Monitoring Program to Verify 303(d) Metals Listings for Selected Rivers and Creeks

Quality Assurance Project Plan

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Washington State Department of Ecology
Environmental Assessment Program
Olympia, Washington

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Background and Problem Statement

In January 1998, the Washington Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), Northwest Environmental Advocates, and Northwest Environmental Defense Center agreed to a cleanup schedule directing how Washington state will improve the health of nearly 700 water segments on the 303(d) list. In light of this agreement, Ecology's Environmental Assessment Program (EAP) has been reviewing the 1998 303(d) list to determine how to best address the various listings.

During the course of this review, 13 metals listings for five rivers and one creek were identified as needing verification sampling before resources were committed to TMDLs (Table 1). These listings are based on old or questionable data, as described in more detail in Appendix A. The historical data for these waterbodies shows violations of Washington State acute or chronic water quality standards (173-201A-040 WAC). The listings are based on monitoring by Ecology, the U.S. Geological Survey (USGS), or Seattle-METRO.

Project Description

The goal of the monitoring program proposed here will be to verify the validity of the metals listings in Table 1. The approach will be the same as in a previous 303(d) metals verification study conducted by EAP for the upper Yakima River (Johnson, 2000). Following Ecology (2001) guidance, the decision to recommend retaining a waterbody or waterbody parameter on the 303(d) list will be based on finding at least one exceedance of state standards.

Study objectives will be as follows:

- Obtain accurate and representative data on the concentrations of the metals of interest in each waterbody
- Analyze the data for exceedances of state standards.
- Provide recommendations to the Ecology Water Quality Program, affected regional offices, and other interested parties for retaining or removing each of these waterbodies/parameters from the 303(d) list.

EAP will conduct routine water quality monitoring over a one-year period for each of the waterbodies identified in Table 1. Samples will be collected every other month, beginning in July 2001. Clean sampling techniques and low-level analytical methods will be used. Metals will be analyzed as dissolved (Ag, Cr, Cu) or total (Hg) in keeping with state standards. Other parameters to be measured will include conductivity, hardness, total suspended solids, and flow. A draft report on the results of the monitoring program and attendant 303(d) recommendations is planned for October 2002.

Table 1. 1998 303(d) Metals Listings Where Verification Sampling is Proposed

Segment Waterbody Parameter	Data Source Basis for Listing	Reason for Verification Sampling
WA-07-1050 Snohomish River Cu,Hg	USGS ambient data (dates uncertain) 4 excursions near Monroe (station07A111)	Inconsistent with EAP data for nearby locations.
WA-09-1015 Mill Creek Hg	Ecology ambient 1987-90 data Numerous excursions at station 09E090 (r.m. 1.5)	Cleanup of major source (Western Processing) has occurred.
WA-09-1015 Mill Creek Hg	METRO 1989-90 data 2 excursions at station 0317 (r.m. 1.0)	Cleanup of major source (Western Processing) has occurred.
WA-09-1015 Mill Creek Hg	Ecology ambient 1984-90 data Numerous excursions at station 09E070 (r.m. 0.1)	Cleanup of major source (Western Processing) has occurred.
WA-34-1010 Palouse River Cr	Ecology ambient 1987-91data 5 excursions at Hooper (station 34A070)	Ecology Cr data prior to 1994 are suspect.
WA-37-1040 Yakima River Hg,Ag	USGS Fuhrer (1996) 2 excursions (1987-90) above Ahtanum Cr. (station #32)	EAP sampling has shown USGS metals data from this time period may be unreliable.
WA-37-1010 Yakima River Hg,Ag	USGS Fuhrer (1996) 2 excursions (1987-90) above Satus Cr. (station #52)	EAP sampling has shown USGS metals data from this time period may be unreliable.
WA-37-1010 Yakima River Hg	USGS Fuhrer (1996) 3 excursions (1987-90) at Kiona (station #50)	EAP sampling has shown USGS metals data from this time period may be unreliable.
WA-38-1010 Naches River Ag	USGS Fuhrer (1996) 2 excursions (1987-90) near north Yakima (station #26)	EAP sampling has shown USGS metals data from this time period may be unreliable.
WA-54-1020 Spokane River Cr	Ecology ambient 1989-91 data 2 excursions at station 54A120 (r.m. 66)	Ecology Cr data prior to 1994 are suspect .

Organization and Schedule

EAP Project Lead – Art Johnson (360)407-6766
EAP Field Sampling – Steve Golding (360)407-6701
EAP Contaminant Studies Unit Supervisor – Dale Norton (360/407-6765)
Manchester Environmental Laboratory Director – Stuart Magoon (360/871-8813)
Manchester Inorganics Unit Supervisor – Jim Ross (360/871-8808)
Ecology Quality Assurance Officer – Cliff Kirchmer (360/407-6455)

July 2001……First sample set collected and delivered to laboratory
May 2002……Last sample set collected and delivered to laboratory
July 2002……Laboratory analyses completed
October 2002……..Draft project report completed
November 2002……..Data entry to EIM database
December 2002…….. Final project report completed

Data Quality Objectives

Table 2 shows the applicable state surface water quality standards for the metals being monitored in this project. The standards for hardness dependent metals (Ag, Cr, and Cu) were calculated for the lowest hardness value recorded in the historical data for the proposed sampling sites.

Table 2. Washington State Surface Water Quality Standards (WAC 173-201A)

Metal	Hardness* (mg/L)	Acute Standard (ug/L)	Chronic Standard (ug/L)
Dissolved Ag	20	0.22	no standard
Dissolved Cr	25	176	57
Dissolved Cu	10	1.9	1.6
Total Hg	25	no standard	0.012
Dissolved Hg	25	2.1	no standard

*lowest hardness anticipated for this metal; Hg standards are not hardness dependent

Table 3 lists project targets for accuracy, precision, bias, and required reporting limits. Sources of bias from sampling collection, transportation, and storage will be minimized by adherence to EPA Method 1669. The reporting limits are based on past performance by Manchester, using the methods selected for this project. To minimize the effect of measurement imprecision when

comparing the data to the standards, reporting limits should be 10x lower than the standard. The lowest reporting limit available through Manchester is 1/6th the chronic standard.

