River and Stream Water Quality Monitoring Report

Water Year 2012

October 2013
Publication No. 13-03-042

DEPARTMENT OF ECOLOGY
State of Washington

Publication and Contact Information

This report is available on the Department of Ecology's website at
https://fortress.wa.gov/ecy/publications/SummaryPages/1303042.html

Finalized data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search Study ID AMS001.

Ecology's Activity Tracker Code for this study is 01-600.

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Cover photo: Chehalis River at Porter station 23A070 (by Bill Ward, Nov 15, 2011).

River and Stream
Water Quality Monitoring Report

Water Year 2012

by

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Abstract

The Washington State Department of Ecology (Ecology) collected monthly water quality data at 88 stream monitoring stations during Water Year 2012 (October 1, 2011 through September 30, 2012). We also collected 30-minute interval temperature data at 38 sites. Temperatures were measured year-round at eight of these stations; the rest were measured from July through September 2012. In addition, we continued a continuous oxygen monitoring program at 10 sites.

The principal goals of this ongoing monitoring program are to monitor trends in water quality of rivers and streams in Washington State, to support a probabilistic monitoring program (Merritt, 2006), and to support Clean Water Act Section 303(d) reporting.

This report documents methods and data quality for Water Year 2012. Data quality was generally acceptable; exceptions were qualified or rejected. Measured variance indicated we are likely to meet our trend detection goals for all parameters except total suspended sediment.

This year's annual report includes a quality control analysis of (1) continuously monitored data using multi-parameter (oxygen, temperature, pH, and conductivity) instruments and (2) total phosphorus data collected from lakes monitoring for aquatic plants.

A description of Ecology's long-term monitoring program and access to historical data can be found on Ecology's Internet web site at www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html.

Acknowledgements

The success of the Water Year 2012 ambient monitoring program, and the quality of the data, are attributable to the following people:

- Our dedicated monitoring staff spent long hours working in all kinds of weather, traffic, and road conditions. Without this kind of commitment, Appendix D would be much longer.

  Water Year 2012 samplers and their lifetime sample counts (at least since we began keeping track) were Andrew Albrecht (21), Andrew Pellkofer (178), Bill Ward (3631), Casey Clishe (737), Dan Dugger (396), Daniel Sherratt (1272), David Hallock (2821), Howard Christensen (146), Jason Myers (709), Jim Ross (2111), Mike Anderson (404), and Troy Warnick (570).

- Bill Ward conducted the continuous stream temperature monitoring project with regional assistance from Dan Dugger, Mike Anderson, Tighe Stuart, and Howard Christensen.
- Brad Hopkins, Bill Ward, and Dan Dugger reviewed the draft report; Maggie Bell-McKinnon reviewed the lake monitoring sections.
- Jean Maust and Joan LeTourneau formatted and edited the final report.

Manchester Environmental Laboratory (MEL) staff did their usual meticulous best to provide high quality data with remarkably fast turn-around times. The folks there are a pleasure to work with, especially Nancy R., Leon, and Dean, our go-to people for process questions, sampling needs, and analytical questions, respectively.

- Nancy Rosenbower performed sample tracking services with help from Nancy Jensen, Aileen Richmond, Susan Carrell, Meredith Jones, and Deborah Clark.
- Dean Momohara supervised the Inorganics section. Dean was always responsive to our needs and willing to re-analyze samples if there were any questions.
- Kim Archer, Daniel Baker, Crystal Bowlen, Sally Cull, Nancy Jensen, Aileen Richmond, Rebecca Wood and Heidi Chuhran performed general chemistry analyses.
- Nancy Jensen, Sally Cull, and Susan Carrell were responsible for the microbiology.
- Sally Cull, Meredith Jones, Dean Momohara, and Rebecca Wood worked on low-level metals, and Sally Cull prepared metals sample containers.
- Leon Weiks provided sample containers and other supplies, and Leon and Dean provided transport services.
- Joel Bird managed the lab and kept everything working smoothly.

Introduction

The Washington State Department of Ecology (Ecology) and its predecessor agency have operated an ambient water quality monitoring program since 1959. Between 1995 and 2010, the basic program consisted of monthly water quality monitoring for conventional parameters at 62 long-term stations and 20 basin (rotating) stations on rivers and streams throughout Washington State. Beginning with Water Year (WY) 2011, we added more long-term stations and reduced the number of basin stations. In addition, we sampled 6 special project stations.

Our data are provided free to the public and are widely used by academics, consultants, local governments, schools, and others interested in the quality of Washington's flowing waters.

Within Ecology, data generated by ambient monitoring are used to:

- Determine if waters are meeting standards or are in need of cleanup (e.g., www.ecy.wa.gov/programs/wq/303d/index.html).
- Identify trends in water quality characteristics (e.g., Hallock, 2005).
- Refine and verify Total Maximum Daily Load (TMDL) models.
- Develop water quality-based permit conditions.
- Conduct site-specific evaluations (e.g., Hallock, 2004).

A generalized assessment of water quality at particular stations is provided online (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html) in the form of a water quality index (WQI; Hallock, 2002). The WQI and trends at long-term stations are reported in *Washington State Water Quality Conditions in 2005 based on Data from the Freshwater Monitoring Unit* (Hallock, 2005). This report describes the WY 2012 monitoring program and discusses the quality of the data collected in WY 2012. More detailed analyses and interpretations of ambient monitoring data are reported elsewhere (for example, see our reports at www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

Other Ecology programs conduct some of their own analyses. For example, Ecology's Water Quality Program applies its own data reduction procedures prior to producing Washington State's Water Quality Assessment [303(d) & 305(b) Report], which includes the list of waters needing to be cleaned up (www.ecy.wa.gov/programs/wq/303d/index.html

Goals and Objectives

The primary goals of the River and Stream Ambient Monitoring Program are to monitor trends in the water quality of Washington's rivers and streams, to support a companion probabilistic biological monitoring program (Merritt, 2006), and to support Clean Water Act Section 303(d) reporting.

Beginning with WY 2011, we modified the objectives for basin stations and added a new station type. See Hallock (2011) for a description of our previous monitoring design; a white paper discussing the redesign of our monitoring objectives is available on request.

- **Long-term station** objectives are unchanged. Stations are monitored every year to track water quality changes over time (trends), assess inter-annual variability, and collect current water quality information. These stations are generally located near the mouths of major rivers, below major population centers, where major streams enter Washington, or upstream from most anthropogenic (human-caused) sources of water quality problems.

- **Basin stations** are selected to support the "Water Quality Assessment" process and Clean Water Act (303(d)) listings (http://ecy.wa.gov/programs/wq/303d/index.html). Specific objectives are to:
  - Confirm current Category 5 (Polluted Waters) listings: Some listings are based on old or suspect data; recent data of known quality will help remove waterbodies from the Category 5 list that are currently supporting standards.
  - Determine a category for currently unlisted waterbodies.
  - Better define current Category 5 listings.
  - Determine whether Category 2 (Waters of Concern) listings should be Category 1 (Meets Standards) or Category 5.
  - Identify *high quality* Tier III waters.

- **Sentinel sites** are *long-term* stations with the following objectives:
  - Support Ecology's probabilistic *watershed health* monitoring program.
  - Characterize reference conditions.
  - Provide trend data for reference conditions.
  - Monitor climate change.

- **Special project station** objectives are unchanged. These stations are typically sampled to address a particular question, and they are usually supported by funding external to the ambient monitoring program. We may not sample these stations for the entire usual suite of sampled parameters, or we may sample extra parameters. Special project stations will not necessarily represent typical water quality conditions.

Monitoring in Water Year 2012

In WY 2012, we monitored 66 long-term, 11 basin, and 5 sentinel stations (82 total). In addition, we monitored 6 stations associated with special projects (with external funding) in Ecology's Southwest Region. All the special project stations were associated with the Intensively Monitored Watersheds (IMW) project (see www.ecy.wa.gov/programs/eap/imw).

Besides routine grab-sample monitoring, we conducted the following additional monitoring activities:

- We collected 30-minute interval temperature data from about July through September 2012 at long-term and basin stations.
- We conducted bi-monthly metals monitoring at 12 selected stations.
- We conducted continuous monitoring for temperature, dissolved oxygen, pH, and conductivity at 10 stations, including six stations in support of IMW work. Results were delivered in near-real-time to the Internet by satellite telemetry at most stations.

Methods

Sampling Network

The ambient monitoring network in WY 2012 consisted of monthly water collection at all stations. Ambient stations monitored during WY 2012 are listed in Table 1. Appendix A lists current and historical monitoring locations and the years they were monitored by Ecology and its predecessor agency.

A description of our long-term monitoring program, access to most historical data, and previous annual reports can be found on Ecology's Internet web site at www.ecy.wa.gov under the "Environmental Assessment" program and "River and Stream Water Quality."

Table 1. Ecology stream ambient monitoring stations for Water Year 2012.
See Appendix A.

Key	Station	Location	Status[a]	Key	Station	Location	Status[a]
1	01A050	Nooksack R @ Brennan	C	45	25F060	Mill Cr nr mouth	P
2	01A120	Nooksack R @ No Cedarville	C	46	26B070	Cowlitz R @ Kelso	C
3	01F070	SF Nooksack @ Potter Rd	B	47	27B070	Kalama R nr Kalama	C
4	03A060	Skagit R nr Mount Vernon	C	48	27D090	EF Lewis R nr Dollar Corner	C
5	03B050	Samish R nr Burlington	C	49	28D170	Salmon Cr @ NE 199th/Hill rd	B
6	04A100	Skagit R @ Marblemount	C	50	31A070	Columbia R @ Umatilla	C
7	05A070	Stillaguamish R nr Silvana	C	51	31E060	Glade Cr @ SR14	B
8	05A090	SF Stillaguamish R @ Arlington	C	52	32A070	Walla Walla R nr Touchet	C
9	05A110	SF Stillaguamish R nr Granite Falls	C	53	33A050	Snake R nr Pasco	C
10	05B070	NF Stillaguamish R @ Cicero	C	54	34A070	Palouse R @ Hooper	C
11	05B110	NF Stillaguamish R nr Darrington	C	55	34A170	Palouse R @ Palouse	C
12	05L100	Church Cr @ 284th St	B	56	34B110	SF Palouse R @ Pullman	C
13	05M050	Montague Cr @ Hwy 530	B	57	35A150	Snake R @ Interstate Br	C
14	07A090	Snohomish R @ Snohomish	C	58	35B060	Tucannon R @ Powers	C
15	07C070	Skykomish R @ Monroe	C	59	35D120	NF Asotin Cr blw Lick Cr	S
16	07D050	Snoqualmie R nr Monroe	C	60	36A070	Columbia R nr Vernita	C
17	07D130	Snoqualmie R @ Snoqualmie	C	61	37A090	Yakima R @ Kiona	C
18	07R050	French Cr nr mouth	B	62	37A205	Yakima R @ Nob Hill	C
19	08C070	Cedar R @ Logan St/Renton	C	63	38A050	Naches R @ Yakima on US HWY 97	C
20	08C110	Cedar R nr Landsburg	C	64	39A055	Yakima R @ Umtanum Cr Footbridge	C
21	09A080	Green R @ Tukwila	C	65	39A090	Yakima R nr Cle Elum	C
22	09A190	Green R @ Kanaskat	C	66	39R050	Umtanum Cr nr mouth	S
23	10A070	Puyallup R @ Meridian St	C	67	41A070	Crab Cr nr Beverly	C
24	11A070	Nisqually R @ Nisqually	C	68	45A070	Wenatchee R @ Wenatchee	C
25	12A110	Clover Cr abv Steilacoom Lk	B	69	45A110	Wenatchee R nr Leavenworth	C
26	13A060	Deschutes R @ E St Bridge	C	70	46A070	Entiat R nr Entiat	C
27	14C050	Happy Hollow Cr at WA106	B	71	48A075	Methow R nr Pateros @ Metal Br	C
28	16A070	Skokomish R nr Potlatch	C	72	48A140	Methow R @ Twisp	C
29	16B130	Hamma Hamma R @ Lena Creek Camp	S	73	49A070	Okanogan R @ Malott	C
30	16C090	Duckabush R nr Brinnon	C	74	49A190	Okanogan R @ Oroville	C
31	18B070	Elwha R nr Port Angeles	C	75	49B070	Similkameen R @ Oroville	C
32	19C060	West Twin R nr mouth	P	76	53A070	Columbia R @ Grand Coulee	C
33	19D070	East Twin R nr mouth	P	77	54A120	Spokane R @ Riverside State Pk	C
34	19E060	Deep Cr nr mouth	P	78	55B070	Little Spokane R nr mouth	C
35	20B070	Hoh R @ DNR Campground	C	79	56A070	Hangman Cr @ mouth	C
36	20E100	Twin Cr @ Upper Hoh Rd Br	S	80	57A150	Spokane R @ Stateline Br	C
37	20F070	Lake Cr at Hwy 101	B	81	59A080	Colville R @ Greenwood Loop Rd	C
38	22A070	Humptulips R nr Humptulips	C	82	59B200	Little Pend Oreille R nr NatWildRef	S
39	23A070	Chehalis R @ Porter	C	83	60A070	Kettle R nr Barstow	C
40	23A160	Chehalis R @ Dryad	C	84	61A070	Columbia R @ Northport	C
41	24B090	Willapa R nr Willapa	C	85	61B070	Deep Cr nr mouth	B
42	24F070	Naselle R nr Naselle	C	86	61C100	Onion Cr @ Widow-Hawks Rd	B
43	25D050	Germany Cr @ mouth	P	87	62A090	Pend Oreille R @ Metaline Falls	C
44	25E060	Abernathy Cr nr mouth	P	88	62A150	Pend Oreille R @ Newport	C

[a] C: long-term
S: Sentinel
B: basin
P: Special Project (Intensively Monitored Watersheds)

Sample Collection and Analysis

We collected water samples from the majority of stations as single, near-surface grab samples from highway bridges. We sampled a small subset of stations from the bank, off of culverts, and other locations. Sampling locations are identified on our web site.

We monitored for 12 standard water quality parameters monthly at all stations (Table 2).

Table 2. Water quality parameters monitored in Water Year 2012.
*Standard parameters collected at all stations are in **bold**.*

Parameter	Method	Typical Reporting Limit
Ammonia, total	SM 4500 NH3H	0.01 mg/L
Carbon, dissolved organic	SM 5310 B	1 mg/L
Carbon, total organic	SM 5310 B	1 mg/L
Chlorophyll	SM 10200H3	0.1 ug/L
Conductivity	SM 2510 B	NA
Fecal coliform bacteria	SM 9222 D	1 colony/100 mL
Hardness	SM 2340 B	Not specified
Metals: mercury	EPA 245.7	0.002 ug/L
Metals: other	EPA 200.8	various
Nitrate + nitrite, total	SM 4500 NO3I	0.01 mg/L
Nitrogen, total	SM 4500 NB	0.025 mg/L
Nitrogen, total (dissolved)	SM 4500 NB	0.025 mg/L
Oxygen, dissolved	SM 4500 OC	0.01 mg/L
pH	SM 4500 H+	NA
Phosphorus, soluble reactive	SM 4500 PG	0.003 mg/L
Phosphorus, total	SM 4500 PF	0.005 mg/L
Suspended solids, total	SM 2540 D	1 mg/L
Suspended sediment concentration	ASTMD3977B	1 mg/L
Temperature	SM 2550 B	NA
Turbidity	SM 2130	0.5 NTU

SM: APHA, 2005
EPA: U.S. Environmental Protection Agency, 1983

Besides the 12 water quality parameters, we also recorded barometric pressure (to calculate percent oxygen saturation) and stream stage measurements, where necessary, to enable flow determination for most long-term stations and some basin stations. We collected metals samples bi-monthly at 12 stations and additional parameters, such as total organic carbon and chlorophyll, by request at selected stations.

Sample collection and analytical methods are described in our standard operating procedures (Ward, 2007; Ward, 2011), ambient monitoring quality assurance (QA) documents (Hallock and Ehinger, 2003; Hallock, 2012a; and Hopkins, 1996), and Manchester Environmental Laboratory's *Lab Users Manual* (MEL, 2008). Further, to ensure sampler consistency, we use a new staff training program, do annual staff training, and also conduct annual staff method audits (*ride-alongs*).

Program Changes

All long-term monitoring programs experience changes in sampling or analytical procedures that can potentially affect results. Normally, these changes are implemented to improve precision or reduce bias. Most changes will have only a minor effect on a synoptic analysis of the data, but even minor improvements in procedures should be considered when evaluating long-term trends.

We made no changes to collection, analytical, or quality control (QC) procedures in WY 2012 that we believe will materially affect trends. However, we did make or anticipate several changes which should not materially affect our data:

- We changed pH electrodes from an Orion model 250A, which is no longer available, to a Hach model HQ40d with the PHC281 pH probe. Comparison tests are reported in Hallock (2012b).
- We explored the possibility of using a smaller filtration apparatus beginning with WY 2014 for pre-processing grab samples used in the laboratory analysis of orthophosphorus (OP), described below.
- We explored an increasing bias in conductivity measurements relative to Manchester Environmental Laboratory (MEL) measurements, described below.

All known and suspected changes to methods and procedures during the history of the stream monitoring program, as well as large-scale environmental changes that may affect a trend analysis, are documented in Appendix B.

Smaller Filtration Apparatus

In previous years, the Freshwater Monitoring Program (FMU) used a 142 mm diameter filter to pre-process grab samples for the laboratory analysis of orthophosphorus (OP). However, these large filters have become more expensive and we would like to switch to a smaller filter (102 mm) of identical material. This change also requires using a smaller filter stand.

We collected duplicate grab samples during several months and from all ambient runs. We field filtered samples using both large and small filters and filter stands. We determined differences between laboratory results for both filters by linear regression (Sokal and Ralph, 1995). Linear regression results indicated that there were no significant differences ($p > 0.05$) between OP laboratory results that were field filtered with large and small filter stands (Table 3).

In addition, samplers reported that the smaller filters performed as expected and were able to filter even turbid water in a reasonable amount of time.

Based on these results, FMU, with the concurrence of the Freshwater Technical Coordination Team, plans to change to the small filters beginning with WY 2014 (October, 2013).

Table 3. Linear Regression results for comparisons between larger filter stands and small filter stands.
Large Filter = a + b Small Filter; n = 138.

	Coefficients	Standard Error	t Stat	P-value
Intercept (a)	0.0002285	0.000236	0.966455	0.336
Slope (b)	0.9635951	0.008886	108.4434	<0.001
R Square 0 .98				

Conductivity

FMU has used several different 100 uS/cm sodium chloride conductivity standards over the last few years in an attempt to ensure the best calibration accuracy. Concerns about a 500 mL VWR-brand standard degrading or becoming contaminated before we could use it all prompted us to change to a smaller 100 mL “one-shot” snap-top standard in the spring of 2006. However, we also discovered problems with the accuracy and consistency of this standard and switched to a 100 mL screw top standard by Ricca in the summer of 2009. Similar issues with this standard prompted us to switch to an even smaller Ricca 20 mL foil packet in the winter of 2011.

We observed an increasing bias during this period in the relative percent difference (RPD) between our field samples and laboratory-measured conductivity (Figure 1). After some testing, we concluded that this bias may be due to inconsistency in the standards we have been using relative to MEL’s standard. (MEL manufactures their own suite of standards as needed and calibrates their instruments when they vary by more than 5% from their standards.)

Beginning with WY 2014, we intend to return to using a 500 mL Ricca standard as a stock solution, taking 100 mL aliquots in the field for calibration checks. In addition, we will perform daily calibration check measurements against a standard provided by MEL.

