Quality Assurance Project Plan

Puyallup River Watershed Fecal Coliform Bacteria Total Maximum Daily Load Study

by
Lawrence Sullivan

Washington State Department of Ecology
Environmental Assessment Program
Olympia, Washington 98504-7710

December 2006

Publication Number 06-03-115

This plan is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/0603115.html

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

If you need this publication in an alternate format, call Carol Norsen at 360-407-7486. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

Quality Assurance Project Plan

Puyallup River
Fecal Coliform Bacteria
Total Maximum Daily Load Study

December 2006

2004 303(d) Listings Addressed in this Study: (see Table 1)

Waterbody Numbers: WA-10-1010, -1020, -1021, -1022, -1032, -1040, -1050, -1060

Project Code: 06-044

Approvals

Approved by:	December 2006
Cindy James, Client/TMDL Lead, Water Quality Program, Southwest Regional Office (SWRO)	Date
Approved by:	December 2006
Kim McKee, Unit Supervisor, Water Quality Program, SWRO	Date
Approved by:	December 2006
Kelly Susewind, Section Manager, Water Quality Program, SWRO	Date
Approved by:	December 2006
Lawrence Sullivan, Project Manager, Field Lead, and EIM Data Engineer, Water Quality Studies Unit	Date
Approved by:	December 2006
Anise Ahmed, Project Oversight, Water Quality Studies Unit	Date
Approved by:	December 2006
Karol Erickson, Unit Supervisor, Water Quality Studies Unit	Date
Approved by:	December 2006
Will Kendra, Section Manager, Watershed Ecology Section	Date
Approved by:	December 2006
Stuart Magoon, Director, Manchester Environmental Laboratory	Date
Approved by:	December 2006
Bill Kammin, Ecology Quality Assurance Officer	Date

Table of Contents

Abstract

The Puyallup River, White River, Clear Creek, Swan Creek, and Boise Creek have been listed by the state of Washington under Section 303(d) of the Clean Water Act for non-attainment of Washington State fecal coliform (FC) bacteria criteria. The listings are based on sampling done by the Washington State Department of Ecology (Ecology) in 1987, 1993, 1995, 1996, 2000, 2001, and 2002.

The Environmental Protection Agency requires states to set priorities for cleaning up 303(d) listed waters and to establish a Total Maximum Daily Load (TMDL) for each. A TMDL entails an analysis of how much of a pollutant load a waterbody can assimilate without violating water quality standards. The Puyallup River TMDL Study will address the 303(d) listings for bacteria within the watershed.

This Quality Assurance Project Plan describes the technical study that will monitor levels of FC bacteria in the Puyallup River watershed, and will form the basis for allocation of contaminant loads to sources. The study will be conducted by Ecology's Environmental Assessment Program.

What is a Total Maximum Daily Load, or TMDL?

Federal Clean Water Act Requirements

The federal Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards are set to protect designated uses such as cold water biota and drinking water supply.

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

Water Quality Assessment/Categories 1-5

The 303(d) list identifies polluted waters in Washington. The Water Quality Assessment tells a more complete story about the condition of Washington's water. This assessment divides water bodies into one-of-five categories:

Category 1 – Meets tested standards for clean water.

Category 2 – Waters of concern.

Category 3 – No data available.

Category 4 – Polluted waters that do not require a TMDL since the problems are being solved in one of three ways:
- 4a. Has a TMDL approved and it's being implemented.
- 4b. Has a pollution control plan in place that should solve the problem.
- 4c. Impaired by a non-pollutant such as low-water flow, dams, and culverts.

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

TMDL Process Overview

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each of the Category 5 waterbodies on the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. Then the local community works with Ecology to develop a strategy to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities.

Elements Required in a TMDL

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

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

The TMDL must also consider seasonal variations and include a margin of safety that recognizes the limitations in the knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Total Maximum Daily Load Analyses: Loading Capacity

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

Introduction

Water quality monitoring has identified reaches of the Puyallup River, White River, Clear Creek, Swan Creek, and Boise Creek that do not meet state or federal water quality standards for FC bacteria. As a result, these reaches have been included on Washington State's 303(d) List for 2004 (Table 1).

This Quality Assurance (QA) Project Plan describes the technical study that will develop FC bacteria TMDLs for the Puyallup River and its tributaries. These TMDLs will set water quality targets to meet FC bacteria standards, identify key reaches for source reduction, and allocate pollutant loads to point and nonpoint sources. The study will be conducted by Ecology's Environmental Assessment (EA) Program in cooperation with Ecology's Water Quality Program at the Southwest Regional Office, and other local governments.

Table 1. Reaches of the Puyallup River, White River, Clear Creek, Swan Creek, and Boise Creek with Category 5 Clean Water Act Section 303(d) listings (2004 list) for fecal coliform bacteria (FC) not meeting water quality standards. These listings will be addressed in the Puyallup River FC TMDL study.

Waterbody	Listing ID	Township, Range, Section
Puyallup River	16712 7498	20N 04E 22 20N 04E 18
White River	16711 16708 16709	21N 05E 29 20N 06E 34 20N 04E 49
Clear Creek	7501	20N 03E 11
Swan Creek	7514	20N 03E 11
Boise Creek	16706	20N 06E 34

Project Objectives

Objectives of the proposed study are as follows:

- Determine FC bacteria concentrations and loads from tributaries, point sources, and drainages in the Puyallup River study area under various seasonal and hydrological conditions, including storms.
- Establish FC load allocations (for nonpoint sources) and wasteload allocations (for point sources) to protect beneficial uses, including primary and secondary contact. The study will develop wasteload allocations for stormwater, but due to limited resources, every source of stormwater runoff will not be characterized. Stormwater wasteload allocations will be estimated based on the best available data.
- Identify the sources and relative contributions of FC loadings to the Puyallup River so clean-up activities can focus on the largest sources.

Water Quality Standards and Beneficial Uses

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

A revised water quality standards rule (Chapter 173-201A WAC) was adopted on July 1, 2003. The freshwater bacteria criteria portion of this version has recently been approved by the U.S. Environmental Protection Agency (EPA).

The Puyallup River is classified as *Secondary Contact Recreation* water (previously Class B) from the mouth to river mile (RM) 1, *Primary Contact Recreation* water (previously Class A) from RM 1 to RM 31.6 (Kings Creek), and *Extraordinary Primary Contact Recreation* (previously Class AA) from Kings Creek to the headwaters.

The White River is classified as *Primary Contact Recreation* water (Class A) from the mouth to Mud Mountain Dam and *Extraordinary Primary Contact Recreation* (Class AA) from Mud Mountain Dam to the headwaters. Clear Creek, Swan Creek, and Boise Creek are classified as *Primary Contact Recreation* waters.

Numeric criteria for specific water quality parameters are intended to protect designated uses. Under the revised water quality standards, while the waterbody classification system has changed, the FC bacteria numeric target for each of the waterbodies included in this study has not. Freshwater standards are listed below for bacteria (Table 2).

Table 2. Water Contact Recreation Bacteria Criteria in Fresh Water.

Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.
Secondary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies/100 mL.

The FC criteria have two statistical components, a geometric mean and an upper limit value that 10% of the samples cannot exceed. Concentrations of fecal coliforms measured in environmental samples follow log-normal distribution. In Washington State FC TMDL studies, the upper limit statistic (i.e. not more than 10% of the samples shall exceed) has been interpreted to be equivalent to the 90^{th} percentile value of the log normalized values (Cusimano, 1997; Joy, 2000; Sargeant, 2002). Colony forming units (cfu) is assumed to be equivalent to colonies for purpose of comparing to water quality standards.

Background

Study Area

The Puyallup River basin, Water Resource Inventory Area 10 (Figure 1), drains an area of approximately 1,065 square miles and has over 728 miles of rivers and streams which flow over 1,287 linear miles. Included in the watershed are more than a dozen cities and towns, including the state's third largest city, Tacoma. The major streams of the basin are the Puyallup River and its two largest tributaries: the White and Carbon Rivers. The study area excludes the Clarks Creek and South Prairie Creek watersheds, where bacteria TMDLs have recently been done. The study area also excludes the direct drainages to Puget Sound that are not directly connected to the Puyallup River. The TMDL does not have jurisdiction on the Puyallup and Muckleshoot Reservations.

The Puyallup River originates from the Puyallup glacier of Mount Rainier in the Cascade Range and empties into Puget Sound at Commencement Bay. The lower reach of the Puyallup River is a relatively flat floodplain ranging in elevation from sea level at Commencement Bay to approximately 50 feet at the confluence of the White and Puyallup Rivers. The mouth of the Puyallup River is a salt-wedge estuary, with deeper marine water overlain by a layer of fresh water.

The White River enters the Puyallup River near the city of Puyallup and drains a 494 square-mile basin with a total length of 68 miles. Mud Mountain Dam, at about river mile 28 on the White River, affects flow in the White River. Water is removed from the White River at about river mile 24 and stored in Lake Tapps, then returned to the White River at about river mile 4. Water stored in Lake Tapps was previously used for power generation but is no longer the case; so, much more water is now kept in the mainstem of the White River.

The Puyallup River basin has a temperate marine climate with warm, dry summers and cool, wet winters. The mean annual temperature is about 52^{o}F (degrees Fahrenheit). The warmest month is July, with an average temperature of about 64^{o}F; the coolest month is January, with an average temperature of about 39^{o}F. Annual average rainfall in the basin ranges from 40 inches at the city of Puyallup to 70 inches at Electron Dam on the Puyallup River (RM 41). Mountain snowpack has been recorded at up to 150 inches. Eighty percent of the precipitation occurs during the months of October through March. Snow occasionally falls in the lower watershed, but it soon melts.

The Puyallup River basin was one of the first watersheds in Puget Sound to experience the full impacts of industrial, urban, and agricultural development. The Puyallup River basin has been substantially altered from its historic condition. In particular, the lower river bears little resemblance to its historic past. Extensive urban growth, heavy industry, a large modern marine port, an extended revetment and levee system and agriculture have combined to significantly alter the natural landscape. The area is experiencing rapid residential growth, generally into areas that were previously agricultural.

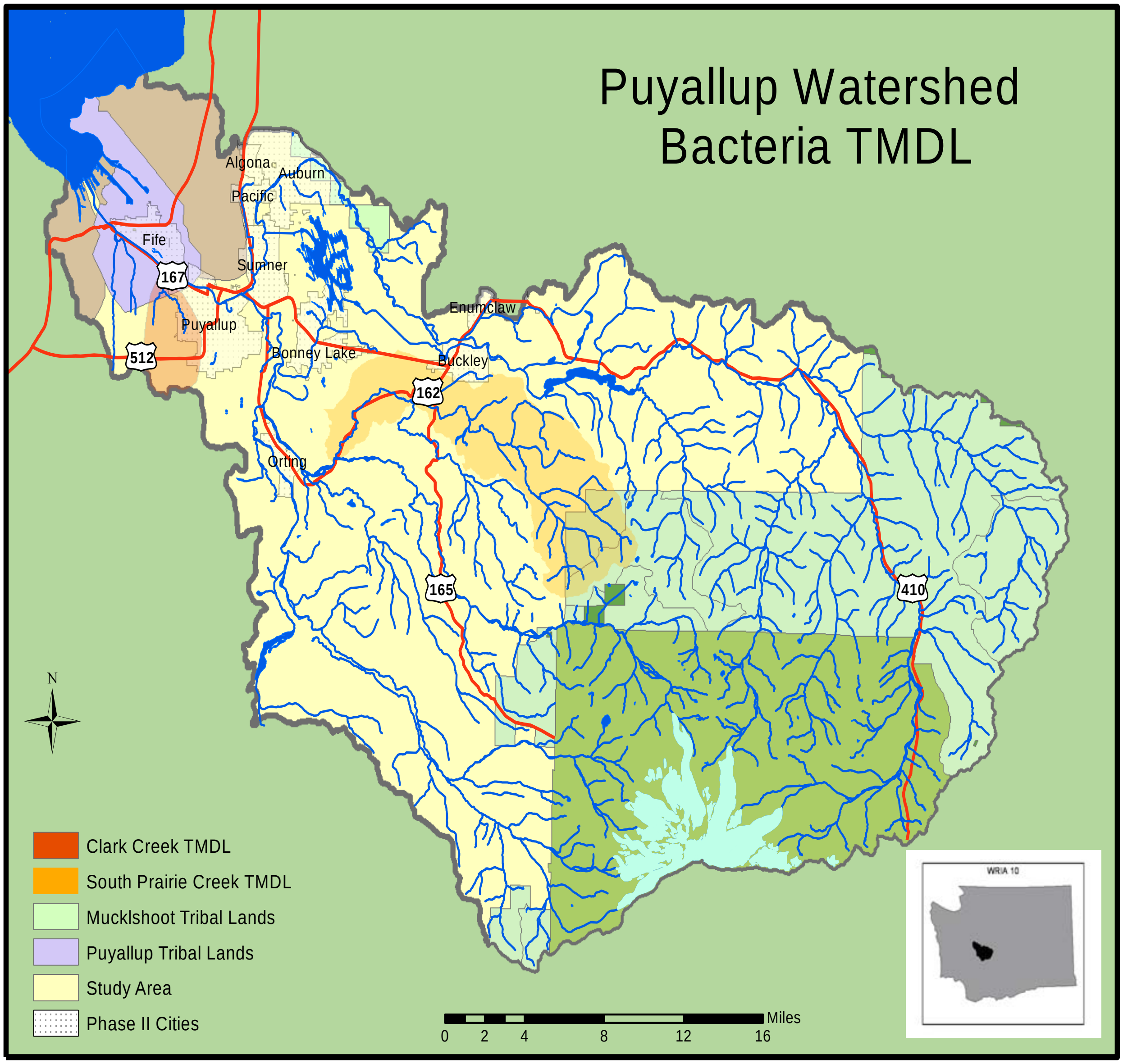

Figure 1. Study Area

Potential Sources of Bacteria

Point Sources/ Permit Holders

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

The Puyallup River watershed serves as receiving water to three separate municipal wastewater treatment plants (WWTP). These include the city of Puyallup, the town of Orting, and the town of Carbonado WWTPs. The White River watershed also includes four WWTPs. These include the city of Enumclaw, the city of Sumner, the city of Buckley, and the Rainier School WWTPs (Table 3). This list excludes point sources that may be in the Clarks Creek or South Prairie Creek watersheds, which have been addressed in other TMDLs.

Table 3. WWTPs in the Puyallup Watershed TMDL.

Wastewater Treatment Plant	Treatment	Receiving Water
City of Puyallup	UV	Puyallup River
Town of Orting Town of Carbonado	UV Chlorination	Carbon River
City of Enumclaw City of Sumner City of Buckley Rainier School	UV UV UV Chlorination	White River

Wildlife and Background Sources

A wide variety of perching birds, upland game birds, raptors, and waterfowl are found within the Puyallup watershed. Birds, elk, deer, beaver, muskrat, and other wildlife in rural areas are potential sources of FC bacteria. Open fields are attractive feeding grounds for some birds whose presence can increase FC counts in runoff.

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

Nonpoint Sources

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

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

Stormwater Sources

During precipitation events, rainwater washes the surface of the landscape, pavement, rooftops, and other impervious surfaces. This stormwater runoff can accumulate and transport fecal matter via stormwater drains to receiving waters and potentially degrade water quality (Lubliner, 2005).

NPDES Phase II stormwater regulations require stormwater permits from large and medium Municipal Separate Storm Sewer Systems (MS4s) as established by Title 40 CFR 122.26, except for municipal separate storm sewers (MS3s) owned or operated by the Washington State Department of Transportation (WSDOT). Phase I permittees in the Puyallup watershed TMDL include the city of Tacoma, King County, and Pierce County. Stormwater contributions from each permittee will be differentiated by bracketing the permittees' jurisdictions with sampling sites.

NPDES Phase II stormwater regulations require stormwater permits for all municipalities located in urbanized areas or cities outside of urbanized areas that have a population of greater than 10,000. Ecology has completed a Phase II Municipal Stormwater Permit for Western Washington. Phase II cities in the Puyallup watershed TMDL include Algona, Auburn, Bonney Lake, Buckley, Enumclaw, Fife, Orting, Pacific, Puyallup, and Sumner.

