Skagit County Monitoring Program

SCMP

Annual Report

2022 Water Year

(October 2021 – September 2022)

Skagit County Public Works
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SCMP

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This report is available online at
https://www.skagitcounty.net/Departments/PublicWorksCleanWater/WQmonitoring.htm.

Table of Contents

Table of Figures

Table of Tables

Definitions

Ag-CAO	-	Critical Areas Ordinance: Ongoing Agriculture
Ag-NRL	-	Agricultural Natural Resource Lands
BMP	-	Best Management Practice
County	-	Skagit County
CSI	-	Samish Initiative
CV	-	Coefficient of Variation
DO	-	Dissolved Oxygen
Ecology	-	Washington State Department of Ecology
EPA	-	Environmental Protection Agency
FC	-	Coliform
GMHB	-	Growth Management Hearings Board
MPN	-	Most Probable Number
NH_3	-	Ammonia
NO_3+ NO_2	-	Nitrate + Nitrite
NTU	-	Nephelometric Turbidity Units
OP	-	Orthophosphate
pH	-	Power of Hydrogen
PIC	-	Pollution Identification and Correction
QAPP	-	Quality Assurance Project Plan
RR-NRL	-	Rural Resource Natural Resource Lands
RSD	-	Relative Standard Deviation
SCC	-	Skagit County Code
SCMP	-	Skagit County Monitoring Program
7-DADMax	-	7-Day Average of Daily Maximum Temperatures
SRC	-	Site Report Card
TKN	-	Total Kjeldahl Nitrogen
TMDL	-	Total Maximum Daily Load
TP	-	Total Phosphorous
TSS	-	Total Suspended Solids
VSP	-	Voluntary Stewardship Program
WQI	-	Water Quality Index
WRC	-	State of Washington Water Research Center
WY	-	Water Year

1 Executive Summary

Skagit County Public Works has completed the nineteenth year of water quality monitoring under the Skagit County Water Quality Monitoring Program. This is the annual report for the 2022 water year.

Data collected during this project indicates that many Skagit County streams, both within and outside of the agricultural areas, do not meet state water quality standards for *E. coli*, temperature, and/or dissolved oxygen. None of the 40 sites has met all water quality standards for the entire project, although some sites meet the standards most of the time. The standards are developed to protect salmonid populations, recreation, and downstream shellfish resources. Streams not meeting the standards represent less-than-ideal conditions for those uses. Conditions in Skagit County range from watercourses with occasional failures to continual inability to meet the standards. The Samish and Skagit Rivers have shown drastic improvement and primarily positive trends over the course of this program. Most of the substandard water quality occurs in slow-moving agricultural sloughs and in creeks that have low flow in the warmer months. Further investigation is ongoing to determine the causes of poor water quality in each case. Some cases may represent natural conditions rather than human-caused problems.

Trends analyses of water temperature, dissolved oxygen, bacterial concentrations, and other metrics reveal strong differences between watersheds and timeframes across the county. Some watersheds have mostly negative trends across the nineteen-year monitoring period but show many positive trends in a more recent timeframe, such as the last ten years.

Some sites have seen a reduction in fecal coliform over the length of the program, while others have seen increases. For water year 2022, 33% of the sites met the former fecal coliform standards, while 65% of the sites met the new *E. coli* state standards. The improved sites are a result of the hard work and dedication of the residents, farmers, tribes, government, environmental groups, establishing and enforcing strong regulations, and continued vision for a clean and sustainable environment that the citizens of Skagit County and the state of Washington continually portray.

Most dissolved oxygen trends show a positive increase across all timeframes. This is despite an abundant increase in water temperatures. These trends may suggest a reduction of biological oxygen demand in the watercourses, and it is great news for salmon. Total phosphorus and orthophosphate concentrations have significantly increased at a subset of sites throughout the length of the program. These sites are primarily located in the west portion of Skagit County. Phosphorus is often a limiting nutrient for freshwater algae, which means it can lead to algae blooms when an excess amount is present.

The Skagit County Water Quality Monitoring Program has now collected a robust dataset of 19 years throughout the County. Questions on the program can be addressed to Emma Santana at emmas@co.skagit.wa.us or 360-416-1443.

Skagit County Monitoring Program Annual Report

2022 Water Year
(October 2021 - September 2022)

2 Introduction

The Skagit County Monitoring Program (SCMP) began in October 2003 as part of Skagit County's (County) program to assess the effectiveness of Skagit County Code (SCC) Chapter 14.24.120: Critical Areas Ordinance for Areas of Ongoing Agriculture (Ag-CAO). The revised ordinance (Skagit County Ordinance O20030020) was passed by the Skagit County Board of Commissioners in June 2003 in response to a compliance order from the Western Washington Growth Management Hearings Board (GMHB).

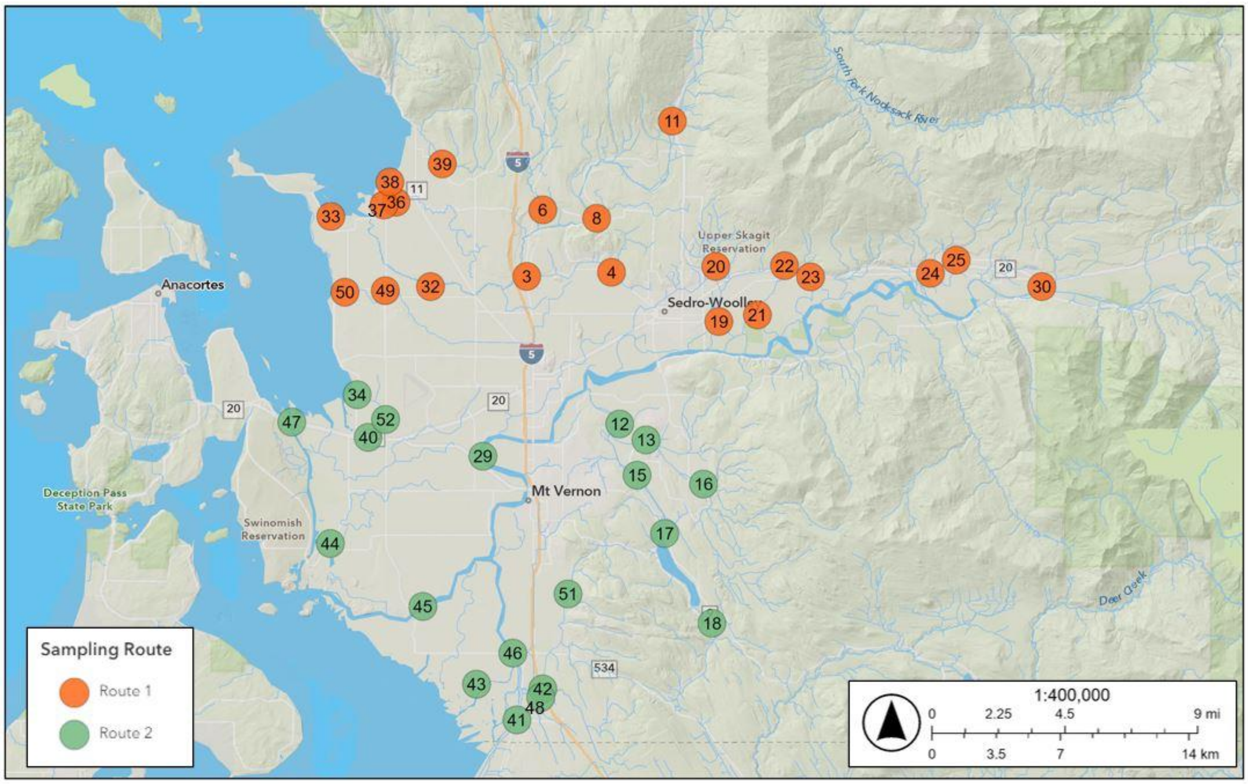
The ordinance requires farmers to "do no harm" to adjacent watercourses and relies on specific watercourse protection measures and more generalized best management practices (BMPs) to protect the watercourses instead of requiring buffers. The associated Skagit County Resolution R20030210 committed the County to conduct water quality monitoring in the agricultural areas as one method of assessing if the 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 GMHB. 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 2022 Water Year (WY). Results from the first eighteen years of this program have been reported previously (Skagit County 2004-2021). This current report contains data and analysis from water years 2004 – 2022.

R20040211 also required the County to conduct a triennial review of the Ag-CAO, including the water quality monitoring program, to seek public comment 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 were studied. The legislature subsequently passed additional legislation to extend the "time out" to 2011. In 2011, the Washington State Legislature adopted the recommendations from one research group studying the critical areas regulations and created the Voluntary Stewardship Program (VSP). Skagit County enrolled in the program in 2012. The counties that enrolled agreed to maintain existing critical areas protections and ensure streams are protected using voluntary measures.

2.1 Sampling Locations

Figure 1 is a map with the sampling sites monitored by the SCMP. **Table 1** and **Table 2** list the sampling site's names and their land use designations. Forty sites are currently included in the program. These sites are located primarily in agricultural zones, designated by the County as Agriculture-Natural Resource Lands (Ag-NRL) and Rural Resource-Natural Resource Lands (RR-NRL). Other sites were selected 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 SCMP was designed to determine current conditions and long-term trends in water quality at these sampling locations. The data are also suitable for determining compliance with state water quality standards.

Figure 1 – Ambient sampling sites in the SCMP



A secondary purpose for some sites included in the SCMP is to provide data to the Washington State Department of Ecology (Ecology) in support of their Total Maximum Daily Load (TMDL) or water cleanup programs in Skagit County. The sites that provide TMDL data are in agricultural zones and are integral to the determination of trends and conditions in those areas. Active water cleanup plans in Skagit County include the Lower Skagit Tributaries Temperature TMDL, the Samish Bay Watershed Fecal Coliform TMDL, the Padilla Bay Bacteria TMDL and the Lower Skagit River Fecal Coliform TMDL.

Table 1 - Sample site locations and types in the SCMP

Site ID	Watercourse	Location	Latitude	Longitude	Site Type[1]
3	Thomas Creek	Old Hwy 99 N	48.526	-122.339	3
4	Thomas Creek	F&S Grade Rd	48.528	-122.276	2
6	Friday Creek	Prairie Rd	48.559	-122.327	4
8	Swede Creek	Grip Rd	48.555	-122.287	3
11	Samish River	State Route 9	48.602	-122.231	1
12	Nookachamps Creek	Swan Rd	48.454	-122.270	3,6
13	E.F. Nookachamps Creek	State Route 9	48.446	-122.251	3,6
15	Nookachamps Creek	Knapp Rd	48.429	-122.258	2,6
16	E.F. Nookachamps Creek	Beaver Lake Rd	48.424	-122.208	2,6
17	Nookachamps Creek	Big Lake Outlet	48.400	-122.237	1,6
18	Lake Creek	State Route 9	48.356	-122.202	1,6
19	Hansen Creek	Hoehn Rd	48.504	-122.197	3,6
20	Hansen Creek	Northern State	48.531	-122.199	1,6
21	Coal Creek	Hoehn Rd	48.507	-122.169	3
22	Coal Creek	Highway 20	48.531	-122.149	1
23	Wiseman Creek	Minkler Rd	48.526	-122.130	1
24	Mannser Creek	Lyman Hamilton Hwy	48.528	-122.041	2
25	Red Cabin Creek	Hamilton Cem. Rd	48.534	-122.023	1
29	Skagit River	River Bend Rd	48.439	-122.372	5,6
30	Skagit River	Cape Horn Rd	48.521	-121.960	5
32	Samish River	Thomas Rd	48.521	-122.410	3
33	Alice Bay Pump Station	Samish Island Rd	48.555	-122.483	3
34	No Name Slough	Bayview-Edison Rd	48.468	-122.464	3
36	Edison Slough	W. Bow Hill Rd	48.562	-122.436	3
37	South Edison Pump Station	Farm to Market Rd	48.561	-122.444	3
38	North Edison Pump Station	North Edison Rd	48.572	-122.441	3
39	Colony Creek	Colony Rd	48.581	-122.401	2
40	Big Indian Slough	Bayview-Edison Rd	48.447	-122.457	3
41	Maddox Slough/Big Ditch	Milltown Rd	48.309	-122.346	3
42	Hill Ditch/Carpenter	Cedardale Rd	48.324	-122.327	3
43	Wiley Slough	Wylie Rd	48.326	-122.372	3
44	Sullivan Slough	La Conner-Whitney	48.395	-122.485	3
45	Skagit River – North Fork	Moore Rd	48.364	-122.416	5,6
46	Skagit River – South Fork	Fir Island Rd	48.342	-122.349	5,6
47	Swinomish Channel	Twin Bridges Boat Launch	48.455	-122.512	7
48	Fisher Creek	Franklin Rd	48.320	-122.328	3,6
49	Joe Leary Slough	Farm to Market Rd	48.519	-122.444	3,6
50	Joe Leary Slough	Bayview-Edison Rd	48.518	-122.474	3,6
51	Carpenter Creek	East Stackpole Rd	48.370	-122.310	1,6
52	Little Indian Slough	Farm to Market Rd	48.459	-122.444	6

[1]See Table 2 for site type descriptions.

Table 2 - Sample site type descriptions for the SCMP

Site Type Number	Description	Number of Sites[1]
1	Ag-upstream: Located to determine status/trends at upstream end of agricultural areas.	8
2	Ag-midstream: Located to determine status/trends in the middle of agricultural areas.	4
3	Ag-downstream: Located to determine status/trends at downstream end of a watercourse in agricultural areas.	20
4	Reference: Located to determine status/trends in a non-agricultural area, such as urban/suburban or rural reserve, for comparison with agricultural area results.	1
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.	16
7	Swinomish Channel: Located to provide a water quality baseline for Swinomish Channel	1

[1]Some sites have more than one type of designation

2.2 Sample Site Revisions

A total of 19 of the 40 sites (sites 3 - 13, 15 - 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 are used to help interpret trends in water quality for sites continued in the SCMP. Not all 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. Several intermediate sites on the Samish River were discontinued, leaving one upstream and one downstream site on the Samish.

Two sample sites were moved from their original locations as delineated in the Quality Assurance Project Plan (QAPP). 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 tide gate and associated saltwater intrusion. This change was 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. The 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 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 Ecology and the Western Washington Agricultural Association. Most of the flow from that system discharges through the west end into Swinomish Channel. The Rexville Pump Station site was initially chosen because it was cited as a possible fecal coliform source in the Lower Skagit Fecal Coliform TMDL (Pickett 1997). However, fecal coliform (FC) readings at the site during this study were generally low. Because of the low FC readings, 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.

For the 2017 season, Skagit County re-designated two sites to better reflect current land use patterns: Site 16 (East Fork Nookachamps Creek) was moved from Ag-Upstream to Ag-Midstream due to some agricultural activity directly upstream of the sample location. Site 23 (Wiseman Creek) was moved from Ag-Midstream to Ag-Upstream due to the cessation of agricultural activities upstream of the sample location.

In 2018, construction activities required Skagit County to pause sampling at Site 31, located near Dike District 20's floodgate near Francis Road. Sampling at the site was not resumed post-construction and the site was officially removed from the sampling list in 2022.

At the start of the 2022 water year, three original sites were removed from the sampling plan and four new sites were added. Site 14 along College Creek was dropped due to its location outside of Skagit County's jurisdiction. Site 28, an urban reference site located on Brickyard Creek, was removed due to being dry for large portions of the year and not being as helpful in understanding the primarily agricultural sites. Site 35 on Joe Leary Slough was also removed from the sampling program.

In replacement of Site 35, two sites were added on Joe Leary Slough to narrow down pollution sources and to help inform the Padilla Bay Bacteria TMDL. Site 49 was added as a midstream site on Joe Leary Slough at Farm to Market Road and Site 50 was added at the tide gate terminus where the waterway meets Padilla Bay.

Site 51, located on Carpenter Creek at East Stackpole Road, was added to understand worsening trends observed downstream at Site 42. The data collected at this site also helps support the Lower Skagit Tributaries Temperature TMDL and other Ecology work related to Skagit Bay shellfish monitoring.

Site 52, located at Little Indian Slough at Farm to Market Road, was added based on high bacteria levels observed by Skagit County Stream and Storm Teams and Ecology. The regular monitoring at this site helps inform the efforts to reduce pollution and the Padilla Bay Bacteria TMDL.

2.3 Sampling Frequency

Samples are taken biweekly at each site for the SCMP. Sites are sampled on one of two routes, with each route being completed every other week. Two weeks of sampling for Route 1 were missed due to a flood event during the week of November 18th, 2021, and extreme weather the week of December 29th, 2021. All other ambient sampling trips were conducted on schedule during the 2022 water year. Sampling may have taken place on different days each week, depending on scheduling and logistics.

2.4 Clean Samish Initiative

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

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

2.5 2008 Review by the State of Washington Water Research Center

Skagit County contracted with the State of Washington Water Research Center (WRC) for a review of its water quality program. The WRC Review Report draft was received in March 2008, and the final report was received in June 2008 (Cichosz and Barber 2008).

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

2.6 Funding

A proposal was submitted in February 2003 to Ecology for consideration in its fiscal year 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, fiscal year 2004 through fiscal year 2008.

The Centennial Clean Water Grant, that funded the program at 75%, ended in December 2008, with the remaining 25% having come from County funds. Work since that date has been funded by Skagit County's Clean Water Program (CWP). Skagit County has received some EPA funding to address Samish Bay watershed FC issues, but the core activities of the SCMP will continue to be funded out of the CWP.

3 Methods

Standard water quality monitoring methods are used in the SCMP. The methods are derived from several sources, including guidance from Ecology and the EPA. A brief description of monitoring procedures follows, and detailed monitoring procedures can be found in the QAPP developed for the program (Skagit County 2004b).

Each site in the monitoring program is visited once every two weeks. At each visit, dissolved oxygen (DO), temperature, pH, turbidity, conductivity, and salinity are measured, and samples are obtained for FC determinations. On a quarterly basis, additional water samples are obtained for laboratory quantification of nutrients that include total Kjeldahl nitrogen (TKN), ammonia (NH_3), nitrate (NO_3) and nitrite (NO_2), total phosphorus (TP), orthophosphate (OP), and total suspended solids (TSS).

Discharge measurements were made up until 2008 in selected locations and were intended to provide a general indication of the flow regime for that watercourse and as an aid in interpreting other water quality parameters. As Ecology has added several stream gauges in the area, Skagit County has de-emphasized performing manual discharge measurement.

