URBAN STREAMS MONITORING PROGRAM REPORT 2009

City of Bellingham
Department of Public Works Laboratory
March 2010

Contents

1.0 Introduction

Urban streams can be tremendous assets. They are an integral part of the environment, economy, and community through which they flow. Healthy streams support vital functions of the aquatic environment like providing fish habitat and flood control. Their presence bolsters adjacent property values and allows recreational opportunities such as fishing and swimming. Beyond their banks, stream health is interconnected with disease control, greenway services and the state of the near-shore marine environment.

Degradation of urban streams can interfere with the vital functions of streams and can minimize or curtail recreational activities. Habitat may no longer support viable fish populations, flooding may threaten homes and businesses, and bacteria and other pollutants may render streams unfit for swimming and other recreational activities.

Streams are degraded when land disturbing activities such as constructing roads, parking lots, and residential, commercial, and industrial buildings occur. The end result can be impaired or lost habitat, loss of natural flood control mechanisms, stream corridors that are no longer aesthetically pleasing, and loss of recreation areas.

The City of Bellingham recognizes that urban activities impact streams and is working to understand and minimize these impacts through a variety of programs and projects. Among the various programs and projects are stream restoration, stream hydrology, stormwater treatment, and water quality monitoring programs as well as public education and ordinances that protect critical areas.

1.1 Effects of Urbanization

Urbanized areas contain large amounts of impervious surface that has replaced natural vegetation. Stormwater that runs across impervious surfaces and is no longer absorbed by soils leads to extremes in stream flow. Runoff from rain events can cause rapid, flashy increases in flow that lead to erosion, scour and habitat loss. Dry season flows are no longer maintained by the slow release of water absorbed by soils.

In addition, as water from rain events moves quickly across pavement and other impervious surfaces it picks up sediment and pollutants to be deposited into streams. Large amounts of sediment can clog gills, smother organisms that are the food source for fish, cover spawning beds, and destroy habitat. Chemicals flushed from streets and lawns can be toxic or increase oxygen depletion in the water. Two separate fish kills on Baker Creek in 2003 were correlated with storm events (LaCroix et al., 2004). Terrestrial bacteria, including fecal coliform bacteria, can be flushed into streams in large numbers rendering streams unfit for recreational uses.

Physical alterations to streams can have profound effects on the stability and integrity of natural systems. Artificial channel modifications including channelization, the placement of culverts, and bank stabilization measures such as retaining walls and riprap, degrades or eliminates habitat and in some cases prevents fish passage.

Removal of riparian (near-stream) vegetation can make streams become more prone to erosion and pollution. Additionally riparian vegetation provides canopy cover that helps keep stream water cool, a necessary factor in the survival of many native fish species.

Returning streams to a physical state closer to natural conditions and preventing pollutants from entering streams improves water quality and habitat, which can lead to greater diversity and numbers of fish and other aquatic organisms. Stream restoration can also decrease flooding and provide more recreational opportunities for urban residents and a more visually pleasing landscape. The next sections of this report highlight the efforts by the City to improve Bellingham's urban streams.

2.0 Stream Restoration

The City has spent considerable effort in recent years on stream restoration projects designed to mitigate habitat degradation that has occurred as a consequence of human activities. Figure 2.0-5 shows restoration projects on Bellingham's urban streams. Projects have included restoring and replanting riparian buffers, removing artificial channel modifications, stabilizing banks, and improving fish habitat through a variety of specific habitat objectives. Details of individual projects can be found in Appendix A.

Riparian buffer restoration (shown in green on Figure 2.0-5) has been performed on stream segments throughout the City. This process of restoring natural function to the land along stream corridors includes the removal of non-native plant species and replanting with native trees, shrubs, and other plants. Riparian vegetation provides a buffer area which filters out pollutants from urban runoff. Riparian vegetation also stabilizes stream banks, regulates stream temperatures, and provides leaf litter that aquatic insects and microorganisms use as a food source. The riparian zone provides habitat and migration corridors for wildlife.

Artificial channel modifications change the natural balance of stream systems. Culverts and other physical barriers can impede passage of fish and sediment transport. Figure 2.0-5 provides the locations where fish passage barriers have been removed or modified (pink rectangles). Channelization, the straightening of streambeds, causes increased flooding, sedimentation, erosion, and loss of habitat. In many cases urban streams have been disconnected from their natural flood-plains through channel modifications. Natural flood-plains perform an essential role in flood prevention and habitat creation and

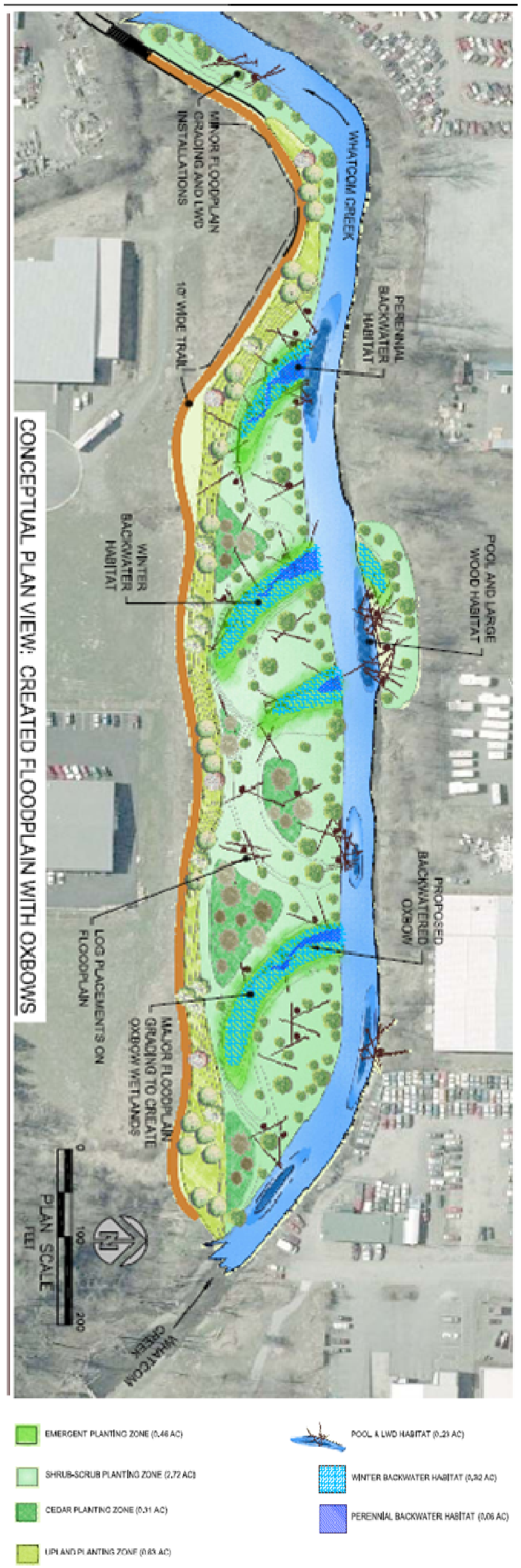


Figure 2.0-1 Restoration Plan: Red Tail Reach

Figure 2.0-2. Fish-passable culvert on Connelly Creek at Donovan Ave.

they help maintain the hydrological balance in stream systems.

The removal of artificial channel modifications includes removing physical barriers (Figures 2.1-1), replacing obstructive culverts with fish-passable culverts (Figure 2.0-2), returning channelized reaches of streams to a more natural meander or braided form, reconnecting streams to their natural flood-plain, and replacing armored bank stabilization structures with more natural structures such as designed log jams (Figure 2.0-3).

The City's strategies to improvement fish habitat have been complex and varied. The course of action for a given stream depends on the specific characteristics of the stream system and the species of fish that currently or could potentially inhabit the stream. Some of the fish habitat restoration projects in Bellingham's urban streams (Figure 2.0-5, shown in blue) have included the creation of backwater areas (Figure 2.0-4) which provide low velocity refuges for juvenile fish in times of high flows, the addition of spawning gravel to streams that have experienced downcutting and channel erosion, the restoration of pool-riffle sequences which provide spawning and resting areas for fish, and restoring stream banks to a more natural sloped shape rather than the sharply down cut banks indicative of urbanization.

Expected benefits of stream restoration include improved riparian habitat, lessening flow extremes, canopy cover to promote cooler water temperatures and a corresponding increase of dissolved oxygen in the summer months, reduced sediment and pollutant loads, reduced erosion, increased populations of fish and other aquatic life, and improved aesthetics. All of these improvements lead to more recreation opportunities and increased property values along the improved stream corridors.

Figure 2.0-3. Placement of root wads and large woody debris for bank stabilization on Whatcom Creek.

Figure 2.0-4. Backwater pond created on Cemetery Creek to provide low velocity refuge for juvenile fish in times of high flow.

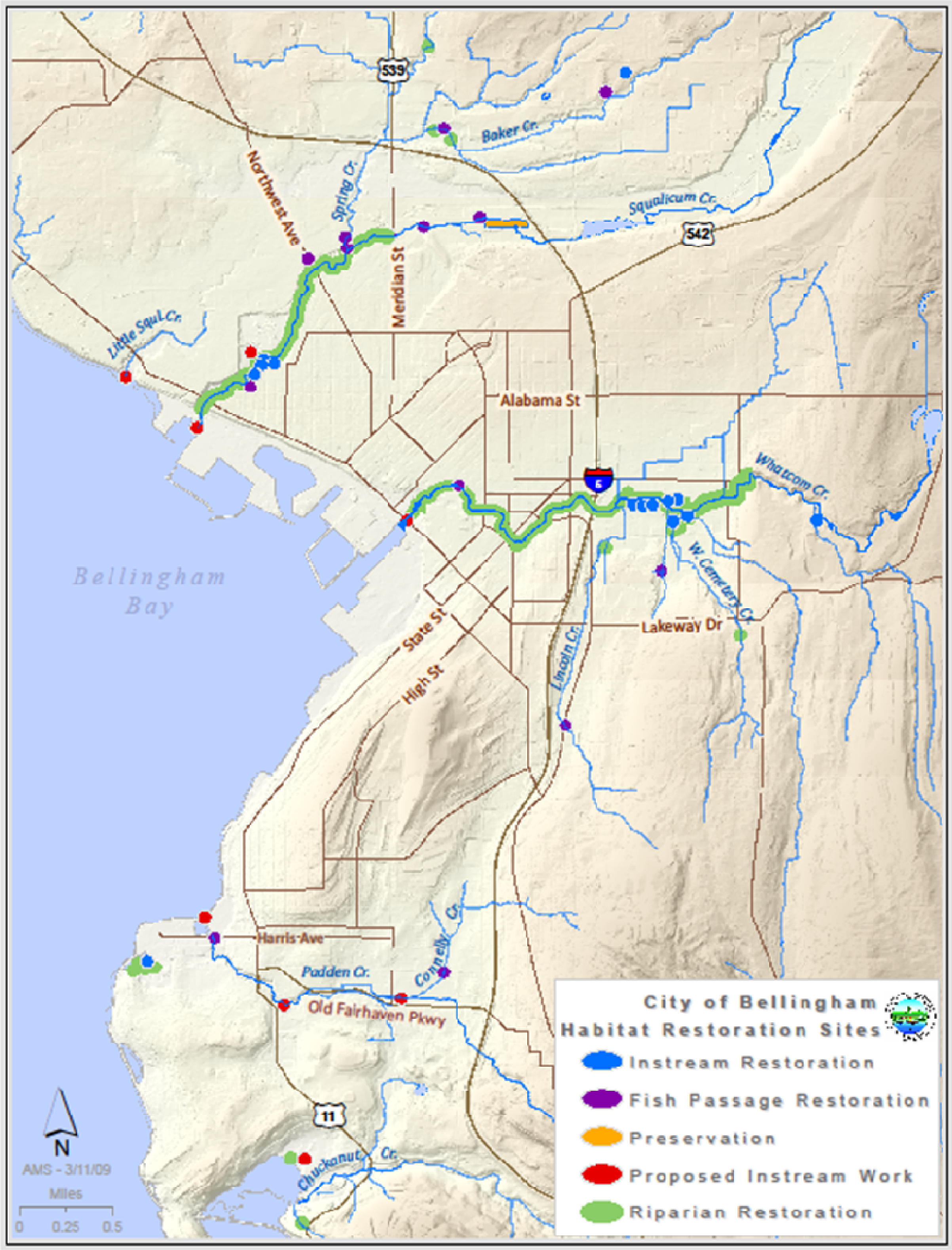


Figure 2.0-5. Location and types of stream restoration projects within the City of Bellingham (March 2009).

2.1 Restoration Projects in 2009

During 2009 planning and work was begun at several sites along Padden Creek to restore the creek's path to a more natural condition and improve riparian buffers between the creek and nearby houses. This major restoration project includes the relocation of fish, alteration of the streambed to restore the 100-year flood plain, creating a more winding coarse, planting of native vegetation as riparian habitat and improvement to city greenways. Likewise, plans to daylight and restore habitat on Little Squalicum Creek and Willow Spring (a tributary to Squalicum Creek) implement many of these same measures.

2.2 Bellingham's 303(d) listings

Virtually every pond, creek and stream in the City has been modified through human endeavors. Table 2.2-1. catalogs Bellingham's current 303(d) listings for urban streams. As Mill Wheel and Silver Beach Creeks are tributaries to Lake Whatcom, they are monitored as part of Lake Whatcom TMDL efforts and are not included in the Urban Streams Program. Information regarding the Lake Whatcom can be found on the City's website: http://www.cob.org. Padden and Squalicum Creeks are slated for TMDL tract during the 2009 water year. In all cases, innovative TMDL studies, clean-up and restoration efforts have already begun.

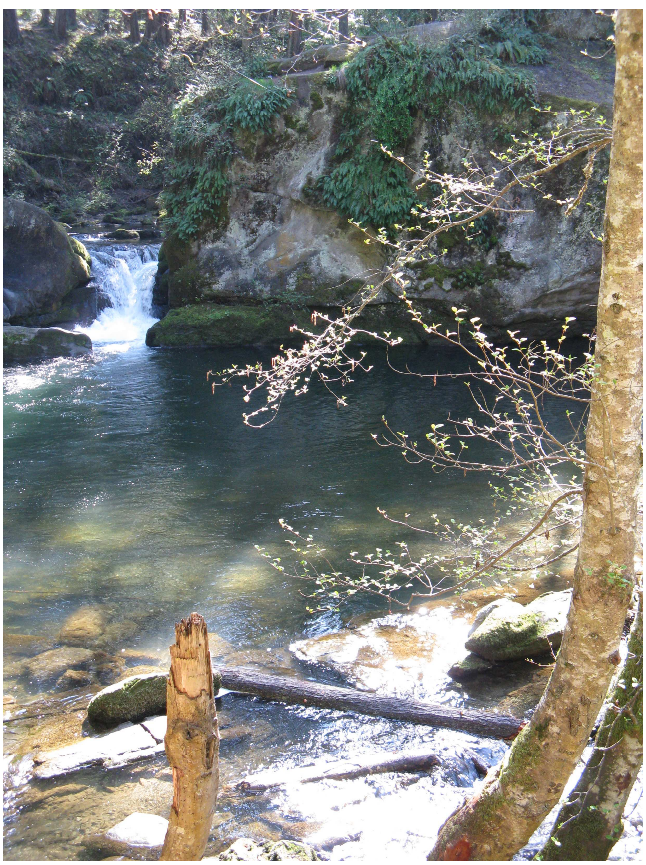


Table 2.2-1. Bellingham's Urban Stream 303(d) listings by parameter.

Creek	Temp	DO	Fecal	Zinc
Chuckanut		x	x	
Padden	x	x	x	
Connelly	x	x	x	
Whatcom	x	x	x	
Hanna	x		x	
Cemetery	x	x	x	
Lincoln	x	x	x	
Fever	x	x	x	x
Squalicum	x	x	x	
Baker			x	
Silver		x	x	
Mill Wheel			x	
Silver Beach			x	

3.0 Stream Hydrology

Stream hydrology data provide information for developing restoration strategies and are an important part of assessing stormwater and land development impacts to stream flows. The City of Bellingham Stormwater Utility is currently supporting hydrological assessment of specific reaches on Whatcom, Squalicum, Padden, and Chuckanut Creeks. Stream gauging stations on these creeks provide data on gauge heights (relative height of the water) measured at 15 minute intervals.

After the stream gauge data has been collected and converted to flow, hydrographs of stream flow are generated to study the hydrological regime of a particular stream reach. The information derived from hydrographs is used to analyze high and low flows and flow duration. This analysis is important because almost all of the water quality parameters we use to measure stream health are dependent on flow.

Decisions based on the analysis of stream discharge affect the operation of in-stream flood control dams (present on Padden, Squalicum and Whatcom Creeks), the type and size of new stormwater structures to be installed, where different types of stream restoration can have the greatest impact, assessing available fish habitat, determining the potential for erosion and scouring, and can also be used by City planners when considering development options within a watershed.

Figure 3.0-1 illustrates the effects of flow on fecal coliform levels in Padden Creek during the summer of 2009. When low flow conditions persist, water bodies heat up faster, promoting algae and bacteria growth whch in turn drives dissolved oxygen out of solution. Exceedence of state water quality standards almost always occur under these conditions.

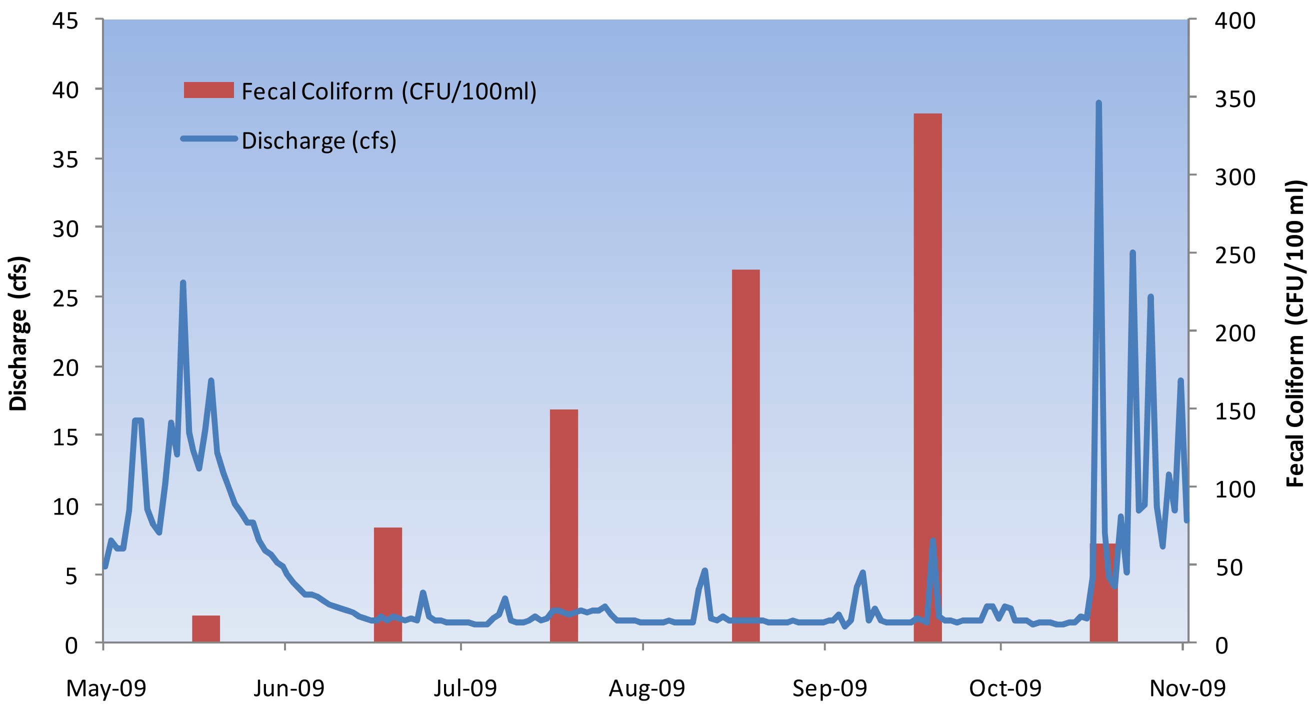


Figure 3.0-1. Effects of flow on fecal coliform levels during the warm summer months on Padden Creek in 2009.

4.0 Stormwater Treatment

The City of Bellingham Stormwater Utility has made a considerable investment in improving the quality of stormwater entering Bellingham's urban streams. Strategies for stormwater management included an illicit discharge program, stormwater treatment, stormwater monitoring, and a rigorous inspection program for new construction projects.

Always on the forefront of stormwater treatment technologies, in 2009 the City took on the resurfacing of a large part of Northshore Dr. and the streets surrounding civic field with pervious pavement bike lanes and sidewalks. The pervious pavement allows stormwater to infiltrate to underlying sand filters instead of flowing untreated directly to the nearest water body. The new surface has helped to reduce both area's stormwater contribution significantly.

Studies of specialized stormwater treatment media and facilities designed to remove phosphorus also continued in 2009. This includes study of a Filterra™ vault which utilizes a proprietary media along with the natural nutrient uptake of plants to remove pollutants. It also includes the study of various forms of media called Alumina that removes soluble phosphorus from stormwater via a process called Sorption.

Figure 4.0-1. Bellingham is leading the way in stormwater treatment by installing the new Filterra™ vault (left) and Alumina filter media vault (right) in the Lake Whatcom watershed.

Figure 4.0-2. Rain garden in the Bellingham City Hall parking lot. Run-off enters the rain garden through the curb cut shown in the photograph. Pollutants are taken up by the plants or removed by filtration within the soils. Treated water is slowly discharged to Whatcom Creek, behind the rain garden.

To complement these new technologies, special projects to map impervious surfaces, treated areas, and pollutant inputs around the City were also undertaken in 2009. Now completed, the product of these project provides an invaluable tool for the understanding and management of stormwater.

As in years prior, the Utility continues to maintain many underground filter cartridge vaults and low impact rain gardens to treat runoff from streets and parking lots. A few prominent examples of raingardens are behind Bellingham City Hall (Figure 4.0-2), next to the Market Depot downtown, and at Blodel-Donovan Park. Rain gardens are an innovative, low-cost alternative to conventional stormwater treatment. Like the Filterra™ vault, pollutants are removed through the natural filtration properties of soil and plants. Rain gardens can help minimize extremes in flow by allowing water to infiltrate into the ground.

5.0 Water Quality Monitoring

One of the longest running monitoring programs within the City is the Urban Streams Monitoring Program. This program, which began in 1990, was developed by the City to obtain baseline water quality data for streams in Bellingham and to use this data to assess water quality in the streams. The City also uses the data to compare the water quality in Bellingham's urban streams to the water quality standards described in the Washington State Department of Ecology (Ecology) rule - Chapter 173-201A WAC, *Water Quality Standards for Surface Waters of the State of Washington* (1997, 2003, 2006). The Urban Streams Monitoring Program is not intended to directly interface with the Ecology rules as they pertain to determination of impaired status but to give context to the water quality observed in Bellingham's urban streams.

While the City makes every attempt to capture meaningful data, it should be recognized that all tests are collected by grab samples. These samples may or may not be representative of the true character of water quality with Bellingham's urban streams. This data should not be used for the determination of regulatory compliance or noncompliance.

Ecology uses various water quality criteria to protect existing and designated uses of surface waters in Washington. The rule was originally promulgated in 1997 and underwent significant revision in 2003. These revisions changed the 1997 class-based system to a designated uses approach. The 2003 rule underwent further revisions after the US Environmental Protection Agency (EPA) failed to approve portions of the rule. Under the amended 2003 rule Bellingham's urban streams are designated the Aquatic Life Use (ALU) of Core Summer Salmonid Habitat for temperature, dissolved oxygen, pH, and turbidity. For recreational activities, Bellingham's streams are designated for Primary Contact Recreational Use according to fecal coliform count.

Ecology adopted revisions to the 2003 rule on December 21, 2006. These changes apply to stream monitoring conducted in 2008. The fecal coliform bacteria revised standard was approved by the EPA in 2005. For purposes of this report, the Class-based designations are presented in addition to Use-based criteria. This allows for ease of comparison of streams from year to year.

5.1 Procedures and Quality Control

All analyses are performed by the staff of the City of Bellingham's state accredited laboratory. Protocols used are described in Standard Methods for the Examination of Water and Wastewater, 21st Edition (APHA, AWWA, WEF, 2005). Protocols for each parameter are listed in Appendix B.

Samples for fecal coliform bacteria are collected one to six inches below the surface of the water in clean, sterile 250-ml polypropylene bottles. Samples are kept on ice for transportation to the laboratory. In the laboratory, samples are kept refrigerated (< 4°C) until analyzed. Analysis for fecal coliform bacteria (SM 9222 D) is completed within six hours of collection (Appendix B).

Quality control for fecal coliform includes a laboratory duplicate (one sample, two measurements) and a field duplicate (two samples collected from the same sampling location) analyzed monthly along with regular stream samples. The laboratory duplicates serve to check the reproducibility of the instruments and the Laboratory Technician's technique. The purpose of the field duplicate is to indicate site heterogeneity or how representative the measurement is for a particular site. Agreement between the duplicates is assessed. If the difference between the duplicate samples is out of the calculated range of acceptable results or data appear questionable, the data are investigated. Results of the investigation are noted. The data can be left unchanged, flagged, or removed as the investigation dictates (Appendix B).

Field measurements for dissolved oxygen (SM 4500-O G), temperature (SM 2550 B), pH (SM 4500-H^+ B), and conductivity (SM 2510 B) are taken using a Hydrolab Quanta field monitor**.** Quality control includes pre and post calibration of the Hydrolab, testing check standards, and two field duplicates (two measurements from the same sampling location). If check standard measurements are out of a specified range, the instrument is recalibrated and retested with the check standards (Appendix B). Assessment of field duplicates follows the same procedure as for fecal coliform bacteria.

Turbidity measurements (SM 2130 B) are conducted on a benchtop turbidimeter. Quality control includes a laboratory duplicate, a field duplicate, and testing check standards. If check standard measurements are out of a specified range, the instrument is recalibrated and retested with the check standards (Appendix B). Assessment of laboratory and field duplicates follows the same procedure as for fecal coliform bacteria.

5.2 Sampling

The City of Bellingham urban streams have been monitored for the past 17 years. Twelve sites have been consistently sampled throughout the monitoring program. Eighteen sites have been sampled since 2002. One additional site was added at the end of 2006. The quantity of samples collected per year from each site has varied from four to twelve. Since 2002 all sites have been sampled monthly. Latitude and longitude of each sample site are provided in Table 5.2-1.

Sampling locations are shown on the drainage basin maps supplied at the end of this report. The sampling program includes four sites on Whatcom Creek as well as four of its tributaries - Hanna, Cemetery, Lincoln, and Fever Creeks (Whatcom Drainage Map). There are three sampling sites on Squalicum Creek and a sampling site on its main tributary, Baker Creek (Squalicum Drainage Map). Padden Creek is sampled at four locations and on its main tributary, Connelly Creek (Chuckanut and Padden Drainage Map). Silver Creek has one sample site (Silver Drainage Map) and Chuckanut Creek is sampled only near the mouth (Chuckanut and Padden Drainage Map).

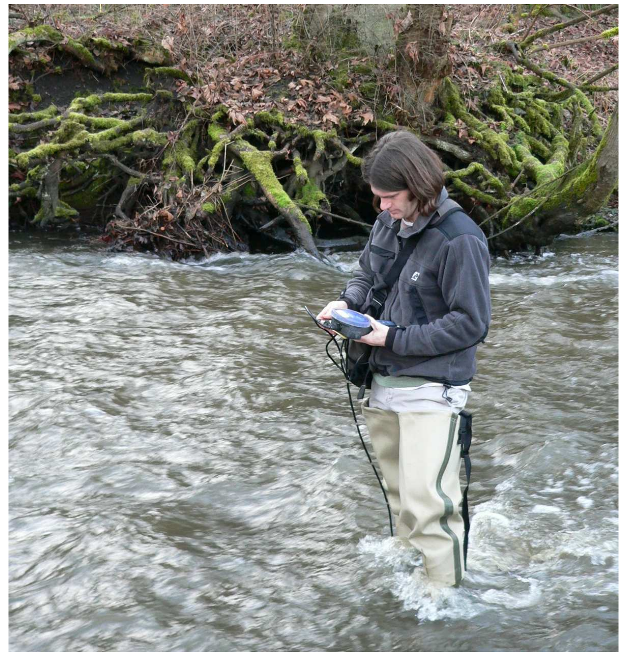


Table 5.2-1. Latitude and longitude of urban stream sample sites, NAD84 datum.

Stream Site	Latitude	Longitude
Chuckanut Creek (Mouth)	48° 42' 02"	122° 29' 37"
Padden Creek (38th St.)	48° 42' 20"	122° 28' 02"
Padden Creek (30th St.)	48° 42' 49"	122° 28' 41"
Connelly Creek (Donovan)	48° 43' 01"	122° 28' 47"
Padden Creek (22nd St.)	48° 42' 92"	122° 29' 39"
Padden Creek (Mouth)	48° 43' 10"	122° 30' 25"
Whatcom Creek (Control Dam)	48° 45' 27"	122° 25' 20"
Hanna Creek (WTP)	48° 45' 08"	122° 26' 08"
Cemetery Creek (Whatcom Cr)	48° 45' 12"	122° 27' 12"
Lincoln Creek (Fraser)	48° 45' 06"	122° 27' 36"
Fever Creek (Valencia)	48° 45' 35"	122° 26' 47"
Whatcom Creek (Valencia)	48°45' 14"	122° 26' 42"
Whatcom Creek (I-5)	48° 45' 15"	122° 27' 45"
Whatcom Creek (Dupont)	48° 45' 20"	122° 28' 50"
Squalicum Creek (E. Bakerview)	48° 47' 21"	122° 26' 18"
Squalicum Creek (Meridian)	48° 46' 32"	122° 29' 07"
Baker Creek (Squalicum Pkwy)	48° 46' 29"	122° 29' 29"
Squalicum Creek (Mouth)	48° 45' 47"	122° 30' 22"
Silver Creek (Graveline)	48° 49' 30"	122° 32' 41"

Levels of fecal coliform bacteria, dissolved oxygen, temperature, pH, turbidity, and conductivity are measured at each site. All but conductivity are water quality parameters included in the WAC. Criteria included in the WAC but not sampled by the City include toxic, radioactive or deleterious material concentrations, and dissolved gases.

Conductivity results for individual stream segments are not included in this report. The 2008 results for this parameter have not changed significantly from the 2002 results. Conductivity measurements for 2002 can be found in the *Urban Streams Monitoring Program Report 2002* (City of Bellingham, 2002b).

A comparison of the stream sites sampled show that Bellingham's urban streams rarely meet all of the water quality standards for overall Class A* designation (Table 5.2-2). The overall classification of a stream is based on the parameter which confers the lowest class designation on that water body. Thus a single violation of a single parameter can dictate whether or not a stream site meets overall Class A requirements.

In 2009, only Padden Creek at 38th and Squalicum Creek at Meridian met Class A standards. Chuckanut Creek, Padden Creek at 30th, Hanna Creek, and three sites on Whatcom Creek (Control Dam, Valencia, and I-5) met overall Class B standards.

Likewise, Bellingham's urban streams rarely meet all of the designated use standards. In 2009, Padden Creek at 38th, Whatcom Creek at the Control Dam and Valencia Street, and Squalicum Creek at E. Bakerview and Meridian met Primary Contact Recreational Use standards. None of the sites met all of the Aquatic Life Use requirements of Core Summer Salmonid Habitat.

The following sections provide sampling data collected during 2009. Historical data for is also provided for comparison of the water quality parameters sampled for each site. Raw data tables used to construct percent exceedence figures are provided in Appendix C.

Table 5.2-2. Overall class designation for all stream segments from 1991 to 2009. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards).

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
Chuckanut (mouth)	B	X	X	X	X	X	B	X	X	A	X	B	X	B	X	X	B	B	B
Padden (38th)						B	B	X	AA	A	X	A	B	X	A	A	A	X	A
Padden (30th)	X	B	X	X	X	A	B	X	X	A	A	A	X	X	X	B	B	X	B
Connelly (Donovan)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)															X	X	X	B	X
Padden (mouth)	X	X	X	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X
Whatcom (Control Dam)	X	X	B	X	X	X	B	X	B	B	B	X	X	X	X	X	B	B	B
Hanna (WTP)					X							B	X	X	X	X	X	X	B
Cemetery (Whatcom Cr)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Lincoln (Fraser)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Fever (Valencia)				X	X	X	X	X	X	X	X	X	B	X	X	X	X	X	X
Whatcom (Valencia)																	A	B	B
Whatcom (I-5)	B	B	X	X	X	X	B	X	X	B	X	B	B	X	B	B	B	B	B
Whatcom (Dupont)	X	X	X	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X
Squalicum (E. Bakerview)		B		X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X
Squalicum (Meridian)	B	A	X	X	X	X	B	B	B	X	B	B	A	X	X	B	A	X	A
Baker (Squalicum)	B	X	X	X	X	X	A	B	X	X	X	X	X	X	X	X	X	X	X
Squalicum (Mouth)	B	B	X	X	X	X	A	X	X	X	X	X	X	B	X	X	X	A	X
Silver (Graveline)														X	X	X	X	X	X

*For consistency and ease of comparisons, Ecology class designations used before 2006 are presented in addition to current Ecology designated use standards. They are not meant to directly interface with the Ecology rules as they pertain to determination of impaired status but to give context to the water quality observed in Bellingham's urban streams.