The study will also evaluate stormwater contributions from the WSDOT highways stormwater collection systems. A formal draft WSDOT Municipal Stormwater Permit will be made available for public comment in summer 2006. The permit issuance date is dependent upon the nature and volume of comments. Under the new general permit, WSDOT stormwater discharges will be required to meet Washington State surface water quality standards (Ecology 2006b).

Historical Data Review

USGS

The U.S. Geological Survey (USGS) currently operates twelve streamflow gages in the Puyallup watershed. Data from ten gages are directly applicable to the Puyallup TMDL, as well as data from one historic gage (Table 4). Two additional streamflow gages (on Clarks Creek near the city of Tacoma and on South Prairie Creek near the Town of South Prairie) are outside of the study area because these creeks were addressed in previous FC TMDLs. Ecology does not currently operate any streamflow gages in the watershed.

Table 4. USGS Gages in the Study Area

USGS Gage #	Site Description	Years of Data
12101500	Puyallup River at Puyallup	May 1914 - Sep 2005
12093500	Puyallup River near Orting	Jan 1932 - Sep 2005
12092000	Puyallup River near Electron	Jan 1909 - Sep 2005
12102190	Swan Creek near Tacoma	Jan 1990 - Dec 2004
12100496	White River near Auburn	Jan 1988 - Sep 1998
12099000	White River at Buckley	Jan 1982 - Sep 2005
12099600	Boise Creek at Buckley	Mar 1977 - Sep 2005
12099200	White River above Boise Creek	Jan 2004 - Sep 2005
12098500	White River above Buckley	Jan 1929 - Sep 2003
12101100	Lake Tapps Diversion at Dieringer	Jan 1958 - Sep 2005
12097500	Greenwater River at Greenwater	Mar 1978 - Sep 2005

There are three USGS gages on the Puyallup River and one on Swan Creek, a tributary to the Puyallup. The Puyallup River at Puyallup (#12101500) has been operating from May 1914 to the present. Mean monthly flow data for this gage are summarized in Figure 2. The center line of the box plot represents the arithmetic mean of the data, while the top and bottom of the box plots represent the 90th and 10th percentiles, respectively, of the data. The lines extending from the top and bottom of the box plots represents the range of the data. Swan Creek near Tacoma (#12012190) contains data from January 1990 to December 2004 and is summarized in Figure 3.

The Puyallup River near Orting (#12093500) and the Puyallup River near Electron (#12092000) are summarized in the Appendix. All gages on the mainstem Puyallup show elevated streamflows in the winter rainy season (November-February) and in the summer snow melt season (May-July). Swan Creek does not receive seasonal snow melt and shows elevated flow during the winter rainy season, with minimal flow from July through September.

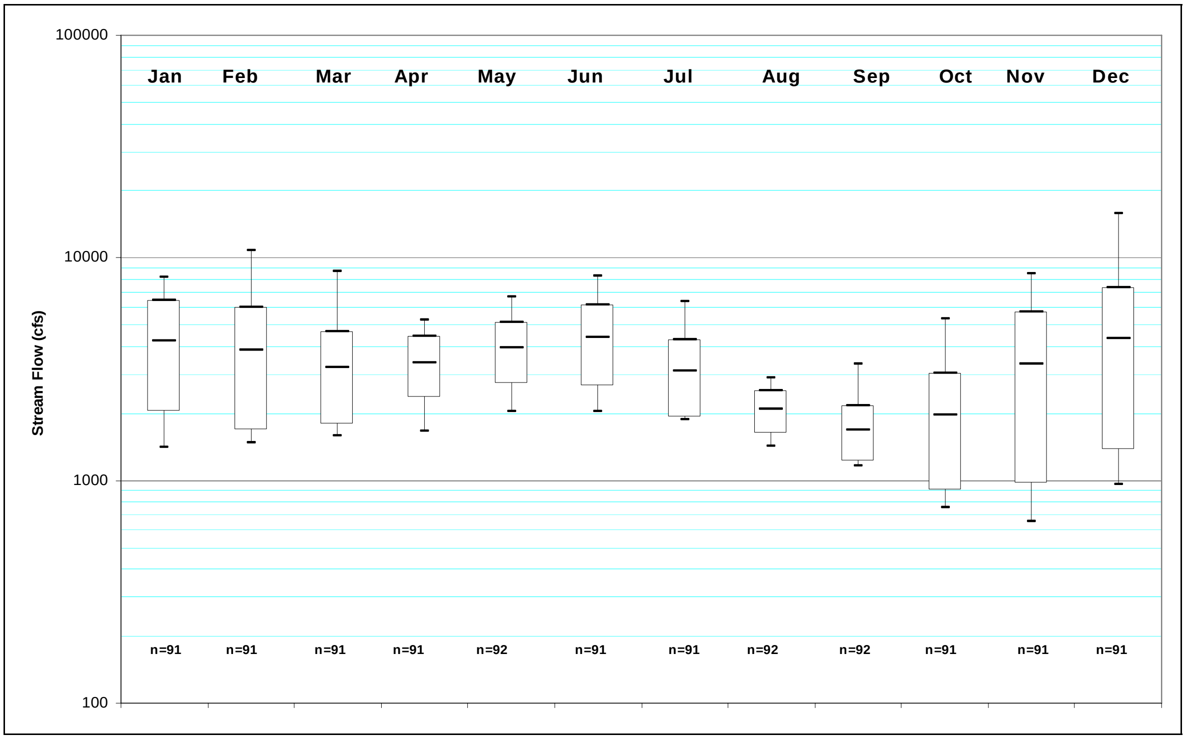

Figure 2. Monthly streamflow data for USGS Gage #12101500 (Puyallup River at Puyallup, 05/14-09/05).

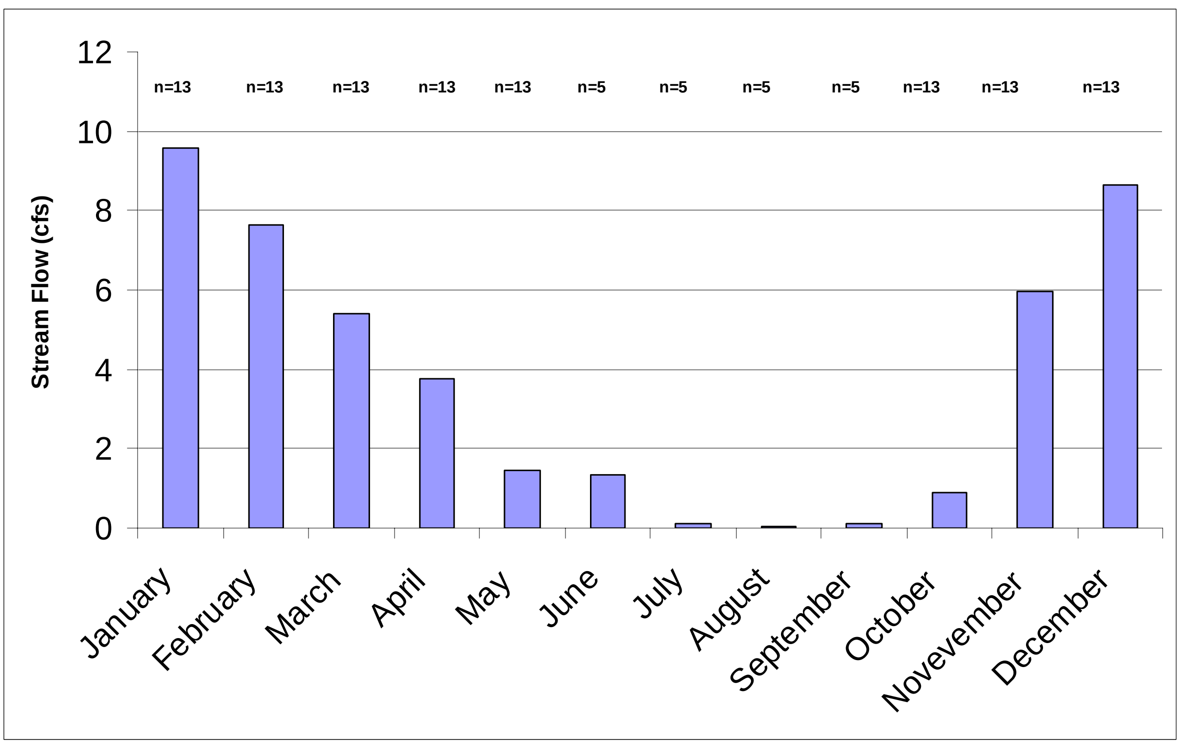

Figure 3. Stream gage mean monthly flows for USGS Gage #12102190 (Swan Creek near Tacoma, 01/90-12/04).

The USGS maintains three gages on the White River, as well as three tributary gages. The USGS maintained a gage at the White River near Auburn from 1988 to 1998. Figure 4 summarizes the mean monthly flow from this gage. The White River at Buckley (#12099000) contains data from January 1982 to the present and is summarized in Figure 5. Flow data from the Boise Creek at Buckley (#12099000) is summarized in Figure 6 and contains data from 1977 to 2005. The White River above Boise Creek (#12099200), the White River above Buckley (#12098500), the Lake Tapps Diversion at Dieringer (#12101100), and the Greenwater River at Greenwater (#12097500) are summarized in the Appendix.

All gages on the White River show elevated streamflows in the winter rainy season (November-February) and in the summer snow melt season (May-July). Boise Creek shows elevated flow during the winter rainy season, with decreased flow from July through September. There are no whiskers extending from the bottom of the box plots for the White River near Auburn and Boise Creek at Buckley because the distribution of the data resulted in a calculated 10 percentile value which is lower than the lower range of the data. In these cases, the upper mark in the box is the mean and the lower line is the lowest measured value.

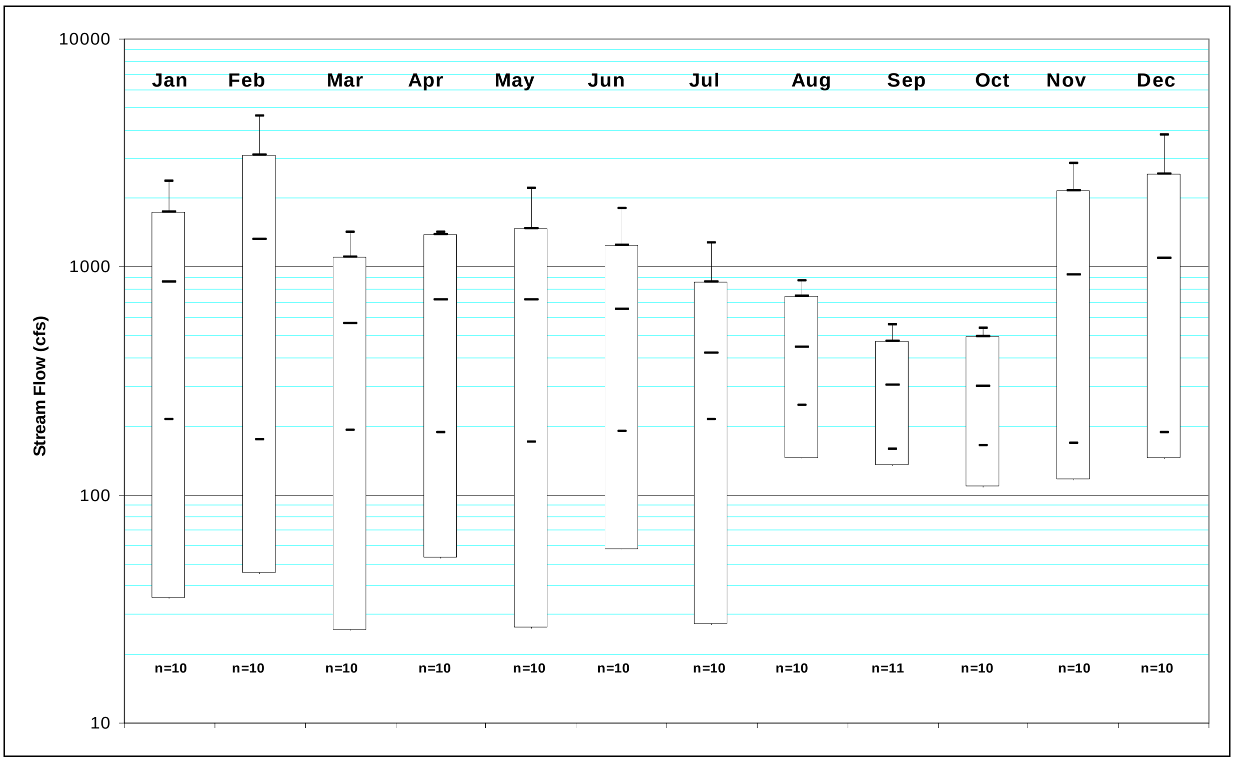

Figure 4. Monthly streamflow data for USGS Gage #12100496 (White River near Auburn, 01/88-09/98).

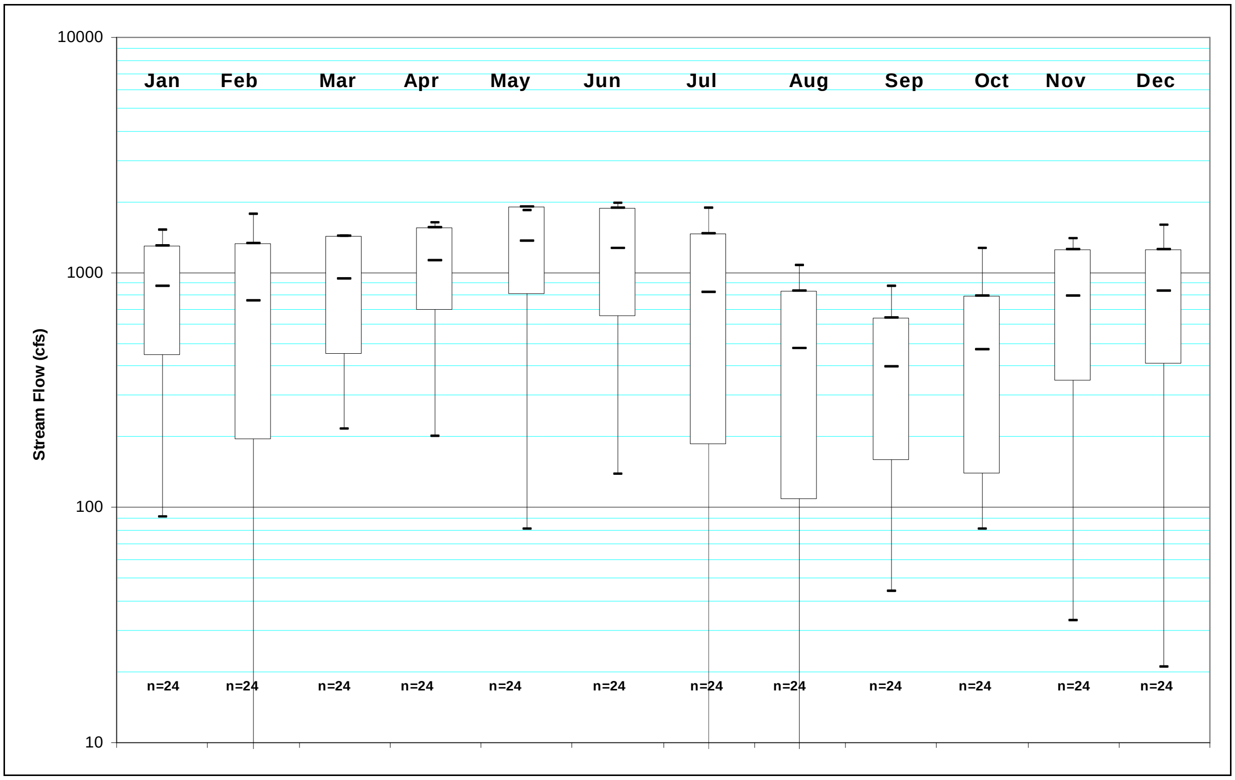

Figure 5. Monthly streamflow data for USGS Gage #12099000 (White River at Buckley, 01/82-09/05).

