

**Skagit County Monitoring Program
Annual Report - 2017 Water Year
(October 2016 – September 2017)**



Tannins produced by organic materials turn the water brown at Swede Creek



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Skagit County Water Quality Monitoring Program – 2017 Water Year Annual Report

Executive Summary

Skagit County has completed the thirteenth year of water quality monitoring under the Skagit County Water Quality Monitoring Program. This program was established to help determine if the Skagit County Critical Areas Ordinance for Ongoing Agriculture (SCC 14.24.120) was sufficient to protect water quality in areas of ongoing agriculture. Forty monitoring stations were established in agricultural areas as well as reference locations outside of the agricultural zones. Monitoring began in October 2003 and is continuing. Reports are published after each water year (October 1- September 30). This report is the 14th annual report, for the 2017 water year.

Data collected during this project indicates that many Skagit County streams, within and outside of the agricultural areas, do not meet state water quality standards for fecal coliform, temperature, and/or dissolved oxygen. None of the 40 sites has met all water quality standards for the entire project, although some sites meet the standards most of the time. The standards are developed to protect salmonid populations, recreation, and downstream shellfish resources, so streams not meeting the standards represent less-than-ideal conditions for those uses. Conditions in Skagit County streams range from watercourses with occasional failures to a pattern of continual inability to meet the standards. Most of the substandard water quality occurs in tributaries to the Skagit River and in the Samish Basin, while the Skagit River itself meets most standards on most occasions. Further investigation will be necessary to determine the causes of poor water quality in each case. Some cases may represent natural conditions rather than human-caused problems.

A major focus of the program is the determination of trends in water quality both within and outside of the agricultural zones. Based on court decisions that the Growth Management Act requires protection of critical areas, but not restoration, the county uses trends monitoring as a method to determine whether water quality conditions are deteriorating in the county. Trends analysis for the 14 years of the program reveals a mixed pattern of beneficial and deleterious trends both inside and outside of the agricultural areas. While many watercourses both inside and outside of the agricultural areas show declining trends in water quality, stations in the Samish Basin show a higher proportion of improving trends, especially in fecal coliform bacteria. County water quality enhancement programs have focused on the Samish Basin, so improving trends there show that the programs are resulting in improved water quality.

Skagit County data has also proved useful to Ecology in their water cleanup (Total Maximum Daily load or TMDL) efforts, especially the Samish Bay Watershed Fecal Coliform TMDL. Skagit County, in cooperation with many local and state partners through the Clean Samish Initiative, is comprehensively addressing pollution in the Samish Bay Watershed. County data, supplemented by volunteer data, has shown severe fecal coliform contamination in many areas of the watershed. The County has received EPA funding to address Samish Bay Watershed pollution issues and is working in partnership with the Washington State Department of Ecology, the Skagit Conservation District, local tribes, and other partners in locating properties with possible pollution sources and seeking cooperative solutions to those problems.

The Washington State Department of Ecology used Skagit County data from the South Fork Skagit River to determine that additional monitoring for the County's NPDES Phase II Stormwater Permit was not necessary. In most cases, water bodies with TMDLs require additional monitoring in association with the stormwater permits, but County data showed that the South Fork Skagit had improved substantially since the TMDL went into effect, and that additional stormwater monitoring was not necessary at the time of permit issuance.

County staff participate in local and regional technical groups and in training of volunteer monitoring groups. Staff also give numerous presentations throughout the year to interested organizations. Fecal coliform results are displayed on a map on the Skagit County web page: <http://www.skagitcounty.net/Departments/PublicWorksCleanWater/main.htm>. Skagit County staff sponsor many community outreach events and participate in other events organized by partner organizations.

The program was supported through 2008 by a Centennial Clean Water grant from the Department of Ecology. Grant match and all current funding is provided by Skagit County's Clean Water Program. All monitoring is governed by an Ecology-approved Quality Assurance Project Plan.

The Skagit County Water Quality Monitoring Program has collected 14 years of high-quality data. Questions on the program can be addressed to Rick Haley at rickh@co.skagit.wa.us or 360-416-1400.

Skagit County Monitoring Program Annual Report

2017 Water Year
(October 2016-September 2017)

Introduction

The Skagit County Monitoring Program started in October 2003, as part of Skagit County's program to assess the effectiveness of Skagit County Code Chapter 14.24.120, Critical Areas Ordinance for Areas of Ongoing Agriculture. The revised ordinance (Skagit County Ordinance O20030020) was passed by the Skagit County Board of Commissioners in June 2003 in response to a Compliance Order from the Western Washington Growth Management Hearings Board.

The ordinance requires farmers to "do no harm" to adjacent watercourses, and relies on specific Watercourse Protection Measures and more generalized Best Management Practices to protect the watercourses instead of requiring buffers on the streams. The associated Skagit County Resolution R20030210 committed the County to conduct water quality monitoring in the agricultural areas as one method of assessing if the County's ordinance was sufficient to protect the aquatic resources in agricultural areas. The resolution was subsequently amended in June 2004 as Resolution R20040211 in response to additional Compliance Orders from the Western Washington Growth Management Hearings Board. This second resolution provided details about the water quality monitoring program in addition to other topics not associated with water quality. Included in R20040211 is the requirement for annual reporting on the water quality monitoring program. This document is intended to satisfy that requirement for the 2016 Water Year.

R20040211 also required the County to conduct a triennial review of the Critical Areas Ordinance for Areas of Ongoing Agriculture, including the water quality monitoring program, to seek public comment on the regulations and monitoring program, and to make changes if necessary. However, the State of Washington passed SSB 5248 in 2007, which placed a "time out" on changes to critical areas regulations impacting agriculture until 2010 while the statewide issues regarding agricultural regulation are studied. The legislature subsequently passed additional legislation to extend the "time out" to 2011. In 2011, Washington State Legislature adopted the recommendations from one research group studying the critical areas regulations and created the Voluntary Stewardship Program (VSP). Skagit County decided to enroll in the program in 2012. Any county that enrolled agreed to maintain existing critical areas protections and ensure streams are protected using voluntary measures.

Sampling Locations

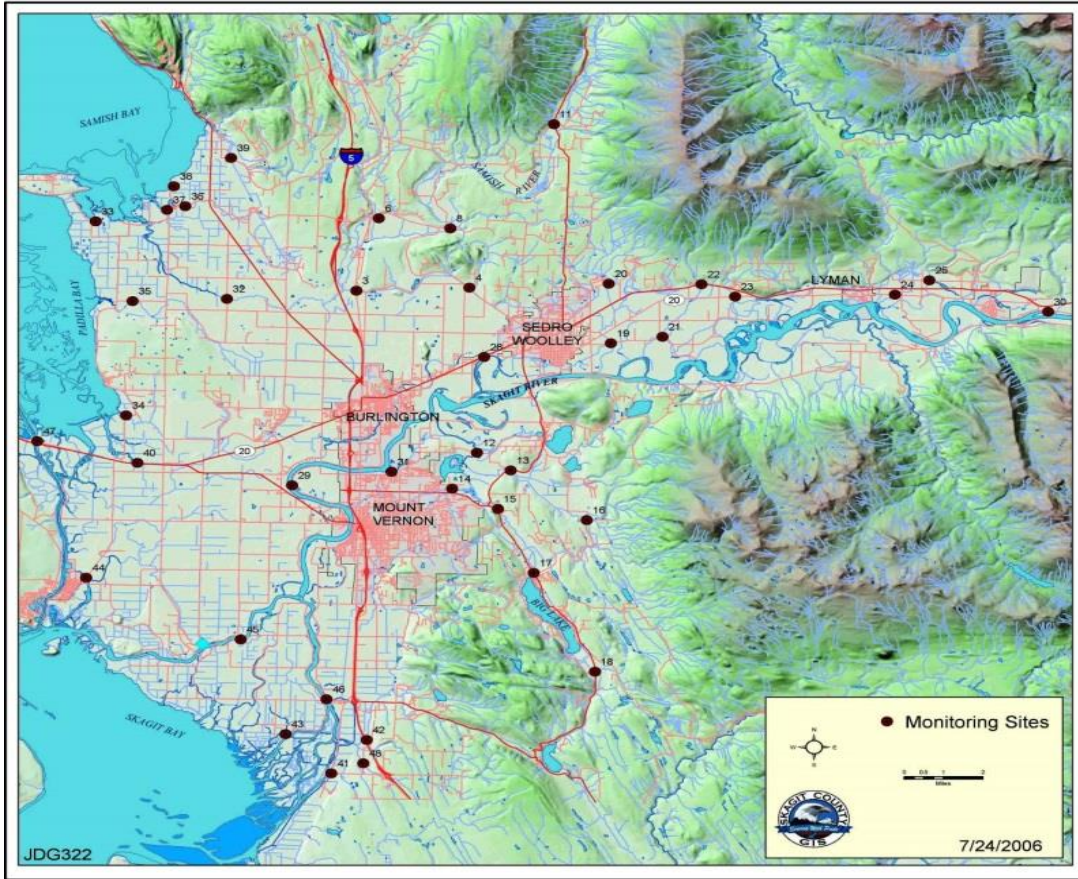
Figure 1 is a map with the sampling sites in the Skagit County Monitoring Program marked. Tables 1 and 2 list the sampling sites and site descriptions for the Skagit County Monitoring Program. Forty sites are currently included in the Program. These sites are located primarily in the agricultural zones (Agriculture-Natural Resource and Rural Resource). Other sites are located to provide context to, and comparisons with, the sites in the agricultural zones. These

include sites located just upstream or downstream of agricultural areas or in streams draining suburban watersheds.

The monitoring program was designed to determine current conditions and long-term trends in water quality at the sampling locations. The data is also suitable for determining compliance with state water quality standards.

A secondary purpose for some of the sites included in the monitoring program is to provide data to the Washington State Department of Ecology in support of their TMDL or Water Cleanup programs in Skagit County. The sites that provide TMDL data are also in the agricultural zones and are integral to the determination of trends and conditions in those areas. Active Water Cleanup plans in Skagit County include the Lower Skagit Tributaries Temperature TMDL, the Samish Bay Watershed Fecal Coliform TMDL, and the Lower Skagit River Fecal Coliform TMDL. Improvements made as a result of the latter program indicate that the Lower Skagit River is a candidate for removal from Ecology's Impaired Waters list.

This year, for the first time in the program, we redesignated two sites to better reflect current land use patterns: Site 16 (East Fork Nookachamps Creek) was moved from Ag-Upstream to Ag-Midstream due to some agricultural activity directly upstream of the sample location. Site 23 (Wiseman Creek) was moved from Ag-Midstream to Ag-Upstream due to the cessation of agricultural activities upstream of the sample location.



**Figure 1. Sample Sites in the Skagit County Monitoring Program
Refer to Tables 1 and 2 for site locations and descriptions.**

Table 1. Sample Sites for Skagit County Monitoring Program

Site Number	Watercourse	Location	Latitude	Longitude	Site Type¹
3	Thomas Creek	Old Hwy 99 N	48.526	-122.339	3
4	Thomas Creek	F&S Grade Rd	48.528	-122.276	2
6	Friday Creek	Prairie Rd	48.559	-122.327	4
8	Swede Creek	Grip Rd	48.555	-122.287	3
11	Samish River	State Route 9	48.602	-122.231	1
12	Nookachamps Creek	Swan Rd	48.454	-122.270	3,6
13	E.F. Nookachamps Creek	State Route 9	48.446	-122.251	3,6
14	College Way Creek	College Way	48.436	-122.286	4
15	Nookachamps Creek	Knapp Rd	48.429	-122.258	2,6
16	E.F. Nookachamps Creek	Beaver Lake Rd	48.424	-122.208	2,6
17	Nookachamps Creek	Big Lake Outlet	48.400	-122.237	1,6
18	Lake Creek	State Route 9	48.356	-122.202	1,6
19	Hansen Creek	Hoehn Rd	48.504	-122.197	3,6
20	Hansen Creek	Northern State	48.531	-122.199	1,6
21	Coal Creek	Hoehn Rd	48.507	-122.169	3
22	Coal Creek	Hwy 20	48.531	-122.149	1
23	Wiseman Creek	Minkler Rd	48.526	-122.130	1
24	Mannser Creek	Lyman Hamilton Hwy	48.528	-122.041	2
25	Red Cabin Creek	Hamilton Cemetery Rd	48.534	-122.023	1
28	Brickyard Creek	Hwy 20	48.497	-122.268	4
29	Skagit River	River Bend Rd	48.439	-122.372	5,6
30	Skagit River	Cape Horn Rd	48.521	-121.960	5
31	Drainage Dist 20 floodgate	Francis Rd	48.445	-122.317	3
32	Samish River	Thomas Rd	48.521	-122.410	3
33	Alice Bay Pump Station	Samish Island Rd	48.555	-122.483	3
34	No Name Slough	Bayview-Edison Rd	48.468	-122.464	3
35	Joe Leary Slough	D'Arcy Rd	48.520	-122.462	3
36	Edison Slough at school	W. Bow Hill Rd	48.562	-122.436	3
37	Edison Pump Station	Farm to Market Rd	48.561	-122.444	3
38	North Edison Pump Station	North Edison Rd	48.572	-122.441	3
39	Colony Creek	Colony Rd	48.581	-122.401	2
40	Big Indian Slough	Bayview-Edison Rd	48.447	-122.457	3
41	Maddox Slough/Big Ditch	Milltown Rd	48.309	-122.346	3
42	Hill Ditch	Cedardale Rd	48.324	-122.327	3
43	Wiley Slough	Wylie Rd	48.326	-122.372	3
44	Rexville Pump Station	Summer's Drive	48.366	-122.419	3
	Sullivan Slough ²	La Conner-Whitney Rd	48.395	-122.485	3
45	Skagit River – North Fork	Moore Rd	48.364	-122.416	5,6
46	Skagit River – South Fork	Fir Island Rd	48.342	-122.349	5,6
47	Swinomish Channel	County Boat Launch	48.455	-122.512	7
48	Fisher Creek	Franklin Rd	48.320	-122.328	3,6

¹See Table 2 for site type descriptions²Site 44 was moved in June, 2005. See text for details

Table 2. Sample Site Type Descriptions for Skagit County Monitoring Program

Site Type Number	Description	Number of Sites¹
1	Ag-upstream: Located to determine status/trends at upstream end of agricultural areas.	6
2	Ag-midstream: Located to determine status/trends in the middle of agricultural areas.	6
3	Ag-downstream: Located to determine status/trends at downstream end of a watercourse in agricultural areas.	20
4	Reference: Located to determine status/trends in a non-agricultural area, such as urban/suburban or rural reserve, for comparison with agricultural area results.	3
5	Skagit River: Located to determine status/trends in the mainstem Skagit River or the forks. The Skagit may show effects from a wide variety of sources.	4
6	TMDL: Located to provide information for the Department of Ecology's TMDL efforts.	12
7	Swinomish Channel: Located to provide a water quality baseline for Swinomish Channel	1

¹Some sites have more than one type designation

Nineteen of the 40 sites (sites 3-25) are continued from the Skagit County Baseline Monitoring Project (Skagit County 2004a). The Baseline Project used nearly identical methods to monitor water quality at 27 sites. Five additional sites were part of the Samish Bay Watershed Water Quality Monitoring Program (Skagit County 2003). The data from the Baseline and Samish Projects will be used to help interpret trends in water quality for sites continued in the Skagit County Monitoring Program. Not all of the Baseline sites could be continued into the current program due to limited resources and the need to expand the current program into the Skagit Delta, where there were no Baseline sites. In particular, several intermediate sites on the Samish River were discontinued, leaving one upstream and one downstream site on the Samish.

A proposal was submitted in February 2003 to the Department of Ecology for consideration in their FY 2004 Centennial Clean Water Grants program. The proposal was accepted and a grant of nearly \$500,000 was awarded to support five years of the monitoring program, FY 2004 through FY 2008.

Results from the first ten years of this program have been reported previously (Skagit County 2004-2017). This report contains data and analysis from water years 2004 – 2017.

Methods

Standard water quality monitoring methods are used in the Skagit County Monitoring Program. The methods are derived from several sources, including the Department of Ecology and the U.S. Environmental Protection Agency. A brief description of monitoring procedures follows, and detailed monitoring procedures can be found in the Quality Assurance Project Plan developed for the program (Skagit County 2004b).

Each site in the monitoring program is visited every two weeks. At each visit, dissolved oxygen, temperature, pH, turbidity, conductivity, and salinity are measured and samples are obtained for fecal coliform determinations. Additional water samples are obtained for laboratory quantification of plant nutrients (total nitrogen, ammonia, nitrate, nitrite, total phosphorus and orthophosphate) and total suspended solids on a quarterly basis. Stream discharge was measured at selected sites as time and staffing permitted through 2008.

The sample routes are designed so that each station is visited at approximately the same time of day on each visit, to minimize the effects of diurnal variation in water quality parameters on overall data variability.

Data collected is entered into a custom database, and then is checked for accuracy against the original data sheets. Output from the database is exported into Excel[®] spreadsheets for data summary and analysis. These spreadsheets are also published on the County's web site:

<http://www.skagitcounty.net/SCMP>

Activity Summary

Weekly Sampling

Weekly sampling on a regular schedule is often referred to as “ambient sampling” to distinguish it from storm sampling that occurs in response to rain events. All weekly sampling trips were conducted on schedule during the 2017 water year, beginning in October 2016. Sampling normally took place on Tuesdays, but occasionally took place on other days to accommodate holiday and laboratory schedules. Occasionally samples are taken on different days because of flooding or other acts of nature. Sampling activities are illustrated in Figure 2.

Storm Sampling

As part of its Pollution Identification and Correction (PIC) Program, Skagit County conducts additional water quality sampling in the Samish Basin during significant rain events. Data collected during these rain events is not included in the tabulation of regular sampling events to preclude undue influence of storm events on Trends Analysis.

Funding

The Centennial Clean Water Grant that funded the program at 75% ended in December 2008, with the remaining 25% coming from County funds. Subsequent work was funded by Skagit County's Clean Water Program. Skagit County has received EPA funding to address Samish Bay Watershed fecal coliform issues, but the core activities of the Skagit County Monitoring Program will continue to be funded out of the Clean Water Program.



Figure 2. Dr. Andy James from UW takes a water sample at a tributary of Thomas Creek

Sample Site Revisions

Three sample sites were moved from the original location as delineated in the QAPP. Site 35 on Joe Leary Slough was moved approximately 3,500 feet upstream from Bayview-Edison Road to D'Arcy Road to solve right-of-entry problems. Site 40 on Big Indian Slough was moved approximately 2,800 feet upstream to solve right-of-entry problems and to move away from the tidegate and associated saltwater intrusion. These two changes were made prior to any sampling. Site 42 on Hill Ditch/Carpenter Creek was moved approximately 4,300 feet upstream because the original site at Pioneer Highway was subject to backwater from the Skagit River, and in early samples it was determined that primarily Skagit River water was being sampled instead of Hill Ditch/Carpenter Creek water. These changes were approved by the Department of Ecology as revisions to the QAPP in 2003 and 2004.

In June 2005, the sample site at Rexville Pump Station (Site 44), at the east end of the Sullivan Slough watershed, was moved to the west end of Sullivan Slough, at La Conner-Whitney Road. This move was made in consultation with the Department of Ecology and the Western Washington Agricultural Association. The majority of flow from that system discharges through

the west end into Swinomish Channel. The Rexville Pump Station site was initially chosen because it was cited as a possible fecal coliform source in the Lower Skagit Fecal Coliform TMDL (Pickett 1997). However, fecal coliform readings at the site during this study were generally low, and coupled with the infrequent discharges from the pump station, it was determined that sampling efforts would be better spent nearer the outlet of the slough.

2008 Review of Skagit County Water Quality Program by State of Washington Water Research Center

Skagit County contracted with the State of Washington Water Research Center (WRC) for a review of its water quality program. The WRC Review Report draft was received in March, 2008, and the final report was received in June 2008. The report is available on the Skagit County web site at: www.skagitcounty.net/SCMP.

Skagit County is implementing the report recommendations as the budget allows. Recommendations that have already been incorporated into the program include expansion of the sampling program to better identify pollution source locations (through the County's Pollution Identification and Correction program), increased use of stream discharge information, and some of the statistical recommendations.

Data Summary

Graphs and tables on the following pages report results from the Skagit County Monitoring Program for dissolved oxygen, temperature, and fecal coliform. Please note that each graph within a series may have a different scale due to differences between sample sites. Full data listings for each sampling event at each sample site are included in Appendix A. A summary of water quality results for each sample site is included in Appendix B.

The graphs are meant to give an overall picture of the water quality at a given site over time. They are not intended to fully describe the conditions at that site, only to give an "at a glance" indication of the conditions over the course of the project. Detailed descriptive statistics are included in the summary tables and in Appendix B. Results of the Trends Analysis are described in the Data Analysis section that follows the Data Summary.

Temperature

Water temperature governs the metabolic rate of aquatic organisms. Excessive temperature can serve as a stress on fish and other cold-water organisms, and extreme temperatures can be lethal.

For the water years 2004-2007 and 2009-2017, temperatures were measured with Stowaway Tidbit[®] data loggers from Onset Computer Company. These devices were set to measure water temperature every half hour. They are normally deployed in June and retrieved in late August or early September. During those years, several of the data loggers were missing at the end of each monitoring period. Some had apparently been lost due to channel changes associated with heavy rains in late summer, while others may have been vandalized. For the 2008 water year, a computer programming error resulted in the data loggers measuring temperature for only two

weeks in late June and early July. Since annual peak temperatures occur later in the summer, the 2008 data logger data was not very useful. However, temperatures are also measured at each sampling visit, and this data is displayed in the tables and graphs on the following pages for all years of the program. Readers interested in the continuous temperature data collected in 2004-2007 can access those graphs in the 2007 Water Year Annual Report at this web address: www.skagitcounty.net/scmp.

Table 3 shows the daily maximum temperatures for the last five years of the study, based on data collected at biweekly samplings. Because the state water quality standards are based on 7-day average maximums (7-DAMs), the maximums reported on Table 3 are not directly comparable to the state temperature standard, but are displayed here as an indication of the relative condition of each stream and for comparison of the temperature conditions from year to year.

Table 4 contains the 7-day average maximums for those sample sites where continuous temperature data is available. These data are directly comparable to the state water quality standards as described on the table and in the next paragraph.

In the fall of 2006, the Washington State Department of Ecology revised its water quality standards (WAC 173-201a) to comply with a request from the U.S. Environmental Protection Agency. Included in this revision were several changes to temperature and dissolved oxygen standards for Skagit County watercourses. In particular, the lower Skagit River, Hansen, Nookachamps, Fisher, and Carpenter Creeks, and the upper Samish River and tributaries were placed in the “Core salmonid spawning and rearing” use category. This change had the effect of imposing more stringent temperature and dissolved oxygen standards on these streams. Formerly, each of these streams was held to a 7-DAM standard of 17.5°C, but with the revised standards these streams must now meet a 7-DAM standard of 16°C. There were no changes to other streams in the county. Currently, Sites 3-4, 28, 31-44, and 48 are held to the 17.5 °C standard, while all other sites are held to the 16°C standard, including marine Site 47.

In addition to changes in the general standard, the revisions to the state temperature standards in 2006 also added spawning period temperature standards to some streams in the county. Portions of the Samish River, Friday Creek, Hansen Creek, Lake Creek, and East Fork Nookachamps Creek have a 13°C limit from February 15 to June 15 to protect steelhead spawning and egg incubation. The Skagit River upstream from Sedro-Woolley has a 13°C limit from September 1 through May 15 to protect spawning and egg incubation for several salmonids.

After a very dry 2015 water year and higher than normal precipitation in 2016, 2017 was characterized by a series of wetter and dryer than normal months. Overall precipitation was near normal for the entire year.

Six of the 21 sites with continuous temperature monitoring had a maximum 7-day average maximum temperature that did not exceed the EPA water quality standard in 2017, compared with four of 22 sites in 2016. Data loggers were deployed in a few other sites but were missing by the end of the summer. Temperature dataloggers are generally not deployed in agricultural drainage ditches.

Trends Analysis had revealed many sites with significant declines in temperature between 2004 and 2012. Most of these significant declines had disappeared by the end of 2013. For 2017, there were no stations with significant declining temperatures and six stations with increasing temperatures, compared to 14 stations with increasing temperature at the of 2016. Many salmonid-bearing streams in Skagit County exceed temperature standards each summer. Ecology has developed temperature remediation cleanup plans (TMDLs) for Fisher, Carpenter, Nookachamps, and Hansen Creeks, but many other Skagit County streams also exceed temperature standards.

Graphs on the pages following Table 4 show the temperature data collected during biweekly visits. Gaps in the data represent streams that were either dry or flooded at sampling time.

Table 3. Temperature Results
Maximum temperature recorded during biweekly sampling for watercourses in the
last five years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	Highest daily temperature (°C)				
			2013	2014	2015	2016	2017
3	Thomas Creek	Old Hwy 99 North	18.9	20.2	20.1	19.6	19.2
4	Thomas Creek	F&S Grade Rd	16.2	16.3	16.6	15.9	15.3
6	Friday Creek	Prairie Rd	19.7	19.7	19.8	20.1	18.6
8	Swede Creek	Grip Rd	17.9	18.1	18.2	17.8	17.8
11	Samish River	State Route 9	17.2	17.2	14.6	14.1	13.5
12	Nookachamps Creek	Swan Rd	21.9	24.8	21.4	21.4	21.1
13	E.F. Nookachamps Creek	State Route 9	19.9	23.4	20.4	19.1	19.6
14	College Way Creek	College Way	16.7	20.8	18.0	17.7	17.3
15	Nookachamps Creek	Knapp Rd	22.5	23.1	21.8	21.8	22.0
16	E.F. Nookachamps Creek	Beaver Lake Rd	18.3	20.5	19.0	18.7	18.1
17	Nookachamps Creek	Big Lake Outlet	23.5	24.4	23.0	21.9	22.8
18	Lake Creek	State Route 9	17.0	18.7	17.2	16.3	16.3
19	Hansen Creek	Hoehn Rd	18.1	18.4	19.0	18.1	17.3
20	Hansen Creek	Northern State	15.6	16.2	15.6	15.3	15.3
21	Coal Creek	Hoehn Rd	16.3	17.5	16.9	16.1	15.7
22	Coal Creek	Hwy 20	15.4	15.7	15.5	14.6	15.3
23	Wiseman Creek	Minkler Rd	14.5	16.2	14.1	15.2	15.0
24	Mannser Creek	Lyman Hamilton Hwy	12.9	15.0	12.5	12.1	12.5
25	Red Cabin Creek	Hamilton Cemetery Rd	11.7	12.5	13.9	11.8	11.7
28	Brickyard Creek	Hwy 20	18.6	18.6	14.9	16.7	14.5
29	Skagit River	River Bend Rd	15.4	16.6	17.6	16.6	15.9
30	Skagit River	Cape Horn Rd	15.0	15.3	16.3	14.8	15.3
31	DD20 near floodgate	Francis Rd	19.4	19.4	13.7	15.2	10.8
32	Samish River	Thomas Rd	19.9	20.2	21.6	20.7	20.1
33	Alice Bay Pump Station	Samish Island Rd	25.5	27.2	25.9	23.4	22.7
34	No Name Slough	Bayview-Edison Rd	22.2	25.6	21.1	25.9	21.5
35	Joe Leary Slough	D'Arcy Rd	24.0	24.0	21.8	20.5	20.3
36	Edison Slough at school	W. Bow Hill Rd	29.8	32.4	30.1	27.6	27.0
37	Edison Pump Station	Farm to Market Rd	27.5	27.5	26.8	26.3	23.6
38	North Edison Pump Sta.	North Edison Rd	25.6	25.6	26.1	22.4	22.2
39	Colony Creek	Colony Rd	18.2	18.2	18.1	17.1	16.6
40	Big Indian Slough	Bayview-Edison Rd	16.2	22.1	18.7	17.3	19.4
41	Maddox Slough/Big Ditch	Milltown Rd	20.1	23.7	22.0	21.4	22.4
42	Hill Ditch	Cedardale Rd	22.5	23.1	21.7	21.3	22.0
43	Wiley Slough	Wylie Rd	21.5	21.9	21.2	20.1	19.6
44	Sullivan Slough	La Conner-Whitney Rd	17.2	21.7	19.6	18.1	20.0
45	Skagit River – North Fork	Moore Rd	16.0	17.2	18.1	17.3	16.4
46	Skagit River – South Fork	Fir Island Rd	16.3	17.6	18.3	17.7	16.7
47	Swinomish Channel	County Boat Launch	15.7	18.0	16.8	17.0	18.5
48	Fisher Creek	Franklin Rd	14.6	14.6	14.3	13.4	13.5

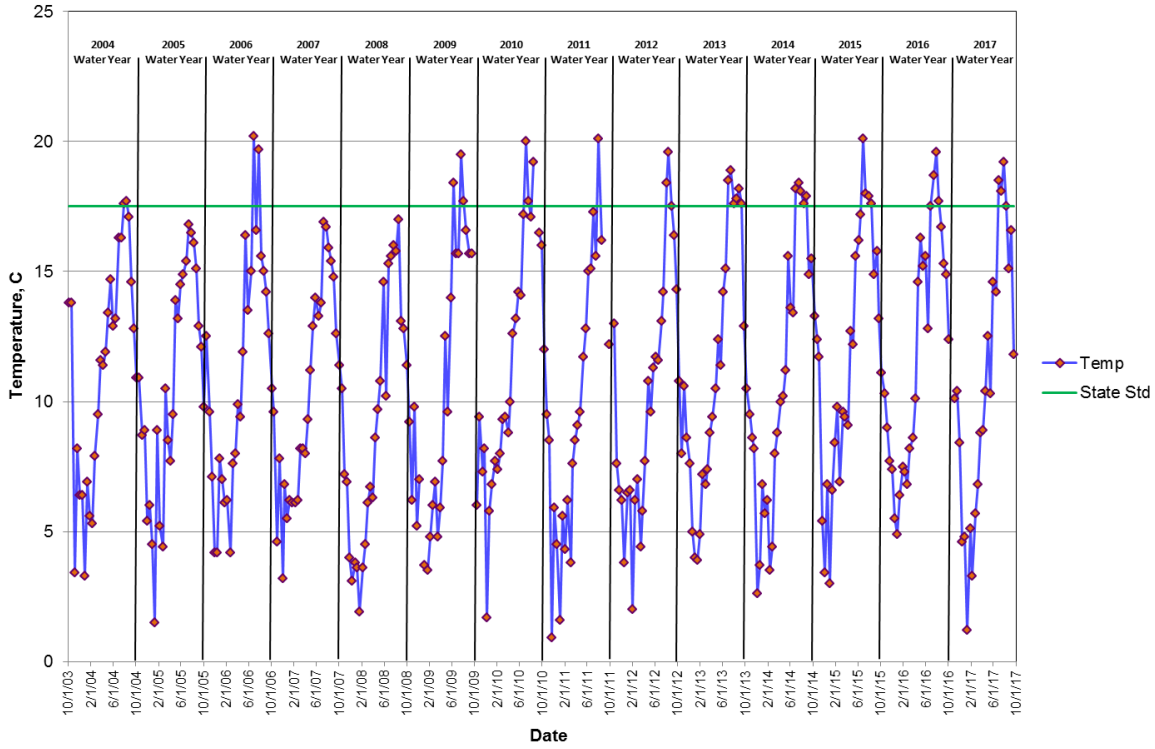
Data from biweekly site visits

Table 4. Five-Year Temperature Results Summary
Maximum 7-day average maximum temperatures for 2011-2016 of the
Skagit County Monitoring Program

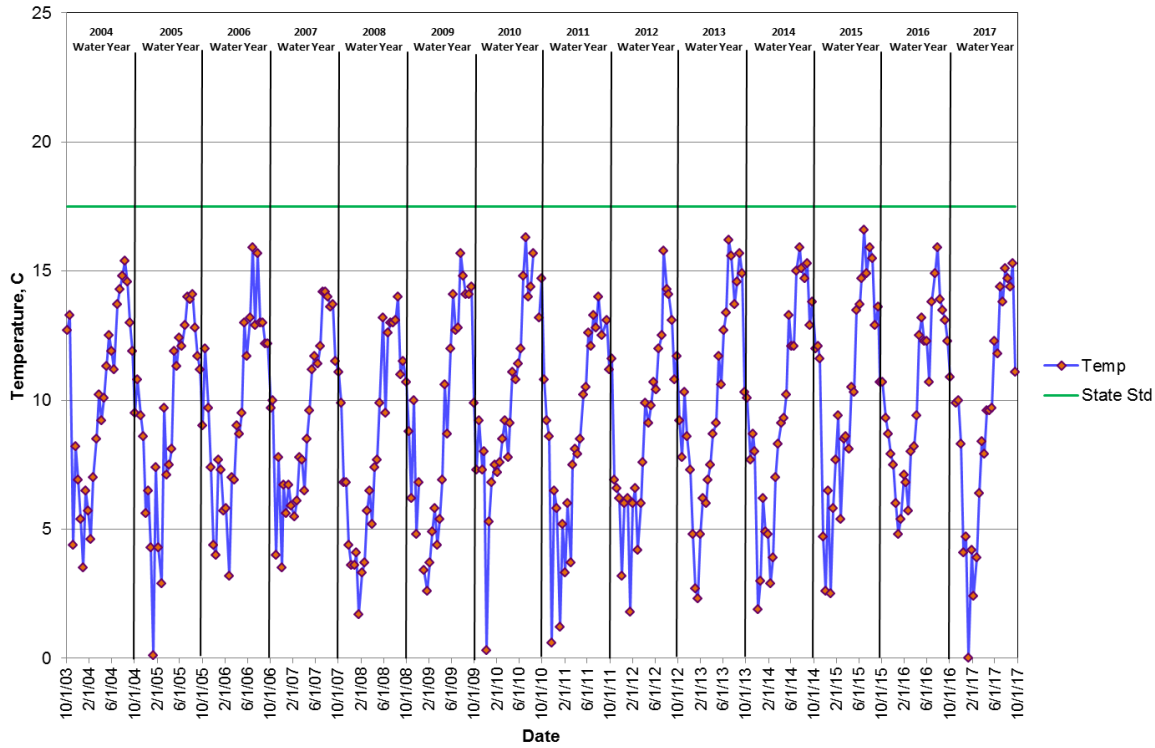
Site Number	Watercourse	Location	Max. 7DAM (°C)				
			2013	2014	2015	2016	2017
3	Thomas Creek	Old Hwy 99 North	n/a	21.6	21.5	21.2	20.2
4	Thomas Creek	F&S Grade Rd	16.4	n/a	17.8	16.7	16.1
6	Friday Creek	Prairie Rd	19.3	n/a	22.9	21.6	n/a
8	Swede Creek	Grip Rd	17.9	19.8	20.4	18.4	17.6
11	Samish River	State Route 9	13.3	15.3	15.4	14.8	14.8
12	Nookachamps Creek	Swan Rd	n/a	n/a	n/a	23.5	22.9
13	E.F. Nookachamps Creek	State Route 9	n/a	n/a	23.3	20.8	20.5
14	College Way Creek	College Way	17.7	n/a	n/a	n/a	n/a
15	Nookachamps Creek	Knapp Rd	21.9	n/a	24.7	23.3	22.3
16	E.F. Nookachamps Creek	Beaver Lake Rd	n/a	n/a	23.4	21.2	20.8
17	Nookachamps Creek	Big Lake Outlet	24.7	26.4	27.1	25.2	25.5
18	Lake Creek	State Route 9	17.4	n/a	n/a	18.2	18.0
19	Hansen Creek	Hoehn Rd	n/a	n/a	21.2	21.1	19.0
20	Hansen Creek	Northern State	n/a	n/a	n/a	16.3	17.1
21	Coal Creek	Hoehn Rd	16.8	n/a	n/a	20.0	15.9
22	Coal Creek	Hwy 20	16.6	n/a	18.9	17.4	n/a
23	Wiseman Creek	Minkler Rd	n/a	19.6	n/a	n/a	n/a
24	Mannser Creek	Lyman Hamilton Hwy	13.2	13.3	14.2	17.2	13.9
25	Red Cabin Creek	Hamilton Cemetery Rd	n/a	n/a	n/a	n/a	n/a
28	Brickyard Creek	Hwy 20	n/a	n/a	n/a	n/a	n/a
29	Skagit River	River Bend Rd	n/a	n/a	n/a	n/a	n/a
30	Skagit River	Cape Horn Rd	n/a	n/a	17.1	15.2	11.9
31	DD 20 near floodgate	Francis Rd	n/a	n/a	n/a	n/a	n/a
32	Samish River	Thomas Rd	19.5	20.4	22.7	n/a	20.2
33	Alice Bay Pump Station	Samish Island Rd	n/a	n/a	n/a	n/a	n/a
34	No Name Slough	Bayview-Edison Rd	n/a	n/a	n/a	n/a	n/a
35	Joe Leary Slough	D'Arcy Rd	n/a	n/a	n/a	n/a	n/a
36	Edison Slough at school	W. Bow Hill Rd	n/a	n/a	n/a	n/a	n/a
37	Edison Pump Station	Farm to Market Rd	n/a	n/a	n/a	n/a	n/a
38	North Edison Pump Station	North Edison Rd	n/a	n/a	n/a	n/a	n/a
39	Colony Creek	Colony Rd	17.1	19.2	19.4	18.3	17.3
40	Big Indian Slough	Bayview-Edison Rd	n/a	n/a	n/a	n/a	n/a
41	Maddox Slough/Big Ditch	Milltown Rd	22.4	n/a	25.4	21.1	24.9
42	Hill Ditch	Cedardale Rd	23.8	n/a	27.3	25.9	25.7
43	Wiley Slough	Wylie Rd	n/a	n/a	n/a	n/a	n/a
44	Sullivan Slough	LaConner-Whitney Rd	n/a	n/a	n/a	n/a	n/a
45	Skagit River – North Fork	Moore Rd	n/a	n/a	n/a	18.7	17.7
46	Skagit River – South Fork	Fir Island Rd	n/a	n/a	n/a	n/a	n/a
47	Swinomish Channel	County Boat Launch	n/a	n/a	n/a	n/a	n/a
48	Fisher Creek	Franklin Rd	14.4	n/a	16.1	15.1	14.8

Data from continuous temperature data loggers

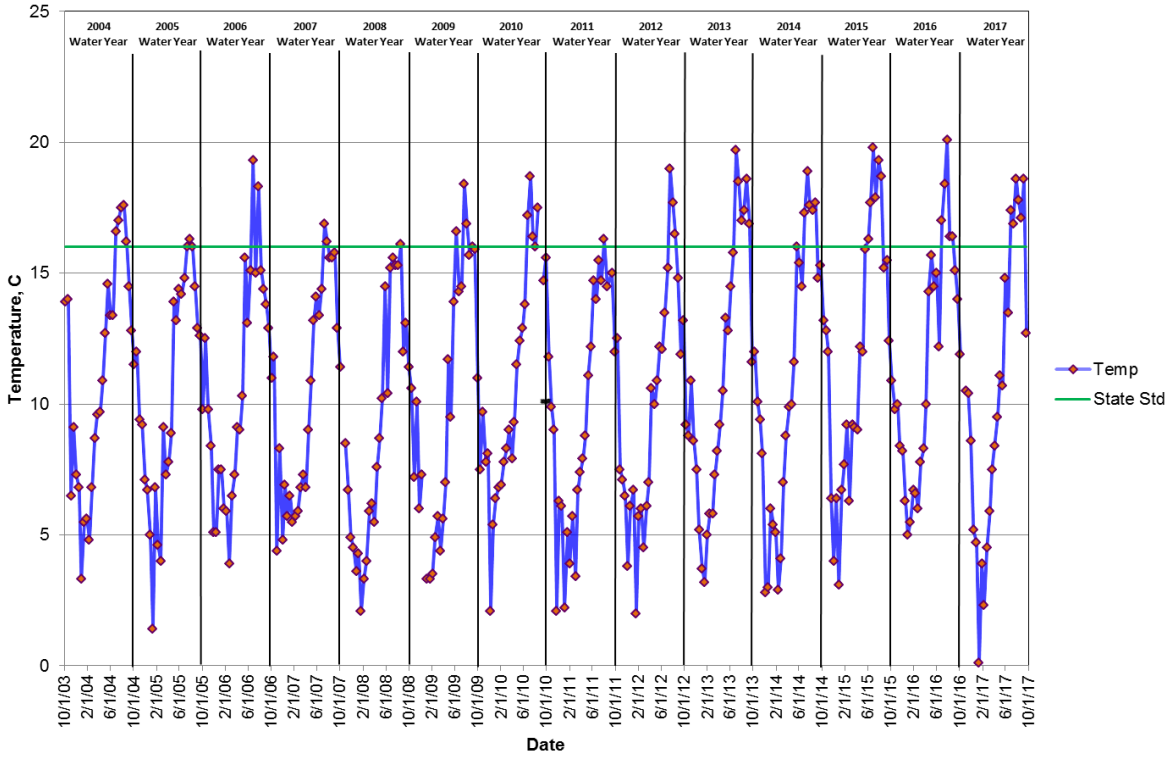
Thomas Creek at Highway 99 - Site 3 Temperature



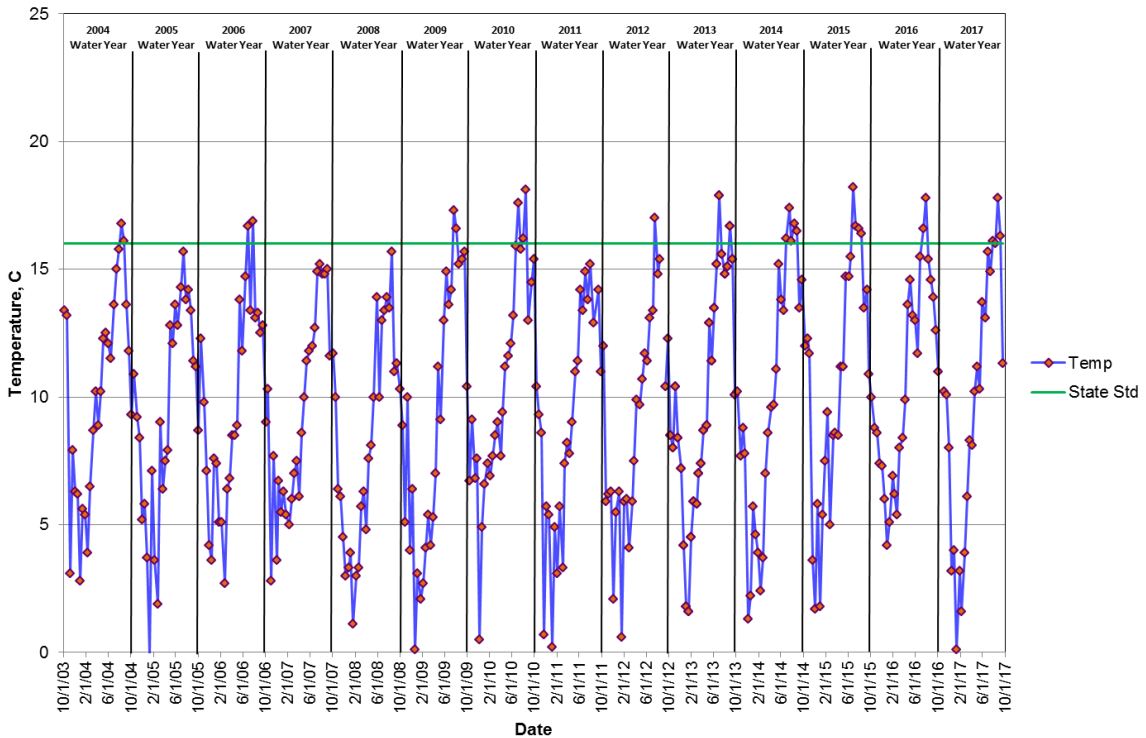
Thomas Creek at F&S Grade Road - Site 4 Temperature



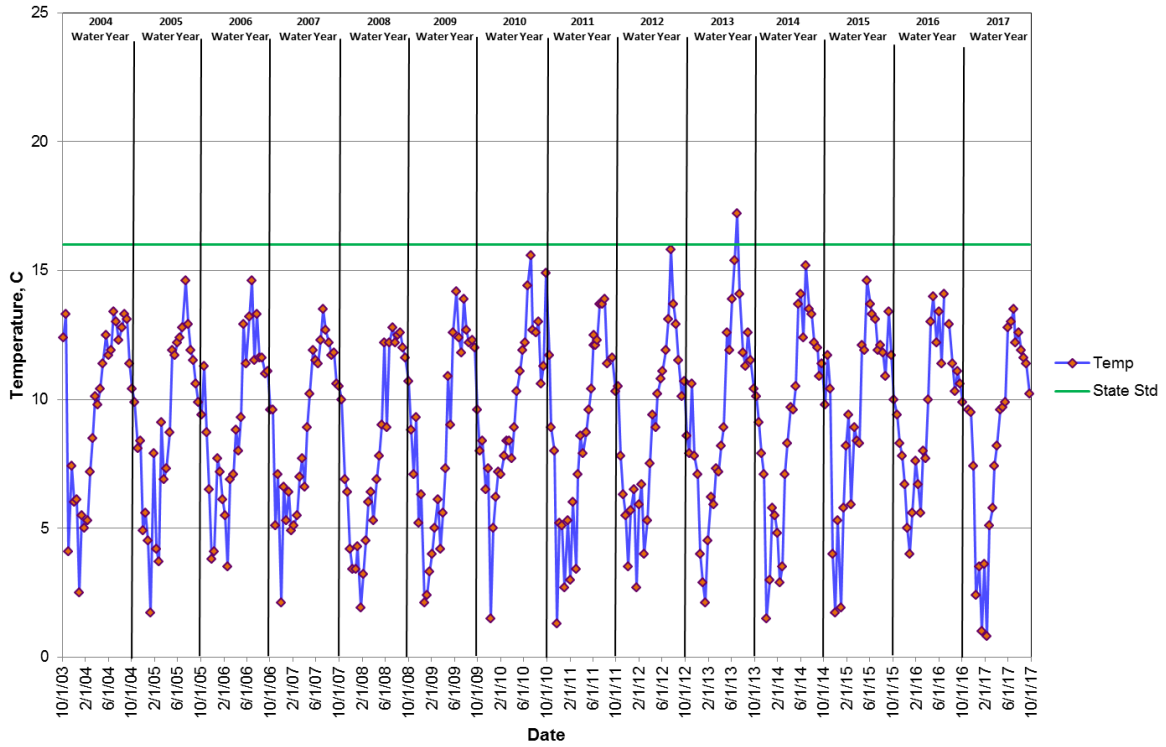
Friday Creek at Prairie Road - Site 6 Temperature



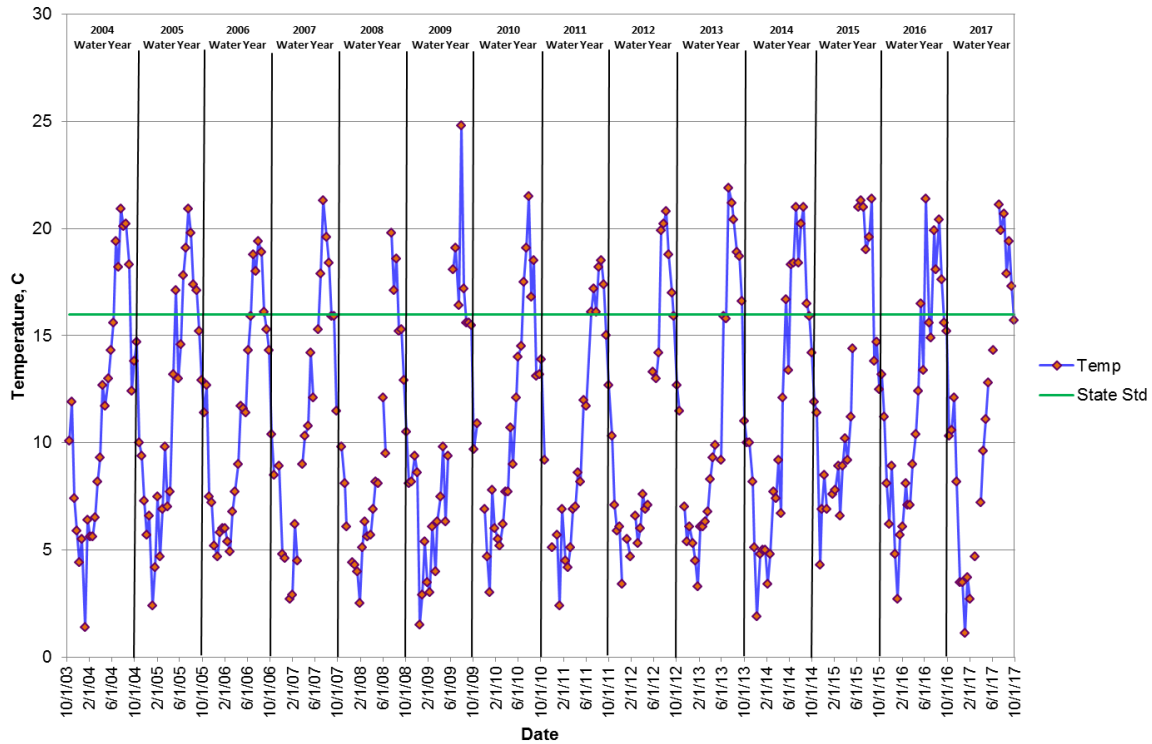
Swede Creek at Grip Road - Site 8 Temperature



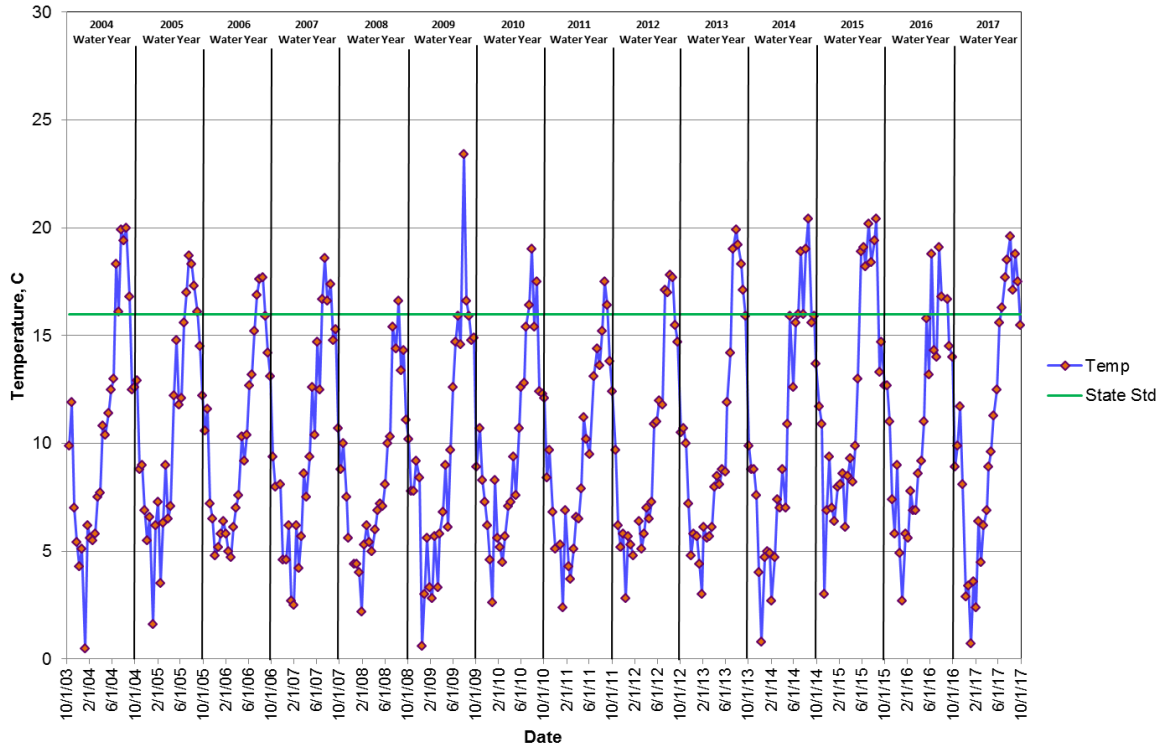
Samish River at Highway 9 - Site 11 Temperature



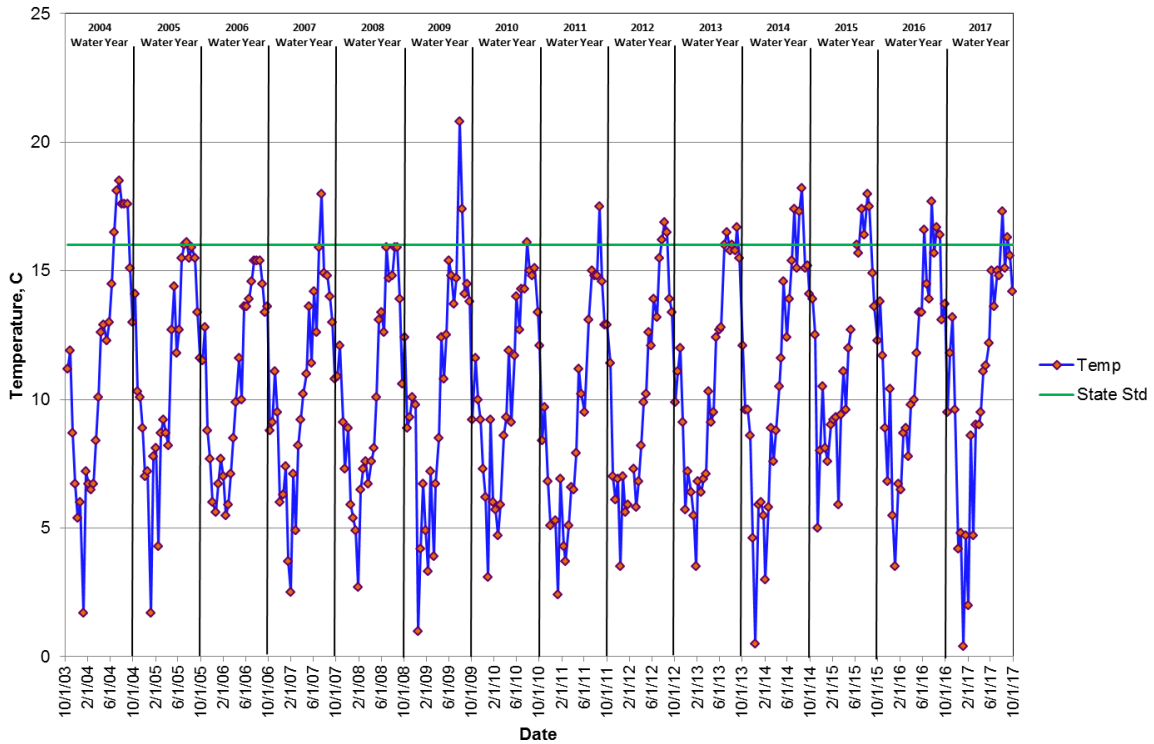
Nookachamps Creek at Swan Road - Site 12 Temperature



