River and Stream Water Quality Monitoring Report

Water Year 2010

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Cover photo: Morning on the Elwha River near Port Angeles; station 18B070
(by Troy Warnick).

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River and Stream
Water Quality Monitoring Report

Water Year 2010

by
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Waterbody Number: Statewide

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Abstract

The Washington State Department of Ecology (Ecology) collected monthly water quality data at 100 stream monitoring stations during Water Year 2010 (October 1, 2009 through September 30, 2010). We also collected 30-minute interval temperature data at 36 sites, mostly from July through September 2010. In addition, we began a continuous oxygen monitoring program at three sites.

The principal goals of this ongoing monitoring program are to characterize the rivers and streams of Washington State and to track changes in water quality.

This report documents methods and data quality for Water Year 2010. This year's annual report includes a quality control analysis of continuously monitored data using a multiparameter (oxygen, temperature, pH, and conductivity) instrument.

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 2010 ambient monitoring program, and the quality of the data, are attributable to the following people:

- Bill Ward, Bruce Barbour, Chris Coffin, Daniel Sherratt, Jason Myers, Mike Anderson, and Troy Warnick collected samples. These guys spend long hours working in all kinds of weather, traffic, and road conditions. Without their dedication, Appendix D would be much longer.
- Bill Ward conducted the continuous stream temperature monitoring project.
- Howard Christensen and Jason Myers provided streamflow data.
- Brad Hopkins, Bill Ward, and Mike Anderson reviewed the draft report;
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- Cindy Cook and Joan LeTourneau formatted and edited the final report.

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- Nancy Rosenbower performed sample tracking services with help from Nancy Jensen, Aileen Richmond, Susan Carrell, Meredith Jones, and Deborah Clark.
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- 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.
- Stuart Magoon managed the lab and kept everything working smoothly.

Introduction

The Washington State Department of Ecology (Ecology) and its predecessor agency have operated a long-term ambient water quality monitoring program since 1959. For more than 15 years, the basic program has 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. In Water Year (WY) 2010 we sampled at an additional 18 special project stations.

Our data are provided free to the public and are widely used by academics, consultants, local government entities, 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).

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] that is the list of waters needing to be cleaned up (www.ecy.wa.gov/programs/wq/303d/index.html).

This report describes the WY 2010 monitoring program and discusses the quality of the data collected in WY 2010. 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).

Goals and Objectives

The primary goals of the River and Stream Ambient Monitoring Program are to characterize water quality and to evaluate spatial and temporal changes in water quality (trends).

Through WY 2010, we have defined types of monitoring stations and their objectives as follows:

- **Long-term 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 the state, or upstream from most anthropogenic (human-caused) sources of water quality problems.
- **Basin stations** are generally monitored for one year only (although they may be re-visited periodically) to collect current water quality information. These stations are selected to support the waste discharge permitting process, TMDL assessments, site-specific needs, and to allow expanded coverage over a long-term network. Some basin stations are selected to target known problems and may not necessarily reflect conditions representative of the entire basin.
- **Special project 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.

Beginning with WY 2011, we modified the objectives for basin stations and added a new station type.

- **Long-term stations:** Same as before.
- **Basin stations:** 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; we hope recent data of known quality will help to 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.
  - Resolve category 2 ("Waters of concern") listings: should they be category 1 ("Meets standards") or category 5?
  - Identify "high quality" Tier III waters.
- **Special project stations:** Same as before.
- **Sentinel sites:** These 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.

Monitoring in Water Year 2010

In WY 2010, we monitored the usual 62 long-term and 20 basin stations.

In addition, we monitored 18 stations associated with special projects (and external funding). Eight of these were in the Eastern Region, four in the Northwest Region, and six in the Southwest Region. Ten of the stations were associated with the "Intensively Monitored Watersheds" (IMW) project (see www.ecy.wa.gov/programs/eap/imw). Seven stations were part of a larger Spokane River study. One station included field parameters during summer months only in support of continuous monitoring.

We collected 30-minute interval temperature data from about July through September 2010 at many long-term and a few basin stations, as well as conducted bi-monthly metals monitoring at 12 selected stations.

We also conducted 15-minute interval monitoring for temperature, dissolved oxygen, pH, and conductivity at nine stations: the Big Quilcene River, Colville River, Deschutes River, and six stations in support of IMW work. Sensors recorded data at 15-minute intervals. Results were delivered in near-real-time to the Internet by satellite telemetry at all stations except the Deschutes.

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Methods

Sampling Network

The ambient monitoring network in WY 2010 consisted of monthly water collection at 100 stations (Table 1 and Appendix A).

We sampled all stations year-round except for one special project station. We monitored the Colville River at Blue Creek from May through September for field parameters only.

The locations of ambient stations monitored during WY 2010 are presented in Table 1. Appendix A lists current and historical monitoring locations and the years they were monitored by Ecology and its predecessor agency. Historical data for these stations are available from the ambient monitoring program on request.

Also, a description of our long-term monitoring program, access to 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 2010. See Appendix A.

Key	Station	Location	Status[a]	Key	Station	Location	Status[a]
1	01A050	Nooksack River at Brennan	C	51	27B070	Kalama River near Kalama	C
2	01A120	Nooksack River at North Cedarville	C	52	27D090	EF Lewis River near Dollar Corner	C
3	03A060	Skagit River near Mount Vernon	C	53	28B085	Washougal R above Ltl Washougal R	B
4	03A080	Skagit River above Sedro Woolley	B	54	31A070	Columbia River at Umatilla	C
5	03B050	Samish River near Burlington	C	55	31B110	Rock Creek at Bickleton Hwy	B
6	03B077	Samish River above Parson Creek	B	56	31C012	Alder Creek at 6 Prong Road Bridge	B
7	04A100	Skagit River at Marblemount	C	57	31D010	Pine Creek at One Mile Bridge	B
8	05A070	Stillaguamish River near Silvana	C	58	32A070	Walla Walla River near Touchet	C
9	05A090	SF Stillaguamish River at Arlington	C	59	33A050	Snake River near Pasco	C
10	05A110	SF Stillaguamish River near Granite Falls	C	60	34A070	Palouse River at Hooper	C
11	05B070	NF Stillaguamish River at Cicero	C	61	34A170	Palouse River at Palouse	C
12	05B110	NF Stillaguamish River near Darrington	C	62	34B110	SF Palouse River at Pullman	C
13	05G050	Jim Creek at Jordan Road	B	63	35A150	Snake River at Interstate Bridge	C
14	07A090	Snohomish River at Snohomish	C	64	35B060	Tucannon River at Powers	C
15	07B075	Pilchuck River at Russel Road	B	65	35F050	Pataha Creek near mouth	B
16	07C070	Skykomish River at Monroe	C	66	36A070	Columbia River near Vernita	C
17	07D050	Snoqualmie River near Monroe	C	67	37A090	Yakima River at Kiona	C
18	07D130	Snoqualmie River at Snoqualmie	C	68	37A205	Yakima River at Nob Hill	C
19	07P070	Patterson Creek near Fall City	B	69	39A055	Yakima River at Umtanum Cr Footbrg	B
20	08C070	Cedar River at Logan Street/Renton	C	70	39A090	Yakima River near Cle Elum	C
21	08C110	Cedar River near Landsburg	C	71	39B090	Cle Elum River near Roslyn	B
22	09A080	Green River at Tukwila	C	72	41A070	Crab Creek near Beverly	C
23	09A190	Green River at Kanaskat	C	73	43A070	Crab Creek at Irby	B
24	10A070	Puyallup River at Meridian Street	C	74	45A070	Wenatchee River at Wenatchee	C
25	11A070	Nisqually River at Nisqually	C	75	45A110	Wenatchee River near Leavenworth	C
26	13A060	Deschutes River at E Street Bridge	C	76	46A070	Entiat River near Entiat	C
27	15F050	Big Beef Creek at mouth	S1	77	48A075	Methow River near Pateros at Metal Br.	C
28	15L050	Seabeck Creek at mouth	S1	78	48A140	Methow River at Twisp	C
29	15M070	Llt Anderson Cr at Anderson Hill Road	S1	79	49A070	Okanogan River at Malott	C
30	15N070	Stavis Creek near mouth	S1	80	49A190	Okanogan River at Oroville	C
31	16A070	Skokomish River near Potlatch	C	81	49B070	Similkameen River at Oroville	C
32	16C090	Duckabush River near Brinnon	C	82	53A070	Columbia River at Grand Coulee	C
33	17A060	Big Quilcene River near mouth	B	83	53C070	Hawk Creek at Miles-Creston Road	B
34	18B070	Elwha River near Port Angeles	C	84	54A070	Spokane River at Long Lake	S2
35	19C060	West Twin River near mouth	S1	85	54A090	Spokane River at Ninemile Bridge	S2
36	19D070	East Twin River near mouth	S1	86	54A120	Spokane River at Riverside State Pk	C
37	19E060	Deep Creek near mouth	S1	87	54A130	Spokane River at Fort Wright Bridge	S2
38	20B070	Hoh River at DNR Campground	C	88	55B070	Little Spokane River near mouth	C
39	22A070	Humptulips River near Humptulips	C	89	56A070	Hangman Creek at mouth	C
40	23A070	Chehalis River at Porter	C	90	57A123	Spokane River at Sandifer Bridge	S2
41	23A160	Chehalis River at Dryad	C	91	57A140	Spokane River at Plante's Ferry Park	S2
42	24B090	Willapa River near Willapa	C	92	57A146	Spokane River at Sullivan Road	S2
43	24B130	Willapa River at Lebam	B	93	57A150	Spokane River at Stateline Bridge	C
44	24F070	Naselle River near Naselle	C	94	57A240	Spokane River at Lake Coeur d'Alene	S2
45	24K060	Forks Creek above Hatchery (outfall)	B	95	59A110	Colville River at Blue Creek	S3
46	25D050	Germany Creek at mouth	S1	96	59A140	Colville River at Newton Road	B
47	25E060	Abernathy Creek near mouth	S1	97	60A070	Kettle River near Barstow	C
48	25F060	Mill Creek near mouth	S1	98	61A070	Columbia River at Northport	C
49	26B070	Cowlitz River at Kelso	C	99	62A090	Pend Oreille River at Metaline Falls	B
50	26C073	Coweeman River at 3802 Allen Street	B	100	62A150	Pend Oreille River at Newport	C

[a] C: long-term.
B: basin.
S1: Intensively Monitored Watersheds (IMW).
S2: Spokane River Project.
S3: Continuous monitoring support (field parameters, summer months only).

