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COVER PHOTO: Yakima River between Zillah and Granger in August of 2022.
Photo credit: Jim Carroll

[1] https://www.ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

Lower Yakima River Monitoring for Aquatic Life Parameters to Support Water Quality Gaging

Data Summary Report

by

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Abstract

Previous water quality monitoring within the Lower Yakima River Basin, particularly between Union Gap and Mabton, has shown areas with high water temperatures and low dissolved oxygen (DO) levels. These adverse conditions can negatively impact fish and aquatic life that depend on cool, oxygenated waters.

The Department of Ecology (Ecology) coordinated the collection of water quality data in support of the United States Geological Survey's (USGS) continuous water quality monitoring conducted at several Lower Yakima River locations in 2022 and 2023. The United States Bureau of Reclamation (USBR), along with the Yakima Basin Integrated Plan (YBIP) and Benton Conservation District (BCD), sponsored the USGS water quality monitoring gages to provide calibration data to construct a water quality model that simulates water temperature and DO. The model will assess different water management strategies to improve fish migration in the Yakima River corridor.

This report only summarizes laboratory and field water quality data collected by Ecology to support the continuous water quality monitoring by the USGS. The USGS data are available from USGS databases. Ecology data were uploaded to Ecology's Environmental Information Management (EIM) database. This Ecology data summary includes a quality assurance (QA) evaluation of the data and their proper qualification. The objectives of the Ecology study were to:

- Collect biweekly samples (2022) and monthly samples (2023) of suspended solids, turbidity, nutrients, organic carbon, and alkalinity in the Lower Yakima River mainstem and major tributaries.
- Monitor continuous (diel) temperature, turbidity, and DO at select stations.
- Submit results of monitoring into Ecology's EIM database, as appropriate.

Introduction

Background

The USBR, in coordination with the YBIP and the BCD, aims to understand the coupled dynamics that cause high water temperature and low DO in the Lower Yakima River. The goal is to improve the water quality in the river to improve fish spawning, rearing, and migration throughout the Yakima River corridor.

To better understand the temperature and DO levels in the Lower Yakima River, USBR, YBIP, and BCD sponsored several continuous water quality monitoring gages in 2022 and 2023. The continuous water quality monitoring will support the development of an Ecology water quality model (Pickett 2017) that can simulate water temperature and DO levels in the Yakima basin. USBR will use the calibrated Ecology model to simulate different water management scenarios, such as pulse releases of water from reservoirs. The model will allow water managers to predict what changes in temperature and DO levels are expected from the different management action scenarios.

The USGS installed and conducted continuous water quality monitoring for parameters such as temperature, turbidity, specific conductivity, DO, pH, and nitrate at five Lower Yakima River sites for the 2022 and 2023 irrigation seasons (shown in Figure 2):

- Yakima River above Ahtanum Creek (USGS #12500450; Ecology station YKUG)
- Yakima River near Emerald (USGS #12507573; Ecology station YKEM)
- Yakima River below Prosser (USGS #12509500; near Ecology station YKPR)
- Yakima River at Kiona (USGS #12510500; Ecology station YKKO)
- Yakima River at Van Giesen Bridge (USGS #12511800; Ecology station YKVG)

This Ecology project is a complementary monitoring study that supported the USGS gaging on the Yakima River in 2022 and 2023. The USBR contracted with Ecology to sample water chemistry and conduct additional water quality monitoring in the Lower Yakima River mainstem. The additional monitoring provided a more thorough data set that can be used to calibrate a water quality model for temperature and primary productivity (which causes DO levels to change) to understand important dynamics affecting aquatic life use throughout the basin.

Study Area

The study area is located within Water Resource Inventory Area (WRIA) 37 in the Lower Yakima River Basin. It consists of the mainstem Yakima River and the mouths of its major tributaries from river mile (RM) 121.7 (upstream of the city of Yakima) downstream to RM 8.4 at the Van Giesen Bridge in West Richland (Figure 1). The Lower Yakima River basin lies in Yakima County and Benton County. Yakima and Richland are the largest municipalities in the basin, along with many other smaller cities. The Reservation of the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation, or YN) lies on the west bank of the Yakima River from Ahtanum Creek near Union Gap to Mabton, and the river in this reach flows mostly within the boundaries of the Yakama Nation Reservation (Figure 1).

This study only sampled within the lower Yakima River reach as adequate water quality sampling had already been conducted in the upper reaches of the Yakima River (Urmos-Berry et al. 2021) to develop a water quality model of the Upper Yakima River. The sampling conducted for this study will allow for a full model calibration of the lower Yakima River, which can then be combined with the upper Yakima River model to create a continuous model of the entire river system.

The Yakima River runs through a valley of highly productive agricultural lands (particularly fruit tree crops, wine grapes, and hops), while the surrounding hills are shrub-steppe grasslands. The Yakima River agricultural lands are a highly managed irrigated system. The USBR owns and operates five major reservoirs within the system: Keechelus, Kachess, and Cle Elum reservoirs at the upstream end of the upper Yakima Valley; Bumping Lake and Rimrock Lake in the Naches River basin. Although these five reservoirs are all outside the study area, the managed release of flow from the reservoirs is the dominant driver of flow entering the Lower Yakima River during the irrigation season. Storage in these upper reservoirs is highly dependent on snowpack in the surrounding mountainous watersheds.

Flows in the Lower Yakima River are also significantly affected by the operations of many irrigation districts. The largest of these are:

- Roza Irrigation District
- Selah-Moxee Irrigation District
- Sunnyside Valley Irrigation District
- Wapato Irrigation Project
- Kennewick Irrigation District
- Columbia Irrigation District

History of study area

Land use in the Lower Yakima Valley is predominantly irrigated agriculture heavily reliant on the Yakima River for irrigation water supply. The Yakima River Basin is one of the most irrigated areas in Washington State. As mentioned, USBR operates the Yakima Project, which greatly influences stream discharge volumes in the Yakima River and some of its tributaries. The USBR delivers water to meet downstream demands, such as irrigation, power production, and instream flow for fish protection. To meet these demands, the USBR releases water from storage reservoirs in the upper basins of the Yakima River.

Management of water resources for human use has changed the seasonal distribution of streamflow in the Yakima River from natural and historical conditions. Originally, streamflow was highest during the spring snowmelt season and lowest during summer. Because Congress and court adjudications have mandated irrigation water delivery, streamflow in the summer is much higher than historically.

High temperatures, suspended solids, turbidity, and pesticides have been documented in the Lower Yakima for decades. As a result, several reaches of the Lower Yakima and several of its tributaries do not meet Washington State water quality criteria.

Water quality issues of concern in the Lower Yakima River basin include high water temperature, low DO, high pH, high suspended sediments, high turbidity, and high levels of toxic substances. These water quality issues in the basin impact the beneficial uses of the water, threatening the health of aquatic animals and fish living in affected areas.

In the latter decades of the 21st century, Congress and the courts have mandated that fishery concerns be addressed, including defining minimum flow levels in the Lower Yakima River. Driven by these fishery mandates and agricultural losses during drought years, more than 35 government and stakeholder groups met for 12 years, culminating in 2010 with the YBIP. The YBIP plans for large-scale projects are designed to ensure additional flow volumes in the Lower Yakima River to support fish and increase water supply during drought years. The YBIP also focuses on restoration of the watershed, riparian areas, and fish habitat.

Parameters of interest and potential sources

This monitoring study focuses on temperature, DO, and the parameters that interplay with river metabolism, as metabolic processes in a riverine ecosystem can impact DO levels. These parameters are important in providing a healthy habitat for salmonids and other aquatic life.

See the QAPP (Carroll 2022) for more details of past studies.

Water temperature has received the most attention from the fishery restoration efforts in the Yakima River basin. High temperatures in the Lower Yakima River are known to reach levels in the summer (nearing 30°C), creating a barrier to salmonid migration (Gendaszek and Appel 2021).

Pickett (2017) and USGS (2009) have shown that some of the primary causes of high water temperatures in the Lower Yakima include:

- Summer days in the Yakama River basin are hot, dry, and cloudless, providing maximum solar radiation to the water.
- The wide width of the Yakima River does not allow riparian vegetation shade to block very much solar radiation.
- The Yakima River has lost floodplain and riparian functions due to channelization, development on the floodplains, disconnection of the floodplain by levees and other structures, and reductions in spring flood flows due to reservoir management.

- The Yakima River has low flow in parts of the river due to water diversions. Lower flow and shallow depths allow the water to heat up faster than deeper water.

Sometimes, Yakima River temperatures are positively impacted by upstream reservoir releases. Fishery needs are being addressed by current water management by requiring minimum instream flow in critical locations, such as below Parker. As part of Yakima River water management, a volume of reservoir water has been set aside to be released at the call of fishery managers to create a cold-water pulse during cool summer weather. The sudden and rapid migration of salmon during this pulse is well documented.

In addition to water temperature, DO levels are linked to aquatic ecosystem health. Low DO is primarily driven by productivity in the river, as noted in previous studies by the USGS (2009), summarized below. Primary productivity from algal and plant growth requires warm temperatures, light, and food (nutrients) to proliferate, which is why this study sampled both DO and nutrients such as nitrogen and phosphorus. The warm temperature of the Yakima River provides an ideal water temperature for algal and plant growth. Clear water provides ample light through the water column for primary productivity. The Yakima River turbidity may limit light conditions in some parts of the river, where the light is blocked from reaching the river bottom, where attached algae and plants grow on the substrate. The most limiting nutrients in freshwater rivers like the Yakima River are usually phosphorus and nitrogen. The most likely sources of nutrient loading to the Yakima River are from agriculture return flows and wastewater discharges.

Many facilities in the Lower Yakima River basin are covered by a National Pollutant Discharge Elimination System (NPDES) or State Waste Discharge permit. These include individual permits and several general permits.

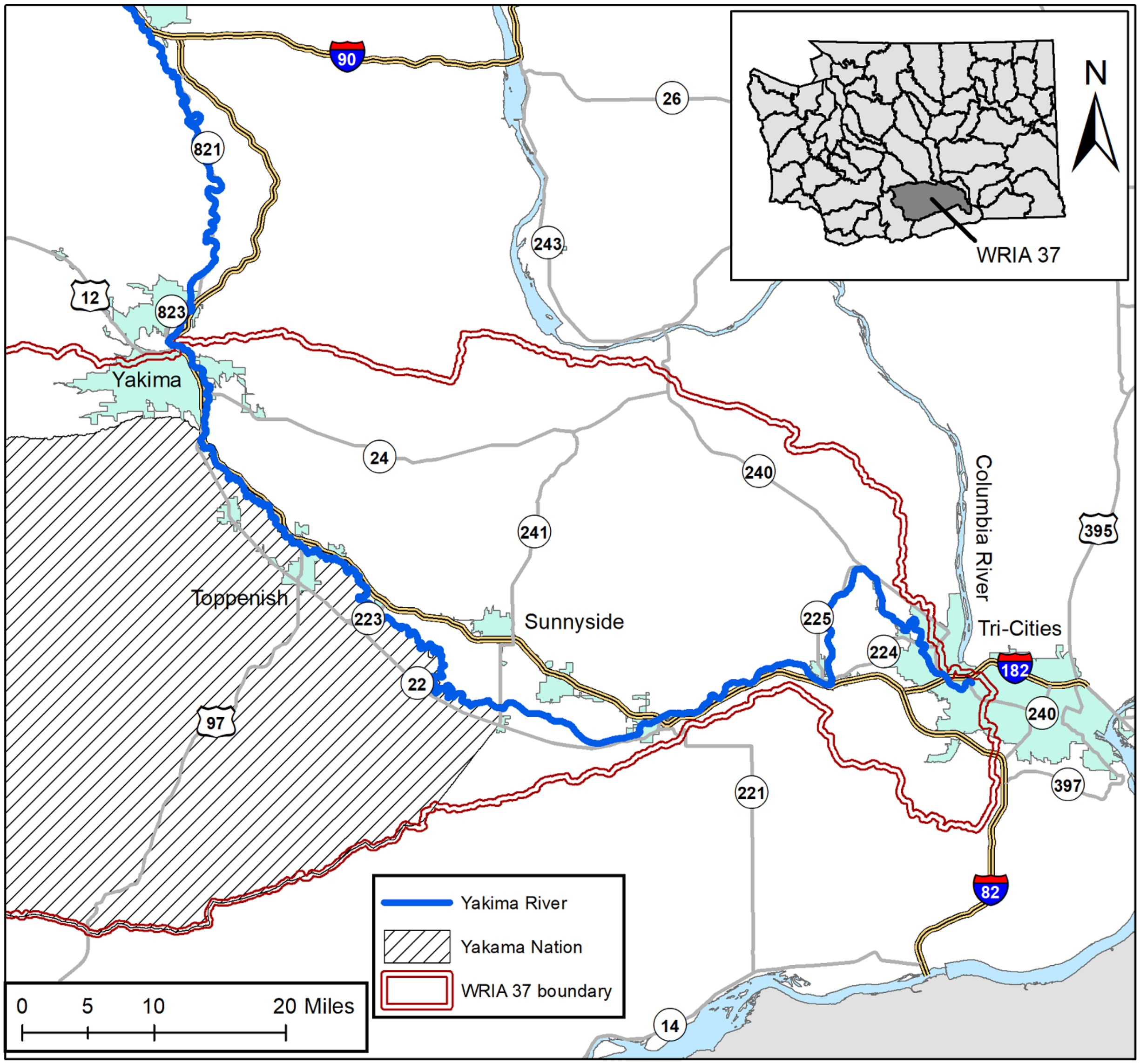


Figure 1. Study area map for Lower Yakima River (Water Resource Inventory Area #37) where Ecology monitored water quality for aquatic life parameters.

Project Description

Project Goals

The goal of this study was to collect water quality data, field measurements, and water samples from the mainstem Lower Yakima River to allow for robust calibration of a water quality model in that area. Ecology collected these data in contract with the USBR to support the USGS' continuous water quality monitoring in the Lower Yakima River in 2022 and 2023. The data will be part of a larger data set used to model and simulate water temperature and DO levels in the Lower Yakima River Basin.

Project Objectives

Fieldwork took place from June to November 2022 and April to November 2023.

Specific objectives of the study were to:

- Collect biweekly samples (2022) and monthly samples (2023) of suspended solids, turbidity, nutrients, organic carbon, and alkalinity in the Lower Yakima River mainstem and major tributaries.
- Monitor continuous (diel) temperature, turbidity, and DO at stations (shown in Figure 2), and described in Table A1 (2022) and Table A2 (2023) in Appendix A.
- Submit results of monitoring into Ecology's EIM database, as appropriate.

Study Design and Methods

Ecology collected samples and field data in the Lower Yakima River from June to November 2022 and April to November 2023. This data collection effort followed the study design in the Quality Assurance Project Plan (QAPP) — Lower Yakima River Monitoring to Support Water Quality Gaging (Carroll 2022).

Ecology conducted synoptic sampling and monitoring every two weeks at 11 locations in 2022 and monthly at 7 locations in 2023. Figure 2 shows a map of the sampling locations. Tables A1 and A2 in Appendix A list the monitoring locations and the types of data that Ecology collected at each location. Another collaborative monitoring project between Ecology and the Yakama Nation monitored many other tributaries to the Lower Yakima River in 2022 and 2023, as outlined in another QAPP (Carroll and Perra 2022).

Discrete Field Measurements and Water Sampling

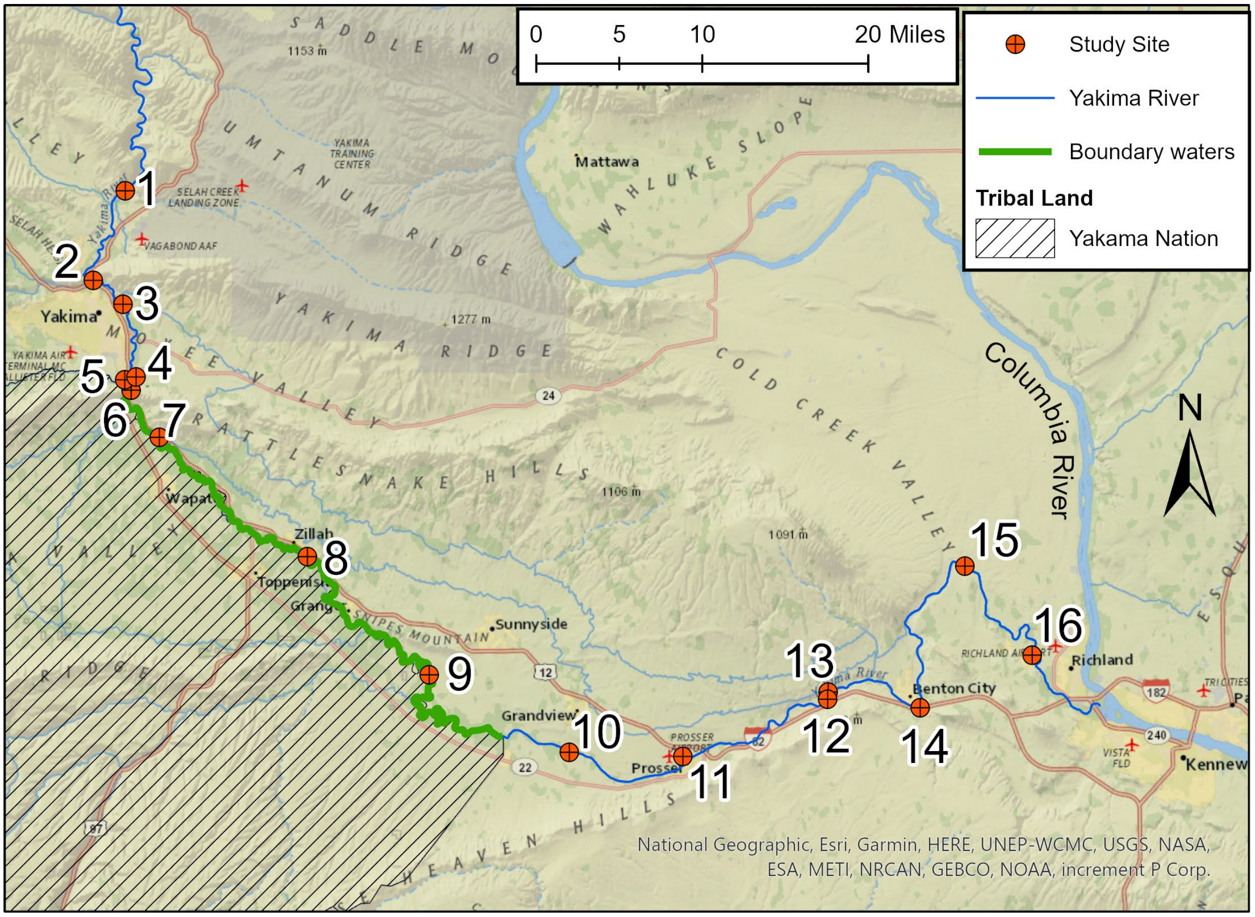
Ecology collected discrete field measurements and water samples every 2 weeks at 11 locations in 2022 and monthly at 7 locations in 2023. Ecology measured pH, DO, specific conductivity, and temperature using Hydrolab® multi-probe sondes during the sampling surveys. Measurements were also used as quality control (QC) checks on other continuously deployed DO and turbidity data loggers. Ecology also collected water samples for DO, and field staff performed Winkler titrations to determine DO concentrations.

Table 1 lists the sample parameters and analytical methods used to analyze the discrete water samples taken in the field. Several laboratories were used to analyze the samples.

Table 1. Sample parameters, analytical methods, and laboratories.

Parameter	Analytical Method	Laboratory
Alkalinity	SM2320B	MEL, OEL, ALS
Ammonia	SM4500NH3H	OEL
Dissolved Organic Carbon	SM5310B	MEL, ALS
Nitrate + Nitrite	EPA353.2	OEL
Orthophosphate	SM4500P-G	MEL, ALS
Total Organic Carbon	SM5310B	MEL, ALS
Total Phosphorus	SM4500P-H	MEL, KING
Total Persulfate Nitrogen	SM4500NB	KING
Total Suspended Solids	SM2540D	MEL
Total Non-volatile Suspended Solids	EPA160.4	MEL
Chlorophyll a	SM10200H3	MEL

MEL = Ecology's Manchester Environmental Laboratory; OEL = Onsite Environmental Laboratory, Redmond, WA; KING = King County Environmental Laboratory, Seattle, WA; ALS = ALS Environmental Laboratory, Kelso, WA



Map Marker	Study Location ID	Monitoring Site Name
1	YKSM	Yakima River at Selah Moxee diversion
2	NACM	Naches River near mouth
3	ROZP	Roza Power Canal return to Yakima
4	MOXM	Moxee Ditch near mouth
5	WHCM	Wide Hollow Creek near mouth
6	YKUG	Yakima River above Ahtanum Creek (USGS station)
7	YKPK	Yakima River at USBR Parker gage
8	YKET	Yakima River above East Toppenish Drain
9	YKEM	Yakima River near Emerald (USGS station)
10	YKEU	Yakima River at Euclid Bridge
11	YKPR	Yakima River at Prosser Dam (USGS downstream of dam)
12	YKAC	Yakima River above Chandler Canal Return
13	CHAN	Chandler Canal Return
14	YKKO	Yakima River at Kiona (USGS station)
15	YKWD	Yakima River at Wanawish Dam
16	YKVG	Yakima River at Van Giesen Bridge (USGS station)

Figure 2. Map of 2022 monitoring sites for the Lower Yakima River Monitoring.

Continuous pH, DO, Conductivity, and Turbidity Monitoring

In addition to the discrete sampling, at two locations (YKSM and YKPR in Figure 2 and Table 1), Ecology deployed Hydrolab® multi-probe sondes for continuous long-term monitoring from June through the first week of November 2022. These sondes recorded water temperature, pH, dissolved oxygen, and conductivity at 15-minute to 30-minute intervals. Sondes were replaced and re-calibrated every two weeks. Ecology also collected discrete measurements with another Hydrolab® sonde for QC checks.

Ecology deployed Onset® Hobo® or miniDOT® DO data loggers, generally from June to November 2022 and April to November 2023. The data loggers logged DO measurements every 15 – 30 minutes. Ecology also collected Winkler dissolved oxygen samples and took discrete dissolved oxygen measurements with a Hydrolab® sonde for QC checks of the loggers.

Ecology also installed an FTS DS-12® turbidity meter datalogger at YKSM (Figure 2 and Table 1) from June to November 2022 and April to November 2023. Discrete turbidity readings were done with Hach portable hand-held turbidity meters for QC checks on the continuous turbidity datalogger.

Continuous Water, Air, and Dew Point Temperature Monitoring

Ecology deployed Onset® Hobo® temperature and Onset® Hobo® RH/Temp data loggers at select locations throughout the study area (see Tables A1 and A2). Deployments include:

- Water temperature dataloggers logging every 30 minutes.
- Air temperature dataloggers logging every hour.
- Relative humidity dataloggers at one location (YKET) logging every hour.

Other Special Studies

Ecology collected other types of data through special studies. The data from these special studies support the other data collected for this study. These studies are:

- Time-of-Travel
- Light extinction

The data collected from these special studies are not found in Ecology's EIM online database since they do not fit the database's format.

Data Quality

Water Sample Quality Assurance

Ecology field staff collected water samples for laboratory parameter analysis. Most water samples were sent to Manchester Environmental Lab (MEL) for sample analysis, but some samples were sometimes sent to other contract labs. Table B-2 in Appendix B lists the laboratory used for each parameter for each sampling event in 2022. In 2023, all samples were sent to MEL.

Sample Variability (analytical and field precision)

Field replicates were routinely collected, in which two samples were collected from the same location and time. Field replicates evaluate sample precision, a measure of the variability in the results due to random error. Random error is imparted by the variation in concentrations of samples from the environment and other introduced sources of variation (e.g., field and laboratory analytical procedures). The QAPP — Lower Yakima River Monitoring to Support Water Quality Gaging (Carroll 2022) established the measurement quality objectives (MQOs), or expected targets, for the analytical and field precision.

Analytical Precision

MEL and other contract labs evaluated analytical precision by analyzing lab duplicates. Lab duplicates consisted of two subsamples taken from the same sample container and analyzed separately. The paired duplicate samples' relative percent difference (RPD) was calculated. On a parameter basis, a pooled mean of all RPDs from the entire study period was compared to the associated target RPD (MQO).

Table 2 below presents the evaluation of results for the lab analytical precision. At least 10% of the submitted field samples were selected to evaluate analytical precision. The quality assurance evaluation only used lab duplicate results that were above the reporting limit. The labs achieved good analytical precision during the project. All pooled mean RPDs for each parameter were below the MQO target of a pooled mean of less than 20%.

Field Precision

Table 3 presents the results for field precision. About 10% of field samples submitted for laboratory analysis were blind replicate samples. All field precision results met the MQO targets except for ammonia field precision. Most of the replicate sample results for ammonia were below the method reporting limit (MRL) and, thus, were not used for the evaluation. Only 4 replicates were above the MRL but still very close to the MRL (all below 0.084 mg/L), leaving them very sensitive to greater percent differences for even very small differences in the results. Still, all ammonia results were flagged as estimates since they did not meet the MQO target.

Sample Bias

Laboratory Control Samples and Matrix Interference

The laboratories assessed analytical bias by using lab control samples and matrix spikes. The pooled mean recoveries of all lab control samples and matrix spikes results recoveries were all within MQO targets for all parameters (Table 2). No analytical bias was shown.

Sample Contamination

Analytical Method Blanks

Laboratories routinely ran method blanks during each run of samples to check for contamination in the method analysis process. All laboratory blank results showed no contamination at or above the method reporting limit for each parameter.

Field Sample Blanks

Field sample blanks were routinely submitted blindly to the laboratories for each sampling event. Laboratory de-ionized water was used as the field sample blank. The sample blank water was taken into the field and exposed to the sampling event field conditions. Dissolved blank samples were submitted by running field sample blank water through field filtering devices. All field sample blank results for all parameters showed no contamination at or above each method reporting limit, except one Total Phosphorus field blank sent in on June 27, 2023. That field blank result was 0.012 mg/L, barely over the method reporting limit (MRL) of 0.01 mg/L. Over the course of the field collection in 2022 and 2023, 19 Total Phosphorus field blanks were submitted for analysis. The other 18 field blanks for Total Phosphorus showed no contamination at or above the MRL of 0.01 mg/L, suggesting no systematic bias from contamination in the field collection process or procedures.

Laboratory Case Narratives

MEL and the contract labs provided a case narrative for each set of sample batches. The case narratives provide information on sample condition at the time of arrival to the laboratory and other laboratory quality assurance measures or issues. Almost all samples were received within holding times and at proper temperatures. Some issues arise from being analyzed out of hold time and from laboratory QC analyses being outside of acceptance limits. Exceptions are all listed in Table B3 of Appendix B.

Table 2. Lab Precision and Bias Results from 2022 and 2023 samples.

Parameter	Number of Samples	Number of Lab Duplicates[1]	RL mg/L	Lab Precision Target (% RPD)	Actual Lab Precision Mean % RPD	Actual Lab Precision Median % RPD	Lab Control Samples Target Range	Lab Control Samples Actual Range	Lab Control Samples Mean Recovery	Matrix Spikes Target Range	Matrix Spikes Actual Range	Matrix Spikes Mean % Recovery
Alkalinity	176	31	2.0	<20	1.9	0.7	80–120	89–105	98.8	75–125	92–96	94.3
Ammonia	168	16	0.05	<20	12.6	9.5	80–120	89–112	100.8	75–125	78–110	97.5
Dissolved Organic Carbon	176	27	0.5	<20	4.3	3.0	80–120	90–105	97.1	75–125	77–112	98.7
Nitrate–Nitrite	192	17	0.010	<20	2.6	0.6	80–120	98–105	100.5	75–125	78–112	101.1
Orthophosphate	176	23	0.003	<20	3.5	2.0	80–120	92–106	98.8	75–125	77–112	99.8
Total Organic Carbon	176	30	0.5	<20	3.4	2.0	80–120	87–105	97.0	75–125	86–115	97.9
Total Phosphorus	176	51	0.01	<20	3.7	2.0	80–120	87–107	96.9	75–125	77–108	96.1
Total Persulfate Nitrogen	168	40	0.1	<20	3.0	2.0	80–120	89–107	97.7	75–125	92–118	100.4
Total Suspended Solids	168	58	1.0	<20	5.8	4.0	80–120	83–104	98.5	75–125	—	—

[1] Results reported at or below the reporting limit were excluded from evaluation.

RPD = Relative Percent Difference

RL = Reporting Limit

Table 3. Field Precision (Total Variability) results from 2022 and 2023 sample events.

Parameter	Number of samples	Number of replicates used in evaluation[1]	Target Precision (median RSD%)	RL (mg/L)	Mean RSD%	Median RSD%
Alkalinity	176	18	<10	2.0	1.16	0.17
Ammonia	168	4	<10	0.05	19.14	18.74
Dissolved Organic Carbon	176	18	<10	0.5	4.59	3.38
Nitrate-Nitrite	192	18	<10	0.010	3.93	0.82
Orthophosphate	176	17	<10	0.003	1.84	0.84
Total Organic Carbon	176	18	<10	0.5	3.26	2.66
Total Phosphorus	176	18	<10	0.01	3.28	1.93
Total Persulfate Nitrogen	168	16	<10	0.1	1.91	1.50
Total Non-Volatile Suspended Solids	176	17	<15	1.0	4.74	0.00
Total Suspended Solids	168	17	<15	1.0	4.96	1.17

Note. Only 4 out of 16 ammonia pairs results were detected above the RL of 0.05mg/L. All 4 ammonia pairs above the RL were near the RL, thus showing higher RSD%.

RSD = Relative Standard Deviation

RL = Reporting Limit

[1] Results reported at or below the reporting limit were excluded from evaluation.

Field Measurements Quality Assurance

Ecology used water quality sondes and dataloggers to make discrete and continuous field measurements throughout the project timeline. All instruments were pre-calibrated before being taken to the field for discrete measurements or deployed for continuous measurements. All instruments were post-calibrated on their return from the field. Field QC checks were also used to check on instrument calibration while deployed.

Table 4 presents the MQO targets used to assess the quality of the data collected by the sondes and data loggers. Post-calibration QC checks were compared to the MQO targets. Discrete and continuous data were accepted, qualified, or rejected based on the MQO target ranges.

Table 4. Multi-parameter sonde and datalogger MQOs.

Parameter	Unit	Accept	Qualify	Reject
Dissolved Oxygen	mg/L	≤ ±0.5	> ±0.5 and ≤ ±1.0	> ±1.0
Dissolved Oxygen	% saturation	≤ ±5%	> ±5% and ≤ ±15%	> ±15%
pH	standard unit	≤ ±0.2	> ±0.2 and ≤ ±0.8	> ±0.8
Specific Conductance	µS/cm	≤ ±10%	> ±10% and ≤ ±20%	> ±20%
Water Temperature	°C	≤ ±0.2	> ±0.2 and ≤ ±0.8	> ±0.8
Turbidity*	NTU	≤ ±10%	> ±10% and ≤ ±20%	> ±20%

Note. Criteria expressed as a percentage of readings; for example, buffer = 100.2 µS/cm and Hydrolab = 98.7 µS/cm; (100.2–98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%.

Discrete Measurements with Multi-Probe Sondes

Ecology calibrated and QC-checked Hydrolab® MiniSonde (MS) and HL4 multi-probe sondes with certified standards according to manufacturers' specifications and then used the sondes to take discrete measurements during sampling events. Table 5 lists the type of sondes used, serial numbers, and number of surveys each was used. Sondes calibrations were post-checked after each event. Table C1 in Appendix C lists the instantaneous discrete measurements and any applied qualifiers for data collected with multi-parameter sondes.