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 through the length of the program.

Data are collected on paper field sheets and later entered in an electronic database which is then checked for accuracy against the original data sheets. Microsoft Excel spreadsheets are used for data summary and analysis. These spreadsheets are appendices to this report and are published on the County's web site (https://www.skagitcounty.net/Departments/PublicWorksCleanWater/WQmonitoring.htm).

3.1 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 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 SCMP 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 worsening. Once trends are detected, efforts should be undertaken to determine if they 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 conditions that are likely caused by local circumstances.

One statistical tool in use to assess trends 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 DO. 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 SCMP 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 for this report was computed using Sanitas software (Intelligent Design Technologies, 1998). For most analyses, twelve seasons were designated, starting with the beginning of each month. This approach was recommended in the review of the SCMP by the WRC. Observations below detection limits were replaced with one-half of the detection limit per the software user manual. The software ignores missing data, so no accommodation for absent data was necessary.

The SCMP completed trends analysis via the Seasonal Kendall's Test for 18 key parameters at each sampling location. The parameters tested include pH, DO, DO percent saturation, temperature, turbidity, FC, NH_3, NO_3+NO_2, TP, OP, TKN, and TSS. Temperature data from biweekly sampling visits were used for this analysis instead of continuous data collected during the summer months because the 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 bi-weekly visits were collected at the same time of day for any individual station, the trends analysis should not be biased by differences caused by sampling time of day.

Three periods were analyzed for trends in this report: the full 19 years of SCMP data, the most recent ten years of data, and the most recent five years of data. Analyzing trends over three different timeframes allows a more detailed picture of what changes have been occurring across the county. For example, a creek may exhibit a small trend in increasing DO from 19 years ago as compared to now, but it may also show a strong trend in decreasing DO from five years ago as compared to now. Analyzing a combination of time periods reveals a clearer picture of what is happening than can be ascertained from a single trend over the course of 19 years.

Several sites have extended dry periods during most summers and/or are flooded during high water events and are not sampled. The Sanitas trends analysis program was unable to compute trends based on 12 seasons for those sites due to the consistent lack of data for the dry or flooded periods. For those sites, trends were calculated based on four seasons, beginning in January, April, July, and October. All trend analyses on nutrient data mentioned above are also performed using four seasons, as these are only sampled quarterly.

Data used for the Seasonal Kendall's Test can be subject to autocorrelation, where each successive datum is correlated with the previous point. This situation usually occurs when samples are collected more frequently than monthly. For the SCMP, DO, temperature, and FC 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. Our approach for these parameters has been to conduct the analysis using all data and repeat the analysis using monthly averages to avoid autocorrelation. In the cases where there are differences, it would probably be prudent to use the monthly averages. A summary of Seasonal Kendall's Test results for all parameters, significant or not, can be found in Appendix C.

3.2 Data Quality

3.2.1 Quality Assurance Project Plan (QAPP)

The SCMP operates under a QAPP that was approved by Ecology in 2003. This plan details sampling strategies, equipment to be used, and all other aspects of the sampling program. Ecology approval of the QAPP was required for Skagit County to be eligible for grant funds.

3.2.2 Equipment Calibration and Maintenance

The turbidity meter (Lamotte Model 2020we) is calibrated the afternoon before or the morning of each sampling trip, and the reading before calibration is recorded.

The pH meter (Hanna Instruments Model 8314) is calibrated on the morning of each sampling trip. The pH meter is recalibrated during the trip if questionable results are obtained.

The DO/temperature/conductivity meter (YSI Model 2030 Pro) is calibrated for DO using the built-in calibration chamber (water-saturated air). The meter is recalibrated to local elevation at each sample site prior to sampling.

The DO meter probe is deployed in areas with sufficient current (> 0.5 feet per second) 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 whenever possible with sample containers rinsed at least three times with sample water and are analyzed immediately.

3.2.3 Lab Samples

Laboratory samples for nutrients are collected using clean equipment with a sampling wand as close as possible to the thalweg of the watercourse. Care is taken to prevent oversampling of the surface film or disturbing the bottom. For nutrient and TSS samples the sampling container is rinsed at least three times with the water to be sampled. The sample is then 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 ice until they are delivered to the lab on the same day.

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

3.2.4 Personnel

The project manager performs most samplings that generate data for this report. Any other staff that perform samplings and collections are adequately trained by the project manager according to EPA-approved sampling methods prior to sampling. Due to regular staff turnover and availability of assisting staff members, some staff may collect sample data only once, though repeated participation and experience with the project manager is preferred when possible.

3.2.5 *Duplicate Analysis*

Duplicate field samples are collected to assess the accuracy and precision of the analytical methods. FC duplicates are collected at a 20% rate and selected nutrient duplicates are collected at a 10% rate. The selected nutrient duplicates (TP, OP, NO_3, and/or NH_3) are intended to provide a precision estimate for all the nutrient analyses.

Table 3 summarizes the results of the duplicate analyses for the 2022 water year, using the coefficient of variation (CV) statistic. In this report, coefficient of variation is considered synonymous with relative standard deviation (RSD).

Variability in FC for the 2022 water year was 43.1, which is above the original target level set out in the 2003 QAPP of 33. While this goal was not met, it is comparable to the annual average across this program of 43.9. The overall average has a very small annual standard deviation of 3.0, indicating the lack of change in FC variability over the 19 years of the program. EC had a high CV of 45.6, also exceeding the target of 33. The high variability of the FC and EC results may be partially due to the use of the Most Probable Number (MPN) analysis technique. This method was chosen for the SCMP because at the time the Skagit County Health Department laboratory was certified for the method, and because it is reportedly more reliable for samples with high turbidity, which are often encountered in the SCMP (Michaud 1991). The program continued using MPN when it switched to Edge Analytical in 2009 to maintain data comparability. Fecal coliform variability in the SCMP, although higher than the initial target level, is similar to that seen in other monitoring programs in Washington.

Total Phosphorus, orthophosphate, and nitrate all meet the target CV of 10 for nutrients, however ammonia did not with a CV of 16.1. Ammonia can easily be introduced when sampling or during analysis because it can be found on human skin due to the breakdown of proteins and other molecules. Throughout the sampling program, the CV of ammonia has been highly variable ranging from 0 to 31.

Table 3 - Data quality duplicate analysis for 2022 Water Year

		Coefficient of Variation (RSD)	
Parameter	**n**	**2022 Results**	**Target[1]**
Fecal Coliform	208	43.1	33
E. coli	207	45.6	33
Total Phosphorus	8	5.2	10
Orthophosphate	8	5.3	10
Nitrate	8	6.4	10
Ammonia	8	16.1	10

[1] Target precision for fecal coliform is as listed in 2003 QAPP. Target precision for all nutrients is 10%.

4 Data Summaries and Trends Analysis

All measurements for the parameters are available in **Appendix A** and summary statistics over the length of the program are included in **Appendix B**.

Trends were calculated for 30 measured or calculated parameters (e.g., monthly averages) at 36 of the sites, for a total of 1,080 tests. The four sites added to the monitoring program in 2022 (Sites 49 – 52) were not statistically analyzed because five years of data are required to increase the datasets robustness and reduce statistical error. Of the 1,080 tests, 421 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving or positive (e.g., increased dissolved oxygen, reduced temperature) made up 226 of the significant trends, or 54 percent. Negative or deleterious trends (e.g., reduced dissolved oxygen, increased nutrients) accounted for the remaining 195, or 46 percent of the significant trends. In relation to the global trend in acidification of surface waters, declining pH was considered a negative trend for this report. There were also statistically significant nutrient trends where the slope was zero, and these are not included in the above counts. The statistical analysis used was very sensitive, and a slope of zero simply means that the slope was less than 0.0001 units, though the directionality as positive or negative was still given.

All trends can be found in the tables in **Appendix C**. Positive significant trends are shaded green and negative are shaded red. Trends that achieved 95% confidence in statistical significance are shaded the darkest blue in the confidence column. Some trends were very close to achieving 95% confidence but fell short. Trends that achieved 90% confidence are shaded in a slightly lighter blue, and trends that achieved 80% confidence in even lighter blue. This helps to inform the reader of all changes that may be occurring at the sampling site, even if they are not statistically significant at a 95% confidence level. Any parameters that showed a significant trend with a slope of 0 are highlighted in yellow in the slope column.

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

Gaps in the data represent streams that were either flooded or dry at sampling time or may represent equipment malfunctions.

4.1 Site Sampling Times

The SCMP maintains sampling times as a temporal control for data analysis. Route 1 primarily samples the northern half of the county, while Route 2 primarily covers the southern half. The lower the range of sampling time each week, the better. This is an exceptionally difficult task over such a long period. It is common to experience equipment problems, staff availability issues, bad weather, injuries, flat tires, closed roads, and inaccessible watercourses. In addition, the removal and addition of sites contribute to these variations. Despite these obstacles, the SCMP has maintained remarkably small sampling windows across 19 years (**Tables 4 and 5**).

Table 4 – Historical sampling times for Route 1, which primarily samples the northern half of Skagit County. The table on the left includes all years of the program that sampling times were recorded. The table on the right is from the most recent water year.

Route 1 - All 19 years combined					
Site	Mean	Min	Max	Range (hrs)	n
22	8:34	7:28	10:05	2:37	281
25	8:52	7:48	10:20	2:32	245
30	9:04	8:00	10:30	2:30	280
24	9:21	8:15	10:50	2:35	278
23	9:39	8:27	11:00	2:33	256
21	9:54	8:38	11:20	2:42	253
19	10:06	8:50	11:30	2:40	261
20	10:20	9:05	12:00	2:55	280
11	10:43	9:25	12:05	2:40	281
8	11:20	9:40	12:55	3:15	280
4	11:43	9:55	13:35	3:40	278
3	11:59	10:05	13:50	3:45	279
6	12:12	10:15	14:05	3:50	280
39	12:33	10:30	14:20	3:50	278
36	12:48	10:40	14:35	3:55	280
38	13:03	10:55	14:50	3:55	277
37	13:18	11:05	15:05	4:00	279
33	13:33	11:20	15:20	4:00	277
32	14:02	11:45	15:50	4:05	281
49	13:14	11:50	14:45	2:55	25
50	13:30	12:05	15:00	2:55	25

Route 1 - Water Year 2022					
Site	Mean	Min	Max	Range (hrs)	n
22	8:14	7:45	9:05	1:20	25
25	8:34	7:55	9:25	1:30	21
30	8:47	8:10	9:36	1:26	24
24	9:03	8:20	9:50	1:30	24
23	9:20	8:42	10:15	1:33	23
21	9:34	8:52	10:35	1:43	23
19	9:46	9:05	10:50	1:45	23
20	9:59	9:05	11:10	2:05	25
11	10:20	9:25	11:25	2:00	25
8	10:39	9:40	11:45	2:05	25
4	10:54	9:55	11:55	2:00	24
3	11:09	10:05	12:10	2:05	25
6	11:21	10:15	12:25	2:10	25
39	11:41	10:30	12:35	2:05	25
36	11:56	10:40	12:57	2:17	25
38	12:12	10:55	13:40	2:45	25
37	12:26	11:05	13:50	2:45	25
33	12:42	11:20	14:05	2:45	25
32	13:02	11:45	14:30	2:45	25
49	13:14	11:50	14:45	2:55	25
50	13:30	12:05	15:00	2:55	25

Table 5 - Historical sampling times for Route 2, which primarily samples the southern half of Skagit County. The table on the left includes all years of the program that sampling times were recorded. The table on the right is from the most recent water year.

Route 2 - All 19 years combined					
Site	Mean	Min	Max	Range (hrs)	n
29	8:18	7:00	9:44	2:44	279
52	8:29	8:05	9:26	1:21	23
40	8:47	7:35	10:13	2:38	277
34	9:00	7:50	10:26	2:36	276
47	9:14	8:05	10:40	2:35	282
44	9:33	8:30	11:00	2:30	281
45	9:57	8:55	11:40	2:45	279
43	10:17	9:00	11:56	2:56	281
46	10:32	9:10	12:07	2:57	280
41	10:47	9:25	12:30	3:05	283
48	10:59	9:35	12:47	3:12	283
42	11:14	9:45	13:04	3:19	281
51	11:16	10:30	12:16	1:46	26
18	11:45	10:10	13:40	3:30	281
17	12:01	10:25	14:00	3:35	281
16	12:23	10:40	14:19	3:39	281
15	12:42	10:55	14:46	3:51	279
13	12:56	11:05	15:01	3:56	280
12	13:10	11:20	15:30	4:10	278

Route 2 - Water Year 2022					
Site	Mean	Min	Max	Range (hrs)	n
29	8:00	7:40	9:00	1:20	26
52	8:29	8:05	9:26	1:21	23
40	8:39	8:20	9:42	1:22	26
34	8:53	8:30	9:52	1:22	26
47	9:04	8:40	10:06	1:26	26
44	9:24	8:59	10:27	1:28	26
45	9:47	9:20	10:50	1:30	26
43	10:08	9:37	11:10	1:33	26
46	10:21	9:48	11:21	1:33	25
41	10:36	9:59	11:40	1:41	26
48	10:46	10:07	11:50	1:43	26
42	11:00	10:18	12:03	1:45	26
51	11:16	10:30	12:16	1:46	26
18	11:43	10:54	12:42	1:48	26
17	11:57	11:06	12:56	1:50	26
16	12:21	11:29	13:16	1:47	26
15	12:32	11:14	13:32	2:18	25
13	12:45	11:45	13:46	2:01	26
12	12:57	11:55	14:00	2:05	26

4.2 Annual Rainfall and Air Temperatures

Monthly precipitation totals and average air temperatures were collected from the Washington State University AgWeatherNet Mount Vernon station for the entire 19 water years of this program (**Tables 6, 7)**. Summary statistics are calculated on the right for each month and below for each year.

The 2022 water year had moderate amount of rainfall compared to the precipitation observed over the 19-year history. Total rainfall was 31.93 inches, which is only 0.52 inches below the 19-year mean of 32.45 inches. November 2021 saw the greatest amount of rain recorded over the 19-year history, with 8.15 inches accumulated. However, in September 2022, only 0.02 inches of rainfall occurred, which was the driest September throughout the program's history.

Some of the most interesting statistics on **Table 6** are at the bottom: The monthly mean wet and dry seasonal rainfall, and the seasonal extremes category, which divides the wet by the dry. This creates a ratio that can illustrate extremes in seasonal rainfall. Monitoring these ratios across a changing climate can be informative in monitoring changes in water quality. You can see that some years you may get a near equivalent amount of total precipitation in the wet season as the dry season, whereas a year can be as extreme as nearly seven times as much precipitation in the wet season as occurs in the dry. The 2022 water year had a moderately high ratio of 3.02 in this comparison.

Monthly temperature statistics are summarized in **Table 7.** Mean monthly temperatures for each year that are greater than 0.9°F different from the full period average are highlighted in red or blue for above or below, respectively. In the lower section of the table, the full years' average temperatures are shown and compared to the 19-year mean. Differences exceeding 0.9°F above or below the mean are again highlighted. Seven out of the 19 years exceed this difference from the average.

The Seasonal Extremes in the bottom row is the ratio of average monthly wet season temperature to average monthly dry season temperature. It is lower if the wet and dry seasons are more disparate in average temperatures, or higher if the two seasons are more alike in that year.

Table 6 - Monthly precipitation totals for the history of the Skagit County Monitoring Program. Cells are shaded blue or red to illustrate above and below average rainfall for a month, respectively. The threshold of 0.5 inches of rain to constitute an "average" shading of grey is arbitrarily chosen and does not constitute an authoritative metric. Raw data sourced from WSU AgWeatherNet Mount Vernon Station.

	WY 2004	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	WY 2013	WY 2014	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020	WY2021	WY2022	Mean	Low	High
October	5.34	2.71	4.01	1.98	4.82	1.37	5.67	1.76	1.96	3.87	1.51	6.07	3.39	5.26	5.39	2.32	4.21	3.54	4.29	3.66	1.37	6.07
November	4.66	6.84	4.20	5.61	2.68	5.55	5.31	3.74	4.67	3.89	3.48	3.90	7.85	5.99	6.22	4.20	2.14	2.92	8.15	4.84	2.14	8.15
December	2.87	4.36	3.42	3.05	3.71	3.18	1.25	3.26	1.25	3.52	2.34	3.73	7.05	3.21	3.76	3.79	3.50	4.25	2.92	3.39	1.25	7.05
January	4.01	4.11	6.54	5.47	2.75	3.79	2.81	6.01	2.92	5.13	4.70	4.69	3.21	1.62	4.79	1.81	5.90	3.71	3.76	4.09	1.62	6.54
February	1.35	3.15	3.2	2.96	2.91	1.25	1.25	1.72	4.49	2.02	3.89	2.97	4.63	3.18	5.78	2.27	4.82	4.89	1.87	3.08	1.25	5.78
March	3.44	2.77	1.51	4.52	4.36	2.24	2.16	3.37	3.77	2.10	4.45	2.51	3.88	5.01	2.79	1.35	2.84	1.61	3.30	3.05	1.35	5.01
April	0.28	4.11	3.16	0.89	2.40	2.71	2.53	3.90	4.31	4.60	3.26	1.48	2.17	3.00	4.73	2.45	1.61	1.16	1.54	2.65	0.28	4.73
May	3.65	1.73	2.24	1.09	2.09	2.22	4.57	4.17	2.4	2.58	3.68	0.60	1.27	2.36	0.35	0.88	3.13	0.87	2.45	2.23	0.35	4.57
June	1.80	1.90	1.10	1.58	2.25	0.16	1.66	0.91	3.14	1.27	1.14	0.61	2.78	0.94	1.52	1.42	3.07	0.91	3.11	1.65	0.16	3.14
July	0.61	0.74	0.82	1.27	0.64	0.51	0.05	1.39	1.3	0.00	1.29	0.11	0.59	0.01	0.04	0.83	0.83	0.00	0.30	0.60	0.00	1.39
August	6.29	2.22	0.23	0.81	2.23	0.52	1.17	0.42	0.01	1.34	0.88	1.46	2.88	0.04	0.17	0.86	0.64	0.96	0.22	1.23	0.01	6.29
September	3.27	1.96	1.78	2.36	0.50	1.31	2.87	0.87	0.14	4.10	2.64	2.12	1.32	1.59	1.36	5.24	1.07	3.18	0.02	1.98	0.02	5.24
																			Mean	2.70	0.00	8.15
																				Mean	Low	High
Annual	37.57	36.6	32.21	31.59	31.34	24.81	31.30	31.52	30.36	34.42	33.26	30.25	41.02	32.21	36.90	27.42	33.76	28.00	31.93	32.45	24.81	41.02
Low	0.28	0.74	0.23	0.81	0.5	0.16	0.05	0.42	0.01	0.00	0.88	0.11	0.59	0.01	0.04	0.83	0.64	0.00	0.02	0.33	0.00	0.88
High	6.29	6.84	6.54	5.61	4.82	5.55	5.67	6.01	4.67	5.13	4.7	6.07	7.85	5.99	6.22	5.24	5.9	4.89	8.15	5.90	4.67	8.15
Mean	3.13	3.05	2.68	2.63	2.61	2.07	2.61	2.63	2.53	2.87	2.77	2.52	3.42	2.68	3.08	2.29	2.81	2.33	2.66	2.70	2.07	3.42
Mean Wet (Oct-Apr)	3.14	4.01	3.72	3.50	3.38	2.87	3.00	3.39	3.34	3.59	3.38	3.62	4.60	3.90	4.78	2.60	3.57	3.15	3.69	3.54	2.60	4.78
Mean Dry (May-Sep)	3.12	1.71	1.23	1.42	1.54	0.94	2.06	1.55	1.40	1.86	1.93	0.98	1.77	0.99	0.69	1.85	1.75	1.18	1.22	1.54	0.69	3.12
Seasonal Extremes*	1.00	2.34	3.01	2.46	2.19	3.04	1.45	2.19	2.39	1.93	1.75	3.70	2.60	3.94	6.95	1.41	2.04	2.66	3.02	2.64	1.00	6.95

*Seasonal extremes in the ratio of average monthly rainfall for the wet to dry season

(red)	> 0.5" below mean
(blue)	> 0.5" above mean
(grey)	± 0.5" of mean
(yellow)	No data, mean value listed

Table 7 - Monthly air temperature averages for the entire history of the Skagit County Monitoring Program. Cells are shaded red or blue to illustrate above and below average temperature for a month, respectively. The threshold of 0.9 degrees Fahrenheit to constitute an "average" shading of grey is arbitrarily chosen and does not constitute an authoritative metric.

