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Spokane River   
PCBs and Other Toxics   
at the Spokane Tribal Boundary

Recommendations for Development of a   
Long-Term Monitoring Plan

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**Cover photo:** Little Falls Pool looking upstream from the Union Gospel Mission dock.

(Photo taken by Brandee Era-Miller).

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Spokane River   
PCBs and Other Toxics   
at the Spokane Tribal Boundary

Recommendations for Development of a

Long-Term Monitoring Plan

by

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# Abstract

The Department of Ecology conducted seasonal monitoring for targeted toxic contaminants during 2015 – 2016 at the eastern Spokane Tribal boundary on the Spokane River. This monitoring area is downstream of all known sources of PBDEs, PCBs and metals (cadmium, copper, lead, and zinc). Toxics monitoring was conducted to provide recommendations for the establishment of a long-term monitoring program at the site.

Surface water and suspended sediment samples were taken during the three major hydraulic river regimes: spring high flow, summer low flow, and winter moderate flow and analyzed for PCBs, PBDEs, dioxins/furans, and metals (cadmium, copper, lead, and zinc). Several collection and extraction techniques were used to ensure detection of PCBs and PBDEs in surface water including CLAM (Continuous Low-level Aqueous Monitoring device), XAD-2 and liquid-liquid extraction with two-liter composite samples. Suspended sediments were collected with sediment traps deployed for four months at a time.

Recommendations were made to continue long-term monitoring at the eastern Spokane Tribal boundary site with some minor changes in collection techniques and toxic parameters to consider for analysis.

# Acknowledgements

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# Introduction

##### This study established recommendations for a long-term toxics monitoring station on the mainstem Spokane River at the eastern Spokane Tribal Boundary. The monitored parameters included: polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), dioxins/furans and metals (cadmium, copper, lead and zinc). Data from the study will be used to inform and design a long-term monitoring program for the upstream Spokane Tribal boundary site.

Specific objectives for this project include:

* Characterize toxics in surface water and suspended sediments in the Spokane River at the Spokane Tribal Boundary during the 3 hydrologic regimes; spring high flow, summer low flow and winter moderate flow.
* Use data from the study to support the development of standard operating procedures (SOP) for use of the Continuous Low-level Aqueous Monitoring device (CLAM) and to support another Washington State Department of Ecology (Ecology) study: *Assessment Methods for Sampling Low-Level Toxics in Surface Waters* (Hobbs and McCall, 2016). The goal of the low-level toxics study is to characterize the precision and accuracy of different high-volume collection methods for use with low-level analytical methods like the EPA 1600 series methods, with special focus on PCBs.

## Background

The federal Clean Water Act, adopted in 1972, has as its interim goal “water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water” wherever attainable. Development and implementation of state water quality standards is a key step in achieving this goal.

Multiple reaches of Spokane River does not meet Washington State surface water quality standards and has been placed on the impaired waters 303(d) list for PCBs, dioxins/furans and metals (see Appendix A for a table of all the 303(d) listings for toxics parameters in the Spokane River). There are elevated levels of other toxic chemicals including polybrominated diphenyl ethers (PBDEs) and metals. In 2009 the Washington State Department of Health (DOH) issued a fish consumption advisory, recommending limiting the amount of fish eaten from the river due to the levels of PCBs and PBDEs.

To address impairments for metals a Total Maximum Daily Load (TMDL) or water cleanup plan was developed for dissolved cadmium, lead, and zinc in 1999 (Butkus and Merrill, 1999). A task force (Spokane River Regional Toxics Task Force or SRRTTF) was created in 2012 to lead the effort to find and reduce PCBs in the Spokane River (<http://srrttf.org/>).

A number of studies and cleanup activities have occurred and are ongoing to address contamination in the Spokane River watershed (Serdar et al., 2011). The majority of these have focused on the upstream portion of the river, where known contamination exists. For the purposes of this document, upstream Spokane River refers to areas upstream of Lake Spokane.

The monitoring location for this study is located in Little Falls Pool, a 5-mile section of the Spokane River downstream of Lake Spokane between Long Lake Dam and Little Falls Dam (Figure 1). There is a lack of toxics monitoring data for this 5-mile section of the river. The Spokane Tribal Water Quality Standards apply at the confluence with Chamokane Creek. The Spokane Tribal Water Quality standards differ from the Washington State’s Human Health and Aquatic Life water quality criteria. For example, the total PCB criterion in water for the protection of Human Health for the Spokane Tribe of Indians is 1.3 pg/L while Washington’s Human Health total PCB criterion is 7 pg/L.

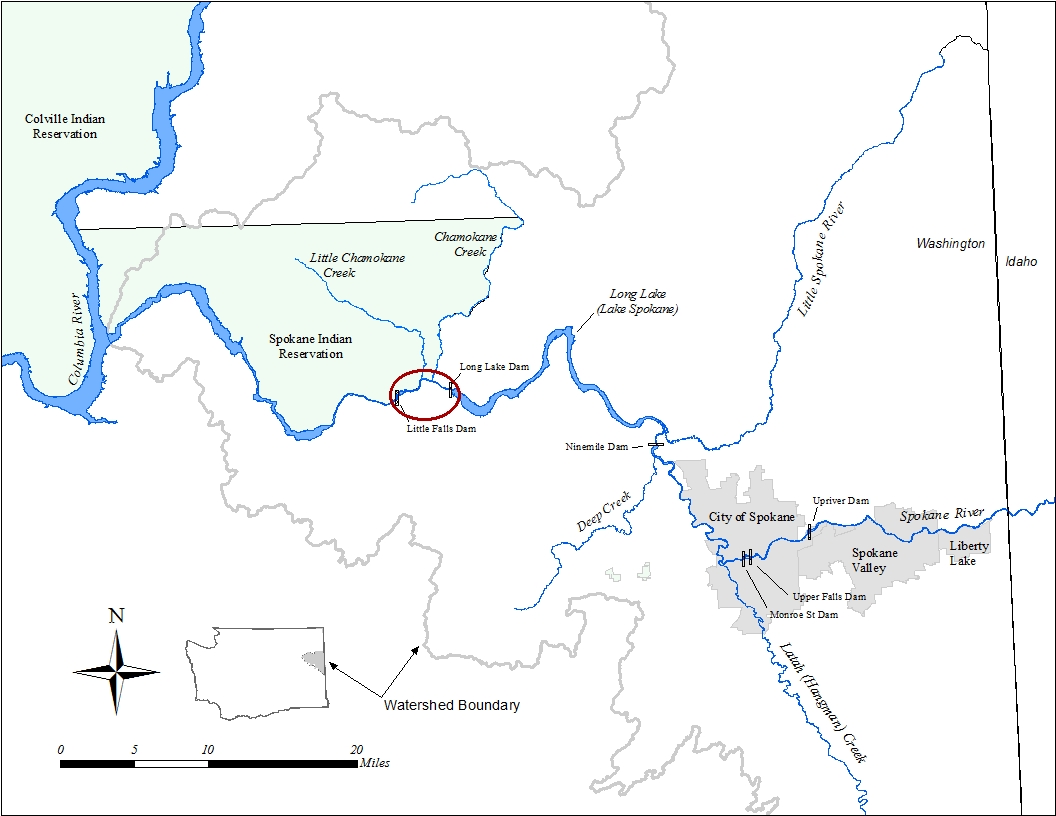


Figure 1. Spokane River Watershed within Washington State (Little Falls Pool circled).

Results from Ecology’s Freshwater Fish Tissue Contaminant Monitoring Program indicate that concentrations of PCBs and PBDEs in Spokane River fish from 2012 were much lower in Little Falls Pool compared to all the other monitoring locations upstream (Seiders et al., 2014). Another Ecology study showed that surficial sediments collected in 2003-2004 in Little Falls Pool were lower for PCBs than upstream monitoring locations (Serdar et al., 2011). Figure 2 shows the surficial sediment organic carbon-normalized total PCB concentrations. Because of the lower PCBs in fish and sediments in Little Falls Pool, surface water concentrations for PCBs and other toxics in Little Falls Pool were unknown but expected to be lower than areas upstream.



Figure 2. Organic Carbon Normalized Total PCBs in Spokane River Surficial Sediments.

## Study Area

The Spokane River begins in Idaho at the outlet of Lake Coeur d’Alene and flows west 112 miles to the Columbia River. The Spokane River watershed encompasses over 6,000 square miles in Washington and Idaho (Serdar et al., 2011). The river flows through the smaller cities of Post Falls and Coeur d’Alene in Idaho and large urban and industrial areas in Spokane Valley and Spokane in Washington. Spokane Tribe of Indians reservation encompasses the north bank of the lower river from Chamokane Creek, below Long Lake Dam, downstream to the Columbia River confluence.

The Spokane River sits atop the western portion of the Spokane Valley-Rathdrum Prairie Aquifer. There is significant interchange between the river and the aquifer. The river is the largest contributor to the aquifer (49% of aquifer inflow) but is also the largest recipient of aquifer water at about 58% of aquifer outflow (MacInnis et al., 2009).

The Spokane River has seven major dams. From upstream to downstream they are: Post Falls Dam, Upriver Dam, Upper Falls Dam, Monroe Street Dam, Nine Mile Dam, Long Lake Dam and Little Falls Dam.

The Spokane River watershed is located in a transition area between the barren scablands of the Columbia Basin to the west, coniferous forests and mountainous regions to the north and east, and prairie lands to the south. Spokane receives 16.5 inches of rain annually on average. Spring snowmelt dominates flows in the Spokane River from April through June as shown in Figure 3.

Figure 3. Historical Average Annual Flow for the Spokane River near the City of Spokane

# Study Design and Methods

During 2015-2016 surface water and suspended sediments were collected in Little Falls pool near the upstream boundary of the Spokane Tribe Reservation. The Spokane Tribe’s Water Quality Standards become applicable to the Spokane River at this site. Little Falls pool is the 5-mile section of the Spokane River between Long Lake Dam and Little Falls Dam. Surface water samples were collected from the Union Gospel Mission (UGM) dock (right bank) and the sediment traps were placed just upstream along the left bank as shown in Figure 4.

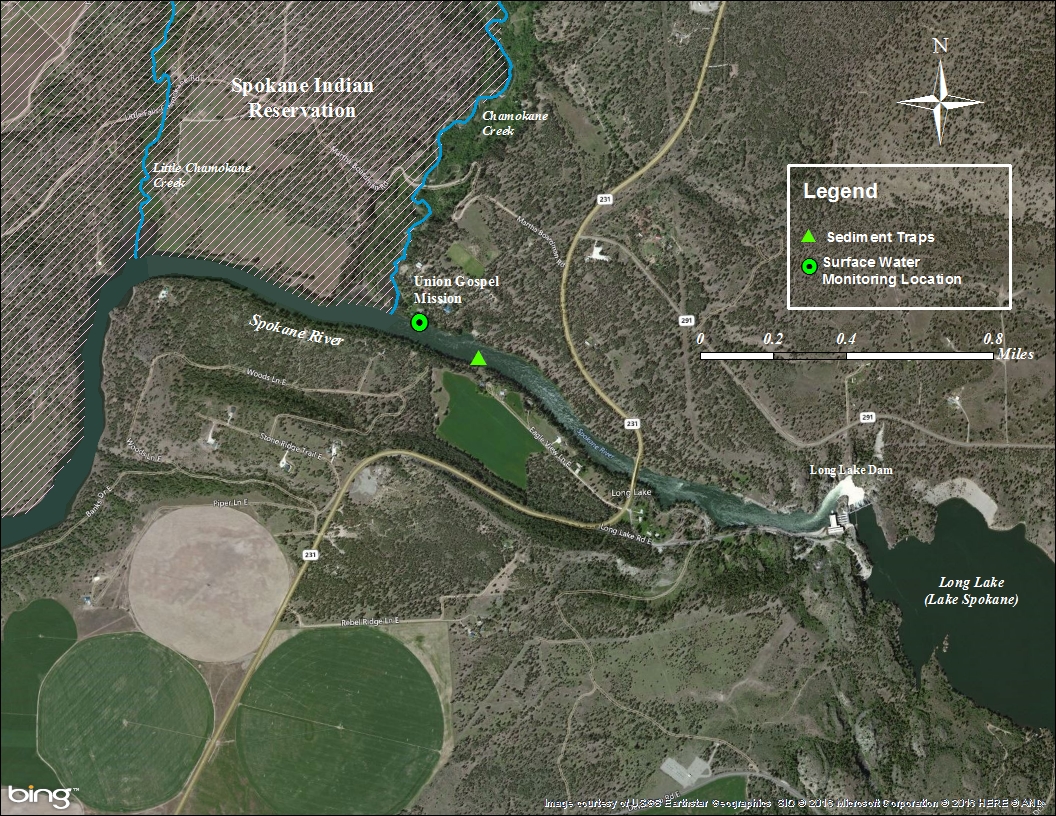


Figure 4. Monitoring Locations for the Study.