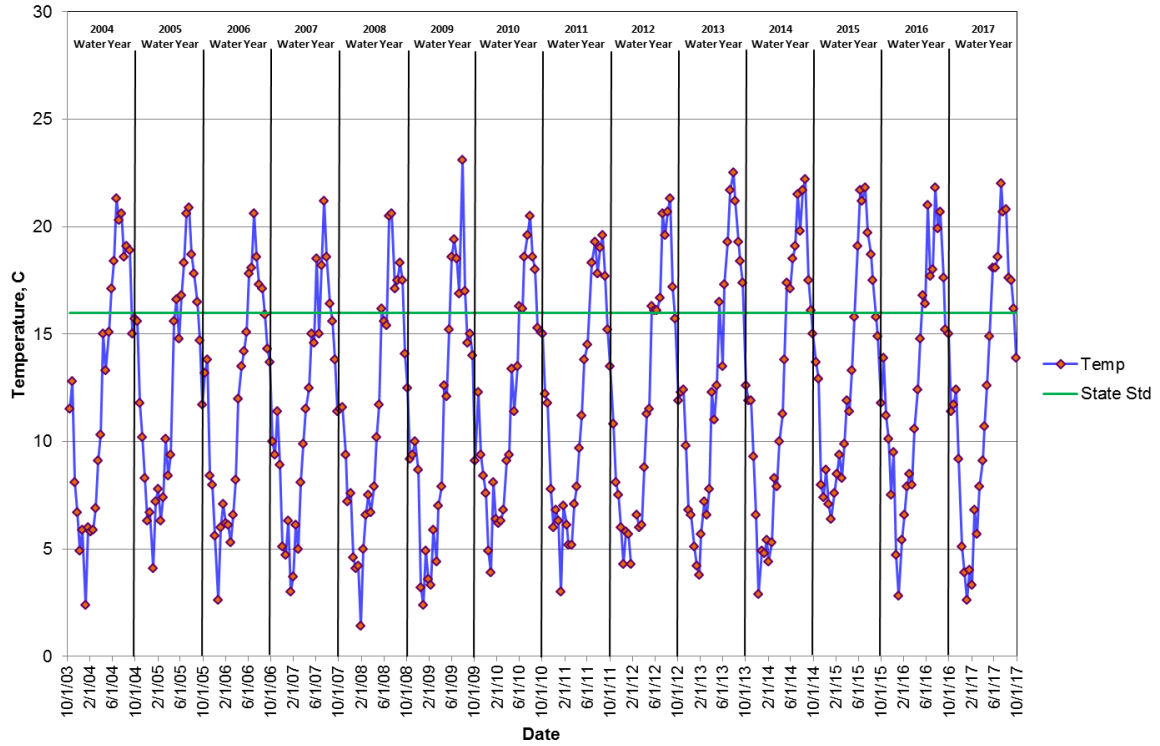
East Fork Nookachamps Creek at Highway 9 - Site 13 Temperature



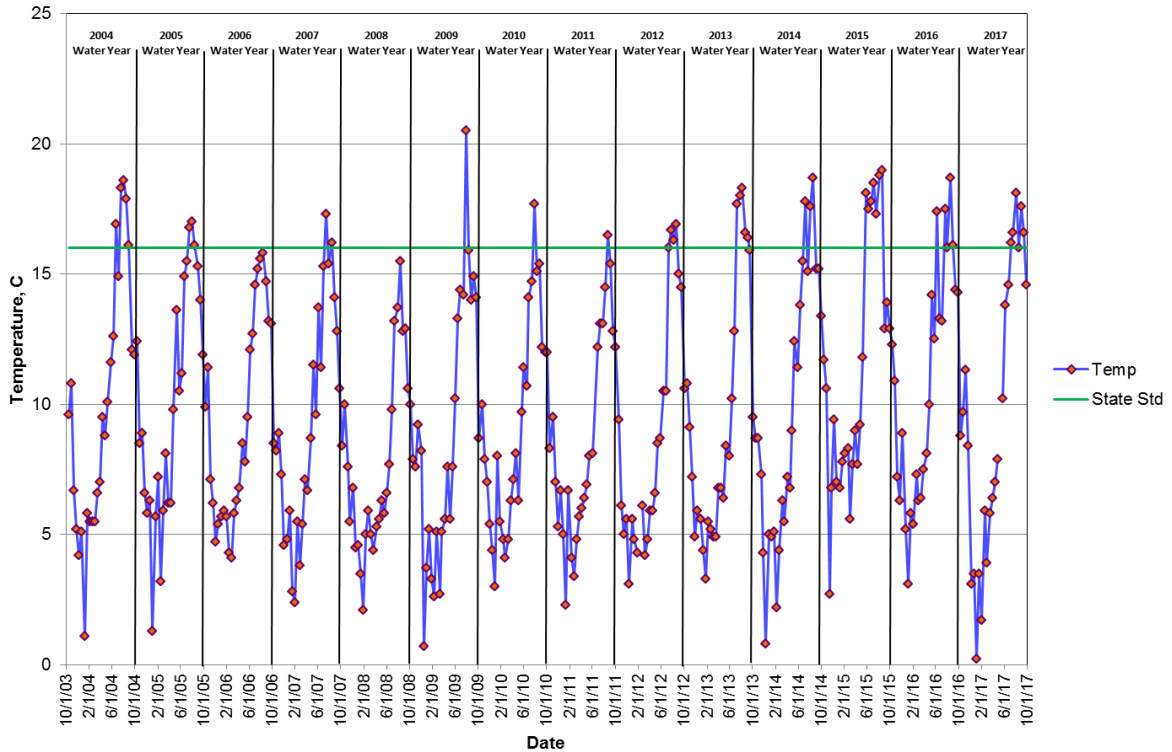
College Way Creek at College Way - Site 14 Temperature



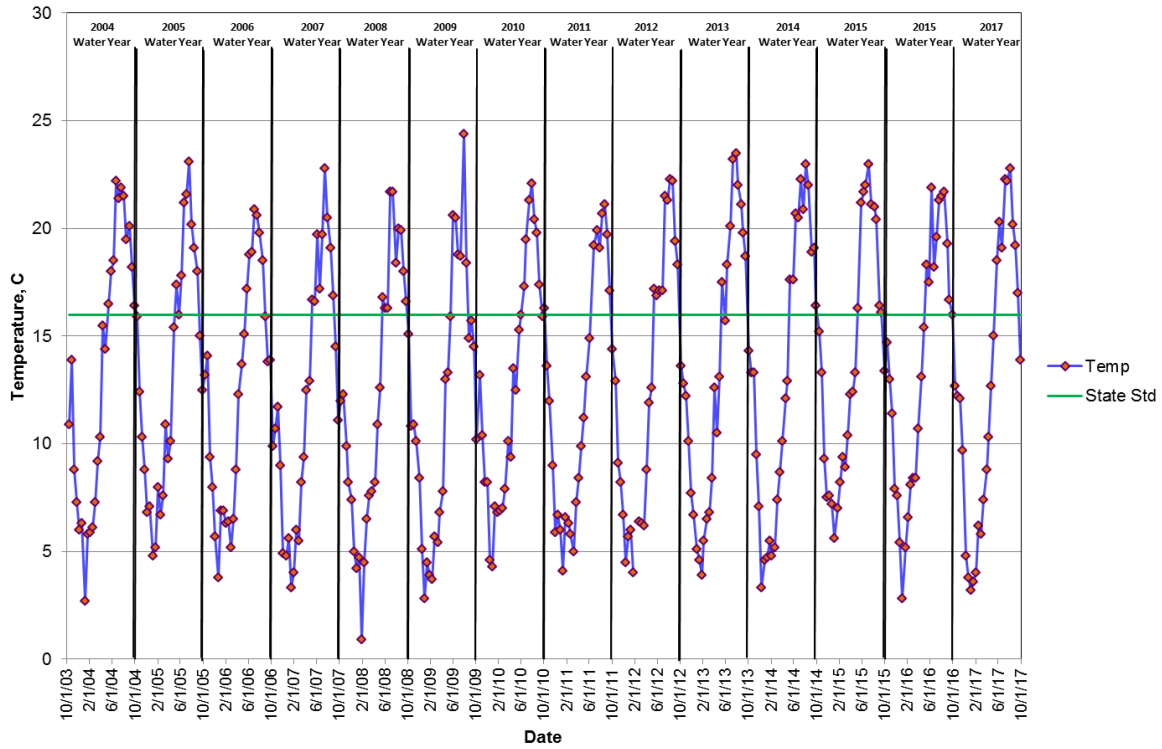
Nookachamps Creek at Knapp Road - Site 15 Temperature



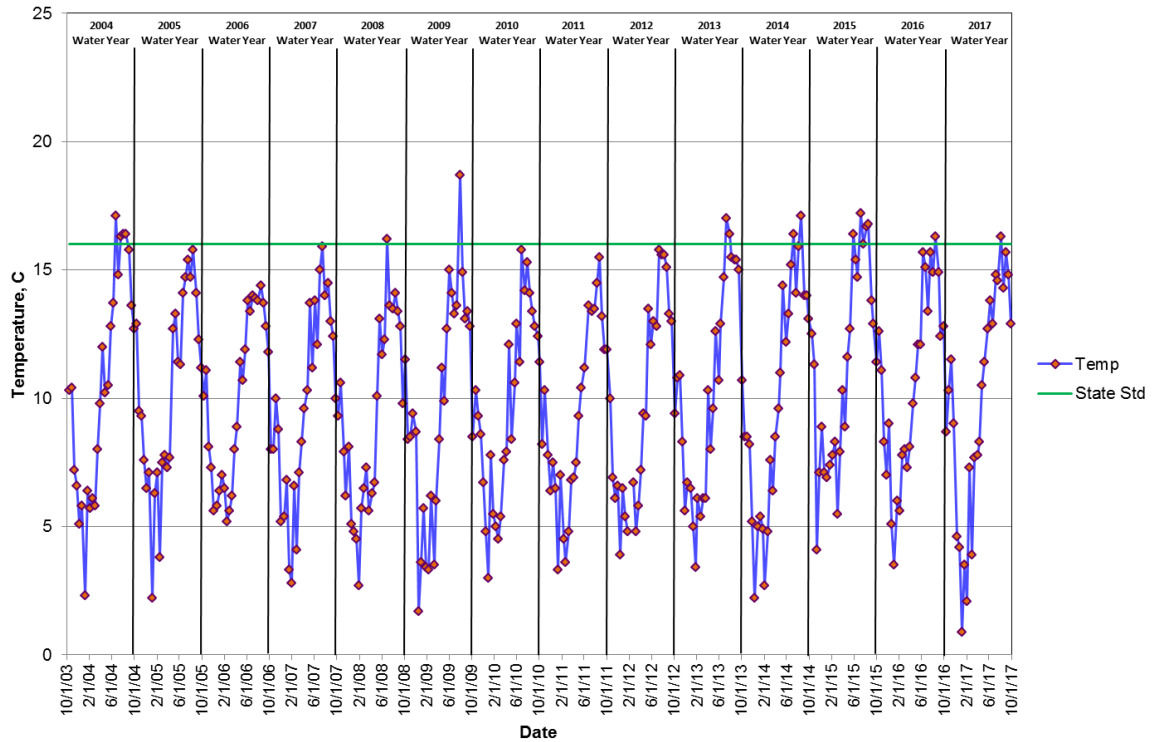
East Fork Nookachamps Creek at Beaver Lake Road - Site 16 Temperature



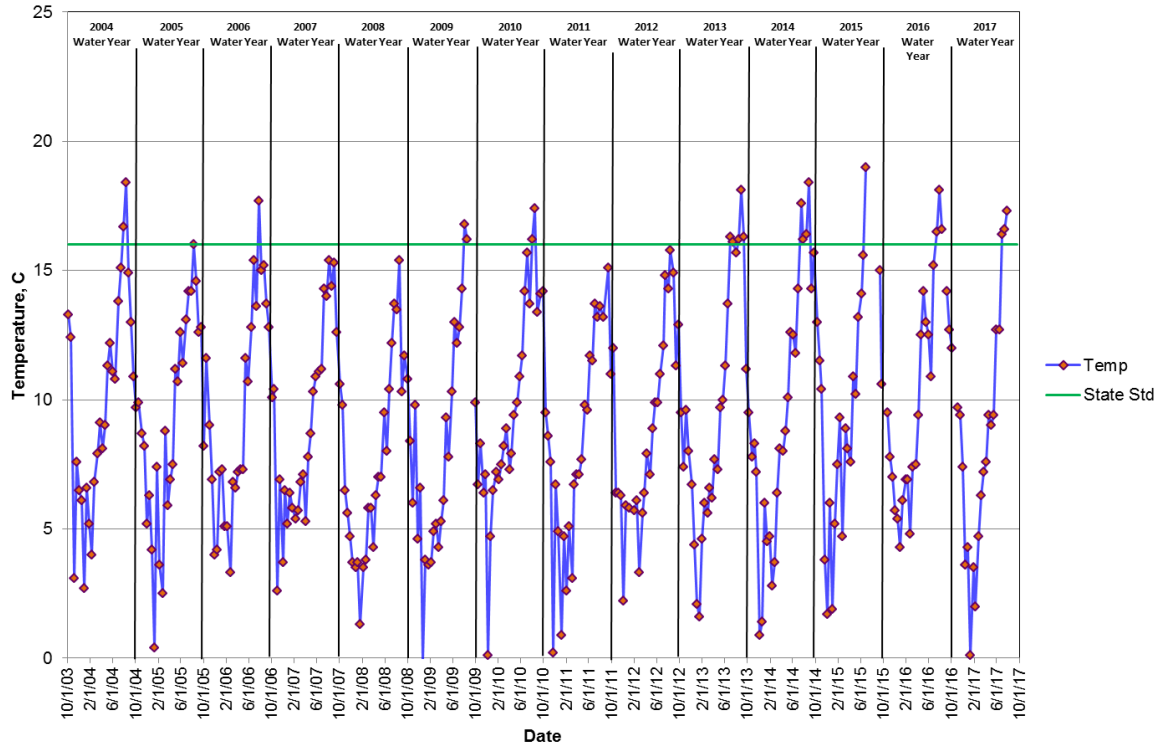
Nookachamps Creek at Big Lake Outlet - Site 17 Temperature



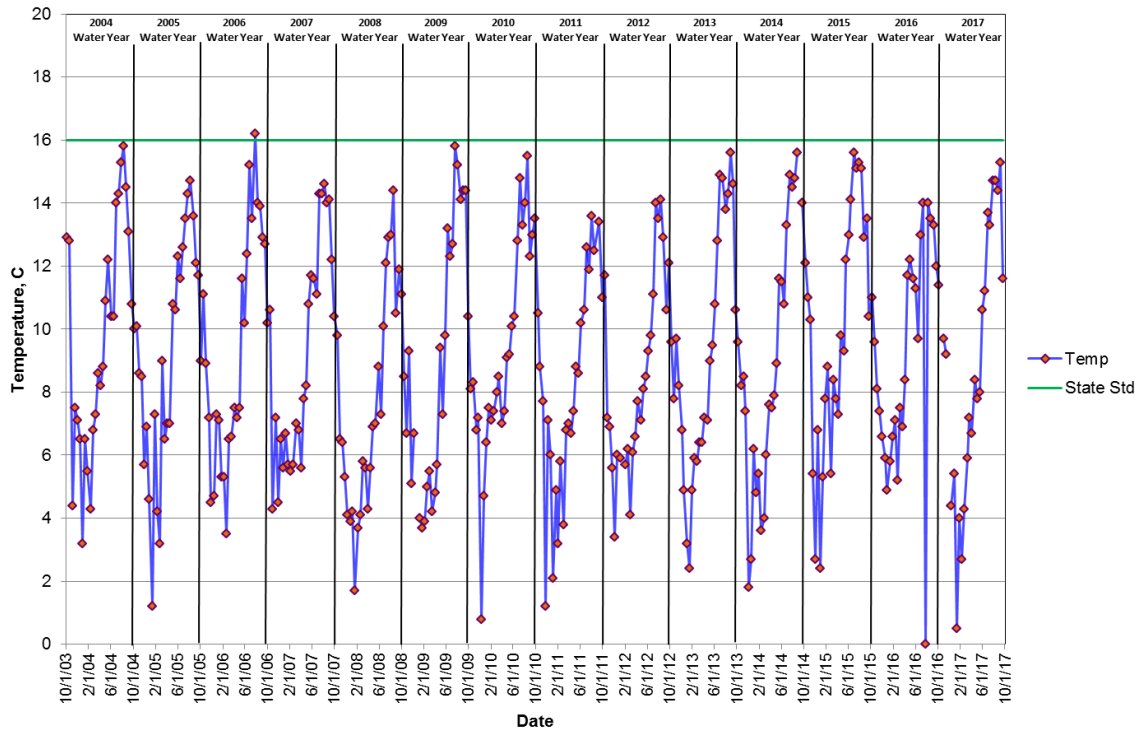
Lake Creek at Highway 9 - Site 18 Temperature



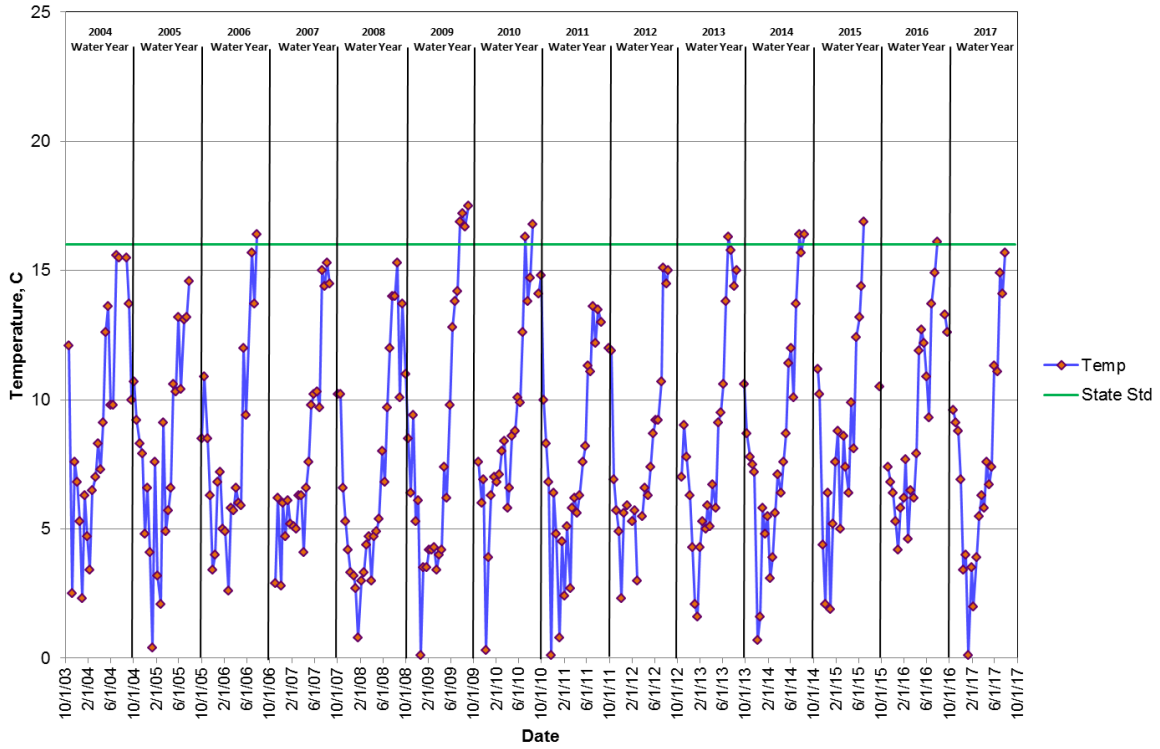
Hansen Creek at Hoehn Road - Site 19 Temperature



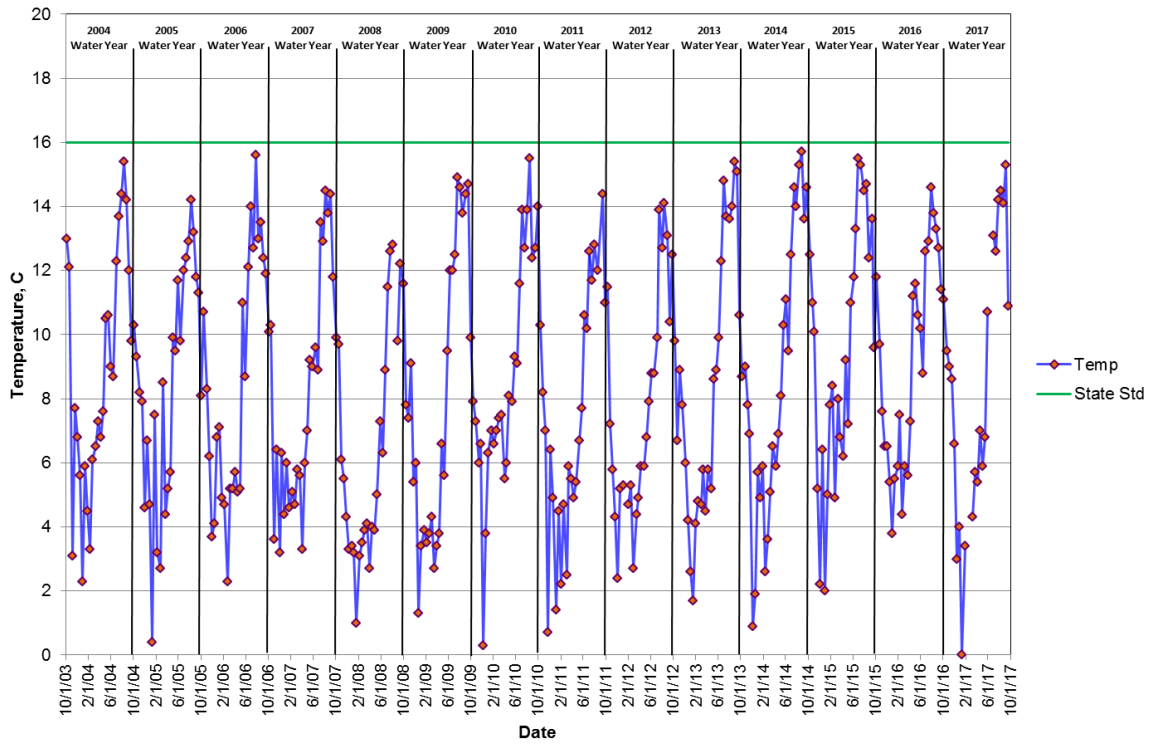
Hansen Creek at Northern State Hospital - Site 20 Temperature



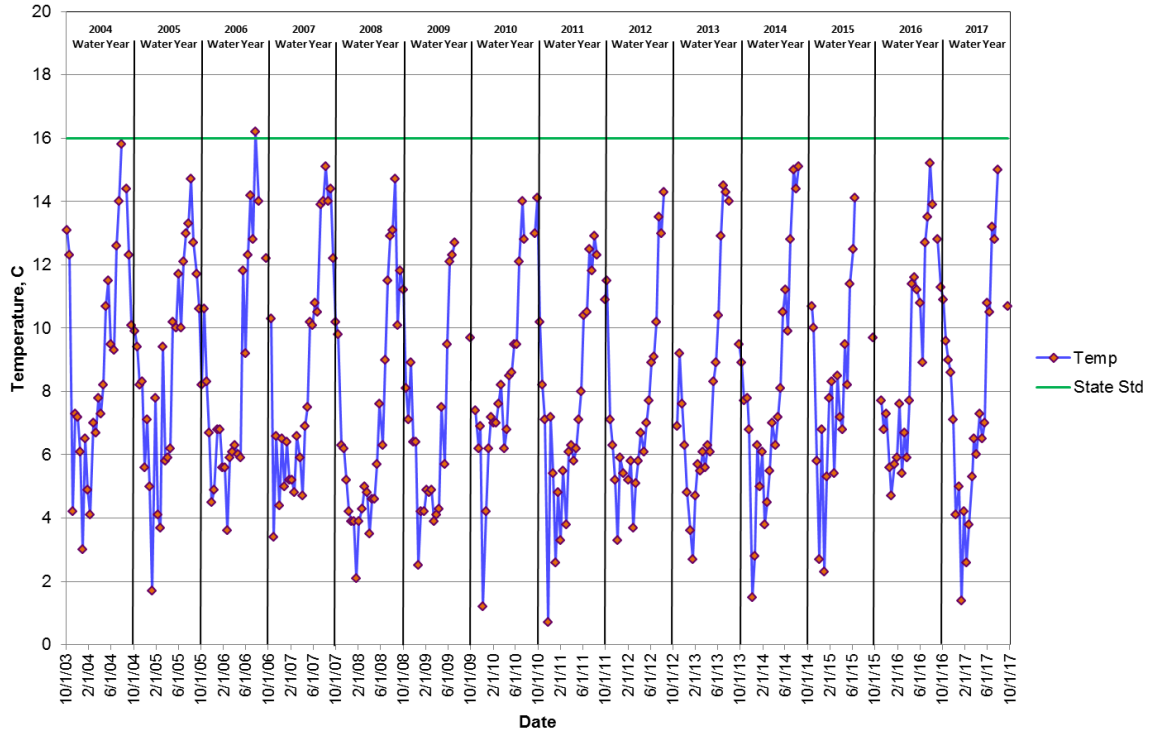
Coal Creek at Hoehn Road - Site 21 Temperature



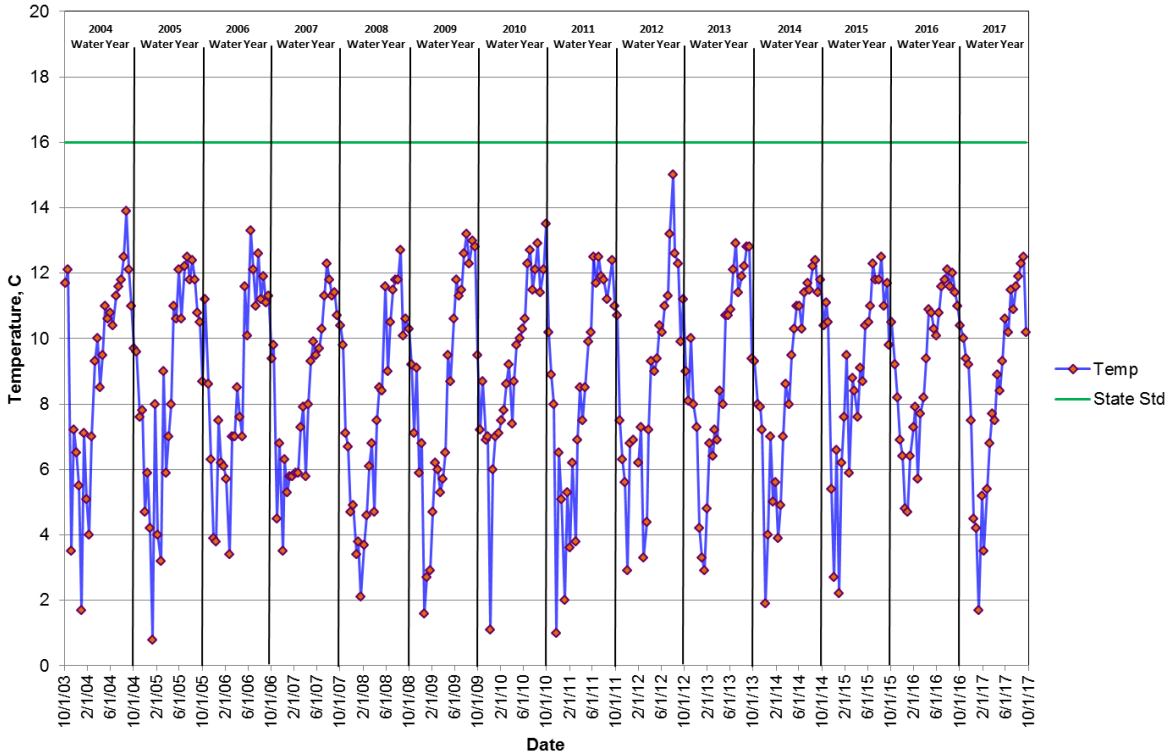
Coal Creek at Highway 20 - Site 22 Temperature



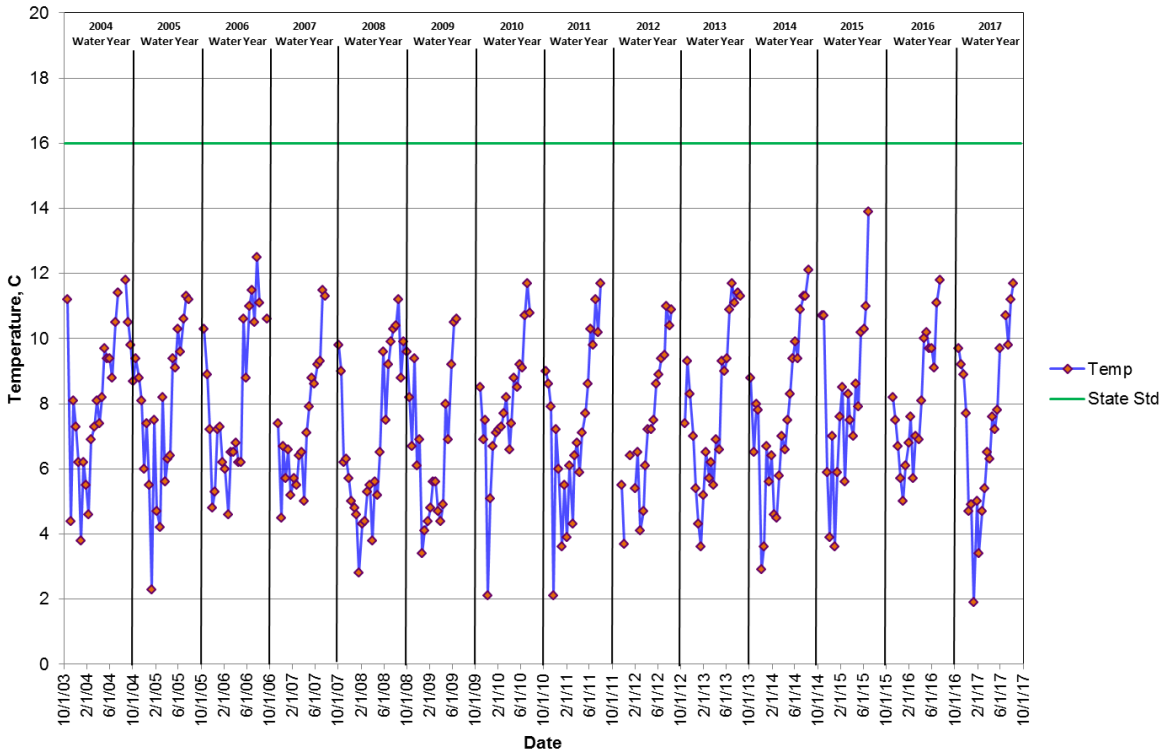
Wiseman Creek at Minkler Road - Site 23 Temperature



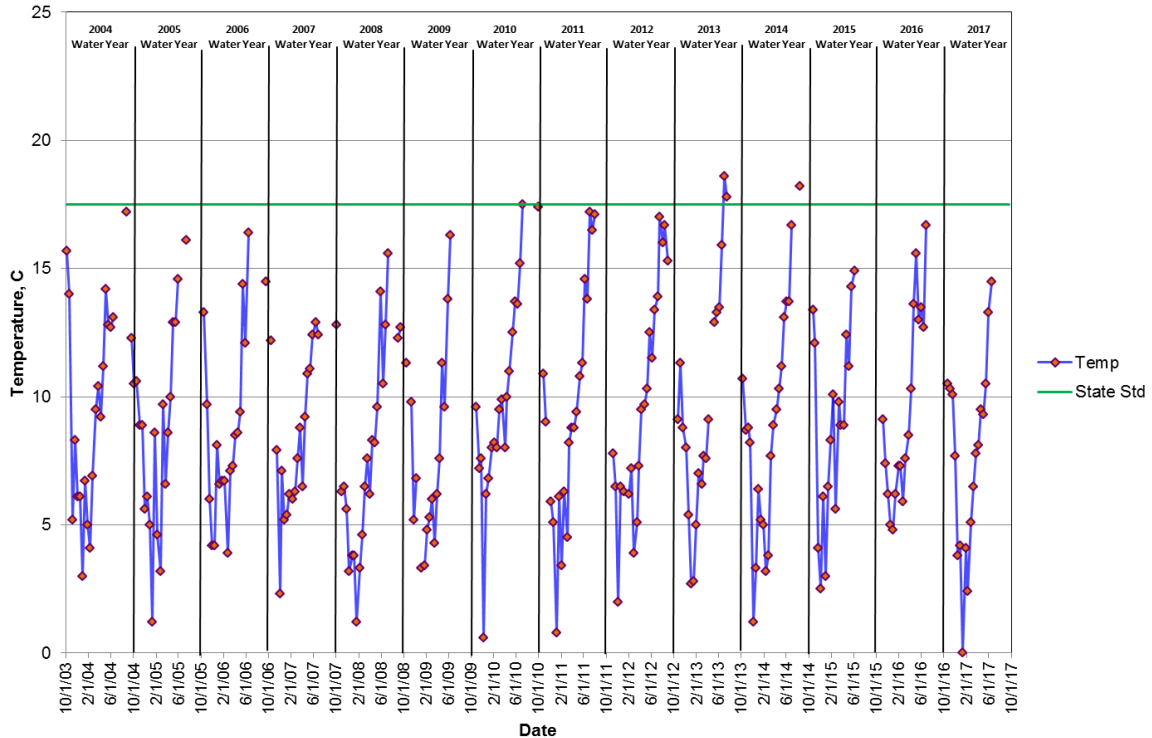
Mannser Creek at Lyman-Hamilton Highway - Site 24 Temperature



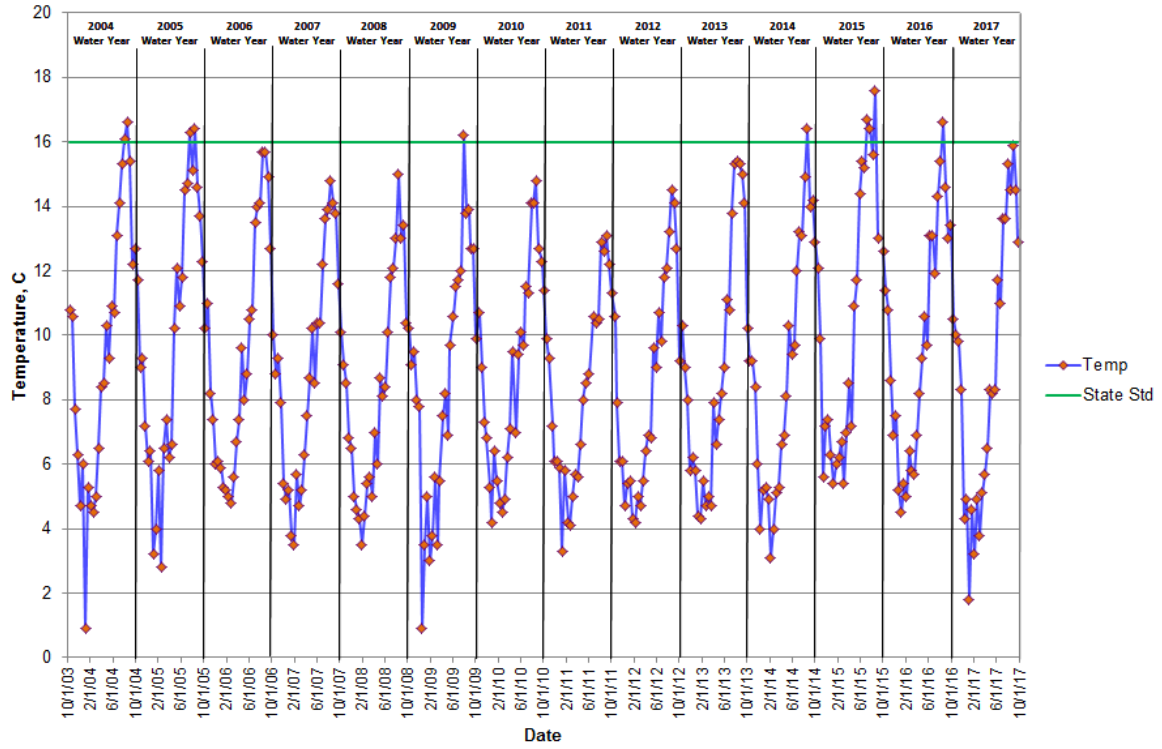
Red Cabin Creek at Hamilton Cemetery Road - Site 25 Temperature



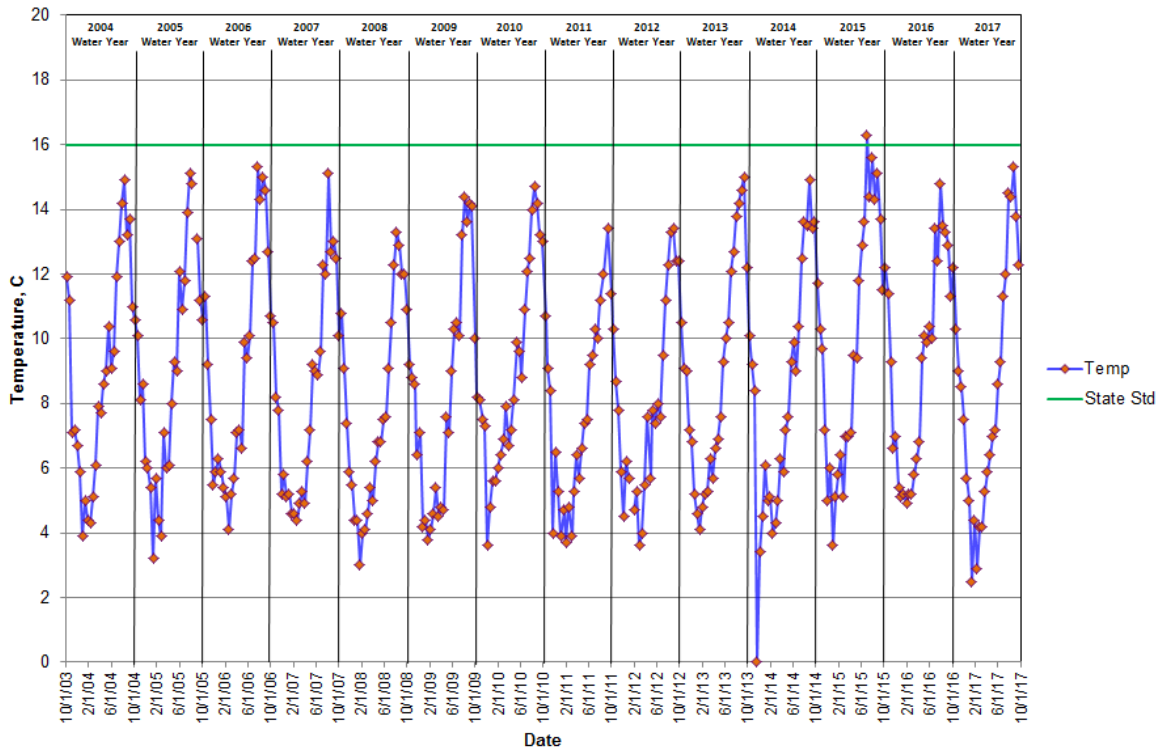
Brickyard Creek at Highway 20 - Site 28 Temperature



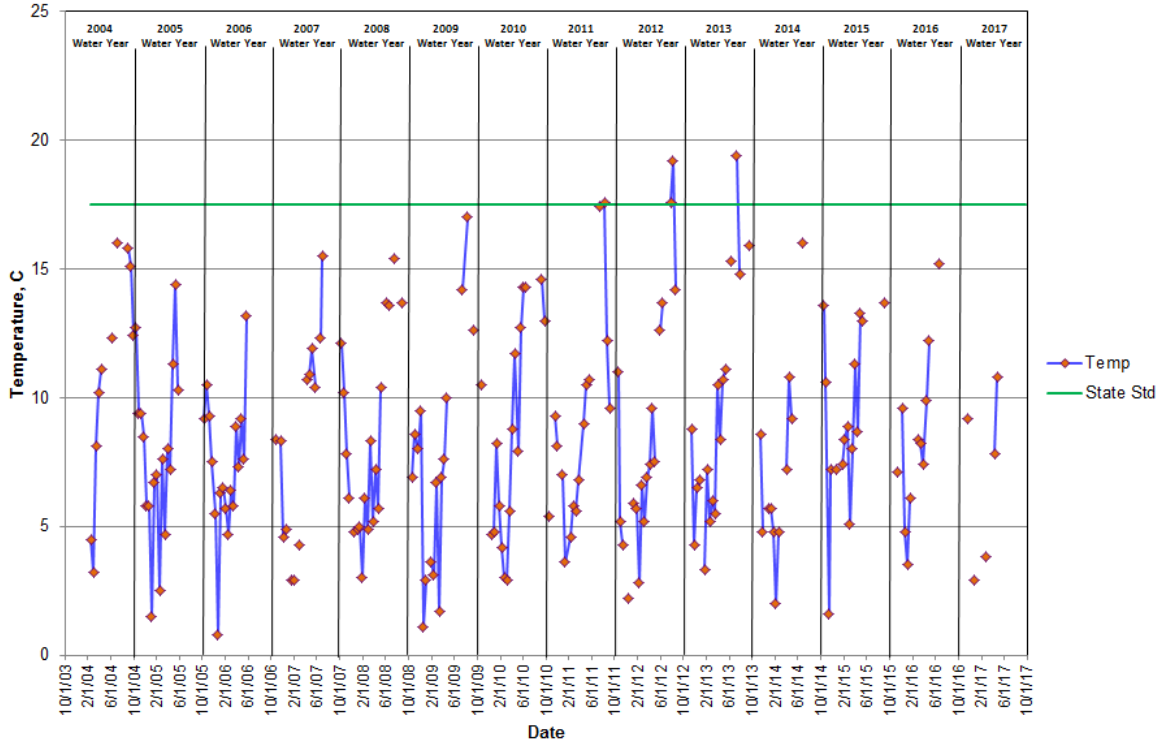
Skagit River at River Bend Road - Site 29 Temperature



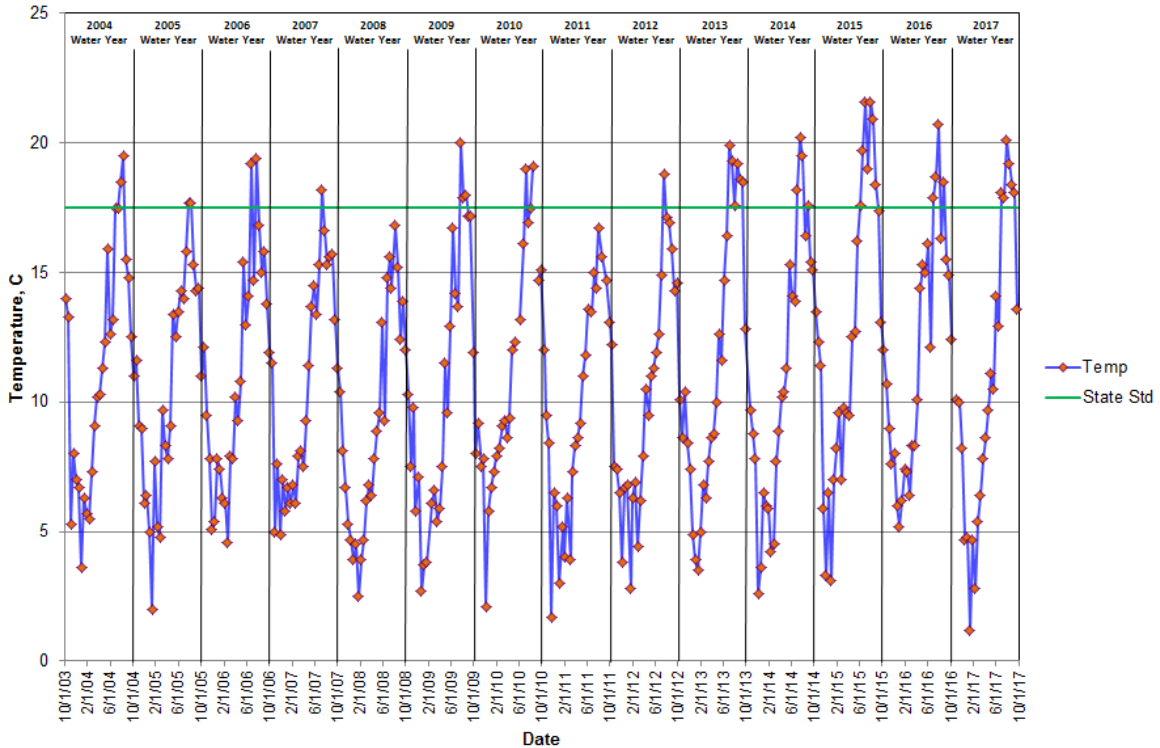
Skagit River at Cape Horn Road - Site 30 Temperature



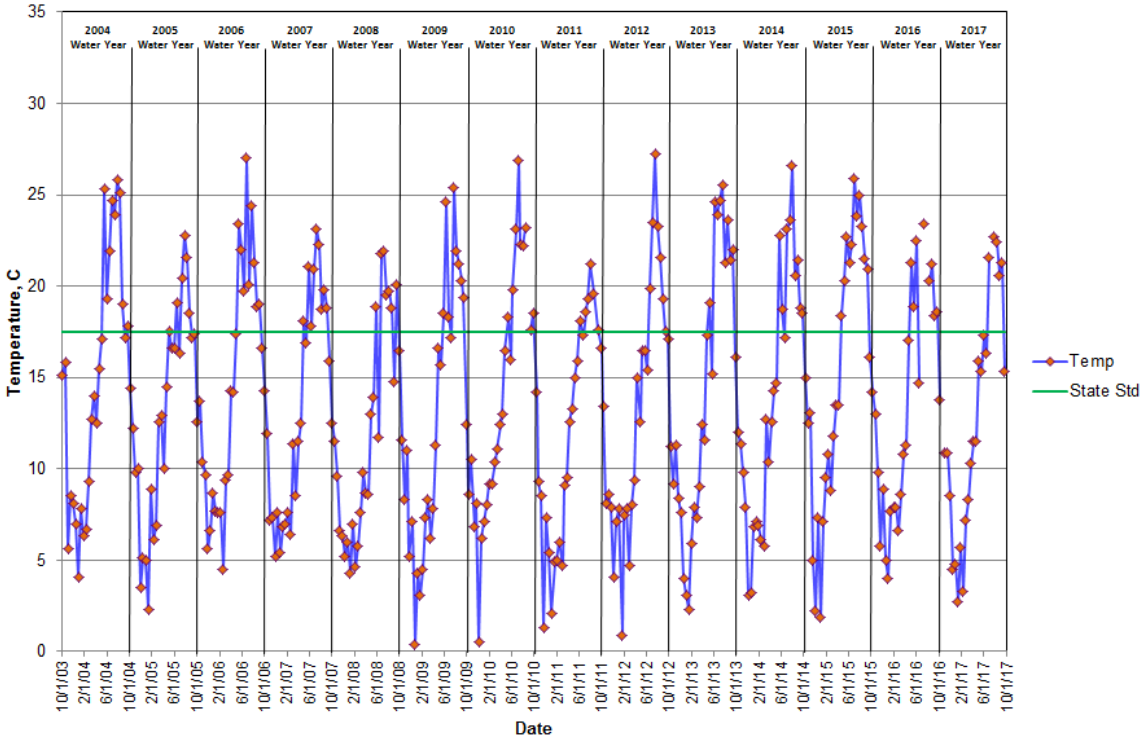
Drainage District 20 Ditch at Floodgate - Site 31 Temperature



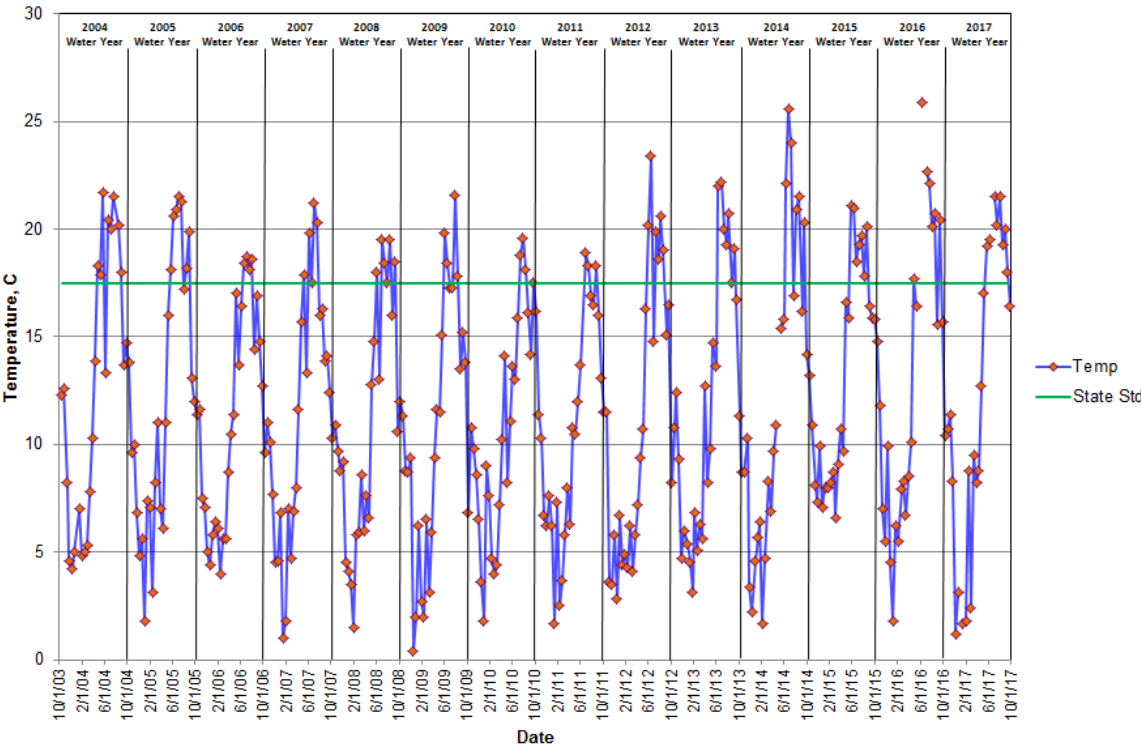
Samish River at Thomas Road - Site 32 Temperature



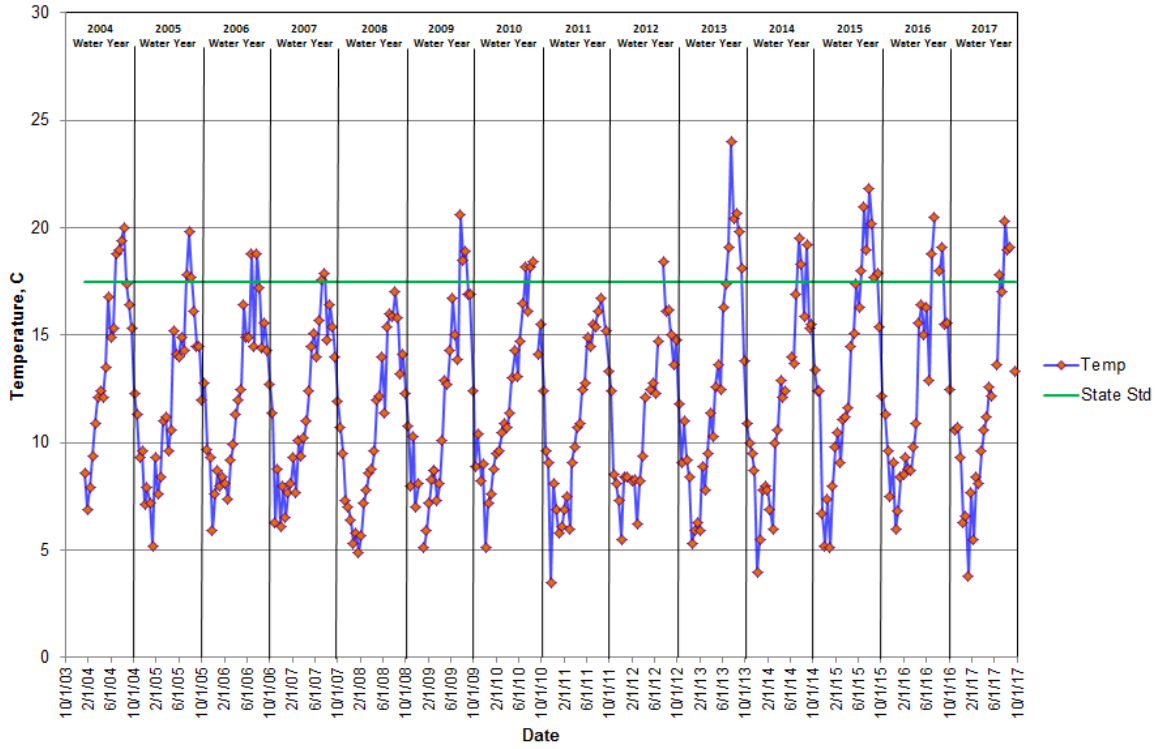
Alice Bay Pump Station - Site 33 Temperature