Table 5. Serial number and types of sondes used for discrete measurements.

Hydrolab Sonde #	Hydrolab Type	Serial Number #	# Surveys Used
53	HL4	SN15104H400271	9
54	HL4	SN15100H400270	10
37	MS5	SN091200048592	1
45	MS5	SN130500064703	1

pH and conductivity QA

Post-calibration check measurements for conductivity and pH were compared to the MQO targets in Table 4. All conductivity post-checks were within the acceptable target range except for sampling events in May, June, and July 2023, when post-checks deemed conductivity to be qualified as estimated. All pH post-checks also met the acceptable target range, except for the sample event on August 23 – 24, 2022, when post-checks deemed the pH data qualified as estimated.

Table 6. Post-calibration quality control checks for pH and conductivity for field sondes.

Sonde #	Field Use Dates	Conductivity 100 µs QC check (%)	Conductivity 1000 µs QC check (%)	pH 7 QC check	pH 10 QC check	Remark
37	6/28/22–6/29/22	0.2	-1.0	0.04	-0.03	—
54	7/12/22–7/13/22	6.5	8.2	0.05	-0.01	—
54	8/2/22–8/3/22	3.1	0.1	0.02	0.01	—
54	8/10/22–8/11/22	3.4	-0.3	-0.02	-0.01	—
54	8/23/22–8/24/22	3.5	-0.2	0.00	0.22	Qualify pH EST
54	9/6/22–9/7/22	3.1	0.2	0.04	0.03	—
54	9/20/22–9/21/22	2.7	0.0	-0.01	-0.01	—
54	10/4/22–10/5/22	3.0	-0.4	0.14	0.07	—
54	10/18/2022–10/19/2022	3.1	-1.1	-0.07	-0.06	—
53	10/25/2022–10/26/2022	2.7	0.5	0.00	-0.02	—
54	10/25/2022–10/26/2022	3.2	0.2	-0.10	-0.06	—
45	10/11/2022–10/25/2022	1.4	0.6	-0.07	-0.01	—
54	11/7/2022–11/8/2022	3.4	0.1	-0.10	0.01	—

Sonde #	Field Use Dates	Conductivity 100 µs QC check (%)	Conductivity 1000 µs QC check (%)	pH 7 QC check	pH 10 QC check	Remark
53	3/24/2023–3/25/2023	4.7%	0.8%	0.00	0.03	—
53	4/3/2023–4/4/2023	-2.5%	0.6%	-0.02	0.01	—
53	5/15/2023–5/16/2023	-22.8%	-0.4%	0.11	0.09	Qualify conductivity EST
53	6/12/2023–6/13/2023	-10.5%	-0.7%	-0.06	0.02	Qualify conductivity EST
53	7/17/2023–7/18/2023	-9.8%	-0.2%	-0.18	-0.02	Qualify conductivity EST
53	8/21/2023–8/22/2023	1.8%	0.4%	-0.17	-0.08	—
53	9/11/2023–9/12/2023	-3.0%	-0.1%	0.04	0.08	—
53	10/16/2023–10/17/2023	-9.9%	-3.9%	-0.06	-0.02	—

Note. The percentage difference between the conductivity standard and the sonde's conductivity reading is compared to the MQO ranges for conductivity in Table 4. Likewise, the pH difference between the pH standard and the sonde's pH reading is also compared to the MQO ranges for pH in Table 4. The conductivity post calibration for sonde #53 in May 2023 was not rejected because the sonde passed the 1000 µS/cm check and the zero check, even though the 100 µS/cm check was > 20%. There could have been issues with the 100 µS/cm calibration stock solution. Sonde #53 also had difficulty with the 100 µS/cm post-calibration for the next 2 surveys (June and July). All conductivity field measurements for the three months were qualified as estimates.

QC = quality control

Temperature QA

The temperature sensor on each sonde was post-checked in ice and room-temperature baths. Table 7 shows the bath results for each sonde. All sonde temperature post-check temperatures met the MQO target of less than 0.2°C and were deemed acceptable.

Table 7. Post-calibration average absolute temperature differences between datalogger temperature and calibration baths.

Hydrolab Sonde #	Type	Serial No	Parameter	Ice Bath Average Absolute Difference (°C)	Room Bath Average Absolute Difference (°C)
53	HL4	SN15104H400271	Water Temperature	0.11	0.03
54	HL4	SN15100H400270	Water Temperature	0.1	0.03
37	MS5	SN091200048592	Water Temperature	0.05	0.03
45	MS5	SN130500064703	Water Temperature	0.05	0.02

Dissolved Oxygen QA

Ecology applied a linear slope adjustment to the raw instrument data for dissolved oxygen before assessing if the data met the MQO targets. The Winkler QC check data indicated that a slight slope adjustment should be applied to HL#54 DO measurement data. Figure 3 shows the HL#54 DO versus Winkler DO data before the correction, and Figure 4 shows the HL#54 DO versus Winkler DO data after the correction. After completing the correction, the root mean squared error (RMSE) of HL#54 versus the Winkler DO was 0.25 mg/L, with a coefficient of variation (CV) around the mean of 2.7%. The corrected DO data from HL#54 was deemed acceptable for use.

HL#54 was the primary sonde used for discrete DO measurements in 2022. However, at times, other sondes were used to make discrete DO measurements in 2022. These DO measurements were qualified as estimates because there was not enough Winkler QC data to correct the sonde.

In 2023, Hydrolab #53 was used for all surveys. Ecology also applied a slight slope adjustment to the raw Hydrolab DO measurements based on the DO versus Winkler DO measurements. Figure 5 and Figure 6 show a comparison of DO and Winkler DO readings before the correction and after the correction, respectively. After completing the adjustment, the RMSE of HL#53 versus the Winkler DO was 0.22 mg/L, with a CV around the mean of 2.3%. The adjusted DO data collected in 2023 from HL#53 was deemed acceptable for use.

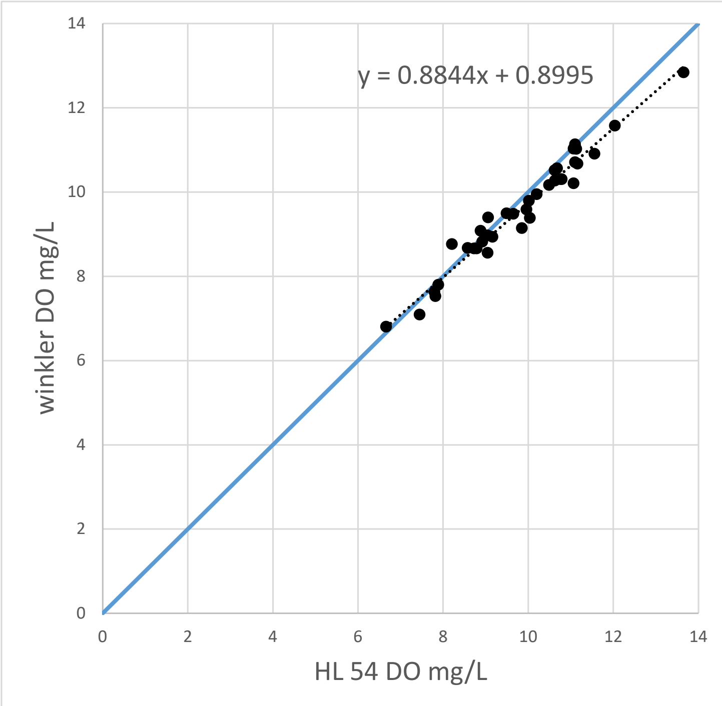


Figure 3. Hydrolab 54 (HL#54) dissolved oxygen (DO) versus Winkler DO data before correction, including linear slope equation of uncorrected data (dashed line) shown with a 1:1 solid line.

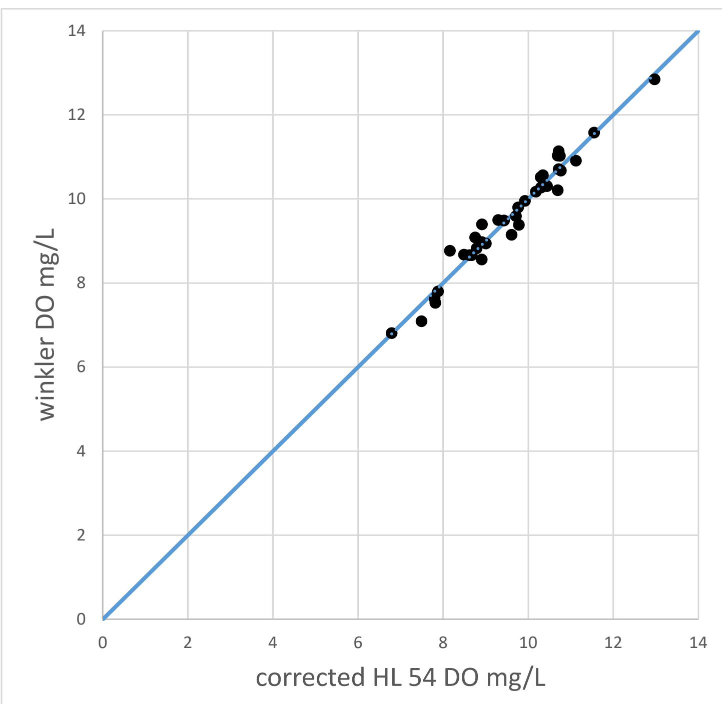


Figure 4. Hydrolab 54 (HL#54) dissolved oxygen (DO) versus Winkler DO data after linear slope correction, shown with a 1:1 solid line.

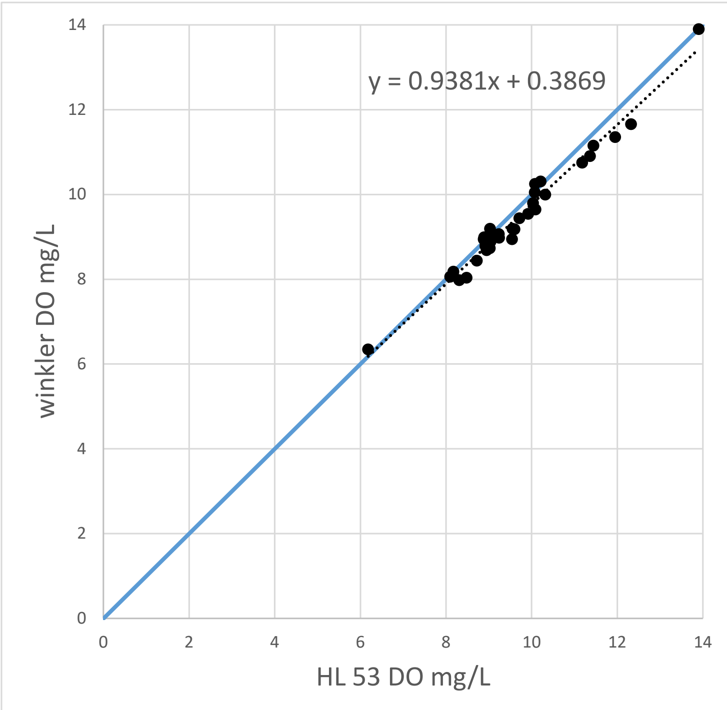


Figure 5. Hydrolab 53 (HL#53) dissolved oxygen (DO) versus Winkler DO data before correction, including linear slope equation of uncorrected data (dashed line) shown with a 1:1 solid line.

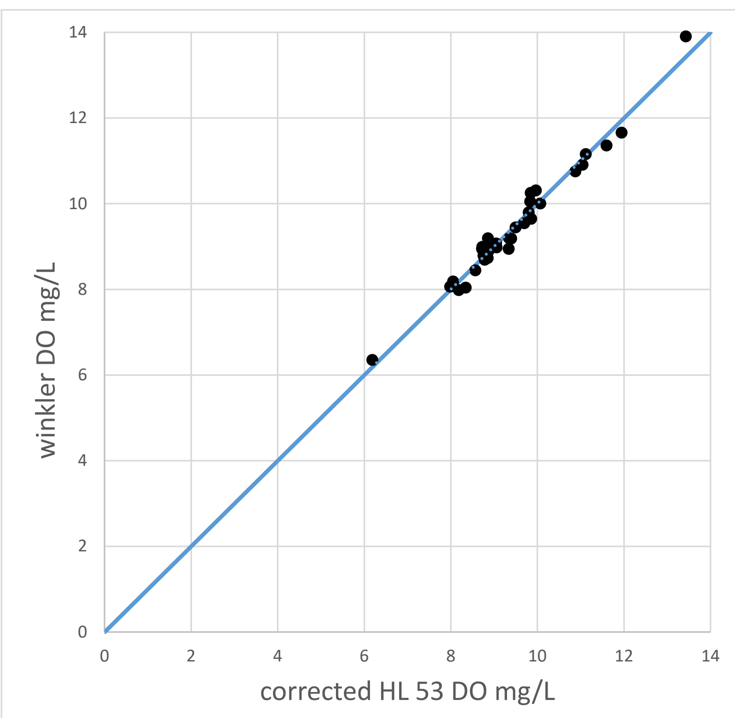


Figure 6. Hydrolab 53 (HL#53) dissolved oxygen (DO) versus Winkler DO data after linear slope correction, shown with a 1:1 solid line.

Discrete Turbidity Measurements

Ecology calibrated a Hach® portable turbidity meter (model 2100P) at the beginning of each season, and checks were made against the standards. The primary calibration and calibration checks used Hach® Formazin primary turbidity standards. Pre-checks for an upcoming sampling week were used as a post-check for the previous run. All calibration checks with calibration standards were within a recovery range of 92–111% (2022) and 92–108% (2023).

Continuous DO Monitoring

Onset® Hobo Dissolved Oxygen data loggers or miniDOT® DO data loggers were deployed at several locations. The data loggers were pre- and post-checked using air-saturated water (bubbler and/or fountain) readings and DO Winkler titration results from both room-temperature and cool water baths. While deployed, check measurements were made using calibrated field sondes and DO Winkler water samples. Ecology assessed the post-check calibration data, field check measurements, and dissolved oxygen Winkler titration results to evaluate the quality of continuous DO data. Ecology applied a slope adjustment to the raw instrument data. Adjusted data are flagged as “IA” (instrument adjusted) in EIM. Selected intervals of continuous data were rejected due to biofouling or sensor error.

Table 8 shows the average and maximum absolute DO difference (in mg/L) between the individual DO data loggers and the post-calibration DO bath. All data loggers met the MQO for continuous DO of less than or equal to 0.5 mg/L.

Table 8. Average and maximum absolute differences in datalogger DO (mg/L) and DO calibration bath.

Site	Year	Logger Type	Serial No	Average Absolute Difference (mg/L)	Maximum Absolute Difference (mg/L)
YKET	2022	HOBO_DO	SN20645555	0.04	0.2
NACM	2022	HOBO_DO	SN20645550	0.04	0.16
YKEU	2022	HOBO_DO	SN20645552	0.02	0.1
YKET	2022	MiniDOT	SN258678	0.01	0.05
CHAN	2022	MiniDOT	SN808854	0.01	0.06
YKAC	2022	MiniDOT	SN441440	0.01	0.06
YKAC	2022	MiniDOT	SN222333	0.01	0.03
YKEU	2022	MiniDOT	SN341412	0.01	0.06
YKVG	2023	MiniDOT	SN085826	0.01	0.03
YKKO	2023	MiniDOT	SN108203	0.01	0.04
YKPR	2023	MiniDOT	SN109851	0.03	0.06
NACM	2023	MiniDOT	SN222333	0.04	0.08
YKSM	2023	MiniDOT	SN258678	0.12	0.16
YKET	2023	MiniDOT	SN280281	0.08	0.11
YKEU	2023	MiniDOT	SN341412	0.09	0.10

Table D1 in Appendix D lists the locations, instrument information, and deployment dates. Rejected results with dates and times are found in Table D2. Plots of the DO time series by site are shown in Figure D1.

Continuous Temperature Monitoring

Onset® Hobo Temperature data loggers or miniDOT® DO data loggers were deployed throughout the study area to record water and air temperatures. The data loggers were pre- and post-checked in ice and room temperature water baths against a NIST-certified thermometer. At locations where water samples were also collected, a Hydrolab® HL4 multi-probe sonde was also used as a discrete field QC check on the data logger.

Table 9 shows the average and maximum absolute temperature difference (in °C) between the individual DO data loggers and the post-calibration DO bath. All datalogger temperature post-check temperatures met the MQO target of less than 0.2°C and were deemed acceptable.

Continuous water temperature records were compared to air temperature records to identify any periods when the data logger might have been de-watered. De-watered record results were removed.

Table 9. Post-calibration average absolute temperature differences between datalogger temperature and calibration baths.

Site	Year	Logger Type	Serial No	Ice Bath Average Absolute Difference (°C)	Room Bath Average Absolute Difference (°C)
CHAN	2022	Hobo_water_temp	10227087	0.06	0.06
MOXM	2022	Hobo_water_temp	10227142	0.15	0.03
NACM	2022	Hobo_water_temp	10225427	0.16	0.03
ROZP	2022	Hobo_water_temp	10225441	0.12	0.02
YKWD	2022	Hobo_water_temp	10225455	0.05	0.05
WHCM	2022	Hobo_water_temp	10225478	0.12	0.04
YKPK	2022	Hobo_water_temp	10227105	0.18	0.06
YKAC	2022	Hobo_water_temp	10227090	0.01	0.09
YKET	2022	Hobo_water_temp	10225280	0.06	0.06
YKEU	2022	Hobo_water_temp	10227128	0.04	0.08
YKPR	2022	Hobo_water_temp	10225431	0.06	0.07
YKSM	2022	Hobo_water_temp	10221679	0.13	0.03
YKPR	2022	Hobo_air_temp	10225449	0.08	0.05
YKET	2022	Hobo_air_temp	10225286	0.06	0.04
YKEU	2022	Hobo_air_temp	10227146	0.06	0.08
YKSM	2022	Hobo_air_temp	10225290	0.06	0.04
NACM	2023	miniDOT_water_temp	222333	0.01	0.03

Site	Year	Logger Type	Serial No	Ice Bath Average Absolute Difference (°C)	Room Bath Average Absolute Difference (°C)
YKSM	2023	miniDOT_water_temp	258678	0.04	0.04
YKET	2023	miniDOT_water_temp	280281	0.02	0.04
YKEU	2023	miniDOT_water_temp	341412	0.03	0.05
YKEU	2023	Hobo_air_temp	10221679	0.02	0.07
YKPR	2023	Hobo_air_temp	10225286	0.02	0.12
YKET	2023	Hobo_air_temp	10225425	0.04	0.13
YKSM	2023	Hobo_air_temp	10227115	0.02	0.11
YKSM	2023	Hobo_water_temp	10221691	0.05	0.10
YKAC	2023	Hobo_water_temp	10225280	0.03	0.12
YKWW	2023	Hobo_water_temp	10225427	0.07	0.02
MOXEE	2023	Hobo_water_temp	10225468	0.03	0.08
ROZP	2023	Hobo_water_temp	10227087	0.02	0.15
WHCM	2023	Hobo_water_temp	10227102	0.01	0.06
YKPR	2023	Hobo_water_temp	10227111	0.06	0.01
YKET	2023	Hobo_water_temp	10227128	0.08	0.03
NACM	2023	Hobo_water_temp	10227132	0.05	0.15
YKEU	2023	Hobo_water_temp	10227135	0.03	0.01

An Onset® RH/Temp data logger was used to collect dew point temperature at one site (YKET). Before and after deployment, the data logger was checked for air temperature and humidity to determine if the logger was properly functioning. Temperature was verified at room temperature against previously calibrated HOBO tidbit V2 loggers. Humidity was checked based on the expected value for saturated sodium chloride (NaCl) salt. The saturated salt was placed in an open tray at the bottom of the cooler, with the Onset RH/Temp data logger placed on a rack over the salt. Table 10 shows the average absolute error for temperature (°C) and humidity (%).

Table 10. Post-calibration average absolute error for temperature and humidity for datalogger.

Site	Logger_Type	Serial No	Parameter	Room_AirTemp (°C)	Room_Humidity (%)
YKET	Relative Humidity	SN1002566	Dew Point Temperature	0.16	0.7

Table E1 in Appendix E lists the locations, instrument information, and deployment dates. Rejected results with dates and times are found in Table E2. Plots of the temperature time series by site are shown in Figures E1 and E2.

Continuous Sonde monitoring at YKSM and YKPR

At two locations (YKSM and YKPR) in 2022, Ecology deployed Hydrolab® multi-probe sonde data loggers for continuous long-term monitoring. Deployed from June through the first week of November 2022, the sondes recorded water temperature, pH, DO, and conductivity. Measurements were logged every 15–30 minutes. Four dedicated sondes were swapped out and re-calibrated every two weeks at each site (Table 11). Ecology also collected discrete measurements with other Hydrolab® sondes for QC field checks.

Table 11. Hydrolab sonde dataloggers used at YKSM and YKPR in 2022.

Hydrolab Sonde #	Hydrolab Type	Serial No	Location Deployed
45	MS5	SN130500064703	YKSM
37	MS5	SN091200048592	YKSM
36	MS5	SN091200048590	YKPR
15	DS4a	SN000100037385	YKPR

pH and conductivity QA

Post-calibration check measurements for conductivity and pH were compared to the MQO targets in Table 4. All conductivity post-checks were within the acceptable target range of less than 10% of the difference between the sonde reading and calibration standard. All pH post-checks also met the acceptable target range, except for the YKPR sample event July 25 – Aug 10, 2022 (Hydrolab #15) and YKPR sample event Sept 21 – Oct 5, 2022 (Hydrolab #36), when post-checks deemed the pH data to be qualified as estimated. Accordingly, the pH time series from these sample events were qualified as estimated in the EIM database.

Table 12. Post-calibration quality control checks for pH and conductivity for deployed sondes.

Sonde#	Location Event	Deployment Dates	Conductivity 100 us QC check (%)	Conductivity 1000 us QC check (%)	pH 7 QC check	pH 10 QC check	Remark
45	YKSM-1	6/23/22–7/5/22	2.7	1.6	0.03	0.01	—
37	YKSM-2	7/5/22–7/26/22	1.0	0.0	-0.03	-0.02	—
45	YKSM-3	7/26/22–8/9/22	0.8	-0.1	0.04	0.03	—
37	YKSM-4	8/9/22–8/23/22	0.6	0.3	0.01	0.00	—
45	YKSM-5	8/23/22–9/6/22	1.3	0.0	0.05	0.00	—
37	YKSM-6	9/6/22–9/20/22	0.6	-0.4	0.00	0.07	—

Sonde#	Location Event	Deployment Dates	Conductivity 100 us QC check (%)	Conductivity 1000 us QC check (%)	pH 7 QC check	pH 10 QC check	Remark
45	YKSM-7	9/20/22–10/4/22	-0.3	-1.5	-0.02	0.03	—
37	YKSM-8	10/4/22–10/18/22	-0.8	-0.5	-0.09	0.00	—
45	YKSM-9	10/18/22–10/25/22	1.4	0.6	-0.07	-0.01	—
37	YKSM-10	10/25/22–11/7/22	-1.2	-0.5	-0.06	-0.05	—
36	YKPR-1	6/29/22–7/12/22	3.0	0.1	-0.09	-0.03	—
15	YKPR-2	7/13/22–7/26/22	5.1	0.1	**-0.27**	0.07	Qualify pH
36	YKPR-4	8/10/22–8/24/22	0.9	-0.6	-0.12	-0.04	—
36	YKPR-5	8/24/22–9/7/22	4.0	0.7	0.10	0.04	—
36	YKPR-6	9/7/22–9/21/22	-4.3	missing	**0.23**	missing	Qualify pH
36	YKPR-7	9/21/22–10/5/22	-0.3	-1.7	-0.03	**-0.25**	Qualify pH
15	YKPR-8	10/5/22–10/19/22	0.4	-5.0	0.00	0.00	—
36	YKPR-9	10/19/22–10/26/22	4.4	1.4	-0.18	0.16	—
36	YKPR-10	10/26/22–11/8/22	-1.0	-2.3	0.15	-0.02	—

Note. The percentage difference between the conductivity standard and the sonde's conductivity reading is compared to the MQO ranges for conductivity in Table 5. Likewise, the pH difference between the pH standard and the sonde's pH reading is also compared to the MQO ranges for pH in Table 5.
QC = quality control

Temperature QA

The temperature sensor on each sonde was post-checked in ice and room-temperature baths. Table 13 shows the bath results for each sonde. All sonde temperature post-check temperatures met the MQO target of less than 0.2°C and were deemed acceptable.

Table 13. Post-calibration average and maximum absolute temperature differences between datalogger termperature and calibration baths.

Hydrolab Sonde #	Type	Serial No	Parameter	Ice Bath Average Absolute Difference (°C)	Room Bath Average Absolute Difference (°C)
15	DS4a	SN000100037385	Water Temperature	0.06	0.03
36	MS5	SN091200048590	Water Temperature	0.07	0.03
37	MS5	SN091200048592	Water Temperature	0.05	0.03
45	MS5	SN130500064703	Water Temperature	0.05	0.02

Dissolved Oxygen QA

Hydrolab® data loggers with DO sensors were pre- and post-checked using air-saturated water (bubbler and/or fountain) readings and DO Winkler titration results from both room-temp and cool water baths. While deployed, check measurements were made using calibrated field sondes and DO Winkler water samples. Ecology assessed the field check measurements to evaluate the quality of continuous DO data. In three cases, Ecology applied a slope adjustment to the raw instrument data to fit the field check data better. Figure 7 shows regressions of the adjusted raw data and the field check data for each Hydrolab® data logger. Adjusted data are flagged as "IA" (instrument adjusted) in EIM. Selected intervals of continuous data were rejected due to biofouling or sensor error.

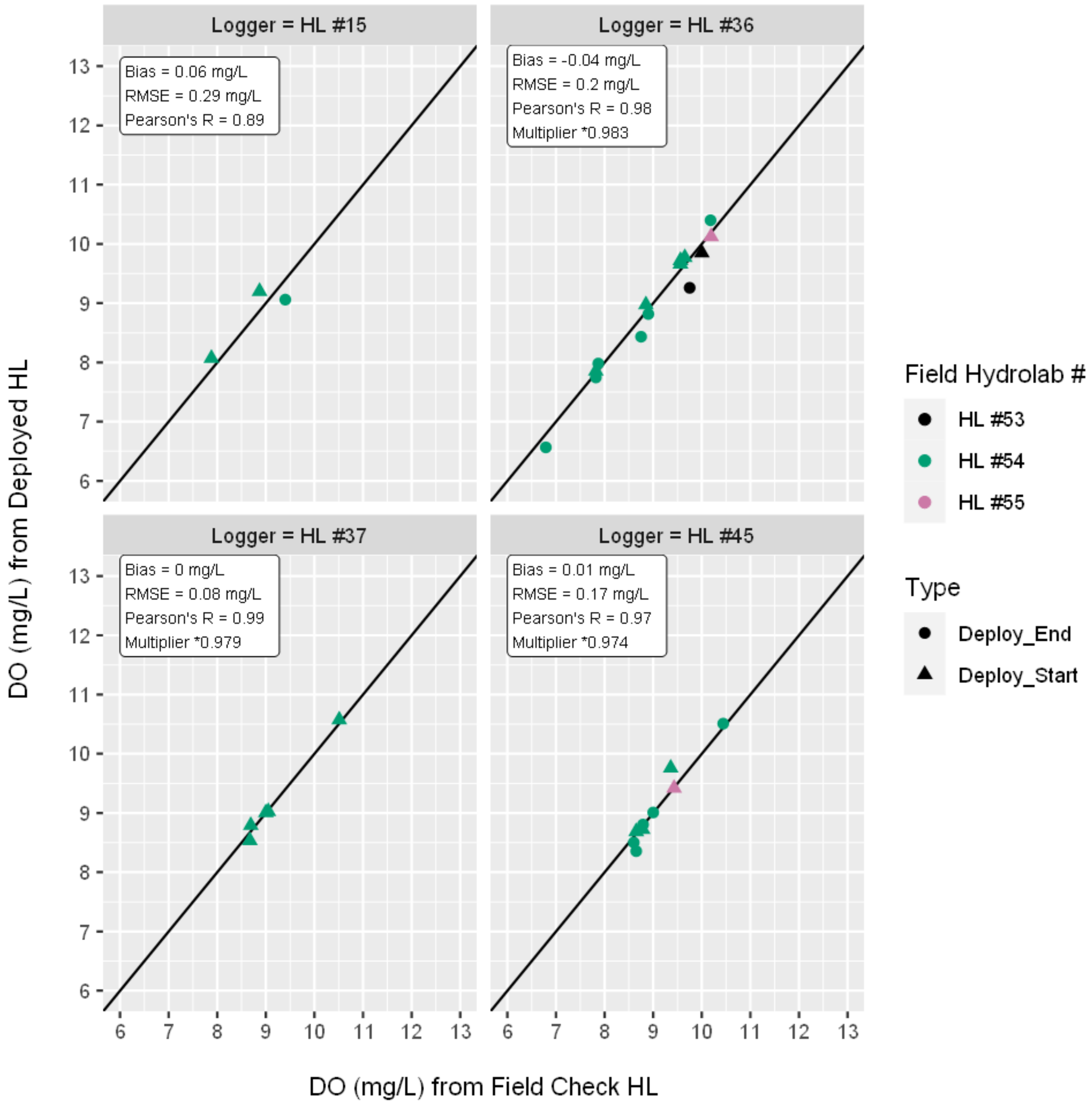


Figure 7. Regressions of data logger dissolved oxygen (DO), and field check DO for 2022 DO dataloggers at YKSM and YKPR.

Table D1 in Appendix D lists the locations, instrument information, and deployment dates. Rejected results with dates and times are found in Table D2. Plots of the temperature time series by site are shown in Figures D1 and D2.

Continuous Turbidity monitoring at YKSM

Ecology installed a telemetered stream turbidity station at one mainstem site in the Lower Yakima River (YKSM). Factory-calibrated FTS® DTS-12 in-situ turbidity sensor measured turbidity at 15-minute intervals throughout the study periods (July – Nov 2022 and April – Nov 2023).

Discrete field QC checks on turbidity were made at the turbidity gage during sampling visits using Hach portable turbidity meter (model 2100P). If significant differences were observed between the portable meters and the turbidity gage, then the turbidity sensor was removed for inspection and cleaning using de-ionized water.

Ecology first converted the raw 15-minute turbidity monitoring data to hourly averages. Before hourly averaging, 15-minute data were reviewed, and suspicious readings were flagged for removal. Suspicious readings were identified as sudden short-term peaks in turbidity, which cannot be confirmed by other stations. These peaks indicate the possibility of either sensor interference by debris in the water or near-shore disturbances that are not representative of the water body.

The meter was returned to the factory for post-calibration following each field season. The meter used in 2022 had a post-calibration result within 6.5% of true values. The meter used in 2023 had a post-calibration result within 3.0% of true values. The MQO for accepting the turbidity data are post-calibration values less than <10% of true values. Ecology accepted the data "as is" and did not apply any corrections to the hourly turbidity data. After flagged data had been removed, the hourly gage turbidity data were loaded into EIM.

Table F1 in Appendix F lists the location, instrument information, and deployment dates. Rejected results with dates and times are found in Table F2. Plots of the turbidity time series are shown in Figures F1 and F2.

Results

Data collected during this study, Lower Yakima River Monitoring for Aquatic Life Parameters to Support Water Quality Gaging, are presented in the following appendices:

• Appendix A lists monitoring locations, descriptions, and parameters collected or measured at each location.

