Spokane River Urban Waters Source Investigation and Data Analysis Progress Report (2009-2011)

Source Tracing for PCB, PBDE, Dioxin/Furan, Lead, Cadmium, and Zinc

DEPARTMENT OF ECOLOGY
State of Washington

September 2012
Publication No. 12-04-025

Publication and Contact Information

This report is available on the Department of Ecology's Web site at
https://fortress.wa.gov/ecy/publications/SummaryPages/1204025.html

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Source Tracing for PCB, PBDE, Dioxin/Furan, Lead, Cadmium, and Zinc

by

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Waterbody Number(s):
WRIA 54
WRIA 55
WRIA 56
WRIA 57

Appendix D provides definitions for all data flags used in this project.

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Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMP	Best management practice
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System software
LSCS	Local Source Control Specialist
MEL	Manchester Environmental Laboratory
NPDES	(See Glossary above)
NTR	National Toxics Rule
PBDE	polybrominated diphenyl ethers
QAPP	Quality Assurance Project Plan
Spokane	City of Spokane
SPU	Seattle Public Utilities
SRM	Standard reference materials
SRRTTF	Spokane River Regional Toxics Task Force
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resources Inventory Area
WWTP	Wastewater treatment plant

Units of Measurement

dw	dry weight
kg	kilograms, a unit of mass equal to 1,000 grams.
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
ng/Kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units

pg/L	picograms per liter (parts per quadrillion)
ug/Kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity

Acknowledgements

The authors of this report thank the following people for their contribution to this project:

- City of Spokane:
    - Lynn Schmidt, Gary Kaesemeyer, Raylene Gennett, Lars Hendron
- Washington State Department of Ecology staff:
    - Ted Hamlin, Dave George, Richard Koch, Jeremy Ryf, Mike Hepp, Dave Duncan
    - Dale Norton, Brandee Era-Miller, Brandi Lubliner, Jim Ross
    - Lisa Brown, Dave Moore, Diana Washington, Jim Bellatty
    - Lori Rodriguez

Introduction

The Urban Waters Initiative was passed in 2007 to provide researchers with additional resources to identify and eliminate contaminants of concern (CoC) in three important watersheds. The three watersheds included the Spokane River, Duwamish, and Commencement Bay. This report describes progress in the Spokane River from 2009 through the end of 2011.

Spokane is the largest contributor of stormwater and wastewater treatment plant discharge to the Spokane River. The City discharges were identified as a main contributor of CoC to the Spokane River (Serdar et al. 2006, Serdar et al., 2011). The Urban Waters Program determined the City of Spokane (Spokane) would be the main focus of our efforts.

Urban Waters conducted a pilot study in the Liberty Lake area to evaluate sewer and storm system sampling and business visit methods, and begin to understand local CoC concentrations in an area with minimal to no direct sources. We completed a report in 2010 that described our efforts, what we needed to do next and how we might be successful in approaching source tracing in Spokane (Fernandez and Hamlin, 2010).

The initial focus was up-the-pipe source tracing to gain the best results with limited resources. The results from the Parsons and Terragraphics (2007) stormwater report were used to identify priority stormwater and combined sewer overflow basins to trace. Upstream tracing would find sources of contamination to eliminate. Contaminants of Concern include polychlorinated biphenyls (PCB), Polybrominated diphenyl ethers (PBDE), dioxin/furan, lead, cadmium, and zinc.

Urban Waters would then conduct a series of small studies to identify additional sources to pursue after completion of the work in the first three drainage basins: Union, Erie, and CSO 34 (See study area). The first study would gather information on additional drainage basins discharging to the section of the river where PCB concentrations were highest as identified in Ecology's 2005 fish survey (Serdar and Johnson, 2006). An in-river sediment study for PBDE would help narrow down sections of the river and their piped system basins that may contribute to elevated levels of PBDE. Urban Waters also created a placeholder for groundwater sampling if efforts found the need to source trace in the Spokane Valley-Rathdrum Prairie Aquifer. The Aquifer runs underneath parts of Idaho and several communities in Spokane County including Spokane.

Urban Waters would use a combination of business visits and sampling to find sources. Investigators would then use the appropriate regulation from the Resource Conservation and Recovery Act, Clean Water Act, and the Model Toxics Control Act to eliminate the sources of contamination. We partnered with the Spokane Regional Health District (SRHD) and provided funding through the Local Source Control Partnership. The SRHD hired a business visit consultant called a Local Source Control Specialist (LSCS) to provide voluntary checklist visits at businesses in the basins of concern. These visits would attempt to determine if the business may be contributing to contamination to the Spokane River. The SRHD consultant would then provide guidance or refer them to the proper Ecology Program to provide the business with best management practices, or other actions they should implement to eliminate the source.
Our tracing efforts include historical analysis of land use and geographic information system (GIS) mapping to help trace up pipes and keep track of our progress.

Our final approach included an adaptive management component, including continual process checks, to address data gaps and necessary process changes quickly to insure continued aggressive progress.

Urban Waters worked with Ecology's Water Quality, Toxics Cleanup, and Environmental Assessment Programs to broaden and combine resources for the following additional source characterization and river monitoring projects:

- Air Deposition Literature Review (EAP)
- Spokane River monitoring plan (EAP)
- NE Washington Lake Background Study (TCP, EAP, UW)

Urban Waters developed a sampling plan and quality assurance project plan describing where to begin work and how to find new sources outside the initial identified drainage basins (Fernandez and Hamlin, 2009).

Contaminants of Concern

Polychlorinated Biphenyls (PCB)

PCB enters the Spokane River from industrial discharges, wastewater treatment plants, stormwater, local urban air deposition, and long-range air deposition to the Coeur d' Alene Basin where the Spokane River begins. PCB releases may come from mishandling transformers, caulking leachate, soap, motor oil, and other still unknown sources.

The Kaiser Trentwood aluminum plant is a well-known historic source in the Spokane Valley. Since 1995, Kaiser has taken major steps to reduce PCB concentrations in its wastewater. Kaiser and Inland Empire Paper each have a National Pollutant Discharge Elimination System (NPDES) permit to manage their PCB-contaminated wastewater. Ecology's Water Quality Program oversees these permits. The General Electric site was contaminated with PCB, impacting the aquifer near the river (Serdar et al. 2006). Ecology's Toxic Cleanup Program oversaw a 1999 cleanup of this site.

The Washington State Department of Health (WDOH) and the Spokane Regional Health District (SRHD) currently have an advisory to avoid or limit consumption of fish in parts of the Spokane River due to elevated PCB levels. The largest concentrations of PCB in fish or sediment have been found between the Idaho border and Upriver Dam.

The ecological implications of PCB contamination in the Spokane River have been assessed by Art Johnson (2001) from Ecology's Environmental Assessment Program. Johnson concluded there may be adverse effects on the salmonid populations, fish-eating mammals, and benthic invertebrates residing in the river reaches downstream of Kaiser. He did not find evidence of risk to fish-eating birds. Johnson points out elevated concentrations of PCB in the fine-grained sediments between Kaiser and Monroe Street Dam as one of the factors influencing his risk calculation for benthic invertebrates. This includes the area behind Upriver Dam. In 2001, Ecology's Toxics Cleanup Program placed a cap on the PCB-contaminated sediments behind Upriver Dam. This may have abated some of the risk to benthic invertebrates.

Polybrominated Diphenyl Ether (PBDE)

Studies indicate PBDE are building up in people's bodies, animals, and the environment (Serdar and Johnson 2006b; Peele et al. 2004, Johnson and Olson 2001, Johnson et al. 2006). There are no water quality or fish tissue standards for PBDE. Washington State had concerns about increasing levels in the environment, bio-accumulative potential, and effects on neurologic development and reproduction effects in laboratory animals. This prompted the State to develop a plan to reduce PBDE inputs to the environment (Peele, 2004). Ecology recently published data from ten rivers and ten lakes indicating that Spokane River fish tissue contains the highest levels of PBDE of the 20 sites tested (Serdar and Johnson, 2006).

Dioxin and Furan

As with the PBDE, we do not yet know the full extent of contamination or the sources of dioxin/furan in the Spokane River. Recent screening-level data suggested dioxin/furan needed further investigation in the Spokane watershed. Ecology conducted fish sampling in the Spokane River in 2003. A single rainbow trout fillet sample from the Nine Mile reach had a tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) toxic equivalents of 0.36 ng/Kg (Seiders et al., 2006, Seiders et al. 2007). The EPA National Toxics Rule human health criterion for dioxin/furan in fish tissue is 0.065 ng/Kg. Although this criterion is based on human health risks – one in a million excess lifetime cancer risk – it is used to assess water quality violations. It is not a threshold for issuing public-health fish consumption advisories.

The 303(d) lists three sections within the Spokane River as impaired for 2,3,7,8 TCDD TEQ. All three sections are listed as Category 2 based on fish tissue data. This was lowered from a Category 3 in 2004 to a Category 2 in 2008 and 2010. Three sections of the Spokane River are listed as category 5 for total 2,3,7,8 TCDD.

Metals

High levels of arsenic, zinc, lead, and cadmium contaminate much of the bottom sediments in the Spokane River (Johnson and Norton, 2001). Ecology developed a total maximum daily load (TMDL) in 1999 that limits zinc, lead, and cadmium discharges to the river (Pelletier, 1998).

The current 303(d) listings along the Spokane River for metals include:

- Lead: 12 segments along the Spokane River are listed as Category 4A.
- Zinc: 12 segments along the Spokane River are listed as Category 4A.
- Cadmium: One segment along the Spokane River is listed as Category 4A which is located at the Washington-Idaho border.

The arsenic and lead concentrations prompted WDOH and SRHD to issue an advisory urging people to reduce contact with shoreline sediments along parts of the river. In 2003, SRHD issued a sediment advisory for lead and arsenic.

The primary source of dissolved and particulate metals loading to the Spokane River is from the Coeur d'Alene Basin Superfund Site in Idaho, a basin-wide legacy mining site. The Basin was designated a Superfund site in 1983. EPA, with support from the Basin Commission, is conducting cleanup actions under a Record of Decision (ROD). TCP provides technical support and document review in the cleanup planning process as a member of the Basin Commission. Staff involvement focuses on addressing those areas in the Basin identified as most directly affecting water quality in the Spokane River.

Although cleanup is occurring, recent river sampling at the Idaho-Washington border show that dissolved zinc and particulate lead concentrations continue to exceed water quality standards. Fish tissue analysis also showed high levels of lead, zinc, and cadmium from fish collected between the Idaho-Washington border and Lake Spokane (Serdar and Johnson, 2006). TCP has been pursuing state led/funded cleanup actions at nine recreational shoreline sites identified in the ROD along this stretch of the river.

Study Area

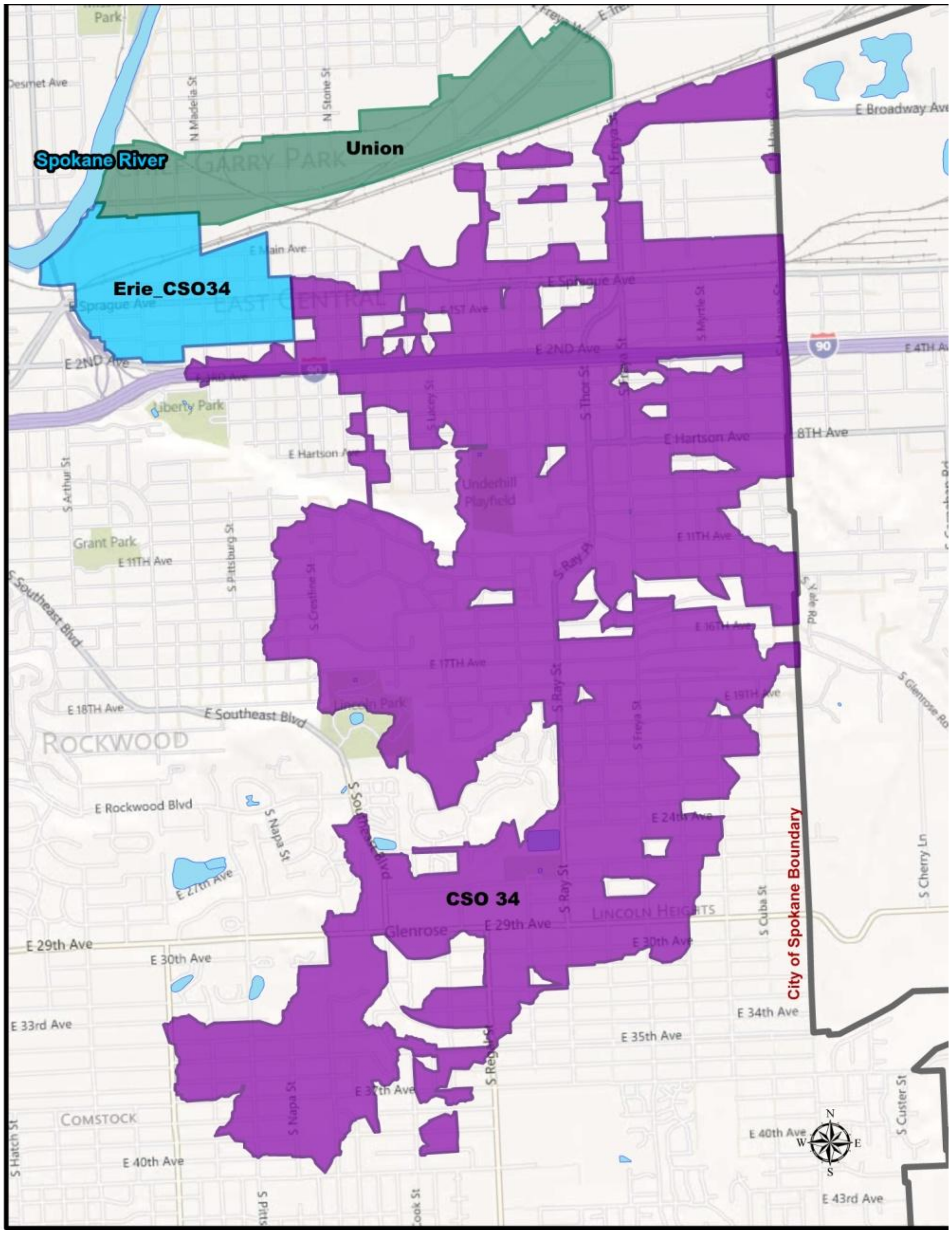
Our initial study area for all CoC included two drainage basins (Figure 1):

- Union Basin
- CSO 34

CSO 34 was later broken into two basins for tracing, separated by the CSO weir. The area above the weir will be referred to as CSO 34 while the area below the weir will be referred to as Erie Basin. CSO 34's overflow weir outflows into a long pipe that receives stormwater before it discharges into the river. It was a natural separation point for the contributions from above and below the weir since CSO 34 may not overflow during a storm event.

Source tracing efforts were initiated in Union basin because of its smaller size and because it was stormwater only.

Figure 1. Initial basins chosen for source tracing and elimination activities.

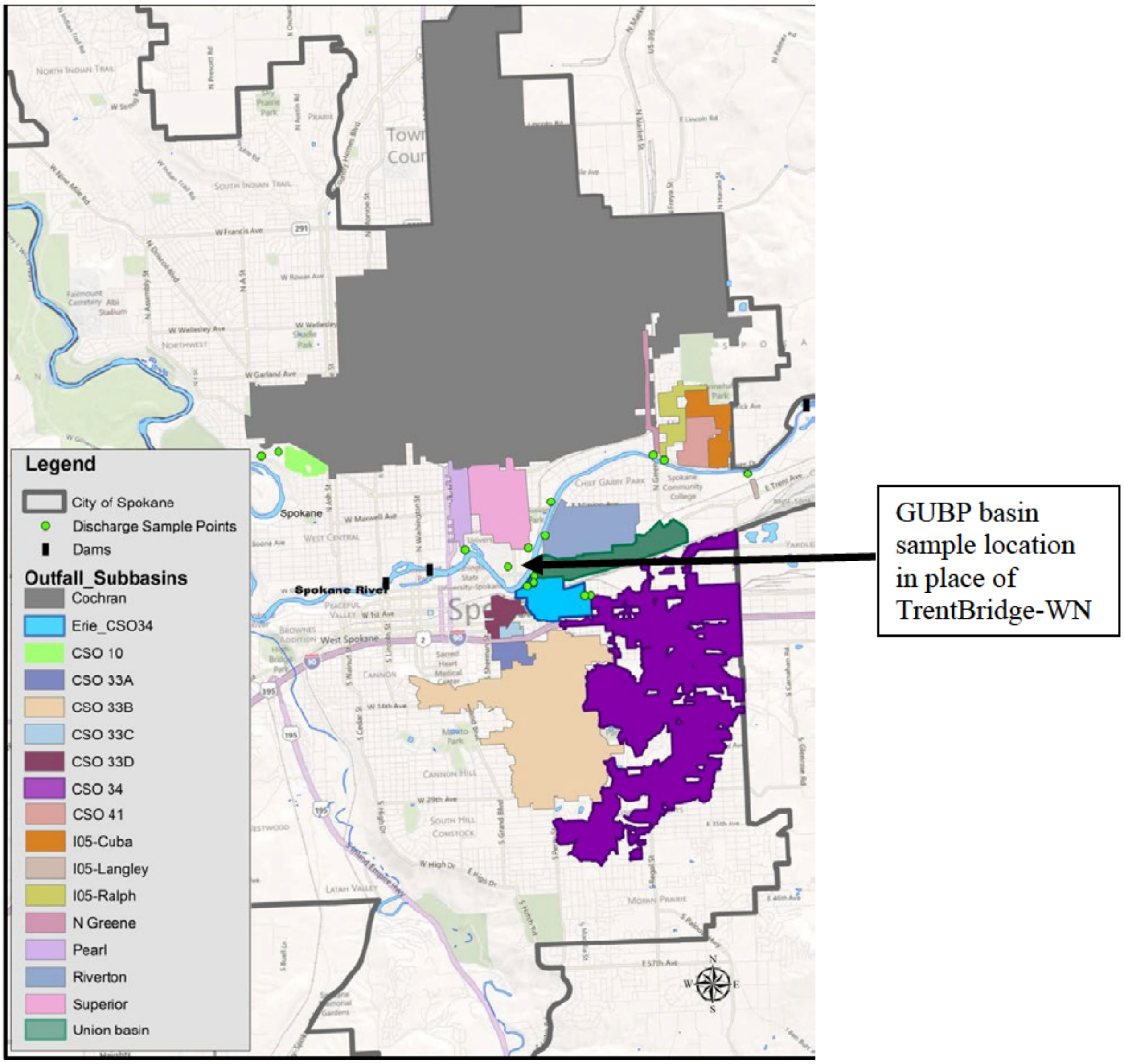


It was initially believed Union basin discharged at a separate point from CSO 34 and Erie basin. Exploration of the system with the cooperation of Spokane revealed all basins converged and discharged at one point into the river. The concentration originally attributed to CSO 34 and Erie basins in the 2007 stormwater report is a comingled sample of all three basins. This is important to note because this report directed our tracing investigation. This knowledge prompted a modification in the stormwater study and will help with future stormwater loading work.

