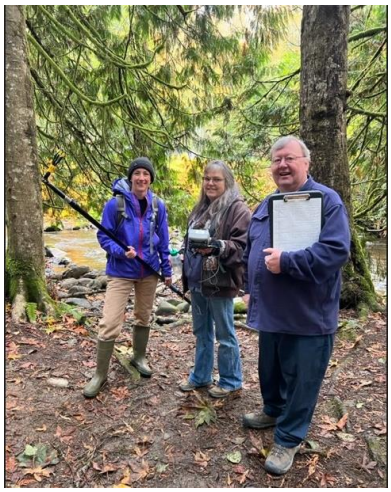
2021-2022

Skagit Stream Team Water Quality Report

Citizen Monitoring Summary for Samish Bay, Padilla Bay, Ace of Hearts, Gages Slough, Trumpeter Basin, Kulshan Creek and Nookachamps Creek



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2021 - 2021 Annual Water Quality Report




Published September 2023

Sponsored by:
Skagit Conservation District and Padilla Bay National Estuarine Research Reserve

in partnership with:
City of Mount Vernon, City of Anacortes, City of Burlington, Skagit County, and Local Citizens

The 2021/22 Skagit Stream Team program was funded by:
Washington State Conservation Commission, Skagit County, City of Mount Vernon, City of Anacortes and the City of Burlington

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2021-2022 Skagit Stream Team Annual Water Quality Report

Table of Contents

List of Tables

List of Figures

I. Introduction

This report summarizes the results of the 2021-2022 Skagit Stream Team Program, the twenty-third consecutive year of data collection by volunteers. From October 2021 through August 2022, sixty-nine dedicated citizen volunteers monitored the water quality of freshwater streams that drain into Skagit County's Samish Bay, Padilla Bay, the Skagit River and Burrows Bay. In addition, eleven of those volunteers formed the Padilla Bay Storm Team, sampling twelve sites in the Padilla Bay watershed during fourteen rain events.

This report is meant to provide useful and reliable background water quality data. It is not intended to provide a legal documentation of water quality violations. All data and methods are available to the public.

Background

The Skagit Stream Team Program was established in 1998 to educate and involve local citizens in the protection and stewardship of local streams. Sponsors include Skagit Conservation District (SCD) in partnership with the Padilla Bay National Estuarine Research Reserve (PBNERR), City of Mount Vernon, City of Burlington, City of Anacortes, and Skagit County. Funding was provided by the Washington State Conservation Commission, the Washington State Department of Ecology's Centennial Clean Water Fund Program and partnering jurisdictions. Local citizens volunteered over 1,200.5 hours during the 2021-2022 sampling season.

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Skagit Stream Team Objectives

- To inspire community stewardship of water resources by educating local citizens about land use and non-point sources of pollution and involving them in the process of water quality data gathering.
- To develop and implement a routine sampling program that can be used to assess water quality trends, characterize the existing water quality of priority freshwater drainages, and determine how water quality conditions compare to State Standards.
- To document improvements in water quality because of the implementation of Best Management Practices on farmlands and the repair and/or replacement of failing septic systems.
- To teach community volunteers the sampling and analytical techniques used by environmental professionals, how to manage the data collected and create a database, and the importance of establishing a long-term water quality monitoring program.

Volunteers measured fecal coliform (FC) bacteria, dissolved oxygen (DO), water temperature, turbidity, and total depth. Some of the questions the study hoped to address were:

- How do water quality conditions compare to State Standards in our priority watersheds?
- Could water quality conditions support aquatic life such as salmon?

II. Methods

Efforts were made to assure high quality data from this volunteer-based study. Quality Assurance/Quality Control (QA/QC) plans and laboratory plans were submitted to and approved by the WA Department of Ecology. These plans have since been updated and revised. Volunteers were given ten hours of training before sampling in the field and were accompanied by a trainer for their first sampling. All analysis and collection methods are detailed in the QA/QC plan and are available on request.

The Samish watershed had two upper and two lower teams, and was coached by Cindy Pierce, SCD. The Padilla Bay watershed had two teams each on No Name Slough, Joe Leary Slough, and in the village of Bay View, coached by Susan Wood, PBNERR. Nookachamps Creek had two upper and two lower teams coached by Cindy Pierce, SCD. Kulshan Creek, and Trumpeter Basin each had two teams coached by Kristi Carpenter, SCD. Gages Slough had two teams coached by Cindy Pierce. Ace of Hearts/Happy Valley Creek sites were monitored by two teams coached by Susan Wood.

At each site, samples were usually taken every two weeks. Temperature, dissolved oxygen (DO), and salinity (when applicable) were measured on-site with an electronic YSI Data Probe. Field measurements and samples were taken just below the surface, in the deepest part of the stream that could be reached. Depth was measured for some sites using staff gages. Samples were tested for Fecal coliform either at the Padilla Bay volunteer lab (Padilla, Samish, Nookachamps samples), taken to Burlington Wastewater Treatment Plant (Gages Slough), taken to the Mount Vernon Wastewater Treatment Plant (Trumpeter Basin, Kulshan Creek) or the Anacortes Waste Water Treatment Plant (Ace of Hearts and Happy Valley Creeks) for analysis. Turbidity was measured either in Padilla Bay's lab or in the field. Volunteers also recorded water appearance and color. Quality procedures are outlined in more detail in Appendix C.

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Quality control checks by staff were conducted periodically in the lab and in the field to assure that volunteers were using proper and consistent protocols.

The data was recorded on field sheets (See Appendix D) and transferred to a Microsoft Excel spreadsheet by a volunteer. Padilla Bay staff verified all data entries, making edits as appropriate. Any anomalies were recorded in the metadata and values replaced by "NA" or corrected in the case of obvious mistakes, e.g. degrees Fahrenheit used in lieu of Celsius or switching dissolved oxygen % saturation with milligrams per liter.

In accordance with state standards, annual fecal coliform (FC) results were calculated using the geometric mean. "Too Numerous To Count" (TNTC) results were assigned a value of 1600 CFU/100 ml. Averages were calculated for dissolved oxygen, temperature and turbidity levels.

For fecal coliform in this report, we have begun using the protocol used by the Burlington, Mount Vernon, and Anacortes wastewater treatment plants so that results are comparable. Calculated values for 2021-22 monthly graphs follow the protocol used by Lab Standard Methods 9222 D-2006, and EPA Microbiological Methods for Monitoring the Environment, Water, and Wastes, EPA/600/8- 78/017 (US EPA 1978). This protocol requires methods replicates to fall within an ideal counting range (20 – 60 FC colonies per plate). This range is where counting accuracy is the highest. Outside of this range counting accuracy is not deemed as robust and these values should not be used in final reporting. If both values are outside this range, the value closest to being within the range is used. All previous annual means were calculated by averaging two methods replicates (subsamples from the same sample).

III. Padilla Bay Storm Team

The Storm Team volunteers monitored sites on Joe Leary Slough, No Name Slough, and Bay View drainages. Monitoring many sites throughout the drainage during storm events when high fecal coliform numbers are expected may detect priority areas for clean-up. Special thanks to our Storm Team volunteers for their ongoing commitment – in the worst of weather. Complete data are found in Appendix B.

IV. Sites

Stream Team and Storm Team sites are within Skagit County watersheds that drain to Skagit, Padilla, Fidalgo, and Samish Bays (Figure 0; click on map to view online, interactive map: https://arcg.is/11iLLa).

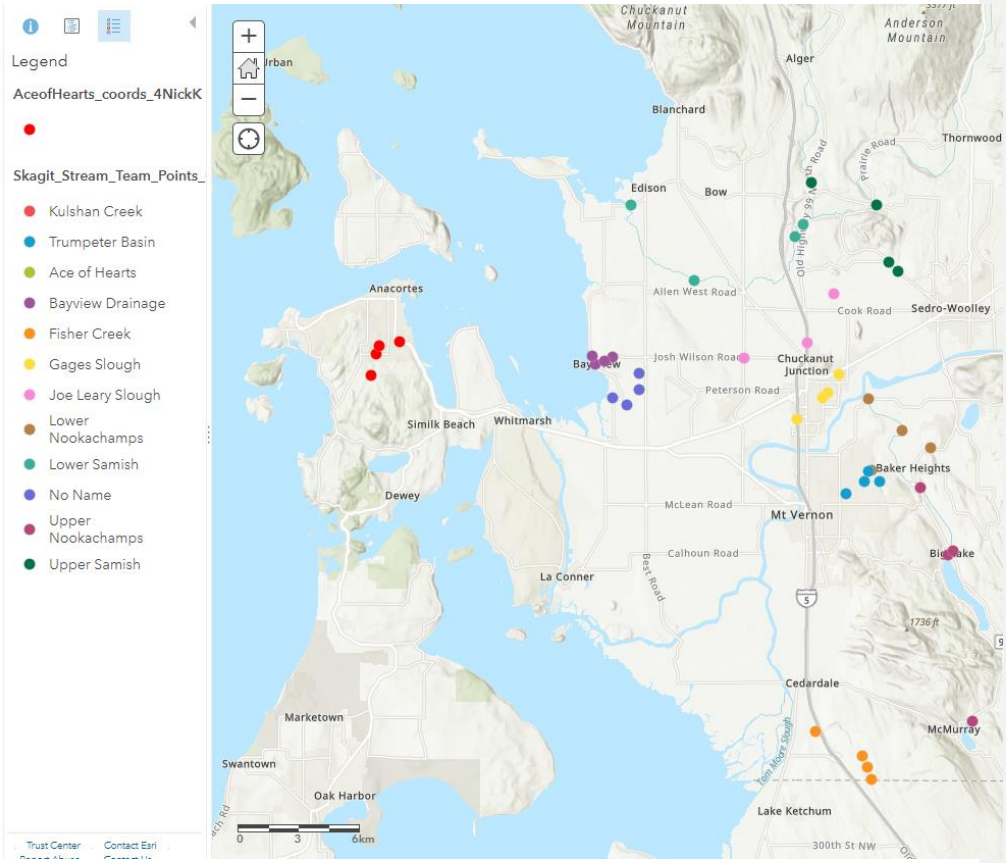

Figure 0. All Stream Team sampling sites for 2021-2022.

Samish River Watershed

Figure 1. Map of Samish Stream Team Sites

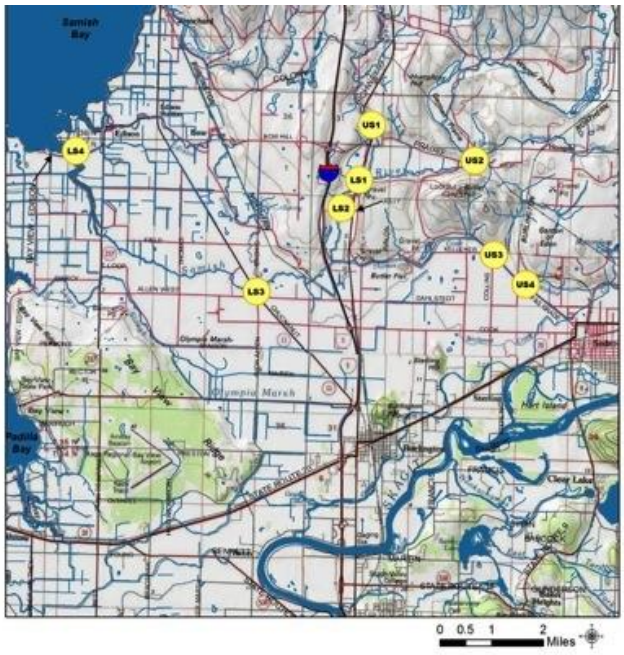

Table 1. Samish Stream Team Sampling Locations

US1	Friday Creek @ Pomona Grange Park	N48º33'55.02 W122º20'49.49
US2	Swede Creek @ Grip Rd	N48º33'17.75 W122º17'16.23
US3	Thomas Creek @ F&S Grade Rd	N48º31'42.93 W122º16'44.69
US4	Willard Creek @ 8274 F & S Grade Rd	N48º31'13.65 W122º15'58.07
LS1	Hwy 99 Bridge over Samish River	N48º31'32.58 W122º20'24.78
LS2	Samish River @ Jolly Road	N48º32'25.47 W122º20'36.36
LS3	Thomas Road Bridge over Samish River	N48º31'0.69 W122º22'43.29
LS4	Mouth of the Samish River (boat dock)	N48º19'11 W122º19'47

Nookachamps Creek

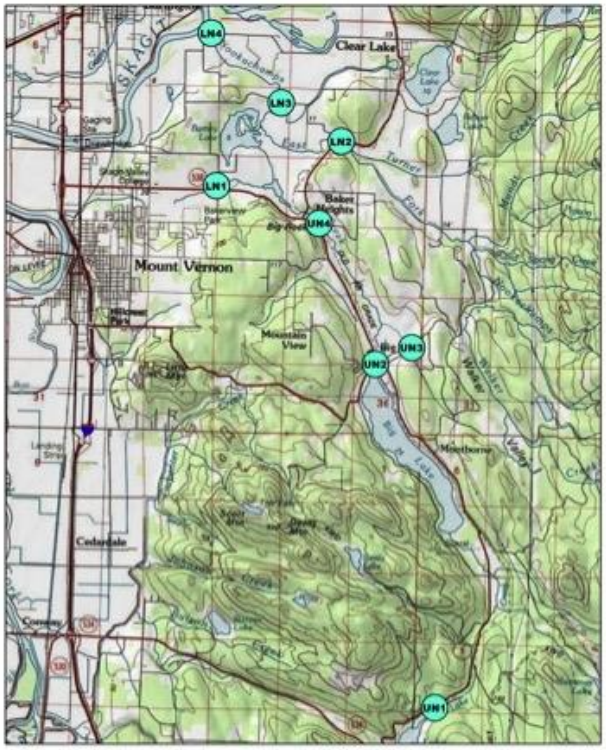

Figure 2. Map of Nookachamps Creek Stream Team Sites

Table 2. Nookachamps Creek Stream Team Sampling Locations

UN1	Lake McMurray Estates	N48°19’37 W122°13’10
UN2	Big Lake Outflow	N48°23’57 W122°14’24
UN3	Otter Pond Road	N4824’10 W122°13’44
UN4	Knapp Road	N4825’43 W122°15’32
LN1	SR 538 and N Waugh Road	N48º26’10.14 W122º17’29.88
LN2	SR 9 and Babcock	N48º26’45.56 W122º15’8.65
LN3	Swan Road	N48º27’13.79 W122º16’17.84
LN4	Francis Road	N48º28’5.47 W122º17’38.72

No Name Slough

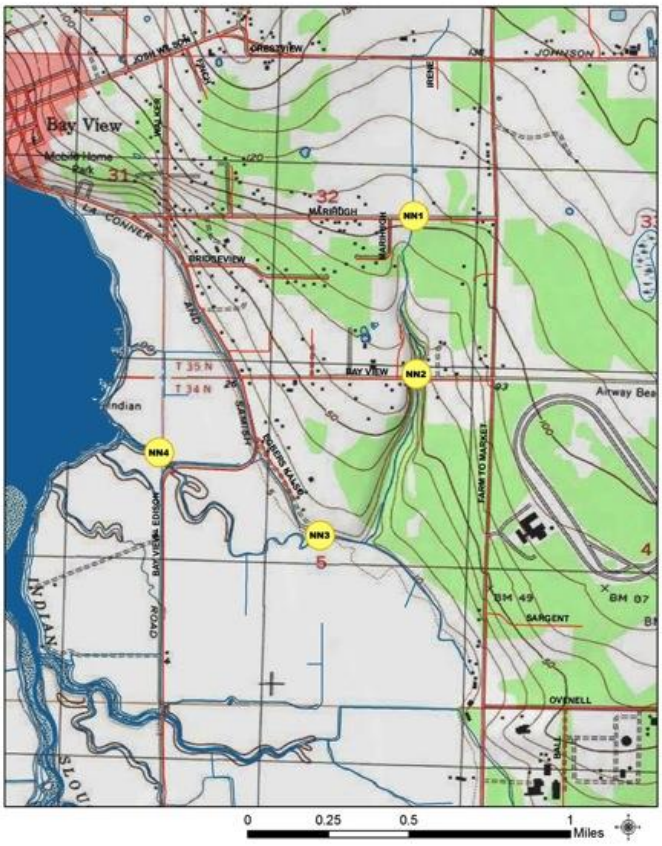

Figure 3. Map of No Name Slough Stream Team Sites

Table 3. No Name Slough Stream Team Sampling Locations

NN1	Marihugh Road Culvert	N48º17’53. W122º17’31
NN2	Bay View Road Ravine	N48º18’121 W122º17’41
NN3	Egber’s Field Bridge	N48º18’30. W122º17’53
NN4	Field Culvert, Bay View-Edison Road	N48º19’11 W122º19’47

Bay View Drainage

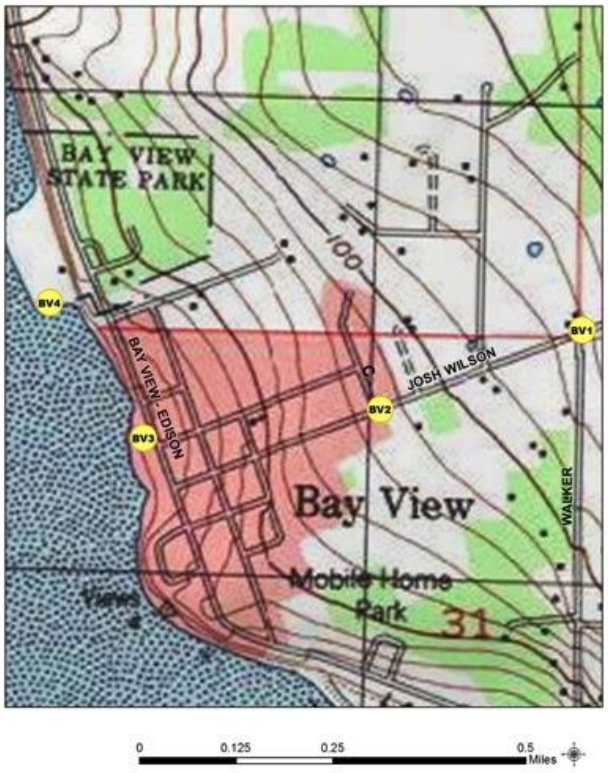

Figure 4. Map of Bay View Stream Team Sites

Table 4. Bay View Stream Team Sampling Locations

BV1	Wilson Road and Walker Road	N48º29'11.94 W122º27'58.92
BV2	Wilson Road and C Street	N48º29'6.3 W122º28'19.26
BV3	Culvert at Boat Launch	N48º29'4.02 W122º28'43.2
BV4	N Beach at Bay View State Park	N48º29'13.02 W122º28'53.04

Joe Leary Slough

Figure 5. Map of Joe Leary Slough Stream Team Sites

Table 5. Joe Leary Slough Stream Team Sampling Locations

JL1	Dahlstedt Road	N48º30'53.35 W122º19'2.46
JL2	Hwy 99	N48º29'35.37 W122º20'6.61
JL3	Wilson Rd and Avon-Allen Rd.	N48º29'11.33 W122º22'41.96
JL4	Tide Gate	N48º31'4.90 W122º28'27.87

Trumpeter Basin

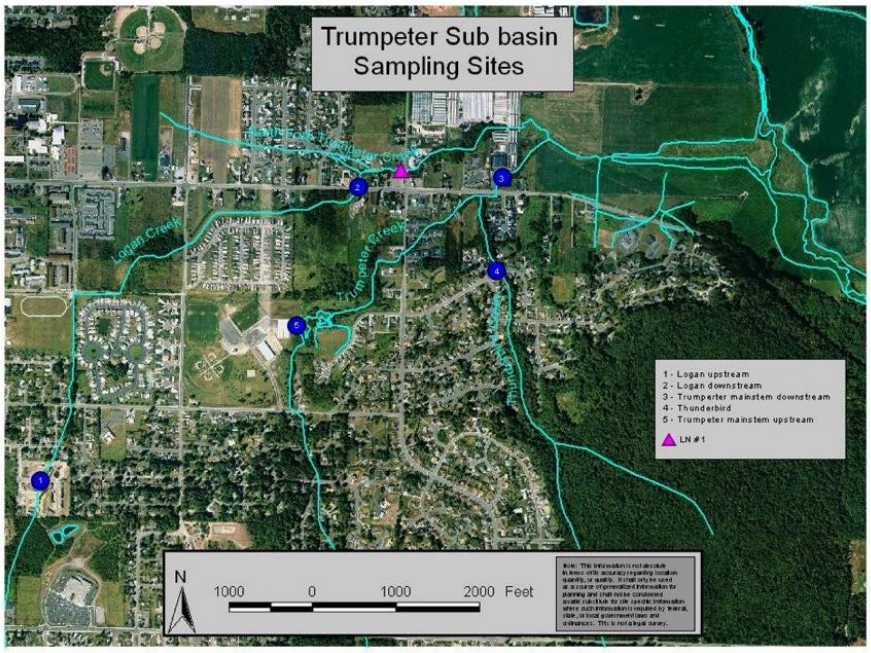

Figure 6. Map of Trumpeter Basin Stream Team Sites

Table 6. Trumpeter Basin Stream Team Sampling Locations

TB1	Stonebridge Adult Community, Logan Creek Bridge	N48º25'33 W122º18'32
TB2	College Way west of Martin .Waugh Road, Logan Creek	N48º26'09 W122º17'12
TB3	College Way at Trumpeter/Thunderbird confluence	N48º26'07 W122º17'17
TB4	Culvert on Kiowa, Thunderbird	48º25'53 W122º17'12
TB5	Bakerview Park Footbridge, Trumpeter	N48º25'51 W122º17'48

Kulshan Creek

Figure 7. Map of Kulshan Creek Stream Team Sites

Table 7. Kulshan Creek Stream Team Sampling Locations

KC1	North end of S 14th .Kulshan Trail	N48º25'59 W122º19'27
KC2	Parker Way	N48º25'59 W122º19'17
KC3	S side Roosevelt.1 blk W of Parker Way	N48º26'11 W122º19'25
KC4	E of Riverside - N of RR crossing	N48º25'54 W122º20'04
KC5	Freeway Drive at Lions Park	N48º25'43 W122º20'28

Ace of Hearts/Happy Valley Creeks

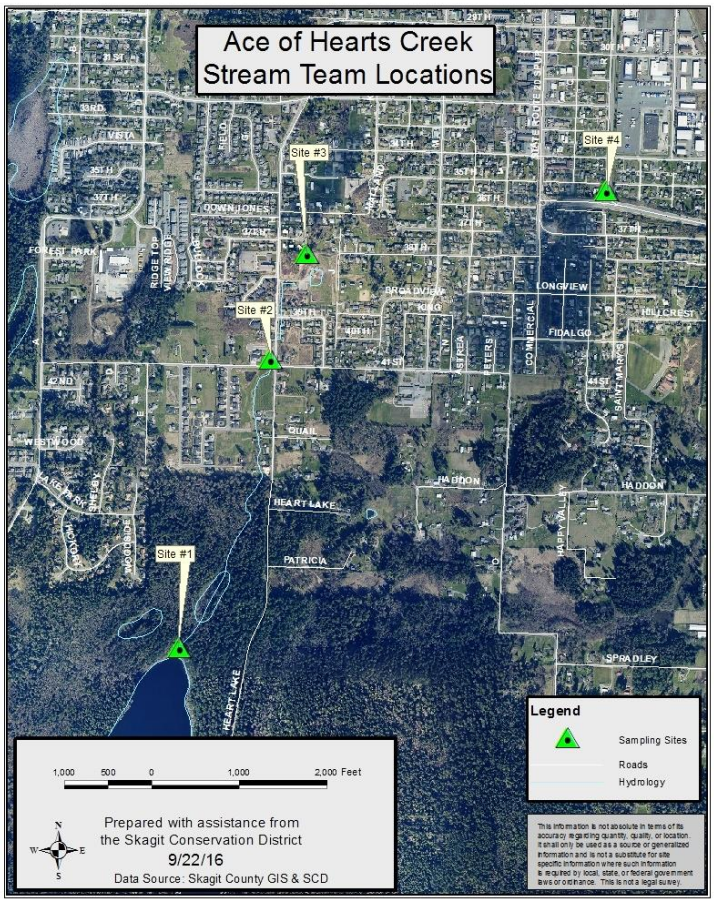

Figure 8. Map of Ace of Hearts/Happy Valley Stream Team Sites

Table 8. Ace of Hearts/Happy Valley Creek Stream Team Sampling Locations

AH1	Heart Lake outlet	N48d28'42.56" W122d37'44.97"
AH2	41st and H Ave	N48d29'16.62" W122d37'31.59"
AH3	Rotary Dog Park	N48d29'29.53" W122d37'25.27"
AH4	Happy Valley Creek	N48d29'37.28" W122d36'35.56"

Gages Slough

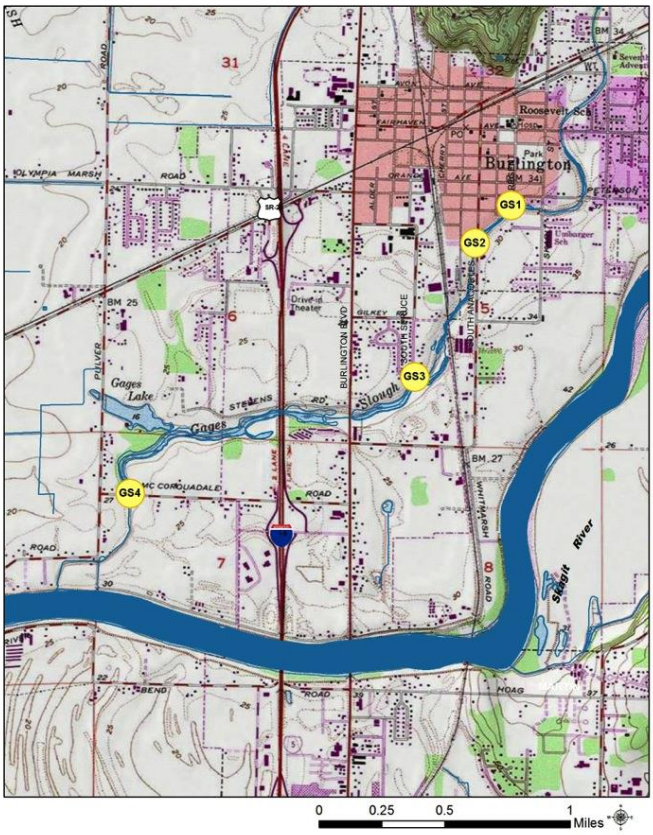

Figure 9. Map of Gages Slough Stream Team Sites

Table 9. Gages Slough Stream Team Sampling Locations

GS1	Regent and East Rio Vista Streets	N48º28’16 W122º19’19
GS2	South Anacortes Street	N48º28’08 W122º19’30
GS3A	South Spruce Street	N48º27’40 W122º19’48
GS4A	McCorquedale Road	N48°27' 33 W122°20' 9

V. Results

This section presents the data collected during the 2021-2022 season. It provides a preliminary overview for each parameter followed by details for each watershed and a comparison of annual site averages for the past seventeen sampling seasons. Annual data for all watersheds are provided in Appendix A.