Surface water and suspended sediments were collected following the monitoring plan laid out in the Quality Assurance (QA) Project Plan for the study (Era-Miller, 2015). Samples were collected during 3 separate monitoring events in order to cover each of the 3 major flow regimes in the Spokane River: spring high flow, summer low flow and winter moderate flow. Figure 5 shows the surface water monitoring events overlaid onto the sediment trap deployment periods. Sediment traps were deployed for about 4.5 months each from late spring 2015 through early summer 2016. Surface water samples were taken over a 24 hour period during each event and were comprised of both composite and grab samples.



Figure 5. Daily Discharge (CFS) in Little Falls Pool and Sampling Events.

*Discharge Data obtained from Avista.*

## Field Procedures

### Surface Water

Surface water samples were collected as composites with the exception of low-level metals which were collected as discreet grab samples. The primary method for collection and extraction of PCBs and PBDEs was through the use of active samplers called Continuous Low-level Aqueous Monitoring (CLAM) devices. The CLAM is submersible and extracts water on-site through a Solid Phase Extraction (SPE) disk at a flow rate of 5-75 ml per minute for up to 36 hours. More information on the CLAM can be found at the manufacturer’s website: <http://aqualytical.com/water-sampling-equipment/>.

CLAMs were deployed in the river and also used in the laboratory to extract water samples that were collected and composited during the same sampling period.

Approximately 20 liters of water were collected for extraction with CLAM in the lab. Varied volumes of water were filtered through CLAMs in the field (15 – 40 liters). Filtering efficiency is effected by battery life and the operating differences of each CLAM pump, and by the physical characteristics of the water sampled. For example, water with higher amounts of suspended particulates can clog the SPE disks inside the CLAM more quickly and slow down the filtering rate. Table 1 shows all the collection methods that were used to collect surface water for the study.

Table 1. Collection Methods for Toxics and Conventionals in Surface Water.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Collection Method | Collection Period  (24 hours) | Collection Event |
| PCBs & PBDEs | CLAM (Field)† | On-site Continuous | May and September 2015 |
| 20 L (CLAM at lab)† | ½ fill at deployment – ½ at retrieval |
| PCBs | 20 L (XAD-2 at lab) | ½ fill at deployment – ½ at retrieval | January 2016 |
| 2 Liter | ½ fill at deployment – ½ at retrieval |
| DOC, TOC, TSS & TNVSS | Specific bottle | ½ fill at deployment – ½ at retrieval | All 3 |
| Hardness & metals | Grab | Sample 1 Sample 2 | All 3 |

†: All CLAM deployments had significant PCB contamination due to high-density polypropylene SPE disks.

DOC: Dissolved Organic Carbon; TOC: Total Organic Carbon; TSS: Total Suspended Solids;

TNVSS: Total non-volatile suspended solids

CLAM: Continuous Low Level Aqueous Monitoring device

XAD-2: Sorption media for contaminant monitoring

Results from the May and September 2015 sampling events revealed significant PCB and PBDE contamination from the high-density polypropylene SPE disk housing attached to the CLAMs. For the January 2016 sample event, XAD-2 was used by the laboratory instead of the CLAM for filtering the 20-liter composite samples. XAD-2 is a type of sorption media made up of small polymer resin beads. The SPE disks in the CLAM use a sorption media called HLB. Both media types are designed to sorb soluble organic chemicals. Additionally, 2-liter composite samples were also collected in January and were processed through liquid-liquid extraction instead of the CLAM or XAD-2 methods. Due to additional laboratory costs of setting up the XAD-2, only PCBs were analyzed for in January 2016.

At deployment and again at retrieval of the CLAM field samples, half the container volume of surface water was collected and transferred into appropriate sample containers for compositing (Table 1). Metals and hardness samples were collected as discreet grabs at the beginning and end of each 24 hour collection event. Collecting metals samples as discreet grabs as opposed to compositing, reduces the chance of background contamination that is often seen with low-level metals sampling.

Surface water measurements were also taken at the beginning and end of each 24 hour collection event using a Hydrolab MiniSonde®. Measurements included:

* Temperature
* pH
* Conductivity
* Dissolved Oxygen

The following Environmental Assessment Program (EAP) Standard Operation Procedures (SOPs) were used for water sampling:

* *Sampling of Pesticides in Surface Waters, Version 2.1* (Anderson, 2015)
* *Collection and Field Processing of Metals Samples, Version 1.5* (Ward, 2015)
* *Standard Operating Procedures for Hydrolab® DataSonde® and HL4 Multiprobes, Version 2.1* (Anderson, 2016)

### Sediment Traps

Suspended sediment traps were deployed in duplicate at the long-term monitoring site. Each duplicate trap sample was analyzed separately for toxics, except for the Fall-Winter period where one of the traps was lost and could not be retrieved. Duplicate traps were placed roughly 200 feet (61 meters) a part. Each trap holds 2 collection cylinders (each with a collection area of 78.5 cm2 and a height-to-width ratio of 5) for a total of 4 cylinders for the monitoring site. After 4 months the accumulated sediment was collected and replaced with new cylinders, allowing sedimentation rates to be calculated for 3 separate 4-month collection periods.

The sediment traps were suspended in the water column with an anchor, snag line, and hardshell float. The hardshell float sits 6 feet below the water surface so that the trap can stay taut with fluctuating water levels and so it’s not disturbed by vessel traffic or floating debris. The trap sits approximately 3 feet above the reservoir bottom. The trap is retrieved by dragging a hook to grab the snag line underwater. Additional information on the deployment and retrieval of the sediment traps is available in the QA project plan (Era-Miller, 2015).

Analysis of suspended sediments included the following parameters:

* Percent solids
* TOC
* Cadmium, copper, lead, and zinc
* PCB congeners
* PBDEs
* Dioxins and furans

Sediments were centrifuged to remove excess water and then frozen after each collection event such that all the samples could be analyzed together, thus minimizing batch-specific analytical variation.

## Laboratory Procedures

Project samples were analyzed at Ecology’s Manchester Environmental Laboratory (MEL) in Manchester, Washington and by AXYS Laboratories in Surrey, B.C. (Table 2). High resolution analytical methods were used for all the PCB, PBDE and dioxins/furan analyses.

Table 2. Parameters and Analytical Methods.

|  |  |  |
| --- | --- | --- |
| Parameter | Analytical Method | Laboratory |
| **Surface Water (composites and grabs)** | | |
| TOC & DOC | SM 5310B | MEL |
| TSS | SM 2540D |
| TNVSS | SM 2540B/E |
| Hardness\* | SM 2340B |
| Cd, Cu, Pb, & Zn\* | EPA 200.8 |
| PCBs | EPA 1668c | AXYS |
| PBDEs | EPA 1614 |
| **Surface Water (CLAM and XAD-2)** | | |
| PCBs | EPA 1668c | AXYS |
| PBDEs | EPA 1614 |
| **Suspended Sediments** | | |
| % Solids | SM 2540G | MEL |
| TOC | PSEP – TOC |
| Cd, Cu, Pb, & Zn | EPA 200.7 |
| PCBs | EPA 1668c | AXYS |
| PBDEs | EPA 1614 |
| Dioxins/furans | EPA 1613 |

\* Hardness and metals collected as single discreet grab samples

MEL: Ecology Manchester Environmental Laboratory

AXYS: AXYS laboratory

CLAM: Continuous Low-Level Aquatic Monitoring device

EPA: the Environmental Protection Agency

SM: Standard Methods

PSEP: Puget Sound Estuary Protocols

TOC: total organic carbon

TSS: total suspended solids

TNVSS: total non-volatile suspended solids

DOC: dissolved organic carbon

Cd: cadmium; Cu: copper; Pb: lead; and Zn: zinc

## Data Quality

The study data were reviewed by the report authors, the analytical chemists and Manchester Environmental Laboratory (MEL). The majority of the study data were found to meet the laboratory measurement quality objectives (MQOs) outlined in the QA Project Plan (Era-Miller, 2015). See Appendix B, Table B-1 for a summary of how the project data compared to MQOs. Some of the project data have been qualified due to data quality concerns, but are acceptable as qualified and reported.

### 

### Blank Censoring and Inclusion of Tentatively Identified Results

Results were censored against blanks on a congener-specific basis using the “3x rule” where if the sample result had less than 3 times the concentration detected in the blank, it was changed from a detection to a non-detected result, thus receiving a U, UJ, or NUJ qualifier. Data from all the samples extracted with CLAM were censored against the results from a blank SPE disk that was kept at the laboratory after disk preparation and conditioning and later analyzed with the rest of the samples. This censoring method helped to account for the background contamination present in the SPE disk housing. Data from the samples extracted through XAD-2 and liquid-liquid methods were censored against the laboratory method blank that was run with each batch.

The “3x rule” was chosen for censoring to be consistent with recent surface water studies conducted by Limnotech for SRRTTF (Limnotech, 2015 and 2016). Limnotech conducted low-flow synoptic surveys in 2014 and 2015 for the purposes of calculating a semi-quantitative mass-balance assessment for PCBs in the Spokane River between the Lake Coeur d’Alene outlet and Nine Mile Dam. The “3x rule” can allow for more false positives causing calculations of total PCBs to sometimes be biased high. Use of the “3x rule” can also allow for the inclusion of more congeners to aid in source identification efforts. MEL recommends use of the “5x rule” for high resolution methods such as 1668c, while “10x rule” is often used for low resolution methods.

Results qualified with a NJ (tentatively identified estimate) were treated as estimated results in both the environmental samples and blanks and were used in the summation of result totals.

### Data Availability

Copies of the original laboratory case narratives can be obtained from the lead study author.

The suspended sediment data is available electronically for download from Ecology’s EIM database under Study ID BERA0012. EAP does not have a standard operating procedure (SOP) for sample collection methods using CLAM and XAD-2 and thus data from these methods are not currently entered into EIM. The CLAM and XAD-2 data are available in Appendix C, Table C-1 and C-2.

Data for the surface samples collected in January 2016 as 2-liter composites and extracted through the liquid-liquid extraction process was entered into EIM. Liquid-liquid extraction is an accredited method. The 2-liter composite samples were censored using a “5x rule” for entry into EIM. The 2-liter data is also available in Appendix C, Table C-2 where it is censored using the “3x rule”.

### Surface Water

#### Field Measurements

Temperature, pH, conductivity and dissolved oxygen were measured in the field using a Hydrolab MiniSonde®. The Hydrolab was calibrated before each of the three seasonal monitoring events. A post-calibration check was performed after the September 2015 event and only conductivity appeared to be moderately out of range (calibration solution of 100 us/cm was measured at 121 us/cm).

#### PCBs and PBDEs

Contamination of PCBs and PBDEs in the CLAM high-density polypropylene SPE (solid phase extraction) disk housing that holds the HLB sorption media was the biggest issue with the surface water samples. Due to the contamination, all the CLAM data were censored against a blank “clean” SPE disk that was extracted and analyzed along with each analytical batch. The 20 liter XAD and 2 liter sample results were censored against laboratory method blanks.

There were multiple types of CLAM blanks analyzed for PCBs and PBDEs during the study (Tables 3 and 4). There were similar concentrations of total PCBs and PBDE 47, 99 and 209 during within sampling event, though the September sampling event had less than half the concentrations of the May sampling event. The contaminant levels in the CLAM blanks indicate a fairly constant background signal, especially for PCBs. Censoring all the CLAM data against the SPE Lab disk blank run with each batch of samples helped to evenly account for contamination across the study. CLAMs were not used in January 2016 due to the SPE disk contamination issues.