Table 3. Data Quality Objectives

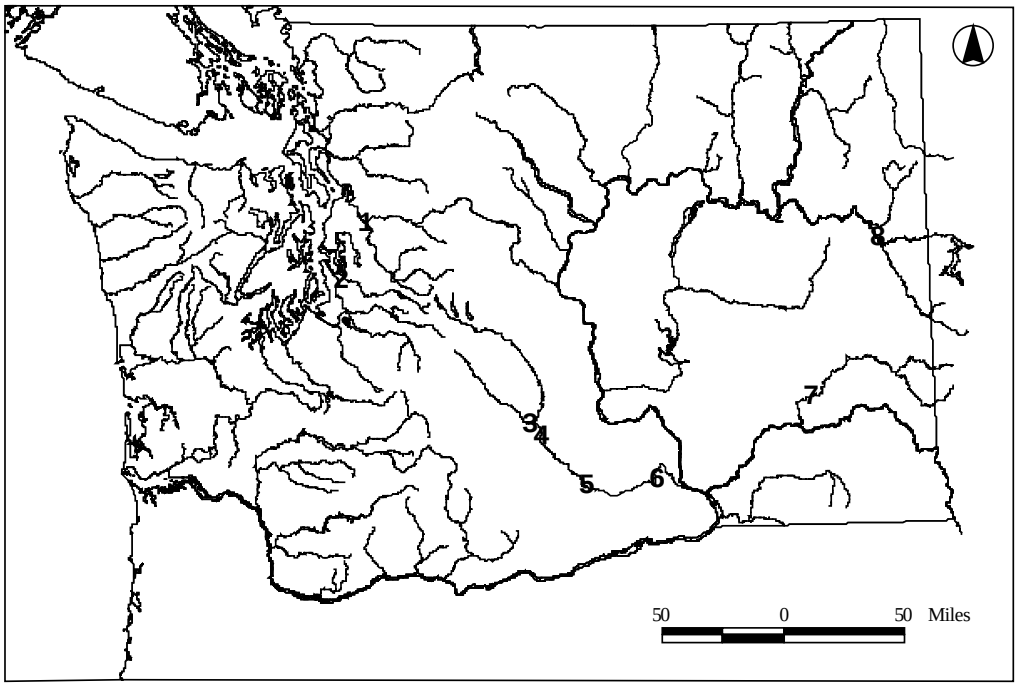
Parameter	Accuracy (% deviation from true value)	Precision (RSD)	Bias (% of true value)	Required Reporting Limit
Ag	30%	10%	10%	0.02 ug/L
Cr	30%	10%	10%	0.2 ug/L
Cu	30%	10%	10%	0.05 ug/L
Hg	30%	10%	10%	0.002 ug/L
Hardness	15%	5%	5%	1 mg/L
TSS	15%	5%	5%	1 mg/L
Conductivity	15%	5%	5%	1 umhos/cm

Sampling Design

Nine monitoring sites are proposed as shown in Figure 1. Each site for which there is a 303(d) listing will be sampled, except for Mill Creek. Because of the proximity of the three historical Mill Creek stations, only the upper and lower sites will be monitored.

The metals analyzed for each waterbody will be limited to those for which it is 303(d) listed. In order to obtain a more comprehensive set of data for Ag and Hg in the Yakima drainage, these two metals will be analyzed for all the Yakima and Naches River sampling sites.

Sampling will be conducted at each of the above sites on six occasions over a one-year period to cover a range of flow and runoff conditions. Sample size was selected to balance representativeness against cost. Although the historical data on which some of the listings are based included larger numbers of samples (e.g., lower Yakima River), it has already been established that, except for Mill Creek, these data are unreliable (Table 1, Appendix A). Therefore a larger sampling effort is not warranted. In order to evaluate a waterbody for possible 303(d) listing, Ecology requires a minimum sample size of three for toxic pollutants in the water column (Ecology, 2001).



1. Snohomish River near Monroe (USGS station 07A111)
2. Mill Creek (river miles 1.5 and 0.1)
3. Naches River near Yakima (USGS station 26)
4. Yakima River above Ahtanum Creek (USGS station 32)
5. Yakima River above Satus Creek (USGS station 52)
6. Yakima River at Kiona (USGS station 50)
7. Palouse River @ Hooper (Ecology station 34A070)
8. Spokane River @ Riverside St. Park (Ecology station 54A120)

Figure 1. Proposed Sampling Sites for Verifying Selected 303(d) Metals Listings

All samples will be collected as simple grabs. Clean sampling techniques will be used, following the guidance in EPA (1995) *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Levels*. Dissolved Ag, Cr, and Cu will be determined on samples filtered in the field. Mercury will be analyzed as total. Ancillary parameters will include temperature, conductivity, hardness, and total suspended solids. Flow data will be obtained from the EAP Stream Hydrology Unit, USGS, or gauged in the field.

Table 4 shows the number of samples to be analyzed and an estimate of the laboratory cost.

Table 4. Cost Estimate for Metals Verification Samples

Sample Type	Analysis	No. of Determinations	Sampling Events	Total Determinations	Cost per Sample	Cost Subtotals
Field Samples	Dissolved Ag	4	6	24	34	816
"	Dissolved Cr	2	6	12	34	408
"	Dissolved Cu	1	6	6	34	204
"	Total Hg	7	6	42	48	2016
"	Hardness	9	6	54	12	648
"	TSS	9	6	54	10	540
"	Conductivity	9	6	54	7	378
Field Replicates*	Dissolved Ag	2	1	2	34	68
"	Dissolved Cr	2	1	2	34	68
"	Dissolved Cu	1	1	1	34	34
"	Total Hg	3	1	3	48	144
"	Hardness	6	1	6	12	72
Lab Duplicates*	Dissolved Ag	2	1	2	34	68
"	Dissolved Cr	2	1	2	34	68
"	Dissolved Cu	1	1	1	34	34
"	Total Hg	3	1	3	48	144
Filter Blanks	Ag,Cr,Cu	1	3	3	238	714
Bottle Blanks	Ag,Cr,Cu	1	3	3	238	714
Bottle Blanks	Hg	1	3	3	48	144
					+0.45 micron filters @ $21 ea =	885
					+500 mL teflon bottles @ $14 ea =	1179
					+acid preservative @ $7 ea =	591
					TOTAL LAB COST =	$ 9,937

*one replicate and one duplicate for each metal for each waterbody;
a hardness sample to be collected with each replicate

Field Procedures

Table 5 lists the sample size, container, preservation, and holding time for each parameter. Sample containers will be obtained from Manchester Laboratory. Metals sampling methods will follow EPA Method 1669. Field activities will be recorded in ink in a bound notebook of waterproof paper. Chain of custody will be maintained.

Table 5. Field Procedures

Parameter	Sample Size	Container	Preservation	Holding Time
Ag	500 mL	500 mL Teflon bottle	HNO_3 to pH<2, 4^oC	6 months
Cr	500 mL	500 mL Teflon bottle	HNO_3 to pH<2, 4^oC	6 months
Cu	500 mL	500 mL Teflon bottle	HNO_3 to pH<2, 4^oC	6 months
Hg	500 mL	500 mL Teflon bottle	HNO_3 to pH<2, 4^oC	28 days
Hardness	100 mL	125 mL poly bottle	HNO_3 to pH<2, 4^oC	6 months
TSS	1000 mL	1000 mL poly bottle	Cool to 4^oC	7 days
Conductivity	300 mL	500 mL polyl bottle	Cool to 4^oC	28 days

The samples will be taken away from the bank by wading into center channel or from the bank with the bottle attached to the end of a 12-foot polyethylene pole. Metals samples will be collected directly into pre-cleaned 500 mL Teflon bottles. Samples for dissolved metals will be filtered in the field through a pre-cleaned 0.45 um Nalgene filter unit (#450-0045, type S). The filtrate will be transferred to a new pre-cleaned 500 mL Teflon bottle. The whole water and filtered water samples will be preserved to pH <2 with sub-boiled 1:1 nitric acid, carried in small Teflon vials, one per sample. Teflon sample bottles, Nalgene filters, and Teflon acid vials will be cleaned by Manchester, as described in Kammin et al. (1995), and sealed in plastic bags. Non-talc nitrile gloves will be worn by personnel filtering the samples. Filtering will be done in a glove box constructed of a PVC frame and polyethylene cover.