Sample Collection and Analysis

We collected 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, except a few special project stations, in WY 2010 (Table 2).

Table 2. Water quality parameters monitored in Water Year 2010.
*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 µg/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 µg/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	NA
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 an earlier annual report (Hallock et al., 1998), our field monitoring protocols (Ward et al., 2001), standard operating procedures (Ward, 2007a; Ward, 2007b; Ward, 2010, in draft), ambient monitoring quality assurance documents (Hallock and Ehinger, 2003; Hallock, 2007; and Hopkins, 1996), and Manchester Environmental Laboratory's *Lab Users Manual* (MEL, 2008).

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 procedures in WY 2010 that we believe will affect trends.

However, in WY 2008 and 2009 we incorrectly calculated flows at station 39A090 Yakima River near Cle Elum. We inadvertently included flow from the Cle Elum River, which enters downstream of our station. Flows were also calculated incorrectly at 53A070 Columbia River below Grand Coulee Dam from WY 2005 through WY 2009 (some flows sources were double-counted). We have corrected the data for these years in our database, on the web, and in the Environmental Information Management (EIM) database.

We made the following procedural changes to the program in WY 2010:

- We redesigned basin station objectives, added a new station type (see *Introduction*), added several new long-term stations, and reduced the number of basin stations. These changes will begin in WY 2011.
- We began recording stage as measured, required correction, and an estimate of the amount of measurement error. Previously, we only recorded corrected stage.
- We began lowering blank samples off the bridge (without entering the water), rather than simply adding blank water to the sample container. The previous procedure would not have captured contamination due to material falling off the bridge.

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.

Continuous Temperature Monitoring

The program 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.

We try to deploy the loggers by early July and retrieve them in late September. However, because nearly half of our monitoring stations have supplemental temperature criteria that apply during fall through spring, we hope to move towards year-round temperature monitoring, where possible, as resources allow.

We 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 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 were placed in a free-flowing location at a depth to avoid exposure to air resulting from low streamflows. Detailed protocols are found in Ward (2010, in draft) and quality control 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. Our grab-sample monitoring program does a poor job of capturing daily low oxygen concentrations.

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

In WY 2010, we deployed Hydrolab® Minisondes with optical oxygen sensors (LDO) or an In Situ® optical oxygen sensor (RDO) at nine stations, six in support of the IMW special projects and three in support of other projects (Table 3). All instruments but one were connected to near real-time telemetry stations. We deployed a self-contained system (without telemetry) in the Deschutes River at E Street (13A060). All instruments recorded temperature, oxygen, and conductivity readings every 15 minutes. Three instruments 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 3. Stations monitored for continuous oxygen in Water Year 2010.

Station	Name	Objective
13A060	Deschutes River at E Street	WQS evaluation; support intensive
17A060	Big Quilcene River near mouth	Evaluate oxygen during period designated for supplemental temperature standards
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
25D050	Germany Creek at mouth	Support IMW project
25E060	Abernathy Creek near mouth	Support IMW project
25F060	Mill Creek near mouth	Support IMW project
59A110	Colville River at Blue Creek	WQS evaluation; support proposed TMDL

WQS: Water Quality Standards.

Metals Monitoring

Metals monitoring continued in WY 2010 at 12 stations (Table 4). Metals samples were collected every other month beginning in October 2009.

Table 4. Bi-monthly sampling stations for metals in Water Year 2010.

Station	Name		Station	Name
01A050	Nooksack River at Brennan		37A090	Yakima River at Kiona
03B050	Samish River near Burlington		45A110	Wenatchee River near Leavenworth
05A070	Stillaguamish River near Silvana		49A190	Okanogan River at Oroville
11A070	Nisqually River at Nisqually		54A090	Spokane River at Ninemile Bridge
16A070	Skokomish River near Potlatch		57A150	Spokane River at Stateline Bridge
24F070	Naselle River near Naselle		60A070	Kettle River near Barstow

Samples were analyzed for hardness, total mercury, as well as total and dissolved arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc. Collection and analytical methods are discussed in more detail in Ward (2007b) and Hopkins (1996).

We selected stations for metals monitoring based on known problem areas (e.g., Spokane River) and sites where we have little current data. However, Hallock (2010) showed that metals are not generally a problem in ambient streams. Repeat monitoring is not cost-effective at most stations. Beginning with WY 2011, our metals monitoring objectives will be to

- 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.

Lake Monitoring

Although Ecology currently has no statewide lake monitoring program, Ecology management agreed to fund the analysis of total phosphorus samples collected incidentally from lakes visited by aquatic plant monitoring staff. Plant monitoring staff collected 45 samples from 30 lakes, including 11 hypolimnion samples and three duplicate samples for quality control (QC) purposes. They visited one lake twice.

The Quality Assurance Project Plan for this monitoring project (Bell-McKinnon, in draft) was produced as an addendum to aquatic plant monitoring QC documents, which are currently being developed.

Quality Assurance

Ecology's Manchester Environmental Laboratory (MEL) quality assurance (QA) program includes the use of QC charts, check standards, in-house matrix spikes, laboratory blanks, and performance evaluation samples. For a more complete discussion of laboratory QA, see Manchester Laboratory's *Quality Assurance Manual* (MEL, 2006) 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 (2007).

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. This eliminates instream and sample collection variability. Remaining variability is attributable to field processing and laboratory analysis.
3. *Field Blank Samples.* These consisted of the submission and analysis of de-ionized water. These are field process blanks. The blank 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 were identified as QC samples, but sample type (duplicate, split, or blank) and station were not identified.

Altogether, we processed 141 field QC samples for standard parameters: 17 field blanks, 62 field duplicates (sequential), and 62 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 meets all QA 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 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, if the bias was relatively small and consistent (i.e., the pre-deployment bias was just within the required limits and in the same direction), we may adjust results.

In addition, we compared the data to field temperature measurements taken at deployment and retrieval with a calibrated alcohol thermometer or thermistor. We also compared results to the monthly measurements collected during grab-sample monitoring surveys.

We reviewed all data graphically, and deleted anomalies prior to uploading results into the database.

Continuous Multiple Parameter Monitoring (Dissolved Oxygen)

We used Hallock (2009) to assess the quality of data collected by optical oxygen sensors. 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 2010. 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). 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 2010, no samples exceeded the chronic un-ionized ammonia criteria. Un-ionized ammonia was more than 10% of the chronic criterion at four stations: Jim Cr @ Jordan Rd (05G050), Green R @ Tukwila (09A080), Crab Cr @ Irby (43A070; on two occasions), Colville River at Newton Rd (59A140)

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 5 and 6. Our web presentation now uses the 2006 criteria for current data. In any case, the Ecology ambient monitoring program's comparison of results to water quality criteria 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 more than 14,000 possible standard water quality results in WY 2010, 372 results (2.6%) were missed. As in WY 2009, this is a larger than usual number of missed results for us. Many results (144) were missed because the station was inaccessible or frozen. Other reasons for missing results include road construction (72), no flow (36), shipping problems (8), and an unusual number of lost results due to equipment failure (37). Appendix D gives more detailed explanations for each missed result.

Instantaneous flow was recorded at all of the 62 long-term stations. However, flows were not available on 15 occasions at different long-term stations for various reasons. Flows at four long-term stations were coded as estimates, generally because the rating curve was too old to be reliable or because the nearest gage was too far upstream.

Discharge was recorded at 23 of the 38 basin and special project stations. Discharge was not recorded during some months at several basin stations for various reasons.

Table 5. 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	<=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. There are additional temperature criteria during specified seasons for some waterbodies.

Table 6. 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.

Continuous Temperature Monitoring

During WY 2010, we successfully monitored continuous temperature at 24 western Washington and 12 eastern Washington stations (Table 7). We were unable to retrieve two eastern Washington water loggers (Crab Creek and Walla Walla River). Data from these stations may be available later. One logger failed (Little Washougal River).

The seven-day average of the daily maximum temperature (7-DADMax) failed to meet the basic 2006 criteria at most stations (32 stations, 89%). Nine stations did not meet supplemental temperature criteria (Table 8). More stations would probably have failed the supplemental criteria, but deployment dates at most stations rarely include the beginning and ending of the supplemental season.

Seasonal maximum temperatures were cooler in 2010 than in 2009. Last year, maximum temperatures at the warmest five stations ranged from 29.1 to 30.0 ºC. In 2010, the five stations with the warmest seasonal water temperatures based on continuous monitoring data were:

- 34A170 Palouse R at Palouse (28.2 ºC)
- 34A070 Palouse R at Hooper (28.0 ºC)
- 35B060 Tucannon R at Powers (25.4 ºC)
- 07B075 Pilchuck R at Russel Rd. (23.9 ºC)
- 59A140 Colville R at Newton Rd. (23.6 ºC)

Table 7. Temperature summary for Water Year 2010 (°C).

