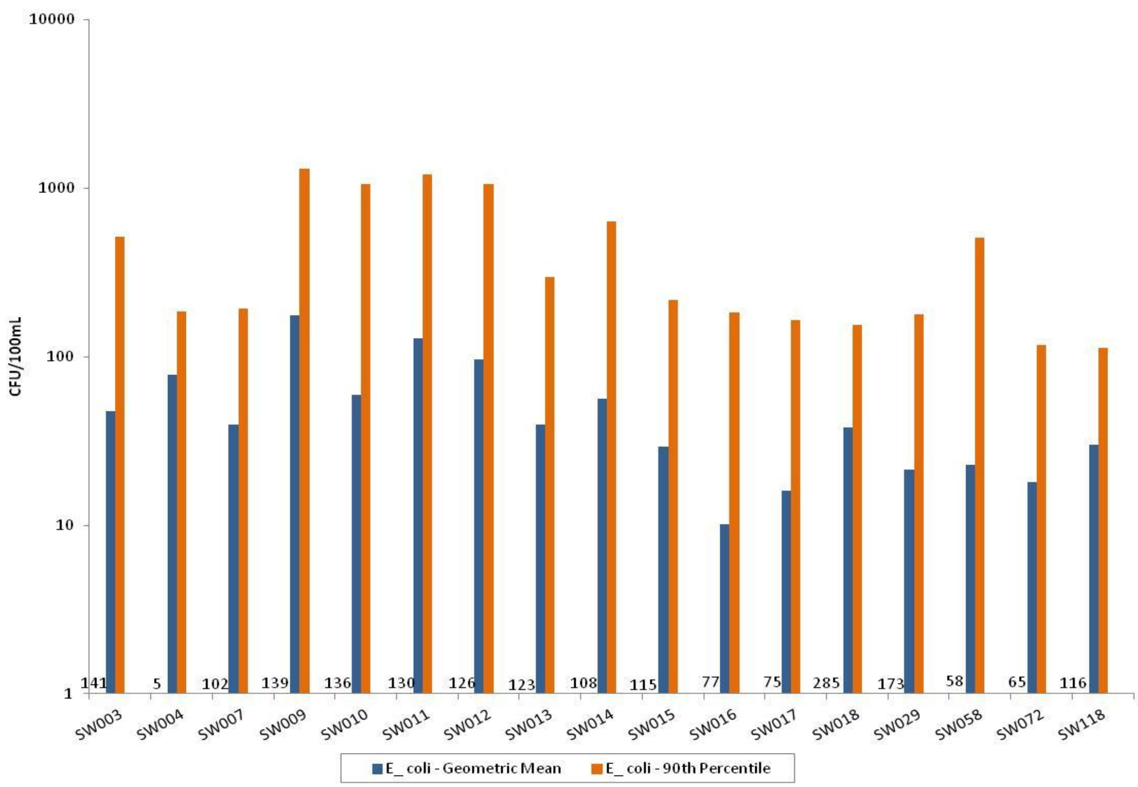

Figure 6.26 Class AA Freshwater *E.coli* Results: Period of Record through 2010

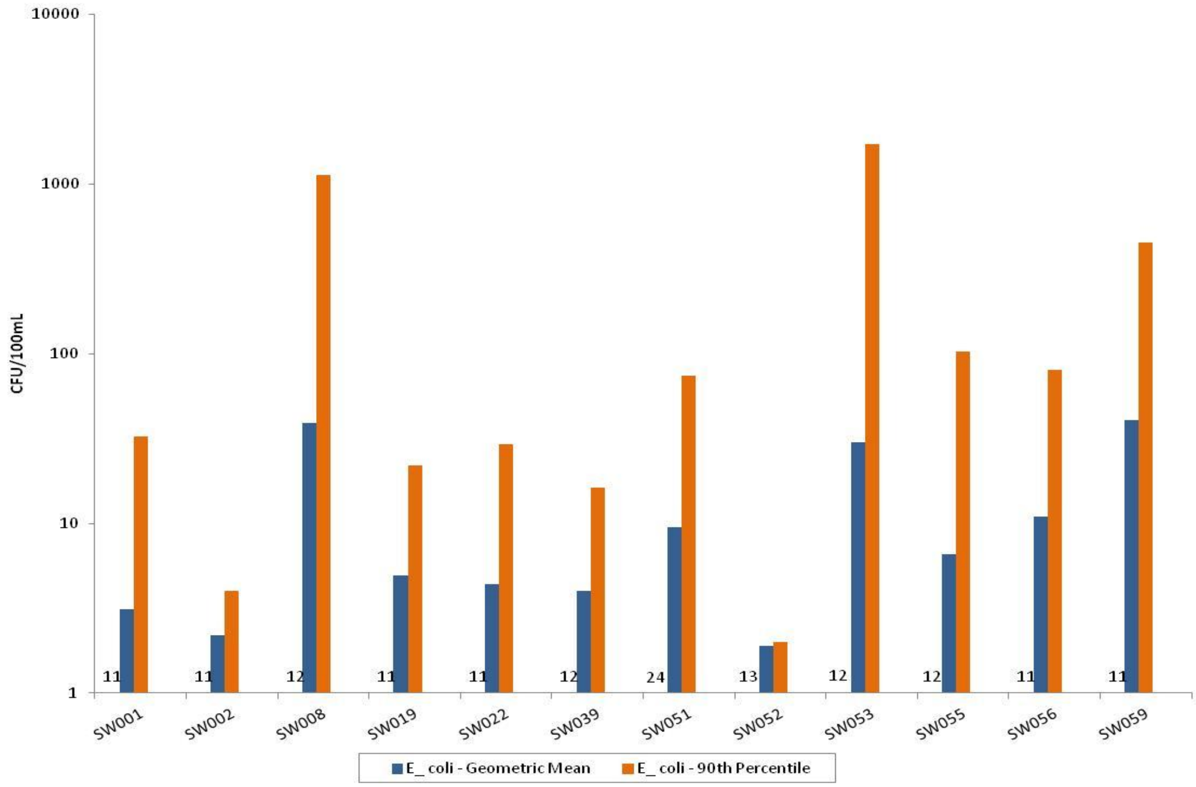

Figure 6.27 Class AA Marine Water *E.coli* Results: 2011

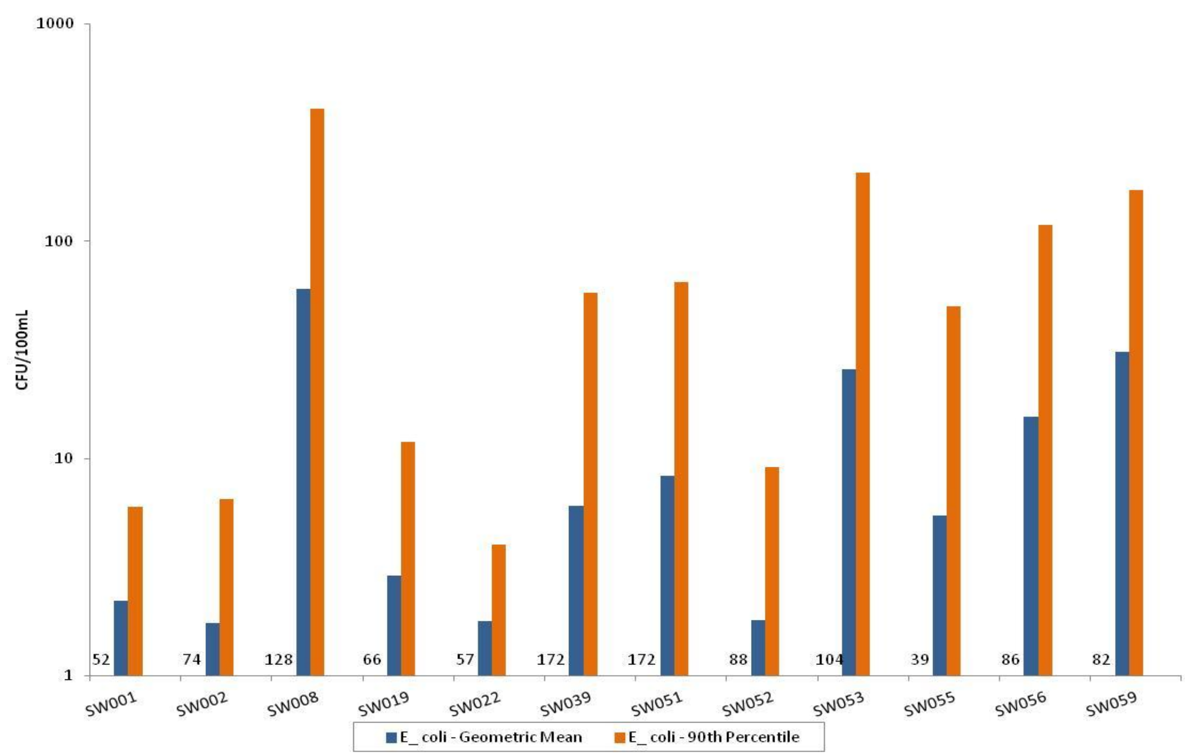

Figure 6.28 Class AA Marine Water *E.coli* Results: Period of Record through 2010

6.5.2. Class A Waters

As summarized in Table 6.4, the fecal coliform bacteria results for Class A waters were highly correlated (coefficients of determination greater than 0.90 and slope of the best-fit line close to 1) with the *E. coli* results. As described in section 6.3.1, the generally high correlations are not surprising since *E. coli* is a species in the fecal coliform bacteria group. The high correlation indicates that the fecal coliform bacteria are from fecal material from humans and other warm-blooded animals rather than from other bacteria types that are not necessarily fecal in origin (e.g., *Klebsiella*). Sample Site SW030 (in Bellingham Bay) has the poorest relationship between fecal coliform bacteria and *E.coli* with a coefficient of determination of 0.37 and slope of 0.62.

The generally high correlation between fecal coliform bacteria and *E.coli* is reflected in similar trends of fecal coliform bacteria and *E.coli* densities at sample sites. As shown in Figure 6.29, the Class A freshwater sites with the highest geometric means and 90th percentiles during 2011 are Sites SW026 and SW028 located on Portage Island and Site SW035 located along the Lummi Peninsula/Portage Bay shoreline. Figure 6.30 illustrates, the Class A freshwater sites with the highest geometric means and 90th percentiles over the period of record are located on Portage Island (SW024, SW025, SW026, SW027, and SW028) with an additional Site SW037 located along the Lummi Peninsula/Portage Bay Shoreline. As shown in Figure 6.31 Sites SW006 and SW023 respectively located in Portage Bay and Lummi Bay had the lowest geometric mean and 90th percentile for Class A marine water sites during 2011. In contrast, as shown in Figure 6.32, Site SW038 has one of the highest geometric mean and 90th percentile for a Class A marine water for the period of record.

Table 6.4 Relation Between Fecal Coliform Bacteria and *E.coli* – Class A Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW025	17	0.98	72.38	0.98
SW026	52	1.00	0.00	1.00
SW027	59	1.00	17.94	0.99
SW028	75	0.98	9.69	0.96
SW031	172	1.00	-0.54	1.00
SW033	71	1.00	0.49	1.00
SW035	83	1.00	2.35	1.00
SW037	170	1.00	15.68	1.00
Marine Water				
SW006	87	1.00	0.15	1.00
SW023	85	1.00	0.26	0.99
SW030	245	0.62	18.62	0.37
SW032	393	1.00	17.73	0.99
SW034	186	1.00	0.53	0.99
SW036	156	1.00	0.52	1.00
SW038	379	1.00	1.80	1.00

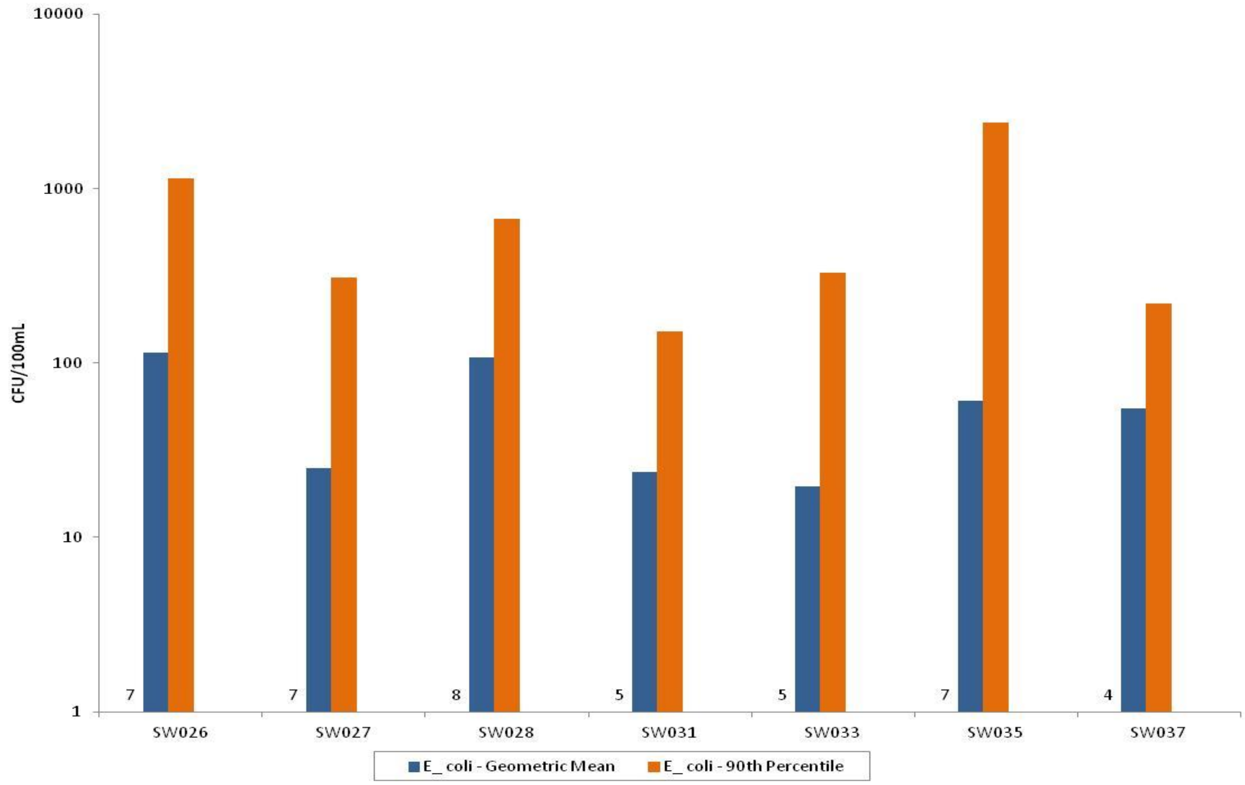

Figure 6.29 Class A Freshwater *E.coli* Results: 2011

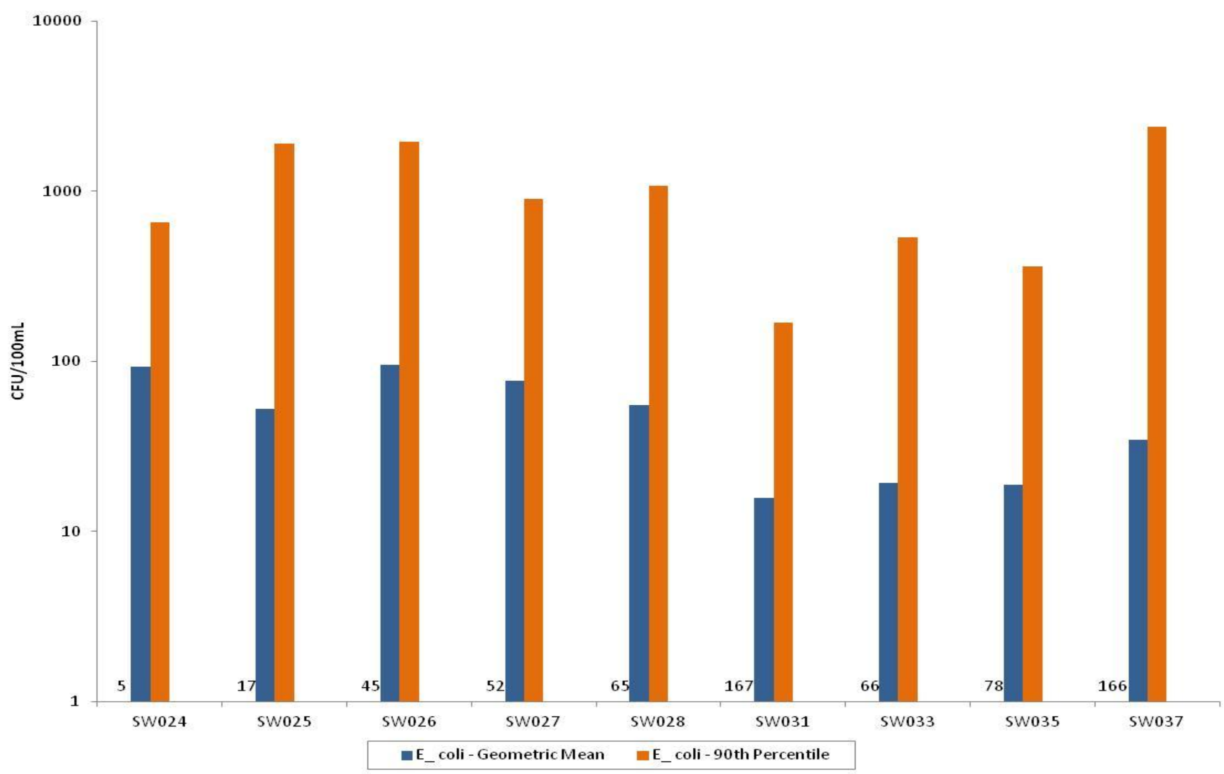

Figure 6.30 Class A Freshwater *E.coli* Results: Period of Record through 2010

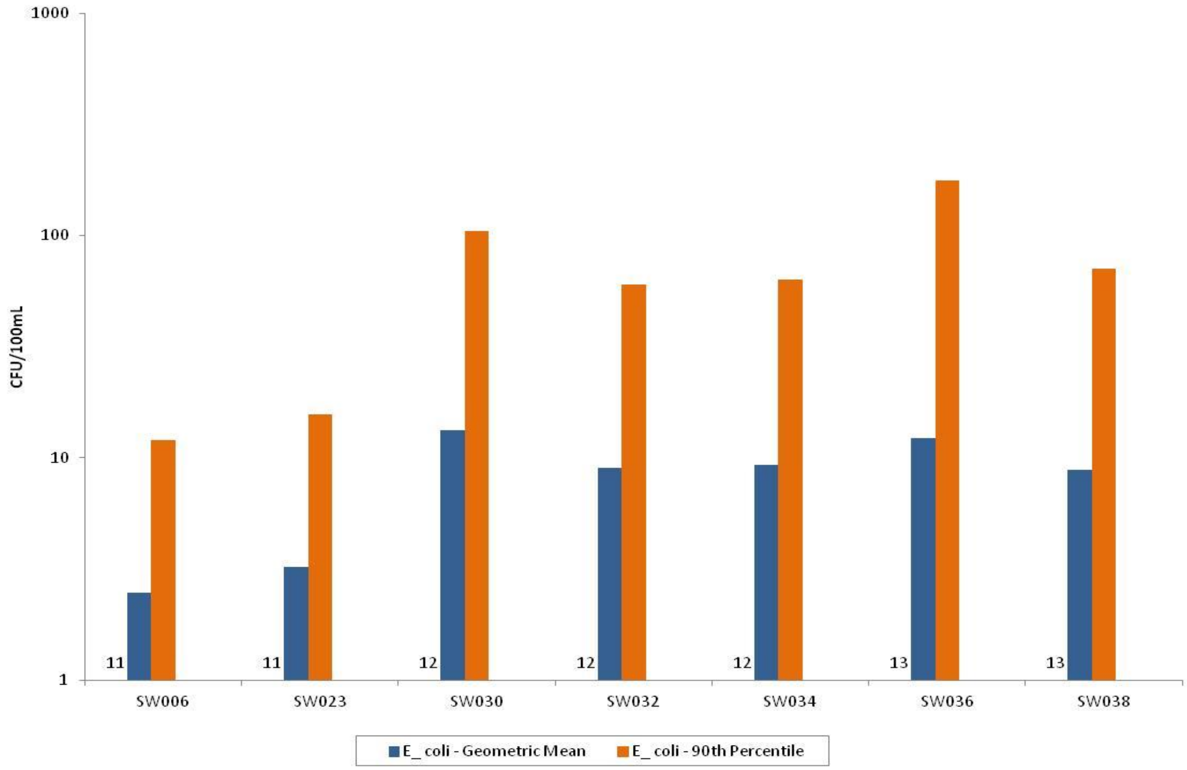

Figure 6.31 Class A Marine Water *E.coli* Bacteria Results: 2011

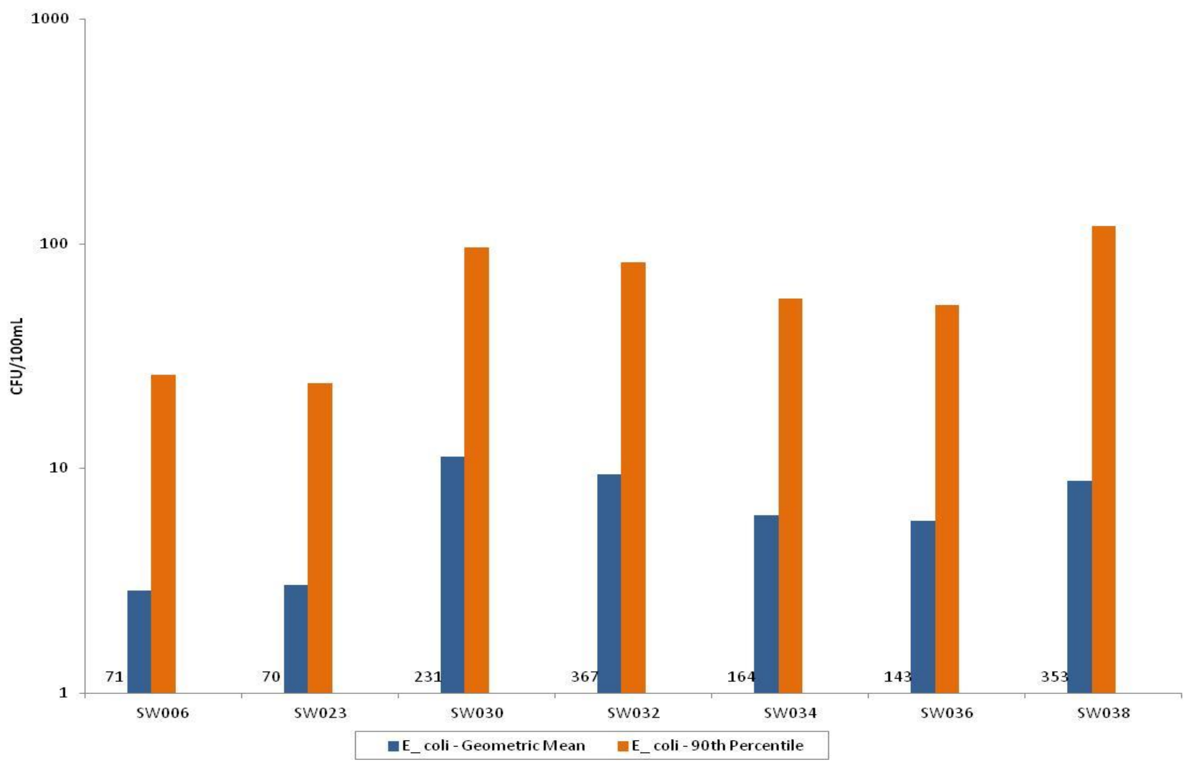

Figure 6.32 Class A Marine Water *E.coli* Bacteria Results: Period of Record through 2010

6.6. Water Temperature Results

Similar to bacteria, the standards for water temperature are set at a maximum value. If the maximum measured water temperature is greater than the water quality criteria, the sample results indicate that the characteristic uses of the water body are not fully supported. The existing sampling program collects single measurements of water temperature at all sample sites during a sampling run that typically occurs once each month. Since the water quality standards are expressed as the 7-day average of the daily maximum value in the case of freshwater sites, and the 1-day maximum temperature for marine water sites, the collected data do not allow a direct comparison with the applicable water quality standards. However, the sample results provide an indicator of whether the water quality standards were exceeded at that time. Box-and-whisker plots were also generated to depict seasonal variations and trends over the period of record from a representative sample site from the same water body classification. The top and bottom of the box represent the bounds of the first and third quartiles, while the red triangle inside the box represents the second quartile or median. The whiskers extending from the box indicate variability outside the upper and lower quartiles. Any data not included between the whiskers are plotted as an outlier with a small green dot.

Continuous recording water temperature probes were deployed at ten of the surface water monitoring sites during 2011. The data collected at the ten sites with continuous temperature dataloggers will allow direct comparison with the applicable water quality standards at these sites. Due to lost equipment eight of the ten sites have a complete data set for 2011 and another site has a seven month continuous water temperature record.

6.6.1. Class AA Waters

The Class AA freshwater quality standard for water temperature is a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summer time spawning, temperature shall not exceed a 7DADM temperature of 13.0°C. As shown in Figure 6.33, the water quality data collected during 2011 indicate that this standard was exceeded at 7 of the 16 sample sites. As shown in Figure 6.35 of the 7 sites that did not achieve the water quality standard during 2011, 4 sites achieved the standard at least 75% of the time sampled, and 3 sites achieved the standard less than 75% of the time sampled during 2011. Although sample Site SW004 is shown in Figure 6.33 to have met this standard during 2011, these results reflect the laboratory findings from only one sample. As described previously, SW004 is only sampled during flood conditions in the Nooksack River where sampling at Site SW118 would be dangerous. As shown in Figure 6.33 and Figure 6.34, the water temperature was always below the standard at two of the Class AA freshwater monitoring sites (SW029 and SW004). Site SW029 is in a largely forested watershed that drains a portion of the Lummi Peninsula.

The Class AA marine standard for water temperature is a 1-day maximum temperature of 13.0°C. As shown in Figure 6.36 and Figure 6.37, the water temperature exceeded the standard at least once at all of the Class AA marine water quality monitoring sites both during 2011 and during the period of record through 2010. As shown in Figure 6.35, 13 of the 24 Class AA marine water sites achieved the standard at least 75% of the time sampled during 2011, while the remaining 11 sample sites achieved the standard less than 75% of the time sampled during 2011.

As shown in Figure 6.38, the water temperature sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009 on the Lummi River along the northern Reservation boundary) have generally been below the 16.0°C threshold over the period of record. In contrast, as shown in Figure 6.39, the water temperature sample results for the representative Class AA marine water site (SW002 in Lummi Bay) have commonly been above the 13.0°C threshold over the period of record. Site SW002 is located on the tide flats of Lummi Bay and the water temperature increases as the tidal waters flow over the mud flats. There is likely not an anthropogenic cause for the elevated temperatures at this location.

As shown by the box-and-whisker plot in Figure 6.40, the water temperature at Site SW009 varies during the year with the highest temperatures occurring during July and August and the lowest temperatures during December and January. As shown in Figure 6.41, a similar pattern occurs at Site SW002 except that the lowest temperature occurs during February.

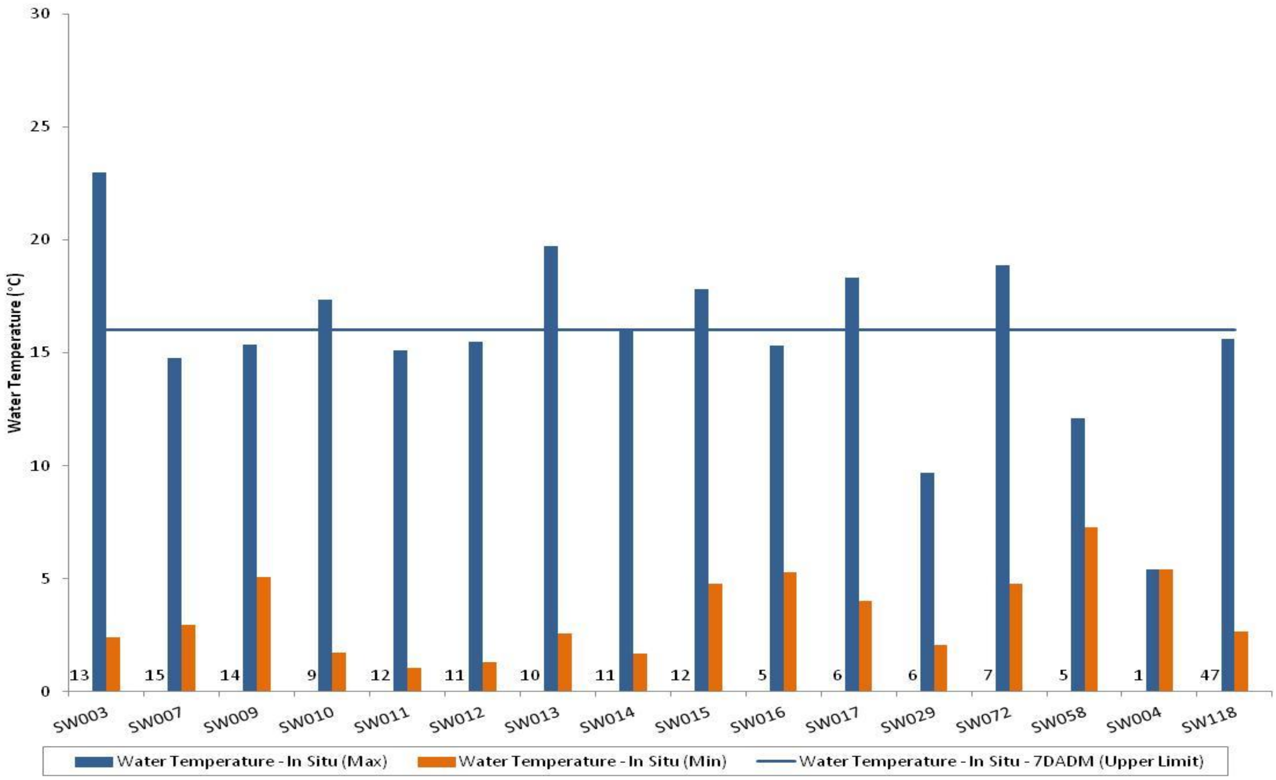

Figure 6.33 Class AA Freshwater Temperature Results Compared with Water Quality Standards: 2011

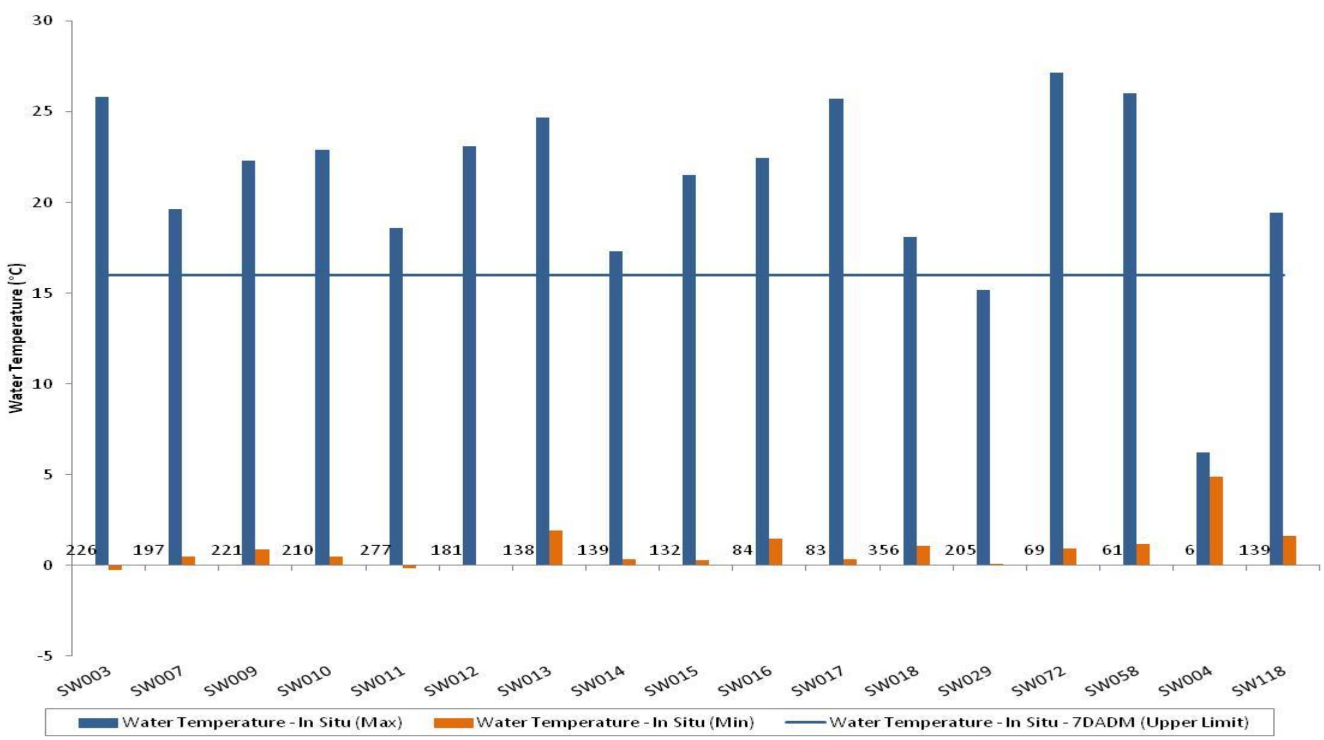

Figure 6.34 Class AA Freshwater Temperature Results Compared with Water Quality Standards: Period of Record through 2010

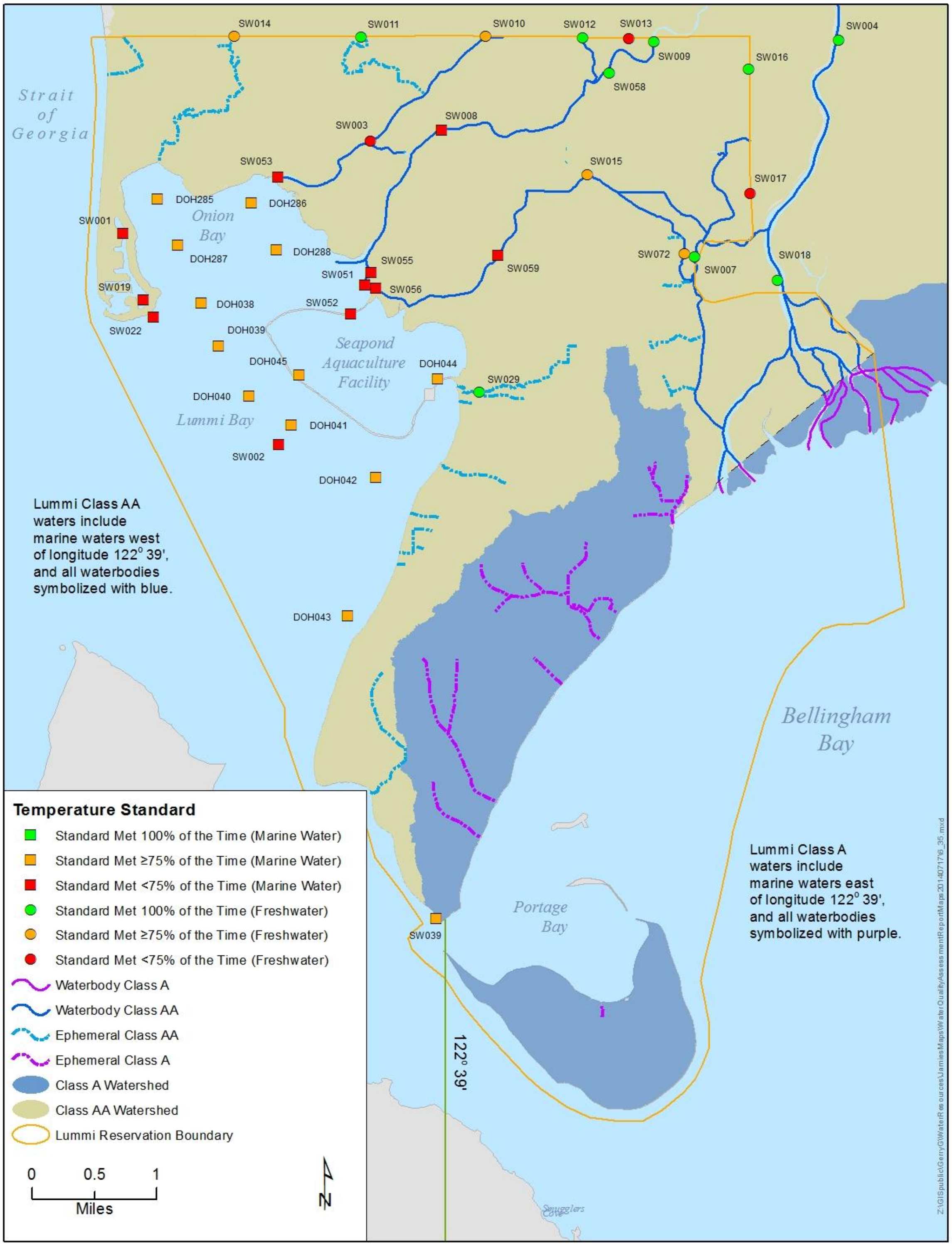

Figure 6.35 Class AA Freshwater and Marine Water Temperature Compliance with Water Quality Standards: 2011

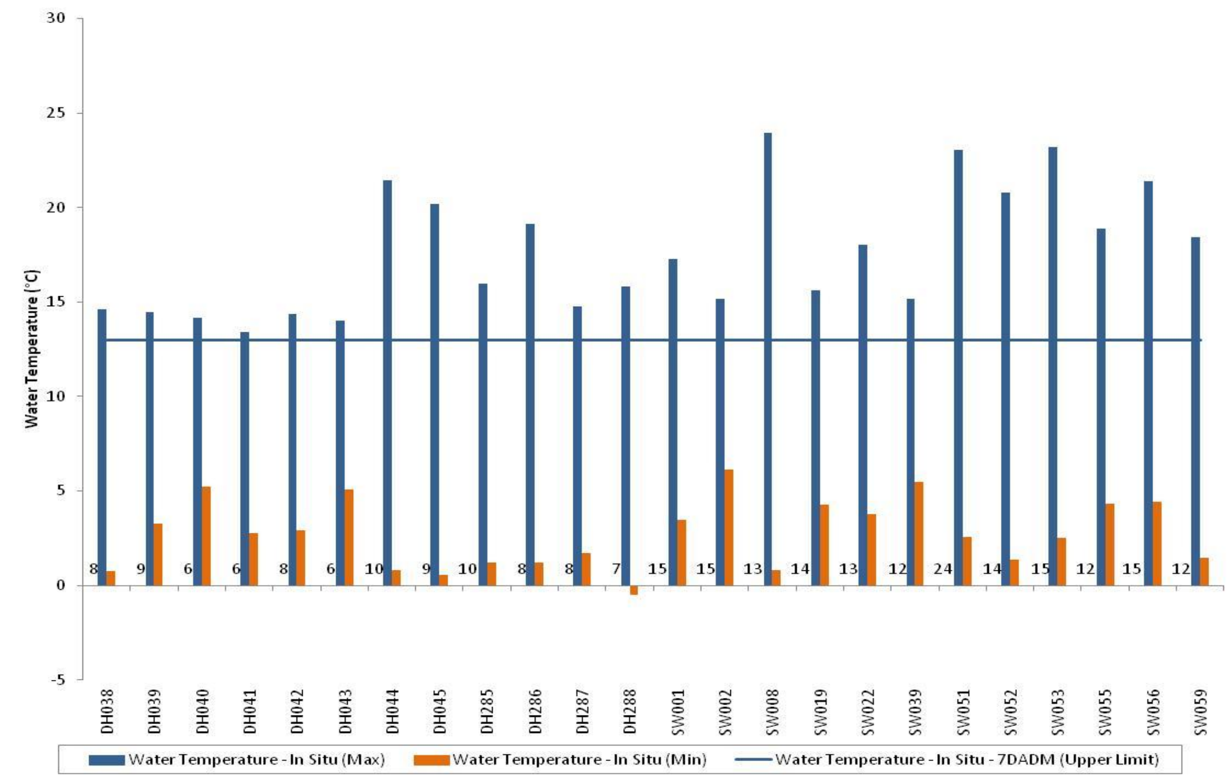

Figure 6.36 Class AA Marine Water Temperature Results Compared with Water Quality Standards: 2011

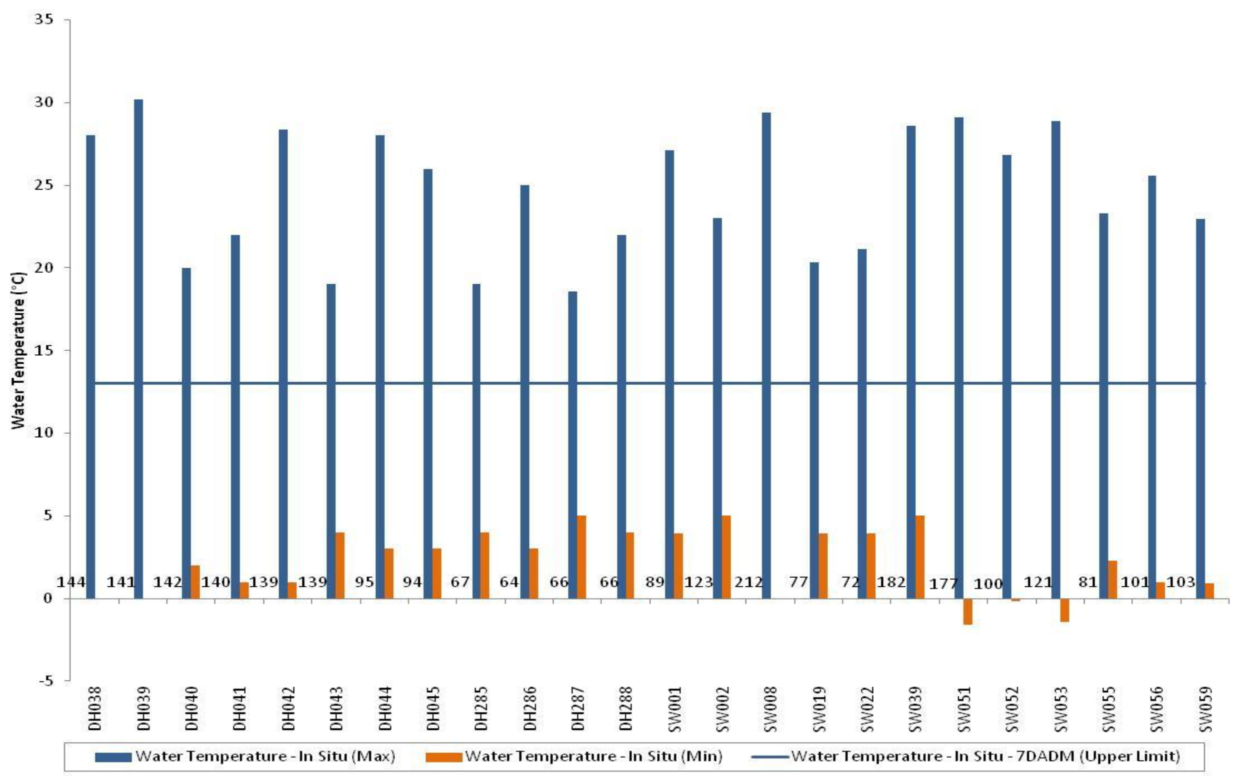

Figure 6.37 Class AA Marine Water Temperature Results Compared with Water Quality Standards: Period of Record through 2010

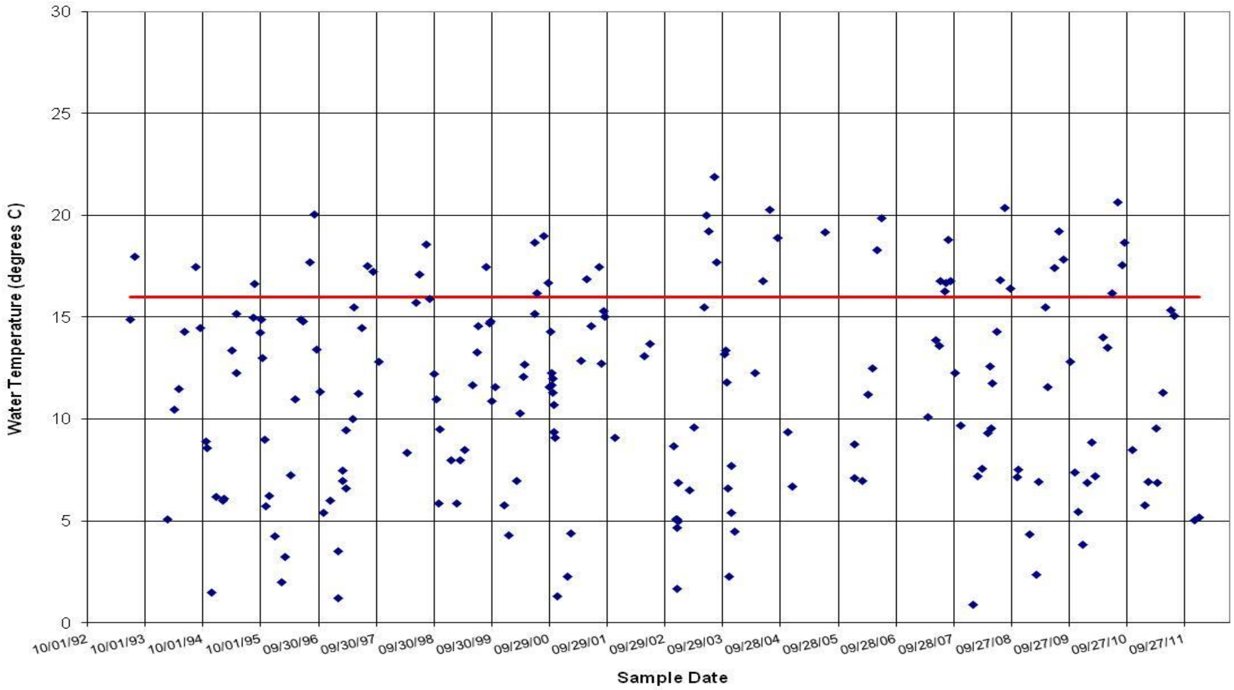

Figure 6.38 Class AA Freshwater Temperature Results, Site SW009

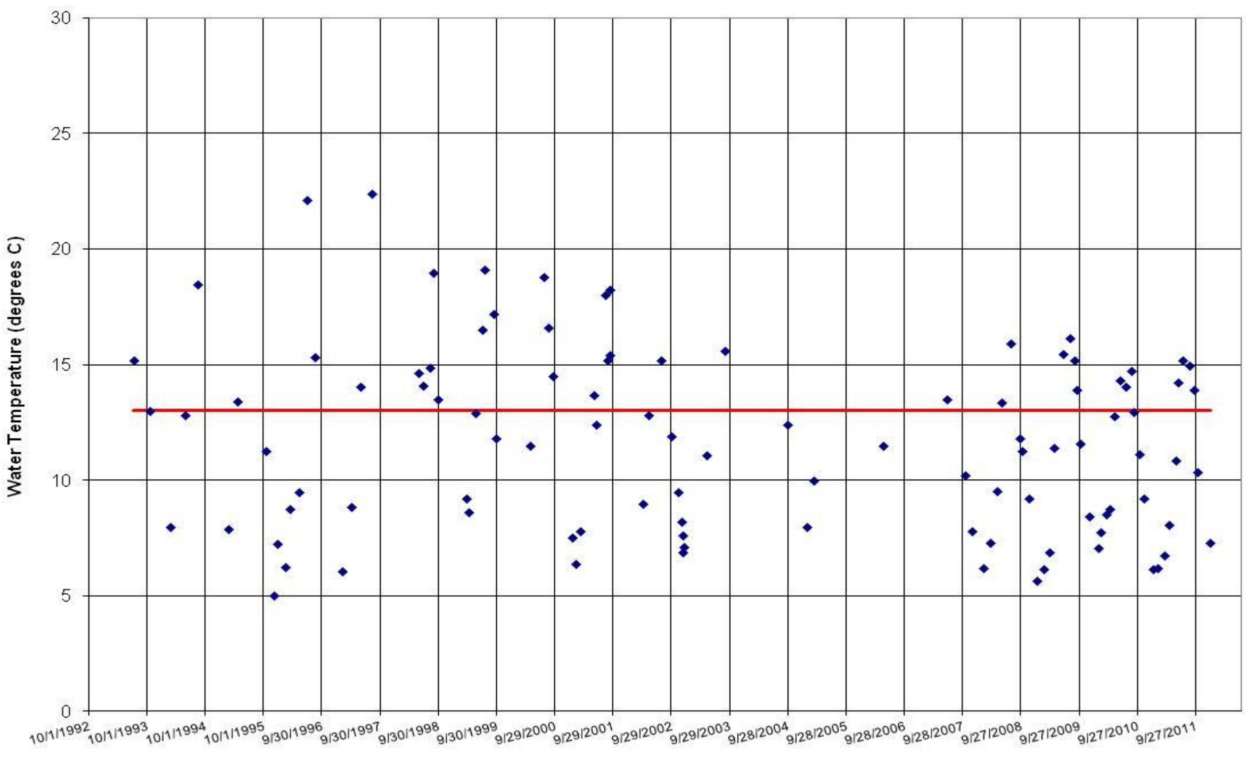

Figure 6.39 Class AA Marine Water Temperature Results, Site SW002

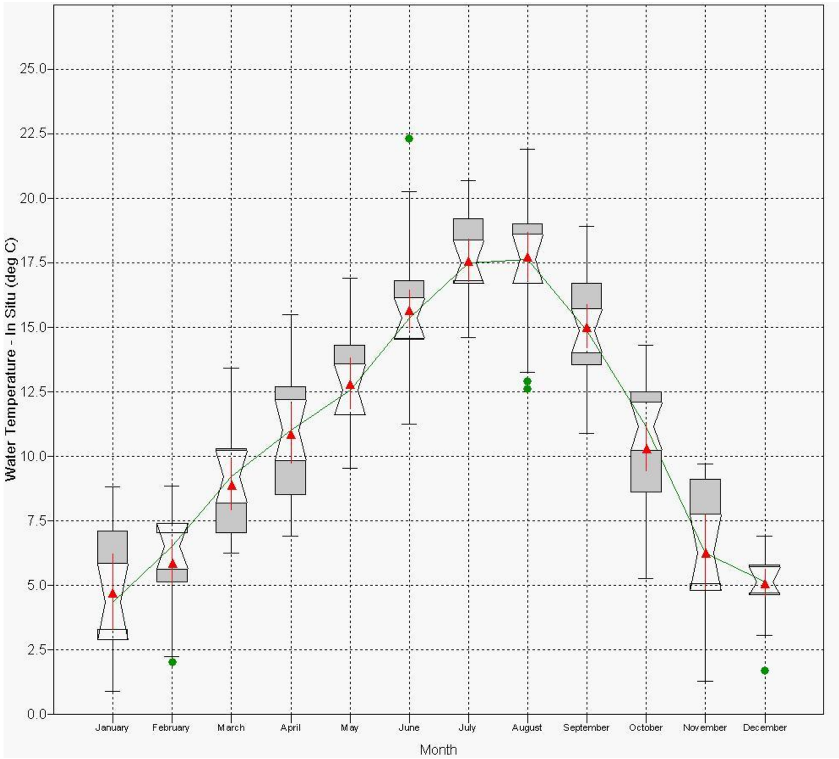

Figure 6.40 Monthly Temperature Variation for Period of Record, Site SW009

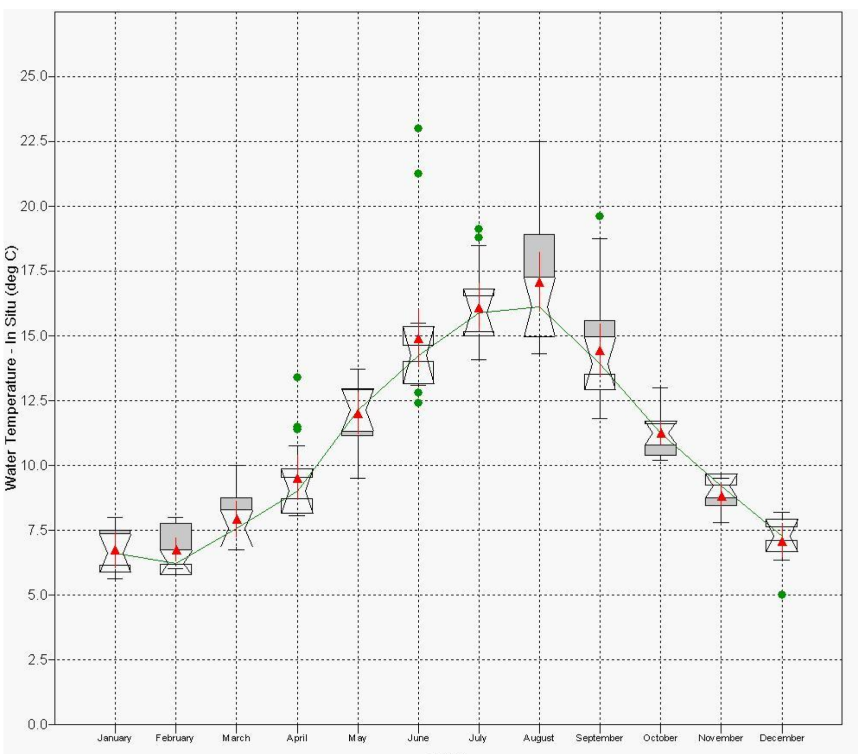

Figure 6.41 Monthly Temperature Variation for Period of Record, Site SW002

6.6.2. Class A Waters

The Class A freshwater standard for water temperature is a 7-day average of the daily maximum value (7DADM) of 17.5°C. As shown in Figure 6.42, the water quality data collected during 2011 suggest that this standard was achieved at all but 1 of the 8 sample sites. As shown in Figure 6.44, the one sample site that did not achieve the water quality standard 100% of the time sampled during 2011 achieved the standard at least 75% of the time sampled. As shown in Figure 6.43, the water temperature was always below the standard at two of the Class A freshwater monitoring sites (SW024 and SW025). Both of these sites are in a largely forested watershed that drains a portion of Portage Island and are sites that are sampled infrequently due to limited flowing water.