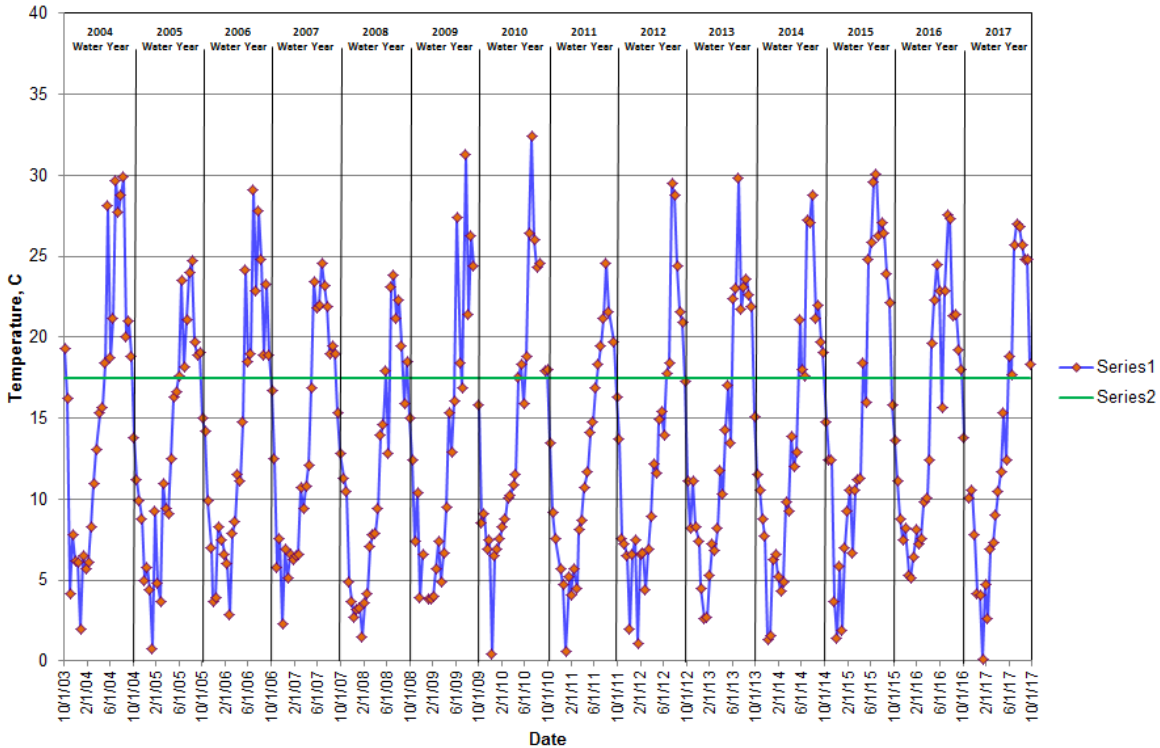
No Name Slough at Bayview-Edison Road - Site 34 Temperature



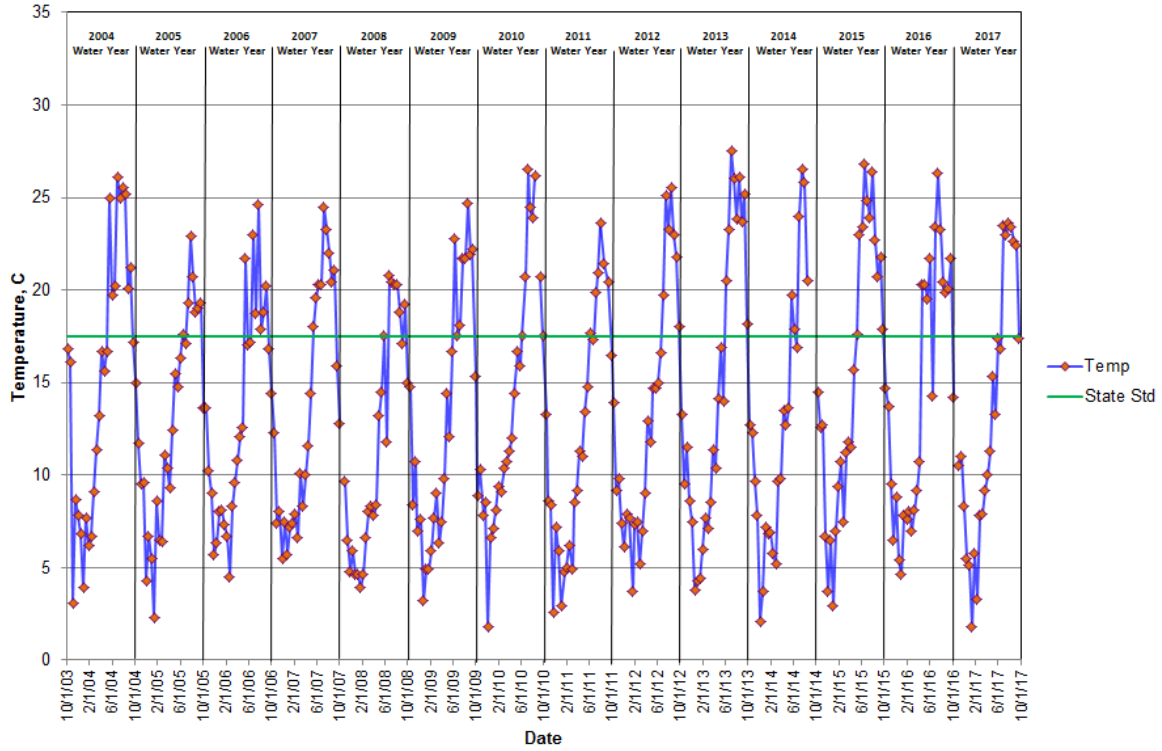
Joe Leary Slough at D'Arcy Road - Site 35 Temperature



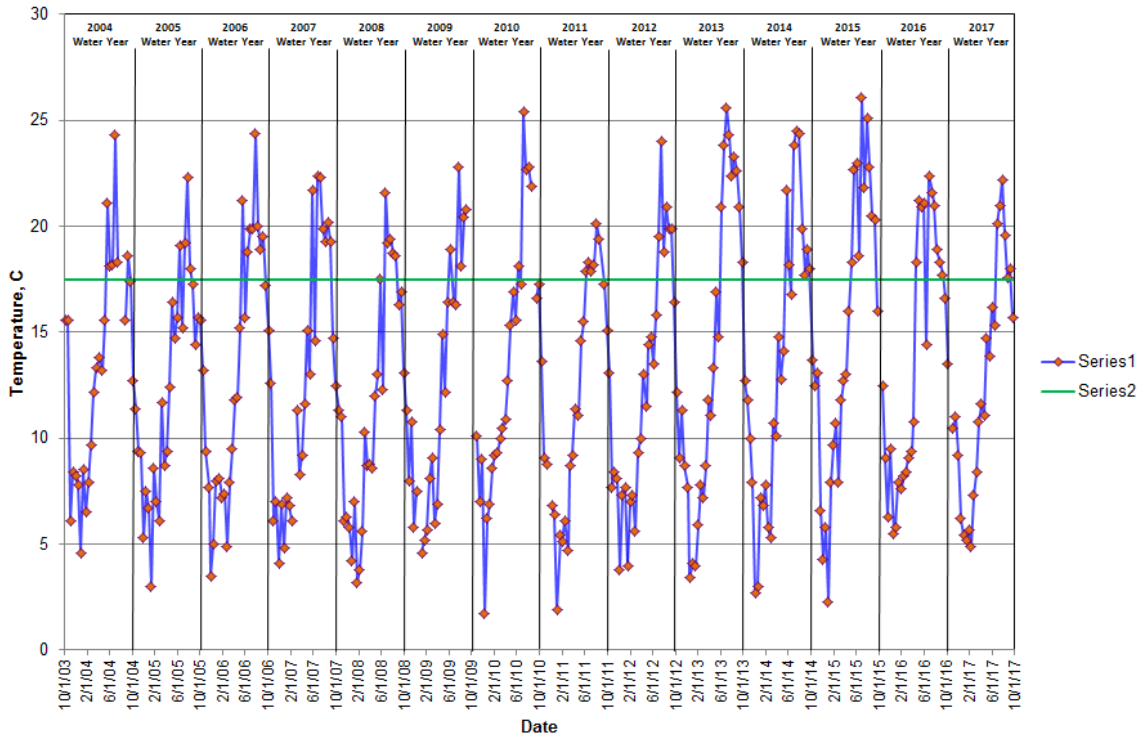
Edison Slough at Edison School - Site 36 Temperature



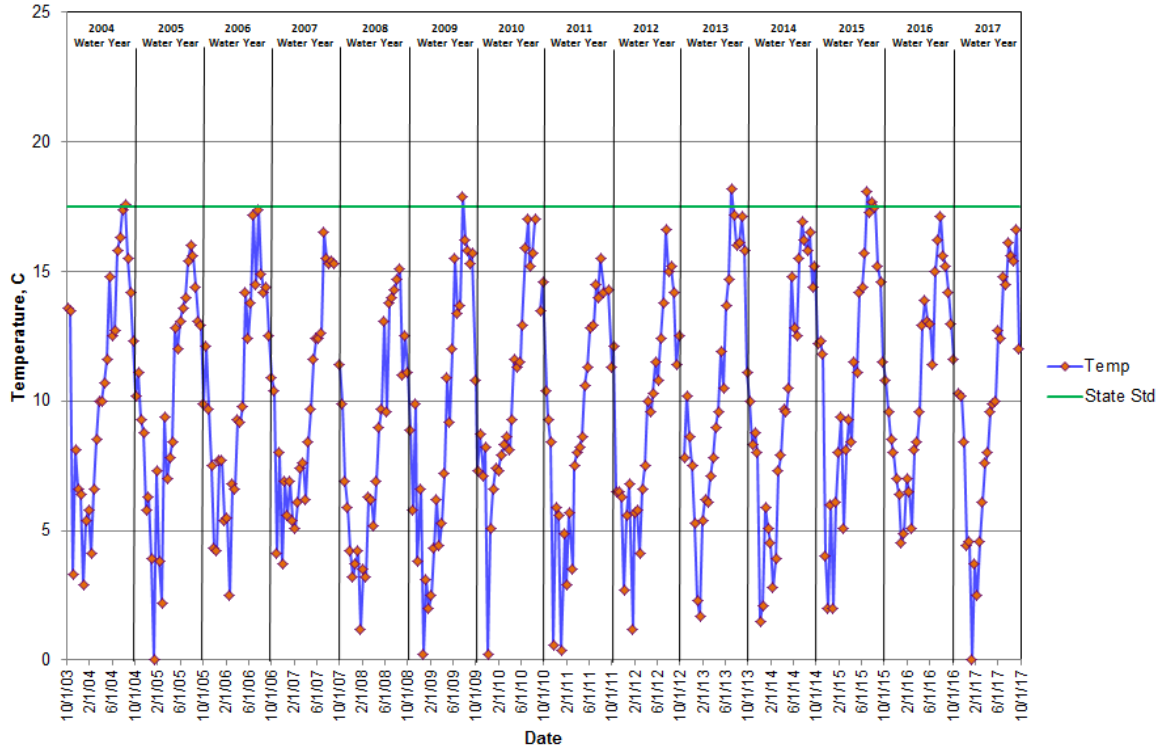
Edison Pump Station - Site 37 Temperature



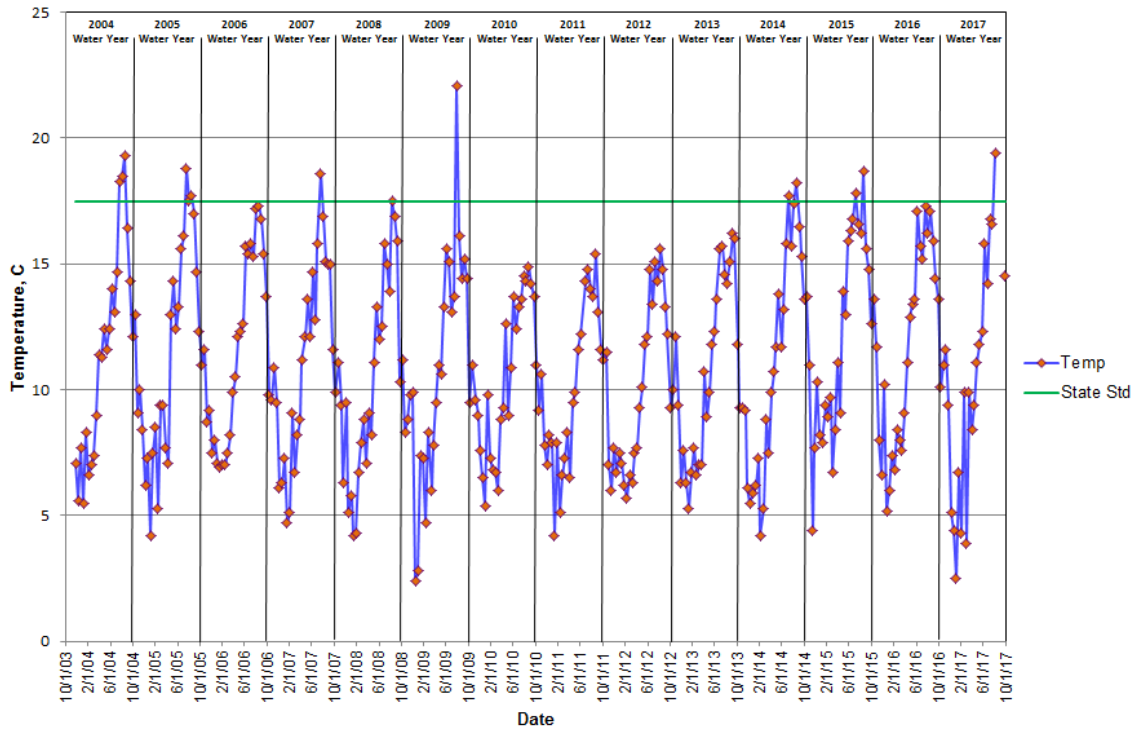
North Edison Pump Station - Site 38 Temperature



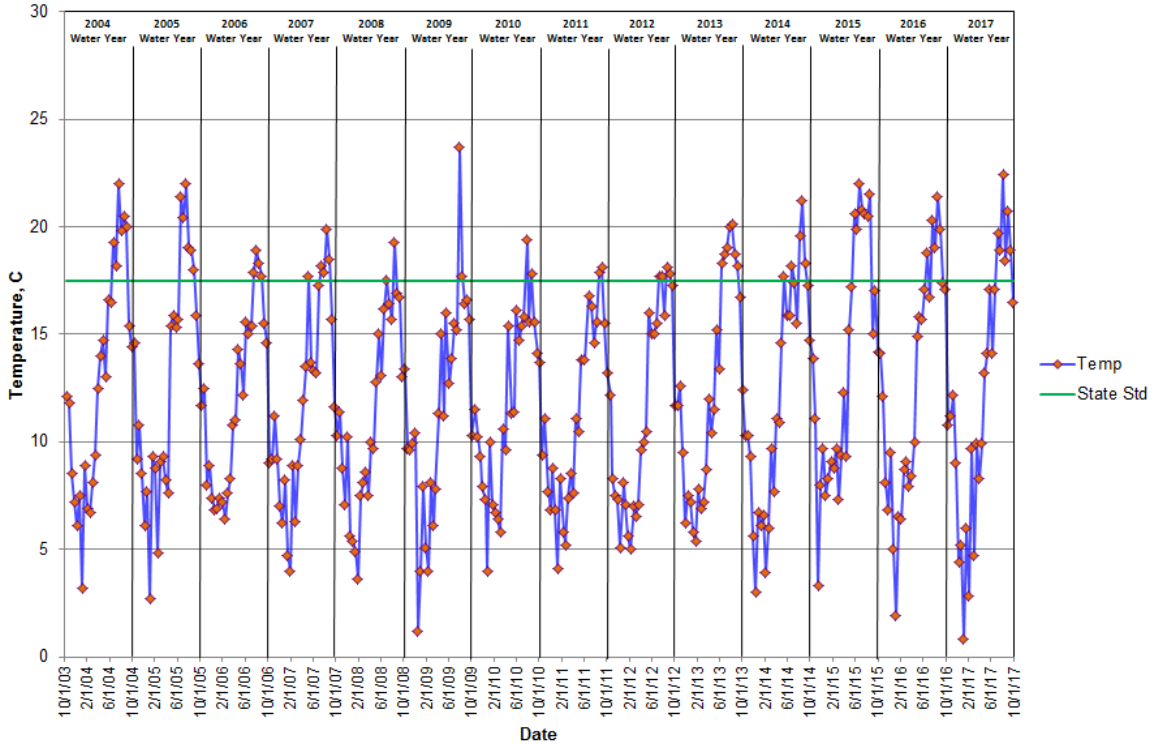
Colony Creek at Colony Road - Site 39 Temperature



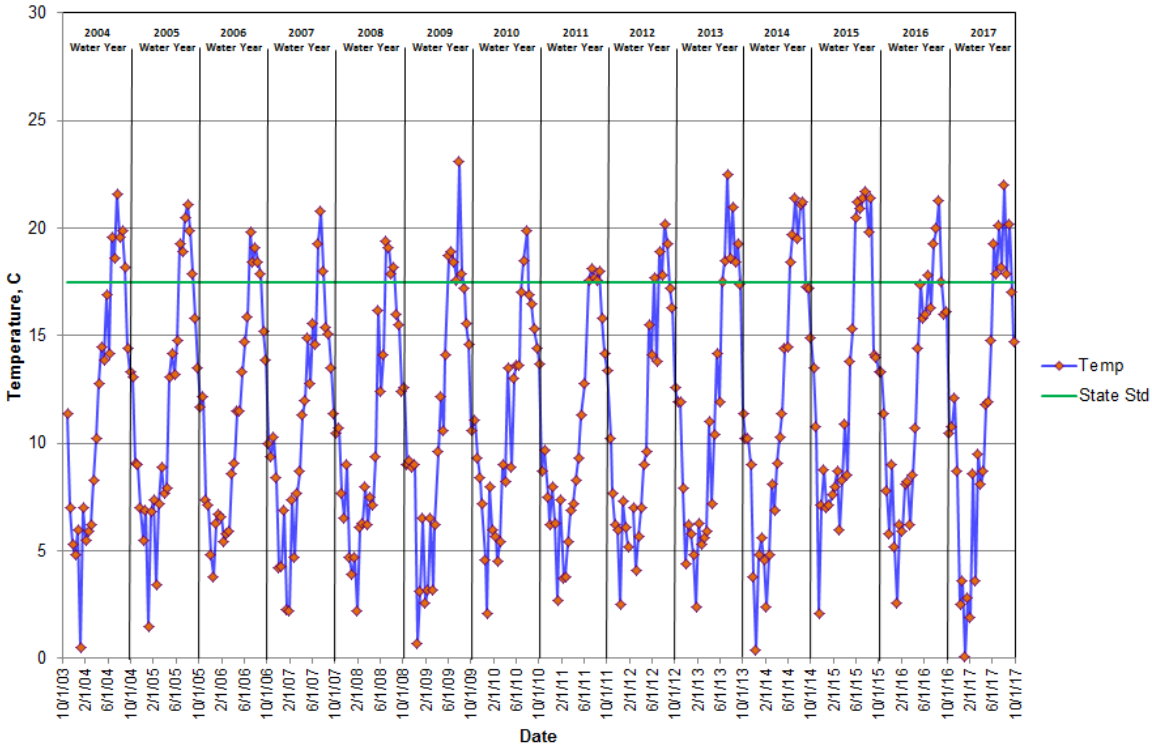
Big Indian Slough at Highway 20 Truck Scales - Site 40 Temperature



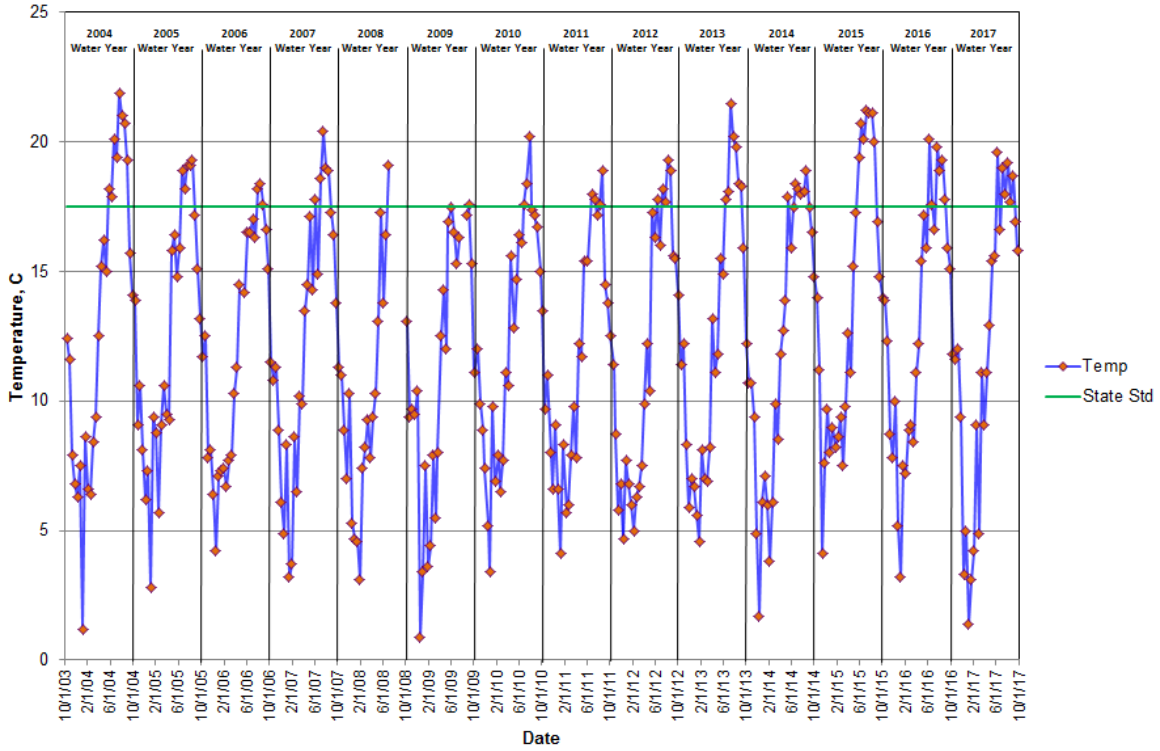
Maddox Creek/Big Ditch at Milltown Road - Site 41 Temperature



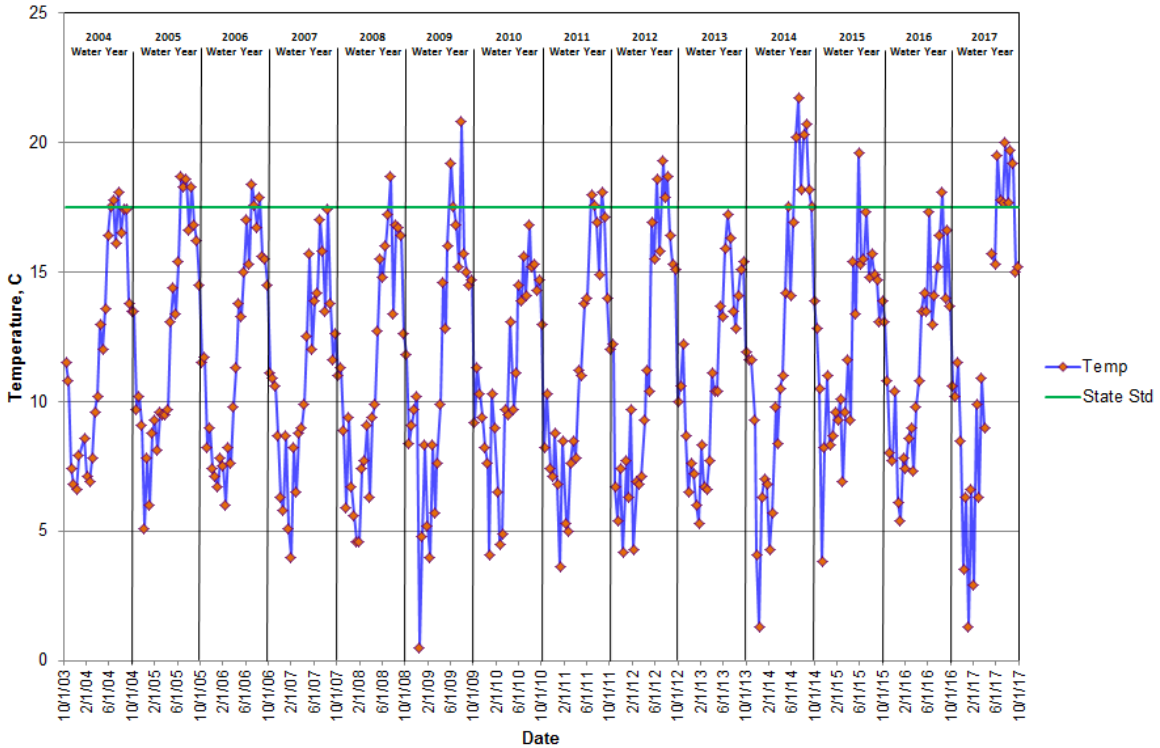
Carpenter Creek/Hill Ditch at Cedardale Road - Site 42 Temperature



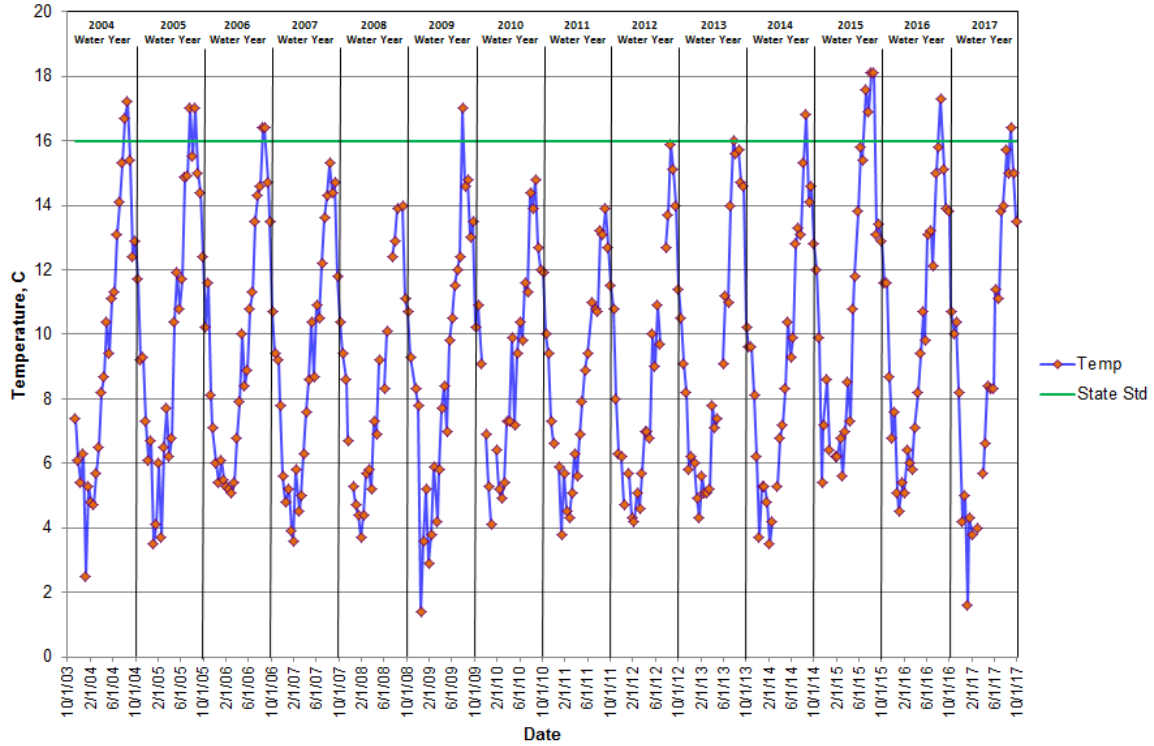
Wiley Slough at Wylie Road - Site 43 Temperature



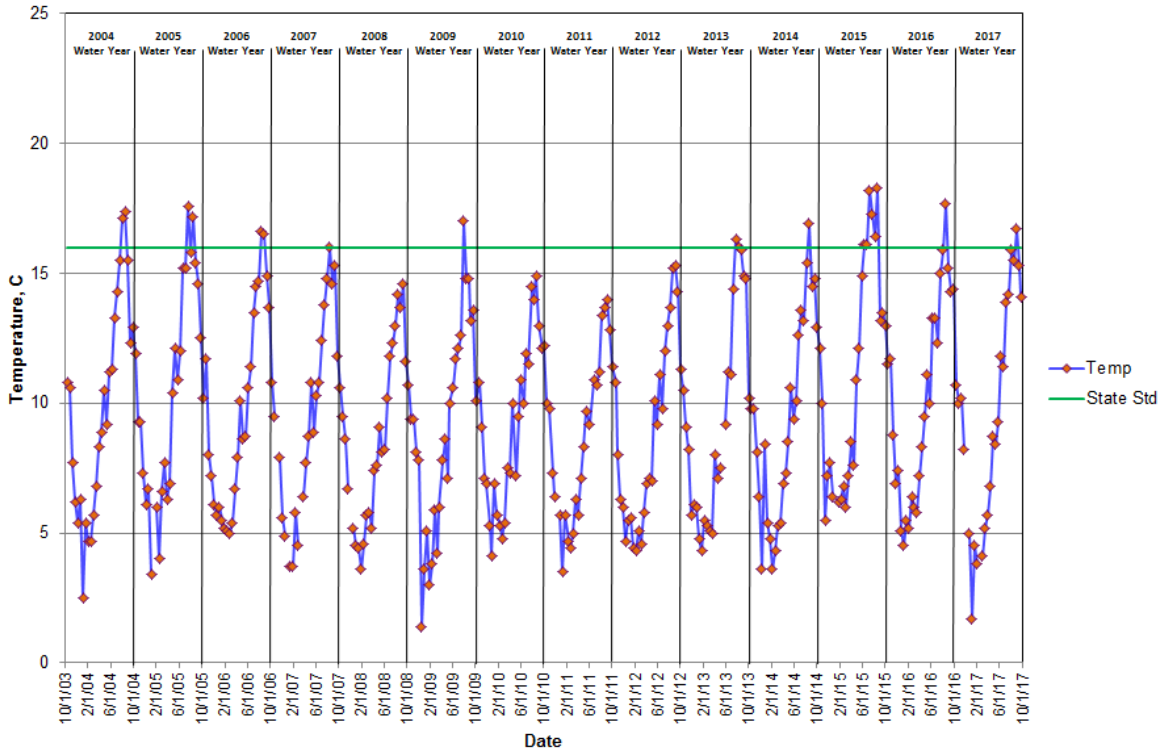
Sullivan Slough at LaConner-Whitney Road - Site 44 Temperature



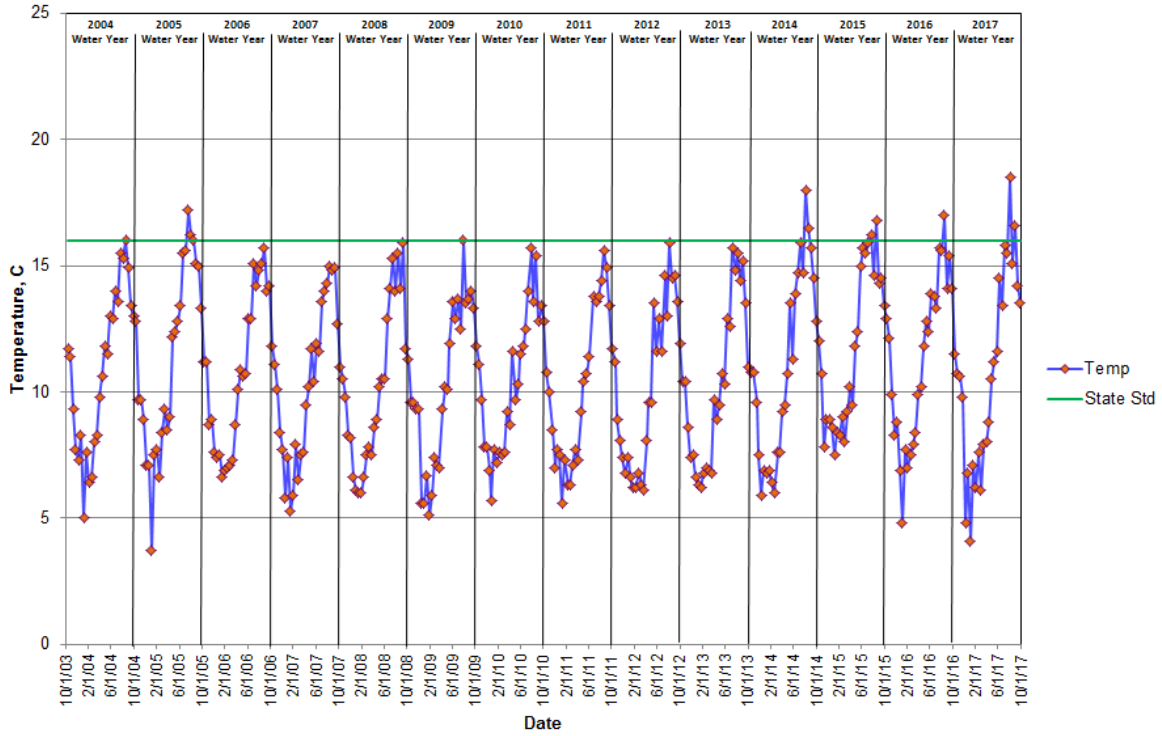
North Fork Skagit River near Moore Road - Site 45 Temperature



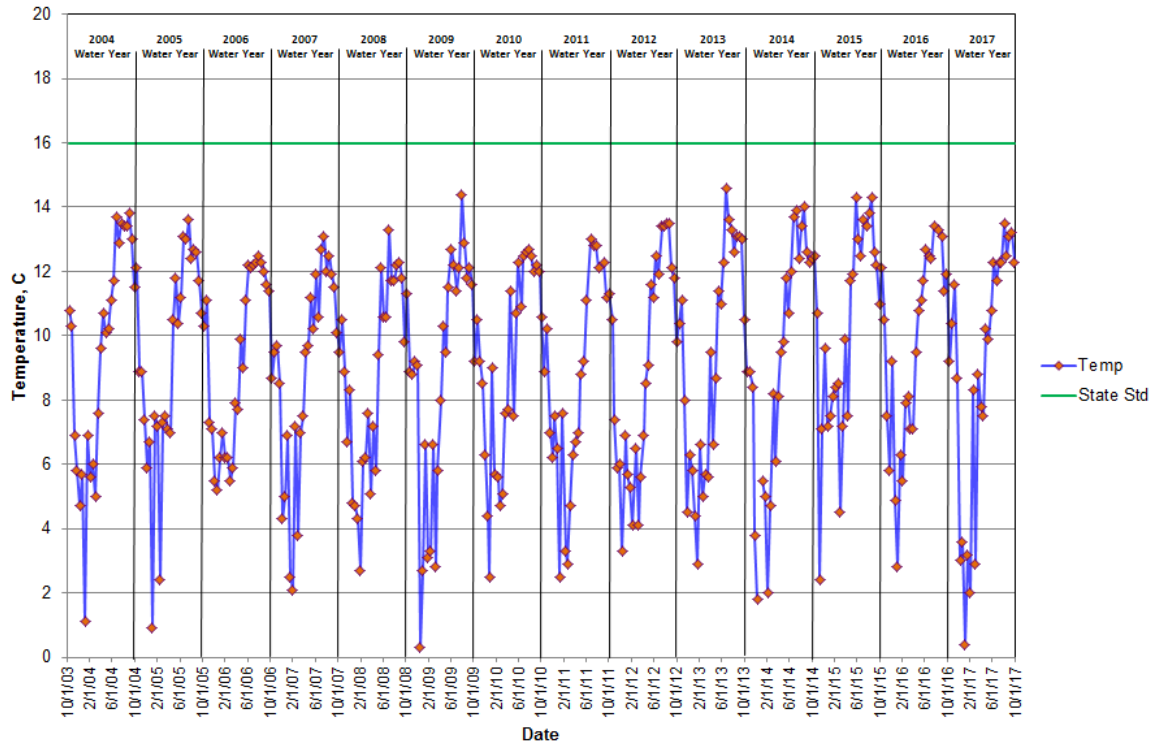
South Fork Skagit River at Conway Boat Ramp - Site 46 Temperature



Swinomish Channel at County Boat Ramp - Site 47 Temperature



Fisher Creek at Franklin Road - Site 48 Temperature



Dissolved Oxygen

Dissolved oxygen (DO) measurements determine how much oxygen is available in the water for fish and other organisms. DO measurements were taken with a meter at each site during each visit, except in rare instances of equipment malfunction. A summary of DO readings (in mg/L) obtained during the 2016 water year is provided in Table 5. Table 6 summarizes data from the last five years of the study. The pages following Table 6 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2016 water years. Gaps in the data represent streams that were either flooded or dry at sampling time, or may represent equipment malfunctions.

The state water quality standards for dissolved oxygen are based on single-day minimum measurements. For some lowland watercourses in the Skagit County Monitoring Program (Sites 3-4, 28, 31-44, and 48), the minimum standard is 8.0 mg/L. For the marine site (Site 47), the standard is 6.0 mg/L. For all other sites, the standard is 9.5 mg/L. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

Seven sites met the oxygen standards in the 2017 water year, the same as in 2016 – compared to six sites in 2015 and only one site in 2014. Others met the oxygen standard for most of the year. In a few streams, oxygen levels showed steep declines in summer as can be seen by the graphs on the following pages. These declines are usually associated with very low flows.

In the drainage infrastructure and lower sloughs, dissolved oxygen levels can be greatly influenced by algal activity. During large algae blooms, the oxygen produced during photosynthesis can lead to very high oxygen levels during the day. However, at those same times, nighttime oxygen levels can be very low as the large populations of algae turn from producing oxygen to consuming it. Because our oxygen readings are taken during the day, the monitoring program does not account for these nighttime oxygen reductions. During times when algae blooms are dying off, the decomposition of the dying algae can lead to very low oxygen levels both day and night. The results, as can be seen in the graphs of the drainage sites, are widely fluctuating dissolved oxygen levels depending on the state of the algal blooms at sampling time.

Table 5. Dissolved Oxygen Results
Summary of Dissolved Oxygen (DO) measurements in the
Skagit County Monitoring Program 2017 Water Year

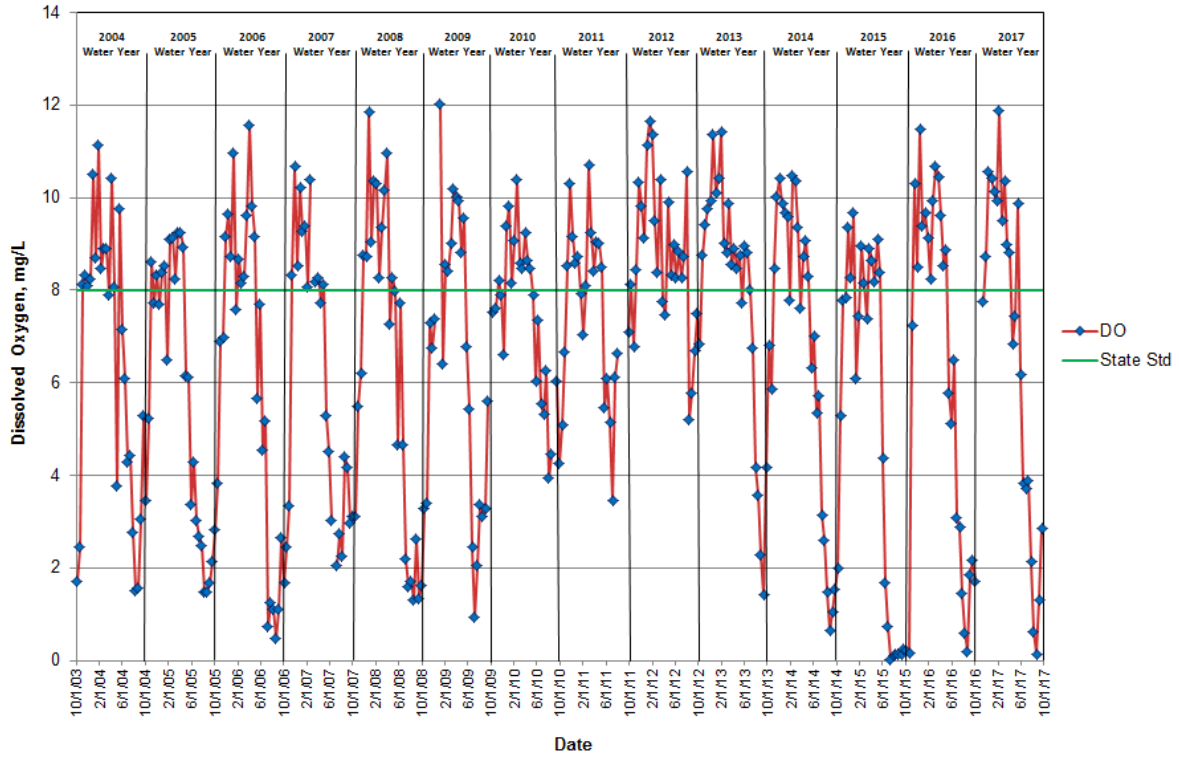
Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std¹
3	Thomas Creek	Old Hwy 99 N	6.57	0.14	8.0
4	Thomas Creek	F&S Grade Rd	11.51	9.30	8.0
6	Friday Creek	Prairie Rd	11.79	9.99	9.5
8	Swede Creek	Grip Rd	10.57	7.35	9.5
11	Samish River	State Route 9	9.35	6.86	9.5
12	Nookachamps Creek	Swan Rd	8.43	4.66	9.5
13	E.F. Nookachamps Creek	State Route 9	10.03	7.06	9.5
14	College Way Creek	College Way	9.74	5.29	9.5
15	Nookachamps Creek	Knapp Rd	8.42	1.09	9.5
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.66	7.72	9.5
17	Nookachamps Creek	Big Lake Outlet	10.23	6.95	9.5
18	Lake Creek	State Route 9	11.15	7.43	9.5
19	Hansen Creek	Hoehn Rd	10.37	5.96	9.5
20	Hansen Creek	Northern State	11.56	9.32	9.5
21	Coal Creek	Hoehn Rd	11.68	7.89	9.5
22	Coal Creek	Hwy 20	11.86	9.66	9.5
23	Wiseman Creek	Minkler Rd	12.31	10.63	9.5
24	Mannser Creek	Lyman Hamilton Hwy	7.50	5.40	9.5
25	Red Cabin Creek	Hamilton Cemetery Rd	12.34	11.00	9.5
28	Brickyard Creek	Hwy 20	10.23	7.32	8.0
29	Skagit River	River Bend Rd	11.37	8.75	9.5
30	Skagit River	Cape Horn Rd	11.71	8.96	9.5
31	Drainage District 20 floodgate	Francis Rd	5.92	2.01	8.0
32	Samish River	Thomas Rd	11.39	9.22	8.0
33	Alice Bay Pump Station	Samish Island Rd	8.18	4.56	8.0
34	No Name Slough	Bayview-Edison Rd	7.82	0.67	8.0
35	Joe Leary Slough	D'Arcy Rd	4.98	3.59	8.0
36	Edison Slough at school	West Bow Hill Rd	10.36	4.59	8.0
37	Edison Pump Station	Farm to Market Rd	8.25	0.04	8.0
38	North Edison Pump Station	North Edison Rd	8.41	0.24	8.0
39	Colony Creek	Colony Rd	10.98	6.49	8.0
40	Big Indian Slough	Bayview-Edison Rd	4.67	2.52	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	6.57	2.70	8.0
42	Hill Ditch	Cedardale Rd	8.33	3.31	9.5
43	Wiley Slough	Wylie Rd	4.52	0.96	8.0
44	Sullivan Slough	La Conner-Bayview Rd	7.49	2.50	8.0
45	Skagit River – North Fork	Moore Rd	11.48	9.47	9.5
46	Skagit River – South Fork	Fir Island Rd	11.44	8.70	9.5
47	Swinomish Channel	County Boat Launch	9.03	6.85	6.0
48	Fisher Creek	Franklin Rd	11.64	9.74	9.5

¹Washington State Water Quality Standard per WAC 173-201A

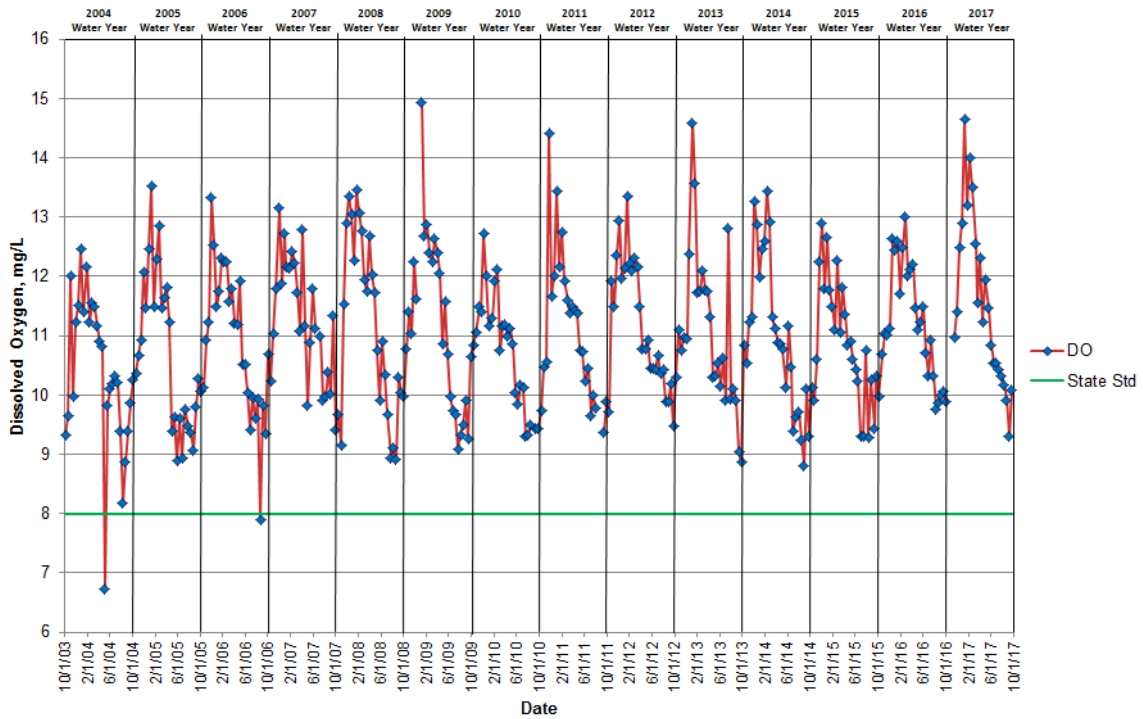
Table 6. Dissolved Oxygen Results Summary
Mean Dissolved Oxygen levels for five years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	Mean Dissolved Oxygen (mg/L)				
			2013	2014	2015	2016	2017
3	Thomas Creek	Old Hwy 99 North	7.9	6.9	5.4	6.2	6.6
4	Thomas Creek	F&S Grade Rd	11.1	11.0	10.9	11.2	11.5
6	Friday Creek	Prairie Rd	11.0	11.1	10.8	11.4	11.8
8	Swede Creek	Grip Rd	10.7	10.8	10.3	10.4	10.6
11	Samish River	State Route 9	8.7	8.5	8.3	8.7	9.4
12	Nookachamps Creek	Swan Rd	9.5	9.3	8.0	9.1	8.4
13	E.F. Nookachamps Creek	State Route 9	10	9.9	9.0	9.9	10.0
14	College Way Creek	College Way	8.8	9.2	8.5	9.0	9.7
15	Nookachamps Creek	Knapp Rd	8.0	8.1	7.3	7.7	8.4
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.5	11.4	10.7	11.3	11.7
17	Nookachamps Creek	Big Lake Outlet	9.7	9.9	9.1	9.6	10.2
18	Lake Creek	State Route 9	10.8	11.0	10.5	10.8	11.2
19	Hansen Creek	Hoehn Rd	9.9	10.4	9.8	10.2	10.4
20	Hansen Creek	Northern State	11.1	11.1	10.7	11.3	11.6
21	Coal Creek	Hoehn Rd	10.9	11.0	10.8	11.2	11.7
22	Coal Creek	Hwy 20	11.6	11.8	11.2	11.6	11.9
23	Wiseman Creek	Minkler Rd	11.8	11.8	11.8	11.6	12.3
24	Mannser Creek	Lyman Hamilton Hwy	6.0	6.4	7.2	7.0	7.5
25	Red Cabin Creek	Hamilton Cemetery Rd	11.6	11.7	11.4	12.1	12.3
28	Brickyard Creek	Hwy 20	9.0	9.1	8.8	9.2	10.2
29	Skagit River	River Bend Rd	11.0	11.1	10.6	11.0	11.4
30	Skagit River	Cape Horn Rd	10.9	11.2	10.9	11.2	11.7
31	DD20 near floodgate	Francis Rd	7.3	8.0	5.7	7.4	5.9
32	Samish River	Thomas Rd	10.8	10.7	10.4	10.9	11.4
33	Alice Bay Pump Station	Samish Island Rd	8.4	9.2	9.3	10.3	8.2
34	No Name Slough	Bayview-Edison Rd	5.9	6.6	6.6	7.6	7.8
35	Joe Leary Slough	D'Arcy Rd	5.5	5.2	5.3	5.4	5.0
36	Edison Slough at school	W. Bow Hill Rd	9.3	8.8	8.7	9.9	10.4
37	Edison Pump Station	Farm to Market Rd	6.7	6.9	6.0	8.6	8.3
38	North Edison Pump Station	North Edison Rd	7.8	7.2	6.5	10.4	8.4
39	Colony Creek	Colony Rd	10.7	10.8	10.2	10.7	11.0
40	Big Indian Slough	Bayview-Edison Rd	5.2	5.1	4.3	4.1	4.7
41	Maddox Slough/Big Ditch	Milltown Rd	5.2	5.9	5.7	7.8	6.6
42	Hill Ditch	Cedardale Rd	9.4	8.0	8.9	9.0	8.3
43	Wiley Slough	Wylie Rd	5.6	5.0	5.3	5.3	4.5
44	Sullivan Slough	La Conner-Whitney Rd	6.4	6.9	6.7	6.2	7.5
45	Skagit River – North Fork	Moore Rd	11.2	11.3	10.7	11.0	11.5
46	Skagit River – South Fork	Fir Island Rd	11.2	11.2	10.8	11.3	11.4
47	Swinomish Channel	County Boat Launch	8.6	8.7	8.4	8.5	9.0
48	Fisher Creek	Franklin Rd	10.9	11.0	10.7	11.0	11.6

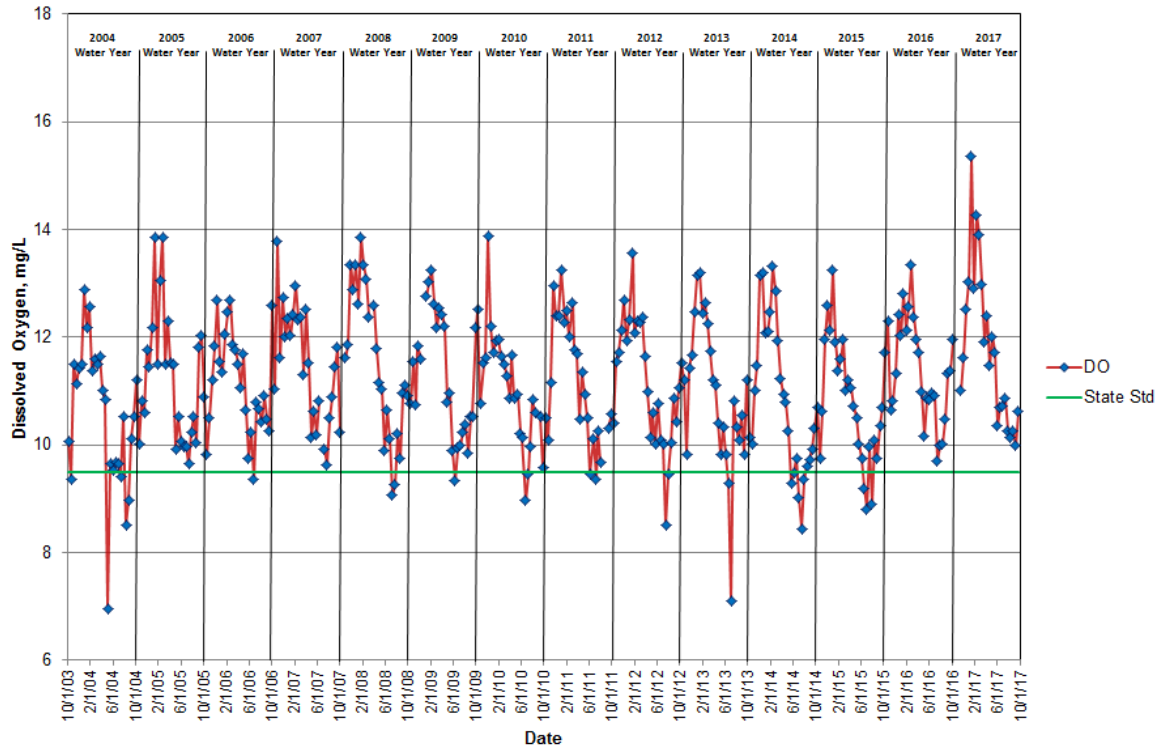
Thomas Creek at Highway 99 - Site 3 Dissolved Oxygen