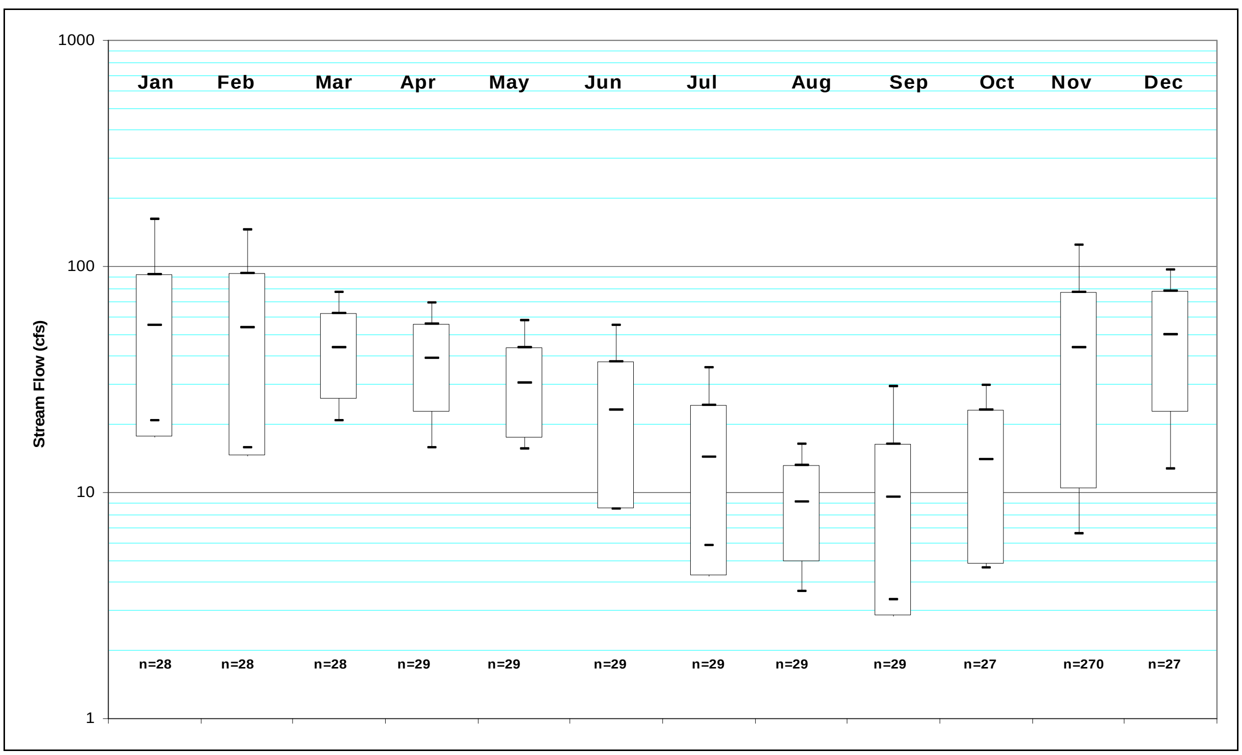

Figure 6. Monthly streamflow data for USGS Gage #12099600 (Boise Creek at Buckley, 03/77-09/05).

Washington State Department of Ecology

Ambient Monitoring

The Department of Ecology collects ambient monitoring data, including FC, at multiple sites on the Puyallup River (Figures 7 and 8). The blue line in the center of the box plots on Figure 8 represents the geometric mean and should be compared to the blue dashed line that spans the graph, which represents the geometric mean (geomean) portion of the water quality standard for FC. The red line at the top of the box plots represents the 90th percentile and should be compared to the red dashed line spanning the graph, which is the "ten percent not to exceed" portion of the water quality standard.

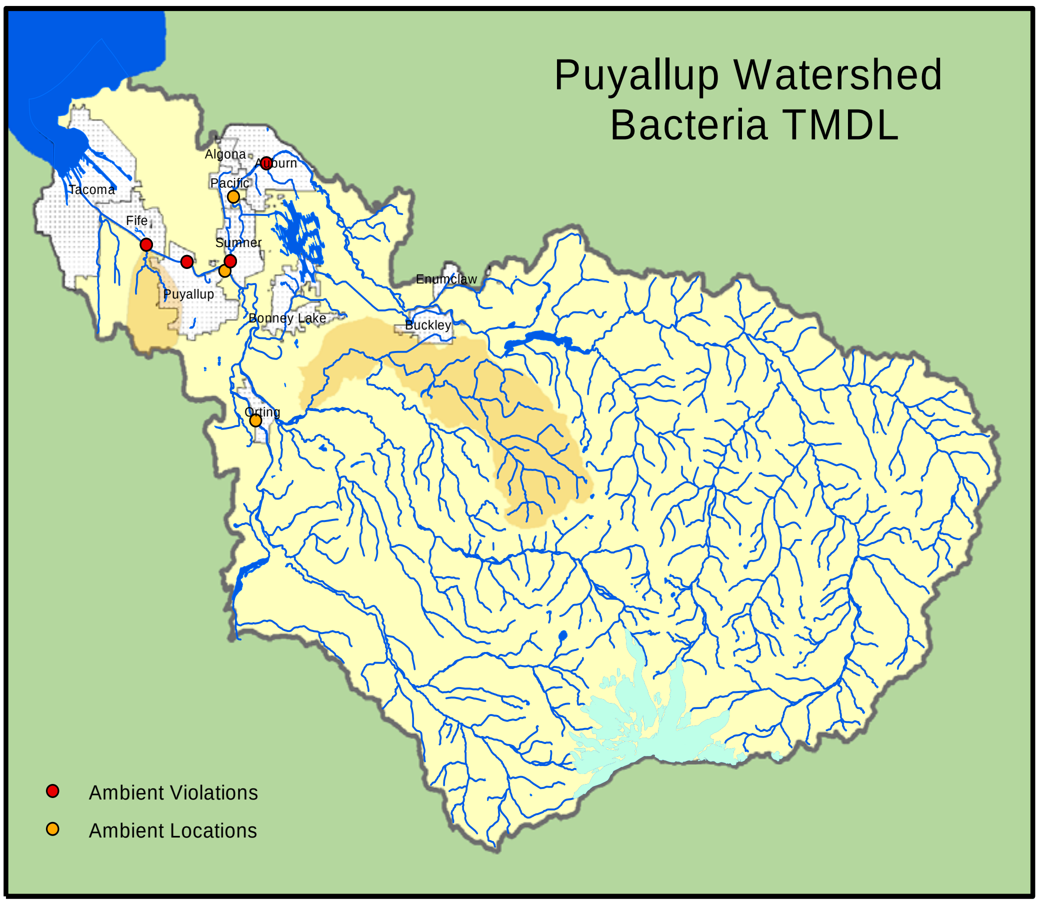

Figure 7. Department of Ecology ambient monitoring sites.

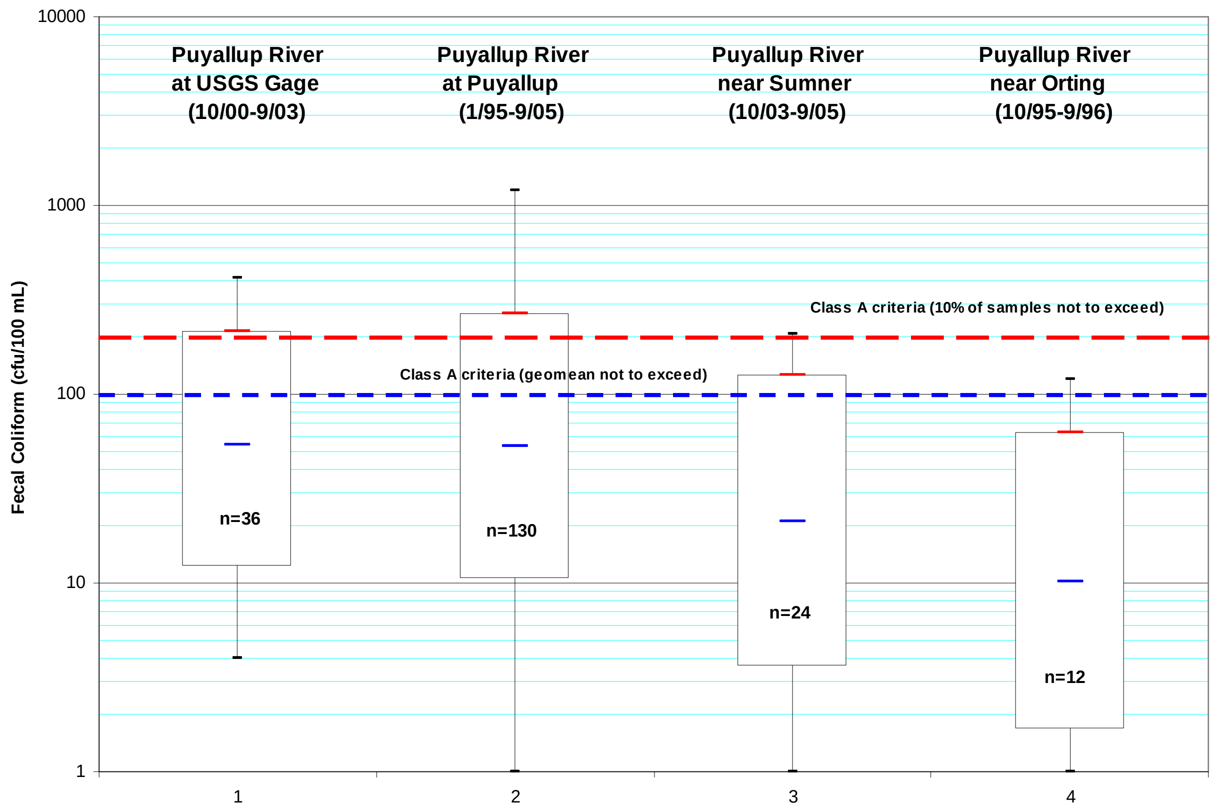

Figure 8. Summary of Puyallup River ambient bacteria data from Department of Ecology.

Bacteria counts from October 2000 to September 2003 at Station 10A075, Puyallup River at USGS Gage (near Fife), indicate non-compliance with Washington State water quality standards with slightly more than ten percent of the samples greater than 200 coliform forming units (cfu)/100 mL (Figure 9). The bacteria data from the Puyallup River at Puyallup (Station 10A050) also indicate non-compliance. The Puyallup River near Sumner (Station 10A080) and the Puyallup River near Orting (Station 10A110) both show compliance with the standards.

Bacteria data from the Puyallup River at Puyallup (Station 10A050) dates back to 1995 and contains sufficient data points (130) to allow for seasonal analysis. This site shows a marked increase in bacteria during the winter rainy season (November through February) and early spring (March and April) (Figure 9). Fecal coliform loading also shows a strong seasonal trend, with elevated bacteria loading in the wet season (Figure 10). Fecal coliform loads are determined by taking the number of cfu over the volume of the sample (e.g. #cfu/100 mL) and multiplying by the volume of streamflow over time (e.g. cubic feet per second).

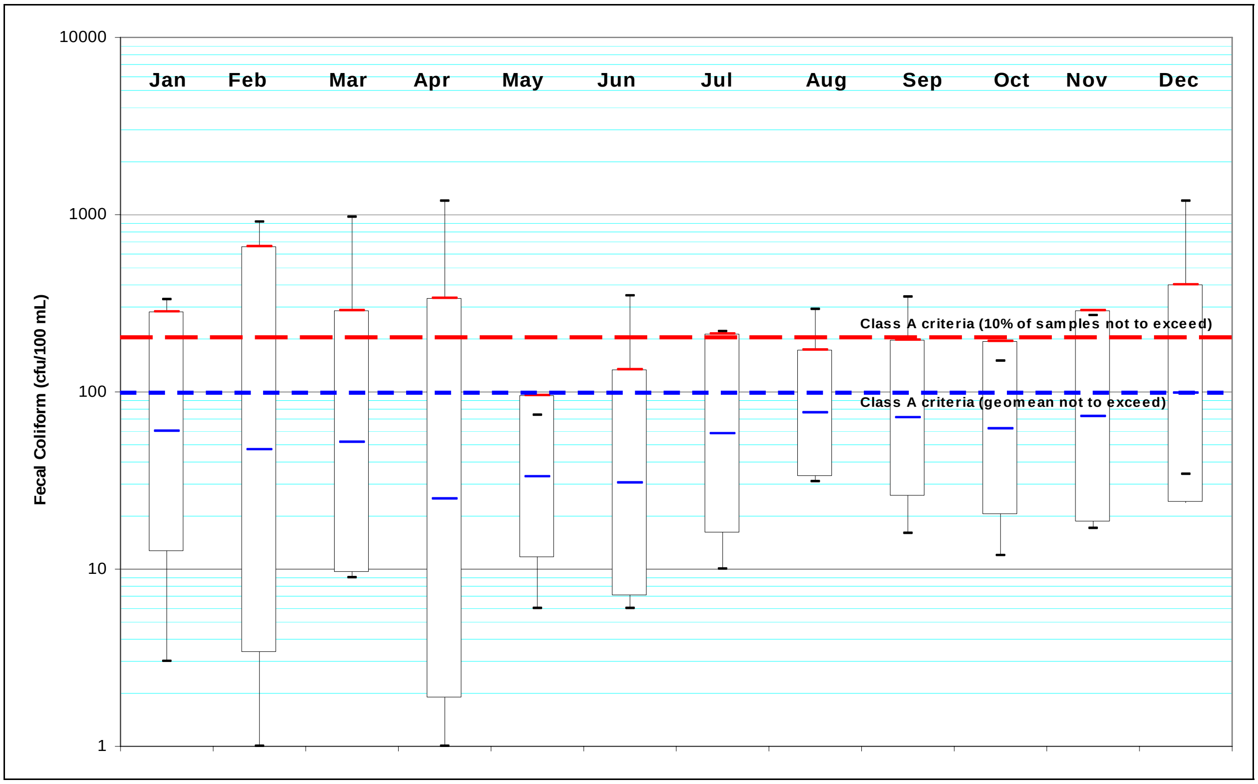

Figure 9. Summary of monthly fecal coliform counts at Station 10A050, Puyallup River at Puyallup (01/95-09/05, n=11).

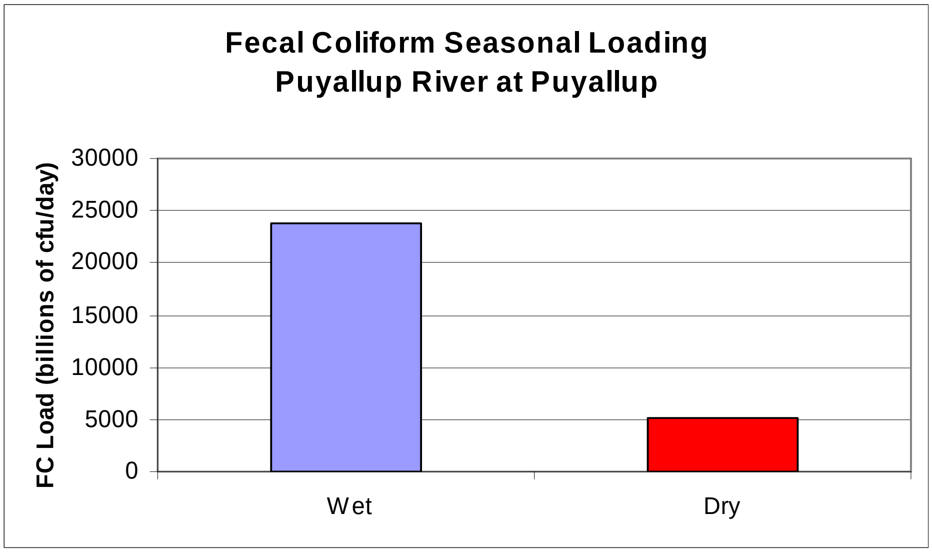

Figure 10. Summary of seasonal fecal coliform loading at Station 10A050, Puyallup River at Puyallup (01/95-09/05).

