Skagit County Monitoring Program

Annual Report - 2007 Water Year (October 2006 – September 2007)

Lake Creek near Highway 9

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April 2008

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This report is available online at www.skagitcounty.net/SCMP

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Skagit County Water Quality Monitoring Program – 2007 Water Year Annual Report
Executive Summary

Skagit County has completed the fourth 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 natural resources 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 expected to continue at least through September 2009. Reports are published after each water year (October 1- September 30). This report is the fourth annual report, for the 2007 water year.

The program is supported through 2008 by a Centennial Clean Water grant from the Department of Ecology. All monitoring is governed by an Ecology-approved Quality Assurance Project Plan. Skagit County data is considered suitable for inclusion in the state Environmental Information Management database.

Data collected during this project indicate 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. 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 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 parameters 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 embarked on trends monitoring as a method to determine whether water quality conditions are deteriorating in the county. Trends analysis for the first four years of the program reveals a mixed pattern of beneficial and deleterious trends both inside and outside of the agricultural areas. It is apparent from this mixed pattern that water quality problems in Skagit County need to be addressed by each individual watershed.

Skagit County data has also proved useful to Ecology in their water cleanup (TMDL) efforts. County staff also participate in local and regional technical groups and in training of volunteer monitoring groups. Staff give numerous presentations throughout the year to interested organizations.

The Skagit County Water Quality Monitoring Program has collected four years of high-quality data. The program is scheduled to continue at least through the 2009 water year. Questions on the program can be addressed to Rick Haley at rickh@co.skagit.wa.us or 360-336-9400.

Skagit County Monitoring Program Annual Report

2007 Water Year
(October 2006-September 2007)

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 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 sampling 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 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 2007 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.

On October 8, 2007, the Skagit County Commissioners passed Resolution R20070499. This resolution reiterated the need to conduct the triennial review despite the County's inability to make changes to the Ongoing Agriculture portion of the Critical Areas Ordinance because of SSB 5248. Another portion of the resolution required Skagit County Public Works to seek an outside review of the water quality monitoring program by a "credentialed academic." Skagit County has contracted with the Washington State Water Research Center to conduct the review and produce a report in the spring of 2008. This report is expected to cover data collection, analysis, next steps to be taken, and respond to comments generated by the triennial review.

A public workshop for the triennial review was held on December 6, 2007. Public testimony about the water quality monitoring program was received along with comment letters. Comments on the water quality program included suggestions for additional statistical analysis

and the observation that the data show that most Skagit County watercourses in the program do not meet state water quality standards. The materials presented and a summary of comments submitted are available on the Skagit County web pages at:

http://www.skagitcounty.net/Common/Asp/Default.asp?d=SalmonStrategy&c=General&p=adaptmanagement.htm

The comments received during the triennial review were forwarded to the Washington State Water Research Center. Any changes to the monitoring program, especially in the area of data analysis, will be considered after the review is complete.

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. While it was not specifically designed to determine compliance of the watercourses with state water quality standards, the data is suitable for such determinations.

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 Total Maximum Daily Load (TMDL) 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.

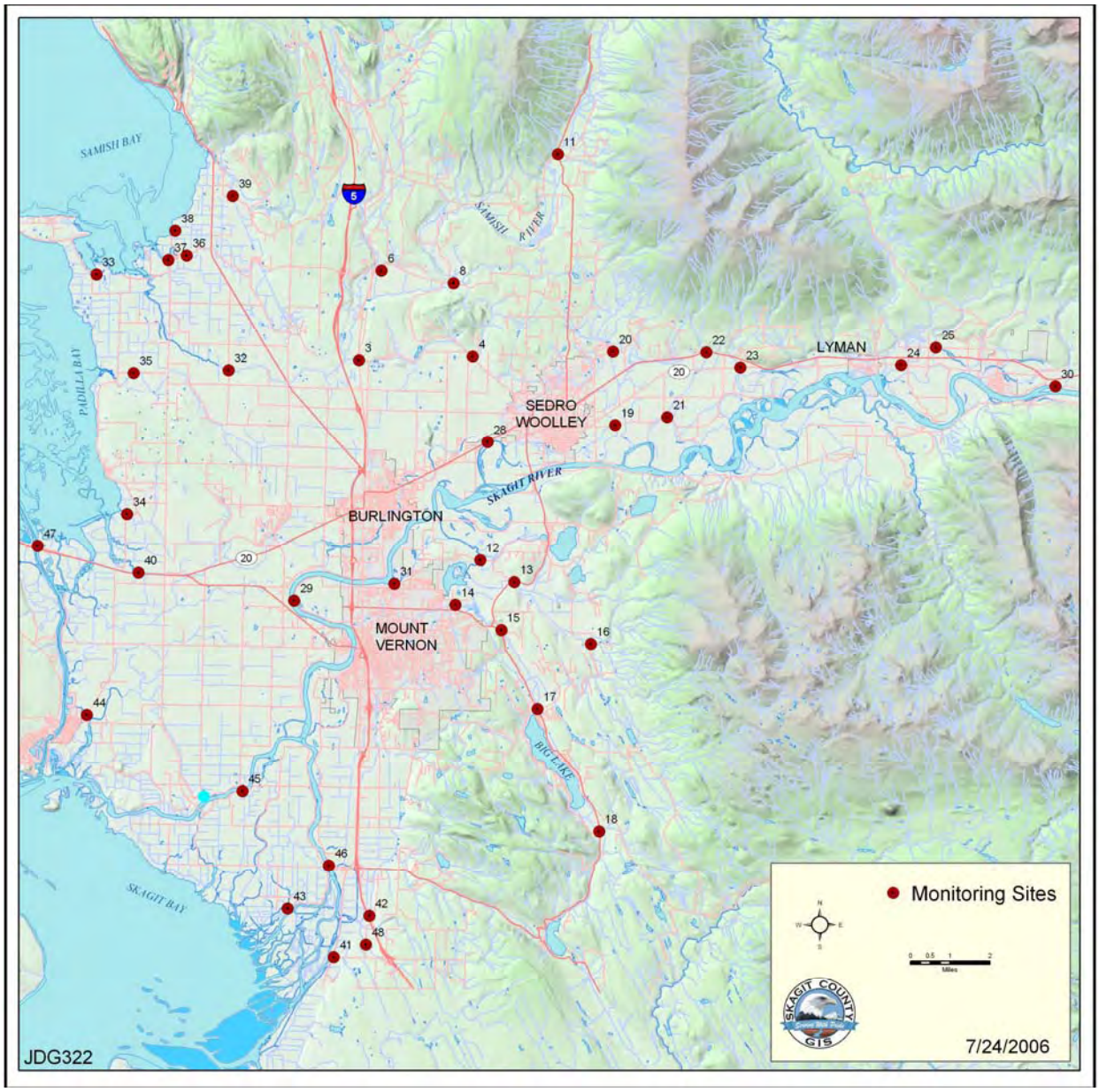


Figure 1. Sample Sites in the Skagit County Monitoring Program
Refer to Tables 1 and 2 for site locations and descriptions.

Table 1. Sample Sites for Skagit County Monitoring Program

Site Number	Watercourse	Location	Latitude	Longitude	Site Type[1]
3	Thomas Ck	Old Hwy 99 N	48.526	-122.339	3
4	Thomas Ck	F&S Grade	48.528	-122.276	2
6	Friday Ck	Prairie Rd	48.559	-122.327	4
8	Swede Ck	Grip Rd	48.555	-122.287	3
11	Samish R	State Route 9	48.602	-122.231	1
12	Nookachamps Ck	Swan Rd	48.454	-122.270	3,6
13	E.F. Nookachamps Ck	State Route 9	48.446	-122.251	3,6
14	College Way Ck	College Way	48.436	-122.286	4
15	Nookachamps Ck	Knapp	48.429	-122.258	2,6
16	E.F. Nookachamps Ck	Beaver Lake Rd	48.424	-122.208	1,6
17	Nookachamps Ck	Big Lake Outlet	48.400	-122.237	1,6
18	Lake Ck	State Route 9	48.356	-122.202	1,6
19	Hansen Ck	Hoehn Rd	48.504	-122.197	3,6
20	Hansen Ck	Northern State	48.531	-122.199	1,6
21	Coal Ck	Hoehn Rd	48.507	-122.169	3
22	Coal Ck	Hwy 20	48.531	-122.149	1
23	Wiseman Ck	Minkler Rd	48.526	-122.130	2
24	Mannser Ck	Lyman Hamilton Hwy	48.528	-122.041	2
25	Red Cabin Ck	Hamilton Cem Rd	48.534	-122.023	2
28	Brickyard Ck	Hwy 20	48.497	-122.268	4
29	Skagit R	River Bend Rd	48.439	-122.372	5,6
30	Skagit R	Cape Horn Rd	48.521	-121.960	5
31	Drain Dist 20 floodgate	Francis Rd	48.445	-122.317	3
32	Samish R	Thomas Rd	48.521	-122.410	3
33	Alice Bay Pump Station	Samish Island Rd	48.555	-122.483	3
34	Noname 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	-122.435	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 Ck	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	Summers Drive	48.366	-122.419	3
	Sullivan Slough[2]	La Conner-Whitney Rd	48.395	-122.485	3
45	Skagit R – North Fork	Moore Rd	48.364	-122.416	5,6
46	Skagit R – South Fork	Fir Island Rd	48.342	-122.349	5,6
47	Swinomish Channel	County Boat Launch	48.455	-122.512	7
48	Fisher Ck	Franklin Rd	48.320	-122.328	3,6

[1]See Table 2 for site type descriptions

[2]Site 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 Sites[1]
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 ag 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

[1]Some 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 three years of this program have been reported previously (Skagit County 2004c, Skagit County 2006, Skagit County 2007). This report contains data and analysis from water years 2004, 2005, 2006, and 2007.

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. On alternate visits (every four weeks), additional water samples are obtained for quantifying plant nutrients (total nitrogen, ammonia, nitrate, nitrite, total phosphorus and orthophosphate), and total suspended solids. Stream discharge is measured at selected sites during the alternate visits.

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 specially-designed 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 - All weekly sampling trips were conducted on schedule during the 2007 water year, beginning on October 4, 2006. Sampling normally took place on Tuesdays except during holiday weeks (Thanksgiving and Christmas), when sampling took place on Mondays to accommodate laboratory schedules. Occasionally samples are taken on different days because of flooding or other acts of nature. Sampling activities are illustrated in Figure 2.

Grant Activity - Centennial Clean Water grants require a Quality Assurance Program Plan (QAPP). A draft QAPP was submitted to the Department of Ecology in September, 2003. Ecology comments were incorporated into the document and a final QAPP was submitted to Ecology in October 2003. Ecology accepted the QAPP and a final grant agreement was signed by Ecology and the County Commissioners in January 2004. At this point expenditures on the Skagit County Monitoring Program became grant-eligible, with reimbursement from the Centennial Clean Water Grant program at a 75% rate.

The grant requires quarterly reports and annual data submissions. Skagit County has submitted quarterly reports through all quarters of 2007. The first annual data submission was made in January 2005. Another submission was made in January 2006.

Figure 2. Mike See obtains a sample at Sullivan Slough (Site 44).

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 discharged 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.

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 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.

Temperatures were measured with Stowaway Tidbit® dataloggers 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. Temperature was also measured at each sampling visit.

Several of the dataloggers were missing at the end of the monitoring period. Some had apparently been lost due to channel changes associated with heavy rains in late summer, while others may have been vandalized.

Table 3 shows the daily and 7-day average maximums (7-DAM) for the 2007 water year for those stations where temperature data was obtained, compared to the state standard for that station. The state temperature standards are based on the 7-DAM so that occasional abnormally hot days do not result in temperature standard violations. 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 were held to a 7-DAM standard of 17.5ºC, but with the revised standards these streams must now meet a 7-DAM standard of 16ºC. There were no changes to other streams in the county. Currently, Sites 3-4, 28, and 31-44 are held to the 17.5 ºC standard, while all other sites are held to the 16ºC standard. Most watercourses in the Skagit County Monitoring Program exceeded state temperature standards at some point during the summer.

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 13ºC limit from February 15 to June 15 to protect steelhead spawning and egg incubation. The Skagit River upstream from Sedro-Woolley has a 13ºC limit from September 1 through May 15 to protect spawning and egg incubation for several salmonids.

Table 4 summarizes temperature data for the four years of the study. Graphs on the pages following Table 4 illustrate daily temperature maximums and minimums for the sample sites with temperature data in the Skagit County Monitoring Program. These graphs show data collected during the critical summer period. Temperature data collected during site visits for the non-summer months can be found in Appendix A.

Each graph shows daily high and low temperatures with a line representing the state water quality standard for that water body. The state standard is actually based on the 7-day average maximum temperature, so individual readings over the standard may not constitute a water quality standards violation.

As mentioned above, state temperature standards were revised in late 2006 for several streams in the Skagit County Monitoring Program. The lines on the graphs representing the standards were placed at the current standard temperature for that water body.

Table 3. 2007 Temperature Results
Maximum temperature and relationship to state standards for watercourses in the Skagit County Monitoring Program, 2007 Water Year

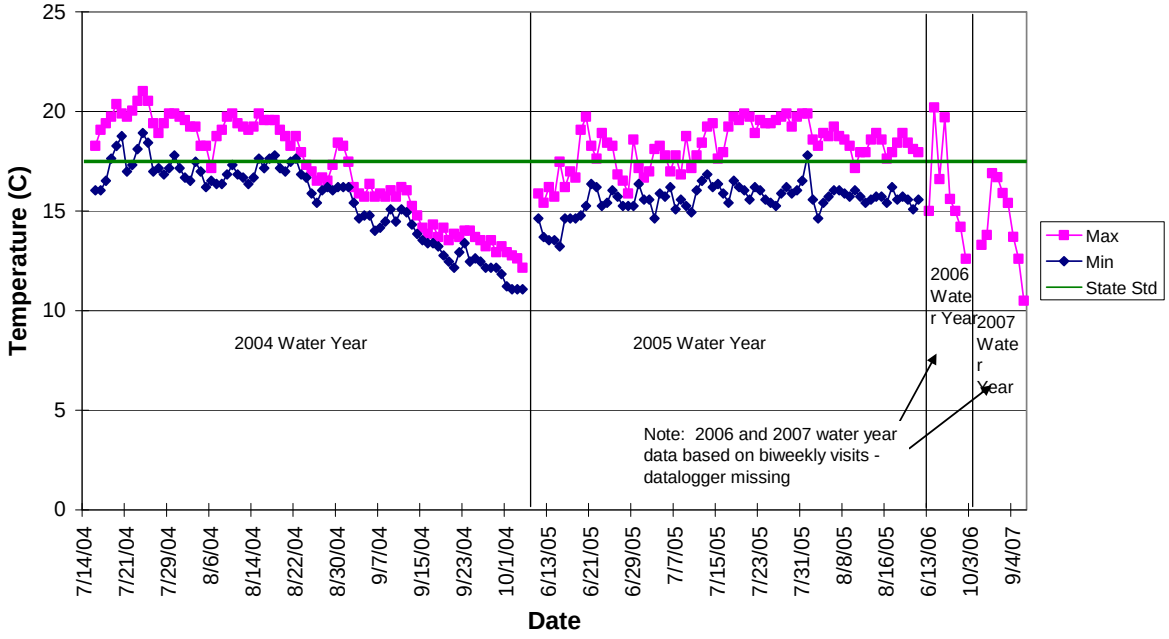
Site Number	Watercourse	Location	Daily Maximum (°C)	Maximum 7-DAM (°C)	State Std[1] (°C)
3	Thomas Ck	Old Hwy 99 N	16.9	N/A	17.5
4	Thomas Ck	F&S Grade	20.3	18.9	17.5
6	Friday Ck	Prairie Rd	22.8	20.8	16.0
8	Swede Ck	Grip Rd	19.7	18.6	16.0
11	Samish R	State Route 9	15.6	14.6	16.0
12	Nookachamps Ck	Swan Rd	21.3	N/A	16.0
13	E.F. Nookachamps Ck	State Route 9	21.0	20.1	16.0
14	College Way Ck	College Way	18.6	18.1	16.0
15	Nookachamps Ck	Knapp	24.0	22.9	16.0
16	E.F. Nookachamps Ck	Beaver Lake Rd	21.6	20.1	16.0
17	Nookachamps Ck	Big Lake Outlet	25.9	25.1	16.0
18	Lake Ck	State Route 9	19.5	18.4	16.0
19	Hansen Ck	Hoehn Rd	22.5	20.6	16.0
20	Hansen Ck	Northern State	19.5	18.0	16.0
21	Coal Ck	Hoehn Rd	18.9	18.2	16.0
22	Coal Ck	Hwy 20	18.4	17.3	16.0
23	Wiseman Ck	Minkler Rd	15.1	N/A	16.0
24	Mannser Ck	Lyman Hamilton Hwy	15.5	13.9	16.0
25	Red Cabin Ck	Hamilton Cem Rd	17.3	16.0	16.0
28	Brickyard Ck	Hwy 20	N/A	N/A	17.5
29	Skagit R	River Bend Rd	14.8	N/A	16.0
30	Skagit R	Cape Horn Rd	16.1	15.3	16.0
31	Drain Dist 20 floodgate	Francis Rd	N/A	N/A	17.5
32	Samish R	Thomas Rd	21.7	19.9	17.5
33	Alice Bay Pump Station	Samish Island Rd	23.1	N/A	17.5
34	Noname Slough	Bayview-Edison Rd	25.7	22.9	17.5
35	Joe Leary Slough	D'Arcy Rd	20.8	18.9	17.5
36	Edison Slough at school	W. Bow Hill Rd	29.6	27.6	17.5
37	Edison Pump Station	Farm to Market Rd	29.1	27.9	17.5
38	North Edison Pump St.	North Edison Rd	22.4	N/A	17.5
39	Colony Ck	Colony Rd	16.5	N/A	17.5
40	Big Indian Slough	Bayview-Edison Rd	25.4	22.0	17.5
41	Maddox Slough/Big Ditch	Milltown Rd	24.2	22.7	17.5
42	Hill Ditch	Cedardale Rd	24.7	20.2	16.0
43	Wiley Slough	Wylie Rd	20.4	N/A	17.5
44	Sullivan Slough	La Conner-Whitney Rd	31.0	26.6	17.5
45	Skagit R – North Fork	Moore Rd	17.1	16.4	17.5
46	Skagit R – South Fork	Fir Island Rd	16.0	N/A	17.5
47	Swinomish Channel	County Boat Launch	15.0	N/A	17.5
48	Fisher Ck	Franklin Rd	15.6	14.7	16.0

[1]Washington State Water Quality Standard per WAC 173-201A
[2]Dry during summer temperature monitoring
[3]Temperatures recorded during biweekly sampling – no continuous datalogger

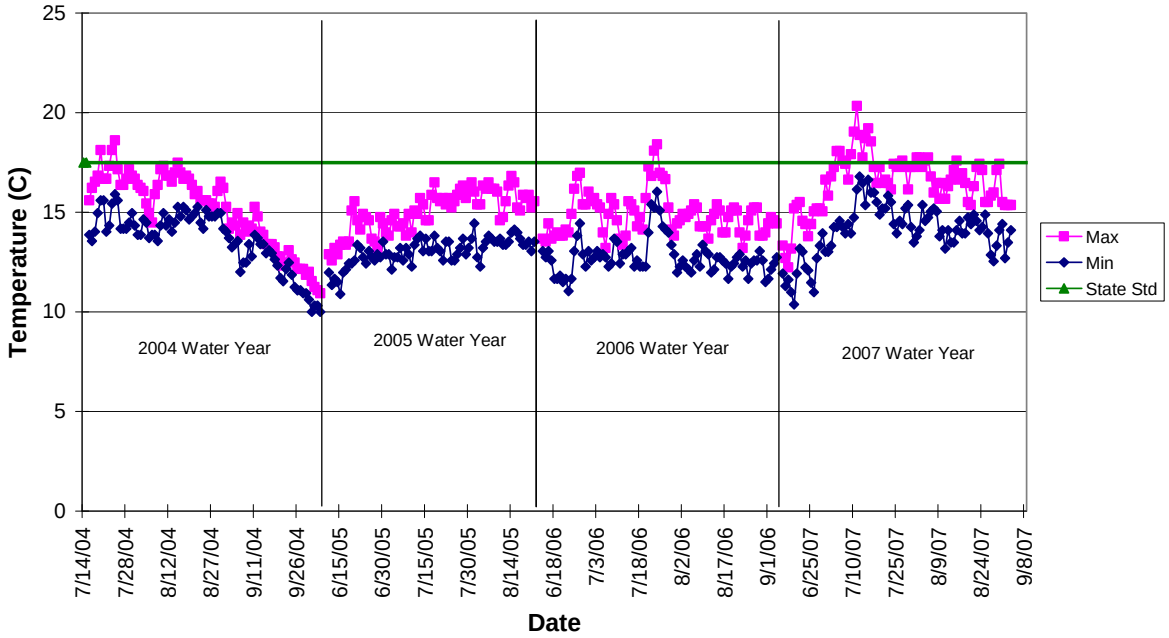
Table 4. Four-Year Temperature Results Summary
Maximum 7-day average maximum temperatures for the four years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	Max. 7DAM (°C) 2004	2005	2006	2007
3	Thomas Ck	Old Hwy 99 North	20.3	19.7	N/A	N/A
4	Thomas Ck	F&S Grade	17.5	16.1	17.3	18.9
6	Friday Ck	Prairie Rd	21.0	19.6	21.3	20.8
8	Swede Ck	Grip Rd	19.1	17.5	19.3	18.6
11	Samish R	State Route 9	16.0	16.4	15.8	14.6
12	Nookachamps Ck	Swan Rd	24.2	N/A	20.6	N/A
13	E.F. Nookachamps Ck	State Route 9	21.5	19.8	21.6	20.1
14	College Way Ck	College Way	N/A	17.2	18.4	18.1
15	Nookachamps Ck	Knapp	22.4	21.6	23.2	22.9
16	E.F. Nookachamps Ck	Beaver Lake Rd	21.3	19.8	20.6	20.1
17	Nookachamps Ck	Big Lake Outlet	24.9	24.6	25.1	25.1
18	Lake Ck	State Route 9	18.8	17.6	18.4	18.4
19	Hansen Ck	Hoehn Rd	21.0	19.7	20.7	20.6
20	Hansen Ck	Northern State	19.6	18.9	19.0	18.0
21	Coal Ck	Hoehn Rd	18.6	17.3	18.2	18.2
22	Coal Ck	Hwy 20	N/A	N/A	17.5	17.3
23	Wiseman Ck	Minkler Rd	16.6	20.1	21.3	N/A
24	Mannser Ck	Lyman Hamilton Hwy	15.9	14.6	14.3	13.9
25	Red Cabin Ck	Hamilton Cem Rd	16.0	N/A	17.6	16.0
28	Brickyard Ck	Hwy 20	N/A	N/A	N/A	N/A
29	Skagit R	R Bend Rd	N/A	N/A	N/A	N/A
30	Skagit R	Cape Horn Rd	N/A	N/A	14.9	15.3
31	Drain Dist 20 near floodgate	Francis Rd	N/A	N/A	N/A	N/A
32	Samish R	Thomas Rd	20.5	19.1	20.7	19.9
33	Alice Bay Pump Station	Samish Island Rd	21.4	26.2	27.1	N/A
34	Noname Slough	Bayview-Edison Rd	N/A	22.4	22.8	22.9
35	Joe Leary Slough	D'Arcy Rd	22.8	19.5	24.1	18.9
36	Edison Slough at school	W. Bow Hill Rd	30.1	29.8	29.3	27.6
37	Edison Pump Station	Farm to Market Rd	27.4	27.1	26.8	27.9
38	North Edison Pump Station	North Edison Rd	15.9	N/A	28.1	N/A
39	Colony Ck	Colony Rd	20.4	19.0	19.7	N/A
40	Big Indian Slough	Bayview-Edison Rd	N/A	20.2	24.2	22.0
41	Maddox Slough/Big Ditch	Milltown Rd	25.7	N/A	25.7	22.7
42	Hill Ditch	Cedardale Rd	N/A	23.8	24.6	20.2
43	Wiley Slough	Wylie Rd	22.6	N/A	N/A	N/A
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	25.4	22.6	22.3	26.6
45	Skagit R – North Fork	Moore Rd	17.5	18.3	17.6	16.4
46	Skagit R – South Fork	Fir Island Rd	19.1	N/A	N/A	N/A
47	Swinomish Channel	County Boat Launch	N/A	N/A	N/A	N/A
48	Fisher Ck	Franklin Rd	15.7	14.5	15.0	14.7

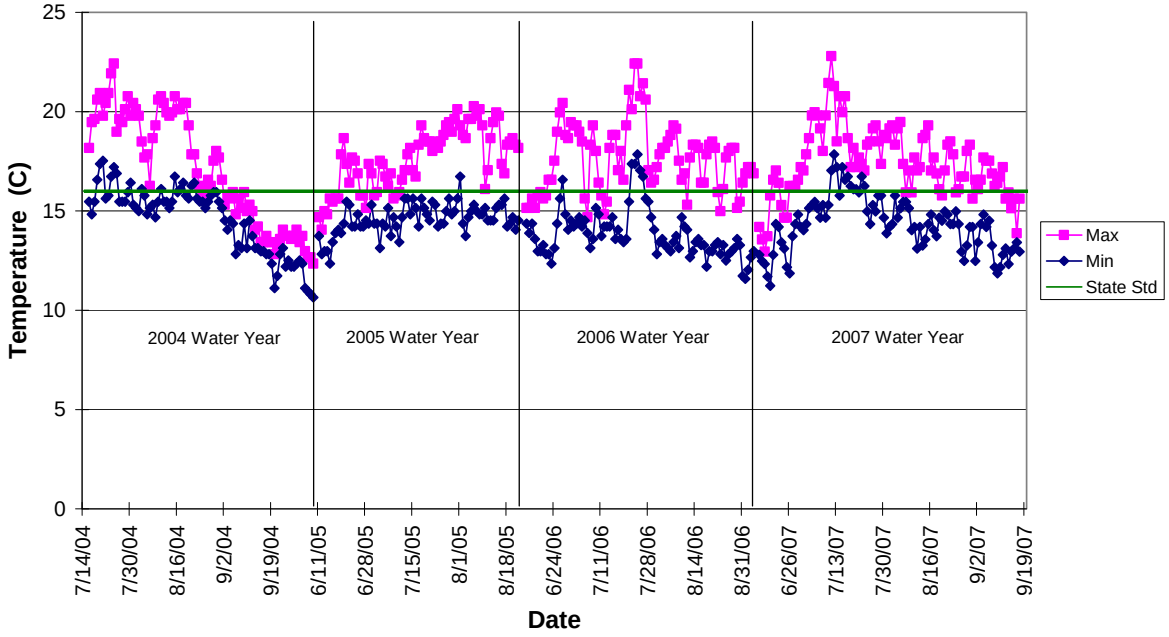
Thomas Creek at Hwy 99 - Site 3
Temperature



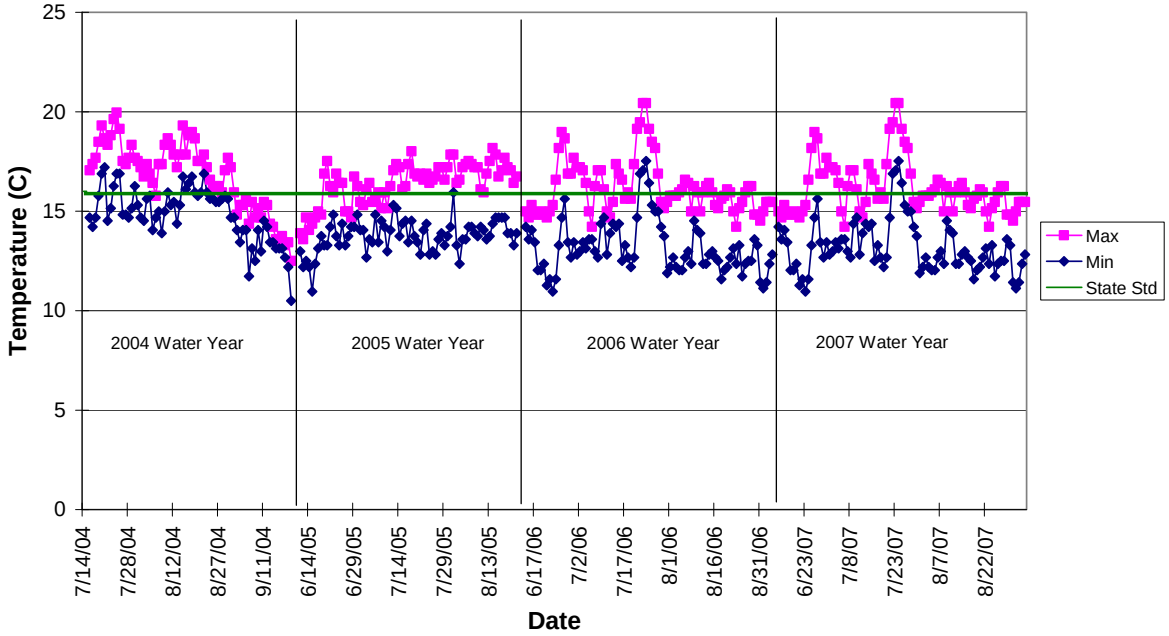
Thomas Creek at F&S Grade Rd - Site 4
Temperature



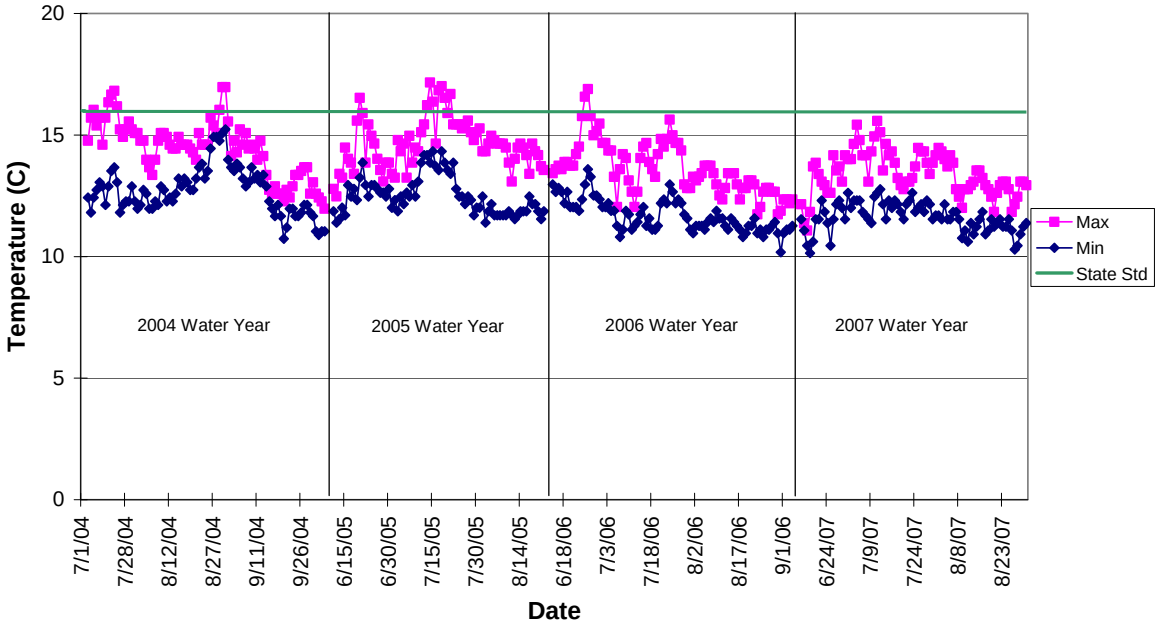
Friday Creek at Prairie Rd - Site 6
Temperature



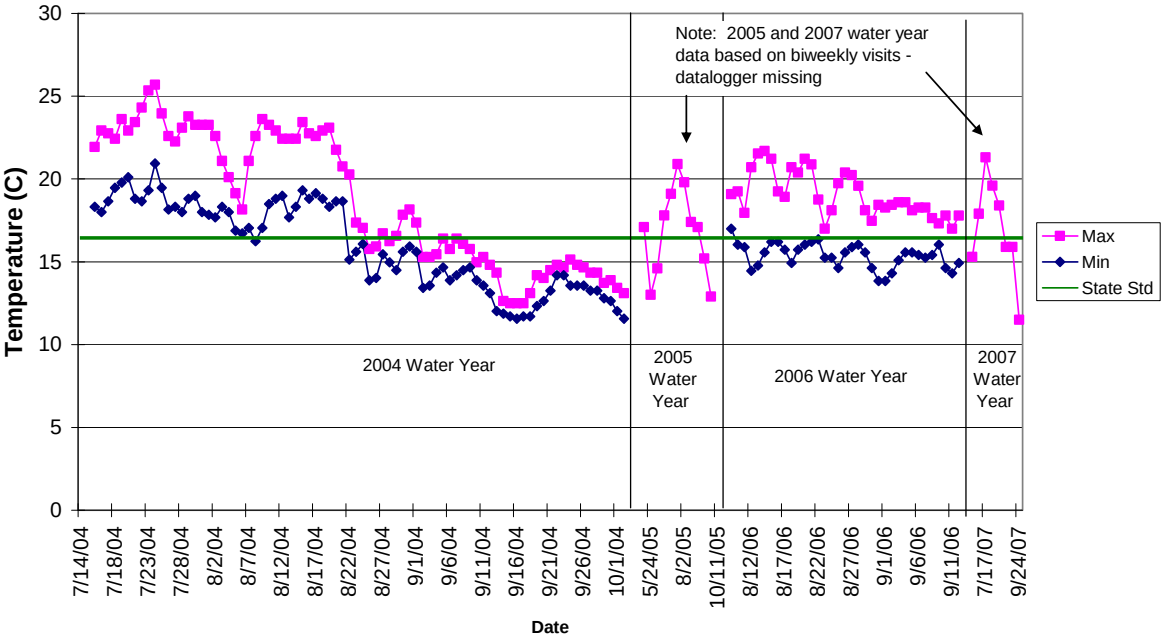
Swede Creek at Grip Rd - Site 8
Temperature



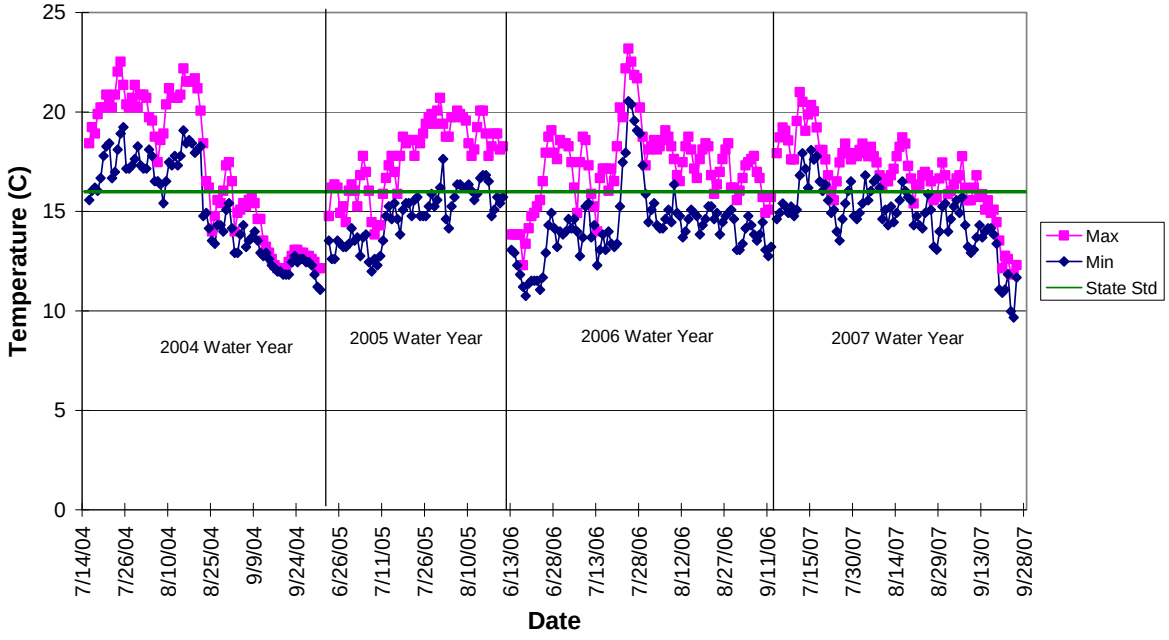
Samish River at Hwy 9 - Site 11
Temperature



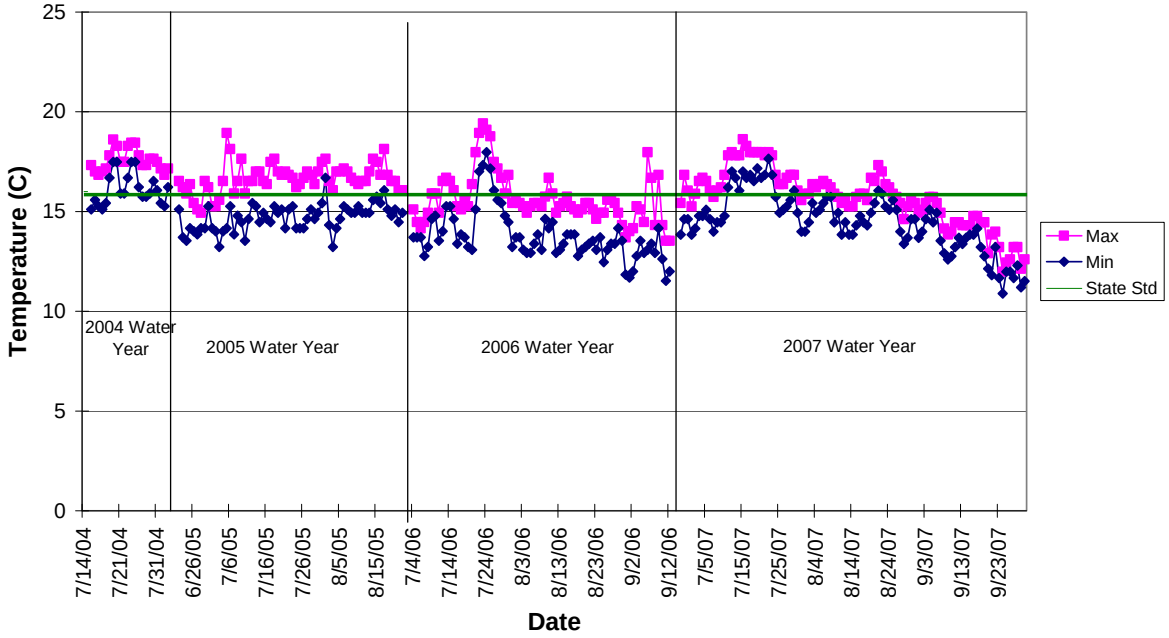
Nookachamps Creek at Swan Rd - Site 12
Temperature



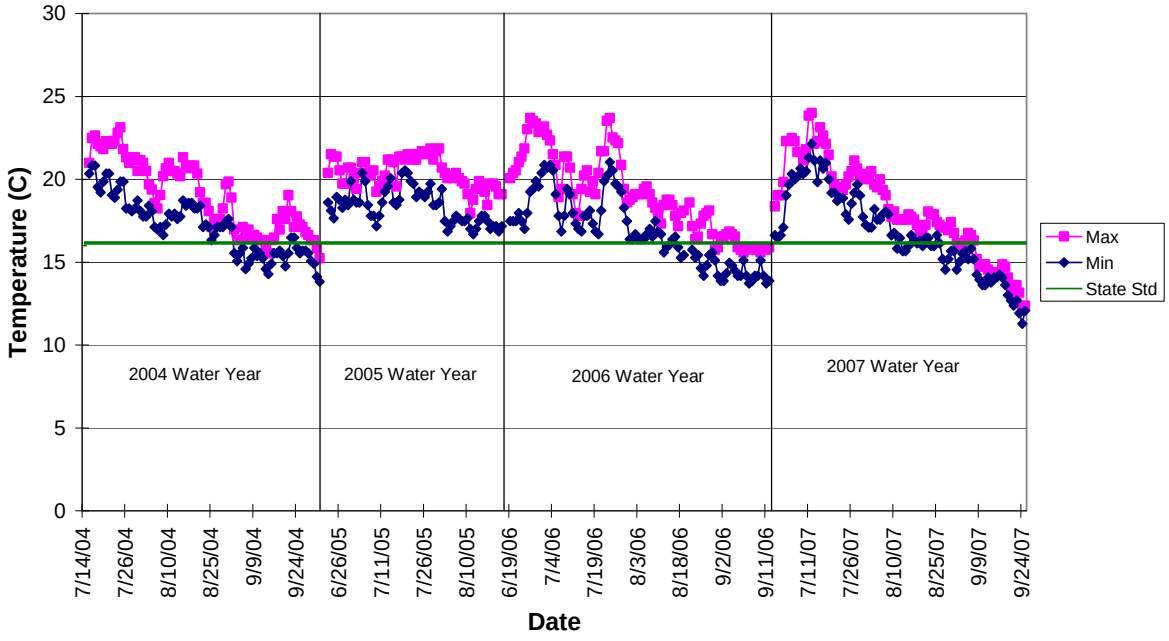
EF Nookachamps Creek at Hwy 9 - Site 13
Temperature



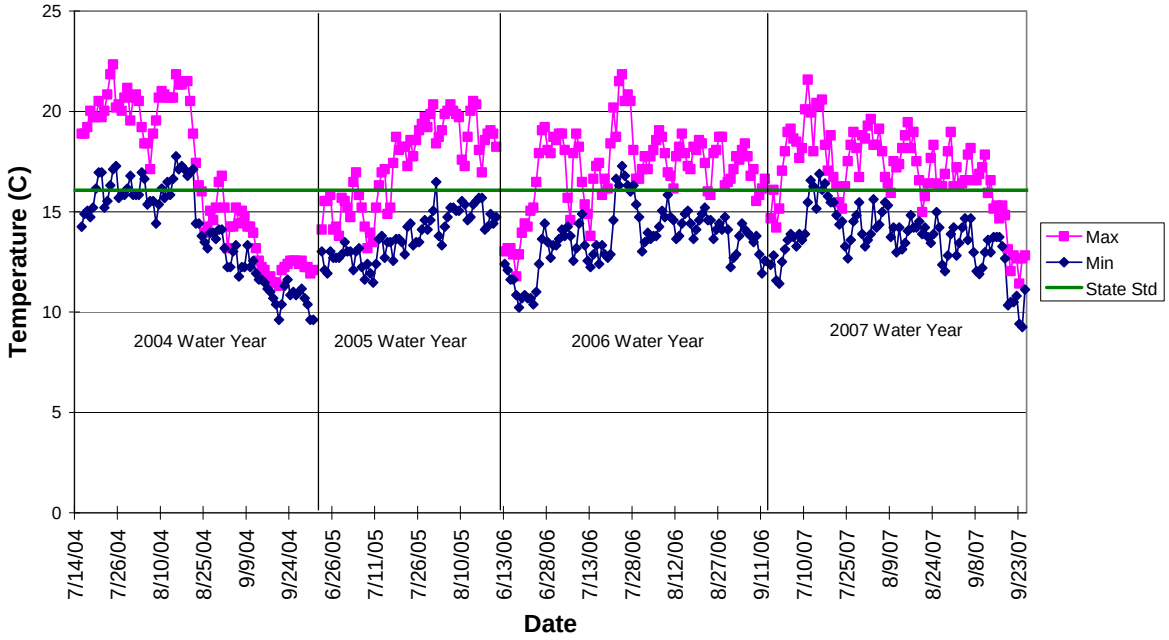
College Way Creek at College Way - Site 14
Temperature