Seasonal 7-DADMax exceeding 2006 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]		
01A120	16	Yes	17.8	15-Aug-10	**17.4**	27-Jul-10	28-Sep-09	27-Sep-10
03B077	16	Yes	17.1	8-Jul-10	**16.1**	9-Jul-10	30-Jun-10	20-Oct-10
05A070	17.5	Yes	23.4	16-Aug-10	**22.5**	15-Aug-10	30-Jun-10	1-Oct-10
05B070	16	Yes	22	15-Aug-10	**21.2**	15-Aug-10	30-Jun-10	1-Oct-10
05B110	12	Yes	19	17-Aug-10	**18.5**	14-Aug-10	30-Jun-10	24-Sep-10
05G050	16	Yes	22.3	15-Aug-10	**21.3**	15-Aug-10	30-Jun-10	24-Sep-10
07B075	16	Yes	23.9	16-Aug-10	**22.9**	15-Aug-10	30-Jun-10	1-Oct-10
07D050	17.5	No	20.5	6-Aug-10	**19.6**	28-Jul-10	1-Jul-10	10-Aug-10
07D130	16	No	19.4	5-Aug-10	**18.8**	15-Aug-10	1-Jul-10	29-Sep-10
07P070	16	Yes	18.6	10-Jul-10	**17.5**	9-Jul-10	1-Jul-10	24-Sep-10
08C110	16	Yes	13.5	27-Sep-10	13.0	15-Aug-10	24-Sep-09	29-Sep-10
09A190	16	Yes	17.3	17-Aug-10	**17.0**	15-Aug-10	1-Jul-10	29-Sep-10
11A070	16	Yes	16.8	17-Aug-10	**16.5**	15-Aug-10	13-Jul-10	22-Sep-10
13A060	17.5	No	19.6	9-Jul-10	**18.7**	15-Aug-10	22-Sep-09	22-Sep-10
16A070	16	Yes	14.1	5-Aug-10	13.9	27-Jul-10	13-Jul-10	24-Sep-10
16C090	16	Yes	13.6	17-Aug-10	13.1	15-Aug-10	20-Jul-10	24-Sep-10
18B070	16	No	15.9	25-Aug-10	15.4	22-Aug-10	20-Jul-10	24-Sep-10
20B070	16	Yes	17.2	15-Aug-10	**16.7**	14-Aug-10	18-Sep-09	24-Sep-10
23A070	17.5	Yes	23.4	15-Aug-10	**22.3**	15-Aug-10	18-Sep-09	15-Sep-10
23A160	16	Yes	23.2	16-Aug-10	**22.1**	15-Aug-10	22-Sep-09	22-Sep-10
24B130	16	Yes	20.1	16-Aug-10	**19.2**	15-Aug-10	14-Jul-10	22-Sep-10
24K060	16	Yes	20.3	15-Aug-10	**19.2**	14-Aug-10	14-Jul-10	22-Sep-10
27B070	16	Yes	18.8	9-Jul-10	**17.8**	27-Jul-10	27-Jun-10	15-Sep-10
28B085	16	Yes	22.9	16-Aug-10	**21.9**	15-Aug-10	22-Jun-10	15-Sep-10
34A070	17.5	No	28	5-Aug-10	**27.2**	27-Jul-10	8-Jul-10	15-Nov-10
34A170	20	No	28.2	26-Jul-10	**26.3**	25-Jul-10	30-Jun-10	15-Nov-10
34B110	17.5	No	22.3	11-Jul-10	**21.2**	28-Jul-10	30-Jun-10	15-Nov-10
35B060	17.5	No	25.4	26-Jul-10	**24.3**	5-Aug-10	8-Jul-10	15-Nov-10
39A055	17.5	No	19.4	17-Aug-10	**18.9**	16-Aug-10	6-Jul-10	1-Nov-10
39A090	16	Yes	20.1	17-Aug-10	**19.8**	15-Aug-10	6-Jul-10	22-Oct-10
46A070	17.5	Yes	20.9	15-Aug-10	**19.4**	12-Aug-10	7-Jul-10	22-Oct-10
48A070	17.5	Yes	21.6	18-Aug-10	**21.1**	16-Aug-10	7-Jul-10	22-Oct-10
48A140	17.5	Yes	18.8	18-Aug-10	**18.3**	16-Aug-10	7-Jul-10	22-Oct-10
53C070	16	No	19.5	29-Jul-10	**18.7**	27-Jul-10	1-Jul-10	6-Oct-10
55B070	16	No	18.2	11-Jul-10	**17.6**	27-Jul-10	6-Jul-10	6-Oct-10
59A140	17.5	No	23.6	29-Jul-10	**22.7**	28-Jul-10	6-Jul-10	6-Oct-10

[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 8. Stations exceeding the 13 ºC supplemental temperature criteria (Payne, 2006).

Station		7-DADMax [a]		Supplemental Season	Deploy Date	Retrieve Date
		Max	Date [b]			
01A120	Nooksack River at No Cedarville	13.9	16-Sep	09/15-07/01	1-Jan-10	27-Sep-10
05B070	NF Stillaguamish River at Cicero	16.3	1-Sep	09/01-07/01	30-Jun-10	1-Oct-10
05G050	Jim Creek at Jordan Rd	15.7	16-Sep	09/15-07/01	30-Jun-10	24-Sep-10
09A190	Green River at Kanaskat	15.9	16-Sep	09/15-07/01	1-Jul-10	29-Sep-10
11A070	Nisqually River at Nisqually	14.9	18-Sep	09/15-07/01	13-Jul-10	22-Sep-10
20B070	Hoh River at DNR Campground	14.8	1-Sep	09/01-07/01	1-Jan-10	24-Sep-10
20B070	Hoh River at DNR Campground	13.4	24-Jun	09/01-07/01	1-Jan-10	24-Sep-10
23A070	Chehalis River at Porter	15.4	15-May	10/01-05/15	1-Jan-10	15-Sep-10
23A160	Chehalis River at Dryad	16.9	16-Sep	09/15-07/01	1-Jan-10	22-Sep-10
23A160	Chehalis River at Dryad	17.3	25-Jun	09/15-07/01	1-Jan-10	22-Sep-10
39A090	Yakima River near Cle Elum	16.5	15-Sep	09/15-06/15	6-Jul-10	22-Oct-10

[a] This is the 7-day period with the highest average of daily maximum temperatures.
[b] 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.

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). Daily maximum, minimum, and average values will also be stored in Ecology's EIM database once the required procedures are developed.

We were unable to process data from stations supporting the IMW project (Table 3) in time to be included in this report. Results from other continuous multiple parameter monitoring are discussed below.

Oxygen

All 7-day averages of daily minimums (7-DADMin) of dissolved oxygen concentrations met or were better than criteria at the Deschutes and Big Quilcene River stations (Table 9). The minimum 7-DADMin at station 59A110 Colville River at Blue Creek was 6.2 mg/L, well below the 8.0 mg/L criterion. This reach of the Colville River is Category 4A (has a TMDL) for oxygen in the 2008 Water Quality Assessment (Koch, 2009).

Temperature

All 7-DADMax for temperature met or were better than criteria at the Deschutes and Big Quilcene River stations, and seasonal results from the Quilcene station were also below supplemental temperature criteria (Table 9). The maximum 7-DADMax at station 59A110 Colville River at Blue Creek was 22.5 ºC, well above the 17.5 ºC criterion. This reach of the Colville River is unlisted for temperature in the 2008 Water Quality Assessment (Koch, 2009), although reaches upstream and downstream are listed as Category 5.

pH

Only station 59A110 Colville River at Blue Creek had acceptable QC for pH and then only for the first half of the deployment period. Even though the acceptable data probably did not include the critical period, the 7-DADMax pH slightly exceeded the 8.5 criterion for a brief period in mid-May. This reach of the Colville River is unlisted for pH.

Table 9. Maximum 7-DADMax and minimum 7-DADMin compared to water quality criteria. *Values not meeting criteria are in bold.*

Station	7-DAD Max/Min	Date	Criteria/Comment
Dissolved Oxygen (mg/L)			
13A060	8.4	8/7/2010	7-DADMin ≥ 8.0 mg/L. (Record may not have included seasonal minimum.)
17A060	10.1	9/17/2010	7-DADMin ≥ 9.5 mg/L
59A110	**6.2**	7/28/2010	7-DADMin ≥ 8.0 mg/L
Temperature (ºC)			
13A060	16.8	8/7/2010	7-DADMax ≤ 17.5 °C (Record may not have included seasonal maximum.)
17A060	15.2 & 12.8	8/15/2010 & 9/16/2010	7-DADMax ≤ 16 and 13 °C (Seasonal criterion 9/15 through 7/1)
59A110	**22.5**	7/28/2010	7-DADMax ≤ 17.5 °C
pH (standard units)			
59A110	**8.6**	5/15/2010	6.5 ≤ pH ≤ 8.5 (Data record may not have included seasonal maximum.)

Metals Monitoring

During WY 2010, of the 1,224 possible metals results (12 stations x 6 months x 17 analytes), we failed to collect 34 results (two samples). Field staff could not sample the Kettle River at Barstow in December because the river was frozen. The sampler processed a blank instead of the river sample at the Skokomish River in June.

Of the 629 dissolved metals and total mercury results reported, 7 (1.1%) exceeded 2006 Washington State water quality standards chronic criteria (Table 10). Dissolved zinc exceeded the criterion in the Spokane River at Stateline in all months zinc was sampled. The Spokane River has a TMDL for metals, mostly due to legacy contamination from upstream mining practices. See Hallock (2010) for a detailed review of metals in the Spokane River.

Table 10. Metals results from Water Year 2010 exceeding the 2006 water quality standards criteria.