• Appendix B lists the sample collection details, laboratories used to analyze surface water samples by parameter and sample event, laboratory sample results, summary of laboratory case summaries, and Winkler titration results for dissolved oxygen.

• Appendix C lists discrete surface water multi-parameter sonde measurements.

• Appendix D lists continuous long-term monitoring locations with instrument information, deployment dates, and data qualifiers. It contains charts showing the pH, dissolved oxygen, conductivity, and turbidity results at several locations. It also lists any gaps in the data due to sensor fouling or logger error codes.

• Appendix E lists continuous temperature monitoring locations with instrument information and deployment dates. It also contains charts showing the temperature time series results at each location.

• Appendix F lists continuous turbidity monitoring locations with instrument information and deployment dates. It also contains charts showing the turbidity time series results.

All data in Appendices are available from Ecology's EIM online database.[2]

Results may be accessed by searching EIM using the User Study ID (JICA0006), the Study Name (Lower Yakima River Monitoring for Aquatic Life Parameters to Support Water Quality Gaging), or the EIM location ID of any of the locations listed in Appendix A.

[2] https://apps.ecology.wa.gov/eim/search/default.aspx.

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Glossary, Acronyms, and Abbreviations

Glossary

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Effluent: An outflowing of water from a natural body of water or from a man-made structure. For example, the treated outflow from a wastewater treatment plant.

Geometric mean: A mathematical expression of the central tendency (an average) of multiple

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector, such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

BCD	Benton Conservation District
CV	coefficient of variation
DO	dissolved oxygen
DOC	dissolved organic carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System software
IA	instrument adjustment
MEL	Manchester Environmental Laboratory
MQO	Measurement Quality Objective
MRL	method reporting limit
POTW	publicly owned treatment works
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	reporting limit
RM	river mile
RMSE	root mean squared error
RPD	relative percent difference
RSD	relative standard deviation
SOP	standard operating procedures
TMDL	Total Maximum Daily Load (see glossary)
TNVSS	total non-volatile suspended solids
TOC	total organic carbon
TP	total phosphorus
TPN	total persulfate nitrogen
TSS	total suspended solids
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
YBIP	Yakima Basin Integrated Plan
YN	Yakima Nation

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
mg/L	milligrams per liter (parts per million)

s.u.	standard units
µmhos/cm	micromhos per centimeter
µg/L	microgram per liter (parts per billion)
µS/cm	microsiemens per centimeter, a unit of conductivity

Appendices

Appendix A. Monitoring Locations

Table A1. Monitoring locations with a list of measurements and parameters collected at each location in 2022.

Study Location ID	Monitoring Site Name	WQ Samples	Sonde (discrete)	Sonde Data Logger	Nitrate Data Logger	Water Temp Data Logger	Air Temp Data Logger	RH/Dew Point Data Logger	DO Data Logger	Turbidity Data Logger	Light Meter
YKSM	Yakima River at Selah Moxee diversion	X	X	X	—	X	X	—	—	X	X
NACM	Naches River near mouth	X	X	—	—	X	—	—	X	—	—
ROZP	Roza Power Canal return to Yakima	—	—	—	—	X	—	—	—	—	—
MOXM	Moxee Ditch near mouth	—	—	—	—	X	—	—	—	—	—
WHCM	Wide Hollow Creek near mouth	—	—	—	—	X	—	—	—	—	—
YKUG	Yakima River @ Union Gap	X	X	USGS	USGS	—	—	—	—	USGS	—
YKET	Yakima River above East Toppenish Drain	X	X	—	—	X	X	X	X	—	—
YKPK	Yakima River at USBR Parker gage	—	—	—	—	X	—	—	—	—	—
YKEM	Yakima River below Granger (Emerald)	X	X	USGS	USGS	—	—	—	—	USGS	—
YKEU	Yakima River at Euclid Bridge	X	X	—	—	X	X	—	X	—	—
YKPR	Chandler Diversion	X	X	X	—	X	X	—	—	—	X
YKAC	Yakima River above Chandler Return	X	X	—	—	X	—	—	X	—	—
CHAN	Chandler Return	X	X	—	—	X	—	—	X	—	—
YKKO	Yakima River @ Kiona	X	X	USGS	—	—	—	—	—	—	—
YKWD	Yakima River at Wanawish Dam	—	—	—	—	X	—	—	—	—	—
YKVG	Yakima River @ Van Giesen	X	X	USGS	—	—	—	—	—	—	—

USGS = United States Geological Survey; WQ = water quality; Sonde = Hydrolab Sonde; Temp = temperature; RH = relative humidity; DO = dissolved oxygen

Table A2. Monitoring locations with a list of measurements and parameters collected at each location in 2023.

Study Location ID	Monitoring Site Name	WQ Samples	Sonde (discrete)	Sonde Data Logger	Nitrate Data Logger	Water Temp Data Logger	Air Temp Data Logger	RH/Dew Point Data Logger	DO Data Logger	Turbidity Data Logger	Light Meter
YKSM	Yakima River at Selah Moxee diversion	X	X	—	—	X	X	—	X	X	X
NACM	Naches River near mouth	X	X	—	—	X	—	—	X	—	—
ROZP	Roza Power Canal return to Yakima	—	—	—	—	X	—	—	—	—	—
MOXM	Moxee Ditch near mouth	—	—	—	—	X	—	—	—	—	—
WHCM	Wide Hollow Creek near mouth	—	—	—	—	X	—	—	—	—	—
YKUG	Yakima River @ Union Gap	X	X	USGS	USGS	—	—	—	—	USGS	—
YKET	Yakima River above East Toppenish Drain	X	X	—	—	X	X	X	X	—	—
YKPK	Yakima River at USBR Parker gage	—	—	—	—	X	—	—	—	—	—
YKEM	Yakima River below Granger (Emerald)	X	X	USGS	USGS	—	—	—	—	USGS	—
YKEU	Yakima River at Euclid Bridge	X	X	—	—	X	X	—	X	—	—
YKPR	Chandler Diversion	X	X	—	—	X	X	—	X	—	X
YKAC	Yakima River above Chandler Return	—	—	—	—	X	—	—	X	—	—
CHAN	Chandler Return	—	—	—	—	X	—	—	X	—	—
YKKO	Yakima River @ Kiona	—	—	—	—	X	—	—	X	X	—
YKWD	Yakima River at Wanawish Dam	—	—	—	—	X	—	—	—	—	—
YKVG	Yakima River @ Van Giesen	—	—	—	—	X	—	—	X	X	—

USGS = United States Geological Survey; WQ = water quality; Sonde = Hydrolab Sonde; Temp = temperature; RH = relative humidity; DO = dissolved oxygen

Appendix B. Laboratory Results – Surface Water

Table B1. Sample analysis laboratories used in 2022 (only MEL used in 2023) for Lower Yakima River Monitoring.

Sample Parameter	Jun 28–29	Jul 12–13	Aug 2–3	Aug 9–10	Aug 23–24	Sep 6–7	Sep 20–21	Oct 4–5	Oct 18–19	Oct 25–26	Nov 7–8
Alkalinity	OEL	OEL	OEL	OEL	OEL	MEL	MEL	MEL	MEL	OEL	ALS
Ammonia	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL
Dissolved Organic Carbon	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL
Nitrate + Nitrite	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL	OEL
Orthophosphate	MEL	MEL	MEL	MEL	MEL	ALS	ALS	MEL	MEL	MEL	MEL
Total Organic Carbon	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL
Total Phosphorus	MEL	MEL	MEL	MEL	MEL	KING	KING	MEL	MEL	MEL	MEL
Total Persulfate Nitrogen	KING	KING	KING	KING	KING	KING	KING	KING	KING	KING	KING
Total Suspended Solids	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL
Total Non-volatile Suspended Solids	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL
Chlorophyll a	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL	MEL

MEL = Ecology's Manchester Environmental Laboratory; OEL = Onsite Environmental Laboratory, Redmond, WA
KING = King County Environmental Laboratory, Seattle, WA; ALS = ALS Environmental Laboratory, Kelso, WA.

Table B2. Laboratory results for surface water samples collected in 2022 for Lower Yakima River Monitoring to Support Water Quality Gaging.

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	CHLA (µg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
CHAN	6/29/2022	11:00	54	0.05 U	1.4 J	1.12	0.3	0.0423	34	1.4	0.747	0.0814	39
CHAN	7/13/2022	11:10	66	0.05 U	4.9	1.44	0.6	0.0632	11	1.66	0.918	0.0781	13
CHAN	8/3/2022	10:33	120	0.05 U	—	1.86	0.9	0.0868	4	1.91	1.39	0.101	5
CHAN	8/10/2022	12:40	46	0.05 U	1.4	1.72	0.94	0.0633	6	1.83	1.25	0.0787	7
CHAN	8/24/2022	9:50	86	0.05 U	1.9 J	1.79	1	0.0719	7	2.14	1.27	0.0862	8
CHAN	9/7/2022	10:13	94	0.05 U	2.1	1.72	1	0.052 J	4	1.75	1.25	0.0697	5
CHAN	9/21/2022	11:10	96.2	0.05 U	2.4 J	1.67	1.1	0.068	4	1.87	1.44	0.0891	5
CHAN	10/5/2022	13:45	107	0.05 U	1.4	1.56	1.2	0.092	28 J	1.79	1.64	0.101	31 J
CHAN	10/19/2022	10:43	100 J	0.05 U	4.2	1.48	1.2	0.0836	6	1.77	1.61	0.0964	8
CHAN	11/8/2022	10:55	60.1	0.05 U	5	3.6	0.69	0.0564 J	25	3.8	1.02	0.104	28
NACM	6/28/2022	10:45	26	0.05 U	—	0.89 J	0.05 U	0.0084	7	0.996	0.136	0.0178	9
NACM	7/12/2022	8:35	30	0.05 U	—	0.92	0.05 U	0.0086	9	0.946	0.128	0.0231	11
NACM	8/2/2022	8:50	34	0.05 U	—	0.98	0.07	0.0121	5	1.17	0.234	0.0192	6
NACM	8/9/2022	8:28	36	0.052	—	0.99	0.1	0.0093	3	1.1	0.212	0.0175	4
NACM	8/23/2022	8:23	38	0.05 U	—	1.02	0.14	0.016	5	1.31	0.25	0.0312	8
NACM	9/6/2022	8:55	32.2	0.05 U	—	0.91	0.065	0.05 U	12	1.02	0.125	0.0244	15
NACM	9/20/2022	9:18	32.7	0.05 U	—	0.94	0.05 U	0.05 U	8	1.07	0.128	0.0187	10
NACM	10/4/2022	9:40	35.4	0.05 U	—	0.81	0.05 U	0.0064	4	0.948	0.16	0.0146	5
NACM	10/18/2022	9:35	40 J	0.05 U	—	0.78	0.074	0.0077	2	0.916	0.201	0.0135	3
NACM	10/25/2022	10:45	44	0.05 U	—	0.76	0.15	0.0105	2 J	0.824	0.257	0.0174	3 J
NACM	11/7/2022	10:10	35.4	0.05 U	—	2	0.27	0.0188	12	2.2	0.405	0.0393	15
YKAC	6/29/2022	11:30	58	0.05 U	1.3 J	1.22	0.32	0.039	7	1.47	0.646	0.0561	8
YKAC	7/13/2022	12:05	78	0.05 U	—	1.73	0.56	0.0652	10	1.87	0.965	0.09	13
YKAC	8/3/2022	11:05	62	0.05 U	2.6	1.92	0.94	0.103	2	2.13	1.42	0.114	3
YKAC	8/10/2022	13:15	98	0.05 U	—	1.86	0.85	0.0506	1 U	2.03	1.19	0.0639	2
YKAC	8/24/2022	10:30	96	0.05 U	—	2.09	0.84	0.0521	2	2.27	1.16	0.0661	3
YKAC	9/7/2022	10:48	110	0.05 U	—	1.92	0.83	0.05 UJ	2	2.02	1.19	0.0541	3
YKAC	9/21/2022	11:30	109	0.05 U	—	1.87	0.94	0.05 U	1 U	2.06	1.29	0.0592	1

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	CHLA (µg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
YKAC	10/5/2022	13:25	123	0.05 U	—	1.85	1.1	0.0639	1 UJ	2.02	1.52	0.0704	2 J
YKAC	10/19/2022	11:00	110 J	0.05 U	—	1.61	1.1	0.0707	1 U	1.79	1.58	0.0797	2
YKAC	10/26/2022	10:35	100	0.05 U	—	2.22	1.3	0.0926	12 J	1.71	1.68	0.114	14 J
YKAC	11/8/2022	10:30	63.7	0.05 U	—	3.7	0.72	0.057 J	19	3.7	1.06	0.102	23
YKEM	5/18/2022	16:00	—	—	—	—	0.22	—	—	—	—	—	—
YKEM	6/1/2022	16:00	—	—	—	—	0.15	—	—	—	—	—	—
YKEM	6/9/2022	13:40	—	—	—	—	0.13	—	—	—	—	—	—
YKEM	6/15/2022	11:20	—	—	—	—	0.16	—	—	—	—	—	—
YKEM	6/28/2022	14:00	44	0.05 U	1 J	1.12	0.067	0.0208	14	1.25	0.338	0.0391	16
YKEM	7/12/2022	12:10	50	0.05 U	6.6	1.37	0.23	0.0185	7	1.48	0.491	0.0403	9
YKEM	8/2/2022	12:25	60	0.05 U	2.2	1.46	0.61	0.0476	7	1.62	0.908	0.0671	9
YKEM	8/9/2022	11:35	64	0.05 U	4.6	1.48	0.6	0.0381	10 J	1.61	0.865	0.0637	12 J
YKEM	8/23/2022	11:12	64	0.05 U	2.2 J	1.53	0.64	0.0416	6	1.69	0.801	0.0572	7
YKEM	9/6/2022	11:45	72.2	0.05 U	3.1	1.43	0.62	0.05 U	4	1.57	0.819	0.0523	6
YKEM	9/20/2022	12:05	71	0.05 U	3.5	1.57	0.49	0.05 U	7	1.58	0.771	0.062	9
YKEM	10/4/2022	12:30	83	0.05 U	2.6	1.4	0.82	0.0559	5	1.69	1.16	0.0678	7
YKEM	10/18/2022	12:40	82 J	0.05 U	3.6	1.64	0.88	0.0644	11	1.4	1.26	0.0767	13
YKEM	10/25/2022	13:38	84	0.05 U	2.7	1.15	0.87	0.064	4 J	1.34	1.16	0.0702	4 J
YKEM	11/7/2022	12:55	53.5	0.05 U	4.5	3	0.54	0.052 J	23	3.1	0.842	0.0942 J	27
YKET	6/28/2022	13:00	36	0.05 U	1.4 J	1	0.05 U	0.0168 J	13	1.25	0.19	0.0439	15
YKET	7/12/2022	10:55	40	0.05 U	5.6	1.05	0.05 U	0.0123	8	1.53	0.226	0.0297	10
YKET	8/2/2022	10:57	42	0.05 U	3.6 J	1.15	0.16	0.0257	5	1.42	0.341	0.0406	6
YKET	8/9/2022	10:42	44	0.05 U	3.2	1.21	0.13	0.0204	4	1.39	0.292	0.0347	5
YKET	8/23/2022	10:20	48	0.05 U	3.1 J	1.46	0.097	0.0152	2	1.57	0.213	0.0366	3
YKET	9/6/2022	10:55	52.2	0.05 U	2.8	1.25	0.079	0.05 U	2	1.47	0.187	0.027	3
YKET	9/20/2022	11:20	53.9	0.05 U	4.1	1.47	0.05 U	0.05 U	6	1.56	0.261	0.0433	7
YKET	10/4/2022	11:35	58	0.05 U	3.8	1.41	0.14	0.0322	2	1.54	0.356	0.0424	4
YKET	10/18/2022	11:58	100 J	0.05 U	8.4	1.36	0.29	0.0466	9	1.48	0.537	0.0625	11
YKET	10/25/2022	12:42	66	0.05 U	3.4	1.07	0.41	0.057	3 J	1.22	0.579	0.061	4 J
YKET	11/7/2022	12:00	46.7	0.05 U	3.8	2.8	0.31	0.0369	15	2.9	0.528	0.0661	19

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	CHLA (µg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
YKEU	6/28/2022	15:00	52	0.05 U	0.7 J	1.15	0.32	0.0431	25	1.25	0.647	0.0755	29
YKEU	7/12/2022	13:10	66	0.05 U	6	1.32	0.62	0.0666	16	1.73	1.05	0.0876	19
YKEU	8/2/2022	13:30	84	0.05 U	1.6	1.81	1	0.0832	3	1.98	1.44	0.0977	5
YKEU	8/9/2022	13:05	46	0.05 U	1.5	1.68	1	0.0611	3	1.67	1.34	0.0749	5
YKEU	8/23/2022	12:10	84	0.05 U	1.6 J	1.86	1	0.0739	4	1.91	1.35	0.0851	6
YKEU	9/6/2022	12:45	92.9	0.05 U	1.3	1.69	1.1	0.057	3	1.74	1.32	0.0757	4
YKEU	9/20/2022	13:05	94.3	0.05 U	2	1.65	1.2	0.075	3	1.92	1.52	0.0928	4
YKEU	10/4/2022	13:15	104	0.05 U	2.3	1.59	1.3	0.103	3	1.71	1.74	0.11	4
YKEU	10/18/2022	13:45	100 J	0.05 U	3.5	1.52	1.2	0.0937	4	1.52	1.66	0.0932	5
YKEU	10/25/2022	14:35	94	0.05 U	2.6	1.25	1.2	0.0957	3 J	1.44	1.5	0.101	4 J
YKEU	11/7/2022	13:45	56.5	0.05 U	4.6	4.5	0.65	0.0586	33	4.5	1.04	0.114	39
YKKO	6/29/2022	10:20	58	0.05 U	2 J	1.18	0.34	0.0395	24	1.33	0.651	0.0684	28
YKKO	7/13/2022	10:27	32	0.05 U	9.7	1.67	0.58	0.054	10	1.78	1.02	0.0837	13
YKKO	8/3/2022	9:50	96	0.05 U	2.9	1.98	1	0.0971	3	1.95	1.48	0.112	4
YKKO	8/10/2022	12:00	92	0.05 U	1.5	1.65	0.85	0.0505	3	1.97	1.15	0.0651	4
YKKO	8/24/2022	11:05	92	0.05 U	2.9 J	2.05	0.88	0.0551	2	2.28	1.11	0.0684	4
YKKO	9/7/2022	11:20	103	0.05 U	2.9	1.66	0.88	0.05 UJ	2	1.94	1.2	0.0534	3
YKKO	9/21/2022	12:10	101	0.05 U	3.4	1.83	1.1	0.058	2 U	2	1.37	0.0757	3
YKKO	10/5/2022	12:55	110	0.05 U	3.3	1.7	1.1	0.0742	2 J	1.86	1.5	0.0796	3 J
YKKO	10/19/2022	12:00	100 J	0.05 U	23.4	1.49	1.1	0.0739	5	1.84	1.6	0.087	7
YKKO	10/26/2022	11:11	100	0.05 U	7	1.52	1.2	0.101	11 J	1.64	1.64	0.109	13 J
YKKO	11/8/2022	11:40	60.9	0.05 U	7.9	4.1	0.72	0.0561 J	25	3.9	1.09	0.107	30
YKPR	6/29/2022	13:15	56	0.05 U	1.2 J	1.18	0.39	0.045	13	1.37	0.767	0.0759	16
YKPR	7/13/2022	8:00	70	0.05 U	4.6	1.43	0.64	0.0628	8	1.66	1.02	0.0846	10
YKPR	8/3/2022	7:33	90	0.05 U	2.4 J	1.69	0.93	0.0879	4	1.96	1.44	0.105	6
YKPR	8/10/2022	8:00	90	0.05 U	1.9	1.73	0.97	0.0662	4	1.99	1.28	0.0792	5
YKPR	8/24/2022	7:25	92	0.079	1.4 J	1.99	1	0.0708	6	2	1.39	0.0837	8
YKPR	9/7/2022	8:10	101	0.05 U	1.7	1.63	1.1	0.051 J	3	1.82	1.34	0.068	4
YKPR	9/21/2022	8:45	101	0.05 U	2.3	1.77	1.1	0.064	3	2	1.46	0.0772	4
YKPR	10/5/2022	9:15	114	0.05 U	3.4	1.68	1.3	0.0849	3 J	1.75	1.71	0.0943	4 J

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	CHLA (µg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
YKPR	10/19/2022	9:00	100 J	0.05 U	3	1.46	1.2	0.0818	4	1.64	1.7	0.0888	5
YKPR	10/26/2022	8:35	100	0.067	2.5	1.65	1.3	0.0946	3 J	1.47	1.54	0.101	4 J
YKPR	11/8/2022	9:00	62.2	0.05 U	4.1	3.6	0.68	0.0584 J	15	3.5	1.02	0.0979	18
YKSM	6/28/2022	9:00	38	0.05 U	1.1 J	1.05	0.05 U	0.0093 J	7	1.14	0.243	0.0208	9
YKSM	7/12/2022	7:40	36	0.05 U	—	1.42	0.15	0.0181	5	1.49	0.359	0.0323	7
YKSM	8/2/2022	7:30	30	0.05 U	—	1.38	0.086	0.0179	9	1.32	0.362	0.033	11
YKSM	8/9/2022	7:20	32	0.05 U	—	1.14	0.12	0.0179	7	1.3	0.259	0.032	9
YKSM	8/23/2022	7:15	34	0.05 U	—	1.41	0.15	0.0206	6	1.44	0.268	0.0329	8
YKSM	9/6/2022	7:45	47.4	0.05 U	—	1.45	0.15	0.05 U	2	1.5	0.257	0.0323	3
YKSM	9/20/2022	8:07	59.8	0.05 U	—	2.14	0.12	0.05 U	1	2.13	0.371	0.0388	2
YKSM	10/4/2022	8:20	63.5	0.05 U	—	1.89	0.22	0.0472	2	2.09	0.514	0.0578	4
YKSM	10/18/2022	8:21	60 J	0.05 U	—	1.27	0.25	0.038	2	1.47	0.503	0.0477	3
YKSM	10/25/2022	8:58	62	0.05 U	—	0.93	0.29	0.0288	2 J	1.07	0.437	0.0346	3 J
YKSM	11/7/2022	8:50	47.9	0.05 U	—	2.6	0.21	0.0449	10	2.7	0.403	0.0452	13
YKUG	5/18/2022	17:05	—	—	—	—	0.11	—	—	—	—	—	—
YKUG	6/1/2022	16:45	—	—	—	—	0.071	—	—	—	—	—	—
YKUG	6/9/2022	14:40	—	—	—	—	0.053	—	—	—	—	—	—
YKUG	6/15/2022	12:45	—	—	—	—	0.066	—	—	—	—	—	—
YKUG	6/28/2022	11:30	36	0.05 U	0.8 J	1.03 J	0.05 U	0.0181	9	1.24	0.244	0.0309	11
YKUG	7/12/2022	9:25	38	0.05 U	3.8	1.31	0.09	0.0216	8	1.25	0.291	0.0369	10
YKUG	8/2/2022	9:38	36	0.05 U	2.3	1.3	0.18	0.0305	9	1.27	0.455	0.0475	11
YKUG	8/9/2022	9:40	38	0.05 U	2.4	1.19	0.2	0.0285	6	1.23	0.325	0.0432	8
YKUG	8/23/2022	9:14	38	0.05 U	2.7 J	1.36	0.2	0.0243	6	1.39	0.339	0.0384	8
YKUG	9/6/2022	9:50	46.2	0.05 U	3.5	1.35	0.16	0.05 U	5	1.37	0.281	0.043	6
YKUG	9/20/2022	10:15	51	0.051	6.1 J	1.45	0.13	0.05 U	6	1.53	0.35	0.0621	7
YKUG	10/4/2022	10:27	56.5	0.05 U	2.8	1.79	0.25	0.0505	7	1.46	0.489	0.0596	9
YKUG	10/18/2022	10:50	60 J	0.05 U	3.7	1.47	0.34	0.0566	4	1.3	0.567	0.0684	6
YKUG	10/25/2022	11:30	110	0.05 U	3.5	1.04	0.44	0.0581	3 J	1.2	0.61	0.0635	4 J
YKUG	11/7/2022	11:05	48.2	0.05 U	3.9	2.7	0.31	0.0359	13	2.6	0.518	0.0591	16
YKVG	6/29/2022	9:00	58	0.05 U	2 J	1.24	0.31	0.0427	25	1.35	0.673	0.0748	29

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	CHLA (µg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
YKVG	7/13/2022	9:38	76	0.05 U	6.6	1.75	0.45	0.0604	16	1.95	0.91	0.0914	19
YKVG	8/3/2022	9:08	96	0.05 U	2.1	2.09	0.8	0.111	4	2.15	1.27	0.126	5
YKVG	8/10/2022	11:17	92	0.05 U	2.2 J	1.89	0.66	0.0626	4	2.12	0.98	0.0776	5
YKVG	8/24/2022	11:40	94	0.05 U	2.7 J	2.12	0.77	0.0682	3	2.33	1.1	0.0823	4
YKVG	9/7/2022	11:55	114	0.05 U	2.1	1.81	0.77	0.05 U	2 U	2.09	1.05	0.0659	3
YKVG	9/21/2022	12:45	106	0.05 U	4.4	1.9	0.99	—	3	2.17	1.32	0.0726	4
YKVG	9/21/2022	13:15	—	—	—	—	—	0.056	—	—	—	—	—
YKVG	10/5/2022	12:10	113	0.05 U	3.9	1.91	1	0.0689	2	1.99	1.43	0.0791	3
YKVG	10/19/2022	12:45	110 J	0.05 U	4.8	1.75	0.85	0.0748	7 J	1.68	1.64	0.0913	9
YKVG	10/26/2022	12:00	100	0.05 U	4.7	1.64	1.8	0.101	4 J	1.84	1.63	0.11	5 J
YKVG	11/8/2022	12:30	60.9	0.05 U	8.6	4.7	0.67	0.0634 J	25	4.8	1.18	0.129	31

Alk = Alkalinity
NH3 = Ammonia
CHLA = Chlorophyll a
DOC = Dissolved Organic Carbon
NO3/NO2 = Nitrate/Nitrite as N
OP = Ortho-Phosphate
TNVSS = Total Non-volatile Suspended Solids
TOC = Total Organic Carbon
TPN = Total Persulfate Nitrogen
TP = Total Phosphorus
TSS = Total Suspended Solids
J = Analyte was positively identified. The reported result is an estimate.
U = Analyte was not detected at or above the reported result.
UJ = Analyte was not detected at or above the reported estimate.

Table B3. Laboratory results for surface water samples collected in 2023 for Lower Yakima River Monitoring to Support Water Quality Gaging.

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
NACM	4/3/2023	9:24	48.1	—	2.26	0.044	0.0063	3	2.31	—	0.0176	4
NACM	4/24/2023	9:12	38.1	0.01 UJ	2.58	0.213	0.0112	29 J	2.41	0.281 J	0.0502	35 J
NACM	5/15/2023	9:07	24.3	0.073	1.56	0.117	0.0168	85 J	1.71	0.18	0.0943	96 J
NACM	6/12/2023	9:35	32.4	0.02	1.08	0.043	0.0138	15	1.22	0.1 U	0.0343	18
NACM	7/17/2023	9:24	42.5	0.021	1.15	0.077	0.0115	6	1.22	0.146	0.0196	8
NACM	8/21/2023	9:26	39.1	0.01 U	1.29	0.053	0.0108	6	1.19	0.103 J	0.0235	8
NACM	9/11/2023	9:23	34.3	0.01 U	0.91	0.028	0.0151	18 J	1.15	0.1 U	0.0317	—
NACM	10/16/2023	8:56	44.8 J	0.012	0.83	0.121	0.0096	3	0.951	0.148	0.0169	4
YKEM	4/3/2023	14:53	73.6	—	2	0.618	0.0484	5	2.2	—	0.0621	7
YKEM	4/24/2023	14:13	65.4	0.015 J	2.35	0.45	0.0456	25	2.54	0.602 J	0.0761	30
YKEM	5/15/2023	12:08	84.1	0.055	1.85	0.291	0.0445	44	1.98	0.401	0.101	49
YKEM	6/12/2023	12:15	64.6	0.02	1.55	0.42	0.0436	7	1.73	0.577	0.0618	9
YKEM	7/17/2023	12:10	66.1	0.039	1.55	0.487	0.04	7	1.7	0.671	0.0551	9
YKEM	8/21/2023	15:37	69.4	0.014	1.35	0.573	0.0316	5	1.56	0.736 J	0.051	6
YKEM	9/11/2023	14:40	73.5	0.01 U	1.39	0.702	0.0418	4 J	1.54	0.778	0.0542	—
YKEM	10/16/2023	11:25	190	0.01 U	1.36	1.41	0.0743	4	1.49	1.46	0.0844	5
YKET	4/3/2023	11:25	62.5	—	2.71	0.258	0.0436	7	2.56	—	0.0588	9
YKET	4/24/2023	11:15	77.4	0.016 J	2.25	0.198	0.0318	24	2.33	0.285 J	0.0722	30
YKET	5/15/2023	11:08	36.2	0.06	1.71	0.171	0.0326	54 J	1.83	0.284	0.0857	61 J
YKET	6/12/2023	11:24	49.6	0.01 U	1.42	0.068	0.0253	6	1.55	0.168	0.0466	7
YKET	7/17/2023	11:25	46.4	0.019	1.39	0.065	0.0174	7	1.52	0.178	0.0338	9
YKET	8/21/2023	12:04	48.4	0.01 U	1.31	0.024	0.0128	3	1.27	0.11 J	0.0242	4
YKET	9/11/2023	11:00	51.9	0.01 U	1.25	0.066	0.0156	4 J	1.41	0.124	0.0232	—
YKET	10/16/2023	10:42	68.4	0.01 U	1.2	0.242	0.0249	2	1.42	0.314	0.0378	3
YKEU	4/3/2023	13:07	86.4	—	2.14	0.798	0.0773	12	2.3	—	0.0946	15
YKEU	4/24/2023	12:46	71.8	0.046 J	2.5	0.666	0.0689	42 J	2.55	0.866 J	0.129	48 J
YKEU	5/15/2023	13:46	49.7	0.067	2.09	0.428	0.0593	97	2.15	0.589	0.148	106
YKEU	6/12/2023	13:42	77.8	0.039	1.54	0.902	0.0846	21	1.82	1.1	0.11	24

Study Location ID	Date	Time (local)	Alk (mg/L)	NH3 (mg/L)	DOC (mg/L)	NO3/NO2 (mg/L)	OP (mg/L)	TNVSS (mg/L)	TOC (mg/L)	TPN (mg/L)	TP (mg/L)	TSS (mg/L)
YKEU	7/17/2023	13:56	94.7	0.038	1.87	0.893	0.0832	5	1.95	1.13	0.09	6
YKEU	8/21/2023	14:17	96.2	0.023	1.55	1.41	0.089	3	1.76	1.6 J	0.103	4
YKEU	9/11/2023	13:25	103	0.01 U	1.69	1.43	0.0964	2 J	1.88	1.49	0.0928	—
YKEU	10/16/2023	13:30	114	0.011	1.5	1.84	0.106	2	1.61	1.93	0.111	3
YKPR	4/3/2023	12:23	77.4	—	2.25	0.77	0.0818	6	2.58	—	0.102	9
YKPR	4/24/2023	11:59	90.3	0.059 J	2.36	0.763	0.0726	33	2.62	0.987 J	0.126	39
YKPR	5/15/2023	13:12	51.8	0.08	2.05	0.455	0.0601	80	2.11	0.608	0.152	89
YKPR	6/12/2023	14:17	78	0.038	1.81	0.955 J	0.0809	18	1.91	1.1	0.106	21
YKPR	7/17/2023	14:47	102	0.035	1.96	0.84	0.0951	1	2.16	1.11	0.101	2
YKPR	8/21/2023	13:15	110	0.02	1.86	1.6	0.0805	9	1.89	1.77 J	0.107	10
YKPR	9/11/2023	11:50	107	0.01 U	1.7	1.4	0.0821	5 J	1.88	1.47	0.0868	—
YKPR	10/16/2023	14:15	120	0.01 U	1.5	1.87	0.0952	6	1.7	1.96	0.104	7
YKSM	4/3/2023	8:10	60.1	—	2.07	0.046	0.0067	4	1.85	—	0.0189	6
YKSM	4/24/2023	8:17	49.4	0.019 J	1.66	0.147	0.0249	18 J	1.8	0.246 J	0.0535	22 J
YKSM	5/15/2023	8:17	48.4	0.054	1.98	0.2	0.0405	12	2.24	0.347	0.0634	16
YKSM	6/12/2023	8:26	51.3	0.049	1.71	0.283	0.0445	4	1.9	0.45	0.0569	6
YKSM	7/17/2023	8:13	33.4	0.025	1.32	0.147	0.0182 J	8	1.27	0.233	0.0328	11
YKSM	8/21/2023	8:17	37.2	0.01 U	1	0.079	0.0136	4	1.21	0.119 J	0.0251	5
YKSM	9/11/2023	8:18	53.1	0.01 U	1.47	0.144	0.0278	1 J	1.48	0.238	0.0346	—
YKSM	10/16/2023	8:00	66.9 J	0.01 U	1.42	0.268	0.0348	2	1.49	0.36	0.0407	2
YKUG	4/3/2023	10:15	60.2	—	1.86	0.199	0.0314	7	2.09	—	0.0475	10
YKUG	4/24/2023	10:07	45.4	0.092 J	2.16	0.224	0.027	31 J	2.36	0.332 J	0.0695	37 J
YKUG	5/15/2023	10:04	37.4	0.053	1.83	0.183	0.0301	51	1.83	0.325	0.0904	58
YKUG	6/12/2023	10:33	46.1	0.022	1.38	0.199	0.0429	15	1.58	0.335	0.0602	18
YKUG	7/17/2023	10:14	40.9	0.036	1.28	0.181	0.0299 J	8	1.32	0.309	0.0427	11
YKUG	8/21/2023	10:46	43.1	0.01 U	1.17	0.115	0.0275	5	1.35	0.169 J	0.0395	6
YKUG	9/11/2023	10:00	47.2	0.012	1.18	0.14	0.0208	10 J	1.22	0.208	0.0352	—
YKUG	10/16/2023	9:48	67.8	0.018	1.26	0.377	0.0255	5	1.46	0.461	0.0416	6

Table B3. Summary of issues in the Laboratory Case Narratives.