Basin polygons were provided by Parsons and Terragraphics, Inc. and Spokane. Field recon showed basin polygons were not accurate in relation to the piped collection system. Future work should include a refined GIS basin polygon layer. However, the basins are adequate for representing the general area covered by the piped collection systems.

Figure 2 shows all basins where Urban Waters attempted to sample for all CoC through 2011. Green discharge points indicate a sample was collected. This includes the additional basins chosen for river discharge characterization in our QAPP addendum (Table B-1). The discharges are located in the river section where PCB fish tissue results were the highest (Serdar and Johnson, 2006).

Figure 2. Stormwater and CSO basins explored for source tracing purposes through 2011. Sample locations are in green.

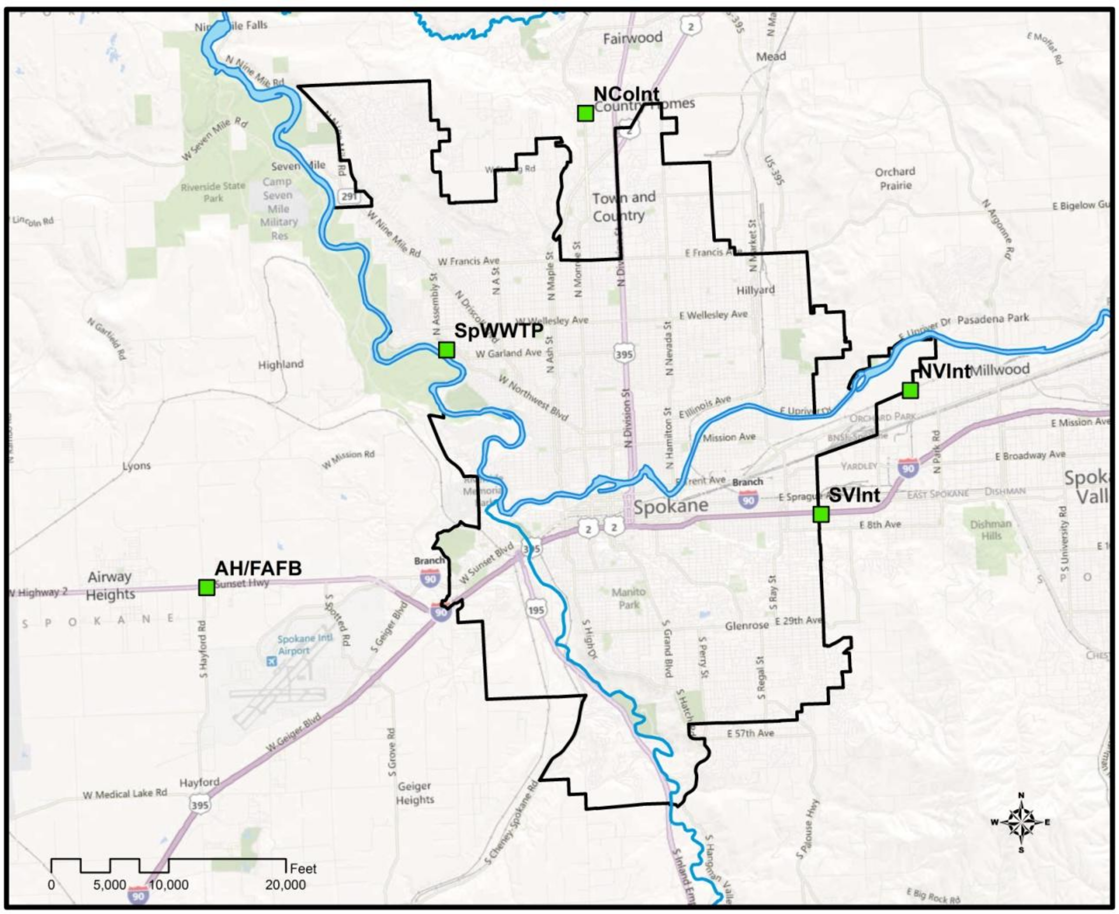


Urban Waters collected at least one sample from all locations except CSO 41 and Cuba. CSO 41 did not overflow during our sampling events and Cuba did not have sufficient flow for a sample. GUBP replaced the TrentBridge-WN basin due to inaccurate mapping and verification of a possible zinc source. GUBP basin's sample location is included as indicated but does not have a basin polygon in GIS.

In addition, two locations were chosen further downstream where Cochran basin discharged near TJ Meenach bridge. This was a combination CSO and stormwater discharge similar to Erie and CSO 34. Parsons and Terragraphics (2007) study showed this basin as a high PCB loading catchment so it was included (Parsons and Terragraphics, 2007).

The study area also includes the influent to Spokane's wastewater treatment plant (SpWWTP), the Riverside Park Water Reclamation Facility (RPWRF), and four upstream interceptors (Figure 3). Locations were chosen to characterize the concentrations entering the treatment plant and those entering the City's system from outside the City boundaries. This sectioned off the sewer system to identify system branches that may benefit from source tracing. The interceptors include wastewater from two Spokane Valley locations, Spokane County, and Fairchild Air Force Base. Only two parameters were collected at these locations, PBDE and dioxin/furan, because Spokane already monitors for PCB and metals.

Figure 3. Sampling locations within the RPWRF sanitary sewer collection system.



*Road data provided by Bing Maps

Sampling Methods

Water Collection

Stormwater grab samples were taken from manholes using a pole and clean-certified glass bottle. Some surface flow and flow into catch basin samples were collected by hand using a clean-certified bottle. Temperature, pH, and dissolved oxygen were collected in the field using an Oakton "PC10" Meter with an Oakton "GX-2" Probe and recorded on a field sheet. Samples were homogenized and poured into their respective analytic containers per the QAPP. We no longer homogenize our water samples with decontaminated equipment due to equipment contamination issues.

We were unable to collect flow rate manually. Flow depth, depth to water, and flow rate were all limiting factors for flow collection. In turn, measuring flow depth is required to calculate volume. Without confined space entry necessary to manually measure, or permanent flow devices with this capability, it was not possible to determine depth.

Storm events are difficult to sample. Storms in Spokane are often short and intense and rainfall occurs in the late afternoon, overnight, or early morning. Storms tend to be isolated and fall within pockets of the city, so following weather predictions does not indicate it will rain in the particular area of concern. Time to mobilize and reach manholes for sampling often forced sampling as the storm event was near the end so only one grab could be collected before flow stopped or was too shallow to collect. This was not the case in the Liberty Lake pilot.

Flow-triggered composite samplers would help resolve these issues. However, limitations include:

- Cost
- Placement options
- High-flow system blow out of flow meter and sample tube
- Low-flow system measurement accuracy and sample tube partial submergence

Urban Waters purchased two flow-triggered samplers in 2011 but were unable to make them operational. Spokane will assist our efforts through the purchase, installation, and maintenance of two flow-triggered composite samplers in 2012.

In cases where we have limitations, a sediment sampler may be a better alternative.

Sediment and Soil Collection

Sediment samples were taken with a stainless steel, decontaminated auger or a clean-certified glass bottle. The sampling method chosen depended on:

- Depth of sediment
- Sediment consistency
- Water retention

If water was present, Spokane provided a vactor truck to remove as much water as possible without contacting the sediment. We were unable to use a box sampler successfully because the larger particulates prevented closure.

Soil samples were collected at the surface using a decontaminated, stainless steel scoop.

Analytical Methods and Detection Limits

Table 1 shows the analytical methods used including reporting limits.

Table 1. Analytical Methods

Analyte	Matrix	Analytical Method	Lab	Reporting Limit or MQL
PBDE congener	water	EPA 8270	MEL	0.002-0.005 ug/L (209, 0.01-0.05 ug/L)
	soil/sediment			1-5 ug/Kg (209, 2-5 ug/Kg)
PCB congener	water	EPA 1668	Contract	0.01-0.5 ng/L
PCB Congener	water	EPA 8082	MEL	0.0033-0.1 ug/L
	soil/sediment			0.5-100 ug/Kg
TSS	water	EPA 160.2; SM 2540D	MEL	1 mg/L
Dioxins/Furans	water	EPA 1613B	Contract	As defined in EPA 1613B for each congener
	soil/sediment			
Total Metals: Priority Pollutant list (13 metals)	water	EPA methods 200.8 & 245.1; EPA 6020 & 245.5	MEL	As listed in table 5 on p.130 of MEL's User Manual, 9th Edition
	soil/sediment			
TCLP Metals	sediment	EPA Method 1311/6000 series	MEL	0.00005 – 0.01 mg/L depending on the metal
TDS	water	EPA 160.1	MEL	20 mg/L
Phosphorus	water	SM 4500P-F	MEL	1 µg/L
Grain size	soil/sediment	PSEP* 1986B	Contract	NA
TOC/DOC	water	EPA 415.1 SM 5310B	MEL	1 mg/L
TOC	soil	PSEP-TOC; 1986B	MEL	0.1%
Conductivity	water	EPA 120.1	MEL	1 mhos/cm @ 25ºC
Hardness*	water	SM2340B	MEL	0.30 mg/L

* In 2009, hardness was included as an ancillary parameter when collecting water samples for metals analysis for Water Quality purposes.

Analytical method 8270 was chosen for analyzing PBDE. This method is considerably less in cost and turnaround time for the lab to produce results. It has a higher detection limit and shorter congener list than EPA Method 1614, which can analyze all 209 congeners with some co-elution. EPA Method 8270 analyzes for 13 congeners including the most common found in the environment, BDE-47, BDE-99, and BDE-209.

The Parsons and Terragraphics (2007) Spokane River stormwater study showed PBDE concentrations in stormwater were detectable in Spokane's outfalls at the detection limits described in Table 1. However, their results and Urban Water's results for BDE-209 hovered near the detection limit. This congener is the only one still in use, so including EPA Method 1614 in the QAPP for future use when BDE-209 is near the detection limit will prevent improper source characterization.

We used the lower resolution analytical methods for most sediment analyses due to the lower cost per analysis. Lower resolution methods are practical for sediment analysis because most of our CoC accumulate in sediment, effectively raising the reporting limit. The higher resolution analytical methods may be used when a congener pattern would enhance our tracing ability. High resolution methods analyze for all congeners and can provide a congener pattern that may create a unique fingerprint for a source.

EPA Method 608 was also added to our list in 2011 for the purposes of Water Quality compliance. Choice of PCB EPA method (1668-209 congeners, 8082-22 congeners, or 608-aroclor) depends on:

- Detection limit needs
- Available funds
- Previous data collection method for comparability and trend identification

Appendix D provides definitions for all data flags used in this project.

Data Quality

PCB Data Quality

We are currently using two methods for PCB analysis, EPA Method 8082 and 1668. Method 8082 is useful for a higher concentration analysis. It is comparable to Water Quality's EPA Method 608 for compliance. There is discussion on whether we should use method 608 for sources with Clean Water Act violations. This may need to be included in our QAPP for future work.

EPA Method 1668 is used for low level concentrations. It requires much cleaner sampling techniques than 8082 and requires more time for analysis, quality assurance and quality control both at the lab and for this program, and is higher cost. We are currently working on gaining permission from EPA for using this method for Clean Water Act violations because of our Spokane River water quality standard of 170 pg/L.

The QAPP originally called for use of EPA Method 1668A for PCB low level analyses. During our work version 1668B was released in draft. We used 1668B for a short time; however, QA/QC criteria issues required us to revert to a modified 1668A analysis. EPA Method 1668C has recently been released as draft. The difference is mostly in regards to acceptance criteria and is considered better overall than the previous versions (personal correspondence: Karin Feddersen, EAP). We are now using method 1668C for all future low level analyses.

We had continual difficulty with clean lab blanks and field blanks. They were typically impacted with lower chlorinated congeners, including PCB-11, commonly found in inks and dyes. It was not a concern for sediment samples since concentrations in sediment are usually much higher. To reduce further contamination problems in the field, we now collect the sample directly into the bottle when possible or collect samples in a clean-certified glass container that is disposed of after each use. We no longer homogenize our water samples with decontaminated equipment.

The initial use of N and NJ-flagged data was deemed acceptable because of the usefulness in using this data for source tracing using congener patterns. N and NJ flags are essentially "tentative identification" with the NJ having an approximate concentration. However, because of the need to compare homologue sums and totals to previous data and future compliance data, N-flagged data will not be included in totals. NJ-flagged data is still under consideration and may be removed in the future for compliance purposes.

Lab blank contamination was assessed by congener and all data above five times the blank concentration was accepted. Anything between five and 10 times the blank was accepted as an estimate and qualified with a J. There is a possibility that future use of Method 1668 for compliance will require different acceptance criteria for congener data. Urban Waters is discussing options with Water Quality and EPA.

We analyzed a total of two field blanks and two rinsate blanks to monitor for ambient and cross contamination respectively (Table 2). The rinsate blank included lab-provided water poured into our stainless steel container used for homogenizing samples and then collected in a clean certified amber 1-liter bottle using our stainless steel funnel. We also collected one equipment blank and two water blanks.

Table 2. Field and equipment blank results for PCB EPA Method 1668

Sample ID	Collection Date	Total PCB (pg/L)	Congeners detected	Purpose
T2	6/8/2009	**165 J**	Mono (1) Di (4,5/8) Tri (18,31) Penta (110) Hexa (139/149)	Transfer blank
SW Blank	10/27/2009	**194 J**	Di (5/8,7,11,15) Tri (18,31) Tetra (47,48)	Transfer blank
ISCO	1/20/2010	Waiting on QA/QC	Waiting on QA/QC	Cross-contamination from tubing
ANAT	1/20/2010	Waiting on QA/QC	Waiting on QA/QC	Transfer blank suitability and final rinse for decontamination suitability
ECOL	1/20/2010	Waiting on QA/QC	Waiting on QA/QC	Transfer blank suitability and final rinse for decontamination suitability
PR Rinsate blank Avg.	3/28/2011	**260 J**	Mono (2) Di (4,6) Tri (17,20,22,24,28,33,39) Tetra (60, 71) Penta (86/97/117,105,124) Hexa (142,153,161)	Rinsate blank
BLANK	7/20/2011	**667 J**	Mono (1) Tri (18,20/33,28,31) Tetra (54,62,67) Penta (100,116/125) Hexa (135,138,148)	Rinsate blank

Bold = detected concentration

Individual congener results were compared to sample data. Any sample data results less than five times the blank were qualified with a B and not included in the total. Anything between five and ten times the blank were qualified with a J. All data more than ten times the blank were not qualified. The full congener results are available from Ecology by request.

PBDE Data Quality

In most cases data quality objectives were met with a few exceptions as qualified. Matrix interference increased the reporting limits significantly for one sample. Data reports are available from Ecology by request.

We analyzed one transfer blank and one rinsate blank to monitor for ambient and cross contamination respectively (Table 3). The rinsate blank included lab-provided water poured into our stainless steel container used for homogenizing samples and then collected in a clean certified amber 1-liter bottle using our stainless steel funnel. To determine clean equipment cross-contamination from the composite sampler, lab water was run through the composite sampler using Tygon tubing from a clean-certified glass container to a clean-certified glass container (Sample ID = ISCO). The ANAT sample and ECOL samples contained laboratory clean water from Anatek and Ecology's ERO lab prep room respectively.

Table 3. Field and equipment blank results for PBDE EPA Method 8270 in µg/L

Sample ID	Collection Date	PBDE-047	PBDE-049	PBDE-066	PBDE-071	PBDE-099	PBDE-100	PBDE-138	PBDE-153	PBDE-154	PBDE-183	PBDE-184	PBDE-191	PBDE -209	Purpose
SW Blank	10/27/2009	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	0.052 U	Transfer blank
ISCO	1/20/2010	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 UJ	0.004 U	0.011 U	Cross-contamination from tubing
ANAT	1/20/2010	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U	0.01 U	Transfer blank suitability and final rinse for decontamination suitability
ECOL	1/20/2010	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 UJ	0.004 U	0.01 U	Transfer blank suitability and final rinse for decontamination suitability
BLANK	7/20/2011	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 UJ	0.004 U	0.011 U	Rinsate blank

All field and rinsate blank results were below reporting limits.

Dioxin and Furan Data Quality

Pacific Rim Laboratories in B.C., Canada analyzed all dioxin/furan samples. Pacific Rim submitted case narratives to Karin Feddersen from MEL who reviewed and modified data as appropriate to meet Ecology's QA/QC standards outlined in MEL's Lab Manual (Ecology, 2008). MEL provided written case narratives assessing the quality of the data following the National Functional Guidelines for Superfund Organic Methods Data Review (EPA, 2005a). With a few exceptions, the results met acceptance criteria and are usable as qualified. All reports are available from Ecology by request.

We analyzed a total of two field blanks and two rinsate blanks to monitor for ambient and cross contamination respectively (Table 4). The rinsate blank included lab-provided water poured into our stainless steel container used for homogenizing samples and then collected in a clean-certified amber 1-liter bottle using our stainless steel funnel. The ISCO sample consisted of water run through our composite sampler using tygon tubing from a clean-certified glass container to a clean-certified glass container.