The Class A marine water quality standard for water temperature is a 1-day maximum temperature of 16.0°C. As shown in Figure 6.45, the water quality collected during 2011 suggests that this standard was achieved at 11 of the 18 Class A marine water quality sample sites. As shown in Figure 6.44, all of the 7 sites sampled during 2011 that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time sampled during 2011. As shown in Figure 6.46, the water temperature exceeded the standard at all of the 18 Class A marine water quality monitoring sites on at least one occasion over the period of record through 2010.

As shown in Figure 6.47, the water temperature sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018 and SW118 on the Nooksack River along the Reservation boundary) have generally been below the 16.0° C Class AA threshold over the period of record. However, in the last two years water temperatures above the standard have become more frequent. As shown in Figure 6.48, the water temperature sample results for the representative Class A marine water site (SW030 in Bellingham Bay) have also generally been below the 16.0°C Class A criterion over the period of record. Site SW030 is located on the tide flats of Bellingham Bay, which at this location are not as extensive as the tide flats of Lummi Bay near Site SW002. However, similar to Site SW002, the water temperature increases as the tidal waters flow over the mud flats and there does not appear to be an anthropogenic cause for the elevated water temperatures observed at this location.

As shown in Figure 6.49, the water temperature at Site SW118 varies during the year with the highest temperatures occurring during July and August and the lowest temperatures during December through February. As shown in Figure 6.50, a similar pattern occurs at Site SW030.

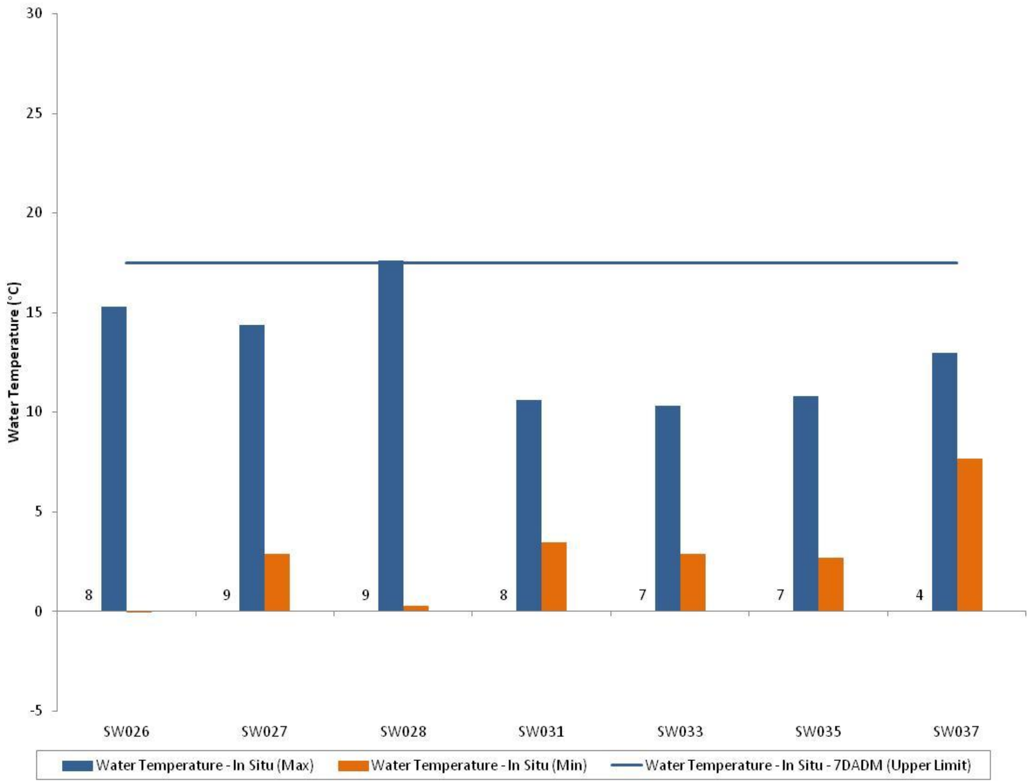

Figure 6.42 Class A Freshwater Temperature Results Compared with Water Quality Standards: 2011

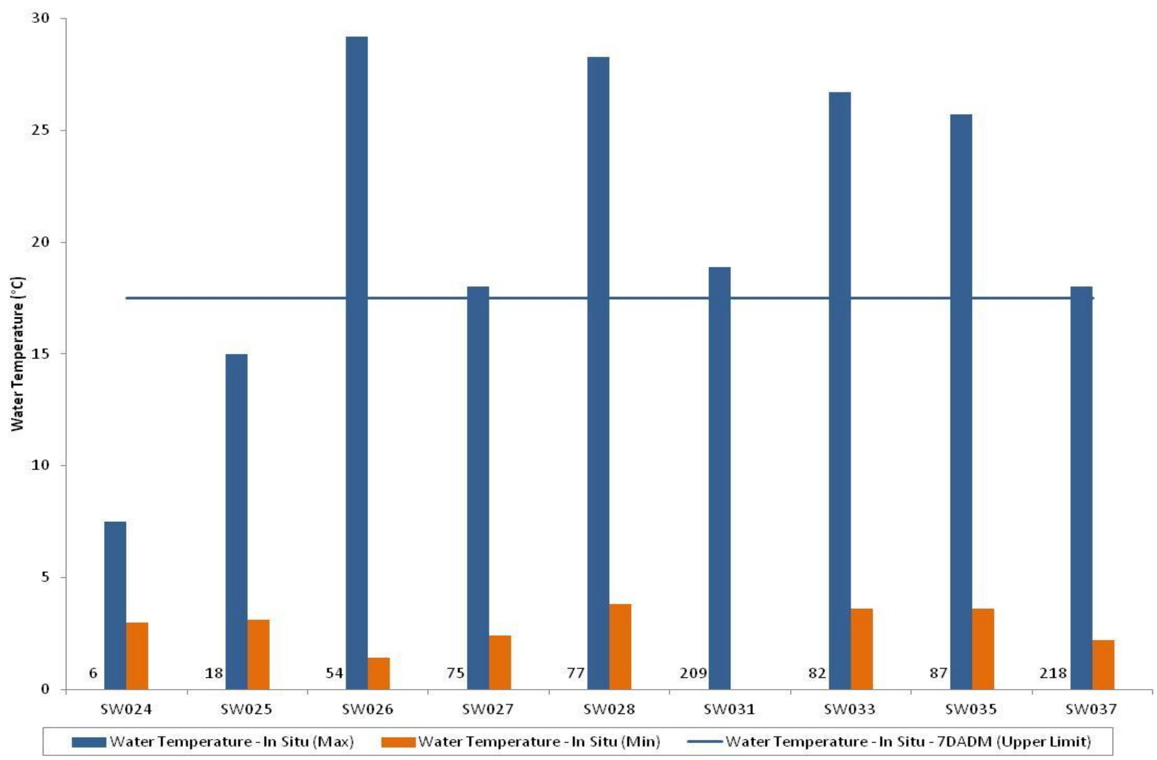

Figure 6.43 Class A Freshwater Temperature Results Compared with Water Quality Standards: Period of Record through 2010

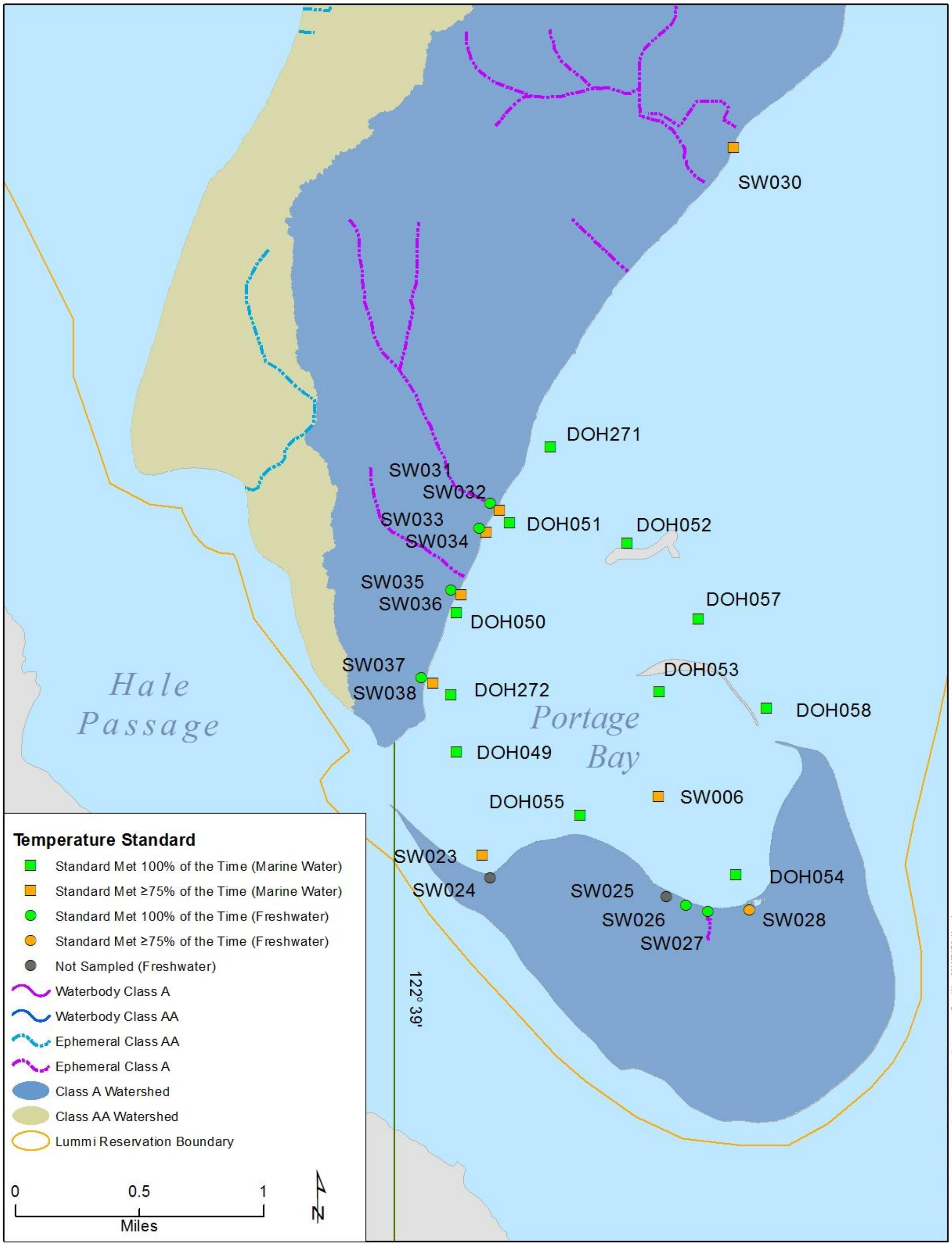

Figure 6.44 Class A Freshwater and Marine Water Temperature Compliance with Water Quality Standards: 2011

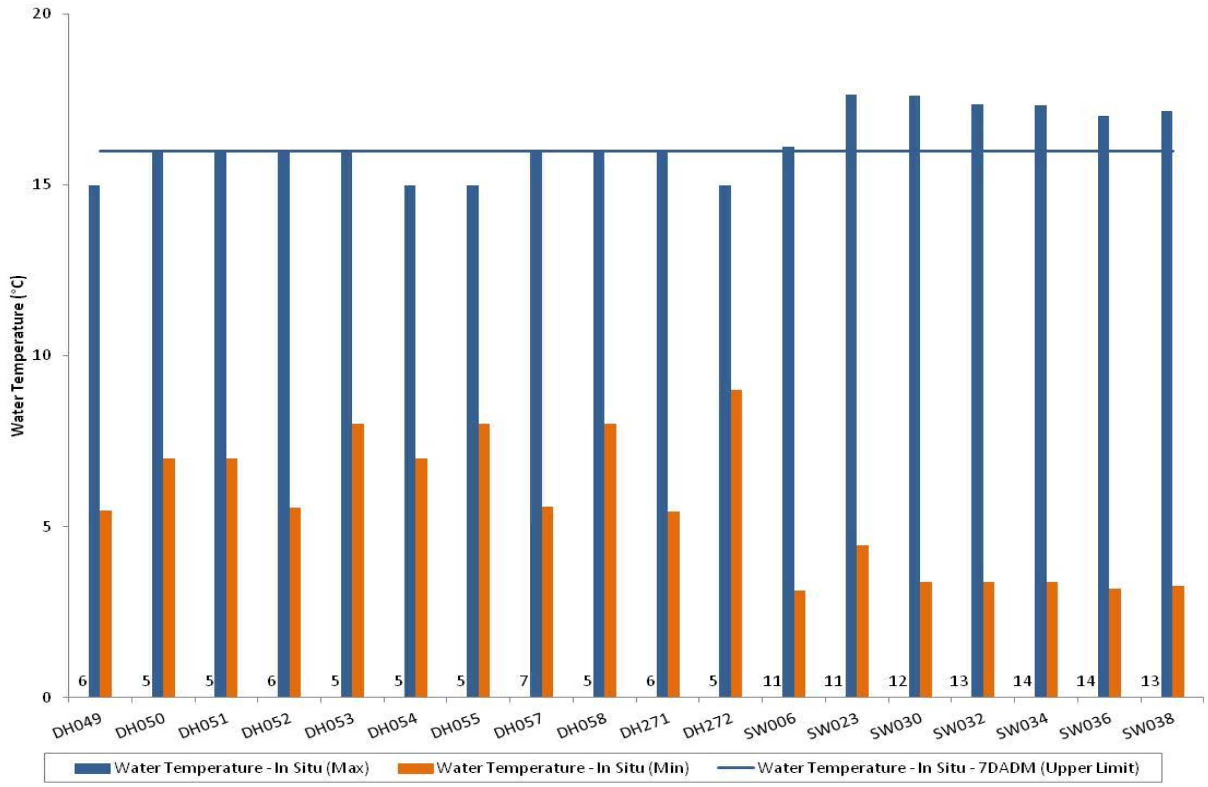

Figure 6.45 Class A Marine Water Temperature Results Compared with Water Quality Standards: 2011

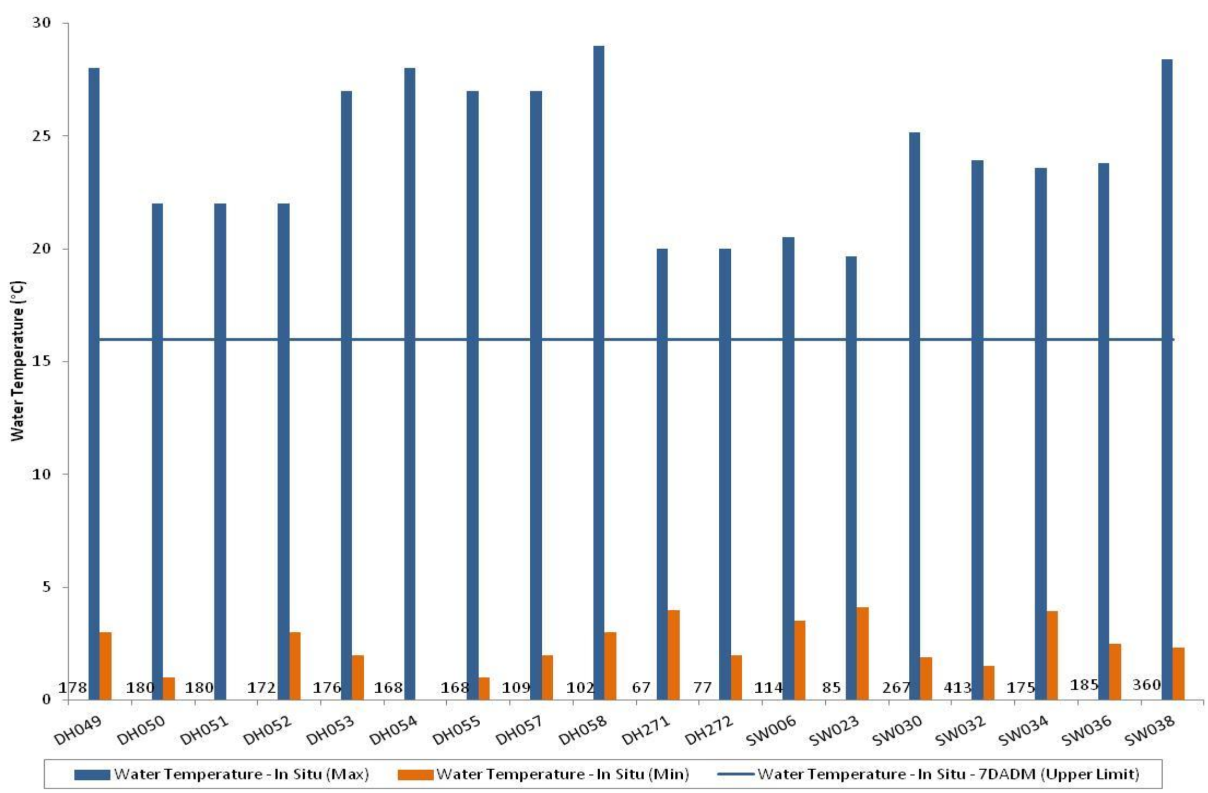

Figure 6.46 Class A Marine Water Temperature Results Compared with Water Quality Standards: Period of Record through 2010

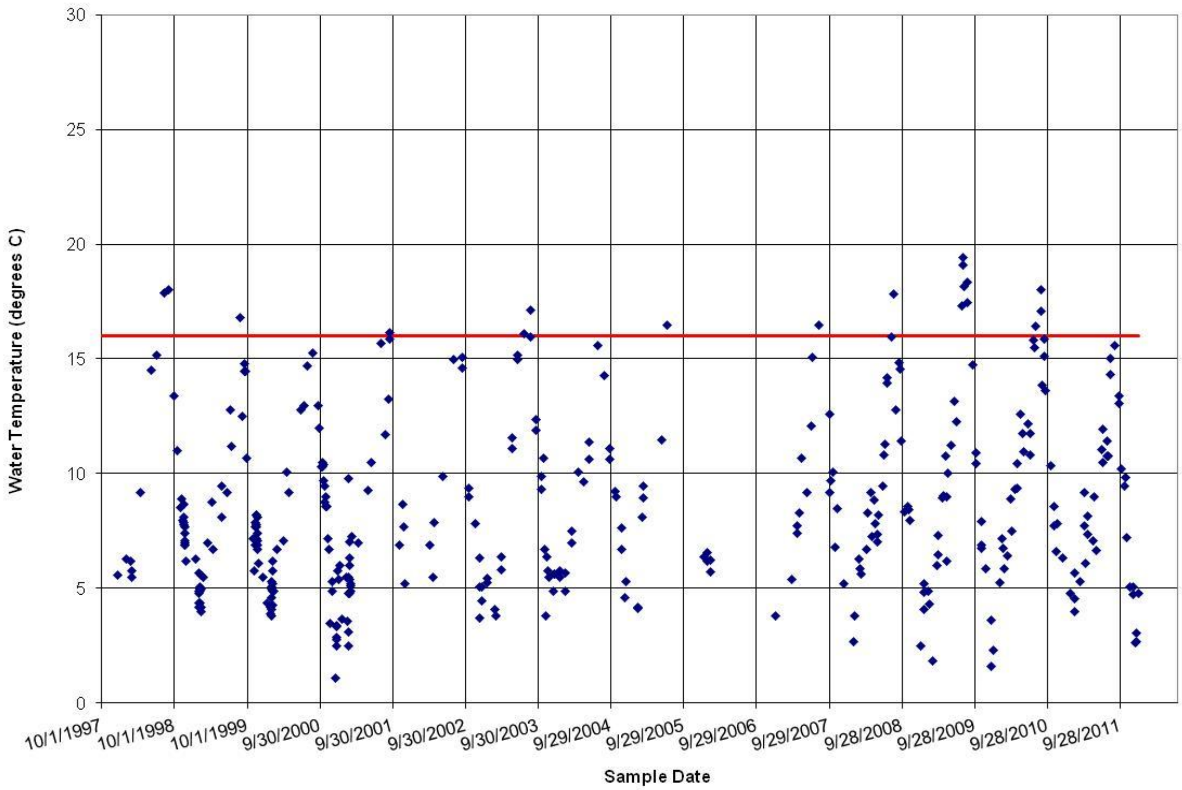

Figure 6.47 Class AA Freshwater Temperature Results, Site SW018/SW118

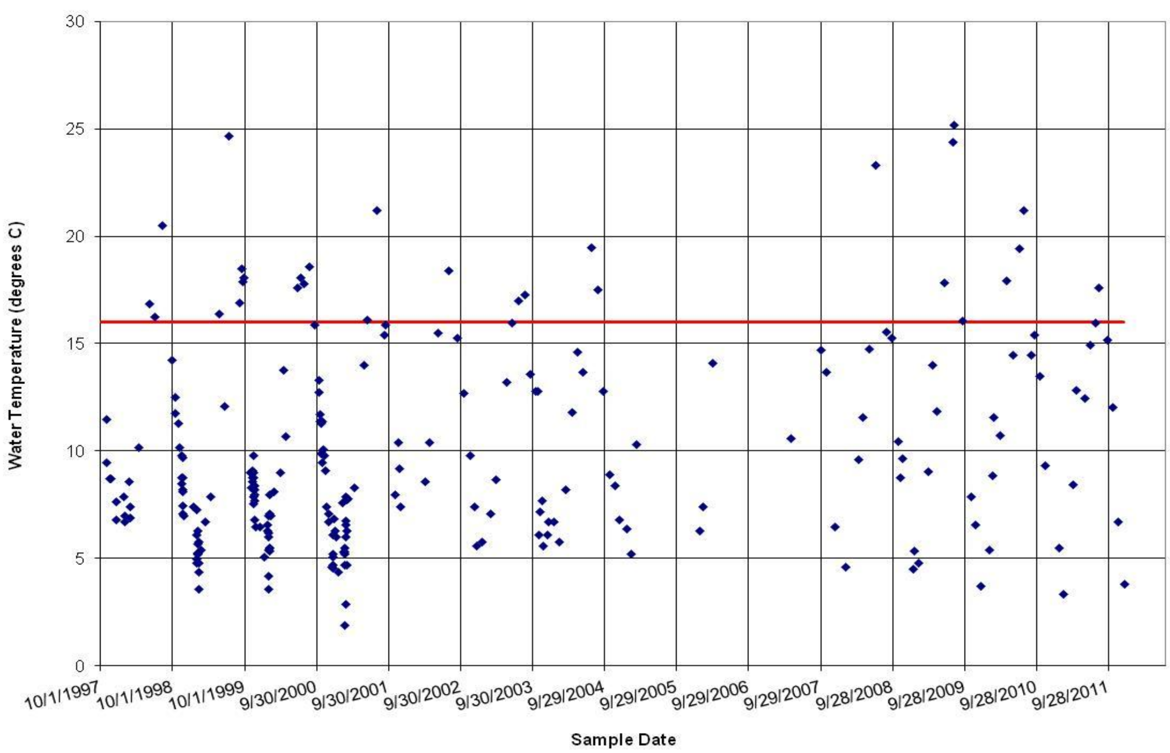

Figure 6.48 Class A Marine Water Temperature Results, Site SW030

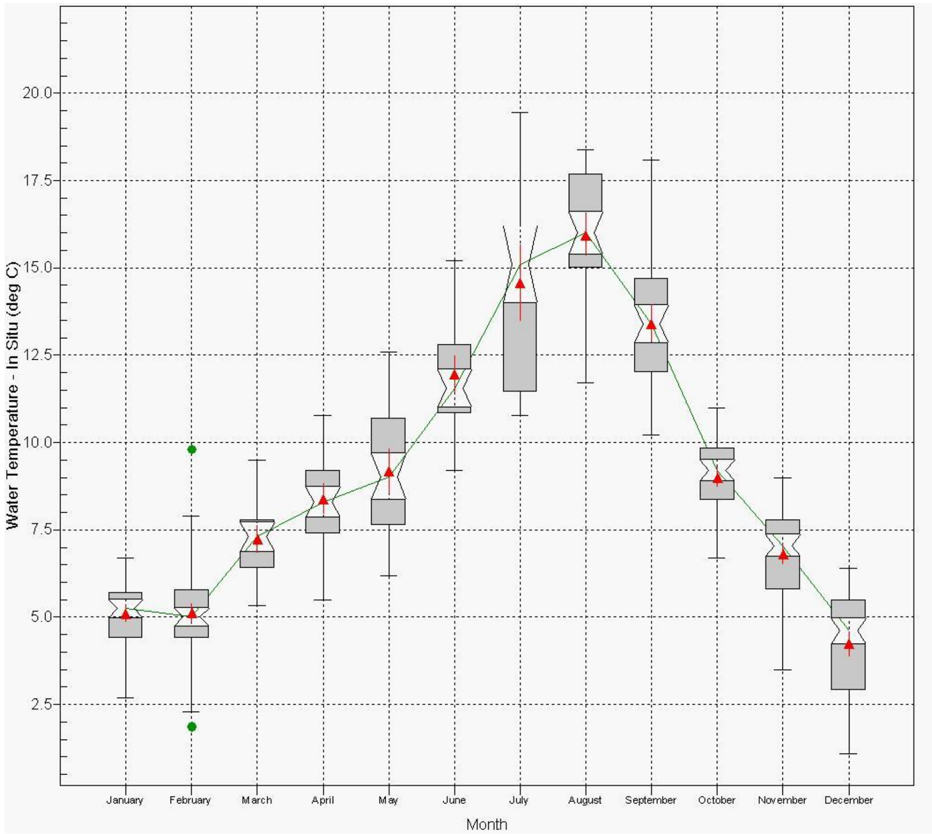

Figure 6.49 Monthly Temperature Variation for Period of Record, Site SW018/SW118

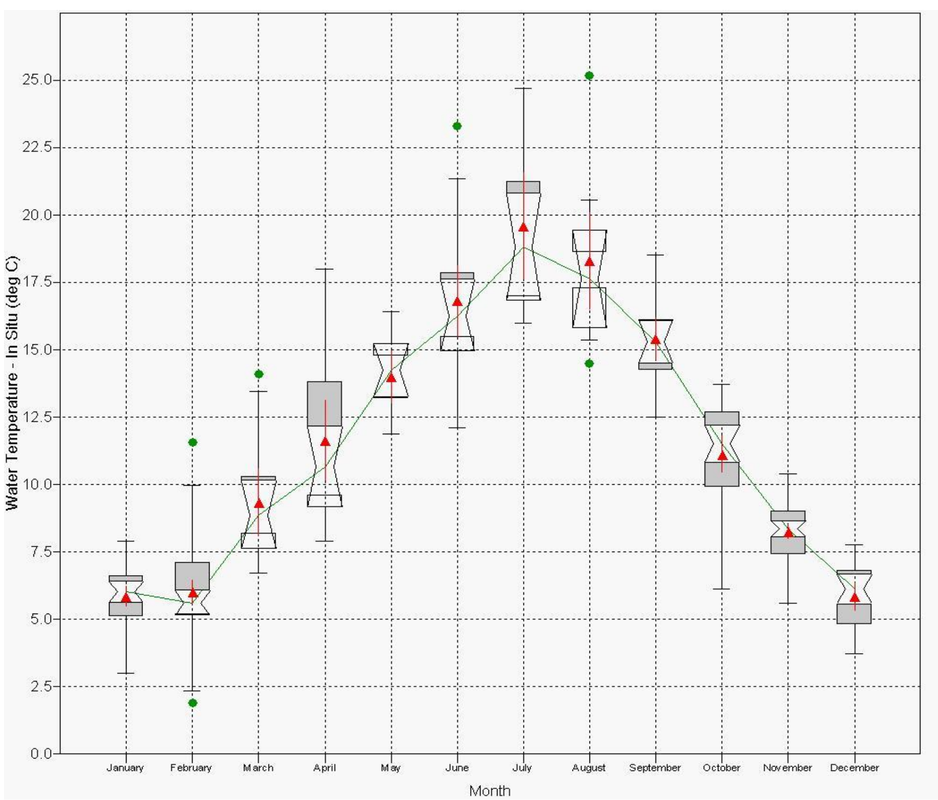

Figure 6.50 Monthly Temperature Variation for Period of Record, Site SW030

6.7. Continuous Temperature Results

The water quality standards for water temperature are established as a maximum value. If the maximum measured water temperature is greater than the water quality criteria, the characteristic uses of the water body are not fully supported. Prior to 2010, the sampling program only collected single measurements of water temperature at each site during a sampling run that typically occurs once each month. Because the water quality standards are expressed as the 7-day average of the daily maximum (7DADM) water temperature in the case of freshwater sites, and the 1-day maximum water temperature for marine water sites, continuous temperature monitoring is needed to accurately evaluate compliance with the water quality standards. Continuous recording water temperature probes were deployed at 10 of the monitoring sites during 2011. Temperature is measured continuously by each probe and the average temperature is recorded every 30 minutes at each site. The temperature data are downloaded from the dataloggers on a monthly basis. The data collected at the 10 sites with continuous temperature dataloggers allows direct comparison with the applicable water quality standards. Six freshwater Class AA sites and four marine water Class AA sites were chosen in the Jordan Creek, Lummi River, Smuggler's Slough, and Nooksack River watersheds. Due to lost equipment of the water temperature dataloggers, eight sites have a complete data set for 2011 and one site has seven months of data.

6.7.1. Class AA Freshwater

The Class AA freshwater quality standard for water temperature is a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summer time spawning, temperature shall not exceed a 7DADM temperature of 13.0°C. Continuous water temperature data were collected at the following freshwater Class AA sites during 2011:

- SW003 – Jordan Creek at North Red River Road
- SW009 – Lummi River at Slater Road
- SW011 – Jordan Creek at Slater Road
- SW012 – Schell Creek at Slater Road
- SW015 – Smuggler's Slough at Lummi Shore Road

As shown in Figure 6.51 though Figure 6.55, the continuous water temperature data collected during 2011 indicate that the water quality criterion was exceeded at four of the five sites monitored. Site SW011 located on Jordan Creek at Slater Road was the only Class AA freshwater site to meet the water quality standard in 2011. The water quality standard is generally exceeded at the remaining sites from the beginning of June through the end of September, with the exception of Site SW015, where the standard was exceeded from May through mid-August. As shown in Figure 6.51 through Figure 6.55, the highest water temperatures occurred during July and August for all of the sites except Site SW009 where the highest water temperatures were recorded in September and Site SW015 where the highest water temperatures were recorded in June. The lowest temperatures occurred during February for all of the sites except Sites SW011 and SW015 where the lowest temperatures occurred in January. As shown in Figure 6.33, Site SW012 (Schell Creek at Slater Road) did not exceed the water temperature standard during 2011 when sampled monthly. However, as shown in Figure 6.53, Site SW012 exceeded the 7DADM standard for 14 weeks during 2011. Site SW003 had the highest water temperatures of all the sites, with the 7DADM greater than 25^{o}C for one week in both July and August.

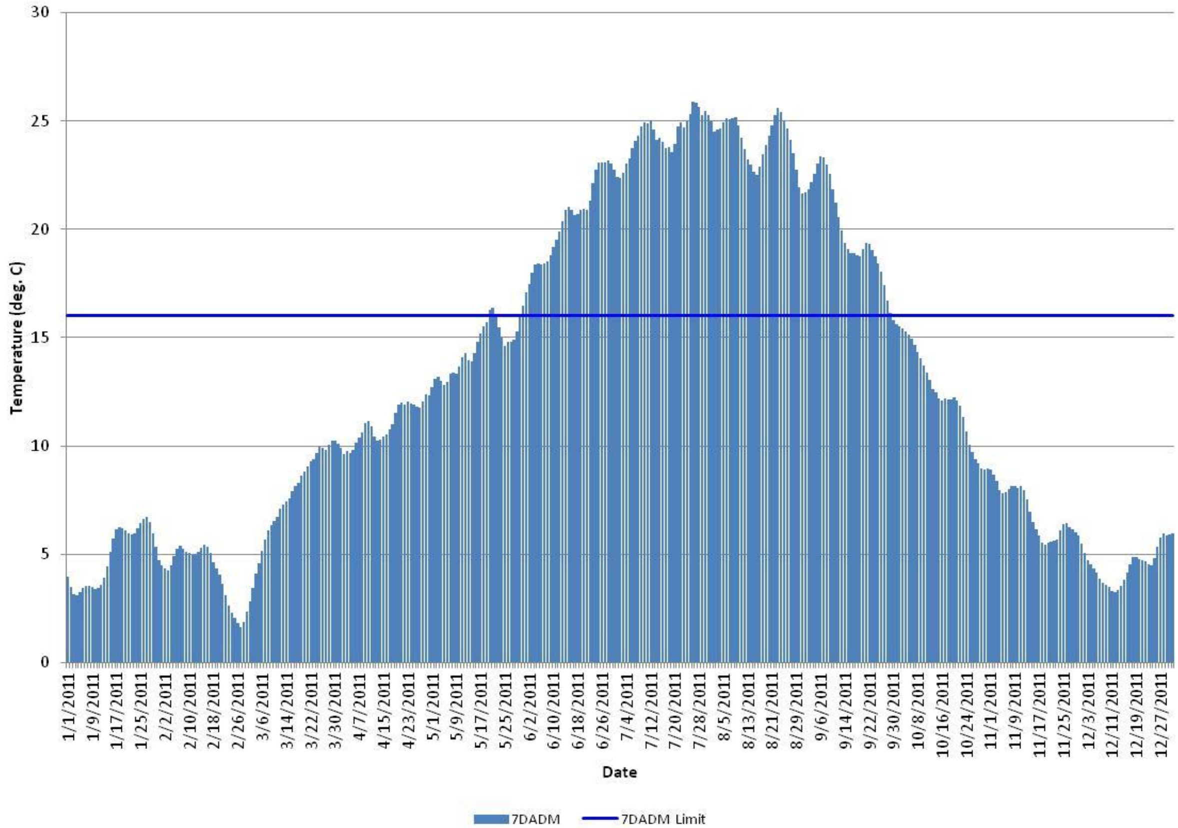

Figure 6.51 Maximum 7-Day Water Temperature Results, Site SW003

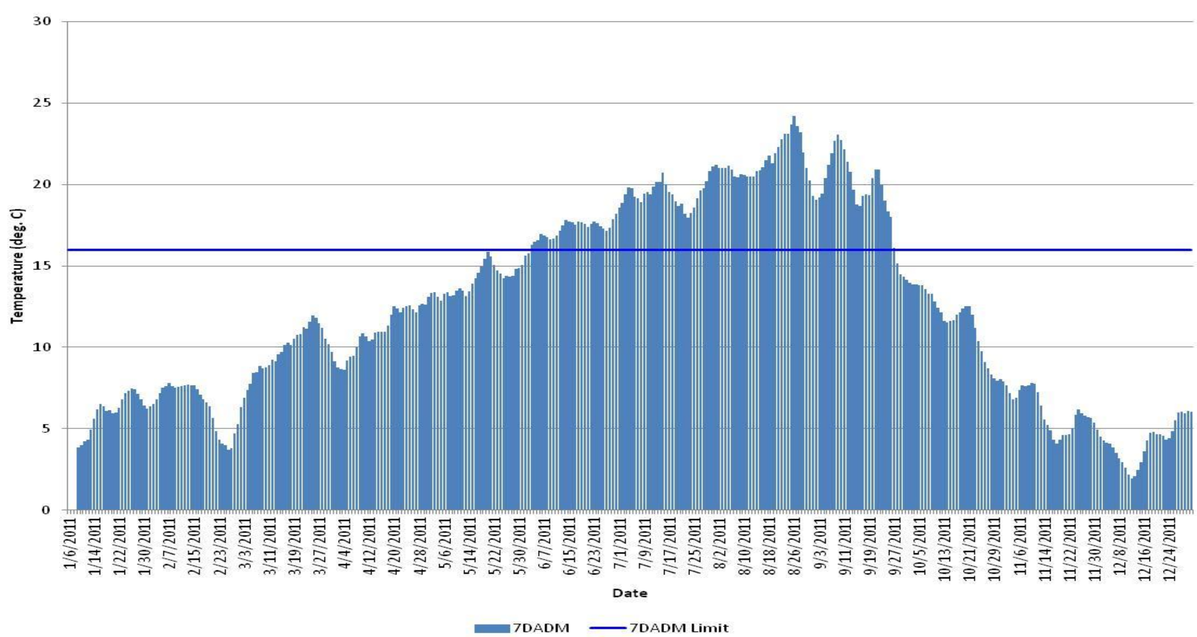

Figure 6.52 Maximum 7-Day Water Temperature Results, Site SW009

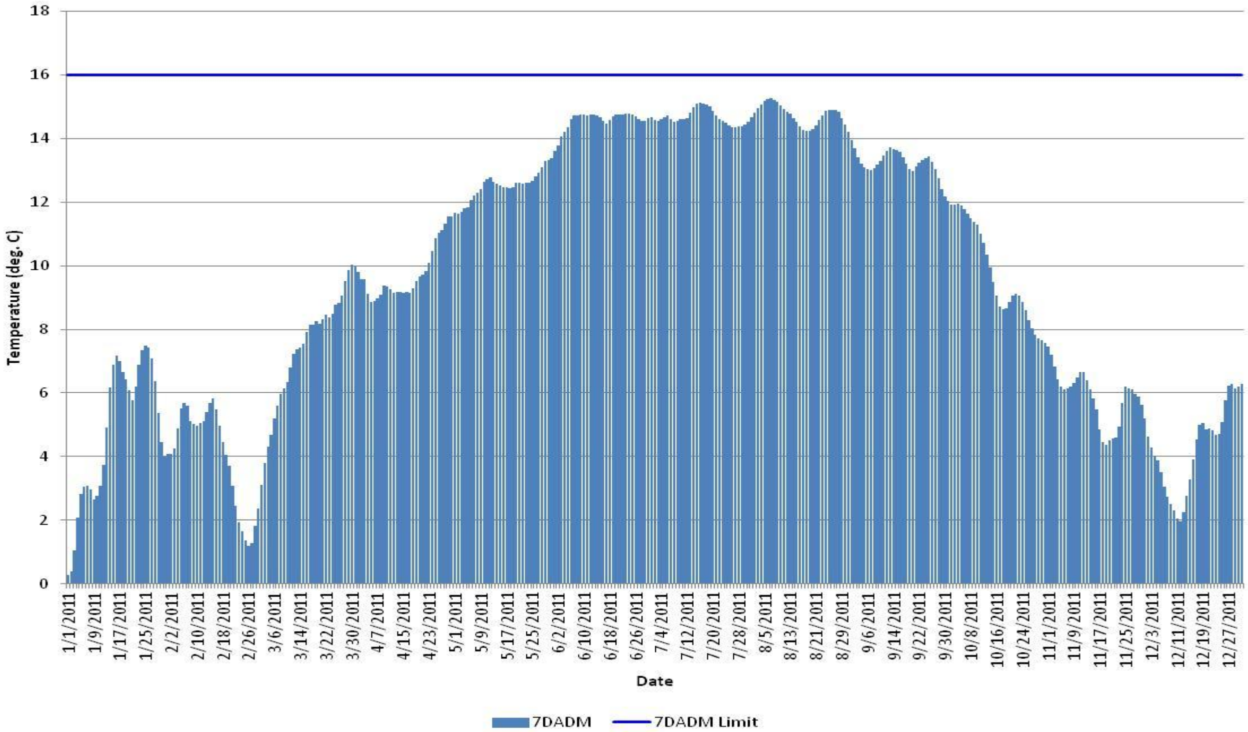

Figure 6.53 Maximum 7-Day Water Temperature Results, Site SW011

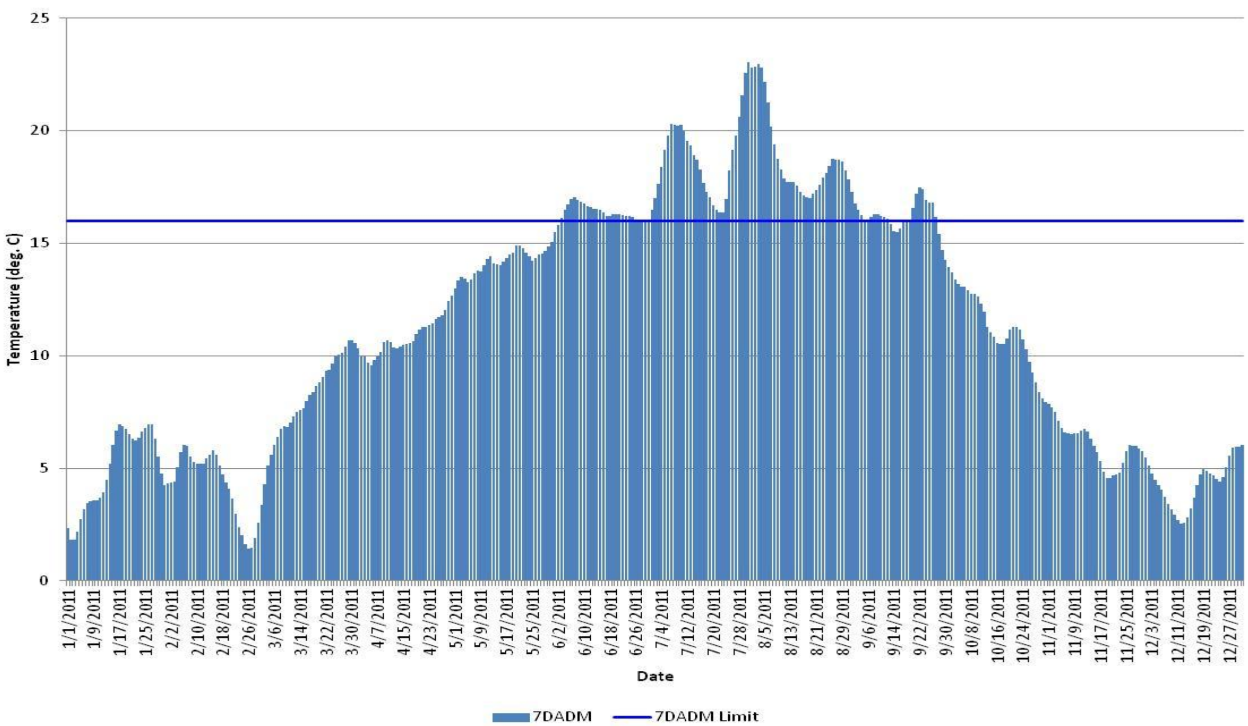

Figure 6.54 Maximum 7-Day Water Temperature Results, Site SW012

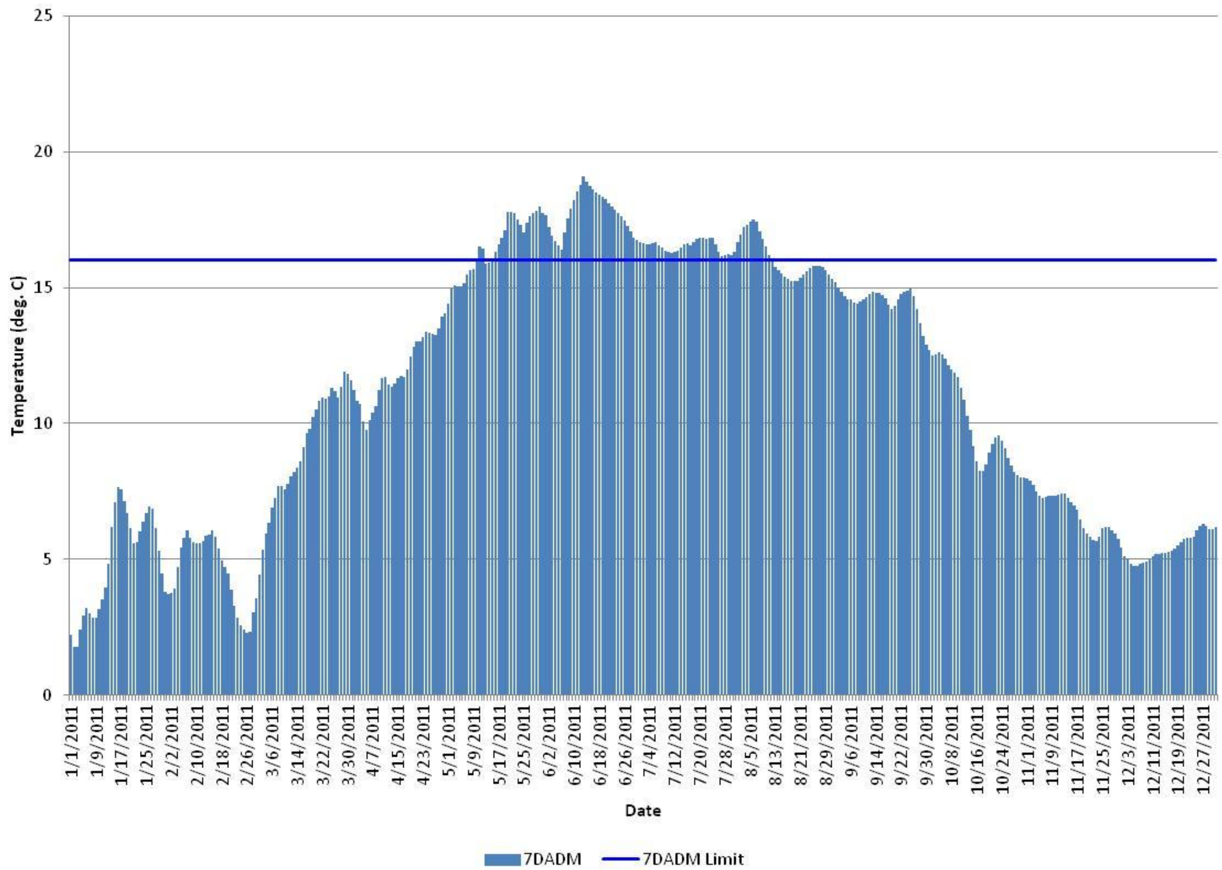

Figure 6.55 Maximum 7-Day Water Temperature Results, Site SW015

6.7.2. Class AA Marine Water

The Class AA marine water standard for water temperature is a 1-day maximum temperature of 13.0°C. Continuous water temperature data were collected at the following marine water Class AA sites during 2011:

- SW008 – Lummi River at Hillaire Road Bridge
- SW051 – Lummi River mouth (7 months of data collected in 2011)
- SW053 – Jordan Creek mouth
- SW059 – Smuggler's Slough at Kwina Road

As shown in Figure 6.56 through Figure 6.59, the water temperature exceeded the standard at all of the Class AA marine continuous water temperature monitoring sites during 2011. The water quality standard is generally exceeded at the Class AA marine water sites from the beginning of April through the beginning of October. As shown in Figure 6.56 through Figure 6.59, the highest temperatures occurred during June, July, and August and lowest temperatures occurred during January and February. Site SW059 (Smuggler's Slough at Kwina Road), which has the most tree cover of all the marine sites, always had water temperatures below 25^{o}C, whereas the other three sites consistently had water temperatures reaching above 25^{o}C during the warmest months. Site SW051 (Lummi River mouth) and Site SW053 (Jordan Creek mouth), which are both tidally influence and sampled near the tide flats of Lummi Bay, had a 1-Day maximum of nearly 30^{o}C in July 2011. The sites located furthest downstream (SW008, SW051, SW053, and SW059) in the watersheds have higher temperatures during the summer months than those sample sites located upstream.