Table 3. Total PCBs in CLAM Blanks.

|  |  |  |
| --- | --- | --- |
| CLAM  Blank Type | Total PCBs (pg/disk)\* | |
| May 2015 | Sept 2015 |
| Lab SPE Disk | 2593 | 1229 |
| Field SPE Disk | 2664 | -- |
| Trip Blank | 2456 | -- |
| Transfer Blank | 3258 | 867 |

\* Concentrations are shown as total PCBs in picograms per disk.

Table 4. PBDEs in CLAM Blanks.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CLAM  Blank Type | **PBDE 47** (pg/disk)\* | | **PBDE 99** (pg/disk)\* | | **PBDE 209** (pg/disk)\* | |
| May 2015 | Sept 2015 | May 2015 | Sept 2015 | May 2015 | Sept 2015 |
| Lab Disk | 86 | 30 | 89 | 21 | 664 | 450 U |
| Field Disk | 50 | -- | 53 | -- | 622 | -- |
| Trip Blank | 57 | -- | 45 | -- | 585 | -- |
| Transfer Blank | 80 | 59 | 68 | 45 | 848 | 560 |

\* Concentrations are shown as picograms per disk.

-- Not analyzed.

U: Not detected at the result value shown.

As part of the investigative work into how well CLAMs perform as an assessment tool for PCBs, PBDEs and other low-level organic chemicals in surface water, an analysis of breakthrough was performed on two samples during the May 2015 surface water sampling. The two samples had an additional disk used, so that the disks were attached in series on the CLAM. The first disk in series was spiked with a field spike solution containing PCB-31L, PCB-95L, PCB-153L and PBDE-138L, while the second disk was not field spiked. All the field spiked disks recovered at 84 – 92% for the PCB surrogates and at 69 –77% for PBDE-138L. The second (non-spiked) disks recovered at 0 – 1%, suggesting that PCBs and PBDEs do not readily break through the CLAM SPE disks.

#### Metals

A transfer and filter blank was collected during each of the three surface water sampling events to account for any potential laboratory or sampling equipment contamination for the total and dissolved metals samples. There were no detections in any of the metals blanks except for one copper-total result of 0.14 ug/L taken during the May sampling event. The associated sample result was 0.67 ug/L (Table 10 *– Results Section*).

### Suspended Sediments

Suspended sediments were analyzed for PCBs, PBDEs, dioxin/furans and metals. There were fewer data quality issues overall with the suspended sediment samples compared to the surface water samples. This appeared to be associated with the sediments having higher concentrations relative to the laboratory method blanks. There were a few exceptions, noted as follows.

#### Dioxin/furans

Most of the dioxin/furan data were qualified as estimates due to chromatographic interferences, contamination in the blank, low labeled internal standard recoveries, and mass ion ratios outside the control limits.

#### Metals

Approximately 60% of the metals samples were beyond holding time limits at the time of analysis and were therefore “J” qualified as estimates by MEL. The project manager chose to freeze all samples and have them analyzed later in the same batch in order to minimize batch-specific analytical variability. More than half the samples were frozen for over a year prior to analysis.

## Assessment Criteria

Table 5 shows the relevant Washington State and Spokane Tribal water quality and sediment criteria. The State criteria apply to the surface water and suspended sediment above the confluence of Chamokane Creek with the Spokane River and the Tribal criteria apply below the confluence. Both Washington State and Spokane Tribal criteria for the protection of human health for total PCBs are below the detection capabilities of current analytical technology at 7 and 1.3 pg/L (part per quadrillion), respectively.

Data for surface water samples extracted through CLAM and XAD-2 will not be used for formal assessment of attainment of water quality standards.

Washington State and the Spokane Tribe of Indians have hardness-based acute and chronic criteria for the protection of aquatic life for cadmium, copper, lead and zinc. The hardness-based calculations are the same for both entities except the Spokane Tribe of Indians have slightly lower (more restrictive) criteria for copper.

Neither Washington State nor the Spokane Tribe of Indians have criteria for PBDEs and there are no freshwater sediment cleanup screening thresholds for dioxin.

Table 5. Applicable Freshwater Criteria for Surface Water and Sediment from the Spokane River.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Matrix | Washington State  Freshwater Criteria1 | Spokane Tribal  Freshwater Criteria2 |
|  |  | Human Health Protection (pg/L) | Human Health Protection (pg/L) |
| Total PCBs | Water | 7 | 1.3 |
| 2,3,7,8-TCDD (dioxin) | 0.013 | 0.000104 |
|  |  | Aquatic Life (Chronic) | Aquatic Life (Chronic) |
| Cadmium | Water | HB | same as WA State |
| Copper | HB | HB\* |
| Lead | HB | same as WA State |
| Zinc | HB | same as WA State |
|  |  | Washington State  Freshwater Sediment (ug/Kg dry weight) | |
|  |  | Cleanup Objective3 | Cleanup Screening Level3 |
| Total PCBs (Aroclor) | Sediment | 110 | 2500 |
| Cadmium | 2.1 | 5.4 |
| Copper | 400 | 1200 |
| Lead | 360 | > 1300 |
| Zinc | 3200 | > 4200 |

1 Water Quality Standards for the Surface Waters of the State of Washington (Ecology, 2006).

2 Spokane Tribe of Indians Surface Water Quality Standards (STI, 2010).

3 Sediment Management Standards (Ecology, 2013).

\* The Spokane Tribal Aquatic Life Chronic Criterion for copper is lower than Washington’s.

HB: Hardness Based.

# Results

## Surface Water

### Conventional Measurements

During each of the three sample events, instantaneous field measurements including temperature, conductivity, pH, and dissolved oxygen (DO) were obtained at the UGM site. Results are presented in Table 6. While pH was fairly consistent over the course of the study, temperature, conductivity and dissolved oxygen results were more variable. Higher conductivity values during the September monitoring events are indicative of the influence of groundwater in the river.

Table 6. Ambient Surface Water Measurements at the UGM Monitoring Site.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Date | 5/4/15 | 5/5/15 | 9/9/15 | 9/10/15 | | 1/27/16 |
| Time | 1725 | 1720 | 1900 | 1045 | 1845 | 1230 |
| Temperature (C°) | 12.6 | 12.3 | 17.0 | 17.2 | 17.2 | 5.4 |
| Conductivity (umhos/cm) | 118 | 120 | 247 | 249 | 246 | 169 |
| pH (pH units) | 7.5 | 7.9 | 7.9 | 7.8 | 7.9 | 7.2 |
| Dissolved Oxygen (mg/L) | 10.92 | 10.77 | 7.90 | 8.00 | 8.07 | 10.51 |

### General Chemistry

Table 7 shows the general chemistry results for the study. Total organic carbon (TOC) and Total Suspended Solids (TSS) are generally low in the Spokane River compared to other rivers in the State and current study results reflect this. The TOC results were below 2 mg/L and TSS ranged from not-detected at 1 mg/L to a high of 3 mg/L. Total non-volatile suspended sediments (TNVSS) are a measure of the inorganic portion of suspended sediments. TNVSS ranged from not-detected at 1 mg/L to a high of 2 mg/L.

Table 7. General Chemistry Results (mg/L) from the UGM Monitoring Site.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample Type | Composite | | Grab | | Composite | | Replicate | | Composite | | Replicate | |
| Sample No. | 1505050-10 | | -11 | | 1509068-10 | | -11 | | 1602016-10 | | -11 | |
| Start Date | 5/4/15 | | 5/5/15 | | 9/9/15 | | | | 1/26/16 | | | |
| Start Time | 1725 | | 1720 | | 1940 | | 1945 | | 1120 | | 1130 | |
| End Date | 5/5/15 | | NA | | 9/10/15 | | | | 1/27/16 | | | |
| End Time | 1720 | | 1055 | | 1055 | | 1650 | | 1650 | |
| Total Organic Carbon | **1.7** |  | **1.8** |  | **1.1** |  | 1.0 | U | **1.3** |  | **1.3** |  |
| Dissolved Organic Carbon | **1.5** |  | **1.5** |  | 1.0 | U | 1.0 | U | **1.0** |  | **1.1** |  |
| Total Suspended Solids | **2** |  | **2** |  | 2 | U | 1 | U | **3** |  | **3** |  |
| TNVSS | **1** |  | 2 | U | 2 | U | 1 | U | 2 | UJ | **2** |  |

**Bolded** values indicate detected results.

J = Analyte was positively identified, reported result is an approximate concentration.

U = Not detected above the reported quantitation limit.

UJ = Not detected above the reported estimated quantitation limit.

NA = Not applicable.

### PCBs

As described in the *Data Quality* section, all surface water samples using CLAMs were censored against a blank SPE disk that was kept at the laboratory after disk preparation and conditioning and later analyzed with the rest of the samples. The XAD-2 and 2 liter samples were censored against laboratory method blanks. Factoring out the contamination by censoring against the blank SPE disks significantly lowered the total PCB (tPCB) congener results for the May and September events.

Full results for surface water data collected and extracted through the CLAM method are available in Appendix C, Table C-1. Surface water data extracted through XAD-2 (20 liter composite samples) and liquid-liquid methods (2 liter samples) are shown in Appendix C, Table C-2. Table 8 gives the tPCB results and volumes of water sampled. The actual volume from the 20 liter canisters used for composting samples in closer to 19.5 liters. Total PCBs are calculated by dividing the tPCB mass in picograms (pg) by the volume of water samples in liters (L) to get a final result in pg/L. Figure 6 shows tPCB results for both the environmental samples and transfer blanks.

Table 8. Total PCBs in Surface Water from the UGM Monitoring Site.



NA = not applicable – Original sample mass not given by Lab, but reported as pg/L.

Figure 6. Total PCB Results (pg/L) for Surface Water Sampling.

Transfer blank concentrations are included in Figure 6 for all three sampling events because they can be subtracted from the associated environmental results to get a more conservative estimate of concentrations for each sampling event. The 2 liter samples are an exception as they had no transfer blank collected for them.

The Washington State Human Health criterion and the Spokane Tribe of Indian’s water quality criterion for total PCBs are shown in Figure 6 at 7 pg/L and 1.3 pg/L to give a general idea of surface water results compared to criteria. As stated in the *Assessment Criteria* and *Data Quality* sub-sections of this report, surface water data extracted through CLAM and XAD-2 will not be entered into EIM or used for assessment of attainment of water quality standards.

After subtraction of the transfer blank concentrations shown in Figure 6, the mean seasonal tPCB concentrations for the study were found to range from 63 – 87 pg/L at the UGM monitoring site (Table 9). Given the inclusion of NJ qualified data and use of the “3x rule” for blank censoring, these total values may be biased slightly high.

Table 9. Seasonal Surface Water Results for Total PCBs.



N: Number of samples

\* Mean daily flow calculated from hourly discharge data from Long Lake Dam

### PBDEs

PBDEs were analyzed for the May and September sampling events but not in January. PBDE 47 was the only congener among the 3 most prevalent and common PBDEs (47, 99 and 209) that was clearly detected above the background noise of PBDEs that were detected in the CLAM SPE disk blanks and laboratory method blanks (Figure 7). PBDE 47 concentrations were fairly similar across both sampling seasons ranging from 15 – 32 pg/L. There was more variability among the PBDE 99 and 209 results in general with only half of the samples having detections. The September PBDE 209 results for the 20 liter composite samples analyzed with CLAMs in the laboratory were higher relative to all the other samples (400 and 830 pg/L compared to ND – 245 pg/L).



Figure 7. PBDE 47, 99 and 209 Results (pg/L) for Surface Water Sampling.

### Metals

Six grab samples (two per sampling event) for both total and dissolved cadmium, copper, lead and zinc were collected at the UGM site during the study. All metals concentrations were 1-2 orders of magnitude below the State of Washington’s hardness-based chronic criteria for the protection of aquatic life and the Spokane Tribe of Indian’s hardness-based chronic criteria for copper (Table 10). The Spokane Tribe of Indians have a slightly lower chronic criterion for copper.

There were no detections of metals in the transfer (total) and filter (dissolved) blanks associated with each sampling event, with the exception of total copper (0.14 ug/L) in one of the samples from the May.

Table 10. Metals Concentrations (ug/L) in Grab Samples Compared to Water Quality Criteria†.



† Water Quality Standards for the Surface Waters of the State of Washington (Ecology, 2006) Aquatic Life Chronic Criteria and Spokane Tribe of Indians Water Quality Criterion for Copper (STI, 2010).