Laboratory Work Order	Date Samples were Received at MEL	Issues
2206060	6/29/22–6/30/22 and 7/14/22(chlorophyll)	DOC samples NACM and YKUG and OP samples YKSM and YKET for OP were partially frozen and qualified as estimates. Chlorophyll-A samples YKSM, YKUG, YKET, YKEM, YKEU, YKPR, YKAC, CHAN, YKKO, and YKVG were analyzed out of hold time due to laboratory error and were qualified as estimates. The duplicate relative percent differences (RPDs) for TSS and TNVSS were greater than the acceptance limit. The source samples were from a different work order, and the RPDs were not evaluated.
2207069	7/13/22–7/14/22	None.
2208092	8/3/22–8/4/22	Chlorophyll samples YKET and YKPR were leaking acetone and were qualified as estimates.
2208076	8/10/22–8/11/22	Chlorophyll sample YKVG was leaking acetone and was qualified as an estimate.
2208077	8/24/22–8/26/22	Chlorophyll samples YKUG, YKET, YKEM, YKEU, YKPR, CHAN, YKKO, and YKVG were received over temperature and were qualified as estimates.
2209072	9/8/22–9/9/22	TNVSS and TSS sample YKPR reporting limit was raised due to laboratory error; sample was sourced from alkalinity bottle. Samples YKPR, YKAC, CHAN, and YKKO were analyzed by ALS Environmental for orthophosphate outside of holding time and were qualified as estimates.
2209073	9/21/22–9/22/22	Chlorophyll samples YKUG and CHAN were leaking and were qualified as estimates.
2210034	10/5/22–10/6/22	Duplicate RPDs were not within the acceptance limits for TNVSS. TNVSS and TSS samples YKPR, YKAC, CHAN, and YKKO were overfull, could not be homogenized, and were qualified as a result. Sample CHAN for TSS contained fast settling solids, and results were qualified as an estimate.
2210035	10/19/22–10/21/22, 10/25/22	The replicate differences were not within the acceptance limit for TSS. Sample YKVG for TNVSS was analyzed using an improper filter due to vendor error and was qualified as an estimate. All alkalinity samples were analyzed by OnSite outside of hold time and were qualified as estimates.
2210039	10/26/22–10/27/22	TSS and TNVSS for all samples except CHAN were analyzed outside of hold time due to laboratory error and were qualified as estimates.
2211025	11/8/22, 11/10/22, and 11/14/22	Sample YKEM was received with ice in its container and was qualified as an estimate. Orthophosphate samples YKPR, YKAC, CHAN, YKKO, and YKVG were received and analyzed out of hold time due to a shipping issue and were qualified as estimates.
2304049	4/4/23	None.

Laboratory Work Order	Date Samples were Received at MEL	Issues
2304050	4/25/23	All samples for ammonia and TPN were analyzed out of hold time, and the result qualified as an estimate. Sample YKSM, NACM, and YKEU for TSS and TNVSS contained fast settling solids; the result was qualified as an estimate.
2305038	5/16/23	Samples NACM and YKET for TSS/TNVSS contained fast settling solids; the results were qualified as estimates.
2306027	6/13/23	Sample YKPR for NO3/NO2 was analyzed out of hold time; the result was qualified as an estimate.
2307050	7/18/23 and 7/19/23	Samples YKSM and YKUG for OP were received and analyzed out of hold time, and the results were qualified as estimates.
2308057	8/22/23	All samples for TPN were analyzed out of hold time due to laboratory error, the results were qualified as estimates.
2309050	9/12/23 and 9/13/23	None.
2310028	10/17/23	Samples YKSM and NACM for alkalinity were analyzed out of hold time due to laboratory error, the results were qualified as estimates.

Note. Example: 1903029-23; 1903029 is the laboratory work order number, and -23 is the specific sample. Together, these make up the sample ID. In some cases, results were reported to the method detection limit (MDL) instead of the reporting limit (RL). Results greater than the MDL but below the reporting limit (RL) were qualified as estimates, indicated with a "J."

None = Samples were received within hold times and at proper temperatures. No other issues were noted.

MEL = Manchester Environmental Laboratory

Alk = Alkalinity

NH3 = Ammonia

NO3/NO2 = Nitrate/Nitrite

NO3 = Nitrate

OP = Ortho-Phosphate

TPN = Total Persulfate Nitrogen

TSS/TNVSS= Total Suspended Solids/Total Non-Volatile Suspended Solids

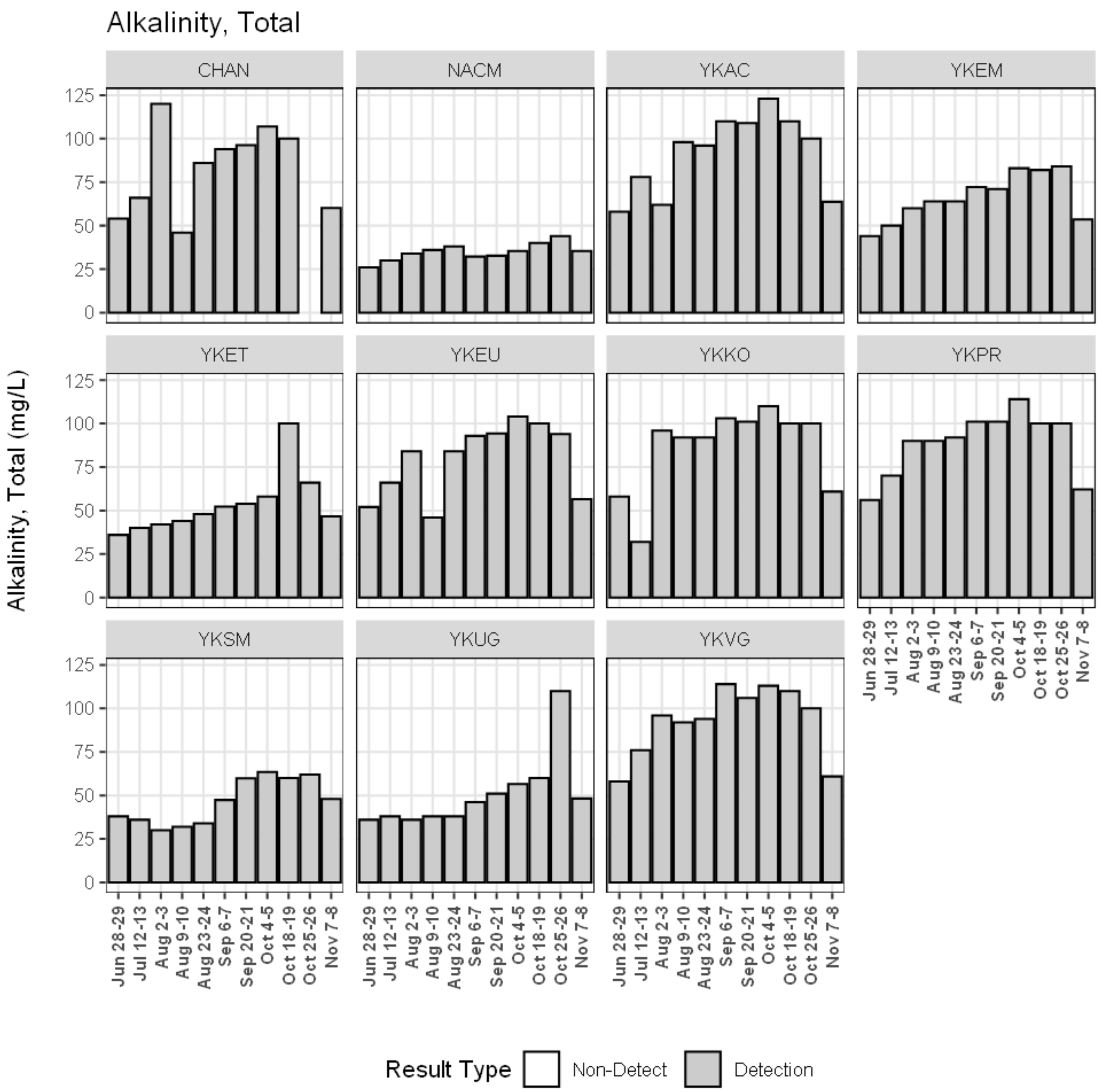

Figure B1. Laboratory results by sample site for total alkalinity in mg/L of 2022 water samples.

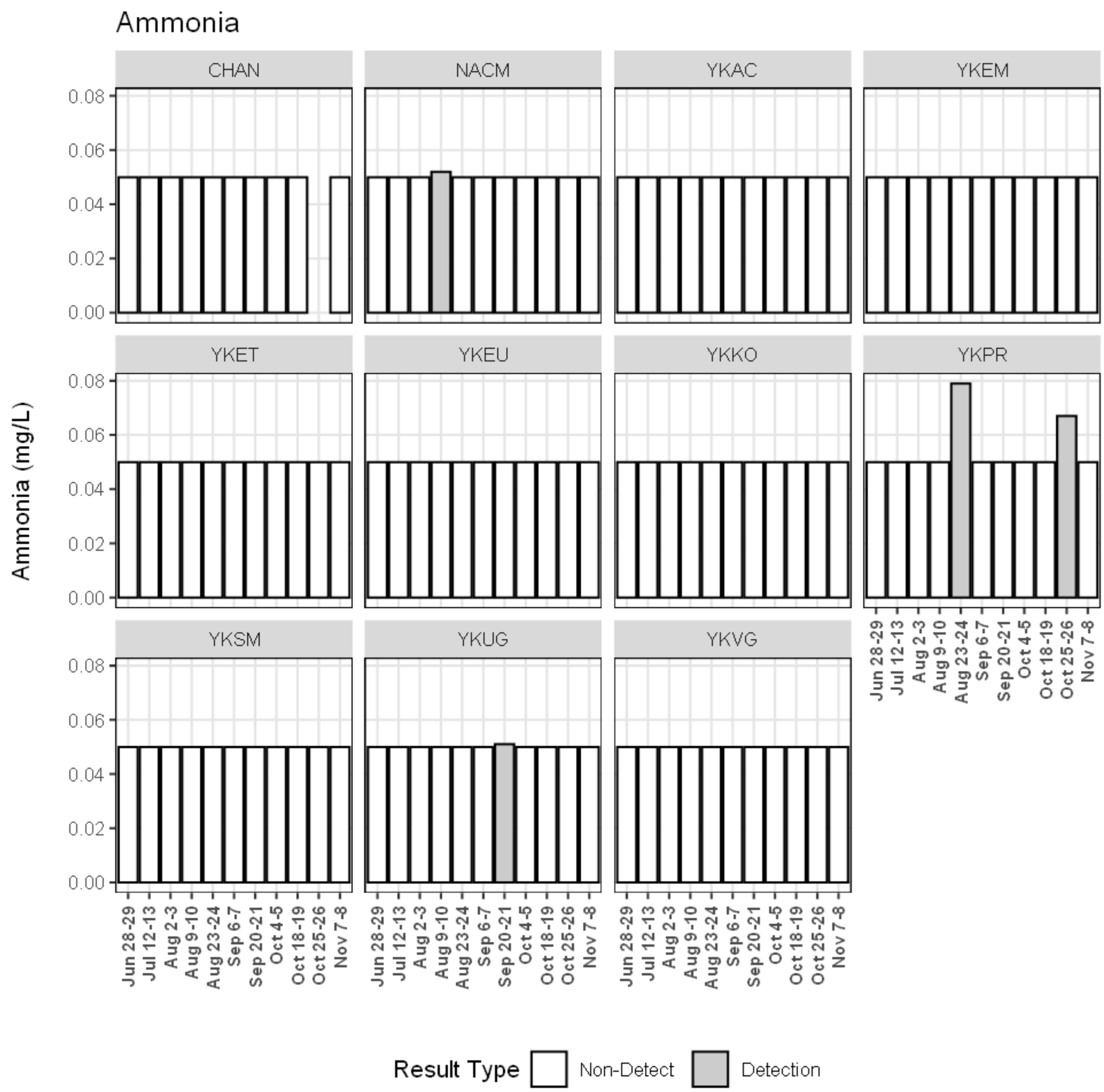

Figure B2. Laboratory results by sample site for ammonia in mg/L of 2022 water samples.

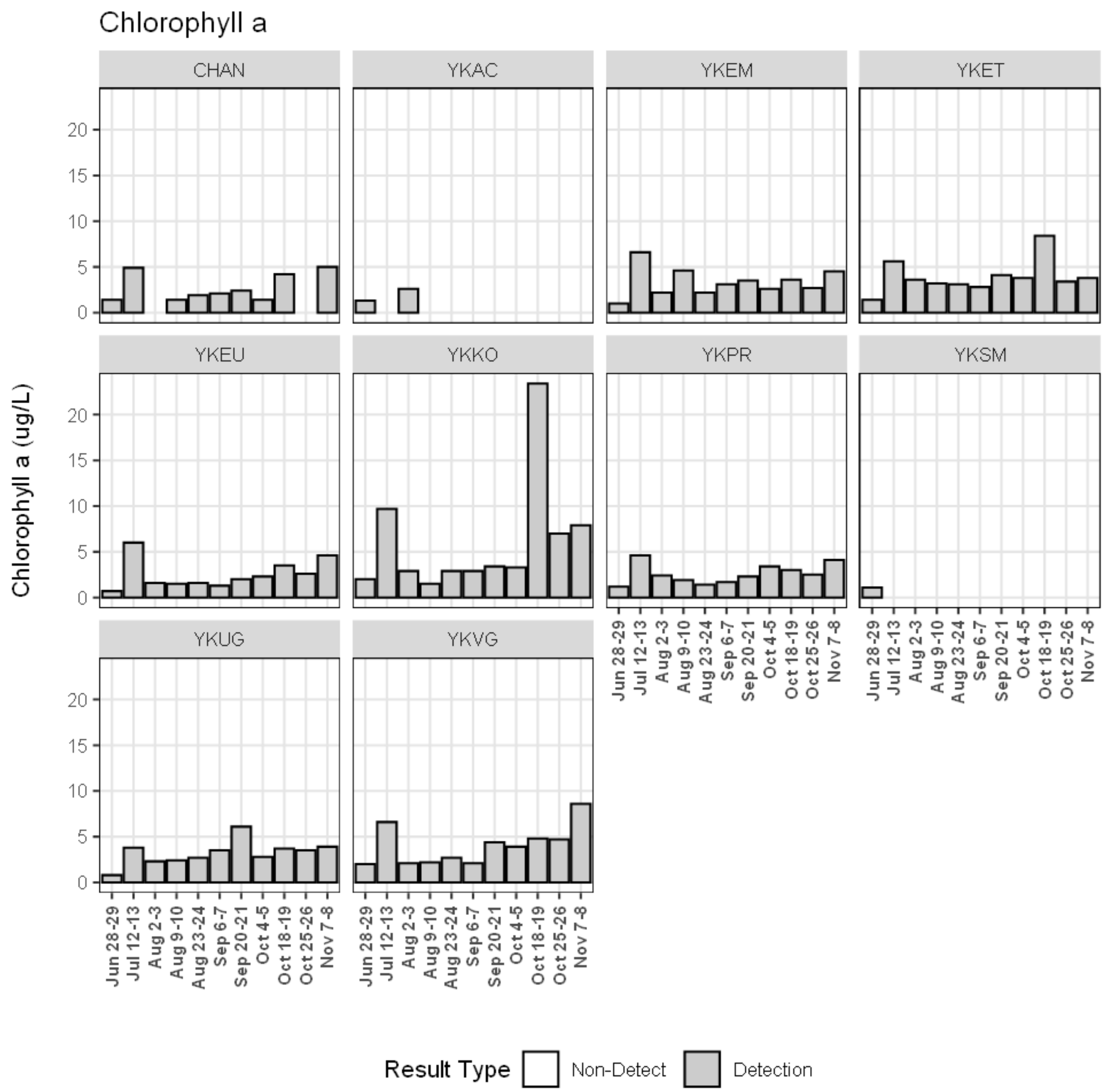

Figure B3. Laboratory results by sample site for chlorophyll A in µg/L of 2022 water samples.

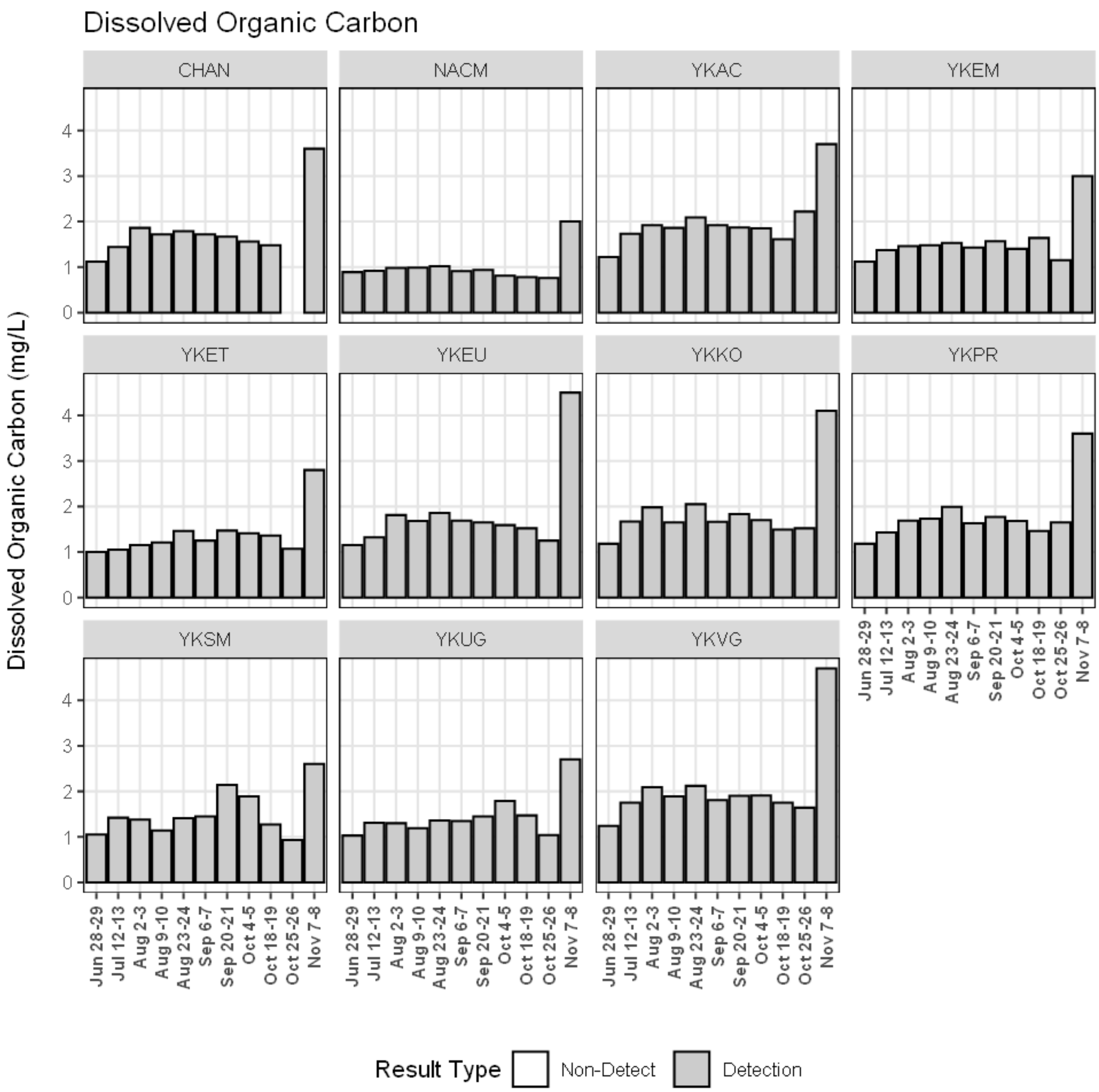

Figure B4. Laboratory results by sample site for dissolved organic carbon in mg/L of 2022 water samples.

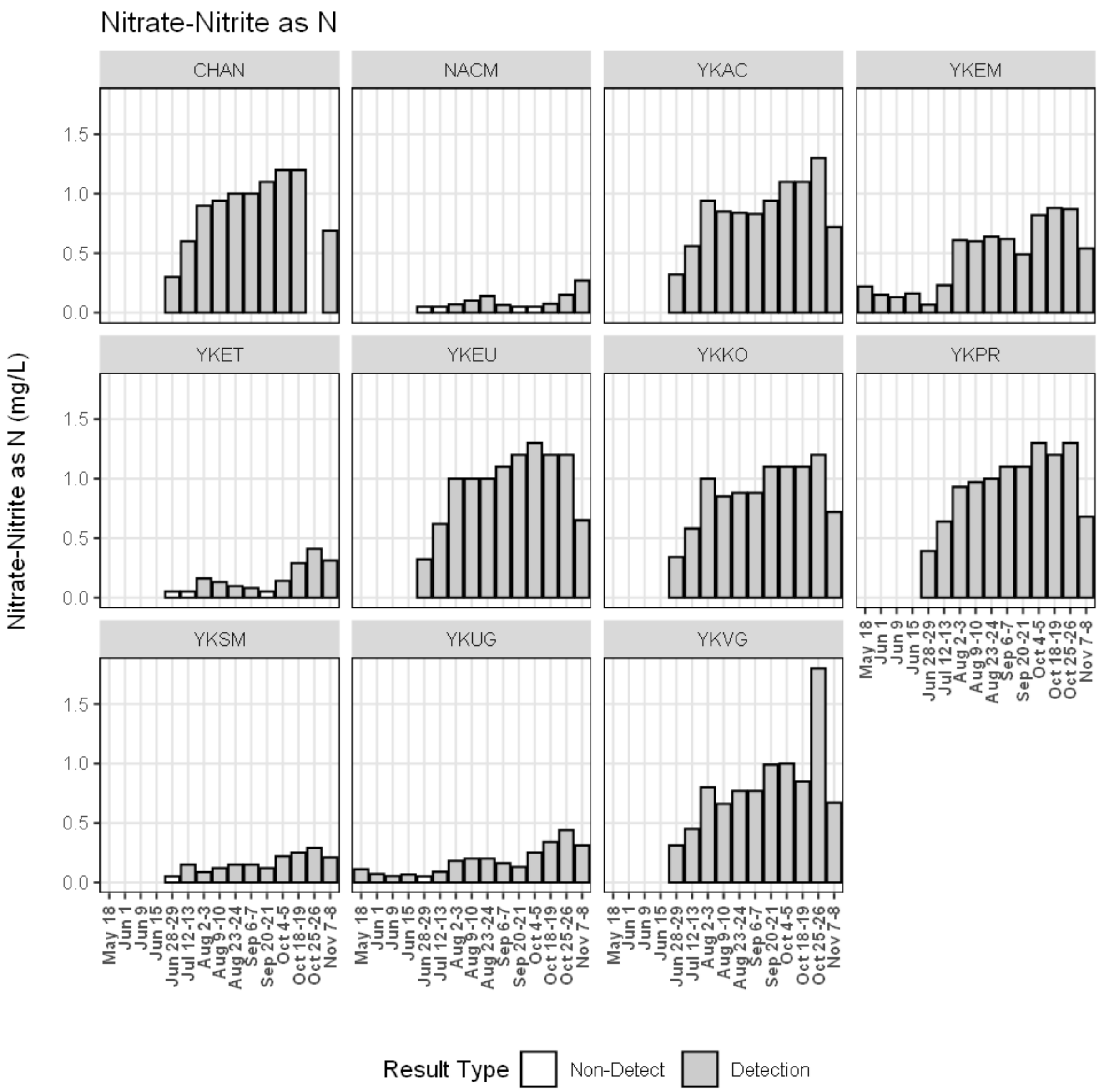

Figure B5. Laboratory results by sample site for nitrate-nitrite as N in mg/L of 2022 water samples.

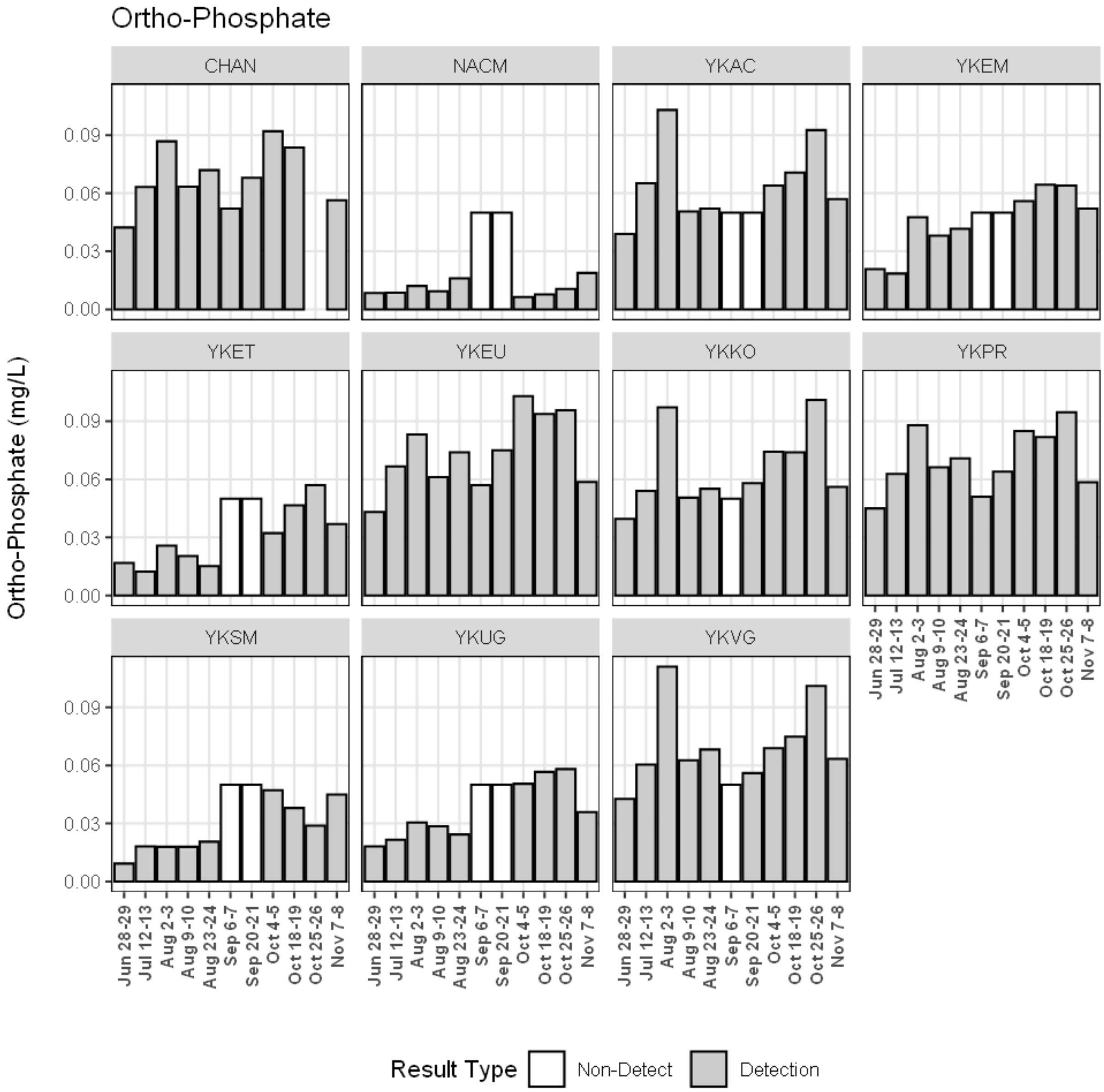

Figure B6. Laboratory results by sample site for ortho-phosphate in mg/L of 2022 water samples.

For the September 6–7 and September 20–21 samplings, a different laboratory (ALS – see table B1) was used for conducting orthophosphate analyses. ALS had a reporting limit of 0.05 mg/L for their methodology, which resulted in several "non-detects" at some stations during those sample events.