Date	Parameter	Hardness (mg/L)	Result (µg/L)	Chronic Criterion (µg/L)	Percent Over Chronic Criterion	Acute Criterion (µg/L)	Percent Over Acute Criterion
01A050 Nooksack River at Brennan							
10/19/2009	Hg	53.7	0.0311	0.012	159%	2.1	--
57A150 Spokane River at Stateline Bridge							
10/12/2009	Zn_DIS	21.7	32.9	28.6372	15%	31.36	5%
12/14/2009	Zn_DIS	20.8	46.4	27.6276	68%	30.26	53%
2/8/2010	Zn_DIS	22.7	46.2	29.7515	55%	32.58	42%
4/12/2010	Zn_DIS	21	50.2	27.8526	80%	30.50	65%
6/14/2010	Zn_DIS	20.8	46.8	27.6276	69%	30.26	55%
8/16/2010	Zn_DIS	22.5	29.7	29.5293	1%	32.34	--

Hg: mercury.
Zn_DIS: dissolved zinc.

Lake Monitoring

An analysis of total phosphorus data collected from lakes in 2010 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 2010 we collected almost 16,000 non-QC water quality results, including metals and various other parameters in addition to the standard 12 parameters listed under *Sample Collection and Analysis*.

- We coded 30 results (0.2%) "4" indicating that the data are usable, but there were questions about the quality. Most of these were soluble reactive phosphorus results that were analyzed over the holding time. The lab also reported these data as estimates. The remainder were cases where the nitrate plus nitrite result was greater than the total nitrogen result.
- We coded 88 results (0.5%) "5" or greater indicating serious data quality questions; these data will not be routinely used. This practice gives us the opportunity to explain quality issues to prospective users. Forty-nine of these were temperature results from eastern Washington in March and April where the thermistor failed. Twenty-two were pH results from the November northwest monitoring trip where the pH meter failed.

Manchester Laboratory assigned a qualifier to 19% of usable results. Three results (0.02%) were qualified as being greater than the reported number ("G"), 627 results (4.0%) were qualified as estimates ("J"), 2308 results (15%) as below the reporting limit ("U"), and 9 results (0.1%) were coded as both estimates and below the reporting limit ("UJ"). Eighty-three percent of all ammonia results were below the reporting limit, as were 16% of orthophosphate results (Table 11).

Table 11. Results qualified by Manchester Laboratory as being below the reporting limit.

Parameter	Reporting Limit (mg/L except where otherwise noted)	Number of results coded U or UJ	Number of acceptable results	Percent of results coded U or UJ
Ammonia	0.01	961	1159	83%
Chlorophyll	0.05 µg/L	0	20	0%
Fecal coliform bacteria	1	137	1151	12%
Hardness	Not specified	0	71	0%
Metals	Various	551	1205	46%
Nitrate+Nitrite	0.01	102	1159	9%
Nitrogen, total	0.025	28	1159	2%
Organic carbon, dissolved	1	28	178	16%
Organic carbon, total	1	49	290	17%
Orthophosphate	0.003	181	1159	16%
Phosphorus, total	0.005	58	1158	5%
Suspended sediment concentration	1	21	108	19%
Suspended solids	1	136	1158	12%
Turbidity	0.5 NTU	65	1159	6%

Errors in EIM and Web Databases

Data verification identified four instances where results in the EIM database were different than results in our primary database. The sample time was incorrect in EIM for data collected 8/4/2010 from the Deschutes River (13A060). In addition, 23 results that had been rejected were in EIM. These were temperatures collected in eastern Washington in March 2010 where the thermistor failed a subsequent QC check. Lastly, 44 results were missing in the EIM database. We corrected the EIM database on 2/10/2011.

All data in our preliminary web database matched those in our primary database. However, 43 results were missing in the web database. We loaded these on 2/9/2011.

Comparison to Quality Control Requirements

Decision Quality Objectives

Decision quality objectives (DQOs) are based on RMS values by concentration range (Table 12). In practice, estimates of variability are strongly influenced by extreme values, especially when the sample size is small. Also, the variability estimate is skewed downward for the lowest concentration ranges because data below the reporting limit are censored and, therefore, sample pairs below this limit have a variance of zero.

Table 12. Root mean square (RMS) of the standard deviation of sequential samples, field splits, and laboratory splits.

Results exceeding 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	4.4	0.52	10	No field splits		No lab splits	
	>50-100	8.8	0.75	25				
	>100-150	13.2	1.3	12				
	>150	26.4	1.9	11				
Fecal col. bacteria (colonies /100 mL)	1-1000	88	17.5	62	No field splits		12.4	179
	>1000	176	NA	0			NA	0
Ammonia (µg N/L)	≤20	1.76	0.42	57	0.37	58	0.35	69
	>20-100	8.8	1.52	5	2.40	4	0.63	5
	>100	17.6	NA	0	NA	0	NA	0
Nitrogen, total (µg N/L)	≤100	8.8	3.11	10	2.92	10	1.24	20
	>100-200	17.6	12.6	13	4.87	7	3.34	15
	>200-500	44	14.2	24	8.54	24	5.28	25
	>500	88	**241**	15	**126**	21	20.2	18
Nitrate+nitrite-nitorgen (µg N/L)	≤100	8.8	1.43	19	0.72	19	0.88	26
	>100-200	17.6	2.48	13	2.08	13	0.92	13
	>200-500	44	2.28	15	3.70	15	2.29	20
	>500	88	41.3	15	29.3	15	16.0	15
Oxygen, dissolved (mg O_2 /L)	≤ 8	0.70	NA	0	No field splits		No lab splits	
	> 8-10	0.88	0.08	14				
	> 10-12	1.06	0.15	32				
	>12	2.11	0.21	15				
pH	All	0.66	0.06	62	No field splits		No lab splits	
Phosphorus, soluble reactive (µg P/L^{-1})	≤50	4.4	2.26	57	2.26	57	0.28	92
	>50-100	8.8	0.82	4	0.54	4	0.57	6
	>100	17.6	12.0	1	13.4	1	0.00	1
Phosphorus, total (µg P/L)	≤50	4.4	1.18	45	0.77	45	0.70	57
	>50-100	8.8	3.68	13	2.39	13	1.59	13
	>100	17.6	3.39	3	0.41	3	3.70	3
Solids, suspended (mg /L)	≤10	0.88	0.61	46	No field splits		0.54	51
	>10-20	1.76	**3.32**	8			0.92	30
	>20-50	4.4	**4.79**	5			3.63	19
	>50	8.8	**10.5**	3			**16.1**	14
Temperature (ºC)	All	2.64	0.04	60	No field splits		No lab splits	
Turbidity (NTU)	≤10	0.88	0.32	54	No field splits		0.24	68
	>10-20	1.76	0.00	2			1.18	10
	>20-50	4.4	1.17	4			2.20	10
	>50	8.8	5.59	2			6.01	9

[a] Maximum permissible standard error to meet Quality Assurance Monitoring Plan (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 a number of cases, lab split samples had greater variability than field QC samples, probably because lab splits are often based on different samples than the field QC samples. Field sequential samples occasionally had less variability than the field splits. Usually, a single field split pair with poor precision was responsible.

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

One field split constituent/concentration range failed our Quality Assurance Monitoring Plan (QAMP) DQO (Hallock and Ehinger, 2003), which specifies that DQOs be evaluated against field splits, where possible. The highest range of total nitrogen samples exceeded the DQO due to one particularly poor sample split.

Four field sequential constituent categories failed to meet the DQO criteria, but instream variability is included in these sample pairs so their variability is not a true measure of sampling plus analytical error. The highest concentration total nitrogen (TN) category failed DQO criteria due to several poorly matched sample pairs. As in years past, the variability in sequential samples for total suspended solids (TSS) concentrations tends to be particularly high, even in lab splits. This underscores the inherent variability in measurements of stream sediment.

The criteria in Table 12 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, 2007). 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 13.

No parameters exceeded MQO criteria based on field split samples or sequential samples.

Blanks

Most results for analyses of blank samples were "below reporting limits," or less than 3 uS (microsiemens) for specific conductivity (Table 14). Blanks were not measured for temperature, dissolved oxygen, pH, or fecal coliform bacteria.

Protocols specify that four dissolved metals blank samples should be submitted annually, one from each run. In WY 2010, we collected seven dissolved metals blanks and three total metals blanks.

Historically, blanks for dissolved zinc frequently (43% of the time) exceeded (did not meet) reporting limits of 1 ug/L (though always < 5 ug/L, the reporting limit for total zinc). As a result, we set the quality code field = 4 for reported 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, except one was equal to 3 uS.

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 Manchester Laboratory's *Quality Assurance Manual* (MEL, 2006) or were either re-run or coded as determined by laboratory staff (e.g., as an estimate, "J").

Table 13. Average relative standard deviation (RSD) of replicate samples collected in Water Year 2010.

Parameter (units)	Precision MQO (%)	Sequential Sample RSD (%)	*n*	Field Split RSD (%)	*n*
Carbon, total organic	10	2.5	12	2.6	12
Carbon, dissolved organic	10	4.0	11	2.0	11
Specific conductance	10	0.6	55	No field splits	
Fecal coliform bacteria (>20 colonies /100 mL)	50% < 20 90% < 50	32 24	43 12	No field splits	
Ammonia	10	1.2	62	1.0	62
Nitrogen, total	10	4.6	62	2.9	62
Nitrate+nitrite-nitrogen	10	1.6	62	0.9	62
Oxygen, dissolved	10	0.7	61	No field splits	
pH	10	0.5	62	No field splits	
Phosphorus, soluble reactive	10	4.8	62	5.6	62
Phosphorus, total	10	5.0	61	3.6	61
Solids, suspended	15	12	62	No field splits	
Suspended sediment concentration	15	NA	0	No field splits	
Temperature	10	0.9	60	No field splits	
Turbidity	15	9.6	62	No field splits	

"*n*" is the number of sample pairs.