Table 4. Field and equipment blank results for Dioxin/Furan EPA Method 1613

Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Purpose
T2	6/8/2009	4.07 U	**0**	Transfer blank
SW Blank	10/27/2009	**25.5 J**	**0.111 J**	Transfer blank
ISCO	1/20/2010	**17.6**	**0.930**	Cross-contamination from tubing
ANAT	1/20/2010	**38.6**	**0**	Transfer blank suitability and final rinse for decontamination suitability
ECOL	1/20/2010	**1.99**	**0**	Transfer blank suitability and final rinse for decontamination suitability
BLANK	7/20/2011	**32.3**	**0.411**	Rinsate blank
PR Rinsate blank	3/28/2011	Waiting on data	Waiting on data	Rinsate blank

Bold = detected concentration

Although some dioxin/furan was identified in the blanks, the concentration was low enough that data qualification was unnecessary. Blank samples now contain contract lab water only to prevent the need for further clean water checks.

Metals Data Quality

We analyzed a total of two transfer blanks and one rinsate blank to monitor for ambient and cross contamination respectively (Table 5). The rinsate blank included lab-provided water poured into our stainless steel container used for homogenizing samples and then collected in a clean-certified amber 1-liter bottle using our stainless steel funnel. The ANAT sample and ECOL samples contained laboratory clean water from Anatek and Ecology's ERO lab prep room respectively.

Blank concentrations for metals were less than five times the sample data. No data qualifications were necessary. Laboratory water provided by Anatek contained chromium and copper so should not be used for metals transfer blanks. Laboratory water provided by Ecology's Eastern Regional Office laboratory contained nickel and copper so should not be used for metals transfer blanks. All blanks had some concentration of copper, three blanks contained nickel and two contained chromium. Our rinsate blank contained all three metals. Blank samples now contain MEL water only to eliminate the need for additional blank analysis.

Table 5. Metals field and equipment blank results in µg/L

Sample ID	Collection Date	Anti-mony	Arsenic	Bery-llium	Cad-mium	Chrom-ium	Copper	Lead	Mercury	Nickel	Sele-nium	Silver	Thal-lium	Zinc	Purpose
T2	6/8/2009	0.2 U	0.1 U	0.1 U	0.1 U	0.50 U	**0.18**	0.1 U	0.05 U	0.10 U	0.5 U	0.1 U	0.1 U	5 U	Transfer blank
SW Blank	10/27/ 2009	0.2 U	0.1 U	0.1 U	0.1 U	0.50 U	**0.38**	0.1 U	0.05 U	**0.10**	0.5 U	0.1 U	0.1 U	5 U	Transfer blank
ANAT	1/20/ 2010	0.2 U	0.1 U	0.1 U	0.1 U	**0.50**	**0.37**	0.1 U	0.05 U	0.10 U	0.5 U	0.1 U	0.1 U	5 U	Transfer blank suitability and final rinse for decontamination suitability
ECOL	1/20/ 2010	0.2 U	0.1 U	0.1 U	0.1 U	0.50 U	**2.08**	0.1 U	0.05 U	**5.91**	0.5 U	0.1 U	0.1 U	5 U	Transfer blank suitability and final rinse for decontamination suitability
BLANK	7/20/ 2011	0.2 U	0.1 U	0.1 U	0.1 U	**0.57**	**0.36**	0.1 U	0.05 U	**0.10**	0.5 U	0.1 U	0.1 U	5 U	Rinsate blank

Bold = detected concentration

Pattern Tracing

Pattern identification is a useful technique for source tracing (Garvey et al., 2002), especially for contaminants such as PCB where there are 209 different forms. The different forms, or congeners, differ in concentration within a sample creating a “fingerprint.” This “fingerprint” can be used to help identify the source. Pattern recognition techniques can range from a gross visual comparison of homologues to more sophisticated pattern analysis software. Software can decipher multiple patterns within a sample, and identify particular source types by looking at all 209 congeners.

Urban Waters currently uses the visual homologue comparison technique to determine the number of sources, but it is difficult to determine the actual source without more detailed individual congener comparisons.

Another method of pattern recognition includes mathematical software such as principle component analysis (PCA) or positive matrix factorization (PMF). Both of these methods have been used in PCB source tracing in other areas as well as locally. The Parsons and Terragraphics (2007) study used PCA to identify groupings of basins with similar congener patterns. In turn, Delaware River source tracing efforts used PMF analysis to assist with source apportionment. The PMF program identified six congener patterns associated with various sources (Du et al., 2008).

The PMF software in particular is capable of assisting researchers with identifying particular sources quickly and with less sample points. Future use of this software may be warranted to increase source tracing efficiency.

Source Tracing Prioritization

Basin prioritization for source tracing relies on many factors. For example, basin size, outfall concentrations, basin loading to the river, historical and current land use, etc. Some of these factors are more difficult to obtain than others. In particular, determining a concentration or loading-based trigger point for a heterogeneous stormwater and CSO basin system has its challenges.

Concentration comparison between the Liberty Lake pilot project and work in Spokane will be used to help determine basin priority for source tracing until we gain better information on stormwater background concentrations from air deposition.

Loading was not calculated for current basin work because flow velocity data collection was not possible with Urban Waters' current equipment. Consideration of basin loading may modify basin priority. Using loading for prioritizing source tracing must be done with caution. Basin size must be taken into account if loading is used as a form of prioritizing source tracing activity, especially with ubiquitous chemicals in combination with low-level analysis.

For example, PCB is ubiquitous and has been detectable in most stormwater samples where cross or ambient contamination is not an issue. Cochran Basin is several times larger than any other basin and will always discharge a substantial load to the river even at urban "background" concentrations. The dilution factor due to the volume of the basin makes it difficult to identify a single source, particularly when dealing with such low contaminant concentrations. In this case, source tracing in a large basin would be equivalent to trying to find a needle in a haystack. Further, while the Parsons and Terragraphics (2007) study showed Cochran Basin as the second highest load via stormwater, fish tissue concentrations in the Spokane River where Cochran discharges are well below those around the Mission Park area where PCB fish tissue concentrations are the highest.

System diversion, low impact development, and other forms of volume reduction may be more useful than source tracing and expensive monitoring.

There are many factors that influence concentration, flow, and loading. Storm intensity and duration, basin topography, and percent of impervious surface are just a few. These factors make comparison of data difficult spatially and temporally. Using the sediment sampler where possible to collect CoC associated with turbidity or TSS may help to eliminate some of the issues with stormwater grab concentrations, flow, and loading in relation to prioritizing source tracing efforts. Sediment sampling that captures a full storm event will make factors like flow-based loading less critical for source tracing.

PCB Section

Overview

This section summarizes PCB results within the Spokane Basin that include WRIA's 54-57.

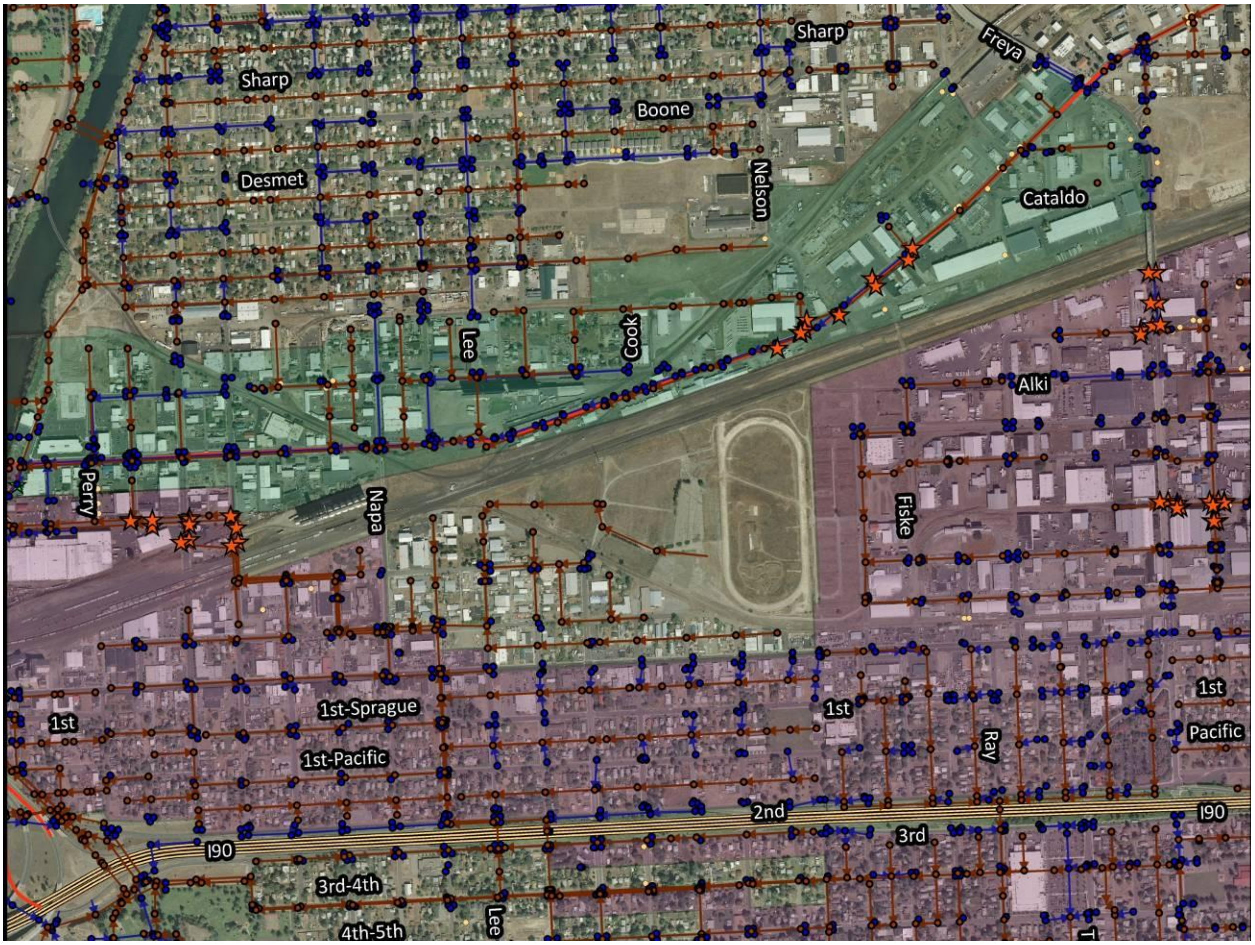
PCB source tracing focused on Union Basin and CSO 34/Erie Basin stormwater and combined sewer overflow basins due to recommendations from the 2007 Spokane River stormwater analysis report (Parsons and Terragraphics, 2007). The ten additional basins were selected for characterization because of their location between Upriver and Monroe St. dams. A 2005 Ecology report showed the highest fish tissue concentrations along the stretch of river between Upriver and Monroe St. dams (Serdar and Johnson, 2005). Investigation within Spokane expanded our focus area where necessary.

General progress for PCB source tracing and elimination included:

- Collected 57 samples between 2009 and September 2011.
- Collected data on a total of eleven stormwater and three CSO basins within Spokane.
- Identified two sources of PCB to the river.
- Requested and received an EAP literature review on current air deposition.
- Participated in a general area background concentration study in fish and sediments for northeast Washington waterbodies.
- Identified homologue patterns for various media.
- Provided guidance and training to local government and internal staff on method 1668 and sampling techniques.
- Continue to participate in Technical Track workgroup for the Spokane Regional Toxics Task Force.
- Continue to investigate four sources of PCB to the City's storm system from data collected by Spokane (Figure 4).

Spokane conducted source tracing and elimination work for PCB within their storm system. Because Union basin was one of the known contaminated discharges, they began their work in this basin approximately one year after we started. They collected sediment from catch basins and their connected drywells while Urban Waters worked with businesses on compliance. The City also completed several system modifications to reduce turbidity, which should also reduce any river PCB contamination due to air deposition and any unknown sources discharging to the system.

Figure 4. Spokane catch basin locations where the city found elevated PCB concentrations. Catch basins under investigation are denoted by orange stars.

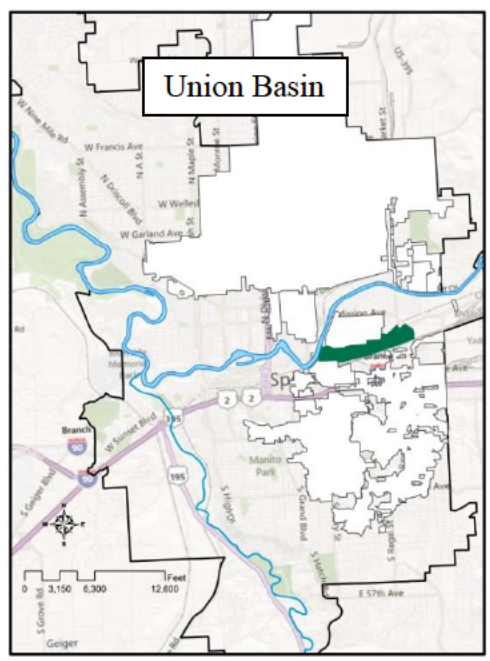


The hot spots in figure 4 came from Spokane's initial EPA Method 8082 aroclor analysis screen. Recent work by Spokane showed duplicate samples analyzed using EPA Method 1668 revealed a different set of hot spots (City of Spokane, 2012). Future efforts will take into account the 1668 locations and modify our source tracking efforts accordingly.

- Identified the following data and procedural gaps:
  - Clear decision points to determine when a basin needs upstream tracing and when a basin is considered "clean." Reasons include:
    - All basin outfalls sampled contained PCB that exceeded the 3.37 pg/L water quality standard.
    - Reliably detecting a concentration at 3.37 pg/L is not currently possible with the on-going blank contamination and matrix interference issues.
    - Although Spokane and Urban Waters took measures to remediate a source in Union Basin, concentrations at the outfall did not decrease after the cleanout.
  - Understanding and separating local and long range air deposition from other sources.
  - Interactive tool to assist with tracking all local data gathered on PCB to better understand sources.
  - Product list, concentrations, and congener patterns for inadvertently produced PCB.
  - Positive Matrix Factorization software to help identify different sources from collected data.
  - Determine if chiral signature analysis would be useful for any of our work as they have done elsewhere (C.S. Wong et al., 2001; B.J. Asher et al., 2007).
  - A document or webpage that reviews and makes available the body of literature on PCB source tracing and elimination collected over the past three years with source lists.

Results/Discussion

Union Basin



PCB source identification and elimination activity within Union Basin through October 2011 included:

- Collected PCB samples from eight locations within Union Basin to source trace and monitor for best management practice effectiveness.
- Obtained seasonal and storm concentration variability from basin outfall.
- Analyzed Urban Waters' data and the Spokane's data to determine possible hot spots within the basin.
- Industrial stormwater permittee in basin completed work to stop discharging turbid water to the system under Urban Waters guidance. Although the permittee does not have a known PCB source, PCB is associated with turbidity, so this should eliminate any river PCB contamination due to air deposition or any unknown sources discharging to the system.

- Required a recycling facility to obtain an Industrial Stormwater Discharge Permit for lead and turbidity under Urban Waters guidance. The facility discharged to a catch basin with elevated PCB concentrations and other CoC. Data analysis is underway for PCB source determination. Facility stormwater discharge elimination activities are on-going.
- Performed sampling training and sampling plan review for Spokane for source tracing and sampling PCB in their catch basin and drywells within Union basin.
- Found PCB soil contamination on Spokane property surrounding the City Parcel site; this prompted cleanout and eventual disconnection of the system from the river. City Parcel went through TCP cleanup for PCB transformer oil contamination.
- Conducted historical research of an area just north of the Trent Ave. Bridge along the east bank based on a past complaint. A river bank soil and groundwater investigation is recommended to determine if it is a source.
- Currently working with Spokane to pinpoint a potential source along Trent Avenue. This was identified from their composite catch basin sampling and confirmed with our Trent (1384910ST) stormwater sample.

Results/Discussion

Urban Waters attempted to sample five branches within Union Basin's piped stormwater system. Figure B-2 displays the sample locations within Union Basin. All results are shown in Table 6.

Table 6. Total PCB results in Union basin *Bold = detected concentration*

Sample ID	Collection Date	Matrix	Total PCB-8082 (ng/Kg or ng/L)	Total PCB-1668 (ng/L)	Season	Storm event Precip. from Felts Field (in)	Location	Sample Type
Upstream Trent Ave Branch								
TRENT-TPC	6/25/2009	sed	**5,820**	ns	Summer	na	Catch Basin	Comp. scoop
1384910ST (Trent)	1/24/2011	sw	ns	**188**	Winter	0.49	Branch	Grab
	5/16/2011	sw	ns	**86.5**	Spring	0.29	Branch	Grab
Crestline-Springfield Ave Branch								
COOK - SPRG	6/25/2009	sed	**980,000**	ns	Summer	na	Catch Basin	Comp. scoop
CR/ADM	8/12/2009	sw	ns	**226**	Summer	0.27	Branch	Grab
CRSPADM	2/16/2010	sw	**325**	ns	Winter	No data	Branch	Grab
	6/4/2010	sw	**14.1**	ns	Spring	0.56	Branch	Grab
	7/2/2010	sw	**114**	**223**	Summer	0.28	Branch	Grab
	1/13/2011	sw	**33.4**	ns	Winter	0.33	Branch	Grab
	3/28/2011	sw	ns	QA/QC in progress	Spring	No data	Branch	Grab
Napa St-Springfield Ave. Branch								
NAPA-SPRG	9/9/2010	sw	ns	**285**	Fall	0.06	Branch	Grab
	1/24/2011	sw	ns	**103**	Winter	0.49	Branch	Grab
	5/16/2011	sw	ns	**745**	Spring	0.29	Branch	Grab
	7/29/2011	sed	**17,000**	ns	Summer	Na	Branch	Grab
Union Outfall								
UNIONLPT	6/8/2009	sw	ns	**73.0**	Spring	0.29	Outfall	Grab
	10/2/2009	sw	ns	**58.2**	Fall	0.11	Outfall	Grab
	2/16/2010	sw	ns	**460**	Winter	0.12	Outfall	Grab
	4/29/2010	sw	ns	**60.6**	Spring	0.48	Outfall	Grab
	9/9/2010	sw	ns	**256**	Fall	0.06	Outfall	Grab
	1/7/2011	sw	ns	**55.3**	Winter	0.19	Outfall	Grab
	7/13/2011	sw	ns	QA/QC in progress	Summer	0.42	Outfall	Grab

Urban Waters collected at least one sample from Union's outfall for all four seasons to assess seasonal variability. Total PCB concentrations ranged from 55.3 – 460 ng/L. Table 7 provides concentration criteria and ranges for perspective.