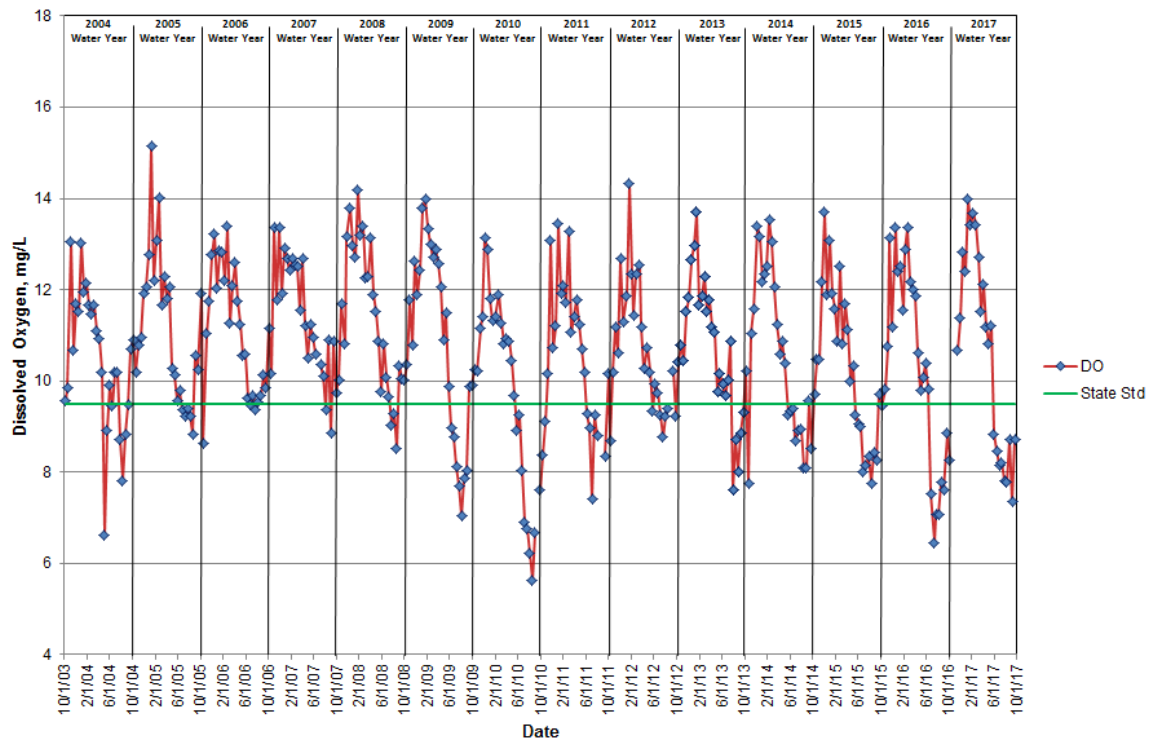
Thomas Creek at F&S Grade Road - Site 4 Dissolved Oxygen



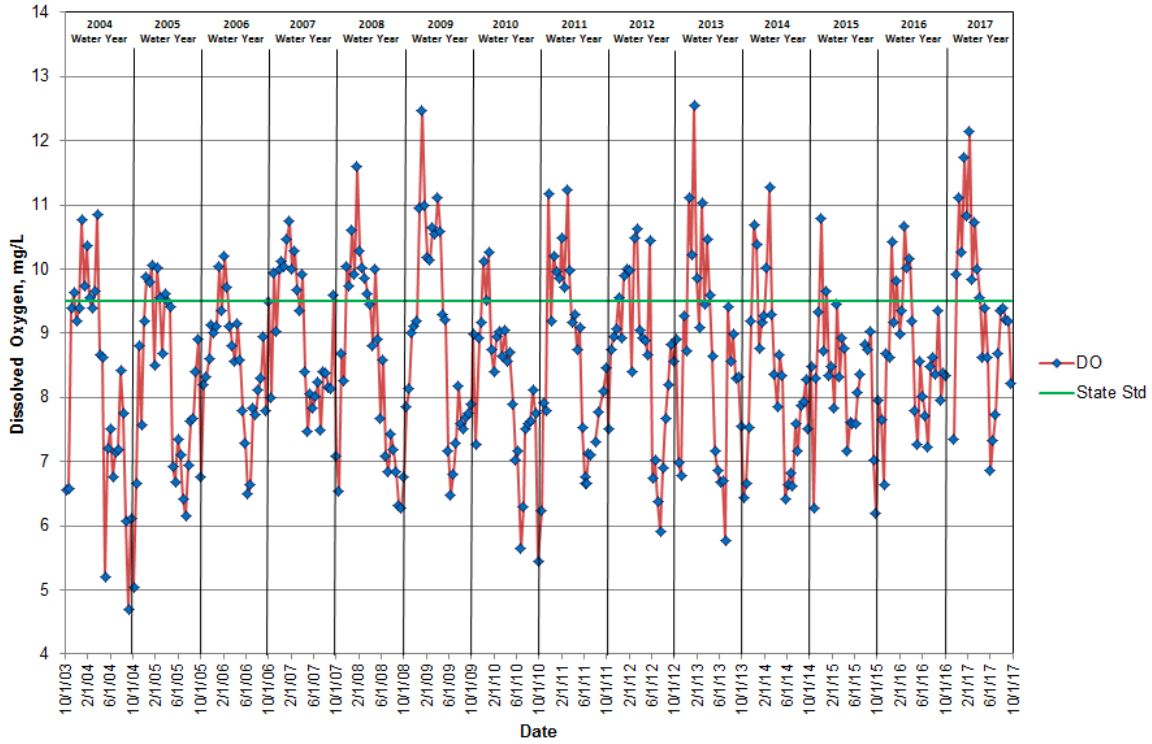
Friday Creek at Prairie Road - Site 6 Dissolved Oxygen



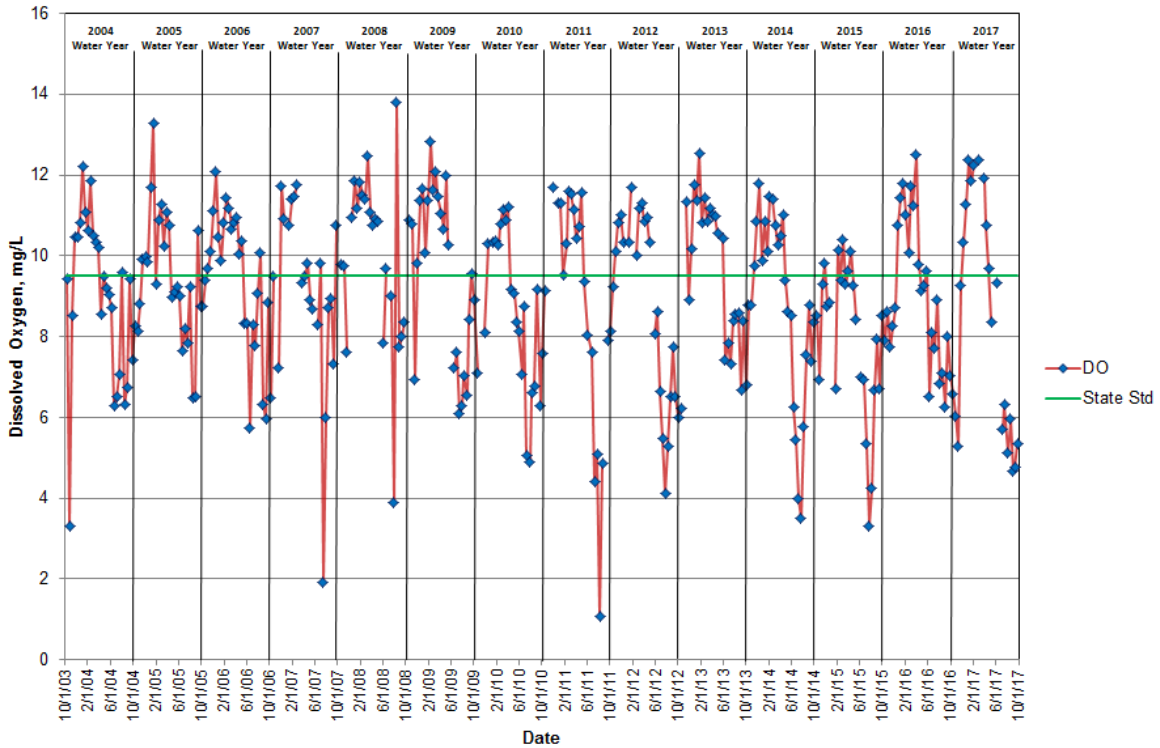
Swede Creek at Grip Road - Site 8 Dissolved Oxygen



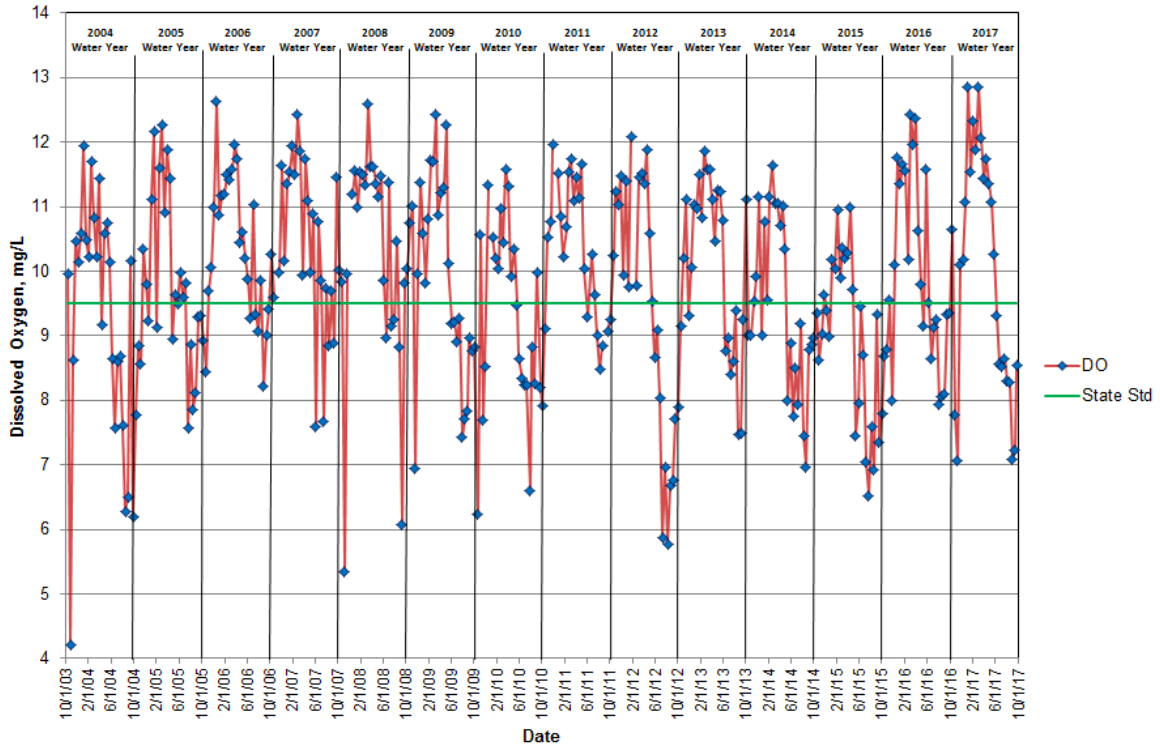
Samish River at Highway 9 - Site 11 Dissolved Oxygen



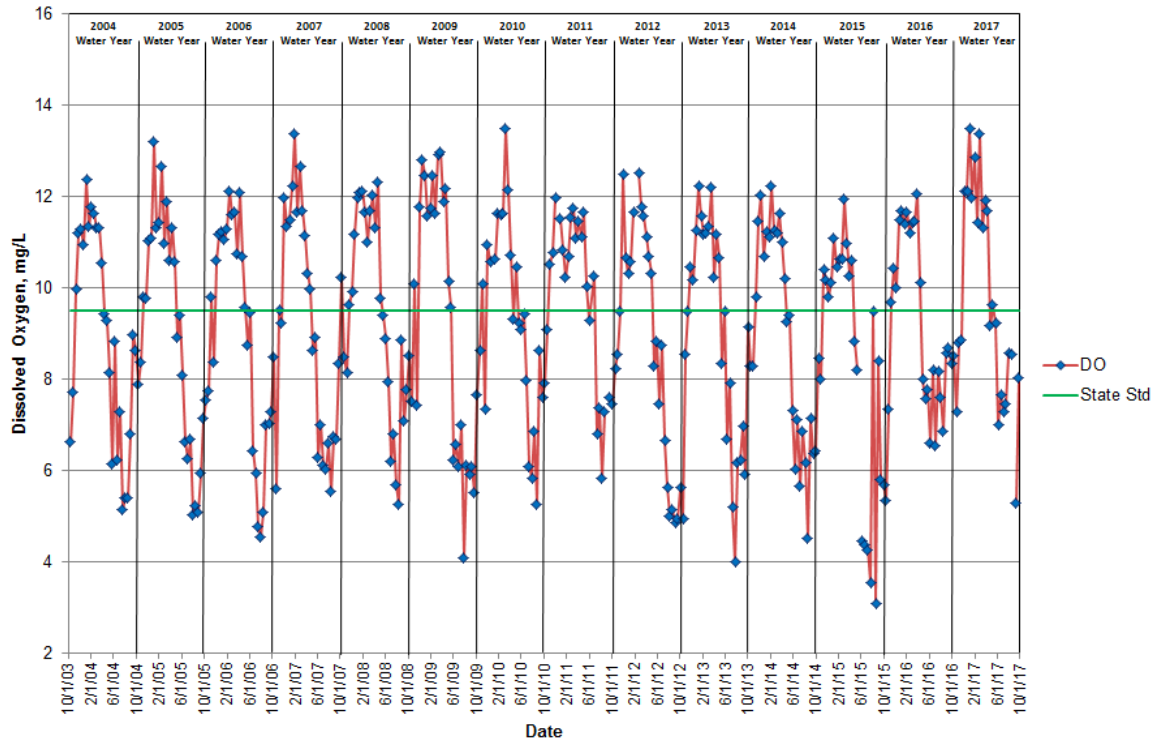
Nookachamps Creek at Swan Road - Site 12 Dissolved Oxygen



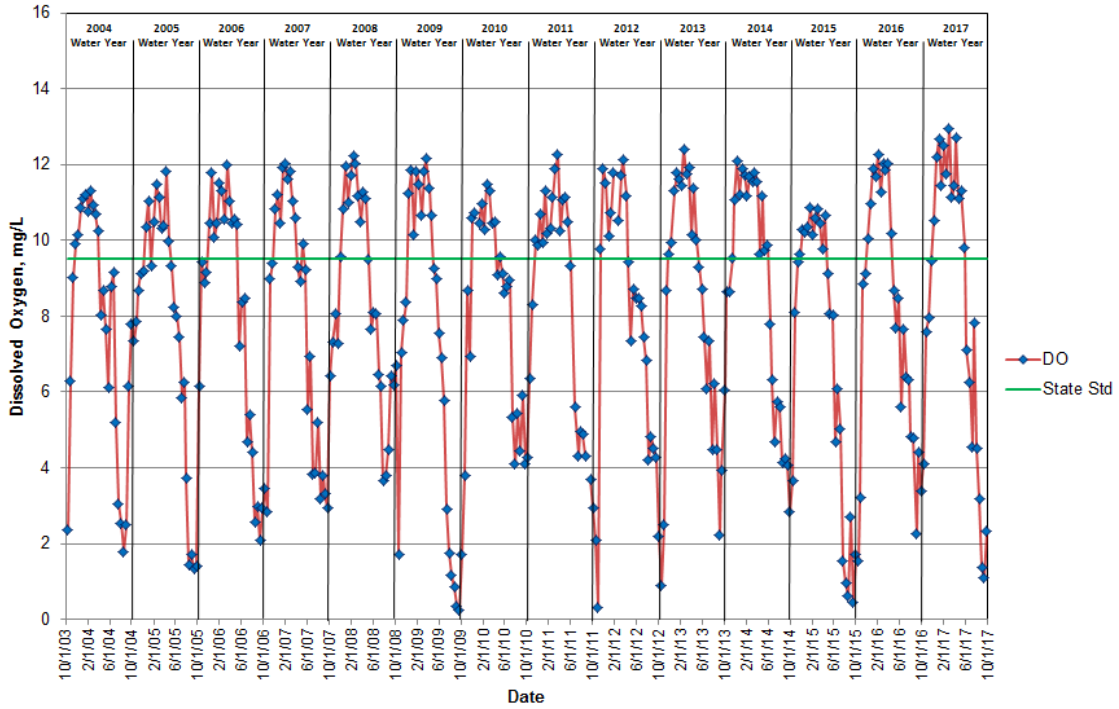
East Fork Nookachamps Creek at Highway 9 - Site 13 Dissolved Oxygen



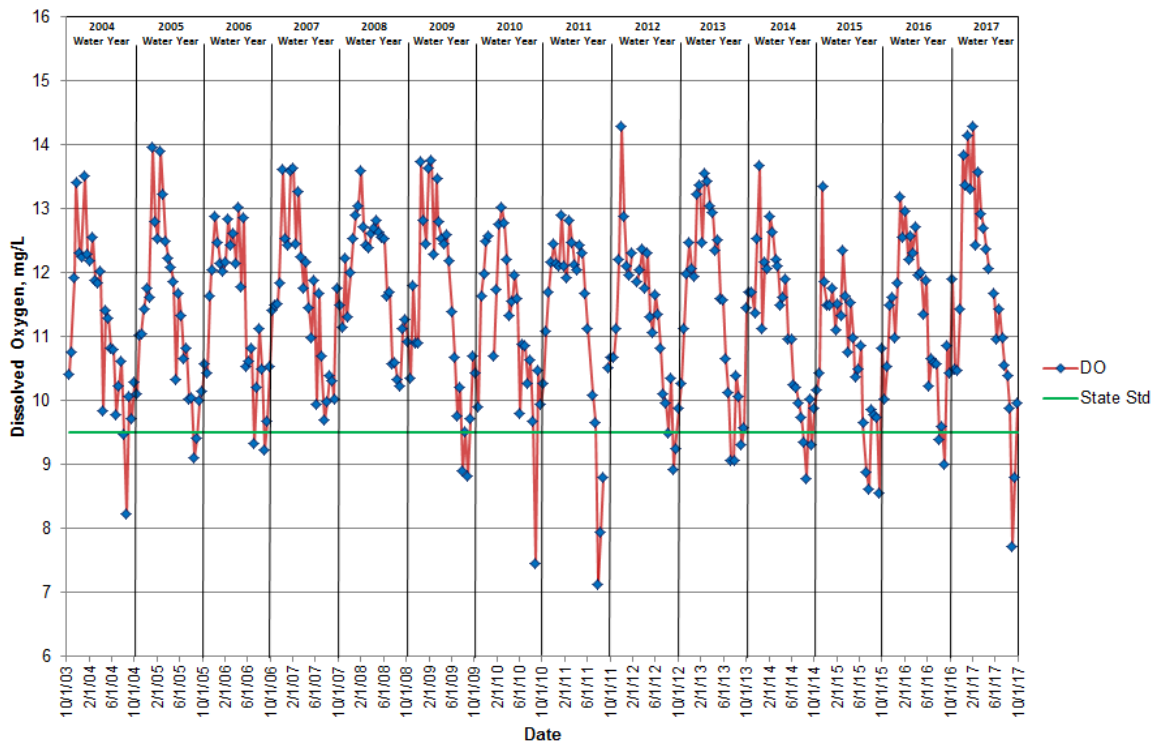
College Way Creek at College Way - Site 14 Dissolved Oxygen



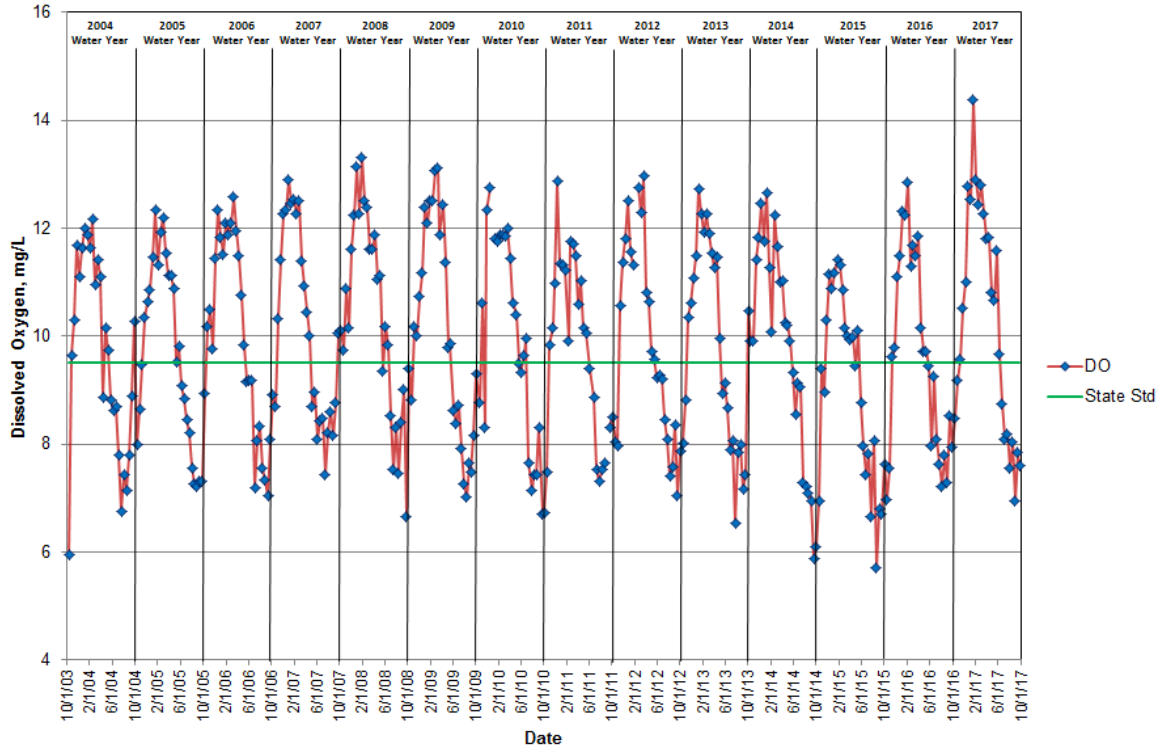
Nookachamps Creek at Knapp Road - Site 15 Dissolved Oxygen



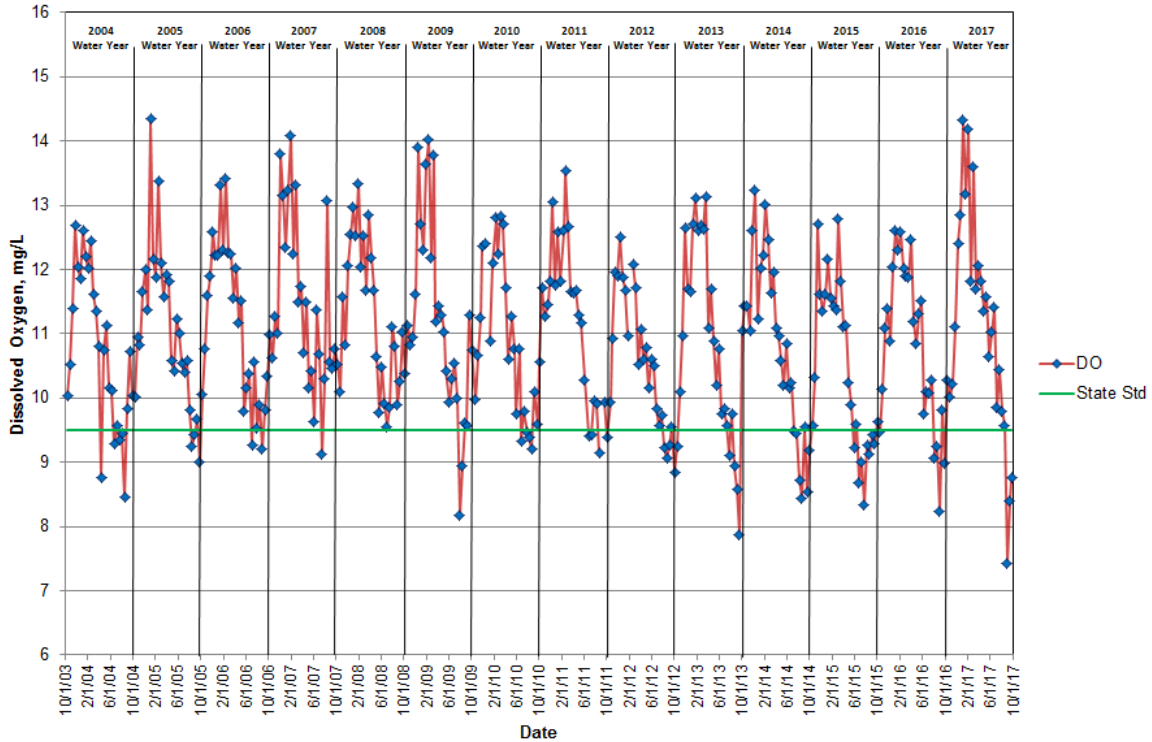
East Fork Nookachamps Creek at Beaver Lake Road - Site 16 Dissolved Oxygen



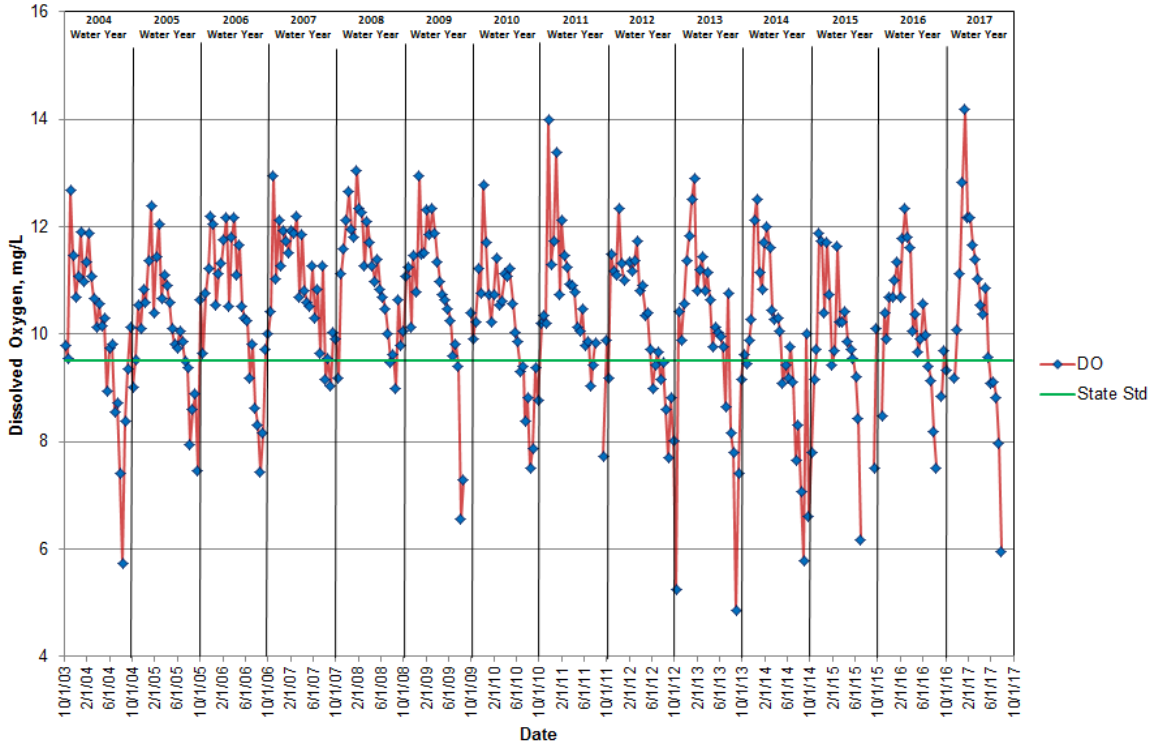
Nookachamps Creek at Big Lake Outlet - Site 17 Dissolved Oxygen



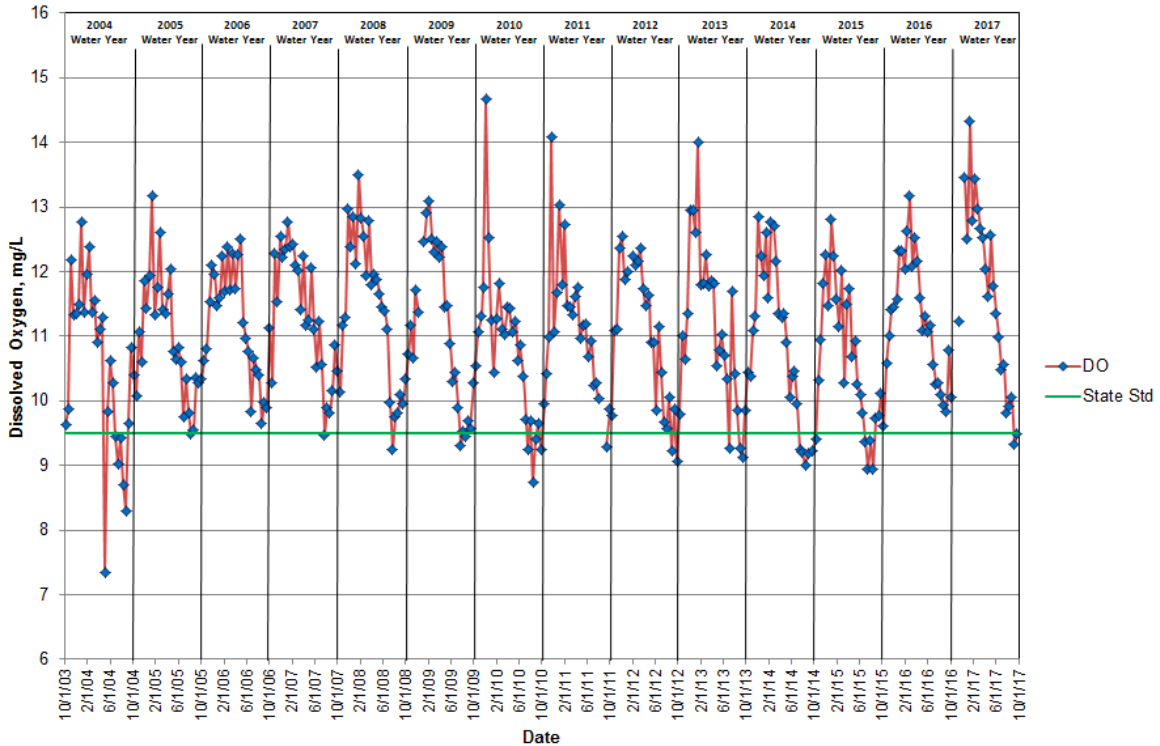
Lake Creek at Highway 9 - Site 18 Dissolved Oxygen



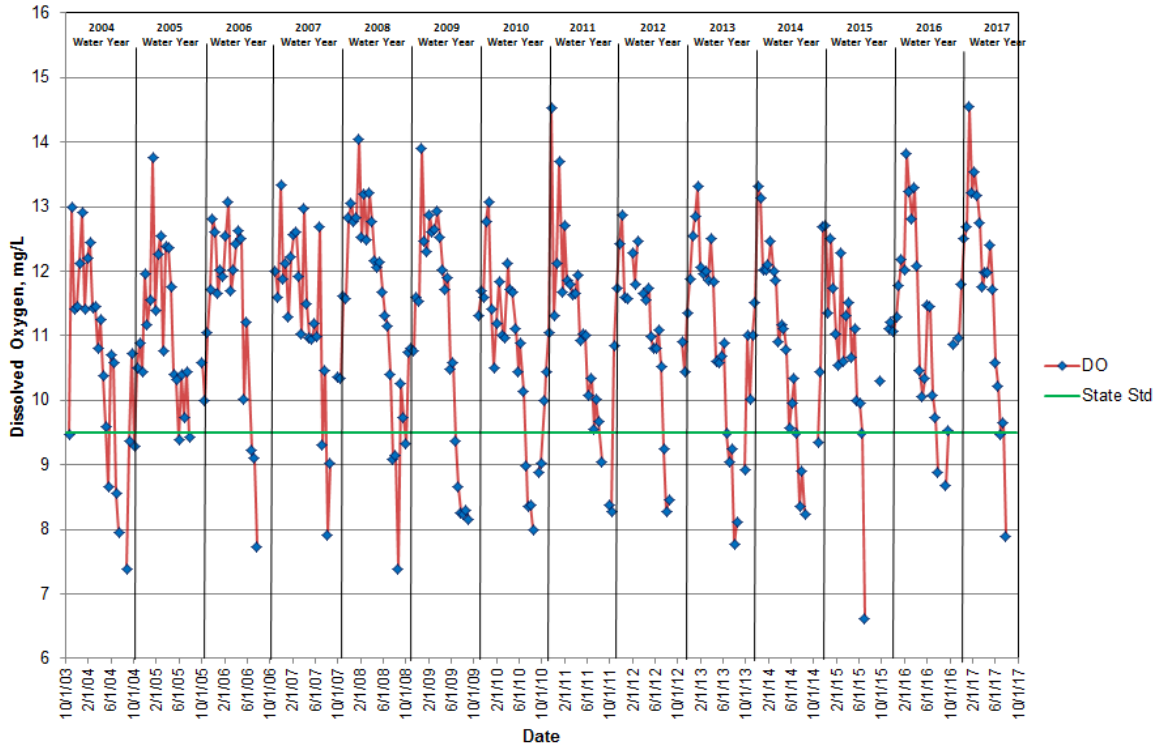
Hansen Creek at Hoehn Road - Site 19 Dissolved Oxygen



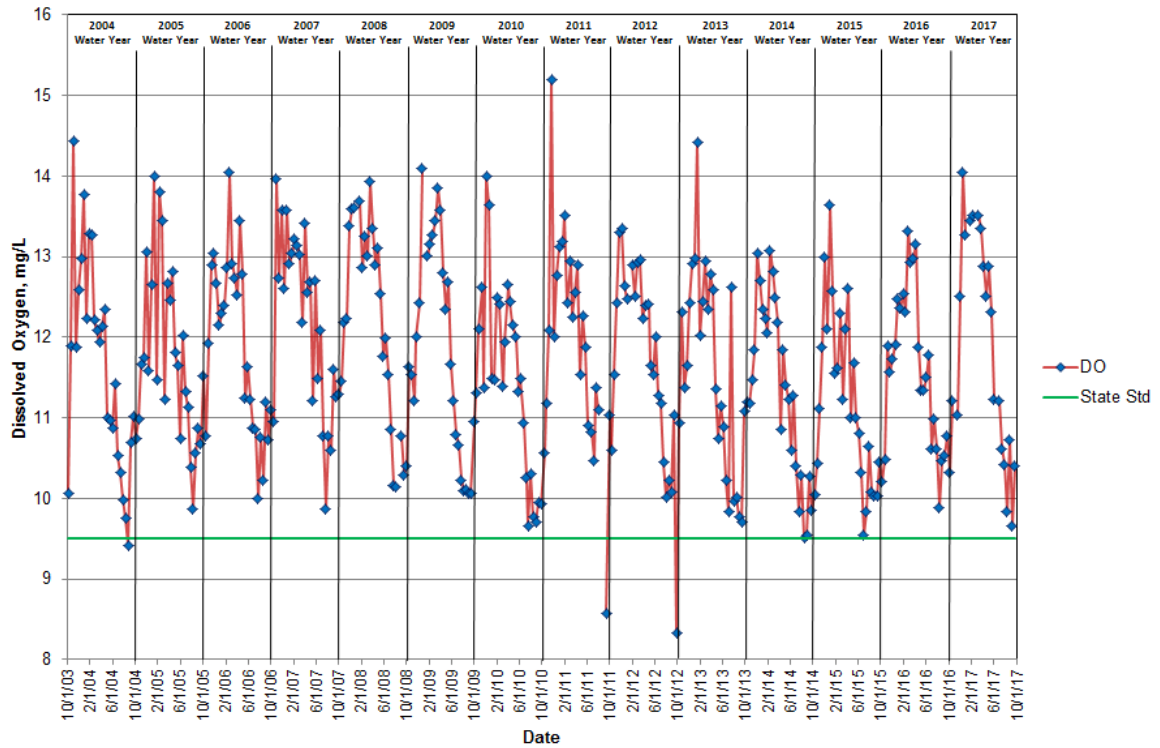
Hansen Creek at Northern State Hospital - Site 20 Dissolved Oxygen



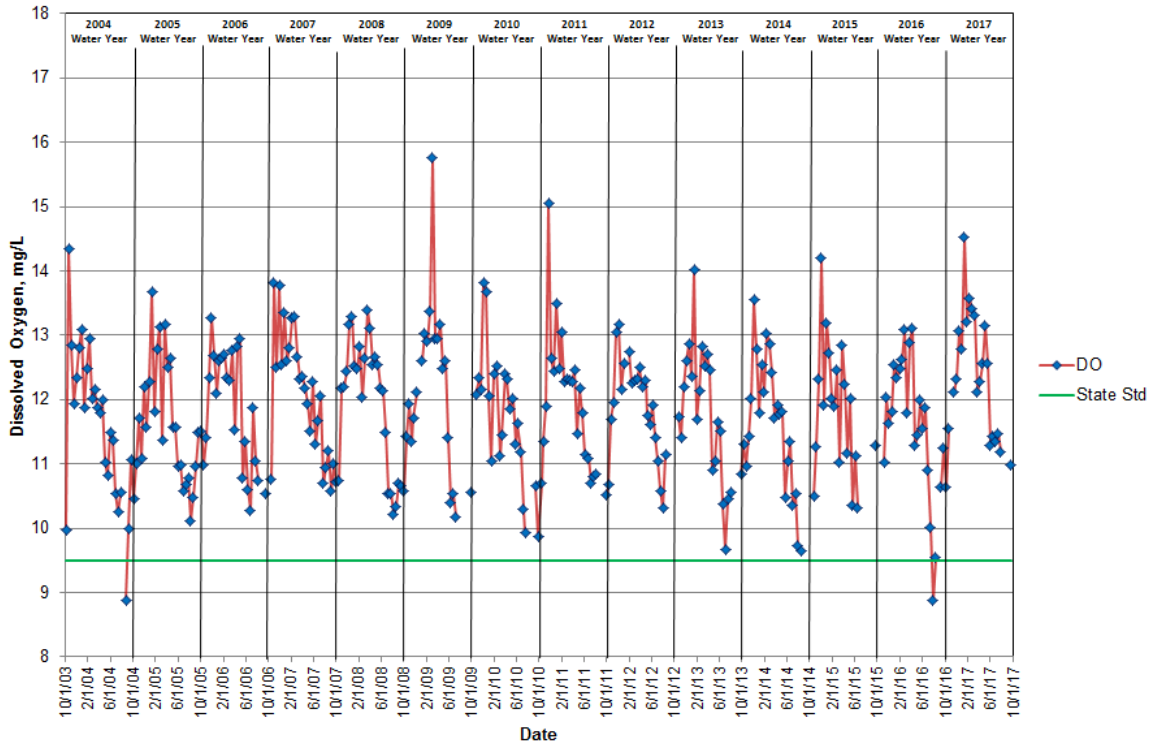
Coal Creek at Hoehn Road - Site 21 Dissolved Oxygen



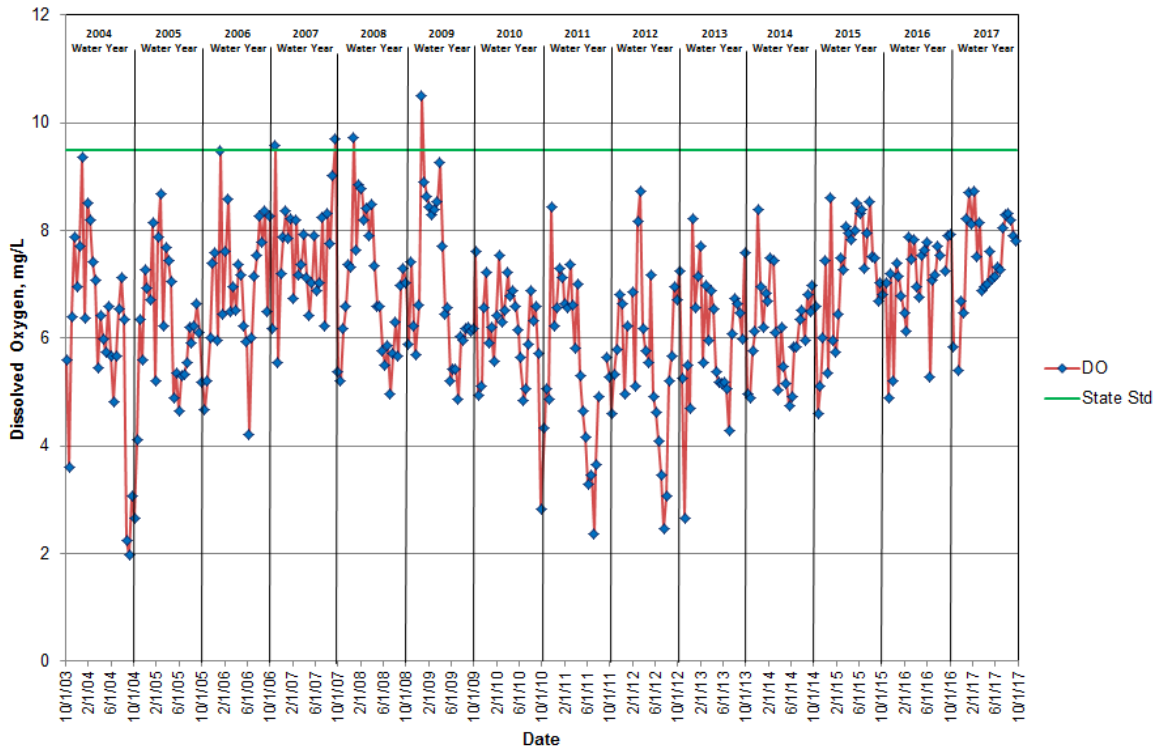
Coal Creek at Highway 20 - Site 22 Dissolved Oxygen



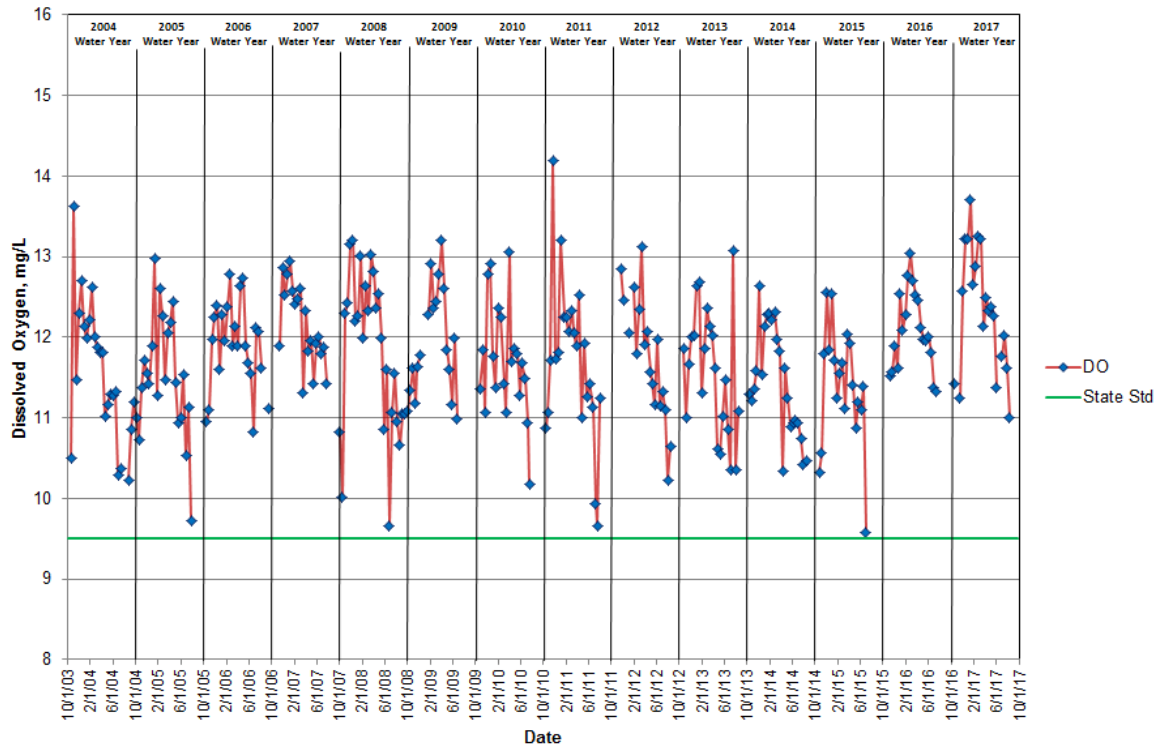
Wiseman Creek at Minkler Road - Site 23 Dissolved Oxygen



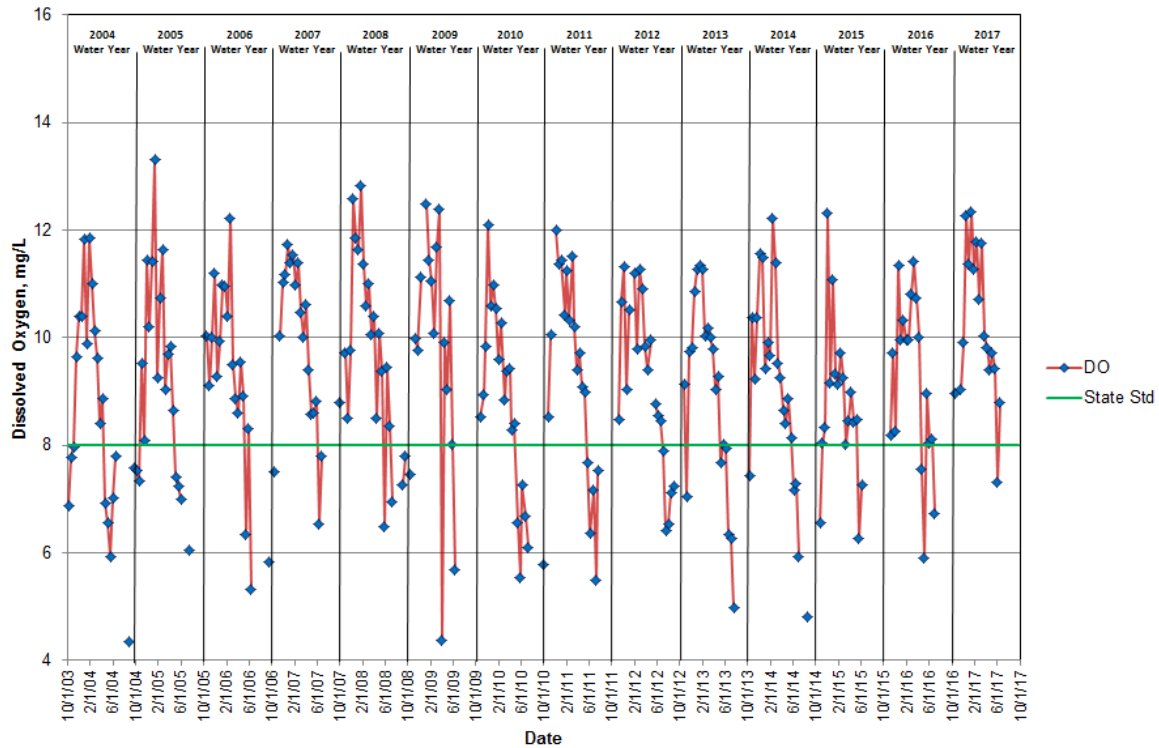
Mannser Creek at Lyman-Hamilton Highway - Site 24 Dissolved Oxygen



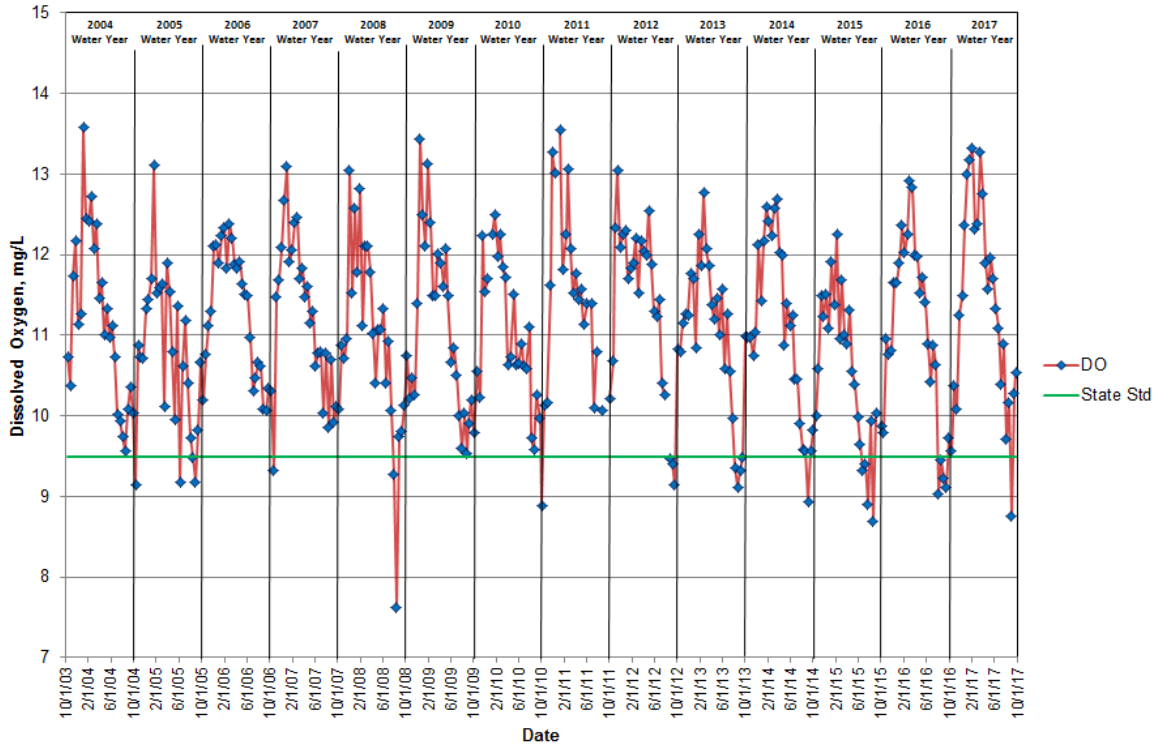
Red Cabin Creek at Hamilton Cemetery Road - Site 25 Dissolved Oxygen



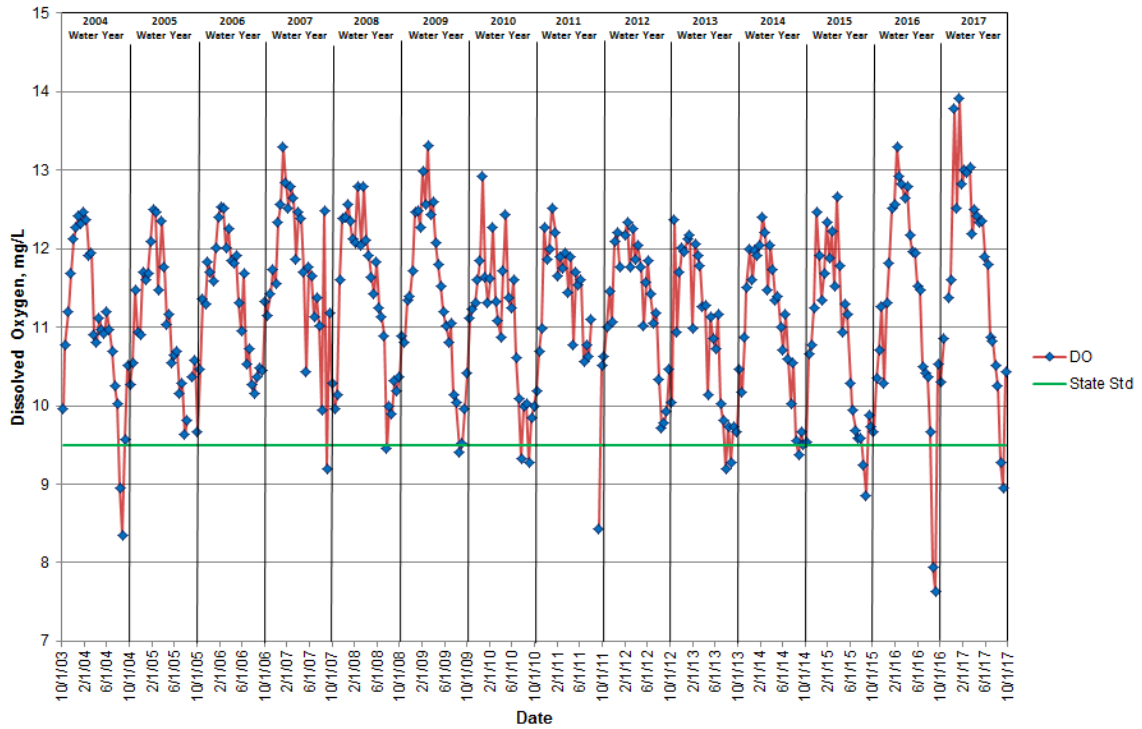
Brickyard Creek at Highway 20 - Site 28 Dissolved Oxygen