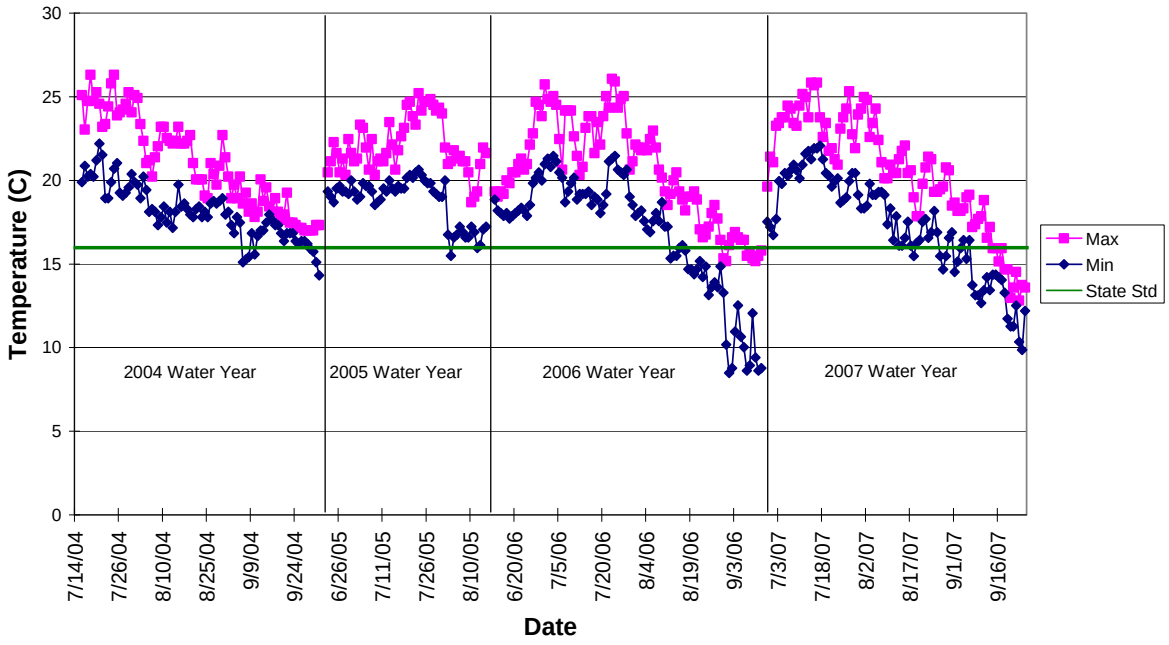
Nookachamps Creek at Knapp Rd - Site 15
Temperature



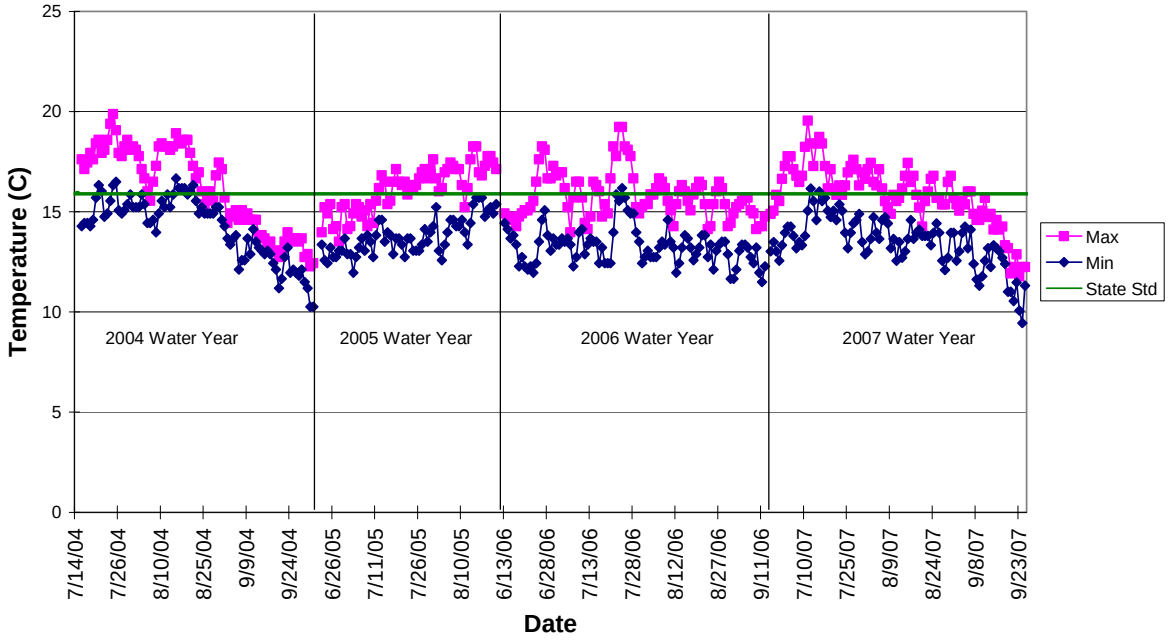
EF Nookachamps Creek at Beaver Lk Rd - Site 16
Temperature



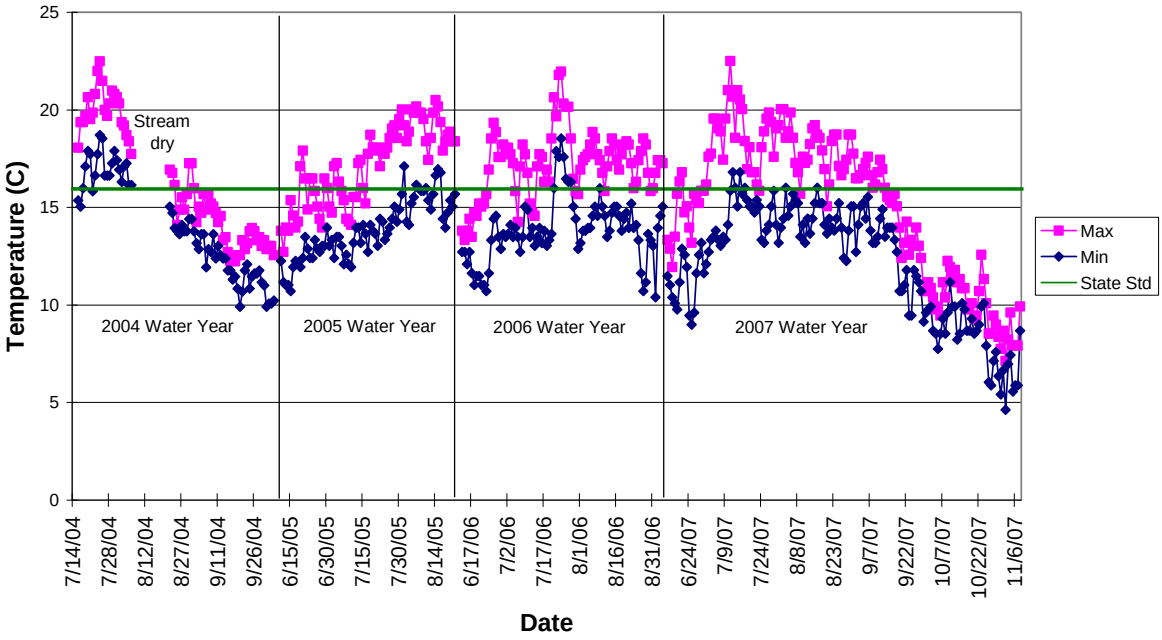
Nookachamps Creek at Big Lake Outlet - Site 17
Temperature



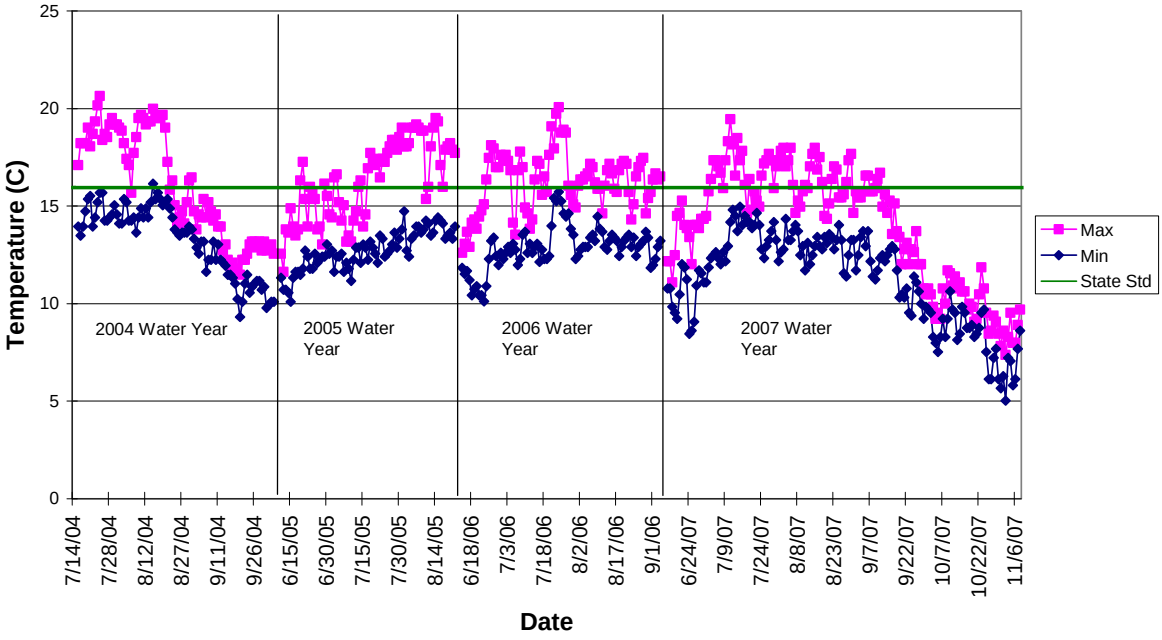
Lake Creek at Hwy 9 - Site 18
Temperature



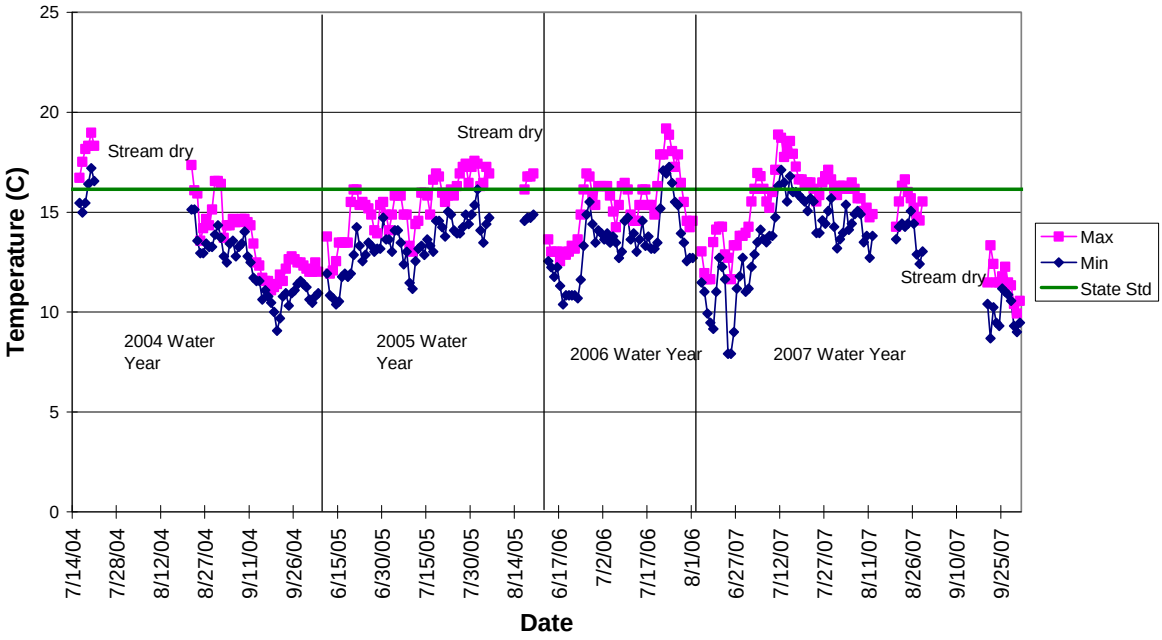
Hansen Creek at Hoehn Rd - Site 19
Temperature



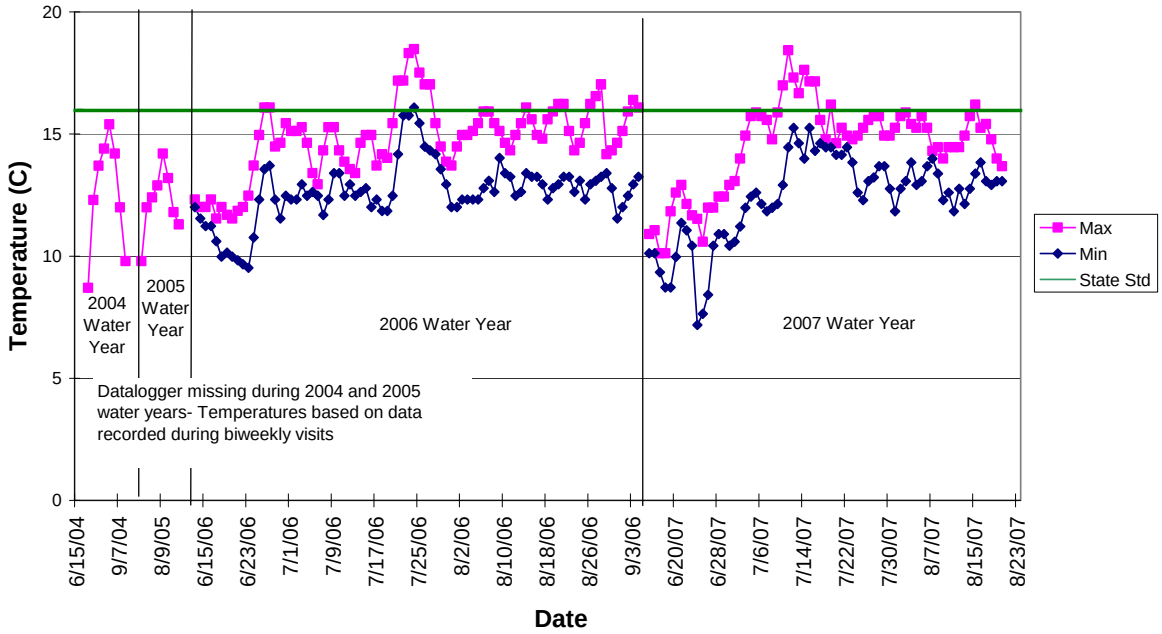
Hansen Creek at Northern State Hospital - Site 20
Temperature



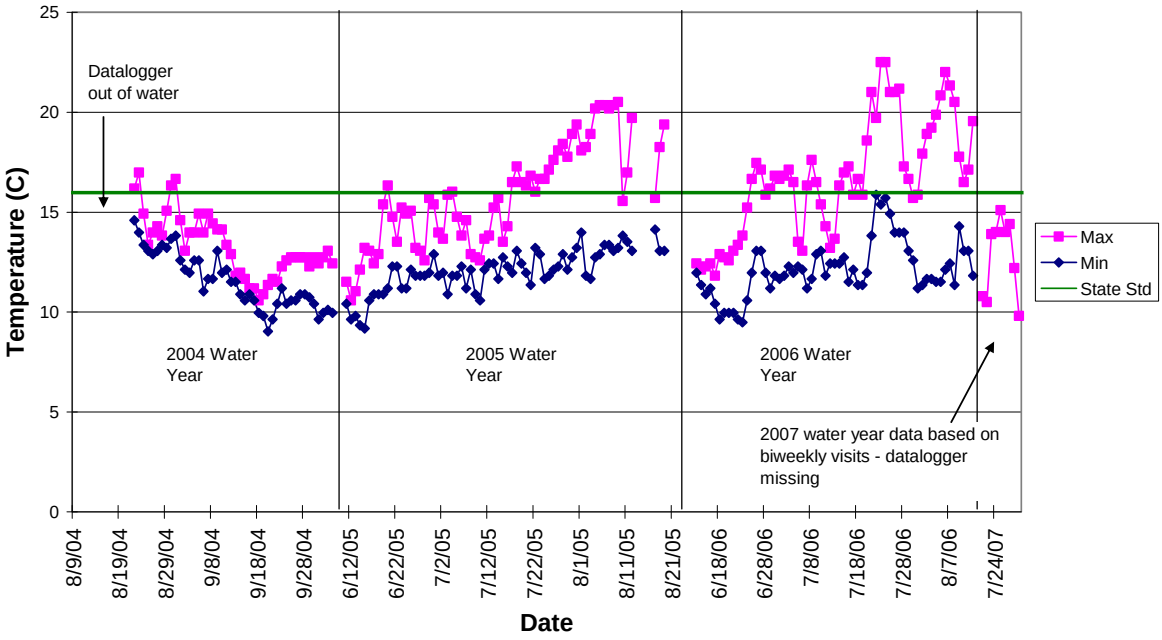
Coal Creek at Hoehn Rd - Site 21
Temperature



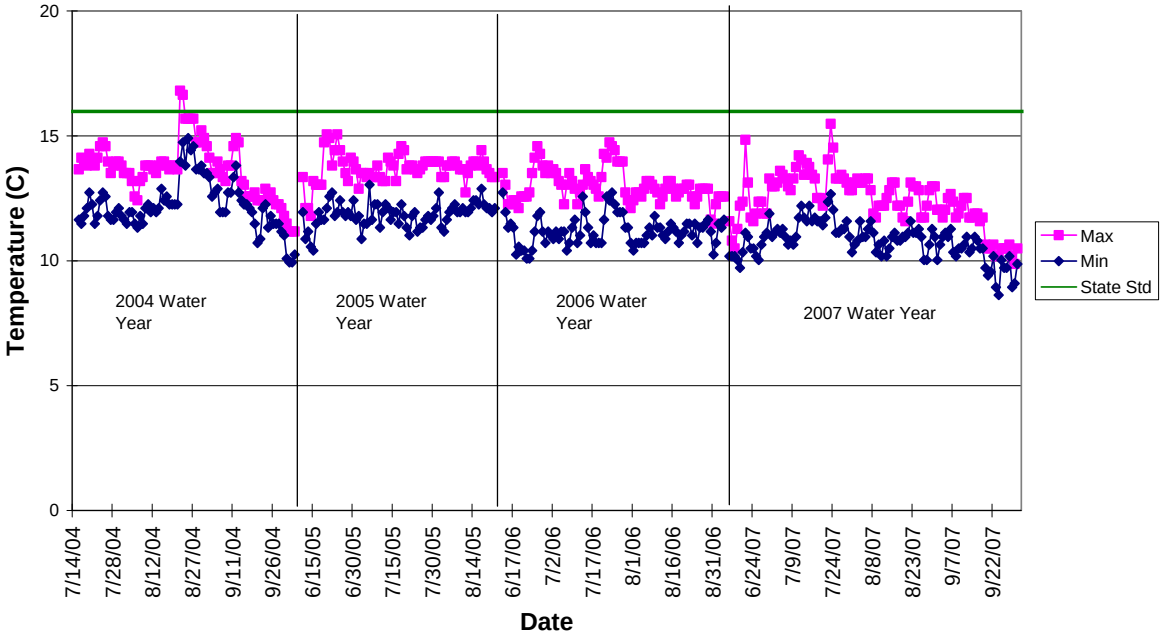
Coal Creek at Hwy 20 - Site 22
Temperature



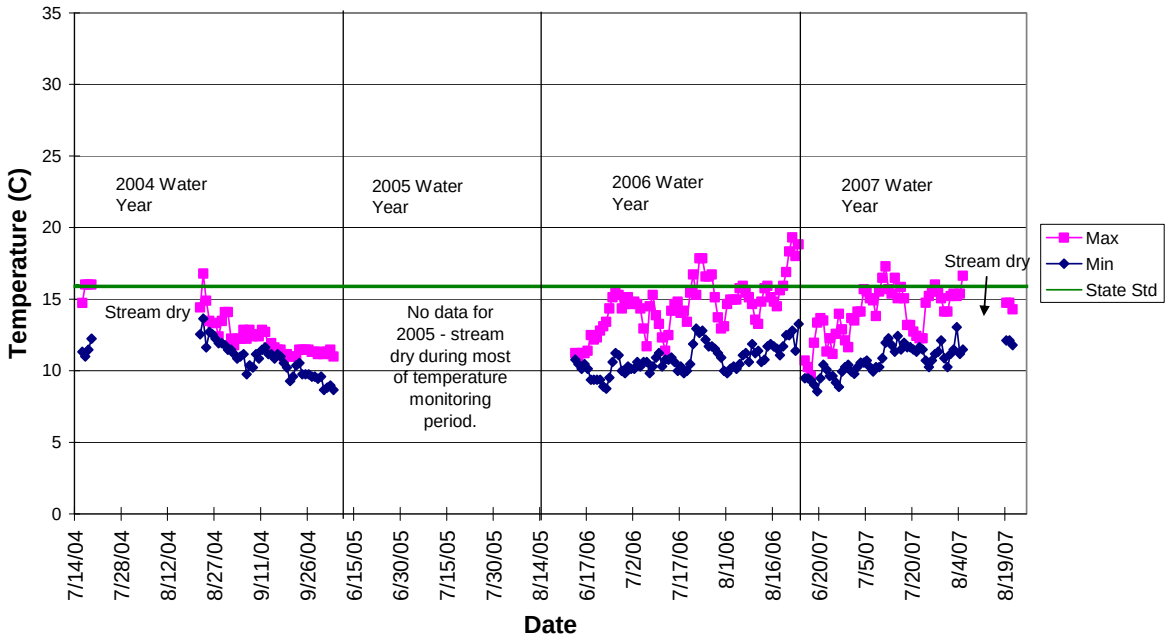
Wiseman Creek at Minkler Rd - Site 23
Temperature



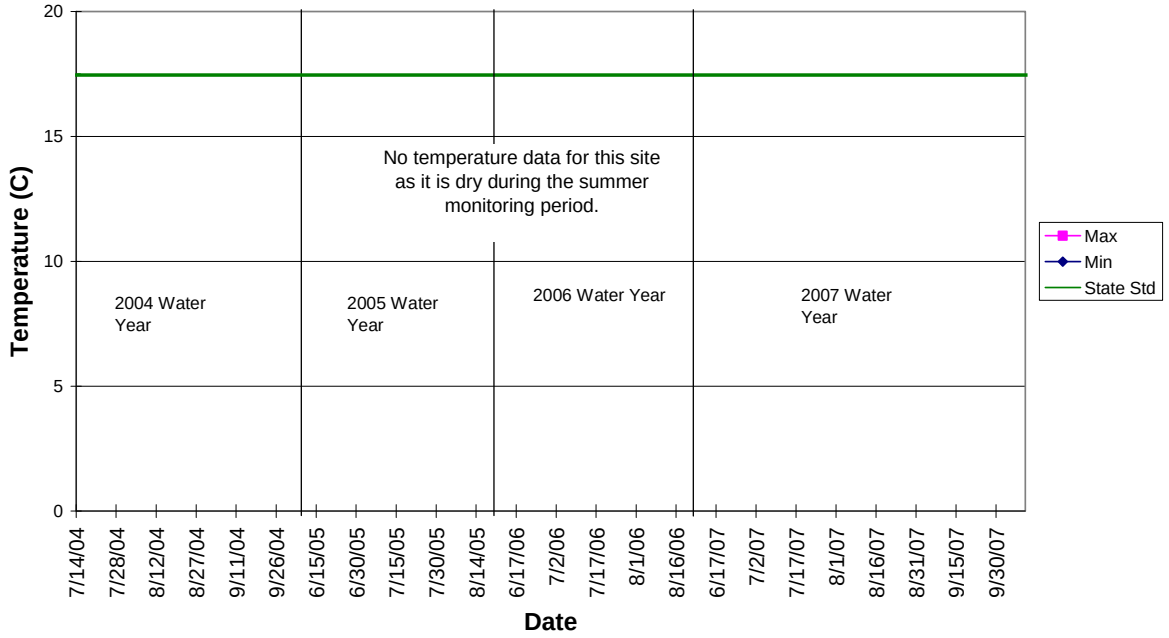
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Temperature



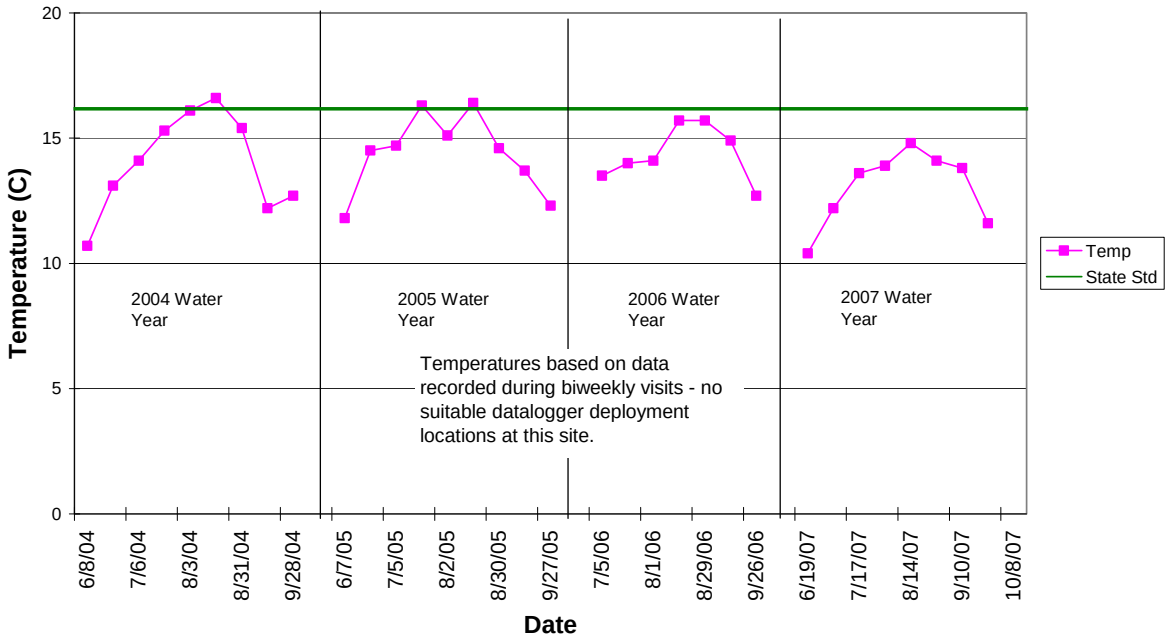
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Temperature



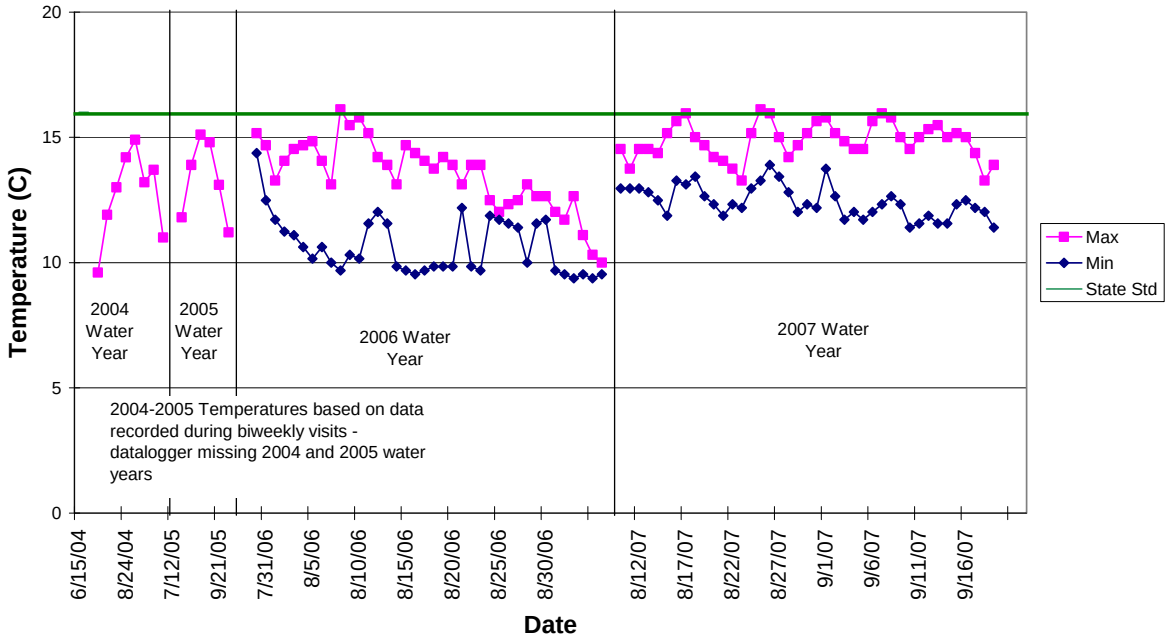
Brickyard Creek at Hwy 20 - Site 28
Temperature



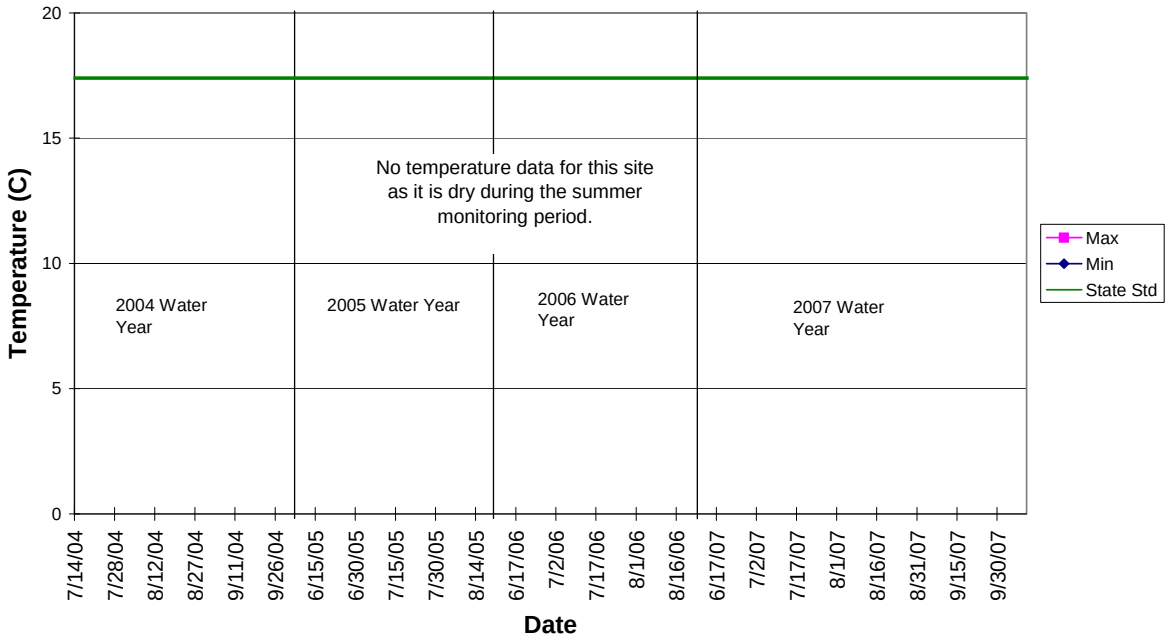
Skagit River at River Bend Rd - Site 29
Temperature



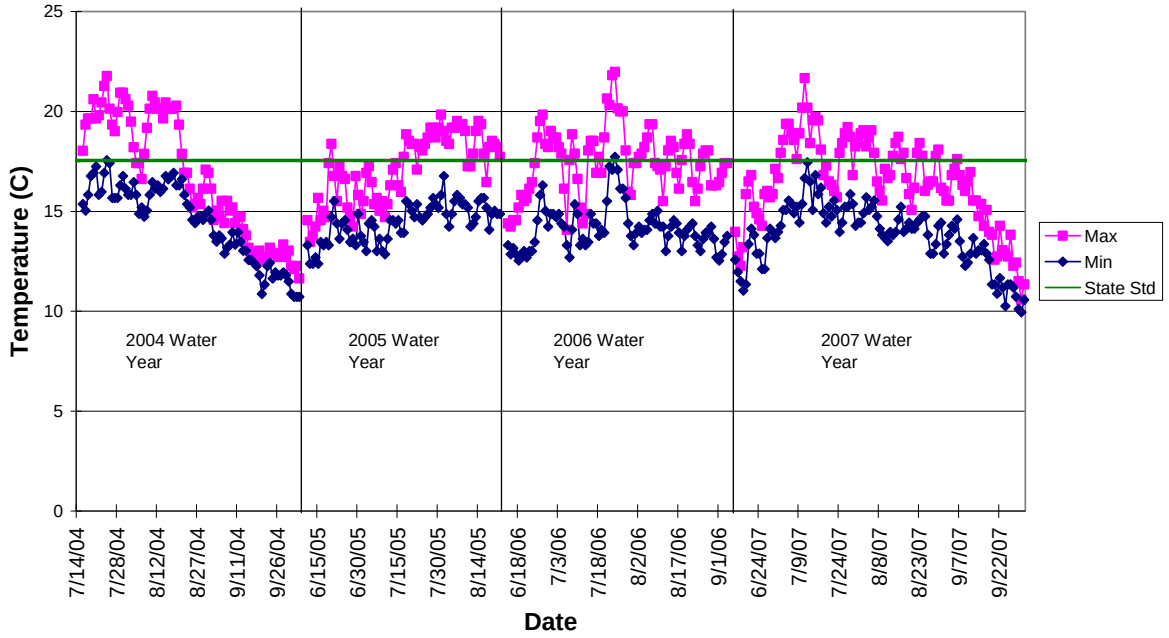
Skagit River at Cape Horn Rd - Site 30
Temperature



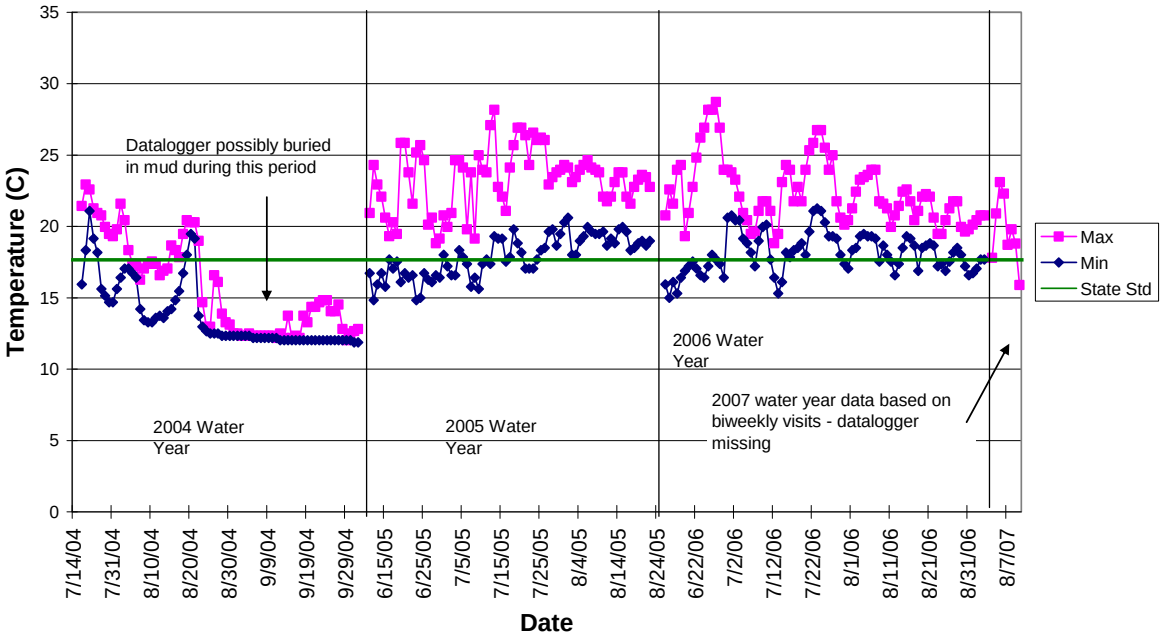
Drainage District 20 Ditch at Floodgate - Site 31
Temperature



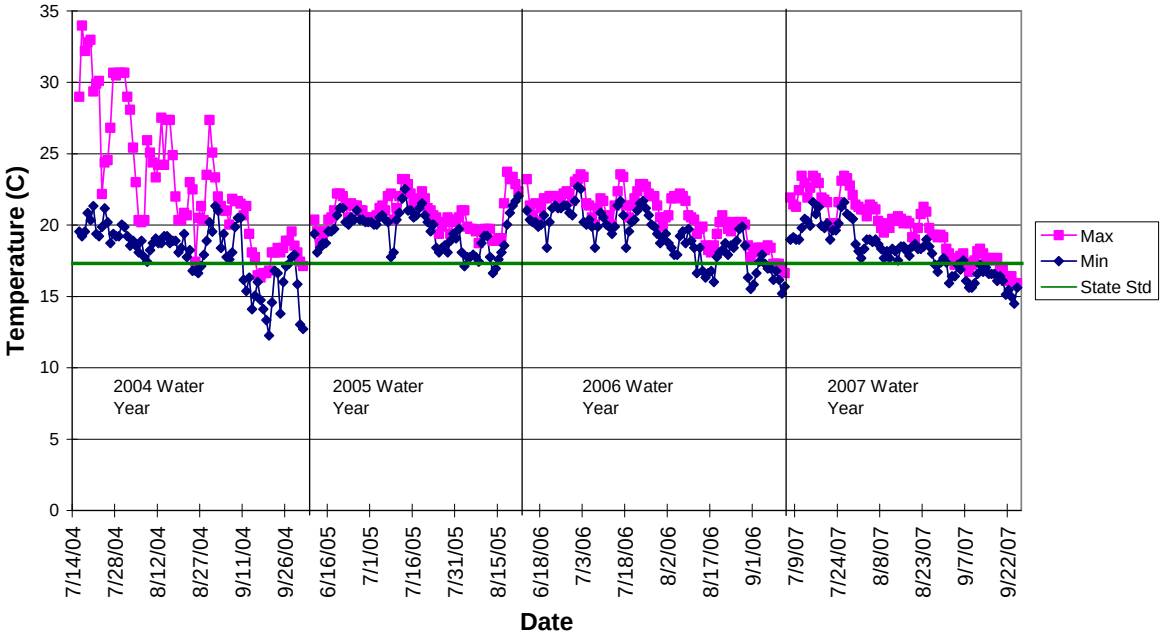
Samish River at Thomas Rd - Site 32
Temperature



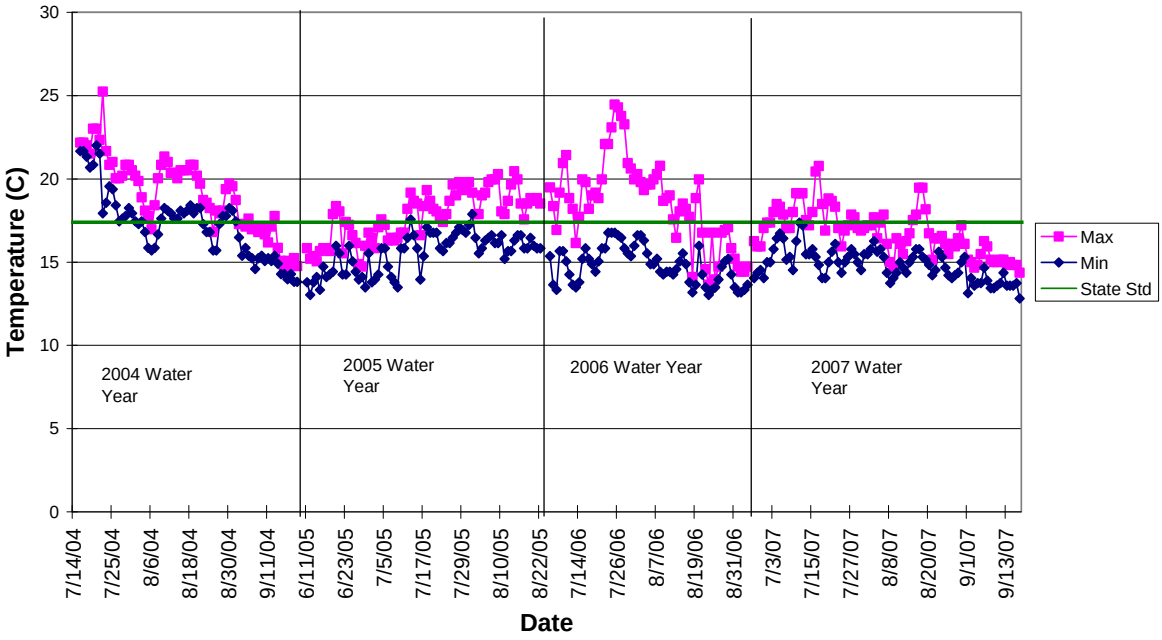
Alice Bay Pump Station - Site 33
Temperature