The Department of Ecology also collects ambient monitoring data, including FC, at multiple sites on the White River (Figure 7 and 11). The bacteria data from the White River at Sumner (Station 10C070) indicate non-compliance to the water quality standards with more than ten percent of the samples greater than 200 cfu/100 mL. The White River upstream of Sumner (Station 10C085) also shows non-compliance for both the 90th percentile and geomean criteria. The White River near Auburn (Station 10C095) demonstrates compliance with the standards.

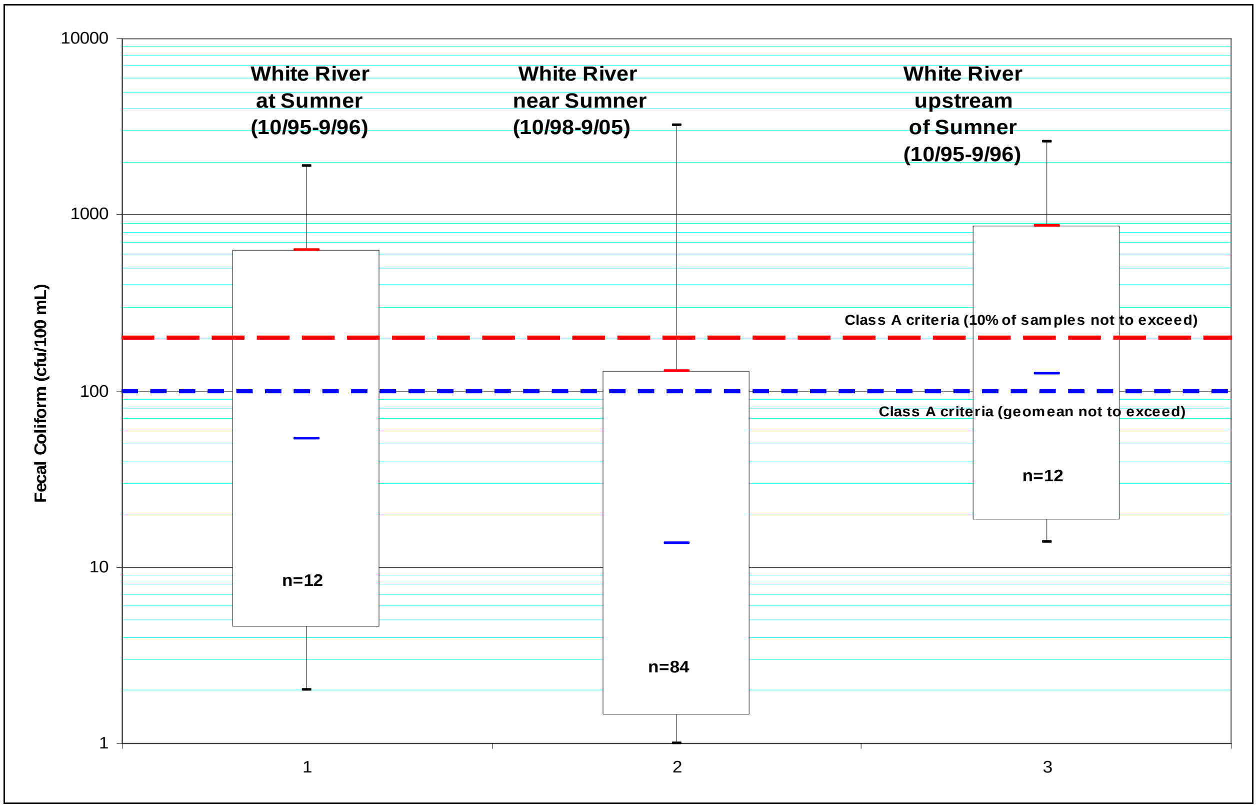

Figure 11. Summary of White River ambient bacteria data from Department of Ecology.

Bacteria data from the White River near Auburn (Station 10C095) dates back to 1998 and contains sufficient data points (84) to allow for season analysis. This station shows elevated bacteria counts during the winter rainy season and early spring (Figure 12). There is also an increase in bacteria counts during the summer months of July and August, although the standards are met. Fecal coliform loading also shows a strong seasonal trend, with elevated bacteria loading in the wet season (Figure 13).

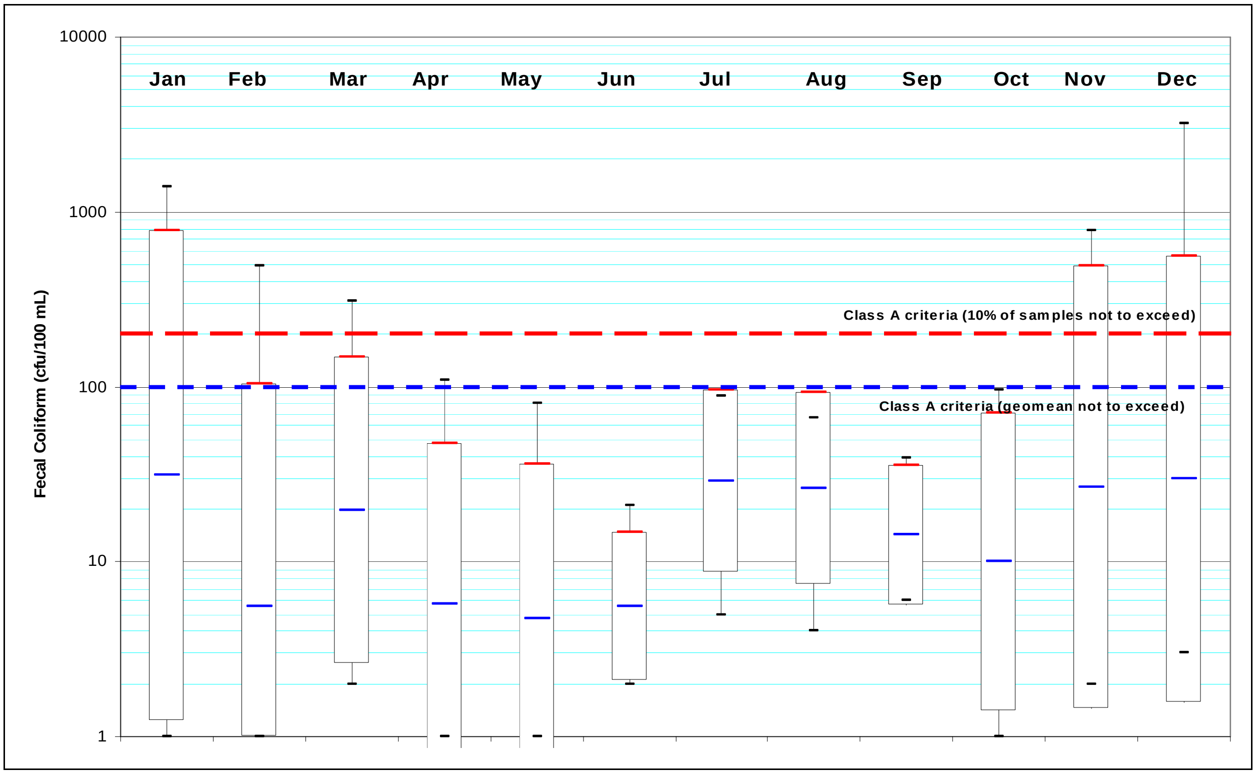

Figure 12. Summary of monthly fecal coliform counts at Station 10C095, White River near Auburn (10/98-09/05, n=7).

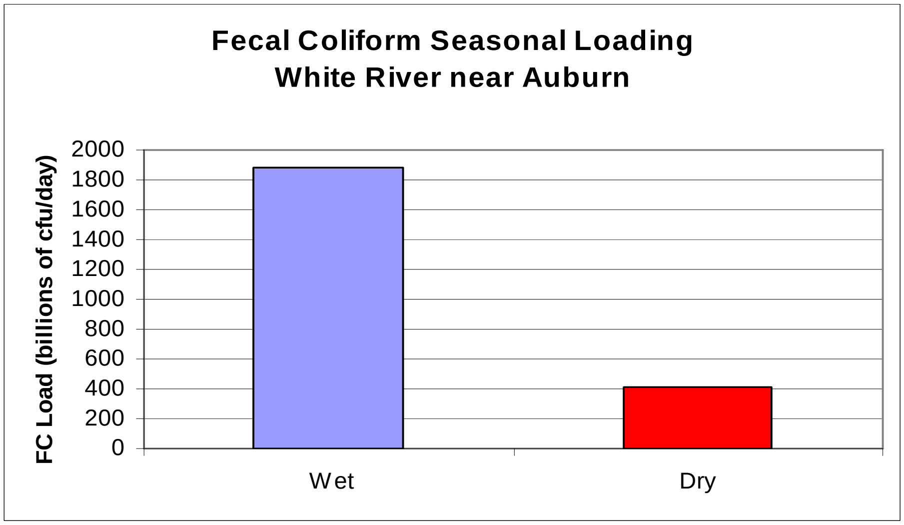

Figure 13. Summary of seasonal fecal coliform loading at Station 10C095.

Lower White River Nutrient TMDL

The Lower White River Nutrient TMDL was not designed to comprehensively address bacteria, but bacteria data were collected to add to the existing set of information. The bacteria results (Table 5) show that for the mainstem and tributary sites, Boise Creek has significantly higher bacteria levels than other sampling locations. This site did not meet the state criterion for Class A waters (geometric mean not to exceed 100 cfu/100 mL, and less than 10 percent of the samples not to exceed 200 cfu/100 mL). Of the mainstem sites, only WR23.1 violated the criterion. This site is just downstream of Boise Creek, and hence influenced by it.

Table 5. Fecal coliform data from the Lower White River TMDL.

Site	Geometric Mean	Percent over 200 org./100 mL	Water Quality Violation
Mainstem sites			
WR04.9	9	0%	
WR06.3	11	0%	
WR08.0	10	0%	
WR10.3	11	0%	
WR14.9	14	0%	
WR20.4	23	0%	
WR23.1	41	17%	Yes
WR25.2	11	0%	
Tributaries			
Boise Creek	284	83%	Yes
Bowman Creek	23	0%	
WRTRB15.4	17	0%	
WRTRB15.5	4	0%	
Point Sources			
Buckley WTP	4		
Enumclaw WTP	560		
Rainier School WTP	11954		
White River Hatchery	2		

At the time of the study, results for the point sources show that the Rainier School WWTP was not effectively disinfecting their effluent nor meeting their monthly and weekly permit limit of 200 and 400 cfu/100 mL, respectively. Results for the Enumclaw WWTP ranged between 200 and 400 cfu/100 mL, with the exception of September 24, 1996, when levels were 2,200 cfu/100 mL. The Buckley WWTP and the White River Hatchery levels were consistently low. (Erickson, 1999)

Puyallup Tribe

The Puyallup Tribe has collected bacteria data on tributaries to the Puyallup River and White River including Swan, Clear, Voight, Fennel, Boise, and Canyon Creeks (Figure 14).

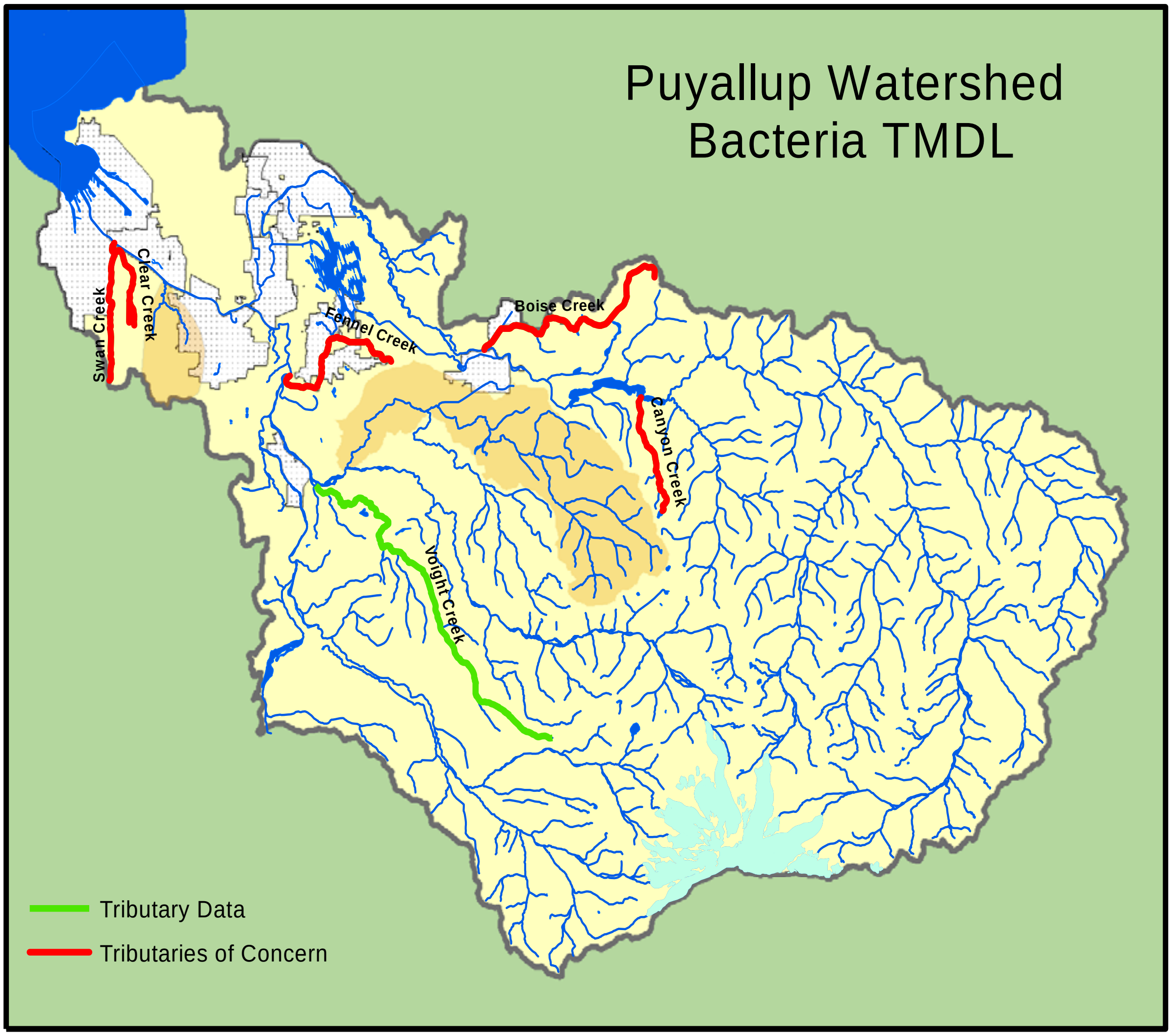

Figure 14. Tributaries sampled by the Puyallup Tribe for fecal coliform.

Swan Creek and Clear Creek, tributaries to the lower Puyallup in Tacoma, show FC impairments. The two sites on Swan Creek show impairments for both the 90th percentile and geometric mean portions of the standard. Site Clr 3 on Clear Creek also exceeds both portions of the standard and Site Clr 1 exceeds the 90th percentile portion (Figure 15).