Dissolved Oxygen Standards

Dissolved oxygen (DO) measurements determine how much oxygen is available in the water for aquatic life. The state water quality standards for dissolved oxygen are based on aquatic life uses. Streams in this program fall under three categories based on aquatic life use. For Nookachamps Creek, Trumpeter Basin, Kulshan Creek, and Upper Samish Site 2, the standard is a lowest 1 day minimum of 9.5 mg L^{-1} required for core summer salmonid habitat. (Higher dissolved oxygen levels are better.) For the lowland watercourses, Joe Leary Slough, No Name Slough, Bay View, Gages Slough and all Samish sites except Swede Creek (Upper Samish 2), the minimum standard is a lowest 1 day minimum of 8.0 mg L^{-1} for salmon spawning and rearing. Ace of Hearts and Happy Valley Creeks in Anacortes are classified for salmon rearing and migration, with the lower DO standard of a lowest 1 day minimum of 6.5 mg L^{-1}

Seasonal averages are presented in a time series since sampling inception for the purpose of comparison between sites and between years, but this data cannot determine whether the water body meets the standard. The standard is based on the lowest single-day measurement, not on the seasonal or annual average. It is important to note that most of the teams do not monitor during the warmer summer months when DO would likely drop with warmer air and water temperatures.

Temperature Standards

Temperature is a water quality concern in part because warm water holds less dissolved oxygen than cool water. Many northwest fish species require cool temperatures and high oxygen levels at various stages in their life cycle. Warm water temperatures can cause stress to animals that lowers resistance to disease and infections. Many factors affect water temperature. These include large fluctuations in air temperature, changes in the shape of stream channel and lake margins, reductions in overhanging vegetation, turbidity, and reductions in water flow.

State standards for temperature are based on the 7-day average of the daily maximum temperatures (7-DADMax). For Nookachamps Creek, Trumpeter Basin, Kulshan Creek, and Upper Samish Site 2, that maximum is 16°C. All other sites must be less than 17.5ºC to meet standards. (Lower temperatures are better.)

The average temperatures presented below are used for comparison, but this data cannot determine whether the water body meets the standard. Most sites were not monitored during the critical summer warm periods, and none were monitored daily to obtain a 7-DADMax.

Turbidity Standards

Turbidity is a measurement of water clarity. Turbidity data in this report are not referenced to a state standard because that standard is relative to naturally occurring background levels and varies for each stream. For streams with background levels less than 50 NTU (all Stream Team sites), turbidity should not exceed 5 NTU above the background level. Short-term occurrences of high turbidity are not as harmful to aquatic animals as extended periods of moderately elevated turbidity.

Fecal Coliform Standards

Fecal coliform bacteria live in the digestive system of warm-blooded animals, including birds, livestock, and humans. They are not directly harmful to humans or aquatic life, but their presence indicates the possible presence of disease-causing microbes. To meet state standards, streams must meet two criteria:

- Part I: The geometric mean of fecal coliform bacteria levels cannot exceed 100 colony-forming units (CFU)/100 ml. A minimum of five samples in the database is needed to calculate the geometric mean.
- Part II: No more than 10% of the samples can exceed 200 CFU/100 ml.

State regulations for fecal coliform use the geometric mean, which reduces the weight of occasional extreme results or results that don't fall within a reasonable range of the overall sample database This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000-fold over a given period.

Upper Samish River Results

Upper Samish (US) site 1 is at the Pomona Grange, US2 at Swede Creek, US3 at Upper Thomas Creek, and US4 at Willard Creek.

Commented [LM(B3]: Add overall average annual figures here?

Dissolved Oxygen

Sites US1, 2, and 3 in the Samish River maintained dissolved oxygen (DO) levels above the state standards of 8.0 mg L^{-1} for sites 1,3, and 4, and 9.5 mg L^{-1} for Site US2 (salmon rearing habitat) throughout the sampling season, fall 2021 through spring 2022 (Figure 10). As in past years, Site US4, Willard Creek, had the lowest levels, with 2 occurrences below the state standard of 8.0 mg L^{-1}, in October 2021 and June 2022 at 5.67 and 7.69 mg L^{-1} respectively. The same site had the highest DO in late February 2022 at 18.03 mg L^{-1}. Sites were not sampled during the warmest summer months when dissolved oxygen is likely to be lowest.

Upper Samish site averages DO (fall-spring) over 16 years remained above the standard of 8.0 mg L^{-1} over all years except for site 4, Willard Creek, which fell below standard each early fall in all years except 2009, 2020, and 2022 (Figure 11). Site US 2 fell below its standard of 9.5 mg L^{-1} in fall of 2010 and 2016. The red line shows the minimum single day low for this waterway.

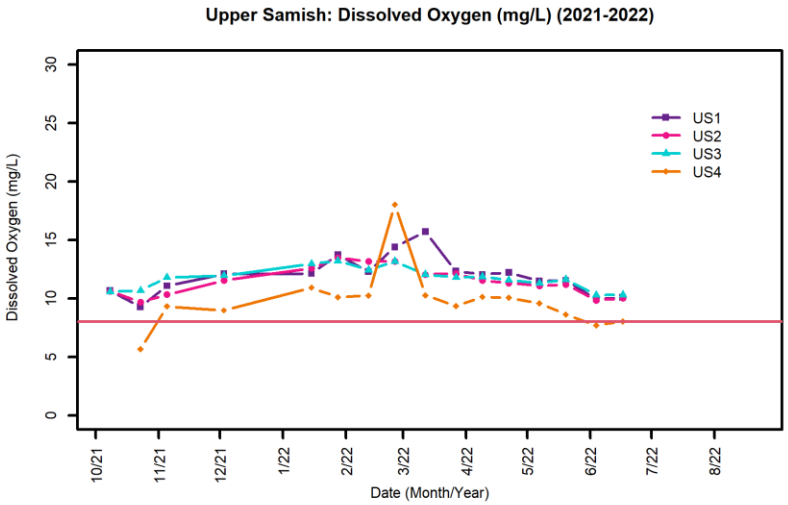

Figure 10. Upper Samish dissolved oxygen (mg L^{-1}): 2021 – 2022

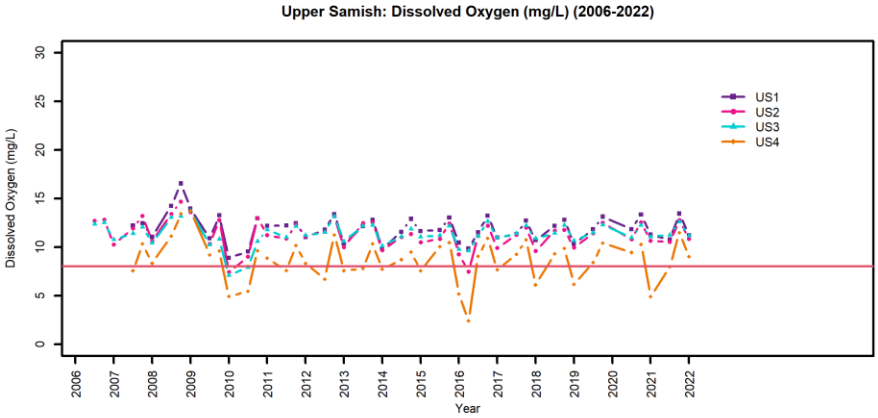

Figure 11. Upper Samish dissolved oxygen (mg L^{-1}) averages by season: 2006-2022

Temperature

All temperatures were under the upper limit (Figure 12) as in all past sampling years since 2006 (Figure 13). No sampling occurred during summer months. Temperatures were similar amongst all Upper Samish sites. The red line shows the maximum 7-day average for this waterway.

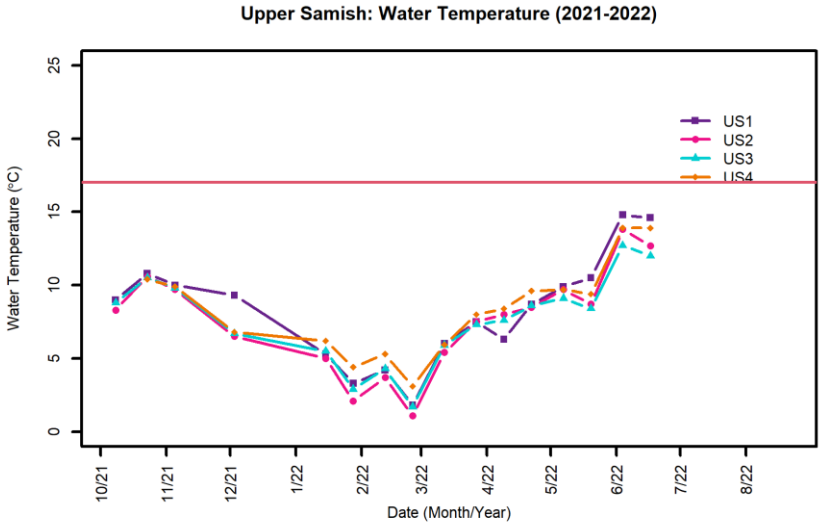

Figure 12. Upper Samish River water temperatures (°Celsius) fall – spring of 2021 – 2022

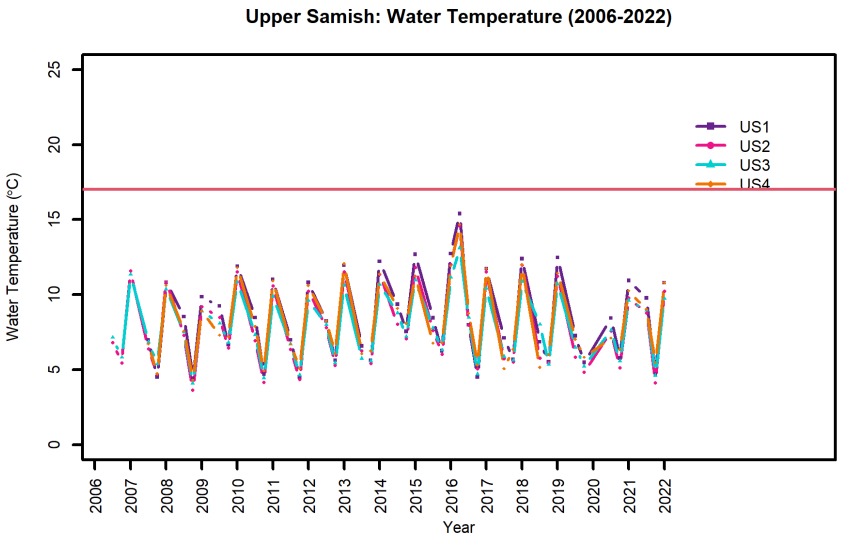

Figure 13. Upper Samish water temperature averages by season (fall-spring): 2006-2022

Turbidity

Turbidity levels in the Upper Samish (Figure 14) were similar between sites, between 3.0 and 37.7 NTU, except for Site 3, Thomas Creek, where turbidity jumped to 87.3 NTU in October. (This corresponded to a rise in fecal coliform levels) Site 3 remained slightly higher than the other sites over the sampling period. Site 1, Pomona Grange remained slightly lower than the other sites except in December, when it rose to 21.3 NTU. Fall – spring seasonal averages have remained below 50 NTU since sampling began in 2006 (Figure 15).

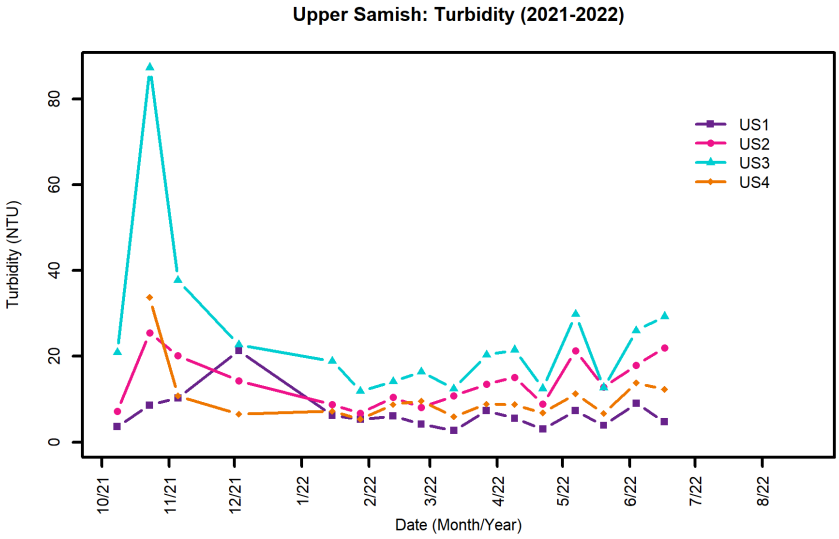

Figure 14. Upper Samish Turbidity (NTUs) : 2021 – 2022

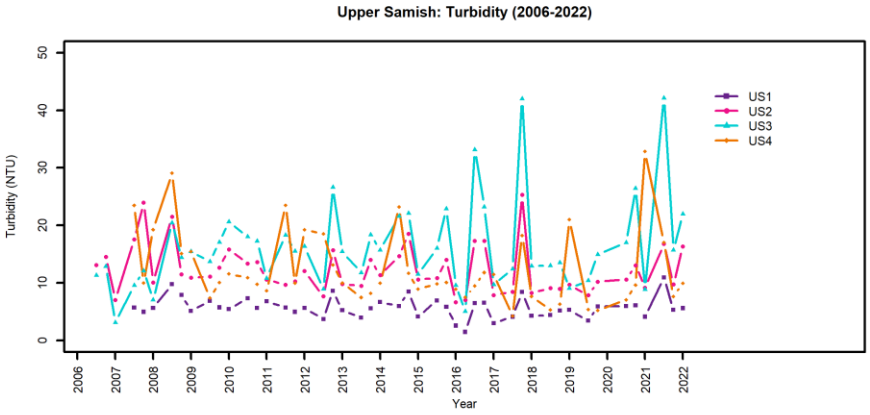

Figure 15. Upper Samish turbidity (NTU) averages by season: 2006-2022

Fecal Coliform

Fecal coliform (FC) levels in the Upper Samish watershed in 2021-2022 samples failed to meet both standards criteria in all sites but US1, Pomona Grange (Table 10). US2, Swede Creek samples passed criterion 1 (The geomean of FC samples was greater than 100 CFU/100mL.) but failed criterion 2 (More than 10% of geomeans were greater than 200 CFU/100mL.). US3 and US4 failed both criteria. Samples

from US 1, 2, and 3 remained above 100 CFU/100 mL for October, November, and December, as well as May-June, with US3 spiking in late February (Figure 16).

Values for the 2021-2022 sampling season follow the seasonal pattern over the past 16 years of sampling but with a notable spike in fecal coliform at site US4 in 2021 (Figure 17). The red line shows the 100 CFU $100mL^{-1}$ geomean upper limit for WA.

Table 10. Calculated geomeans of fecal coliform levels (CFU/100mL) Upper Samish 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
US1 Pomona Grange	30.91	Pass	Pass	Pass Both Standards
US2 Swede Creek	39.45	Pass	Fail	Does Not Pass Both
US3 Upper Thomas Creek	143.58	Fail	Fail	Does Not Pass Both
US4 Willard Creek	129.73	Fail	Fail	Does Not Pass Both

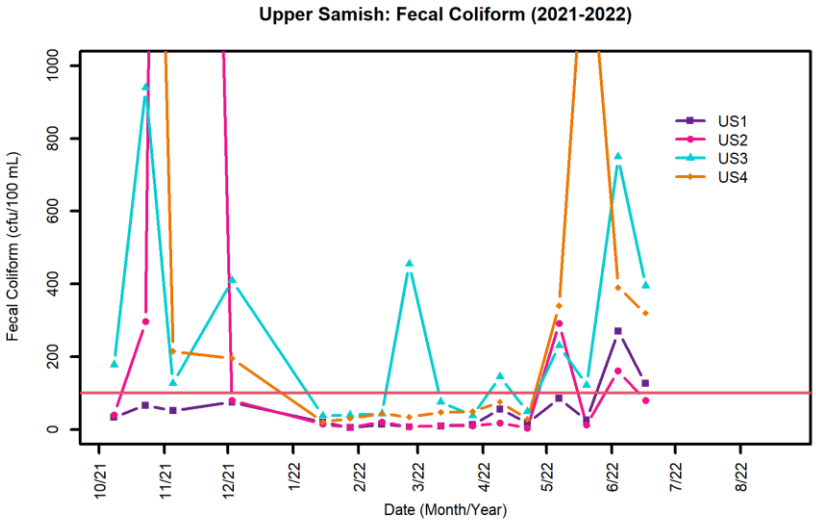

Figure 16. Upper Samish River Fecal Coliform (colonies per 100mL) 2021-2022

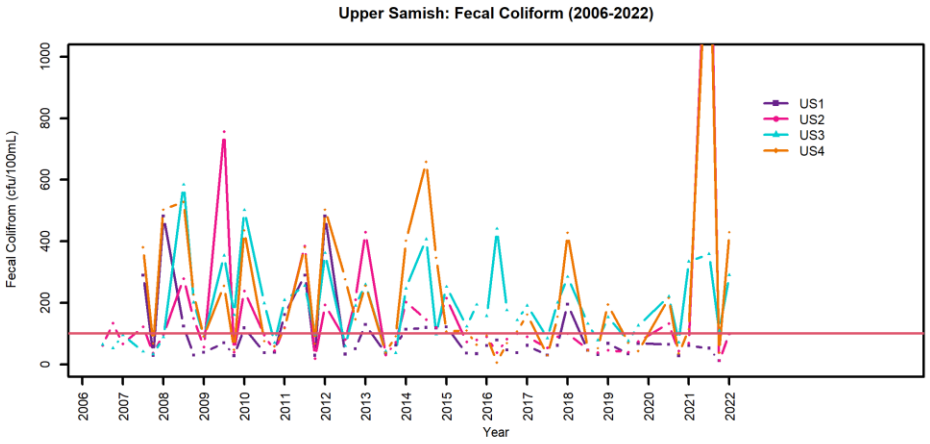

Figure 17. Upper Samish fecal coliform geometric means by season: 2006-2022

Lower Samish Results

Lower Samish (LS) site 1 is at Highway 99, LS2 at Jolly Road, LS3 at Chuckanut Dr., and LS4 is at the boat docks.

Dissolved oxygen

Dissolved oxygen levels were similar for all Lower Samish sites and stayed above the 8mg L^{-1} single day low standard for all fall-spring 2021-2022 samples. Sites were not sampled during the warmest summer months when dissolved oxygen is likely to be lowest. Average seasonal dissolved oxygen levels (Figure 19) have been consistent over 16 years at sites 1-3. Site 4, at the boat docks, dropped below the 8mgL^{-1} standard in early fall of 2008, fall and winter of 2010, and winter of 2018. The red line shows the minimum single day low for this waterway.

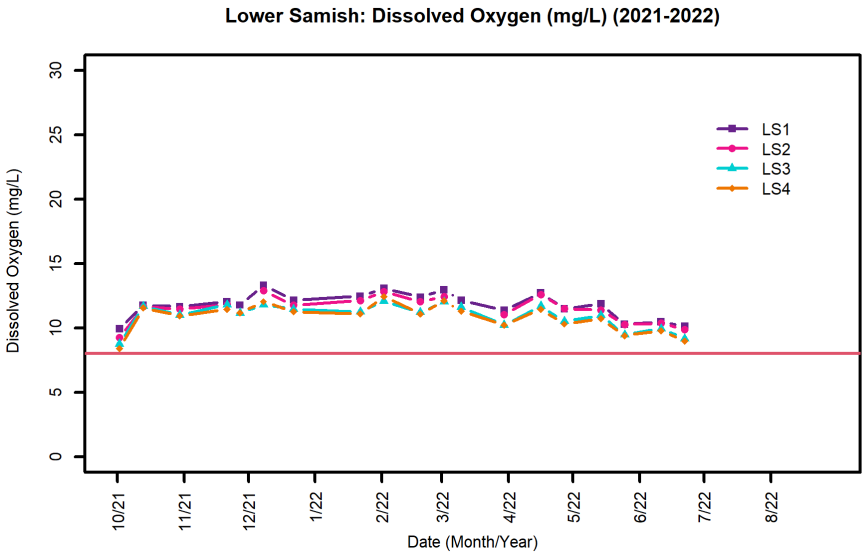

Figure 18. Lower Samish River dissolved oxygen (mg L-1), 2021-2022.

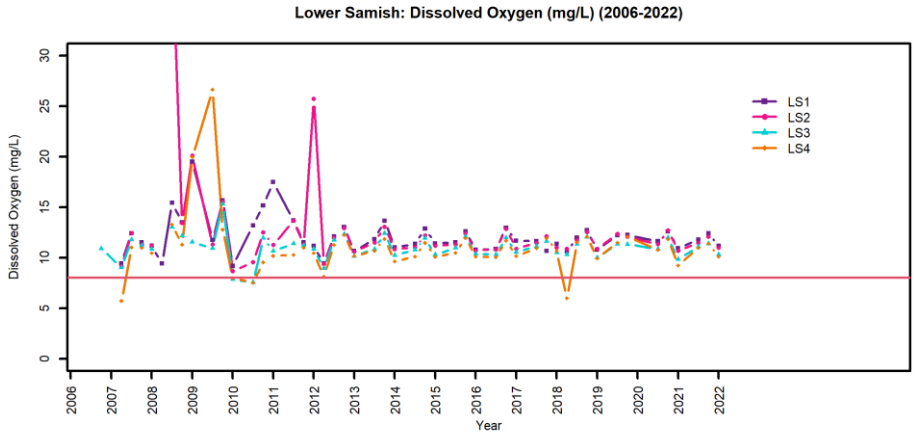

Figure 19. Lower Samish dissolved oxygen averages by season:2006-2022.

Water temperature

Water temperatures were similar across all Lower Samish sites and remained below the upper limit of 17.5°C throughout fall2021-spring 2022 sampling (Figure 20). Average seasonal temperatures stayed below the upper limit for Lower Samish of 17.5°C throughout the past 16 years of fall-spring sampling (Figure 21). This may not be the case for summer months when no sampling occurred. The red line shows the maximum 7-day average for this waterway.

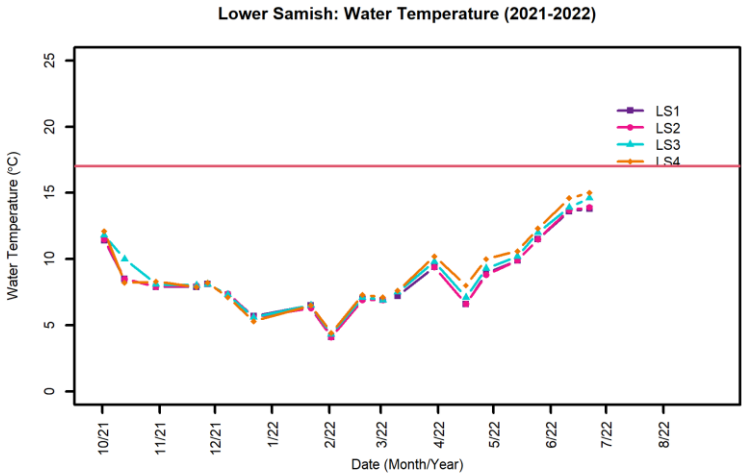

Figure 20. Lower Samish Temperature: 2021 – 2022

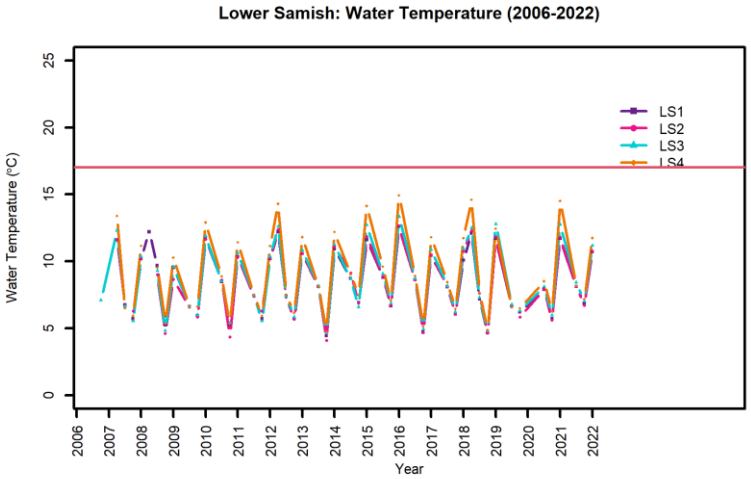

Figure 21. Lower Samish water temperature averages by season: 2006-2022.

Turbidity

The Samish Basin was not designated a set background turbidity level (Skagit County, 2000) but samples remained below 50 NTU throughout most of fall 2021 – spring 2022 sampling. Exceptions were site LS4 at the boat docks in the estuary, where turbidity reached 58.4 NTU in late November 2021 and site LS1 at the highway 99 bridge, which reached 81.4 NTU in March, 2022 (Figure 22). Seasonal averages have remained below 40 NTU throughout the Lower Samish since sampling began in 2006 (Figure 23).

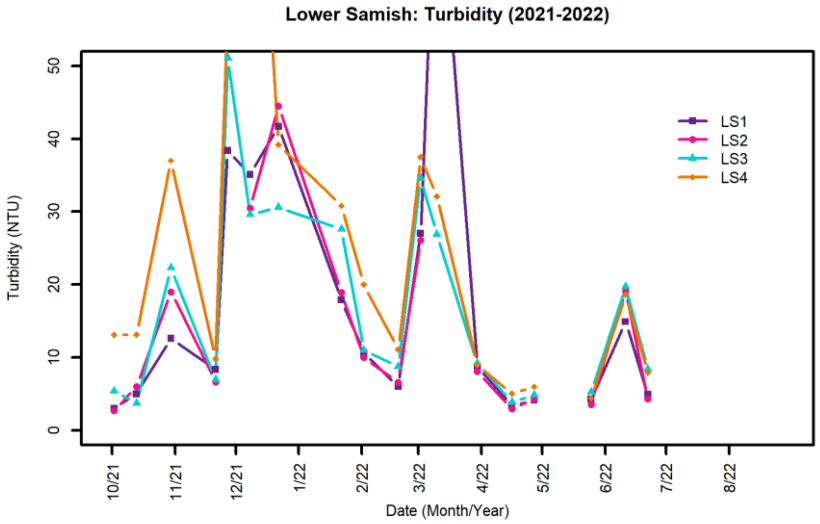

Figure 22. Lower Samish Turbidity: 2021-2022.

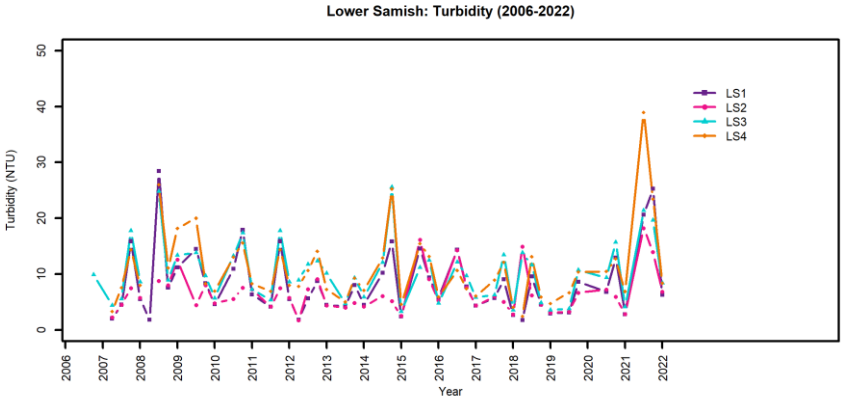

Figure 23. Lower Samish average turbidity levels by season: 2006-2022

Fecal coliform

Fecal coliform levels for the Lower Samish passed both standards criteria in all sites except for LS1, under the Samish Bridge at Highway 99 (Table 11; Figure 24). LS1 samples passed criterion 1 but failed criterion 2. Figure 25 shows the variability of fecal coliform values over the 16 year sampling period. The red line shows the 100 CFU 100mL^{-1} geomean upper limit for WA.