Table 14. Results of field process blank (de-ionized water) samples.

Parameter	Reporting Limit	Number Above Reporting Limit (concentration)	Sample Size n
Metals (µg/L)	Various	5[a] (1 dissolved copper at 0.28, 1 dissolved lead at 0.32, and 3 dissolved zinc at 2.1, 1.2, and 1.2)	83
Carbon, dissolved organic (mg/L)	1	0[b]	4
Carbon, total organic (mg/L)	1	0	5
Hardness (mg/L)	0.3	0[b]	1
Ammonia (ug/L)	10	0	10
Nitrate+nitrite-nitrogen (ug/L)	10	0	10
Soluble reactive phosphorus (ug/L)	3	0[b]	10
Specific conductivity (uS)	NA	NA (mean: 1.6 uS, std dev: 0.74)	9
Suspended solids (ug/L)	1	0	6
Total nitrogen (ug/L)	25	0	10
Total nitrogen, dissolved (ug/L)	25	0	2
Total phosphorus (ug/L)	5	0[b]	10
Turbidity (NTU)	0.5	0	6

NA: not applicable.
[a] Excludes 4 estimated ("J") results at the reporting limit
[b] Includes 1 or 2 estimated ("J") results at the reporting limit.

Continuous Temperature Monitoring

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

Most of the temperature loggers were deployed by July 14. We deployed four Olympic Peninsula loggers on July 20. We deployed eight loggers in the fall of 2009 with the intent of collecting year-round data; six of these were successful. Sediment buried two loggers (Humptulips and Cowlitz Rivers); no valid data were available from these loggers for 2010.

Continuous Multiple Parameter Monitoring

Dissolved Oxygen

None of the Hydrolab® dissolved oxygen sensors failed QC requirements (Table 15). Four of the nine sensors needed a small constant adjustment to account for probable calibration error. All sensors were extremely stable, with little or no drift over the course of the deployment.

Table 15. Quality Control (QC) results from continuous multiple parameter monitoring. *Average and RSD were calculated after applying offset and removing rejected data.*

Station	Offset[a]	Average Percent Difference	RSD	Comment
Dissolved Oxygen (mg/L)				
13A060	NA	-1.5%	1.0%	Excellent precision, stable, clean
17A060	NA	0.7%	1.1%	Excellent precision, stable, some noise
19C060	NA	-0.72%	0.81%	Good precision, stable, some noise
19D070	0.53	0.09%	1.93	Reject data through Jun 14. (Orientation resulted in sedimentation preventing accurate measurements.) After Jun 14, good precision, stable, noise especially in Aug and Sep.
19E060	NA	0.26%	0.55%	Two questionable data pairs; otherwise excellent precision and stable but noisy
25D050	NA	-1.00%	1.37%	Good precision, stable, two periods of noise
25E060	0.23	0.08%	1.44%	Fair precision, stable, small amount of noise
25F060	NA	0.96%	0.99%	Good precision, stable, moderate noise
59A110	-0.47	-0.2%	1.4%	Excellent precision, stable, clean
Temperature (ºC)				
13A060	NA	-0.6%	1.0%	Excellent precision, stable, clean
17A060	NA	1.7%	1.4%	Excellent precision, stable, clean
19C060	NA	-1.15%	0.93%	Excellent precision, stable, clean
19D070	NA	-0.5%	0.57%	Reject data through Jun 14. (Orientation resulted in sedimentation preventing accurate measurements.) After Jun 14, excellent precision, stable, clean
19E060	-0.17	0.27%	1.28%	Excellent precision, stable, clean
25D050	NA	0.49%	1.90%	Fair precision, stable, clean
25E060	NA	-1.62%	3.16%	Acceptable precision, stable, clean
25F060	NA	0.10%	2.16%	Fair precision, stable, clean
59A110	NA	0.9%	1.8%	Excellent precision, stable, clean
Conductivity (uS/cm)				
13A060	3.25	-0.1%	1.8%	Good precision, stable, clean
17A060	NA	2.0%	1.4%	Good precision, stable, clean
19C060	NA	-0.11%	0.89%	Good precision, stable, mostly clean. One data point removed during period of high flux.
19D070	NA	0.0%	0.42%	Reject data through Jun 14. (Orientation resulted in sedimentation preventing accurate measurements.) After Jun 14, precise, stable, clean.
19E060	2.6	0.10%	0.69%	Excellent precision, stable, some noise.
25D050	NA	-0.78%	2.88%	Reject Feb 14 through May 17; otherwise excellent precision, stable, moderate noise
25E060	-1.6	0.21%	1.96%	Good precision, stable, moderate noise
25F060	0.68	0.12%	1.66%	Good precision, stable, moderate noise
59A110	7.25	-0.5%	1.7%	Excellent precision, stable, frequent noise
pH (standard units)				
13A060		6.2%	4.6%	Reject: inconsistent relative to grab sample
17A060	NA	2.0%	3.6%	Reject: inconsistent relative to grab sample
59A110	NA	0.4%	0.9%	Good precision through Aug 10, then reject due to drift

[a] Constant added to continuous data only if original average percent difference was >2.0%.
NA=Not appropriate.

Some sensors were "clean" but most exhibited some "noise," where the signal dropped sharply (Figure 1). In a number of cases, this was caused by sediment buildup in the sensor housing; in other cases, like those with a single unusually low value, the cause is unknown. However, the noise usually occurred as a sharp and obvious change rather than a gradual one, and so was easy to spot and remove.

Except for noise in some signals, which can be a nuisance to clean up, the optical dissolved oxygen sensors were so reliable that most differences between sensor results and Winkler grab samples may be attributable to imprecision in the Winkler analysis.

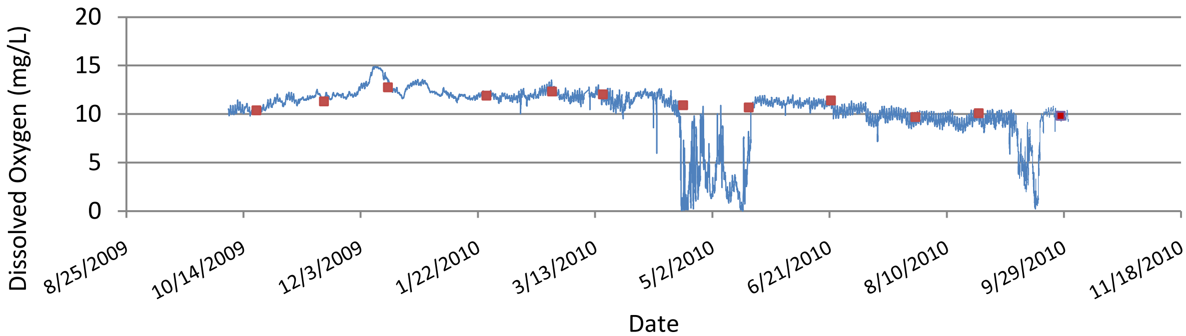

Figure 1. Continuous dissolved oxygen from station 25D050.
Discrete QC samples are marked with red squares.

Temperature

The temperature signal from all sensors was both stable and clean. In most cases, precision was excellent, with less than ±0.4 ºC difference between grab sample temperatures and recorded temperatures. Sensors deployed in WRIA 25 were less precise, with one difference as great as 0.8 ºC. Why this greater imprecision should be unique to WRIA 25 is unclear.

Conductivity

Conductivity signals did not exhibit a steady drift, but one sensor (25D050) exhibited an unexplained offset for about three months (which will be removed rather than adjusted). Another sensor (19D070) was imprecise until mid-June after which it matched grab sample results within 3 uS/cm. The instrument at 19D070 was initially deployed facing slightly upstream which, we believe, caused sediment to accumulate in the sensor housing. All data from this deployment will be rejected prior to mid-June, when the instrument was adjusted to face slightly downstream.

The conductivity sensors exhibited more apparent signal noise than oxygen or temperature sensors. Noise was usually expressed as a single unusually high value, though sometimes the value would be unusually low.

pH

pH was not a critical parameter for this monitoring and was only included because three of the instruments included pH sensors. We rejected data from stations 13A060 and 17A060 because of imprecision relative to grab sample pH. At station 59A110, pH results began to drift after about three months. Long-term continuous monitoring for pH may be possible but will require regular maintenance, including cleaning and replacing the electrolyte in the reference electrode.

Lake Monitoring

The average RSD from lake monitoring duplicate results was 13.2%, below the MQO of 20%. RSDs for individual duplicate pairs were also low with the exception of a single pair near the reporting limit (Table 16). Because of the mathematical nature of the calculation, RSDs are often higher at low concentrations of the analyte being measured.

Table 16. Lake total phosphorus sample quality control (QC) results (ug/L).

Lake	Date	Result	Duplicate	Duplicate Type	RSD
Clear (Thurston)	05/06/2010	9.3	9.6	Lab Split	2.2%
Clear (Spokane)	07/19/2010	17.6	22	Field Duplicate	15.7%
Mattoon (Kittitas)	09/29/2010	16.2	16.5	Field Duplicate	1.3%
Silver (Whatcom)	06/23/2010	5 U	6.9	Field Duplicate	22.6%
Burke (Grant)	9/15/2010	17.3	19.5	Lab Split	8.5%
Diamond (Pend Oreille)	7/16/2010	5 U	5 U	Lab Split	0.0%
Fiorito (Kittitas)	6/9/2010	34.7	36.9	Lab Split	4.3%
Mattoon (Kittitas)	6/9/2010	13.9 J	14.5	Lab Split	3.0%

Manchester Laboratory QC results were within the specifications provided in laboratory QC guidance (MEL, 2006).