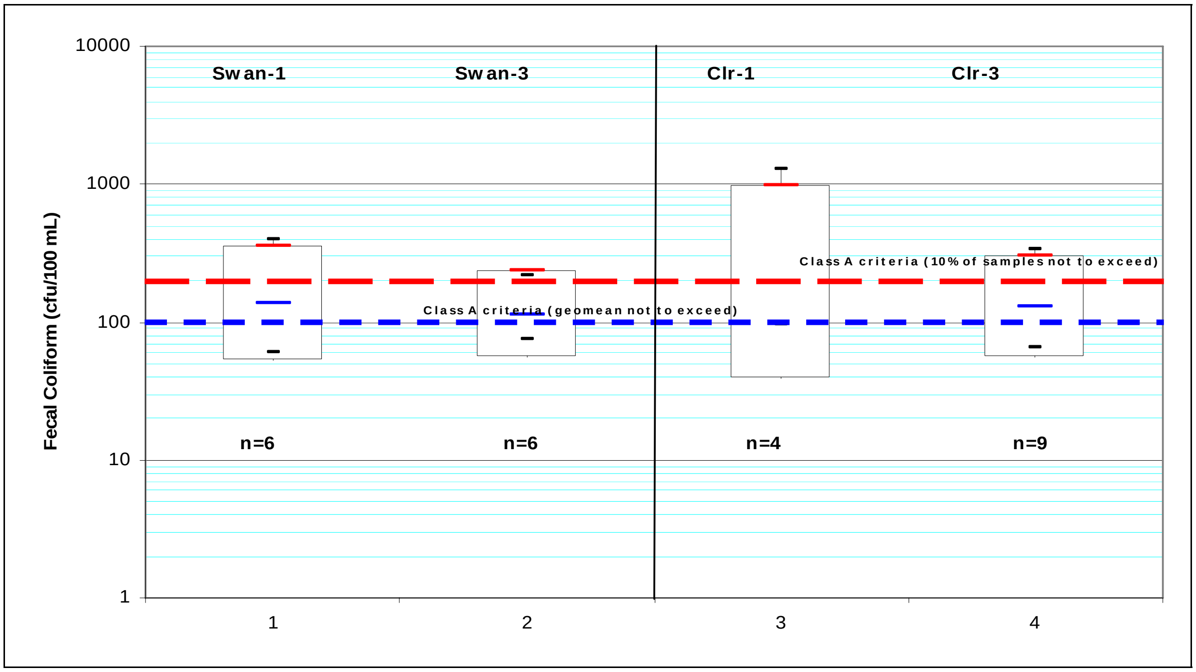

Figure 15. Summary of fecal coliform data collected by the Puyallup Tribe on Swan and Clear Creeks (01/00-03/05).

Fennel Creek, a tributary to the Puyallup River near Sumner, also shows FC impairments. The two sites on Fennel Creek show non-compliance with both portions of the standard (Figure 16).

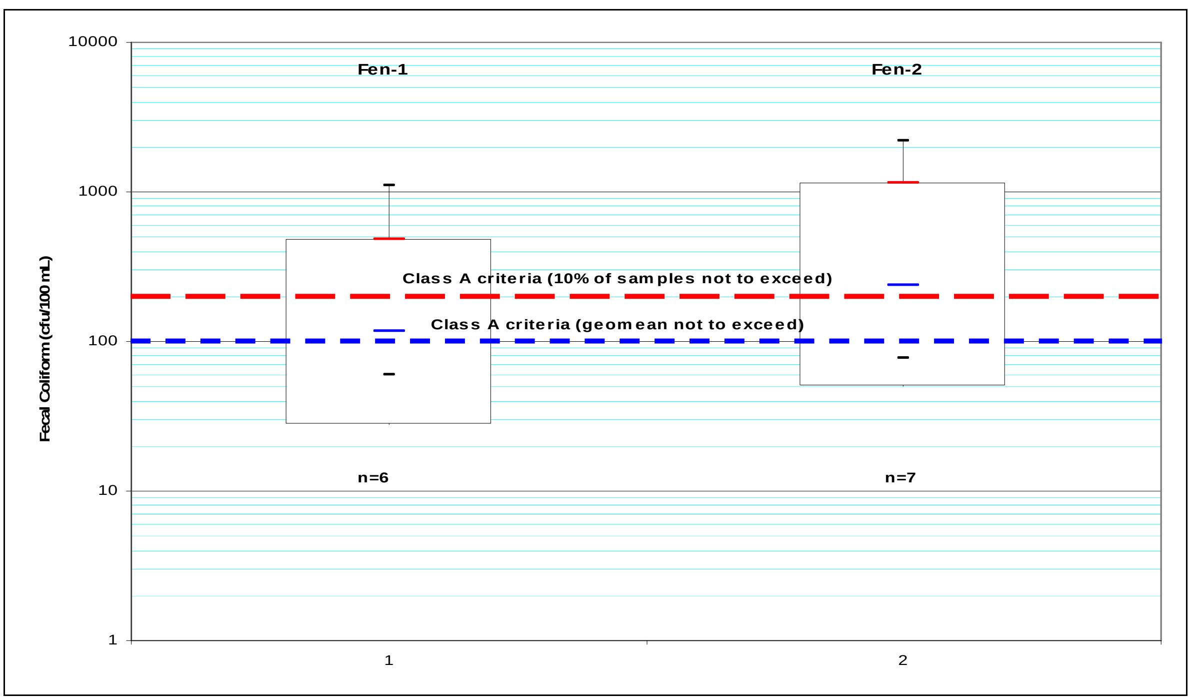

Figure 16. Summary of fecal coliform data collected by the Puyallup Tribe on Fennel Creek (10/1999-06/2005).

Boise Creek, a tributary to the White River near Buckley, also shows signs of bacteria pollution. Two sites on Boise Creek show non-compliance with both parts of the standard (Figure 17).

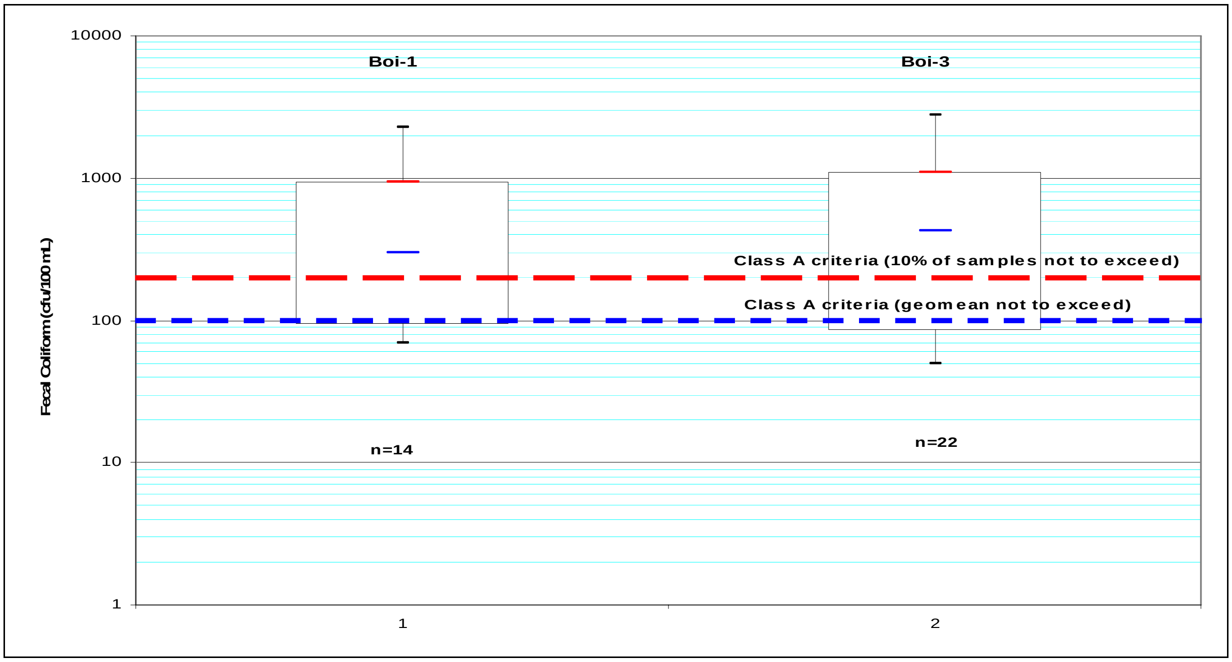

Figure 17. Summary of fecal coliform data collected by the Puyallup Tribe on Boise Creek (03/99-12/04).

Canyon Creek, a tributary of the White that flows into Mud Mountain Lake, exceeds both portions of the standard (Figure 18).

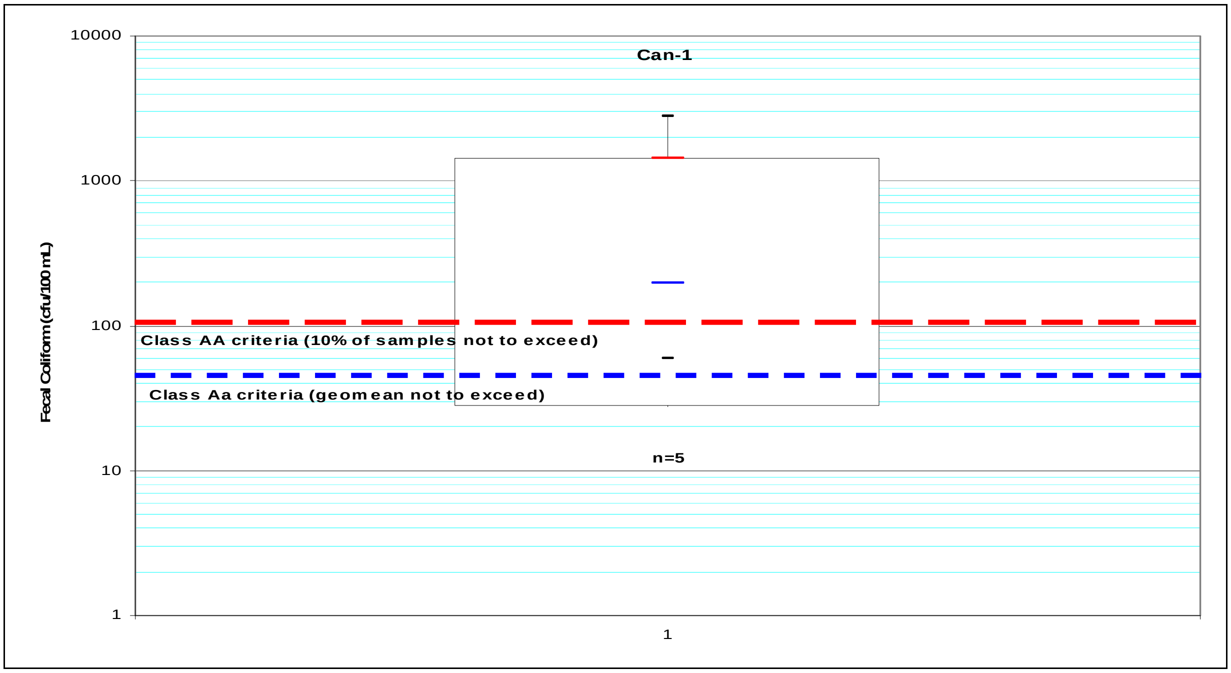

Figure 18. Summary of fecal coliform data collected by the Puyallup Tribe on Canyon Creek (01/00-06/05).

Pierce County

Basin Plans

Pierce County developed the Mid-Puyallup Basin Plan to identify the actions Pierce County will take to reduce flood hazards, protect water quality, and protect fish and wildlife habitat in the Mid-Puyallup drainage basin. The Mid-Puyallup drainage basin is 58 square miles of land and streams draining to the Puyallup River from approximately River Mile 7, west of the city of Puyallup, to the High Bridge at River Mile 26.5, south of Orting. The study area does not include the other portions of the Puyallup River, the Carbon River, or the White River because these rivers will be addressed in future basin plans. Streams include Fennel, Canyon Falls, Ball, Horsehaven, and Van Ogle Creeks, as well as one unnamed creek. (Pierce County, 2005)

The Mid-Puyallup Basin Plan identifies two specific FC problem areas in the study. The report indicates concern that a trailer park at the easterly end of 176th Street East near Orting may have a failing septic system that could be releasing untreated sewage into Horsehaven Creek. The trailer park has been abandoned and is involved in litigation. The plan also reports that flooding in the basin could cause on-site sewer systems to fail. The groundwater table in the area is shallow and rises during the wet season. This rise in the water table could cause on-site sewer system failures. The extent of failed on-site sewer systems due to groundwater flooding or surface water flooding has not been examined. (Pierce County, 2005)

Ambient Monitoring

Pierce County has collected bacteria data on tributaries near Lake Tapps (Figure 19). Government Canal Inlet and Outlet show indications of FC pollution exceeding the 90th percentile portion of the standard. Salmon Springs Creek near Sumner is violating both portions of the standard and Salmon Springs Creek Upstream is violating the 90th percentile portion of the standard.

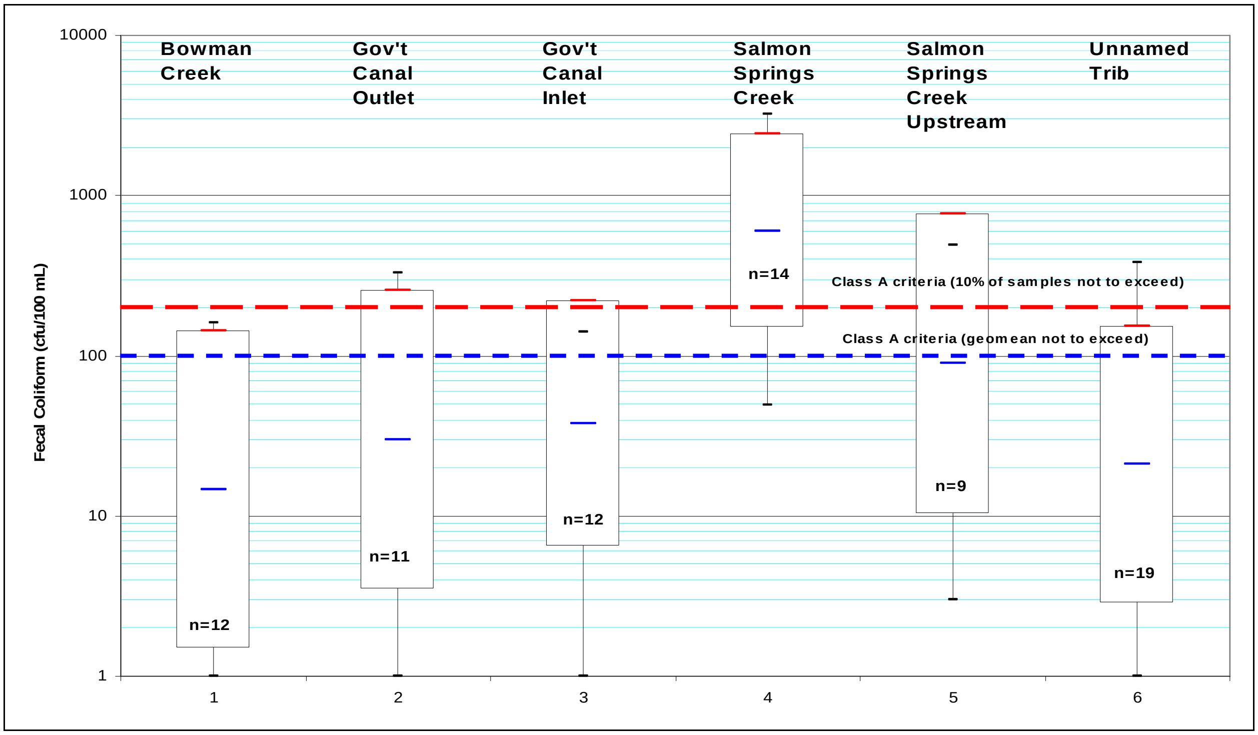

Figure 19. Pierce County bacteria data (05/05-0606).

Pierce County also has recent flow monitoring data on lower portion of Fennel Creek and on Canyon Falls Creek near Orting. Fennel Creek is summarized in Figure 20 and Canyon Falls Creek is summarized in Figure 21.

