Sequim-Dungeness Clean Water District Pollution Identification & Correction Plan Trends Monitoring Program Annual Report

April 2017 - March 2018

***Prepared by*:**
Clallam County Health & Human Services, Environmental Health Section and Clallam County Roads, Streamkeepers Program

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Sequim-Dungeness Clean Water District
Pollution Identification & Correction Plan
Trends Monitoring Program
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Introduction

In 2001 Clallam County established a shellfish protection district named the Sequim-Dungeness Clean Water District (District) by adopting Chapter 27.16 of Clallam County Code (CCC). The boundaries of the District include "The Dungeness Watershed and those waters influenced by it through the irrigation system, and other independent tributaries to the Strait of Juan de Fuca, from Bagley Creek east to and including the Sequim Bay Watershed." (The boundaries of the District generally coincide with the boundaries of Clallam County's Marine Recovery Area, or MRA, where the County is also required to implement an enhanced Onsite Sewage Management Plan under RCW 70.118A).

State law (RCW 90.72) directs formation of shellfish protection districts where nonpoint pollution threatens water quality "…upon which the continuation or restoration of shellfish farming or harvesting is dependent." By 1997 water quality monitoring had begun to show increasing bacterial pollution in and around Dungeness Bay. In 2000, 2001, and 2003, the Washington State Department of Health downgraded portions of the Dungeness Bay shellfish growing area due to bacterial pollution understood to stem from nonpoint sources within the watershed.

In May 2015, Clallam County Environmental Health, with the assistance of staff and volunteers from Streamkeepers of Clallam County, initiated a Baseline Trends Monitoring Program to track surface water quality in the Sequim-Dungeness Clean Water District. This effort was called for by the Pollution Identification & Correction Plan for the Sequim Bay-Dungeness Watershed Clean Water District (PIC Plan). Created by PIC Project Partners for the District in 2014, the PIC Plan is one element of the shellfish downgrade response plan for the Sequim-Dungeness Clean Water District. The Baseline Trends Monitoring study area includes major freshwater drainages within the District.

This is the third annual PIC Trends Monitoring report, covering the period April 2017 through March 2018.

Future annual Baseline Trends reports will likely transition to a calendar year beginning January 1 and ending December 31.

Sampling Approach and Results

The objective of the Baseline Trends Monitoring Program is to consistently monitor long-term water quality in order to evaluate trends at or near the mouths of waterways throughout the District. This information helps prioritize waterways for further targeted investigation and eventual pollution cleanup as described in the PIC Plan. Further, trends monitoring builds upon at least two decades of prior water quality studies. As in past investigations, we focused on water quality parameters associated with human sewage and animal waste such as fecal coliforms and nutrients.

Sampling locations were chosen as close to the discharge points of the streams as practical given ownership, access, and tidal conditions. Twelve streams were designated Tier 1 sites and nine streams were designated Tier 2 sites. Tier 1 sites were sampled monthly for both fecal coliforms (fecals) and nutrients (NH4, NO2, NO3, TN, PO4, TP, and silicates). Tier 2 sites were sampled quarterly (January, April, August, November) for fecal coliforms only.

In addition to bacteria and nutrients sampling, temperature, dissolved oxygen, pH, conductivity, salinity, turbidity, and barometric pressure were recorded at all sample sites. Discharge was recorded for the Dungeness River and McDonald Creek given the availability of real-time gauges. Elsewhere, stream water level (stage) measurements were taken. Table **1** describes sites and sampling conducted while Figures 1-3 show sample site locations.

Table 1. Site locations and **type of sampling performed from April 2017 through March 2018.** Tier 1 sites were sampled monthly for fecal coliforms (F) and nutrients (N). Tier 2 sites were sampled quarterly for fecal coliforms only. At all sites, standard water quality measurements were taken of temperature, dissolved oxygen, pH, conductivity, salinity, turbidity, and barometric pressure, though the project QAPP (Chadd et al. 2017) required temperature and salinity measurements only. Dung. Bay/R. = Dungeness Bay/River. Seq. Bay = Sequim Bay. SJF = Strait of Juan de Fuca.

	Stream/Site Name	Receiving Waters	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Tier 1 Streams	Dungeness 0.7	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Meadowbrook 0.2	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Meadowbrook Slough 0.23	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Golden Sands Slough 0.0	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Cooper 0.1	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Cassalery 0.0/0.6 (Tide Dependent)	Dung.Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Matriotti 0.3a	Dung. R.	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Lotzgesell 0.1	Dung. R.	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Sequim Bay State Park Creek 0.0/0.1 (Tide Dependent)	Seq. Bay	*	*	F N	F N	F N	F N	*	F N	F N	F N	F N	F N
	Bell 0.2	Seq. Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Johnson 0.0	Seq. Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
	Jimmycomelately 0.15	Seq. Bay	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N	F N
Tier 2 Streams	Bagley 0.7a	SJF	F				F			F		F		
	Siebert 1.0	SJF	F				F			F		F		
	Agnew Creek/Ditch 0.3	SJF	F				F			F		F		
	McDonald 01.6	SJF	F				F			F		F		
	Hurd 0.2	Dung. R.	F				F			F		F		
	Gierin 1.8	Dung.Bay	F				F			F		F		
	Dean 0.17	Seq. Bay	F				**			F		**		
	No Name 0.03	Seq. Bay	F				F			F		F		
	Chicken Coop 0.24	Seq. Bay	F				F			F		F		

* Sequim Bay State Park Creek inaccessible in April and May 2017 due to construction road closure. Insufficient flow at Sequim Bay State Park in October 2017. Sequim Bay State Park Creek 0.1 station added in January 2018 to avoid tidal influence at sample site.

**Insufficient flow/volume at Dean Creek in August 2017 and no safe access at Dean Creek in January 2018.

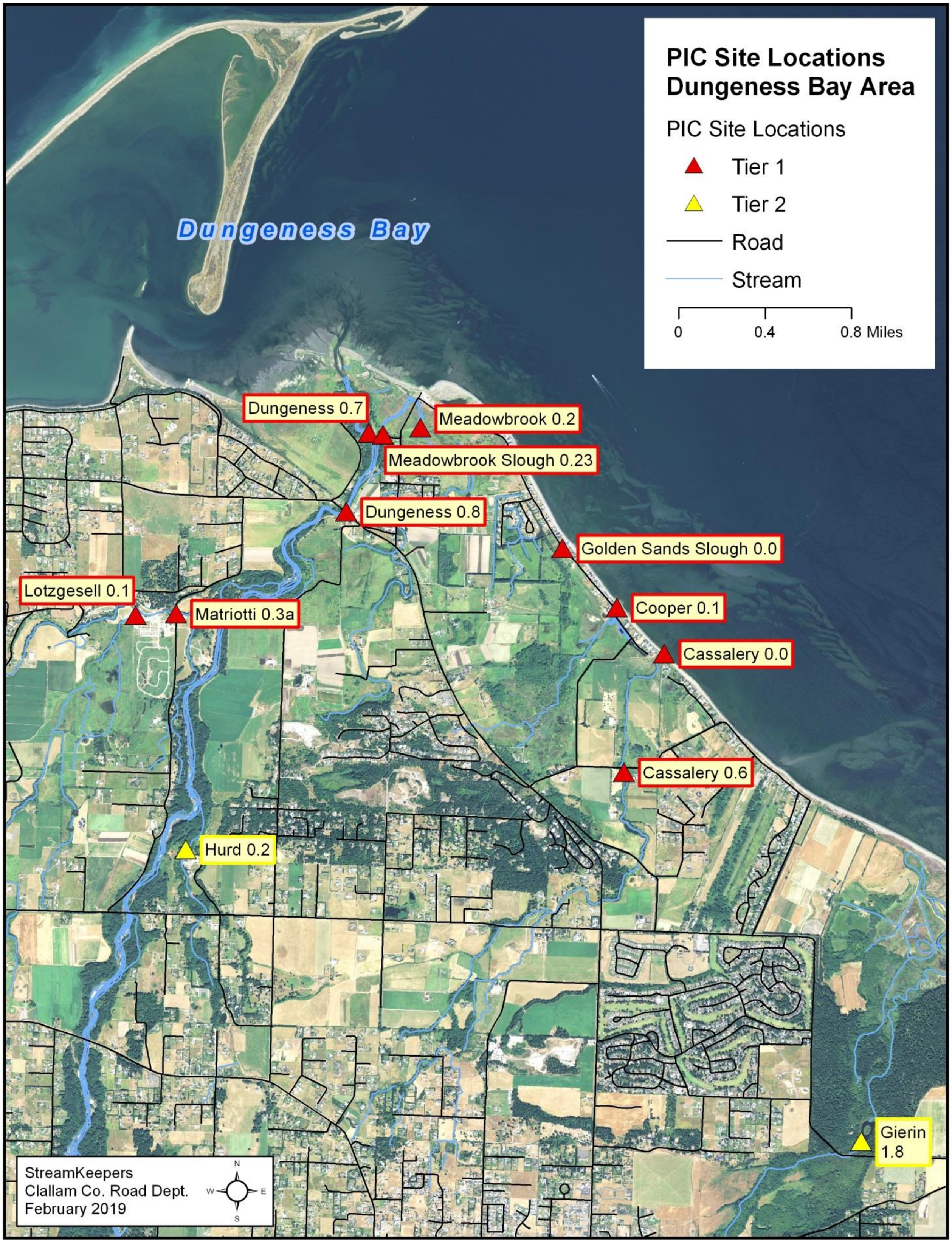

Figure 1**.** PIC Baseline Trends Monitoring sample sites, Dungeness Bay area. Dept. of Ecology real-time flow meter located at Dungeness 0.8.

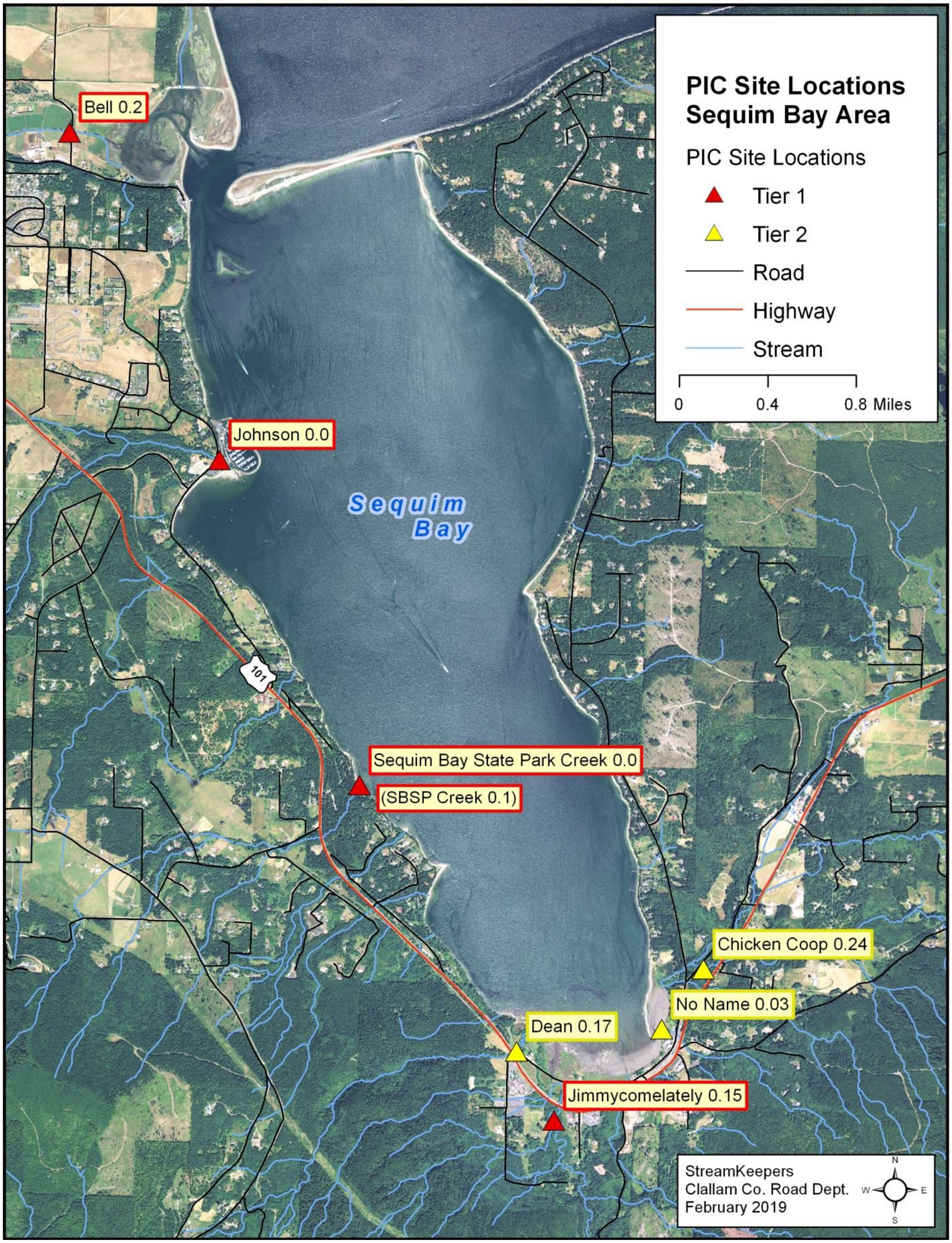

Figure 2. PIC Baseline Trends Monitoring sample sites, Sequim Bay area.