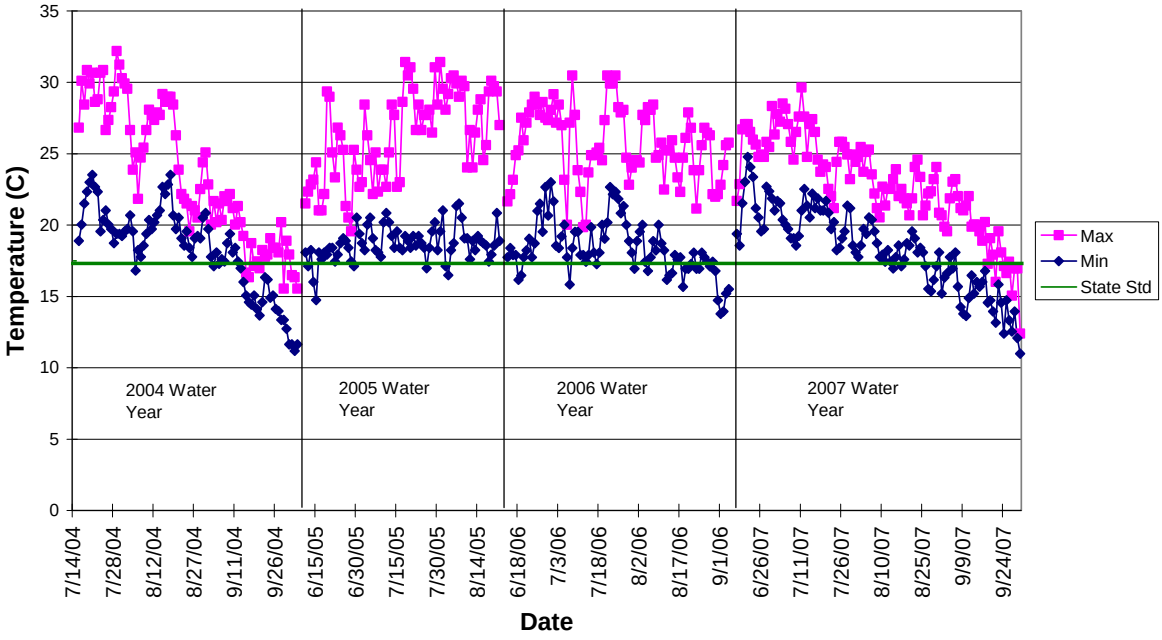
No Name Slough at Bayview-Edison Rd - Site 34
Temperature



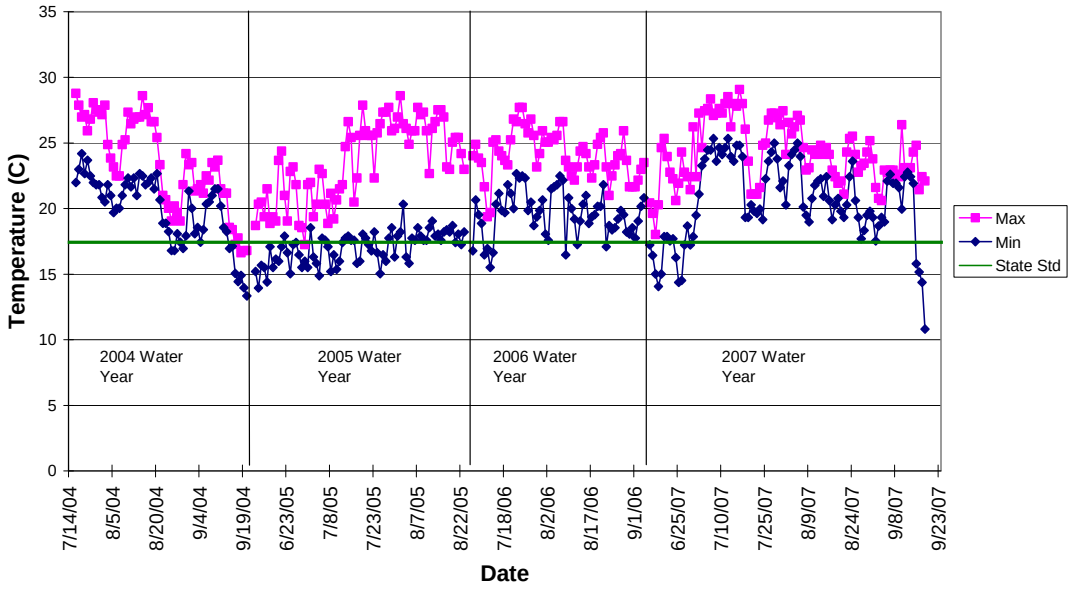
Joe Leary Slough at D'Arcy Rd - Site 35
Temperature



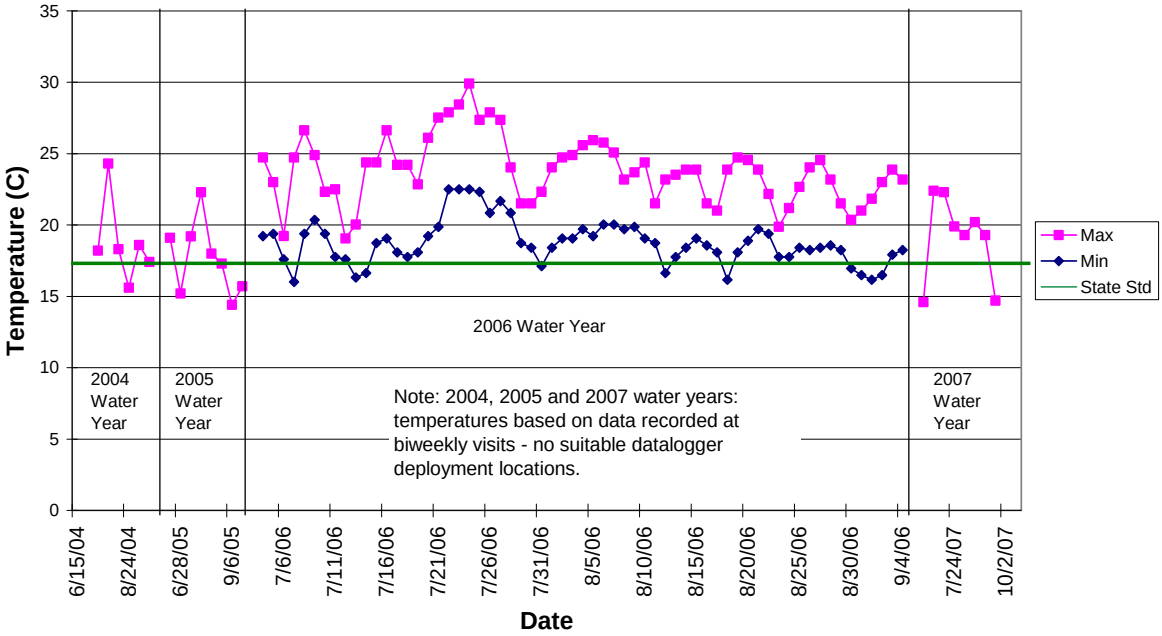
Edison Slough at School - Site 36
Temperature



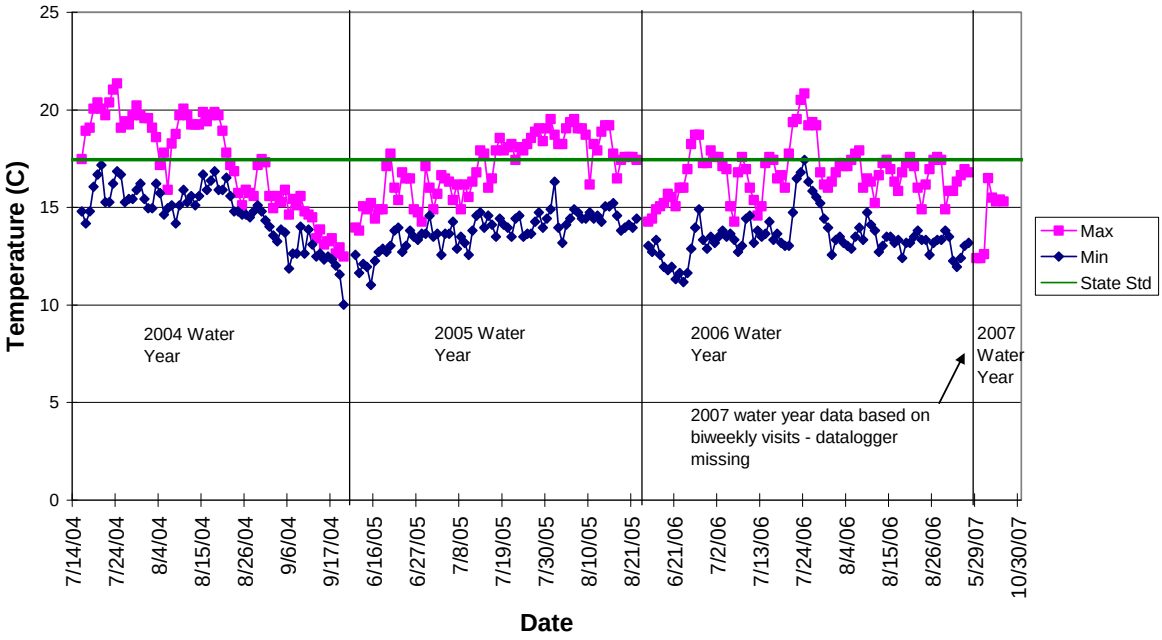
Edison Pump Station - Site 37
Temperature



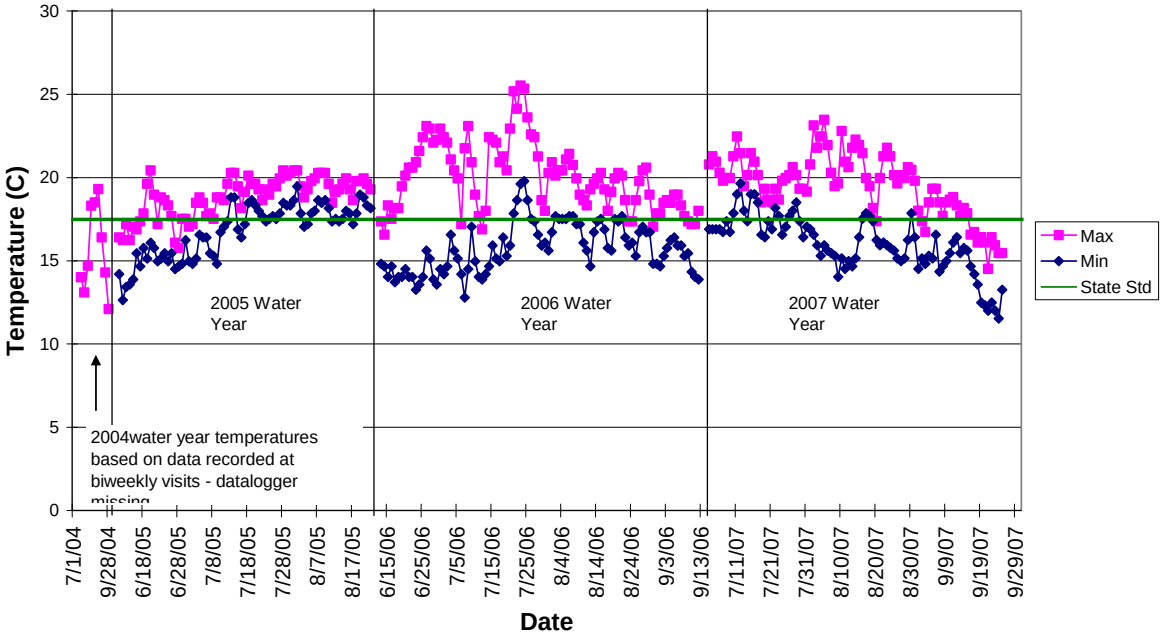
North Edison Pump Station - Site 38
Temperature



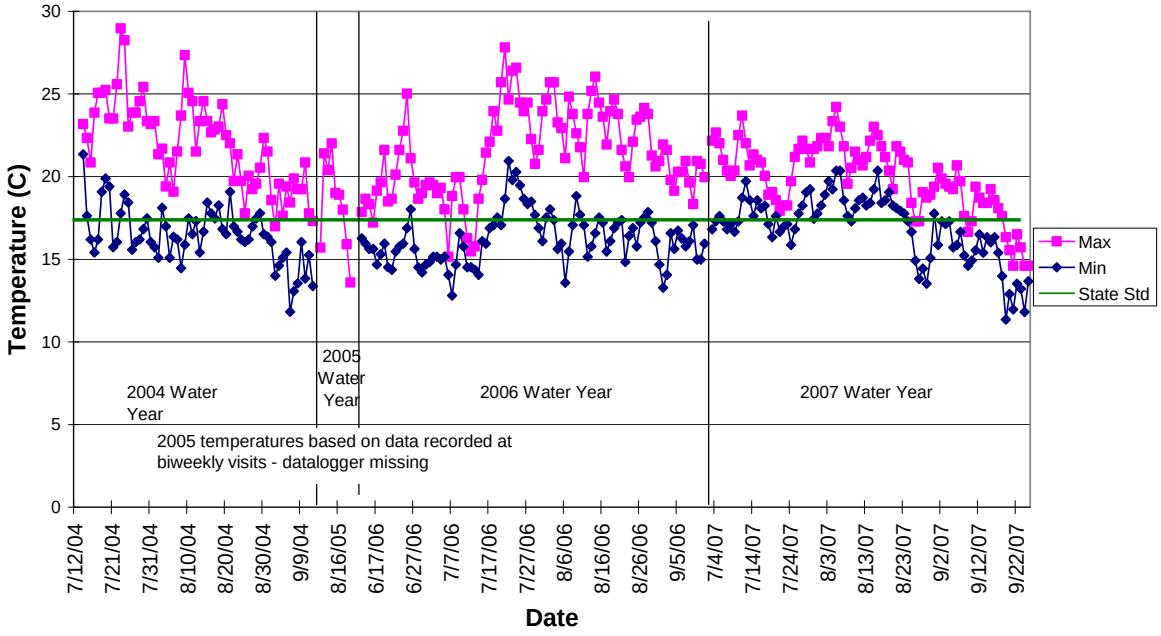
Colony Creek at Colony Rd - Site 39
Temperature



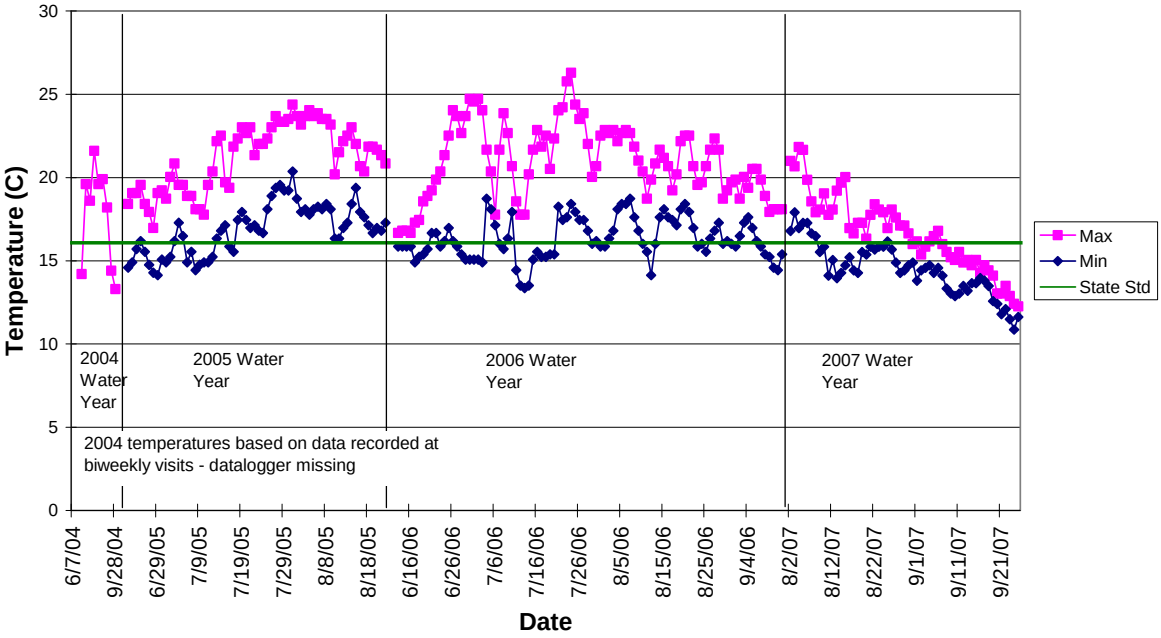
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Temperature



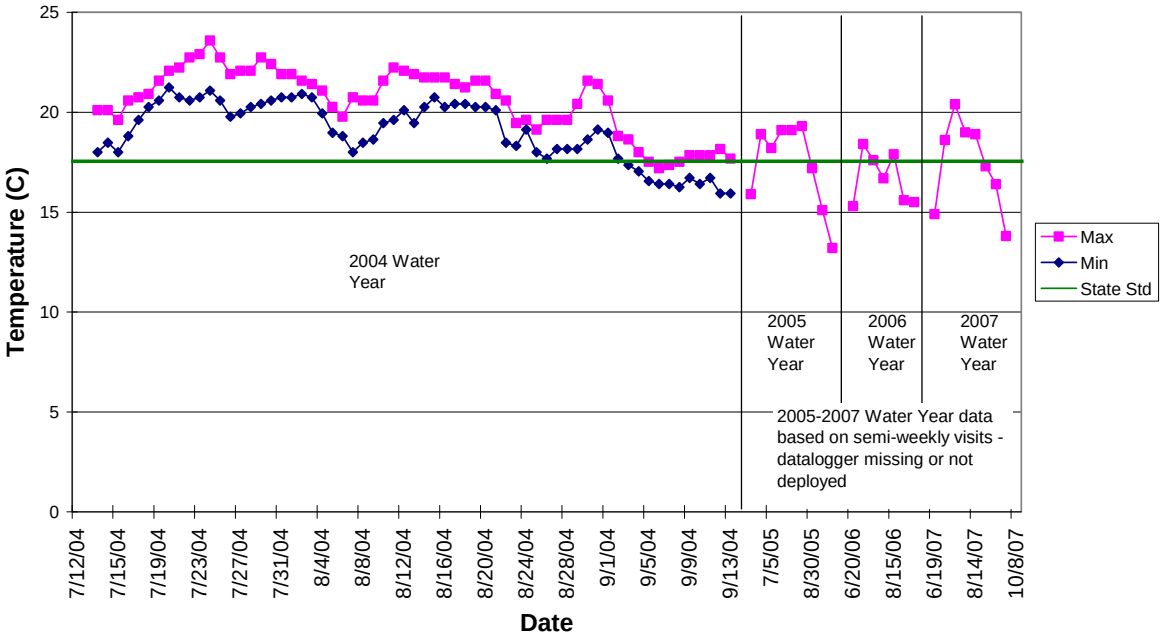
Maddox Creek / Big Ditch at Milltown Rd - Site 41
Temperature



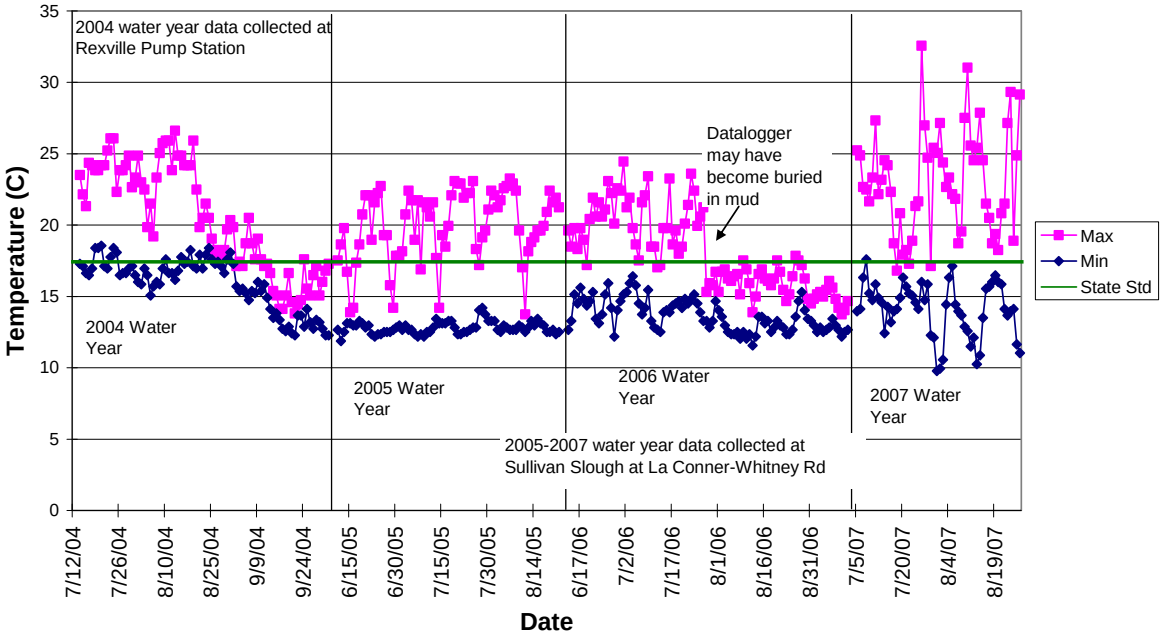
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Temperature



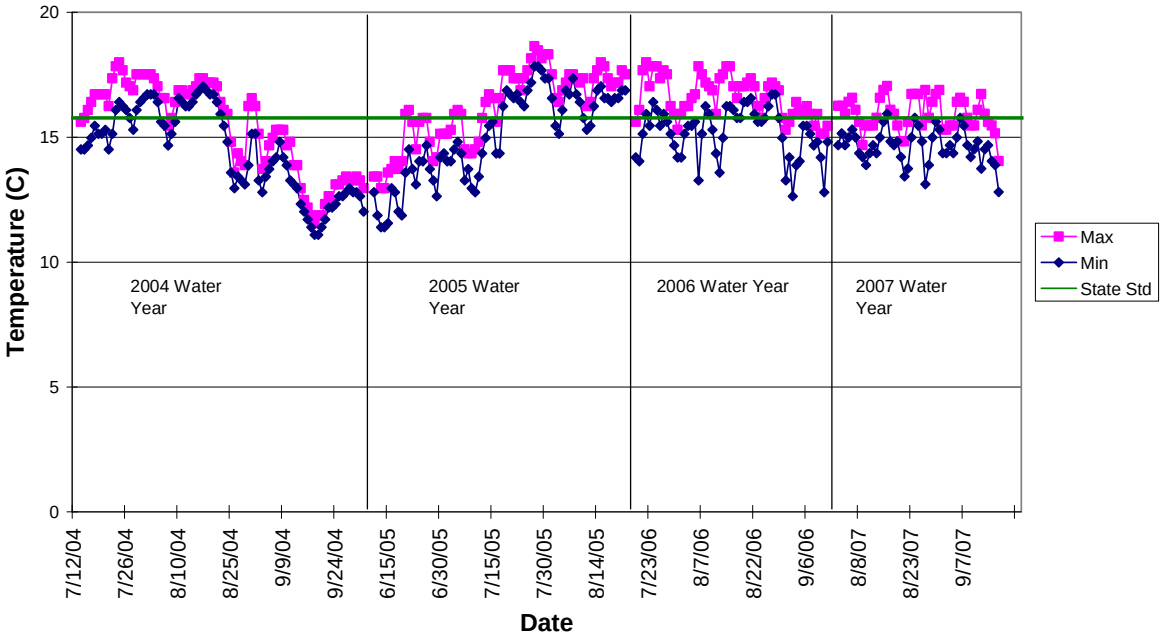
Wiley Slough at Wylie Rd - Site 43
Temperature



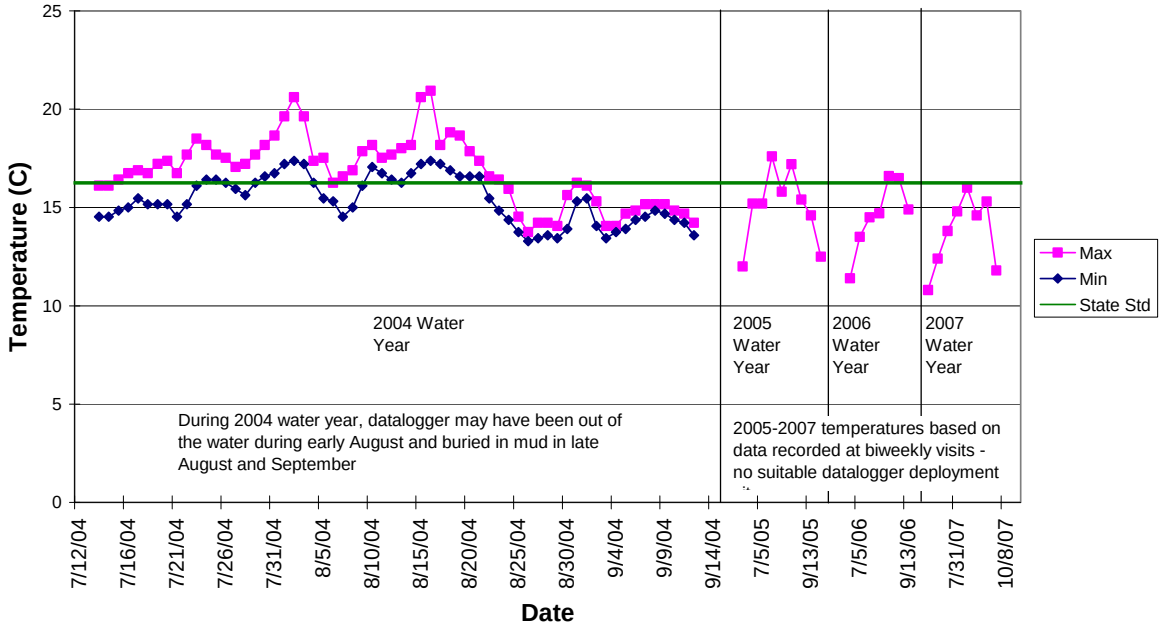
Sullivan Slough at La Conner-Whitney Rd - Site 44
Temperature



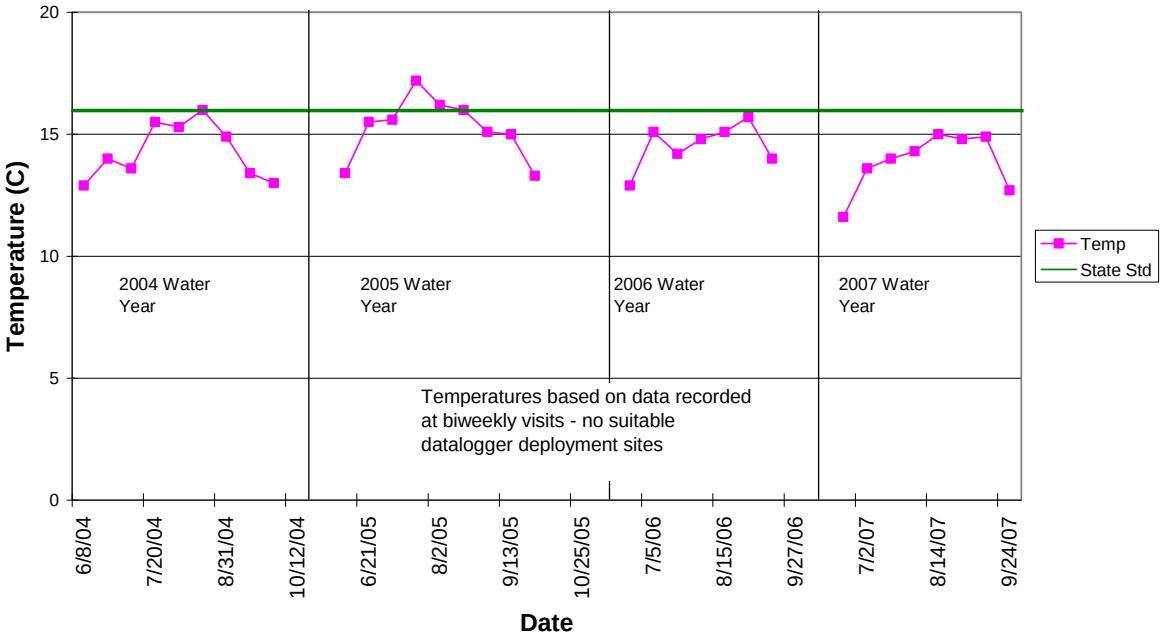
North Fork Skagit River near Moore Rd - Site 45
Temperature



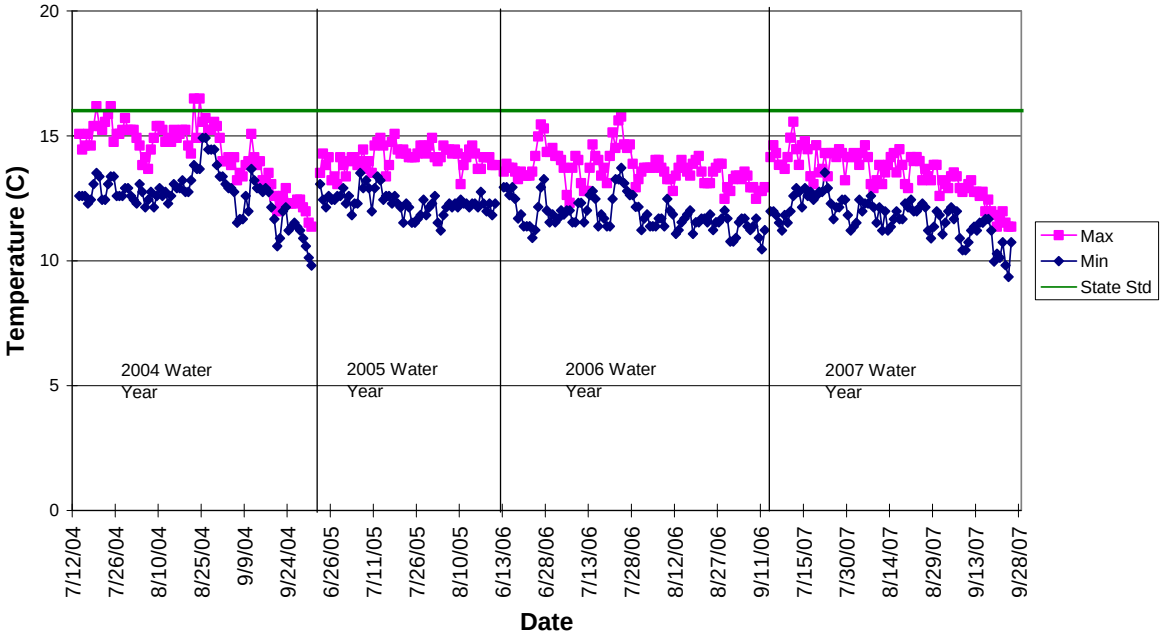
S F Skagit River at Conway Boat Ramp - Site 46
Temperature



Swinomish Channel at County Boat Ramp - Site 47
Temperature



Fisher Creek at Franklin Rd - 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 at each site during each visit. A summary of DO readings (in mg/L) obtained during the 2007 water year is provided in Table 5. Table 6 summarizes data from the four years of the study. The pages following Table 6 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2007 water years.

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), 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. This represents a change from previous years, as the Department of Ecology reviewed fish usage in the Skagit and Samish Basins and redesignated several watercourses for the stricter standard. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

Many streams in the Skagit County Monitoring Program meet oxygen standards all or most of the year. In a few streams, oxygen levels show steep declines in summer. 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. 2007 Dissolved Oxygen Results
Dissolved Oxygen (DO) measurements in the Skagit County Monitoring Program
2007 Water Year

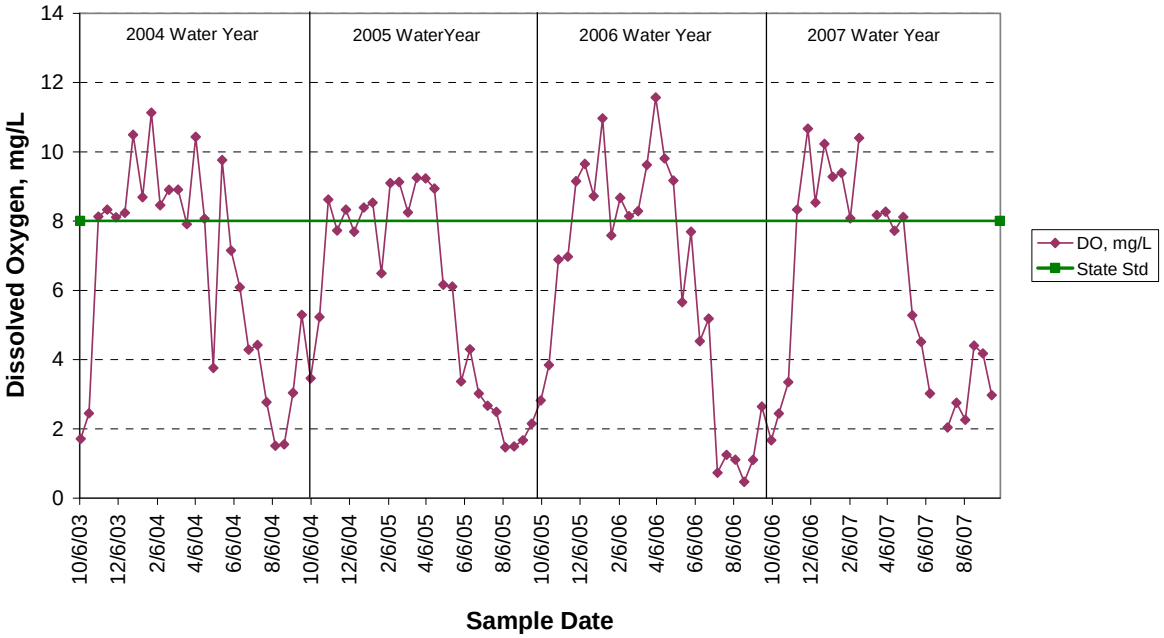
Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std[1]
3	Thomas Ck	Old Hwy 99 N	6.1	1.7	8.0
4	Thomas Ck	F&S Grade	11.3	9.8	8.0
6	Friday Ck	Prairie Rd	11.6	9.6	9.5
8	Swede Ck	Grip Rd	11.5	8.9	9.5
11	Samish R	State Route 9	9.0	7.5	9.5
12	Nookachamps Ck	Swan Rd	9.1	1.9	9.5
13	E.F. Nookachamps Ck	State Route 9	10.4	7.6	9.5
14	College Way Ck	College Way	9.1	5.5	9.5
15	Nookachamps Ck	Knapp	7.8	2.9	9.5
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.6	9.7	9.5
17	Nookachamps Ck	Big Lake Outlet	10.1	7.4	9.5
18	Lake Ck	State Route 9	11.5	9.1	9.5
19	Hansen Ck	Hoehn Rd	10.9	9.0	9.5
20	Hansen Ck	Northern State	11.4	9.5	9.5
21	Coal Ck	Hoehn Rd	11.4	7.9	9.5
22	Coal Ck	Hwy 20	12.2	9.9	9.5
23	Wiseman Ck	Minkler Rd	12.1	10.6	9.5
24	Mannser Ck	Lyman Hamilton Hwy	7.6	5.6	9.5
25	Red Cabin Ck	Hamilton Cem Rd	12.2	11.3	9.5
28	Brickyard Ck	Hwy 20	9.9	6.5	8.0
29	Skagit R	River Bend Rd	11.2	9.3	9.5
30	Skagit R	Cape Horn Rd	11.7	9.2	9.5
31	Drain Dist 20 floodgate	Francis Rd	7.6	3.8	8.0
32	Samish R	Thomas Rd	11.1	9.6	8.0
33	Alice Bay Pump Station	Samish Island Rd	11.7	4.1	8.0
34	Noname Slough	Bayview-Edison Rd	6.1	1.5	8.0
35	Joe Leary Slough	D'Arcy Rd	6.3	4.8	8.0
36	Edison Slough at school	W. Bow Hill Rd	9.3	4.0	8.0
37	Edison Pump Station	Farm to Market Rd	7.6	1.7	8.0
38	North Edison Pump Station	North Edison Rd	9.1	1.9	8.0
39	Colony Ck	Colony Rd	11.1	8.8	8.0
40	Big Indian Slough	Bayview-Edison Rd	5.4	2.4	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	7.0	3.2	8.0
42	Hill Ditch	Cedardale Rd	8.0	3.9	9.5
43	Wiley Slough	Wylie Rd	6.2	2.8	8.0
44	Sullivan Slough	La Conner-Bayview Rd	8.0	5.3	8.0
45	Skagit R – North Fork	Moore Rd	11.2	9.5	9.5
46	Skagit R – South Fork	Fir Island Rd	11.1	9.9	9.5
47	Swinomish Channel	County Boat Launch	9.2	6.9	6.0
48	Fisher Ck	Franklin Rd	11.3	9.7	9.5

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

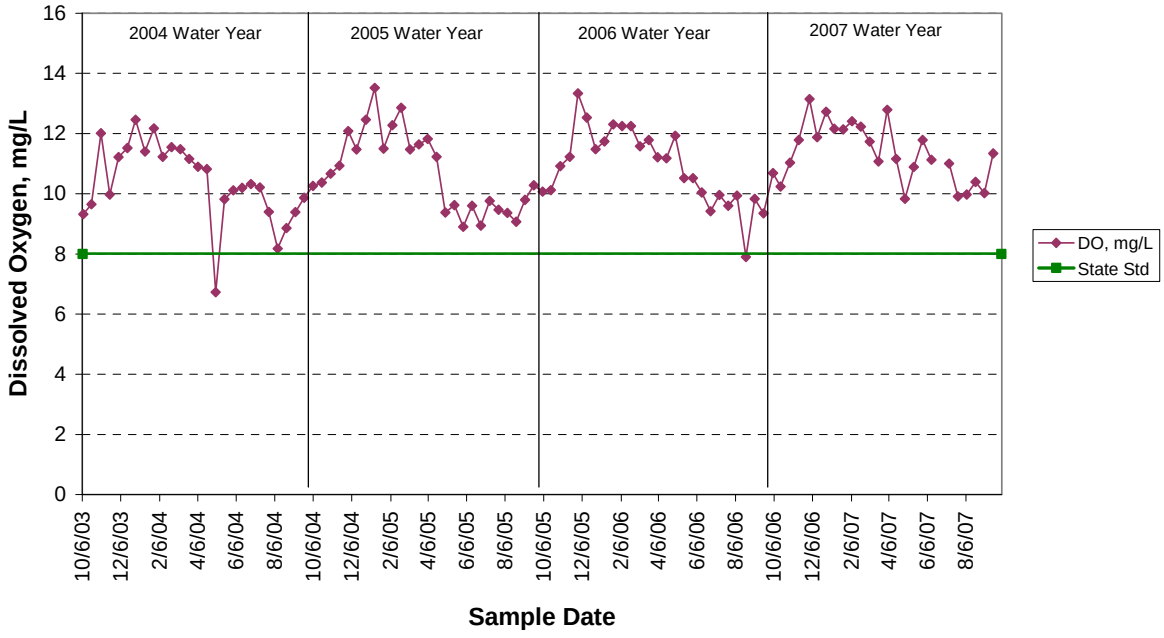
Table 6. Four-Year Dissolved Oxygen Results Summary
Mean Dissolved Oxygen levels for the four years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	Mean dissolved oxygen (mg/L) 2004	2005	2006	2007
3	Thomas Ck	Old Hwy 99 North	6.5	5.9	6.2	6.1
4	Thomas Ck	F&S Grade	10.4	10.7	10.9	11.3
6	Friday Ck	Prairie Rd	10.5	11.2	11.1	11.6
8	Swede Ck	Grip Rd	10.4	11.1	11.2	11.5
11	Samish R	State Route 9	8.2	8.2	8.4	9.0
12	Nookachamps Ck	Swan Rd	9.0	9.4	9.5	9.1
13	E.F. Nookachamps Ck	State Route 9	9.3	9.8	10.3	10.4
14	College Way Ck	College Way	9.0	9.1	9.0	9.1
15	Nookachamps Ck	Knapp	7.8	7.8	8.2	7.8
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.2	11.4	11.4	11.6
17	Nookachamps Ck	Big Lake Outlet	9.7	9.7	10.0	10.1
18	Lake Ck	State Route 9	10.7	11.1	11.2	11.5
19	Hansen Ck	Hoehn Rd	10.0	10.1	10.5	10.9
20	Hansen Ck	Northern State	10.5	11.0	11.2	11.4
21	Coal Ck	Hoehn Rd	10.7	11.1	11.4	11.4
22	Coal Ck	Hwy 20	11.7	11.8	11.9	12.2
23	Wiseman Ck	Minkler Rd	11.6	11.6	11.8	12.1
24	Mannser Ck	Lyman Hamilton Hwy	6.1	6.2	6.8	7.6
25	Red Cabin Ck	Hamilton Cem Rd	11.6	11.5	11.9	12.2
28	Brickyard Ck	Hwy 20	8.6	9.2	9.2	9.9
29	Skagit R	R Bend Rd	11.2	10.8	11.3	11.2
30	Skagit R	Cape Horn Rd	11.0	11.1	11.3	11.7
31	Drain Dist 20 near floodgate	Francis Rd	8.7	8.1	9.0	7.6
32	Samish R	Thomas Rd	10.3	10.8	10.8	11.1
33	Alice Bay Pump Station	Samish Island Rd	10.4	7.6	9.5	11.7
34	Noname Slough	Bayview-Edison Rd	5.9	6.6	6.6	6.1
35	Joe Leary Slough	D'Arcy Rd	5.2	4.0	5.0	6.3
36	Edison Slough at school	W. Bow Hill Rd	9.3	7.6	8.4	9.3
37	Edison Pump Station	Farm to Market Rd	7.6	5.5	5.8	7.6
38	North Edison Pump Station	North Edison Rd	6.5	7.0	6.4	9.1
39	Colony Ck	Colony Rd	10.1	10.8	10.8	11.1
40	Big Indian Slough	Bayview-Edison Rd	4.0	4.6	4.8	5.4
41	Maddox Slough/Big Ditch	Milltown Rd	5.2	5.2	5.9	7.0
42	Hill Ditch	Cedardale Rd	6.7	7.1	7.6	8.0
43	Wiley Slough	Wylie Rd	4.9	4.2	4.6	6.2
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	4.2	10.4	8.6	8.0
45	Skagit R – North Fork	Moore Rd	11.2	11.1	11.4	11.2
46	Skagit R – South Fork	Fir Island Rd	11.0	11.0	11.3	11.1
47	Swinomish Channel	County Boat Launch	8.4	8.7	8.8	9.2
48	Fisher Ck	Franklin Rd	10.8	10.9	11.0	11.3

