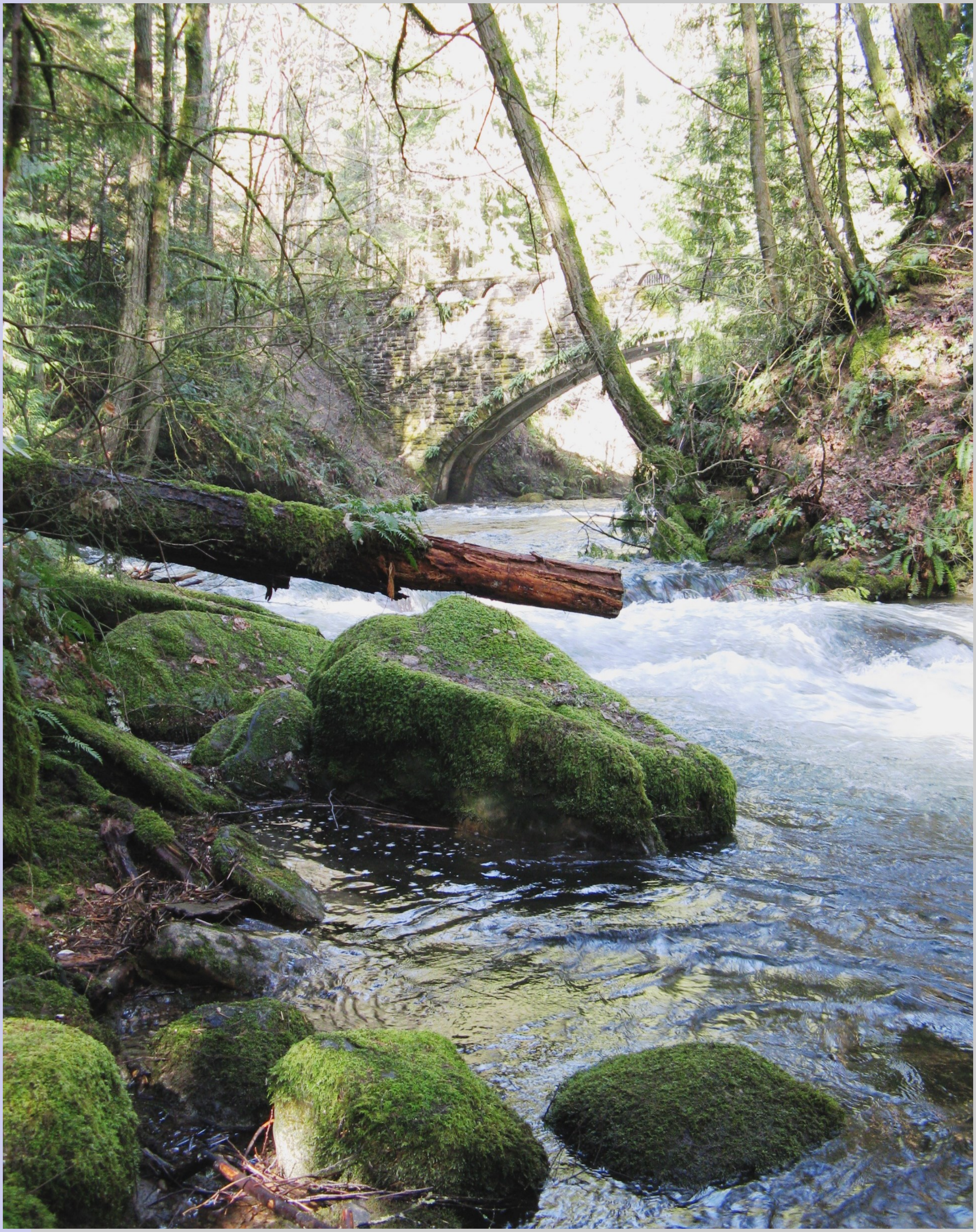
URBAN STREAMS MONITORING PROGRAM REPORT 2013



City of Bellingham
Department of Public Works Laboratory

Preface

This year's Urban Streams Report marks a shift to a more comprehensive analytical view of the data . As in years past, tracking of the individual stream sites ability to meet water quality criteria within the previous calendar year will continue, however, to maximize the utility of the long standing data set, more data will now be analyzed and presented in the context of historical trends. This shift will hopefully allow for better understanding of the overall health of our urban streams, and translate to more informed restoration and stormwater management decisions. As always, special attention will continue to be paid to the causes and effects of outlying occurrences throughout the monitoring period. We hope you find this new format useful.

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Appendices

Executive Summary for 2013

The status of Bellingham's urban streams for the period ending in 2013 is mixed. In line with historical trends, the best overall water quality was recorded at Chuckanut Creek and Padden Creek at 38th St., along with Whatcom Creek at the Valencia and I-5 sites. Three of the Whatcom Tributaries (Cemetery, Lincoln and Fever Creeks) displayed the poorest overall water quality.

Fecal Coliform: As in years past, fecal coliform levels were most often the limiting factor in determining overall classification of the streams. Oddly enough, fecal coliform levels were also the *only* measured parameter to show any significant change over the past 10 years. Decreasing geometric means (geomean) trends were recorded at 13 of the 18 currently monitored sites, while increasing geomeans were recorded at only two. Based on historical values, it could be said that the fecal coliform parameter had the most room for improvement. It is a testament to the City's stormwater management, stream cleanup, and restoration efforts that so much progress has been made.

There is still room for improvement on the fecal coliform front. The three greatest decreases over the past 10 years were seen on Connelly Creek (-20.7 cfu/100 ml/yr), Cemetery Creek (-17.2 cfu/100 ml/yr), and Padden Creek at 22nd (-13.5 cfu/100 ml/yr). Yet, in the 24 years of urban stream sampling, none of these sites have ever qualified for the Aquatic Life Use (ALU)/Class A standard (100 CFU/100 ml, w/ no more than 10% of all samples exceeding 200 CFU/100 ml). Elsewhere, Fever and Lincoln Creeks (+11.1 and + 7.1 cfu/100 ml/yr, respectively), were the only two sites to show significant increases to fecal coliform geomeans over the past 10 years. This suggests that special attention may want to be paid to efforts in these subwatersheds.

Dissolved Oxygen: Bellingham's urban streams rarely qualify for the 9.5 mg/l ALU/Class AA designation for dissolved oxygen, and none of the monitoring sites did so in 2013. Historically, only Chuckanut Creek comes close, being assigned the ALU/Class AA designation five out of the last 10 years. No other site has more than 2 occurrences of reaching the ALU/Class AA designation. Analysis of data over the past 10 years shows no statistically significant change to dissolved oxygen levels at any of the urban streams monitoring locations.

Temperature: Ambient temperatures in 2013 were warmer than usual. According to the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center, summer temperatures in Washington were "much above normal". This resulted in many of the Padden Creek and Whatcom Creek Tributary sites that usually meet the 16°C ALU/Class AA designation failing to in 2013. With the exception of Whatcom Creek sites, all of the urban stream monitoring sites have obtained the ALU/Class AA criteria four or more times over the past 10 years (based on conventional sampling). However, results of enhanced sampling suggest that the actual number of sites remaining below the 16°C threshold is less than currently shown. No statistically significant trends were found in temperature data for 2004-2013.

pH, Conductivity and Turbidity: The pH of Bellingham's urban streams has been consistent, with all sites staying within the ALU/Class AA/B/C range over the past 10-years. Likewise, conductivity has been stable, showing no appreciable differences over the last decade. Turbidity values were varied, with the 2013 average turbidities below the 5 and 10-year averages on Chuckanut Creek and most of the Padden Creek drainage, above the 5 and 10-year averages in the Squalicum drainage, and mixed on Whatcom Creek and its tributaries. No statistically significant trends in turbidity records were found for the past 10 years.

Introduction

The health of urban waterways has become an increasingly prominent and politically charged topic on a national scale. Legislation to protect our aquatic resources has become more stringent and the trickle down effects can be seen in tighter controls on municipal, industrial and construction stormwater permits, an increasing number of clean-up/restoration projects, and an increase in mandated water quality monitoring efforts. Like many other local jurisdictions, improving water quality is now among the top priorities of the City of Bellingham, as witnessed in its Legacies and Strategic Commitments to its citizens.

At 24 years and counting, the City of Bellingham's Urban Stream Monitoring Program (USMP) is one of the longest standing status and trends programs in the region. Maintaining such a robust data set has allowed the City to not only quantify improvements to water quality due to restoration, stormwater treatment and stewardship efforts, but also to win the support of the Washington State Department of Ecology in conducting innovative Total Maximum Daily Load pilot projects (see Sections 1.1 and 2.0).

The City of Bellingham (City) recognizes that urban activities impact streams and is working to understand and minimize these impacts through a variety of water quality improvement programs. These programs include stream clean-up, restoration, hydrological gauging, stormwater treatment, illicit discharge elimination, water quality monitoring, public education and ordinances that protect critical areas.

This report describes many of the current efforts of the City to improve water quality in its jurisdiction, and updates the on-going water quality monitoring results with data from 2013. Section 1.0 details the listed status of urban streams within the City's boundaries. Section 2.0 describes the work undertaken in 2013 to clean up and restore streams. Section 3.0 details the City's hydrological monitoring. The activities of the City of Bellingham Storm and Surface Water Utility are outlined in Section 4.0. Section 5.0 describes the current Washington State water quality standards as well as the methodology by which our laboratory collects and analyzes water quality data. Sections 6.0 - 9.0 contain updated long term water quality data. Finally, section 10.0 provides summary of the state of Bellingham's urban streams in 2013.

1.0 Status and Trends

One of the benefits of maintaining such a long standing water quality data set is that it facilitates tracking the condition of streams, which in turn allows impaired water bodies to be identified, problem areas to be targeted for remediation and the results of restoration efforts to be quantified.

1.1 Bellingham's 303(d) Listings

Section 303(d) of the Federal Clean Water Act requires states to develop lists of impaired water bodies. Table 1.1-1. catalogs current 303(d) category 5 (impaired) and 4a (active TMDL) listings for urban streams within Bellingham's boundaries. Maps of current listed stream reaches can be found in Appendix D. As Mill Wheel and Silver Beach Creeks are tributaries to Lake Whatcom, they are monitored as part of Lake Whatcom Total Maximum Daily Load (TMDL) efforts and are not included as part of the Urban Streams Monitoring Program. A TMDL is a structured water quality improvement plan that establishes limits on pollutants that can be discharged to a water body in order for state water quality standards to be met. Information regarding Lake Whatcom can be found at: http://www.cob.org/services/environment/lake-whatcom/index.aspx.

The determination of which water bodies included on the 303(d) list will be assigned TMDL plans is made by the Washington State Department of Ecology (Ecology). Of Bellingham's urban streams, Padden, Squalicum, Whatcom Creek and it's tributaries are all assigned, or are in the process of being assigned a TMDL for fecal coliform and temperature. Foreseeing this possibility years ago, the City has been actively putting pollution control projects in place on these streams. Such projects include innovative water quality studies, habitat studies, clean-up work and restoration efforts.

The City has been conducting enhanced water quality monitoring of select 303d listed stream reaches in an effort to better understand the water quality dynamics of impaired local waters. For more information on enhanced monitoring, please see section 5.2.2 of this document.

Table 1.1-1. Bellingham's Urban Stream 303(d) Impaired waters (catagories 4a & 5) listings by parameter.

Creek	Temp	DO	Fecal	Zinc
Chuckanut		5	5	
Padden	4A	5	5	
Connelly	4A	5	5	
Whatcom	4A	5	5	
Hanna	4A		5	
Cemetery	4A	5	5	
Lincoln	4A	5	5	
Fever	4A	5	5	5
Squalicum	4A	5	5	
Baker		5	5	
Mill Wheel			5	
Silver Beach			5	

1.2 Trend Studies

From the onset of the USMP, the data collected by the City of Bellingham has been presented mostly as it relates to state and federal water quality standards. While that information is critical to defining the current status of our waterways, the value of this dataset for showing trends and forecasting future conditions has been somewhat underutilized. In recent years, the evaluation of water quality trends has become a much more prominent tool in deciding where and how to focus clean-up and restoration efforts. As such, status and trends monitoring is now a critical part of State issued NPDES municipal stormwater permit requirements, with required sampling beginning in 2014.

Figures 1.2-1 and 1.2-2 below are examples of how long term status and trends data can be utilized.

Figure 1.2-1. exhibits the ten year trend in fecal coliform geometric means (geomeans) as they relate to temperature changes at the Dupont St. monitoring site on Whatcom Creek (the 30-value moving geomean is the standard used by the National Shellfish Sanitation Program, 2011). While seasonal trends of geomeans fluctuating with temperature is apparent, linear modeling shows there is very little probability that the decreasing trend in fecal coliform geomean is dependent on temperature change ($r^2 = 0.0004$). Further, the slope of the temperature trendline over the period is not significantly different than zero ($p = 0.98$, $\alpha = 0.05$), suggesting that factors other than temperature regime change (e.g. clean-up and source control) are likely responsible for decreases.

Figure 1.2-2 details mean critical period (June 1 - October 1) temperature (CPT) trends at Whatcom Creek sites and its tributaries over the past ten years. Such analysis is useful in understanding stream dynamics as they pass through different habitat regimes, are influenced by tributaries, and flow through Bellingham's urban landscape.

The thermal regime of Whatcom Creek is of special interest to the City of Bellingham, as it is the modeling basis for TMDL work on not only the Whatcom Creek drainage but Padden and Squalicum Creeks as well (Hood et al., 2011). The effects of source water conditions, tributary input, established riparian habitat, and topographic

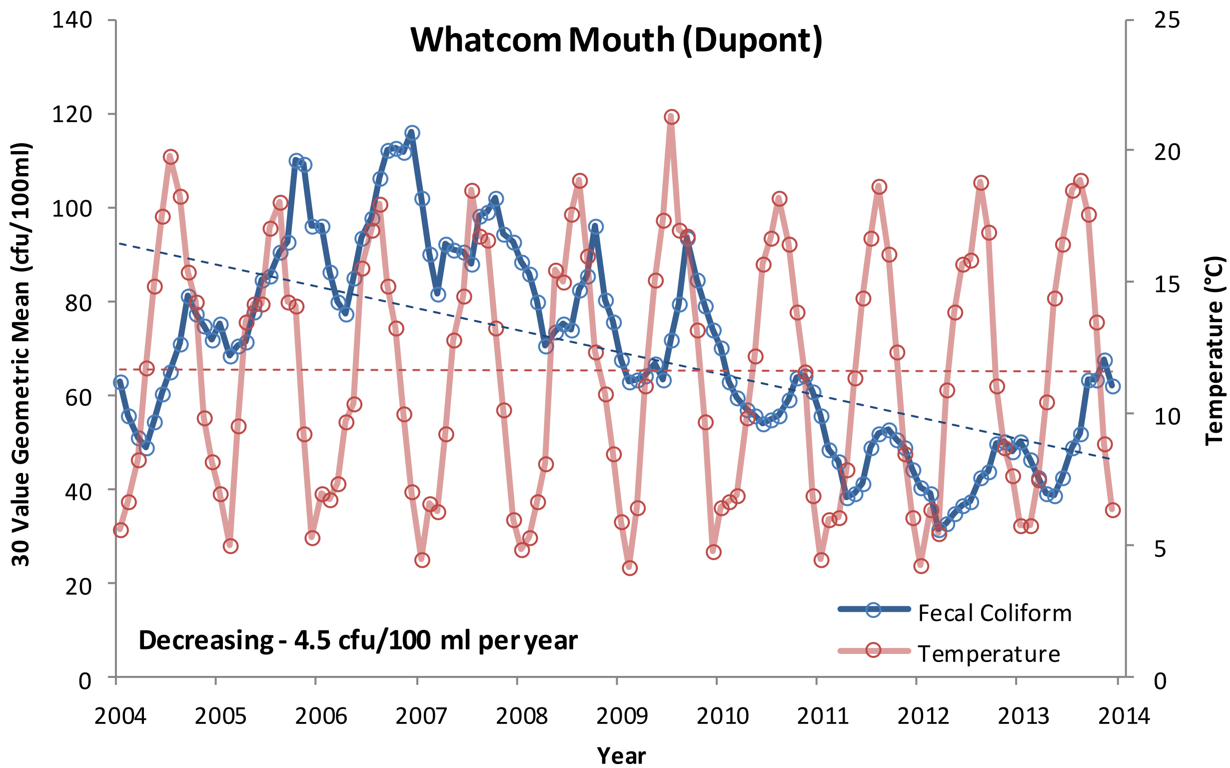


Figure 1.2-1. Ten-year trends in 30-value moving fecal coliform geometric means as they relate to temperature at Whatcom Creek's Dupont site for the period 2004-2013. While fecal coliform values show a decreasing trend of –4.5 cfu/100 ml per year, the slope of the temperature trendline was not significantly different than zero ($p = 0.98$, $\alpha = 0.05$). Linear modeling shows there is very little probability that the decreasing fecal coliform trend is dependent on temperature change ($r^2 = 0.0004$). The 30-value moving geomean is the standard used by the National Shellfish Sanitation Program (2011).

relief on stream temperature are evident in Figure 1.2-2. Over the 2004-2013 period, the Control Dam site near the headwaters of Whatcom Creek recorded an overall mean CPT of 18.0°C (21.5°C max). This provides an excellent example of how natural conditions in Lake Whatcom can elevate stream temperatures above the 16°C Aquatic Life Use (ALU) and confound efforts to meet water quality standards. In comparison, the Valencia site, below the forested and cascading stream reach within Whatcom Falls Park, recorded an overall mean CPT of 16.8°C (17.0°C max). The I-5 site, below the confluence of Fever, Cemetery and Lincoln Creeks recorded a mean CPT of 16.5°C (19.2°C max), and the Dupont St. site recorded an overall mean CPT of 16.3°C (18.9°C max). Thus illustrating the cooling effects of riparian shade and stream flow. The overall reduction in mean CPT between the Control Dam and Dupont St. sites was 1.7°C for the 2004-2013 period, with 1.2°C of that cooling occurring before the Valencia site.

In support of these findings, a TMDL study conducted in 2002 by City of Bellingham personnel found the highest 7-Day Average Daily Maximum (7DADMAX) recorded at the Control Dam (headwaters) site to be 1.1°C higher than that recorded at Dupont St. (mouth), with 1.3°C of cooling occurring in the first mile of the creek as it passes through Whatcom Falls Park. From there, temperature increased 0.2°C as the creek passed through more urbanized areas (Hood, 2011). A more recent City of Bellingham study conducted in 2011 (Bellingham, 2012) found even greater temperature reductions as Whatcom Creek flowed through Bellingham (2.7°C decrease from Control Dam to Dupont St.). As in the 2002 study, the cooling was found to occur in the Whatcom Falls reach, and then warm 0.3°C between there and Dupont St.

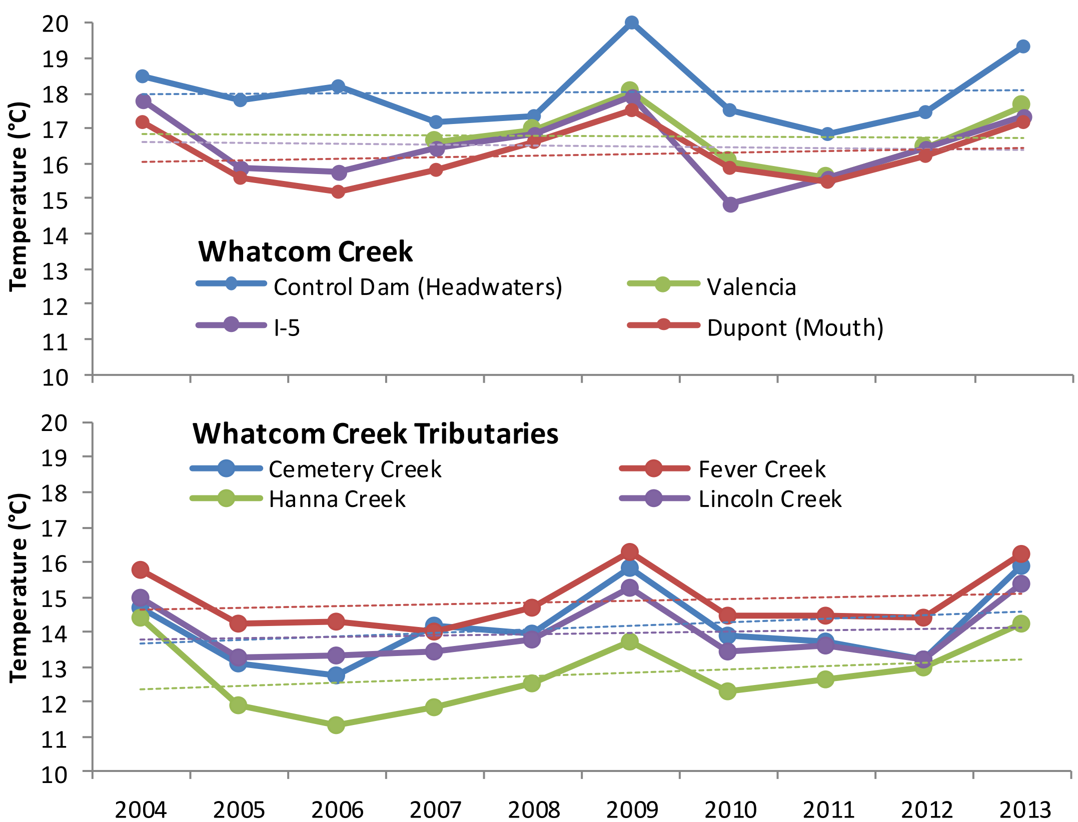


Figure 1.2-2. Mean critical period (June 1 - October 1) temperatures (CPT) on Whatcom Creek and its tributaries for the period 2004-2013.

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 urbanization. In 2013, the City continued development of a Habitat Restoration Master Plan based on aquatic and terrestrial habitat function. When finished, it is expected to provide guidance on where best to apply preservation, restoration and recovery efforts across the City. Figure 2.0-1 shows the locations of 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. More information on the City's restoration efforts can be found at: http://www.cob.org/services/environment/restoration/index.aspx

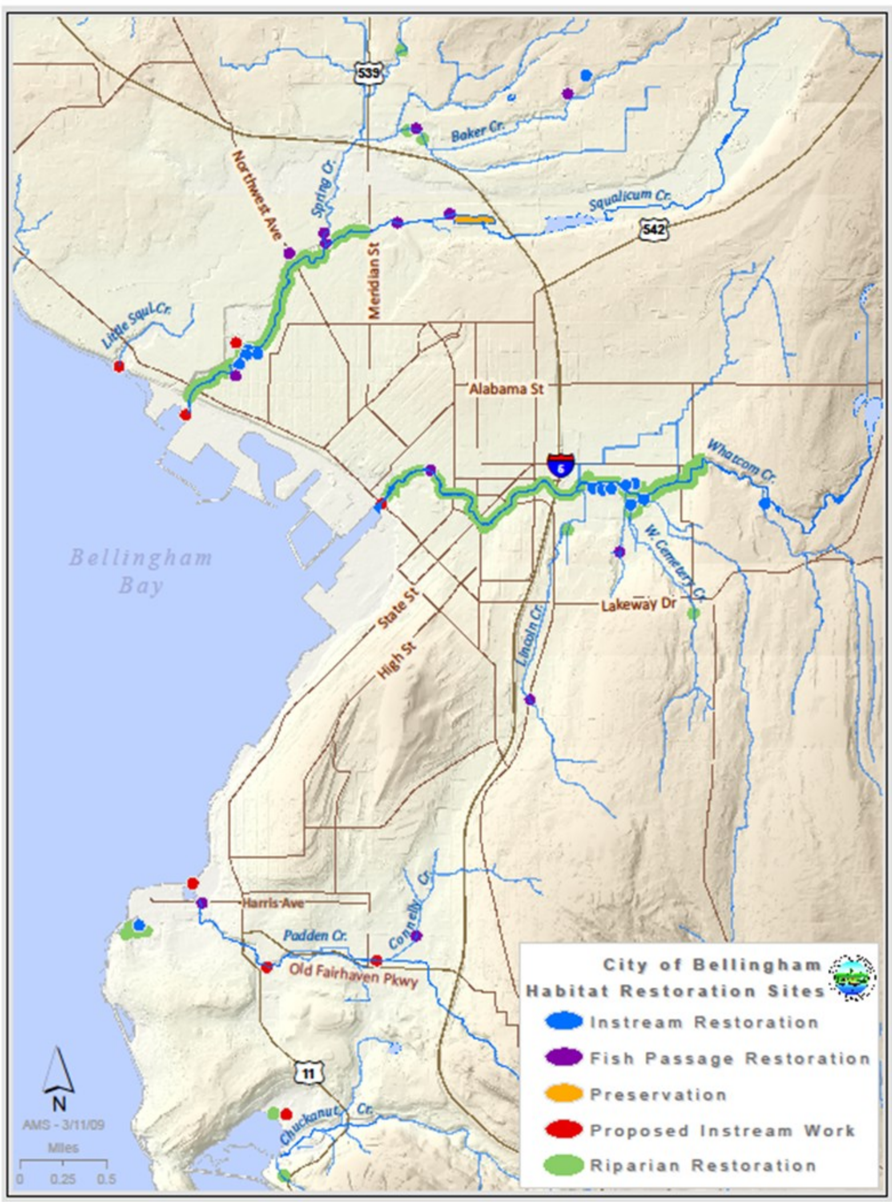


Figure 2.0-1. Location and types of stream restoration projects within the City of Bellingham (March 2009).

3.0 Stream Hydrology

Stream hydrology data provide information for developing restoration strategies, determining the adequacy of stormwater infrastructure to control for flooding and assessing land use impacts to stream flows. The City of Bellingham Storm and Surface Water Utility is currently supporting hydrological assessment of specific reaches on Whatcom, Squalicum, Padden, and Chuckanut Creeks.

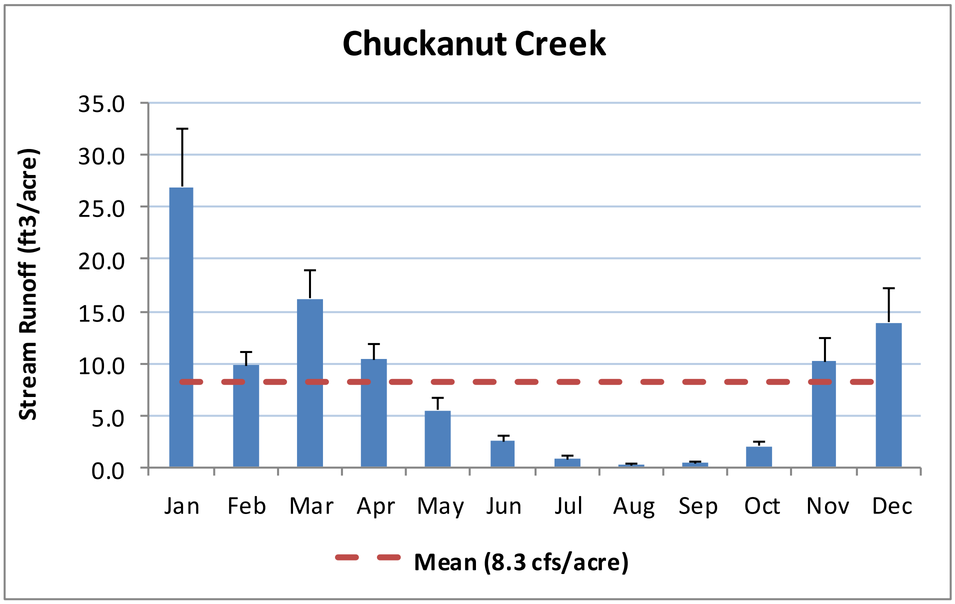
Decisions based on the analysis of stream discharge affect the operation of instream flood control dams (present on Padden, Connelly, Squalicum, and Whatcom Creeks), the type and size of new stormwater structures to be installed, where different types of stream restoration can have the greatest success, assessing available fish habitat, determining the potential for erosion, scouring and water quality impacts to receiving waters. It can also be used by City planners when considering development options within a watershed. Finally, the hydrology of a given stream can often be tied to changes seen in water quality data.

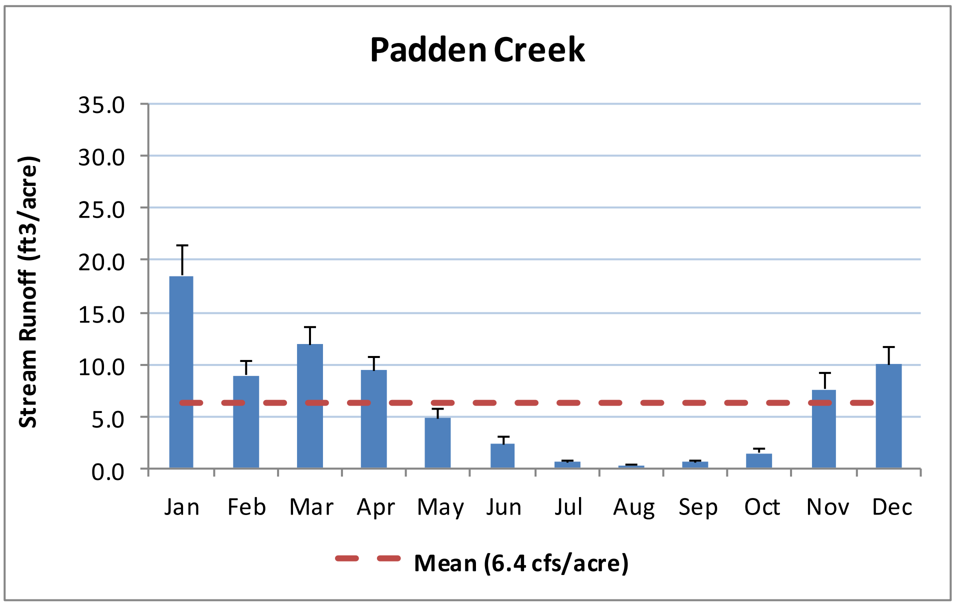
Figures 3.0-1 through 3.0-5 on the following pages show calculated average monthly runoff for the period of record at Bellingham's discharge monitoring stations. These figures are reached by normalizing the total monthly mean discharge rates by the area of the respective watershed. As expected, Whatcom Creek had the greatest mean runoff per acre (16.6 cfs/acre). Surprisingly however, Chuckanut Creek had a higher mean runoff flow (8.3 cfs/acre) than both Padden (6.4 cfs/acre) and Squalicum (6.0 cfs/acre) Creeks. As the Chuckanut Creek Drainage is largely comprised of forested areas in contrast to the more urban (and impervious) landscape surrounding the other creeks, these results were somewhat unexpected. However, when City of Bellingham rainfall data were analyzed it was found that the Chuckanut Basin receives much more rain annually than either the Padden and Squalicum basins (Table 3.0-1). This, accompanied by stream bathymetric properties (steep banks) and flood control dam modulation on Padden and Squalicum goes a long way towards explaining this result.

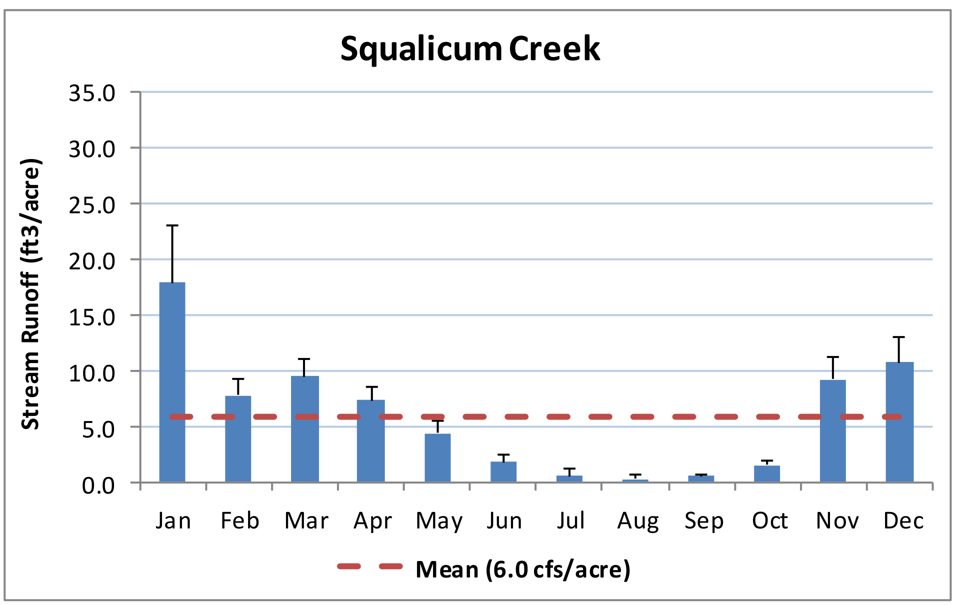
Figures 3.0-6 through 3.0-10 use box and whisker plots to depict the high, low, median, 25th and 75th percentile flow by year at each of Bellingham's gauging stations. This allows for inter-annual variance to be examined, and exceptional events to be highlighted. Combined with historical weather, restoration and Urban Streams Program data, this information can be used to qualify changes to stream water quality, stream morphology, and to better predict and manage for conditions that lead to flooding and scouring.

Table 3.0-1. Average annual precipitation at sites representative of Bellingham's four major stream basins, 2004-2013.

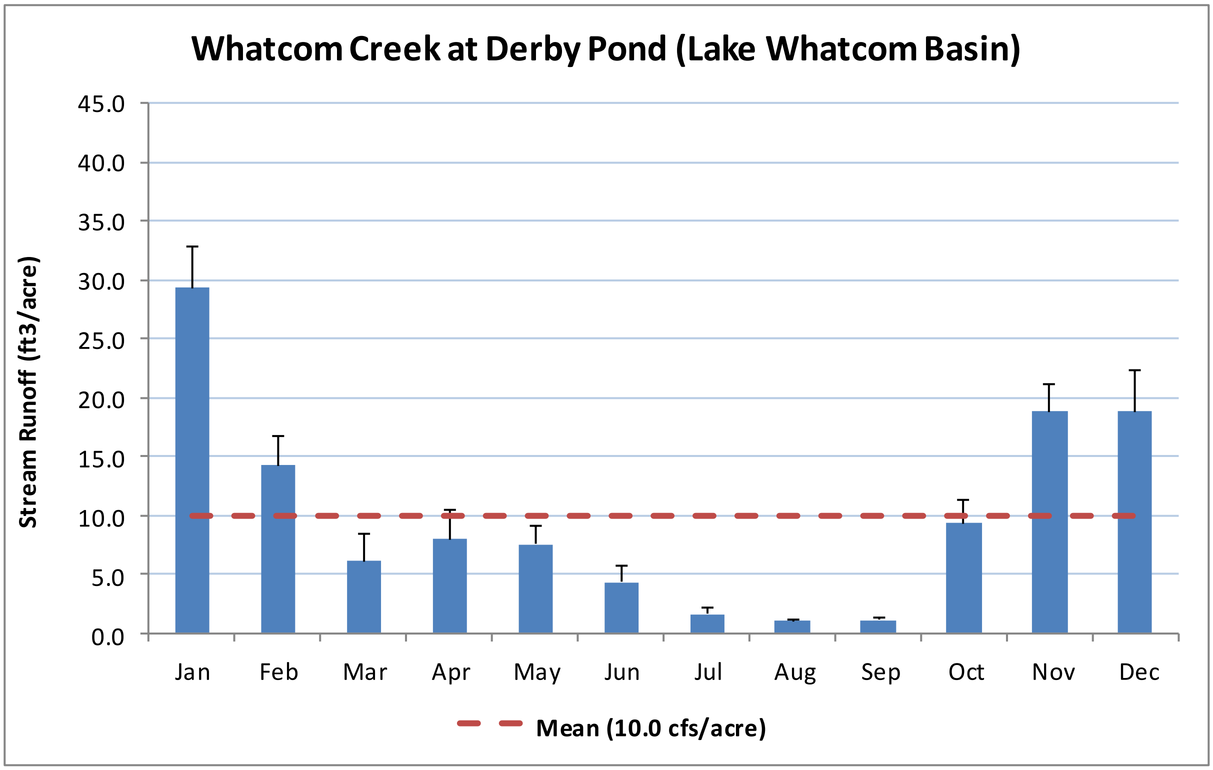
Stream Basin	**Chuckanut**	**Padden**	**Squlicum**	**Whatcom**
Station Site	Plantation Range	38th Street	Bakerview Spur	Bloedel Donovan
10-year Average Annual Rainfall	61 in.	41 in.	34 in.	45 in.

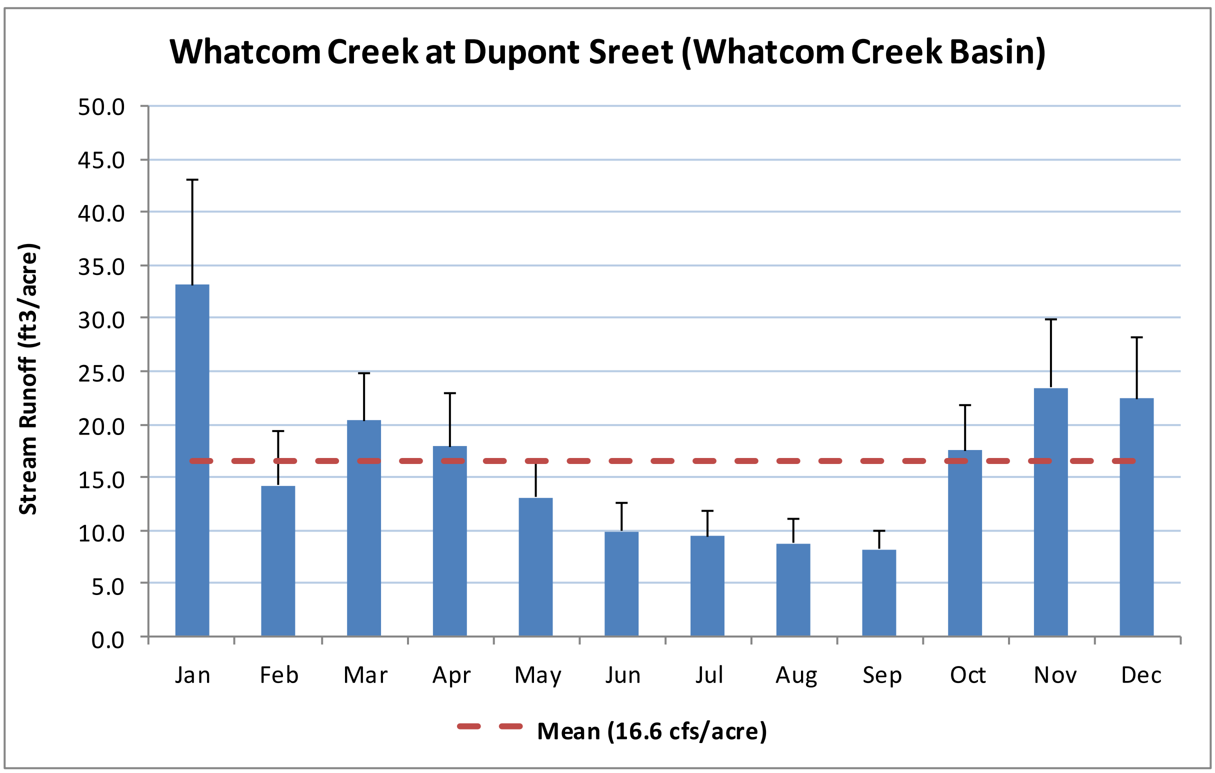




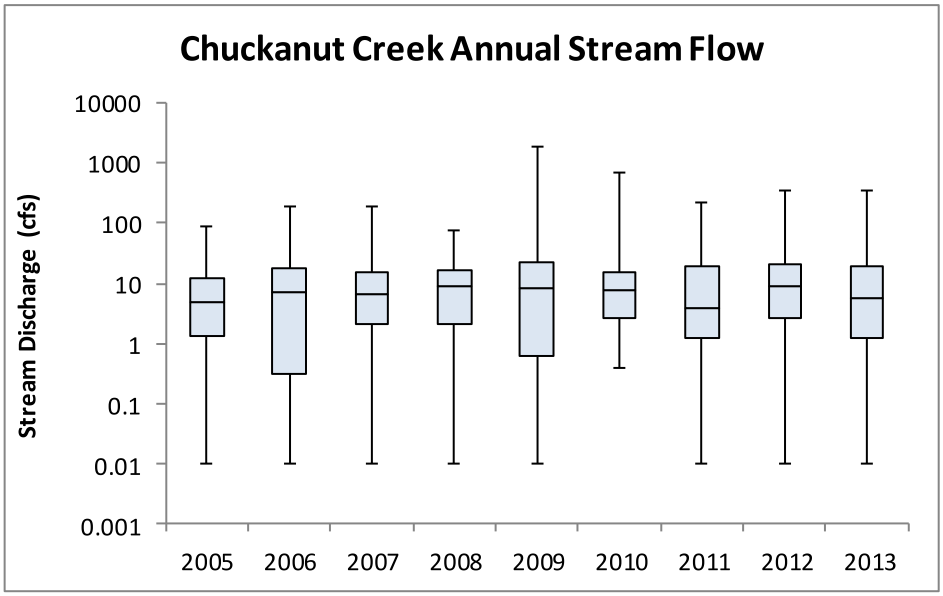


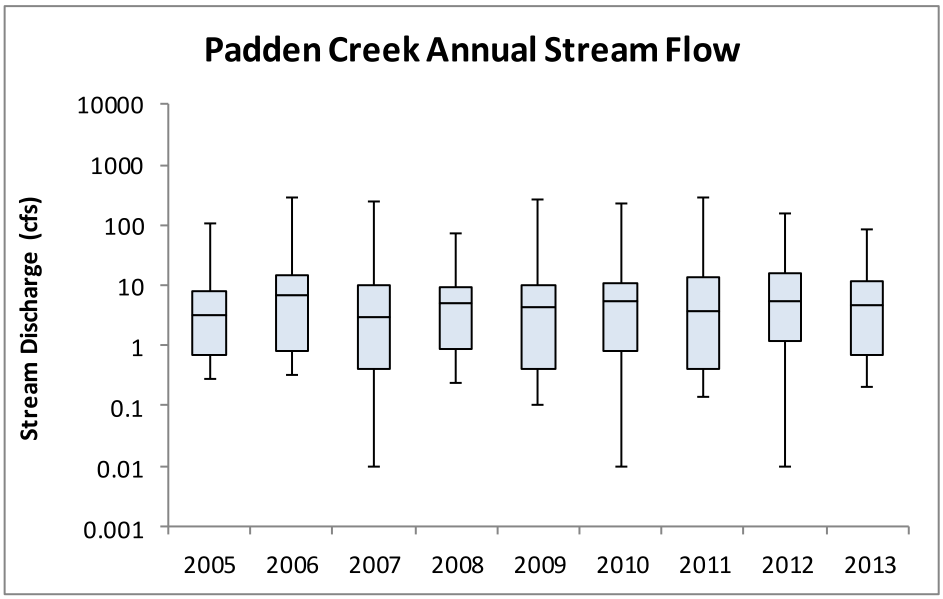
Figures 3.0-1,2&3. Average monthly runoff (discharge/acres) for Chuckanut, Padden and Squalicum Creek Drainage Basins over the period of record at each site. The average monthly runoff rates are calculated by normalizing the total monthly creek discharge by the area of the respective drainage basin. Monthly data was subject to a 70% completeness rule for inclusion in data set. Error bars represent the standard error that may be associated with variation in monthly values between years.