	WY 2004	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	WY 2013	WY 2014	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020	WY 2021	WY2022	Low	High	Mean
October	54.3	50.6	46.8	47.2	48.0	50.0	50.6	51.9	50.7	51.3	49.1	56.8	54.4	53.5	49.6	49.8	47.9	50.4	50.5	46.8	56.8	50.7
November	44.0	43.2	34.4	42.8	41.1	47.8	47.1	42.5	42.5	46.4	43.7	43.9	41.7	51.0	46.4	46.1	42.9	44.7	47.3	34.4	51.0	44.2
December	41.9	41.1	39.9	39.5	38.3	35.9	36.4	42.8	39.6	41.2	37.1	43.1	42.4	36.2	37.4	41.4	42.3	42.3	35.5	35.5	43.1	39.7
January	41.9	41.0	43.6	36.2	36.7	38.2	46.7	40.7	40.1	37.2	41.0	43.5	42.6	36.4	44.1	41.7	43.7	42.5	40.4	36.2	46.7	41.0
February	43.5	41.1	39.1	41.5	40.0	39.9	45.6	38.0	42.2	43.0	38.7	47.5	46.5	40.1	39.3	33.5	40.9	39.1	40.6	33.5	47.5	41.1
March	47.5	46.7	44.0	45.3	40.8	41.4	46.1	45.2	43.1	45.7	46.8	49.3	48.7	45.8	43.6	43.1	42.4	43.5	45.7	40.8	49.3	45.0
April	52.4	49.4	46.8	47.4	45.4	49.2	49.2	45.1	49.8	48.6	50.5	49.6	53.4	50.5	49.3	49.8	49.7	49.1	46.5	45.1	53.4	49.0
May	56.3	56.2	55.0	52.3	53.7	55.0	52.1	51.6	53.2	55.4	57.1	56.3	56.9	55.4	57.1	56.6	56.0	53.7	51.9	51.6	57.1	54.8
June	61.3	57.1	58.6	56.0	55.6	60.0	56.8	57.4	56.1	60.5	59.2	62.8	59.6	59.8	58.9	59.2	58.2	62.8	59.1	55.6	62.8	58.9
July	62.4	61.4	61.1	62.0	59.7	64.4	60.7	60.1	60.6	62.5	64.1	65.9	63.1	62.5	64.5	63.0	61.7	62.8	63.8	59.7	65.9	62.4
August	65.4	61.5	59.2	59.9	61.9	61.7	60.8	61.1	62.9	63.9	64.4	64.3	63.8	63.7	62.6	64.0	61.9	62.6	64.7	59.2	65.4	62.6
September	57.0	54.7	56.0	54.6	57.0	59.2	58.8	60.4	57.1	59.7	60.4	57.2	57.6	59.7	57.5	59.1	60.2	58.1	59.0	54.6	60.4	58.1
																			Mean	33.5	65.9	50.6
																				Mean	Low	High
Low	41.9	41	34.4	36.2	36.7	35.9	36.4	38	39.6	37.2	37.1	43.1	41.7	36.2	37.4	33.5	40.9	39.1	35.5	38.0	33.5	43.1
High	65.4	61.5	61.1	62	61.9	64.4	60.8	61.1	62.9	63.9	64.4	65.9	63.8	63.7	64.5	64	61.9	62.8	64.7	63.2	60.8	65.9
Mean	52.3	49.9	48.0	48.2	47.4	49.4	50.2	48.8	49.2	50.5	50.2	53.0	52.1	50.4	50.3	49.8	49.8	50.3	50.4	50.0	47.4	53.0
Mean Wet (Oct-Apr)	45.5	44.0	41.3	42.1	40.8	42.2	45.4	43.5	43.0	44.1	42.7	47.4	46.1	43.8	43.4	42.6	43.4	43.8	43.3	43.6	40.8	47.4
Mean Dry (May-Sep)	59.1	56.7	56.1	55.4	55.6	58.3	56.4	56.0	56.6	58.4	59.3	59.4	59.1	58.6	58.3	58.6	58.0	58.2	57.5	57.7	55.4	59.4
Seasonal Extremes	0.77	0.77	0.74	0.76	0.73	0.72	0.81	0.78	0.76	0.76	0.72	0.80	0.78	0.75	0.74	0.73	0.75	0.75	0.75	0.8	0.7	0.8

(grey)	± 0.9°F of mean
(red)	> 0.9°F above mean
(blue)	> 0.9°F below mean
(yellow)	No data, mean value listed

4.3 Water 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.

Background

For the water years 2004 - 2007 and 2009 - 2022, temperatures were measured with Stowaway Tidbit® data loggers from Onset Computer Company. These devices were set to measure water temperature every half hour. They are normally deployed in late June and retrieved in early September. Several of the data loggers have gone missing by the end of each monitoring period. Some may have been lost due to channel changes associated with heavy rains in late summer, while others may have been vandalized. For the 2008 water year, a computer programming error resulted in the data loggers measuring temperature for only two weeks in late June and early July. Since annual peak temperatures occur later in the summer, the 2008 data logger data were not very useful.

In the fall of 2006, Ecology revised its water quality standards (WAC 173-201a) to comply with a request from the EPA. Included in this revision were several changes to temperature and DO standards for Skagit County watercourses. In particular, the lower Skagit River, Hansen, Nookachamps, Fisher, and Carpenter Creeks, and the upper Samish River and its tributaries were placed in the “Core salmonid spawning and rearing” use category. This change had the effect of imposing more stringent temperature and DO standards on these streams. Formerly, each of these streams was held to a 7-day average of the daily maximum temperatures (7-DADMax) standard of 17.5ºC, but with the revised standards, these streams must now meet a 7-DADMax standard of 16ºC. There were no changes to other streams in the County. Currently, Sites 3 - 4, 32 – 38, 40 – 41, 43 – 44, 49 – 50, and 52 are held to the 17.5 ºC standard, while all other sites are held to the 16ºC standard, including marine Site 47.

In addition to changes in the general standard, the revisions to the state temperature standards in 2006 also added spawning period temperature standards to some streams in the county. Portions of the Samish River, Friday Creek, Hansen Creek, Lake Creek, and East Fork Nookachamps Creek have a 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.

Results

Table 8 displays the daily maximum temperatures for the last five years of the study, based on data collected at bi-weekly samplings. Because the state water quality standards are based on 7-DADMax, the maximums reported on Table 8 are not directly comparable to the state temperature standard but are displayed here as an indication of the relative condition of each stream and for comparison of the temperature conditions from year to year.

Trends analyses reveal that in comparison to the start of the program 19 years ago, 11 sites have shown a significant increase in temperature (**Figure 2**). Over the most recent ten years, 13 sites show an increase while one shows a decrease (**Figure 3**). All the decreasing 10-year trends are interestingly in the southern portion of the County. The 13 declining sites are a large change from the 2021 water year, where there was only one decreasing trend on the 10-year scale. Trends from the most recent five years of data (**Figure 4**) show three sites significantly increasing in temperature, with no sites showing a significant decrease.

Table 9 contains the 7-DADMax values for those sample sites where continuous temperature data is available. These data are directly comparable to the state water quality standards as described on the table and in the text above. A total of 23 dataloggers were deployed for the summer of 2022. Of these, one went missing and one was incorrectly programmed. The remaining 21 dataloggers were retrieved and their data analyzed.

A heat wave across western Washington in late July and early August 2022 led to high water temperatures. Out of 14 sites where data loggers were deployed and still submerged underwater, 12 recorded their 7-DADMax during the dates of July 26th – 31st when this heatwave occurred. The 7-DADMax temperatures that were recorded in Thomas Creek (Sites 3 and 4), Swede Creek (Site 8), Nookachamps Creek (Site 12), Upper Coal Creek (Site 22), Mannser Creek (Site 24), and Maddox/Big Ditch (Site 41) in 2022 were the highest on record for at least the last 5 years.

Ecology has developed temperature remediation plans (TMDLs) for Fisher, Carpenter, Nookachamps, and Hansen Creeks, but many other Skagit County streams also exceed temperature standards.

Table 8 - Maximum watercourse temperatures recorded from bi-weekly sampling. Cells shaded green pass state standard. There is a 0.2 allowance in the standard for variation in equipment calibration. These samplings are taken at nearly the same time of day, each week they are sampled, and do not represent the hottest temperature that each site may have reached on a given day.

Site Number	Watercourse	Location	Highest daily temperature (°C)				
			2018	2019	2020	2021	2022
3	Thomas Creek	Old Hwy 99 North	18.4	17.8	18.4	18.7	19.5
4	Thomas Creek	F&S Grade Rd	14.9	14.8	14.7	15.2	15.5
6	Friday Creek	Prairie Rd	19.2	18.0	17.8	18.8	19.0
8	Swede Creek	Grip Rd	16.9	16.5	16.2	16.2	16.8
11	Samish River	State Route 9	13.2	13.6	15.2	12.6	15.1
12	Nookachamps Creek	Swan Rd	22.5	21.0	20.1	21.8	21.1
13	E.F. Nookachamps Creek	State Route 9	21.9	19.4	18.6	24.0	20.1
15	Nookachamps Creek	Knapp Rd	22.7	20.1	22.1	25.3	21.6
16	E.F. Nookachamps Creek	Beaver Lake Rd	19.8	17.5	17.0	20.4	17.8
17	Nookachamps Creek	Big Lake Outlet	23.6	21.3	22.5	26.9	23.1
18	Lake Creek	State Route 9	18.1	16.4	16.3	21.9	16.7
19	Hansen Creek	Hoehn Rd	17.6	18.1	18.5	18.0	18.9
20	Hansen Creek	Northern State	15.4	14.9	14.8	14.7	15.2
21	Coal Creek	Hoehn Rd	15.2	15.6	16.5	14.9	16.9
22	Coal Creek	Hwy 20	15.2	15.3	15.1	14.5	15.6
23	Wiseman Creek	Minkler Rd	14.1	14.2	15.5	15.8	15.5
24	Mannser Creek	Lyman Ham. Hwy	11.9	12.5	12.9	15.3	15.2
25	Red Cabin Creek	Hamilton Cem. Rd	11.2	11.9	12.4	11.5	12.4
29	Skagit River	River Bend Rd	16.2	16.0	14.7	15.7	15.3
30	Skagit River	Cape Horn Rd	15.4	15.6	15.0	15.0	14.8
32	Samish River	Thomas Rd	19.3	18.8	18.2	19.4	19.0
33	Alice Bay Pump Station	Samish Island Rd	25.0	22.1	22.9	22.6	23.9
34	No Name Slough	Bayview-Edison Rd	27.0	25.3	24.8	25.7	23.5
36	Edison Slough	W. Bow Hill Rd	30.2	28.3	27.0	29.5	29.0
37	South Edison Pump Station	Farm to Market Rd	25.5	23.3	25.8	26.6	26.7
38	North Edison Pump Station	North Edison Rd	24.4	22.3	20.9	23.8	24.6
39	Colony Creek	Colony Rd	17.4	15.3	20.5	16.1	16.5
40	Big Indian Slough	Bayview-Edison Rd	19.5	18.3	17.7	20.6	17.9
41	Maddox/Big Ditch	Milltown Rd	21.7	21.4	20.8	21.3	21.1
42	Hill Ditch/Carpenter	Cedardale Rd	20.8	20.9	21.2	21.9	21.1
43	Wiley Slough	Wylie Rd	27.2	20.2	19.3	19.2	19.9
44	Sullivan Slough	La Conner-Whitney	18.3	16.7	20.1	14.7	17.7
45	Skagit River – N. Fork	Moore Rd	16.4	17.0	15.6	16.5	16.3
46	Skagit River – S. Fork	Fir Island Rd	16.7	17.0	15.9	16.9	16.6
47	Swinomish Channel	Twin Bridges Launch	16.1	16.2	17.0	16.3	15.7
48	Fisher Creek	Franklin Rd	15.3	14.0	14.0	15.8	15.2
49	Joe Leary Slough	Farm to Market Rd					16.7
50	Joe Leary Slough	Bayview-Edison Rd					20.4
51	Carpenter Creek	East Stackpole Rd					17.0
52	Little Indian Slough	Farm to Market Rd					16.8

Table 9 - Maximum seven-day average of the daily maximum temperatures (Max 7-DADMax) for the past 5 years. This data is from continuous temperature loggers (TidbiTs), with measurements taken every 30 minutes. Cells shaded green pass state standard. There is a 0.2 allowance in the standard for variation in equipment calibration.

Site Number	Watercourse	Location	2018	2019	2020	2021	2022
3	Thomas Creek	Old Hwy 99 North	20.2	n/a	19.9	22.4	22.4*
4	Thomas Creek	F&S Grade Rd	17.0	16.5	16.2	n/a⁺	18.1
6	Friday Creek	Prairie Rd	22.6	21.3	20.0	24.0	22.8
8	Swede Creek	Grip Rd	19.0	17.8	17.4	19.0◊	20.3
11	Samish River	State Route 9	14.8	n/a	15.1	15.6	15.3
12	Nookachamps Creek	Swan Rd	23.5	23.5	21.0*	22.0◊	22.4*
13	E.F. Nookachamps Creek	State Route 9	21.7	n/a	20.7	24.1	23.8
15	Nookachamps Creek	Knapp Rd	23.8	n/a	23.0	27.3	25.4
16	E.F. Nookachamps Creek	Beaver Lake Rd	22.2	20.1	n/a	23.5	n/a⁺
17	Nookachamps Creek	Big Lake Outlet	26.5	n/a	25.6	27.8	27.2
18	Lake Creek	State Route 9	19.5	19.2	18.6	23.1*	20.6
19	Hansen Creek	Hoehn Rd	20.1	19.7	20.3	23.1*	20.2
20	Hansen Creek	Northern State	17.8	n/a	16.5	18.9	n/a⁺
21	Coal Creek	Hoehn Rd	18.6	20.3	17.8	20.8*	18.7
22	Coal Creek	Hwy 20	17.5	16.8	16.7	18.9	19.4
24	Mannser Creek	Lyman Hamilton Hwy	13.7	13.4	14.0	16.8	18.8
30	Skagit River	Cape Horn Rd	n/a	17.1	14.8**	n/a⁺	17.0*
32	Samish River	Thomas Rd	21.2	20.6	n/a	22.1	20.0*
39	Colony Creek	Colony Rd	18.4	17.5	17.4	19.6	19.4
41	Maddox Creek/Big Ditch	Milltown Rd	25.9	25.0	24.4	22.9	27.1
42	Hill Ditch/Carpenter	Cedardale Rd	25.9	24.9	24.6	24.0	24.7◊
45	Skagit River – North Fork	Moore Rd	19.4	n/a	17.2*	n/a⁺	17.4◊
48	Fisher Creek	Franklin Rd	16.8	16.5	16.1	17.2	16.5

*Incomplete dataset, as the TidbiT probe was out of the water for some of the summer measurement period. It is possible that this value could have been higher.

**TidbiT out of water for part of season. Analysis of USGS temperature monitoring station 12200500 near Mount Vernon, in comparison to the incomplete data from SCMP site 30 infers that the actual 7-DADMax likely occurred near 16.0 °C.

⁺ TidbiT data logger was not recovered, or logger was incorrectly programmed.

◊ TidbiT not deployed until later in the season. Compared to timing of the other 7-DADMax's, it is likely the actual max was missed.

Figure 2 – Nineteen-year trends in watercourse temperatures.