**Bold** = Visual aid for detected compounds.

Highlighted numbers show dissolved metals concentrations compared to applicable water quality criteria.

U = Not detected above the reported quantitation limit.

NA = Not analyzed.

## Sediment Traps

Sediment traps were deployed for 3 hydrological periods ranging from 134 – 138 days or about 4.5 months each from late spring 2015 through early summer 2016. Table 11 gives the sample information and general chemistry results for sediment trap samples. Most of the sediment tables and figures are also color-coded in this section of the report to correspond with the sampling periods.

Table 11. Sediment Trap Sample Information.



TOC = Total Organic Carbon

rep = replicate sediment trap

### PCBs

Total PCB congener results for the sediment traps are shown in Figure 8. The full suite of congener results are in Appendix C, Table C-3. Concentrations for Spring-Summer (green) and Winter-Spring (blue) sampling periods and between the replicate samples were similar, ranging from 8 – 13 ug/kg (ppb), while the single Fall-Winter (yellow) sample had a concentration between 2-3 times higher (29 ppb). All tPCB results were below the Washington State Freshwater Sediment Cleanup Objective (SCO) of 110 ug/Kg (*based on* *total PCB Aroclors*).



Figure 8. Total PCB Congeners in Suspended Sediments (ug/Kg, dry weight).

PCB homologue analyses of the suspended sediment samples did not indicate an easily discernable difference between homologue patterns among the three sampling periods (Figure 9). The majority of the congeners came from the tetra-, penta- and hexa- homologue groups.



Figure 9. Homologue Distribution of PCBs in Suspended Sediments.

### PBDEs

PBDEs followed the same pattern as PCBs with the Fall-Winter having 2-3 times the concentration of the Spring-Summer and Winter-Spring sampling periods (Figure 10). The full suite of PBDE congener results can be found in Appendix C, Table C-4.



Figure 10. Total PBDEs in Suspended Sediments (ug/Kg, dry weight).

### Dioxins and Furans

Dioxins and furans followed the same pattern as PCBs and PBDEs with the Fall-Winter having 2-3 times the concentration of the other sampling periods (Table 12 and Figure 11). Figure 11 graphs the calculated dioxin Toxicity Equivalent Quotient (TEQ) values. TEQs are toxicity-weighted totals that are based on 2,3,7,8-TCDD, the most toxic of the dioxin congeners.

Table 12. Dioxins and Furans Results for Sediment Traps (pg/g, part per trillion, dry weight).



1 Toxicity Equivalent Quotient (TEQ) calculated using Toxic Equivalency Factors (TEFs) from EPA, 2010.

**Bold**: Visual aid for detected compounds.

ND = 0: Non-detected values (UJ qualified) are not included in the TEQ calculation.

J: Analyte positively identified, results is an estimate.

NJ: Analyte tentatively identified, result is approximate.

UJ: Analyte not found at the estimated reporting limit shown.



Figure 11. Dioxins and Furans TEQs.

### Metals

Suspended sediments were analyzed for cadmium, copper, lead and zinc. Concentrations were generally low and well below the Washington’s freshwater Sediment Clean-up Objectives (SCO) and Clean-up Screening Levels (CSL), with exception of cadmium exceeding both SCO and CSL for all samples (Table 13).

Table 13. Metals Results for Sediment Traps (mg/Kg, part per million, dry weight).



**Bold** = Visual aid for detected compounds.

J = Analyte positively identified, results is an estimate.

SCO = Sediment Cleanup Objective; CSL = Cleanup Screening Level

Metals generally followed the same pattern as PCBs, PBDEs and dioxins with the Fall-Winter having a higher concentration than the other sampling periods, but the difference was less (Figure 12).



Figure 12. Seasonal Cadmium, Copper, Lead, and Zinc in Suspended Sediments.

## PCB Congener Patterns in all Matrices

A qualitative analysis of PCB congeners detected in all the surface water and suspended sediment samples, including the CLAM disk blanks, revealed some noticeable patterns (See Appendix C, Table C-5). Presence of a congener in Table C-5 indicates that it was detected. If the chemical signal was particularly strong compared to background contamination it is bolded and underlined. The following patterns were observed:

* Far more congeners and coelutes (two or more congeners reported together) were detected in the suspended sediment samples compared to the surface water samples. There were 91 congeners or coelutes routinely detected in the suspended sediment samples and 18 routinely detected in the surface water samples. All of the prominent PCBs found in surface water samples were also present in the suspended sediment samples.
* The lighter molecular weight congeners (mono- through tetra- homologues) were the major contamination contributors in the high-density polypropylene CLAM disk housing, including PCB-011 (Table C-5). The heavier PCBs (penta- through Octa- homologues) were more prominent in the surface water samples.

# Discussion

## Seasonality and River Flow

Flow discharge in the Spokane River at the study sites located in Little Falls Pool, is determined almost entirely by the discharge of water from Long Lake Dam at the outlet of Lake Spokane. Spokane River flows are largely controlled by dam operations. Natural seasonal events such as spring snowmelt and storm events in the spring, fall and winter can also impact river flow.

Hydrological events can influence both erosion and runoff processes in riverine and reservoir systems. Stormwater runoff can wash contaminants off the land and into surface water. Fluctuating water levels in a reservoir can lead to resuspension and transport of deposited sediments downstream (Thornton et al., 1990). Lake Spokane was drawn-down in January 2016 while sediment traps were deployed in Little Falls Pool. This draw-down happens about every other year on average when winter flows allow (Avista, Personal Communication).

The role of seasonal river flows and the Lake Spokane draw-down event along with timing of the surface water and sediment trap sample collection likely influenced study results. This will be explored further in the following discussion.

## Surface Water

In June 2016 and February 2017, as part of Ecology’s study: *Assessment Methods for Sampling Low-Level Toxics in Surface Waters* (Low Level study), CLAMs were used to measure PCBs at the UGM monitoring site (Hobbs and McCall, 2016). Researchers for the Low Levelstudy collaborated with the researchers of this study to compile a more robust data set for the CLAM data. This data will be used to draft a Standard Operating Procedure (SOP) for use of the CLAM in monitoring toxics chemicals in Washington State surface waters.

While the 2017 CLAM results from the Low Levelstudy are not yet available, the June 2016 results were found to be similar to those in the current Spokane Tribal Boundary study (Table 14). The precision between triplicate CLAM sample results for the Low Levelstudy was very good with a relative standard deviation (RSD) of 2.6%. The similarity of tPCB results between to the two studies, especially between samples collected in May 2015 and June 2016 (similar seasons) ads to a preponderance of evidence that tPCB concentrations in surface water at the UGM site tend to trend below 100 pg/L. Mean concentrations of tPCBs (after transfer blank subtraction) for the Spokane Tribal Boundary Study range from 63-87 pg/L.

Table 14. Total PCBs in Surface Water at the UGM Monitoring Site from Two Studies.



NA = not applicable – Original sample mass not given by Lab, but reported as pg/L.

† = Data from Assessment Methods for Sampling Low-Level Study (*report in draft*).

\* = Values reported after subtraction of transfer blank results.

The researchers for the Low Levelstudy used CLAM disks with a stainless steel housing instead of high-density polypropylene and found considerably less background contamination. Total PCB concentrations in the SPE blank disks accounted for only 1-2% of the tPCBs in samples for the Low Level Study, while tPCB SPE blank disk concentrations accounted for roughly half of the tPCBs in the Spokane Tribal Boundary Study (Table 15).

Table 15. Contribution of Total PCBs to Samples from SPE Disk Blank Results.

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\* = Data from Assessment Methods for Sampling Low-Level Study (*report in draft*).

## Suspended Sediments

### Increased Contaminant Signal in Fall-Winter Deployment

The increase in suspended sediment contaminant concentrations in the Fall-Winter (9/10/15 – 1/26/16) sediment trap deployment period was further explored for PCBs. Figure 13 shows the relative Total PCB concentrations when normalized to % solids and % TOC. The increased concentration in Fall-Winter is still present, though significantly reduced when TOC is accounted for.



Figure 13. Total PCBs in Suspended Sediments Normalized to % Solids and % TOC.

One possibility for why there were higher contaminant concentrations in the Fall-Winter suspended sediment sample is that Lake Spokane was drawn-down in January 2016, when the sediment traps were deployed in Little Falls pool (see Figure 14). Depositional lake sediments may have been mobilized downstream during the draw-down causing a relative spike in PCBs for the 4.5 month deployment period. Another possibility is that storm events contributed to wash off of PCBs from the land during this period. Rainfall data shows a significant storm occurred in the Spokane River watershed in early December, including over an inch of rain on December 7th, 2015 (Weather Underground). There was a sudden increase in discharge from Long Lake Dam on December 9th which may have been in response to the December storm event (see Figure 14).



Figure 14. Mean Total PCBs (ppb) in Suspended Sediments with Hydrograph.

### Sediment Traps versus Centrifugation

Suspended sediments were also collected at the same time as CLAM samples during the *Assessment Methods for Low-Level Toxics* (Low Level)study (Hobbs and McCall, 2016). Suspended sediments were collected with EAP’s centrifuge trailer system that consists of 2 large capacity flow-through centrifuges (Alpha Laval, Sedisamp II, Model 101L). Sampling occurred over a 24-hour period with more than 1600 liters of river water processed through each centrifuge.

Figure 15 presents the total PCB concentrations from the replicate centrifuges on June 10, 2016 (13.2 and 15.8 ppb). These results are similar to the Spring-Summer (4/29/15 – 9/10/15) and Winter-Spring (1/26/16 – 6/9/16) results from the Spokane Tribal Boundary study. Total PBDE concentrations from June 10, 2016 are also similar to Spring-Summer and Winter-Spring results (Figure 16). February 2017 suspended sediment data from the Low Levelstudy are not yet available.



Figure 15. PCBs in Suspended Sediments at the UGM site Collected by Sediment Traps and Centrifugation.



Figure 16. PBDEs in Suspended Sediments at the UGM site Collected by Sediment Traps and by Centrifugation.

## 

# Conclusions

Results of this 2015–2016 study support the following conclusions:

* The mean of seasonal total PCB surface water concentrations for the study ranged from 63 – 87 pg/L at the upper Spokane Tribal boundary monitoring location (Union Gospel Mission dock) using several collection and extraction methods (2 liter, CLAM and XAD-2). Surface water results are higher than the Washington State Human Health water quality criterion (7 pg/L) and the Spokane Tribal water quality criterion of 1.3 pg/L for Total PCBs. Study results were calculated using less conservative data censoring and data reduction methods (3x laboratory method blank or CLAM SPE disk blank and inclusion of NJ qualified data) that could potentially bias results high. Data generated from CLAM and XAD-2 will not be used for formal assessment of water quality criteria attainment and were not entered into Ecology’s EIM database.
* The CLAM collection method employed during this study used SPE disk housings made of high-density polypropylene which contained measurable levels of the mono- through tetra- PCB congeners as well as some PBDEs. Though the authors’ were able to censor the environmental samples against the blank CLAM SPE disk results, there would be more confidence in the data had the sampling system not been contaminated.
* Metals (cadmium, copper, lead, and zinc) in seasonal surface water grab samples were 1-2 orders of magnitude lower than the State of Washington’s hardness-based chronic criteria for the protection of aquatic life and the Spokane Tribe of Indian’s hardness-based chronic criteria for copper. Metals in suspended sediment samples were well below Washington’s freshwater sediment screening levels, except for cadmium which exceeded the Sediment Clean-up Objective and Clean-up Screening level.
* All total PCB results for suspended sediments from sediment traps were below the Washington State Freshwater Sediment Cleanup Objective of 110 ug/Kg.
* PCB, PBDE and dioxins/furan concentrations were 2 – 3 times higher in suspended sediments from traps deployed during the fall – winter (9/10/15 – 1/26/16) monitoring period compared to the other 2 monitoring periods.