Mill Creek flows will be measured with a Swoeffer or Marsh-McBirney meter and top-setting rod. Temperature will be determined with a precision thermometer.

The samples will be placed in polyethylene bags and held on ice for transport to Ecology HQ. The samples will be kept in a secure cooler and transported to Manchester Laboratory within one to two days of collection.

Laboratory Procedures

Table 6 shows the schedule for sample arrival, expected range of results, and the laboratory procedures to be used. All sample will be analyzed at Manchester Laboratory.

The laboratory will save excess sample for 60 days from the time the data is sent to the project lead to give time for its review.

Table 6. Laboratory Procedures

Analyte	Sample Matrix	Number of Samples*	Expected Range of Results	Sample Prep Method	Analytical Method
Ag	filtered water	4	<0.02 - 1 ug/L	analyze directly	EPA 200.8
Cr	filtered water	2	<0.05 - 5 ug/L	analyze directly	EPA 200.8
Cu	filtered water	1	<0.05 - 5 ug/L	analyze directly	EPA 200.8
Hg	whole water	7	<0.002 - 0.2 ug/L	EPA 245.7**	EPA 245.7**
Hardness	whole water	9	1 - 200 mg/L	N/A	SM2340B
TSS	whole water	9	1 - 200 mg/L	N/A	EPA 160.2
Conductivity	whole water	9	1 - 500 umhos/cm	N/A	EPA 120.1

*to arrive every other month for one year, beginning July 2001
**a CVAF method modified by Manchester to use CVAA

Quality Control

Table 7 shows the field and laboratory quality control (QC) samples to be analyzed for this project.

Field QC

Field QC samples for metals will include filter blanks, bottle blanks, and replicates at the frequency indicated in Table 7.

Field blanks will be analyzed to detect contamination arising from sample containers, the filtration procedure, preservative, or sample handling. The filter and bottle blanks will be prepared using the deionized water filled Teflon sample bottles provided by Manchester. To prepare the blanks, a bottle will be opened in the field, half of its contents poured into the Nalgene filter unit, and the remainder acidified, forming the bottle blank. The filtrate will be

transferred to a new bottle, after rinsing with a small amount of filtrate, and acidified, forming the filter blank.

Field replicates (samples collected separately, approximately 15 minutes apart) will provide an estimate of the total variability from sampling and analysis. One replicate sample will be collected for each metal being analyzed for each waterbody. A corresponding replicate hardness sample will be collected with each metals replicate.

Table 7. Quality Control Procedures

1. FIELD

Parameter	Filter blanks	Bottle Blanks	Replicates
Ag	3	3	2
Cr	3	3	2
Cu	3	3	1
Hg	NA	3	3
Hardness	NA	NA	6
TSS	NA	NA	NA
Conductivity	NA	NA	NA

2. LABORATORY

Parameter	Check Standards	Method Blanks	Analytical Duplicates	Lab Control Sample	Stand. Ref. Material	Matrix Spike & Duplicate
Ag	10%	2/batch	2*	1/batch**	1/batch***	1/batch
Cr	10%	2/batch	2*	1/batch**	1/batch***	1/batch
Cu	10%	2/batch	1*	1/batch**	1/batch***	1/batch
Hg	10%	2/batch	3*	1/batch**	1/batch***	1/batch
Hardness	1/batch	1/batch	1/batch	1/batch	NA	NA
TSS	1/batch	NA	1/batch	1/batch	NA	NA
Conductivity	1/batch	NA	1/batch	1/batch	NA	NA

*total number of samples for project
**High Purity Standards TMDW or equivalent
***SLRS-3 or equivalent

Laboratory QC

Laboratory QC samples for metals will include check standards, method blanks, analytical duplicates, laboratory control samples (LCS), standard reference material (SRM), and matrix spikes & matrix spike duplicates. Laboratory QC samples for other parameters will follow routine Manchester practice.

The metals QC samples will be analyzed at the frequency indicated in Table 7. Note that the method blank is to be done in duplicate. Manchester is encouraged to do the analyses within each batch in random order to eliminate the effects of any systematic changes in factors that cannot be controlled (see Appendix B).

The SRM will be SLRS-4 (Riverine Water Reference Material for Trace Metals, National Research Council Canada) or equivalent. SLRS-4 certified values for Cu and Cr are 1.81+/-0.08 ug/L and 0.33+/-0.02 ug/L, respectively. At present, there is no SRM for low-level Ag or Hg in water. Manchester will analyze High Purity Standards TMDW or equivalent as a LCS for Ag, Cr, and Cu. Certified values are 20 ug/L for Cr and Cu, and 2 ug/L for Ag. The LCS Manchester uses for Hg is a 0.025 ug/L dilution of a second source stock standard.

The appropriate levels to use for matrix spikes will be determined through a preliminary analysis of field samples provided by the project lead. The spiking level should be close to the sample concentration. If the sample levels are so low that they cannot be used to set the spiking level, then the spiking level should be at least 10x greater than the MDL reported by the laboratory. Sufficient sample will be provided so that the same matrix can be spiked throughout the course of the study.

Duplicates (laboratory splits) will provide estimates of analytical variability. The duplicate analysis will be done on one of the field replicate pairs, to allow an assessment of analytical vs. total variability.

Manchester's data reports to the project lead will include the metals concentrations measured in spiked samples and in the unspiked samples, in addition to percent recovery. Manchester will report the results from analyzing check standards. Manchester will report the metals concentrations measured in the LCS and the SRM, the name and sources of the materials used, and the certified values, in addition to percent recovery. Manchester will report both the censored and uncensored results for all method blanks.

Data Review, Verification, and Validation

The project lead will review Manchester's data and case narratives for errors or omissions and to ensure that the narratives accurately describe compliance of QC results with acceptance criteria. Data validation will be done by the project lead using professional judgement as to whether Manchester followed the procedures in the QAPP.

Once the data have been verified and validated, a determination will be made if DQOs have been met, following Manchester Laboratory SOP #1 (Appendix B) and using an Excel spreadsheet provided by Cliff Kirchmer, Ecology's QA Officer.

Data Quality Assessment

Once it has been determined that the data are satisfactory, the metals data will be screened for standards exceedances by comparing the concentrations to the chronic standard at the lowest hardness value recorded for each sampling site. The standards will be calculated with the most recent revision of Ecology's TSDCALC9.XLW spreadsheet. If exceedances are found, a more detailed comparison to the standards will be made.
The conclusion that standards are exceeded will take QC estimates of precision and bias into account. Following Ecology (2001) guidance, finding a single significant exceedance will result in a recommendation that the waterbody or waterbody parameter be retained on the 303(d) list.

References

Ecology. 2001 (draft). Water Quality Program Policy 1-11: Assessment of Water Quality for the Section 303(d) List. Washington State Dept. Ecology, Olympia, WA.

EPA. 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Levels. EPA 821-R-95-034.

EPA. 1996. The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit from a Dissolved Criterion. EPA 823-B-96-007.

Johnson, A. 2000. Concentrations of 303(d) Listed Metals in the Upper Yakima River. Washington State Dept. Ecology, Olympia, WA. Pub. No. 00-03-024.

Kammin, W.R., S. Cull, R. Knox, J. Ross, M. McIntosh, and D. Thompson. 1995. Labware Cleaning Protocols for the Determination of Low-level Metals by ICP-MS. American Environmental Laboratory 7(9).