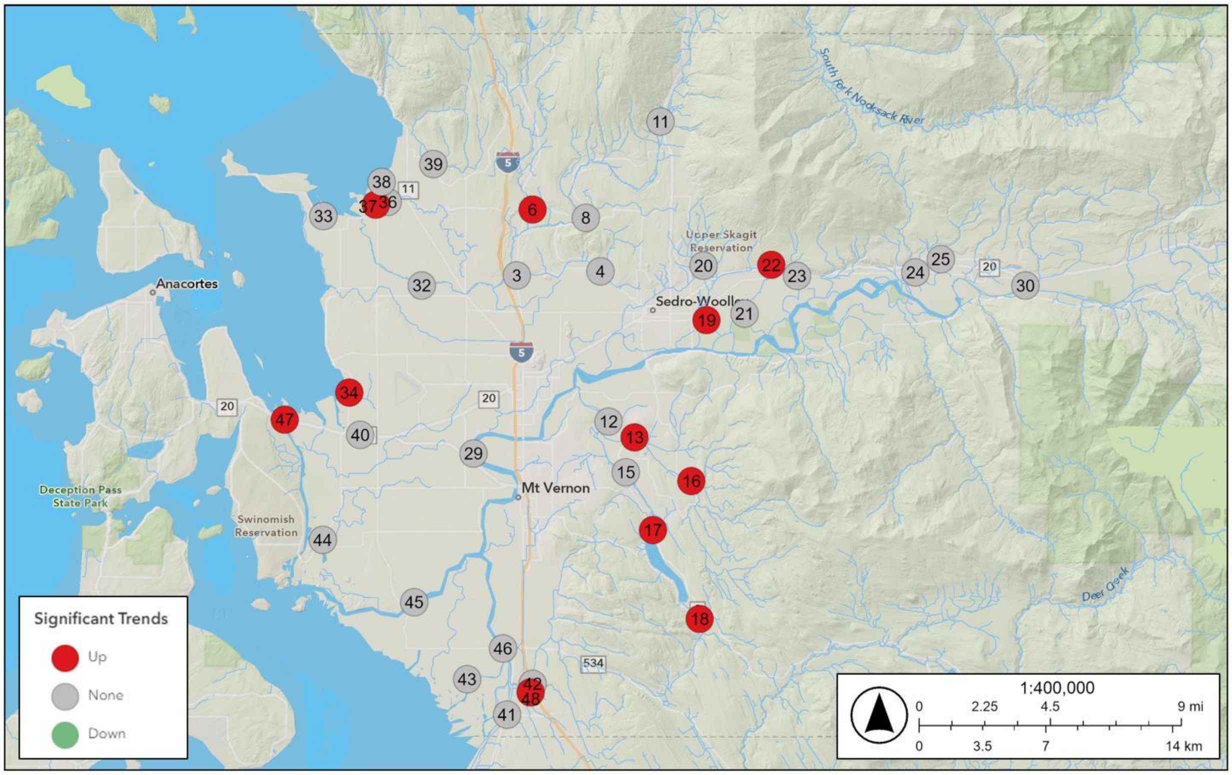


Figure 3 - Ten-year trends in watercourse temperatures.

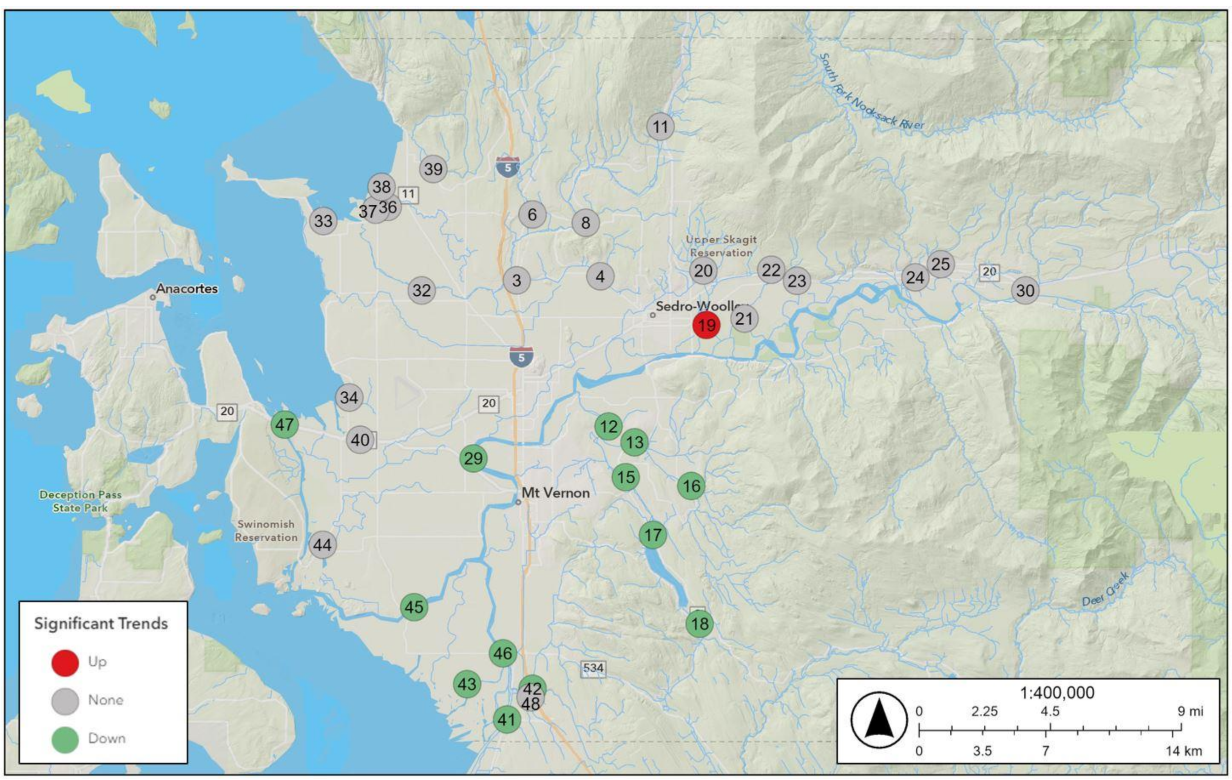
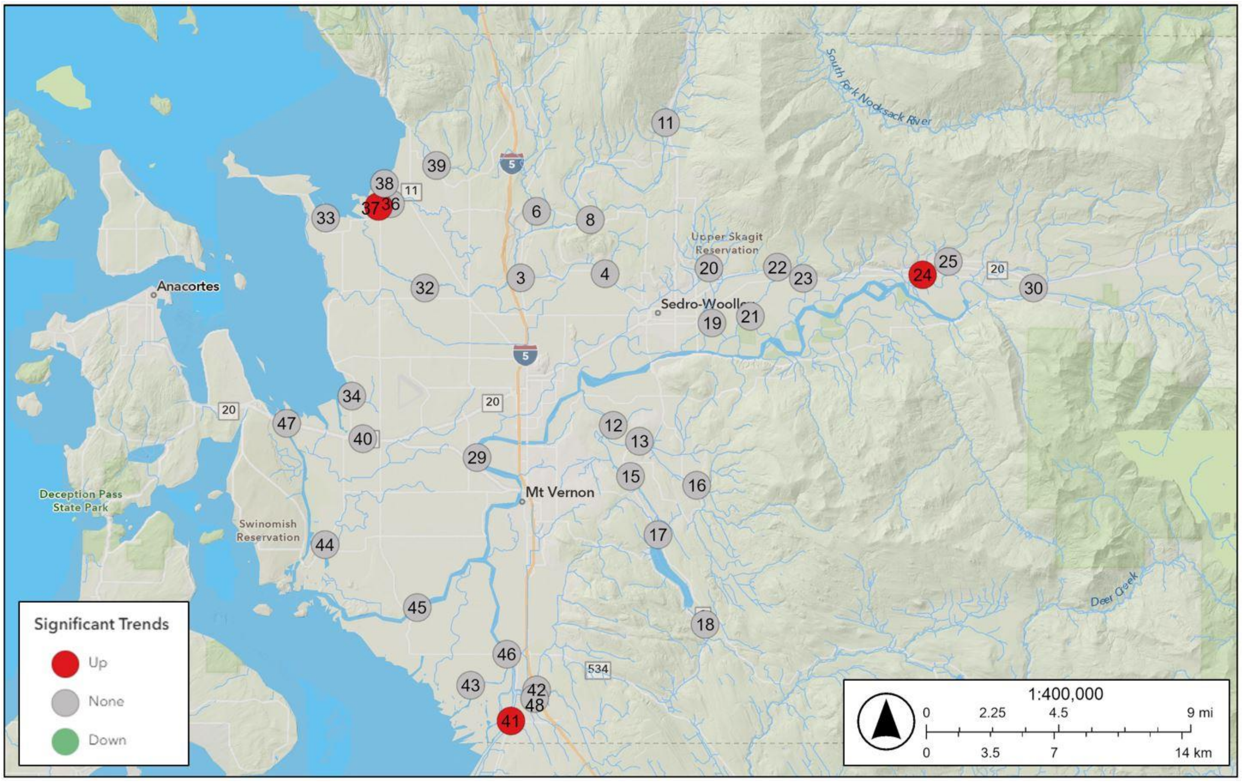


Figure 4 - Five-year trends in watercourse temperatures.



4.4 Dissolved Oxygen (DO)

Dissolved oxygen (DO) measurements determine how much oxygen is available in the water for fish and other organisms. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

Background

In April 2022, the state standards for DO were increased from previous criteria. This increase was based off EPA guidance and the DO requirements for viable salmon eggs and larvae. The state DO water quality standard is based on single-day minimum measurements. The sites categorized as Core Summer Salmon Habitat (Sites 6 - 30, 39, 42, 45, 46, 48, and 51) are now required to have DO concentrations greater than 10 mg/L or a 95% DO saturation level. The sites categorized as Salmon Spawning, Rearing, and Migration (Sites 3 - 4, 32 – 38, 40 – 41, 43 – 44, 49 – 50, and 52) are also required to have DO concentrations greater than 10 mg/L but have a lower DO saturation level of 90%. The state DO standards for marine sites are evaluated on a quality scale, with 6.0 mg/L rated as “excellent”. In this report, the 6.0 mg/L concentration is considered the required standard for Site 37.

Results

A summary of DO readings obtained during the 2022 water year is provided in **Table 10**. A summary of data from the most recent five years of this program can be found in **Table 11**.

Out of the 39 freshwater sites, only one met the updated oxygen standards for the entire 2022 water year (Site 25, Red Cabin Creek). A total of three sites met the oxygen standard based on the average oxygen saturation percentages (Sites 23, 25, 48). In a few streams, oxygen levels show steep declines in summer. These declines are usually associated with very low flows, less velocity, and higher temperatures. The site on Swinomish Channel (Site 47) met the DO standard of 6.0 mg/L.

In the ditches and lower elevation sloughs, DO 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, night-time 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 night-time oxygen reductions. During times when algae blooms are dying off, the decomposition of the dying algae can also lead to very low oxygen levels, both day and night. The results are widely fluctuating DO levels, depending on the state of the algal blooms at sampling time. These fluctuations are very extreme, and data has been recorded from as low as 0% to as high as 300% oxygen saturation.

Trends analysis shows that in the 19 years since the program began, 12 sites have shown an increase in DO levels, while 6 have shown a decrease (**Figure 5**). The sites with significant trends appear to be spread county-wide. In the most recent ten years (**Figure 6**), trends show 18 sites increasing DO levels, while 2 are decreasing. These sites also appear to be spread county-wide. In the most recent five years (**Figure 7**), trends show eight sites decreasing in DO levels. These sites appear to be clustered in the lower Samish, lower Nookachamps, and South Skagit watersheds. The generally increasing DO levels on longer timescales are great news for water quality across the county. Possible contributions could be from lower biological oxygen demand (BOD), which can be a result of a decrease in pollution.

Table 10 - Dissolved oxygen (DO) measurements for 2022 water year. Cells shaded green pass state standard. A margin of error allowance is given at 0.2 mg/L.

Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	State Standard[1]
3	Thomas Creek	Old Hwy 99 N	5.7	0.4	8.0
4	Thomas Creek	F&S Grade Rd	11.2	8.1	8.0
6	Friday Creek	Prairie Rd	11.0	0.2	9.5
8	Swede Creek	Grip Rd	10.7	6.9	9.5
11	Samish River	State Route 9	8.6	5.7	9.5
12	Nookachamps Creek	Swan Rd	8.1	3.6	9.5
13	E.F. Nookachamps Creek	State Route 9	9.1	4.8	9.5
15	Nookachamps Creek	Knapp Rd	8.8	1.3	9.5
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.7	8.9	9.5
17	Nookachamps Creek	Big Lake Outlet	10.5	6.8	9.5
18	Lake Creek	State Route 9	11.6	9.2	9.5
19	Hansen Creek	Hoehn Rd	9.6	0.9	9.5
20	Hansen Creek	Northern State	11.4	9.3	9.5
21	Coal Creek	Hoehn Rd	11.1	7.0	9.5
22	Coal Creek	Hwy 20	12.1	9.6	9.5
23	Wiseman Creek	Minkler Rd	12.0	7.5	9.5
24	Mannser Creek	Lyman Hamilton Hwy	7.1	5.6	9.5
25	Red Cabin Creek	Hamilton Cem. Rd	12.0	10.3	9.5
29	Skagit River	River Bend Rd	11.6	7.5	9.5
30	Skagit River	Cape Horn Rd	11.5	9.4	9.5
32	Samish River	Thomas Rd	10.9	9.1	8.0
33	Alice Bay Pump Station	Samish Island Rd	7.4	1.1	8.0
34	No Name Slough	Bayview-Edison Rd	7.3	0.2	8.0
36	Edison Slough	West Bow Hill Rd	9.0	3.3	8.0
37	South Edison Pump Station	Farm to Market Rd	6.0	0.1	8.0
38	North Edison Pump Station	North Edison Rd	3.9	0.1	8.0
39	Colony Creek	Colony Rd	11.1	7.9	9.5
40	Big Indian Slough	Bayview-Edison Rd	4.3	0.1	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	5.7	3.0	8.0
42	Hill Ditch/Carpenter	Cedardale Rd	7.8	3.7	9.5
43	Wiley Slough	Wylie Rd	4.7	1.6	8.0
44	Sullivan Slough	La Conner-Whitney	5.9	1.1	8.0
45	Skagit River – North Fork	Moore Rd	11.6	9.7	9.5
46	Skagit River – South Fork	Fir Island Rd	11.5	9.5	9.5
47	Swinomish Channel	Twin Bridges Launch	8.7	6.8	6.0
48	Fisher Creek	Franklin Rd	11.5	9.6	9.5
49	Joe Leary Slough	Farm to Market Rd	4.8	2.4	8.0
50	Joe Leary Slough	Bayview-Edison Rd	5.5	0.3	8.0
51	Carpenter Creek	East Stackpole Rd	9.5	2.3	9.5
52	Little Indian Slough	Farm to Market Rd	5.2	0.3	8.0

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

Table 11 - Mean dissolved oxygen (DO) levels for the most recent five years. Cells shaded green pass state standard. A margin of error allowance is given at 0.2 mg/L.

Site Number	Watercourse	Location	Mean Dissolved Oxygen (mg/L)				
			2018	2019	2020	2021	2022
3	Thomas Creek	Old Hwy 99 North	6.1	5.8	6.5	6.8	5.7
4	Thomas Creek	F&S Grade Rd	11.6	11.5	11.4	11.2	11.2
6	Friday Creek	Prairie Rd	11.6	11.6	11.4	11.7	11.0
8	Swede Creek	Grip Rd	10.8	10.7	11.0	10.9	10.7
11	Samish River	State Route 9	9.4	9.0	9.30	9.1	8.6
12	Nookachamps Creek	Swan Rd	9.0	9.4	8.5	9.4	8.1
13	E.F. Nookachamps Creek	State Route 9	10.0	9.6	8.9	9.0	9.1
15	Nookachamps Creek	Knapp Rd	8.6	8.3	8.1	7.6	8.8
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.7	12.0	11.7	11.7	11.7
17	Nookachamps Creek	Big Lake Outlet	10.4	10.2	9.7	10.1	10.5
18	Lake Creek	State Route 9	11.1	11.3	11.3	11.1	11.6
19	Hansen Creek	Hoehn Rd	10.3	10.3	10.3	10.2	9.6
20	Hansen Creek	Northern State	11.6	11.5	11.5	11.5	11.4
21	Coal Creek	Hoehn Rd	11.8	11.6	11.2	11.9	11.1
22	Coal Creek	Hwy 20	12.1	11.8	11.8	12.0	12.1
23	Wiseman Creek	Minkler Rd	12.2	12.2	11.8	12.3	12.0
24	Mannser Creek	Lyman Ham. Hwy	7.9	7.9	7.9	7.5	7.1
25	Red Cabin Creek	Hamilton Cem. Rd	12.2	12.2	11.8	11.9	12.0
29	Skagit River	River Bend Rd	11.4	11.1	11.4	11.3	11.6
30	Skagit River	Cape Horn Rd	11.5	11.3	11.4	11.4	11.5
32	Samish River	Thomas Rd	10.9	11.2	11.3	11.2	10.9
33	Alice Bay Pump Station	Samish Island Rd	11.1	9.2	8.6	8.8	7.4
34	No Name Slough	Bayview-Edison Rd	8.0	7.0	7.4	6.5	7.3
36	Edison Slough	W. Bow Hill Rd	11.2	8.9	8.0	9.7	9.0
37	South Edison Pump Station	Farm to Market Rd	7.9	8.2	4.8	6.6	6.0
38	North Edison Pump Station	North Edison Rd	7.5	7.4	4.0	4.0	3.9
39	Colony Creek	Colony Rd	11.0	11.1	11.0	10.6	11.1
40	Big Indian Slough	Bayview-Edison Rd	5.4	5.1	5.1	5.2	4.3
41	Maddox/Big Ditch	Milltown Rd	7.1	7.4	6.4	5.1	5.7
42	Hill Ditch/Carpenter	Cedardale Rd	8.9	8.5	7.9	7.9	7.8
43	Wiley Slough	Wylie Rd	5.0	4.8	4.1	3.5	4.7
44	Sullivan Slough	La Conner-Whitney	6.3	6.3	7.3	5.4	5.9
45	Skagit River – North Fork	Moore Rd	11.6	11.3	11.5	11.4	11.6
46	Skagit River – South Fork	Fir Island Rd	11.6	11.4	11.6	11.3	11.5
47	Swinomish Channel	Twin Bridges Launch	8.8	8.8	8.7	8.6	8.7
48	Fisher Creek	Franklin Rd	11.4	11.6	11.4	11.4	11.5
49	Joe Leary Slough	Farm to Market Rd					4.8
50	Joe Leary Slough	Bayview-Edison Rd					5.5
51	Carpenter Creek	East Stackpole Rd					9.5
52	Little Indian Slough	Farm to Market Rd					5.2

Figure 5 - Nineteen-year trends in dissolved oxygen (DO).