5.3 Water Quality Parameters

5.3.1 Fecal Coliform Bacteria

The water quality parameter that historically has most often determined the overall classification of Bellingham's urban streams is fecal coliform bacteria. Stream sites sampled by the City rarely meet the Primary Contact Recreational Use (Class A) standards for this parameter (Table 5.3.1-1).

In 2009, Padden Creek at 38th and Whatcom Creek at the Control Dam met the stringent Class AA criteria for fecal coliform bacteria. Whatcom Creek at Valencia and Squalicum Creek at E. Bakerview and Meridian met Class A criteria. Chuckanut Creek, Padden Creek at 30th, Hanna Creek and Whatcom Creek at I-5 met Class B standards. The remaining 10 sites did not meet Class A or B criteria for fecal coliforms. Figure 5.3.1-1 shows the minimum, maximum, and geomean values for all stream segments sampled in 2008. Figure 5.3.1-2 provides the percent of samples that exceeded fecal coliform water quality standards.

Fecal coliform bacteria are normal inhabitants of the digestive tracts of warm-blooded animals. The presence of fecal coliforms in water indicates contamination from fecal sources. While these bacteria do not usually cause illness directly, fecal coliforms are considered an indicator of pathogens that cause a variety of water-borne illnesses and conditions including eye, ear, and skin conditions, upper respiratory illness, and most commonly, gastro-intestinal illness.

Table 5.3.1-1 The fecal coliform bacteria class designation for all stream segments from 1991 to 2009. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards).

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
Chuckanut (mouth)	B	X	X	X	A	X	A	X	X	A	X	B	X	B	X	X	B	B	B
Padden (38th)						AA	AA	X	AA	AA	X	AA	B	X	A	AA	AA	X	AA
Padden (30th)	X	B	X	X	B	A	A	X	X	AA	A	A	X	X	X	B	B	X	B
Connelly (Donovan)	X	X	X	X	B	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)															X	X	X	B	X
Padden (mouth)	X	X	X	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X
Whatcom (Control Dam)	B	AA	B	B	A	B	B	A	A	AA	A	AA	AA	AA	AA	AA	AA	AA	AA
Hanna (WTP)					X							A	X	X	X	X	X	X	B
Cemetery (Whatcom Cr)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Lincoln (Fraser)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X
Fever (Valencia)				X	X	X	X	X	X	X	X	X	B	X	X	X	X	X	X
Whatcom (Valencia)																	AA	AA	A
Whatcom (I-5)	B	B	X	B	X	X	B	A	X	AA	X	AA	AA	X	B	A	AA	AA	B
Whatcom (Dupont)	X	X	X	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X
Squalicum (E. Bakerview)		B		X	B	X	X	X	X	B	X	X	X	X	X	X	X	X	A
Squalicum (Meridian)	B	A	X	X	B	X	B	A	B	X	B	A	AA	X	X	B	A	X	A
Baker (Squalicum)	B	X	X	X	X	X	A	A	X	X	X	X	X	X	X	X	X	X	X
Squalicum (Mouth)	B	B	X	X	B	X	A	X	X	X	X	X	X	B	X	X	X	A	X
Silver (Graveline)														X	X	X	X	X	X

While the origin of fecal coliform bacteria in streams is from fecal sources, the levels of bacteria found in streams arise from a variety of causes. Initially bacteria are washed into streams via surface runoff (primarily animal sources), leaking septic systems, or broken sewer lines. This initial flush of bacteria may be diluted as the stream proceeds downstream or may settle into bottom sediments where extended survival and growth are possible, particularly as temperatures increase (Ishii et al., 2006; Davies et al., 1995; Goyal and Adams, 1984). Recreational and wildlife activities as well as agitation from storm events can cause resuspension of sediment-bound bacteria, increasing the bacterial concentration in overlying waters.

Bellingham's urban streams are classified as Primary Contact Recreational waters by the Surface Water Standards 2003 rule (WAC 173-201A-200). Under the 1997 rule Bellingham's streams were designated as Class A waters (WAC 173-201A-030). Table 5.3.1-2 compares the 1997 rule to the 2003 rule. The requirements for Class A and the designated use are equivalent.

The fecal coliform criteria for Class A (Primary Contact Recreational) fresh waters includes a geometric mean (geomean) value of 100 or less colony forming units (CFU) per 100 milliliters (ml) water where not more than 10 percent of all samples obtained for calculating the geomean exceed 200 CFU/100 ml (WAC 173-201A-030, WAC 173-201A-200 Table 200 (2)(b)).

The Class B (Secondary Contact Recreational) fresh water fecal coliform criteria includes a geomean of 200 or less CFU/100 ml with the caveat that not more than 10 percent of all samples obtained for calculating the geomean have values exceeding 400 CFU/100 ml (WAC 173-201A-030, WAC 173-201A-200 Table 200 (2)(b)). Tables 5.2-2 and 5.3.1-1 classify streams using a geomean calculated from all samples taken within the year, taking into account the percent of those samples that exceed 200 (or 400) CFU/100 ml.

Table 5.3.1-2. Comparison of the 1997 Ecology rule to the approved 2003 rule for the fecal coliform bacteria standard for fresh surface waters in Washington.

FECAL COLIFORM BACTERIA		
1997 Rule		**Ammended 2003 Rule (2006)**
Class	**Geomean**	**Category**
Class AA	50 CFU/100 ml, no more than 10% of all samples exceed 100 CFU/100 ml	Extraordinary Primary Contact
Class A	100 CFU/100 ml, no more than 10% of all samples exceed 200 CFU/100 ml	Primary Contact
Class B	200 CFU/100 ml, no more than 10 % of all samples exceed 400 CFU/100 ml	Secondary Contact

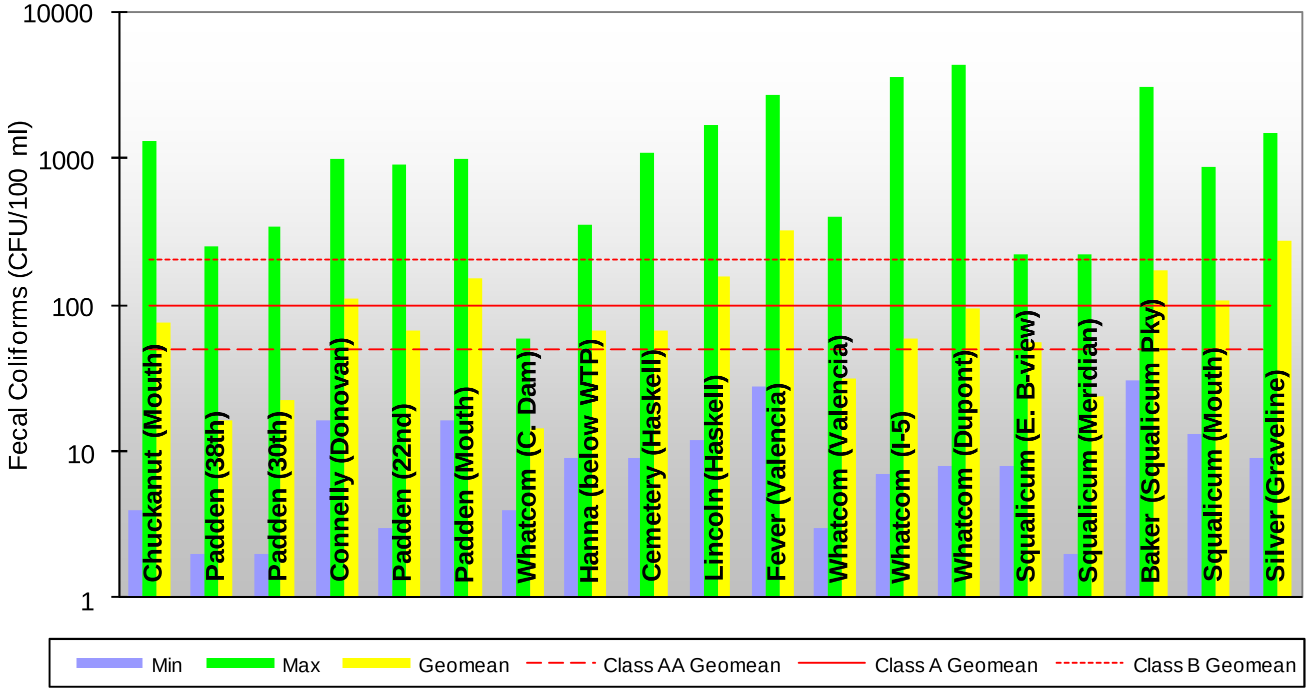


Figure 5.3.1-1. Fecal coliform bacteria minimum, maximum, and geomean values for all stream segments sampled in 2009. Red lines indicate the maximum geomean value allowed by the Class AA, A (Primary Recreational Contact), and B criteria for fecal coliform bacteria. *Note this graph uses a logarithmic scale*.

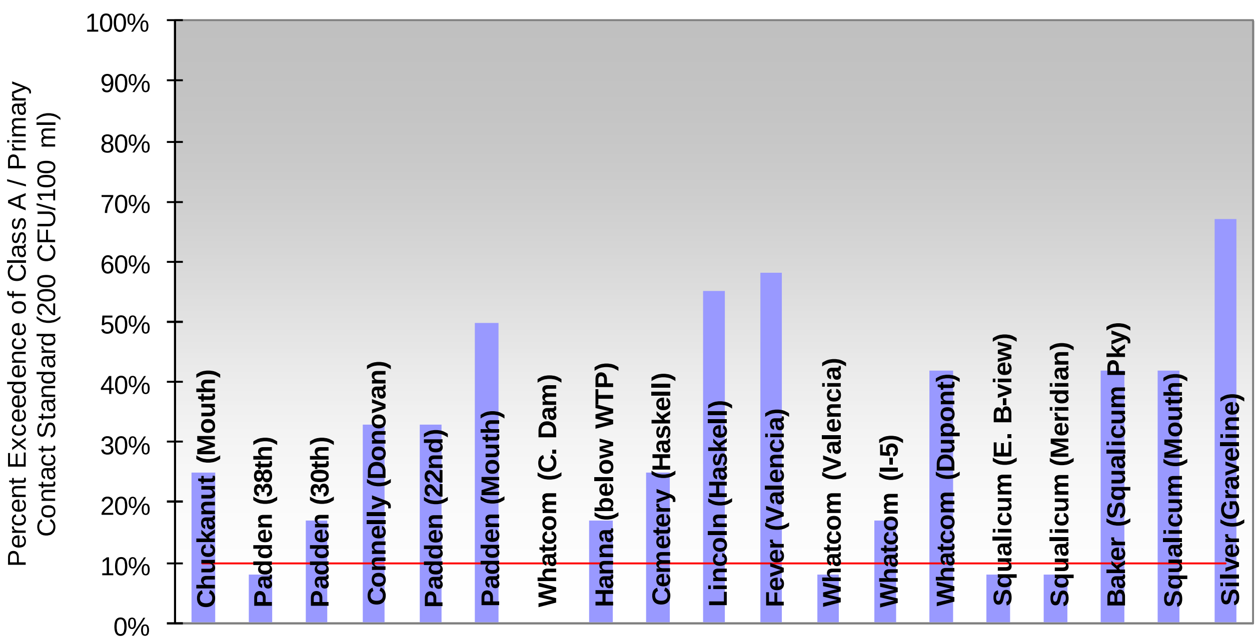


Figure 5.3.1-2. Fecal coliform percent exceedence of the Class A / Primary Recreational Contact standard for all stream segments sampled in 2009. Whatcom Creek at the Control Dam was the only site with no exceedences for 2009.

5.3.2 Dissolved Oxygen

Of all the stream sites sampled in 2009, only Chuckanut Creek met the stringent Core Summer Salmonid Habitat Aquatic Life Use (ALU) criterion for dissolved oxygen. The Core Summer Salmonid Habitat ALU level for dissolved oxygen equates to a Class AA designation.

Of the rest of Bellingham's urban streams, eleven sites met the Class A criterion for dissolved oxygen in 2009 (Table 5.3.2-1), while five sites met Class B standards. Only Cemetery Creek and Squalicum Creek at E. Bakerview did not meet Class A or B standards for dissolved oxygen. Figure 5.3.2-1 provides the minimum, maximum, and average values for dissolved oxygen in all stream segments sampled in 2009. Figure 5.3.2-2 shows the percent of samples that fell below the Class A criterion. All samples besides those taken on Chuckanut Creek were below ALU criterion.

Aquatic organisms require oxygen to survive. Oxygen in water is gained from the atmosphere and produced during photosynthesis. Running water, because of its churning action, contains higher levels of oxygen than still water. Oxygen is consumed during respiration, decomposition, and various chemical reactions.

Oxygen in water is measured in its dissolved form. The amount of oxygen dissolved in water is related to temperature. Cold water can hold more oxygen than warm water; warm water becomes saturated with oxygen more quickly than cold water. In summer months as the water becomes warmer, it holds less and less dissolved oxygen. If the water becomes too warm, even at 100% saturation, dissolved oxygen levels may become suboptimal for some fish and other aquatic organisms.

In addition to elevated temperature, inputs of pollution can cause lower dis-

Table 5.3.2-1. Dissolved oxygen class designation for all stream segments from 1991 to 2009. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards).

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
Chuckanut (mouth)	A	A	A	X	X	B	A	A	A	A	A	A	B	A	A	AA	A	A	AA
Padden (38th)						B	A	A	A	A	A	A	A	B	A	A	A	B	A
Padden (30th)	A	A	A	X	X	A	A	A	A	A	A	AA	B	B	A	A	A	A	A
Connelly (Donovan)	A	A	A	X	X	B	A	B	A	B	B	A	B	B	A	A	A	A	B
Padden (22nd)															A	AA	A	A	A
Padden (mouth)	B	A	A	X	X	B	A	A	A	A	A	A	A	B	A	A	A	A	B
Whatcom (Control Dam)	B	A	A	X	X	B	A	B	B	A	B	A	B	B	A	A	A	A	B
Hanna (WTP)					X							B	AA	B	A	A	A	AA	A
Cemetery (Whatcom Cr)	X	A	X	X	X	B	B	B	A	A	B	B	X	X	X	A	X	X	X
Lincoln (Fraser)	X	A	A	X	X	B	B	X	A	A	B	B	B	B	B	A	B	B	B
Fever (Valencia)				X	X	B	A	B	A	A	A	A	A	B	B	A	A	A	A
Whatcom (Valencia)																	A	A	A
Whatcom (I-5)	B	A	A	X	X	B	A	A	AA	A	A	A	A	B	A	A	A	A	A
Whatcom (Dupont)	A	A	A	B	B	B	A	A	AA	A	B	A	A	X	B	A	A	B	B
Squalicum (E. Bakerview)				X	X	X	X	X	B	B	A	X	X	X	X	X	X	B	X
Squalicum (Meridian)	B	A	A	X	X	B	B	A	B	A	A	A	A	B	B	A	A	A	A
Baker (Squalicum)	A	A	A	X	X	B	A	A	A	AA	A	A	B	B	B	B	A	A	A
Squalicum (Mouth)	A	A	A	X	X	B	A	A	A	AA	A	A	B	B	A	A	A	A	A
Silver (Graveline)														B	A	AA	A	A	A

solved oxygen levels. Feces from animals and failing septic systems, grass clippings, leaves and woody debris, and urban and agricultural run-off, all contain organic matter that is decomposed by microorganisms, which use oxygen in the process. The amount of oxygen consumed by these organisms in breaking down organic compounds is known as biochemical oxygen demand (BOD). BOD also measures oxygen consumed by the chemical oxidation of inorganic matter. Variables that can affect the rate of oxygen consumption include temperature, pH, the types and abundance of microorganisms, and the type of organic and inorganic materials present in the water (USEPA, 1997). If BOD is high, less dissolved oxygen is available to fish and macroinvertebrates.

To meet the stringent Core Summer Salmonid Habitat ALU criterion, the revised 2003 WAC states that dissolved oxygen must remain above 9.5 mg/L. This equates to Class AA by the 1997 rule. Also by the 1997 rule, dissolved oxygen must be 8.0 mg/L or higher to qualify as a Class A stream and 6.5 mg/L or higher to meet Class B standards. WQP Policy 1-11 (Ecology, 2006) states that a water body may be considered impaired when a minimum of 3 and at least 10% of single grab samples, such as those collected for the Urban Streams Monitoring Program, in a given year do not meet the dissolved oxygen water quality criteria.

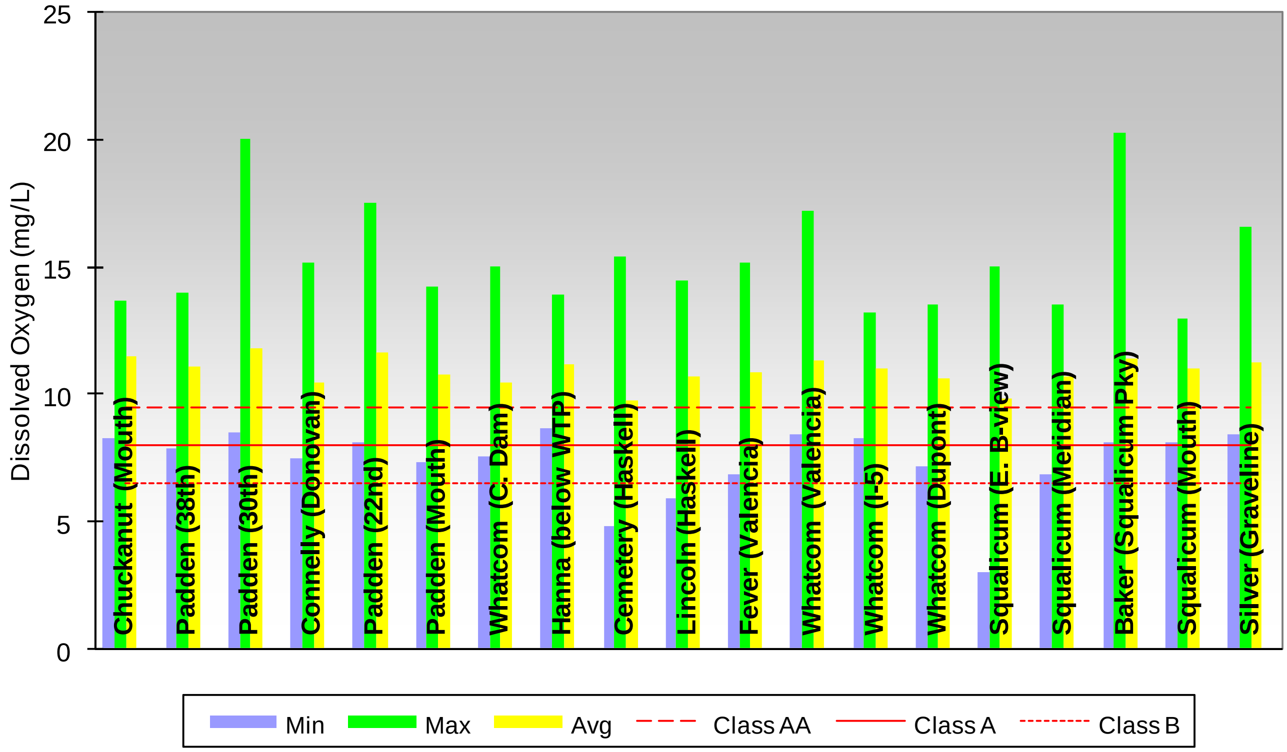


Figure 5.3.2-1. Minimum, maximum, and average dissolved oxygen levels for all stream segments sampled in 2009. Red lines indicate the lowest dissolved oxygen levels allowed for the different surface water classes (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation is equivalent to Class AA.

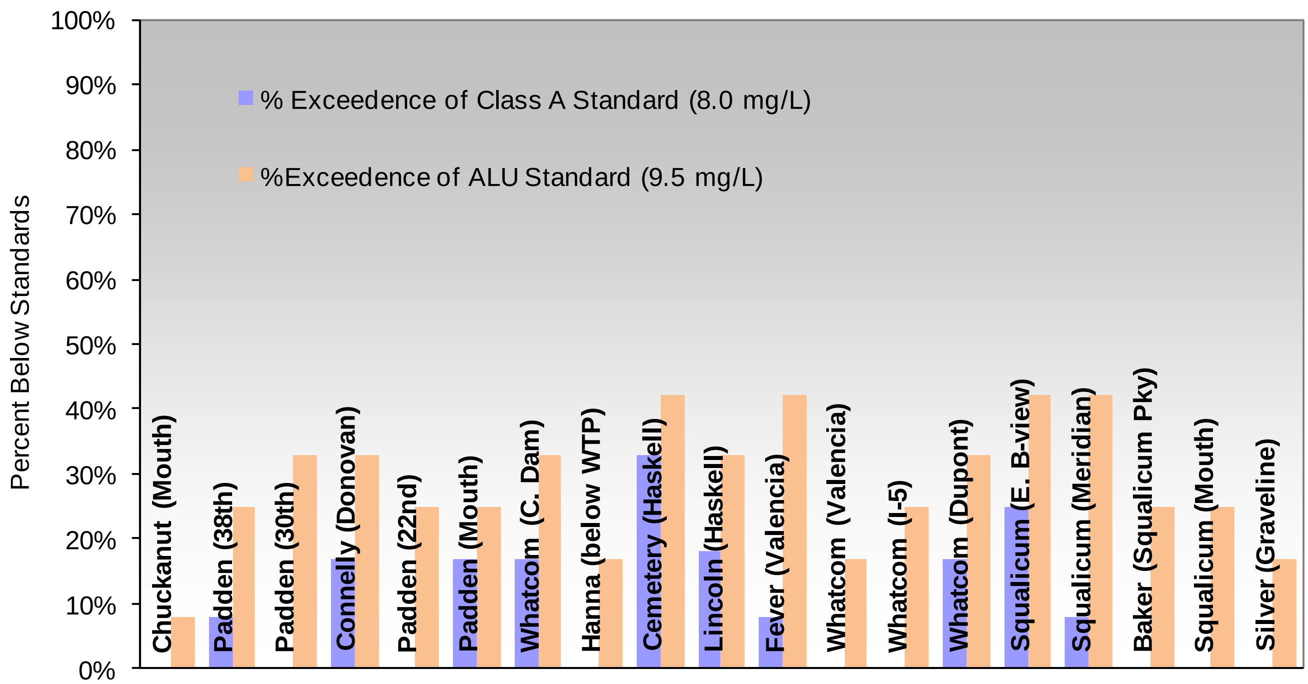


Figure 5.3.2-2. Percent of dissolved oxygen samples below the Class A (8.0 mg/L) and Aquatic Life Use (ALU, 9.5 mg/L) standards for all stream segments sampled in 2009.

5.3.3 Temperature

In 2009, nine urban steam segments met the stringent Core Summer Salmonid Habitat ALU / Class AA standard for temperature; seven additional sites met the Class A standard; while three Whatcom Creek sites met the Class B standard. Figure 5.3.3-1 shows minimum, maximum, and average temperatures found in the stream segments sampled in 2009. Figure 5.3.3-2 provides the percent of samples that exceeded the Class A criterion.

The WAC 173-201A-030 states that temperatures in Core Summer Salmonid Habitat (2006) / Class AA (1997) streams may not exceed 16°C, Class A streams may not exceed 18°C, and Class B streams may not exceed 21°C. A water body is considered impaired if more than 3 of all samples and greater than 10% of samples taken during the year in question are in excceedence. A temperature measurement in excess of the standard is not a violation, however, if the exceedence is the result of natural conditions. In this case, temperature increases due to human activities shall not exceed 0.3 °C and incremental temperature increases from nonpoint sources shall not exceed 2.8° C (WAC 173-201A-030, WQP 1-11).

According to WQP 1-11, Aquatic Life Use criterion for temperature is preferably based on a rolling 7 Day Average of Daily Maximums (7DADMAX). It is only in the absence of continuous monitoring data that single grab sample data is considered. In 2008, the sampling frequency for the Urban Streams Monitoring Program did not allow for the calculation of this value. However, the necessary continuous monitoring programs are now being run as part of TMDL and restoration studies. As results become available they will be incorporated into the Urban Streams Monitoring Program.

Table 5.3.3-1. Temperature class designation for all stream segments from 1991 to 2009. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards).

Sampling Site	‘91	‘92	‘93	‘94	‘95	‘96	‘97	‘98	‘99	‘00	‘01	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09
Chuckanut (mouth)	AA	A	AA	A	A	A	B	B	AA	AA	AA	AA	AA	AA	AA	AA	A	AA	AA
Padden (38th)						A	B	A	AA	AA	A	AA	A	A	AA	A	A	AA	A
Padden (30th)	AA	B	A	B	B	A	B	A	AA	AA	A	AA	B	A	AA	AA	A	AA	A
Connelly (Donovan)	AA	B	A	B	A	B	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	AA
Padden (22nd)															AA	AA	A	AA	AA
Padden (mouth)	A	A	A	A	A	A	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	A
Whatcom (Control Dam)	B	X	B	X	B	X	B	X	A	B	B	B	X	X	X	X	B	B	B
Hanna (WTP)					B							X	AA	AA	AA	AA	AA	AA	AA
Cemetery (Whatcom Cr)	AA	A	AA	B	A	B	A	B	AA	AA	A	A	A	A	AA	AA	A	A	A
Lincoln (Fraser)	A	B	A	B	B	B	A	B	AA	AA	A	AA	A	A	AA	AA	AA	AA	AA
Fever (Valencia)				B	A	A	B	B	AA	A	A	A	A	A	A	A	A	AA	A
Whatcom (Valencia)																	B	B	B
Whatcom (I-5)	A	B	B	X	B	B	B	X	AA	B	B	B	B	B	B	B	B	B	B
Whatcom (Dupont)	A	B	B	X	B	B	B	X	AA	B	B	B	B	B	B	A	B	A	A
Squalicum (E. Bakerview)				B	A	B	B	B	AA	A	A	A	A	A	A	AA	A	AA	AA
Squalicum (Meridian)	AA	A	A	B	A	B	B	B	A	AA	A	AA	AA	AA	A	A	AA	AA	AA
Baker (Squalicum)	AA	AA	A	B	A	A	A	B	AA	AA	AA	AA	A	A	AA	AA	AA	AA	AA
Squalicum (Mouth)	AA	A	A	B	A	A	A	A	AA	AA	AA	AA	AA	A	AA	AA	AA	AA	AA
Silver (Graveline)														A	AA	AA	A	AA	AA

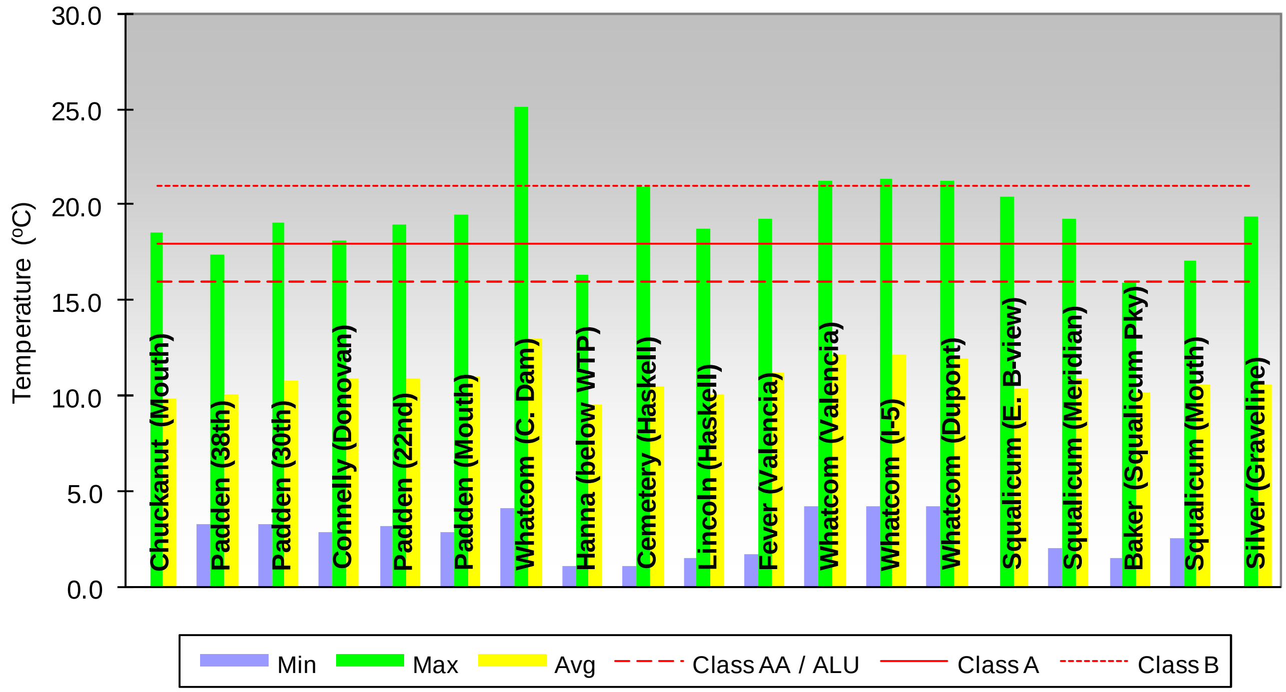


Figure 5.3.3-1. Minimum, maximum, and average temperature values for all stream segments sampled in 2009. Red lines indicate the highest temperature allowed by the different surface water standards (AA/ALU, A, and B).

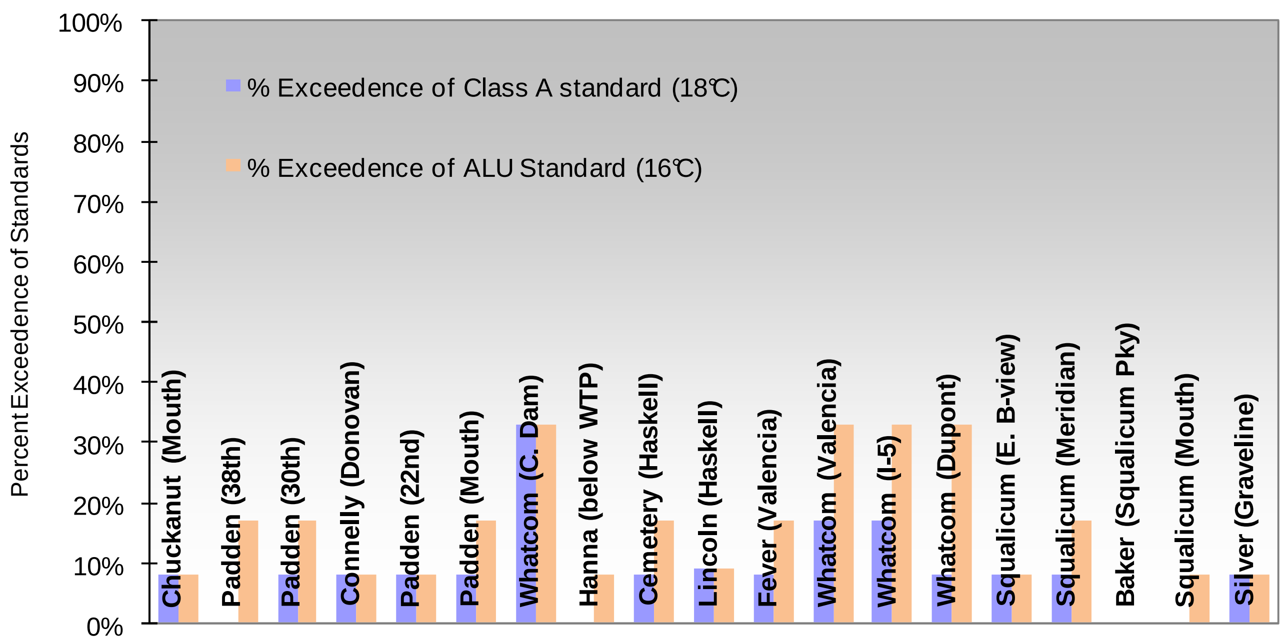


Figure 5.3.3-2. Percent temperature exceedences of Class A (18°C) and Aquatic Life Use (ALU, 16°C) standards for all stream segments sampled in 2009.

5.3.4 pH

The stream segments sampled in the Urban Streams Monitoring Program almost always meet Aquatic Life Use (ALU) and Class A standards for pH. In 2009 that trend was continued.

The pH of water measures the concentration of hydrogen ions in the water, or the relative acidity or alkalinity of water. The value of pH is calculated using the negative logarithm of the hydrogen ion concentration. Thus, a change of one pH unit represents a 10-fold change in the concentration of hydrogen ions.

The pH of a stream can affect organisms living in the water directly. The chemical conditions in acidified waters are intolerable to some aquatic creatures or have sublethal physiological effects; some animals may actively avoid such waters. There are also indirect effects. The solubility and availability of nutrients can be affected by pH. Heavy metals can be more soluble at lower pH, therefore more bioavailable and consequently more toxic.

A change in pH can indicate the presence of pollution. Organic matter introduced into streams during periods of low flow can cause low pH values. Lime applied to agricultural lands, lawns, and golf courses can be washed into streams during storm events, raising pH. Additionally, photosynthesis, respiration, and decomposition also affect pH levels.