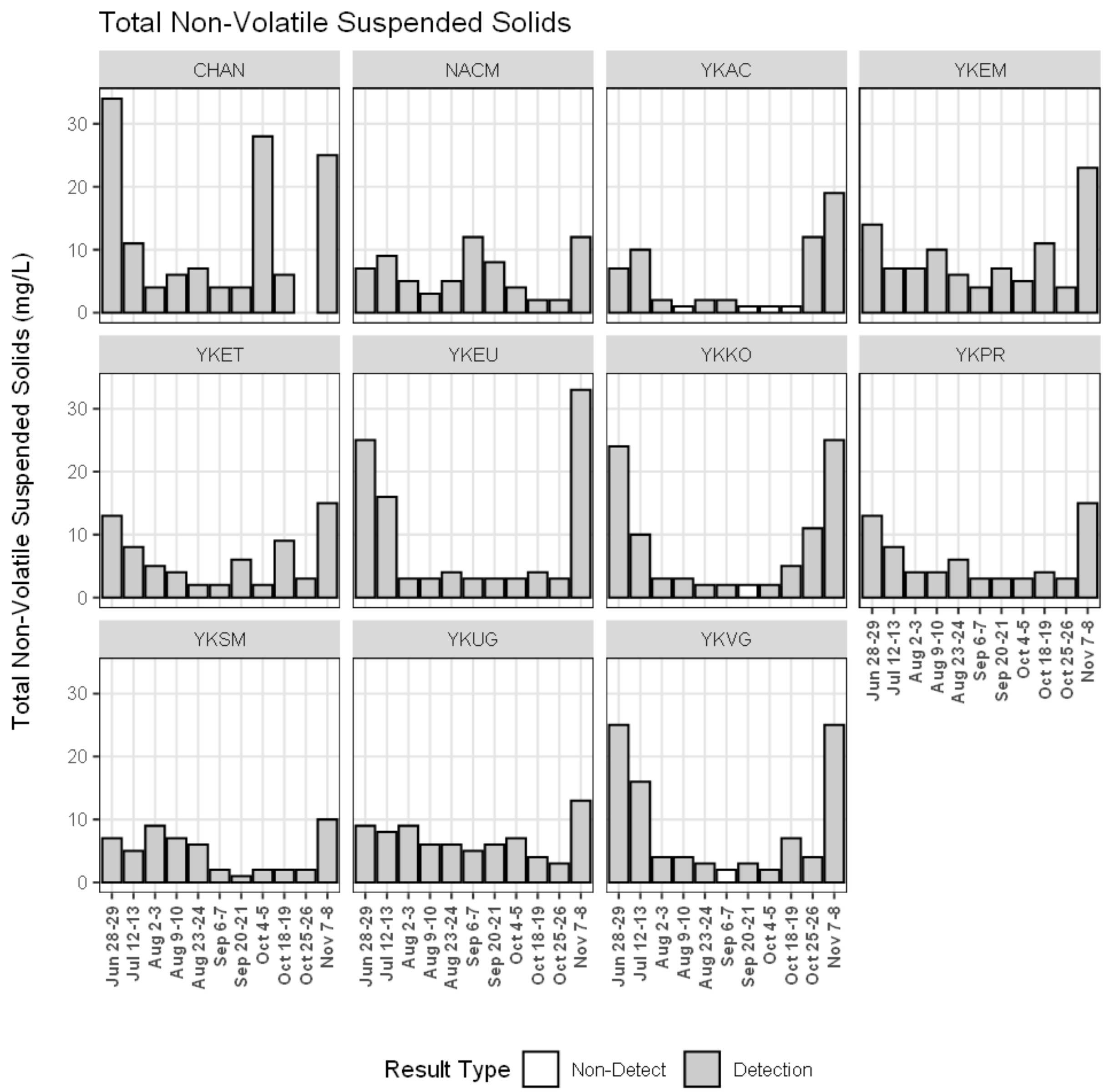

Figure B7. Laboratory results by sample site for total non-volatile suspended solids in mg/L of 2022 water samples.

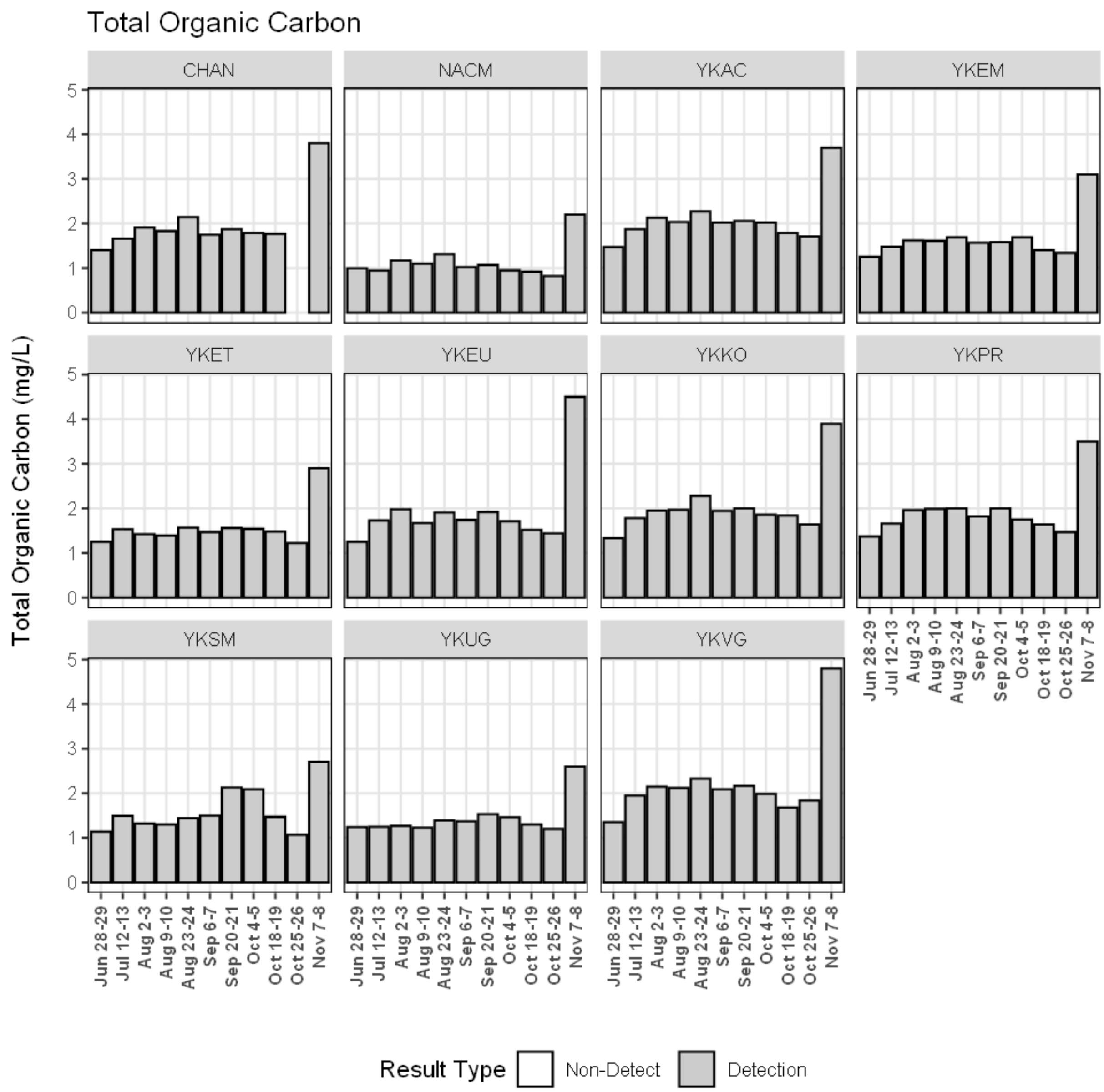

Figure B8. Laboratory results by sample site for total organic carbon in mg/L of 2022 water samples.

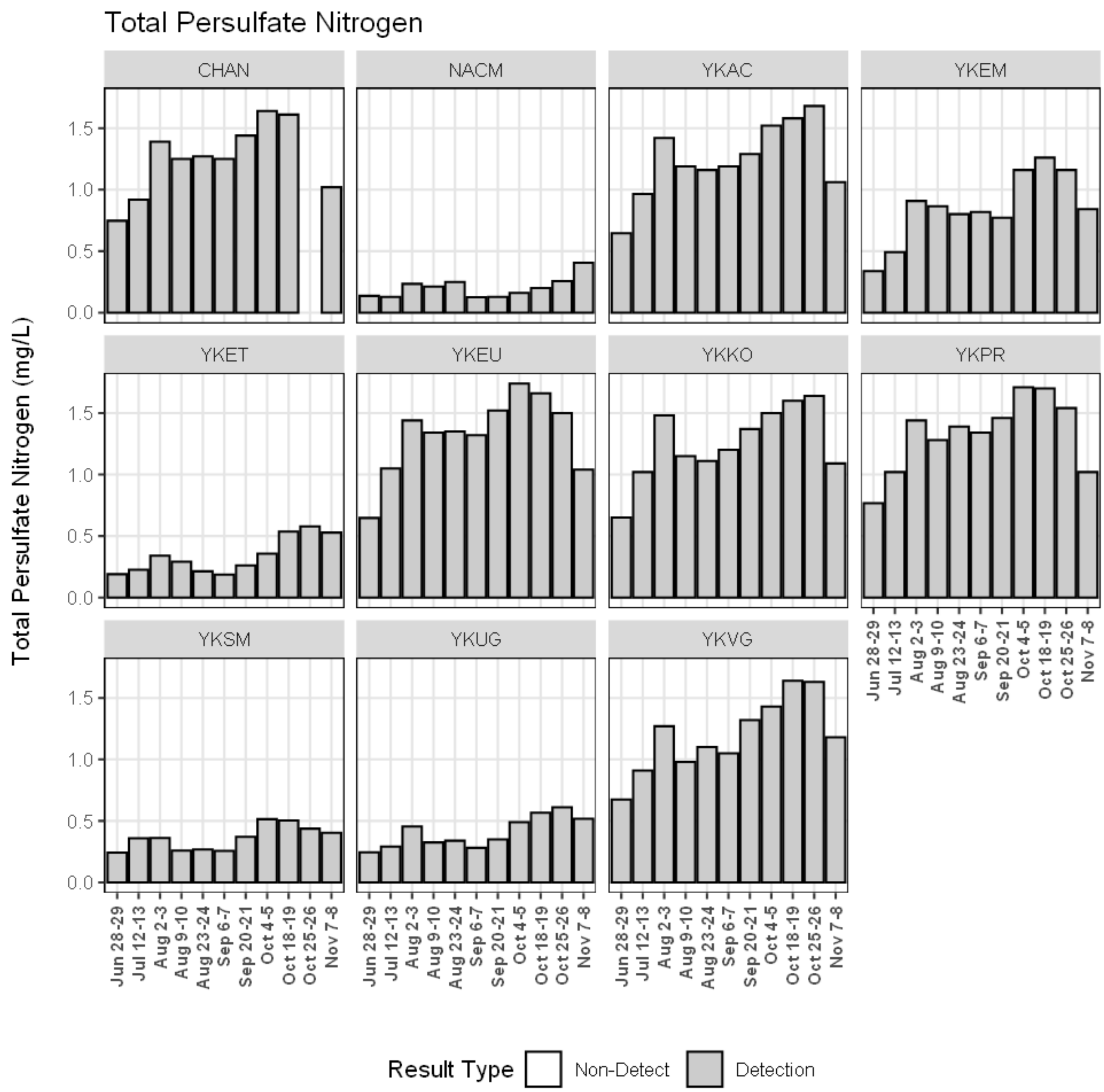

Figure B9. Laboratory results by sample site for total persulfate nitrogen in mg/L of 2022 water samples.

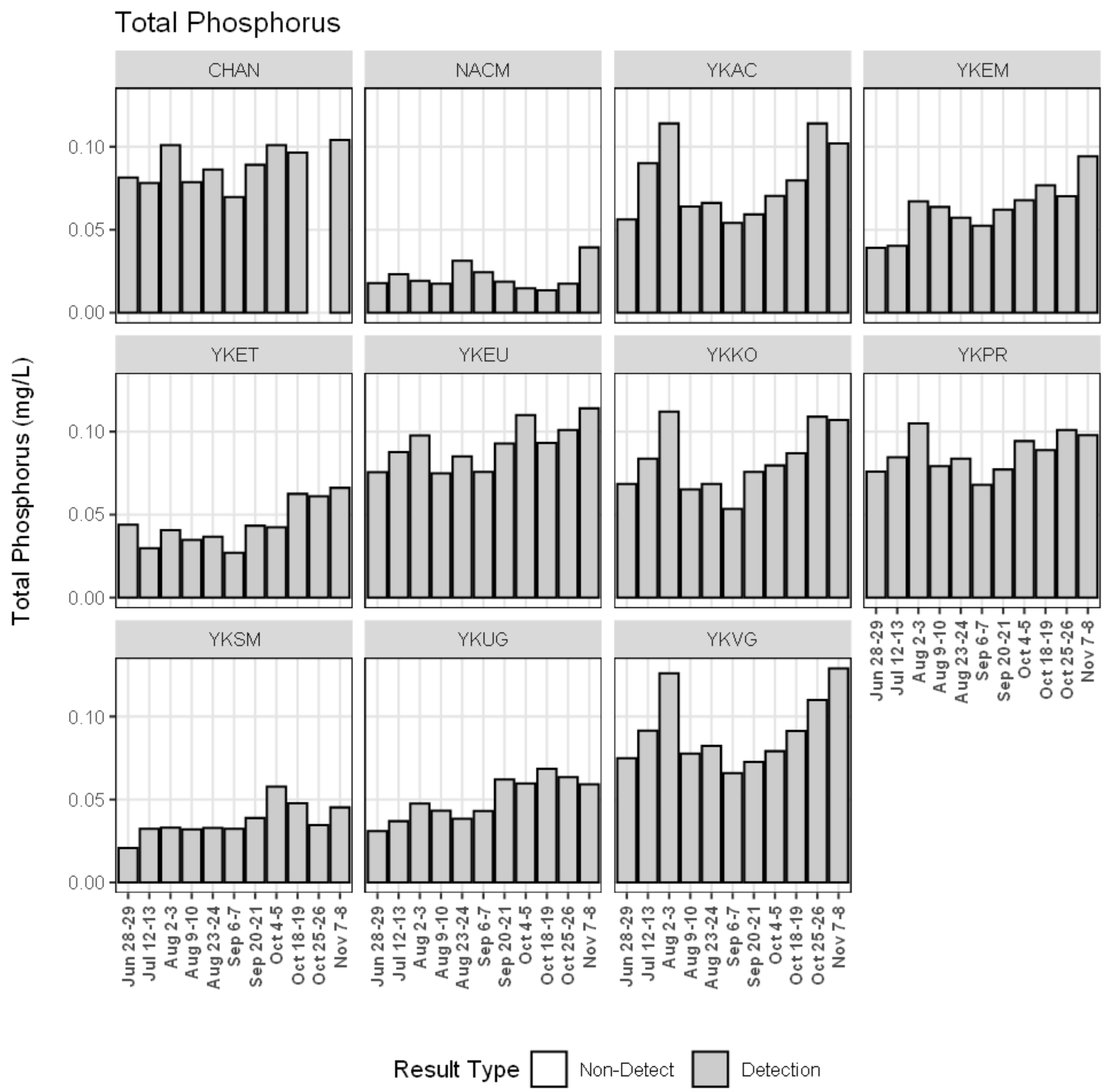

Figure B10. Laboratory results by sample site for total phosphorus in mg/L of 2022 water samples.

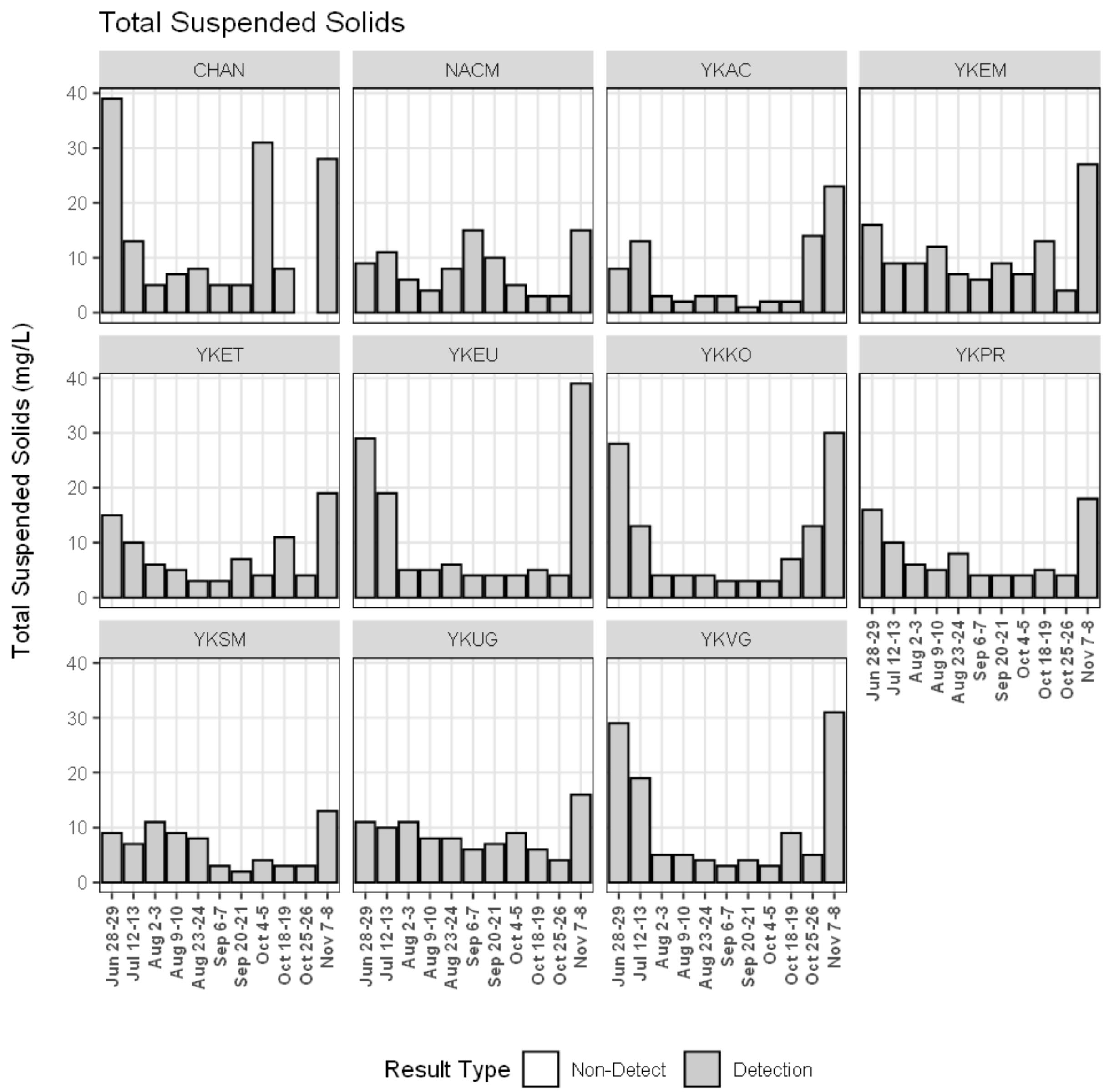

Figure B11. Laboratory results by sample site for total suspended solids in mg/L of 2022 water samples.

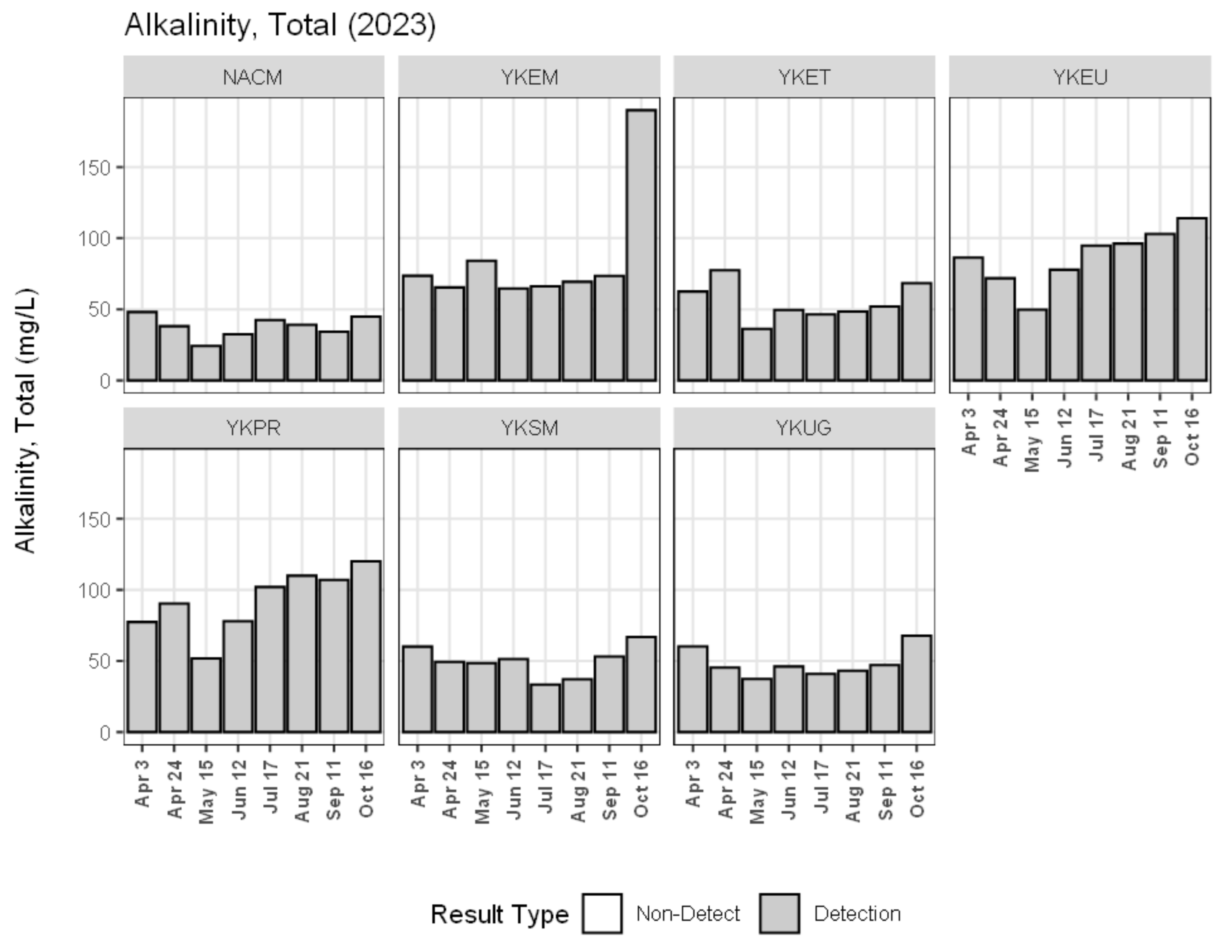

Figure B12. Laboratory results by sample site for total alkalinity in mg/L of 2023 water samples.

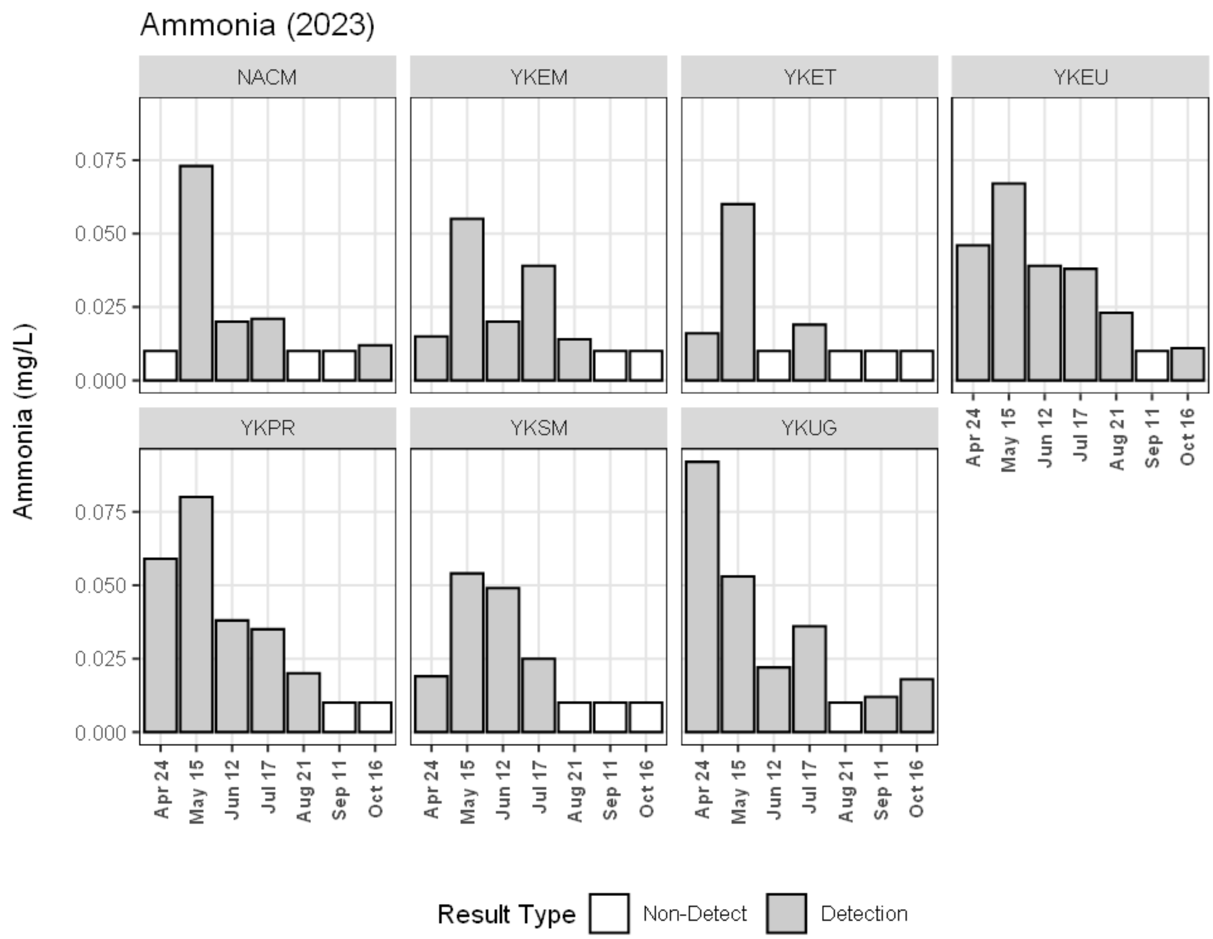

Figure B13. Laboratory results by sample site for ammonia in mg/L of 2023 water samples.

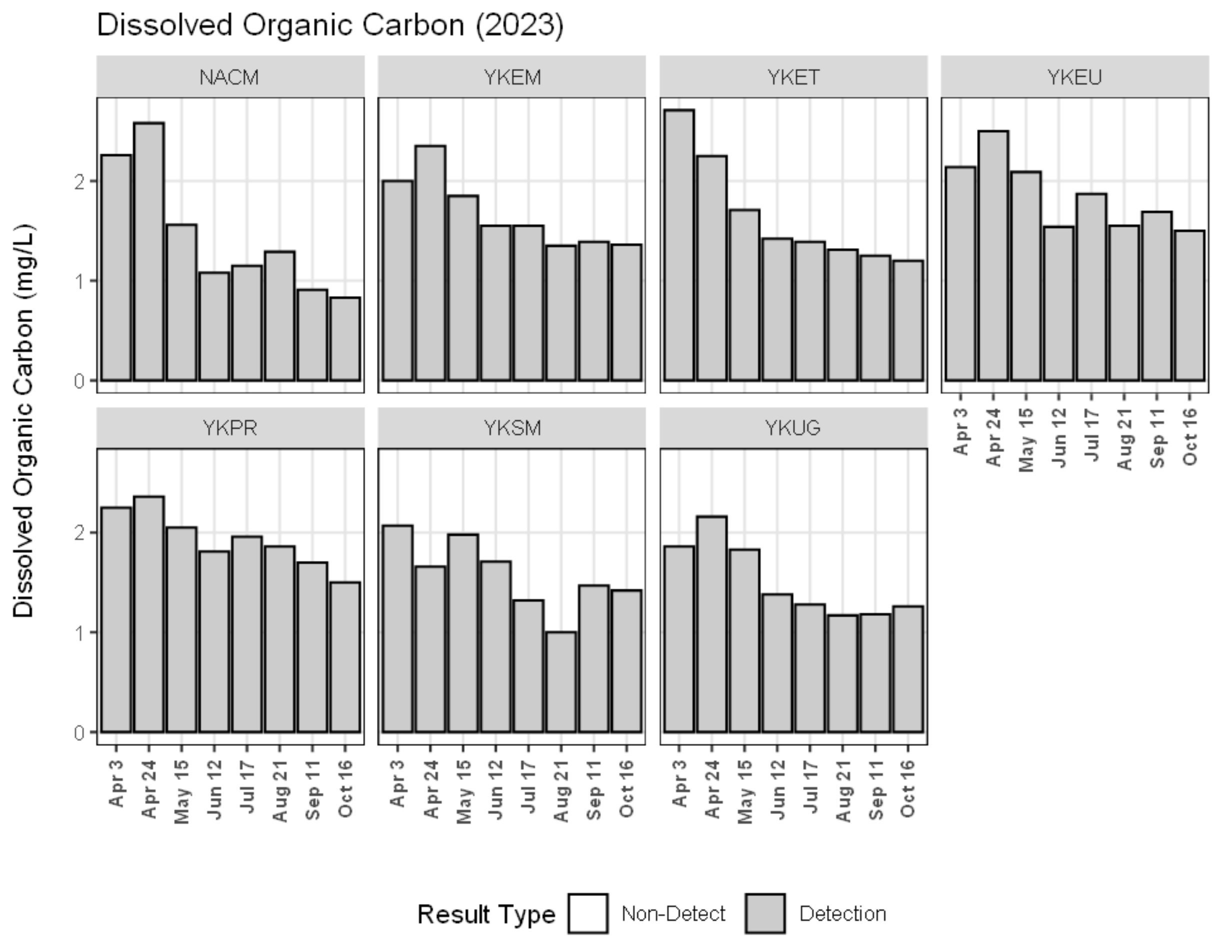

Figure B14. Laboratory results by sample site for dissolved organic carbon in mg/L of 2023 water samples.