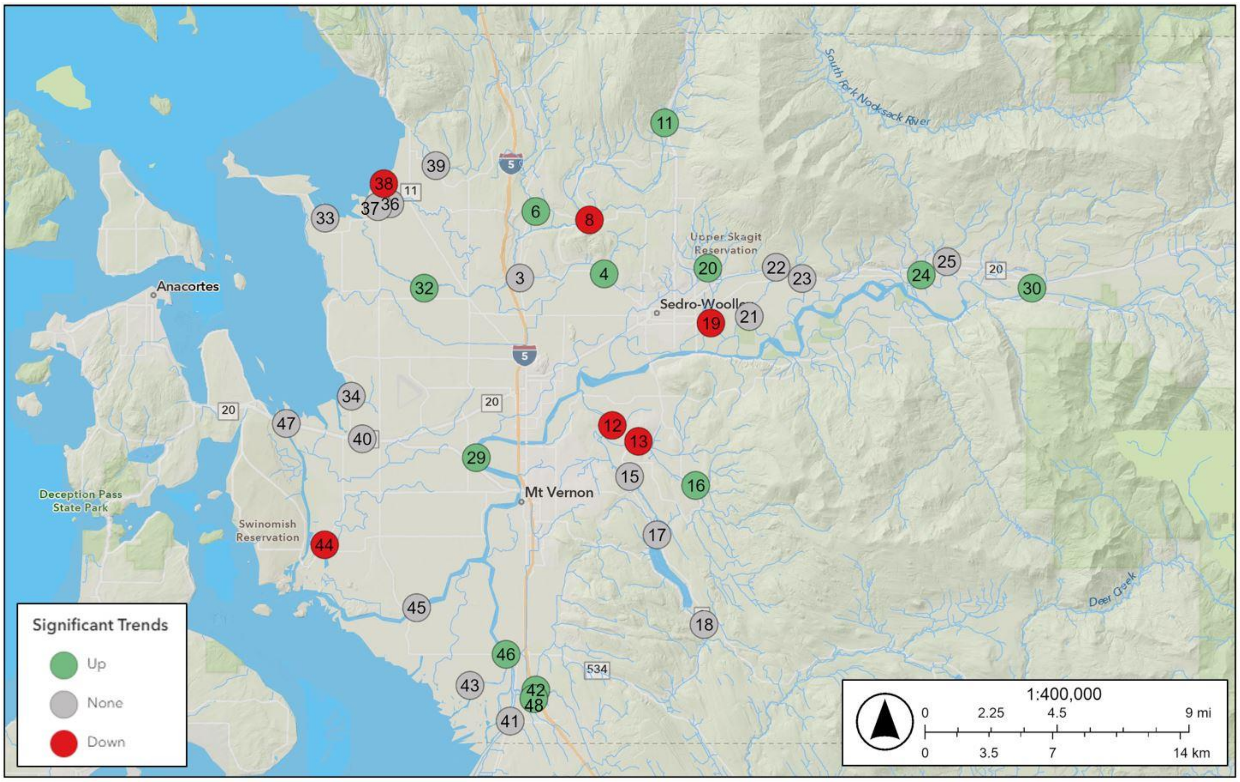


Figure 6 - Ten-year trends in dissolved oxygen (DO).

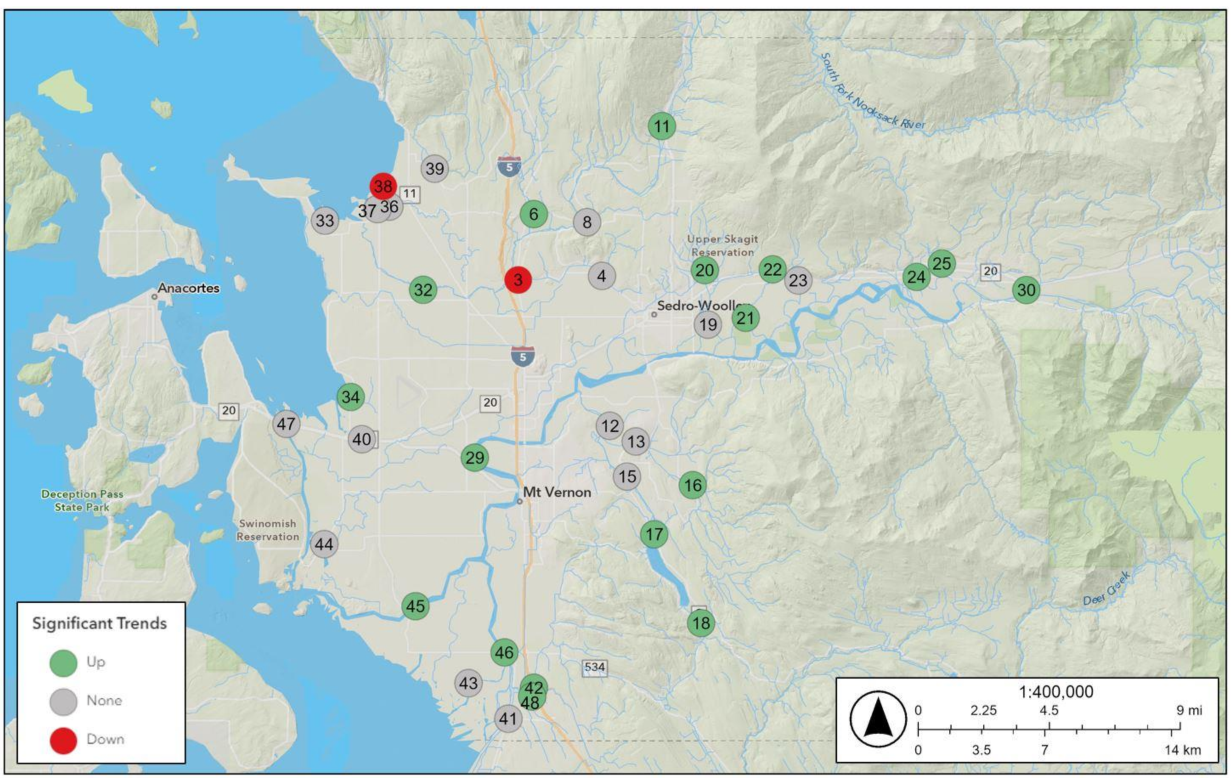
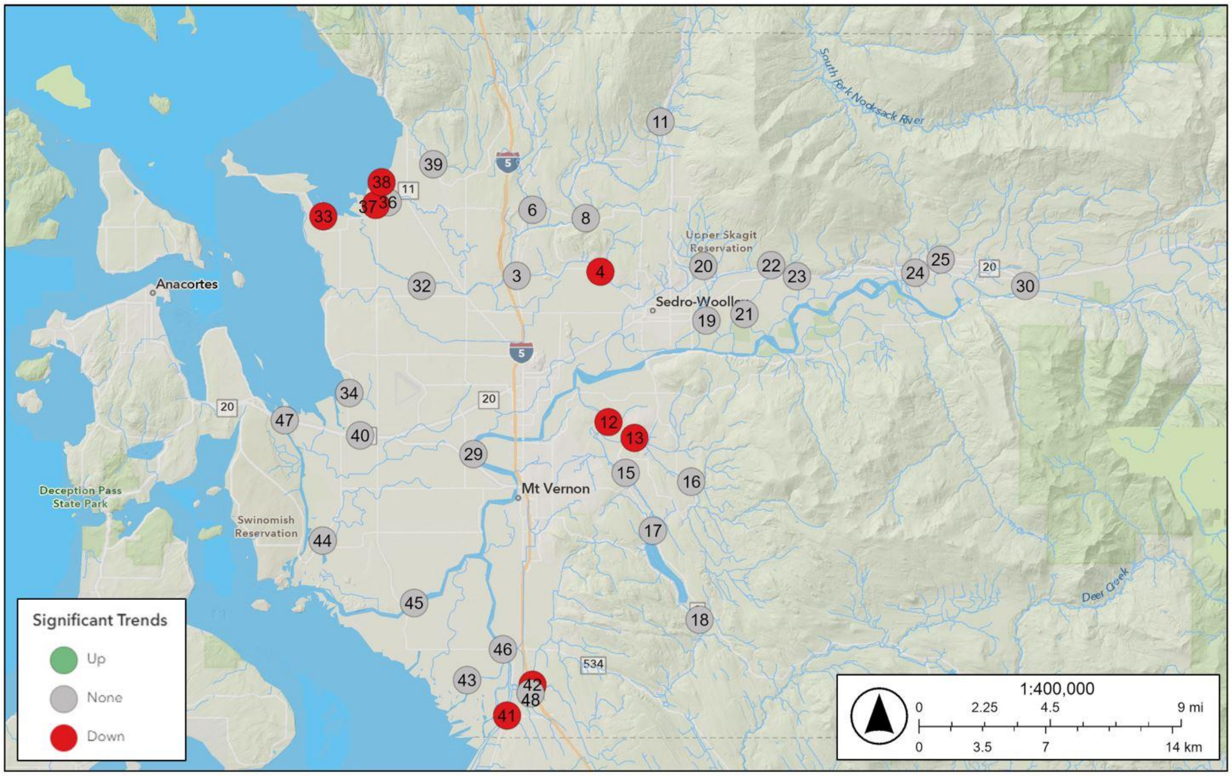


Figure 7 - Five-year trends in dissolved oxygen (DO).



4.5 Fecal Coliform and *Escherichia coli*

Fecal coliform (FC) is a group of bacteria found in the intestines of warm-blooded animals. *Escherichia coli* (EC) is one of the specific bacteria species within that group. Although FC and EC measurements do not directly quantify disease-causing organisms, they serve as an indicator of the possible presence of such bacteria, viruses, and protozoa. The sources of FC and EC organisms reaching the watercourses of Skagit County may include runoff from failing septic tanks, livestock operations, wildlife, recreationists, and pets.

Background

Samples for FC measurements were taken during each site visit and were submitted to the Skagit County Health Department Water Lab (2003-2008) or Edge Analytical (2009-2022) for analysis by the most probable number (MPN) method. Beginning in the 2021 water year, samples submitted to Edge Analytical were also analyzed for EC by the MPN method.

State standards for these bacteria are based on the geometric mean of the samples as well as the percent of the samples that exceed given criteria. Prior to 2020, state standards for recreational water contact of fresh water were set for FC. For most of the watercourses in the SCMP (Sites 3-20, 28-29, 31-46, 48) FC was not to exceed a geometric mean of 100 MPN per 100mL, with no more than 10% of the measurements exceeding 200 MPN per 100 mL. For the upriver sites (Sites 21-25, 30) the standard was a geometric mean of 50 MPN per 100 mL, with no more than 10% of the measurements exceeding 100 MPN per 100 mL. These FC standards expired on December 31, 2020. Primary contact recreation bacteria criteria are now based on EC. For all freshwater sites, EC must not exceed a geometric mean of 100 MPN per 100 mL, with no more than 10% of all samples exceeding 320 MPN per 100 mL. For the marine site (site 47), a more stringent standard of 14 MPN with no more than 10% exceeding 41 MPN is enforced to protect shellfish beds.

The SCMP now collects and reports data for both FC and EC. FC measurements allow for comparison to historic data and assessment of progress on TMDLs that were written based on the now expired FC standards. EC results allow for determination of whether sites are meeting current water quality criteria.

Results

For the 2022 water year, 13 sites met the former FC standard (33% of sites, **Table 12**) compared to 10 sites at the start of the program (25% of sites). Meanwhile, 26 sites met the new EC standard for the 2022 water year (65% of sites, **Table 13**). Water year 2021 had similar results with 24 sites meeting the EC standards (62% of sites). Most sites that did not meet the standards did so due to having more than 10% of samples with FC counts over 200 MPN and/or with EC counts greater than 320 MPN. The sites meeting and exceeding FC standards have been consistent over the past five years (**Table 14**). The new state standards are designed to better indicate when contact with the water may pose a threat to human health and seeing that more sites meet those criteria is a positive sign for assessing Skagit County's water quality.

Trends analysis shows that in the 19 years since the program began, five sites have shown improvement with a significant decline in FC counts, while seven sites have shown deterioration with an increase in FC counts (**Figure 8**). There is a clear clustering of improved sites in the upper Samish Bay watershed, with increased counts in the lower Samish Bay watershed near Edison. Multiple sites in the South Skagit watershed have also seen significant increases in FC counts over the length of the program. In the most recent ten years, two sites have shown improvement, while four sites have shown deterioration (**Figure 9**). In the most recent five years, four sites have shown significantly increased FC counts (**Figure 10**).

While some sites have seen improvements in fecal coliform concentrations through ambient monitoring, water quality during storm events remains problematic. Storm sampling events in the Samish Basin associated with the CSI continue to show excessive fecal coliform concentrations at some sites.

Table 12 - Fecal coliform (FC) results (MPN/100mL) for 2022 water year. Cells shaded green pass former state standard.[1]

Site Number	Watercourse	Location	n	Geometric mean (MPN)[1]	Percentage > 100 or 200 MPN[1]
3	Thomas Creek	Old Hwy 99 N	24	63	21
4	Thomas Creek	F&S Grade Rd	23	220	57
6	Friday Creek	Prairie Rd	24	38	8
8	Swede Creek	Grip Rd	24	46	17
11	Samish River	State Route 9	24	18	0
12	Nookachamps Creek	Swan Rd	26	43	0
13	E.F. Nookachamps Creek	State Route 9	26	43	8
15	Nookachamps Creek	Knapp Rd	26	54	4
16	E.F. Nookachamps Creek	Beaver Lake Rd	26	28	4
17	Nookachamps Creek	Big Lake Outlet	26	12	0
18	Lake Creek	State Route 9	21	23	15
19	Hansen Creek	Hoehn Rd	24	84	14
20	Hansen Creek	Northern State	21	54	8
21	Coal Creek	Hoehn Rd	24	100	48
22	Coal Creek	Hwy 20	22	12	13
23	Wiseman Creek	Minkler Rd	23	17	23
24	Mannser Creek	Lyman Hamilton Hwy	20	23	4
25	Red Cabin Creek	Hamilton Cemetery Rd	26	11	10
29	Skagit River	River Bend Rd	24	12	12
30	Skagit River	Cape Horn Rd	24	6	0
32	Samish River	Thomas Rd	26	58	8
33	Alice Bay Pump Station	Samish Island Rd	24	56	17
34	No Name Slough	Bayview-Edison Rd	24	61	23
36	Edison Slough	W. Bow Hill Rd	24	172	54
37	South Edison Pump Station	Farm to Market Rd	26	196	54
38	North Edison Pump Station	North Edison Rd	26	155	46
39	Colony Creek	Colony Rd	25	67	29
40	Big Indian Slough	Bayview-Edison Rd	26	281	54
41	Maddox/Big Ditch	Milltown Rd	26	79	19
42	Hill Ditch/Carpenter	Cedardale Rd	26	107	28
43	Wiley Slough	Wylie Rd	25	114	27
44	Sullivan Slough	La Conner-Whitney Rd	26	101	35
45	Skagit River – North Fork	Moore Rd	26	7	0
46	Skagit River – South Fork	Fir Island Rd	24	8	0
47	Swinomish Channel	Twin Bridges Launch	26	9	38
48	Fisher Creek	Franklin Rd	26	77	27
49	Joe Leary Slough	Farm to Market Rd	23	85	25
50	Joe Leary Slough	Bayview-Edison Rd	24	126	38
51	Carpenter Creek	East Stackpole Rd	23	127	38
52	Little Indian Slough	Farm to Market Rd	24	419	65

[1] Former state water quality standards for fecal coliform required waterbodies to have a geometric mean of less than 50 (Sites 21-25, 30) or 100 (Sites 3-20, 28-29, 31-46, 48 - 51) Most Probable Number (MPN) per 100 mL with less than 10% of the samples greater than 100 (sites 21-25, 30) or 200 MPN (sites 3-20,28-29, 31-46, 48 - 51). Marine locations (Site 47) are required to be < 14 MPN with no more than 10% > 14 MPN.

Table 13 – *E. coli* (EC) results (MPN/100 mL) for 2022 water year. Cells shaded green pass the current state standard.[1]

Site Number	Watercourse	Location	n	Geometric mean (MPN / 100 mL)	Percentage > 320 MPN / 100 mL
3	Thomas Creek	Old Hwy 99 N	24	38	13
4	Thomas Creek	F&S Grade Rd	23	138	35
6	Friday Creek	Prairie Rd	24	23	0
8	Swede Creek	Grip Rd	24	37	8
11	Samish River	State Route 9	24	15	0
12	Nookachamps Creek	Swan Rd	26	33	0
13	E.F. Nookachamps Creek	State Route 9	26	29	0
15	Nookachamps Creek	Knapp Rd	26	38	0
16	E.F. Nookachamps Creek	Beaver Lake Rd	26	21	4
17	Nookachamps Creek	Big Lake Outlet	26	8	0
18	Lake Creek	State Route 9	21	15	4
19	Hansen Creek	Hoehn Rd	24	67	10
20	Hansen Creek	Northern State	21	33	8
21	Coal Creek	Hoehn Rd	24	76	29
22	Coal Creek	Hwy 20	22	11	0
23	Wiseman Creek	Minkler Rd	23	15	14
24	Mannser Creek	Lyman Hamilton Hwy	20	20	4
25	Red Cabin Creek	Hamilton Cemetery Rd	26	10	0
29	Skagit River	River Bend Rd	24	9	12
30	Skagit River	Cape Horn Rd	24	4	0
32	Samish River	Thomas Rd	26	49	4
33	Alice Bay Pump Station	Samish Island Rd	24	21	0
34	No Name Slough	Bayview-Edison Rd	24	27	8
36	Edison Slough	W. Bow Hill Rd	24	93	17
37	South Edison Pump Station	Farm to Market Rd	26	108	21
38	North Edison Pump Station	North Edison Rd	26	86	25
39	Colony Creek	Colony Rd	25	46	25
40	Big Indian Slough	Bayview-Edison Rd	26	39	12
41	Maddox/Big Ditch	Milltown Rd	26	46	12
42	Hill Ditch/Carpenter	Cedardale Rd	26	61	4
43	Wiley Slough	Wylie Rd	25	68	8
44	Sullivan Slough	La Conner-Whitney Rd	26	50	8
45	Skagit River – North Fork	Moore Rd	26	4	0
46	Skagit River – South Fork	Fir Island Rd	24	5	0
47	Swinomish Channel	Twin Bridges Launch	24	6	0
48	Fisher Creek	Franklin Rd	26	34	4
49	Joe Leary Slough	Farm to Market Rd	23	43	4
50	Joe Leary Slough	Bayview-Edison Rd	24	67	8
51	Carpenter Creek	East Stackpole Rd	23	58	12
52	Little Indian Slough	Farm to Market Rd	24	144	39

[1] State water quality standards for *E. coli* require waterbodies to have a geometric mean of less than 100 Most Probable Number (MPN) per 100 mL and less than 10% of the samples are greater than 320 MPN per 100 mL. Marine locations (site 47) are required to be less than 14 MPN with no more than 10% greater than 14 MPN.