The pH of uncontaminated rainwater in equilibrium with atmospheric carbon dioxide is 5.6. Normally the acids in rainwater are neutralized as the rainwater passes through soil (Allan, 1995). In urbanized areas much of the precipitation falls onto impervious surfaces and flows directly into rivers and streams. There may be further acidification processes at work on these surfaces (Mason, 1989). Even when there are not large areas of impervious surface, the acid neutralizing mechanisms in the soil may not be able to keep pace during heavy continuous rain. During an event of this type, rainwater runs over

Table 5.3.4-1. The pH class designation for all stream segments from 1991 to 2009. ("AA" - met Class AA/A/B standards; "X" - did not meet Class AA/A/B standards).

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
Chuckanut (mouth)	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (38th)						AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (30th)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Connelly (Donovan)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (22nd)															AA	AA	AA	AA	AA
Padden (mouth)	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	X	AA	AA	AA
Whatcom (Control Dam)	X	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Hanna (WTP)					AA							AA	AA	AA	AA	X	AA	AA	AA
Cemetery (Whatcom Cr)	AA	AA	X	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA
Lincoln (Fraser)	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA
Fever (Valencia)				AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Valencia)																	AA	AA	AA
Whatcom (I-5)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Dupont)	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (E. Baker-				AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (Meridian)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Baker (Squalicum)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (Mouth)	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Silver (Graveline)														AA	AA	AA	AA	AA	AA

the surface and enters streams with its chemical composition little changed (Mason, 1989).

Class AA/A/B and Core Summer Salmonid Habitat ALU designated surface water pH must be within the range of 6.5 to 8.5 (WAC 173-201A-030). A stream segment is in violation if more than 3 excursions and greater than 10% of the grab samples taken are outside the 6.5 to 8.5 range (Department of Ecology, WQP Policy 1-11, 2006).

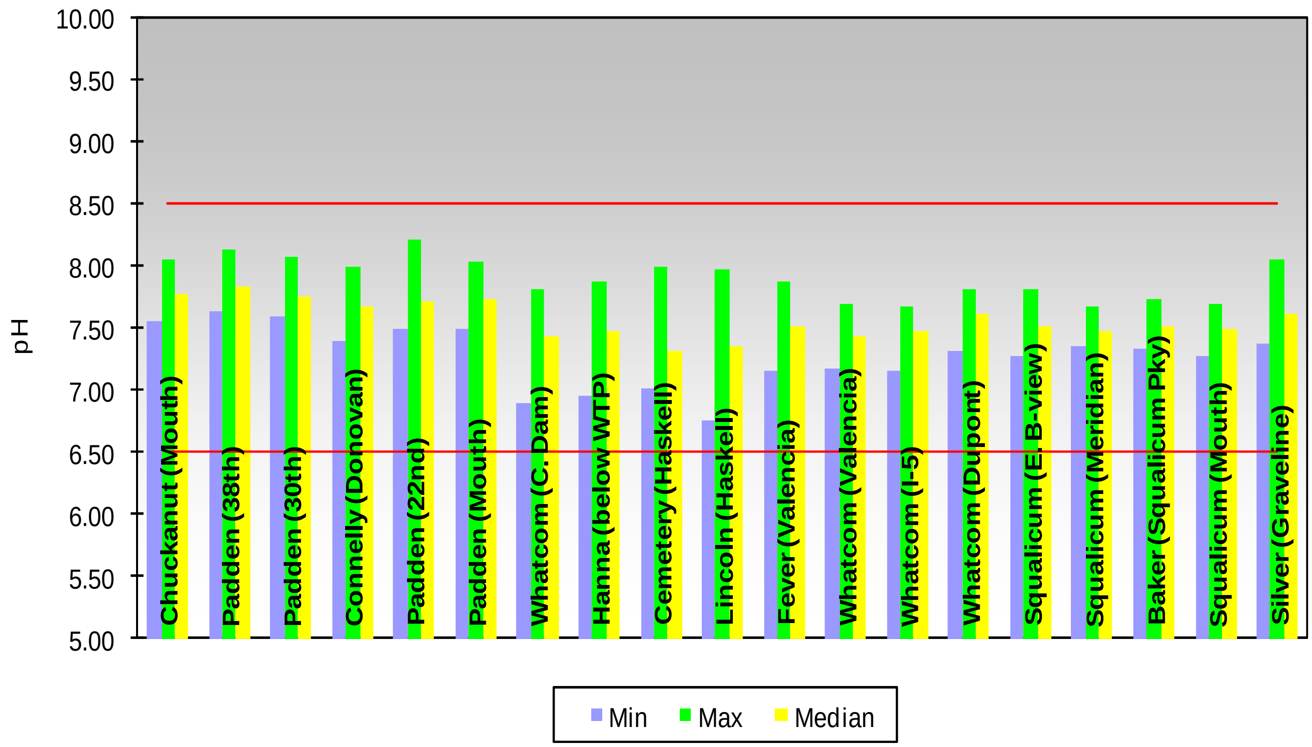


Figure 5.3.4-1. The pH minimum, maximum, and median values for all stream segments sampled in 2009. Red lines indicate the minimum and maximum values allowed by the Class AA/A/B and Aquatic Life Use (ALU) criteria for pH.

5.3.5 Turbidity

Turbidity measures the degree to which light traveling through a water column is scattered by the suspended organic (including algae) and inorganic particles in the water. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU) and is used to estimate the amount of total suspended material in the water. Turbidity readings can be affected by temperature, water color from dissolved solids (Malcomb, 1985) and the shape, size, and surface area of particles (Packman et al., 2002).

The amount of suspended materials found in stream systems can be attributed to many factors. The flow rate of a water body is a primary factor influencing turbidity concentrations. Fast running water can carry more particles and larger sized sediment. A change in flow rate can also affect turbidity. If the speed of the water current increases, particulate matter from the bottom sediments may be resuspended.

Heavy rains can pick up sand, silt, clay, and organic particles from the land, particularly from construction sites, and carry them to surface waters. Erosion from rainfall, run-off, and high stream velocities may result in higher concentrations of suspended particles in streams. Watershed development and poor land use practices can cause increased erosion, organic matter, and nutrients, all of which cause increases in suspended materials and algae growth. There are large amounts of impervious surfaces and land disturbing activities in urban areas and natural settling areas have been removed. As a consequence, during storm events sediment is carried through storm drains to streams and rivers.

Some suspended matter is natural and beneficial to aquatic systems. Excesses, however, can affect the health of aquatic organisms. Studies have found that exposure to turbidities of 25 to 50 NTU for extended periods can reduce feeding and growth in trout and salmon fingerlings and may cause them to emigrate (Sigler et al., 1984; Harvey, 1989). Other studies have found that turbidities between 10 and 60 NTU for only two to four days can disrupt feeding and territorial behavior in juvenile salmon (Berg, 1982; Bjornn and Reiser, 1991).

The Ecology turbidity criterion for Class A surface waters is based on a relative change in NTU above background rather than a single value or range of values. "Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more that a 10 percent increase in turbidity when the background is more than 50 NTU" (WAC 173-201A-030).

These criteria are mainly used to measure inputs from point sources such as streamside construction activities (Joy, 2002). In this case, background turbidity is established by sampling upstream from the construction site. Determining background turbidity for stream systems that lack such a point source is problematic and the Ecology policy fails to address this issue. Bellingham streams lack reference sites that could provide a true background turbidity measurement.

Due to difficulty in applying point source criteria to non-point source systems, turbidity is not included in class determination for Bellingham's urban streams. In order to provide more pertinent context to the turbidity values recorded by the Urban Streams Monitoring Program, this report presents turbidity values both as yearly average trends for the past 10 years and as a comparison between this year's data and the previous 5 and 10 year overall turbidity averages.

For the ten year period ending in 2009, the majority of Bellingham's urban streams showed decreasing turbidity trends. Chuckanut Creek, Whatcom Creek at the Control Dam, Squalicum Creek at Meridian St. and Squalicum Creek at the mouth were the only stream segments to have ascending turbidity trends. For most stream segments, lightly higher turbidity values were recorded in 2009 than in 2008. Ten year turbidity trends for the period ending in 2009 and average turbidities are detailed in Table 5.3.5-1. Figure 5.3.5-1 provides minimum, maximum, and average turbidity values for all stream segments sampled in 2009.

Table 5.3.5-1. Average turbidity trends 2000-2009. A “+” sign indicates an increasing turbidity trend, while a “-” sign indicates a decreasing turbidity trend.

Stream Segment	10 Year Trend	Slope (NTU/ Year)	2009 Average	5 Year Average	10 Year Average
Chuckanut Cr (Mouth)	+	0.24	5.05	5.14	4.20
Padden Cr (38th)	-	-0.25	2.20	2.66	3.44
Padden Cr (30th)	-	-0.26	3.16	2.78	3.78
Connelly Cr (Donovan)	-	-0.29	5.58	6.06	7.46
Padden Cr (22nd)	-	-0.34	4.03	4.08	4.08
Padden Cr (Mouth)	-	-0.25	4.39	4.87	6.08
Whatcom Cr (C. Dam)	+	0.02	2.11	1.55	1.82
Hanna Cr (below WTP)	-	-0.22	5.80	5.81	6.20
Cemetery Cr (Haskell)	-	-0.36	5.43	7.59	8.13
Lincoln Cr (Haskell)	-	-0.27	8.05	6.41	7.94
Fever Cr (Valencia)	-	-0.36	6.24	5.92	7.24
Whatcom Cr (Valencia)	-	-0.68	2.71	2.23	3.56
Whatcom Cr (I-5)	-	-0.03	3.63	2.72	3.18
Whatcom Cr (Dupont)	-	-0.04	5.45	3.43	3.94
Squalicum Cr (E. Bakerview)	-	-0.33	7.07	8.21	8.79
Squalicum Cr (Meridian)	+	0.30	9.70	8.87	7.98
Baker Cr (Squalicum Pky)	-	-0.07	6.01	6.69	6.77
Squalicum Cr (Mouth)	+	0.16	7.87	7.98	7.42
Silver Cr (Graveline)	-	-0.28	5.74	7.31	7.70

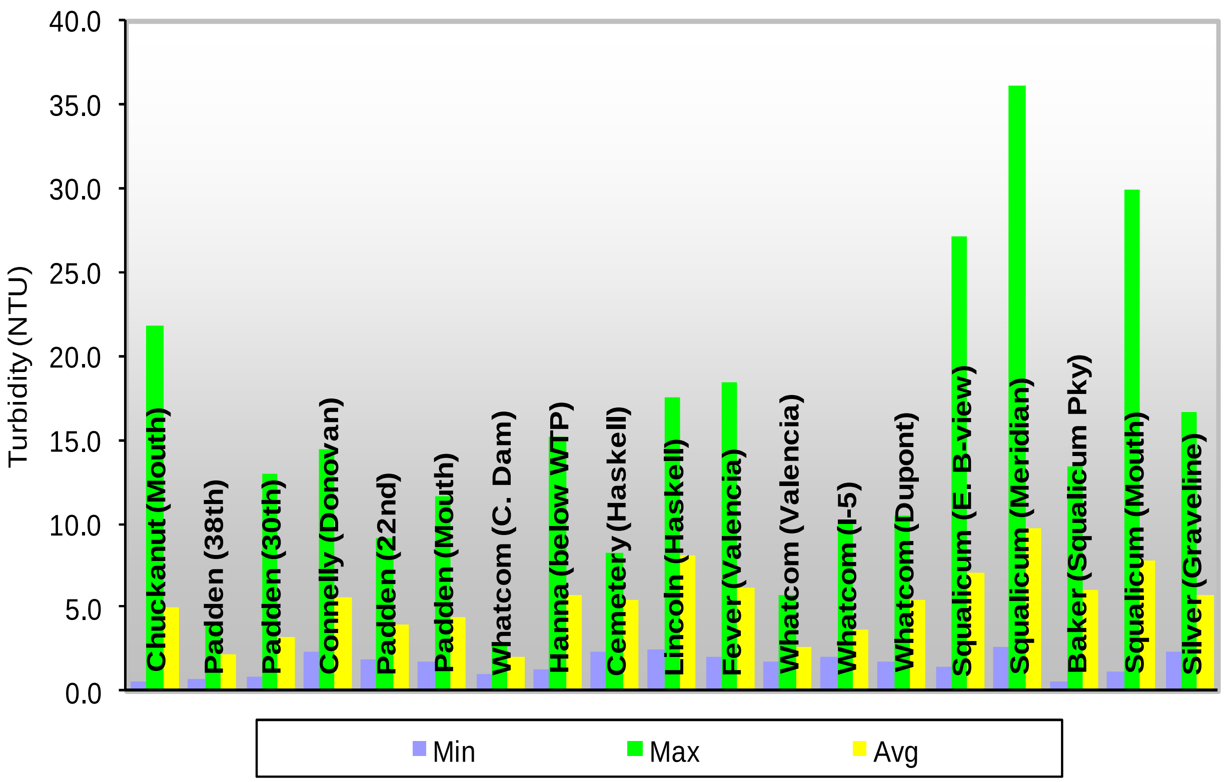


Figure 5.3.5-1. Minimum, maximum, and average turbidity values for all stream segments sampled in 2009.

5.3.6 Specific Conductivity

Conductivity measures the ability of water to conduct an electric current and is directly related to the total dissolved ions in the water. Conductivity is reported in microSiemans per centimeter (µ S/cm) corrected to 25°C. Conductivity in streams can be extremely variable. This natural variation is due to the characteristics of a watershed: mainly the type of rocks weathered, how much precipitation falls, the composition of the precipitation (largely dependant on distance from the ocean), and the relative contribution of ground water to total flow (Allan, 1995). Groundwater typically contains higher concentrations of ions than surface water because of a longer association with rocks (Allan, 1995). Since stream flow is reliant on a combination of surface water and groundwater, during drier periods the concentration of ions in a stream may increase as stream flow becomes more dependent on groundwater inputs. Evaporation can also contribute to increased conductivity levels by concentrating ions in water.

Conductivity can be useful as a general water quality measurement. Pollution from point and non-point sources contributes to the amount of dissolved ions in water. Significant changes in conductivity measurements can indicate contamination from these sources.

The USEPA found that rivers in the United States had a range from 50 to 1500 µS/cm (1997). The USEPA also reported that streams that supported "good mixed fisheries" had a range from 150 to 500 µS/cm. Conductivity outside this range may not support some aquatic organisms.

The City of Bellingham has monitored conductivity since 1994. Historically, the range has been from 28 to 581 µS/cm. This excludes measurements of 1001 µS/cm in 1996 taken at Squalicum Creek mouth and 890 µS/cm taken at Padden Creek mouth in 2001. Both of these measurements were taken at the mouths of streams and it is suspected that the high values are the result of the salt water wedge, an effect of high tide.

In 2009, conductivity in Bellingham's urban streams ranged from 59 to 374 µS/cm (Figure 5.3.6-1), which is not appreciably different from previous years. Low conductivity values are a natural characteristic of Bellingham streams.

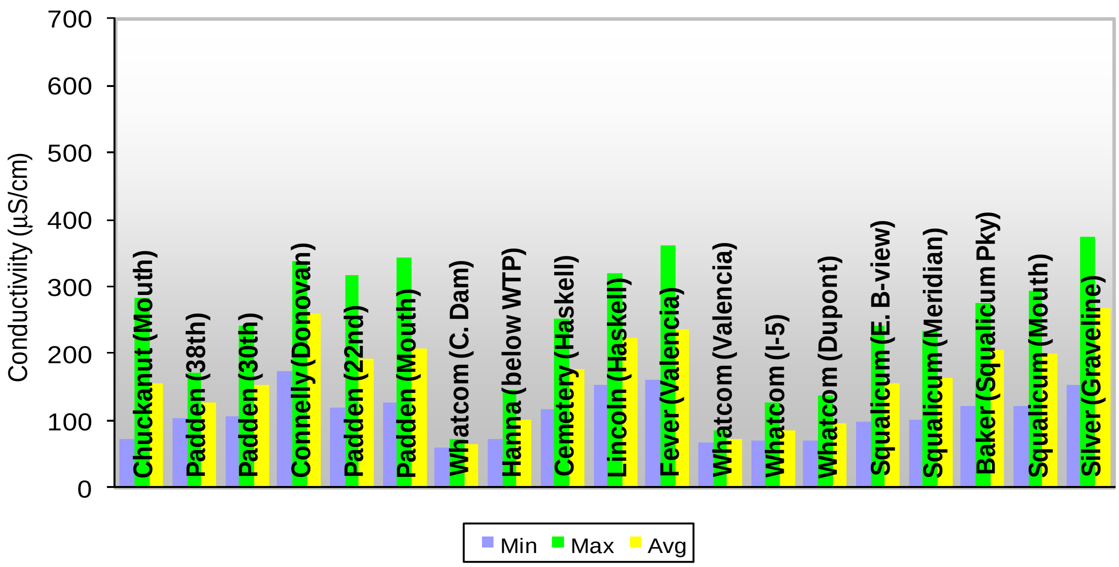


Figure 5.3.6-1. Minimum, maximum, and average conductivity values for all stream segments sampled in 2009. No numeric criterion exists in the WAC for conductivity.

6.0 Chuckanut Creek Drainage Basin

The drainage area of Chuckanut Creek is approximately 4,834 acres (City of Bellingham, 1995). The creek flows through mostly forested lands and some residential areas. It discharges to an estuary in Chuckanut Bay, adjacent to Bellingham Bay. Most of the creek lies outside Bellingham city limits.

Chuckanut Creek has been included in Bellingham's Urban Stream Monitoring Program since 1990 and is sampled at one site, near the mouth (Figure 6.0-1). Samples are collected approximately 1200 feet from the discharge point into Chuckanut Bay (Chuckanut Drainage Map). Table 6.0-1 shows the number of samples collected per year from 2000 to 2009.

In 2008, Chuckanut Creek met the temperature and pH Aquatic Life Use (ALU) criteria, but failed to meet the dissolved oxygen and the fecal coliform designated use criteria.

Chuckanut Creek did not meet overall Class A designation for 2009. The Class A criterion for temperature (≤18℃), dissolved oxygen (≥8.0 mg/L) and pH (6.5 -8.5) were met. However, the Class A criteria for fecal coliform bacteria was not met because more than 10% of the fecal coliform results were above 200 CFU/100 ml. Chuckanut Creek meet Class B standards for fecal coliforms and therefore received a Class B rating for 2009. The average turbidity for 2009 was 5.1 NTU, which is equal to the 5 year average (5.1 NTU) and above the 10 year average (4.2 NTU). Conductivity was relatively unchanged from previous years.

Table 6.0-1. Number of samples* taken per year for Chuckanut Creek from 2000 to 2009.

Sampling Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mouth	4	8	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

Figure 6.0-1 Chuckanut Creek mouth sampling site.

Fecal Coliform Bacteria

Fecal coliform concentrations for 2009 follow the expected trend of higher values in the warmer months, possibly as bacteria become more concentrated due to lower flows, and/or as higher temperatures encourage extended survival or growth of bacterial populations (Figure 6.0-2). The geomean for the Chuckanut Creek mouth site was 76 CFU/100 ml. Three of the twelve samples (25%) collected at the site contained more than 200 CFU/100 ml (Figure 6.0-3).

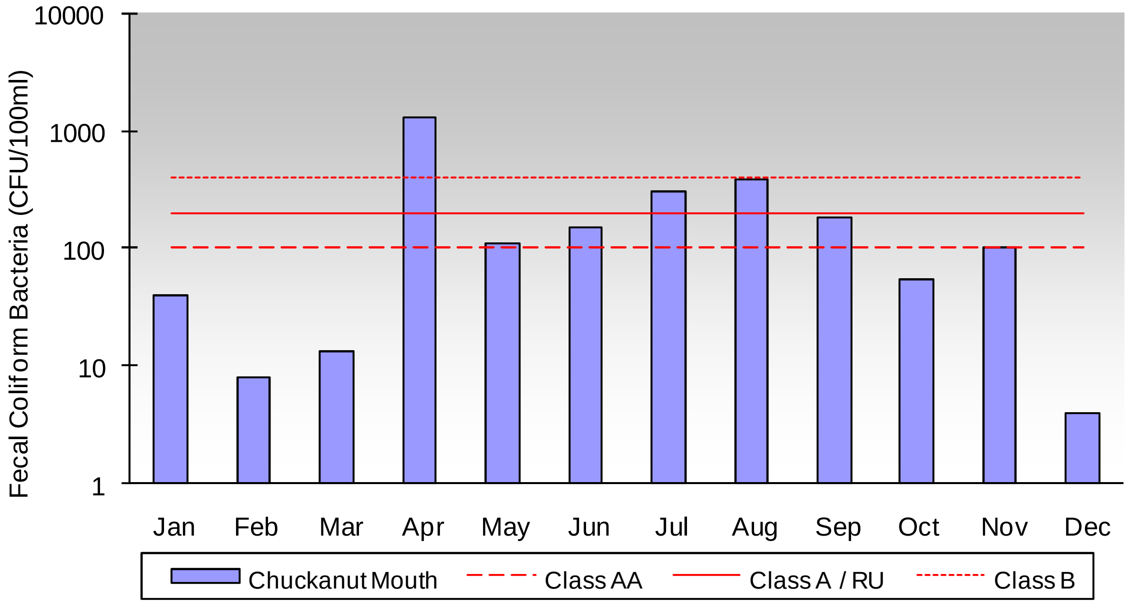


Figure 6.0-2. Fecal coliform bacteria levels for Chuckanut Creek sampling site by month for 2009. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

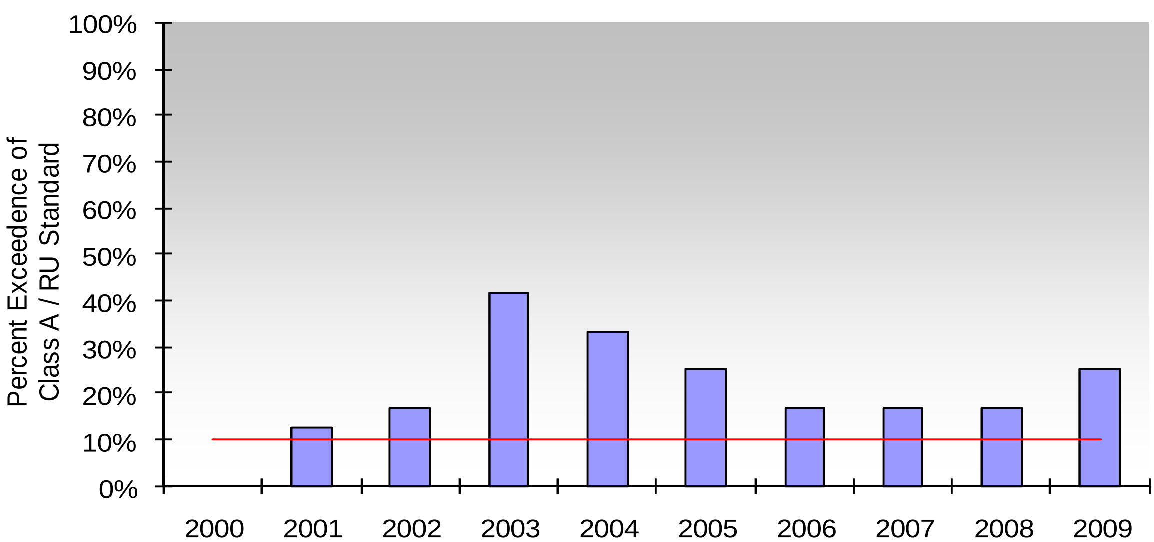


Figure 6.0-3. Percent exceedence of the Class A / Recreational Use standards for fecal coliform bacteria by year for the Chuckanut Creek sampling site, 2000 to 2009.

Dissolved Oxygen

Dissolved oxygen levels for 2009 follow a typical seasonal trend with the lowest levels found in the warmer summer months when temperatures are higher (Figure 6.0-4). The average dissolved oxygen level in 2009 was 11.5 mg/L.

Dissolved oxygen levels in Chuckanut Creek fell below the ALU standard of 9.5 mg/L only once in 2009 and did not fall below the 8.0 mg/L class A standard. The percent of samples below the Class A standard from 2000 to 2009 and below the Core Summer Aquatic Life Use (ALU) standard from 2006 to 2009 are provided in Figure 6.0-5.

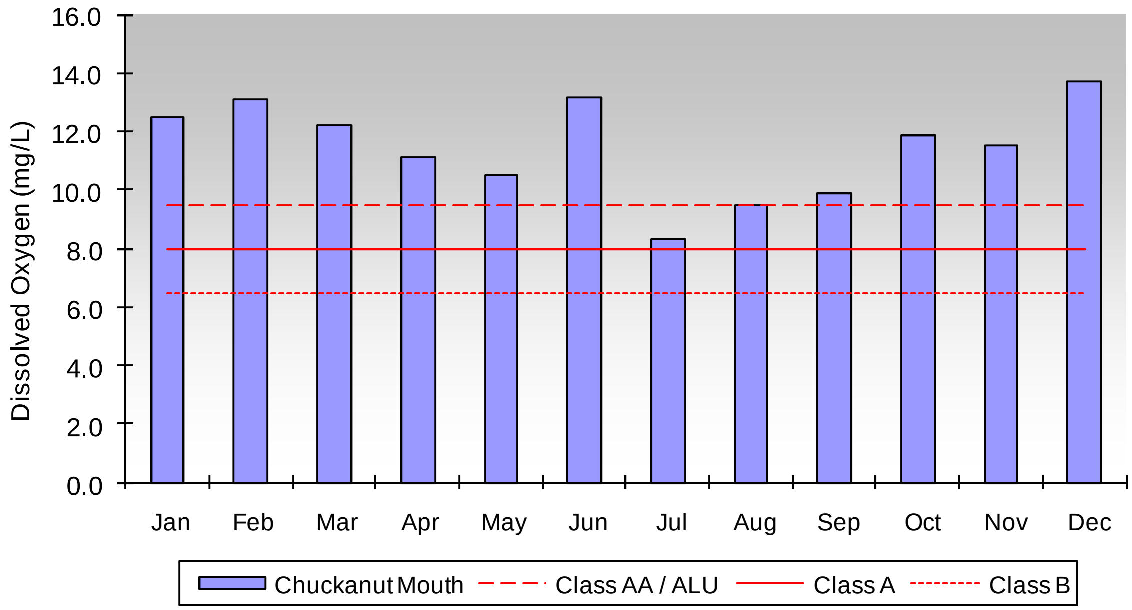


Figure 6.0-4. Monthly 2009 dissolved oxygen levels for Chuckanut Creek. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

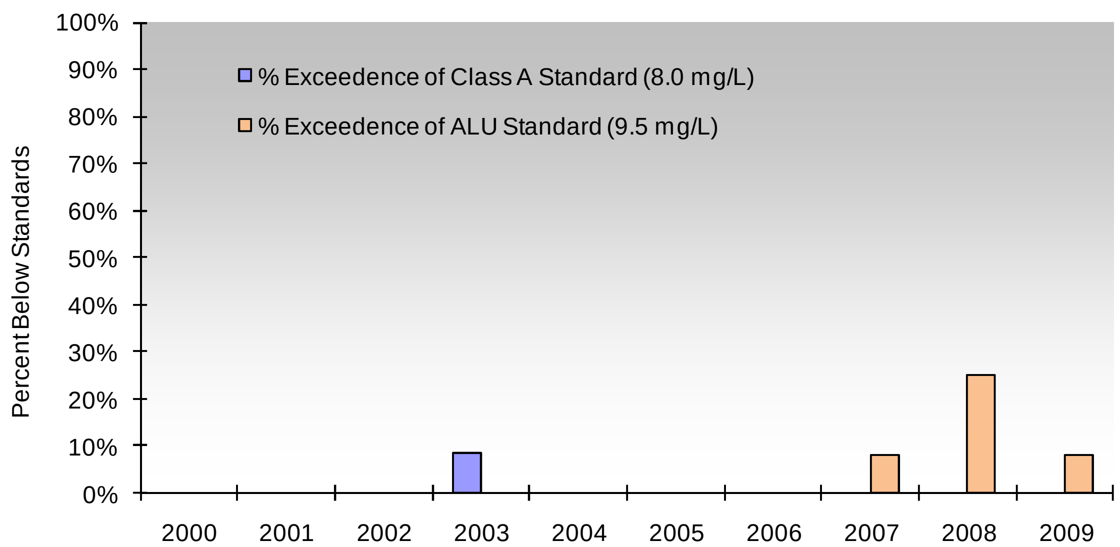


Figure 6.0-5. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Chuckanut Creek sampling site 2000 to 2009 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006.

Temperature

Recorded temperature for Chuckanut Creek was higher than normal during 2009, exceeding both the Class A (18℃) and Aquatic Life Use (ALU) (16℃) standards during July. The temperature profile follows a seasonal trend with higher values found in the warmer summer months (Figure 6.0-6). The average temperature for 2009 was 9.8℃.

Temperature in Chuckanut Creek rarely exceeds standards. This year marks the first exceedence of the Class A standard during the past 10 years, and the Core Summer Salmonid Habitat ALU standard has been exceeded only twice since its' use began in 2006 (Figure 6.0-7).

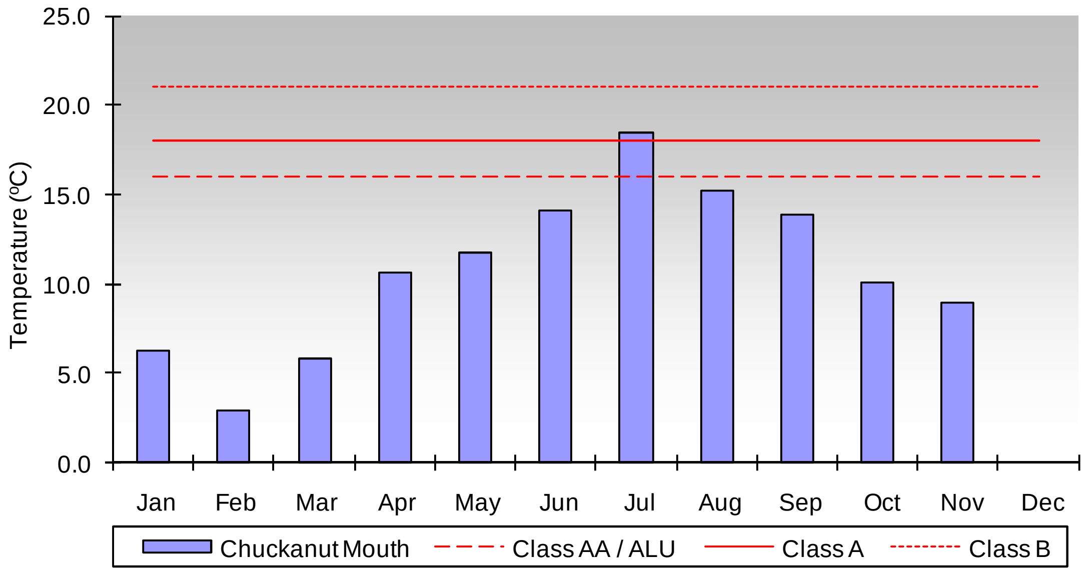


Figure 6.0-6. Monthly temperature measurements for the Chuckanut Creek sampling site in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). The Core Summer Salmonid Habitat ALU is equivalent to Class AA.

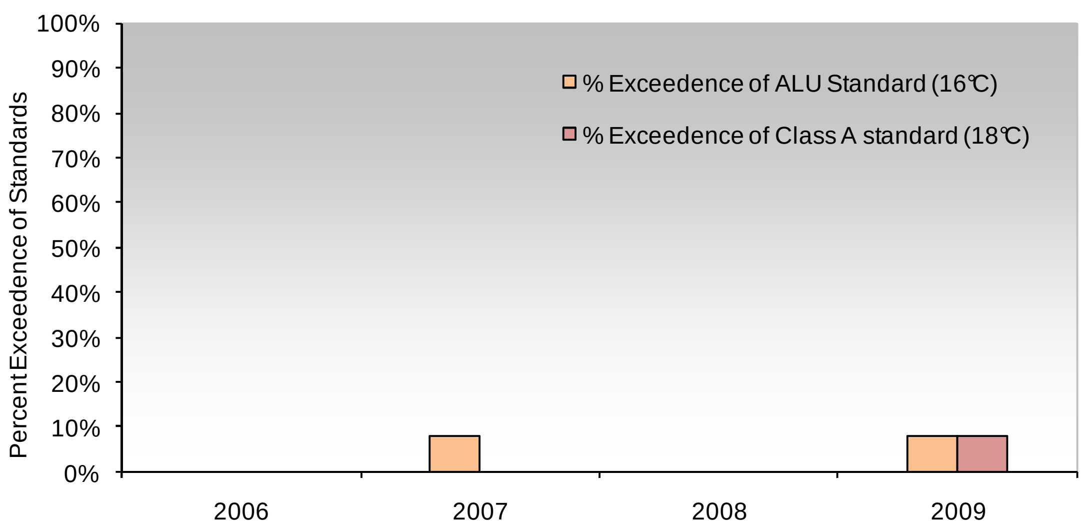


Figure 6.0-7. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16℃) for the Chuckanut Creek sampling site 2006 to 2009. This year marks the first exceedence of the Class A (18℃) standard since 1998.