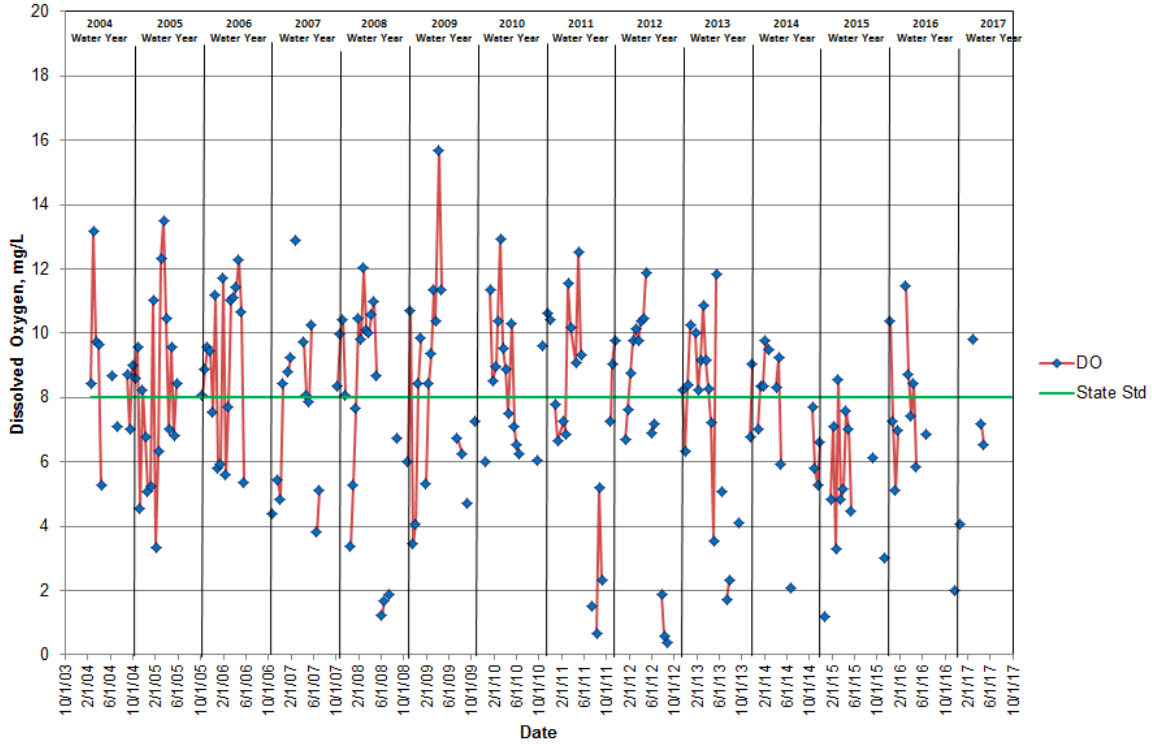
Skagit River at River Bend Road - Site 29 Dissolved Oxygen



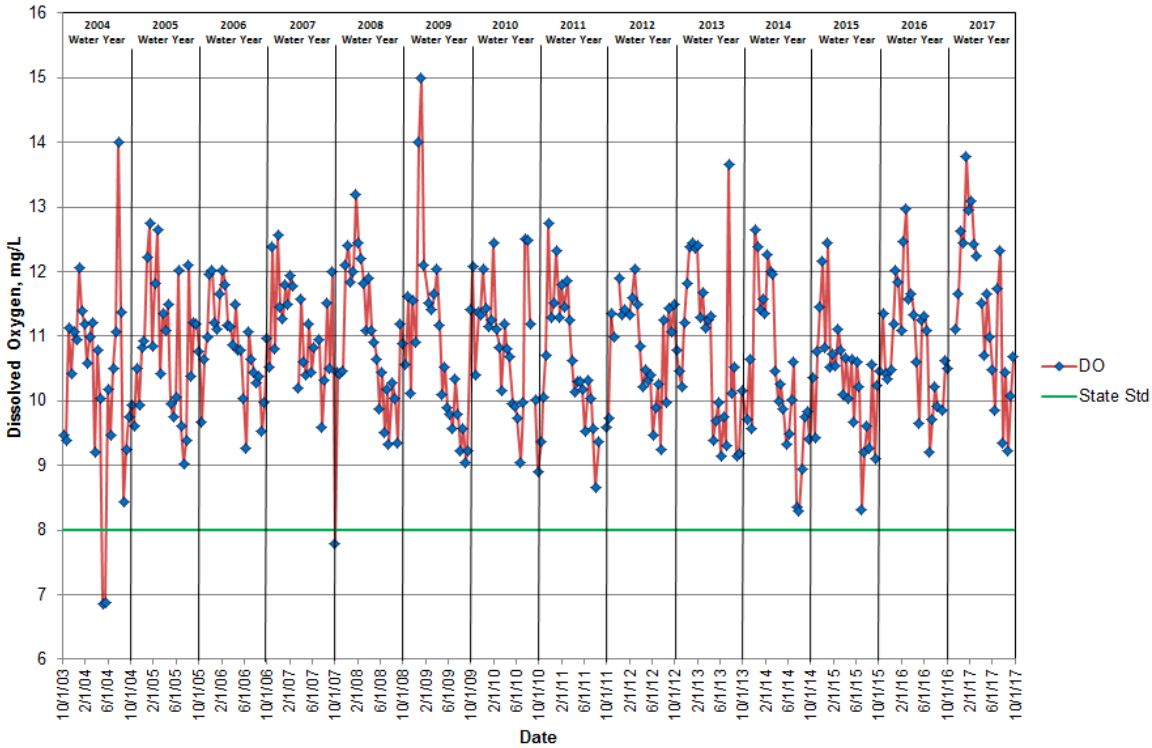
Skagit River at Cape Horn Road - Site 30 Dissolved Oxygen



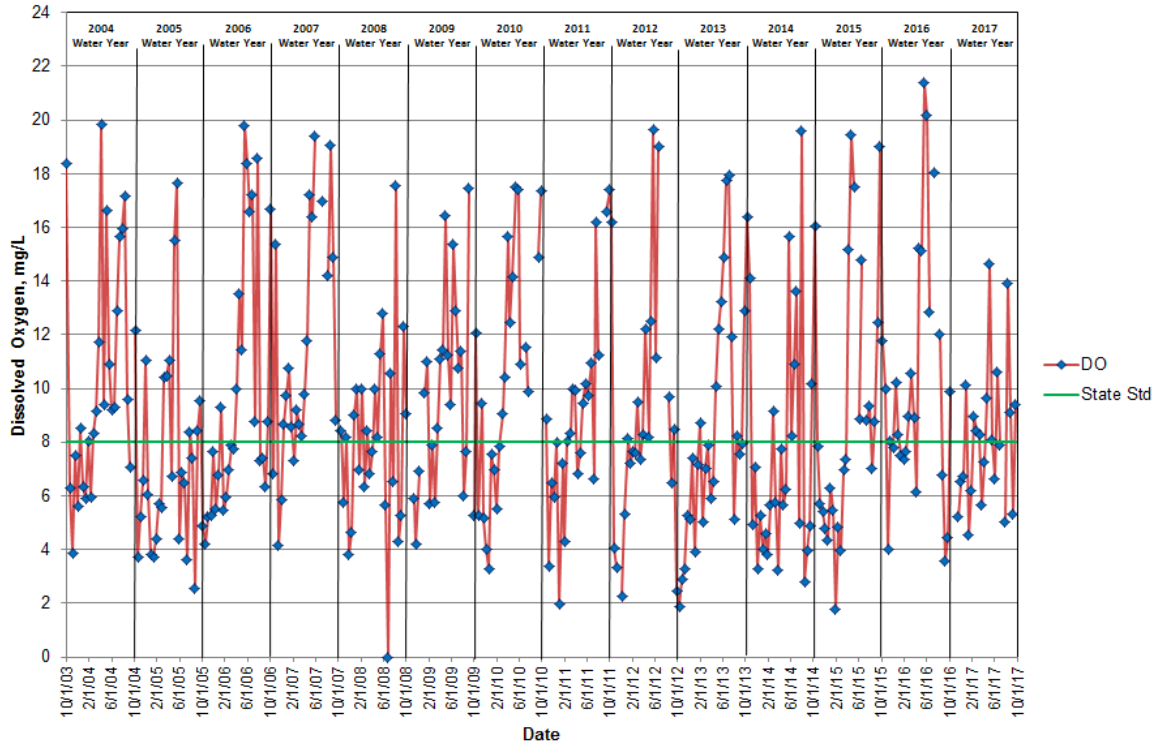
Drainage District 20 Ditch at Floodgate - Site 31 Dissolved Oxygen



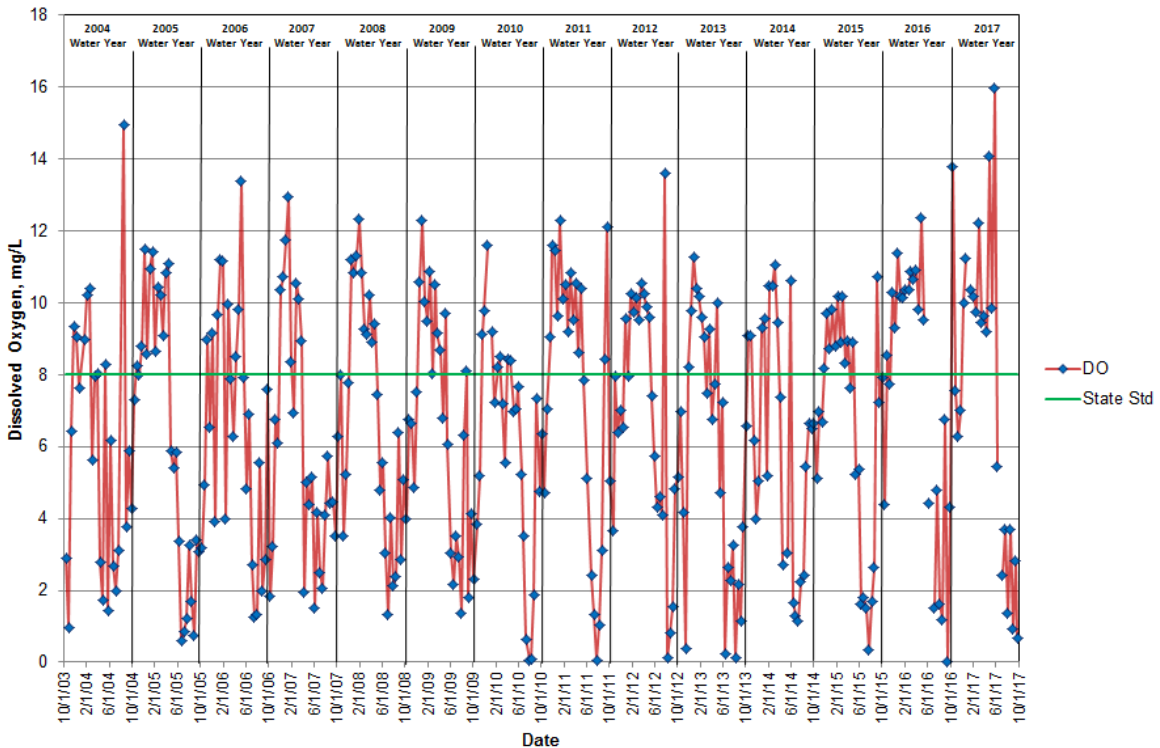
Samish River at Thomas Road - Site 32 Dissolved Oxygen



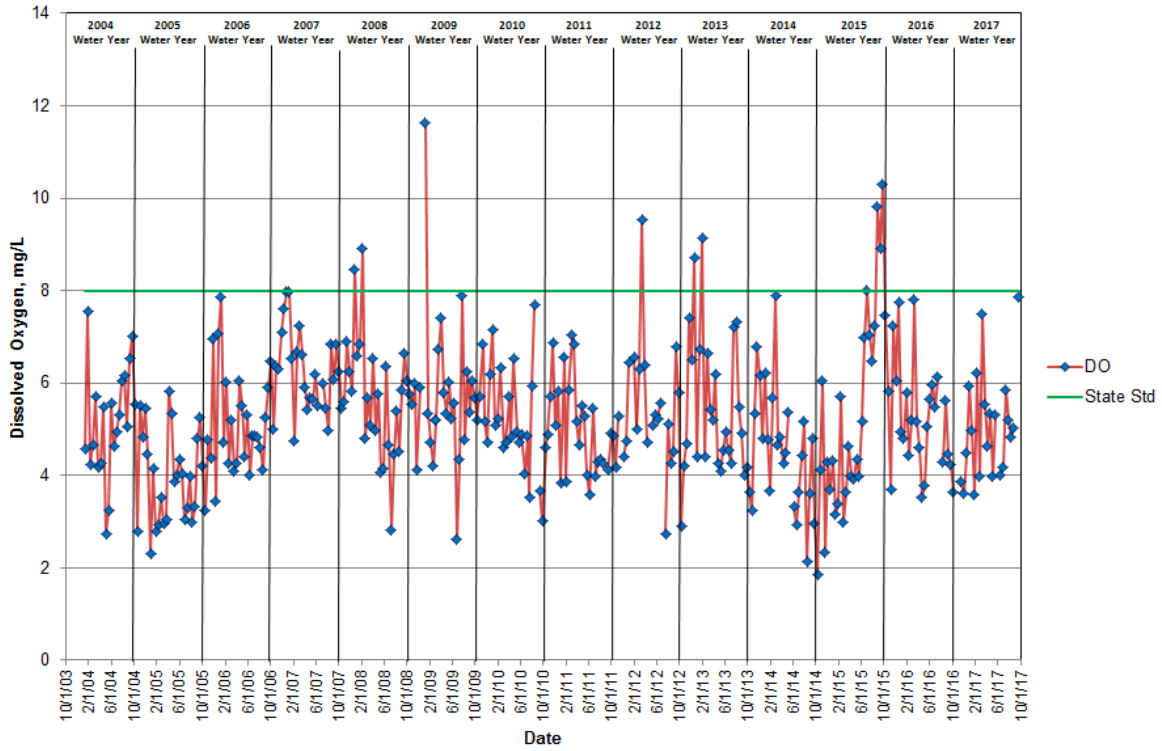
Alice Bay Pump Station - Site 33 Dissolved Oxygen



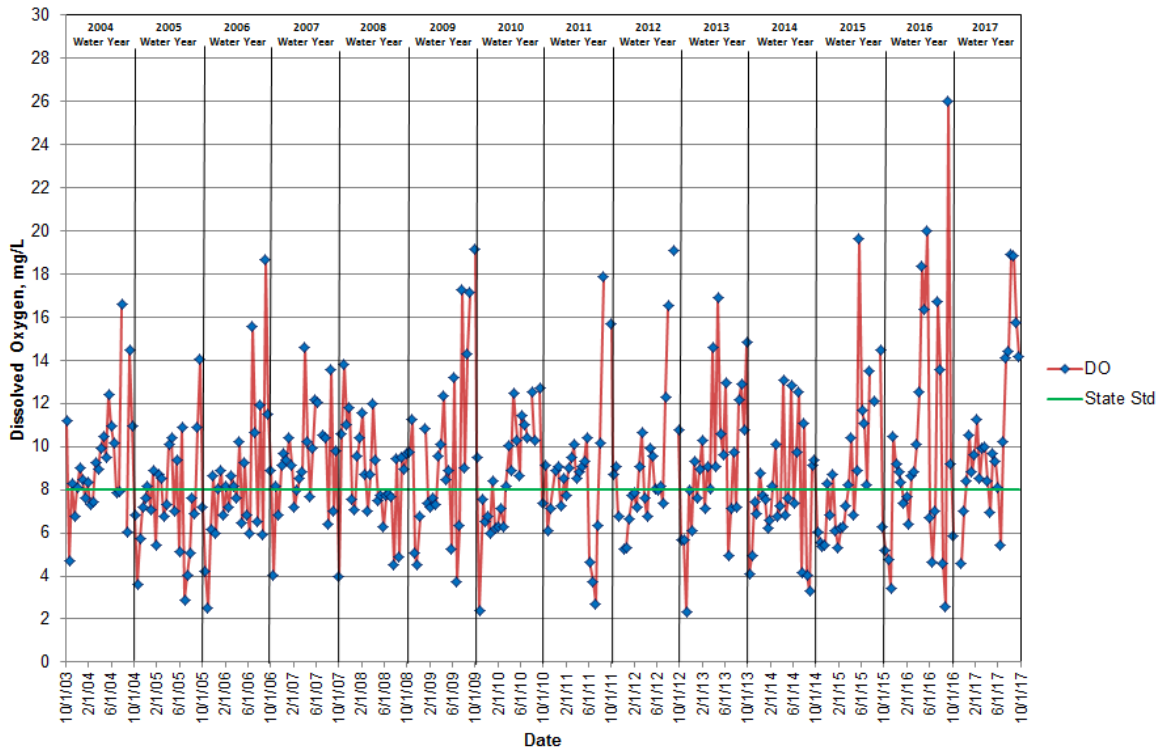
No Name Slough at Bayview-Edison Road - Site 34 Dissolved Oxygen



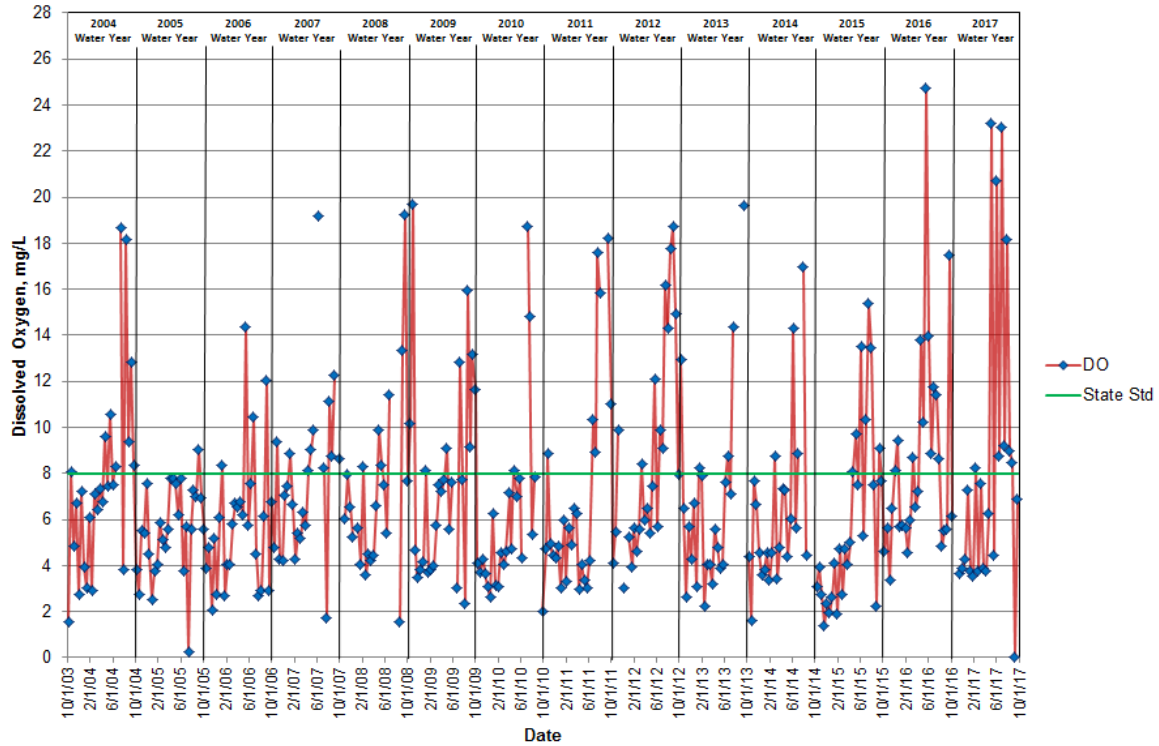
Joe Leary Slough at D'Arcy Road - Site 35 Dissolved Oxygen



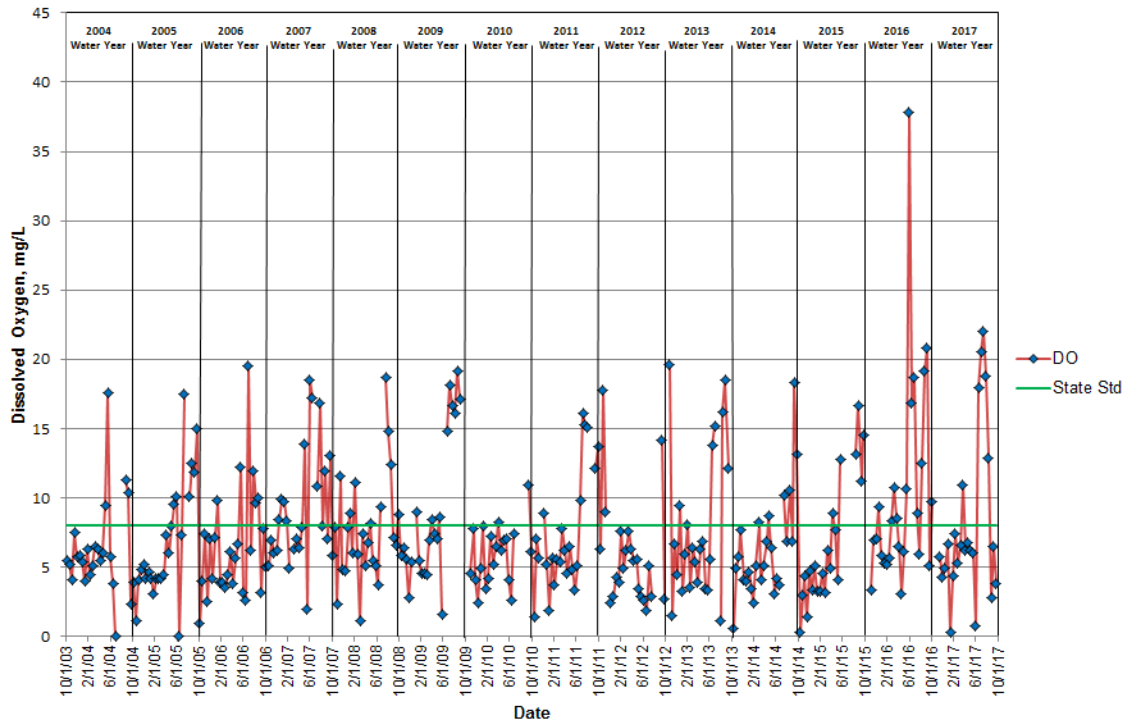
Edison Slough at Edison School - Site 36 Dissolved Oxygen



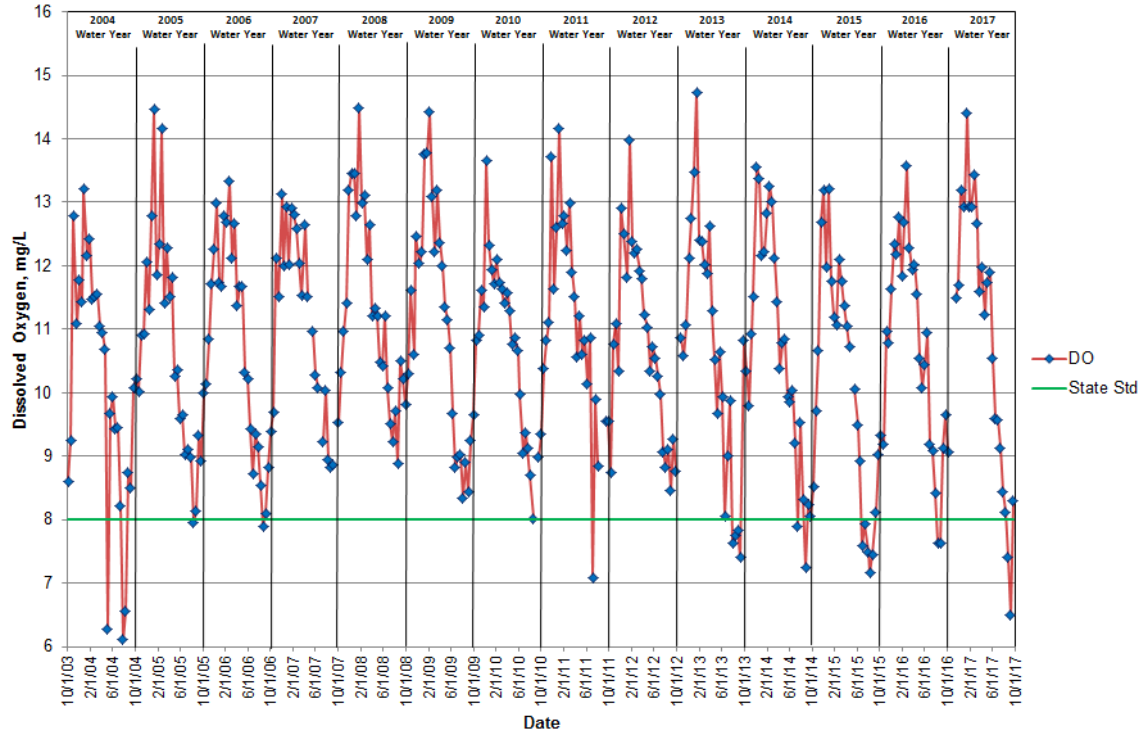
Edison Pump Station - Site 37 Dissolved Oxygen



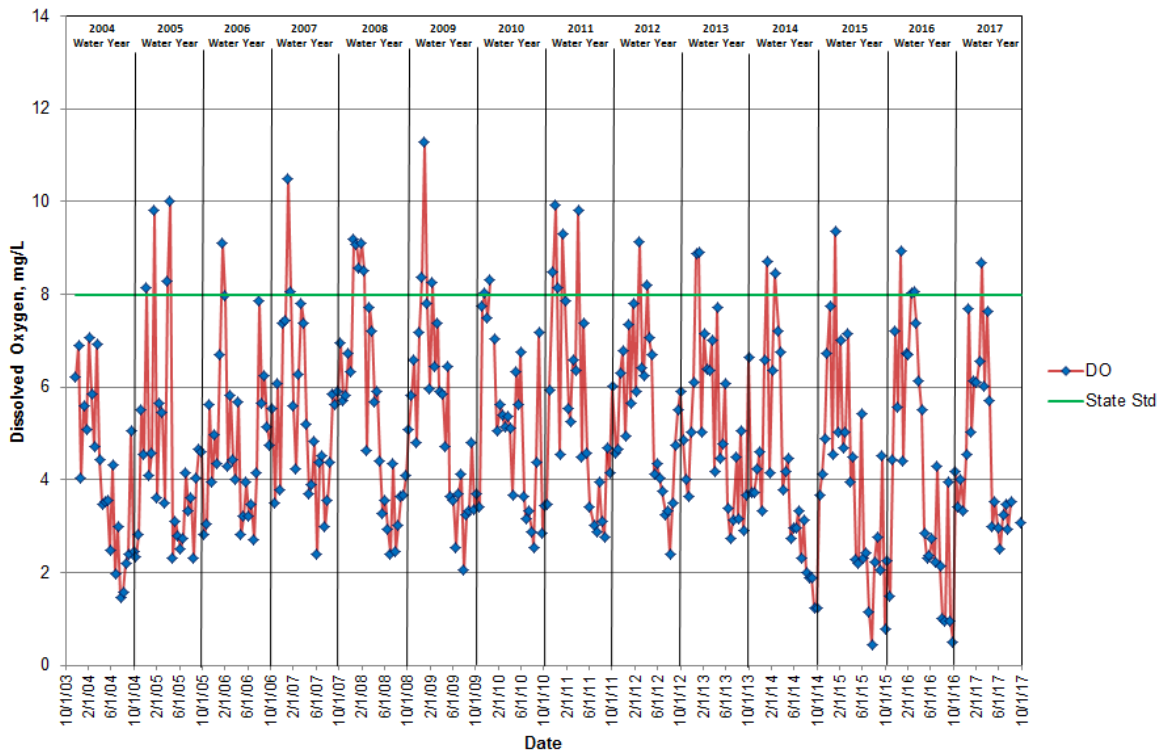
North Edison Pump Station - Site 38 Dissolved Oxygen



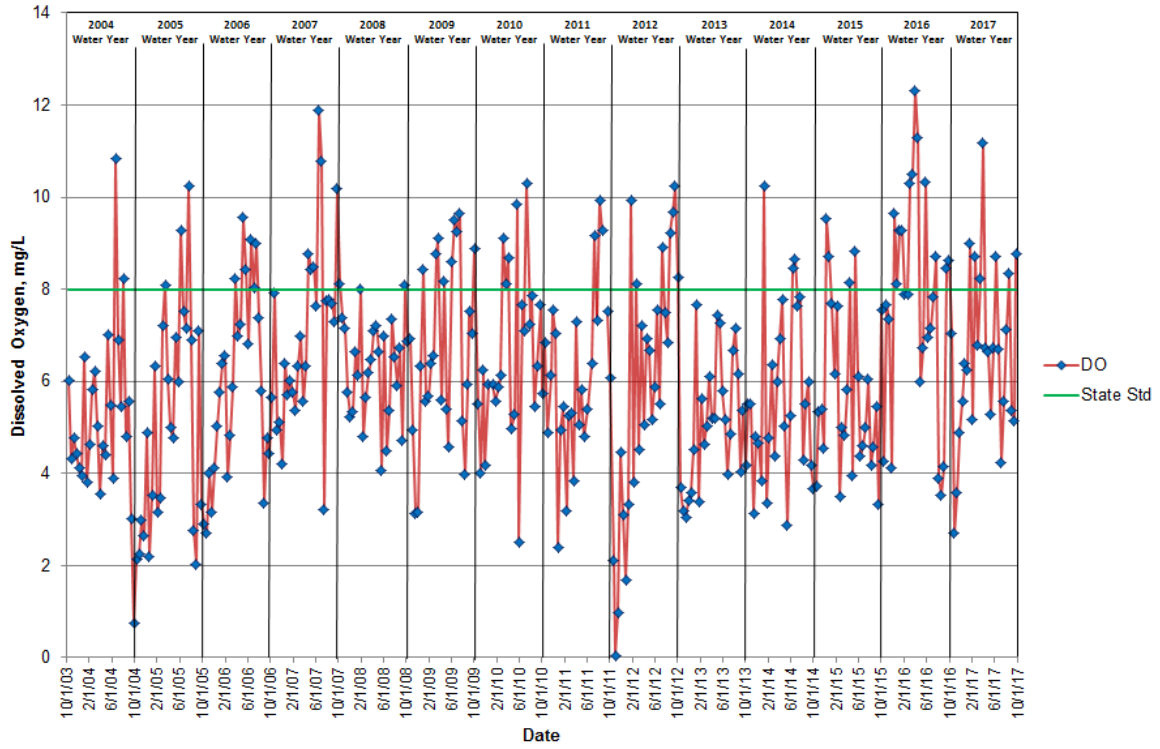
Colony Creek at Colony Road - Site 39 Dissolved Oxygen



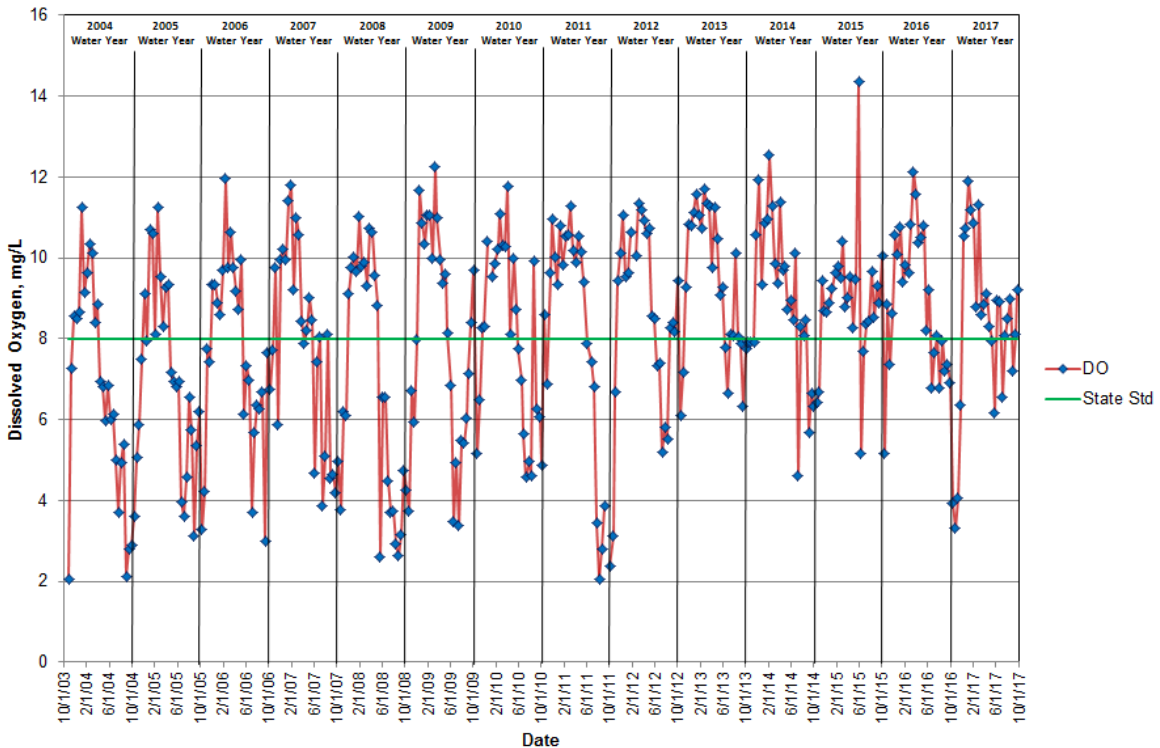
Big Indian Slough at Highway 20 Truck Scales - Site 40 Dissolved Oxygen



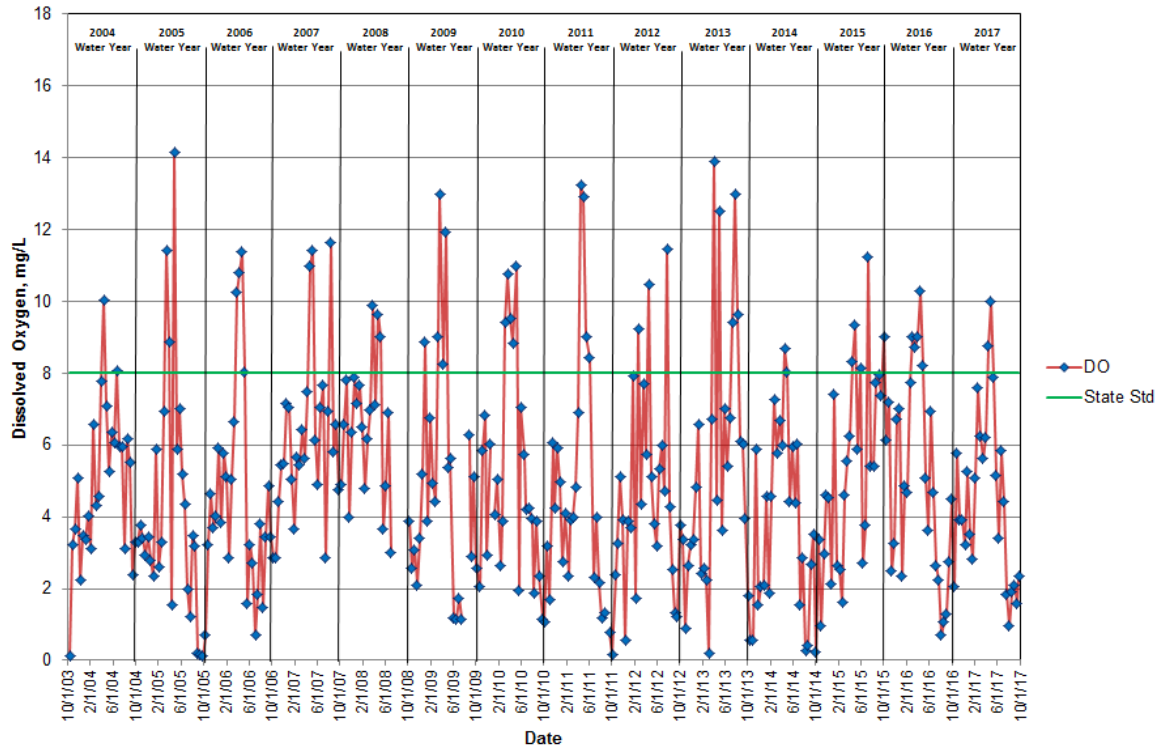
Maddox Creek/Big Ditch at Milltown Road - Site 41 Dissolved Oxygen



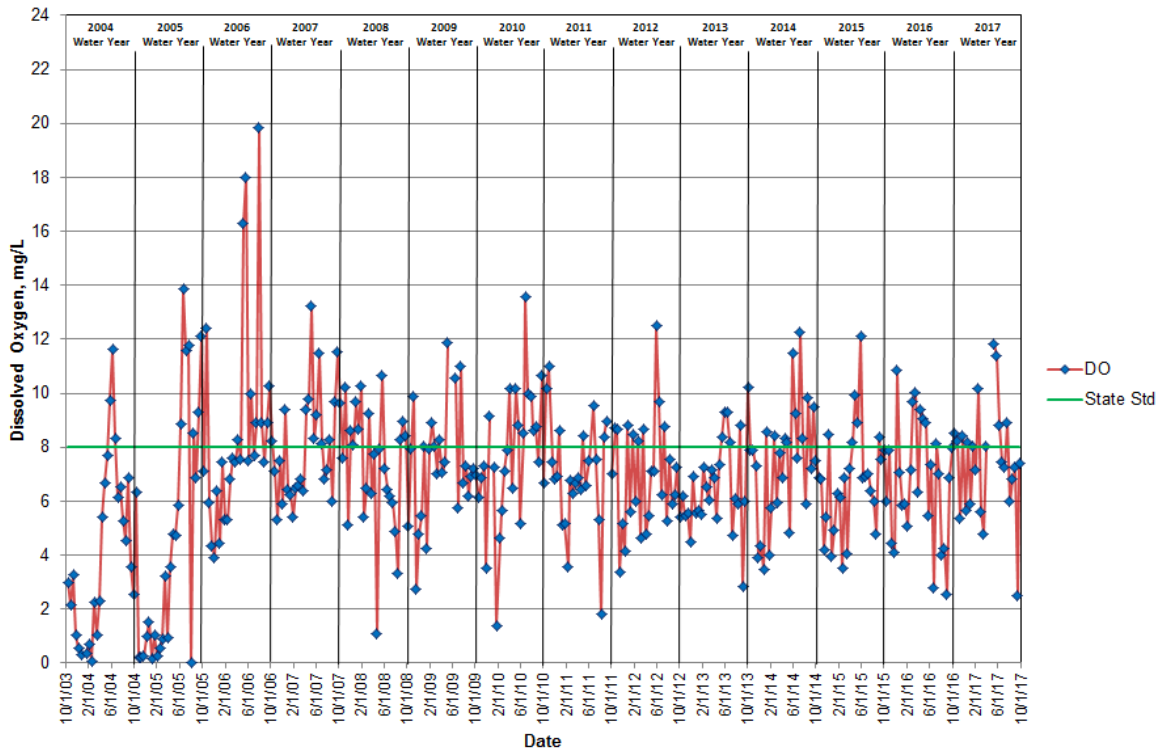
Carpenter Creek/Hill Ditch at Cedardale Road - Site 42 Dissolved Oxygen



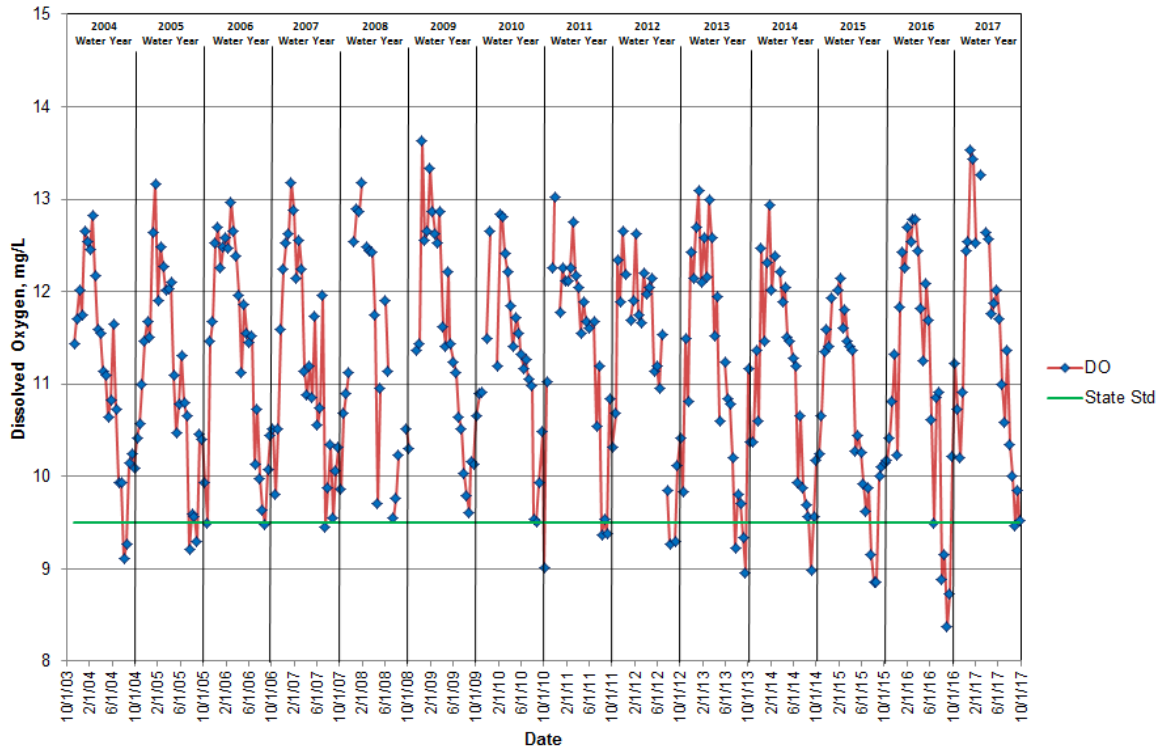
Wiley Slough at Wylie Road - Site 43 Dissolved Oxygen



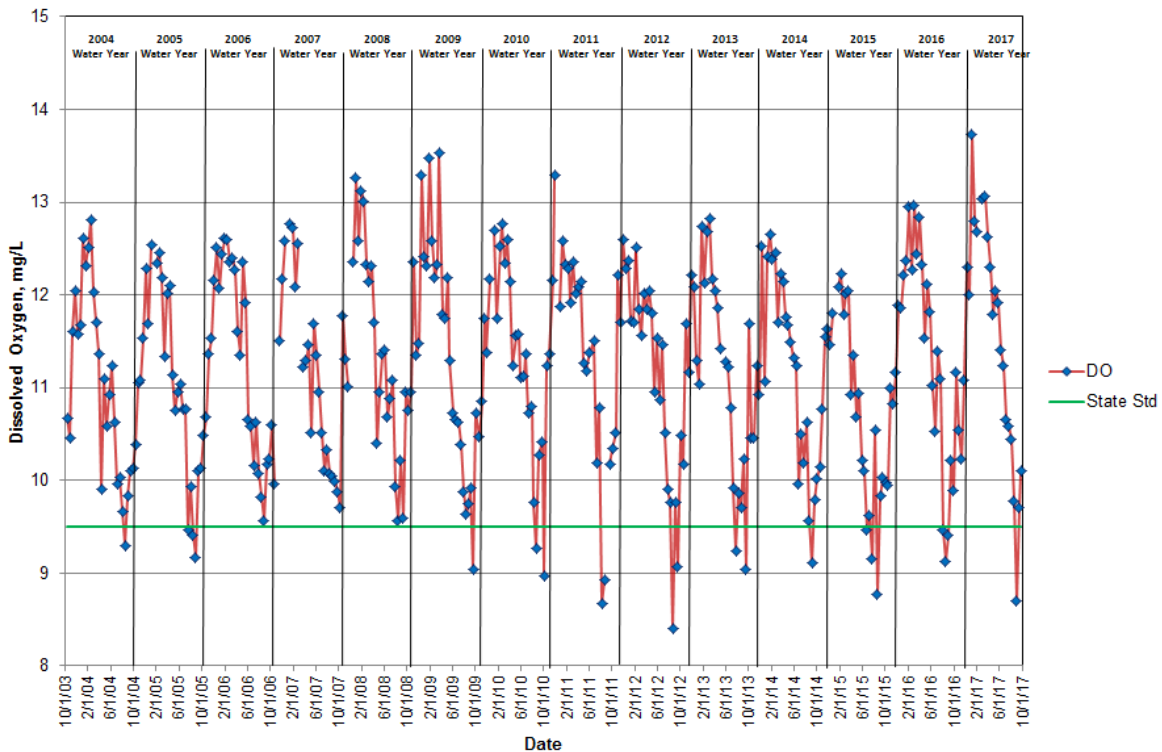
Sullivan Slough at LaConner-Whitney Road - Site 44 Dissolved Oxygen



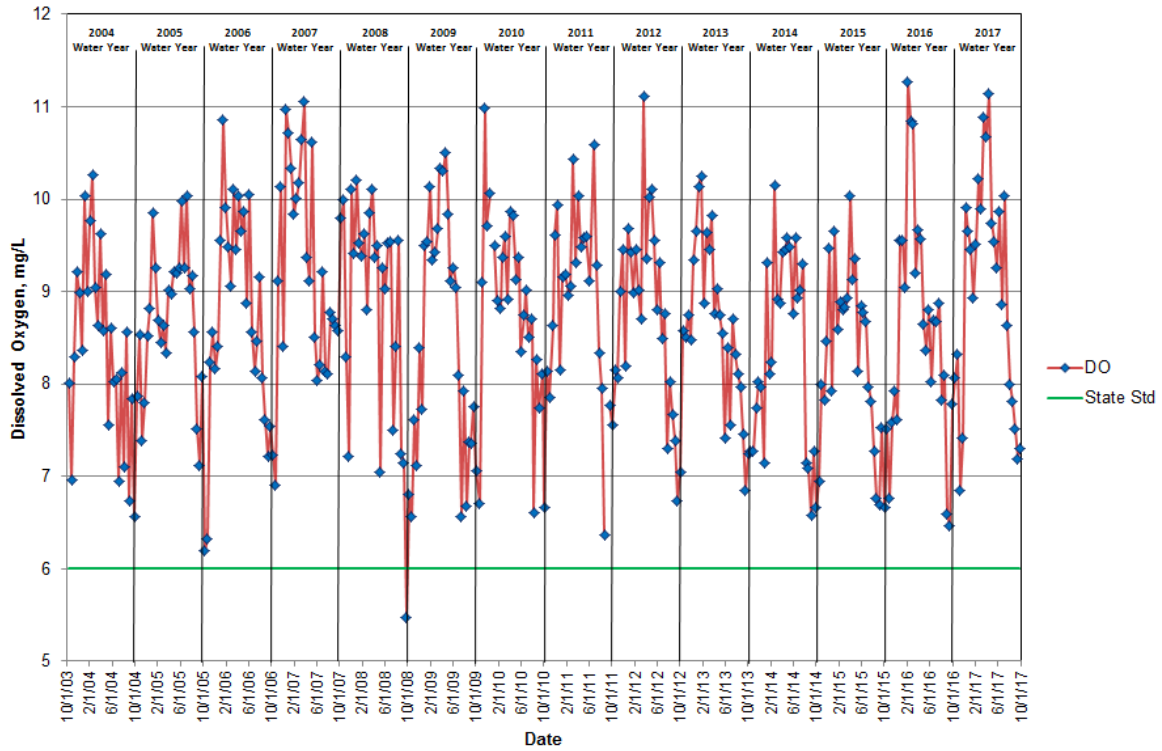
North Fork Skagit River near Moore Road - Site 45 Dissolved Oxygen



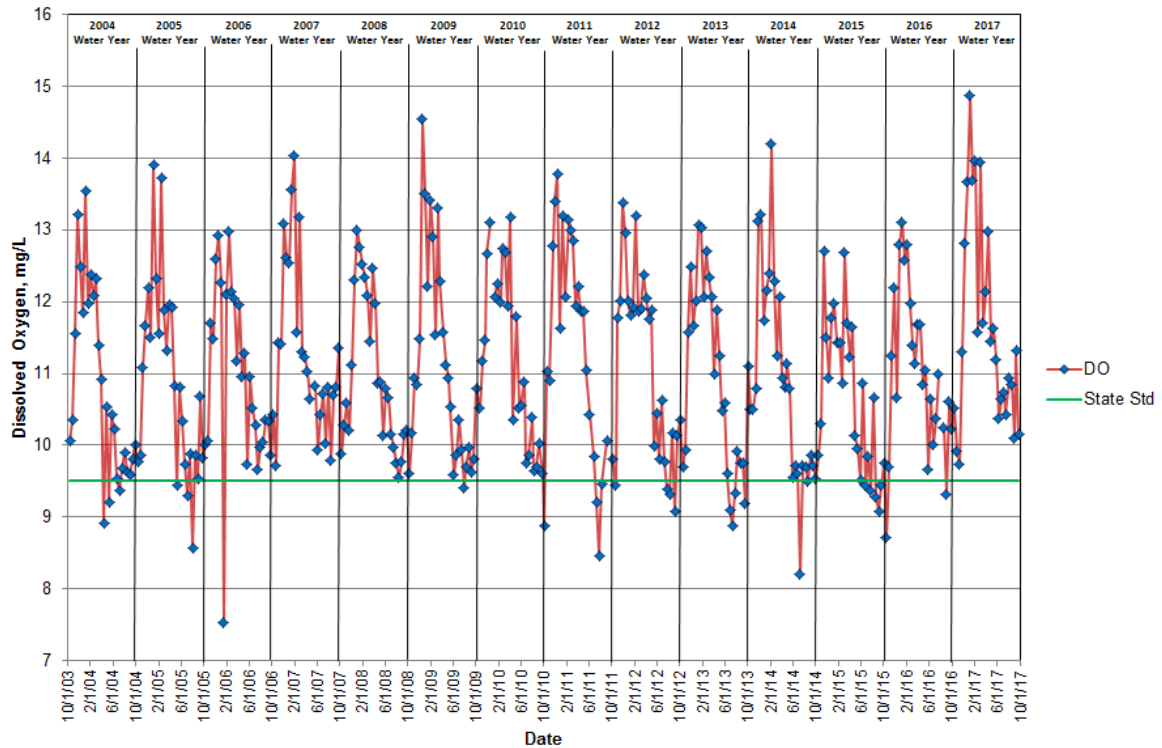
South Fork Skagit River at Conway Boat Ramp - Site 46 Dissolved Oxygen



Swinomish Channel at County Boat Ramp - Site 47 Dissolved Oxygen



Fisher Creek at Franklin Road - Site 48 Dissolved Oxygen



Fecal Coliform

Fecal coliform is a measurement of the amount of enteric bacteria from warm-blooded animals present in a watercourse. Although fecal coliform measurements do not directly quantify disease-causing organisms, they serve as an indicator of the possible presence of such bacteria, viruses, and protozoa.

Samples for fecal coliform measurements are taken at each site during each visit and submitted to the Skagit County Health Department Water Lab (2003-2008) or Edge Analytical (2009-2017) for analysis by the Most Probable Number method.

Fecal coliform measurements for the 2017 water year, in “most probable number” (mpn) of bacterial colonies per 100 ml, are summarized in Table 7. State standards for fecal coliform are based on the geometric mean of the samples as well as the percent of the samples that exceed given criteria. For most of the watercourses in the Skagit County Monitoring Program (sites 3-20, 28-29, 31-46, 48), fecal coliform is not to exceed a geometric mean of 100 mpn, with no more than 10% of the measurements exceeding 200 mpn. For the upriver sites (sites 21-25, 30), the standard is a geometric mean of 50 mpn, with no more than 10% of the measurements exceeding 100 mpn. For the marine site (site 47), a more stringent standard of 14 mpn with no more than 10% exceeding 41 mpn is enforced to protect shellfish beds.

Table 8 gives the geometric mean fecal coliform at each site for the last five years of the study. For the 2017 water year, 13 sites met the standard based on ambient sampling for the entire water year, which is the same number as 2016 and more than the seven sites in 2015. Most sites that did not meet the standard did so due to having more than 10% of samples with fecal coliform counts in excess of 200 mpn. Storm sampling in the Samish Basin also continues to show excessive fecal coliform during rain events.

The 2008 water year was marked by several incidents of high fecal coliform counts at County monitoring stations in the Samish Bay Watershed. Each incident was triggered by moderate to heavy rainfall. These high counts resulted in at least four closures of the Samish Bay shellfish beds to commercial harvest. The most serious incident resulted in a mandatory closure of Samish Bay in response to a sample count of 17,000 mpn units/100 mL from the Samish River at Thomas Road on April 29, 2008.

The 2009, 2010, and 2011 water years saw continued high fecal coliform counts in the Samish River and elsewhere in the Samish Bay Watershed, and many additional closures of shellfish beds. County and Storm Team volunteer monitoring continued to document the relationship between high rainfall events and excess fecal coliform. This ongoing situation prompted the Washington State Department of Ecology to initiate the Clean Samish Initiative in 2009, a partnership of over 20 Federal, State, and County governmental organizations as well as shellfish industry and non-profit groups. This effort is aimed at making immediate improvements in the Samish Bay Watershed fecal coliform situation. Although state standard exceedances and shellfish bed closures continued during 2017, average fecal coliform counts and loading of bacteria to Samish Bay have declined (see Trends discussion below).

The sources of fecal coliform organisms reaching the watercourses of Skagit County could include runoff from failing septic tanks, livestock operations, wildlife, recreationists, and pets. Methods to identify bacterial sources through DNA testing or other innovative strategies are under development but are expensive and not necessarily ready for widespread application. Skagit County did complete a Microbial Source Tracking (DNA) testing project in 2011. Results from that study indicated high frequency of ruminant and avian sources, and less frequent human input. Skagit County received grant funding from EPA to support a program to identify sources of fecal coliform pollution in the Samish Basin through a Pollution Identification and Correction program similar to Kitsap County's program. This program is now in full operation. A full report of Clean Samish Initiative activities will be published separately.

Graphs on the pages following Table 8 illustrate fecal coliform levels for water years 2004-2017 at each of the sample sites. The scale on each graph differs in order to fully illustrate the variability at each site.