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

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 (WY) 2010 study by Ecology's River and Stream monitoring program.

Conclusions

- Most quality control results were within the limits specified in our Quality Assurance Management Plan and were consistent with findings in previous years.
- Except where noted otherwise, data collected can be used without qualification.
- Optical oxygen sensors were remarkably reliable and consistent, even when deployed for a year or more.
- Conductivity sensors also performed well, and even pH sensors show promise. However, some effort is necessary to remove noise from the signal.

Recommendations

- Incidental phosphorus samples at lakes monitored for aquatic plants required minimal effort for collection, data processing, and quality control review. This monitoring should be continued.
- Stand-alone multiple parameter monitoring can be successful but requires regular maintenance to ensure everything is functioning properly. Telemetered systems, which can be routinely checked in a few minutes from the office, should be used whenever possible and always if data loss is unacceptable.
- The continuous temperature monitoring program deployment period should be expanded to year-round at all ambient stations. These datasets may be used to assess applicable supplemental temperature criteria and to help monitor climate changes.

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Appendices

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Appendix A. Station Description and Period of Record

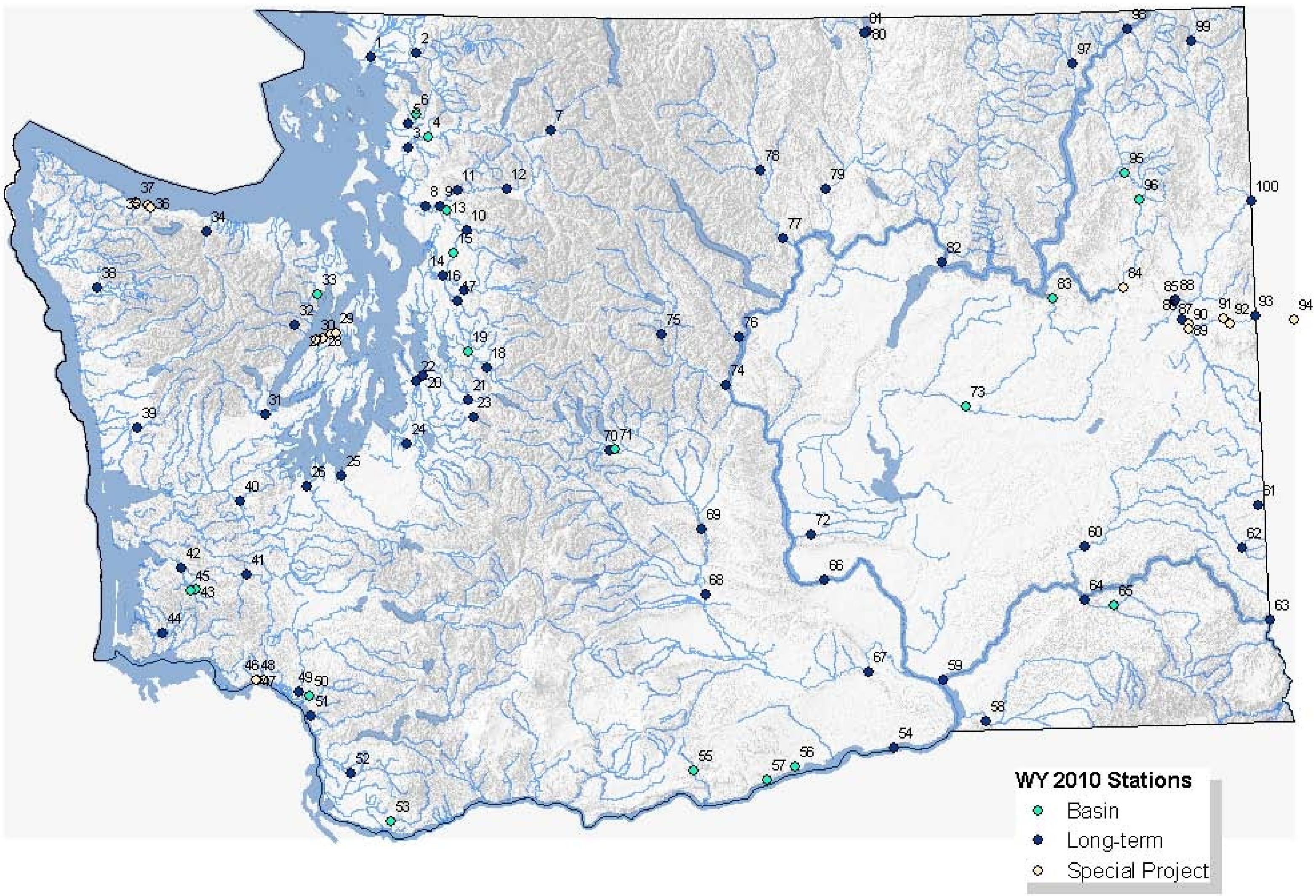

Figure A-1. Map showing stations monitored in Water Year 2010.

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--->
01A050	Nooksack R @ Brennan	L			X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
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
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	S.F. Nooksack @ Potter Rd	B					X	X X
01G070	M.F. 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 Road	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
03A070	Skagit R nr Sedro Woolley	B			X X X			
03A080	Skagit R abv Sedro Woolley	B						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
03B070	Samish R nr Hoogdal	B			X			
03B077	Samish R abv Parson Cr	B						
03B080	Samish R. nr Prairie	B					X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
03C060	Friday Cr Blw Hatchery	B			X		X X	
03C080	Friday Cr at Alger	B			X			
03D050	Nookachamp Ck nr Mouth	B					X	X
03E050	Joe Leary Slough nr Mouth	B						X
03F070	Hill Ditch @ Cedardale Rd	B						X
04A060	Skagit R @ Concrete	B			X X XXX	XXXXXXXXXX	XX X	
04A100	Skagit R @ Marblemount	L	X	XXXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
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
05A090	SF Stillaguamish R @ Arlington	L			X X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX
05A110	SF Stillaguamish R nr Granite Falls	L	X	XXXXXXX	X		X XXXXX	XXXXXXXXXX
05B070	NF Stillaguamish R @ Cicero	L		XXXXXXXX	XX X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX
05B090	NF Stillaguamish R @ Oso	B			X			
05B110	NF Stillaguamish R nr Darrington	L			X		X XXXXX	XXXXXXXXXX
05G050	Jim Cr @ Jordan Rd	B						
07A090	Snohomish R @ Snohomish	L	X	XXXXXXXX X	XX X XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
07A100	Snohomish R. @ Short School Rd.	B						
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	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
07B075	Pilchuck R @ Russel Rd.	B						
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
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			
07D050	Snoqualmie R nr Monroe	L			X		XX XXXXX	XXXXXXXXXX
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
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	
07Q070	Raging R @ Fall City	B					X	X
07R050	French Cr nr Mouth	B					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
08C080	Cedar R @ Maplewood	B					X	

Station Number	Name	Long-term or Basin	Water Year Sampled					
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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
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 Creek abv Lynnwood	B					X	
08K090	Ship Canal @ Freemont	B					X	
08K100	North Creek nr Everett	B					X	
08L070	Laughing Jacobs Cr nr Mouth	B						X
08M070	SF Thornton Cr @ 107th Ave NE	B						X
08N070	Johns Creek @ 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
09A090	Green R @ 212th St nr Kent	B			X XX	XXXXXXXXXX	XX X	
09A110	Green R @ Auburn	B		XXXXX X	XX			
09A130	Green 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
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

Station Number	Name	Long-term or Basin	Water Year Sampled	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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 Creek @ Orillia	B				XXXXXX	X X	
09E090	Mill Creek - Kent on W Valley Hwy	B				XXXXXX	X	
09F150	Newaukum Creek 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 Creek near mouth	B						X
09M050	North Creek at Seahurst Pk	B						X
09N050	Mullen Slough @ Frager Rd.	B						
09Q060	Redondo Cr. abv Marine View Dr. S.	B						
10A050	Puyallup R @ Puyallup	B	X	XXXXXXXX X	XXX XXXXX	XXX		XXX
10A070	Puyallup R @ Meridian St	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
10A075	Puyallup R @ East Main St.	B						X
10A080	Puyallup R. nr Sumner	B						X
10A090	Puyallup R @ McMillin	B			X X			
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 River @ 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			

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
10D070	Boise Cr @ Buckley	B		XXX	X			X
10D090	Boise Cr nr Enumclaw	B		XXX				
10E070	Salmon Cr @ Sumner	B			X			
10F070	So Prairie Cr nr Crocker	B			X			
10F090	South Prairie Ck nr S. Prairie	B					X	
10G080	Hylebos Creek @ 8th St. E	B						
10H070	Lk Tapps Tailrace @ E. Valley Hwy.	B						X
10I050	Joe's Creek @ SR 509	B						X
10J050	Lakota Cr. @ Dumas Bay Center	B						
11A070	Nisqually R @ Nisqually	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
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	
12A130	Clover Cr nr Parkland	B		XX				
12B070	Leach Cr nr Steilacoom	B		XXX	X			X
12C060	Flett Cr. @ 75th St. W.	B						
12C070	Flett Cr @ Custer Rd	B		XXX	X			
12D050	Ponce de Leon Ck nr mouth	B					XXX	
12F090	Spanaway Cr @ Old Military Rd.	B						X
13A050	Deschutes R @ Tumwater	B		XXXXX X	X X			
13A060	Deschutes R @ E St Bridge	L			XX	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX
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			