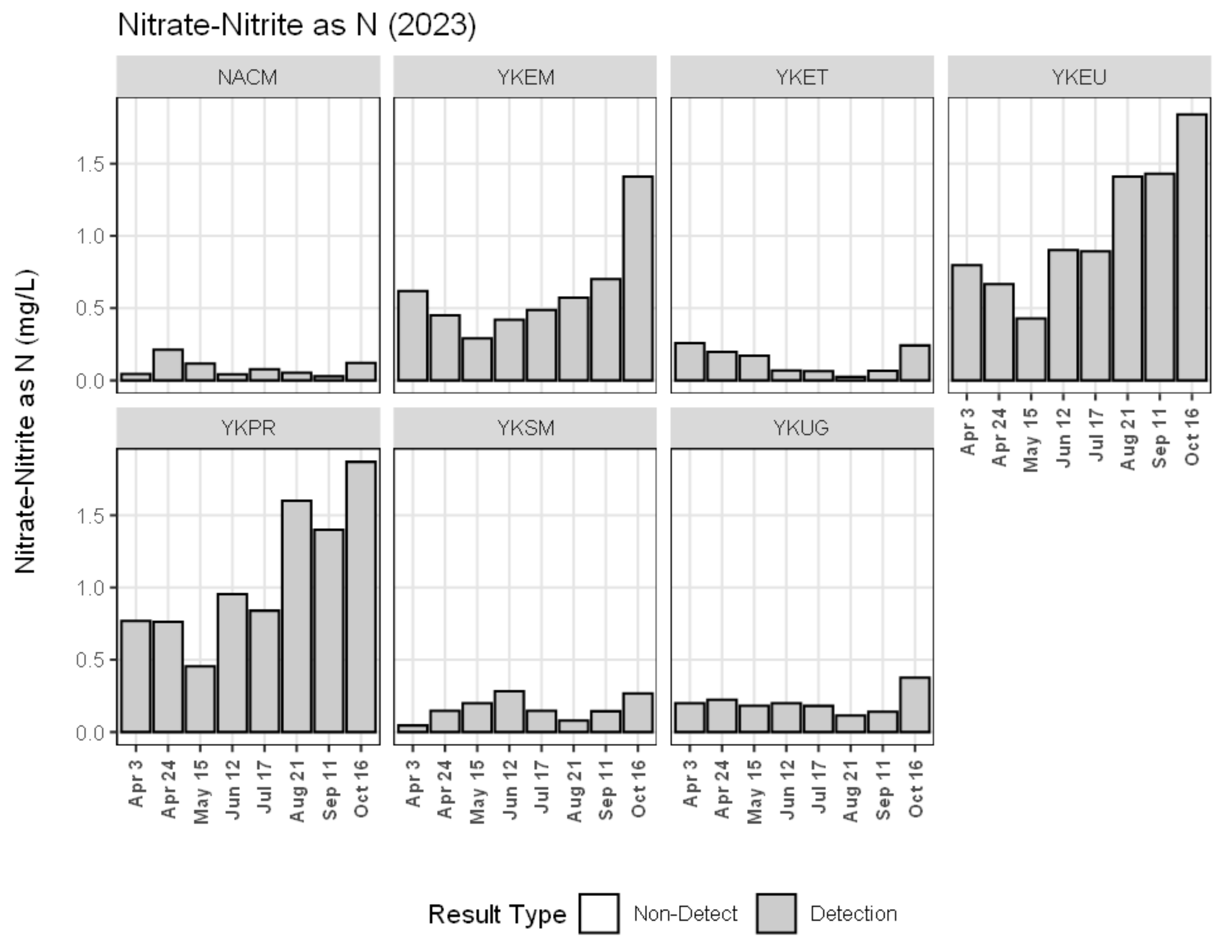

Figure B15. Laboratory results by sample site for nitrate-nitrite as N in mg/L of 2023 water samples.

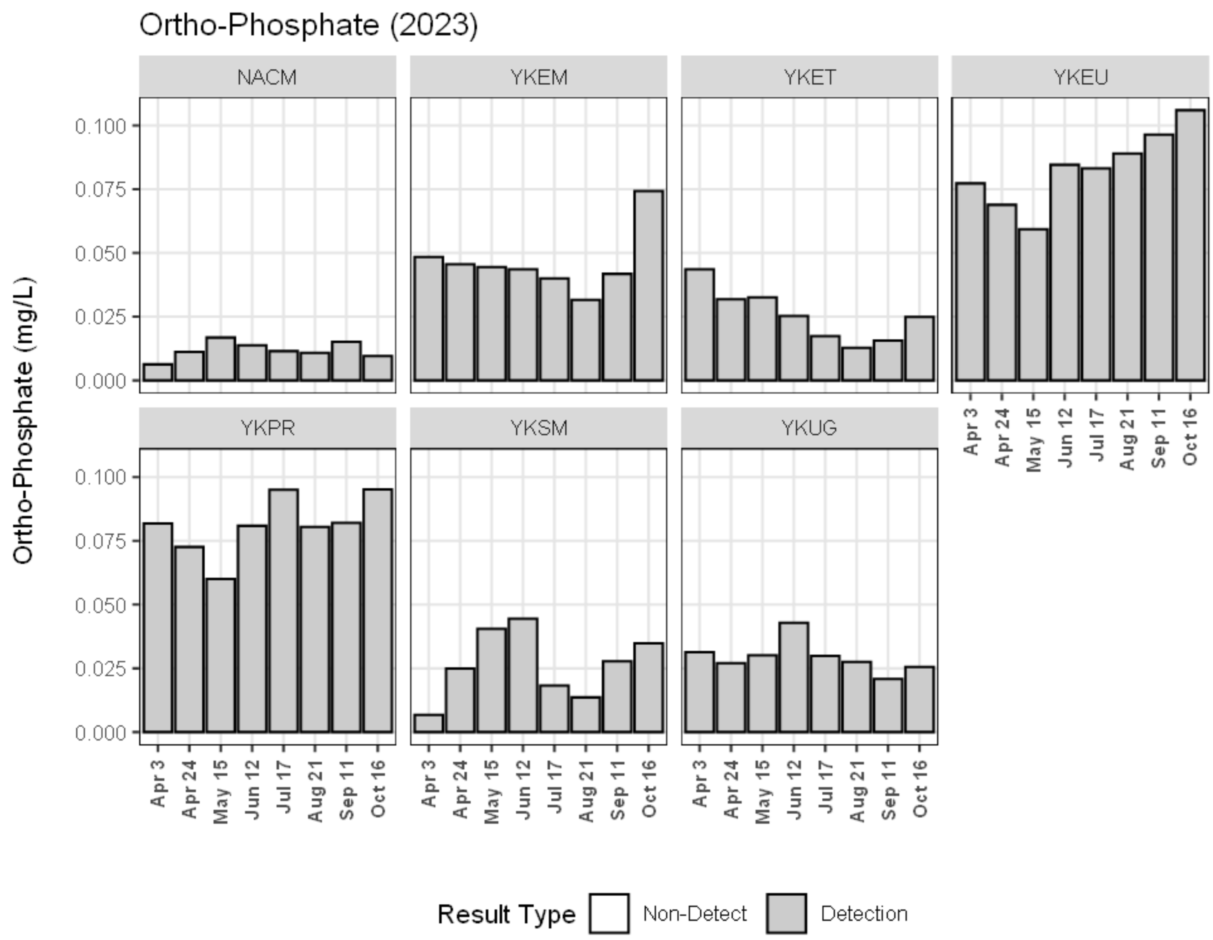

Figure B16. Laboratory results by sample site for ortho-phosphate in mg/L of 2023 water samples.

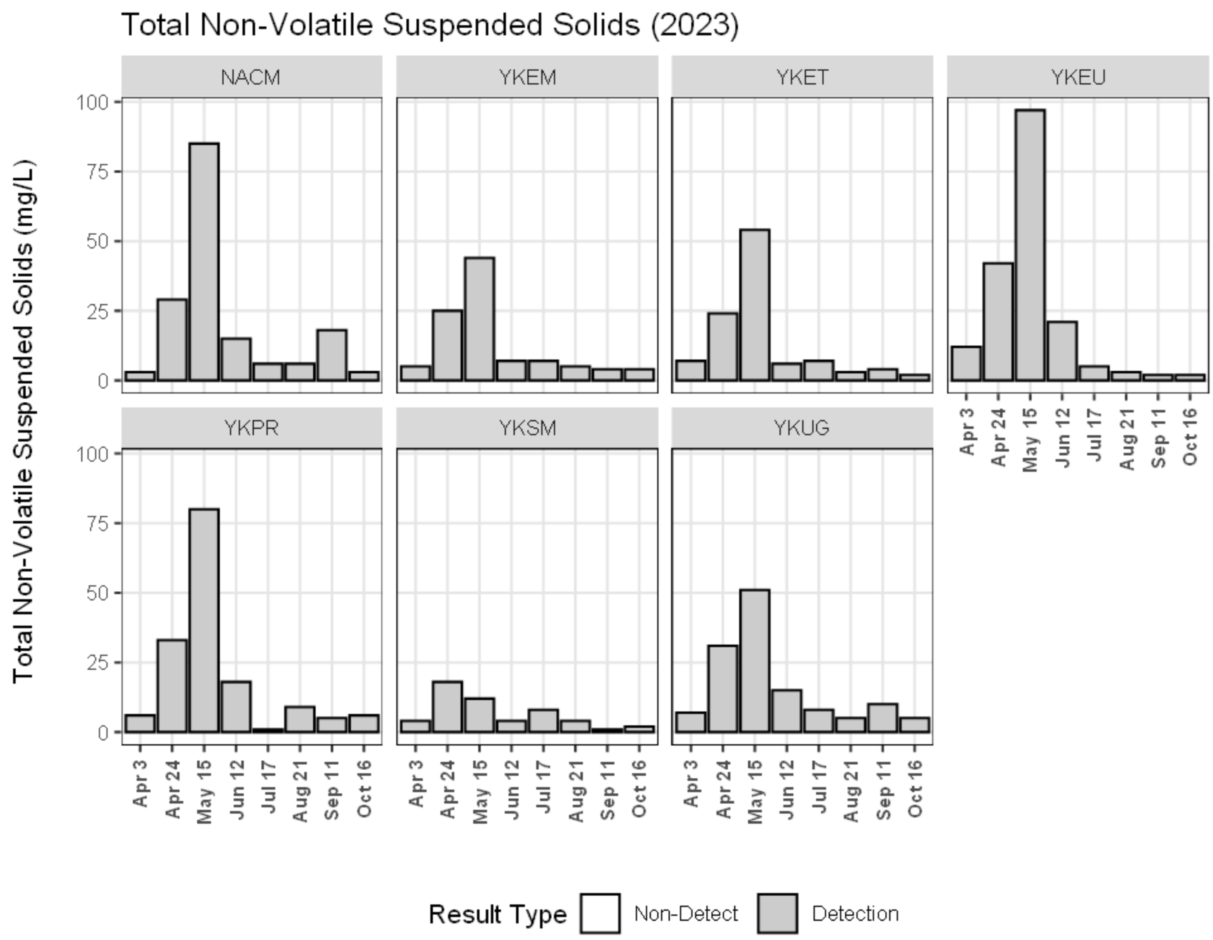

Figure B17. Laboratory results by sample site for total non-volatile suspended solids in mg/L of 2023 water samples.

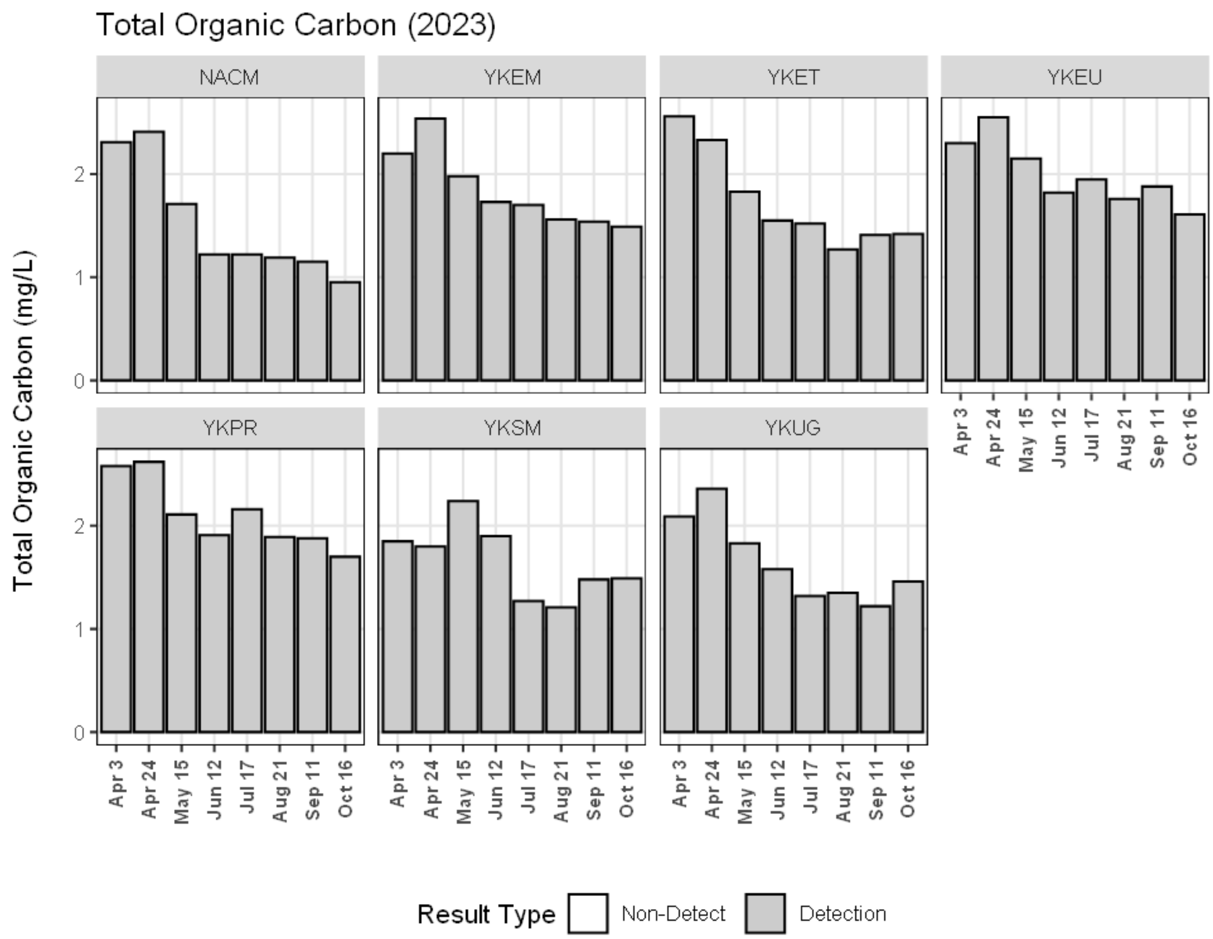

Figure B18. Laboratory results by sample site for total organic carbon in mg/L of 2023 water samples.

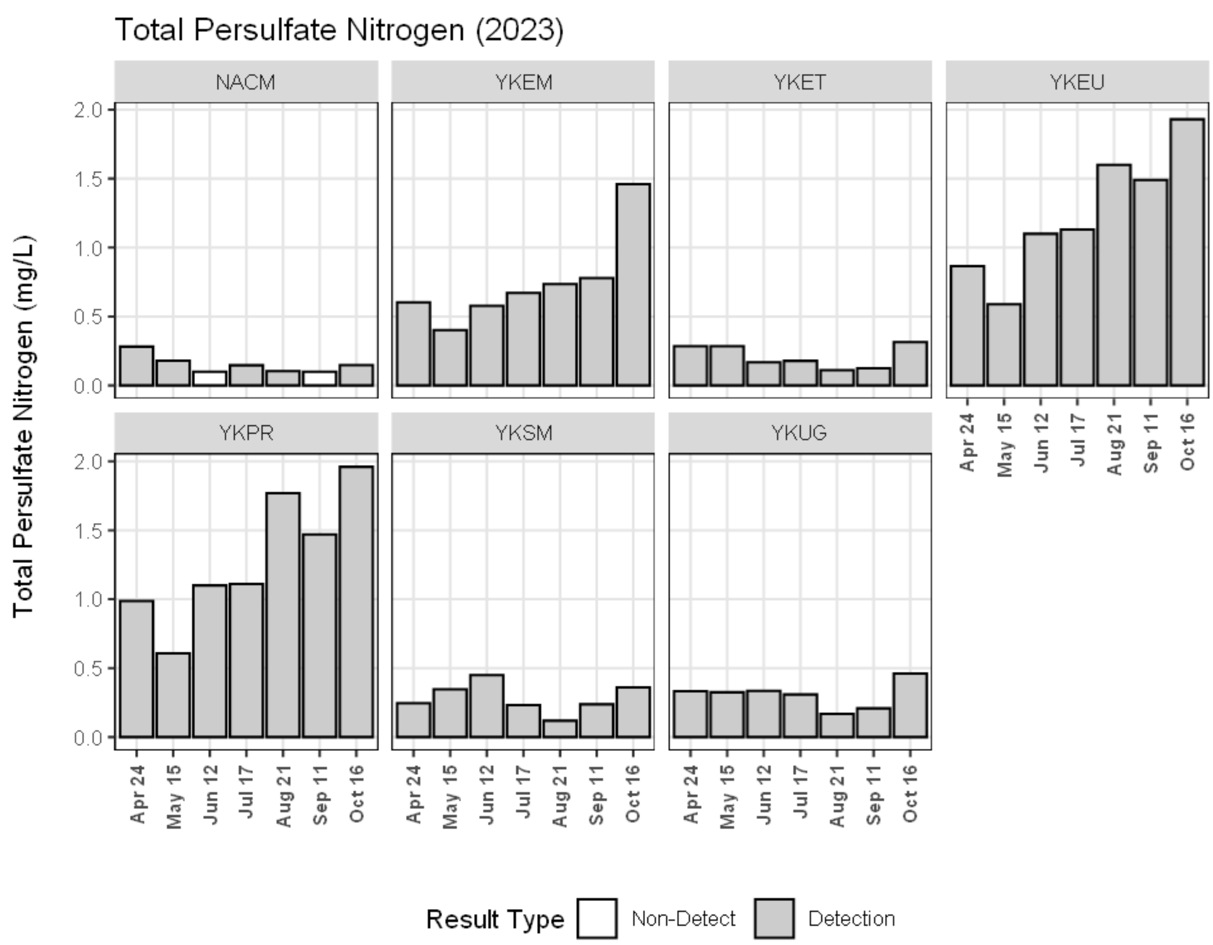

Figure B19. Laboratory results by sample site for total persulfate nitrogen in mg/L of 2023 water samples.

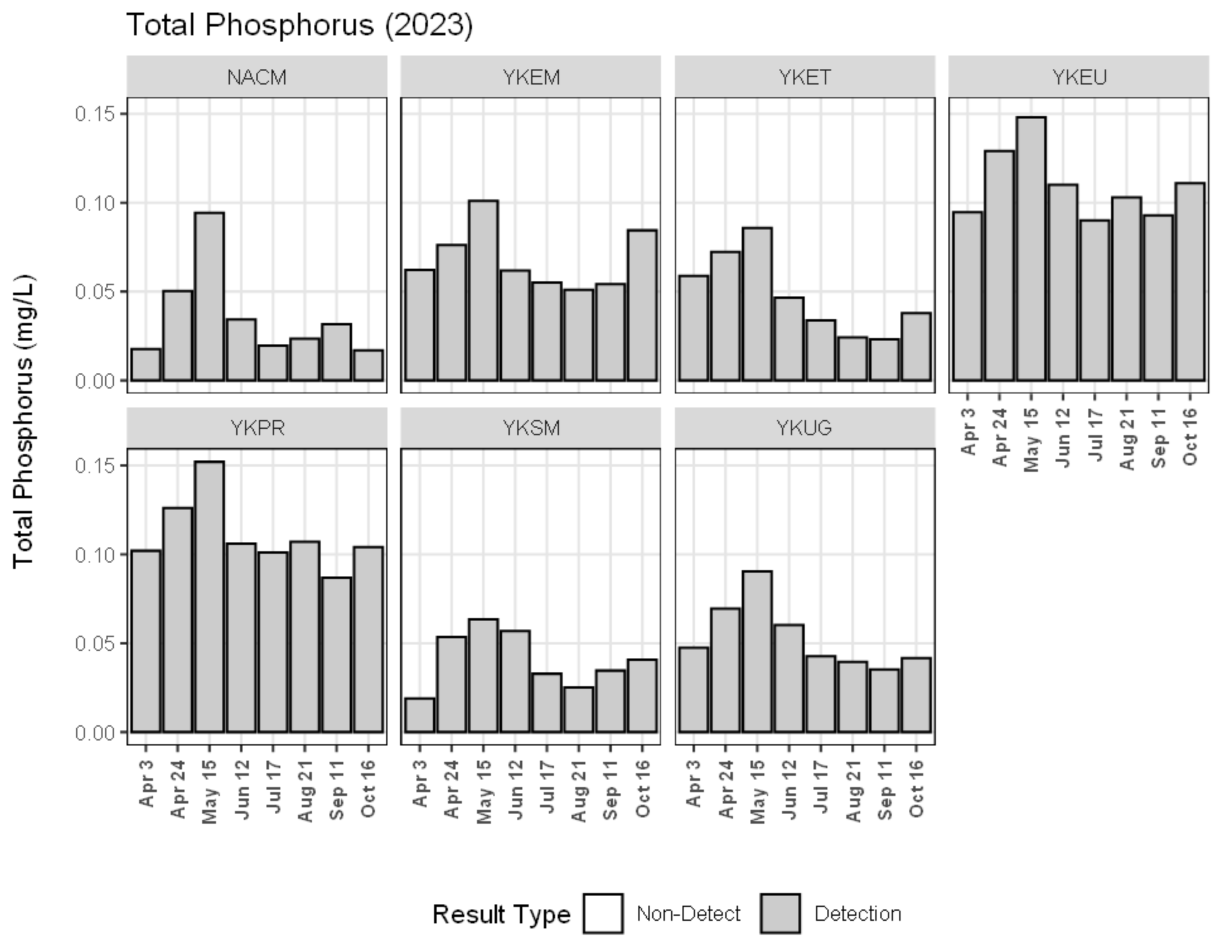

Figure B20. Laboratory results by sample site for total phosphorus in mg/L of 2023 water samples.

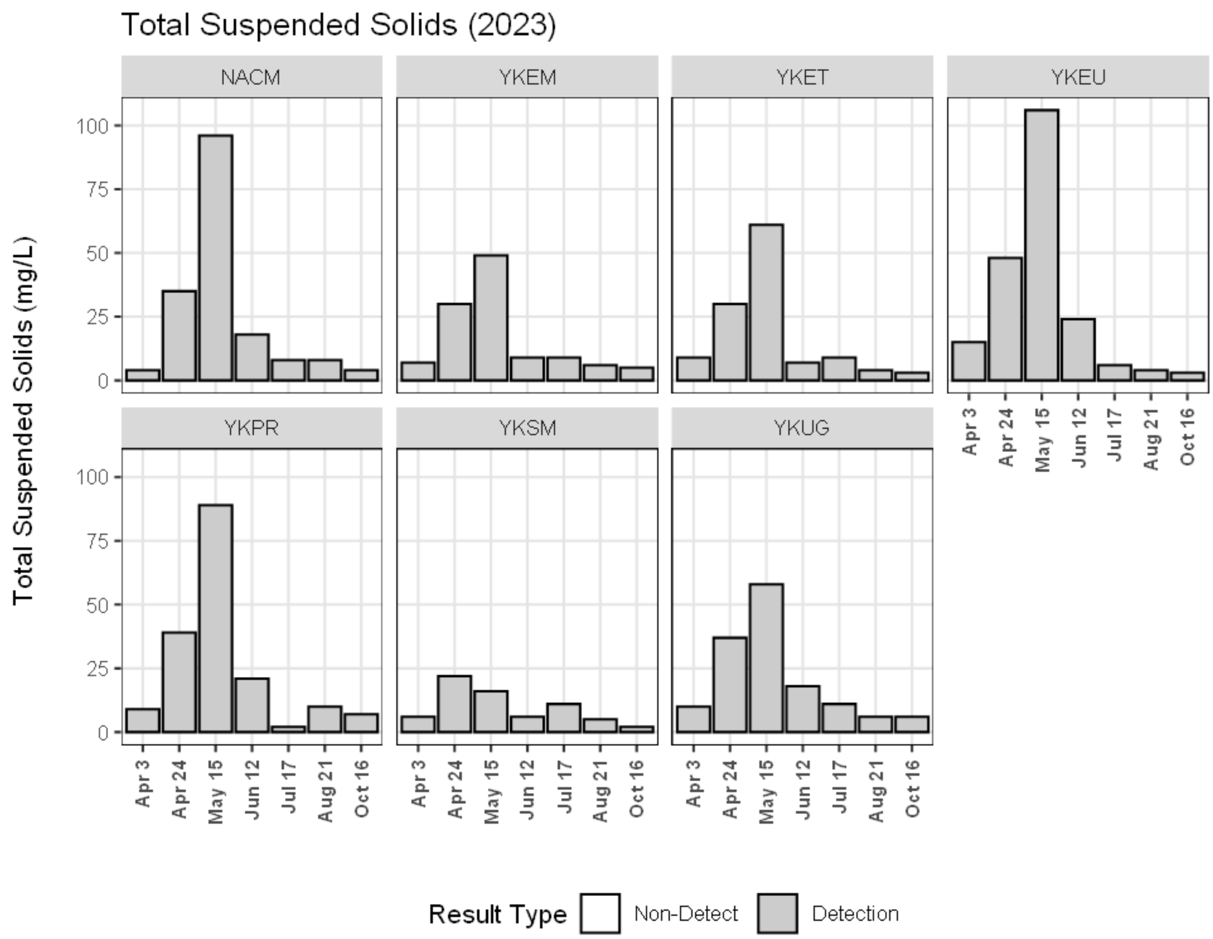

Figure B21. Laboratory results by sample site for total suspended solids in mg/L of 2023 water samples.

Table B5. Location, date, and time of dissolved oxygen sample collection and dissolved oxygen Winkler titration results.

Study Location ID	Date Collected	Time Collected (local)	Dissolved Oxygen (mg/L)
YKSM	6/28/2022	9:32	10.20
YKEU	6/28/2022	15:45	8.99
YKVG	6/29/2022	9:00	8.79
YKPR	6/29/2022	13:00	8.69
YKSM	7/12/2022	7:40	8.82
YKEU	7/12/2022	13:10	9.95
YKPR	7/13/2022	8:00	7.79
YKAC	7/13/2022	12:05	10.56
YKEU	8/2/2022	13:30	9.59
YKPR	8/3/2022	7:33	7.63
YKAC	8/3/2022	11:05	11.03
YKSM	8/9/2022	7:20	8.94
YKEU	8/9/2022	13:05	9.14
YKPR	8/10/2022	8:00	7.09
YKAC	8/10/2022	12:15	11.92
YKAC	8/10/2022	13:15	12.84
YKSM	8/23/2022	7:20	8.66
YKEU	8/23/2022	12:10	8.56
YKPR	8/24/2022	7:30	6.80
YKVG	8/24/2022	11:40	9.38
YKSM	9/6/2022	7:45	8.66
YKEU	9/6/2022	12:45	9.79
YKPR	9/7/2022	8:15	7.53
YKVG	9/7/2022	11:55	10.21
YKSM	9/20/2022	8:07	8.76
YKEU	9/20/2022	13:05	10.52
YKPR	9/21/2022	8:45	8.97
YKVG	9/21/2022	12:45	11.13
YKSM	10/4/2022	8:20	8.67
YKEU	10/4/2022	13:15	11.02
YKPR	10/5/2022	9:15	9.08
CHAN	10/5/2022	13:45	10.31
YKSM	10/18/2022	8:21	9.49
YKEU	10/18/2022	13:45	10.71
YKPR	10/19/2022	9:00	9.39
YKVG	10/19/2022	12:45	10.91
YKSM	10/25/2022	8:58	10.30

Study Location ID	Date Collected	Time Collected (local)	Dissolved Oxygen (mg/L)
YKEU	10/25/2022	14:35	10.91
YKPR	10/26/2022	8:35	9.80
YKVG	10/26/2022	12:00	11.52
YKSM	11/7/2022	8:50	11.58
YKEU	11/7/2022	13:45	10.27
YKPR	11/8/2022	9:00	10.17
YKVG	11/8/2022	12:30	10.67
YKSM	4/3/2023	8:10	11.36
YKEM	4/3/2023	14:37	11.16
YKSM	4/24/2023	8:17	10.75
YKEM	4/24/2023	14:13	10.25
YKSM	5/15/2023	8:17	9.54
YKSM	6/12/2023	8:26	9.19
YKPR	6/12/2023	14:17	8.69
YKSM	7/17/2023	8:13	9.05
YKPR	7/17/2023	14:47	13.87
YKSM	8/21/2023	8:17	8.89
YKEM	8/21/2023	15:37	8.99
YKSM	9/11/2023	8:18	8.44
YKEM	9/11/2023	14:40	8.94
YKSM	10/16/2023	8:00	8.98
YKPR	10/16/2023	14:15	9.80

Appendix C. Field Measurements — Discrete

Table C1. Discrete surface water sonde and turbidity measurements from 2022 and 2023.