Turbidity

Turbidity in Chuckanut Creek rarely reaches or exceeds levels considered deleterious to salmon and trout (Berg, 1982; Sigler et al., 1984; Harvey, 1989; Bjornn and Reiser, 1991). Despite a higher maximum than in years past, this trend was continued in 2009. The maximum turbidity measured in was 21.8 NTU in January and the minimum turbidity measured was 0.5 NTU in July. Higher turbidities are expected during the winter months since more precipitation can be expected at this time of year. Despite an average gain of 0.24 NTU/Year over the past 10 years, the average turbidity for Chuckanut Creek in 2008 was 5.1 NTU, which is the same as the 5 year average and greater than the 10 year average (Figure 6.0-8).

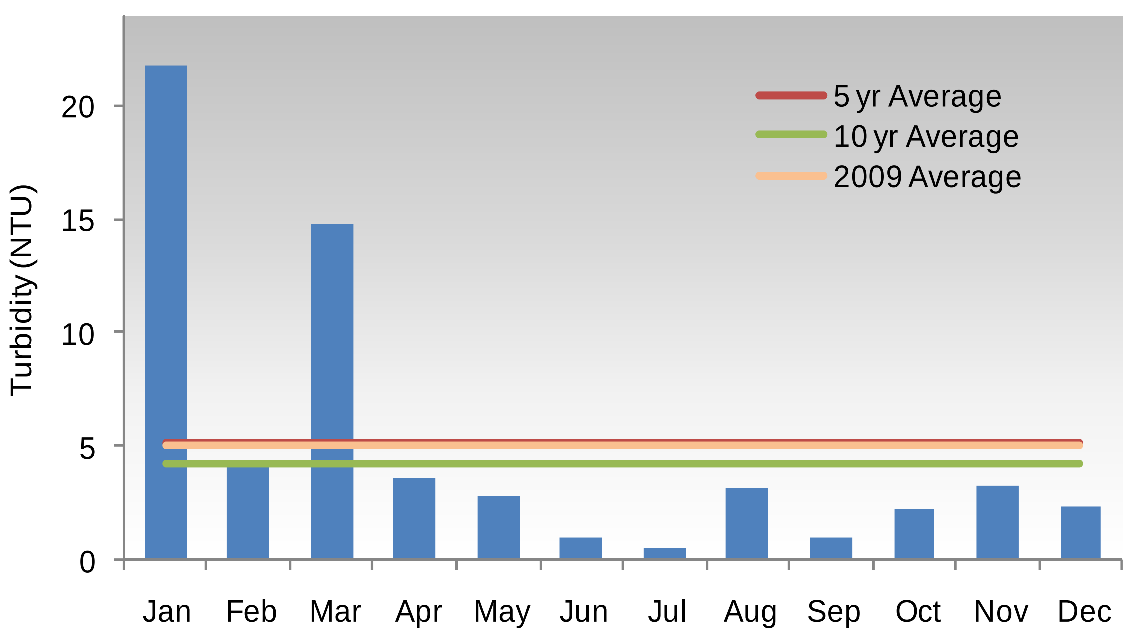


Figure 6.0-8. Monthly turbidity values and yearly averages for the Chuckanut Creek sampling site in 2009. Presented with yearly, 5-year and 10-year averages.

7.0 Padden Creek Drainage Basin

Padden Creek flows from its headwaters, Lake Padden, to an estuary adjacent to Bellingham Bay. The Padden Creek drainage area is approximately 3840 acres (Ecology, 1997) and the creek receives inputs from Western Washington University as well as residential areas and a commercial area located at the base of Sehome Hill. The largest tributary to Padden Creek is Connelly Creek.

Padden Creek flows through mainly residential areas and parks. A small industrial area is located near the mouth. Much of the riparian zone in wooded. The course of Padden Creek is restricted by the placement of culverts at various points along the waterway, including a 5-block culvert between 17th and 22nd Streets.

Padden Creek is sampled at four locations: 38th St., 30th St. (Figure 7.0-1), 22nd St., and near the mouth (Figure 7.0-4), approximately 1500 feet upstream from its discharge point. Connelly Creek, the main tributary to Padden Creek, is sampled at Donovan Ave. (Figure 7.0-7) (Chuckanut and Padden Drainage Map). Table 7.0-1 shows the number of samples collected at each sampling site from 2000 to 2009.

In 2009, Padden Creek at 38th street was the only site to meet the Recreational Use Standard for Fecal Coliform. In addition, the sites at 22nd Street and Connelly Creek were the only ones able to meet Aquatic Life Use (ALU) standards for Temperature. While all sites in the Padden Creek drainage met pH ALU standards, no other ALU standards were met.

In 2009, the Padden Creek site at 38th street met overall Class A water quality standards, while the site at 30th street met overall Class B standards. None of the other sites met overall Class A or Class B standards.

Table 7.0-1. Number of samples* taken per year for Padden and Connelly Creek from 1999 to 2008.

Sampling Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2008
38th Street	4	8	12	12	12	12	12	12	12	12
30th Street	4	8	12	12	12	12	12	12	12	12
Connelly	4	8	12	12	12	12	12	12	12	12
22nd Street						12	12	12	12	12
Mouth	4	8	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

In 2009, all of the Padden Creek sites met or exceeded the Class A temperature standard (≤18.0℃) and the Class AA/A/B pH standard. With the exception of 22nd St. and Connelly Creek, all of the sites also met the Class A Dissolved Oxygen standard (≥8.0 mg/L). The 22nd St. and Connelly Creek sites met the Class B standard (6.5 mg/L).

As is often the case, water quality criteria for fecal coliform proved to be the limiting factor in Padden Creek class rankings. While the Padden Creek site at 38th steet was able to meet the stringent Class AA standards, no other site was able to meet the Class A standard. The site at 30th St. did meet the Class B standard. The other three sites did not meet either the Class A or Class B standards for fecal coliform bacteria. Though the 22nd street site did meet the Class A geomean criterion, more than 10% or of the samples contained greater than 400 cfu/100 ml (Class B). Neither Connelly Creek nor Padden Creek at the Mouth were able to meet either of the Class B criteria.

With the exception of the 30th St. site, the average turbidites for Padden Creek sites were all below the respective 5 year and 10 year averages in 2009. The average turbidity for the 30th St. site in 2009 was above the 5-year average but below the 10-year average. The highest average turbidity for 2009 was found at Connelly Creek (14.5 NTU), while Padden Creek at 38th St. had the lowest average turbidity (0.7 NTU). Connelly Creek recorded an average turbidity of 5.6 NTU. Average turbidity values for 2009 are listed along side respective 5 and 10 year averages in Table 7.0-5. Conductivity was consistent with previous years.

Figure 7.0-1. Padden Creek 30th St. sampling site.

Fecal Coliform Bacteria

The fecal coliform levels found in Padden and Connelly Creeks follow the expected trend of higher levels in the summer months, possibly as bacteria become more concentrated as flow decreases and/or as warmer temperatures encourage extended survival and growth of bacterial populations (Figures 7.0-2, 7.0-2a). The geomean for each sampling location is provided in Table 7.0-2. The percent of samples that exceeded 200 CFU/100 ml is presented in Figures 7.0-3 and 7.0-3a.

All sampling sites have experienced levels of fecal coliforms over 200 CFU/100 ml in previous years, particularly Connelly Creek and Padden mouth. In 2002, in response to concerns about the elevated levels of fecal coliform bacteria in the lower reaches of Padden Creek, City of Bellingham staff conducted extensive water testing from 30th St. to the mouth. Water samples were collected and tested for fecal coliform bacteria, specifically, *Escherichia coli* (*E. coli*). Connelly Creek was identified as the only point source of bacteria found during the Padden Creek Survey (City of Bellingham, 2002a).

As a follow up to the Padden Creek Survey, in 2003 bacterial testing was performed on Connelly Creek from 40th St. to the confluence with Padden Creek (City of Bellingham, 2003). No point sources of fecal contamination were identified with the exception of a failing septic system. The Whatcom County Department of Health worked with the homeowner to correct this problem and a new septic system was installed at the site.

The City of Bellingham Stormwater Utility also conducted follow up testing on Padden and Connelly Creeks in 2005. Results were inconclusive and further testing will be scheduled to find if additional point sources of fecal coliforms can be determined.

Table 7.0-2. The 2009 fecal coliform geomean values (CFU/100 ml) for sampling sites on Padden and Connelly Creeks.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Geomean (CFU/100 ml)	16	22	111	66	151

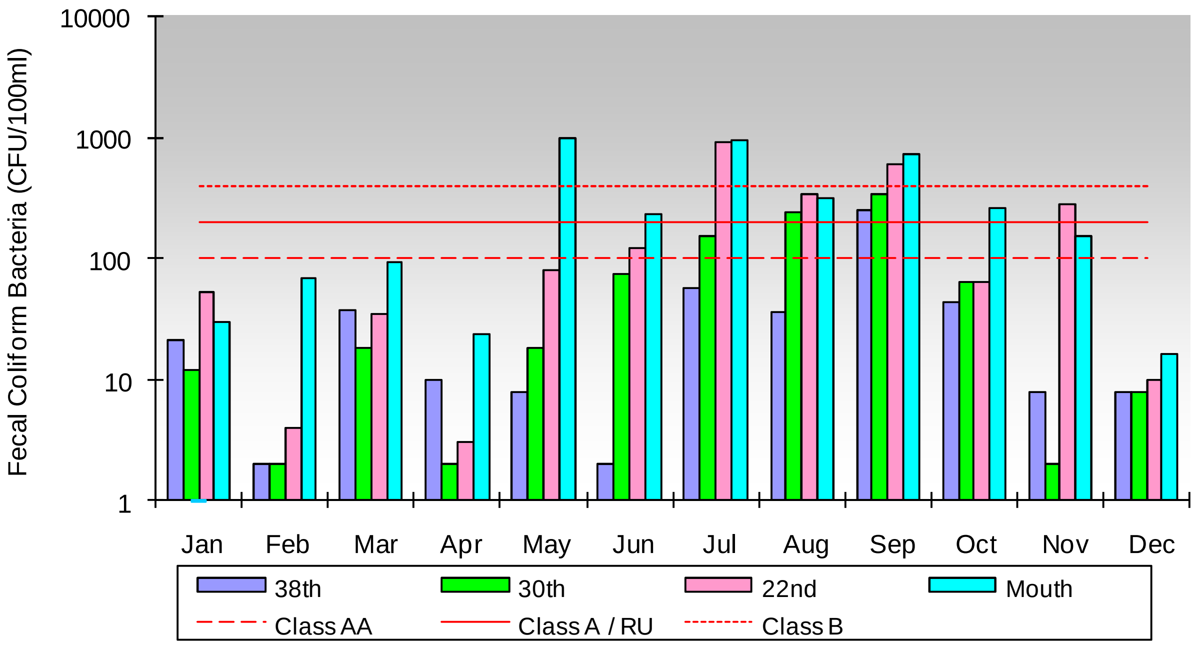


Figure 7.0-2. Monthly 2009 fecal coliform levels for Padden Creek sampling sites. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

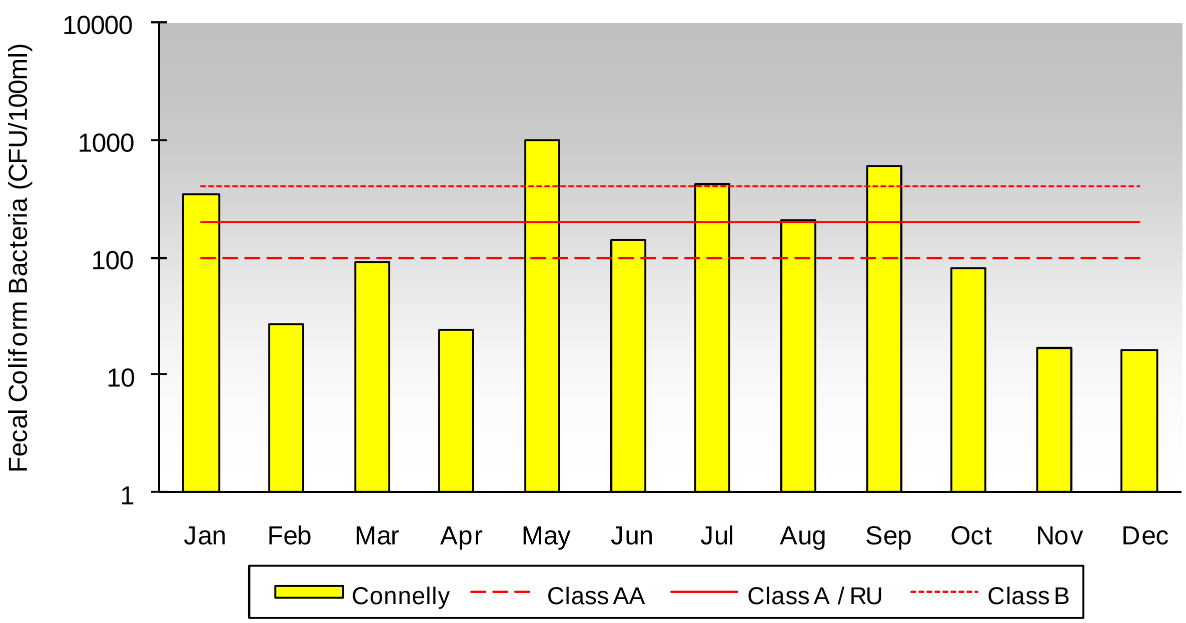


Figure 7.0-2a. Monthly 2009 fecal coliform levels for Connelly Creek sampling site. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

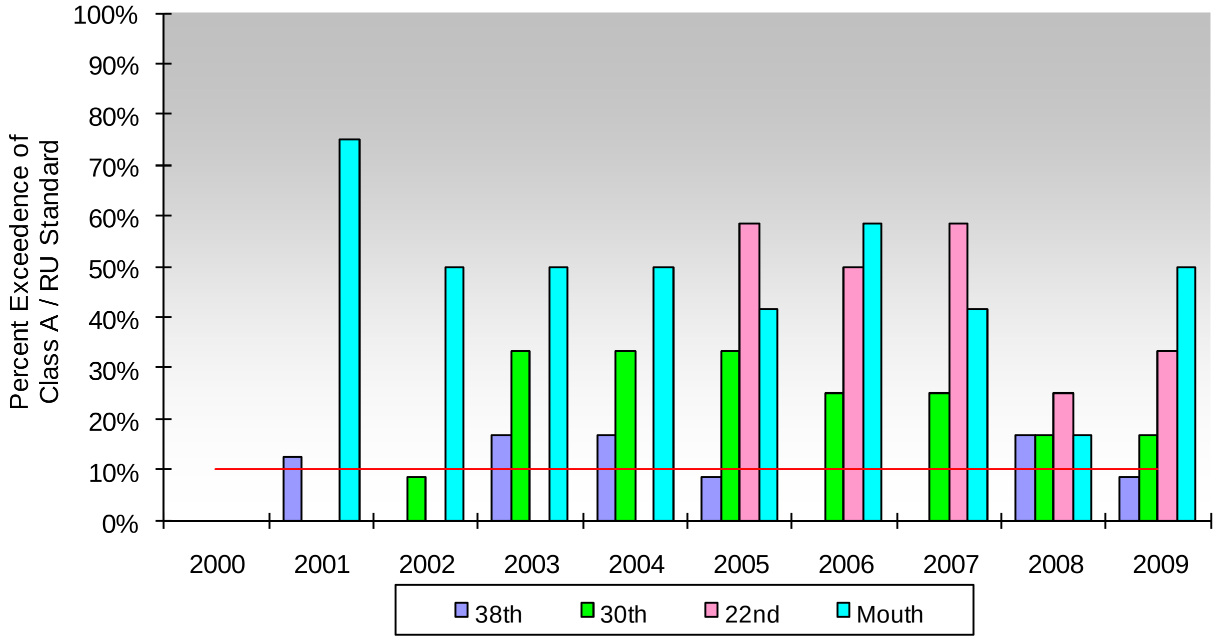


Figure 7.0-3. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Padden Creek sampling sites, 2000 to 2009. Sampling began on 22nd Street in 2005. All other gaps represent a 0% exceedence rate.

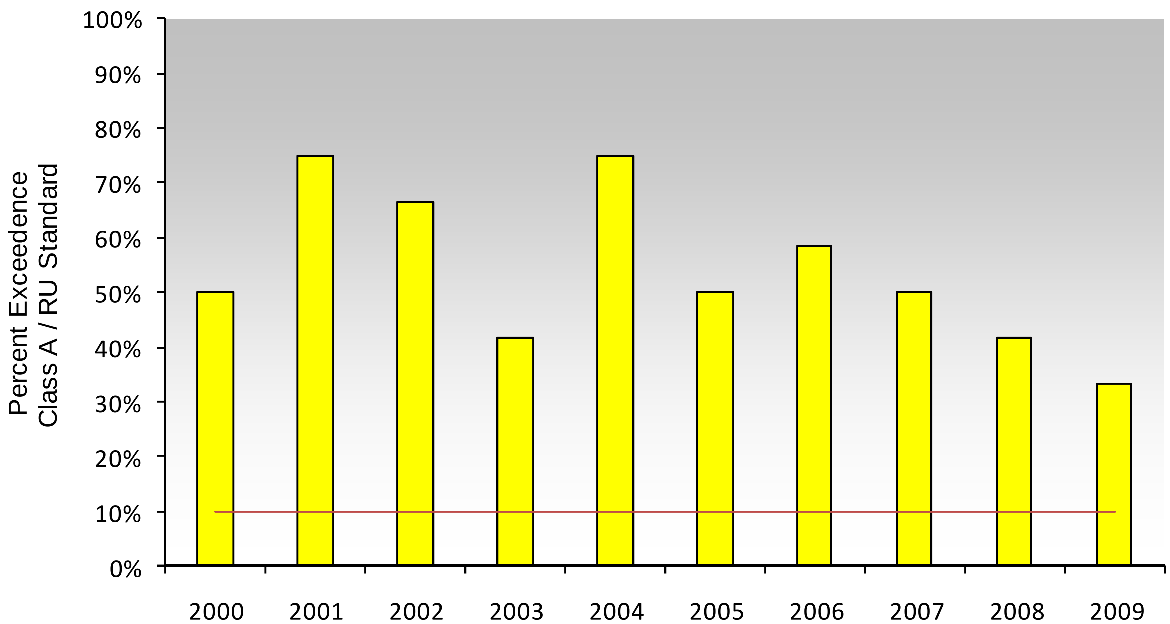


Figure 7.0-3a. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Connelly Creek, 2000 to 2009.

Dissolved Oxygen

In 2009, none of the Padden or Connelly Creek sites remained above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) criteria of 9.5 mg/L for dissolved oxygen. The Core Summer Salmonid Habitat ALU is equivalent to the Class AA standard. Padden Creek at the mouth and Connelly Creek also failed to remain above the 8.0 mg/L Class A standard, but did remain above the 6.5 mg/L Class B standard. Dissolved oxygen in these two creeks follows an expected trend with lower levels in the warmer summer months (Figures 7.0-5, 7.0-5a). Average dissolved oxygen values are provided in Table 7.0-3.

Since use designations were implemented in 2006, every stream segment in the Padden Creek drainage has failed to meet the 9.5 mg/L ALU criteria in at least one year (Figures 7.0-6, 7.0-6a). Connelly Creek has had the most frequent occurrence of low dissolved oxygen.

Table 7.0-3. Average dissolved oxygen values for Padden and Connelly Creeks in 2009.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Average DO (mg/L)	11.1	11.8	10.5	11.7	10.8

Figure 7.0-4. Padden Creek mouth sampling site.

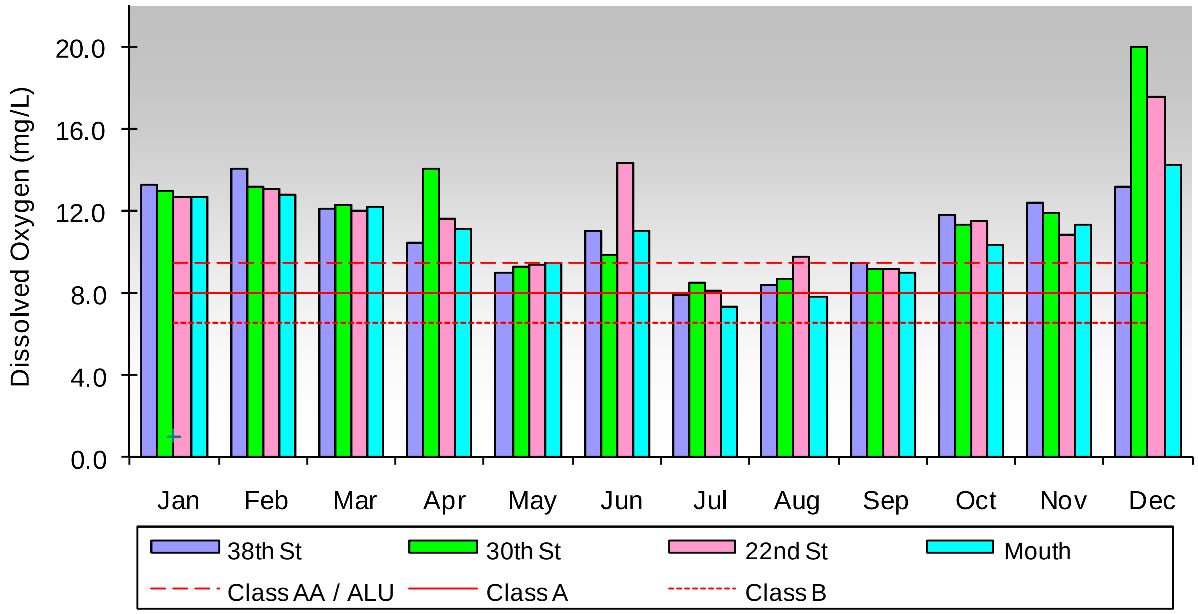


Figure 7.0-5. Dissolved oxygen for Padden Creek sampling sites by month in 2009. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

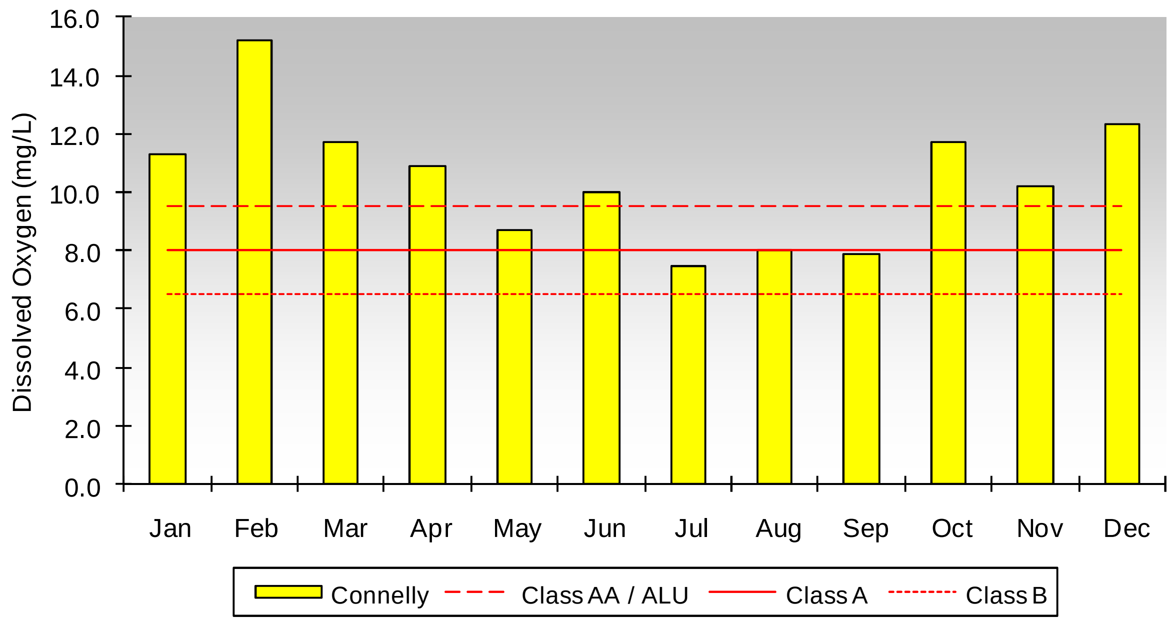


Figure 7.0-5a. Dissolved oxygen for the Connelly Creek sampling site by month in 2009. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

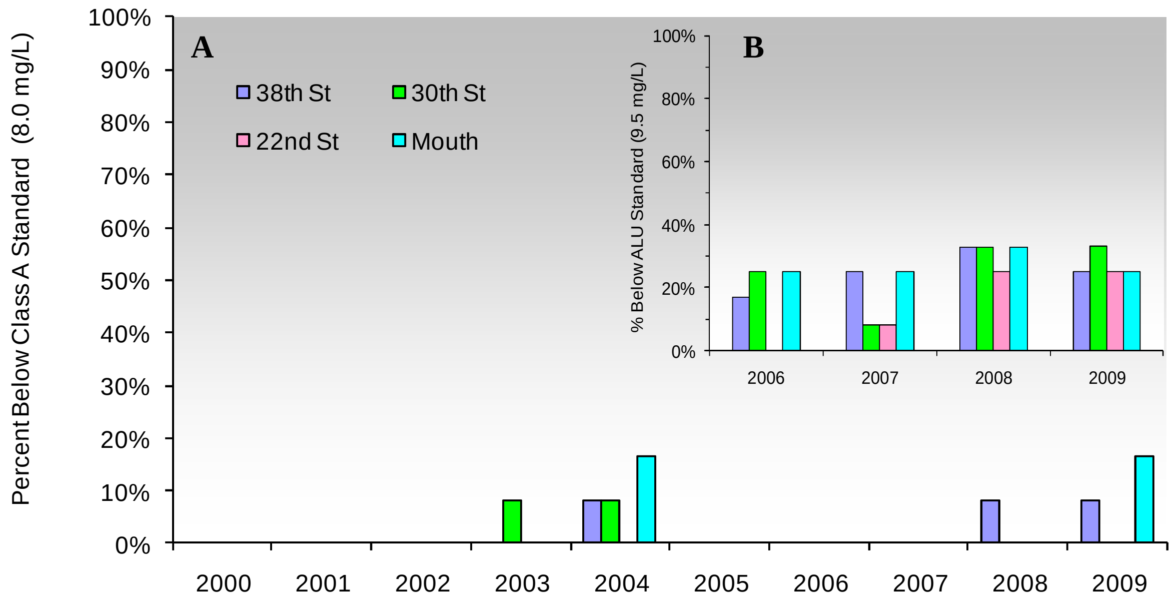


Figure 7.0-6. A. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for Padden Creek sampling sites 2000 to 2009. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2009. Sampling began on 22nd St. in 2005. All other gaps in graph represent a 0% rate of samples below standards.

Figure 7.0-6a. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Connelly Creek sampling site 2000 to 2009 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006. Gaps in graph represent a 0% rate of samples below standards.

Temperature

Temperatures in Padden Creek at 22nd St. and Connelly Creek met the 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU) criterion in 2009. The Core Summer Salmonid Habitat ALU is equivalent to Class AA. All other sites met the Class A (18°C) standard. The temperature profile for all segments shows the expected seasonal trend with higher temperatures in the summer months (Figures 7.0-8, 7.0-8a). Average temperatures are provided in Table 7.0-4.

Temperatures in Padden and Connelly Creeks do not exceed standards often. The 18°C Class A standard has not been exceeded in greater than 10% of all samples taken in any year since 1999. However, due to an unusually hot summer in 2009, the 16°C ALU designation was exceeded at the 38th Street, 30th Street, and Mouth sites on Padden Creek for the first time since implementation of the designated use criteria in 2006 (Figures 7.0-9, 7.0-9a).

Table 7.0-4. Average temperatures for sampling sites on Padden and Connelly Creek, 2009.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Average Temperature (°C)	10.0	10.8	10.8	10.9	11.0

Figure 7.0-7. Connelly Creek sampling site.

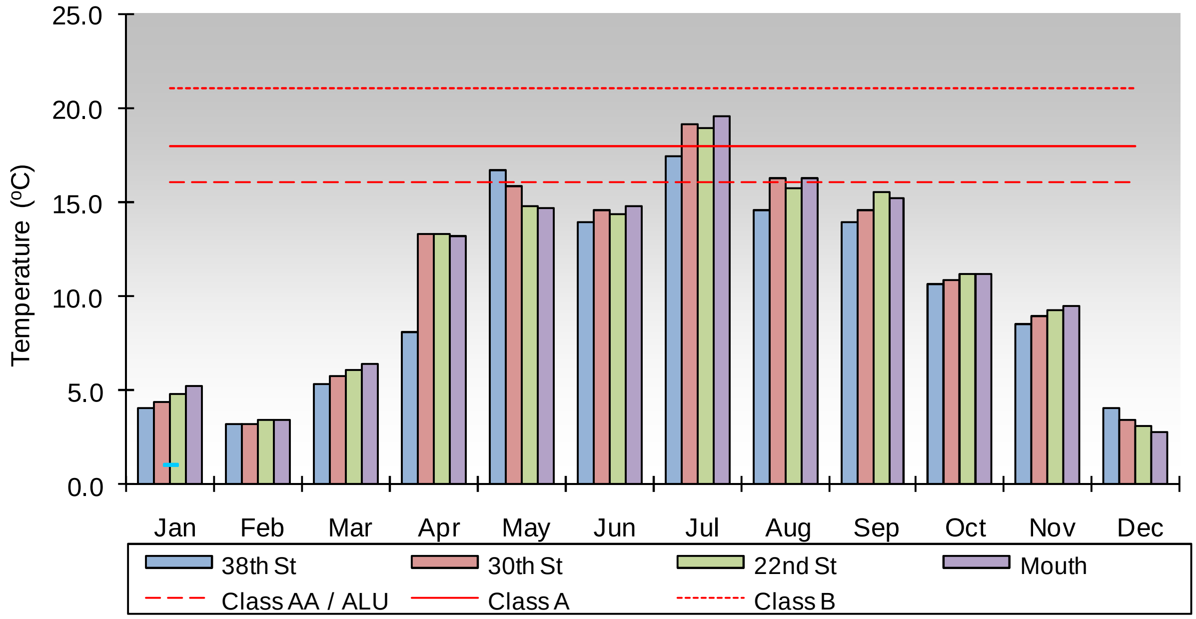


Figure 7.0-8. Monthly temperature measurements for Padden Creek sampling sites in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

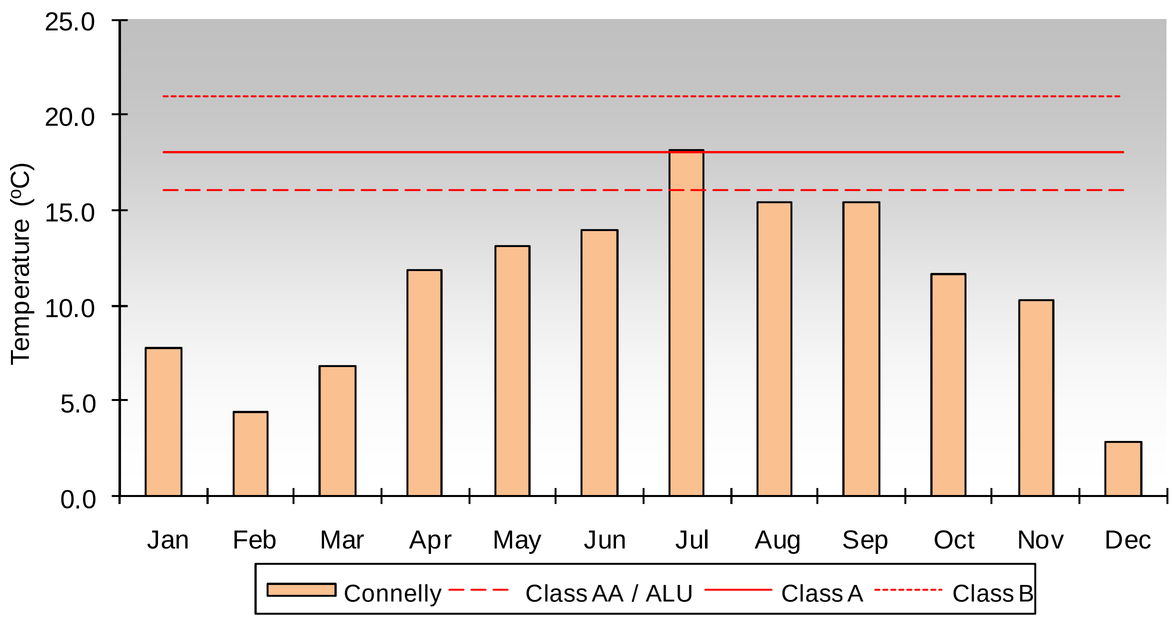


Figure 7.0-8a. Monthly temperature measurements for the Connelly Creek sampling site in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

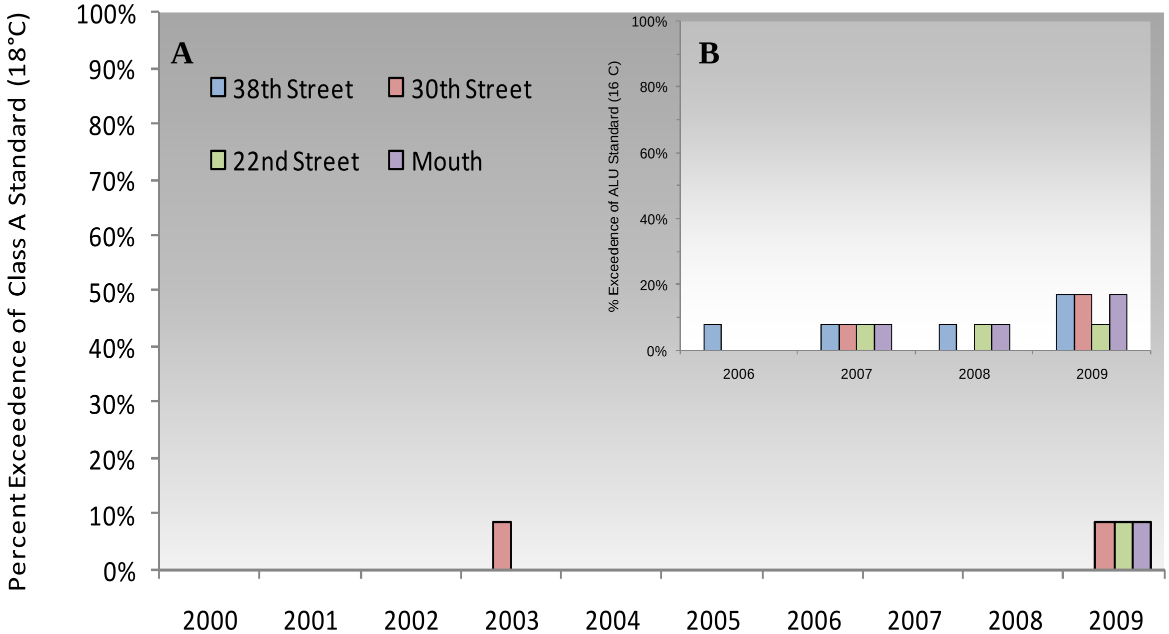


Figure 7.0-9. A. Percent of samples with temperatures in excess of the Class A standard (18℃) for Padden Creek sampling sites 2000 to 2009. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16℃) from 2006-2009. Sampling began on 22nd Street in 2005. All other gaps in graph represent a 0% exceedence rate.