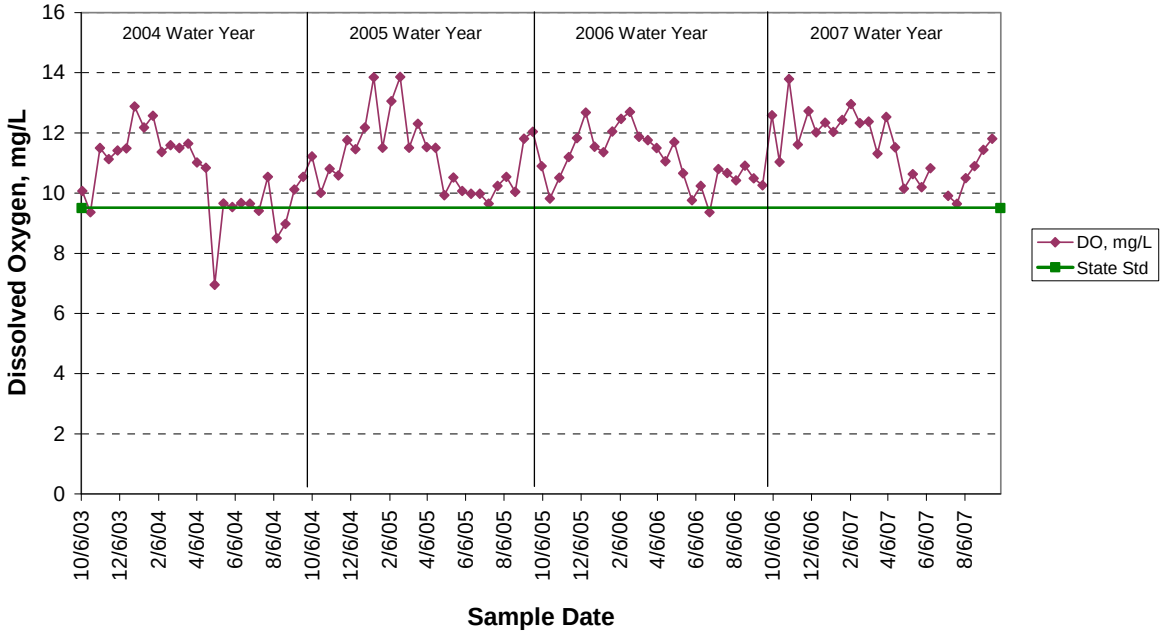
Thomas Creek at Hwy 99 - Site 3
Dissolved Oxygen



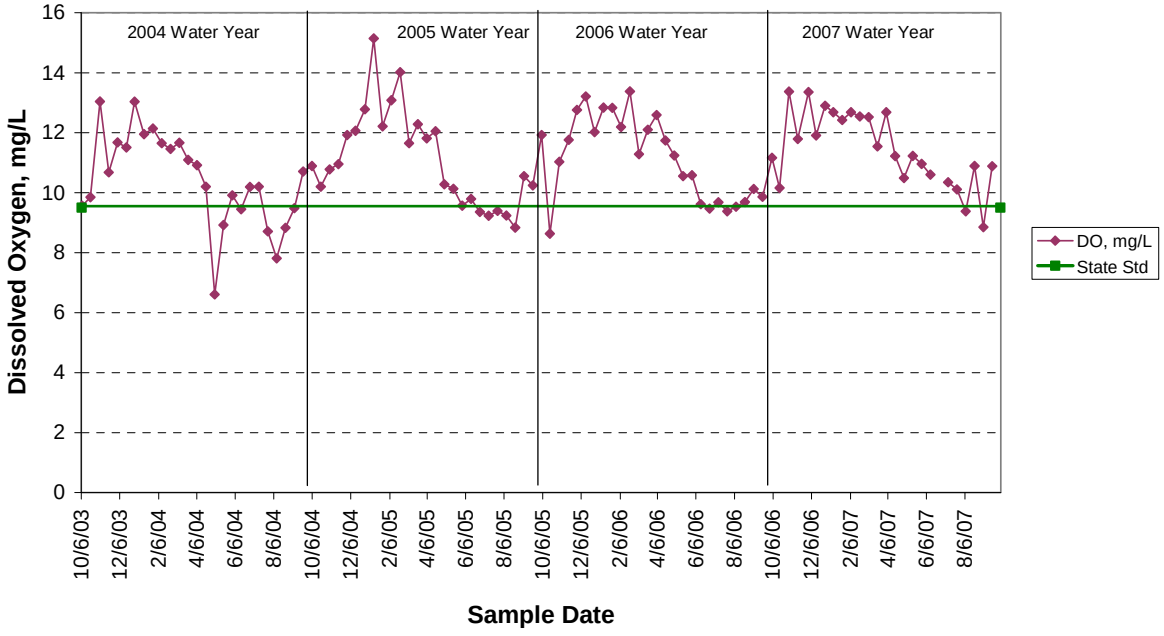
Thomas Creek at F&S Grade Rd - Site 4
Dissolved Oxygen



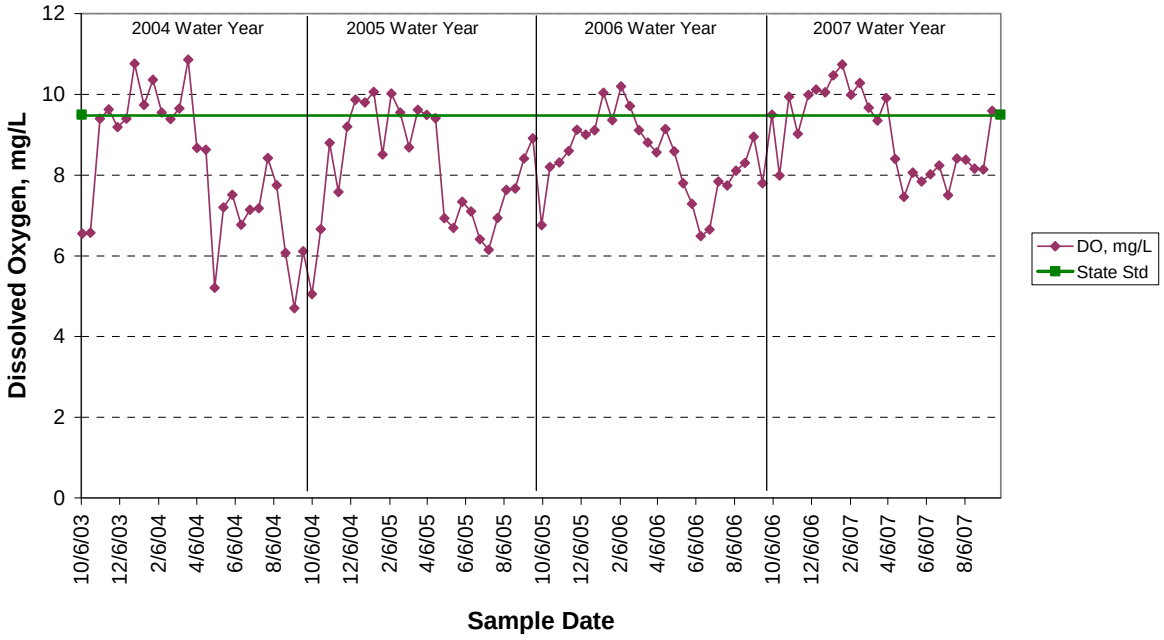
Friday Creek at Prairie Rd - Site 6
Dissolved Oxygen



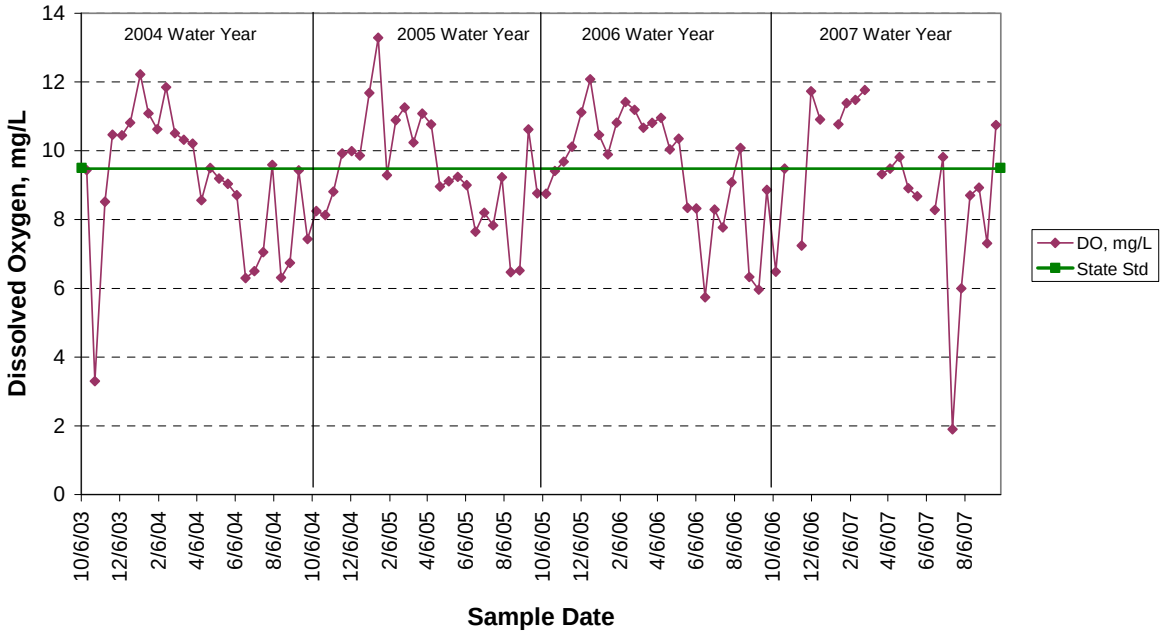
Swede Creek at Grip Rd - Site 8
Dissolved Oxygen



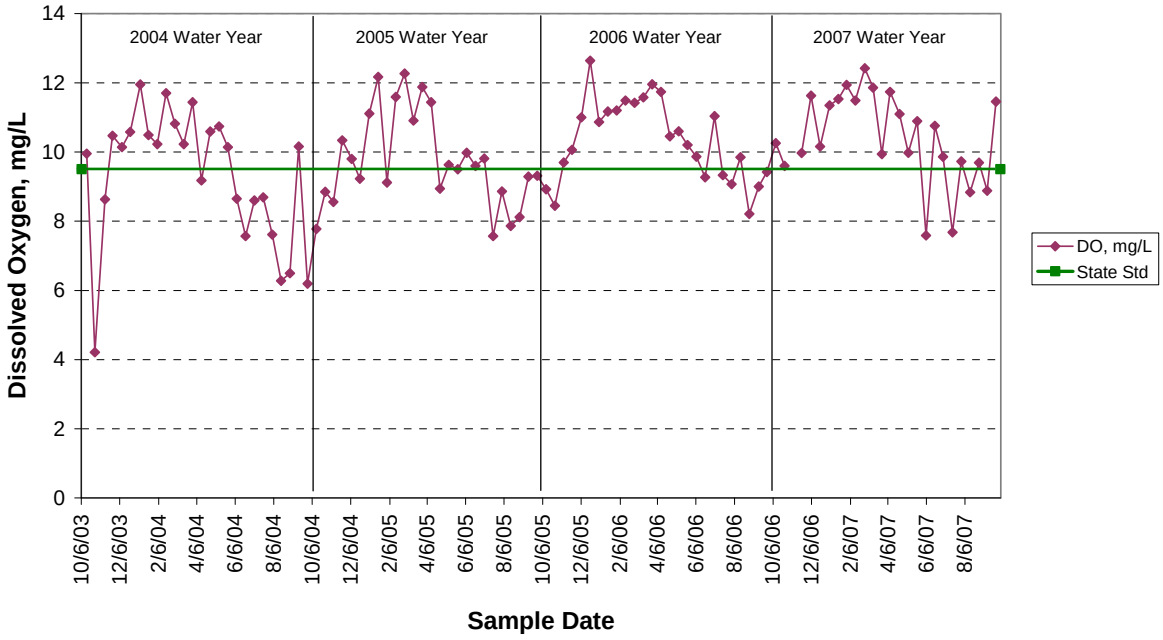
Samish River at Hwy 9 - Site 11
Dissolved Oxygen



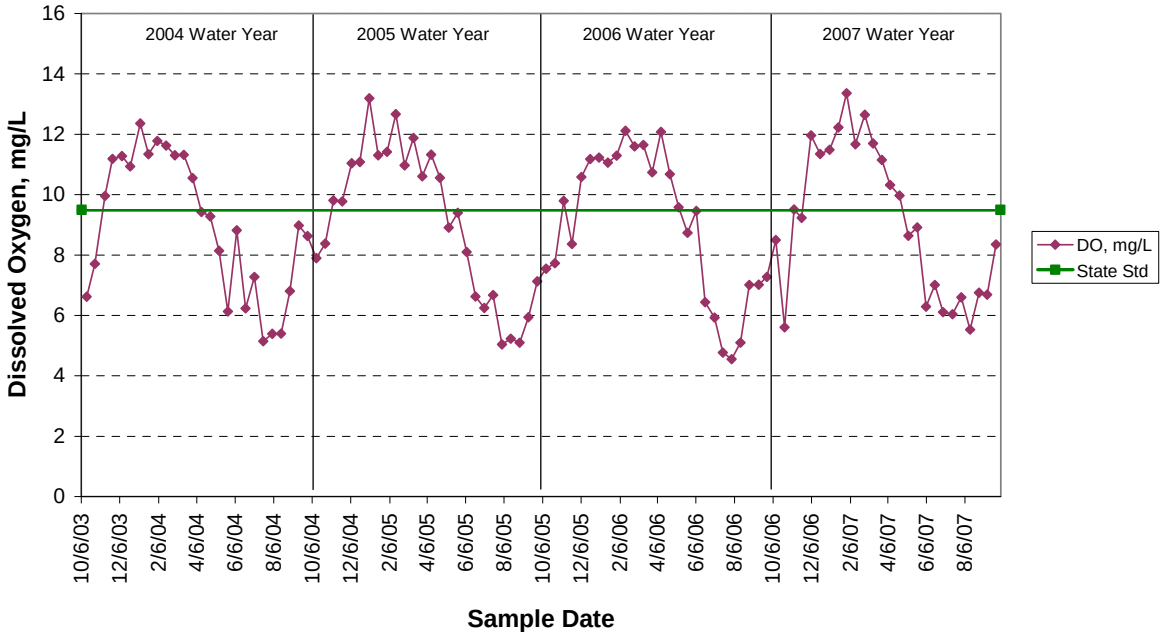
Nookachamps Creek at Swan Rd - Site 12
Dissolved Oxygen



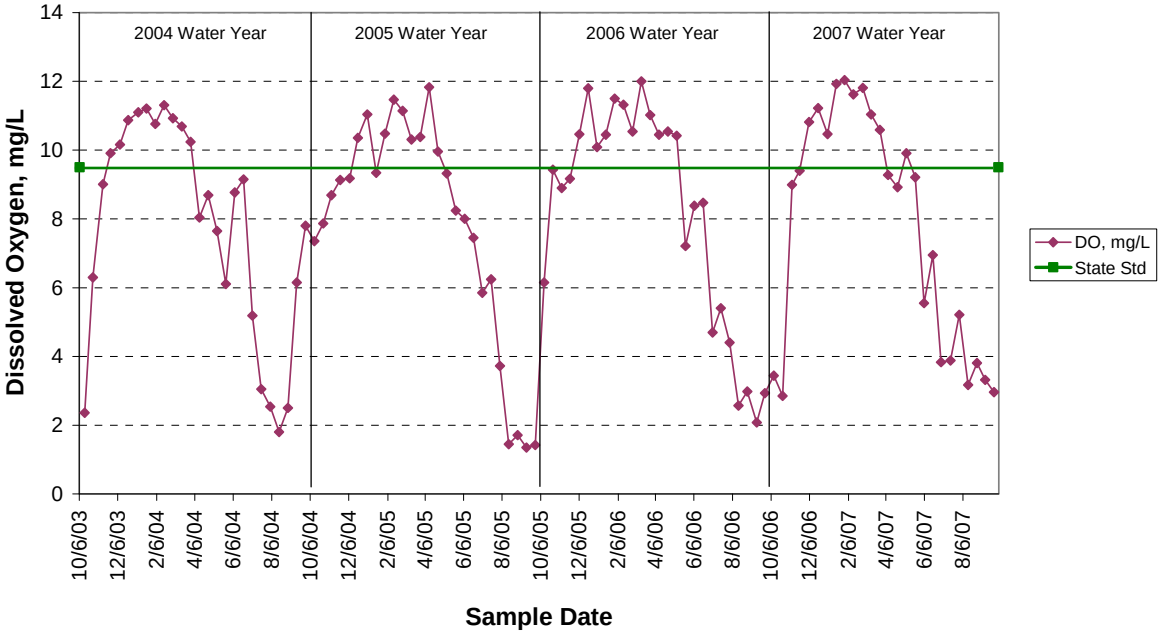
E.F. Nookachamps Creek at Hwy 9 - Site 13
Dissolved Oxygen



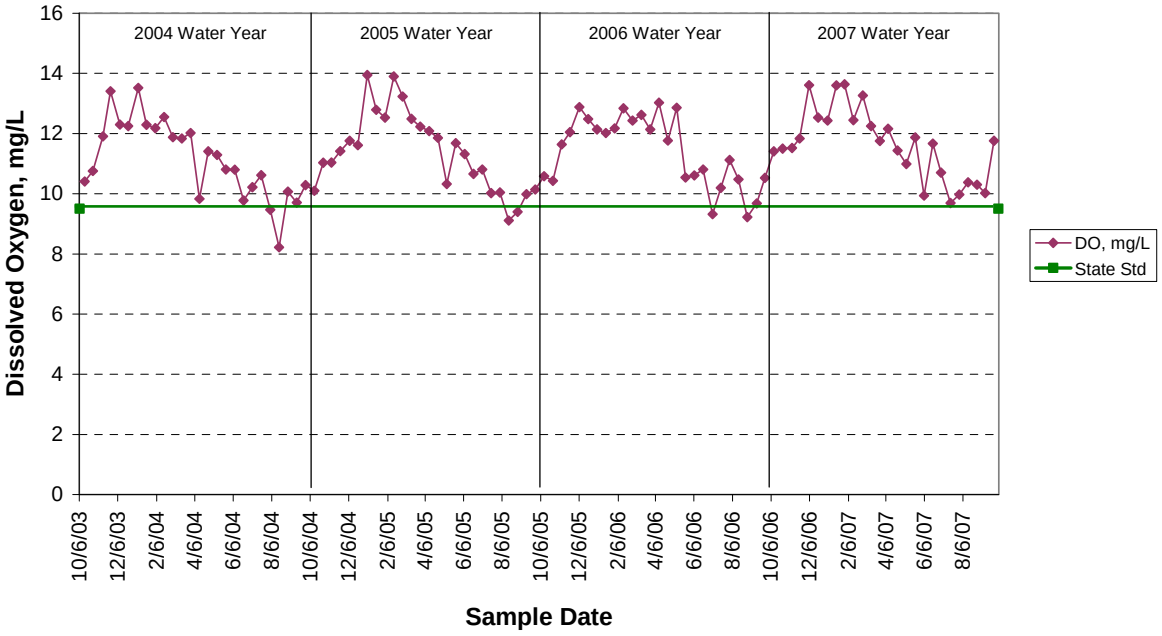
College Way Creek at College Way - Site 14
Dissolved Oxygen



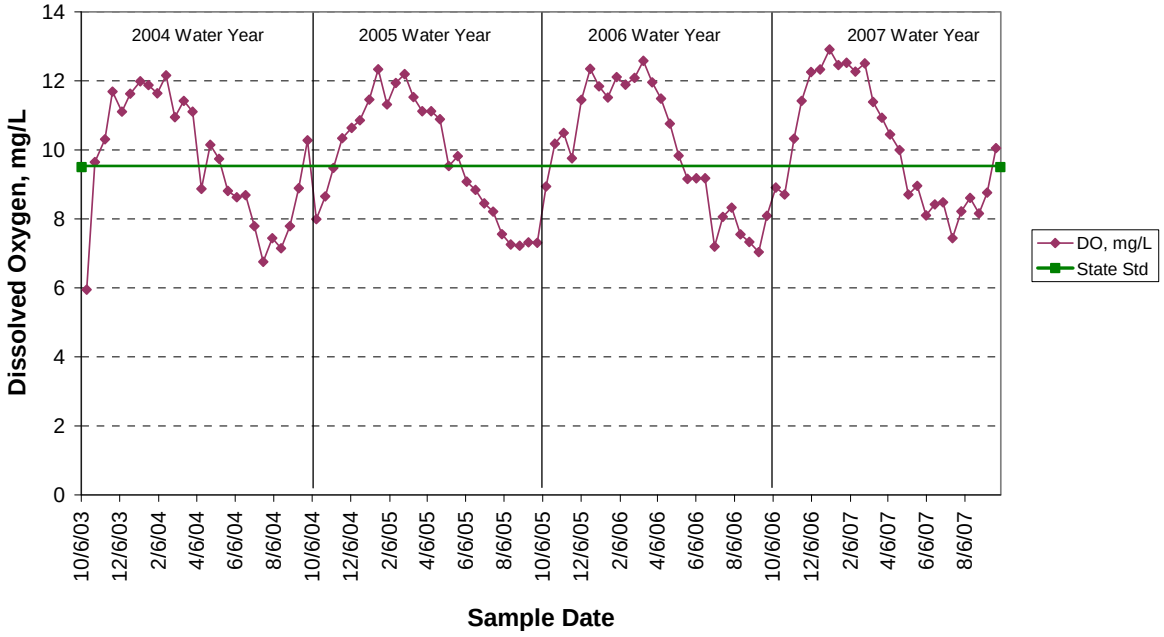
Nookachamps Creek at Knapp Rd - Site 15
Dissolved Oxygen



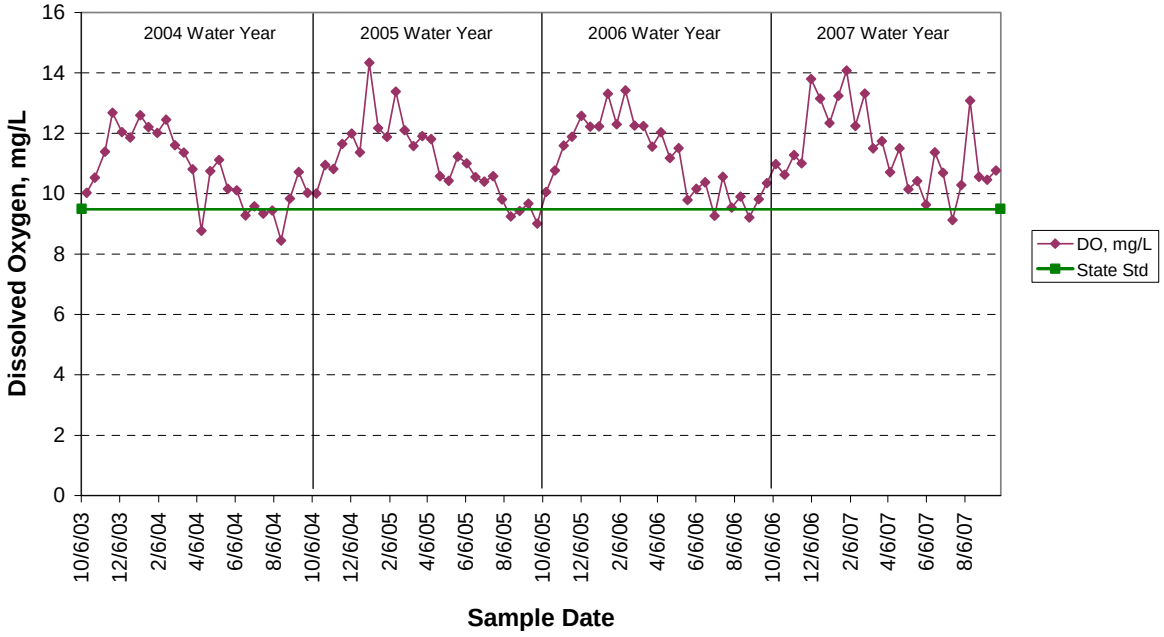
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Dissolved Oxygen



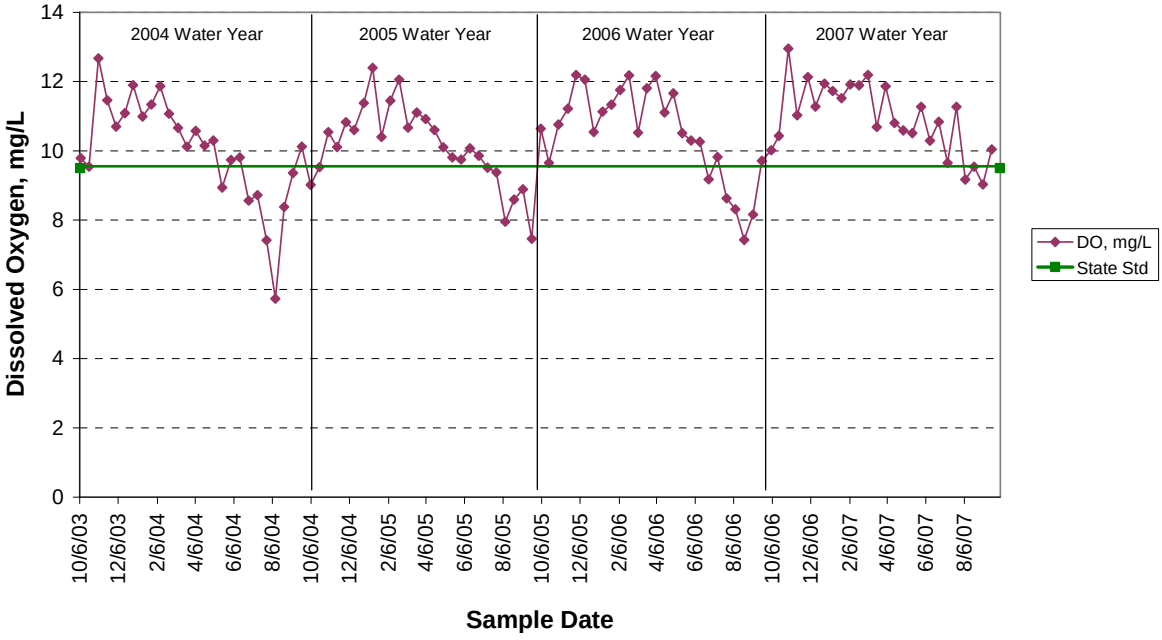
Nookachamps Creek at Big Lake Outlet - Site 17
Dissolved Oxygen



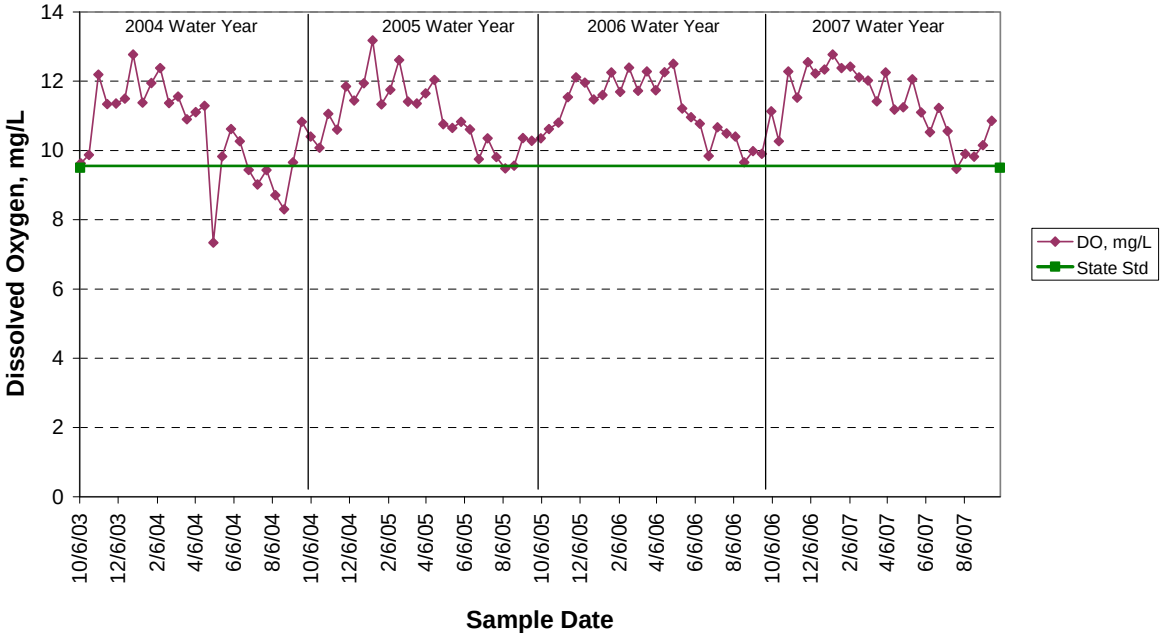
Lake Creek at Hwy 9 - Site 18
Dissolved Oxygen



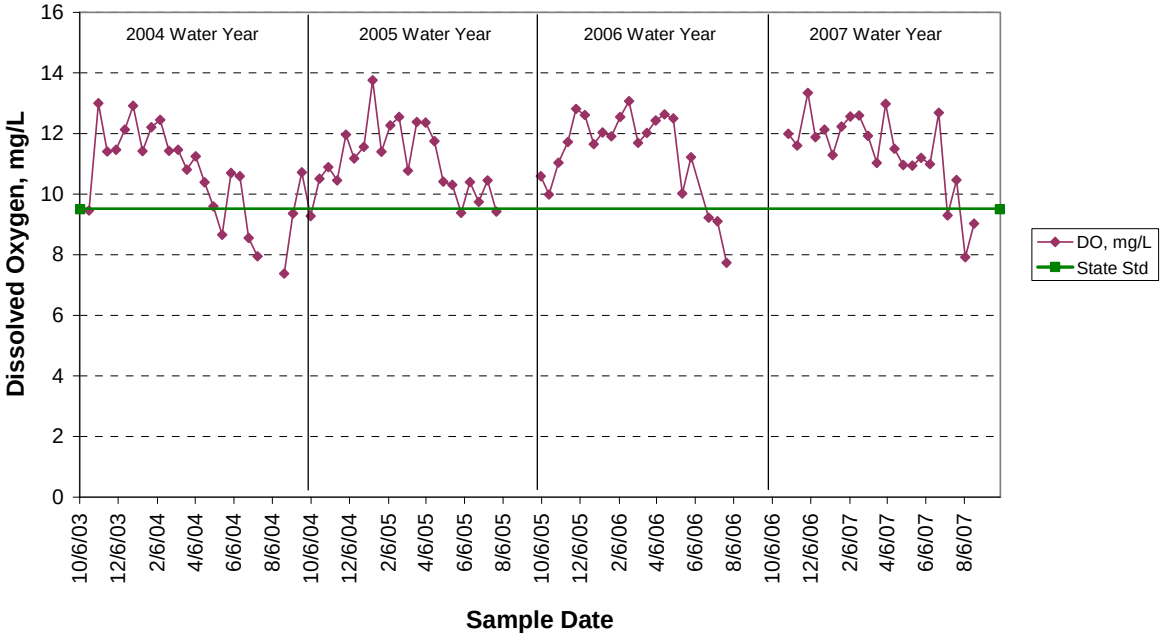
Hansen Creek at Hoehn Rd - Site 19
Dissolved Oxygen



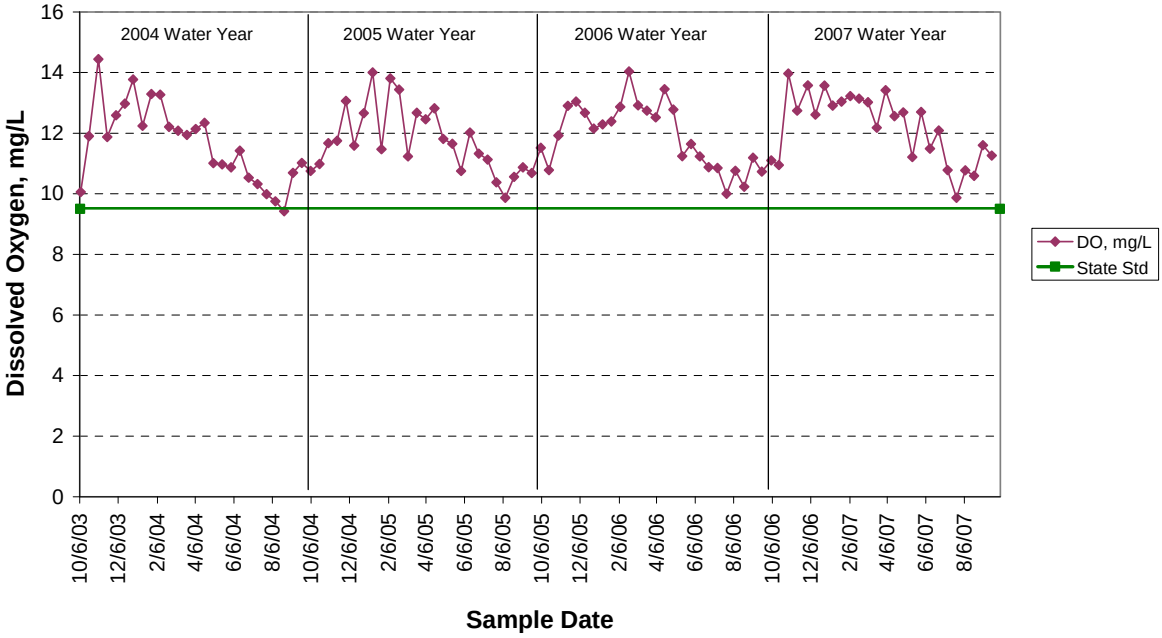
Hansen Creek at Northern State Hospital - Site 20
Dissolved Oxygen



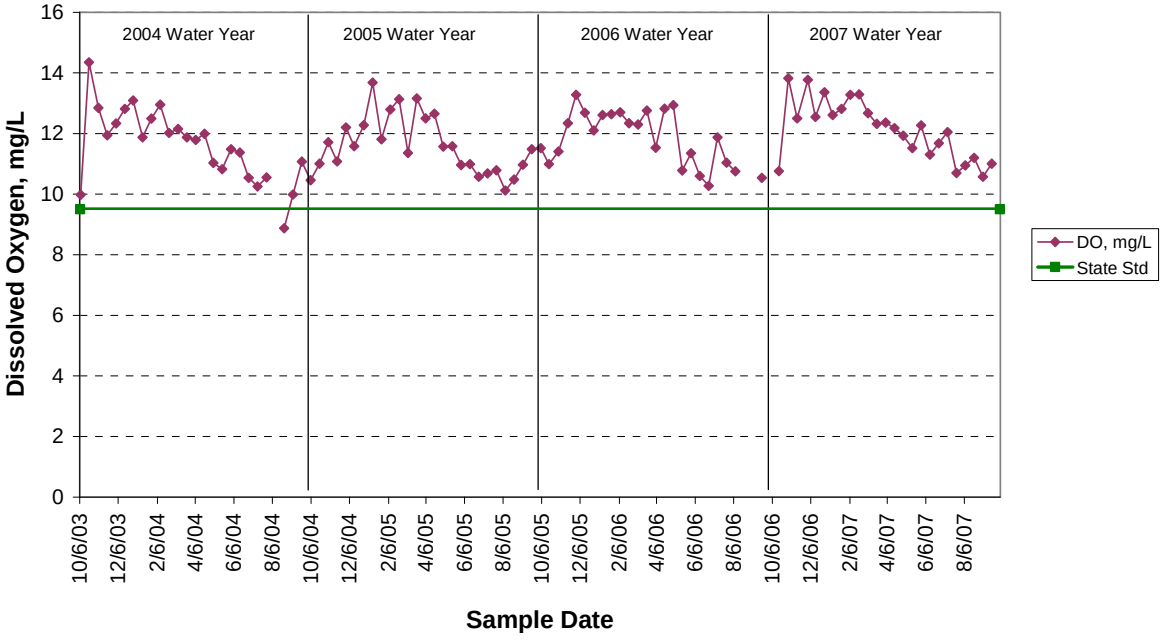
Coal Creek at Hoehn Rd - Site 21
Dissolved Oxygen



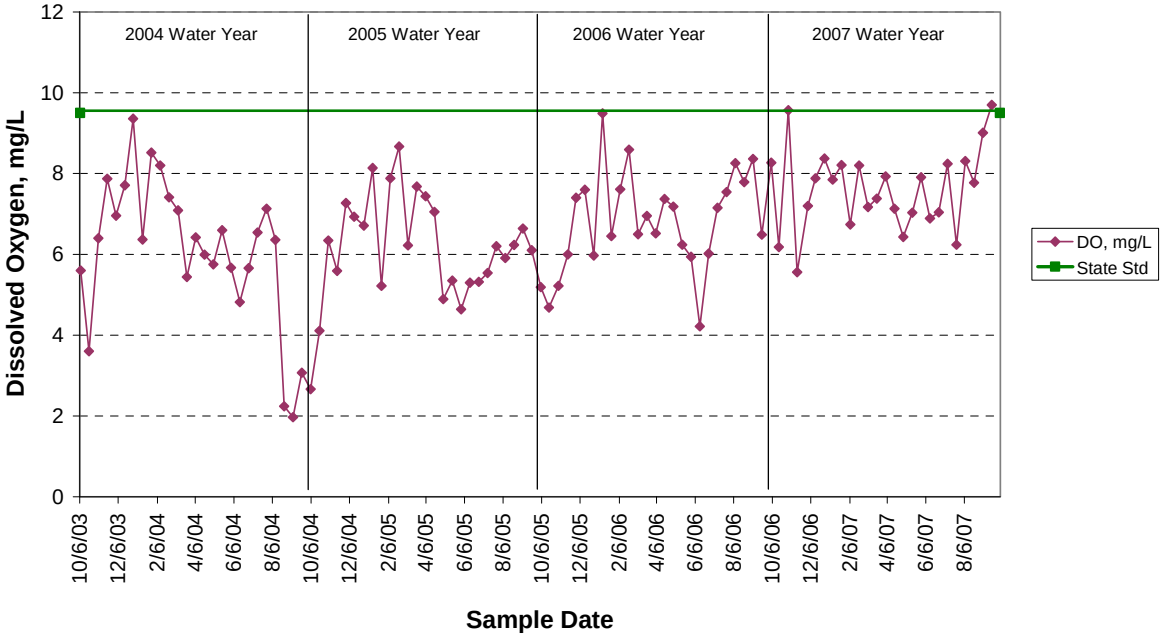
Coal Creek at Hwy 20 - Site 22
Dissolved Oxygen



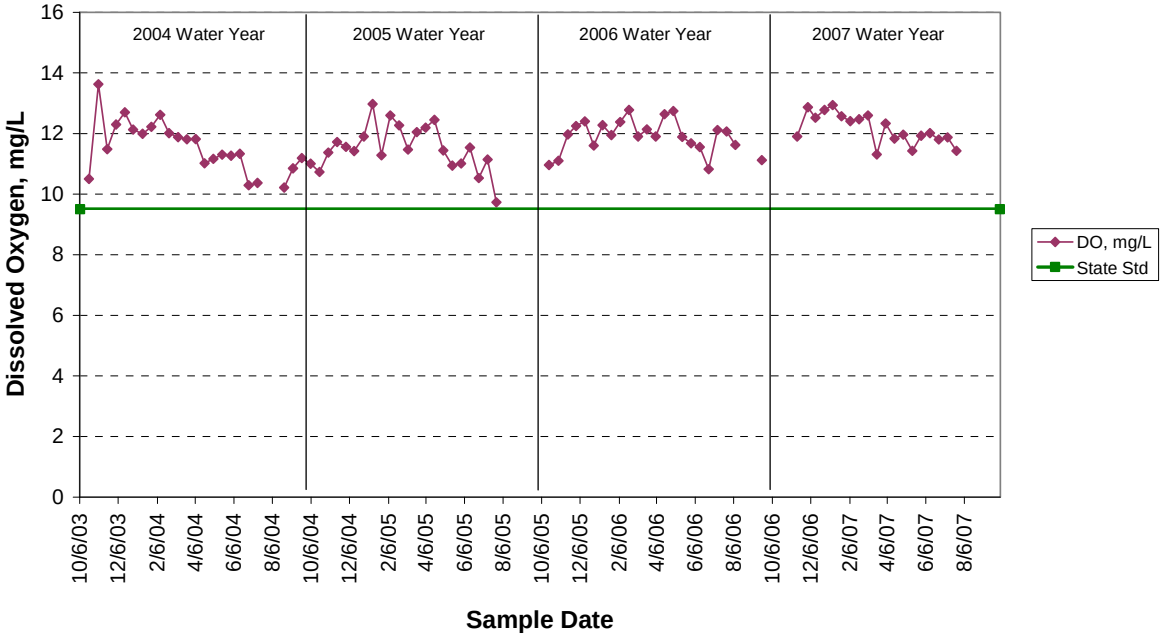
Wiseman Creek at Minkler Rd - Site 23
Dissolved Oxygen



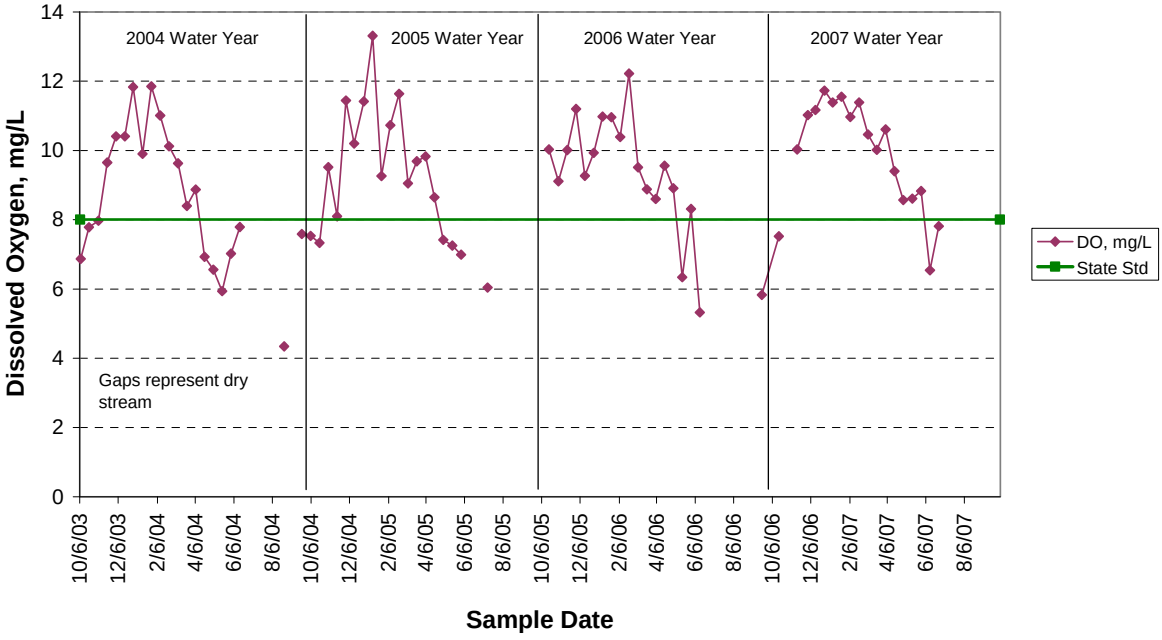
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Dissolved Oxygen