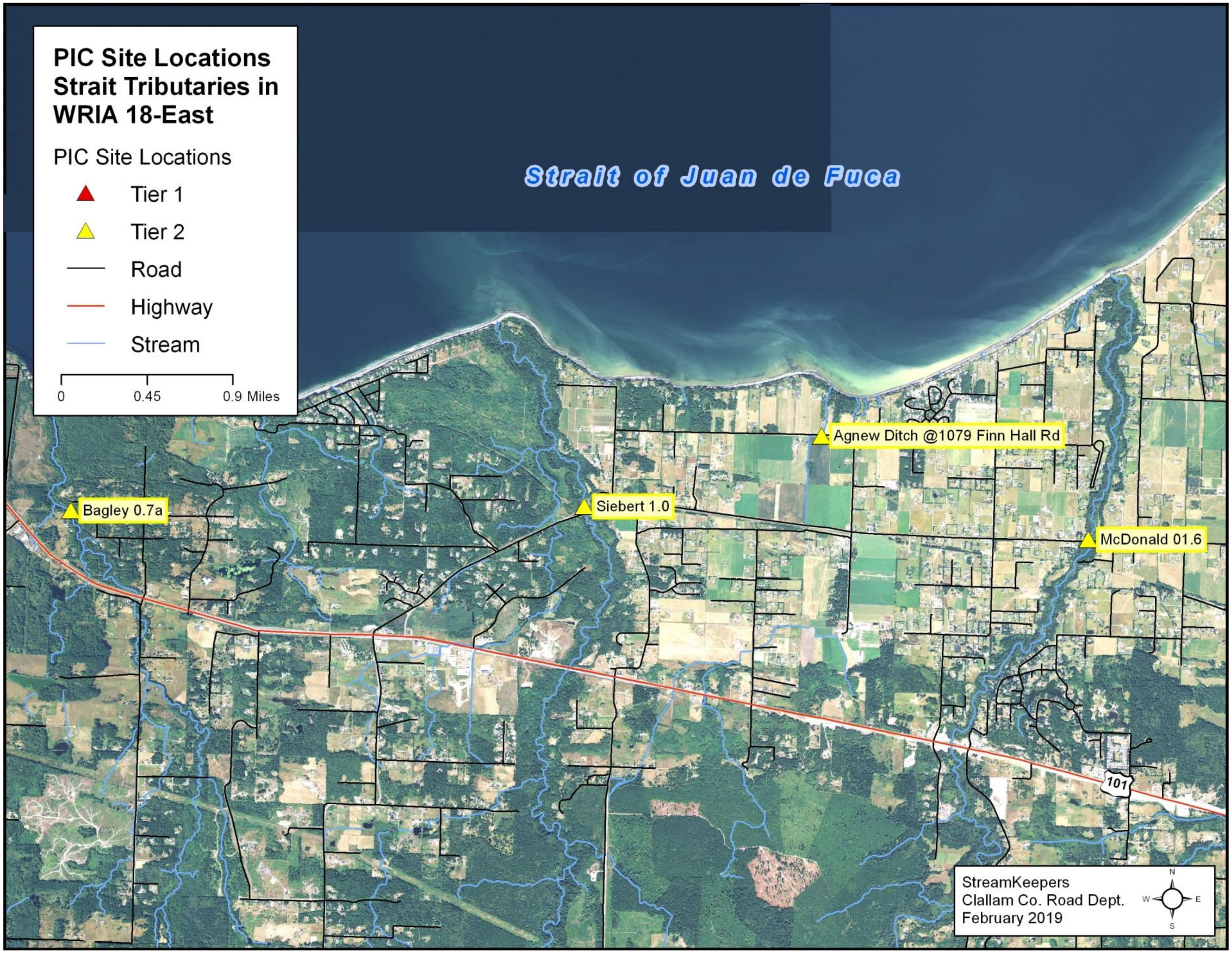

Figure 3. PIC Baseline Trends Monitoring sample sites, waters west of Dungeness Bay.

Data Caveats

- Nutrients samples were analyzed by the University of Washington Marine Chemistry Lab (UW). As of 2015, the Washington Department of Ecology no longer recognizes the validity of UW nutrients analysis procedures for data interpretation for the 303(d) list under the Clean Water Act. Hence, nutrients data are for general descriptive purposes only. We chose to use the UW lab because 1) it has traditionally been used to analyze nutrients samples from the Clean Water District, 2) it is inexpensive and logistically more accommodating, 3) side-by-side comparisons between the UW and Ecology labs in 2013-14 showed generally good correlation (Environmental Health Services and Streamkeepers Program 2014), and 4) we do not intend to use nutrients data to guide regulatory decisions.
- Data qualifiers used are per Ecology's Environmental Information Management (EIM) system.
- No rejected (REJ) data were used in our analyses.
- Field replicates were averaged with regular samples.
- Field blanks were recorded and used for quality control (QC) analyses but were not used in this report to generate statistics or figures.
- Some of the sites are tidally influenced, as can be seen in the salinity data presented below. We tried sampling during low-tide conditions, but this was not always possible. Alternate sites were sampled at Cassalery Creek and Sequim Bay State Park when tides prohibited collection of freshwater observations.

Data Quality Analysis

Various data quality analyses helped PIC Project Partners decide where Measurement Quality Objectives (MQO) had been met.

Blanks Analysis—Fecal Coliforms

In general, one fecal coliform field blank (FB) is prepared each sampling tour. From April 2017 through March 2018, all fecal coliform field blanks were "non-detects" *except* for the blank prepared during the November 14, 2017 quarterly sampling tour from which 76 fecal coliform CFU/100 mL were measured. The blank itself was rejected and all fecal coliform data from the November sampling tour were qualified as "J-variants," or laboratory data estimates, because "…one or more QC screens have not passed but the QA officer believes the data to be reasonably trustworthy for general water-quality assessments" (Chadd et al. 2017).

Many of the fecal coliform concentrations measured from among the November 2017 quarterly samples were much lower than the field blank. As such, it is unlikely that some source of contamination affected the samples collected during the tour, and the problem seems to have been limited to the blank itself.

In addition to field blanks, the Clallam County Water Laboratory prepares and analyzes a lab blank 1) before running samples, 2) after every ten samples, and 3) after running all samples. Lab blank results are not reported to the PIC Baseline Trends Monitoring Program. Rather, these blanks serve as an internal control for the laboratory. For the period of this report no fecal coliform data were rejected or qualified due to laboratory blanks. Clallam County Environmental Health Laboratory is accredited by Washington Department of Ecology and follows Membrane Filter Standardized Method SM9222D.

Blanks Analysis—Nutrients

At least one nutrient field blank is prepared for each PIC Basleline Trends Monitoring tour. Table 2 summarizes nutrient field blank results. UW Marine Chemistry Laboratory provides annual Minimum Detection Limits (MDL). Synthesized Reporting Limit (RL) is calculated as the larger of 3.18 * Annual MDL *or* FB mean + 1 Standard Deviation (SD), per Chadd et al. 2017.

Various field blanks contained high nutrient concentrations and prompted speculation around potential sources of contamination. This became most pronounced in January 2018 where all nutrient field blanks appeared problematic. The entire blank preparation protocol was reviewed and updated, field kits were stocked with new sample preparation bottles, and a fresh source of deionized water was supplied.

Further, the current iteration of the Pollution Identification and Correction QAPP is inadequate in addressing the problematic nutrient field blanks and associated environmental data. As such, Tukey's method for identifying outliers was used to flag nutrient blanks for exclusion when calculating mean and standard deviation of the field blanks dataset (statistics needed to generate the synthesized reporting limit). Environmental data corresponding to these outlier blanks have been qualified as "J-variants" (laboratory data estimates) following lengthy discussions between PIC partners and Washington Department of Ecology Environmental Assessment Program. Factors considered include 1) sample sites with expected low nutrient concentrations produced nutrient levels below field blank values, 2) sample sites with expected high nutrient concentrations produced nutrient levels above field blank values, 3) potential negative consequences of including nutrient data estimates in analyses are minimal, and 4) nutrients data are already assumed not suitable for inclusion in Washington State's EIM database. Various proposed edits have been compiled in order to guide future QAPP updates.

Beyond field blanks, UW Marine Chemistry Laboratory internal QA/QC involves nutrient lab blank preparation and analysis. These analyses are not presented here, as the lab only reports data that have passed internal controls. To date, laboratory nutrient blanks have never prompted data qualification or corrective action.

Table 2. Nutrients field blank (FB) results, Tukey fence calculations, outlier analysis, and synthetic reporting limit (RL) calculations. All values in [µg/L]. Field blank outliers were excluded from mean, standard deviation (SD), and RL calculations.

Arrival Date	[PO_4-P]	[SiO_4-Si]	[NO_3-N]	[NO_2-N]	[NH_4-N]	TP	TN
17-Apr-17	0.1	6.8	0.0	0.4	2.9	4.0	~~150.0~~ [1]
9-May-17	0.4	0.0	0.0	0.1	0.3	1.3	20.2
13-Jun-17	0.7	5.8	0.9	0.0	0.0	1.2	29.8
18-Jul-17	0.8	8.4	0.0	0.5	2.2	0.8	60.1
14-Aug-17	1.1	15.3	1.0	0.0	0.1	2.7	91.8
19-Sep-17	0.7	5.4	0.9	0.0	7.2	1.9	63.1
10-Oct-17	0.0	10.1	0.0	0.0	1.4	3.4	21.9
13-Nov-17	1.5	15.8	0.3	0.0	~~59.6~~ [1]	0.0	20.0
12-Dec-17	~~89.7~~ [1]	~~105.5~~ [1]	0.5	0.2	3.6	~~91.9~~	43.9
8-Jan-18	~~48.9~~ [1]	~~3875.8~~ [1]	~~236.8~~ [1]	~~3.4~~ [1]	~~45.4~~ [1]	~~57.1~~ [1]	~~480.8~~ [1]
13-Feb-18	~~33.8~~ [1]	40.1	0.0	0.0	3.6	~~34.4~~ [1]	10.8
13-Mar-18	1.3	8.3	~~2.9~~ [1]	0.0	18.5	1.9	45.0

[1] *Field blanks with values above Tukey's upper fence and below Tukey's lower fence were classified as outliers and excluded from subsequent mean and SD calculations.*

	[PO_4-P]	[SiO_4-Si]	[NO_3-N]	[NO_2-N]	[NH_4-N]	TP	TN
Median	0.9	9.3	0.37	0.01	3.2	2.3	44.5
1st Quartile	0.6	6.5	0.00	0.00	1.1	1.3	21.5
3rd Quartile	9.5	21.9	0.95	0.24	10.0	11.6	70.3
IQR [2]	9.0	15.3	0.95	0.24	8.9	10.3	48.8
Upper Fence [3]	23.0	44.9	2.4	0.6	23.4	27.1	143.4
Lower Fence [4]	-12.9	-16.5	-1.4	-0.4	-12.3	-14.2	-51.7

[2] *Inter-Quartile Range*
[3] *Tukey's upper fence, defined as 3rd quartile + k(IQR) where k = 1.5 (a standard formula).*
[4] *Tukey's lower fence, defined as 1st quartile – k(IQR) where k = 1.5 (a standard formula).*

	[PO_4-P]	[SiO_4-Si]	[NO_3-N]	[NO_2-N]	[NH_4-N]	TP	TN
Total Outliers	3	2	2	1	2	3	2
Percent Outliers	25.0%	16.7%	16.7%	8.3%	16.7%	25.0%	16.7%
2017 MDL [5]	0.4	6.3	4.0	0.2	0.7	0.4	9.5
3.18(MDL)	1.3	20.0	12.7	0.6	2.2	1.3	30.2
Blanks Mean	0.7	11.6	0.4	0.1	4.0	1.9	40.7
Blanks SD	0.5	11.0	0.4	0.2	2.3	1.3	25.2
Synthetic RL [6]	1.3	22.6	12.7	0.6	6.3	3.2	65.9

[5] *Minimum Detection Limit provided annually by UW Marine Chemistry Laboratory.*
[6] *Synthetic RL defined as maximum of 3.18(MDL) or Mean + SD per QAPP (Chadd et al. 2017).*

Field Replicate Analysis—Fecal Coliforms

Field replicates of fecal coliform grab samples are collected at the rate of one for every 5% of sites or at least one per sampling tour. Field replicates help assess precision and confidence in sampling procedures.

Primary samples and replicates from each sampling day are compared in terms of relative standard deviation (RSD). In general, Clallam County Water Laboratory analyzes the field replicate and a laboratory duplicate of the field replicate; the mean of these two values is reported as “replicate” in Table 3, below.

QAPP section 6.2 describes the desired level of agreement between qualifying pairs of primary FC samples and field replicates (after pairs with averages below 20 CFU/100mL have been excluded). Half of all pairs should have less than or equal to 20% RSD, ninety-per-cent of qualifying pairs should have less than or equal to 50% RSD, and all qualifying pairs should have less than 85% RSD. Table 4, below, compares observed results against these criteria for the reporting period.

No fecal coliform data were qualified based on field replicate analyses, as replicate pairs met measurement quality objectives described in QAPP section 6.2 (Chadd et al. 2017).

Table 3. Fecal coliform field replicate results. Here each fiield replicate and a laboratory duplicate of the field replicate are averaged and reported as a single, composite value called "replicate."

Date	Type	FC CFU	Mean	%RSD
4/17/17	primary	196		
4/17/17	replicate	196	196	0.0%
4/18/17	primary	38		
4/18/17	replicate	47	42.5	15.0%
5/9/17	primary	82		
5/9/17	replicate	33	57.5	60.3%
6/13/17	primary	134		
6/13/17	replicate	112	123	12.6%
7/18/17	primary	466		
7/18/17	replicate	361	413.5	18.0%
8/14/17	primary	500		
8/14/17	replicate	510	505	1.4%
8/15/17	primary	22		
8/15/17	replicate	60	41	65.5%
9/19/17	primary	68		
9/19/17	replicate	82	75	13.2%
10/10/17	primary	26		
10/10/17	replicate	22	24	11.8%
11/13/17	primary	58		
11/13/17	replicate	93	75.5	32.8%
11/14/17	primary	20		
11/14/17	replicate	25	22.5	15.7%
12/12/17	primary	4		
12/12/17	replicate	2	3	**47.1%** [1]
1/8/18	primary	12		
1/8/18	replicate	2	7	**101.0%** [1]
1/9/18	primary	10		
1/9/18	replicate	7	8.5	**25.0%** [1]
2/13/18	primary	40		
2/13/18	replicate	29	34.5	22.5%
3/13/18	primary	18		
3/13/18	replicate	16	17	**8.3%** [1]
				Total Pairs: 16
				Excluded Pairs: 4
				Qualifying Pairs: 12

[1] *Primary/replicate pairs with means less than 20 CFU (bold) are excluded from MQO analysis.*

Table 4. Fecal coliform data Measurement Quality Objectives.