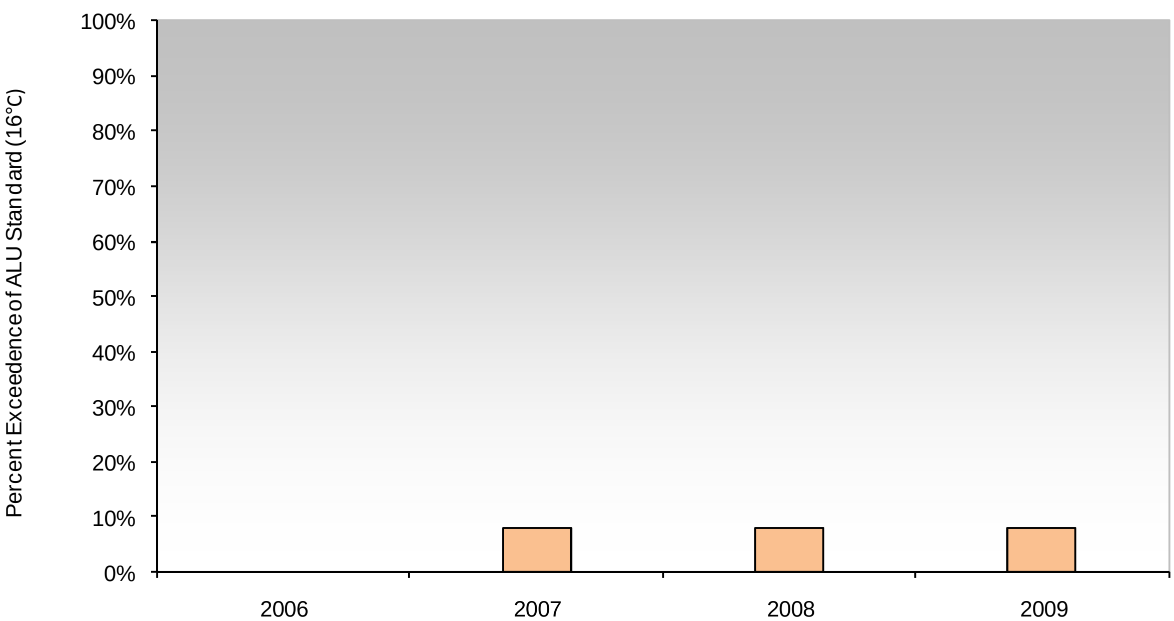


Figure 7.0-9a. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16℃) for the Conn elly Creek sampling site 2006 to 2009. There have been no exceedences of the Class A (18℃) stan dard since 1998. Gaps in graph represent a 0% exceedence rate.

pH

The pH at all sites monitored on Padden and Connelly Creeks generally falls within the range prescribed by Ecology for Aquatic Life Use (ALU) and all classes of freshwater bodies (6.5 to 8.5). In 2009, pH for all sites fell within the prescribed range. Graphs are not included in this section because pH is so rarely exceeded.

Turbidity

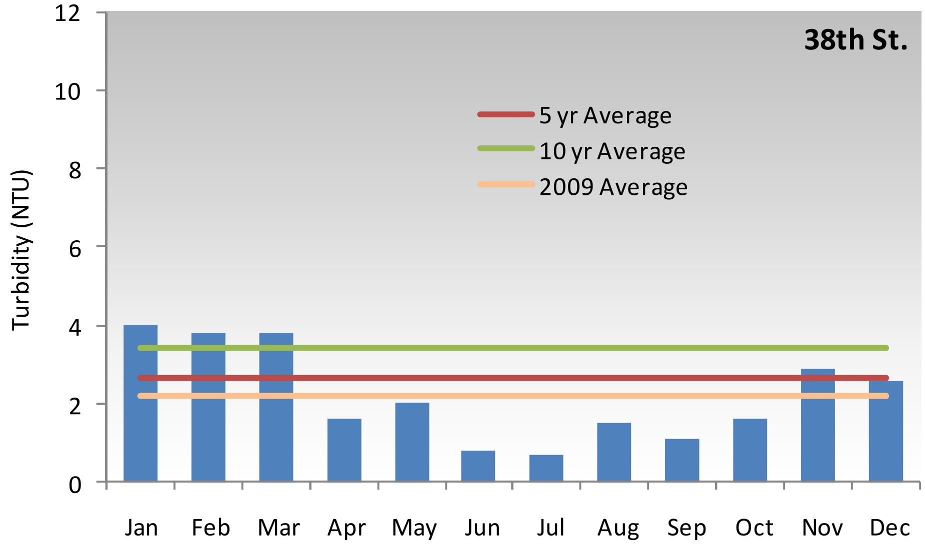
Turbidity in Padden and Connelly Creeks is generally below 10 NTU, with occasional spikes. In 2009, the average turbidities for the 38th Street, 22nd Street, Mouth and Connelly Creek sites were all below their respective 5 and 10 year averages. Average turbidity for the 30th Street site was below the 10-year average but above the 5-year average (Figures 7.0-10a-e) . Maximum, minimum and average turbidity for all sampling sites in 2009 are provided in Table 7.0-5. Turbidity spikes in January, March and May all correlate with rainfall events surrounding the sampling date.

Ten year turbidity trends at Padden and Connelly Creek sites were all descending in 2009. A reassuring sign that restoration efforts along the Padden Creek drainage may be having positive effects on water quality. The 38th St. site is decreasing 0.25 NTU/year, 30th St. is decreasing 0.26 NTU/year, 22nd St. is decreasing 0.34 NTU/year and the site at the mouth is decreasing 0.25 NTU/year. Connelly Creek is decreasing 0.29 NTU/year.

Table 7.0-5 The average, maximum and minimum turbidity for sampling sites on Padden and Connelly Creek in 2009.

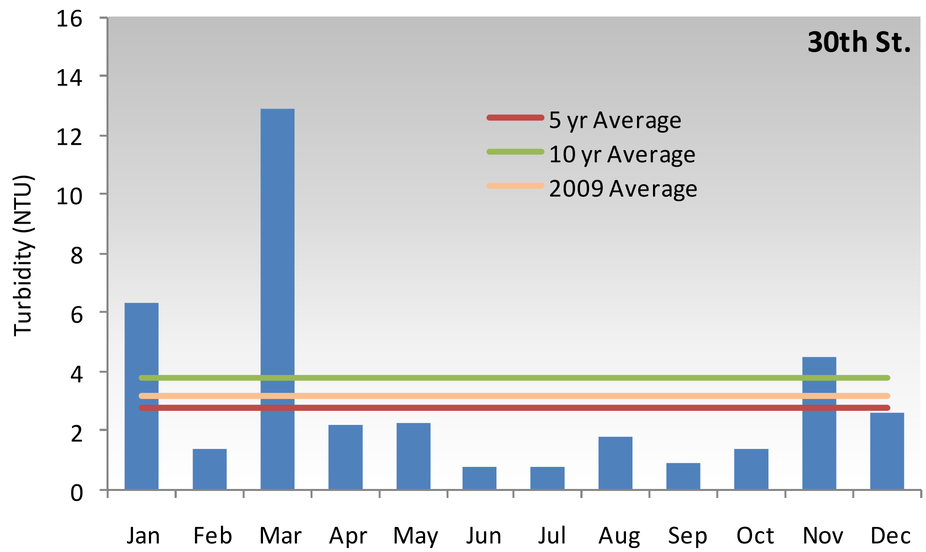
Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
2008 Average (NTU)	2.2	3.2	5.6	4.0	4.4
2008 Maximum (NTU)	4	12.9	14.5	9.2	11.7
2008 Minimum (NTU)	0.7	0.8	2.3	1.9	1.8

a.

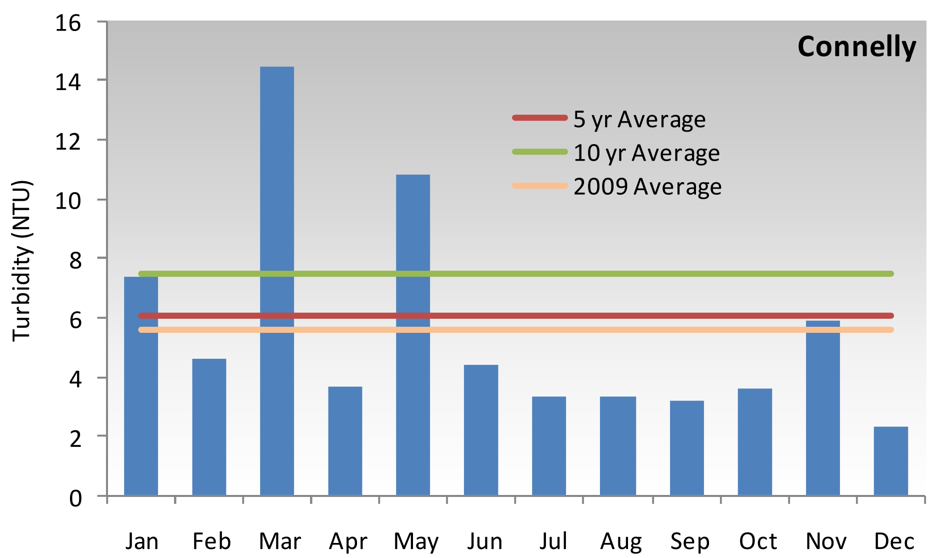


Figures 7.0-10a,b&c. Monthly turbidity values for Padden Creek drainage sampling sites at 38th St., 30th St. and the Connelly Creek during 2009. Presented with yearly, 5-year and 10-year averages.

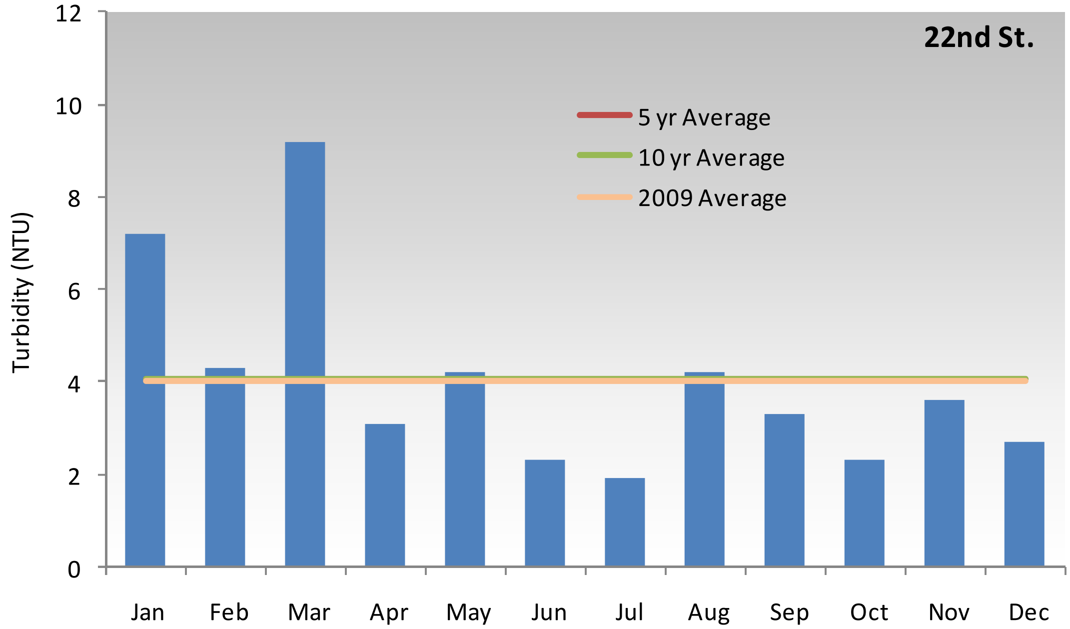
b.



c.

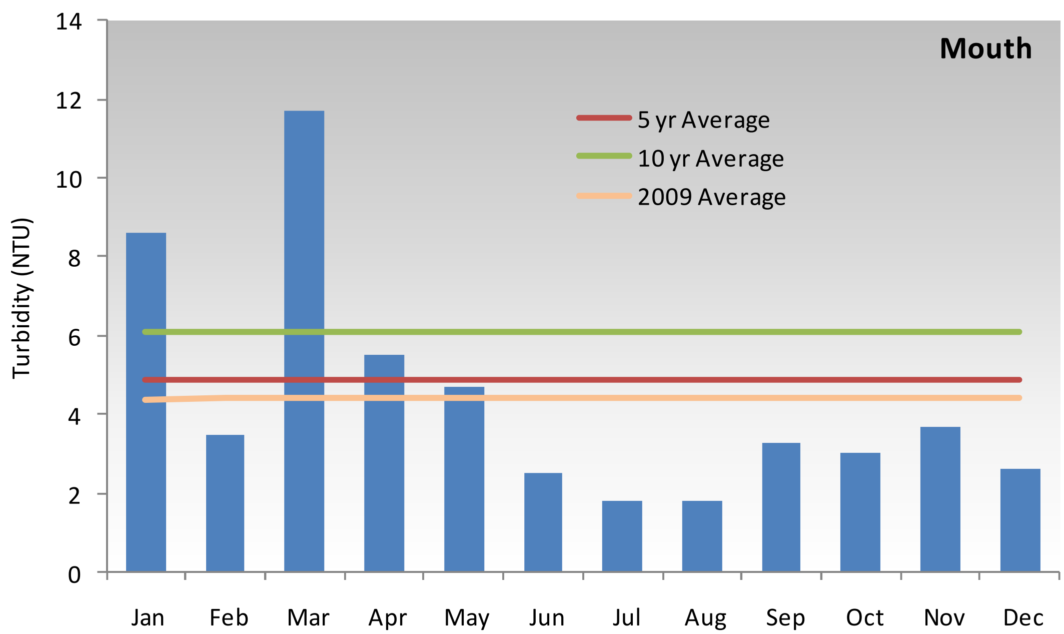


d.

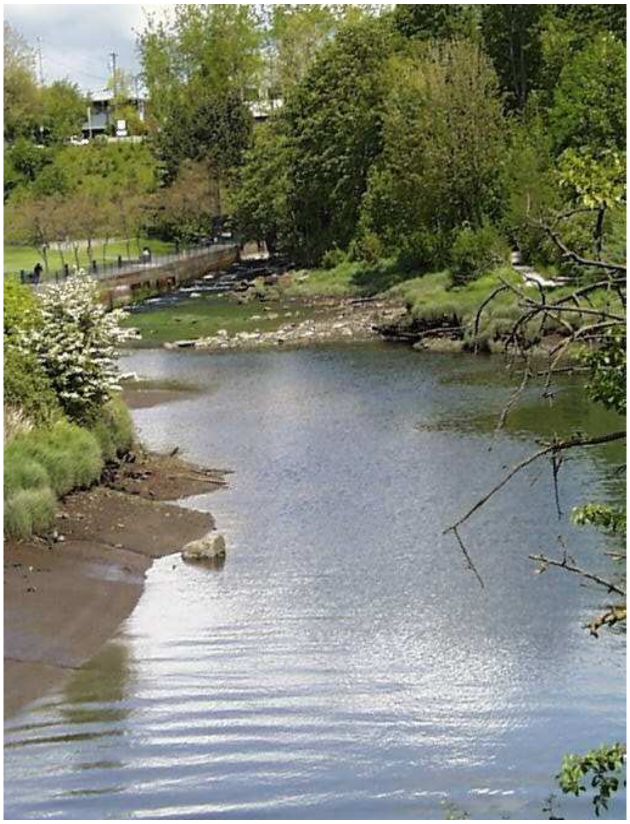


Figures 7.0-10d&e. Monthly turbidity values for Padden Creek sampling sites at 22nd St. and the Mouth during 2009. Presented with yearly, 5-year and 10-year averages.

e.



8.0 Whatcom Creek Drainage Basin



The origin of Whatcom Creek is the natural outlet of Lake Whatcom at the northwest end of the lake. Whatcom Creek flows approximately four miles through residential, commercial, industrial, and wooded areas to the mouth at Bellingham Bay near downtown Bellingham and has a drainage basin of approximately 5,790 acres (City of Bellingham, 1982).

In the upper reaches, the creek cuts through the Chuckanut Sandstone formation, a geological belt of sandstone dating back fifty million years. Erosion of the sandstone has created a deep gorge and waterfalls along the upper reaches. This segment of the creek is in wooded and residential areas. It is shaded and the flow tends to be more rapid.

The creek flattens after leaving the Whatcom Falls Park area and enters a mainly industrial and commercial area. The flow in the lower reaches of the creek is slower than in the upper reaches. A great deal of impervious surface area surrounds this reach of the creek. Much of the creek in this flat area lacks shade, though restoration efforts by the City of Bellingham/Washington Conservation Corps crews in recent years have made enormous strides in revegetating this region with trees and other native plants.

The Whatcom Creek drainage basin contains several creeks that contribute to the flow in Whatcom Creek. Hanna Creek flows into Whatcom Creek in Whatcom Falls Park and is one of the main low flow contributors to Whatcom Creek. Hanna Creek has a drainage area of approximately 480 acres (City of Bellingham, 1995) and flows through residential and wooded areas.

Fever Creek drains into Whatcom Creek near Interstate 5. This small urban creek flows through residential and industrial areas and is characterized by channelization for much of its run. It has a drainage basin of approximately 580 acres (City of Bellingham, 1995).

Lincoln Creek also discharges to Whatcom Creek near Interstate 5 and has been channelized for much of its course. Lincoln Creek flows through commercial, industrial and residential areas and drains approximately 804 acres (City of Bellingham, 1995).

Cemetery Creek flows through mostly residential and wooded areas and joins Whatcom Creek near Racine Street. It has a drainage area of approximately 1,670 acres (City of Bellingham, 1995).

Whatcom Creek is sampled at four

locations: below the Control Dam at the south end of Scudders Pond (Figure 8.0-1), at Valencia St. (Figure 8.0-2), adjacent to Interstate 5 (Figure 8.0-3), and at Dupont St. (Figure 8.0-4). Four Whatcom Creek tributaries are sampled. Hanna Creek (Figure 8.0-5) is sampled below the City of Bellingham Water Treatment Plant approximately 1000 feet upstream from the confluence with Whatcom Creek. Cemetery Creek (Figure 8.0-8) is sampled near the Haskell Business Center, just upstream from the confluence with Whatcom Creek. Lincoln Creek (Figure 8.0-11) is sampled at a location adjacent to the Geary softball fields and approximately 1200 feet upstream from the confluence with Whatcom Creek. Fever Creek (Figure 8.0-12) is sampled at Valencia Street approximately 3500 feet upstream from the confluence with Whatcom Creek (see the Whatcom Drainage Map for sampling locations). Table 8.0-1 shows the number of samples taken at each sampling location by year.

Whatcom Creek and its' tributaries rarely meet all of the designated use criteria. In fact, The City of Bellingham conducted a Total Maximum Daily Load (TMDL) study in 2002/2003 on Whatcom Creek due to an Ecology listing as a 303(d) impaired waterway for temperature and fecal coliform bacteria (Shannahan et al.).

Figure 8.0-1. Whatcom Creek sampling site at the Control Dam.

Fecal coliform data in the 2004 report of the study detailed the loading of fecal coliforms to the creek system. Ecology has issued an implementation plan to reduce fecal coliform bacteria in Whatcom Creek (Hood, 2006).

In 2009, the Control dam and Valencia St. sites on Whatcom Creek were the only sites to meet the Primary Contact Recreational Use Standard for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml). The sites on Hanna and Lincoln Creeks

Table 8.0-1. Number of samples* taken per year for Whatcom Creek and its tributaries from 2000 to 2009.

Sampling Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Control Dam	4	8	12	12	12	12	12	12	12	12
Hanna			9	10	12	10	11	12	12	12
Cemetery	4	8	12	12	12	12	12	12	12	11
Lincoln	4	8	12	12	12	12	12	12	12	12
Fever	4	8	12	12	11	12	12	12	12	12
Valencia							4	12	12	12
I-5	4	8	12	12	12	12	12	12	12	12
Dupont	4	8	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

Figure 8.0-2. Whatcom Creek sampling site at Valencia St.

were the only sites to meet Aquatic Life Use (ALU) temperature criterion of 16°C. None of the sites met dissolved oxygen ALU criterion (≥9.5 mg/L). All sites remained within the designated pH ALU range of 6.5-8.5.

Likewise, none of the sites on Whatcom Creek nor its tributaries met overall Class A designation for 2009. The Whatcom Creek sites at the Control Dam, Valencia and I-5 were however able to meet the criteria for overall Class B designation, as was Hanna Creek.

Hanna and Lincoln Creeks met the more stringent Class AA criterion for temperature (≤ 16℃), while Cemetery Creek, Fever Creek and Whatcom Creek at Dupont met the Class A temperature standard (≤ 18℃). Whatcom Creek at the Control Dam, Valencia, and I-5 sites met the Class B standard (≤ 21℃).

In 2009, none of the sampling locations met the Class AA standard for dissolved oxygen (9.5 mg/L). Though Hanna Creek, Fever Creek, Whatcom Creek at Valencia St. and at I-5 did meet the Class A standard (8.0 mg/L). Lincoln Creek and Whatcom Creek at Dupont and the Control Dam met the Class B standard (6.5 mg/L). Cemetery Creek was the only stream segment not to meet Class A or B standards for dissolved oxygen.

Whatcom Creek at the Control Dam was the only site to meet the more stringent Class AA standard for fecal coliform bacteria (geomean ≤50 CFU/100 ml; no more than 10% of samples >100 CFU/100 ml). Whatcom Creek at Valencia met the Class A standards (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml), and the Whatcom Creek I-5 site along with Hanna Creek met Class B standards (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml). No other sites on Whatcom Creek or the tributaries met Class A or B standards.

All stream segments sampled met the Class AA/A/B standard for pH (6.5 to 8.5).

The average turbidities for Whatcom Creek and tributary sites were all higher in 2009 than in 2008. The highest average turbidity on Whatcom Creek was found at the Dupont site (5.5 NTU), while the Control Dam site had the lowest average turbidity (2.1 NTU). Of the tributaries, Lincoln Creek had the highest average turbidity (8.0 NTU) and Cemetery Creek had the lowest (5.4 NTU). Average turbidity values for 2009 are listed along side respective 5 and 10 year averages in Table 8.0-5. Conductivity was consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels in Whatcom Creek and its tributaries were similar to those found in 2008. Geomean values for all sampling locations are provided in Table 8.0-2. Bacterial concentrations show the expected trend of higher values in the summer months at all sampling locations, presumably as bacteria become more concentrated due to lower flows, and/or as warmer temperatures encourage extended survival or growth of bacterial populations (Figures 8.0-6, 8.0-6a). Unusually high numbers of fecal coliform colonies were found at many sites during September. This is likely do to the abnormally high temperatures recorded in 2009 allowing the bacteria to thrive. The percent of samples that contained fecal coliform levels higher than 200 CFU/100 ml for 2000 to 2009 is presented in Figures 8.0-7 and 8.0-7a.

Figure 8.0-4. Whatcom Creek sampling site at Dupont Street.

Table 8.0-2. Fecal coliform geomean values for sampling sites on Whatcom Creek and its tributaries, 2009.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Geomean (CFU/100ml)	14	31	59	94	67	67	156	314

Figure 8.0-3. Whatcom Creek sampling site at I-5.

Figure 8.0-5. Hanna Creek sampling site.

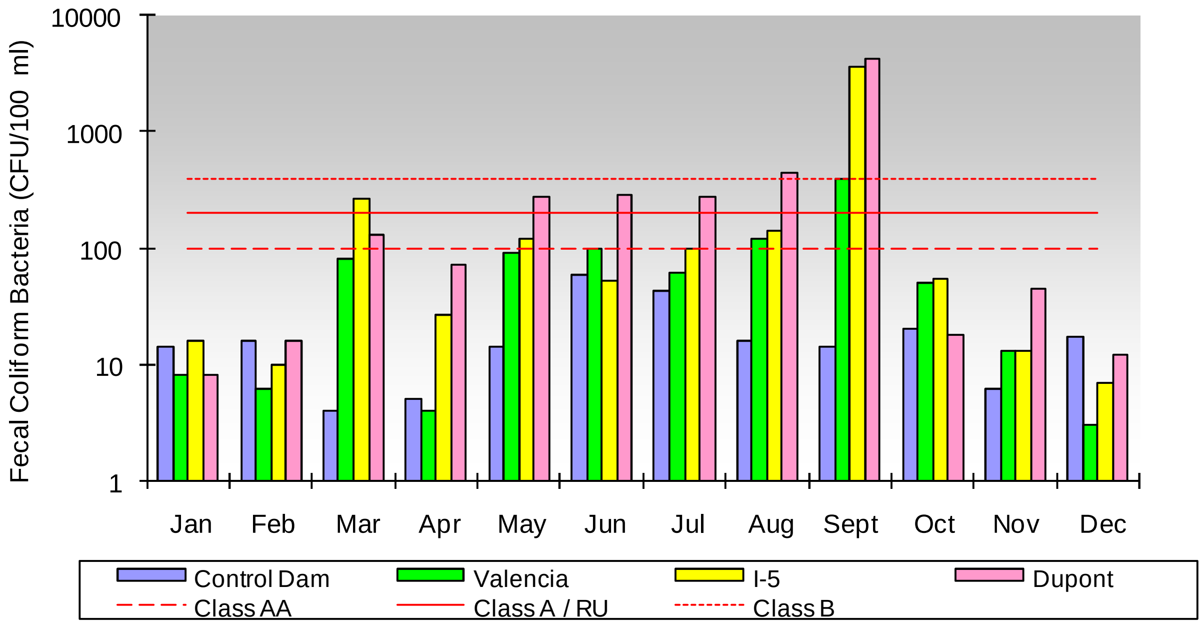


Figure 8.0-6. Monthly 2009 fecal coliform levels for sampling sites on Whatcom Creek. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

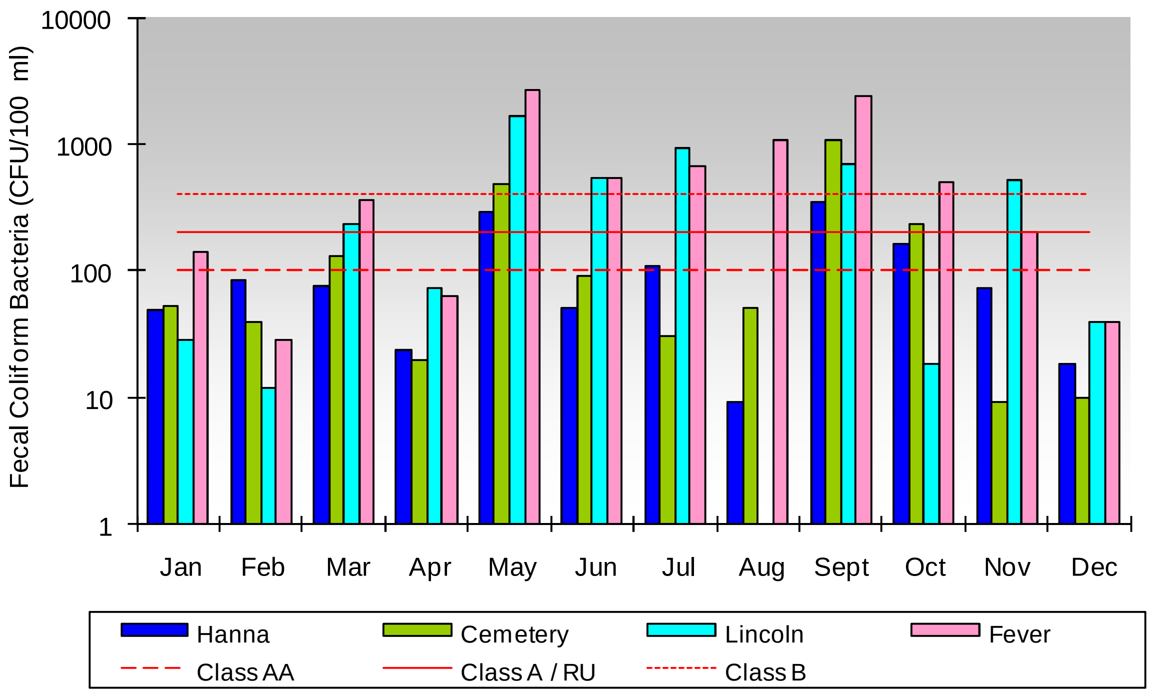


Figure 8.0-6a. Monthly 2009 fecal coliform levels for sampling sites on Whatcom Creek tributaries. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

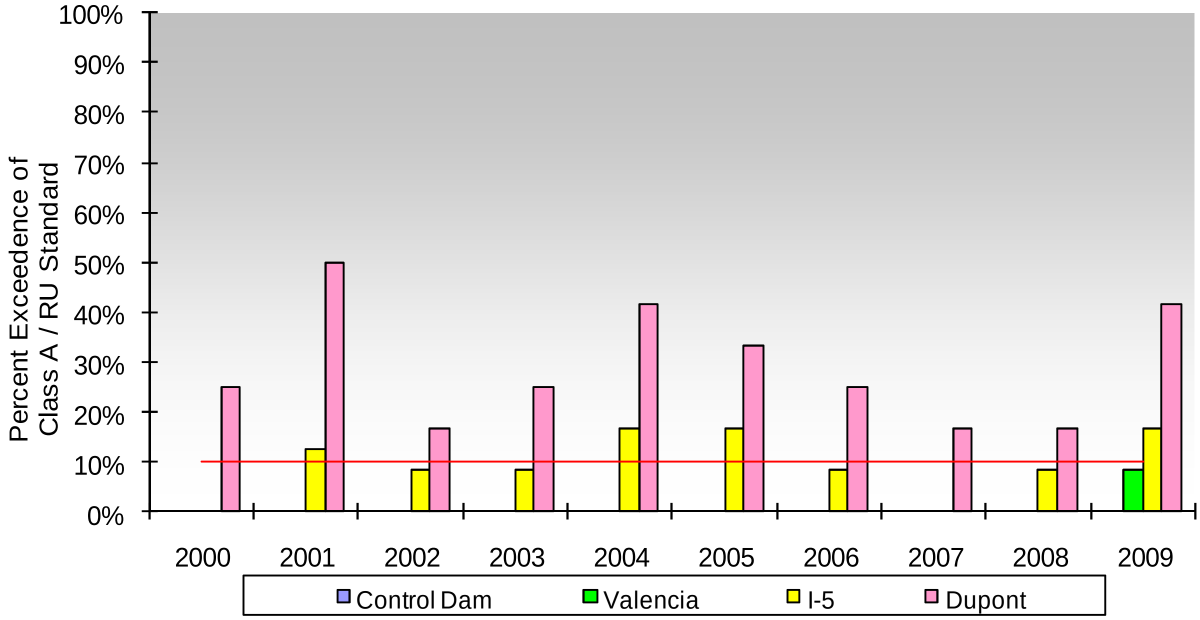


Figure 8.0-7. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Whatcom Creek sampling sites, 2000 to 2009. Sampling at Valencia began in 2007. Gaps represent a 0% exceedence rate.