Table 7. 2017 Fecal Coliform Results
Summary of Fecal Coliform Readings in Skagit County Monitoring Program
2017 Water Year

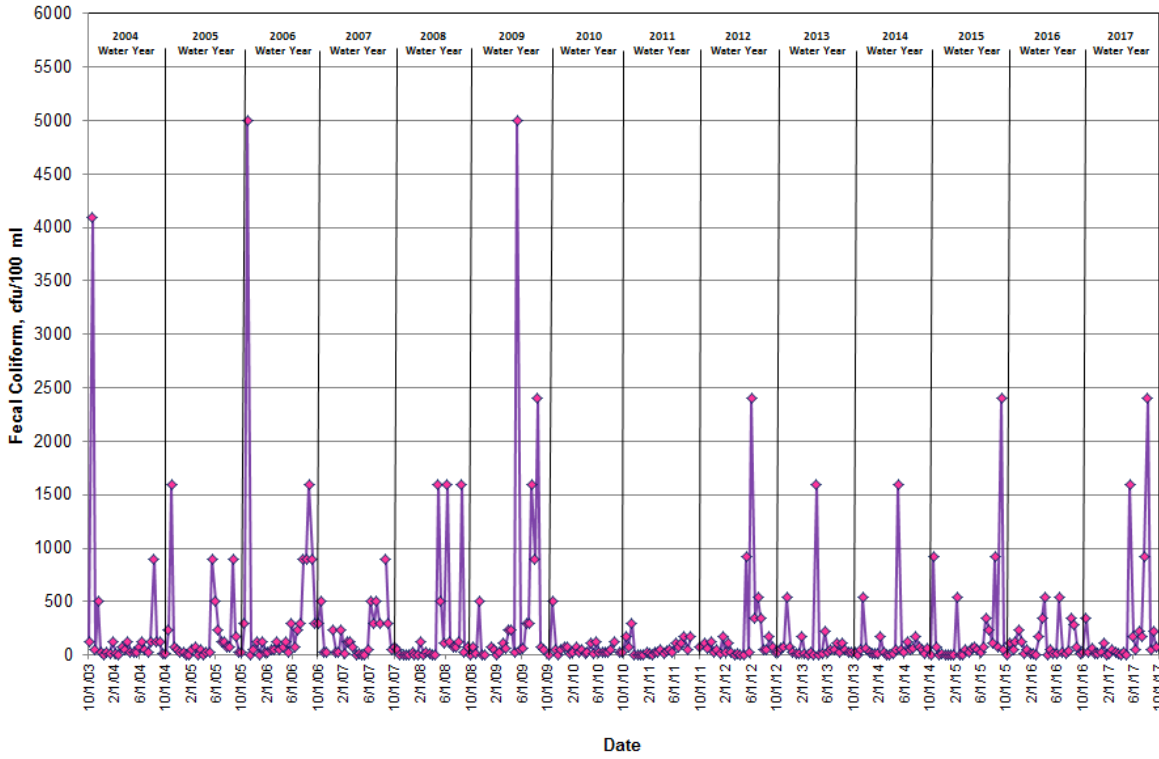
Site Number	Watercourse	Location	Number	Geometric mean (mpn) ¹	% > 100 or 200 ¹
3	Thomas Creek	Old Hwy 99 N	26	63	23
4	Thomas Creek	F&S Grade Rd	26	107	19
6	Friday Creek	Prairie Rd	26	29	8
8	Swede Creek	Grip Rd	26	40	12
11	Samish River	State Route 9	26	14	4
12	Nookachamps Creek	Swan Rd	22	79	27
13	E.F. Nookachamps Creek	State Route 9	26	41	15
14	College Way Creek	College Way	26	172	46
15	Nookachamps Creek	Knapp Rd	26	62	23
16	E.F. Nookachamps Creek	Beaver Lake Rd	25	28	8
17	Nookachamps Creek	Big Lake Outlet	26	12	4
18	Lake Creek	State Route 9	26	24	8
19	Hansen Creek	Hoehn Rd	22	53	23
20	Hansen Creek	Northern State	25	50	16
21	Coal Creek	Hoehn Rd	21	53	33
22	Coal Creek	Hwy 20	25	18	20
23	Wiseman Creek	Minkler Rd	23	10	9
24	Mannser Creek	Lyman Hamilton Hwy	26	15	15
25	Red Cabin Creek	Hamilton Cemetery Rd	22	12	18
28	Brickyard Creek	Hwy 20	18	42	17
29	Skagit River	River Bend Rd	26	9	0
30	Skagit River	Cape Horn Rd	26	3	0
31	Drainage Dist 20 floodgate	Francis Rd	5	21	0
32	Samish River	Thomas Rd	26	48	12
33	Alice Bay Pump Station	Samish Island Rd	24	30	13
34	No Name Slough	Bayview-Edison Rd	24	65	21
35	Joe Leary Slough	D'Arcy Rd	24	91	33
36	Edison Slough at school	W. Bow Hill Rd	25	97	36
37	Edison Pump Station	Farm to Market Rd	26	317	65
38	North Edison Pump Station	North Edison Rd	25	148	50
39	Colony Creek	Colony Rd	26	57	35
40	Big Indian Slough	Bayview-Edison Rd	23	43	9
41	Maddox Slough/Big Ditch	Milltown Rd	26	87	31
42	Hill Ditch	Cedardale Rd	26	42	12
43	Wiley Slough	Wylie Rd	26	68	12
44	Sullivan Slough	La Conner-Bayview Rd	24	127	29
45	Skagit River – North Fork	Moore Rd	24	7	0
46	Skagit River – South Fork	Fir Island Rd	25	13	0
47	Swinomish Channel	County Boat Launch	26	6	0
48	Fisher Creek	Franklin Rd	26	69	12

¹ State water quality standards for fecal coliform requires water bodies to have a geometric mean of less than 50 (sites 21-25,30) or 100 (sites 3-20,28-29, 31-46, 48) colony forming units (cfu) or Most Probable Number (mpn) per 100 ml and less than 10% of the samples >100 (sites 21-25,30) or >200 cfu (sites 3-20,28-29, 31-46, 48). Marine locations (site 47) are required to be <14 cfu with no more than 10% >41 cfu.

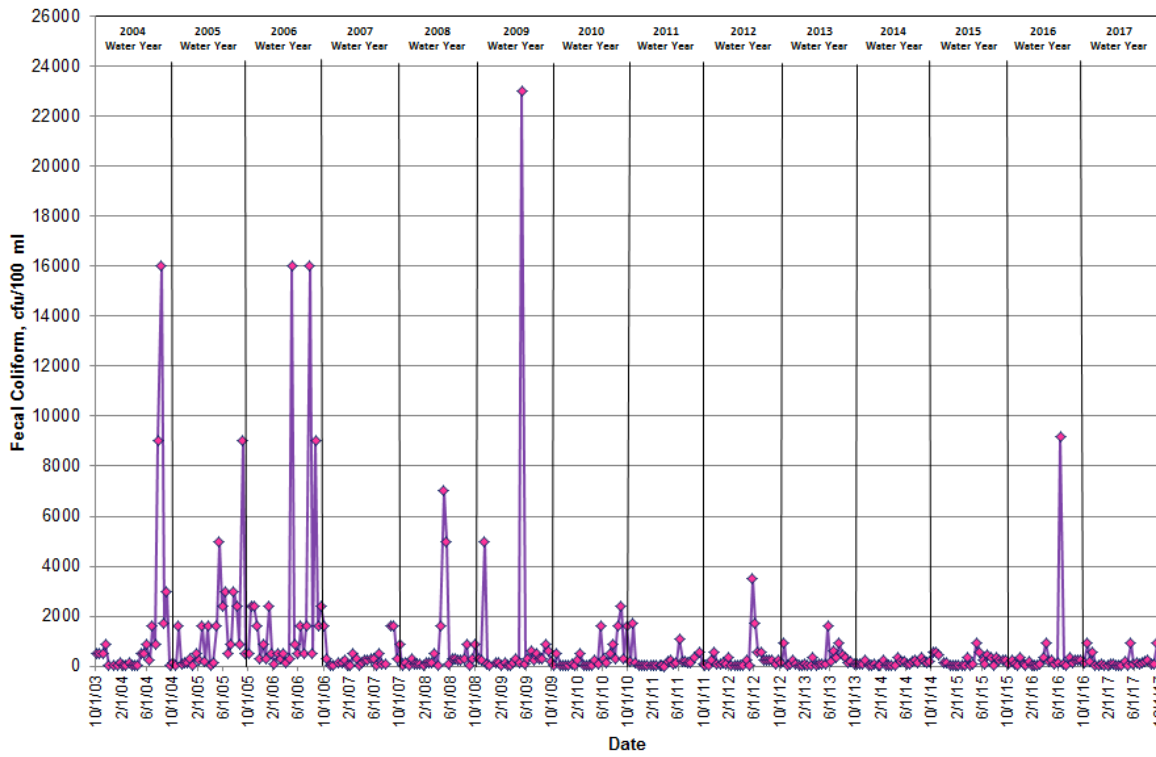
Table 8. Five-Year Fecal Coliform Results Summary
Geometric mean fecal coliform levels (mpn/100 mL) for the last five years of the
Skagit County Monitoring Program

Site Number	Watercourse	Location	2013	2014	2015	2016	2017
3	Thomas Creek	Old Hwy 99 N	41	37	46	49	63
4	Thomas Creek	F&S Grade Rd	134	84	133	138	107
6	Friday Creek	Prairie Rd	31	28	36	34	29
8	Swede Creek	Grip Rd	51	34	63	59	40
11	Samish River	State Route 9	14	10	13	26	14
12	Nookachamps Creek	Swan Rd	68	54	107	65	79
13	E.F. Nookachamps Creek	State Route 9	55	48	64	59	41
14	College Way Creek	College Way	131	101	148	106	172
15	Nookachamps Creek	Knapp Rd	58	49	93	54	62
16	E.F. Nookachamps Creek	Beaver Lake Rd	32	19	25	44	28
17	Nookachamps Creek	Big Lake Outlet	15	9	23	16	12
18	Lake Creek	State Route 9	48	41	41	50	24
19	Hansen Creek	Hoehn Rd	67	186	71	114	53
20	Hansen Creek	Northern State	46	34	45	35	50
21	Coal Creek	Hoehn Rd	59	66	91	84	53
22	Coal Creek	Hwy 20	13	15	19	22	18
23	Wiseman Creek	Minkler Rd	11	13	7	12	10
24	Mannser Creek	Lyman Hamilton Hwy	12	11	17	12	15
25	Red Cabin Creek	Hamilton Cemetery Rd	7	10	12	6	12
28	Brickyard Creek	Hwy 20	41	58	34	33	42
29	Skagit River	River Bend Rd	7	5	10	14	9
30	Skagit River	Cape Horn Rd	4	5	5	6	3
31	Drainage District 20 floodgate	Francis Rd	17	11	83	15	21
32	Samish River	Thomas Rd	42	47	50	54	48
33	Alice Bay Pump Station	Samish Island Rd	70	63	27	54	30
34	No Name Slough	Bayview-Edison Rd	131	64	171	71	65
35	Joe Leary Slough	D'Arcy Rd	125	120	63	98	91
36	Edison Slough at school	W. Bow Hill Rd	66	102	105	120	97
37	Edison Pump Station	Farm to Market Rd	267	197	166	386	317
38	North Edison Pump Station	North Edison Rd	148	285	222	264	148
39	Colony Creek	Colony Rd	54	81	91	76	57
40	Big Indian Slough	Bayview-Edison Rd	43	32	119	29	43
41	Maddox Slough/Big Ditch	Milltown Rd	104	95	123	61	87
42	Hill Ditch	Cedardale Rd	81	67	104	43	42
43	Wiley Slough	Wylie Rd	118	45	109	106	68
44	Sullivan Slough	La Conner-Bayview Rd	176	75	179	157	127
45	Skagit River – North Fork	Moore Rd	7	6	7	6	7
46	Skagit River – South Fork	Fir Island Rd	7	7	12	9	13
47	Swinomish Channel	County Boat Launch	5	5	5	6	6
48	Fisher Creek	Franklin Rd	138	50	96	92	69

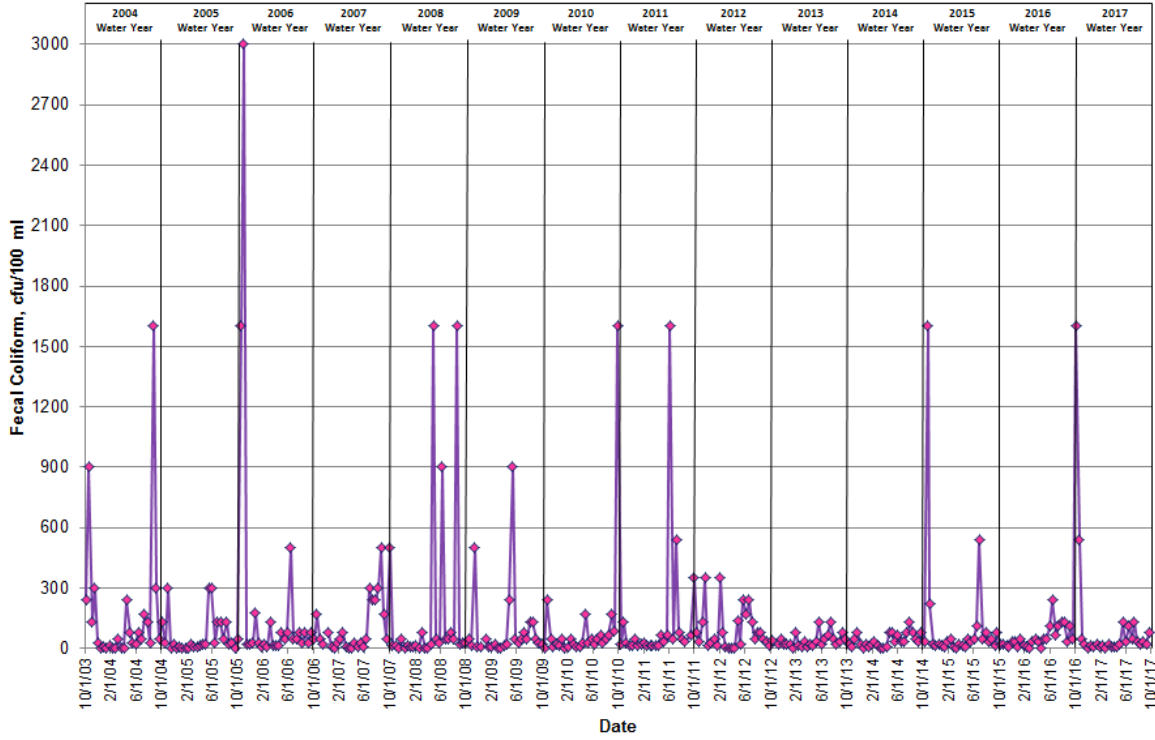
Thomas Creek at Highway 99 - Site 3 Fecal Coliform



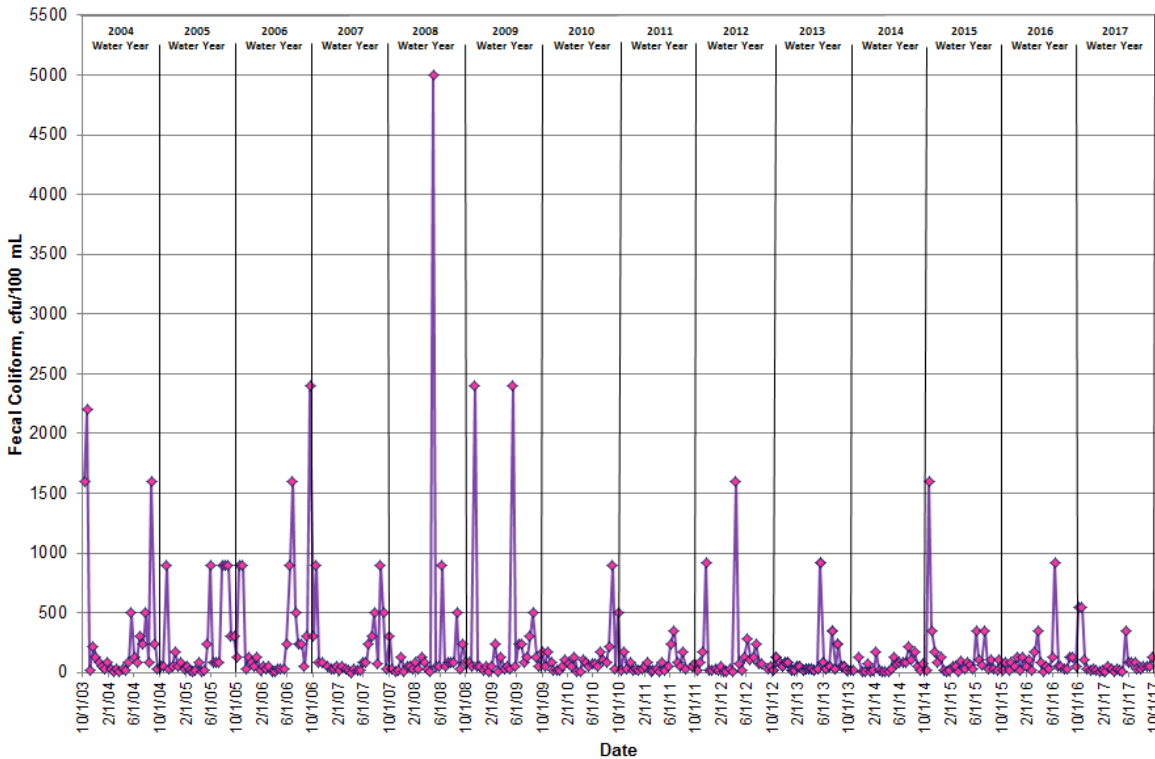
Thomas Creek at F&S Grade Road - Site 4 Fecal Coliform



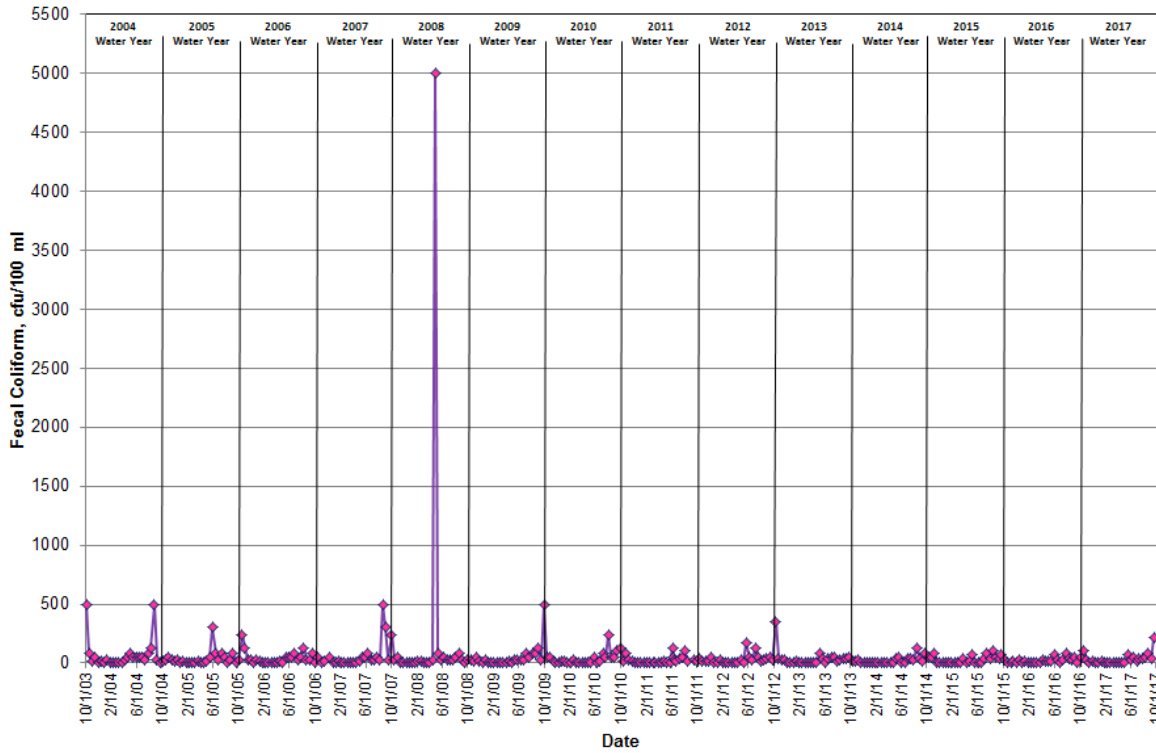
Friday Creek at Prairie Road - Site 6 Fecal Coliform



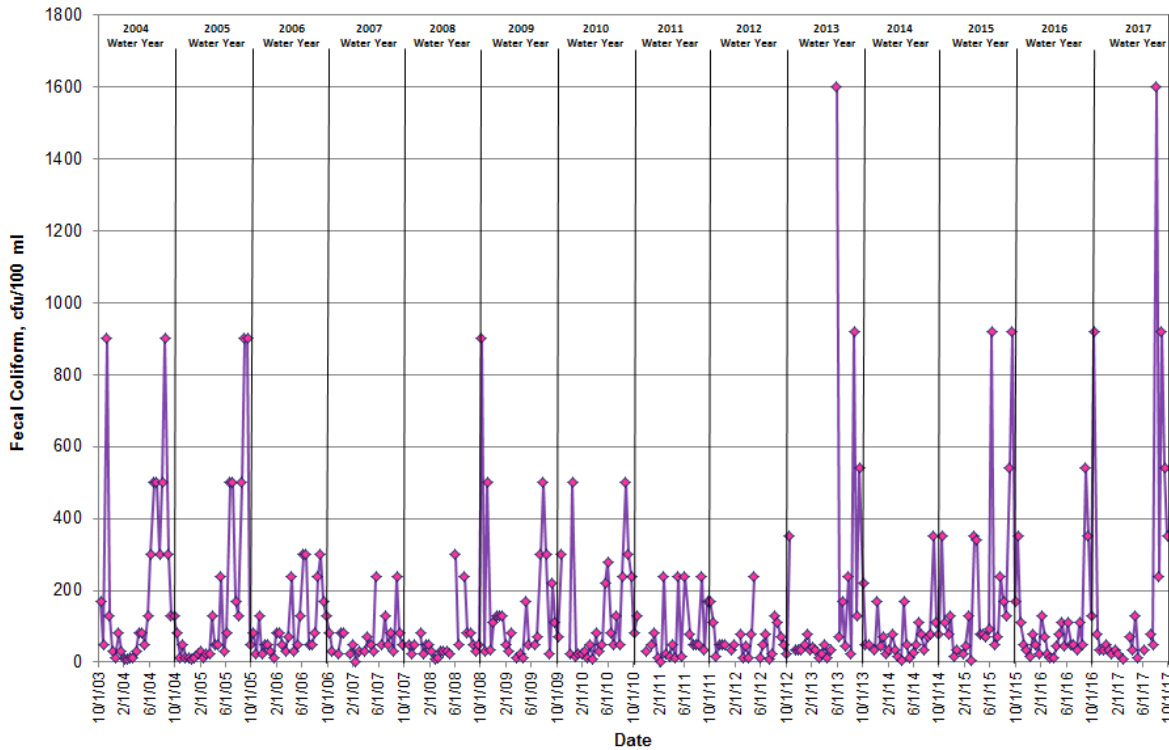
Swede Creek at Grip Road - Site 8 Fecal Coliform



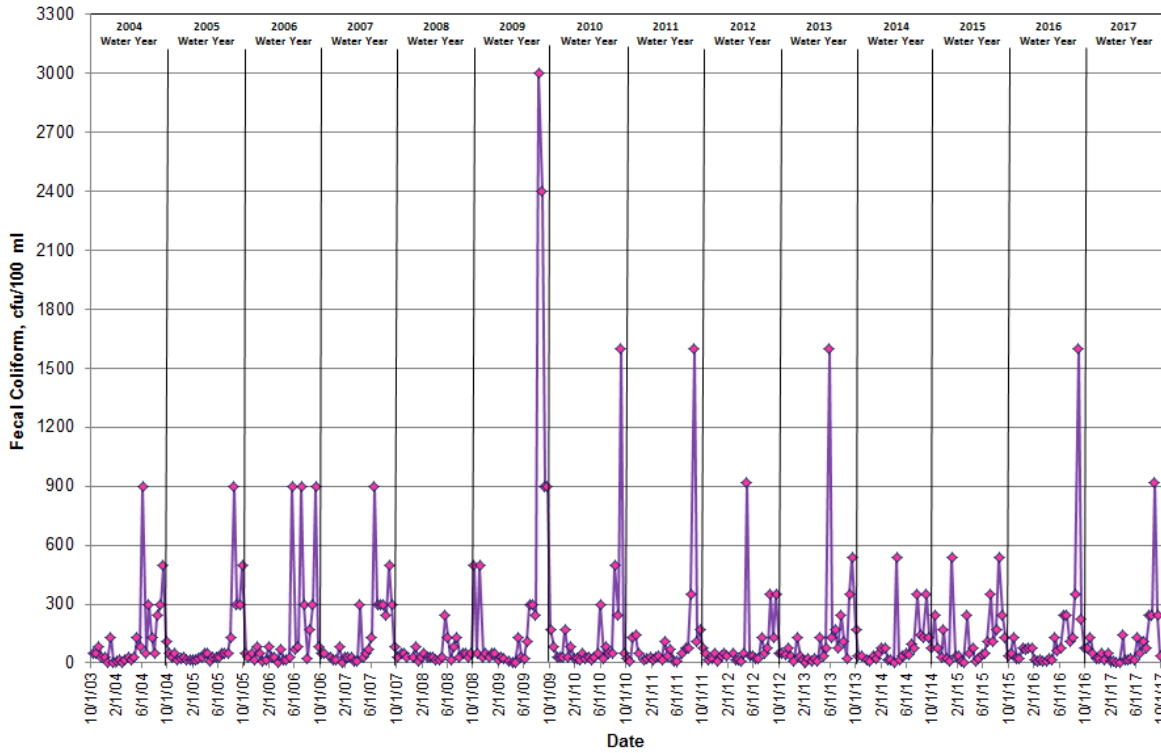
Samish River at Highway 9 - Site 11 Fecal Coliform



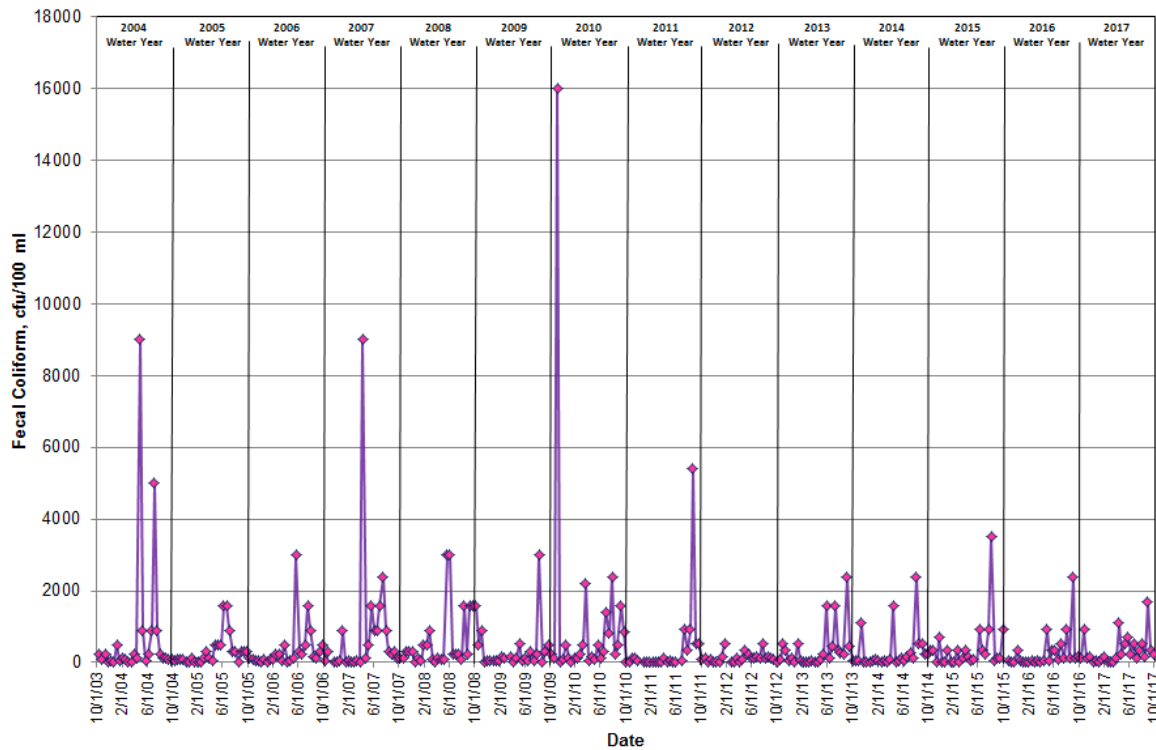
Nookachamps Creek at Swan Road - Site 12 Fecal Coliform



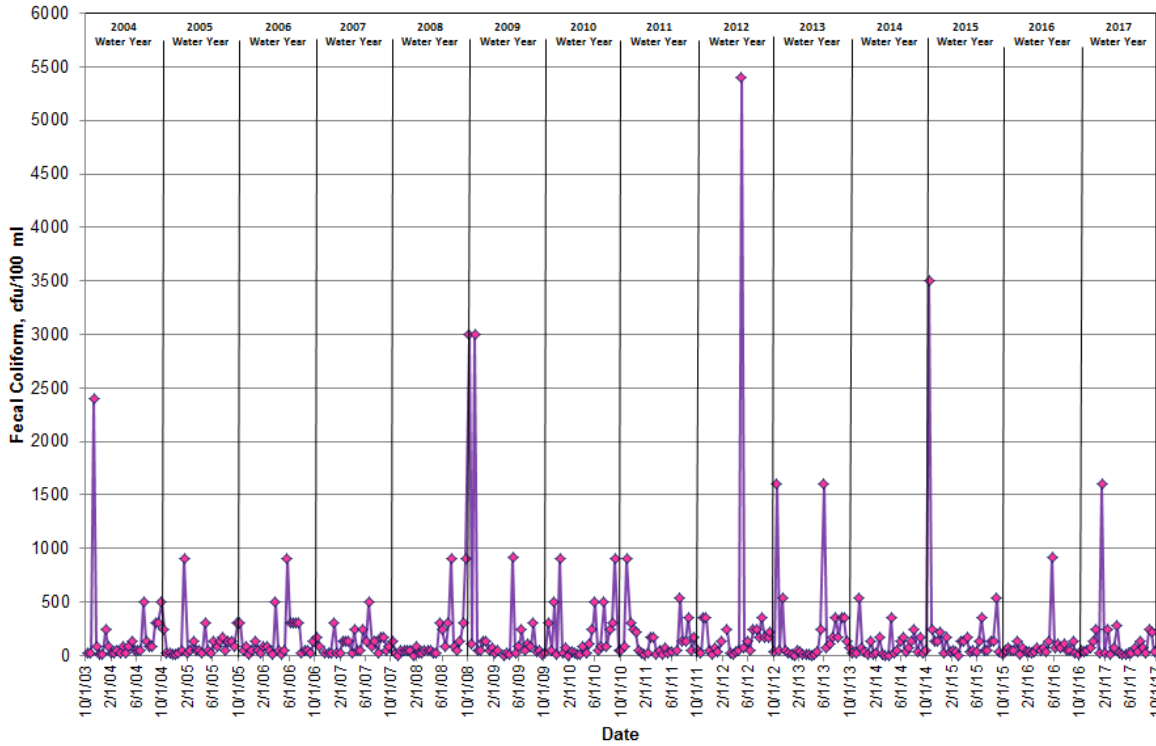
East Fork Nookachamps Creek at Highway 9 - Site 13 Fecal Coliform



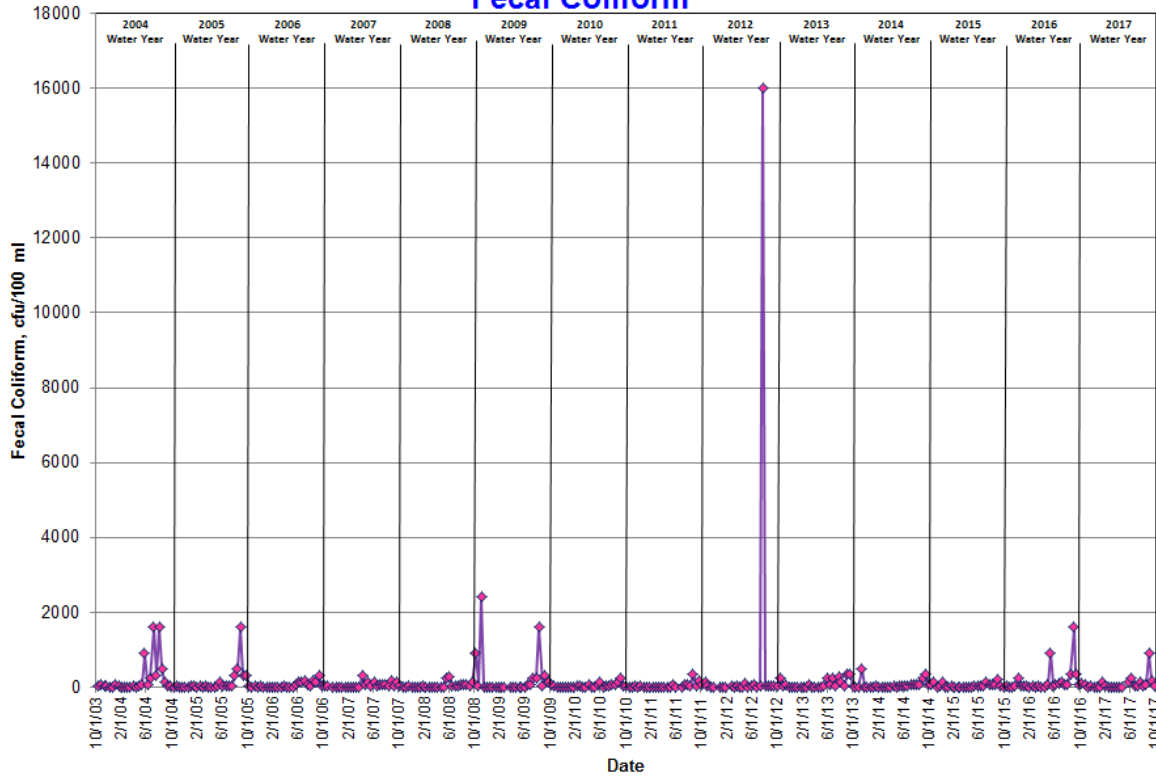
College Way Creek at College Way - Site 14 Fecal Coliform



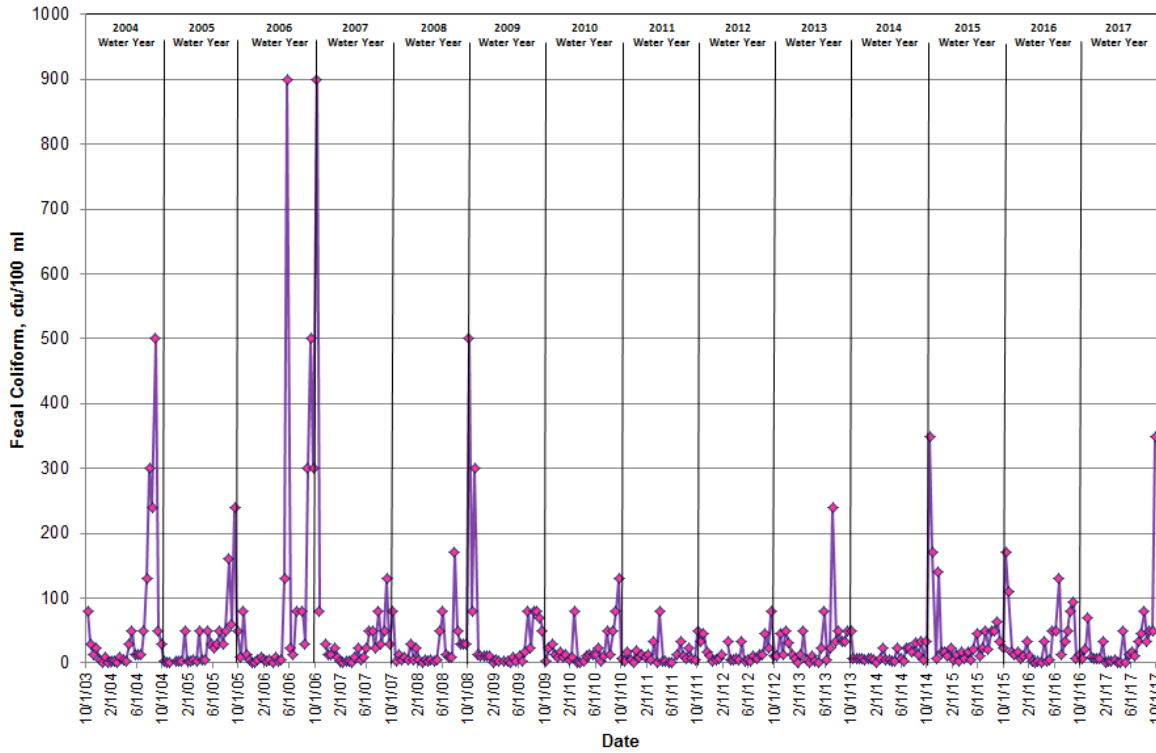
Nookachamps Creek at Knapp Road - Site 15 Fecal Coliform



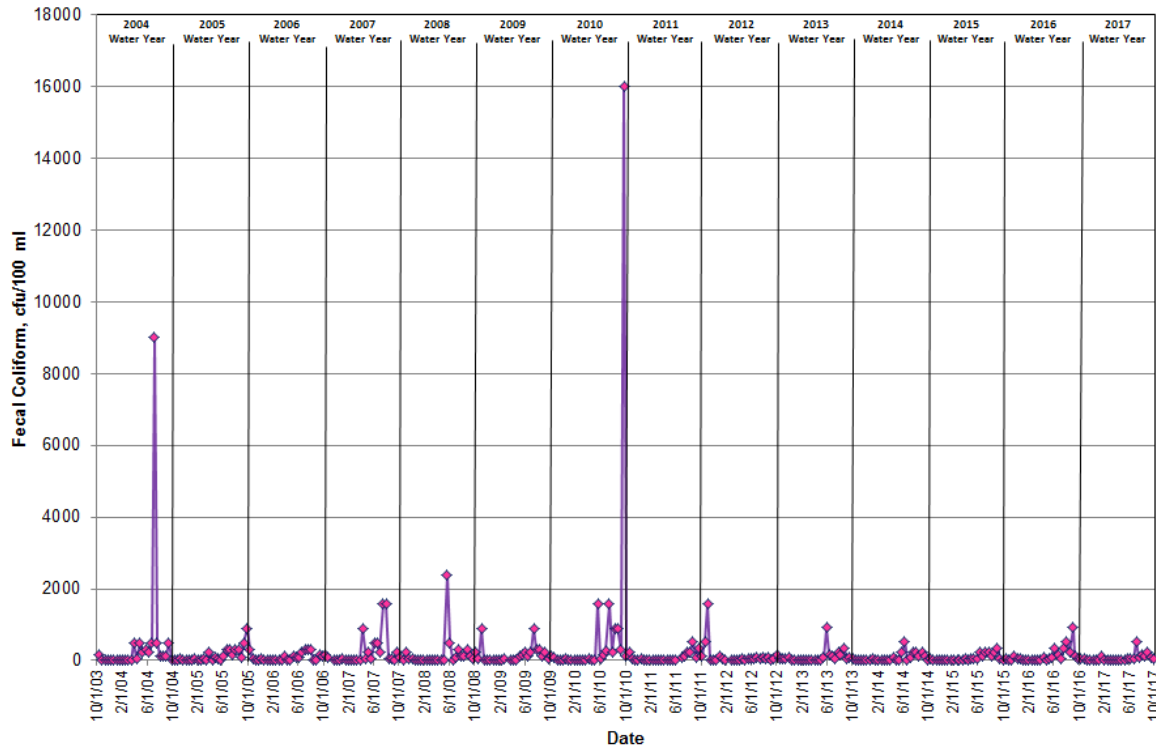
East Fork Nookachamps Creek at Beaver Lake Road - Site 16 Fecal Coliform



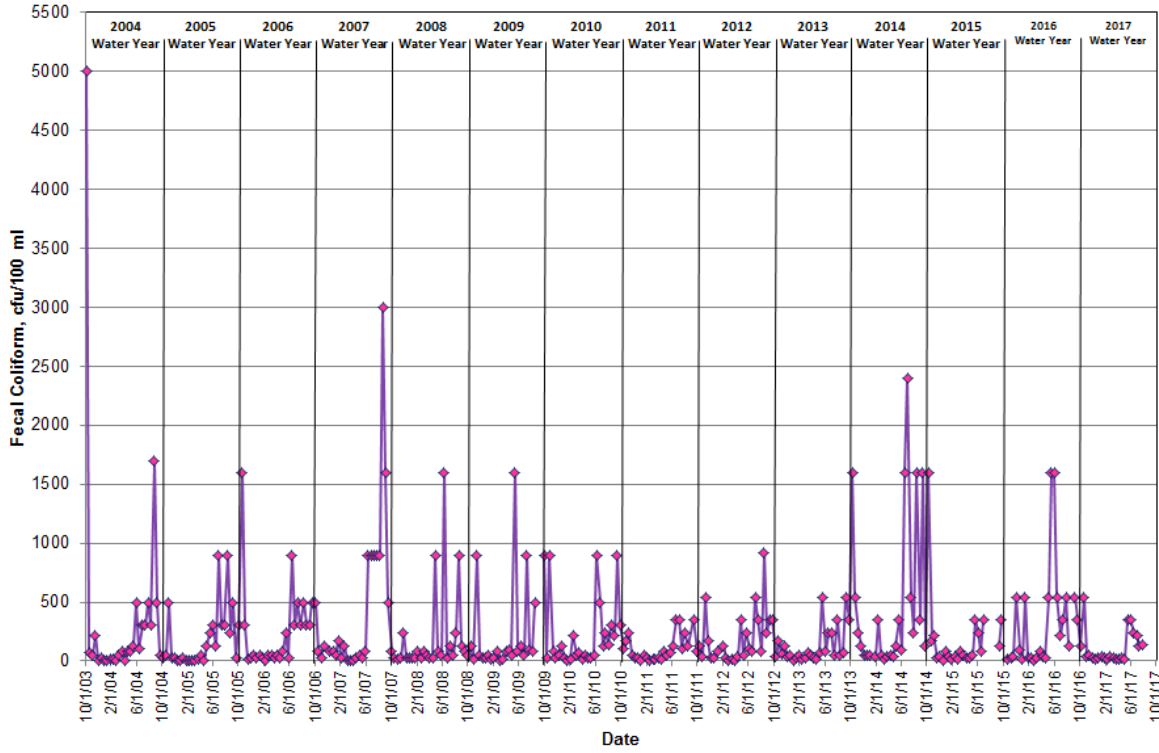
Nookachamps Creek at Big Lake Outlet - Site 17 Fecal Coliform



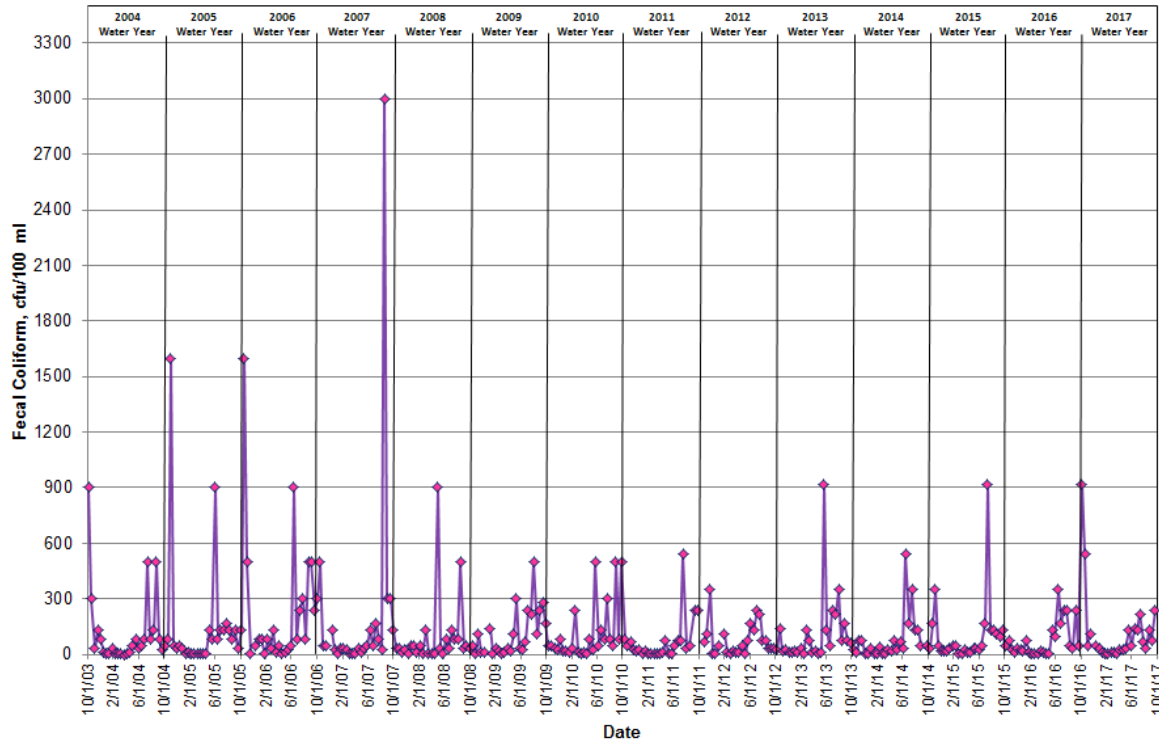
Lake Creek at Highway 9 - Site 18 Fecal Coliform



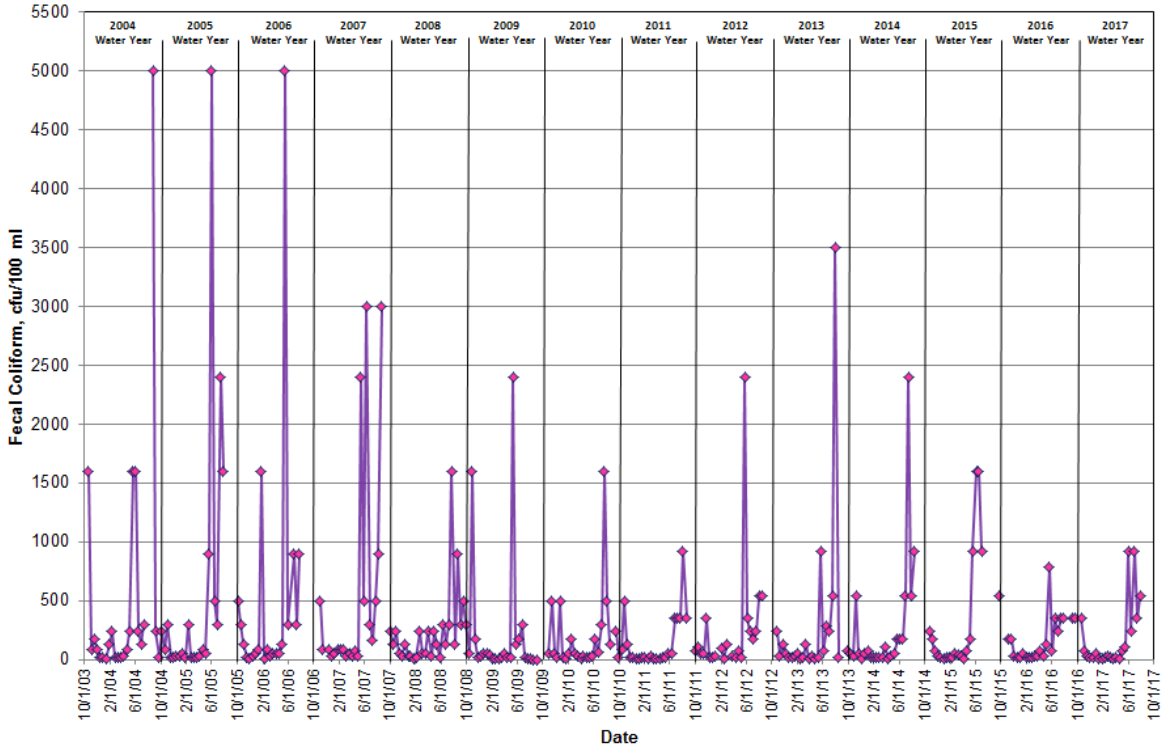
Hansen Creek at Hoehn Road - Site 19 Fecal Coliform



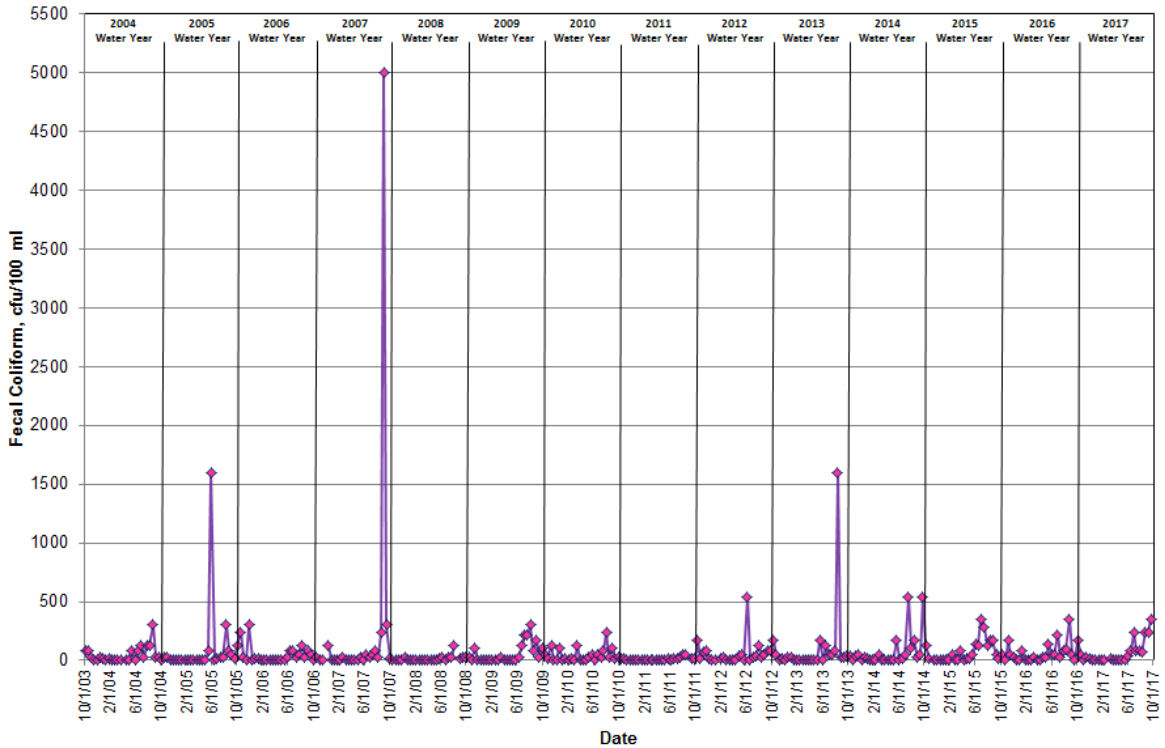
Hansen Creek at Northern State Hospital - Site 20 Fecal Coliform



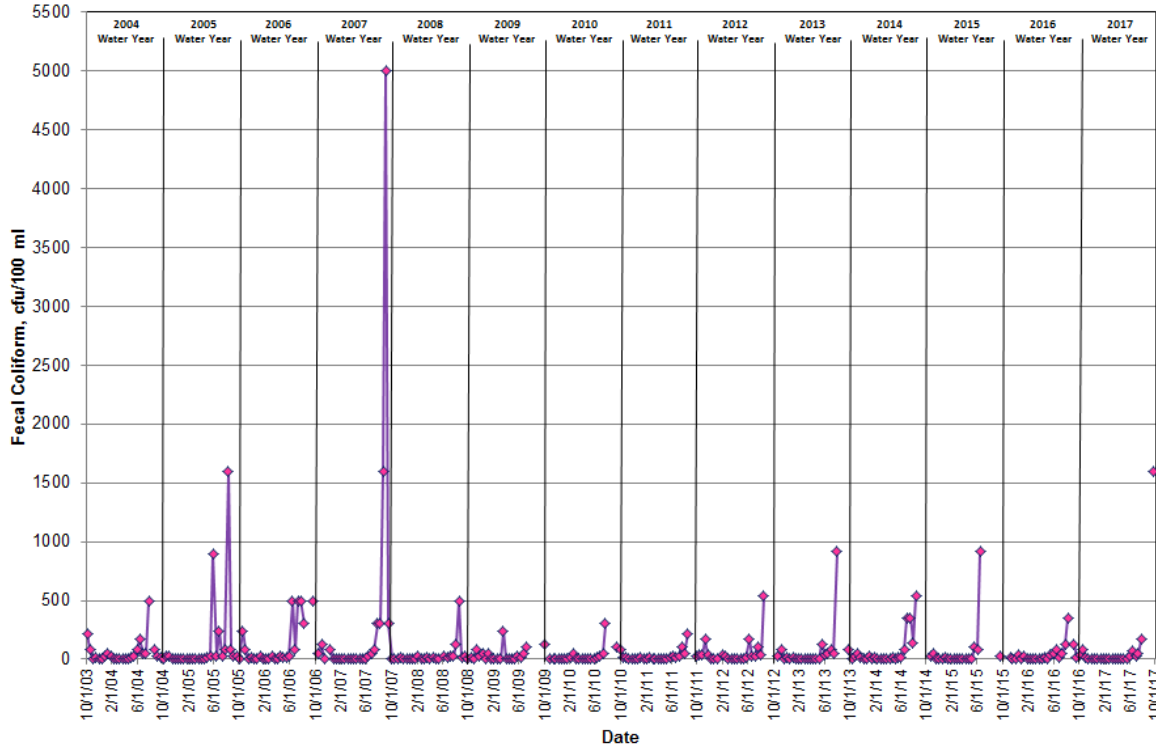
Coal Creek at Hoehn Road - Site 21 Fecal Coliform