QC Tiers:	Pairs in Tier	% Pairs in Tier	% Pairs Required	MQO Met?
Pairs ≤ 20% RSD	8	67%	50%	YES
Pairs ≤ 50% RSD	10	91%	90%	YES
Pairs ≤ 85% RSD	12	100%	100%	YES

Field Replicate Analysis—Nutrients

Nutrient field replicates are also collected alongside 5% of all samples (or at least one replicate each tour). These replicates are again compared against their primary samples to calculate Relative Standard Deviation. Primary/replicate pairs with means less than five times the reporting limit are excluded from RSD calculation. QAPP Table 1 (Chadd et al. 2017) describes acceptable annual median RSD values, and sampling results are compared against the criteria below.

Nutrient sample replicate analysis generally showed a high degree of precision among primary/replicate pairs and no data were qualified as a result of this analysis.

Table 5. Nutrients field replicate results and QC analysis.

Analyte	Data Pairs	Median RSD	RSD Criterion	Data Qualified
Ammonia	7	4.83%	15%	none
Nitrate	12	0.58%	10%	none
Nitrite	12	1.79%	10%	none
Phosphate	12	1.19%	10%	none
Silicate	12	0.42%	10%	none
Total N	12	0.97%	10%	none
Total P	12	1.38%	10%	none

Field Replicate Analysis—Physical and Chemical Parameters

The PIC Baseline Trends Water Quality Monitoring Program calls for in situ measurements of water temperature and salinity at all sample sites. Barometric pressure (BP), dissolved oxygen (DO), pH, specific conductance (SPC), and turbidity measurements are also collected (though not required), given the facility of data collection with multimeter probes.

Measurement quality objectives of physical and chemical data are described in terms of maximum allowable percent relative standard deviation and/or maximum allowable difference between primary samples and replicates. Where two criteria are provided, at least one must be met for data to pass unqualified and avoid corrective action. Table 6, below, summarizes comparison of environmental data against MQO criteria. Salinity and tempreature criteria stem from the PIC Project QAPP (Chadd et al. 2017) while all other criteria are inherited from the Streamkeepers Program QAPP (Chadd 2017).

Table 6. Physical/chemical water quality field replicate QC analysis.

Parameter	Units	Data Pairs	Max. RSD	RSD Criterion	Max. Difference	Difference Criterion	Data Qualified
BP	in Hg	17	-	NA	0.01	0.05	none
DO	mg/L	18	-	1% per pair	0.10	0.20	none
pH	-	17	-	NA	0.00	0.20	none
Salinity	ppt/PSU	17	-	5% per pair	0.00	0.02	none
SPC	µS/cm	12	0%	5% per pair	-	NA	none
Temp.	deg. C	17	-	NA	0.00	0.20	none
Turbidity	FNU	18	-	7% per pair	1.00	1.00	none

Laboratory Standards Checks--Nutrients

In addition to internal controls metioned previously, UW Marine Chemistry Laboratory uses check standards to assess bias stemming from analytical methods. Wherever standards are not met, analyses are repeated. Data reported by the lab have passed all internal QA/QC screening. To date no nutrient data have required qualification or corrective action following laboratory data quality analyses.

Compliance with Project QAPP and SOPs

In compliance with the project QAPP (Chadd et al. 2017), environmental data were collected following standard operating procedures (SOP).

Water samples for the purpose of fecal coliform testing were collected in sterile polypropylene (PP) bottes, stored in coolers with ice packs for less than 8 hours, and analyzed at Clallam County Water Laboratory.

Meanwhile, samples for nutrients testing were collected in either acid-washed PP or acid-washed high-density polyethylene (HDPE) bottles, chilled with ice packs in coolers, and shipped overnight to UW Marine Chemistry Laboratory in Seattle, WA.

In situ physical and chemical water quality measurements (temperature, DO concentration, pH, conductivity, salinity, turbidity) were collected using a YSI ProDSS field meter which was calibrated prior to sampling episodes and checked afterward.

Where necessary, data have been flagged with appropriate qualifiers based on QA/QC measures.

In one notable instance, two FC grab samples collected on February 13, 2018 at sites Sequim Bay State Park 0.1 and Cassalery 0.6 contained small amounts of ice upon receipt by Clallam County Water Laboratory. Ice was observed in the streams at the time of sample collection, and samples were chilled in a cooler with ice packs during transport to the lab.

It is unlikely that freezing appreciably influenced sample results in this case. However, SOPs were updated to underscore the importance of using bubble wrap to separate grab samples from ice packs during storage, transport, and shipping in coolers.

Environmental Data Summary

PIC Baseline Trends Monitoring environmental data collected between April 2017 and March 2018 are presented in Appendix 1. These data are explored visually and descriptively, below. Rejected data have been excluded.

Fecal Coliforms

All PIC Baseline Trends Monitoring streams fecal coliform data for the reporting period are summarized below.

Times series fecal coliform data for Meadowbrook Slough follow as this waterway received significant attention and pollution correction efforts throughout the reporting period.

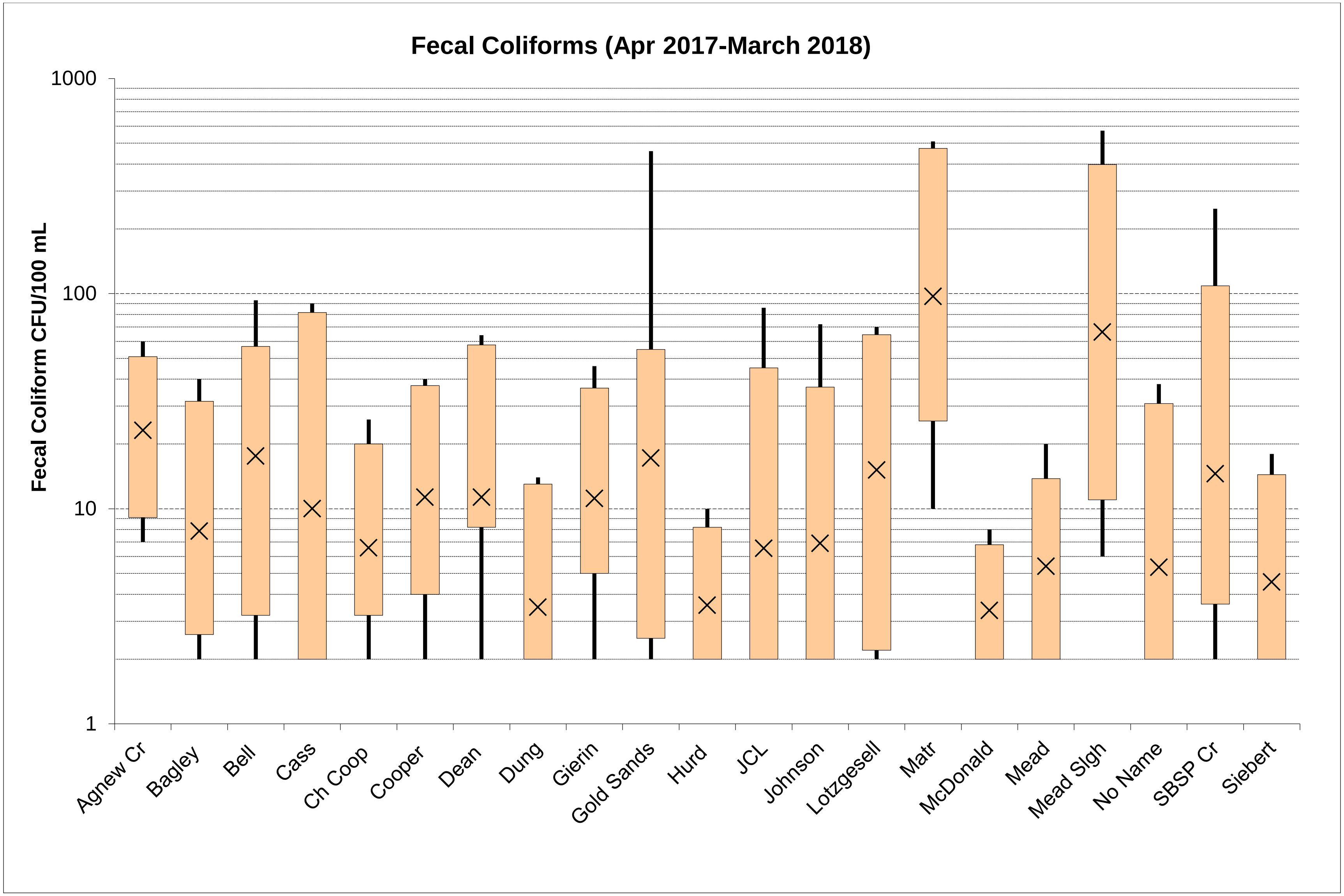

Figure 4. Fecal Coliforms, all CWD streams. Note log scale. X marks geometric mean; bottom and top of box represent observed 10th and 90th percentiles; ends of whiskers represent extremes.

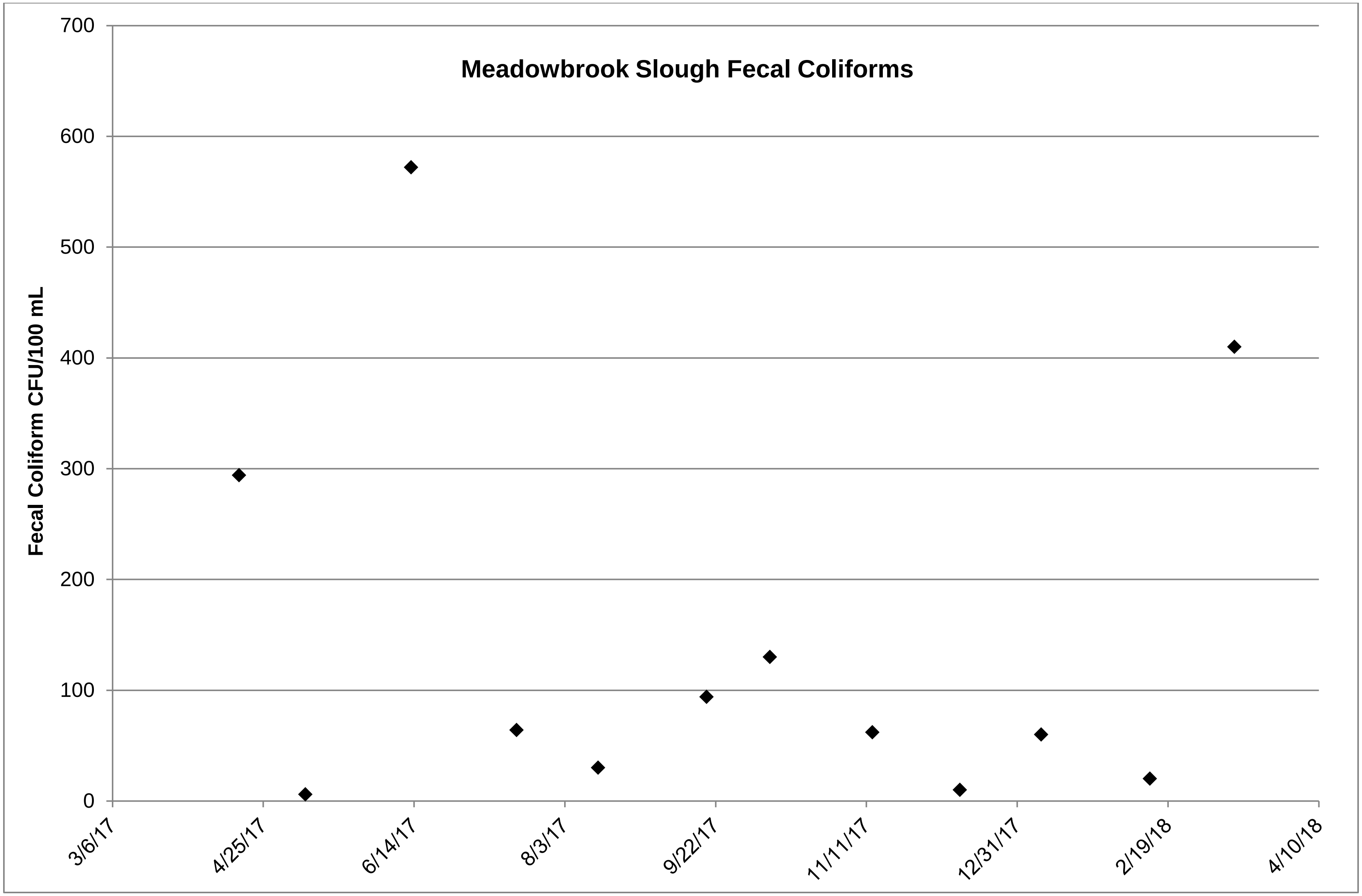

Figure 5. Fecal Coliform values vs. time at Meadowbrook Slough, in Colony-Forming Units per 100 mL (CFU/100 mL).

Nutrients

Nutrients results are summarized below. Nutrients data are collected monthly at Clean Water District Tier 1 streams only.