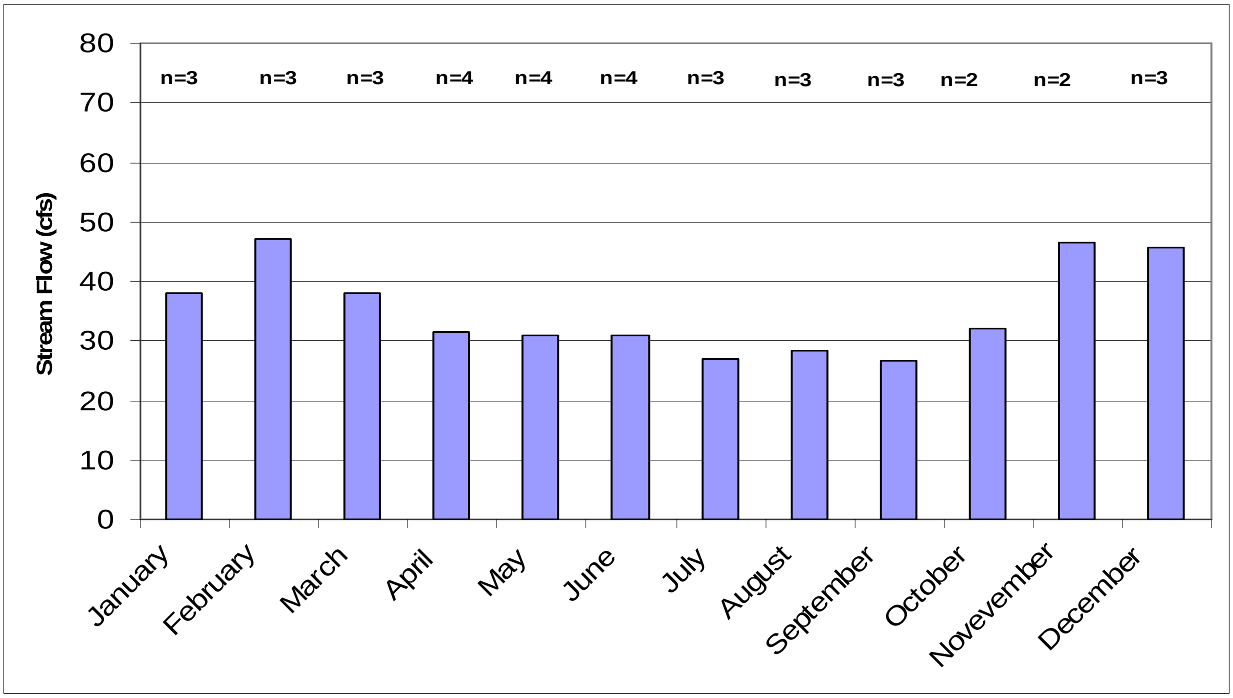

Figure 20. Pierce County flow data on Fennel Creek (04/03-06/06).

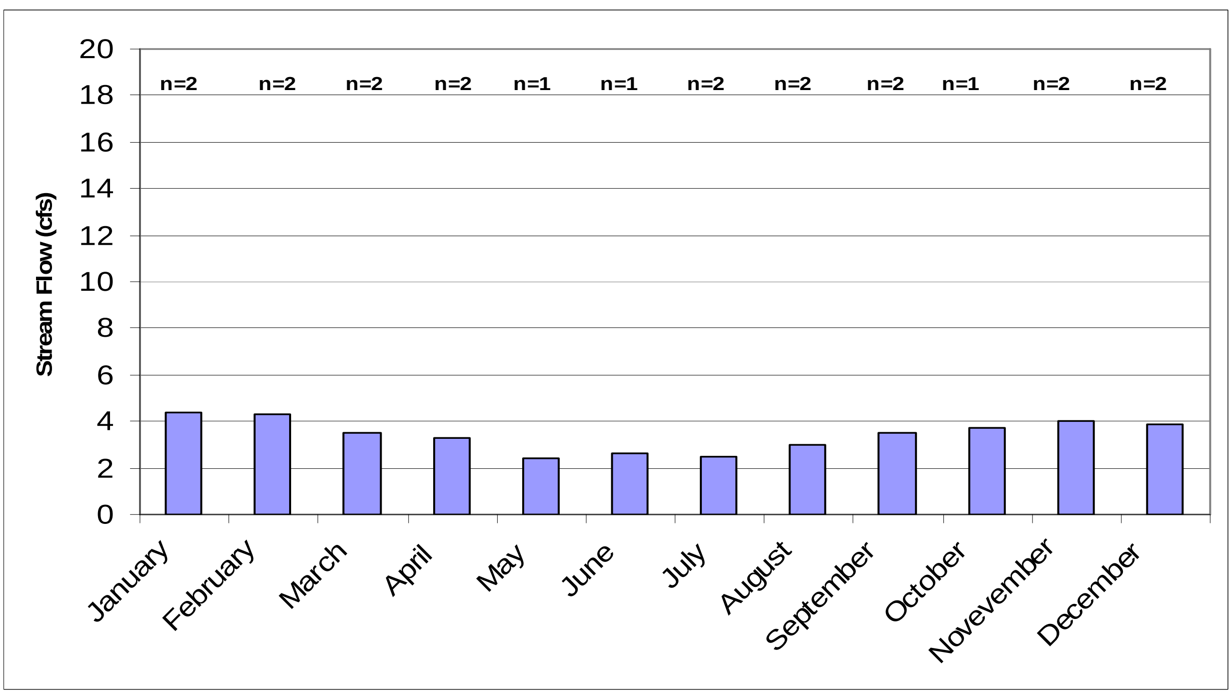

Figure 21. Pierce County flow data on Canyon Falls Creek (07/04-04/06).

Project Description

Study Design

The project objectives (page 7) will be met through measuring annual and seasonal FC bacteria concentrations and loads in the study area. Twelve months (October 2006 through September 2007) of FC and flow data will be collected to calculate basic FC concentration and loading data in various reaches of the watershed.

The sampling design will use a fixed network of sites sampled twice monthly (Table 6 and Figure 22). The fixed network will target tributaries as well as mainstem sites and bracket land uses to help identify sources. Sampling for each survey will be conducted over three days by a two-person crew. Samples will be taken as grab samples from a single location for all tributary sites and mainstem sites. Sampling will occur at the lowest tide possible for monitoring stations influenced by tides. Storm events will not be explicitly targeted, but it is expected that several storm events will be caught during the normal sampling.

Instantaneous discharge measurements, or streamflow gaging station readings, will be obtained at each site during each sampling event to determine flow. Flow measurements will be continuously recorded at ten USGS gaging stations in the watershed.

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

- Provide an estimate of the geometric mean and 90th percentile statistics of FC counts over the year and within seasons.
- Provide reach specific bacteria loads and concentrations to define areas of FC contributions. With accurate flow monitoring, FC load contributions can be separated from FC load losses due to die-off or settling. Tributary and point source loads will also be quantified.
- Help delineate any jurisdictional responsibilities for FC sources.
- Determine the impact of various land uses on FC concentrations.

Stations were selected to distinguish tributary from mainstem contributions and to distinguish among residential, agricultural, and recreational contributions within defined jurisdictions. Major tributaries and drains to each waterbody will be sampled as close to their confluence with the mainstem as possible.

There are 50 sites: 8 on the mainstem of the Puyallup River, 15 on tributaries to the Puyallup River, 8 on the mainstem of the White River, 12 on tributaries to the White River, and 7 at the wastewater treatment plants.

Arrangements will be made to split samples with the wastewater treatment plants. Sites may be added or removed from the sampling plan depending on preliminary results. Due to the size of the watershed, follow-up sampling to pinpoint sources may be needed after the completion of the TMDL.

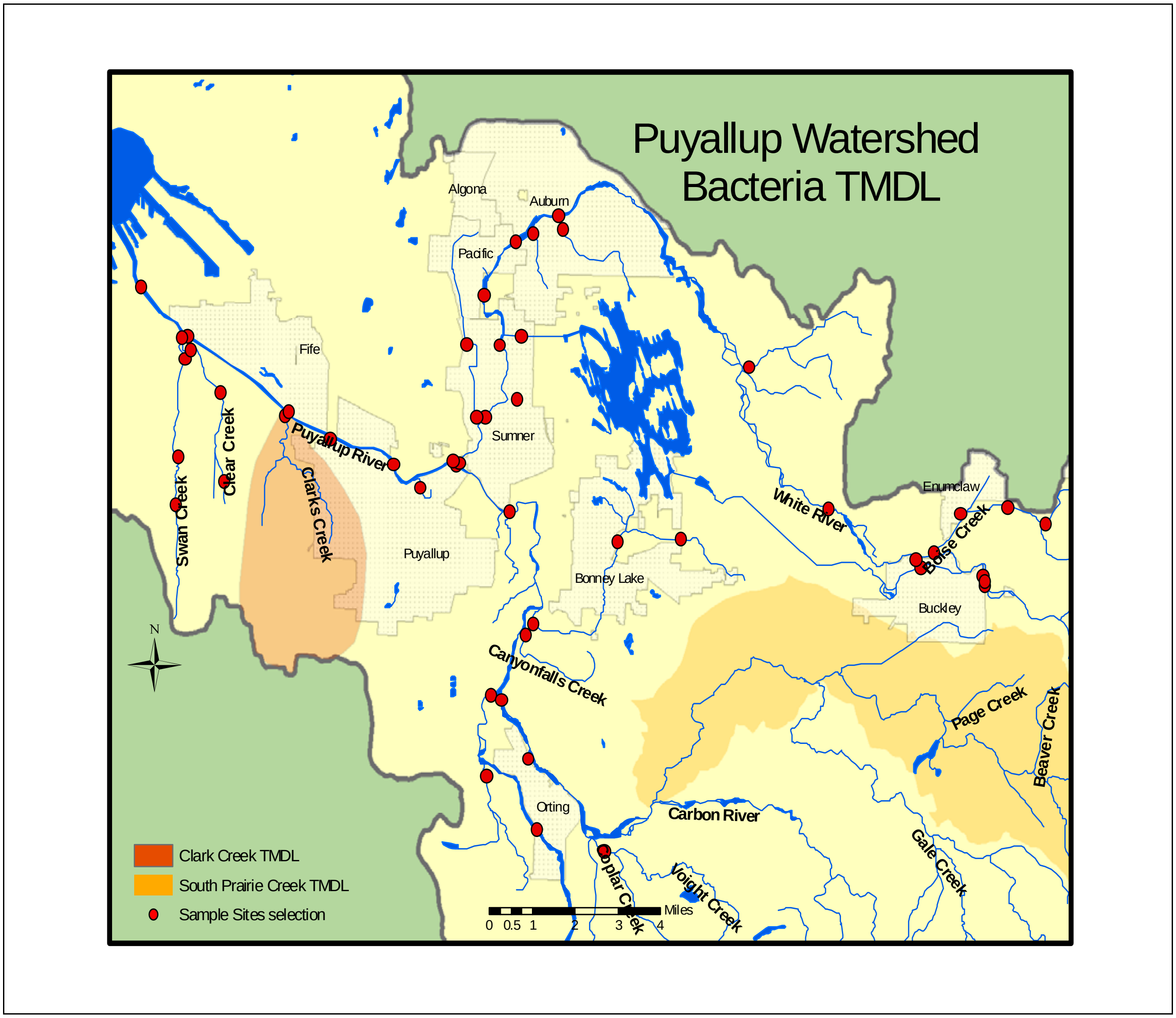

Figure 22. Sample Sites for the Puyallup Watershed TMDL.

Table 6. Sample Sites for the Puyallup Watershed Fecal Coliform (FC) TMDL.

Station ID	Site Description	RM	Stream Type	FC Measurement	Flow Measurement
10-PUY-1.4	Puyallup River at Lincoln	1.4	mainstem	x	
10-PUY-3.0	Puyallup River upstream of Swan Creek	2.9	mainstem	x	
10-PUY- 5.7	Puyallup River upstream of Clarks Creek	5.7	mainstem	x	
10-PUY-8.5	Puyallup River at Meridian St	8.5	mainstem	x	USGS
10-PUY-10.3	Puyallup River upstream of the White R	10.3	mainstem	x	
10-PUY-12.0	Puyallup River at HWY 162 near Sumner	12.0	mainstem	x	
10-PUY-17.7	Puyallup River upstream of the Carbon R	17.7	mainstem	x	
10-PUY-21.5	Puyallup River at Orting	21.5	mainstem	x	USGS
10-SWN-0.01	Swan Creek at mouth	0.01	tributary	x	x
10-SWN-0.6	Swan Creek at Pioneer Way	0.6	tributary	x	x
10-SWN-2.7	Swan Creek at 64th	2.7	tributary	x	x
10-SWN-3.9	Swan Creek at 80th	3.9	tributary	x	USGS
10-CLR-0.4	Clear Creek at mouth	0.4	tributary	x	x
10-CLR-1.7	Clear Creek at Pioneer Way	1.7	tributary	x	x
10-CLR-3.6	Clear Creek at 72nd	3.6	tributary	x	x
10-DEE-0.3	Deer Creek near mouth	0.3	tributary	x	x
10-FNL-0.4	Fennel Creek near mouth	0.4	tributary	x	x
10-FNL-4.1	Fennel Creek at Sumner-Buckley Hwy	4.1	tributary	x	x
10-FNL-5.8	Fennel Creek upstream of Bonney Lk	5.8	tributary	x	x
10-CNF-0.2	Canyon Falls Creek near mouth	0.2	tributary	x	x
10-UNO-0.3	Unnamed tributary S of Orting near mouth	0.3	tributary	x	x
10-CAR-0.2	Carbon River near mouth	0.2	tributary	x	x
10-VOI-0.4	Voight Creek downstream of hatchery	0.4	mainstem	x	USGS
10-WHT-0.01	White River at mouth	0.01	mainstem	x	
10-WHT-1.4	White River at 142nd	1.4	mainstem	x	
10-WHT-3.3	White River at 24th St E	3.3	mainstem	x	USGS
10-WHT-4.8	White River at 8th St E	4.8	mainstem	x	
10-WHT-6.2	White River at East Valley Highway	6.2	mainstem	x	USGS
10-WHT-7.5	White River at R ST	7.5	mainstem	x	USGS
10-WHT-18.9	White River downstream of Buckley	18.9	mainstem	x	
10-WHT-23.8	White River upstream of Buckley	23.8	mainstem	x	
10-MIL-0.2	Mill Creek near mouth	0.2	tributary	x	x
10-MIL-2.2	Mill Creek near Hwy 167	2.2	tributary	x	x
10-SAL-0.2	Salmon Creek at East Valley Hwy	0.2	tributary	x	x
10-BOW-0.3	Bowman Creek at Kersey Way	0.3	tributary	x	x
10-TAS-0.01	Tributary to White at Auburn River HS	0.01	tributary	x	x
10-LTD-0.4	Lake Tapps diversion near White River	0.4	tributary	x	x
10-LTD-23.7	Lake Tapps diversion near Buckley	23.7	tributary	x	x
10-UNW-0.2	Tributary to White at 180th	0.2	tributary	x	x
10-RSSW-0.01	Stormwater drainage at Rainer Sch. WWTP	0.01	tributary	x	x
10-BOI-0.01	Boise Creek at mouth	0.01	tributary	x	x
10-BOI-2.2	Boise Creek at 256th	2.2	tributary	x	x
10-BOI-3.2	Boise Creek at 284th	3.2	tributary	x	x
10-PY-WWTP	City of Puyallup WWTP	6.8	WWTP	x	WWTP Records
10-OT-WWTP	Town of Orting WWTP	2.0	WWTP	x	WWTP Records
10-CB-WWTP	Town of Carbonado WWTP	11.8	WWTP	x	WWTP Records
10-EC-WWTP	City of Enumclaw WWTP	23.1	WWTP	x	WWTP Records
10-SM-WWTP	City of Sumner WWTP	0.2	WWTP	x	WWTP Records
10-BK-WWTP	City of Buckley WWTP	21.8	WWTP	x	WWTP Records
10-RS-WWTP	Rainer School WWTP	25.2	WWTP	x	WWTP Records

Representativeness

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

Comparability

Samples will be collected at all WWTPs, when possible, in conjunction with the routine samples collected by the WWTP operators. Ecology results will be compared to the results from each WWTP.

Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for the Puyallup River TMDL is to correctly collect and analyze 100% of the FC samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled such as flooding, inadequate rain for storm sampling, or site access problems that can interfere with this goal. A lower limit of five samples per site will be required for comparison to state criteria, which should easily be met for all sites. WAC 173-201A states:

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

Investigatory samples may be collected at sites not included in this Quality Assurance (QA) Project Plan; or, if necessary, a site may be added to further characterize FC problems in an area. Such sampling that does not meet the lower limit criterion of five samples per site will still be useful for source identification and other analyses, but not used to set load or waste load allocations.