Appendix A

June 4, 2001

TO: Alison Beckett, Water Quality Program

FROM: Art Johnson, Environmental Assessment Program

SUBJECT: **Recommendations to De-list or Verify Certain 303(d) Waterbodies for Metals Excursions in Water**

In light of our agreement with EPA, Northwest Environmental Advocates, and Northwest Environmental Defense Center on a cleanup schedule for 303(d) listed waterbodies, EAP has been reviewing the 1998 list to determine the best approach for addressing these pollution problems.

During the course of this review, 45 metals listings for 11 rivers and streams were identified where newer water quality data justify their removal from the 303(d) list or where further sampling should be conducted to verify old or questionable data on which the listing is based (Table 1). The reasoning behind these recommendations is described in more detail below.

People considering these recommendations should be aware that metals data collected in the 1980s (and more recently in some instances) were often subject to contamination in the field or laboratory (see, for example, Windom, 1991). Newer data can be more accurate when clean sampling techniques and low-level analytical methods are used. EAP has made several efforts to verify 303(d) metals listings based on older data (Hopkins, 1995; Johnson and Hopkins, 1991; Johnson, 2000). In each of these, no evidence was found that state standards were being exceeded.

1. **WA-07-1160 / Skykomish River / Cu, Pb**, **Ag -** These listings are based on a single composite effluent sample from the Monroe WWTP where calculations indicated water quality standards could be exceeded at the edge of the dilution zone (Golding, 1996). In the opinion of NWRO, this sample is not representative of current effluent quality (Kevin Fitzpatrick, Ecology-NWRO, personal communication).

   Verification sampling is recommended for these listings. [Note to readers of QAPP: Following completion of this memo, it was decided that any additional sampling would be the responsibility of Monroe WWTP.]

2. **WA-07-1020, 1050 / Snohomish River / Cu, Hg -** These listings are for Ecology station 07A090 (Snohomish River @ Snohomish - Cu) and USGS station 07A111 (Snohomish River near Monroe – Cu, Hg). The Ecology data are from 1982 - 1984; the USGS data appear to be from the 1980s but exact dates are uncertain.

   EAP has more recent Cu data for the station at Snohomish (Table 2). In 12 samples collected over a three-year period between October 1995 and August 1997, dissolved Cu concentrations ranged from 0.43 - 0.94 ug/L. The chronic state standard for the minimum hardness measured at this station (11 mg/L) is 1.7 ug/L. Therefore, it appears there is sufficient data to justify removing the Cu listing for the Snohomish River @ Snohomish.

   No new data are available for the Snohomish River further upstream near Monroe. Sampling is recommended to verify the Cu and Hg listings for this station.

3. **WA-08-1095 / Bear-Evans / Creek Hg -** The mercury listing for METRO station 0484 on this creek appears to be due to a reporting error (Jonathan Frodge, King County, personal communication). Sediment samples were apparently included in the database without the matrix code (which identifies the sample matrix, i.e., water, sediment, tissue, etc.). I reviewed all of King County's Hg in water data for station 0484 from Jan 1, 1988, to the present (the last five years of data are in Table 3). No samples have had Hg detected.

   The Bear-Evans Creek Hg listing should be removed.

4. **WA-08-1130 / May Creek / Cu, Pb, Zn -** May Creek is listed for Cu, Pb, and Zn excursions at several sites sampled by METRO in 1994. However, the dissolved concentrations which exceeded the standards were calculated values, not measured directly (King County, 1994).

   King County has more recent measurements of dissolved metals concentrations in May Creek at a station just east of I-410 (Table 4). Eight samples collected between May 1998 and December 1999 had maximum Cu, Pb, and Zn concentrations of 3.9, <0.5, and 5.6 ug/L, respectively. At the lowest hardness measured at this station (37 mg/L), the state chronic criteria are 4.8 ug/L for Cu, 0.84 ug/L for Pb, and 45 ug/L for Zn.

   Because the listings were based on a theoretical calculation and recent direct measurements show no violations of standards, it is recommended that the May Creek Cu, Pb, and Zn listings be removed.

5. **WA-09-1020 / Green River / Cr** - Among the Green River listings is one excursion of the Cr standard at each of two Ecology ambient monitoring stations during 1987 – 1991. Ecology's ambient monitoring data for Cr prior to 1994 are suspect and have been removed from the EAP data base (Dave Hallock, EAP, personal communication).

   King County provided dissolved Cr data for two stations sampled on the Green River from May 1998 through December 1999 (Table 5). Fifteen samples have been analyzed and Cr has not been detected at or above 0.4 - 0.5 ug/L. The chronic water quality standard for the lowest hardness measured at these stations (17 ug/L) is 42 ug/L.

   The Green River Cr listing should be removed.

6. **WA-09-1015 / Mill Creek / Cd, Cr, Cu, Hg, Zn -** These listings are based on 1984 - 1990 METRO and Ecology data for four stations in the lower 1.5 mile of the creek. A major pollution source, the Western Processing superfund site, is located in this reach but has since been cleaned up. The cleanup site is between the river mile 1.5 and 1.0 sampling stations listed in Table 1.

   King County has recent metals data for river mile 1.0 downstream of Western Processing (station 0317 at S. 196th Street) (Table 6). In six sets of samples collected from May 1998 to December 1999, the maximum dissolved Cd, Cr, Cu, and Zn concentrations were <0.2, 0.57, 3.4, and 23 ug/L, respectively. At the lowest hardness value measured (25 mg/L), the chronic state standards are 0.37, 57, 3.5, and 32 ug/L, respectively. Hg was not detected at or above 0.2 ug/L; the state chronic standard is 0.012 ug/L total recoverable and the acute standard is 2.1 ug/L dissolved. All samples were within standards for Cd, Cr, Cu, and Zn. The reporting limit for Hg was not low enough to compare to the chronic standard.

   Landau Associates has done routine water quality monitoring in Mill Creek above and below the Western Processing site. The data collected since 1990 for Cd, Cr, Hg, Zn, hardness, and flow are in Table 7. The most significant improvements to water quality are thought to have occurred in the late 1980's when steps were taken to control surface water runoff from Western Processing (Bill Enkeboll, Landau Associates, personal communication). Landau station C1 is located immediately upstream of the Western Processing site; station C4 is 2500 feet downstream of the site.

   In the early 1990s, some of Laundau's results for dissolved Cd and dissolved Zn exceeded chronic water quality standards (e.g., Cd in 1993). However, in each of these instances the corresponding total Cd and Zn concentrations were much lower than in the dissolved sample suggesting contamination occurred in the filtration process. These data should be rejected. The remaining Landau data show no violations of the chronic standards for Cd, Cr, or Zn.

Upstream station C1: The maximum dissolved Cd concentration measured was 0.78 ug/L (1/15/90); at the corresponding hardness of 69 mg/L, the chronic standard is 0.78 ug/L. Dissolved Cr was below the reporting limit of 10 ug/L in all samples; at the lowest hardness value measured (34 mg/L), the chronic standard is 74 ug/L. Except for two samples collected in 1990, the maximum dissolved Zn concentration was 57 ug/L (12/2/96); at the corresponding hardness of 54 mg/L, the chronic standard is 62 ug/L.

Downstream station C4: The maximum dissolved Cd concentration measured was 0.65 ug/L (3/22/94); at the corresponding hardness of 59 mg/L, the chronic standard is 0.84 ug/L. Landau stopped analyzing dissolved Cd at station C4 in 1997. All but one of the total Cd results for 1997 – 2000 have been at or below the chronic standard for the dissolved fraction. Dissolved Cr was below the reporting limit of 10 ug/L in all samples; at the lowest hardness value measured (34 mg/L), the chronic standard is 74 ug/L. Except for two samples collected in 1990, the maximum dissolved Zn concentration was 54 ug/L (12/2/96); at the corresponding hardness of 44 mg/L, the chronic standard is 52 ug/L.

Landau's Hg data show the acute standard is being met. As with the King County data, Hg reporting limits were not low enough to compare to the chronic standard.

The King County and Landau Associates data show that Mill Creek is meeting standards for Cd, Cr, Cu, and Zn. Therefore, it is recommended that these listing be removed. There is a need for low-level Hg data on Mill Creek; verification sampling is recommended.

7. **WA-10-1087 / Wilkeson Creek / Cu** - This listing is based on a single composite effluent sample from Wilkeson WWTP where calculations indicated water quality standards could be exceeded at the edge of the dilution zone (Hoyle-Dodson, 1997). EAP recently conducted an intensive sampling program for Cu at Wilkeson WWTP that included the final effluent and Wilkeson Creek above and below the outfall (Golding and Johnson, 2001). In eight sets of samples collected between July and November 2000, no violations of the chronic state standard were found. Calculations showed there was no reasonable potential for the chronic standard to be exceeded under critical low flow conditions or for any of the sampling events.

   The Cu listing for Wilkeson Creek should be removed.

8. **WA-34-1010 / Palouse River / Cr** - The Palouse River @ Hooper (Ecology station 34A070) is listed for five Cr excursions between 1987 and 1991. As previously mentioned, Ecology's Cr data prior to 1994 are suspect.

   Verification sampling is recommended.

9. **WA-37-1010, 1040 / Lower Yakima River / Ag, Hg -** These listing are based on 1987 - 1990 USGS data showing two or three excursions for Ag and/or Hg in the main stem above Ahtanum Creek, above Satus Creek, and at Kiona (Fuhrer, 1996). Metals sampling by EAP in the upper Yakima River has shown that USGS metals data from this time period may be unreliable. Upper river 303(d) listings for Ag, Hg, and other metals do not appear to be justified (Johnson, 2000 - see WRIA 39 below).

   USGS has obtained more recent Ag data for their station above Ahtanum Creek (Table 8); Hg was not analyzed. Of 16 samples obtained between May 1999 and January 2000, all had less than 1 ug/L dissolved Ag. The acute state standards for the two lowest hardness values measured at this site (38 and 50 mg/L) are 0.65 and 1.0 ug/L (there is no state chronic standard for Ag). Although these USGS results and previous upstream sampling by EAP suggest the Ag listings for the lower river may not be warranted, a lower detection limit will be required to demonstrate it.

   Verification sampling is recommended for the lower Yakima Ag and Hg listings.

10. **WA-38-1010 / Naches River / Ag -** This listing for the Naches River near Yakima is also based on potentially unreliable USGS data reported in Fuhrer (1996).

    Verification sampling is recommended.

11. **WA-39-1010, 1030 / Upper Yakima River / Ag, Cd, Cu, Hg -** The listings are for the Yakima River @ Cle Elum and @ Umtanum. Again, these conclusions are based on USGS 1987 - 1990 data. Ecology collected eighteen sets of mainstem samples and eighteen sets of tributary samples in this reach during March 1999 - January 2000 and found no violations of water quality standards for any of the listed metals (Johnson, 2000). Limited recent sampling by USGS in 1999 also showed no violations of the Ag, Cd, or Cu standards at Cle Elum or at Umtanum; Hg was not analyzed (Johnson, 2000).

    The upper Yakima listings for Ag, Cd, Cu, and Hg should be removed.

12. **WA-54-1020 / Spokane River / Cr -** The Spokane River is listed for Cr, based on suspect 1989 - 91 Ecology data for a station at Riverside State Park (54A120).

    Verification sampling is recommended.

In summary, I recommend that the following 303(d) listings be removed, based on new data or an error in the listing:

WA-07-1020 Snohomish River @ Snohomish - Cu
WA-08-1095 Bear-Evans Creek - Hg
WA-08-1130 May Creek - Cu, Pb, Zn
WA-09-1020 Green River - Cr
WA-09-1015 Mill Creek - Cd, Cr, Cu, Zn
WA-10-1087 Wilkeson Creek - Cu
WA-39-1010, 1030 Upper Yakima River - Ag, Cd, Cu, Hg

Verification sampling is recommended for the following listings:

WA-07-1160 Skykomish River @ Monroe - Cu, Pb, Ag
WA-07-1050 Snohomish River near Monroe - Cu, Hg
WA-09-1015 Springbrook Mill Creek - Hg
WA-34-1010 Palouse River @ Hooper - Cr
WA-37-1010, 1040 Lower Yakima River - Ag, Hg
WA-38-1010 Naches River - Ag
WA-54-1020 Spokane River @ Riverside State Park – Cr

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Table 1. 1998 303(d) Listings for Metals in Water Where De-Listing or Verification Sampling is Proposed

WRIA	Waterbody	Parameter	Data Source	Basis for Listing	Recommendation		Reason for Recommendation
					De-list	Verify	
7	Skykomish River	Cu,Pb,Ag	Ecology (Golding, 1996)	Calculated excursion based on a Monroe WWTP effluent sample		x	Data may not be representative of effluent quality
7	Snohomish River	Cu	Ecology ambient 1982-84 data	Many excursions @ Snohomish (07A090)	x		Newer Ecology ambient data show standards being met
7	Snohomish River	Cu,Hg	USGS ambient data	4 excursions near Monroe (07A111)		x	Inconsistent with EAP data for nearby locations
8	Bear-Evans Creek	Hg	Seattle-Metro 1988/90 data	2 excursions at station 0484 (r.m. 1.0)	x		Listed in error; newer King Co. data shows no detections
8	May Creek	Cu	METRO 1994 data	1 excursion at SR-900 crossing	x		Newer King Co. data show no excursions
8	May Creek	Cu	METRO 1994 data	1 excursion upstream of Honey Creek	x		"
8	May Creek	Cu	METRO 1994 data	1 excursion at mouth of Lk. Washington	x		"
8	May Creek	Pb, Zn	METRO 1994 data	2-3 excursions at mouth	x		"
8	May Creek	Pb,Zn	METRO 1994 data	2-3 excursions upstream of Honey Creek	x		"
8	May Creek	Pb	METRO 1994 data	2 excursions at SR-900 culvert crossing	x		"
8	May Creek	Pb	METRO 1994 data	2 excursions at 164 NE	x		"
8	May Creek	Pb	METRO 1994 data	2 excursions at upstream canyon end	x		"
9	Green River	Cr	Ecology 1987 ambient data	1 excursion near Kent (09A090)	x		Newer King Co. data show no excursions
9	Green River	Cr	Ecology 1991 ambient data	1 excursion at Tukwila (09A080)	x		"
9	Mill Creek	Cr,Hg	Ecology ambient 1987-90 data	2 Cr excursions/ numerous Hg excursions at station 09E090 (r.m. 1.5)	x	x(Hg)	Cleanup of major source (Western Processing) has occurred
9	Mill Creek	Hg	METRO 1989-90 data	2 excursions at station 0317 (r.m. 1.0)	x	x(Hg)	"
9	Mill Creek	Cd,Cu,Zn	Ecology (Yake, 1985)	2 excursions near 196th St. (r.m. 1.1)	x	x(Hg)	"
9	Mill Creek	Cd,Cr,Hg,Zn	Ecology ambient 1984-90 data	2-4 excursions/numerous Hg excursions at station 09E070 (r.m. 0.1)	x	x(Hg)	"
10	Wilkeson Creek	Cu	Ecology (Hoyle-Dodson, 1997)	Calculated excursion based on a Wilkeson WWTP effluent sample	x		Newer Ecology data show standards being met
34	Palouse River	Cr	Ecology ambient 1987-91data	5 excursions at Hooper (34A070)		x	Ecology Cr data prior to 1994 are suspect
37	Yakima River	Hg,Ag	USGS Fuhrer (1996)	2 excursions (1987-90) above Ahtanum Cr. (station #32)		x	EAP sampling has shown USGS metals data from this time period may be unreliable.
37	Yakima River	Hg,Ag	USGS Fuhrer (1996)	2 excursions (1987-90) above Satus Cr. (station #52)		x	"
37	Yakima River	Hg	USGS Fuhrer (1996)	3 excursions (1987-90) at Kiona (station #50)		x	"
38	Naches River	Ag	USGS Fuhrer (1996)	2 excursions (1987-90) near north Yakima (station #26)		x	"
39	Yakima River	Cd,Cu,Hg	USGS Fuhrer (1996)	2-6 excursions (1987-90) at Cle Elum (station #6)	x		Newer Ecology data show standards being met
39	Yakima River	Ag,Cd,Cu,Hg	USGS Fuhrer (1996)	2-4 excursions (1987-90) at Umtanum (station #19)	x		"
54	Spokane River	Cr	Ecology ambient 1989-91 data	2 excursions at station 54A120 (r.m. 66)		x	Ecology Cr data prior to 1994 are suspect

Table 2. EAP Dissolved Metals Data for the Snohomish River @ Snohomish (station 07A090)

Date	**Cu** (ug/L)	Cd (ug/L)	Pb (ug/L)	Ni (ug/L)	Zn (ug/L)	Hardness (mg/L)
16-Oct-95	**0.71**	0.04 U	0.039	1 U	3.4	15
17-Dec-95	**0.73**	0.04 U	0.03 U	1 U	5.0 U	17
19-Feb-96	**0.94**	0.03	0.051	0.40	1.1 B	13
22-Apr-96	**0.64**	0.02 U	0.026	0.38	0.69	16
17-Jun-96	**0.50**	0.02 U	0.022	0.27	0.9	16
19-Aug-96	**0.49**	0.02 U	0.02 U	0.41	1.2	22
21-Oct-96	**0.65**	0.01 U	0.037	0.38	1.2 J	16
15-Dec-96	**0.48**	0.01 U	0.03 U	0.35	0.87	20
17-Feb-97	**0.77**	0.03 U	0.03 U	0.29	1.3	13
21-Apr-97	**0.83**	0.02 U	0.02 U	0.46	0.61	11
16-Jun-97	**0.49**	0.02 U	0.026	0.22	0.62	11
18-Aug-97	**0.43**	0.02 U	0.02	0.27	1.2	20

U = not detected at or above reported value
B = blank contamination
J = estimated value

Table 3. King County Data on Mercury Concentrations in Bear-Evans Creek
[Data obtained through Jonathan Frodge, King County]

Station	Date	Parameter	Analysis	Result		
O484	1-Apr-96	Mercury,	Total, CV	<MDL	mg/L	0.002
O484	16-Apr-96	Mercury,	Total, CV	<MDL	mg/L	0.002
O484	18-Mar-97	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	18-Mar-97	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	2-Oct-97	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	29-Oct-97	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	16-Dec-97	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	5-Jan-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	14-Jan-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	27-May-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	18-Sep-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	18-Sep-98	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	28-Oct-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	28-Oct-98	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	7-Dec-98	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	7-Dec-98	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	24-Feb-99	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	24-Feb-99	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	24-Jun-99	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	24-Jun-99	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	9-Nov-99	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	9-Nov-99	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	6-Dec-99	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	6-Dec-99	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	6-Dec-99	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	6-Dec-99	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	1-Feb-00	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	1-Feb-00	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	29-Feb-00	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	29-Feb-00	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	12-Jun-00	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	12-Jun-00	Mercury,	Dissolved	<MDL	mg/L	0.0006
O484	8-Nov-00	Mercury,	Total, CV	<MDL	mg/L	0.0006
O484	8-Nov-00	Mercury,	Dissolved	<MDL	mg/L	0.0006

Table 4. King County Data on Dissolved Cu, Lead, and Zn Concentrations in May Creek East of I-405
[Data obtained through Jonathan Frodge, King County]

Date	Cu (ug/L)	Pb (ug/L)	Zn (ug/L)	Hardness (mg/L)
27-May-98	1.6	<0.5	1.9	41
18-Sep-98	3.9	<0.5	5.7	68
28-Oct-98	1.4	<0.5	1.9	63
7-Dec-98	1.4	<0.5	2.6	42
24-Feb-99	1.6	<0.5	2.1	37
24-Jun-99	1.7	<0.5	1.5	46
9-Nov-99	1.7	<0.5	3.1	48
6-Dec-99	1.4	<0.5	2.6	38

Table 5. King County Data on Dissolved Chromium Concentrations in the Green River
above Newaukum Cr. (B319) and at Fort Dent Park (3106)
[Data obtained from Douglas Henderson, King County]

Station	Date	Chromium (ug/L)	Hardness (mg/L)
B319	27-May-98	<0.5	17
B319	28-Oct-98	<0.5	27
B319	7-Dec-98	<0.4	19
B319	24-Feb-99	<0.4	22
B319	24-Jun-99	<0.4	17
B319	24-Jun-99	<0.4	17
B319	9-Nov-99	<0.4	22
B319	6-Dec-99	<0.4	17
3106	27-May-98	<0.5	25
3106	28-Oct-98	<0.5	52
3106	7-Dec-98	<0.5	27
3106	24-Feb-99	<0.4	29
3106	24-Jun-99	<0.4	26
3106	9-Nov-99	<0.4	35
3106	6-Dec-99	<0.4	23

Table 6. King County Metals Data for Mill Creek at (station 0317)
[Data obtained through Douglas Henderson, King County]

Date	Metal	Value (ug/L)	Hardness (mg/L)
27-May-98	Cadmium, Dissolved	<0.2	25
28-Oct-98	Cadmium, Dissolved	<0.2	45
7-Dec-98	Cadmium, Dissolved	<0.2	66
24-Feb-99	Cadmium, Dissolved	<0.1	39
9-Nov-99	Cadmium, Dissolved	<0.1	37
6-Dec-99	Cadmium, Dissolved	<0.1	49
27-May-98	Chromium, Dissolved	<0.5	25
28-Oct-98	Chromium, Dissolved	<0.6	45
7-Dec-98	Chromium, Dissolved	<0.7	66
24-Feb-99	Chromium, Dissolved	0.49	39
9-Nov-99	Chromium, Dissolved	0.57	37
6-Dec-99	Chromium, Dissolved	0.42	49
27-May-98	Copper, Dissolved	2.6	25
28-Oct-98	Copper, Dissolved	3.4	45
7-Dec-98	Copper, Dissolved	2.7	66
24-Feb-99	Copper, Dissolved	2.6	39
9-Nov-99	Copper, Dissolved	2.7	37
6-Dec-99	Copper, Dissolved	3.1	49
27-May-98	Mercury, Dissolved	<0.2	25
28-Oct-98	Mercury, Dissolved	<0.2	45
7-Dec-98	Mercury, Dissolved	<0.2	66
24-Feb-99	Mercury, Dissolved	<0.2	39
9-Nov-99	Mercury, Dissolved	<0.2	37
6-Dec-99	Mercury, Dissolved	<0.2	49
18-Mar-97	Mercury, Total	<0.2	50
2-Oct-97	Mercury, Total	<0.2	39
29-Oct-97	Mercury, Total	<0.2	32
16-Dec-97	Mercury, Total	<0.2	33
5-Jan-98	Mercury, Total	<0.2	33
14-Jan-98	Mercury, Total	<0.2	40
27-May-98	Mercury, Total	<0.2	25
28-Oct-98	Mercury, Total	<0.2	45
7-Dec-98	Mercury, Total	<0.2	66
24-Feb-99	Mercury, Total	<0.2	39

Table 6. King County Mill Creek Metals Data (continued)

Date	Metal	Value (ug/L)	Hardness (mg/L)
9-Nov-99	Mercury, Total	<0.2	37
6-Dec-99	Mercury, Total	<0.2	49
27-May-98	Zinc, Dissolved	13	25
28-Oct-98	Zinc, Dissolved	15	45
7-Dec-98	Zinc, Dissolved	23	66
24-Feb-99	Zinc, Dissolved	17	39
9-Nov-99	Zinc, Dissolved	17	37
6-Dec-99	Zinc, Dissolved	21	49

Table 7. Landau Associatiates Data on Metals Concentrations in Mill Creek
[Data obtained through Bill Enkeboll, Landau Associates]

Station	Date	Hardness (mg/L)	Flow (cfs)	Cadmium Dissolved (µg/L)	Cadmium Total (µg/L)	Chromium Dissolved (µg/L)	Chromium Total (µg/L)	Mercury Dissolved (µg/L)	Mercury Total (µg/L)	Zinc Dissolved (µg/L)	Zinc Total (µg/L)
C1	1/15/90	69	17.4	0.78	0.5 U	16	10 U			403	47
C1	2/14/90	78	13.2	0.5 U	0.5 U					47	62
C1	3/13/90	88	10.0	0.5 U	0.5 U					38	177
C1	4/17/90	57	18.6	0.5 U	0.5 U	10 U	10 U			82	86
C1	5/2/90	57		0.5 U	0.5 U					88	76
C1	6/13/90	65	13.9	0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	36	51
C1	7/17/90	121	1.3	0.5 U	0.5 U					23	37
C1	8/27/90	110	1.9	0.5 U	0.5 U					20 U	50
C1	9/19/90	111	0.9	0.5 U	0.5 U					22	34
C1	10/10/90	86	1.9	0.5 UJ	0.5 UJ	10 U	10 U			64 UJ	26
C1	12/17/90	95	12.5	0.5 UJ	0.5 UJ					36	44
C1	1/22/91	108	13.3	0.5 U	0.5 U	10 U	10 U			26	35
C1	2/25/91	94	11.4	0.5 U	0.5 U					24	31
C1	3/26/91	93	12.5	0.5 U	0.5 UJ					28	29
C1	4/15/91	100	8.2	0.5 U	0.5 UJ	10 U	10 U			47 UJ	33
C1	5/22/91	118	3.5	0.5 U	0.5 U					33	21
C1	11/13/91	47.7	7.4	0.5 U	0.5 U					47	65
C1	12/11/91	79.5	5.6	0.5 U	0.5 U					42	49
C1	2/4/92	68.4	16.3	0.5 U	0.5 U	10 U	10 U			36	39
C1	2/25/92	77	11.5	0.5 U	0.5 U					22	37
C1	3/23/92	103	3.3	0.5 U	0.5 U					26	25
C1	4/13/92	65	6.6	0.5 UJ	0.5 U	10 U	10 U			22	44
C1	5/5/92	97.8	2.2	0.5 U	0.5 UJ					20 U	20 U
C1	6/2/92	110	1.5	0.5 U	0.5 U					20 U	20 U
C1	7/15/92	88	2.4	0.5 U	0.5 U	10 U	10 U	0.056 UJ	0.059 UJ	20 U	20 U
C1	8/17/92	118	2.9	0.5 U	0.5 U					20 U	20 U
C1	9/16/92	118	3.5	3.93	0.5 U					20 U	20 U
C1	10/12/92	89.5	2.8	0.5 U	0.5 U	10 U	10 U			20 U	20 U
C1	11/23/92	51.3	7.9	0.5 U	0.5 U					84	42
C1	12/16/92	74.6	7.3	0.664	0.5 U					39	43
C1	2/1/93	90.4	6.8	0.5 U	0.5 U	10 U	10 U			24	30

Table 7. Laundau Mill Creek Data (continued)

Station	Date	Hardness (mg/L)	Flow (cfs)	Cadmium Dissolved (µg/L)	Cadmium Total (µg/L)	Chromium Dissolved (µg/L)	Chromium Total (µg/L)	Mercury Dissolved (µg/L)	Mercury Total (µg/L)	Zinc Dissolved (µg/L)	Zinc Total (µg/L)
C1	2/22/93	96	3.5	0.5 U	0.5 U					28	47
C1	3/30/93	73	7.5	0.528 J	0.5 U					20 U	31
C1	4/28/93	74.9	10.8	0.5 U	0.5 U	10 U	10 U			20 U	28
C1	5/17/93	120	3.2	0.5 U	0.5 U					20 U	20 U
C1	6/22/93	113	0.9	0.5 U	0.5 U					20 U	20 U
C1	7/8/93	113	1.2	0.5 U	0.5 U	10 U	10 U	0.154 UJ	0.172 UJ	20 U	20 U
C1	8/18/93	93.3		13.8	0.5 U					28	44
C1	10/4/93	108	2.8	0.5 UJ	0.5 U					20 U	20 U
C1	10/27/93	70.5	0.5	0.5 U	0.5 U	10 U	10 U			23	31
C1	11/18/93	46.7	1.0	0.5 U	0.5 U					40	85
C1	12/6/93	60.9	1.4	0.5 U	0.5 U					20 U	31
C1	1/17/94	94.1	2.0	0.5 U	0.5 U	10 U	10 U			24	38
C1	2/22/94	76.2		0.5 U	0.5 U					20 U	30
C1	3/22/94	63.6		0.5 U	0.5 U					21	35
C1	4/18/94	97.8		0.5 U	0.5 U	10 U	10 U			20 U	20 U
C1	5/17/94	80.4		0.5 U	0.5 U					117	20 U
C1	6/20/94	86.6		0.5 U	0.5 U					20 U	20 U
C1	7/18/94	111		0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	20 U	20 U
C1	8/22/94	104		0.5 U	0.5 U					20 U	20 U
C1	9/19/94	99.2		0.5 U	0.5 U					20 U	21
C1	10/18/94	95.9	0.4	0.5 U	0.5 U	10 U	10 U			20 U	20 U
C1	11/15/94	34.5		0.5 UJ	0.5 U					42	66
C1	12/5/94	54.7		0.5 UJ	0.5 U					28	39
C1	1/17/95	76.4		0.706 J	0.5 U					20	24
C1	4/17/95	103		0.5 U	0.5 U					20 U	20 U
C1	7/18/95	105		0.5 U	0.5 U	10 U	10 U	0.212	0.2 U	20 U	20 U
C1	10/16/95	39.7		0.25 U	0.25 U					35	44
C1	2/28/96	111		0.5 U	0.5 U					21	30
C1	5/6/96	104		0.5 U	0.5 U					20.1	32.8
C1	8/5/96	96.5		0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	112	39.3
C1	12/2/96	54.2		0.5 U	0.5 U					56.9	60 UJ
C1	2/17/97	92.5			0.5 U						53.7 UJ
C1	5/27/97	83.3			0.63 J						72.7 UJ