Table 14 - Geometric mean FC results for most recent five years (MPN/100 mL). Cells shaded green pass state geometric mean standard.

Site Number	Watercourse	Location	2018	2019	2020	2021	2022
3	Thomas Creek	Old Hwy 99 N	47	50	37	64	63
4	Thomas Creek	F&S Grade Rd	138	131	94	169	220
6	Friday Creek	Prairie Rd	39	28	26	29	38
8	Swede Creek	Grip Rd	53	29	54	51	46
11	Samish River	State Route 9	12	11	15	23	18
12	Nookachamps Creek	Swan Rd	56	45	56	77	43
13	E.F. Nookachamps Creek	State Route 9	22	38	42	51	43
15	Nookachamps Creek	Knapp Rd	63	64	50	57	54
16	E.F. Nookachamps Creek	Beaver Lake Rd	22	22	19	37	28
17	Nookachamps Creek	Big Lake Outlet	14	17	10	22	12
18	Lake Creek	State Route 9	26	41	39	51	23
19	Hansen Creek	Hoehn Rd	57	62	29	65	84
20	Hansen Creek	Northern State	48	37	45	60	54
21	Coal Creek	Hoehn Rd	65	63	49	90	100
22	Coal Creek	Hwy 20	13	11	7	9	12
23	Wiseman Creek	Minkler Rd	18	10	14	17	17
24	Mannser Creek	Lyman Hamilton Hwy	13	14	12	19	23
25	Red Cabin Creek	Hamilton Cemetery Rd	5	6	10	7	11
29	Skagit River	River Bend Rd	9	7	9	13	12
30	Skagit River	Cape Horn Rd	5	4	4	4	6
32	Samish River	Thomas Rd	41	58	55	41	58
33	Alice Bay Pump Station	Samish Island Rd	24	33	42	63	56
34	No Name Slough	Bayview-Edison Rd	59	48	88	113	61
36	Edison Slough	W. Bow Hill Rd	56	49	106	68	172
37	South Edison Pump Station	Farm to Market Rd	214	188	291	154	196
38	North Edison Pump Station	North Edison Rd	148	113	127	198	155
39	Colony Creek	Colony Rd	61	58	36	55	67
40	Big Indian Slough	Bayview-Edison Rd	81	47	92	125	281
41	Maddox Slough/Big Ditch	Milltown Rd	52	46	64	85	79
42	Hill Ditch/Carpenter	Cedardale Rd	51	48	111	121	107
43	Wiley Slough	Wylie Rd	82	74	56	112	114
44	Sullivan Slough	La Conner-Whitney Rd	67	45	107	123	101
45	Skagit River – North Fork	Moore Rd	8	4	6	9	7
46	Skagit River – South Fork	Fir Island Rd	13	9	11	13	8
47	Swinomish Channel	Twin Bridges Launch	6	4	7	6	9
48	Fisher Creek	Franklin Rd	78	56	60	82	77
49	Joe Leary Slough	Farm to Market Rd					85
50	Joe Leary Slough	Bayview-Edison Rd					126
51	Carpenter Creek	East Stackpole Rd					127
52	Little Indian Slough	Farm to Market Rd					419

Figure 8 - Nineteen-year trends in fecal coliform (FC).

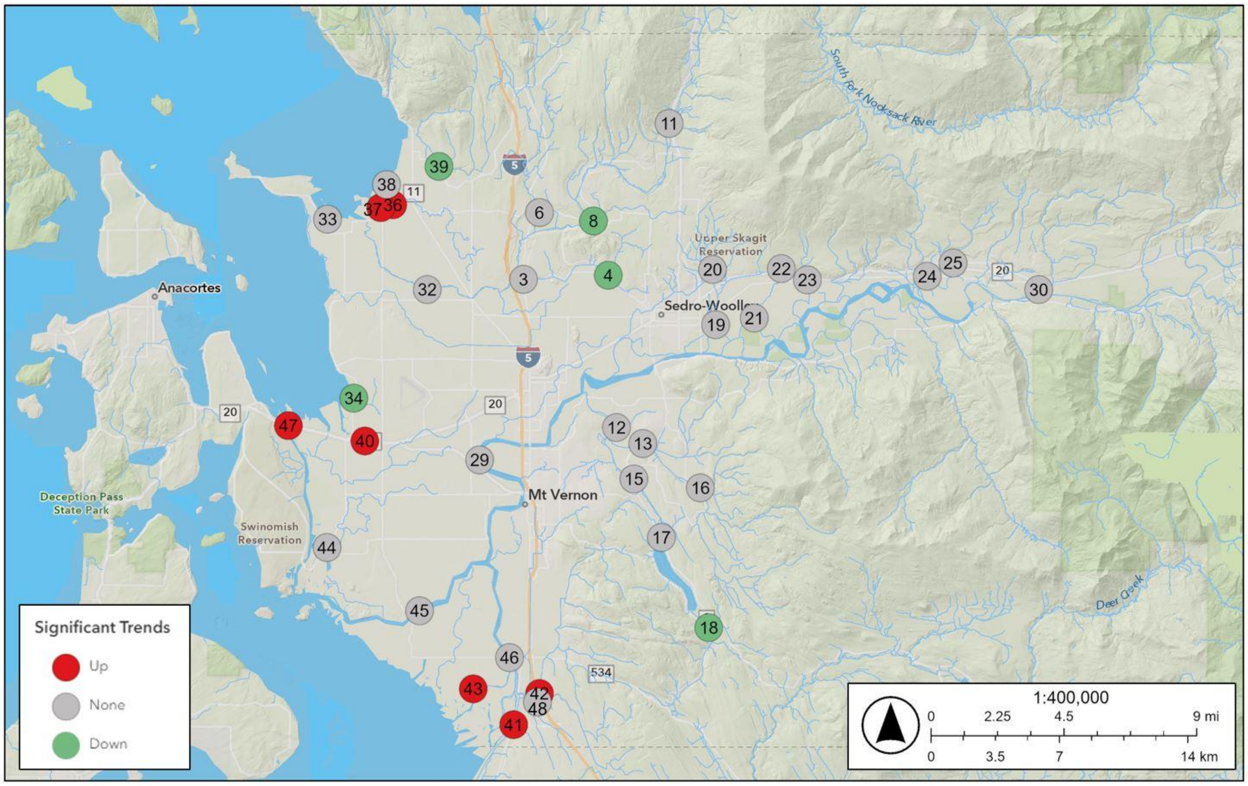


Figure 9 - Ten-year trends in fecal coliform (FC).

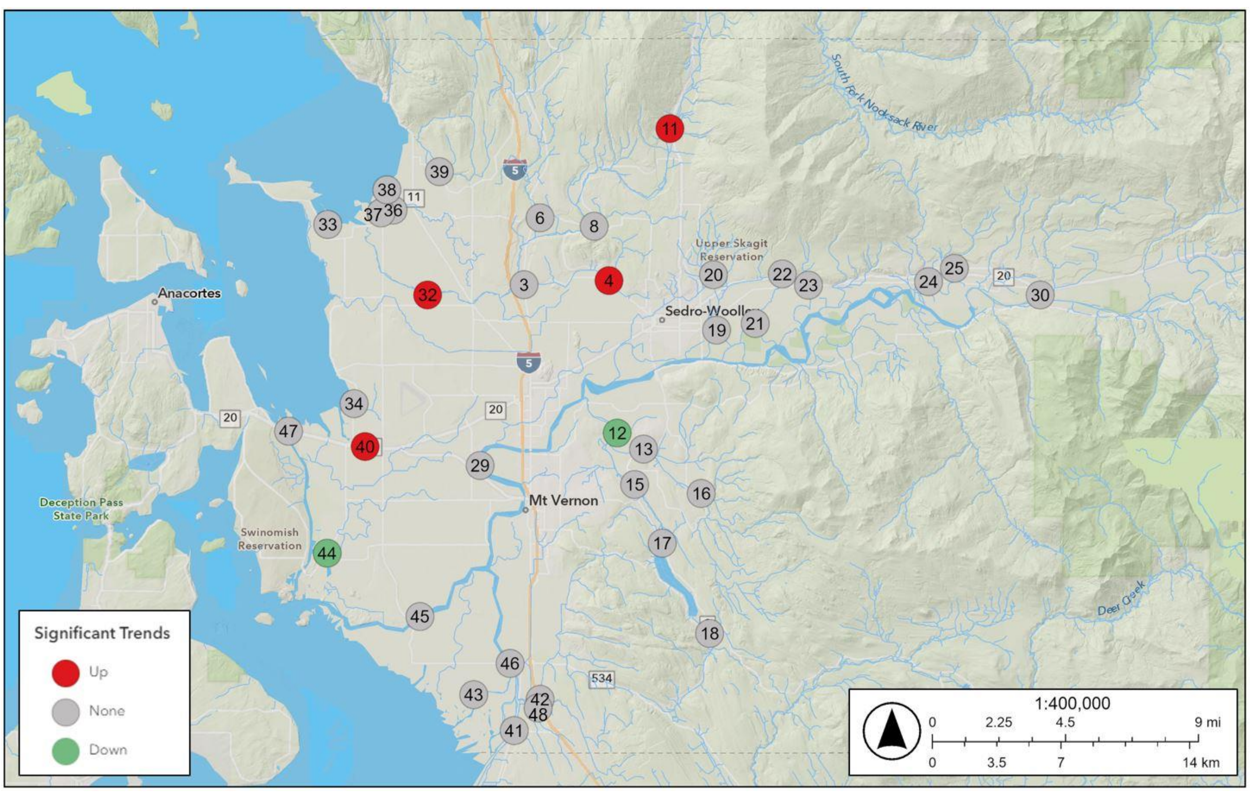
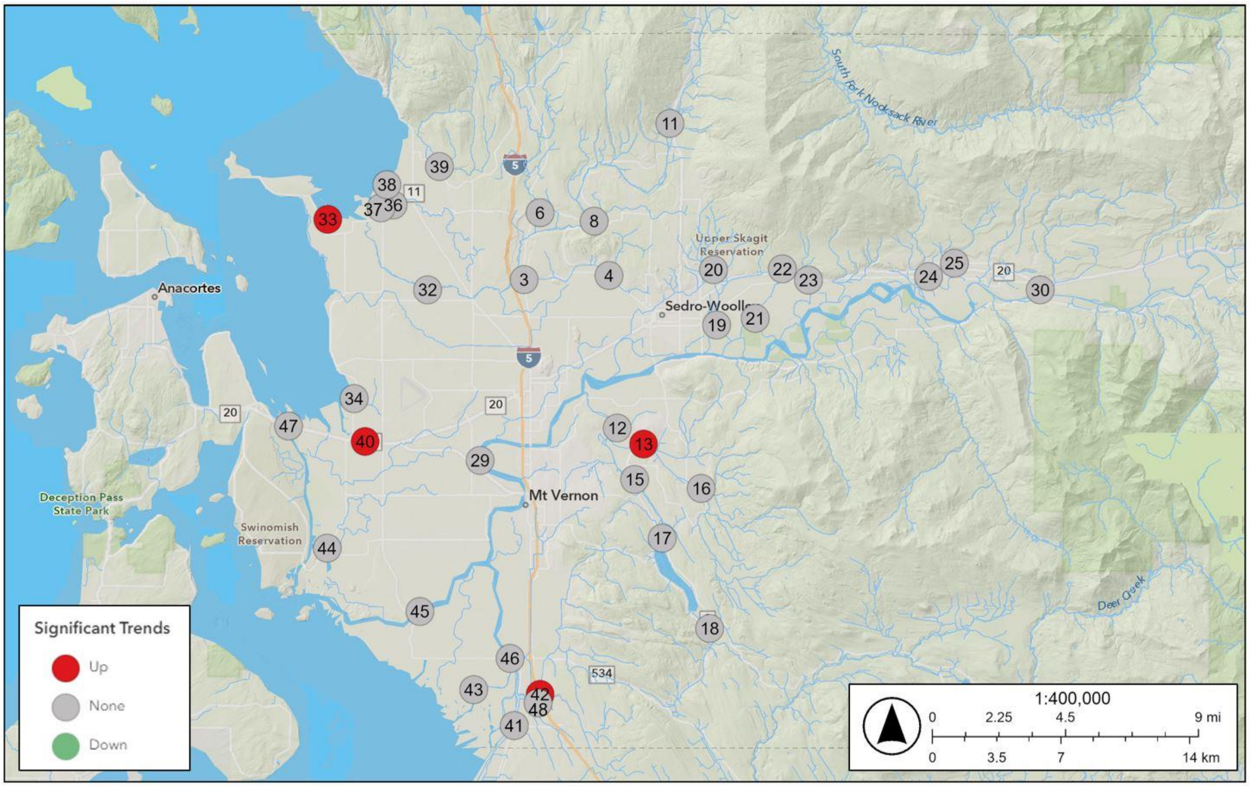


Figure 10 - Five-year trends in fecal coliform (FC).



4.6 Nutrients

Nutrients, like phosphorus and nitrogen, are essential for plant and animal growth, but an abundance of them can lead to negative consequences. Both nitrogen and phosphorus are fertilizers used in agriculture that can run-off into our waterways. Excessive nutrient levels can lead to large blooms of algae which can increase DO levels during the day when algae are photosynthesizing and large decreases in DO at night when the algae are respiring. DO also decreases when the algae die and decompose. Nutrients from freshwater sources discharged into Puget Sound can contribute to marine algal blooms and hypoxic conditions there as well. Algal blooms can become harmful to recreationists when there are cyanobacteria present, which make ingestion of the water toxic to humans and their pets.

Background

Nutrients were sampled monthly from the beginning of the program in water year 2004 up until water year 2008. After the close of the grant from Ecology, maintaining monthly sampling of all nutrients was deemed too cost-prohibitive for the ongoing project budget. Quarterly sampling began at that time to allow for trend determinations in four seasons, rather than twelve.

Nitrogen is a nutrient that can be found in various forms in our waterways. Ammonia (NH_3), nitrate (NO_3^-), and nitrite (NO_2^-) are the three inorganic forms. Total Kjeldahl Nitrogen (TKN) is a measure of the organic forms of nitrogen found in molecules added with the amount ammonia. Phosphorus is commonly found in the inorganic form of orthophosphate (PO_4^{3-}) in the water. The measurement of total phosphorus (TP) combines both the organic and inorganic forms of phosphorus in one measurement. Nitrogen is often a "limiting nutrient" for marine algae, which means that when an excess of nitrogen shows up in the water in the right temperature and sunlight conditions, it often leads to algae blooms. In freshwater, phosphorous is commonly the limiting nutrient for algae. There are currently no numeric state standards for nutrients as factors in algal blooms.

Results

Water samples for nutrients measurements were taken at each site on a quarterly basis. A large caveat with only quarterly samples is that the trends results are determined by a single sample on one day of an entire three-month period. While imperfect, this is still valuable for identifying and analyzing possible trends. If the conditions of the watercourses sampled were truly random with too great of an intermittence (3 months) to have value, then running a trends analysis should show no discernible trend in the data. Any direction of the data would be determined as non-existent or non-significant. The analyses returning a large number of significant trends, even with incredibly small slopes (e.g., parts per billion per year), show that this sampling remains valuable at the three-month interval.

Some of these trends are statistically significant even though the actual change in nutrient levels observed in the watercourse is incredibly small. When interpreting data, it is important to take into consideration the actual change over time of that nutrient in the watercourse, as is provided in the tables in **Appendix C**. For example, over the nineteen-year course of this program, a nutrient at a site may have increased by half of a milligram per liter (part per million), or at a different site it may have increased by one microgram per liter (part per billion), or less. Despite this, both analyses could show statistically significant increases in this nutrient on a map.

Table 15 gives mean nutrient values for selected parameters for the 2022 water year. All nutrient values are included in **Appendix A**, with summary statistics found in **Appendix B**, and trends analyses in **Appendix C**.

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

The following trends analyses were performed only on the 19-year dataset, representing the entire length of this program's monitoring. The significant nutrient trends have a combined total of 35 decreasing trends (less nutrients) and 24 increasing trends (more nutrients), with 22 of those being phosphorous. Total Phosphorous shows a significant increase at ten sites across the County (**Figure 11**). Orthophosphate had 12 sites that display a significant increase (**Figure 12**). No sites had significant decreases in total phosphorus or orthophosphate.

Total Kjeldahl Nitrogen shows a decrease at seven sites, and an increase at no sites, with no obvious clustering pattern (**Figure 13**). Ammonia levels have gone down at 16 sites around the county with no sites showing an increasing trend. These significant decreases are observed throughout the County (**Figure 14**). Nitrate + Nitrite levels have decreased at 12 sites spread across the county and have increased at only two sites. The two sites that increased concentrations are marine or marine-influenced (**Figure 15**).

Overall, phosphorus (total and orthophosphate) nutrients are increasing in many of the ditches and slower moving waterways throughout the County. These increases may potentially lead to additional algae blooms and the subsequent problems with oxygen levels.

Table 15 - Mean nutrient values (mg/L) for 2022 water year.