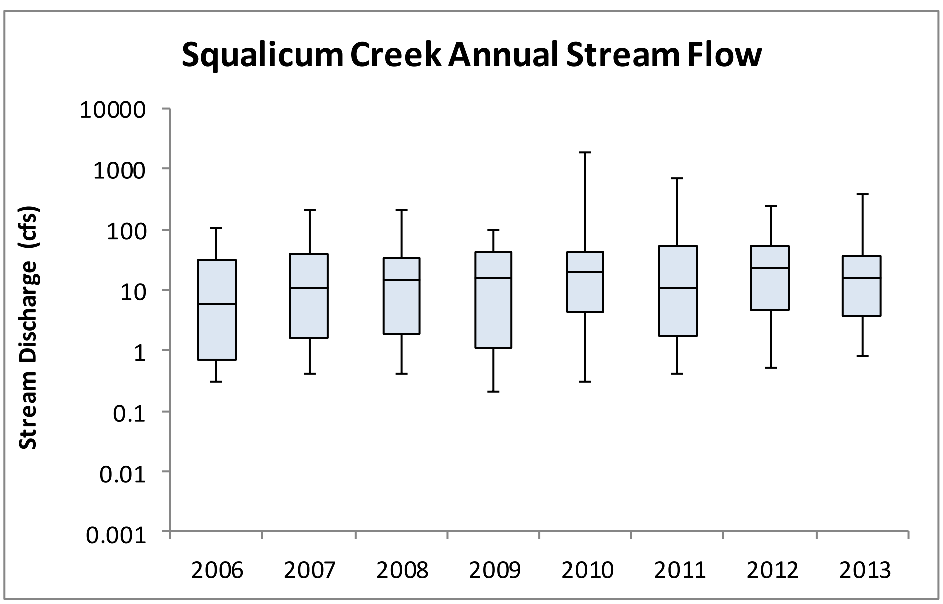




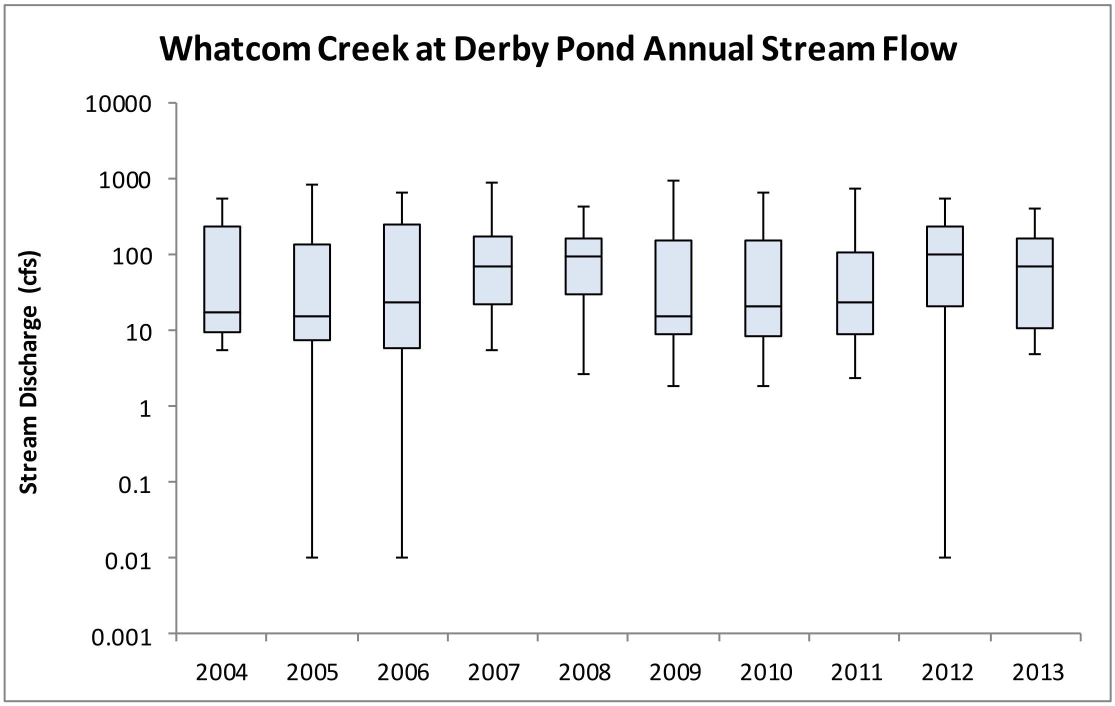
Figures 3.0-4&5. Average monthly runoff (discharge/acres) for Lake Whatcom and Whatcom Creek Drainage Basins over the period of record at each site. The average monthly runoff rates are calculated by normalizing the total monthly creek discharge by the area of the respective drainage basin. Flow attributed to the Lake Whatcom Basin has been removed from Dupont Street figures to represent conditions in the Whatcom Creek Basin only. Note that Whatcom Creek is a controlled system, and as such may display discharge conditions not attributable to runoff alone. See pg. 73 for more information. Error bars represent the standard error that may be associated with variation in monthly values between years.

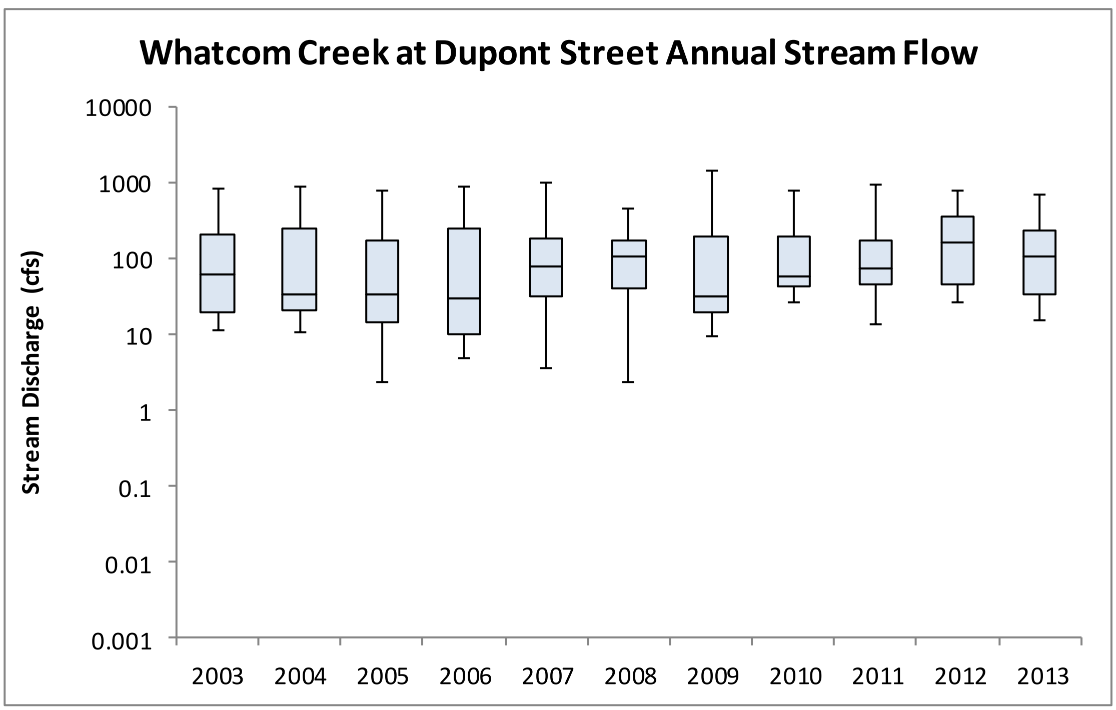






Figures 3.0-6 through 3.0-8. Box and Whiskers plots of annual stream flows for City of Bellingham gauging stations since program inception. Annual medians are depicted by the horizontal lines through the boxes, while the 25th and 75th percentiles are represented by the bottom and top of the boxes, respectively. Whiskers indicate annual minimums and maximums. Minimums shown at 0.01 cfs should be considered < 0.1 cfs and are for all intent and purposes equivalent to 0 cfs. Data presented on a logarithmic scale.





Figures 3.0-9&10. Box and Whiskers plots of annual stream flows for City of Bellingham gauging stations on Whatcom Creek. Annual medians are depicted by the horizontal lines through the boxes, while the 25th and 75th percentiles are represented by the bottom and top of the boxes, respectively. Whiskers indicate annual minimums and maximums. Minimums shown at 0.01 cfs should be considered < 0.1 cfs and are for all intent and purposes equivalent to 0 cfs. Data presented on a logarithmic scale.

4.0 Stormwater Treatment

Over the years, Bellingham has built and expanded buildings, roadways, sidewalks, landscaping and other portions of an urban landscape. Bellingham also receives on average 36 inches of rainfall per year. Naturally, runoff from the urban landscape has grown with the City.

Through the years, understanding of impacts from urban runoff has also grown. Stormwater has come to be considered the single greatest source of pollutants entering U.S. waterways. A recent study by the Department of Ecology (2008) found that nearly 75% of pollution entering the Puget Sound is from stormwater outfalls. In Bellingham, a large portion of the City's stormwater system drains to urban streams on its way to Bellingham Bay.

In 1990 the City of Bellingham began a Storm and Surface Water Utility (SSWU) to address the issues of stormwater pollution. Under the auspices of the federal National Pollutant Discharge Elimination System (NPDES) for stormwater, the SSWU is charged with working towards improvement of water quality in Bellingham's streams, lakes and nearshore waters.

Figure 4.0-1. The green roof installed on the Bellingham Children's Museum. An example of the City of Bellingham's commitment to LID practices.

With a population of under 100,000, Bellingham is considered a Phase II municipality for the purposes of NPDES permitting. This defines the requirements of the City for stormwater clean-up and management. The SSWU program provides services including: maintenance of our existing stormwater systems, review and enforcement of stormwater pollution codes, administration of stormwater mitigation, educational outreach, and water quality monitoring towards meeting compliance. The City's Storm and Surface Water Utility is constantly evaluating, retrofitting and improving Bellingham's stormwater system towards the goal of protecting the health of local water bodies and by extension, its citizens.

The City of Bellingham stormwater system is comprised of both natural and manufactured conveyance and detention systems. Natural conveyance systems include creeks and lakes that receive and channel runoff from rain and other sources. Manufactured conveyance systems consist of a network of open ditches, catchbasins, closed pipes, manholes, and water quality facilities such as ponds, vaults, storm filters, and bioswales. Bellingham also continues to be a leader among Phase II municipalities in integrating low impact development (LID) into infrastructure (Figure 4.0-1). All of these systems work in concert to control the quantity and improve the quality of runoff before it is discharged into major streams, lakes and Bellingham Bay.

Since the advent of the SSWU many stormwater mitigation facilities have been constructed. They fall in two categories, public facilities constructed to mitigate public or regional issues and private facilities owned and maintained by the private sector.

Public Facilities: There is a total of 267 facilities owned and maintained by the Storm and Surface Water Utility. These facilities include 5 regional detention ponds; 117 detention/water quality ponds, vaults or pipes; 56 water quality swales; 84 storm filters; 5 rain gardens and miles of ditches being maintained to provide a water quality function.

Private Facilities: There are 706 facilities on private properties providing treatment and/or storage of Stormwater, serving an area totaling approximately 2,921 acres. Private stormwater systems include approximately 185 detention facilities, 504 water quality/combined facilities and 17 miscellaneous facilities (oil water separators etc).

As part of a continued commitment to improve the health of Lake Whatcom and meet the goals of the lake's TMDL, a key component to the City's stormwater treatment strategy is implementing controls that reduce the amount of phosphorus entering Lake Whatcom. As of 2013, there were 37 public and 7 private stormwater facilities within the City's jurisdiction of the Lake Whatcom watershed, treating approximately 300 acres.

In addition, there were 41 single family home stormwater retrofits completed under the Homeowner Incentive Program for Lake Whatcom residents last year. That brings the total properties retrofit under the program to 84 with another 44 permitted for construction going forward. Under the program, participants can receive up to $6,000 reimbursement for retrofits such as riparian plantings, removal of impervious surfaces, lawn replacement, installation of infiltration trenches and planting raingardens.

In 2013 the City continued evaluating specialized filter medias for installation in vaults around Lake Whatcom. In addition to the removal of suspended solids, the new medias are formulated to remove dissolved phosphorus from stormwater. While continuing the evaluation, all Lake Whatcom watershed media systems have been fitted with these new phosphorus absorbing materials. Preliminary information points to a removal rate of 50 to 60 percent using the media.

Finally, the SSWU and City of Bellingham Laboratory are presently gearing up to conduct a comprehensive suite of status and trends monitoring to meet the requirements of the NPDES phase II permit. The monitoring will include stream water quality, flow, habitat and sediment chemistry measurements at 8 urban stream monitoring sites, as well as study of bacteria, sediment chemistry and mussel tissue toxicity at 6 urban nearshore marine sites. Look for results as they pertain to the Urban Streams Monitoring Program to be included here in years to come. A more detailed view of the program can be found here: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp.html

More information regarding the Storm and Surface Water Utility and its programs can be found online at http://www.cob.org/services/utilities/surface-storm/index.aspx.

5.0 Water Quality Monitoring

The Urban Streams Monitoring Program is one of the longest running monitoring programs within the City. Beginning in 1990, the program 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 those 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). However, the USMP is not intended to directly interface with the Ecology rules as they pertain to regulatory compliance or determination of impaired status, but to give context to the water quality observed in Bellingham's urban streams.

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. Ecology adopted revisions to the 2003 rule on December 21, 2006. Under the 2006 rule, Bellingham's urban streams are designated as Aquatic Life Use (ALU) of Core Summer Salmonid Habitat for temperature, dissolved oxygen, pH, and turbidity. Bellingham's streams are also designated for Primary Contact Recreational Use (RU) according to fecal coliform count. With the exception of the fecal coliform bacteria standard that was approved by the EPA in 2005, these changes apply to all stream monitoring conducted since 2006. 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, 22nd Edition (APHA, AWWA, WEF, 2012). 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 handled according to SM 9060 B 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 Analyst 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 YSI Pro Plus field monitor**.** Quality control includes pre and post calibration of the YSI Pro Plus , 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 Hach 2100P meter. 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

5.2.1 Conventional Sampling

The City of Bellingham urban streams have been monitored for the past 24 years. Twelve sites have been consistently sampled throughout the monitoring program. Five more of the current sites were added in 2002 and one additional site was added at the end of 2006. Several sites, such as those along Silver Creek (outside city limits), have been discontinued as the needs of the City and USMP have changed. 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.

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' 58"	122° 29' 17"
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"

Sampling locations are shown on the drainage basin maps supplied in Appendix E 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 (also known as Spring Creek - see section 9.0, Squalicum Drainage Map). Padden Creek is sampled at four locations and on its main tributary, Connelly Creek (Chuckanut and Padden Drainage Map). Chuckanut Creek is sampled only near the mouth (Chuckanut and Padden Drainage Map).

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 bioassessment, contaminated sediments, phosphorus, toxic substances and total dissolved gases.

The maximum, minimum and average conductivity results for individual stream segments can be found on page 27. The 2013 results for this parameter have not changed significantly from prior years. Conductivity measurements for 2002 and earlier can be found in the *Urban Streams Monitoring Program Report 2002* (City of Bellingham, 2002b).

5.2.2 Enhanced Sampling

In 2013 the City of Bellingham continued to conduct enhanced sampling on select 303d listed stream reaches. Enhanced sampling uses continuous monitoring equipment and more frequent grab sampling to rigorously investigate the causes and validity of 303d listings. Data collected via these methods provide a more comprehensive picture of overall water quality in the City's urban streams.

The advantages of enhanced sampling include the ability to calculate 7-day averages of daily maximums (7DADMAX) and 7-day averages of daily minimums (7DADMIN) from continuous monitoring data. Ecology currently considers the 7DADMAX for temperature and 7DADMIN for dissolved oxygen the best ways to assess water quality for these parameters. They are the preferred method for determining 303d status. In addition, more frequent grab sampling for parameters like fecal coliform allows for a better estimation of overall geometric means.

As Bellingham's streams are most often listed for exceedences of temperature, dissolved oxygen and fecal coliform standards, sampling efforts are usually conducted during Ecology's designated "dry" summer season (June 1 - September 30) when these factors are of most concern. Results of enhanced sampling are then included in class/aquatic life use/recreational contact use designation analysis for the streams in question that year.

In 2013, Squalicum Creek was once again chosen to be monitored using enhanced sampling protocol. From June 1st until October 1st Squalicum Creek Drainage sites were sampled weekly for fecal coliform and were continuously monitored (15 min data) for temperature and dissolved oxygen levels. Results of enhanced sampling in the Squalicum Creek drainage can be found in Section 9.0. This data will be used to support Ecology's Squalicum Creek Watershed Stormwater Pilot TMDL (Ecology, 2012).

5.2.3 Historical Sampling

Historically, Bellingham's urban streams have rarely met 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.

Based on conventional sampling in 2013, only the Padden at 38th site met Class A standards while Chuckanut Creek, Hanna Creek, Cemetery Creek and all Whatcom Creek sites met Class B standards. None of the other urban stream sites were able to meet either the Class A or Class B standards.

In 2013, Padden Creek at 38th, Whatcom Creek at the Control Dam, Valencia and I-5 met Primary Contact Recreational Use standards. None of the stream sites met all of the Aquatic Life Use requirements of Core Summer Salmonid Habitat.

The following sections provide conventional sampling data collected during 2013. 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 1994 to 2013. ("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). Designations based on conventional sampling.

Sampling Site	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Chuckanut (mouth)	X	X	X	B	X	X	A	X	B	X	B	X	X	B	B	B	AA	AA	B	B
Padden (38th)			B	B	X	AA	A	X	A	B	X	A	A	A	X	A	A	B	A	A
Padden (30th)	X	X	A	B	X	X	A	A	A	X	X	X	B	B	X	B	B	A	B	X
Connelly (Donovan)	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)												X	X	X	B	X	B	X	X	X
Padden (mouth)	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X	X	X	X	X
Whatcom (Control Dam)	X	X	X	B	X	B	B	B	X	X	X	X	X	B	B	B	B	B	B	B
Hanna (WTP)		X							B	X	X	X	X	X	X	B	A	X	X	B
Cemetery (Whatcom Cr)	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	B	X	X	B
Lincoln (Fraser)	X	X	X	B	X	X	X	X	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	X	X	X	X
Whatcom (Valencia)														A	B	B	A	A	A	B
Whatcom (I-5)	X	X	X	B	X	X	B	X	B	B	X	B	B	B	B	B	A	A	A	B
Whatcom (Dupont)	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X	A	B	B	B
Squalicum (E. Baker-	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	B	B	X	X
Squalicum (Meridian)	X	X	X	B	B	B	X	B	B	A	X	X	B	A	X	A	A	A	X	X
Baker (Squalicum)	X	X	X	A	B	X	X	X	X	X	X	X	X	X	X	X	B	X	X	X
Squalicum (Mouth)	X	X	X	A	X	X	X	X	X	X	B	X	X	X	A	X	B	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 for the USMP rarely meet the Primary Contact Recreational Use (Class A) standards for this parameter (Table 5.3.1-1).

In 2013, Whatcom Creek at the Control Dam and Valencia were the only sites to meet the stringent Class AA criteria for fecal coliform bacteria. Padden Creek at 38th and Whatcom Creek at I-5 met Class A criteria. Chuckanut Creek, Hanna Creek and Whatcom Creek at Dupont met Class B standards. The remaining 11 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 2013. Most maximum values for 2013 were recorded for September during a first-flush storm event. 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 potential 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 waterborne illnesses and conditions including eye, ear, and skin conditions, upper respiratory illness, and most commonly, gastrointestinal illness.

Table 5.3.1-1 The fecal coliform bacteria class designation for all stream segments from 1994 to 2013. ("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). Designations based on conventional sampling.

Sampling Site	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Chuckanut (mouth)	X	A	X	A	X	X	A	X	B	X	B	X	X	B	B	B	AA	AA	B	B
Padden (38th)			AA	AA	X	AA	AA	X	AA	B	X	A	AA	AA	X	AA	A	B	A	A
Padden (30th)	X	B	A	A	X	X	AA	A	A	X	X	X	B	B	X	B	B	A	B	X
Connelly (Donovan)	X	B	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)												X	X	X	B	X	B	X	X	X
Padden (mouth)	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X	X	X	X	X
Whatcom (Control Dam)	B	A	B	B	A	A	AA	A	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	B	AA
Hanna (WTP)		X							A	X	X	X	X	X	X	B	A	X	X	B
Cemetery (Whatcom Cr)	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	B	X	X	X
Lincoln (Fraser)	X	X	X	B	X	X	X	X	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	X	X	X	X
Whatcom (Valencia)														AA	AA	A	AA	AA	A	AA
Whatcom (I-5)	B	X	X	B	A	X	AA	X	AA	AA	X	B	A	AA	AA	B	AA	AA	A	A
Whatcom (Dupont)	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X	AA	B	B	B
Squalicum (E. Baker-	X	B	X	X	X	X	B	X	X	X	X	X	X	X	X	A	B	A	X	X
Squalicum (Meridian)	X	B	X	B	A	B	X	B	A	AA	X	X	B	A	X	A	AA	A	X	X
Baker (Squalicum)	X	X	X	A	A	X	X	X	X	X	X	X	X	X	X	X	B	X	X	X
Squalicum (Mouth)	X	B	X	A	X	X	X	X	X	X	B	X	X	X	A	X	B	X	X	X

While the origin of fecal coliform bacteria in streams is assumed to be from fecal sources, the levels of bacteria found in streams arise from a variety of causes. Most bacteria are likely washed into streams via surface runoff (primarily from wildlife and pet waste), but leaking sewer lines are also of concern. 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 2006 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 2006 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 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 2006 rule for the fecal coliform bacteria standard for fresh surface waters in Washington.

FECAL COLIFORM BACTERIA		
1997 Rule		**2006 Rule**
Class	**Geometric Mean**	**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

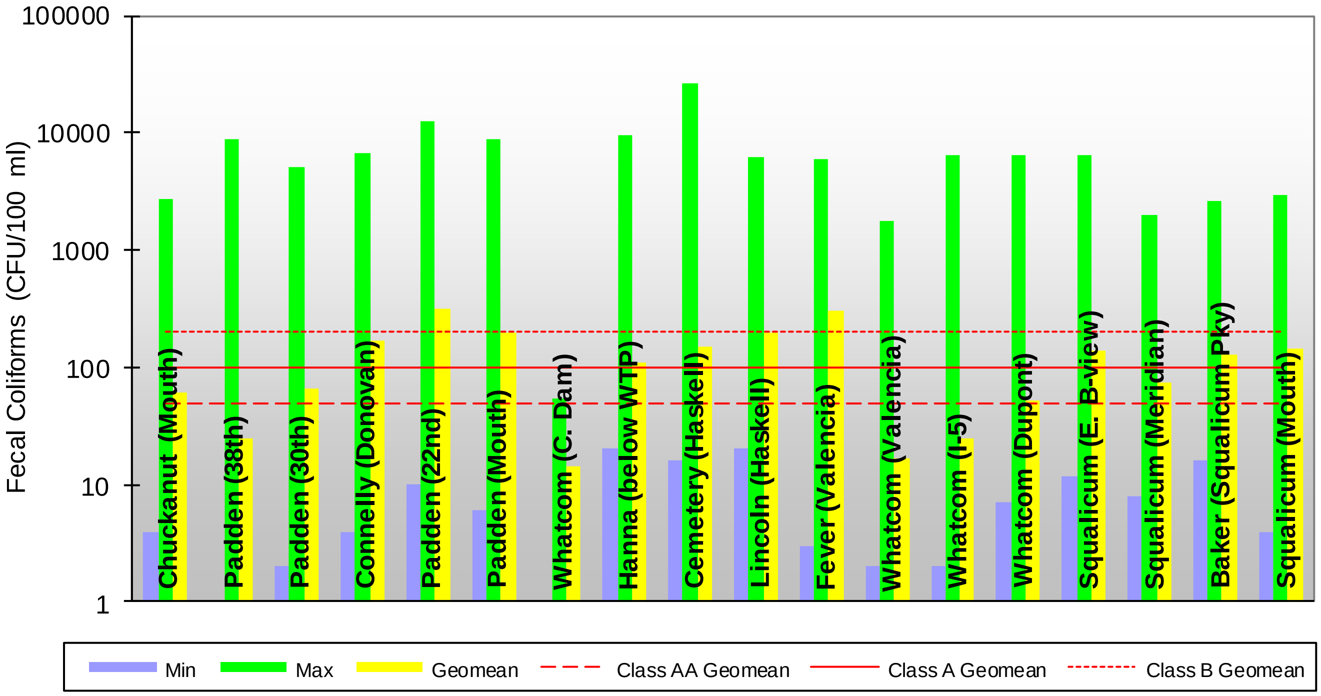


Figure 5.3.1-1. Fecal coliform bacteria minimum, maximum, and geomean values for all stream segments sampled in 2013. Red lines indicate the maximum geomean value allowed by the Class AA, A (Primary Recreational Contact), and B criteria for fecal coliform bacteria. *Note this graph uses a logarithmic scale*.

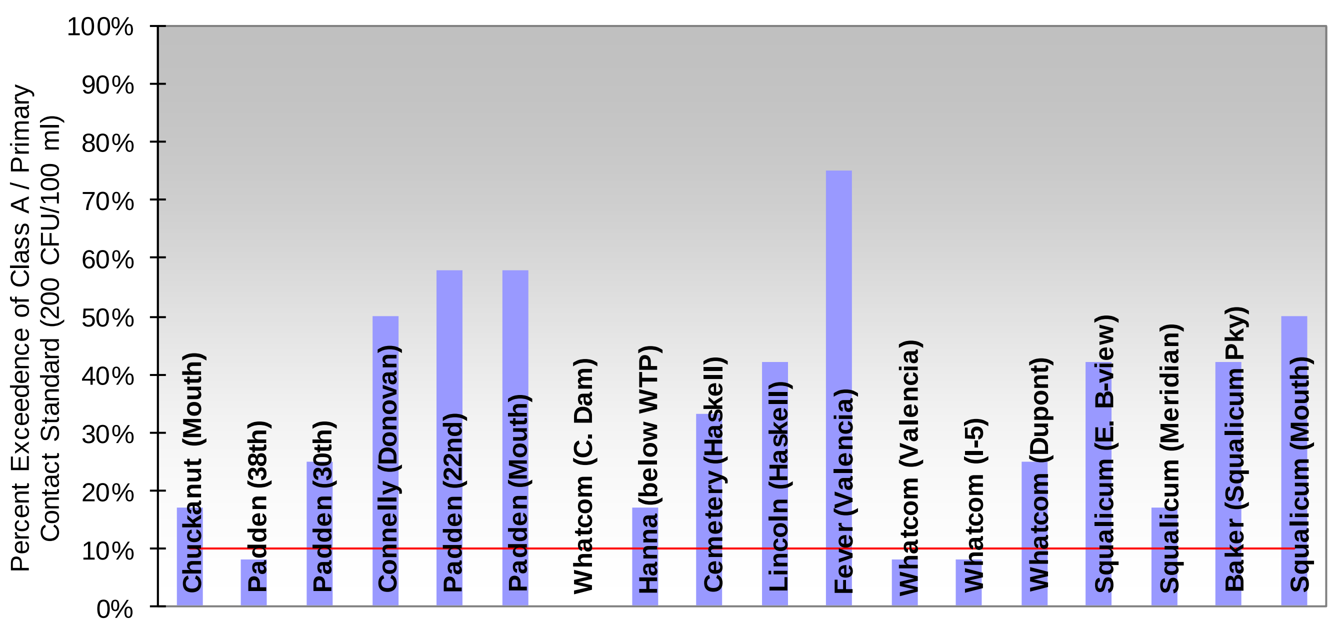


Figure 5.3.1-2. Fecal coliform percent exceedence of the Class A / Primary Recreational Contact standard for all stream segments sampled in 2013. Whatcom Creek at the Control Dam had no exceedences for 2013. Based on conventional sampling events.

5.3.2 Dissolved Oxygen

In 2013, none of the urban stream monitoring sites 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.

Chuckanut Creek, all Padden Creek sites, Connelly Creek, the Valencia and I-5 sites on Whatcom Creek, Hanna Creek, Fever Creek, and the Squalicum Creek Mouth met the Class A criterion for dissolved oxygen in 2013 (Table 5.3.2-1). Lincoln Creek, Whatcom Creek at the Control Dam and Dupont Street, Baker Creek and Squalicum Creek at Meridian met Class B standards. Cemetery Creek and Squalicum Creek at E. Bakerview failed to meet Class B standards. Figure 5.3.2-1 provides the minimum, maximum, and average values for dissolved oxygen in all stream segments sampled in 2013. Figure 5.3.2-2 shows the percent of samples that fell below the Class A and ALU criteria.

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.

Table 5.3.2-1. Dissolved oxygen class designation for all stream segments from 1994 to 2013. ("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). Designations based on conventional sampling.

Sampling Site	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Chuckanut (mouth)	X	X	B	A	A	A	A	A	A	B	A	A	AA	A	A	AA	AA	AA	AA	A
Padden (38th)			B	A	A	A	A	A	A	A	B	A	A	A	B	A	A	A	A	A
Padden (30th)	X	X	A	A	A	A	A	A	AA	B	B	A	A	A	A	A	A	A	AA	A
Connelly (Donovan)	X	X	B	A	B	A	B	B	A	B	B	A	A	A	A	B	A	B	A	A
Padden (22nd)												A	AA	A	A	A	A	A	AA	A
Padden (mouth)	X	X	B	A	A	A	A	A	A	A	B	A	A	A	A	B	A	A	A	A
Whatcom (Control Dam)	X	X	B	A	B	B	A	B	A	B	B	A	A	A	A	B	A	B	A	B
Hanna (WTP)		X							B	AA	B	A	A	A	AA	A	A	A	AA	A
Cemetery (Whatcom Cr)	X	X	B	B	B	A	A	B	B	X	X	X	A	X	X	X	B	X	X	X
Lincoln (Fraser)	X	X	B	B	X	A	A	B	B	B	B	B	A	B	B	B	B	B	B	B
Fever (Valencia)	X	X	B	A	B	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A
Whatcom (Valencia)														A	A	A	A	A	AA	A
Whatcom (I-5)	X	X	B	A	A	AA	A	A	A	A	B	A	A	A	A	A	A	A	A	A
Whatcom (Dupont)	B	B	B	A	A	AA	A	B	A	A	X	B	A	A	B	B	A	A	B	B
Squalicum (E. Bakerview)	X	X	X	X	X	B	B	A	X	X	X	X	X	X	B	X	A	B	B	X
Squalicum (Meridian)	X	X	B	B	A	B	A	A	A	A	B	B	A	A	A	A	A	A	A	B
Baker (Squalicum)	X	X	B	A	A	A	AA	A	A	B	B	B	B	A	A	A	A	B	A	B
Squalicum (Mouth)	X	X	B	A	A	A	AA	A	A	B	B	A	A	A	A	A	A	A	A	A

In addition to elevated temperature, inputs of pollution can cause lower dissolved 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.

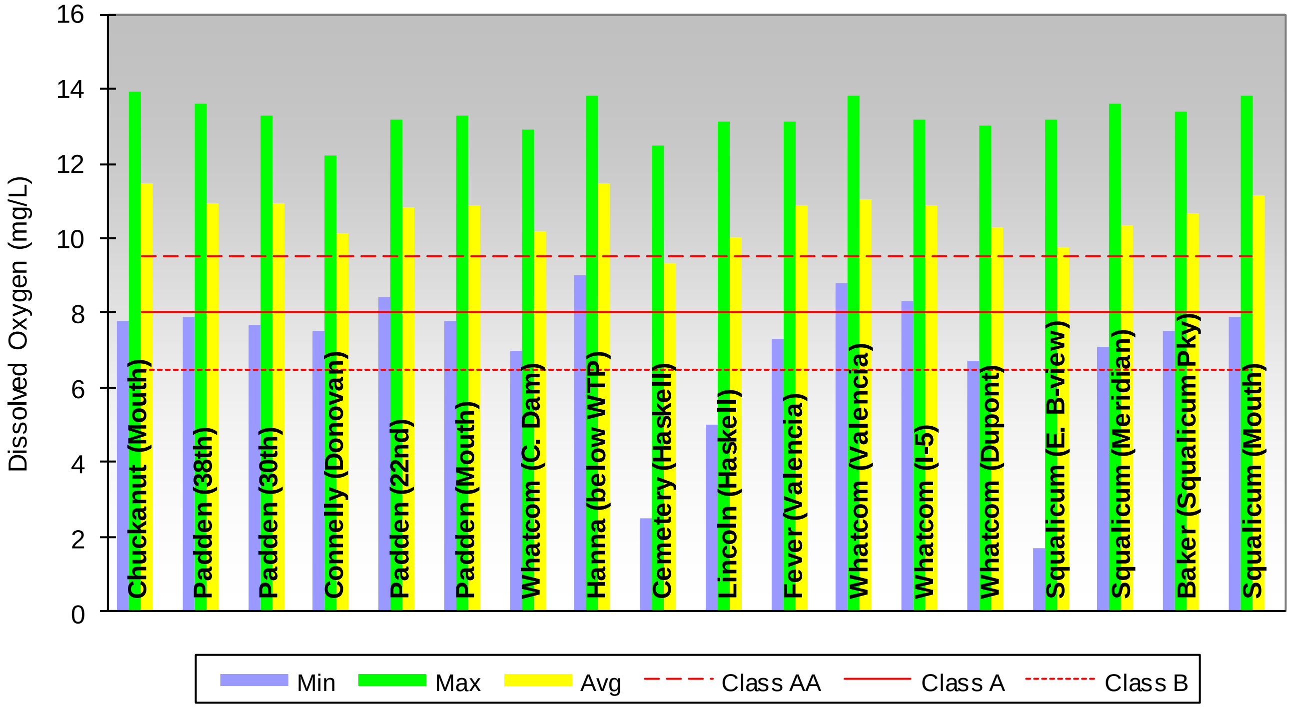


Figure 5.3.2-1. Minimum, maximum, and average dissolved oxygen levels for all stream segments sampled in 2013. Red lines indicate the lowest dissolved oxygen levels allowed for the different surface water classes (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation is equivalent to Class AA.

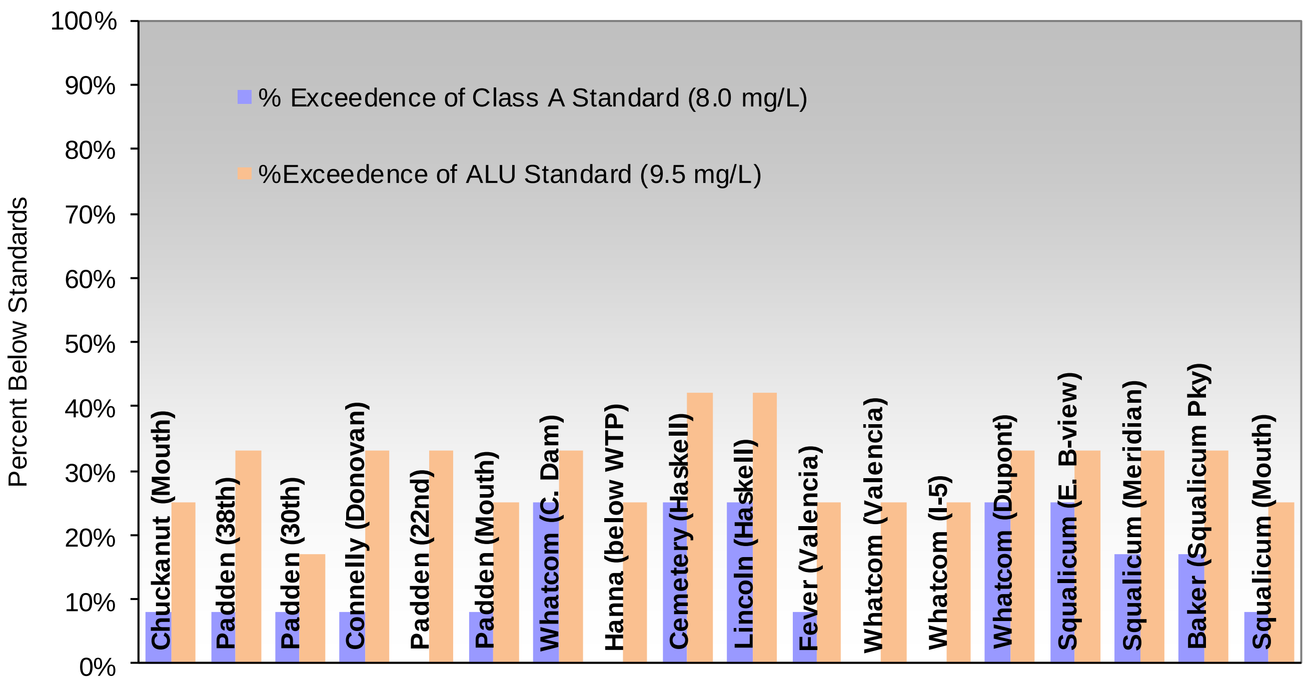


Figure 5.3.2-2. Percent of dissolved oxygen samples below the Class A (8.0 mg/L) and Aquatic Life Use (ALU, 9.5 mg/L) standards for all stream segments sampled in 2013.

5.3.3 Temperature

In 2013, only five urban stream segments met the stringent Core Summer Salmonid Habitat ALU / Class AA standard for temperature, while eight sites met the Class A standard. All Whatcom Creek sites and Cemetery Creek were in the Class B category. Figure 5.3.3-1 shows minimum, maximum, and average temperatures found in the stream segments sampled in 2013. 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 a minimum of 3 of all samples and greater than 10% of samples taken during the year in question are in exceedence. 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). Finally, certain reaches of Chuckanut, Squalicum and Whatcom Creeks are listed by Ecology as requiring supplemental spawning and incubation protection for salmonids. Those reaches require temperatures below 13°C from Feb. 15 - June 15.

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 2013, the sampling frequency for the Urban Streams Monitoring Program did not allow for the calculation of this value for most stream segments. 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 Report.

Table 5.3.3-1. Temperature class designation for all stream segments from 1994 to 2013. ("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). Designations based on conventional sampling.