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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
15G050	Little Mission Cr. @ Hwy 300	B						X
15H050	Stimson Creek @ 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
15M070	Llt Anderson Cr. @ Anderson Hill Rd	B						XXXXX
15N070	Stavis Cr. nr Mouth	B						XXXXX
16A070	Skokomish R nr Potlatch	L		XXXXXXXX X	X XXX XX	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX
16B070	Hamma Hamma R nr Mouth	B		XXXXXX X	X X			
16B110	Hamma Hamma R nr Eldon	B			XX		X	
16B130	Hamma Hamma River @ Lena Creek Ca	L						
16C070	Duckabush R @ Mouth	B		XXXXXXXX X	X X			
16C090	Duckabush R nr Brinnon	L			XXX		XXXXXX	XXXXXXXXXX
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
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			
17B100	Chimacum Cr @ Chimacum	B					X	
17B110	Chimacum Cr nr Chimacum	B			X			

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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
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
19D070	East Twin R. nr Mouth	B						XXXXX
19E060	Deep Cr. nr mouth	B						XXXXX
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
20C070	Ozette R @ Ozette	B	X	XX				
20D070	Dickey R nr La Push	B					X	
20E100	Twin Creek @ Upper Hoh Rd Br	L						
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
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			

Station Number	Name	Long-term or Basin	Water Year Sampled					
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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	
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
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
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 River @ Moon Road Bridge	B					XX X XXX	
23F070	Mill Ck 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
24B095	Willapa R nr Menlo	B						X
24B130	Willapa R @ Lebam	B	X	XX X	XX	XXXXXXXXXX	XXX	
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	

Station Number	Name	Long-term or Basin	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
			Water Year Sampled				
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
24G070	Bear Branch nr Naselle	B	X	X			
24H070	Middle Nemah R nr Nemah	B		X			
24J070	South Nemah R nr Nemah	B		X			
24K060	Forks Cr abv Hatchery (outfall)	B					
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	
25C070	Elochoman R nr Cathlamet	B	X	X XX		X	X
25D050	Germany Cr @ mouth	B					XXXXX
25E060	Abernathy Cr nr mouth	B					XXXXX
25E100	Abernathy Cr. @ DNR	B					XXXX
25F060	Mill Cr. nr mouth	B					XXXXX
25F100	Mill Cr. @ DNR	B					XXXX
25G060	Coal Cr. @ Harmony Rd.	B					
26B070	Cowlitz R @ Kelso	L	XXXXXXX	XX X XX	XXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
26B100	Cowlitz R @ Castle Rock	B	XXX	X XXXX			X
26B150	Cowlitz R @ Toledo	B	XXXXX	X X XX	X	X	
26B180	Cowlitz 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					

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
26C080	Coweeman R av 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 River 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`
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`			
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`
27E070	Cedar Cr nr Etna	B					`     X`	
27F070	Gee Cr @ Ridgefield	B					`     X`	
28A090	Columbia blw Vancouver WA	B		`        XX`	`X`			
28A091	Columbia 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						
28B090	Washougal R nr Washougal	B		`  XXXXXXXX`	`X`			
28B110	Washougal R blw Canyon Ck	B					`     X  X`	`X`
28C070	Burnt Br Cr @ Mouth	B			`   X`			`    XX  XX`
28C110	Burnt Br Cr @ Vancouver	B			`   X`			

Station Number	Name	Long-term or Basin		<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
				Water Year Sampled				
28D070	Salmon Cr @ Salmon Creek	B			X			
28D110	Salmon Cr nr Battle Ground	B			X			
28E070	Weaver Cr nr Battle Ground	B			X			
28F070	Lake R nr Ridgefield	B					X	
28G070	Gibbons Ck nr Washougal	B					X	X
28H070	Campen Cr nr Washougal	B						X
28I120	Lacamas Creek @ 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	
30B070	Klickitat R nr Pitt	B		XXX	X XXXXXXX	X		
30C070	Little Klickitat 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
31A090	Columbia R @ McNary Dam	B	X	XXXXXXXXXX				
31A130	Columbia R nr Yakima R Mouth	B		X				
31B110	Rock Creek @ Bickleton Hwy	B						
31C012	Alder Crk @ 6 Prong Rd Bridge	B						
31D010	Pine Creek @ One Mile Bridge	B						
32A070	Walla Walla R nr Touchet	L	X	XXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
32A090	Walla Walla R nr Lowden	B			XX			
32A100	Walla Walla at east Detour Road Br	B					X	X

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
32A110	Walla Walla R @ College Pl	B			XX XX			
32B070	Touchet R @ Touchet	B			X XX XX	XXXXXXXXXX	XXX X	
32B075	Touchet R. @ Cummins Rd.	B						X X
32B080	Touchet at Sims Road	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
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
34A075	Palouse River @ Hwy 26	B						X
34A080	Palouse River above Rebel Flat	B						X
34A085	Palouse R @ Shields Rd Bridge	B					X	X
34A090	Palouse R nr Diamond	B			X X			
34A109	Palouse River blw Colfax	B						X
34A110	Palouse R abv Buck Canyon	B			X XX			
34A120	Palouse R at Colfax	B						X X
34A170	Palouse R @ Palouse	L			X		XXXXXXXX	XXXXXXXXXX
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
34B130	SF Palouse R blw Sunshine	B			X			XXX

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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 Trib Whitman Fm	B			X			
34E070	Rock Creek 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 Creek @ Pullman	B						X
34N070	Missouri Flat Creek @ Pullman	B						X
35A100	Snake R blw Lwr Granite Dam	B			X			
35A150	Snake R @ Interstate Br	L		XXXXX XX			XXXXXXXXX	XXXXXXXXXX
35A200	Snake R nr Anatone	B			XXXXXXXX			
35B060	Tucannon R @ Powers	L			X XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX
35B090	Tucannon R @ Smith Hollow	B						X
35B100	Tucannon R @ Territorial Road	B						X
35B110	Tucannon R nr Delaney	B	X	X				
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 @ Asotin	B			X		X X	X

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
35E070	Clearwater R @ US12/95	B					X	
35F050	Pataha Cr near mouth	B						X X
35F070	Pataha Cr @ Archer Rd	B					X	X
35F095	Pataha Cr @ Tatman Road	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
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
37A095	Yakima 2 mi blw Prosser	B					X	

Station Number	Name	Long-term or Basin	Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
37A100	Yakima below Prosser	B				X	
37A110	Yakima R @ Prosser	B		X XX			
37A130	Yakima R @ Mabton	B		X XX		X	
37A149	Yakima R @ Granger No Side	B		X			
37A150	Yakima R @ Granger So 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
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 Drin 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 Creek @ Randall Park	B					XX
37F070	Sulphur Ck Wasteway @ McGee Rd	B				X	
37F080	Sulphur Creek @ Holaday Road	B					X
37G050	Ahtanum Crk @ Fulbright Park	B					X
37G120	Ahtanum Cr @ 62nd Ave	B					XX
37I070	Moxee Drain @ Birchfield Rd.	B					XX
37J060	Snipes Creek nr Mouth	B					
38A050	Naches R @ Yakima on US HWY 97	L	XXXXXXX			X XX	X X X
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 Creek	B	XXXX			X	
38C070	Rattlesnake Cr nr Nile	B	XX				

Station Number	Name	Long-term or Basin	Water Year Sampled					
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
38D070	Bumping R @ American R	B		XX				
38E070	American R @ American R	B		XX				
38F070	Little Naches nr Cliffdell	B		XXX			X	
38G070	Cowiche Cr. @ Powerhouse Rd.	B						XX
38G120	Cowiche Cr @ Zimmerman rd	B						XX
39A050	Yakima R @ Harrison Bridge	B					XX	XXX X
39A055	Yakima R. @ Umtanum Cr Footbrg	L						
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
39B070	Cle Elum R nr Cle Elum	B			X X			
39B090	Cle Elum R nr Roslyn	B					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						
39M100	Swauk Cr. @ Lauderdale Junction	B						
41A070	Crab Cr nr Beverly	L	X	XXXXXXXXXX	XXX XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX
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 Creek @ Hwy 17	B					X	X
41E070	Sand Hollow Creek 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

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
43A080	Crab Creek @ Odessa	B						X
43A095	Crab Creek @ Amnen Road	B						X
43A100	Crab Ck @ Marcelus Road	B					X	X
43A110	Crab Creek at Tokio Road	B						X
43A130	Crab Creek @ US23	B						X
43A150	Crab Ck @ Bluestem Road	B					X	X
43B090	Lake Ck @ Coffeepot Road	B					X	
43C070	Goose Creek nr Wilbur	B						X
44A070	Columbia R blw Rock Is Dam	B			X XX XX	XXXXXXXXXX	XX	
44A190	Columbia River @ Hwy 2 Bridge	B						X
45A070	Wenatchee R @ Wenatchee	L		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
45A075	Wenatchee River @ 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
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 @ 2 Rvr Grav.Pit	B						X
45Q060	Eagle Cr. nr mouth	B						XX
45R050	Noname Creek 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
47A070	Chelan R @ Chelan	B		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XX X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
47B070	Columbia R @ Chelan Station	B					X X	
48A070	Methow R nr Pateros	L	X	XXXXXXX	X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXX
48A075	Methow River nr Pateros @ Metal Br.	L						X
48A130	Methow R nr Twisp	B			X XX	XXXXXXXXX		
48A140	Methow R @ Twisp	L				X	XX X XXXXX	XXXXXXXXXX
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 River 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
49A090	Okanogan R @ Okanogan	B			X XX	XXXXXXXXX	X	X
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
49B070	Similkameen R @ Oroville	L		XXXXXXX	XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
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	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
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
53C070	Hawk Creek @ Miles-Creston Rd.	B						X
54A050	Spokane R @ Mouth	B					XXXX	
54A070	Spokane R @ Long Lake	B	X	XXXXXXX X	XXXXXXXXXX	XX		XX
54A089	Spokane R 2 mi blw Ninemile dam	B			XX			
54A090	Spokane R @ Ninemile Br	B			X X			X XX
54A120	Spokane R @ Riverside State Pk	L			XXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
54A130	Spokane R @ Fort Wright Br	B			X X			
55B070	Little Spokane R nr Mouth	L			X X XXX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX
55B075	Little Spokane @ Painted Rocks	B					X	
55B080	Little Spokane R nr Griffith Spring	B					XX	
55B082	Little Spokane R abv Dartford Creek	B					XX X	
55B085	Little Spokane nr Dartford	B		XXXXXXX				
55B090	Little Spokane R abv Wandermere	B			X			
55B100	Little Spokane R abv Deadman Creek	B					XX X	
55B200	Little Spokane @ Chattaroy	B					X X	
55B300	Little Spokane River @ Scotia	B						X
55C065	Deadman Cr nr Mouth	B					X	
55C070	Peone (Deadman) Creek abv L 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
56A200	Hangman Creek @ Bradshaw Road	B					X	
57A120	Spokane R @ Spokane	B			X			