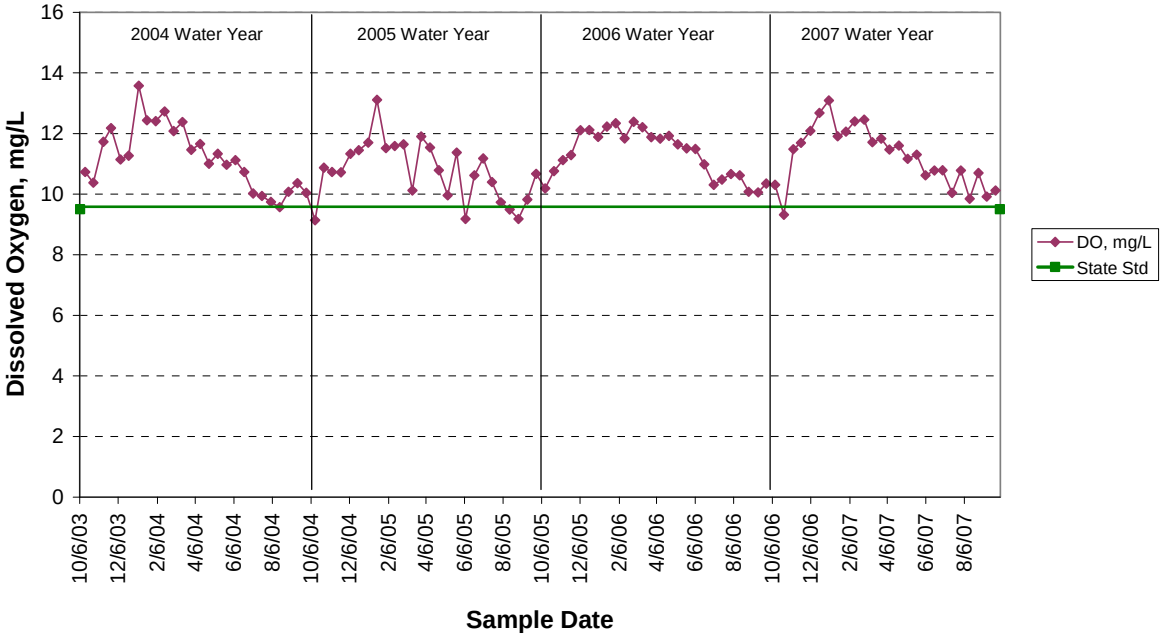
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Dissolved Oxygen



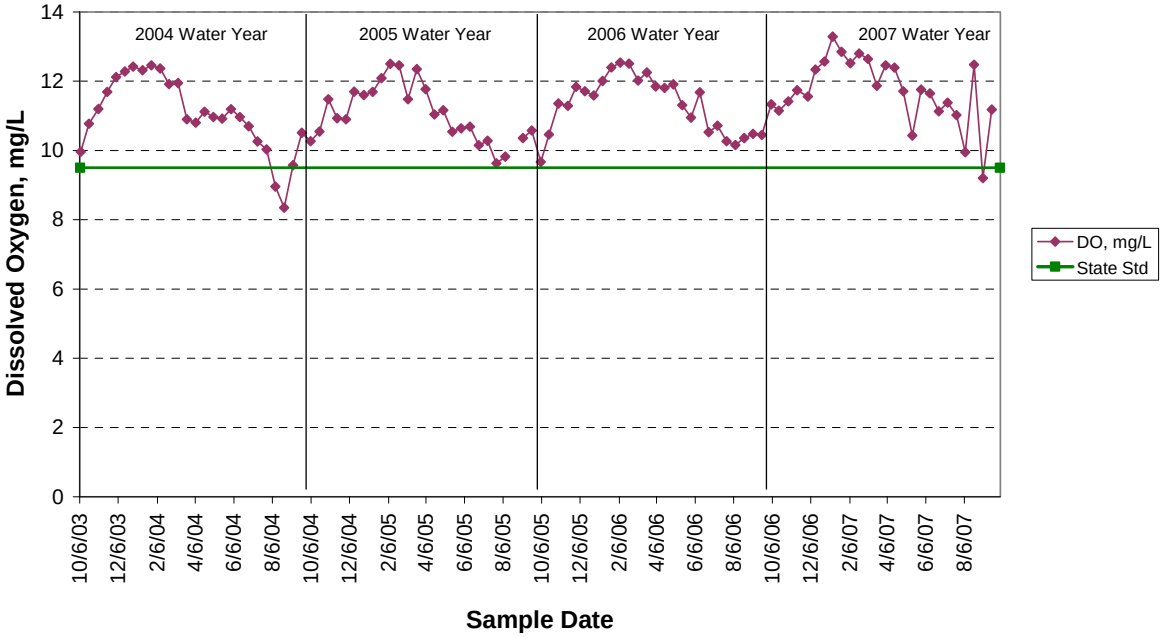
Brickyard Creek at Hwy 20 - Site 28
Dissolved Oxygen



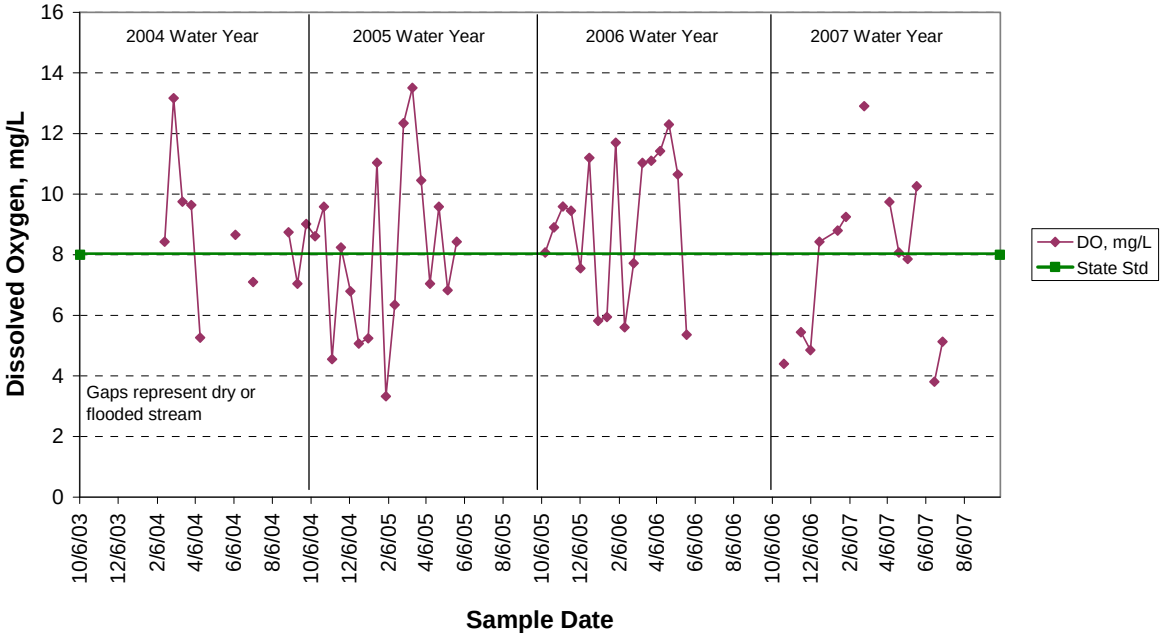
Skagit River at River Bend - Site 29
Dissolved Oxygen



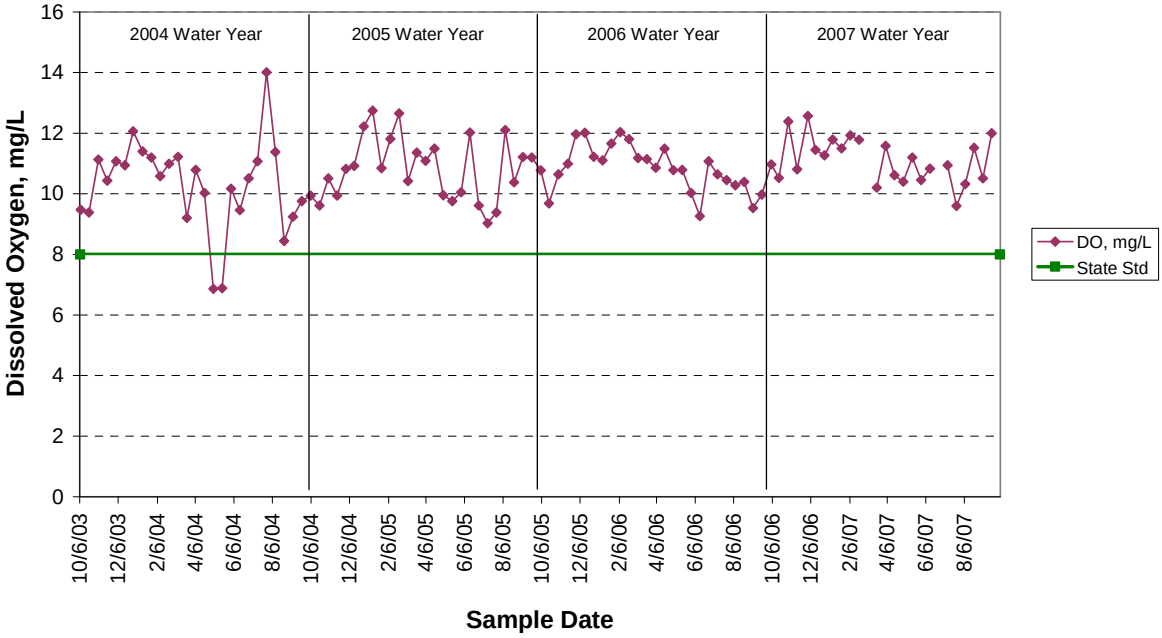
Skagit River at Cape Horn Rd - Site 30
Dissolved Oxygen



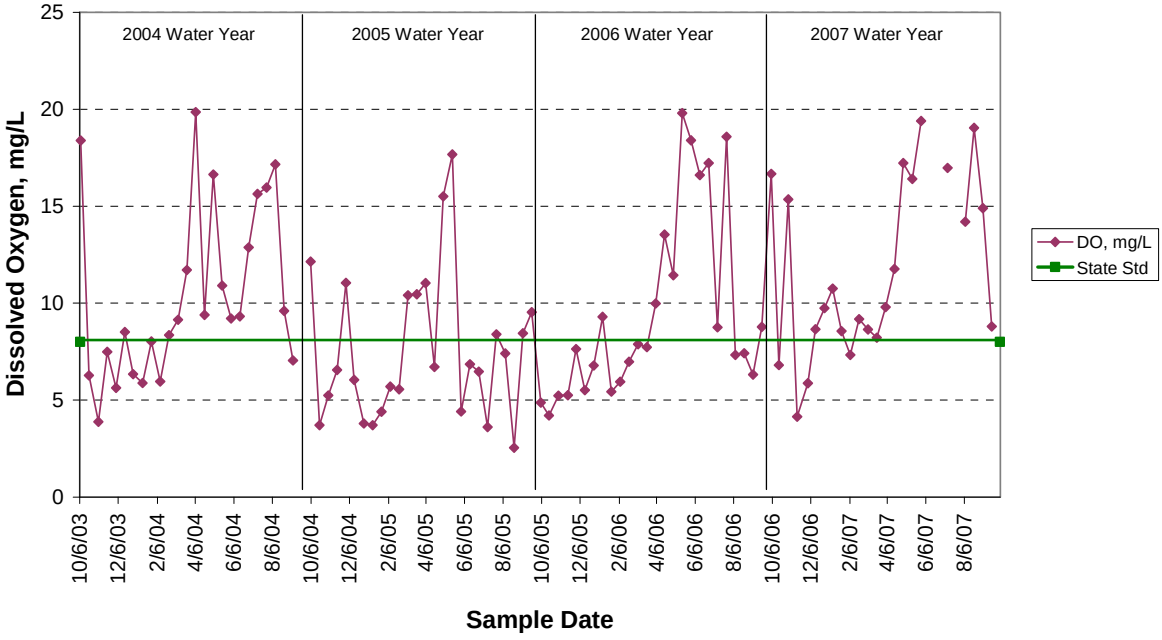
Drainage District 20 Ditch at Floodgate - Site 31
Dissolved Oxygen



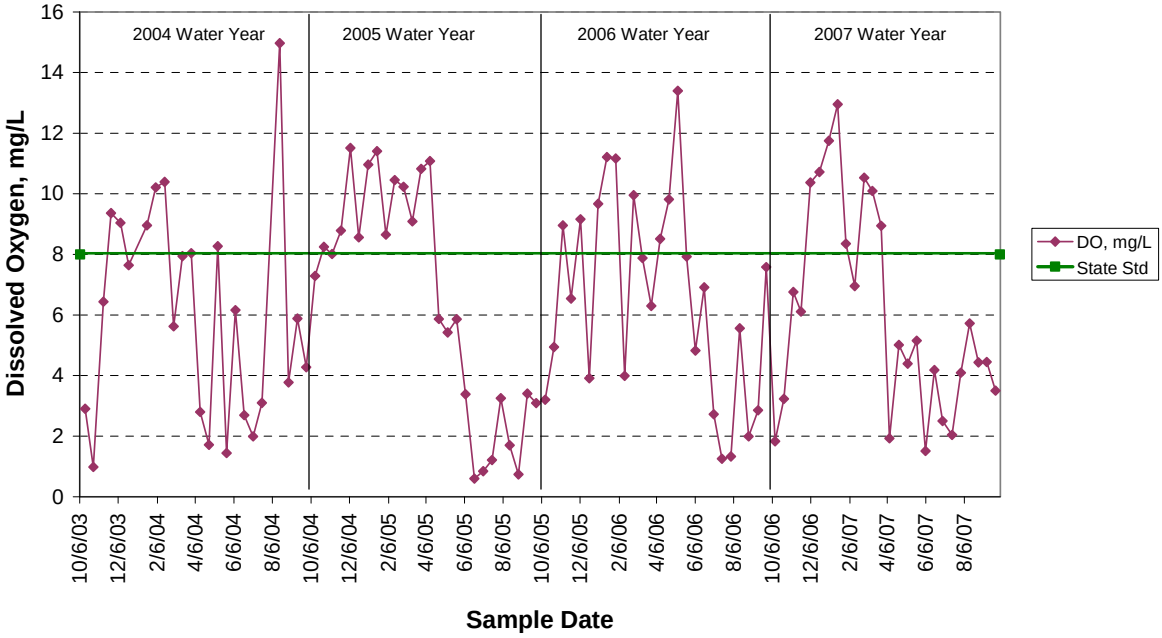
Samish River at Thomas Rd - Site 32
Dissolved Oxygen



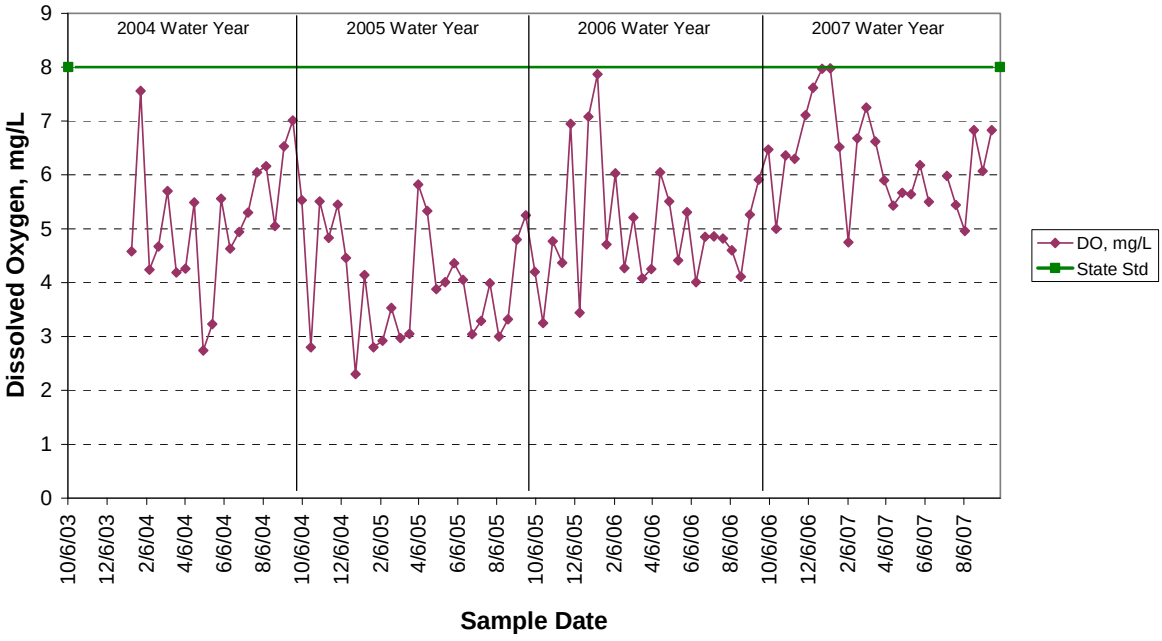
Alice Bay Pump Station - Site 33
Dissolved Oxygen



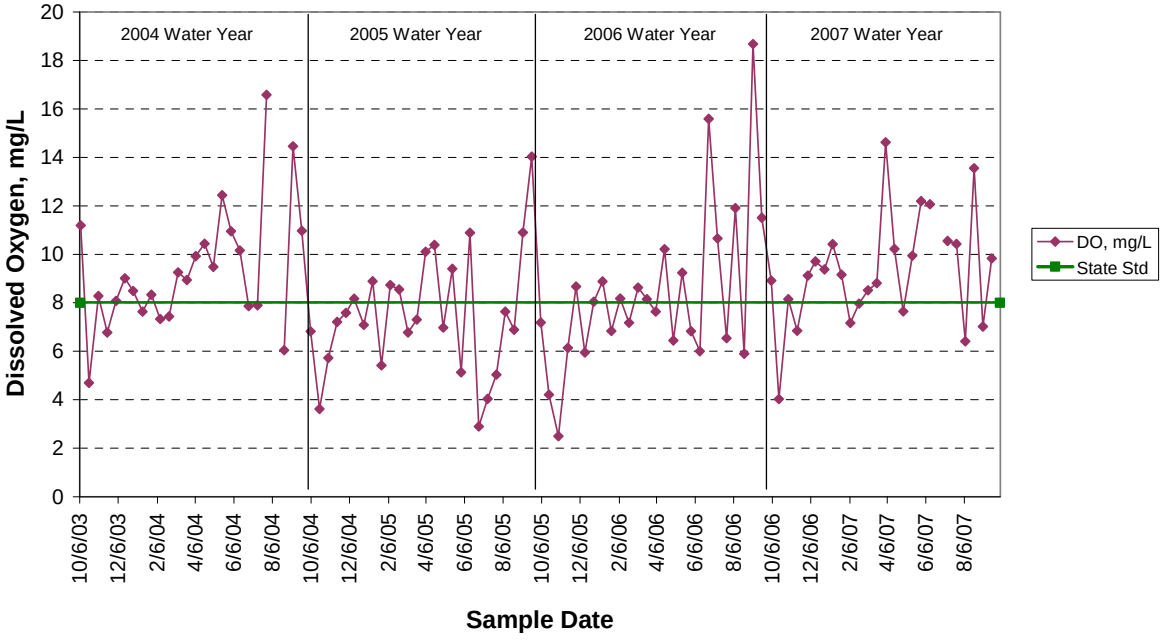
No Name Slough at Bayview-Edison Rd - Site 34
Dissolved Oxygen



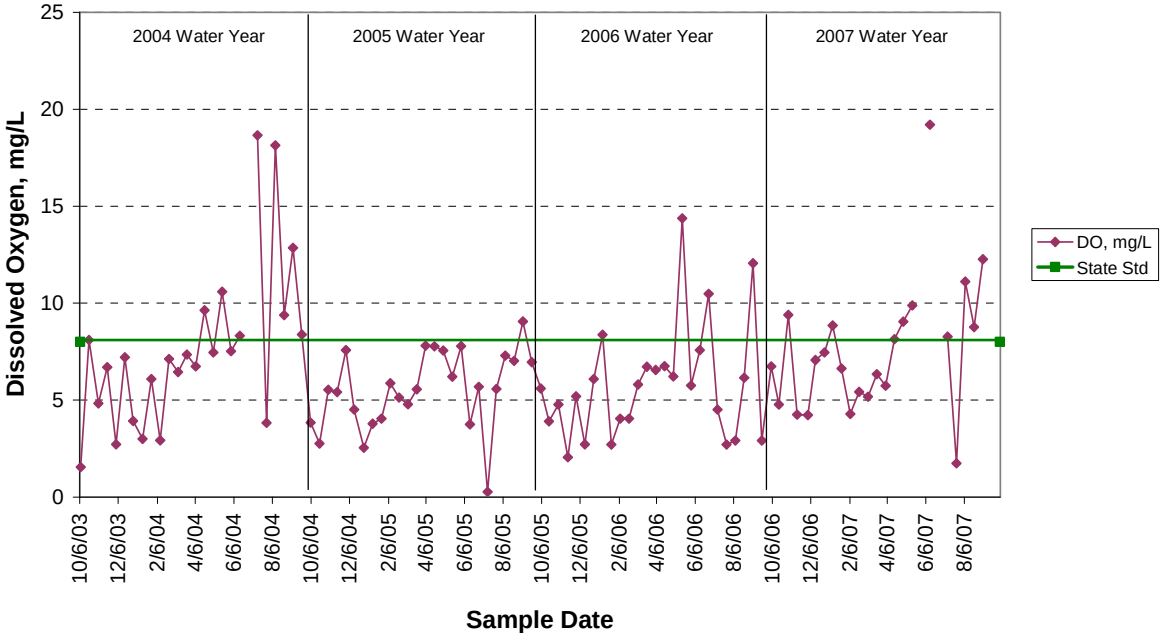
Joe Leary Slough at D'Arcy Rd - Site 35
Dissolved Oxygen



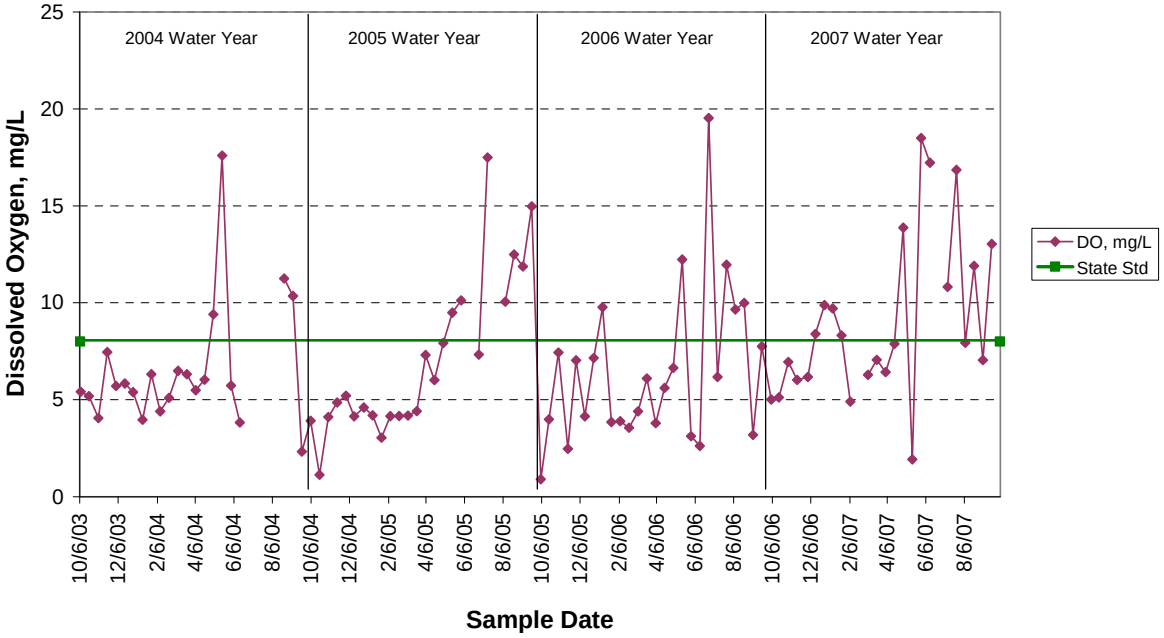
Edison Slough at Edison School - Site 36
Dissolved Oxygen



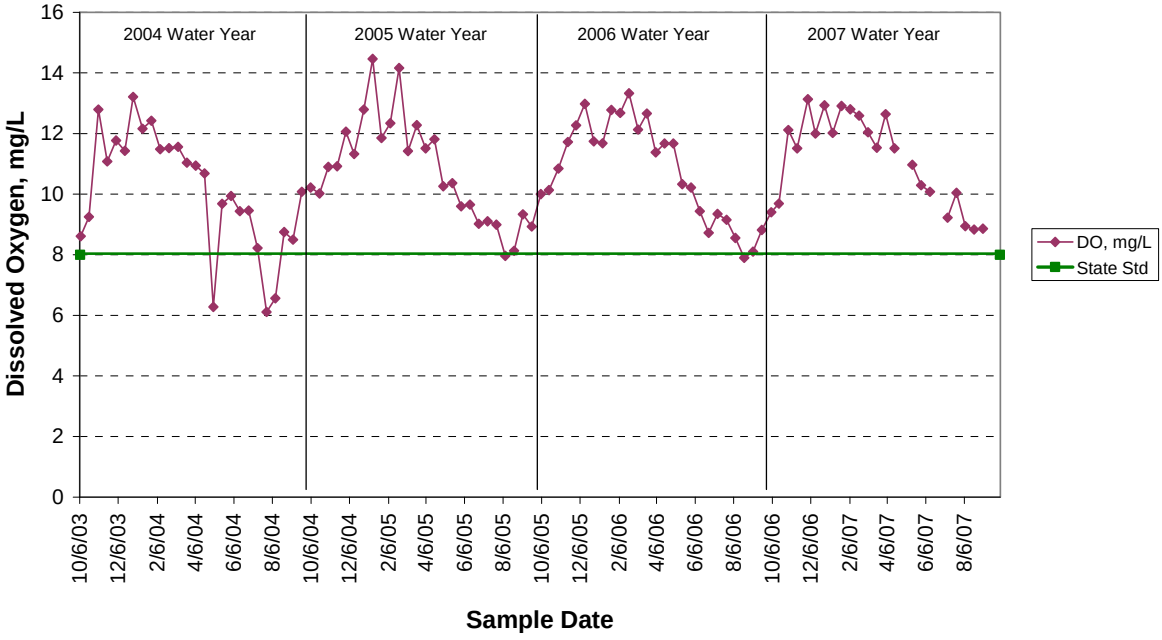
Edison Pump Station - Site 37
Dissolved Oxygen



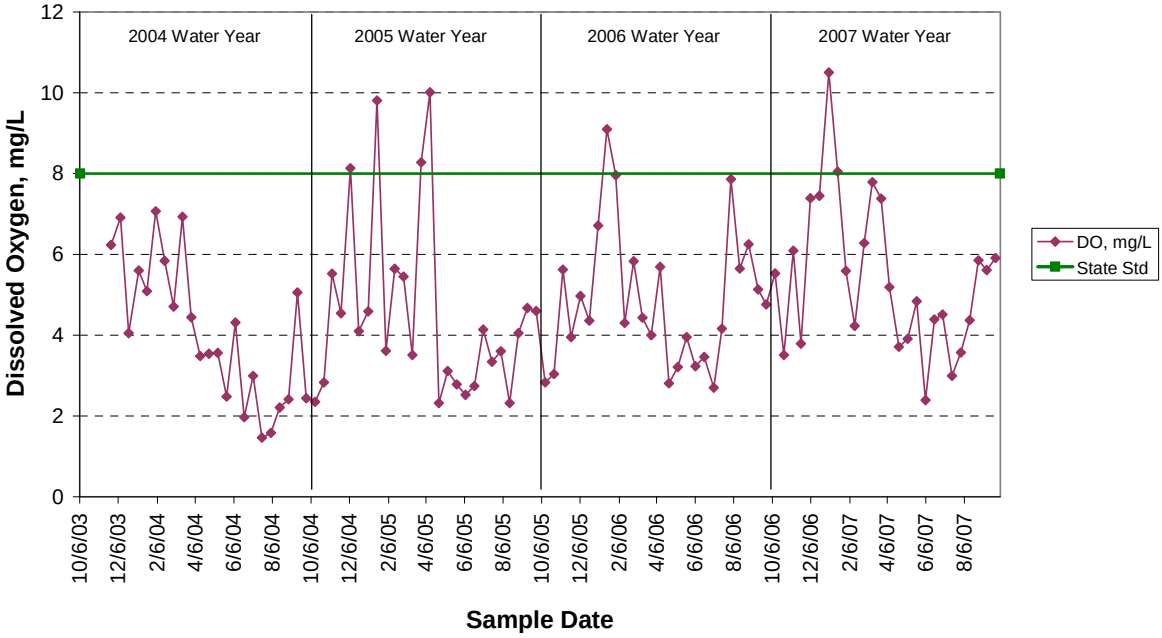
North Edison Pump Station - Site 38
Dissolved Oxygen



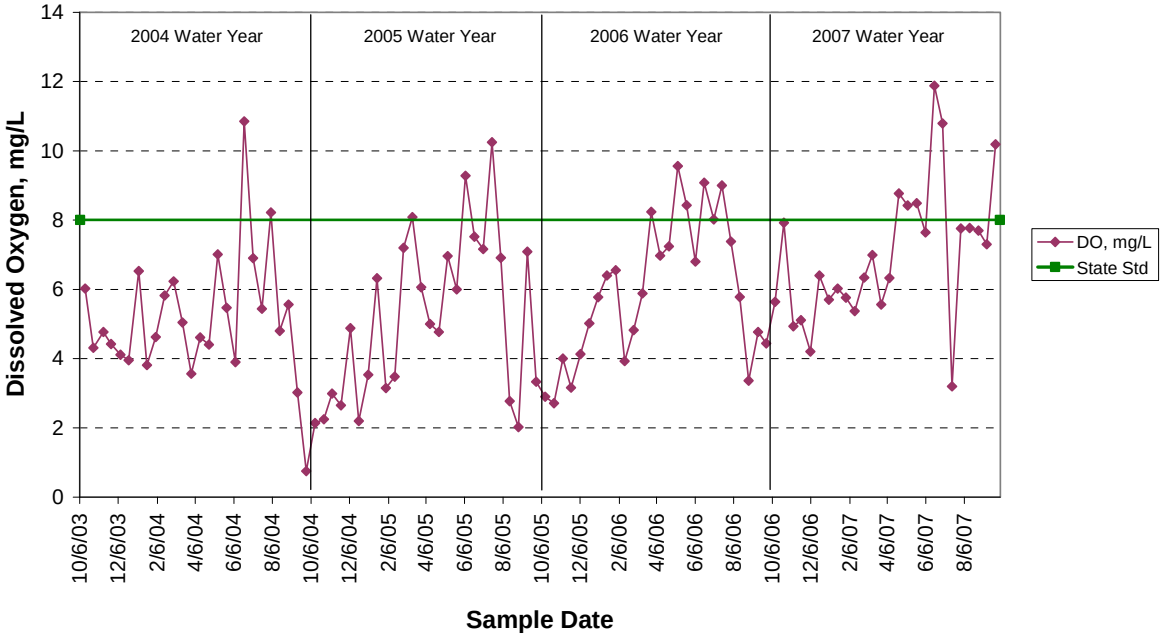
Colony Creek at Colony Rd - Site 39
Dissolved Oxygen



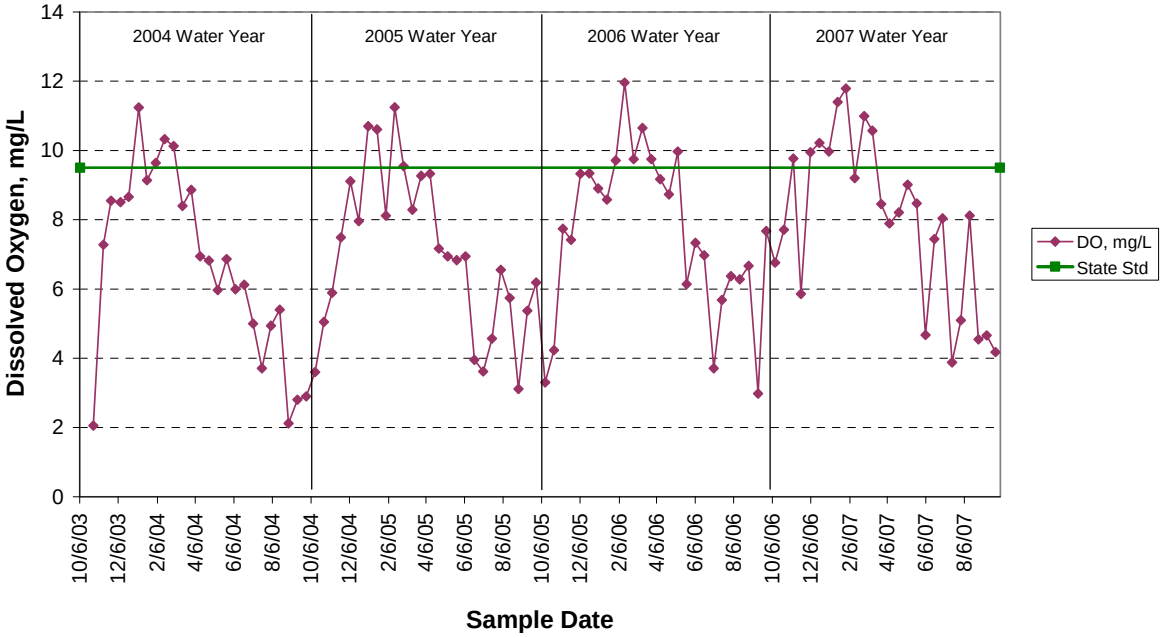
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Dissolved Oxygen



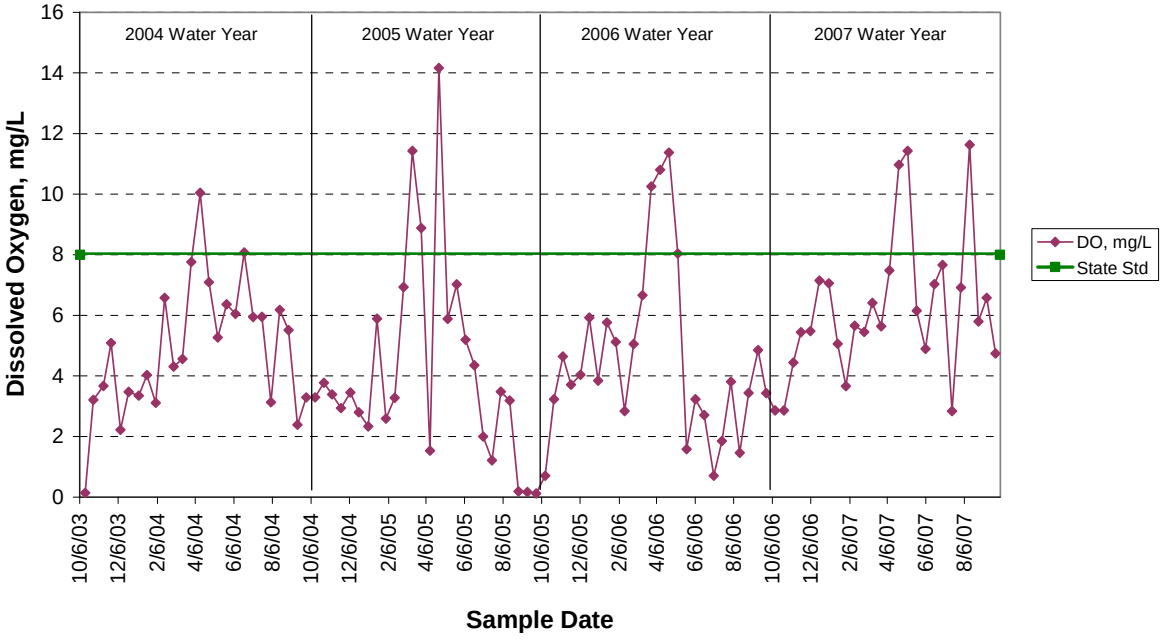
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Dissolved Oxygen



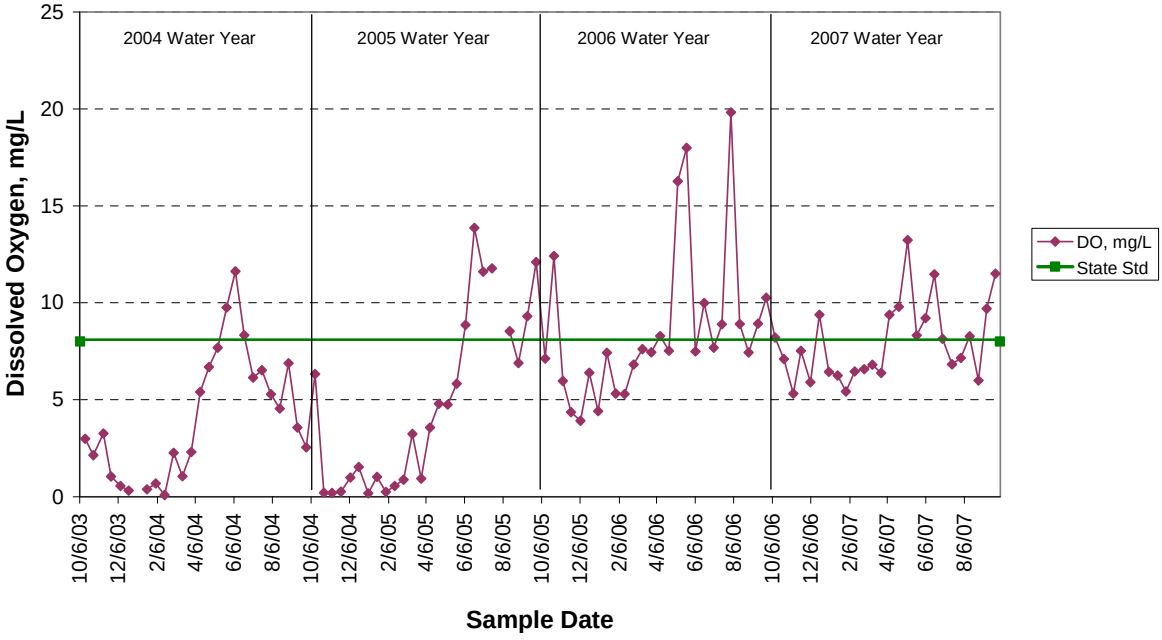
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Dissolved Oxygen



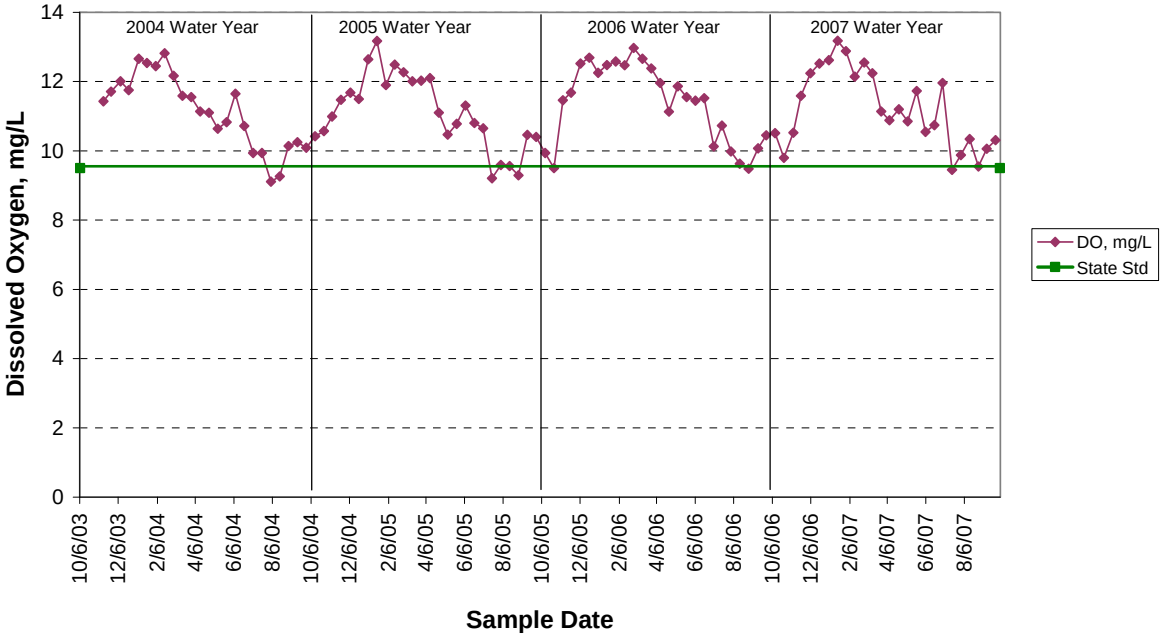
Wiley Slough at Wylie Rd - Site 43
Dissolved Oxygen



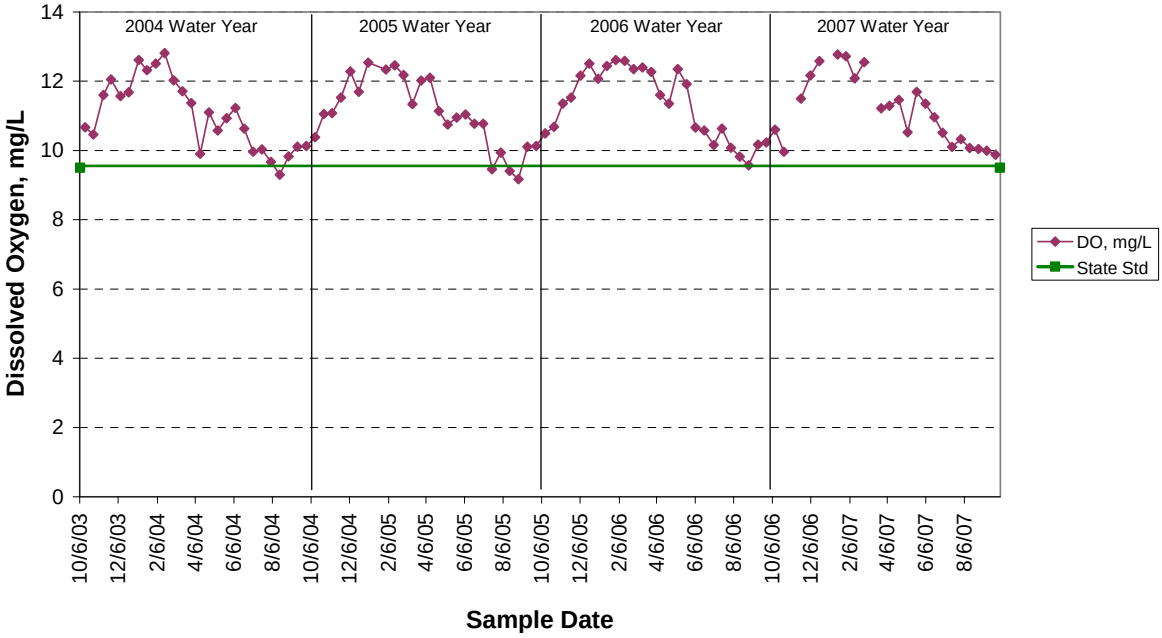
Sullivan Slough at La Conner-Whitney Rd - Site 44
Dissolved Oxygen



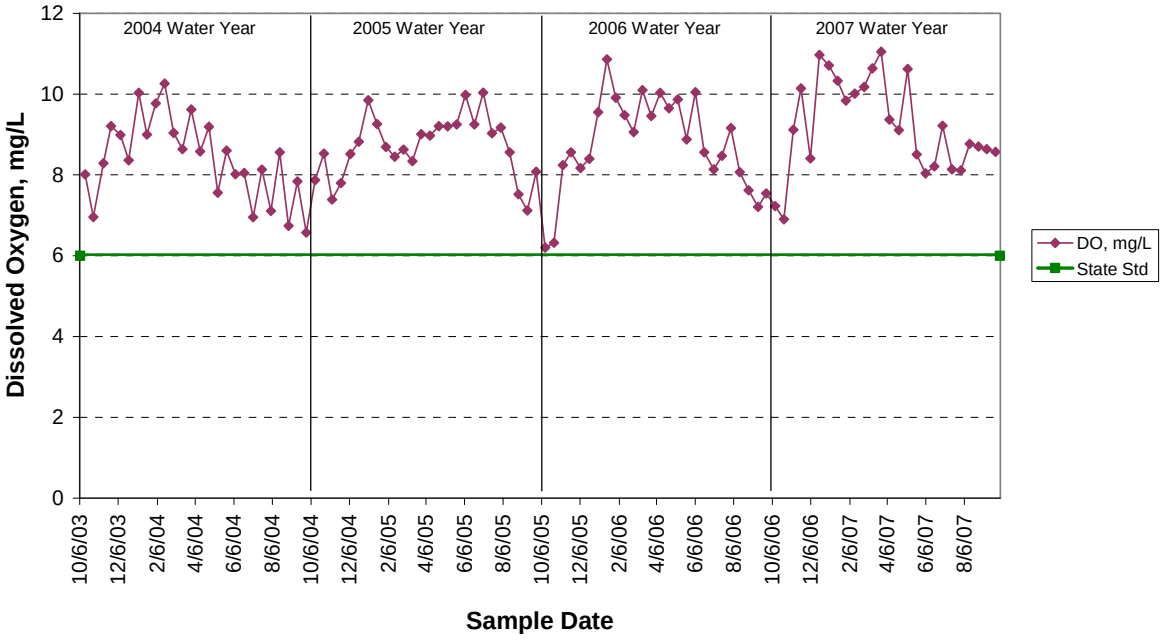
N.F. Skagit near Moore Rd - Site 45
Dissolved Oxygen



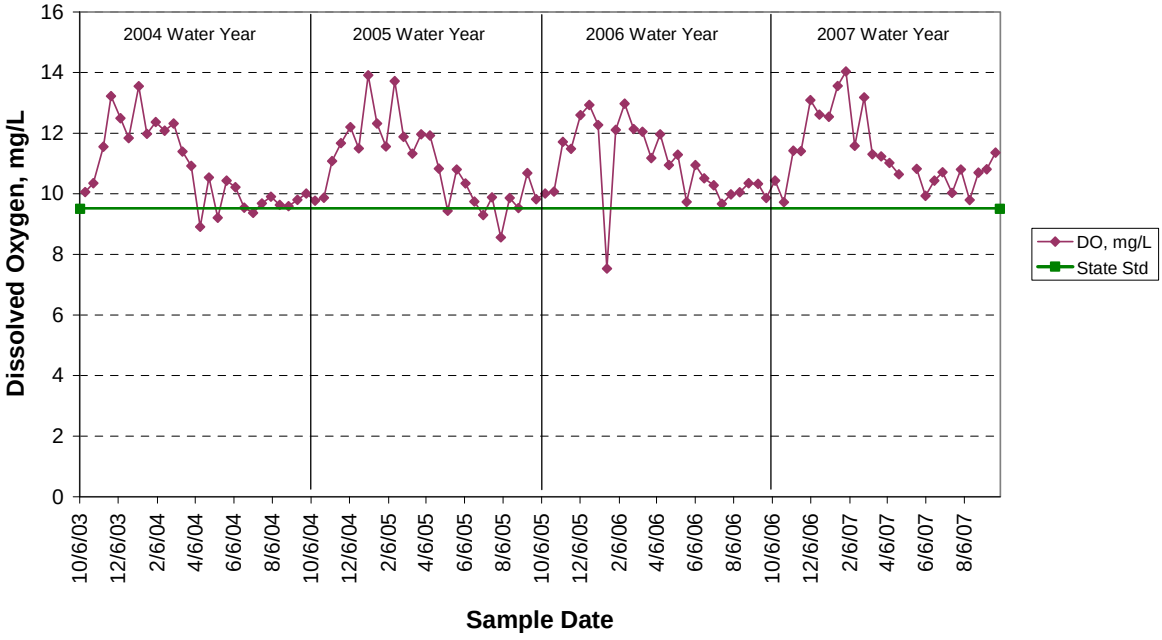
S.F. Skagit at Conway Boat Ramp - Site 46
Dissolved Oxygen



Swinomish Channel at County Boat Ramp - Site 47
Dissolved Oxygen



Fisher Creek at Franklin Rd - 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. Samples for fecal coliform measurements are taken at each site during each visit and submitted to the Skagit County Health Department Water Lab for analysis by the Most Probable Number method.