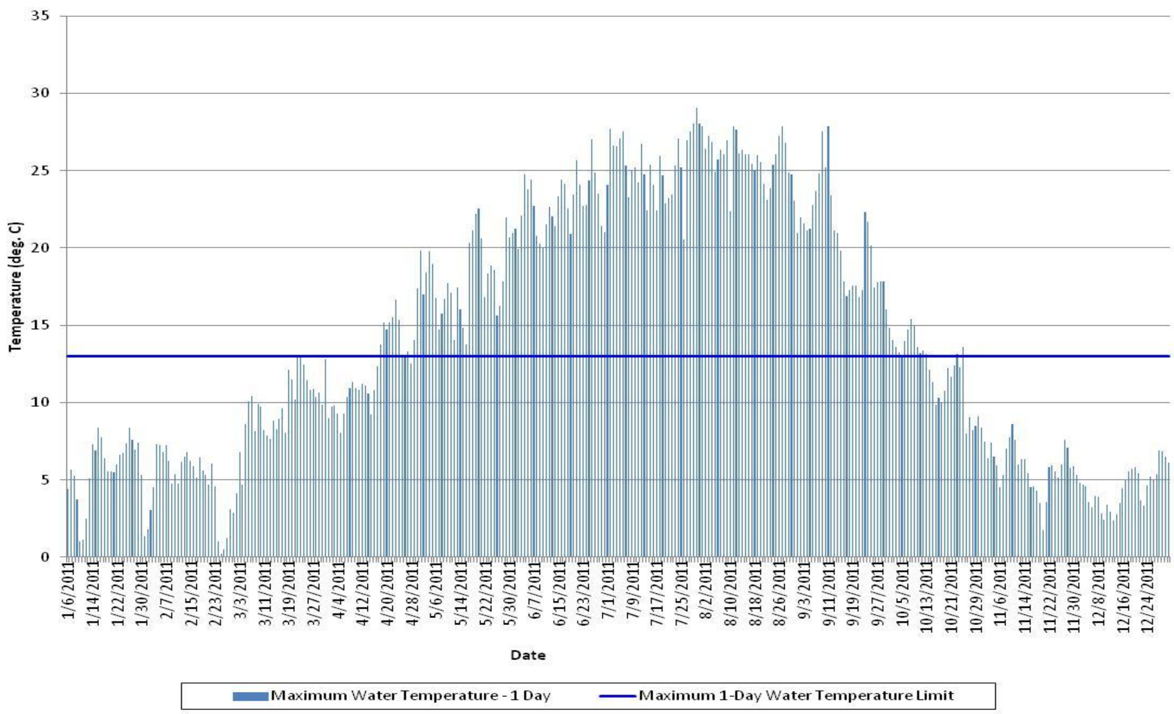

Figure 6.56 Maximum 1-Day Water Temperature Results, Site SW008

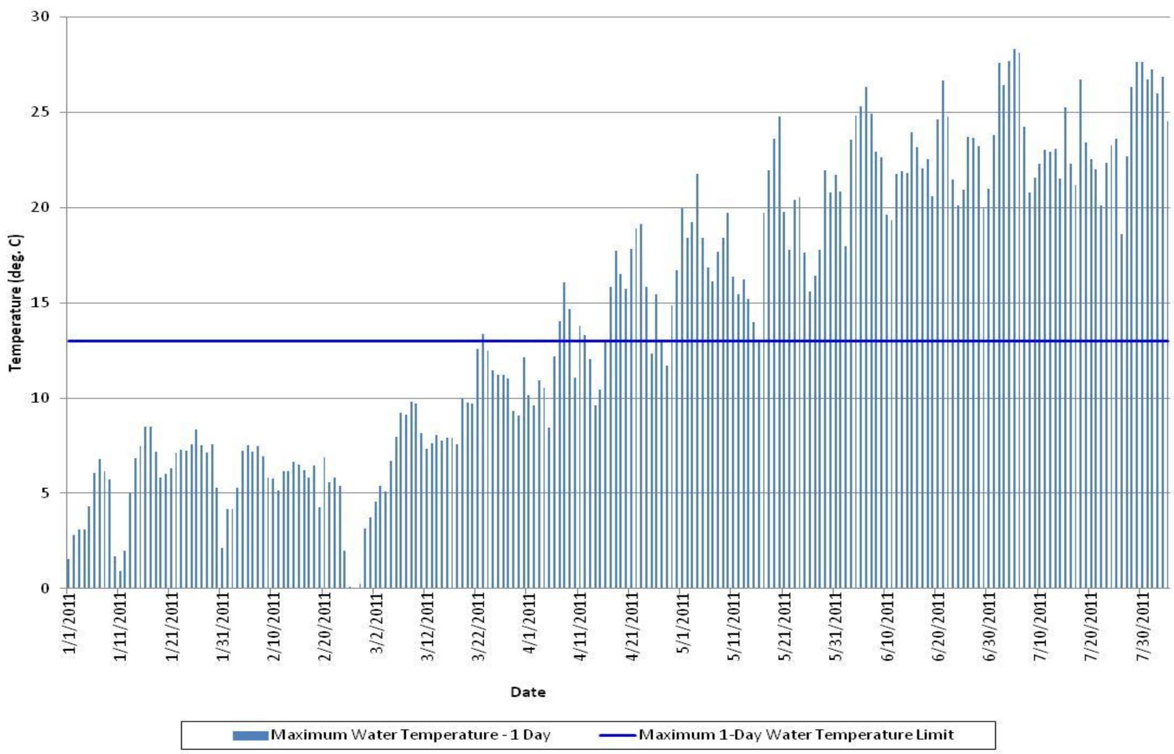

Figure 6.57 Maximum 1-Day Water Temperature Results, Site SW051

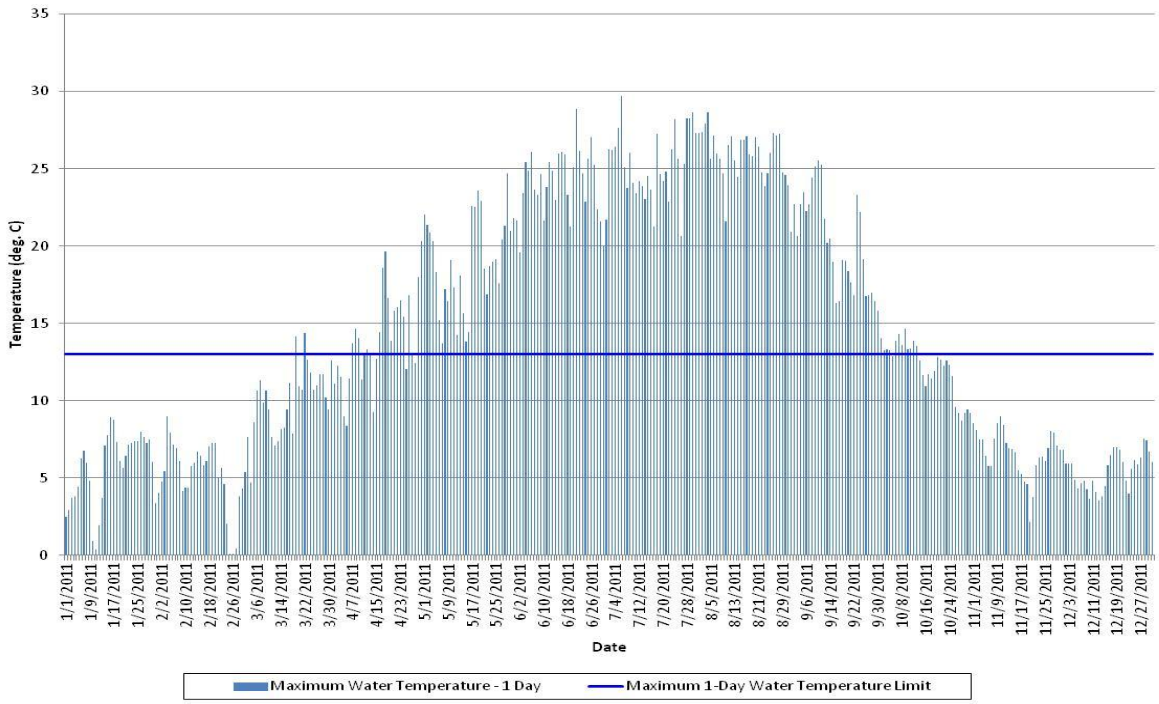

Figure 6.58 Maximum 1-Day Water Temperature Results, Site SW053

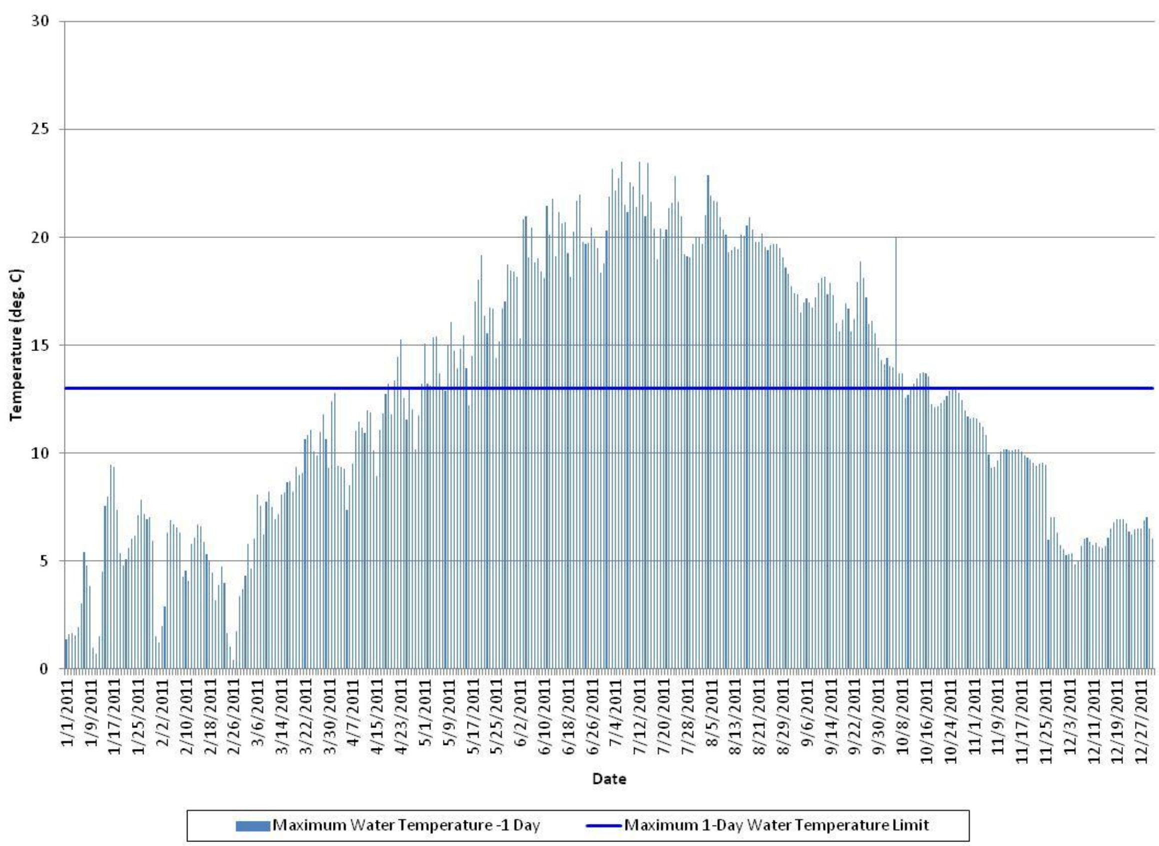

Figure 6.59 Maximum 1-Day Water Temperature Results, Site SW059

6.8. Dissolved Oxygen Results

In contrast to the bacteria and water temperature criteria, the water quality standards for dissolved oxygen are a minimum value. If the maximum or minimum measured dissolved oxygen levels are less than the water quality standard, the sample results indicate that the characteristic uses of the water body are not supported. The spatial median intergravel dissolved oxygen concentration is currently not measured at the sample sites so it is not possible to determine compliance with the water quality standards for Class AA freshwater sites.

6.8.1. Class AA Waters

The Class AA freshwater quality standard for dissolved oxygen is a minimum of 11.0 mg/l and a spatial median intergravel dissolved oxygen concentration greater than 8.0 mg/l. The spatial median intergravel dissolved oxygen concentration is currently not measured at the sample sites so it is not possible to determine compliance with the water quality standards for Class AA freshwater sites. As shown in Figure 6.60, the water quality data collected during 2011 indicate that the 11.0 mg/l part of the standard was achieved at least once for 12 of the 16 sample sites and was not achieved at the four remaining sites. However, as discussed previously if the maximum or minimum measured dissolved oxygen levels are less than the water quality standard, the characteristic uses of the water body are not supported and the water quality standard is not achieved. As shown in Figure 6.62, although 12 of the 16 sample sites achieved the water quality standard on at least one occasion during 2011, none of the sites achieved the standard 100% of the time sampled. Only two sites achieved the standard at least 75% of the time sampled, and the remaining 14 sites achieved the standard less than 75% of the time sampled during 2011. Although Site SW004 is shown in Figure 6.60 to have met the dissolved oxygen standard during 2011, this result is from only one sample. As shown in Figure 6.61, the dissolved oxygen levels have been above the 11.0 mg/l criterion at least once at every site except for Site SW072, where dissolved oxygen has never been measured above the 11.0 mg/l criterion. Site SW004 is the only site to meet the minimum dissolved oxygen level requirement over the period of record. All other Class AA freshwater sites have had measured minimum dissolved oxygen levels below the water quality standard on at least one occasion.

The Class AA marine water quality standard for dissolved oxygen is a 1-day minimum daily concentration of 7.0 mg/l. As shown in Figure 6.63, the water quality data collected during 2011 suggest that this standard was achieved at least once at all 24 of the sample sites, and 17 of the 24 sample sites were consistently above the standard during 2011. As shown in Figure 6.62, of the 7 sample sites that were not consistently above the water quality standard during 2011, 5 of the sites achieved the water quality standard at least 75% of the time sampled. As shown in Figure 6.64, the dissolved oxygen standard was consistently achieved over the period of record at Site SW039 (along Hale Passage) and DH038 (Lummi Bay) of the Class AA marine water monitoring sites.

As shown in Figure 6.65, the dissolved oxygen sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009) have generally been below the minimum 11.0 mg/l criterion over the period of record. In contrast, as shown in Figure 6.66, the dissolved oxygen sample results for the representative Class AA marine water site (SW002) have generally been above the 7.0 mg/l criterion over the period of record.

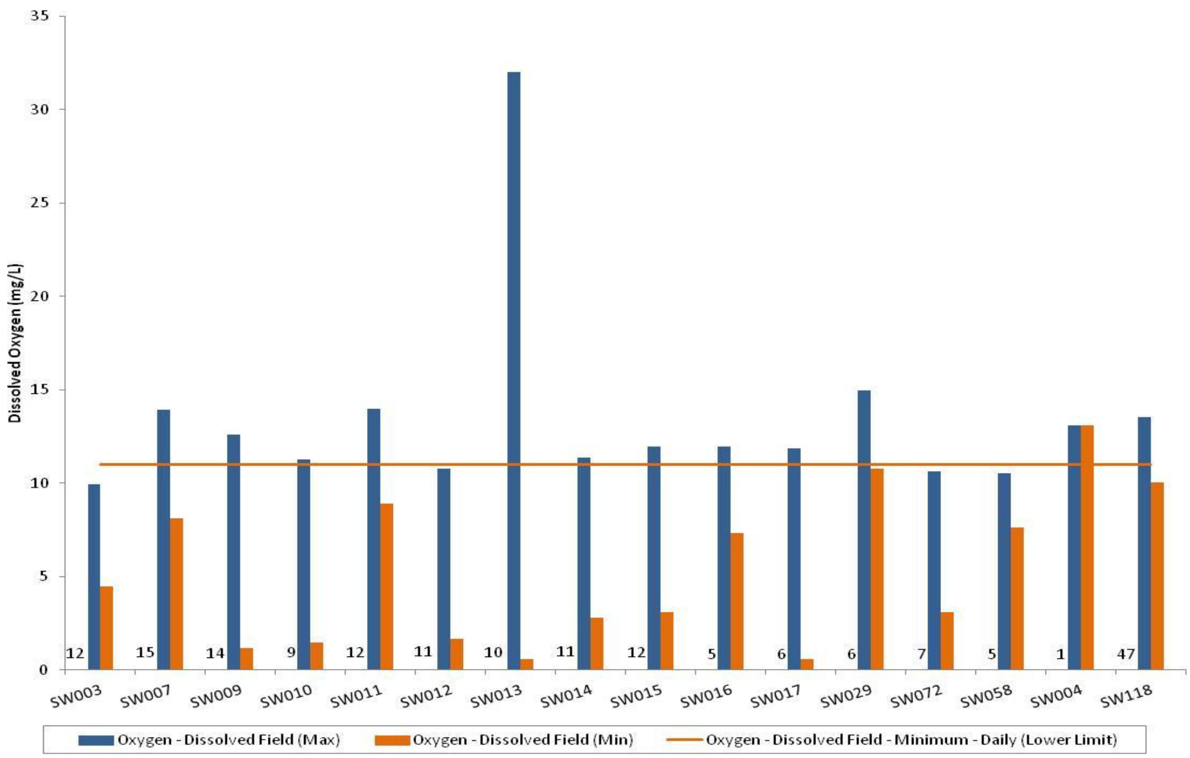

Figure 6.60 Class AA Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: 2011

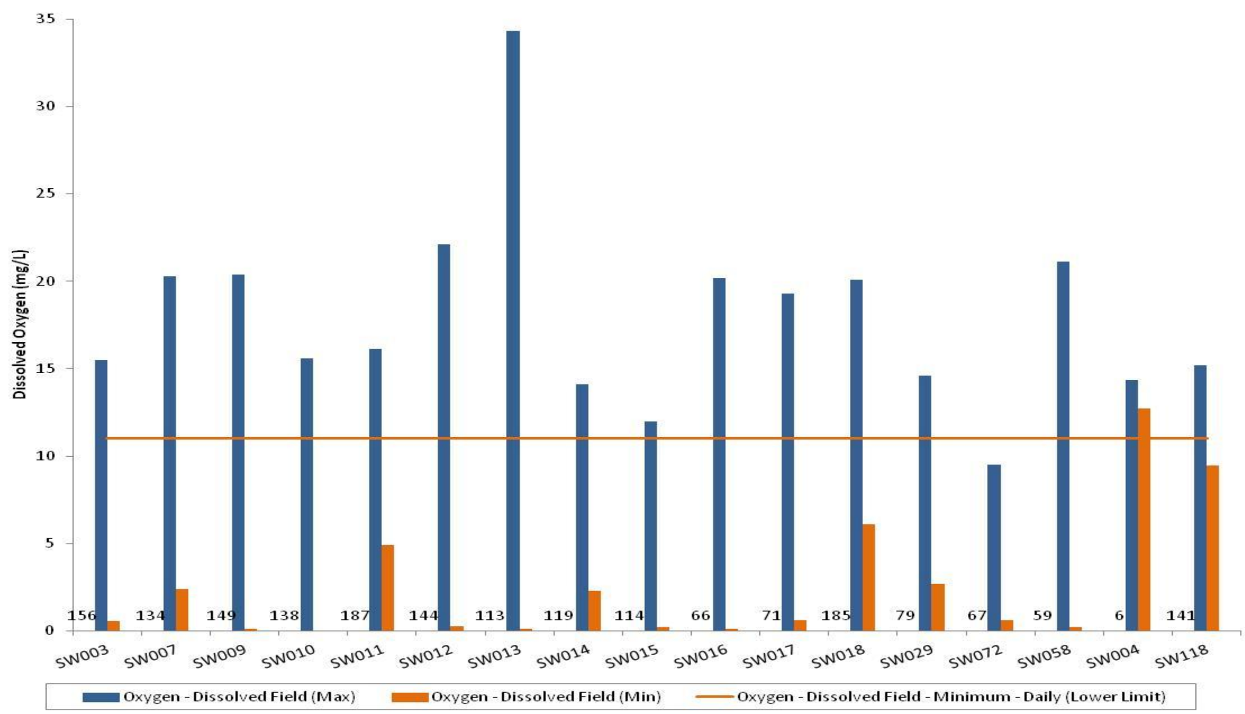

Figure 6.61 Class AA Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2010

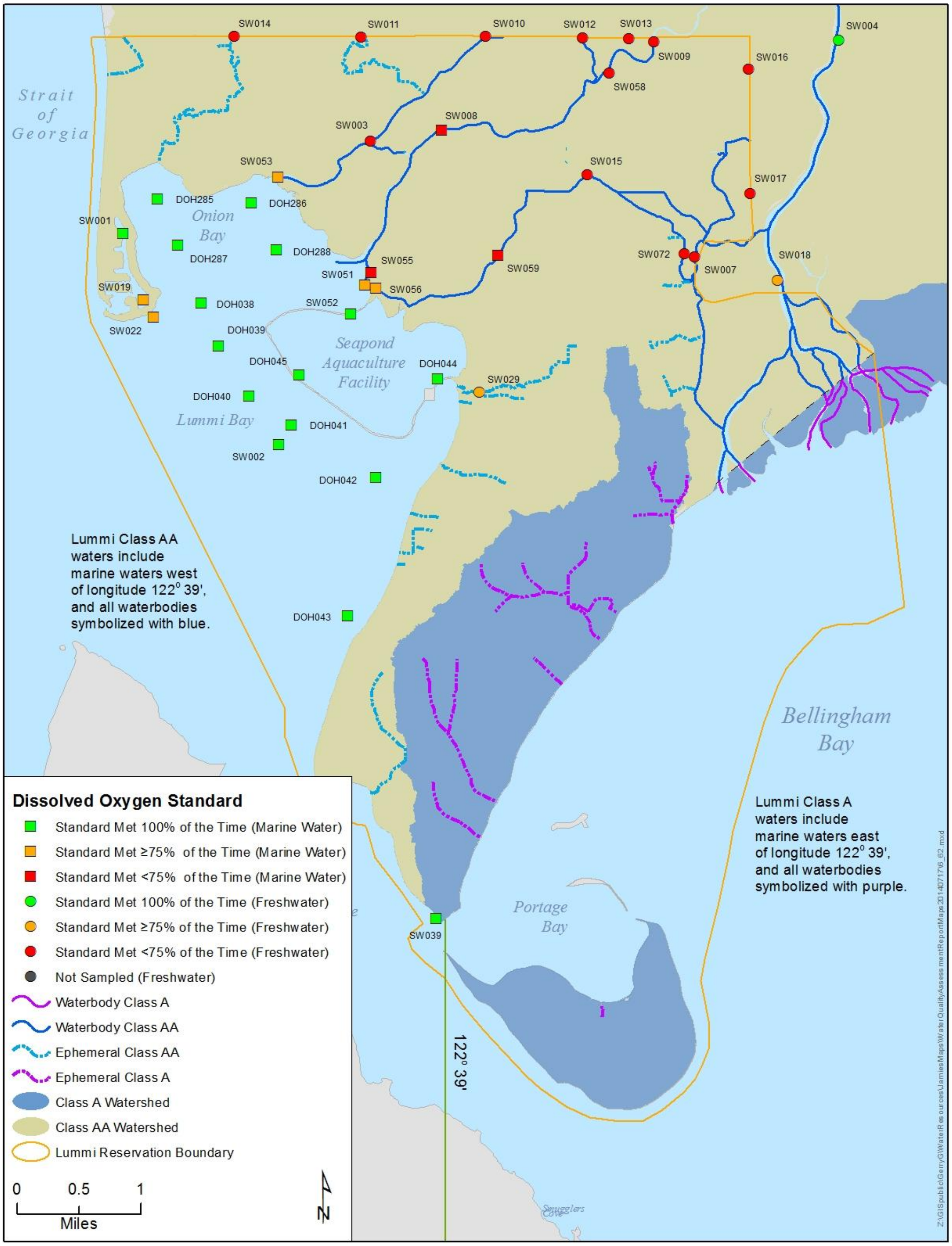

Figure 6.62 Class AA Fresh and Marine Water Dissolved Oxygen Compliance with Water Quality Standards: 2011

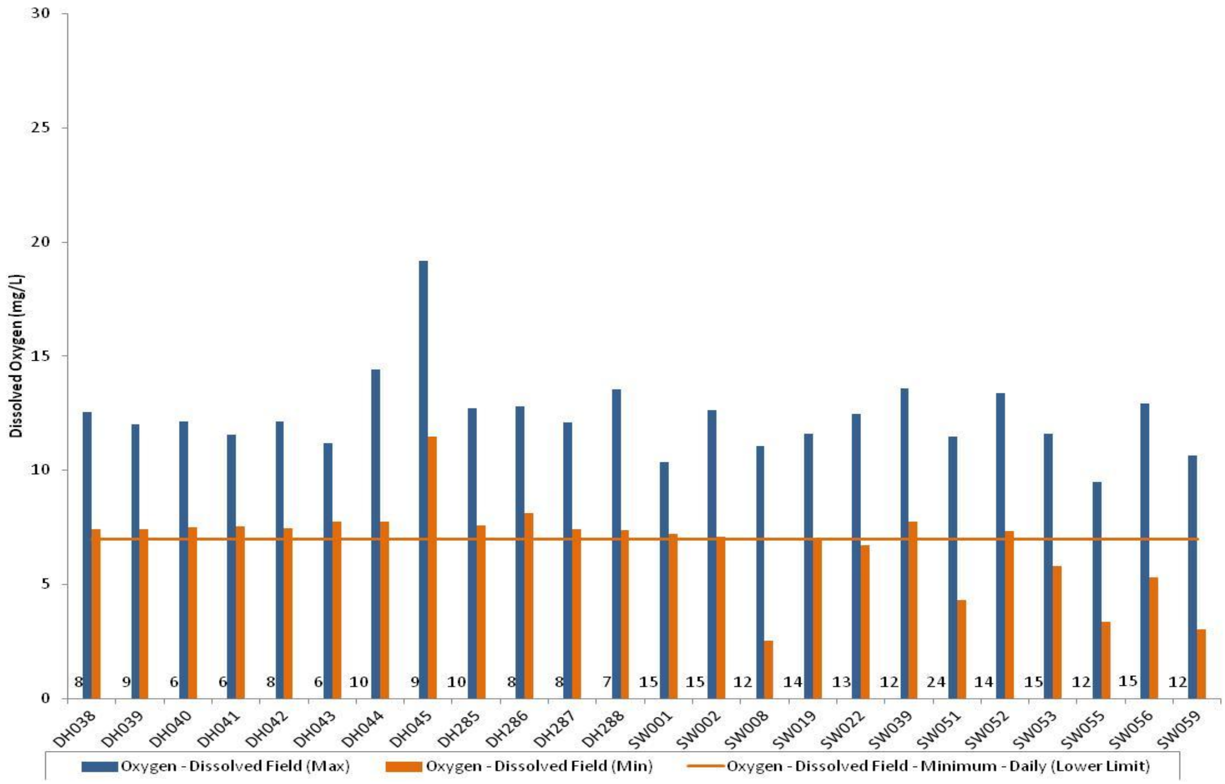

Figure 6.63 Class AA Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: 2011

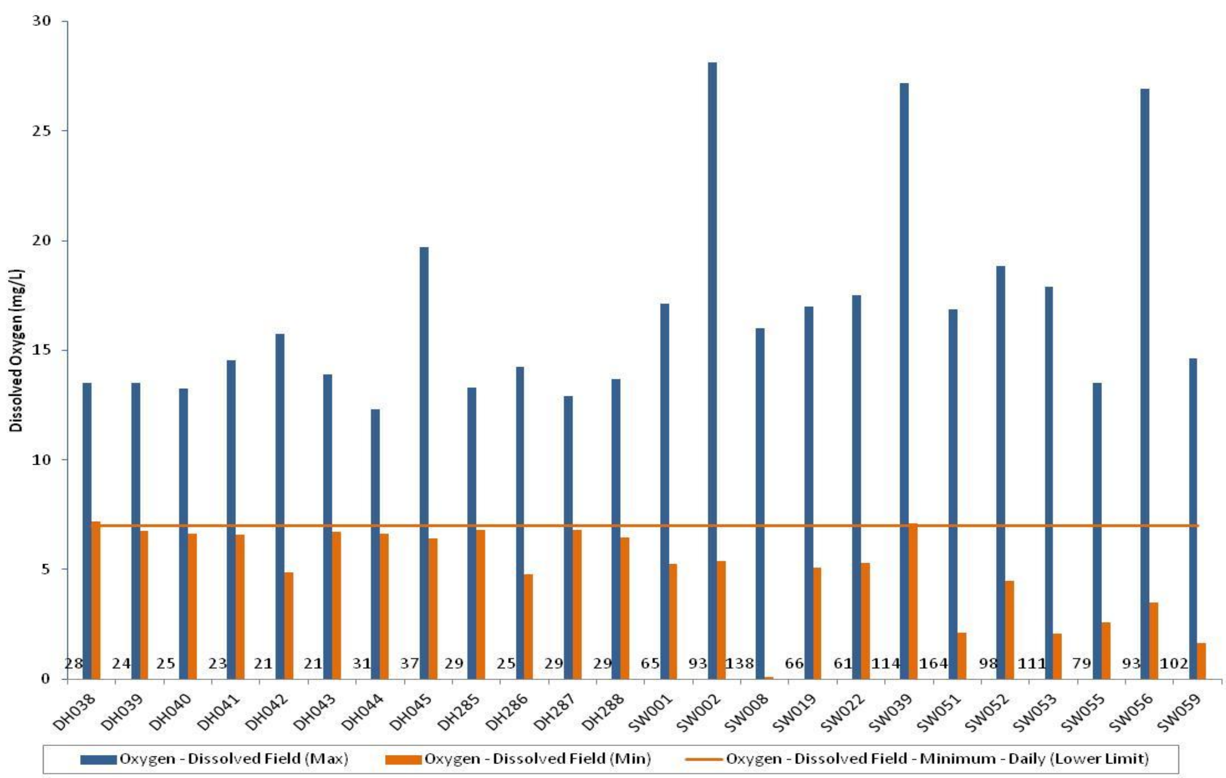

Figure 6.64 Class AA Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2010

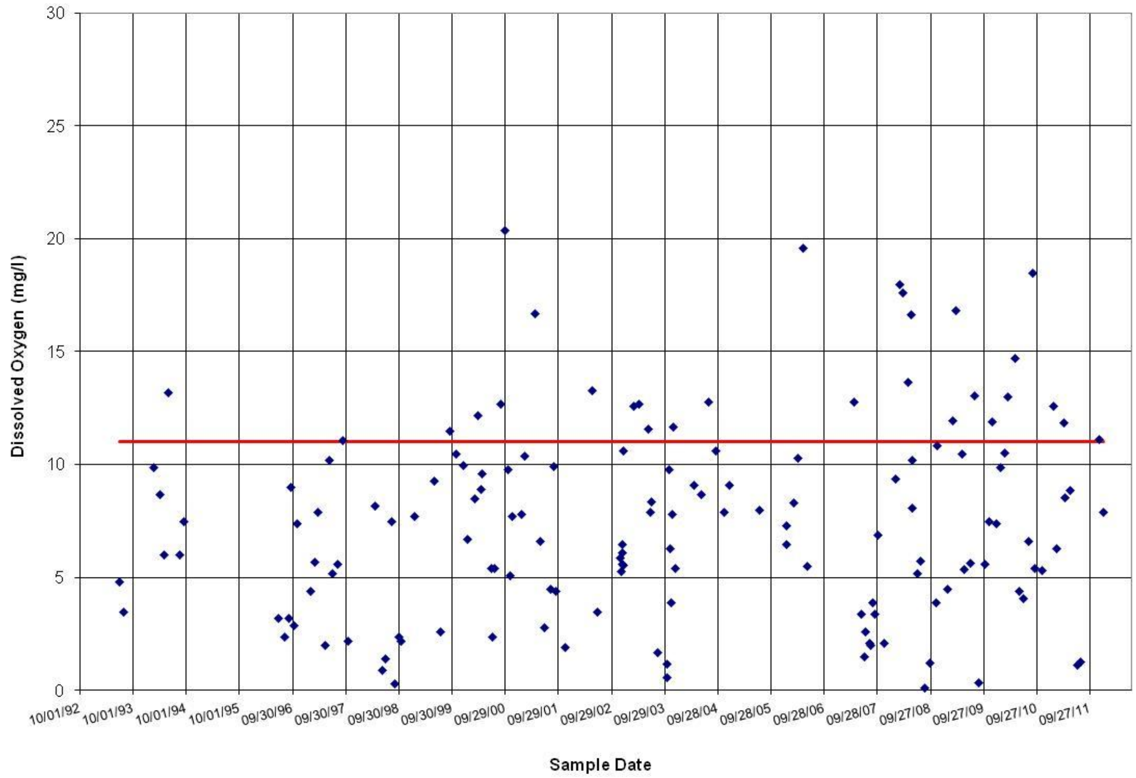

Figure 6.65 Class AA Freshwater Dissolved Oxygen Results, Site SW009

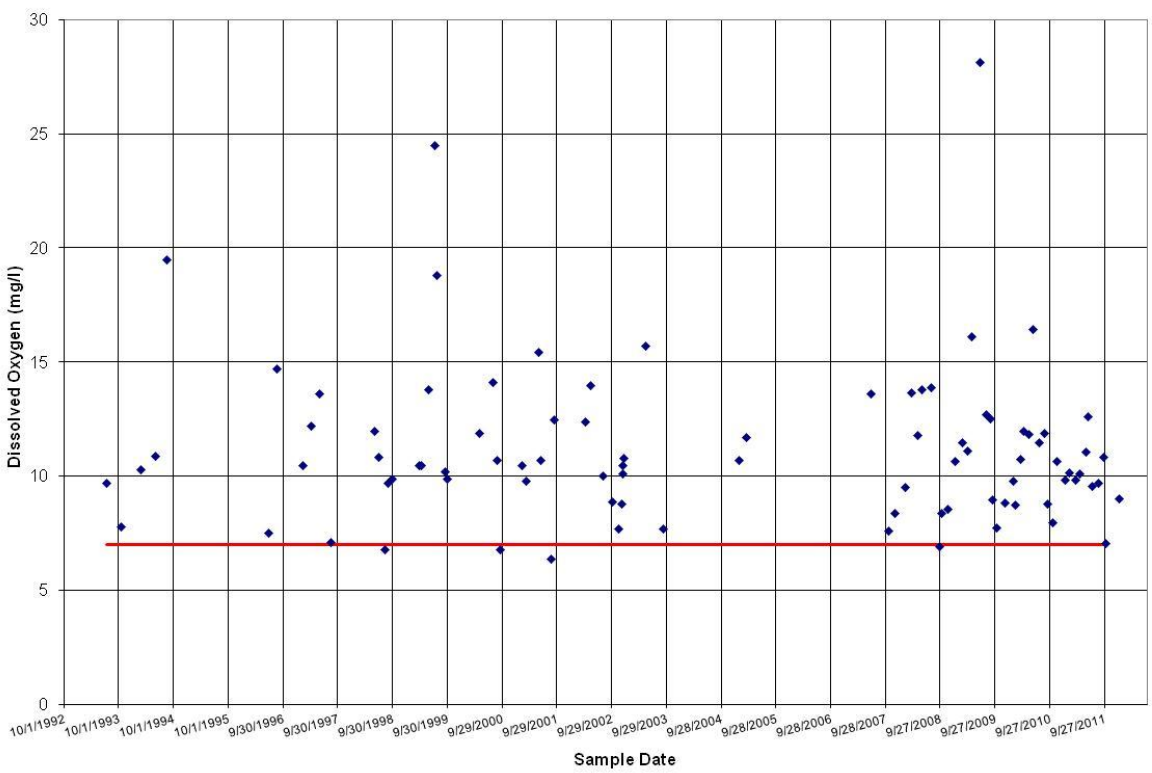

Figure 6.66 Class AA Marine Water Dissolved Oxygen Results, Site SW002

6.8.2. Class A Waters

The Class A freshwater quality standard for dissolved oxygen is a minimum value of 8.0 mg/l. As shown in Figure 6.67, the water quality samples collected during 2011 suggest that this standard was achieved at least one time for all seven sample sites, while the standard was consistently achieved at only one of the seven sites. As shown in Figure 6.69, 6 of the 7 sites sampled during 2011 achieved the water quality standard at least 75% of the time sampled. As shown in Figure 6.68, the dissolved oxygen was above the minimum standard at least one time at each of the nine Class A freshwater monitoring sites over the period of record through 2010. Although Site SW024 is shown to have met the standard during the period of record, this result reflects only two samples.

The Class A marine water quality standard for dissolved oxygen is a 1-day minimum concentration of 6.0 mg/l. As shown in Figure 6.69 and Figure 6.70, the dissolved oxygen levels were consistently above the 6.0 mg/l criterion during 2011 at all seven sample sites. As shown in Figure 6.71, the dissolved oxygen levels consistently exceeded the standard at all of the Class A marine water quality monitoring sites except Site SW030 over the period of record through 2010.

As shown in Figure 6.72, the dissolved oxygen sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018 and SW118 on the Nooksack River along the Reservation boundary) have generally been above the minimum 11.0 mg/l Class AA threshold over the period of record. As shown in Figure 6.73, all the dissolved oxygen sample results except one in 2008 for the representative Class A marine water site (SW030 in Bellingham Bay) were above the minimum 6.0 mg/l Class A threshold over the period of record.

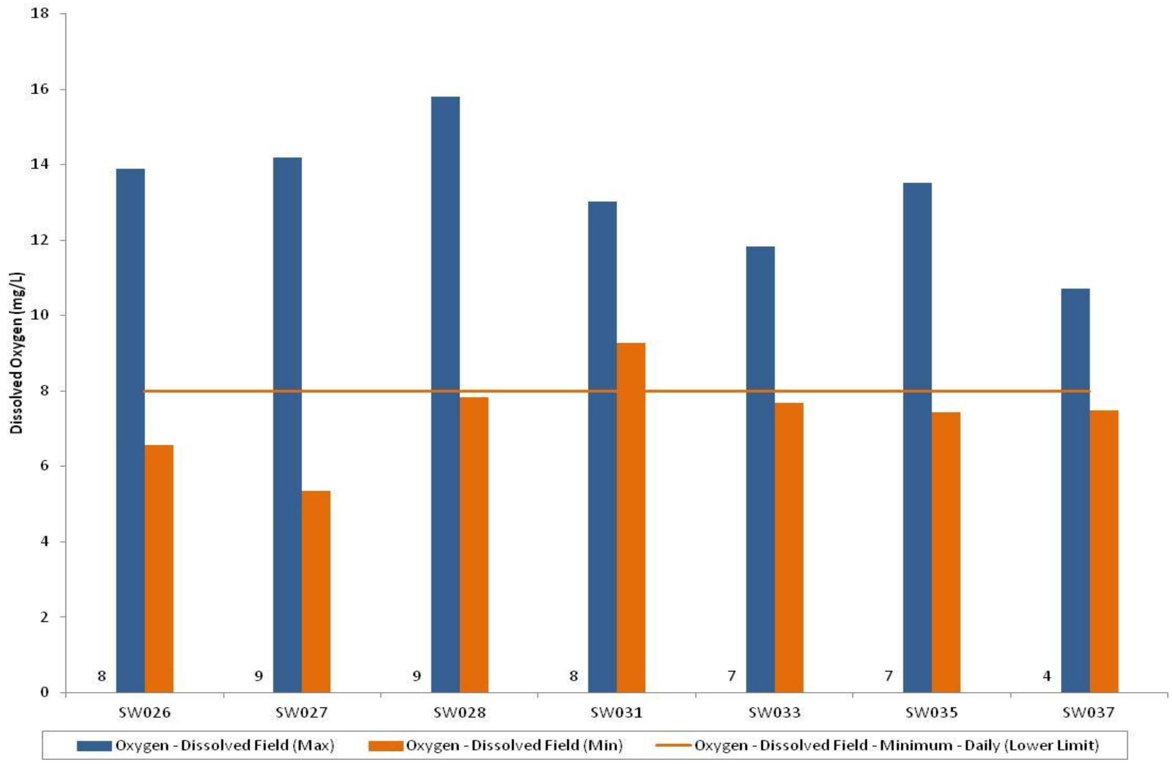

Figure 6.67 Class A Freshwater Dissolved Oxygen Results Compared With Water Quality Standards: 2011

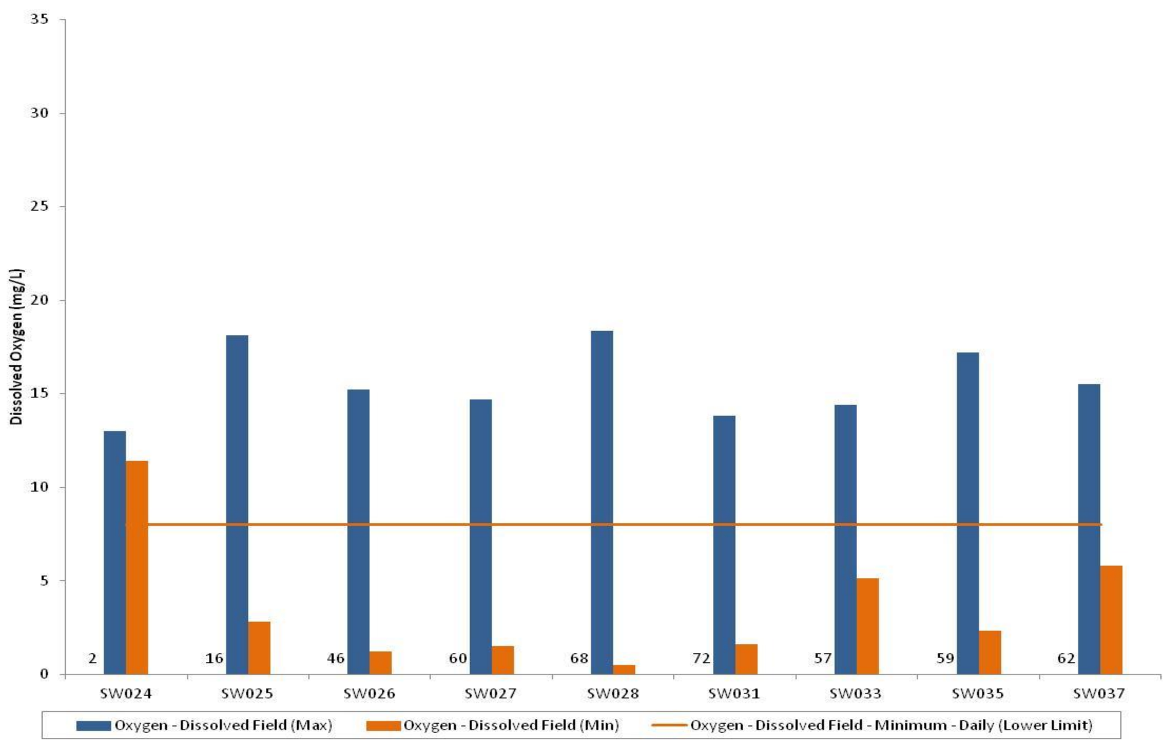

Figure 6.68 Class A Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2010

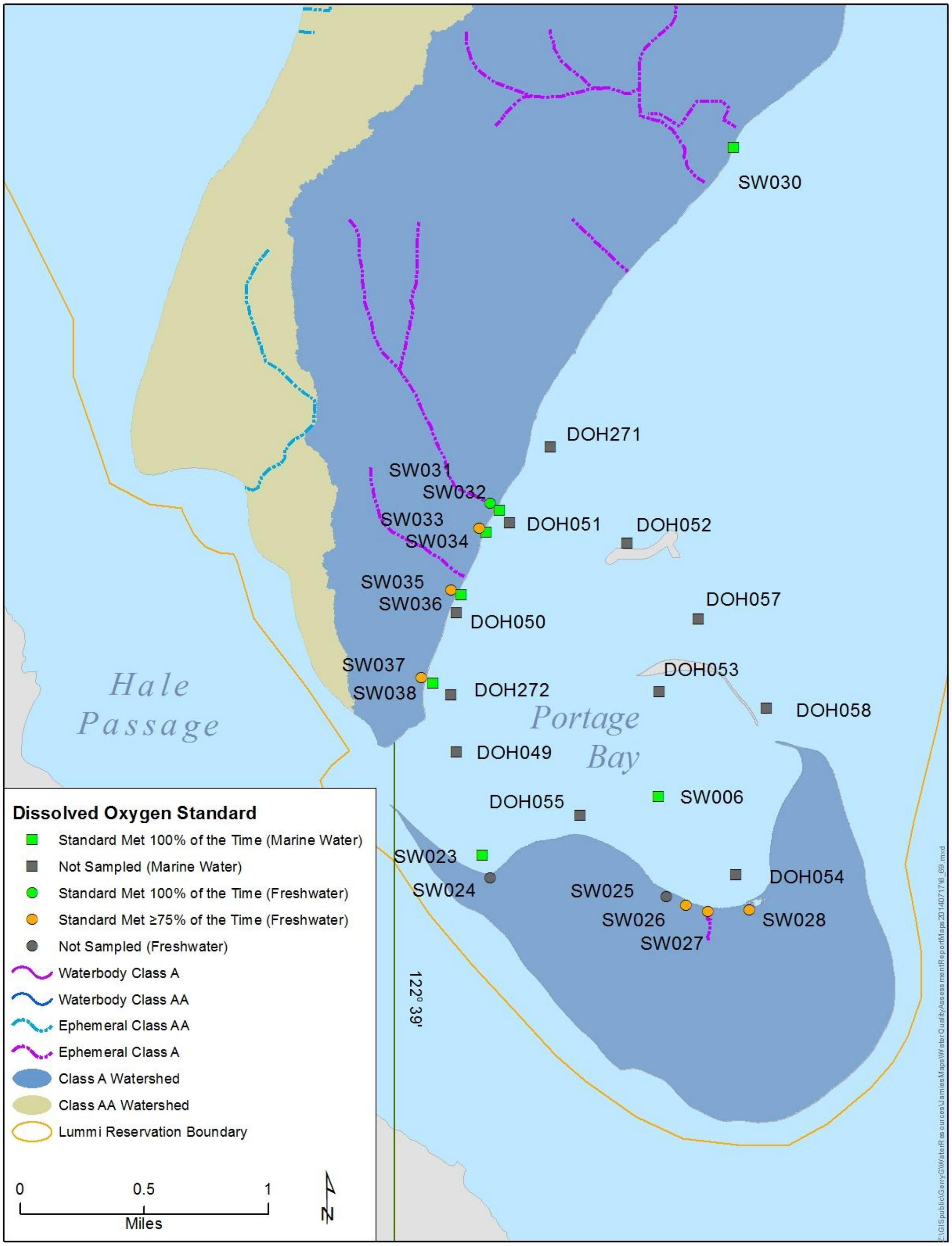

Figure 6.69 Class A Fresh and Marine Water Dissolved Oxygen Compliance with Water Quality Standards: 2011