Table 7. Criteria and range comparison of total PCB concentration data to Union Basin outfall results

Data	***Total PCB in ng/L***
Urban Waters Report (Union Basin Outfall)	55.3 – 460
Parsons and Terragraphics (Union Basin Outfall)	16.1-168
Washington State Water Quality Standard	0.17
Spokane Tribal Water Quality Standard	0.00337
Freshwater chronic toxic substance criteria	14
Freshwater acute toxic substance criteria	2000
Liberty Lake Pilot Study (maximum for sewer and stormwater combined)	12.4

Here are some concentration comparisons:

- All water sample results were well above the Washington State Water Quality Standard and the Spokane Tribal Standard for PCB.
- 100% of the water samples from Union Basin exceeded the freshwater chronic toxic substance criteria but were below the acute criteria (WAC 173-201A-240).
- All water results exceeded the maximum PCB concentration found in the Liberty Lake Pilot Study for sanitary sewer and stormwater combined.
- Results of the two sediment samples did not exceed the 1 mg/Kg MTCA unrestricted land use limit for PCB.

The highest concentrations were detected in both fall and winter sampling events. Elevated concentrations occurred with high turbidity. A regression analysis of turbidity and PCB shows a link between the two parameters.

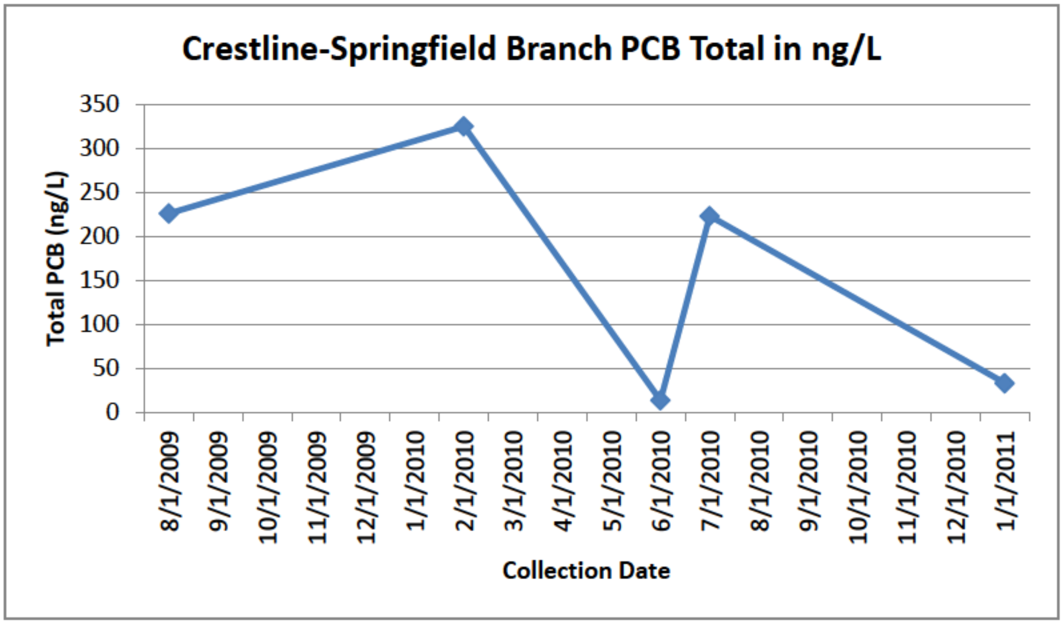
The higher outfall concentration in winter was expected because of the work the City was undertaking to clean out the system from a known source. Conversations with the City of Tacoma revealed they saw similar spikes in concentration after cleanout. Possible reasons include mobilized sediment, increased flushing or lack of sediments in catch basin to reduce turbulence. This is not confirmed with data comparison.

The concentration fluctuation from season to season and storm to storm was expected. There was a noticeable shift in the homologue congener pattern as source elimination activities were conducted upstream (Figure 6). It was less clear whether the work significantly reduced the concentration at the outfall.

Historical research revealed the only known PCB source came from the City Parcel site, which underwent cleanup through the TCP program. The City Parcel on-site cleanup standard is 10 mg/Kg (ppm); the final site cover was designed to prevent runoff from leaving the site. A cleanup level of 1 mg/Kg was established for an adjacent City alley right-of-way to protect unrestricted pedestrian access. The City did not sample the surrounding storm system to determine if contaminated sediment was present. The remedial action did not consider possible sediment removal from the system for protection of the Water Quality Standard in the river.

The LSCS identified a City street drywell with overflow to Union basin near the southwest corner of the City Parcel property as a possible conduit of PCB to the river. A sediment sample from the connected drywell at the corner of Cook St. and Springfield Ave. (Cook-Sprg) showed a concentration of 980,000 ng/Kg total PCB. The stormwater in-pipe concentration (CRSPADM and CR/ADM) was 226 ng/L. The City cleaned out the system. Subsequent stormwater sampling showed a general lowering in concentration over the next year (Figure 5).

Figure 5. Total PCB concentrations at Crestline-Springfield branch over time.



The elevated in-pipe water sample result obtained on July 2010 prompted us to reinvestigate the site for additional sources. Spokane disconnected the drywell from the system on December 14, 2011 to prevent any further discharge to the river. We will collect an additional branch sample to confirm sources have been eliminated.

Pattern tracing:

Pattern identification is a useful technique for source tracing (Garvey et al., 2002). Below are three figures showing the different homologue patterns seen in Union Basin (Figure 6-8). The first two samples collected at Union along with the fifth sample showed a similar pattern to the Crestline-Springfield branch pattern. The remaining three samples appear to be more influenced by the Springfield-Crestline and Trent branch samples.

Additional patterns may be identified using other methods which were not available.

Figure 6. Union Basin outfall percent homologue patterns.

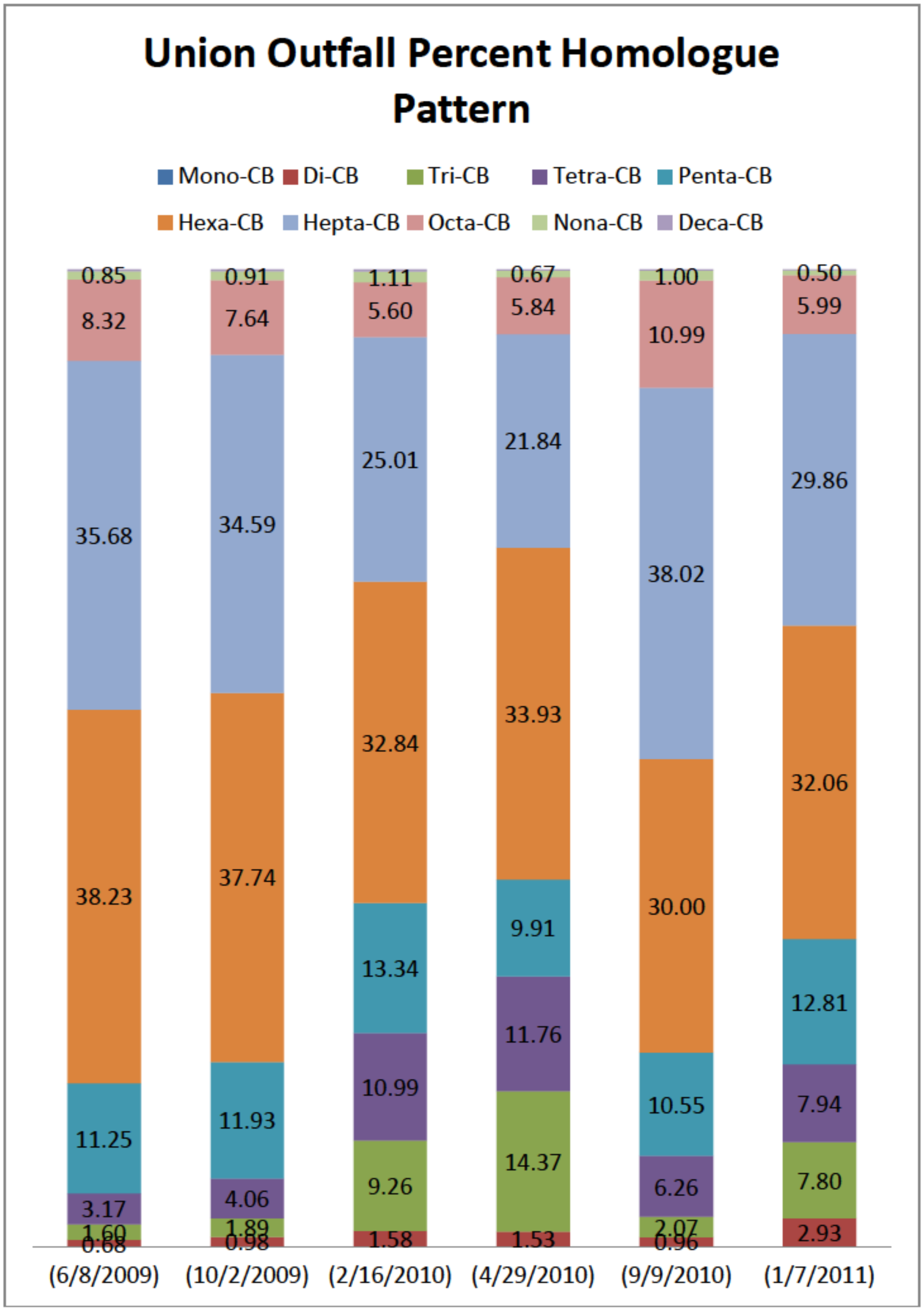


Figure 7. Crestline-Springfield branch stormwater homologue patterns.

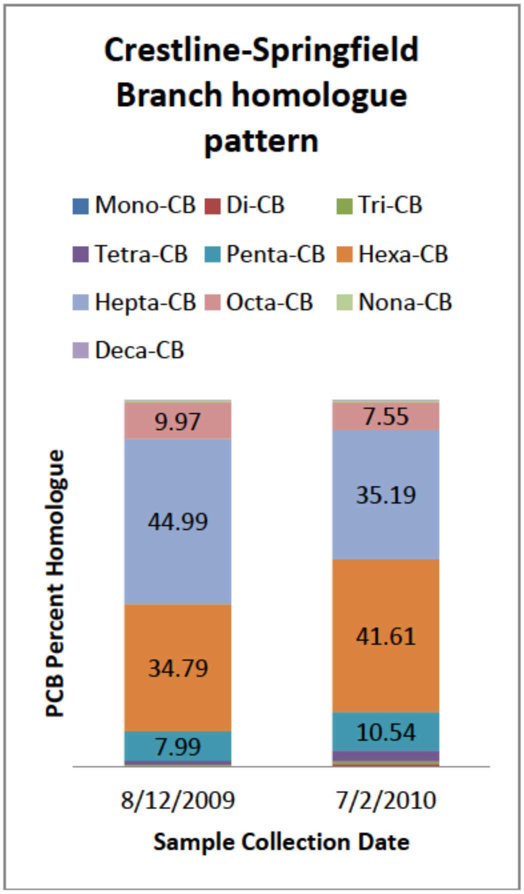
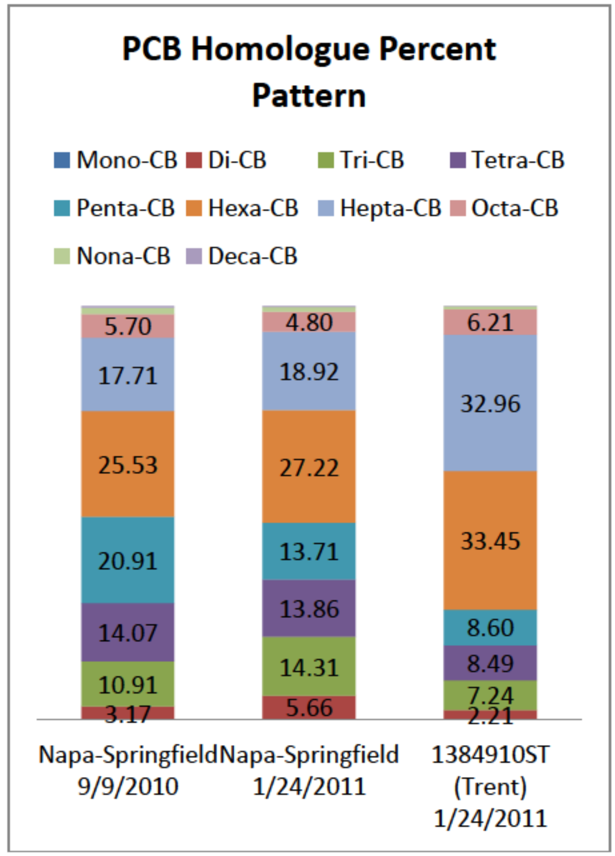


Figure 8. Napa-Springfield and upstream Trent branch stormwater PCB homologue percent patterns.



Erie Basin/CSO 34

Basin outfall monitoring began in 2009. Basin investigations began in 2010 after Union Basin sources were mostly identified.

Table 8 shows results for CSO 34 and Erie Basin investigations.

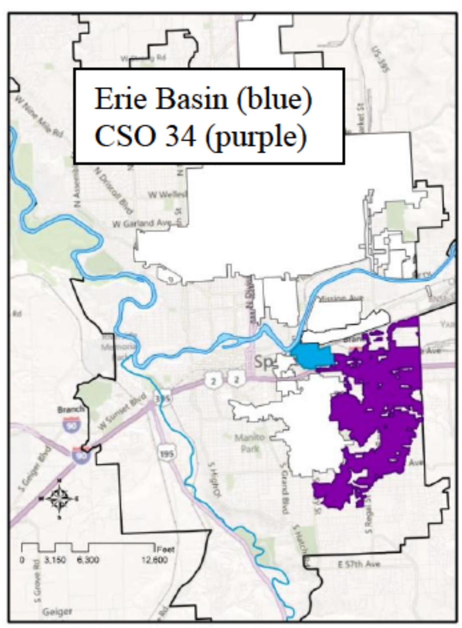


Table 8. Total PCB results for CSO 34 and Erie Basin investigations

Sample ID	Collection Date	Matrix	Total PCB (ng/L)	Basin	Season	Location	Method	Storm event Precip. from Felts Field (in)
CSO 34 Above Weir								
CSO34A	7/15/2010	sa	**8.91**	CSO 34	Summer	Above Weir	1668A	na
CSO 34 Overflow Below Weir								
CSO34B	6/8/2009	cso	**24.7**	CSO 34	Spring	Weir Overflow	1668A	0.29
	10/23/2009	cso	**11.9**	CSO 34	Fall	Weir Overflow	1668A	0.75
	4/22/2010	cso	**39.0**	CSO 34	Spring	Weir Overflow	1668A	0.27
	1/13/2011	cso	**7.18**	CSO 34	Winter	Weir Overflow	1668A	0.33
BNSF/ENX Facility								
FLYASH	2/3/2010	Waste Solid	120 U	Erie	Winter	Facility ground	8082	0.01
Napa St and Riverside Ave Intersection								
BECK	11/5/2010	sed	**4630 J**	Erie	FALL	Drywell	8082	na
Erie Basin Outfall								
ErieLPt/ CSO34B	6/8/2009	cso	**23.9**	Erie	Spring	Outfall	1668A	0.29
	1/13/2011	sw	**8.11**	Erie	Winter	Outfall	1668A	0.33
ERIELPt	10/2/2009	sw	**58.3**	Erie	Fall	Outfall	1668A	0.11
	2/16/2010	sw	**62.6**	Erie	Winter	Outfall	1668A	0.12

sed = sediment; sa = sanitary sewer water; sw = stormwater; cso = combined sewer and stormwater overflow; na = not applicable; **Bold** = detected concentration

Around 55% of the water samples exceeded the freshwater chronic criteria of 14 ng/L (WAC 173-201A-240). The sediment sample did not exceed the MTCA unrestricted land use concentration of 1 mg/Kg for PCB.

Four samples were collected while CSO 34 was overflowing (CSO34B). Concentrations ranged from 7.04 – 39.0 ng/L Total PCB. The two elevated CSO 34 concentrations indicate there may be a traceable source; the size of the basin will make locating a source difficult. Spokane is focusing their composite catch basin sampling in the lower industrial portion of the basin.

Erie's stormwater outfall samples show concentrations of 58.3 and 62.5 ng/L total PCB, which is well above the 8.42 ng/L and 30.9 ng/L maximum concentration results for stormwater from the Liberty Lake Study and the basin addendum sampling results respectively. This may indicate a traceable source. Spokane catch basin sampling found an area of elevated PCB on the corner of Hogan Street and Front Street. Investigation into the source is currently under way.

Two samples were collected at Erie's outfall while CSO 34 was overflowing. Concentrations at CSO 34's weir and at Erie's outfall are similar, 24.6 vs. 23.9 and 7.04 vs. 8.05 ng/L total PCB, indicating CSO 34 dilutes any sources within Erie basin when overflowing.

The BECK sample was collected due to nearby radiator shop activity. Results did not show elevated PCB in the drywell, so no further action in that branch was taken. The FLYASH catch basin was collected near a railroad and a flyash transfer facility. The results were below detection limits and will not be pursued.

Additional Sampling

Other Basins

Ten additional basins to Union, Erie, and CSO 34 were added to the sampling analysis plan (Table B-1, Figure B-1). All basin outfalls were located within the area between Upriver Dam and Monroe St. Dam where the highest fish tissue PCB concentration was found in the 2005 Ecology monitoring report (Johnson et al., 2006). The final list of basins sampled with PCB results are displayed in Table 9.