Sampling Site	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Chuckanut (mouth)	A	A	A	B	B	AA	AA	AA	AA	AA	AA	AA	AA	A	AA	AA	AA	AA	AA	AA
Padden (38th)			A	B	A	AA	AA	A	AA	A	A	AA	A	A	AA	A	AA	AA	AA	AA
Padden (30th)	B	B	A	B	A	AA	AA	A	AA	B	A	AA	AA	A	AA	A	AA	AA	AA	A
Connelly (Donovan)	B	A	B	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	AA	AA	AA	AA	A
Padden (22nd)												AA	AA	A	AA	AA	AA	AA	AA	A
Padden (mouth)	A	A	A	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	A	AA	AA	AA	A
Whatcom (Control Dam)	X	B	X	B	X	A	B	B	B	X	X	X	X	B	B	B	B	B	B	B
Hanna (WTP)		B							X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	A
Cemetery (Whatcom Cr)	B	A	B	A	B	AA	AA	A	A	A	A	AA	AA	A	A	A	A	AA	AA	B
Lincoln (Fraser)	B	B	B	A	B	AA	AA	A	AA	A	A	AA	AA	AA	AA	AA	AA	AA	AA	A
Fever (Valencia)	B	A	A	B	B	AA	A	A	A	A	A	A	A	A	AA	A	AA	AA	AA	A
Whatcom (Valencia)														B	B	B	A	A	A	B
Whatcom (I-5)	X	B	B	B	X	AA	B	B	B	B	B	B	B	B	B	B	A	A	A	B
Whatcom (Dupont)	X	B	B	B	X	AA	B	B	B	B	B	B	A	B	A	A	A	A	A	B
Squalicum (E. Baker-	B	A	B	B	B	AA	A	A	A	A	A	A	AA	A	AA	AA	AA	AA	AA	A
Squalicum (Meridian)	B	A	B	B	B	A	AA	A	AA	AA	AA	A	A	AA	AA	AA	A	AA	AA	AA
Baker (Squalicum)	B	A	A	A	B	AA	AA	AA	AA	A	A	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (Mouth)	B	A	A	A	A	AA	AA	AA	AA	AA	A	AA	AA	AA	AA	AA	AA	AA	AA	AA

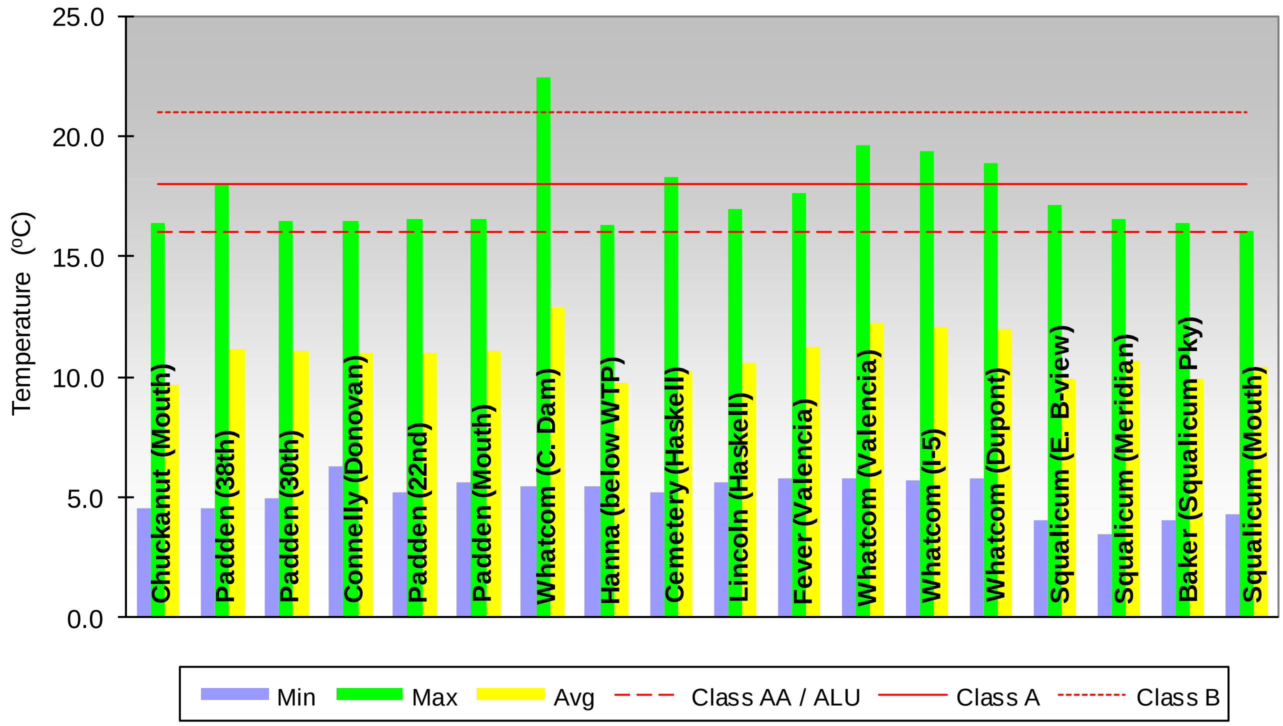


Figure 5.3.3-1. Minimum, maximum, and average temperature values for all stream segments sampled in 2013. Red lines indicate the highest temperature allowed by the different surface water standards (AA/ALU, A, and B).

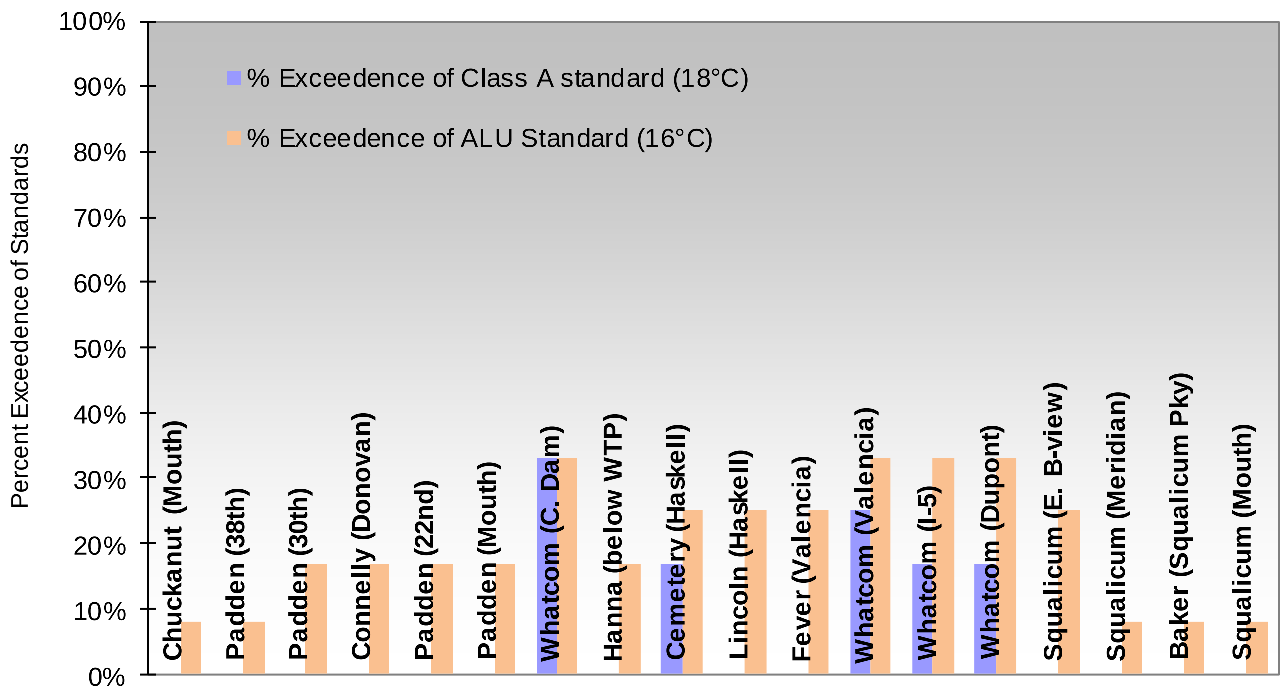


Figure 5.3.3-2. Percent temperature exceedences of Class A (18°C) and Aquatic Life Use (ALU, 16°C) standards for all stream segments sampled in 2013.

5.3.4 pH

The stream segments sampled in the Urban Streams Monitoring Program almost always meet Aquatic Life Use (ALU) and Class AA/A/B standards for pH. In 2013 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 the surface and

Table 5.3.4-1. The pH class designation for all stream segments from 1994 to 2013. ("AA" - met Class AA/A/B standards; "X" - did not meet Class AA/A/B standards).

Sampling Site	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Chuckanut (mouth)	X	AA	AA	AA	AA	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	AA	AA	AA	AA
Padden (30th)	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Connelly (Donovan)	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (22nd)												AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (mouth)	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Control Dam)	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Hanna (WTP)		AA							AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Cemetery (Whatcom Cr)	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Lincoln (Fraser)	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	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	AA	AA	AA	AA
Whatcom (Valencia)														AA	AA	AA	AA	AA	AA	AA
Whatcom (I-5)	X	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Dupont)	X	AA	AA	AA	AA	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	AA	AA	AA	AA
Squalicum (Meridian)	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Baker (Squalicum)	X	X	AA	AA	AA	AA	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	AA

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).

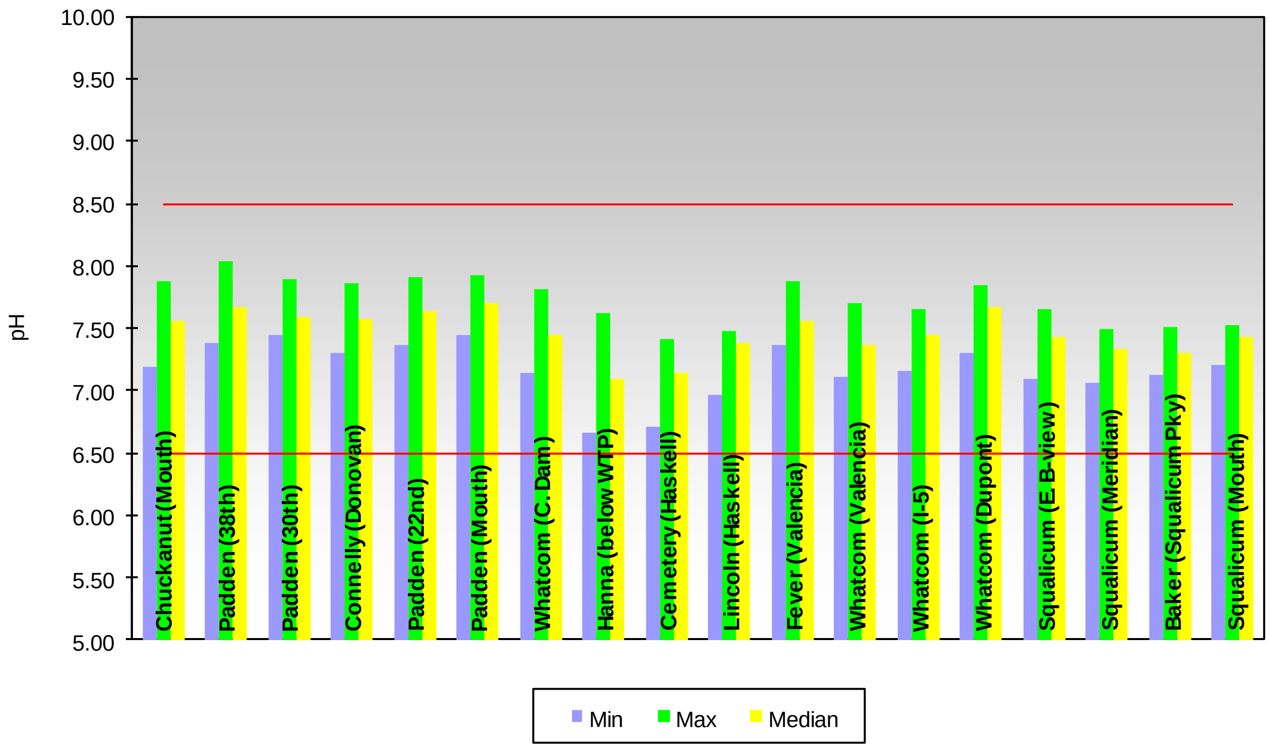


Figure 5.3.4-1. The pH minimum, maximum, and median values for all stream segments sampled in 2013. Red lines indicate the minimum and maximum values allowed by the Class AA/A/B and Aquatic Life Use (ALU) criteria for pH.

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 season, 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 re-suspended.

Heavy rains can pick up sand, silt, clay, and organic particles from the land, particularly from disturbed surfaces, 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 in combination with natural processes 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 stream corridors where 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 trends for the past 10 years and comparisons between this year's data and the previous 5 and 10 year overall turbidity averages.

For the ten year period ending in 2013, none of the stream sites sampled as part of the Urban Streams Monitoring Program displayed turbidity trends that were significantly different than zero.

In both January and November of 2013, stream sampling occurred during winter storms that both recorded over 1.5 inches over 48 hours. In addition, samples taken in September were collected during an unusually strong end-of-summer downfall totaling about an inch or rain. Due to these occurrences, the turbidities of most samples were abnormally high for all three months and the cumulative effects on average turbidities in 2013 are significant. The influence of these events serve to illustrate the power of stormwater to alter urban stream conditions.

The 5-year, 10-year, and 2013 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 2013.

Table 5.3.5-1. Yearly, 5-year and 10-year average turbidities.

Stream Segment	2013 Average	5 Year Average	10 Year Average
Chuckanut Cr (Mouth)	4.60	4.93	4.93
Padden Cr (38th)	2.71	2.77	2.92
Padden Cr (30th)	5.88	3.99	3.51
Connelly Cr (Donovan)	5.53	7.46	6.93
Padden Cr (22nd)	4.00	5.38	4.80
Padden Cr (Mouth)	4.99	8.61	6.87
Whatcom Cr (C. Dam)	1.50	1.69	1.77
Hanna Cr (below WTP)	6.05	5.85	5.77
Cemetery Cr (Haskell)	9.30	7.04	7.44
Lincoln Cr (Haskell)	7.22	7.40	7.14
Fever Cr (Valencia)	6.71	6.34	6.29
Whatcom Cr (Valencia)	2.24	2.23	2.41
Whatcom Cr (I-5)	3.54	3.07	2.97
Whatcom Cr (Dupont)	4.26	3.72	3.48
Squalicum Cr (E. Bakerview)	9.88	8.66	8.52
Squalicum Cr (Meridian)	11.81	10.33	9.19
Baker Cr (Squalicum Pky)	9.17	7.60	7.02
Squalicum Cr (Mouth)	10.18	8.71	8.09

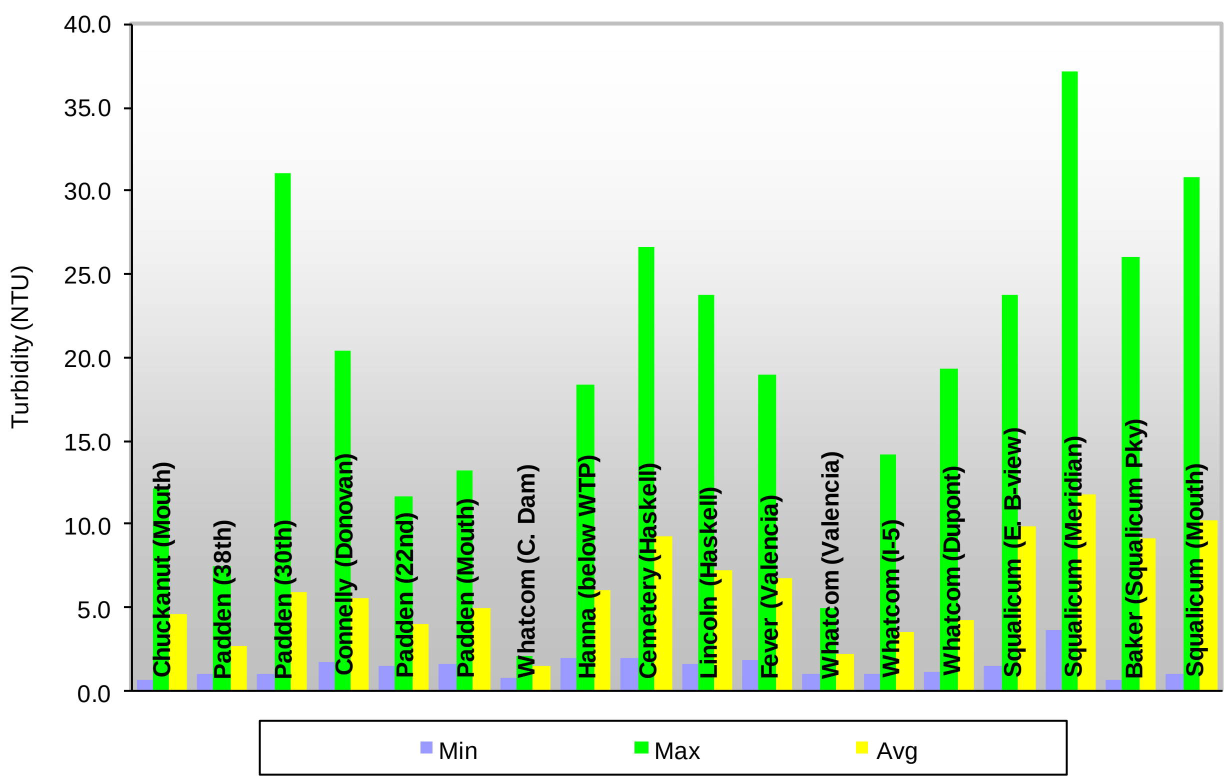


Figure 5.3.5-1. Minimum, maximum, and average turbidity values for all stream segments sampled in 2013.

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 (μS/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 taken at Squalicum Creek mouth in 1996 and 890 μS/cm taken at Padden Creek mouth in 2001. These measurements were taken at the mouths of streams and it is suspected that the high values are the result of salt water wedges, an effect of high tide.

In 2013, conductivity in Bellingham's urban streams ranged from 40 to 285 μS/cm (Figure 5.3.6-1), which is not appreciably different from previous years.

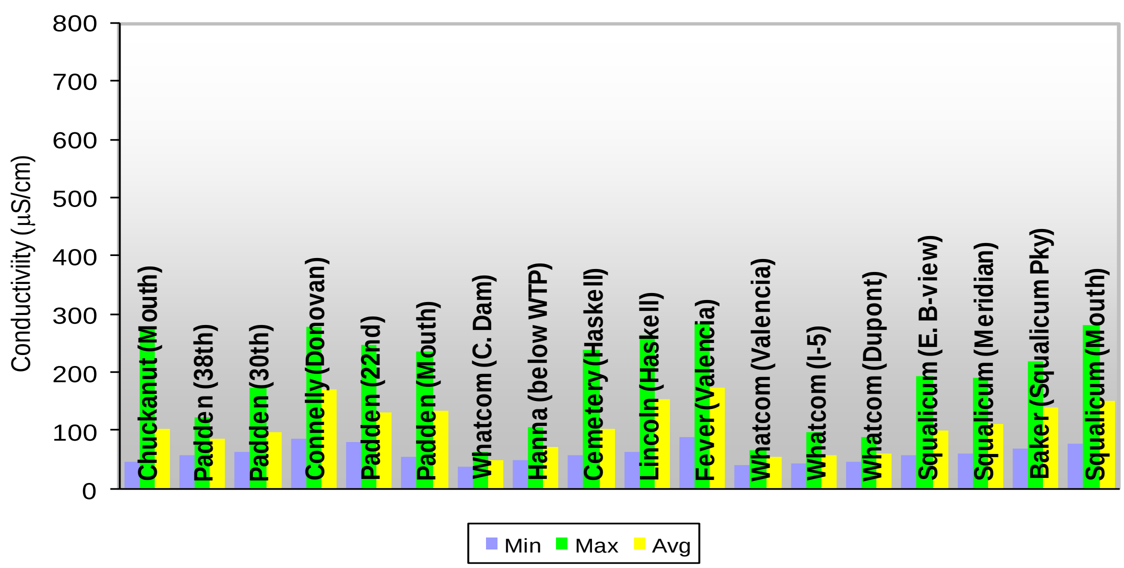


Figure 5.3.6-1. Minimum, maximum, and average conductivity values for all stream segments sampled in 2012. No numeric criterion exists in the WAC for conductivity.

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).

Chuckanut Creek met the Aquatic Life Use (ALU) criteria for temperature (16° C) and pH (6.5 - 8.5 s.u.) in 2013. However, the ALU for dissolved oxygen (9.5 mg/L) and the Primary Recreational Contact designated use criteria for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml) were not met.

Chuckanut Creek was able to meet the Class A criterion for dissolved oxygen (8.0 mg/L) and the Class B criteria for fecal coliform (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml), earning Chuckanut an overall Class B rating for 2013.

The average turbidity for 2013 was 4.6 NTU, which is below both the 5 year average of 4.8 NTU and the 10 year average of 4.9 NTU. Conductivity was relatively unchanged from previous years.

Figure 6.0-1 Chuckanut Creek mouth sampling site.

Fecal Coliform Bacteria

Fecal coliform concentrations for 2013 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 poulations. The geomean at the Chuckanut Creek mouth site was 61 CFU/100 ml. Two of the twelve samples (17%) collected at the site contained more than 200 CFU/100 ml (Figure 6.0-2). Analysis of the 30 value moving geometric mean for all samples taken in the last 10 years show a significant decreasing trend of – 5.3 CFU/100 ml/year (Figure 6.0-3).

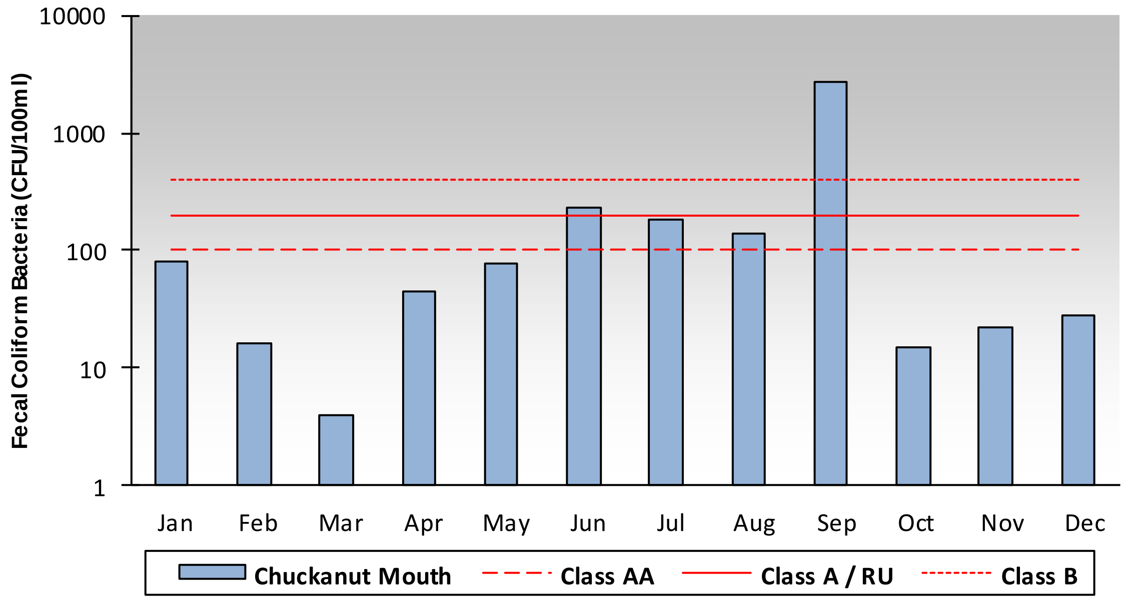


Figure 6.0-2. Fecal coliform bacteria levels for Chuckanut Creek sampling site by month for 2012. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

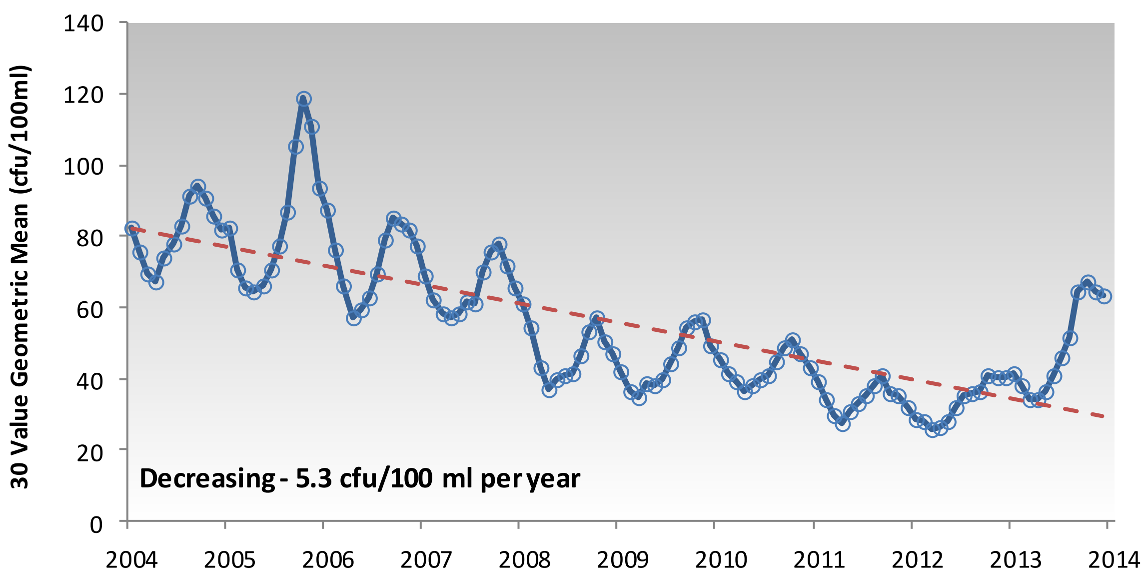


Figure 6.0-3. Thirty value moving geometric mean trend for all samples collected 2004 through 2013. Trend (red) shows significant decreasing trend of –5.3 cfu/100 ml/year ($p = 9.62^{e-24}$, $\alpha = 0.05$).

Dissolved Oxygen

Dissolved oxygen levels for 2013 follow a typical seasonal trend of low levels found in the warmer summer months when temperatures are higher (Figure 6.0-4). The low dissolved oxygen level was 7.8 mg/L and the average was 11.4 mg/L. Dissolved oxygen levels in Chuckanut Creek fell below the ALU standard of 9.5 mg/L twice and below the 8.0 mg/L class A standard once in 2013. While the ten year trend in dissolved oxygen values appears positive, the slope of the trendline is not significantly different than zero (Figure 6.0-5).

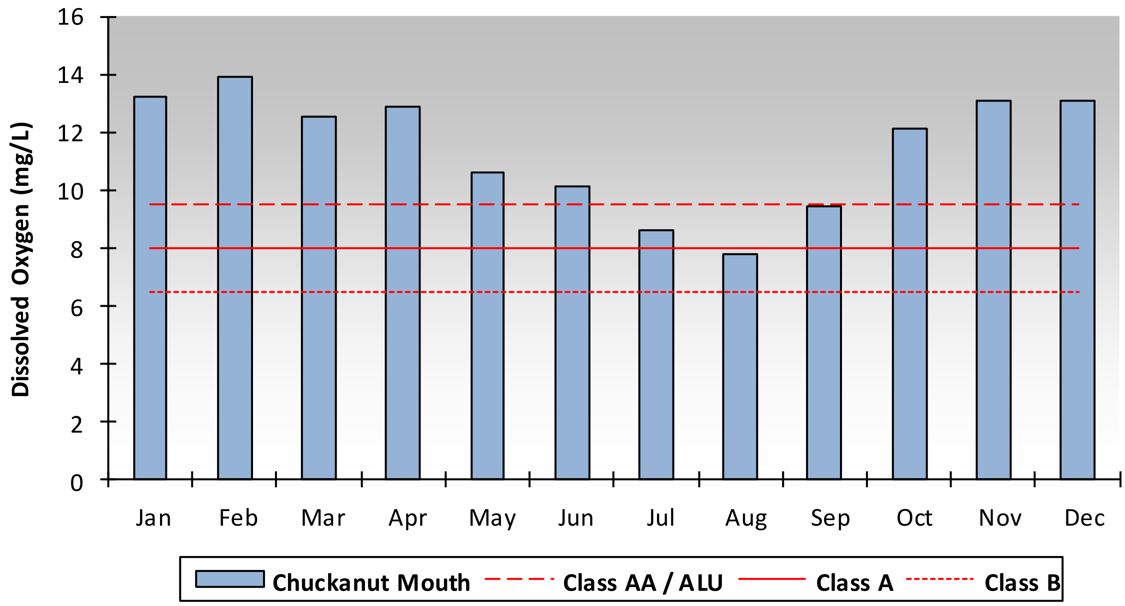


Figure 6.0-4. Monthly 2013 dissolved oxygen levels for Chuckanut Creek. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

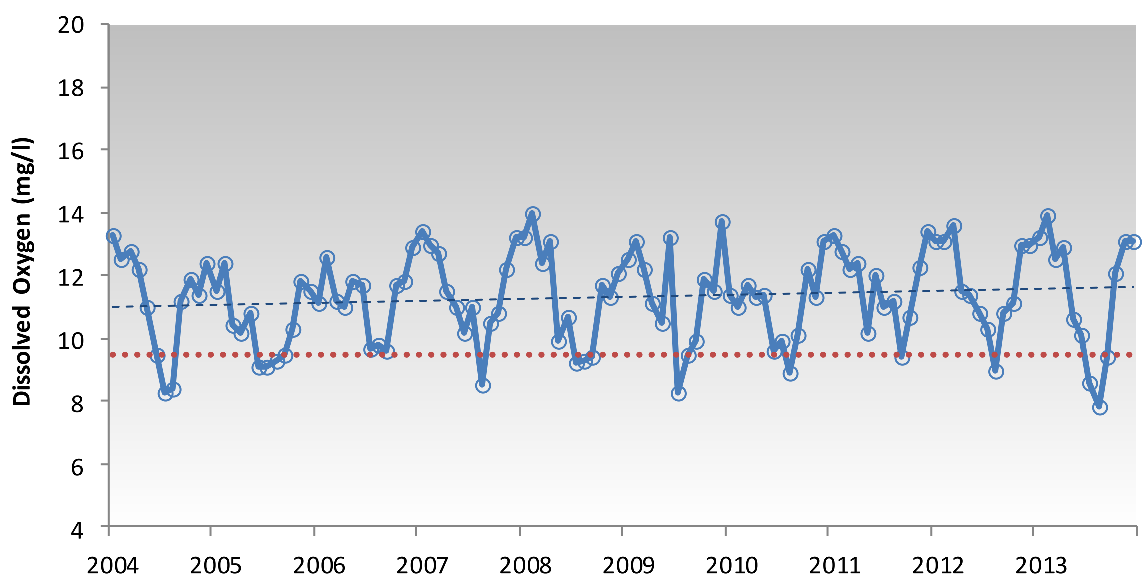


Figure 6.0-5. Ten year dissolved oxygen trend for Chuckanut Creek (2004-2013). Although the trendline (blue) appears positive, the probability that the slope is different than zero is not significant (p = 0.21, α = 0.05). Red dotted line indicates the Aquatic Life Use criteria of 9.5 mg/L.

Temperature

The recorded temperature for Chuckanut Creek did not exceed the Class A criteria (18°C) in 2013, and exceeded the Aquatic Life Use (ALU) (16°C) standard only once during the year. The temperature profile followed normal seasonal trends (Figure 6.0-6). The maximum temperature for 2013 was recorded in August at 16.4°C. The average temperature was 9.7° C.

Temperatures in Chuckanut Creek rarely exceed standards. The Core Summer Salmonid Habitat ALU standard has been exceeded only three times in the past 10 years. Though the slope of the 10 year trendline appears to be slightly negative, it is not significantly different from zero (Figure 6.0-7).

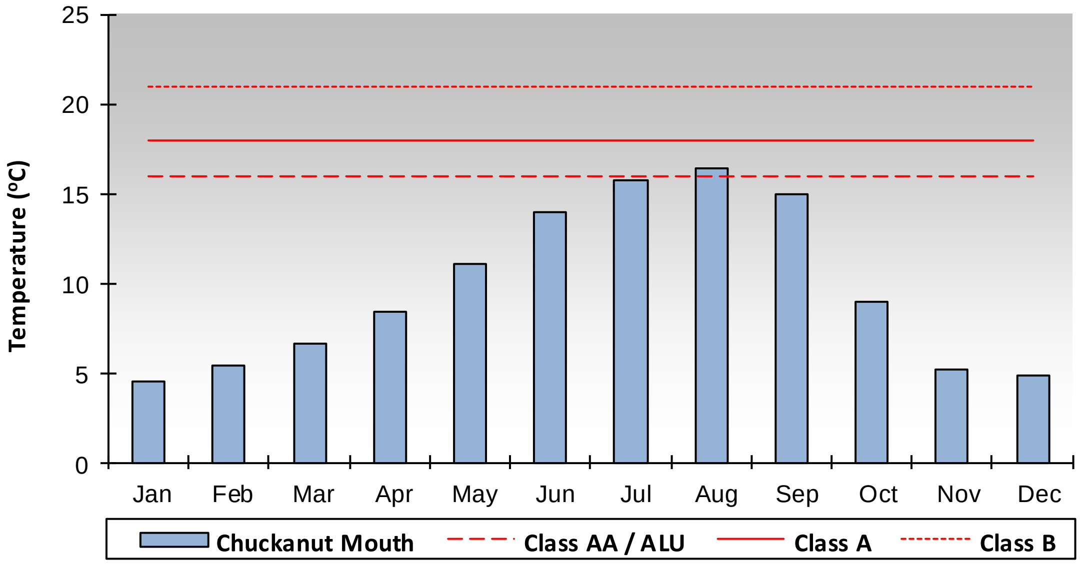


Figure 6.0-6. Monthly temperature measurements for the Chuckanut Creek sampling site in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). The Core Summer Salmonid Habitat ALU is equivalent to Class AA.

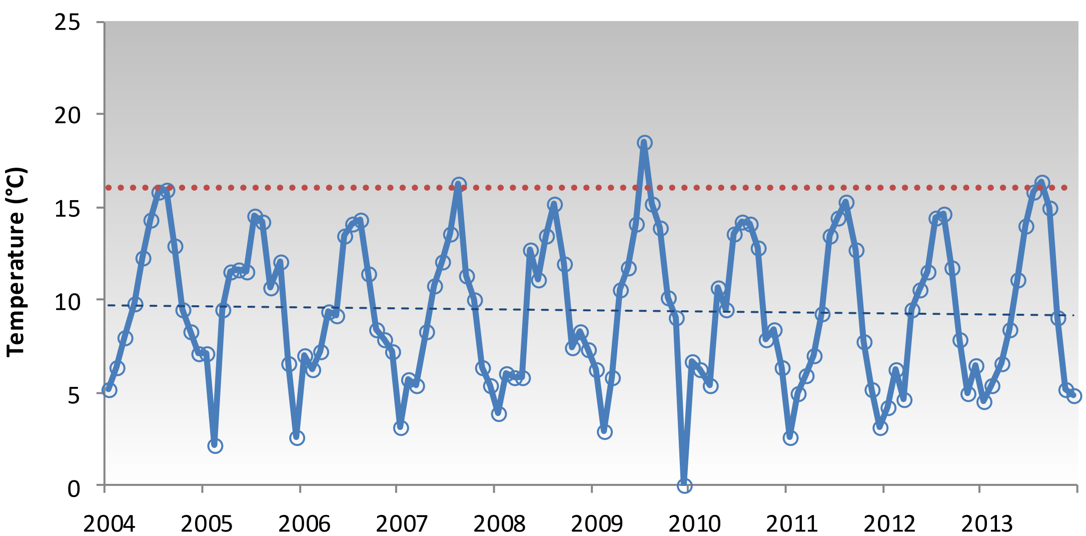


Figure 6.0-7. Ten year temperature trend for Chuckanut Creek (2004-2013). Although the trendline (blue) appears slightly negative, the probability that the slope is different than zero is not significant ($p = 0.64$, $\alpha = 0.05$). Red dotted line indicates the Aquatic Life Use criteria of 16°C.

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). This trend continued in 2013. The maximum turbidity measured was 12.1 NTU in both January and November. The minimum turbidity measured was 0.6 NTU in August. Higher turbidities are expected during the winter months as more precipitation occurs at this time of year. The average turbidity for Chuckanut Creek in 2013 was 4.6 NTU, which is less than both the 5 year and 10 year averages. The ten year trendline slope is not significantly different than zero (Figure 6.0-8).

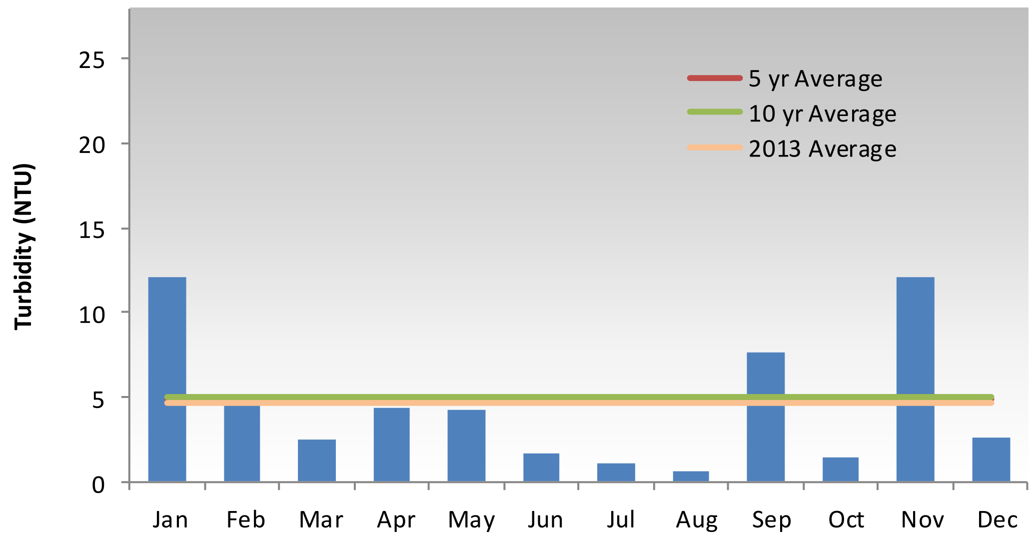


Figure 6.0-8. Monthly turbidity values and yearly averages for the Chuckanut Creek sampling site in 2013. Presented with yearly, 5-year and 10-year averages. Spikes in January, September and November are storm related.

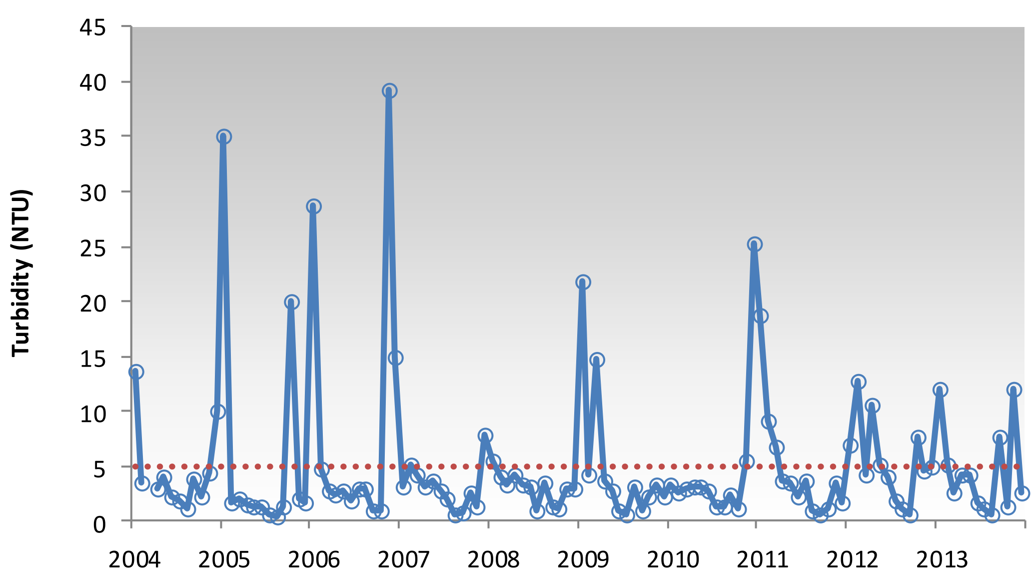


Figure 6.0-9. Ten year turbidity trend for Chuckanut Creek Mouth illustrate the effects of storm events on average turbidity. Red dotted line depicts the ten year average of 4.9 NTU.

Hydrology

The Chuckanut Creek gauging station has been in service since 2005. It is located approximately 300 feet downstream of the footbridge in Arroyo Park. Chuckanut Creek typically has higher volume of discharge than Padden Creek, but less than Squalicum Creek. Exceptions to this typical trend occur occasionally when rain events cause the peak flow of Padden Creek to spike higher than that of Chuckanut.

In 2013, Chuckanut Creek had a minimum discharge (flow) of < 0.1 cubic feet per second (cfs) on multiple days in July and August, a maximum discharge of 349 cfs on 1/9 and an average discharge of 13.1 cfs.

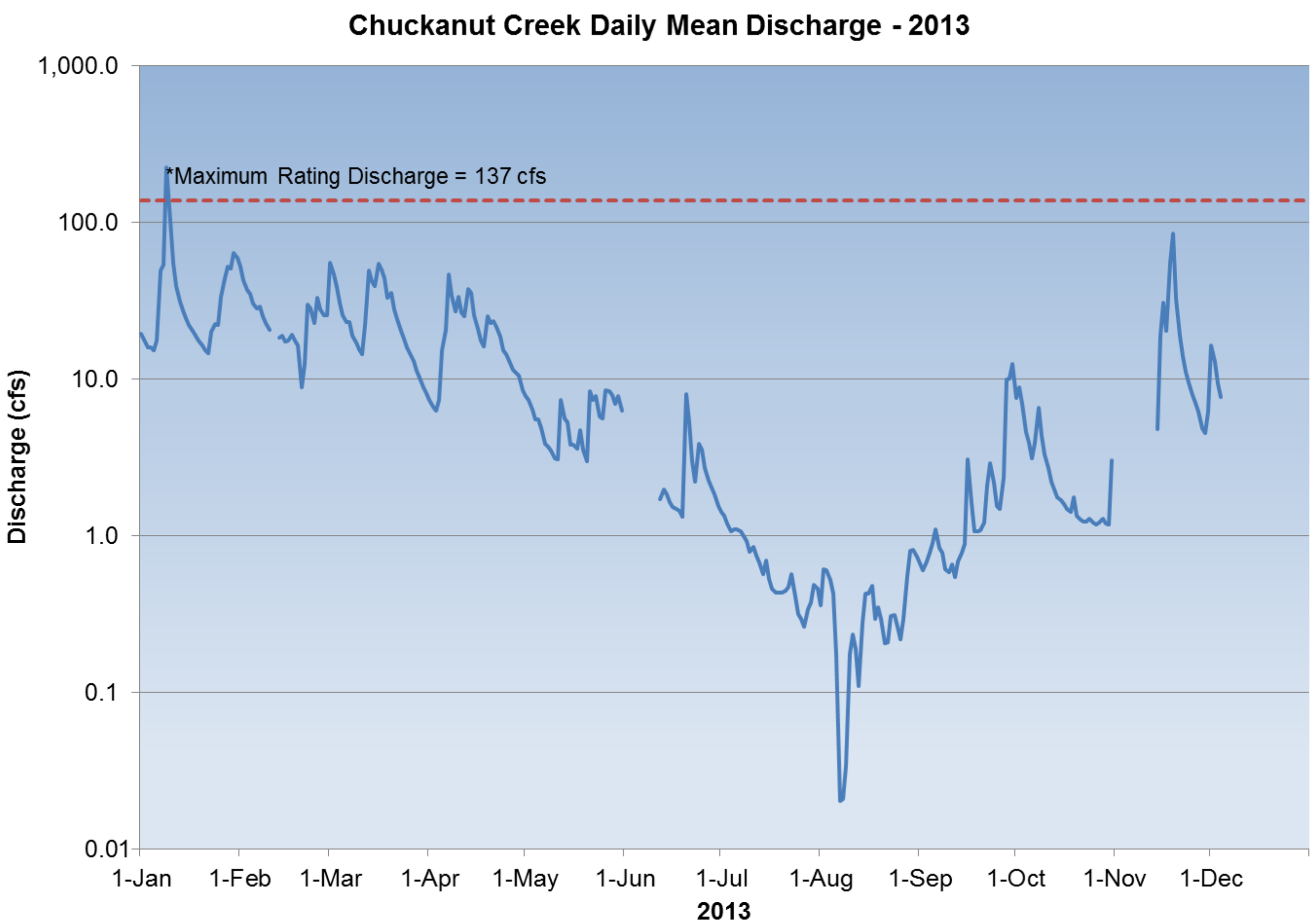


Figure 6.0-10. Daily mean discharge on Chuckanut Creek during 2013. Discharge values above the maximum rating discharge of 137 cfs are of poor quality and should be interpreted cautiously. Breaks in record are due to equipment malfunction. This hydrograph uses a logarithmic scale.