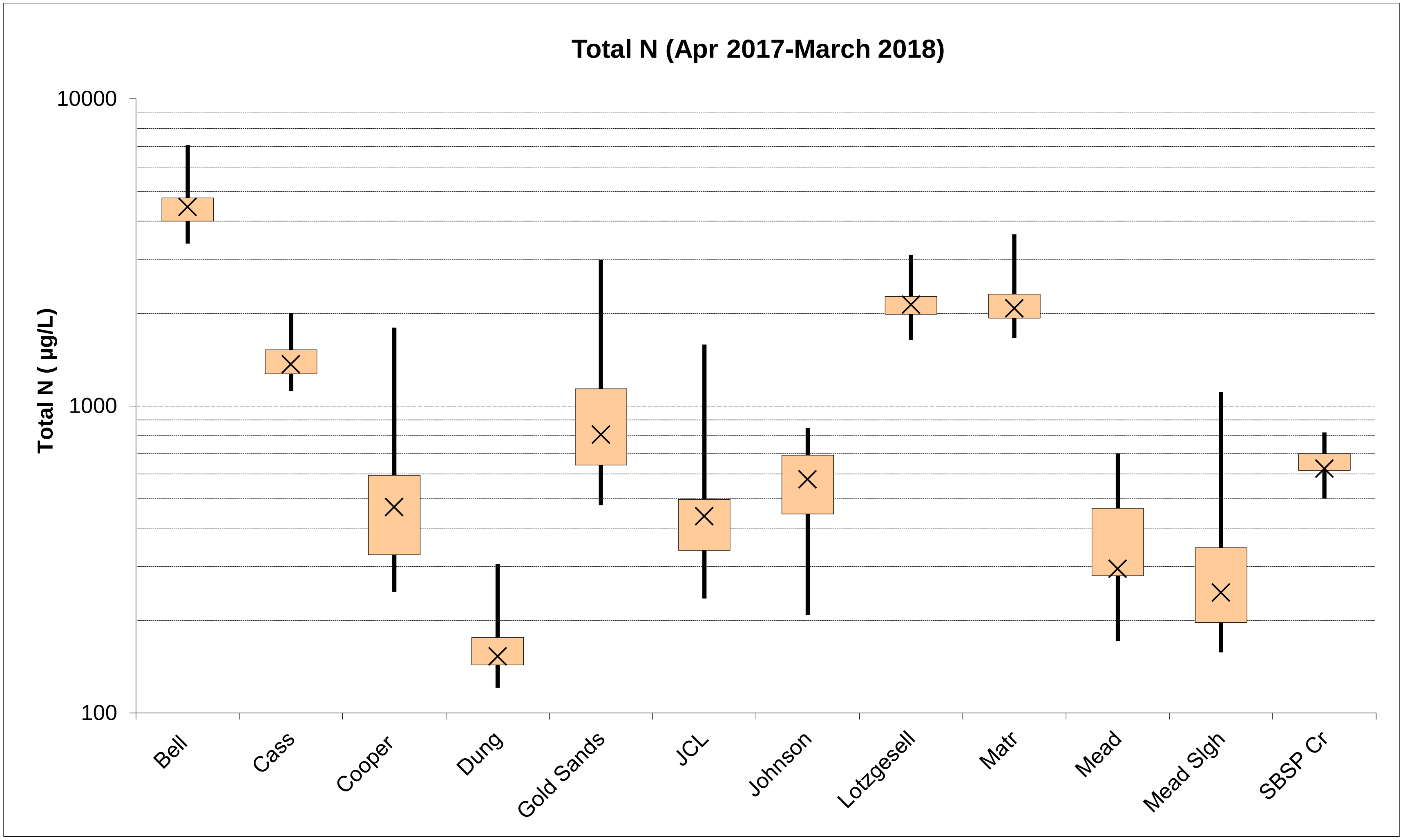

Figure 6. Total nitrogen. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

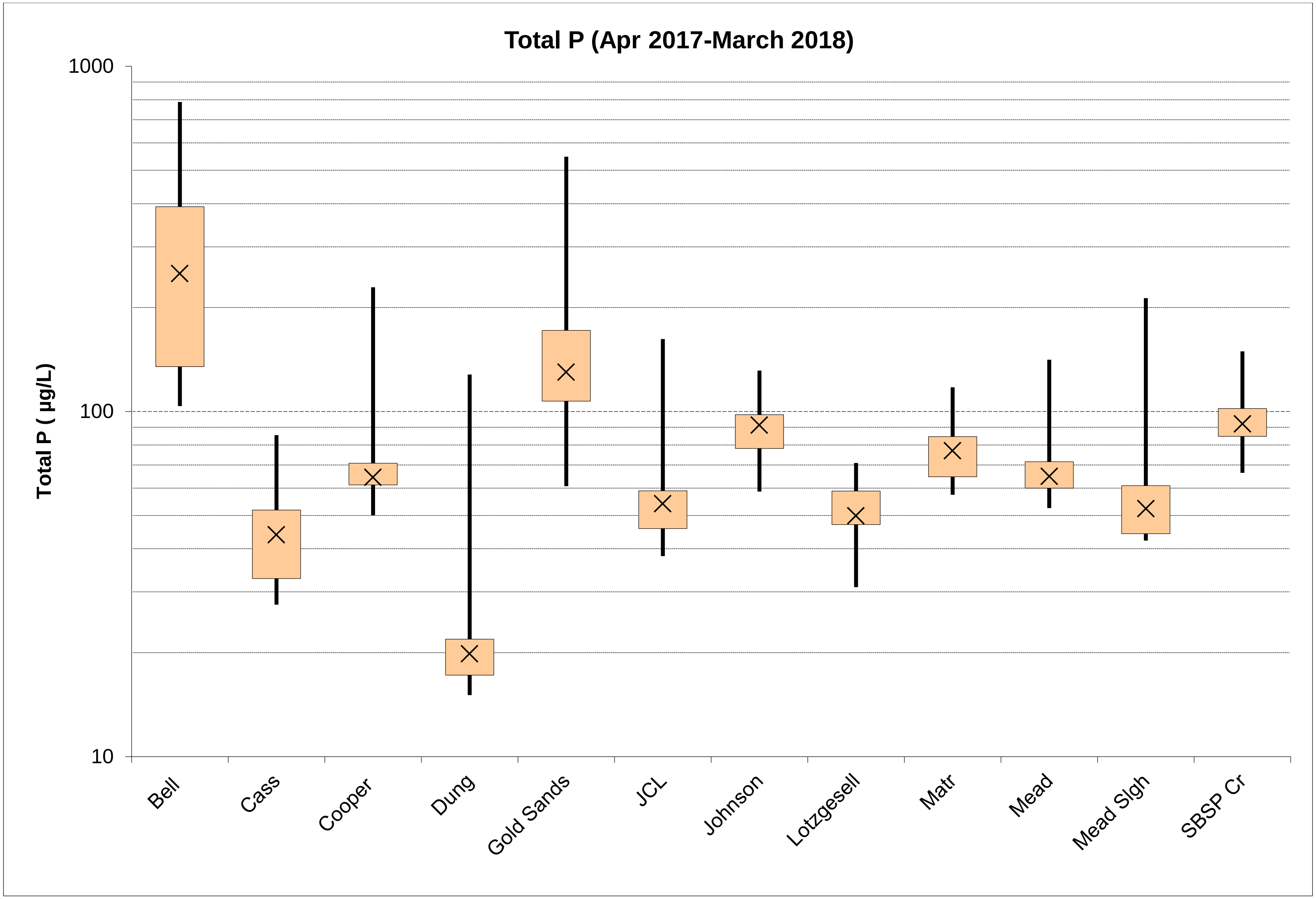

Figure 7. Total phosphorus. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

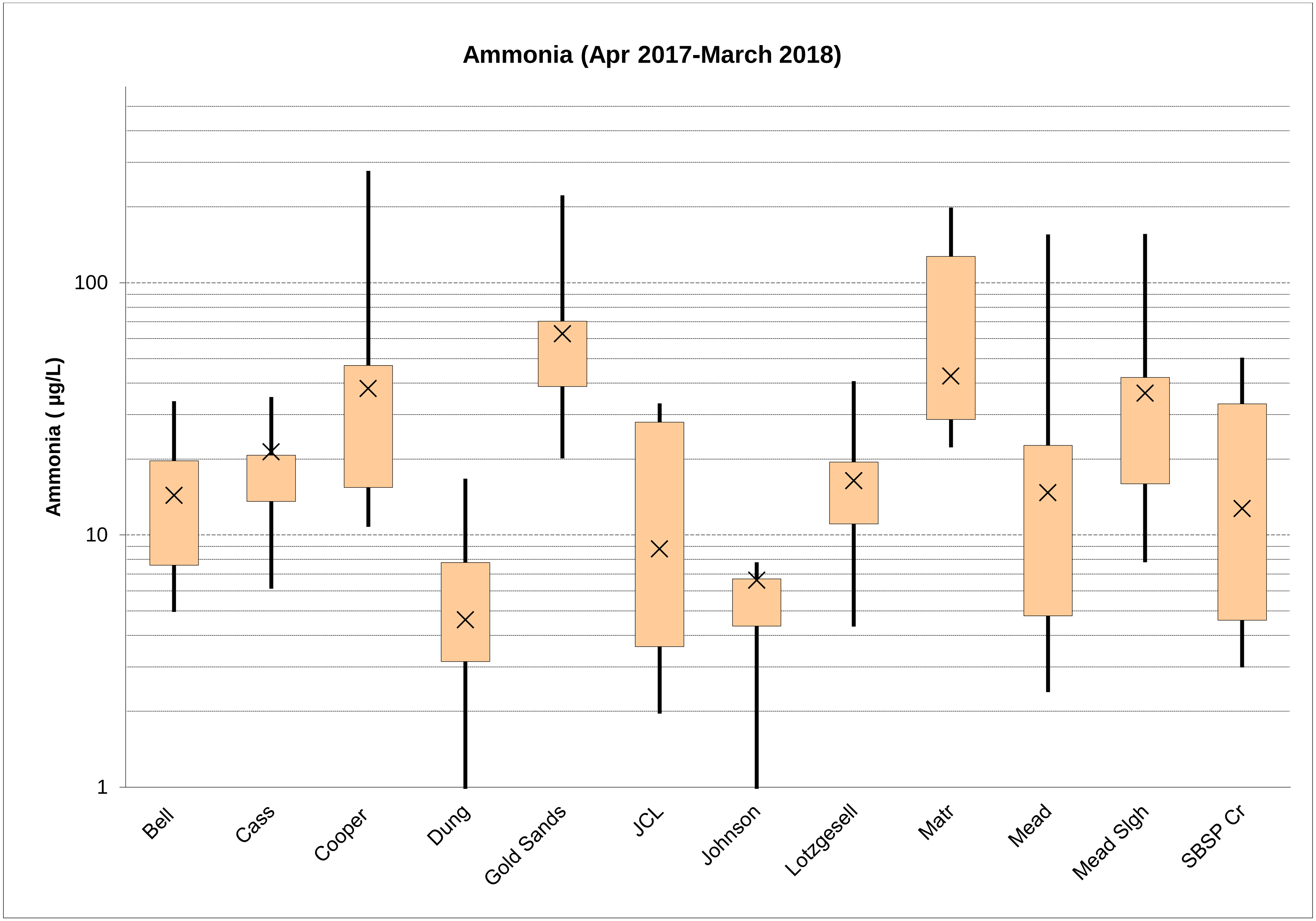

Figure 8. Ammonia. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

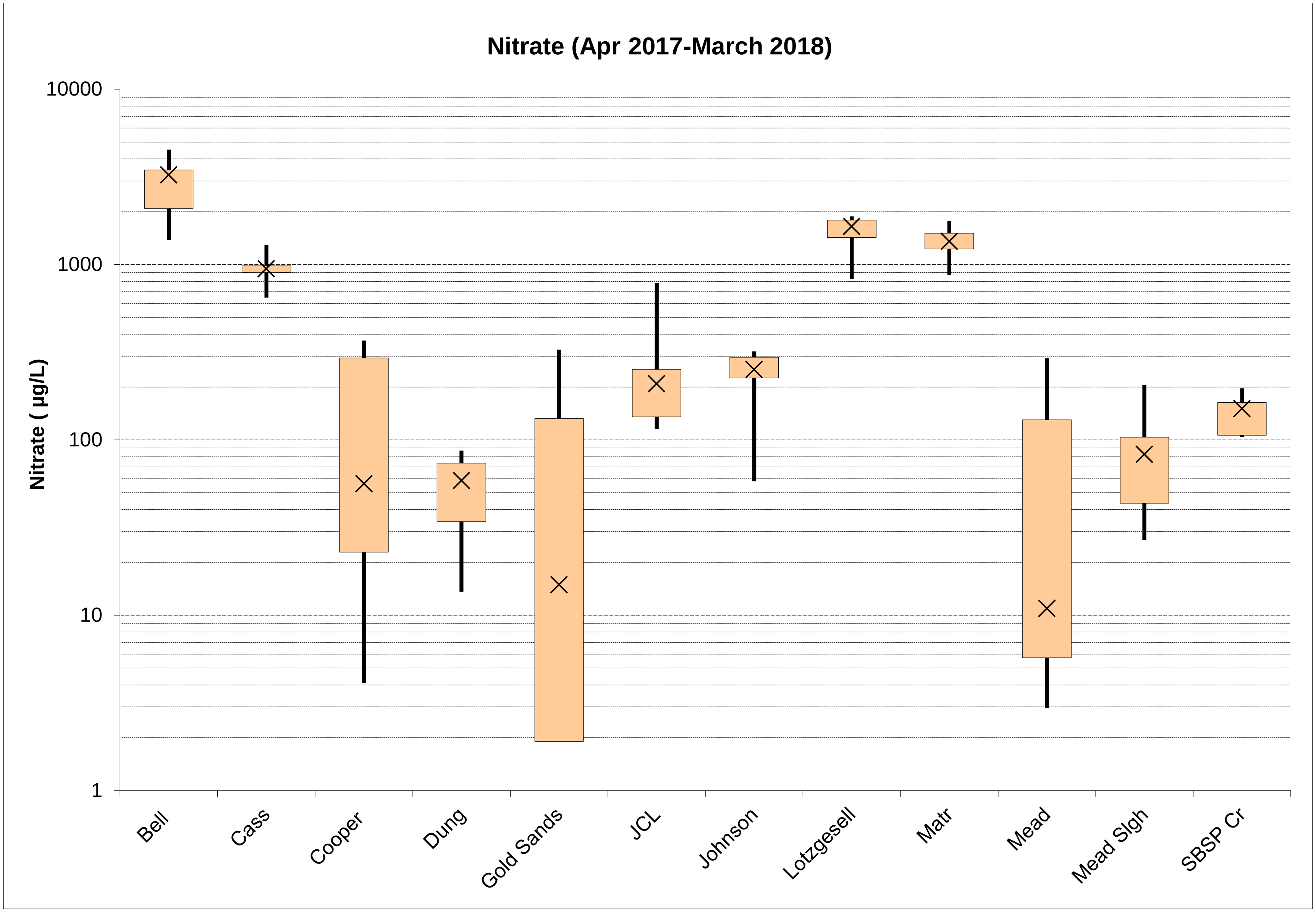

Figure 9. Nitrate as N. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

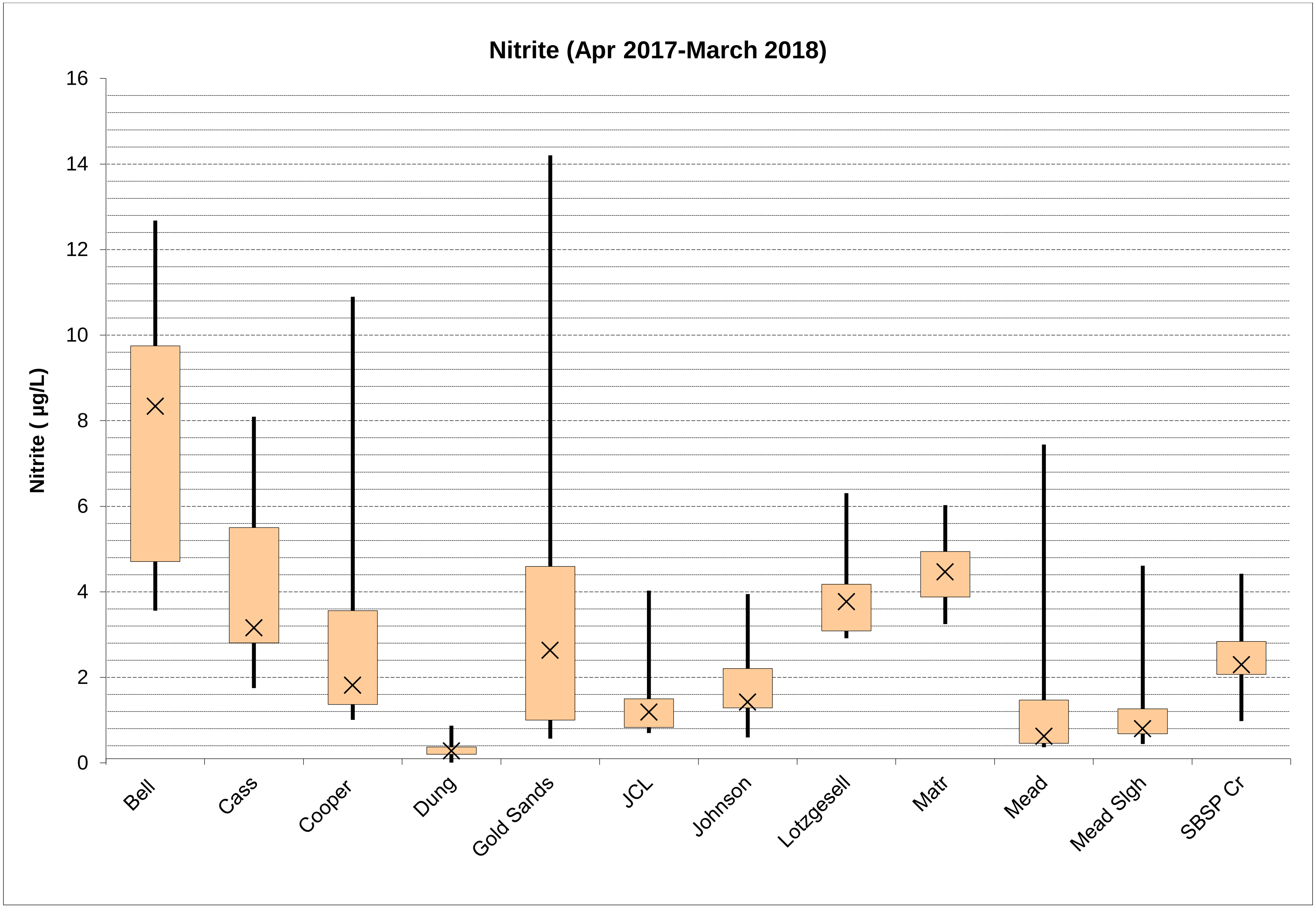

Figure 10. Nitrite as N. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

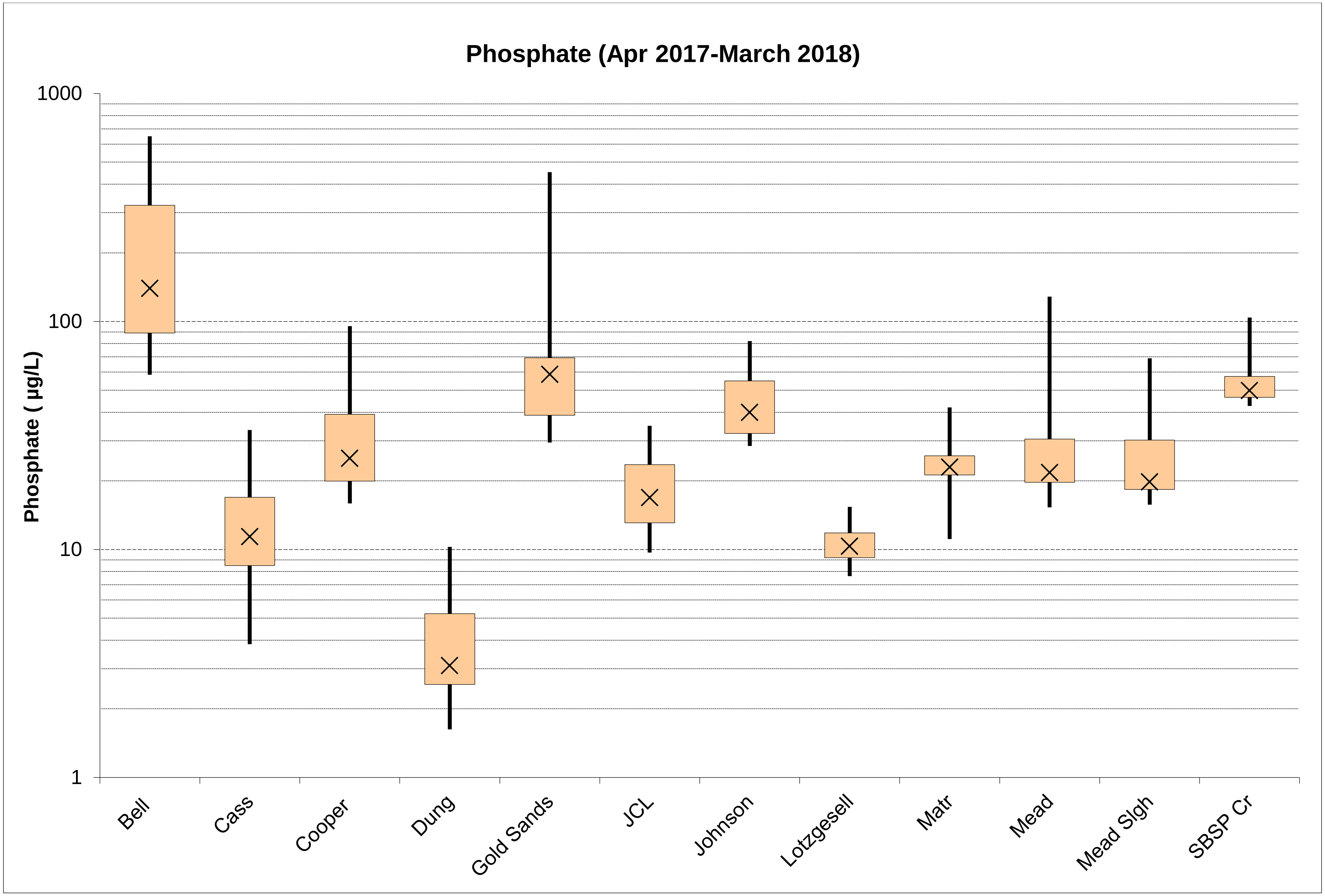

Figure 11. Phosphate as P. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

Physical and Chemical Water Quality Parameters