Table 11. Calculated geomeans of fecal coliform levels (CFU/100mL) Lower Samish 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
LS1 Samish Bridge at 99	31.15	Pass	Fail	Does Not Pass Both
LS2 Jolly Road	36.90	Pass	Pass	Pass Both Standards
LS3 Chuckanut Bridge	40.50	Pass	Pass	Pass Both Standards
LS4 Boat Docks	39.77	Pass	Pass	Pass Both Standards

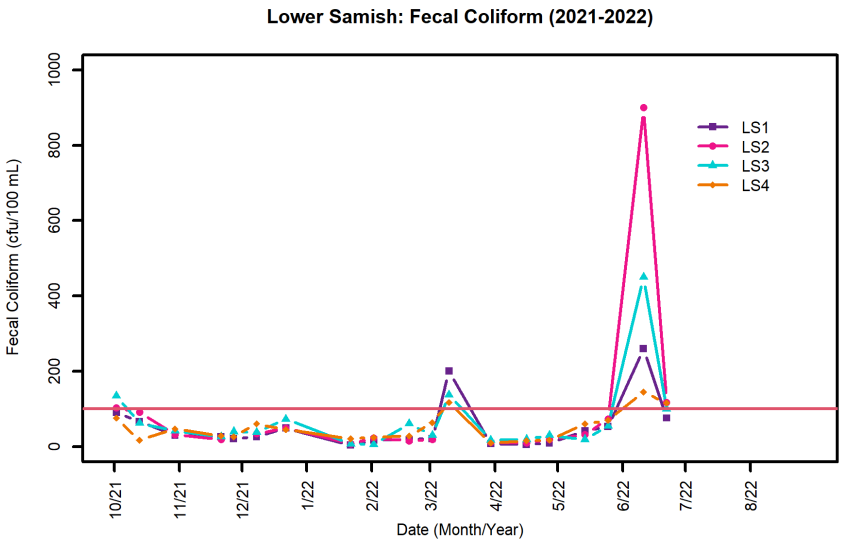

Figure 24. Lower Samish Fecal Coliform: 2021-2022

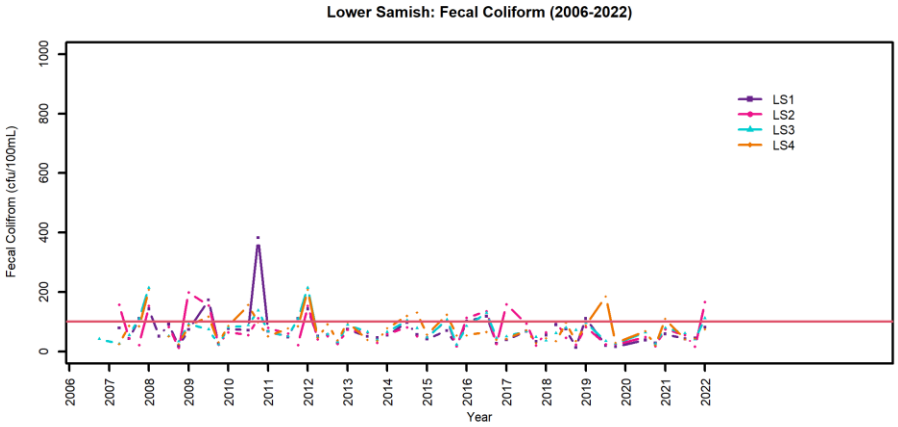

Figure 25. Lower Samish fecal coliform geometric means by season: 2006-2022

Upper Nookachamps Results

UN1 is at Lake McMurray, UN2, Big Lake, UN3, Otter Pond Rd, and UN4 is at Knapp Rd.

Dissolved oxygen

All sites except for UN3 at Otter Pond Road had DO levels below 9.5 mg L^{-1} in October 2021, with UN1 at Lake McMurray and UN4 at Knapp Road staying as low as 3 mg L^{-1} throughout the fall (Figure 26). As in years past, UN1 levels were consistently lower than the other sites throughout the sampling season, dropping to 5 mg L-1 in late May 2022. Site UN4 also dipped back below 9.5 mgL^{-1} at this time. Sites were not sampled in summer months when dissolved oxygen is expected to be lowest. Seasonal DO averages, not just single measurements in this basin continue to consistently fall below the single day lowest minimum, **indicating a serious long-term danger for salmonids.** The red line shows the minimum single day low for this waterway.

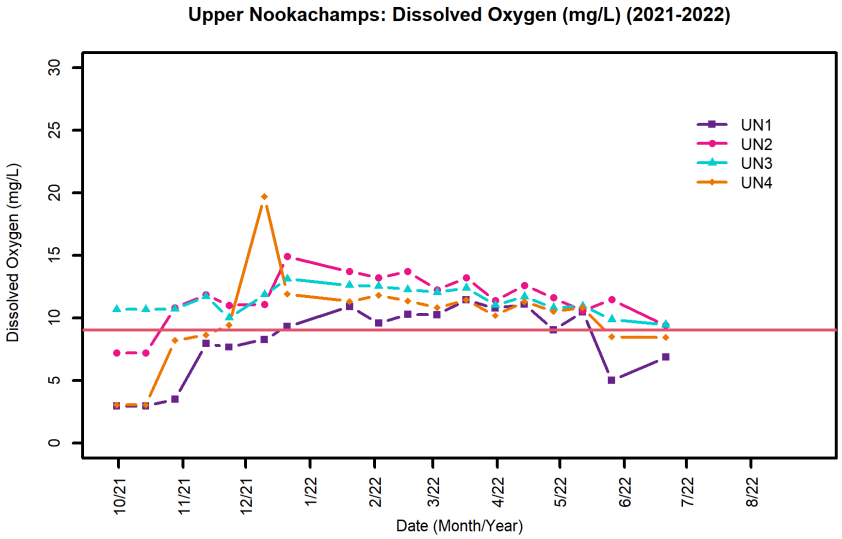

Figure 26. Dissolved oxygen (mg L^{-1}) Upper Nookachamps 2021-2022

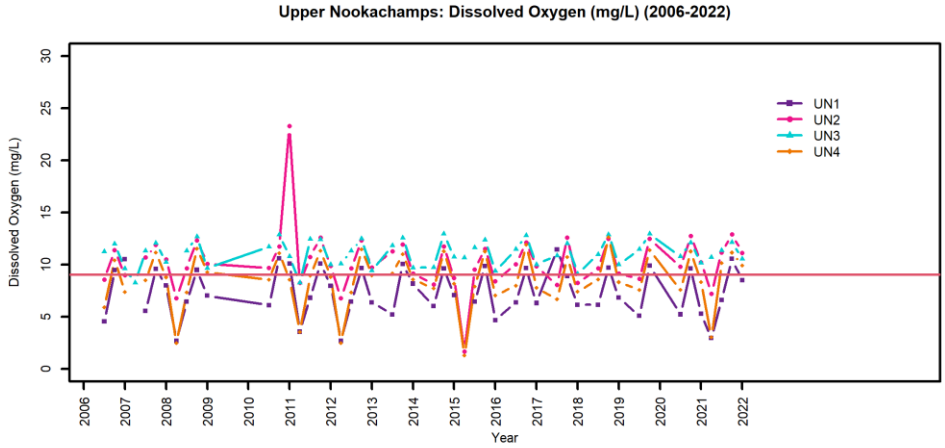

Figure 27. Upper Nookachamps dissolved oxygen (mg L^{-1}) averages by season: 2006-2022

Temperature

Temperatures for Upper Nookachamps sites stayed below the standard of 16° C until June 2022 (Figure 28). Samples were not taken during the summer. Seasonal average temperatures over 16 years remain consistent for all Upper Nookachamps sites, reaching near or slightly above the standard in late spring,

though seasonal averages for 2021-2022 remained below the maximum (Figure 29). The red line shows the maximum 7-day average for this waterway.

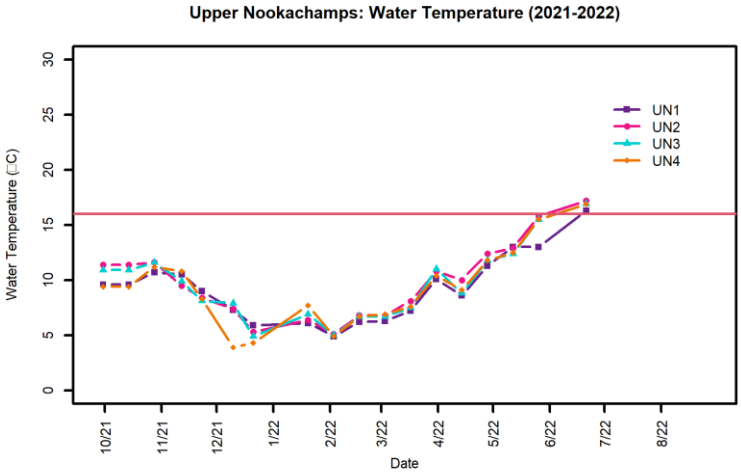

Figure 28. Upper Nookachamps Temperature: 2021-2022

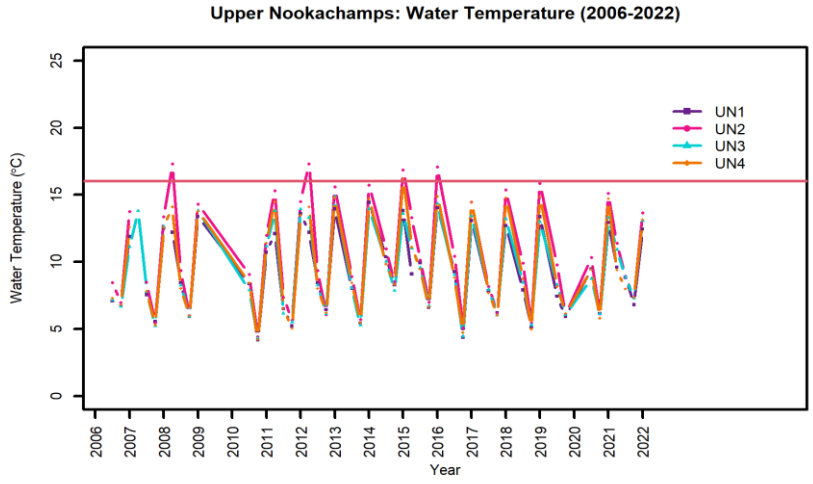

Figure 29. Upper Nookachamps water temperature averages by season: 2006-2022.

Turbidity

Turbidity levels remained low in all sites throughout the fall-spring 2021-2022 sampling season, with just one site, UN3 at Otter Pond, rising to 48NTU in March (Figure 30). Seasonal averages over 16 years show consistent turbidity levels between 0 and 20 NTU (Figure 31).

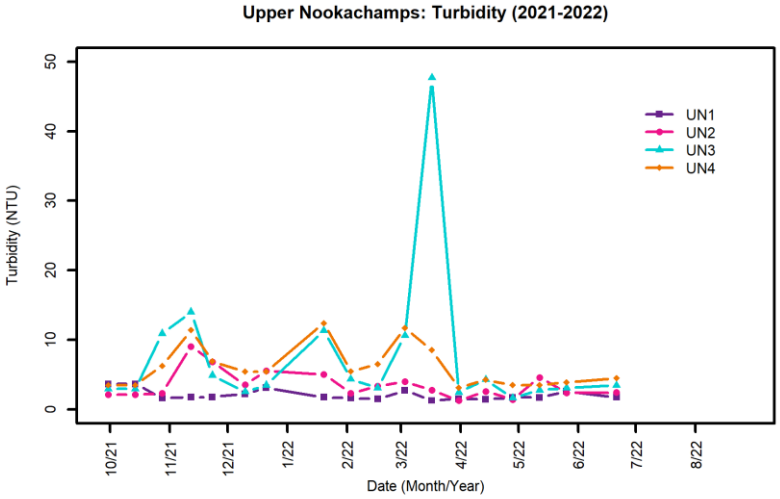

Figure 30. Upper Nookachamps turbidity spring-fall, 2021-2022

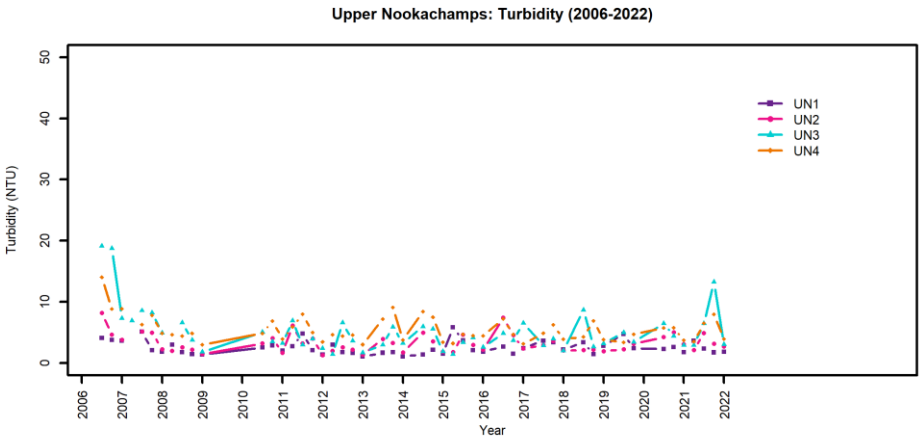

Figure 31. Upper Nookachamps average turbidity levels by season: 2006-2022

Fecal Coliform

Fecal coliform levels for the Upper Nookachamps passed both standards criteria in all sites except for UN3 at Otter Pond Rd, where more than 10% of samples had more than 200 CFU/100mL (Table 12; Figure 32). Fecal coliform values at UN3 and UN4 remained lower in the last few years than in most previous sampling years since 2006 (Figure33). The red line shows the 100 CFU $100mL^{-1}$ geomean upper limit for WA.

Table 12. Calculated geomeans of fecal coliform levels (CFU/100mL) Upper Nookachamps 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
UN1	8.30	Pass	Pass	Pass Both Standards
UN2	9.73	Pass	Pass	Pass Both Standards
UN3	24.40	Pass	Fail	Does Not Pass Both
UN4	42.09	Pass	Pass	Pass Both Standards

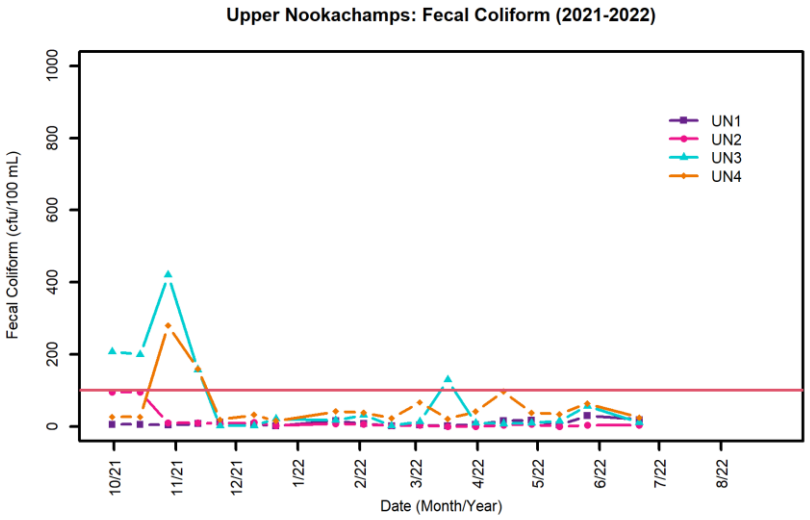

Figure 32. Upper Nookachamps Fecal Coliform: 2021-2022

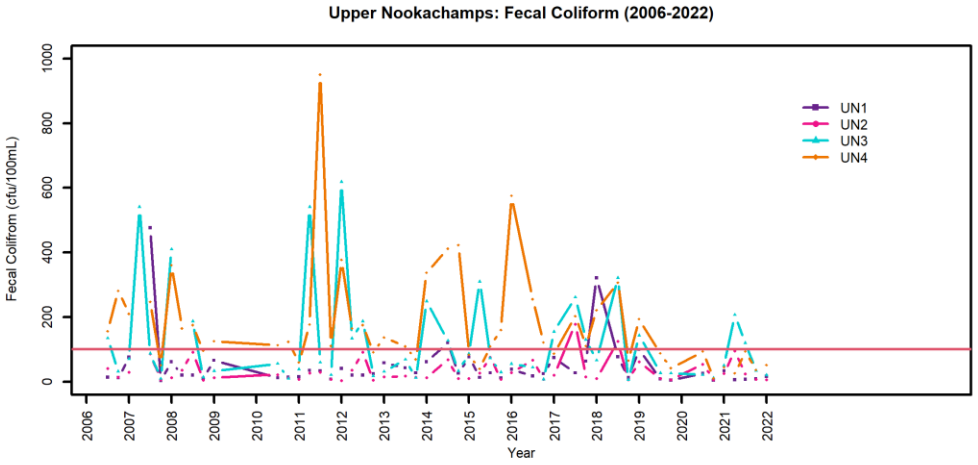

Figure 33. Upper Nookachamps Creek fecal coliform geometric means by season: 2006-2022.

Lower Nookachamps Results

LN1 is at College Way, LN2, Highway 9, LN3, Swan Rd, and LN4 is at Francis Road.

Dissolved oxygen

All Lower Nookachamps Creek sites had similar dissolved oxygen levels in 2021-2022 (Figure 34). All sites but LN1 at College Way were below the single day lower limit in October 2021. Site LN1 was below standard once in May and June 2022. LN2 at Swan Rd. was below standard in June 2022. These results followed the trend seen over 16 years of sampling (Figure 35). The red line shows the maximum 7-day average for this waterway.

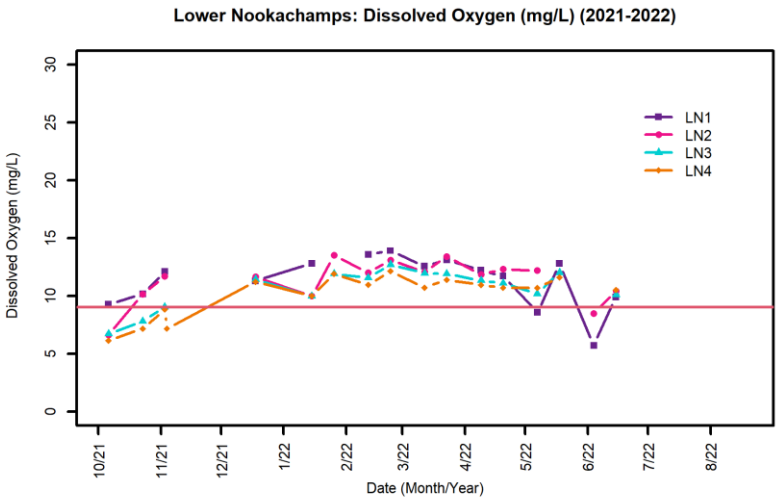

Figure 34. Lower Nookachamps DO, 2021-2022

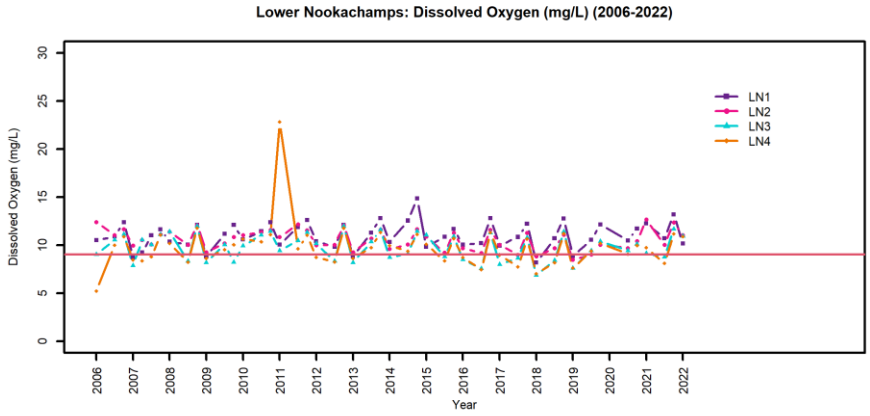

Figure 35. Lower Nookachamps dissolved oxygen (mg L^{-1}) averages by season: 2006-2022

Temperature

Temperatures for all sites were similar and below the state standard of 16°C during fall-spring sampling, except for LN2 at Highway 9 in June (Figure 36). No samples were taken during the warmest summer months. These data followed the trend seen over 16 sampling years (Figure 37). The red line shows the maximum 7-day average for this waterway.

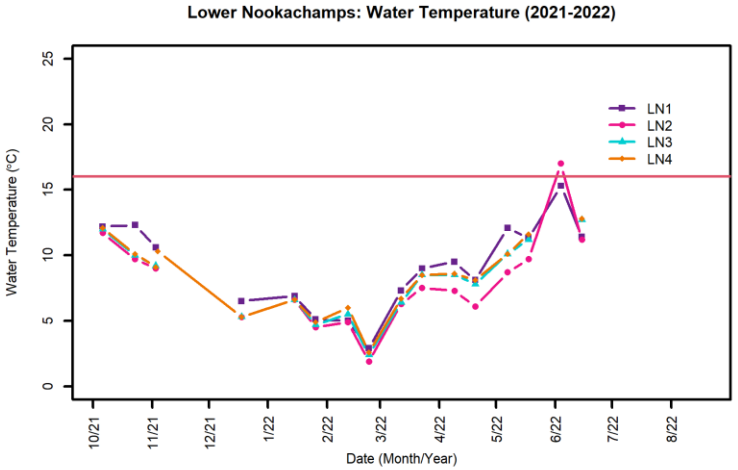

Figure 36. Lower Nookachamps Temperature: 2021-2022

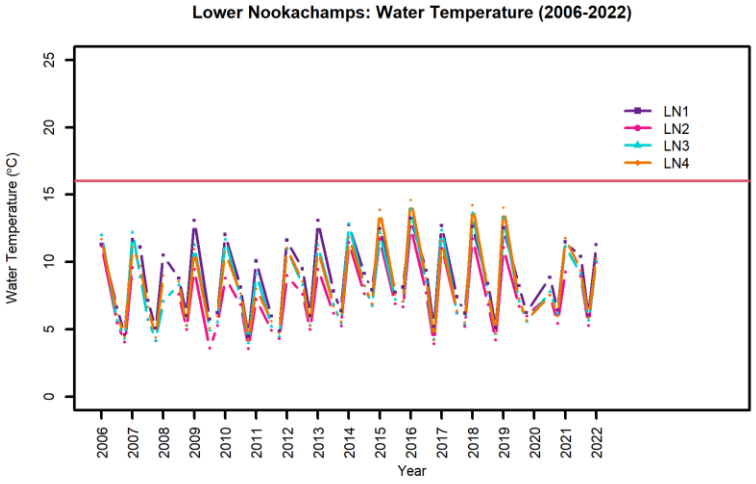

Figure 37. Upper Nookachamps water temperature averages by season: 2006-2022

Turbidity

Turbidity levels were below 30 NTU throughout the fall-spring sampling (Figure 38). These samples align with average seasonal means over 16 years of sampling (Figure 39).

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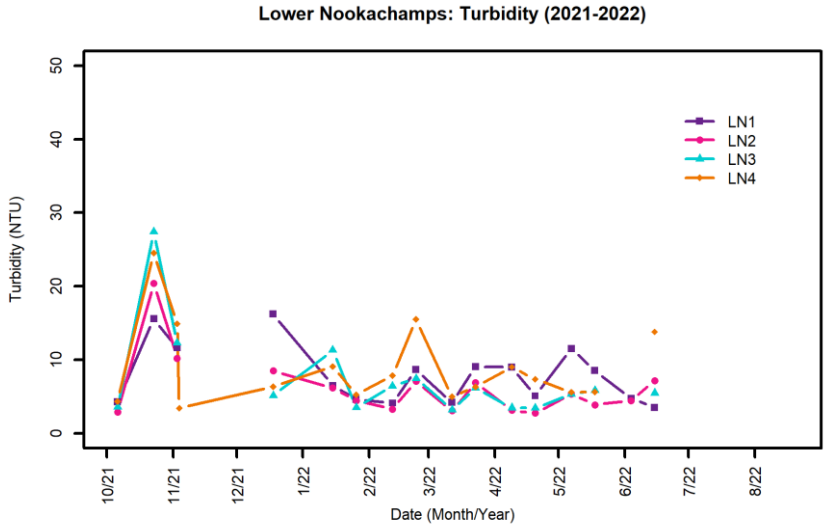

Figure 38. Lower Nookachamps turbidity, 2021-2022

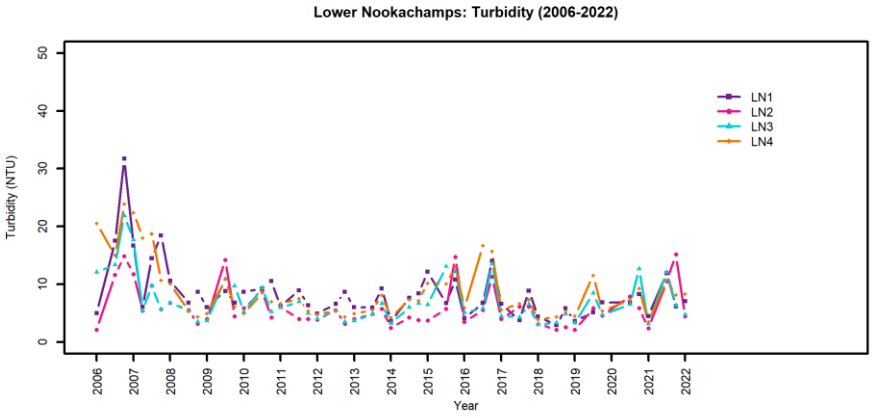

Figure 39. Lower Nookachamps Turbidity average turbidity levels by season: 2006-2022

Fecal coliform

Fecal coliform levels for the Lower Nookachamps passed both standards criteria in all sites except for LN1 at College Way, where it failed both criteria (Table 13; Figure 40). Site LN1 Fecal coliform geometric means by season remain above standard and higher than other sites this year, as over most of the last 16 years of sampling (Figure 41). THIS WATERWAY REQUIRES ATTENTION. The red line shows the 100 CFU 100mL-1 geomean upper limit for WA.