Table 9. PCB totals from 11 basin outfalls to the Spokane River

Sample ID	Collection Date	Matrix	Total PCB Method 1668 (ng/L)	Basin	Season	Location	Storm event Precip. from Felts Field (in)
AvistaP	5/10/2011	Pond Water	**0.091**	Avista	Spring	Outfall	NA
Cochran	10/14/2009	SW	**10.6**	Cochran	Fall	Outfall	0.35
Cochran	10/23/2009	SW	**6.89**	Cochran	Fall	Outfall	0.75
Cochran	10/26/2009	SW	**4.63**	Cochran	Fall	Outfall	0.62
CSO 10	10/23/2009	SW/SA	**6.33**	CSO 10	Fall	Weir Overflow	0.75
CSO33	7/13/2011	SA	**5.85**	CSO33	Summer	Weir Overflow	0.42
GUBP	4/22/2010	SW	**19.6**	GUBP	Spring	Outfall	0.27
Langley	7/19/2011	SW	**QA/QC in progress**	Langley	Summer	Outfall	0.08
NWGreen	10/14/2009	SW	**22.3**	NWGreen	Fall	Outfall	0.35
NWGreen	10/23/2009	SW	**31.1**	NWGreen	Fall	Outfall	0.75
NWGreen	10/26/2009	SW	**15.8**	NWGreen	Fall	Outfall	0.62
Pearl	10/14/2009	SW	**10.3**	Pearl	Fall	Outfall	0.35
Pearl	10/23/2009	SW	**16.5**	Pearl	Fall	Outfall	0.75
Pearl	10/26/2009	SW	**5.67**	Pearl	Fall	Outfall	0.62
Ralph	4/21/2011	SW	**7.36**	Ralph	Spring	Outfall	0.01

Sample ID	Collection Date	Matrix	Total PCB Method 1668 (ng/L)	Basin	Season	Location	Storm event Precip. from Felts Field (in)
Riverton	5/16/2011	SW	**24.4**	Riverton	Spring	Outfall	0.39
Superior	10/14/2009	SW	**11.6**	Superior	Fall	Outfall	0.35
Superior	10/23/2009	SW	**6.86**	Superior	Fall	Outfall	0.75
Superior	10/26/2009	SW	**3.94**	Superior	Fall	Outfall	0.62

Bold = detected concentration

Average total PCB concentrations for stormwater from Parsons and Terragraphics (2007) study were analyzed for Cochran, Superior, and Riverton Basin outfalls during spring 2007 (Table 10).

Table 10. Basin outfall total PCB concentration comparison of Parsons and Terragraphics (2007) results and Urban Waters results.

Study	*Season*	*Cochran Total PCB Conc. (ng/L)*	*Superior Total PCB Conc. (ng/L)*	*Riverton Total PCB Conc. (ng/L)*
Parsons and Terragraphics (2007)	Spring	12.9	17.8	22.3
Urban Waters Report	Fall	7.28	7.36	24.2 (Spring)

For both Cochran and Superior Basins, the spring average concentrations were higher than the fall. Superior Basin showed the most pronounced seasonal difference. This could be due to storm characteristics since the homologue pattern for Superior Basin found during the Parsons and Terragraphics (2007) spring sampling was similar to the results from our fall sampling. The homologue patterns for Cochran Basin were also similar for both seasons.

The homologue pattern for Riverton Basin from Parsons and Terragraphics (2007) study was dominated by penta-CB and hexa-CB homologues; however, the 2011 result revealed a hexa-CB and hepta-CB dominant pattern similar to Union Basin's Crestline-Springfield branch that contained the transformer oil contamination. This along with higher average concentrations than the other basin outfalls indicate two sources that require further investigation.

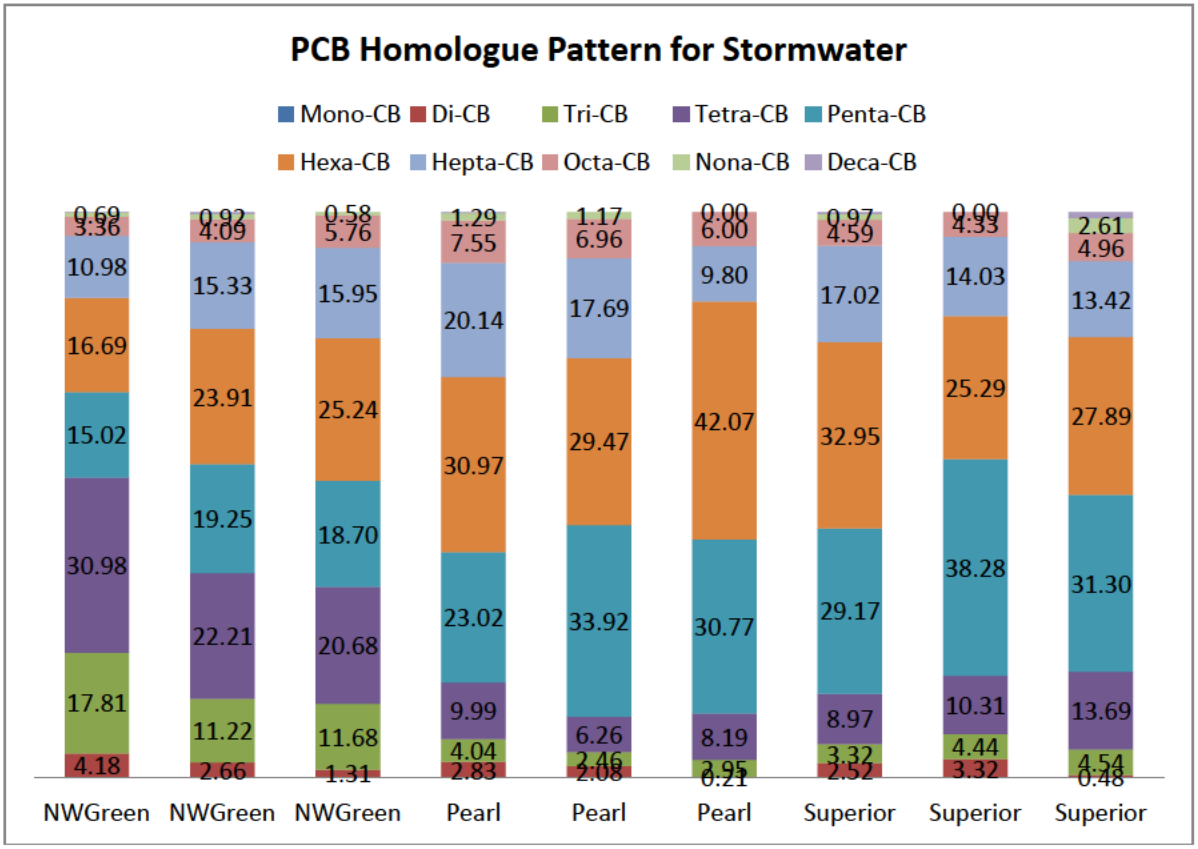
For perspective, Table 11 shows the range for stormwater PCB concentrations found in the Liberty Lake study and the basin outfall addendum results. Six of the basins had at least one sample above the maximum concentration found in Liberty Lake.

Table 11. Range for stormwater total PCB concentrations for Liberty Lake Pilot Study and Urban Waters

Study	*Total PCB range (ng/L)*
Liberty Lake Pilot Study	0.458 - 8.42
Urban Waters Report	3.69 - 30.9

Tracing Patterns:
As an example of some additional patterns we can look for, Figure 9 displays three storm results for three sites. In addition to the shift from the Union outfall pattern, dominated by hexa-CB and hepta-CB homologues, the three stormwater basin outfall locations below revealed a penta-CB and hexa-CB dominant or a tetra-CB, penta-CB, and hexa-CB dominant mixture. These are more similar to our Napa-Springfield pattern and may have a similar source.

Figure 9. PCB homologue patterns for stormwater from three basins.



In addition, patterns stayed similar through all three storms for Pearl and Superior, while NWGreen showed a change in pattern. This may indicate more than one source.

Samples of Opportunity

A few samples were collected outside our identified Basins when the opportunity presented itself (Table 12).

Table 12. Total PCB results for opportunistic sample collection events

Sample ID	Collection Date	Matrix	Total PCB Method 8082 (ng/Kg or ng/L)	Total PCB Method 1668 (ng/L)	Basin	Season	Location	Storm event Precip. from Felts Field (in)
Front	6/19/2009	SW	NS	**0.368**	Front	Spring	Branch	0.62

Sample ID	Collection Date	Matrix	Total PCB Method 8082 (ng/Kg or ng/L)	Total PCB Method 1668 (ng/L)	Basin	Season	Location	Storm event Precip. from Felts Field (in)
River Ext	6/7/2011	GW	NS	**0.347**	SVRP Aquifer	Spring	Exposed Aquifer	na
FMCB	5/7/2010	Sediment	**93,000**	NS	Front	Spring	Catch Basin	na
BrownCB Avg	5/14/2010	Sediment	**12,400**	NS	Brown	Spring	Catch Basin	na
NSLFL	2/3/2010	Waste Liquid	26U	NS	na	Winter	Facility Sump	Na
NSLFC	2/11/2010	Waste Liquid	80U	NS	na	Winter	Facility Sump	na
NSLFCBPad	2/11/2010	Catch basin Cleanout Leachate	43U	NS	na	Winter	Facility Sump	na

Bold = detected concentration

The Front sample connects at the base of CSO34/Erie's outfall. The sample did not contain elevated levels of PCB in relation to all other data collected in Spokane and Liberty Lake areas.

During a construction project along Division St, groundwater was exposed approximately six feet from ground level (River Ext). Concentrations were similar to that from the Front sample.

FMCB was collected from a boat repair shop catch basin under investigation. Concentrations indicated there may be a low-level source. Old light fixtures and ballasts were stored on the property. The property has since transferred ownership and Water Quality is working with the facility to disconnect the catch basin and design proper stormwater management structures.

BrownCB was collected on a city street directly in front of a building supply company with outside storage. The facility has stormwater structures in place and the location was chosen to determine if any contamination left the site. The concentration was within the range found in the Liberty Lake Pilot Project, 4780 – 13600 ng/Kg. No further action was taken.

The NSLFL and NSLFC samples were collected from landfill leachate and condensate that discharges to the sanitary sewer. Concentrations from this source were expected to be elevated, so EPA Method 8082 was used. Both results were below detection limits, so the landfill is not suspected to be a point source.

The NSLFCBPad sample focused on leachate from a stormwater catch basin sediment drying pad. Concentrations were below detection limits; however, it may be necessary to collect and run an additional sample using EPA Method 1668. Several stormwater catch basin pad facilities are under development and low-level data will help with understanding concentrations that may discharge from these facilities.

An Urban Waters dangerous waste investigation at a hydraulic equipment company in Spokane Industrial Park revealed a large hydraulic oil spill. The facility conducted a PCB aroclor analysis which was below reporting limits. The spill was ruled out as a PCB source.

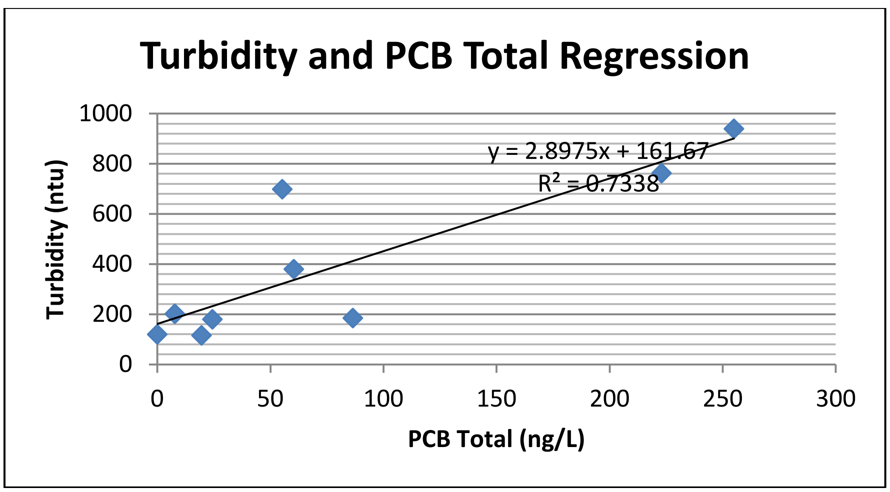
Statistical Analysis

Although initially TDS and DOC samples were analyzed, linear regression did not reveal any significant correlations. Collection of these parameters was eliminated. We continue to collect TOC. Carbon is used in modeling calculations and may be useful if we choose to model fate and transport in the future.

A simple linear regression was calculated for total PCB in stormwater against the following general parameters: DOC, TOC, TSS, TDS, and turbidity. PCB had the strongest association with turbidity (Figure 10). Turbidity measures the opacity of the water, which is influenced by the amount and type of suspended particulate. PCB tend to adsorb to fine particulate. This association may indicate a higher concentration of fine particulate since the association with total suspended particulate was not as strong.

Because the regression appears strongly influenced by two data points, additional data points should be collected to confirm this association.

Figure 10. Linear regression of turbidity and PCB in stormwater.



PBDE Section

Overview

This section describes our PBDE source tracing and elimination activities within the Spokane Basin that include WRIAs 54-57. It also includes future activity recommendations. We sampled a combination of sanitary sewer, stormwater, waste, and sediment.

The stormwater discharge focus included Erie Basin and CSO 34. This area was chosen because elevated concentrations were reported in Ecology's 2009 Supplemental Report (Lubliner, 2009).

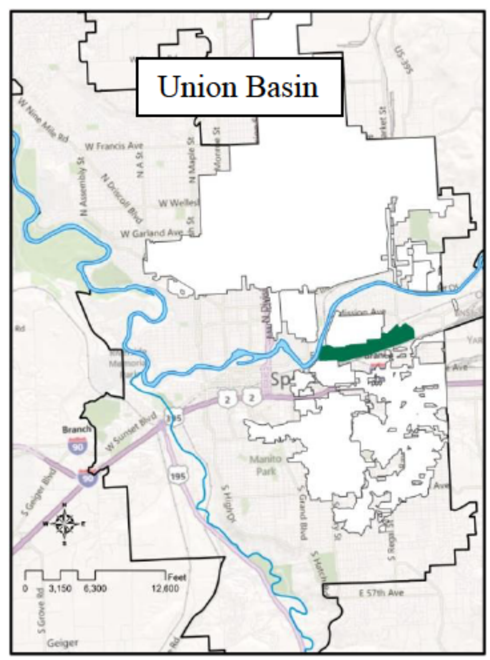
The discovery that the Erie_CSO34 manhole sampled in 2007 included discharge from Union basin prompted inclusion of Union Basin for PBDE characterization and possible tracing. Ecology's 2009 report did not indicate Union basin as a possible source of PBDEs; however, reporting limits for deca-BDE were higher than Urban Water's current limits.

In addition, Serdar and Johnson found the highest PBDE fish tissue concentrations in the Spokane River around Ninemile just downstream of Riverside Park Water Reclamation Facility (Serdar and Johnson 2006). Because Spokane's new NPDES permit includes PBDE effluent monitoring, we did not sample the effluent. We instead sampled the influent and four interceptors.

Results/Discussion

Union Basin

After determining the CSO34 results included the Union basin branch, additional samples were collected for a short time to make sure the previous sampling event did not miss a source flush.



Union basin progress through October 2011 included:

- PBDE samples collected from three locations within Union basin to source trace and monitor for best management practice effectiveness.
- Seasonal variability obtained from outfall; the highest concentration occurred during winter.
- Required recycling facility to obtain Industrial Stormwater Discharge Permit for lead and turbidity. A street catch basin sample has prompted further investigation of the site as a contributor of PBDE.

Figure B-2 displays the sample locations within Union Basin. Results are shown in Table 13.

Table 13. Union basin sample results for total PBDE

Sample ID	Collection Date	Matrix	PBDE Total (µg/L)	Storm event Precip. from Felts Field (in)	Season	Location	Sample Type
Upstream Trent Ave. Branch							
1384910ST Trent	1/24/2011	sw	0.015 NJ	0.49	Winter	Branch	Grab
	5/16/2011	sw	**0.008 J**	0.29	Spring	Branch	Grab
Napa St-Springfield Branch							
NAPA-Sprg	9/9/2010	sw	**0.302**	0.06	Summer	Branch	Grab
	1/24/2011	sw	**0.056**	0.49	Winter	Branch	Grab
	5/16/2011	sw	**0.616 J**	0.29	Spring	Branch	Grab
Union Outfall							
UNIONLPT	2/16/2010	sw	**0.122 J**	0.12	Winter	Outfall	Grab
	4/29/2010	sw	0.049 NJ	0.48	Spring	Outfall	Grab
	9/9/2010	sw	**0.083**	0.06	Summer	Outfall	Grab
	1/7/2011	sw	0.016 NJ	0.19	Winter	Outfall	Grab
	3/29/2011	sw	ns	0.18	Spring	Outfall	Grab
	7/13/2011	sw	ns	0.42	Summer	Outfall	Grab

sw = stormwater; ns = not sampled; **Bold** = detected concentration

Urban Waters collected at least one sample from the outfall for winter, spring, and summer to begin to characterize seasonal variability. The concentration ranged from ND – 0.122 µg/L. Results from the 2007 stormwater study showed concentrations from ND – 0.0068 µg/L. In both cases, at least half of the samples were below the reporting limit. Two of the six results were above the detection limit, with the highest concentration detected in winter.

The concentration fluctuated seasonally and between storm events, which was expected. The higher concentration was influenced by detection of BDE-209 or deca-BDE. The higher detection limit for this congener may have influenced the degree of fluctuation.

The maximum concentration we found in stormwater during our Liberty Lake study was 0.073 µg/L while the maximum concentration for the basins other than CSO 34, Erie, and Union was 0.128 µg/L. The Union outfall results lay between the Liberty Lake maximum and the additional basins' outfall maximum.