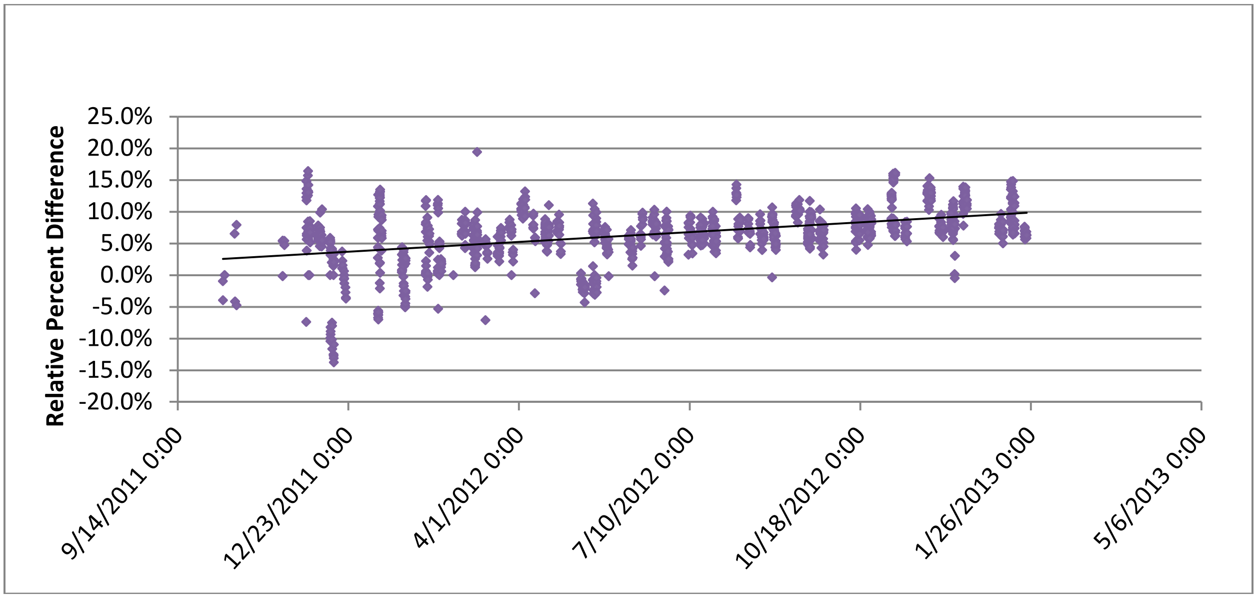

Figure 1. Relative Percent Difference for field and Manchester Environmental Laboratory (MEL) conductivity results from 10/2011 to 1/2013.

Continuous Temperature Monitoring

This program's goal is to collect summer, diel (24-hour) temperature data with 30-minute monitoring intervals at most long-term and current basin ambient monitoring stations, as well as at some special request stations. The data are primarily used for trend analyses and to determine the stream's compliance with water quality standards.

The scope of this program is being incrementally expanded (as resources and locations allow) with the establishment of year-round temperature (and in some instances, seasonal oxygen) monitoring stations. During this past year, we established four more year-round temperature stations, increasing the total to twelve.

We try to deploy the loggers that collect summer data by early July and retrieve them in late September. We also try to swap out the loggers at our year-round stations following a similar (June-September) schedule.

We typically deploy two Onset StowAway TidbiT® temperature loggers at each site, one in water and one in air. All deployed loggers are shaded with a PVC pipe and installed in a location considered representative of the surrounding environment. We usually install stream temperature loggers about six inches off the stream bottom to minimize potential influence from groundwater inflow. Loggers are placed in a free-flowing location at a depth to avoid exposure to air resulting from low streamflows.

Beginning in WY 2012, we set all deployed loggers to *standard time*. Previously, we deployed loggers primarily during daylight savings time and we used local time because it matched field sample times. However, we found that the new loggers would not follow local time and this caused year-round deployment sample time issues (local time has twice-yearly time shifts). In addition, we completely adjusted all our historical logger data sample times to *standard time*.

Detailed protocols are found in Ward (2011) and QC requirements in Ward (2005).

Continuous Oxygen Monitoring

Like temperature, oxygen concentration changes in a sinusoidal pattern over a 24-hour period. Oxygen concentration is typically lowest in the morning and highest in the late afternoon. Usually, daily lows are of the most interest because they have the most impact on aquatic life. Due to sampling logistics and laboratory sample holding time issues, our grab-sample monitoring program typically does a poor job of capturing daily low oxygen concentrations.

To measure daily low oxygen concentrations, we need diel oxygen data. We are primarily interested in annual lows (usually occurring in mid to late summer), but we are also interested in concentrations that coincide with the beginning and ending of salmonid spawning seasons, which vary according to location.

In WY 2012, we deployed Hydrolab® Minisondes with optical oxygen sensors (LDO) or In Situ® optical oxygen sensors (RDO) at 10 stations, 6 in support of the IMW project and 4 to supplement grab sample monitoring (Table 4). All instruments were connected to near real-time telemetry stations. We also deployed two self-contained systems (without telemetry) in 2012, but both of these failed the end of the year QC review. The two failed deployments were at 05L070-Church Cr near Stanwood and 07R050- French Creek- near mouth. All instruments recorded temperature, oxygen, and conductivity readings every 15 minutes. Several instruments also recorded pH. Our methods are described in Hallock (2009). We hope to expand this program in the future; however, we have no dedicated funding and are dependent on available resources.

Table 4. Stations monitored for continuous oxygen in Water Year 2012.

Station	Name	Objective
08C110	Cedar River near Landsburg	Long-term; reference conditions
19C060	West Twin River near mouth	Support IMW project
19D070	East Twin River near mouth	Support IMW project
19E060	Deep Creek near mouth	Support IMW project
20F070	Lake Creek at Lake Pleasant Hwy 101	Confirm Category 5 listing for temperature and oxygen; provide data for "natural conditions" assessment
25D050	Germany Creek at mouth	Support IMW project
25E060	Abernathy Creek near mouth	Support IMW project
25F060	Mill Creek near mouth	Support IMW project
28D170	Salmon Creek @ NE 199th St.	Confirm Category 5 listing for temperature; support other work in basin
41A070	Crab Creek near Beverly	Oxygen is Category 2 (pH is 5). Assess to move to 1 or 5.

IMW: Intensely Monitored Watersheds

Metals Monitoring

Metals monitoring continued in WY 2012 at 12 stations (Table 5). Metals samples were collected every other month beginning in October 2011.

Table 5. Bi-monthly sampling stations for metals in Water Year 2012.

Station	Name		Station	Name
01A120	Nooksack R @ No Cedarville		34B110	SF Palouse R @ Pullman
07D050	Snoqualmie R nr Monroe		37A205	Yakima R @ Nob Hill
07R050	French Cr nr mouth		39A090	Yakima R nr Cle Elum
10A070	Puyallup R @ Meridian St		49B070	Similkameen R @ Oroville
12A110	Clover Cr abv Steilacoom Lk		57A150	Spokane R @ Stateline Br
27B070	Kalama R nr Kalama		61C100	Onion Cr @ Widow-Hawks Rd

Samples were analyzed for hardness, total mercury, and total and dissolved arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc except at Nooksack at North Cedarville and at Puyallup at Meridian Street which were only analyzed for total mercury.

Collection procedures and analytical methods are discussed in more detail in Ward (2007) and Hopkins (1996).

Our current objectives for metals monitoring are as follows:

- Continue trend monitoring in the Spokane River at Stateline Bridge.
- Assess metals at the few remaining long-term stations where we have never collected metals data.
- Assess metals at basin stations in developed areas or in areas with a history of mining in the watershed.
- Assess for mercury in the Puyallup and Nooksack Rivers, which receive glacial melt water.

Lake Monitoring

Although Ecology currently has no official statewide lake monitoring program, Ecology management agreed to fund the analysis of total phosphorus samples collected from lakes visited by staff, as part of Ecology’s aquatic plant monitoring program. Plant monitoring staff collected 21 samples from 14 lakes. Two lakes were visited twice, duplicates were collected from two lakes, and hypolimnion samples were collected from three lakes.

The author of the QA Project Plan for this monitoring project is Bell-McKinnon (2011).

Quality Assurance

The Freshwater Ambient Monitoring QA program can be broken out into two primary focus areas:

1. Those that involve laboratory analysis of the samples.
2. Those concerning the collection and processing of the water samples in the field.

Ecology's MEL QA program includes the use of:

- QC charts
- check standards
- in-house matrix spikes
- laboratory blanks
- performance evaluation samples

For a more complete discussion of laboratory QA, see MEL's *Quality Assurance Manual* (MEL, 2012) and their *Lab Users Manual* (MEL, 2008).

The QA program for field sampling consisted of three parts:

1. Adherence to standard operating procedures for sample/data collection and periodic evaluation of sampling personnel.
2. Consistent instrument calibration methods and schedules.
3. The collection of field QC samples during each sampling run.

Our QA program is described in detail in Hallock and Ehinger (2003) and Hallock (2012a).

Three types of field QC samples were collected:

1. *Duplicate (Sequential) Field Samples.* These consisted of an additional sample collection made approximately 15-20 minutes after the initial collection at a station. These samples represent the total variability due to short-term, instream dynamics; sample collection and processing; and laboratory analysis.
2. *Duplicate (Split) Field Samples.* These consisted of one sample (usually the duplicate sequential sample) split into two containers that are processed as individual samples. We do this to eliminate instream and sample collection variability so we can assess the remaining variability attributable to field processing and laboratory analysis.
3. *Field Blank Samples.* These consisted of the submission and analysis of de-ionized water and are true field process blanks. The blank de-ionized water was poured into cleaned sample collection equipment, and the sampler simulated collecting a water sample, including lowering the sampling device to the water surface. The expected value for each analysis is the reporting limit for that analysis. Significantly higher results would indicate that sample contamination had occurred during field processing or during laboratory analysis.

We submit QC samples semi-blind to the laboratory. Samples are identified as QC samples, but sample type (duplicate, split, or blank) and station are not identified.

In WY 2012, we processed 114 field QC samples for standard parameters: 15 field blanks, 50 field duplicates (sequential), and 49 field split samples. In addition, the laboratory conducted its own splits of some field QC samples. The central tendency of the variance of pairs of split field samples was summarized by calculating the square root of the mean of the sample-pair variances (root-mean-square - RMS). These figures provide an unbiased and higher estimate than other commonly used statistics (for example, mean or median of the standard deviations).

We use a two-tiered system to evaluate data quality of individual results based on field QC. The first tier consists of four automated checks: holding time, variability in field duplicates, reasonableness of the result, and the balance of nutrient species. Results exceeding pre-set limits are flagged. The second tier QC evaluation consists of a manual review of the data flagged in the first tier. Data are then coded from 1 through 9 (1 = data meet all QC requirements, 9 = data are unusable). Criteria for assigning codes are discussed in more detail in Hallock and Ehinger (2003). We do not routinely use or distribute data with quality codes greater than 4.

Finally, data management includes verification at several stages:

- We verify field data entry quarterly by comparing field data forms to printouts from the database.
- At the end of the WY, we electronically compare data in Ecology's Environmental Information Management (EIM) database and in the database used for our web presentation to the primary database.
- We visually check plots of streamflow versus stage height for anomalies. For flows determined independent of stage records, this method confirms the flow. (Most flows are derived from continuous recorders and based on date and time, not stage.) For flows based on stage, this method confirms that the flow was correctly determined from the flow curve, but the method cannot ensure that stage was correctly recorded.

Continuous Temperature Monitoring

The quality of the continuous temperature data was assessed by calibration checks using a certified reference thermometer before and after a deployment. If a pre-survey calibration check indicated that a logger's accuracy was not within the required limits (0.2 °C for water and 0.4 °C for air) when compared to a certified reference thermometer, then the logger was rejected and not deployed (Ward, 2005).

If a logger failed a post-survey calibration check, then the results may be rejected or we may adjust results if the change in bias between pre- and post-deployment calibration checks was <0.05 ºC (i.e., the pre-deployment bias was just within the required limits and the post-deployment bias was just outside the limits).

All datasets are graphically reviewed to identify and delete anomalies. In addition, we compare the data to the field temperature measurements taken at deployment and retrieval with a calibrated alcohol thermometer or thermistor. We also assess the differences between the continuous results recorded by the logger and monthly measurements collected during grab-sample monitoring surveys.

We upload all finalized results and summaries into our database, our webpage, and Ecology's EIM database.

Continuous Multiple Parameter Monitoring

We used the procedures outlined in Hallock (2009) to assess the quality of data collected by multi-parameter probes.

In most cases, we compared grab sample results to continuous results determined by linear interpolation between the recorded results preceding and following the grab sample time. All times were first adjusted to Pacific Standard Time. We performed the following QC checks:

- Examination of a plot of continuous data overlaid with grab sample data for signs of outliers (caused, for example, by signal noise) in the continuous data, or drift in the continuous data compared to the grab data.
- Calculation of the mean difference between continuous and grab sample results. If >2%, continuous results were adjusted for offset and drift, where such adjustment was appropriate as indicated by a plot of the data. This adjustment was made prior to conducting additional QC evaluations.
- Comparison of the average relative standard deviation (RSD) of continuous and grab sample data pairs to the precision requirements in Hallock (2009).
- Comparison of individual differences between continuous and grab sample results to the accuracy requirements in Hallock (2009).

Results and Discussion

The primary purpose of this report is to present the results of Ecology's stream monitoring in WY 2012. The main body of the report describes the sampling program and interprets QC results. Appendix C describes where our monitoring data can be found. Raw data are available in computer formats on request and are posted on Ecology's web pages (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html). Unpublished data are also available online but are considered "preliminary."

Monthly Ambient Monitoring

A station-by-station data analysis is not within the scope of this report. Individual results not meeting the 2006 water quality criteria in Washington's Water Quality Standards (WAC Chapter 173-201A), excluding un-ionized ammonia, are identified in reports on our web site (www.ecy.wa.gov/apps/watersheds/riv/exceed). The un-ionized ammonia criteria are complicated to determine and are rarely exceeded (not met) in ambient waters. In WY 2012, no samples exceeded the chronic un-ionized ammonia criteria. Un-ionized ammonia was more than 15% of the chronic criterion at two stations: Glade Creek at SR14 (31E060**;** 35% of criterion) and South Fork Palouse River at Pullman (34B110; 26% of criterion).

Effective December 20, 2006, Ecology adopted an aquatic life system for classifying the state's waterbodies, dropping the AA, A, B, and C system in the 1997 standards (Ecology, 2006). Some of the numeric criteria from the new 2006 water quality standards are listed in Tables 6 and 7. The Ecology ambient monitoring program's comparison of results to water quality criteria on our web pages is not a formal determination of water quality *violations.* Determining violations requires additional considerations such as human impact or multiple results not meeting a criterion, and in some cases continuous data are desired. (See www.ecy.wa.gov/programs/wq/303d//policy1-11Rev.html.)

Of the nearly 13,000 possible standard water quality results in WY 2012, we only missed collecting 227 results (1.8%). Most results (101) were missed because of sampler error due to scheduling problems or delays that resulted in a station being dropped. Weather-related causes such as the station being frozen or inaccessible due to snow resulted in 66 missed samples. Other reasons for missing results included road construction or other access problems (24), equipment failure (12), and one station dried up in the summer (24). Appendix D gives more detailed explanations for each missed result.

Flows are not available for 4 of 5 sentinel stations or for 5 of 11 basin stations (Table 8).

In addition, 27 flows were not available at various times and stations due to ice, equipment failure, failure of the sampler to record stage, and for unknown reasons. We identified all flows from 19 stations as (1)"estimated" because rating curves were out of date or imprecise, (2) mean daily flow (rather than instantaneous) was used, or (3) for other reasons.

Table 6. Water quality criteria in the 2006 water quality standards associated with aquatic life uses[a].

Results outside the ranges shown do not meet the criterion.

Aquatic Life Use	Temperature (7-DADMax)[b] (°C)	Oxygen (1-day minimum) (mg/L)	pH (standard units)
Char spawning	<=9		
Char spawning and rearing	<=12	>9.5	6.5<=pH<=8.5
Salmon and trout spawning[c]	<=13		
Core summer salmonid habitat	<=16	>9.5	6.5<=pH<=8.5
Salmonid spawning rearing and migration	<=17.5	>8.0	6.5<=pH<=8.5
Salmonid rearing and migration only	<=17.5	>6.5	6.5<=pH<=8.5
Non-anadromous interior redband trout	<=18	>8.0	6.5<=pH<=8.5
Indigenous warm-water species	<=20	>6.5	6.5<=pH<=8.5

[a] WAC 173-201A-602 (Ecology, 2006) identifies use designations for waterbodies and some exceptions to the standard criteria listed above. Metals criteria, most of which are a function of hardness, are not listed here.

[b] 7-DADMax = 7-day average of the daily maximum temperature.

[c] An additional temperature criterion applies during specified seasons for some waterbodies (Payne, 2006).

Table 7. Water quality criteria in the 2006 water quality standards associated with contact recreation.[a]

Results outside the ranges given do not meet the criterion.

Recreation Use	Fecal Coliform Bacteria (cfu/100 mL)	
	10%	Geometric Mean
Extraordinary primary contact recreation	<=100	<=50
Primary contact recreation	<=200	<=100
Secondary contact recreation	<=400	<=200

[a] WAC 173-201A-602 (Ecology, 2006) identifies use designations for waterbodies.

Table 8. Flows are not available for these stations.

Station	Station Name	Station Type
05M050	Montague Cr @ Hwy 530	Basin
14C050	Happy Hollow Cr at WA106	Basin
16B130	Hamma Hamma R @ Lena Creek Camp	Sentinel
20E100	Twin Cr @ Upper Hoh Rd Br	Sentinel
20F070	Lake Cr at Hwy 101	Basin
31E060	Glade Cr @ SR14	Basin
39R050	Umtanum Cr nr mouth	Sentinel
59B200	Little Pend Oreille R nr NatWildRef	Sentinel
61C100	Onion Cr @ Widow-Hawks Rd	Basin

Continuous Temperature Monitoring

During WY 2012, our summer monitoring goals were met at 22 western Washington and 16 eastern Washington stations (Table 9). We collected data at two additional special request stations (SF Stillaguamish nr Centennial Trail and NF Stillaguamish nr Centennial Trail) but these data did not include the critical period because they were deployed late. We were unable to find two eastern Washington water loggers (Glade Cr @ SR14 and Walla Walla River) and consider them lost. In addition, data was lost at one eastern Washington station where the logger was vandalized (Kettle River nr Barstow).

We also had successful Fall-Spring deployments at seven Western Washington stations.

The seven-day average of the daily maximum temperature (7-DADMax) failed to meet the basic 2006 criteria at most stations (33 of 40 stations, 82%). Nine stations did not meet supplemental temperature criteria (Table 10). More stations would probably have failed the supplemental criteria, but deployment dates at most stations rarely include the beginning or ending of the supplemental season.

Seasonal maximum temperatures were more typical in 2012 than in the previous two years. In 2011, maximum temperatures at the warmest five stations ranged from 23.0 to 26.9 ºC. In 2012, maximum temperatures at the warmest five stations ranged from 23.9 to 29.3 ºC (Table 11). However, this may be partly due to the relatively few stations monitored in WY 11, especially in eastern Washington.

Table 9. Temperature summary for Water Year 2012 (°C).

Stations with 7-DADMax exceeding criteria (excluding special seasonal criteria) are shown in bold.