Laboratory Budget

Table 7 outlines the laboratory budget anticipated to complete the fecal coliform analyses for samples collected during this TMDL.

Table 7. Laboratory Budget.

Program	No. Stations	No. Events	Samples Per Event	Parameter	Unit Cost	Total Samples	Total Cost
Twice-Monthly Sampling	50	24	1	FC MF	21	1200	$25,200
QA Sampling	10	24	1	FC MF	21	240	$5,040
Project Total							$30,240

[1] Costs include 50% Ecology discount for Manchester Environmental Laboratory; the remaining 50% is paid through base funding.

Sampling Procedures

Field sampling and measurement protocols will follow those listed in the Watershed Ecology Section (previously the Watershed Assessment Section) Protocols Manual (Ecology, 1993). Grab samples will be collected directly into pre-cleaned containers supplied by Manchester Environmental Laboratory (MEL) and described in the MEL User's Manual (MEL, 2005). Sample parameters, containers, volumes, preservation requirements, and holding times are listed in Table 8. Bacteria samples for laboratory analysis will be stored on ice and delivered to MEL within 24 hours of collection via the Ecology courier.

Twenty percent of FC samples will be duplicated in the field in a side-by-side manner to assess field and lab variability. Samples will be collected in the thalweg and just under the water's surface.

Table 8. Containers, preservation requirements and holding times for samples collected during the Puyallup River TMDL Study (MEL, 2005).

Parameter	Bottle	Preservative	Holding Time	Standard Method	Reporting Limit
Fecal Coliform	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours	SM MF 9222D	1 cfu/100 mL

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition.

Measurement Procedures

Estimation of instantaneous flow measurements will follow the Environmental Assessment Program's Stream Hydrology Unit (SHU) protocols manual (Ecology, 2000). Flow volumes will be calculated from continuous stage height records and rating curves developed prior to, and during, the project. Stage height will be measured by pressure transducer and recorded by a data logger every 15 minutes. All data loggers will be downloaded monthly. Staff gages will be installed at other selected sites. During the field surveys, streamflow will be measured at selected stations and staff gage readings will be recorded. A flow rating curve will be developed for sites with a staff gage. The methods used for measuring velocity and FC are included in Table 9 below.

Measurement Quality Objectives

Sampling, laboratory analysis, and data assessment steps have several sources of error that should be addressed by measurement quality objectives. Precision in laboratory measurements (measurement quality objectives) can be more easily controlled than field sampling variability. Precision needs to be as high as possible in the laboratory. Precision for bacteria field replicates is expressed as the relative standard deviation (RSD) and results should not exceed 30% RSD.

Microbiological and analytical methods, expected range of sample results, and method resolution are listed in Table 9. The expected range of sample results are based on historical data from similar watersheds. The reporting limits of the methods listed in the table meet the expected range of results and the required level of sensitivity to meet project objectives.

Table 9. Targets for precision and reporting limits for the measurement systems.

Analysis	Method	Duplicate Samples Relative Standard Deviation (RSD)	Reporting Limits and Resolution
Field Measurement			
Velocity[1]	Marsh McBirney Flow-Mate Flowmeter	0.1 ft/s	0.01 ft/s
Laboratory Measurement			
Fecal Coliform – MF	SM 9222D	30% RSD[2]	1 cfu/100 mL

[1] as units of measurement, not percentages.

[2] replicate results with a mean of less than or equal to 20 cfu/100 mL will be evaluated separately.

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, AWWA and WEF, 1998)

The target for precision of FC determinations in Table 9 is based on historical performance by MEL for environmental samples taken around the state by the Watershed Ecology Section (Mathieu, 2005a). Bias is also a component of data accuracy; however, bias from the true value is very difficult to determine for FC. Bias in field measurements will be minimized by strictly following sampling and handling protocols. Standards for microbiological determinations are not available.

Quality Control Procedures

Total variation for field sampling and laboratory determination will be assessed by collecting replicate samples. The differences between duplicate results for bacteria samples tend to have a high RSD compared to other water quality parameters. Bacteria sample precision will be assessed by collecting duplicates for approximately 20% of samples in each survey. MEL routinely duplicates sample analyses in the laboratory to determine the presence of bias in analytical methods. The difference between field variability and laboratory variability is an estimate of the sample field variability.

All samples will be analyzed at MEL. MEL will follow standard quality control procedures (MEL, 2005). Field sampling and measurements will follow quality control protocols described in Ecology (1993). If any of these quality control procedures are not met, the associated results will be qualified and used with caution, or not used at all.

Standard Methods (APHA, AWWA and WEF, 1998) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for nonpotable water tested for compliance purposes. MEL has a maximum holding time for microbiological samples of 24 hours (MEL, 2005) that is recommended by Standard Methods (APHA, AWWA, and WEF, 1998) for drinking water samples (<30 hours) and other types of water tested when compliance isn't an issue (<24 hours). MEL accepts samples Monday through Friday, which means Ecology can sample Sunday through Thursday.

To identify any problems with holding times, two comparison studies were conducted during the Yakima Area Creeks TMDL (Mathieu, 2005b). A total of twenty FC samples were collected in 500 mL bottles and each split into two, 250 mL bottles. The samples were driven to MEL within six hours. One set of the split samples was analyzed upon delivery. The other set was stored overnight and analyzed the next day. Both sets were analyzed using the MF method. Replicates were compared to the Measurement Quality Objectives in Table 9.

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

Data Management Procedures

Field measurement data will be entered into a field book with waterproof paper in the field and then entered into EXCEL® spreadsheets (Microsoft, 2001) as soon as possible after returning from the field. This database will be used for preliminary analysis and to create a table to up load data into the Department of Ecology Environmental Information Management System (EIM).

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

An EIM user study (LSUL0001) has been created for this TMDL study, and all monitoring data will be available via the internet once the project data has been validated. The URL address for this geospatial database is: www.ecy.wa.gov/eim/index/htm. All data will be uploaded to EIM by the EIM data engineer once it has been validated.

All spreadsheet files, paper field notes, and GIS products created as part of the data analysis and model building will be kept with the project data files.

Audits and Reports

The project manager will be responsible for submitting quarterly reports and a final technical report to the Water Quality Program TMDL lead for this project, according to the project schedule.

Data Verification and Validation

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL Lab Users Manual (MEL, 2005). Lab results will be checked for missing and improbable data. Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager from MEL for each set of samples.

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

As soon as FC data are verified by MEL, the laboratory microbiologist will notify the field lead by e-mail or by phone of FC results greater than 200 cfu/100 mL. The field lead will then notify the Eastern Regional Office (ERO) Client Staff Contact and Water Quality Section Manager by e-mail of these elevated counts in accordance with EA Program Policy 1-03. The ERO Client Staff Contact will notify local authorities or permit managers as appropriate.

Data received from LIMS will be checked for omissions against the Request for Analysis forms by the field lead. Data can be in EXCEL® spreadsheets (Microsoft, 2001) or downloaded tables from Ecology's EIM system. These tables and spreadsheets will be located in a file labeled *DRAFT* until data validity is completed. Field replicate sample results will be compared to the measurement quality objectives in Table 9. Data requiring additional qualifiers will be reviewed by the project manager.

After data validity and data entry tasks are completed, all field, laboratory, and flow data will be entered into a file labeled *FINAL*, and then into the EIM system. EIM data will be independently reviewed by another EA Program field assistant for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken.
At the end of the field collection phase of the study, the data will be compiled in a data summary. Quarterly progress reports will be available every three months throughout the 12-month data collection period of the project.

Data Quality (Usability) Assessment

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution of transformed data. Streamflow data will be frequently reviewed during the field data survey season to check longitudinal water balances. Fecal coliform mass balance calculations will be performed on a reach basis. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, regressions) will be made using WQHYDRO (Aroner, 2003) and EXCEL® (Microsoft, 2001) software.

Data will be applied to several TMDL methods of evaluation. The statistical rollback method (Ott, 1995) will be applied to FC data distributions to determine target count reductions along key reaches of each waterbody during critical conditions. Ideally, at least 20 data points are needed from a broad range of hydrologic conditions to determine an annual FC distribution. If sources of FC vary by season and create distinct critical conditions, seasonal targets may be required. Fewer data will provide less confidence in FC reduction targets, but the rollback method is robust enough to provide general targets for planning implementation measures.

Project Organization

The roles and responsibilities of Ecology staff are as follows:

Environmental Assessment Program

- *Lawrence Sullivan, Project Manager, EIM Data Engineer, and Field Lead, Water Quality Studies Unit*: Responsible for overall project management. Defines project objectives, scope, and study design. Writes the QA Project Plan. Develops the TMDL and writes the technical report. Manages the data collection program. Leads field surveys with staff. Collects data, enters project data into the EIM system, and reviews data quality.

- *Brandon Slone, Field Assistant, Water Quality Studies Unit*: Assists staff in field preparations, data collection, and sample processing.

- *Karol Erickson, Unit Supervisor, Water Quality Studies Unit*: Approves the QA Project Plan, budget, and TMDL report.

- *Will Kendra, Section Manager, Watershed Ecology Section*: Approves the QA Project Plan and final TMDL report.

- *Stuart Magoon, Leon Weiks, and Pam Covey, Ecology Manchester Laboratory Staff*: Provide laboratory staff and resources, sample processing, analytical results, laboratory contract services, and QA/QC data. Review sections of the QA Project Plan relating to laboratory analysis.

- *Bill Kammin,, Ecology Quality Assurance Officer*: Reviews the QA Project Plan and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of the project.

Water Quality Program

- *Cindy James, Overall TMDL Project Lead, Water Quality Program, Southwest Regional Office:* Acts as point of contact between Ecology technical study staff and interested parties. Coordinates information exchange and technical advisory group formation and organizes meetings. Supports, reviews, and comments on QA Project Plan, and technical report. Responsible for implementation, planning, and preparation of TMDL document for submittal to EPA.

- *Kim McKee, Unit Supervisor, Water Cleanup/Technical Assistance, Water Quality Program, Southwest Regional Office*: Responsible for approval of QA Project Plan and TMDL submittal to EPA.

Project Schedule

Table 10. Project schedule for the Puyallup River Watershed Total Maximum Daily Load study.

Environmental Information System (EIM) Data Set	
EIM Data Engineer	Lawrence Sullivan
EIM User Study ID	LSUL0001
EIM Study Name	Puyallup River Watershed Bacteria TMDL
EIM Completion Due	February 28, 2008
Quarterly Reports	
Report Author Lead	Lawrence Sullivan
Schedule:	
1st Quarter Report	February 28, 2007
2nd Quarter Report	May 31, 2007
3rd Quarter Report	August 31, 2007
4th Quarter Report	November 30, 2007
Final Report	
Report - Author Lead	Lawrence Sullivan
Schedule:	
Report - Supervisor Draft Due	August 31, 2008
Report - Client/Peer Draft Due	September 30, 2008
Report - External Draft Due	November 15, 2008
Report - Final Due (original)	March 31, 2009

References

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

Aroner, E. R., 2003. WQHYDRO: Water Quality/Hydrology Graphics/Analysis System. Portland, OR.

Cusimano, R., 1997. Water Quality Assessment of Tributaries to the Snohomish River and Nonpoint Source Pollution TMDL Study. Washington State Department of Ecology, Olympia, WA. 52 pgs. Publication No. 97-334. www.ecy.wa.gov/biblio/97334.html

Ecology, 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Washington State Department of Ecology, Olympia, WA. Publication No. 93-e04. www.ecy.wa.gov/biblio/93e04.html

Ecology, 2000. Determination of Instantaneous Flow Measurements of Rivers and Streams. Stream Hydrology Unit, Washington State Department of Ecology, Olympia, WA.

Ecology, 2006a. 2004 Water Quality Assessment (Final) – Category 5 Listings. www.ecy.wa.gov/programs/wq/303d/2002/2004_documents/list_by_category-cat5.html Washington State Department of Ecology, Olympia, WA.

Ecology, 2006b. NPDES and General Permit Information on the Washington State Department of Ecology Water Quality Web Site. www.ecy.wa.gov/programs/wq/permits/index.html

Ecology, 2006c. Retrieval of Washington Department of Ecology Data Collected from River and Streams. Water Resource Inventory Area 34. www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

Erickson, K., 1999. Review Draft: Assimilative Capacity Study for Nutrient Loading in the Lower White River. Washington State Department of Ecology, Olympia WA. Publication No. 00-03-001. www.ecy.wa.gov/biblio/0003001.html

Joy, J., 2000. Lower Nooksack River Basin Bacteria Total Maximum Daily Load Evaluation. Washington State Department of Ecology, Olympia WA. 60 pgs. Publication No. 00-03-006. www.ecy.wa.gov/biblio/0003006.html

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

Lubliner, B., 2005. Quality Assurance Project Plan: South Fork Palouse River Pesticide, PCB, and Fecal Coliform Stormwater Pilot Study. Washington State Department of Ecology, Olympia, WA. Publication No. 05-03-115. www.ecy.wa.gov/biblio/0503115.html

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

Mathieu, N., 2005a. Draft Memorandum - Summary of Replicate Precision for Twelve Total Maximum Daily Load (TMDL) Studies and Recommendations for Precision Measurement Quality Objectives for Bacteria and Conventional Water Quality Parameters. Environmental Assessment Program, Washington Sate Department of Ecology, Olympia, WA.

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

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

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

Pierce County, 2005. Mid-Puyallup Basin Plan. Pierce County Water Program, Tacoma, WA. www.co.pierce.wa.us/pc/services/home/environ/water/ps/basinplans/midpuy.htm

Sargeant, D., 2002. Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. 46 pgs. Publication No. 02-03-014. www.ecy.wa.gov/biblio/0203014.html

WAC 173-201A: Water Quality Standards for surface waters in the State of Washington Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html

Appendix: USGS Stream Gage Data

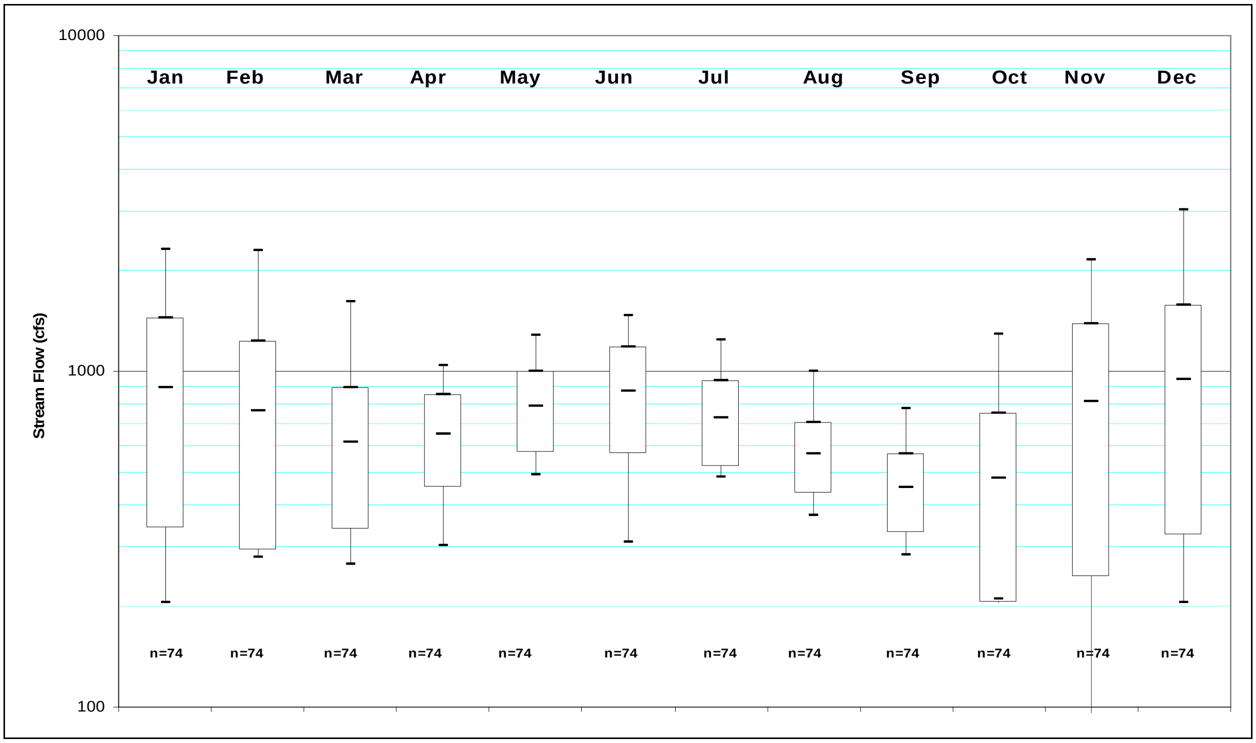

Figure A-1. Monthly streamflow data for USGS Gage #12093500 (Puyallup River near Orting, 01/32-09/05).