Summaries of physical and chemical water quality parameters covering the reporting period follow.

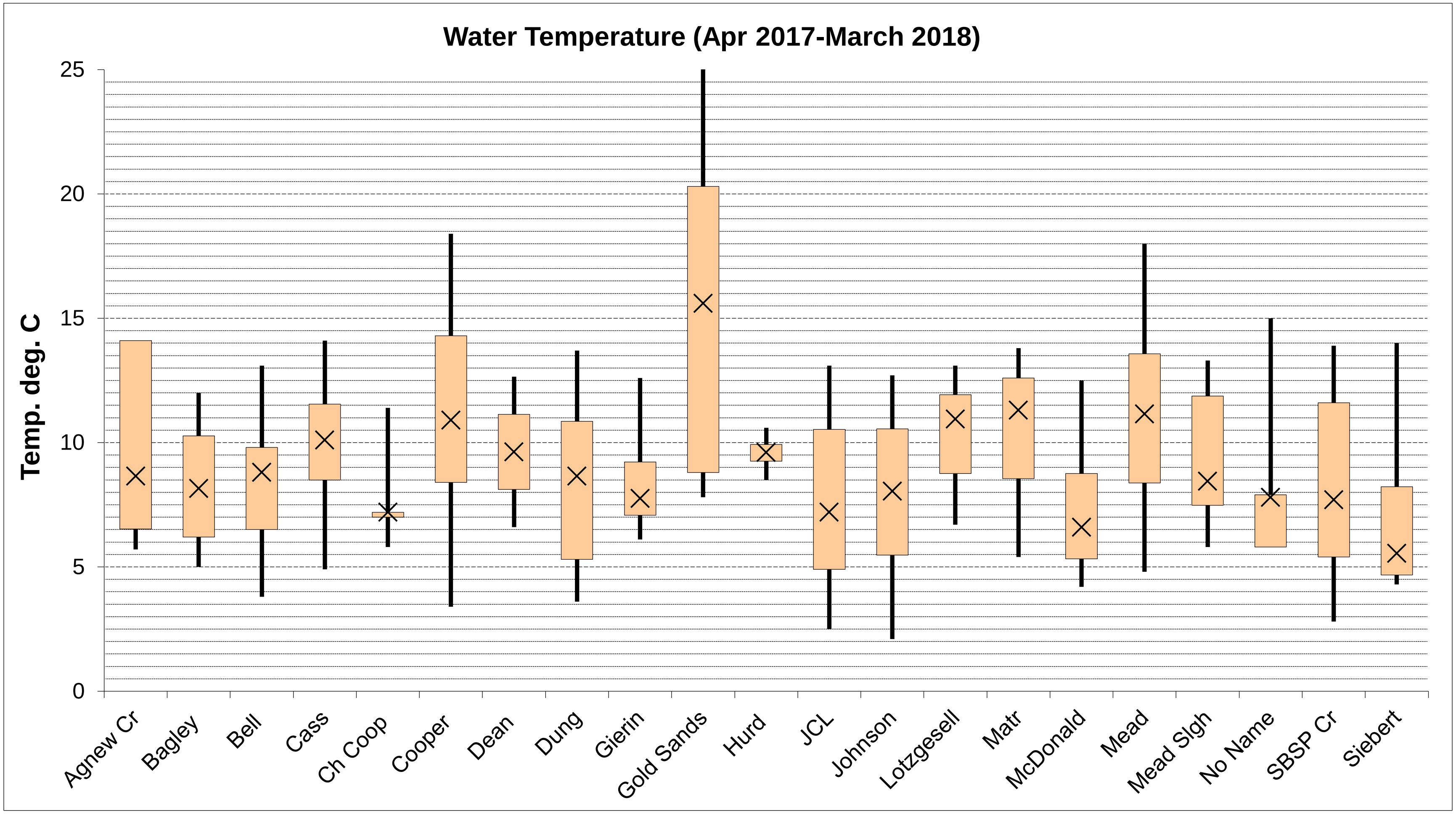

Figure 12. Water temperature. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values. For evaluative purposes, the State's maximum 7-day average of daily maxima for salmonid core summer habitat (the designated use for all sites) is 16°C (Washington Department of Ecology 2006).

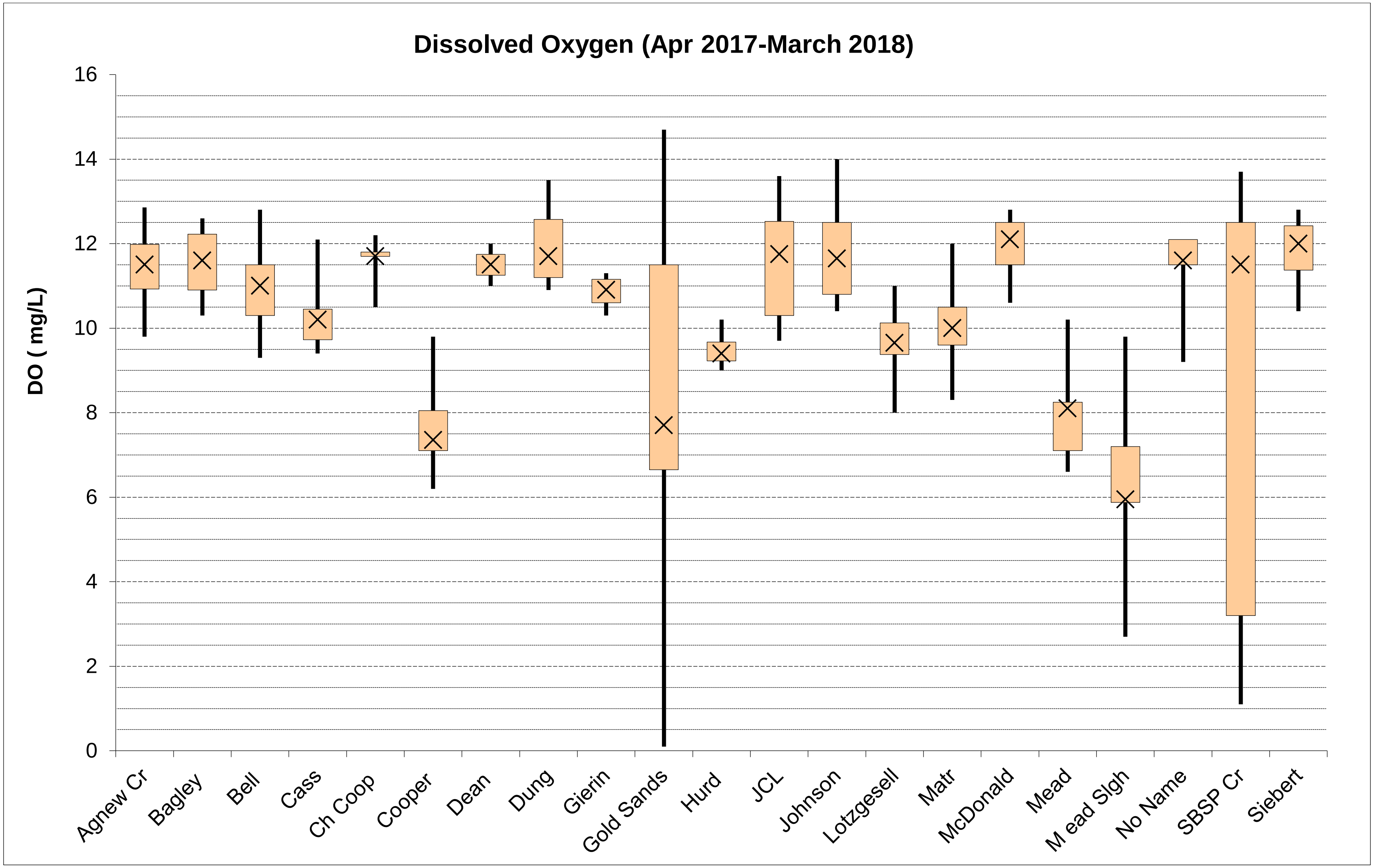

Figure 13. Dissolved Oxygen. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values. For evaluative purposes, the State one-day minimum for the salmonid core summer habitat critical period (the designated use for all these sites) is 9.5 mg/L (Washington Department of Ecology 2006).