Table 13. Calculated geomeans of fecal coliform levels (CFU/100mL) Lower Nookachamps 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
LN1 College Way	187.9888	Fail	Fail	Does Not Pass Both
LN2 Hwy 9 Bridge	46.57576	Pass	Pass	Pass Both Standards
LN3 Swan Road	31.64794	Pass	Pass	Pass Both Standards
LN4 Francis Road	49.57598	Pass	Pass	Pass Both Standards

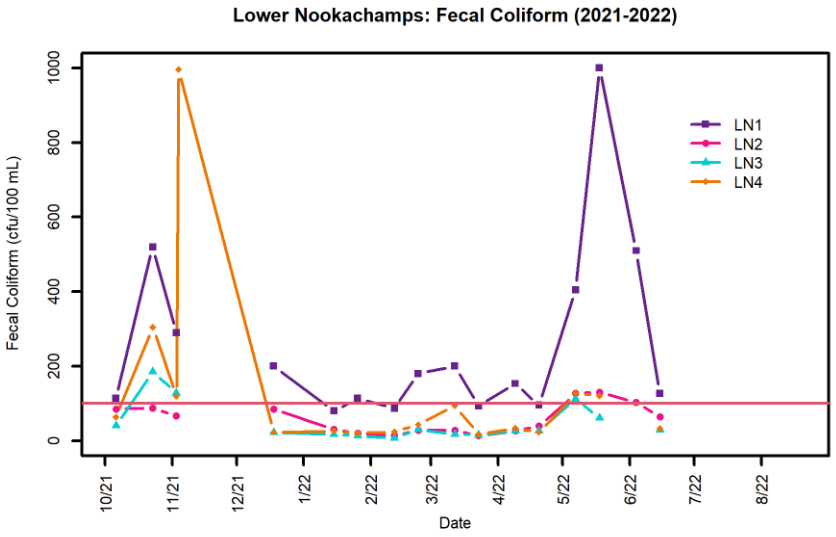

Figure 40. Lower Nookachamps Fecal Coliform: 2021-2022

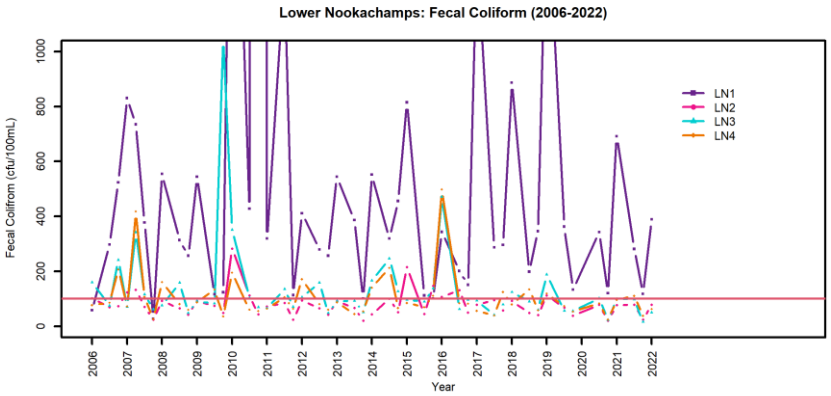

Figure 41. Lower Nookachamps fecal coliform geometric means by season: 2006-2022

No Name Slough Results

NNS1 is at Marihugh Road, NNS2, Marihugh and Bayview-Edison Rd., NNS3, Egbers Field, and NNS4, at the Field culvert.

Dissolved oxygen

Outside of late fall and winter, dissolved oxygen levels fell below the state standard of 8mg L-1 for this water way at all sites throughout much of the sampling season (Figure 42). NNS1 rose above the limit on one sampling day in April and NNS4 did so in late June. The upper stream dries up in early summer. NNS1 and 2 had the highest average DO consistently since sampling began in 2006, whereas NNS3 and 4 frequently drop below the standard (Figure 43). The red line shows the single day lower limit for aquatic species in this waterway.

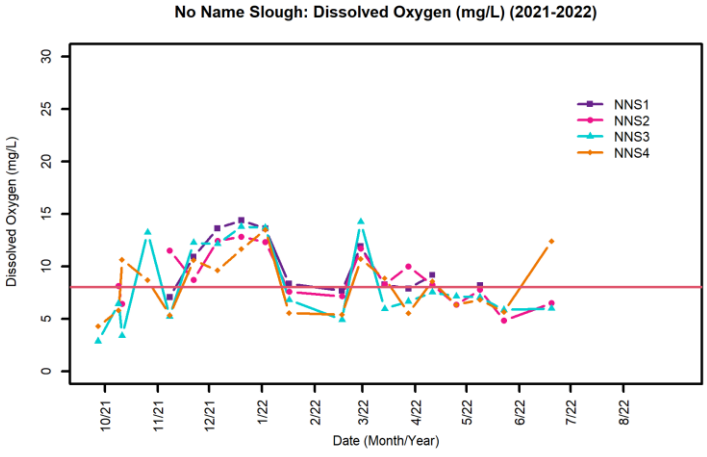

Figure 42. Dissolved oxygen (mg L^{-1}) in No Name Slough in 2021-2022

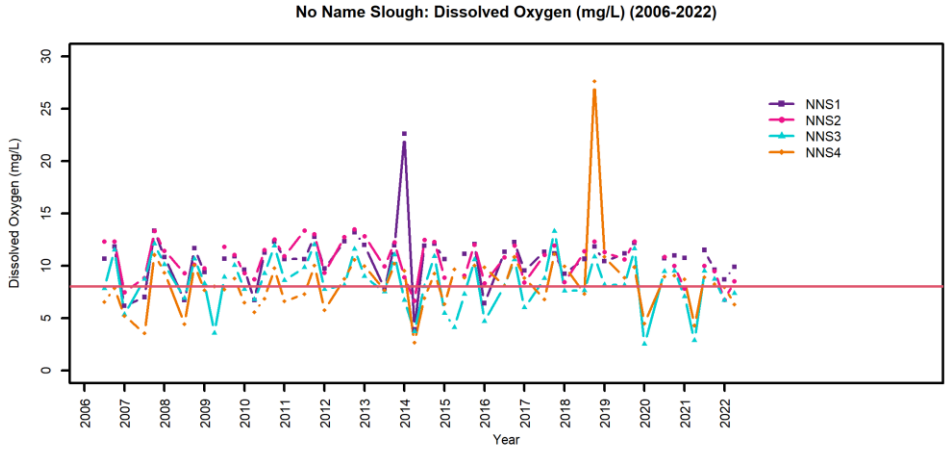

Figure 43. No Name Slough dissolved oxygen (mg L^{-1}) averages by season: 2006-2022

Temperature

Temperatures at No Name Sites 1-3 were within the optimum range of <17.5°C throughout the sampling period (Figure 44). No samples were taken during the warmest summer season when temperatures were most likely above state standard. Seasonal average temperatures remain aligned with the trend over the past 16 sampling years (Figure 45). The red line shows the maximum 7-day average for this waterway.

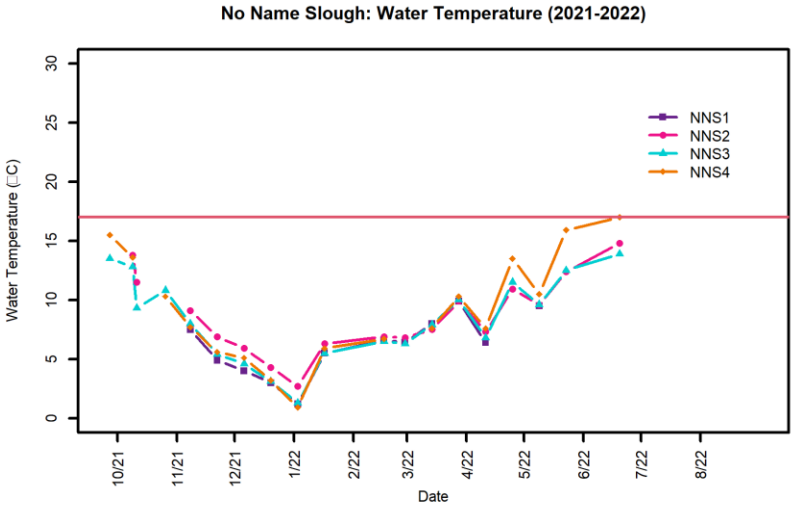

Figure 44: No Name Slough Temperature: 2021-2022.

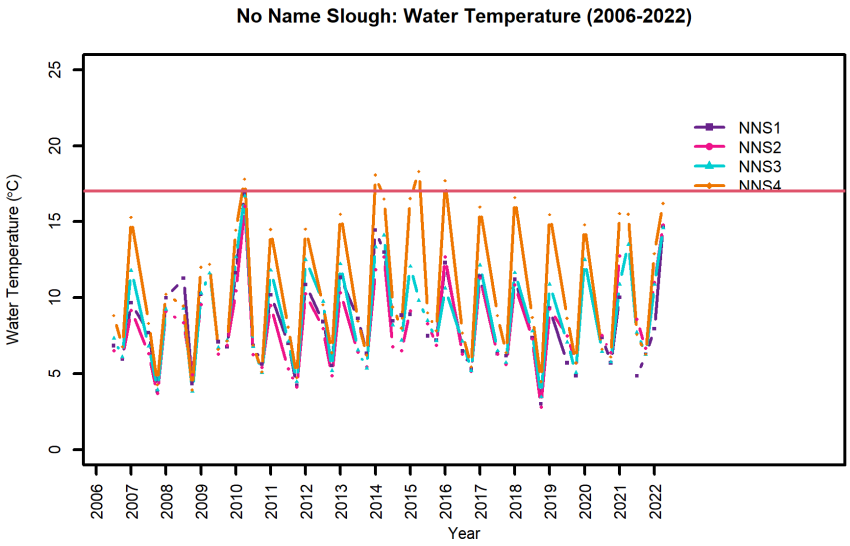

Figure 45. No Name Slough water temperature averages by season: 2006-2022

Turbidity

Turbidity levels were generally low during 2021-2022, except in late February 2022 when site NNS3 and 4 climbed to 103 and 158 respectively (Figure 46). Turbidity at these sites was higher in 2021-2022 than any previous sampling years (Figure 47).

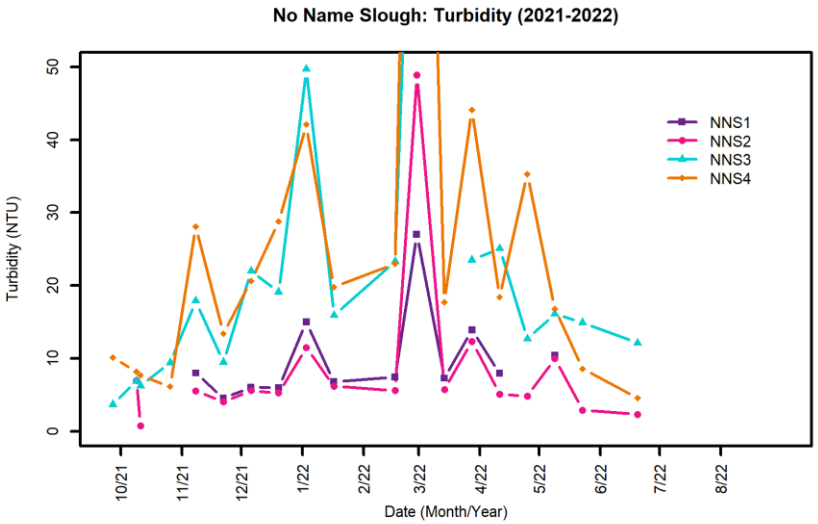

Figure 46. No Name Slough Turbidity: 2021-2022

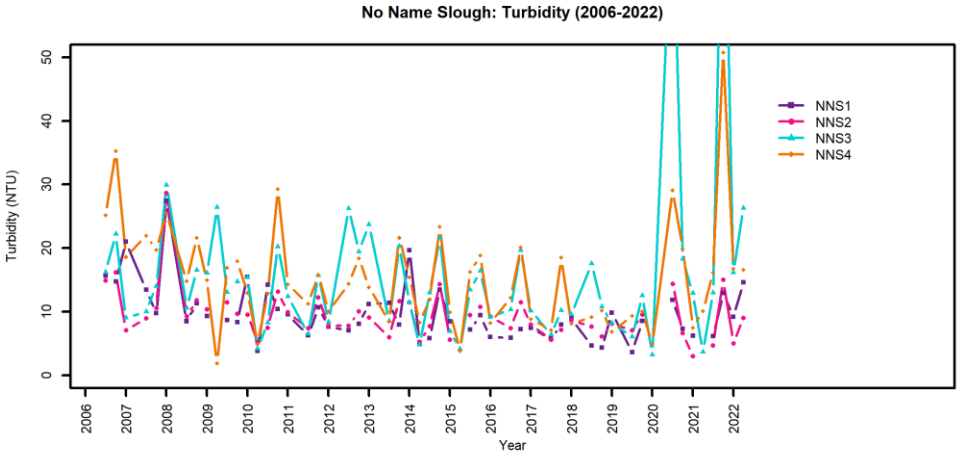

Figure 47. No Name Slough average turbidity levels by season: 2006-2022

Fecal coliform

All No Name Slough sites failed both fecal coliform criteria, except site NNS4 at Bayview-Edison Road, which passed only the part 1 criterion (Table 14; Figure 48). This site has exceeded the upper limit for fecal coliform over all sampling years (Figure 49). **THIS WATERWAY REQUIRES INTERVENTION.** The red line shows the 100 CFU 100mL^{-1} geomean upper limit for WA.

Table 14. Calculated geomeans of fecal coliform levels (CFU/100mL) No Name Slough 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
NNS1 Marihugh Road Culvert	113.88	Fail	Fail	Does Not Pass Both
NNS2 Bayview Road Ravine	18.84	Pass	Fail	Does Not Pass Both
NNS3 Egber's Field Bridge	104.40	Fail	Fail	Does Not Pass Both
NNS4 Culvert, Bayview-Edison Road	87.55	Pass	Fail	Does Not Pass Both

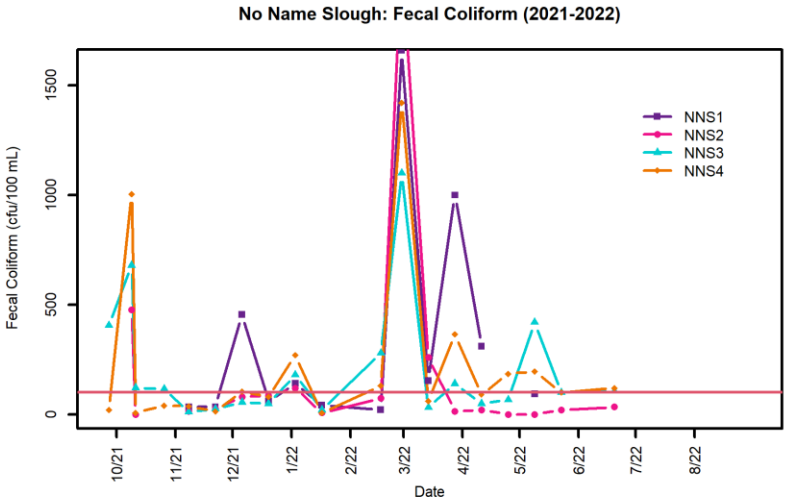

Figure 48. No Name Slough Fecal Coliform: 2021-2022

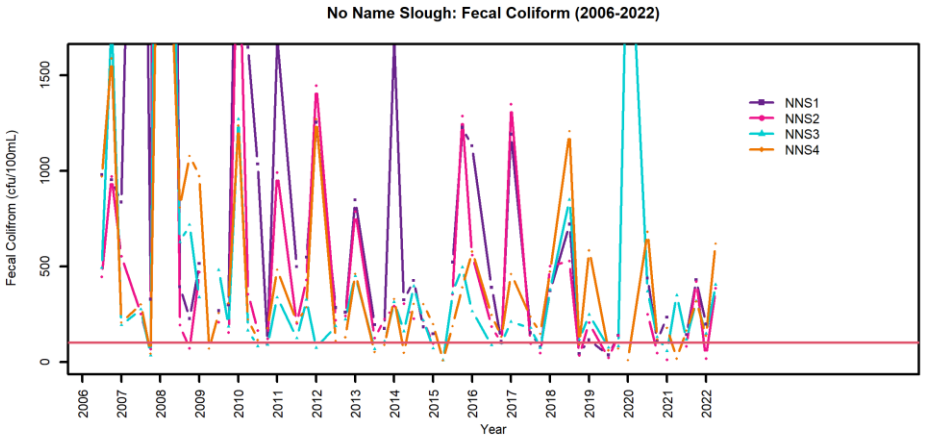

Figure 49. No Name Slough fecal coliform geometric means by season: 2006-2022

Bay View Drainage Results

In the Bay View drainage, sites 1-3 are roadside ditches that dry up between rainy periods and at these times site 4 is often without water due to low tide. BV1 is at Walker Rd., BV2, C St., BV3, Bayview boat launch, and BV4 is at Bayview State Park.

Dissolved Oxygen

Dissolved oxygen remained above standard in all sites that were able to be sampled throughout fall-spring sampling period, except site BV2, which was below standard in early November, 2021 (Figure 50). These data align with seasonal averages since sampling began in 2007, again with BV2 being the only site to (infrequently) fall below standard (Figure 51). The red line shows the minimum single day low for this waterway.

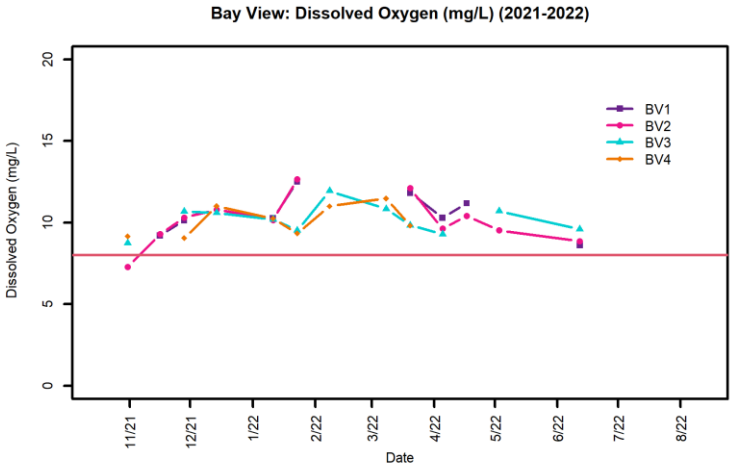

Figure 50. Bay View Drainage DO: 2021-2022

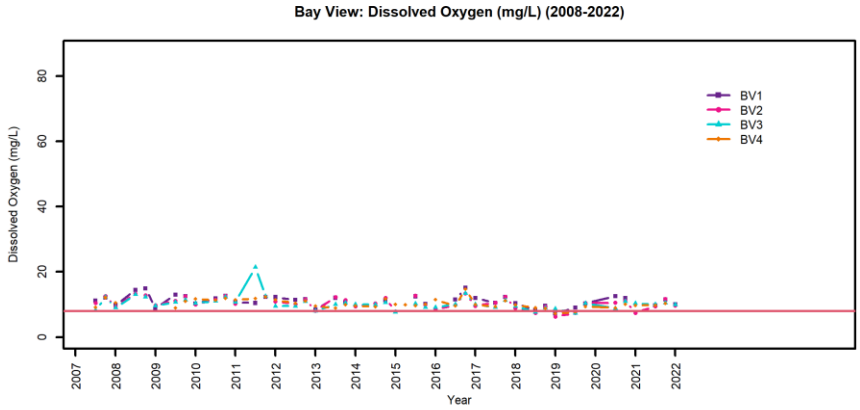

Figure 51. Bay View Drainage dissolved oxygen (mg L^{-1}) averages by season 2007-2022

Temperature

Temperatures in all Bayview sites remained below the maximum of 17.5°C during 2021-2022 sampling. Site BV4, where the drainage meets the bay, is usually higher than the other sites and is the only site where average seasonal temperatures exceeded the upper limit since sampling began in 2008 (Figure 53). The red line shows the maximum 7-day average for this waterway.

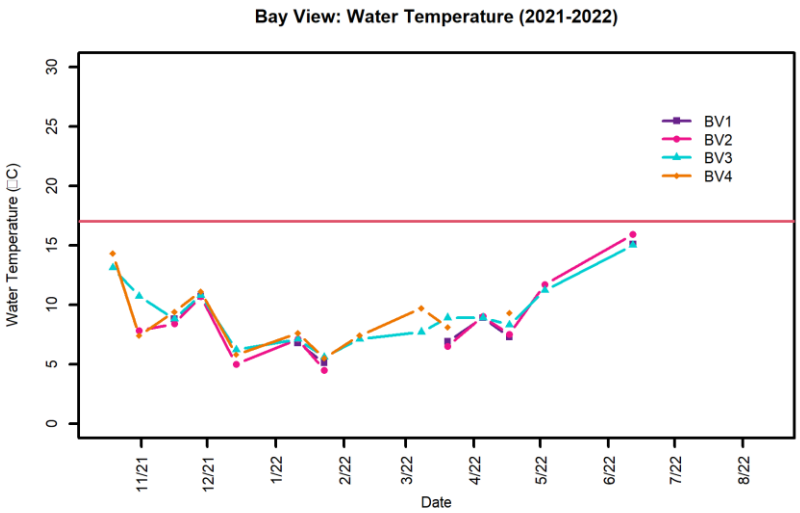

Figure 52. Bay View Drainage Temperature: 2021-2022

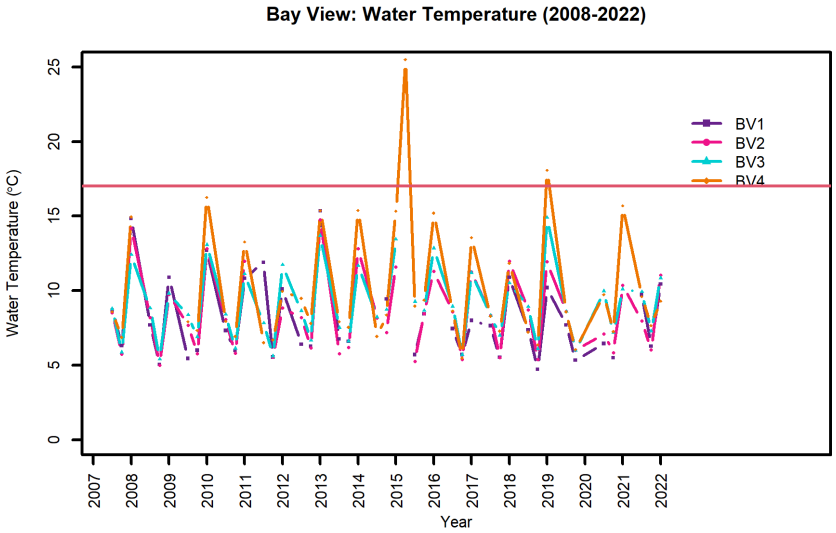

Figure 53. Bay View Drainage water temperature averages by season: 2006-2022

Turbidity

Turbidity levels remained mainly below 50 NTU at all sites in 2021-22 sampling season except for BV4, which reached 140NTU in December, and BV2 at C St., which reached over 40 and over 60 NTU in April and May respectively (Figure 54). Seasonal average turbidity levels have remained consistently low since sampling began in 2008 (Figure 55). Site BV4 winter average was the highest of all Bay View averages in 15 years.

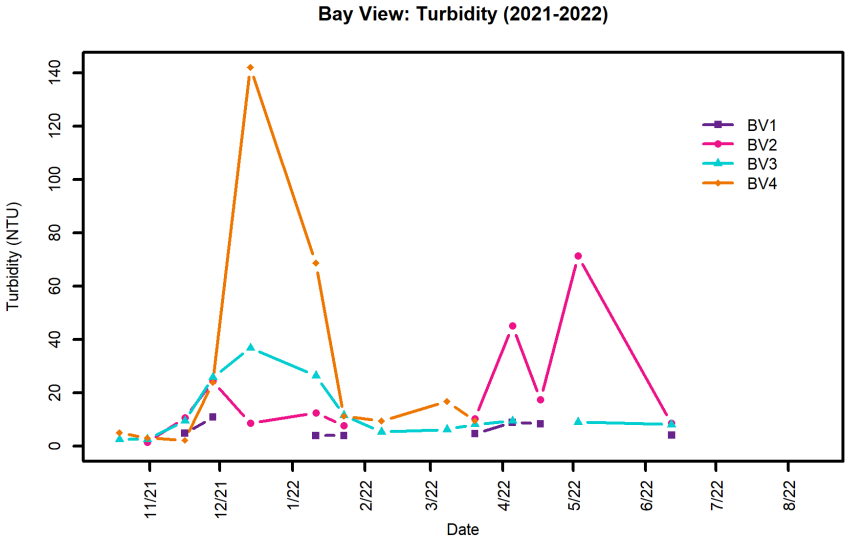

Figure 54: Bay View Turbidity 2021-2022

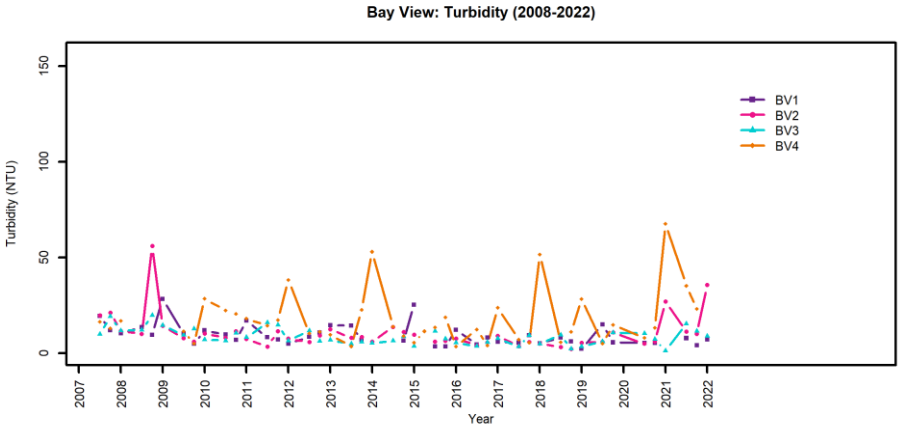

Figure 55. Bay View Drainage average turbidity levels by season: 2007-2022

Fecal coliform

It should be noted that there are many missing data for this drainage during the 2021-22 sampling seasons. Only one Bay View site, BV4 at the state park, passed both fecal coliform criteria during the 2021-22 sampling season (Table 15; Figure 56). The other sites each passed the part 1 criterion but failed part 2; more than 10% of samples exceeded 200 CFU 100mL^{-1}. Geometric means of fecal coliform levels were lower in this season than most previous years (Figure 57). Considering sparse data, the geometric means may be higher than shown for 2021-22 and based on this time series, it is likely that still **THIS WATERWAY REQUIRES ATTENTION.** The red line shows the 100 CFU 100mL^{-1} geomean upper limit for WA.