Station	Criterion	Sup. Criterion[a]	Deployment Maximum		7-DADMax [b]		Deploy Date	Retrieve Date
			Max	Date/Time [c]	Max	Date [c]		
05A070	17.5	Yes	22.8	05-Aug-12	21.6	15-Aug-12	24-Jul-12	11-Oct-12
05B070	16	Yes	21	05-Aug-12	20	14-Aug-12	24-Jul-12	21-Sep-12
05A085	16	Yes	23.9	05-Aug-12	22.6	15-Aug-12	24-Jul-12	11-Oct-12
05B050	16	Yes	21.9	18-Aug-12	20.9	16-Aug-12	08-Aug-12	11-Oct-12
05B110	12	Yes	17.6	17-Aug-12	17.2	15-Aug-12	24-Jul-12	21-Sep-12
05L100	16	No	19.2	05-Aug-12	17.5	14-Aug-12	24-Jul-12	11-Oct-12
05M050	16	No	23.3	05-Aug-12	22.3	14-Aug-12	24-Jul-12	21-Sep-12
07D130	16	No	19.4	16-Aug-12	18.9	15-Aug-12	24-Jul-12	21-Sep-12
09A190	16	Yes	18.3	17-Aug-12	17.9	14-Aug-12	28-Jun-12	21-Sep-12
11A070	16	Yes	17.6	05-Aug-12	16.8	14-Aug-12	10-Jul-12	21-Sep-12
13A060	17.5	No	20.3	05-Aug-12	19.4	14-Aug-12	06-Jul-12	24-Sep-12
14C050	16	No	11.5	05-Aug-12	11.2	14-Aug-12	20-Jun-12	20-Sep-12
16A070	16	Yes	14.5	05-Aug-12	13.6	06-Aug-12	23-Jul-12	20-Sep-12
16C090	16	Yes	13.9	15-Aug-12	13.6	14-Aug-12	23-Jul-12	20-Sep-12
18B070	16	No	14.9	17-Aug-12	14.5	14-Aug-12	23-Jul-12	20-Sep-12
20B070	16	Yes	16.8	05-Aug-12	16.4	14-Aug-12	23-Jul-12	20-Sep-12
20E100	12	No	9.04	07-Sep-12	9	05-Sep-12	17-Jul-12	28-Sep-12
22A070	16	Yes	21.5	16-Aug-12	20.4	14-Aug-12	23-Jul-12	20-Sep-12
23A070	17.5	Yes	23.8	16-Aug-12	22.9	14-Aug-12	12-Jun-12	23-Oct-12
23A160	16	Yes	23.7	17-Aug-12	22.4	14-Aug-12	26-Jun-12	17-Sep-12
24F070	16	Yes	21.2	16-Aug-12	20.1	14-Aug-12	17-Jul-12	17-Sep-12
26B070	17.5	No	19.4	05-Aug-12	17.6	04-Aug-12	11-Jun-12	23-Oct-12
27B070	16	Yes	18.6	06-Aug-12	18	15-Aug-12	22-Jun-12	18-Sep-12
28D170	16	Yes	21.6	17-Aug-12	20.6	15-Aug-12	22-Jun-12	18-Sep-12
34A070	17.5	No	29.1	12-Jul-12	28.1	11-Jul-12	12-Jul-11	29-Oct-12
34A170	20	No	29.3	12-Jul-12	28.3	11-Jul-12	27-Jun-12	29-Oct-12
34B110	17.5	No	23.4	12-Jul-12	22.9	11-Jul-12	27-Jun-12	29-Oct-12
39A090	16	Yes	19	17-Aug-12	18.7	18-Aug-12	26-Jun-12	30-Oct-12
39R050	17.5	Yes	22.6	19-Aug-12	22.3	16-Aug-12	26-Jun-12	30-Oct-12
41A070	17.5	No	27.9	18-Jul-12	26.4	08-Aug-12	18-Jul-12	30-Oct-12
46A070	17.5	Yes	21	14-Aug-12	20.6	16-Aug-12	17-Jul-12	14-Nov-12
48A070	17.5	Yes	21.5	18-Aug-12	21.2	15-Aug-12	17-Jul-12	19-Nov-12
48A140	17.5	Yes	18.8	05-Aug-12	18.4	15-Aug-12	17-Jul-12	19-Nov-12
55B070	16	No	19.4	18-Jul-12	18.4	21-Jul-12	18-Jul-12	16-Nov-12
56A070	17.5	No	24.3	18-Jul-12	23	21-Jul-12	18-Jul-12	16-Nov-12
59A080	17.5	No	22.4	19-Aug-12	21.8	17-Aug-12	17-Jul-12	06-Nov-12
59B200	17.5	No	19.7	18-Jul-12	18.6	08-Aug-12	18-Jul-12	06-Nov-12
61B070	16	No	21	08-Aug-12	20.2	07-Aug-12	18-Jul-12	06-Nov-12
61C100	16	No	16.4	08-Aug-12	15.6	08-Aug-12	18-Jul-12	16-Nov-12
62C070	16	No	11.7	08-Aug-12	11.2	08-Aug-12	18-Jul-12	07-Nov-12

[a] Indicates whether station has supplemental spawning and incubation protection temperature criteria (Payne, 2006).
[b] This is the 7-day period with the highest average of daily maximum temperatures.
[c] There may be other dates or other 7-day periods with the same maximum. Date shown is middle of 7-day period.

Table 10. Stations exceeding the 13 ºC supplemental temperature criterion (Payne, 2006).

Station	Station Name	7-DADMax [a]		Supplemental Season	Deploy Date	Retrieve Date
		Max	Date			
05A085	SF Stillaguamish R nr Centennial	18.1	17-Sep	09/15-07/01	24-Jul-12	11-Oct-12
05B050	NF Stillaguamish R nr Centennial	18.5	7-Sep	09/01-07/01	08-Aug-12	11-Oct-12
05B070	NF Stillaguamish R @ Cicero	17.6	5-Sep	09/01-07/01	24-Jul-12	21-Sep-12
09A190	Green R @ Kanaskat	17.1	16-Sep	09/15-07/01	28-Jun-12	21-Sep-12
11A070	Nisqually R @ Nisqually	15.4	16-Sep	09/15-07/01	10-Jul-12	21-Sep-12
20B070	Hoh R @ DNR Campground	15.5	5-Sep	09/01-07/01	23-Jul-12	20-Sep-12
22A070	Humptulips R nr Humptulips	14.5	15-Sep	02/15-07/01	04-Oct-11	23-Jul-12
23A160	Chehalis R @ Dryad	15	1-Jul	09/15-07/01	26-Jun-12	17-Sep-12
39A090	Yakima R nr Cle Elum	16.6	17-Sep	09/15-06/15	26-Jun-12	30-Oct-12

[a] This is the middle of the 7-day period with the highest average of daily maximum temperatures during the first or last part of the supplemental season. Stations that exceeded the criterion at both the beginning and ending of the season are listed twice.

Table 11. The five stations with the warmest maximum temperatures in 2012 and the maximum temperatures at those stations since 2009 (ºC).

Station	Station Name	2012	2011	2010	2009
34A170	Palouse R @ Palouse	29.3	26.8	28.2	28.7
34A070	Palouse R @ Hooper	29.1	26.9	28	29.1
41A070	Crab Cr nr Beverly	27.9	NS	NS	29.9
56A070	Hangman Cr @ Mouth	24.3	NS	NS	25.5
05A085	SF Stillaguamish R nr Centennial Tr	23.9	NS	NS	NS

NS: Not Sampled

Continuous Multiple Parameter Monitoring

Continuous data from multiple parameter monitoring are maintained at the River and Stream Flow Monitoring web pages (www.ecy.wa.gov/programs/eap/flow/shu_main.html). Continuous monitoring data from the IMW stations were presented in this report as well. We rejected all results from stations 05L070 Church Creek and 07R050 French Creek (see the Quality Control section). Results from other continuous multiple parameter monitoring stations are discussed below.

Dissolved Oxygen

Four stations met criteria for 7-day averages of daily minimums (7-DADMin) for dissolved oxygen concentrations.

- 08C110 - Cedar R nr Landsburg
- 25D050- Germany Cr @ mouth
- 25E060- Abernathy Cr nr mouth
- 25F060- Mill Cr nr mouth)

Six stations did not meet criteria for 7-day averages of daily minimums (7-DADMin) of dissolved oxygen concentrations during the critical period (July-September), when the highest annual temperatures and lowest annual oxygen concentrations are expected (Table 12).

- 20F070- Lake Cr at Hwy 101
- 28D170- Salmon Cr @ NE 199th/Hill Rd
- 41A070- Crab Cr nr Beverly
- 19C060- West Twin R nr mouth
- 19D070- East Twin R nr mouth
- 19E060- Deep Cr nr mouth)

Station 41A070-Crab Creek near Beverly had the lowest daily minimum dissolved oxygen concentration of 6.14 mg/L. The criterion (7-DADMin >6.5 mg/L) for 41A070 is considerably low as compared to other stream segments within the Lower Crab Creek watershed. Currently, lower Crab Creek is under a Category 2 listing for dissolved oxygen. Potential factors influencing dissolved oxygen and other water quality constituents are being reviewed by current water quality improvement projects in the Lower Crab Creek watershed (Ecology, 2013).

Temperature

7-DADMax for temperature was warmer than the basic criteria at:

- 28D170- Salmon Cr @ NE 199th/Hill Rd
- 41A070- Crab Cr nr Beverly
- 25D050 - Germany Cr @ mouth
- 25E060- Abernathy Cr nr mouth

Station 41A070-Crab Cr nr Beverly exceeded the 7-DADMax temperature criteria by 10.4 °C (Table 12).

Five stations met seasonal criteria of daily maximums (7-DADMax) for temperature.

- 08C110- Cedar R nr Landsburg
- 25E060- Abernathy Cr nr mouth
- 25F060- Mill Cr nr mouth
- 19D070- East Twin R nr mouth
- 19E060- Deep Cr nr mouth

Temperature data from 20F070-Lake Creek at Hwy 101 was rejected due to decreased water levels in the channel during the low flow period resulting in prolonged air temperature exposure.

One or more reaches of these streams are already listed as Category 5 for temperature in the 2012 Water Quality Assessment

- Deep Creek
- Lake Creek
- Germany Creek
- Abernathy Creek
- Mill Creek
- Crab Creek

Salmon Creek was moved to Category 4A in 2012 from the Category 5 2008 listing.

pH

Station 41A070- Crab Creek near Beverly exceeded the upper pH criterion (Table 12). This reach of the Crab Creek is listed as Category 5 for pH.

Table 12. Maximum 7-DADMax temperature and pH and minimum 7-DADMin oxygen compared to water quality criteria.
Values not meeting criteria are in bold.

Station	7-DADM[a]	Date[b]	Criteria/Comment
Dissolved Oxygen (mg/L)			
08C110	10.33	8/14/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30.
20F070	**8.12**	8/15/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 7.95.
28D170	**8.01**	8/15/2012	7-DADMin > 9.5 mg/L; data available between 11/23 and 9/30. Minimum single-day DO was 7.79 on 8/17
41A070	**6.14**	9/28/2012	7-DADMin > 6.5 mg/L; data available between 4/30 and 9/30. Minimum single-day DO was 6.02 on 9/8.
25D050	8.12	8/15/2012	7-DADMin > 8.0 mg/L; data available between 4/30 and 9/30. Minimum single-day DO was 7.95 on 8/16.
25E060	8.87	8/18/2012	7-DADMin > 8.0 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.74 on 8/16.
25F060	9.05	8/15/2012	7-DADMin > 8.0 mg/L; data available between 10/27 and 9/30. Minimum single-day DO was 8.90.
19C060	**8.31**	7/8/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.31
19D070	**9.49**	8/3/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.98 on 8/16.
19E060	**8.59**	9/7/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.39 on 9/8.

Table 12 continued on next page

Temperature (ºC)			
08C110	13.17	7/9/2012	7-DADMax ≤ 16.0 °C or < 13 °C seasonal criterion 9/15 through 5/15; data available between 10/1 and 9/30. 7-DADMax after 9/15 was **13.4**.
28D170	**20.52**	8/14/2012	7-DADMax ≤ 16.0 °C or < 13 °C seasonal criterion 02/15 through 06/15; data available between 10/1 and 9/30. 7-DADMax from 02/15 through 06/15 was **13.72** on 5/15. Temperature was **21.5** on 8/17.
41A070	**27.92**	7/10/2012	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30. Temperature was 28.5 on 7/9.
25D050	**20.12**	8/14/2012	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30. Temperature was **20.9** on 8/16.
25E060	**19.78**	8/14/2012	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30. Temperature was 20.7 on 8/16.
25F060	16.44	8/14/2012	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30. Temperature was **18.5** on 8/16.
19C060	14.83	8/24/2012	7-DADMax ≤ 16.0 °C or < 13 °C seasonal 02/15 through 07/01. Temperature was **15.2** on 8/25.
19D070	15.15	08/08/2012	7-DADMax ≤ 16.0 °C or <13 °C seasonal 02/15 through 07/01. 7-DADMax from 02/15 through 07/01 was 11.5 on 6/18. Temperature was 15.5 on 08/19.
19E060	14.76	08/24/2012	7-DADMax ≤ 16.0 °C or <13 °C seasonal 02/15 through 07/01. 7-DADMax from 02/15 through 07/01 was 10.8 on 5/22.
pH (standard units)			
08C110	7.93	7/30/2012	6.5 ≤ pH ≤ 8.5; data available between 10/1 and 9/30. The individual daily maximum was 8.02.
28D170	8.22	1/14/2012	6.5 ≤ pH ≤ 8.5; data available between 11/23 and 9/30. The individual daily maximum was 8.44.
41A070	**9.13**	8/2/2012	6.5 ≤ pH ≤ 8.5; data available between 5/4 and 9/30. The individual daily maximum was 9.19.
20F070	7.98	10/16/2012	6.5 ≤ pH ≤ 8.5; data available between 10/5 and 5/7. The individual daily maximum was 8.60.

[a] The highest seven day average of daily maximums in each dataset for temperature or pH, or the lowest seven day average of daily minimums for dissolved oxygen datasets.
[b] Date is the middle of the averaged 7-day period.
DO: Dissolved Oxygen

Metals Monitoring

During WY 2012, we collected all of the possible metals results at 8 of the 12 stations. The sampler failed to collect metals in December at 10A070 Puyallup River and 12A110 Clover Creek. We missed dissolved metals at 34B110 SF Palouse River in August because the filter failed. 61C100 Onion Creek was frozen in February. We also collected a few additional metals analytes, on occasion, from stations that were intended to be collected for mercury only.

Of the 533 dissolved metals and total mercury results reported, 7 (1.3%) exceeded 2006 Washington State water quality standards chronic criteria (Table 13). Dissolved zinc exceeded the criterion in the Spokane River at Stateline in most months and dissolved lead exceeded criteria twice. The Spokane River has a TMDL for metals, mostly due to legacy contamination from upstream mining practices. See Hallock (2010) for a review of long-term metals monitoring in the Spokane River.

Mercury exceeded the chronic criterion a single time at Clover Creek. It is not unusual to see occasional isolated mercury results exceed the criterion.

Table 13. Metals results from Water Year 2012 exceeding 2006 water quality standards criteria.

Date	Parameter	Hardness (mg/L)	Result (ug/L)	Chronic Criterion (ug/L)	Percent Over Chronic Criterion	Acute Criterion (ug/L)	Percent Over Acute Criterion
12A110 Clover Creek above Steilacoom Lake							
8/29/2012	Hg	NA	0.0275	0.012	129	2.1	--
57A150 Spokane River at Stateline Bridge							
4/17/2012	Pb_DIS	22	0.879	0.468	88	12.02	--
6/25/2012	Pb_DIS	16.9	0.48	0.35	38	8.92	--
12/13/2011	Zn_DIS	19.4	42.5	26.0	63	28.5	49
2/14/2012	Zn_DIS	20	49.3	26.7	84	29.3	68
4/17/2012	Zn_DIS	22	71.8	29.0	148	31.7	126
6/25/2012	Zn_DIS	16.9	36.3	23.2	57	25.4	43

Hg: mercury
Zn_DIS: dissolved zinc

Lake Monitoring

An analysis of total phosphorus data collected from lakes in 2012 is beyond the scope of this report. Data are available from Ecology's EIM database under project ID AMS002B-2 (provisional data) or AMS002B (published data).

Quality Assurance

In 2012 we collected almost 16,000 non-QC water quality results. These results included metals and various other parameters in addition to the standard 12 parameters listed in Table 2.

- We coded 26 results (0.2%) "4" indicating that the data are usable, but there were questions about the quality. These were from a variety of stations, dates, and parameters.
- We coded 173 results (1.1%) "5" or greater indicating serious data quality questions; these data will not be routinely used or provided. This practice gives us the opportunity to explain quality issues to prospective users before they obtain the data. Most of these results were coded "9" because we are not certain the sample was collected from the right location.

We qualified 17% of usable results. Of these, 710 results (4.6%) were qualified as estimates ("J"), 1847 results (12%) as below the reporting limit ("U"), 2 results (0.01%) were coded as both estimates and below the reporting limit ("UJ"), and 6 results (0.03%) were listed as greater than the reported value ("G"). Seventy percent of all ammonia results were below the reporting limit, as were 14% of orthophosphate results and 43% of all metals results (Table 14). ("Below the reporting limit" indicates that the analyte was present at an undetermined concentration less than the value reported.)

Table 14. Results qualified by Manchester Environmental Laboratory (MEL) as being below the reporting limit.

Parameter	Reporting Limit (mg/L except where otherwise noted)	Number of results coded U or UJ	Total number of results	Percent of results coded U or UJ
Ammonia	0.01	722	1032	70%
Chlorophyll	0.05 ug/L	0	35	0%
Fecal coliform bacteria	1	181	1033	18%
Hardness	Not specified	0	62	0%
Metals	Various	438	1026	43%
Nitrate+Nitrite	0.01	71	1032	7%
Nitrogen, total	0.025	23	1032	2%
Organic carbon, total	1	27	72	38%
Orthophosphate	0.003	134	948	14%
Phosphorus, total	0.005	40	1000	4%
Phosphorus, total reactive	0.005	1	8	13%
Suspended sediment concentration	1	20	69	29%
Suspended solids	1	88	1033	9%
Turbidity	0.5 NTU	104	1033	10%

Errors in EIM and Web Databases

The automated data verification process identified 421 instances where results in the EIM database ("transitional" project AMS001-2) were different than the results in our primary database. At 66 stations there were 384 results for barometric pressure (BP) that did not match results in our primary database. However, average BP differences for all of the mismatched results were low (0.004 mm Hg). This was most likely due to rounding errors and differences in significant digit formats between the two data sources. In addition, 21 oxygen results from 10/10/2011 and one from 2/22/2012 within the central and eastern regions were mismatched due to correctional factors that were not applied in EIM. For the same reasons, 15 temperature results from August 27, 28 and 29 were mismatched as well. One mismatched result was an incorrectly entered temperature value collected on 2/22/2012 from Hangman Creek at mouth which we failed to correct in EIM. A mismatched result for specific conductivity and pH was found at the same station during the same collection date as well.

In addition, 3 results (2 pH and 1 specific conductivity) from the Nooksack River at Brennan had not been entered into EIM at all. However, corrections and missing data were entered into EIM during October 2013.

All results in our preliminary web database did match results in our primary database. In addition, there were no results missing and no extra results found within the web database.

Comparison to Quality Control Requirements

Data Quality Objectives

Data quality objectives (DQOs) are based on RMS values broken out by concentration range (Table 15). In practice, estimates of variability are strongly influenced by extreme values, especially when the sample size (n) is small. Also, the variability estimate is skewed downward for the lowest concentration ranges because data below the reporting limit are censored. In other words, the reporting limit is given for any result below that limit and, therefore, sample pairs below this limit have a variance of zero.

Table 15. Root mean square (RMS) of the standard deviation of sequential samples, field splits, and laboratory splits.

Results exceeding Quality Assurance Monitoring Plan (QAMP) DQO criteria (Hallock and Ehinger, 2003) are shown in bold.