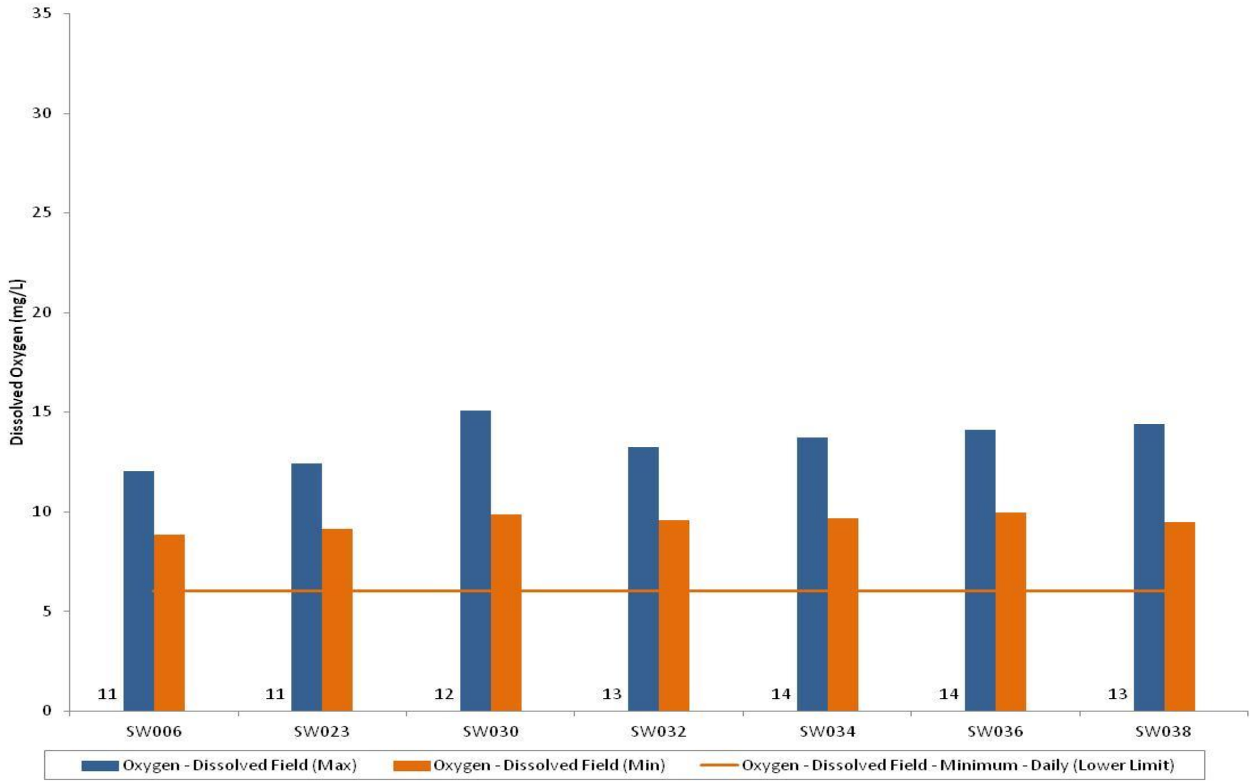

Figure 6.70 Class A Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: 2011

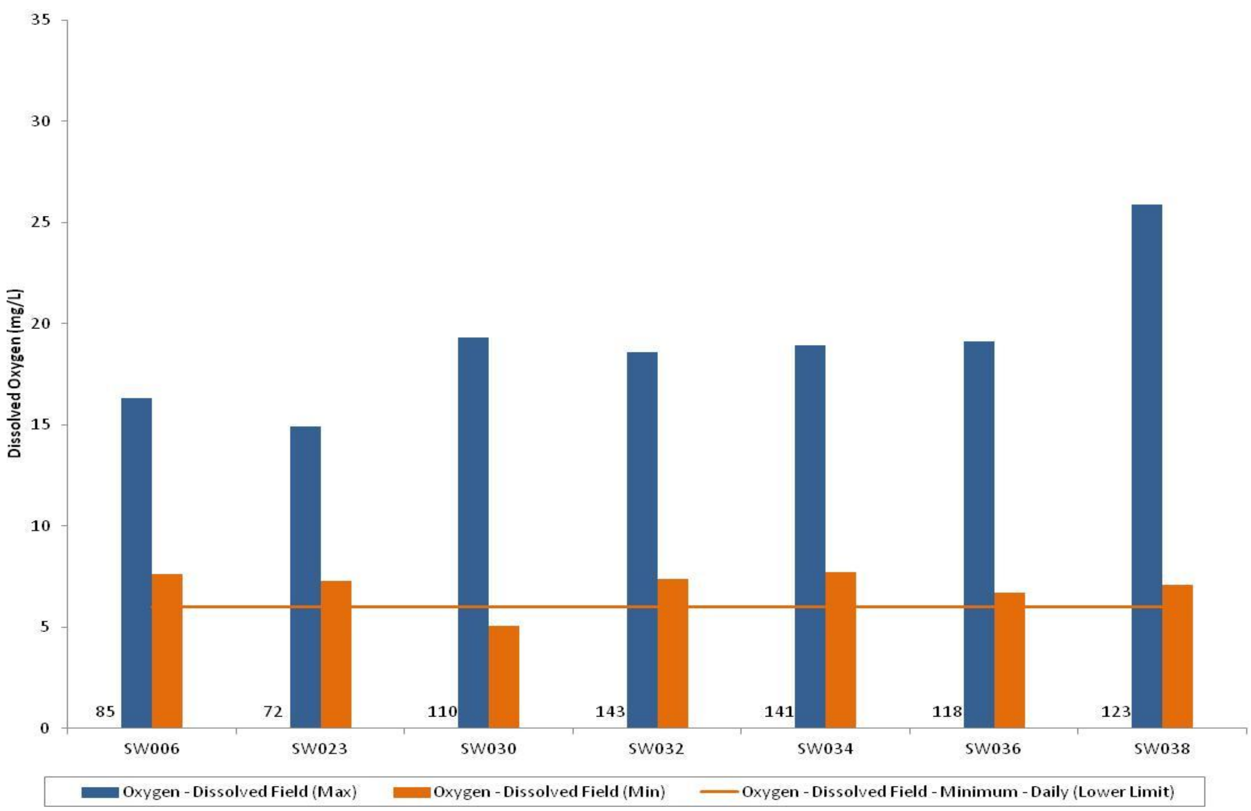

Figure 6.71 Class A Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2010

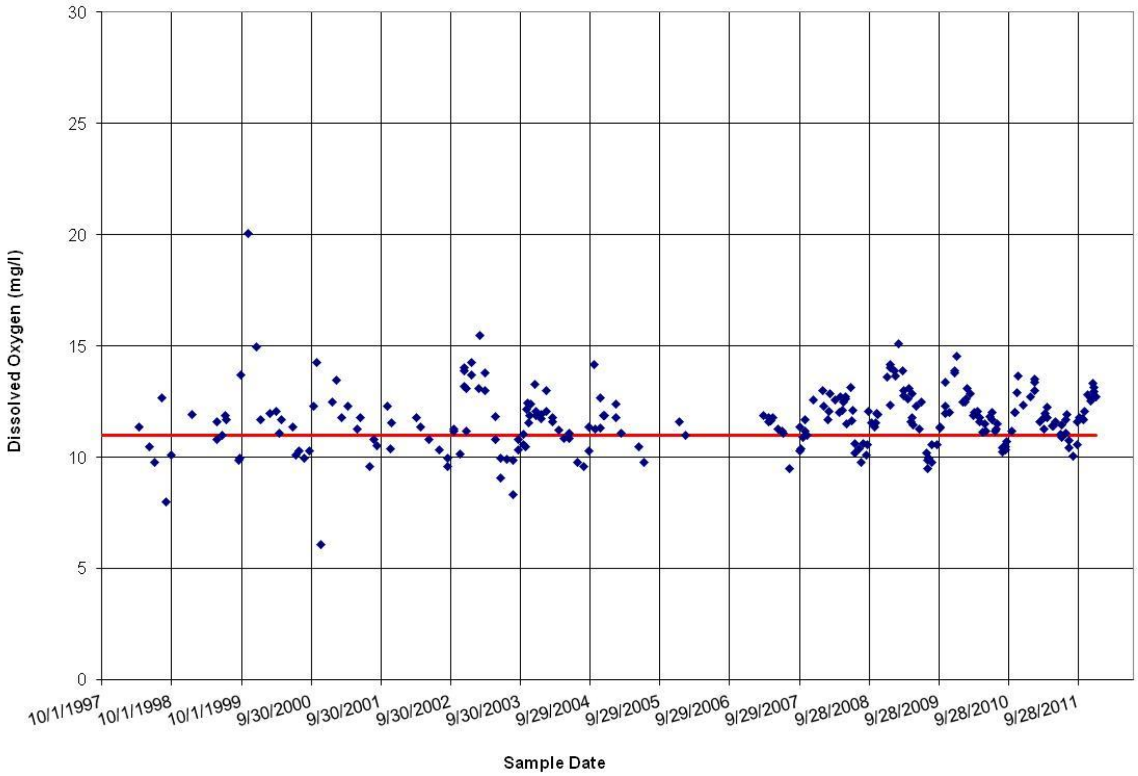

Figure 6.72 Class AA Freshwater Dissolved Oxygen Results, Site SW018/SW118

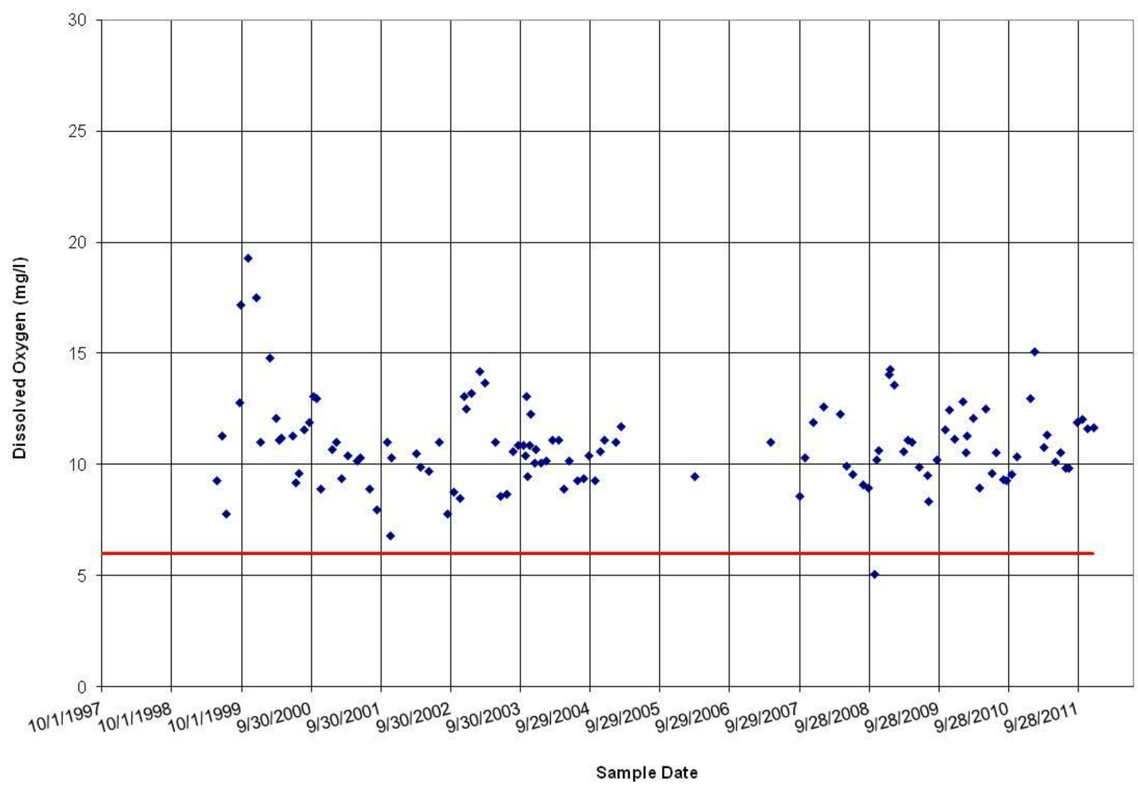

Figure 6.73 Class A Marine Water Dissolved Oxygen Results, Site SW030

6.8.3. Relationship between Dissolved Oxygen and Temperature

Water temperature influences the concentration of dissolved oxygen in a water body. In general, cold water can hold more oxygen than warm water. Adequate concentrations of dissolved oxygen are necessary for the health of fish and other aquatic organisms and to prevent offensive odors caused by anaerobic bacteria. Low dissolved oxygen levels can impact organisms' growth rates, swimming ability, susceptibility to diseases, and the ability to survive other environmental stressors and pollutants.

As summarized in Table 6.5, the relation between temperature and dissolved oxygen varies from site to site and there is generally a poor relationship between the two water chemistry variables. The best relationship, as defined by the highest coefficient of determination (r^2) and slope of the best-fit line close to 1, is for Site DH044 (inside Lummi Seaponds Aquaculture Dike).

Table 6.5 Relation Between Dissolved Oxygen and Temperature

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	188	-0.17	9.55	0.15
SW007	178	-0.30	14.37	0.37
SW009	182	-0.17	9.16	0.04
SW010	168	-0.18	7.39	0.08
SW011	328	-0.29	13.35	0.29
SW012	203	-0.15	9.01	0.05
SW013	133	0.60	0.97	0.23
SW014	168	-0.41	12.47	0.46
SW015	138	0.06	5.05	0.01
SW016	74	0.03	7.50	0.00
SW017	80	0.13	5.80	0.03
SW018	240	-0.23	13.66	0.37
SW025	16	0.57	6.19	0.25
SW026	55	-0.07	11.14	0.02
SW027	88	-0.35	14.01	0.32
SW028	85	-0.15	13.57	0.07
SW029	97	-0.42	14.04	0.43
SW032	153	-0.05	11.57	0.01
SW034	165	-0.05	11.53	0.01
SW036	119	-0.10	12.11	0.06
SW038	122	-0.12	12.37	0.06
SW058	63	-0.28	9.59	0.05
SW072	74	-0.04	4.75	0.01
SW118	198	-0.24	14.25	0.75
Marine Water				
DH038	52	-0.09	10.07	0.03
DH039	43	-0.05	10.16	0.01
DH040	39	0.00	9.66	0.00
DH041	35	0.26	7.24	0.14
DH042	35	0.02	9.50	0.00
DH043	29	0.00	9.96	0.00
DH044	59	-0.25	12.68	0.76
DH045	71	-0.18	14.46	0.10
DH285	47	0.03	9.67	0.00
DH286	35	0.05	9.35	0.02
DH287	43	-0.08	10.10	0.02
DH288	40	-0.12	11.02	0.07
SW001	111	0.00	9.47	0.00
SW002	162	0.13	9.52	0.03
SW006	128	-0.07	11.37	0.04
SW008	176	-0.22	10.34	0.32
SW019	98	-0.07	10.04	0.03
SW022	97	-0.10	11.18	0.03
SW023	107	-0.14	11.92	0.16
SW030	125	-0.17	12.91	0.20
SW031	109	-0.19	11.69	0.10
SW033	86	-0.11	10.07	0.09
SW035	72	0.05	9.14	0.01
SW037	76	-0.16	11.32	0.15
SW039	135	0.22	8.23	0.09
SW051	192	-0.15	11.11	0.23
SW052	130	-0.18	12.48	0.36
SW053	160	-0.16	11.25	0.24
SW055	91	-0.08	8.57	0.04
SW056	126	0.17	7.74	0.10
SW059	152	-0.18	9.05	0.15

6.9. pH Results

The water quality standards for pH (hydrogen ion concentration) set a range of acceptable values. If the maximum or minimum measured pH is not within the specified range, the sample results indicate that the characteristic uses of the water body are not supported.

6.9.1. Class AA Waters

The Class AA freshwater quality standard for pH is not less than 6.5 and not more than 8.5. As shown in Figure 6.74, the water quality data collected during 2011 indicate that the pH standard was achieved at 6 of the 16 sample sites. Although Site SW004 is shown in Figure 6.74 to have met the pH standard during 2011, this result is from only one sample. As described above, Site SW004 is only sampled during flood conditions in the Nooksack River. As shown in Figure 6.76, 8 of the 16 sample sites that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time during 2011. As shown in Figure 6.75, the pH standard was always achieved at 3 of the 16 sample sites (SW004, SW011, and SW012) over the period of record. The highest pH (most alkaline) levels were measured at the Nooksack River site (SW018/SW118) and the lowest pH (most acidic) levels were measured in a perennial stream (SW029) that drains an undeveloped portion of the Reservation.

The Class AA marine water quality standard for pH is not less than 7.0 and not more than 8.5. As shown in Figure 6.77, the water quality data collected during 2011 indicate that this standard was achieved at 13 of the 24 sample sites. As shown in Figure 6.76, of the 11 sites that did not achieve the water quality standard 100% of the time sampled during 2011, 8 of those sites achieved the standard at least 75% of the time sampled. As shown in Figure 6.78, 11 of the 24 sample sites met the pH standard over the period of record. The highest pH value was measured at the sample site along the Lummi River at the Hillaire Road Bridge (SW008) and the lowest pH value was measured at the mouth of the Lummi River before the river discharges to Lummi Bay (SW051).

As shown in Figure 6.79, the pH sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009) have generally been more than 6.5 and less than 8.5 units. However, when there were multiple measurements during a particular day, the results were averaged in the data shown in Figure 6.79.

As shown in Figure 6.80, the pH sample results for the representative Class AA marine water site (SW002) have always been above the 7.0 pH threshold but have exceeded the 8.5 pH units threshold on two occasions over the period of record. Figure 6.79 and Figure 6.80 also show the gap in the pH data record that resulted from a combination of equipment malfunctions and staff changes before being measured consistently in 2008.

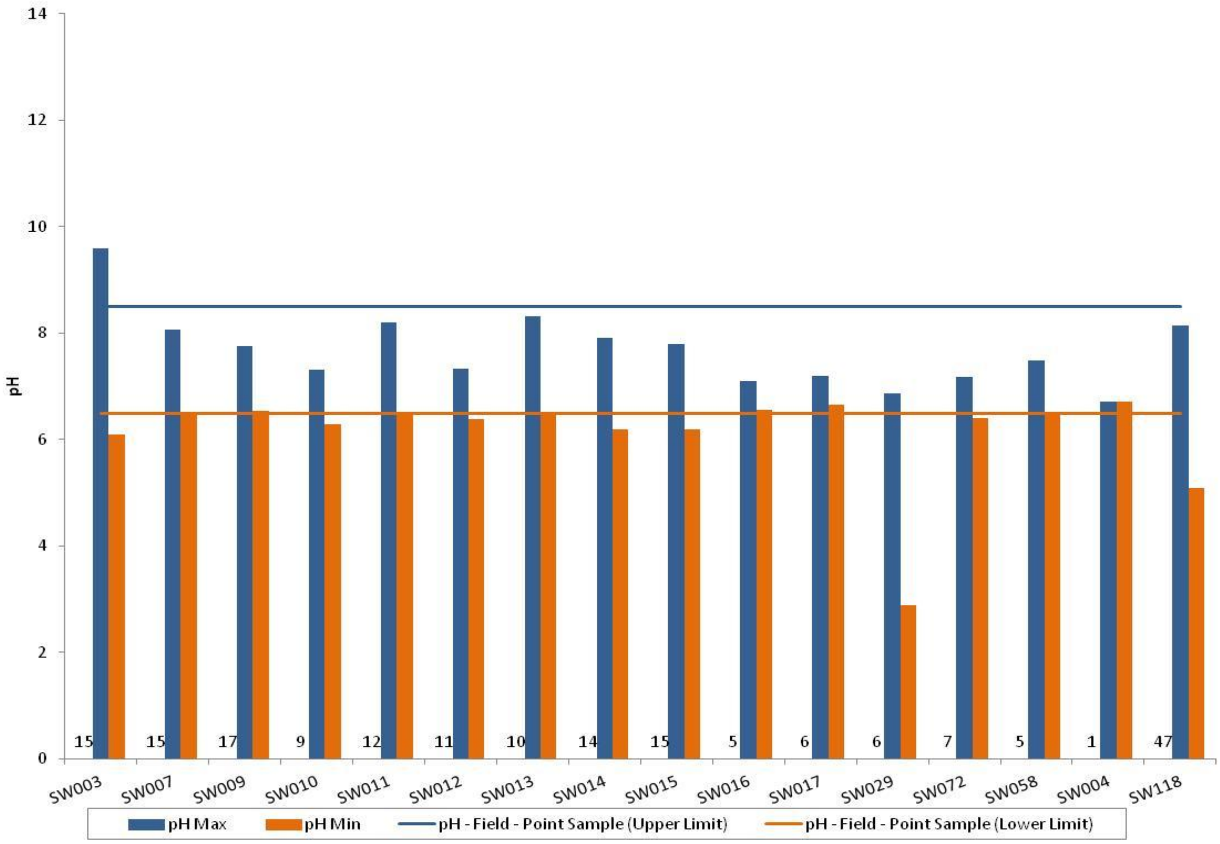

Figure 6.74 Class AA Freshwater pH Results Compared with Water Quality Standards: 2011

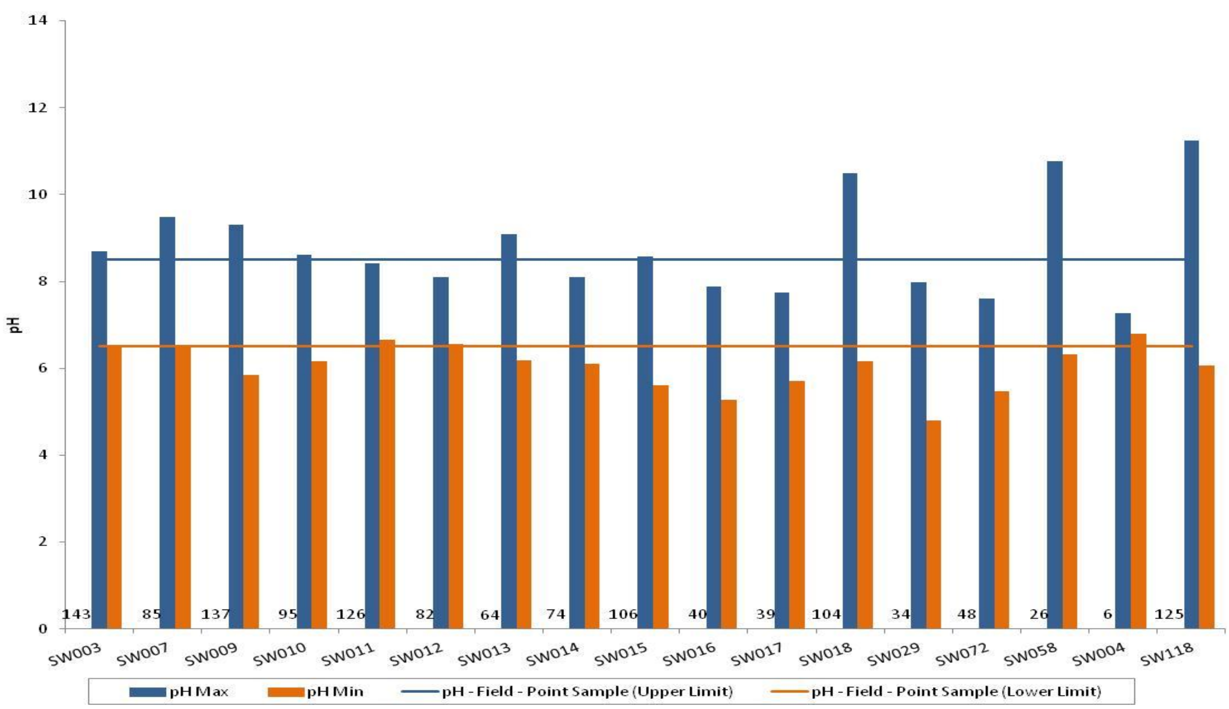

Figure 6.75 Class AA Freshwater pH Results Compared with Water Quality Standards: Period of Record through 2010

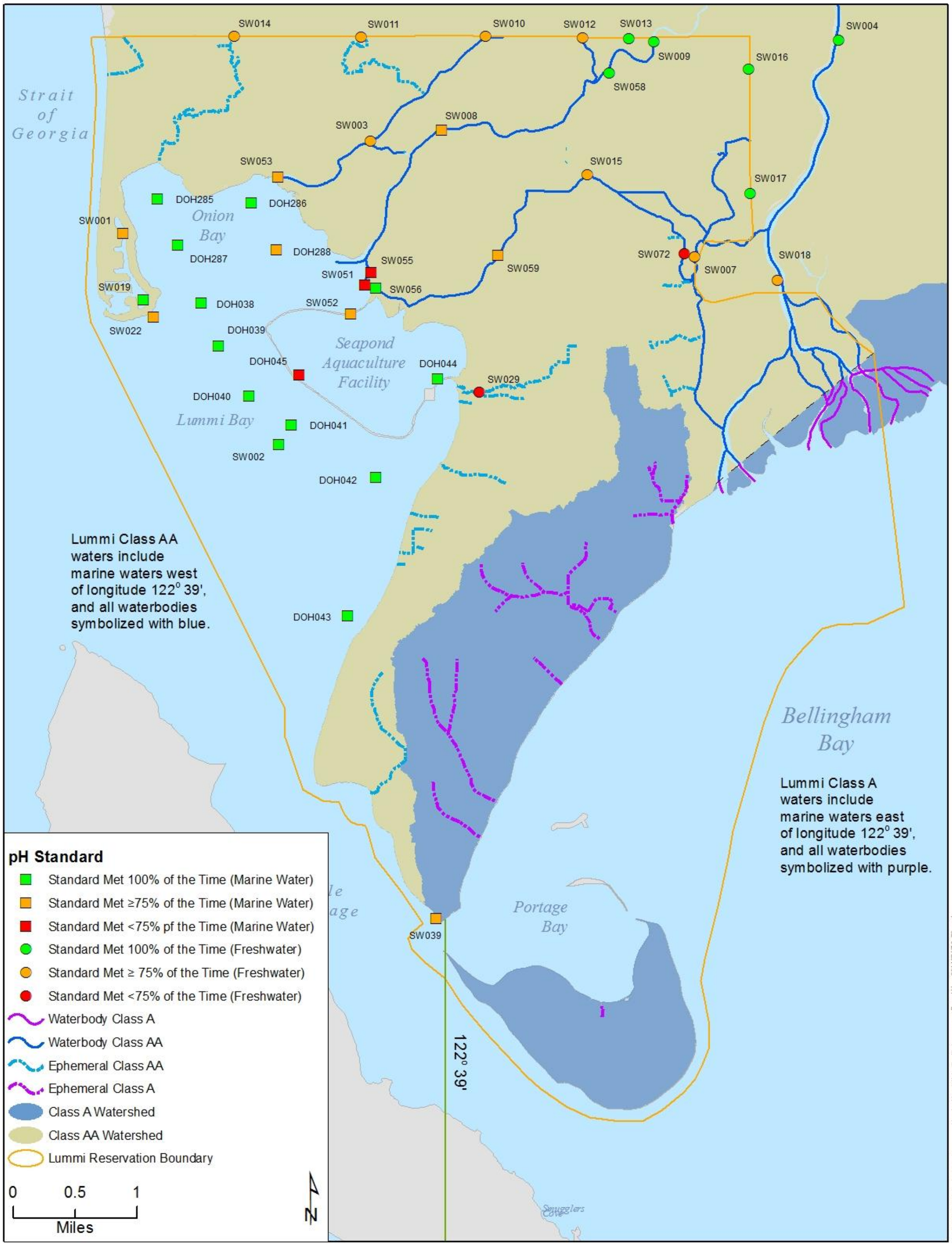

Figure 6.76 Class AA Freshwater and Marine Water pH Compliance with Water Quality Standards: 2011

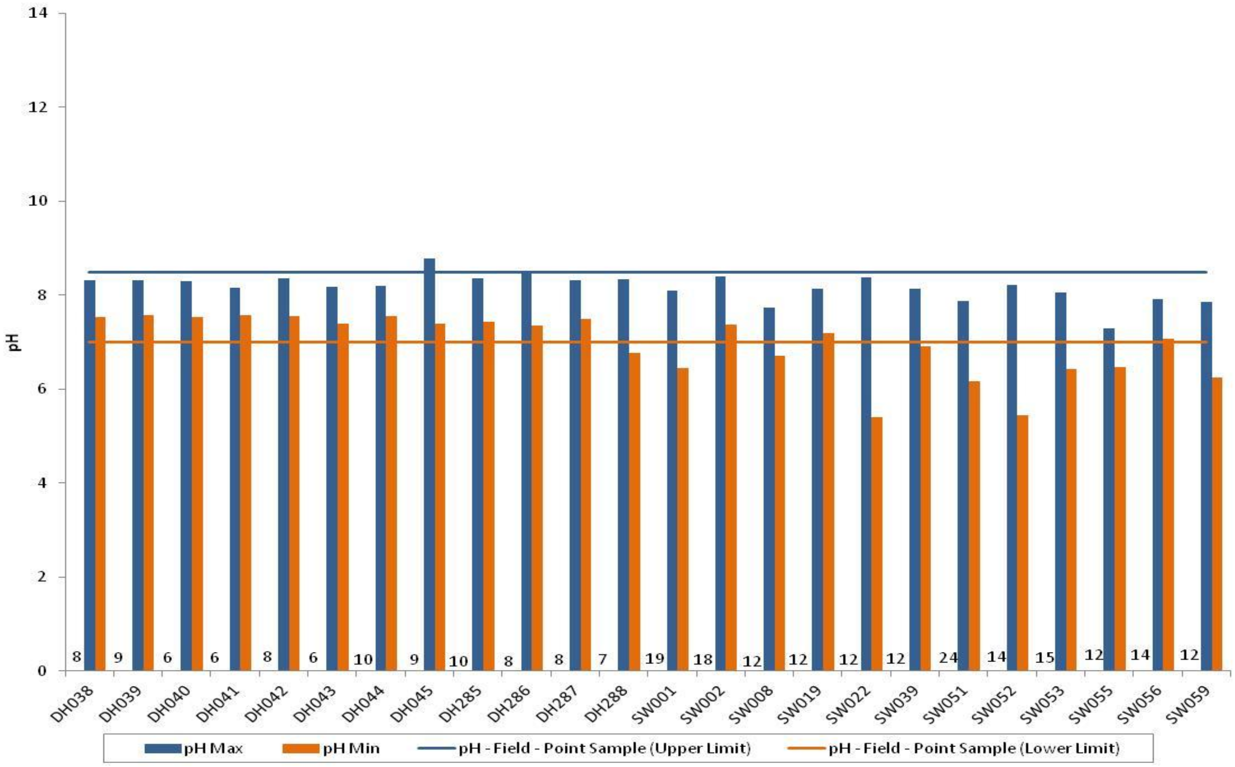

Figure 6.77 Class AA Marine Water pH Results Compared with Water Quality Standards: 2011

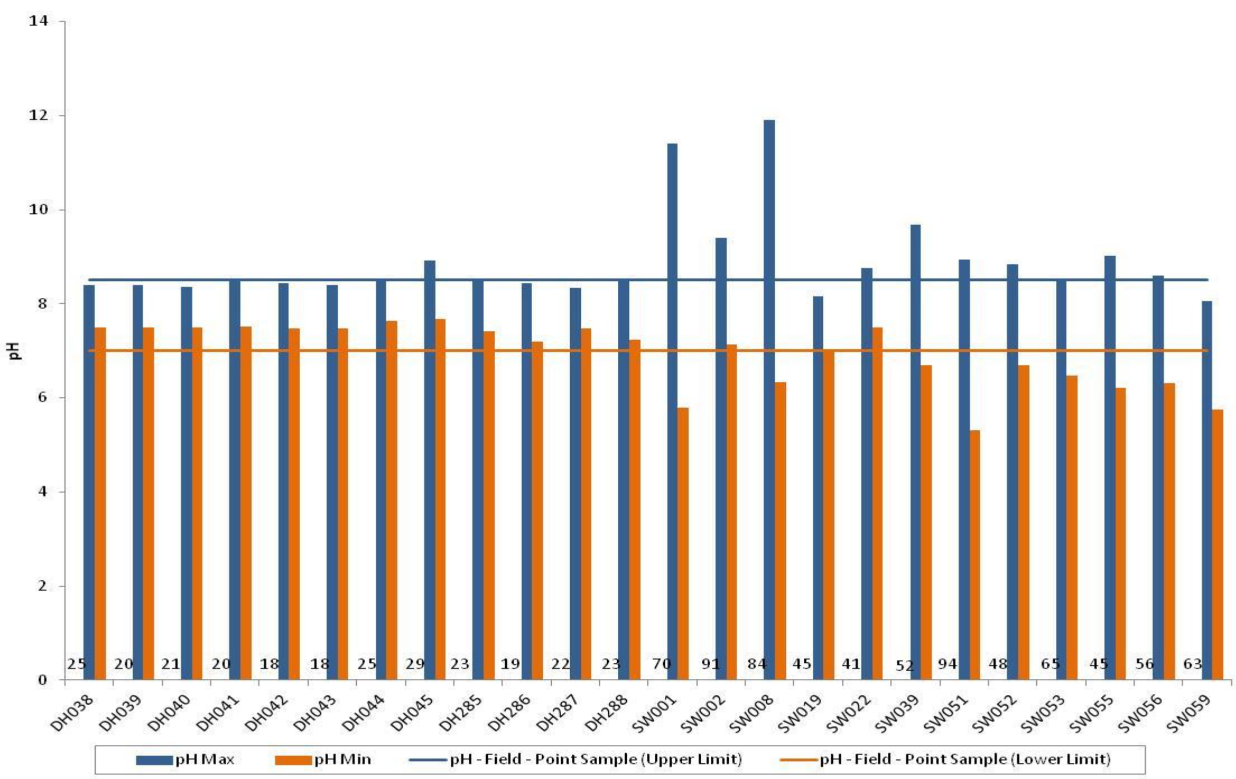

Figure 6.78 Class AA Marine Water pH Results Compared with Water Quality Standards: Period of Record through 2010

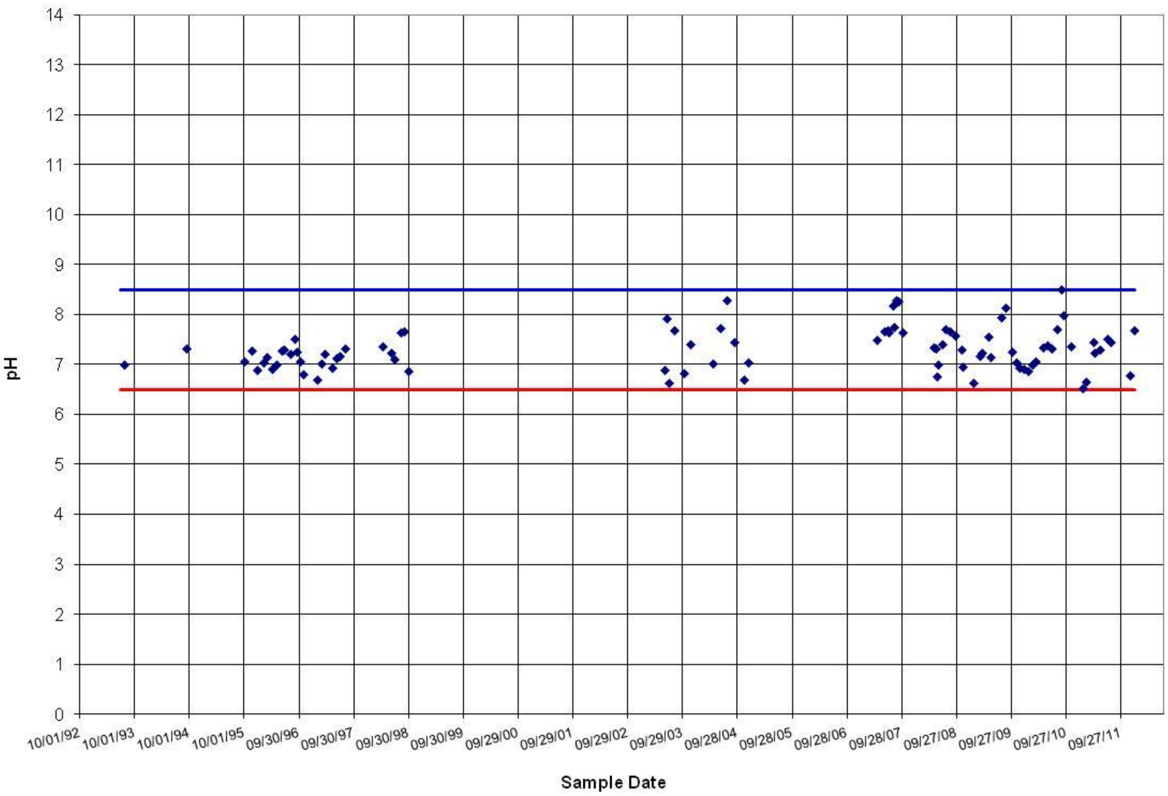

Figure 6.79 Class AA Freshwater pH Results, Site SW009

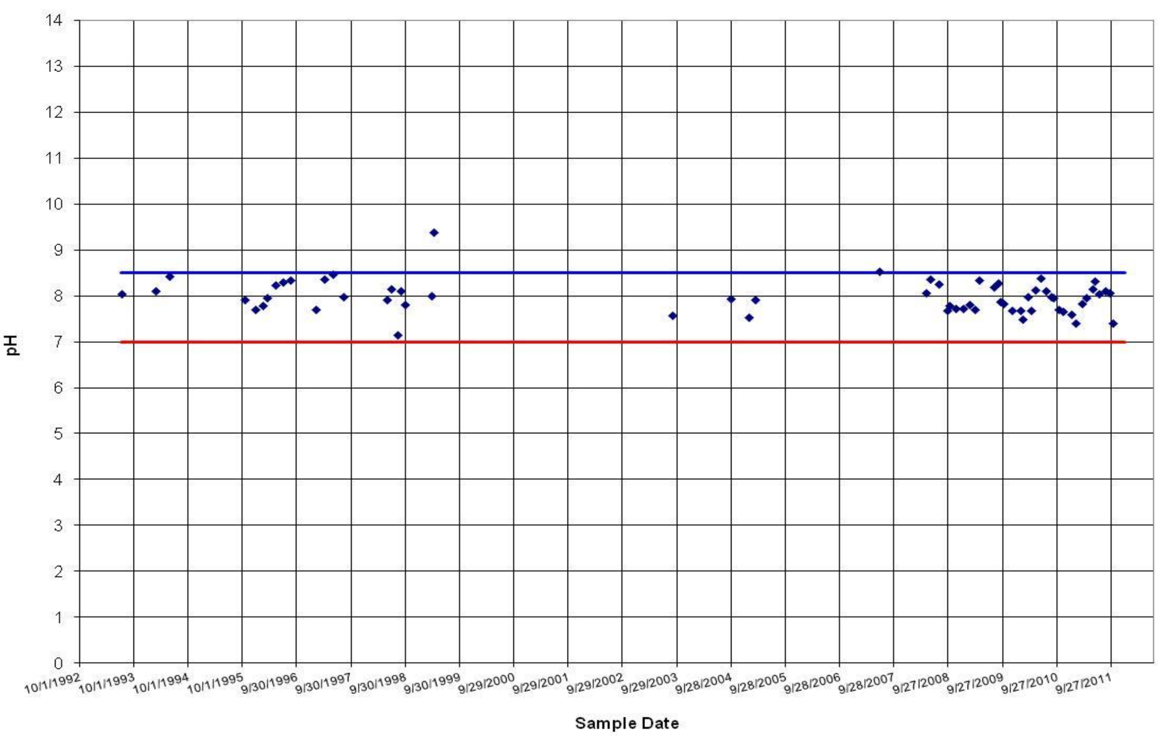

Figure 6.80 Class AA Marine Water pH Results, Site SW002

6.9.2. Class A Waters

The Class A freshwater quality standard for pH is not less than 6.5 and not more than 8.5. As shown in Figure 6.81, the water quality data collected during 2011 indicate that the standard was achieved at 4 of the 7 sample sites. As shown in Figure 6.83, of the 3 sites that did not achieve the water quality standard 100% of the time sampled during 2011, 2 of those sites achieved the standard at least 75% of the time sampled. As shown in Figure 6.82, the pH standard was achieved at Site SW024 and Site SW037 for the period of record. Site SW037 is along a relatively dense residential area along the Portage Bay shoreline. The lowest pH values were measured at Site SW033, which drains a wooded area along the Lummi Peninsula.

The Class A marine water quality standard for pH is not less than 7.0 and not more than 8.5. As shown in Figure 6.84, the water quality data collected during 2011 indicate that this standard was achieved at 1 of the 7 Class A marine water quality sample sites. As shown in Figure 6.83, all 6 sites sampled during 2011 that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time sampled. As shown in Figure 6.85, none of the sample sites met the standard consistently over the period of record. At 5 of the 7 sites, the pH was above the maximum pH threshold and below the minimum pH threshold at least once. The highest pH value over the period of record was measured at the sample site located in Portage Bay along Lummi Shore Road (SW032) and the lowest pH value was measured in another part of Portage Bay just offshore of Site SW024 (SW023).

As shown in Figure 6.86, the pH sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018/SW118 on the Nooksack River along the Reservation boundary) have generally met the standard over the period of record but there have been several measurements both above and below the standard. As shown in Figure 6.87, the pH sample results for the representative Class A marine water site (SW030 in Bellingham Bay) have generally met the standard but there are several measurements below the 7.0 pH units threshold over the period of record. Similar to the Class AA pH results, Figure 6.84 and Figure 6.85 show the gap in the pH data record that resulted from a combination of equipment malfunctions and staff changes.

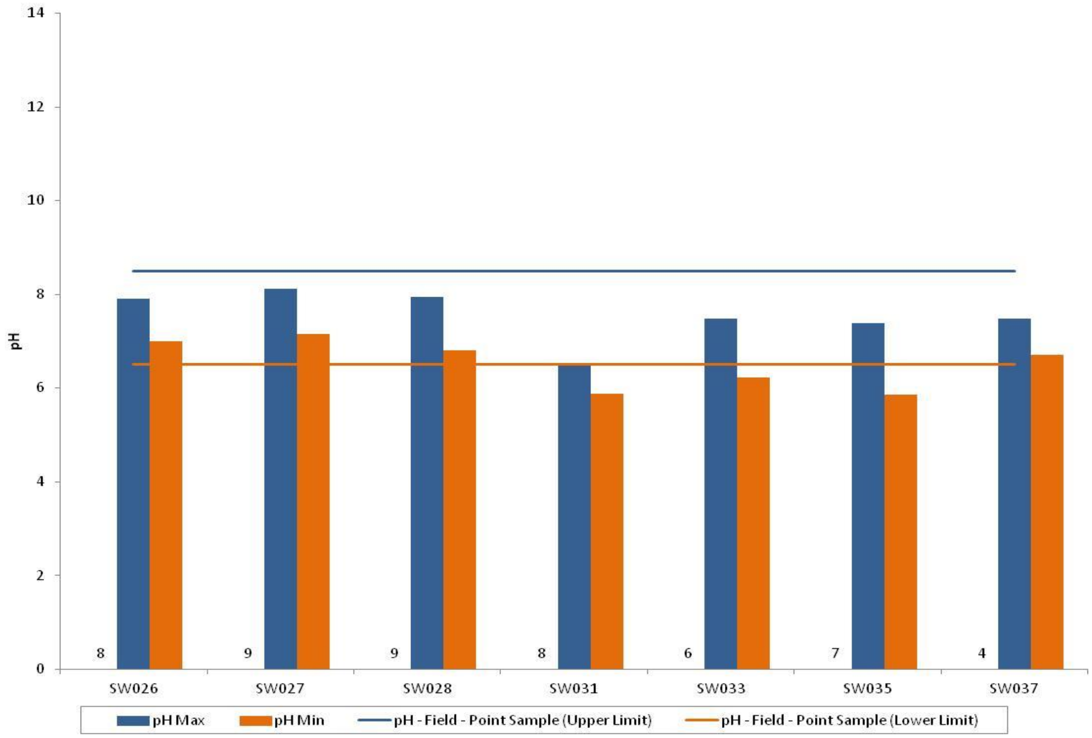

Figure 6.81 Class A Freshwater pH Results Compared with Water Quality Standards: 2011

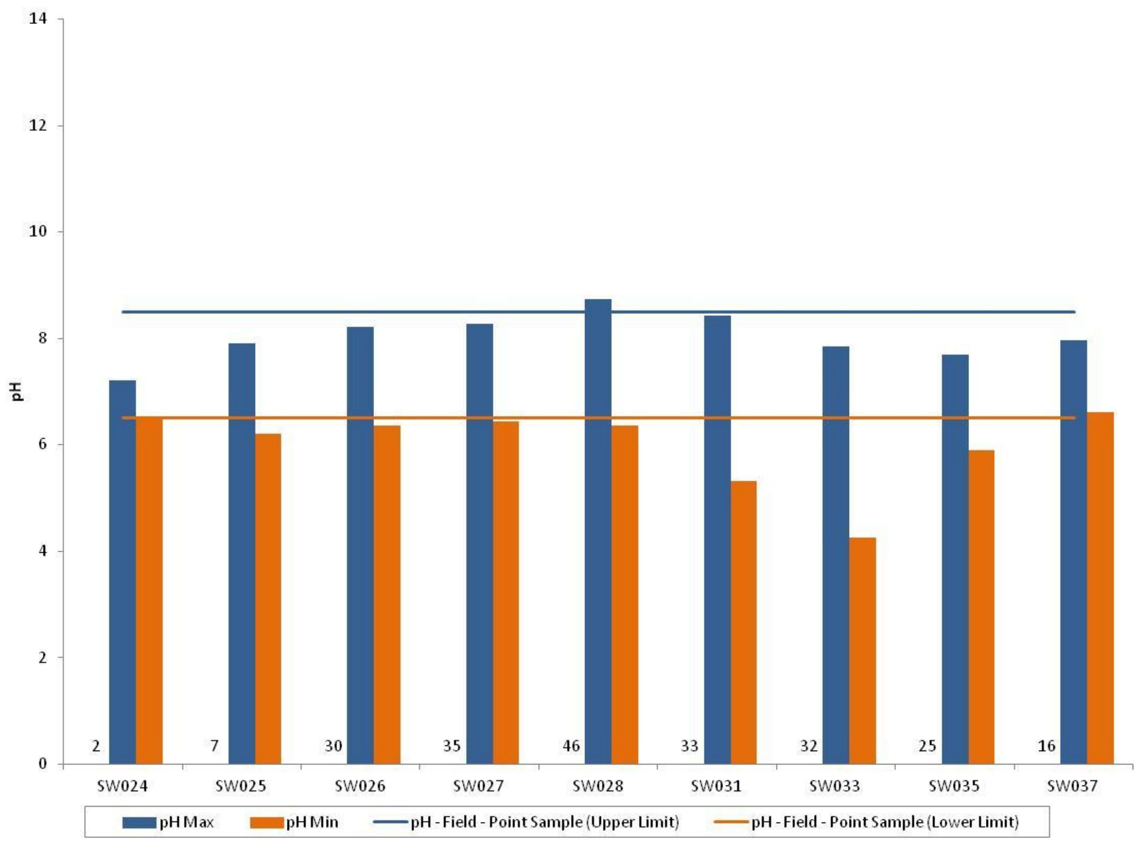

Figure 6.82 Class A Freshwater pH Results Compared with Water Quality Standards: Period of Record through 2010

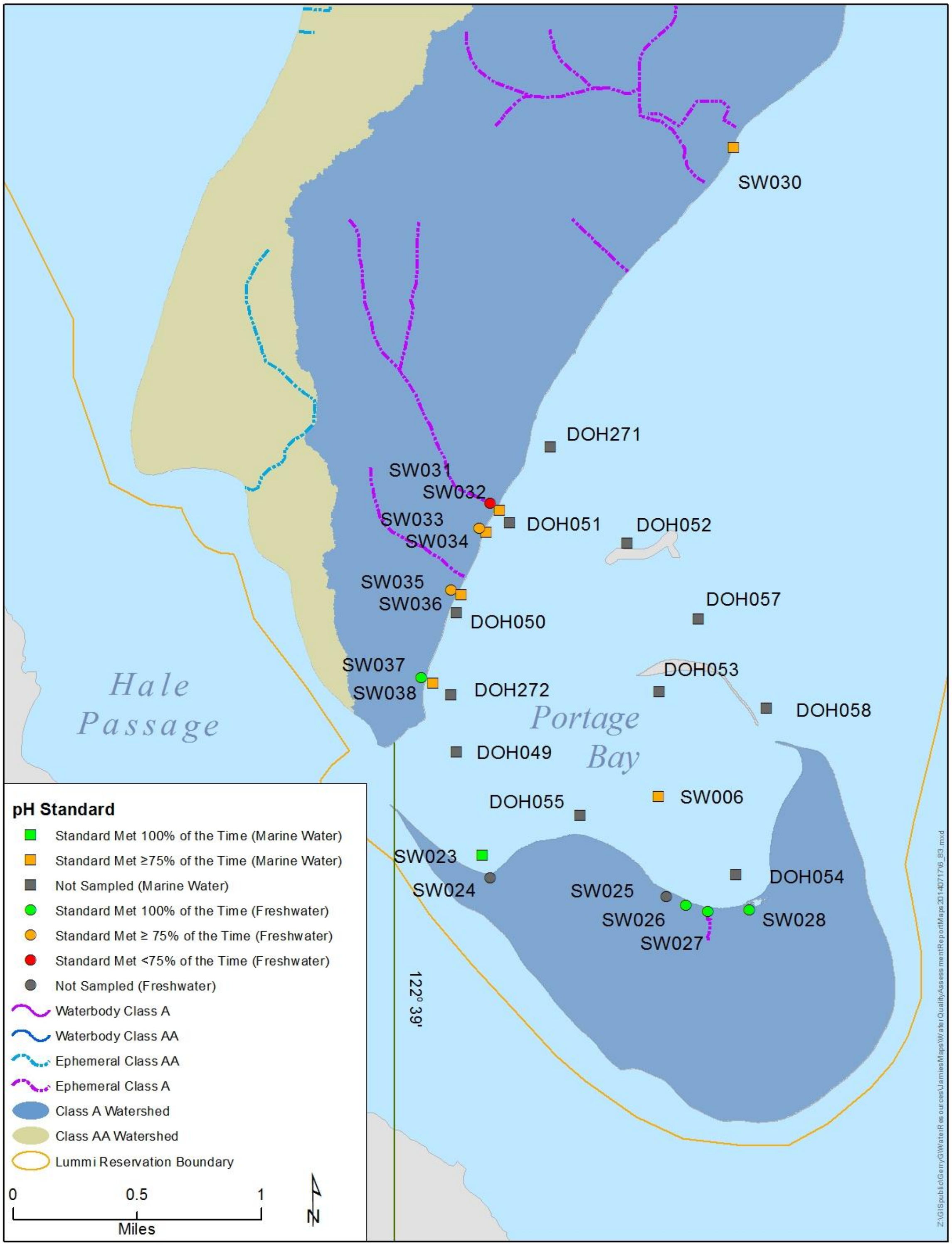

Figure 6.83 Class A Freshwater and Marine Water pH Compliance with Water Quality Standards: 2011

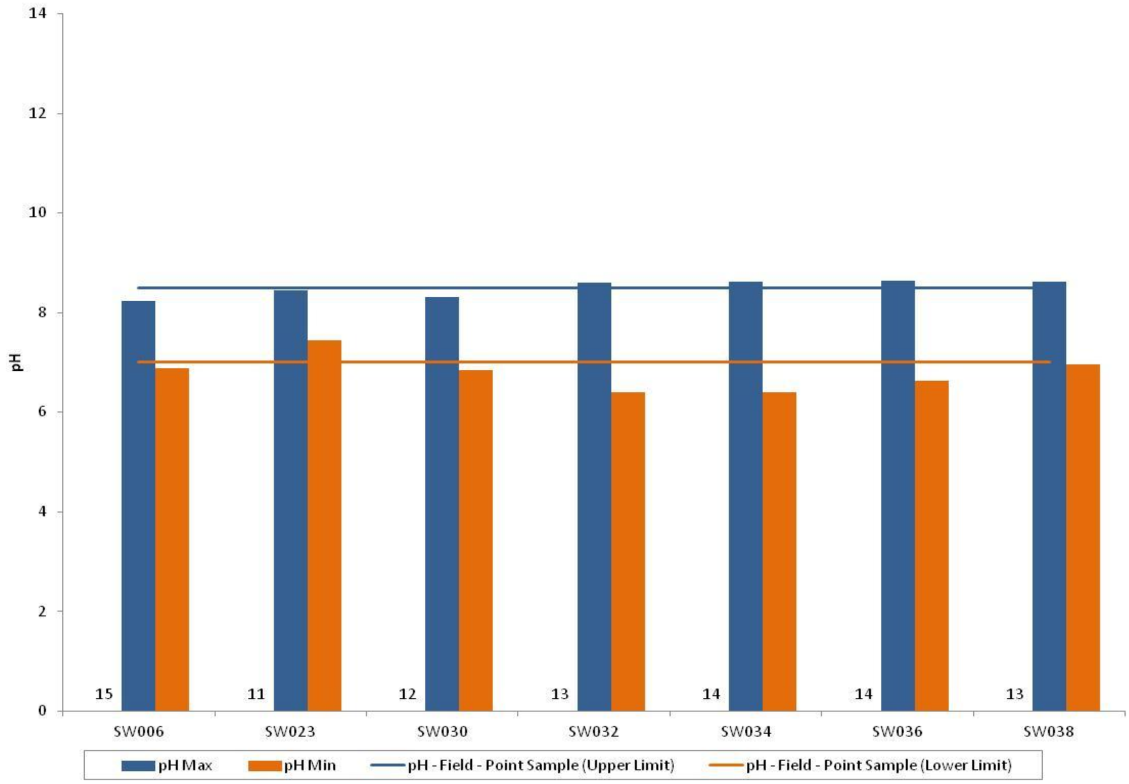

Figure 6.84 Class A Marine Water pH Results Compared with Water Quality Standards: 2011

