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DEPARTMENT OF
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River and Stream Ambient Monitoring Report for Wateryear 1995

Final Report

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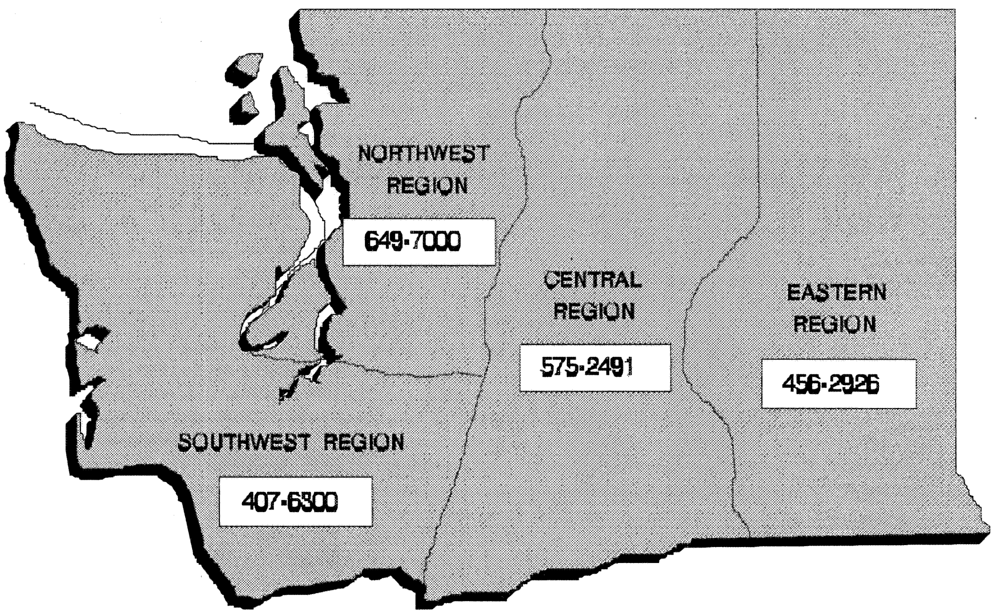

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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

River and Stream Ambient Monitoring Report for Wateryear 1995

Final Report

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Olympia, Washington 98504-7710

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Thanks!

Abstract

The Washington State Department of Ecology collected monthly water quality information at 84 river and stream monitoring stations during Wateryear (WY) 1995 (October 1, 1994, through September 30, 1995). The primary goals of this ongoing monitoring program are to characterize the rivers and streams of Washington State and to track changes in water quality. Water quality for WY 1995 was average relative to previous years. The fecal coliform bacteria geometric mean was the most frequently violated criterion based on individual samples. The geometric mean criterion was exceeded 154 times, and 99 samples exceeded the "10 percent not to exceed" criterion out of about 1000 samples collected. Forty-seven of 84 stations had at least one sample that exceeded the geometric mean criterion. Twenty-eight stations were west of the Cascades of which 14 were stations on streams that drain to Puget Sound. Temperature standards were violated 65 times at 37 stations on both sides of the Cascades. Dissolved oxygen and pH standards were violated 46 and 28 times, respectively, at 20 and 15 stations. With a few exceptions, median monthly stream flows in WY 1995 at the time of sampling were normal.

Introduction

The Washington State Department of Ecology (Ecology) has operated a long-term Ambient Water Quality Monitoring Program since 1970. The program consists of monthly water quality monitoring for conventional parameters at about 80 stations on rivers and streams within Washington State. The primary goals of this program are to characterize stream water quality and to evaluate spatial and temporal changes in water quality (trends). Within Ecology, the data generated by the River and Stream Ambient Monitoring Program are used to (1) determine if designated uses are supported (e.g., Ecology, 1994a), (2) to support wasteload allocation models, water quality based permits, etc., (3) to prepare 305(b) and other management reports, and (4) to provide water quality information necessary for Centennial Clean Water Fund and other grant awards.

This purpose of this report is to

- describe the Wateryear (WY) 1995 monitoring program,
- provide a brief overview of water quality in Washington State in WY 1995,
- discuss data quality, and
- present results.

More detailed analyses and interpretations of ambient monitoring data are reported elsewhere. The Ambient Monitoring Section (AMS) analyzes results at specific stations in response to requests by clients (e.g., Hallock, 1996a). Some analyses are conducted by other programs, for example, Ecology's Water Quality Program applies its own data reduction procedures prior to developing the bi-annual 305(b) report. Finally, the AMS analyzes data from four hydrologic basins annually in accordance with the basin approach to water quality management (Wrye, 1993).

The basin approach consists of a five-year cycle of scoping, data collection, data analysis, planning, and implementation of plans in 20 hydrologic basins statewide. In any given year, each of the above activities will be underway in four basins, one in each Ecology region.

Basins monitored in 1995 and reported here are scheduled for data analysis in 1996 (see "Sampling Network." Basins with focused data collection (monitoring) efforts in 1996 are Esquatzel/Crab Creek, Okanogan, Island/Snohomish, and South Puget Sound.

Methods

Sampling Network

The ambient monitoring network in WY 1995 consisted of monthly water collection at two types of stations: (1) core/benchmark and (2) basin stations. Core and benchmark stations are monitored every year to track water quality changes over time (trends) and to assess inter-annual variability, as well as to collect current water quality information. Core stations are generally located near the mouths of major rivers and below major population centers. Benchmark stations are located upstream from most anthropogenic sources of water quality problems and where major streams enter the state, and are intended to monitor background conditions. Basin stations are monitored for one year only (although they may be re-visited every five years) to collect current water quality information. These stations are selected to support Ecology's basin approach to water quality management, the waste discharge permitting process, and to allow expanded coverage over an all-core network. Some basin stations may be selected to target known problems and may not necessarily reflect *ambient* conditions.

The locations for ambient stations monitored during WY 1995 are presented in Figure 1 and Table 1. Appendix A lists current and historical monitoring locations and the years they were monitored by Ecology and its predecessor agencies. Historical data for these stations are available from Ecology's Ambient Monitoring Section on request. Basins monitored more intensively in WY 1995 were Skagit/Stillaguamish (Figure 2), Columbia Gorge (Figure 3, top), Horseheaven/Klickitat (Figure 3, bottom), and Upper Columbia/Pend Oreille (Figure 4).

Sample Collection and Analysis

The majority of water samples were collected as single surface grab samples from highway bridges using a stainless steel sampler similar to the dissolved oxygen (DO) sampler design presented in Figure 4500-O:1 of the 18th Edition of Standard Methods (APHA, 1992). Water samples for fecal coliform bacteria, total suspended solids (TSS), and metals analyses were collected as discrete samples directly in the sample containers. Samples for fecal coliform bacteria and metals determination were collected in a flow orienting sampler specifically designed to hold the sample bottle. The TSS bottle was attached as a passenger to the DO sampler. Twelve water quality constituents were monitored at all stations monthly in WY 1995 (Table 2) and eight metals plus total hardness were monitored bimonthly at selected stations (Table 3). All water samples were collected approximately 15 cm below the water surface.

Concurrent with collection of water samples, on-site measurements were taken for barometric pressure, time of day, *in-situ* temperature, pH, conductivity, and, if required, stage height (for flow determination).

All water samples collected in WY 1995 were submitted to the Ecology Manchester Environmental Laboratory (MEL) for analysis. Laboratory methods, detection limits, holding times, and other information for each of the above parameters is presented in Table 4. Specific details on methods are available from the references cited in Table 4 and in the MEL, Laboratory User's Manual (Ecology, 1994b).

Metals Monitoring

During WY 1994 and 1995 the Freshwater Ambient Monitoring Unit made great strides in improving Ecology's low level metals monitoring capabilities. The Freshwater Unit completed a