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 is 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 that is currently being removed.

Padden Creek is sampled at four locations: 38th St., 30th St. (Figure 7.0-4), 22nd St. (Figure 7.0-15), and near the mouth (Figure 7.0-5), approximately 1500 feet upstream from its discharge point. Connelly Creek, the main tributary to Padden Creek, is sampled at Donovan Ave. (Figure 7.0-8).

Based on conventional sampling in 2013, none of the sites in the Padden Creek drainage were able to meet all of the Aquatic Life Use (ALU) and Recreational Use (RU) standards. However, Padden Creek at 38th street did meet overall Class A water quality standards. The sites at 30th Street, 22nd Street, the Mouth and Connelly Creek were not able to meet overall Class A or Class B standards.

Results of monitoring indicate that only the 38th Street site met the stringent ≤16.0°C ALU/Class AA temperature standard in 2013. All other sites in the drainage met the ≤18.0°C Class A standard. All sites,

including Connelly Creek, met the Class A dissolved oxygen standard (≥8.0 mg/L), but none were able to meet the ALU/Class AA standard of ≥ 9.5 mg/L.

The limiting factor for most of the Padden Creek drainage sites was fecal coliform values. Only the 38th Street site was able to meet any of the class based standards, receiving a class A fecal coliform rating for 2013 (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml).

In 2013, the average turbidities for the 38th Street, Padden Mouth and Connelly Creek sites were below both the 5-year and 10-year averages, while the 22nd and 30th Street sites were above. The highest average turbidity for 2013 was found at the Padden Creek Mouth (5.9 NTU), while Padden Creek at 38th St. had the lowest average turbidity at 2.7 NTU (Table 7.0-4).

As in years past, all sites on Padden Creek and Connelly Creek met the Aquatic Life Use (ALU) standards for pH (6.5 - 8.5 s.u.). Conductivity was also consistent with previous years.

Chronic Low Flow Conditions

Low flow conditions of 0.4 cfs or below have been recorded in Padden Creek in every year since the gauge station was installed in 2005. Historically, low flows have been documented in Padden Creek since the 1960's when the City stopped using Lake Padden as a water supply. In 2002 the Washington Department of Fish and Wildlife (WDFW) approved a request from the Nooksack Salmon Enhancement Association (NSEA) to install a siphon pulling water from Lake Padden in order to keep the creek at levels adequate to support fish populations downstream. However, the siphon was removed in 2005 after the City asked that Ecology be consulted regarding the effects of siphoning on Lake Padden shoreline habitat. Pipe flanges were subsequently installed in the Lake Padden control gate (Figure 7.0-1) in case siphoning is requested by state officials in the future. Information regarding Lake Padden water quality can be found here: http://www.wwu.edu/iws/ and here: http://w.p4lp.org/.

Figure 7.0-1. Dry control gate spillway at Lake Padden in September of 2011.

Fecal Coliform Bacteria

The fecal coliform levels found during sampling of Padden and Connelly Creeks followed the expected trend of higher levels in the summer months. Samples taken in September exhibit especially elevated levels due to first-flush rainfall conditions during collection. The geomeans for 2013 were similar to those in 2012 (Table 7.0-1). The number of samples that exceeded 200 CFU/100 ml is presented in Figures 7.0-2a&b.

With the exception of the 38th Street site, all of the monitoring locations in the Padden Creek Drainage had significant descending 10-year trends in fecal coliform

Table 7.0-1. Fecal coliform geomean values and 10-year trends for monitoring sites on Padden and Connelly Creeks in 2013.

Sampling Site	Geomean (CFU/100 ml)	Trend (CFU/100 ml/yr)
38th Street	25	0
30th Street	65	-1.8
Connelly	171	-20.7
22nd Street	319	-13.5
Mouth	198	-9.2

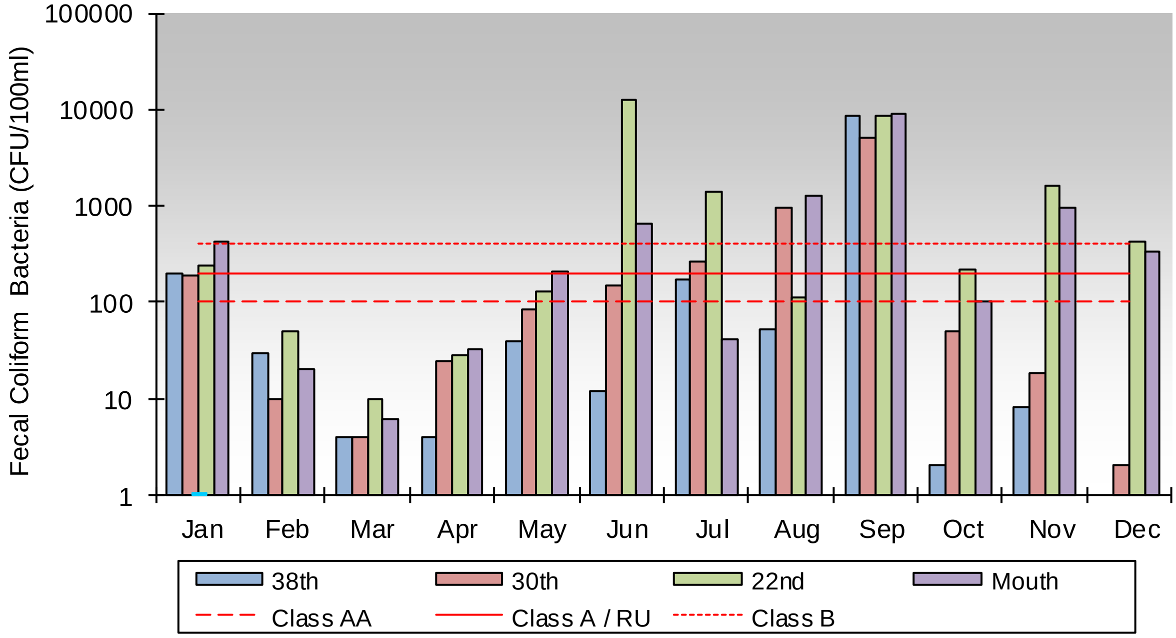


Figure 7.0-2a. Monthly 2013 fecal coliform levels for Padden Creek sampling sites. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

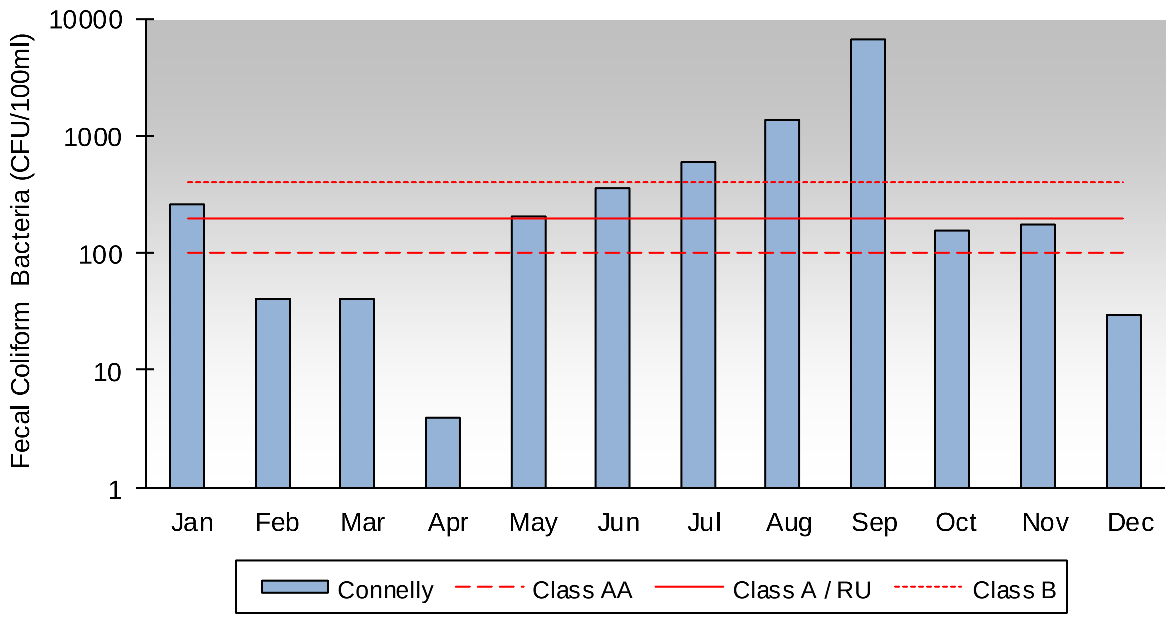
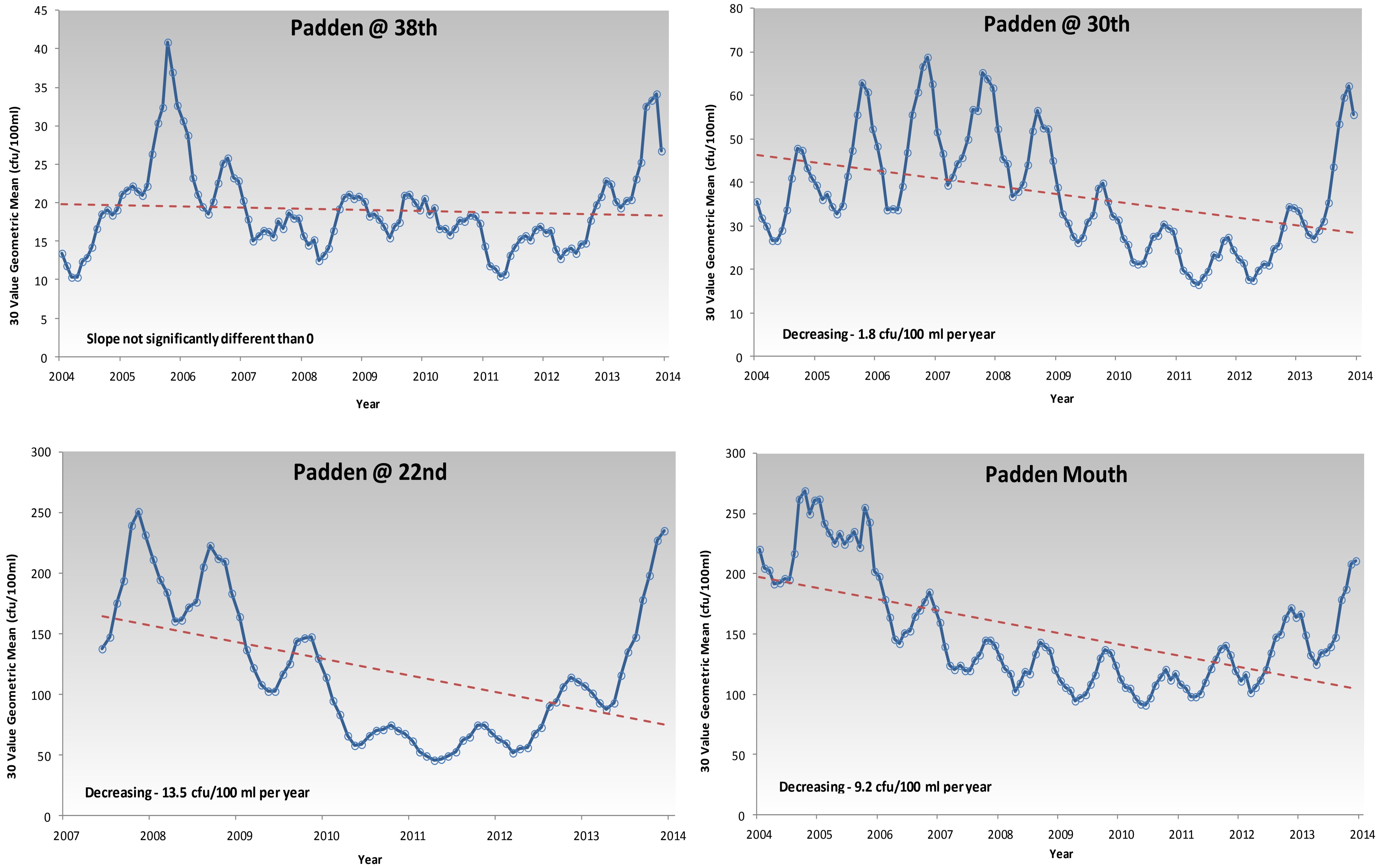
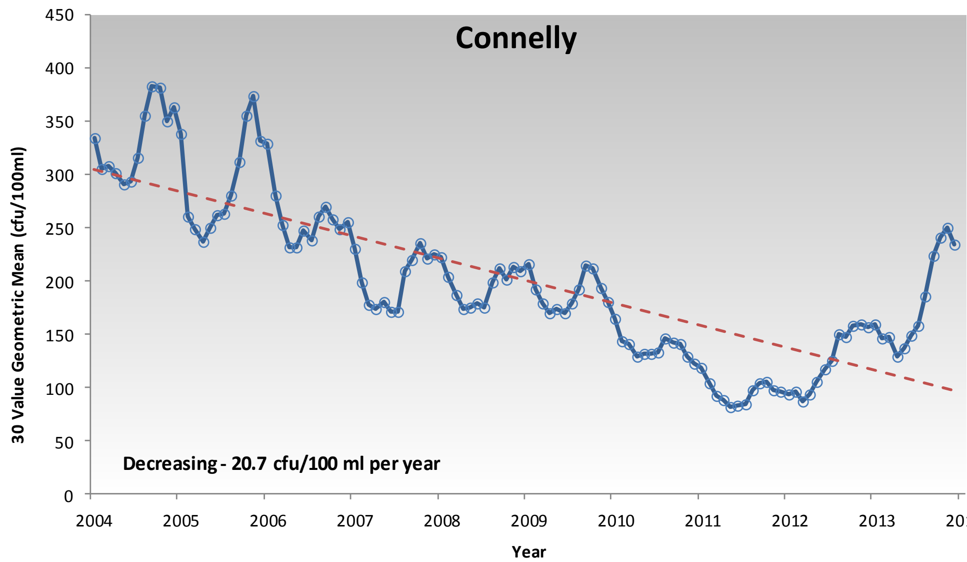


Figure 7.0-2b. Monthly 2013 fecal coliform levels for Connelly Creek sampling site. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A.. *Note this graph uses a logarithmic scale.*



Figures 7.0-3 a-d. Thirty value moving geometric mean trends for all fecal coliform samples collected 2004 through 2013. With the exception of the 38th Street site, all of the monitoring locations in the Padden Creek Drainage had significant descending 10-year trends in fecal coliform geomeans (38th: $p = 0.414$; 30th: $p = 8.28^{e-06}$; 22nd: $p = 3.00^{e-05}$; Mouth: $p = 4.46^{e-12}$, $\alpha = 0.05$). Noticeable uptick during 2013 is likely the influence of sampling during several large, first flush rain events that occurred during the period. Trendline in red.



Figures 7.0-3e. Thirty value moving geometric mean trend for all samples collected at the Connelly Creek site 2004 through 2013. Linear model analysis of the trendline shows significant descending trend of –20.7 cfu/100ml/yr ($p = 3.22^{e-27}$, α=0.05). Trendline in red.

Dissolved Oxygen

In 2013, all sites in the Padden Creek Drainage remained above the 8.0 mg/L Class A standard, but none were able to meet 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. Dissolved oxygen in these two creeks follows an expected trend with lower levels in the warmer summer months (Figures 7.0-6a&b). Average dissolved oxygen values are provided in Table 7.0-2.

While most of the ten year dissolved oxygen trendlines appear positive, recorded values have fallen below the 9.5 mg/L ALU standard at least once every year for every site, and none of the slopes are significantly different than zero (Figure 7.0-7a-e.).

Figure 7.0-4. Padden Creek 30th St. sampling site.

Figure 7.0-5. Padden Creek mouth sampling site.

Table 7.0-2. Average dissolved oxygen values for Padden and Connelly Creeks in 2013.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Average DO (mg/L)	10.9	10.9	10.2	10.8	10.9

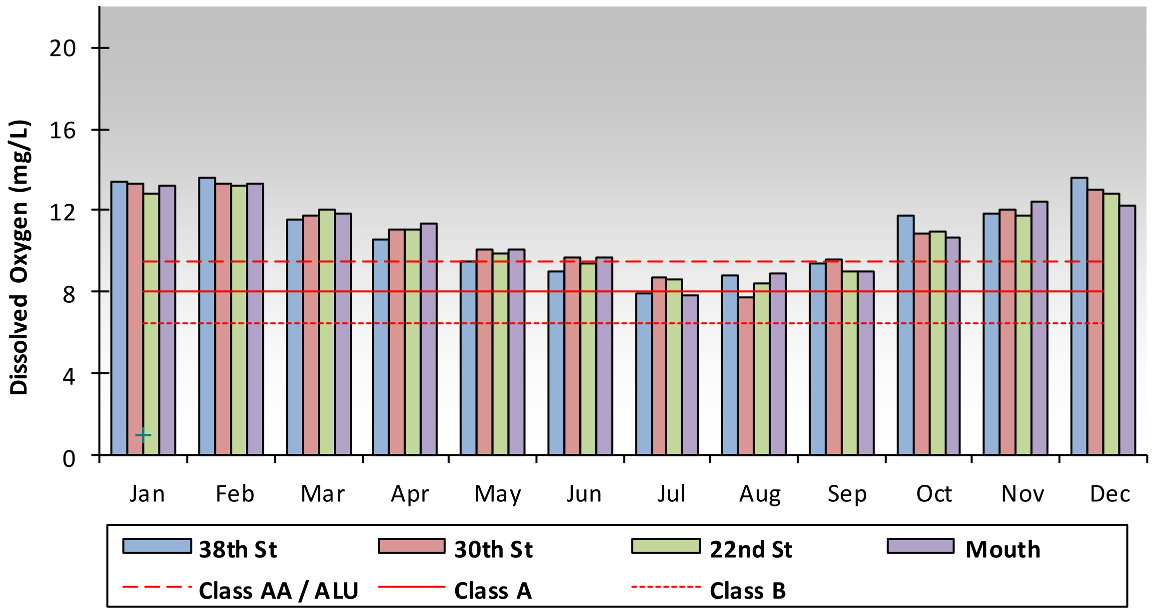


Figure 7.0-6a. Dissolved oxygen for Padden Creek sampling sites by month in 2013. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

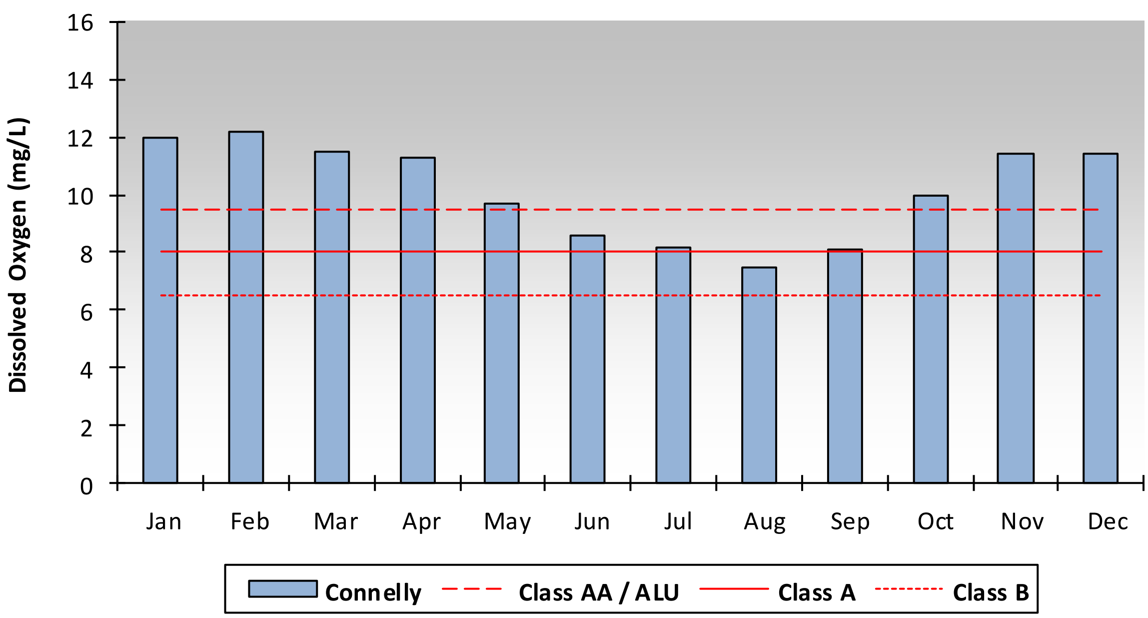
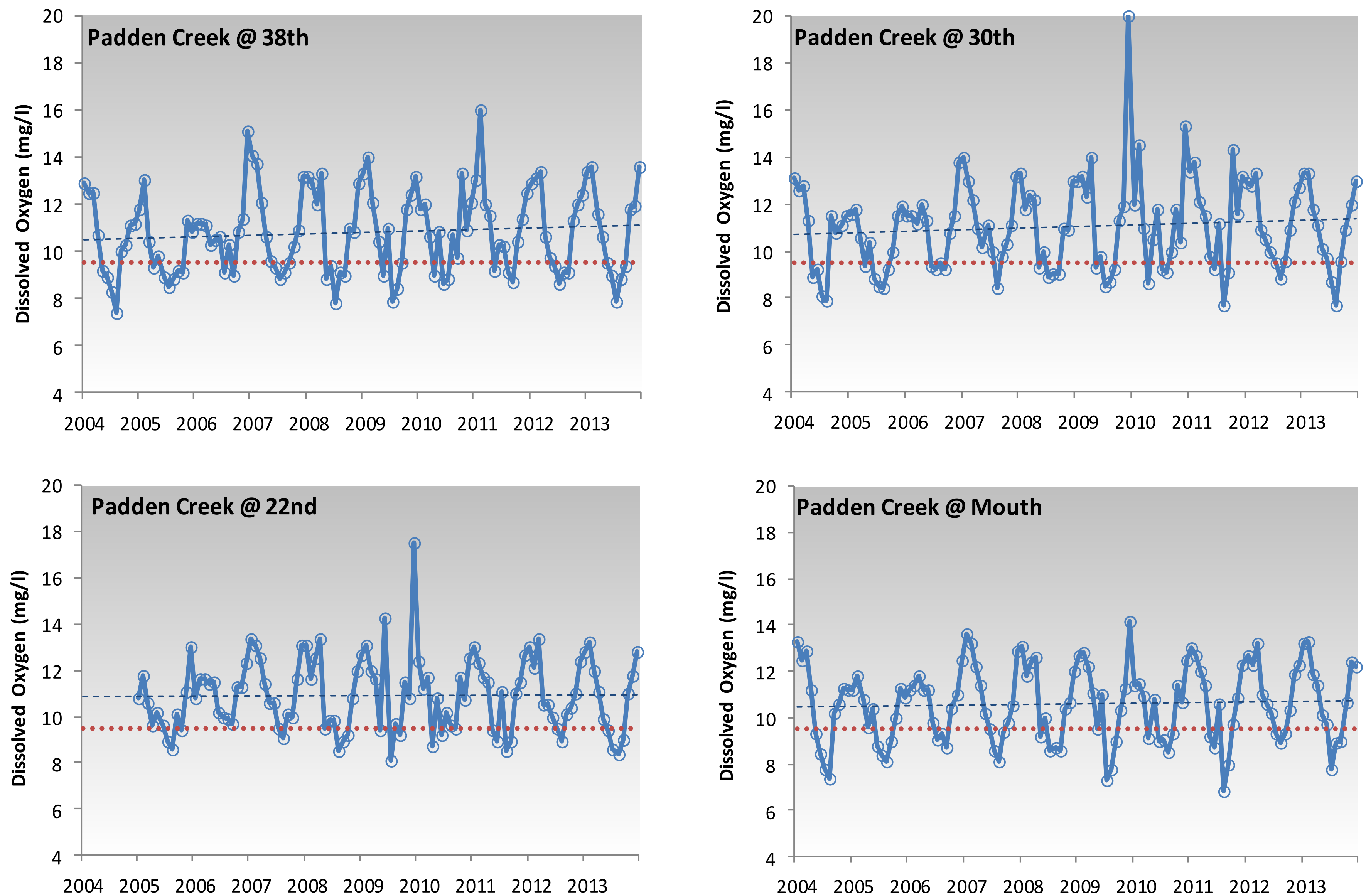


Figure 7.0-6b. Dissolved oxygen for the Connelly Creek sampling site by month in 2013. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.



Figures 7.0-7a-d. Ten year dissolved oxygen trend for Padden Creek sites (2004-2013). Although the trendlines (blue) appear positive, the probability that the slopes are different than zero is not significant (38th: $p = 0.30$; 30th: $p = 0.29$; 22nd: $p = 0.87$; Mouth: $p = 0.55$, $\alpha = 0.05$). Red dotted line indicates the Aquatic Life Use criteria of 9.5 mg/L.

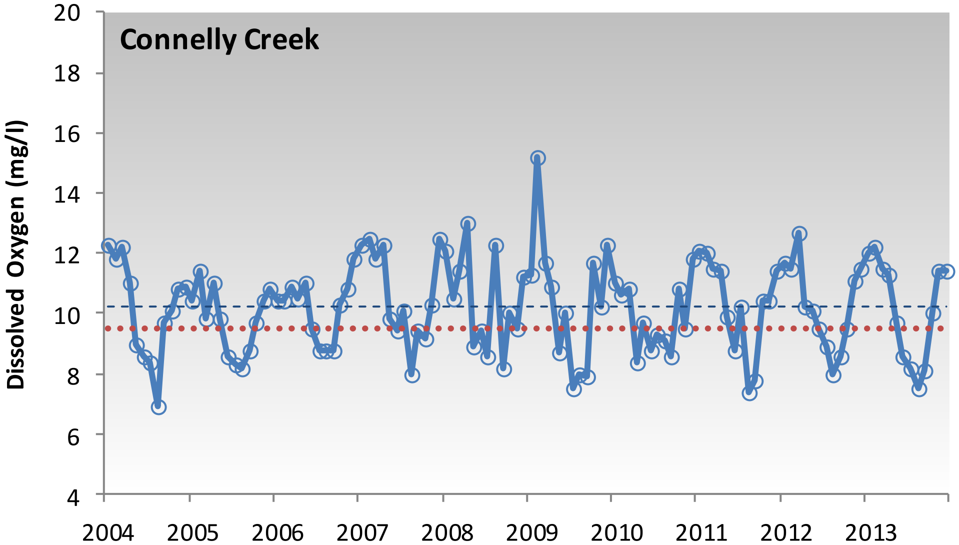


Figure 7.0-7e. Ten year dissolved oxygen trend (blue) for Connelly Creek sites (2004-2013). The probability that the slope is different than zero is not significant (p = 0.94, α = 0.5).

Figure 7.0-8. Connelly Creek sampling site.

Temperature

Only Padden Creek at 38th Street was able to meet the 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU)/Class AA criterion in 2013. All other sites in the drainage met the 18°C Class A standard. 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. The temperature profiles for all segments in 2013 show the expected seasonal trend with higher temperatures in the summer months (Figures 7.0-9a&b). Average temperatures are provided in Table 7.0-3.

Although some of the ten year trendlines appear slightly negative, none of the slopes are significantly different than zero (Figure 7.0-10a-e.).

Table 7.0-3. Average temperatures for sampling sites on Padden and Connelly Creek, 2013.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Average Temperature (°C)	11.2	11.1	11.0	11.0	11.1

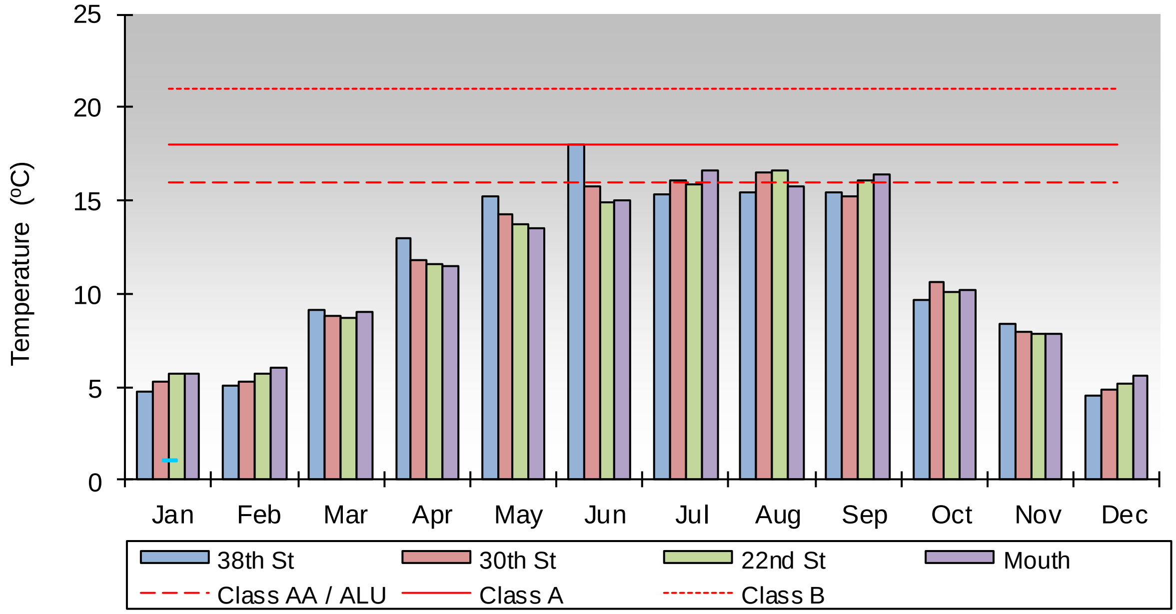


Figure 7.0-9a. Monthly temperature measurements for Padden Creek sampling sites in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

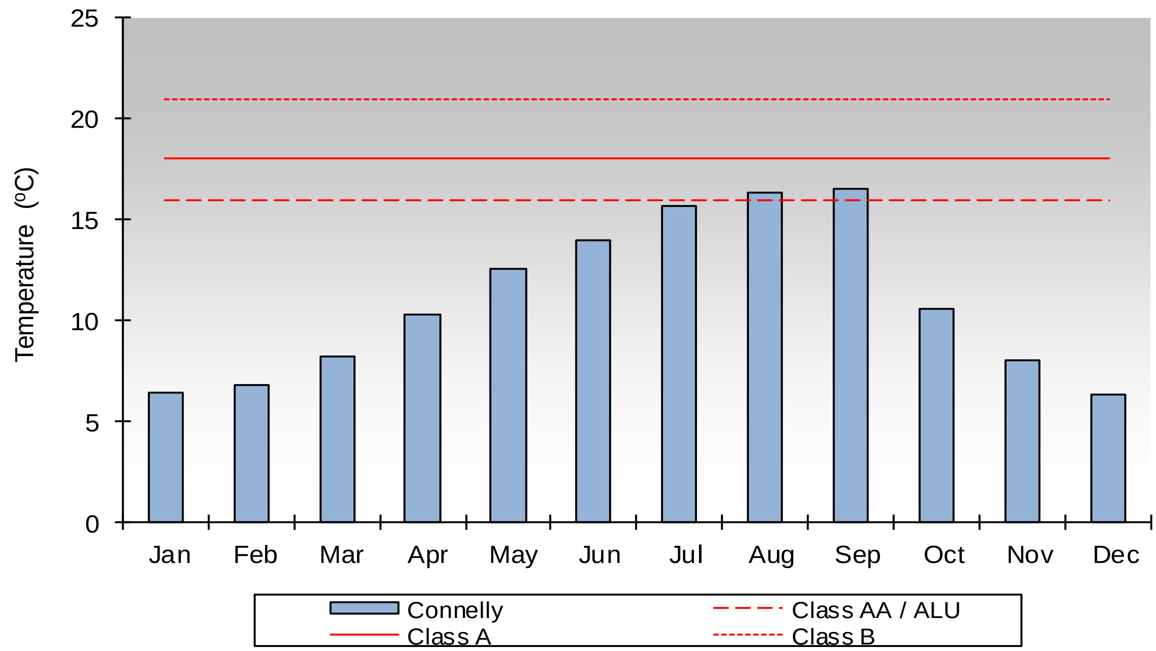
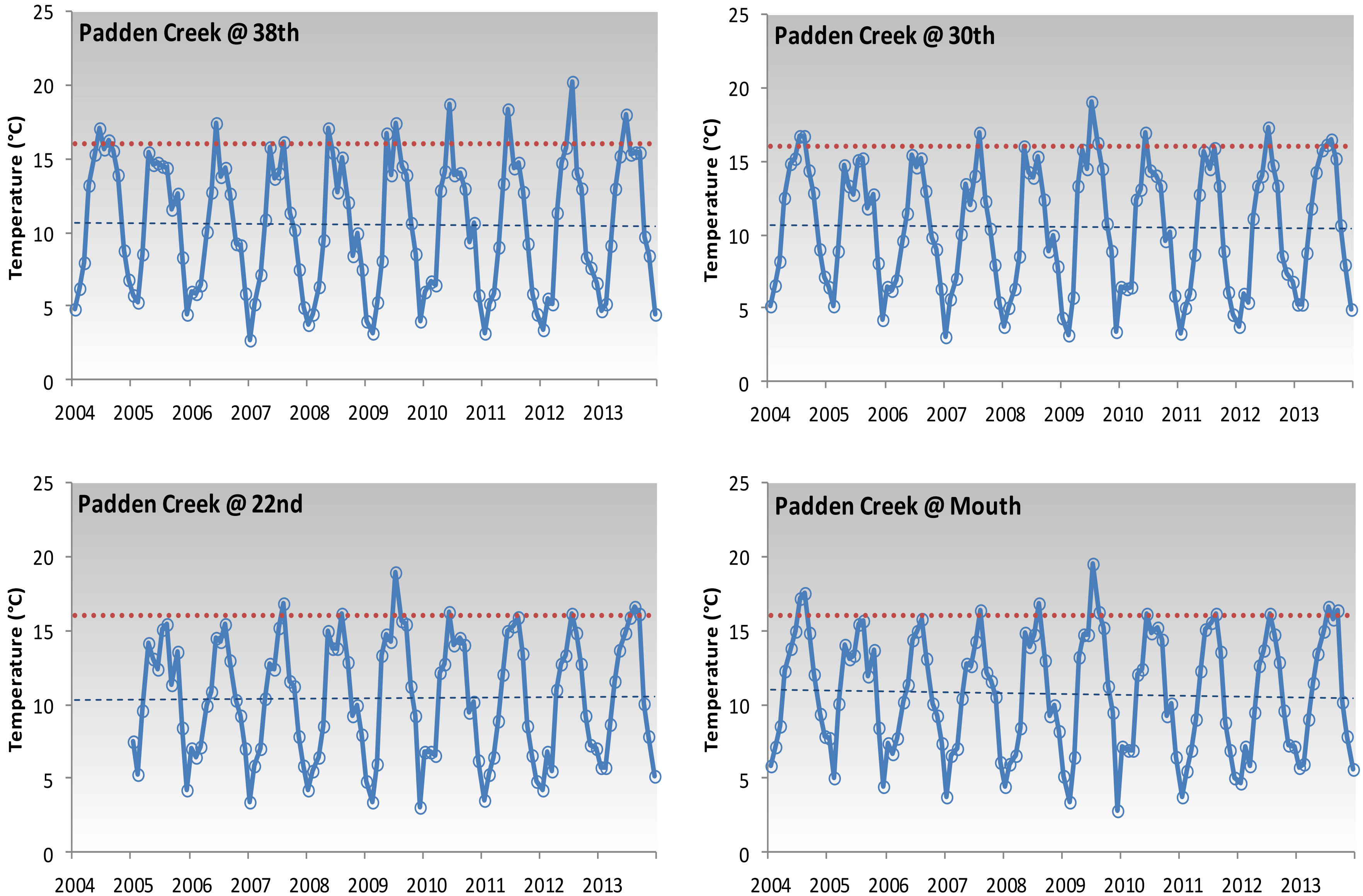


Figure 7.0-9b. Monthly temperature measurements for the Connelly Creek sampling site in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.



Figures 7.0-10a-d. Ten year temperature trends for Padden Creek sites (2004-2013). Although some trendlines (blue) appear slightly negative, the probability that the slopes are different than zero is not significant for all sites (38th: $p = 0.87$; 30th: $p = 0.85$; 22nd: $p = 0.86$; Mouth: $p = 0.66$, $\alpha = 0.05$). Red dotted line indicates the Aquatic Life Use criteria of 16°C.

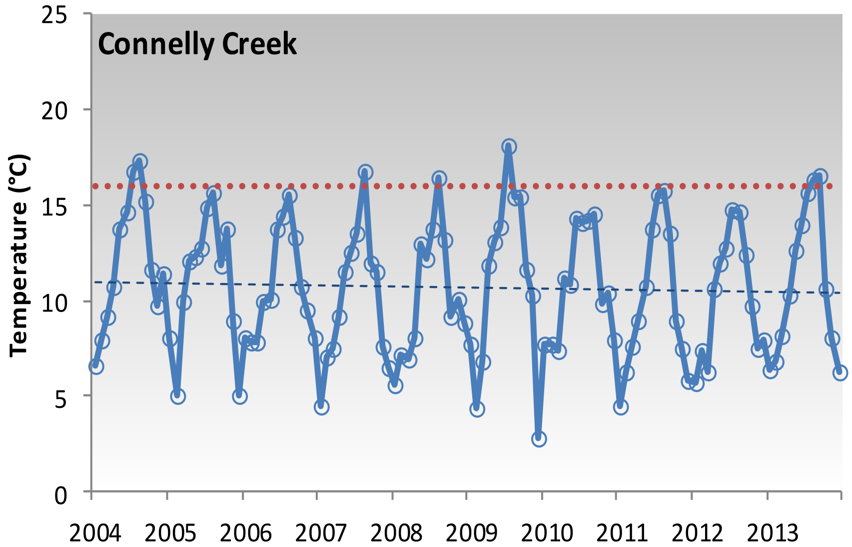


Figure 7.0-10e. Ten year temperature trend for Connelly Creek (2004-2013). Although trendline (blue) appears slightly negative, the probability that the slope is different than zero is not significant ($p = 0.56$, $\alpha = 0.05$).

pH

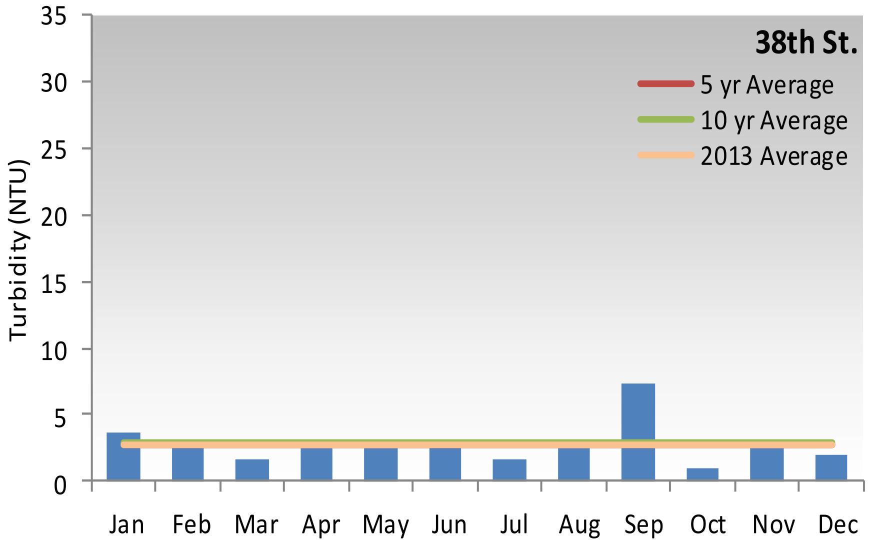
The pH at all sites monitored on Padden and Connelly Creeks generally falls within the range prescribed by Ecology for Aquatic Life Use (ALU) and all classes of freshwater bodies (6.5 to 8.5). In 2013, pH for all sites fell within the prescribed range. Graphs are not included in this section because pH is so rarely exceeded

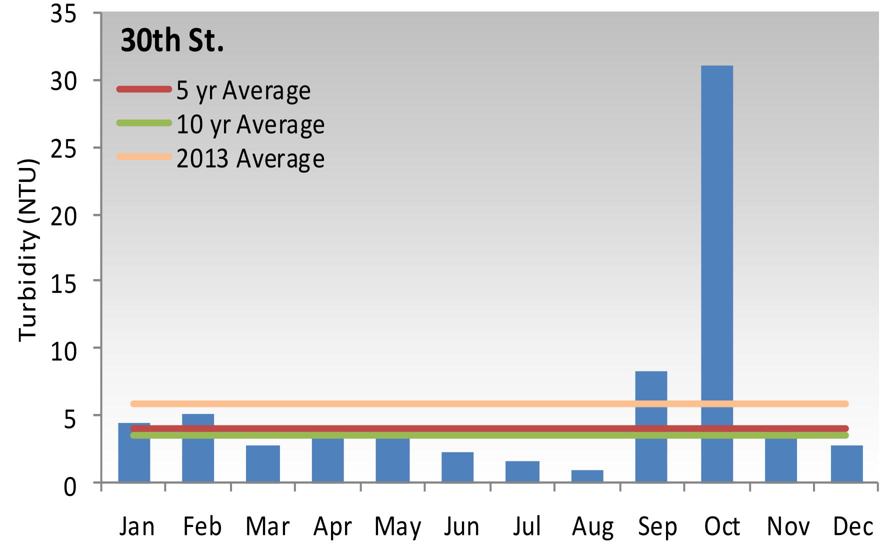
Turbidity

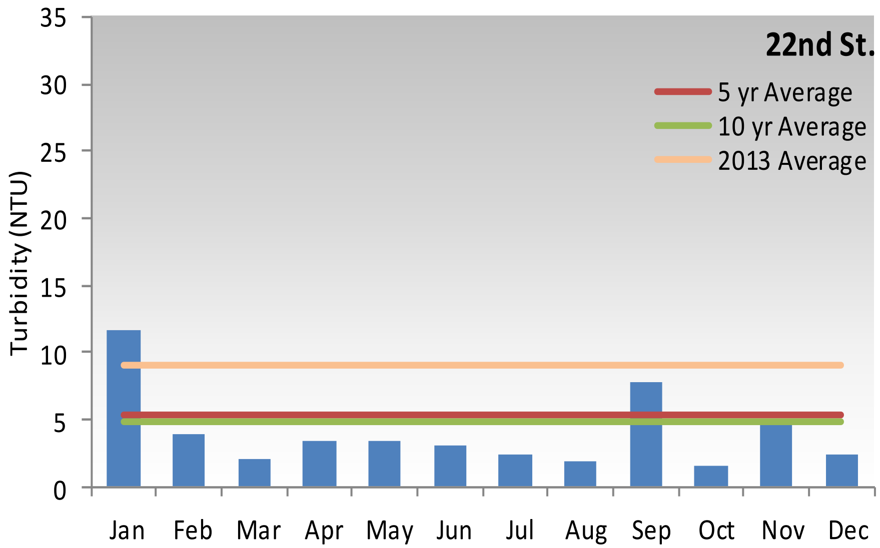
Turbidity in Padden and Connelly Creeks is generally below 10 NTU, with occasional spikes. This trend continued in 2013, with the average turbidities for the 38th Street, Padden Mouth and Connelly Creek sites below both the 5-year and 10-year averages. However, both the 22nd and 30th Street sites were above the 5-year and 10-year averages. Rain events during January and September are likely the cause of the higher than usual turbidity at 22nd, but the elevated turbidity at 30th street is due to a spike of unknown cause in October (31.1 NTU). Average, maximum and minimum turbidity values for 2013 are listed in Table 7.0-4. Average turbidity values for Padden Creek in 2013 are displayed alongside their respective 5-year and 10-year averages in figures 7.0-11a-d, while 10-year trendlines are displayed in figures 7.0-12a-d. Connelly Creek average turbidity and trendlines are displayed in figures 7.0-13&14. None of the trendlines were found to be significantly different than zero in 2013.