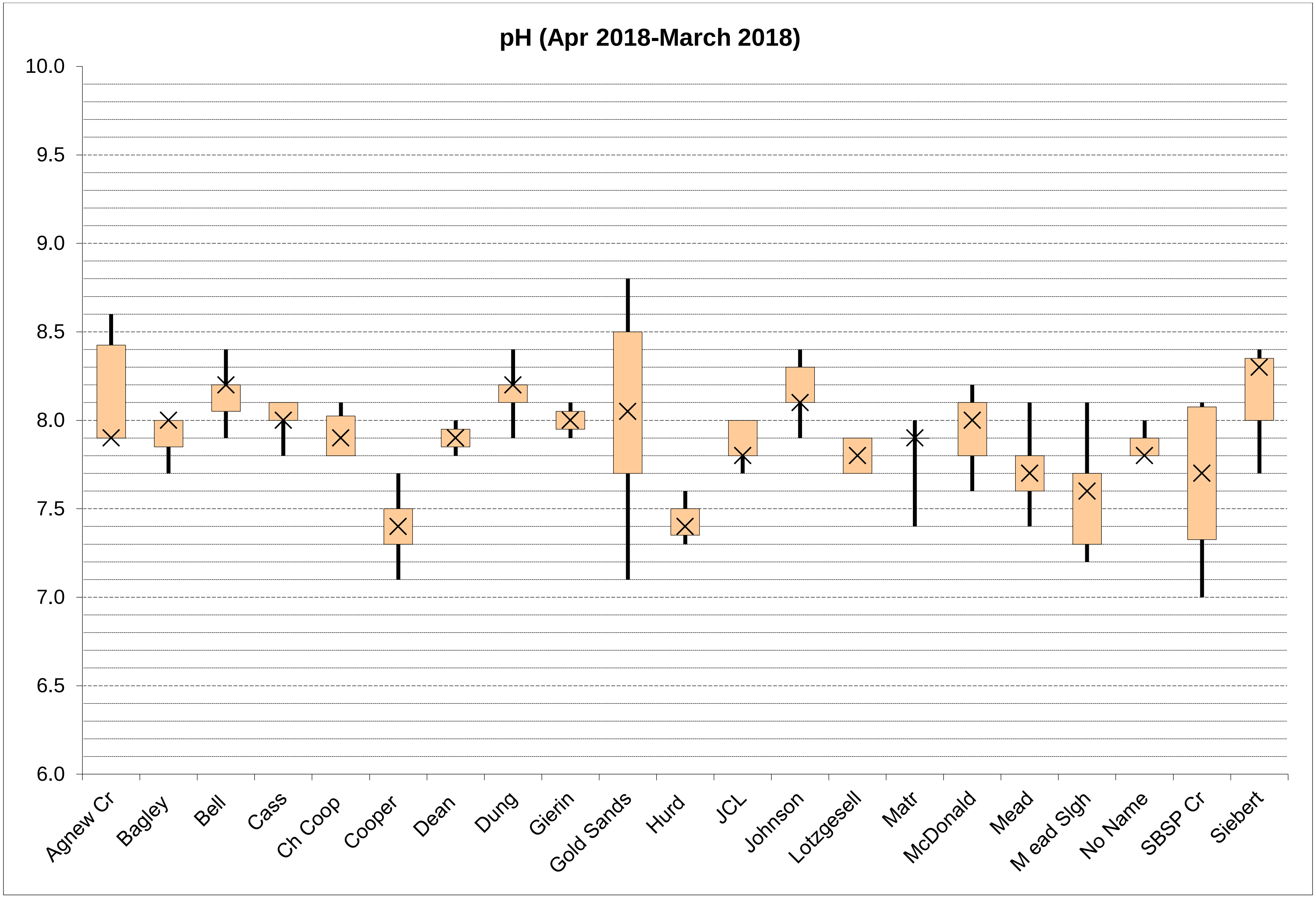

Figure 14. pH. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values. For evaluative purposes, the State standard range for the designated uses of all these sites is 6.5-8.5 (Washington Department of Ecology 2006).

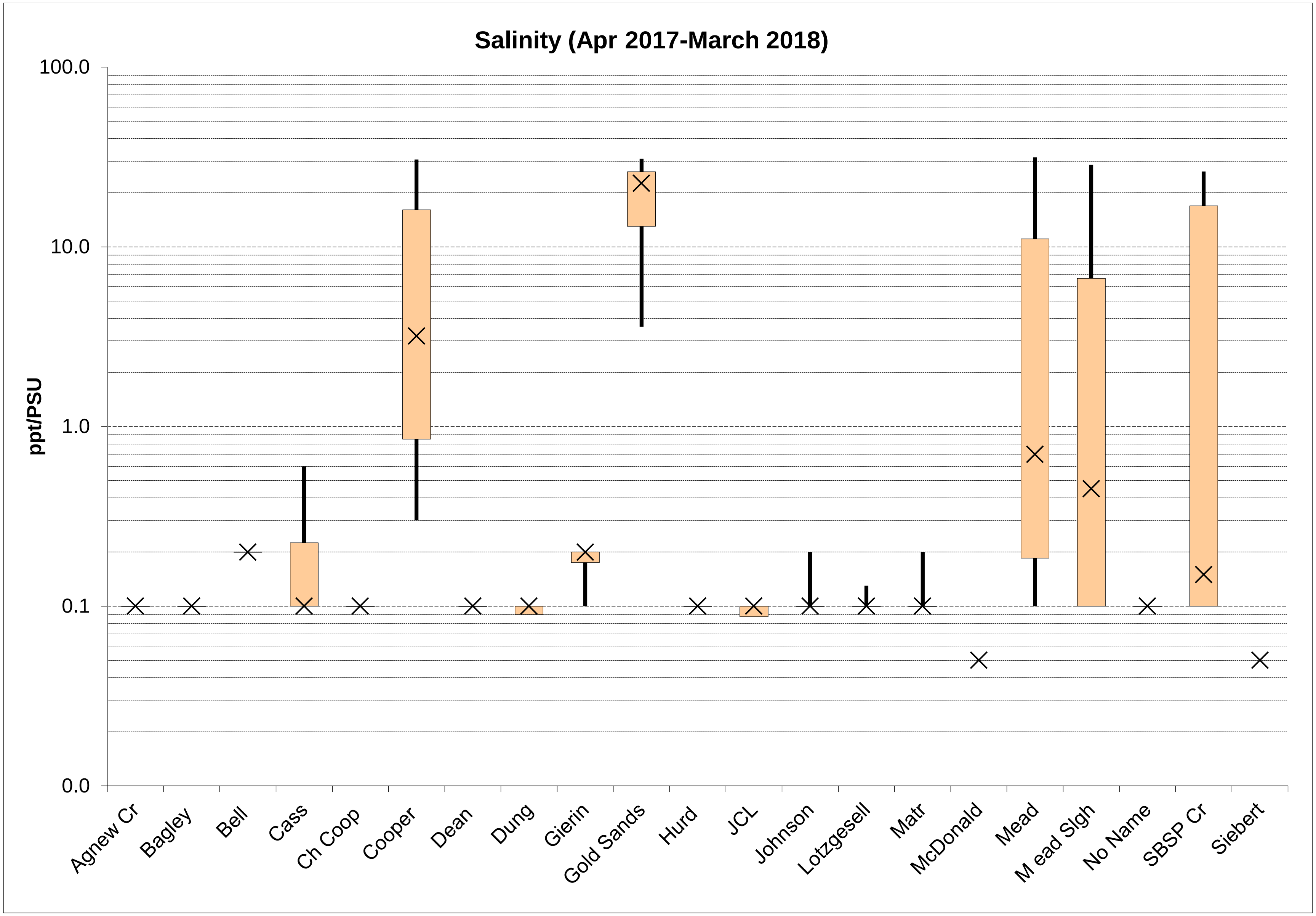

Figure 15. Salinity (PSS). X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

Discussion

Fecal Coliforms

A primary driver of PIC work remains pathogens reduction and PIC Baseline Trends Monitoring for fecal coliforms plays an important role in selecting focus areas for targeted monitoring, investigations, and pollution correction.

Between April 2017 and March 2018 Matriotti Creek and Meadowbrook Slough stood out in terms of bacteriological water quality sampling, with relatively high fecal coliform geometric means, 90^{th} percentiles, and maximum values.

Matriotti Creek has received attention in past years through Total Maximum Daily Load (TMDL) studies and implementation of cleanup efforts. In 2013-2014, for example, Lower Matriotti and Lotzgesell Creeks were found to account for a significant amount of bacterial loading in the Lower Dungeness (Environmental Health and Streamkeepers 2017b).

Targeted water quality monitoring and investigations shifted to the lower Matriotti Creek area starting in 2018 with subsequent parcel surveys/investigations in various stream segments. To date, one seep with high bacteria concentrations has been diverted from the stream, one non-conforming sewage system adjacent to the stream has been identified, and changes to streamside animal-keeping practices are happening.

Pollution investigation and correction activities peaked in Meadowbrook Slough in 2017 with targeted water quality sampling, onsite sewage system dye testing, and septic inspection compliance efforts. Two failing septic sysetems were identified in the upper portion of the slough, one of which has been repaired. The second failing system should be repaired in 2019, likely with cost-share financial assistance.

Golden Sands Slough fecal coliform geometric mean and 90^{th} percentile appear lower than in previous years, though a broad range of bacteria concentrations is still observed, with occasional high values.

Golden Sands Slough received the bulk of PIC targeted monitoring and pollution correction efforts from 2015-2017, and various long-standing non-conforming sewage disposal systems have been replaced with conforming systems. Still, multiple non-conforming systems remain on the docket for correction, each in various stages of replacement.

Further, project partners have found through targeted water quality monitoring that site GS 0.0 does not necessarily represent water quality throughout Golden Sands Slough. Often, salinity measurements evidence a marine water component and bacteria concentrations vary spatially and temporally throughout the slough. Hence, caution should be exercised if attempting to draw conclusions regarding upland influences from GS 0.0 water quality data.

Nutrients

This year Bell Creek appears to stand out with relatively high levels of total nitrogen, total phosporous, nitrate, nitrite, and phosphate as P as compared to other Clean Water district Streams. Geometric means, observed 3rd quartiles, and upper extrema rank higher than other streams for these parameters.

Meanwhile, Golden Sands Slough and Matriotti Creek ammonia levels appear higher than those observed in other Clean Water District Streams upon comparison of geometric means, 3rd quartiles, and maximum values.

Physical and Chemical Water Quality Parameters

Appendix 1 reproduces all data collected through PIC Baseline Trends Monitoring. Dissolved oxygen percent saturation, specific conductance, turbidity, flow, and stage data are not a required part of the monitoring effort and are not explored through analyses here. These data are, however, readily collected alongside required data following Streamkeepers' QAPP (Chadd 2017).

Cooper Creek, Golden Sands Slough, Meadowbrook Creek, and Meadowbrook Slough salinity data suggest at least periodic marine water influence at these sites.

Secondary sample sites were added at Sequim Bay State Park Creek (0.1) and Cassalery Creek (0.6) to avoid complications with low flow events and tides that occasionally confound data collection. The highest salinity measurements at Sequim Bay State Park Creek and Cassalery Creek come from the lower, primary sample sites when the secondary site was not used.

Cooper Creek, Golden Sands Slough, and Meadowbrook Creek sample sites generally lack shading from vegetation and various high water temperatures were recorded at these sites, above all during the summer months.

Golden Sands Slough displays some of the greatest range in water temperature, dissolved oxygen, and pH. During the summer months, periphyton growth appears to accompany high water temperatures, and anecdotal reports describe the slough as "bubbling" with apparent biological activity.

Conclusion

This project highlights the merits of selecting PIC Focus Areas based on information generated by a long-term water quality monitoring effort.

PIC Baseline Trends Monitoring first guided selection of a pilot project in Golden Sands, with the bulk of work completed from 2015-2017. Various unacceptable methods of household wastewater management were discovered through targeted water sampling and parcel investigations. Some of these waste systems have been improved while others await correction. Meanwhile, the outlook in the slough seems to have improved somewhat in terms of bacteria levels. Occasional high bacteria concentrations are still measured in the slough, but these do not approach the high levels seen in 2015. Still, we should apply caution when looking for a causal relationship between upland activities and fecal coliform concentrations at Golden Sands 0.0, as water quality data may reflect marine water conditions as often as freshwater quality.

Again, selection of Meadowbrook Slough and portions of Matriotti and Lotzgesell Creeks for focused PIC activities hinged on direction from PIC Baseline Trends Monitoring. Significant effort went into Meadowbrook Slough investigations in 2017. Two failing septic systems were identified adjacent to the slough; one has been fixed while the second awaits repair, likely in early 2019.

While various concerns have also been suggested in lower Matriotti and Lotzgesell Creeks following targeted water quality monitoring and investigations, this PIC Focus Area is only now transitioning to the correction phase of the project. Some of the changes needed in the watershed should far outlast this iteration of the PIC Project given land uses, parcel sizes, and the nature of non-point pollution sources. For example, large riparian buffer restoration projects would likely keep bacterial pollution from animals and surface water runoff out of the streams (among other benefits). Still, some gains in the focus area will likely come from household wastewater management improvements as residences with questionable septic systems exist here too.

PIC Baseline Trends Monitoring results indicate that PIC Projects can, coupled with other activities in the Dungeness Watershed, lead to water quality improvements. As the backlog of needed pollution correction measures slowly come online, follow-up targeted sampling will be critical to determine if such fixes produce measureable improvements in water quality. Continued long-term monitoring will hopefully ensure that improvements are sustained. In recent years, various shellfish growing area upgrades in Dungeness Bay have improved access to recreational and commercial shellfish harvest opportunities. Continued PIC work, in concert with other Dungeness Watershed projects, should lead to further gains.