Table 15. Calculated geomeans of fecal coliform levels (CFU/100mL) Bay View 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
BV1 Walker Road	35.88	Pass	Fail	Does Not Pass Both
BV2 C Street	46.25	Pass	Fail	Does Not Pass Both
BV3 Boat Launch	64.39	Pass	Fail	Does Not Pass Both
BV4 State Park	35.90	Pass	Pass	Pass Both Standards

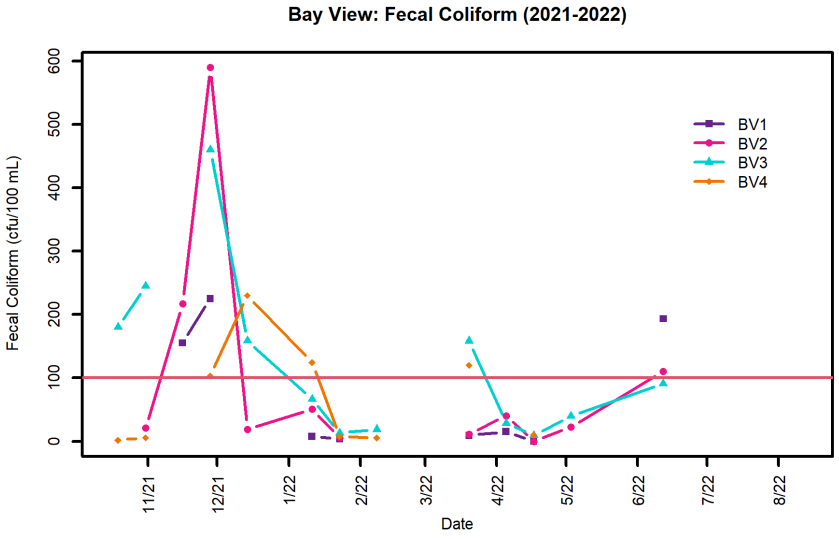

Figure 56. Bay View Drainage Fecal Coliform: 2021-2022

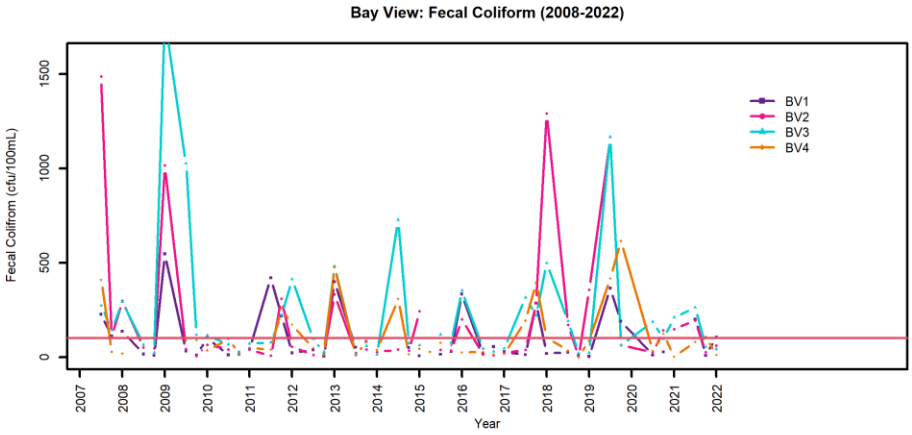

Figure 57. Bay View Drainage fecal coliform geometric means by season: 2008-2022

Joe Leary Slough Results

Joe Leary Slough flows slowly through flattened farmland without shaded riparian area from its headwaters along an industrial area in north Burlington all the way to its mouth in Padilla Bay. JL1 is at Dahlstedt Rd, JL2, Hwy 99 and Gear Rd, JL3, Wilson Rd. and Avon Allen, and JL4 is at the tide gate. The red line shows the minimum single day low for this waterway.

Dissolved oxygen

Consistent with all past sampling years, dissolved oxygen levels were consistently below standards for all sites, even during the cold winter months (Figures 58 and 59).

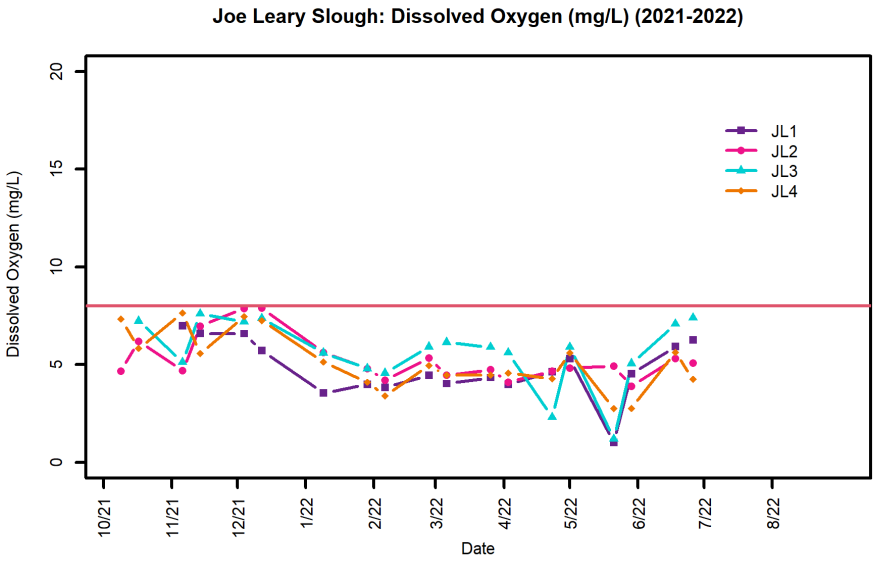

Figure 58. Joe Leary Slough DO: 2021-2022

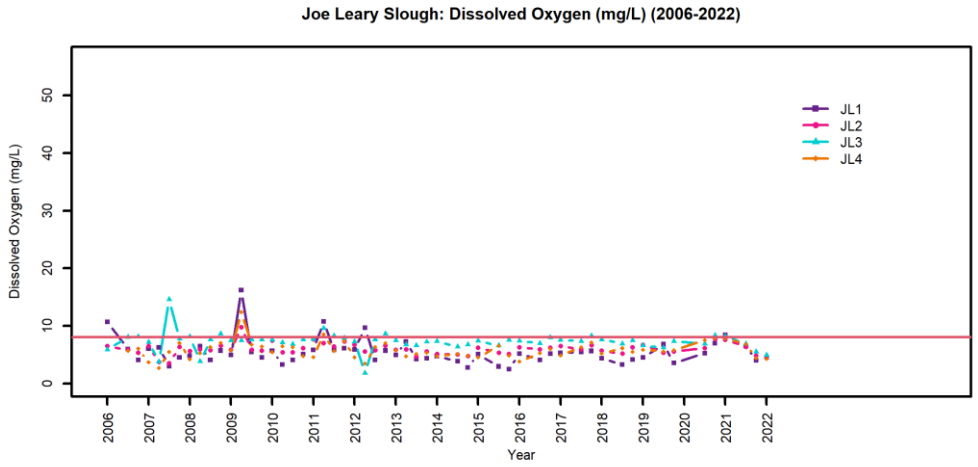

Figure 59. Joe Leary Slough dissolved oxygen (mg L^{-1}) averages by season 2006-2022.
Sites 1, 3 and 4 temperatures were above 17.5 °C in June. The red line shows the minimum single day low for this waterway.

Temperature

Temperatures were below the upper maximum through fall through spring of 2021-22 except during the final sampling in June at sites JL1, 3, and 4 (Figure 60). It is likely temperatures remained above the upper maximum during summer months when no sampling occurred. Fall-spring seasonal average temperatures consistently stay below the upper limit over time (Figure 61). The red line shows the maximum 7-day average for this waterway.

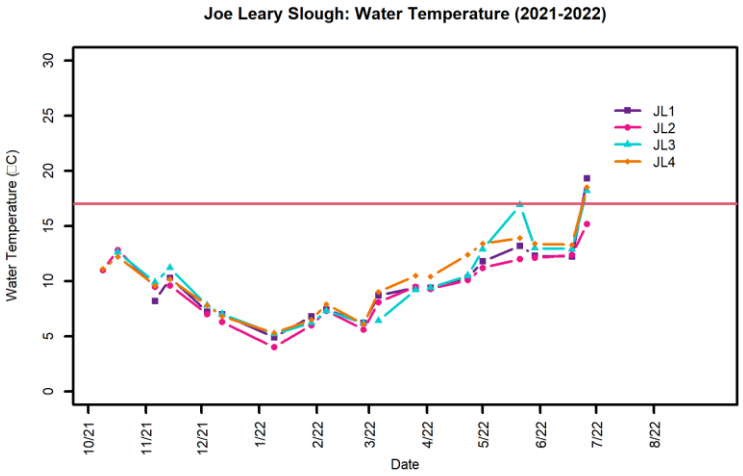

Figure 60. Joe Leary Slough Temperature: 2021-2022

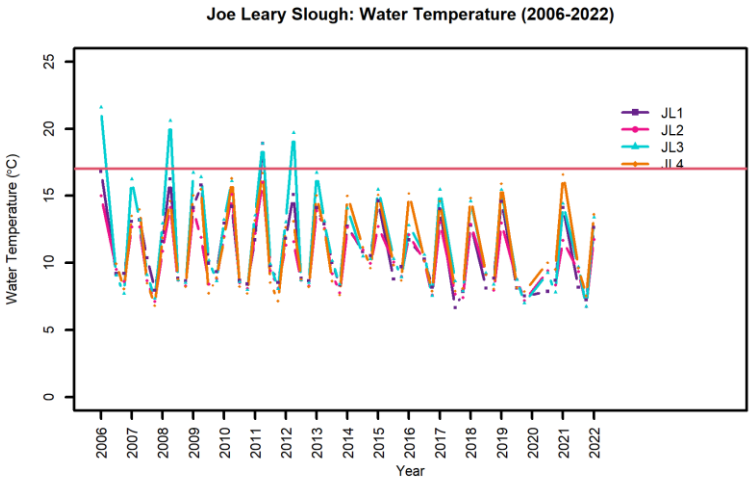

Figure 61. Upper Nookachamps water temperature averages by season: 2006-2022

Turbidity

In 2021-22 sampling, as in all other years, Joe Leary Slough saw the highest turbidity levels of all waterways in this survey (Figures 62 and 63). Note the higher y-axis scale limit compared to other turbidity figures. Site JL3 had higher seasonal average turbidity levels during this sampling period compared to any past years (Figure 63).

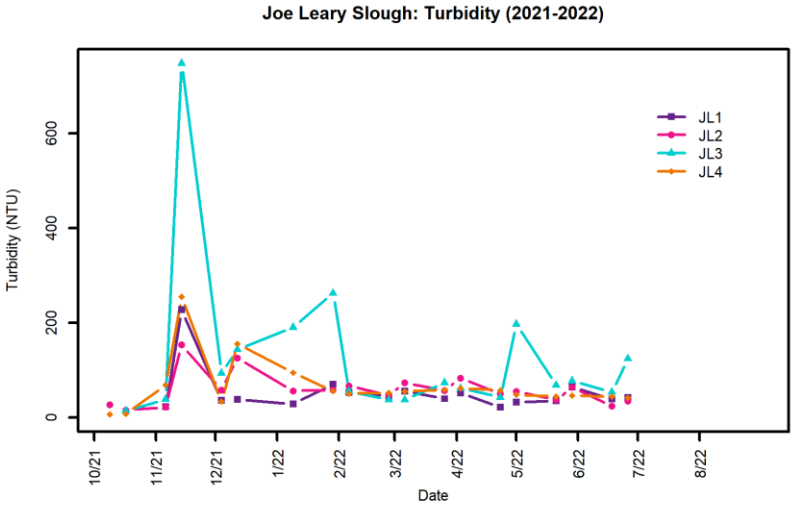

Figure 62. Joe Leary Slough Turbidity: 2021-2022.

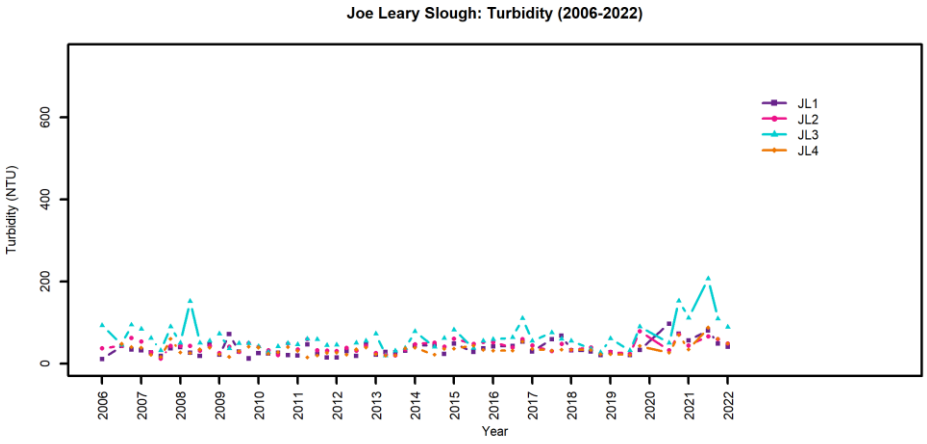

Figure 63. Joe Leary Slough average turbidity levels by season: 2006-2022.

Fecal coliform

No sites in Joe Leary Slough passed the Part 2 fecal coliform limit criterion and site JL3 at Wilson Rd failed both (Table 16). Site JL2 at Highway 99 had levels too numerous to count in November 2021 (Figure 64). This site has been consistently above upper limits since sampling began in 2006 (Figure 65).

Table 16. Calculated geomeans of fecal coliform levels (CFU/100mL) Joe Leary Slough 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
JL1 Dahlstedt Road	84.24	Pass	Fail	Does Not Pass Both
JL2 Hwy 99 at Gear Road	151.15	Fail	Fail	Does Not Pass Both
JL3 Wilson/Avon Allen	70.81	Pass	Fail	Does Not Pass Both
JL4 Tide Gate	72.87	Pass	Fail	Does Not Pass Both

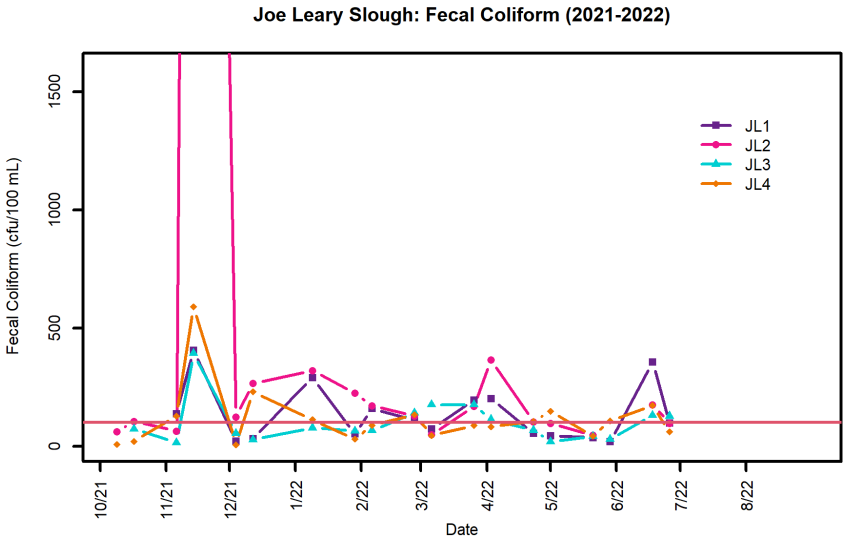

Figure 64. Joe Leary Slough Fecal Coliform: 2021-2022

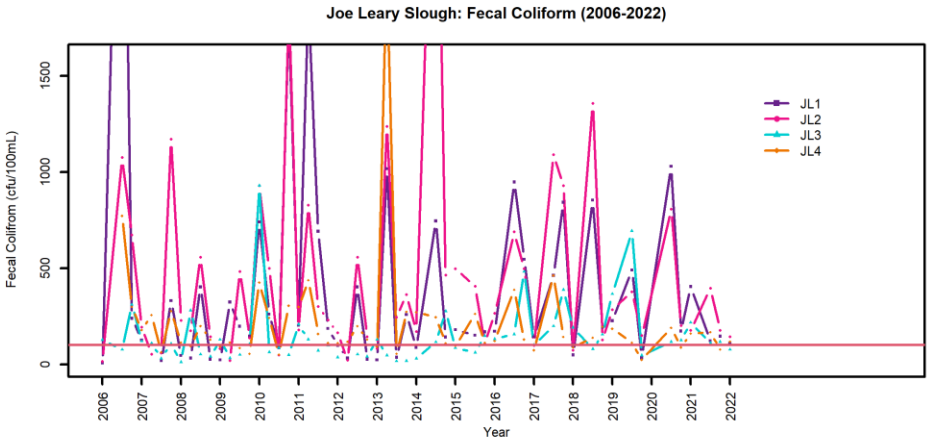

Figure 65. Joe Leary Slough fecal coliform geometric means by season (fall-spring) from 2006-2022

Trumpeter Basin Results

Site TC1 is at Stonebridge Adult Community, TC2, Frazier Home, College Way, TC3, Summerson Nursery, TC4, Kiowa St, and TC5 is at Bakerview Park.

Dissolved oxygen

Dissolved oxygen levels remained above the single day minimum of 9.5mg L-1 at all sites except TC3 and 5 in October 2021 and TC5 alone at the end of June 2022 (Figure 66). Seasonal average DO remained above standard as in most years since 2007, with site TC5 being one of the highest (Figure 67).

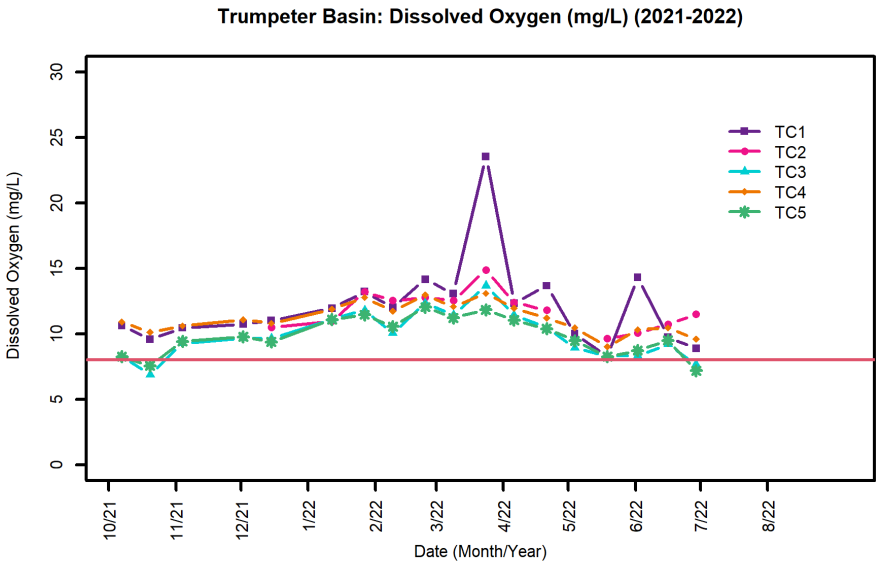

Figure 66. Trumpeter Basin DO: 2021-2022

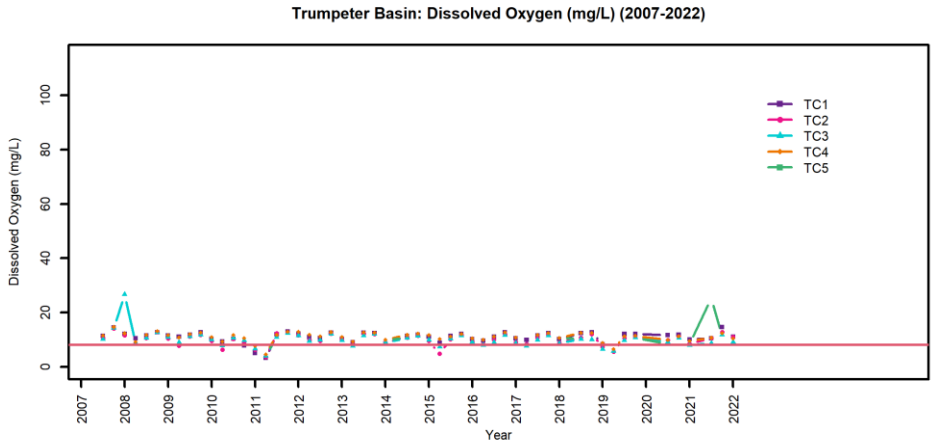

Figure 67. Trumpeter Basin dissolved oxygen (mg L^{-1}) averages by season:2007-2022

Temperature

Water temperatures were similar and remained below upper limits at all sites during fall-spring 2021-22 (Figure 68). Seasonal temperatures were lower on average than in previous sampling years (Figure 69). The red line shows the maximum 7-day average for this waterway.

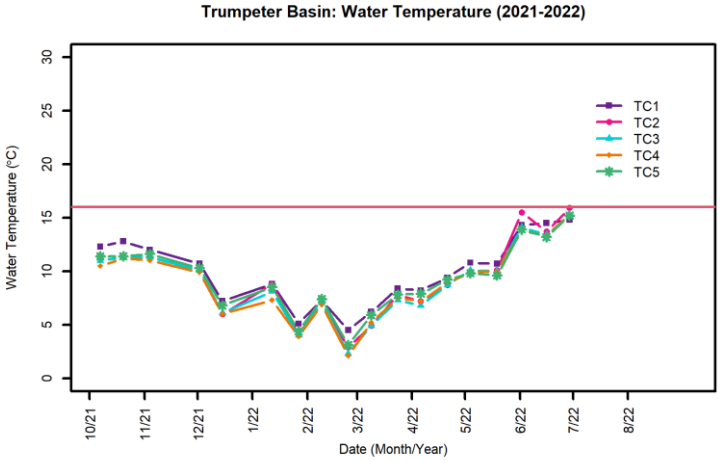

Figure 68. Trumpeter Basin Temperature: 2021-2022

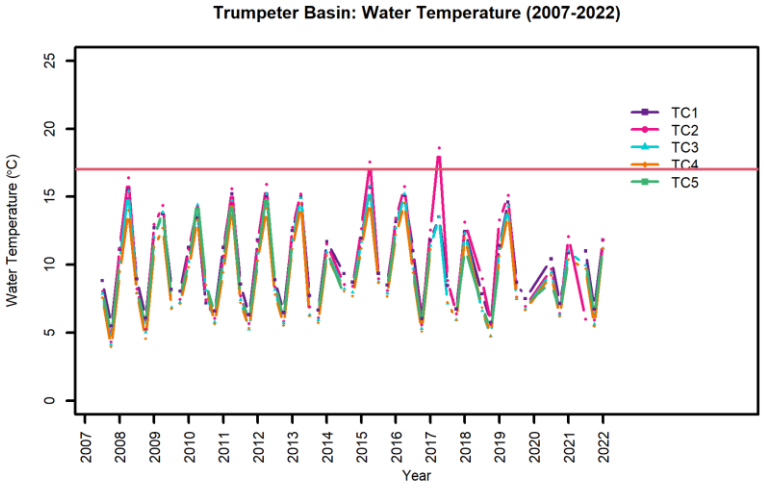

Figure 69. Upper Nookachamps water temperature averages by season:2007-2022

Turbidity

Turbidity levels for Trumpeter Basin were below 40 NTU for all sites during 2021-22 sampling seasons (Figure 70). This sampling year's seasonal average turbidity levels are in keeping with all previous sampling years, which have never exceeded 50 NTU (Figure 71).

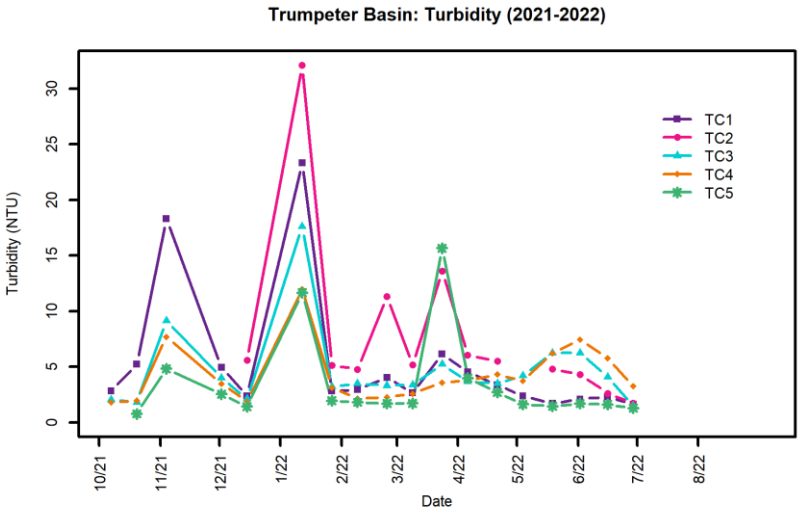

Figure 70. Trumpeter Basin Turbidity: 2021-2022

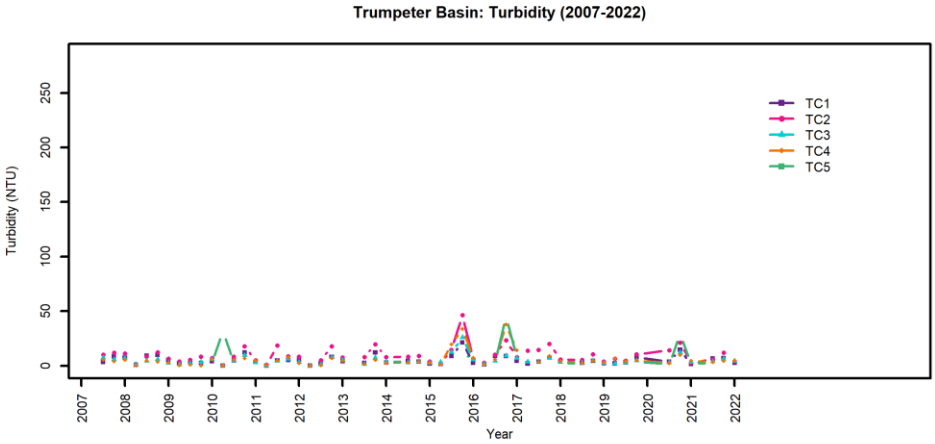

Figure 71. Trumpeter Basin average turbidity levels by season:2007-2022

Fecal coliform

Fall-spring sampling again yielded failures to pass the Part 2 criterion at all sites and both Part 1 and Part 2 criteria at site TC3 at Summerson Nursery (Table 17 and Figure 72). This basin has remained

consistently above standards since sampling began in 2007 (Figure 73). **THIS WATERWAY REQUIRES ATTENTION.** The red line shows the 100 CFU 100mL^{-1} geomean upper limit for WA.