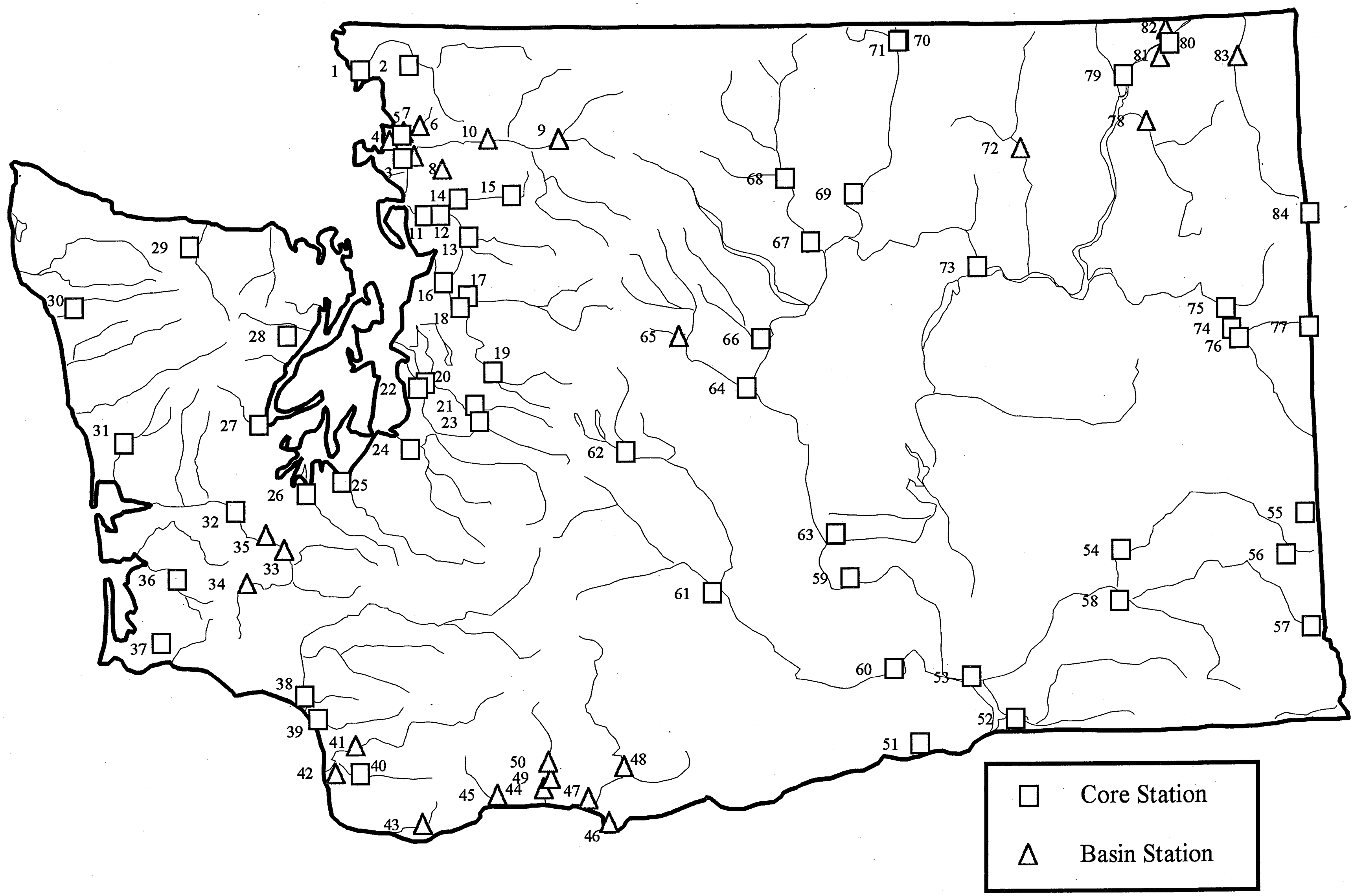


Figure 1. Ecology's river and stream monitoring stations for Wateryear 1995.

Table 1. Ecology river and stream ambient monitoring stations for Wateryear 1995.

Map	Station	Station Name	Map	Station	Station Name
1	01A050	Nooksack R @ Brennan	43	28B110	Washougal R blw Canyon Ck
2	01A120	Nooksack R @ No Cedarville	44	29B070	White Salmon R nr Underwood
3	03A060	Skagit R nr Mount Vernon	45	29C070	Wind R nr Carson
4	03B045	Samish R nr Mouth	46	29D070	Rattlesnake Cr nr Mouth
5	03B050	Samish R nr Burlington	47	29E070	Gilmer Cr nr Mouth
6	03B080	Samish R nr Prairie	48	30A070	Columbia R @ The Dalles
7	03C060	Friday Cr Blw Hatchery	49	30B060	Klickitat R nr Lyle
8	03D050	Nookachamp Ck nr Mouth	50	30C070	Little Klickitat nr Wahkiacus
9	04A100	Skagit R @ Marblemount	51	31A070	Columbia R @ Umatilla
10	04E050	Finney Cr near Birdsview	52	32A070	Walla Walla R nr Touchet
11	05A070	Stillaguamish R nr Silvana	53	33A050	Snake R nr Pasco
12	05A090	SF Stillaguamish @ Arlington	54	34A070	Palouse R @ Hooper
13	05A110	SF Stilly nr Granite Falls	55	34A170	Palouse R @ Palouse
14	05B070	NF Stillaguamish @ Cicero	56	34B110	SF Palouse R @ Pullman
15	05B110	NF Stilly nr Darrington	57	35A150	Snake R @ Interstate Br
16	07A090	Snohomish R @ Snohomish	58	35B060	Tucannon R @ Powers
17	07C070	Skykomish R @ Monroe	59	36A070	Columbia R nr Vernita
18	07D050	Snoqualmie R nr Monroe	60	37A090	Yakima R @ Kiona
19	07D130	Snoqualmie R @ Snoqualmie	61	37A205	Yakima R @ Knob Hill
20	08C070	Cedar R @ Logan St/Renton	62	39A090	Yakima R nr Cle Elum
21	08C110	Cedar R nr Landsburg	63	41A070	Crab Cr nr Beverly
22	09A080	Green R @ Tukwila	64	45A070	Wenatchee R @ Wenatchee
23	09A190	Green R @ Kanaskat	65	45A110	Wenatchee R nr Leavenworth
24	10A070	Puyallup R @ Meridian St	66	46A070	Entiat R nr Entiat
25	11A070	Nisqually R @ Nisqually	67	48A070	Methow R nr Pateros
26	13A060	Deschutes R @ E St Bridge	68	48A140	Methow R @ Twisp
27	16A070	Skokomish R nr Potlatch	69	49A070	Okanogan R @ Malott
28	16C090	Duckabush R nr Brinnon	70	49A190	Okanogan R @ Oroville
29	18B070	Elwha R nr Port Angeles	71	49B070	Similkameen R @ Oroville
30	20B070	Hoh R @ DNR Campground	72	52A110	Sanpoil R 13 mi S. Republic
31	22A070	Humptulips R nr Humptulips	73	53A070	Columbia R @ Grand Coulee
32	23A070	Chehalis R @ Porter	74	54A120	Spokane R @ Riverside State Pk
33	23A100	Chehalis R @ Prather Rd	75	55B070	Little Spokane R nr Mouth
34	23A160	Chehalis R @ Dryad	76	56A070	Hangman Cr @ Mouth
35	23E070	Black River @ Moon Road Bridge	77	57A150	Spokane R @ Stateline Br
36	24B090	Willapa R nr Willapa	78	59A080	Colville R abv Kettle Falls
37	24F070	Naselle R nr Naselle	79	60A070	Kettle R nr Barstow
38	26B070	Cowlitz R @ Kelso	80	61A070	Columbia R @ Northport (USGS)
39	27B070	Kalama R nr Kalama	81	61C070	Onion Cr nr Northport
40	27D090	EF Lewis R nr Dollar Corner	82	61D070	Sheep Cr nr Northport
41	27E070	Cedar Cr nr Etna	83	62A090	Pend Oreille @ Metaline Falls
42	27F070	Gee Cr @ Ridgefield	84	62A150	Pend Oreille R @ Newport