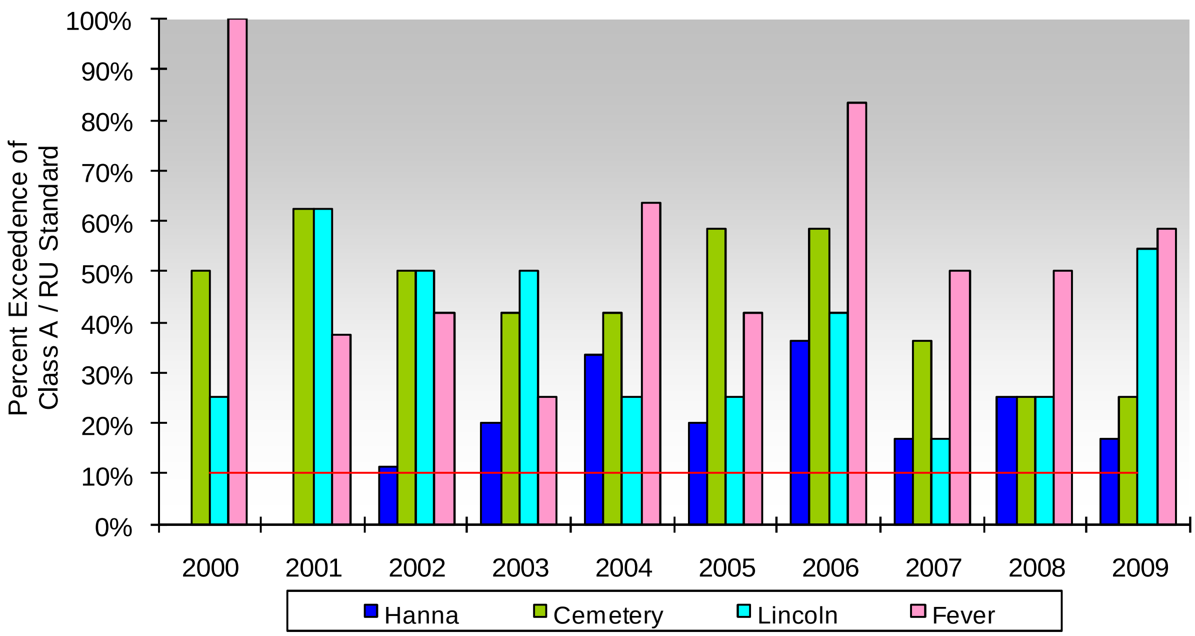


Figure 8.0-7a. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Whatcom Creek tributaries sampling sites, 2000 to 2009. Hanna Creek was sampled 2002 to 2009 only. All other gaps represent a 0% exceedence rate.

Dissolved Oxygen

During 2009, none of the Whatcom Creek Drainage sites met the 9.5 mg/L Core Summer Salmonid Aquatic Life Use (ALU) standard for dissolved oxygen. The dissolved oxygen ALU designation equates to the Class AA standard. The Valencia and I-5 sites on Whatcom Creek maintained Class A dissolved oxygen standards (≥8.0 mg/L), as did Hanna and Fever Creek. The Control Dam and Dupont sites on Whatcom Creek along with Lincoln Creek met Class B standards (≥6.5 mg/L). Cemetery Creek failed to meet either Class A or B standards (Figures 8.0-9 and 8.0-9a).

Dissolved oxygen levels in Whatcom Creek and its tributaries have fallen below 8.0 mg/L frequently in previous years (Figures 8.0-10, 8.0-10a). Dissolved oxygen followed the expected trend in 2009 of lower values in the warmer summer months as water temperatures rose. Average dissolved oxygen values are provided in Table 8.0-3.

Table 8.0-3. Average dissolved oxygen values for Whatcom Creek and its tributaries in 2009.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Average DO (mg/L)	10.5	11.3	11.0	10.6	11.2	9.8	10.7	10.8

Figure 8.0-8. Cemetery Creek sampling site

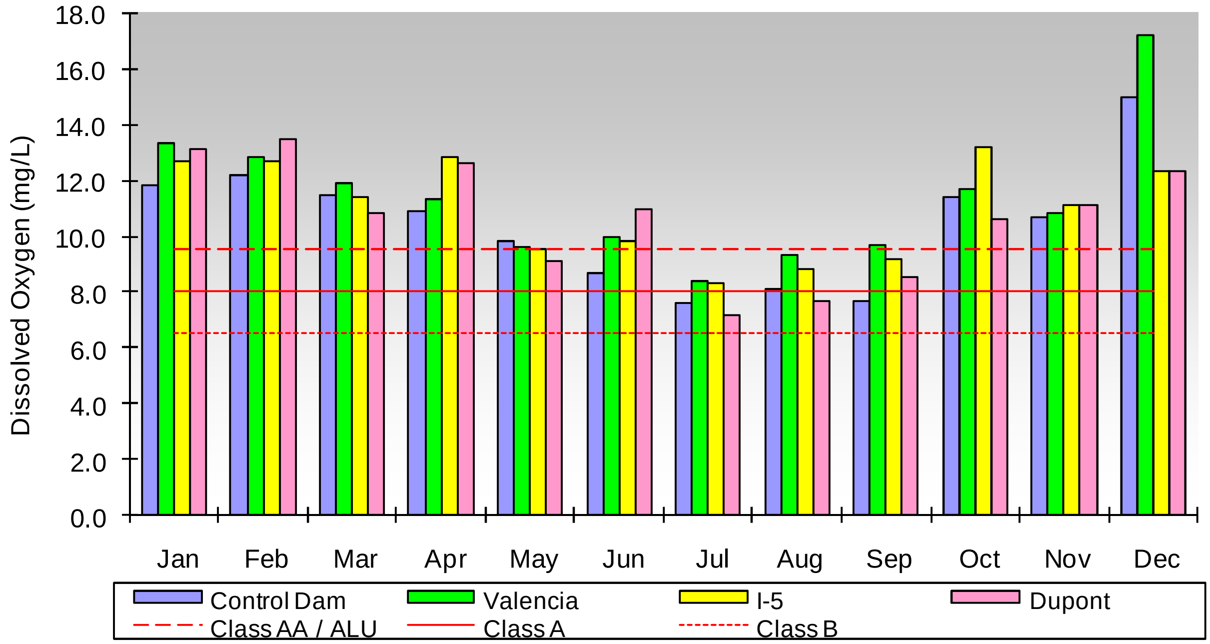


Figure 8.0-9. Monthly 2009 dissolved oxygen levels for Whatcom Creek sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

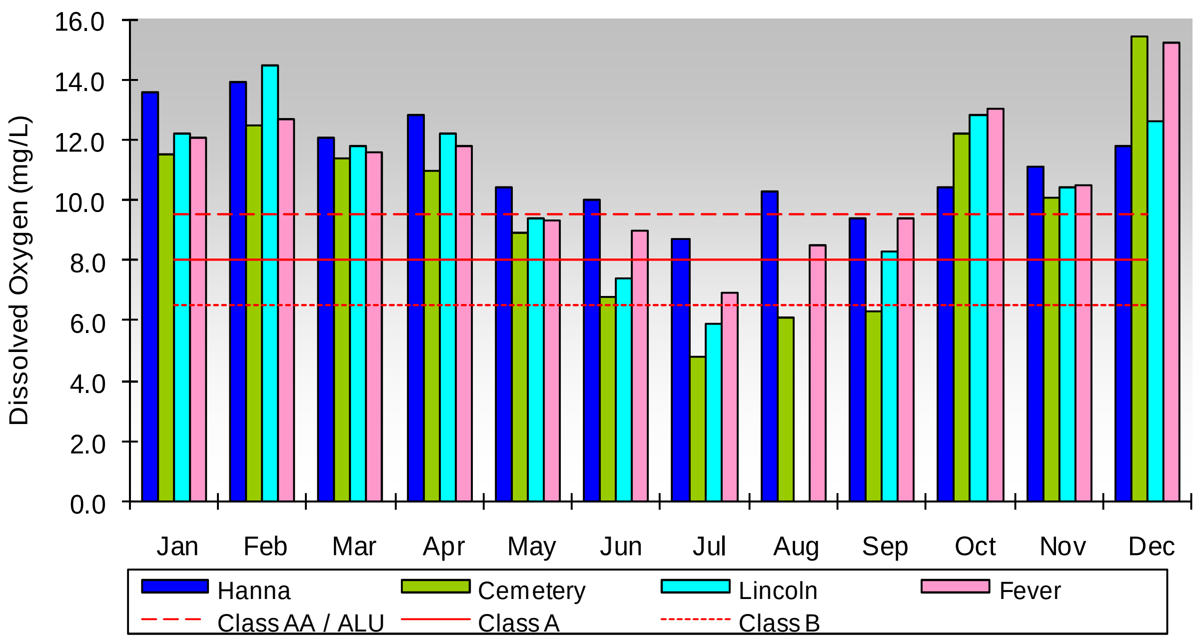


Figure 8.0-9a. Monthly 2009 dissolved oxygen levels for Whatcom Creek tributaries sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

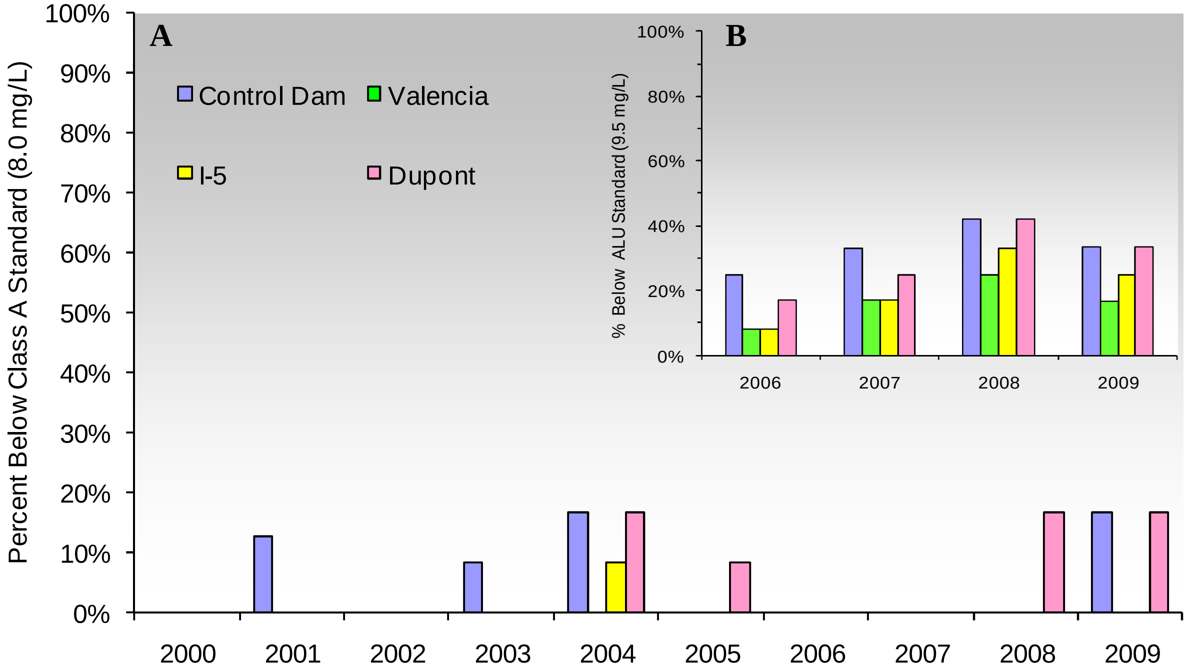


Figure 8.0-10. A. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for Whatcom Creek sampling sites 2000 to 2009. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2009. Sampling at Valencia began in 2007. Gaps represent a 0% rate of samples below standards.

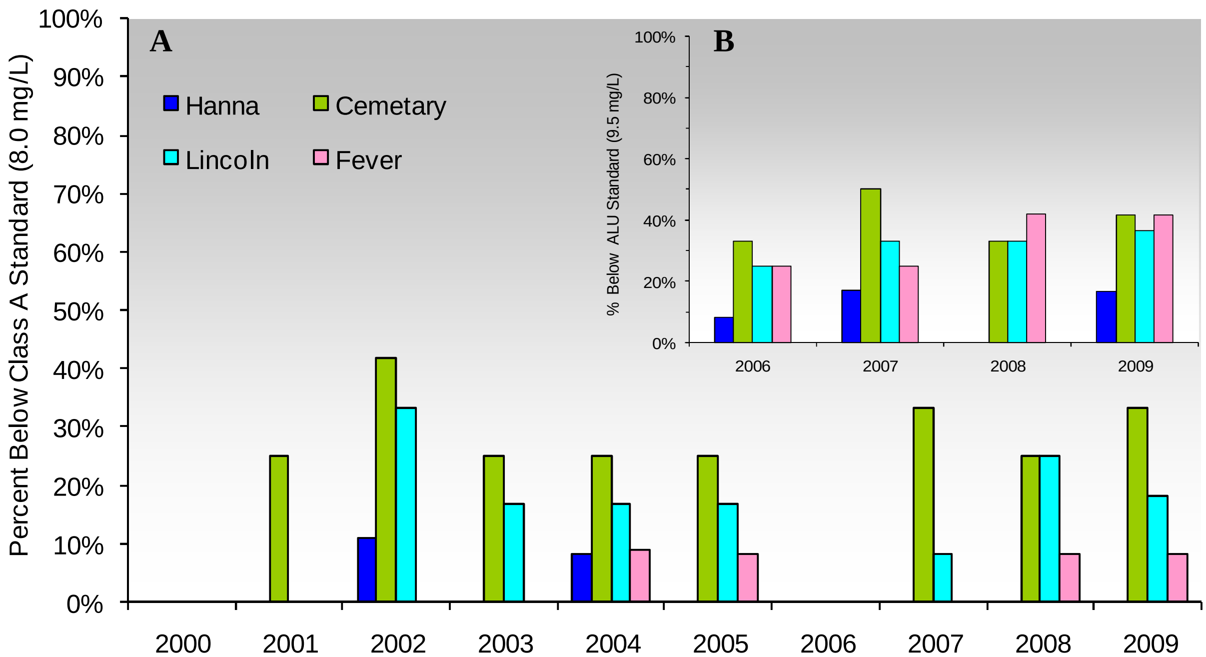


Figure 8.0-10a. A. Percent of dissolved oxygen samples below 8.0 mg/L for Whatcom Creek tributaries sampling sites 2000 to 2009. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2009. Hanna Creek was sampled 2002 to 2009 only. All other gaps represent a 0% rate of samples below standards.

Temperature

Whatcom Creek chronically experiences temperature in excess of the 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation during the warmer summer months. This phenomenon is not surprising as the source water for Whatcom Creek, basin one of Lake Whatcom, has had recorded temperatures higher than 20° C in the upper epilimnion during summer months. While none of the stream segments on Whatcom Creek were able to meet the ALU standard in 2009, the Dupont St. site did meet the <18°C Class A standard and the Control Dam, Valencia and I-5 sites all met the <21°C Class B standard.

Temperatures above 16°C are not as common in the Whatcom Creek tributaries. In 2009 Hanna and Lincoln Creeks maintained temperatures below the <16°C ALU criterion, while Cemetery and Fever Creeks met the <18°C Class A standard.

The expected seasonal trend with higher temperatures in the warmer summer months is apparent for both Whatcom Creek and its tributaries (Figures 8.0-13, 8.0-13a). Average temperatures for 2009 are provided in Table 8.0-4. The percent of samples with temperatures higher than 18°C for Whatcom Creek and its tributaries for 2000 to 2009 are provided in Figures 8.0-14 and 8.0-14a.

Figure 8.0-11. Lincoln Creek sampling site.

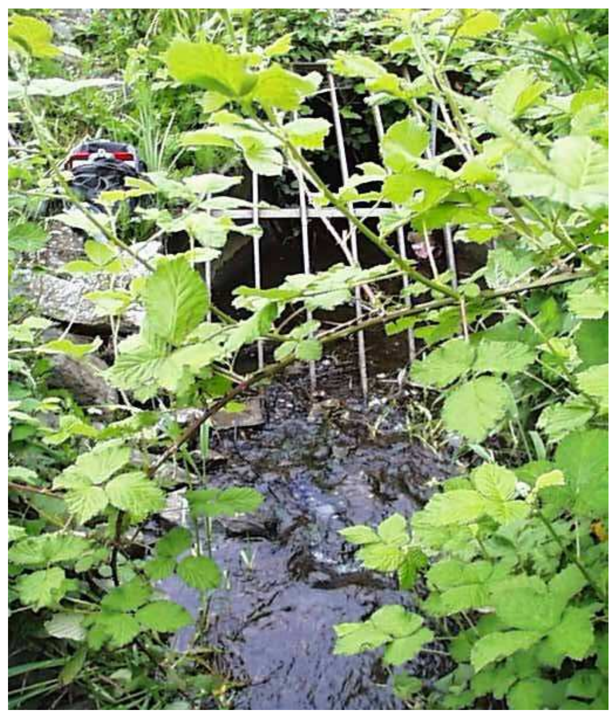


Figure 8.0-12. Fever Creek sampling site.

Table 8.0-4. Average temperatures for sampling sites on Whatcom Creek and tributaries, 2009.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Average Temperature (°C)	12.9	12.2	12.1	11.9	9.5	10.5	10.1	11.2

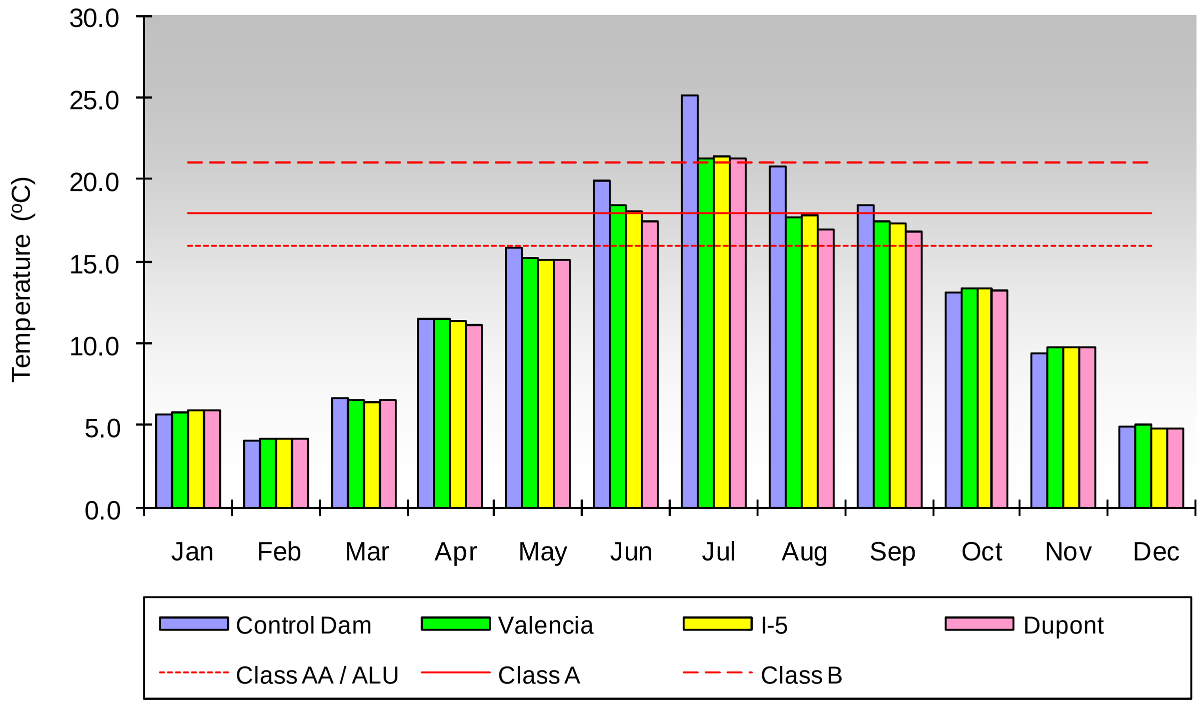


Figure 8.0-13. Monthly temperature measurements for Whatcom Creek sampling sites in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

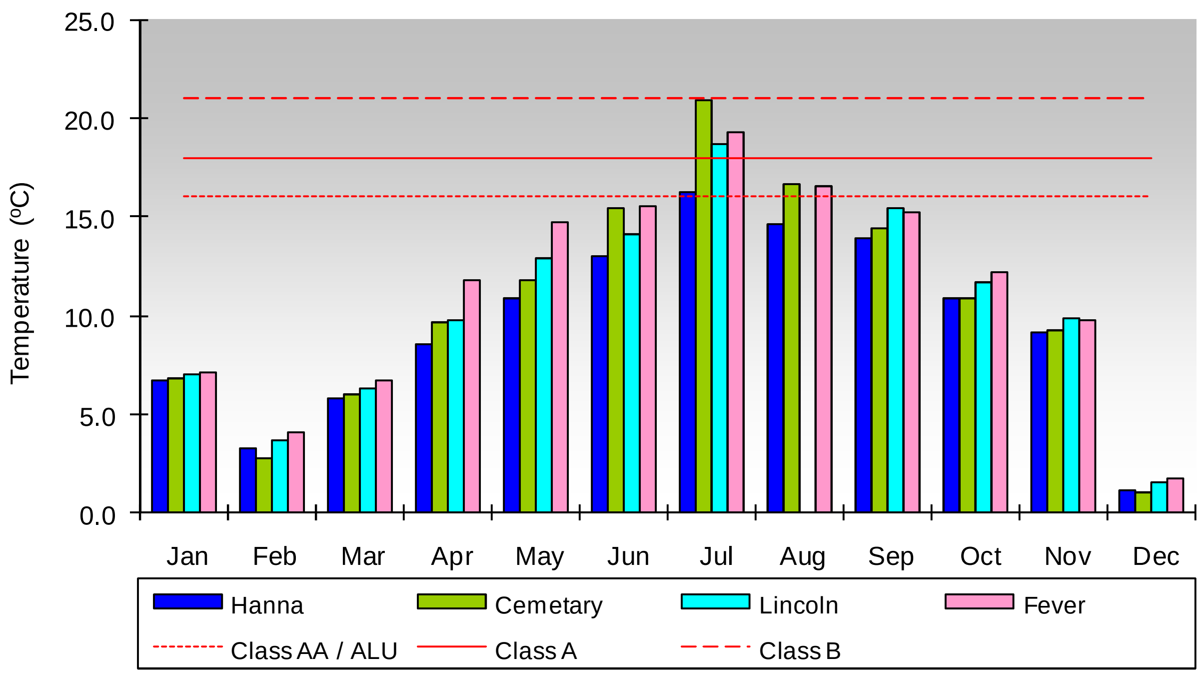


Figure 8.0-13a. Monthly temperature measurements for Whatcom Creek tributaries sampling sites in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

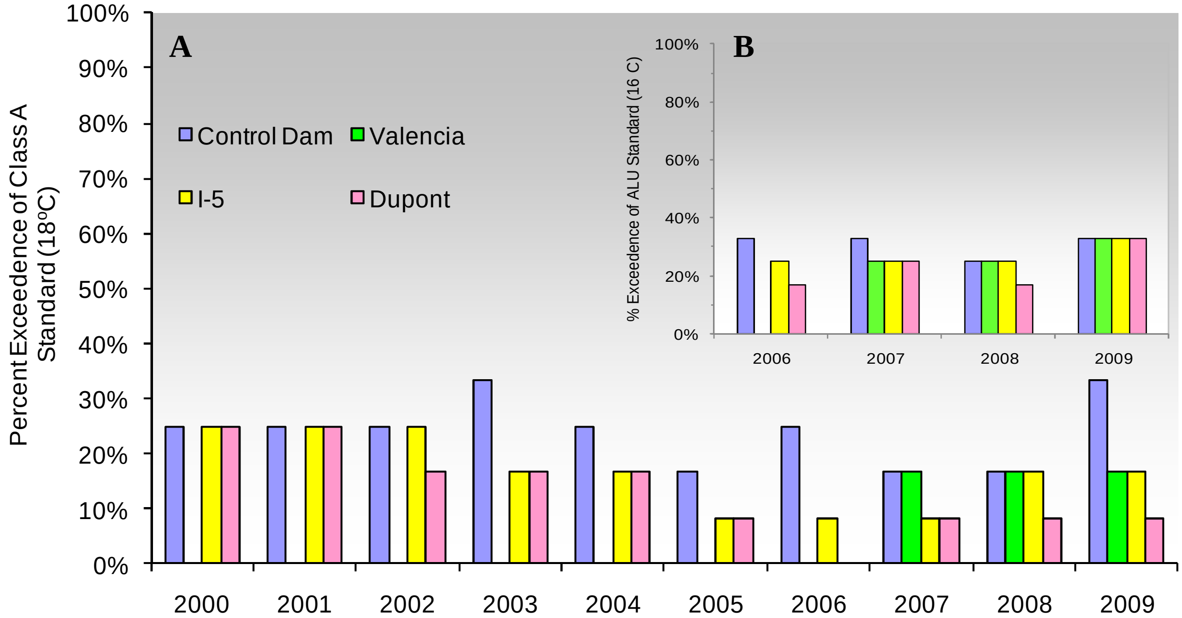


Figure 8.0-14. A. Percent of samples with temperatures in excess of the Class A standard (18℃) for Whatcom Creek sampling sites 2000 to 2009. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16℃) from 2006-2009. Sampling at Valencia began in 2007. Gaps represent a 0% exceedence rate.

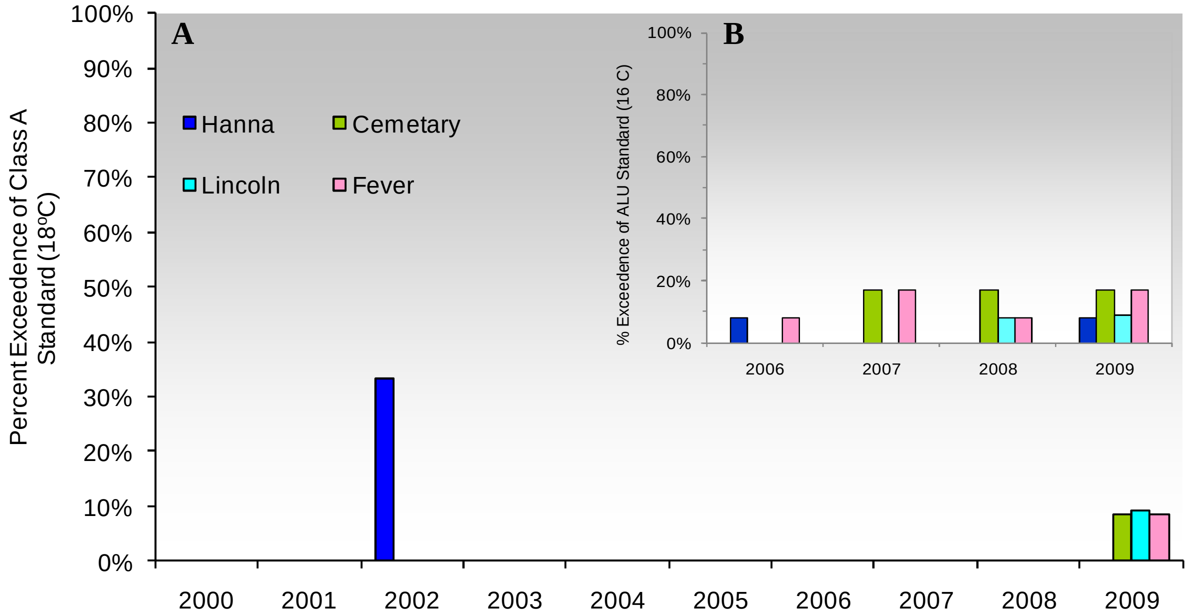


Figure 8.0-14a. A. Percent of samples with temperatures in excess of the Class A standard (18℃) for Whatcom Creek tributary sampling sites 2000 to 2009. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16℃) from 2006-2009. Hanna Creek was sampled 2002 to 2009 only. All other gaps represent a 0% exceedence rate.

pH

The pH at all sites monitored on Whatcom Creek and its tributaries generally fall within the range prescribed by Ecology for all classes of freshwater bodies, 6.5 to 8.5. During 2009 all Whatcom Creek and tributary sites were once again within this standard. Graphs are not included in this section because pH is so rarely exceeded.

Turbidity

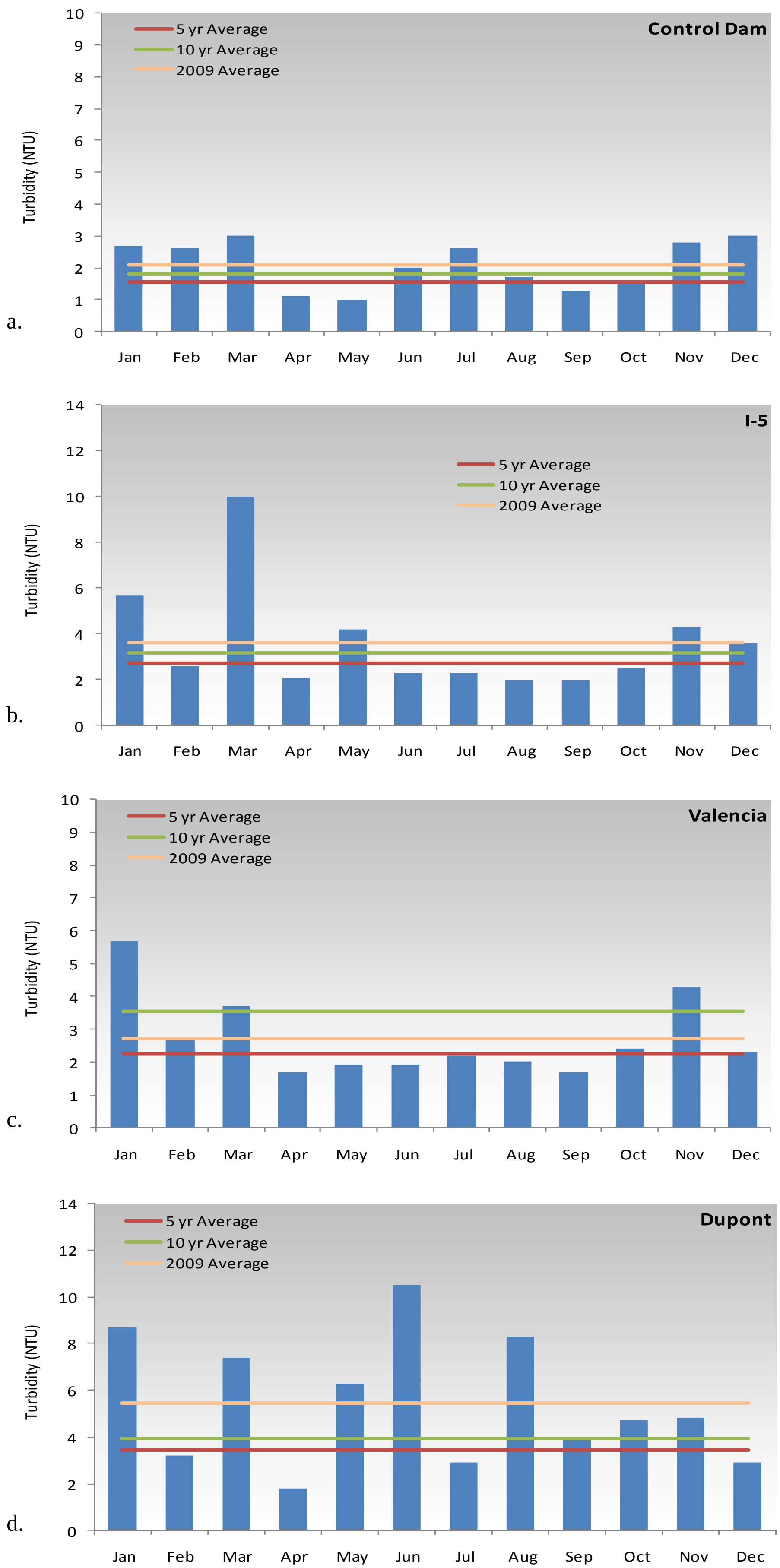
Turbidity in Whatcom Creek is usually lower than its tributaries. This trend continued in 2009. The average turbidities and their respective 5 and 10 year averages are provided in figures 8.0-15a-d and 8.0-16a-d. Maximum, minimum and average turbidity for all sampling sites in 2009 are provided in Table 8.0-5.

With the exception of the Control Dam site on Whatcom Creek, ten year turbidity trends for Whatcom Creek and its' tributaries were descending in 2009. Such trends are likely in part due to City lead restoration efforts. The average turbidity at the Control Dam on Whatcom Creek has increased slightly at 0.02 NTU/Year over the past ten years. Average turbidities at the Valencia, I-5 and Dupont sites on Whatcom Creek have all decreased at rates of 0.68 NTU/Year, 0.03 NTU/Year and 0.04 NTU/Year respectively. Turbidities on the Whatcom Creek tributaries have decreased at rates of 0.22 NTU/Year, 0.36 NTU/Year, 0.27 NTU/Year and 0.36 NTU/Year for Hanna, Cemetery, Lincoln and Fever Creeks respectively.