Parameter (units)	Range	$S_{err\ (mp)}$ [a]	Field Sequential RMS	*n*	Field Split RMS	*n*	Lab Split RMS	*n*
Specific conductance (µS/cm)	≤50 >50-100 >100-150 >150	4.4 8.8 13.2 26.4	0.0 3.08 3.51 15.0	8 22 7 12	No field splits		No lab splits	
Fecal col. bacteria (colonies /100 mL)	1-1000 >1000	88 176	14.2 71	49 1	No field splits		9.5 NA	42 0
Ammonia (µg N/L)	≤20 >20-100 >100	1.76 8.8 17.6	1.65 **12.8** 5.2	36 6 2	1.04 **14.1** 0.71	38 7 2	0.27 0.50 NA	14 2 0
Nitrogen, total (µg N/L)	≤100 >100-200 >200-500 >500	8.8 17.6 44 88	7.67 10.6 7.5 **436**	15 8 13 14	8.39 8.95 7.92 **1255**	13 6 14 14	5.58 13.4 7.31 12.4	6 1 5 5
Nitrate+nitrite-nitrogen (µg N/L)	≤100 >100-200 >200-500 >500	8.8 17.6 44 88	2.30 3.34 3.22 44.6	21 8 8 13	2.13 1.80 2.03 85	18 8 8 13	1.54 1.41 3.97 13.3	7 1 4 4
Oxygen, dissolved (mg O_2 /L)	≤ 8 >8-10 >10-12 >12	0.70 0.88 1.06 2.11	NA 0.15 0.10 0.14	0 9 16 22	No field splits		No lab splits	
pH	All	0.66	0.06	49	No field splits		No lab splits	
Phosphorus, soluble reactive (µg P/L^{-1})	≤50 >50-100 >100	4.4 8.8 17.6	0.41 0.87 NA	44 6 0	0.50 0.72 NA	52 5 0	0.49 0.19 NA	20 4 0
Phosphorus, total (µg P/L)	≤50 >50-100 >100	4.4 8.8 17.6	2.12 4.70 3.00	39 9 2	**5.50** 1.81 0.71	37 8 2	0.48 0.67 NA	11 5 0
Solids, suspended (mg /L)	≤10 >10-20 >20-50 >50	0.88 1.76 4.4 8.8	**1.79** **8.14** **5.57** **19.0**	37 6 3 4	No field splits		0.41 1.035 1.70 NA	15 7 5 0
Temperature (ºC)	All	2.64	0.25	50	No field splits		No lab splits	
Turbidity (NTU)	≤10 >10-20 >20-50 >50	0.88 1.76 4.4 8.8	**0.93** 0 0.79 NA	45 1 4 0	No field splits		0.15 1.70 0.87 NA	19 2 4 0

[a] Maximum permissible standard error to meet QAMP DQO (Hallock and Ehinger, 2003).
n: number of sample pairs
NA: not applicable

In general, variability of repeated measures followed the expected pattern of field sequential samples > field split samples > lab split samples. However, in some cases, field split or lab split samples had greater variability than field QC samples. Why this should be for field splits isn't clear. Lab splits are often based on different samples than the field QC samples. In either case, a single split pair with poor precision was often responsible.

Variability between paired samples as measured by RMS was generally low.

Three field split constituent/concentration ranges failed our QAMP DQO (Hallock and Ehinger, 2003), which specifies that DQOs be evaluated against field splits, where possible. The mid-range of ammonia, the high range of total nitrogen, and the low range of total phosphorus samples exceeded their DQOs. In the case of ammonia, two split pairs were particularly poor (0.085/0.047 and 0.01U/0.039 mg/L). Two total nitrogen pairs were extremely high (>45 mg/L) which drove the RMS up, even though the splits were relatively close. There was one particularly poor phosphorus sample pair (0.0434/0.0057 mg/L).

Several field sequential constituent categories failed to meet DQO criteria, but instream variability is included in these sample pairs so their variability is not a true measure of sampling plus analytical error. As in years past, the variability in sequential samples for total suspended solids (TSS) concentrations tended to be particularly high. This underscores the inherent variability in measurements of stream sediment.

No lab split constituent/concentration ranges failed DQO requirements. However, we only evaluated lab duplicates collected prior to January 2012. MEL still performs duplicate analyses and evaluates the results, but because of a change in data management procedures at the lab we are no longer able to process the results electronically.

The criteria in Table 15 are based on desired trend power. (We want to be able to detect a 20% change over a ten-year period with 90% confidence.) Parameters that consistently do not meet the DQO criteria are unlikely to meet our goals for trend detection. The variability in most parameters indicates equivalent or greater trend power than the goal specified in our QAMP (Hallock and Ehinger, 2003). Our ability to detect trends in TSS, however, is likely to be worse than our goal.

Measurement Quality Objectives

Measurement quality objectives (MQOs) for accuracy are based on comparisons (usually against standards) during calibration checks (Hallock, 2012a). Checks failing criteria cause an immediate corrective action (usually recalibration). Bias MQOs are evaluated at the laboratory based on spike recovery. Precision MQO evaluations are based on comparisons to average relative standard deviation (RSD) of field split pairs. Results are presented in Table 16.

Only the total organic carbon (TOC) and the total suspended solids (TSS) exceeded MQO criteria based on field split samples or sequential samples. However, we only collected three TOC QC samples and one pair was poor. TSS is notoriously imprecise, as we saw in the analysis of DQOs.

Table 16. Average relative standard deviation (RSD) of replicate samples collected in Water Year 2012.

Results exceeding QAMP MQO criteria (Hallock, 2012a) are shown in bold.

Parameter (units)	Precision MQO (%)	Sequential Sample RSD (%)	*n*[a]	Field Split RSD (%)	*n*[a]
Carbon, total organic	10	**16.8**	3	**17.0**	3
Chlorophyll	25	5.8	1	No field splits	
Specific conductance	10	0.92	49	No field splits	
Fecal coliform bacteria (>20 colonies /100 mL)	≥50% < 20 ≥90% < 50	56.3[b] 93.8[b]	16 16	No field splits	
Ammonia	10	5.3	50	6.2	47
Nitrogen, total	10	5.2	50	5.4	47
Nitrate+nitrite-nitrogen	10	1.9	50	2.6	47
Oxygen, dissolved	10	0.8	47	No field splits	
pH	10	0.4	49	No field splits	
Phosphorus, soluble reactive	10	3.4	50	3.3	47
Phosphorus, total	10	6.2	50	7.8	47
Solids, suspended	15	**17.2**	50	No field splits	
Suspended sediment concentration	15	8.9	3	No field splits	
Temperature	10	0.9	50	No field splits	
Turbidity	15	10.1	50	No field splits	

[a] "*n*" is the number of sample pairs.

[b] This is the percent of sample pairs (where the average is >20 colonies/100 mL) with RSD < 20% or <50%.

Blanks

Most results for analyses of blank samples were "below reporting limits," or less than 3 uS (microsiemens) for specific conductivity (Table 17). Blanks were not measured for temperature, dissolved oxygen, pH, or fecal coliform bacteria.

Protocols specify that one dissolved metals blank sample should be submitted annually from each run that collects metals. In WY 2012, we failed to collect dissolved metals blanks from the North and Western runs.

Historically, blanks for dissolved zinc frequently (43% of the time) exceeded (did not meet) reporting limits of 1 ug/L (though results were always < 5 ug/L, the reporting limit for total zinc). As a result, we set the quality code field = 4 for detected dissolved zinc results < 5 ug/L. The effect of this action is that our low-level zinc data on the Internet will be annotated with the footnote: “Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person.”

All conductivity blanks were less than 3 uS/cm, except two which were rejected due to sampler error.

Laboratory staff assessed the remaining elements of the laboratory QA program through a manual review of laboratory QC results including check standards, in-house matrix spikes, and laboratory blanks. Results were within acceptable ranges as defined by MEL’s *Quality Assurance Manual* (MEL, 2012) or were either re-run or coded as determined by laboratory staff (e.g., as an estimate, “J”).

Table 17. Results of field process blank (de-ionized water) samples.

Parameter	Reporting Limit	Number Above Reporting Limit	Sample Size *n*
Metals (ug/L)	Various	1 [a]	42
Carbon, total organic (mg/L)	1	0	1
Hardness (mg/L)	0.3	0	3
Ammonia (ug/L)	10	0	13
Nitrate+nitrite-nitrogen (ug/L)	10	0	13
Soluble reactive phosphorus (ug/L)	3	0	15
Specific conductivity (uS/cm)	NA	NA (mean: 1.2 uS, std dev: 0.44) [b]	9
Suspended solids (ug/L)	1	0	11
Total nitrogen (ug/L)	25	0	14
Total phosphorus (ug/L)	5	0	12
Turbidity (NTU)	0.5	0	10

NA: not applicable
[a] Dissolved zinc blank reported as 1.9J
[b] Excludes two results rejected due to sampler error.

Continuous Temperature Monitoring

Pre- and post-deployment calibration checks, using a certified reference thermometer, met or exceeded (were better than) the criteria for the instruments (Ward, 2005).

Most of the summer temperature loggers were deployed by July 24.

Continuous Multiple Parameter Monitoring

Some deployments extended beyond the water year reviewed in this annual report; however, for continuous multiple parameter monitoring, we reviewed all data from each location. Deployments at two locations, 05L070-Church Cr near Stanwood and 07R050- French Creek-near mouth failed QC requirements for all parameters due to excess sedimentation, frequent decreases in water levels during the summer months and sensor malfunction. We rejected all data from all deployments at these locations. Both deployments were "stand-alone" (i.e., not telemetered), illustrating the usefulness of telemetry, where problems can be identified and corrected relatively quickly. Several stations that had only single QA grab samples obtained during the deployment periods were coded "estimates".

Continuous monitoring data from the IMW stations were processed in time to be included in this QC review, which is performed after visually reviewing data and removing anomalous data points.

Dissolved Oxygen

In addition to 05L070-Church Cr near Stanwood and 07R050- French Creek, Hydrolab®, dissolved oxygen sensors failed QC requirements (Table 18) at one additional station for a 4-month period (19C060-West Twin river near mouth; deployment period: 5/22-9/25).

Each of the 11 remaining stations except 20F070 needed a small constant value adjustment (offset) based on check sample results to account for probable calibration errors. Stations that required slight positive offsets were 08C110, 28D170, 25E060, 25F060, 19E060, 19D070 and 19C060. Station 41A070 required a small negative offset for two deployment periods.

Generally, most LDO sensors were extremely stable, with little or no drift over the course of the deployment. Though oxygen sensors were generally quite "clean," unexplained spikes occurred at times. These spikes usually occurred as a sharp and obvious change rather than a gradual one, and so were easy to spot and remove prior to the numerical QC review reported in Table 18. On the whole, the RSD between the optical dissolved oxygen sensor results and Winkler results is 0.8% greater than the RSD between sequentially collected Winkler grab samples (Table 18).

Table 18. Quality control (QC) results from continuous multiple parameter monitoring.

Average and RSD were calculated after applying offset and removing rejected data. A positive Average indicates that check samples were higher than matching continuous results. Rejected deployments and data considered "unreliable estimates" are in ***bold****.*

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
Dissolved Oxygen (mg/L)					
08C110	4/18 08:15	None (1.92)	-0.01%	1.58%	
	7/16 08:30	None (-0.63)	-0.36%	3.31%	
	9/17 08:00	-0.57 (-5.70)	-0.28%	3.76%	
28D170	12/6 10:30	None (-1.16)	0.00%	0.00 %	Code "estimate" because only one valid check sample.
	1/10 12:30	+1.02 (8.16)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	4/10 11:30	+.81 (6.71)	0.01%	2.02%	
	5/22 10:30	+.33 (3.06)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	9/18 10:15	None (1.41)	0.00%	0.40%	
41A070	08/08 09:00	-0.46 (-5.68)	0.01%	3.17%	
	09/12 16:15	-0.26 (-2.54)	-0.00%	1.77%	Code "estimate" because only one valid check sample.
20F070	07/24 13:00	None (.90)	-0.01%	1.10%	
25E060	11/14 13:35	+0.49 (4.20)	-0.04%	0.49%	
	2/6 13:20	+0.36 (2.80)	-0.03%	0.58%	
	4/9 12:30	+.86 (6.80)	0.05%	1.73%	
	9/17 15:30	+0.57 (5.40)	-0.02%	1.19%	
25F060	12/05 12:50	None (1.37)	0.00%	0.06%	
	9/18 14:30	+.43 (3.76)	-0.13%	1.71%	
19E060	12/20 15:40	+0.7 (5.60)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	1/24 15:20	+0.43 (3.52)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	2/29 14:05	+0.32 (2.57)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	3/27 16:00	+0.31 (2.67)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	5/22 16:20	+0.38 (3.33)	0.00%	0.31%	Code "estimate" because only one valid check sample.
	9/25 15:45	+.65	0.00%	1.28%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
		(6.38)			
19D070	2/29 16:00	+0.36 (2.80)	-0.03%	1.17%	
	8/28 16:30	+0.5 (4.80)	**4.76%**	**3.45%**	**Code "estimate": Offset did not meet QC requirements.**
19C060	12/21 08:15	+0.86 (6.71)	-0.1%	2.61%	
	3/27 16:40	+0.29 (2.38)	0.0%	0.54%	
	5/22 17:10	+0.68 (5.66)	**5.7%**	**4.14%**	**Code "estimate": Offset did not meet QC requirements.**
	9/25 16:30	+2.13 (20.44)	**0.4%**	**9.19%**	**Code as "estimate": Positive drift is indicated after offset is applied. RSD is excessive, though within QC requirements.**
Temperature (ºC)					
08C110	04/18 08:15	-0.5 (-8.78)	-1.21%	6.72%	
	07/16 08:30	+0.5 (4.27)	-0.59%	4.48%	
	09/17 08:00	+0.45 (4.15)	0.01%	0.98%	
28D170	12/6 10:30	-0.2 (-5.71)	0.00%	0.00	Code "estimate" because only one valid check sample.
	1/10 11:45	-0.3 (-5.26)	0.00%	0.00	Code "estimate" because only one valid check sample.
	4/10 10:45	-0.4 (-5.51)	0.51%	1.99%	
	5/22 10:30	None (0.00)	0.00	0.00	Code "estimate" because only one valid check sample.
	9/18 10:15	None (-.38)	0.00%	0.27%	Code "estimate" because only one valid check sample.
41A070	08/08 09:00	-0.4 (2.68)	0.11%	1.95%	
	09/12 16:15	None (-1.16)	0.00%	0.81%	Code "estimate" because only one valid check sample.
20F070	04/24 14:10	None (0.92)	0.14%	0.61%	
25E060	11/14 13:35	None (-1.39)	0.10%	1.05	
	2/6 13:20	-0.4 (-7.65)	-0.12%	5.13%	
	4/9 12:30	-0.45 (-7.42)	0.10%	4.84%	
	9/17 15:30	-0.28 (-2.02)	0.08%	1.35%	
25D050	1/9 16:15	-0.2 (-3.13)	-0.26%	1.99%	
	2/6 14:15	-0.7 (-13.21)	0.00%	0.00%	Code "estimate" because only one valid check sample
	4/9 12:30	-0.45 (-7.42)	-0.27%	4.84%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
	9/17 14:00	-0.28 (-2.02)	-0.11%	1.35%	
25F060	12/5 12:50	+0.57 (7.75)	-0.45%	0.92%	
	08/13 14:55	-.42 (-5.17)	-0.06%	1.35%	Data gap after 8/13 (sensor malfunction)
19E060	12/20 15:40	+0.23 (3.70)	0.04%	0.50%	
	01/24 15:20	+0.70 (12.50)	0.00%	0.00%	
	02/29 14:05	+.50 (10.87)	0.00%	0.00%	Code “estimate” because only one valid check sample.
	03/27 16:00	+0.60 (8.22)	0.00%	0.00%	Code “estimate” because only one valid check sample.
	05/22 16:20	+.25 (2.55)	-0.23%	1.96%	Code “estimate” because only one valid check sample.
	09/25 15:45	+.32 (2.60)	0.00%	0.84%	
19D070	02/29 16:00	+.23 (4.20)	0.16%	2.47%	
	03/27 17:25	None (0.94)	-2.58%	1.80%	Code “estimate” because only one valid check sample.
	05/22 17:10	+.84 (7.43)	0.00%	0.00%	
	06/26 18:30	+0.84	7.43%	0.00%	Code “estimate” because only one check sample.
19C060	12/21 08:15	None (.4)	0.36%	1.14%	
	3/27 16:40	+0.63 (11.20)	0.51%	2.61%	Grab samples were consistent.
	5/22 17:10	None (1.10)	0.00%	0.00%	
	9/25 16:30	+0.43 (3.4)	0.07%	0.80%	
Conductivity (uS/cm)					
08C110	10/17 09:15	+4 (8.70)	0.00%	0.00%	
	4/18 08:15	+2 (4.88)	0.00%	0.00%	
	07/16 08:30	+1 (2.05)	-0.40%	0.98%	
	09/17 08:00	-1 (-1.54)	0.00%	0.00%	
28D170	12/06 10:30	+4 (10.81)	0.00%	8.08%	Code “estimate” because only one valid check sample.
	01/10 12:30	+5 (12.50)	0.00%	0.00%	Code “estimate” because only one valid check sample.
	4/10 11:30	**+5 (13.98)**	**2.63%**	**8.75%**	Code as “estimate”: Positive drift is indicated after offset is applied.
	5/22 10:30	+4 (10.30)	0.00%	7.64%	Code “estimate” because only one valid check sample.
	9/18 10:15	+1	0.18	0.00%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
		(1.36)			
41A070	08/08 09:00	+13.5 (2.44)	-0.38%	3.39%	
	09/12 16:15	-16.0	0.00%	0.00%	Code "estimate" because only one valid check sample.
20F070	04/24 14:10	+3.57 (7.3)	-1.19%	5.57%	
25E060	11/14 13:35	-5 (-10.09)	0.44%	2.99%	Grab samples were inconsistent.
	02/06 13:20	None (.65)	-0.25%	3.32%	
	04/09 12:50	-2 (-6.16)	0.10%	2.21%	
	09/17 15:25	-4.2 (-8.33)	2.61%	3.37%	
25D050	01/09 16:15	+1 (2.14)	-1.78%	3.13%	
	02/06 14:15	+3 (6.25)	-0.20%	4.44%	Code "estimate" because only one valid check sample.
	04/09 12:30	-0.5 (-1.08)	1.17%	2.47%	
	09/17 15:30	-1.6 (-4.18)	2.77%	0.87%	
25F060	12/05 12:50	None (1.84)	1.84%	0.34%	
	07/17 14:30	-0.8(-2.28)	0.34%	1.67%	
19E060	12/20 15:40	-3.3 (-3.85)	3.44%	2.48%	
	1/24 15:20	None (0.00)	0.00	0.00	Code "estimate" because only one valid check sample.
	2/28 14:05	**-8 (-11.59)**	**11.59%**	**8.70%**	**Reject Data.** Only one check sample.
	3/27 16:00	**-7 (-9.72)**	**9.72%**	**7.23%**	**Reject Data.** Only one invalid check sample.
	5/22 16:20	**-8 (-10.50)**	**10.50%**	**7.76%**	**Reject data**. Drift and check samples inconsistent.
	9/25 15:45	**-15 (13.34)**	**13.34%**	**10.10%**	**Reject data**. Drift and check samples inconsistent. RSD did not meet QC requirements.
19D070	2/29 16:00	+2.2 (2.58)	-0.21%	1.58%	
	8/28 16:30	None (-0.34)	-0.19%	1.28%	
19C060	12/21 08:15	None (-1.9)	-0.45%	2.48%	
	3/27 16:40	-9.33 (-13.5)	0.30%	6.82%	Excessive drift.
	5/22 17:10	-12.5 (-17.6)	-0.42%	3.38%	
	9/25 16:30	-14.6 (-15.1)	0.18%	2.13%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
pH (standard units)					
08C110	4/18 08:15	None (0.33)	0.00%	0.32%	
	7/16 08:30	+0.24 (3.28)	0.01%	2.35%	
	09/17 08:30	-0.05 (-0.74)	0.00%	0.52%	
28D170	12/6 10:15	-0.16 (-2.21)	0.00%	0.00%	Code “estimate” because only one valid check sample.
	1/10 11:00	+0.3 (4.14)	0.00%	0.00 %	Code “estimate” because only one valid check sample.
	4/10 11:00	None (0.46)	0.14%	0.65%	
	5/22 10:45	+0.25 (3.42)	0.00%	0.00 %	Code “estimate” because only one valid check sample.
	9/18 10:30	+0.21 (3.00)	0.02%	1.98%	
41A070	08/08 09:00	+.24 (-2.82)	-0.01%	2.07%	
	9/12 16:00	-0.37 (4.39)	0.00%	0.00%	Code “estimate” because only one valid check sample.
20F070	04/24 14:10	None (-0.12)	-0.14%	0.04%	

[a] Constant added to continuous data only if original average percent difference (in parentheses) was >2.0%.
[b] Percent difference between continuous data and grab sample after applying offset.