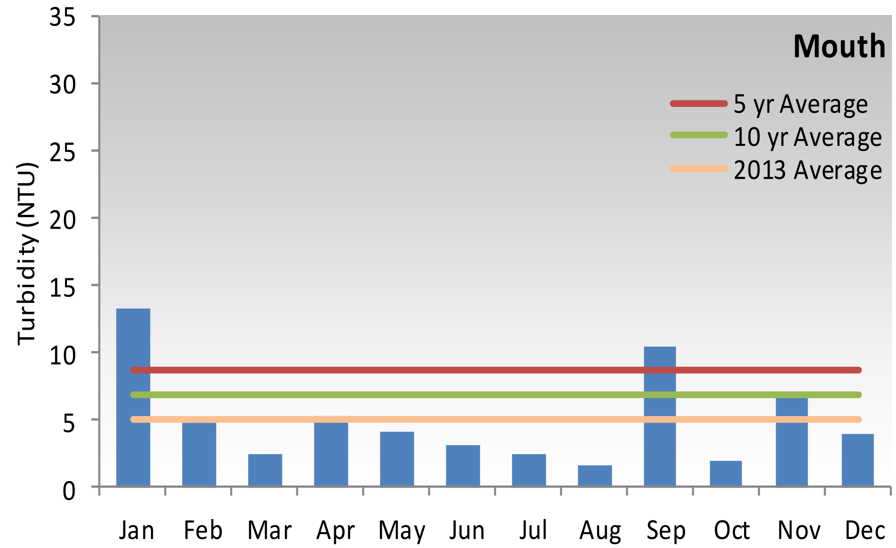
Table 7.0-4. The average, maximum and minimum turbidity for sampling sites on Padden and Connelly Creek in 2013.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
2012 Average (NTU)	2.7	5.9	5.5	4.0	5.0
2012 Maximum (NTU)	7.4	31.1	20.4	11.6	13.2
2012 Minimum (NTU)	1.0	1.0	1.7	1.5	1.6

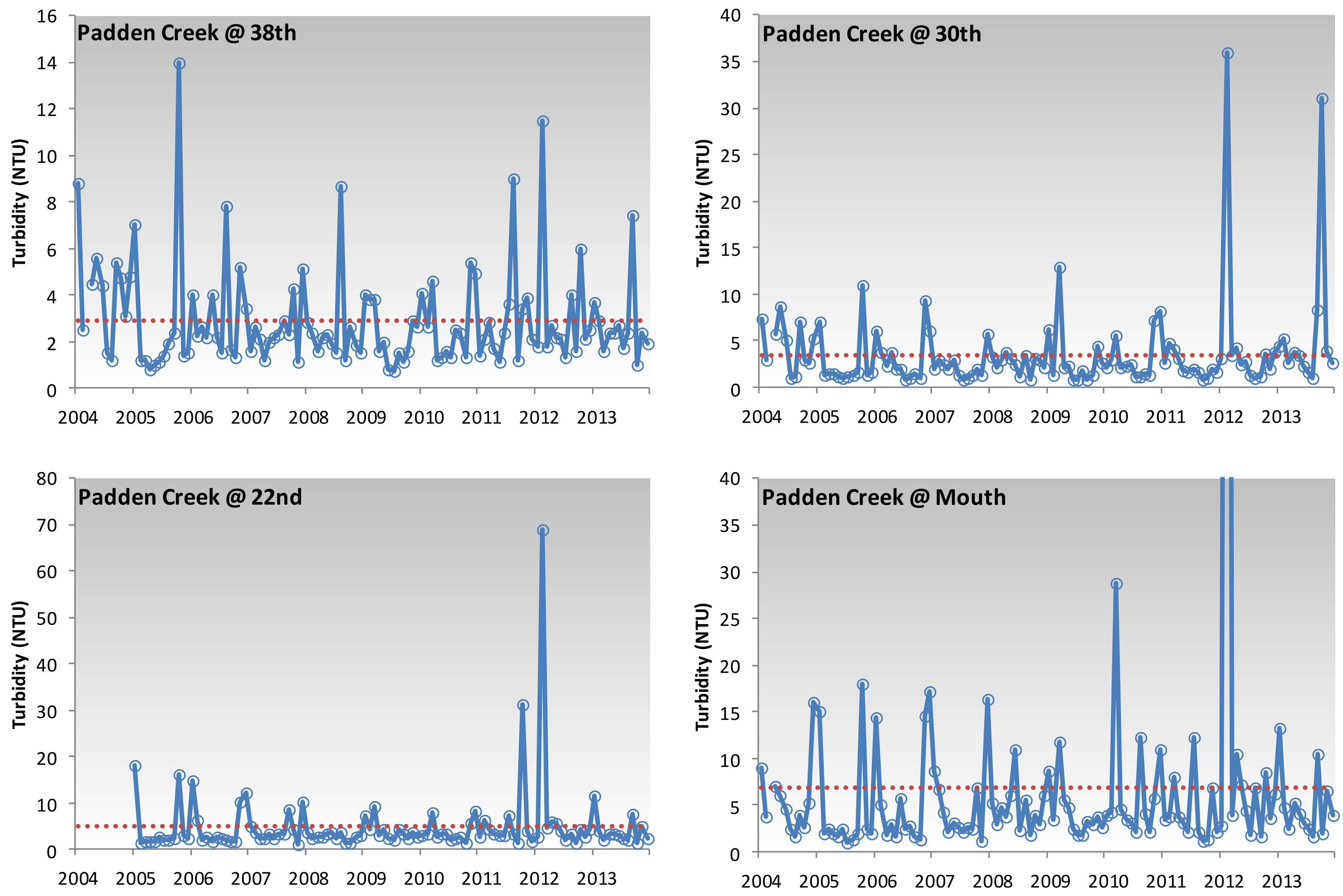








Figures 7.0-11a-d. Monthly turbidity values for Padden Creek sampling sites at 38th St., 30th St. and the Connelly Creek during 2013. Presented with yearly, 5-year and 10-year averages.



Figures 7.0-12a-d. Ten year turbidity trends for Padden Creek sites illustrate the effects of storm events on average turbidity. Red dotted lines depict the ten year averages. Trendlines (not shown) are not significantly different than zero (38th: $p = 0.36$; 30th: $p = 0.23$; 22nd: $p = 0.45$; Mouth: $p = 0.31$, $\alpha = 0.05$).

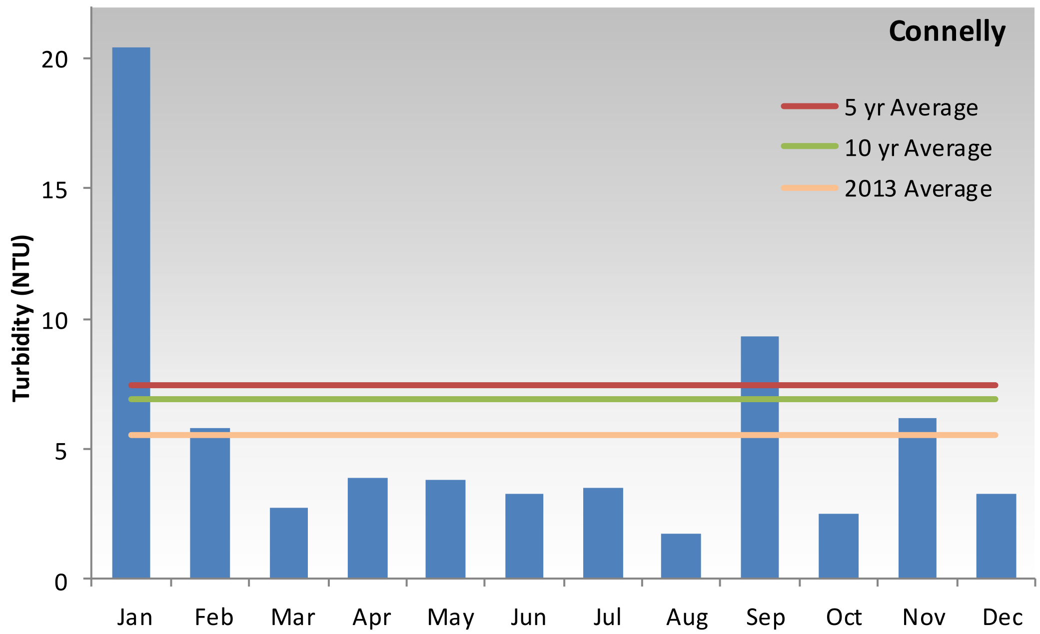


Figure 7.0-13. Monthly turbidity values for Connelly Creek sampling site during 2013. Presented with yearly, 5-year and 10-year averages.

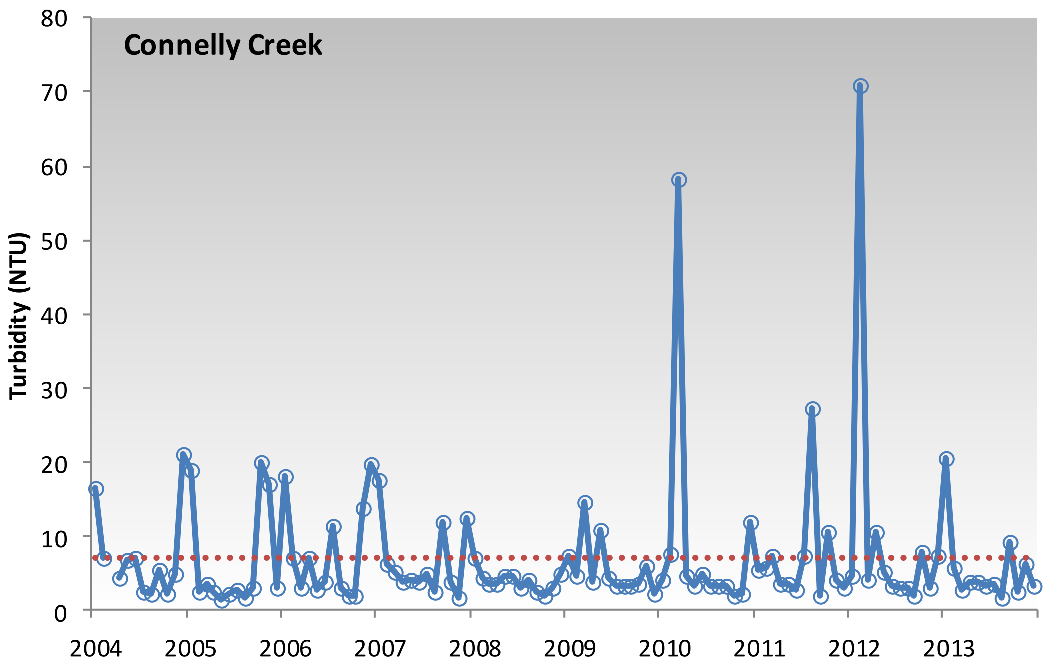


Figure 7.0-14. Ten year turbidity trend for Connelly Creek illustrates the effects of storm events on average turbidity. Red dotted lines depict the ten year averages. Trendlines (not shown) are not significantly different than zero (p = 0.87, α = 0.05).

Hydrology

The Padden Creek gauging station has been in service since 2005. It is located in Fairhaven Park approximately 50 feet downstream of the footbridge below the playground. Overall, Padden Creek has lowest discharge volume of all of Bellingham's gauged sites, yet it is also prone to very sudden and steep increases in flow at the start of rain events.

Padden Creek is well known for its low flows during the summer months (Figures 7.0-2 and 7.0-15). Only the contributions of Connelly Creek keep it's downstream reaches flowing. Without adequate flow, it is nearly impossible to meet all of Ecology's water quality criteria.

In 2013, Padden Creek at the gauge had a minimum discharge (flow) of 0.17 cubic feet per second (cfs) August 22nd-23rd, a maximum discharge of 84.9 cfs on January 9th and an average discharge of 7.47 cfs. The data gap during October and November was due to data logger malfunction.

Figure 7.0-15. Low flows at the 22nd St. site on Padden Creek. Most of the visible flow is from Connelly Creek.

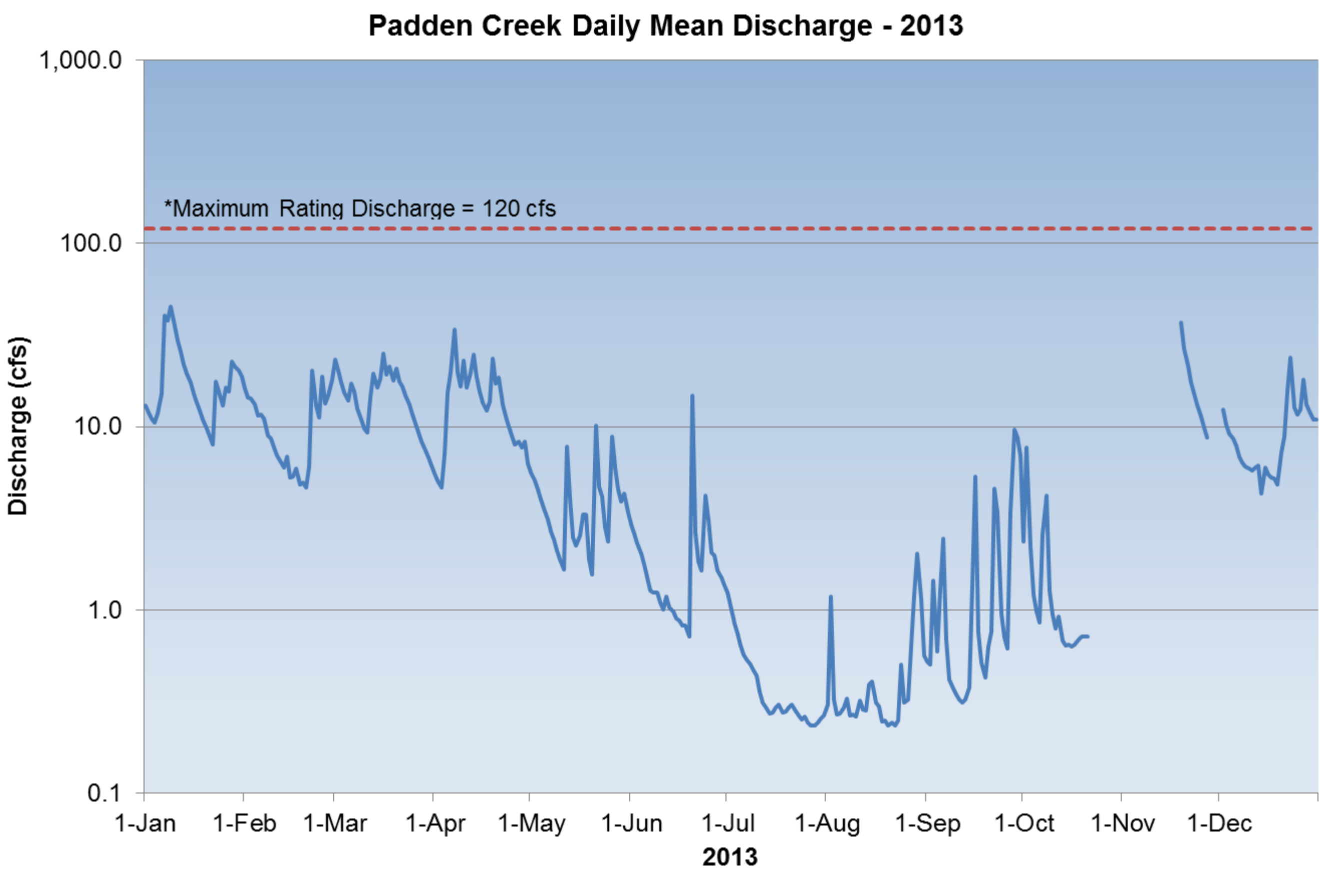
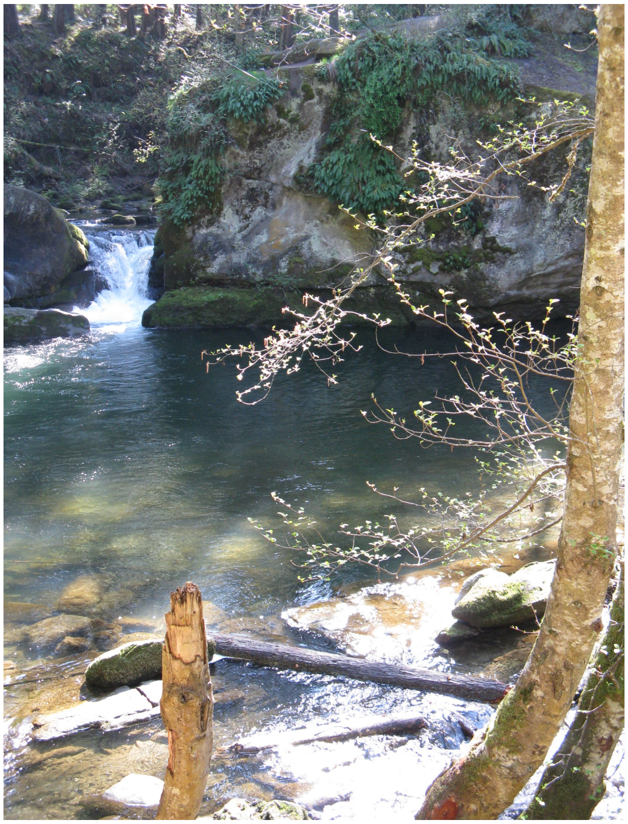


Figure 7.0-13. Daily mean discharge on Padden Creek during 2013. Discharge values above the maximum rating discharge of 120 cfs are of poor quality and should be interpreted cautiously. Data deleted during May due to the sensor being exposed to air during low flows. Data gap during Oct. - Nov. due to equipment malfunction. This hydrograph uses a logarithmic scale.

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. More information regarding Lake Whatcom water quality can be found at: http://www.cob.org/services/environment/lake-whatcom/index.aspx. From the lake outlet, 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 constructed conveyance 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 flows through constructed channels 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 8.0-6), and at Dupont St. (Figure 8.0-7). Four Whatcom Creek tributaries are sampled. Hanna Creek (Figure 8.0-10) is sampled below the City of Bellingham Water Treatment Plant approximately 1000 feet upstream from the confluence with Whatcom Creek. Cemetery Creek (Figure 8.0-11) is sampled near the Haskell Business Center, just upstream from the confluence with Whatcom Creek. Lincoln Creek (Figure 8.0-14) is sampled at a location adjacent to the Frank Geri softball fields and approximately 1200 feet upstream from the confluence with Whatcom Creek. Fever Creek (Figure 8.0-15) is sampled at Valencia Street approximately 3500 feet upstream from the confluence with Whatcom Creek (see the Whatcom Drainage Map for sampling locations).

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.). Fecal coliform data in the 2004 report of the study detailed the loading of fecal coliforms to the creek system. The City and Department of Ecology are now working cooperatively under a TMDL plan to reduce fecal coliform bacteria in Whatcom Creek (Hood, 2006).

With the exception of Dupont Street, every site on Whatcom Creek met the Primary Contact Recreational Use Standard for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples > 200 CFU/100 ml) in 2013. None of the tributaries were able to meet the Recreational Use Standard. In addition, no site along Whatcom Creek or its tributaries met the Aquatic

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

Life Use (ALU) temperature criterion of 16° C or the dissolved oxygen ALU criterion of (≥9.5 mg/L). All sites remained within the designated pH ALU range of 6.5-8.5.

In 2013, no Whatcom Drainage sites achieved the overall Class A designation. All Whatcom Creek sites did meet the criteria for overall Class B designation however. Due to high fecal coliform levels, none of the tributaries were awarded the Class A or B designation.

Hanna, Lincoln and Fever Creeks met the Class A temperature standard (≤ 18°C) in 2013, while all Whatcom Creek sites and Cemetery Creek met the Class B standard (≤ 21°C).

Hanna Creek, Fever Creek and the Valencia and I-5 sites on Whatcom Creek all met the Class A standard (8.0 mg/L), while Lincoln Creek and the Control Dam and Dupont Whatcom Creek sites met the Class B standard (6.5 mg/L). Cemetery Creek failed to meet either the Class A or Class B standard.

The Control Dam and Valencia Street sites on Whatcom Creek were the

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

only sites 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) in 2013. The I-5 site met the Class A standard (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml) and Hanna Creek and Dupont Street met Class B standards (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml). Cemetery, Lincoln and Fever Creeks were unable to meet Class A or Class B standards.

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

The highest average turbidity on Whatcom Creek was found at the Dupont site (4.3 NTU), while the Control Dam site had the lowest average turbidity (1.5 NTU). Of the tributaries, Cemetery Creek had the highest average turbidity (9.3 NTU) and Hanna Creek had the lowest (6.1 NTU). Average turbidity values for 2013 are listed along side respective 5 and 10 year averages in Table 8.0-4. Conductivity was consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels in Whatcom Creek and its tributaries were all greater than those found in 2012. Geomean values for all sampling locations are provided in Table 8.0-1. Bacterial concentrations were varied throughout the year in the Whatcom Creek drainage, and did not show an obvious trend of higher values in the summer months. High values in September are likely due a to a heavy, "first flush" rain event on the day of collection (Figures 8.0-4a&b).

While all the Whatcom Creek monitoring sites had significant descending 10-year trends in fecal coliform geomeans in 2013, trends in Whatcom tributaries were mixed. Cemetery Creek was negative, Lincoln and Fever Creeks were positive, and Hanna Creek was not significantly different than zero. Geomeans and trends can be found in Table 8.0-1 & Figures 8.0-5a–h.

Table 8.0-1. Fecal coliform geomean values and trends for sampling sites on Whatcom Creek and its tributaries, 2013.

Sampling Site	Geomean (CFU/100 ml)	Trend (CFU/100 ml/yr)
Control Dam	14	- 1.0
Valencia	17	- 1.1
I-5	25	- 1.9
Dupont	52	- 4.5
Hanna	110	0
Cemetery	152	- 17.2
Lincoln	198	+ 7.1
Fever	299	+ 11.1

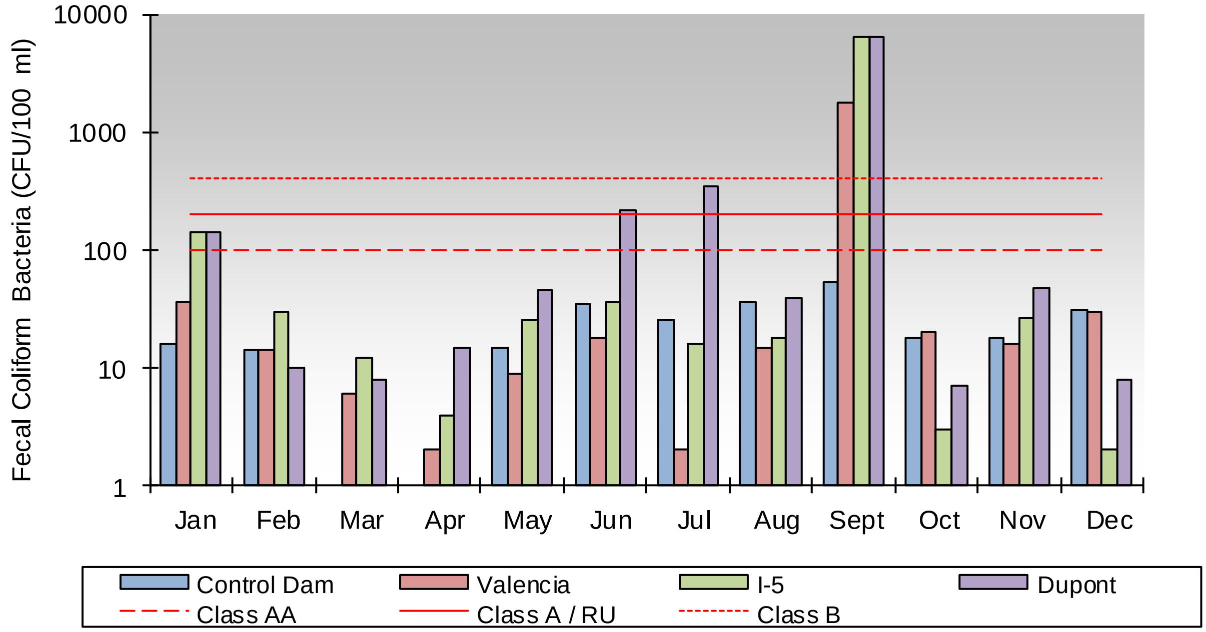


Figure 8.0-6a. Monthly 2013 fecal coliform levels for sampling sites on Whatcom Creek. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

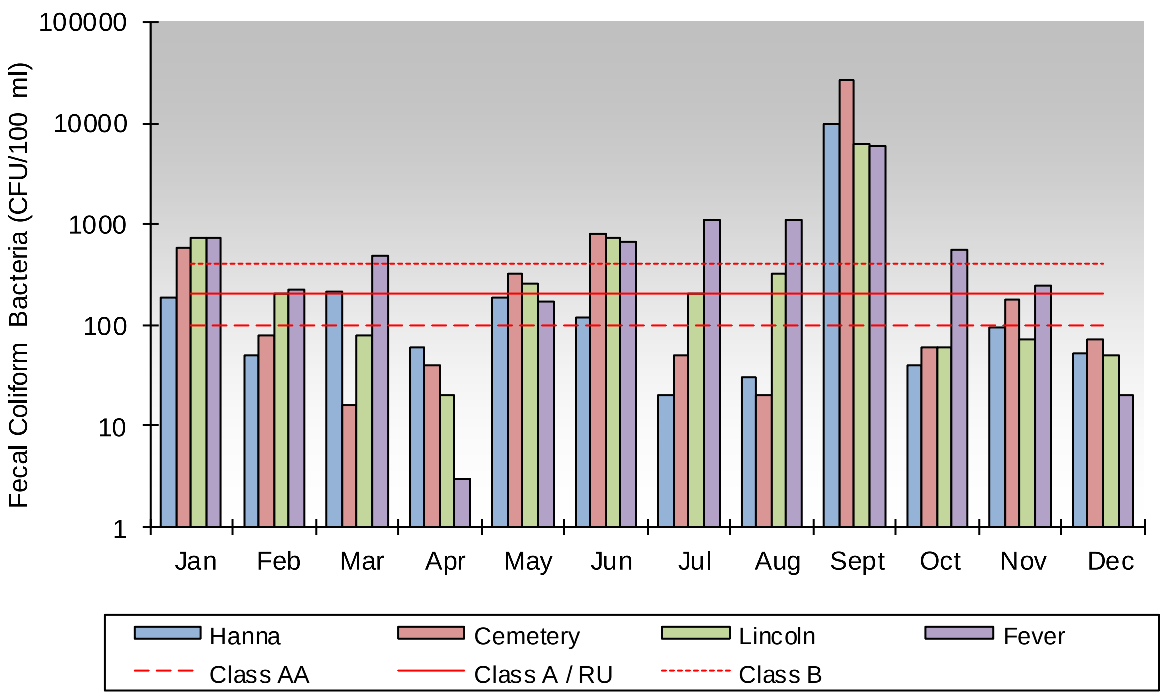
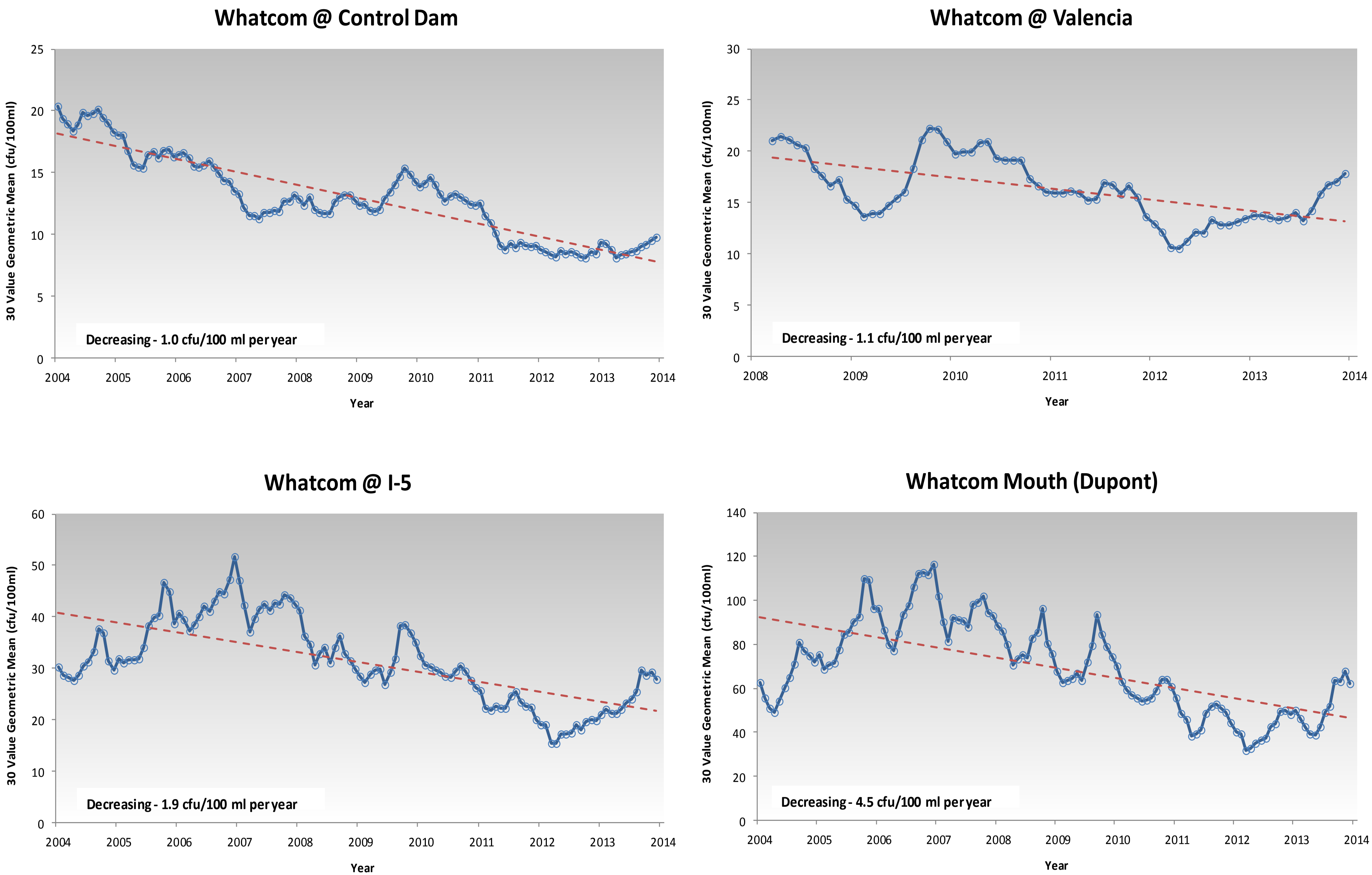
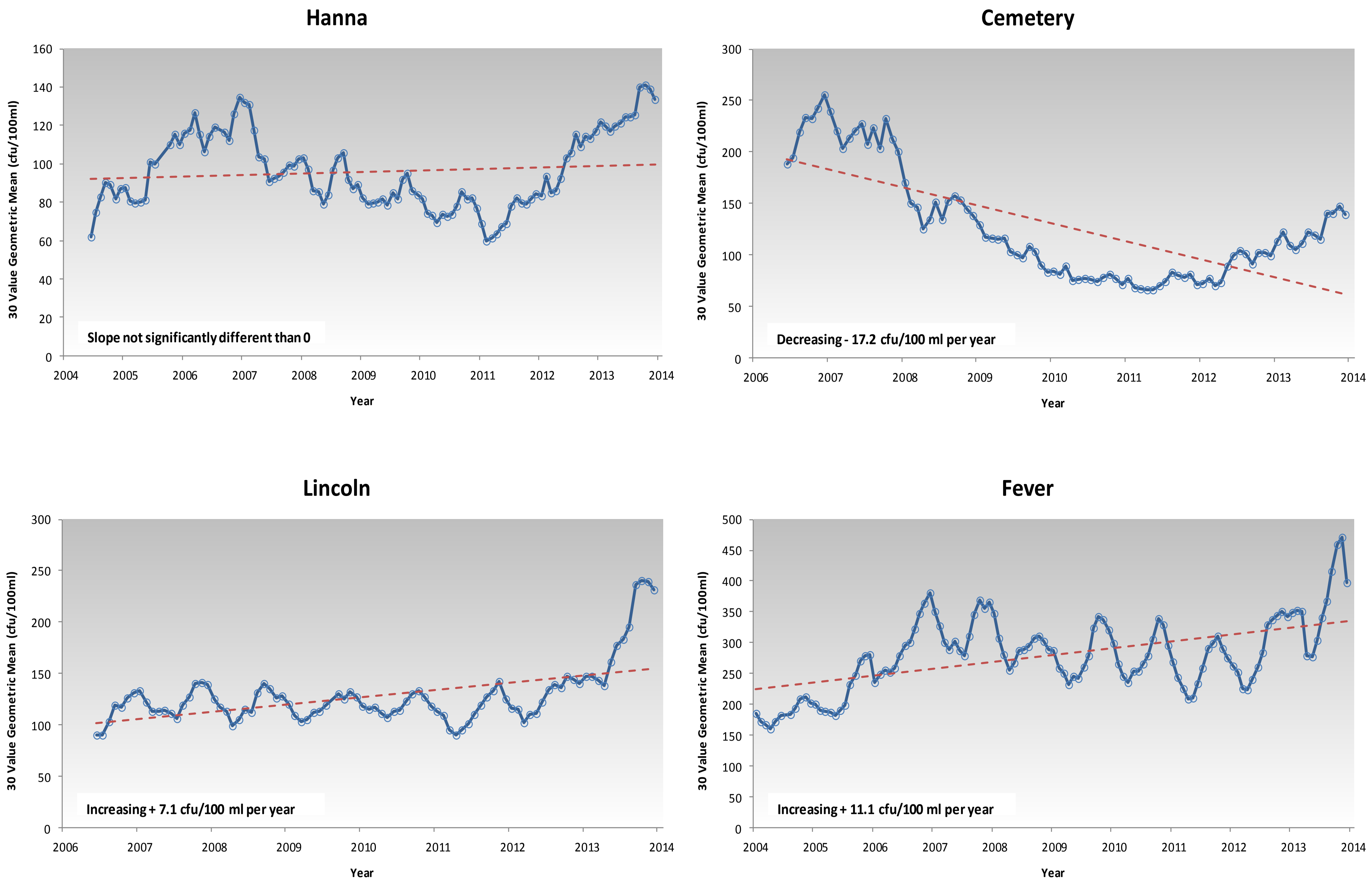


Figure 8.0-6b. Monthly 2013 fecal coliform levels for sampling sites on Whatcom Creek tributaries. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*



Figures 8.0-5 a-d. Thirty value moving geometric mean fecal coliform trends for Whatcom Creek samples collected 2004 through 2013. All of the monitoring locations had significant descending 10-year trends in fecal coliform geomeans (Contol Dam: $p = 4.31^{e-44}$; Valencia: $p = 5.42^{e-08}$; I-5: $p = 3.21^{e-17}$; Dupont: $p = 6.51^{e-15}$, $\alpha = 0.05$). Noticeable uptick during 2013 is likely the influence of sampling during several large, first flush rain events that occurred during the period. Trendlines in red.



Figures 8.0-5 e-h. Thirty value moving geometric mean fecal coliform trends for Whatcom Creek Tributary samples collected 2004 through 2013. Cemetery Creek displayed a significant negative trend (3.84^{e-15}, α = 0.05), Lincoln and Fever Creeks were significantly positive (p = 7.60^{e-08} and 4.82^{e-10}, α = 0.05), and the slope of the Hanna Creek trendline was not significantly different than zero (p = 0.23 , α = 0.05). Noticeable uptick during 2013 is likely the influence of sampling during several large, first flush rain events that occurred during the period. Trendlines in red.

Dissolved Oxygen

During 2013, none of the sites in the Whatcom Creek drainage 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, along with Hanna and Fever Creeks qualified for the Class A dissolved oxygen standards (≥ 8.0 mg/L), while Lincoln Creek and Whatcom Creek at the Control Dam and Dupont met the Class B standards (≥6.5 mg/L; Figures 8.0-8a&b).

The number of times dissolved oxygen levels in Whatcom Creek and its tributaries fell below standards in 2013 was similar to previous years (Figures 8.0-9a-h). Dissolved oxygen followed the expected trend of lower values in the warmer summer months as water temperatures rose. Average dissolved oxygen values are provided in Table 8.0-2.

There were no ten year dissolved oxygen trendlines in the Whatcom Creek Drainage that were significantly different than zero for the period of 2004-2013 (Figures 8.0-9a-h).

Table 8.0-2. Average dissolved oxygen values for Whatcom Creek and its tributaries in 2013.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Average DO (mg/L)	10.2	11.5	10.9	10.3	11.5	9.3	10.0	10.9

Figure 8.0-6. Whatcom Creek sampling site at I-5.