The source of higher than normal values found at the Dupont St. site during June and August of 2009 are unknown, but due to the lack of these spikes at sites further up Whatcom Creek it can be assumed that they are due to local disturbances. High values at all sites in January, March, May and November correlate with a rain.

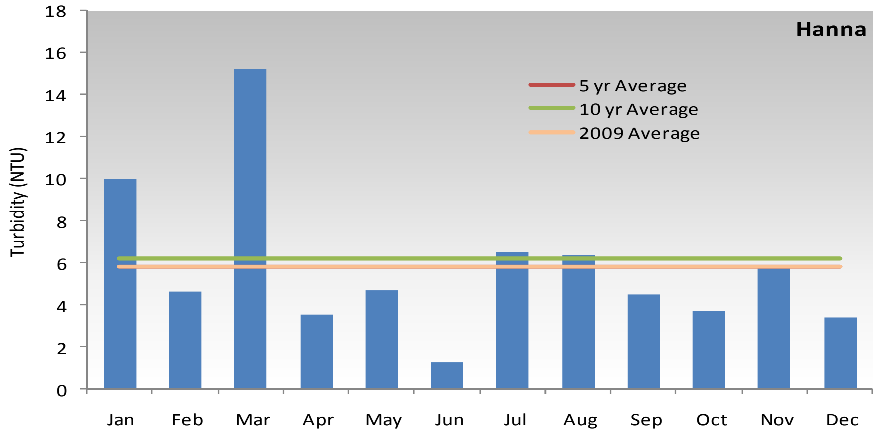
Table 8.0-5. The average, maximum and minimum turbidity for sampling sites on Whatcom Creek and its tributaries in 2009.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
2009 Average (NTU)	2.1	2.7	3.6	5.5	5.8	5.4	8.0	6.2
2009 Maximum (NTU)	3.0	5.7	10.0	10.5	15.2	8.2	17.6	18.4
2009 Minimum (NTU)	1.0	1.7	2.0	1.8	1.3	2.3	2.5	2.0

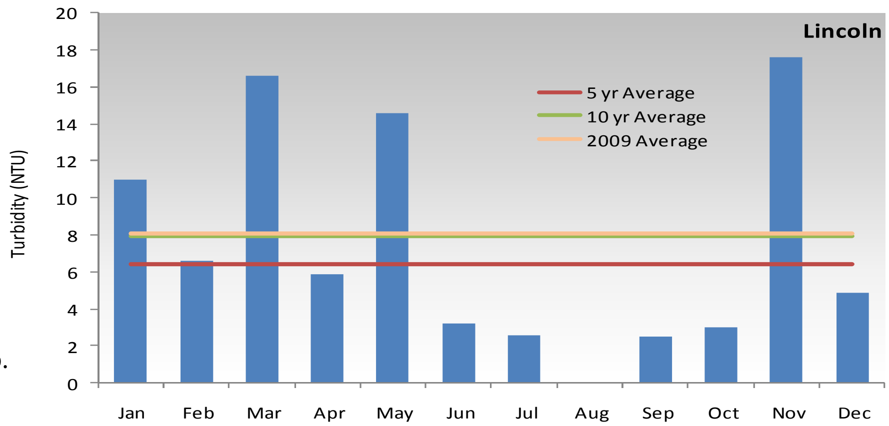


Figures 8.0-15a-d. Monthly turbidity values for Whatcom Creek Sampling sites in 2009. Presented with yearly, 5-year and 10-year averages.

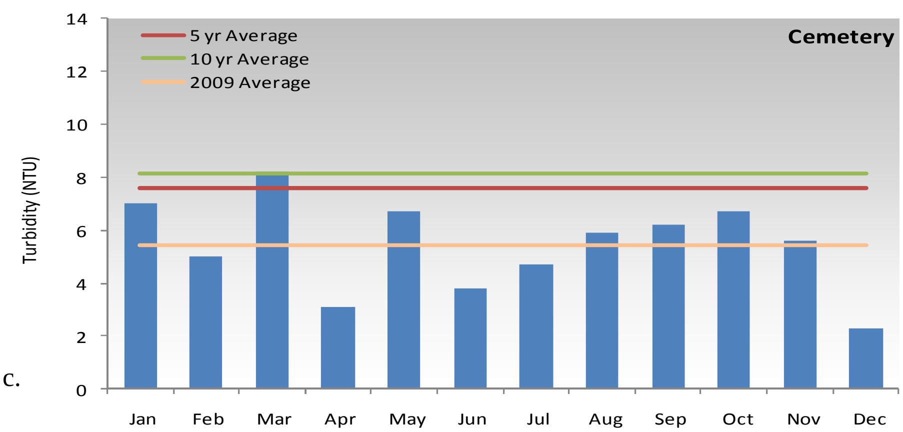
a.



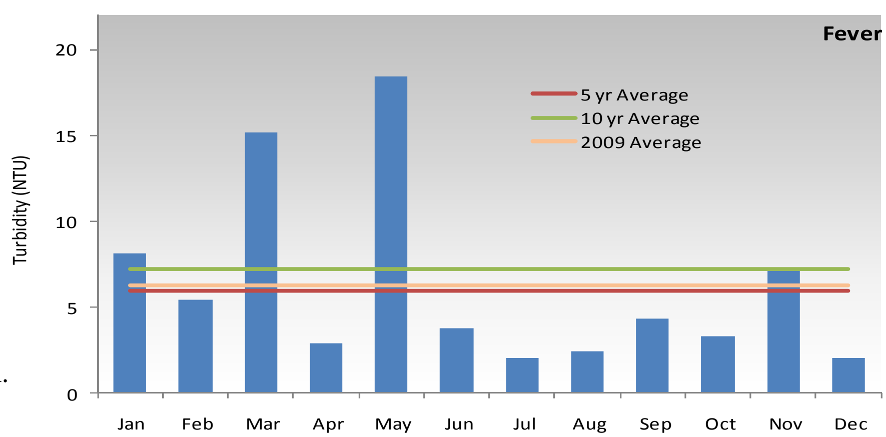
b.



c.



d.



Figures 8.0-16a-d. Monthly turbidity values for Whatcom Creek tributaries in 2009. Presented with yearly, 5-year and 10-year averages.

9.0 Squalicum Creek Drainage Basin

Squalicum Creek runs almost 10 miles from Squalicum and Toad Lakes to Bellingham Bay and has a drainage area of approximately 15,800 acres (City of Bellingham, 1992). It flows through agricultural and wooded land as well as industrial, commercial, and residential areas. Channel modification including large culverts and channelization are present on Squalicum Creek.

Figure 9.0-1. Squalicum Creek mouth sampling

The major contributor to Squalicum Creek is Baker Creek (also known as Spring Creek), which has a drainage area of approximately 3,150 acres (City of Bellingham, 1995). Baker Creek flows through agricultural, wooded, industrial, commercial, and residential areas.

Squalicum Creek is sampled at three locations: at E. Bakerview Rd. (Figure 9.0-2) near the intersection of Hannegan Rd. and E. Bakerview Rd., in Cornwall Park near Meridian St. (Figure 9.0-5), and the mouth (Figure 9.0-1), approximately 1200 feet upstream from its discharge point into Bellingham Bay (Squalicum Creek Drainage Map). Baker Creek (Figure 9.0-8), Squalicum Creek's major tributary, is sampled just upstream from its confluence with Squalicum Creek at Squalicum Pky. (Squalicum Creek Drainage Map). Table 9.0-1 shows the number of samples taken at each sampling location by year.

In 2009 all of the sites in the Squalicum Creek drainage except the Meridian St. site met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) criteria for temperature (≤16℃) and pH (6.5 to 8.5). However, none of the sites met the ≥ 9.5 mg/L dissolved oxygen ALU measure. The E. Bakerview and Meridian sites on Squalicum Creek met Primary Contact Recreational Use standards for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml). The Recreational Use standards are equivalent to a Class A rating.

Due mostly to the above fecal coliform standards, Squalicum Creek at Merid-

Table 9.0-1. Number of samples* taken per year for Squalicum and Baker Creeks from 2000 to 2009.

Sampling Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E. Bakerview	4	8	12	12	12	12	12	12	12	12
Meridian	4	8	12	12	12	12	12	12	12	12
Baker Creek	4	8	12	12	12	12	12	12	12	12
Mouth	4	8	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

Figure 9.0-2. Squalicum Creek sampling site at E. Bakerview Rd.

ian St. was the only site in the Squalicum Creek drainage to achieve the overall Class A designation for 2009. The E. Bakerview site was the only other site to meet either Class A or B fecal coliform standards. All sites did however meet the Class AA criterion for temperature (≤16°C) and the Class AA/Class A/Class B standards for pH (6.5 to 8.5). In addition, all sites but the E. Bakerview site met the Class A standard for dissolved oxygen (≥ 8.0 mg/L). The E. Bakerview Rd. did not meet Class A or Class B (≥ 6.5 mg/L) criteria.

The average turbidites for Squalicum and Baker Creek sites in 2009 were slightly higher than averages in 2008. The highest average turbidity on Squalicum Creek was 9.7 NTU at the Meridian site. The lowest average turbidity was 6.0 NTU on Baker Creek. Average turbidity values for 2009 are listed along side respective 5 and 10 year averages in Table 9.0-5. Conductivity was consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels for 2009 in the upper reaches of Squalicum Creek were somewhat lower than values found in previous years, while values at the Mouth were higher. Fecal Coliform values in Baker Creek were not appreciably different from previous years (Figures 9.0-3, 9.0-4). Fecal coliforms at all sites show the expected trend of higher concentrations in the warmer summer months. Higher values found in March and November correlate with significant rain events. The percent of samples from Squalicum and Baker Creeks with fecal coliform levels higher than 200 CFU/100 ml for 2000 to 2009 is presented in Figure 9.0-4 The geomean values are provided in Table 9.0-2.

Table 9.0-2. Fecal coliform geomean values for sampling sites on Squalicum and Baker Creek, 2009.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Geomean (CFU/100ml)	56	24	168	107

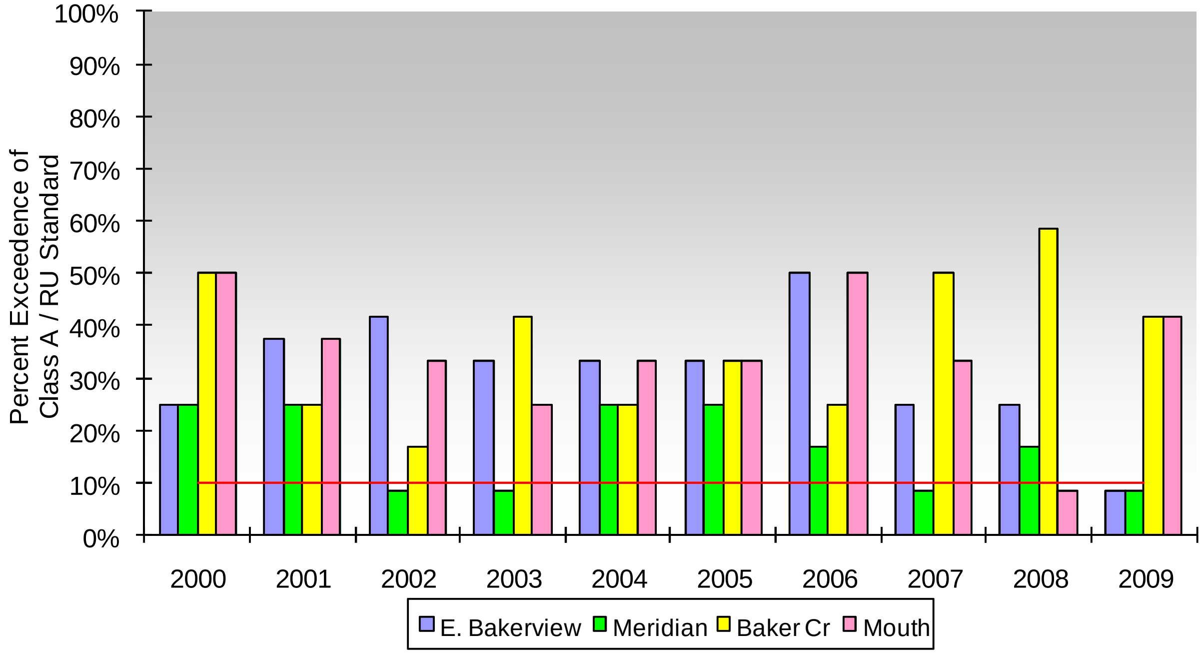


Figure 9.0-3. Monthly 2009 fecal coliform levels for sampling sites on Squalicum and Baker Creeks. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

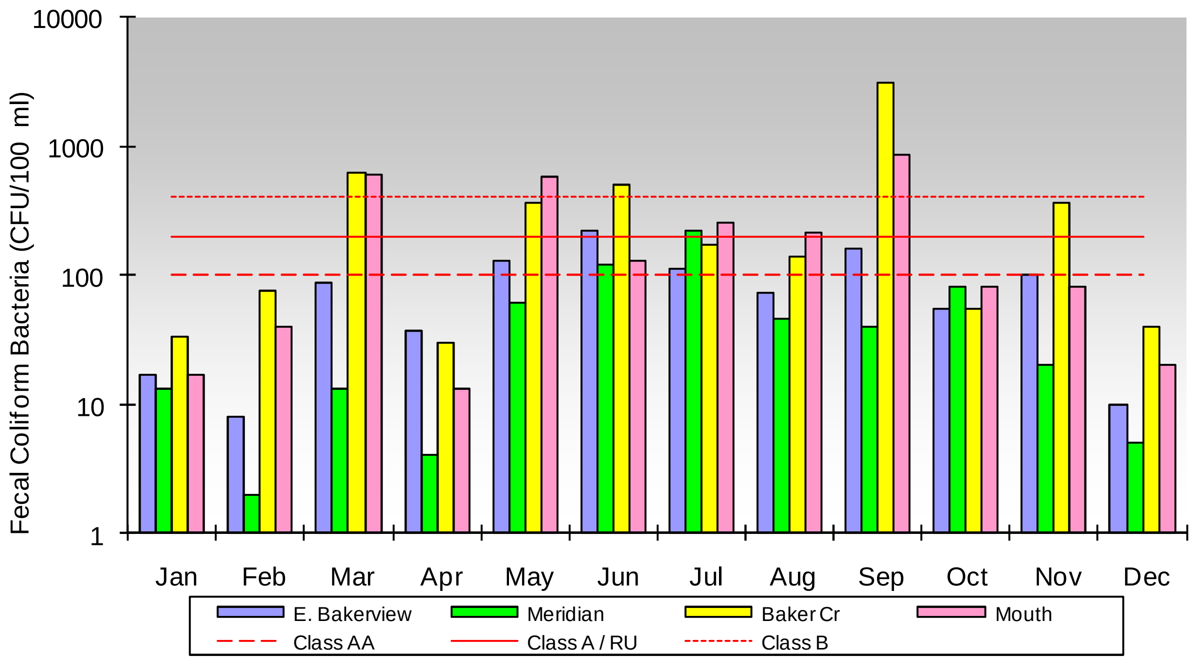


Figure 9.0-4 Percent exceedence of the Class A / RU standard for fecal coliform bacteria by year for Squalicum and Baker Creek sampling sites, 2000 to 2009. Gaps represent a 0% exceedence rate.

Dissolved Oxygen

None of the stream segments in the Squalicum Creek drainage met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard in 2009. At ≥9.5 mg/L, the ALU is equivalent to Class AA.

Squalicum Creek at Meridian St., the Mouth and Baker Creek all met the Class A standard for dissolved oxygen (≥ 8.0 mg/L) in 2009. Squalicum Creek at E. Bakerview Rd. did not meet Class A or Class B standards. Dissolved oxygen at this site was below 6.5 mg/L during July and August of 2009. The E. Bakerview sampling site has frequently experienced low dissolved oxygen levels in previous years, most likely due to low flows in the summer months. The other sampling sites have also had periodic low dissolved oxygen measurements (Figure 9.0-7). Dissolved oxygen in all creek segments sampled in 2009 followed an expected trend of lower values in the warmer summer months (Figure 9.0-6). Average dissolved oxygen values are shown in Table 9.0-3.

Figure 9.0-5. Squalicum Creek sampling site at Meridian St.

Table 9.0-3. Average dissolved oxygen values for Squalicum and Baker Creek in 2009.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Average DO (mg/L)	9.8	10.7	11.4	11.0

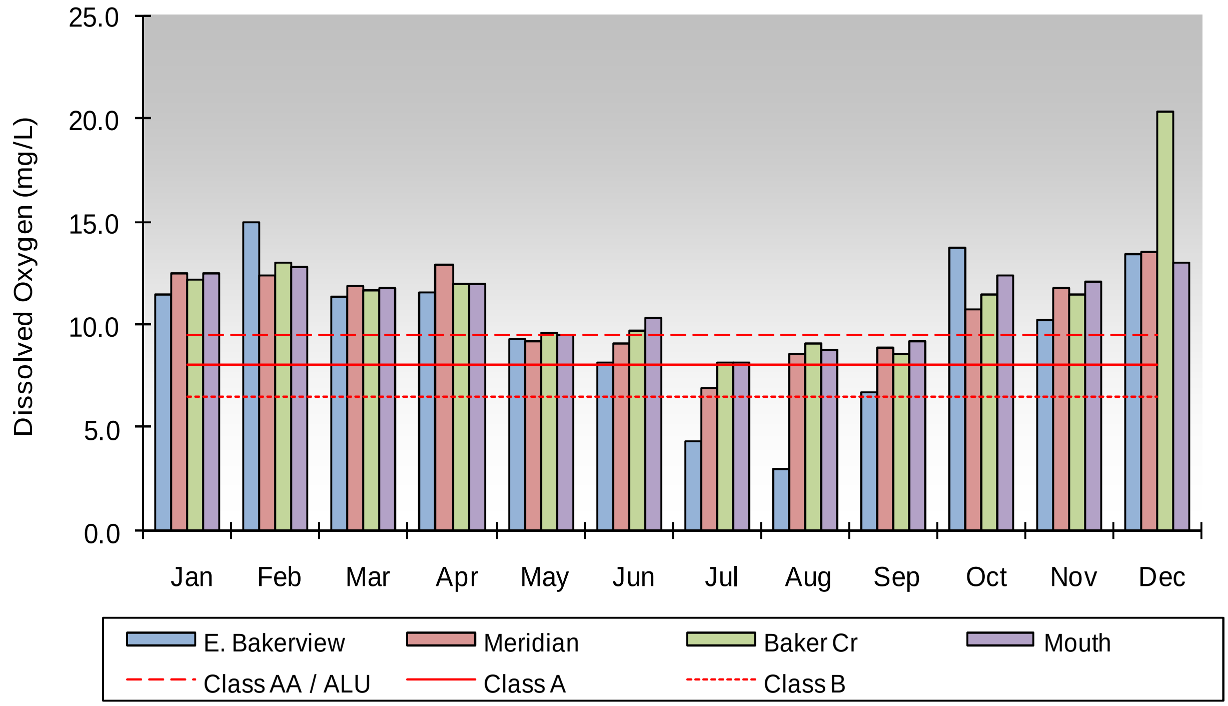


Figure 9.0-6. Monthly 2009 dissolved oxygen levels for Squalicum and Baker Creek sampling sites. Red lines the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

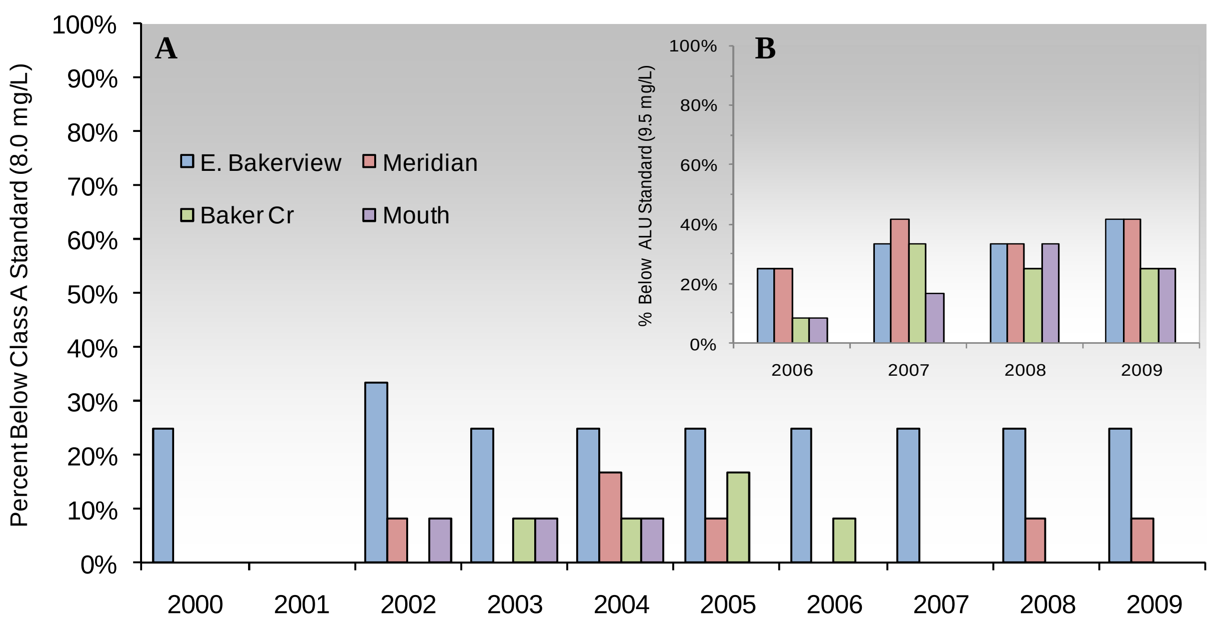


Figure 9.0-7. A. Percent of samples with dissolved oxygen levels below the Class A standard (8.0 mg/L) at Squalicum and Baker Creek sampling sites 2000 to 2009. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2009. Gaps represent a 0% rate of samples with dissolved oxygen values below standards.

Temperature

Temperatures in Squalicum and Baker Creeks remained below the stringent 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation for all but the Meridian St. site in 2009. The Core Summer Salmonid Habitat ALU is equivalent to the Class AA rating. The Meridian St. site obtained the Class A (18° C) designation. Temperatures above 18°C have not been recorded in these creeks since 1998. The percent of samples exceeding the 16°C ALU designation from 2006 to 2009 are presented in Figure 9.0-10.

The expected seasonal trend of higher temperatures in the warmer summer months, lower temperatures in the winter months is apparent for the 2009 data (Figure 9.0-9). Average temperatures for 2009 are provided in Table 9.0-4.

Table 9.0-4. Average temperatures for sampling sites on Squalicum and Baker Creeks, 2009.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Average Temperature (°C)	10.3	10.9	10.2	10.6

Figure 9.0-8. Baker Creek sampling site.

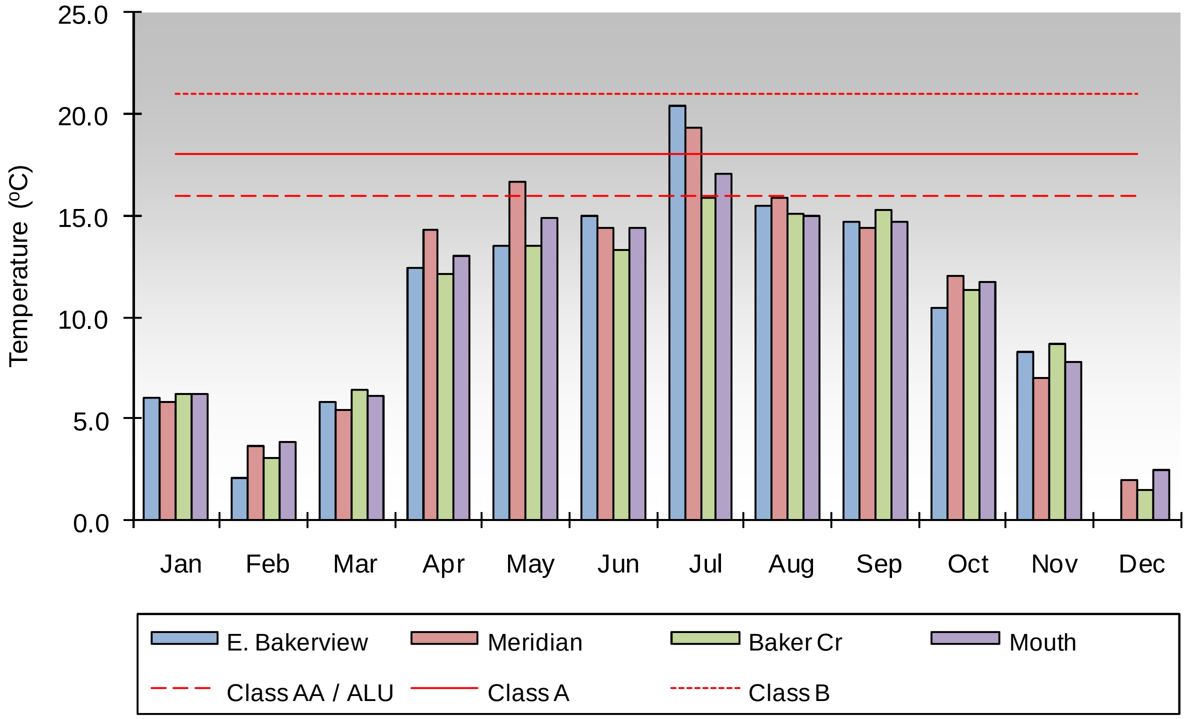


Figure 9.0-9. Monthly temperature measurements for Squalicum and Baker Creek sampling sites in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

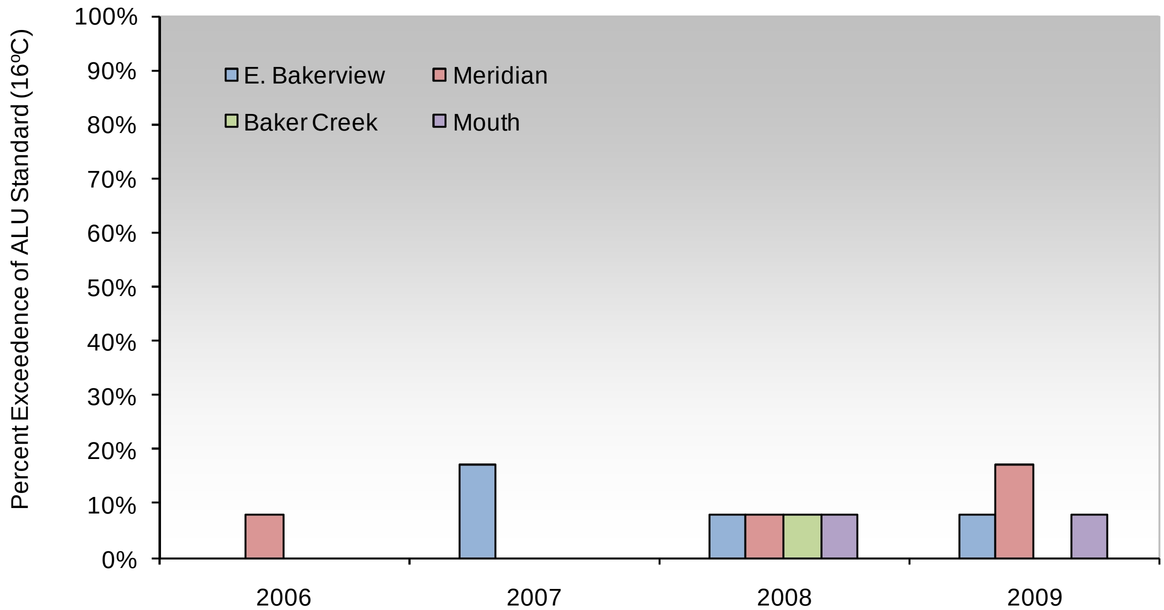


Figure 9.0-10. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16℃) for Squalicu m and Baker Creek sampling sites 2006 to 2009. Until 2009, there had been no exceedences of the 18°C Class A standard since 1998. Gaps represent a 0% exceedence rate.

pH

The pH at sites monitored on Squalicum and Baker Creeks generally fall within the range prescribed by Ecology for all classes of freshwater bodies, 6.5 to 8.5. During 2009 all Squalicum and Baker Creek sites were once again within this standard. Graphs are not included in this section because pH is so rarely exceeded.

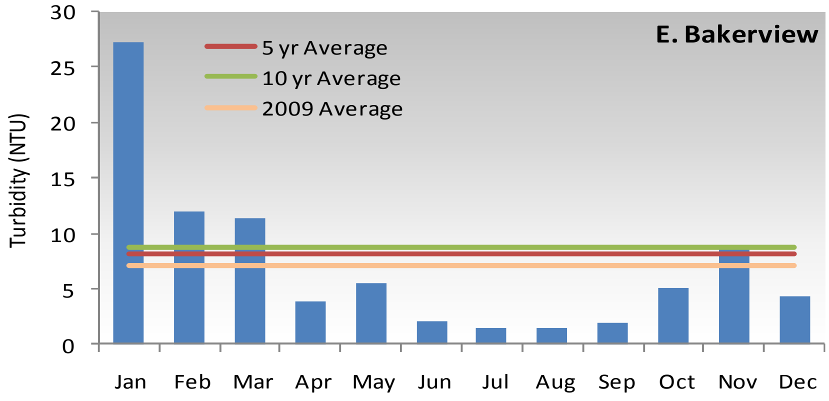
Turbidity

In 2009, the average turbidities of the sampling sites on Squalicum and Baker Creeks were higher than averages in 2008. The Squalicum Creek sites at Meridian and at the Mouth both show increasing 10-year turbidity trends (0.30 NTU/Year and 0.16 NTU/Year respectively). Squalicum Creek at E. Bakerview and Baker Creek had decreasing 10-year turbidity trends at 0.33 NTU/Year and 0.07 NTU/Year respectively.

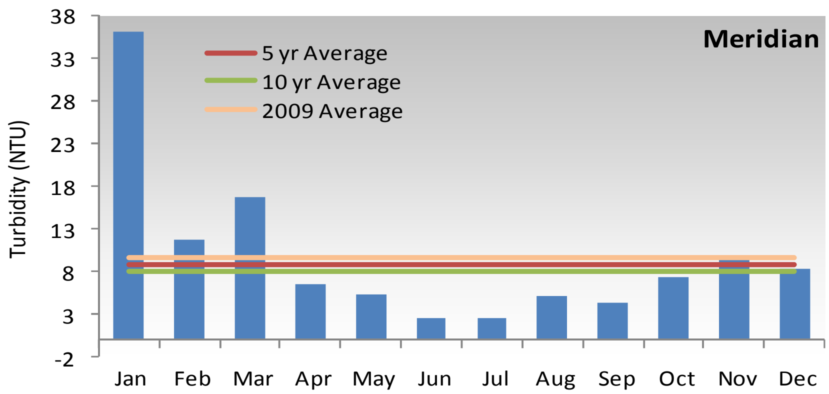
In 2009 the turbidity levels in Squalicum and Baker Creeks show the typical trend of lower values in the drier months and higher values during the wet season (Figures 9.0-11 a-d). Higher turbidity values in January, March and May correlate with significant rainfall events. The reason for high level during July on Baker Creek are unknown. Average, maximum and minimum turbidity values for 2009 is provided in Table 9.0-5.

Table 9.0-5. The average, maximum and minimum turbidity values for Squalicum and Baker Creek sampling sites in 2009 .

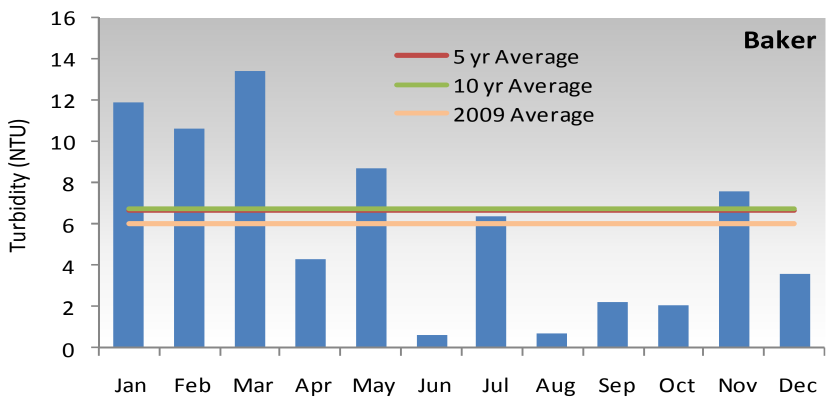
Sampling Site	E. Bakerview	Meridian	Baker	Mouth
2008 Average (NTU)	7.1	9.7	6.0	7.9
2008 Maximum (NTU)	27.2	36.1	13.4	30.0
2008 Minimum (NTU)	1.4	2.6	0.6	1.1



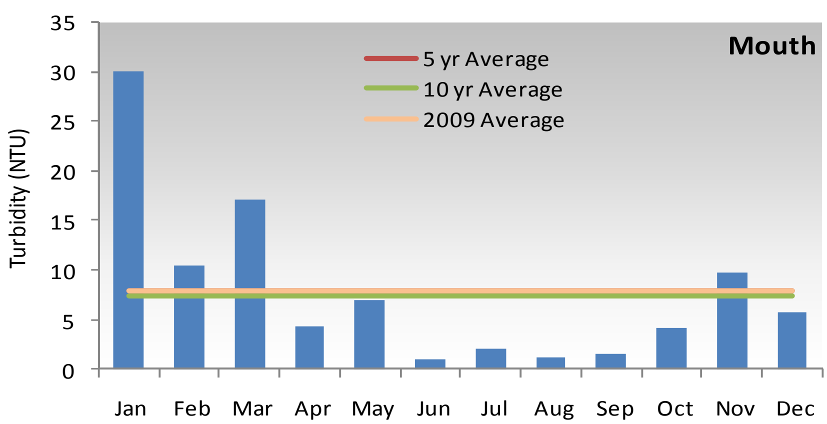
a.



b.



c.



d.