# Recommendations

Results of this 2015–2016 study support the following recommendations:

* Sediment traps provide an excellent seasonal average of pollutants in the water column and have fewer data quality issues (e.g., blank contamination). Seasonal Sediment trap monitoring should continue at the eastern Spokane Tribal boundary monitoring site in Little Falls Pool (upstream of Chamokane Creek and near the Union Gospel Mission) to assess contaminant trends. Sediment trap monitoring could be expanded if resources are available to include the Upriver Dam and Nine Mile Dam reservoirs since they showed relative contaminant trends in the Spokane River. Specific enhancements to sediment trap monitoring include:
  + Provide additional secure means of retrieval (besides just a snag line) with the use of either a transponder or being cabled to the bank.
  + Deploy multiple traps per site to ensure that enough solid sample material is collected for analyses.
  + Analyses should include both PCB congeners and PBDEs. Dioxins/furans and any metals of interest could be added to the analyte list if funding allows.
* Continue seasonal contaminant monitoring with CLAMs at the eastern Spokane Tribal boundary surface water monitoring location (Union Gospel Mission dock). Use of stainless steel disk housing should eliminate contamination issues from high-density polypropylene housing. Analysis should be conducted for PCBs, and PBDEs if funding allows.
* Surface water monitoring during draw-down events in Lake Spokane could confirm if increased levels of contaminants sorbed to sediments are transported into Little Falls Pool. CLAMs could be used to test for PCBs and other contaminants of interest. Total Suspended Solids (TSS) and turbidity should be monitored at the same time.

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# Appendices

## 

## Appendix A. 303(d) Listings for Toxics in the Spokane River

Table A-1 shows all the water quality impairments and waters of concern for toxics parameters in the mainstem Spokane River including Lake Spokane. Not shown in Table A-1 are the listings for category 1 (meets tested criteria) and category 3 (insufficient data).

Table A-1. 303(d) Listings for Toxic Parameters in the Spokane River.



## Appendix B. Data Quality Tables

Table B-1. Results for Laboratory Measure Quality Objectives (MQOs).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Matrix / Sampling Dates** | **LCS**  **(%**  **Recovery)** | **Pass?** | **Duplicate samples (RPD)** | **Pass?** | **MS**  **(%**  **Recovery)** | **Pass?** | **MSD (RPD)** | **Pass?** | **Surrogate Recoveries**  **(%**  **Recovery)** | **Pass?** |
| DOC & TOC | Surface Water | 80 – 120 | Yes | ≤20% | Yes | 75 – 125 | Yes | ≤20% | NAF | NA | NA |
| TSS & TNVSS | 80 – 120 | Yes | ≤20% | Yes | NA | NA | NA | NA | NA | NA |
| Hardness | 85 – 115 | Yes | ≤20% | NAF | 75 – 125 | Yes | ≤20% | Yes | NA | NA |
| Cd, Cu, Pb, & Zn | 85 –115 | Yes | ≤20% | NAF | 75 –125 | Yes | ≤20% | Yes | NA | NA |
| PCBs | CLAM | 50 – 150 | Yes | ≤50% | NAF | NA | NA | NA | NA | 25 – 150 | Yes |
| PBDEs | 50 – 150 | Yes | ≤50% | NAF | NA | NA | NA | NA | 25 – 150 | Mostly (a) |
| PCBs | XAD-2 | 50 – 150 | Yes | ≤50% | NAF | NA | NA | NA | NA | 25 – 150 | Yes |
| PCBs | 2 Liter | 50 – 150 | Yes | ≤50% | NAF | NA | NA | NA | NA | 25 – 150 | Yes |
| TOC | Suspended Sediment | 80 – 120 | Yes | ≤20% | Yes | NA | NA | NA | NA | NA | NA |
| % solids | NA | NA | ≤20% | NAF | NA | NA | NA | NA | NA | NA |
| Cd, Cu, & Pb | 85 – 115 | Yes | ≤20% | Yes | 75 – 125 | Mostly (b) | ≤20% | Yes | NA | NA |
| Zinc | 85 – 115 | Yes | ≤20% | Yes | 75 – 125 | No (c) | ≤20% | No | NA | NA |
| PCBs | 50 – 150† | Mostly (d) | ≤50% | Yes (e) | NA | NA | NA | NA | 25 – 150 | Yes |
| PBDEs | 50 – 150† | Yes | ≤50% | Yes (f) | NA | NA | NA | NA | 25 – 150 | Yes |
| Dioxins/furans | 25 – 150† | Mostly (g) | ≤50% | Yes | NA | NA | NA | NA | 25 – 150 | Yes |

NA = Not applicable.

NAF = Not analyzed for.

Yes = Defined as 100% of the specific QA/QC compounds were within acceptance limits defined by the laboratory method quality objectives (MQOs).

Mostly = Defined as >50% of the specific QA/QC compounds were within acceptance limits defined by the laboratory MQOs.

Some = Defined as <50% of the specific QA/QC compounds were within acceptance limits defined by the laboratory MQOs.

No = None of the specific QA/QC compounds were within acceptance limits defined by laboratory MQOs.

**Notes for Table B-1 (continued)**

† Per Method for Ongoing Precision and Recovery (OPR), internal standards and labeled compounds.

1. For the May 2015 sampling, all the surrogates were within recovery limits. For September, 2 of 4 samples had slightly low recoveries for PBDE 209L at 23% and 24%.
2. The MS and MSD for copper were within recovery acceptance limits (75 – 125%). The MS for cadmium was slightly high (126%) and the MS for lead was low (73%), however the MSD recoveries for both cadmium and copper were acceptable. The source sample results for cadmium and lead were therefore qualified as estimates (“J”).
3. MS and MSD recoveries for zinc were not calculated due to homogeneity in the source sample.
4. The OPR criteria were met for all the labeled standards with the exception of PCBs 001, 002 and 003, which had no recoveries at all, therefore the associated samples were qualified as estimates with a “J” flag. Labeled CB congener recoveries and Clean-up standard recoveries were all within acceptance limits.
5. Almost all (143/146) of the detected duplicate congener pairs had an RPD ≤50% with an average RPD of 8%.
6. All (n = 35) of the detected duplicate congener pairs had an RPD ≤50% with an average RPD of 8%.
7. The OPR criteria were met for the dioxin/furan analysis. With the exception of the labeled standards in sample number 1606061-2, the rest of the samples met the labeled standard recovery control limits. Due to possible low bias, the results associated with the out of control labeled compound recoveries in the sample were flagged as estimated with either a “J” or “UJ” flag.

## Appendix C. Data Tables

Table C-1 and C-2 (See attached Excel spreadsheets).

Table C-3. PCB Results for Sediment Traps, pg/g, part per trillion, dry weight.