Temperature

The temperature signal from all sensors was both stable and clean. Small constant positive and negative adjustments were applied at various deployment periods for all stations based on check sample results. In 70% of deployments, precision was satisfactory compared to the allowed ±0.4 ºC difference between grab sample temperatures and recorded temperatures. However, 30% of grab samples did not meet the allowed ±0.4 ºC difference prior to applying offset corrections. This may be caused by slightly different locations for grab samples and sensor deployments. Grab samples should be collected as close to sensor deployment locations as possible.

We coded some continuous deployments as “estimates” because there was only one valid check sample obtained between deployment periods.

Conductivity

Some conductivity deployments exhibited apparent drift (28D170 and 19E060). To bring continuous data in line with check sample results, all stations required offset adjustments at various different deployment periods (Table 18). We rejected part of the dataset from 19E060 because the check sample conductivity from the 2/28-9/25 deployment period did not meet QC requirements to determine an offset with confidence. Likewise, check sample conductivity did not meet QC requirements at Station 41A070 for the deployment period ending in 08/08. There was an excessive 220 day data gap from 9/25 to 05/03 due to sensor malfunction. One small negative adjustment was applied to 41A070 from 8/08 to 9/12.

As previously observed in WY 2011, the conductivity sensors during the WY 2012 deployments exhibited more apparent noise than oxygen or temperature sensors. Noise was usually expressed as a single unusually high value, though sometimes the value was unusually low.

pH

Quality control (QC) results from continuous multiple parameter monitoring are presented in Table 18. However, pH was not a critical parameter for continuous monitoring and was included only because most of the instruments included pH sensors. PH data was not obtained at the IMW stations. Long-term continuous monitoring for pH will require telemetry, regular maintenance of the pH sensors, maintenance of battery voltage, and regular check samples.

Lake Monitoring

The average RSD from lake monitoring duplicate results was 9.9%, well below the MQO of 20% (Bell-McKinnon, 2011) but higher than previous years. RSDs for individual duplicate pairs were also all below 20% (Table 19). Oddly, RSD from lab splits were consistently greater than RSD from field duplicate samples.

Table 19. Lake total phosphorus sample quality control (QC) results (mg/L).

Lake	Date	Result	Duplicate	Duplicate Type	RSD
CLETH111E	8/30/2012 8:45	0.015 J	0.0127	Lab Split	11.7%
CONOK211E	8/20/2012 13:43	0.0156	0.0142	Field Duplicate	6.6%
MARKI111E	7/13/2012 9:07	0.0088	0.0067	Lab Split	19.2%
SILWH171E	9/14/2012 15:23	0.0071	0.0069	Field Duplicate	2.0%

MEL's QC results were within the specifications provided in laboratory QC guidance (MEL, 2012).

We consider QC results to be acceptable; data may be used without qualification beyond those applied by MEL.

Total phosphorus results and Secchi depth data were entered into EIM and independently reviewed for transcription errors.

Conclusions and Recommendations

Following are conclusions and recommendations resulting from this Water Year 2012 study by Ecology's River and Stream monitoring program.

Conclusions

- Most quality control (QC) results were within the limits specified in our Quality Assurance Monitoring Plan and were consistent with findings in previous years.
- We are likely to be able to meet our trend detection goal of a 20% change over a ten-year period with 90% confidence for all parameters except total suspended solids.
- Except where noted otherwise, data collected can be used without qualification.

Recommendations

- The QC review for continuous data is time-consuming. A thorough QC review will require dedicated staff. Failing this, streamlined and automated procedures should be developed to enable existing staff to perform at least a partial review.
- Several continuous monitoring stations had only a single QA grab sample collected during monthly site visits during the deployment. As a consequence, many of the deployments were coded as “estimates” and some did not meet QC requirements. To improve QC review for future deployments, a minimum of two QC grab samples should be obtained before and after servicing of multi-parameter probes. To improve the QC review for continuous temperature, factors influencing the differences between discrete and continuous temperature measurements (i.e., measurement locations and variations resulting from water depth) will be reviewed.

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Appendices

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Appendix A. Station Description and Period of Record

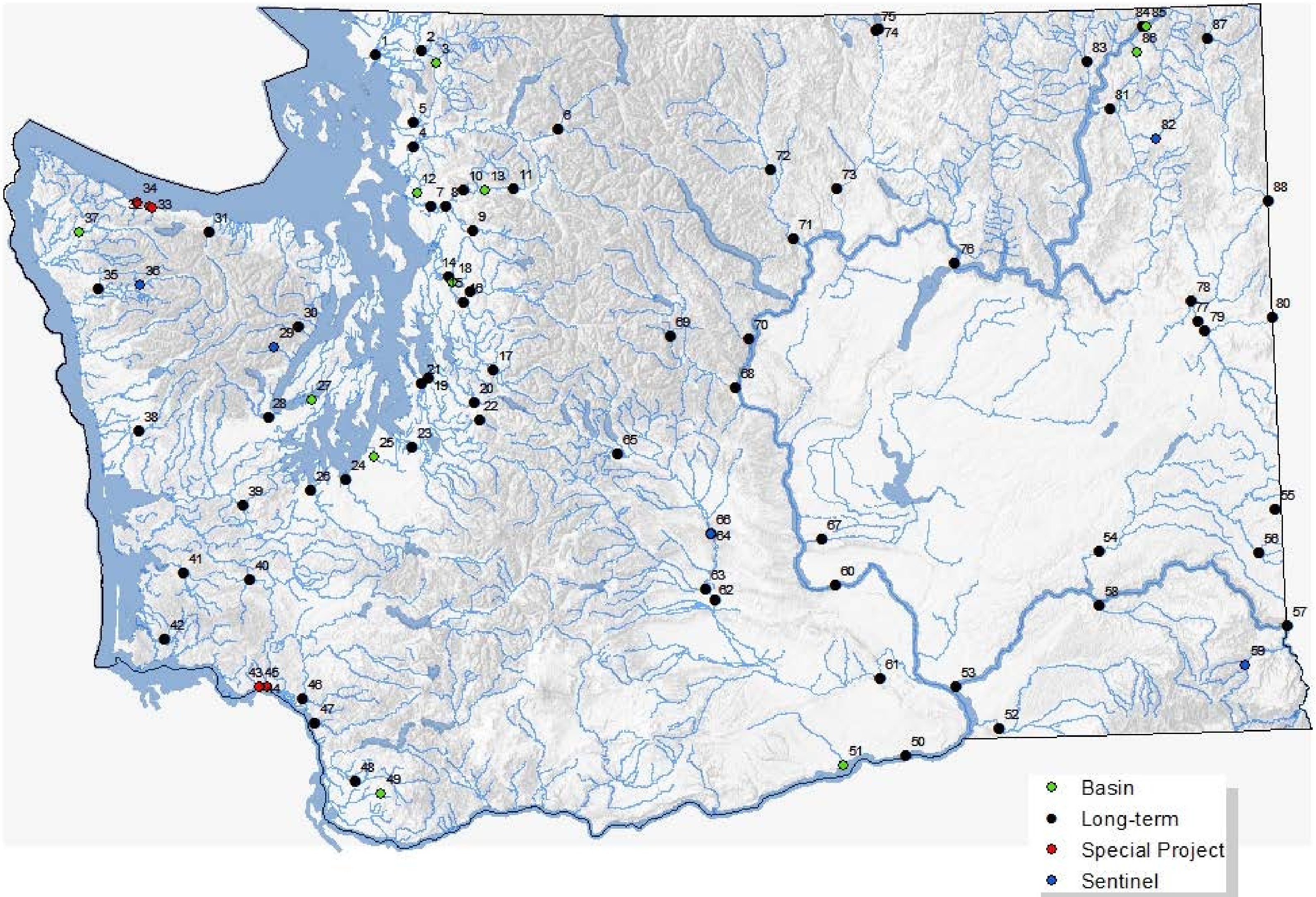

Figure A-1. Map showing stations monitored in Water Year 2012.

See Table 1 for the key.

Monitoring History for Environmental Assessment Program Ambient Monitoring Stations

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
01A050	Nooksack R @ Brennan	L			X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
01A070	Nooksack R @ Ferndale	B		XXXXXXXX	XX X X				
01A090	Nooksack R nr Lynden	B			X X X				
01A120	Nooksack R @ No Cedarville	L	X	XXXXXXXX X	XX X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
01A140	Nooksack R above the MF	B					X	X X	
01B050	Silver Cr nr Brennan	B					XX		
01D070	Sumas R nr Huntingdon BC	B			X X XXX	XXXXXXXXXX	XXX X		
01D080	Sumas R @ Jones Road	B						X	
01D090	Sumas R @ Sumas	B			X X				
01D120	Sumas R nr Nooksack	B					X		
01E050	Whatcom Cr @ Bellingham	B			X X		X		
01E070	Whatcom Cr @ Lake Outlet	B			X				
01E090	Whatcom Lake nr Bellingham	B		XXX X	X				
01F070	SF Nooksack @ Potter Rd	B					X	X X	X
01G070	MF Nooksack R	B					X	X X	
01H070	Terrell Cr nr Jackson Rd	B						X	
01N060	Bertrand Cr @ Rathbone Rd	B						X	
01T050	Anderson Cr @ South Bay Rd	B						X	
01U070	Fishtrap Cr @ Flynn Rd	B						X	
03A050	Skagit R @ Conway	B			X X				
03A060	Skagit R nr Mount Vernon	L	X	XXXXXXXX X	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
03A070	Skagit R nr Sedro Woolley	B			X X X				
03A080	Skagit R abv Sedro Woolley	B						X X	X
03B045	Samish R nr Mouth	B					X	X	
03B050	Samish R nr Burlington	L	X	XXXXXXXX X	XX X XXX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
03B070	Samish R nr Hoogdal	B			X				
03B077	Samish R abv Parson Cr	B							X
03B080	Samish R nr Prairie	B					X		
03C060	Friday Cr Blw Hatchery	B			X		X X		
03C080	Friday Cr at Alger	B			X				
03D050	Nookachamp Cr nr Mouth	B					X	X	
03E050	Joe Leary Slough nr Mouth	B						X	
03F070	Hill Ditch @ Cedardale Rd	B						X	

Station		Long-term				Water Year Sampled			
Number	Name	or Basin		<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
04A060	Skagit R @ Concrete	B			X X XXX	XXXXXXXXXX	XX X		
04A100	Skagit R @ Marblemount	L	X	XXXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
04A140	Skagit R @ Newhalem	B			X X				
04B070	Baker R @ Concrete	B		XXXX	XXX	XXXXXXXXXX	XX X		
04B150	Baker Lake @ Boulder Cr	B			XXXXX	X			
04C070	Sauk R nr Rockport	B			XXX	XXXXXXXXXX	XX X	X	
04C110	Sauk R @ Darrington	B	X	XX					
04C120	Sauk R @ Backman Park	B						X	
04E050	Finney Cr near Birdsview	B					X		
05A050	Stillaguamish R @ Stanwood	B			X				
05A055	Hat Slough nr Stanwood	B			X				
05A070	Stillaguamish R nr Silvana	L	X	XXXXXXXXXX	XX X XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
05A090	SF Stillaguamish R @ Arlington	L			X X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
05A110	SF Stillaguamish R nr Granite Falls	L	X	XXXXXXX	X		X XXXXX	XXXXXXXXXX	XXX
05B070	NF Stillaguamish R @ Cicero	L		XXXXXXXX	XX X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
05B090	NF Stillaguamish R @ Oso	B			X				
05B110	NF Stillaguamish R nr Darrington	L			X		X XXXXX	XXXXXXXXXX	XXX
05G050	Jim Cr @ Jordan Rd	B							X
05L100	Church Cr @ 284th St	B							X
05M050	Montague Cr @ Hwy 530	B							X
07A090	Snohomish R @ Snohomish	L	X	XXXXXXXX X	XX X XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
07A100	Snohomish R @ Short School Rd	B							X
07A109	Snohomish R nr Monroe NE	B			X				
07A110	Snohomish R nr Monroe SW	B			X				
07A111	Snohomish R nr Monroe (USGS)	B			XX X	XX			
07B055	Pilchuck R @ Snohomish	B			X X XX	XXXXXXXXXX	XXX X		
07B075	Pilchuck R @ Russel Rd	B							X
07B090	Pilchuck R nr Lake Stevens	B			X				
07B120	Pilchuck R @ Robe-Menzel Rd	B						X	
07B150	Pilchuck R @ Menzel Lake Rd	B						X	
07C070	Skykomish R @ Monroe	L			X X XXX	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXX
07C090	Skykomish R @ Sultan	B			X X				
07C120	Skykomish R nr Gold Bar	B	X	XXXXXXXXXX	X XX	XXXXXXXXXX	XXX	X	
07C170	Skykomish R nr Miller R	B			X				

Station Number	Name	Long-term or Basin	Water Year Sampled						
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
07D050	Snoqualmie R nr Monroe	L			X		XX XXXXX	XXXXXXXXXX	XXX
07D070	Snoqualmie R nr Carnation	B			X XX XXX	XXXXXXXXXX	XXX X		
07D100	Snoqualmie R abv Carnation	B						X	
07D130	Snoqualmie R @ Snoqualmie	L	X	XXXXXXXXXX	X XXX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
07D150	M F Snoqualmie R nr Ellisville	B					X	X	
07E055	Sultan R @ Sultan	B		XXXXXXXX X	XX X		X	X	
07F055	Woods Cr @ Monroe	B			X X		X X		
07G070	Tolt R nr Carnation	B		XXXXXXXXXX	X		X		
07M070	SF Snoqualmie R at North Bend	B					X		
07M120	SF Snoqualmie R @ 468th Ave SE	B						X	
07N070	NF Snoqualmie R near Ellisville	B					X		
07P070	Patterson Ck nr Fall City	B					X X		X
07Q070	Raging R @ Fall City	B					X	X	
07R050	French Cr nr Mouth	B					X		X
08A070	McAleer Cr nr Mouth	B			X				
08A090	Upper McAleer Cr	B			X				
08B070	Sammamish R @ Bothell	B	X	XXXXXXXXXX	XX X X XX	XXXXXXXXXX	XXXXX X		
08B110	Sammamish R @ Redmond	B			X		X		
08B130	Issaquah Cr nr Issaquah	B		XXX X	XX X X		X		
08C070	Cedar R @ Logan St/Renton	L	X	XXXXXXX	X X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
08C080	Cedar R @ Maplewood	B					X		
08C090	Cedar R @ Maple Valley	B			X		X		
08C100	Cedar R @ RR Grade Rd	B						X	
08C110	Cedar R nr Landsburg	L	X	XXX	X XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
08D070	Mercer Slough nr Bellevue	B			X				
08E090	Kelsey Cr @ Monitor Site	B			X				
08E110	Upper Kelsey Cr	B			X				
08F070	May Cr nr Mouth	B			X				
08G070	Valley Cr nr Mouth	B			X				
08H070	Thornton Cr nr Mouth	B			X				
08H100	North Branch Thornton Cr	B			X				
08J070	West Branch Thornton Cr	B			X				
08J100	Swamp Cr abv Lynnwood	B					X		
08K090	Ship Canal @ Freemont	B					X		

Station Number	Name	Long-term or Basin	Water Year Sampled	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
08K100	North Cr nr Everett	B					X		
08L070	Laughing Jacobs Cr nr Mouth	B						X	
08M070	SF Thornton Cr @ 107th Ave NE	B						X	
08N070	Johns Cr @ Gene Coulon Park	B						X	
09A060	Duwamish R @ Allentown Br	B				XXXXXXXXXX	XX		
09A070	Duwamish R @ Foster	B	X	XXXXXXXX					
09A080	Green R @ Tukwila	L					XXXXXXXXX	XXXXXXXXXX	XXX
09A090	Green R @ 212th St nr Kent	B			X XX	XXXXXXXXXX	XX X		
09A110	Green R @ Auburn	B		XXXXX X	XX				
09A130	Green R Abv Big Soos/Auburn	B	X	XXXXXXXXXX	X		X		
09A150	Green R nr Auburn	B			X				
09A170	Green R nr Black Diamond	B			X				
09A190	Green R @ Kanaskat	L	X	XX	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
09B070	Big Soos Cr blw Hatchery	B			X X				
09B090	Big Soos Cr nr Auburn	B		XXXX	XX		X X		
09C070	Des Moines Cr nr Mouth	B			X		X	X	
09C090	Des Moines Cr @ So 200th	B			X				
09D070	Miller Cr nr Mouth	B			X			X X	
09D090	Miller Cr @ Ambaum Blvd SW	B			X				
09E070	Mill Cr @ Orillia	B				XXXXXX	X X		
09E090	Mill Cr @ Kent on W Valley Hwy	B				XXXXXX	X		
09F150	Newaukum Cr nr Enumclaw	B					X		
09H090	Black R @ Monster Rd SW	B					X	X	
09J090	Longfellow Cr abv 24-25th St juctn	B						XX	
09K070	Fauntleroy Cr nr Mouth	B						XX	
09L060	Walker Cr near mouth	B						X	
09M050	North Cr at Seahurst Pk	B						X	
09N050	Mullen Slough @ Frager Rd	B							X
09Q060	Redondo Cr abv Marine View Dr S	B							X
10A050	Puyallup R @ Puyallup	B	X	XXXXXXXX X	XXX XXXXX	XXX		XXX	
10A070	Puyallup R @ Meridian St	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
10A075	Puyallup R @ East Main St	B						X	
10A080	Puyallup R nr Sumner	B						X	
10A090	Puyallup R @ McMillin	B			X X				

Station Number	Name	Long-term or Basin	Water Year Sampled	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
10A110	Puyallup R @ Orting	B	X	XXX XXXXXX	XXX X XX	XXXXXXXXXX	XX X X		
10B070	Carbon R nr Orting	B		XX	XX		X		
10B090	Carbon R @ Fairfax	B			X				
10C070	White R @ Sumner	B			XX XX	XXXXXXXXXX	XX X X		
10C085	White R nr Sumner	B		X	X X		X		
10C090	White R @ Auburn	B		XXXXX	X X				
10C095	White R @ R Street	B					X	XXXXXXX X	
10C110	White R blw Buckley	B			X				
10C130	White R @ Buckley	B					X		
10C140	White R nr Buckley	B			X				
10C150	White R nr Greenwater	B			X				
10D070	Boise Cr @ Buckley	B		XXX	X			X	
10D090	Boise Cr nr Enumclaw	B		XXX					
10E070	Salmon Cr @ Sumner	B			X				
10F070	South Prairie Cr nr Crocker	B			X				
10F090	South Prairie Cr nr S Prairie	B					X		
10G080	Hylebos Cr @ 8th St E	B							X
10H070	Lake Tapps Tailrace @ E Valley Hwy	B						X	
10I050	Joe's Cr @ SR 509	B						X	
10J050	Lakota Cr @ Dumas Bay Center	B							X
11A070	Nisqually R @ Nisqually	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
11A080	Nisqually R @ McKenna	B	X	XXXXXXXXXX	X		XX X		
11A090	Nisqually R abv Powell Cr	B			X XX	XXXXXXXXXX	X		
11A110	Nisqually R @ LaGrande	B			X				
11A140	Nisqually R @ Elbe	B			X X XX	X			
12A070	Chambers Cr nr Steilacoom	B		XXXXX	XX X	XXXXXX	XX X X		
12A100	Chambers Cr blw Steilacoom Lk	B		XX	X		XXX		
12A110	Clover Cr abv Steilacoom Lk	B		XXX	X		XXXX		X
12A130	Clover Cr nr Parkland	B		XX					
12B070	Leach Cr nr Steilacoom	B		XXX	X			X	
12C060	Flett Cr @ 75th St W	B							X
12C070	Flett Cr @ Custer Rd	B		XXX	X				
12D050	Ponce de Leon Cr nr mouth	B					XXX		
12F090	Spanaway Cr @ Old Military Rd	B						X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
13A050	Deschutes R @ Tumwater	B		XXXXX X	X X				
13A060	Deschutes R @ E St Bridge	L			XX	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXX
13A080	Deschutes R nr Olympia	B			X X X				
13A150	Deschutes R nr Rainier	B	X	XXX	X X XX	XXXXXXXXXX	XX X		
14A060	Goldsborough Cr @ Shelton	B					X X		
14A070	Goldsborough Cr nr Shelton	B		XXX X	X				
14C050	Happy Hollow Cr at WA106	B							X
15A070	Dewatto R nr Dewatto	B			XXX		X	X	
15B050	Chico Cr nr Chico	B					X	X	
15B070	Chico Cr nr Bremerton	B		XXXXX	X				
15C070	Clear Cr @ Silverdale	B					X	X	
15D070	Tahuya R @ Tahuya River Rd	B						X	
15D090	Tahuya R nr Belfair	B					X		
15E070	Union R nr Belfair	B					X	X	
15F050	Big Beef Cr @ Mouth	B						XXXXX	XX
15G050	Little Mission Cr @ Hwy 300	B						X	
15H050	Stimson Cr @ Hwy 300	B						X	
15J050	Big Mission Cr @ Hwy 300	B						X	
15K070	Olalla Cr @ Forsman Rd	B						X	
15L050	Seabeck Cr @ mouth	B						XXXXX	XX
15M070	Llt Anderson Cr @ Anderson Hill Rd	B						XXXXX	XX
15N070	Stavis Cr nr Mouth	B						XXXXX	XX
16A070	Skokomish R nr Potlatch	L		XXXXXXXX X	X XXX XX	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
16B070	Hamma Hamma R nr Mouth	B		XXXXXX X	X X				
16B110	Hamma Hamma R nr Eldon	B			XX		X		
16B130	Hamma Hamma R @ Lena Creek Camp	B							XX
16C070	Duckabush R @ Mouth	B		XXXXXXXX X	X X				
16C090	Duckabush R nr Brinnon	L			XXX		XXXXXX	XXXXXXXXXX	XXX
16D070	Dosewallips R @ Brinnon	B	X	XXXXXXXXXX	X XXX		X		
16E070	Finch Cr @ Hoodsport	B					X X		
17A060	Big Quilcene R nr mouth	B						XX	X
17A070	Big Quilcene R nr Quilcene	B	X	XXXXXXX	XXX		X X		
17B070	Chimacum Cr nr Irondale	B					X		
17B090	Chimacum Cr @ Hadlock	B			X				