Table 17. Calculated geomeans of fecal coliform levels (CFU/100mL) Trumpeter Basin 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
TC1 Stonebridge Adult Comm.	171.9488	Fail	Fail	Does Not Pass Both
TC2 Frazier Home	48.89814	Pass	Fail	Does Not Pass Both
TC3 Summerson Nursery	163.736	Fail	Fail	Does Not Pass Both
TC4 Kiowa Street	48.56149	Pass	Fail	Does Not Pass Both
TC5 Bakerview Park	31.20004	Pass	Fail	Does Not Pass Both

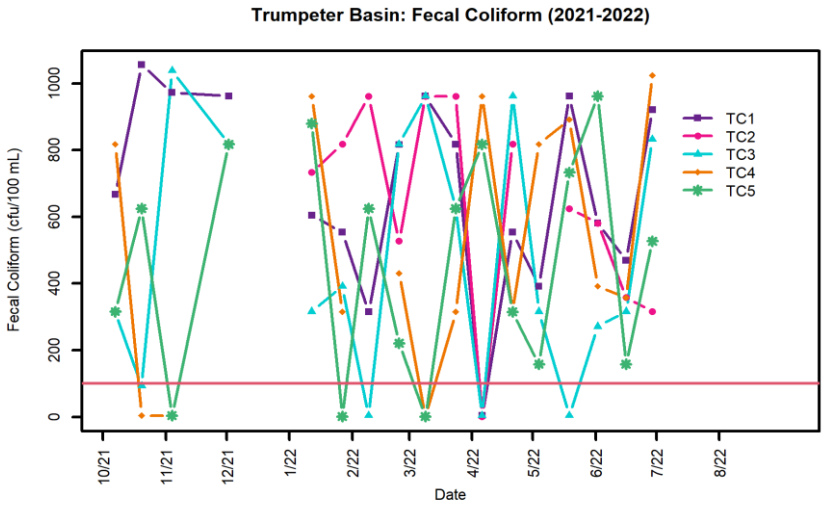

Figure 72. Trumpeter Basin Fecal Coliform: 2021-2022

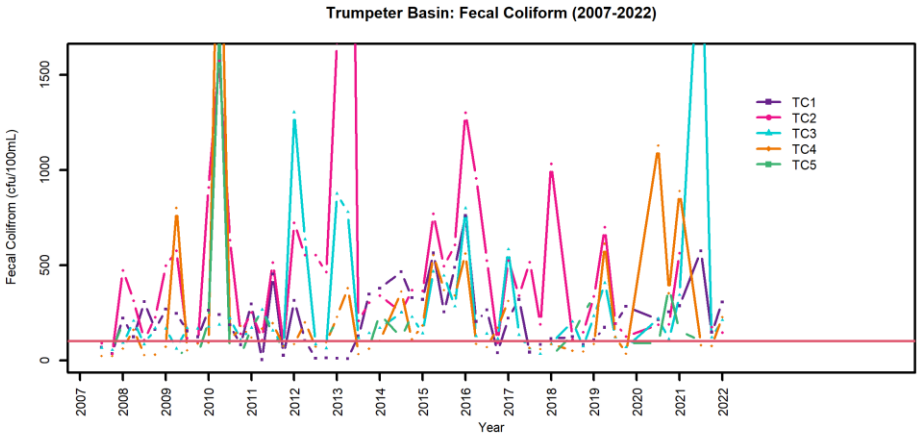

Figure 73: Trumpeter Basin fecal coliform geometric means by season: 2007-2022.

Kulshan Creek Results

Kulshan Creek (KC) site 1 is at the North end of S 14th .Kulshan Trail. KC2 is at Parker Way. KC3 is at Roosevelt. KC4 is East of Riverside north of RR crossing. KC5 is at Lions Park.

Dissolved oxygen

As in past years, DO in all Kulshan Creek sites went below the state standard of 9.5mg L^{-1} this sampling year (Figure 74). Site 3 remained well below standard most of the year. This creek has had below standard seasonal average DO levels in sites KC2-5 throughout its Stream Team sampling history (Figure 75). The red line shows the minimum single day low for this waterway.

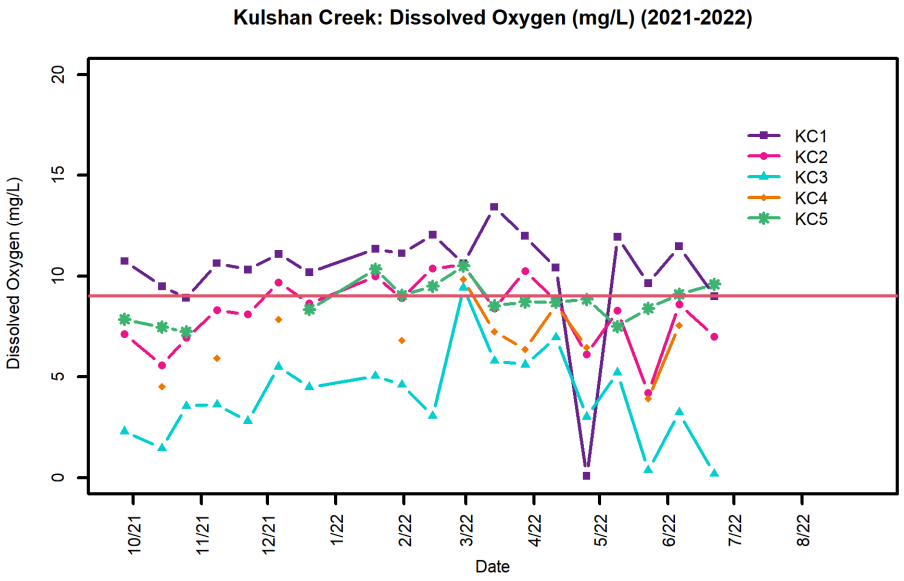

Figure 74. Kulshan Creek DO: 2021-2022

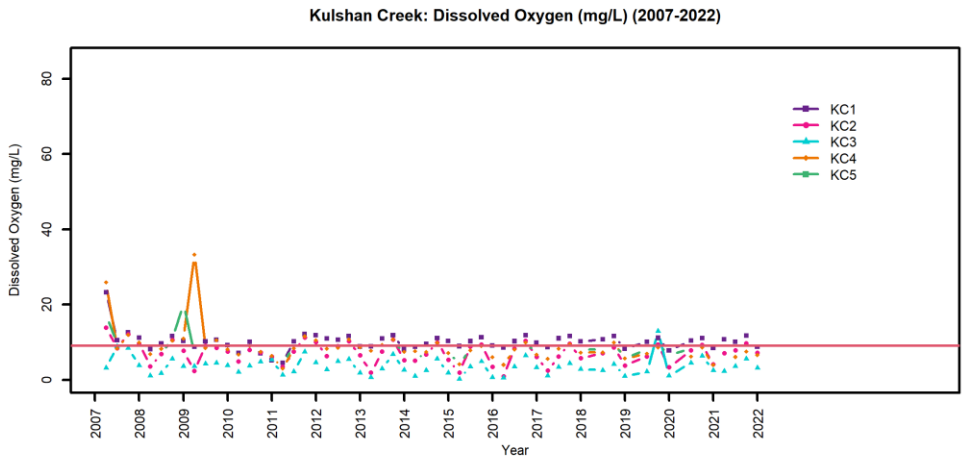

Figure 75. Kulshan Creek dissolved oxygen (mg L^{-1}) averages by season (fall-spring) from 2007-2022

Temperature

Temperatures remained below upper limits in Kulshan Creek during fall-spring 2021-22 (Figure 76). These likely climbed above standard during summer months when no sampling occurred. Seasonal average temperatures follow this same pattern of raising to or slightly above the upper limit in late spring and starting at or above in fall (Figure 77). The red line shows the maximum 7-day average for this waterway.

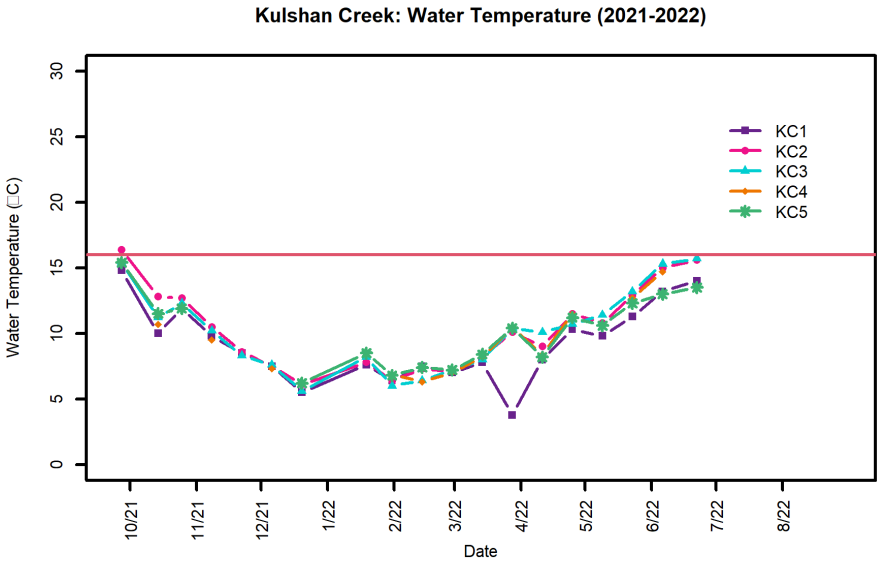

Figure 76. Kulshan Creek Temperature: 2021-2022

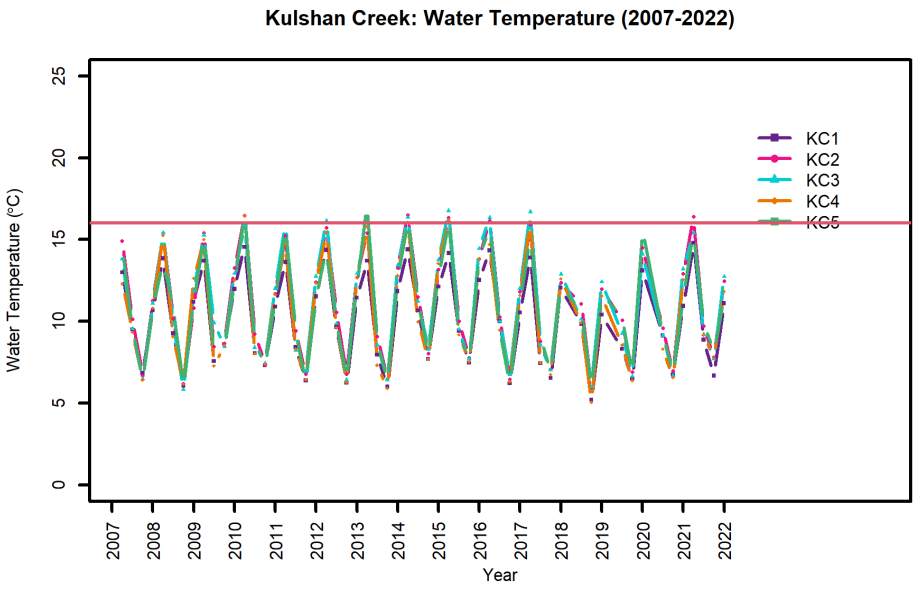

Figure 77. Upper Nookachamps water temperature averages by season:2007-2022.

Turbidity

Turbidity for Kulshan Creek was generally lower than most streams, with one mild rise to between 50 and 80 NTU at all sites (Figure 78). Seasonal average turbidity levels have remained below 40 NTU over all sampling years since 2007 (Figure 79).

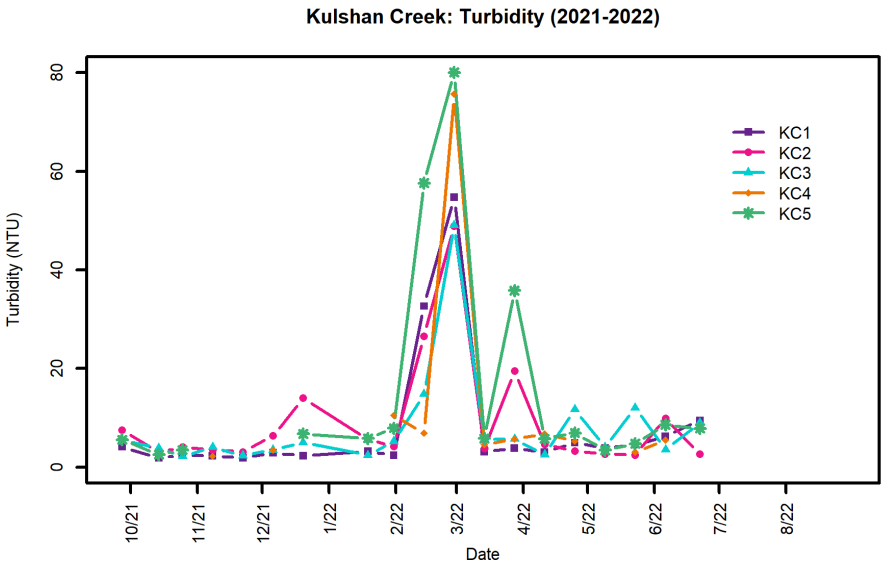

Figure 78. Kulshan Creek Turbidity: 2021-2022

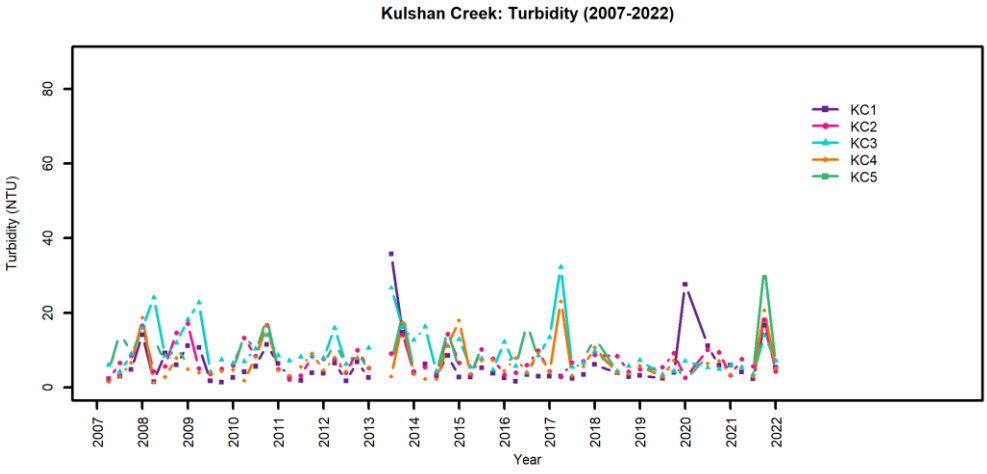

Figure 79. Kulshan Creek average turbidity levels by season: 2007-2022.

Fecal coliform

No Kulshan Creek sites passed both fecal coliform level criteria and sites KC2 and 5 failed both (Table 18). Sites KC1, 3, and 4 passed the Part 1 criterion. Figure 80 shows the fecal coliform levels consistently far above the 100 CFU mL^{-1} limit, which is consistent with seasonal geomeans for all previous sampling years since 2007 (Figure 81). The red line shows the 100 CFU $100mL^{-1}$ geomean upper limit for WA.

Table 18. Calculated geomeans of fecal coliform levels (CFU/100mL) Kulshan Creek 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
KC1 S. 14th St.	20.53	Pass	Fail	Does Not Pass Both
KC2 Parker Way	119.64	Fail	Fail	Does Not Pass Both
KC3 Roosevelt Ave.	36.10	Pass	Fail	Does Not Pass Both
KC4 Riverside Dr.	31.62	Pass	Fail	Does Not Pass Both
KC5 Lions Park	135.96	Fail	Fail	Does Not Pass Both

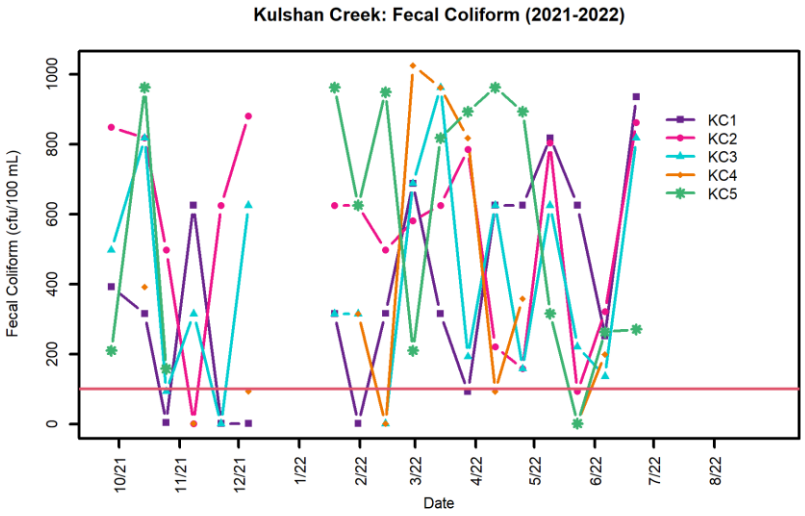

Figure 80. Kulshan Creek Fecal Coliform: 2021-2022

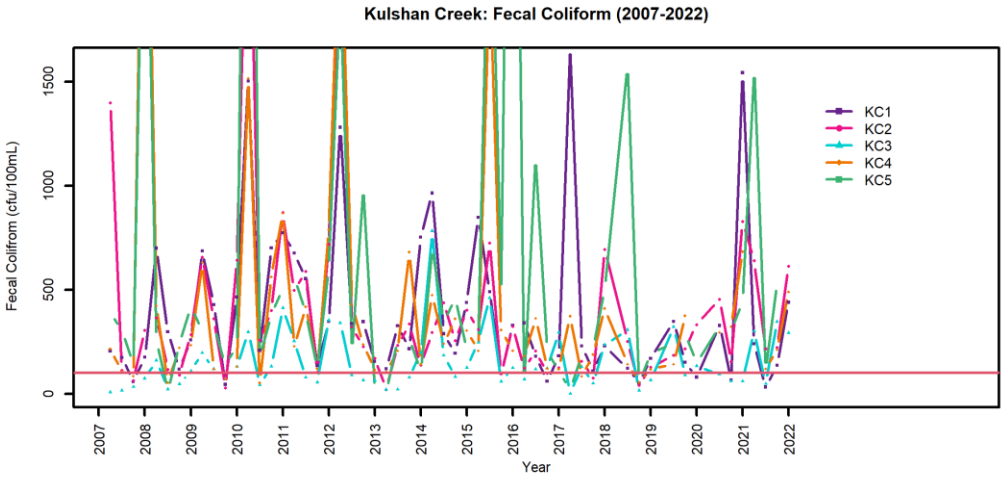

Figure 81. Kulshan Creek fecal coliform geometric means by season:2007-2022.

Ace of Hearts Creek

Ace of Hearts is the outlet of Heart Lake in the Anacortes Community Forest Lands and runs to Fidalgo Bay, above ground for the first two miles, then through pipes underground until it empties into the bay. Note that sampling for Ace of Hearts Creek began in 2017, 10-11 years after other sites in this survey. Site AHH1 is at the Heart Lake outlet, AHH2, H Ave and 41st St., AHH3, Rotary dog park, AHH4 is at Happy Valley Creek.

Dissolved oxygen

Dissolved oxygen for all sites was again above the standard throughout fall-spring 2021-22 (Figure 82). Seasonal averages remained above standard as in all previous years since sampling began in 2016 (Figure 83). The red line shows the minimum single day low for this waterway.

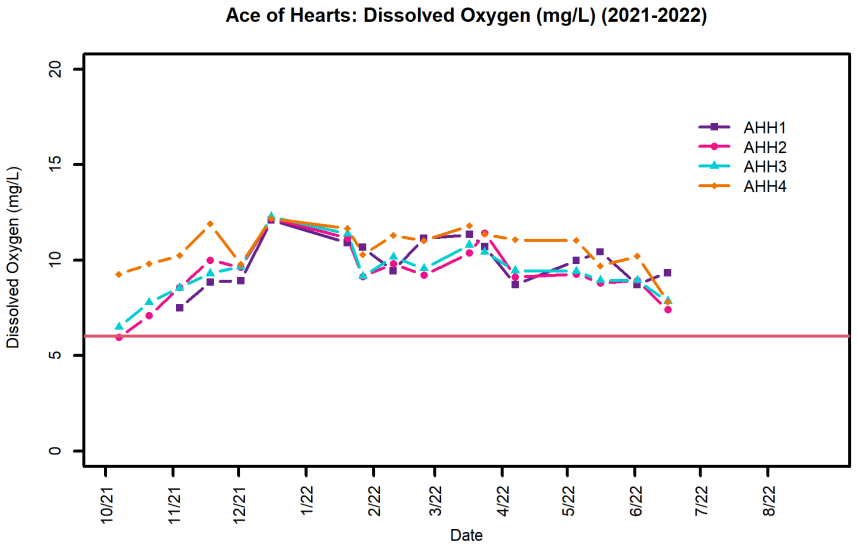

Figure 82. Ace of Hearts DO: 2021-2022

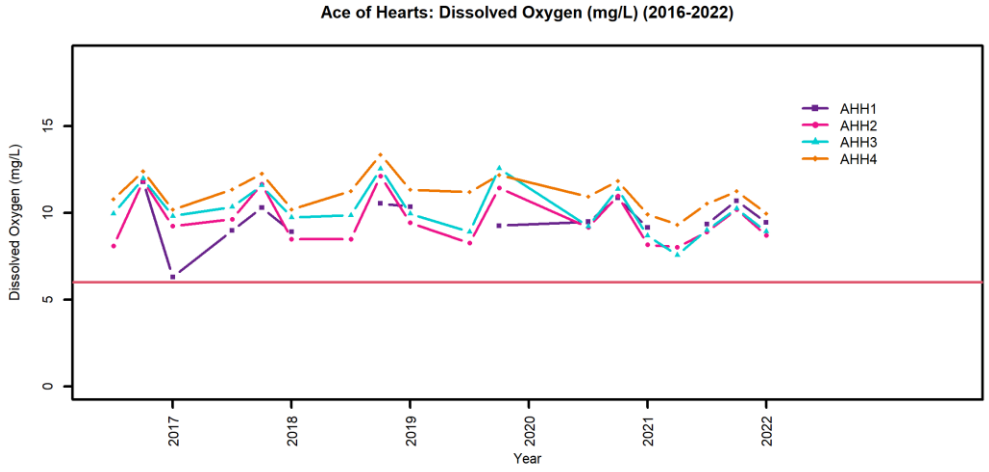

Figure 83. Ace of Hearts dissolved oxygen (mg L^{-1}) averages by season:2016-2022

Temperature

Temperatures at all sites stayed below the upper limit for this creek, 17.5 ° (Figure 84). As in other Stream Team waterways, Ace of Hearts sites were not sampled in summer months. Here, water dries up completely in summer. Seasonal average temperatures have remained below the standard during fall-spring sampling since 2017 (Figure 85). The red line shows the maximum 7-day average for this waterway.

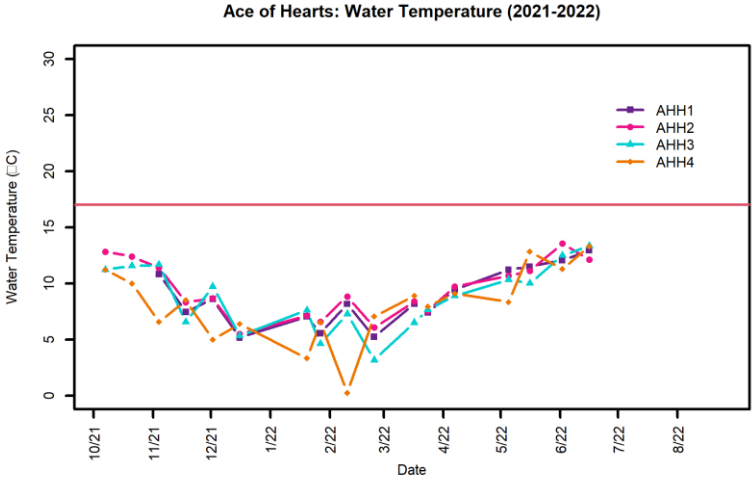

Figure 84. Ace of Hearts Temperature: 2021-2022

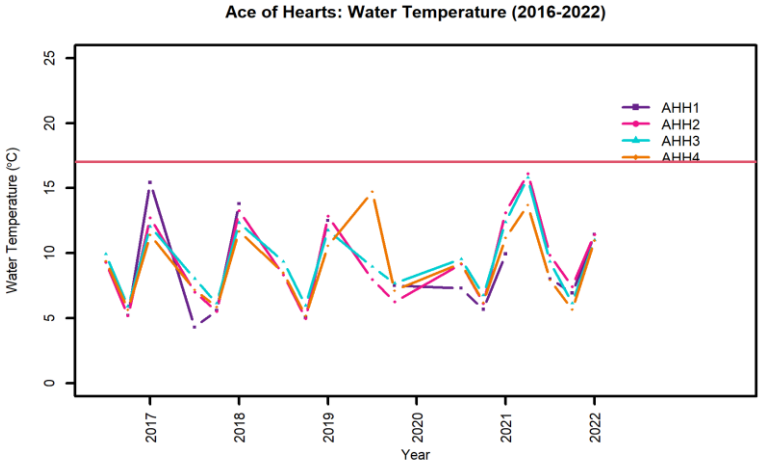

Figure 85. Ace of Hearts Upper Nookachamps water temperature averages: 2017-2022.

Turbidity

Turbidity levels for Ace of Heart and Happy Valley Creeks were below 40 NTU at all sites throughout 2021-22 (Figure 86). Seasonal averages since 2017 have been below 15 NTU (Figure 87).

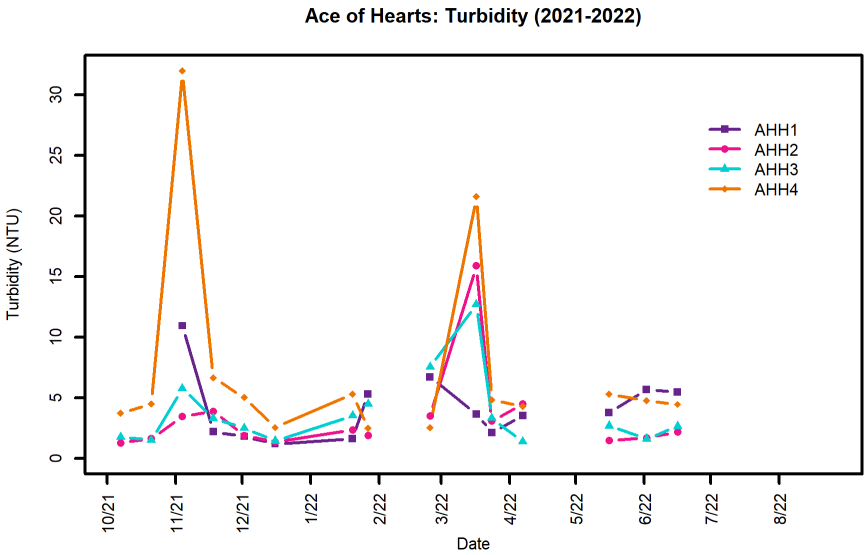

Figure 86. Ace of Hearts Turbidity: 2021-2022

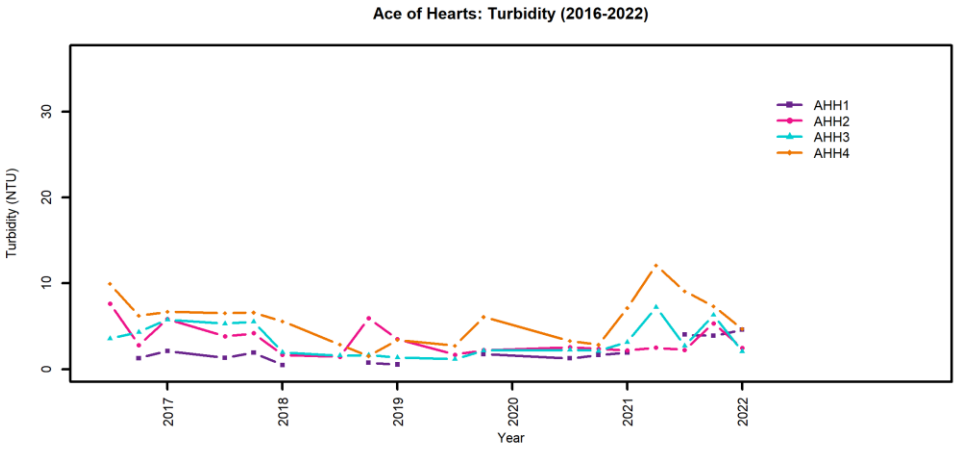

Figure 87. Ace of Hearts Average turbidity levels by season: 2017-2022.