Fecal coliform measurements for the 2007 water year, in colony-forming units per 100 ml (cfu), are summarized in Table 7. Four-year results are summarized in Table 8. 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 cfu, with no more than 10% of the measurements exceeding 200 cfu. For the upriver sites (sites 21-25, 30), the standard is a geometric mean of 50 cfu, with no more than 10% of the measurements exceeding 100 cfu. For the marine site (site 47), a more stringent standard of 14 cfu with no more than 10% exceeding 41 cfu is enforced to protect shellfish beds.

Table 7 gives the geometric mean fecal coliform at each site for all four years of the study. All Skagit River sites (sites 29, 30, 45, and 46) and Swinomish Channel (site 47) met the state standard for fecal coliform for all four years of this project. Most other watercourses in the Skagit County Monitoring Program did not meet the standard, although for the 2007 water year, more sites than ever (14) met the standard for the entire water year. However, some of these sites may violate the standard for shorter portions of the year.

The sources of fecal coliform organisms reaching the watercourses of Skagit County could include runoff from failing septic tanks, livestock operations, wildlife, and pets. Methods to identify bacterial sources are under development but are expensive and not necessarily ready for widespread application.

Graphs on the pages following Table 8 illustrate fecal coliform levels for water years 2004-2007 at each of the sample sites. The scale on each graph differs in order to fully illustrate the variability at each site.

Table 7. 2007 Fecal Coliform Results

Summary of Fecal Coliform Readings in Skagit County Monitoring Program, 2007 Water Year

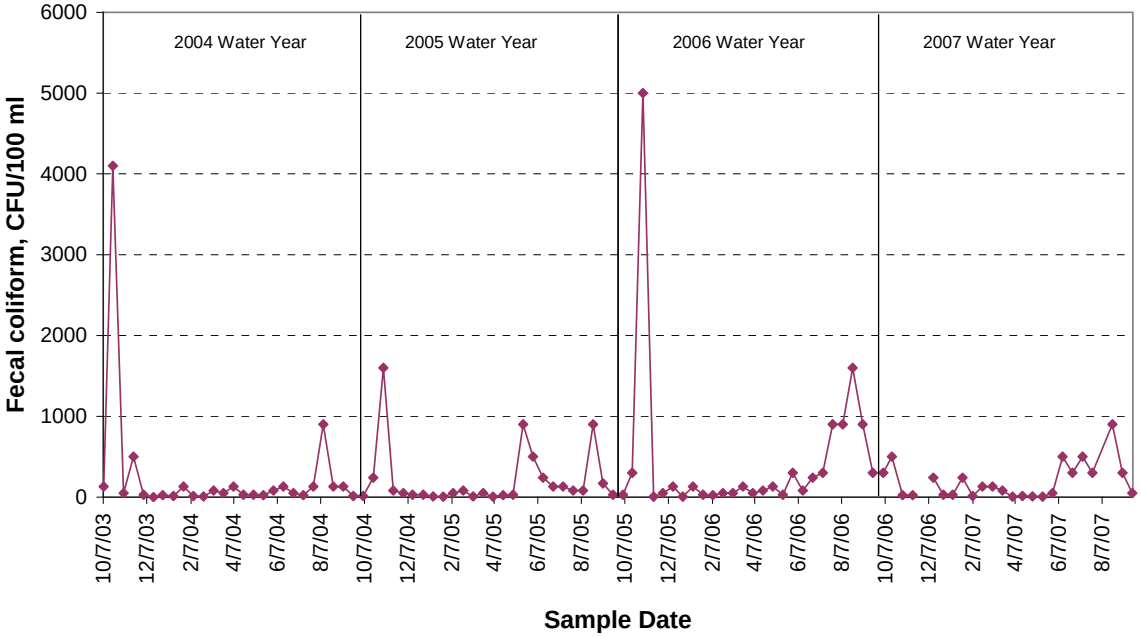
Site Number	Watercourse	Location	N	Geometric mean (cfu)[1]	% > 100 or 200[1]
3	Thomas Ck	Old Hwy 99 North	24	77	42
4	Thomas Ck	F&S Grade	24	187	54
6	Friday Ck	Prairie Rd	24	39	21
8	Swede Ck	Grip Rd	24	66	29
11	Samish R	State Route 9	24	14	8.3
12	Nookachamps Ck	Swan Rd	21	49	9.5
13	E.F. Nookachamps Ck	State Route 9	24	65	33
14	College Way Ck	College Way	24	193	54
15	Nookachamps Ck	Knapp	24	84	17
16	E.F. Nookachamps Ck	Beaver Lake Rd	24	24	4.2
17	Nookachamps Ck	Big Lake Outlet	24	16	4.2
18	Lake Ck	State Route 9	24	61	29
19	Hansen Ck	Hoehn Rd	24	126	33
20	Hansen Ck	Northern State	24	49	17
21	Coal Ck	Hoehn Rd	21	168	43
22	Coal Ck	Hwy 20	24	12	13
23	Wiseman Ck	Minkler Rd	23	21	22
24	Mannser Ck	Lyman Hamilton Hwy	24	16	4.2
25	Red Cabin Ck	Hamilton Cem Rd	18	7	5.6
28	Brickyard Ck	Hwy 20	17	58	12
29	Skagit R	R Bend Rd	24	7	0.0
30	Skagit R	Cape Horn Rd	23	6	4.3
31	Drain Dist 20 near floodgate	Francis Rd	12	24	8.3
32	Samish R	Thomas Rd	24	42	13
33	Alice Bay Pump Station	Samish Island Rd	24	28	8.3
34	Noname Slough	Bayview-Edison Rd	24	118	50
35	Joe Leary Slough	D'Arcy Rd	23	192	57
36	Edison Slough at school	W. Bow Hill Rd	24	41	17
37	Edison Pump Station	Farm to Market Rd	24	135	33
38	North Edison Pump Station	North Edison Rd	23	57	13
39	Colony Ck	Colony Rd	24	77	33
40	Big Indian Slough	Bayview-Edison Rd	24	11	4.2
41	Maddox Slough/Big Ditch	Milltown Rd	24	71	33
42	Hill Ditch	Cedardale Rd	24	61	25
43	Wiley Slough	Wylie Rd	24	75	13
44	Sullivan Slough	La Conner-Whitney Rd	24	76	25
45	Skagit R – North Fork	Moore Rd	24	5	0.0
46	Skagit R – South Fork	Fir Island Rd	22	7	0.0
47	Swinomish Channel	County Boat Launch	23	3	0.0
48	Fisher Ck	Franklin Rd	24	106	33

[1]State water quality standard 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) 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.

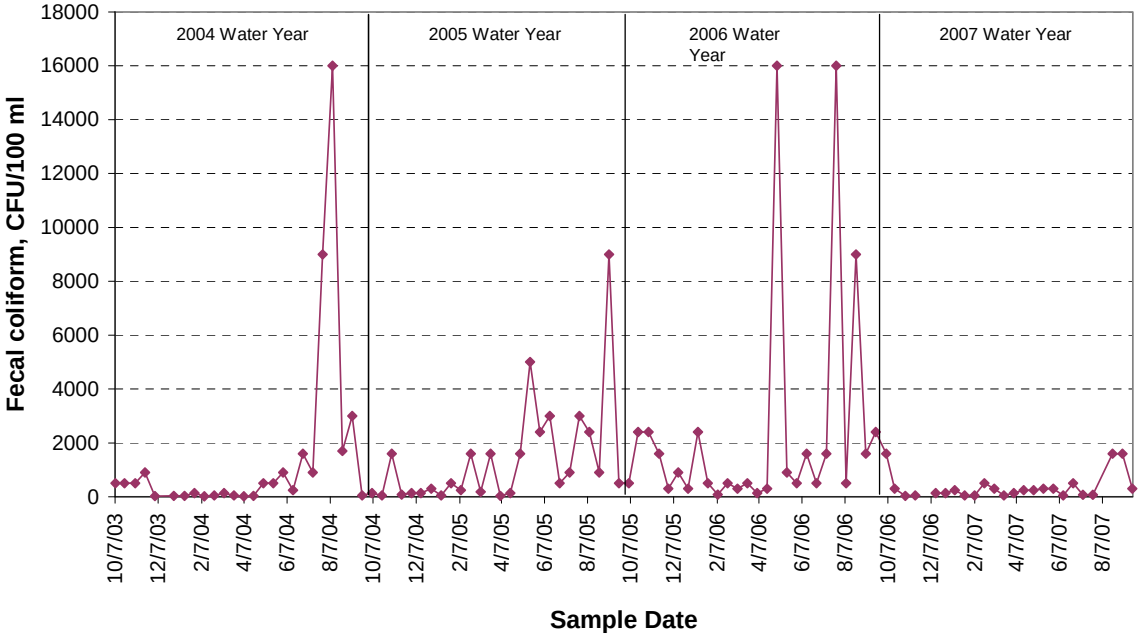
Table 8. Four-Year Fecal Coliform Results Summary
Geometric mean fecal coliform levels for the four water years of the
Skagit County Monitoring Program

Site Number	Watercourse	Location	2004	2005	2006	2007
3	Thomas Ck	Old Hwy 99 North	57	65	121	77
4	Thomas Ck	F&S Grade	255	516	950	187
6	Friday Ck	Prairie Rd	43	24	55	39
8	Swede Ck	Grip Rd	95	83	113	66
11	Samish R	State Route 9	22	15	22	14
12	Nookachamps Ck	Swan Rd	90	64	75	49
13	E.F. Nookachamps Ck	State Route 9	44	44	57	65
14	College Way Ck	College Way	171	143	157	193
15	Nookachamps Ck	Knapp	78	71	78	84
16	E.F. Nookachamps Ck	Beaver Lake Rd	54	28	20	24
17	Nookachamps Ck	Big Lake Outlet	15	11	16	16
18	Lake Ck	State Route 9	68	50	45	61
19	Hansen Ck	Hoehn Rd	75	54	107	126
20	Hansen Ck	Northern State	37	43	77	49
21	Coal Ck	Hoehn Rd	110	112	115	168
22	Coal Ck	Hwy 20	15	8	11	12
23	Wiseman Ck	Minkler Rd	14	13	23	21
24	Mannser Ck	Lyman Hamilton Hwy	43	21	17	16
25	Red Cabin Ck	Hamilton Cem Rd	14	8	9	7
28	Brickyard Ck	Hwy 20	53	41	55	58
29	Skagit R	R Bend Rd	14	10	7	7
30	Skagit R	Cape Horn Rd	3	3	5	6
31	Drain Dist 20 near floodgate	Francis Rd	88	46	89	24
32	Samish R	Thomas Rd	64	86	85	42
33	Alice Bay Pump Station	Samish Island Rd	96	92	62	28
34	Noname Slough	Bayview-Edison Rd	79	214	204	118
35	Joe Leary Slough	D'Arcy Rd	115	108	143	192
36	Edison Slough at school	W. Bow Hill Rd	83	42	71	41
37	Edison Pump Station	Farm to Market Rd	102	162	197	135
38	North Edison Pump Station	North Edison Rd	180	70	120	57
39	Colony Ck	Colony Rd	95	100	156	77
40	Big Indian Slough	Bayview-Edison Rd	48	43	51	11
41	Maddox Slough/Big Ditch	Milltown Rd	25	30	73	71
42	Hill Ditch	Cedardale Rd	22	18	27	61
43	Wiley Slough	Wylie Rd	55	80	56	75
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	14	20	44	76
45	Skagit R – North Fork	Moore Rd	6	9	6	5
46	Skagit R – South Fork	Fir Island Rd	13	13	8	7
47	Swinomish Channel	County Boat Launch	6	3	4	3
48	Fisher Ck	Franklin Rd	77	96	76	106

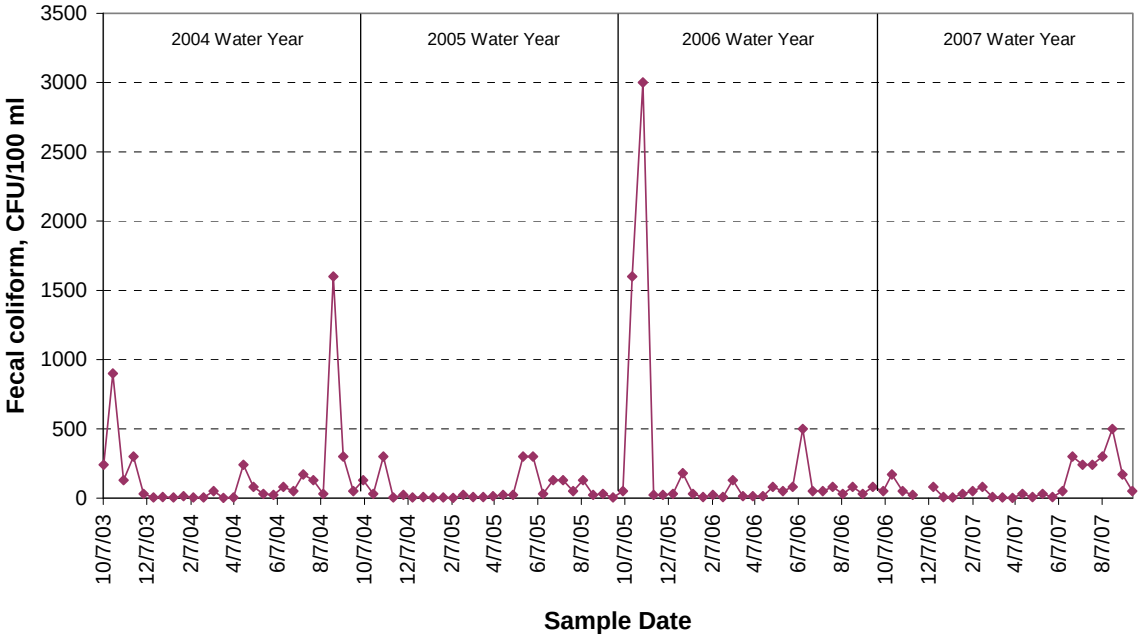
Thomas Creek at Hwy 99 - Site 3
Fecal coliform



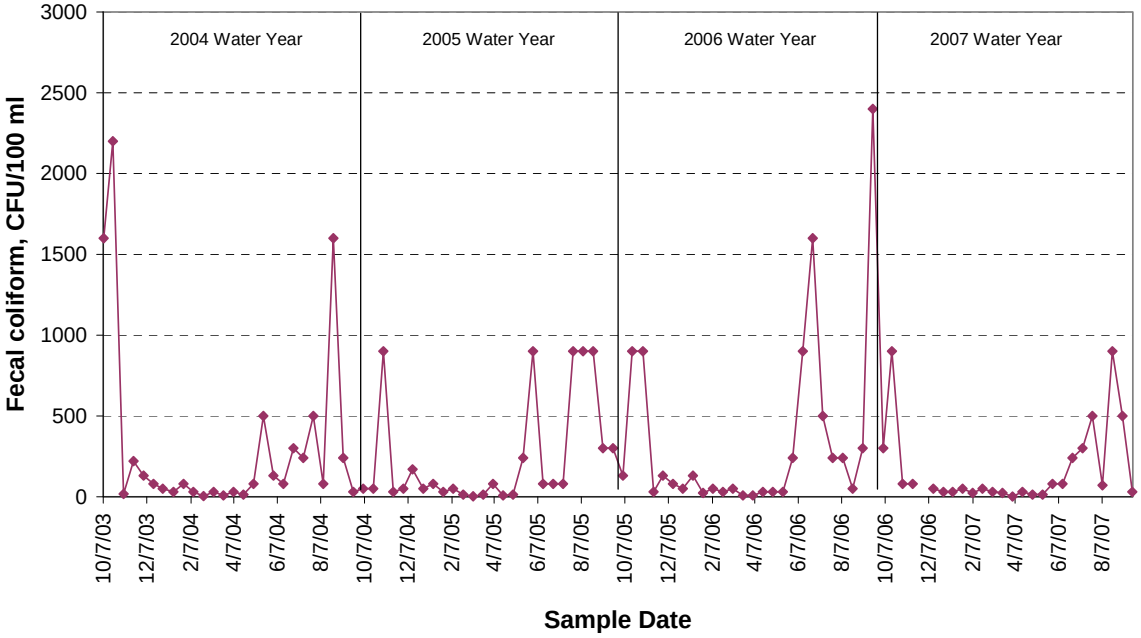
Thomas Creek at F&S Grade Rd - Site 4
Fecal coliform



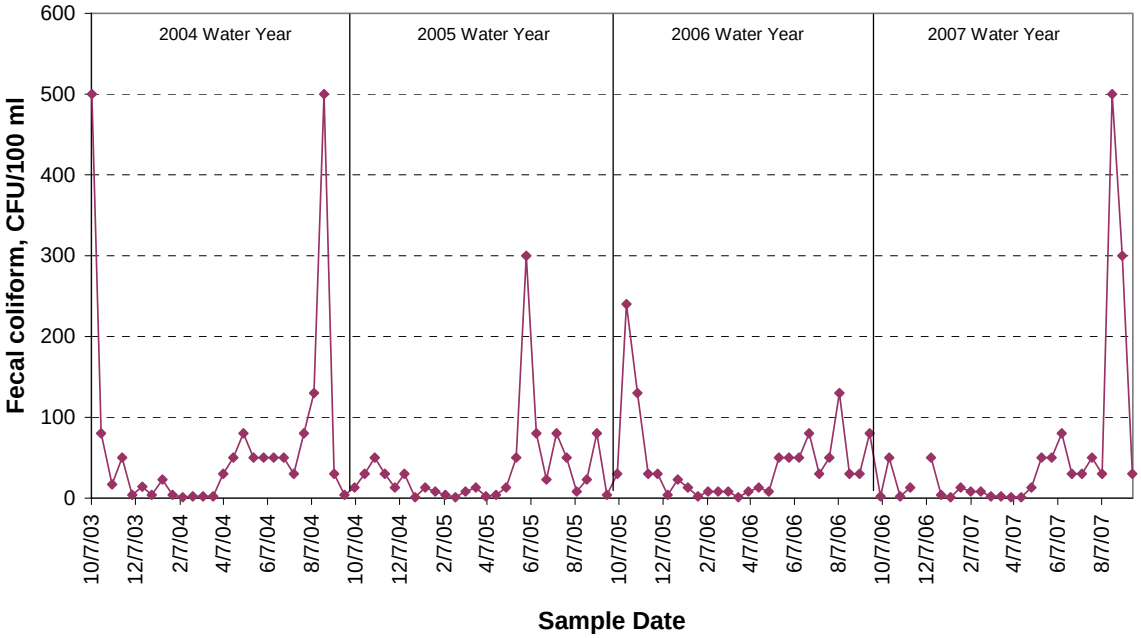
Friday Creek at Prairie Rd - Site 6
Fecal coliform



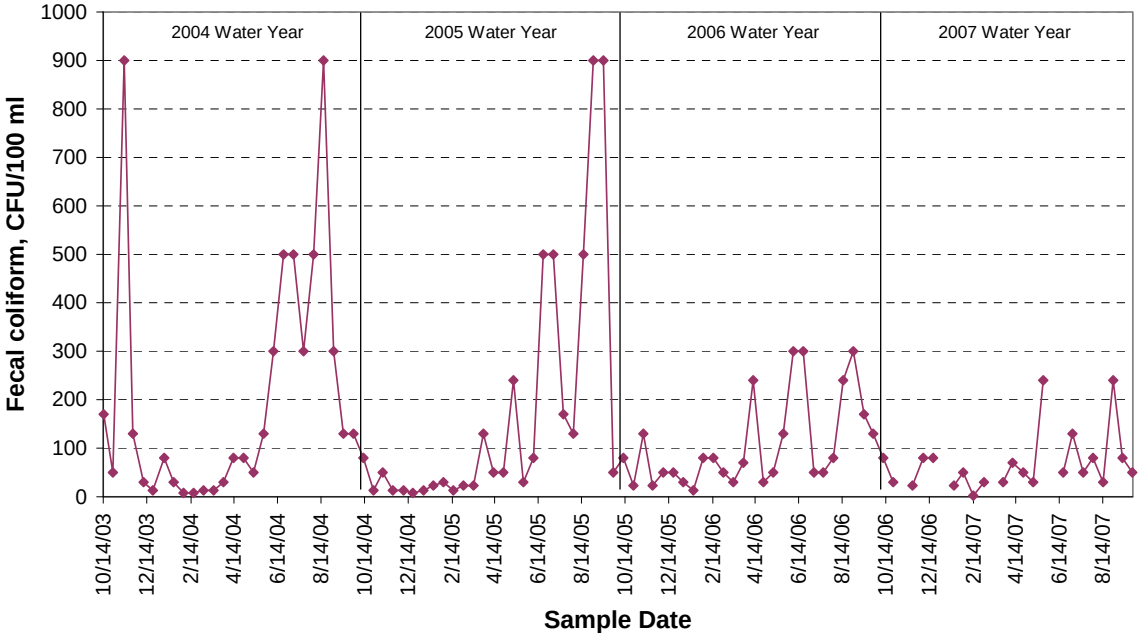
Swede Creek at Grip Rd - Site 8
Fecal coliform



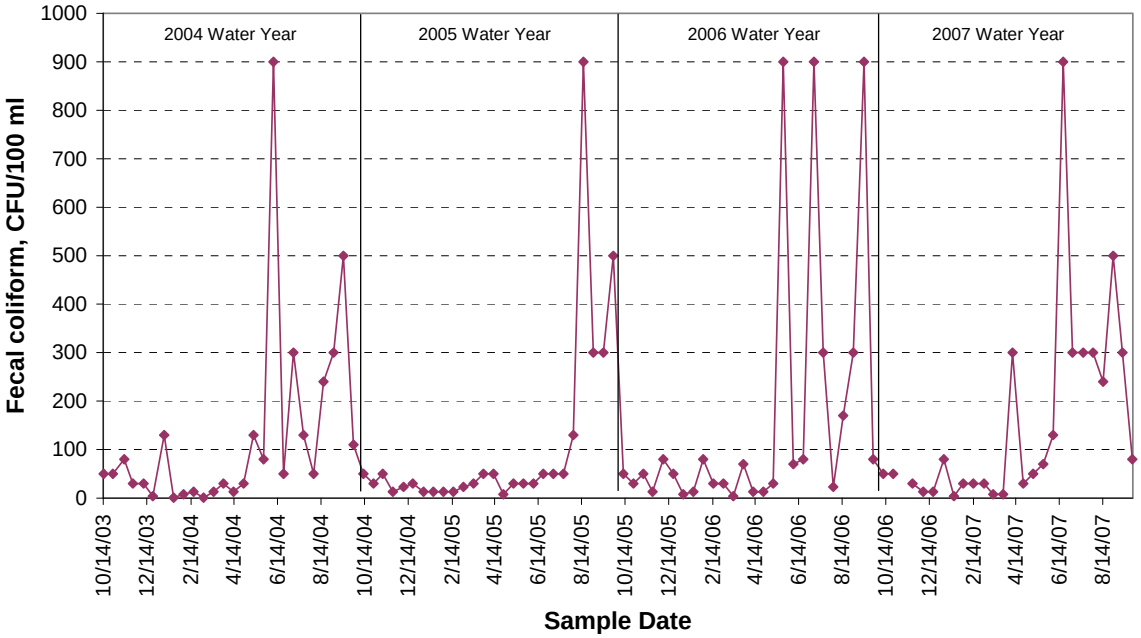
Samish River at Hwy 9 - Site 11
Fecal coliform



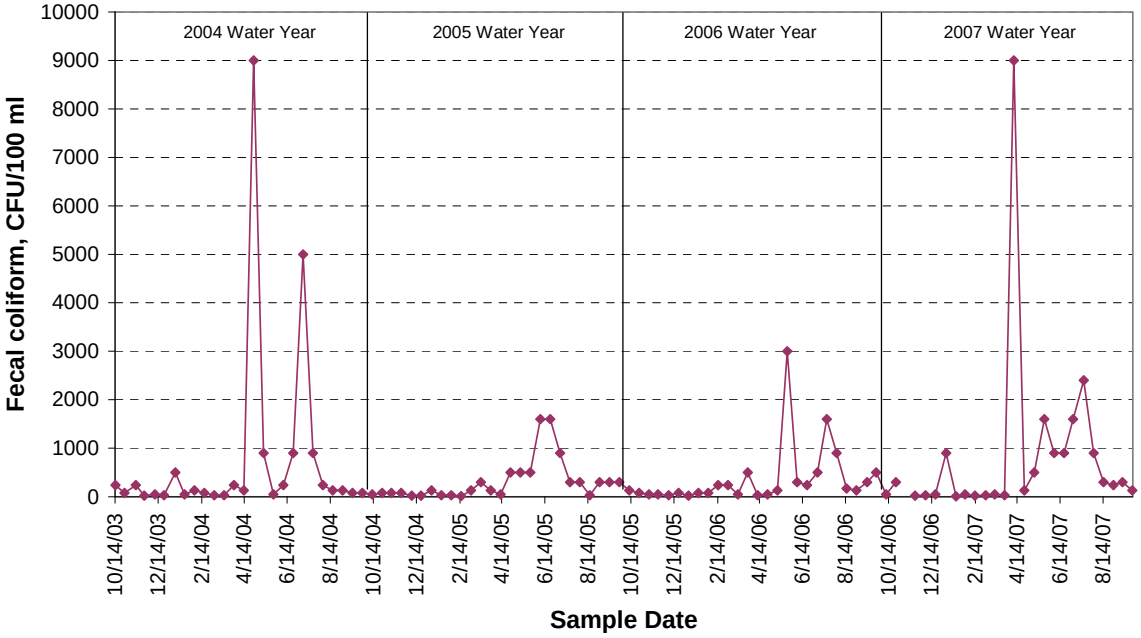
Nookachamps Creek at Swan Rd - Site 12
Fecal coliform



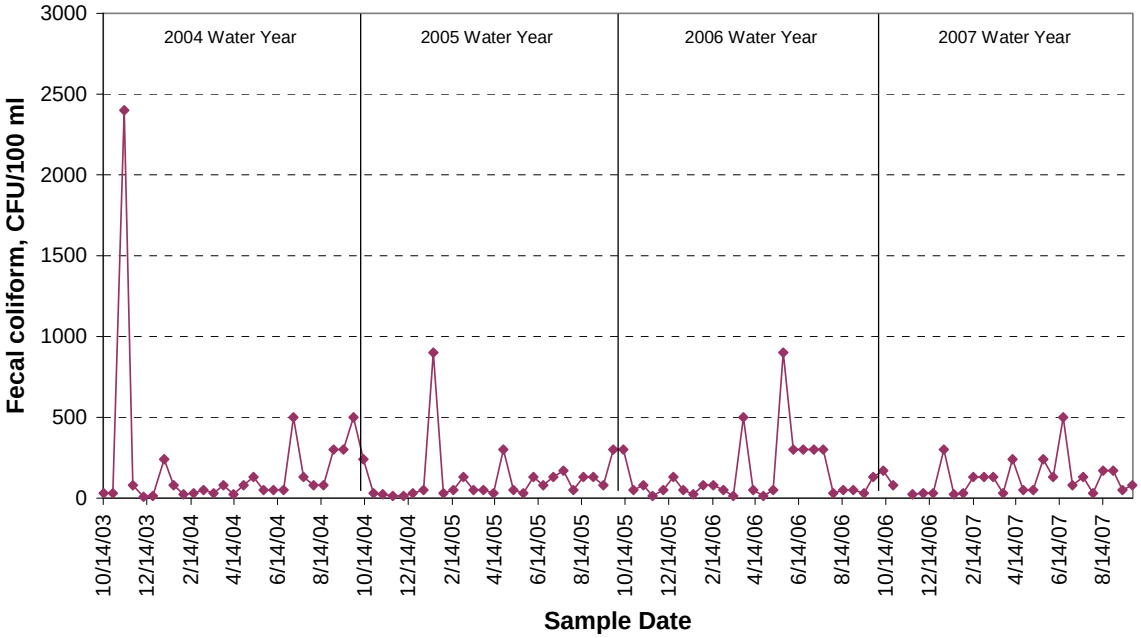
E.F. Nookachamps Creek at Hwy 9 - Site 13
Fecal coliform



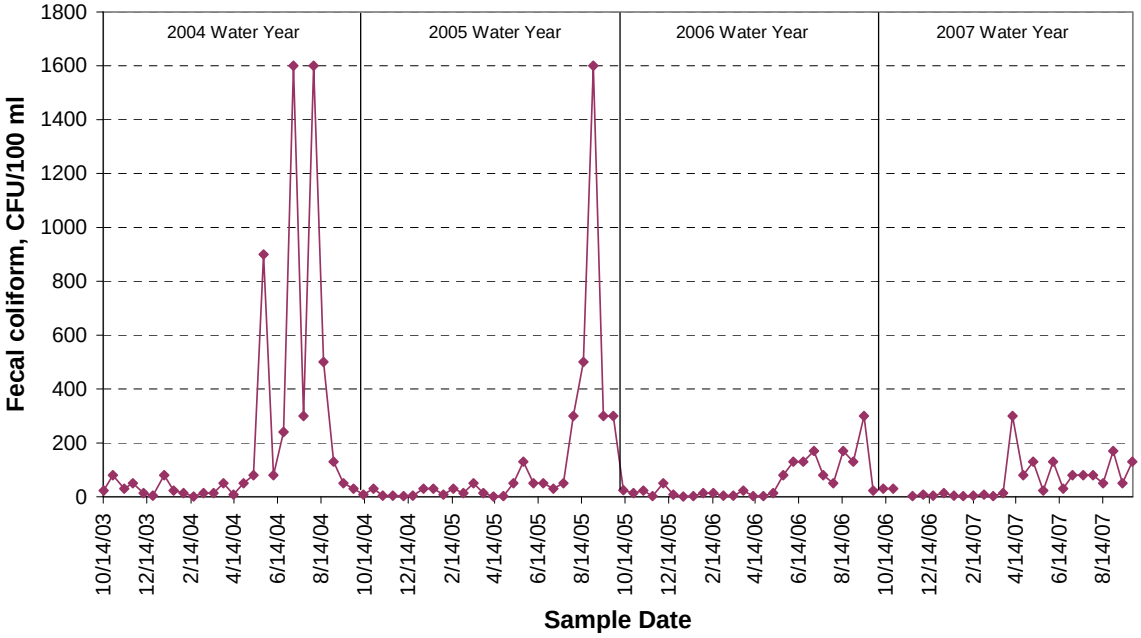
College Way Creek at College Way - Site 14
Fecal coliform



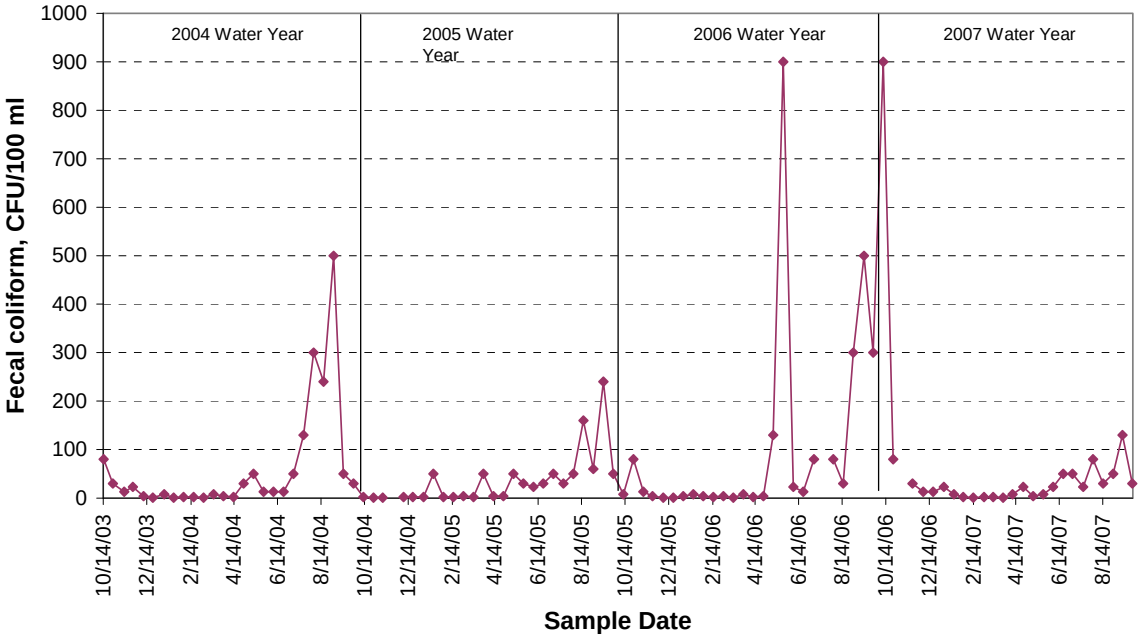
Nookachamps Creek at Knapp Rd - Site 15
Fecal coliform



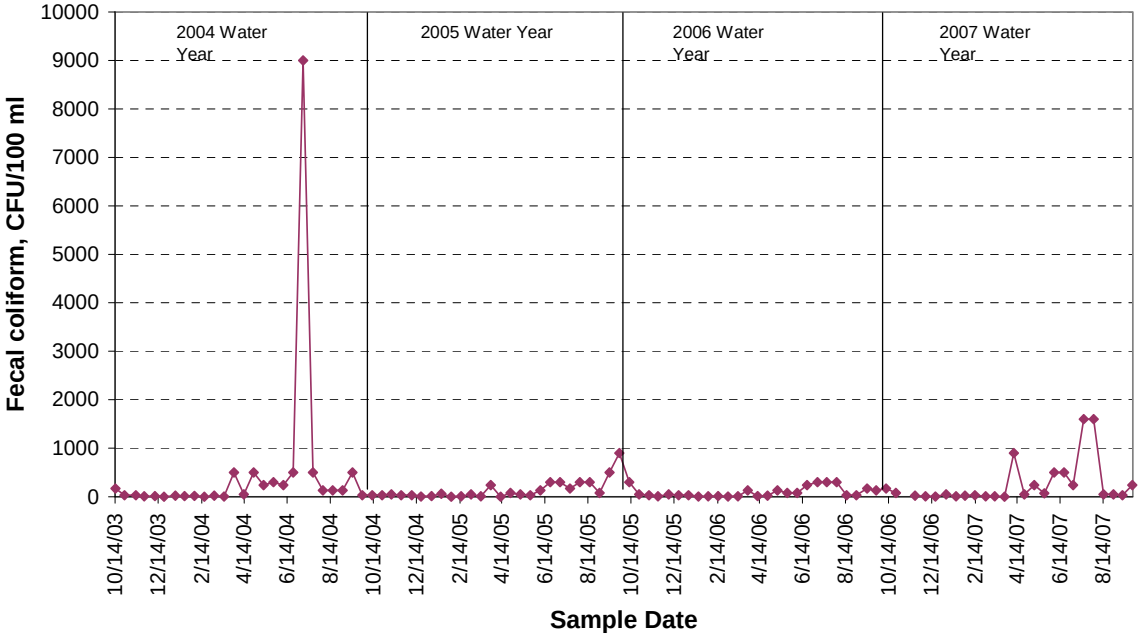
E.F. Nookachamps Creek at Beaver Lk Rd - Site 16
Fecal coliform



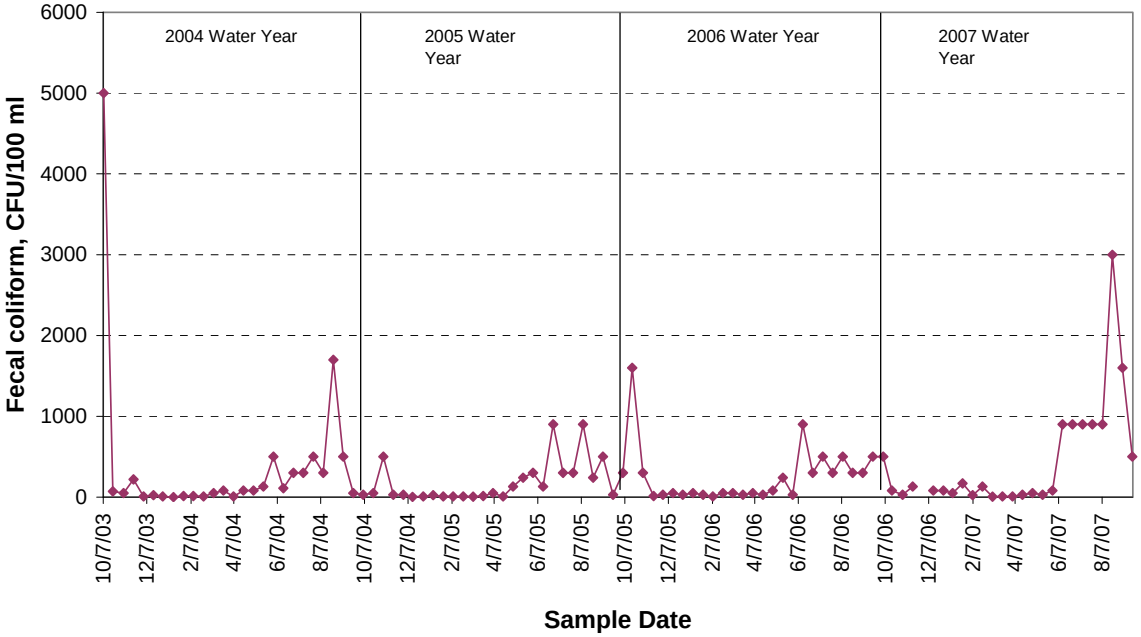
Nookachamps Creek at Big Lake Outlet - Site 17
Fecal coliform