Figure 8.0-7. Whatcom Creek sampling site at Dupont

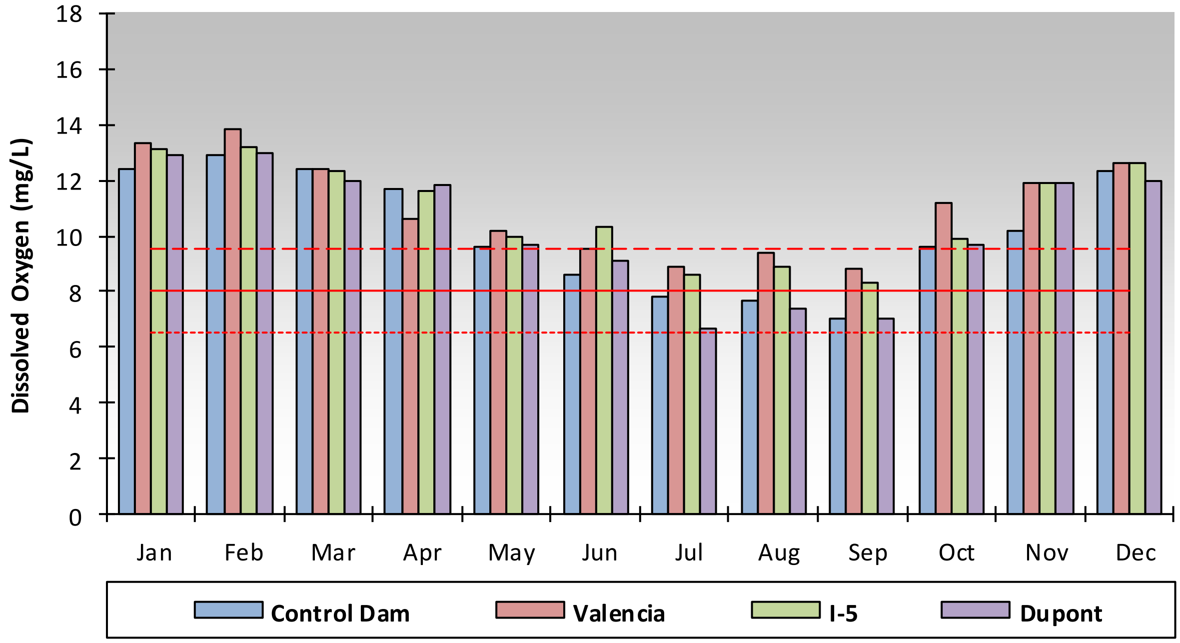


Figure 8.0-8a. Monthly 2013 dissolved oxygen levels for Whatcom Creek sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

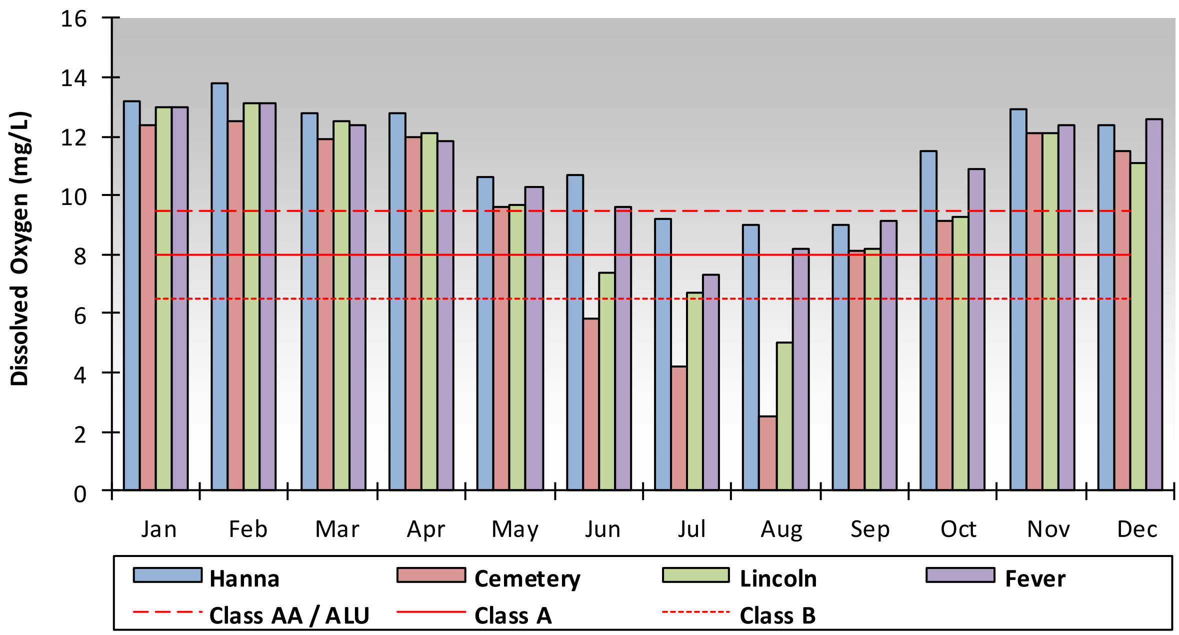


Figure 8.0-8b. Monthly 2013 dissolved oxygen levels for Whatcom Creek tributaries sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

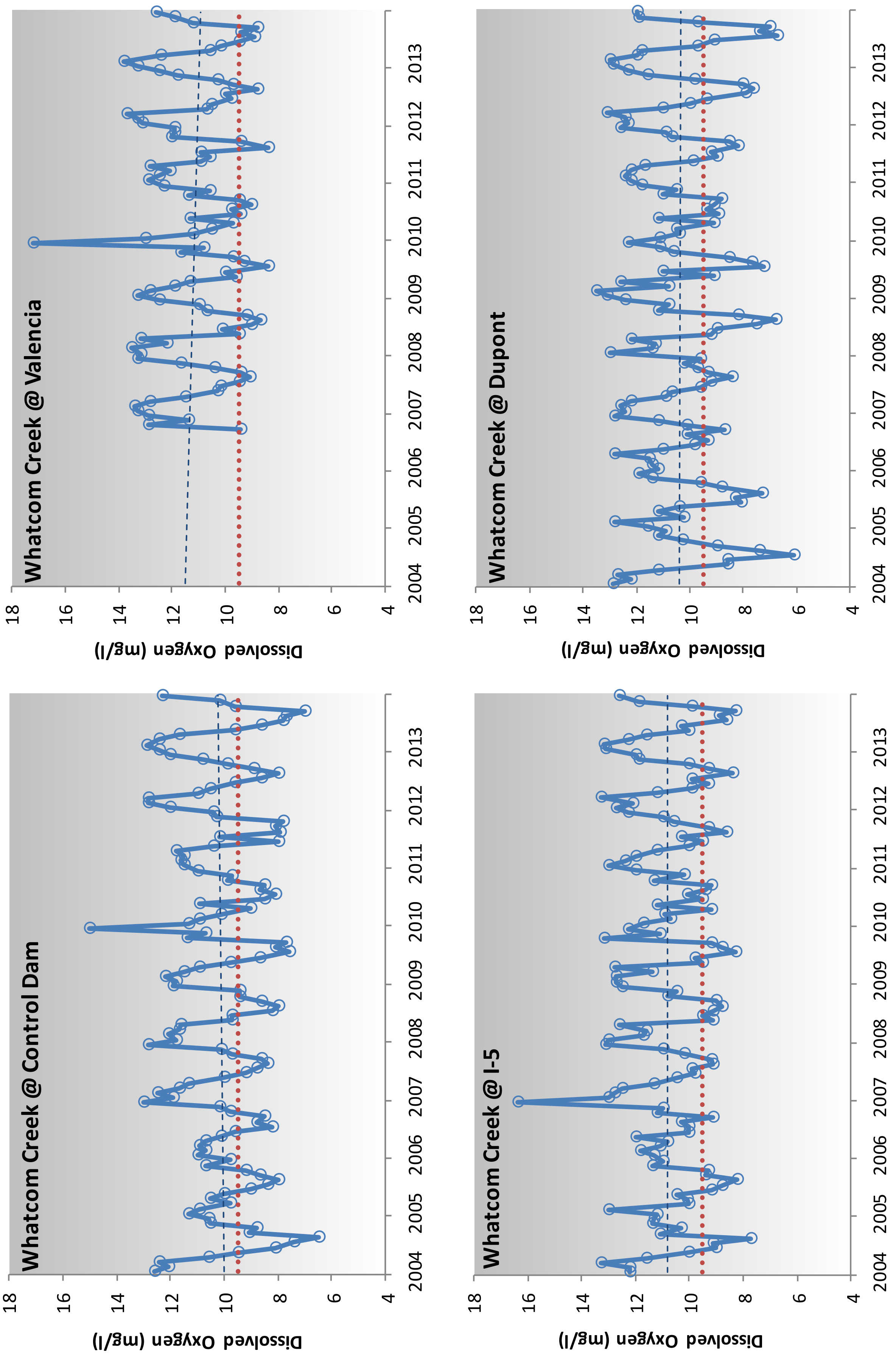


Figure 8.0-9 a-d. Ten year dissolved oxygen trendlines (blue) for Whatcom Creek sites in 2013. None of the trendlines were significantly different from zero (Contol Dam: p = 0.70; Valencia: p = 0.88; I-5: p = 0.98; Dupont: p = 0.93, α = 0.05). Red dotted line depicts the 9.5 mg/l Aquatic Life Use standard.

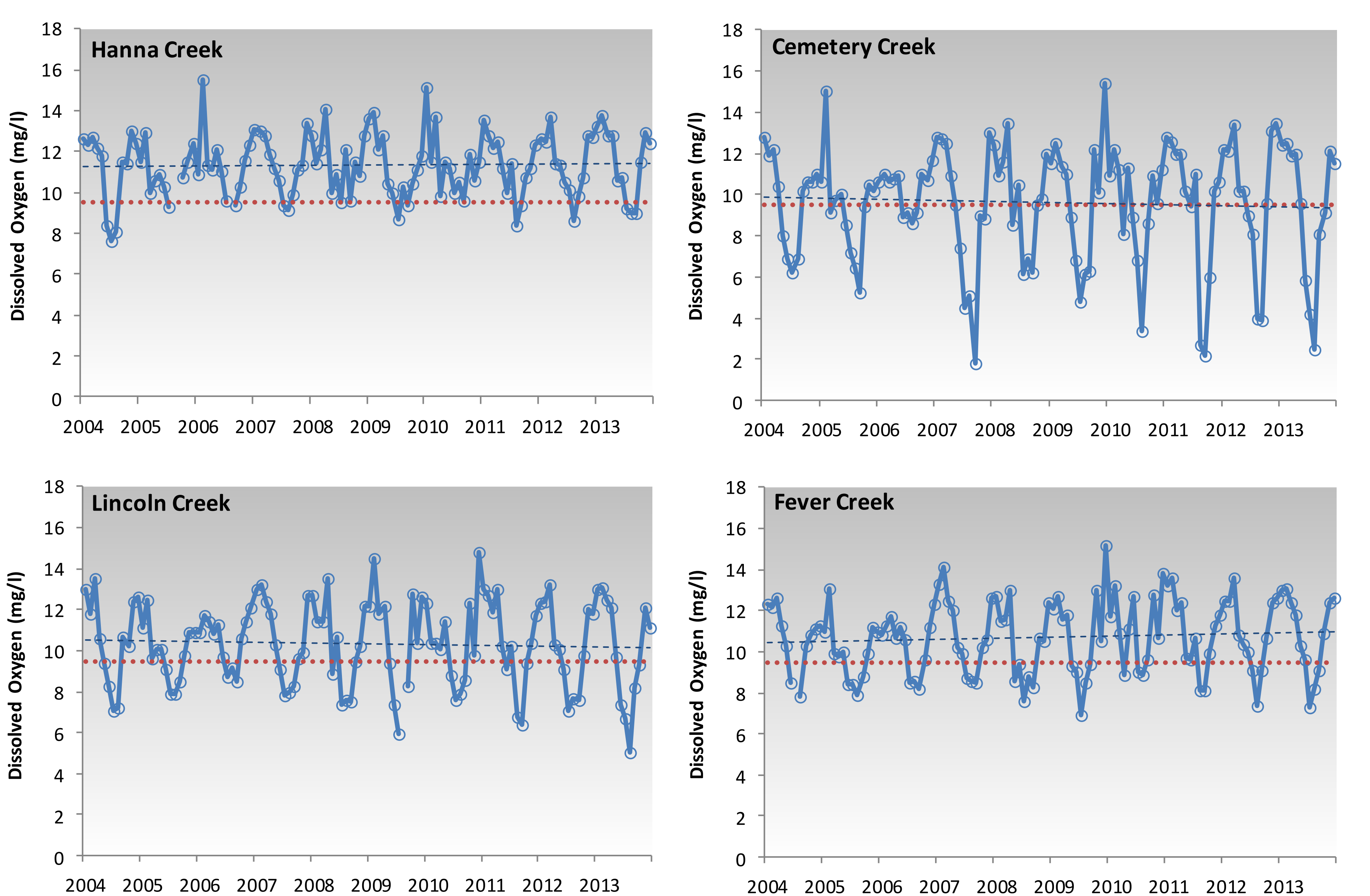


Figure 8.0-9 e-h. Ten year dissolved oxygen trendlines (blue) for Whatcom Creek Tributary sites in 2013. None of the trendlines were significantly different from zero (Hanna: $p = 0.82$; Cemetery: $p = 0.73$; Lincoln: $p = 0.58$; Fever: $p = 0.34$, $\alpha = 0.05$). Red dotted line depicts the 9.5 mg/l Aquatic Life Use standard.

Figure 8.0-10. Hanna Creek sampling site.

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.

During 2013, all four Whatcom Creek monitoring sites were only able to meet the <21°C Class B standard, and also failed to maintain temperatures under 13°C as required for supplemental spawning and incubation protection during May and June. Temperatures above 16°C are not as common in the Whatcom Creek tributaries. However, in 2013 none of the tributaries were able to meet the <16°C ALU criterion. Hanna, Lincoln and Fever Creeks met the < 18°C Class A criterion, while Cemetery Creek met the < 21°C Class B criterion.

The expected seasonal trend with higher temperatures in the warmer summer months is apparent for both Whatcom Creek and its tributaries (Figures 8.0-12a&b). Average temperatures for 2013 are provided in Table 8.0-3. None of the Whatcom Creek Drainage sites displayed ten year trendlines that were significantly different than zero in 2013 (Figures 8.0-13a-h).

Figure 8.0-11. Cemetery Creek sampling site.

Table 8.0-3. Average temperatures for sampling sites on Whatcom Creek and tributaries, 2013.

Sampling Site	**C. Dam**	**Valencia**	**I-5**	**Dupont**	**Hanna**	**Cemetery**	**Lincoln**	**Fever**
Average Temperature (°C)	12.9	12.2	12.1	12.0	9.7	10.3	10.6	11.3

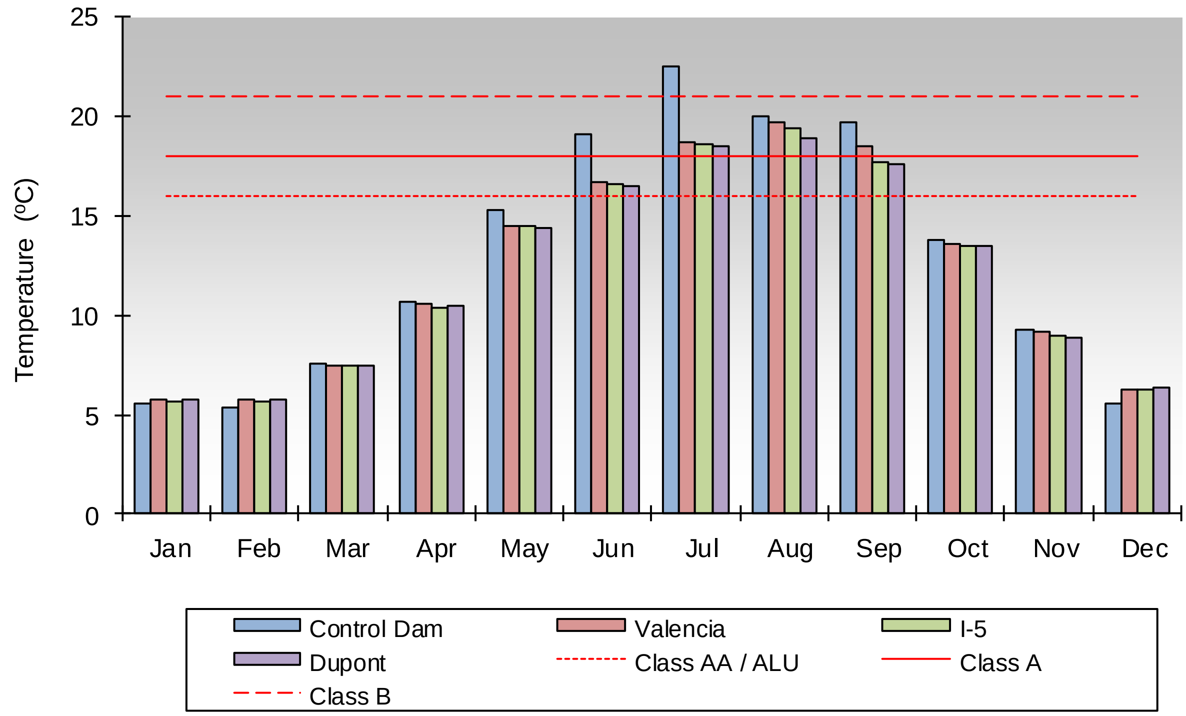


Figure 8.0-12a. Monthly temperature measurements for Whatcom Creek sampling sites in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

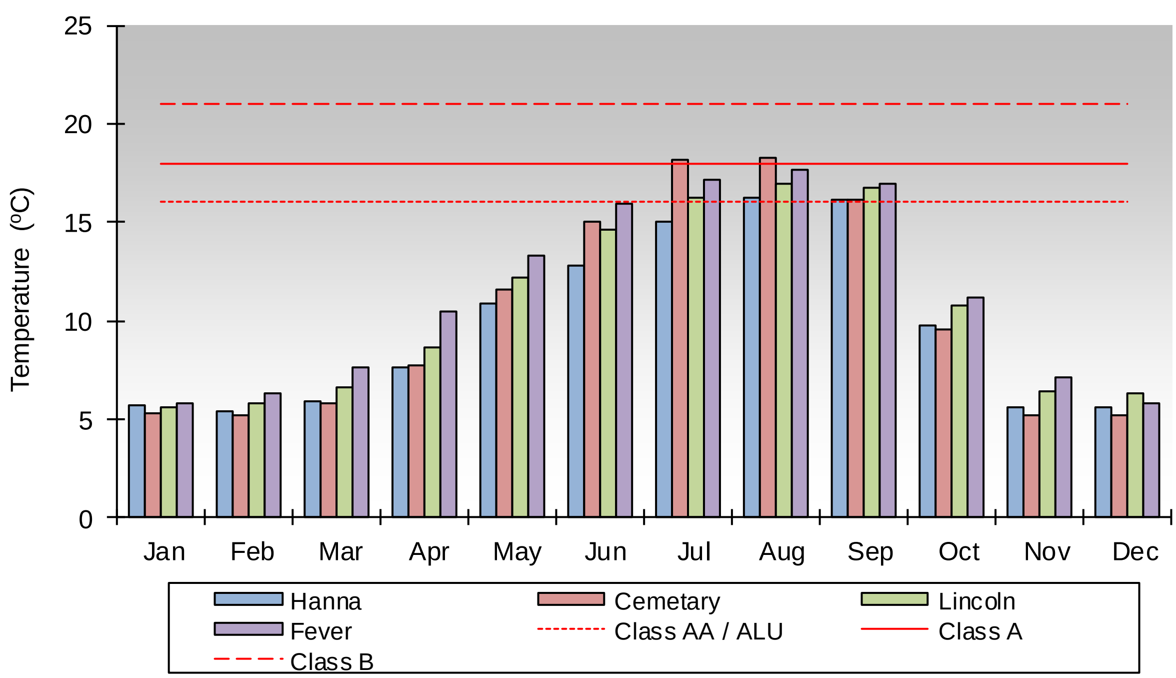


Figure 8.0-12b. Monthly temperature measurements for Whatcom Creek tributaries sampling sites in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

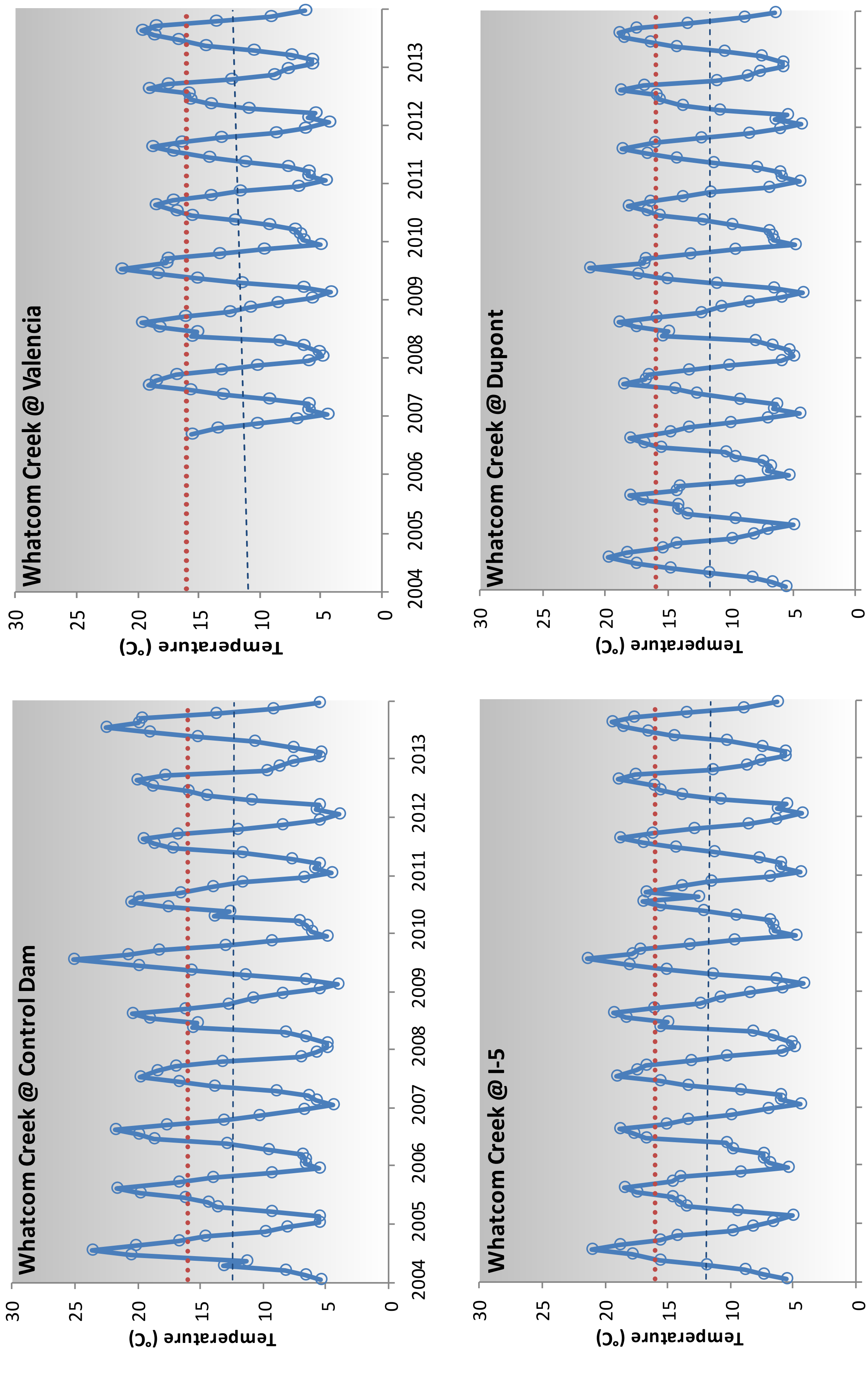


Figure 8.0-13 a-e. Ten year temperature trends at Whatcom Creek sites, 2004-2013. Trendlines (blue) were not significantly different than zero (Contol Dam: p = 0.94; Valencia: p = 0.63; I-5: p = 0.81; Dupont: p = 0.98, α = 0.05). Red dotted line depict the 16°C Aquatic Life Use standard.

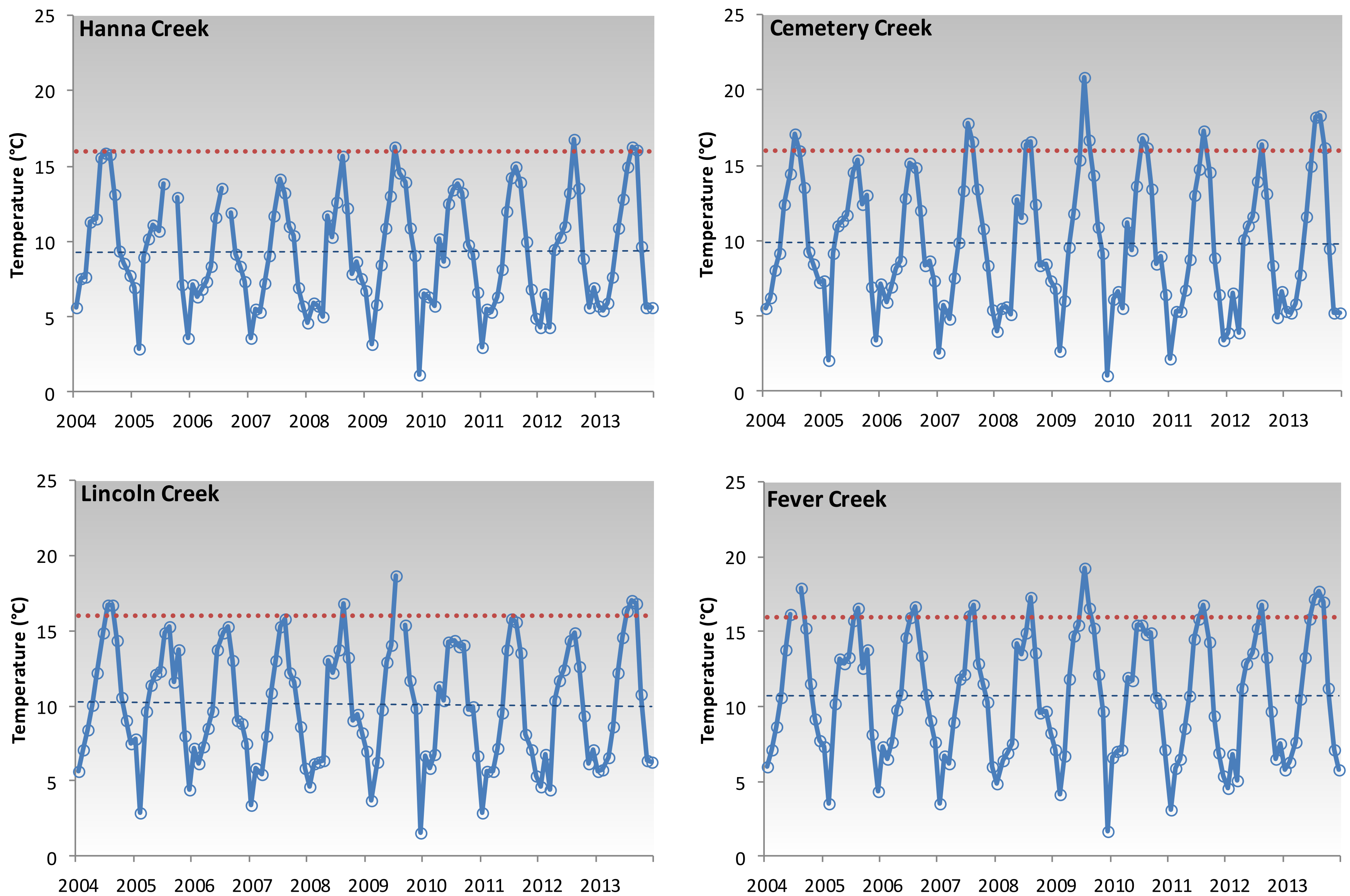


Figure 8.0-13 f-h. Ten year temperature trends at Whatcom Creek Tributaries, 2004-2013. Trendlines (blue) were not significantly different than zero (Hanna: $p = 0.95$; Cemetery: $p = 0.91$; Lincoln: $p = 0.77$; Fever: $p = 0.86$, $\alpha = 0.05$). Red dotted line depict the 16°C Aquatic Life Use standard.

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 2013 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 2013. The average turbidities and their respective 5 and 10 year averages are provided in figures 8.0-16a-h. Maximum, minimum and average turbidity for all sampling sites in 2013 are provided in Table 8.0-4.

Ten year turbidity trends are displayed in figures 8.0-17a-h. None of the Whatcom Creek Drainage monitoring sites turbidity trendlines were significantly different than zero in 2013.

Large rain events during January and September are likely the cause of higher than normal turbidity values found at most Whatcom Creek and tributary sites in 2013.

Table 8.0-4. The average, maximum and minimum turbidity for sampling sites on Whatcom Creek and its tributaries in 2013.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
2013 Average (NTU)	1.5	2.2	3.5	4.3	6.1	9.3	7.2	6.7
2013 Maximum (NTU)	2.1	5.0	14.2	19.3	18.4	26.6	23.8	18.9
2013 Minimum (NTU)	0.7	1.0	1.0	1.1	1.9	2.0	1.6	1.8

Figure 8.0-14. Lincoln Creek sampling site.

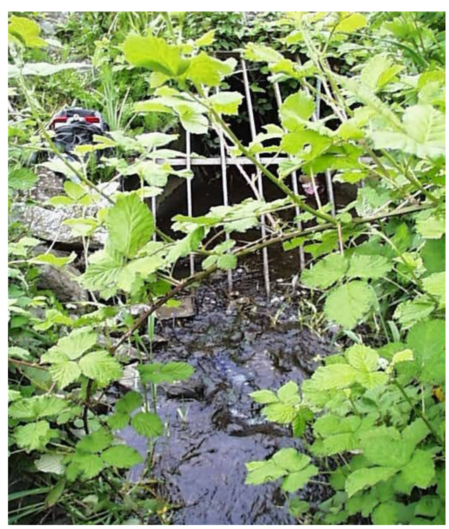
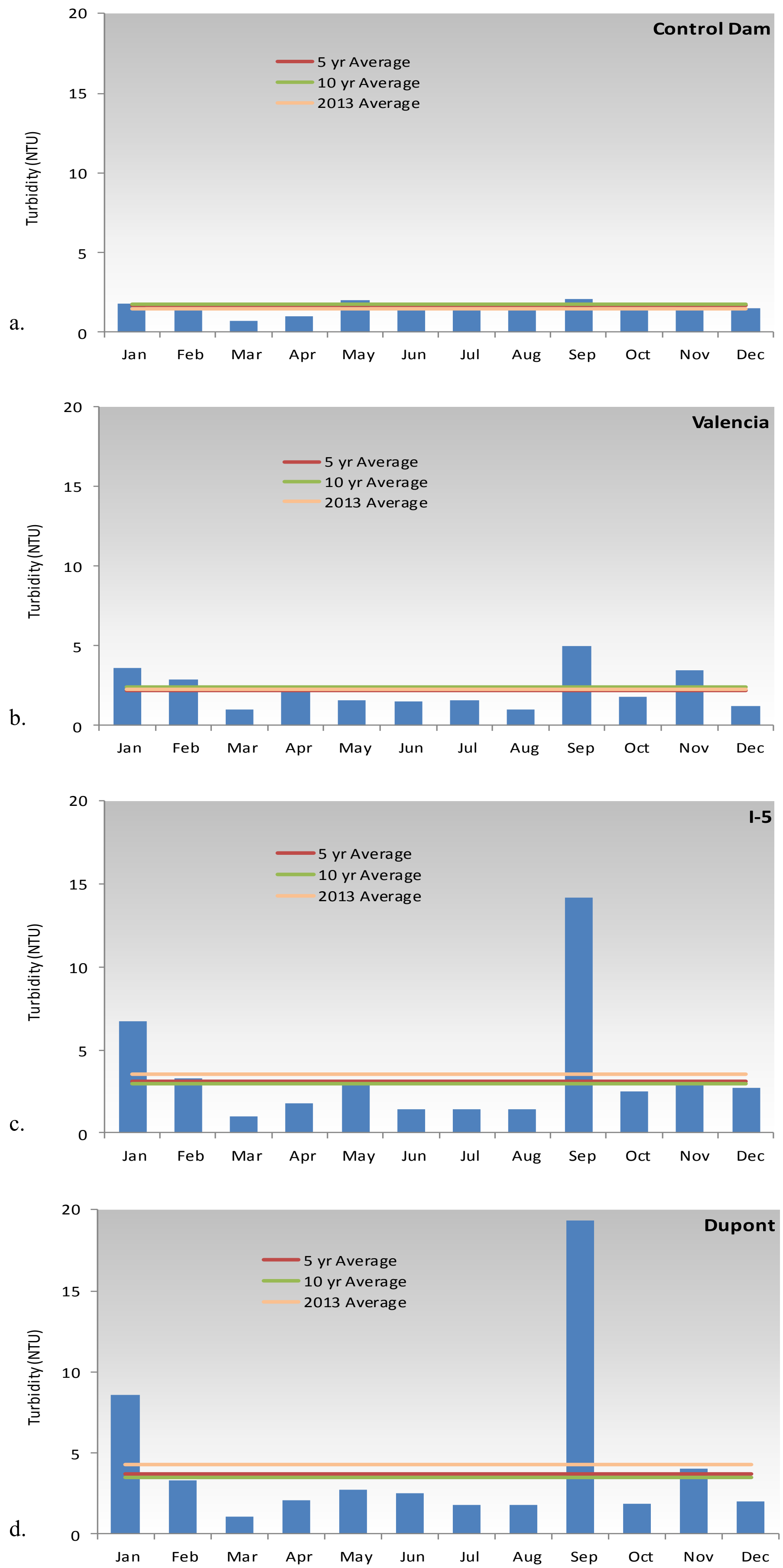
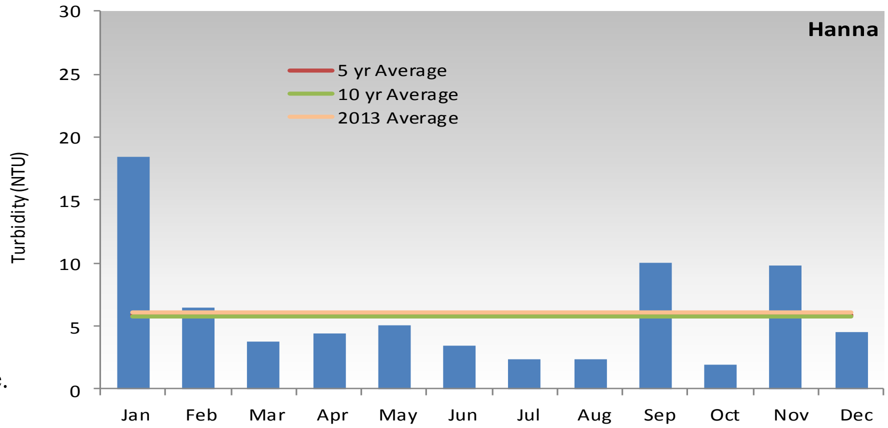
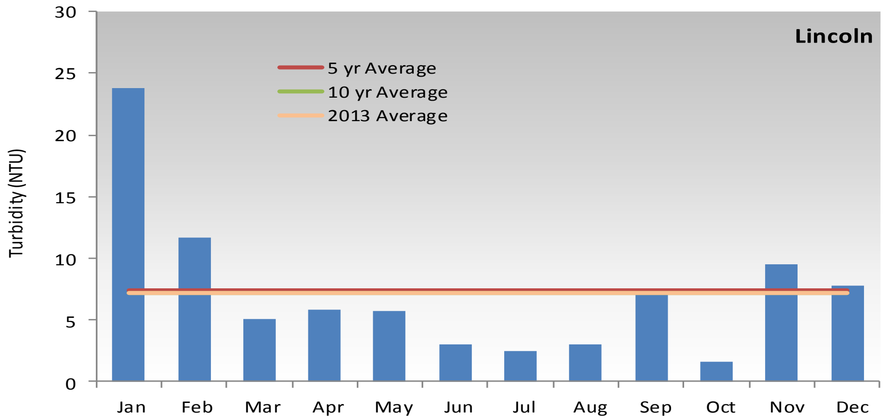


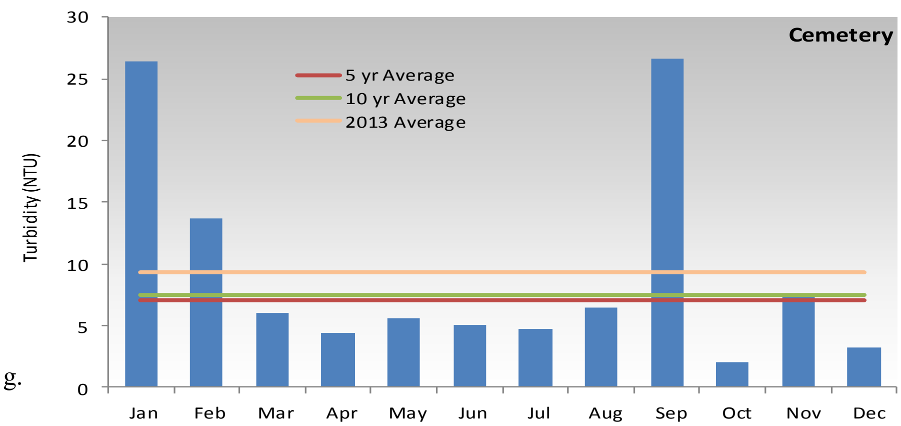
Figure 8.0-15. Fever Creek sampling site.

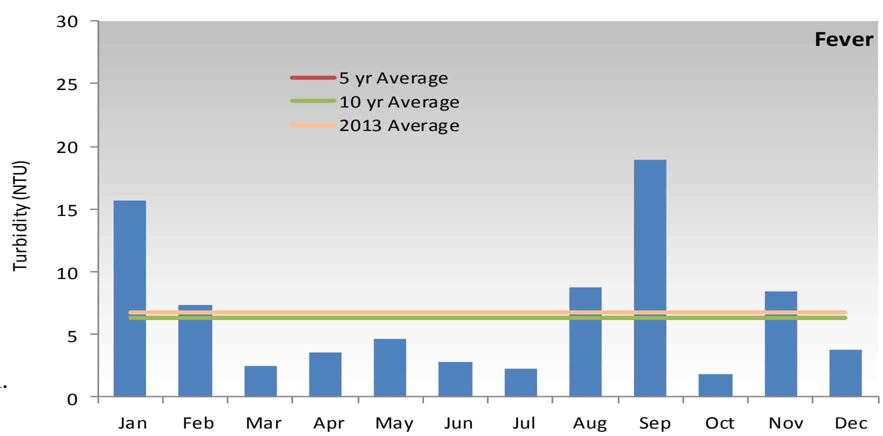


Figures 8.0-16a-d. Monthly turbidity values for Whatcom Creek Sampling sites in 2013. Presented with yearly, 5-year and 10-year averages.

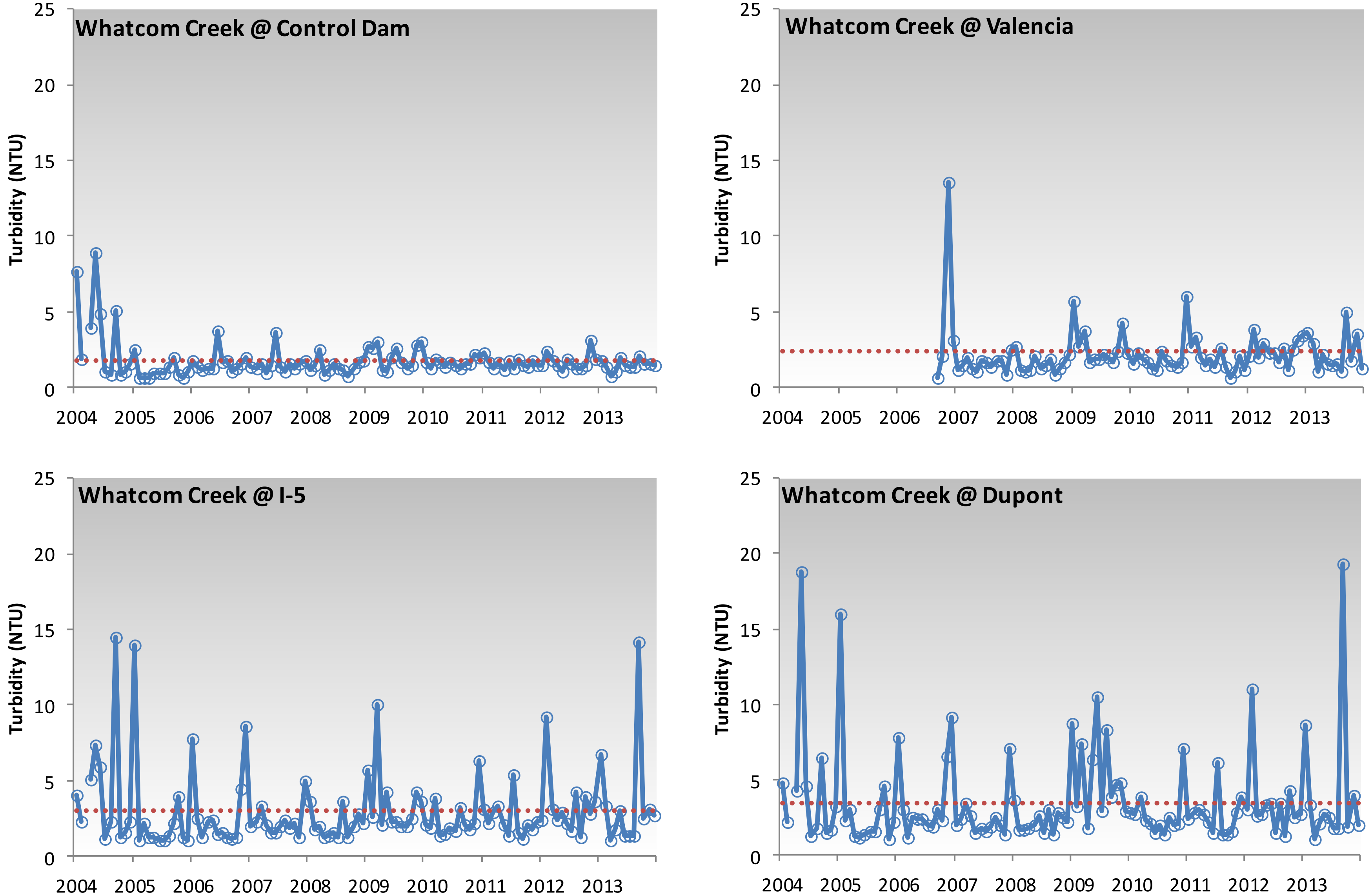
e.


f.


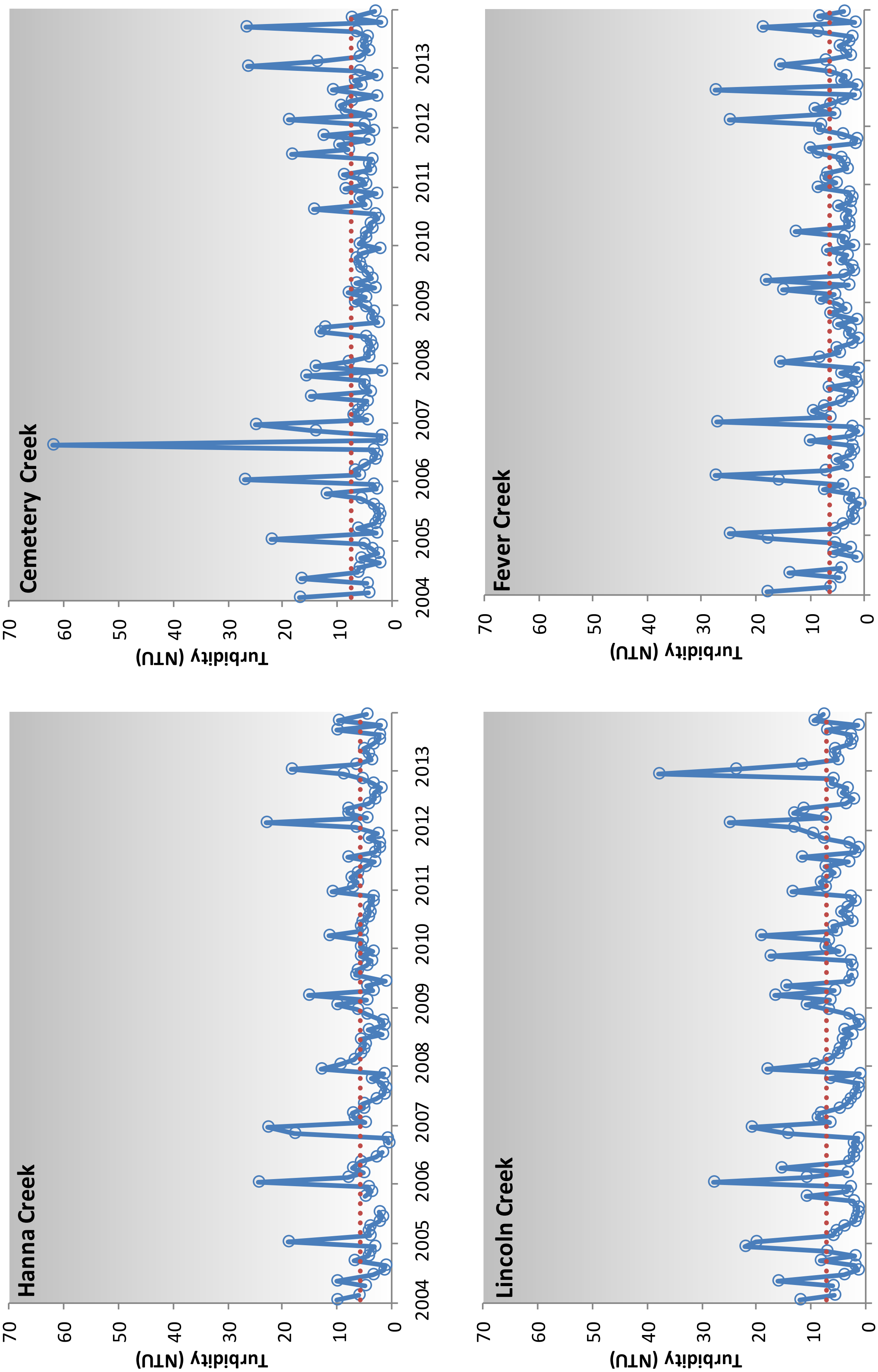
g.


h.


Figures 8.0-16f-h. Monthly turbidity values for Whatcom Creek tributaries in 2013. Presented with yearly, 5-year and 10-year averages.



Figures 8.0-17a-d. Ten year turbidity trends for Whatcom Creek sites illustrate the effects of storm events on average turbidity. Red dotted lines depict the ten year averages. Trendlines (not shown) are not significantly different than zero (Control Dam: $p = 0.06$; Valencia: $p = 0.93$; I-5: $p =$ 0..82; Dupont: $p = 0.82$, $\alpha = 0.05$).



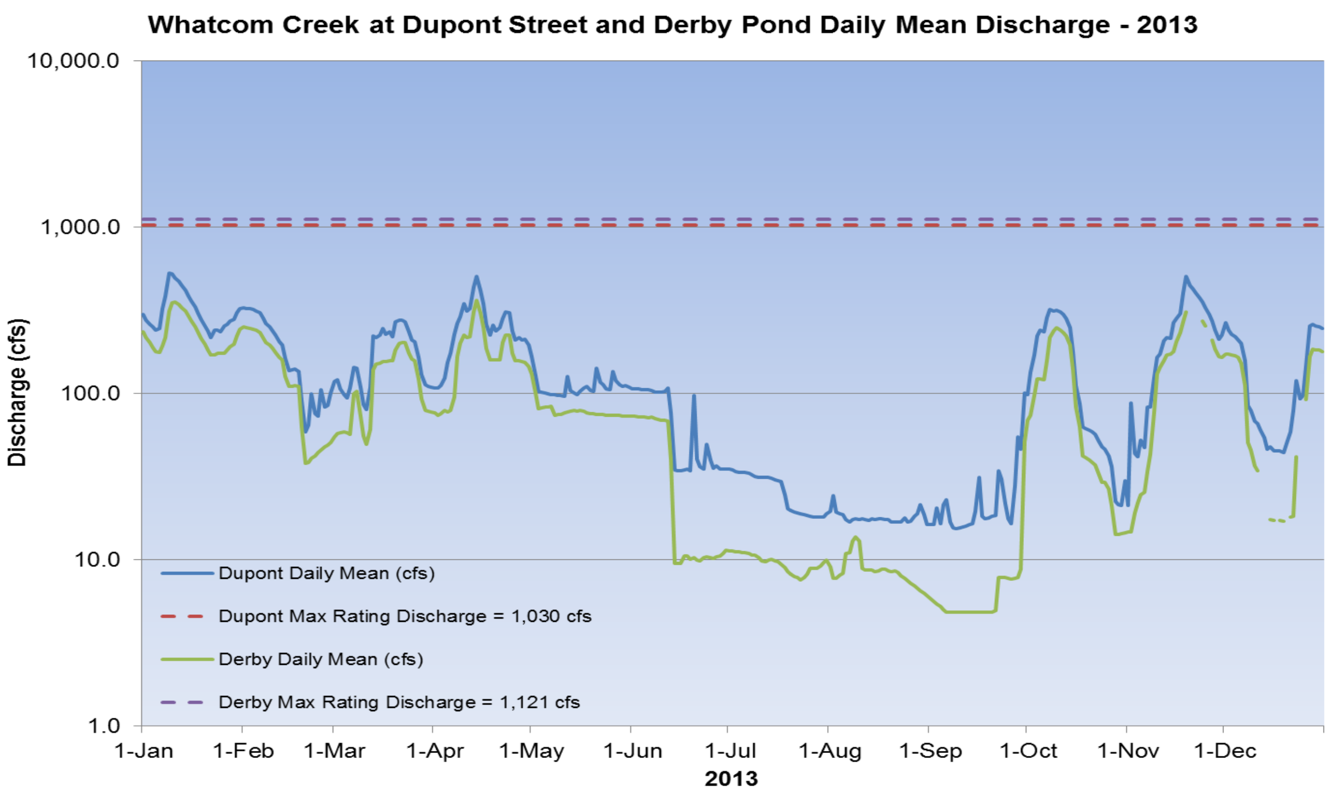
Figures 8.0-17e-h. Ten year turbidity trends for Whatcom Creek Tributary sites illustrate the effects of storm events on average turbidity. Red dotted lines depict the ten year averages. Trendlines (not shown) are not significantly different than zero (Hanna: $p = 0.97$; Cemetary: $p = 0.89$; Lincoln: $p = 0.51$; Fever: $p = 0.76$, $\alpha = 0.05$).

Hydrology

As the largest urban stream flowing through Bellingham, two gauging stations were established on Whatcom Creek in 2001. One is located in Whatcom Falls Park on the bank of Derby (Fish) Pond and the other above Dupont Street near the Mouth. Differences between the hydrographs of the two sites can be explained by a combination of factors: Operation of the control dam and fish hatchery check gates is seen in Derby Pond data as observable drops or climbs, while it is moderated by the influence of tributaries at the Dupont site; and operational changes at the City of Bellingham Screenhouse can also affect flow downstream. Different bathymetric properties (gradual vs. steep banks) at the two sites affects signal moderation when flows change; and the large surface area, sunlight, and slow, pond-like conditions at Derby Pond promote much more evaporation than that of the channelized stream at Dupont Street.

The Control Dam is operated as part of the City's Lake Whatcom level management strategy, which is determined by five primary factors: maximum surface elevation as required by law to protect lakeside properties, water availability for storage and treatment, drinking water demand by the citizens of Bellingham, flood control, and salmon habitat in Whatcom Creek. Changes in discharge due to Control Dam operation can be seen approximately 1/2 hour from time of operation at Derby Pond, and 3 to 4 hours later at Dupont St. depending on the amount of discharge. More information regarding Control Dam operation can be found here:http://www.cob.org/services/environment/lake-whatcom/lw-level.aspx

In 2013, Whatcom Creek at Derby Pond had a minimum discharge (flow) of 4.8 cubic feet per second (cfs) from September 6th—21st, a maximum discharge of 405 cfs on April 13th and 14th, and an average discharge of 94.5 cfs. Whatcom Creek at Dupont St. on the other hand had a minimum discharge (flow) of 15 cfs on September 8th, a maximum discharge of 716 cfs on November 19th and an average discharge of 140 cfs.



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 mostly agricultural land before entering Bellingham city limits and passing through industrial, commercial, and residential areas. Channel modification including large culverts and constructed conveyance are present on Squalicum Creek.

Figure 9.0-1. Squalicum Creek mouth sampling site.

The major contributor to Squalicum Creek is Baker Creek (called Spring Creek in some City documents, but listed as Baker Creek by the State), 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.

Compared to other urban streams, the Squalicum Creek basin has a large proportion of flow that originates from outside city limits. As such, water quality conditions from outside of City of Bellingham jurisdiction can have significant influence on the findings at urban stream monitoring sites.

Squalicum Creek is sampled at three locations: at E. Bakerview Rd. where the creek enters city limits (Figure 9.0-3), in Cornwall Park near Meridian St. (Figure 9.0-11), 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 9.0-10), Squalicum Creek's major tributary, is sampled just upstream from its confluence with Squalicum Creek at Squalicum Pwy. (Squalicum Creek Drainage Map).

303d Listings and Enhanced Sampling

Based largely on historical grab sample data from the Urban Streams Monitoring Program (Mid-90's through early 2000's), several stream segments on Squalicum and Baker Creeks are included in Ecology's 303d list (Figure 9.0-2). In 2013, those reaches were again chosen for enhanced sampling efforts. From June 1st until October 1st, all sites on Squalicum and Baker Creeks were sampled weekly for fecal coliform. In addition, the Squalicum Creek sites at E. Bakerview, Meridian and the Mouth were continuously monitored (15 min data) for temperature and dissolved oxygen levels. The enhanced sampling parameters were chosen based on the 303d listings for those stream reaches in 2013.

With the exception of E. Bakerview, every site in the Squalicum Creek drainage met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) criteria for temperature (≤16°C) in 2013. However, none of the sites met the ≥ 9.5 mg/L dissolved oxygen ALU measure, nor the 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 to high fecal coliform levels in 2013, none of the sites in the Squalicum Creek drainage were able to meet either the overall Class A or Class B designation.

While none of the Squalicum drainage sites met either the Class A (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml) or Class B (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml) standards for fecal coliform, the Meridian, Mouth and Baker Creek sites did meet the the Class AA (≤16°C) temperature criterion, and the E. Bakerview site met the Class A (≤18°C) standard. The Mouth site met the Class A standard for dissolved oxygen (≥ 8.0 mg/L), while the Meridian and Baker Creek sites met the Class B standard (≥ 6.5 mg/L). The E. Bakerview site was not able to meet either the Class A or Class B standard for dissolved oxygen in 2013.

The average turbidities for Squalicum and Baker Creek sites in 2013 were all higher than averages in 2012. The highest average turbidity on Squalicum Creek was 11.8 NTU at the Meridian site. The lowest average turbidity was 9.2 NTU at the Baker Creek. Average turbidity values for 2013 are

Figure 9.0-2. 303d listings of Squalicum Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All of the listed segments are listed for excess fecal coliform bacteria. The segment containing the Meridian sampling site and the segment outside the City limits are also listed for temperature and dissolved oxygen. The segment below the E. Bakerview is listed for dissolved oxygen and fecal coliform.

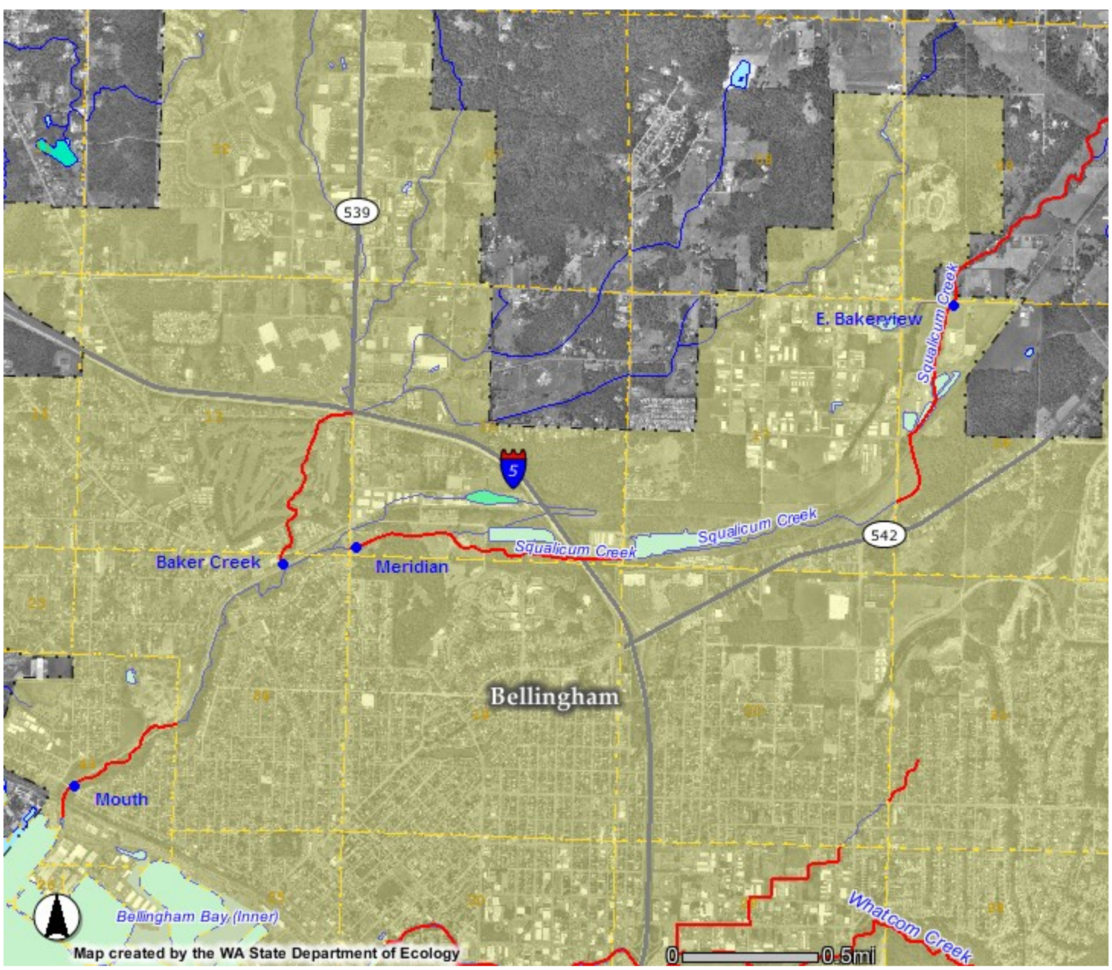


Figure 9.0-3. Squalicum Creek sampling site at E. Bakerview Rd.

listed along side respective 5 and 10 year averages in Table 9.0-5. Conductivity and pH were consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels recorded during conventional sampling in 2013 were less than values found in previous years (Figures 9.0-4). Despite this, none of the sites in the Squalicum Creek drainage were able to meet the Class A (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml) or Class B (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml) fecal coliform standards.

As with the majority of our urban creek sites, all three sites on Squalicum Creek exhibited negative 10-year trends in fecal coliform geomeans for the period ending in 2013. However, the Baker Creek site trendline was not significantly different than zero (Figures 9.0-6a-d).

Enhanced Fecal Coliform Sampling

Enhanced sampling for fecal coliform was conducted in the Squalicum Creek Drainage from June through October , 2013. Samples were taken on a weekly basis during that period. In contrast to results from 2012, results of enhanced sampling suggest higher fecal coliform levels than determined by monthly conventional sampling for all sites in the Squalicum drainage (Table 9.0-1, Figure 9.0-5). The enhanced sampling results are slightly skewed towards the high end due to collection during a first flush rain event in August and again during heavy rains in September. Even so, the results of enhanced sampling serve to reinforce the results of monthly conventional sampling, as none of the sites would have met the Recreational Use/Class A standard based on either regime. Thus the 303d listings for fecal coliform in Squalicum and Baker Creek continued to be substantiated in 2013.

Table 9.0-1. Conventional sampling (CS), enhanced sampling (ES) and ten-year trend fecal coliform geomean values for monitoring sites on Squalicum and Baker Creek in 2013.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
CS Geomean (CFU/100ml)	140	74	127	142
ES Geomean (CFU/100ml)	323	136	167	386
Trend (CFU/100ml/yr)	-9.7	-1.9	0	-1.6

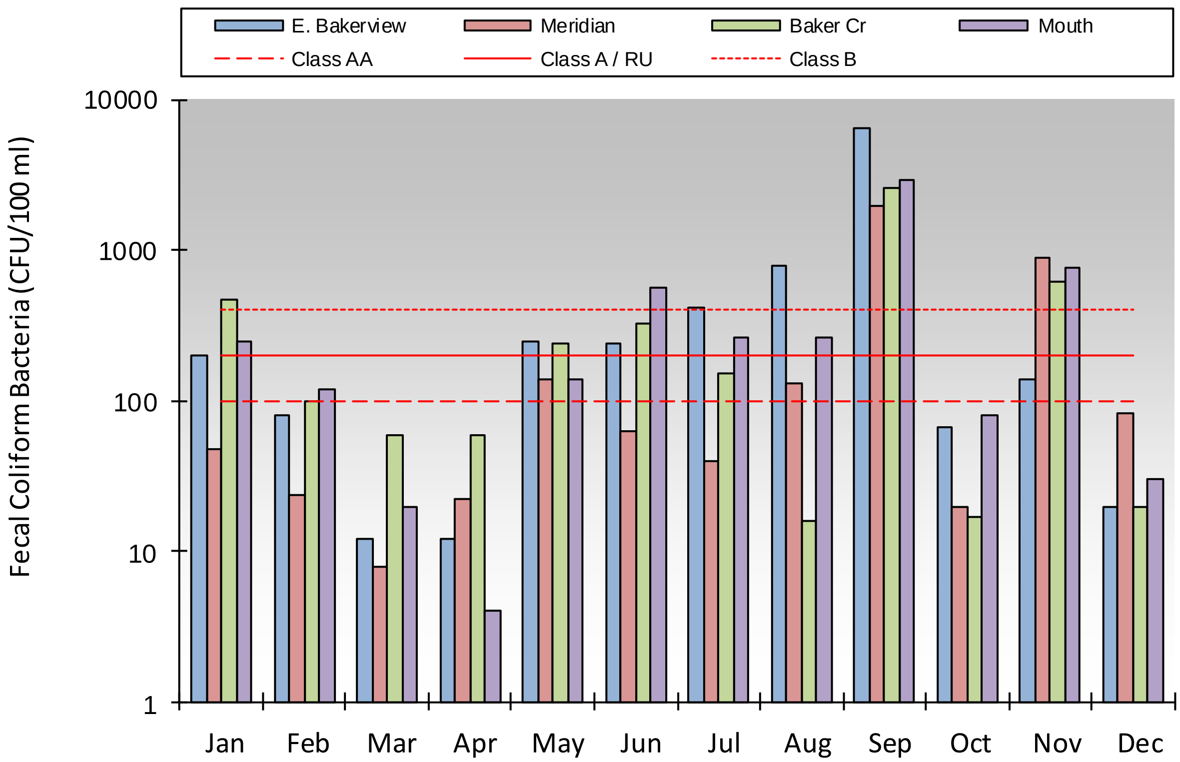


Figure 9.0-4. Monthly 2013 fecal coliform levels for sampling sites on Squalicum and Baker Creeks. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

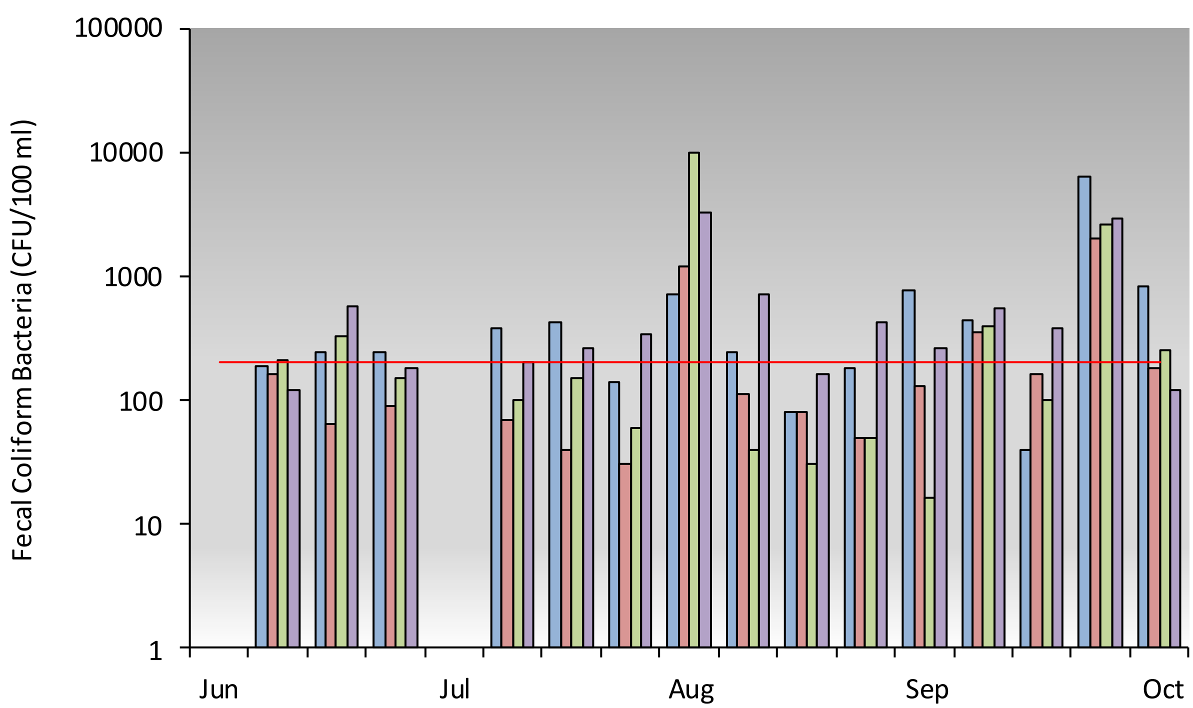


Figure 9.0-5. Fecal coliform levels during enhanced sampling June - October 2013. Red line indicates the numeric criteria for the calculated geomean for the Primary Contact Recreational Use (RU) designation (Class A). Spikes in August and September due to first flush/heavy rainfall conditions at the time of collection. Data gaps due to error in analysis. *Note this graph uses a logarithmic scale.*

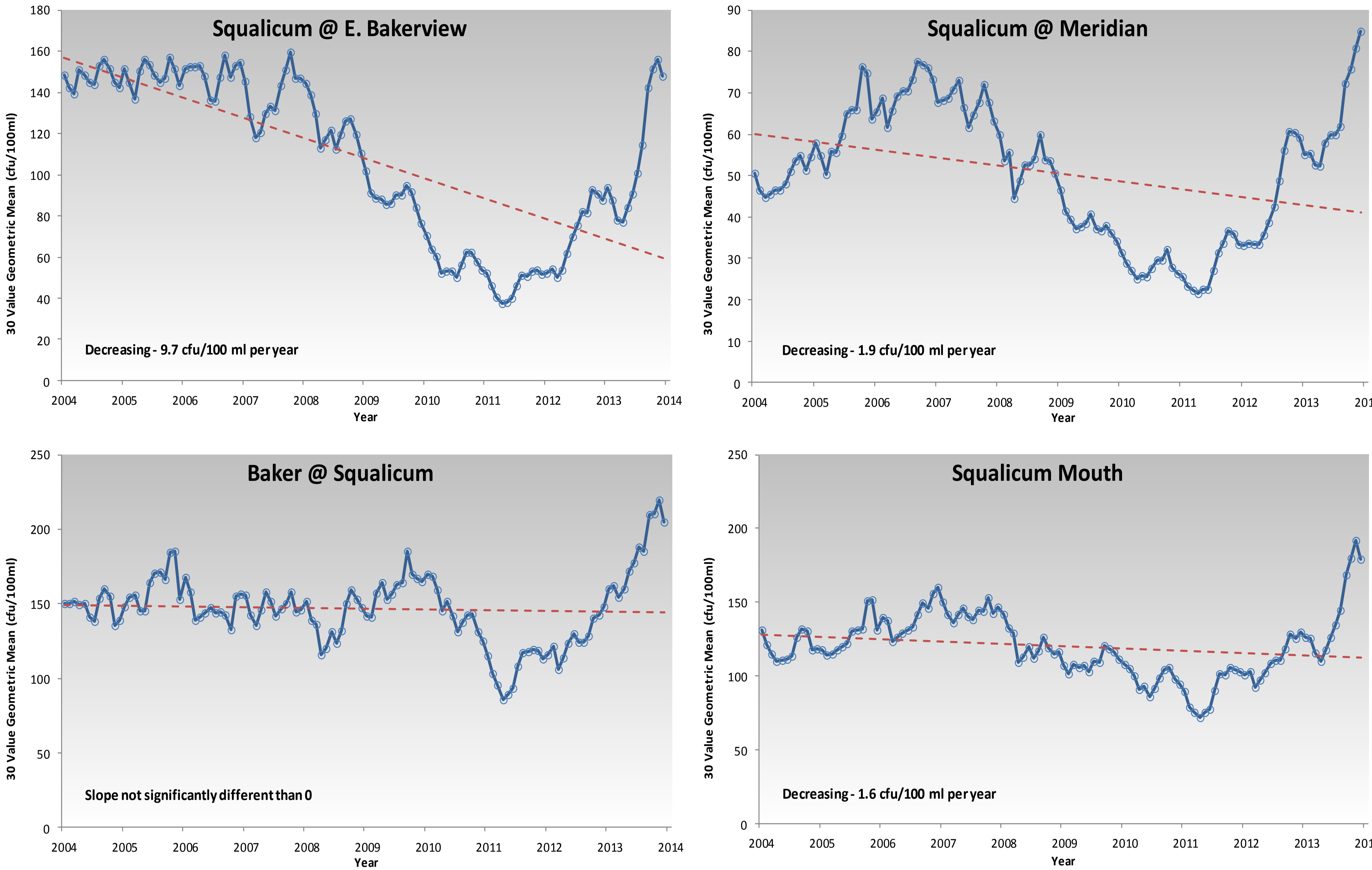


Figure 9.0-6a-d. Thirty value moving geometric mean fecal coliform trends for Squalicum Creek Drainage samples collected 2004 through 2013. Baker Creek was the only site that did not have a significant descending 10 year trendline (red) in fecal coliform geomeans (E.Bakerview: $p = 2.35^{e-20}$; Meridian: $p = 1.43^{e-04}$; Baker Creek: $p = 0.47$; Mouth: $p = 0.02$, $\alpha = 0.05$). Noticeable uptick during 2013 is likely the influence of sampling during several large, first flush rain events that occurred during the period.

Dissolved Oxygen

None of the stream segments in the Squalicum Creek drainage met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard in 2013. At ≥9.5 mg/L, the ALU is equivalent to Class AA. Results of enhanced monitoring collaborate this, showing that with a few exceptions, dissolved oxygen levels remained below the 9.5 mg/L ALU for most of the June - October critical period.

Based on conventional sampling in 2013, only the Squalicum Mouth site was able to meet the Class A standard for dissolved oxygen (≥8.0 mg/L). The Meridian and Baker Creek sites met the Class B standard of ≥6.5 mg/L (Figure 9.0-7), while the E. Bakerview site failed to meet either standard.

In the past, the E. Bakerview sampling site has frequently experienced low dissolved oxygen levels during the summer months, most likely due to low flows and warmer temperatures (Figures 9.0-8a and 9.0-10). Based on stream discharge levels (Figure 9.0-14), it can be extrapolated that low flows are significant factor in low dissolved oxygen levels throughout the Squalicum Creek drainage.

Dissolved oxygen in all creek segments sampled in 2013 followed an expected trend of lower values in the warmer summer months (Figure 9.0-7). Average dissolved oxygen values are shown in Table 9.0-2. There were no ten year dissolved oxygen trendlines in the Squalicum Creek Drainage that were significantly different than zero for the period of 2004-2013 (Figures 9.0-8a-d).

Table 9.0-2. Average dissolved oxygen values for Squalicum and Baker Creek in 2013. Based on conventional sampling.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Average DO (mg/L)	9.8	10.4	10.7	11.1

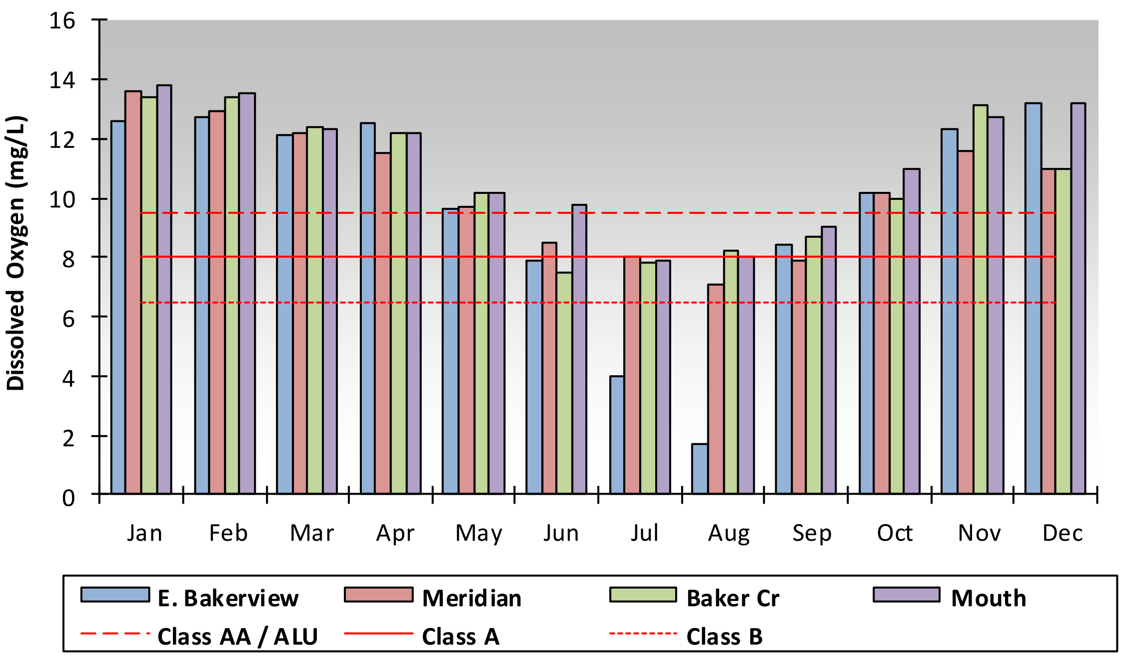
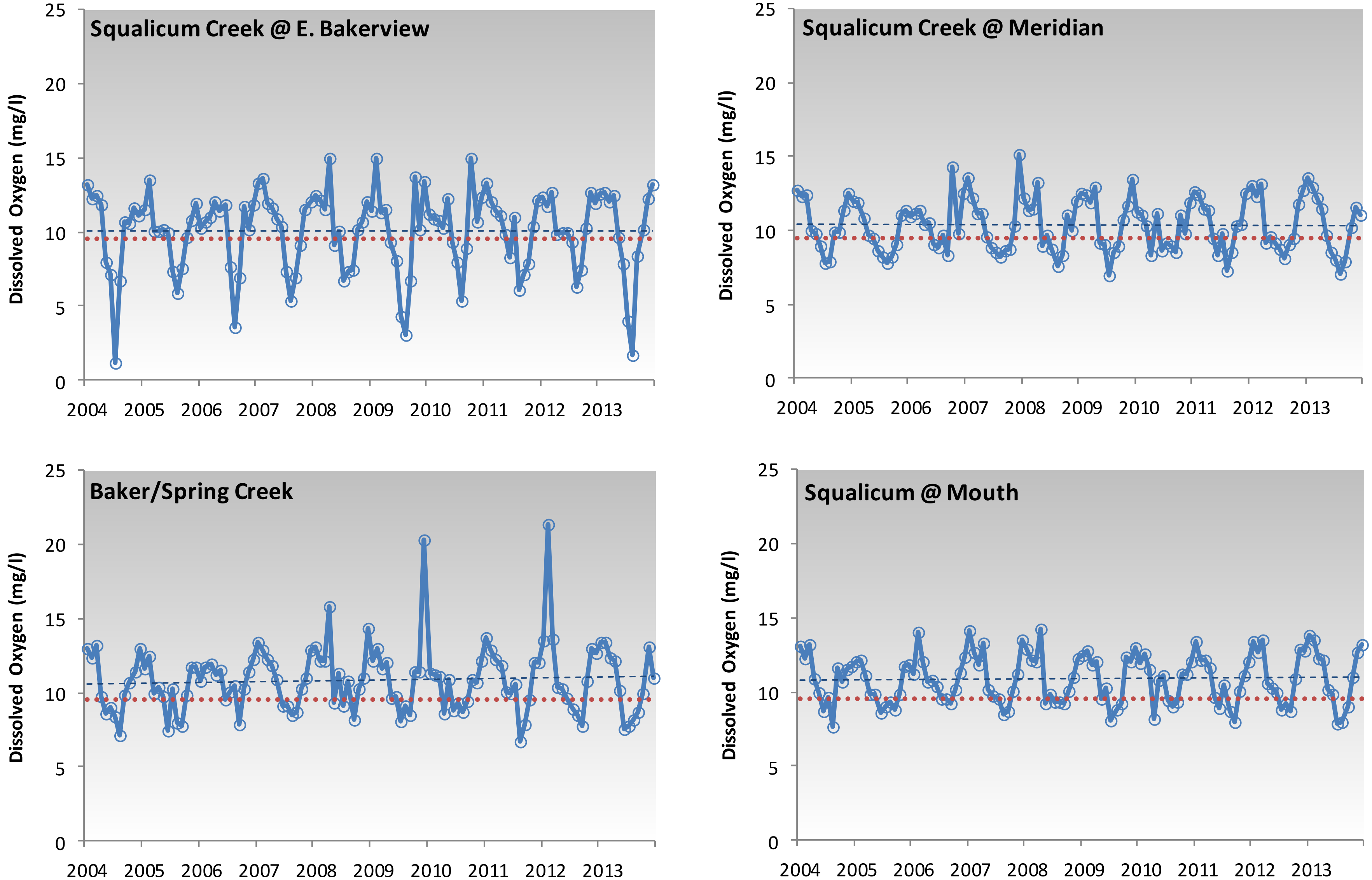


Figure 9.0-7. Monthly 2013 dissolved oxygen levels for Squalicum and Baker Creek sampling sites. Red lines the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA. Based on conventional sampling.



Figures 9.0-8a-d. Ten year dissolved oxygen trendlines (blue) for Squalicum Creek sites in 2013. None of the trendlines were significantly different from zero (E. Bakerview: p = 0.97; Meridian: p = 0.93; Baker Creek: p = 0.50; Mouth: p= 0.77, α = 0.05). Red dotted lines depict the 9.5 mg/l Aquatic Life Use standard.

Temperature

Results of conventional sampling in 2013 indicate the stringent 16° C Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation was met for all-sites except E. Bakerview (9.0-9). The E. Bakerview site met the 18°C Class A criterion. However, results of enhanced sampling prove otherwise as the 7DADMAX exceeded the 16°C ALU 76 out of a possible 122 times for the E. Bakerview site, 57/122 times for the Meridian Creek site and 95/122 times for the Squalicum Mouth site.

Average temperatures for 2013 are provided in Table 9.0-3. None of the Squalicum Creek Drainage sites displayed ten year trendlines that were significantly different than zero in 2013 (Figures 9.0-12a-d).

Table 9.0-3. Average temperatures for sampling sites on Squalicum and Baker Creeks, 2013. Based on conventional sampling.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Average Temperature (°C)	10.0	10.7	10.0	10.4

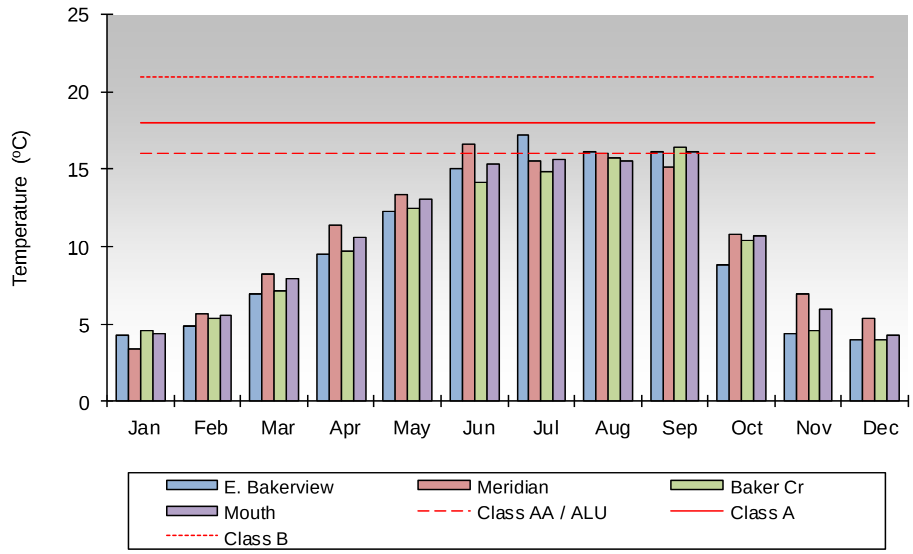


Figure 9.0-9. Monthly temperature measurements for Squalicum and Baker Creek sampling sites in 2013. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA. Based on conventional sampling.

Figure 9.0-10. Baker Creek sampling site.

Figure 9.0-11. Squalicum Creek sampling site at Meridian St.

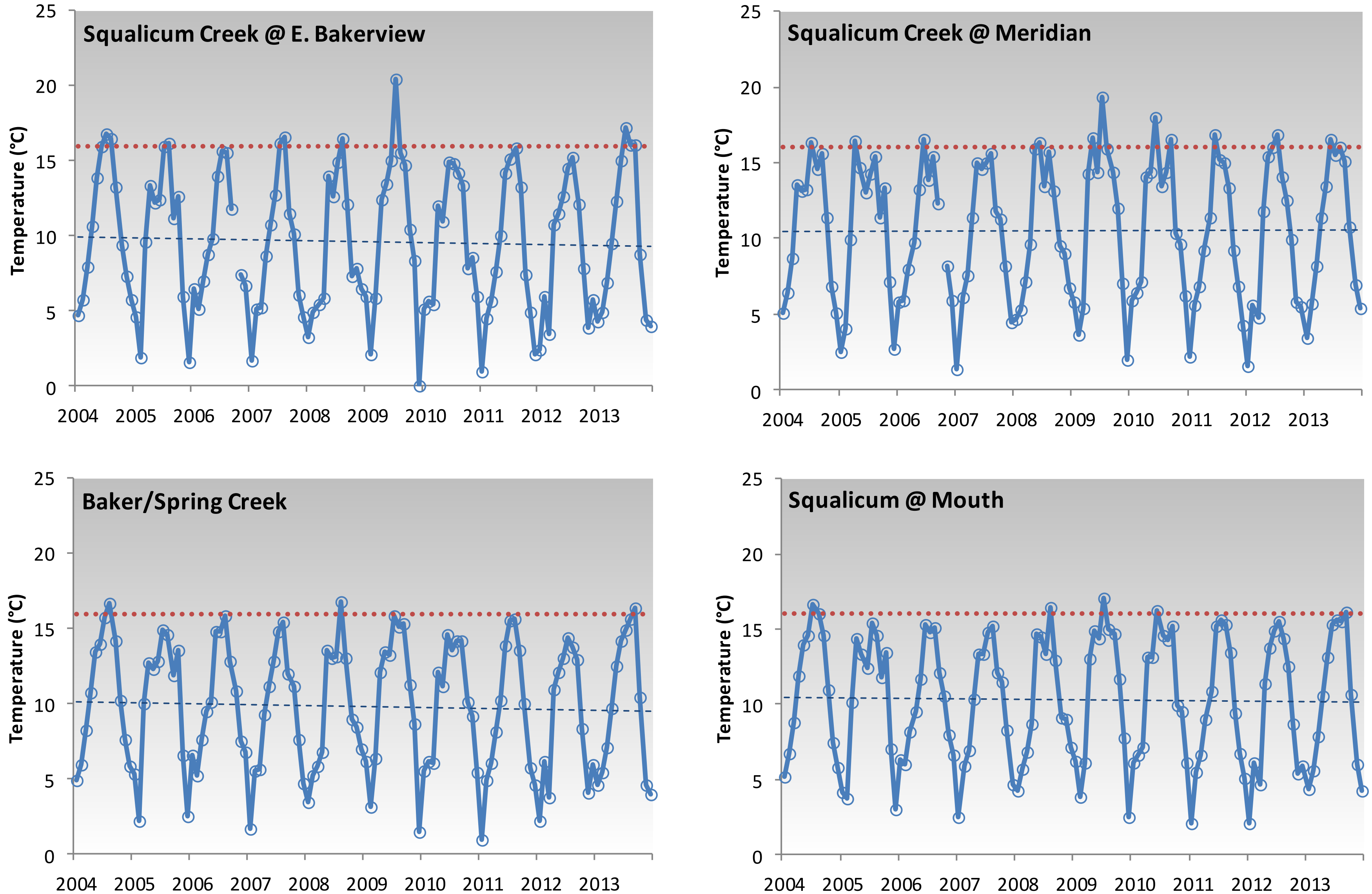


Figure 9.0-12a-d. Ten year temperature trends at Squalicum Creek Drainage sites, 2004-2013. Trendlines (blue) were not significantly different than zero (E. Bakerview: $p = 0.64$; Meridian: $p = 0.99$; Baker: $p = 0.50$; Mouth: $p = 0.79$, $\alpha = 0.05$). Red dotted lines depict the 16°C Aquatic Life Use standard.