Station Number	Name	Long-term or Basin	Water Year Sampled						
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
17B100	Chimacum Cr @ Chimacum	B					X		
17B110	Chimacum Cr nr Chimacum	B			X				
17C070	Jimmycomelately Cr near Mouth	B						XX	
17G060	Tarboo Cr nr mouth	B						X	
18A050	Dungeness R nr Mouth	B						XXXXXX	
18A070	Dungeness R nr Sequim	B	X	XXXXXXX	XXX		X X	XX	
18B070	Elwha R nr Port Angeles	L	X	XXXXXXX X	XXX		XXXXXX	XXXXXXXXXX	XXX
18B080	Elwha R @ McDonald Br (USGS)	B			XXXXX	XX			
19A070	Pysht R nr Pysht	B			XXX				
19B070	Hoko R nr Mouth	B			X				
19B090	Hoko R nr Sekiu	B			XX				
19C060	West Twin R nr mouth	B						XXXXX	XXX
19D070	East Twin R nr Mouth	B						XXXXX	XXX
19E060	Deep Cr nr mouth	B						XXXXX	XXX
20A090	Soleduck R nr Forks	B			XXX		X		
20A130	Soleduck R nr Fairholm	B		XXXXXXXX X	X				
20B070	Hoh R @ DNR Campground	L		XXXXXXXXXX	X XXX XX	X	XXXXXX	XXXXXXXXXX	XXX
20C070	Ozette R @ Ozette	B	X	XX					
20D070	Dickey R nr La Push	B					X		
20E100	Twin Cr @ Upper Hoh Rd Br	B							XX
20F070	Lake Cr at Hwy101	B							X
21A070	Queets R @ Queets	B		XXXXXXXXXX	X X		X		
21A080	Queets R nr Clearwater (USGS)	B			XX	XX			
21A090	Queets R abv Clearwater	B			XX				
21B090	Quinault R @ Lake Quinault	B	X	X XXXXXX	X XXX XX	X	X		
21C070	Clearwater R nr Queets	B			XX				
21D070	NF Quinault R @ Amanda	B			XXXXXXXXX	XX			
22A070	Humptulips R nr Humptulips	L	X	XXXXXXXXXX	X XXX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
22B070	WF Hoquiam R nr Hoquiam	B		XXXXX	XX		X		
22C050	Chehalis R nr Montesano	B			XX XX	XXXXXXXXXX	XXX		
22C070	Chehalis R nr Fuller	B			X X				
22D070	Wishkah R nr Wishkah	B		XXXXX	XX X				
22F090	Wynoochee R nr Montesano	B	X	XXXXXXXX X	X XX X				
22G070	Satsop R nr Satsop	B		XXXXXXXXXX	XX X XXX	XXXXXXXXXX	XX X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
22H070	Cloquallum Cr nr Elma	B		XXXX	X X X				
22J070	Wildcat Cr nr McCleary	B			X				
23A070	Chehalis R @ Porter	L	X	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
23A100	Chehalis R @ Prather Rd	B					XXX	XXXX	
23A110	Chehalis R @ Galvin	B			X X X				
23A120	Chehalis R @ Centralia	B			XX	XXXXXXXXXX	XX X		
23A130	Chehalis R @ Claquato	B					X		
23A140	Chehalis R @ Adna	B			X X X				
23A160	Chehalis R @ Dryad	L	X	XXXXXXX	XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
23A170	Chehalis R nr Doty	B						X	
23B050	Newaukum @ Mouth	B					X		
23B070	Newaukum R nr Chehalis	B		XXXXXXXX	X X X		X		
23B090	SF Newaukum R @ Forest	B			X				
23C070	NF Newaukum R @ Forest	B			X				
23D055	Skookumchuck R @ Centralia	B					X X		
23D070	Skookumchuck R nr Centralia	B	X	X					
23E060	Black R @ Hwy 12	B						X	
23E070	Black R @ Moon Road Bridge	B					XX X XXX		
23F070	Mill Cr nr Bordeaux	B					X		
23G070	SF Chehalis R @ Beaver Creek Rd	B					X	X	
24B090	Willapa R nr Willapa	L		XX X	XXXXX XXXX	XX XXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
24B095	Willapa R nr Menlo	B						X	
24B130	Willapa R @ Lebam	B	X	XX X	XX	XXXXXXXXXX	XXX		X
24B150	Willapa R @ Swiss Picnic Rd	B						X	
24C070	SF Willapa R @ South Bend	B			X				
24D070	North R nr Raymond	B			X XX		XX		
24D090	North R @ Artic	B					X		
24E070	North Nemah R @ Nemah	B			X X				
24F040	Naselle R @ Mouth	B			X				
24F055	Naselle R @ Naselle	B			X				
24F070	Naselle R nr Naselle	L		XX X	X X XXXX	X	X XXXXX	XXXXXXXXXX	XXX
24G070	Bear Branch nr Naselle	B		X	X				
24H070	Middle Nemah R nr Nemah	B			X				
24J070	South Nemah R nr Nemah	B			X				

Station Number	Name	Long-term or Basin	Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
24K060	Forks Cr abv Hatchery (outfall)	B						X
25A070	Columbia R @ Cathlamet	B	XX	X X				
25A075	Columbia R @ Bradwood	B		XXXXXX				
25A110	Columbia R @ Fisher Is Lt	B	XXXXX					
25A115	Columbia R nr Longview	B	XX	X X				
25A150	Columbia R blw Longview Br	B	X	X				
25B070	Grays R nr Grays River	B		X XX		X		X
25C070	Elochoman R nr Cathlamet	B	X	X XX		X	X	
25D050	Germany Cr @ mouth	B					XXXXX	XXX
25E060	Abernathy Cr nr mouth	B					XXXXX	XXX
25E100	Abernathy Cr @ DNR	B					XXXX	
25F060	Mill Cr nr mouth	B					XXXXX	XXX
25F100	Mill Cr @ DNR	B					XXXX	
25G060	Coal Cr @ Harmony Rd	B						X
26B070	Cowlitz R @ Kelso	L	XXXXXXX	XX X XX	XXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
26B100	Cowlitz R @ Castle Rock	B	XXX	X XXXX			X	
26B150	Cowlitz R @ Toledo	B	XXXXX	X X XX	X	X		
26B180	Cowlitz R nr Kosmos B Cispus	B	X|XXXXXXXX					
26B190	Cowlitz R nr Randle	B	X	X X X				
26B200	Cowlitz R nr Kosmos	B		X				
26C070	Coweeman R @ Kelso	B	XXXXX	XX X	XXXXXX	XXX X		
26C073	Coweeman R @ 3802 Allen Street	B						X
26C080	Coweeman R abv Goble Cr	B				X		
26C090	Coweeman R nr Rose Valley	B		X X				
26D070	Toutle R nr Castle Rock	B	XXXXXXXX X	X X X XX	XXXXXXXXXX	XXX		
26E070	Cispus R nr Kosmos	B		X	XXX			
26F050	Olequa Cr at 7th Street	B					X	
27A070	Columbia R @ Kalama	B	XX	X XX				
27A110	Columbia R nr St. Helens	B	XX	X				
27B050	Kalama R @ Kalama	B	XXXXXXXXXX	X				
27B070	Kalama R nr Kalama	L		XX XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
27B090	Kalama R @ Upper Hatchery	B		X				
27B110	Kalama R @ Pigeon Springs	B		X				
27C070	Lewis R @ Woodland @ I-5	B	XXXXX X	X XX				

Station Number	Name	Long-term or Basin	Water Year Sampled						
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
27C080	Lewis R @ Co Rd 16	B					X		
27C110	Lewis R @ Ariel	B	X	X	XXX	X			
27D090	EF Lewis R nr Dollar Corner	L			XXX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
27E070	Cedar Cr nr Etna	B					X		
27F070	Gee Cr @ Ridgefield	B					X		
28A090	Columbia R blw Vancouver WA	B		XX	X				
28A091	Columbia R blw Vancouver OR	B		XX	X				
28A100	Columbia R @ Vancouver	B						X X	
28A165	Columbia R @ Warrendale	B			XXXXXXX				
28A170	Columbia R blw Bonneville	B		XX	X				
28A175	Columbia R @ Bonneville Dam	B		XX	X X				
28B070	Washougal R @ Washougal	B		X	X XX XX		X	X	
28B085	Washougal R abv Ltl Washougal R	B							X
28B090	Washougal R nr Washougal	B		XXXXXXXX	X				
28B110	Washougal R blw Canyon Cr	B					X X	X	
28C070	Burnt Br Cr @ Mouth	B			X			XX XX	
28C110	Burnt Br Cr @ Vancouver	B			X				
28D070	Salmon Cr @ Salmon Cr	B			X				
28D110	Salmon Cr nr Battle Ground	B			X				
28D170	Salmon Cr @ NE 199th/Hill rd	B							X
28E070	Weaver Cr nr Battle Ground	B			X				
28F070	Lake R nr Ridgefield	B					X		
28G070	Gibbons Cr nr Washougal	B					X	X	
28H070	Campen Cr nr Washougal	B						X	
28I120	Lacamas Cr @ Goodwin Road	B						X	
28J070	Little Washougal Cr @ Blair Road	B						X	
29B070	White Salmon R nr Underwood	B		XXXXXXXXXX	X XX XXXX	XXXX	X		
29B090	White Salmon R @ Husum St	B						X	
29C070	Wind R nr Carson	B			X XXXX	XXXX	X		
29D070	Rattlesnake Cr nr Mouth	B					XXX	X	
29E070	Gilmer Cr nr Mouth	B					XXX		
30A070	Columbia R @ The Dalles	B		XX	XXXXXXXX		X		
30A090	Columbia R @ The Dalles Dam	B		X					
30B060	Klickitat R nr Lyle	B					XX		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
30B070	Klickitat R nr Pitt	B		XXX	X XXXXXXX	X			
30C070	Little Klickitat R nr Wahkiacus	B			X		XX		
30C090	Little Klickitat R @ Olson Rd	B						X	
30C150	Little Klickitat R @ Hwy 97	B						X	
31A070	Columbia R @ Umatilla	L		X	XXXXX		XXXXXXXXX	XXXXXXXXXX	XXX
31A090	Columbia R @ McNary Dam	B	X	XXXXXXXXXX					
31A130	Columbia R nr Yakima R Mouth	B		X					
31B110	Rock Cr @ Bickleton Hwy	B							X
31C012	Alder Cr @ 6 Prong Rd Bridge	B							X
31D010	Pine Cr @ One Mile Bridge	B							X
31E060	Glade Cr @ SR14	B							X
32A070	Walla Walla R nr Touchet	L	X	XXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
32A090	Walla Walla R nr Lowden	B			XX				
32A100	Walla Walla R at E Detour Road Br	B					X	X	
32A110	Walla Walla R @ College Place	B			XX XX				
32B070	Touchet R @ Touchet	B			X XX XX	XXXXXXXXXX	XXX X		
32B075	Touchet R @ Cummins Rd	B						X X	
32B080	Touchet R at Sims Rd	B					X	X	
32B100	Touchet R @ Bolles	B			XX		X	X	
32B120	Touchet R nr Dayton	B			XX				
32B130	Touchet R @ Dayton	B	X	X			XX		
32B140	Touchet R above Dayton	B					X		
32C070	Mill Cr @ Swegle Rd	B			X XX			X	
32C110	Mill Cr @ Tausick Way	B			X X		X		
33A010	Snake R nr Mouth	B		X					
33A050	Snake R nr Pasco	L		XXXXXXX X	X		XXXXXXXXX	XXXXXXXXXX	XXX
33A070	Snake R blw Ice Harbor Dam	B		X	X XXXXXX	XXXXXXXXXX	XX		
34A070	Palouse R @ Hooper	L	X	XXXXXXXXXX	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
34A075	Palouse R @ Hwy 26	B						X	
34A080	Palouse R above Rebel Flat	B						X	
34A085	Palouse R @ Shields Rd Bridge	B					X	X	
34A090	Palouse R nr Diamond	B			X X				
34A109	Palouse R blw Colfax	B						X	
34A110	Palouse R abv Buck Canyon	B			X XX				

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
34A120	Palouse R at Colfax	B						X X	
34A170	Palouse R @ Palouse	L			X		XXXXXXXX	XXXXXXXXXX	XXX
34A200	Palouse R nr Stateline	B						X	
34B070	SF Palouse R nr Colfax	B			X XX				
34B075	SF Palouse R @ Shawnee Rd	B						X	
34B080	SF Palouse R @ Albion	B						X	
34B090	SF Palouse R nr Pullman	B			X X				
34B110	SF Palouse R @ Pullman	L			X X XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
34B130	SF Palouse R blw Sunshine	B			X			XXX	
34B140	SF Palouse R @ Busby	B					X		
34C060	Paradise Cr at Mouth	B					X	XXX	
34C070	Paradise Cr nr Pullman	B			X				
34C100	Paradise Cr @ Border	B					X	XXX	
34D070	SF Palouse R Trib Whitman Fm	B			X				
34E070	Rock Cr at Revere	B					X		
34F090	Pine Cr @ Rosalia	B					X	X	
34H070	Pleasant Valley Cr blw St John	B						X	
34J050	Union Flat Cr nr Mouth	B						X	
34J070	Union Flat Cr @ Winona Rd	B						X	
34J090	Union Flat Cr @ Hwy 26	B						X	
34J120	Union Flat Cr @Almota Rd	B						X	
34K050	Rebel Flat Cr @ Mouth	B						X	
34K080	Rebel Flat Cr @ Repp Rd	B						X	
34K120	Rebel Flat Cr @ Fairgrounds	B						X	
34L050	Cow Cr @ mouth	B						X	
34M070	Dry Cr @ Pullman	B						X	
34N070	Missouri Flat Cr @ Pullman	B						X	
35A100	Snake R blw Lwr Granite Dam	B			X				
35A150	Snake R @ Interstate Br	L		XXXXX XX			XXXXXXXXX	XXXXXXXXXX	XXX
35A200	Snake R nr Anatone	B			XXXXXXXX				
35B060	Tucannon R @ Powers	L			X XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXX
35B090	Tucannon R @ Smith Hollow	B						X	
35B100	Tucannon R @ Territorial Road	B						X	
35B110	Tucannon R nr Delaney	B	X	X					

Station Number	Name	Long-term or Basin		<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
					Water Year Sampled				
35B120	Tucannon R @ Brines Road	B						X	
35B150	Tucannon R nr Marengo	B					X	X	
35C070	Grande Ronde R nr Anatone	B			X	XXX	X		
35D070	Asotin Cr @ 2nd Street	B			X		X X	X	
35D120	NF Asotin Cr blw Lick Cr	B							X
35E070	Clearwater R @ US12/95	B					X		
35F050	Pataha Cr near mouth	B						X X	X
35F070	Pataha Cr @ Archer Rd	B					X	X	
35F095	Pataha Cr @ Tatman Rd	B						X	
35F110	Pataha Cr @ Rosy Grade	B						X	
35L050	Almota Cr @ mouth	B						X	
35L140	Almota Cr @ Klemgard Rd	B						X	
35Q050	Little Almota Cr @ Mouth	B						X	
35R050	Steptoe Cr @ Mouth	B						X	
35R120	Steptoe Cr blw Stewart	B						X	
35R140	Steptoe Cr abv Stewart	B						X	
35S060	Wawawai Cr @ mouth	B						X	
35U070	Alkali Flat Cr nr Mouth	B						X	
35U090	Alkali Flat Cr abv Hay	B						X	
35U140	Alkali Flat Cr @ Little Alkali Rd	B						X	
35U190	Alkali Flat Cr @ Penewawa Rd	B						X	
35W070	Mud Flat Cr @ Mouth	B						X	
35Y070	Penewawa Cr nr Mouth	B						X	
35Y110	Penewawa Cr @ Looney Br	B						X	
35Y170	Penewawa Cr abv Goose cr	B						X	
35Z070	Little Penewawa Cr @ Mouth	B						X	
36A055	Columbia R @ Port of Pasco	B			X				
36A060	Columbia R @ Pasco	B		XX					
36A065	Columbia R @ Richland	B			X				
36A070	Columbia R nr Vernita	L		XX XX	X X XXX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
37A060	Yakima R @ VanGiesen Br	B			X XX				
37A070	Yakima R nr Richland	B			X				
37A090	Yakima R @ Kiona	L	X	XXX XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
37A095	Yakima R 2 mi blw Prosser	B					X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
37A100	Yakima R below Prosser	B					X		
37A110	Yakima R @ Prosser	B			X XX				
37A130	Yakima R @ Mabton	B			X XX		X		
37A149	Yakima R @ Granger N Side	B			X				
37A150	Yakima R @ Granger S Side	B			X				
37A170	Yakima R nr Toppenish	B			X XX		X		
37A190	Yakima R @ Parker	B			X XXXXXXX	XXXXXXXXXX	XXX	X	
37A200	Yakima R abv Ahtanum Cr (USGS)	B			XX X	XX			
37A205	Yakima R @ Nob Hill	L					XXXXX	XXXXXXXXXX	XXX
37A210	Yakima R nr Terrace Height	B			XX XX		X		
37B060	Satus Cr @ Satus	B			XX				
37C060	Toppenish Cr nr Satus	B			XX				
37D080	Marion Drain nr Granger	B			XX				
37E050	Wide Hollow Cr @ Main Street	B						XX	
37E070	Wide Hollow Cr @ Union Gap	B			X X		X		
37E090	Wide Hollow Cr @ Goodman	B			X X				
37E120	Wide Hollow Cr @ Randall Park	B						XX	
37F070	Sulphur Cr Wasteway @ McGee Rd	B					X		
37F080	Sulphur Cr @ Holaday Road	B						X	
37G050	Ahtanum Cr @ Fulbright Park	B						X	
37G120	Ahtanum Cr @ 62nd Ave	B						XX	
37I070	Moxee Drain @ Birchfield Rd	B						XX	
37J060	Snipes Cr nr Mouth	B							X
38A050	Naches R @ Yakima on US HWY 97	L		XXXXXXX			X XX	X X X	XX
38A070	Naches R @ Yakima	B			X X				
38A110	Naches R @ Naches	B	X	X	X				
38A130	Naches R nr Naches	B		XXXX					
38B070	Tieton R @ Oak Cr	B		XXXX			X		
38C070	Rattlesnake Cr nr Nile	B		XX					
38D070	Bumping R @ American R	B		XX					
38E070	American R @ American R	B		XX					
38F070	Little Naches R nr Cliffdell	B		XXX			X		
38G070	Cowiche Cr @ Powerhouse Rd	B						XX	
38G120	Cowiche Cr @ Zimmerman Rd	B						XX	