| Sampling Season | Spring - Summer | | | | Fall - Winter | | Winter - Spring | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample Dates | 4/29/15 - 9/10/15 | | | | 9/10/15 - 1/26/16 | | 1/26/16 - 6/9/16 | | | |
| Sample No. | 1606061-1 | | 1606061-2 | | 1606061-3 | | 1606061-4 | | 1606061-5 | |
| PCB-001 | **5.28** | **J** | **6.47** |  | **6.52** |  | **3.18** |  | **2.36** |  |
| PCB-002 | **12.1** |  | **12.4** |  | **15.7** |  | **9.69** |  | **9.3** |  |
| PCB-003 | **8** | **J** | **7** |  | **8.28** |  | **4.7** |  | **3.77** |  |
| PCB-004 | **4.19** | **J** | **6.29** |  | **8.17** |  | **9.41** |  | **4.03** |  |
| PCB-005 | 1.93 | UJ | **0.336** | **NJ** | **0.46** | **J** | **0.135** | **J** | **0.23** | **J** |
| PCB-006 | **2.11** | **J** | **2.98** |  | **5.84** |  | **2.47** |  | **3.32** |  |
| PCB-007 | 1.8 | UJ | **0.986** |  | **1.2** | **J** | **0.497** |  | **0.669** |  |
| PCB-008 | **9.58** |  | **13.1** |  | **24.5** |  | **10.6** |  | **14.9** |  |
| PCB-009 | 1.67 | UJ | **1.08** |  | **1.4** |  | **0.584** |  | **0.722** |  |
| PCB-010 | 1.76 | UJ | **0.279** | **J** | **0.527** | **NJ** | **0.392** |  | **0.209** | **J** |
| PCB-011 | **68.1** |  | **95** |  | **166** |  | **44** |  | **70.7** |  |
| PCB-012/013 | **5.23** | **J** | **7.23** |  | **12.1** |  | **5.06** |  | **7.18** |  |
| PCB-014 | **2.94** | **J** | **0.578** | **J** | **1.3** | **J** | **0.429** | **NJ** | **0.521** | **NJ** |
| PCB-015 | **36.9** |  | **46.3** |  | **118** |  | **41.4** |  | **55** |  |
| PCB-016 | **13.9** |  | **14.9** |  | **33** |  | **24.6** |  | **23.9** |  |
| PCB-017 | **19.3** |  | **16.2** |  | **42.7** |  | **24.2** |  | **27.1** |  |
| PCB-018/030 | **43.7** |  | **33.3** |  | **80.4** |  | **58.2** |  | **61.3** |  |
| PCB-019 | **5.25** | **J** | **5.02** |  | **10.2** |  | **7.45** |  | **5.39** |  |
| PCB-020/028 | **187** |  | **183** |  | **547** |  | **214** |  | **291** |  |
| PCB-021/033 | **26.1** |  | **29.9** |  | **79.4** |  | **36.4** |  | **54.3** |  |
| PCB-022 | **35.2** |  | **36.7** |  | **95.3** |  | **40.9** |  | **54.6** |  |
| PCB-023 | 0.506 | UJ | 0.168 | UJ | **0.224** | **J** | **0.089** | **J** | 0.113 | UJ |
| PCB-024 | **1.08** | **J** | **0.591** | **J** | **1.56** |  | **0.872** |  | **0.939** |  |
| PCB-025 | **11.1** |  | **8.65** |  | **25** |  | **10.7** |  | **14.2** |  |
| PCB-026/029 | **19.2** |  | **19.2** |  | **53** |  | **24.1** |  | **32.3** |  |
| PCB-027 | **4.99** | **J** | **3.7** |  | **10.7** |  | **5.87** |  | **6.3** |  |
| PCB-031 | **106** |  | **107** |  | **296** |  | **127** |  | **170** |  |
| PCB-032 | **4.47** |  | **5.24** |  | **22** |  | **15.6** |  | **13.6** |  |
| PCB-034 | **1.71** | **J** | **1.17** |  | **4.05** |  | **1.41** |  | **2.27** |  |
| PCB-035 | **4.08** | **J** | **5.18** |  | **12.7** |  | **4.25** |  | **6.23** | **NJ** |
| PCB-036 | 0.486 | NUJ | **0.735** | **J** | **1.26** |  | 0.197 | NUJ | 0.342 | NUJ |
| PCB-037 | **67.3** |  | **61.5** |  | **210** |  | **74.3** |  | **108** |  |
| PCB-038 | **1.41** | **J** | **1.24** |  | **2.11** |  | **0.447** | **NJ** | **0.52** | **NJ** |
| PCB-039 | **2.05** | **J** | **2.29** |  | **6.74** |  | **1.9** | **NJ** | **2.76** |  |
| PCB-040/041/071 | **89.7** |  | **77.2** |  | **304** |  | **112** |  | **173** |  |
| PCB-042 | **78.2** |  | **71.7** |  | **236** |  | **78.6** |  | **119** |  |
| PCB-043 | **11.3** | **J** | **8.59** |  | **25.8** |  | **9.31** |  | **14.1** |  |
| PCB-044/047/065 | **314** |  | **268** |  | **778** |  | **274** |  | **397** |  |
| PCB-045/051 | **35.3** |  | **32.3** |  | **80.3** |  | **37.1** |  | **47** |  |
| PCB-046 | **10.4** |  | **8.11** |  | **24.9** |  | **11.2** |  | **14.9** |  |
| PCB-048 | **41.8** |  | **37.5** |  | **122** |  | **42.8** |  | **64.8** |  |
| PCB-049/069 | **203** |  | **174** |  | **538** |  | **164** |  | **257** |  |
| PCB-050/053 | **31.4** |  | **22** |  | **63.1** |  | **26.9** |  | **37.1** |  |
| PCB-052 | **344** |  | **291** |  | **817** |  | **284** |  | **415** |  |
| PCB-054 | 0.452 | NUJ | 0.363 | UJ | **0.809** | **NJ** | 0.32 | U | 0.396 | UJ |
| PCB-055 | **2.47** | **J** | 0.328 | UJ | 0.452 | UJ | 0.136 | UJ | 0.214 | UJ |
| PCB-056 | **124** |  | **115** |  | **420** |  | **148** |  | **214** |  |
| PCB-057 | **1.14** | **J** | **1.01** |  | **3.82** |  | **0.919** | **J** | **1.45** |  |
| PCB-058 | **1.87** | **J** | **1.83** |  | **6.2** |  | **1.67** | **J** | **2.79** |  |
| PCB-059/062/075 | **28.5** |  | **24.6** |  | **77.8** |  | **24.1** |  | **35.9** |  |
| PCB-060 | **63.7** |  | **59** |  | **162** |  | **67.6** |  | **93.2** |  |
| PCB-061/070/074/076 | **562** |  | **498** |  | **1590** |  | **510** |  | **779** |  |
| PCB-063 | **16.5** |  | **15.3** |  | **48.2** |  | **14.4** |  | **21.4** |  |
| PCB-064 | **158** |  | **127** |  | **391** |  | **127** |  | **194** |  |
| PCB-066 | **418** |  | **402** |  | **1320** |  | **391** |  | **601** |  |
| PCB-067 | **8.2** | **J** | **6.7** |  | **23.3** |  | **7.64** |  | **11.8** |  |
| PCB-068 | **6.43** | **J** | **6.58** |  | **14.7** |  | **4.85** |  | **5.73** |  |
| PCB-072 | **5.34** | **J** | **4.74** |  | **14.7** |  | **3.99** |  | **6.16** |  |
| PCB-073 | 0.117 | UJ | 0.113 | UJ | 0.232 | UJ | 0.0343 | UJ | 0.105 | UJ |
| PCB-077 | **40** |  | **35** |  | **106** |  | **40.8** |  | **53.8** |  |
| PCB-078 | 0.936 | UJ | 0.324 | UJ | 0.447 | UJ | 0.135 | UJ | 0.212 | UJ |
| PCB-079 | **7.52** | **J** | **6.79** |  | **19.9** |  | **5.03** |  | **7.18** |  |
| PCB-080 | 0.835 | UJ | 0.291 | UJ | 0.401 | UJ | 0.121 | UJ | 0.189 | UJ |
| PCB-081 | **1.57** | **J** | **1.34** |  | **3.5** |  | **1.06** |  | **1.6** |  |
| PCB-082 | **65.2** |  | **49.7** |  | **168** |  | **48.6** |  | **72.8** |  |
| PCB-083/099 | **435** |  | **316** |  | **1020** |  | **235** |  | **371** |  |
| PCB-084 | **113** |  | **85.6** |  | **301** |  | **78.2** |  | **123** |  |
| PCB-085/116/117 | **128** |  | **114** |  | **352** |  | **86.3** |  | **132** |  |
| PCB-086/087/097/109/119/125 | **344** |  | **272** |  | **872** |  | **226** |  | **348** |  |
| PCB-088/091 | **88.3** |  | **67.4** |  | **239** |  | **53.6** |  | **86.4** |  |
| PCB-089 | **5.11** | **J** | **4.5** |  | **17.4** |  | **5.38** |  | **7.71** |  |
| PCB-090/101/113 | **578** |  | **416** |  | **1290** |  | **309** |  | **483** |  |
| PCB-092 | **106** |  | **82.5** |  | **259** |  | **60.6** |  | **94.7** |  |
| PCB-093/095/098/100/102 | **404** |  | **280** |  | **884** |  | **237** |  | **349** |  |
| PCB-094 | **2.9** | **J** | **2.27** |  | **7.03** | **NJ** | **1.71** |  | **2.66** |  |
| PCB-096 | **3.18** | **J** | **2.14** |  | **7.38** |  | **2.17** |  | **3.25** |  |
| PCB-103 | **5.41** | **J** | **4.06** |  | **13.5** |  | **2.79** |  | **4.53** |  |
| PCB-104 | 0.117 | UJ | 0.168 | UJ | 0.259 | UJ | **0.045** | **NJ** | 0.107 | UJ |
| PCB-105 | **219** |  | **163** |  | **484** |  | **156** |  | **219** |  |
| PCB-106 | 2.29 | UJ | 0.559 | UJ | 0.675 | UJ | 0.206 | UJ | 0.552 | UJ |
| PCB-107 | **43.7** |  | **35.1** |  | **99.4** |  | **29.4** |  | **40.9** |  |
| PCB-108/124 | **14.5** |  | **14.5** |  | **43.7** |  | **12.9** |  | **18.8** |  |
| PCB-110/115 | **641** |  | **484** |  | **1520** |  | **387** |  | **587** |  |
| PCB-111 | **1.36** | **NJ** | 0.292 | UJ | **1** | **J** | **0.15** | **NJ** | **0.279** | **J** |
| PCB-112 | 0.444 | UJ | 0.287 | UJ | 0.491 | UJ | 0.0583 | UJ | 0.181 | UJ |
| PCB-114 | **13** | **J** | **9.69** |  | **26.2** |  | **8.72** |  | **12.5** |  |
| PCB-118 | **511** |  | **392** |  | **1220** |  | **347** |  | **500** |  |
| PCB-120 | **3.01** | **J** | **2.25** |  | **6.88** |  | **1.62** |  | **2.44** |  |
| PCB-121 | 0.453 | UJ | 0.299 | UJ | 0.512 | UJ | **0.077** | **NJ** | 0.189 | UJ |
| PCB-122 | **6.24** | **J** | **5.65** |  | **15.6** |  | **5.3** |  | **7.3** |  |
| PCB-123 | **13.5** |  | **10.8** |  | **29.9** |  | **7.16** |  | **10.7** |  |
| PCB-126 | 2.1 | UJ | **2.33** |  | **5.21** |  | **1.79** |  | **2.36** |  |
| PCB-127 | 2.37 | UJ | **0.885** |  | **2.41** |  | **0.492** |  | **1.09** |  |
| PCB-128/166 | **113** |  | **74.9** |  | **231** |  | **57.7** |  | **85.7** |  |
| PCB-129/138/160/163 | **769** |  | **519** |  | **1680** |  | **362** |  | **549** |  |
| PCB-130 | **49.5** |  | **33.8** |  | **100** |  | **22.9** |  | **36** |  |
| PCB-131 | **7.19** | **J** | **3.22** | **J** | **14.7** |  | **2.98** |  | **4.69** | **NJ** |
| PCB-132 | **195** |  | **113** |  | **435** |  | **96.6** |  | **148** |  |
| PCB-133 | **11.7** |  | **8.48** |  | **27.5** | **NJ** | **5.52** |  | **8.13** |  |
| PCB-134/143 | **25.5** |  | **18.5** |  | **58.8** |  | **13.3** |  | **21.2** |  |
| PCB-135/151/154 | **231** |  | **145** |  | **491** |  | **101** |  | **159** |  |
| PCB-136 | **69.2** |  | **37.3** |  | **142** |  | **28.5** |  | **45.9** |  |
| PCB-137 | **18.5** |  | **16.8** |  | **55.2** |  | **12.4** |  | **18.7** |  |
| PCB-139/140 | **9.04** | **J** | **5.57** | **J** | **21.5** |  | **4.31** | **NJ** | **7.62** |  |
| PCB-141 | **121** |  | **73.4** |  | **240** |  | **52.1** |  | **80.2** |  |
| PCB-142 | 2.42 | UJ | 1.07 | UJ | 1.63 | UJ | 0.597 | UJ | 1.26 | UJ |
| PCB-144 | **29.3** |  | **15.6** |  | **48.1** |  | **11.4** |  | **18.2** |  |
| PCB-145 | 0.117 | UJ | 0.104 | UJ | **0.587** |  | **0.038** | **NJ** | **0.066** | **NJ** |
| PCB-146 | **116** |  | **85.7** |  | **245** |  | **56.5** |  | **87.6** |  |
| PCB-147/149 | **542** |  | **328** |  | **1220** |  | **249** |  | **377** |  |
| PCB-148 | **1.56** | **J** | **0.538** | **J** | **2.96** | **NJ** | **0.415** | **NJ** | **0.559** | **J** |
| PCB-150 | **0.601** | **J** | **0.315** | **NJ** | **1.77** | **NJ** | **0.391** | **J** | **0.284** | **NJ** |
| PCB-152 | **0.236** | **NJ** | 0.104 | UJ | **0.432** | **J** | **0.257** | **J** | **0.426** | **NJ** |
| PCB-153/168 | **681** |  | **457** |  | **1520** |  | **298** |  | **478** |  |
| PCB-155 | **0.747** | **NJ** | **0.87** |  | **2.76** |  | **0.416** |  | **0.733** |  |
| PCB-156/157 | **65.9** |  | **46.1** |  | **122** |  | **37.6** |  | **57** |  |
| PCB-158 | **55.3** |  | **36.1** |  | **125** |  | **29.3** |  | **44.2** |  |
| PCB-159 | 1.7 | UJ | **6.86** | **J** | **20.9** |  | **0.576** | **J** | **0.892** | **NJ** |
| PCB-161 | 1.66 | UJ | 0.736 | UJ | 1.12 | UJ | 0.41 | UJ | 0.863 | UJ |
| PCB-162 | **1.77** | **J** | **2.04** | **J** | **3.6** | **J** | **1.04** | **J** | **1.3** | **J** |
| PCB-164 | **48.3** |  | **33.1** |  | **102** |  | **22.3** |  | **35.5** |  |
| PCB-165 | 1.83 | UJ | 0.813 | UJ | 1.23 | UJ | 0.453 | UJ | 0.954 | UJ |
| PCB-167 | **28.6** |  | **18.6** |  | **51.2** |  | **14.6** |  | **21.1** |  |
| PCB-169 | 1.67 | UJ | 1.4 | UJ | 3.05 | UJ | 0.807 | UJ | 1.39 | UJ |
| PCB-170 | **212** |  | **150** |  | **305** |  | **86.8** |  | **141** |  |
| PCB-171/173 | **65.6** |  | **45.9** |  | **93.2** |  | **23.7** |  | **36.7** |  |
| PCB-172 | **45.1** |  | **26.3** |  | **66** |  | **15.1** |  | **23.4** |  |
| PCB-174 | **210** |  | **127** |  | **337** |  | **87.1** |  | **137** |  |
| PCB-175 | **10.4** |  | **5.55** |  | **15.3** |  | **3.34** |  | **5.69** |  |
| PCB-176 | **24.8** | **NJ** | **15.3** |  | **40.4** |  | **10.1** |  | **18** |  |
| PCB-177 | **112** |  | **72** |  | **174** |  | **48.7** |  | **74.9** |  |
| PCB-178 | **48.8** |  | **35.3** |  | **99.8** |  | **23.4** |  | **37.3** |  |
| PCB-179 | **86.7** |  | **56.5** |  | **148** |  | **37.6** |  | **68.6** |  |
| PCB-180/193 | **581** |  | **352** |  | **827** |  | **240** |  | **361** |  |
| PCB-181 | **0.54** | **NJ** | **0.996** | **NJ** | **1.75** | **NJ** | **0.619** |  | **0.917** |  |
| PCB-182 | **2.21** | **J** | **1.03** |  | **3.52** | **J** | **0.721** |  | **0.828** |  |
| PCB-183/185 | **159** |  | **99.5** |  | **248** |  | **59.8** |  | **101** |  |
| PCB-184 | **1.69** | **J** | **1.04** | **NJ** | **3.78** | **J** | **0.738** |  | **1.23** |  |
| PCB-186 | 0.117 | UJ | 0.25 | UJ | **0.211** | **J** | 0.0865 | UJ | 0.156 | UJ |
| PCB-187 | **316** |  | **208** |  | **607** |  | **141** |  | **224** |  |
| PCB-188 | **0.55** | **NJ** | **0.573** | **J** | **1.38** |  | **0.308** |  | **0.481** |  |
| PCB-189 | **9.32** | **J** | **5.84** |  | **13.1** |  | **3.97** |  | **5.67** |  |
| PCB-190 | **50.7** |  | **29.9** |  | **58.2** |  | **17.2** |  | **24.4** |  |
| PCB-191 | **8.95** | **J** | **4.14** |  | **11.7** | **J** | **2.86** |  | **4.13** |  |
| PCB-192 | 0.117 | UJ | 0.274 | UJ | 0.222 | UJ | 0.0948 | UJ | 0.171 | UJ |
| PCB-194 | **117** |  | **81.8** |  | **189** |  | **54.7** |  | **83.6** |  |
| PCB-195 | **47.8** |  | **32.5** |  | **78.4** |  | **22.2** |  | **37.2** |  |
| PCB-196 | **62.2** |  | **42.3** |  | **108** |  | **25.8** |  | **44.7** |  |
| PCB-197/200 | **20.2** |  | **13.4** |  | **39.1** | **NJ** | **8.88** |  | **16.9** |  |
| PCB-198/199 | **154** |  | **110** |  | **305** |  | **83.5** |  | **136** |  |
| PCB-201 | **14.3** |  | **11.5** |  | **29.5** |  | **8.06** |  | **13.2** |  |
| PCB-202 | **34.4** |  | **24.4** |  | **70.2** |  | **17.2** |  | **28.2** |  |
| PCB-203 | **111** |  | **67.2** |  | **199** |  | **53.4** |  | **80** |  |
| PCB-204 | **0.282** | **NJ** | **0.131** | **NJ** | 0.197 | UJ | **0.085** | **NJ** | **0.127** | **J** |
| PCB-205 | **5.79** | **J** | **3.83** |  | **8.85** |  | **2.67** |  | **4.31** |  |
| PCB-206 | **67.4** |  | **53.2** |  | **154** |  | **45.1** |  | **73.8** |  |
| PCB-207 | **8.75** | **J** | **13.9** |  | **22.9** |  | **6.83** |  | **10.9** |  |
| PCB-208 | **21** |  | **36.5** |  | **54.7** |  | **15.5** |  | **25.8** |  |
| **PCB-209** | **46.1** |  | **40.7** |  | **81.7** |  | **25** |  | **39.9** |  |
| **1-Mono** | **25** |  | **26** |  | **31** |  | **18** |  | **15** |  |
| **2-Di** | **129** |  | **174** |  | **339** |  | **115** |  | **157** |  |
| **3-Tri** | **554** |  | **536** |  | **1533** |  | **672** |  | **875** |  |
| **4-Tetra** | **2604** |  | **2295** |  | **7191** |  | **2388** |  | **3568** |  |
| **5-Penta** | **3744** |  | **2816** |  | **8885** |  | **2304** |  | **3480** |  |
| **6-Hexa** | **3191** |  | **2080** |  | **6963** |  | **1481** |  | **2287** |  |
| **7-Hepta** | **1945** |  | **1237** |  | **3054** |  | **803** |  | **1266** |  |
| **8-Octa** | **567** |  | **387** |  | **1027** |  | **276** |  | **444** |  |
| **9-Nona** | **97** |  | **104** |  | **232** |  | **67** |  | **111** |  |
| **Total PCBs** | **12904** |  | **9695** |  | **29337** |  | **8150** |  | **12244** |  |