A source was identified off the Napa Street branch. Three stormwater samples were collected with results ranging from 0.056 – 0.616 µg/L total PBDE. The recycling facility suspected of contributing is now under a general stormwater permit for lead and other contaminants. The best management practices implemented at the facility should reduce the PBDE source. Because there is no water quality standard for PBDE and dangerous waste regulations have a limit of 100 ppm, Ecology has not regulated specifically for PBDE at any of the sources.

Erie Basin/CSO 34

We collected three CSO 34 samples as the basin was overflowing and one additional sample at the Erie Basin outfall when CSO 34 was overflowing (Table 14). We also collected two samples at the Erie Basin outfall.

Basin outfall monitoring began in 2009. Basin investigations began in 2010 after Union Basin sources were mostly identified.

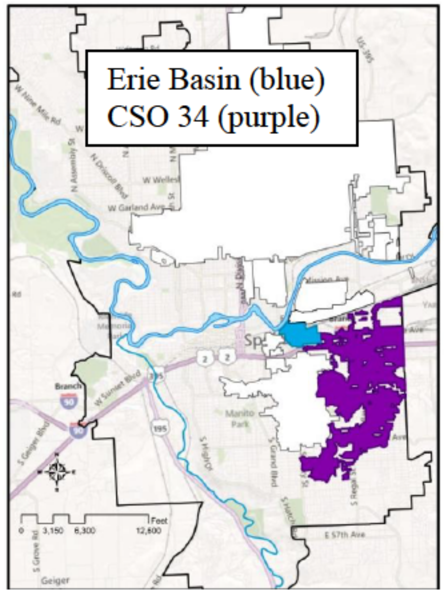


Table 14. CSO34 below weir overflow and Erie basin discharge

Sample ID	Collection Date	Matrix	PBDE Total (ug/L)	Season	Location	Sample Type	Storm event Precip. from Felts Field (in)
CSO 34 overflow discharge							
CS034B	10/23/2009	cso	**0.094**	Fall	Overflow	Grab	0.75
	4/22/2010	cso	**0.598**	Spring	Overflow	Grab	0.27
	1/13/2011	cso	**0.038**	Winter	Overflow	Grab	0.33
CSO 34 overflow and Erie basin discharge							
ERIELPT/CSO34	1/13/2011	cso	**0.039 J**	Winter	Outfall	Grab	0.33
Erie basin discharge							
ERIELPT	10/2/2009	sw	**0.008**	Fall	Outfall	Grab	0.11
	2/16/2010	sw	**0.087**	Winter	Outfall	Grab	0.12

sw = stormwater; cso = combined sewer and stormwater overflow; **Bold** = detected concentration

The sample labeled ErieLPt/CSO34 is a combination of both basins. When the sample was taken we were unaware CSO34 was overflowing.

Most of the outfall concentrations were within or near the range we found in Liberty Lake for stormwater of 0.0008 – 0.073 ug/L. The concentration from CSO34B on 4/22/2010 (0.598 ug/L) is the only sanitary sewer - stormwater mixture within the range of the Liberty Lake project sewer water results of 0.092 – 1.079 ug/L. It is also similar to the influent results from the Riverside Park Water Reclamation Facility. We will need to gather the overflow volume data from Spokane and precipitation data from the National Weather Service to compare to the overflow event concentrations to see if there may be a link between overflow volume, storm intensity, and the higher concentration.

Other Basins

Ten additional basins to Union, Erie, and CSO 34 were added to the sampling analysis plan (Table 15). All basin outfalls were located within the area between Upriver Dam and Monroe St. Dam where the highest stormwater/CSO PBDE concentration was found in the 2009 Ecology Spokane Stormwater Supplemental Report (Lubliner, 2009). The Riverside Park Water Reclamation Facility, which is located near the area with the highest PBDE fish tissue results from 2005, will be monitored by Spokane.

Table 15. PBDE totals from 11 basin outfalls to the Spokane River

Basin ID	Matrix	PBDE Total (µg/L)	Season	Sample Type	Date	Storm event Precip. from Felts Field (in)
AvistaP	sw	0.011U	Spring	Grab	5/10/2011	NA
Cochran	sw	0.054UJ	Fall	Grab	10/14/2009	0.35
Cochran	sw	**0.015 J**	Fall	Grab	10/23/2009	0.75
Cochran	sw	**0.002 J**	Fall	Grab	10/26/2009	0.62
CSO10	sa/sw	**0.006 J**	Fall	Grab	10/23/2009	0.75
CSO33	sa/sw	**0.002 J**	Summer	Grab	7/13/2011	0.42
GUBP	sw	**0.080**	Spring	Grab	4/22/2010	0.27
Langley	sw	**0.039**	Summer	Grab	7/19/2011	0.08
NWGreen	sw	0.051U	Fall	Grab	10/14/2009	0.35
NWGreen	sw	**0.013**	Fall	Grab	10/23/2009	0.75
NWGreen	sw	**0.128**	Fall	Grab	10/26/2009	0.62
Pearl	sw	0.054UJ	Fall	Grab	10/14/2009	0.35
Pearl	sw	**0.009 J**	Fall	Grab	10/23/2009	0.75
Pearl	sw	0.051U	Fall	Grab	10/26/2009	0.62
Ralph	sw	0.004 NJ	Spring	Grab	4/21/2011	0.01
Riverton	sw	**0.041**	Spring	Grab	5/16/2011	0.39
Superior	sw	**0.007**	Fall	Grab	10/14/2009	0.35
Superior	sw	**0.004 J**	Fall	Grab	10/23/2009	0.75
Superior	sw	0.051U	Fall	Grab	10/26/2009	0.62

SW = stormwater; SA/SW = sanitary sewer and stormwater water mixture; **Bold** = detected concentration

Riverton, Superior, and Cochran Basins were sampled in 2007 (Lubliner, 2009). Both Riverton and Superior results were either ND or flagged with NJ, so are not comparable. Cochran Basin total PBDE results ranged from ND – 0.010 µg/L which is similar to the 2011 range of ND – 0.012 µg/L.

Sewer Sampling

Sewer samples were taken at the two Spokane Valley, one northern Spokane County, and the Airway Heights/ Fairchild Air Force Base interceptors to Spokane’s system (Table 16).

Table 16. Sanitary sewer sample results for PBDE

Sample ID	Collection Date	Total PBDE (µg/L)	TDS (mg/L)	Season
AH/FAFB	6/3/2009	**0.097**	**422**	Spring
SVInt	6/10/2009	**0.396**	**422**	Spring
NCoInt	6/17/2009	**0.328**	**499**	Spring
NVInt	6/17/2009	**0.180**	not enough sample	Spring
SpWWTPDay	7/15/2009	**0.437**	**388**	Summer
SpWWTPNt (Avg)	7/15/2009	**0.460**	**366**	Summer
CSO34A	7/15/2010	**0.047 J**	NS	Summer

Bold = detected concentration

Spokane Valley's south valley interceptor (SVInt) and Spokane County's northern interceptor (NCoInt) have the highest concentrations at 0.396 ug/L and 0.328 respectively. They were similar to the 12-hour composite samples collected from 12am-12pm and 12pm-12am at the RPWRF headworks (0.437 ug/L and 0.46 ug/L respectively). Conducting upstream source tracing at these two interceptors may be warranted; however, they are well within the range of concentrations found in the sewer samples in the Liberty Lake study (0.092-1.079 ug/L).

Analysis of the effluent data RPWRF will collect during the new permit cycle will provide a larger data set. This will help us understand how it contributes to the concentrations found in the Spokane River fish in that reach. In addition, utilizing the City's interceptor flow data will provide better guidance on prioritizing upstream tracing.

Samples of Opportunity

A few samples were collected when the opportunity presented itself (Table 17).

Table 17. Results from additional investigations within Spokane

Sample ID	Collection Date	Matrix	PBDE Total (µg/L)	Season	Storm event Precip. from Felts Field (in.)	Location	Sample Type
Front St Outfall							
FMCB	5/7/2010	sed	**370.3**	Spring	na	Catch basin	Composite grab
C34Front	6/19/2009	sw	**0.340**	Spring	0.06	Branch	Grab
C34Front	3/29/2011	sw	**0.034**	Spring	0.18	Branch	Grab
BrownCB Avg	5/14/2010	sed	**3.30**	Spring	na	Catch basin	Grab
BECK	11/5/2010	sed	**35.0 J**	Fall	na	Drywell	Composite grab
Flyash	2/3/2010	sed	**4.10**	Winter	na	Ground	Composite grab

Appendix D provides definitions for all data flags used in this project.

Sample ID	Collection Date	Matrix	PBDE Total (µg/L)	Season	Storm event Precip. from Felts Field (in.)	Location	Sample Type
ZeroRez	6/2/2011	ww	**11.9 J**	Spring	na	carpet cleaning truck tank	Grab of carpet wash water from several facilities
NSLFC	2/11/2010	liquid waste	0.011U	Winter	na	sump	Grab
NSLFCBPad	2/11/2010	sw	**0.246**	Winter	na	sump	Grab
NSLFL	2/3/2010	liquid waste	0.010U	Winter	na	sump	24-hr composite

sed = sediment; ww = waste water; **Bold** = detected concentration; sw = stormwater; na = not applicable

Sampling showed one source to the Spokane River that discharged to C34Front Street branch. It was traced to a boat manufacturing and repair facility that stored carpet and upholstery from old boats around the storm drain. The catch basin sediment sample collected at the facility contained the highest PBDE sediment concentration found in our sampling efforts to date (370.3 µg/L). The facility has new owners that will install proper stormwater management structures. Although the concentration was a magnitude lower at the downstream C34 Front location in 2011 than 2009, it is hard to tell if this concentration decrease is permanent without further sampling. This would be a good candidate for a sediment sampler analysis.

The BECK's sediment sample results of 35.0 µg/L were elevated compared to the Flyash and BrownCB samples. The analysis had significant matrix interferences which raised the reporting limits (Table 3). The location may contain a PBDE source; however, the system was disconnected due to metals contamination, so it is no longer a direct discharge source for concern.

The carpet cleaning wastewater also showed elevated levels of PBDE at 11.94 µg/L. Urban Waters worked with SRHD, the Washington Waters group, and local carpet cleaners on educational materials to prevent discharging wastewater to the ground or storm drain. This practice is common among carpet cleaners.

Statistical Analysis

Linear regression analysis revealed no strong associations between PBDE and the general parameters: TOC, DOC, TDS, TSS, and turbidity. We also collected temperature, DO, and pH but have not looked for associations with PBDE.

Chlorinated Dioxins and Furans Section

Overview

Three sections of the Spokane River are listed as impaired for 2,3,7,8-TCDD TEQ according to Water Quality Program's WQ Atlas mapping database. The listing dropped from a category 3 waterbody in 2004 to a category 2 in 2008. A category decrease indicates a decrease in water quality impairment. Three sections of the Spokane River are listed as category 5 for total 2,3,7,8 TCDD.

Our initial investigation includes the following areas:

- Union basin
- RPWRF influent and four interceptors

Both of the discharge points chosen are within a Spokane River reach on the 303(d) list. Ecology's 2009 Supplemental Report indicated Union basin and Superior basin may have upstream sources of dioxin/furan (Figure 2). Superior Basin was added to our additional basin outfall characterization sampling plan.

RPWRF and the interceptors to Spokane's sanitary sewer system were chosen as a starting point to determine the concentrations entering the plant and if any particular interceptor area contained a traceable source (Figure 3).

Results/Discussion

Union Basin

In 2007, Ecology sampled sediment at the outfall manhole that corresponds to sample ID: UnionLPt (Lubliner, 2009). Ecology also conducted a study to characterize dioxin by land-use (Yake et al., 1998). The Union sediment result of 17.30 TEQ in ng/Kg fell within the upper range of the urban land use data from Yake's study (0.13-19 TEQ in ng/Kg). It exceeded all three sediment samples collected in our Liberty Lake pilot project (max = 9.09 TEQ in ng/Kg).

Figure B-2 displays the sample locations within Union Basin. Results for Union Basin investigations are shown in Table 18.

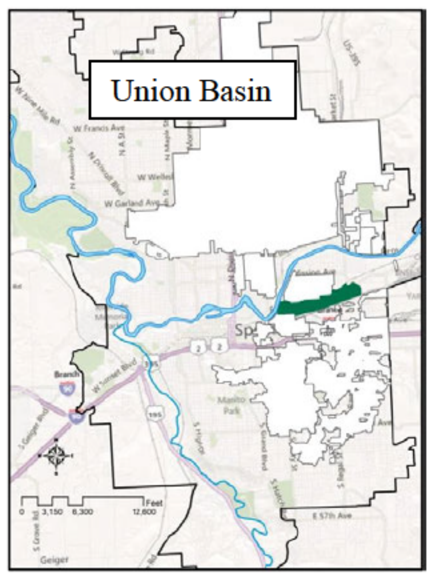


Table 18. Union Basin dioxin/furan sampling results

Sample ID	Date	Matrix	Storm event Precip. From Felts Field (in)	Total tetra-octa D/F (pg/L)	2,3,7,8 - TCDD TEQ (pg/L)	Season	Sample Type
Napa St-Springfield Ave. Branch							
NAPA-SPRG	9/9/2010	sw	0.06	**3329.33**	**18.8**	Summer	Grab
	1/24/2011	sw	0.49	**2258.59**	**9.54**	Winter	Grab
	5/16/2011	sw	0.29	**3744.83**	**9.78**	Spring	Grab
	7/29/11	sed	na	**1817.29 (ng/Kg)**	**5.49 (ng/Kg)**	Summer	Comp. scoop
Upstream Trent Ave Branch							
1384910ST (Trent)	1/24/2011	sw	0.49	**3669.69**	**15.6**	Winter	Grab
	5/16/2011	sw	0.29	**2083.66**	**7.80**	Spring	Grab
TRENT-TPC	6/25/2009	sed	na	**2414.70 (ng/Kg)**	**6.17 (ng/Kg)**	Summer	Comp. scoop
Crestline-Springfield Ave Branch							
CRSPADM	7/2/2010	sw	0.28	**12752.5**	**51.0**	Summer	Grab
Union Basin Outfall							
UNIONLPT	6/8/2009	sw	0.29	**2125.25**	**8.72**	Spring	Grab
	10/2/2009	sw	0.11	**1033.79**	**3.66**	Fall	Grab
	2/16/2010	sw	0.12	**5077.86**	**8.17**	Winter	Grab
	4/29/2010	sw	0.48	**1852.60**	**6.42**	Spring	Grab
	9/9/2010	sw	0.06	**6324.97**	**29.1**	Fall	Grab
	1/7/2011	sw	0.19	**324.310**	**3.41**	Winter	Grab
	3/29/2011	sw	0.18	**Waiting on analysis**	**Waiting on analysis**	Spring	Grab

sed = sediment; sw = stormwater; na = not applicable; **Bold** = detected concentration

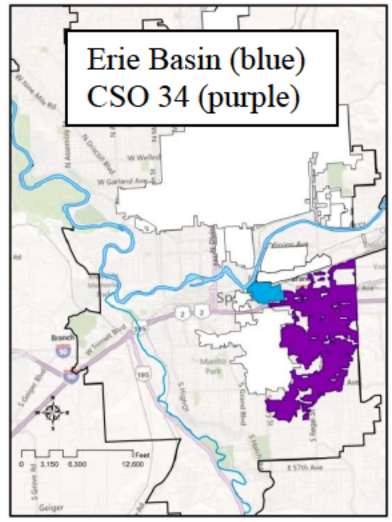
The Napa-Sprg and Trent-TPC sediment sample results fell within the typical urban land use range for soils from Yake's study. The Crestline-Springfield branch showed the highest TEQ as well as total tetra-octa dioxin/furan concentrations. The elevated total came from a high concentration of OCDD. OCDD is the sum of the octa or eight chlorine atom forms of dioxin. It is associated with combustion. Further source investigation should be conducted along this branch.

The Parsons and Terragraphics (2007) Spokane stormwater study collected sediment from Union's outfall pipe to assess dioxin/furan concentrations. The outfall contained 17.30 ng/Kg dw TEQ dioxin/furan total. The Trent-TPC and Napa-SPRG samples were well below the outfall concentrations. These two sites have been ruled out as an elevated source.

The Union outfall stormwater concentration range was 3.66 – 29.1 pg/L TEQ dioxin/furan. All but one sample fell within a similar concentration range to the Liberty Lake Pilot Project (1.61 – 8.14 pg/L TEQ). The highest sample happened during a low precipitation, fall storm. This may indicate a source is present that undergoes dilution during high flow events.

Erie Basin/CSO34

Urban Waters collected samples at CSO34 above and below the weir along with the Erie Basin system low point to determine if dioxin/furan sources were present (Table 19).



Concentrations were similar to those found in the Liberty Lake Pilot Project (1.61 – 8.14 pg/L 2,3,7,8-TCDD TEQ).

Flow data from Spokane CSO system will need to be used to get a better idea of whether the CSO 34B concentrations warrant further source investigations in the system.

The CSO34A sanitary sewer sample concentration is similar to other sanitary sewer system results from this study. This supports the finding from the Liberty Lake Pilot Project that stormwater may be a larger source than sanitary sewer (Fernandez and Hamlin, 2010).

The ENX samples and FLYASH sample were collected when a storm event showed fly ash running off the property. Flyash can be contaminated with dioxin/furan and metals. The results indicated the flyash is not a source of dioxin/furan; however, the turbidity was elevated due to the ash. Urban Waters worked with the facility to reduce stormwater discharge to lower turbidity to the storm system.