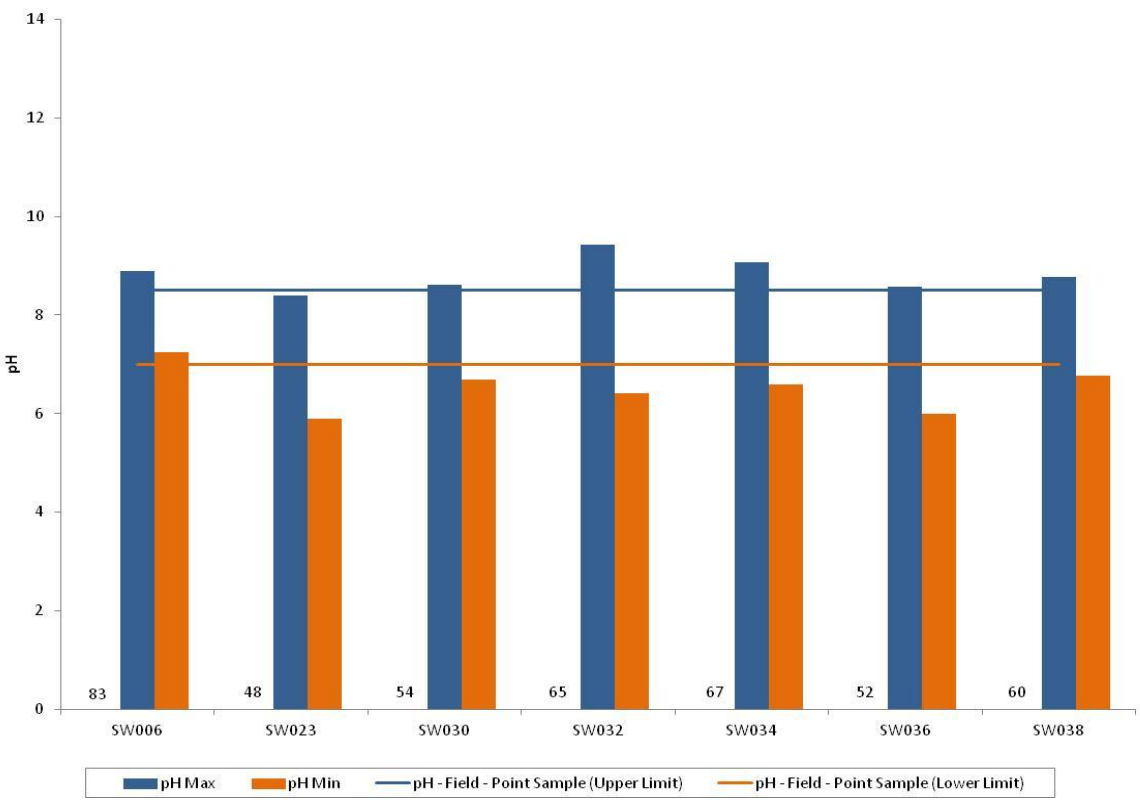

Figure 6.85 Class A Marine Water pH Results Compared with Water Quality Standards: Period of Record through 2010

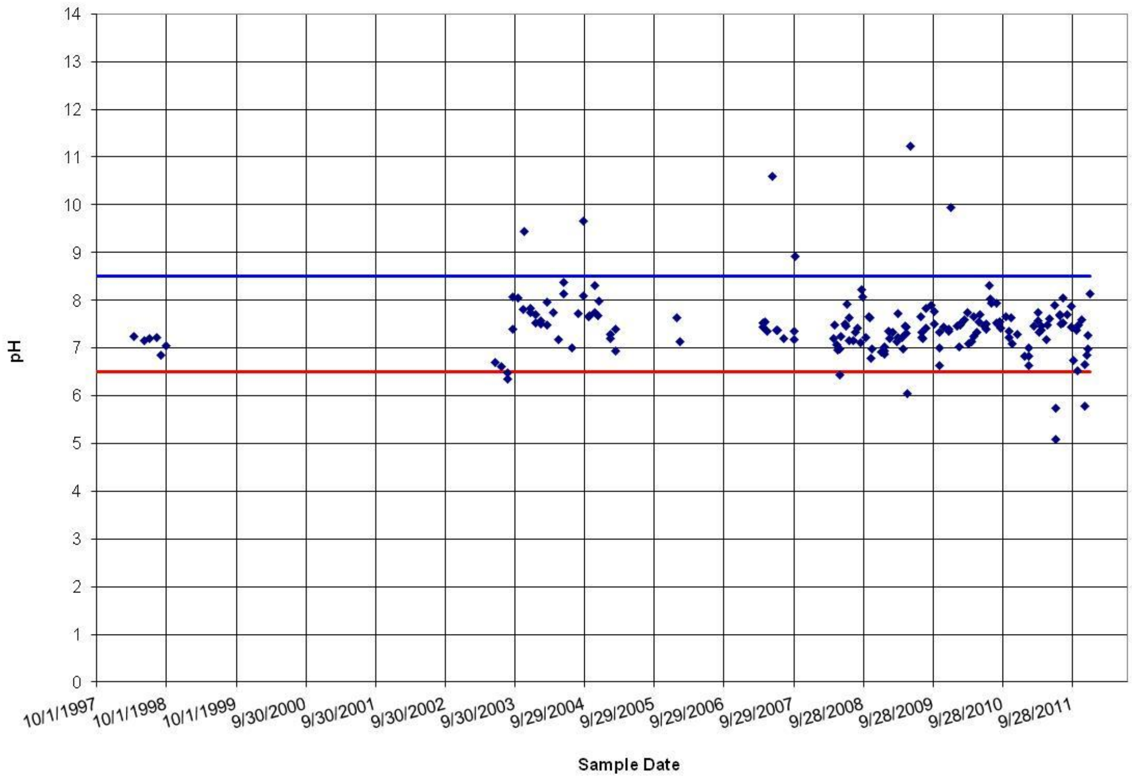

Figure 6.86 Class AA Freshwater pH Results, Site SW018/SW118

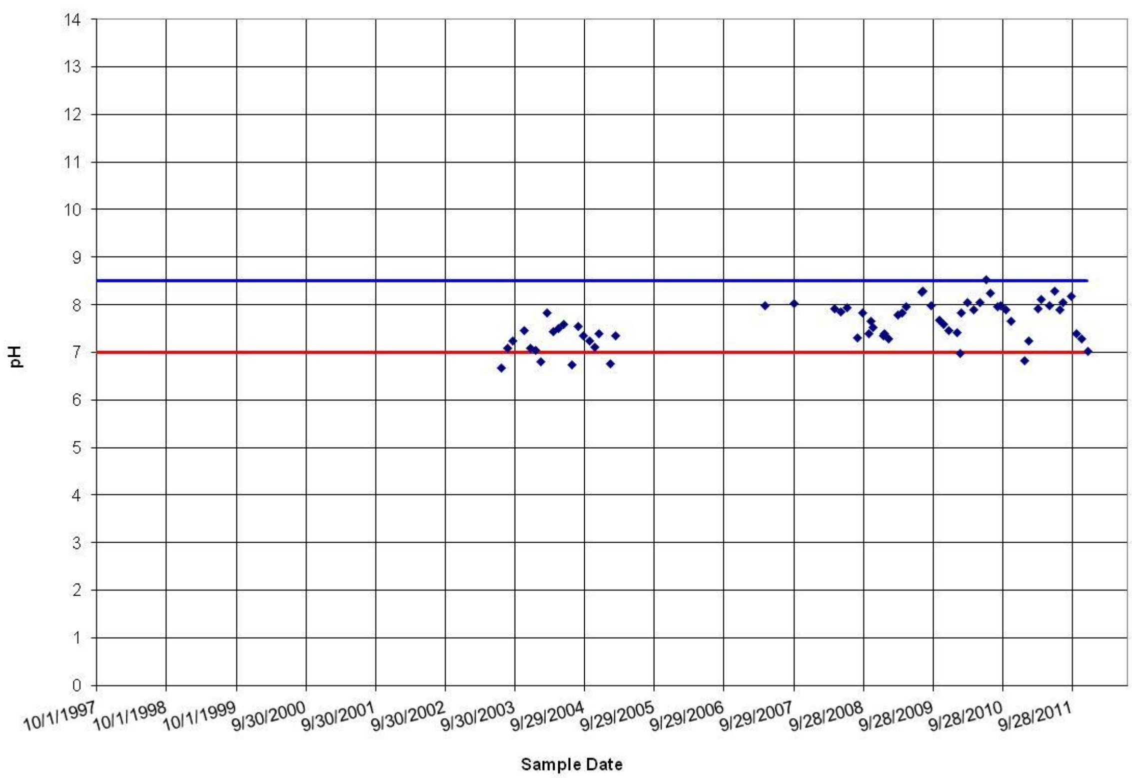

Figure 6.87 Class A Marine Water pH Results, Site SW030

6.10. Turbidity Results

The turbidity water quality standard is expressed as relative to background turbidity levels and is the same for Class AA and Class A waters. To comply with the Lummi Nation water quality standards, the turbidity level shall not exceed 5 nephelometric turbidity units (NTUs) over background turbidity when the background turbidity is less than or equal to 50 NTUs or the turbidity shall not exceed more than 10 percent of the background turbidity when the background turbidity is greater than 50 NTUs. For regulatory purposes (e.g., a construction site) the background turbidity is measured upstream from where storm water from a site discharges to receiving waters and compliance is determined by comparison of this upstream value with the turbidity measurement collected downstream from the point or points that the storm water from the site discharges to the receiving waters.

6.10.1. Nephelometer Results

Turbidity is a measure of the degree to which light is scattered by suspended particulate material and soluble colored compounds in the water. It provides an estimate of the muddiness or cloudiness of the water due to clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Turbidity is commonly measured with a nephelometer and is reported in nephelometric turbidity units (NTUs). Turbidity is also commonly measured with a Secchi disc. Equipment and staff constraints have previously limited the collection of turbidity data at the surface water quality sample stations. These obstacles were overcome in April 2008 and a nephelometer is now used regularly to determine both background levels and for regulatory compliance with the water quality standards. On the marine boat accessible run and Lummi Bay DOH support run (Table 4.1) a Secchi disc is used to measure water clarity. Secchi depth measurements have not been collected consistently during the period of record, but since 2009 Secchi depth has been measured at all sample sites during monthly marine boat runs. It is recognized that turbidity levels are highly dependent on stream flow and that since stream flow is not commonly measured at most of the sample stations, the comparability of the turbidity data between sites and sampling events is limited. However, the increased measurement of turbidity as part of the ambient water quality program will help establish the background turbidity level for compliance with the water quality standards.

As shown in Figure 6.88, sample Sites SW012 and SW014 were the only Class AA freshwater sample sites that were always below 50 NTUs during 2009 through 2011. The average turbidity was below 50 NTUs at 12 of the 15 sites. During 2009 through 2011, the highest Class AA freshwater turbidity measured was 627 NTUs at Site SW009 (Lummi River at Slater Road) and the lowest turbidity measured was 1 NTU at Site SW011 (Jordan Creek at Slater Road). As shown in Figure 6.89, during 2009 through 2011, six of the eight Class A sample sites were always below 50 NTUs. All the sample sites have a low number of data values due to low flow or no flow during the summer months.

Turbidity is measured using the nephlometer at marine sample sites in the Lummi River Delta and along the Lummi Peninsula/Portage Bay shoreline. As shown in Figure 6.90, the turbidity at all Class AA marine sample sites were greater than 50 NTUs at least once during 2009 through 2011, except at three of the sites (DH044, DH045 and SW052). However, the average turbidity was below 50 NTUs at all Class AA marine sample sites. Sample Site

SW008 (Lummi River at Hillaire Road Bridge) had the highest turbidity recorded of the Class AA Marine sample sites, at 308 NTUs. Site SW008 is downstream from Site SW009 on the Lummi River but is a Class AA marine water site (LWRD 2008a). The maximum turbidity at Site SW008 (308 NTUs) is lower than the maximum value at Site SW009, which at 627 NTUs was the highest turbidity value of all 25 freshwater sites. As shown in Figure 6.91, all Class A marine sample sites had turbidity values exceeding 50 NTUs at least once during 2009 through 2011. Sample Site SW030 (Bellingham Bay) had the highest Class A marine water turbidity recorded, 821 NTUs, and an average turbidity greater than 50 NTUs. As shown in Figure 6.91, the turbidity at the sample sites generally decreased further along the Lummi Peninsula/Portage Bay shoreline moving away from the mouth of the Nooksack River toward Hermosa Beach. These trends suggest that the large quantity of highly turbid water flowing down the Nooksack River impacts turbidity measurements at the Portage Bay sample sites.

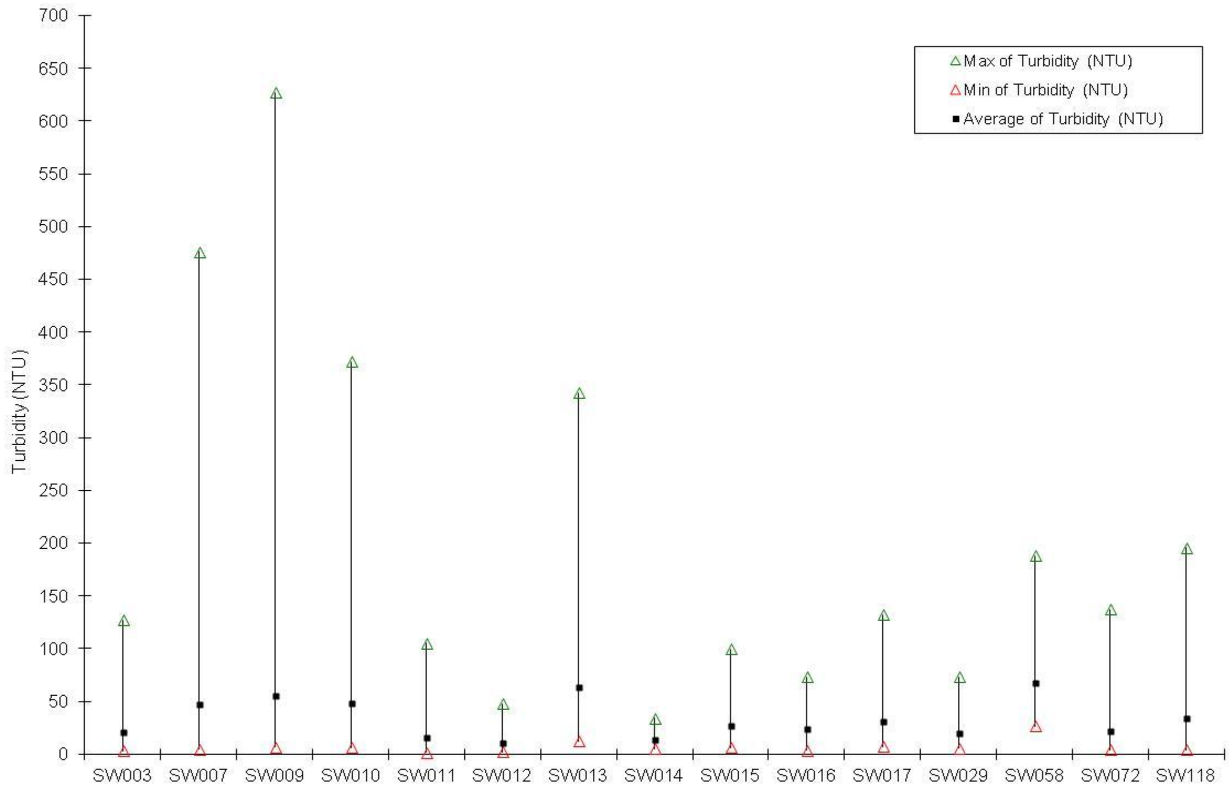

Figure 6.88 Class AA Freshwater Turbidity Results (NTU): 2009 - 2011

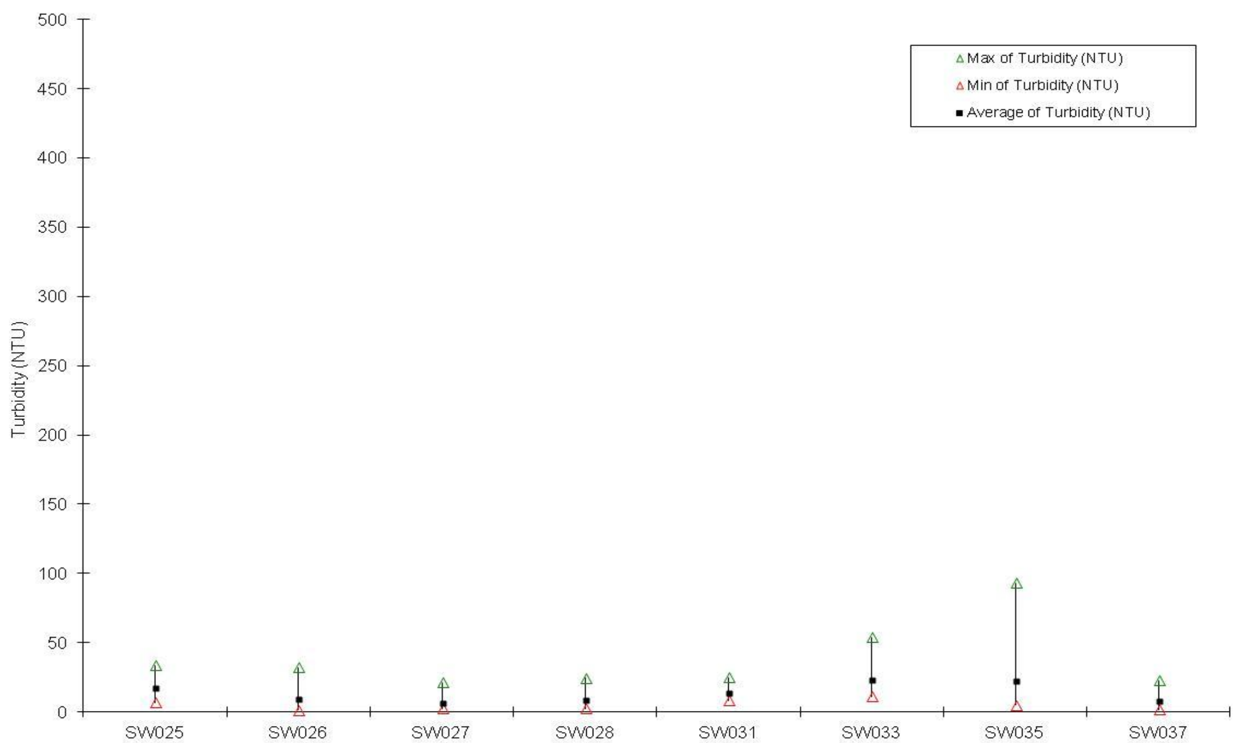

Figure 6.89 Class A Freshwater Turbidity Results (NTU): 2009 - 2011

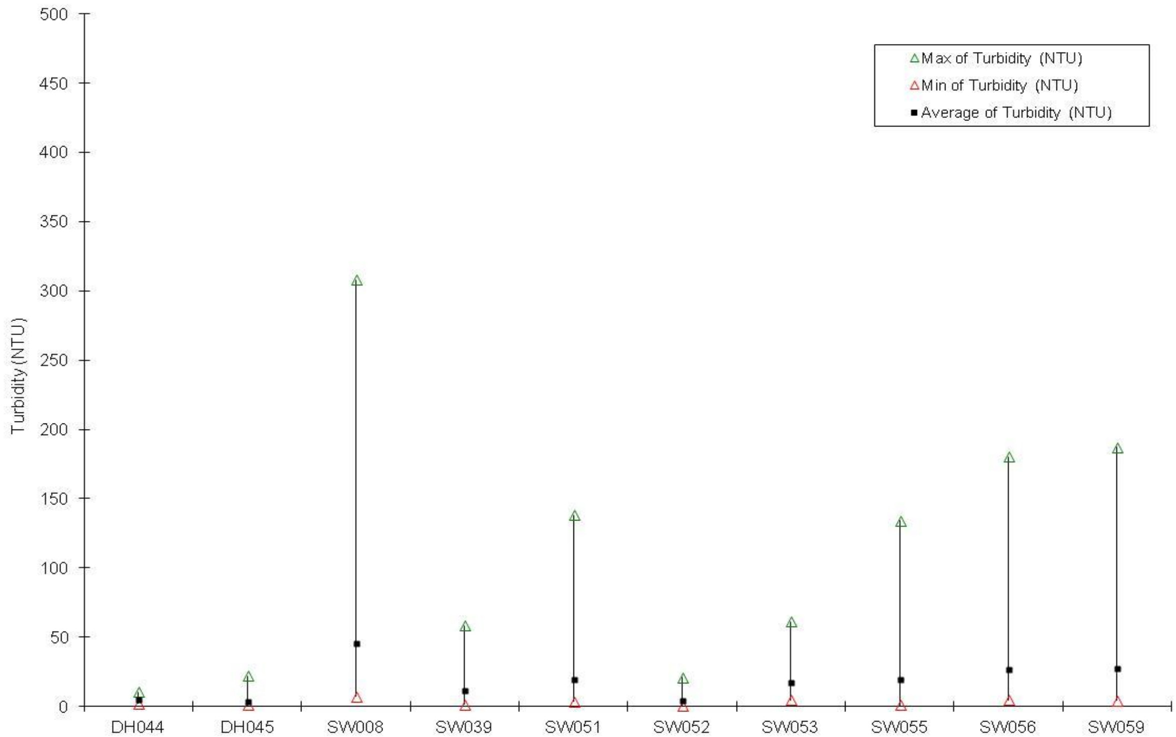

Figure 6.90 Class AA Marine Water Turbidity Results (NTU): 2009 - 2011

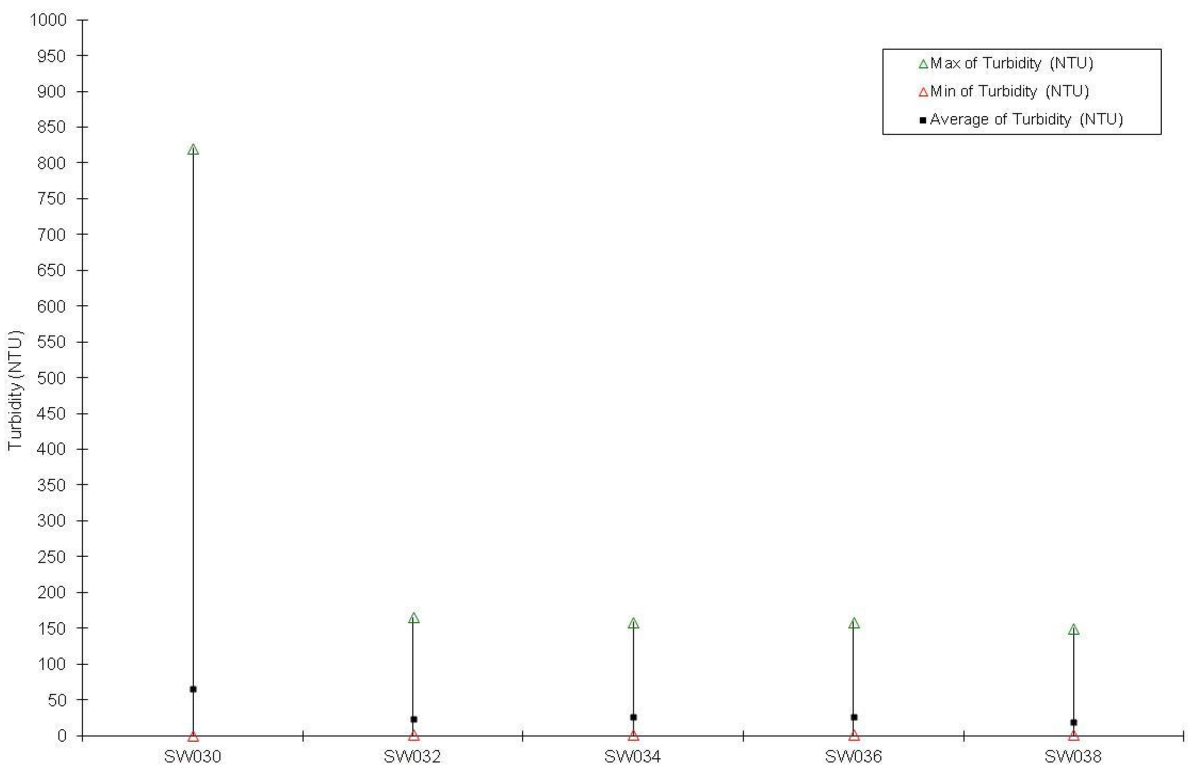

Figure 6.91 Class A Marine Water Turbidity Results (NTU): 2009 - 2011

6.10.2. Total Suspended Solid Results

Total suspended solids (TSS) are very closely associated with turbidity and are expressed in milligrams per liter (mg/l). Total suspended solids have been measured at five reference stations on a quarterly basis. The five reference stations and associated water quality classifications are the following:

- Site SW002 - Class AA Marine Water
- Site SW003 - Class AA Freshwater
- Site SW006 - Class A Marine Water
- Site SW009 - Class AA Freshwater
- Site SW015 - Class AA Freshwater

During 2011, a TSS sample was taken each quarter at two of the five reference stations and three times at Sites SW003, SW009 and SW015, due to no flow being present during the third quarter. As all of the Class A freshwater sites on the Reservation are small intermittent streams, the limited availability of flow at these Class A freshwater sites makes monthly sampling for the nutrient suite (including TSS) impractical due to schedule and cost considerations.

As shown in Figure 6.92 the quarterly TSS measurements at 2 of the 5 sample sites were below 50 mg/l during the period of record through 2011 with the lowest TSS levels measured at Site SW006 (Portage Bay). The highest TSS levels were measured at Site SW009 (Lummi River at Slater Road) for the period of record through 2011. Two measurements at this station were collected on August 23, 2001 during a period when the Nooksack River was discharging to the Lummi River channel (which occurs when the flow in the Nooksack River is above approximately 9,600 cfs). A third high TSS measurement was collected November 7, 2008 following several days of significant rainfall. Figure 6.93 shows the TSS measurements over the period of record through 2011 at the three Class AA surface water sites in the Lummi Bay watershed. As shown in Figure 6.93 although a TSS measurement greater than 50 mg/l was recorded at Sites SW002 and SW015, in general the TSS measurements at these sites are less than 50 mg/l.

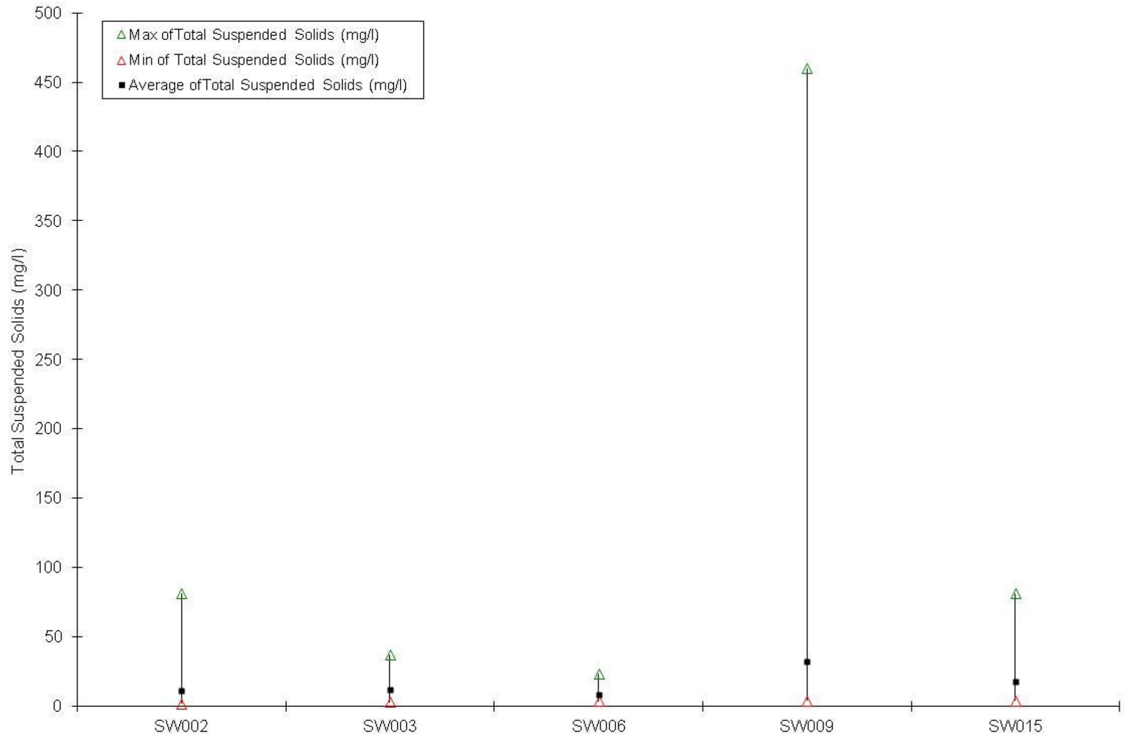

Figure 6.92 Total Suspended Solids Results: Period of Record through 2011

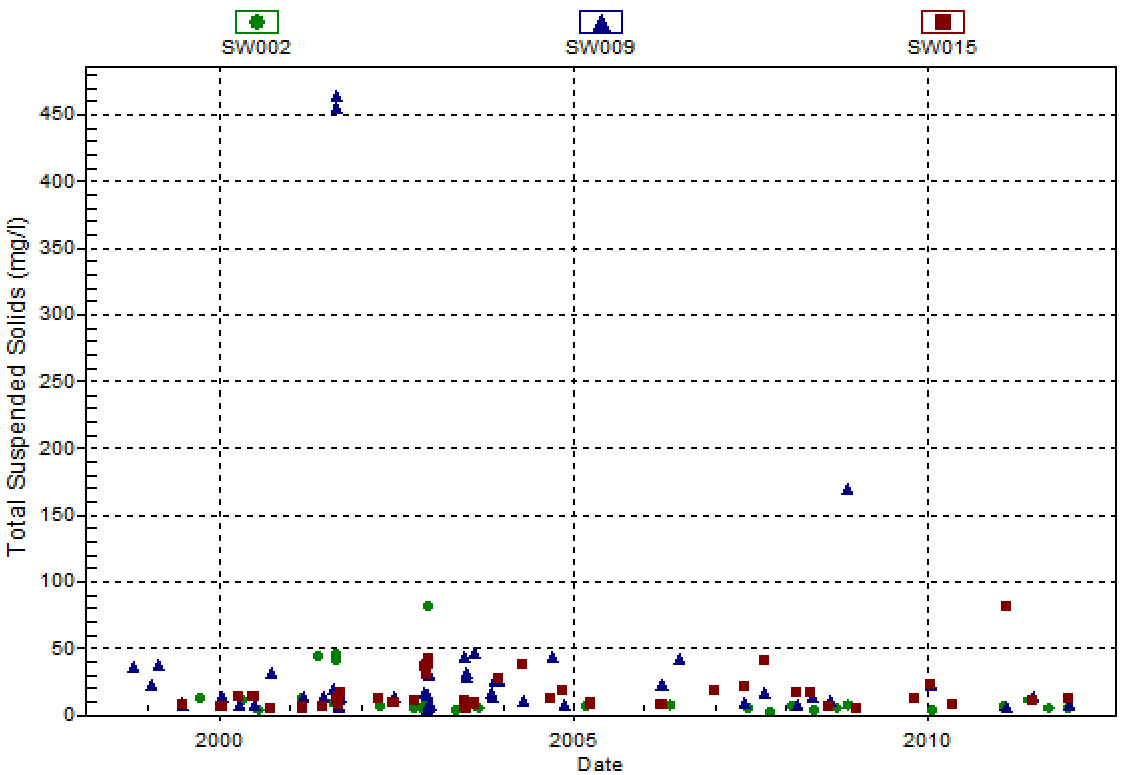

Figure 6.93 Total Suspended Solids Results at Class AA Surface Water Sites: Period of Record through 2011

6.11.Nutrients Results

A nutrient suite, including total phosphorus (milligrams per liter) and total nitrogen (milligrams per liter), is measured quarterly at the same five reference sites where TSS is measured. Similar to TSS the limited availability of flow during the third quarter of 2011 reduced the number of nutrient samples collected at three of the five sites. Phosphorus and nitrogen are essential nutrients for plant growth. However, elevated phosphorus and nitrogen levels can result in algae blooms, which can interfere with other aquatic life forms (Hem 1989) and can cause a number of environmental and health problems including:

- Aesthetic degradation – water with large algae blooms is murky, has bad odor, and is generally undesirable for water contact recreation such as swimming, wading, fishing, and boating.
- Aquatic habitat degradation – algae can result in low oxygen levels in the water when the algae decay, which can result in winter and summer fish kills.
- Toxin production – certain species of blue-green algae can produce toxins that can affect people and animals that swim and drink from water with severe algae blooms.
- Drinking water degradation – excessive algae in drinking water supplies can affect the taste and odor of drinking water and increase treatment costs.
- Disrupt fish harvests – excess algae can clog fishing nets.

6.11.1.Total Phosphorus Results

During 2011, a total phosphorus sample was taken each quarter at two of the five reference stations and three times at Sites SW003, SW009 and SW015, due to no flow being present during the third quarter. As shown in Figure 6.94 and Figure 6.95, Site SW009 had the highest total phosphorus values measured over the period of record through 2011, and the two marine water sites (SW002 and SW006) had the lowest total phosphorus values over the period of record. The two other freshwater sample sites in the floodplain (SW003 and SW015) had similar ranges and average total phosphorus levels.

Phosphorus is highly immobile and needs to be attached to a surface for transportation. Soil is frequently a point of attachment for phosphorus, and when soils are exposed, they are susceptible to erosion and can easily be washed into streams and bays during storm events together with the adhered phosphorus. Large areas of land that have been cleared for agriculture and construction sites and are not configured with proper best management practices can contribute a significant amount of nutrient-containing sediments to nearby water bodies.

As shown in Figure 6.95, although there are a few instances with higher total phosphorus levels in the freshwater sites, particularly along the Lummi River at Slater Road (Site SW009), the total phosphorus measurements are generally below 1 mg/l over the period of record. As reported in Dunne and Leopold (1978), in 1967 a committee of the American Water Works Association (AWWA) published the range of usual concentrations of phosphorus in discharges from various land uses. The usual concentration of phosphorus in rural runoff from agricultural lands is 0.05 to 1.1 mg/l and the usual concentration of phosphorus for rural runoff from non-agricultural lands is 0.04 to 0.2 mg/l. There was insufficient data for the AWWA committee to make an estimate for the usual range of phosphorus concentration where farm animal waste was the source, but the committee estimated a range of 3.5 to 9 mg/l of phosphorus for domestic waste. The concentration of total phosphorus at the freshwater sites indicates that the sources of phosphorus are from agricultural land, which is prevalent in off-Reservation watersheds.

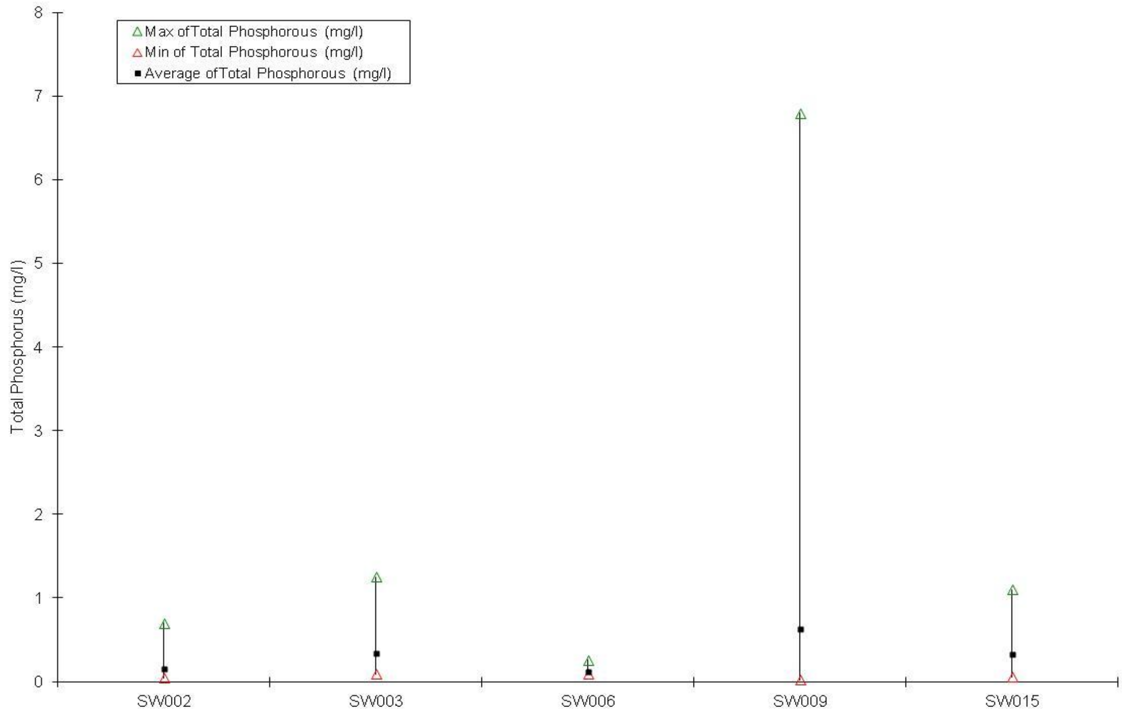

Figure 6.94 Total Phosphorus Results: Period of Record through 2011

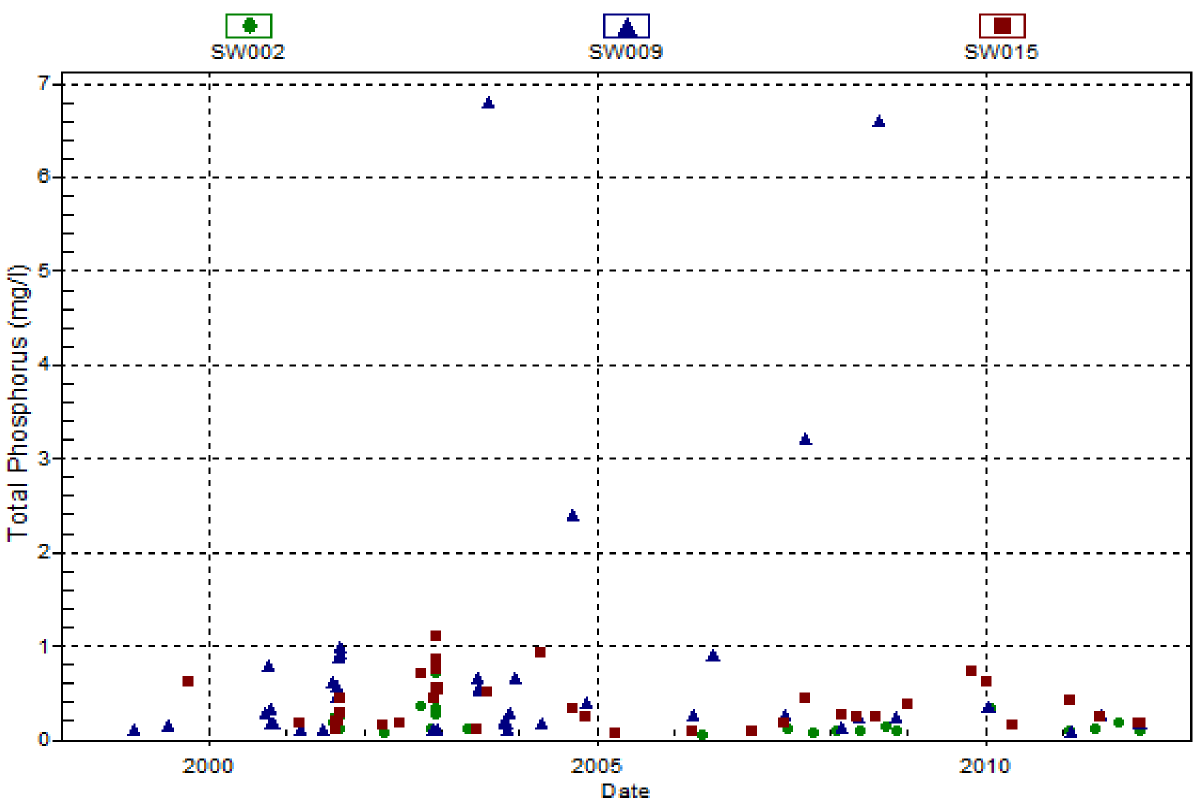

Figure 6.95 Total Phosphorus Results at Class AA Surface Water Sites: Period of Record through 2011

6.11.2. Total Nitrogen Results

Total nitrogen (milligrams per liter) is the sum of the various forms of nitrogen (nitrite, nitrate, and Total Kjeldahl Nitrogen). In the water quality samples collected on the Reservation, the form of nitrogen with the largest concentration was typically Total Kjeldahl Nitrogen (TKN), which is the sum of ammonia (NH_3) and organic nitrogen. As described above, during 2011 total nitrogen was collected four times at two of the five sites and three times for the remaining sites. As shown in Figure 6.96, similar to TSS and total phosphorous, the highest total nitrogen values measured over the period of record through 2011 were at Site SW009 (Lummi River at Slater Road), and the lowest levels measured were at the marine water sites in Lummi Bay (SW002) and Portage Bay (SW006).

As shown in Figure 6.97, the Total Kjeldahl Nitrogen levels in the freshwater sites are all less than 10 mg/l. As reported in Dunne and Leopold (1978), in 1967 a committee of the American Water Works Association (AWWA) published the range of usual concentrations of nitrogen in discharges from various land uses. The usual concentration of nitrogen in rural runoff from agricultural lands is 1 to 70 mg/l and the usual concentration of nitrogen for rural runoff from non-agricultural lands is 0.1 to 0.5 mg/l. There was insufficient data for the AWWA committee to make an estimate for the usual range of nitrogen concentration where farm animal waste was the source, but the committee estimated a range of 18 to 20 mg/l of nitrogen for domestic waste. Based on the concentrations from the AWWA committee, the high levels of total nitrogen at Site SW009 indicate that dairy waste spills or manure applications during the wet season could be the source of excess nitrogen.

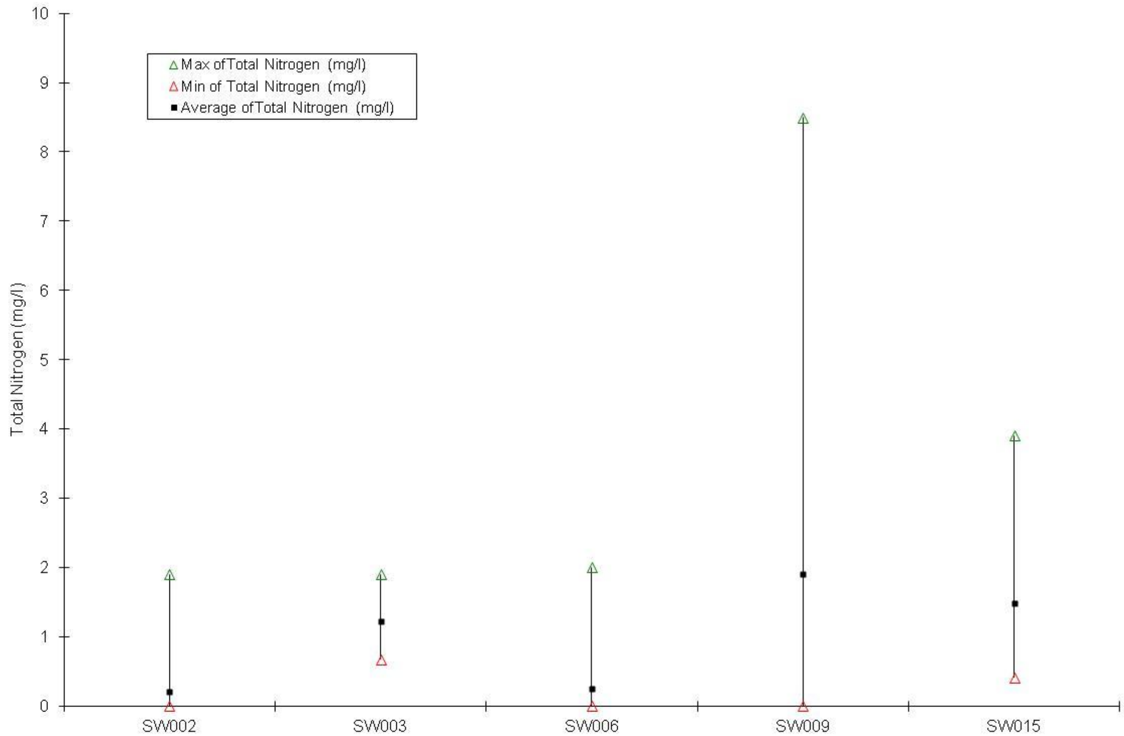

Figure 6.96 Total Nitrogen Results: Period of Record through 2011

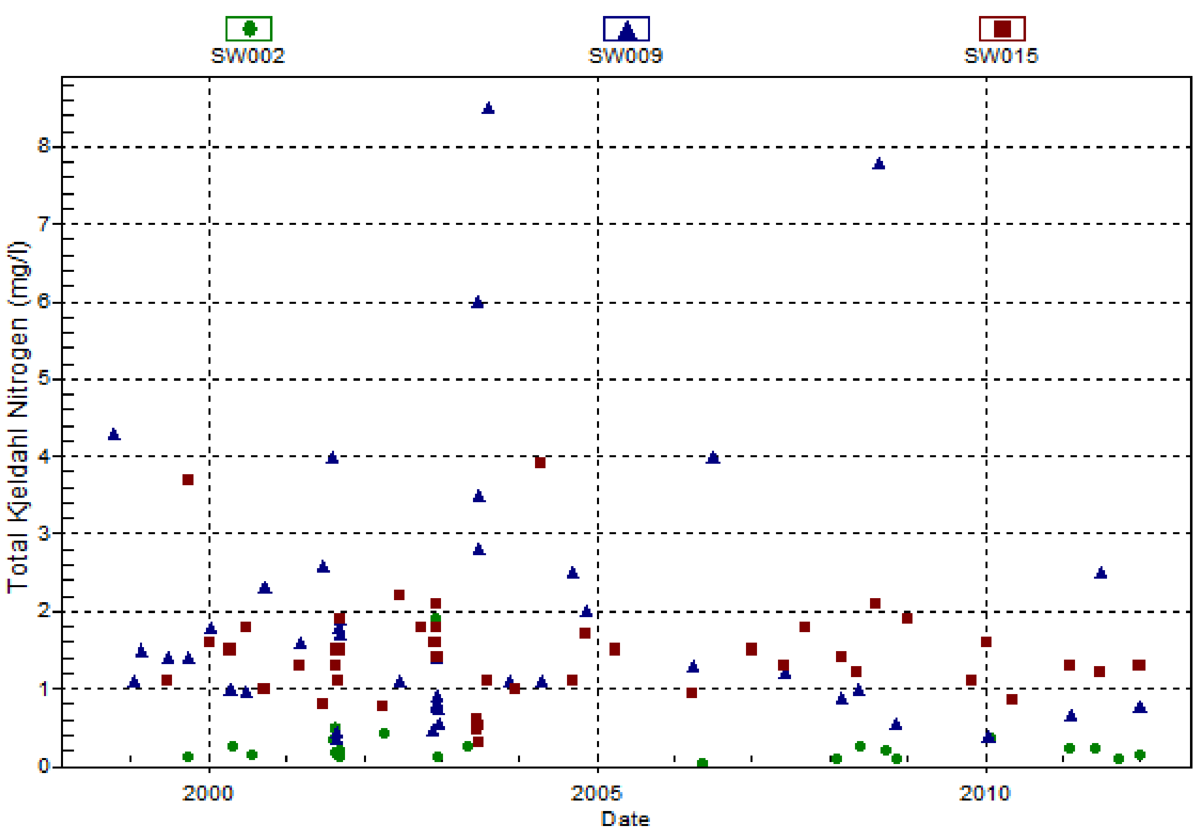

Figure 6.97 TKN Results at Class AA Surface Water Sites: Period of Record through 2011

7. DISCUSSION

Reservation water quality remains complex due to the interaction of marine waters and freshwater, variable tidal conditions during sampling, and seasonal weather patterns. During the summer, upland sites can dry out or become saline, and are often heated due to solar radiation. Once the wet season starts, flow begins at the sites that dried out, and the water column becomes less saline. During the wet season, the waters tend to have dense populations of bacteria and low concentrations of dissolved oxygen (bacteria consume oxygen, which contribute to the lower dissolved oxygen levels). The cycle starts again at the beginning of the next dry season.

The water quality parameters at most of the sites during 2011 followed the trends of the 2003 to 2010 period: a recurrence of elevated bacteria levels, elevated temperatures, and low dissolved oxygen levels compared to the improvements in these parameters observed during 2000 and 2001. As shown in Table 7.1 and Table 7.2, the water quality at many sites during 2011 did not meet one or more of the water quality standards. None of the sample sites in the Lummi Bay Watershed achieved all of the water quality standards during 2011.

The mainstem of the Nooksack River at Marine Drive (SW118) showed a decrease in bacteria levels during 2011 compared to levels observed during the 2003 through 2009 period. The Nooksack River met fecal coliform water quality standards and the TMDL standard for the second year in a row, which had not been accomplished since 2007. However, the sample sites in Portage Bay (SW032, SW034, SW036, and SW038) showed a decrease in water quality compared with 2010 as none of the sites met the Class A marine water quality standards for fecal coliform bacteria during 2011. Overall, a continuing trend observed in both the Bellingham and Lummi Bay watersheds was the introduction of fecal contamination into these bays from rivers, ditches, and streams originating off the Reservation. There are water quality and water quantity challenges in the Nooksack and Lummi River watersheds due to off-Reservation land development and agriculture. The primary data relationships used to form these conclusions were the elevated fecal coliform bacteria levels at freshwater sites and also marine sites in close proximity to large freshwater sources.

Dilution and deactivation from the saline waters in the bays decreased the bacteria densities from the levels found in the freshwater sample sites, but not enough to consistently avoid exceeding water quality criteria protective of shellfish harvesting. Figure 7.1 and Figure 7.2 show how the geometric mean of the fecal coliform bacteria density decreases moving downstream in the Lummi River and Jordan Creek watersheds over the period of record through 2011. Both of these water bodies discharge to Lummi Bay. Site SW009 shown in Figure 7.1 is located in the Lummi River channel at the northern boundary of the Reservation, Site SW008 is located where the Lummi River channel flows under the Hillaire Road Bridge, Site SW051 is located where the Lummi River discharges to Lummi Bay, and sites DH288, DH040, and SW002 are located in Lummi Bay (see Figure 4.1). The geometric mean decreases along the Lummi River from 233 cfu/100 ml at the Reservation boundary (SW009) to 10 cfu/100 ml at the mouth of the Lummi River (SW051). Sites SW010 and

SW011 shown in Figure 7.2 are located along the northern Reservation boundary and contribute to Site SW003, which is located just upstream from where the channel flows under North Red River Road. Site SW053 is located just downstream from the tide gates at Lummi Bay at the mouth of Jordan Creek, and sites DH286 and DH287 are located in Lummi Bay. The geometric mean decreases along Jordan Creek from 89 cfu/100 ml and 162 cfu/100ml at the Reservation boundary (SW010 and SW011 respectively) to 28 cfu/100 ml at the mouth of Jordan Creek (SW053), and to 5 cfu/100 ml and 3 cfu/100 ml in Lummi Bay (DH286 and DH287 respectively).

Figure 7.3 and Figure 7.4 show how the 90th percentile of the fecal coliform bacteria density decreases moving downstream in the Lummi River and Jordan Creek watersheds over the period of record through 2011. The 90th percentile decreases along the Lummi River from 2,400 cfu/100 ml at the Reservation boundary (SW009) to 67 cfu/100 ml at the mouth of the Lummi River (SW051). The 90th percentile decreases along the Jordan Creek from 2,400 cfu/100 ml and 1,200 cfu/100 ml at the Reservation boundary (SW010 and SW011 respectively) to 210 cfu/100 ml at the mouth of Jordan Creek (SW053), to 34 cfu/100 ml and 8 cfu/100 ml in Lummi Bay (DH286 and DH287 respectively).