**Bold** = Visual aid for detected compounds.

J = Analyte positively identified, results is an estimate.

NJ = Analyte tentatively identified, result is approximate.

UJ = Analyte not found at the estimated reporting limit shown.

NUJ = Analyte tentatively identified and not found at the estimated reporting limit shown.

Table C-4. PBDE Results for Sediment Traps, pg/g, part per trillion, dry weight.



**Bold** = Visual aid for detected compounds.

J = Analyte positively identified, results is an estimate.

NJ = Analyte tentatively identified, result is approximate.

UJ = Analyte not found at the estimated reporting limit shown.

Table C-5. PCB Congeners Detected in Surface Water and Suspended Sediments.

| **Surface Water Samples** | | | | | | **Sediment Traps** | | | Homologue Group |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May 2015 | September 2015 | January 2016 | | CLAM Disk Blanks | |
| CLAMs (lab and field) | CLAMs (lab and field) | XAD | 2 Liter | May 2015 | September 2015 | May - Aug 2015 | Aug 2015 - Jan 2016 | Jan - Jun 2016 |
|  |  |  |  | **PCB-001** | PCB-001 | PCB-001 | PCB-001 | PCB-001 | 1 |
|  |  |  |  | **PCB-002** | **PCB-002** | **PCB-002** | **PCB-002** | **PCB-002** | 1 |
|  |  |  |  | **PCB-003** | **PCB-003** | PCB-003 | PCB-003 | PCB-003 | 1 |
|  |  |  |  | **PCB-004** | PCB-004 | PCB-004 | PCB-004 | PCB-004 | 2 |
|  |  |  |  | **PCB-006** | **PCB-006** | PCB-006 | PCB-006 | PCB-006 | 2 |
|  |  |  |  | PCB-007 | **PCB-007** |  |  |  | 2 |
|  |  |  |  | **PCB-008** | **PCB-008** | **PCB-008** | **PCB-008** | **PCB-008** | 2 |
|  |  |  |  | PCB-009 | PCB-009 |  | PCB-009 |  | 2 |
|  | PCB-010 |  |  |  |  |  |  |  | 2 |
|  |  |  |  | **PCB-011** | **PCB-011** | **PCB-011** | **PCB-011** | **PCB-011** | 2 |
|  |  |  |  | PCB-012/013 | **PCB-012/013** | PCB-012/013 | **PCB-012/013** | PCB-012/013 | 2 |
|  |  |  |  |  | PCB-014 |  |  |  | 2 |
|  |  |  |  | **PCB-015** | **PCB-015** | **PCB-015** | **PCB-015** | **PCB-015** | 2 |
|  |  |  |  | **PCB-016** | **PCB-016** | **PCB-016** | **PCB-016** | **PCB-016** | 3 |
|  |  |  |  | **PCB-017** | **PCB-017** | **PCB-017** | **PCB-017** | **PCB-017** | 3 |
|  |  |  |  | **PCB-018/030** | **PCB-018/030** | **PCB-018/030** | **PCB-018/030** | **PCB-018/030** | 3 |
|  | **PCB-019** |  |  | **PCB-019** |  | PCB-019 | **PCB-019** | PCB-019 | 3 |
|  | PCB-020/028 |  |  | **PCB-020/028** | **PCB-020/028** | **PCB-020/028** | **PCB-020/028** | **PCB-020/028** | 3 |
|  |  |  |  | **PCB-021/033** | **PCB-021/033** | **PCB-021/033** | **PCB-021/033** | **PCB-021/033** | 3 |
|  |  |  |  | **PCB-022** | PCB-022 | **PCB-022** | **PCB-022** | **PCB-022** | 3 |
|  |  |  |  |  |  |  | PCB-024 |  | 3 |
|  |  |  |  | **PCB-025** | PCB-025 | **PCB-025** | **PCB-025** | **PCB-025** | 3 |
|  |  |  |  | **PCB-026/029** | PCB-026/029 | **PCB-026/029** | **PCB-026/029** | **PCB-026/029** | 3 |
|  | PCB-027 |  |  | PCB-027 | PCB-027 | PCB-027 | **PCB-027** | PCB-027 | 3 |
|  |  |  |  | **PCB-031** | **PCB-031** | **PCB-031** | **PCB-031** | **PCB-031** | 3 |
|  |  |  |  | **PCB-032** | PCB-032 | PCB-032 | **PCB-032** | **PCB-032** | 3 |
|  | PCB-034 |  |  |  |  | PCB-034 | PCB-034 | PCB-034 | 3 |
|  |  |  | PCB-035 |  | PCB-035 | PCB-035 | **PCB-035** | PCB-035 | 3 |
|  |  |  |  | **PCB-037** | PCB-037 | **PCB-037** | **PCB-037** | **PCB-037** | 3 |
|  |  |  |  |  |  | PCB-038 | PCB-038 |  | 3 |
|  |  |  |  |  | PCB-039 | PCB-039 | PCB-039 |  | 3 |
|  | **PCB-040/041/071** |  |  | **PCB-040/041/071** | PCB-040/041/071 | **PCB-040/041/071** | **PCB-040/041/071** | **PCB-040/041/071** | 4 |
|  | **PCB-042** |  | **PCB-042** | **PCB-042** | **PCB-042** | **PCB-042** | **PCB-042** | **PCB-042** | 4 |
|  | PCB-043 |  |  |  |  | **PCB-043** | **PCB-043** | **PCB-043** | 4 |
|  |  |  |  | **PCB-044/047/065** | **PCB-044/047/065** | **PCB-044/047/065** | **PCB-044/047/065** | **PCB-044/047/065** | 4 |
|  |  |  |  | **PCB-045/051** | **PCB-045/051** | **PCB-045/051** | **PCB-045/051** | **PCB-045/051** | 4 |
|  | PCB-046 |  | PCB-046 | PCB-046 |  | **PCB-046** | **PCB-046** | **PCB-046** | 4 |
|  | **PCB-048** |  |  | **PCB-048** | PCB-048 | **PCB-048** | **PCB-048** | **PCB-048** | 4 |
|  | **PCB-049/069** | PCB-049/069 |  | **PCB-049/069** | **PCB-049/069** | **PCB-049/069** | **PCB-049/069** | **PCB-049/069** | 4 |
|  | **PCB-050/053** |  |  | **PCB-050/053** | PCB-050/053 | **PCB-050/053** | **PCB-050/053** | **PCB-050/053** | 4 |
|  | **PCB-052** |  |  | **PCB-052** |  | **PCB-052** | **PCB-052** | **PCB-052** | 4 |
|  | PCB-054 |  |  |  |  |  |  |  | 4 |
|  | **PCB-056** | PCB-056 | **PCB-056** | **PCB-056** | PCB-056 | **PCB-056** | **PCB-056** | **PCB-056** | 4 |
|  | PCB-057 |  |  |  |  | PCB-057 | PCB-057 |  | 4 |
|  |  |  |  |  |  | PCB-058 | PCB-058 | PCB-058 | 4 |
|  | **PCB-059/062/075** |  |  | PCB-059/062/075 | PCB-059/062/075 | **PCB-059/062/075** | **PCB-059/062/075** | **PCB-059/062/075** | 4 |
|  | **PCB-060** |  |  | **PCB-060** | PCB-060 | **PCB-060** | **PCB-060** | **PCB-060** | 4 |
|  | **PCB-061/070/074/076** | PCB-061/070/074/076 | **PCB-061/070/074/076** | **PCB-061/070/074/076** | PCB-061/070/074/076 | **PCB-061/070/074/076** | **PCB-061/070/074/076** | **PCB-061/070/074/076** | 4 |
|  | PCB-063 |  |  |  |  | **PCB-063** | **PCB-063** | **PCB-063** | 4 |
|  | **PCB-064** | PCB-064 |  |  | PCB-064 | **PCB-064** | **PCB-064** | **PCB-064** | 4 |
|  | **PCB-066** | PCB-066 |  | **PCB-066** | PCB-066 | **PCB-066** | **PCB-066** | **PCB-066** | 4 |
|  | PCB-067 |  |  |  |  | PCB-067 | **PCB-067** | **PCB-067** | 4 |
|  |  |  |  | PCB-068 | **PCB-068** | PCB-068 | **PCB-068** | PCB-068 | 4 |
|  | PCB-072 |  |  |  |  | PCB-072 | **PCB-072** | PCB-072 | 4 |
|  | PCB-077 | PCB-077 | PCB-077 |  |  | **PCB-077** | **PCB-077** | **PCB-077** | 4 |
| PCB-079 | PCB-079 |  |  |  |  | PCB-079 | **PCB-079** | PCB-079 | 4 |
|  |  |  |  |  |  | PCB-081 | PCB-081 | PCB-081 | 4 |
| **PCB-082** | **PCB-082** | PCB-082 | PCB-082 |  |  | **PCB-082** | **PCB-082** | **PCB-082** | 5 |
| **PCB-083/099** | **PCB-083/099** | **PCB-083/099** |  | **PCB-083/099** | PCB-083/099 | **PCB-083/099** | **PCB-083/099** | **PCB-083/099** | 5 |
| **PCB-084** | **PCB-084** | PCB-084 | **PCB-084** |  |  | **PCB-084** | **PCB-084** | **PCB-084** | 5 |
| **PCB-085/116/117** | **PCB-085/116/117** | PCB-085/116/117 | **PCB-085/116/117** |  |  | **PCB-085/116/117** | **PCB-085/116/117** | **PCB-085/116/117** | 5 |
| **PCB-086/087/097/109/119/125** | **PCB-086/087/097/109/119/125** | PCB-086/087/097/109/119/125 | **PCB-086/087/097/109/119/125** | PCB-086/087/097/109/119/125 | PCB-086/087/097/109/119/125 | **PCB-086/087/097/109/119/125** | **PCB-086/087/097/109/119/125** | **PCB-086/087/097/109/119/125** | 5 |
| **PCB-088/091** | **PCB-088/091** | PCB-088/091 | PCB-088/091 |  | PCB-088/091 | **PCB-088/091** | **PCB-088/091** | **PCB-088/091** | 5 |
| PCB-089 | PCB-089 |  |  |  |  | PCB-089 | **PCB-089** | PCB-089 | 5 |
| **PCB-090/101/113** | **PCB-090/101/113** | **PCB-090/101/113** | **PCB-090/101/113** | **PCB-090/101/113** | PCB-090/101/113 | **PCB-090/101/113** | **PCB-090/101/113** | **PCB-090/101/113** | 5 |
| **PCB-092** | **PCB-092** | PCB-092 | PCB-092 |  |  | **PCB-092** | **PCB-092** | **PCB-092** | 5 |
| **PCB-093/095/098/100/102** | **PCB-093/095/098/100/102** | PCB-093/095/098/100/102 |  |  |  | **PCB-093/095/098/100/102** | **PCB-093/095/098/100/102** | **PCB-093/095/098/100/102** | 5 |
|  | PCB-094 |  |  |  |  | PCB-094 | PCB-094 | PCB-094 | 5 |
|  | PCB-096 |  |  |  |  | PCB-096 | PCB-096 | PCB-096 | 5 |
|  |  |  |  |  |  | PCB-103 | **PCB-103** | PCB-103 | 5 |
| **PCB-105** | **PCB-105** |  |  |  |  | **PCB-105** | **PCB-105** | **PCB-105** | 5 |
| PCB-107 | PCB-107 |  | PCB-107 |  |  | **PCB-107** | **PCB-107** | **PCB-107** | 5 |