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Appendix 1: Data from April 2017 – March 2018

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Agnew Creek/Ditch 0.3	4/18/2017	38								29.79	12.9	116	10.5	8.6	0.1	183	5		-0.32
Agnew Creek/Ditch 0.3	8/15/2017	22								29.85	9.8	95	14.1	7.9	0.1	148	4		0.46
Agnew Creek/Ditch 0.3	11/14/2017	20								29.71	11.3	93	6.8	7.9	0.1	257	7		0.28
Agnew Creek/Ditch 0.3	1/9/2018	10								29.49	11.7	95	5.7		0.1	253	11		0.38
Bagley 0.7a	4/18/2017	2								29.83	11.1	98	9.7	8.0	0.1	147	5		-12.40
Bagley 0.7a	8/15/2017	12								29.86	10.3	96	12.0	8.0	0.1	250	1		-12.60
Bagley 0.7a	11/14/2017	40								29.70	12.1	100	6.6	7.7	0.1	119	16		-12.08
Bagley 0.7a	1/9/2018	4								29.50	12.6	100	5.0		0.1	118	7		-12.18
Bell 0.2	4/17/2017	4	4001	104	2089	5	8	58	8411	29.81	11.0	97	9.7	8.0	0.2	404	3		1.24
Bell 0.2	5/9/2017	18	4097	180	3169	5	10	123	8675	30.08	11.2	98	9.7	8.1	0.2	458	3		0.98
Bell 0.2	6/13/2017	42	5181	392	3461	7	13	323	8522		9.9	91	11.9	8.0	0.2	493	6		0.78
Bell 0.2	7/18/2017	56	7072	789	4516	7	19	650	8779	30.03	9.3	88	13.1	7.9	0.2	502	5		0.68
Bell 0.2	8/14/2017	52	5106	600	3381	5	8	420	7748	30.02	9.7	92	13.1	8.2	0.2	437	4		1.04
Bell 0.2	9/19/2017	48	5070	390	3531	5	9	225	9238	29.73	10.4	95	10.9	8.2	0.2	473	4		1.00
Bell 0.2	10/10/2017	26	4756	634	3244	4	6	467	8924	29.87	10.8	95	9.8	8.4	0.2	475	4		1.04
Bell 0.2	11/13/2017	58	3853	251	1490	12	35	152	7912	29.60	10.3	89	8.8		0.2	429	7		1.28
Bell 0.2	12/12/2017	4	4445	114	3719	10	27	89	8929	30.48	12.0	94	5.8		0.2	487	2		1.06
Bell 0.2	1/8/2018	12	3377	174	1941	8	25	139	8467	29.78	11.5	94	6.5		0.2	393	4		1.48
Bell 0.2	2/13/2018	20	4327	295	3043	13	20	122	8491	30.28	12.8	97	3.8	8.1	0.2	422	5		1.26
Bell 0.2	3/13/2018	18	4647	135	3246	9	14	82	7037	29.68	11.3	95	7.5	8.2	0.2	448	3		1.16
Cassalery 0.0	4/17/2017	10	2011	85	831	5	47	33	7253	29.81	10.0	91	10.7	7.8	0.6	1160	5		-2.77
Cassalery 0.0	5/9/2017	2	1285	50	942	3	18	18	7972	30.09	10.6	94	10.3	8.1	0.2	388	4		-2.56
Cassalery 0.0	6/13/2017	30	1117	56	890	3	17	17	6338		9.8	92	12.6	8.0	0.2	467	4		
Cassalery 0.0	7/18/2017	4	1451	42	907	3	27	18	7546	30.04	9.5	92	14.1	8.1	0.5	938	2		4.10

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Cassalery 0.0	8/14/2017																		
Cassalery 0.0	9/19/2017	62	1346	33	945	2	15	10	6364	29.75	10.1	93	11.2	8.0	0.3	558	3		
Cassalery 0.0	10/10/2017																		
Cassalery 0.0	11/13/2017																		
Cassalery 0.6	4/17/2017																		0.48
Cassalery 0.6	5/9/2017																		0.48
Cassalery 0.6	6/13/2017																		0.50
Cassalery 0.6	7/18/2017																		0.44
Cassalery 0.6	8/14/2017	84	1338	45	916	3	12	8	6042	30.02	9.4	89	13.1	8.0	0.1	230	2		0.48
Cassalery 0.6	9/19/2017																		0.46
Cassalery 0.6	10/10/2017	56	1385	31	978	3	42	4	6229	29.86	10.3	91	9.9	8.1	0.1	228	2		0.44
Cassalery 0.6	11/13/2017	2	1179	37	647	2	7	7	6419	29.58	9.5	83	8.7		0.1	235	2		0.54
Cassalery 0.6	12/12/2017	2	1231	28	958	3	20	12	6748	30.48	11.4	89	5.8		0.1	236	2		0.53
Cassalery 0.6	1/8/2018	2	1478	33	1004	6	22	15	6922	29.76	10.4	88	7.9		0.1	248	2		0.62
Cassalery 0.6	2/13/2018	2	1658	48	1183	8	26	11	6369	30.27	12.1	93	4.9	8.0	0.1	252	3		0.60
Cassalery 0.6	3/13/2018	90	1876	58	1288	7	23	9	6328	29.69	10.4	91	9.0	8.0	0.1	249	6		0.58
Chicken Coop 0.24	4/18/2017	2								29.85	11.7	97	7.2	7.8	0.1	127	7		-3.12
Chicken Coop 0.24	8/15/2017	26								29.94	10.5	96	11.4	8.1	0.1	232	1		-4.68
Chicken Coop 0.24	11/14/2017	6								29.86	11.8	97	7.0	8.0	0.1	177	3		-4.20
Chicken Coop 0.24	1/9/2018	6								29.57	12.2	99	5.8		0.1	128	6		-3.16
Cooper 0.1	4/17/2017	6	495	75	58	2	19	29	8002	29.81	7.1	67	12.4	7.3	1.0	1965	2		-3.67
Cooper 0.1	5/9/2017	18	442	83	28	1	19	26	8041	30.07	7.8	75	13.6	7.4	0.4	764	5		-4.01
Cooper 0.1	6/13/2017	6	333	66	10	1	13	23	7051		9.3	95	16.4	7.7	0.4	793	2		-4.00
Cooper 0.1	7/18/2017	4	248	62	4	1	15	20	9919	30.04	8.8	93	18.4	7.5	0.3	716	1		-4.12
Cooper 0.1	8/14/2017	28	353	70	16	1	37	16	7276	30.02	7.8	83	16.8	7.3	4.4	7914	3		-4.15
Cooper 0.1	9/19/2017	26	310	54	25	2	60	19	7381	29.76	7.1	70	12.7	7.1	6.1	10732	2		-4.20
Cooper 0.1	10/10/2017	38	311	63	55	2	42	24	5558	29.88	6.3	60	9.4	7.3	12.6	21114	4		-3.61
Cooper 0.1	11/13/2017	40	1800	229	286	11	431	95	2882	29.53	6.2	65	8.8		29.7	46201	11		-2.70

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pressure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Cooper 0.1	12/12/2017	2	562	62	276	6	83	60	1261	30.48	7.5	74	7.2		30.6	47608	3		-2.94
Cooper 0.1	1/8/2018	6	769	50	368	7	73	41	5326	29.76	7.2	72	7.8		26.6	41913	3		-2.28
Cooper 0.1	2/13/2018	4	691	69	330	3	39	39	3483	30.27	9.8	74	3.4	7.5	2.0	3789	4		
Cooper 0.1	3/13/2018	32	517	59	315	2	24	19	7088	29.71	7.1	62	8.6	7.5	1.6	2990	1		-3.40
Dean 0.17	4/18/2017	2								29.88	11.0	92	12.7	7.8	0.1	130			-10.27
Dean 0.17	11/14/2017	64								29.85	12.0	98	6.6	8.0	0.1	189	17		-10.00
Dungeness 0.7	4/17/2017	4	247	22	41	0	3	3	4405	29.79	11.7	100	8.2	7.9	0.0	32	3		
Dungeness 0.7	5/9/2017	2	196	22	36	0	3	3	3763	30.04	11.7	101	9.1	8.2	0.1	118	3		
Dungeness 0.7	6/13/2017	4	121	20	14	0	3	3	2215	30.10	11.3	100	10.4	8.1	0.0	104	5		
Dungeness 0.7	7/18/2017	2	145	19	14	0	4	2	3348	30.03	11.2	107	13.4	8.2	0.1	114	2		
Dungeness 0.7	8/14/2017	2	152	19	29	0	0	3	2937	30.02	11.0	105	13.7	8.4	0.1	128	1		
Dungeness 0.7	9/19/2017	4	150	17	75	1	12	5	3507	29.76	10.9	102	12.2	8.2	0.1	156	2		
Dungeness 0.7	10/10/2017	4	154	17	87	1	21	2	3579	29.89	11.2	99	9.7	8.2	0.1	166	1		
Dungeness 0.7	11/13/2017	14	305	128	73	1	5	10	3083	29.50	11.9	99	6.7		0.1	107	41		
Dungeness 0.7	12/12/2017	2	138	15	60	0	5	7	3398	30.45	12.8	98	5.0		0.1	138	3		
Dungeness 0.7	1/8/2018	2	166	17	74	0	5	6	3638	29.72	12.5	100	5.3		0.1	125	4		
Dungeness 0.7	2/13/2018	2	125	22	68	0	8	5	3408	30.24	13.5	101	3.6	8.1	0.1	135	3		
Dungeness 0.7	3/13/2018	14	170	22	57	0	14	2	3893	29.74	12.8	102	5.3	8.2	0.1	156	2		
Dungeness 0.8	4/17/2017																	409	
Dungeness 0.8	5/9/2017																	541	
Dungeness 0.8	6/13/2017																	638	
Dungeness 0.8	7/18/2017																	348	
Dungeness 0.8	8/14/2017																	186	
Dungeness 0.8	9/19/2017																	112	
Dungeness 0.8	10/10/2017																	77.9	
Dungeness 0.8	11/13/2017																	882	
Dungeness 0.8	12/12/2017																	290	
Dungeness 0.8	1/8/2018																	485	
Dungeness 0.8	2/13/2018																	454	
Dungeness 0.8	3/13/2018																	250	

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Gierin 1.8	4/18/2017	12								29.89	11.1	95	8.1	8.1	0.2	414	7		-1.14
Gierin 1.8	8/15/2017	46								29.96	10.3	97	12.6	8.0	0.1	169	6		-0.78
Gierin 1.8	11/14/2017	14								29.85	10.7	89	7.4	7.9	0.2	366	2		-0.84
Gierin 1.8	1/9/2018	2								29.56	11.3	92	6.1		0.2	368	4		-0.88
Golden Sands Slough 0.0	4/17/2017	22	578	98	27	1	56	40	3063	29.79	7.6	88	16.0	7.4	22.6	35758	2		0.00
Golden Sands Slough 0.0	5/9/2017	18	717	111	0	1	54	36	1230	30.06	12.9	149	19.6	8.5	10.7	17959	3		-0.59
Golden Sands Slough 0.0	6/13/2017	20	1136	207	0	1	25	59	6046		12.6	157	22.3	8.8	15.3	25091	6		-1.12
Golden Sands Slough 0.0	7/18/2017	37	856	141	0	1	31	32	4579	30.04	14.7	204	25.2	8.5	24.0	37798	6		-1.12
Golden Sands Slough 0.0	8/14/2017	57	664	127	3	3	95	29	4031	30.03	10.2	116	21.0	8.0	3.6	6529	5		-1.05
Golden Sands Slough 0.0	9/19/2017	13	476	110	3	2	108	40	5109	29.76	10.4	122	15.6	7.8	24.4	38344	6		-0.75
Golden Sands Slough 0.0	10/10/2017	14	2158	459	2	3	338	244	6759	29.89	0.1	1	10.0	7.1	17.2	27486	13		-0.35
Golden Sands Slough 0.0	11/13/2017	460	2991	547	104	14	296	452	8471	29.53	0.2	2	8.7		27.9	43689	7		-0.30
Golden Sands Slough 0.0	12/12/2017	2	535	61	308	5	44	65	1262	30.48	7.7	78	7.9		30.6	47502	2		-0.60
Golden Sands Slough 0.0	1/8/2018	2	755	61	327	4	69	66	1549	29.76	7.1	73	7.8		30.9	47981	10		0.08
Golden Sands Slough 0.0	2/13/2018	7	1109	160	116	3	56	58	7254										
Golden Sands Slough 0.0	3/13/2018	17	1147	133	182	5	70	80	4955	29.72	6.2	57	8.9	8.1	8.0	13700	1		-0.20
Hurd 0.2	4/18/2017	4								29.86	10.2	90	9.7	7.6	0.1	164	1		-2.41
Hurd 0.2	8/15/2017	2								29.93	9.3	84	10.6	7.3	0.1	167	1		-2.43
Hurd 0.2	11/14/2017	10								29.82	9.0	79	9.5	7.4	0.1	165	1		-2.27
Hurd 0.2	1/9/2018	2								29.56	9.5	82	8.5		0.1	163	1		-2.39
Jimmycomelately 0.15	4/17/2017	2	702	52	239	1	4	10	10368	29.81	11.7	96	7.0	7.8	0.1	118	7		1.38
Jimmycomelately 0.15	5/9/2017	48	421	40	187	1	4	12	11020	30.10	11.8	97	7.4	8.0	0.1	133	3		1.10
Jimmycomelately	6/13/2017	20	359	50	137	1	4	17	9170	30.11	10.7	95	10.6	7.8	0.1	181	1		0.86