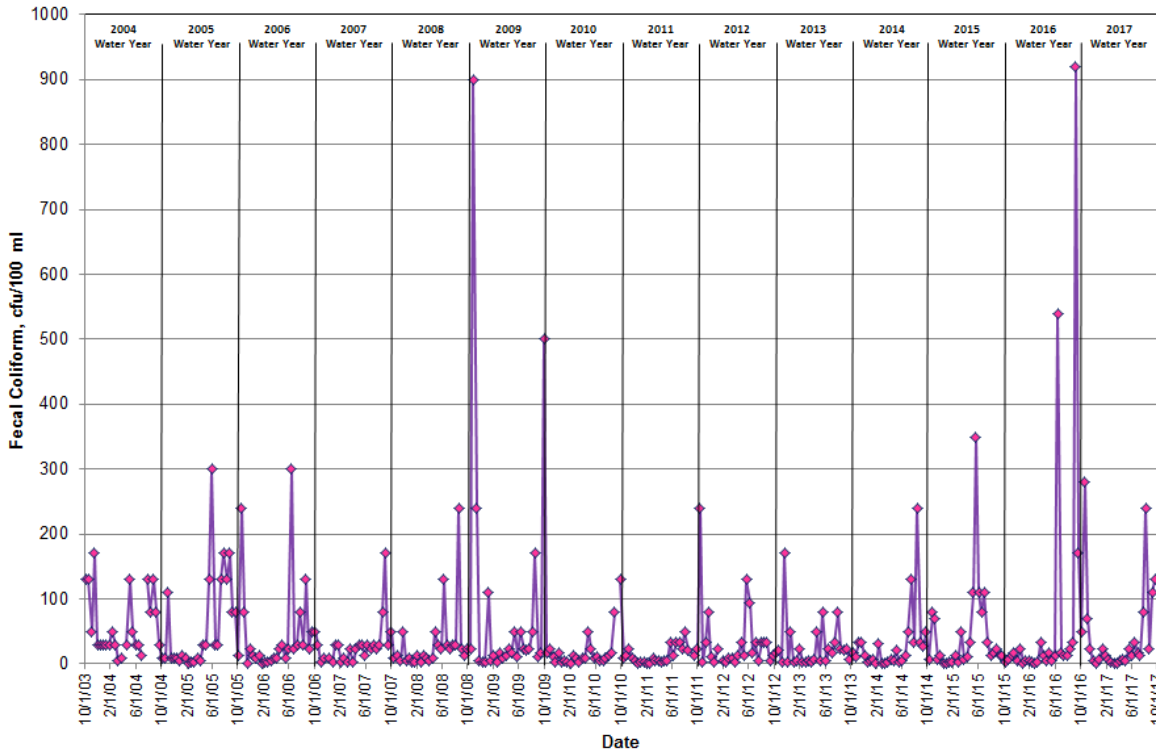
Coal Creek at Highway 20 - Site 22 Fecal Coliform



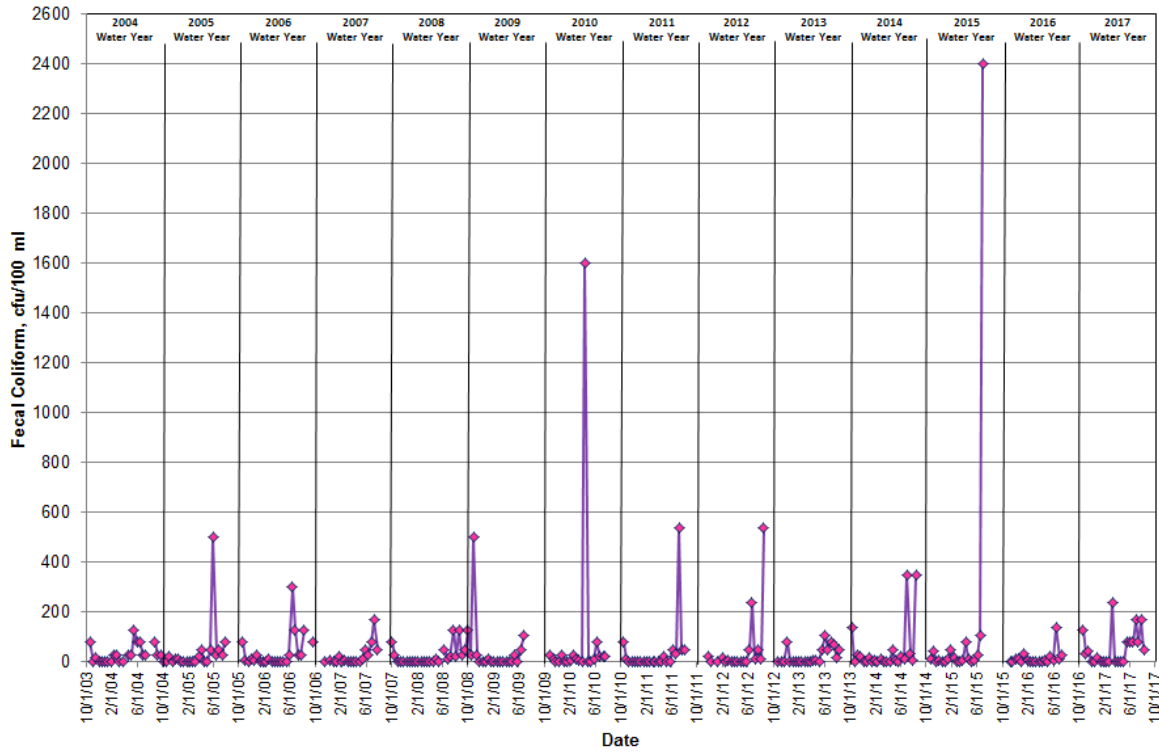
Wiseman Creek at Minkler Road - Site 23 Fecal Coliform



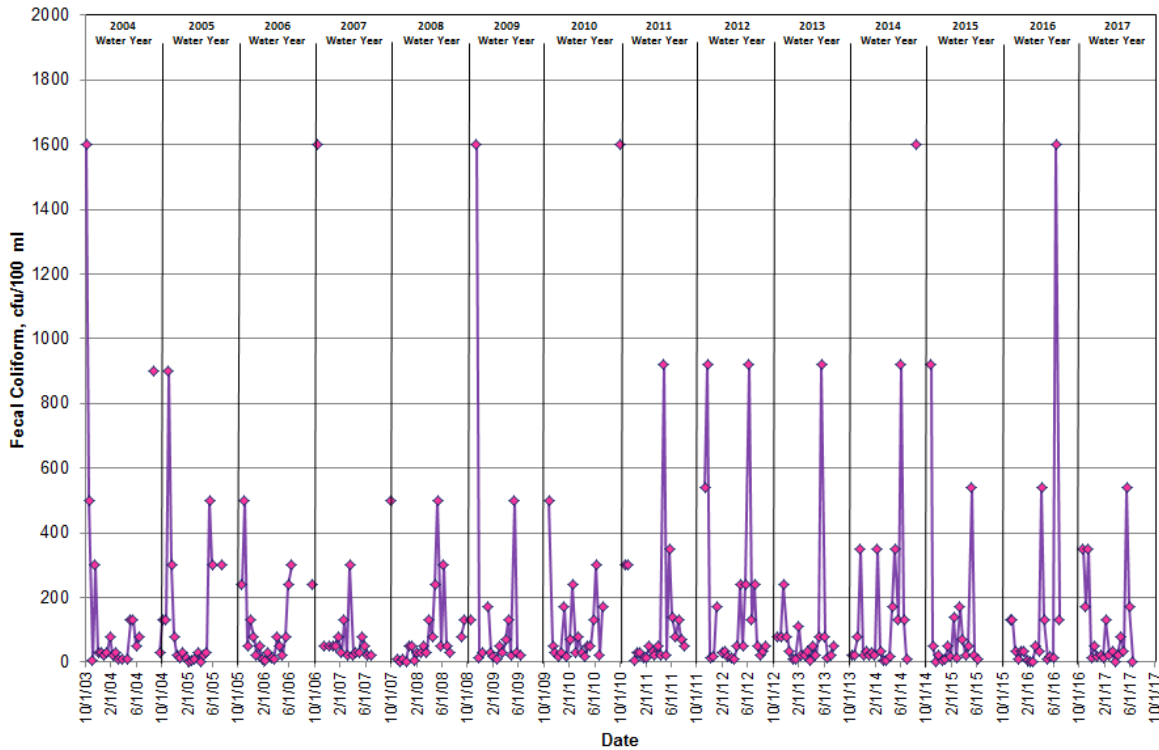
Mannser Creek at Lyman-Hamilton Highway - Site 24 Fecal Coliform



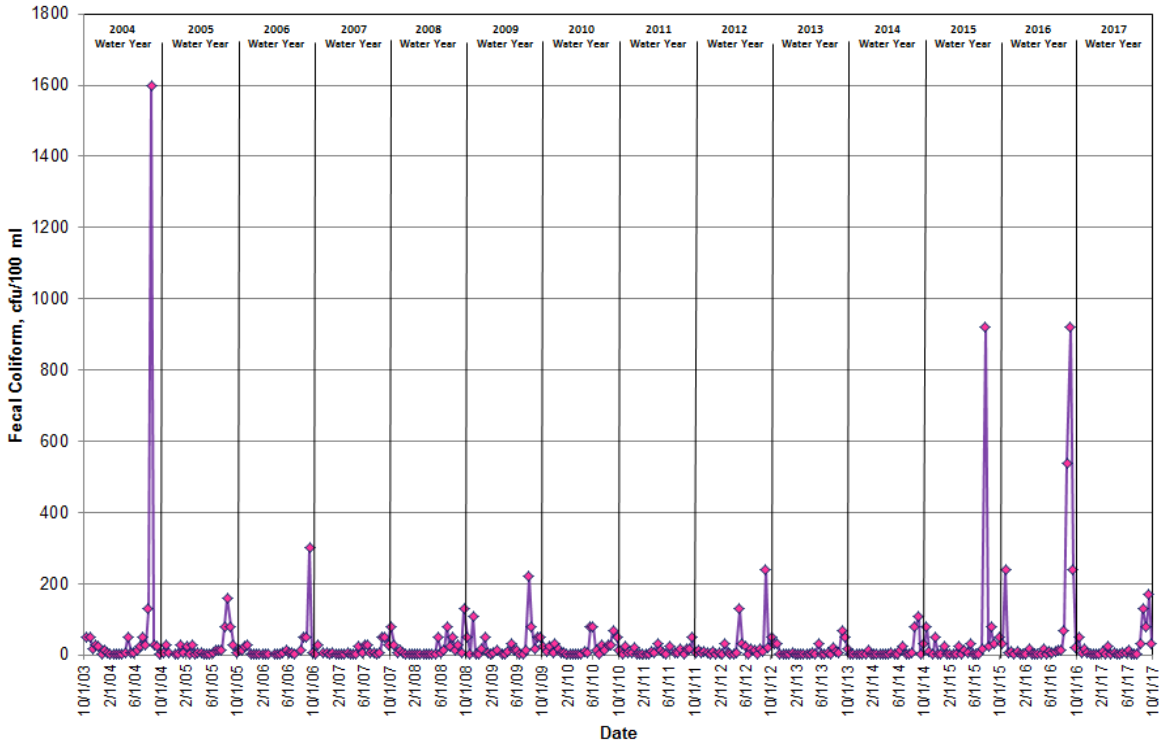
Red Cabin Creek at Hamilton Cemetery Road - Site 25 Fecal Coliform



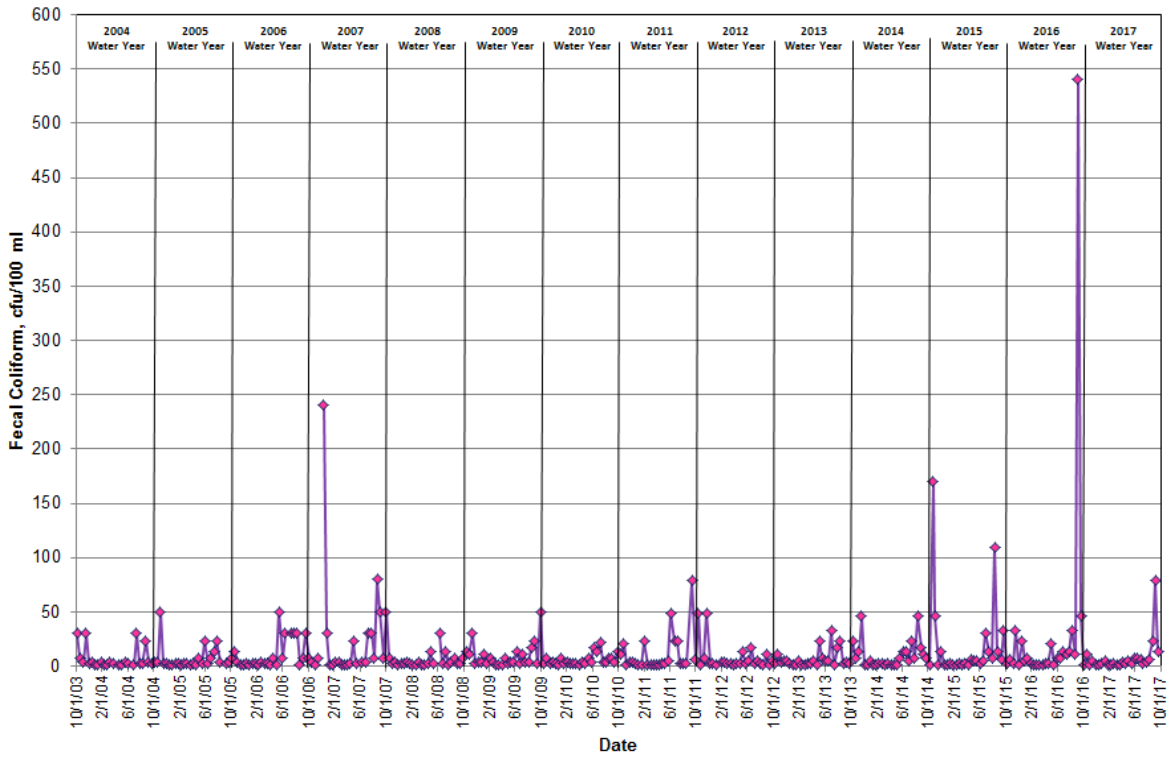
Brickyard Creek at Highway 20 - Site 28 Fecal Coliform



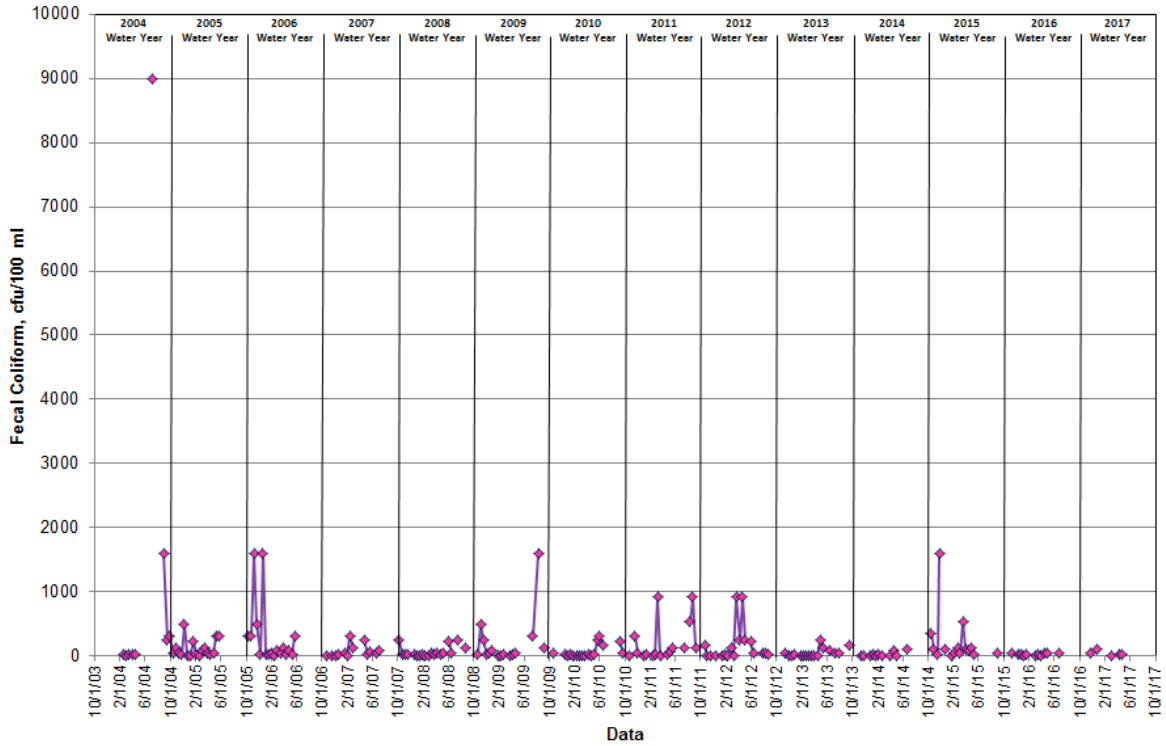
Skagit River at River Bend Road - Site 29 Fecal Coliform



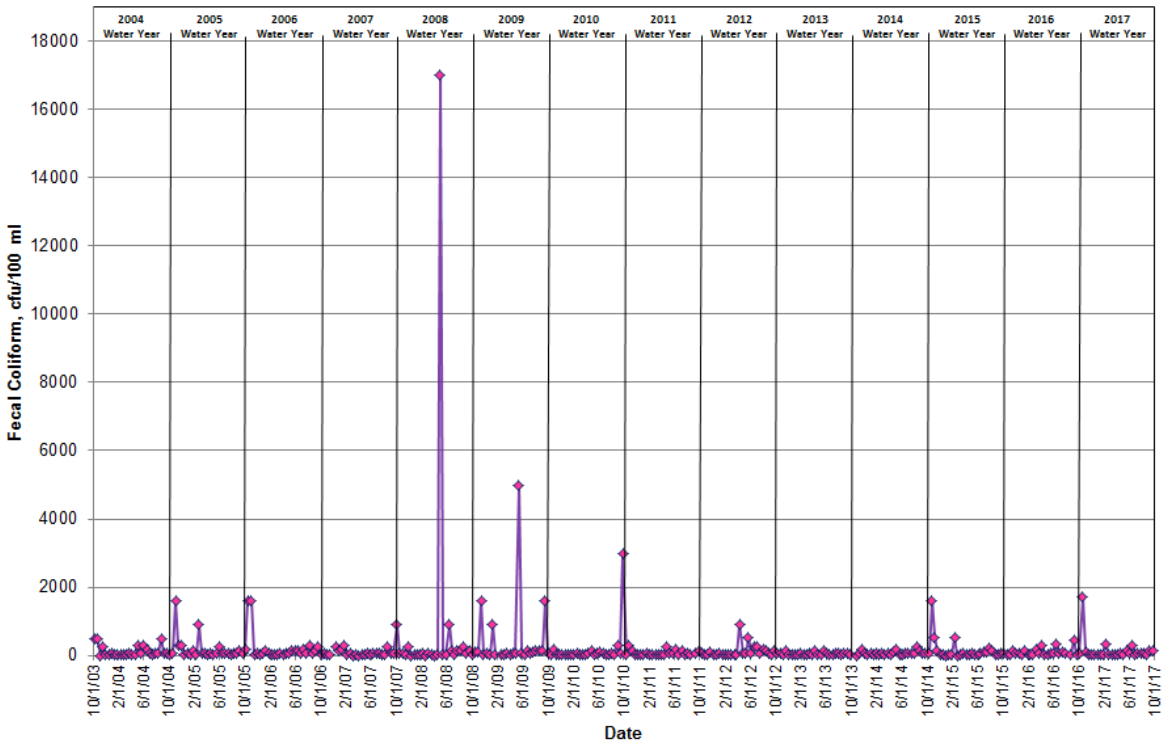
Skagit River at Cape Horn Road - Site 30 Fecal Coliform



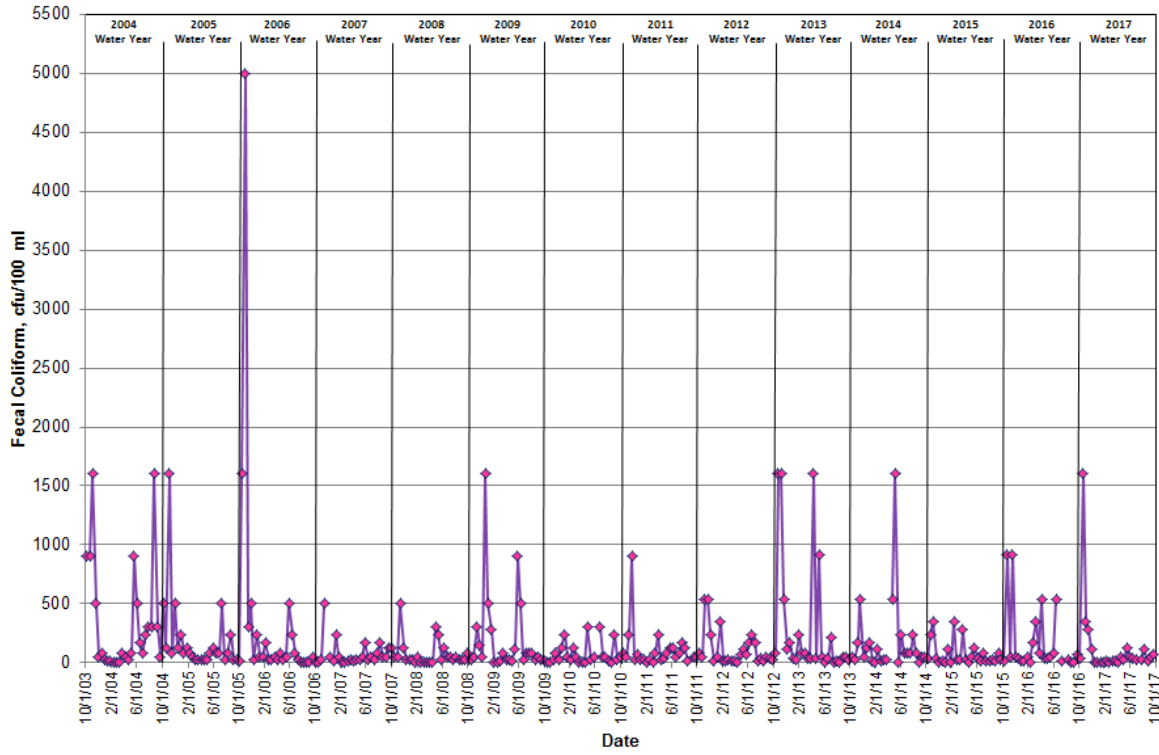
Drainage District 20 Ditch at Floodgate - Site 31 Fecal Coliform



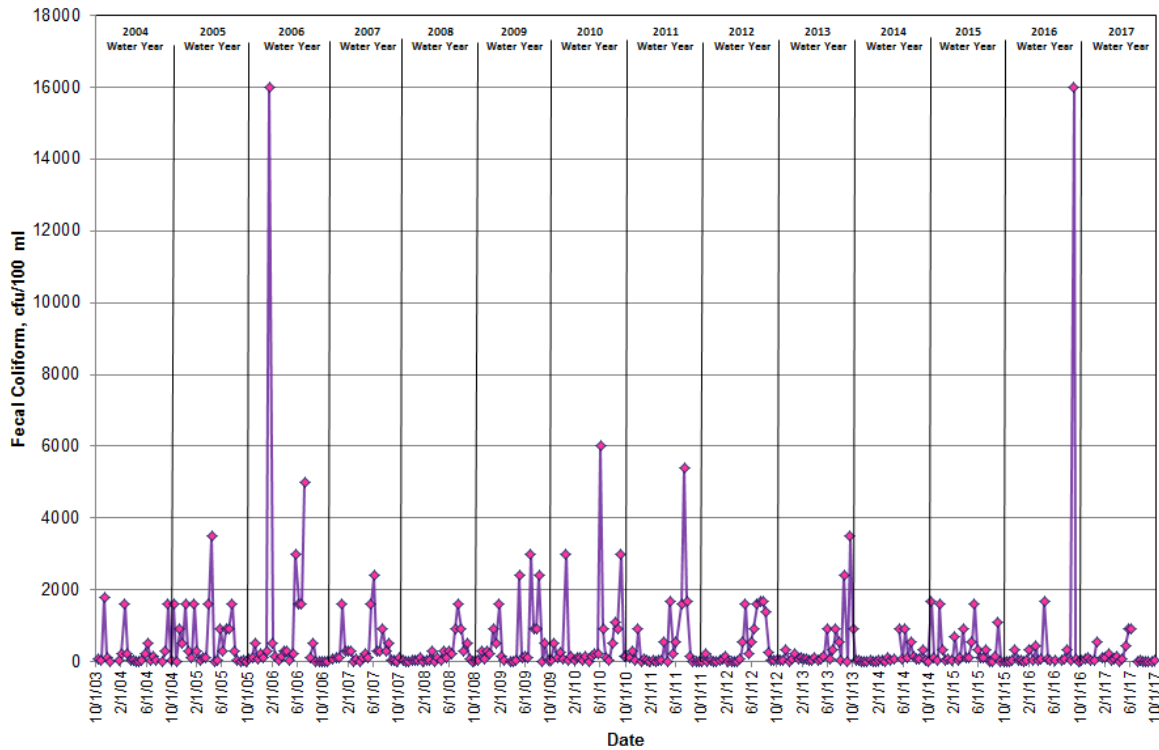
Samish River at Thomas Road - Site 32 Fecal Coliform



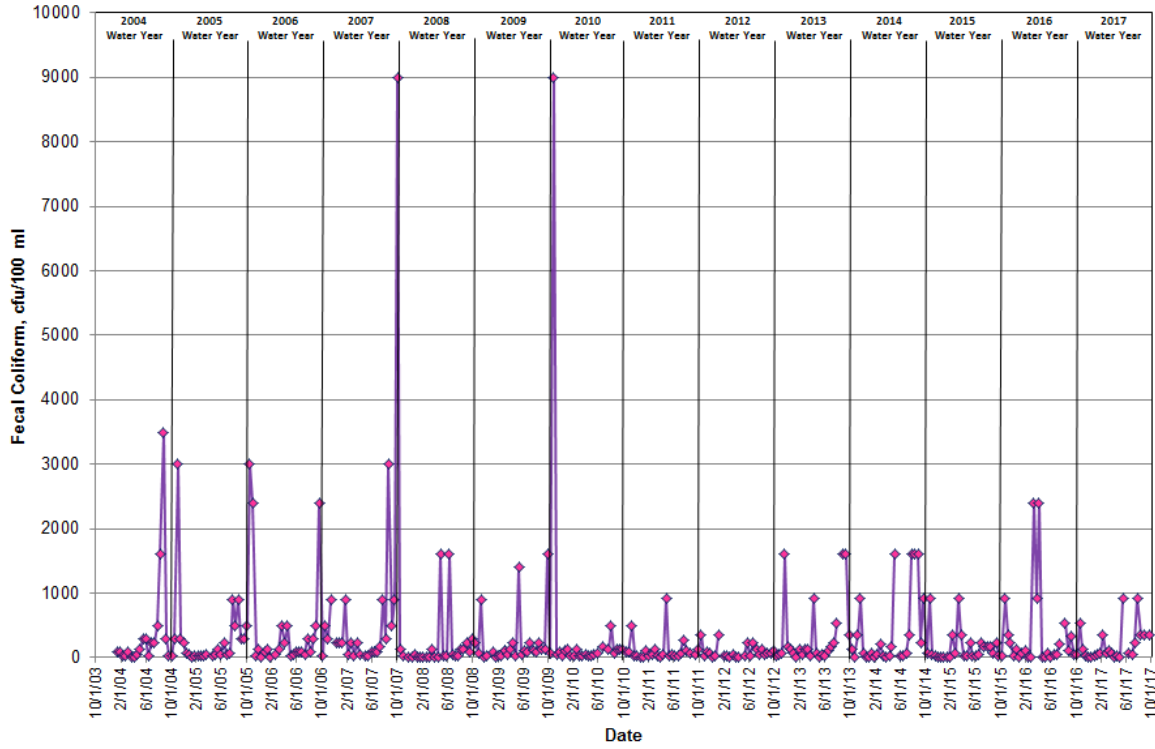
Alice Bay Pump Station - Site 33 Fecal Coliform



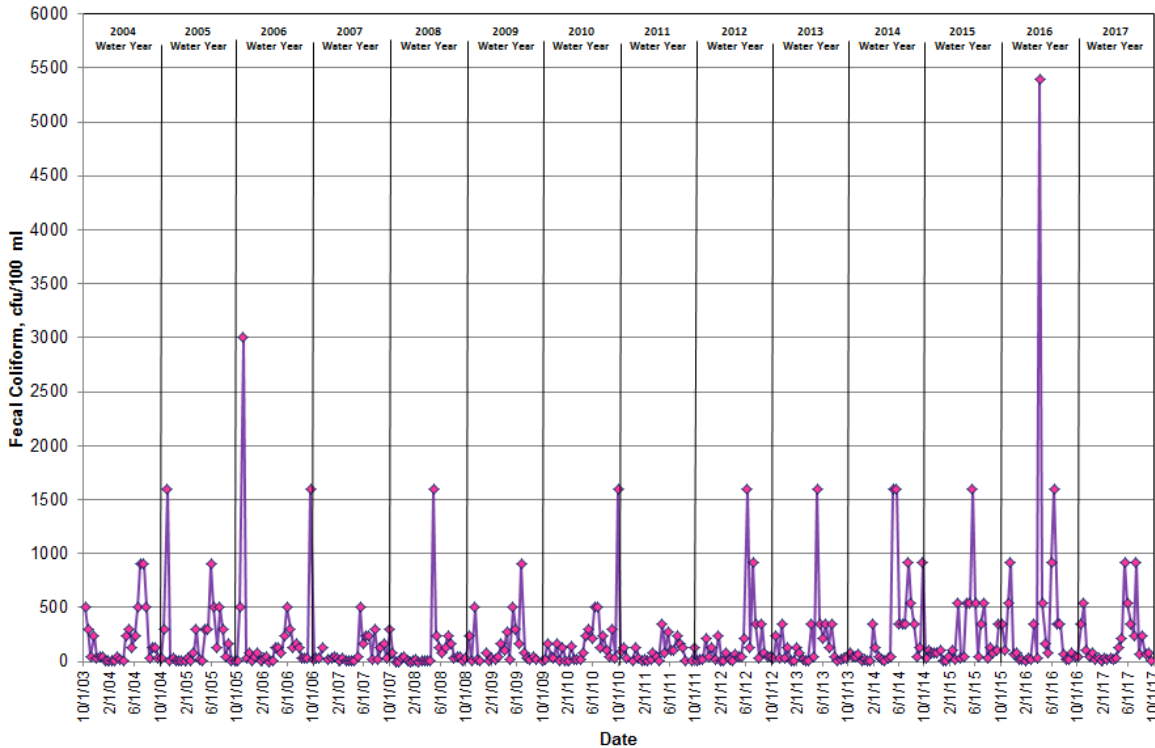
No Name Slough at Bayview-Edison Road - Site 34 Fecal Coliform



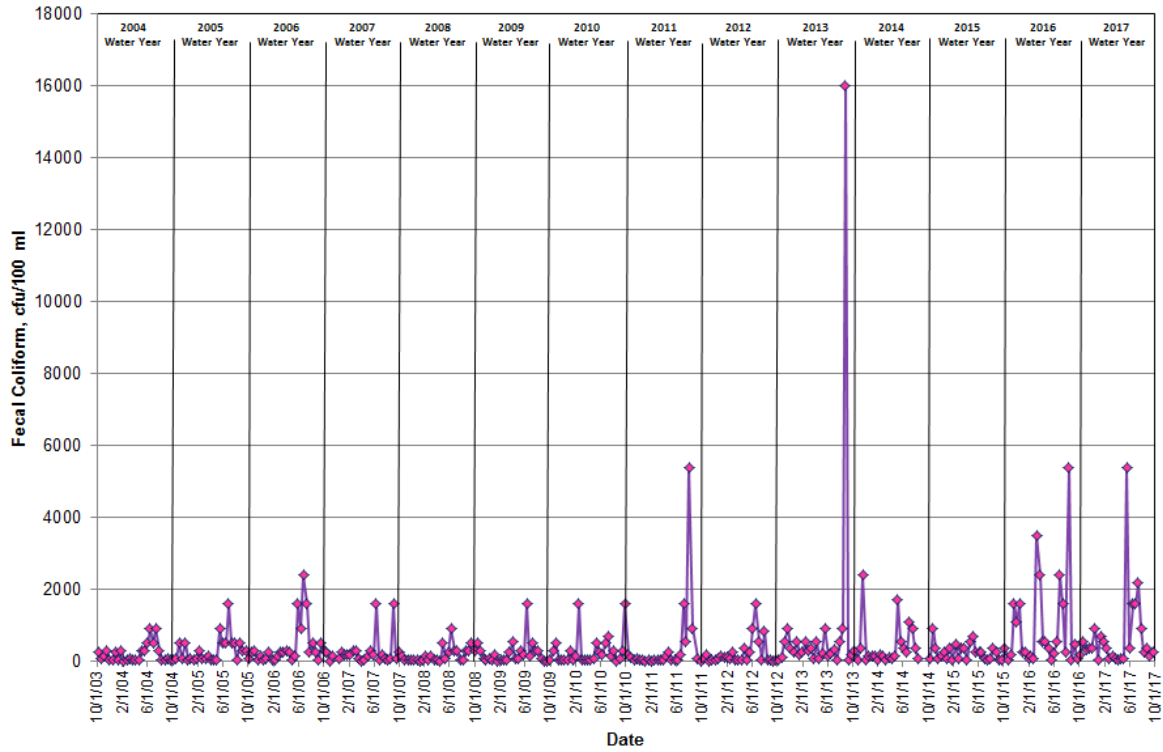
Joe Leary Slough at D'Arcy Road - Site 35 Fecal Coliform



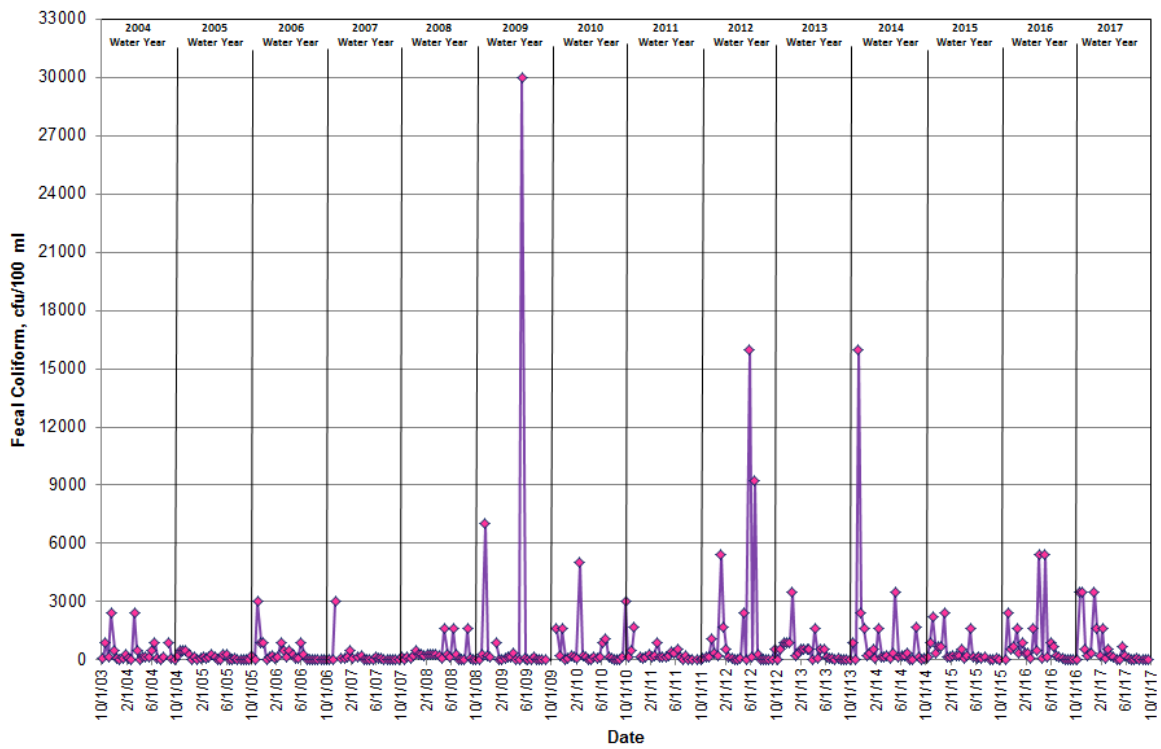
Edison Slough at Edison School - Site 36 Fecal Coliform



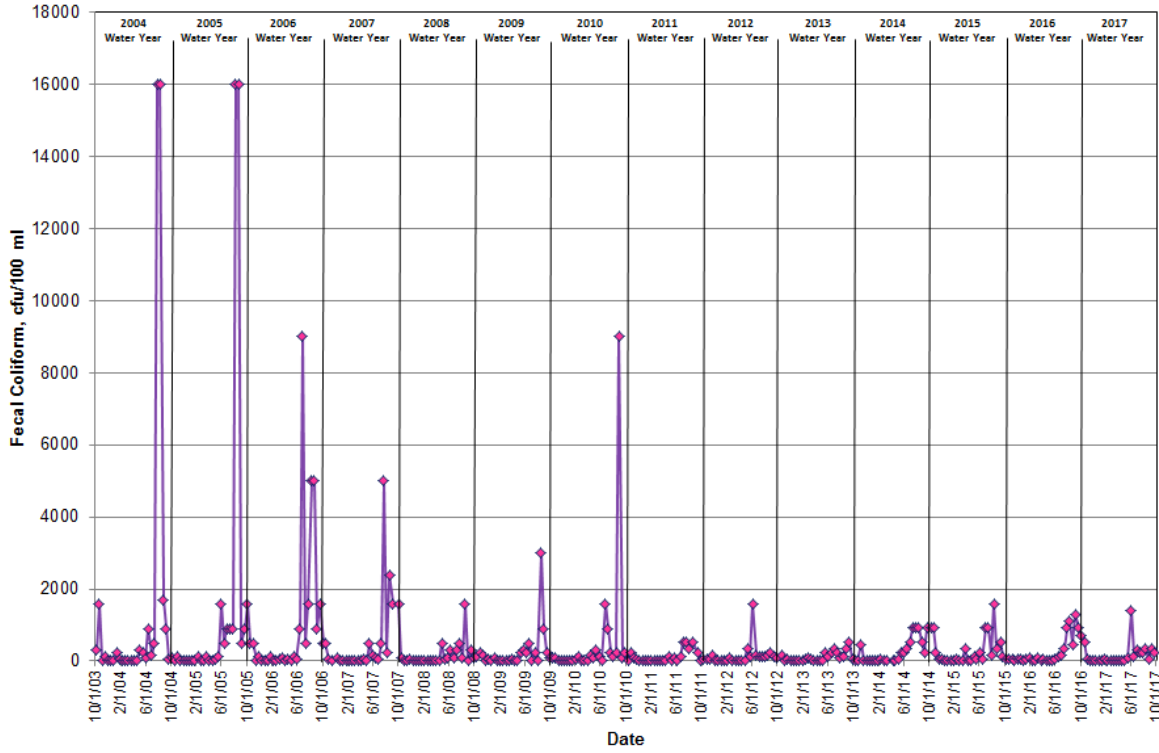
Edison Pump Station - Site 37 Fecal Coliform



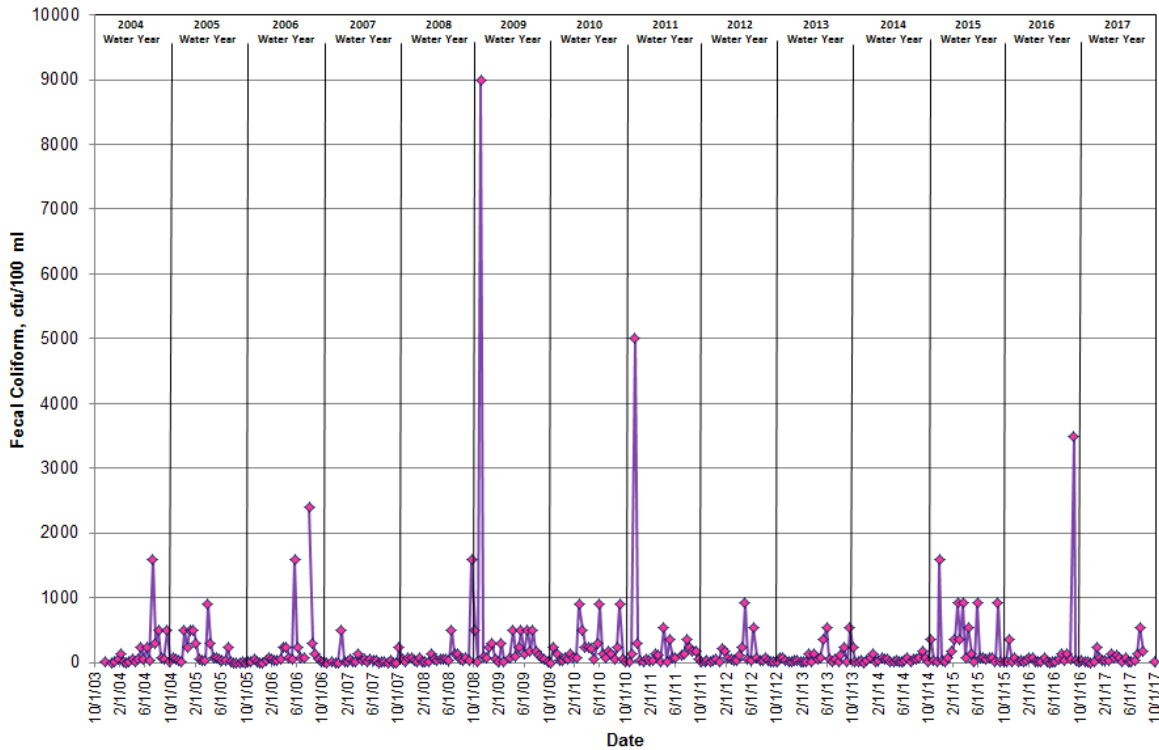
North Edison Pump Station - Site 38 Fecal Coliform



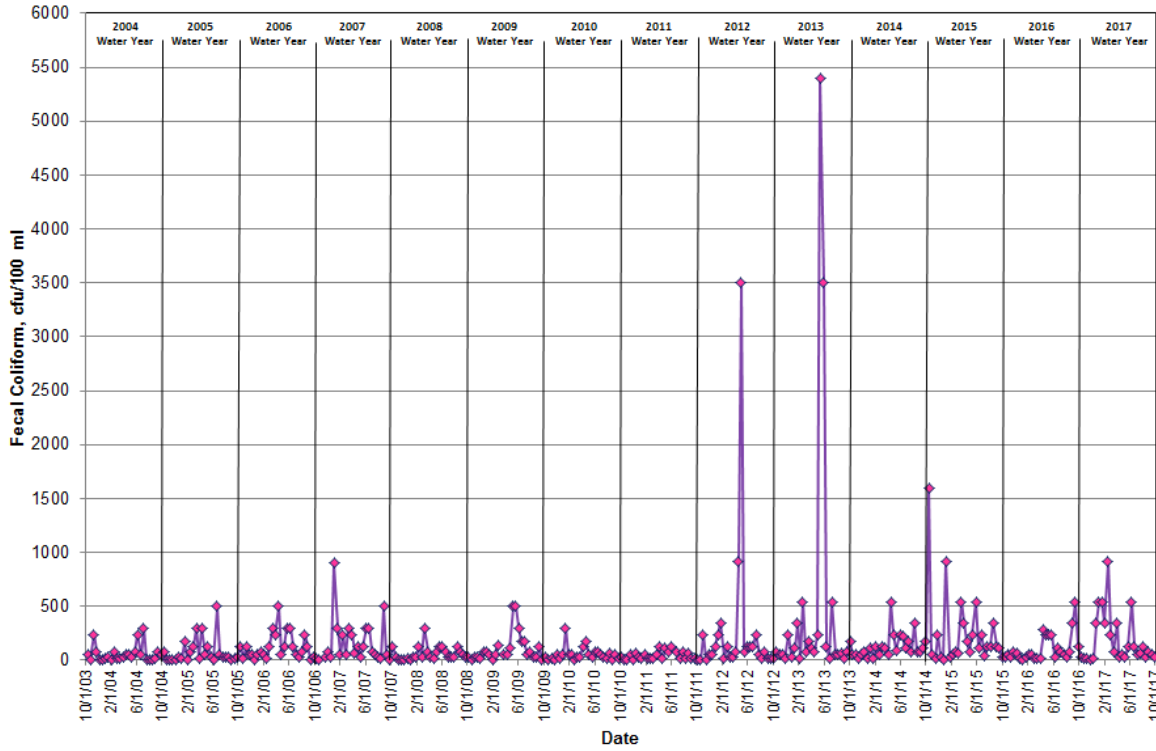
Colony Creek at Colony Road - Site 39 Fecal Coliform



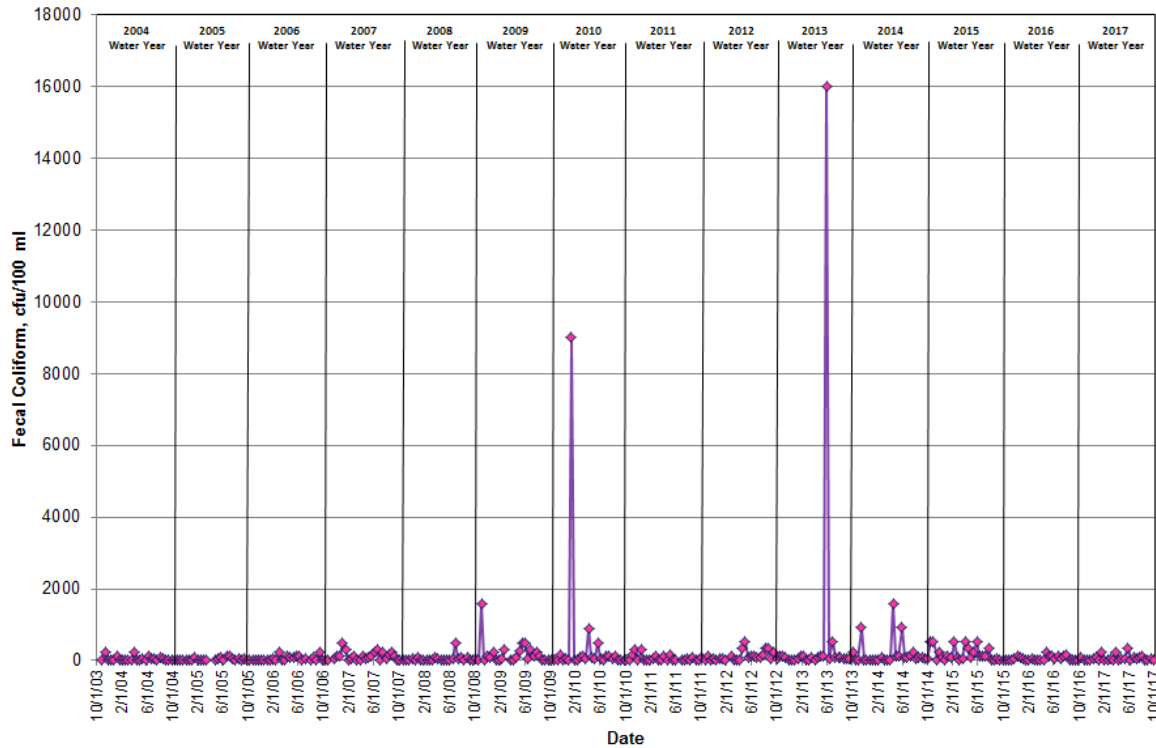
Big Indian Slough at Highway 20 Truck Scales - Site 40 Fecal Coliform



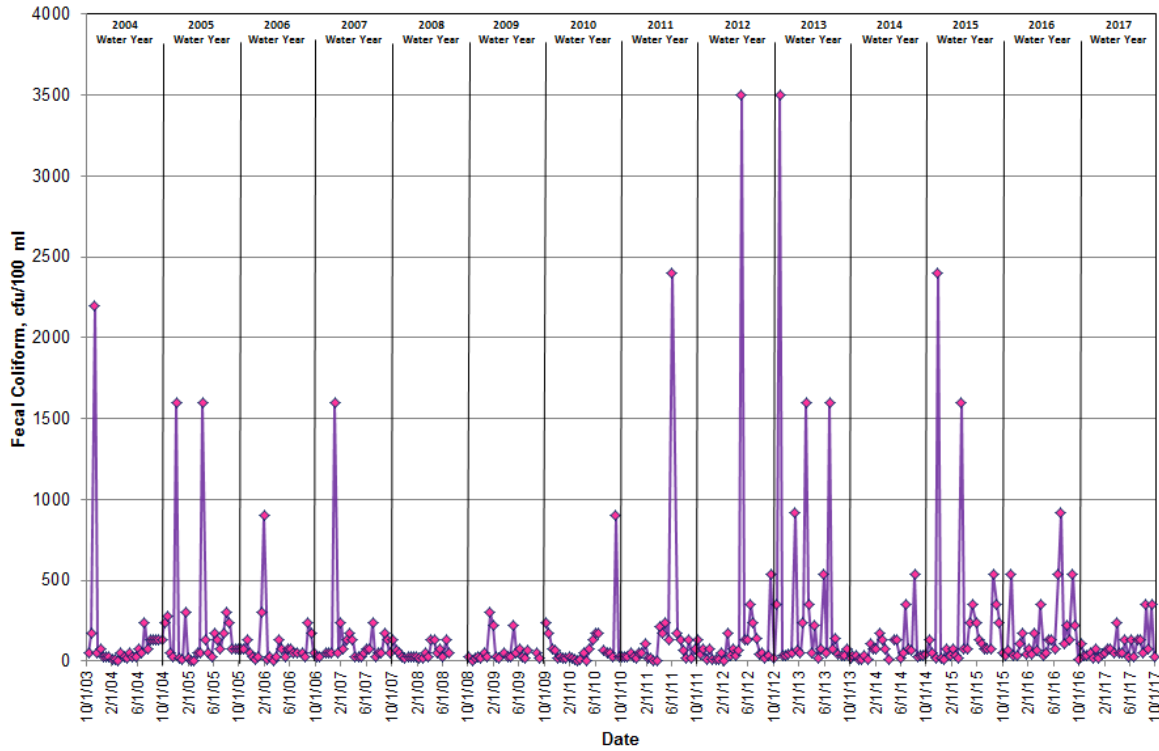
Maddox Creek/Big Ditch at Milltown Road - Site 41 Fecal Coliform



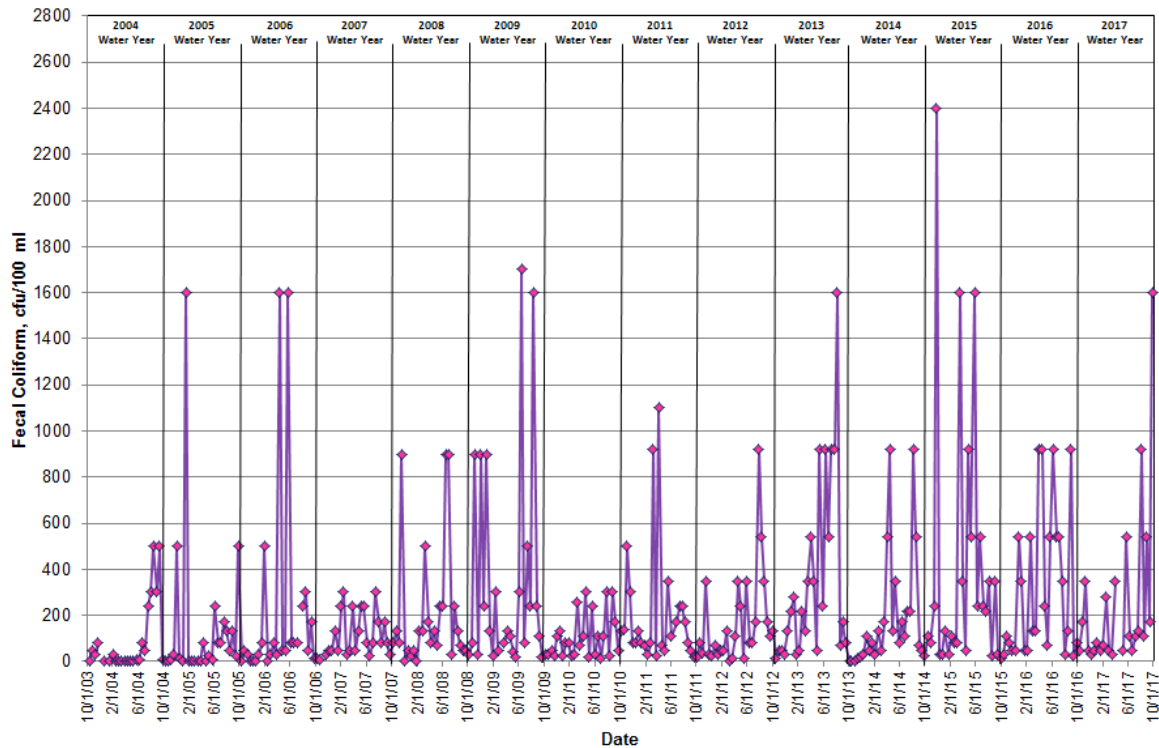
Carpenter Creek/Hill Ditch at Cedardale Road - Site 42 Fecal Coliform