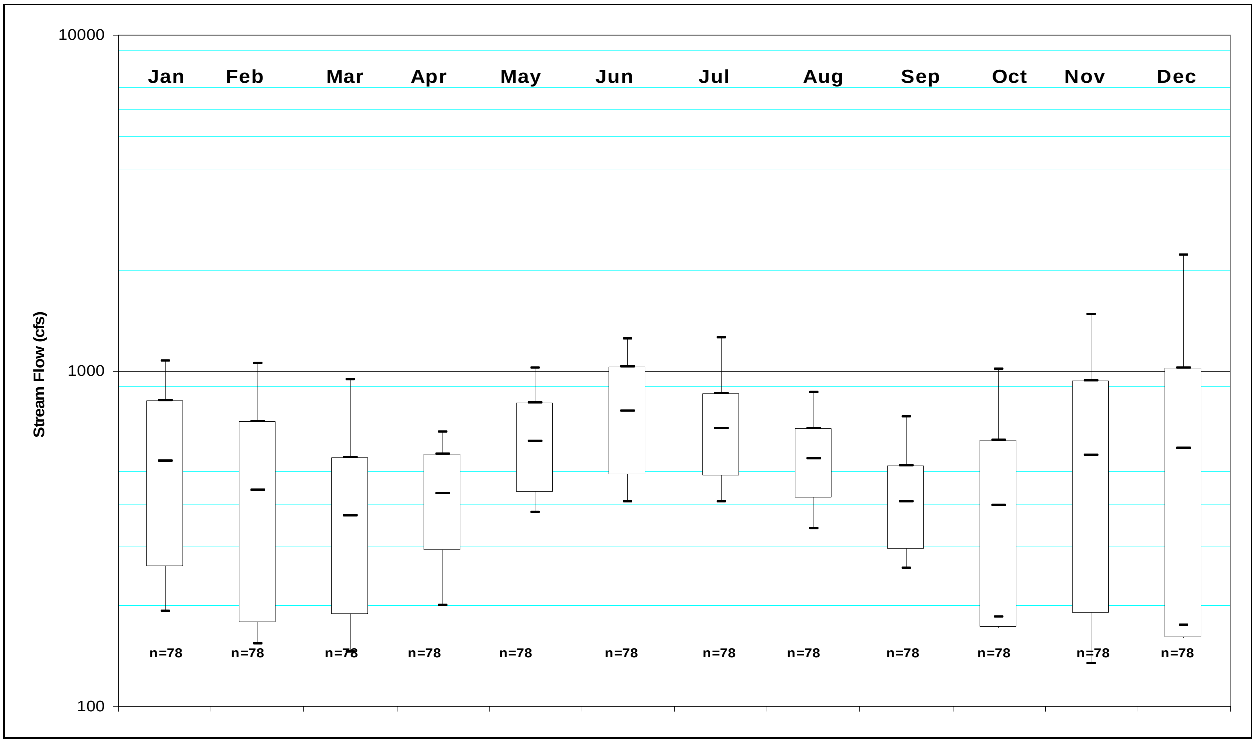

Figure A-2. Monthly streamflow data for USGS Gage #12092000 (Puyallup River near Electron, 01/09-09/05).

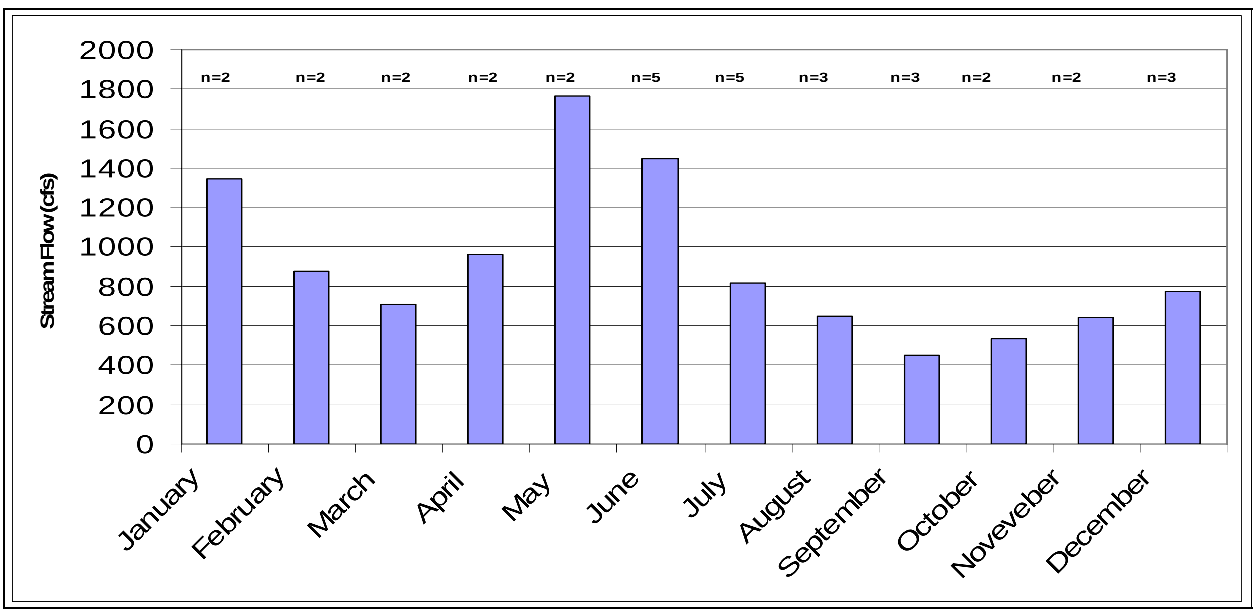

Figure A-3. Stream gage mean monthly flows for USGS Gage #12099200 (White River above Boise Creek, 01/04-09/05).

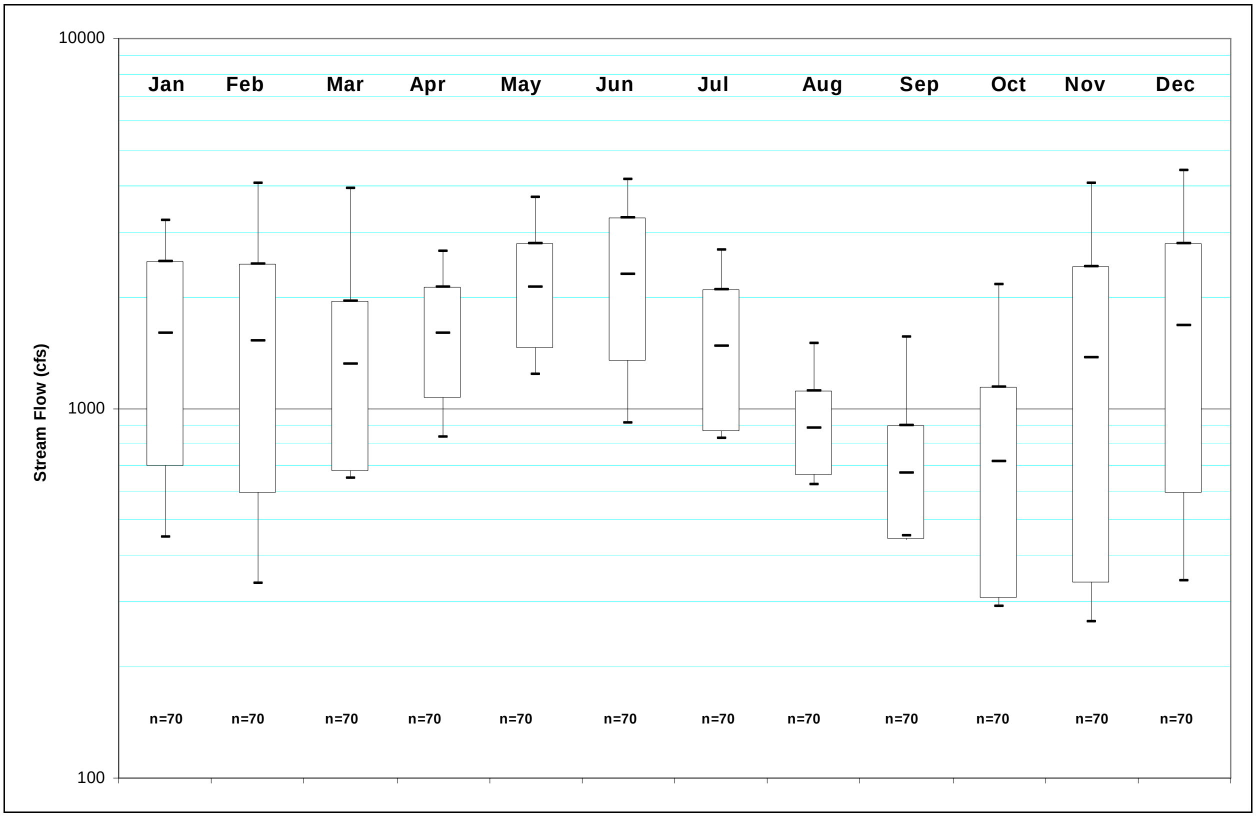

Figure A-4. Monthly streamflow data for USGS Gage #12098500 (White River above Buckley, 01/29-09/03).

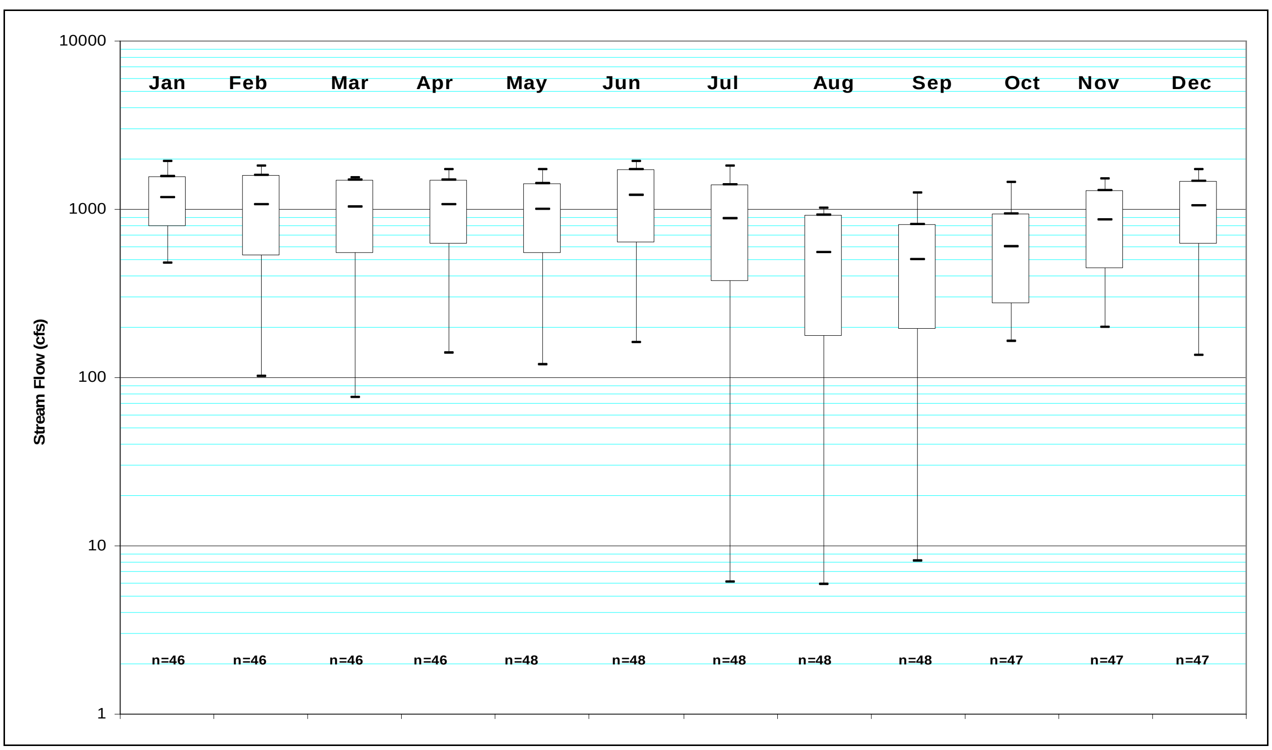

Figure A-5. Monthly streamflow data for USGS Gage #12101100 (Lake Tapps Diversion at Dieringer, 01/58-09/05).

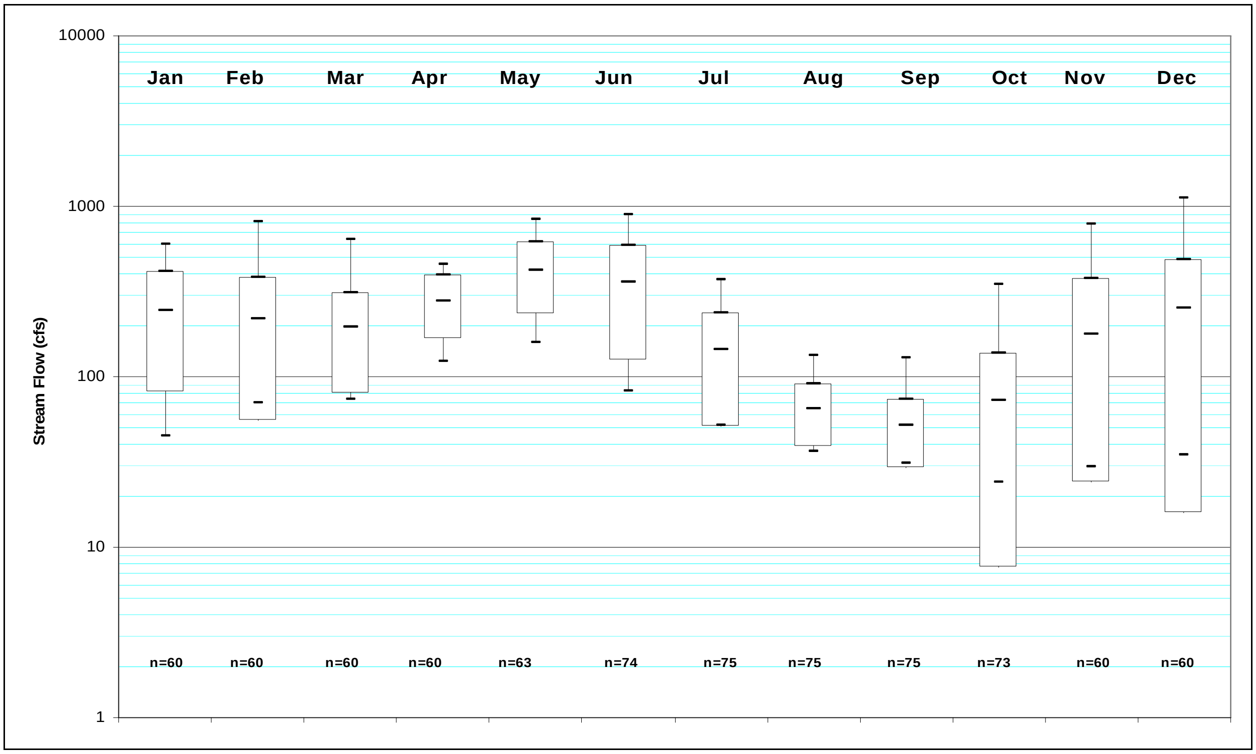

Figure A-6. Monthly streamflow data for USGS Gage #12097500 (Greenwater River at Greenwater, 03/78-09/05).