Figure 7.5 shows how the geometric mean of the fecal coliform bacteria density generally decreases moving from the Nooksack River main channel south into Portage/Bellingham Bay. The geometric mean decreases in the Nooksack River from 26 cfu/100 ml at the Reservation boundary (SW118) to 6 cfu/100 ml at the southeastern most DOH site in Portage Bay (DH049). Figure 7.6 depicts a similar decreasing trend for the 90th percentile of fecal coliform bacteria at the same sites in the Bellingham Bay watershed. The 90th percentile decreases from 79 cfu/100 ml in the Nooksack River at the Reservation boundary (SW118) to 49 cfu/100 ml at the southeastern most DOH site in Portage Bay (DH049).

Overall, when comparing fecal coliform densities in the two major watersheds on the Reservation (Lummi Bay and Portage Bay), water quality sites in the Lummi Bay watershed have a higher geometric mean and 90th percentile than sites in the Portage Bay watershed. In Figure 7.1 and Figure 7.2, which depict changes in fecal coliform bacteria geometric mean moving downstream in the Lummi Bay watershed, the y-axis (fecal coliform bacteria densities) ranges from 2 – 233 cfu/100 ml. In comparison, Figure 7.5 shows Portage Bay watershed fecal coliform geometric means ranging between 5.5 – 26 cfu/100 ml. Similar results are observed in the 90th percentile calculations for fecal coliform bacteria. The 90th percentile of sample sites in the Lummi Bay watershed range between 4.5 – 2,400 cfu/100 ml; sample sites in the Portage Bay watershed range from 33 – 100 cfu/100 ml. The poor water quality in the Lummi Bay watershed is a major concern due to the potential for new closures of important tribal shellfish beds.

Table 7.1 Extent Lummi Bay Meets Lummi Water Quality Standards and Designated Uses Supported During 2011

Location		Dissolved Oxygen (mg/L)	Temperature (^oC)	pH	Fecal Coliform Bacteria (cfu/100ml)	Enterococcus (cfu/100ml)	Full Support
LUMMI BAY WATERSHED	**Jordan Creek**						**NO**
	SW010	X	X	X	X	X	
	SW011	X	•	X	X	X	
	SW003	X	X	X	X	X	
	SW053	X	X	X	X	X	
	Lummi River						**NO**
	SW009	X	•	•	X	X	
	SW008	X	X	X	X	X	
	SW013	X	X	•	X	X	
	SW051	X	X	X	X	X	
	SW055	X	X	X	X	•	
	SW058	X	•	•	X	X	
	Smuggler's Slough						**NO**
	SW072	X	X	X	•	X	
	SW015	X	X	X	•	X	
	SW059	X	X	X	X	X	
	SW056	X	X	•	X	X	
	Schell Creek						**NO**
	SW012	X	•	X	X	X	
	Onion Creek						**NO**
	SW014	X	X	X	X	X	
	Seapond Creek						**NO**
	SW029	X	•	X	X	X	
	East Reservation Boundary						**NO**
	SW016	X	•	•	X	X	
	SW017	X	X	•	•	•	
	Sandy Point Channel						**NO**
	SW001	•	X	X	•	•	
	SW019	X	X	•	•	X	
	Lummi Bay						**NO**
	SW002	•	X	•	•	•	
	SW022	X	X	X	•	•	
	SW052	•	X	X	•	•	
	DH038	•	X	•	•	N/A	
	DH039	•	X	•	•	N/A	
	DH040	•	X	•	•	N/A	
	DH041	•	X	•	•	N/A	
	DH042	•	X	•	•	N/A	
	DH043	•	X	•	•	N/A	
	DH044	•	X	•	•	N/A	
	DH045	•	X	X	•	N/A	
	DH285	•	X	•	•	N/A	
	DH286	•	X	X	•	N/A	
	DH287	•	X	•	•	N/A	
	DH288	•	X	X	•	N/A	

X = standard not achieved; • = standard achieved; N/A = Not determined

Table 7.2 Extent Bellingham Bay Meets Lummi Water Quality Standards and Designated Uses Supported During 2011

	Location	Dissolved Oxygen (mg/L)	Temperature (°C)	pH	Fecal Coliform Bacteria (cfu/100ml)	Enterococcus (cfu/100ml)	Full Support
BELLINGHAM BAY WATERSHED	**Nooksack River**						**NO**
	SW118	X	•	X	•	X	
	Kwina Slough						**NO**
	SW007	X	•	X	•	X	
	Lummi Shore Road Watershed						**NO**
	SW031	•	•	X	•	X	
	SW032	•	X	X	X	•	
	SW033	X	•	X	X	X	
	SW034	•	X	X	X	•	
	SW035	X	•	X	X	X	
	SW036	•	X	X	X	X	
	SW037	X	•	•	X	X	
	SW038	•	X	X	X	X	
	SW039	•	X	X	•	•	
	Portage Island						**NO**
	SW026	X	•	•	X	X	
	SW027	X	•	•	X	X	
	SW028	X	X	•	X	X	
	Portage Bay						**NO**
	SW006	•	X	X	•	•	
	SW023	•	X	•	•	•	
	SW030	•	X	X	X	•	
	DH049	N/A	•	N/A	•	N/A	
	DH050	N/A	•	N/A	•	N/A	
	DH051	N/A	•	N/A	•	N/A	
	DH052	N/A	•	N/A	•	N/A	
	DH053	N/A	•	N/A	•	N/A	
	DH054	N/A	•	N/A	•	N/A	
	DH055	N/A	•	N/A	•	N/A	
	DH057	N/A	•	N/A	•	N/A	
	DH058	N/A	•	N/A	•	N/A	
	DH271	N/A	•	N/A	•	N/A	
	DH272	N/A	•	N/A	X	N/A	

X – Water quality parameter does not meet the Lummi Water Quality Standard
• – Water quality parameter meets the Lummi Water Quality Standard
N/A – Water quality parameter is not measured as part of the Program

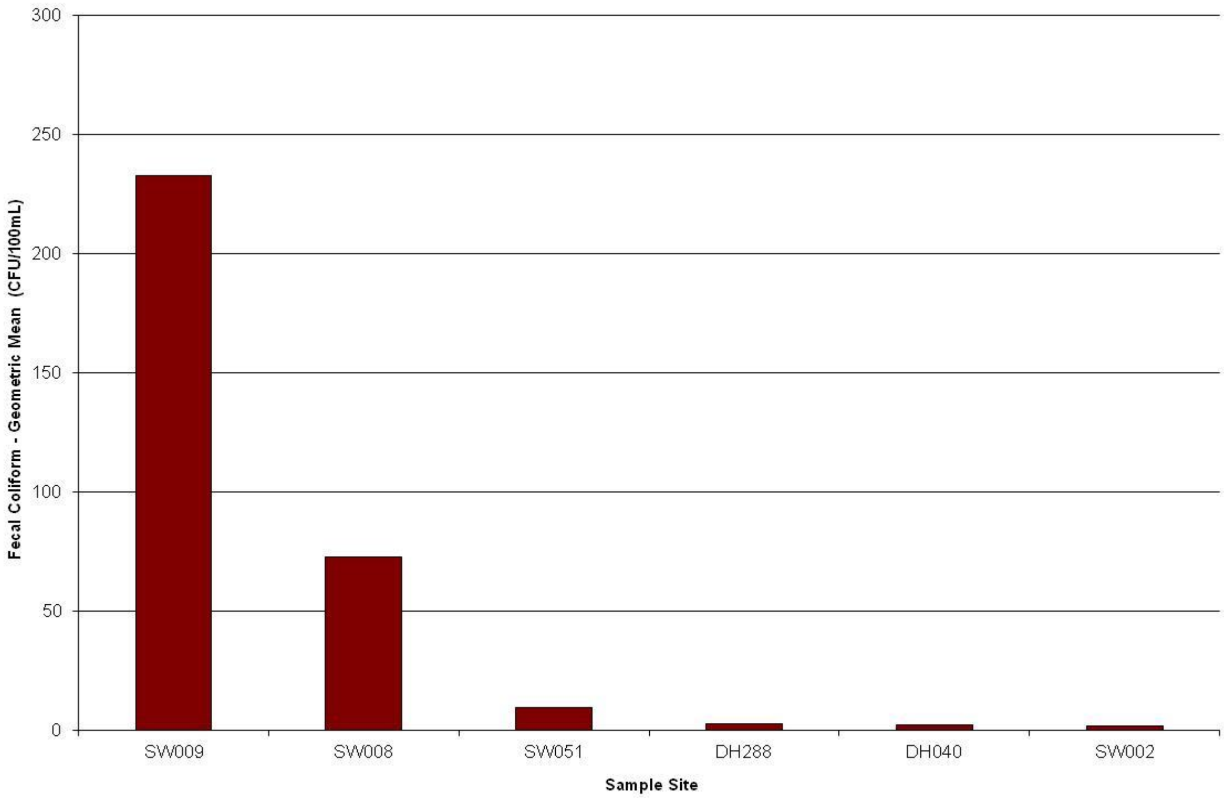

Figure 7.1 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Lummi River and Lummi Bay: Period of Record through 2011

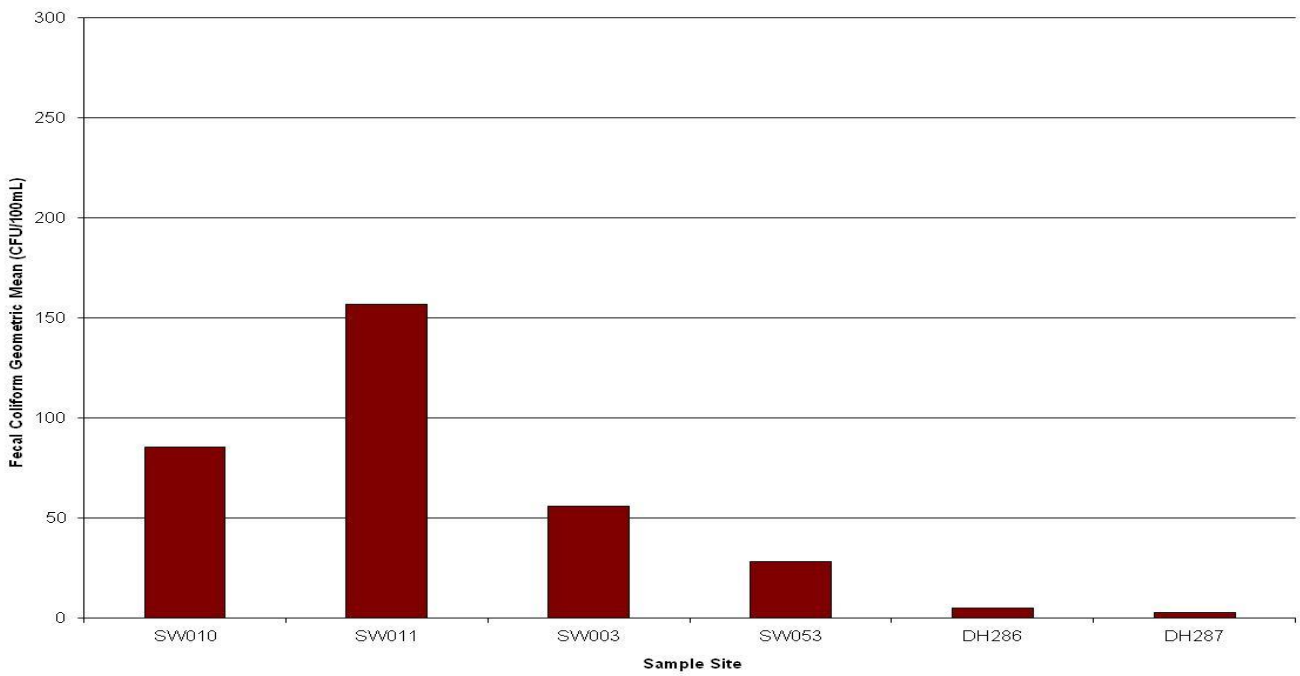

Figure 7.2 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Jordan Creek/Lummi Bay Watershed: Period of Record through 2011

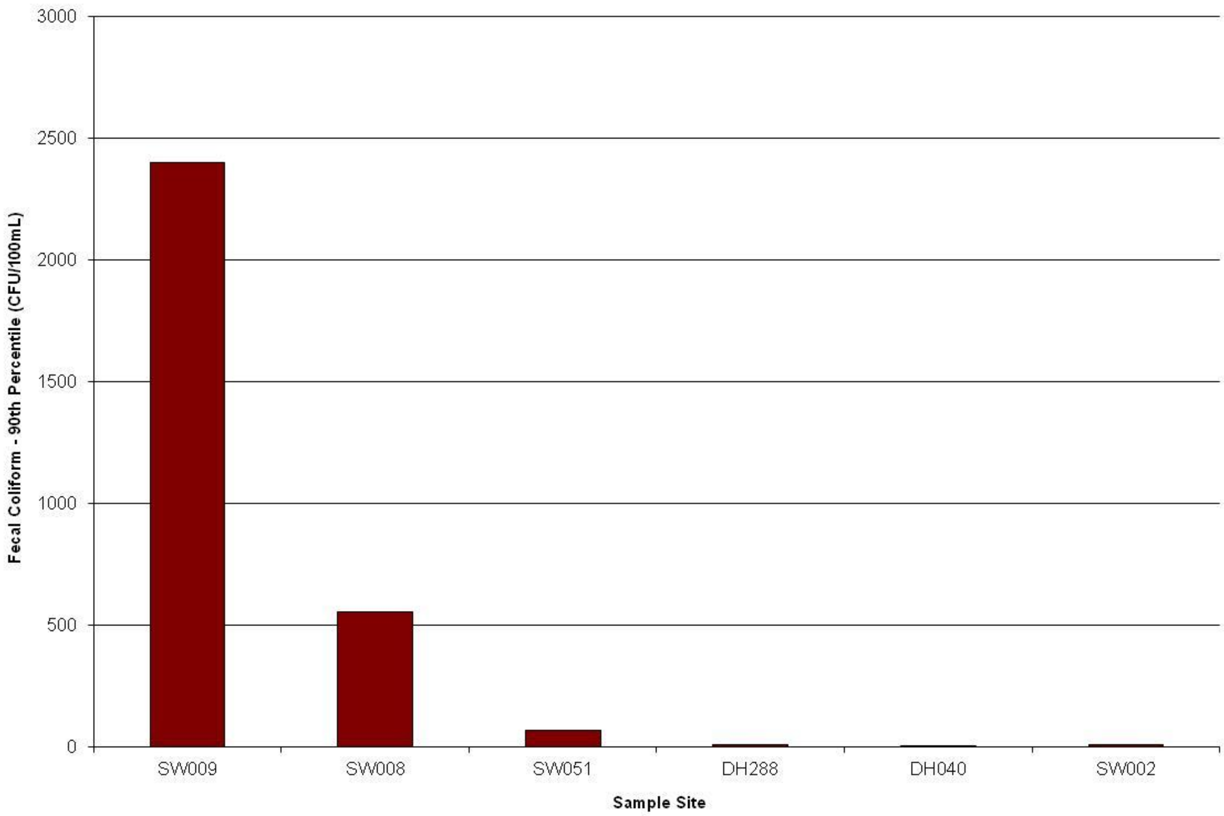

Figure 7.3 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Lummi River and Lummi Bay: Period of Record through 2011

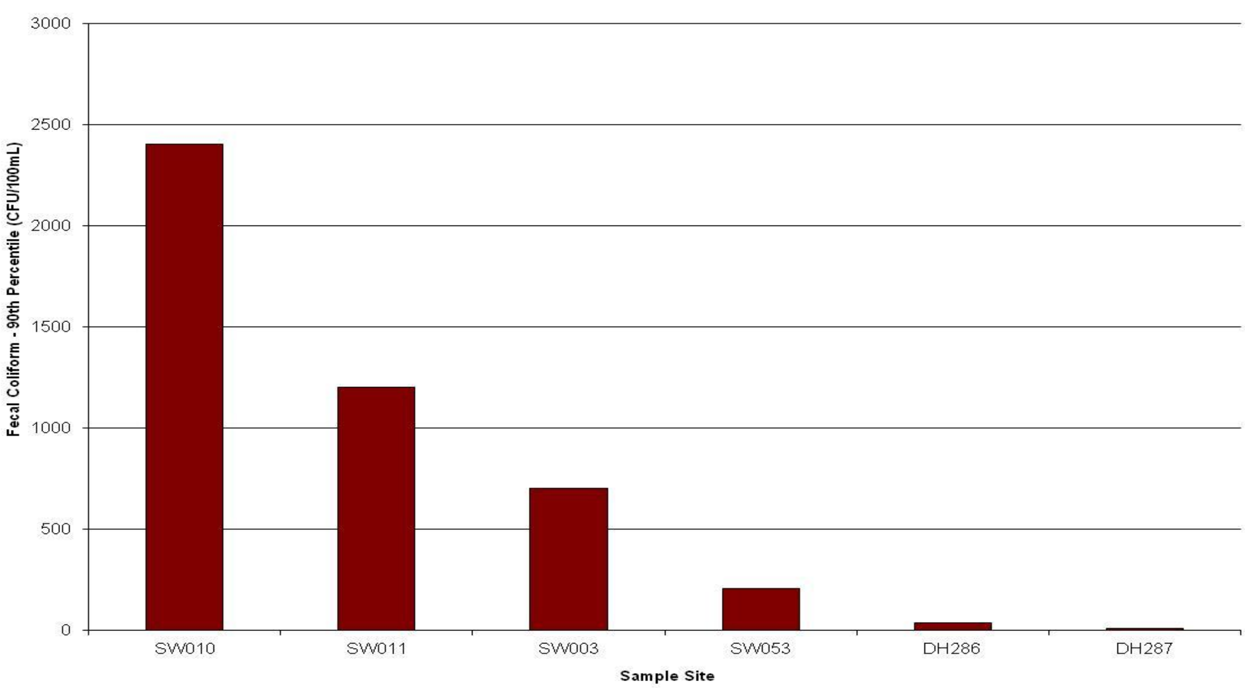

Figure 7.4 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Jordan Creek/Lummi Bay Watershed: Period of Record through 2011

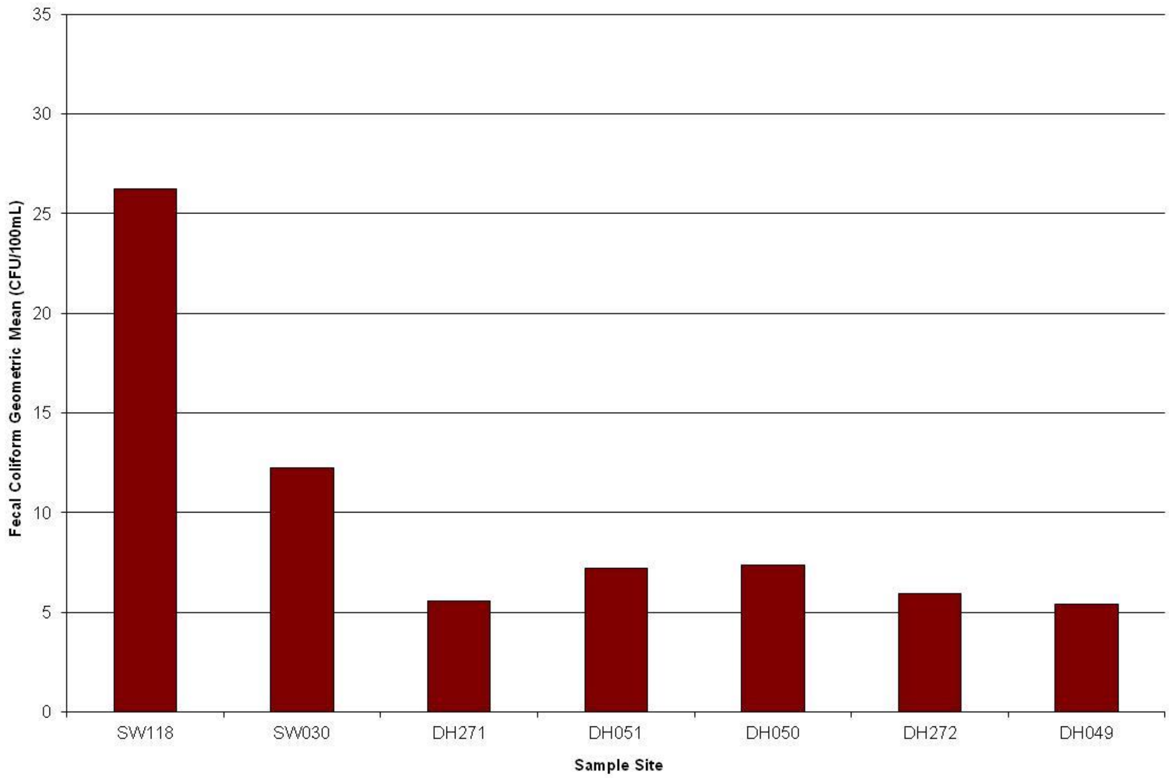

Figure 7.5 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Nooksack River/Bellingham Watershed: Period of Record through 2011

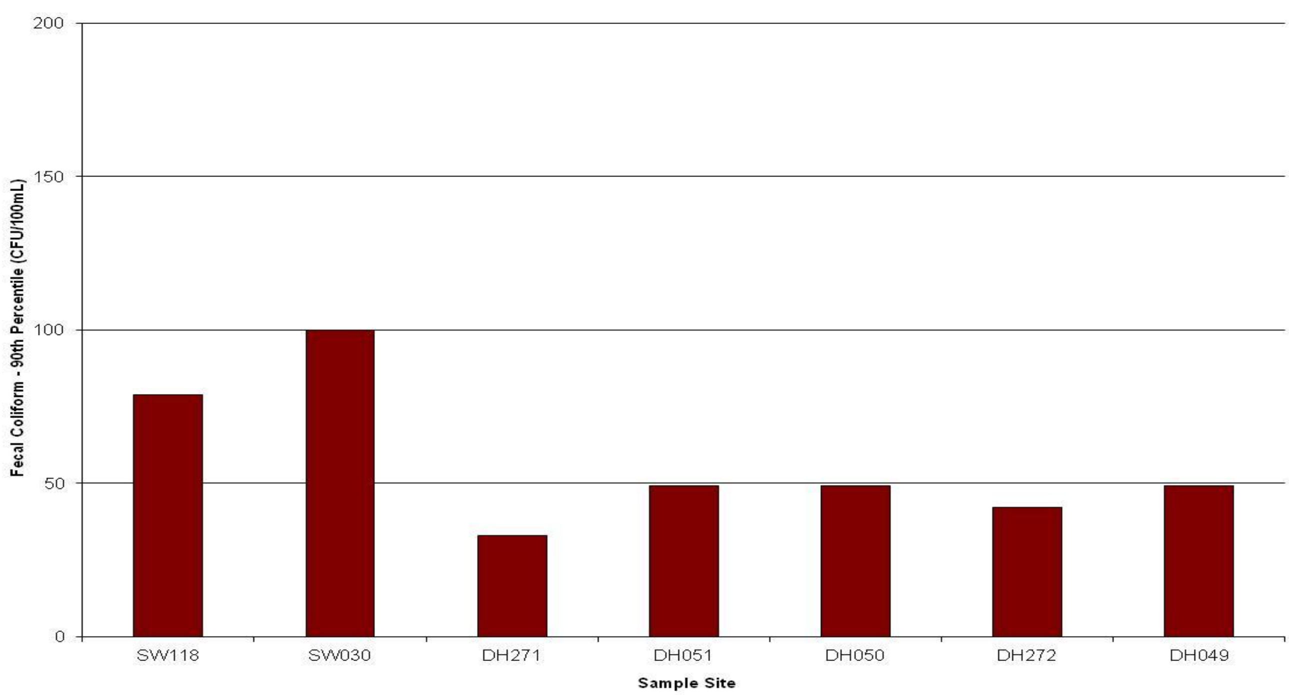

Figure 7.6 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Nooksack River/Bellingham Bay Watershed: Period of Record through 2011

7.1. Causes and Sources of Lummi Waters Not Supporting Designated Uses

None of the waters in the Lummi Bay watershed and the Portage Bay watershed support their designated uses because of increased fecal coliform densities, increased temperatures, low dissolved oxygen levels, and/or pH levels (Table 7.1 and Table 7.2). In the Lummi Bay watershed, temperature, pH, and fecal coliform were the most common reason that designated uses are not supported. The primary source of these impairments in the Lummi Bay watershed is off-Reservation agricultural practices. In the Portage Bay watershed, pH, fecal coliform bacteria, and enterococcous bacteria were the most common causes of waters not supporting their designated use. Again, off-Reservation agricultural land use is the major source of high fecal coliform densities, particularly the Nooksack River watershed, which drains the majority of the agricultural lands in lower Whatcom County.

Fecal coliform bacteria are of particular importance because they are the indicator organism used in the National Shellfish Sanitation Program (NSSP) to classify shellfish beds as suitable for commercial harvest. Both the Lummi and Nooksack River watersheds contain land uses that contribute fecal coliform bacteria to surface waters. As shown in Figure 7.1 through Figure 7.4, the highest fecal coliform bacteria levels are measured along the Reservation boundary, indicating an off-Reservation source. All or portions of approximately 220 acres of tribal shellfish beds in Portage Bay were closed to commercial harvest over the November 1996 to May 2006 period due to bacterial contamination attributed to poor dairy nutrient management practices in the Nooksack River (DOH 1997, Ecology 2000).

The decrease in fecal coliform bacteria densities during 2000 and 2001 in both the Nooksack River and Portage Bay was a positive indication that fecal coliform bacteria pollution prevention efforts were succeeding in the Nooksack River watershed. However, fecal coliform bacteria levels rose again in these water bodies during the 2003 to 2008 period. During 2008 through 2010, the mainstem of the Nooksack River (SW118) showed a continual decrease in fecal coliform bacteria levels. During 2011, the Nooksack River met fecal coliform water quality standards where it flowed onto the Reservation, however, the geometric mean increased from 21 cfu/100 ml in 2010 to 23 cfu/100 ml in 2011. Along the Lummi Peninsula nearshore areas of Portage Bay, storm water during the onset of the wet season typically contains elevated fecal coliform bacteria levels, but flows are very low. By the time the flows increase, fecal coliform bacteria levels are substantially reduced. Intensive shoreline sampling over the 1998 through 2001 period demonstrated that local sources of fecal coliform bacteria are not a significant source of fecal contamination to Portage Bay (LWRD 1999, LWRD 2006a, LWRD 2006b). Small freshwater streams on Portage Island contain elevated fecal coliform bacteria levels, but as described above, flows are very low and do not appear to be a significant source of fecal contamination to Portage Bay. A herd of cattle present on the uninhabited Portage Island is thought to be the main source of high fecal coliform bacteria concentrations in the freshwater streams. Removal of the cattle is currently being conducted, which should reduce the fecal coliform bacteria entering Portage Bay from Portage Island.

Land use practices in the Lummi River watershed are likely the primary cause of the elevated bacteria levels, elevated temperatures, and depressed dissolved oxygen values in the surface waters along the Reservation boundary. Fecal coliform bacteria levels well above the Lummi Nation Surface Water Quality Standards were common along the Reservation boundary sample sites in the early and mid-1990s, and had been decreasing during 2001 and 2002. However, during the 2003 through 2011 period, bacteria levels at many sites along the boundary increased again.

Just as the freshwater system influences the marine waters in the bays, the marine waters influence the freshwater system with upstream flows during high tides. This is especially notable in the Lummi Bay watershed where saline waters reached to the northern Reservation boundary.

As shown in Table 7.1 and Table 7.2, the collected data suggest that 25 of 58 sample sites (43 %) throughout the Reservation achieved the water temperature standards during 2011. As noted previously, continuous water temperature data are not collected at most sites so a direct compliance assessment for water temperature is not possible at most sites. However, the 2011 results are comparable to results from previous years and reflect improved conditions relative to 2010 when the temperature standard was achieved at 20 sites. Some of these exceedences are caused by naturally occurring conditions, such as Site SW002 in Lummi Bay, where the tide flat is exposed to full sunlight in the summer. However, at other sites these exceedences are likely due to human-caused factors such as the removal of riparian vegetation and/or drainage alterations that decrease the amount of groundwater available to moderate surface water temperatures in the summer. The extent to which anthropogenic influences have contributed to elevated water temperatures at the various sample sites has not been established.

Dissolved oxygen levels also vary considerably throughout the year, and not always inversely to temperature. As shown in Table 7.1 and Table 7.2, the majority of water bodies do not achieve the dissolved oxygen (mg/l) water quality standards except Portage Bay and Lummi Bay. At some sites, the deviation of dissolved oxygen and temperature from their expected pattern appears to be due to elevated primary production of oxygen by algae that increases the dissolved oxygen levels concurrent with elevated temperatures. The dissolved oxygen values could range from low to high to low again over a 24-hour period. To explore this phenomenon further, water quality should be sampled several times a day over the course of several days at representative sites.

Other causes of high dissolved oxygen levels concurring with elevated water temperatures may be due to wave entrainment of air or the water heating more rapidly than the rate at which dissolved oxygen maintains equilibrium concentrations in water. In places such as Lummi Bay, air entrainment, primary production, and rapid heating are likely occurring and contributing to elevated dissolved oxygen values. In many places on the Reservation, dissolved oxygen values fall below applicable water quality criteria. Similar to temperature, there are places where extremely low dissolved oxygen values could be due to naturally occurring conditions (e.g., an area without shade where the streambed is in the photic zone and flows are generally low to stagnant). At sites where human created or induced changes occurred (e.g., clearing of vegetation, drainage of groundwater, increased nutrient loading), the extremes of dissolved oxygen variation have likely been increased due to the human activity setting the stage for increased primary production. Similarly, high bacteria densities, often created by anthropogenic activities, can cause drops in dissolved oxygen concentrations as the bacteria consume oxygen during metabolism. The extent to which anthropogenic influences have contributed to depressed dissolved oxygen levels at the various sample sites has not been estimated.

8. SUMMARY AND CONCLUSIONS

The goals of the Lummi Nation Surface Water Quality Monitoring Program are to document ambient water quality and water quality trends on the Lummi Indian Reservation (Reservation), evaluate regulatory compliance of waters flowing through and onto the Reservation including compliance with Lummi Nation Surface Water Quality Standards (LWRD 2008a), and support the development and implementation of water quality regulatory programs on the Reservation.

This report presents the surface water quality data collected during calendar year 2011, compares the 2011 results to data from 1993 to 2010, presents interpretations of these data with respect to the Program goals, and provides the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

Water quality on the Reservation is complex for a number of reasons including the Reservation location in the estuaries of the Lummi River and the Nooksack River where marine and fresh waters interact, the approximately 38 miles of marine shoreline and 7,000 acres of tidelands, and the weather patterns that influence the water quality at the sampling sites.

The water quality parameters measured during calendar year 2011 were largely similar to the measured water quality parameters during previous years with a few exceptions. The water quality parameters at the monitoring sites during 2011 generally followed the trends of the time period 2003 to 2010. That is, generally elevated bacteria levels, higher temperatures, and lower dissolved oxygen levels compared to the Lummi Nation Water Quality Standards (LWRD 2008a). Fecal coliform bacteria levels in the mainstem of the Nooksack River at the Reservation border (SW118) improved during 2011 compared to the trends of 2003 through 2007. However, fecal coliform bacteria levels increased at Site SW118 compared with bacteria data obtained in 2010. During 2011, fecal coliform bacteria levels at Site SW118 were lower than the Total Maximum Daily Load (TMDL) target of a geometric mean of 39 coliform forming units/100 ml established for the lower Nooksack River (Ecology 2000 and 2002), and the 90^{th} percentile water quality standard for Class AA freshwater bodies. The water quality parameters are generally more degraded in the sites further inland, and gradually improve downstream towards the marine waters on the Reservation.

The marine waters of Lummi Bay and the Sandy Point Marina continue to have relatively good quality, while the surface waters within the Lummi River watershed continue to have the poorest water quality of the sites sampled on the Reservation. Sampling of the Nooksack River indicated variable water quality with elevated fecal coliform bacteria readings during 2011 that are a cause of concern even though improvements were observed compared to the 2003 through 2007 period. Achievement of the fecal coliform water quality standards and TMDL goals in the Nooksack River where it flows onto the Reservation and the decreasing levels of fecal coliform bacteria in Portage Bay are signs that technical assistance and enforcement actions in the Nooksack River Basin are helping improve the water quality. The continuing poor water quality in the Lummi River and tributaries to Lummi Bay, particularly with respect to increased fecal coliform bacteria contamination, is a major concern due to the potential for new closures of important tribal shellfish beds. The members of the Lummi Nation use these shellfish beds for ceremonial, subsistence, and commercial purposes.

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10. APPENDIX A- LUMMI NATION SURFACE WATER QUALITY RESULTS: 2011

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
1/10/2011	DH038	-1											
1/18/2011	DH038	9											
5/16/2011	DH038	10											
7/11/2011	DH038	19.5											
10/19/2011	DH038	14											
11/1/2011	DH038	11											
1/10/2011	DH039	-0.5											
1/18/2011	DH039	9.5											
5/16/2011	DH039	10											
7/11/2011	DH039	21.25											
10/19/2011	DH039	15											
11/1/2011	DH039	11.5											
1/10/2011	DH040	-1											
5/16/2011	DH040	10											
7/11/2011	DH040	19.5											
10/19/2011	DH040	16.5											
11/1/2011	DH040	11.5											
1/10/2011	DH041	-0.5											
5/16/2011	DH041	10											
7/11/2011	DH041	20											
10/19/2011	DH041	17											
11/1/2011	DH041	10.5											
1/10/2011	DH042	-0.5											
5/16/2011	DH042	12											
7/11/2011	DH042	20											
10/19/2011	DH042	17											
11/1/2011	DH042	11											
1/10/2011	DH043	-0.5											
5/16/2011	DH043	12.5											
7/11/2011	DH043	23											
10/19/2011	DH043	19											
11/1/2011	DH043	12											
1/10/2011	DH044	2											
1/18/2011	DH044	12											
7/11/2011	DH044	25											
10/19/2011	DH044	15.5											
11/1/2011	DH044	12											
1/10/2011	DH045	1											
1/18/2011	DH045	9											
7/11/2011	DH045	23.5											
10/19/2011	DH045	15.25											
11/1/2011	DH045	14											
1/18/2011	DH049	4.5											
1/18/2011	DH052	4											

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
1/18/2011	DH057	5											
1/18/2011	DH271	4											
1/10/2011	DH285	0.5											
1/18/2011	DH285	5.25											
5/16/2011	DH285	10.5											
7/11/2011	DH285	18.5											
10/19/2011	DH285	15.75											
11/1/2011	DH285	9.5											
1/10/2011	DH286	-0.05											
1/18/2011	DH286	6.5											
5/16/2011	DH286	9.5											
7/11/2011	DH286	18.5											
10/19/2011	DH286	15											
11/1/2011	DH286	10											
1/10/2011	DH287	-1											
1/18/2011	DH287	8											
5/16/2011	DH287	11											
7/11/2011	DH287	19											
10/19/2011	DH287	14.5											
11/1/2011	DH287	11											
1/10/2011	DH288	0											
1/18/2011	DH288	5											
5/16/2011	DH288	10											
7/11/2011	DH288	17.5											
10/19/2011	DH288	16											
11/1/2011	DH288	10											
1/4/2011	SW001	3.5										1.9	9
2/1/2011	SW001	4			0.0045					0.0045	0.045	1.9	9
3/17/2011	SW001	12										1.9	9
4/11/2011	SW001	12										1.9	10
5/24/2011	SW001	8.5										4	9
6/7/2011	SW001	15			0.009					0.09		38	64
7/6/2011	SW001	15										1.9	9
8/18/2011	SW001	17										1.9	9
9/19/2011	SW001	19.5			0.018					0.0018	0.09	1.9	9
10/5/2011	SW001	16										10	10
12/29/2011	SW001	7.5			0.009					0.009	0.09	2	20
1/4/2011	SW002	5										2	9
2/1/2011	SW002	4.5	100	0.045		1.8	150	0.27				4	10
3/17/2011	SW002	8.25										1.9	9
4/11/2011	SW002	9.25										1.9	9
5/24/2011	SW002											1.9	9
6/7/2011	SW002	14.5	92	0.045		1.7	130	11				4	9
7/6/2011	SW002	23										1.9	9

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
8/18/2011	SW002	16										1.9	9
9/19/2011	SW002	16.5	100	0.14		1.6	150	3				1.9	9
10/5/2011	SW002	12										2	9
12/29/2011	SW002	6	110	0.045		1.6	208	1.5				1.9	9
1/17/2011	SW003	13										96	42
2/7/2011	SW003	8.5	49	0.1		2.1	30	18				20	20
3/29/2011	SW003	12										16	53
4/4/2011	SW003	6.5										110	87
5/12/2011	SW003	13										2400	2005
6/27/2011	SW003	27.5	170	0.17		4.6	72.6	14				280	192
7/22/2011	SW003	21										88	220
8/9/2011	SW003	24										48	87
11/28/2011	SW003	11										26	20
12/13/2011	SW003	5.5	78	0.14		1.5	28	0.53				6	9
1/17/2011	SW004	12.5										60	53
1/4/2011	SW006	5										1.9	9
2/1/2011	SW006	6	87	0.045		1.8	188	1.6				2	20
3/17/2011	SW006	7.5										1.9	9
4/11/2011	SW006	12										1.9	9
5/24/2011	SW006	17.5										1.9	9
6/7/2011	SW006	17.5	99	10		1.6	150	1.8				2	9
7/6/2011	SW006	20										1.9	9
8/18/2011	SW006	17										2	9
9/19/2011	SW006	27.5	70	0.09		1.6	160	1.8				4	9
10/5/2011	SW006	12										14	20
12/29/2011	SW006	8	110	0.045		1.6	130	3.8				1.9	9
1/19/2011	SW007	7										95	31
2/10/2011	SW007	7										8	9
3/30/2011	SW007	10.25										26	87
4/12/2011	SW007											6	10
5/26/2011	SW007	14										56	53
6/23/2011	SW007	17										70	64
7/19/2011	SW007	17.5										42	20
8/8/2011	SW007	17.5										14	9
10/18/2011	SW007	19										94	9
11/15/2011	SW007											16	31
12/14/2011	SW007	6										2	31
1/17/2011	SW008	12.5										110	99
2/7/2011	SW008	9										50	10
3/29/2011	SW008	11.5										150	9
4/4/2011	SW008	5										34	31
5/12/2011	SW008	9										1540	782
6/27/2011	SW008	26.5										54	137
7/22/2011	SW008	20.5										20	620

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
8/9/2011	SW008	22										10	10
9/21/2011	SW008	21.5										1.9	9
10/21/2011	SW008	13										6	9
11/28/2011	SW008	12.5										160	150
12/13/2011	SW008	11.5										16	9
1/17/2011	SW009	12										55	150
2/7/2011	SW009	9	260	0.17		2.1	26	0.27				16	10
3/29/2011	SW009	16										70	53
4/4/2011	SW009	7										76	64
5/12/2011	SW009	14										820	238
6/27/2011	SW009	24	420	1.9		4.5	58.4	21				122	31
7/22/2011	SW009	21.5										240	500
11/28/2011	SW009	8.5										80	120
12/27/2011	SW009		200	0.17		1.9	37.7	14				18	31
1/17/2011	SW010	12.5										6	9
2/7/2011	SW010	7.5										10	31
3/29/2011	SW010	13.5										4	20
4/4/2011	SW010	6.5										60	42
5/12/2011	SW010	19.5										2400	1445
6/27/2011	SW010	22										210	238
7/22/2011	SW010	22										130	1000
11/28/2011	SW010	7.5										8	9
12/13/2011	SW010	5.5										6	9
1/17/2011	SW011	13										84	160
2/7/2011	SW011	9										22	31
3/29/2011	SW011	13										18	31
4/4/2011	SW011	6										1600	780
5/12/2011	SW011	15										196	20
6/27/2011	SW011	19										1.9	10
7/22/2011	SW011	16.5										1600	1100
8/9/2011	SW011	24.5										76	9
11/28/2011	SW011	8.25										62	31
12/13/2011	SW011	9										14	42
1/17/2011	SW012	10.5										58	42
2/7/2011	SW012	8										26	9
3/29/2011	SW012	14										440	9
4/4/2011	SW012	7										76	42
5/12/2011	SW012	21										780	164
6/27/2011	SW012	22										110	10
7/22/2011	SW012	22										520	530
11/28/2011	SW012	10.5										10	10
12/13/2011	SW012	5.5										10	9
1/17/2011	SW013	11.5										18	10
2/7/2011	SW013	7										62	20

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
3/29/2011	SW013	15.5										12	20
4/4/2011	SW013	6										42	9
5/12/2011	SW013	20.5										1760	1013
6/27/2011	SW013	21										460	87
7/22/2011	SW013	22.5										86	1300
8/9/2011	SW013	23										19	2000
11/28/2011	SW013	8.5										34	9
12/13/2011	SW013	5.5										46	10
1/17/2011	SW014	12.5										44	9
2/7/2011	SW014	9							0.012	0.0034	0.066	4	9
3/29/2011	SW014	13.25										22	9
4/4/2011	SW014	6										44	10
5/12/2011	SW014	10										1920	1652
6/27/2011	SW014	21							0.0045	0.007		74	53
7/22/2011	SW014	20.5										380	2000
11/28/2011	SW014	8										16	10
12/13/2011	SW014	5							0.011	0.0034	0.054	4	10
1/17/2011	SW015	12										14	10
2/8/2011	SW015	6	70	0.16		2.9	35.8	21				14	9
3/8/2011	SW015	6.5										52	9
4/14/2011	SW015											40	9
5/18/2011	SW015	17										94	320
6/28/2011	SW015	20.5	180	0.06		6	71.2	54				28	10
7/26/2011	SW015	17.75										70	87
11/30/2011	SW015	6.5										52	53
12/27/2011	SW015		180	0.24		5.7	45.1	52				32	10
1/17/2011	SW016	13.5										16	75
2/8/2011	SW016	8										2	9
3/8/2011	SW016	7										2	9
4/14/2011	SW016											720	210
5/18/2011	SW016	14										6	31
1/17/2011	SW017	13										16	31
2/8/2011	SW017	7										1.9	9
3/8/2011	SW017	6										16	9
4/14/2011	SW017											88	53
5/18/2011	SW017	17										4	20
6/28/2011	SW017	22.5										5	42
1/4/2011	SW019	3.5										2	9
2/1/2011	SW019	3.5										6	9
3/17/2011	SW019	10										1.9	9
4/11/2011	SW019	10										2	9
5/24/2011	SW019	10.5										1.9	9
6/7/2011	SW019	15										4	53
7/6/2011	SW019	26										24	10

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
8/18/2011	SW019	19										14	110
9/19/2011	SW019	20.5										6	9
10/5/2011	SW019	13.5										6	20
12/29/2011	SW019	7.5										10	10
1/4/2011	SW022	3.5										20	9
2/1/2011	SW022	5										4	9
3/17/2011	SW022	9										1.9	9
4/11/2011	SW022	10										1.9	9
5/24/2011	SW022	14.25										2	9
6/7/2011	SW022	14										30	9
7/6/2011	SW022	24										4	9
8/18/2011	SW022	16										1.9	9
9/19/2011	SW022	20.5										1.9	9
10/5/2011	SW022	12.5										1.9	9
12/29/2011	SW022	7.5										26	42
1/4/2011	SW023	7.5										2	9
2/1/2011	SW023	9										1.9	10
3/17/2011	SW023	10										6	20
4/11/2011	SW023	12										1.9	9
5/24/2011	SW023	17										1.9	9
6/7/2011	SW023	14.5										1.9	9
7/6/2011	SW023	21										6	9
8/18/2011	SW023	15										1.9	9
9/19/2011	SW023	27.5										6	10
10/5/2011	SW023	12										18	10
12/29/2011	SW023	8.5										2	9
1/4/2011	SW026	4										84	31
2/1/2011	SW026	3.5										40	9
3/17/2011	SW026	12										56	10
4/11/2011	SW026	11										340	9
5/24/2011	SW026	17										74	10
6/7/2011	SW026	15.75										2400	1000
12/29/2011	SW026	7.5										24	20
1/4/2011	SW027	3.5										4	9
2/1/2011	SW027	3										8	9
3/17/2011	SW027	7.25										14	9
4/11/2011	SW027	10.5										60	9
5/24/2011	SW027	14.5										32	590
6/7/2011	SW027	15										700	2000
12/29/2011	SW027	7.5										10	9
1/4/2011	SW028	3.5										78	53
2/1/2011	SW028	8.25										36	9
3/17/2011	SW028	11										28	9
4/11/2011	SW028	10										24	9

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
5/24/2011	SW028	13										360	9
6/7/2011	SW028	14										620	140
7/6/2011	SW028	20										800	31
12/29/2011	SW028	8.5										52	42
1/19/2011	SW029	9										36	9
2/10/2011	SW029	2										34	9
3/30/2011	SW029	8										620	270
4/4/2011	SW029	7										26	20
4/12/2011	SW029	10.5										1.9	9
5/26/2011	SW029	11										700	210
1/19/2011	SW030	11.5										27	42
2/10/2011	SW030	10										1.9	9
3/30/2011	SW030	9										120	87
4/12/2011	SW030											2.9	31
5/26/2011	SW030	13										70	53
6/23/2011	SW030	16										20	42
7/19/2011	SW030	19.5										13	42
8/8/2011	SW030	18										28	10
9/20/2011	SW030	21										10	4
10/18/2011	SW030	18										1.9	9
11/15/2011	SW030											30	10
12/14/2011	SW030	5										6	9
1/19/2011	SW031	10										6	9
2/10/2011	SW031	7										14	9
3/30/2011	SW031	8.5										160	87
4/12/2011	SW031											4	9
5/26/2011	SW031	13.75										140	31
1/19/2011	SW032	7.5										60	31
2/10/2011	SW032	5										14	10
3/30/2011	SW032	8.5										28	99
4/12/2011	SW032											1.9	9
5/26/2011	SW032	13.5										8	9
6/23/2011	SW032	16										60	9
7/19/2011	SW032	17.5										18	9
8/8/2011	SW032	21										6	9
9/20/2011	SW032	16										8	9
10/18/2011	SW032	15										2	9
11/15/2011	SW032											4	10
12/14/2011	SW032	4.5										2	9
1/19/2011	SW033	10.5										6	42
2/10/2011	SW033	5.5										4	9
3/30/2011	SW033	7.5										140	42
4/12/2011	SW033											1.9	9
5/26/2011	SW033	13										460	64

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
1/19/2011	SW034	13										33	75
2/10/2011	SW034	5.5										1.9	9
3/30/2011	SW034	8										44	87
4/12/2011	SW034											1.9	9
5/26/2011	SW034	13										8	10
6/23/2011	SW034	14.5										60	10
7/19/2011	SW034	17.25										65	9
8/8/2011	SW034	18										4	9
9/20/2011	SW034	20										8	9
10/18/2011	SW034	16										2	9
11/15/2011	SW034											4	10
12/14/2011	SW034	3.5										10	9
1/19/2011	SW035	9										18	9
2/10/2011	SW035	4										1.9	9
3/30/2011	SW035	8										2400	2000
4/4/2011	SW035	5.5										2400	2000
4/12/2011	SW035											5	14.5
5/26/2011	SW035	11.5										1000	2000
1/19/2011	SW036	9.5										50	20
2/10/2011	SW036	4										1.9	9
3/30/2011	SW036	8										260	450
4/4/2011	SW036	5.5										20	42
4/12/2011	SW036											12	9
5/26/2011	SW036	11.5										48	450
6/23/2011	SW036	15.5										14	20
7/19/2011	SW036											8	10
8/8/2011	SW036	19										2	9
9/20/2011	SW036	18.5										6	10
10/18/2011	SW036	16										8	42
11/15/2011	SW036											6	53
12/14/2011	SW036	4.5										8	10
1/19/2011	SW037	7										2	9
3/30/2011	SW037	6.5										170	1700
4/4/2011	SW037	5										110	75
5/26/2011	SW037	15										240	160
1/19/2011	SW038	9										16	111
2/10/2011	SW038	5										1.9	9
3/30/2011	SW038	6.5										66	160
4/4/2011	SW038	5										36	42
4/12/2011	SW038											4	9
5/26/2011	SW038	15										74	120
6/23/2011	SW038	16										16	10
7/19/2011	SW038	16.5										4	9
8/8/2011	SW038	18.5										1.9	9

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
9/20/2011	SW038	18										18	9
10/18/2011	SW038	19										2	10
11/15/2011	SW038											2	10
12/14/2011	SW038	4.5										10	10
1/19/2011	SW039	7										8	42
2/10/2011	SW039	4										2	9
3/30/2011	SW039	9.5										1.9	9
4/12/2011	SW039	13.5										2	9
5/26/2011	SW039	14										12	9
6/23/2011	SW039	17										18	9
7/19/2011	SW039	16										4	9
8/8/2011	SW039	16										12	10
9/20/2011	SW039	15										1.9	9
10/18/2011	SW039	15										1.9	9
11/15/2011	SW039											4	20
12/14/2011	SW039	9										1.9	9
1/17/2011	SW051	11										92	140
2/7/2011	SW051	6										42	20
2/8/2011	SW051	6										12	20
3/8/2011	SW051	5										1.9	9
3/29/2011	SW051	12										6	10
4/4/2011	SW051	5.5										14	31
4/14/2011	SW051											2	10
5/12/2011	SW051	12										1.9	9
5/18/2011	SW051	10										22	20
6/27/2011	SW051	23.5										2	9
6/28/2011	SW051	21										10	10
7/22/2011	SW051	18										2	75
7/26/2011	SW051	17										16	9
8/9/2011	SW051	19.5										1.9	10
8/29/2011	SW051	20										10	31
9/21/2011	SW051	18										2	9
9/28/2011	SW051	15										8	9
10/21/2011	SW051	13										34	31
10/26/2011	SW051	5.5										4	9
11/28/2011	SW051	10										56	20
11/30/2011	SW051	6										12	9
12/12/2011	SW051	3										28	9
12/13/2011	SW051	5.5										110	9
1/19/2011	SW052	5										1.9	10
2/8/2011	SW052	5.5										1.9	10
3/8/2011	SW052	6.25										2	9
4/14/2011	SW052											1.9	9
5/18/2011	SW052	11										1.9	9

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
6/28/2011	SW052	21.5										1.9	9
7/26/2011	SW052	17										1.9	9
8/29/2011	SW052	19										1.9	9
9/28/2011	SW052	18										1.9	9
10/26/2011	SW052	7.5										1.9	9
11/30/2011	SW052	12										1.9	9
12/12/2011	SW052	8.5										1.9	9
1/17/2011	SW053	11.5										140	250
2/7/2011	SW053	7										26	64
3/29/2011	SW053	12										22	20
4/4/2011	SW053	6										56	53
5/12/2011	SW053	9										2400	2005
6/27/2011	SW053	21										30	9
7/22/2011	SW053	20										6	20
8/9/2011	SW053	21.5										2	10
9/21/2011	SW053	23.5										26	110
10/21/2011	SW053	13										24	10
11/28/2011	SW053	12										12	53
12/13/2011	SW053	10										20	20
1/19/2011	SW055	6										64	42
2/8/2011	SW055	6										20	20
3/8/2011	SW055	6.5										4	9
4/14/2011	SW055											1.9	9
5/18/2011	SW055	17										2	53
6/28/2011	SW055	24										1.9	10
7/26/2011	SW055	17.5										1.9	20
8/29/2011	SW055	19.5										4	9
10/26/2011	SW055	7										1.9	9
11/30/2011	SW055	7.5										120	42
12/12/2011	SW055	7										24	9
1/19/2011	SW056	6.5										56	31
2/8/2011	SW056	5										14	10
3/8/2011	SW056	5										4	20
4/14/2011	SW056											6	10
5/18/2011	SW056	12										34	31
6/28/2011	SW056	20.75										58	31
7/26/2011	SW056	16.5										12	9
8/29/2011	SW056	19										2	110
10/26/2011	SW056	7										1.9	9
11/30/2011	SW056	11										86	53
1/17/2011	SW058	11.5										1.9	53
2/7/2011	SW058	10										6	42
3/29/2011	SW058	17										5	31
4/4/2011	SW058	7										38	20

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
5/12/2011	SW058	17										146	150
1/17/2011	SW059	13										28	31
2/8/2011	SW059	6										14	10
3/8/2011	SW059	5.5										2	9
4/14/2011	SW059											500	160
5/18/2011	SW059	115										16	64
6/28/2011	SW059	21										160	10
7/26/2011	SW059	16										120	290
8/29/2011	SW059	21										260	53
11/30/2011	SW059	8										10	10
12/12/2011	SW059	14										6	10
1/19/2011	SW072	7										33	42
2/8/2011	SW072	8										1.9	9
3/8/2011	SW072	5.5										1.9	9
4/14/2011	SW072											110	1300
5/18/2011	SW072	14										14	42
6/28/2011	SW072	21.5										20	64
11/30/2011	SW072	9										20	9
1/19/2011	SW118	6										55	31
2/7/2011	SW118	10.5										28	20
2/8/2011	SW118	8										12	10
2/10/2011	SW118	6.25										2	9
3/8/2011	SW118	8										1.9	9
3/29/2011	SW118	17										4	9
3/30/2011	SW118	10										76	75
4/4/2011	SW118	7										40	53
4/12/2011	SW118											1.9	9
4/14/2011	SW118											66	31
5/12/2011	SW118	13.5										360	10
5/18/2011	SW118	16										18	9
5/26/2011	SW118	16										58	10
6/23/2011	SW118	18										104	53
6/27/2011	SW118	21										1.9	9
6/28/2011	SW118	20										40	9
7/19/2011	SW118	19.5										18	42
7/22/2011	SW118	21										28	42
7/26/2011	SW118	16										22	9
8/8/2011	SW118	17.5										8	20
8/9/2011	SW118	22										32	10
8/29/2011	SW118	22										30	31
9/20/2011	SW118	23										26	10
9/21/2011	SW118	24.5										22	10
9/28/2011	SW118	20.5										140	210
10/18/2011	SW118	17.5										12	10
10/21/2011	SW118	13.5										48	53
10/26/2011	SW118	7.75										20	9
11/15/2011	SW118											20	10
11/28/2011	SW118	7.75										55	31

Table A.1 2011 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
11/30/2011	SW118	9										46	20
12/12/2011	SW118	4.5										6	9
12/13/2011	SW118	4.5										8	9
12/14/2011	SW118	5.5										4	9
12/27/2011	SW118											30	10

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
1/10/2011	DH038	22	8										105.7
1/18/2011	DH038	7.8	7										98.5
3/24/2011	DH038	1.7	3										95.85
5/16/2011	DH038	1.7	2										115.5
7/11/2011	DH038	1.7	1										137.3
10/19/2011	DH038	1.7	4										86
11/1/2011	DH038	7.8	1										78.4
1/10/2011	DH039	33	7										102.8
1/18/2011	DH039	1.7	2										98.5
3/24/2011	DH039	17	3										94.9
5/16/2011	DH039	4	3										109.7
7/11/2011	DH039	1.7	2										134.95
10/19/2011	DH039	1.7											83.1
11/1/2011	DH039	2	1										78.95
1/10/2011	DH040	4.5	7										99.4
3/24/2011	DH040	1.7	4										94.5
5/16/2011	DH040	1.7	4										109.6
7/11/2011	DH040	1.7	2										137.1
10/19/2011	DH040	1.7	6										86.2
11/1/2011	DH040	2	1										79.4
1/10/2011	DH041	11	7										104.3
3/24/2011	DH041	1.7	3										95
5/16/2011	DH041	2	4										108
7/11/2011	DH041	2	3										121
10/19/2011	DH041	1.7	6										87.5
11/1/2011	DH041	2	6										80
1/10/2011	DH042	7.8	7										101.4
3/24/2011	DH042	1.7	4										95
5/16/2011	DH042	1.7	4										127.7
7/11/2011	DH042	1.7	2										129.1
10/19/2011	DH042	1.7	1										82.8
11/1/2011	DH042	7.8	1										79.35
1/10/2011	DH043	4.5	6										99
3/24/2011	DH043	1.7	3										96.6
5/16/2011	DH043	1.7	7										112.9
7/11/2011	DH043	1.7	2										126
10/19/2011	DH043	1.7	6										83.1
11/1/2011	DH043	7.8	1										84
1/10/2011	DH044	1.7	6										121.15
1/18/2011	DH044	1.7	1										100.2
3/24/2011	DH044	17	2										111.75
5/16/2011	DH044	1.7	4										101.6
7/11/2011	DH044	1.7	4										103.2
10/19/2011	DH044	1.7	1										131.6

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
11/1/2011	DH044	13	1										106
1/10/2011	DH045	1.7	6										115.7
1/18/2011	DH045	1.7	1										123.8
3/24/2011	DH045	1.7											118.3
5/16/2011	DH045	1.7	8										197.6
7/11/2011	DH045	1.7	1										180
10/19/2011	DH045	1.7	8										220.05
11/1/2011	DH045		4										130.1
3/30/2011	DH048	4.5											
5/10/2011	DH048	1.7											
9/20/2011	DH048	1.7											
11/15/2011	DH048	4.5											
1/18/2011	DH049	11	9										102.2
3/30/2011	DH049	1.7											
5/10/2011	DH049	4.5											
7/19/2011	DH049	1.7											
9/20/2011	DH049	1.7											
11/15/2011	DH049	22											
3/30/2011	DH050	1.7											
5/10/2011	DH050	33											
7/19/2011	DH050	33											
9/20/2011	DH050	4											
11/15/2011	DH050	13											
3/30/2011	DH051	1.7											
5/10/2011	DH051	6.8											
7/19/2011	DH051	7.8											
9/20/2011	DH051	1.7											
11/15/2011	DH051	17											
1/18/2011	DH052	13	2										102.9
3/30/2011	DH052	1.7											
5/10/2011	DH052	2											
7/19/2011	DH052	13											
9/20/2011	DH052	1.7											
11/15/2011	DH052	33											
3/30/2011	DH053	1.7											
5/10/2011	DH053	2											
7/19/2011	DH053	2											
9/20/2011	DH053	2											
11/15/2011	DH053	13											
3/30/2011	DH054	1.7											
5/10/2011	DH054	1.7											
7/19/2011	DH054	1.7											
9/20/2011	DH054	1.7											
11/15/2011	DH054	13											

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
3/30/2011	DH055	1.7											
5/10/2011	DH055	4.5											
7/19/2011	DH055	45											
9/20/2011	DH055	1.7											
11/15/2011	DH055	11											
1/18/2011	DH057	33	8										104
3/30/2011	DH057	2											
5/10/2011	DH057	1.7											
7/19/2011	DH057	33											
9/20/2011	DH057	1.7											
11/15/2011	DH057	6.8											
3/30/2011	DH058	1.7											
5/10/2011	DH058	4.5											
7/19/2011	DH058	1.7											
9/20/2011	DH058	1.7											
11/15/2011	DH058	1.8											
1/18/2011	DH271	7.8	2										102.5
3/30/2011	DH271	2											
5/10/2011	DH271	1.7											
7/19/2011	DH271	49											
9/20/2011	DH271	1.7											
11/15/2011	DH271	17											
3/30/2011	DH272	540											
5/10/2011	DH272	2											
7/19/2011	DH272	11											
9/20/2011	DH272	1.7											
11/15/2011	DH272	11											
1/10/2011	DH285	23	8										108
1/18/2011	DH285	11	6										98.3
3/24/2011	DH285	1.7	1										95.6
5/16/2011	DH285	1.7	2										115.2
7/11/2011	DH285	1.7	6										130.3
10/19/2011	DH285	1.7	1										93.8
11/1/2011	DH285	1.7	5										79.6
1/10/2011	DH286	13	7										103.4
1/18/2011	DH286	6.8	6										96.7
3/24/2011	DH286	1.7											95.5
5/16/2011	DH286	2	4										138.8
7/11/2011	DH286	1.7	2										142.4
10/19/2011	DH286	11	1										84.7
11/1/2011	DH286	7.8	3										88.3
1/10/2011	DH287	33	8										104.8
1/18/2011	DH287	4.5	7										98.1
3/24/2011	DH287	1.7											95.9

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
5/16/2011	DH287	1.7	2										105.9
7/11/2011	DH287	1.7	7										134.4
10/19/2011	DH287	1.7	4										84.6
11/1/2011	DH287	1.7	1										78.7
1/10/2011	DH288	23	7										108.2
1/18/2011	DH288	7.8	6										99
3/24/2011	DH288	1.7	1										96.9
5/16/2011	DH288	1.7	4										115.6
7/11/2011	DH288	1.7	2										140.3
10/19/2011	DH288	4.5	1										87.9
11/1/2011	DH288	1.7	5										77.9
1/4/2011	SW001	1.9	11										93.75
2/1/2011	SW001	4	2		5350			0.09	0.00045				96.8
3/17/2011	SW001	1.9	10										100.1
4/11/2011	SW001	1.9	6										101.2
5/24/2011	SW001	4	11										114.8
6/7/2011	SW001	38	11		4520			0.072	0.00045				104.3
7/6/2011	SW001	1.9	11										99.7
8/18/2011	SW001	1.9	11										100.5
9/19/2011	SW001	1.9	11		5200			0.45	0.00045				84.5
10/5/2011	SW001	10	11										84.5
12/29/2011	SW001	2	10		5360			0.45	0.00045				91.4
1/4/2011	SW002	2	9										96.4
2/1/2011	SW002	4	3			0.21				0.42	0.16	0.068	99.45
3/17/2011	SW002	1.9	6										97.85
4/11/2011	SW002	1.9	7										103.4
5/24/2011	SW002	1.9	6										119.9
6/7/2011	SW002	4	6			0.22				0.07	0.045	0.02	141.7
7/6/2011	SW002	1.9	7										113.4
8/18/2011	SW002	1.9	8										111.4
9/19/2011	SW002	1.9	1			0.0407				1.5	0.045	0.034	124.7
10/5/2011	SW002	2	2										76.3
12/29/2011	SW002	1.9	2			0.0467						0.068	91.1
1/17/2011	SW003	96	11										78.75
2/7/2011	SW003	22	11			2.3				0.57	0.045	0.045	79
3/29/2011	SW003	16	1										72.6
4/4/2011	SW003	110	11										78.55
5/12/2011	SW003	2400	11										75.7
6/27/2011	SW003	280	11			3.6				0.055	0.045	0.074	75.8
7/22/2011	SW003	88	11										52.2
8/9/2011	SW003	48	11										94.6
11/28/2011	SW003	26	11										49.1
12/13/2011	SW003	6	11			2				0.36	0.045	0.045	39.5
1/17/2011	SW004	60	11										103.5

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
1/4/2011	SW006	1.9	3										97.6
2/1/2011	SW006	2	2			0.43				0.47		0.072	103.9
3/17/2011	SW006	1.9	2										99.5
4/11/2011	SW006	1.9	7										105.5
5/24/2011	SW006	1.9	4										107.8
6/7/2011	SW006	2	2			0.28				0.15	0.045	0.045	99.8
7/6/2011	SW006	1.9	2										107.8
8/18/2011	SW006	2											108.5
9/19/2011	SW006	4	4			0.0988				0.99	0.045	0.018	99.2
10/5/2011	SW006	14	5										95.1
12/29/2011	SW006	1.9	2			0.174						0.074	90.6
1/19/2011	SW007	95	11										100.6
2/10/2011	SW007	8	11										106
3/30/2011	SW007	26	11										99.9
4/12/2011	SW007	6	11										100.7
5/26/2011	SW007	56	11										100.25
6/23/2011	SW007	70	11										100.4
7/19/2011	SW007	42	11										100.8
8/8/2011	SW007	14	11										102.1
10/18/2011	SW007	94	11										69.4
11/15/2011	SW007	16	11										98.7
12/14/2011	SW007	2	11										88.4
1/17/2011	SW008	110											90.4
2/7/2011	SW008	50	11										78
3/29/2011	SW008	150											75.9
4/4/2011	SW008	34	11										73.8
5/12/2011	SW008	1540	11										69.2
6/27/2011	SW008	58	11										31.7
7/22/2011	SW008	20	10										45.6
8/9/2011	SW008	10	11										64
9/21/2011	SW008	1.9	10										72
10/21/2011	SW008	6	10										76.7
11/28/2011	SW008	160	11										82.9
12/13/2011	SW008	16	11										67.5
1/17/2011	SW009	55	11										100.6
2/7/2011	SW009	16	11			3.1				0.37	0.063	0.07	51.7
3/29/2011	SW009	70	1	0									104.3
4/4/2011	SW009	76	11										70.3
5/12/2011	SW009	820	1										81.1
6/27/2011	SW009	122	1	0		1.9				0.045	0.045	0.045	11.55
7/22/2011	SW009	240	1	0									13
11/28/2011	SW009	80	11										87.6
12/27/2011	SW009	18	1			1.6				0.5	0.045	0.13	63
1/17/2011	SW010	10	11										41.7

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
2/7/2011	SW010	10											90.7
3/29/2011	SW010	4	1	0									86.2
4/4/2011	SW010	60	11										92
5/12/2011	SW010	2400	1	0									111.2
6/27/2011	SW010	210	1	0									15.5
7/22/2011	SW010	130	1	0									17.1
11/28/2011	SW010	8	11										22.9
12/13/2011	SW010	6	11										32.9
1/17/2011	SW011	84	11										103.9
2/7/2011	SW011	32	11										104.2
3/29/2011	SW011	18	11										103.3
4/4/2011	SW011	1600	11										100
5/12/2011	SW011	196	11										101.9
6/27/2011	SW011	30	11										87.5
7/22/2011	SW011	1600	11										91.5
8/9/2011	SW011	76	11										95.6
11/28/2011	SW011	62	11										89.9
12/13/2011	SW011	14	11										98
1/17/2011	SW012	58	11										80.6
2/7/2011	SW012	26	11										87.1
3/29/2011	SW012	440	11										84.2
4/4/2011	SW012	76	11										79.2
5/12/2011	SW012	780	11										78.4
6/27/2011	SW012	110	1	0									30.7
7/22/2011	SW012	520	11										17.05
11/28/2011	SW012	10	11										58.8
12/13/2011	SW012	10	11										59.6
1/17/2011	SW013	18	1										30.5
2/7/2011	SW013	62	1	0									86.9
3/29/2011	SW013	12	1	0									45.2
4/4/2011	SW013	42											76.6
5/12/2011	SW013	1760	1	0									57.7
6/27/2011	SW013	460	1	0									24.3
7/22/2011	SW013	86	1	0									89.9
8/9/2011	SW013	19											358.3
11/28/2011	SW013	34	1										46.5
12/13/2011	SW013	46	11										4.2
1/17/2011	SW014	44	11										88.9
2/7/2011	SW014	4	11		50		0.00045	0.088					91.3
3/29/2011	SW014	22	11										90.25
4/4/2011	SW014	44	11										89.4
5/12/2011	SW014	1920	11										82.3
6/27/2011	SW014	74	1		110		0.008	0.186					41.9
7/22/2011	SW014	380	1	0									29.3

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
11/28/2011	SW014	16	11										62.1
12/13/2011	SW014	4	11		80		0.00045	0.201					64.2
1/17/2011	SW015	14	11										63.95
2/8/2011	SW015	14	11			6.6				0.14	0.045	0.045	92.95
3/8/2011	SW015	52	1	0									62.5
4/14/2011	SW015	40	11										73.7
5/18/2011	SW015	98	11										81.2
6/28/2011	SW015	28	1	0		1.4				0.045	0.045	0.045	47.4
7/26/2011	SW015	70	1	0									32.45
11/30/2011	SW015	52	11										51
12/27/2011	SW015	32	11			2.4				0.17	0.045	0.1	77.2
1/17/2011	SW016	16	11										75.7
2/8/2011	SW016	2	11										70.9
3/8/2011	SW016	2	1	0									64.5
4/14/2011	SW016	720	11										99.1
5/18/2011	SW016	6	11										73.1
1/17/2011	SW017	16	11										99.3
2/8/2011	SW017	1.9	11										81.8
3/8/2011	SW017	16	1	0									46
4/14/2011	SW017	88	11										100.8
5/18/2011	SW017	4	1										47.4
6/28/2011	SW017	5	1	0									6.2
1/4/2011	SW019	2	2										93.7
2/1/2011	SW019	6	2										99.2
3/17/2011	SW019	1.9	10										100
4/11/2011	SW019	2	6										99.9
5/24/2011	SW019	1.9	5										129
6/7/2011	SW019	4	6										105.7
7/6/2011	SW019	24	1										92.75
8/18/2011	SW019	14	2										97.8
9/19/2011	SW019	6	2										81.45
10/5/2011	SW019	6	6										76.9
12/29/2011	SW019	10	7										90.65
1/4/2011	SW022	20	9										96.7
2/1/2011	SW022	6	7										114.3
3/17/2011	SW022	4	6										101
4/11/2011	SW022	1.9	7										106.5
5/24/2011	SW022	2	6										139.25
6/7/2011	SW022	30	4										112.9
7/6/2011	SW022	4	8										111
8/18/2011	SW022	1.9	8										106.3
9/19/2011	SW022	1.9	7										95.3
10/5/2011	SW022	1.9	4										72.6
12/29/2011	SW022	26	2										94.5

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
1/4/2011	SW023	2	4										92.8
2/1/2011	SW023	1.9	4										105.8
3/17/2011	SW023	6	8										103.5
4/11/2011	SW023	1.9	7										102.1
5/24/2011	SW023	1.9	8										112
6/7/2011	SW023	1.9	7										101.5
7/6/2011	SW023	6	6										119.7
8/18/2011	SW023	1.9	8										118.2
9/19/2011	SW023	6	5										99.8
10/5/2011	SW023	18	8										95.1
12/29/2011	SW023	2	1										97
1/4/2011	SW026	84	11										98.2
2/1/2011	SW026	40	11										96.2
3/17/2011	SW026	56	11										97.8
4/11/2011	SW026	340	11										110
5/24/2011	SW026	74	11										132.7
6/7/2011	SW026	2400	11										72.7
12/29/2011	SW026	24	11										81.7
1/4/2011	SW027	4	11										105.2
2/1/2011	SW027	8	11										105.8
3/17/2011	SW027	14	11										96.6
4/11/2011	SW027	60	11										97.2
5/24/2011	SW027	32	11										99.8
6/7/2011	SW027	700	11										102.1
12/29/2011	SW027	10	11										49
1/4/2011	SW028	78	11										111.1
2/1/2011	SW028	36	11										118.05
3/17/2011	SW028	28	11										137.9
4/11/2011	SW028	24	11										126
5/24/2011	SW028	360	11										128
6/7/2011	SW028	620	11										85.9
7/6/2011	SW028	800	11										114.9
12/29/2011	SW028	52	11										87
1/19/2011	SW029	36	11										104.7
2/10/2011	SW029	34	11										108.4
3/30/2011	SW029	620	11										98.4
4/4/2011	SW029	26	11										97
4/12/2011	SW029	1.9	11										102.1
5/26/2011	SW029	700	11										94.8
1/19/2011	SW030	27	1										103.3
2/10/2011	SW030	1.9	3										115
3/30/2011	SW030	120	2										102.7
4/12/2011	SW030	2.9	2										108.3
5/26/2011	SW030	70	2										102.5

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
6/23/2011	SW030	20	2										105.4
7/19/2011	SW030	13	2										101.2
8/8/2011	SW030	28	2										104.6
9/20/2011	SW030	4	3										131.1
10/18/2011	SW030	1.9	2										133.9
11/15/2011	SW030	30	2										107.9
12/14/2011	SW030	6	5										99.1
1/19/2011	SW031	6	11										77.6
2/10/2011	SW031	14	11										98
3/30/2011	SW031	160	11										83.8
4/12/2011	SW031	4	11										106.5
5/26/2011	SW031	140	11										83.6
1/19/2011	SW032	60	1										99.3
2/10/2011	SW032	14	2										108.2
3/30/2011	SW032	28	2										101.2
4/12/2011	SW032	1.9	2										110.1
5/26/2011	SW032	8	2										110.2
6/23/2011	SW032	60	2										120.5
7/19/2011	SW032	18	3										100.6
8/8/2011	SW032	6	3										102.95
9/20/2011	SW032	8	8										116.2
10/18/2011	SW032	2	2										109
11/15/2011	SW032	4	4										98.1
12/14/2011	SW032	2	8										100.7
1/19/2011	SW033	6	11										79.9
2/10/2011	SW033	4	11										85.7
3/30/2011	SW033	140	11										76.5
4/12/2011	SW033	1.9	11										100.5
5/26/2011	SW033	460	11										68.7
1/19/2011	SW034	33	1										96.3
2/10/2011	SW034	1.9	2										108.3
3/30/2011	SW034	44	2										101.3
4/12/2011	SW034	1.9	2										107.7
5/26/2011	SW034	8											106.8
6/23/2011	SW034	60											118
7/19/2011	SW034	65	3										102.25
8/8/2011	SW034	4	3										104.2
9/20/2011	SW034	8	8										114.9
10/18/2011	SW034	2	2										105.9
11/15/2011	SW034	4	4										104
12/14/2011	SW034	10	7										100
1/19/2011	SW035	18	11										59
2/10/2011	SW035	1.9	11										97.7
3/30/2011	SW035	2400	11										74.9

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
4/4/2011	SW035	2400	11										73.5
4/12/2011	SW035	8	11										115.4
5/26/2011	SW035	1000	11										80.7
1/19/2011	SW036	50	3										100.9
2/10/2011	SW036	1.9	2										108.1
3/30/2011	SW036	260	2										96
4/4/2011	SW036	20	2										97.7
4/12/2011	SW036	12	9										104.2
5/26/2011	SW036	48	9										118.3
6/23/2011	SW036	14											122.8
7/19/2011	SW036	8	3										105.4
8/8/2011	SW036	2	3										109.3
9/20/2011	SW036	6	6										107.3
10/18/2011	SW036	8	1										105.4
11/15/2011	SW036	6	4										98.2
12/14/2011	SW036	8	8										99.2
1/19/2011	SW037	2	11										77.4
3/30/2011	SW037	170	11										91.8
4/4/2011	SW037	110	11										84.1
5/26/2011	SW037	240	11										71
1/19/2011	SW038	16	8										102.1
2/10/2011	SW038	1.9	2										110.1
3/30/2011	SW038	66	8										101.6
4/4/2011	SW038	36	2										100.3
4/12/2011	SW038	4	2										102.8
5/26/2011	SW038	74	8										105.8
6/23/2011	SW038	16											134.2
7/19/2011	SW038	4	3										105.5
8/8/2011	SW038	1.9	3										104
9/20/2011	SW038	18	7										102.7
10/18/2011	SW038	2	1										99
11/15/2011	SW038	2	5										104.9
12/14/2011	SW038	10	6										98.8
1/19/2011	SW039	8	1										111
2/10/2011	SW039	2	3										99.2
3/30/2011	SW039	1.9	9										96.4
4/12/2011	SW039	2	6										105.3
5/26/2011	SW039	12	2										104.6
6/23/2011	SW039	18											112.2
7/19/2011	SW039	4	2										89.3
8/8/2011	SW039	12	3										114.9
9/20/2011	SW039	1.9	7										86.5
10/18/2011	SW039	1.9	6										87.3
11/15/2011	SW039	4	6										95.7

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
12/14/2011	SW039	1.9	6										80.9
1/17/2011	SW051	92	11										94
2/7/2011	SW051	42											96.5
2/8/2011	SW051	12	11										98.4
3/8/2011	SW051	1.9	11										89.6
3/29/2011	SW051	6											100.7
4/4/2011	SW051	14	10										91
4/14/2011	SW051	2											93.6
5/12/2011	SW051	1.9											87.2
5/18/2011	SW051	22	11										105.5
6/27/2011	SW051	2	11										57.2
6/28/2011	SW051	10											59.4
7/22/2011	SW051	2											87.2
7/26/2011	SW051	16											88.1
8/9/2011	SW051	1.9	10										91.8
8/29/2011	SW051	10											84.6
9/21/2011	SW051	2	10										66.4
9/28/2011	SW051	8	11										77.5
10/21/2011	SW051	34	10										87
10/26/2011	SW051	4	11										85.5
11/28/2011	SW051	56	11										78.2
11/30/2011	SW051	12	11										92.9
12/12/2011	SW051	28	10										93.2
12/13/2011	SW051	110	11										91.3
1/19/2011	SW052	1.9	1										111.9
2/8/2011	SW052	1.9											121.2
3/8/2011	SW052	2	2										105.3
4/14/2011	SW052	1.9											112.2
5/18/2011	SW052	1.9	4										150.7
6/28/2011	SW052	1.9	3										96.5
7/26/2011	SW052	1.9	2										111.5
8/29/2011	SW052	1.9											112.1
9/28/2011	SW052	1.9	9										109.8
10/26/2011	SW052	1.9	8										104.9
11/30/2011	SW052	1.9	8										116.3
12/12/2011	SW052	1.9	1										114.4
1/17/2011	SW053	140											100.6
2/7/2011	SW053	26	11										82.85
3/29/2011	SW053	22	1	0									102.1
4/4/2011	SW053	56	11										81.2
5/12/2011	SW053	2400	11										78.7
6/27/2011	SW053	30	11										93.1
7/22/2011	SW053	6											76.1
8/9/2011	SW053	2	11										117.1
9/21/2011	SW053	26	4										69.4
10/21/2011	SW053	24											87.5
11/28/2011	SW053	12	1										76.8
12/13/2011	SW053	20	1										87.4

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
1/19/2011	SW055	64	10										62.2
2/8/2011	SW055	20	10										74.9
3/8/2011	SW055	4	1	0									50
4/14/2011	SW055	1.9	1										72
5/18/2011	SW055	2	11										52.7
6/28/2011	SW055	1.9	11										64.8
7/26/2011	SW055	1.9	11										40.7
8/29/2011	SW055	4	1										59
10/26/2011	SW055	1.9	10										55.9
11/30/2011	SW055	120	1										59.8
12/12/2011	SW055	24	1										42.4
1/19/2011	SW056	56	10										64
2/8/2011	SW056	14											86.9
3/8/2011	SW056	4	11										79.3
4/14/2011	SW056	6											110.7
5/18/2011	SW056	34											116.4
6/28/2011	SW056	58	10										122.15
7/26/2011	SW056	12											128.5
8/29/2011	SW056	2											144.8
10/26/2011	SW056	1.9	1										56.1
11/30/2011	SW056	86	10										65.7
1/17/2011	SW058	22	1										64.3
2/7/2011	SW058	6	1	0									67.1
3/29/2011	SW058	5	1	0									78.5
4/4/2011	SW058	38	1	0									86
5/12/2011	SW058	146	1	0									83.1
1/17/2011	SW059	28	11										66.6
2/8/2011	SW059	14	11										83.5
3/8/2011	SW059	2	11										53.6
4/14/2011	SW059	500	11										78.05
5/18/2011	SW059	16	11										78.3
6/28/2011	SW059	160	10										36.4
7/26/2011	SW059	120	11										33.6
8/29/2011	SW059	260	1										76.6
11/30/2011	SW059	10	11										58.3
12/12/2011	SW059	6	11										36.6
1/19/2011	SW072	60	1										82.7
2/8/2011	SW072	1.9	1	0									41.9
3/8/2011	SW072	1.9	1	0									42.4
4/14/2011	SW072	110	1	0									55
5/18/2011	SW072	14	11										64.9
6/28/2011	SW072	20	1	0									33.4
11/30/2011	SW072	20	1										40.6
1/19/2011	SW118	55	11										99.1
2/7/2011	SW118	28	11										103.7
2/8/2011	SW118	12	11										103.8

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
2/10/2011	SW118	2	11										103.3
3/8/2011	SW118	1.9	11										92
3/29/2011	SW118	4	11										98.3
3/30/2011	SW118	76	11										99.2
4/4/2011	SW118	40	11										96.9
4/12/2011	SW118	1.9	11										100.1
4/14/2011	SW118	66	11										100.2
5/12/2011	SW118	360	11										94.2
5/18/2011	SW118	18	11										98.9
5/26/2011	SW118	58	11										99.8
6/23/2011	SW118	104	11										100.7
6/27/2011	SW118	64	11										101.3
6/28/2011	SW118	40	11										103
7/19/2011	SW118	18	11										101.8
7/22/2011	SW118	28	11										105.9
7/26/2011	SW118	22	11										108
8/8/2011	SW118	8	11										102.3
8/9/2011	SW118	32	11										106.8
8/29/2011	SW118	30	11										101.4
9/20/2011	SW118	26	11										110.6
9/21/2011	SW118	22	11										101.75
9/28/2011	SW118	140	11										105.05
10/18/2011	SW118	12	11										102.75
10/21/2011	SW118	48	11										103.3
10/26/2011	SW118	20	11										100.35
11/15/2011	SW118	20	11										108
11/28/2011	SW118	55	11										97.8
11/30/2011	SW118	50	11										99.85
12/12/2011	SW118	6	11										98.35
12/13/2011	SW118	8	11										95.75
12/14/2011	SW118	4	11										98.1
12/27/2011	SW118	30	11										99.4

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/10/2011	DH038	12.53	7.66		0.77		27.11	140		43803				
1/18/2011	DH038	10.62	7.58		6.64		18.4	80		29989				
3/24/2011	DH038	9.54	7.79		7.075		29.545	210		46135				
5/16/2011	DH038	10.6	8.02		9.78		27.61	160		43117				
7/11/2011	DH038	12.11	8.33		14.6		22.98	180		36319				
10/19/2011	DH038	8	7.62		10.52		28.41	180		44196				
11/1/2011	DH038	7.4	7.53		9.39		30.29	190		46934				
1/10/2011	DH039	11.3	7.64		3.26		29.06	150		46066				
1/18/2011	DH039	10.23	7.59		6.9		24.09	140		38345				
3/24/2011	DH039	9.47	7.79		7.11		29.38	290		45901				
5/16/2011	DH039	10.46	8.04		9.56		27.85			43487				
7/11/2011	DH039	11.935	8.315		14.415		23.435	230		36960				
10/19/2011	DH039	7.74	7.63		10.45		28.22	250		43938				
11/1/2011	DH039	7.455	7.57		9.42		30.245	210		46859				
1/10/2011	DH040	10.42	7.65		5.24		28.65	180		45134				
3/24/2011	DH040	9.42	7.77		7.12		46041	270		29.48				
5/16/2011	DH040	10.45	8.03		9.58		27.95			43617				
7/11/2011	DH040	12.13	8.3		14.17		23.77	190		37470				
10/19/2011	DH040	8.06	7.69		10.26		28.44	210		44253				
11/1/2011	DH040	7.5	7.54		9.39		30	190		46520				
1/10/2011	DH041	11.56	7.58		2.78		28.99	160		46084				
3/24/2011	DH041	9.5	7.8		7.14		29.34	240		45808				
5/16/2011	DH041	10.29	8.06		9.56		28.21	160		43984				
7/11/2011	DH041	10.78	8.16		13.41		25.27	190		39616				
10/19/2011	DH041	8.18	7.66		10.28		28.51	210		44359				
11/1/2011	DH041	7.56	7.59		9.38		30.21	190		46820				
1/10/2011	DH042	11.3	7.59		2.91		28.53	160		45356				
3/24/2011	DH042	9.38	7.82		7.59		29.52	260		46039				
5/16/2011	DH042	11.95	8.285		10.55		28.02	170		43630				
7/11/2011	DH042	11.41	8.24		14.36		23.71	200		37367				
10/19/2011	DH042	7.73	7.57		10.35		28.27	260		44044				
11/1/2011	DH042	7.485	7.575		9.375		30.215	190		46825				
1/10/2011	DH043	10.49	7.65		5.08		27.77	200		43859				
3/24/2011	DH043	9.62	7.83		7.21		29.39	290		45898				
5/16/2011	DH043	10.77	7.96		9.67		27.44	180		112.2				
7/11/2011	DH043	11.2	8.19		14.01		23.95	230		37713				
10/19/2011	DH043	7.76	7.4		10.41		28.4	300		44192				
11/1/2011	DH043	8.07	7.55		8.7		29.86	70		46398				
1/10/2011	DH044	14.4	7.935		0.795		26.625			43108				
1/18/2011	DH044	10.2	7.55		7.29		25.65			40569				
3/24/2011	DH044	10.8	8.17		8.93		28.01			43772				
5/16/2011	DH044	9.05	8.04		12.99		26.78			41764				
7/11/2011	DH044	7.75	7.855		21.455		27.85			43183				
10/19/2011	DH044	11.35	8.21		13.81		28.89			44694				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
11/1/2011	DH044	10.17	7.76		8.96		29.02			45186				
1/10/2011	DH045	13.84	8.01		0.56		26.87			43539				
1/18/2011	DH045	12.56	7.68		7.37		25.89			40883				
3/24/2011	DH045	11.48	8.32		8.73		27.81			43492				
5/16/2011	DH045	17.53	8.56		13		27.43			42673				
7/11/2011	DH045	13.91	7.4		20.18		26.77			41642				
10/19/2011	DH045	19.175	8.78		13.48		28.905			44720.5				
11/1/2011	DH045	12.49	7.67		8.86		29.08			45265				
3/30/2011	DH048						25							
5/10/2011	DH048						21							
9/20/2011	DH048						22							
11/15/2011	DH048						15							
1/18/2011	DH049	12.9	6.64		5.48		1.31	10		2526				
3/30/2011	DH049						20							
5/10/2011	DH049						7							
7/19/2011	DH049						4							
9/20/2011	DH049						14							
11/15/2011	DH049						17							
3/30/2011	DH050						20							
5/10/2011	DH050						5							
7/19/2011	DH050						0							
9/20/2011	DH050						14							
11/15/2011	DH050						15							
3/30/2011	DH051						20							
5/10/2011	DH051						5							
7/19/2011	DH051						1							
9/20/2011	DH051						12							
11/15/2011	DH051						15							
1/18/2011	DH052	12.79	7.15		5.55		1.74	10		3346				
3/30/2011	DH052						22							
5/10/2011	DH052						9							
7/19/2011	DH052						6							
9/20/2011	DH052						15							
11/15/2011	DH052						21							
3/30/2011	DH053						22							
5/10/2011	DH053						9							
7/19/2011	DH053						7							
9/20/2011	DH053						14							
11/15/2011	DH053						23							
3/30/2011	DH054						24							
5/10/2011	DH054						12							
7/19/2011	DH054						11							
9/20/2011	DH054						14							
11/15/2011	DH054						22							

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
3/30/2011	DH055						22							
5/10/2011	DH055						9							
7/19/2011	DH055						9							
9/20/2011	DH055						14							
11/15/2011	DH055						21							
1/18/2011	DH057	12.935	7.065		5.57		1.575	10		3003				
3/30/2011	DH057						24							
5/10/2011	DH057						12							
7/19/2011	DH057						10							
9/20/2011	DH057						12							
11/15/2011	DH057						25							
3/30/2011	DH058						25							
5/10/2011	DH058						13							
7/19/2011	DH058						21							
9/20/2011	DH058						14							
11/15/2011	DH058						25							
1/18/2011	DH271	12.72	7.23		5.43		2.71	20		5068				
3/30/2011	DH271						20							
5/10/2011	DH271						6							
7/19/2011	DH271						0							
9/20/2011	DH271						10							
11/15/2011	DH271						16							
3/30/2011	DH272						15							
5/10/2011	DH272						8							
7/19/2011	DH272						3							
9/20/2011	DH272						12							
11/15/2011	DH272						15							
1/10/2011	DH285	12.73	7.6		1.23		25.24	90		40998				
1/18/2011	DH285	10.46	7.545		6.7		21.375	90		34387				
3/24/2011	DH285	9.46	7.79		7.39		29.68	170		46296				
5/16/2011	DH285	10.77	8.07		10.745		26.785	130		41891				
7/11/2011	DH285	11.29	8.37		15.99		21.76	140		34557				
10/19/2011	DH285	8.69	7.72		10.84		28	150		43595				
11/1/2011	DH285	7.58	7.44		8.95		30.17	100		46812				
1/10/2011	DH286	12.14	7.47		1.23		26.63	50		43053				
1/18/2011	DH286	10.38	7.47		6.7		19.49	70		31620				
3/24/2011	DH286	9.31	8.09		8.17		29.44	150		45850				
5/16/2011	DH286	12.78	8.29		12.27		24.12	80		38060				
7/11/2011	DH286	11.59	8.52		19.12		21.54	80		34213.5				
10/19/2011	DH286	8.12	7.6		9.49		27.44	80		42905				
11/1/2011	DH286	8.91	7.36		6.59		29.73	90		46459				
1/10/2011	DH287	12.08	7.65		1.73		27.45	130		44111				
1/18/2011	DH287	9.79	7.6		6.44		16.34	50		26970				
3/24/2011	DH287	9.52	7.82		7.32		29.41	210		45902				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
5/16/2011	DH287	10.075	7.975		9.615		27.93	160		43585.5				
7/11/2011	DH287	11.85	8.32		14.77		22.59	180		35757				
10/19/2011	DH287	7.87	7.5		10.54		28.31	200		44052				
11/1/2011	DH287	7.43	7.5		9.36		30.31	200		46951				
1/10/2011	DH288	13.53	7.32		-0.51		24.05	60		39653				
1/18/2011	DH288	10.61	7.59		6.71		19.83	90		32122				
3/24/2011	DH288	9.59	7.76		7.42		29.54	93		46097				
5/16/2011	DH288	10.79	8.07		10.6		27.69	90		43180				
7/11/2011	DH288	12.04	8.35		15.8		23.63	90		37224				
10/19/2011	DH288	8.13	7.66		10.86		28.15	100		43810				
11/1/2011	DH288	7.38	6.77		9.24		30.28	100		46924				
1/4/2011	SW001	10.21	7.445		3.54		28.445	250		45147.5				
2/1/2011	SW001	10.36	7.12	7.7	4.32		28.9	190		45652			0.0045	
3/17/2011	SW001	10.05	7.86		7.13		28.22	320		44222				
4/11/2011	SW001	9.75	7.92		9.15		27.22	310		42619				
5/24/2011	SW001	10.16	7.84		12.77		28.59	300		44292				
6/7/2011	SW001	9.475	7.96	8.1	13.295		23.135	260		36571.5			0.009	
7/6/2011	SW001	8.14	7.95		17.29		27.44	260		42593				
8/18/2011	SW001	8.34	7.97		16.19		27.32	200		42436				
9/19/2011	SW001	7.21	7.6	7.9	14.85		27.21	170		42302			0.0018	
10/5/2011	SW001	7.72	6.46		11.45		28.23	250		43878				
12/29/2011	SW001	9.23	7.55	7.7	6.775		28.68	190		44948.5			0.009	
1/4/2011	SW002	9.855	7.59		6.15		29.22	166.5		45804				
2/1/2011	SW002	10.165	7.415	7.8	6.19	7.5	29.02	170	2.42	45508	2400	0.09		0.23
3/17/2011	SW002	9.845	7.825		6.74		29.435	40		46020				
4/11/2011	SW002	10.135	7.955		8.075		28.78	140		44939.5				
5/24/2011	SW002	11.07	8.14		10.83		28.65	130		44513				
6/7/2011	SW002	12.63	8.32	8.4	14.22	10	22.76	90	1.69	3600	1900	0.09		0.22
7/6/2011	SW002	9.58	8.04		15.17		28.35	80		43902				
8/18/2011	SW002	9.7	8.1		14.94		27.26	140		42403				
9/19/2011	SW002	10.83	8.06	8.3	13.9	0.77	28.18	190	1.09	43700	2600	0.18		0.09
10/5/2011	SW002	7.08	7.4		10.37		29.29	230		45445				
12/29/2011	SW002	9.03		7.8		2.2	29.88	110	2.08	46572	2400	0.09		0.13
1/17/2011	SW003	9.355	6.58		7.8		0.05			106.5				
2/7/2011	SW003	9.95	6.72	6.4	5.52	5.9	0.1		6.13	216	15	0.18		0.86
3/29/2011	SW003	8.36	7.59		9.07		0.36			729				
4/4/2011	SW003	9.53	6.985		6.96		0.175			363				
5/12/2011	SW003	8.6	9.6		7.1		0.06			133				
6/27/2011	SW003	6.66	7.2	7	20.44	6.5	2.52		3.76	4701	150	0.36		1.4
7/22/2011	SW003	4.48	7.4		19.82		10.28			17398				
8/9/2011	SW003	7.3	8.11		22.42		20.06			32126				
11/28/2011	SW003	6.06	6.71		6.13		0.49			994				
12/13/2011	SW003	5.36	7.49	6.1	2.41	4	0.73		8.42	1460	140	0.18		0.74
1/17/2011	SW004	13.07	6.71		5.42		0.02			48				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/4/2011	SW006	10.41	7.19		4.93		27.38	180		43348				
2/1/2011	SW006	12.01	6.88	7.9	3.13	5.9	22.05	110	3.74	35824	1900	0.09		0.18
3/17/2011	SW006	10.17	7.94		6.85		26.59	200		41958				
4/11/2011	SW006	10.65	8.06		8.6		22.28	130		35573				
5/24/2011	SW006	10.62	7.72		12.73		12.06	110		20149				
6/7/2011	SW006	8.83	7.92	8	13.3	5.7	26.69	140	1.55	41630	2300	0.09		0.17
7/6/2011	SW006	9.46	8.22		16.12		19.02	190		30552				
8/18/2011	SW006	9.34	8.14		15.34		24.5	150		38467				
9/19/2011	SW006	9.34	7.7	8.1	14.52	2.4	12.65	230	2.6	20320	1300	0.18		0.18
10/5/2011	SW006	9.14	7.55		11.65		19.58	150		31500				
12/29/2011	SW006	9.12	8.23	7.8	7.07	2.6	28.62	130	2.4	44835	2300	0.09		0.13
1/19/2011	SW007	12.9	6.47		4.81		0.04			86				
2/10/2011	SW007	13.94	7.29		3.88		0.05			112				
3/30/2011	SW007	11.84	7.83		7.9		0.33			126.5				
4/12/2011	SW007	12.01	7.33		7.72		0.05			101				
5/26/2011	SW007	11.645	7.49		8.79		0.04			83				
6/23/2011	SW007	11.02	7.13		11.17		0.03			61				
7/19/2011	SW007	10.9	7.37		11.8		0.03			70				
8/8/2011	SW007	10.35	7.72		14.75		0.03			75				
10/18/2011	SW007	8.11	8.02		8.44		0.05			102				
11/15/2011	SW007	12.595	7.625		5.04		0.05			101				
12/14/2011	SW007	11.865	7.935		2.98		0.07			148.5				
1/17/2011	SW008	11.06	7.15		6.68		0.05			115				
2/7/2011	SW008	9.63	7.21		5.96		0.21			443				
3/29/2011	SW008	8.54	7.73		9.33		3.04			5641				
4/4/2011	SW008	8.77	7.55		7.67		0.51			1027				
5/12/2011	SW008	7.52	7.6		11.51		0.33			679				
6/27/2011	SW008	2.54	7.45		23.95		8.37			14414				
7/22/2011	SW008	3.95	7.43		19.08		11.2			18817				
8/9/2011	SW008	4.84	7.4		22.97		22.08			35050				
9/21/2011	SW008	5.97	7.4		16.18		27.94			43318				
10/21/2011	SW008	7.06	7.16		11.19		27.59			43000				
11/28/2011	SW008	10.33	6.72		5.6		1.15			2266				
12/13/2011	SW008	8.67	7.5		0.79		15.81			26713				
1/17/2011	SW009	12.6	6.53		5.77		0.02			51				
2/7/2011	SW009	6.285	6.65	6.7	6.92	1.6	0.31		13.1	633.5	6.7	0.18		0.65
3/29/2011	SW009	11.87	7.445		9.555		0.4			803				
4/4/2011	SW009	8.55	7.23		6.9		0.25			525				
5/12/2011	SW009	8.85	7.295		11.31		0.33			674.5				
6/27/2011	SW009	1.155	7.52	7.6	15.355		0.5		12	1009	1.5	0.36		2.5
7/22/2011	SW009	1.28	7.45		15.1		3.08			5657				
11/28/2011	SW009	11.14	6.79		5.06		0.03			61				
12/27/2011	SW009	7.915	7.69	7	5.175	2.3	1.91		10.5	3636.5	140	0.09		0.78
1/17/2011	SW010	4.89	6.85		8.29		0.08			168				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/7/2011	SW010	11.03	6.29		6.84		0.2			410				
3/29/2011	SW010	9.79	6.98		9.38		0.47			942				
4/4/2011	SW010	11.27	6.88		6.54		0.33			679				
5/12/2011	SW010	11.15	7.04		15.14		0.16			336				
6/27/2011	SW010	1.48	7.32		17.37		0.47			957				
7/22/2011	SW010	1.7	6.6		15.57		0.23			475				
11/28/2011	SW010	2.8	6.9		6.25		0.38			781				
12/13/2011	SW010	4.55	7.26		1.73		0.61			1245				
1/17/2011	SW011	12.42	6.74		7.55		0.05			101				
2/7/2011	SW011	13.11	6.6		5.54		0.06			120				
3/29/2011	SW011	12.08	7.53		8.51		0.08			164				
4/4/2011	SW011	12.28	7.07		6.49		0.05			112				
5/12/2011	SW011	11.64	7		9.46		0.05			107				
6/27/2011	SW011	8.9	6.46		14.37		0.1			207				
7/22/2011	SW011	9.34	7.7		14.52		0.1			213				
8/9/2011	SW011	9.67	8.21		15.1		0.12			256				
11/28/2011	SW011	11.595	7.14		5.925		0.09			188				
12/13/2011	SW011	13.89	7.815		1.035		0.1			221				
1/17/2011	SW012	9.54	6.69		8.01		0.08			160				
2/7/2011	SW012	10.79	6.39		6.11		0.09			189				
3/29/2011	SW012	9.61	7.26		9.47		0.14			297				
4/4/2011	SW012	9.495	7.035		7.46		0.1			206				
5/12/2011	SW012	8.81	7.1		10.41		0.07			152				
6/27/2011	SW012	3.07	7.22		15.34		0.18			379				
7/22/2011	SW012	1.695	6.92		15.495		0.17			353				
11/28/2011	SW012	7.23	6.85		6.46		0.08			167				
12/13/2011	SW012	8.36	7.34		1.32		0.17			353				
1/17/2011	SW013	3.53	6.55		8.3		0.12			253				
2/7/2011	SW013	10.48	6.5		7.16		0.23			474				
3/29/2011	SW013	5.06	7.07		10.03		0.62			1241				
4/4/2011	SW013	9.16	7.17		7.2		0.29			598				
5/12/2011	SW013	6.25	7.04		11.66		0.29			596				
6/27/2011	SW013	2.33	7.21		17.36		1.14			2213				
7/22/2011	SW013	8.4	7.07		17.59		3.88			7029				
8/9/2011	SW013	32.03	8.31		19.72		3.86			6995				
11/28/2011	SW013	5.71	6.87		6.4		0.47			950				
12/13/2011	SW013	0.55	7.23		2.57		0.54			1096				
1/17/2011	SW014	10.63	6.9		7.23		0.05			104				
2/7/2011	SW014	11.37	6.82	6.5	5.92		0.06			120				
3/29/2011	SW014	10.575	7.05		8.275		0.07			140				
4/4/2011	SW014	11.03	7.06		6.31		0.05			97				
5/12/2011	SW014	9.67	6.87		8.38		0.05			113				
6/27/2011	SW014	4.19	6.67	7.4	15.23		0.16			343				
7/22/2011	SW014	2.875	7.395		16.08		0.43			867				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
11/28/2011	SW014	7.71	7.42		5.87		0.08			179				
12/13/2011	SW014	8.86	7.92	6.2	1.69		0.12			242				
1/17/2011	SW015	7.45	6.89		8.395		0.12			251				
2/8/2011	SW015	11.945	6.575	6.7	4.76	14	0.13		11	263	20	0.18		1.3
3/8/2011	SW015	7.68	6.54		6.25		0.89			1764				
4/14/2011	SW015	8.76	6.8		7.5		0.74			1464				
5/18/2011	SW015	8.12	7.02		15.17		0.57			1149				
6/28/2011	SW015	4.51	7.39	7.2	17.81	12	0.9		4.25	1769	360	0.09		1.2
7/26/2011	SW015	3.175	7.27		16.035		0.88			1722				
11/30/2011	SW015	6.44	6.2		5.42		0.2			409				
12/27/2011	SW015	9.84	7.79	6.9	4.9	4	0.56		11.4	1127	170	0.09		1.3
1/17/2011	SW016	8.91	6.76		8.29		0.11			235				
2/8/2011	SW016	8.96	6.55		5.29		0.26			536				
3/8/2011	SW016	8.07	6.96		5.56		0.42			857				
4/14/2011	SW016	11.97	7.09		7.15		0.13			277				
5/18/2011	SW016	7.33	7		15.34		0.32			647				
1/17/2011	SW017	11.55	6.8		8.55		0.17			351				
2/8/2011	SW017	10.67	6.66		4		0.39			805				
3/8/2011	SW017	5.74	6.89		5.61		1.03			2021				
4/14/2011	SW017	11.87	7.19		8.11		0.44			900				
5/18/2011	SW017	4.47	7.12		18.08		0.55			1110				
6/28/2011	SW017	0.57	7.08		18.35		0.66			1314				
1/4/2011	SW019	9.77	7.5		5.3		29.28	220		46025				
2/1/2011	SW019	10.6	7.47		4.27		29.11	250		45960				
3/17/2011	SW019	9.98	7.89		7.27		28.96	260		45287				
4/11/2011	SW019	9.67	8.02		8.87		27.89	270		43599				
5/24/2011	SW019	11.6	8.14		12.01		28.81	260		44695				
6/7/2011	SW019	9.81	7.93		13.64		18.04	250		29154				
7/6/2011	SW019	7.82	7.985		15.34		27.755	280		43058				
8/18/2011	SW019	8.23	8		15.6		27	250		41999				
9/19/2011	SW019	6.93	7.61		14.935		27.81	230		43143				
10/5/2011	SW019	7.07	7.19		10.94		28.65	210		44492				
12/29/2011	SW019	9.055					29.13	170		45543				
1/4/2011	SW022	10.07	5.41		7.29		29.1	220		45747				
2/1/2011	SW022	12.46	7.42		3.77		28.19	170		44720				
3/17/2011	SW022	10.54	8		6.41		24.77	140		39378				
4/11/2011	SW022	10.32	8.11		8.81		27.91	120		43627				
5/24/2011	SW022	12.35	8.365		12.71		28.59	130		44320				
6/7/2011	SW022	9.45	8.26		16.15		26.52	100		41315				
7/6/2011	SW022	8.88	8.22		18.02		28.01	144		43389				
8/18/2011	SW022	9.07	8.1		15.27		26.58	130		41417				
9/19/2011	SW022	8.29	7.72		13.78		28.09	190		43575				
10/5/2011	SW022	6.75	7.365		10.32		29.25	240		45398				
12/29/2011	SW022	9.63					27.16	80		42767				

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Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/4/2011	SW023	9.41	7.59		6.63		28.99	237		45443				
2/1/2011	SW023	12.41	7.47		4.46		14.5	130		24283				
3/17/2011	SW023	11.62	7.91		7.51		10.03	50		17131				
4/11/2011	SW023	10.07	8.06		8.93		25.66	140		40417				
5/24/2011	SW023	10.97	8.44		12.66		12.69	130		21135				
6/7/2011	SW023	9.18	7.92		12.44		26.93	200		41991				
7/6/2011	SW023	10.42	8.38		17.63		15.46	200		25263				
8/18/2011	SW023	10.18	8.34		15.8		22.89	150		36158				
9/19/2011	SW023	9.46	7.8		14.69		11.28	210		18957				
10/5/2011	SW023	9.14	7.58		11.62		17.42	130		28228				
12/29/2011	SW023	11.83	7.44		5.64		4.62	20		8340				
1/4/2011	SW026	12.36	7.16		-0.01		21.53			35675				
2/1/2011	SW026	13.9	7.86		0.18		0.56			1158				
3/17/2011	SW026	11.01	7.47		9.44		2.46			4616				
4/11/2011	SW026	12.34	7.85		10.57		0.4			819				
5/24/2011	SW026	12.94	7.83		15.17		4.97			8853				
6/7/2011	SW026	6.58	7.005		15.29		18.705			30105.5				
12/29/2011	SW026	8.61	7.91		6.39		23.77			37956				
1/4/2011	SW027	14.19	8.11		2.89		0.18			381				
2/1/2011	SW027	13.83	8		4.11		0.06			120				
3/17/2011	SW027	11.405	7.175		8.1		0.06			122				
4/11/2011	SW027	11.205	7.5		9.085		0.05			109.5				
5/24/2011	SW027	10.63	7.67		12.5		0.06			119				
6/7/2011	SW027	10.44	8.01		14.38		0.08			166				
12/29/2011	SW027	5.35	7.33		6.68		22.222			35600				
1/4/2011	SW028	13.73	7.23		0.27		23.12			38017				
2/1/2011	SW028	15.78	7.785		2.985		1.085			2135.5				
3/17/2011	SW028	15.3	7.33		9.82		3.86			7001				
4/11/2011	SW028	14.1	7.64		9.91		1.78			3417				
5/24/2011	SW028	12.45	7.94		14.37		7.15			12440				
6/7/2011	SW028	7.84	6.8		14.59		17.59			28467				
7/6/2011	SW028	10.03	7.54		17.62		14.91			24418				
12/29/2011	SW028	9.11	7.4		6.39		24.95			39636				
1/19/2011	SW029	13.61	6.65		4.25		0.05			104				
2/10/2011	SW029	14.97	5.4		2.06		0.05			98				
3/30/2011	SW029	11.72	2.89		7.72		0.4			80				
4/4/2011	SW029	11.92	6.86		6.43		0.04			89				
4/12/2011	SW029	12.38	4.49		7		0.5			97				
5/26/2011	SW029	10.78	4.1		9.7		0.04			88				
1/19/2011	SW030	12.99	6.84		5.52		0.2			425				
2/10/2011	SW030	15.08	7.27		3.37		1.87			3564				
3/30/2011	SW030	10.79	7.94		8.45		16.75			27399				
4/12/2011	SW030	11.34	8.14		12.83		1.69			3209				
5/26/2011	SW030	10.11	8		12.48		12.3			20533				

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Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
6/23/2011	SW030	10.57	8.31		14.93		1.19			2312				
7/19/2011	SW030	9.87	7.92		15.98		2.16			4043				
8/8/2011	SW030	9.86	8.06		17.61		1.99			3743				
9/20/2011	SW030	11.9	8.19		15.19		16.38			26642				
10/18/2011	SW030	12.03	7.42		12.06		28.65			44439				
11/15/2011	SW030	11.62	7.3		6.71		19.33			31386				
12/14/2011	SW030	11.66	7.04		3.83		16.46			27348				
1/19/2011	SW031	9.935	6.08		4.885		0.04			85				
2/10/2011	SW031	13.01	6.06		3.45		0.04			79				
3/30/2011	SW031	9.95	5.88		7.88		0.4			81				
4/12/2011	SW031	12.035	6.52		9.935		0.03			75				
5/26/2011	SW031	9.29	6.5		10.605		0.04			79				
1/19/2011	SW032	12.63	6.52		5.05		0.4			813				
2/10/2011	SW032	13.25	6.39		5.53		4.3			7980				
3/30/2011	SW032	10.35	7.84		8.33		21.41			34388				
4/12/2011	SW032	12.14	7.54		10.64		1.33			2559				
5/26/2011	SW032	10.49	7.95		12.46		17.91			28988				
6/23/2011	SW032	11.22	8.6		15.77		10.25			17323				
7/19/2011	SW032	9.89	7.97		15.42		2.56			4763				
8/8/2011	SW032	9.57	8.09		17.36		5.16			9173				
9/20/2011	SW032	11.38	8.13		13.25		10.94			18423				
10/18/2011	SW032	10.07	7.77		11.48		26.2			41010				
11/15/2011	SW032	10	7.59		7.45		25.37			40156				
12/14/2011	SW032	12.11	7.93		3.39		15.01			25102				
1/19/2011	SW033	10.26					0.05			97				
2/10/2011	SW033	11.535	7.04		2.9		0.04			92				
3/30/2011	SW033	9.075	6.225		7.92		0.45			106				
4/12/2011	SW033	11.58	6.79		9.07		0.04			93				
5/26/2011	SW033	7.69	6.99		10.34		0.05			112				
1/19/2011	SW034	12.27	6.4		4.93		0.63			1252				
2/10/2011	SW034	13.73	7.1		4.18		4.26			7749				
3/30/2011	SW034	10.28	7.87		8.31		22.48			35893				
4/12/2011	SW034	12.08	7.63		9.85		1.37			2650				
5/26/2011	SW034	10.24	7.93		12.62		16.62			27050				
6/23/2011	SW034	11.065	8.605		15.795		9.235			15727				
7/19/2011	SW034	10.1	8.125		15.305		2.375			4413.5				
8/8/2011	SW034	9.67	8.19		17.34		5.46			9680				
9/20/2011	SW034	11.09	8.07		13.41		12.73			21183				
10/18/2011	SW034	9.91	7.7		10.82		26.25			41126				
11/15/2011	SW034	10.71	7.6		7.31		24.4			38765				
12/14/2011	SW034	12.06	7.99		3.37		14.58			24492				
1/19/2011	SW035	7.43	6.77		5.33		0.34			697				
2/10/2011	SW035	13.51	6.73		2.7		0.05			98				
3/30/2011	SW035	8.88	6.85		7.96		0.12			259				

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4/4/2011	SW035	9.05	5.85		6.33		0.15			310				
4/12/2011	SW035	12.76	7.235		10.76		0.185			385				
5/26/2011	SW035	9.02	7.38		10.41		0.06			126				
1/19/2011	SW036	12.835	6.68		4.84		1.095			2166				
2/10/2011	SW036	14.13	6.62		3.17		3.32			6240				
3/30/2011	SW036	9.97	7.76		8.17		15.12			28234				
4/4/2011	SW036	11.3	7.05		6.79		7.88			13670				
4/12/2011	SW036	11.95	7.37		8.91		1.55			2978				
5/26/2011	SW036	11.34	8.13		12.17		17.64			28601				
6/23/2011	SW036	11.49	8.64		15.35		11.16			18775				
7/19/2011	SW036	10.28	8.2		15.32		4.51			8080				
8/8/2011	SW036	10.17	8.3		17.01		6.25			10960				
9/20/2011	SW036	10.43	8.05		12.97		13.33			22091				
10/18/2011	SW036	9.95	7.58		10.61		25.86			40580				
11/15/2011	SW036	9.97	7.51		7.45		25.65			40538				
12/14/2011	SW036	11.84	7.86		3.4		13.49			2284				
1/19/2011	SW037	9.25	6.96		7.66		0.18			379				
3/30/2011	SW037	10.71	6.7		8.56		0.7			157				
4/4/2011	SW037	9.95	6.84		8.01		0.13			267				
5/26/2011	SW037	7.47	7.47		12.95		0.14			295				
1/19/2011	SW038	13.01	6.95		4.78		1.33			2588				
2/10/2011	SW038	14.4	7.58		3.26		3.22			5963				
3/30/2011	SW038	10.2	7.74		8.12		25.83			40553				
4/4/2011	SW038	11.17	7.56		7.12		12.57			21120				
4/12/2011	SW038	11.92	8.08		8.41		1.74			3317				
5/26/2011	SW038	10.24	8.04		11.57		18.57			29987				
6/23/2011	SW038	12.37	8.61		15.15		13.96			23033				
7/19/2011	SW038	9.91	8.26		15.9		8.54			14636				
8/8/2011	SW038	9.48	8.24		17.17		9.11			15538				
9/20/2011	SW038	10.13	7.91		12.49		12.06			20136				
10/18/2011	SW038	9.63	7.38		9.71		24.1			38125				
11/15/2011	SW038	10.62	7.48		6.56		25.74			406444				
12/14/2011	SW038	11.83	7.92		3.35		15.7			26232				
1/19/2011	SW039	13.59	7.13		5.46		5.15			9169				
2/10/2011	SW039	10.35	7.49		6.24		25.61			40566				
3/30/2011	SW039	9.53	7.58		7.81		28.33			44331				
4/12/2011	SW039	11.09	8.01		8.52		15.89			26244				
5/26/2011	SW039	9.82	7.86		10.03		28.68			44611				
6/23/2011	SW039	10.07	8.14		13.8		22.97			36318				
7/19/2011	SW039	8.11	7.68		12.93		24.14			38030				
8/8/2011	SW039	9.97	8.01		15.14		24.12			37925				
9/20/2011	SW039	7.74	7.57		12.68		27.29			42493				
10/18/2011	SW039	8.23	6.91		10.16		27.63			43123				
11/15/2011	SW039	9.7	7.28		7.27		26.78			42183				

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12/14/2011	SW039	8.13	6.98		6.78		29.64			46302				
1/17/2011	SW051	11.11	6.76		7.74		1.55			2972				
2/7/2011	SW051	11.48	6.79		6.02		6.83			12000				
2/8/2011	SW051	11.32	6.85		4.94		15.93			26427				
3/8/2011	SW051	9.3	7.55		7.62		21.7			34778				
3/29/2011	SW051	10.04	7.88		8.45		24.99			39507				
4/4/2011	SW051	10.31	7.36		7.64		8.05			13995				
4/14/2011	SW051	9.79	7.75		8.25		18.29			29735				
5/12/2011	SW051	8.9	7.27		12.8		5.09			9053				
5/18/2011	SW051	9.27	7.69		18.84		9.67			16469				
6/27/2011	SW051	4.3	7.64		23.05		23.39			36924				
6/28/2011	SW051	4.5	7.56		22.33		23			36350				
7/22/2011	SW051	7.07	7.57		17.72		26.69			41542				
7/26/2011	SW051	7.3	7.49		17.42		24.22			38054				
8/9/2011	SW051	7.05	7.63		20.66		26.42			41175				
8/29/2011	SW051	6.54	7.65		20.34		26.6			41416				
9/21/2011	SW051	5.6	7.31		15.3		28.22			43726				
9/28/2011	SW051	6.62	7.19		14.5		28.5			44118				
10/21/2011	SW051	8.04	6.88		11.05		27.68			43139				
10/26/2011	SW051	8.52	6.77		7.36		28.73			44950				
11/28/2011	SW051	8.3	6.17		6.7		21.53			34669				
11/30/2011	SW051	9.65	6.98		6.26		26.27			41585				
12/12/2011	SW051	10.36	6.64		3.1		28.1			44693				
12/13/2011	SW051	10.19	6.76		2.55		28.95			46081				
1/19/2011	SW052	12.09	7.5		4.86		25.57			40748				
2/8/2011	SW052	13.39	7.85		3.84		26			41531				
3/8/2011	SW052	11.095	5.46		8.295		27.205			43022.5				
4/14/2011	SW052	11.16	8.12		8.25		26.16			41190				
5/18/2011	SW052	12.79	8.23		15.35		27.1			42142				
6/28/2011	SW052	7.33	8.03		20.78		27.4			42589				
7/26/2011	SW052	9.3	7.77		16.12		27.45			42618				
8/29/2011	SW052	8.71	8.02		19.23		29.05			44813				
9/28/2011	SW052	9.25	7.71		15.01		29.05			44874				
10/26/2011	SW052	10.53	7.5		6.96		29.06			45470				
11/30/2011	SW052	11.98	7.32		6.12		28.05			44135				
12/12/2011	SW052	13.19	7.6		1.38		28.17			45236				
1/17/2011	SW053	11.6	6.84		8.12		2.82			5194				
2/7/2011	SW053	10.175	6.595		5.96		2.225			4194				
3/29/2011	SW053	10.05	7.93		8.59		26.37			41475				
4/4/2011	SW053	9.65	7.06		7.25		1.67			3185				
5/12/2011	SW053	8.735	7.11		10.605		0.35			710				
6/27/2011	SW053	7.045	8.03		23.175		21.09			33618.5				
7/22/2011	SW053	6.26	7.67		17.82		23.93			37658				
8/9/2011	SW053	8.65	8		22.97		22.57			40016				
9/21/2011	SW053	5.82	7.5		15.68		28.03			43436				
10/21/2011	SW053	8.07	7.29		11.48		26.41			41312				
11/28/2011	SW053	7.79	6.43		6.73		25.71			40450				
12/13/2011	SW053	9.72	7.65		2.49		29.03			46200				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/19/2011	SW055	7.99	6.48		4.4		1.36			2632				
2/8/2011	SW055	9.47	6.5		4.88		1.84			3515				
3/8/2011	SW055	5.79	7.04		6.53		8.76			15133				
4/14/2011	SW055	8.22	7.24		7.89		5.66			10044				
5/18/2011	SW055	5.14	6.85		13.53		10.39			17544				
6/28/2011	SW055	5.23	7.29		18.87		23.53			37066				
7/26/2011	SW055	3.36	6.96		17.43		24.69			38716				
8/29/2011	SW055	4.69	6.9		18.94		25.8			40291				
10/26/2011	SW055	5.26	6.6		9.85		28.25			44017				
11/30/2011	SW055	6.94	6.58		6.16		11.58			19553				
12/12/2011	SW055	4.63	6.47		4.3		25.89			41300				
1/19/2011	SW056	8.43	7.75		4.42		0.25			513				
2/8/2011	SW056	11.1	7.75		4.83		0.49			985				
3/8/2011	SW056	9.89	7.64		5.17		2.92			5424				
4/14/2011	SW056	12.94	7.92		7.77		2.8			5166				
5/18/2011	SW056	11.25	7.585		16.205		2.59			4807.5				
6/28/2011	SW056	9.425	7.595		21.37		23.63			37236				
7/26/2011	SW056	10.6	7.65		16.76		27			41979				
8/29/2011	SW056	11.31	7.72		19.47333333		28.16			43595				
10/26/2011	SW056	5.32	7.08		9.5		28.83			44859				
11/30/2011	SW056	7.95	7.65		6.11		2.6			4872				
1/17/2011	SW058	7.6	6.51		8.01		0.28			571				
2/7/2011	SW058	8.03	6.92		7.51		0.15			313				
3/29/2011	SW058	8.57	7.08		17.24		1.64			3119				
4/4/2011	SW058	10.55	7.48		7.27		0.15			323				
5/12/2011	SW058	8.87	7.15		12.09		0.54			1091				
1/17/2011	SW059	7.79	6.25		8.5		0.16			331				
2/8/2011	SW059	10.66	6.94		4.87		0.13			277				
3/8/2011	SW059	6.71	7.03		5.52		0.76			1505				
4/14/2011	SW059	9.21	7.25		7.985		0.53			1065				
5/18/2011	SW059	7.97	7.35		14.52		0.47			946				
6/28/2011	SW059	3.39	7.43		18.42		0.94			1847				
7/26/2011	SW059	3.03	7.46		16.65		9.22			15715				
8/29/2011	SW059	6.63	7.59		17.52		24.09			37870				
11/30/2011	SW059	7.42	7.5		5.09		0.17			360				
12/12/2011	SW059	5.09	7.85		1.45		0.88			1755				
1/19/2011	SW072	10.62	6.54		4.77		0.03			72				
2/8/2011	SW072	5.37	6.4		4.76		0.09			185				
3/8/2011	SW072	5.36	6.77		5.73		0.1			215				
4/14/2011	SW072	6.4	6.94		8.6		0.1			212				
5/18/2011	SW072	6.37	7		16.31		0.12			246				
6/28/2011	SW072	3.1	7.18		18.87		0.13			281				
11/30/2011	SW072	5.14	6.44		5.47		0.05			109				
1/19/2011	SW118	12.72	6.84		4.8		0.04			86				
2/7/2011	SW118	13	6.84		5.68		0.04			91				
2/8/2011	SW118	13.38	6.64		4.58		0.04			96				

Table A.3 2011 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/10/2011	SW118	13.53	7.02		4		0.05			113				
3/8/2011	SW118	11.63	7.46		5.33		0.06			134				
3/29/2011	SW118	11.31	7.76		9.19		0.06			127				
3/30/2011	SW118	11.8	7.58		7.74		0.5			117				
4/4/2011	SW118	12	7.33		6.12		0.05			99				
4/12/2011	SW118	11.8	7.48		8.17		0.05			104				
4/14/2011	SW118	12.27	7.38		6.55		0.04			88				
5/12/2011	SW118	11.43	7.18		7.11		0.03			63				
5/18/2011	SW118	11.43	7.5		9.01		0.04			85				
5/26/2011	SW118	11.62	7.62		6.65		0.04			81				
6/23/2011	SW118	11.05	7.91		11.09		0.03			60				
6/27/2011	SW118	10.91	5.74		11.96		0.4			77				
6/28/2011	SW118	11.47	5.09		10.53		0.03			68				
7/19/2011	SW118	11.09	7.68		11.45		0.03			68				
7/22/2011	SW118	11.71	7.71		10.8		0.03			62				
7/26/2011	SW118	11.96	7.51		10.78		0.03			69				
8/8/2011	SW118	10.46	7.54		14.34		0.03			75				
8/9/2011	SW118	10.76	8.06		15.04		0.03			76				
8/29/2011	SW118	10.06	7.72		15.62		0.04			87				
9/20/2011	SW118	11.635	7.885		13.07		0.05			106				
9/21/2011	SW118	10.585	7.44		13.405		0.05			111				
9/28/2011	SW118	11.79	6.75		10.225		0.03			67.5				
10/18/2011	SW118	11.74	7.375		9.47		0.05			115				
10/21/2011	SW118	11.695	6.54		9.855		0.05			105.5				
10/26/2011	SW118	12.1	7.495		7.23		0.05			106.5				
11/15/2011	SW118	12.83	7.61		5.09		0.05			104				
11/28/2011	SW118	12.575	6.66		4.74		0.03			66				
11/30/2011	SW118	12.715	5.795		5.105		0.04			96				
12/12/2011	SW118	13.345	6.87		2.655		0.06			135				
12/13/2011	SW118	12.995	7.275		2.69		0.07			143.5				
12/14/2011	SW118	13.16	6.99		3.08		0.07			142				
12/27/2011	SW118	12.74	8.14		4.8		0.06			124				

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/10/2011	DH038						3.9		0.77			
1/18/2011	DH038						5.6		6.64			
3/24/2011	DH038						6.3		7.075			
5/16/2011	DH038						6.2		9.78			
7/11/2011	DH038						5.906		14.6			
10/19/2011	DH038						6		10.52			
11/1/2011	DH038						6.234		9.39			
1/10/2011	DH039						6.4		3.26			
1/18/2011	DH039						7.5		6.9			
3/24/2011	DH039						9.1		7.11			
5/16/2011	DH039						6.3		9.56			
7/11/2011	DH039						8.202		14.415			
10/19/2011	DH039						8.333000183		10.45			
11/1/2011	DH039						8.202		9.42			
1/10/2011	DH040						5		5.24			
3/24/2011	DH040						7.8		7.12			
5/16/2011	DH040						4.9		9.58			
7/11/2011	DH040						6.89		14.17			
10/19/2011	DH040						7		10.26			
11/1/2011	DH040						7.546		9.39			
1/10/2011	DH041						4.3		2.78			
3/24/2011	DH041						7		7.14			
5/16/2011	DH041						4.3		9.56			
7/11/2011	DH041						6.234		13.41			
10/19/2011	DH041						7		10.28			
11/1/2011	DH041						6.89		9.38			
1/10/2011	DH042						4.6		2.91			
3/24/2011	DH042						7.7		7.59			
5/16/2011	DH042						5.5		10.55			
7/11/2011	DH042						6.562		14.36			
10/19/2011	DH042						8.666999817		10.35			
11/1/2011	DH042						7.218		9.38			
1/10/2011	DH043						5.3		5.08			
3/24/2011	DH043						8.9		7.21			
5/16/2011	DH043						5		9.67			
7/11/2011	DH043						7.546		14.01			
10/19/2011	DH043						9.843000412		10.4			
11/1/2011	DH043						7.874		8.7			
1/10/2011	DH044					10.45	0.833		0.795			
1/18/2011	DH044					5.835	1.5		7.29			
3/24/2011	DH044					2.94	1.25		8.93			
5/16/2011	DH044					2.17	1		12.99			
7/11/2011	DH044					7.82	0.75		21.455			
10/19/2011	DH044					3.44	0.25		13.81			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
11/1/2011	DH044					10.045	0.833		8.96			
1/10/2011	DH045					8.98	0.833		0.56			
1/18/2011	DH045					2.93	1		7.37			
3/24/2011	DH045					3.14	1		8.73			
5/16/2011	DH045					0.68	0.333		13			
7/11/2011	DH045					22	0.5		20.18			
10/19/2011	DH045					1.515	0.333000004		13.48			
11/1/2011	DH045					1.66	0.667		8.86			
3/30/2011	DH048								9			
5/10/2011	DH048								10			
9/20/2011	DH048								16			
11/15/2011	DH048								9			
1/18/2011	DH049						7.9		5.48			
3/30/2011	DH049								9			
5/10/2011	DH049								13			
7/19/2011	DH049								15			
9/20/2011	DH049								15			
11/15/2011	DH049								9			
3/30/2011	DH050								9			
5/10/2011	DH050								13			
7/19/2011	DH050								15			
9/20/2011	DH050								16			
11/15/2011	DH050								7			
3/30/2011	DH051								9			
5/10/2011	DH051								12			
7/19/2011	DH051								15			
9/20/2011	DH051								16			
11/15/2011	DH051								7			
1/18/2011	DH052						4.1		5.55			
3/30/2011	DH052								9			
5/10/2011	DH052								12			
7/19/2011	DH052								15			
9/20/2011	DH052								16			
11/15/2011	DH052								7			
3/30/2011	DH053								9			
5/10/2011	DH053								13			
7/19/2011	DH053								15			
9/20/2011	DH053								16			
11/15/2011	DH053								8			
3/30/2011	DH054								9			
5/10/2011	DH054								13			
7/19/2011	DH054								15			
9/20/2011	DH054								15			
11/15/2011	DH054								7			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
3/30/2011	DH055								9			
5/10/2011	DH055								13			
7/19/2011	DH055								15			
9/20/2011	DH055								15			
11/15/2011	DH055								8			
1/18/2011	DH057						9.8		5.57			
3/30/2011	DH057								9			
5/10/2011	DH057								12			
7/19/2011	DH057								15			
9/20/2011	DH057								16			
11/15/2011	DH057								8			
3/30/2011	DH058								8			
5/10/2011	DH058								12			
7/19/2011	DH058								15			
9/20/2011	DH058								16			
11/15/2011	DH058								8			
1/18/2011	DH271						9.6		5.43			
3/30/2011	DH271								9			
5/10/2011	DH271								12			
7/19/2011	DH271								15			
9/20/2011	DH271								16			
11/15/2011	DH271								7			
3/30/2011	DH272								9			
5/10/2011	DH272								13			
7/19/2011	DH272								15			
9/20/2011	DH272								15			
11/15/2011	DH272								9			
1/10/2011	DH285						2.8		1.23			
1/18/2011	DH285						4.5		6.7			
3/24/2011	DH285						4.7		7.39			
5/16/2011	DH285						4.9		10.745			
7/11/2011	DH285						4.593		15.99			
10/19/2011	DH285						5		10.84			
11/1/2011	DH285						4.265		8.95			
1/10/2011	DH286						1.64		1.23			
1/18/2011	DH286						3.9		6.7			
3/24/2011	DH286						4.921		8.17			
5/16/2011	DH286						3.6		12.27			
7/11/2011	DH286						2.625		19.12			
10/19/2011	DH286						2.667		9.49			
11/1/2011	DH286						2.953		6.58			
1/10/2011	DH287						4.1		1.73			
1/18/2011	DH287						5.2		6.44			
3/24/2011	DH287						6.4		7.32			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
5/16/2011	DH287						4.9		9.615			
7/11/2011	DH287						5.906		14.77			
10/19/2011	DH287						6.667		10.54			
11/1/2011	DH287						6.562		9.37			
1/10/2011	DH288						1.9		-0.51			
1/18/2011	DH288						3.9		6.71			
3/24/2011	DH288						3.1		7.42			
5/16/2011	DH288						3.6		10.6			
7/11/2011	DH288						2.953		15.8			
10/19/2011	DH288						3.333		10.86			
11/1/2011	DH288						3.281		9.23			
1/4/2011	SW001						4.35		3.54			
2/1/2011	SW001						7.6		4.32	6.3	0.022	
3/17/2011	SW001						10.4		7.13			
4/11/2011	SW001						9.6		9.15			
5/24/2011	SW001						11.483		12.77			
6/7/2011	SW001						11.483		13.295	6.8	0.0265	
7/6/2011	SW001						11.155		17.29			
8/18/2011	SW001						10.827		16.19			
9/19/2011	SW001						14.108		14.85	9.4	0.0975	
10/5/2011	SW001						13.123		11.45			
12/29/2011	SW001						10.171		6.765	10.8	0.0409	
1/4/2011	SW002						5.55		6.15			
2/1/2011	SW002	0.926	0.09	5.4	1.5		5.577		6.19	6.4		
3/17/2011	SW002						1.312		6.74			
4/11/2011	SW002						7.3		8.075			
5/24/2011	SW002						4.265		10.83			
6/7/2011	SW002	2.44	0.1	9.9	2.2		2.953		14.22	9.3		
7/6/2011	SW002						2.625		15.17			
8/18/2011	SW002						4.593		14.94			
9/19/2011	SW002	1.46	0.18	4.4	2		6.234		13.9	10.3		
10/5/2011	SW002						7.546		10.37			
12/29/2011	SW002	1.24	0.09	4.2	1.7		3.609		7.3	9.1		
1/17/2011	SW003					30.25	4		7.8			
2/7/2011	SW003	10	0.2	22	4	42.6	3	0.5	5.52	4.7		
3/29/2011	SW003					10.9	2	-0.5	9.07			
4/4/2011	SW003					23.25	2.5	0	6.96			
5/12/2011	SW003					37.2	3.5	0.5	7.1			
6/27/2011	SW003	24.1	0.25	8.5	3.6	16.2	1.5	-1	20.44	9.8		
7/22/2011	SW003					13.7	2	-1	19.82			
8/9/2011	SW003					5.83	1.5		22.7			
11/28/2011	SW003					6.16	1.5		6.13			
12/13/2011	SW003	9.99	0.2	20	4.3	6.39	1.5		2.41	5.8		
1/17/2011	SW004						75		5.42			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/4/2011	SW006						9		4.93			
2/1/2011	SW006	0.915	0.09	8.8	1.2		13.7		3.13	6.9		
3/17/2011	SW006						7.4		6.85			
4/11/2011	SW006						6.3		8.06			
5/24/2011	SW006						6.89		12.73			
6/7/2011	SW006	1.42	0.12	7.1	1.9		11.155		13.3	5.8		
7/6/2011	SW006						12.795		16.12			
8/18/2011	SW006						12.795		15.34			
9/19/2011	SW006	1.29	0.16	4.5	1.8		14.108		14.52	8.1		
10/5/2011	SW006						11.483		11.65			
12/29/2011	SW006	1.1	0.09	6.4	1.4		6.89		7.07	6		
1/19/2011	SW007					160	7	2	4.81			
2/10/2011	SW007					11.4	3	-3.75	3.88			
3/30/2011	SW007					8.245	2.125	-3.5	7.9			
4/12/2011	SW007					17.6	3	-3	7.72			
5/26/2011	SW007					17.15	2.25	-4	8.79			
6/23/2011	SW007					37.6			11.17			
7/19/2011	SW007					25.2	4		11.8			
8/8/2011	SW007					14.2	3.5	-4	14.75			
10/18/2011	SW007					6.81	0.375		8.44			
11/15/2011	SW007					9.18	0.833		5.04			
12/14/2011	SW007					4.535	0.833		2.98			
1/17/2011	SW008					308	2.75	0	6.68			
2/7/2011	SW008					21.6	2.5	-3	5.96			
3/29/2011	SW008					22.2	1.5	-2.75	9.33			
4/4/2011	SW008					26.2	1	-3	7.67			
5/12/2011	SW008					71.7	0.833	-4	11.51			
6/27/2011	SW008					25	0.583	-5	23.95			
7/22/2011	SW008					11.2	1	-4	19.08			
8/9/2011	SW008					10.4	1.5	-4	22.84			
9/21/2011	SW008					12.3	1.25	-0.5	16.18			
10/21/2011	SW008					7.45	1	-1	11.19			
11/28/2011	SW008					258	0.667		5.6			
12/13/2011	SW008					7.79	1		0.79			
1/17/2011	SW009					627	3		5.77			
2/7/2011	SW009	10.4	0.09	5.5	1.4	19.95	2.875	-1	6.92	5.8		
3/29/2011	SW009					11.25	1.5	-2.75	9.555			
4/4/2011	SW009					24.3	2.5	-1.5	6.9			
5/12/2011	SW009					45.6	2	-1.5	11.31			
6/27/2011	SW009	21.7	0.26	14	6.2	9.95	2.125	-2	15.355	13.1		
7/22/2011	SW009					14.6	1.5	-2.5	15.1			
11/28/2011	SW009					179	4		5.06			
12/27/2011	SW009	9.9	0.18	7.4	2.4	9.22	2		5.195	9.9		
1/17/2011	SW010					20.1	4		8.29			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/7/2011	SW010					246	4	0	6.84			
3/29/2011	SW010					12.2	1.5	-0.75	9.38			
4/4/2011	SW010					372	3.5	0.5	6.54			
5/12/2011	SW010					29.5	3.25	0	15.14			
6/27/2011	SW010					51.8	0.75	-2	17.37			
7/22/2011	SW010					30.5	0.667	-2	15.57			
11/28/2011	SW010					5.77	2.5		6.25			
12/13/2011	SW010					6.8	2		1.73			
1/17/2011	SW011					28.8	2.5		7.55			
2/7/2011	SW011					13.5	2.5		5.54			
3/29/2011	SW011					5.55	1.25		8.51			
4/4/2011	SW011					105	2		6.49			
5/12/2011	SW011					34.3	2	-1.5	9.46			
6/27/2011	SW011					7.35	0.833		14.37			
7/22/2011	SW011					12.5	0.667		14.52			
8/9/2011	SW011					9.53	0.833	-3	15.1			
11/28/2011	SW011					12.35	1		5.925			
12/13/2011	SW011					1.485	0.833		1.035			
1/17/2011	SW012					6.65	4	0.5	8.01			
2/7/2011	SW012					3.77	2.75	-2.75	6.11			
3/29/2011	SW012					2.39	1.25		9.47			
4/4/2011	SW012					3.8	3	-1	7.46			
5/12/2011	SW012					12.1	3	-0.5	10.41			
6/27/2011	SW012					3.77	0.833		15.34			
7/22/2011	SW012					3.045	1	-2.5	15.49			
11/28/2011	SW012					2.22	3		6.46			
12/13/2011	SW012					1.65	1.75		1.32			
1/17/2011	SW013					23.3	4.5		8.3			
2/7/2011	SW013					66.9	5	2	7.16			
3/29/2011	SW013					19.2	3	0.75	10.03			
4/4/2011	SW013					57.1	4	1	7.2			
5/12/2011	SW013					56.9	5	0.5	11.66			
6/27/2011	SW013					22.6	6	0.5	17.36			
7/22/2011	SW013					17.9	3.5	-1	17.59			
8/9/2011	SW013					148	2.25	-2	19.72			
11/28/2011	SW013					32.5	5.5		6.4			
12/13/2011	SW013					11.8	3.5		2.57			
1/17/2011	SW014					14.1	2		7.23			
2/7/2011	SW014					13.5	2		3.92	4.6	0.022	
3/29/2011	SW014					23.6	1.5		8.275			
4/4/2011	SW014					28	1.5		6.31			
5/12/2011	SW014					18.2	1.5		8.38			
6/27/2011	SW014					7.07	0.5		15.23	11.6	0.088	
7/22/2011	SW014					7.21	1.25		16.08			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
11/28/2011	SW014					12.9	1		5.87			
12/13/2011	SW014					8.88	1		1.69	6.1	0.0159	
1/17/2011	SW015					31.95	3.125		8.395			
2/8/2011	SW015	9.88	0.41	81	9.2	99.6	5.5	-1	4.76	9.8		
3/8/2011	SW015					40.9	3	-1.75	6.25			
4/14/2011	SW015					96.4	4.5	0	7.5			
5/18/2011	SW015					14.8	4	0	15.17			
6/28/2011	SW015	22.2	0.25	11	6.7	9.79	3	-2	17.81	7.9		
7/26/2011	SW015					16.5	3.5	-1	16.035			
11/30/2011	SW015					30	5.25		5.42			
12/27/2011	SW015	11.3	0.18	12	6.6	15.5	3.5		4.9	9.6		
1/17/2011	SW016					25.4	2	-1	8.29			
2/8/2011	SW016					12.1	3.25	-2	5.29			
3/8/2011	SW016					5.46	1.25	-1	5.56			
4/14/2011	SW016					73.4	2.5	0.75	7.15			
5/18/2011	SW016					9.95	3	-0.5	15.34			
1/17/2011	SW017					67.1	5	0	8.55			
2/8/2011	SW017					30.3	3	-0.25	4			
3/8/2011	SW017					32.9	3	0	5.61			
4/14/2011	SW017					52.9	3	1	8.11			
5/18/2011	SW017					10.8	2	1	18.08			
6/28/2011	SW017					30.8	0.5	-0.5	18.35			
1/4/2011	SW019						17.3		5.3			
2/1/2011	SW019						14		4.27			
3/17/2011	SW019						15.3		7.27			
4/11/2011	SW019						11.9		8.87			
5/24/2011	SW019						12.9		12.01			
6/7/2011	SW019						13.451		13.64			
7/6/2011	SW019						13.123		15.34			
8/18/2011	SW019						13.451		15.6			
9/19/2011	SW019						16.076		14.935			
10/5/2011	SW019						17.388		10.94			
12/29/2011	SW019						14.108		7.155			
1/4/2011	SW022						6.4		5.41			
2/1/2011	SW022						5.577		3.77			
3/17/2011	SW022						4.593		6.41			
4/11/2011	SW022						4		8.81			
5/24/2011	SW022						4.265		12.71			
6/7/2011	SW022						3.281		16.15			
7/6/2011	SW022						4.8		18.02			
8/18/2011	SW022						4.265		15.27			
9/19/2011	SW022						6.234		13.78			
10/5/2011	SW022						7.874		10.32			
12/29/2011	SW022						3.281		6.87			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/4/2011	SW023						7.9		6.63			
2/1/2011	SW023						6.2		4.46			
3/17/2011	SW023						7.4		7.51			
4/11/2011	SW023						5.3		8.93			
5/24/2011	SW023						4.265		12.66			
6/7/2011	SW023						6.562		12.44			
7/6/2011	SW023						6.562		17.63			
8/18/2011	SW023						6.234		15.8			
9/19/2011	SW023						7.874		14.69			
10/5/2011	SW023						9.843		11.62			
12/29/2011	SW023						5.577		5.59			
1/4/2011	SW026					1.58	0.417	-1	-0.01			
2/1/2011	SW026					2.77	0.333		0.18			
3/17/2011	SW026					3.25	0.333		9.44			
4/11/2011	SW026					6.13	0.333		7.85			
5/24/2011	SW026					10.7	0.25		15.17			
6/7/2011	SW026					4.255	0.25	-0.5	15.29			
12/29/2011	SW026					1.3	0.375		6.39			
1/4/2011	SW027					2.77	0.417	-2.5	2.89			
2/1/2011	SW027					2.67	0.5	-2.5	4.11			
3/17/2011	SW027					2.22	0.5		8.1			
4/11/2011	SW027					2.875	0.417		9.085			
5/24/2011	SW027					5.08	0.333		12.5			
6/7/2011	SW027					9.17	0.25		14.38			
12/29/2011	SW027					5.2	0.333		6.68			
1/4/2011	SW028					2.91	0.833	-2.5	0.27			
2/1/2011	SW028					5.68	1	-1.25	2.985			
3/17/2011	SW028					3.54	0.667	-1.5	9.82			
4/11/2011	SW028					6.42	0.917		9.91			
5/24/2011	SW028					8.38	0.833		14.37			
6/7/2011	SW028					5.39	0.5	-1	14.59			
7/6/2011	SW028					14.9	0.5		17.62			
12/29/2011	SW028					2.77	0.583		6.39			
1/19/2011	SW029					11.1	1.5	-1	4.25			
2/10/2011	SW029					11.1	1.5	-1.5	2.06			
3/30/2011	SW029					73.2	1		7.72			
4/4/2011	SW029					15.9	1		6.43			
4/12/2011	SW029					11.6	0.5	-1.5	7			
5/26/2011	SW029					44.6	0.5	-1	9.7			
1/19/2011	SW030					141	1		5.52			
2/10/2011	SW030					7.06	1		3.37			
3/30/2011	SW030					72.8	1		8.45			
4/12/2011	SW030					31.7	0.5		12.83			
5/26/2011	SW030					64.7	1		12.48			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
6/23/2011	SW030					89.8	0.5		14.93			
7/19/2011	SW030					125	0.917		15.98			
8/8/2011	SW030					85	1		17.61			
9/20/2011	SW030					2.93	0.833		15.19			
10/18/2011	SW030					0.8	1.75		12.06			
11/15/2011	SW030					5.27	1.25		6.71			
12/14/2011	SW030					3.53	0.917		3.83			
1/19/2011	SW031					8.55	0.833	0	4.885			
2/10/2011	SW031					11.9	0.5		3.45			
3/30/2011	SW031					25	0.25		7.88			
4/12/2011	SW031					11.35	1		9.935			
5/26/2011	SW031					17.15	0.9375		10.605			
1/19/2011	SW032					146	1.75		5.05			
2/10/2011	SW032					9.39			5.53			
3/30/2011	SW032					29.8	1.75		8.33			
4/12/2011	SW032					17.6	2.5		10.64			
5/26/2011	SW032					31.2	2.5		12.46			
6/23/2011	SW032					16.2	3		15.77			
7/19/2011	SW032					78.8	2		15.42			
8/8/2011	SW032					26.4	3.25		17.36			
9/20/2011	SW032					8.32	2.5		13.25			
10/18/2011	SW032					1.11	1.5		11.48			
11/15/2011	SW032					2.59	2		7.45			
12/14/2011	SW032					3.63	2.2552		3.39			
1/19/2011	SW033					12.7	0.417		4.65			
2/10/2011	SW033					13.1	1		2.9			
3/30/2011	SW033					28.95	1.5		7.92			
4/12/2011	SW033					11.2	1.5		9.07			
5/26/2011	SW033					22.6	1		10.34			
1/19/2011	SW034					153	1		4.93			
2/10/2011	SW034					7.27	1.5		4.18			
3/30/2011	SW034					28.9	1.75		8.31			
4/12/2011	SW034					15.6	2.5		9.85			
5/26/2011	SW034					23.5	1.75		12.62			
6/23/2011	SW034					20.9	2.75		15.795			
7/19/2011	SW034					158.5	1.25		15.3			
8/8/2011	SW034					27.4	2.5		17.34			
9/20/2011	SW034					4.23	2.5		13.41			
10/18/2011	SW034					1.2	2		10.82			
11/15/2011	SW034					2.61	2.5		7.31			
12/14/2011	SW034					2.13	2.5		3.37			
1/19/2011	SW035					33.9	0.5	0	5.33			
2/10/2011	SW035					8.24	0.5		2.7			
3/30/2011	SW035					93.3	0.667		7.96			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
4/4/2011	SW035					34.1	0.25		6.33			
4/12/2011	SW035					23.75	0.25		10.76			
5/26/2011	SW035					13.4			10.41			
1/19/2011	SW036					159	2.25		4.84			
2/10/2011	SW036					6.76	2.5		3.17			
3/30/2011	SW036					120	1.5		8.17			
4/4/2011	SW036					61.8	1.5		6.79			
4/12/2011	SW036					16.5	3		8.91			
5/26/2011	SW036					27.4	1.75		12.17			
6/23/2011	SW036					15.3	3.25		8.64			
7/19/2011	SW036					41.4	1.75		15.32			
8/8/2011	SW036					15	2.25		17.01			
9/20/2011	SW036					4.43	2.5		12.97			
10/18/2011	SW036					1.54	2.25		10.61			
11/15/2011	SW036					2.9	2.25		7.45			
12/14/2011	SW036					2.34	2.5		3.59			
1/19/2011	SW037					2	0.125		7.66			
3/30/2011	SW037					22.8	0.417		8.56			
4/4/2011	SW037					6.37	0.25		8.01			
5/26/2011	SW037					7.51	0.208		12.95			
1/19/2011	SW038					150	2		4.78			
2/10/2011	SW038					6.18	2.5		3.26			
3/30/2011	SW038					7.13	1.75		8.12			
4/4/2011	SW038					73.8	1.5		7.12			
4/12/2011	SW038					17.5	2.5		8.41			
5/26/2011	SW038					13.4	2.25		11.57			
6/23/2011	SW038					15.2	3		15.15			
7/19/2011	SW038					30.9	3		15.9			
8/8/2011	SW038					12.2	3		17.17			
9/20/2011	SW038					4.83	2.5		12.49			
10/18/2011	SW038					1.5	2.25		9.71			
11/15/2011	SW038					2.14	2		6.56			
12/14/2011	SW038					2.73	2		3.35			
1/19/2011	SW039					47.2	1.5		5.46			
2/10/2011	SW039					2.85	2		6.24			
3/30/2011	SW039					3.55	1.75		7.81			
4/12/2011	SW039					8.13	2.5		8.52			
5/26/2011	SW039					7.73	2		10.03			
6/23/2011	SW039					5.85	2.25		13.8			
7/19/2011	SW039					4.8	2.5		12.93			
8/8/2011	SW039					9.23	2.25		15.14			
9/20/2011	SW039					1.99	2.5		12.68			
10/18/2011	SW039					1.78	2.25		10.16			
11/15/2011	SW039					2.21	2		7.27			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
12/14/2011	SW039					1.26	2.5		6.78			
1/17/2011	SW051					138	1	1.5	7.74			
2/7/2011	SW051					41	1	-4	6.02			
2/8/2011	SW051					75.45	0.5	-4	4.94			
3/8/2011	SW051					8.54	0.667	-4.5	7.62			
3/29/2011	SW051					6.55	0.5	-3.5	8.45			
4/4/2011	SW051					21.7	0.833	-4.75	7.64			
4/14/2011	SW051					7.81	0.5	-4.75	8.25			
5/12/2011	SW051					24.8	0.583	-4.75	12.8			
5/18/2011	SW051					42.1	0.833	-7	18.84			
6/27/2011	SW051					10.6	0.583	-5.75	23.05			
6/28/2011	SW051					11.8	0.5	-5.5	22.33			
7/22/2011	SW051					8.32	0.333	-4.75	17.72			
7/26/2011	SW051					19.7	0.833	-6	17.42			
8/9/2011	SW051					15.4	0.5	-5.5	20.66			
8/29/2011	SW051					11	2.8335	5	20.34			
9/21/2011	SW051					4.33	1.25		15.3			
9/28/2011	SW051					5.02	0.833	-5	14.5			
10/21/2011	SW051					6.85	0.833		11.05			
10/26/2011	SW051					3.56	0.667		7.36			
11/28/2011	SW051					7.23	0.833		6.7			
11/30/2011	SW051					3.49	0.917		6.26			
12/12/2011	SW051					5.04	0.833		3.1			
12/13/2011	SW051					4.5	0.833		2.55			
1/19/2011	SW052					0.73	1.25		4.86			
2/8/2011	SW052					2.71	0.833		3.84			
3/8/2011	SW052					1.625	1		8.295			
4/14/2011	SW052					3.27	0.833		8.25			
5/18/2011	SW052					0.98	0.75		15.35			
6/28/2011	SW052					1.43	1		20.78			
7/26/2011	SW052					6.24	0.667		16.12			
8/29/2011	SW052					6.82	1		19.23			
9/28/2011	SW052					1.03	1		15.01			
10/26/2011	SW052					0.67	0.667		6.96			
11/30/2011	SW052					0.87	1		6.12			
12/12/2011	SW052					0.61	1		1.38			
1/17/2011	SW053					27.2	1.5		8.12			
2/7/2011	SW053					47.15	2		5.96			
3/29/2011	SW053					5.02	1.5		8.59			
4/4/2011	SW053					21.3	1.75		7.25			
5/12/2011	SW053					49.7	2.5		10.605			
6/27/2011	SW053					7.07	2.25		23.175			
7/22/2011	SW053					7.2	3		17.82			
8/9/2011	SW053					6.15	2.25		22.97			
9/21/2011	SW053					9.26	2		15.68			
10/21/2011	SW053					11	2		11.48			
11/28/2011	SW053					6.53	2.5		6.73			
12/13/2011	SW053					5.16	2.25		2.49			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/19/2011	SW055					129	2	1.5	4.4			
2/8/2011	SW055					46.9	2.5	-3	4.88			
3/8/2011	SW055					12.6	2	-1	6.53			
4/14/2011	SW055					9.54	2	-0.5	7.89			
5/18/2011	SW055					9.25	1.25	-0.5	13.53			
6/28/2011	SW055					5.22	0.917	-2	18.87			
7/26/2011	SW055					5.04	1	-1	17.43			
8/29/2011	SW055					3.81	1.5		18.64			
10/26/2011	SW055					4.98	1.25		9.85			
11/30/2011	SW055					23.3	2.5		6.16			
12/12/2011	SW055					22	1.25		4.3			
1/19/2011	SW056					148	3	2.5	4.42			
2/8/2011	SW056					71.3	2.5	0.75	4.83			
3/8/2011	SW056					19.3	2.5	0	5.17			
4/14/2011	SW056					14.7	2.5	0	7.77			
5/18/2011	SW056					14.55	0.833	-1	16.205			
6/28/2011	SW056					15.35	0.667	-2.625	21.37			
7/26/2011	SW056					10.8	0.833	-1.5	16.76			
8/29/2011	SW056					14.25	0.833	-1	19.425			
10/26/2011	SW056					5.49	1		9.52			
11/30/2011	SW056					27.7	1.75		6.11			
1/17/2011	SW058					148	2	0	8.01			
2/7/2011	SW058					39	2.5		7.51			
3/29/2011	SW058					38.4	1	0	10.24			
4/4/2011	SW058					50.2	1.25	0	7.27			
5/12/2011	SW058					30.5	1.5	0	12.09			
1/17/2011	SW059					37.8	4.75		8.5			
2/8/2011	SW059					74.3	3	1	4.87			
3/8/2011	SW059					31.8	3	-1.5	5.52			
4/14/2011	SW059					31.15	3	-0.5	7.985			
5/18/2011	SW059					15.7	2.5	0	14.52			
6/28/2011	SW059					12.9	2.5	-1	18.42			
7/26/2011	SW059					10	1.5	-0.5	16.65			
8/29/2011	SW059					135	1	-1	17.52			
11/30/2011	SW059					26.1	2.5		5.09			
12/12/2011	SW059					8.72	2		1.45			
1/19/2011	SW072					137	6	0	4.77			
2/8/2011	SW072					8.59	2.25	-1	4.76			
3/8/2011	SW072					5.94	3		5.73			
4/14/2011	SW072					5.33	2.5		8.6			
5/18/2011	SW072					4.7	3		16.31			
6/28/2011	SW072					20	1.5	-1	18.87			
11/30/2011	SW072					38.9	1.5		5.47			
1/19/2011	SW118					165	6		4.8			
2/7/2011	SW118					43.5	2.75		5.68			
2/8/2011	SW118					25.3	2		4.58			

Table A.4 2011 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/10/2011	SW118					10.9	1.125		4			
3/8/2011	SW118					5.84	1		5.33			
3/29/2011	SW118					4.68	0.833		9.19			
3/30/2011	SW118					15.8	0.833		7.74			
4/4/2011	SW118					26.6	1		6.12			
4/12/2011	SW118					16.4	0.6		8.17			
4/14/2011	SW118					16.4	0.333		7.38			
5/12/2011	SW118					152	2.5		7.11			
5/18/2011	SW118					28.1	1		9.01			
5/26/2011	SW118					22.3			6.65			
6/23/2011	SW118					34.8	0.75		11.09			
6/27/2011	SW118					12.2	0.917		11.96			
6/28/2011	SW118					19.8	0.833		10.53			
7/19/2011	SW118					26.2	1.5		11.45			
7/22/2011	SW118					30.7	1		10.8			
7/26/2011	SW118					18.7	0.583		10.78			
8/8/2011	SW118					15.6	0.667		14.34			
8/9/2011	SW118					15.2	0.833		15.04			
8/29/2011	SW118					14.5	1		15.62			
9/20/2011	SW118					7.87	1		13.07			
9/21/2011	SW118					6.505			13.4			
9/28/2011	SW118					135	1		10.225			
10/18/2011	SW118					5.38	1.25		9.47			
10/21/2011	SW118					9.62	0.7915		9.855			
10/26/2011	SW118					4.84	0.583		7.23			
11/15/2011	SW118					10.2	0.75		5.09			
11/28/2011	SW118					195.5	2.5		4.74			
11/30/2011	SW118					32.45	1.25		5.105			
12/12/2011	SW118					4.38	0.667		2.655			
12/13/2011	SW118					5.55	0.5		2.695			
12/14/2011	SW118					4.31	0.667		3.08			
12/27/2011	SW118					9.45	0.417		4.8			