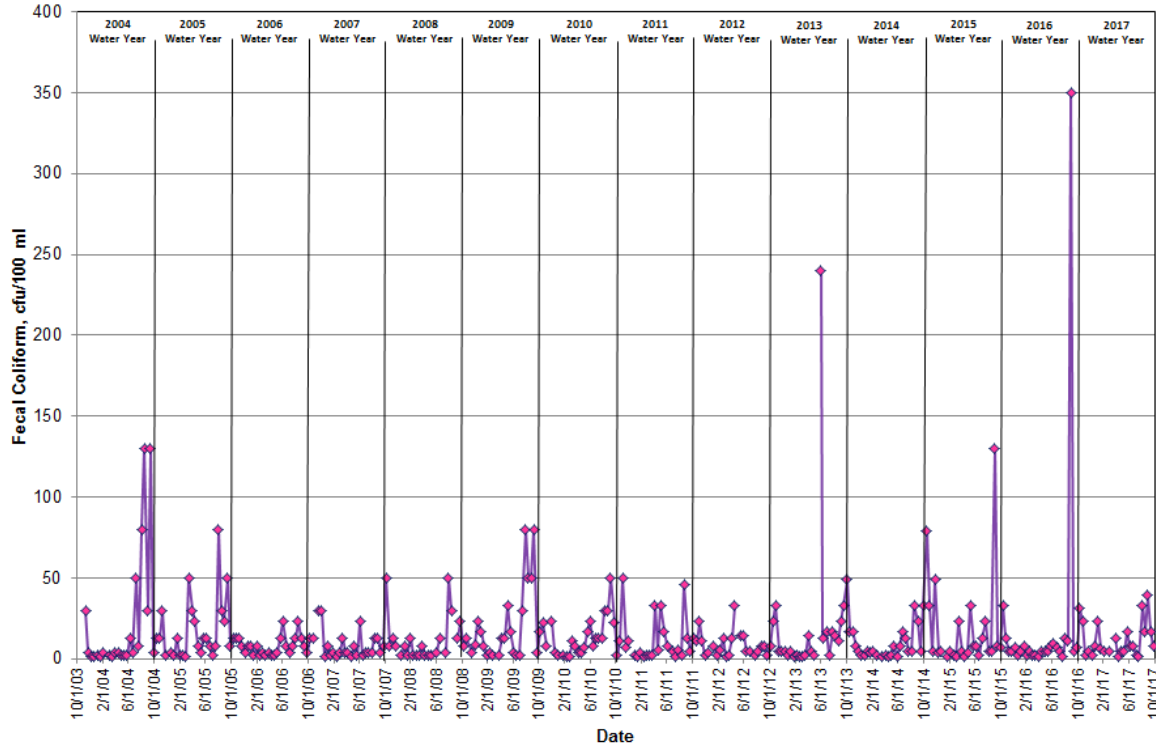
Wiley Slough at Wylie Road - Site 43 Fecal Coliform



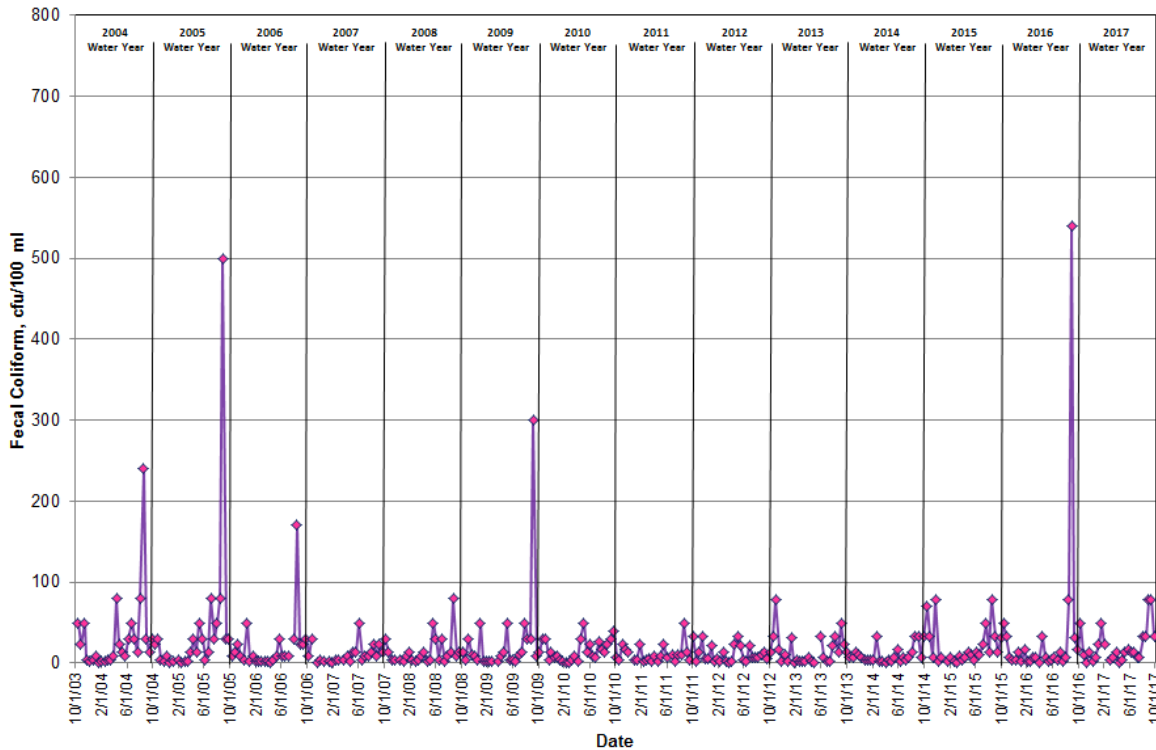
Sullivan Slough at LaConner-Whitney Road - Site 44 Fecal Coliform



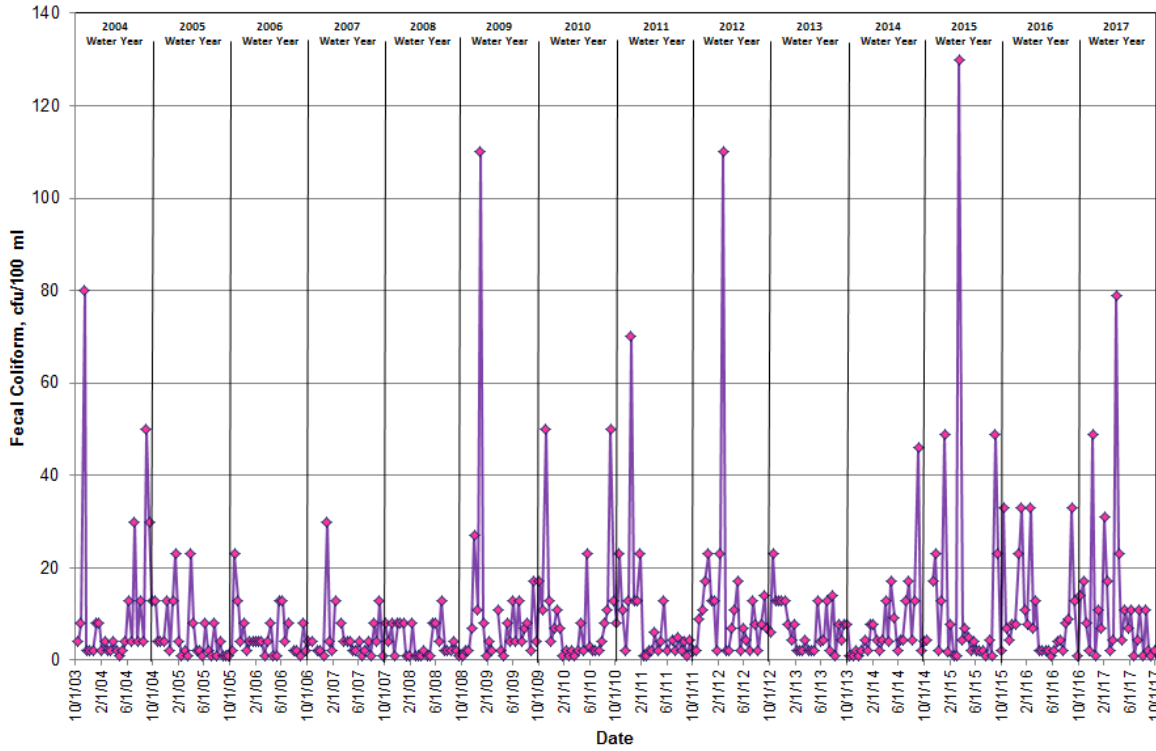
North Fork Skagit River near Moore Road - Site 45 Fecal Coliform



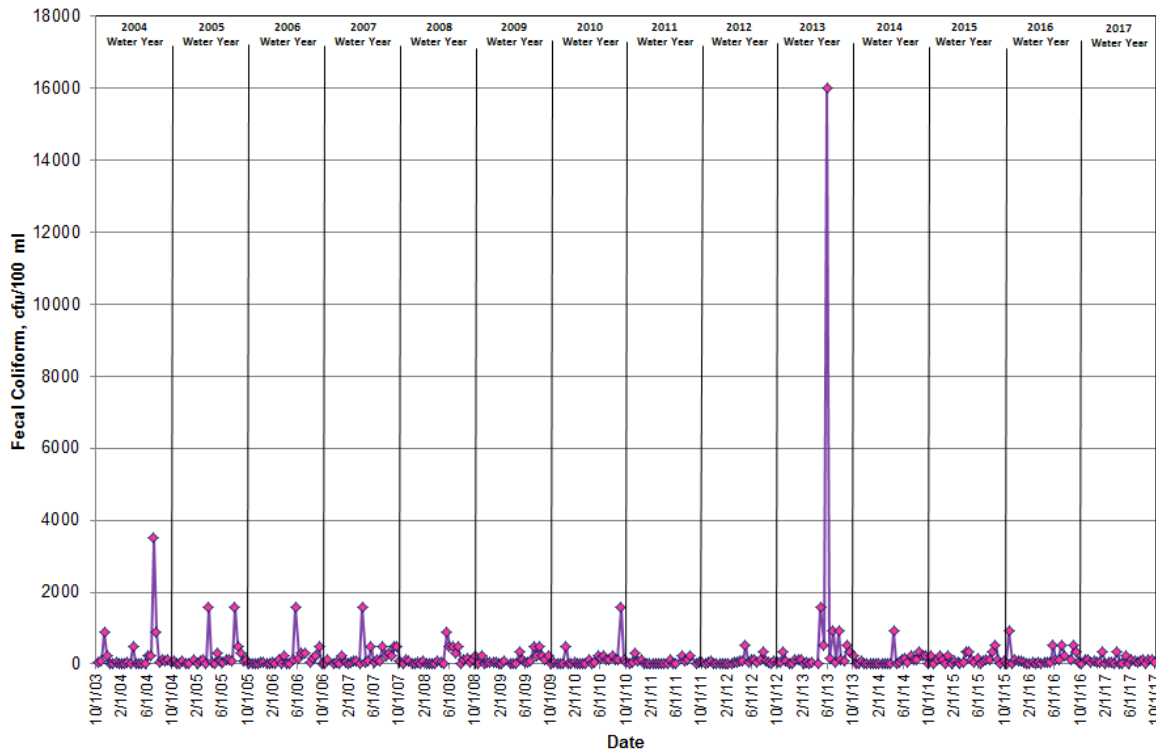
South Fork Skagit River at Conway Boat Ramp - Site 46 Fecal Coliform



Swinomish Channel at County Boat Ramp - Site 47 Fecal Coliform



Fisher Creek at Franklin Road - Site 48 Fecal Coliform



Nutrients

Water samples for measurement of plant nutrients were taken at each station quarterly. Samples were analyzed by Edge Analytical of Burlington, WA. Table 9 gives mean nutrient values for selected parameters for the 2016 water year. All nutrient values are included in Appendix A, with summary statistics found in Appendix B.

Nutrient levels in watercourses help determine the potential for algal activity. Excessive nutrient levels can lead to large blooms of algae, which can increase dissolved oxygen levels during the day but lead to large decreases in dissolved oxygen at night when the algae are respiring, and also when the algae die and decompose. Nutrients from freshwater sources discharged into Puget Sound bays can contribute to marine algal blooms as well.

Most of the natural streams in the program showed moderate levels of total nitrogen, ammonia, and total phosphorus. The drainage infrastructure sampling sites generally had higher levels of nutrients compared to the stream stations.

There are no numeric state standards for nutrients as factors in algal blooms. However, the state has both acute and chronic water quality standards for ammonia toxicity that are calculated from the ammonia level combined with the water temperature and pH for each individual ammonia measurement. Calculation of ammonia standards for a few individual readings suggests that some Skagit County watercourses would exceed the state standards on some occasions.

Table 9. 2017 Nutrient Results
Mean Nutrient Values (Mg/L) for watercourses in the Skagit County Monitoring Program,
2017 Water Year

Site Number	Watercourse	Location	Total Nitrogen ¹	Total Phosphorus	Ammonia	Nitrate + Nitrite
3	Thomas Creek	Old Hwy 99 N	1.27	0.14	0.20	0.61
4	Thomas Creek	F&S Grade Rd	0.30	0.05	0.01	1.14
6	Friday Creek	Prairie Rd	0.24	0.02	0.01	0.58
8	Swede Creek	Grip Rd	0.29	0.04	0.01	0.42
11	Samish River	State Route 9	0.25	0.02	0.01	0.37
12	Nookachamps Creek	Swan Rd	0.35	0.07	0.06	0.35
13	E.F. Nookachamps Creek	State Route 9	0.27	0.03	0.02	0.24
14	College Way Creek	College Way	0.37	0.06	0.03	0.43
15	Nookachamps Creek	Knapp Rd	0.54	0.13	0.07	0.42
16	E.F. Nookachamps Creek	Beaver Lake Rd	0.28	0.04	0.01	0.39
17	Nookachamps Creek	Big Lake Outlet	0.28	0.03	0.02	0.35
18	Lake Creek	State Route 9	0.27	0.02	0.01	0.60
19	Hansen Creek	Hoehn Rd	0.26	0.02	0.02	0.55
20	Hansen Creek	Northern State	0.25	0.03	0.01	0.65
21	Coal Creek	Hoehn Rd	0.77	0.01	0.03	0.77
22	Coal Creek	Hwy 20	0.25	0.04	0.01	0.65
23	Wiseman Creek	Minkler Rd	0.25	0.04	0.01	0.92
24	Mannser Creek	Lyman Hamilton Hwy	0.24	0.03	0.01	0.29
25	Red Cabin Creek	Hamilton Cemetery Rd	0.25	0.05	0.01	0.57
28	Brickyard Creek	Hwy 20	0.35	0.04	0.03	0.79
29	Skagit River	River Bend Rd	0.25	0.04	0.04	0.08
30	Skagit River	Cape Horn Rd	0.40	0.04	0.01	0.08
31	Drainage Dist 20 floodgate	Francis Rd	0.69	0.15	0.08	0.45
32	Samish River	Thomas Rd	0.46	0.03	0.02	0.67
33	Alice Bay Pump Station	Samish Island Rd	1.57	0.45	0.64	0.41
34	No Name Slough	Bayview-Edison Rd	1.09	0.53	0.15	0.43
35	Joe Leary Slough	D'Arcy Rd	1.26	0.26	0.75	0.95
36	Edison Slough at school	W. Bow Hill Rd	0.81	0.39	0.03	0.47
37	Edison Pump Station	Farm to Market Rd	2.70	1.28	0.86	0.77
38	North Edison Pump Station	North Edison Rd	3.10	1.24	0.60	0.63
39	Colony Creek	Colony Rd	0.30	0.09	0.03	1.07
40	Big Indian Slough	Bayview-Edison Rd	1.05	0.22	0.35	0.97
41	Maddox Slough/Big Ditch	Milltown Rd	0.67	0.17	0.11	0.54
42	Hill Ditch	Cedardale Rd	0.42	0.07	0.02	0.35
43	Wiley Slough	Wylie Rd	1.64	0.53	0.48	0.50
44	Sullivan Slough	La Conner-Whitney Rd	1.30	0.32	0.47	0.79
45	Skagit River – North Fork	Moore Rd	0.25	0.03	0.01	0.10
46	Skagit River – South Fork	Fir Island Rd	0.25	0.03	0.01	0.14
47	Swinomish Channel	County Boat Launch	0.25	0.07	0.04	0.27
48	Fisher Creek	Franklin Rd	0.53	0.27	0.04	0.73

¹Total Kjeldahl Nitrogen

Other Parameters

The Skagit County Monitoring Program also measures pH, conductivity, and salinity during each visit to each site. Conductivity and salinity are measured to help interpret other water quality parameters. Measurement of pH shows whether a watercourse is within the range that supports aquatic life. In general, pHs in the Skagit program have been within state standards.

Discharge measurements are made in selected locations and are intended to provide a general indication of the flow regime for that watercourse and as an aid in interpreting other water quality parameters. As the Department of Ecology has added several stream gauges in our area, Skagit County has de-emphasized discharge measurement.

Although results for these parameters are not discussed in detail in the main report, all measurements are available in Appendix A and are summarized in Appendix B.

Water Quality Index

The Water Quality Index (WQI) is an indicator developed by the Washington State Department of Ecology as an overall indicator of water quality at a given site. The Index compares typical water quality parameters with established standards and yields a single, unitless number between 1 and 100 to describe the overall water quality of a site at the time of sampling. The Index can then be summarized in a number of ways to give a site an overall score for a water year. The parameters included in the WQI are dissolved oxygen, temperature, pH, turbidity, suspended solids, fecal coliform, and nutrients.

The WQI is best used to answer general questions about the condition of watercourses, such as “What is the general condition of this stream?” or “How does this stream compare to others in the area?” (Hallock 2002). Because the index is a distillation of many parameters, it is unsuitable for answering detailed questions concerning the water quality of an individual stream. As is demonstrated by the Samish River, a stream can have an adequate WQI score based on ambient sampling, but significant pollution problems revealed by storm sampling.

Ecology rates streams with WQI Overall Score of 80 or greater “of lowest concern.” Streams with ratings of 40-80 are considered “of moderate concern,” while scores less than 40 are considered “of highest concern.”

Water Quality Index calculations for the sample sites in the Skagit County Monitoring Program during the 2016 water year are summarized in Table 10 and categorized for the years 2006-2016 in Table 11. Note that although the WQI was designed for freshwater bodies, we have applied the index to the Swinomish Channel monitoring site (Site 47), which is primarily marine. This allows trend detection over time at this station, but the WQI for Site 47 should not be compared to the freshwater sites.

The WQI results show that several watercourses in the study area fall into the “highest concern” category. Most, but not all, are agricultural drainages with little summer flow that are not considered salmonid habitat.

Table 10. 2017 Water Quality Index Results
Water Quality Index (WQI) determinations for watercourses in the Skagit County
Monitoring Program, 2017 Water Year

Site Number	Watercourse	Location	Mean WQI	Overall Score*	Max	Min
3	Thomas Creek	Old Hwy 99 N	54	41	93	1
4	Thomas Creek	F&S Grade Rd	91	89	95	87
6	Friday Creek	Prairie Rd	89	86	97	78
8	Swede Creek	Grip Rd	80	75	97	61
11	Samish River	State Route 9	85	82	96	65
12	Nookachamps Creek	Swan Rd	44	59	91	1
13	E.F. Nookachamps Creek	State Route 9	71	64	91	43
14	College Way Creek	College Way	58	47	92	18
15	Nookachamps Creek	Knapp Rd	37	28	64	1
16	E.F. Nookachamps Creek	Beaver Lake Rd	87	83	96	64
17	Nookachamps Creek	Big Lake Outlet	83	78	96	66
18	Lake Creek	State Route 9	88	86	96	70
19	Hansen Creek	Hoehn Rd	85	85	96	65
20	Hansen Creek	Northern State	88	84	99	78
21	Coal Creek	Hoehn Rd	88	88	96	74
22	Coal Creek	Hwy 20	89	85	99	73
23	Wiseman Creek	Minkler Rd	95	95	99	88
24	Mannser Creek	Lyman Hamilton Hwy	68	64	91	43
25	Red Cabin Creek	Hamilton Cemetery Rd	94	94	99	85
28	Brickyard Creek	Hwy 20	93	93	96	89
29	Skagit River	River Bend Rd	89	85	98	90
30	Skagit River	Cape Horn Rd	90	88	98	70
31	Drain Dist 20 Floodgate	Francis Rd	32	32	32	32
32	Samish River	Thomas Rd	87	84	94	78
33	Alice Bay Pump Station	Samish Island Rd	49	35	93	10
34	No Name Slough	Bayview-Edison Rd	27	27	45	1
35	Joe Leary Slough	D'Arcy Rd	18	24	50	1
36	Edison Slough	W. Bow Hill Rd	51	38	87	8
37	Edison Pump Station	Farm to Market Rd	14	7	36	1
38	N. Edison Pump Station	North Edison Rd	24	18	40	1
39	Colony Creek	Colony Rd	85	81	98	61
40	Big Indian Slough	Bayview-Edison Rd	17	23	35	1
41	Maddox Slough/Big Ditch	Milltown Rd	47	39	70	21
42	Hill Ditch	Cedardale Rd	84	81	92	77
43	Wiley Slough	Wylie Rd	10	1	36	1
44	Sullivan Slough	La Conner-Bayview Rd	21	16	38	1
45	Skagit River – North Fork	Moore Rd	92	89	98	86
46	Skagit River – South Fork	Fir Island Rd	90	88	98	82
47	Swinomish Channel	County Boat Launch	89	87	95	76
48	Fisher Creek	Franklin Rd	78	75	88	60

*Note: Overall score is the mean of the three lowest monthly scores (Hallock 2002)

Color code: **Lowest Concern** (>80 Overall Score), **Moderate Concern** (40-80), **Highest Concern** (<40)

**Table 11. Number of sites in Water Quality Index (WQI) categories for Skagit County Monitoring Program
Total number = 40 sites**

Year	Green (WQI \geq 80)	Yellow (WQI 40-79)	Red (WQI <40)
2006	3	15	22
2007	6	17	17
2008	10	13	17
2009	17	11	12
2010	13	19	8
2011	20	9	11
2012	13	16	11
2013	15	14	11
2014	16	13	11
2015	16	13	11
2016	15	15	10
2017	20	8	12

Over the course of the Skagit County Monitoring Program, the number of sites in the Green (or “Lowest Concern” category has generally increased while the number of sites in the Red (or “Highest Concern” category decreased early in the study and has held steady the last few years. Streams and ditches in the Red category can have either one water quality parameter that is well below standards or several categories that are.

Water quality during storm events remains problematical as the results from storm event monitoring in the Samish Basin associated with the Clean Samish Initiative continue to show excessive fecal coliform concentrations. More information on Samish water quality is included below.

Data Analysis

Summary statistics for all measured parameters at each sampling site can be found in Appendix B. These statistics can be used as a general indication of water quality conditions at each station. However, water quality conditions vary greatly at each station over time and the summary statistics should not be used as a sole indicator of water quality.

A primary goal of the Skagit County Monitoring Program is to detect trends in water quality over time. The purpose of the trends analysis is to provide indications of whether water quality in agricultural areas is improving, staying the same, or deteriorating. Once trends are detected, efforts could be undertaken to determine if the trends are caused by local activities or by regional conditions such as changes in climate. By comparing trends at stations inside and outside of the agricultural areas and by monitoring climate conditions, it should be possible to determine those conditions that seem to be caused by local circumstances.

One important statistical tool in trends monitoring is the Seasonal Kendall’s Test. This test is designed to determine overall trends in water quality for parameters that vary seasonally, such as

temperature and dissolved oxygen. The Seasonal Kendall's Test has been widely employed for similar purposes in Washington, Oregon, and throughout the country (e.g. Cude 2002, Ehinger 1993, Holdeman et al 2003). Most parameters measured in the Skagit County Monitoring Program have seasonal variation, caused by our local climate which produces comparatively high water flows and low temperatures in the winter and spring, and lower flows with higher temperatures in the summer and early fall.

The Seasonal Kendall's Test was computed using WQStat Plus software (Intelligent Design Technologies, 1998). For most analyses, twelve seasons were designated, starting with the beginning of each month. This approach was recommended in the review of Skagit County's water quality monitoring program by the WRC. Exceptions are noted below. Observations below detection limits were replaced with one-half of the detection limit per the software user manual. The software was able to ignore missing data, so no accommodation for missing data was necessary.

Skagit County has completed trends analysis via the Seasonal Kendall's Test for 19 key parameters or calculated factors at each sampling location. The parameters tested include pH, dissolved oxygen, percent oxygen saturation, temperature, turbidity, fecal coliform, ammonia, nitrate+nitrite, total phosphorus, orthophosphate, total Kjeldahl nitrogen (TKN, an estimate of the total available nitrogen), total suspended solids, and water quality index. Temperature data from biweekly sampling visits were used for this analysis instead of continuous data collected during the summer months because the Seasonal Kendall's Test is not designed for summer-only data. Skagit County continues to examine methods for determining trends in the continuous temperature data. Since the temperature data from biweekly visits was collected at the same time of day for any individual station, the trends analysis should not be biased by differences caused by sampling time of day.

The period used for trends analysis was the 14 full years of Skagit County Monitoring Program data. This period was chosen to coincide with the implementation of the Critical Areas Ordinance for Areas of Ongoing Agriculture (Skagit County Ordinance O20030020).

Several sites have extended dry periods during most summers and/or are flooded during high water events and not sampled. The WQStat trends analysis program was unable to compute trends based on 14 seasons for those sites due to the lack of data for the dry or flooded periods. For those sites, trends were calculated based on four seasons, starting with January, April, July, and October. Trends in WQI were calculated based on four seasons for some additional sites due to lack of summer nutrient data.

Data used for the Seasonal Kendall's Test can be subject to "autocorrelation," where each successive data point is correlated with the previous point (Dave Hallock, Washington Department of Ecology). This situation usually occurs when samples are collected more frequently than monthly. For the Skagit County Monitoring Program, dissolved oxygen, temperature, and fecal coliform data are collected biweekly. Tests are available to detect autocorrelation but in some cases may be confounded by the very seasonality we are trying to accommodate (Dave Hallock, Washington Department of Ecology). Our approach for these parameters has been to conduct the analysis using all data, and repeat the analysis using monthly

averages to avoid autocorrelation (Mike Barber, Washington State Water Research Center). There were very few differences between these two calculations. In the cases where there are differences, it would probably be prudent to use the monthly averages.

A summary of Seasonal Kendall's Test results for those parameters showing a significant trend is provided in Table 12. Complete trends analysis results can be found in Appendix C. These results are discussed in the following section.

Table 12. Trends Analysis Results
Summary of Significant Trends Detected in Skagit County Monitoring Program
2004-2017 Water Years

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
3	DO	356	0.130	5.045	increasing oxygen	
	DO % sat	357	1.110	5.472	increasing oxygen	
	MDO	180	0.132	2.595	increasing oxygen	
	MDO % sat	181	1.164	3.752	increasing oxygen	
	Turb	323	0.228	2.883		increasing turbidity
	OP	99	0.002	2.897		increasing phosphate
4	pH	339	-0.021	-6.312		
	MpH	178	-0.020	-4.572		
	DO	359	0.034	3.402	increasing oxygen	
	MDO	182	0.039	3.256	increasing oxygen	
	DO % sat	360	0.302	6.080	increasing oxygen	
	MDO % sat	182	0.313	5.478	increasing oxygen	
	Turb	326	-0.304	-3.783	decreasing turbidity	
	MTB	171	-0.364	-3.143	decreasing turbidity	
	FC	360	-13.540	-6.553	decreasing fecal coliform	
MFC	180	-24.020	-5.982	decreasing fecal coliform		
6	pH	336	-0.012	-3.164		
	MpH	178	-0.011	-2.703		
	DO % sat	358	0.186	3.390	increasing oxygen	
	MDO % sat	182	0.194	2.643	increasing oxygen	
	Temp	361	0.073	2.154		increasing temperature
	NO3 + NO2	101	-0.008	-2.119	decreasing nitrate/nitrite	
	WQI	98	-0.283	-2.559		decreasing WQI
8	pH	338	-0.008	-2.227		
	DO	359	-0.052	-3.515		decreasing oxygen
	MDO	182	-0.050	-2.810		decreasing oxygen
	DO % sat	360	-0.295	-4.316		decreasing oxygen
	MDO % sat	182	-0.306	-3.127		decreasing oxygen
	Temp	363	0.087	2.302		increasing temperature
	FC	362	-1.927	-4.258	decreasing fecal coliform	
	MFC	182	-4.105	-3.539	decreasing fecal coliform	
	OP	100	0.001	2.788		increasing phosphate
NH3	100	-0.002	-2.900	decreasing ammonia		
11	pH	341	0.017	3.965		
	MpH	178	0.018	3.530		
	DO	361	0.032	2.471	increasing oxygen	
	MDO	182	0.039	2.298	increasing oxygen	
	DO % sat	362	0.249	2.882	increasing oxygen	
	MDO % sat	182	0.286	2.547	increasing oxygen	
	Turb	326	-0.035	-2.280	decreasing turbidity	
	MTB	170	-0.052	-2.352	decreasing turbidity	
	FC	363	-0.128	-2.872	decreasing fecal coliform	
	MFC	180	-0.531	-2.949	decreasing fecal coliform	
	WQI	98	-0.272	-1.991		decreasing WQI
12	pH	315	0.022	5.823		
	MpH	172	0.020	4.054		
	DO	336	-0.053	-2.908		decreasing oxygen
	MDO	181	-0.060	-2.309		decreasing oxygen
	DO % sat	338	-0.336	-2.993		decreasing oxygen
	NO3 + NO2	96	-0.015	-2.959	decreasing nitrate/nitrite	
	OP	96	0.001	4.277		increasing phosphate
	WQI	92	-0.998	-3.550		decreasing WQI

Table 12 (cont.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
13	pH	312	0.016	3.799		
	MpH	163	0.014	3.055		
	NO3 + NO2	97	-0.007	-2.146	decreasing nitrate/nitrite	
	NH3	97	-0.001	-1.967	decreasing ammonia	
14	pH	336	-0.014	-4.233		
	MpH	177	-0.014	-3.482		
	Turb	330	-0.084	-3.572	decreasing turbidity	
	MTB	169	-0.109	-2.993	decreasing turbidity	
	NO2+NO3	99	-0.010	-3.246	decreasing nitrate/nitrite	
	NH3	99	-0.004	-3.333	decreasing ammonia	
	WQI	96	-1.195	-4.096		decreasing WQI
15	pH	339	0.024	6.225		
	MpH	177	0.023	5.255		
	DO % sat	361	0.383	2.790	increasing oxygen	
	MT	182	0.109	2.116		increasing temperature
	MFC	182	3.147	3.181		increasing fecal coliform
	TP	101	0.002	5.580		increasing phosphorus
	OP	101	0.003	4.366		increasing phosphate
	WQI	96	-1.985	-4.920		decreasing WQI
16	pH	337	0.008	2.239		
	MpH	177	0.009	1.995		
	Temp	363	0.074	2.337		increasing temperature
	MT	182	0.115	2.367		increasing temperature
	Turb	331	0.035	2.688		increasing turbidity
	WQI	96	-0.142	-2.084		decreasing WQI
17	pH	337	0.010	2.314		
	MpH	177	0.008	1.643		
	Turb	332	0.094	6.503		increasing turbidity
	MTB	170	0.093	4.692		increasing turbidity
	NO3+NO2	101	0.005	2.448		increasing nitrate/nitrite
	WQI	97	-0.398	-4.600		decreasing WQI
18	pH	339	0.017	4.511		
	MpH	177	0.017	3.341		
	DO	361	-0.028	-2.383		decreasing oxygen
	MDO	182	-0.040	-2.622		decreasing oxygen
	DO % sat	362	-0.155	-2.590		decreasing oxygen
	MDO % sat	182	-0.194	-2.382		decreasing oxygen
	Turb	332	0.030	2.172		increasing turbidity
	FC	362	-0.224	-2.134	decreasing fecal coliform	
WQI	97	-0.301	-3.871		decreasing WQI	
19	DO	348	-0.052	-4.087		decreasing oxygen
	MDO	178	-0.050	-3.301		decreasing oxygen
	DO % sat	349	-0.332	-5.248		decreasing oxygen
	MDO % sat	178	-0.326	-4.429		decreasing oxygen
	Temp	350	0.069	2.000		increasing temperature
	Turb	315	0.068	2.284		increasing turbidity
	NO3+NO2	98	-0.005	-2.001	decreasing nitrate/nitrite	
	WQI	95	-0.504	-3.337		decreasing WQI
20	No significant trends					
21	FC	316	-1.002	-2.588	decreasing fecal coliform	
	MFC	168	-2.751	-2.604	decreasing fecal coliform	

Table 12 (cont.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
22	pH	339	-0.023	-4.230		
	MpH	176	-0.024	-3.378		
	DO	357	-0.033	-3.213		decreasing oxygen
	DO % sat	358	-0.144	-3.099		decreasing oxygen
	MDO % sat	182	-0.133	-2.351		decreasing oxygen
	Temp	360	0.066	2.034		
	FC	359	0.125	3.307		increasing fecal coliform
	MFC	179	0.331	2.666		increasing fecal coliform
23	pH	304	-0.024	-5.613		
	MpH	155	-0.027	-4.211		
	NO3+NO2	94	-0.031	-4.449	decreasing nitrate/nitrite	
24	Turb	329	0.071	5.997		increasing turbidity
	MTB	171	0.067	4.472		increasing turbidity
	FC	360	-0.395	-3.586	decreasing fecal coliform	
	MFC	181	-0.641	-2.887	decreasing fecal coliform	
25	pH	281	-0.018	-3.467		
	MpH	146	-0.020	-2.638		
	Turb	266	0.022	5.231		increasing turbidity
	MTB	138	0.015	2.146		increasing turbidity
28	TKN	76	-0.015	-2.534	decreasing nitrogen	
	NH3	76	-0.004	-3.491	decreasing ammonia	
	WQI	76	-0.332	-3.043		decreasing WQI
29	Turb	320	-0.177	-3.274	decreasing turbidity	
	MTB	170	-0.182	-2.469	decreasing turbidity	
30	Turb	328	-0.166	-3.449	decreasing turbidity	
	MTB	171	-0.232	-2.968	decreasing turbidity	
31	MpH	126	-0.027	-2.475		
	DO	195	-0.171	-3.421		decreasing oxygen
	MDO	130	-0.159	-2.818		decreasing oxygen
	DO % sat	196	-1.469	-3.652		decreasing oxygen
	MDO % sat	132	-1.640	-3.945		decreasing oxygen
	MTB	119	-0.355	-2.406	decreasing turbidity	
	FC	197	-0.912	-2.344	decreasing fecal coliform	
	MFC	130	-2.229	-2.786	decreasing fecal coliform	
32	NH3	59	-0.006	-3.013	decreasing nitrate/nitrite	
	pH					
	MpH					
	DO % sat	358	0.183	2.530	increasing oxygen	
	MDO % sat	183	0.200	1.996	increasing oxygen	
	Temp	363	0.087	2.451		increasing temperature
	FC	364	-0.339	-2.540	decreasing fecal coliform	
	MFC	180	-1.902	-2.637	decreasing fecal coliform	
33	NH3	102	-0.004	-4.549	decreasing ammonia	
	WQI	98	-0.198	-2.334		decreasing WQI
33	Turb	326	-0.308	-2.702	decreasing turbidity	
	MTB	170	-0.394	-2.232	decreasing turbidity	
	FC	363	-0.993	-2.805	decreasing fecal coliform	
	OP	98	0.014	2.892		increasing phosphate

Table 12 (cont.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
34	pH	334	-0.018	-2.964		
	MpH	176	-0.015	-2.150		
	DO % sat	356	0.548	2.496	increasing oxygen	
	Temp	358	0.100	2.700		increasing temperature
	MT	180	0.156	3.733		increasing temperature
	Turb	327	-0.262	-2.934	decreasing turbidity	
	MTB	168	-0.511	-3.442	decreasing turbidity	
	FC	354	-2.193	-2.398	decreasing fecal coliform	
	TP	98	0.006	2.767		increasing phosphorus
	OP	98	0.005	2.646		increasing phosphate
NH3	98	-0.014	-4.824	decreasing ammonia		
35	pH	323	0.030	6.674		
	MpH	173	0.030	5.279		
	Turb	313	-0.466	-2.355	decreasing turbidity	
	MTB	166	-0.672	-2.372	decreasing turbidity	
36	FC	364	1.432	3.057		increasing fecal coliform
	MFC	183	2.297	2.058		increasing fecal coliform
	TP	100	0.005	2.621		increasing phosphorus
	NH3	100	-0.013	-4.119	decreasing ammonia	
37	FC	363	5.454	3.538		increasing fecal coliform
	MFC	181	8.573	3.091		increasing fecal coliform
	OP	100	0.010	2.456		increasing phosphate
38	FC	357	3.443	3.015		increasing fecal coliform
	MFC	181	5.682	2.558		increasing fecal coliform
	NO3+NO2	100	0.007	2.554		increasing nitrate/nitrite
	TP	100	0.019	2.566		increasing phosphorus
	OP	100	0.027	5.201		increasing phosphate
39	pH	335	-0.008	-2.325		
	OP	100	0.002	4.005		increasing phosphate
40	Turb	327	0.234	1.970		increasing turbidity
	TP	99	0.0022	2.989		increasing phosphorus
41	pH	339	0.012	3.472		
	MpH	177	0.013	3.046		
	MDO	180	0.072	2.127	increasing oxygen	
	MDO % sat	182	0.621	1.992	increasing oxygen	
	MT	181	0.090	2.010		increasing temperature
	Turb	333	0.542	7.656		increasing turbidity
	MTB	169	0.493	5.168		increasing turbidity
	FC	363	2.541	4.054		increasing fecal coliform
	MFC	181	3.305	3.243		increasing fecal coliform
	TP	101	0.005	4.266		increasing phosphorus
	OP	101	0.002	2.512		increasing phosphate
	NH3	101	-0.009	-2.868		increasing ammonia
TSS	101	0.000	2.398		increasing susp. solids	
42	pH	337	0.017	4.945		
	MpH	174	0.018	4.187		
	DO	360	0.164	7.245	increasing oxygen	
	MDO	179	0.163	5.377	increasing oxygen	
	DO % sat	361	1.392	8.432	increasing oxygen	
	MDO % sat	181	1.329	6.476	increasing oxygen	
	Turb	331	0.098	5.415		increasing turbidity

MTB	168	0.099	3.624	increasing turbidity
FC	358	1.862	4.070	increasing fecal coliform
MFC	180	2.552	3.274	increasing fecal coliform
OP	101	0.001	2.080	increasing phosphate

Table 12 (cont)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
43	Turb	325	0.477	5.982		increasing turbidity
	MTB	165	0.294	2.739		increasing turbidity
	FC	352	0.420	1.995		increasing fecal coliform
	MFC	176	2.108	2.215		increasing fecal coliform
	TP	98	0.008	2.867		increasing phosphorus
	WQI	94	-0.857	-2.095		decreasing WQI
44	pH	296	-0.023	-4.532		
	MpH	155	-0.023	-3.358		
	DO	314	-0.104	-3.171		decreasing oxygen
	MDO	159	-0.093	-2.402		decreasing oxygen
	DO % sat	317	-1.155	-3.496		decreasing oxygen
	MDO % sat	161	-0.997	-2.307		decreasing oxygen
	Turb	288	0.274	2.083		increasing turbidity
	FC	317	3.684	2.922		increasing fecal coliform
	MFC	160	7.231	2.850		increasing fecal coliform
	TP	80	0.009	4.049		increasing phosphorus
WQI	73	-0.311	-3.699		decreasing WQI	
45	pH	322	0.042	7.188		
	MpH	175	0.038	4.926		
	Turb	318	-0.213	-3.673	decreasing turbidity	
	MTB	166	-0.236	-2.612	decreasing turbidity	
	TSS	96	-0.387	-2.336	decreasing susp. solids	
46	pH	287	0.038	5.417		
	MpH	150	0.036	4.041		
	DO % sat	302	-0.140	-2.677		decreasing oxygen
	MDO % sat	155	-0.124	-2.284		decreasing oxygen
	Turb	279	-0.296	-3.827	decreasing turbidity	
	MTB	145	-0.325	-2.910	decreasing turbidity	
NO3+NO2	89	0.003	2.718		increasing nitrate/nitrite	
47	pH	340	-0.036	-9.344		
	MpH	177	-0.042	-7.217		
	MT	181	0.050	2.814		increasing temperature
	MFC	180	0.206	2.748		increasing fecal coliform
	NO3+NO2	101	0.007	3.412		increasing nitrate/nitrite
	TP	101	0.001	3.421		increasing phosphorus
	OP	101	0.003	4.250		increasing phosphate
	NH3	101	-0.001	-2.040		increasing ammonia
	WQI	85	-0.395	-2.338		decreasing WQI
48	MT	181	0.067	2.428		increasing temperature
	TKN	100	-0.015	-2.629	decreasing nitrogen	
	TP	101	0.0010	3.161		increasing phosphate
	NH3	101	-0.005	-6.116	decreasing ammonia	
	WQI	95	-0.461	-2.158		decreasing WQI

Notes: N = Number of data points

Slope = Magnitude and direction of trend in original units per year

Z = Calculated Kendall's statistic, Z > 1.960 or < -1.960 means statistically significant trend at 95% confidence level

M = Monthly, e.g. MDO represents the Kendall's statistic calculated on monthly means instead of individual biweekly data, in order to control for autocorrelation

Trends analysis results and discussion

Trends were calculated for 19 measured or calculated parameters (such as monthly averages) at each site, for a total of 760 tests. Of those, 248 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving (e.g. increased dissolved oxygen, reduced temperature) made up 77 of the significant trends. Deleterious trends (e.g. reduced dissolved oxygen, increased nutrients) accounted for 120 of the significant trends. The remaining 51 trends were increasing or decreasing pH or monthly pH. A value judgment was not made for those trends as their implications are not clear at this point. There were also statistically significant nutrient trends where the slope was zero that are not included in this count. These results show an increase in improving trends compared to 2016 (61 improving trends in 2016) and a decrease in deleterious trends (120 in 2016)

Because the overall list of significant trends included many redundant items (e.g. biweekly dissolved oxygen and monthly average dissolved oxygen), an abbreviated list, using only the unique trends involving the monthly averages (for pH, dissolved oxygen, temperature, and turbidity) plus the nutrient data and total suspended solids which were already monthly or quarterly, was also looked at for summary statistics. We eliminated any significant pH trends, and nutrient trends with a slope of zero. This data set included 9 parameters at 40 sites for a total of 360 analyses. In this selected data set, there were 125 significant trends, with 47 trends identified as representing improved conditions and 78 identified as deleterious. The proportion of improving trends was about the same in the ag sites (35%) as in the non-ag sites (36%). In the Samish Basin, where the focus of the Clean Samish Initiative has been the reduction of fecal coliform pollution, there were four sites with improving trends in fecal coliform, three sites with worse fecal coliform, and four sites with no significant trend in fecal coliform. The improving sites were all streams tributary to the Samish River, while the worsening sites were all drainage ditches.

Last year's report indicated 35 improving and 90 declining trends for this data set. It is important to remember that these statistics are calculated over the life of the study, so while the 2017 water year may account for the differences between current and past results, the calculated trends are representative of the entire study from October 2003 to September 2017.

At the end of the 2012 water year, twenty-two of the 40 stations showed a significant declining trend in monthly mean water temperature over the life of the study. By the end of the 2015 water year, no stations showed a significant declining trend in monthly mean water temperature, and five sites had significantly increasing monthly mean water temperature. Further increasing temperature trends were found with the inclusion of the 2016 water year data, so by this point there were 16 sites with significantly increasing water temperature. By 2017, it was back down to six sites with increasing temperature. There were no sites with declining temperature. Temperature increases are likely a sign of climate changes since there are no known declines in riparian cover in the study area.

Five of the 40 sites showed a significant increasing trend in mean monthly dissolved oxygen over the life of the study through 2017, three more than last year. There were six stations with a declining trend in dissolved oxygen, a big decrease from the increase from 14 sites at the end of 2016.

Seven sites showed a significantly decreasing trend in monthly fecal coliform, including four sites in the Samish basin, while 10 sites had significantly increasing fecal coliform. This is similar to last year. Three of the sites with increasing fecal coliform were drainage ditches in the Samish Basin.

No sites showed a significant increasing trend in Water Quality Index (WQI), which was also the case last year. Fourteen sites showed a decreasing trend in WQI, three more than last year. This is an indicator that overall water quality could be declining. Some of that decline could be due to three consecutive years of summer drought bringing high temperatures and lower dissolved oxygen.

Many of the deleterious trends were increases in nutrient values. Increased nutrients can lead to excessive blooms of algae, which can upset food webs and lead to dissolved oxygen depletion. In extreme cases, ammonia levels can be high enough to produce direct toxicity. Ammonia toxicity is tied to pH and temperature, so the toxicity of a particular reading must be assessed individually. A spot check of Skagit County ammonia data indicates that observed levels in the drainage infrastructure may occasionally approach chronically toxic levels. There were also many cases where a statistically significant trend in nutrient values was found, but the calculated slope for the nutrient was zero. This is seen as a statistical anomaly based on the number of “ties” in the data, in our case samples that had no detectable nutrients (Younos, 2001). These cases were not included in the tabulation of improving or deleterious trends.

Trend statistics are tools to help us understand changing conditions in our watercourses, but do not completely describe the condition of a watercourse. Many of the sites with no significant trends or improving trends in water quality parameters still do not meet state water quality standards, and therefore still qualify as areas of concern. Many Skagit County sites remain on Ecology’s Impaired Waters list. As previously discussed, high fecal coliform levels in the Samish Bay watershed have led to closures of shellfish beds and loss of revenue for shellfish growers. Dissolved oxygen and temperature conditions are still substandard in many watercourses, resulting in less than ideal rearing conditions for salmonids and other aquatic life.

Data Quality

This section details the steps taken to ensure high quality data in the Skagit County Monitoring Program, and the results of quality control checks.

Sampling Plan (Quality Assurance Project Plan, or QAPP)

The Skagit County Monitoring Program operates under a QAPP approved by Ecology in 2003. This plan details sampling strategies, equipment to be used, and all other aspects of the sampling

program, and Ecology approval was required in order for Skagit County to access grant funds. The plan forms the basis for all sampling activities. The plan may be viewed at:

<https://www.skagitcounty.net/PublicWorksSurfaceWaterManagement/Documents/QAplanfinal103003.pdf>

Quality Control Measures

Field meter calibration - Field meters are calibrated according to manufacturer's recommendations, or more often as needed.

The turbidity meter (Lamotte Model 2020we) is calibrated the afternoon before or the morning of each sampling trip, and the reading before calibration is recorded. For 41 recorded calibrations during this period, the average deviation from the calibration standard was 1.4%. This reflects meter drift between the calibration the afternoon before the sampling trip and the next calibration a week later. It is likely that meter drift during the sampling day is substantially less than 1.4%.

The pH meter (Hanna Instruments Model 8314) is calibrated on the morning of each sampling trip, then left on throughout the sampling trip. The pH meter is recalibrated during the trip if questionable results were obtained. The meter rarely deviated more than 0.02 pH units from the calibration standard.

The dissolved oxygen/temperature/conductivity meter (YSI Model 2030 Pro) is calibrated for dissolved oxygen using the built-in calibration chamber (water-saturated air). The meter is recalibrated to local elevation at each sample site. For several weeks during the 2005 water year, Skagit County recorded the meter deviation from the calibration target for those occasions when the deviation exceeded 1%. During that period, meter deviation exceeded that value 89 times out of 180 sample sites (49%). Average deviation for those 89 calibrations was 2.6%. Since the meter was recalibrated at each sample site, the actual meter drift before use was something less than 1%.

The dissolved oxygen meter probe is deployed in areas with sufficient current (> 0.5 fps) to produce reliable results, or the probe is stirred to produce adequate velocity across the membrane. Samples for pH and turbidity are obtained from the thalweg of the stream with sample containers rinsed at least twice with sample water, and are analyzed immediately.

Lab Samples

Laboratory samples are collected using clean equipment and proper procedures. Samples for nutrient and suspended solids analysis are collected with a sampling wand from the thalweg of the watercourse, and care is taken to prevent oversampling of the surface film or disturbing the bottom. The sampling container is rinsed twice with the water to be sampled. The sample is then obtained and poured into the bottles provided by the contract lab, Edge Analytical of

Burlington, WA, an Ecology-certified laboratory. Samples are capped and placed in a cooler with water ice until they are picked up by the lab on the same day.

Samples for fecal coliform are collected directly into sterile fecal coliform bottles and transported under ice to the laboratory within eight hours of collection.

Quality Control Review

Data from field sheets and lab reports is entered into the Skagit County Water Quality Database. Once all the data for a given date is entered, a printout from the database is produced and compared to the original field and lab data sheets. Any data entry errors are then corrected in the database.

Personnel

The Project Manager has over 30 years of experience monitoring water quality in the freshwater environment. The Project Manager is present on over 80% of the sampling trips and personally trained all other personnel involved.

Duplicate Analysis

Because water quality is constantly changing in streams, duplicate analysis is not attempted for parameters determined in the field – dissolved oxygen, temperature, conductivity, salinity, and turbidity. Instead, we rely on maintenance and calibration of the field meters according to manufacturer's recommendations and experienced field staff to produce reliable field data.

Duplicate samples are collected for fecal coliform at a 20% rate and for selected nutrients at a 10% rate. Selected nutrient duplicates (total phosphorus, orthophosphate, nitrate, and/or ammonia) are intended to provide a precision estimate for all the nutrient analyses.

Table 13 summarizes the results of the duplicate analyses for the 2017 water year. Variability in fecal coliform and nitrate were above target levels, but similar to what was seen in previous years. The high nitrate value was greatly influenced by a single sample where the main sample was far higher than the duplicate.

The high variability of the fecal coliform results is at least partially due to the use of the Most Probable Number (MPN) analysis technique (Don Lennartson, Washington State Department of Health (retired), personal communication). This method was chosen for the Skagit County Monitoring Program because the Skagit County Health Department laboratory was certified for the method, and because it is reportedly more reliable for samples with high turbidity, which are often encountered in the Skagit County Monitoring Program (Michaud 1991). We continued using MPN when we switched to Edge Analytical in 2009 to maintain data comparability. Fecal coliform variability in the Skagit County Monitoring Program, although higher than the initial target level, is similar to that seen in other studies in Washington (Paul Pickett, Washington State

Department of Ecology, personal communication). The reasons for the higher nitrate variability are unknown at this point.

**Table 13. 2016 Data Quality Results
Coefficients of Variation for parameter with duplicates in the
Skagit County Monitoring Program, 2017 Water Year**

Parameter	N	Coefficient of Variation (CV %)	
		2017 Results	Target CV (%)¹
Fecal Coliform	205	41	33
Total Phosphorus	12	7	10 ²
Orthophosphate	4	5	10 ²
Nitrate	12	16	10 ²
Ammonia	4	0	10 ²

¹ Target precision as listed in QAPP

² 10% CV target was listed for all nutrients

Data Quality Summary

The Skagit County Monitoring Program produces reliable data that is suitable for the intended purposes, including assessment of current conditions and trends. Data is collected according to an Ecology-approved Quality Assurance Project Plan. Field parameters are analyzed using calibrated meters and consistent sampling methods. Laboratory samples are handled correctly and analyzed in Ecology-certified laboratories. The database is rechecked for data entry errors. Experienced personnel are involved with every aspect of data collection and analysis. The information collected in the Skagit County Monitoring Program should be considered high quality data.

Skagit County Water Quality Monitoring for the Clean Samish Initiative

Overview

The Clean Samish Initiative was established by Ecology in the fall of 2008 to foster cooperation between local, state, tribal, and federal agencies, non-governmental groups, and citizens to address fecal coliform pollution in the Samish Bay Watershed. Excess fecal coliform pollution in the Samish River and other bay tributaries has resulted in numerous closures of the commercial shellfish beds in Samish Bay. The Clean Samish Initiative participants (over 20 organizations) developed a work plan that included education and outreach, detailed water quality sampling to locate pollution sources, referrals of landowners to resource agencies for pollution abatement, and enforcement of water quality and land use regulations if necessary. Skagit County applied for and received EPA funding in 2010 to conduct a Pollution Identification and Correction (PIC) project in the Samish Basin, incorporating Clean Samish work plan elements into a program designed to locate and eliminate fecal coliform pollution in the Samish Basin.

The Clean Samish Initiative grew out of Ecology's TMDL activities in the Samish Basin. Ecology sampling demonstrated that the Samish River was the largest source of fecal coliform bacteria to Samish Bay. While some of the independent Samish Bay tributaries (e.g. Edison Slough and Colony Creek) and agricultural drainages also contribute bacterial pollution to Samish Bay, the comparatively high discharge rate of the river combined with occasional high coliform counts meant that the river was and continues to be the most important pollution source for Samish Bay.

Activities

Numerous PIC water quality sampling, education, and outreach activities continued during the 2017 water year, and will be summarized in a separate Clean Samish Initiative report. In addition, County staff, in cooperation with the Department of Ecology, have conducted site visits in areas where water quality sampling results indicate pollution sources are present. These visits form the core of the PIC program and are summarized in the separate quarterly Clean Samish reports.

Water quality sampling in the Samish consists of storm event sampling and investigatory sampling, in addition to the ambient sampling reported here. Storm event sampling consists of watershed-wide sampling during storm events in order to characterize the event and locate stream reaches with elevated fecal coliform counts. Investigatory sampling involves samples that may be taken in conjunction with investigations of specific areas or properties.

Recent sampling results for all sites, including those in the Samish Basin, are available at this site:

<http://nras.maps.arcgis.com/apps/MapJournal/index.html?appid=d191d07f2cbf47e9a54e78c78c06c1a8>

Annual Report Summary

The Skagit County Monitoring Program completed the 14th water year of sampling in September 2017. Standard water quality parameters were collected biweekly at 40 sites in watercourses in

both agricultural and non-agricultural areas. Results indicated that many watercourses did not meet state water quality standards for one or more parameters. Trend analysis revealed a pattern of both improving and deteriorating trends, with more deleterious trends evident in the past three years. Skagit County has taken a leading role in addressing water quality problems in the area through the Clean Samish Initiative and its Pollution Identification and Correction program.

The program was substantially funded through the 2008 water year by a Centennial Clean Water Grant from the Washington State Department of Ecology. Currently, all project funding comes from Skagit County's Clean Water Program.



Figure 3. Chinook salmon in the Samish River

References

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