|  | PCB-108/124 |  |  |  |  | **PCB-108/124** | **PCB-108/124** | **PCB-108/124** | 5 |
| **PCB-110/115** | **PCB-110/115** | **PCB-110/115** | **PCB-110/115** | PCB-110/115 | PCB-110/115 | **PCB-110/115** | **PCB-110/115** | **PCB-110/115** | 5 |
|  | PCB-114 |  |  |  |  | **PCB-114** | **PCB-114** | **PCB-114** | 5 |
| **PCB-118** | **PCB-118** | **PCB-118** |  | PCB-118 | PCB-118 | **PCB-118** | **PCB-118** | **PCB-118** | 5 |
|  |  |  |  |  |  | PCB-120 | PCB-120 | PCB-120 | 5 |
|  |  |  |  |  |  | PCB-122 | **PCB-122** | PCB-122 | 5 |
|  |  |  |  |  |  | **PCB-123** | **PCB-123** | **PCB-123** | 5 |
|  |  |  |  |  |  |  | PCB-126 | PCB-126 | 5 |
|  |  |  |  |  |  |  | PCB-127 |  | 5 |
| **PCB-128/166** | **PCB-128/166** | PCB-128/166 | PCB-128/166 |  |  | **PCB-128/166** | **PCB-128/166** | **PCB-128/166** | 6 |
| **PCB-129/138/160/163** | **PCB-129/138/160/163** | **PCB-129/138/160/163** |  | PCB-129/138/160/163 |  | **PCB-129/138/160/163** | **PCB-129/138/160/163** | **PCB-129/138/160/163** | 6 |
| **PCB-130** | PCB-130 |  |  |  |  | **PCB-130** | **PCB-130** | **PCB-130** | 6 |
|  |  |  |  |  |  | PCB-131 | **PCB-131** | PCB-131 | 6 |
| **PCB-132** | **PCB-132** | PCB-132 | PCB-132 |  |  | **PCB-132** | **PCB-132** | **PCB-132** | 6 |
|  |  |  |  |  |  | **PCB-133** | PCB-133 | PCB-133 | 6 |
| PCB-134/143 |  |  |  |  |  | **PCB-134/143** | **PCB-134/143** | **PCB-134/143** | 6 |
| **PCB-135/151/154** | **PCB-135/151/154** | **PCB-135/151/154** | **PCB-135/151/154** | PCB-135/151/154 |  | **PCB-135/151/154** | **PCB-135/151/154** | **PCB-135/151/154** | 6 |
| **PCB-136** | PCB-136 | PCB-136 | PCB-136 |  |  | **PCB-136** | **PCB-136** | **PCB-136** | 6 |
|  | PCB-137 |  |  |  |  | **PCB-137** | **PCB-137** | **PCB-137** | 6 |
|  |  |  |  |  |  | PCB-139/140 | **PCB-139/140** | PCB-139/140 | 6 |
| **PCB-141** | **PCB-141** | PCB-141 | PCB-141 |  |  | **PCB-141** | **PCB-141** | **PCB-141** | 6 |
|  | PCB-144 |  |  |  |  | **PCB-144** | **PCB-144** | **PCB-144** | 6 |
| **PCB-146** | **PCB-146** | PCB-146 | PCB-146 |  |  | **PCB-146** | **PCB-146** | **PCB-146** | 6 |
| **PCB-147/149** | **PCB-147/149** | **PCB-147/149** | **PCB-147/149** | **PCB-147/149** | PCB-147/149 | **PCB-147/149** | **PCB-147/149** | **PCB-147/149** | 6 |
| **PCB-153/168** | **PCB-153/168** | **PCB-153/168** |  | PCB-153/168 |  | **PCB-153/168** | **PCB-153/168** | **PCB-153/168** | 6 |
|  |  |  |  |  |  |  | PCB-155 |  | 6 |
| PCB-156/157 | PCB-156/157 | PCB-156/157 | PCB-156/157 |  |  | **PCB-156/157** | **PCB-156/157** | **PCB-156/157** | 6 |
| PCB-158 | PCB-158 | PCB-158 | PCB-158 |  |  | **PCB-158** | **PCB-158** | **PCB-158** | 6 |
|  |  |  |  |  |  |  | **PCB-159** |  | 6 |
|  |  |  |  |  |  | PCB-162 | PCB-162 | PCB-162 | 6 |
| PCB-164 | PCB-164 | PCB-164 |  |  |  | **PCB-164** | **PCB-164** | **PCB-164** | 6 |
|  | PCB-167 |  |  |  |  | **PCB-167** | **PCB-167** | **PCB-167** | 6 |
| **PCB-170** | **PCB-170** | PCB-170 | PCB-170 |  |  | **PCB-170** | **PCB-170** | **PCB-170** | 6 |
| PCB-171/173 | PCB-171/173 |  |  |  |  | **PCB-171/173** | **PCB-171/173** | **PCB-171/173** | 7 |
| PCB-172 |  |  |  |  |  | **PCB-172** | **PCB-172** | **PCB-172** | 7 |
| **PCB-174** | **PCB-174** | PCB-174 | PCB-174 |  |  | **PCB-174** | **PCB-174** | **PCB-174** | 7 |
|  |  |  |  |  |  | PCB-175 | **PCB-175** | PCB-175 | 7 |
|  | PCB-176 |  |  |  |  | **PCB-176** | **PCB-176** | **PCB-176** | 7 |
| **PCB-177** | **PCB-177** |  | PCB-177 |  |  | **PCB-177** | **PCB-177** | **PCB-177** | 7 |
| PCB-178 | PCB-178 |  | PCB-178 |  |  | **PCB-178** | **PCB-178** | **PCB-178** | 7 |
| **PCB-179** | PCB-179 | PCB-179 | PCB-179 |  |  | **PCB-179** | **PCB-179** | **PCB-179** | 7 |
| **PCB-180/193** | **PCB-180/193** | PCB-180/193 |  |  |  | **PCB-180/193** | **PCB-180/193** | **PCB-180/193** | 7 |
|  |  |  |  |  |  | PCB-182 | PCB-182 |  | 7 |
| **PCB-183/185** | **PCB-183/185** | PCB-183/185 | PCB-183/185 |  |  | **PCB-183/185** | **PCB-183/185** | **PCB-183/185** | 7 |
|  |  |  |  |  |  |  | PCB-184 |  | 7 |
| **PCB-187** | **PCB-187** | PCB-187 | PCB-187 |  |  | **PCB-187** | **PCB-187** | **PCB-187** | 7 |
|  |  |  |  |  |  |  | PCB-188 |  | 7 |
|  |  |  |  |  |  | PCB-189 | **PCB-189** | PCB-189 | 7 |
|  | PCB-190 |  |  |  |  | **PCB-190** | **PCB-190** | **PCB-190** | 7 |
|  |  |  |  |  |  | PCB-191 | PCB-191 | PCB-191 | 7 |
| PCB-194 | PCB-194 |  | PCB-194 |  |  | **PCB-194** | **PCB-194** | **PCB-194** | 8 |
| PCB-195 |  |  |  |  |  | **PCB-195** | **PCB-195** | **PCB-195** | 8 |
|  | PCB-196 |  | PCB-196 |  |  | **PCB-196** | **PCB-196** | **PCB-196** | 8 |
| PCB-197/200 |  |  |  |  |  | **PCB-197/200** | PCB-197/200 | **PCB-197/200** | 8 |
| **PCB-198/199** | PCB-198/199 |  | PCB-198/199 |  |  | **PCB-198/199** | **PCB-198/199** | **PCB-198/199** | 8 |
|  |  |  |  |  |  | **PCB-201** | **PCB-201** | **PCB-201** | 8 |
| PCB-202 | PCB-202 |  | PCB-202 |  |  | **PCB-202** | **PCB-202** | **PCB-202** | 8 |
| PCB-203 | PCB-203 |  | PCB-203 |  |  | **PCB-203** | **PCB-203** | **PCB-203** | 8 |
|  |  |  |  |  |  | PCB-205 | PCB-205 | PCB-205 | 8 |
|  | PCB-206 |  |  |  |  | **PCB-206** | **PCB-206** | **PCB-206** | 9 |
|  |  |  |  |  |  | **PCB-207** | **PCB-207** | **PCB-207** | 9 |
|  |  |  |  |  |  | **PCB-208** | **PCB-208** | **PCB-208** | 9 |
|  |  |  |  |  |  | **PCB-209** | **PCB-209** | **PCB-209** | 10 |

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## Appendix D. Glossary, Acronyms, and Abbreviations

Glossary

**Clean Water Act:** A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation’s waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

**Coelute**: In analytical chromatography when two or more compounds do not separate on the chromatographic column.

**Conductivity:** A measure of water’s ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

**Dissolved oxygen (DO):** A measure of the amount of oxygen dissolved in water.

**Parameter:** Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

**PCB congener**: Any single, unique, well-defined chemical compound in the PCB group. They are identified by the number and position of chlorine atoms around the biphenyl rings. There are theoretically 209 possible congeners.

**pH:** A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

**Point source:** Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**Total Maximum Daily Load (TMDL):**  Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

**Watershed:** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

**303(d) list:** Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

#### Acronyms and Abbreviations

Ecology Washington State Department of Ecology

EIM Environmental Information Management database

EPA U.S. Environmental Protection Agency

MEL Manchester Environmental Laboratory

PBDE polybrominated diphenyl ethers

RM River mile

RPD Relative percent difference

SOP Standard operating procedures

TMDL (See Glossary above)

WAC Washington Administrative Code

WRIA Water Resource Inventory Area

*Units of Measurement*

°C degrees centigrade

cfs cubic feet per second

dw dry weight

ft feet

g gram, a unit of mass

kg kilograms, a unit of mass equal to 1,000 grams

km kilometer, a unit of length equal to 1,000 meters

m meter

mg milligram

mg/Kg milligrams per kilogram (parts per million)

mg/L milligrams per liter (parts per million)

mL milliliters

mm millimeters

ng/g nanograms per gram (parts per billion)

ng/Kg nanograms per kilogram (parts per trillion)

ng/L nanograms per liter (parts per trillion)

pg/g picograms per gram (parts per trillion)

pg/L picograms per liter (parts per quadrillion)

ug/g micrograms per gram (parts per million)

ug/Kg micrograms per kilogram (parts per billion)

ug/L micrograms per liter (parts per billion)

umhos/cm micromhos per centimeter, a unit of conductivity