Fecal coliform

Ace of Hearts Creek has lower fecal coliform levels than most other sites, passing the Part 1 criterion in all sites. Site AHH3 (near the dog park..) and AHH4 at Happy Valley Creek failed the Part 2 criterion (Table 19). All sites exceeded 100 CFU mL^{-1} at some point during 2021-22 (Figure 88). Seasonal fecal coliform geomeans have been lowest nearest Heart Lake since 2017 (Figure 89). The red line shows the 100 CFU $100mL^{-1}$ geomean upper limit for WA.

Table 19. Calculated geomeans of fecal coliform levels (CFU/100mL) Ace of Hearts 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
AHH1 Heart Lake Trail	27.79	Pass	Pass	Pass Both Standards
AHH2 H Ave and 41st St	22.10	Pass	Pass	Pass Both Standards
AHH3 Dog Park	45.13	Pass	Fail	Does Not Pass Both
AHH4 Happy Valley Creek	89.53	Pass	Fail	Does Not Pass Both

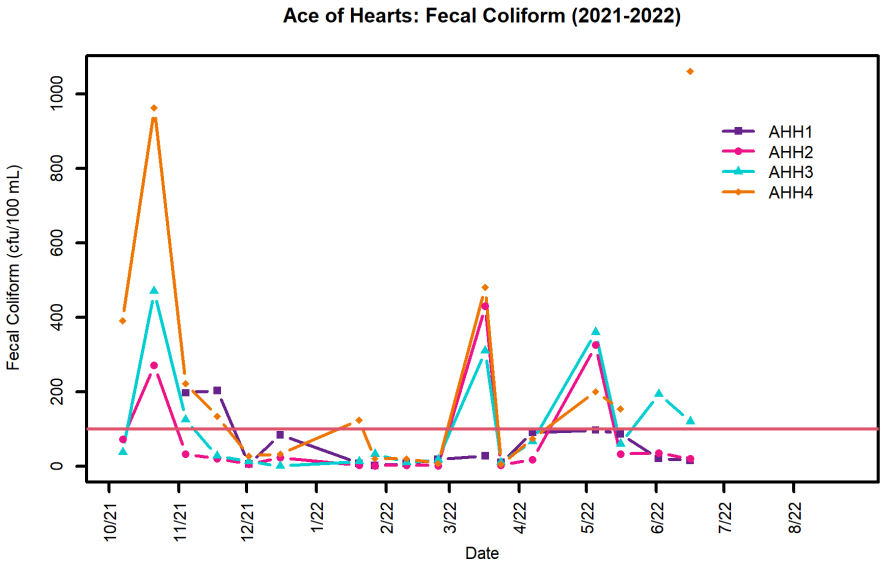

Figure 88. Ace of Hearts Fecal Coliform: 2021-2022

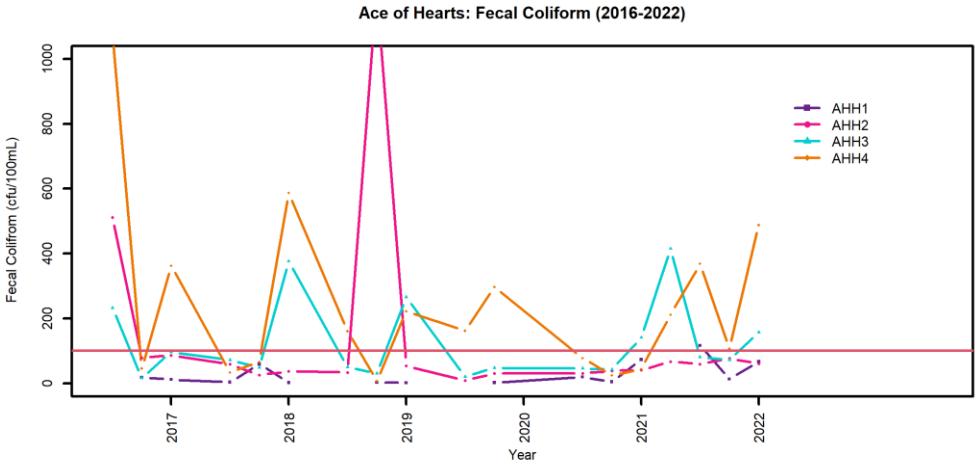

Figure 89: Ace of Hearts Creek fecal coliform geometric means by season: 2007-2022

Gages Slough

Gages Slough is a slow-moving waterway that begins west of Sedro Woolley, following Highway 20 until it turns southward in Burlington, emptying into the Skagit River at the eastern end of Bennet Road. It completely dries up in summer. Site name changes began in 2013-14 due to changes in public access. Current site names and descriptions are shown in Figure 90 and former site names are included in the time series in Figure 91. This stream is monitored every four weeks. Site GS1 is at Regent St and Rio Vista Ave. GS2 is at Anacortes St. GS3 is at Spruce St. GS4 is at S. Goldenrod Rd. Site locations changed slightly due to access since 2014, resulting in new site names but the same color tracks these as one general site over time.

Dissolved oxygen

Dissolved oxygen at all Gages Slough sites was below the lowest one day minimum, 8.0 mg L^{-1}, throughout the year, except for sites GS2 and 3 in early November (Figure 90). Seasonal average DO has been continuously below the lowest 1-day minimum in this waterway except in very few instances since 2007 (Figure 91). The red line shows the minimum single day low for this waterway

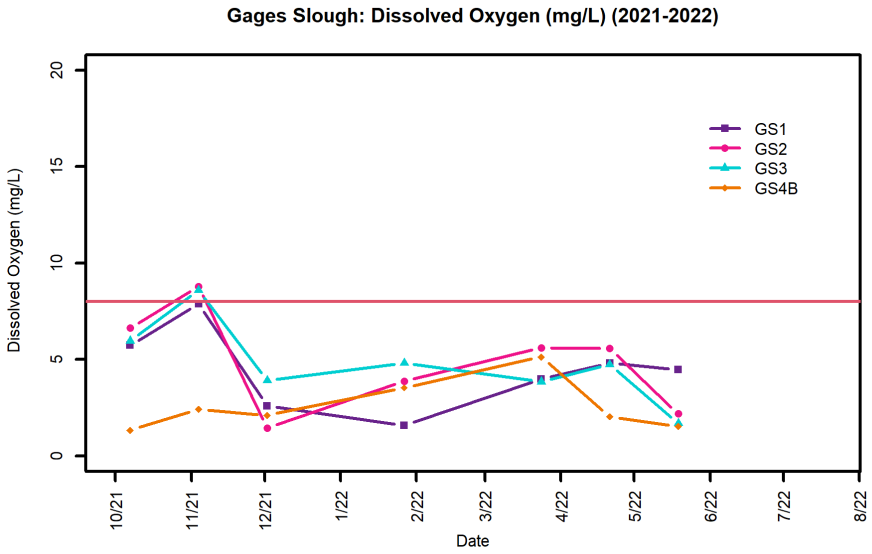

Figure 90. Gages Slough DO: 2021-2022

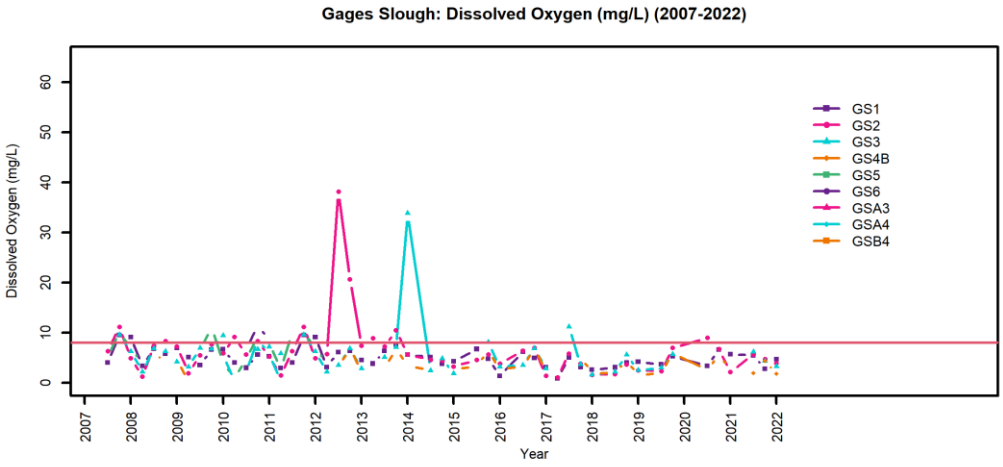

Figure 91. Gages Slough dissolved oxygen (mg L^{-1}) averages by season: 2007-2022

Temperature

All Gages Slough sites were cooler than 17.5°C throughout the fall-spring 2021-22 sampling period (Figure 92). Seasonal average temperatures have slowly decreased since 2007 (Figure 93). The red line shows the maximum 7-day average for this waterway.

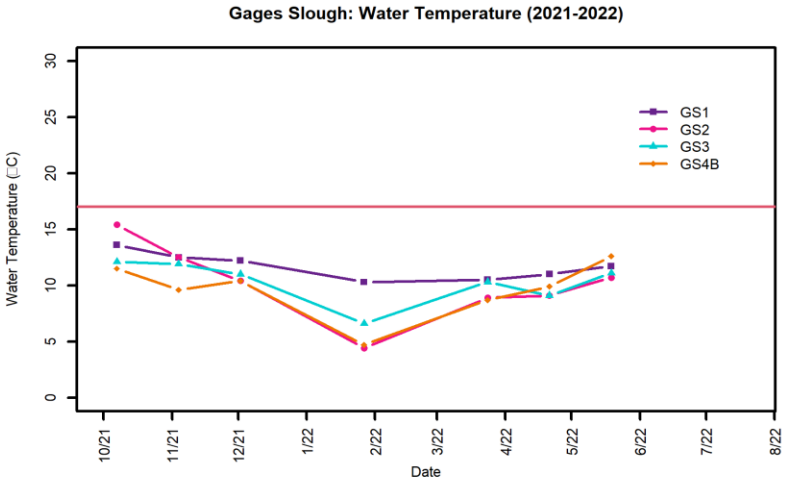

Figure 92. Gages Slough Temperature: 2021-2022

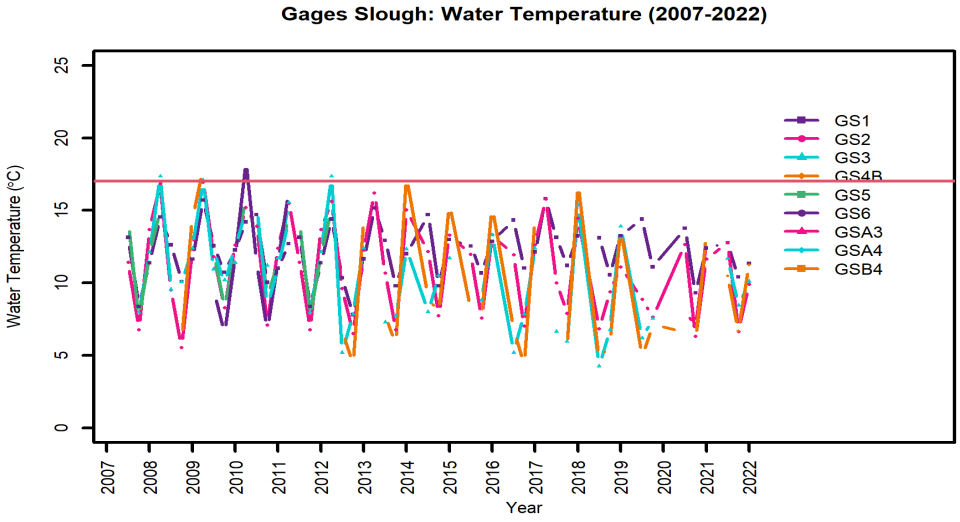

Figure 93. Gages Slough water temperature averages by season: 2007-2022

Turbidity

Turbidity levels at all sites were similar and stayed at or below 25 NTU throughout fall-spring 2021-22 (Figure 94). Seasonal average turbidity has fluctuated mainly between 5 and 50 NTU over 15 years of fall-spring sampling (Figure 95).

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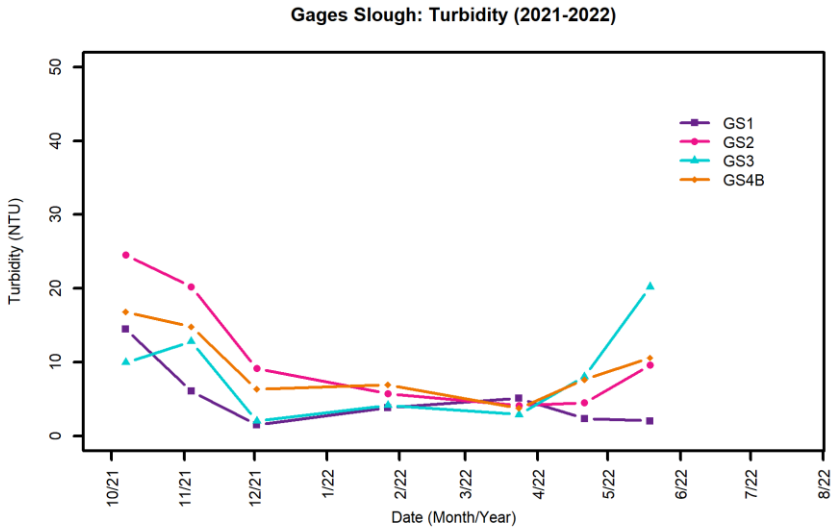

Figure 94. Gages Slough Turbidity: 2021-2022

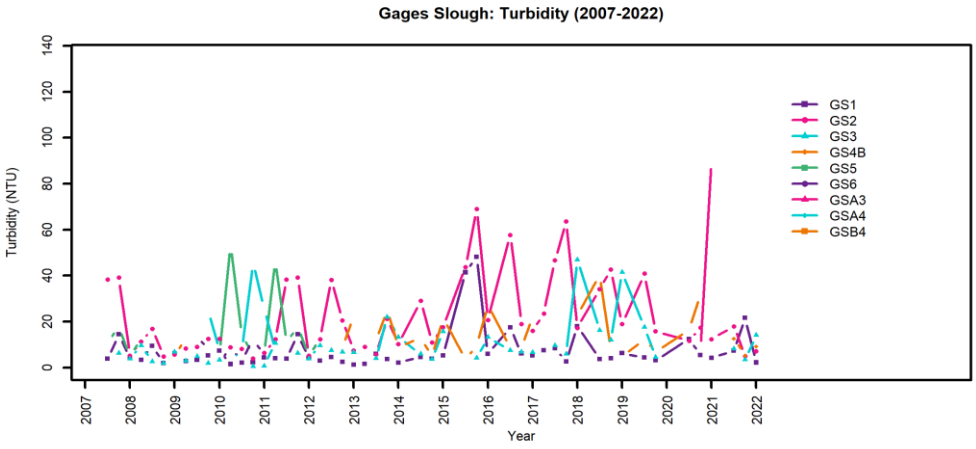

Figure 95. Gages Slough average turbidity levels by season: 2007-2022.

Fecal coliform

Just one site, GS4 at Goldenrod Rd., passed both Part 1 and 2 criteria for fecal coliform (Table 20). Site GS1 failed both criteria and both GS2 and 3 passed Part 1 and failed Part 2 criteria. All sites were above 100 CFU 100 mL^{-1} after October 2021 (Figure 96). Seasonal geomeans since 2007 soar above 100 CFU 100 mL^{-1} except for at site GS3 at Spruce St. (Figure 97). **THIS WATERWAY REQUIRES INTERVENTION.** The red line shows the 100 CFU 100mL^{-1} geomean upper limit for WA.

Table 20. Calculated geomeans of fecal coliform levels (CFU/100mL) Gages Slough 2021-2022

Site	Geomean of Fecal Coliform (CFU/100mL)	Part 1 Criterion	Part 2 Criterion	Both Standards
GS1 Regent & Rio Vista St.	115.5112	Fail	Fail	Does Not Pass Both
GS2 Anacortes St.	38.6263	Pass	Fail	Does Not Pass Both
GS3 S. Spruce St.	29.93966	Pass	Fail	Does Not Pass Both
GS4B S. Goldenrod Rd.	23.0702	Pass	Pass	Pass Both Standards

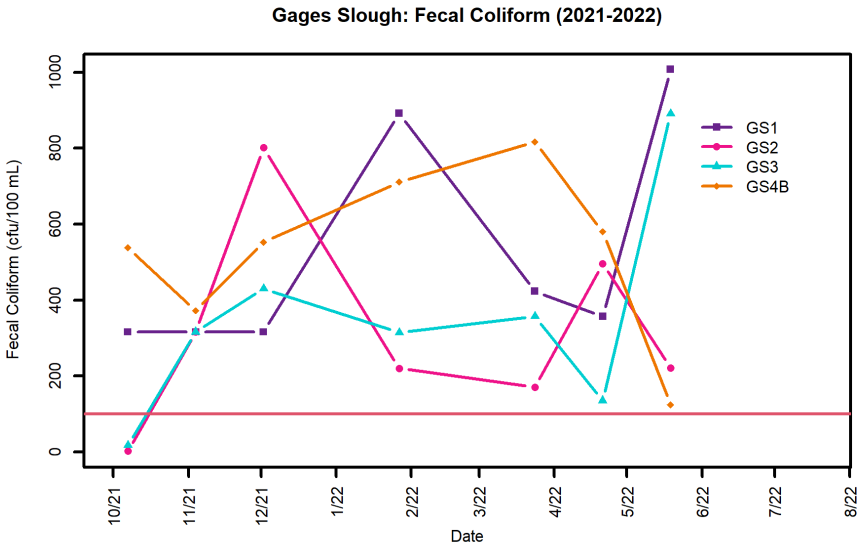

Figure 96. Gages Slough Fecal Coliform: 2021-2022

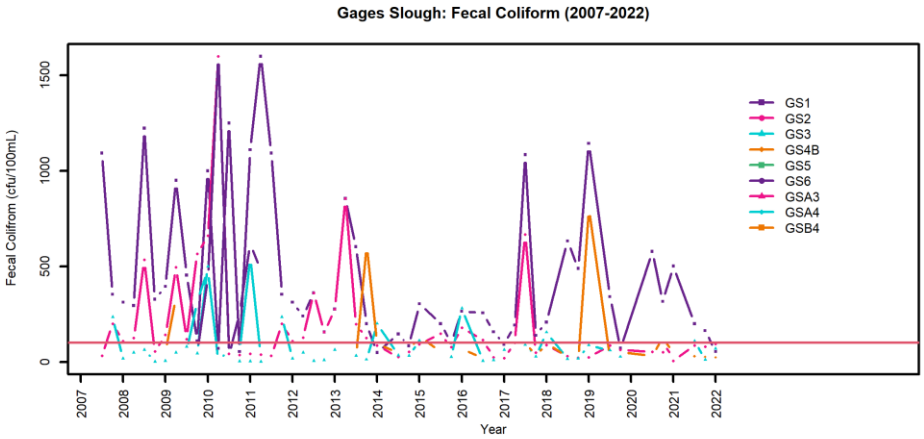

Figure 97. Gages Slough fecal coliform geometric means by season:2007-2022.

Stream Team 2021-2022 Summary

Following graphs show annual means for all sites for each water quality parameter. While it is interesting to compare watersheds, it is important to note that each water body has unique characteristics that naturally influence water quality and differing standards for DO and temperature, based on the type of aquatic life therein. Variation is normal, and what might be considered "healthy" for water backed up behind a tide gate might not be so for a small, wooded stream in the Upper Nookachamps.

Dissolved oxygen

Regulations require corrective action should oxygen levels drop below the one day minimum standard even once. These sites are clearly in need of attention. Upper Nookachamps 1, all Joe Leary sites, Kulshan Creek 2 and all Gages Slough sites have low DO levels.

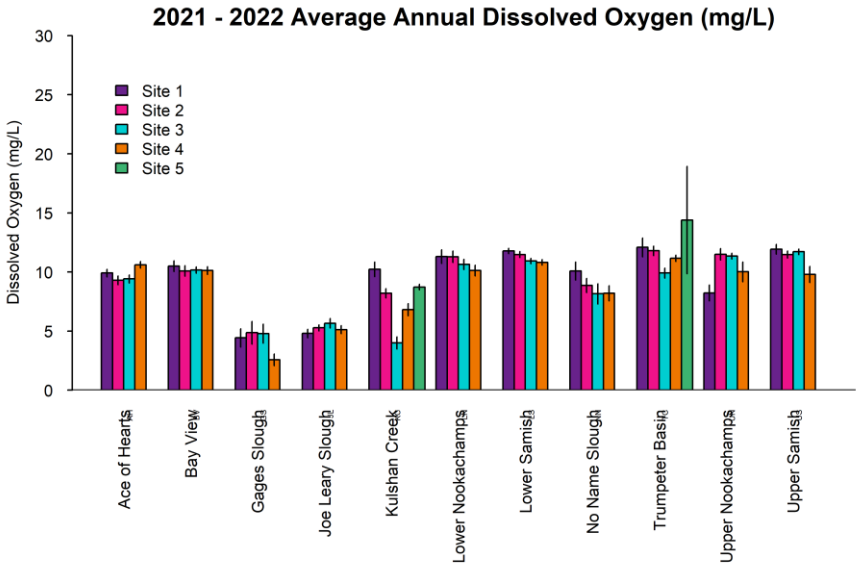

Figure 98. Annual Average Dissolved Oxygen at all Stream Team sites: 2021-2022

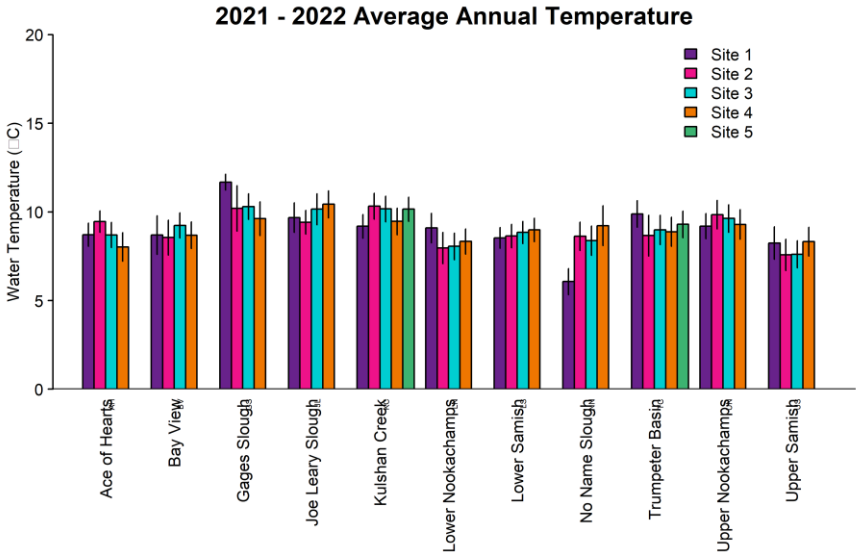

Figure 99. Annual average temperatures at all Stream Team sites: 2021-2022

Turbidity

Turbidity is the parameter with the greatest naturally occurring variability. Comparing all streams, Gages Slough Site 2, and Joe Leary Slough stand out. All Joe Leary sites are 2-3 times higher than most other sites. Along much of Joe Leary's course, it drains cultivated cropland and is periodically dredged to improve drainage.

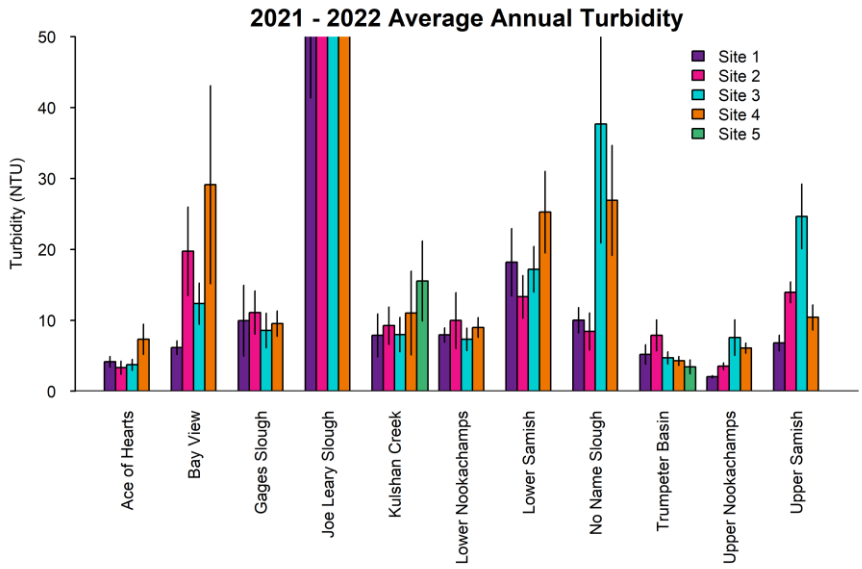

Figure 100. Annual average turbidity at all Stream Team sites: 2021- 2022

Fecal coliform

Fecal coliform is the parameter of greatest interest to regulators, health officials, and shellfish growers. Gages Slough Site 1, Joe Leary Slough Site 2, Kulshan Creek Sites 2 and 5, Lower Nookachamps Site 1, No Name Slough Sites 1 and 3, Trumpeter Basin Site 1 and 3, and Upper Samish Site 3 and 4 each failed to meet Part 1 of the State Standards (annual geomean < 100CFU 100 mL^{-1}) during the 2021-22 sampling period (Figure 101; Table 21).

There is no drainage in this survey that has consistently met the Part 1 criterion since surveys began in 2006 (PBNERR 2017-2022). Out of 46 sites, 18 out of 46 sites in 2015-2016, 13 out of 46 sites in 2016-17, 9 of 46 in 2017-2018, 10 of 46 in both 2018-2019 and 2019-2020, and 11 of 46 in 2021-2022 failed to meet the Part 1 criterion. However, there are some basins showing improvement. Joe Leary Slough met Part 1 standard in 3 of 4 sites for the first time since sampling began in 2006 (Figure 65).