Figure 9.0-11a-d. Monthly turbidity values for Squalicum and Baker Creeks in 2009. Presented with yearly, 5-year and 10-year averages.

10.0 Silver Creek Drainage Basin

Silver Creek is a largely rural creek with a drainage basin of approximately 10,240 acres (Whatcom County Council of Governments, 1989). The eastern portion of the creek flows through gently rolling hills and contains several wetlands and small ponds. The lower two miles of Silver Creek is considered a yazoo tributary of the Nooksack River. A yazoo tributary is a tributary that is prevented from joining the main river because of levees, thus flow is parallel to the main channel.

Figure 10.0-1. Silver Creek sampling site at Graveline Road.

Silver Creek is sampled at one location upstream from the yazoo portion of the creek at Graveline Road (Figure 10.0-1). Sampling began at this site in 2004. The Graveline Rd. site is characterized by wooded areas and farmland. Table 10.0-1 shows the number of samples taken at the Graveline Road site from 2004 to 2009. Sampling at two previous sites on Silver Creek was suspended in recent years because the sites failed to provide results representative of the creek system.

In 2009, only the temperature (≤16.0° C) and pH (6.5 - 8.5) designated use criteria were met for Silver Creek. Silver Creek also failed to achieve overall Class A designation, as was the case for previous years. Dissolved oxygen in this segment met Class A levels of ≥ 8.0 mg/L, temperatures remained below the stringent ≤16.0℃ Class AA/ALU standard, and pH was also maintained at Class AA/A/B levels (6.5 to 8.5). However, the stream segment failed to meet Class A / Primary Contact Recreational Use standards for fecal coliform bacteria. The geomean value was higher than 100 CFU/100 ml and more than 10% of the samples had values in excess of 200 CFU/100 ml. Silver Creek also failed to meet Class B standards for fecal coliforms.

The average turbidity of 5.7 NTU for Silver Creek in 2009 was below the respective 5 year and 10 year averages. The 10-year trend is also decreasing at 0.28 NTU/Year. Conductivity was consistent with previous years.

Table 10.0-1. Number of samples taken per year for Silver Creek from 2004 to 2009.

2004	2005	2006	2007	2008	2009
12	12	12	12	12	12

Fecal Coliform Bacteria

The number of fecal coliforms found at the Graveline Rd. site in 2009 were less than the numbers found in 2008 (Figure 10.0-2, 10.0-3). However, Fecal Coliform levels still far exceeded Primary Contact Recreational Use and Class A standards (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml). The high levels of Fecal Coliform present at this site is likely due to the many pasture fields in the area. The bacteria levels show the expected trend of higher values in the summer months possibly as warmer temperatures allow extended survival or growth of bacteria populations. The geomean value for the site in 2009 was 272 CFU/100ml.

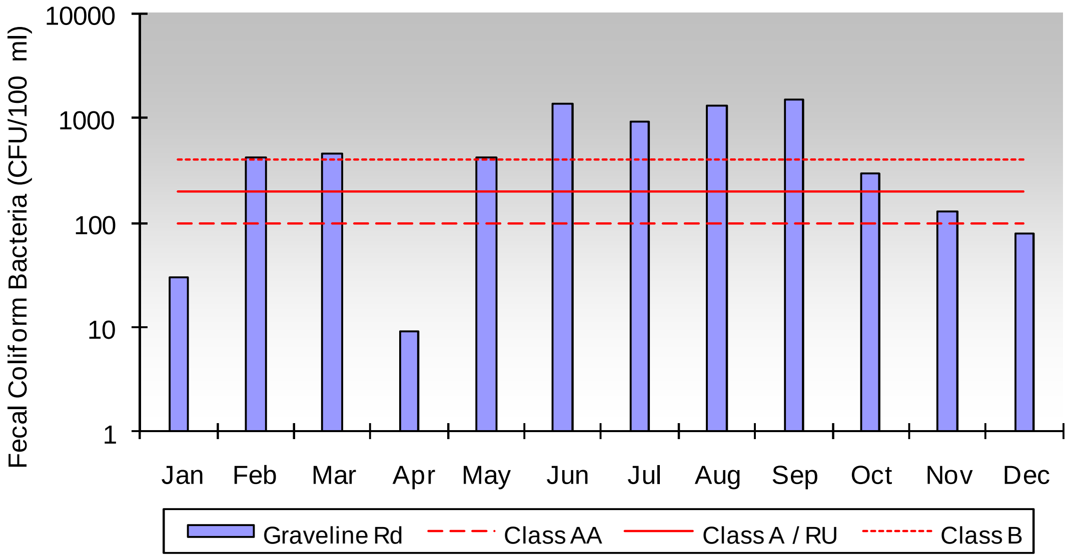


Figure 10.0-2. Monthly 2009 fecal coliform levels for Silver Creek. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

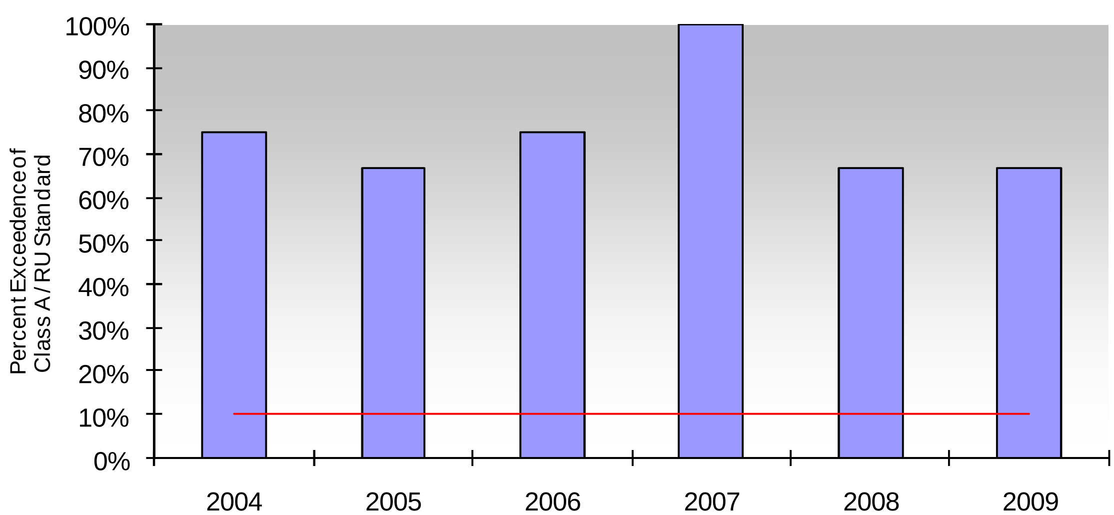


Figure 10.0-3. Percent exceedence of the Class A / RU standard for fecal coliform bacteria by year for Silver Creek, 2004 to 2009.

Dissolved Oxygen

Dissolved oxygen levels in Silver Creek for 2009 followed the general trend of lower values in the warmer months as ambient air temperatures increased (Figure 10.0-4). Silver Creek was not able to meet the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard of ≥9.5 mg/L, however, levels above 8.0 mg/L (Class A) were maintained throughout the year (Figures 10.0-4 & 10.0-5). The average dissolved oxygen for Silver Creek was 11.3 mg/L.

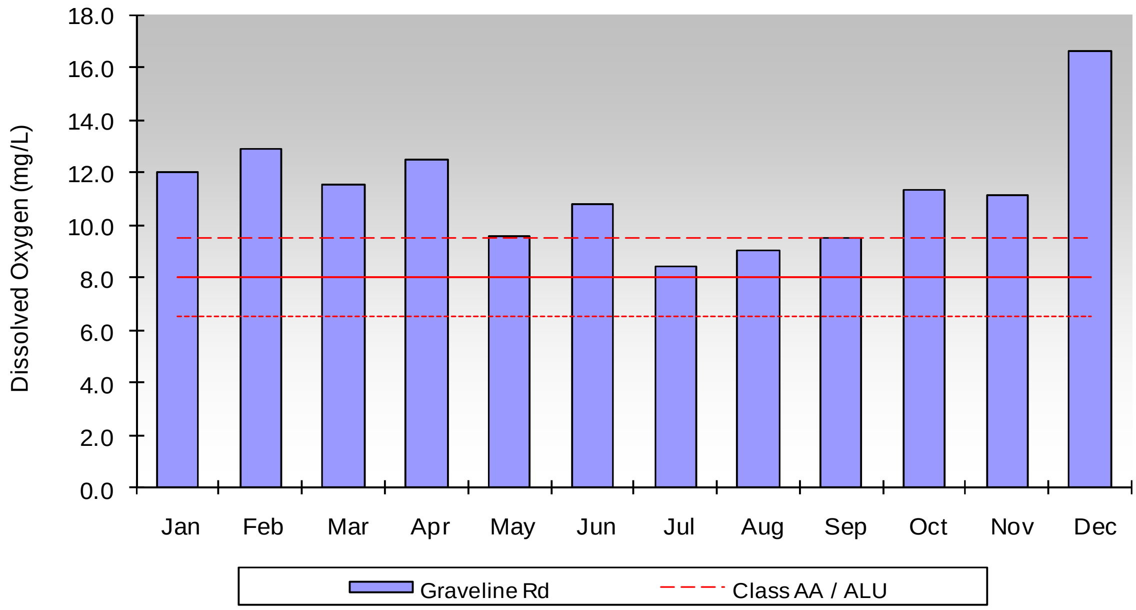


Figure 10.0-4. Monthly 2009 dissolved oxygen levels for Silver Creek at Graveline Rd. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

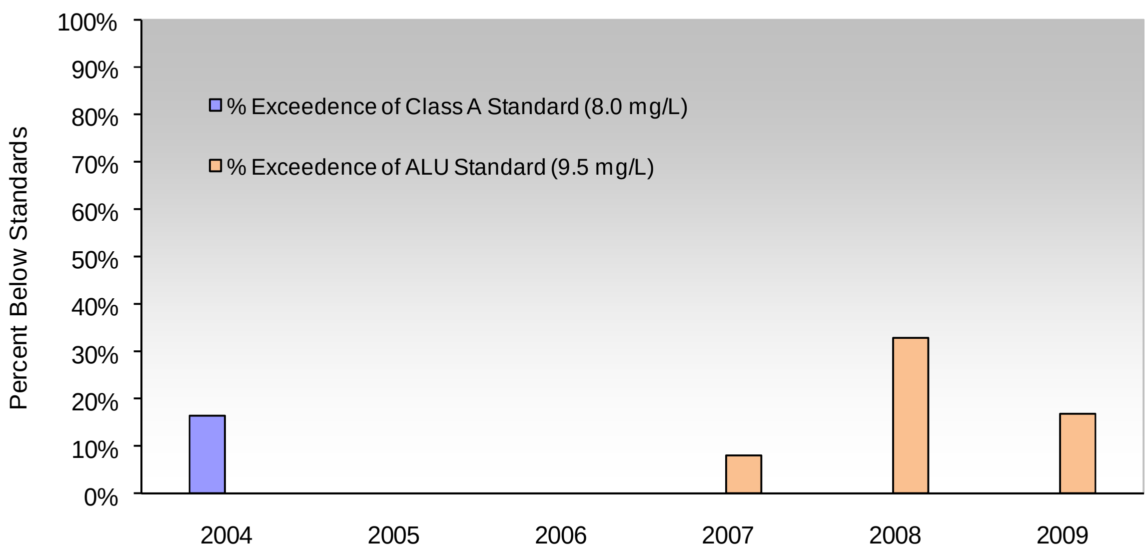


Figure 10.0-5. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Silver Creek sampling site 2004 to 2009 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006.

Temperature

Since sampling began at the Graveline Rd. site in 2004, temperatures in Silver Creek have remained below the 18°C Class A standard. Most years it has also been below the Class AA / Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard. This trend continued in 2009, when Silver Creek met the 16°C Core Summer Salmonid Habitat ALU and Class AA standard.

The average temperature for Silver Creek in 2009 was 10.6 °C and the temperature profile follows a typical trend of higher values in the warmer months (Figure 10.0-6).

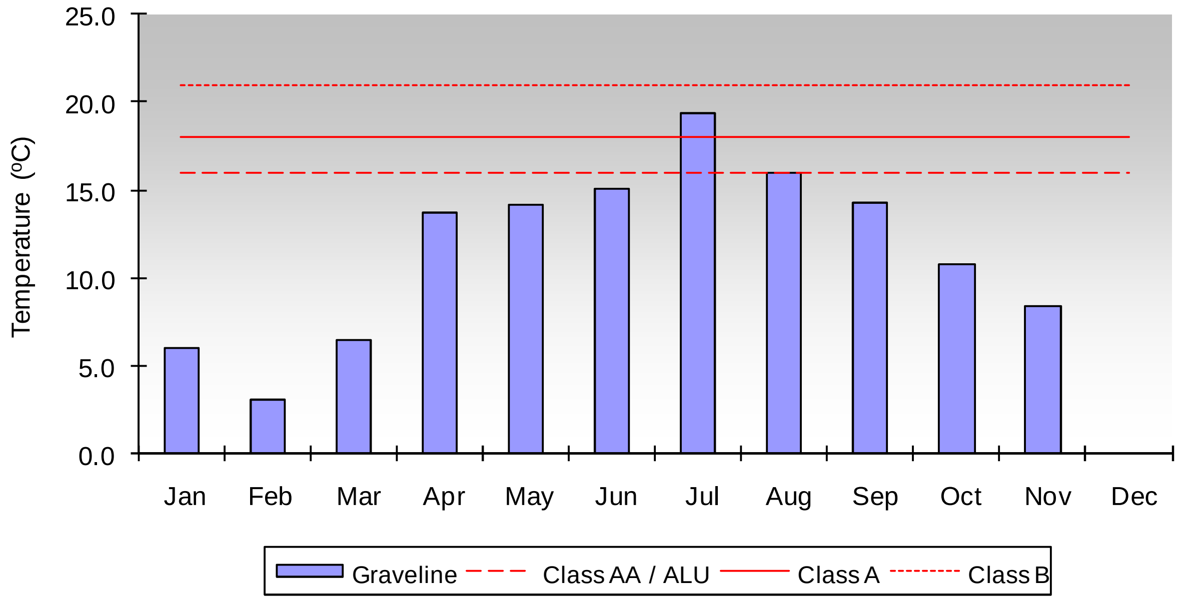


Figure 10.0-6. Monthly temperature measurements for Silver Creek in 2009. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard is equivalent to Class AA.

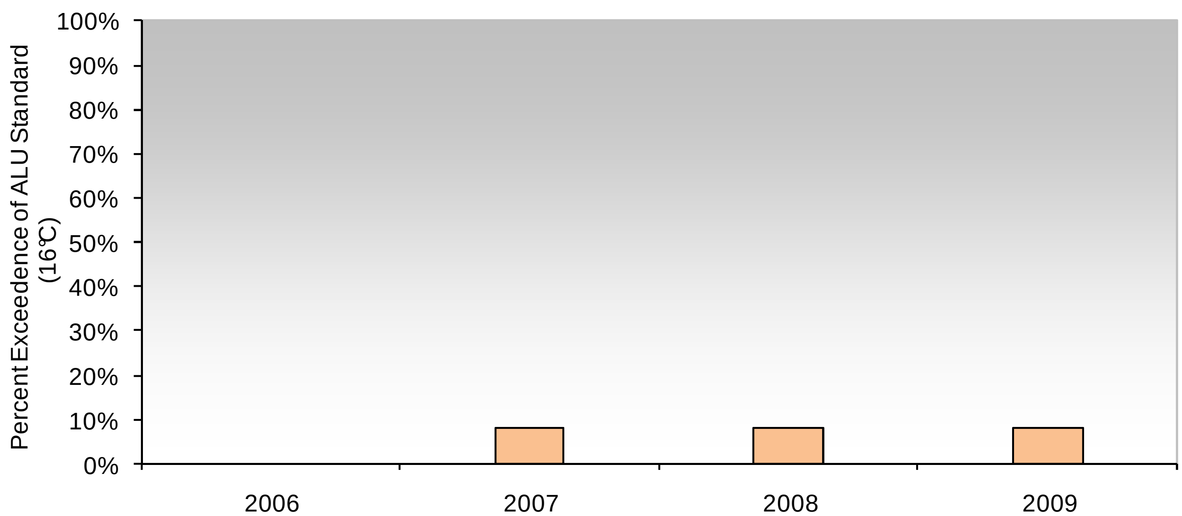


Figure 10.0-7. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16°C) for Silver Creek sampling sites 2006 to 2009. There have been no exceedences of the 18°C Class A standard since sampling began in 2004. Gaps represent 0% exceedence.

Turbidity

The average turbidity for Silver Creek in 2009 was 5.7 NTU, well below the 5 and 10 year averages. The maximum turbidity of 16.6 NTU was recorded in January and correlates with a rain event. The minimum turbidity of 2.4 NTU was recorded in July during the dry season (Figure 10.0-7). The 10-year average turbidity trend for Silver Creek was decreasing by 0.28 NTU/Year in 2009.

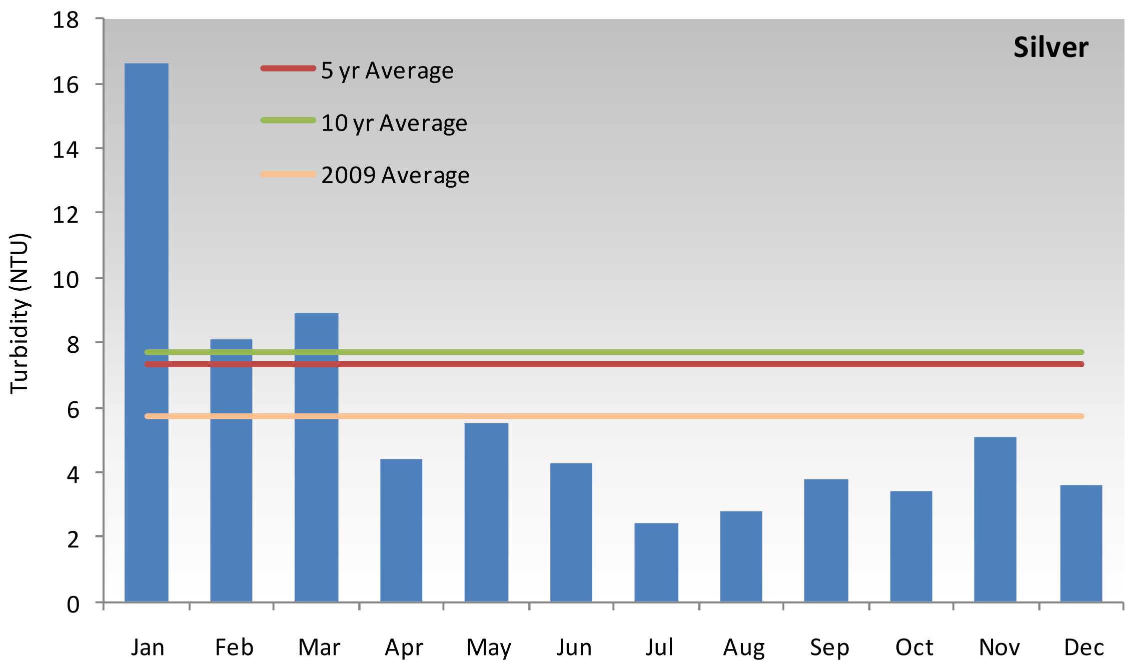


Figure 10.0-7. Monthly turbidity values for Silver Creek in 2009. Presented with the yearly, 5-year and 10-year averages.

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Appendix A.

Detail on selected stream restoration projects within the City of Bellingham. LWD = Large Woody Debris

Creek	Location	Project	Year
Padden	24th St.	Installation of fish friendly culvert	1996
Padden	24th St. to 30th St.	Riparian planting and restoration	2003 on
Padden	24th St. to 30th St.	Placement of LWD Recontour banks Reconnect to historic flood plain Add spawning gravel Create overflow channel	2008/ 2009
Padden	Fairhaven Park	Riparian planting and restoration Move trail away from stream bank	2005/ 2006
Padden	Fairhaven Park	Placement of LWD Recontour banks Reconnect to historic flood plain Add spawning gravel	2008/ 2009
Padden	12th St.	Culvert Improvements: Replace baffles Structures to prevent fish from becoming trapped during high flows	2004
Connelly	Donovan Ave.	Installation of fish passable culvert	2004
Whatcom	Marine Heritage Park	Riparian planting and restoration	1995
Whatcom	Whatcom Falls Park to Mouth	Riparian planting and restoration (some small sections not yet planted)	2000 on
Whatcom	North of Cemetery Creek, East of Racine St.	Salmon Park: Placement of LWD Create backwater swales and a side channel: velocity refuge for fish Breached a constructed berm to reconnect to historic flood plain, creating more natural stream flow	2006
Whatcom	City owned property north of Haskell Business Park	Red Tail Reach: Similar projects to Salmon Park	2007/ 2008
Whatcom	Young St. & Commercial	Culvert Improvements: Replace baffles Work on upstream end to improve fish movement	2004
Cemetery	City owned property east of Haskell Business Park, north of Fraser St.	New creek channel created to mimic an undisturbed stream system Placement of LWD Recontour banks Create three large ponds—velocity refuge and overwintering habitat for juvenile fish	2006
Cemetery	Upstream of confluence with Whatcom Creek	Create Backwater swale—velocity refuge for fish Reconnect to historic flood plain	2006

Creek	Location	Project	Year
Lincoln	Maple St.	Installation of fish friendly culvert	1991
Lincoln	Moore St.	Installation of fish friendly culvert	1998
Squalicum	Meridian St.	Installation of fish friendly culvert	1996/1997
Squalicum	Meridian St. to Mouth	Riparian planting and restoration	2005 on
Squalicum	West St. to Mouth	Lower Squalicum Bank Protection Project: Log jams Log crib wall Root wads Create overflow channel	2005
Squalicum	Squalicum Pkwy.	Retrofit all Culverts: Fish friendly Install baffles Create upstream/downstream pools - fish resting areas	2005
Squalicum	Birchwood Ave. & Squalicum Pkwy	Retrofit culvert to force water from subsurface flow during low flow periods into pipe	2004
Baker	Birchwood Ave.	Installation of fish friendly culvert	1996
Baker	Telegraph Rd.	Riparian planting and restoration Create backwater swale—velocity refuge Recontour banks Reconnect to historic flood plain	2006
Baker	Telegraph Rd.	Installation of fish friendly culvert	2004

Appendix B

YEAR 2008

Quality Control Protocol

Test	Fecal Coliform	Dissolved Oxygen	Temperature	pH	Turbidity	Conductivity
Holding Time	Within 8 hrs	*In situ* analysis	*In situ* analysis	*In situ* analysis	Usually done within 8 hr. Up to 24 hr.	*In situ* analysis
Method	SM 9222 D.	SM 4500-O G.	SM 2550 B.	SM 4500-H^+ B.	SM 2130 B.	SM 2510 B.
Instrumentation		Hydrolab Quanta	Hydrolab Quanta	Hydrolab Quanta	Benchtop Turbidimeter	Hydrolab Quanta
Calibration		Barametric pressure calibration in air.	Factory -set. Annually calibrated against an NIST-traceable thermometer.	Buffers: pH 7.00 and 10.00.	Calibrate with primary standards—1, 10, 100, 1000 NTU standards.	Conductivity standard obtained from an external source. Cell coefficient should be 0.475 +/- 1%, if not, investigate.
Check Standard or Calibration Check		Calibration check-test one sample by Quanta (STM 4500-O G.) and one by Winkler Method (STM 4500-O C). Both samples from same sample site.		Check standard obtained from an external source. Test before and after run.	Calibration check – primary or secondary standard in the range of interest.	In-house conductivity standard, prepared quarterly. Test before and after run.
QC Objectives	Verification of 10% of samples and adjustment of counts based on verification results. Investigate if natural log of lab or field duplicates are different by more than $\pm 2\delta$ of calculated control limits.	Investigate if calibration check is different by 0.5 mg/L or more or if field duplicates are different by more than $\pm 2\delta$ of calculated control limits.	Add or subtract correction factor as necessary. Investigate if field duplicates are different more than $\pm 2\delta$ of calculated control limits.	Investigate if check standard is different by 0.2 pH units or more or if field duplicates are different by more than $\pm 2\delta$ of calculated control limits.	Investigate if lab or field duplicates are different by more than $\pm 2\delta$ of calculated control limits.	Investigate if check standard are different by more than 10% or if field duplicates are different by more than $\pm 2\delta$ of calculated control limits.

Appendix C. Exceedence Frequency Tables

Table C-1. Frequency of Class A surface water standard exceedences for fecal coliform bacteria. Class A surface water standards state that no more than 10% of samples used to calculate the geomean may exceed 200 cfu/100 ml. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	4	1	8	2	12	5	12	4	12	3	12	2	12	2	12	2	12	3	12	24	108	22%
Padden (38th)	0	4	1	8	0	12	2	12	2	12	1	12	0	12	0	12	2	12	1	12	9	108	8%
Padden (30th)	0	4	0	8	1	12	4	12	4	12	4	12	3	12	3	12	2	12	2	12	23	108	21%
Connelly (Donovan)	2	4	6	8	8	12	5	12	9	12	6	12	7	12	6	12	5	12	4	12	58	108	54%
Padden (22nd)											7	12	6	12	7	12	3	12	4	12	27	60	45%
Padden (mouth)	0	4	6	8	6	12	6	12	6	12	5	12	7	12	5	12	2	12	6	12	49	108	45%
Whatcom (Control Dam)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	108	0%
Hanna (Below WTP)					1	9	2	10	4	12	2	10	4	11	2	12	3	12	2	12	20	88	23%
Cemetery (Whatcom)	2	4	5	8	6	12	5	12	5	12	7	12	7	12	4	12	3	12	3	12	47	108	44%
Lincoln (Fraser)	1	4	5	8	6	12	6	12	3	12	3	12	5	12	2	12	3	12	6	12	40	108	37%
Fever (Valencia)	4	4	3	8	5	12	3	12	7	11	5	12	10	12	6	12	6	12	7	12	56	107	52%
Whatcom (Valencia)													0	4	0	12	0	12	1	12	1	40	3%
Whatcom (I-5)	0	4	1	8	1	12	1	12	2	12	2	12	1	12	0	12	1	12	2	12	11	108	10%
Whatcom (Dupont)	1	4	4	8	2	12	3	12	5	12	4	12	3	12	2	12	2	12	5	12	31	108	29%
Squalicum (E Bakerview)	1	4	3	8	5	12	4	12	4	12	4	12	6	12	3	12	3	12	1	12	34	108	31%
Squalicum (Meridian)	1	4	2	8	1	12	1	12	3	12	3	12	2	12	1	12	2	12	1	12	17	108	16%
Baker (Squalicum)	2	4	2	8	2	12	5	12	3	12	4	12	3	12	6	12	7	12	5	12	39	108	36%
Squalicum (mouth)	2	4	3	8	4	12	3	12	4	12	4	12	6	12	4	12	1	12	5	12	36	108	33%
Silver (Graveline Rd)									9	12	8	12	9	12	12	12	8	12	8	12	54	72	75%

Table C-2. Frequency of Class A surface water standard exceedences for dissolved oxygen. Class A surface waters must maintain dissolved oxygen levels of 8.0 mg/L or greater. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	4	0	8	0	12	1	12	0	12	0	12	0	12	0	12	0	12	0	12	1	108	1%
Padden (38th)	0	4	0	8	0	12	0	12	1	12	0	12	0	12	0	12	1	12	1	12	3	108	3%
Padden (30th)	0	4	0	8	0	12	1	12	1	12	0	12	0	12	0	12	0	12	0	12	2	108	2%
Connelly (Donovan)	1	4	1	8	0	12	1	12	1	12	0	12	0	12	0	12	0	12	1	12	5	108	5%
Padden (22nd)											0	12	0	12	0	12	0	12	0	12	0	60	0%
Padden (mouth)	0	4	0	8	0	12	0	12	2	12	0	12	0	12	0	12	0	12	2	12	4	108	4%
Whatcom (Control Dam)	0	4	1	8	0	12	1	12	2	12	0	12	0	12	0	12	0	12	2	12	6	108	6%
Hanna (Below WTP)					1	9	0	10	1	12	0	10	0	11	0	12	0	12	0	12	2	88	2%
Cemetery (Whatcom)	0	4	2	8	5	12	3	12	3	12	3	12	0	12	4	12	3	12	4	12	27	108	25%
Lincoln (Fraser)	0	4	0	8	4	12	2	12	2	12	2	12	0	12	1	12	3	12	2	12	16	108	15%
Fever (Valencia)	0	4	0	8	0	12	0	12	1	11	1	12	0	12	0	12	1	12	1	12	4	107	4%
Whatcom (Valencia)													0	4	0	12	0	12	0	12	0	40	0%
Whatcom (I-5)	0	4	0	8	0	12	0	12	1	12	0	12	0	12	0	12	0	12	0	12	1	108	1%
Whatcom (Dupont)	0	4	0	8	0	12	0	12	2	12	1	12	0	12	0	12	2	12	2	12	7	108	6%
Squalicum (E Bakerview)	1	4	0	8	4	12	3	12	3	12	3	12	3	12	3	12	3	12	3	12	26	108	24%
Squalicum (Meridian)	0	4	0	8	1	12	0	12	2	12	1	12	0	12	0	12	1	12	1	12	6	108	6%
Baker (Squalicum)	0	4	0	8	0	12	1	12	1	12	2	12	1	12	0	12	0	12	0	12	5	108	5%
Squalicum (mouth)	0	4	0	8	1	12	1	12	1	12	0	12	0	12	0	12	0	12	0	12	3	108	3%
Silver (Graveline Rd)									2	12	0	12	0	12	0	12	0	12	0	12	2	72	3%

Table C-3. Frequency of Class A surface water standard exceedences for temperature. Class A surface waters must maintain temperature ≤ 18℃. Shaded cells indicate the number of exceed ences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		Ttl	Ttl	Percent Exceedence
Chuckanut (mouth)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Padden (38th)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	108	0%
Padden (30th)	0	4	0	8	0	12	1	12	0	12	0	12	0	12	0	12	0	12	1	12	2	108	2%
Connelly (Donovan)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Padden (22nd)											0	12	0	12	0	12	0	12	1	12	1	60	2%
Padden (mouth)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Whatcom (Control Dam)	1	4	2	8	3	12	4	12	3	12	2	12	3	12	2	12	2	12	4	12	26	108	24%
Hanna (Below WTP)					3	9	0	10	0	12	0	10	0	11	0	12	0	12	0	12	3	88	3%
Cemetery (Whatcom)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Lincoln (Fraser)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Fever (Valencia)	0	4	0	8	0	12	0	12	0	11	0	12	0	12	0	12	0	12	1	12	1	107	1%
Whatcom (Valencia)													0	4	2	12	2	12	2	12	6	40	15%
Whatcom (I-5)	1	4	2	8	3	12	2	12	2	12	1	12	1	12	1	12	2	12	2	12	17	108	16%
Whatcom (Dupont)	1	4	2	8	2	12	2	12	2	12	1	12	0	12	1	12	1	12	1	12	13	108	12%
Squalicum (E Bakerview)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Squalicum (Meridian)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	108	1%
Baker (Squalicum)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	108	0%
Squalicum (mouth)	0	4	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	108	0%
Silver (Graveline Rd)									0	12	0	12	0	12	0	12	0	12	1	12	1	72	1%

Table C-4. Frequency of Class A surface water standard exceedences for pH. Class A surface waters must maintain pH levels between 6.5 and 8.5. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Padden (38th)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Padden (30th)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Connelly (Donovan)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Padden (22nd)											0	11	0	12	0	12	0	12	0	12	0	59	0%
Padden (mouth)	0	4	0	8	0	12	0	12	0	12	0	11	1	12	0	12	0	12	0	12	1	107	1%
Whatcom (Control Dam)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Hanna (Below WTP)					0	9	0	10	0	12	0	9	1	11	0	12	0	12	0	12	1	87	1%
Cemetery (Whatcom)	0	4	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	1	107	1%
Lincoln (Fraser)	0	4	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	1	107	1%
Fever (Valencia)	0	4	0	8	0	12	0	12	0	11	0	11	0	12	0	12	0	12	0	12	0	106	0%
Whatcom (Valencia)													0	4	0	12	0	12	0	12	0	40	0%
Whatcom (I-5)	0	4	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	1	107	1%
Whatcom (Dupont)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Squalicum (E Bakerview)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Squalicum (Meridian)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Baker (Squalicum)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Squalicum (mouth)	0	4	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	107	0%
Silver (Graveline Rd)									0	12	0	11	0	12	0	12	0	12	0	12	0	71	0%