Station Number	Name	Long-term or Basin	Water Year Sampled						
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
39A050	Yakima R @ Harrison Bridge	B					XX	XXX X	
39A055	Yakima R @ Umtanum Cr Footbridge	L							XXX
39A060	Yakima R @ Ellensburg	B					XX	XX	
39A070	Yakima R nr Thorp	B			X X				
39A080	Yakima R @ Cle Elum	B	X	XXXXXXXXXX	X				
39A090	Yakima R nr Cle Elum	L			X X		XXX XXXXX	XXXXXXXXXX	XXX
39B070	Cle Elum R nr Cle Elum	B			X X				
39B090	Cle Elum R nr Roslyn	B					X		X
39C070	Wilson Cr @ Highway 821	B		XXXX	X X X		X	XX	
39D070	Teanaway R nr Cle Elum	B		XXXXX			X		
39M050	Swauk Cr nr Cle Elum	B							X
39M100	Swauk Cr @ Lauderdale Junction	B							X
39R050	Umtanum Cr nr mouth	B							X
41A070	Crab Cr nr Beverly	L	X	XXXXXXXXXX	XXX XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
41A075	Crab Cr nr Smyrna	B		XXX					
41A090	Crab Cr nr Othello	B			X				
41A110	Crab Cr nr Moses Lake	B		X		XXXX	X X	X	
41D070	Rocky Ford Cr @ Hwy 17	B					X	X	
41E070	Sand Hollow Cr on Hwy 26	B					X		
41F100	Rocky Ford Coulee Drain	B					X		
41G070	Rocky Coulee Wasteway @ K NE Road	B						X	
41H050	Moses Lake at South Outlet	B						X	
41J070	Lind Coulee @ Hwy 17	B						X	
42A070	Crab Cr below Adrian	B						X	
43A070	Crab Cr @ Irby	B		X			X	X	X
43A080	Crab Cr @ Odessa	B						X	
43A095	Crab Cr @ Amnen Road	B						X	
43A100	Crab Cr @ Marcelus Road	B					X	X	
43A110	Crab Cr at Tokio Road	B						X	
43A130	Crab Cr @ US23	B						X	
43A150	Crab Cr @ Bluestem Road	B					X	X	
43B090	Lake Cr @ Coffeepot Road	B					X		
43C070	Goose Cr nr Wilbur	B						X	
44A070	Columbia R blw Rock Is Dam	B			X XX XX	XXXXXXXXXX	XX		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
44A190	Columbia R @ Hwy 2 Bridge	B						X	
45A070	Wenatchee R @ Wenatchee	L		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
45A075	Wenatchee R @ Sleepy Hollow Br	B						X	
45A085	Wenatchee R nr Dryden	B			X				
45A100	Wenatchee R @ Leavenworth	B			X				
45A110	Wenatchee R nr Leavenworth	L	X	XXXXXXXX	XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
45B070	Icicle Cr nr Leavenworth	B			X		X		
45C060	Chumstick Cr nr mouth	B						XX	
45C070	Chumstick Cr nr Leavenworth	B					XXX	X X	
45D070	Brender Cr nr Cashmere	B					XXX	X XX	
45D080	Brender Cr abv Noname Cr	B						X	
45E070	Mission Cr nr Cashmere	B					XXX	X XX	
45J070	Nason Cr nr mouth	B						X	
45K050	White R @ Road 6500 Bridge	B						X	
45L050	Little Wenatchee R @ 2 Rvr Grav Pit	B						X	
45Q060	Eagle Cr nr mouth	B						XX	
45R050	Noname Cr nr Cashmere	B						XX	
45R070	Noname Cr on Mill Rd	B						X	
46A070	Entiat R nr Entiat	L	X	XXXXXXX	X XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
47A070	Chelan R @ Chelan	B		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XX X		
47B070	Columbia R @ Chelan Station	B					X X		
48A070	Methow R nr Pateros	L	X	XXXXXXX	X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXX	
48A075	Methow R nr Pateros @ Metal Br	L						X	XXX
48A130	Methow R nr Twisp	B			X XX	XXXXXXXXX			
48A140	Methow R @ Twisp	L				X	XX X XXXXX	XXXXXXXXXX	XXX
48A150	Methow R @ Winthrop	B						X	
48A170	Methow R @ Weeman Br	B			X				
48A190	Methow R blw Gate Cr	B			X XX	X			
48B070	Chewuch R @ Winthrop	B			X			X	
48C070	Andrews Cr nr Mazama	B			XXXXXXXX	XX			
48D070	Twisp R nr Mouth	B						X	
49A050	Okanogan R nr Brewster	B	X	XXXXXXX X	X				
49A070	Okanogan R @ Malott	L		XXX	X X XX XX	XX XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
49A090	Okanogan R @ Okanogan	B			X XX	XXXXXXXXX	X	X	

Station Number	Name	Long-term or Basin	Water Year Sampled	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
49A110	Okanogan R @ Omak	B						X	
49A130	Okanogan R @ Riverside	B						X	
49A170	Okanogan R @ Janis	B			X				
49A180	Okanogan R @ Tonaskat	B					X		
49A190	Okanogan R @ Oroville	L		XXXXXXX	XX XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
49B070	Similkameen R @ Oroville	L		XXXXXXX	XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
49B090	Similkameen R @ Nighthawk	B					X		
49B110	Similkameen R @ Chopaka, BC	B						XX	
49F070	Bonaparte Cr @ Tonasket	B						X	
49F105	Bonaparte Cr abv Tonasket	B						X	
50A070	Columbia R nr Brewster	B		X					
50A090	Columbia R @ Bridgeport	B		X					
50B070	Foster Cr @ Mouth	B						X	
51A070	Nespelem R @ Nespelem	B				XXXXXXXXXX	XX X		
52A070	Sanpoil R @ Keller	B		XXXXXXX	X XX XX	XXXXXXXXXX	XX X		
52A110	Sanpoil R 13 mi S Republic	B					X		
52A170	Sanpoil R blw Republic	B			X				
52A190	Sanpoil R abv Republic	B			X		X		
52B070	Lake Roosevelt from Keller Ferry	B					X		
53A070	Columbia R @ Grand Coulee	L			X XX XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
53C070	Hawk Cr @ Miles-Creston Rd	B						X	X
54A050	Spokane R @ Mouth	B					XXXX		
54A070	Spokane R @ Long Lake	B	X	XXXXXXX X	XXXXXXXXXX	XX		XX	X
54A089	Spokane R 2 mi blw Ninemile dam	B			XX				
54A090	Spokane R @ Ninemile Br	B			X X			X XX	X
54A120	Spokane R @ Riverside State Pk	L			XXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
54A130	Spokane R @ Fort Wright Br	B			X X				X
55B070	Little Spokane R nr Mouth	L			X X XXX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
55B075	Little Spokane R @ Painted Rocks	B					X		
55B080	Little Spokane R nr Griffith Spring	B					XX		
55B082	Little Spokane R abv Dartford Cr	B					XX X		
55B085	Little Spokane R nr Dartford	B		XXXXXXX					
55B090	Little Spokane R abv Wandermere	B			X				
55B100	Little Spokane R abv Deadman Cr	B					XX X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
55B200	Little Spokane R @ Chattaroy	B					X X		
55B300	Little Spokane R @ Scotia	B						X	
55C065	Deadman Cr nr Mouth	B					X		
55C070	Peone (Deadman) Cr abv Litt Deep Cr	B					XX	X	
55C200	Deadman Cr @ Holcomb Rd	B						X	
55D070	Deer Cr at Hwy 2	B					X		
55E070	Dragoon Cr at Crescent Road	B					X		
56A070	Hangman Cr @ Mouth	L			X X XXX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXX
56A200	Hangman Cr @ Bradshaw Road	B					X		
57A120	Spokane R @ Spokane	B			X				
57A123	Spokane R @ Sandifer Bridge	B						X	X
57A125	Spokane R blw Monroe Street	B						X	
57A130	Spokane R @ Mission St Br	B			X X				
57A140	Spokane R @ Plante's Ferry Park	B						XX	X
57A145	Spokane R @ Trent Br	B			X				
57A146	Spokane R @ Sullivan Rd	B						X	X
57A148	Spokane R @ Barker Rd	B						X	
57A150	Spokane R @ Stateline Br	L	X	XXXXXX X	XX X X		XXXXXXXXX	XXXXXXXXXX	XXX
57A190	Spokane R nr Post Falls	B			XXXXXXX	XXXXXXXXXX	XX		
57A240	Spokane R @ Lake Coeur d'Alene	B						XX	X
59A070	Colville R @ Kettle Falls	B		XXXXXXXXXX	X X XX XX	XXXXXXXXXX	XX X		
59A080	Colville R @ Greenwood Loop Rd	L					X	X	XX
59A110	Colville R @ Blue Cr	B			X			X	X
59A130	Colville R @ Chewelah	B			X			XXX	
59A140	Colville R @ Newton Rd	B						XX	X
59B070	Little Pend Oreille R @ Hwy 395	B						X	
59B200	Little Pend Oreille R nr NatWildRef	B							XX
59C070	Sheep Cr at Long Prairie Rd	B							X
60A050	Kettle R @ Hedlund Bridge	B		X					
60A070	Kettle R nr Barstow	L		XXXXXXX X	X X XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXX
61A070	Columbia R @ Northport	L	X	XXXXXXXXXX	XXXXXXXXXX	XX	XXXXXXXXX	XXXXXXXXXX	XXX
61B070	Deep Cr nr Mouth	B					X	X	X
61C070	Onion Cr nr Northport	B					X		
61C100	Onion Cr @ Widow-Hawks Rd	B							X

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
61D070	Sheep Cr nr Northport	B					X		
62A070	Pend Oreille R @ Waneta BC (USGS)	B		XXX					
62A080	Pend Oreille R @ Border	B			XXXXXX	XX			
62A090	Pend Oreille R @ Metaline Falls	L	X	XXX			XX XX	XXXXXXXXXX	XXX
62A150	Pend Oreille R @ Newport	L	X	XXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
62B070	Skookum Cr nr Mouth	B							X

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Appendix B. Historical Changes in Sampling and Laboratory Procedures, as well as Large-Scale Environmental Changes Potentially Affecting Water Quality

This appendix provides a record of changes in methods and procedures used by Ecology's Freshwater Monitoring Unit to collect and analyze river and stream water quality data. Other environmental changes that may potentially affect water quality over a large area are also recorded here.

Many of the changes listed here are anecdotal and may or may not have affected data quality. Comments prior to October 1988 are based on interviews with individuals involved with the earlier program. Comments after that date have usually been recorded as the changes occurred.

General

- Jun to Sept 1985: Laboratory moved from Ecology's Southwest Regional Office to Manchester.
- Oct 1988: Implemented QA/QC program (See memo from David Hallock, October 17, 1988.)
- Prior to WY91: Samples were sent to contract labs from time to time. These occurrences are not all recorded here. Records are not detailed and only available from bench sheets archived by Manchester Laboratory.
- 1994: The use of Polyacrylamide (PAM) to control erosion from rill irrigation is becoming widespread in eastern Washington. Water quality effects are unknown.
- 1996: Began monitoring discharge at some stations ourselves (mostly basin stations), rather than contracting with USGS.
- 2001: Began running Central (Nov 2001) and Eastern (Feb 2002) runs out of regional offices. Barometric pressures calculated from airport readings, either uncorrected, if available, or re-converted to sea level.
- Jan-Jun 2002: Some barometric pressures collected from the western part of the state may be off by 1.0 mmHg due to calibration errors. The effect of this amount of error on the percent oxygen saturation calculation is insignificant.
- Oct 2005 (except the NW run, which made the change several months earlier): Previously, aliquots for pH, conductivity, and turbidity were obtained from the stainless steel bucket used to collect the oxygen. However, this presented a risk of contamination from the oxygen bottles. The sampler was re-designed so that only the oxygen sample is obtained from the bucket; all other samples are collected in passengers.
- Nov 2007: Implemented a Freshwater Technical Coordination Team-required "ride-along" procedure where a senior staff rides with each sampler once during the year to ensure SOP are followed uniformly.
- Jan 16, 2008: Implemented semi-annual calibration of Operation's Center digital barometer against Hg barometer in Air Lab at HQ. Digital BP read 30.86 before recalibration and 30.54 after. S, N, and W BP data since October 2006 could be up to 0.32 inches Hg high.
- Oct 1, 2010: Changed blank sample procedures. Previously, we added blank water to sample equipment then processed the water as a regular sample. Now, we are lowering the sample equipment from the bridge (without entering the water). This should capture potential contamination falling off the bridge during sampling.

Nutrients

- General: Prior to 1980, USGS labs analyzed samples.
- 1966-1969: One gallon of sample was collected in glass jars and held at room temperature for indefinite periods without preservative.
- 1970-1973: Unknown methods; may have been preserved with HgCl. Filtered in field.
- 1973: Laboratory moved from Tacoma to Salt Lake City.
- 1973-1974: Chilled, no preservative. Held as long as one week. Filtered in field; kept in brown poly bottle.
- 1972-1974?: For a short time, TP and NO3 may have been added by filters (probably 72-74). (Personal communications with Joe Rinnella, USGS).
- Sep 30, 1978: USGS Lab moved to Arvada, CO. Joint program samples sent there; samples collected for Ecology project only may have been analyzed in-house.
- ~1978: Chilled. Brown poly bottle? (the brown poly bottle may have been introduced later). 30-day holding time for NO2+NO3 implemented (status of other nutrients is unknown). (Source of methods prior to 1979: pers. comm. Joe Rinnella, USGS, and Skinner, Earl L. "Chronology of Water Resources Division activities that may have affected water quality values of selected parameters in Watstore, 1970-86. Provisional Report Feb 1989.)
- 1979: For a while, the USGS lab reported nutrient results to the nearest 0.01 units. Values below 0.005 were reported as 0.00. USGS decided to change all Watstore data = 0 to 0.01K back to 1973 for NO2+NO3. Decision on other nutrients is unknown, but they may also have been changed. Most of the 0s in our database have been converted to 0.01K (K-below the detection limit) but a few 0s may remain in the older data.
- 1980: USGS requires NO2+NO3 be preserved with HgCl. Status of other nutrients is unknown. Ecology requirements are unknown.
- Jun 1, 1980 to 1986: Nutrients analyzed by Pat Crawford at Southwest Regional Office.
- Aug 1985: High phosphate values, presumably a result of lab error. (Coded '9-do not use' in our database). (See "Trends in Puget Sound," 1988, Tetra Tech, App. B.)
- 1986 to Apr 1987: Analyzed by various people, mostly Helen Bates, Steve Twiss, and Wayne Kraft at Manchester.
- Jun 1985: Switched from Technicon to Rapid Flow Analysis (Alpkem) auto-analyzers
- Apr 1987 to present: Analyzed by various people at Manchester.
- Jan 1987 to Jul 1987: NO3, NH3, and TP analyzed by contract lab.
- Mar 1990: Began using MFS cellulose acetate filters for field filtration of nutrients. Previously use Millipore, type HA (cellulose nitrate?).
- Sep 17 - Oct 12, 1990: All nutrient samples were contracted out.
- Oct 1990: Dissolved ammonia (P608) and dissolved nitrate+nitrite (P631) were added to the Marine network. Totals (P610 and P630) were dropped.
- Feb 1991: All nutrients sent to contract lab.
- Mar 1991: All nutrients sent to contract lab.
- ~1993: Began collecting nutrients in acid-washed poly-bottle passenger rather than in the stainless-steel bucket used for oxygen determinations.
- Jul 1994: The phosphorus content in laundry detergents is restricted to 0.5% and dishwashing detergent to 8.7% statewide (SSB 5320; WAC 70.85L.020). Phosphorus use had been limited in Spokane County one (?) year earlier.
- Feb 1999: Manchester Laboratory switched from manual to inline digestion for total phosphorus. In early 2003, during the course of evaluating a different method for phosphorus analysis, Manchester Laboratory discovered that the in-line method contained a high bias (4 to

20 ppb). Trend analyses of total phosphorus data should be interpreted carefully if results collected between Feb 1999 and Sept 2003 are included. (See email from Dean Momohara to David Hallock, 31 March 2003.) Total phosphorus data analyzed using this method have been coded "4" indicating a potential quality problem, and given a different name ("TP_PInline" rather than the usual "TP_P").

- Sep 2000: Nitrate+nitrite method nomenclature changed from EPA 353.2 to SM 4500NO3I because the latter method is more specific. The instrument used was changed at around this time from a “Flow analyzer” to a “Flow Injection” instrument and procedures may have changed slightly.
- Before Jul 2001: Ammonia method nomenclature changed from EPA 350.1 to SM 4500NH3H because the latter method is more specific. The instrument used was changed at around this time from a “Flow analyzer” to a “Flow Injection” instrument and procedures may have changed slightly.
- Before Aug 2001: Ortho-phosphorus method nomenclature changed from EPA 365.3M to SM 4500PG because the latter method is more specific. The instrument used was changed at around this time from a “Flow analyzer” to a “Flow Injection” instrument and procedures may have changed slightly.
- Before May 2000: Total nitrogen method nomenclature changed from VALDERRAMA to SM 4500NB because the latter method is more specific. The instrument used was changed at around this time from a “Flow analyzer” to a “Flow Injection” instrument and procedures may have changed slightly.
- Oct 2000: TP method changed from EPA 365.1 to SM4500PI. The former method specifies a manual digestion, while the latter correctly refers to the in-line digestion used by Manchester Laboratory’s Lachat instrument.
- Oct 2000 to Feb 2001: A low bias may apply to TN data. Except for December data, Manchester Laboratory deemed the bias to be small enough that the data did not need to be qualified. December TN results were coded as estimates (See email from M. Lee to David Hallock, March 8, 2001.)
- Oct 2003: TP method changed from SM4500PI to EPA 200.8M, an ICP/MS method with low detection limits and without the bias associated with in-line digestion. Samples are collected in a 60mL container with HCl preservative instead of the earlier 125mL container with H_2SO_4 preservative.
- Oct 1, 2007 we changed total phosphorus analytical methods from EPA200.8M (ICP-MS) to SM4500PH (colorimetric with manual digestion). We made this change because we discovered that at turbidities greater than 4 NTUs, the ICP method is biased low compared to the colorimetric method. (See email from Dave Hallock to Bob Cusimano, October 25, 2007.)
- Jan 15, 2008: OP method changed from SM4500PG to SM4500PF and TOC method changed from EPA415.1 to SM5310B. Neither procedure actually changed.
- Jul 2008: The phosphorus content in dishwasher detergents is restricted in ~~certain counties~~ Spokane County ~~depending on population~~ as of this date (RCW 70.95L.020). (A new law signed in March, 2008, eliminated Clark County from the July 1 deadline and weakened regulations that will start in Whatcom County. Phosphorus in laundry detergents has been restricted since 1994.)
- Jul 2010: The phosphorus content in dishwasher detergents will be restricted statewide as of this date (RCW 70.95L.020).
- Mar, 2013 (after ERM analysis): TP method changed from SM4500PF to SM4500PH. In practices, PH is the same as PF but the instrument changed from Lachat 7500 to Lachat 8000. SM4500PF specifies ‘Automated Ascorbic Acid Reduction Method’ while SM4500PH specifies ‘Manual Digestion and Flow Injection Analysis for Total Phosphorus’.