Table 19. Erie Basin and CSO 34 sampling results for dioxin/furan

Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Storm event Precip. from Felts Field (in)	Season	Sample Type	Note
Madelia Street							
ENXEXIT	5/27/2010	**379.36**	**2.07**	na	Spring	sw	
ENXPROD	5/27/2010	**121**	**0.272**	na	Spring	solid	
ENXSILO	5/27/2010	**197.5**	**0.951**	na	Spring	sw	
ENXYARD	5/27/2010	**2449.64**	**11.4**	na	Spring	sw	
FLYASH	2/3/2010	**78.04**	**0.190**	na	Winter	sed	
	2/3/2010	**3968.34**	**12.2**	na	Winter	sw	
Erie Basin Outfall							

Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Storm event Precip. from Felts Field (in)	Season	Sample Type	Note
ERIELPT	10/2/2009	**1485.73**	**5.58**	0.11	Fall	sw	
	2/16/2010	**1154.9**	**2.19**	0.12	Winter	sw	
ErieLPt/ CSO34B	6/8/2009	**3526.85**	**9.95**	0.29	Spring	sw	ErieLPt with CSO34 overflow
	1/13/2011	**434.01**	**0.870**	0.33	Winter	cso	
CSO 34 above weir-sewer only							
CSO34A	7/15/2010	**33.7**	**0.232**	na	Summer	sa	
CSO 34 below weir during overflow							
CSO34B	6/8/2009	**500.26**	**15.7**	0.29	Spring	cso	
	10/23/2009	**565.77**	**4.47**	0.75	Fall	cso	
	4/22/2010	**1889.4**	**4 .00**	0.27	Spring	cso	
	1/13/2011	**815.7**	**1.90**	0.33	Winter	cso	

sed = sediment; sa = sanitary sewer water; na = not applicable; **Bold** = detected concentration
sw = stormwater; cso = combined sewer and stormwater overflow

Other Basins

Eleven additional basins were sampled including one sample from a facility pond, eight from Spokane municipal stormwater system, and two combined sewer overflows (Table 20).

Table 20. Dioxin/furan results for 11 additional basin outfalls to the Spokane River

Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Storm event Precip. from Felts Field (in)	Season	Sample Type
AvistaP	5/10/2011	**1.37J**	**0.016**	NA	Spring	Grab
Cochran	10/14/2009	**752.78**	**2.54**	0.35	Fall	Grab
	10/23/2009	**564.86**	**1.16**	0.75	Fall	Grab
	10/26/2009	**608.3**	**2.14**	0.62	Fall	Grab
CSO 10	10/23/2009	**355.01**	**1.09**	0.75	Fall	Grab
CSO33	7/13/2011	**426.78**	**0.909**	0.42	Summer	Grab
GUBP	4/22/2010	**581.28**	**3.1**	0.27	Spring	Grab
Langley	7/19/2011	**1864.19**	**13.9**	0.08	Summer	Grab

Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Storm event Precip. from Felts Field (in)	Season	Sample Type
NWGreen	10/14/2009	**1054.6**	**3.92**	0.35	Fall	Grab
	10/23/2009	**896.8**	**2.14**	0.75	Fall	Grab
	10/26/2009	**1121**	**1.59**	0.62	Fall	Grab
Pearl	10/14/2009	**716.15**	**5**	0.35	Fall	Grab
	10/23/2009	**710**	**1.82**	0.75	Fall	Grab
	10/26/2009	**667.09**	**9.15**	0.62	Fall	Grab
Ralph	4/21/2011	**733.55**	**1.26**	0.01	Spring	Grab
Riverton	5/16/2011	**744.58**	**1.25**	0.39	Spring	Grab
Superior	10/14/2009	**579.18**	**1.77**	0.35	Fall	Grab
	10/23/2009	**323.9**	**0.789**	0.75	Fall	Grab
	10/26/2009	**442.9**	**1.03**	0.62	Fall	Grab

Bold = detected concentration

The facility pond contained the lowest concentrations while Langley and Pearl contained the highest concentrations at 13.9 and 9.15 pg/L 2,3,7,8-TCDD TEQ respectively. These concentrations are similar to those found in the Liberty Lake Pilot project (1.61 – 8.14 pg/L 2,3,7,8-TCDD TEQ). Source investigation does not appear to be necessary in these basins.

Sewer Sampling

24-hour composite samples were collected at RPWRF's headworks and at four interceptor locations. The interceptors receive sewage from various neighboring cities and Spokane County. Table 21 shows the results for dioxin/furan sanitary sewer samples.

Table 21. Sanitary sewer results for dioxin/furan

Sample ID	Date	Total tetra- octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Season	Location
SVInt	6/10/2009	**189.48**	**0.101**	Spring	manhole
SpWWTPDay	7/15/2009	**118.56**	**1.71**	Summer	headworks
SpWWTPNt	7/15/2009	**101.37**	**1.66**	Summer	headworks
NVInt1	6/17/2009	**185.4**	**0.214**	Spring	manhole
AH/FAFB-Sa	6/3/2009	**55.3**	**0.202**	Spring	manhole
COInt1	6/17/2009	**215.04**	**0.305**	Spring	manhole

Bold = detected concentration

In general, the sanitary sewer samples were on the lower end of the concentrations found within stormwater. This is consistent with findings from the Liberty Lake Pilot Project. This would suggest dioxin/furan source tracing efforts should focus on stormwater discharges.

Samples of Opportunity

Several samples were collected as opportunities presented themselves. Results are shown in Table 22.

Table 22. Opportunistic sample results for dioxin/furan

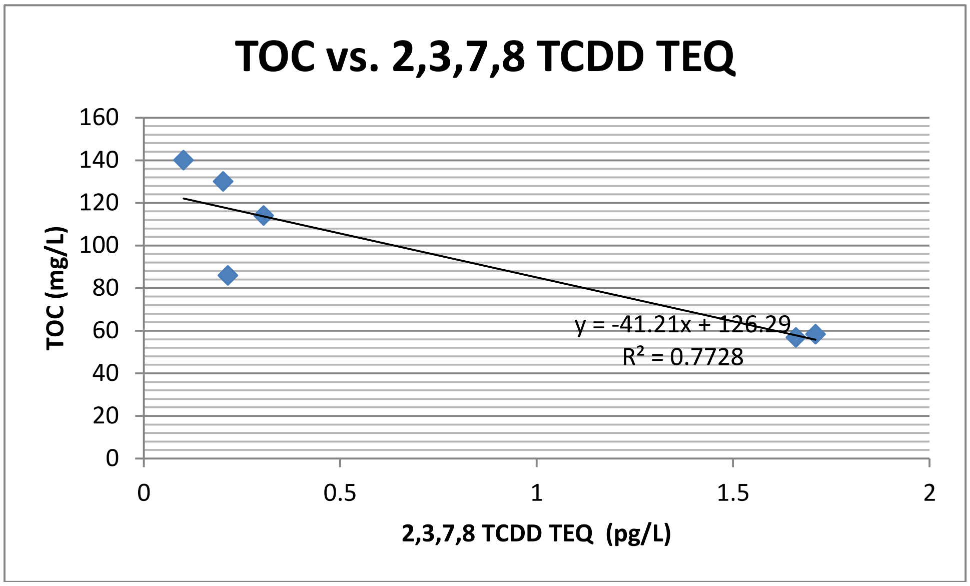
Sample ID	Date	Total tetra-octa D/F (pg/L)	2,3,7,8 TCDD TEQ (pg/L)	Location	Sample Type
River Ext	6/7/2011	101.18J	0.053	Exposed aquifer	gw
ZeroRez	6/2/2011	4629.8	6.15	Carpet cleaning truck tank	ww
NSLFC	2/11/2010	26.57	0	sump	condensate
NSLFCBPad	2/11/2010	1279.23	3.97	sump	sw
NSLFL	2/3/2010	19.91	0.004	sump	leachate
BECK	11/5/2010	Waiting on analysis	Waiting on analysis	Drywell with overflow	sed
BrownCB Avg	5/14/2010	2935.9	8.95	Catch basin	sed

Bold = detected concentration

None of the above sample results contained levels outside the ranges found in the Liberty Lake Pilot Project. Further investigation was not pursued.

Statistical Analysis

Figure 11. TOC vs. total dioxin/furan TEQ linear regression.



Linear regression analysis suggests a strong inverse association between 2,3,7,8 TCDD TEQ and TOC in sanitary sewer (Figure 11). The sample number is low, however, and further data collection is necessary (N=6). No association was found between TSS and dioxin/furan in sanitary sewer.

Because the regression appears strongly influenced by two data points, additional data points should be collected to confirm this association to use for source tracing purposes. For example, high TOC may be used as an inexpensive screen for dioxin/furan unless other investigative factors indicate otherwise. This may influence a fate and transport model for this system. If we can determine the significant source of TOC, such as human waste, we can focus our surface investigations accordingly.

Metals Section

Overview

Stormwater sampling had not been conducted for metals prior to our pilot project in the Liberty Lake area (Fernandez and Hamlin, 2009). Sample results from the Liberty Lake Pilot Project showed lead, cadmium, and zinc are present in stormwater discharges well above reporting limits. This makes metals tracing in storm systems possible. Metals analysis was included when appropriate as we investigated our other CoC sources. This was done to help focus future source investigations and best management practice options for controlling metals to the Spokane River.

We have had little extra capacity to assess or use our metals data for source tracing. PCB work took priority due to permit schedules and community interest. We provided a limited amount of metals data to the Water Quality Program to determine criteria exceedances. We have focused Urban Waters metals efforts on business regulation until time allows us to analyze our data set.

Progress included the following:

- Collected a total of 49 metals samples from various matrices between 2009 and September 2011.
- 12 additional basins sampled to begin concentration characterization of stormwater, industrial and combined sewer overflow discharges for TMDL and NPDES permit management.
- Union, Erie, and CSO 34 basin seasonal characterization for metals.
- Eight Ecology multi-media checklist visits through 2011.
- General Stormwater Permit for lead at a recycler connected to Union basin.
- Radiator shop investigation in Erie basin:
    - Spokane drywell cleanout and disconnection due to lead and zinc contaminations.
    - Initial investigation and ranking of site for future cleanup based on lead soil concentrations.
- One Ecology dangerous waste inspection and cleanup for suspected lead-contaminated paint debris.
- Technical assistance visit to general stormwater permittee to assist with zinc source tracing.
- Joint visit to chrome facility for LSCS training that resulted in cleanup of metals and oil from metals on the ground exposed to the environment.
- Ecology inspection and BMP implementation at steel recycler that led to:
    - Cleanup of sludges on the ground.
    - Redirection of stormwater through proper treatment and swales.
    - Covers for metal scrap containers provided to customers to prevent stormwater contamination.
    - Cover for operations that may contaminate stormwater.
- 155 Local Source Control visits in Union and Erie basins through 2011.

Results/Discussion

Union Basin

We collected 12 samples within Union basin (Table 23, Figure B-2). The Trent samples and NapaSpg samples are branch samples within the stormwater system while the UnionLPt sample is at the outfall manhole for the basin.

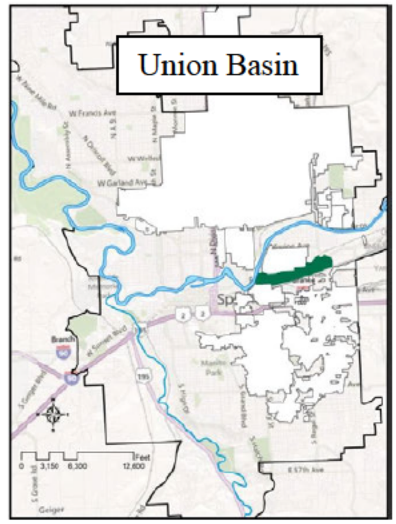


Table 23. Lead, zinc, cadmium, and hardness results for samples collected in Union basin

Sample ID	Collection Date	Cadmium (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness as $CaCO_3$ (mg/L)	Season	System Location	Sample Type
Main Trent Ave. Branch East								
1384910ST Trent	1/24/2011	**1.28**	**38.9**	**453**	**1720**	Winter	Branch	sw
	5/16/2011	**0.33**	**35.8**	**149**	**24.3**	Spring	Branch	sw
Main Trent Ave. Branch West								
Trent-TPC	6/25/2009	**0.36** (mg/Kg)	**34.3** (mg/Kg)	**154** (mg/Kg)	na	Summer	Branch catch basin	sed
Napa St and Springfield Ave Branch								
NAPA-SPRG	9/9/2010	**2.97**	**833**	**752**	**85.4**	Summer	Branch	sw
	1/24/2011	**1.51**	**180**	**582**	**798**	Winter	Branch	sw
	5/16/2011	**3.15**	**1090**	**820**	**120**	Spring	Branch	sw
Union Basin Outfall								
UNIONLPT	6/8/2009	**0.68**	**53.9**	**239**	NS	Spring	Outfall	sw
	10/2/2009	**0.36**	**28.2**	**153**	**46.2**	Fall	Outfall	sw
	2/16/2010	**1.9**	**221**	**632**	**81.9**	Winter	Outfall	sw
	4/29/2010	**0.48**	**41.5**	**249**	**44.1**	Spring	Outfall	sw
	9/9/2010	**1.04**	**113**	**410**	**51.3**	Summer	Outfall	sw
	1/7/2011	**1.05**	**40.7**	**338**	**279**	Winter	Outfall	sw
	3/29/2011	**0.73**	**98.8**	**265**	**58**	Spring	Outfall	sw

na = not applicable; sw = stormwater; sed = sediment; **Bold** = detected concentration

For purposes of comparison, the general stormwater permit limits for facility discharge is 117 µg/L for zinc and 81.6 µg/L for lead. All zinc samples exceeded the benchmark for facilities. Three of the seven samples collected at Union outfall exceeded the benchmark for lead. None of the samples were collected from a facility prior to mixing. For perspective, the Liberty Lake pilot study showed residential neighborhood runoff could exceed the facility 117 µg/L benchmark.

The NapaSpg location that accepts discharge from a recycler exceeded lead benchmarks for all three samples. They are now under a general stormwater permit for lead and zinc. Urban Waters' Water Quality staff is managing their permit and currently working with the facility.

Erie Basin/CSO34

Nine samples were collected in Erie basin and three samples in CSO 34. Investigations into CSO 34 have not begun. Table 24 shows the results for our CoC metals and hardness. Dissolved metals concentrations have not been calculated.

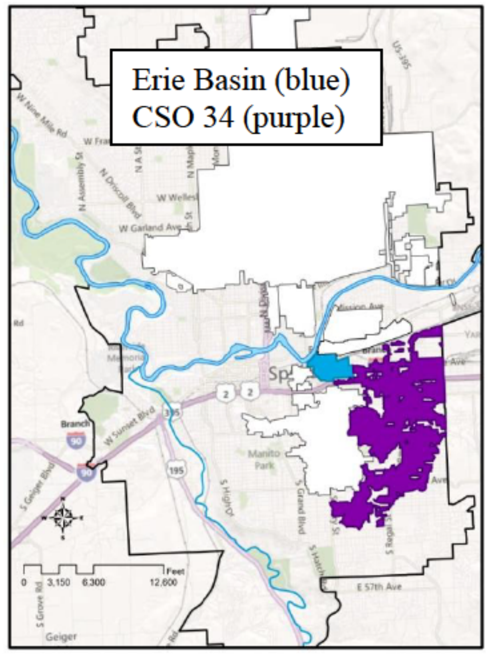


Table 24. Lead, zinc, cadmium, and hardness results for samples collected in Erie and CSO 34 basins

Location	Collection Date	Cadmium (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness as $CaCO_3$ (mg/L)	Season	Location	Sample Type
CSO 34 overflow								
CS034B	6/8/2009	**0.36**	**10.7**	**153**	ns	Spring	Outfall	cso
CSO34B	4/22/2010	**0.46**	**28.8**	**234**	93.7	Spring	Outfall	cso
CSO34B	1/13/2011	**0.29**	**7.14**	**119**	351	Winter	Outfall	cso
Napa St and Riverside Ave Intersection								
BECK	11/5/2010	**1.75 mg/Kg**	**1440 mg/Kg**	**1310 mg/Kg**	na	Fall	Drywell	sed
BNSF/ENX Facility								
ENXexit	5/27/2010	**1.91**	**221**	**1100**	ns	Spring	Surface runoff	sw
ENXprod	5/27/2010	**0.48 mg/Kg**	13.7U mg/Kg	127U mg/Kg	na	Spring	ground	Waste powder
ENXsilo	5/27/2010	**1.3**	**37.4**	**195**	ns	Spring	puddle	sw
ENXyard	5/27/2010	**0.66**	**65.1**	**184**	ns	Spring	puddle	sw
Erie Basin outfall								
ERIELPT	10/2/2009	**0.57**	**37**	**311**	71.7	Fall	Outfall	sw
ERIELPT	2/16/2010	**0.57**	**52.9**	**237**	65.7	Winter	Outfall	sw
ERIELPT/CSO34	6/8/2009	**0.98**	**39.6**	**374**	ns	Spring	Outfall	cso
ERIELPT/CSO34	1/13/2011	**0.33**	**9.6**	**121**	313	Winter	Outfall	cso

sed = sediment; na = not applicable; ns = not sampled; **Bold** = detected concentration
sw = stormwater; cso = combined sewer and stormwater overflow

For reference, all stormwater samples exceeded the general stormwater permit benchmark for zinc (117 µg/L). Lead concentrations from ENXexit exceeded the 87.1 µg/L lead benchmark for a general stormwater facility permittee. Under Urban Waters direction, the facility redesigned their stormwater management system to eliminate discharge to Erie basin.

Lead concentrations indicated sediment from the Beck drywell may designate as dangerous waste. A TCLP analysis of 3.69 mg/Kg was less than a D008 listed dangerous waste level of 5 mg/Kg. However, the lead and zinc concentrations were high enough to designate as a WT02 state-only dangerous waste.

Spokane cleaned out the system and closed off the overflow discharge pipe that discharged to Erie basin. Urban Waters assisted with an initial investigation and dangerous waste investigation at the suspected location for this discharge. The site is now ranked a 4 on the state's Hazardous Sites List and is awaiting future TCP follow-up.

To prevent any possible future migration of contamination through the watershed, soil removal and stormwater swale construction would be ideal. This would prevent stormwater from reaching the City's system which already has issues with flooding during storm events in this location. Soil capping is another alternative as long as a portion of the site is mitigated and designed to capture and infiltrate stormwater.

Other Basins

We collected stormwater samples from 11 basins within Spokane (Table 25). Nine of the 19 samples collected exceeded the general stormwater permit benchmark for zinc. None of the basin outfalls exceeded the general stormwater permit benchmark for lead.