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
0.15																			
Jimmycomelately 0.15	7/18/2017	4	236	48	116	1	10	20	11288	30.05	10.0	93	12.0	7.9	0.1	244	0		0.72
Jimmycomelately 0.15	8/14/2017	2	348	63	116	1	5	22	9033	30.03	9.7	92	13.1	8.0	0.1	265	1		0.70
Jimmycomelately 0.15	9/19/2017	12	309	63	139	1	39	35	7447	29.73	10.0	90	10.5	7.8	0.1	273	2		
Jimmycomelately 0.15	10/10/2017	4	298	57	131	3	44	29	9157	29.87	10.4	89	8.6	8.0	0.1	283	1		0.66
Jimmycomelately 0.15	11/13/2017	86	1583	162	784	4	39	29	6510	29.61	11.8	98	6.8		0.0	104	52		1.86
Jimmycomelately 0.15	12/12/2017	2	473	39	274	1	14	16	8890	30.48	13.2	96	3.0		0.1	158	2		0.84
Jimmycomelately 0.15	1/8/2018	2	562	38	285	2	7	15	8453	29.80	12.5	98	5.0		0.0	113	6		1.22
Jimmycomelately 0.15	2/13/2018	6	453	56	245	1	35	13	8874	30.31	13.6	98	2.5	7.7	0.1	131	4		1.08
Jimmycomelately 0.15	3/13/2018	4	475	56	231	1	2	10	7922	29.64	12.6	99	4.6	7.8	0.1	103	9		1.40
Johnson 0.0	4/17/2017	2	433	91	228	2	5	31	9684	29.80	11.7	99	7.7	7.9	0.1	190	14		0.80
Johnson 0.0	5/9/2017	2	449	60	147	1	7	33	7971	30.09	11.7	99	8.5	8.1	0.1	222	4		0.48
Johnson 0.0	6/13/2017	26	666	97	302	1	6	51	9777	30.11	10.8	97	11.0	8.1	0.1	270	2		0.38
Johnson 0.0	7/18/2017	38	547	99	258	1	9	53	10388	30.03	10.4	97	12.4	8.4	0.1	261	1		0.30
Johnson 0.0	8/14/2017	16	208	59	58	1	0	28	4663	30.02	10.4	98	12.7	8.2	0.1	167	16		0.46
Johnson 0.0	9/19/2017	4	470	89	303	1	8	60	9239	29.73	10.8	97	10.4	8.3	0.2	319	1		0.26
Johnson 0.0	10/10/2017	2	380	96	245	1	2	65	10463	29.86	11.3	97	8.4	8.3	0.2	346	1		0.27
Johnson 0.0	11/13/2017	72	847	131	294	4	8	82	9477	29.61	11.6	97	7.1		0.1	258	8		0.62
Johnson 0.0	12/12/2017	2	605	71	256	1	7	42	10187	30.48	13.3	98	3.7		0.1	246	3		0.45
Johnson 0.0	1/8/2018	4	768	81	248	3	4	38	9103	29.78	12.5	100	5.4		0.1	176	15		0.84
Johnson 0.0	2/13/2018	10	642	92	217	2	6	36	9352	30.30	14.0	100	2.1	8.1	0.1	216	8		0.62
Johnson 0.0	3/13/2018	4	794	110	320	3	9	30	9209	29.66	12.5	100	5.5	8.1	0.1	163	20		0.75
Lotzgesell 0.1	4/17/2017	28	3103	50	1481	3	12	9	8339	29.76	10.8	100	11.8	7.9	0.1	280	5		-1.16
Lotzgesell 0.1	5/9/2017	8	2101	45	1650	3	14	10	9485	30.01	10.2	94	11.8	7.7	0.1	275	6		-1.28
Lotzgesell 0.1	6/13/2017	70	2170	71	1667	4	27	12	7946	30.09	9.7	90	12.3	7.9	0.1	271	11		-1.49

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Lotzgesell 0.1	7/18/2017	32	3094	53	1884	4	16	11	9843	30.01	9.4	89	13.1	7.7	0.1	275	9		-1.33
Lotzgesell 0.1	8/14/2017	28	2181	59	1884	4	5	8	8406	29.98	9.3	88	12.8	7.8	0.1	282	12		-1.35
Lotzgesell 0.1	9/19/2017	68	2250	48	1854	3	14	9	8644	29.71	9.6	89	11.5	7.7	0.1	280	11		-1.35
Lotzgesell 0.1	10/10/2017	4	2059	50	1595	3	13	8	8614	29.85	9.9	89	10.4	7.9	0.1	277	10		-1.47
Lotzgesell 0.1	11/13/2017	30	1750	62	824	5	17	15	7309	29.45	8.0	70	9.0		0.1	291	5		-1.05
Lotzgesell 0.1	12/12/2017	2	1643	48	1272	6	25	12	8318	30.41	9.5	77	6.8		0.1	276	7		-1.18
Lotzgesell 0.1	1/8/2018	2	1945	38	1241	6	23	15	8494	29.69	8.6	73	8.0		0.1	281	3		-0.95
Lotzgesell 0.1	2/13/2018	16	2335	59	1646	3	54	12	8073	30.18	11.0	90	6.7	7.7	0.1	279	5		-1.03
Lotzgesell 0.1	3/13/2018	20	2003	31	1772	4	25	9	7773	29.73	10.1	88	9.1	7.8	0.1	282	4		-1.05
Matriotti 0.3a	4/17/2017	196	2068	67	880	3	43	22	8013	29.76	11.4	105	11.3	8.0	0.1	282	4		-8.30
Matriotti 0.3a	5/9/2017	82	1868	63	1257	5	43	25	9071	30.01	10.5	97	11.9	7.9	0.1	282	5		-8.56
Matriotti 0.3a	6/13/2017	134	2450	117	1514	6	182	23	7845	30.08	9.8	92	12.6	7.9	0.1	274	10		-8.62
Matriotti 0.3a	7/18/2017	466	3628	77	1492	5	300	42	9280	30.03	9.5	92	13.8	7.9	0.1	261	6		-8.67
Matriotti 0.3a	8/14/2017	500	2010	87	1355	4	233	30	6888		9.5	90	13.3	7.9	0.1	270	6		-8.57
Matriotti 0.3a	9/19/2017	68	2264	81	1761	4	37	18	8908	29.69	9.7	88	10.6	7.7	0.1	296	8		-8.52
Matriotti 0.3a	10/10/2017	42	2139	59	1687	3	30	11	8799	29.81	10.0	88	9.7	8.0	0.1	296	12		-8.60
Matriotti 0.3a	11/13/2017	102	1806	68	898	6	41	21	8442	29.55	8.3	72	8.5	7.4	0.2	305	8		-8.30
Matriotti 0.3a	12/12/2017	10	1664	63	1203	6	42	14	8584	30.43	10.3	80	5.5		0.1	300	12		-8.35
Matriotti 0.3a	1/8/2018	12	1822	57	967	5	28	26	8663	29.78	10.2	83	6.6		0.1	280	8		-8.00
Matriotti 0.3a	2/13/2018	40	2080	86	1310	4	59	23	8460	30.15	12.0	94	5.4	7.9	0.1	289	11		-8.20
Matriotti 0.3a	3/13/2018	254	2314	75	1430	5	34	22	7791	29.73	10.5	91	8.6	7.9	0.2	305	9		-8.31
McDonald 01.6	4/18/2017	2								29.80	11.8	99	7.5	8.0	0.1	117	4		
McDonald 01.6	8/15/2017	2								29.85	10.6	99	12.5	8.2	0.1	178	1	11	
McDonald 01.6	11/14/2017	8								29.73	12.4	100	5.7	7.6	0.0	87	15		
McDonald 01.6	1/9/2018	4								29.48	12.8	100	4.2		0.0	94	7	43.2	
McDonald 03.1	4/18/2017																	31.5	
McDonald 03.1	11/14/2017																	50.4	
Meadowbrook 0.2	4/17/2017	12	489	62	14	1	6	22	7642	29.80	8.4	79	12.5	7.7	0.1	297	2		-11.27
Meadowbrook 0.2	5/9/2017	2	298	53	5	0	3	19	7352	30.06	8.2	77	13.1	7.8	0.1	234	1		-11.32

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Meadowbrook 0.2	6/13/2017	2	290	56	3	0	3	17	6360		8.2	82	15.5	8.1	0.1	219	1		-11.28
Meadowbrook 0.2	7/18/2017	6	282	72	8	1	14	22	8073	30.04	7.2	76	18.0	7.7	0.9	1816	2		-12.22
Meadowbrook 0.2	8/14/2017	20	275	71	6	0	3	21	6767	30.03	6.6	78	15.0	7.8	27.0	42709	2		-12.29
Meadowbrook 0.2	9/19/2017	4	222	74	8	0	16	26	7081	29.75	8.0	78	13.1	7.4	1.8	3324	2		-12.40
Meadowbrook 0.2	10/10/2017	12	171	65	5	1	10	30	7218	29.90	7.9	70	9.8	7.6	0.5	1007	2		-12.40
Meadowbrook 0.2	11/13/2017	14	700	141	292	7	230	129	1374	29.54	6.8	73	8.8		31.5	48666	14		-10.60
Meadowbrook 0.2	12/12/2017	2	456	67	104	3	117	33	6328	30.46	8.2	68	5.8		7.2	12539	4		-11.70
Meadowbrook 0.2	1/8/2018	4	492	58	233	3	49	47	3886	29.73	6.6	64	7.7		22.8	36447	3		-10.95
Meadowbrook 0.2	2/13/2018	2	433	65	205	1	22	20	7749	30.25	10.2	79	4.8	7.6	0.2	366	6		-12.48
Meadowbrook 0.2	3/13/2018	10	291	61	105	0	15	15	6612	29.74	8.9	77	8.6	7.7	0.5	1000	1		-12.40
Meadowbrook Slough 0.23	4/17/2017	294	276	42	44	1	9	18	4848	29.81	7.2	60	7.4	7.7	0.1	162	1		-1.73
Meadowbrook Slough 0.23	5/9/2017	6	214	43	41	1	17	19	5098	30.06	7.2	61	8.2	7.5	0.1	155	1		-1.79
Meadowbrook Slough 0.23	6/13/2017	572	198	44	27	1	33	19	4102	30.10	6.5	57	9.7	8.1	0.1	122	1		-1.74
Meadowbrook Slough 0.23	7/18/2017	64	158	44	34	1	41	16	4967	30.04	5.9	56	12.4	7.3	3.2	5770	2		-2.75
Meadowbrook Slough 0.23	8/14/2017	30	228	52	47	0	18	17	4123	30.02	2.7	26	13.0	7.2	4.4	7885	2		-2.80
Meadowbrook Slough 0.23	9/19/2017	94	195	53	82	1	39	23	4283	29.76	6.0	57	13.3	7.3	0.5	1074	2		-2.87
Meadowbrook Slough 0.23	10/10/2017	130	180	44	83	1	20	18	4460	29.88	5.9	55	11.7	7.6	0.2	343	1		-2.83
Meadowbrook Slough 0.23	11/13/2017	62	1112	213	140	5	232	69	3047	29.58	5.8	55	8.7		13.5	22530	10		-0.95
Meadowbrook Slough 0.23	12/12/2017	10	503	67	88	2	153	51	3907	30.49	5.5	52	7.5		22.4	35877	6		-2.00
Meadowbrook Slough 0.23	1/8/2018	60	455	52	206	3	103	46	2778	29.77	5.9	60	7.6		28.7	44862	4		-1.28

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
Meadowbrook Slough 0.23	2/13/2018	20	265	59	110	1	34	20	4150	30.28	9.8	78	5.8	7.6	0.1	169	7		-3.00
Meadowbrook Slough 0.23	3/13/2018	410	309	95	101	1	39	25	3798	29.70	9.0	73	6.1	7.7	0.4	780	3		-2.96
No Name 0.03	4/18/2017	2								29.87	11.5	97	7.9	7.8	0.1	109	11		-2.32
No Name 0.03	8/15/2017	2								29.96	9.2	91	15.0	7.8	0.1	256	13		-2.50
No Name 0.03	11/14/2017	1								29.87	11.6	98	7.8	8.0	0.1	264	28		-2.46
No Name 0.03	1/9/2018	38								29.60	12.1	98	5.8		0.1	144	10		-2.42
Sequim Bay State Park Creek 0.0	4/17/2017																		
Sequim Bay State Park Creek 0.0	5/9/2017																		
Sequim Bay State Park Creek 0.0	6/13/2017	64	651	110	163	1	5	62	8930	30.11	10.6	97	11.6	8.0	0.2	405	4		-5.82
Sequim Bay State Park Creek 0.0	7/18/2017	4	625	85	169	3	61	51	8922	30.05	1.1	13	13.7	7.0	26.3	41005	4		-5.91
Sequim Bay State Park Creek 0.0	8/14/2017	8	603	92	149	4	68	50	6574	30.02	1.5	17	13.9	7.4	22.5	35644	2		-5.93
Sequim Bay State Park Creek 0.0	9/19/2017	248	499	79	106	4	44	46	4655	29.74	3.2	34	11.0	7.3	26.3	41151	2		-5.90
Sequim Bay State Park Creek 0.0	10/10/2017																		
Sequim Bay State Park Creek 0.0	11/13/2017	24	699	149	106	2	6	104	8108	29.62	11.5	98	7.7		0.2	329	11		-5.68
Sequim Bay State Park Creek 0.0	12/12/2017	2	617	66	151	1	13	46	8309	30.50	13.1	98	4.1		0.1	296	2		-5.75
Sequim Bay State Park Creek 0.0	3/13/2018														0.1				-5.68
Sequim Bay	1/8/2018	74	820	91	164	3	4	57	8872	29.78	12.5	100	5.4		0.1	209	10		-6.20

Site	Date	Fecal	TN	TP	NO3-N	NO2-N	NH3-N	PO4-P	SiO4-Si	Pres-sure	DO	DO%	Temp	pH	Sal	Sp. Cond	Turb	Flow	Stage
State Park Creek 0.1																			
Sequim Bay State Park Creek 0.1	2/13/2018	4	758	102	197	2	16	49	8805	30.28	13.7	100	2.8	8.1	0.1	212	7		-6.30
Sequim Bay State Park Creek 0.1	3/13/2018	4	620	96	104	2	3	43	8683	29.63	12.0	99	6.4	8.1	0.1	223	6		-6.33
Siebert 1.0	4/18/2017	2								29.84	11.7	98	4.8	8.4	0.1	123			-17.35
Siebert 1.0	8/15/2017	6								29.87	10.4	102	14.0	8.3	0.1	213	1		-17.64
Siebert 1.0	11/14/2017	18								29.75	12.3	100	6.3	7.7	0.0	77	22		-16.85
Siebert 1.0	1/9/2018	2								29.53	12.8	100	4.3		0.0	81	5		-16.97