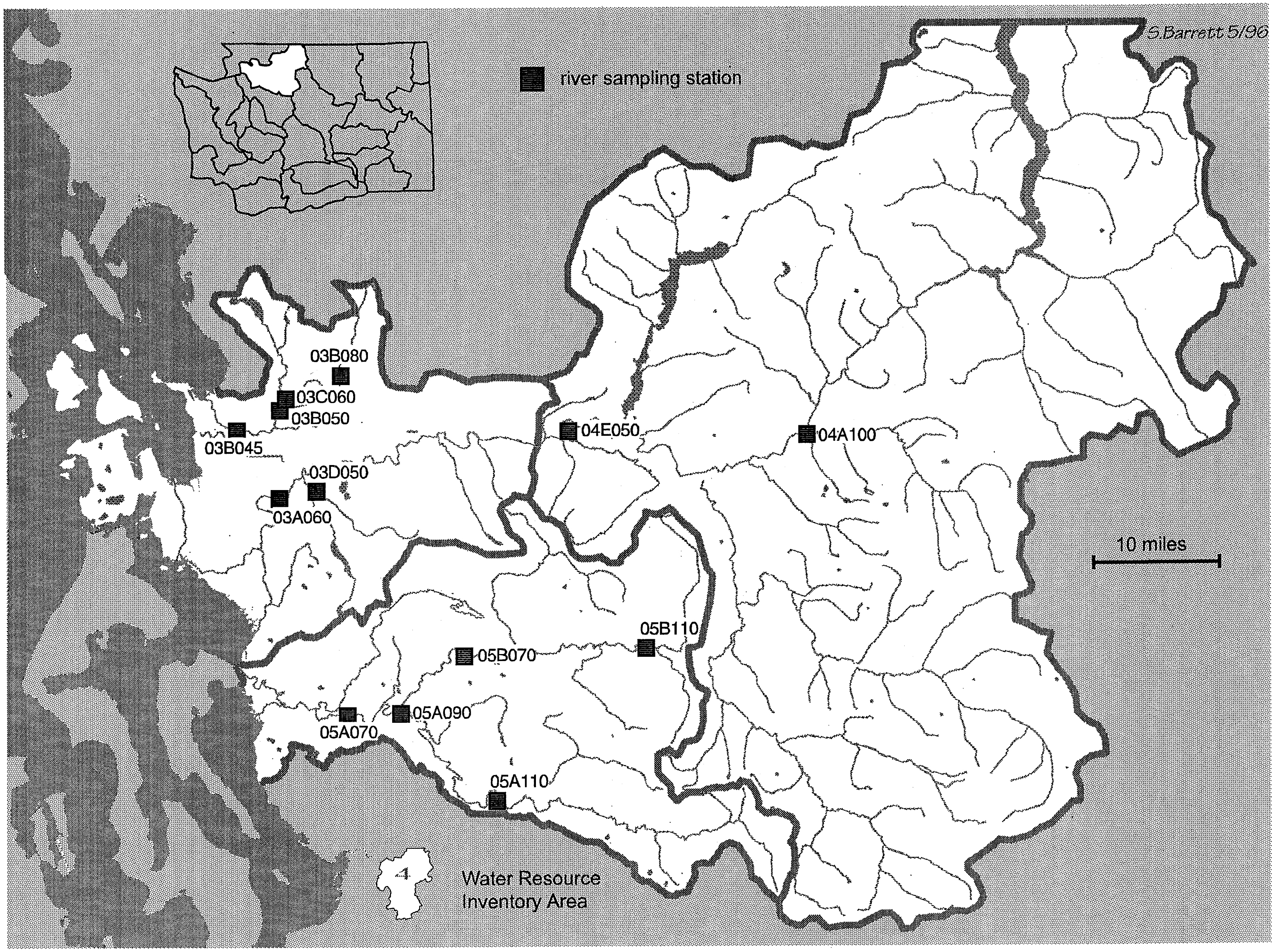
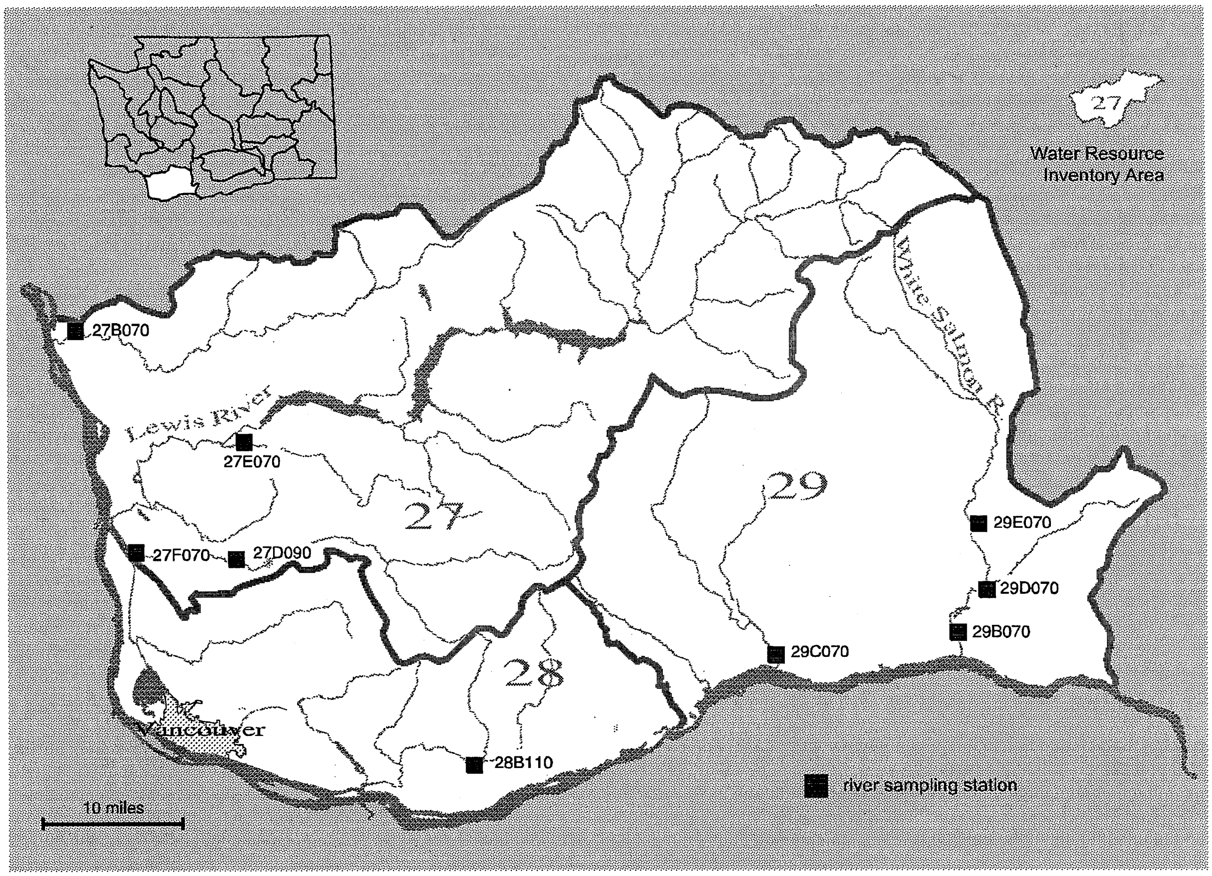


Figure 2. Skagit/Stillaguamish Water Quality Management Area



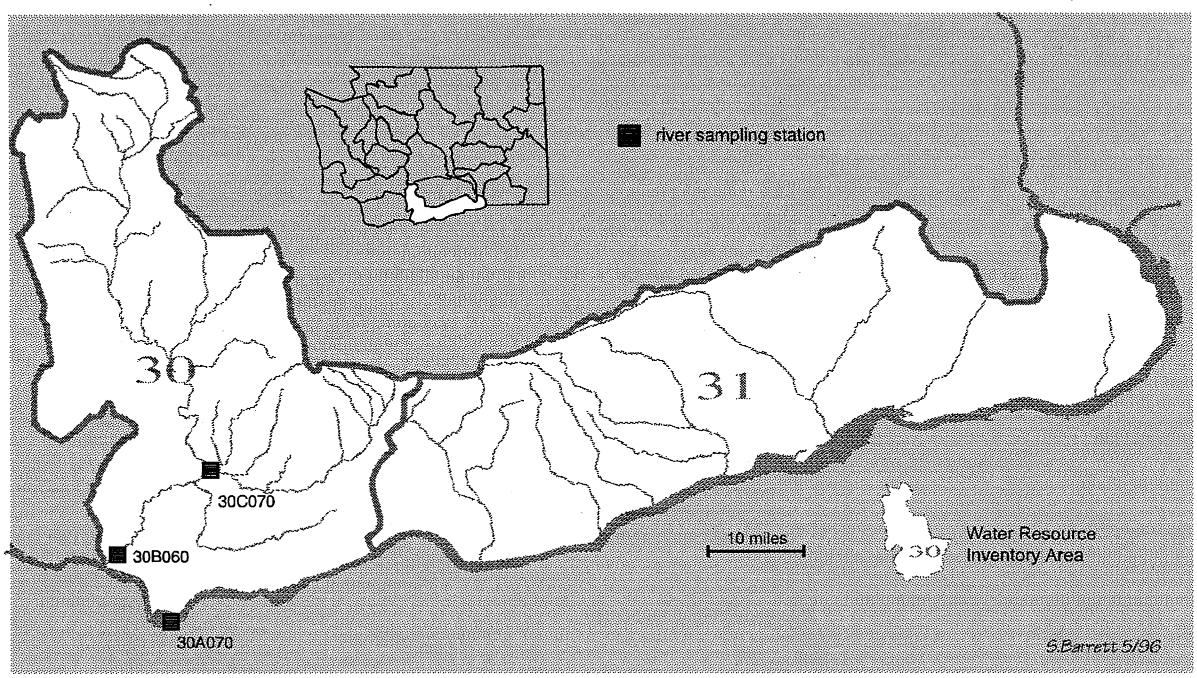
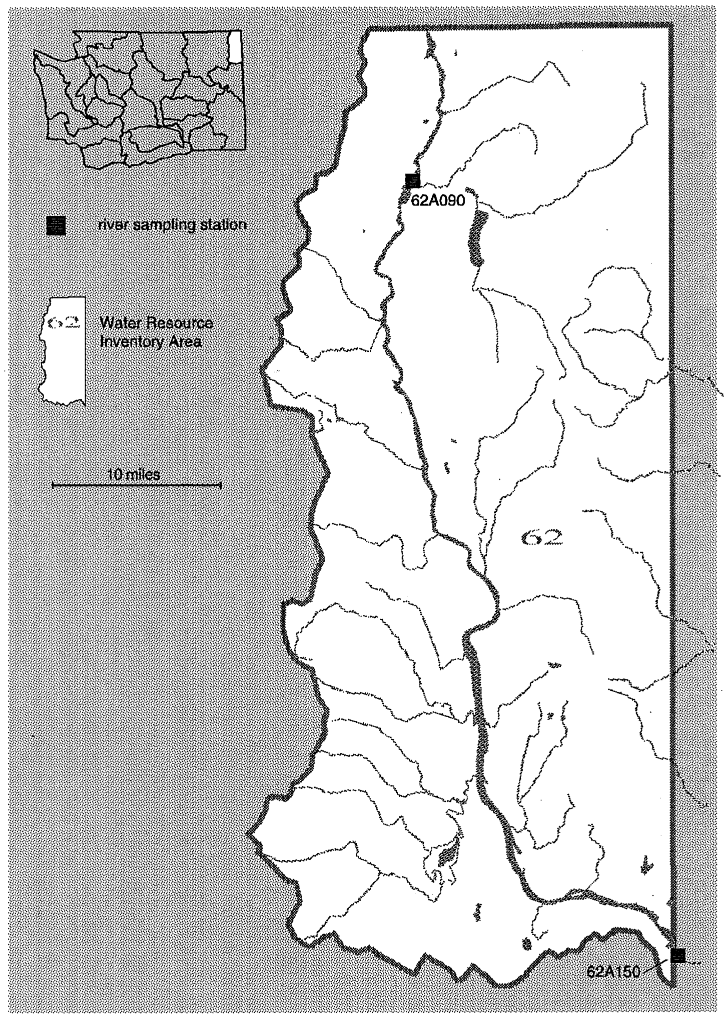


Figure 3. Columbia Gorge (top) and Horseheaven/Klickitat (bottom) Water Quality anagement Areas.



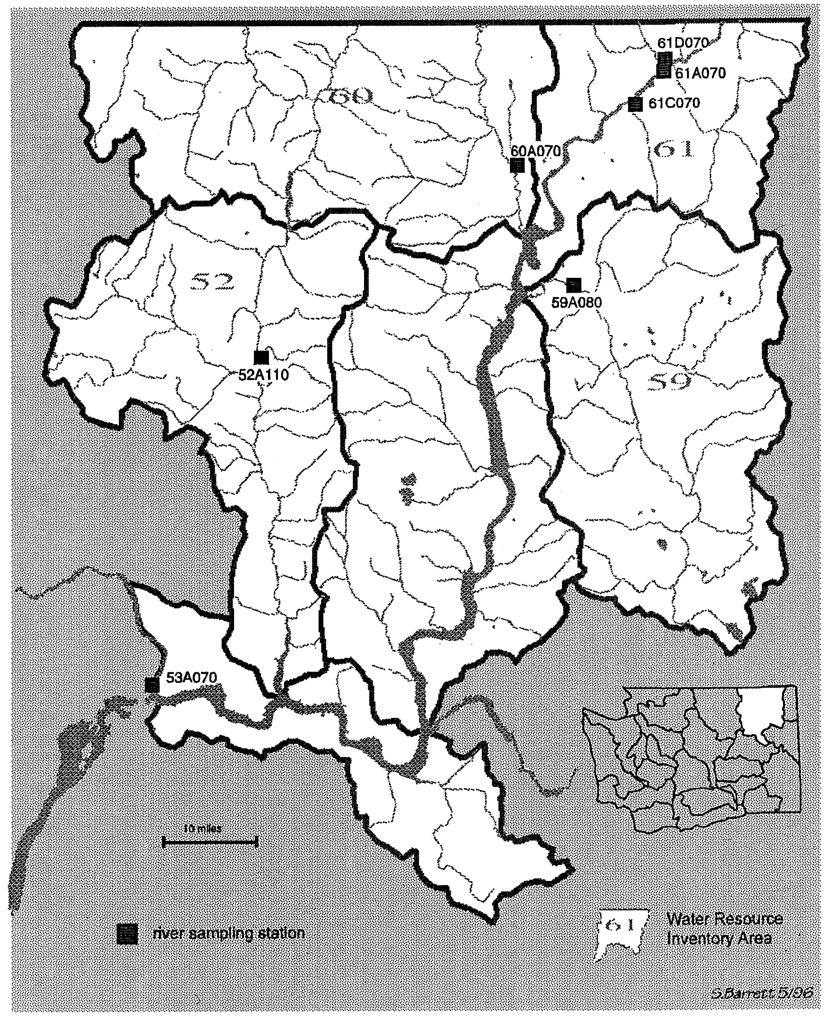


Figure 4. Upper Columbia (left) and Pend Oreille (right) Water Quality Management Area.

Table 2. Water quality constituents monitored monthly in Wateryear 1995 as part of Ecology's River and Stream Ambient Monitoring Program.

Standard constituents monitored at all stations:		
Conductivity	Total Suspended Solids	Total Phosphorus
Dissolved Oxygen	Turbidity	Ammonia
pH	Fecal Coliform Bacteria	Nitrate + Nitrite
Temperature	Soluble reactive phosphorus	Total Nitrogen

Table 3. Metals monitored bi-monthly at listed stations. (All metals were analyzed as "dissolved" except mercury, which was analyzed as "total" and arsenic and chromium which were analyzed as "total recoverable.")

Parameters			
Arsenic	Cadmium	Chromium	Copper
Lead	Mercury	Nickel	Zinc
Total Hardness			

Stations	
03A060	Skagit R nr Mount Vernon
04A100	Skagit R at Marblemount
05A070	Stillaguamish R nr Silvana
10A070	Puyallup R at Meridian St
26B070	Cowlitz R at Kelso
30A070	Columbia R @ Dalles
31A070	Columbia R at Umatilla
52A110	Sanpoil R 13 mi S. Republic
57A150[a]	Spokane R at State Line Br
61A070[a]	Columbia River at Northport
61C070	Onion Creek nr Northport

[a]Total Recoverable Cadmium, Copper, Lead, and Zinc were also measured bi-monthly at these stations.

Table 4. Analytical procedures used in WY 1995 in Ecology's River and Stream Ambient Monitoring Program. (NA = Not applicable)

Parameter	STORET Parameter Code	Volume Req'd	Field Prepare/ Preserve[a]	Analytical Method	Limit of Detection	Holding Time
Conductivity	95	NA	NA	SM 2510-B	NA (µS)	NA
Dissolved Oxygen	300	NA	NA	SMb 4500-OC	0 mg/L	72 hours
pH	400	NA	NA	SM 4500-H	NA (Std Units)	NA
Temperature	10	NA	NA	Thermistor	NA (°C)	NA
Total Suspended Solids	530	1000 mL		SM 2540D,E	1 mg/L	7 days
Turbidity	82079	500 mL		SM 2130	0.5 NTU	48 hours
Fecal Coliform Bacteria	31616	250 mL		SM 9222D	1 colony/ 100 mL	30 hours
Soluble Reactive Phosphorus	671	125 mL	Filter	SM 4500-PF	10 µg/L	48 hours
Total Phosphorus	665	125 mL to pH<2	H2SO4	SM 4500-PF	10 µg/L	28 days
Ammonia Nitrogen	610	125 mL to pH<2	H2SO4	SM 4500D	10 µg/L	28 days
Nitrate + Nitrite Nitrogen	630	125 mL to pH<2	H2SO4	SM 4500F	10 µg/L	28 days

Table 4. Continued

Parameter	STORET Parameter Code	Volume Req'd	Field Prepare/ Preserve[a]	Analytical Method	Limit of Detection[d]	Holding Time
Total Nitrogen	600	125 mL	H_2SO_4 to pH<2	Valderrama 1981	25 µg/L	28 days
Total Hardness	900	100 mL	HNO_3 to pH<2	SM 2340C	1 mg/L	6 months
Arsenic (total recoverable - ICP)	978	1 L	HNO_3 to pH<2	EPA[c] 200.7	30 µg/L	6 months
Cadmium (total recoverable - ICP) to pH<2	1113	1 L	HNO_3	EPA 200.7	3 µg/L	6 months
Cadmium (dissolved - ICP/MS)	1025	1 L	HNO_3 to pH<2	EPA 200.8	0.04 µg/L	6 months
Chromium (total recoverable - ICP)	1118	1 L	HNO_3 to pH<2	EPA 200.7	5 µg/L	6 months
Copper (total recoverable - ICP)	1119	1 L	HNO_3 to pH<2	EPA 200.7	3 µg/L	6 months
Copper (dissolved - ICP/MS)	1040	1 L	HNO_3 to pH<2	EPA 200.8	0.05 µg/L	6 months

Table 4. Continued

Parameter	STORET Parameter Code	Volume Req'd	Field Prepare/ Preserve[a]	Analytical Method	Limit of Detection[d]	Holding Time
Lead (total recoverable - ICP)	1114	1 L	HNO_3 to pH<2	EPA 200.7	20 µg/L	6 months
Lead (dissolved - ICP/MS)	1049	1 L	HNO_3 to pH<2	EPA 200.8	0.02 µg/L	6 months
Mercury (total - Cold Vapor AF)	71900	1 L	HNO_3 to pH<2	EPA 245.7	0.001 µg/L	28 days
Nickel (dissolved - ICP/MS)	1065	1 L	HNO_3 to pH<2	EPA 200.8	1.0 µg/L	6 months
Zinc (dissolved - ICP/MS)	1090	1 L	HNO_3 to pH<2	EPA 200.8	1.0 µg/L	6 months

[a] All lab samples are kept on ice or stored at 4°C prior to analysis
[b] Standard Methods (APHA, 1992).
[c] EPA, 1983.
[d] Detection limits for metals vary. Values shown are approximate.

Metals Monitoring Quality Assurance Project Plan (QAPP) and implemented a pilot project to evaluate the plan's effectiveness. The improvements in field methods were accompanied by improved analytical methods at MEL. Both of these efforts have allowed Ecology to lower the detection limits for select metals to at least a factor of 20 below the Washington State Water Quality Chronic Criteria without compromising data quality.

For WY 1995, bimonthly metals and hardness information were collected starting in November and ending in March at ten stations statewide (Table 3). Metals analyses were performed for dissolved nickel, cadmium, copper, zinc and lead, total recoverable arsenic and chromium, and total mercury. Metals sampling was curtailed in March to provide time to evaluate the previous year's metals information and make modifications before incorporating a metals component into the WY 1996 Freshwater Ambient Monitoring Program. For additional information regarding the metals portion of the Freshwater Ambient Monitoring Program see "Ambient Metals Project Proposal - Final Quality Assurance Project Plan" (Hopkins, 1995).

Data Management

Data generated by the River and Stream Ambient Monitoring Program were entered into two independent computer systems by monitoring staff and laboratory personnel. Monitoring staff entered field data (temperature, dissolved oxygen, barometric pressure, pH, conductivity, and discharge) directly into the ambient monitoring database and verified the data manually for transcription errors. Laboratory data were entered into the laboratory computer and verified by double entry by laboratory personnel for transcription errors. Laboratory data were then sent via electronic mail and combined with field data in the ambient monitoring database management system. All laboratory data were screened through a series of quality control (QC) filters (see the Quality Assurance section). Data exceeding QC standards were evaluated manually. Data of acceptable quality were uploaded to EPA's STORET database. For more detail on data management, see Hallock (1996b).

Quality Assurance

The MEL Quality Assurance (QA) Program includes the use of quality control charts, check standards, in-house matrix spikes and laboratory blanks, along with quarterly performance evaluation samples. For a more complete discussion of laboratory quality assurance, see MEL's Quality Assurance Manual (Ecology, 1988) and Laboratory User's Manual (Ecology, 1994).

The quality assurance (QA) program for field sampling consisted of three parts: (1) adherence to a procedures manual for sample/data collection and periodic evaluation of sampling personnel, (2) instrument calibration methods and schedules, and (3) the collection of a field quality control (QC) sample twice during each sampling run. Our QA program is described in detail in Ehinger (1995).

Three types of field QC samples were collected in order to document data quality and to isolate sources of variability (error) in the data. These were:

- 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 variability due to short-term in-stream processes, sample collection and processing, and laboratory analysis.

- Field Blank - These consisted of the submission and analysis of deionized water. The expected values for all analyses is the reporting limit for that analysis. Significantly higher results would indicate that sample contamination had occurred during field processing or during laboratory analysis.

- Duplicate (Split) Field Samples - These consisted of one sample split into two containers which are processed as individual samples. This eliminates the in-stream variability and isolates the variability to that due to field processing and laboratory analysis.

QC samples were submitted semi-blind to the laboratory (they were identified as QC samples, but sample type (duplicate, blank, or split) and station were not identified).

In all, 95 field QC samples were processed in WY 1995: 66 field split samples, 21 duplicate (sequential) field samples, and 18 field blanks. In addition, the laboratory analyzed some field QC samples in duplicate (*i.e.*, lab split samples). The primary objective of the QC sampling effort in WY 1995 was to quantify the variability due to field processing, rather than total variability, including in-stream. Therefore, unlike previous years, the majority of QC samples were field split samples rather than sequential samples. The central tendency of the variability 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). Because this weights the higher values, these figures provide an unbiased (and higher) estimate than other commonly used statistics (mean or median of the standard deviations).

A two-tiered system was used to evaluate data quality. The first tier consisted of five automated checks, including holding time, variability in field duplicates, and reasonableness of the result. Results exceeding pre-set limits were flagged. The second tier QC evaluation was a manual review of the data flagged in the first tier. Data were then coded from one through nine (one = data meets all QA requirements, nine = data are unusable). Data with quality codes greater than four are generally not used.

Results and Discussion

The primary purpose of this report is to present the results of Ecology's river and stream monitoring in WY 1995. Appendix B contains results for each station monitored in WY 1995. Appendix C is a quarterly summary of data collected during the past six years for each core station. Raw data are available in computer formats on request and the most recent WY's data are posted on Ecology's World Wide Web pages (http://www.wa.gov/ecology).
While a station-by-station data analysis is not within the scope of this report, some general

observations are appropriate. The next two sections (1) discuss general water quality, particularly with respect to Washington's water quality standards (Washington Administrative Code, Chapter 173-201A), and (2) compare discharge in WY 1995 to historical discharge data. Basin stations are included in the following analyses, although they are tabulated separately. However, these stations are sometimes selected because of a known water quality problem and may not necessarily reflect ambient conditions. As a result, the summaries in this report may be somewhat biased toward worse water quality than a true statewide average.

General Water Quality in Wateryear 1995

This discussion is largely based on comparisons to state water quality criteria. An exceedence of criteria usually indicates a violation of the water quality standards, but not always. For example, temperature standards specify that the criteria shall not be exceeded *due to human activities*. Many of the reported exceedences of the temperature criterion may not be due to human activities, for example, the Okanogan River at Oroville is immediately downstream of a lake. However, the ambient monitoring program is not specifically designed to identify causes of water quality. Final determination of whether or not a station is in violation of water quality standards is made by Ecology's Water Quality Program in their bi-annual 305(b) report to EPA (e.g., Ecology, 1994a).

Temperature

Statewide, 37 stations (44 percent of all stations) exceeded the temperature criterion at least once WY 1995 (Table 5). Fifty-four percent of eastern Washington stations and 36 percent of western Washington stations exceeded the criteria at least once. Rivers which exceeded the temperature criteria most often were the Okanogan (which is the outflow of Lake Osoyoos), Walla Walla, Palouse, Tucannon, Kettle, upper Columbia, and the East Fork of the Lewis River.

Oxygen

Statewide, 20 stations (24 percent of all stations) exceeded the oxygen criteria at least once (Table 5). Stations which most frequently exceeded this criteria were either class AA streams (Yakima and Kettle Rivers) which have more restrictive oxygen requirements, or streams which are (presumably) organically enriched (Palouse, South Fork Palouse, Chehalis, and Black Rivers) (Table 6). The Black River had the greatest number of samples exceeding criteria (50 percent).

pH

Fifteen stations (18 percent of all stations) exceeded the pH criteria, all of which were east of the Cascade Mountains (Table 5). The Okanogan and Palouse Rivers and Hangman Creek exceeded the criteria more frequently than other stations (Table 6). High pH in the Okanogan is likely due to the influences of Lake Osoyoos. Riparian clearing and nutrient enrichment has probably affected water quality in the Palouse River and Hangman Creek.

Table 5. Spatial distribution of water quality criteria exceedences for temperature, dissolved oxygen, pH, and fecal coliform bacteria (FC), and high values of total phosphorus (TP) and total suspended solids (TSS) in WY 1995.

Region	No. of Stations or Samples[a]	Parameter						
		Temp	Oxygen	pH	FC[b] (%)	FC[c] (gm)	TP[d]	TSS[e]
BY STATION								
Ecology Region								
Central	19	7	6	5	6	7	7	9
Eastern	20	13	8	10	10	14	12	9
Northwest	23	9	4	0	9	12	15	19
Southwest	22	8	2	0	12	14	11	12
East of Cascades	37	20	14	15	14	19	19	18
West of Cascades	47	17	6	0	23	28	26	31
Puget Sound Basin	29	10	4	0	11	14	18	23
All stations	84	37	20	15	37	47	45	49
BY SAMPLE								
Ecology Region								
Central	228	12	9	10	13	17	12	13
Eastern	240	27	20	18	32	47	44	24
Northwest	276	11	8	0	25	48	22	42
Southwest	264	15	9	0	29	42	24	20
East of Cascades	444	39	29	28	41	58	56	37
West of Cascades	564	26	17	0	58	96	46	62
Puget Sound Basin	348	11	8	0	28	54	26	47
All stations	1008	65	46	28	99	154	102	99

a Number of samples assumes 12 samples per station. Actual number may be less due to equipment malfunction, loss of sample, etc.

b Based on individual results greater than the "10 percent not to exceed" criteria. See text.

c Based on individual results greater than the "geometric mean" criteria. See text.

d There are no state water quality standards for total phosphorus. The number shown is the number of results (or stations with at least one result) that exceeded the 90th percentile of all results (0.099 mg/L).

e There are no state water quality standards for total suspended solids. The number shown is the number of results (or stations with at least one result) that exceeded the 90th percentile of all results (46 mg/L).

Table 6. Exceedences of water quality criteria for Wateryear 1995 river and stream ambient monitoring stations. For each variable, the total number of samples, the number of samples that exceeded criteria, and the percent of samples exceeding criteria are shown. For fecal coliform bacteria, the "Exceed" and "Pct" columns are the number and percent of individual samples exceeding the "10 percent not to exceed" criteria; the "GM" column is the number of individual samples exceeding the geometric mean criteria (see text).

CENTRAL REGION

STATION			TEMPERATURE			OXYGEN			pH			FECAL COLIFORM			
Number	Name	Class	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	GM
Core Stations															
31A070	Columbia R @ Umatilla	A	12	1[a]	8	12	[c]		12	1	8	12			
36A070	Columbia R nr Vernita	A	12	[a]		12			11			12			
37A090	Yakima R @ Kiona	A	12	[b]		12	1	8	11			12	5	42	5
37A205	Yakima R @ Knob Hill	A	12	[b]		12			11			12			
39A090	Yakima R nr Cle Elum	AA	12			12	3	25	12			12	1	8	1
45A070	Wenatchee R @ Wenatchee	A	11	1	9	11			9	2	22	11			
45A110	Wenatchee R nr Leavenworth	AA	12	1	8	12			10			12			
46A070	Entiat R nr Entiat	A	12			12			10			12			
48A070	Methow R nr Pateros	A	12			12			11			12			
48A140	Methow R @ Twisp	A	12			12			11			12			
49A070	Okanogan R @ Malott	A	12	3	25	12	1	8	11			12			
49A190	Okanogan R @ Oroville	A	12	3	25	12	2	17	11	5	45	12			
49B070	Similkameen R @ Oroville	A	12	1	8	12			11	1	9	12			
53A070	Columbia R @ Grand Coulee	A	12	[a]		12	1	8	12			12			
Basin Stations															
29D070	Rattlesnake Cr nr Mouth	A	12			12			12			12	1	8	1
29E070	Gilmer Cr nr Mouth	A	12			12			12			12	3	25	5
30A070	Columbia R @ The Dalles	A	12	2[a]	17	12	1[c]	8	12	1	8	11	1	9	1
30B060	Klickitat R nr Lyle	A	12			12			12			12			1
30C070	Little Klickitat nr Wahkiacus	A	12			12			12			12	2	17	3

[a]Special temperature criteria of 20°C was considered.
[b]The lower Yakima has a special temperature criteria of 21°C which was considered.
[c]Additional oxygen criteria, "dissolved oxygen shall exceed 90 percent of saturation," was included.

Table 6. Continued.

EASTERN REGION

STATION			TEMPERATURE			OXYGEN			pH			FECAL COLIFORM			
Number	Name	Class	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	GM
Core Stations															
32A070	Walla Walla R nr Touchet	B	12	3	25	12			12	1	8	12			3
33A050	Snake R nr Pasco	A	12	2[a]	17	12			12			12			
34A070	Palouse R @ Hooper	B	11	3	27	11			11	3	27	11	1	9	1
34A170	Palouse R @ Palouse	A	12	1[a]	8	12	4	33	12	1	8	12	2	17	5
34B110	SF Palouse R @ Pullman	A	12	1	8	12	5	42	12			12	9	75	9
35A150	Snake R @ Interstate Br	A	11	2[a]	18	12			12			12			1
35B060	Tucannon R @ Powers	A	12	4	33	12			12	2	17	12	3	25	4
41A070	Crab Cr nr Beverly	B	12			12	1	8	11	1	9	12	1	8	2
54A120	Spokane R @ Riverside Pk	A	12	[a]		12			12			12	4	33	4
55B070	Little Spokane R nr Mouth	A	12			12			12			12			1
56A070	Hangman Cr @ Mouth	A	11	1	9	11			11	3	27	11	2	18	3
57A150	Spokane R @ Stateline Br	A	12	2[a]	17	12	2	17	12			12			
60A070	Kettle R nr Barstow	AA	10	3	30	10	3	30	10	2	20	10			
61A070	Columbia R @ Northport	AA	12	3	25	12	1	8	12			12			2
62A150	Pend Oreille R @ Newport	A	12	1[a]	8	12			12			12			
Basin Stations															
52A110	Sanpoil R 13 mi S. Republic	AA	12			12	2	17	12			12	3	25	5
59A080	Colville R abv Kettle Falls	A	11			11	2	18	11			11	5	45	5
61C070	Onion Cr nr Northport	AA	10			10			9	2	22	10	2	20	2
61D070	Sheep Cr nr Northport	AA	10			10			10	2	20	10			
62A090	Pend Oreille @ Metaline Falls	A	12	1[a]	8	12			12	1	8	12			

[a]Special temperature criteria of 20°C was considered.

Table 6. Continued.

NORTHWEST REGION

STATION			TEMPERATURE			OXYGEN			pH			FECAL COLIFORM			
Number GM	Name	Class	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	
Core Stations															
01A050	Nooksack R @ Brennan	A	12			11			11			11	1	9	3
01A120	Nooksack R @ No Cedarville	A	12			11			11			11			
03A060	Skagit R nr Mount Vernon	A	12			12			11			12			
03B050	Samish R nr Burlington	A	12			12			11			12	4	33	6
05A070	Stillaguamish R nr Silvana	A	12	1	8	12			11			12			1
05A090	SF Stillaguamish @ Arlington	A	12	1	8	11			11			11	1	9	1
05A110	SF Stilly nr Granite Falls	AA	12	1	8	11	1	9	11			11			
05B070	NF Stillaguamish @ Cicero	A	12			11			11			11			
05B110	NF Stilly nr Darrington	A	12			11			11			11			
07A090	Snohomish R @ Snohomish	A	12	1	8	11			12			12			3
07C070	Skykomish R @ Monroe	A	11			10			11			11			
07D050	Snoqualmie R nr Monroe	A	12	1	8	11			12			12	3	25	5
07D130	Snoqualmie R @ Snoqualmie	A	12			12			12			12			
08C070	Cedar R @ Logan St/Renton	A	12	1	8	11			11			12	2	17	4
08C110	Cedar R nr Landsburg	AA	12			12			12			12			
09A080	Green R @ Tukwila	A	12	2	17	12	1	8	11			12	3	25	4
09A190	Green R @ Kanaskat	AA	12			12			12			12			
Basin Stations															
03B045	Samish R nr Mouth	A	12			12			11			12	2	17	6
03B080	Samish R nr Prairie	A	12			12			11			12	3	25	4
03C060	Friday Cr Blw Hatchery	A	12			11			11			12			1
03D050	Nookachamp Ck nr Mouth	A	12	1	8	12	4	33	11			12	6	50	10
04A100	Skagit R @ Marblemount	AA	12			12			11			11			
04E050	Finney Cr near Birdsview	AA	12	2	17	12	2	17	11			11			

Table 6. Continued.

SOUTHWEST REGION

STATION			TEMPERATURE			OXYGEN			pH			FECAL COLIFORM			
Number	Name	Class	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	No	Exceed	Pct	GM
10A070	Puyallup R @ Meridian St	A	12			11			12			12	1	8	4
11A070	Nisqually R @ Nisqually	A	12			11			11			12			
13A060	Deschutes R @ E St Bridge	A	12			12			12			11	2	18	2
16A070	Skokomish R nr Potlatch	AA	11			11			11			11			
16C090	Duckabush R nr Brinnon	AA	12			12			12			12			
18B070	Elwha R nr Port Angeles	AA	12			12			12			12			
20B070	Hoh R @ DNR Campground	AA	12			12			12			12			1
22A070	Humptulips R nr Humptulips	A	12			12			12			12			
23A070	Chehalis R @ Porter	A	12	2	17	12			12			12	1	8	1
24B090	Willapa R nr Willapa	A	12	2	17	12			12			12	6	50	6
24F070	Naselle R nr Naselle	A	12			12			12			12	4	33	4
26B070	Cowlitz R @ Kelso	A	11			11			11			9			
27B070	Kalama R nr Kalama	A	9			9			9			9			
27D090	EF Lewis R nr Dollar Corner	A	12	3	25	12			12			12	1	8	1
Basin Stations															
23A100	Chehalis R @ Prather Rd	A	12	2	17	12	3	25	12			12	1	8	3
23A160	Chehalis R @ Dryad	A	12	1	8	12			12			12	3	25	4
23E070	Black River @ Moon Rd Bridge	A	12	1	8	12	6	50	12			12	2	17	4
27E070	Cedar Cr nr Etna	A	12	3	25	12			12			12			3
27F070	Gee Cr @ Ridgefield	A	12	1	8	12			12			12	5	42	6
28B110	Washougal R blw Canyon Ck	A	12			12			12			12	2	17	2
29B070	White Salmon R nr Underwood	A	12			12			12			12			
29C070	Wind R nr Carson	A	12			12			12			12	1	8	1

Fecal Coliform Bacteria

Out of about 1008 samples collected statewide, 154 samples (15 percent) from 47 stations (56 percent of all stations) exceeded the geometric mean criteria for fecal coliform bacteria at least once (Table 5). A strict interpretation of the fecal coliform bacteria standards would consider all of these stations in violation of water quality standards even though 14 of the stations had only a single result greater than the criteria. This is because the geometric mean cannot be based on a period longer than 30 days and no minimum number of samples is specified (Washington Administrative Code, Chapter 173-201A-060 paragraph (3)). Our samples were collected at approximately 30-day intervals.

In past years, stations in western Washington, and particularly stations in Puget Sound, were more likely to exceed the fecal coliform criteria than were eastern Washington stations. This year, the percentage of samples exceeding the geometric mean criteria were relatively similar: 17 percent of samples west of the Cascades, 13 percent on the east side, and 16 percent in Puget Sound. On both sides of the mountains, a little over half of monitored stations had at least one sample that exceeded the geometric mean criteria.

There were five streams where 50 percent or more of the samples exceeded the geometric mean criteria: South Fork Palouse River, Samish River, Nookachamp Creek, Willapa River, and Gee Creek (Table 6). The South Fork Palouse River had by far the highest overall geometric mean (669 colonies/100 mL) followed by Nookachamp Creek (235 colonies/100 mL).

Summary of Water Quality Criteria Exceedences

In WY 1995, only two stations exceeded all four of the water quality criteria which we can readily evaluate with data collected by our program: Columbia River at the Dalles and Palouse River at Palouse. However, except for dissolved oxygen at the Palouse River, neither station exceeded criteria more than once or twice. On the other hand, only 24 stations (29 percent) had no water quality criteria exceedences at all. East of the Cascades, temperature and bacteria were the most frequently exceeded standards, however pH and oxygen violations were also common. In western Washington, bacteria were the biggest problem, followed by temperature. Only a few stations exceeded oxygen criteria and none exceeded the pH criteria.

The percent of samples exceeding water quality standards criteria at core stations in 1995 was very similar to the percent exceeding criteria from WY 1990 through 1994 (Table 7).

Table 7. Percent of samples exceeding water quality standards criteria. Only core stations with samples collected during four or more years from WY 1990 through WY 1995 are included in the above figures to allow a more fair comparison between years. Sixty stations met this criteria.

Parameter	WY 1995	WY 1990-1994
Temperature	7.0	7.4
Oxygen	3.6	2.8
pH	3.2	6.1
Bacteria (geometric mean criteria)	12.2	13.8

Turbidity

Most of the higher turbidity results were from the Puget Sound basin. Of Puget Sound basin stations, 15.6 percent of results exceeded the 90th percentile for all results, compared to 11.8 percent in western Washington (including Puget Sound) and 7.6 percent in eastern Washington. Out of 992 turbidity results, 8 of the highest 10 were from Puget Sound stations and most of these occurred in December 1994 during a run-off event and unusually high flows. The Stillaguamish and Nooksack Rivers and tributaries were the most likely to have high turbidities. The highest turbidity in eastern Washington (450 NTUs) was from the Tucannon River, in July 1995. Field notes commented on overnight thundershowers.

Water quality was not evaluated against the turbidity standard because the standard requires a comparison to background turbidity and this information is not available at most stations.

Other Parameters

Although there are no state water quality standards for total phosphorus (TP) or total suspended solids (TSS), these parameters are important to stream ecology. Streams with relatively high values were determined by comparing concentrations to a criteria defined as the 90th percentile of all samples collected in WY 1995. The 90th percentiles were 0.099 mg/L for TP and 46 mg/L for TSS.

As with turbidity, western Washington stations were somewhat more likely to exceed the 90th percentiles for TSS and TP than were stations in eastern Washington (Table 8). Forty-five and 49 stations had at least one sample which exceeded the 90th percentile for TP and TSS, respectively. However, only six stations for TP and six for TSS had chronically high concentrations (*i.e.,* were represented by more than three samples).

Streams such as the Palouse, Walla Walla, and Yakima Rivers, where both TP and TSS are chronically high, may be particularly good candidates for the application of watershed BMPs (Table 8).

Table 8. Stations with more than three samples exceeding the 90th percentile.

Station		Number of samples exceeding criteria TP	TSS
01A050	Nooksack River at Brennan	<4	5
05A110	SF Stillaguamish nr Granite Falls	<4	6
27F070	Gee Cr @ Ridgefield	11	<4
32A070	Walla Walla River near Touchet	9	4
34A070	Palouse River at Hooper	8	6
34B110	SF Palouse River at Pullman	12	<4
37A090	Yakima River at Kiona	6	4
41A070	Crab Creek near Beverly	4	4

Metals Monitoring

Most metals results were at or near the detection limits of the analytical methods. Of the 240 metals analyses performed in WY 1995 (from 10 stations) only six results on two rivers exceeded water quality criteria (Table 9). Five of the six were from the Spokane River at Stateline Bridge and three of these were violations of the acute zinc criterion. The other two results exceeded the chronic cadmium and chronic lead criteria. The Spokane River has a well-documented problem with metals enrichment due to historical mining practices in Idaho. Exceedences of metals criteria in the Spokane River are likely to continue.

The mercury concentration of 0.0129 µg/L in the Stillaguamish River at Silvana in January 1995 exceeded the chronic criteria. This datum, however, was qualified at MEL with an "N" qualifier indicating the sample spike recovery was not within the control range. Therefore, there is some uncertainty concerning this result.

Table 9. Wateryear 1995 metals concentrations at Ecology's freshwater ambient monitoring sites that exceeded Washington water quality criteria.

Station Name	Date	Metal	Hardness (mg/L)	Concentration (µg/L)	Acute Criteria	Chronic Criteria
Stillaguamish R@ Silvana	01/19/95	Mercury	23.9	0.0129 N	2.4	0.012
Spokane R. @ Stateline	11/07/94	Zinc	23.6	59.7	30.68	27.79
Spokane R. @ Stateline	01/10/95	Zinc	25	79.7	32.21	29.18
Spokane R. @ Stateline	03/06/95	Zinc	23.3	104	30.35	27.49
Spokane R. @ Stateline	03/06/95	Cadmium	23.3	0.406	0.66	0.31
Spokane R. @ Stateline	03/06/95	Lead	23.3	0.818	8.78	0.34

Discharge in Wateryear 1995

In western Washington, discharge in WY 1995 at the time of sampling (instantaneous discharge) was much higher than usual in December and lower than usual during the spring and early summer when compared to the median instantaneous discharge since WY 1977 (Figure 5, top). This analysis is based on *instantaneous* discharge, and may not reflect mean monthly discharge. Field notes indicate that at least one station was inaccessible due to flooding in December. Weather was nearly normal for WY 1995. Rainfall for the year in Seattle was only two inches above normal and no single month had unusual precipitation or temperatures (Seattle Times, 1994 and 1995).

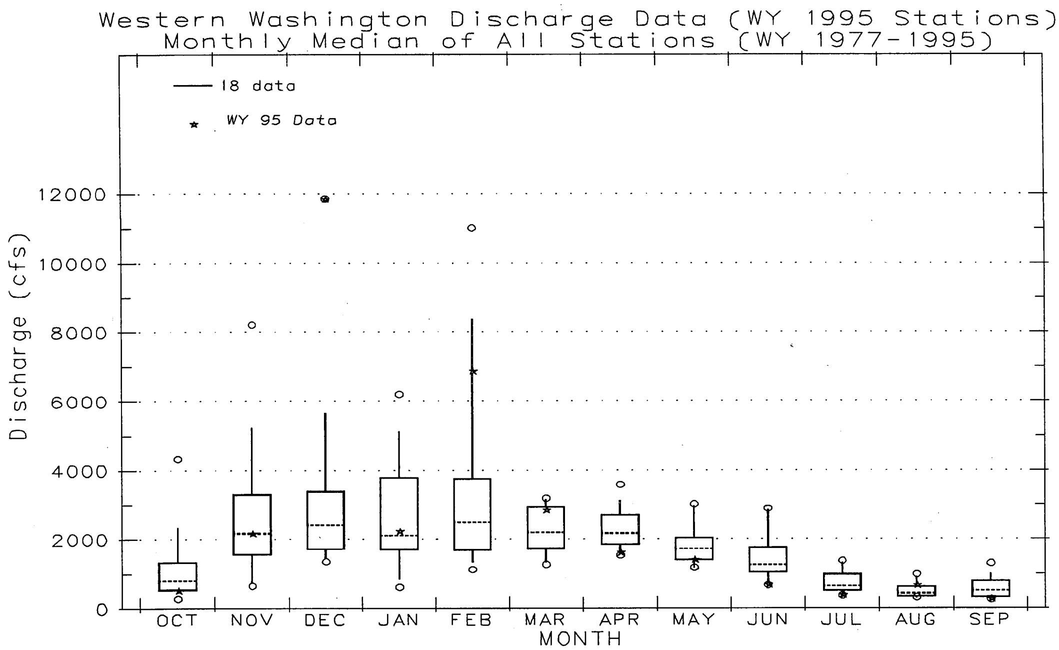
In eastern Washington, instantaneous discharge was generally similar to historical medians except for May and July, when flows were slightly higher (Figure 5, bottom).

Although precipitation duration, intensity, and the time since a previous precipitation event can significantly affect water quality, discharge at the time of sampling is also correlated with a number of water quality parameters. Higher than usual discharges during certain months in WY 1995 may have resulted in higher fecal coliform bacteria, turbidity, and TSS concentrations than usual. Detailed analyses of WY 1995 ambient monitoring data should consider the effect of discharge as well as precipitation.

Quality Assurance

Because the variability of many parameters increases with increasing mean concentration, the RMS values of some variables are presented according to concentration ranges (of the mean of the sample pair) (Table 10). Data from WY 1994 and 1995 are combined in order to increase sample size. The true value of lab variability should be equal to or less than that of the field splits, while the true variability of the field splits should be equal to or less than that of the sequential samples. In practice, the estimates of the variability are strongly influenced by extreme values (which are related to mean value of the sample pair), especially when sample size is small. The analysis is further complicated because all concentration data are truncated at the reporting limit, effectively producing a variance of zero between any two samples which are below this limit. This skews the variability estimate downward for the lowest concentration ranges. Because of these factors a quantitative analysis of these data will be deferred until WY 1996 data are available.

Expected results of the analyses of the blank samples were 'below reporting limits' for all concentrations and turbidity, and less than 3 μS (micro Siemans) for specific conductivity. Temperature, dissolved oxygen, and pH were not measured on blanks, and fecal coliform bacteria samples were submitted only five times during WY 1994 and 1995. All soluble reactive phosphorus, nitrate/nitrite, and suspended solids concentration results were reported as 'less than the reporting limits' (Table 11). Ammonia concentration above the reporting limit (10 $\mu g\ L^{-1}$),



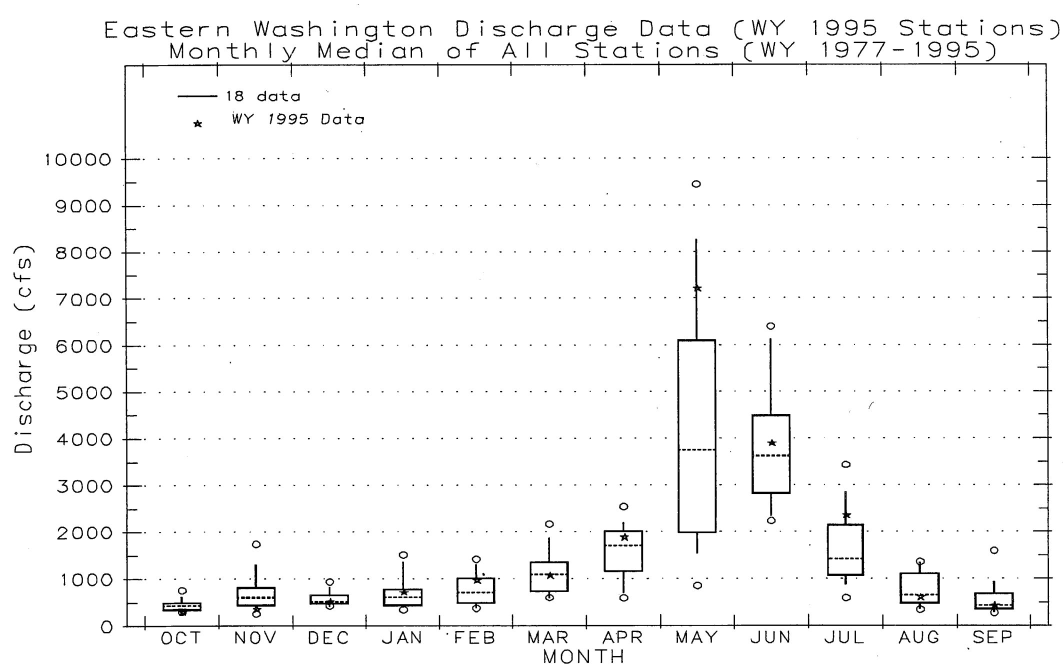


Figure 5. Distribution of discharge data by month in western Washington (top) and eastern Washington (bottom). Distribution is based on the median for each month of historical instantaneous discharge data (since October 1, 1976). Only stations sampled in WY 1995 with nearly continuous records were included (20 stations in eastern Washington and 22 in Western Washington). '*' indicates the monthly median of WY 1995 data. (Plots produced with WQHYDRO, Aroner, 1995.)

Table 10. Root mean square of the standard deviation of sequential samples, field splits, and laboratory splits. *n* = number of sample pairs.

		sequential samples		field splits		lab splits	
Variable	Range	RMS	sample size, *n*	RMS	sample size, *n*	RMS	sample size, *n*
Temperature (C)	all	0.0	*147*	NA	-	NA	-
pH	all	0.1	*143*	0.1	*59*	NA	-
Dissolved oxygen	all	0.1	*149*	0.3	*62*	NA	-
Specific conductivity (mS)	all	1.9	*149*	5.9	*64*	NA	-
Turbidity (NTU)	≤10	0.4	*128*	0.2	*53*	0.2	*106*
	>10	3.2	*22*	8.7	*17*	7.2	*29*
Suspended solids (mg L^{-1})	≤10	0.7	*111*	NA	-	0.5	*74*
	>10	5.9	*39*			13.9	*27*
Total phosphorus (µg L^{-1})	≤50	2.7	*114*	3.5	*50*	4.3	*24*
	>50	12.2	*34*	41.9	*20*	16.0	*3*
Soluble reactive P (µg L^{-1})	≤50	1.1	*132*	1.2	*59*	3.0	*36*
	>50	4.2	*16*	21.6	*10*	6.0	*2*
Total Nitrogen (µg L^{-1})	≤500	38.1	*94*	24.0	*47*	4.2	*22*
	>500	55.4	*53*	102.7	*23*	26.1	*2*
NO_3/NO_2-N (µg L^{-1})	≤500	9.5	*103*	6.3	*51*	15.1	*21*
	>500	40.9	*46*	222.9	*19*	18.1	*4*
NH_3-N (µg L^{-1})	≤20	2.6	*115*	3.0	*50*	1.8	*18*
	>20	12.6	*32*	15.1	*19*	2.9	*7*
Fecal coliform (# 100 mL^{-1})	≤50	7.6	*121*	NA	-	2.6	*74*
	>50	120	*23*			47.6	*25*

*does not include one total nitrogen replicate pair with an extremely high standard deviation (values of 3300 and 17,000 µg L^{-1}).

ranging from 11 to 21 μg L^{-1}, were detected in five of 17 blanks. Total persulfate nitrogen was detected in four and total phosphorus in one of 17 blanks. Turbidity values above the reporting limit were reported in two of 16 blanks. Mean conductivity of blank samples was 1.9 μS (standard error=0.6 μS).

The remaining elements of the laboratory QA program were assessed by laboratory staff through manual review of laboratory quality control charts, check standards, in-house matrix spikes, and laboratory blanks. The results were within acceptable ranges.

Table 11. Results of blind blank (deionized water) sample submission.

Variable	reporting limit	# above reporting limit (conc)	sample size, *n*
Specific conductivity (μS)	NA	mean= 1.9 sd= 0.6	17
Turbidity (NTU)	0.5	2 (0.7, 0.8)	16
Suspended solids (mg L^{-1})	1.0	0	17
Total phosphorus (μg L^{-1})	10	1 (40)	17
Soluble reactive P (μg L^{-1})	10, 5*	0	16
Total Nitrogen (μg L^{-1})	10	4 (22, 25, 34, 99)	17
NO_3/NO_2-N (μg L^{-1})	10	0	17
NH_3-N (μg L^{-1})	10	5 (11, 11, 11, 13, 21)	17
Fecal coliform (# 100 mL^{-1})	1	0	5
*reporting limit decreased from 10 μg L^{-1} in WY94 to 5 μg L^{-1} in WY95.			

Conclusions

1. Overall there were a typical number of water quality standards criteria exceedences in WY 1995. All pH and most oxygen exceedences occurred in eastern Washington. Fecal coliform bacteria and temperature exceedences occurred statewide.

2. Stations with high total suspended solids and total phosphorus concentrations were also distributed throughout the state, although Ecology's Eastern Region had the most stations with chronically high concentrations. Concentrations in Western Washington may have been unusually high due to a run-off event in December, 1994.

3. The following individual stations are worthy of note:

   a) Nookachamp Creek (03D050) - Ten of 12 samples from Nookachamp Creek exceeded the geometric mean criteria for fecal coliform bacteria. Dissolved oxygen was chronically low.
   b) Black River at Moon Road (23E070) - Half the samples taken from the Black River had oxygen concentrations below criteria. Bacteria counts were high in several samples.
   c) Palouse River at Hooper (34A070) - Temperature, TP and TSS were all chronically high. (TSS can be extremely high in the Palouse River at Hooper.)
   d) South Fork Palouse River at Pullman (34B110) - Conventional water quality at this stations is as bad as any station that we monitor. Results indicated chronically low dissolved oxygen, high bacteria, and high nutrients. An earlier study (Hallock, 1993) pointed to sources in both Washington and Idaho. (Restoration projects are underway in the watershed.)
   e) Tucannon River at Powers (35B060) - The temperature criteria was exceeded during more months (4) at this station than at any other station. Fecal coliform bacteria and turbidity were also occasionally high.

4. In western Washington, median instantaneous discharge was higher than historical medians for the previous five years in December and February and lower than usual in the spring and early summer. In eastern Washington, flows in May and July were slightly higher than normal, but were otherwise not unusual.

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