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 2013 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.

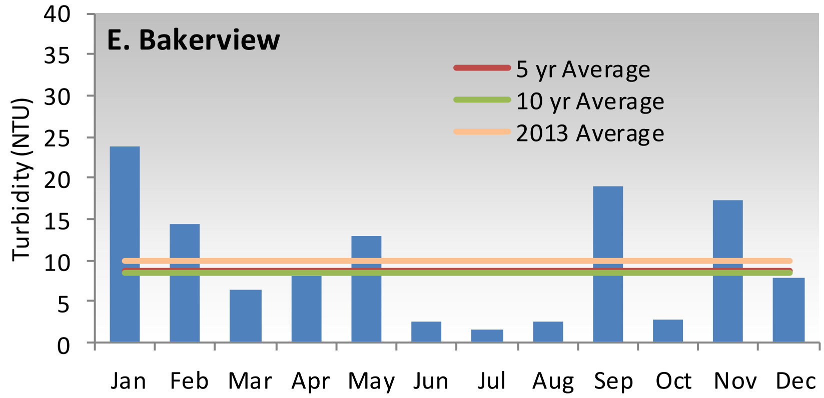
Turbidity

The average turbidities of the sampling sites on Squalicum and Baker Creeks in 2013 were similar to 2012 and higher than those of previous years. The average turbidities for all four sites were above there respective 5-year and 10-year averages (Figures 9.0-13 a-d).

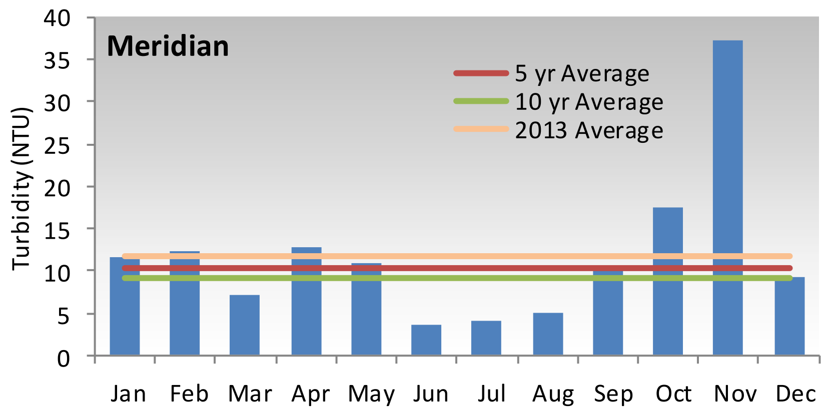
In 2013 the turbidity levels in Squalicum and Baker Creeks show the typical trend of lower values in the drier months and higher values during the wet season (Figures 9.0-13 a-d). High values in February correlate with rainfall. Average, maximum and minimum turbidity values for 2013 is provided in Table 9.0-4.

Table 9.0-4. The average, maximum and minimum turbidity values for Squalicum and Baker Creek sampling sites in 2013 .

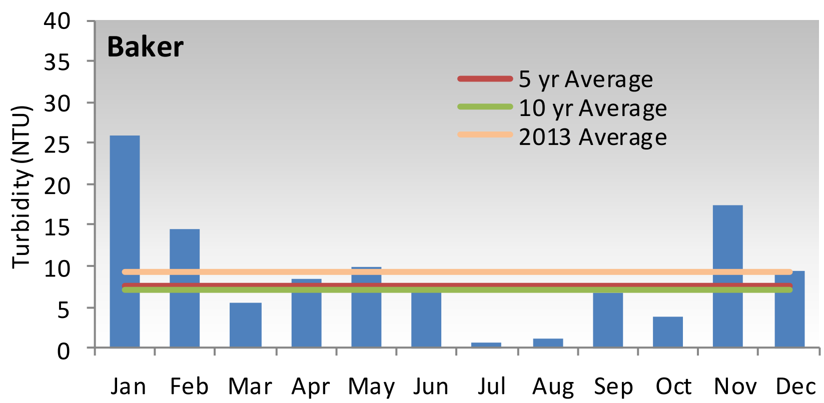
Sampling Site	E. Bakerview	Meridian	Baker	Mouth
2013 Average (NTU)	9.9	11.8	9.2	10.2
2013 Maximum (NTU)	23.7	37.2	26	30.8
2013 Minimum (NTU)	1.1	3.1	0.7	1



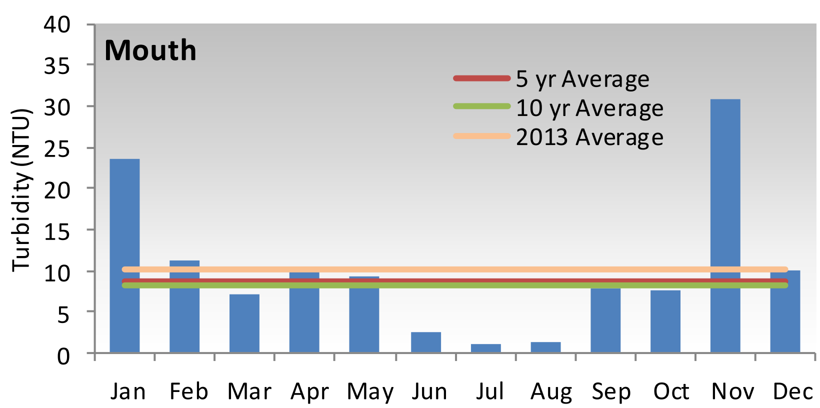
a.



b.



c.



d.

Figure 9.0-13a-d. Monthly turbidity values for Squalicum and Baker Creeks in 2013. Presented with yearly, 5-year and 10-year averages.

Hydrology

The Squalicum Creek gauging station has been in service since 2005. It is located approximately 100 feet upstream West Street off of Squalicum Parkway.

Squalicum Creek typically has a higher volume of discharge than Padden or Chuckanut Creeks and at times has been observed to be as high as those of Whatcom Creek. However, the duration of high flows in Squalicum Creek is noticeably less than that of Whatcom Creek, as is the average discharge.

In 2013, Squalicum Creek had a minimum discharge (flow) of 0.5 cubic feet per second (cfs) on September 19th, a maximum discharge of 1041 cfs on November 19th and an average discharge of 27.7 cfs.

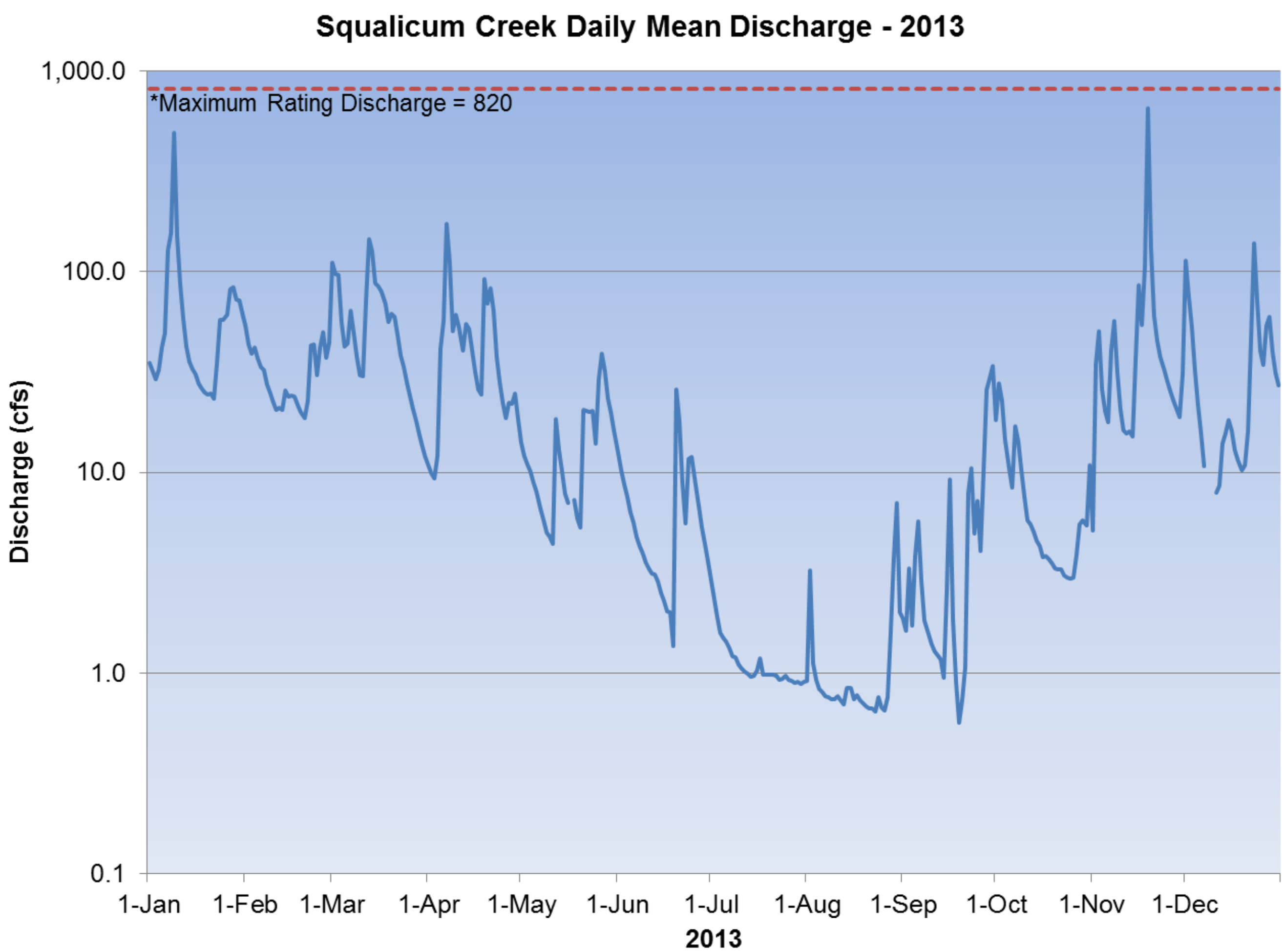


Figure 9.0-14. Daily mean discharge on Squalicum Creek during 2013. Discharge values above the maximum rating discharge of 820 cfs are of poor quality and should be interpreted cautiously. This hydrograph uses a logarithmic scale.

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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
Willow Spring (Squalicum)	Squalicum Park	Daylight Placement of LWD Riparian planting and restoration Recontour banks	2010

Appendix B

Quality Control Protocol

Test	Fecal Coliform	Dissolved Oxygen	Temperature	pH	Turbidity	Conductivity
Holding Time	Within 6 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		YSI Pro Plus	YSI Pro Plus	YSI Pro Plus	Hach 2100P Turbidimeter	YSI Pro Plus
Calibration		Barometric pressure calibration in air.	Factory -set. Annually calibrated against an NIST-traceable thermometer.	Buffers: pH 4.00, 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 YSI (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 over past 10 years. 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	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	4	12	3	12	2	12	2	12	2	12	3	12	1	12	1	12	2	12	2	12	22	120	18%
Padden (38th)	2	12	1	12	0	12	0	12	2	12	1	12	1	12	2	12	1	12	1	12	11	120	9%
Padden (30th)	4	12	4	12	3	12	3	12	2	12	2	12	2	12	1	12	2	12	3	12	26	120	22%
Connelly (Donovan)	9	12	6	12	7	12	6	12	5	12	4	12	2	12	4	12	7	12	6	12	56	120	47%
Padden (22nd)			7	12	6	12	7	12	3	12	4	12	2	12	2	12	7	12	7	12	45	108	42%
Padden (mouth)	6	12	5	12	7	12	5	12	2	12	6	12	5	12	5	12	7	12	7	12	55	120	46%
Whatcom (Control Dam)	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	120	0%
Hanna (Below WTP)	4	12	2	10	4	11	2	12	3	12	2	12	1	12	4	12	6	12	2	12	30	117	26%
Cemetery (Whatcom)	5	12	7	12	7	12	4	12	3	12	3	12	2	12	4	12	6	12	4	12	45	120	38%
Lincoln (Fraser)	3	12	3	12	5	12	2	12	3	12	6	12	2	12	4	12	7	12	5	12	40	120	33%
Fever (Valencia)	7	11	5	12	10	12	6	12	6	12	7	12	7	12	5	12	9	12	9	12	71	119	60%
Whatcom (Valencia)					0	4	0	12	0	12	1	12	0	12	0	12	1	12	1	12	3	88	3%
Whatcom (I-5)	2	12	2	12	1	12	0	12	1	12	2	12	0	12	1	12	1	12	1	12	11	120	9%
Whatcom (Dupont)	5	12	4	12	3	12	2	12	2	12	5	12	1	12	2	12	2	12	3	12	29	120	24%
Squalicum (E Bakerview)	4	12	4	12	6	12	3	12	3	12	1	12	2	12	1	12	6	12	5	12	35	120	29%
Squalicum (Meridian)	3	12	3	12	2	12	1	12	2	12	1	12	1	12	1	12	2	12	2	12	18	120	15%
Baker (Squalicum)	3	12	4	12	3	12	6	12	7	12	5	12	2	12	4	12	6	12	5	12	45	120	38%
Squalicum (mouth)	4	12	4	12	6	12	4	12	1	12	5	12	2	12	5	12	5	12	6	12	42	120	35%

Table C-2. Frequency of Class A surface water standard exceedences for dissolved oxygen for past 10 years. Class A surface waters must maintain dissolved oxygen levels of 8.0 mg/L or greater. Shaded cells indicate the number of exceedences, un-shaded cells indicate the number of samples per year.

SAMPLING SITE	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	120	1%
Padden (38th)	1	12	0	12	0	12	0	12	1	12	1	12	0	12	0	12	0	12	1	12	4	120	3%
Padden (30th)	1	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	12	3	120	3%
Connelly (Donovan)	1	12	0	12	0	12	0	12	0	12	1	12	0	12	2	12	0	12	1	12	5	120	4%
Padden (22nd)			0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	108	0%
Padden (mouth)	2	12	0	12	0	12	0	12	0	12	2	12	0	12	1	12	0	12	1	12	6	120	5%
Whatcom (Control Dam)	2	12	0	12	0	12	0	12	0	12	2	12	0	12	2	12	0	12	3	12	9	120	8%
Hanna (Below WTP)	1	12	0	10	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	117	1%
Cemetery (Whatcom)	3	12	3	12	0	12	4	12	3	12	4	12	2	12	3	12	2	12	3	12	27	120	23%
Lincoln (Fraser)	2	12	2	12	0	12	1	12	3	12	2	12	2	12	2	12	3	12	3	12	20	120	17%
Fever (Valencia)	1	11	1	12	0	12	0	12	1	12	1	12	0	12	0	12	1	12	1	12	6	119	5%
Whatcom (Valencia)					0	4	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	88	0%
Whatcom (I-5)	1	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	120	1%
Whatcom (Dupont)	2	12	1	12	0	12	0	12	2	12	2	12	0	12	0	12	2	12	3	12	12	120	10%
Squalicum (E Bakerview)	3	12	3	12	3	12	3	12	3	12	3	12	1	12	3	12	2	12	3	12	27	120	23%
Squalicum (Meridian)	2	12	1	12	0	12	0	12	1	12	1	12	0	12	1	12	0	12	2	12	8	120	7%
Baker (Squalicum)	1	12	2	12	1	12	0	12	0	12	0	12	0	12	2	12	1	12	2	12	9	120	8%
Squalicum (mouth)	1	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	2	120	2%

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

SAMPLING SITE	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Padden (38th)	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	12	1	12	0	12	3	120	3%
Padden (30th)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Connelly (Donovan)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Padden (22nd)			0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	108	1%
Padden (mouth)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Whatcom (Control Dam)	3	12	2	12	3	12	2	12	2	12	4	12	2	12	2	12	2	12	4	12	26	120	22%
Hanna (Below WTP)	0	12	0	10	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	117	0%
Cemetery (Whatcom)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	2	12	3	120	3%
Lincoln (Fraser)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Fever (Valencia)	0	11	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	3	12	4	119	3%
Whatcom (Valencia)					0	4	2	12	2	12	2	12	1	12	1	12	1	12	2	12	11	88	13%
Whatcom (I-5)	2	12	1	12	1	12	1	12	2	12	2	12	0	12	1	12	1	12	2	12	13	120	11%
Whatcom (Dupont)	2	12	1	12	0	12	1	12	1	12	1	12	1	12	1	12	1	12	2	12	11	120	9%
Squalicum (E Bakerview)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Squalicum (Meridian)	0	12	0	12	0	12	0	12	0	12	1	12	0	12	0	12	0	12	0	12	1	120	1%
Baker (Squalicum)	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	120	0%
Squalicum (mouth)	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	120	0%

Table C-4. Frequency of Class A surface water standard exceedences for pH over past 10 years. 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	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Padden (38th)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Padden (30th)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Connelly (Donovan)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Padden (22nd)			0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	107	0%
Padden (mouth)	0	12	0	11	1	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	119	1%
Whatcom (Control Dam)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Hanna (Below WTP)	0	12	0	9	1	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	116	1%
Cemetery (Whatcom)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Lincoln (Fraser)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Fever (Valencia)	0	11	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	118	0%
Whatcom (Valencia)					0	4	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	88	0%
Whatcom (I-5)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Whatcom (Dupont)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Squalicum (E Bakerview)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Squalicum (Meridian)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Baker (Squalicum)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
Squalicum (mouth)	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	119	0%
	0	12	0	11	0	12	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	118	0%

Appendix D. 303d Listing Maps

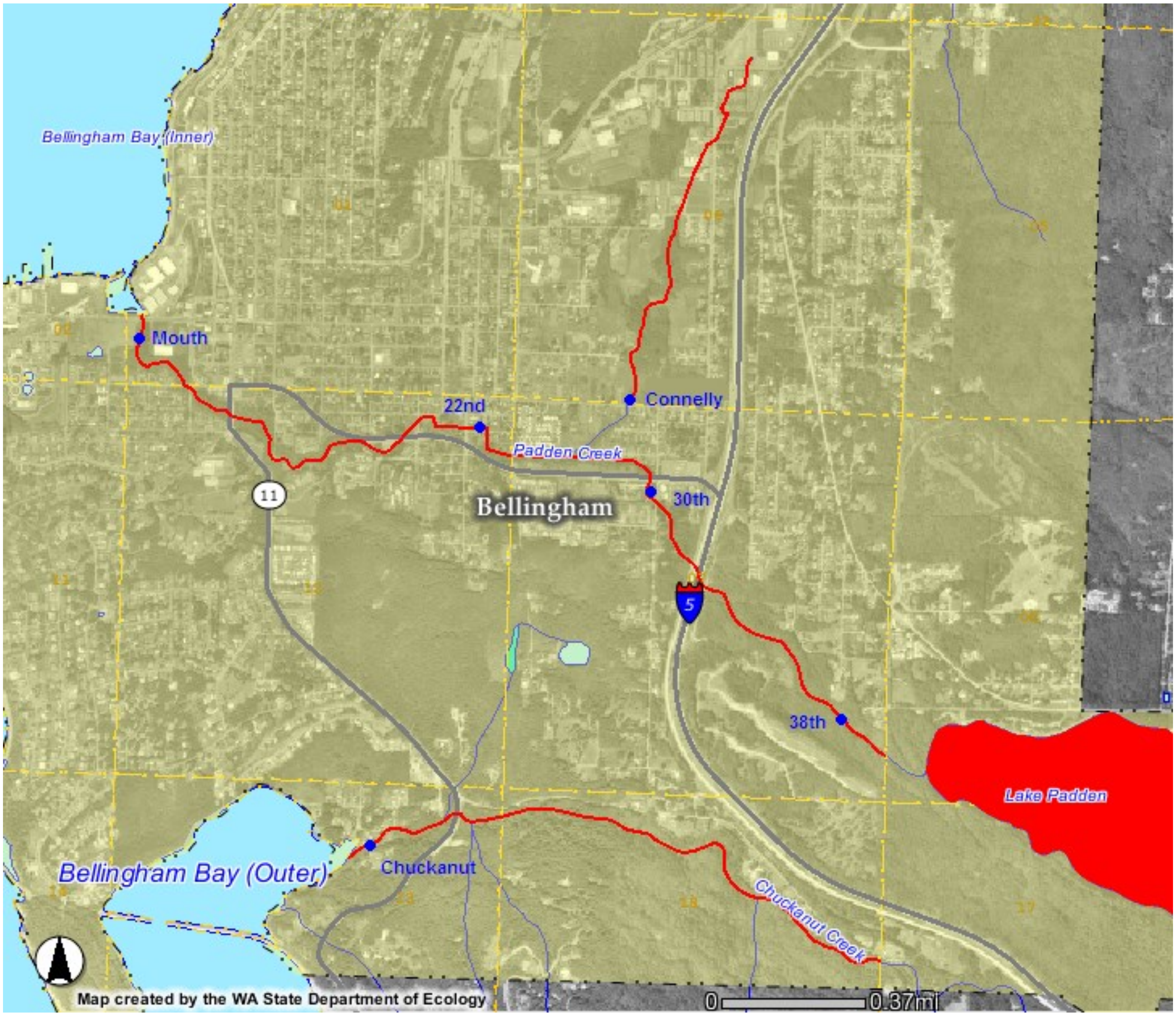


Figure D-1. Map of 303d listed stream segments on Chuckanut and Padden Creek Drainages. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All segments are listed for fecal coliform. In addition, the segments containing the Padden Mouth site, the 30th and 38th St. sites, Connelly Creek and the Chuckanut Mouth site are listed for dissolved oxygen. Finally, the Connelly Creek and Padden 30th/38th segments are listed for temperature exceedences.

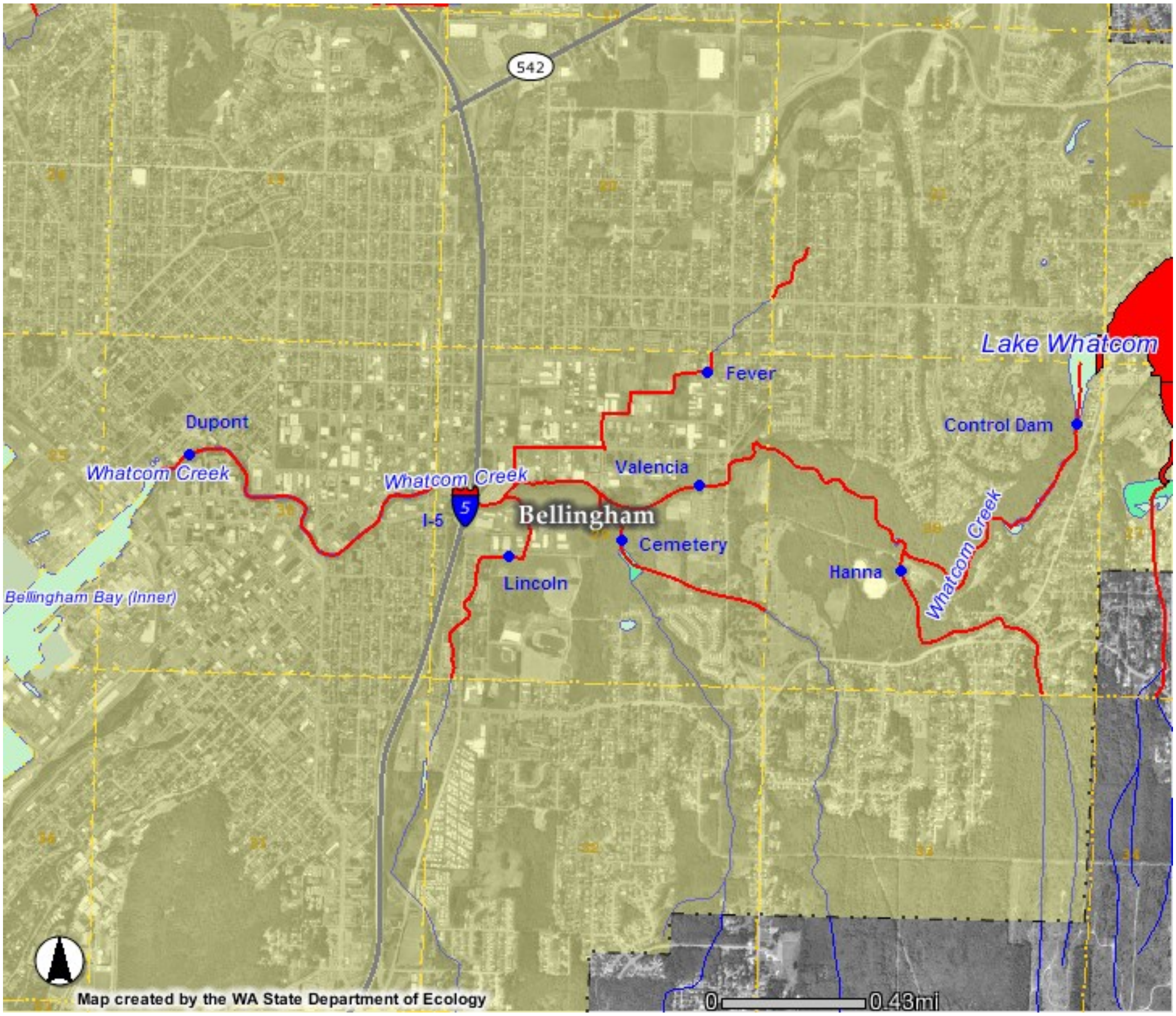


Figure D-2. Map of 303d listings in the Whatcom Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All Segments on Whatcom Creek, as well as Cemetery, Lincoln and Fever Creeks are listed for fecal coliform, temperature and dissolved oxygen. Hanna Creek is listed for fecal coliform and temperature. Fever Creek is also listed for zinc.

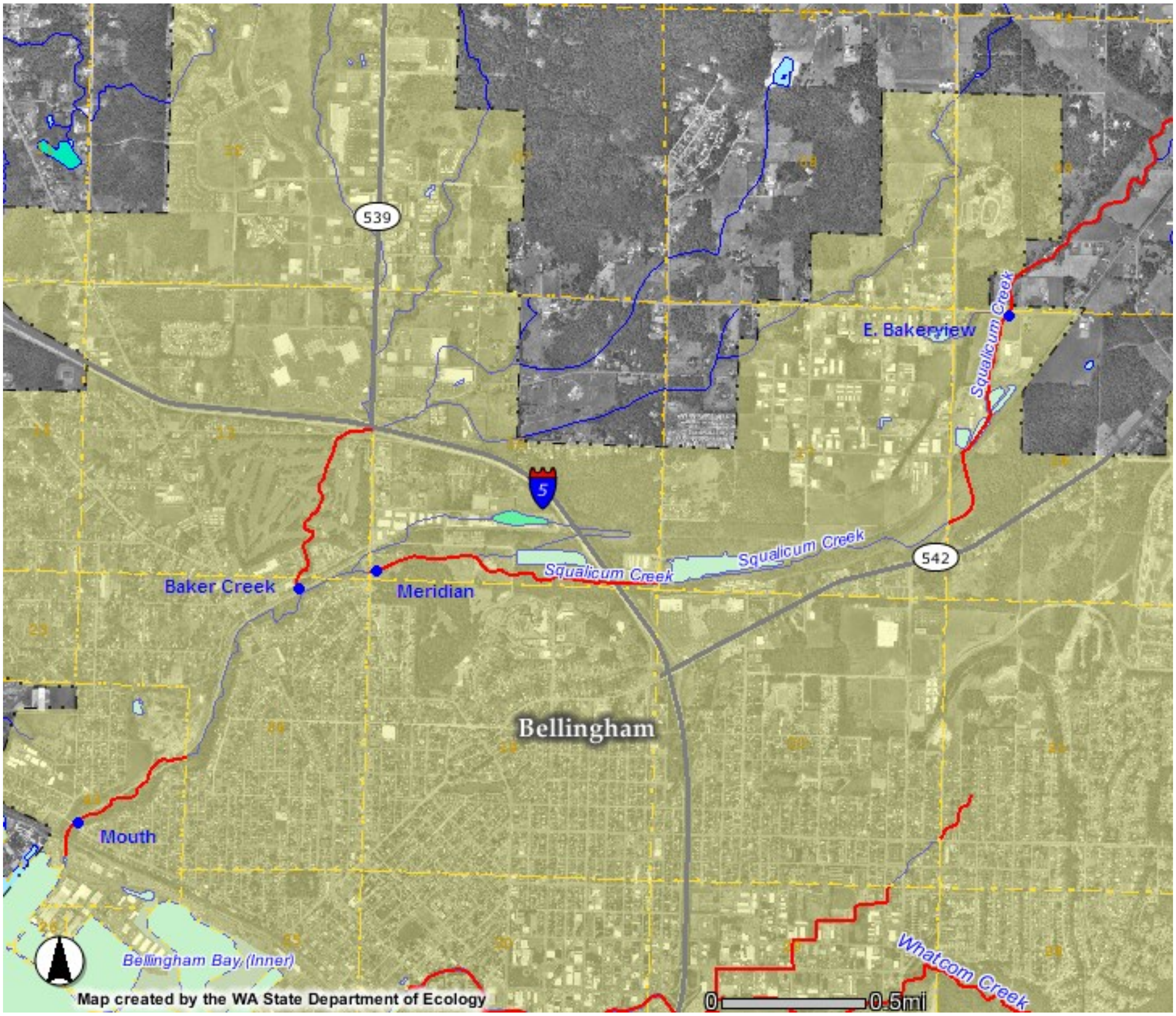
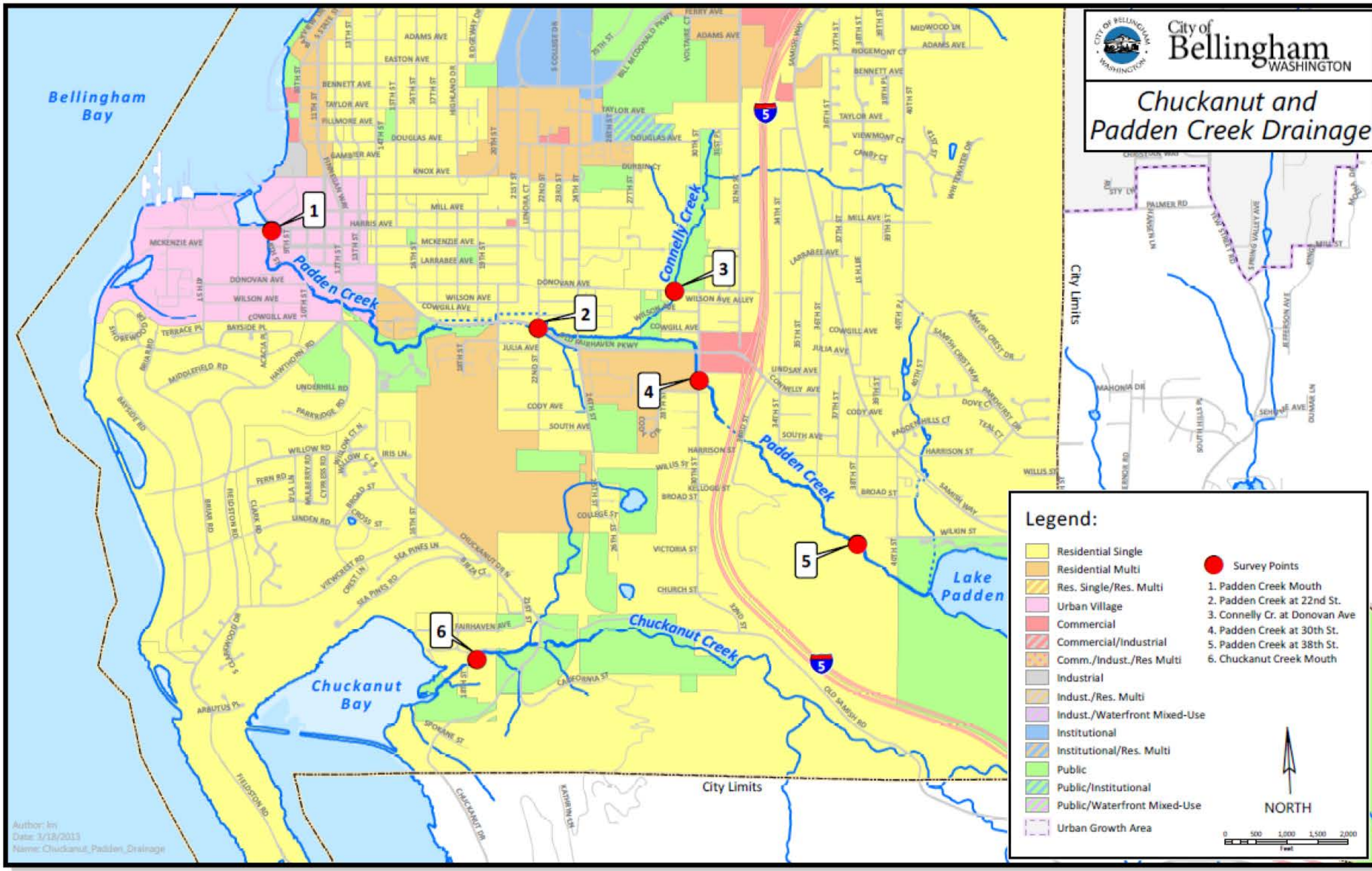
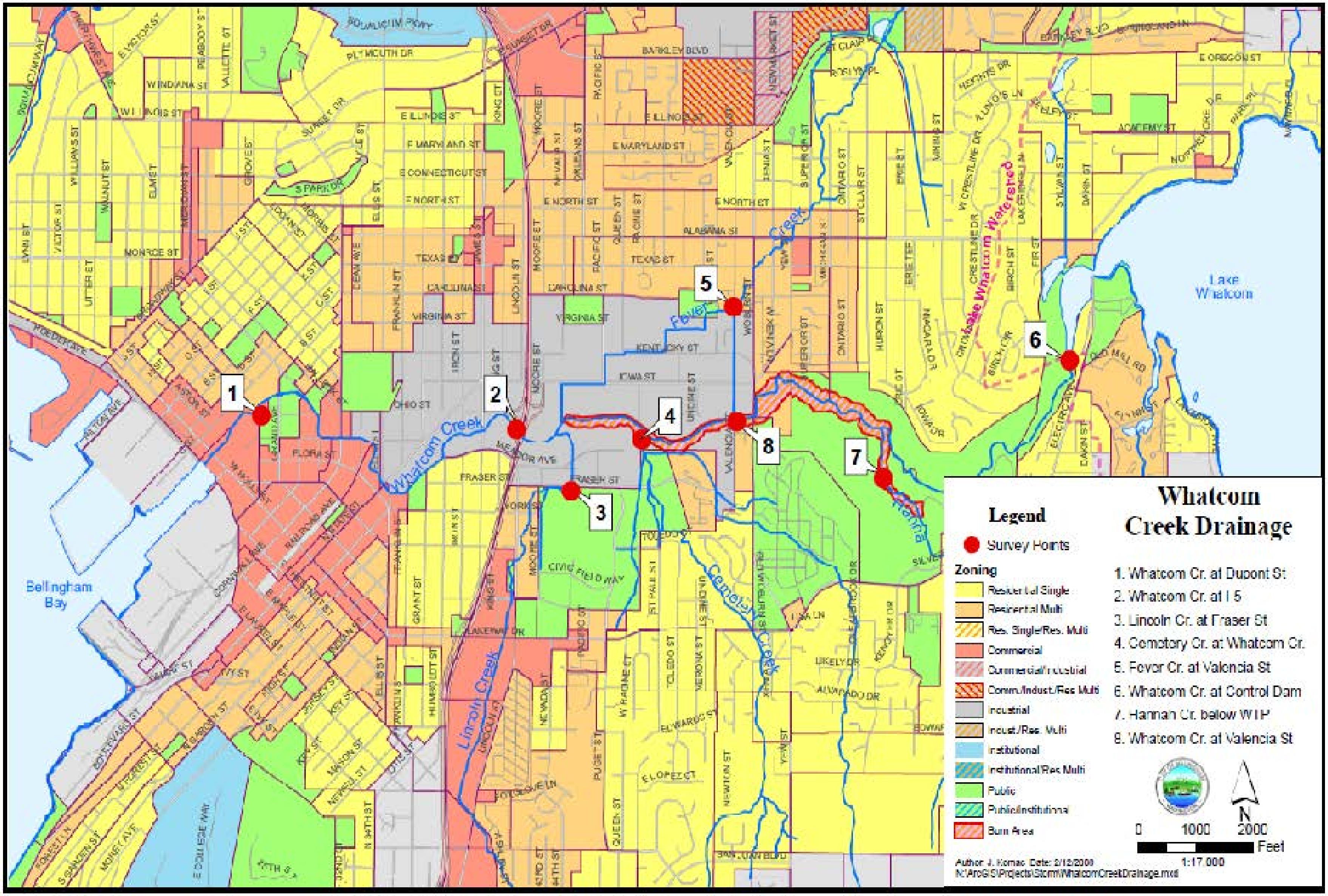
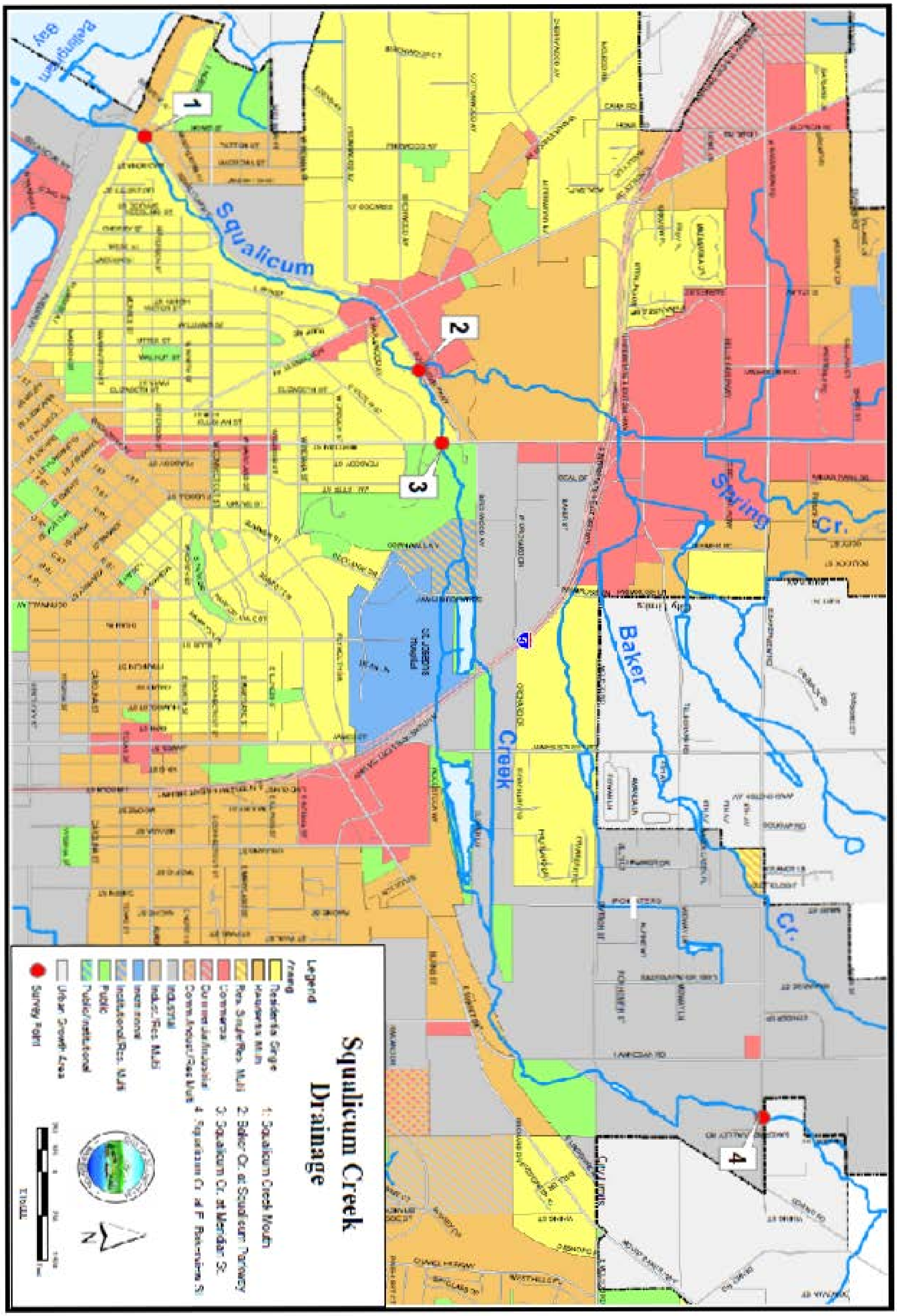


Figure D-3. Map of 303d listings in the Squalicum Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All of the listed segments are listed for excess fecal coliform bacteria. The segment containing the Meridian sampling site and the segment outside the City limits are also listed for temperature and dissolved oxygen. The segment below the E. Bakerview is listed for dissolved oxygen and fecal coliform.

Appendix E. Drainage Maps




Whatcom Creek Drainage
Legend
Survey Points
Zoning
Residential Single
Residential Multi
Res. Single/Res. Multi
Commercial
Commercial/Industrial
Comm./Indust./Res. Multi
Industrial
Indust./Res. Multi
Institutional
Institutional/Res. Multi
Public
Public/Institutional
Burn Area
1. Whatcom Cr. at Dupont St
2. Whatcom Cr. at I 5
3. Lincoln Cr. at Fraser St
4. Cemetery Cr. at Whatcom Cr.
5. Fever Cr. at Valencia St
6. Whatcom Cr. at Control Dam
7. Hannah Cr. below WTP
8. Whatcom Cr. at Valencia St
0 1000 2000 Feet
1:17,000
N
Bellingham Bay
Lake Whatcom
Whatcom Creek
Lincoln Creek
Cemetery Creek
Fever Creek
Lake Whatcom Watershed


Squalicum Creek
Drainage
Legend
Survey Point
1: Squalicum Creek Mouth
2: Baker Cr. at Squalicum Parkway
3: Squalicum Cr. at Meridian St.
Squalicum
Spring Cr.
Baker
Creek
Cr.