Site Number	Watercourse	Location	Total Phosphorus	Total Kjeldahl Nitrogen[1]	Ammonia	Nitrate + Nitrite
3	Thomas Creek	Old Hwy 99 N	0.11	0.25	0.12	0.29
4	Thomas Creek	F&S Grade Rd	0.05	0.25	0.02	0.78
6	Friday Creek	Prairie Rd	0.02	0.21	0.01	0.27
8	Swede Creek	Grip Rd	0.04	0.31	0.01	0.25
11	Samish River	State Route 9	0.02	0.12	0.02	0.20
12	Nookachamps Creek	Swan Rd	0.06	0.19	0.04	0.18
13	E.F. Nookachamps Creek	State Route 9	0.03	0.15	0.02	0.20
15	Nookachamps Creek	Knapp Rd	0.07	0.14	0.02	0.23
16	E.F. Nookachamps Creek	Beaver Lake Rd	0.09	0.18	0.06	0.19
17	Nookachamps Creek	Big Lake Outlet	0.05	0.14	0.02	0.20
18	Lake Creek	State Route 9	0.02	0.25	0.01	0.32
19	Hansen Creek	Hoehn Rd	0.04	0.25	0.03	0.28
20	Hansen Creek	Northern State	0.03	0.30	0.01	0.31
21	Coal Creek	Hoehn Rd	0.03	2.81	0.02	0.49
22	Coal Creek	Hwy 20	0.03	1.22	0.01	0.48
23	Wiseman Creek	Minkler Rd	0.02	0.72	0.01	0.67
24	Mannser Creek	Lyman Hamilton Hwy	0.03	2.13	0.01	0.22
25	Red Cabin Creek	Hamilton Cem. Rd	0.01	2.91	0.01	0.50
29	Skagit River	River Bend Rd	0.03	0.30	0.01	0.06
30	Skagit River	Cape Horn Rd	0.03	0.79	0.01	0.07
32	Samish River	Thomas Rd	0.05	0.98	0.04	0.41
33	Alice Bay Pump Station	Samish Island Rd	0.68	0.38	1.02	0.66
34	No Name Slough	Bayview-Edison Rd	0.58	1.90	0.02	0.09
36	Edison Slough	W. Bow Hill Rd	0.20	1.43	0.02	0.27
37	South Edison Pump Station	Farm to Market Rd	0.91	0.21	0.82	0.32
38	North Edison Pump Station	North Edison Rd	0.99	0.25	1.02	0.84
39	Colony Creek	Colony Rd	0.08	0.12	0.01	0.59
40	Big Indian Slough	Bayview-Edison Rd	0.18	0.54	0.21	0.41
41	Maddox/Big Ditch	Milltown Rd	0.24	1.32	0.21	0.67
42	Hill Ditch/Carpenter	Cedardale Rd	0.05	0.99	0.08	0.37
43	Wiley Slough	Wylie Rd	0.24	0.43	0.56	0.65
44	Sullivan Slough	La Conner-Whitney	0.29	2.30	0.67	0.67
45	Skagit River – North Fork	Moore Rd	0.03	0.25	0.01	0.06
46	Skagit River – South Fork	Fir Island Rd	0.03	0.25	0.01	0.06
47	Swinomish Channel	Twin Bridges Launch	0.08	0.21	0.04	0.18
48	Fisher Creek	Franklin Rd	0.18	0.31	0.02	0.41
49	Joe Leary Slough	Farm to Market Rd	0.32	0.12	0.66	0.86
50	Joe Leary Slough	Bayview-Edison Rd	0.21	0.19	0.34	1.05
51	Carpenter Creek	East Stackpole Rd	0.04	0.15	0.02	0.50
52	Little Indian Slough	Farm to Market Rd	0.39	0.14	0.41	0.20

Figure 11 - Nineteen-year trends in Total Phosphorous (TP).

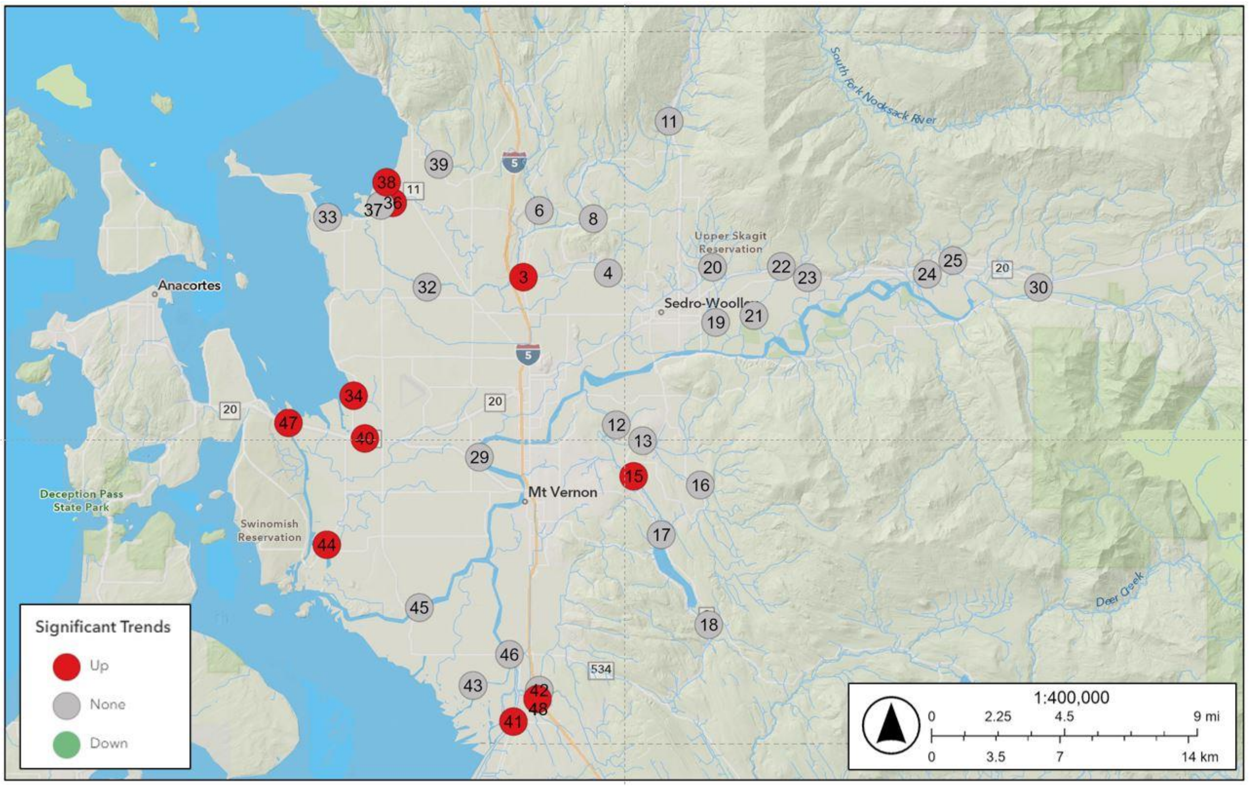


Figure 12 - Nineteen-year trends in Orthophosphate (OP).

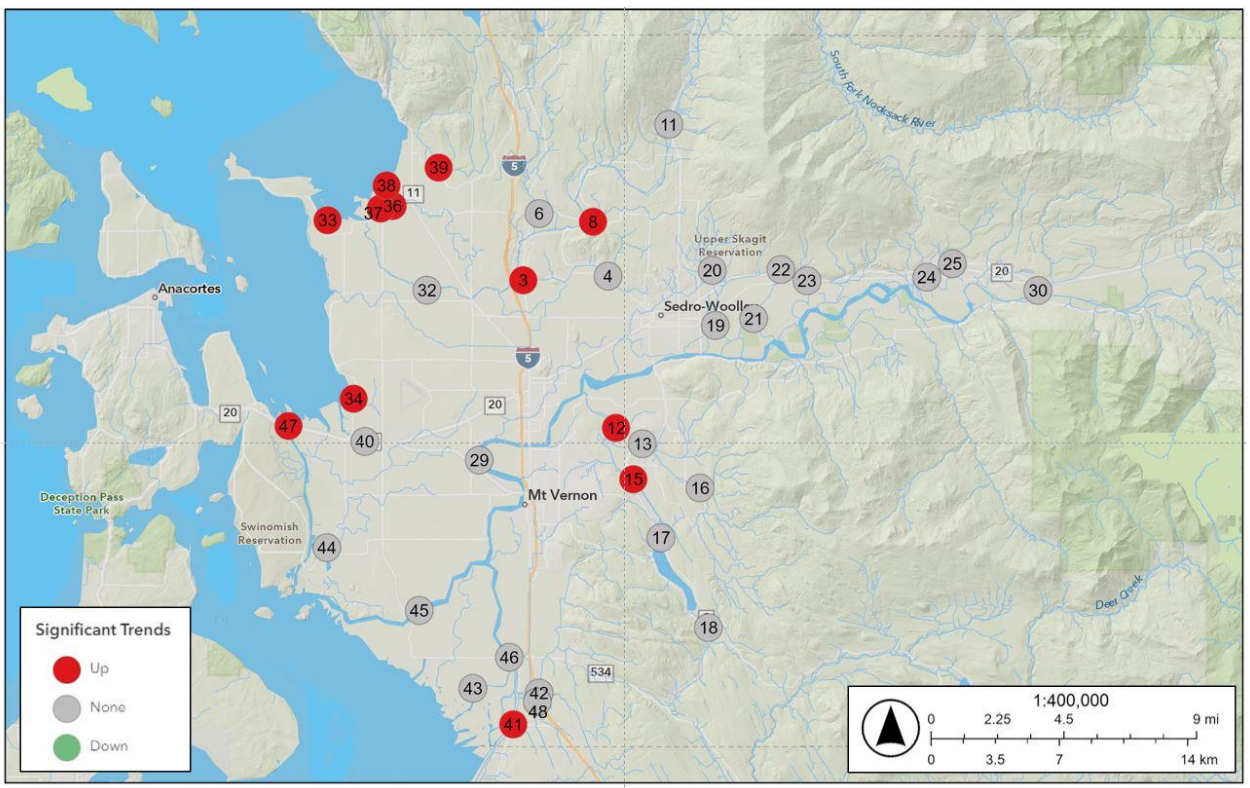


Figure 13 - Nineteen-year trends in Total Kjeldahl Nitrogen (TKN).

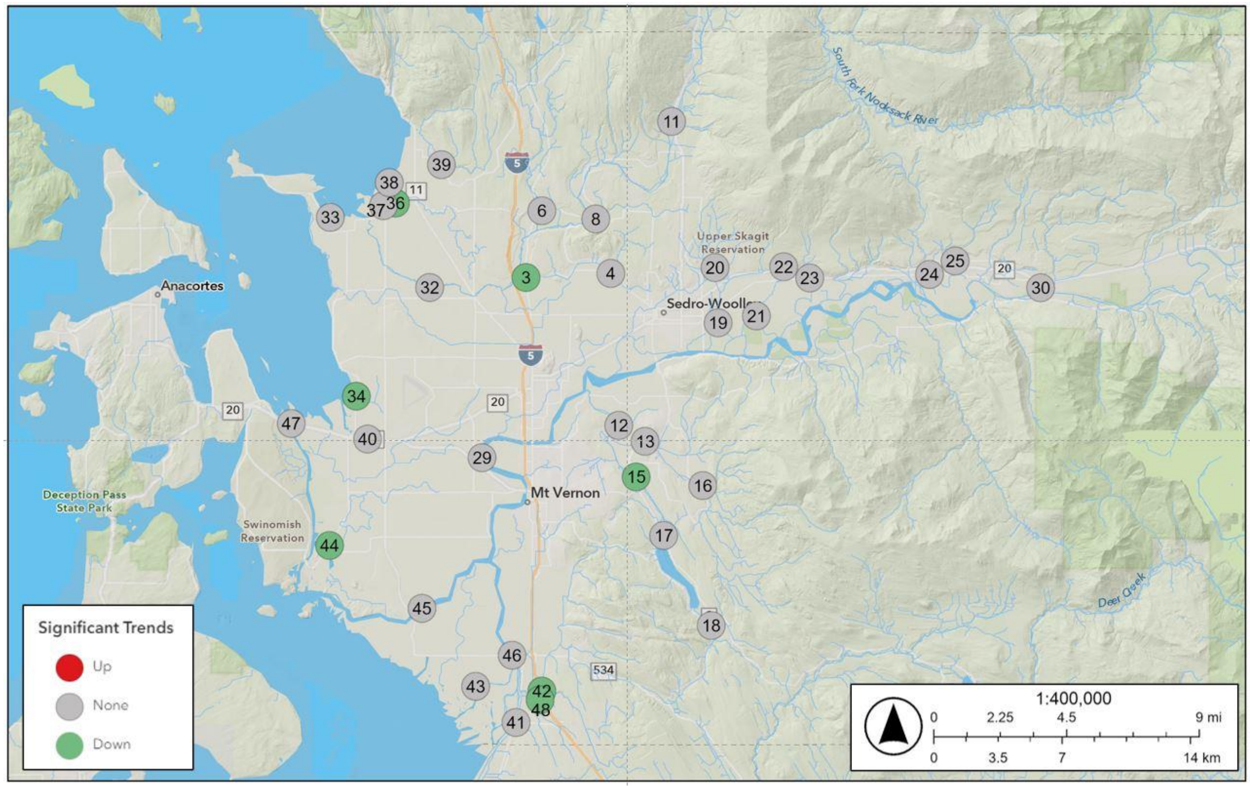


Figure 14 - Nineteen-year trends in Ammonia (NH_3)

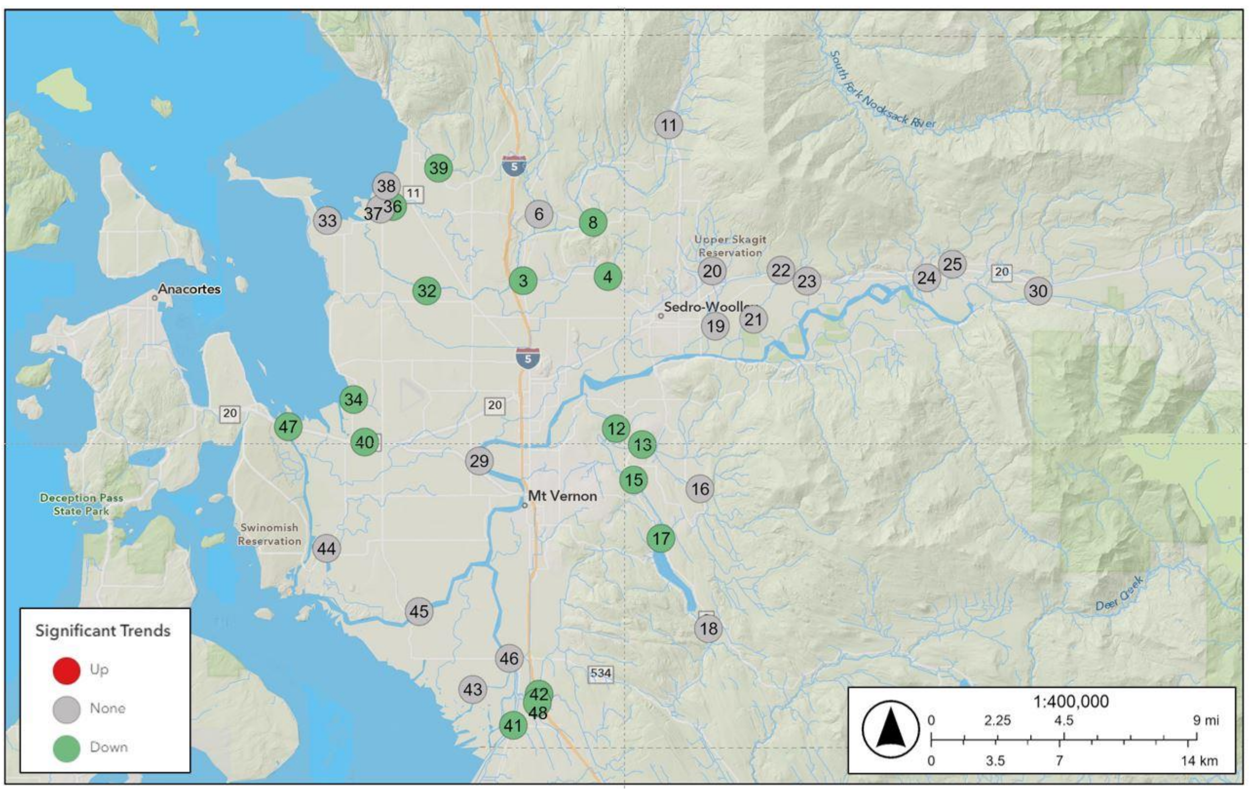
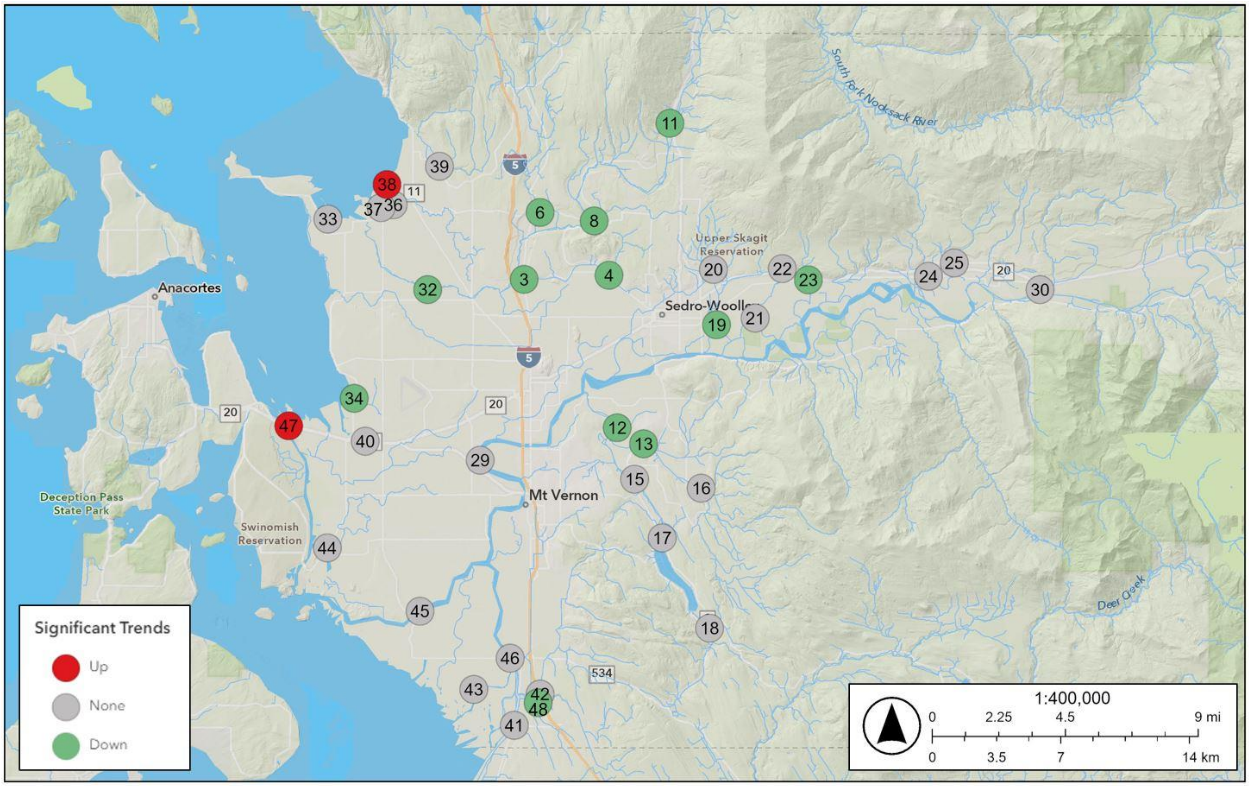