Table 7. Laundau Mill Creek Data (continued)

Station	Date	Hardness (mg/L)	Flow (cfs)	Cadmium Dissolved (µg/L)	Cadmium Total (µg/L)	Chromium Dissolved (µg/L)	Chromium Total (µg/L)	Mercury Dissolved (µg/L)	Mercury Total (µg/L)	Zinc Dissolved (µg/L)	Zinc Total (µg/L)
C1	8/4/97										
C1	11/5/97	62.1			5 U						24
C1	1/23/98	22.4			5 U						42
C1	5/1/98	110			0.5 U						20 U
C1	9/30/98	99.7			0.5 U						17
C1	12/29/98	25.2			0.5 U						38
C1	1/19/99	36.6			0.5 U						28
C1	4/5/99	78			0.5 U						22
C1	7/6/99	99.9			1.5 U						44
C1	10/20/99	96			0.5 U						20 U
C1	1/5/00	61.3			0.66						29.4
C1	4/6/00	86.8			0.5 U						43.4
C1	7/10/00	112			0.5 U						20 U
C1	10/2/00	68.4			0.5 U						20 U
C4	2/1/93	89		2.32	0.5 U	10 U	10 U			37	50
C4	2/22/93	88		0.5 U	0.5 U					44	62
C4	3/30/93	87		2.54 J	0.5 U					29	52
C4	4/28/93	72.5		0.5 U	0.5 U	10 U	10 U			39	53
C4	5/17/93	120		0.5 U	0.62 J					35	70
C4	6/22/93	114		3.06 J	0.593 J					28	59
C4	7/7/93	109		11	0.577 J	10 U	10 U	0.178 UJ	0.176 UJ	31	53
C4	8/18/93	106		0.565 UJ	1.2 J					53	128
C4	10/4/93	97.8		0.5 UJ	0.5 U					20 U	21
C4	10/27/93	54.6		0.5 U	0.5 U	10 U	10 U			20 U	24
C4	11/17/93	63.1		1.89 J	0.507 J					48	61
C4	12/6/93	58.4		0.5 U	0.5 U					25	45
C4	1/17/94	93		0.5 U	0.5 U	10 U	10 U			20 U	36
C4	2/22/94	74.3		0.5 U	0.5 U					24	36
C4	3/22/94	59.2		0.649 J	0.5 U					33	42
C4	4/18/94	99.6		0.5 U	0.5 U	10 U	10 U			20 U	22
C4	5/17/94	66.4		0.5 U	0.5 U					20 U	23
C4	6/20/94	80.1		0.5 U	0.5 U					20 U	20 U

Table 7. Laundau Mill Creek Data (continued)

Station	Date	Hardness (mg/L)	Flow (cfs)	Cadmium Dissolved (µg/L)	Cadmium Total (µg/L)	Chromium Dissolved (µg/L)	Chromium Total (µg/L)	Mercury Dissolved (µg/L)	Mercury Total (µg/L)	Zinc Dissolved (µg/L)	Zinc Total (µg/L)
C4	7/18/94	115		0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	20 U	60
C4	8/22/94	119		0.5 U	0.713 J					20 U	84
C4	9/19/94	93.6		0.5 U	0.5 U					20 U	20
C4	10/18/94	92.8		0.5 U	0.5 U	10 U	10 U			20 U	30
C4	11/15/94	41.3		0.5 UJ	0.5 U					37	54
C4	12/5/94	57.2		0.5 U	0.5 U					40	48
C4	1/17/95	75.5		0.5 U	0.5 U					31	35
C4	4/17/95	102		0.5 U	0.5 U					21	20 U
C4	7/17/95	104		0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	20 U	20 U
C4	10/16/95	34.9		0.25 U	0.25 U					20 U	22
C4	2/28/96	112		0.5 U	0.519					51	59
C4	5/6/96	103		0.5 U	0.5 U					34.8	46.5
C4	8/5/96	85		0.5 U	0.5 U	10 U	10 U	0.2 U	0.2 U	127	49
C4	12/2/96	44.5		0.5 U	0.5 U					54.1	63.8 UJ
C4	2/17/97	85.4			0.5 U						57.9 UJ
C4	5/27/97	109			1.75 J						72.1 UJ
C4	8/4/97										
C4	11/5/97	60.8			5 U						26
C4	1/23/98	22.9			5 U						44
C4	5/1/98	106			0.8						20 U
C4	9/30/98	92.9			0.5						18
C4	12/29/98	21.2			0.5 U						27
C4	1/19/99	35.9			0.5 U						34
C4	4/5/99	78.9			0.5 U						36
C4	7/6/99	90.5			0.9 U						33
C4	10/20/99	97.1			0.5 U						37.8
C4	1/5/00	65.1			0.85						80.4
C4	4/6/00	100			0.5 U						51.2
C4	7/10/00	110			0.5 U						20 U
C4	10/2/00	62.9			0.5 U						31

U = Indicates compound was analyzed for, but was not detected at the reported sample detection limit.

UJ = The analyte was not detected in the sample; the reported sample detection limit is an estimate.

J = Iindicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

B = Possible method blank contamination.

Table 8. USGS Data on Dissolved Ag Concentrations in the Yakima River above
Ahtanum Creek, Station 12510500

[Data obtained through Jennifer Morace, Yakima NAWQA]

Date	Ag (ug/L)	Hardness (mg/L)
19-May-99	< 1	67
9-Jun-99	< 1	
17-Jun-99	< 1	38
30-Jun-99	< 1	
13-Jul-99	< 1	51
29-Jul-99	< 1	
5-Aug-99	< 1	93
6-Aug-99	< 1	93
6-Aug-99	< 1	93
24-Aug-99	< 1	
31-Aug-99	< 1	95
21-Sep-99	< 1	
19-Oct-99	< 1	98
18-Nov-99	< 1	71
7-Dec-99	< 1	50
13-Jan-00	< 1	66

Appendix B

Appendix B is available on request by contacting Art Johnson at (360)407-6766.