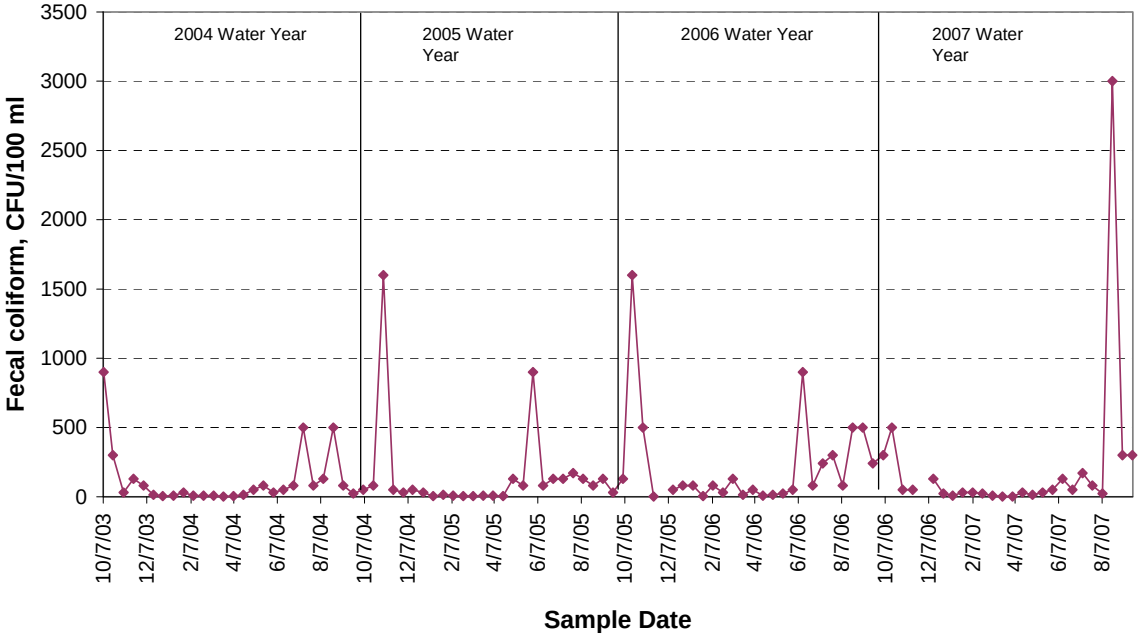
Lake Creek at Hwy 9 - Site 18
Fecal coliform



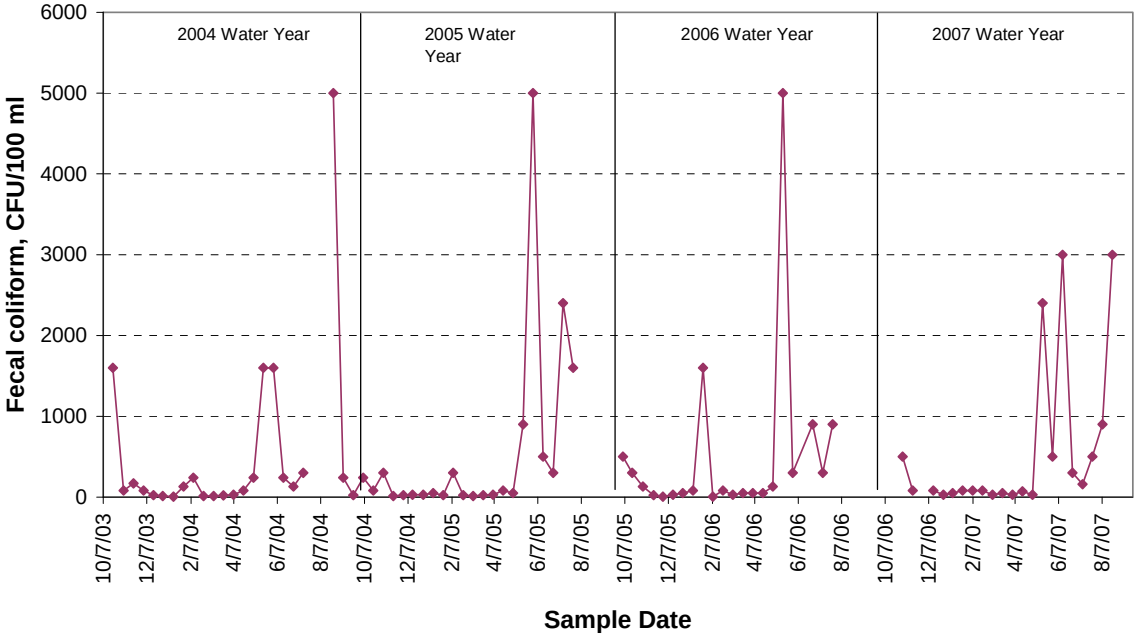
Hansen Creek at Hoehn Rd - Site 19
Fecal coliform



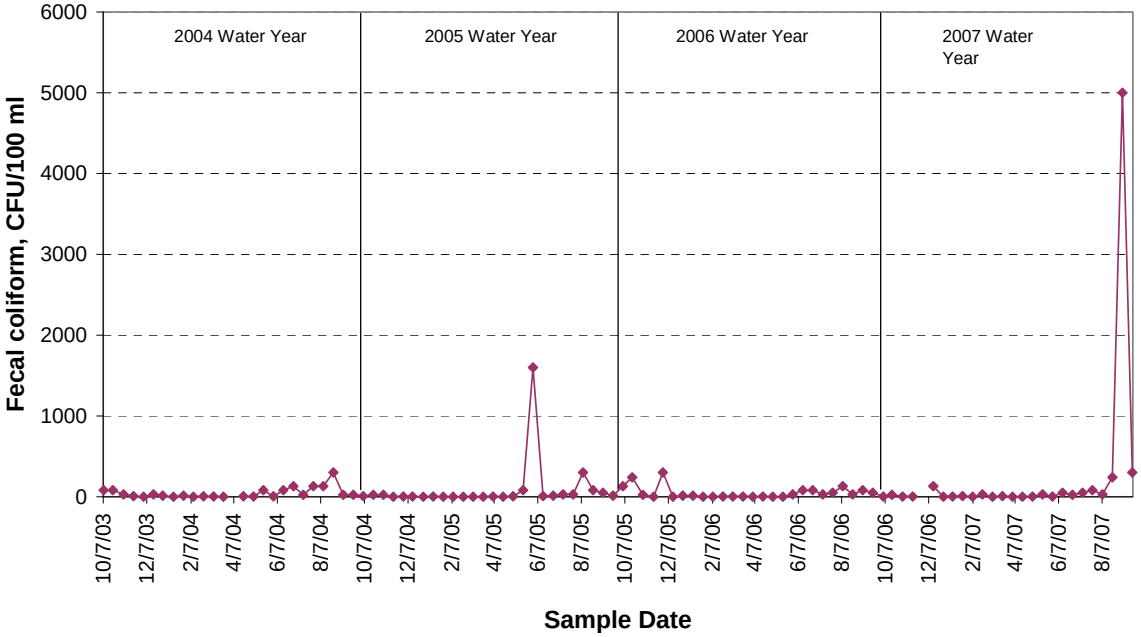
Hansen Creek at Northern State Hospital - Site 20
Fecal coliform



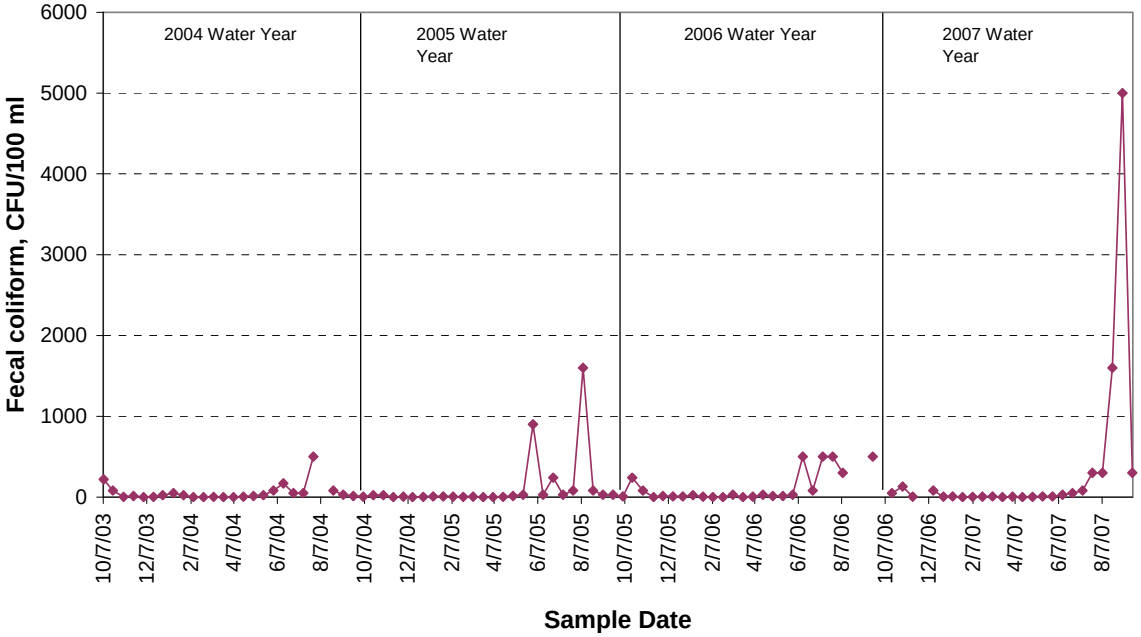
Coal Creek at Hoehn Rd - Site 21
Fecal coliform



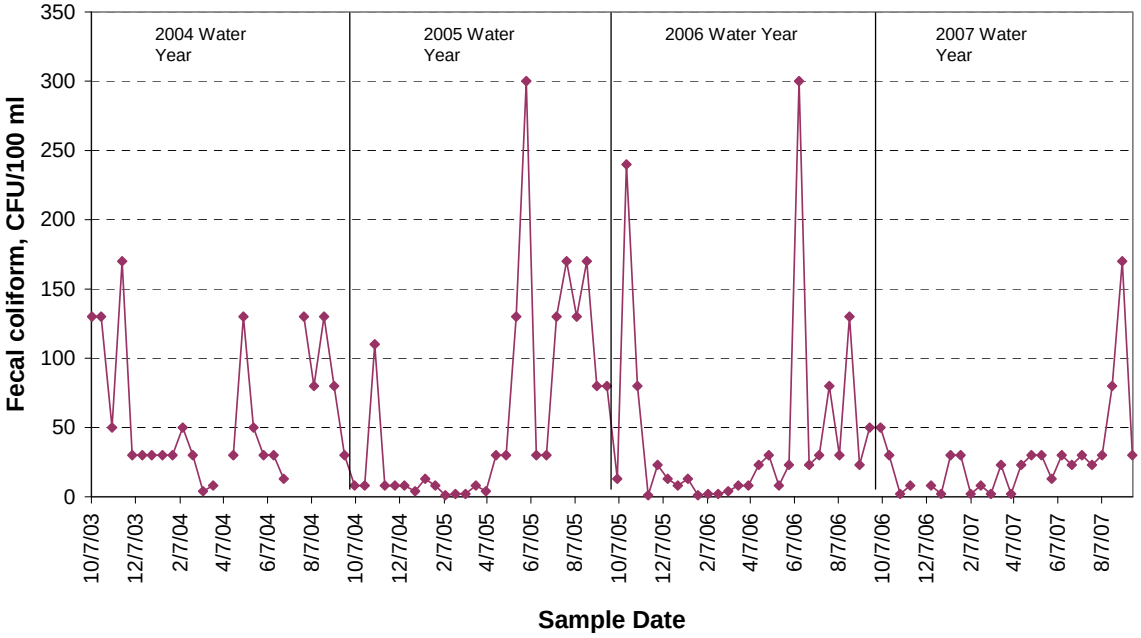
Coal Creek at Hwy 20 - Site 22
Fecal coliform



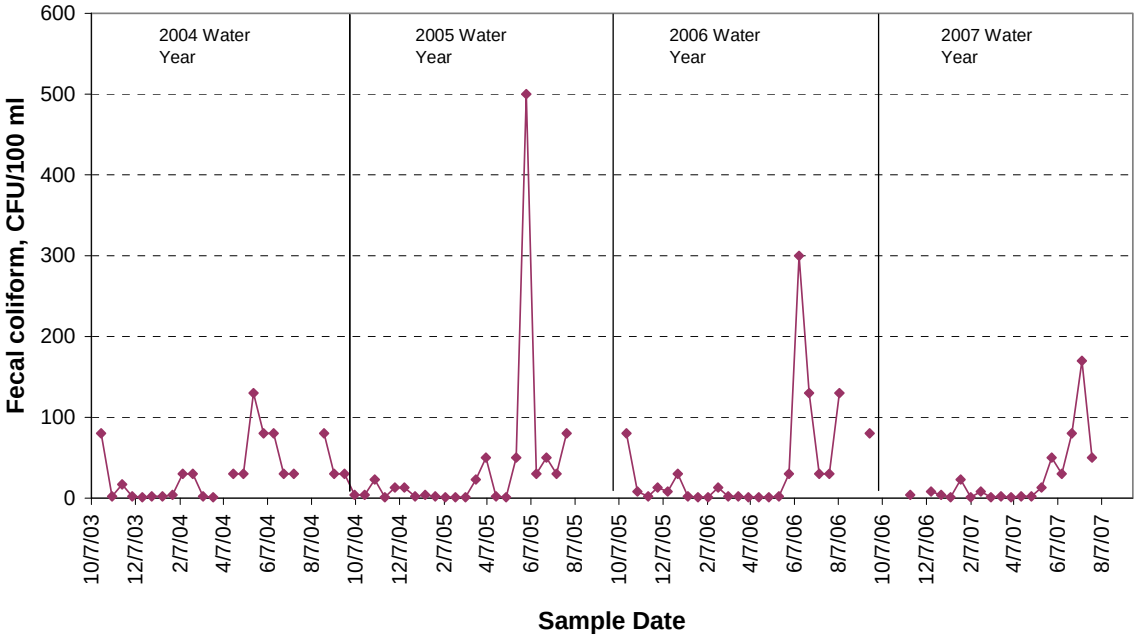
Wiseman Creek at Minkler Rd - Site 23
Fecal coliform



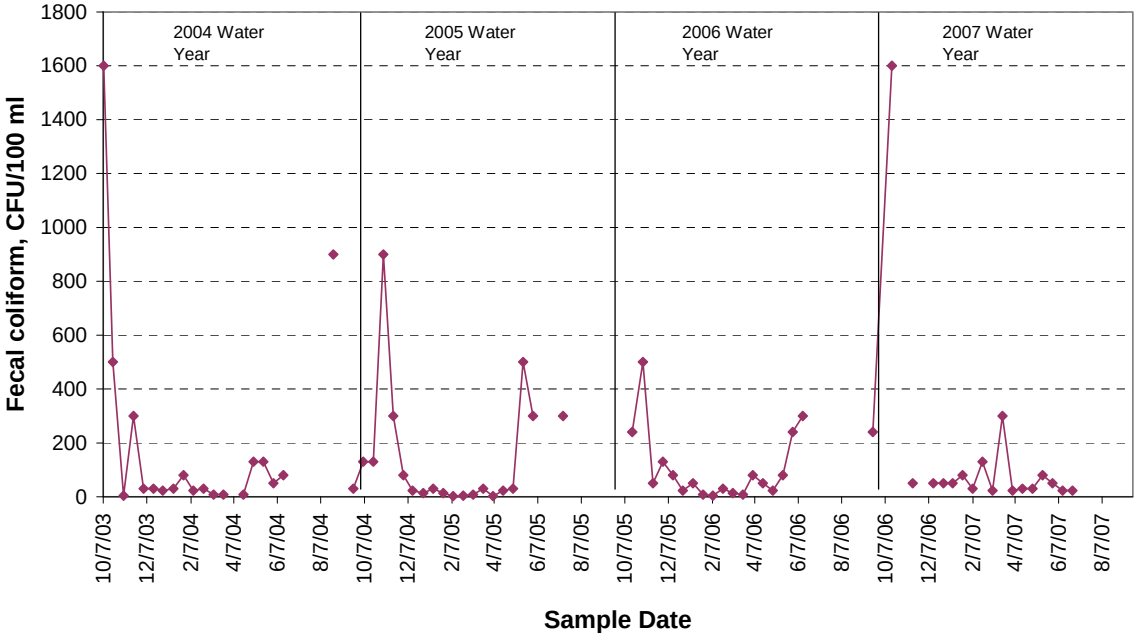
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Fecal coliform



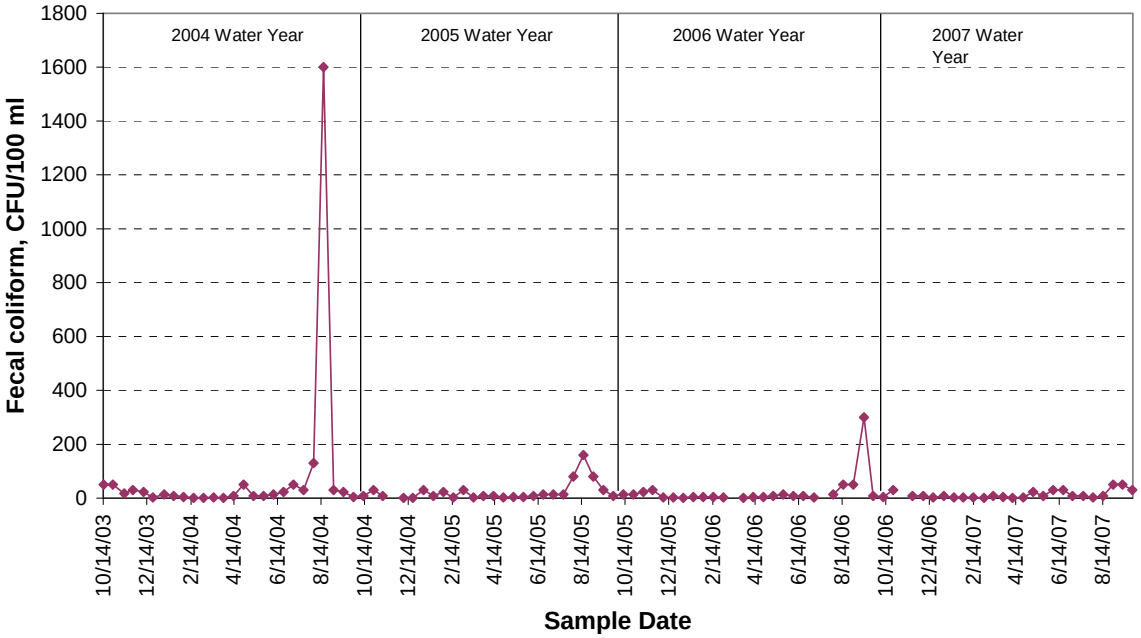
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Fecal coliform



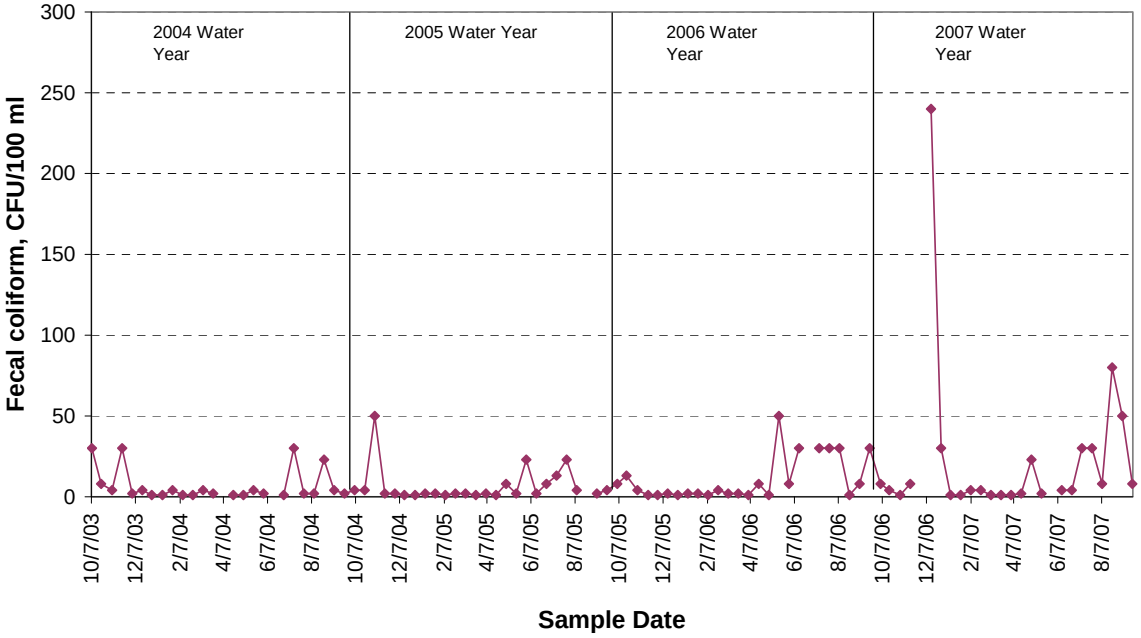
Brickyard Creek at Hwy 20 - Site 28
Fecal coliform



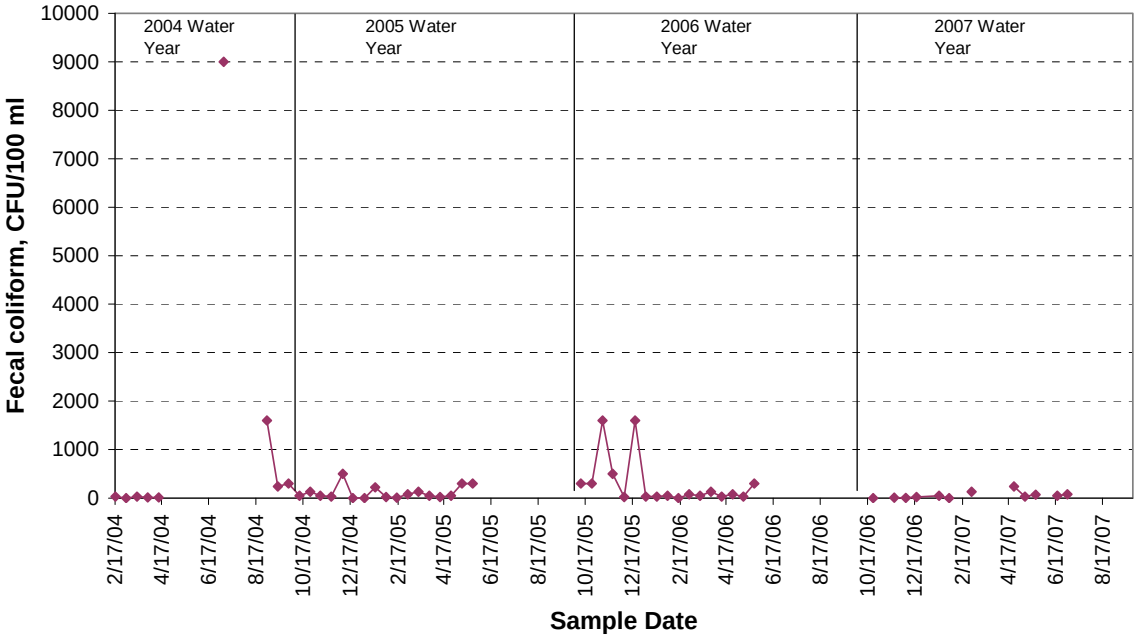
Skagit River at River Bend - Site 29
Fecal coliform



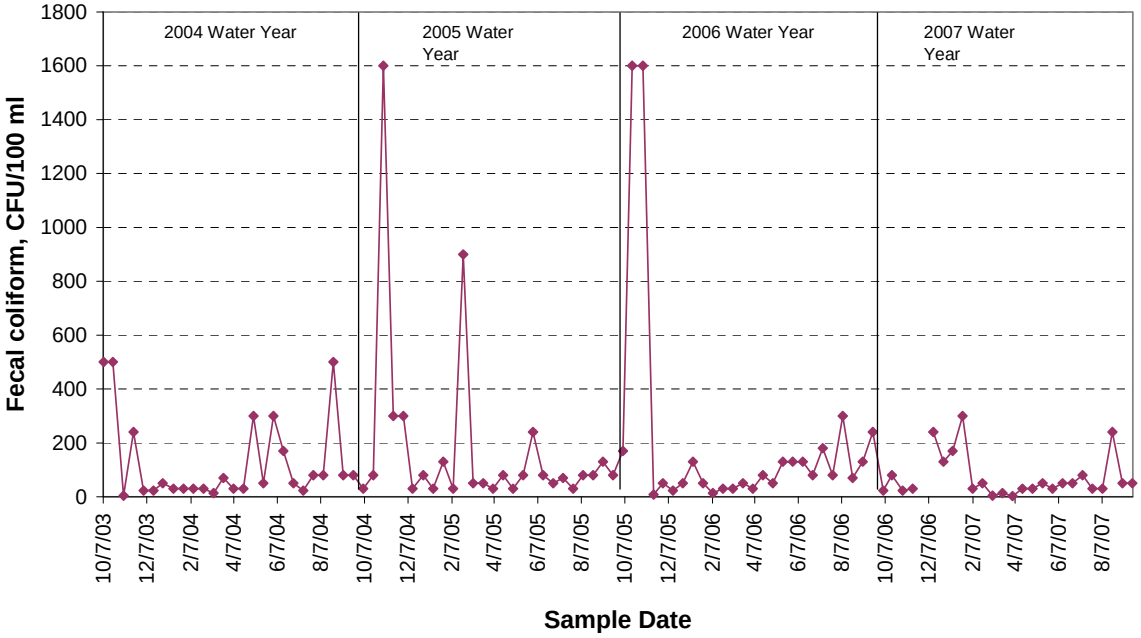
Skagit River at Cape Horn Rd - Site 30
Fecal coliform



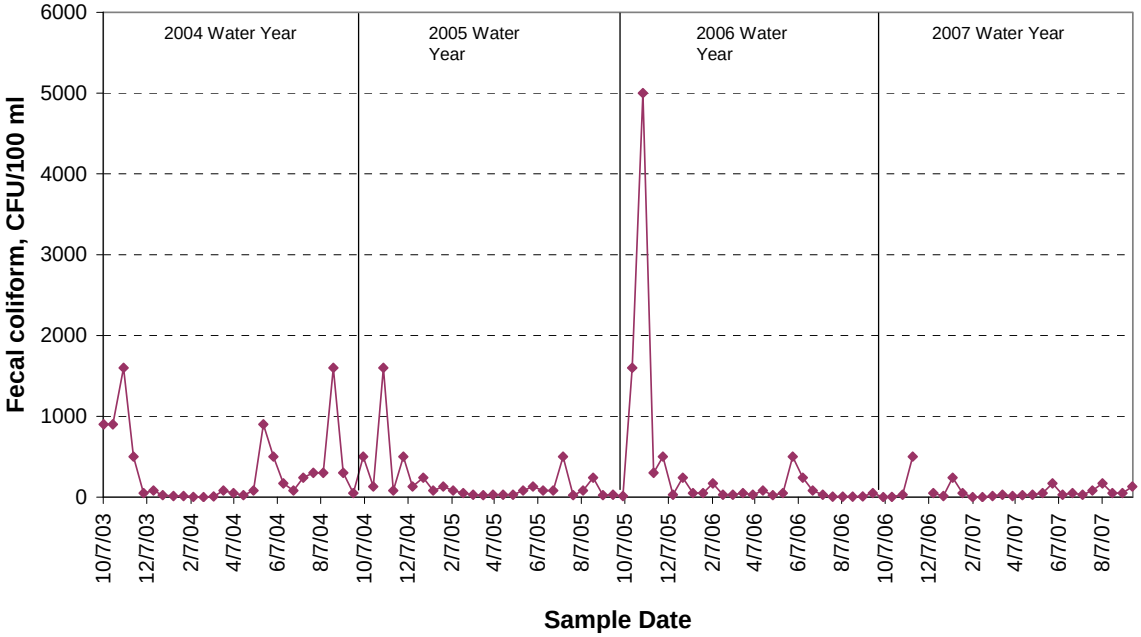
Drainage District 20 Ditch at Floodgate - Site 31
Fecal coliform



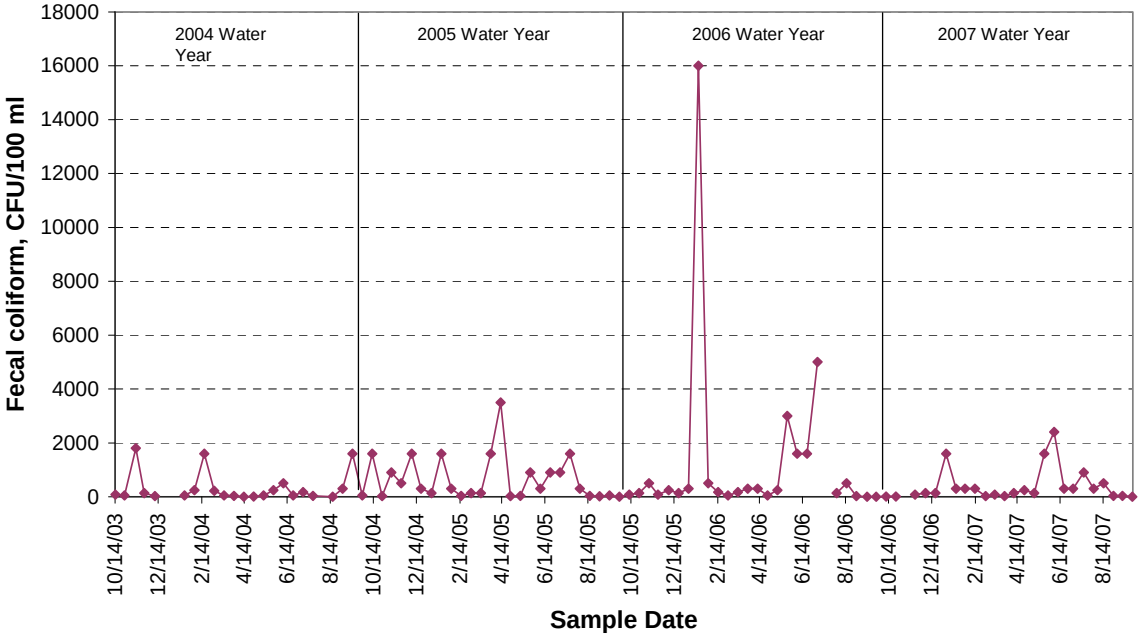
Samish River at Thomas Rd - Site 32
Fecal coliform



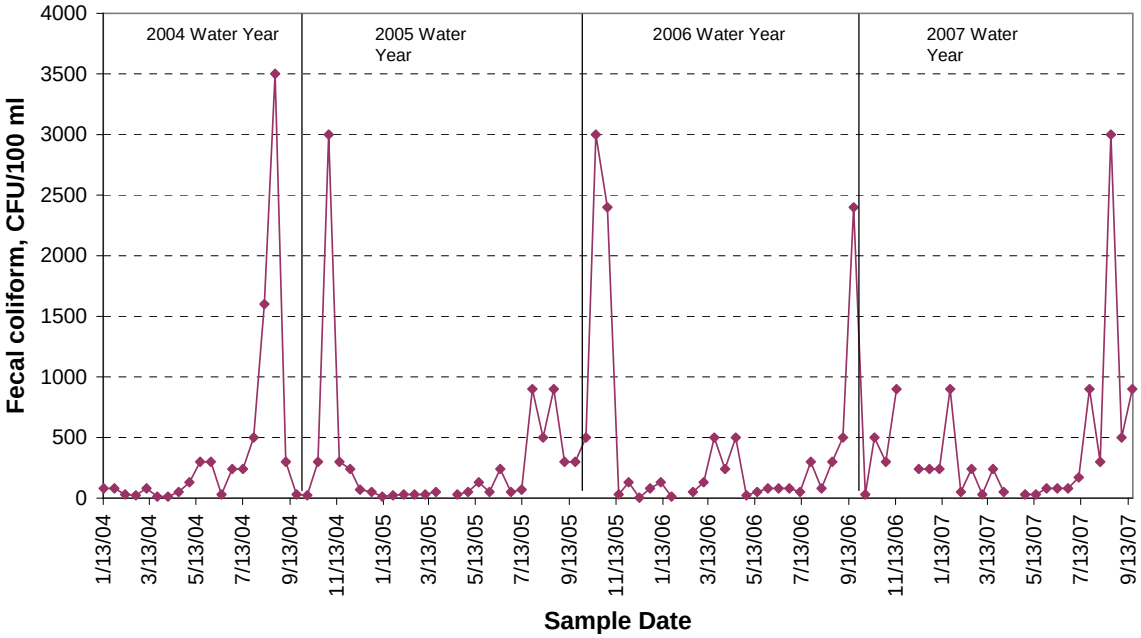
Alice Bay Pump Station - Site 33
Fecal coliform



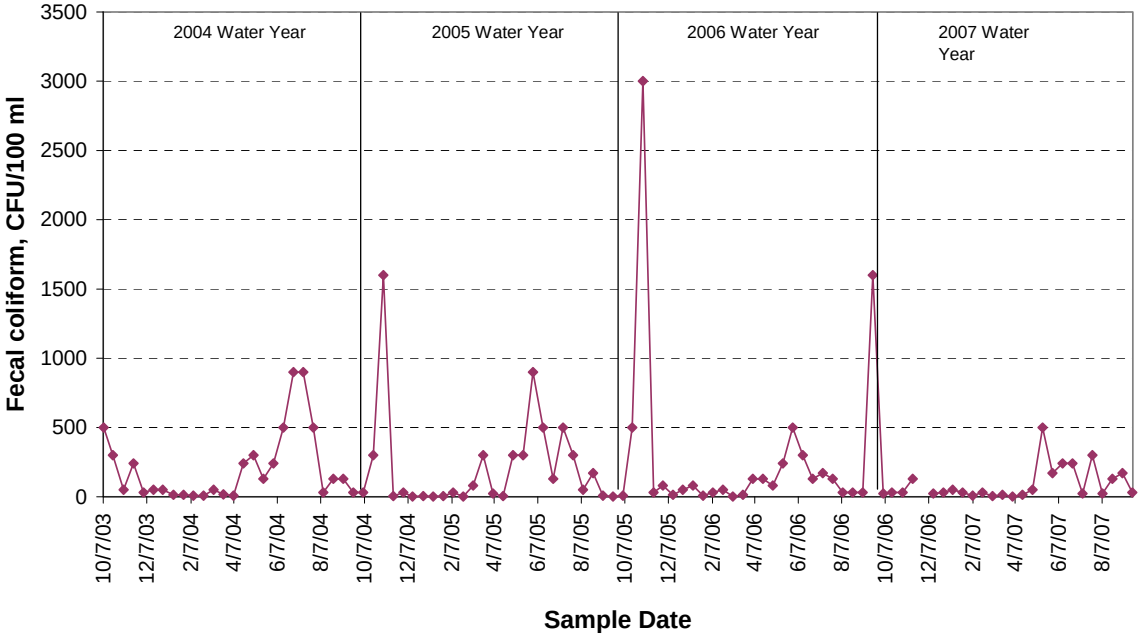
No Name Slough at Bayview-Edison Rd - Site 34
Fecal coliform



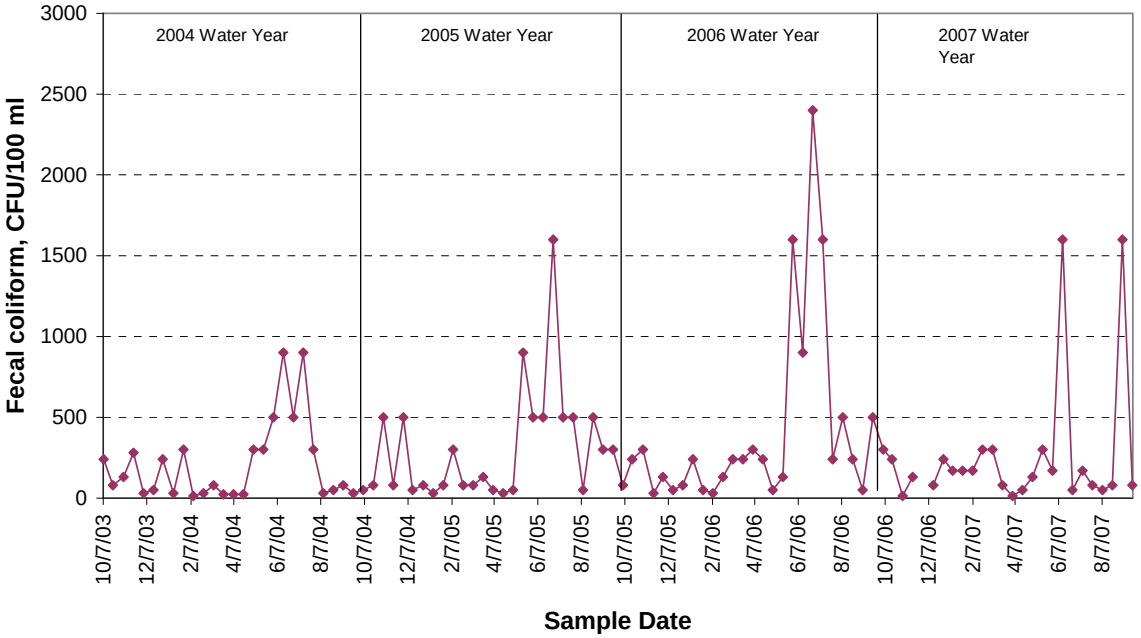
Joe Leary Slough at D'Arcy Rd - Site 35
Fecal coliform



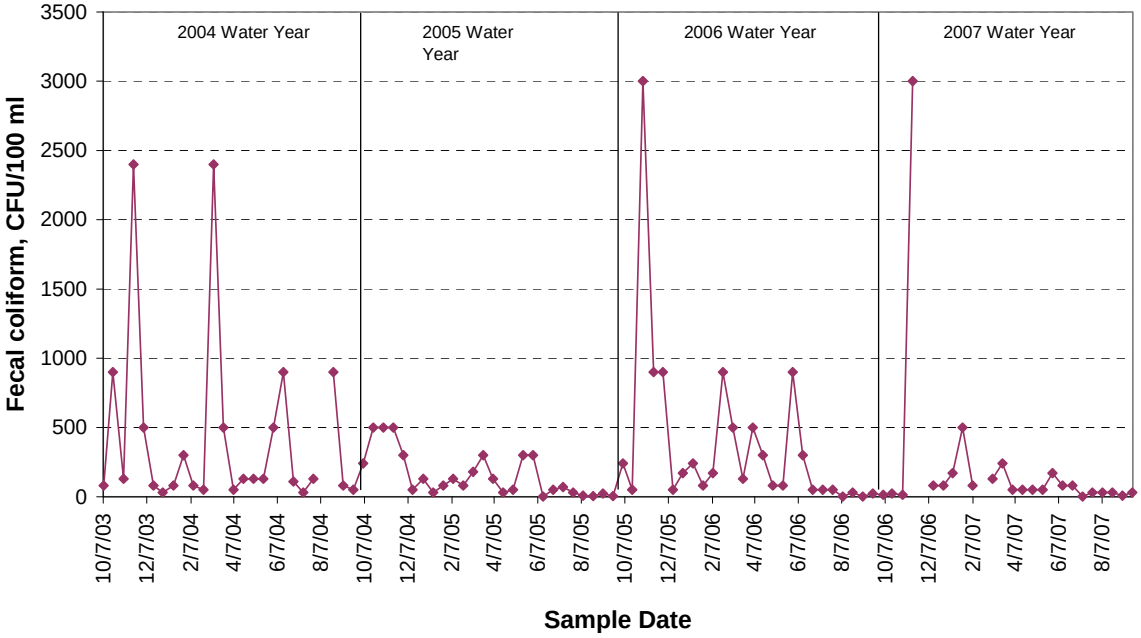
Edison Slough at Edison School - Site 36
Fecal coliform



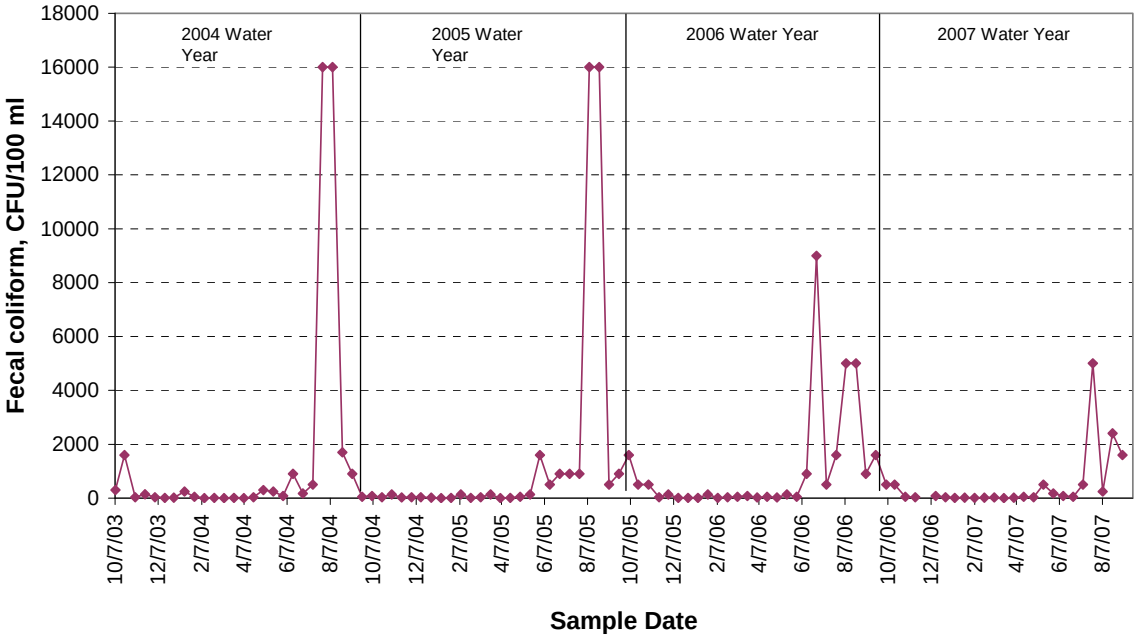
Edison Pump Station - Site 37
Fecal coliform