- October 2013: Changed peristaltic pump/filter stand from one using 142 mm diameter filters to one using 102 mm diameter filters. This apparatus filters samples for the laboratory analysis of orthophosphorus. For more information about this change, see the WY 2012 Annual Report.

Suspended Solids

- General: Filters were usually used, but sometimes Gooch crucibles were used.
- Feb 1978: Began collecting as passenger to oxygen sampler (was previously collected as aliquot of oxygen sampler). (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook.)
- Mid-1985: Amount filtered changed from 250 (?) to 500 ml.
- Sep 17 - Oct 12, 1990: Suspended sediment samples were contracted out.
- Apr 1991: Began collecting 1000 ml of sample.
- Jul 2002: A number of suspended solids results entered into our database as '0' were deleted. We do not know if these results were below reporting limits or "missing data"; 138 results collected between 1972 and 1981 were affected.
- Mar 2003: TSS method reference changed from EPA160.2 to SM 2540D. Methods did not change; the latter reference more accurately reflects analytical procedures. See email from Feddersen, Karin, March 24, 2003.

Conductivity

- Feb 1978: Began calibrating twice monthly using 40, 70, 140, and 200 umho/cm standards. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) Notebook)
- Oct 1991: All meters were re-calibrated Oct 11, 1991. One conductivity meter was not calibrated above 500 umhos/cm (and could not be calibrated). This meter had last been calibrated about 1 year earlier. Most meters read higher than the 100 umhos/cm standard.
- Oct 1994: Switched from Beckman model Type RB-5 (which could not be field calibrated) to Orion Model 126 meter, calibrated daily.
- 1998: Orion meter calibration began drifting during the day. Sometimes meter could only be calibrated to within 4 umhos/cm of the standard. At first, some samplers would correct the data, others would not. Now, these data are uncorrected and coded "J" (estimate).
- Oct 1, 2011: Dropped Orion model 126 meter and started using Hach model HQ40d combination meter for both pH and conductivity.
- Spring 2006 changed from 500 mL to 100 mL "one-shot" standard, both from VWR
- Summer 2009 changed from 100 mL VWR snap-top standard to a 100 mL screw top by Ricca.
- Winter 2011 changed from 100 mL screw top to 20 mL single use packets, both by Ricca
- October 2013 changed from single use packets to 500 mL bottle stock, with 100 mL aliquots used for calibration in the field. Also began measuring MEL-provided standard as a daily check standard. See the 2012 Annual Report for more discussion of conductivity standards.

Fecal Coliform Bacteria

- Early 1980s: field personnel may have analyzed some samples.
- Oct 7, 1975 to Nov 1981: fecal data from eastern Washington may be questionable during this period.

- 1980 to Mar 1988: No changes; analyzed by Nancy Jensen and others at Manchester. However, there is an apparent drop in monthly geometric means in late 1985. The may be coincident with moving the lab to Manchester (see memo from Dave Hallock to Dick Cunningham, June 18, 1991).
- Mar 1988: Switched to new filter with slightly better recovery.
- Nov 2000: Holding time was changed from 30 hours to 24 hours (Standard Methods changed to 24 hours with the 17th edition, 1989). As a result, more data have been coded "J" since then due to exceeding holding times.
- Sep 2003: FC method reference changed from SM 16-909C to SM 9222D. Methods did not change; the latter reference more accurately reflects analytical procedures. See email from Feddersen, Karin, September 15, 2003.
- ~Aug, 2009: Pasco airport began x-raying water samples. Other airports may follow suit eventually. Exposure is < 1 millirad while doses used to kill bacteria on food are >30,000 rads. An unnamed contact at Washington's Department of Health stated that the dose is not a concern. We considered testing for an effect, but the number of samples required to detect a small effect is prohibitively large given the natural variance in bacteria data.

Turbidity

- 1970s: EPA specified a 2100A turbidimeter. Formerly, turbidity units were FTU (?)
- Jan 1976: Turbidity units changed from Jackson Turbidity Units (JTU) to Nephelometric Turbidity Units (NTU). (Source: review of historical reports.) These are roughly equivalent when greater than 25 JTU/NTU, otherwise not.
- Sep 1993: Lab began using a new turbidimeter, Hach model "Ratio X/R."
- Jan 2003: In our database, the units for turbidity results collected prior to January were changed from NTU back to JTU. Though roughly equivalent at JTUs > 25, these are not equivalent for lower measurements; the original units should have been retained.

Field pH

- Oct 7, 1975 to Nov 1981: pH data from eastern Washington are questionable during this period.
- Feb 1978: Began calibrating meter twice monthly. Previous procedures unknown. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook)
- 1986: Changed to Beckman digital pH meter with gel probe.
- Dec 1991: Changed to Orion model 250A meter with "spare water" liquid probe (uses 1M KCl, rather than 4M). Calibrate daily and check calibration three times during the sampling day.
- Oct 1, 2011: Dropped Orion model 250A meter and started using Hach model HQ40d combination meter for both pH and conductivity with electrode PHC281 for pH. See the WY2011 Annual Report for results of a method comparison study.

Temperature

- Feb 1978: Switched from thermometer in bucket to thermistor in river. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook)
- Feb 1985: Checked thermistor calibration daily (internal calibration check based on red-lining needle, not a check against a NIST thermometer) (Memorandum from John Bernhardt, Feb 7, 1985).
- Spring 1994: Switched to YSI 300 meter (precision +/- 0.4C)

- Jan 1, 2001: Began calibrating thermistors prior to each run rather than annually. Some thermistors were found to be as much as 1-2 °C low.
- About May 2006: Began evaluating thermistor calibration at several temperatures and calculating correction coefficients based on a linear regression correction. Corrections are applied upon data entry by the database rather than by the sampler.

Oxygen

- Oct 1, 1977: Began measuring barometric pressure to calculate percent saturation. Previous saturation calculations were presumably based on elevation.
- Mar 1989: Began applying correction factor to results of Winkler analyses based on titration with sodium biiodate to correct sodium thiosulfate normality to 0.025. Previously, thiosulfate was standardized upon preparation, but not during use.

Barometric Pressure

- Feb 1985: Began calibrating barometer before each run based on National Weather Service report from Olympia airport (Memorandum from John Bernhardt, Feb 7, 1985).
- 1995: Began calibrating barometer prior to each run using an on-site mercury barometer rather than pressure as reported by the Olympia airport.
- 2003: Began calibrating barometer prior to each run using an on-site digital barometer rather than the mercury barometer. Calibrating digital barometer to mercury barometer annually.
- Jan 2008: Began calibrating on-site digital barometer twice yearly against a mercury barometer.
- ~April, 2011: Evaluated historical data against elevation-based BP and adjusted quality codes for some data points. Implemented BP QC check which compares BP during data entry to expected BP based on elevation.

Chlorophyll

- Mar 15, 1990: Switched to fluorometric method (from spectrophotometric). New method has lower detection limit (0.02 ug/L) but less precision. (See memo from Despina Strong, April 12, 1990.)

Hardness

- Jul 1, 1991: Began using 125 ml bottle with HNO_3 as preservative. (Previously, aliquot from unpreserved general chemistry bottle was used.)

Metals

- May 1994: Implemented low-level dissolved metals monitoring at selected stations. Metals results prior to this date are questionable unless well above detection limits and have been quality-coded “9” in our database so that they will not routinely be retrieved. Quality problems include inconsistent blank correction and indications of simultaneous peaks and troughs in data series from unrelated stations for results above reporting limits.
- Apr 2010: A review of historical blank data showed that dissolved zinc exceed reporting limits of 1 ug/L 43% of the time (though never greater than 5 ug/L). As a result, we have decided to

set the quality code field = 4 for reported dissolved zinc results < 5 ug/L, which indicates a potential data quality issue.

Flow

- Oct 1, 2009: Began recording uncorrected stage, correction, and error estimate.
- Feb 2011: Processing of flow for ambient stations shifted from Howard Christensen to Jason Myers. Prior to this time, flows below some dams (e.g., Grand Coulee) were miss-calculated. (These flows have been corrected.)
- October, 2011: Decided to remove flows from the web (and replace with a link to our source, typically USGS, USCOE, or in-house) and code flows in EIM "Instantaneous flow based on provisional data obtained from various sources. Not confirmed." We also developed procedures to automate retrieval of flow data and to document and manage metadata used for determining flow (e.g., time of travel correction).

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Appendix C. Water Year 2012: Sources of Raw Data

Data discussed in this report are available in electronic format through various sources:

1. Ambient river and stream monitoring data are available on Ecology's web pages (www.ecy.wa.gov). Look under "Programs," "Environmental Assessment", and "River and Stream Water Quality."

2. Data are available in Ecology's Environmental Information Management (EIM) system. From Ecology's main page (www.ecy.wa.gov), look under "Scientists," "Environmental Monitoring Data", and "EIM." Our project IDs are listed in Table C-1.

Table C-1. Ambient Monitoring EIM projects.

Project ID	Description	Status	Start Date
AMS001	Statewide River and Stream Ambient Monitoring-WY2010 to present (published data)	ONGOING	10/1/2009
AMS001-2	Statewide River and Stream Ambient Monitoring-WY2011 to present-2 (provisional data)	ONGOING	10/1/2009
AMS001B	Statewide River and Stream Ambient Monitoring-Pre 1980	COMPLETED	1/1/1949
AMS001C	Statewide River and Stream Ambient Monitoring-1980 to WY1988	COMPLETED	1/1/1980
AMS001D	Statewide River and Stream Ambient Monitoring-WY1989 through WY1999	COMPLETED	10/1/1988
AMS001E	Statewide River and Stream Ambient Monitoring-WY2000 through WY2009	COMPLETED	10/1/1999
AMS002	Statewide Lake Monitoring	COMPLETED	1/1/1989
AMS002B	Lake Mini-Monitoring (published data)	ONGOING	1/1/2010
AMS002B-2	Lake Mini-Monitoring (provisional data)	ONGOING	1/1/2011
AMS004	Continuous Stream Monitoring	ONGOING	6/1/2001

3. Data are available by contacting the ambient monitoring staff person responsible for ambient monitoring in the Washington State Department of Ecology region, currently:

- Ecology Central Region: Dan Dugger (509.454.4183; ddug461@ecy.wa.gov)
- Ecology Eastern Region: Mike Anderson (509.662.0480; jros461@ecy.wa.gov)
- Ecology Northwest Region: Bill Ward (360.407.6621; bwar461@ecy.wa.gov)
- Ecology Southwest Region: Bill Ward (360.407.6621; bwar461@ecy.wa.gov)

The first two digits of each station number is the Water Resource Inventory Area (WRIA) number. This number can be used to identify which Water Quality Management Area (WQMA) or "basin" each station is in, according to Table C-2.

Table C-2. Washington's Water Quality Management Areas.

Basin	WRIAs		Basin	WRIAs
Cedar/Green	8-9		Nooksack/San Juan	1-2
Columbia Gorge	27-29		Okanogan	48-53
Eastern Olympics	13-14, 16-19		Puyallup/Nisqually	10-12
Esquatzel/Crab Creek	36, 42-43		Skagit/Stillaguamish	3-5
Horseheaven/Klickitat	30-31		Spokane	54-57
Island/Snohomish	6-7		Upper and Lower Snake	32-35
Kitsap	15		Upper Columbia/Pend Oreille	58-62
Lower Columbia	24-26		Upper Yakima	38-39
Lower Yakima	37		Wenatchee	40, 44-47
Mid Columbia	41		Western Olympics	20-23

Ambient Monitoring Data Remarks Codes

Remarks codes in historical data are defined below. Only "U", "J", and "G" were used in WY 2012.

B, V	Analyte was found in the blank, indicating possible contamination.
E	Result is an estimate due to interference.
G, L	True result is equal to or greater than reported value.
H	Sample was analyzed over holding time.
J	Reported result is an estimate.
K, U	Analyte was not detected at or above the reported result.
N	Spike sample recovery was outside control limits.
P	Result is between the detection limit and the minimum quantitation limit (applied to metals).
S	Spreader: one or more bacteria colonies were smeared, possibly obscuring other colonies.
X	High background count of non-target bacteria, possibly obscuring additional colonies.

Appendix D. Water Year 2012: Missing Data

Table D-1. Missing data for the 12 standard parameters.
"X"=missing

Station	Date	Remarks	Temperature	Conductivity	Oxygen	pH	Suspended Solids, total	Total Persulfate Nitrogen	Ammonia-nitrogen	Nitrate+nitrite-nitrogen	Phosphorus, total	Orthophosphate	Turbidity	Fecal Coliform Bacteria
05M050	4/16/2012	Sampler Error: not recorded		x										
07D050	1/23/2012	Equipment Failure: bottle cracked			x									
07D130	5/14/2012	Sampler Error: pH probe contaminated				x								
07R050	4/17/2012	Sampler Error: titration error			x									
08C110	1/23/2012	Weather: inaccessible due to snow/ice	x	x	x	x	x	x						
08C110	5/14/2012	Sampler Error: pH probe contaminated				x								
09A190	5/14/2012	Sampler Error: DO* "lost"			x									
11A070	12/19/2011	Equipment Failure: thermistor failed	x											
13A060	12/19/2011	Equipment Failure: thermistor failed	x											
14C050	12/19/2011	Equipment Failure: thermistor failed	x											
16A070	11/14/2011	Access: bridge construction	x	x	x	x	x	x	x	x	x	x	x	x
16A070	12/19/2011	Equipment Failure: thermistor failed	x											
16B130	12/19/2011	Equipment Failure: thermistor failed	x											
16C090	12/19/2011	Equipment Failure: thermistor failed	x											
20F070	8/28/2012	Misc: no water	x	x	x	x	x	x	x	x	x	x	x	x
20F070	9/25/2012	Misc: no water	x	x	x	x	x	x	x	x	x	x	x	x
23A160	4/9/2012	Equipment Failure: bad starch			x									
24B090	4/9/2012	Equipment Failure: bad starch			x									
24F070	4/9/2012	Equipment Failure: bad starch			x									
31E060	9/12/2012	Sampler Error: not recorded			x									
34A070	12/13/2011	Weather: inaccessible due to snow/ice	x	x	x	x	x	x	x	x	x	x	x	x
34A070	2/14/2012	Sampler error: bad standards		x		x								
34A070	4/17/2012	Sampler error: ran out of time	x	x	x	x	x	x	x	x	x	x	x	x
34A070	7/25/2012	Sampler error: sample spilled			x									
34A170	12/13/2011	Weather: inaccessible due to snow/ice	x	x	x	x	x	x	x	x	x	x	x	x
34A170	2/14/2012	Sampler error: bad standards		x		x								
34B110	11/30/2011	Sampler error: sample "lost"			x									
34B110	2/14/2012	Sampler error: bad standards		x		x								
35A150	2/14/2012	Sampler error: bad standards		x		x								
35B060	2/14/2012	Sampler error: bad standards		x		x								
35D120	2/14/2012	Sampler error: ran out of time	x	x	x	x	x	x	x	x	x	x	x	x
53A070	11/28/2011	Sampler error: no lid for DO* bucket.	x		x									
54A120	11/28/2011	Sampler error: no lid for DO* bucket.			x									

Station	Date	Remarks	Temperature	Conductivity	Oxygen	pH	Suspended Solids, total	Total Persulfate Nitrogen	Ammonia-nitrogen	Nitrate+nitrite-nitrogen	Phosphorus, total	Orthophosphate	Turbidity	Fecal Coliform Bacteria
54A120	2/13/2012	Sampler error: bad standards				x								
55B070	11/28/2011	Sampler error: no lid for DO[*] bucket.			x									
55B070	2/13/2012	Equipment failure: pH not performing				x								
55B070	5/14/2012	Sampler error: bottle lost						x	x	x				
56A070	11/28/2011	Sampler error: no lid for DO[*] bucket.			x									
56A070	1/25/2012	Sampler error: bad standards		x		x								
56A070	2/13/2012	Sampler error: ran out of time	x	x	x	x	x	x	x	x	x	x	x	x
56A070	3/19/2012	Sampler error: ran out of time	x	x	x	x	x	x	x	x	x	x	x	x
57A150	2/14/2012	Sampler error: bad standards		x		x								
59A080	11/28/2011	Sampler error: no lid for DO[*] bucket.			x									
59B200	11/28/2011	Sampler error: no lid for DO[*] bucket.			x									
59B200	1/9/2012	Access: gate locked	x	x	x	x	x	x	x	x	x	x	x	x
60A070	12/14/2011	Weather: inaccessible due to snow/ice	x	x	x	x	x	x	x	x	x	x	x	x
60A070	2/15/2012	Sampler error: bad standards		x		x								
61A070	2/15/2012	Sampler error: bad standards		x		x								
61A070	8/28/2012	Equipment failure: DO[*] seal leaked air			x									
61B070	2/15/2012	Sampler error: bad standards		x		x								
61C100	1/11/2012	Weather: inaccessible due to snow/ice	x	x	x	x	x	x	x	x	x	x	x	x
61C100	2/15/2012	Weather: inaccessible due to snow/ice	x	x	x	x	x	x	x	x	x	x	x	x
62A090	2/15/2012	Sampler error: ran out of time	x	x	x	x	x	x	x	x	x	x	x	x
62A150	2/15/2012	Sampler error: bad standards		x		x								

[*] DO: dissolved oxygen.

Appendix E. Glossary, Acronyms, and Abbreviations

Glossary

Ambient: Background or away from point sources of contamination.

Anadromous: Types of fish, such as salmon, that go from the sea to freshwater to spawn.

Anthropogenic: Human-caused.

Basin: A drainage area or watershed 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.

Bi-monthly: Every other month.

Censored data: Data where the value is only partially known (or reported). For example, measured concentrations below a reporting limit for that analyte may be reported as less than the reporting limit.

Char: Char (genus *Salvelinus*) are distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

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: A measure of the amount of oxygen dissolved in water.

Exceeded: Did not meet.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Grab sample: A discrete sample from a single point in the water column or sediment surface.

Hardness: A measure of the dissolved solids in a water sample (e.g., calcium, magnesium).

Noise: An unwanted perturbation to a wanted signal. Noise is used here to indicate any result not representative of the environmental conditions being monitored.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: 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 to be 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.

Reporting Limit: The reporting limit is the value reported to the project officer by the lab for results measured below that limit. In practice, it is the value where the lab feels it can consistently report a result with confidence. Reporting limits are higher than statistically calculated method detection limits.

Salmonid: Fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Sinusoidal: An oscillation that can be described with a sine function.

Spatial: How concentrations differ among various parts of the river.

Stage height: Water surface elevation.

Synoptic survey: Data collected simultaneously or over a short period of time.

Temporal: Characterize over time (e.g., temporal trends).

Thermistors: Data loggers.

Total maximum daily load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding 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.

Total suspended solids (TSS): Portion of solids retained by a filter.

Trend: A change over time.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Water Year (WY) 2012: October 1, 2011 through September 30, 2012.

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.

7-DADMax: Seven-day average of the daily maximum (usually temperature).

7-DADMin: Seven-day average of the daily minimum (usually oxygen).

Acronyms and Abbreviations

BP	Barometric Pressure
DQO	Data quality objective
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EF	East Fork
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
IMW	Intensely Monitored Watershed
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NF	North Fork
NO_2+NO_3	Nitrate + nitrite-nitrogen
QA	Quality assurance
QAMP	Quality Assurance Monitoring Plan
QC	Quality control
RMS	Root mean squared
RSD	Relative standard deviation
SF	South Fork
SM	Standard method
Std dev	Standard deviation
TMDL	(See Glossary above)
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WQI	Water Quality Index
WRIA	Water Resource Inventory Area
WY	Water year

Units of Measurement

°C	degrees centigrade
cm	centimeter
mg/L	milligrams per liter (parts per million)
mL	milliliters
NTU	nephelometric turbidity units
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
uS	microsiemens per centimeter, a unit of conductivity