Station Number	Name	Long-term or Basin	Water Year Sampled	<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->
57A123	Spokane River@Sandifer Bridge	B						X
57A125	Spokane R blw Monroe St.	B						X
57A130	Spokane R @ Mission St Br	B			X X			
57A140	Spokane River @ Plante's Ferry Park	B						XX
57A145	Spokane R @ Trent Br	B			X			
57A146	Spokane River @ Sullivan Rd.	B						X
57A148	Spokane R @ Barker Rd	B						X
57A150	Spokane R @ Stateline Br	L	X	XXXXXX X	XX X X		XXXXXXXXX	XXXXXXXXXX
57A190	Spokane R nr Post Falls	B			XXXXXXX	XXXXXXXXXX	XX	
57A240	Spokane R @ Lake Coeur d'Alene	B						XX
59A070	Colville R @ Kettle Falls	B		XXXXXXXXXX	X X XX XX	XXXXXXXXXX	XX X	
59A080	Colville R abv Kettle Falls	L					X	X
59A110	Colville R @ Blue Creek	B			X			X
59A130	Colville R @ Chewelah	B			X			XXX
59A140	Colville R @ Newton Rd	B						XX
59B070	Little Pend Oreille @ Hwy 395	B						X
59B200	Little Pend Oreille R nr NatWildRef	L						
59C070	Sheep Ck at Long Prairie Rd.	B						
60A050	Kettle R @ Hedlund Bridge	B		X				
60A070	Kettle R nr Barstow	L		XXXXXXX X	X X XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX
61A070	Columbia R @ Northport	L	X	XXXXXXXXXX	XXXXXXXXXX	XX	XXXXXXXXX	XXXXXXXXXX
61B070	Deep Ck nr Mouth	B					X	X
61C070	Onion Cr nr Northport	B					X	
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
62A150	Pend Oreille R @ Newport	L	X	XXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
62B070	Skookum Ck nr Mouth	B						

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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).

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).

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.

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.

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 HNO3 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.)

Appendix C. Water Year 2010: 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 presented 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-WY2010 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	1/1/2010
AMS004	Continuous Stream Monitoring	ONGOING	6/1/2001

3. Data are available by contacting the Washington State Department of Ecology regional offices:

- Ecology Central Region: Dan Dugger (509.454.4183; ddug461@ecy.wa.gov)
- Ecology Eastern Region: Daniel Sherratt (509.329.3420; dshe461@ecy.wa.gov)
- Ecology Northwest Region: Bill Ward (360.407.6621; bwar461@ecy.wa.gov)
- Ecology Southwest Region: Jason Myers (360.407.6019; jmye461@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 Areas (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" and "J" were used in WY 2010.

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 The reported result is an estimate.
K, U The 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 2010: 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
01A050	12/14/2009	Weather: airlines didn't ship samples												x
01A120	12/14/2009	Weather: airlines didn't ship samples												x
03A060	12/14/2009	Weather: airlines didn't ship samples												x
03A080	12/14/2009	Weather: airlines didn't ship samples												x
03B050	12/14/2009	Weather: airlines didn't ship samples												x
03B077	12/14/2009	Weather: airlines didn't ship samples												x
04A100	12/14/2009	Weather: airlines didn't ship samples												x
05B110	12/14/2009	Weather: airlines didn't ship samples												x
07P070	11/18/2009	Weather: access blocked by flood	x	x	x	x	x	x	x	x	x	x	x	x
23A160	12/14/2009	Weather: unsafe: Ice on bank		x	x	x	x	x	x	x	x	x	x	x
23A160	7/27/2010	Sampler error: DO not recorded			x									
26C073	12/15/2009	Weather: unsafe: Ice on bank		x	x	x	x	x	x	x	x	x	x	x
31B110	12/7/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
31C012	12/7/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
31D010	10/6/2009	No flow	x	x	x	x	x	x	x	x	x	x	x	x
31D010	12/7/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
31D010	8/10/2010	No flow	x	x	x	x	x	x	x	x	x	x	x	x
31D010	9/14/2010	No flow	x	x	x	x	x	x	x	x	x	x	x	x
33A050	5/4/2010	Equipment problem: windy day; thermistor cable too short	x											
33A050	7/19/2010	Road construction: station inaccessible	x	x	x	x	x	x	x	x	x	x	x	x
34A070	12/9/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
34A070	6/9/2010	Weather: unsafe: lightening	x	x	x	x	x	x	x	x	x	x	x	x
34A070	9/21/2010	Equipment problem: meter failed		x										
34A170	12/9/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
34A170	9/21/2010	Equipment problem: meter failed		x										
34B110	12/9/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
34B110	9/21/2010	Equipment problem: meter failed		x										
35A150	9/21/2010	Construction: normal parking closed	x	x	x	x	x	x	x	x	x	x	x	x
35B060	9/21/2010	Equipment problem: meter failed		x										
35F050	9/21/2010	Equipment problem: meter failed		x										
39A055	12/8/2009	Sampler error: DO bottle broke			x									
39A090	12/8/2009	Sampler error: DO bottle broke			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
43A070	12/9/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
43A070	9/21/2010	Equipment problem: meter failed; Sampler error: TP sample lost.		x							x			
46A070	12/7/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
46A070	4/5/2010	Road construction: insufficient time	x	x	x	x	x	x	x	x	x	x	x	x
48A075	9/13/2010	Road construction: station inaccessible	x	x	x	x	x	x	x	x	x	x	x	x
48A140	9/13/2010	Equipment problem: pH probe failed				x								
49A070	9/13/2010	Equipment problem: pH probe failed				x								
49A190	9/13/2010	Equipment problem: pH probe failed				x								
49B070	9/13/2010	Equipment problem: pH probe failed				x								
53A070	9/13/2010	Equipment problem: pH probe failed				x								
53C070	9/13/2010	Equipment problem: pH probe failed				x								
54A070	1/11/2010	Equipment problem: thermistor failed	x											
54A070	9/20/2010	Road construction: insufficient time	x	x	x	x	x	x	x	x	x	x	x	x
54A090	1/11/2010	Equipment problem: thermistor failed	x											
54A090	9/20/2010	Equipment problem: meter failed		x										
54A120	1/11/2010	Equipment problem: thermistor failed	x											
54A120	9/20/2010	Equipment problem: meter failed		x										
54A130	1/11/2010	Equipment problem: thermistor failed	x											
54A130	9/20/2010	Equipment problem: meter failed		x										
55B070	1/11/2010	Equipment problem: thermistor failed	x											
55B070	9/20/2010	Equipment problem: meter failed		x										
56A070	12/14/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
56A070	1/11/2010	Equipment problem: thermistor failed	x											
56A070	9/20/2010	Equipment problem: meter failed		x										
57A123	1/11/2010	Equipment problem: thermistor failed	x											
57A123	9/20/2010	Equipment problem: meter failed		x										
57A140	1/11/2010	Equipment problem: thermistor failed	x											
57A140	9/20/2010	Equipment problem: meter failed		x										
57A146	1/11/2010	Equipment problem: thermistor failed	x											
57A146	9/20/2010	Equipment problem: meter failed		x										
57A150	1/11/2010	Equipment problem: thermistor failed	x											
57A150	9/20/2010	Equipment problem: meter failed		x										
57A240	1/11/2010	Equipment problem: thermistor failed	x											
57A240	9/20/2010	Equipment problem: meter failed		x										
59A140	7/20/2010	Equipment problem: meter failed		x										
60A070	12/8/2009	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
60A070	1/5/2010	Weather: frozen	x	x	x	x	x	x	x	x	x	x	x	x
60A070	5/4/2010	Road construction: station inaccessible	x	x	x	x	x	x	x	x	x	x	x	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
60A070	7/20/2010	Equipment problem: meter failed		x										
61A070	1/5/2010	Weather: unsafe: Snow bank	x	x	x	x	x	x	x	x	x	x	x	x
61A070	2/2/2010	Inaccessible: parking pullout blocked	x	x	x	x	x	x	x	x	x	x	x	x
61A070	9/14/2010	Road construction: station inaccessible	x	x	x	x	x	x	x	x	x	x	x	x
62A090	7/20/2010	Equipment problem: meter failed		x										
62A150	7/20/2010	Equipment problem: meter failed		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.

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.

Salmonid: Any 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) 2010: October 1, 2009 through September 30, 2010.

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

DQO	Data quality objective
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
IMW	Intensively Monitored Watersheds
EPA	U.S. Environmental Protection Agency
MQO	Measurement quality objective
NF	North Fork
NO_2+NO_3	Nitrate + nitrite-nitrogen
QA	Quality assurance
QAMP	Quality Assurance Management 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