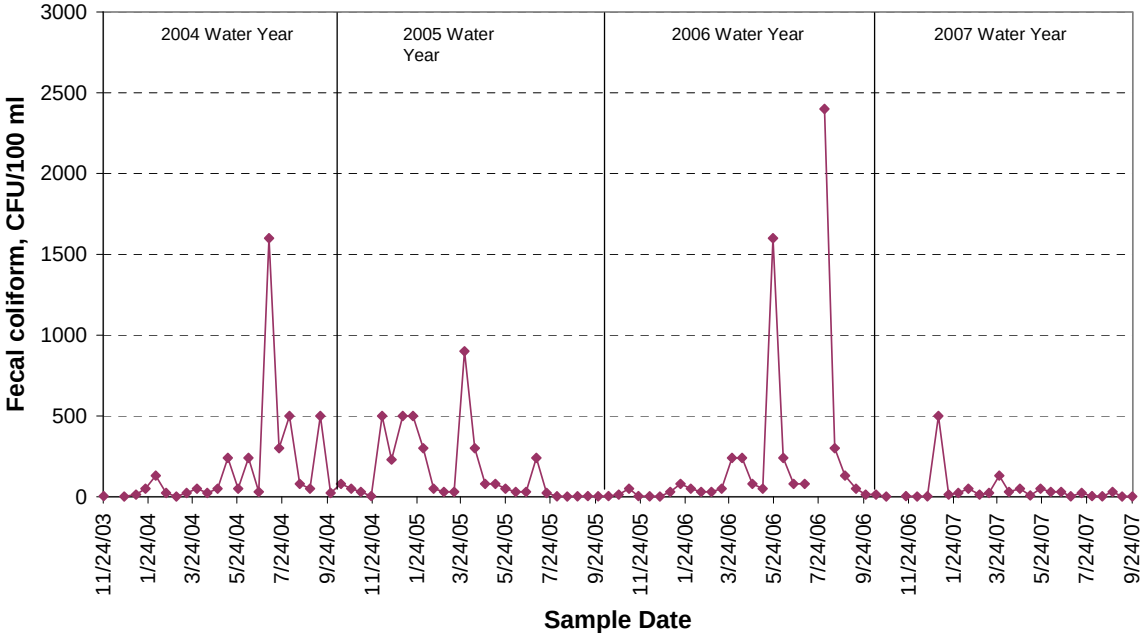
North Edison Pump Station - Site 38
Fecal coliform



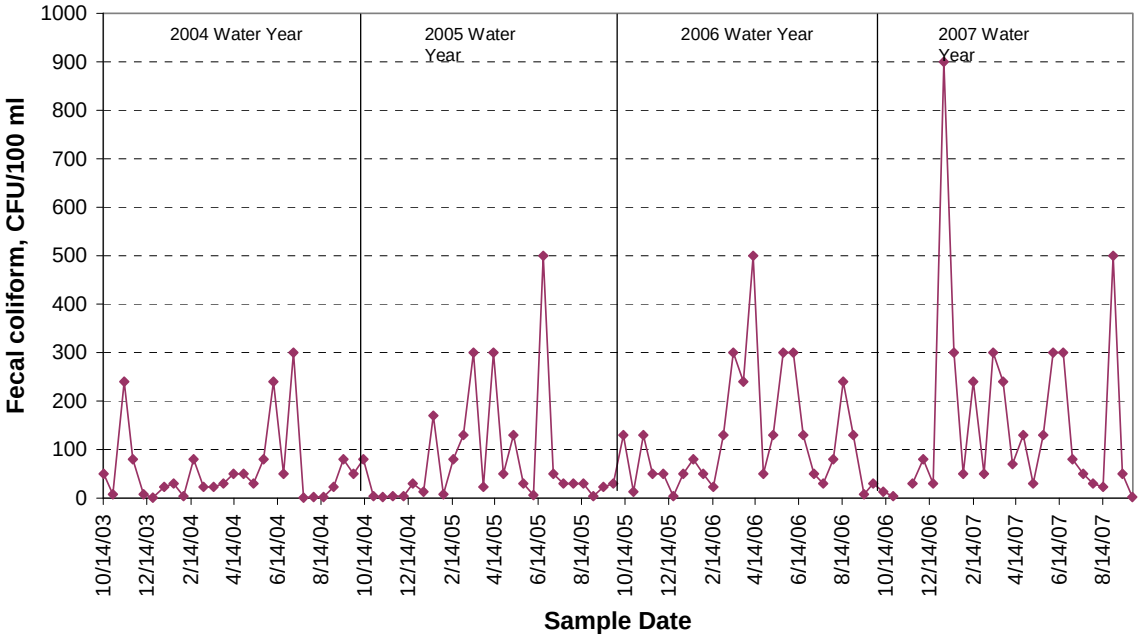
Colony Creek at Colony Rd - Site 39
Fecal coliform



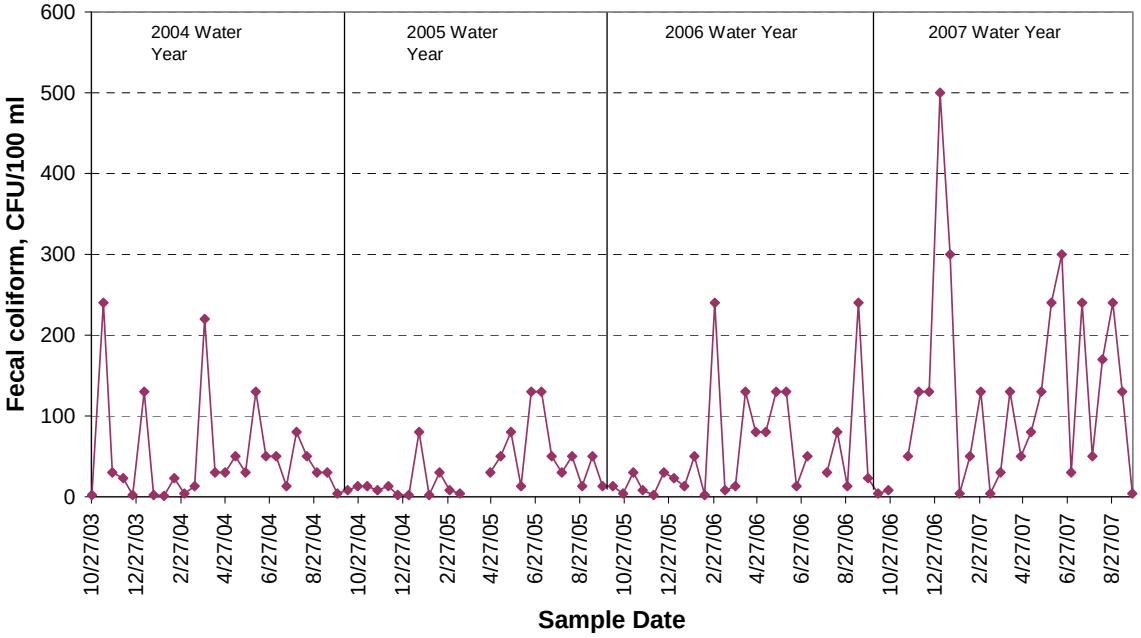
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Fecal coliform



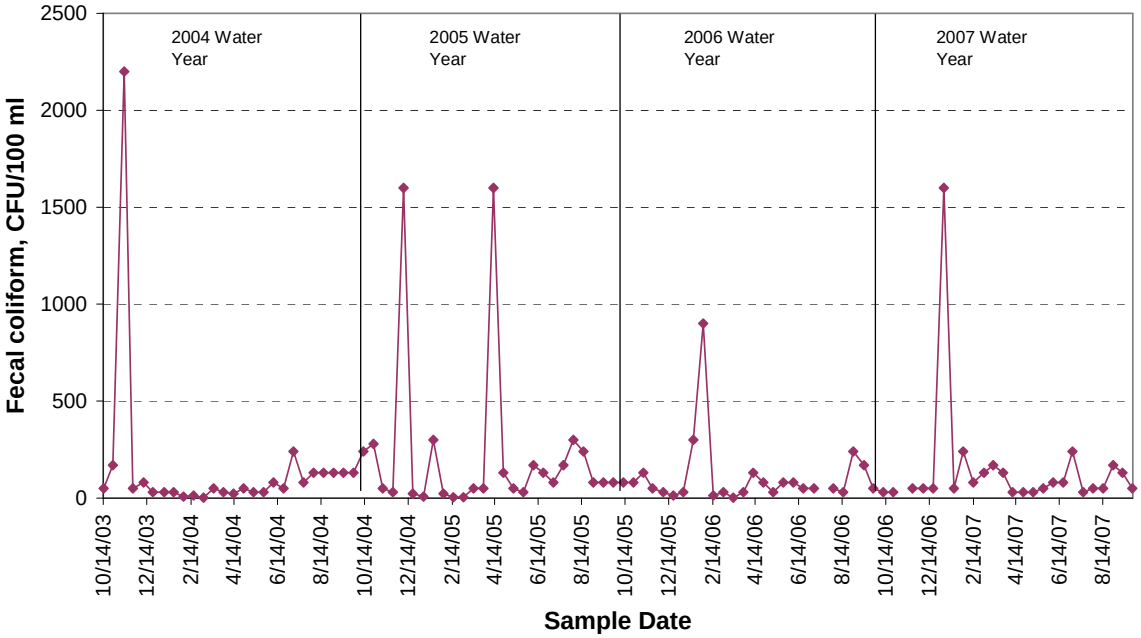
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Fecal coliform



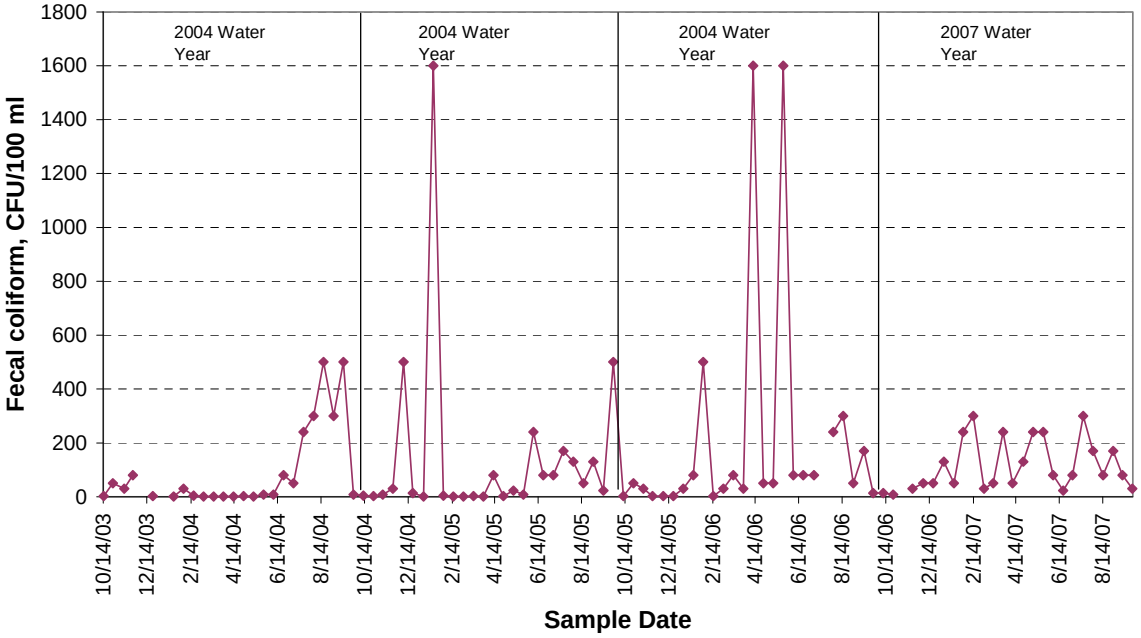
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Fecal coliform



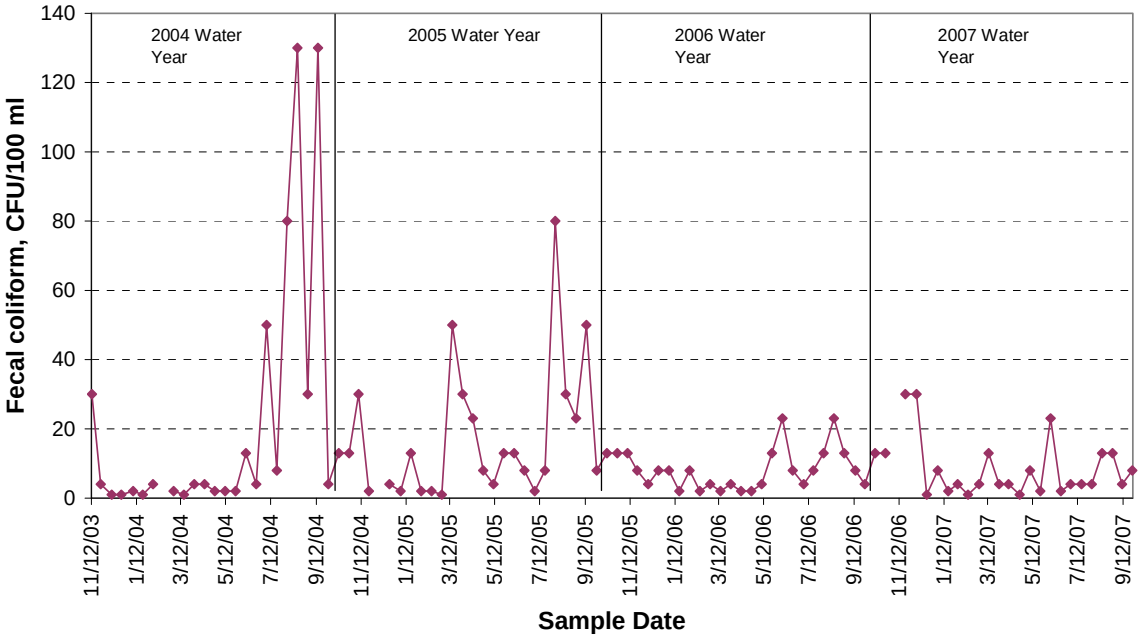
Wiley Slough at Wylie Rd - Site 43
Fecal coliform



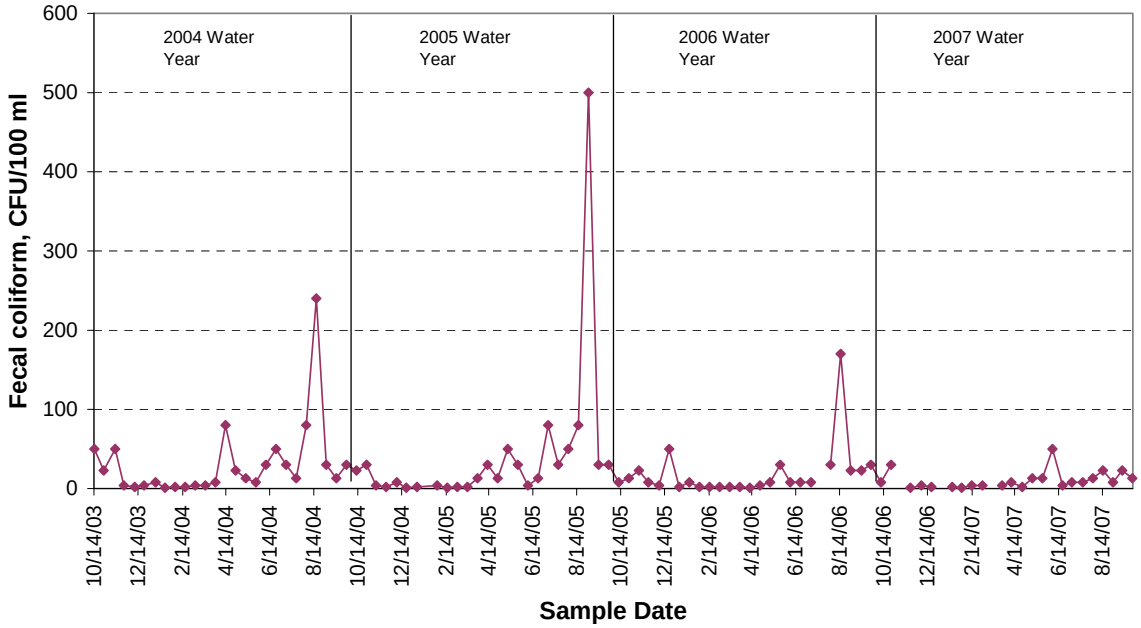
Sullivan Slough at La Conner-Whitney Rd - Site 44
Fecal coliform



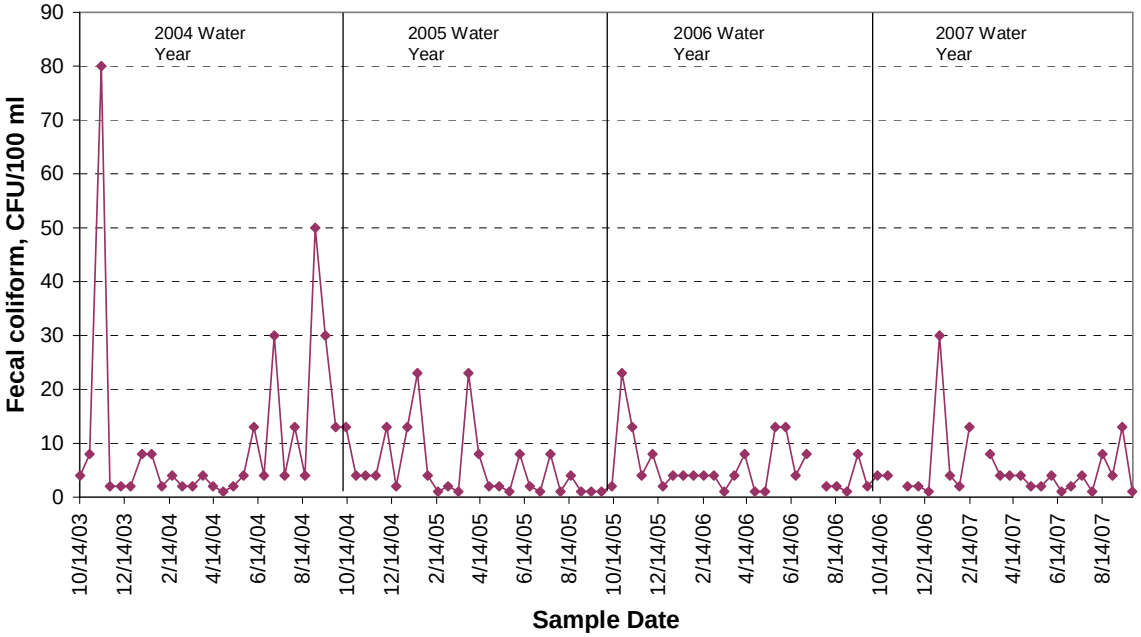
North Fork Skagit River near Moore Rd - Site 45
Fecal coliform



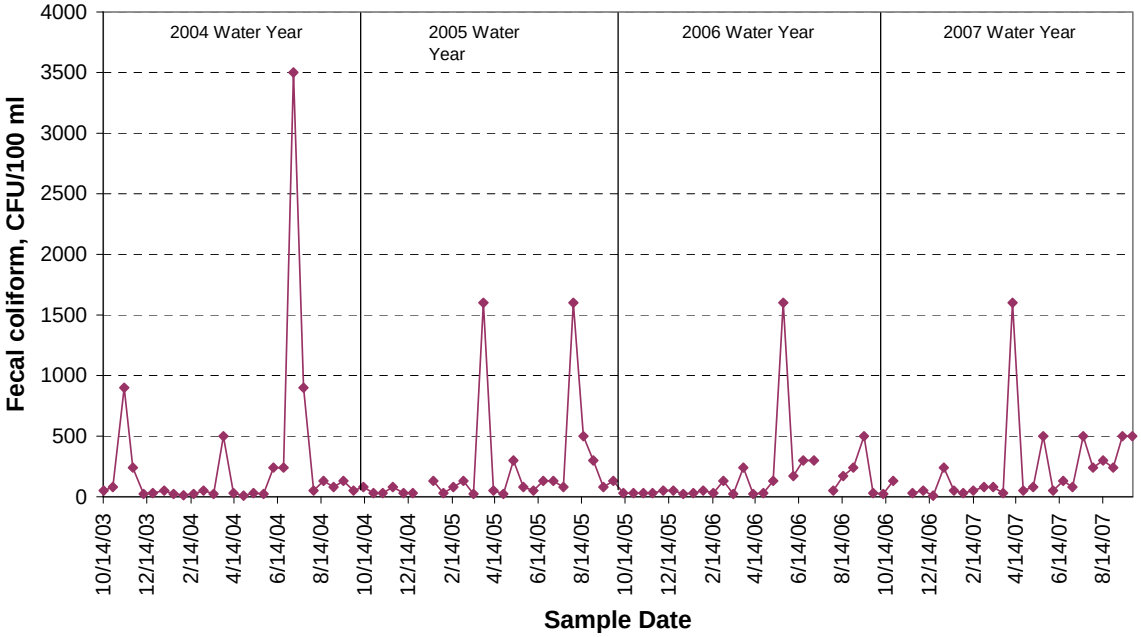
South Fork Skagit River at Conway Boat Ramp - Site 46
Fecal coliform



Swinomish Channel at County Boat Ramp - Site 47
Fecal coliform



Fisher Creek at Franklin Rd - Site 48
Fecal coliform



Nutrients

Water samples for measurement of plant nutrients were taken at each station on every other sampling trip, or once every four weeks. Samples were analyzed by Edge Analytical of Burlington, WA. Table 9 gives mean nutrient values for selected parameters for the 2007 water year. All nutrient values are included in Appendix A, with summary statistics found in Appendix B.

Nutrient levels in watercourses 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.

Most of the streams in the program showed moderate levels of total nitrogen, ammonia, and total phosphorus. The drainage infrastructure sampling sites generally had similar total phosphorus values and higher levels of total nitrogen and ammonia 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 a few Skagit County watercourses would exceed the state standards on rare occasions.

Table 9. 2007 Nutrient Results
Mean Nutrient Values (Mg/L) For Watercourses In The Skagit County Monitoring Program, 2007 Water Year UPDATED.

Site Number	Watercourse	Location	Total Nitrogen[1]	Total Phosphorus	Ammonia
3	Thomas Ck	Old Hwy 99 N	0.80	0.07	0.13
4	Thomas Ck	F&S Grade	0.54	0.07	0.05
6	Friday Ck	Prairie Rd	0.40	0.07	0.04
8	Swede Ck	Grip Rd	0.48	0.06	0.05
11	Samish R	State Route 9	0.31	0.07	0.03
12	Nookachamps Ck	Swan Rd	0.51	0.06	0.08
13	E.F. Nookachamps Ck	State Route 9	0.40	0.05	0.06
14	College Way Ck	College Way	0.52	0.06	0.09
15	Nookachamps Ck	Knapp	0.62	0.07	0.11
16	E.F. Nookachamps Ck	Beaver Lake Rd	0.31	0.05	0.03
17	Nookachamps Ck	Big Lake Outlet	0.42	0.05	0.05
18	Lake Ck	State Route 9	0.41	0.05	0.03
19	Hansen Ck	Hoehn Rd	0.38	0.11	0.04
20	Hansen Ck	Northern State	0.45	0.18	0.03
21	Coal Ck	Hoehn Rd	0.35	0.08	0.03
22	Coal Ck	Hwy 20	0.37	0.10	0.02
23	Wiseman Ck	Minkler Rd	0.37	0.11	0.02
24	Mannser Ck	Lyman Hamilton Hwy	0.40	0.05	0.02
25	Red Cabin Ck	Hamilton Cem Rd	0.33	0.06	0.02
28	Brickyard Ck	Hwy 20	0.63	0.05	0.10
29	Skagit R	River Bend Rd	0.07	0.01	0.07
30	Skagit R	Cape Horn Rd	0.08	0.02	0.02
31	Drain Dist 20 floodgate	Francis Rd	1.20	0.08	0.14
32	Samish R	Thomas Rd	0.42	0.08	0.08
33	Alice Bay Pump Station	Samish Island Rd	2.76	0.41	1.18
34	Noname Slough	Bayview-Edison Rd	1.57	0.55	0.37
35	Joe Leary Slough	D'Arcy Rd	1.29	0.21	0.68
36	Edison Slough at school	W. Bow Hill Rd	1.32	0.49	0.33
37	Edison Pump Station	Farm to Market Rd	2.82	0.74	1.44
38	North Edison Pump Station	North Edison Rd	2.84	0.78	1.12
39	Colony Ck	Colony Rd	0.72	0.12	0.07
40	Big Indian Slough	Bayview-Edison Rd	0.97	0.09	0.33
41	Maddox Slough/Big Ditch	Milltown Rd	1.26	0.14	0.45
42	Hill Ditch	Cedardale Rd	0.56	0.07	0.08
43	Wiley Slough	Wylie Rd	1.50	0.27	0.50
44	Sullivan Slough	Summers Dr/La Conner	1.33	0.30	0.56
45	Skagit R – North Fork	Moore Rd	0.34	0.08	0.02
46	Skagit R – South Fork	Fir Island Rd	0.32	0.06	0.02
47	Swinomish Channel	County Boat Launch	0.37	0.06	0.07
48	Fisher Ck	Franklin Rd	0.67	0.17	0.11

[1]Total 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, usually on a four-week basis. Discharge measurements 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 Index are dissolved oxygen, temperature, pH, turbidity, suspended solids, fecal coliform, and nutrients.

The Index 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.

Ecology rates streams with WQI Overall Score of 80 or greater "of lowest concern." Streams with ratings of 40-80 are considered "of marginal 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 2007 water year are summarized in Table 10. 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.

Table 10. 2007 Water Quality Index Results
Water Quality Index (WQI) determinations for watercourses in the Skagit County Monitoring Program, 2007 Water Year

Site Number	Watercourse	Location	Mean WQI	Overall Score*	Max	Min
3	Thomas Ck	Old Hwy 99 N	70	20	95	18
4	Thomas Ck	F&S Grade	79	54	95	26
6	Friday Ck	Prairie Rd	92	81	100	77
8	Swede Ck	Grip Rd	84	58	98	32
11	Samish R	State Route 9	93	85	99	76
12	Nookachamps Ck	Swan Rd	88	72	99	64
13	E.F. Nookachamps Ck	State Route 9	90	77	99	74
14	College Way Ck	College Way	68	35	97	23
15	Nookachamps Ck	Knapp	60	8	98	7
16	E.F. Nookachamps Ck	Beaver Lake Rd	94	86	100	81
17	Nookachamps Ck	Big Lake Outlet	94	83	100	81
18	Lake Ck	State Route 9	87	66	100	58
19	Hansen Ck	Hoehn Rd	76	40	98	24
20	Hansen Ck	Northern State	80	39	99	19
21	Coal Ck	Hoehn Rd	70	34	95	25
22	Coal Ck	Hwy 20	87	63	100	40
23	Wiseman Ck	Minkler Rd	81	48	100	26
24	Mannser Ck	Lyman Hamilton Hwy	68	56	79	52
25	Red Cabin Ck	Hamilton Cem Rd	96	90	100	89
28	Brickyard Ck	Hwy 20	90	77	97	53
29	Skagit R	River Bend Rd	88	63	99	61
30	Skagit R	Cape Horn Rd	92	78	100	69
31	Drain Dist 20 floodgate	Francis Rd	73	57	97	51
32	Samish R	Thomas Rd	82	47	98	24
33	Alice Bay Pump Station	Samish Island Rd	41	5	93	1
34	Noname Slough	Bayview-Edison Rd	28	1	92	1
35	Joe Leary Slough	D'Arcy Rd	20	1	38	1
36	Edison Slough at school	W. Bow Hill Rd	56	10	98	2
37	Edison Pump Station	Farm to Market Rd	16	1	45	1
38	North Edison PS	North Edison Rd	24	6	49	1
39	Colony Ck	Colony Rd	80	39	99	29
40	Big Indian Slough	Bayview-Edison Rd	56	36	93	29
41	Maddox Sl/Big Ditch	Milltown Rd	58	27	97	23
42	Hill Ditch	Cedardale Rd	72	35	99	16
43	Wiley Slough	Wylie Rd	58	19	93	2
44	Sullivan Sl	La Conner-Bayview Rd	46	21	95	6
45	Skagit R – North Fork	Moore Rd	89	71	99	63
46	Skagit R – South Fork	Fir Island Rd	91	73	99	62
47	Swinomish Channel	County Boat Launch	83	82	98	81
48	Fisher Ck	Franklin Rd	87	67	100	59

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

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, four seasons were designated, starting with January 1, April 1, July 1, and October 1. Exceptions are noted below. These seasons were chosen based on the "water year" used by most hydrologists (October 1 – September 30) and because they correspond to general seasonal conditions in Western Washington. 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 12 key parameters at each sampling location. The parameters tested include pH, dissolved oxygen, 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 time of day. Trends in nutrients were not calculated for three sites due to extended summer dry periods.

The period used for trends analysis was the four 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). However, the detection limit for the analyte changed during the course of the study, and we were unable to find a method to handle the changed detection limit without biasing the data towards increasing or decreasing trends. Therefore, orthophosphate trends were calculated using only data from February 2006 through September 2007, using two seasons (May – Sept and Oct – March).

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 is provided in Table 11. Complete trends analysis results can be found in Appendix C. Skagit County conducted the Seasonal Kendall's Test on 15 parameters at most sites (including monthly averages for dissolved oxygen, temperature, and fecal coliform), except for those noted above that were dry too much of the year for meaningful analysis. Of the 589 trends tests conducted, there were 146 significant trends detected. Some of these represent significant trends in both biweekly and monthly data for the same parameter and site. Eliminating duplicate trends for those cases where both the biweekly and monthly trends were significant, and eliminating the biweekly trends if the monthly trend was not significant, yields 108 distinct trends. Of these 108 trends, 25 were judged to represent deleterious trends, and 58 were considered improving trends. The implications of the remaining 25 trends (all increasing pH) were not readily apparent. Several stations had both significantly improving and significantly declining parameters.

New in the trends results this year is a tendency towards increasing dissolved oxygen. Twenty-six of the 40 stations now have a significantly increasing trend in dissolved oxygen. This is generally considered to be an improving trend, although algal blooms at some sites may have influenced the results. Algal blooms may result in increased dissolved oxygen during daylight hours when algae is producing oxygen, followed by severe declines in dissolved oxygen at night when the algae is no longer producing oxygen but continues to use it. However, many of the improving oxygen conditions occurred in free-flowing streams where algal blooms probably do not play a large role in the oxygen budget.

No stations showed a significantly decreasing trend in dissolved oxygen. After the 2006 water year, only six stations had significantly increasing trends in dissolved oxygen and three stations had significant decreasing trends.

The data also show the continuing presence of significantly increasing trends in pH. Twenty-five of the 40 sites showed increasing pH, while no stations showed significantly decreasing pH. The increases were not of great magnitude, but the number of significant increases raises questions about the source and implications of these trends. Skagit County continues to consult with Ecology personnel about the pH trends.

Trends in fecal coliform included significant increases at two sites – Sites 42 (Hill Ditch/Carpenter Creek) and 44 (Sullivan Slough). Both of these sites are in agricultural areas. There were also four significant decreases in fecal coliform – Sites 24 (Mannser Creek), 33 (Alice Bay Pump Station), 40 (Big Indian Slough), and 46 (South Fork Skagit River). Sites 24, 33, and 40 are in agricultural areas, while Site 46 is on the South Fork of the Skagit and is influenced by all land uses in the county. In addition, three sites which had significantly increasing coliform trends after the 2006 water year - Sites 4 (upper Thomas Creek), 20 (upper Hansen Creek), and 41 (Maddox Creek/Big Ditch) no longer have that significant trend.

Significantly decreasing turbidity was found at seven sample stations - Sites 6 (Friday Creek), 11 (upper Samish River), 13 (lower E.F. Nookachamps Creek), 16 (upper E.F. Nookachamps Creek), 18 (Lake Creek), 24 (Mannser Creek), and 46 (South Fork Skagit River). Decreasing turbidity occurred at both ag and non-ag sites. Increasing turbidity occurred at six stations - Sites 15 (Nookachamps Creek, 28 (Brickyard Creek), 35 (Joe Leary Slough), 37 (Edison Pump Station), 41 (Maddox Creek/Big Ditch), and 42 (Hill Ditch/Carpenter Creek). Increasing turbidity occurred at four Ag sites and one urban/suburban site.

There were eight cases of significantly decreasing nutrients, and 14 cases of increasing nutrients. Site 44 (Sullivan Slough) had significant increases in total nitrogen, nitrate, and ammonia. Sites 34 (Noname Slough) and 35 (Joe Leary Slough) both had significantly increasing total nitrogen and total phosphorus. Increases in nutrients can cause algal blooms and associated water quality problems such as reduced dissolved oxygen.

Water Quality Index, an integrator of several water quality parameters, was significantly increasing (an improving trend) at six locations – Sites 11 (upper Samish), 12 (lower Nookachamps Creek), 24 (Mannser Creek), 40 (Big Indian Slough), 41 (Maddox Creek/Big Ditch), and 43 (Wylie Slough). There were no sites with significantly declining WQI.

The trends analysis results show a mixture of improving and declining trends, with a preponderance of improving trends. These results continue to suggest that water quality problems in Skagit County need to be addressed on an individual stream basis.

Table 11. Trends Analysis Results
Summary of Significant Trends Detected in Skagit County Monitoring Program 2004-2007 Water Years

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
3	pH	103	0.081	5.06		
	TKN	52	0.067	2.023		Increasing nitrogen
	OP	22	0.022	1.967		Increasing phosphate
4	DO	103	0.266	3.741	Increasing oxygen	
	MDO	52	0.290	3.113		
6	DO	103	0.279	4.136	Increasing oxygen	
	MDO	52	0.289	3.784		
	Turb	104	-0.305	-2.618	Decreasing turbidity	
	NO3+NO2	52	-0.046	-2.339	Decreasing nitrate	
8	pH	103	0.064	3.881		
	DO	103	0.325	3.928	Increasing oxygen	
	MDO	52	0.308	3.29		
	NO3+NO2	52	-0.034	-2.002	Decreasing nitrate	
11	pH	103	0.118	6.206		
	DO	104	0.289	3.945	Increasing oxygen	
	MDO	52	0.309	3.351		
	Turb	104	-0.406	-4.171	Decreasing turbidity	
	WQI	48	1.072	3.030	Increasing WQI	
12	pH	100	0.116	7.465		
	WQI	48	1.629	2.299	Increasing WQI	
13	pH	103	0.125	6.328		
	DO	103	0.404	4.27	Increasing oxygen	
	MDO	52	0.425	3.866		
	Turb	103	-0.291	-2.389	Decreasing turbidity	
14	NO3+NO2	51	-0.047	-3.099	Decreasing nitrate	
15	pH	104	0.128	8.261		
	Turb	104	0.431	2.709		Increasing turbidity
16	pH	104	0.087	4.899		
	Turb	104	-0.202	-3.006	Decreasing turbidity	
17	pH	104	0.084	4.091		
	NO3+NO2	52	0.022	2.913		Increasing nitrate
18	pH	104	0.109	6.986		
	DO	104	0.178	2.254	Increasing oxygen	
	MDO	52	0.206	1.996		
	Turb	104	-0.212	-2.14	Decreasing turbidity	
19	pH	103	0.052	2.866		
	DO	104	0.261	3.628	Increasing oxygen	
	MDO	52	0.312	3.228		
20	pH	103	0.044	2.43		
	DO	104	0.261	4.557	Increasing oxygen	
	MDO	52	0.312	3.228		
	MT	52	0.312	3.228		Increasing temperature
	MFC	52	0.312	3.228		
21	pH	88	0.048	2.928		
	DO	89	0.240	2.472	Increasing oxygen	
	MDO	47	0.318	2.378		
	TSS	45	0.000	2.331		

Table 11. Trends Analysis Results (con't)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
22	DO	104	0.188	2.686	Increasing oxygen	
	MDO	52	0.191	2.307		
23	DO	100	0.187	3.265	Increasing oxygen	
	MDO	52	0.185	2.831		
	NO3+NO2	51	-0.082	-2.923	Decreasing nitrate	
24	pH	103	0.093	6.656		
	DO	104	0.476	3.99	Increasing oxygen	
	MDO	52	0.484	4.121		
	Turb	104	-0.155	-2.812	Decreasing turbidity	
	FC	101	-3.390	-3.001	Decreasing coliform	
	MFC	52	-4.645	-2.475		
	NO3+NO2	52	0.016	2.259		Increasing nitrate
	WQI	48	5.800	2.757	Increasing WQI	
25	DO	87	0.216	3.493	Increasing oxygen	
	MDO	47	0.199	2.807		
28	DO	77	0.396	2.11	Increasing oxygen	
	Turb	77	0.674	2.56		Increasing turbidity
	OP	16	0.033	2.042		Increasing phosphate
29	pH	103	0.072	1.972		
30	pH	102	0.051	2.938		
	DO	103	0.231	3.863	Increasing oxygen	
	MDO	52	0.214	3.577		
	MFC	52	0.931	2.432		
31	MT	33	-1.491	-2.395		
32	pH	102	0.093	3.104		
	DO	102	0.254	2.971	Increasing oxygen	
	MDO	52	0.271	2.775		
	NO3+NO2	51	-0.040	-2.512	Decreasing nitrate	
33	FC	103	-17.980	-3.137	Decreasing coliform	
	MFC	52	-23.280	-2.753		
34	pH	102	0.094	3.325		
	TKN	51	0.133	2.348		Increasing nitrogen
	TP	51	0.050	2.848		Increasing phosphorus
35	pH	95	0.142	5.336		
	DO	96	0.555	3.91	Increasing oxygen	
	MDO	48	0.699	3.615		
	Turb	97	5.216	3.647		Increasing turbidity
	TKN	49	0.144	3.28		Increasing nitrogen
	TP	49	0.026	2.401		Increasing phosphorus
	NH3	49	0.110	3.601		Increasing ammonia
36	NH3	52	-0.025	-1.976	Decreasing ammonia	
37	Turb	103	2.748	2.452		Increasing turbidity
	TKN	52	0.297	3.145		Increasing nitrogen
39	pH	102	0.044	2.099		
	DO	101	0.251	2.628	Increasing oxygen	
	MDO	52	0.283	2.251		

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
40	pH	101	0.090	5.405		
	DO	101	0.501	3.245	Increasing oxygen	
	MDO	50	0.438	2.603		
	FC	98	-6.760	-2.287	Decreasing coliform	
	TP	51	0.000	-2.352		
	NH3	51	-0.054	-3.207	Decreasing ammonia	
	TSS	50	-1.397	-2.955	Decreasing solids	
	WQI	48	10.300	3.544	Increasing WQI	
41	pH	104	0.084	4.16		
	DO	104	0.583	3.568	Increasing oxygen	
	MDO	52	0.554	3.051		
	Temp	104	-0.409	-1.973	Decreasing temp	
	Turb	104	0.982	2.583		Increasing turbidity
	FC	103	13.150	3.338		Increasing coliform
	MFC	52	17.620	2.561		
	WQI	48	7.917	2.050	Increasing WQI	
42	pH	103	0.092	6.747		
	DO	103	0.440	3.416	Increasing oxygen	
	MDO	51	0.383	2.554		
	Turb	103	0.257	2.075		Increasing turbidity
	FC	99	9.424	3.273		Increasing coliform
	MFC	51	15.040	3.256		
43	DO	104	0.418	2.073	Increasing oxygen	
	MDO	52	0.546	2.003		
	TP	52	-0.020	-2.389	Decreasing phosphor	
	WQI	48	8.019	2.213	Increasing WQI	
44	pH	103	0.089	3.053		
	DO	102	1.597	5.207	Increasing oxygen	
	MDO	52	1.526	4.038		
	MT	52	-0.451	-2.193		
	FC	100	11.030	2.823		Increasing coliform
	NO3+NO2	52	0.033	4.38		Increasing nitrate
	TKN	52	0.168	3.351		Increasing nitrogen
	NH3	52	0.066	2.507		Increasing ammonia
45	pH	101	0.174	7.328		
46	pH	99	0.106	5.557		
	DO	100	0.088	2.139	Increasing oxygen	
	Turb	100	-1.357	-2.812	Decreasing turbidity	
	FC	99	-1.694	-3.123	Decreasing coliform	
47	DO	104	0.295	3.659	Increasing oxygen	
	MDO	52	0.336	3.175		
	Temp	104	-0.259	-2.167	Decreasing temp	
48	DO	103	0.199	2.889	Increasing oxygen	
	MDO	52	0.213	3.051		
	Temp	104	-0.251	-2.03	Decreasing temp	
	MT	52	-0.350	-2.006		

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

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 www.skagitcounty.net/scmp.

Quality Control Measures

Field Meter calibration

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

The turbidity meter (Lamotte 2020) is calibrated the afternoon before or the morning of each sampling trip, and the reading before calibration is recorded. For 44 recorded calibrations during this period, the average deviation from the calibration standard was 10.6%. 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 10%.

The pH meter (Hanna Instruments 8314) was calibrated on the morning of each sampling trip, then left on throughout the sampling trip. The pH meter was recalibrated during the trip if the meter was turned off or 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 85) 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 (> 1 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 and stored in an identical manner and transported to the Skagit County Health Department laboratory on the same day.

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 25 years of experience monitoring water quality in the freshwater environment. He 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 two 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 12 summarizes the results of the duplicate analyses for the 2007 water year.

Variability in fecal coliform, total phosphorus, orthophosphate, and ammonia were above target levels. The fecal coliform data showed particularly high variability. These results are similar to what was found in the first three years of the Skagit County Monitoring Program and in Skagit County's previous work in the Baseline and Samish Bay Tributaries studies.

Table 12. 2007 Data Quality Results
Coefficients of Variation For parameters with duplicate samples in the Skagit County Monitoring Program – 2007 Water Year UPDATED

		Coefficient of Variation[1]	
Parameter	N	2007 Results	Target CV (%)[2]
Fecal coliform	199	50	33
Total phosphorus	24	18.5	10 [3]
Nitrate	36	10	10 [3]
Ortho-phosphate	12	22.2	10 [3]
Ammonia	31	18.5	10 [3]

[2] Target precision as listed in QAPP

[3] 10% CV target was listed for all nutrients

Fecal coliform duplicates are collected as follows: A 200-ml sample collection bottle is filled and emptied twice with water from the sampling site to serve as rinses. The bottle is then filled again, capped, and homogenized. Care is taken to prevent oversampling of the surface film and disturbance of bottom sediments. Two 100-ml samples are then poured from the sample collection bottle, alternating approximately 50-ml aliquots into each sample container, with the sample collection bottle swirled in between aliquots to maintain homogenization. Once both sample bottles are filled, they are capped (leaving air space) and immediately placed in a cooler with ice.

This method of collection should minimize the variability due to changing water quality and uneven distribution of coliform organisms in the water column. What remains should be an estimate of laboratory variability, assuming that the samples are handled the same between the site and the laboratory.

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 is 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). 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).

Data Quality Summary

The Skagit County Monitoring Program produces reliable data that is suitable for inclusion in Ecology's Environmental Information Management system. 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.

Annual Report Summary

The Skagit County Monitoring Program completed a fourth water year of sampling in September 2007. 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. The program is substantially funded through the 2008 water year by a Centennial Clean Water Grant from the Washington State Department of Ecology.

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