Figure 15 - Nineteen-year trends in Nitrate and Nitrite ($NO_3 + NO_2$)

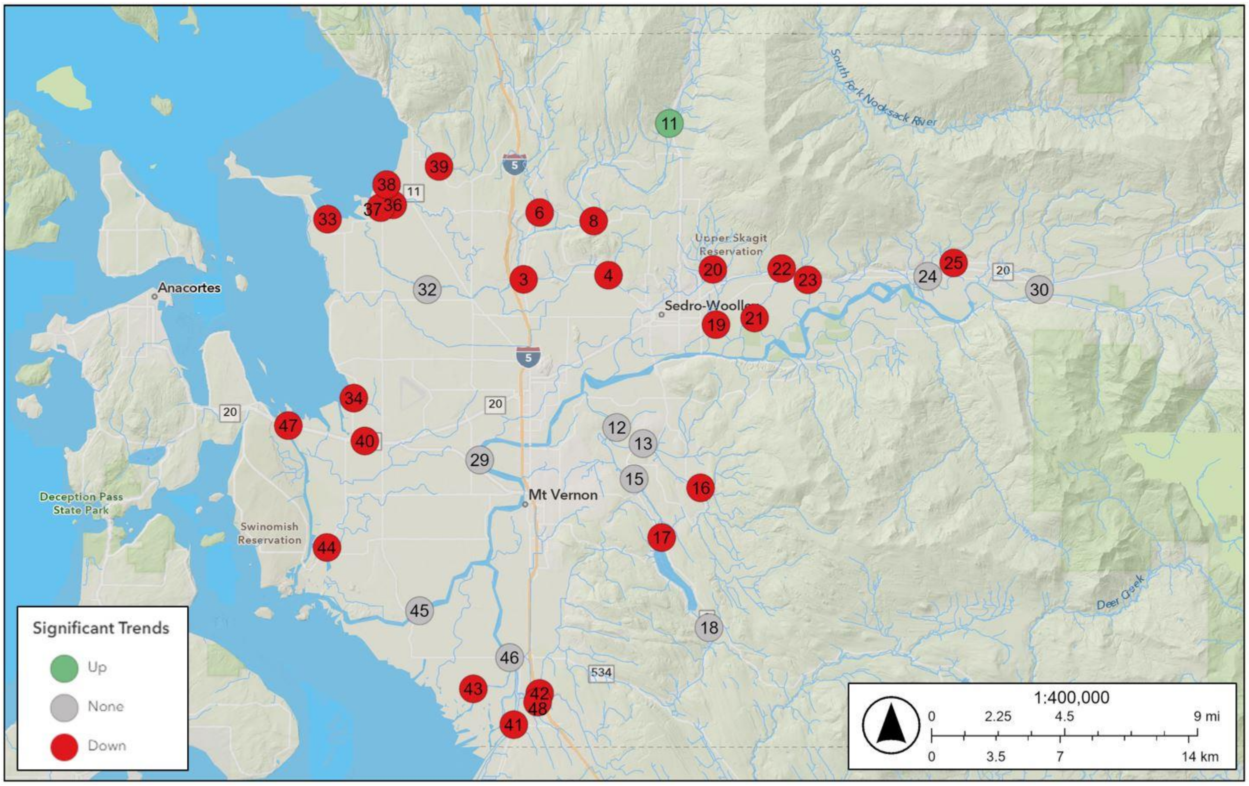


4.7 pH

The SCMP also measures pH during each visit to a site. Measurement of pH shows whether a watercourse is within the range that supports aquatic life. In general, pH in the SCMP has been within state pH standards of 6.5 to 8.5.

Nineteen-year trends analysis on pH across Skagit County revealed 26 sites with significantly decreasing pH and only one site with an increase (**Figure 16**).

Figure 16 - Nineteen-year trends in pH



4.8 Summary Statistics of Significant Trends across Skagit County

To construct a bird's-eye view of what trends are occurring across Skagit County, two summary tables were created. These summary tables were made from the site-specific tables provided in **Appendix C**. These tables consider all the trend analyses run, including the 19-year data (18 trends), the most recent ten-year data (six trends), and the five-year data (six trends). This combines for a total of 30 possible significant trends for each site. The results on these tables are biased toward the temperature and FC parameters, as they account for six of the 30 total trends in the group, and biased even further toward DO, as it accounts for eight total categories. Other parameters populate one or two categories each. For this report, positive trends were listed as: Increase in pH, increase in DO, increase in DO% saturation, decrease in temperature, decrease in turbidity, decrease in FC, decrease in nutrients, and decrease in TSS. Negative, or deleterious trends, were considered as the opposite of these statements.

The first table (**Table 13**) arranges all ambient monitoring sites by their percentage of positive significant trends out of the total significant trends found at the site. The first table does not arrange by the number of trends total, but simply by how positively or negatively a particular site is trending overall. The sites in the county that have the highest ratio of positive trends are listed at the top, and the sites exhibiting the highest ratio of negative trends are at the bottom. This table is a quick reference for overall improving or deteriorating water quality for a site.

The second table (**Table 14**) arranges all ambient sampling monitoring sites by their total number of significant trends recorded. Some sites recorded fewer than ten significant trends, while others recorded over twenty. The second table does not arrange by the ratio of positive or negative trends recorded, but simply by the amount of significant change that is occurring at that site. This table is a quick reference for identifying which sites around the county are experiencing the most significant statistical change in water quality, and which sites not. Sites located at the top of the table are those that have had their water quality parameters change the most.

Table 13 - Summary Statistics of Significant Trends, by Positive/Negative.

Site		Significant Trends				Category
		Total	Positive	Negative	% Positive	
Skagit River	46	10	10	0	100	Skagit - Low
Skagit River	45	8	8	0	100	Skagit - Low
Skagit River	29	12	11	1	92	Skagit - Mid
Samish River	11	11	10	1	91	Ag - Up
Skagit River	30	9	8	1	89	Skagit - Up
Samish River	32	15	12	3	80	Ag - Down
Nookachamps Creek	15	10	8	2	80	Ag - Mid
Hansen Creek	20	9	7	2	78	Ag - Up
Coal Creek	21	9	7	2	78	Ag - Down
Lake Creek	18	8	6	2	75	Ag - Up
Wiseman Creek	23	7	5	2	71	Ag - Up
Nookachamps Creek	12	13	9	4	69	Ag - Down
No Name Slough	34	17	11	6	65	Ag - Down
Fisher Creek	48	14	9	5	64	Ag - Down
Thomas Creek	4	19	12	7	63	Ag - Up
Colony Creek	39	8	5	3	63	Ag - Down
Swede Creek	8	13	8	5	62	Ag - Down
EF Nookachamps	16	13	8	5	62	Ag - Mid
Red Cabin Creek	25	9	5	4	56	Ref - RR
Friday Creek	6	11	6	5	55	Ref - RR
Nookachamps Creek	17	11	6	5	55	Ag - Up
Mannser Creek	24	12	6	6	50	Ag - Mid
Coal Creek	22	6	3	3	50	Ag - Up
Hill Ditch/Carpenter	42	20	8	12	40	Ag - Down
Edison Slough	36	10	4	6	40	Ag - Down
Alice Bay Pump	33	14	5	9	36	Ag - Down
Swinomish Channel	47	12	4	8	33	Ref - Marine
Maddox/Big Ditch	41	16	5	11	31	Ag - Down
Thomas Creek	3	10	3	7	30	Ag- Down
EF Nookachamps	13	14	4	10	29	Ag - Down
Sullivan Slough	44	11	3	8	27	Ag - Down
South Edison Pump Station	37	11	2	9	18	Ag - Down
Big Indian Slough	40	11	2	9	18	Ag - Mid
North Edison Pump Station	38	17	3	14	18	Ag - Down
Hansen Creek	19	12	2	10	17	Ag - Down
Wiley Slough	43	9	1	8	11	Ag - Down

Table 14 - Summary Statistics of Significant Trends, by Total Count.

Site		Significant Trends				Category
		Total	Positive	Negative	% Positive	
Hill Ditch/Carpenter	42	20	8	12	40	Ag - Down
Thomas Creek	4	19	12	7	63	Ag - Up
No Name Slough	34	17	11	6	65	Ag - Down
North Edison Pump Station	38	17	3	14	18	Ag - Down
Maddox/Big Ditch	41	16	5	11	31	Ag - Down
Samish River	32	15	12	3	80	Ag - Down
Fisher Creek	48	14	9	5	64	Ag - Down
Alice Bay Pump	33	14	5	9	36	Ag - Down
EF Nookachamps	13	14	4	10	29	Ag - Down
Nookachamps Creek	12	13	9	4	69	Ag - Down
Swede Creek	8	13	8	5	62	Ag - Down
EF Nookachamps	16	13	8	5	62	Ag - Mid
Skagit River	29	12	11	1	92	Skagit - Mid
Mannser Creek	24	12	6	6	50	Ag - Mid
Swinomish Channel	47	12	4	8	33	Ref - Marine
Hansen Creek	19	12	2	10	17	Ag - Down
Samish River	11	11	10	1	91	Ag - Up
Friday Creek	6	11	6	5	55	Ref - RR
Nookachamps Creek	17	11	6	5	55	Ag - Up
Sullivan Slough	44	11	3	8	27	Ag - Down
South Edison Pump Station	37	11	2	9	18	Ag - Down
Big Indian Slough	40	11	2	9	18	Ag - Mid
Skagit River	46	10	10	0	100	Skagit - Low
Nookachamps Creek	15	10	8	2	80	Ag - Mid
Edison Slough	36	10	4	6	40	Ag - Down
Thomas Creek	3	10	3	7	30	Ag- Down
Skagit River	30	9	8	1	89	Skagit - Up
Hansen Creek	20	9	7	2	78	Ag - Up
Coal Creek	21	9	7	2	78	Ag - Down
Red Cabin Creek	25	9	5	4	56	Ref - RR
Wiley Slough	43	9	1	8	11	Ag - Down
Skagit River	45	8	8	0	100	Skagit - Low
Lake Creek	18	8	6	2	75	Ag - Up
Colony Creek	39	8	5	3	63	Ag - Down
Wiseman Creek	23	7	5	2	71	Ag - Up
Coal Creek	22	6	3	3	50	Ag - Up

4.9 Water Quality Index (WQI)

The Water Quality Index is a tool developed by 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 be summarized to give a site an overall score for a water year. The parameters included in the WQI are DO, temperature, pH, turbidity, suspended solids, FC, and nutrients.

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

Ecology rates streams with WQI Overall Score of 80 or greater "of lowest concern." Streams with ratings of 40-79 are considered "of moderate concern," while scores less than 40 are considered "of highest concern." The annual WQI for each site is calculated from quarterly data because nutrients are collected on this schedule. 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.

Water Quality Index calculations for the sample sites in the SCMP during the 2022 water year are summarized in **Table 15** and are mapped geographically in **Figure 17**. WQI scores over the length of this program are categorized for the years 2009-2022 in **Table 16**.

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

The number of sites in the Lowest Concern category (lavender) had increased from 17 to 23 sites in 2018 and has dropped back down to 16 in 2022. The number of sites in the Highest Concern category (red) category has held steady throughout the length of the program. Streams and ditches in the Highest Concern category can have either one water quality parameter that is well below standards or several categories that are below standards.

Table 15 - Water Quality Index (WQI) results for the 2022 Water Year

Site Number	Watercourse	Location	Overall Score*
3	Thomas Creek	Old Hwy 99 N	67
4	Thomas Creek	F&S Grade Rd	70
6	Friday Creek	Prairie Rd	90
8	Swede Creek	Grip Rd	83
11	Samish River	State Route 9	74
12	Nookachamps Creek	Swan Rd	41
13	E.F. Nookachamps Creek	State Route 9	54
15	Nookachamps Creek	Knapp Rd	60
16	E.F. Nookachamps Creek	Beaver Lake Rd	86
17	Nookachamps Creek	Big Lake Outlet	66
18	Lake Creek	State Route 9	90
19	Hansen Creek	Hoehn Rd	87
20	Hansen Creek	Northern State	86
21	Coal Creek	Hoehn Rd	85
22	Coal Creek	Hwy 20	87
23	Wiseman Creek	Minkler Rd	95
24	Mannser Creek	Lyman Hamilton Hwy	63
25	Red Cabin Creek	Hamilton Cem. Rd.	97
29	Skagit River	River Bend Rd	87
30	Skagit River	Cape Horn Rd	91
32	Samish River	Thomas Rd	88
33	Alice Bay Pump Station	Samish Island Rd	16
34	No Name Slough	Bayview-Edison Rd	29
36	Edison Slough	W. Bow Hill Rd	58
37	South Edison Pump Station	Farm to Market Rd	8
38	North Edison Pump Station	North Edison Rd	1
39	Colony Creek	Colony Rd	71
40	Big Indian Slough	Bayview-Edison Rd	10
41	Maddox Slough/Big Ditch	Milltown Rd	32
42	Hill Ditch/Carpenter	Cedardale Rd	52
43	Wiley Slough	Wylie Rd	19
44	Sullivan Slough	La Conner-Whitney	14
45	Skagit River – North Fork	Moore Rd	91
46	Skagit River – South Fork	Fir Island Rd	91
47	Swinomish Channel	Twin Bridges Boat Launch	59
48	Fisher Creek	Franklin Rd	85
49	Joe Leary Slough	Farm to Market Rd	12
50	Joe Leary Slough	Bayview-Edison Rd	32
51	Carpenter Creek	East Stackpole Rd	61
52	Little Indian Slough	Farm to Market Rd	2

Color code: Low Concern (> 80 Overall Score), Moderate Concern (40 - 80), High Concern (< 40)
*Note: Overall score is the mean of the three lowest monthly scores (Hallock 2002)

Figure 17 - Color coded map of water year 2022 WQI results

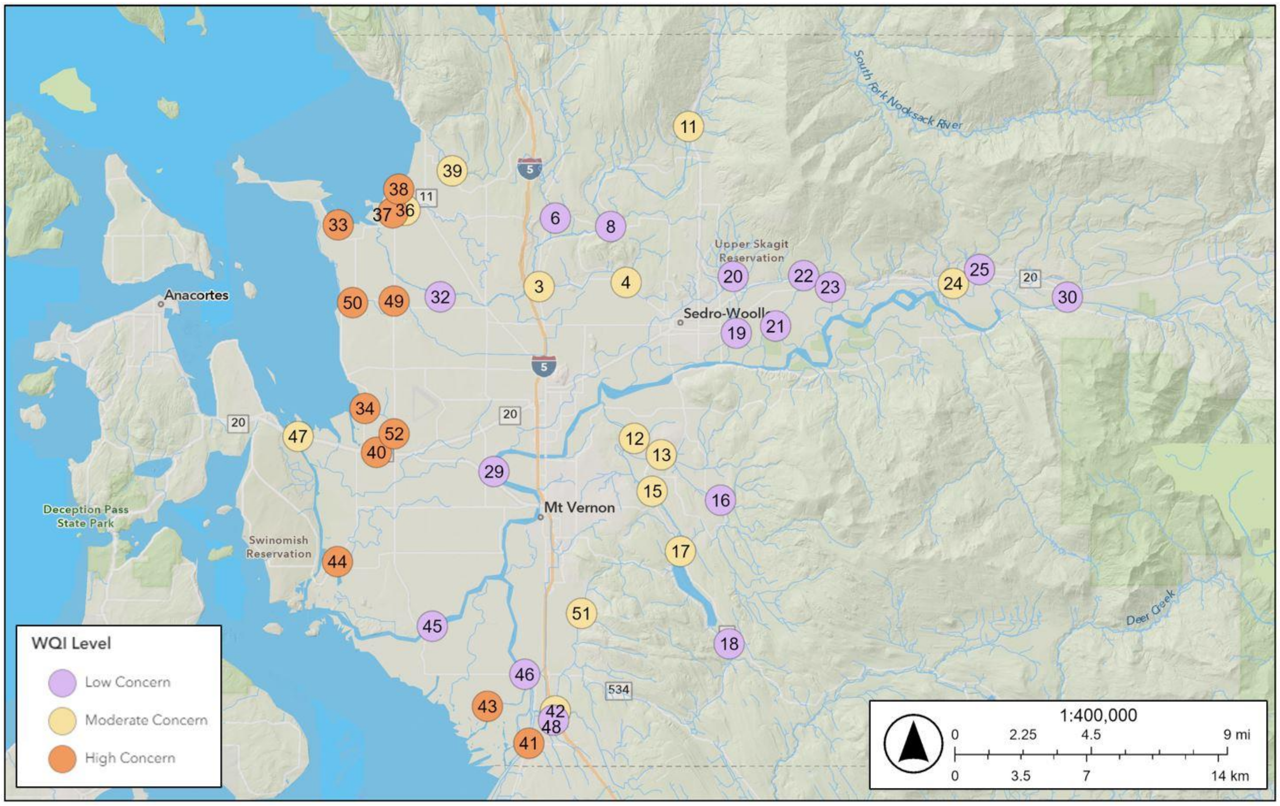


Table 16 - Number of sites in each WQI category

Year	Highest Concern (1 - 40)	Moderate Concern (40 - 79)	Lowest Concern (80 - 100)
2009	12	11	17
2010	8	19	13
2011	11	9	20
2012	11	16	13
2013	11	14	15
2014	11	13	16
2015	11	13	16
2016	10	15	15
2017	12	8	20
2018*	10	6	23
2019*	12	12	15
2020*	10	14	15
2021*	8	14	17
2022	11	13	16

*39 sites sampled from 2018 - 2021

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