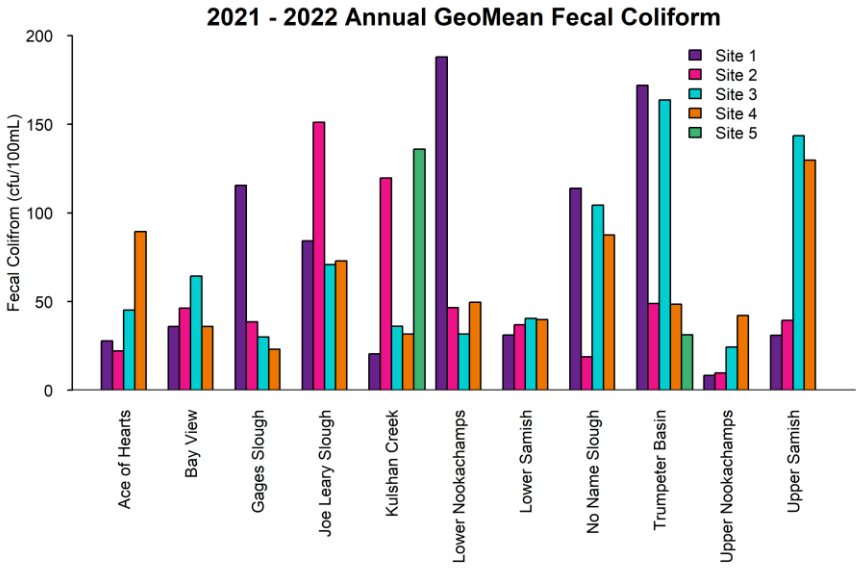

Figure 101. Fecal coliform annual geomeans at all Stream Team sites: 2021-2022

Fecal coliform levels were increasing in many sites between 2014-2018 (PBNERR 2019) but have since somewhat improved. In 2014-15, fifteen sites met both standards. The following two years 13 out of 46 sites met both standards. In 2017-2018, just 10 of 46 sites met both standards. In 2018-2019, just 7 sites met both standards. In 2019-20, 17 sites met both standards (PBNERR 2017-2022) and this year, 2021-2022, fourteen out of forty-six sites met both standards (Table 21). Most-improved basins include Lower Samish, both Upper and Lower Nookachamps and Joe Leary Slough. Gages Slough showed some improvement.

Basins that have degraded over the past several years include Upper Samish, Kulshan Creek, and Trumpeter Creek. Basins which have consistently failed at least one standard in all sites include No Name Slough, Joe Leary Slough, and Trumpeter Basin.

Table 21 below summarizes fecal coliform status by state standards criteria 1 and 2 for all Stream Team sites in 2021-22. Criterion 1 requires the annual geomean to be < 100 CFU $100mL^{-1}$. Criterion 2 requires fewer than 10% of samples contain < 200 CFU 100 mL^{-1}. Bold text indicates sites passing both standards.

Table 21. Summary of fecal coliform status by state standards

	Site 1		Site 2		Site 3		Site 4		Site 5	
	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2
Upper Samish	**pass**	**pass**	pass	fail	fail	fail	fail	Fail		
Lower Samish	pass	fail	**pass**	**pass**	**pass**	**pass**	**pass**	**pass**		
Upper Nookachamps	**pass**	**pass**	**pass**	**pass**	pass	fail	**pass**	**pass**		
Lower Nookachamps	faill	fail	**pass**	**pass**	**pass**	**pass**	**pass**	**pass**		
No Name Slough	fail	fail	pass	fail	faill	fail	pass	fail		
Bay View	pass	fail	pass	fail	pass	fail	**pass**	**pass**		
Joe Leary Slough	fail	fail	fail	fail	pass	fail	pass	fail		
Trumpeter Basin	fail	fail	pass	fail	fail	fail	pass	fail	pass	fail
Kulshan Creek	pass	fail	fail	fail	pass	fail	pass	fail	fail	fail
Ace of Hearts Creek	**pass**	**pass**	**pass**	**pass**	pass	fail	pass	fail		
Gages Slough	fail	fail	pass	fail	pass	fail	**pass**	**pass**		

Storm Team Results

The Storm Team completed a sixth sampling season during fall of 2021 through spring of 2022 in the Padilla Bay watershed. Volunteers sampled 12 sites (Figure 102). Three sites were on Edison Slough, one on Higgins Slough at Peterson Road, one on Little Indian Slough at Farm to Market Road, one on No Name Slough at the end of Egbers-Kalso Road, four in the Bay View village drainage, and just one was in the Joe Leary Slough, the largest freshwater input to Padilla Bay (Table 12). Volunteers sampled 12 sites during fourteen rain events.

Storm team data should be viewed differently from the rest of the Stream Team data. These are collected just after a heavy rain event and do not represent typical conditions. Even a healthy stream can have occasional high fecal coliform levels during/after rain events. The state standard of a maximum of 100 CFU 100 mL^{-1} for waterways impacting shellfish beds is based on an average of at least 10 samples taken over time and in a variety of conditions. *Map created in ArcGIS Online by Mira Lutz.*

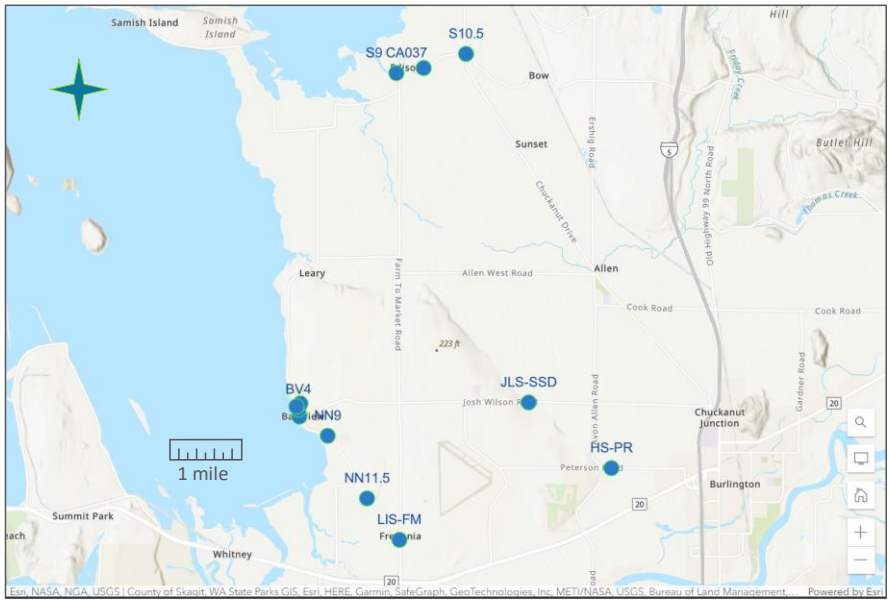

Figure 102. Padilla Bay Storm Team Sampling Sites 2021-2022 shown as blue circles.

Table 22. 2021-2022 Storm Team sampling site codes, descriptions, and locations

Site ID	Location	Lat	Long
S9, #CA037	Edison Slough Pump Station	48.560931	-122.44533
S10	Edison Sough at Edison Elementary School	48.562139	-122.43626
S10.5	Edison Slough at Cobb and Cork	48.565248	-122.42163
HS-PR	Higgins Slough at Peterson Road	48.471939	-122.372181
JLS-SSD	South Spur Ditch (JLS) at Josh Wilson Rd	48.486785	-122.400550
LIS-FM	Little Indian Slough at Farm to Market Road	48.455794	-122.444279
NN11.5	No Name Slough at end of Egbers-Kalso Road	48.465098	-122.455329
NN9	Marihugh and Bay View-Edison Road	48.479283	-122.468683
BV3	South of Bay View State Park	48.485931	-122.479358j
BV4	B Street culvert on beach in Bay View	48.485154	-122.478814
BV5	B Street #2	48.486494	-122.478086
BV7	Cute beach cottage	48.483511	-122.478225

Fecal coliform levels post-storm events exceeded 100 CFU 100 mL^{-1} for these waterways in all sites except Edison Slough and Bay View 7 throughout most of the sampling season (Figure 103; Figure 104a and b). Fecal coliform levels increased in all sites in spring. Higgins and Little Indian Sloughs regularly exceeded 1000 CFU 100 mL^{-1}.

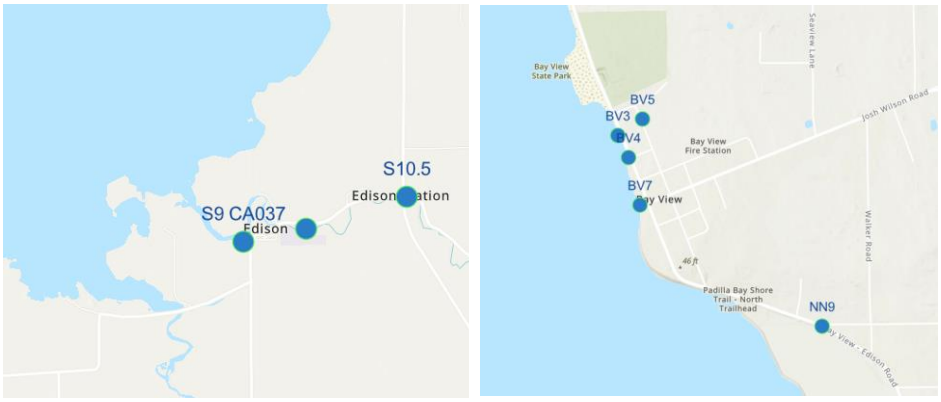

Figure 103. Maps of Edison Slough and Bayview drainage, zoomed in to show specific sampling sites.

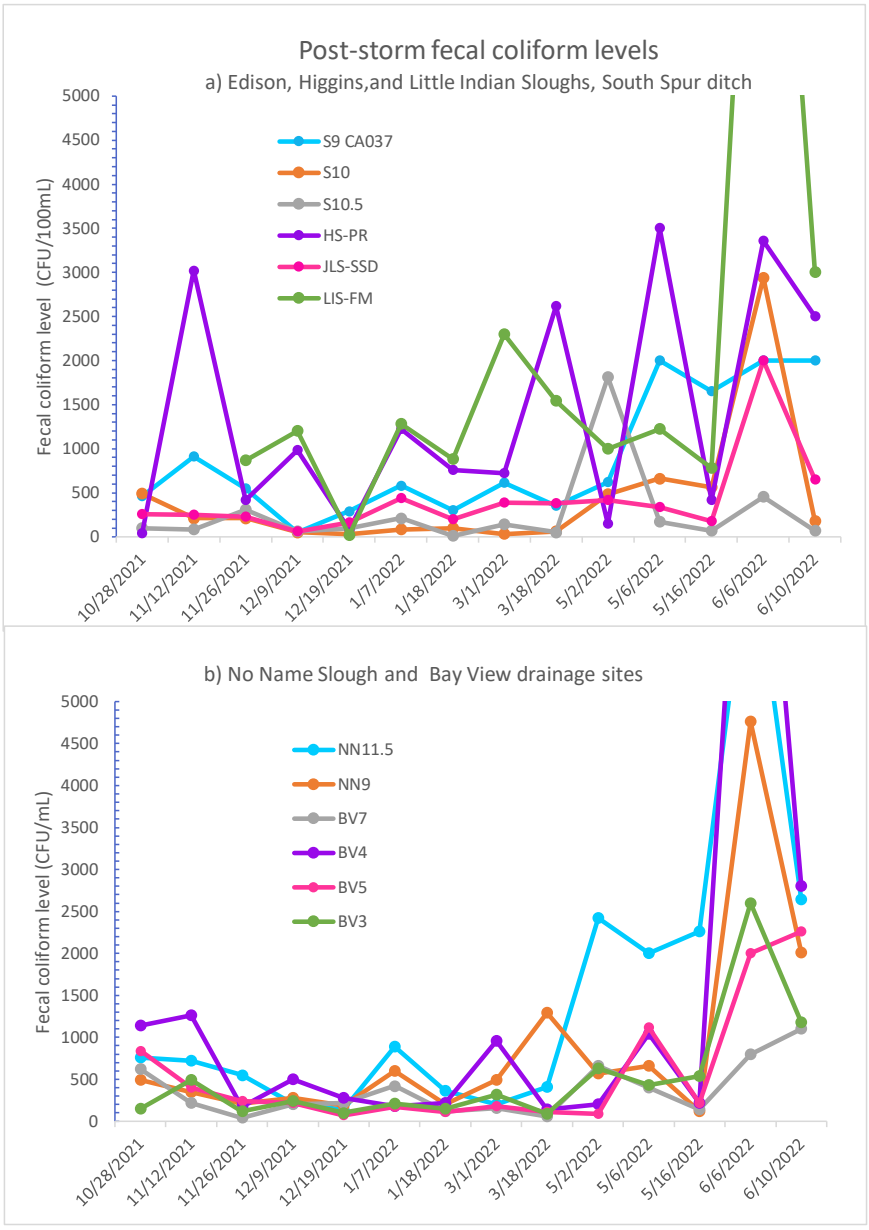

Figure 104. Storm Team Fecal Coliform levels (CFU 100mL^{-1}) a) Samish and Padilla Bay, b) No Name and Bay View

No sites had geometric means that met the Part 1 criterion of 100 CFU 100mL^{-1} (Figure 105) though this is not an ambient monitoring program, and relatively high numbers should be expected. Like the previous years, each of the sloughs showed the highest counts (Figure 106), with Little Indian Slough at Farm to Market Road exceeding all others this season. In Bay View, the B Street culvert (BV 4) continues to have higher counts than nearby Bay View sites.

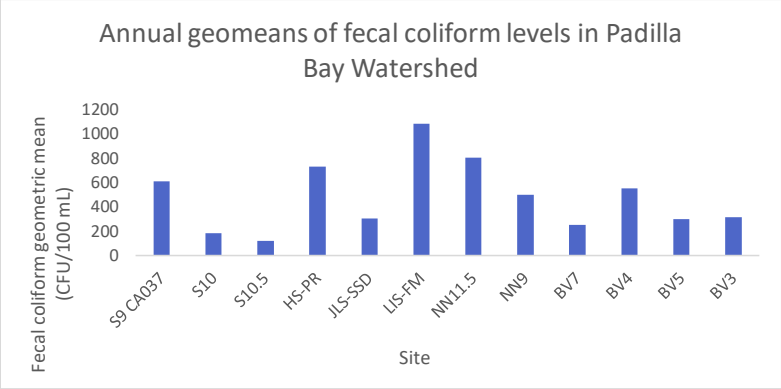

Figure 105. Annual geometric means of fecal coliform levels (CFU 100 mL^{-1}) 2021- 2022.

Figure 106 below compares Fecal coliform annual geometric mean in the Samish and Padilla Bay drainage basins for 2021-2022. Some site changes were made for the 2021-22 sampling year (solo, hot pink bars).

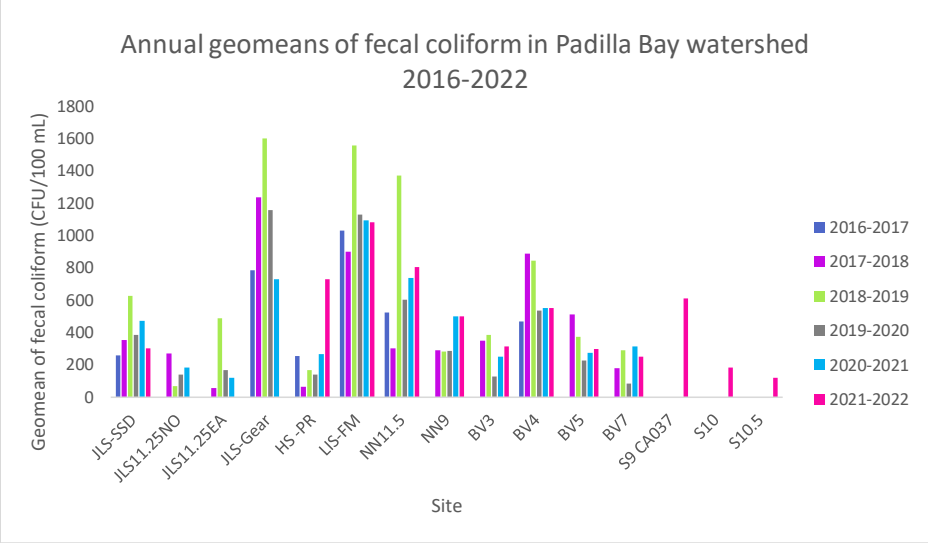

Figure 106. Storm team Fecal coliform annual geometric mean (CFU 100 mL^{-1}) 2016-2022

VI. Conclusion

The 2021-2022 Stream Team volunteers built upon the success of previous years, and provided the twenty-first year of WQ data for Skagit County's priority watersheds. This year saw the continued monitoring of 46 sites and fearless Storm Team's sampling of 12 sites in the Padilla Bay watershed during heavy rain events.

Sixty-nine adult volunteers were exposed to a firsthand view of the impact that non-point source pollution has on local water quality. Along the way they experienced sampling techniques used by environmental professionals, learned the importance of establishing a long-term, routine sampling program, formed lasting friendships and enriched their own lives through volunteering.

Thanks to 1,190 volunteer hours, this program has provided valuable data to citizens and agencies, assessing current conditions so water quality improvements can be made and documented in the future. This is key data for the long-term protection of our water resources. We hope that our data is useful in identifying trends, improvements, and problem areas for the attention of the appropriate agencies and local citizens and that sites with consistently poor water quality, especially fecal coliform may be addressed.

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PBNERR 2022. Skagit Stream Team Water Quality Report: Citizen Monitoring Summary for Samish Bay, Padilla Bay, Ace of Hearts, Gages Slough, Trumpeter Basin, Kulshan Creek and Nookachamps Creek. *Skagit Conservation District and Padilla Bay National Estuarine Research Reserve.* Mount Vernon, WA.

Appendix A – Stream Team Data

Please contact Padilla Bay Education Team to request raw Stream Team data for 2021-22:
Email Chandler Colahan at ccolahan@padillabay.gov or call at 360-428-1066.

Appendix B – 2021-2022 Storm Team Site Descriptions and Data

Site ID	Location	Lat	Long	Location notes on added sites
S9, #CA037	Edison Slough Pump Station	48.560931	-122.445328	Sample from west side of pump station shed
S10	Edison Elementary School	48.562139	-122.436264	Sample from bridge just east of Edison Firehall
S10.5	Edison Slough at Cobb and Cork	48.565248	-122.421631	Sample behind Cobb and Cork, corner of Bow Hill Road and Chuckanut Drive
HS-PR	Higgins Slough at Peterson Road	48.471939	-122.372181	Gravel pulloff for parking
JLS-SSD	South Spur Ditch (JLS) at Josh Wilson Rd	48.486785	-122.400550	Resume this site after construction completed
LIS-FM	Little Indian Slough at Farm to Market Road	48.455794	-122.444279	Park on shoulder just after Joe Leary Slough sign (sampling site across street)
NN11.5	No Name Slough at end of Egbers-Kalso Road	48.465098	-122.455329	
NN9	Marihugh and Bayview-Edison Road	48.479283	-122.468683	Old Storm Team site - across road from Marihugh/Bayview-Edison stop sign
BV7	Cute beach cottage	48.483511	-122.478225	Old Storm Team site - west side of Bayview-Edison Rd at end of Josh Wilson Rd
BV4	B Street culvert on beach in Bayview	48.485154	-122.478814	
BV5	B Street #2	48.486494	-122.478086	Old Storm Team site - Second St at south end of board fence, in the blackberries
BV3	South of Bay View State Park	48.485931	-122.479358	old Storm Team site - 11043 Bayview-Edison Rd, 50 ft north of black mailbox on west side

2021-2022 Storm Team Fecal Coliform Data (CFU 100 mL^{-1})

Date	S9 CA037	S10	S10.5	HS-PR	JLS-SSD	LIS-FM	NN11.5	NN9	BV7	BV4	BV5	BV3
10/28/2021	460	490	100	40	255		760	490	620	1140	840	152
11/12/2021	910	210	80	3020	250		720	350	220	1260	400	490
11/26/2021	550	210	310	420	230	870	550	210	40	170	240	120
12/9/2021	50	50	60	980	60	1200	210	280	200	500	220	240
12/19/2021	290	30	100	80	160	20	140	190	220	280	70	100
1/7/2022	580	80	210	1220	440	1280	890	600	420	180	170	210
1/18/2022	300	100	10	760	200	880	360	200	120	220	110	150
3/1/2022	610	30	140	720	385	2300	200	490	160	960	180	320
3/18/2022	350	60	50	2620	380	1540	410	1290	60	140	110	90
5/2/2022	620	480	1810	146	420	1000	2420	570	660	206	90	630
5/6/2022	2000	660	170	3500	335	1220	2000	660	400	1040	1120	430
5/16/2022	1650	560	70	420	175	780	2260	120	140	220	220	540
6/6/2022	2000	2940	450	3360	2000	11120	7040	4760	800	9840	2000	2600
6/10/2022	2000	180	70	2500	650	3000	2640	2010	1100	2800	2260	1180
Geomean	**611**	**182**	**121**	**731**	**304**	**1084**	**804**	**501**	**250**	**551**	**299**	**313**

Appendix C. Water Quality Objectives

parameter	method	precision (Rel. Std. Dev.)	accuracy	detection level
Dissolved Oxygen (DO)	YSI 55 Probe	Unavailable	± 0.3 mg L-1	0-20 mg L-1
Total depth	Fixed.hand- held Tape	± 20%	± 0.05 meters	0 - 1 cm
Turbidity	Turbidimeter	Unavailable	0.01 NTU	0-19.9 NTU 0-199.9 NTU
Temperature	YSI 55 Probe	Unavailable	0.2° C	°-5 to 45° C

parameter	method	test equipment	filter type	incubation
Fecal coliform bacteria	Membrane Filtration	Millipore sterifil aseptic system	47 mm membrane filter .45 um pore space	Millipore single chamber incubator Temp. range 30°c (±0.5) 44.5°c (±0.2)

Standard Operating Procedures (SOP's)

1. Dissolved Oxygen (DO)- Samples will be taken with a bottle placed in an extension pole and dipped using the Standard Methods. DO will be measured using a YSI 55 probe. Results will be recorded as DO mg L-1.

DO testing procedure (YSI 55 Probe):

i. Turn probe on and calibrate immediately when picking up equipment. Make sure sponge inside the calibration chamber is wet with distilled water.
ii. Place probe in water below the surface of water and move probe back and forth until the reading stabilizes. Record the result in mg L-1. Leave probe on for the rest of the sampling.

2. Temperature will be measured with a YSI probe and recorded in °C.

3. Total depth is measured using depth gauges installed at some sites.

4. Water clarity will be determined by placing a sample into a turbidimeter (EPA approved VWR 66120-200)

i. Warm-up Turbidimeter 30 minutes and calibrates w. 0 NTU polymer standard using the "zero-adjustment".
ii. Thoroughly shake the water sample in a clean sampling jar.
iii. Pour sample into unscratched, clean, and Kim-wiped vial. Mix again
iv. Place in turbidimeter w. index line facing directly out to the front.
v. Read and record the steady reading after the highest readings settle.
vi. If reading is greater than 200 NTU, dilute the sample by 50%. (x 2).

variable	sampling equipment	sample container	sample preservation	maximum holding time
fecal coliform	Pole w.glass bottle	glass bottle pre-sterilized	ice chest with ice pack	1 hr
d. oxygen	YSI probe	instream	none	immediately
total depth	Installed depth gauge	instream	none	immediately
temperature	YSI probe thermometer	instream instream	none none	immediately immediately
turbidity	turbidimeter	glass bottle, wide-mouth	ice chest	2 hrs

Equipment calibration and maintenance

1. Millipore Sterifil Filtration System maintenance

Maintenance: Immediately after use disassemble the apparatus and clean the components to ensure optimum performance.

i. Remove the cover from the funnel. Carefully remove the O-ring using forceps. Remove the support screen from the base by pushing a short blunt rod through the base outlet.

ii. Clean all components with a sponge, hot water, and non-alkaline, non-abrasive cleanser (anti-bacterial soap). Remove stubborn residues on the insides of the holder, cover port, and flask side arms using a plastic bristle brush and pipe cleaner dipped in cleanser (do not use any steel wool or abrasive materials that can harm the components).
iii. Rinse the components with lab water and sterilize.

2. Sample Containers and Equipment maintenance
Maintenance: Empty bottles and place in Liquinox and warm water. Wash with a bottlebrush. Double rinse with tap water and final rinse with distilled water. Autoclave all fecal coliform sample bottles and graduated cylinders.

3. Millipore Portable Single Chamber Incubator maintenance
Maintenance: Clean the exterior case and interior chamber with a damp cloth and warm water (anti-bacterial soap). Give final spray with rubbing alcohol.

4. VWR Turbidimeter
Calibration: Insert 0 NTU polymer standard with the range control set at "20". Set the "Zero Control" to 0. Set the coarse so that the meter reads as close to zero as possible. Calibrate turbidimeter annually.

5. YSI Meters (DO, Temp)
Calibration: Press and release UP ARROW and DOWN ARROW keys at the same time. Enter "0" for altitude and salinity, and ENTER afterwards. Instrument is calibrated.
Maintenance: Turn YSI 55 off and rinse probe with distilled water after each use. Replace membrane filters and Kim-wipe moisturizers monthly. Replace batteries as needed.

Appendix D. Sample Data Sheet

Date:_____

Dupe Site_____

FC Results_____

Lower Samish Watershed
Skagit Stream Team
Water Quality Monitoring

Field Work By_____

Lab Work By:_____

Site LS1. Old Hwy. 99 Samish Bridge

Water Appearance
- ❑ Scum/Film
- ❑ Foam
- ❑ Muddy Brown
- ❑ Milky
- ❑ Clear
- ❑ Oily Sheen
- ❑ Frozen
- ❑ Other_____

Field: Biological/Unusual Observations:

Time of Sample	Total Depth ft	Water Temp ℃
D.O. saturation %	D.O. mg/L	

Lab metadata

Turbidity NTU's

Fecal Coliform ____FC = ____FC / mL **100** mL

Fecal Coliform ____FC = ____FC / mL **100** mL

Site LS2. Samish River @ Jolly Road

Water Appearance
- ❑ Scum/Film
- ❑ Foam
- ❑ Muddy Brown
- ❑ Milky
- ❑ Clear
- ❑ Oily Sheen
- ❑ Frozen
- ❑ Other_____

Field: Biological/Unusual Observations:

Time of Sample	Total Depth ft	Water Temp ℃
D.O. saturation %	D.O. mg/L	

Lab metadata

Turbidity NTU's

Fecal Coliform ____FC = ____FC / mL **100** mL

Fecal Coliform ____FC = ____FC / mL **100** mL

Site LS3. Samish River @ Thomas Road Bridge

Water Appearance
- ❑ Scum/Film
- ❑ Foam
- ❑ Muddy Brown
- ❑ Milky
- ❑ Clear
- ❑ Oily Sheen
- ❑ Frozen
- ❑ Other_____

Field: Biological/Unusual Observations:

Time of Sample	Total Depth ft	Water Temp ℃
D.O. saturation %	D.O. mg/L	

Lab metadata

Turbidity NTU's

Fecal Coliform ____FC = ____FC / mL **100** mL

Fecal Coliform ____FC = ____FC / mL **100** mL

Site LS4. Samish River @ Mouth (Boat Dock)

Water Appearance
- ❑ Scum/Film
- ❑ Foam
- ❑ Muddy Brown
- ❑ Milky
- ❑ Clear
- ❑ Oily Sheen
- ❑ Frozen
- ❑ Other_____

Field: Biological/Unusual Observations:

Time of Sample	Total Depth ft	Water Temp ℃
D.O. saturation %	D.O. mg/L	

Lab metadata

Turbidity NTU's

Fecal Coliform ____FC = ____FC / mL **100** mL

Fecal Coliform ____FC = ____FC / mL **100** mL

Additional notes or observations: