WASHINGTON STATE DEPARTMENT OF ECOLOGY

Metals Concentrations in Rivers and Streams Dropped from the 1994 Section 303(d) List

Abstract

The state of Washington adopted new Water Quality Standards for dissolved metals in 1992. These changes in standards, combined with the lack of compatible data, resulted in the removal of 48 of the 61 locations considered for listing in the draft 1994 303(d) list. Follow-up low-level metals information collected in May and September of 1994 at these 48 locations showed their removal is supported by in-stream metals concentrations. However, five locations did have metals concentrations that were more than one-third the chronic criteria. These five locations were: Juanita Creek, Fairweather Bay tributary, Little Bear Creek, Fife Ditch, and Salzer Creek. Only one of the five, Fife Ditch, should be considered for continued metals monitoring. This recommendation is based on: (1) the elevated arsenic concentration in May 1994 that was more than one-half the chronic criteria, and (2) the proximity of this location to a potential source.

Project Description

Overview

Section 303(d) of the Federal Clean Water Act requires Washington State to develop a list of waterbodies that: (1) do not meet Water Quality Standards, and (2) technology-based controls in place are not sufficient to achieve compliance with Water Quality Standards (Ecology, 1994a). Sixty-one freshwater waterbody segments were considered for listing in the draft 1994 303(d) list based on potential metal problems (see Appendix A). This preliminary list was derived by comparing total recoverable metals information from a variety of sources to water quality criteria for total recoverable metals. With the adoption of new criteria for dissolved metals in 1992, most of the stations initially listed for consideration were removed by default because little data existed on the ambient concentrations of dissolved metals. Of the 61 stations originally listed for consideration for the 1994 303(d) list, only 10 remained (Ecology, 1994b). These 10 stations are shown in Appendix A in bold type. The lack of data on the concentration of dissolved metals at 48 of the 51 remaining stations could have potentially resulted in the removal of stations that do have metal problems. Removal of three of the 51 stations (WA-55-1010, Little Spokane River; WA-54-1020, Spokane River; and WA-CR-1010, lower Columbia River) is warranted based on 1991 or newer data.

by Brad Hopkins
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Project Objectives

The specific objective of this project was to collect follow-up low-level ambient metals data from rivers and streams to determine if the removal of 48 waterbodies from the draft 1994 303(d) list was supported by actual in-stream total recoverable and dissolved metals concentrations.

Methods

The complete sampling design, methods, and data quality objectives are described in detail in a separate Quality Assurance Project Plan (Hopkins, 1995). Therefore, only a brief description is included in this document.

Sample Collection

The Ambient Monitoring Section (AMS) collected the minimum data set required for listing, that is, two samples at least 48 hours apart. To be as representative as possible with only two sampling efforts, one high flow month (May) and one low flow month (September) were chosen for sample collection. The first sampling period was from May 5-19, 1994, and the second was from September 1-21, 1994.

Sample sites were located within the water segment listed in the draft 1994 303(d) list (Appendix A). Figures 1, 1a, and 1b show the approximate locations of the rivers and streams sampled as part of this study. All water samples were collected directly in 500 mL Teflon® bottles with the aid of the stainless steel and Teflon® sampler shown in Figure 2. The sampler was lowered from a bridge to the water surface and allowed to orient itself so the bottle was upstream. Once submerged, the sampler automatically opens the bottle approximately 25 cm under the surface of the water. When sampling from a bridge was not practical, the sample was collected directly in the sample bottle by wading into the stream and submerging the stainless steel sampler.

Cleaning Procedures

Cleaning procedures for sample bottles and filter units are discussed in the Ambient Metals Quality Assurance Project Plan (Hopkins, 1995).

Field Processing

Dissolved Metals
Samples for dissolved metals were vacuum-filtered in the field through a disposable 0.45 μm cellulose nitrate filter. The filtered water sample was transferred to a clean Teflon® bottle.

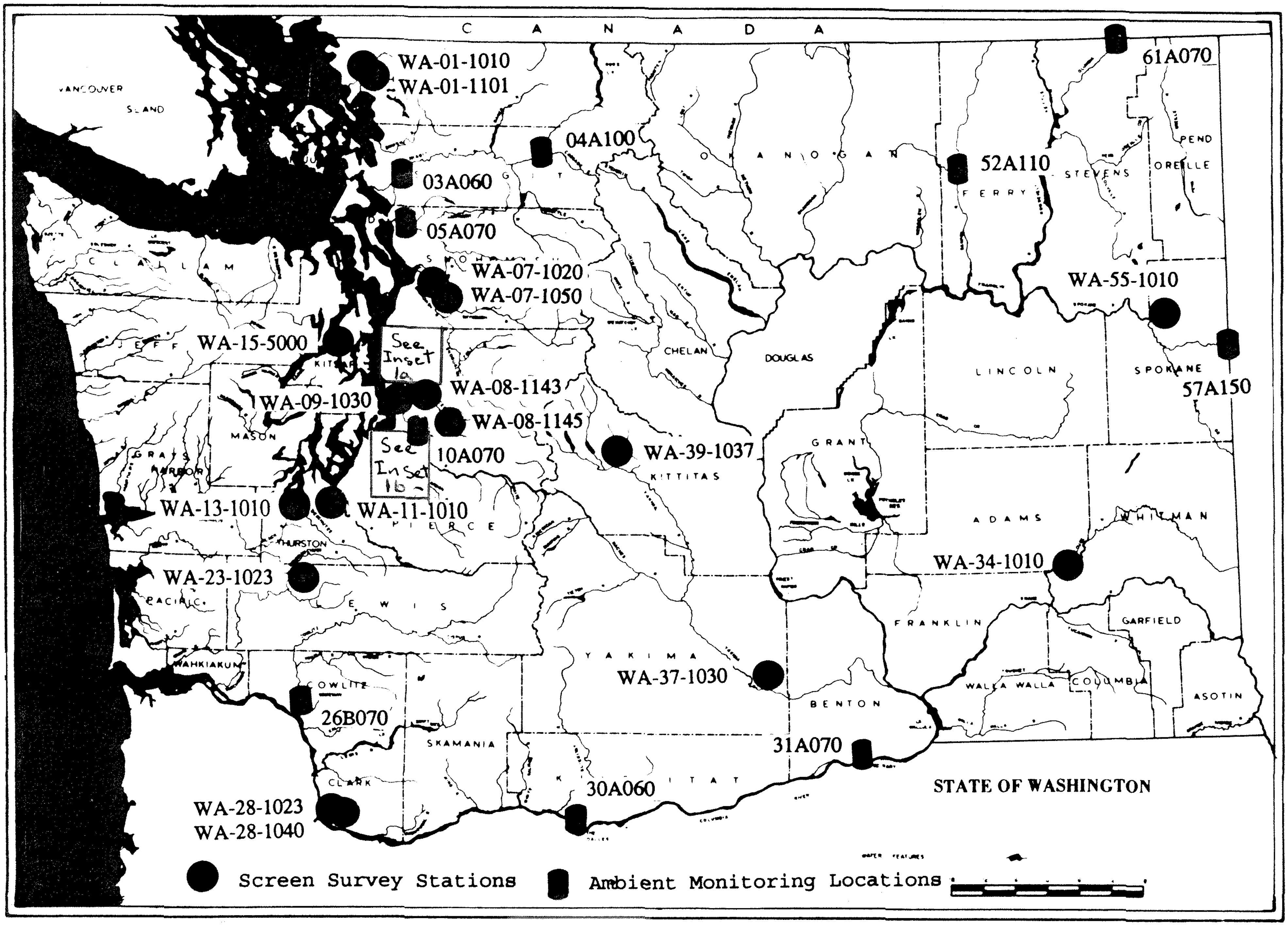

Figure 1. Sampling sites for the Ambient Metals Monitoring Program.

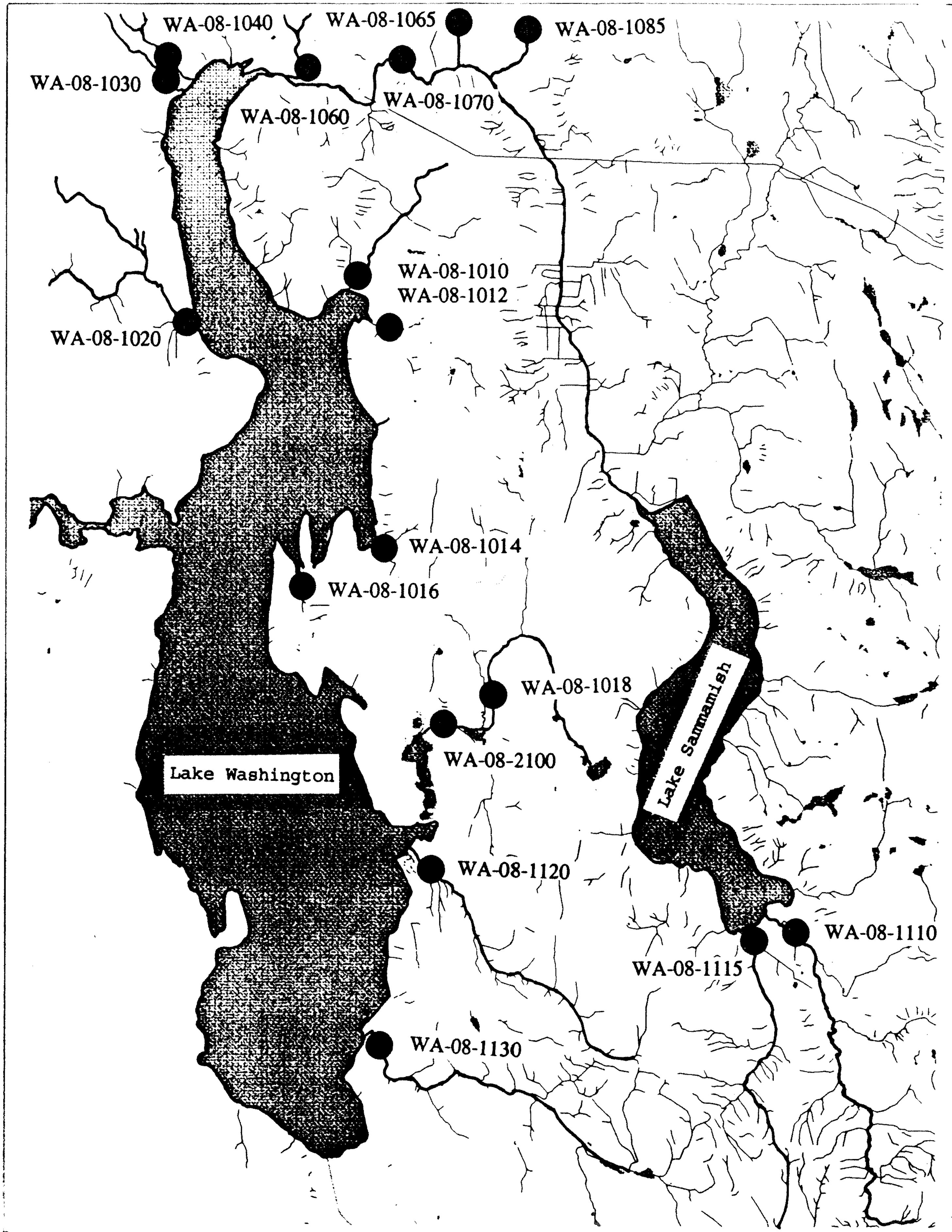

Figure 1a. Inset to Figure 1.

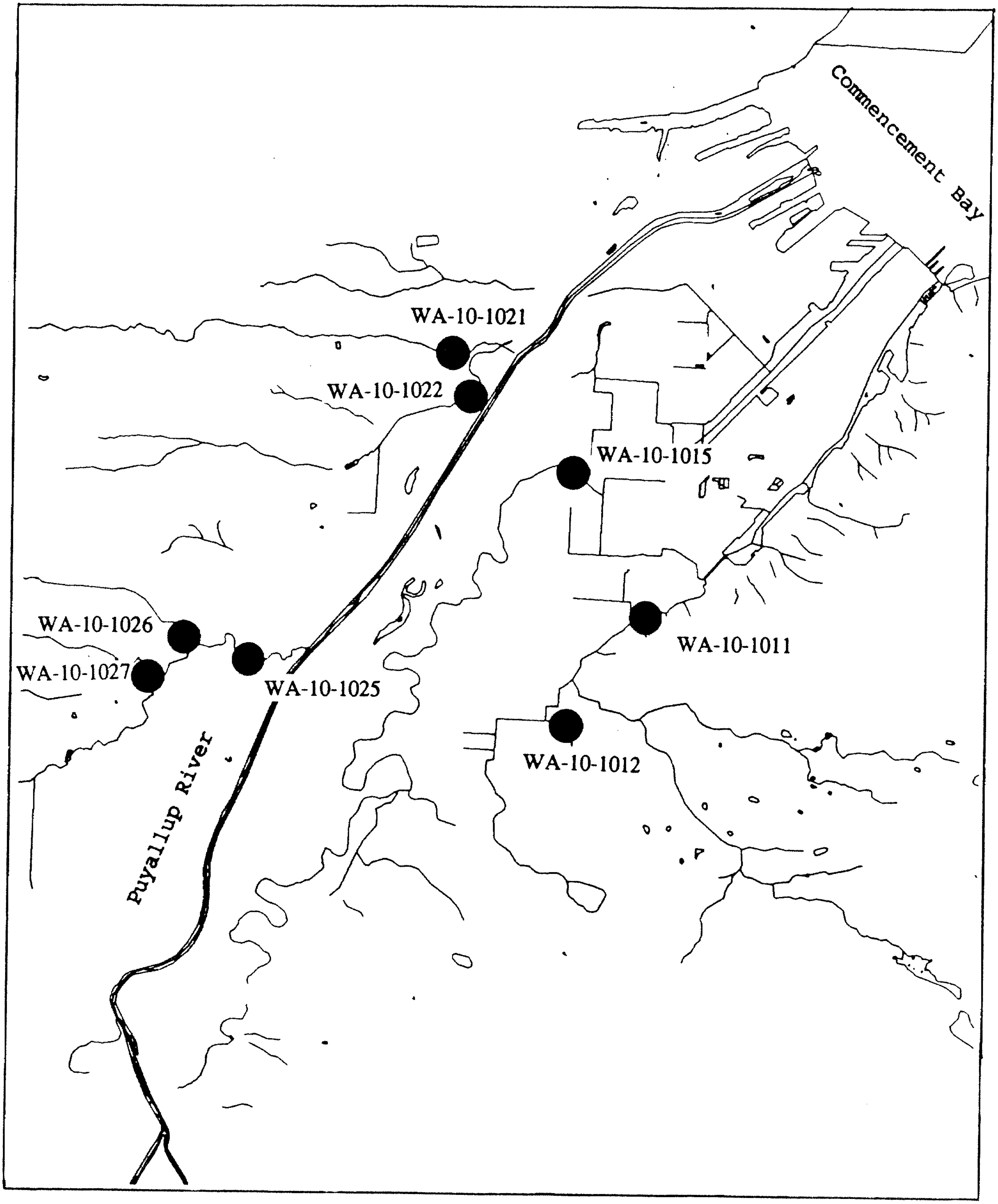

Figure 1b. Inset to Figure 1.

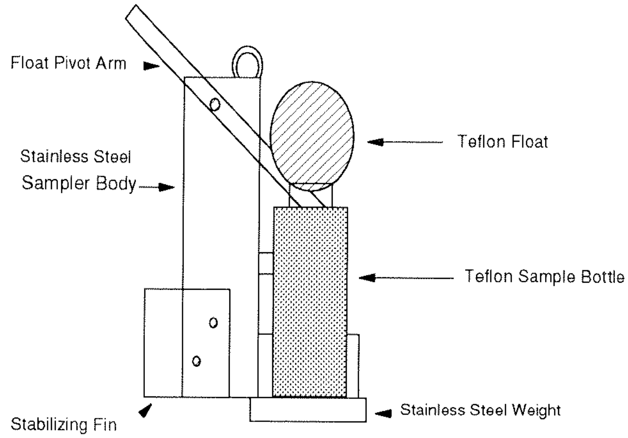

Figure 2. Stainless steel and teflon metals sampler.

A pre-measured volume of acid (5 mL of 1:1 sub-boiled concentrated nitric acid + deionized water) transported in a small Teflon® vial was added (one per sample). Each sample bottle was labeled and placed in a polyethylene bag and iced for transport to the Manchester Environmental Laboratory (MEL).

Total Recoverable Metals
Samples for total recoverable metals were acidified (5 mL of 1:1 sub-boiled concentrated nitric Acid + deionized water) by adding a pre-measured volume of acid from a small Teflon® vial (one per sample) directly into the container used to collect the sample. Each sample was labeled and placed in a polyethylene bag and iced for transport to the MEL.

Field Quality Assurance

Field quality assurance (QA) samples included collection of replicate pairs (sequential samples collected 15 minutes apart) and field splits. Filter and bottle blanks were analyzed during both sampling periods to determine if analytes were present in the sample containers or preservative, and if present at appreciable levels, whether they were a result of sample handling.

Laboratory Analysis

Water samples were analyzed for the metals listed in Table 1. In addition to the five dissolved metals, total mercury, total recoverable arsenic, and chromium were also added. Although the Water Quality Standard for these last three metals was not revised in 1992 to dissolved, stations listed for these metals were also removed from the 1994 303(d) list.

Table 1. Metals analyzed for the follow up low-level metals study and corresponding detection limits.

Parameter	Detection Limit
Nickel (Dissolved)	1 μg/L
Copper (Dissolved)	0.05 μg/L
Zinc (Dissolved)	1 μg/L
Cadmium (Dissolved)	0.04 μg/L
Lead (Dissolved)	0.02 μg/L
Mercury (Total)	0.001 μg/L
Arsenic (Total Recoverable)	30 μg/L
Chromium (Total Recoverable)	5 μg/L

Dissolved Metals
Dissolved metals were analyzed at Ecology's MEL using Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) (a modified version of EPA Method 200.8).

Total Recoverable Metals
Total recoverable metals were analyzed at Ecology's MEL using microwave assisted digestion (EPA Method 202.2) and ICP (a modified version of EPA Method 200.7). Mercury was determined using the Free Bromide Digestion (EPA Method 245.7) and Cold Vapor Atomic Fluorescence (EPA Method 245.1).

Ongoing Verification of Method Detection Limit
Before field collection in May 1994, MEL completed the requirements of Section 10.2.2. Method Detection Limit (MDL) of EPA Method 200.8 (Determination of Trace Elements in Water and Waste by Inductively Coupled Plasma - Mass Spectrometry). The MEL also completed a similar MDL study for follow-up low-level mercury by Cold Vapor Atomic Fluorescence. This MDL study was also repeated in September 1994.

Results and Discussion

Assigning QA Codes

Data from this project were subject to two levels of verification before entry into the final spreadsheet. "Level One" passed the data through a series of checks ranging from holding times to comparing variability between field duplicate results. After passing through the "Level One" filters, quality codes were attached to each datum. These quality codes are as follows:

1 = %RSD at or near Chronic Criteria is $\leq$ 5%
2 = %RSD at or near Chronic Criteria is $\leq$ 10%
3 = %RSD at or near Chronic Criteria is $\leq$ 20%
4 = %RSD at a factor of ten above the Chronic Criteria is $\leq$ 10%
5 = %RSD at a factor of ten above the Chronic Criteria is $\leq$ 20% or %RSD at or near the Chronic Criteria is > 20%
6 = %RSD at a factor of ten above the Criteria > 20%
7 = Not Assigned
8 = Not Assigned
9 = Datum is Unusable (holding time not met)

The "Level Two" QA check consisted of a manual review of remaining QA information and if data quality was further compromised by significant field blank contaminations, or field replicates/splits %RSD > 20%, then the QA data qualifier code was increased by one for each additional QA problem.

Data with quality codes of 1-3 can be used for all intended purposes. Data with quality codes ranging from 4-6 can be used for most applications, but have limitations. Data with quality codes of 7 and 8 should be used as approximate concentrations only. Data with a data quality code of 9 should not be used. For a comprehensive discussion on assigning QA codes see the Ambient Metals Quality Assurance Project Plan (Hopkins, 1995). Tables 2 and 3 summarize the assigning of QA codes that are attached to the final data set for the May and September sampling.

Laboratory QA Evaluation

The MEL prepared written reviews of laboratory QA information evaluating the validity and usefulness of all metals data. These reviews discussed sample holding times, instrument calibration, procedural (method) blanks, matrix spikes, and laboratory control sample analyses. The results of these laboratory QA samples, for the most part, fell within the internal guidelines established by MEL. However, the following exceptions were noted: (1) the reporting limit for lead was raised from 0.02 to 0.035 μg/L in September due to instrument drift, and (2) the SLRS-3 Reference Material for September showed a high bias for cadmium and lead (note the certified value for cadmium is below the detection limit) (Kammin, 1994).

Precision and Accuracy
Quarterly MEL Standard Reference Material SLRS-3, NIST 1643c, NIST 1641c, and low level standards results are presented in Table 4. Also included in Table 4 is the percent relative standard deviation (%RSD) based on this information (see Summary of Calculations). All metal results for all reference materials had %RSD < 20% except for cadmium, lead, and zinc concentrations on SLRS-3. The %RSD for cadmium was > 20%, however, as previous stated in 2 above the certified value for SLRS_3 was below the detection limit of the analytical method. The %RSD on SLRS-3 for lead was 33 and 30 percent for May and September, respectively. The %RSD on SLRS-3 for zinc in September was 27 percent. The

Table 2. Summary of final QA Codes for the May 1994 metals information.

		Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Check Standard nr Chronic	< 5%	1	1	1	1	1	1	NA	NA
	< 10%								
	< 20%								
Standard one order of magnitude above Chronic	< 10%								
	< 20%								
or check standard nr Chronic	> 20%								
	> 20%								
Field Blank (bottle)		0	0	0	0	0	0		
Field Replicate/Split		0	0	1	1	0	0		
Reference Material % Bias		0	0	0	0	1	0		
Reference Material %RSD		0	0	0	0	1	NA		
FINAL QA CODE (see text)		1	1	2	2	3	1		

Table 3. Summary of final QA Codes for the September 1994 metals information.

		Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Reference Material nr Chronic	< 5%	1	1	1	1	1	1	NA	NA
	<10%	1	1	1		1	1		
	<20%								
Standard one order of magnitude above Chronic	<10%								
	<20%								
or Reference material nr Chronic	>20%								
	>20%								
Field Blank (filter)		0	0	0	0	0	NA		
Field Replicate/Split		0	0	0	0	0	0		
Reference Material % Bias		0	0	0	0	0	0		
Reference Material %RSD		0	0	0	0	1	0		
FINAL QA CODE (see text)		2	2	2	1	3	2		

NA = Not Available

Table 4. Reference material results for May and September 1994 metals sampling.

SLRS-3

		Ni	Cu	Zn	Cd	Pb
5/94						
	Result	0.91	1.48	1.93	0.03	0.14
	Duplicate	0.79	1.31	1.1	0.03	0.07
	Actual	0.83	1.35	1.04	0.013	0.068
	% rec R	110	110	186	225	208
	% rec R	95	97	106	213	103
	RPD	15.03	12.13	55	5.24	67.58
	STD	0.06	0.085	0.415	0	0.035
	mean	0.85	1.395	1.515	0.03	0.105
	%RSD	7	6	27	0	33
	%Bias	2	3	46	131	54
9/94						
	Result	0.78779	1.37444	1.24542	0.01796	0.1515
	Result	0.78273	1.43342	1.14437	0.02892	0.08139
	Result	0.72219	1.33193	1.04025	0.01234	0.06244
	Actual	0.83	1.35	1.04	0.013	0.068
	% rec	95	102	120	138	223
	% rec	94	106	110	222	120
	% rec	87	99	100	92	91
	RPD					
	STD	0.0298032	0.02949	0.050525	0.00548	0.035055
	mean	0.7642367	1.40393	1.194895	0.02344	0.116445
	%RSD	4	2	4	23	30
	%Bias	-8	4	15	80	71

NIST 1643c

		Ni	Cu	Zn	Cd	Pb
5/94						
	Result	55.39	19.83	72.04	12.58	34.21
	Duplicate	56.01	19.96	71.57	12.46	34.42
	Actual	60.6	22.3	73.9	12.2	35.3
	% R	91	89	97	103	97
	% rec R	92	90	97	102	98
	RPD	1.12	0.66	0.65	0.94	0.61
	STD	0.31	0.065	0.235	0.06	0.105
	mean	55.7	19.895	71.805	12.52	34.315
	%RSD	1	0.3	0.3	0.5	0.3
	%Bias	-8	-11	-3	3	-3
9/94						
	Result	61.7871	22.7467	79.8115	12.5935	36.0949
	Duplicate	58.8418	21.9664	74.6329	11.9389	36.2299
	Actual	60.06	22.3	73.9	12.2	35.3
	% rec	102.87562	102.00314	107.999323	103.22541	102.2518414
	% R	97.971695	98.504036	100.991746	97.8598361	102.6342776

Table 4. Continued.

NIST 1643c

	Ni	Cu	Zn	Cd	Pb
9/94					
STD	1.47265	0.39015	2.5893	0.3273	0.0675
mean	60.31445	22.35655	77.2222	12.2662	36.1624
%RSD	2	2	3	3	0.2
%Bias	0.4	0.3	5	0.5	2

Mercury

	NIST 1641 c 5/94	NIST 1641 c 7/94	3 PPT Standard ug/L 9/94
	0.02871	0.0298	0.003043
	0.02566	0.02858	0.00272
	0.02871	0.0366	0.002552
	0.02644	0.02905	0.00274
	0.02784	0.02868	0.002896
	0.02665	0.02919	0.00289
	0.02625	0.03126	0.003598
	0.02602	0.03489	0.002823
	0.0286		
	0.02777		
	0.02708		
	0.02656		
mean	0.0271908	0.0310063	0.00290775
STD	0.0010498	0.0028792	0.00029418
%RSD	4	9	10
%Bias	-8	5	-3
MDL			0.00092372

Standard 0.3 ug/L

	Ni	Cu	Zn	Cd	Pb
3/15/94					
	0.307809	0.28596	0.316581	0.309309	0.304593
	0.306326	0.278539	0.219867	0.303042	0.29439
	0.3388	0.350455	0.371253	0.294619	0.321896
STD	0.0149711	0.0322948	0.06259246	0.00601866	0.011353292
Mean	0.317645	0.3049847	0.302567	0.30232333	0.306959667
%RSD	5	11	21	2	4
%Bias	6	2	0.8	0.8	2
9/94					
	0.2748	0.3268	0.33172	0.30701	0.36646
	0.26978	0.39267	0.72885	0.29016	0.29095
	0.2996	0.34443	0.34534	0.28372	0.32612
	0.23382	0.31387	0.31542	0.30125	0.30499

Table 4. Continued.

		Ni	Cu	Zn	Cd	Pb
9/94						
	STD	0.0234906	0.0298824	0.17267435	0.0091217	0.028491407
	Mean	0.2695	0.3444425	0.4303325	0.295535	0.32213
	%RSD	9	9	40	3	9
	%Bias	-10	15	43	-1	7

Standard 1 ug/L

		Ni	Cu	Zn	Cd	Pb
5/94						
		1.03398	1.02278	0.991862	1.02114	1.02758
		0.930681	0.917744	1.61044	1.02005	1.0357
		0.977232	0.965853	0.917124	0.998399	1.0322
		0.980094	1.00306	0.936295	1.00828	1.00755
		0.981369	0.980166	0.910553	0.991019	1.00916
		0.97288	0.996146	0.963012	1.01461	0.998863
	STD	0.0300113	0.0333992	0.24997577	0.01108398	0.013896797
	Mean	0.9793727	0.9809582	1.054881	1.00891633	1.018508833
	%RSD	3	3	24	1	1
	%Bias	-2	-2	5	0.9	2
9/94						
		1.06203	1.05627	1.06823	1.05081	1.08684
		0.93652	0.95134	0.95128	0.90372	0.95226
		0.93922	1.0696	0.98152	1.03587	1.06878
		0.8425	0.88793	0.86335	0.95147	0.9515
	STD	0.0779544	0.0752232	0.07322142	0.06051557	0.063288497
	Mean	0.9450675	0.991285	0.966095	0.9854675	1.014845
	%RSD	8	8	8	6	6
	%Bias	-5	-0.9	-3	-1	1

Standard 50 ug/L

		Ni	Cu	Zn	Cd	Pb
		50.1672	49.7363	52.2916	48.8259	49.6888
		48.952	49.4767	52.4964	48.8	49.5468
		47.6311	49.3364	50.927	48.0979	49.1015
	STD	1.0356582	0.1656624	0.69658632	0.3372436	0.250194897
	Mean	48.916767	49.516467	51.905	48.5746	49.4457
	%RSD	2	0.3	1.3	0.7	0.5
	%Bias	-2	-1	4	-3	-1

STD = Standard Deviation
%RSD = Percent Standard Deviation
%R = Percent recovery
%RD = Percent recovery of duplicate
RPD = Relative Percent Difference

lead and zinc results for NIST 1643c for the same dates were < 20% RSD. It should be noted the certified concentration of lead for NIST 1643c of 35.3 $\mu g/L$ is more than ten times higher than the average chronic criteria calculated in this study. However, the certified concentration of zinc for NIST 1643c of 73.9 $\mu g/L$ was within the range of chronic criteria encountered within this study. Therefore, the final QA code for zinc in May was not increased by one, while the QA codes for lead were increased by one. Laboratory splits were all < 20% RSD save the September results for lead of 23% which also increased the September QA code for lead by one.

Bias
Quarterly MEL Standards and Reference Materials were also used to determine the laboratory percent bias (for formulas see Summary of Calculations) which are also presented in Table 4. All metals, except cadmium, zinc, and lead, were within the limit of $\pm$ 10% bias. Bias for cadmium and zinc for SLRS-3 was > 10%, however, the same limitation discussed when addressing precision and accuracy apply here. Analysis of SLRS-3 for lead did show a high bias for both months and the QA codes were increased by one.

Blanks
Laboratory blanks were analyzed at a frequency of two blanks per analytical batch. All laboratory blank results were below the reporting limit and no sample results were compromised.

Field QA Evaluation

Precision
Replicate pairs, field splits, and %RSD calculations based on this information, are included in Tables 5 and 6 for the May and September sampling, respectively. All %RSD for replicate pair and field splits were < 20% RSD, except for May cadmium (field split) and September lead results (field replicate). Both QA codes for these months were increased by one.

Filter and Bottle Blanks
Bottle and filter blank results are included in Tables 5 and 6. Contamination was present in only one blank sample. Zinc was detected in the May filter blank. The degree of this zinc contamination was small when the detected concentration of 1.01 $\mu g/L$ is compared to the detection limit of 1.0 $\mu g/L$. The QA code for zinc in May was increased by one based on the filter blank contamination. However, the result was not qualified with a V qualifier code (contamination of bottle), because the extent of contamination was insignificant.

Final Data Set

Data generated to evaluate the removal of stations from the final WY 1994 303(d) list are included in Table 7. Appendix B provides the corresponding Washington Water Quality Standards (WWQS) acute and chronic criteria for the specific location for the individual sampling dates. No violations of WWQS were found during this study, however, five

Table 5. Quality assurance information for May 1994 metals sampling.

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Bottle Blanks	0.087052	0.035839	0.022085	0.000385	0.00102	0.001 U	30 U	5 U
Filter Blanks	0.17918	0.04717	1.01	0.00175	0.008069	NA	NA	NA

Field Replicate 1

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	0.634126	1.08	2.49	0.025269	0.118			
Replicate	0.670065	1.07	2.39	0.019875	0.111			
STD	0.0179695	0.005	0.05	0.002697	0.0035			
mean	0.6520955	1.075	2.44	0.022572	0.1145			
%RSD	3	0.6	2	12	3			

Lab Split of Replicate 1

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	0.670065	1.07	2.39	0.019875	0.111			
Split	0.691958	1.05	2.29	0.024004	0.113			
STD	0.0109465	0.01	0.05	0.0020645	0.001			
mean	0.6810115	1.06	2.34	0.0219395	0.112			
%RSD	2	0.9	2	9	0.9			

Field Replicate 2

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	0.496448	0.348	2.08	0.01408	0.01952	0.0011 P	30 U	5 U
Replicate	0.490536	0.358	2.15	0.012963	0.019956	0.001 U	30 U	5 U
STD	0.002956	0.005	0.035	0.0005585	0.000218	5E-05		
mean	0.493492	0.353	2.115	0.0135215	0.019738	0.00105 P		
%RSD	0.6	1	2	4	1	5		

Field Split of Replicate 2

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	0.544067	0.484	1.6	0.009057	0.07	0.001 U	30 U	5 U
Split	0.462729	0.452	1.3	0.014606	0.072	0.001 U	30 U	5 U
STD	0.040669	0.016	0.15	0.0027745	0.001	0		
mean	0.503398	0.468	1.45	0.0118315	0.071	0.001 U		
%RSD	8	3	10	23	1	0		

Table 6. Quality assurance information for September 1994 metals sampling.

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Bottle Blanks	1 U	0.05 U	1 U	0.04 U	0.02 U	0.001 U	30 U	5 U
Filter Blanks	1 U	0.05 U	1 U	0.04 U	0.02 U	NA	NA	NA

Field Replicate 1

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	1 U	0.549	1 U	0.04 U	0.035 U	0.001 U	30 U	5 U
Replicate	1 U	0.559	1.1 P	0.04 U	0.02 U	0.0012 P	30 U	5 U
STD	0	0.005	0.05	0	0.0075	0.0001 P	0	0
mean	1 U	0.554	1.05 P	0.04 U	0.0275 U	0.0011	30	5 U
%RSD	0	0.9	5	0	27	9		

Lab Split of Field Replicate 1

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	1 U	0.549	1 U	0.04 U	0.035 U	0.001 U	30 U	5 U
Split	1 U	0.53	1.2 P	0.04 U	0.02 U	0.001 P	30 U	5 U
STD	0	0.0095	0.1	0	0.0075	0		
mean	1 U	0.5395	1.1 P	0.04 U	0.0275 U	0.001 P		
%RSD	0	2	9	0	27	0		

Field Replicate 2

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	1 U	1	1 P	0.04 U	0.066 P	0.0018 P	30 U	5 U
Replicate	1 U	1.03	1.4 P	0.04 U	0.021 P	0.0015 P	30 U	5 U
STD	0	0.015	0.2	0	0.0225	0.00015		
mean	1 U	1.015	1.2 P	0.04	0.0435 P	0.00165 P		
%RSD	0	1	17	0	52	9		

Laboratory Duplicate

	Ni	Cu	Zn	Cd	Pb	Hg	As	Cr
Actual	1 U	1	1 P	0.04 U	0.066 P	0.001 U	30 U	5 U
Split	1 U	1.08	1.5 P	0.04 U	0.03 P	0.001 U	30 U	5 U
STD	0	0.04	0.25	0	0.018	0		
mean	1 U	1.04	1.25 P	0.04	0.048 P	0.001 U		
%RSD	0	4	20	0	38	0		

Table 7. Metals concentrations (ug/L) at locations removed from the 1994 303(d) list based on the adoption of the 1992 dissolved metals criteria

Waterbody #	Date	Name	Nickel	Copper	Zinc	Cadmium	Lead	Mercury	Arsenic	Chromium	Hardness
WA-01-1010	5/17/94	Nooksack R	1.42 1	0.411 P 1	1 U 2	0.04 U 2	0.02 U 3	0.001 U 1	30 U	5 U	36.3
	9/20/94		1 P 2	0.34 P 2	1 U 3	0.04 U 2	0.02 U 6	0.0027 P 2	30 U	5 U	47
WA-01-1101	5/17/94	Silver Ck	2.4 1	0.56 1	2.06 2	0.04 U 2	0.02 U 3	0.0011 P 1	30 U	5 U	146
	9/20/94		1.9 P 2	0.38 P 2	2.5 P 3	0.04 U 2	0.048 P 6	0.0026 P 2	30 U	5 U	147
WA-07-1020	5/17/94	Snohomish R	1 U 1	0.446 P 1	2.21 2	0.04 U 2	0.039 P 3	0.001 U 1	30 U	5 U	14.8 J
	9/20/94		1 U 2	0.5 P 2	1 U 3	0.04 U 2	0.024 P 6	0.0011 P 2	30 U	5 U	17.8
WA-07-1050	5/17/94	Snohomish	1 U 1	0.4 P 1	1 U 2	0.04 U 2	0.025 P 3	0.001 U 1	30 U	5 U	13.7
	9/20/94		1 U 2	0.517 2	1 U 3	0.04 U 2	0.02 U 6	0.0012 P 2	30 U	5 U	17.8
WA-08-1010	5/12/94	Juanita Ck	1.18 1	0.707 1	2.73 2	0.04 U 2	0.07 P 3	0.0015 P 1	30 U	5 U	95.2
	9/6/94		1 U 2	0.842 2	2.4 P 3	0.04 U 2	0.71 P 6	0.0011 P 2	30 U	5 U	89.8
WA-08-1012	5/12/94	Forbes Ck	1.16 1	1.08 1	2.81 2	0.04 U 2	0.108 P 3	0.0016 P 1	30 U	5 U	104
	9/6/94		1 U 2	1.34 2	2.1 P 3	0.04 U 2	0.079 P 6	0.001 U 2	30 U	5 U	106
WA-08-1014	5/12/94	Yarrow Bay Trib	1.22 1	1.13 1	9.32 2	0.04 U 2	0.265 3	0.002 P 1	30 U	5 U	107
	9/6/94		1 U 2	0.87 2	6.1 P 3	0.04 U 2	0.1 P 6	0.001 U 2	30 U	5 U	105
WA-08-1016	5/12/94	Fairweather Bay Trib	1.88 1	2.61 1	4.02 2	0.04 U 2	0.28 3	0.0031 P 1	30 U	5 U	122
	9/6/94		1.3 P 2	4.41 2	2.4 P 3	0.04 U 2	0.31 P 6	0.0069 P 2	30 U	5 U	126
WA-08-1018	5/12/94	Kensey Ck	1.02 1	1.28 1	5.13 2	0.04 U 2	0.201 3	0.0022 P 1	30 U	5 U	86.7
	9/6/94		1 U 2	0.734 2	2.5 P 3	0.04 U 2	0.099 P 6	0.0015 P 2	30 U	5 U	81.8
WA-08-1020	5/12/94	Thorton Ck	1.24 1	0.939 1	3.96 2	0.04 U 2	0.264 3	0.0016 P 1	30 U	5 U	112
	9/6/94		1.1 P 2	1.06 2	4.3 P 3	0.04 U 2	0.27 P 6	0.0013 P 2	30 U	5 U	106
WA-08-1030	5/12/94	Mcaleer Ck	1.28 1	1.29 1	3.73 2	0.04 U 2	0.346 3	0.0037 P 1	30 U	5 U	79.2
	9/6/94		1 U 2	0.41 P 2	2.5 P 3	0.04 U 2	0.074 P 6	0.0019 P 2	30 U	5 U	107
WA-08-1040	5/12/94	Lyon Ck	1.06 1	0.702 1	2.64 2	0.04 U 2	0.118 P 3	0.0013 P 1	30 U	5 U	110
	9/6/94		1 U 2	0.754 2	2.4 P 3	0.04 U 2	0.069 P 6	0.001 U 2	30 U	5 U	106

Table 7. Continued.

Waterbody #	Date	Name	Nickel	Copper	Zinc	Cadmium	Lead	Mercury	Arsenic	Chromium	Hardness
WA-08-1060	5/12/94	Swamp Ck	1.3 1	0.733 1	2.61 2	0.04 U 2	0.127 P 3	0.0023 P 1	30 U	5 U	87.2
	9/6/94		1 U 2	0.712 2	1.5 P 3	0.04 U 2	0.092 P 6	0.001 U 2	30 U	5 U	85.8
WA-08-1065	5/12/94	North Ck	1.06 1	0.543 1	1.63 P 2	0.04 U 2	0.097 P 3	0.0029 P 1	30 U	5 U	76.7
	9/6/94		1 U 2	0.586 2	1.1 P 3	0.04 U 2	0.061 P 6	0.0012 P 2	30 U	5 U	77.7
WA-08-1070	5/16/94	Sammamish R	1.1 1	0.678 1	2.02 2	0.04 U 2	0.09 P 3	0.001 U 1	30 U	5 U	59.5
	9/19/94		1 U 2	0.539 2	1.5 P 3	0.04 U 2	0.045 P 6	0.0016 P 2	30 U	5 U	74.4
WA-08-1085	5/12/94	Little Bear Ck	1 U 1	0.538 1	2.87 2	0.247 P 2	0.136 P 3	0.0026 P 1	30 U	5 U	60.1
	9/6/94		1 U 2	0.49 P 2	3.5 P 3	0.16 P 2	0.1 P 6	0.0018 P 2	30 U	5 U	63.2
WA-08-1110	5/16/94	Issaquah Ck	1 U 1	0.515 1	1.48 P 2	0.04 U 2	0.075 P 3	0.001 U 1	30 U	5 U	46.9
	9/19/94		1 U 2	0.789 2	2.7 P 3	0.04 U 2	0.096 P 6	0.0016 P 2	30 U	5 U	59.8
WA-08-1115	5/12/93	Tibbetts Ck	1.06 1	0.664 1	1.72 P 2	0.04 U 2	0.041 P 3	0.0014 P 1	30 U	5 U	121
	9/6/94		1 U 2	0.605 2	1.2 P 3	0.04 U 2	0.034 U 6	0.0014 P 2	30 U	5 U	179
WA-08-1120	5/12/93	Coal Ck	1.67 1	0.751 1	1.2 P 2	0.04 U 2	0.03 P 3	0.0012 P 1	30 U	5 U	189
	9/6/94		1.4 P 2	0.652 2	1 P 3	0.04 U 2	0.035 U 6	0.0025 P 2	30 U	5 U	222
WA-08-1130	5/12/93	May Ck	1 U 1	0.95 1	2.01 2	0.04 U 2	0.11 P 3	0.0021 P 1	30 U	5 U	71.1
	9/6/94		1 U 2	0.535 2	1.1 P 3	0.04 U 2	0.053 P 6	0.0015 P 2	30 U	5 U	81.2
WA-08-1143	5/16/94	Cedar R	1 U 1	0.273 P 1	1.15 P 2	0.04 U 2	0.054 P 3	0.001 U 1	30 U	5 U	31
	9/19/94		1 U 2	0.17 P 2	1 P 3	0.04 U 2	0.02 U 6	0.001 U 2	30 U	5 U	37.9
WA-08-1145	5/16/94	Cedar R	1 U 1	0.19 1	1 U 2	0.04 U 2	0.022 P 3	0.001 U 1	30 U	5 U	30.4
	9/19/94		1 U 2	0.13 P 2	1 U 3	0.04 U 2	0.02 U 6	0.001 U 2	30 U	5 U	35.4
WA-08-2100	5/12/94	Mercer Slough	1.1 1	2.77 1	4.64 2	0.04 U 2	0.316 3	0.0025 P 1	30 U	5 U	99.7
	9/6/94		1 U 2	1.48 2	2.6 P 3	0.04 U 2	0.12 P 6	0.0016 P 2	30 U	5 U	93.8
WA-09-1022	5/13/94	Hill (Mill) Ck	1.12 1	0.765 1	1.77 P 2	0.04 U 2	0.036 P 3	0.0013 P 1	30 U	5 U	115
	9/7/94		1 U 2	1 2	1 P 3	0.04 U 2	0.066 P 6	0.0018 P 2	30 U	5 U	87.7
WA-09-1026	5/18/94	Soos Ck	1 U 1	0.484 P 1	1.6 P 2	0.04 U 2	0.07 P 3	0.001 U 1	30 U	5 U	52.5
	9/21/94		1 U 2	0.28 P 2	1 U 3	0.04 U 2	0.02 U 6	0.0012 P 2	30 U	5 U	55.9

Table 7. Continued.

Waterbody #	Date	Name	Nickel	Copper	Zinc	Cadmium	Lead	Mercury	Arsenic	Chromium	Hardness
WA-09-1028	5/13/94	Newaukum Ck	1 U 1	0.628 1	1 U 2	0.04 U 2	0.022 P 3	0.0014 P 1	30 U	5 U	59.3
	9/7/94		1 U 2	0.48 P 2	1 U 3	0.04 U 2	0.035 U 6	0.0018 P 2	30 U	5 U	63.5
WA-09-1030	5/16/94	Green R	1 U 1	0.19 P 1	1 U 2	0.04 U 2	0.02 P 3	0.001 U 1	30 U	5 U	18.3
	9/19/94		1 U 2	0.21 P 2	1 U 3	0.04 U 2	0.02 U 6	0.0015 P 2	30 U	5 U	22.8
WA-10-1011	5/13/94	Hylebos Ck	1.15 1	0.466 P 1	1.24 P 2	0.04 U 2	0.059 P 3	0.0019 P 1	30 U	5 U	116
	9/7/94		1 U 2	0.48 P 2	1 U 3	0.04 U 2	0.17 P 6	0.0015 P 2	30 U	5 U	137
WA-10-1012	5/13/94	Fife Ditch	2 1	1.07 1	3.59 2	0.04 P 2	0.146 P 3	0.0064 P 1	110 P	5 U	135 J
	9/7/94		1 U 2	0.669 2	1.5 P 3	0.04 U 2	0.035 U 6	0.0056 P 2	69 p	5 U	99.3
WA-10-1015	5/13/94	Wapato Ck	1 U 1	0.353 P 1	1.19 P 2	0.04 U 2	0.026 P 3	0.001 U 1	30 U	5 U	87.4
	9/7/94		1 U 2	0.501 2	1 U 3	0.04 U 2	0.038 P 6	0.0014 P 2	30 U	5 U	91.2
WA-10-1021	5/13/94	Clear Ck	1 U 1	0.348 P 1	2.08 2	0.04 U 2	0.02 U 3	0.0011 P 1	30 U	5 U	79.9
	9/7/94		1 U 2	0.33 P 2	1 U 3	0.04 U 2	0.035 U 6	0.0012 P 2	30 U	5 U	81.7
WA-10-1022	5/13/94	Swan Ck	1 U 1	0.449 P 1	1.46 P 2	0.04 U 2	0.031 P 3	0.001 U 1	30 U	5 U	68.3
	9/7/94		1 U 2	0.3 P 2	1 U 3	0.04 U 2	0.035 U 6	0.0015 P 2	30 U	5 U	72.6
WA-10-1025	5/13/94	Clarks Ck	1 U 1	0.24 P 1	1.66 P 2	0.04 U 2	0.041 P 3	0.001 U 1	30 U	5 U	81.4
	9/7/94		1 U 2	0.19 P 2	1.1 P 3	0.04 U 2	0.18 P 6	0.0016 P 2	30 U	5 U	83.7
WA-10-1026	5/13/94	Unnamed Ck	1 U 1	0.18 P 1	2.22 2	0.04 U 2	0.02 U 3	0.0032 P 1	30 U	5 U	61.3
	9/7/94		1 U 2	0.818 2	4.5 P 3	0.04 U 2	0.064 P 6	0.0018 P 2	30 U	5 U	68.6
WA-10-1027	5/13/94	Diru Ck	1 U 1	0.367 P 1	1 U 2	0.04 U 2	0.023 P 3	0.001 U 1	30 U	5 U	87.1
	9/7/94		1 U 2	0.37 P 2	1 U 3	0.04 U 2	0.02 U 6	0.0025 P 2	30 U	5 U	92.2
WA-11-1010	5/6/94	Nisqually R	1 U 1	0.735 1	1.46 P 2	0.04 U 2	0.026 P 3	0.0011 P 1	30 U	5 U	25.1
	9/2/94		1 U 2	0.549 2	1 U 3	0.04 U 2	0.035 U 6	0.001 U 2	30 U	5 U	26.7
WA-13-1010	5/6/94	Deschutes R	1 U 1	0.415 P 1	0.89 P 2	0.04 U 2	0.02 U 3	0.001 U 1	30 U	5 U	41.5
	9/2/94		1 U 2	0.42 P 2	1.1 P 3	0.04 U 2	0.052 P 6	0.001 U 2	30 U	5 U	50.4

Table 7. Continued.

Waterbody #	Date	Name	Nickel	Copper	Zinc	Cadmium	Lead	Mercury	Arsenic	Chromium	Hardness
WA-15-5000	5/13/94	Clear Ck	1 U 1	0.252 P 1	2.18 2	0.04 U 2	0.034 P 3	0.0011 P 1	30 U	5 U	74.9
	9/7/94		1 U 2	0.21 P 2	1.7 P 3	0.04 U 2	0.02 U 6	0.0013 P 2	30 U	5 U	72.6
WA-23-1023	5/6/94	Salzer Ck	1.53 1	1.05 1	4.26 2	0.04 U 2	0.094 P 3	0.0012 P 1	30 U	5 U	52.1
	9/2/94		1.2 P 2	2.6 2	10.7 3	0.04 U 2	0.355 6	0.0012 P 2	30 U	5 U	56.3 E
WA-28-1023	5/6/94	Cougar Ck	1 U 1	0.625 1	2.05 2	0.04 U 2	0.229 3	0.001 U 1	30 U	5 U	101
	9/2/94		1 U 2	0.38 P 2	1.3 P 3	0.04 U 2	0.039 P 6	0.001 U 2	30 U	5 U	99.7
WA-28-1040	5/6/94	Burnt Bridge Ck	1 U 1	1.08 1	2.49 2	0.04 U 2	0.118 P 3	0.0015 P 1	30 U	5 U	85.4
	9/2/94		1 U 2	0.697 2	1.7 P 3	0.04 U 2	0.15 P 6	0.0017 P 2	30 U	5 U	98.2
WA-34-1010	5/5/94	Palouse R	1.14 1	1.61 1	1.72 P 2	0.04 U 2	0.074 P 3	0.0017 P 1	30 U	5 U	89.2
	9/1/94		1.3 P 2	1.68 2	1.6 P 3	0.04 U 2	0.077 P 6	0.001 U 2	30 U	5 U	142
WA-37-1030	5/5/94	Sulfer Ck	1.13 1	1.03 1	1.88 P 2	0.04 U 2	0.52 P 3	0.006 P 1	30 U	5 U	148
	9/1/94		1 U 2	1.18 2	2.5 P 3	0.04 U 2	0.3 P 6	0.0017 P 2	30 U	5 U	142
WA-39-1037	5/5/94	Crystal Ck	1 U 1	1	2	2	3	0.0018 P 1	30 U	5 U	78.9
	9/1/94		1 U 2	0.5 P 2	1 U 3	0.04 U 2	0.054 P 6	0.001 U 2	30 U	5 U	41.5
WA-CR-1030	5/5/94	Columbia R	1 U 1	1.13 1	1.48 P 2	0.04 U 2	0.023 P 3	0.001 U 1	30 U	5 U	72.3
	9/1/94		1 U 2	1.19 2	1.7 P 3	0.04 U	0.07 P 6	0.001 U 2	30 U	5 U	61.3

U = Undetected at this concentration.
P = Concentration above detection limit but below quantitation limit.
[box] = Concentration more than one-third the chronic criteria listed in Table 8.

locations did have metals concentrations that were more than one-third the chronic criteria and they are listed in Table 8. Only one of the five locations, WA-10-1012 Fife Ditch, should be considered for continued monitoring. This sample location was a ditch approximately 300 meters from a documented source of arsenic, the B and L Woodwaste Landfill (Norton, 1983). The May arsenic concentration of 110 μg/L was more than one-half the WWQS Chronic Criteria of 190 μg/L. The elevated arsenic level combined with the proximity to a documented potential source of arsenic, may suggest a continuing problem that should be monitored. The remaining four locations do not warrant continued monitoring without additional information concerning potential sources in the watershed.

Summary and Recommendations

This project was successful despite the fact that only a few of the locations tested showed even moderate metal concentrations, and only one location should be considered for possible follow-up investigation. The low-level metals sampling methods and analytical procedures developed for this project have enhanced Ecology's capability of quantifying low concentrations of dissolved metals against which to compare to WWQS chronic criteria.

Without the capability, and without a comprehensive monitoring program, Ecology's Statewide Water Quality Assessment Section 305(b) report and Section 303(d) list to the Environmental Protection Agency (EPA) must rely on information solicited from various sources with varying degrees of quality. The weakness of this type of metals data set is magnified by the limitations of the analytical methods used for metals determination. The evaluation of such data during the 1994 305(b) process would have resulted in locations being included in the 1994 303(d) list in error. This incorrect listing was avoided, not based on an assessment of the quality of the data or subsequent follow up investigations, but due to lack of data to compare to the new WWQS for dissolved metal concentrations. Hopefully, situations like these can be avoided in the future with the transition by Ecology to a basin approach to water quality management. If this approach is implemented, as designed, Ecology would have the opportunity to direct monitoring activities to confirm or rebut data of uncertain quality prior to locations being listed on the 303(d) list. If Ecology plans to continue using water quality information from numerous sources to evaluate conditions in Washington State and wants to avoid incorrect inclusion of waterbodies on the 303(d) list, it should: 1) insist all data sets have a minimum level of QA information, 2) evaluate the QA information to determine the data sets usefulness, 3) direct Ecology's basin monitoring activities to confirm or rebut questionable data before waterbodies are included on the 303(d) list.

Table 8. Locations with metals concentrations (ug/L) at least one-third the Chronic Criteria.

Sample Location	Date	Chromium	Chronic Criteria	Copper	Chronic Criteria	Lead	Chronic Criteria	Zinc	Chronic Criteria	Cadmium	Chronic Criteria	Nickel	Chronic Criteria	Arsenic	Chronic Criteria	Mercury	Chronic Criteria
Juanita Creek	9/6/94	5U	189.5	0.84	9.3	0.71P	1.9	2.4P	86.21	0.04U	0.9	1U	136.8	30U	190	0.0011P	0.012
Fairweather Bay Tributary	9/6/94	5U	250.1	4.41	12.4	0.31P	2.9	2.4P	114.9	0.04U	1.2	1.3P	182.1	30U	190	0.0069P	0.012
Little Bear Creek	5/12/94	5U	136.4	0.538	6.6	0.136	1.1	2.87	61.4	0.247P	0.66	1U	97.4	30U	190	0.0026P	0.012
Fife Ditch	5/13/94	5U	264.7	1.07	13.2	0.146P	3.2	3.59	121.8	0.04P	1.24	2	193.1	110P	190	0.0064P	0.012
	9/7/94	5U	205.8	0.669	10.1	0.035U	2.2	1.5P	93.9	0.04U	0.98	1U	148.9	69P	190	0.0056P	0.012
Salzer Creek	9/2/94	5U	129.3	2.6	6.24	0.355	1.05	10.7	58	0.04U	0.62	1.2P	92.1	30U	190	0.0012P	0.012

P = Above the detection limit but below the quatitation limit.
U = Undetected at this concentration.
[box] = Concentrations of concern.

Summary of Calculations

$\underline{\% \ RSD^*} = (S/X) * 100$

where
S = Standard deviation (n-1)
X = Mean of laboratory results

$$\underline{\% \ Bias^*} = \frac{X - T}{T} * 100$$

where
X = Mean of the results of replicate analysis
T = True concentrations

$\underline{MDL^{**}} = t * S$

where
t = Student's t value for 99% confidence levels and a standard deviation estimate with n-1 degrees of freedom (t=3.14 for 7 replicates)
S = Standard deviation of the 7 replicates.

*From (Lombard, 1991)
**From EPA method 200.8.

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APPENDIX A

Water Segments on the Preliminary 1994 List With Potential Metal Problems

Appendix A. Water Segments on the preliminary 1994 303(d) list with potential metal problems. Bold type face indicates waterbodies on the final 1994 303(d) list (Ecology, 1994).

Waterbody Segment Number	Waterbody Name	Parameter Exceeding Standards
1) WA-01-1010	Nooksack River	Lead, Cadmium
2) WA-01-1101	Silver Creek	Arsenic
3) WA-01-3110	**Whatcom Creek**	**Metals**
4) WA-07-1020	Snohomish River	Copper, Cadmium, Mercury
5) WA-07-1050	Snohomish River	Copper, Cadmium, Mercury
6) WA-08-1010	Juanita Creek	Mercury, Copper, Lead, Zinc
7) WA-08-1012	Forbes Creek	Copper, Lead
8) WA-08-1014	Yarrow Bay Tributary	Copper, Lead
9) WA-08-1016	Fairweather Bay Tributary	Copper, Lead
10) WA-08-1018	Kelsey Creek	Cadmium, Copper, Lead
11) WA-08-1020	Thornton Creek	Cadmium, Copper, Lead, Zinc
12) WA-08-1030	Mcaleer Creek	Mercury, Copper, Lead, Zinc
13) WA-08-1040	Lyon Creek	Cadmium, Copper, Lead, Zinc
14) WA-08-1060	Swamp Creek	Copper, Lead
15) WA-08-1065	North Creek	Cadmium, Copper, Lead
16) WA-08-1070	Sammamish River	Copper, Lead
17) WA-08-1085	Little Bear Creek	Copper, Lead, Zinc
18) WA-08-1095	**Bear-Evans Creek**	**Mercury**, Copper, Lead
19) WA-08-1110	Issaquah Creek	Mercury, Copper, Lead
20) WA-08-1115	Tibbetts Creek	Copper, Lead
21) WA-08-1120	Coal Creek	Mercury, Copper, Lead
22) WA-08-1130	May Creek	Copper
23) WA-08-1143	Cedar River @ Logan St Bridge	Copper
24) WA-08-1145	Cedar River @ Maplewood	Copper, Lead, Mercury
25) WA-08-2100	Mercer Slough	Mercury
26) WA-09-1010	**Duwamish River**	**Cadmium, Copper, Lead, Mercury, Zinc**
27) WA-09-1015	**Springbrook (Mill) Creek**	**Cadmium, Copper, Lead, Mercury, Zinc**
28) WA-09-1020	**Green River**	**Cadmium, Copper, Mercury, Lead**
29) WA-09-1022	Hill (Mill) Creek	Copper, Lead
30) WA-09-1026	Soos Creek	Copper, Lead, Nickel, Mercury
31) WA-09-1028	Newaukum Creek	Copper, Lead
32) WA-09-1030	Green River	Mercury, Lead
33) WA-10-1010	Puyallup River	Copper, Lead, Zinc, Cadmium, Mercury

Appendix A. Continued.

Waterbody Segment Number	Waterbody Name	Parameter Exceeding Standards
34) WA-10-1011	Hylebos Creek	Copper, Mercury
35) WA-10-1012	Fife Ditch	Copper, Lead, Zinc, Cadmium
36) WA-10-1015	Wapato Creek	Metals
37) WA-10-1021	Clear Creek	Metals
38) WA-10-1022	Swan Creek	Copper, Mercury
39) WA-10-1025	Clarks Creek	Metals
40) WA-10-1026	Unnamed Creek	Metals
41) WA-10-1027	Diru Creek	Metals
42) WA-11-1010	Nisqually River	Cadmium, Copper, Lead, Mercury
43) WA-13-1010	Deschutes River	Cadmium, Copper, Mercury
44) WA-15-5000	Clear Creek	Metals
45) WA-23-1023	Salzer Creek	Metals
46) WA-25-5010	**Longview Ditches**	**Cadmium, Lead, Zinc**
47) WA-28-1023	Cougar Creek	Metals
48) WA-28-1040	Burnt Bridge Creek	Chromium, Lead, Mercury
49) WA-34-1010	Palouse River	Copper, Lead, Mercury
50) WA-37-1030	Sulphur Creek Wasteway	Metals
51) WA-39-1037	Crystal Creek	Metals
52) WA-47-1014	**Mitchell Creek**	**Arsenic**
53) WA-47-1020	**Railroad Creek**	**Arsenic**
54) WA-47-1030	**Stehekin River**	**Arsenic**
55) WA-54-1020	Spokane River	Cadmium, Copper, Lead, Mercury, Zinc
56) WA-55-1010	Little Spokane River	Cyanide, Mercury
57) WA-57-1010	**Spokane River**	**Cadmium, Copper, Lead, Mercury, Zinc**
58) WA-CR-1010	Columbia River	Copper, Lead, Zinc, Cadmium, Copper, Chromium, Mercury
59) WA-CR-1020	Columbia River	Copper, Lead, Zinc, Cadmium, Copper, Mercury
60) WA-CR-1030	Columbia River	Lead, Mercury, Copper
61) WA-CR-1060	FDR Lake	Cadmium, Copper, Lead, Mercury, Zinc

APPENDIX B

Corresponding Washington State Acute and Chronic Metals Criteria for the May and September Sampling Dates

Appendix B. Corresponding Washington State acute and chronic metals criteria for the May and September sampling dates.

Waterbody Number	Chromium(tri) Acute	Chromium(tri) Chronic	Copper Acute	Copper Chronic	Lead Acute	Lead Chronic	Zinc Acute	Zinc Chronic	Cadmium Acute	Cadmium Chronic	Nickel Acute	Nickel Chronic
WA-01-1010	757.25	90.26	5.88	4.29	15.44	0.60	44.18	40.02	1.08	0.44	571.68	63.55
	935.68	111.53	7.50	5.35	21.45	0.84	54.99	49.81	1.45	0.54	711.33	79.08
WA-01-1101	2367.46	282.19	21.82	14.08	90.80	3.54	143.68	130.14	5.20	1.32	1855.74	206.30
	2380.73	283.77	21.97	14.17	91.60	3.57	144.51	130.89	5.24	1.33	1866.49	207.50
WA-07-1020	363.18	43.29	2.53	1.99	4.93	0.19	20.66	18.71	0.39	0.22	267.62	29.75
	422.45	50.35	3.01	2.33	6.23	0.24	24.16	21.88	0.48	0.25	312.85	34.78
WA-07-1050	340.92	40.64	2.35	1.86	4.47	0.17	19.35	17.53	0.36	0.21	250.69	27.87
	422.45	50.35	3.01	2.33	6.23	0.24	24.16	21.88	0.48	0.25	312.85	34.78
WA-08-1010	1667.94	198.81	14.59	9.77	52.69	2.05	100.01	90.58	3.21	0.94	1292.41	143.68
	1590.05	189.53	13.81	9.30	48.91	1.91	95.18	86.21	3.00	0.90	1230.12	136.75
WA-08-1012	1793.20	213.74	15.85	10.54	58.96	2.30	107.79	97.63	3.55	1.01	1392.79	154.84
	1821.39	217.10	16.14	10.71	60.41	2.35	109.54	99.22	3.62	1.03	1415.41	157.35
WA-08-1014	1835.45	218.78	16.28	10.80	61.14	2.38	110.42	100.01	3.66	1.03	1426.70	158.61
	1807.31	215.42	16.00	10.63	59.68	2.33	108.67	98.42	3.58	1.02	1404.11	156.09
WA-08-1016	2043.65	243.59	18.43	12.08	72.25	2.82	123.40	111.77	4.25	1.15	1594.17	177.22
	2098.37	250.11	19.00	12.42	75.28	2.93	126.82	114.87	4.40	1.18	1638.28	182.13
WA-08-1018	1544.95	184.15	13.36	9.02	46.77	1.82	92.39	83.68	2.89	0.88	1194.09	132.75
	1473.07	175.58	12.64	8.58	43.43	1.69	87.95	79.66	2.70	0.84	1136.75	126.37
WA-08-1020	1905.41	227.11	17.00	11.23	64.79	2.52	114.77	103.96	3.86	1.07	1482.90	164.85
	1821.39	217.10	16.14	10.71	60.41	2.35	109.54	99.22	3.62	1.03	1415.41	157.35
WA-08-1030	1434.61	171.00	12.27	8.35	41.68	1.62	85.57	77.51	2.61	0.82	1106.10	122.96
	1835.45	218.78	16.28	10.80	61.14	2.38	110.42	100.01	3.66	1.03	1426.70	158.61

Appendix B. Continued.

Waterbody Number	Chromium(tri)		Copper		Lead		Zinc		Cadmium		Nickel	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
WA-08-1040	1877.49	223.79	16.71	11.06	63.33	2.47	113.04	102.38	3.78	1.06	1460.47	162.36
	1821.39	217.10	16.14	10.71	60.41	2.35	109.54	99.22	3.62	1.03	1415.41	157.35
WA-08-1060	1552.25	185.02	13.43	9.07	47.12	1.84	92.84	84.09	2.91	0.88	1199.92	133.39
	1531.81	182.58	13.23	8.94	46.15	1.80	91.58	82.95	2.85	0.87	1183.60	131.58
WA-08-1065	1397.42	166.56	11.90	8.13	40.02	1.56	83.28	75.43	2.52	0.80	1076.49	119.67
	1412.32	168.34	12.05	8.22	40.68	1.59	84.20	76.26	2.55	0.80	1088.35	120.99
WA-08-1070	1135.03	135.29	9.37	6.54	28.96	1.13	67.16	60.83	1.89	0.65	868.39	96.54
	1363.00	162.46	11.56	7.92	38.49	1.50	81.16	73.51	2.43	0.78	1049 12	116.63
WA-08-1085	1144.40	136.41	9.46	6.60	29.34	1.14	67.73	61.35	1.91	0.66	875.79	97.36
	1192.52	142.14	9.92	6.89	31.28	1.22	70.68	64.02	2.02	0.68	913.86	101.59
WA-08-1110	934.05	111.33	7.49	5.34	21.39	0.83	54.89	49.72	1.44	0.54	710.05	78.94
	1139.72	135.85	9.41	6.57	29.15	1.14	67.44	61.09	1.90	0.66	872.09	96.95
WA-08-1115	2029.92	241.96	18.29	12.00	71.49	2.79	122.54	110.99	4.21	1.14	1583.11	175.99
	2797.47	333.44	26.44	16.76	117.70	4.59	170.76	154.66	6.54	1.55	2204.89	245.12
WA-08-1120	2924.83	348.62	27.83	17.56	126.13	4.92	178.81	161.96	6.96	1.62	2308.66	256.65
	3336.88	397.74	32.39	20.15	154.81	6.03	204.93	185.62	8.34	1.84	2645.38	294.09
WA-08-1130	1313.29	156.54	11.08	7.62	36.33	1.42	78.10	70.74	2.31	0.75	1009.62	112.24
	1464.21	174.53	12.56	8.53	43.03	1.68	87.40	79.16	2.68	0.83	1129.69	125.59
WA-08-1143	665.43	79.32	5.07	3.75	12.63	0.49	38.65	35.01	0.91	0.39	500.23	55.61
	784.48	93.51	6.12	4.45	16.31	0.64	45.83	41.51	1.14	0.46	592.93	65.92
WA-08-1145	654.86	78.06	4.98	3.68	12.32	0.48	38.02	34.43	0.89	0.39	492.02	54.70
	741.84	88.42	5.74	4.20	14.95	0.58	43.25	39.18	1.05	0.43	559.67	62.22

Appendix B. Continued

Waterbody	Chromium(tri)		Copper		Lead		Zinc		Cadmium		Nickel	
Number	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
WA-08-2100	1732.25	206.47	15.24	10.17	55.88	2.18	104.00	94.20	3.38	0.98	1343.91	149.40
	1647.83	196.41	14.38	9.65	51.70	2.01	98.76	89.45	3.16	0.93	1276.31	141.89
WA-09-1022	1947.11	232.08	17.43	11.49	67.01	2.61	117.37	106.31	3.97	1.09	1516.44	168.58
	1559.53	185.89	13.50	9.11	47.46	1.85	93.29	84.50	2.93	0.89	1205.74	134.04
WA-09-1026	1024.44	122.11	8.33	5.88	24.70	0.96	60.40	54.71	1.64	0.59	781.14	86.84
	1078.47	128.55	8.83	6.20	26.75	1.04	63.70	57.69	1.76	0.62	823.73	91.57
WA-09-1028	1131.90	134.92	9.34	6.52	28.84	1.12	66.97	60.65	1.88	0.65	865.92	96.26
	1197.15	142.69	9.96	6.91	31.46	1.23	70.96	64.27	2.03	0.69	917.53	102.00
WA-09-1030	432.14	51.51	3.08	2.39	6.46	0.25	24.73	22.40	0.50	0.26	320.26	35.60
	517.40	61.67	3.79	2.88	8.54	0.33	29.79	26.99	0.64	0.31	385.73	42.88
WA-10-1011	1960.96	233.74	17.57	11.57	67.76	2.64	118.24	107.09	4.01	1.10	1527.59	169.82
	2247.25	267.86	20.56	13.34	83.74	3.26	136.14	123.31	4.84	1.26	1758.49	195.49
WA-10-1012	2220.35	264.65	20.27	13.17	82.19	3.20	134.45	121.78	4.76	1.24	1736.75	193.07
	1726.55	205.80	15.18	10.13	55.59	2.17	103.65	93.88	3.37	0.98	1339.35	148.89
WA-10-1015	1555.16	185.37	13.46	9.08	47.25	1.84	93.02	84.25	2.91	0.88	1202.24	133.65
	1610.33	191.94	14.01	9.42	49.88	1.94	96.44	87.35	3.06	0.91	1246.32	138.55
WA-10-1021	1444.99	172.23	12.37	8.41	42.15	1.64	86.21	78.09	2.63	0.82	1114.37	123.88
	1471.59	175.41	12.63	8.58	43.37	1.69	87.86	79.57	2.70	0.84	1135.57	126.24
WA-10-1022	1270.77	151.47	10.67	7.36	34.52	1.35	75.48	68.37	2.21	0.73	975.87	108.49
	1335.93	159.24	11.30	7.75	37.31	1.45	79.49	72.00	2.36	0.76	1027.61	114.24
WA-10-1025	1467.17	174.88	12.59	8.55	43.16	1.68	87.58	79.33	2.69	0.83	1132.04	125.85
	1501.03	178.91	12.92	8.75	44.72	1.74	89.67	81.22	2.78	0.85	1159.04	128.85
WA-10-1026	1163.08	138.63	9.63	6.71	30.08	1.17	68.87	62.38	1.95	0.67	890.57	99.00
	1275.34	152.01	10.71	7.39	34.72	1.35	75.76	68.62	2.22	0.73	979.50	108.89

Appendix B. Continued

Waterbody	Chromium(tri)		Copper		Lead		Zinc		Cadmium		Nickel	
Number	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
WA-10-1027	1550.79	184.85	13.41	9.06	47.05	1.83	92.75	84.01	2.90	0.88	1198.75	133.26
	1624.77	193.66	14.15	9.51	50.58	1.97	97.33	88.16	3.10	0.92	1257.87	139.84
WA-11-1010	559.77	66.72	4.15	3.13	9.65	0.38	32.32	29.27	0.71	0.33	418.41	46.51
	588.83	70.19	4.40	3.30	10.44	0.41	34.06	30.85	0.76	0.35	440.86	49.01
WA-13-1010	845.01	100.72	6.67	4.81	18.31	0.71	49.49	44.83	1.26	0.49	640.24	71.18
	990.76	118.09	8.01	5.68	23.45	0.91	58.35	52.85	1.57	0.57	754.62	83.89
WA-15-5000	1370.50	163.36	11.64	7.96	38.82	1.51	81.62	73.93	2.45	0.78	1055.08	117.29
	1335.93	159.24	11.30	7.75	37.31	1.45	79.49	72.00	2.36	0.76	1027.61	114.24
WA-23-1023	1018.05	121.35	8.27	5.84	24.46	0.95	60.01	54.35	1.63	0.59	776.10	86.28
	1084.79	129.30	8.89	6.24	27.00	1.05	64.08	58.04	1.77	0.62	828.71	92.13
WA-28-1023	1750.72	208.68	15.42	10.28	56.81	2.21	105.15	95.24	3.43	0.99	1358.72	151.05
	1732.25	206.47	15.24	10.17	55.88	2.18	104.00	94.20	3.38	0.98	1343.91	149.40
WA-28-1040	1525.96	181.89	13.17	8.91	45.88	1.79	91.22	82.62	2.84	0.87	1178.93	131.06
	1710.87	203.93	15.02	10.04	54.81	2.14	102.67	93.00	3.32	0.97	1326.78	147.50
WA-34-1010	1581.35	188.49	13.72	9.24	48.50	1.89	94.64	85.72	2.98	0.90	1223.16	135.98
	2314.21	275.84	21.26	13.75	87.65	3.42	140.34	127.11	5.04	1.29	1812.63	201.51
WA-37-1030	2393.99	285.35	22.11	14.25	92.39	3.60	145.35	131.65	5.28	1.33	1877.22	208.69
	2314.21	275.84	21.26	13.75	87.65	3.42	140.34	127.11	5.04	1.29	1812.63	201.51
WA-39-1037	1430.16	170.47	12.22	8.32	41.48	1.62	85.30	77.26	2.60	0.81	1102.56	122.57
	845.01	100.72	6.67	4.81	18.31	0.71	49.49	44.83	1.26	0.49	640.24	71.18
WA-CR-1030	1331.41	158.70	11.26	7.73	37.12	1.45	79.21	71.75	2.35	0.76	1024.01	113.84
	1163.08	138.63	9.63	6.71	30.08	1.17	68.87	62.38	1.95	0.67	890.57	99.00

[box] = Corresponding criteria to values boxed in Table 8.

Appendix B Continued.

Washington State Acute and Chronic Metal Criteria

Arsenic (As)Acute=360 μg/L
Chronic=190 μg/L

Cadmium (Cd)Acute=$\leq$ (0.865)($e^{1.128[(\ln(\text{hardness})]-3.828)}$ μg/L
Chronic=$\leq$ (0.865)($e^{0.7852[(\ln(\text{hardness})]-3.490)}$ μg/L

Chromium Hex (Cr)Acute=16.0 μg/L
Chronic=11.0 μg/L

Chromium Tri (Cr) * Acute=$\leq$ ($e^{0.8190[(\ln(\text{hardness})]+3.688)}$ μg/l
Chronic=$\leq$ ($e^{0.8190[(\ln(\text{hardness})]+1.561)}$ μg/L

Copper (Cu)Acute=$\leq$ (0.862)($e^{0.9422[(\ln(\text{hardness})]-1.464)}$ μg/L
Chronic=$\leq$ (0.862)($e^{0.8545[(\ln(\text{hardness})]-1.465)}$ μg/L

Lead (Pb)Acute=$\leq$ (0.687)($e^{1.237[(\ln(\text{hardness})]-1.460)}$ μg/L
Chronic=$\leq$ (0.687)($e^{1.237[(\ln(\text{hardness})]-4.705)}$ μg/L

Mercury (Hg)Acute = 2.4 μg/L
Chronic= 0.012 μg/L

Nickel (Ni)Acute=$\leq$ (0.95)($e^{0.8460[(\ln(\text{hardness})]+3.3612)}$ μg/L
Chronic=$\leq$ (0.95)($e^{0.8460[(\ln(\text{hardness})]+1.1645)}$ μg/L

Zinc (Zn)Acute=$\leq$ (0.891)($e^{0.8473[(\ln(\text{hardness})]+0.8604)}$ μg/L
Chronic=$\leq$ (0.891)($e^{0.8473[(\ln(\text{hardness})]+0.7614)}$ μg/L

* Where method to measure trivalent chromium are unavailable, these criteria are to be represented by total recoverable chromium.