Study Location ID	Date/Time (local)	Temp (C)	Conductivity (uS/cm)	pH (units)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
CHAN	6/29/22 11:00	19.2	132	7.6	8.7 J	12.6
CHAN	7/13/22 11:10	23.4	166	8.0	8.5	4.0
CHAN	8/3/22 10:33	25.4	223	8.1	8.7	2.9
CHAN	8/10/22 12:40	24.1	220	8.0	8.9	2.4
CHAN	8/24/22 9:50	24.3	219	8.2 J	8.1	3.6
CHAN	9/7/22 10:13	21.3	233	8.2	9.2	3.2
CHAN	9/21/22 11:10	17.2	234	8.1	9.6	2.5
CHAN	10/5/22 13:45	18.3	262	8.3	10.4	2.1
CHAN	10/19/22 10:43	14.3	248	8.0	9.7	4.1
CHAN	11/8/22 10:55	6.5	140	7.1	10.5	21.1
NACM	6/28/22 10:45	13.9	55	7.5	10.4 J	6.9
NACM	7/12/22 8:35	13.5	65	7.4	9.8	12.3
NACM	8/2/22 8:50	18.1	81	7.7	9.0	2.8
NACM	8/9/22 8:28	19.1	83	7.6	8.6	2.8
NACM	8/23/22 8:23	18.0	85	8.1 J	9.1	5.0
NACM	9/6/22 8:55	18.3	72	7.6	10.0	8.6
NACM	9/20/22 9:18	14.3	74	7.6	9.9	6.6
NACM	10/4/22 9:40	14.4	80	7.7	9.8	4.2
NACM	10/18/22 9:35	11.8	90	7.7	10.3	2.6
NACM	10/25/22 10:45	8.3	104	8.0	12.1 J	2.4
NACM	11/7/22 10:10	5.1	77	7.3	11.4	18.2
YKAC	6/29/22 11:30	20.4	140	8.3	10.8 J	5.9
YKAC	7/13/22 12:05	24.5	189	8.5	10.3	5.4
YKAC	8/3/22 11:05	25.2	254	8.5	10.7	2.2
YKAC	8/10/22 12:15	24.9	238	8.8	12.5	
YKAC	8/10/22 13:15	25.6	240	8.8	13.0	1.2
YKAC	8/24/22 10:30	24.0	234	8.5 J	9.5	1.4
YKAC	9/7/22 10:48	21.0	258	8.4	10.3	1.2
YKAC	9/21/22 11:30	16.6	257	8.3	10.9	0.9
YKAC	10/5/22 13:25	18.4	288	8.7	13.2	1.5
YKAC	10/19/22 11:00	13.9	269	8.3	11.4	1.5
YKAC	10/26/22 10:35	10.6	244	8.2	11.1 J	5.8
YKAC	11/8/22 10:30	6.7	151	7.5	11.1	20.1
YKEM	6/28/22 14:00	18.9	99	7.4	9.5 J	7.2
YKEM	7/12/22 12:10	20.0	121	7.6	8.6	4.9
YKEM	8/2/22 12:25	21.5	148	7.6	7.9	5.0
YKEM	8/9/22 11:35	21.0	153	7.6	7.5	4.7

Study Location ID	Date/Time (local)	Temp (C)	Conductivity (uS/cm)	pH (units)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
YKEM	8/23/22 11:12	22.0	155	8.0 J	7.5	3.9
YKEM	9/6/22 11:45	19.7	166	7.8	7.9	3.8
YKEM	9/20/22 12:05	16.9	166	7.7	8.5	3.9
YKEM	10/4/22 12:30	16.7	199	7.7	8.6	3.8
YKEM	10/18/22 12:40	13.7	198	7.8	9.3	5.1
YKEM	10/25/22 13:38	10.4	202	8.0	11.0 J	2.7
YKEM	11/7/22 12:55	6.6	122	7.4	10.7	18.3
YKET	6/28/22 13:15	18.2	81	7.8	10.1 J	6.2
YKET	7/12/22 10:55	18.6	89	7.7	9.4	5.2
YKET	8/2/22 7:55	18.1	96	7.5	7.7	
YKET	8/2/22 10:57	18.8	95	7.5	9.0	2.7
YKET	8/9/22 10:42	18.9	99	7.4	8.2	2.5
YKET	8/10/22 14:00	21.5	99	8.1	10.0	
YKET	8/23/22 10:20	20.2	104	8.0 J	8.7	1.5
YKET	9/6/22 10:55	17.8	113	7.6	9.1	2.4
YKET	9/20/22 11:20	16.4	121	7.9	10.1	2.1
YKET	10/4/22 11:35	16.2	132	7.9	10.1	1.6
YKET	10/18/22 11:58	13.5	139	8.0	10.7	3.9
YKET	10/25/22 12:42	10.0	155	8.2	—	2.5
YKET	11/7/22 12:00	6.3	102	7.3	11.0	15.5
YKEU	6/28/22 15:45	20.8	126	7.7	9.2 J	13.5
YKEU	7/12/22 13:20	22.9	166	8.2	9.9	6.2
YKEU	8/2/22 13:30	26.1	220	8.3	9.7	2.9
YKEU	8/9/22 13:05	23.6	217	8.2	9.6	3.2
YKEU	8/10/22 9:04	22.6	215	7.9	7.8	
YKEU	8/23/22 12:10	24.2	215	8.4 J	8.9	3.4
YKEU	9/6/22 12:45	21.6	231	8.3	9.8	2.5
YKEU	9/20/22 13:05	17.9	232	8.2	10.3	2.4
YKEU	10/4/22 13:15	18.2	257	8.3	10.7	2.3
YKEU	10/18/22 13:45	15.0	244	8.2	10.7	3.0
YKEU	10/25/22 14:35	11.0	241	8.1	11.1 J	2.4
YKEU	11/7/22 13:45	7.0	134	7.4	10.3	31.6
YKKO	6/29/22 10:20	19.9	137	7.8	9.3 J	9.2
YKKO	7/13/22 10:27	23.6	182	8.3	9.2	5.5
YKKO	8/3/22 9:50	24.8	242	8.3	8.3	2.1
YKKO	8/10/22 12:00	25.2	233	8.5	10.4	1.9
YKKO	8/24/22 11:05	24.6	230	8.7 J	9.6	1.3
YKKO	9/7/22 11:20	21.6	245	8.6	10.9	1.9
YKKO	9/21/22 12:10	17.3	244	8.5	11.0	1.7
YKKO	10/5/22 12:55	18.5	270	8.8	12.9	1.5

Study Location ID	Date/Time (local)	Temp (C)	Conductivity (uS/cm)	pH (units)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
YKKO	10/19/22 12:00	14.4	255	8.5	12.1	3.2
YKKO	10/26/22 11:11	10.6	245	8.2	12.0 J	4.8
YKKO	11/8/22 11:40	6.7	64	7.5	10.9	23.1
YKPR	6/29/22 13:00	20.4	145	7.5	8.7 J	10.1
YKPR	7/13/22 8:00	22.7	181	7.7	7.9	5.6
YKPR	8/3/22 7:33	24.6	211	7.9	7.8	3.2
YKPR	8/10/22 8:00	22.8	235	7.7	7.5	2.8
YKPR	8/24/22 7:30	23.7	236	7.9 J	6.8	3.3
YKPR	9/7/22 8:10	20.8	251	7.4	7.8	2.0
YKPR	9/21/22 8:45	17.1	251	7.8	8.9	1.5
YKPR	10/5/22 9:15	17.4	278	7.8	8.8	2.2
YKPR	10/19/22 9:00	14.3	279	7.9	8.9	2.5
YKPR	10/26/22 8:35	10.4	245	7.8	9.8 J	2.4
YKPR	11/8/22 9:00	6.4	145	7.4	10.2	17.6
YKSM	6/28/22 9:30	15.6	80	7.8	10.4 J	3.6
YKSM	7/12/22 7:40	15.9	83	7.3	8.8	2.4
YKSM	8/2/22 7:30	15.1	67	7.4	9.4	4.7
YKSM	8/9/22 7:20	16.9	69	7.5	9.0	4.0
YKSM	8/23/22 7:15	18.6	78	7.6 J	8.7	3.9
YKSM	9/6/22 7:45	16.6	100	7.8	8.6	2.1
YKSM	9/20/22 8:07	15.2	133	7.9	8.2	1.7
YKSM	10/4/22 8:20	14.5	137	7.7	8.5	2.3
YKSM	10/18/22 8:21	11.4	137	7.6	9.3	2.6
YKSM	10/25/22 8:58	8.5	136		10.4	1.9
YKSM	11/7/22 8:50	5.5	101	7.5	11.6	9.0
YKUG	6/28/22 11:30	15.8	83	7.6	9.9 J	5.7
YKUG	7/12/22 9:25	15.5	83	7.6	9.3	7.1
YKUG	8/2/22 9:46	16.5	81	7.4	9.1	4.7
YKUG	8/9/22 9:40	17.6	84	7.4	8.5	3.8
YKUG	8/23/22 9:14	19.1	92	7.9 J	8.7	3.9
YKUG	9/6/22 9:50	16.3	100	7.6	9.6	4.1
YKUG	9/20/22 10:15	15.2	114	7.8	9.8	4.7
YKUG	10/4/22 10:27	15.1	128	7.7	9.7	3.3
YKUG	10/18/22 10:50	12.2	140	7.6	10.5	3.2
YKUG	10/25/22 11:30	9.2	159	8.0	11.9 J	2.0
YKUG	11/7/22 11:05	5.8	105	7.4	11.1	14.2
YKVG	6/29/22 9:00	19.8	140	7.9	8.9 J	8.8
YKVG	7/13/22 9:38	24.7	187	8.3	7.3	5.4
YKVG	8/3/22 9:08	25.0	250	8.6	8.0	2.2
YKVG	8/10/22 11:17	25.3	234	8.7	9.3	1.8

Study Location ID	Date/Time (local)	Temp (C)	Conductivity (uS/cm)	pH (units)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
YKVG	8/24/22 11:40	25.2	237	9.1 J	9.8	2.1
YKVG	9/7/22 11:55	22.3	253	8.9	10.7	1.6
YKVG	9/21/22 12:45	17.3	256	8.7	10.7	2.1
YKVG	10/5/22 12:10	18.5	276	8.8	11.2	1.5
YKVG	10/19/22 12:45	14.5	266	8.5	11.1	4.0
YKVG	10/26/22 12:00	10.9	256	8.4	11.9 J	2.6
YKVG	11/8/22 12:30	6.5	142	7.3	10.8	35.6
YKSM	4/3/2023 8:10	5.16	125.4	7.96	11.6	2.63
YKSM	4/24/2023 8:17	9.04	103.7	7.79	10.87	8.99
YKSM	5/15/2023 8:17	14.69	100.7 J	7.66	9.69	10.96
YKSM	6/12/2023 8:26	17.81	111.2 J	7.78	8.86	4.14
YKSM	7/17/2023 8:13	17.37	81 J	7.66	9.05	5.05
YKSM	8/21/2023 8:17	17.7	77.3	7.78	8.87	3.33
YKSM	9/11/2023 8:18	17.82	113.2	7.85	8.57	1.48
YKSM	10/16/2023 8:00	11.99	145.9	7.69	9.05	2.22
NACM	4/3/2023 9:24	3.85	96.6	8.49	13.2	3.16
NACM	4/24/2023 9:12	6.98	81.8	7.79	11.46	23
NACM	5/15/2023 9:07	9.37	50 J	7.27	10.13	47.63
NACM	6/12/2023 9:35	14.28	69.1 J	7.61	9.11	16.2
NACM	7/17/2023 9:24	18.9	104.6 J	8.12	9.34	3.19
NACM	8/21/2023 9:26	—	88.2	—	—	5.66
NACM	9/11/2023 9:23	16.72	77.9	7.65	9.35	15.73
NACM	10/16/2023 8:56	11.73	101.5	7.69	10.14	2.99
YKUG	4/3/2023 10:15	5.57	132.3	8.26	12.33	4.5
YKUG	4/24/2023 10:07	9.18	106.3	7.86	10.9	15.33
YKUG	5/15/2023 10:04	12.25	76 J	7.33	9.66	35.2
YKUG	6/12/2023 10:33	16.52	100.6 J	7.76	9.04	12.07
YKUG	7/17/2023 10:14	18.76	97.2 J	7.94	9.06	4.99
YKUG	8/21/2023 10:46	17.57	92.8	7.91	9.3	3.25
YKUG	9/11/2023 10:00	17.38	107.4	7.66	9.17	9.69
YKUG	10/16/2023 9:48	12.04	156.3	7.71	9.58	4.31
YKET	4/3/2023 11:25	6.75	138.8	7.87	11.61	5.42
YKET	4/24/2023 11:15	11.02	114.6	7.86	10.53	12.8
YKET	5/15/2023 11:08	14.38	76.9 J	7.37	9.54	28.63
YKET	6/12/2023 11:24	18.97	103.8 J	8.34	10.42	6.13
YKET	7/17/2023 11:25	20.7	110.8 J	8.19	9.14	3.15
YKET	8/21/2023 12:04	18.38	103.8	8.14	9.87	2.39
YKET	9/11/2023 11:00	18.59	116.3	7.92	8.94	3.12
YKET	10/16/2023 10:42	12.97	160.1	7.69	9.11	2.03
YKEM	4/3/2023 14:37	8.46	175.6	8.29	11.12	4.57

Study Location ID	Date/Time (local)	Temp (C)	Conductivity (uS/cm)	pH (units)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
YKEM	4/24/2023 14:13	12.47	144.6	8.03	9.84	11.45
YKEM	5/15/2023 12:08	15.47	93.2 J	7.42	8.75	25.4
YKEM	6/12/2023 12:15	20.52	144.2 J	8.11	8.94	6.72
YKEM	7/17/2023 12:10	22.86	161.1 J	8.03	7.19	5.57
YKEM	8/21/2023 15:37	19.44	157.5	8.02	8.73	3.94
YKEM	9/11/2023 14:40	19.85	174.1	8.31	8.72	3.09
YKEM	10/16/2023 11:25	13.69	240.5	8.33	8.92	3.21
YKEU	4/3/2023 13:07	8.57	189.7	8.04	11.47	7.03
YKEU	4/24/2023 12:46	13.87	173.5	7.91	9.77	20.2
YKEU	5/15/2023 13:46	16.94	111 J	7.34	8.75	40.13
YKEU	6/12/2023 13:42	22.34	185 J	8.07	9.83	12.23
YKEU	7/17/2023 13:56	26.4	240.5 J	8.65	9.75	3.14
YKEU	8/21/2023 14:17	21.12	238.7	8.31	9.17	2.95
YKEU	9/11/2023 13:25	20.78	250.3	8.13	9.71	2.43
YKEU	10/16/2023 13:30	14.23	321.6	7.77	9.45	2.41
YKPR	4/3/2023 12:23	9.27	193.3	7.86	10.49	5.77
YKPR	4/24/2023 11:59	13.25	185.9	7.79	9.05	19.13
YKPR	5/15/2023 13:12	17.82	116.8 J	7.4	8.63	42
YKPR	6/12/2023 14:17	22.12	197.8 J	7.83	8.78	10.83
YKPR	7/17/2023 14:47	26.71	270.4 J	8.92	13.43	1.33
YKPR	8/21/2023 13:15	21.5	319.8	7.2	8.42	4.92
YKPR	9/11/2023 11:50	21.01	272.3	8.24	10.77	2.85
YKPR	10/16/2023 14:15	14.5	306.6	8.01	9.8	4.06

Temp = temperature
J = Estimate
Blank = not measured

Appendix D. Continuous Long-Term Monitoring

Continuous long-term monitoring (15-minute to 1-hour intervals) results for pH, dissolved oxygen, and conductivity.

Note: Continuous long-term monitoring data presented below are in chart format. The continuous data records are too large to include in the report. All data are available from Ecology's EIM online database.[3]

Table D1. Continuous long-term monitoring locations with instrument information, deployment dates, and data qualifiers.

Study Location ID	Instrument ID	Start Date/Time (PST)	End Date/Time (PST)	pH Data Qualifier	pH Bias Adjust (s.u.)	DO Data Qualifier	DO Multiply Adjust	Cond Data Qualifier	Cond Bias Adjust (µS/cm)
YKSM	Hydrolab #45	6/23/22 7:45	6/28/22 5:00	none	none	IA	0.974	none	none
YKSM	Hydrolab #37	7/5/22 13:00	7/26/22 5:00	none	none	IA	0.979	none	none
YKSM	Hydrolab #45	7/26/22 5:15	8/9/22 5:00	none	none	IA	0.974	none	none
YKSM	Hydrolab #37	8/9/22 5:15	8/23/22 5:00	none	none	IA	0.979	none	none
YKSM	Hydrolab #45	8/23/22 5:15	9/6/22 5:00	none	none	IA	0.974	none	none
YKSM	Hydrolab #37	9/6/22 5:15	9/20/22 6:00	none	none	IA	0.979	none	none
YKSM	Hydrolab #45	9/20/22 6:15	10/4/22 6:00	none	none	IA	0.974	none	none
YKSM	Hydrolab #37	10/4/22 6:15	10/18/22 6:00	none	none	IA	0.979	none	none
YKSM	Hydrolab #45	10/18/22 6:15	10/25/22 6:15	none	none	IA	0.974	none	none

[3] https://apps.ecology.wa.gov/eim/search/default.aspx

Study Location ID	Instrument ID	Start Date/Time (PST)	End Date/Time (PST)	pH Data Qualifier	pH Bias Adjust (s.u.)	DO Data Qualifier	DO Multiply Adjust	Cond Data Qualifier	Cond Bias Adjust (µS/cm)
YKSM	Hydrolab #37	10/25/22 6:30	11/7/22 9:15	none	none	IA	0.979	none	none
YKPR	Hydrolab #36	6/29/22 12:00	7/12/22 14:00	none	none	IA	0.983	none	none
YKPR	Hydrolab #15	7/13/22 7:00	7/25/22 16:00	EST	none	EST	1.0	none	none
YKPR	Hydrolab #36	8/10/22 10:00	10/5/22 8:00	EST	none	IA	0.983	none	none
YKPR	Hydrolab #15	10/5/22 9:00	10/19/22 7:30	none	none	EST	1.0	none	none
YKPR	Hydrolab #36	10/19/22 9:00	11/8/22 9:00	none	none	IA	0.983	none	none
CHAN	SN808854	6/23/22 8:30	10/31/22 8:00	not logged	not logged	IA	1.0317	not logged	not logged
NACM	SN20645550	6/27/22 23:00	10/31/22 12:30	not logged	not logged	IA	0.9693	not logged	not logged
YKAC	SN441440	6/23/22 9:45	10/31/22 9:30	not logged	not logged	IA	1.0374	not logged	not logged
YKAC	SN222333	8/10/22 11:15	10/31/22 9:30	not logged	not logged	IA	1.0017	not logged	not logged
YKET	SN20645555	6/30/22 10:30	10/31/22 11:10	not logged	not logged	IA	0.9548	not logged	not logged
YKET	SN258678	8/10/22 13:00	10/31/22 11:10	not logged	not logged	IA	1.0168	not logged	not logged
YKEU	SN20645552	6/30/22 11:15	10/25/22 13:30	not logged	not logged	IA	0.992	not logged	not logged
YKEU	SN341412	8/10/22 8:04	10/25/22 13:30	not logged	not logged	IA	1.0125	not logged	not logged
NACM	SN222333	4/3/23 9:36	11/14/23 11:21	not logged	not logged	none	none	not logged	not logged

Study Location ID	Instrument ID	Start Date/Time (PST)	End Date/Time (PST)	pH Data Qualifier	pH Bias Adjust (s.u.)	DO Data Qualifier	DO Multiply Adjust	Cond Data Qualifier	Cond Bias Adjust (µS/cm)
YKET	SN280281	4/3/23 11:25	11/13/23 15:32	not logged	not logged	none	none	not logged	not logged
YKEU	SN341412	4/3/23 13:47	11/13/23 14:06	not logged	not logged	none	none	not logged	not logged
YKKO	SN108203	4/5/23 10:57	11/12/23 16:23	not logged	not logged	none	none	not logged	not logged
YKPR	SN109851	4/3/23 12:53	11/13/23 12:44	not logged	not logged	none	none	not logged	not logged
YKSM	SN258678	4/3/23 9:16	11/13/23 8:53	not logged	not logged	none	none	not logged	not logged
YKVG	SN085826	4/5/23 9:55	11/12/23 16:15	not logged	not logged	none	none	not logged	not logged

IA = Instrument result adjusted; reported result meets study objectives.

EST = Data considered an estimate based on post-check versus reference standard.

DO = dissolved oxygen

Cond = conductivity

Table D2. Data gaps in the time series. Data rejected due to site maintenance, meter issues, or data not meeting study's measurement quality objectives.

Study Location ID	Instrument ID	Start Date/Time (PST)	End Date/Time (PST)	Parameter
NACM	SN20645550	8/9/2022 13:30	8/30/2022 8:30	DO
YKET	SN20645555	7/21/2022 0:00	7/27/2022 10:30	DO
YKET	SN20645555	7/31/2022 0:00	8/3/2022 9:30	DO
YKET	SN20645555	8/7/2022 0:00	8/10/2022 13:20	DO
YKEU	SN20645552	7/22/2022 9:00	7/24/2022 11:00	DO
NACM	SN222333	4/24/2023 21:21	5/6/2023 23:06	DO
YKET	SN280281	6/12/2023 10:55	6/12/2023 12:16	DO
YKET	SN280281	6/30/2023 8:46	6/30/2023 9:16	DO
YKET	SN208281	8/21/2023 11:46	8/21/2023 12:02	DO
YKEU	SN341412	6/12/2023 15:47	6/12/2023 16:54	DO
YKEU	SN341412	8/21/2023 15:54	8/21/2023 16:06	DO
YKKO	SN108203	6/14/2023 9:47	6/14/2023 10:20	DO
YKKO	SN108203	8/22/2023 11:10	8/22/2023 12:23	DO
YKPR	SN109851	6/12/2023 11:33	6/12/2023 15:25	DO
YKSM	SN258678	6/12/2023 8:26	6/12/2023 9:21	DO
YKSM	SN258678	8/21/2023 8:21	8/21/2023 9:23	DO
YKVG	SN085826	6/14/2023 10:45	6/14/2023 12:13	DO
YKVG	SN085826	8/13/2023 10:33	8/13/2023 11:13	DO
YKVG	SN085826	8/22/2023 9:33	9/22/2023 10:25	DO
YKPR	Hydrolab #36	7/4/22 4:00	7/4/22 6:00	DO
YKPR	Hydrolab #36	8/24/22 6:00	8/24/22 9:00	DO
YKPR	Hydrolab #36	9/7/22 7:00	9/7/22 9:00	DO
YKPR	Hydrolab #36	9/21/22 8:00	9/21/22 10:00	DO
YKPR	Hydrolab #36	10/26/22 7:00	10/26/22 10:00	DO
YKSM	Hydrolab #45	6/23/22 8:45	6/23/22 9:30	DO
YKPR	Hydrolab #36	7/4/22 12:00	7/4/22 14:00	Sp.Cond.
YKPR	Hydrolab #36	7/7/22 8:00	7/7/22 10:00	Sp.Cond.
YKPR	Hydrolab #36	7/9/22 8:00	7/9/22 10:00	Sp.Cond.
YKPR	Hydrolab #36	8/24/22 6:00	8/24/22 9:00	Sp.Cond.
YKPR	Hydrolab #36	9/7/22 7:00	9/7/22 9:00	Sp.Cond.
YKPR	Hydrolab #36	9/21/22 8:00	9/21/22 10:00	Sp.Cond.
YKPR	Hydrolab #36	10/26/22 7:00	10/26/22 10:00	Sp.Cond.
YKSM	Hydrolab #45	6/23/22 8:45	6/23/22 9:30	Sp.Cond.
YKSM	Hydrolab #45	10/18/22 7:30	10/18/22 8:00	Sp.Cond.
YKPR	Hydrolab #36	8/24/22 6:00	8/24/22 9:00	pH

YKPR	Hydrolab #36	9/7/22 7:00	9/7/22 9:00	pH
YKPR	Hydrolab #36	9/21/22 8:00	9/21/22 10:00	pH
YKPR	Hydrolab #36	10/26/22 7:00	10/26/22 10:00	pH
YKSM	Hydrolab #45	6/23/22 8:45	6/23/22 9:30	pH

DO = dissolved oxygen
Sp.Cond = specific conductivity

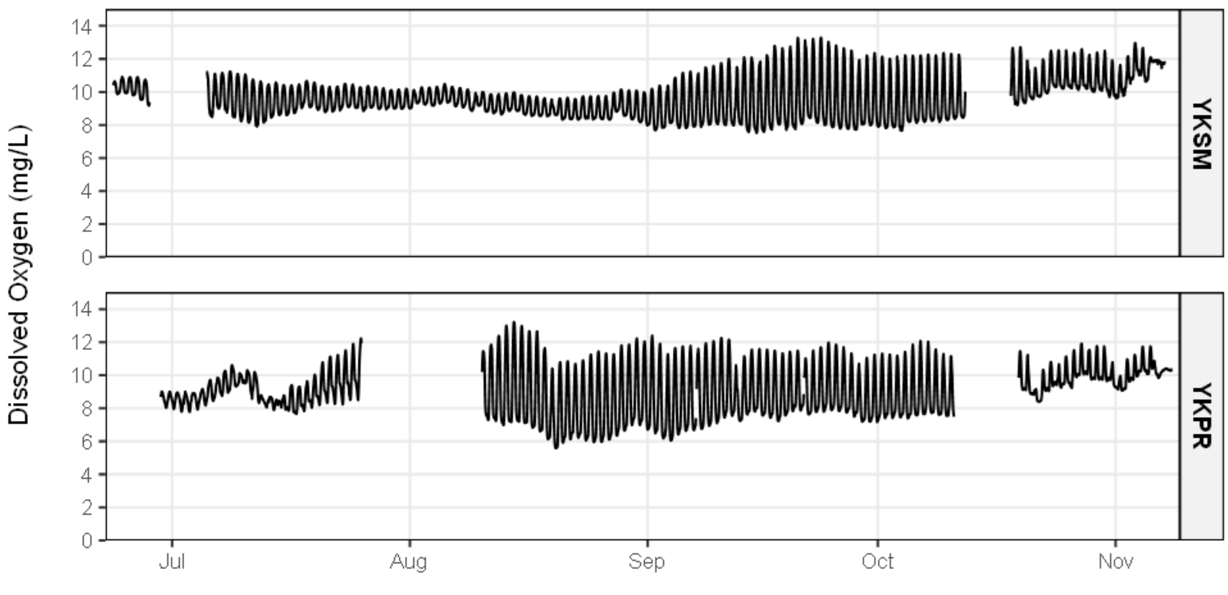

Figure D1. Dissolved oxygen measured in 2022 at the study sites YKSM and YKPR.

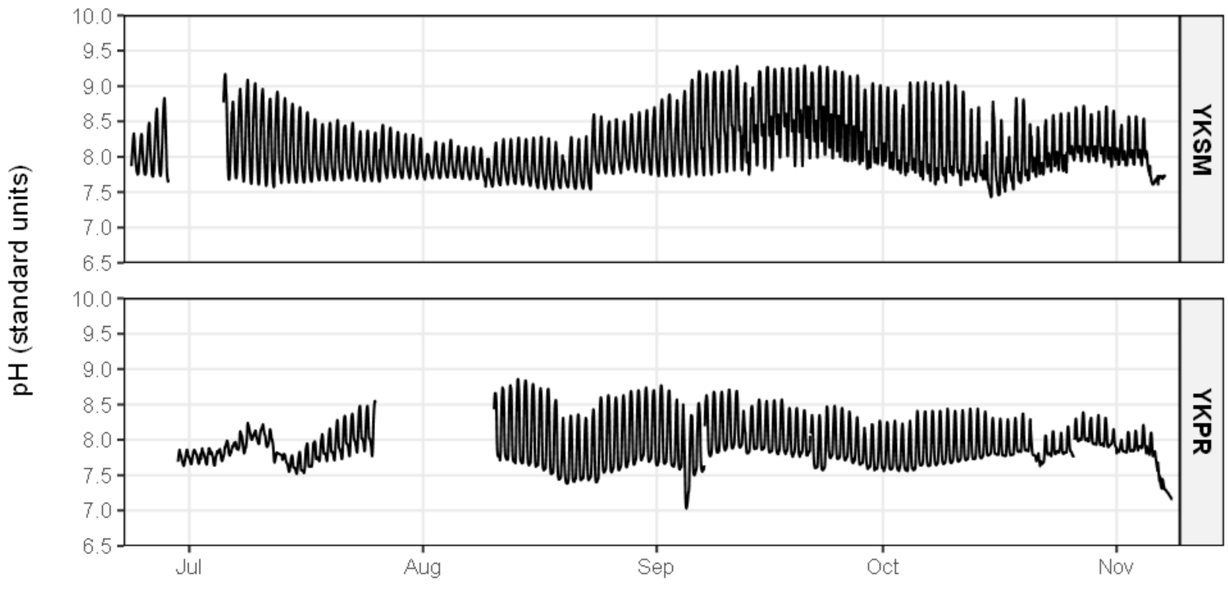

Figure D2. pH measured in 2022 at the study sites YKSM and YKPR.

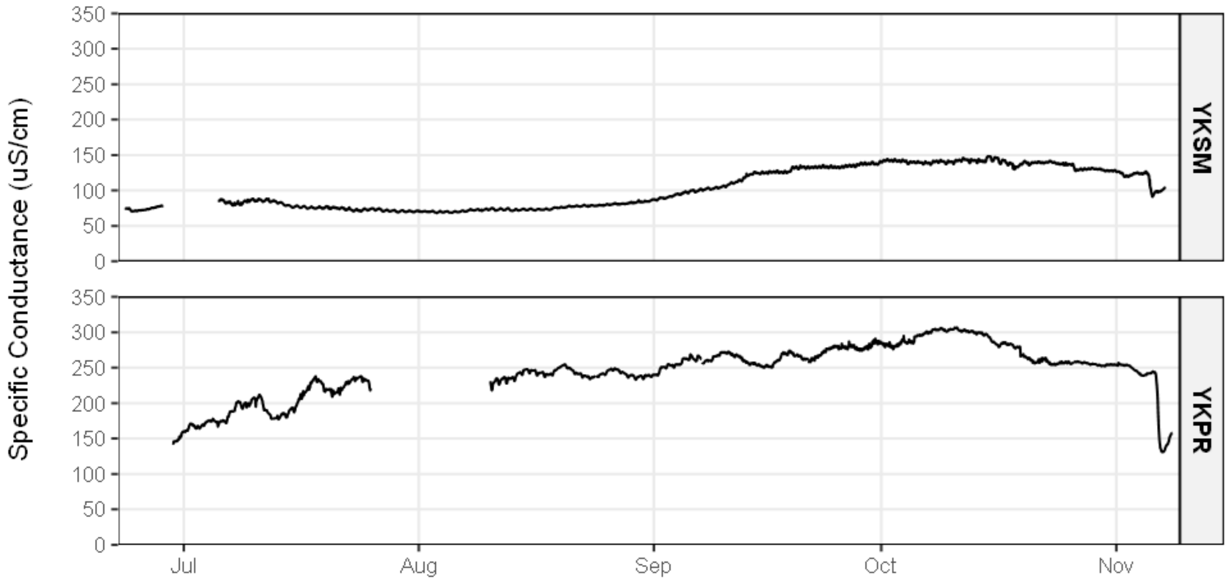

Figure D3. Specific conductivity measured in 2022 at the study sites YKSM and YKPR.

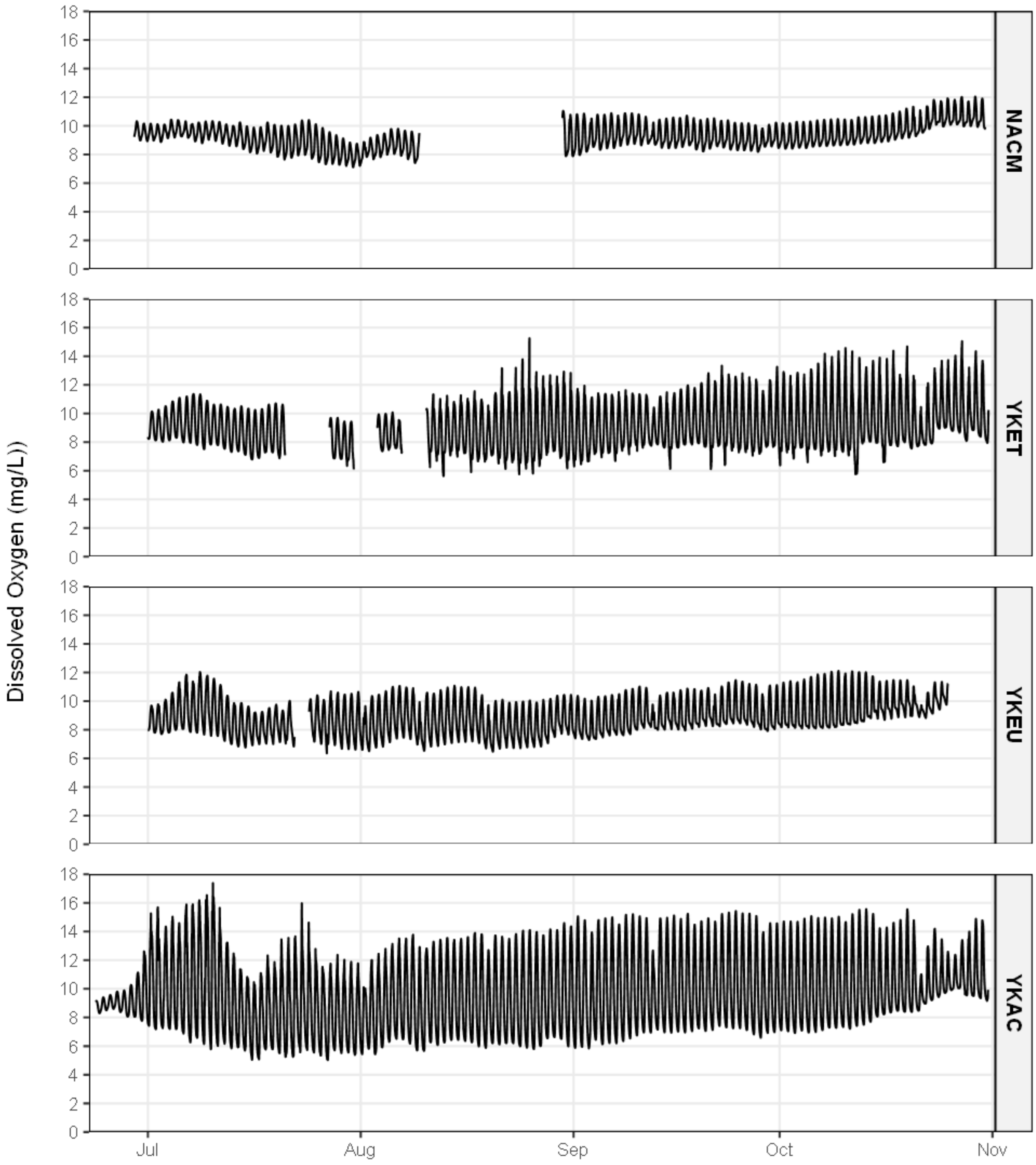

Figure D4. Dissolved oxygen measured in 2022 at the study sites.

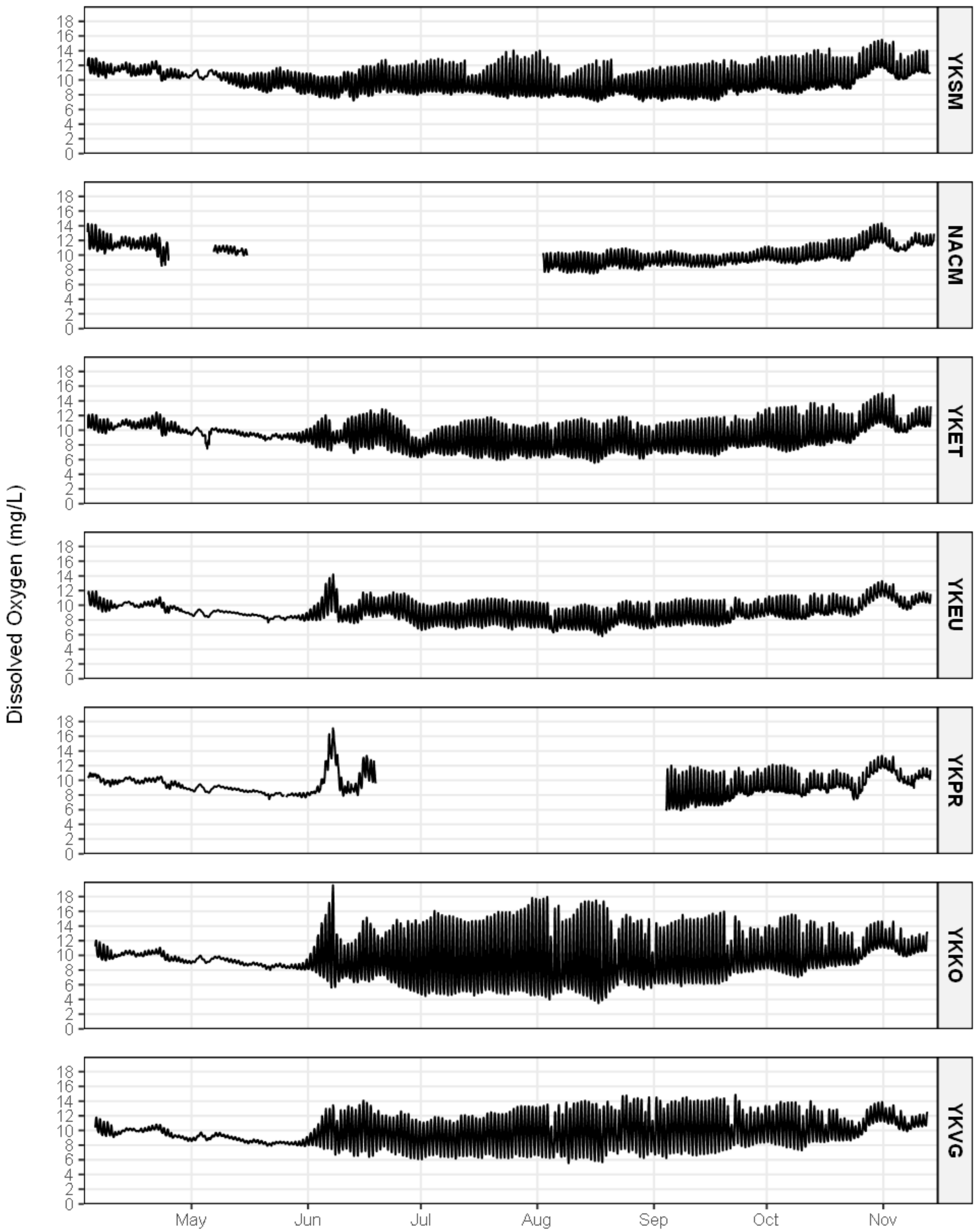

Figure D5. Dissolved oxygen measured in 2023 at study sites.

Appendix E. Temperature and Dew Point

Temperature data results for air, water, and dew point monitoring in 2022.

Note: Continuous temperature monitoring data presented below are in chart format. The continuous data records are too large to include in the report. All data are available from Ecology's EIM online database.[4] Search for Study_ID JICA0006.

Table E1. Temperature and dew point data logger locations with instrument information and deployment dates.

Study Location ID	Water Serial No.	Water Start Date/Time (PST)	Water End Date/Time (PST)	Air Serial No.	Air Start Date/Time (PST)	Air End Date/Time (PST)	Dew Serial No.	Dew Start Date/Time (PST)	Dew End Date/Time (PST)
CHAN	SN10227087	6/23/22 8:30	10/31/22 8:00	—	—	—	—	—	—
MOXM	SN10227142	7/11/22 23:00	10/26/22 8:25	—	—	—	—	—	—
NACM	SN10225427	6/16/22 13:00	10/31/22 12:30	—	—	—	—	—	—
ROZP	SN10225441	7/12/22 7:00	10/25/22 14:45	—	—	—	—	—	—
WHCM	SN10225478	7/12/22 6:15	10/26/22 7:55	—	—	—	—	—	—
YKPK	SN10227105	7/11/22 23:00	10/27/22 9:25	—	—	—	—	—	—
YKAC	SN10227090	6/23/22 9:45	10/31/22 9:30	—	—	—	—	—	—
YKET	SN10225280	6/30/22 10:30	10/31/22 11:10	SN10225286	6/30/22 10:30	10/31/22 11:10	SN1002566	7/12/22 10:45	10/31/22 11:10
YKEU	SN10227128	6/30/22 11:15	10/25/22 13:30	SN10227146	6/30/22 11:15	10/25/22 13:30	—	—	—
YKPR	SN10225431	6/23/22 11:00	11/8/22 9:00	SN10225449	6/23/22 11:00	10/31/22 11:00	—	—	—

[4] https://apps.ecology.wa.gov/eim/search/default.aspx

Study Location ID	Water Serial No.	Water Start Date/Time (PST)	Water End Date/Time (PST)	Air Serial No.	Air Start Date/Time (PST)	Air End Date/Time (PST)	Dew Serial No.	Dew Start Date/Time (PST)	Dew End Date/Time (PST)
YKSM	SN10221679	6/27/22 23:00	11/7/22 8:50	SN10225290	6/27/22 23:00	11/7/22 8:50	—	—	—
YKWD	SN10225455	7/12/22 13:00	12/28/22 15:30	—	—	—	—	—	—
YKET	SN10227128	4/3/23 11:30	11/13/23 14:30	SN10225425	4/3/23 11:30	11/13/23 14:30	SN1002566	4/3/2023 11:18	11/13/2023 15:18
YKEU	SN10227135	4/3/23 13:30	11/13/23 13:00	SN10221679	4/3/23 13:30	11/13/23 13:00	—	—	—
YKPR	SN10227111	4/3/23 12:30	11/13/23 12:00	SN10225286	4/3/23 13:00	11/13/23 12:00	—	—	—
YKSM	SN10221691	4/3/23 9:00	11/13/23 8:00	SN10227115	4/3/23 9:00	11/13/23 8:00	—	—	—
MOXEE	SN10225468	4/4/23 16:30	11/14/23 7:00	—	—	—	—	—	—
WHCR	SN10227102	4/4/23 15:30	11/13/23 15:00	—	—	—	—	—	—
NACM	SN10227132	4/3/23 10:00	11/14/23 10:30	—	—	—	—	—	—
ROZA	SN10227087	4/10/23 5:30	9/5/23 17:00	—	—	—	—	—	—
YKAC	SN10225280	4/5/23 12:30	11/13/23 12:30	—	—	—	—	—	—
YKKO	SN108203	8/22/23 11:53	11/12/23 16:23	—	—	—	—	—	—
YKKO	SN10227110	4/5/23 11:00	8/22/23 11:00	—	—	—	—	—	—
YKVG	SN85826	8/22/23 10:25	11/12/23 16:15	—	—	—	—	—	—
YKVG	SN10225285	4/5/23 10:00	8/22/23 9:00	—	—	—	—	—	—

Study Location ID	Water Serial No.	Water Start Date/Time (PST)	Water End Date/Time (PST)	Air Serial No.	Air Start Date/Time (PST)	Air End Date/Time (PST)	Dew Serial No.	Dew Start Date/Time (PST)	Dew End Date/Time (PST)
YKWD	SN10225427	5/17/23 15:00	11/12/23 14:30	—	—	—	—	—	—

Table E2. Rejected water temperature data due to air exposure.

Study Location ID	Serial No	Start Date/Time (PST)	End Date/Time (PST)
CHAN	SN10227087	10/25/2022 21:30	10/26/2022 23:30
ROZP	SN10225441	9/26/2022 8:30	9/30/2022 12:00
ROZP	SN10225441	10/5/2022 5:30	11/8/2022 0:00
YKWD	SN10225455	9/7/22 9:30	9/25/22 14:30
YKET	SN10227128	6/12/23 11:30	6/12/23 12:00
YKEU	SN10227135	6/12/23 16:00	6/12/23 17:00
YKPR	SN10227111	6/12/23 14:00	6/12/23 15:00
YKSM	SN10221691	6/12/23 9:00	6/12/23 9:30
YKSM	SN10221691	8/21/23 8:30	8/21/23 9:30
WHCR	SN10227102	6/13/23 15:30	6/13/23 16:00
ROZA	SN10227087	4/14/23 13:30	4/23/23 22:00
ROZA	SN10227087	5/30/23 17:30	6/3/23 14:00
ROZA	SN10227087	6/5/23 2:00	6/6/23 18:30
YKKO	SN10227110	6/14/23 9:30	6/14/23 10:00
YKVG	SN10225285	6/14/23 12:00	6/14/23 12:30

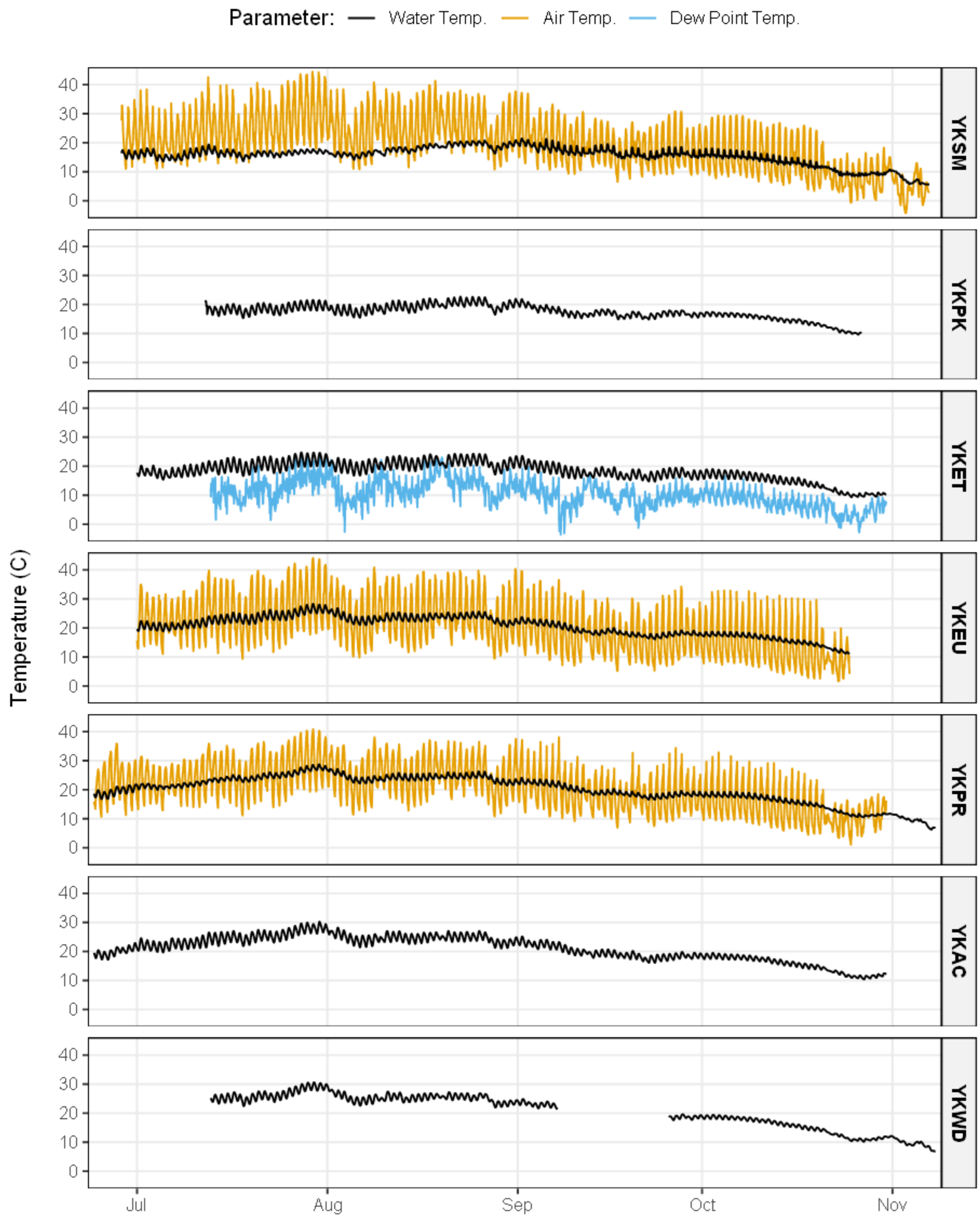

Figure E1. Temperature measured in 2022 at the Yakima mainstem study sites.

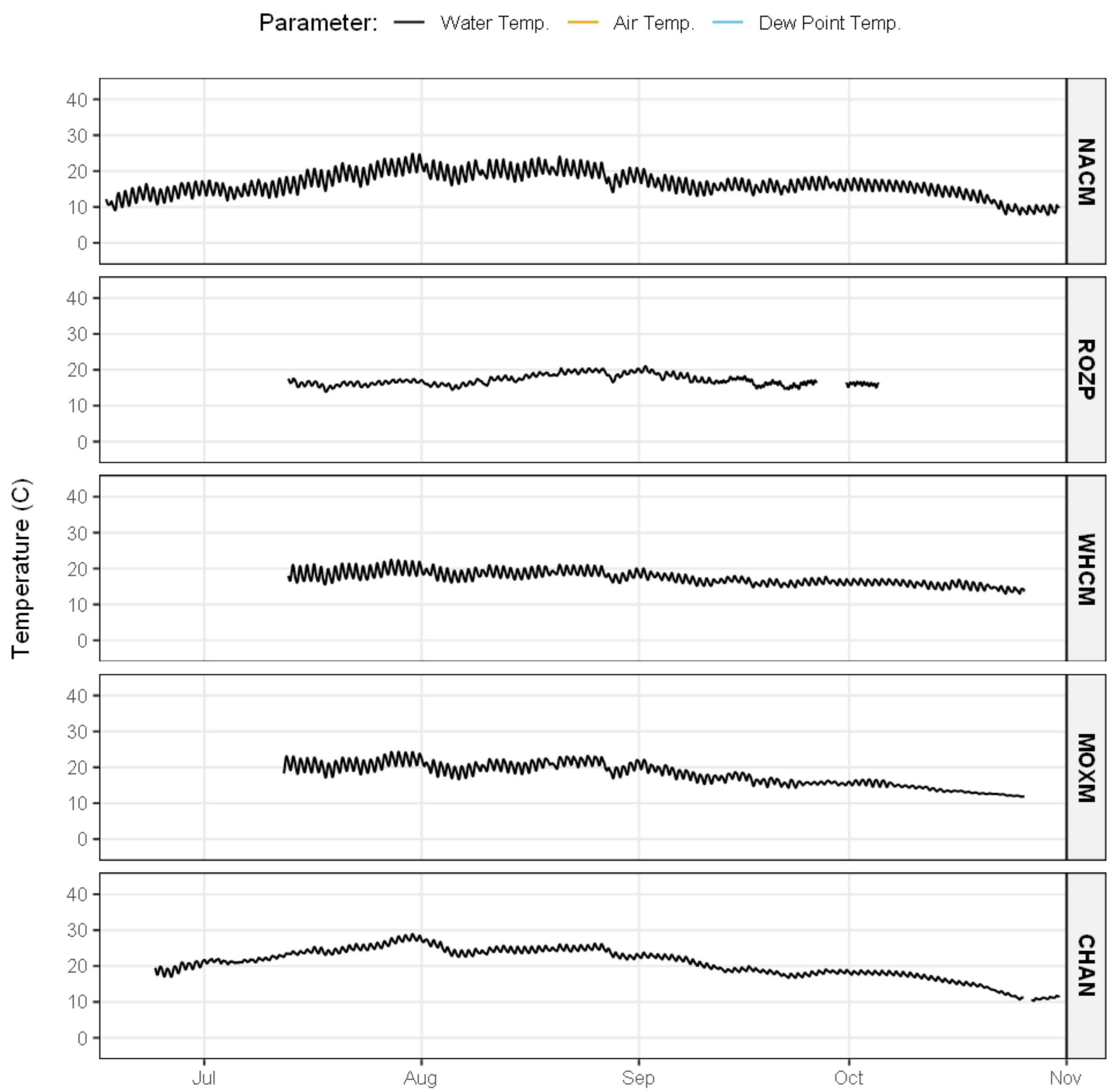

Figure E2. Temperature measured in 2022 at tributary study sites.

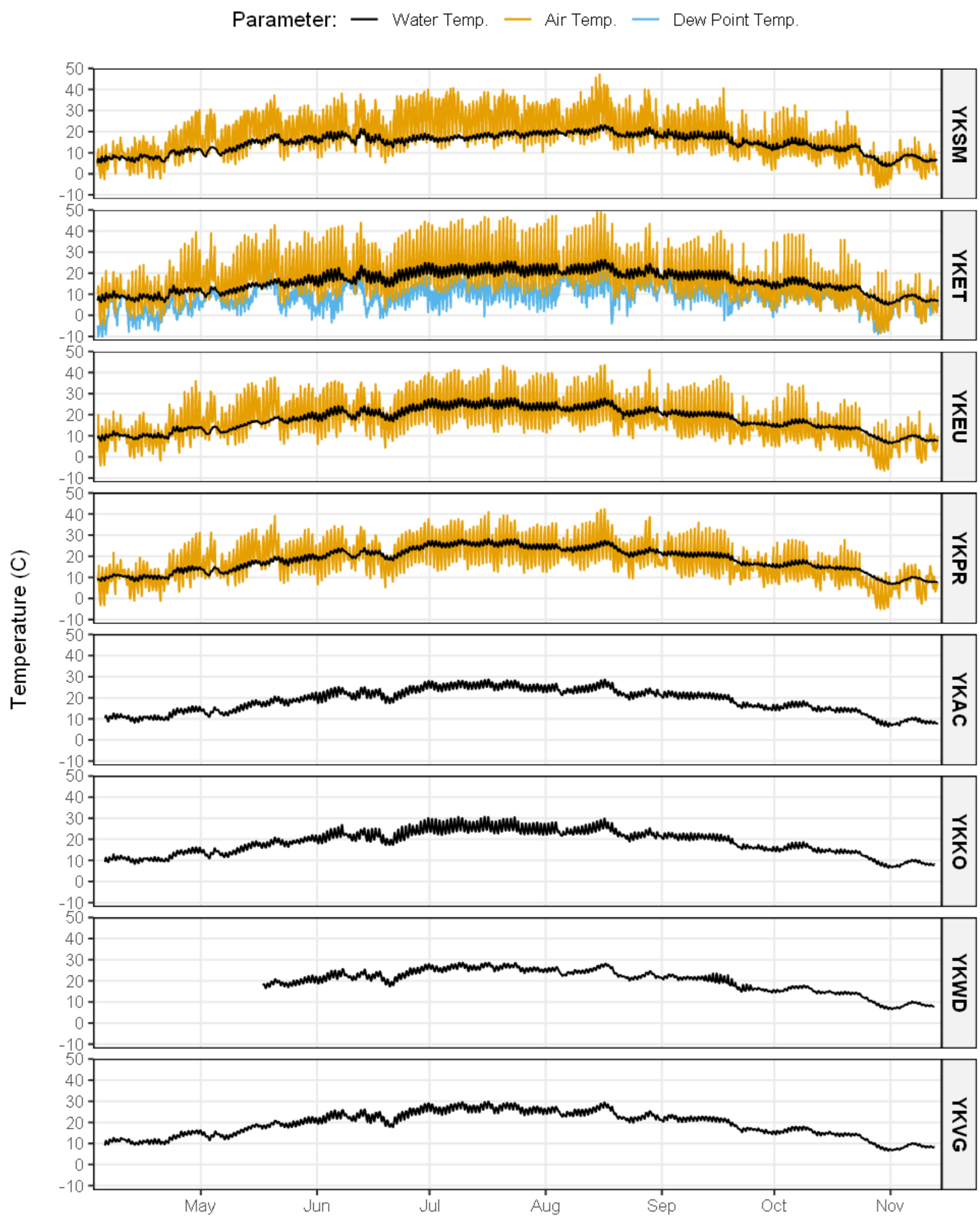

Figure E3. Temperature measured in 2023 at Yakima mainstem study sites.

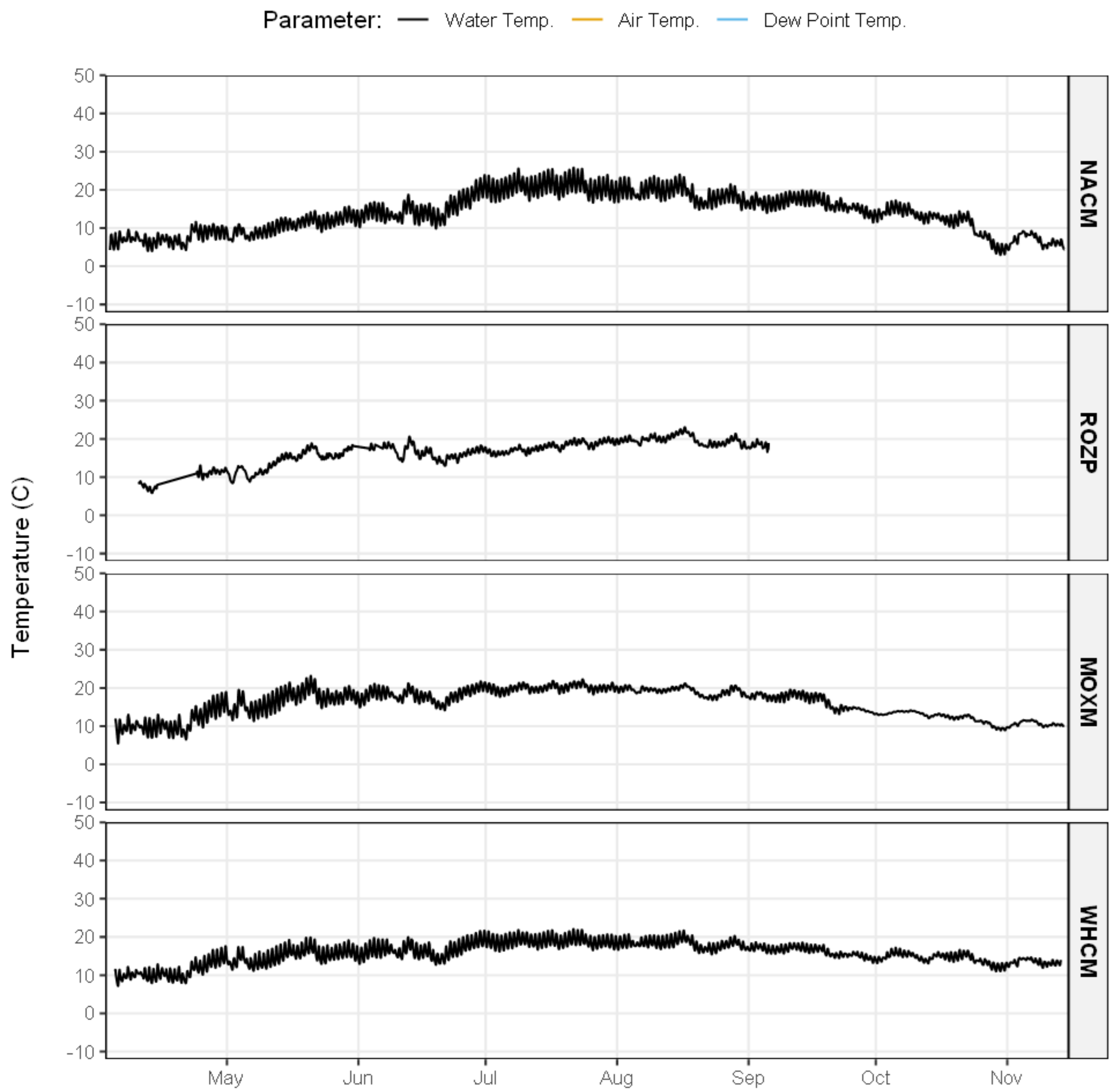

Figure E4. Temperature measured in 2023 at tributary study sites.

Appendix F. Turbidity

Turbidity data monitoring results for 2022 and 2023.

Note: Continuous turbidity monitoring data presented below are in chart format. The continuous data records are too large to include in the report. All data are available from Ecology's Environmental Information Management (EIM) online database at https://apps.ecology.wa.gov/eim/search/default.aspx. Search for Study ID JICA0006.

Table F1. Turbidity data logger locations with instrument information and deployment dates.

Study Location ID	Serial No.	Start Date/Time (PST)	End Date/Time (PST)
YKSM	SN116916	7/5/22 13:00	11/30/22 11:00
YKSM	SN116916	4/3/23 08:00	11/13/23 13:00

Table F2. Rejected or gaps for the turbidity data in the time series.

Study Location ID	Instrument ID	Start Date/Time (PDT)	End Date/Time (PDT)
YKSM	SN116916	9/14/22 3:00	9/14/22 5:00
YKSM	SN116916	7/27/23 20:00	7/27/23 23:00
YKSM	SN116916	7/28/23 0:00	8/3/23 0:00
YKSM	SN116916	8/28/23 0:00	9/1/23 0:00

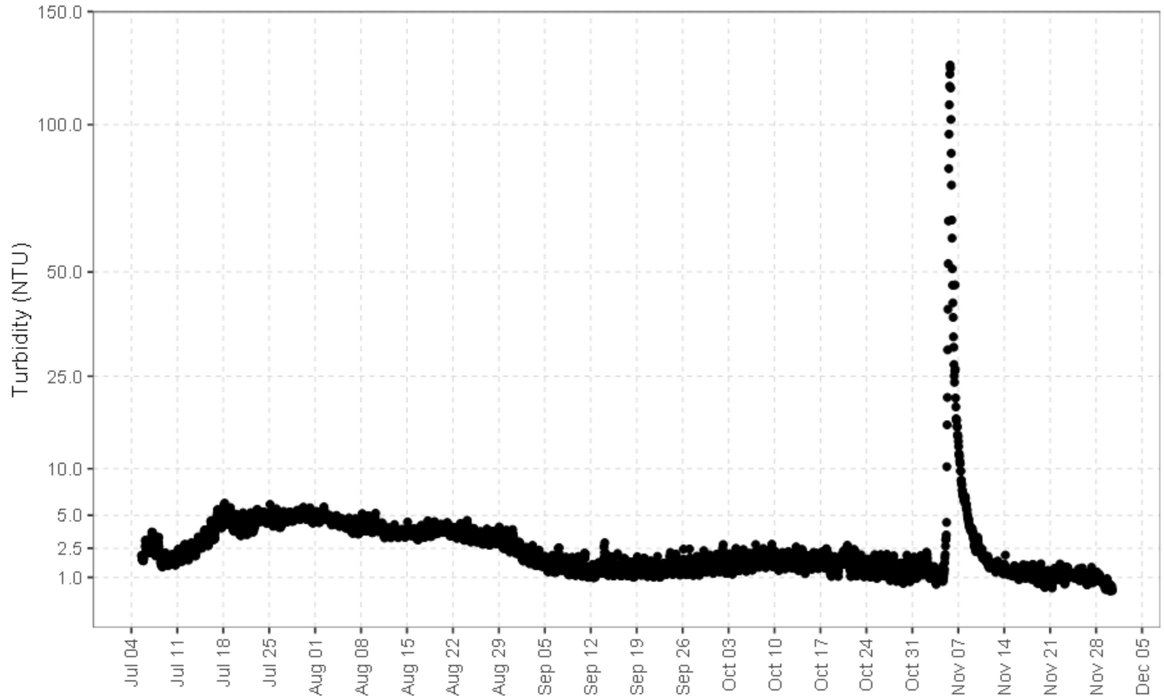

Figure F1. Continuous turbidity data collected in 2022 at station YKSM.

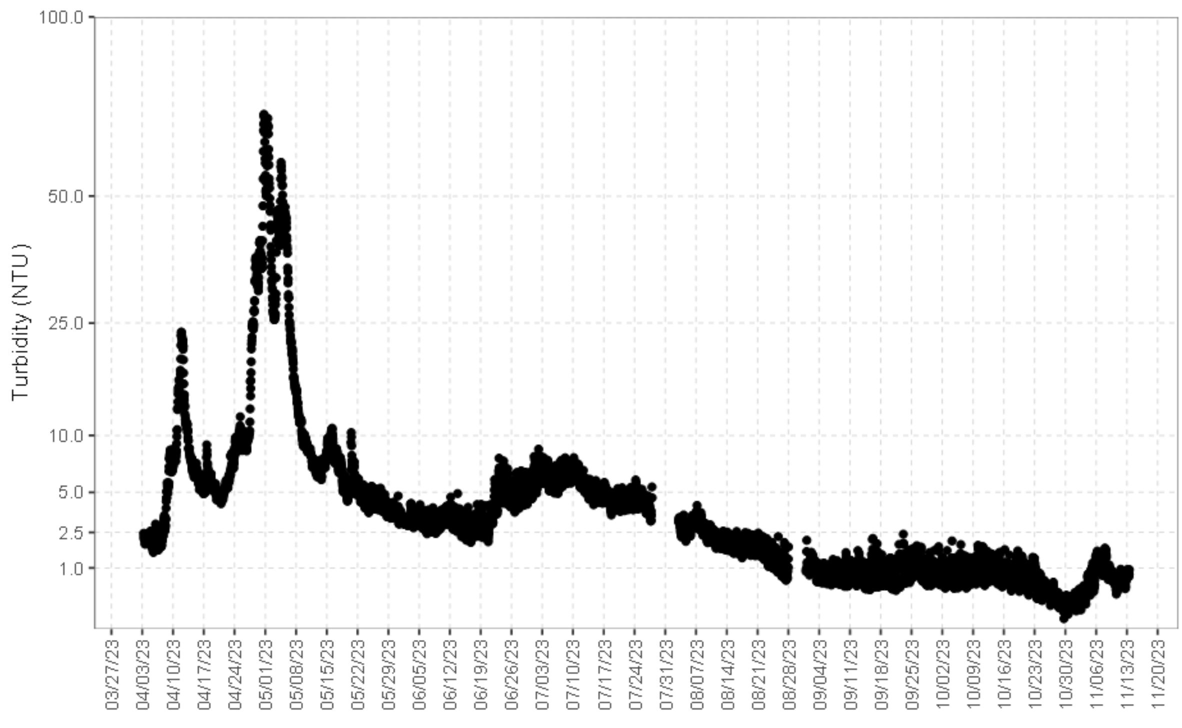

Figure F2. Continuous turbidity data collected in 2023 at station YKSM.