Table 25. Lead, zinc, cadmium, and hardness results for samples collected at 11 stormwater basin outfalls to the Spokane River

Basin ID	Collection Date	Cadmium (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness as CaCO3 (mg/L)	Season	Sample Type
AvistaP	5/10/2011	**0.19**	0.10U	**6.5**	**98.0**	Spring	sw
Cochran	10/14/2009	**13.7**	**0.2**	**93.5**	**25.8**	Fall	sw
	10/23/2009	**12.4**	**0.16**	**78.2**	**19.3**	Fall	sw
	10/26/2009	**12.9**	**0.16**	**73.7**	**15.3**	Fall	sw
CSO 10	10/23/2009	**17.9**	**0.2**	**87.2**	**13.9**	Fall	sa/sw
CSO33	7/13/2011	**10.4**	**0.23**	**114**	**49**	Summer	sa/sw
GUBP	4/22/2010	**9.61**	**0.27**	**162**	**17.7**	Spring	sw
Langley	7/19/2011	**27**	**0.42**	**280**	**46.4**	Summer	sw

Basin ID	Collection Date	Cadmium (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness as $CaCO_3$ (mg/L)	Season	Sample Type
NWGreen	10/14/2009	**14.2**	**0.33**	**177**	**39.9**	Fall	sw
	10/23/2009	**23.6**	**0.47**	**257**	**38**	Fall	sw
	10/26/2009	**21.1**	**0.37**	**152**	**21.4**	Fall	sw
Pearl	10/14/2009	**11.6**	**0.18**	**121**	**32.5**	Fall	sw
	10/23/2009	**29.8**	**0.27**	**149**	**21.3**	Fall	sw
	10/26/2009	**15.3**	**0.14**	**76.9**	**15.4**	Fall	sw
Ralph	4/21/2011	**14.9**	**0.21**	**126**	**171**	Spring	sw
Riverton	5/16/2011	**24.1**	**0.25**	**103**	**24.6**	Spring	sw
Superior	10/14/2009	**10**	**0.18**	**110**	**34.5**	Fall	sw
	10/23/2009	**14.6**	**0.19**	**120**	**28.7**	Fall	sw
	10/26/2009	**21.1**	**0.16**	**117**	**19.5**	Fall	sw

sw = stormwater;   sa/sw = sanitary sewer and stormwater mixture;   **Bold** = detected concentration

Urban Waters provided the October 2009 outfall data to the Water Quality Program. This should be continued with future metals data so Water Quality can compare results to the Water Quality Criteria acute and chronic surface water standards.

Because six of the 11 outfalls sampled exceeded the general stormwater permit benchmark for facilities, it is unclear whether source tracing individual basins is the best option for zinc. Exploration into whether the elevated zinc levels are caused by a ubiquitous product such as tires or galvanized materials is warranted. Further discussion is needed for zinc tracing in stormwater.

Three storm events were collected from four basins during Fall 2009. Table 26 shows the concentration ranges during this time period.

Table 26. Concentration ranges for outfalls from three storms during Fall 2009

Sample ID	Lead Concentration Range (µg/L)	Cadmium Concentration Range (µg/L)	Zinc Concentration Range (µg/L)
Cochran	12.4 - 13.7	0.16 - 0.2	73.7 - 93.5
NWGreen	14.2 - 23.6	0.33 - 0.47	152 - 257
Pearl	11.6 - 29.8	0.14 - 0.27	76.9 - 149
Superior	10 - 21.1	0.16 - 0.19	110 - 120

To provide a frame of reference, the general stormwater permit provides facilities with benchmark concentrations for lead and zinc, 81.6 µg/L and 117 µg/L respectively. Lead was never exceeded while zinc had several exceedances.

Samples of Opportunity

We analyzed four additional samples within Spokane for metals (Table 27).

Table 27. Lead, zinc, cadmium, and hardness results for samples collected within Spokane.

Location	Collection Date	Cadmium (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness as $CaCO_3$ (mg/L)	Season	Location	Sample Type
C34Front	6/8/2009	0.003 U	**1.07**	**43.9**	ns	Spring	Outfall	sw
BrownCB Avg	5/14/2010	**0.47 mg/Kg**	**51.3 mg/Kg**	**188 mg/Kg**	na	Spring	Catch basin	sed
ZrRz	6/2/2011	**2.7**	**64.3**	**2380**	**119**	Spring	carpet cleaning truck tank	ww
River Ext	6/7/2011	**0.12**	**19.1**	**73.1**	**123**	Spring	gw	sw

gw = ground water; sw = stormwater; sed = sediment; ww = waste water
ns = not sampled; na = not applicable; **Bold** = detected concentration

C34Front: Business practices along this branch or storm system were suspected of contributing contamination to the river. The results did not indicate further investigation.

BrownCB: The business discharging stormwater to this system had a SIC code that may indicate a possible source. Historical research at the site showed past contamination that had been cleaned up. Ecology needs to review the data and determine if the catch basin sediments are elevated enough to warrant a stormwater sample for compliance purposes.

ZrRz: Urban Waters collected wash water from a carpet cleaning truck. The zinc level is of concern and further discussion on the implications of carpet wash water as a source of zinc is necessary. Urban Waters has collaborated with Ecology's Washington Waters group on a business education handout to carpet cleaners describing proper discharge options.

Urban Waters also investigated a carpet cleaning operation discharging to a swale. Technical assistance was provided and the activity was stopped.

River Ext: This sample was collected from an exposed area of groundwater during Spokane construction activities. Urban Waters is interested in possible groundwater contamination during construction activities. Analysis of the data in relation to typical aquifer concentrations within the Spokane Valley-Rathdrum Prairie aquifer needs to be completed.

General Progress

Here is an abbreviated list of accomplishments to date:

- TCP conducted follow-up investigation of a PCB voluntary cleanup site within Union Basin to determine its potential for impact to city storm drain systems. Stormwater was found to discharge direct to ground from a drainage swale to dry well.
- LSCS has completed all initial visits for the Union Basin catchment and is completing follow-up.
    - Several businesses with potential, significant or unresolved problems were referred to Ecology for compliance inspections and follow-up monitoring. A total of eight businesses have been referred to Ecology for follow-up. General issues include:
        - Metals recycler bins distributed without lids causing ground contamination.
        - Oils from recycling operations causing ground contamination.
        - Old, tar-like paint mismanagement causing ground contamination.
        - Car fluid ground contamination.
        - Stormwater system metals, PCB, and PBDE contamination.
        - Carpet wash water illicit disposal.
- LSCS is currently working in CSO 34/Erie Basin. Combined total for businesses visited in Erie, and Union basins through 2011 is 155.
- Ecology completed eight multi-media checklist visits through 2011.
- Identified sources for several CoCs which are in various stages of cleanup.
- Completed a design for a low cost storm-drain sediment sampler.
- Developed a business brochure and general brochure for Urban Waters Initiative.
- Assisted with the development of a carpet wash water brochure produced by Washington Waters.
- Engaged with local governments and public by participating in presentations, advisory committees, media events, etc.
- Monthly or bi-monthly data-sharing meeting between Spokane, UW, and Ecology's Municipal Stormwater Permit Writer regarding stormwater source tracing and implementation of their Municipal Stormwater Permit.

- Provided technical assistance and training to ERO Ecology and the regulated community for source tracing and analytical techniques.
    - With municipalities and industries looking at treatment options for capturing toxics.
    - With Spokane involved with pilot project for testing treatment technologies. Having them include some toxicants of concern in pilot testing.
- Created interactive GIS mapping database for assistance with source tracing spatially.
- Designed a GIS pilot project that should provide enhanced features for data analysis, tracing, and monitoring of sources to the Spokane basin.
- Developed sampling protocols for storm drain sediments and water.
- Analyzed stormwater and CSO samples for total phosphorus for use by other programs.

The Local Source Control Specialist from SRHD succeeded in getting outside storage and work areas cleaned up and contaminants out of contact with stormwater. We did not see a drop in concentration of our contaminants over time however, which may indicate that a portion of our contamination is historic or unrelated to the current business practices in the area. Without flow data it is difficult to compare storm events beyond looking for a general concentration decrease over time.

Air Deposition Literature Review: Urban Waters requested EAP conduct a literature review in an effort to identify past studies of airborne pollutants of CoC in areas similar to Spokane River. Minimal information was found. Any data available was used to help determine the significance of the long-range and short-range air deposition contribution to Spokane River contamination. The report concluded we should investigate air deposition as a significant source to stormwater (Era-Miller, 2011).

Spokane River Monitoring Plan: A comprehensive multimedia (water, sediment and tissue) toxics monitoring effort has been underway by the Toxics Studies unit in our Environmental Assessment Program. Urban Waters requested additional sampling locations and more research regarding the best form of sample collection to better monitor for CoC in our unique system. It will help determine if our efforts have made a difference over the long-term and keep track of the congener trends in the river. We will continue working with EAP to help form the monitoring plan including area tours, information sharing, and plan review (Era-Miller, 2012).

NE Washington Lakes Background Study: In a cooperative effort, Headquarters EAP, ERO TCP and the Urban Waters Initiative pooled funds for a study of northeastern Washington lakes. This was an attempt to characterize background concentrations of CoC in sediments and fish tissue. This information allows us to take into account concentrations of pollutants that would be considered ubiquitous in the general environment.

Urban Waters can use the data (uploaded to Ecology's EIM database) in conjunction with the air deposition literature review for eastern Washington by Era-Miller in 2012 to help understand the effect air deposition has on our sources. This will include a look at congener and spatial patterns. It will also help us determine at what concentration we end our upstream investigation of a basin and begin to focus on other forms of source control (Johnson et al., 2011).

Spokane River Regional Toxics Task Force: The task force was included as a requirement in the latest rounds of NPDES discharge permitting along the Spokane River. This will allow the dischargers and Ecology to work together and develop a comprehensive plan for the identification and elimination of Category 5, 303(d) listed contaminants to the Spokane River. Urban Waters is providing technical assistance to the task force on an as-needed basis. Our current work is focused on source tracing and quality assurance project plan development and review, and participating as a presenter and panel participant at their PCB technical workshop.

Source Reductions

- TCP Cleanup Sites: Spokane River metals sites (five completed, four in progress—which includes one previously completed site undergoing repair); PCB-impacted sediment removal action and capping action completed at two sites; and Remedial Investigation/Feasibility Studies are in progress for three additional sites (PCBs & metals) located adjacent to the River.

- A PBDE source was traced to a boat manufacturing and repair facility that stored carpet and upholstery from old boats around the storm drain. All waste has been removed from the facility and new owners will install proper stormwater management structures. Sample results show a magnitude decrease in stormwater concentrations.

- Metals contamination in a storm system was traced to radiator shop activity. The system was disconnected to eliminate the source.

- PCB contamination in a storm system was connected to a transformer facility. The system was disconnected to eliminate the source.

Conclusions

Monitoring and Research

The Spokane River watershed is unique and may be compounding the issue of elevated CoC in fish tissue. Unique characteristics include 1) low TSS and TOC in the River which may affect partitioning by increasing the dissolved fraction, 2) many outfalls with concentrations typical of other urban cities discharging to a relatively small waterbody, 3) ready aquifer exchange with the river that potentially affects CoC behavior, etc. Our major findings include the following:

PCB

- PCB sources to the Spokane River are more diffuse than originally suspected.
- Basin field observation, historical research of past activity, and homologue pattern work can be useful for PCB source tracing.

PBDE

- Air deposition may be a large source for PBDE.
- Sanitary sewer influent PBDE results were generally higher than stormwater outfall results. Upstream investigation by the wastewater treatment plant permittees may be useful for source identification.
- Carpet cleaning washwater is a source of PBDE and should not be disposed on the ground.

Dioxin/Furan

- There is a dioxin/furan source along the Crestline-Springfield branch within Union Basin that needs further investigation.
- More focus on dioxin/furan source tracing will be necessary to determine accurate source contributions and implement effective cleanup and prevention measures. Other CoC have taken priority due to current regulatory and community needs. Data suggests dioxin/furan source tracing efforts should focus on stormwater discharges.
- Limited data on carpet cleaning wash water and landfill leachate and condensate within Spokane suggest these types of waste are not sources of dioxin/furan above typical urban concentrations. An assessment of local typical urban concentrations will assist with clarifying this assumption.
- An association was found between 2,3,7,8 TCDD TEQ and TOC in sanitary sewer wastewater. Further investigation needs to be conducted into the significance of this finding with respect to source identification needs.
- Additional data collection and source characterization of dioxin/furan within the basin is necessary. Air deposition is often the dominant source pathway for dioxin and furan. OCDD was the highest concentration found of the 17 compounds analyzed. OCDD is a dominant form of dioxin by-product formed during incomplete combustion.

Metals

- Elevated concentrations of zinc are found in carpet wash water.
- We found elevated levels of zinc and lead from a recycler and radiator shop.
- Concentrations of lead and zinc in stormwater often exceed the general stormwater benchmarks for industrial facilities.
- Additional analysis of lead, cadmium, and zinc concentrations in relation to Water Quality standards should be completed by the Water Quality Program to determine how to handle what appear to be ubiquitous sources.

Inspections

In general, the local business visits are not as successful at finding the CoC as expected. This may indicate: 1) a significant portion of our contamination is historic and unrelated to the current business practices, or 2) there are other practices yet to be determined in the area that may contribute to the contamination.

Typical checklist visits without contaminant specific investigation goals make identifying sources difficult. Developing an additional contaminant specific list of possible sources and practices to investigate may be necessary for Ecology inspectors to fill the LSCS visit gap. The LSCS visits have been useful for removing any materials that may contain a variety of CoC from stormwater or sanitary sewer contact.

- Business visits have limited effectiveness for finding PCB sources.
- Ecology business visits were effective for finding PBDE sources.
- PBDE sources must be managed by regulation of other contaminants in the same waste stream. There are no current regulations for doing so directly.
- Current regulations from various Ecology programs do not recognize the low-level PCB analytical method for compliance purposes at the facility level. The only regulatory application is setting the 303d listing of a waterbody.

Education

Source tracing contamination at low concentrations presented unforeseen challenges for regulators and the regulated community. There was a general lack of knowledge regarding low-level analytical methods, data validation, and data interpretation.

Source tracing and elimination activities required various education activities for the local government, environmental groups, and business sectors. These included waste-specific brochures as well as training in analytical methodology, sampling and source tracing plan development, data validation, and data interpretation.

Recommendations

Sampling and Analysis

- Complete source investigations and elimination activities in the three basins of concern—Union, Erie, and CSO 34—to remove an active discharge of CoC to the Spokane River.
- Expand our research to include characterizing diffuse sources that contribute to stormwater contamination. This will provide an understanding of the local effect of air deposition and help direct elimination activities where appropriate.
- Put together a hydrologic, fish bioaccumulation, and congener pattern fate and transport model for PCB, PBDE, and Dioxin/Furan through partnership with the Environmental Assessment Program, university researchers, and the technical contractor chosen to write the Toxics Task Force Comprehensive Plan. This will help us better characterize and identify significant sources, so source investigation and elimination activity prioritization is optimized. It will also narrow down those sources suspected of affecting fish tissue concentrations.
- Assess the information from the Northeast Washington Lakes Reports and Air Deposition Literature Review for incorporation into the source tracing process.
- Complete work with the Environmental Assessment Program (EAP) to develop a long-term monitoring strategy for the Spokane River to help monitor for measurable progress towards CoC reduction in the river.
- Within the next fiscal year, complete a GIS pilot project that will allow Urban Waters to more easily incorporate data for spatial analysis and source tracing. It should also assist with monitoring progress and, if successful, can be expanded to include data from other entities conducting similar efforts in the watershed.
- Develop more accurate basin polygons using the piped system and contour GIS layers for basins of concern to prevent missing possible sources during business visits. Due to inaccurate basin polygons, the recycling facility source in Union Basin was identified through sampling and reconnaissance because the basin polygon did not include that parcel when the LSCS put together the business visit list.

PCB

- Conduct river sampling in the section between Upriver Dam and Monroe Street Dam and compare data congener patterns to largescale sucker whole fish data to assist with source identification in this section of elevated fish tissue concentrations.
- Put resources towards congener pattern analysis both spatially and within a basin using methods such as principal component analysis and positive matrix factorization to assist with source tracing.
- Determine whether looking at chiral signatures would be beneficial for source tracing in our area.

PBDE

- Look into low-level congener method for analysis to decrease the reporting limit for deca-BDE. This will eliminate any bias on total PBDE concentrations that the deca-BDE concentrations observed near the reporting limit have on total concentrations.

Dioxin/Furan

- Continue collecting dioxin/furan samples from various media during investigations of any CoC to increase the data set for future analysis.
- Investigate the significance of the association between 2,3,7,8 TCDD TEQ and TOC in sanitary sewer water for source identification.
- Focus source tracing efforts along the Crestline-Springfield branch within Union basin.

Lead, Cadmium, Zinc

- It may be useful to look at zinc sources in tires and galvanized materials to determine their contribution to stormwater.

Process Improvements

- Continue to explore the various options for upstream monitoring work to determine when a basin no longer contains a local source.
- Identify clear decision points to determine when a basin needs upstream tracing and when a basin is considered “clean.”
- Update QAPP to reflect any analytical and sampling technique method changes.

PCB

- Combine resources with the Spokane River Regional Toxics Task Force to assist with gaining a comprehensive understanding of PCB sources to the Spokane River. We can work together on determining the best course of action for source elimination as sources are uncovered.
- Build product list with concentrations and congener patterns for inadvertently-produced PCB.
- Put together a separate document incorporating the body of literature on PCB source tracing and elimination collected over the past three years with source lists. This should include literature on chiral signature analysis used throughout the country for source identification (C.S. Wong et al., 2001; B.J. Asher et al., 2007).

PBDE

- Ecology should consider regulatory limits and/or BMPs for PBDEs in order for Urban Waters to effectively eliminate sources once identified. In the interim, general BMP guidance and outreach may be a timely and effective way to reduce PBDEs to the river.

- Put together a short handout describing which products may still contain PBDE after ban implementation, along with a list of products containing penta, octa, and deca-BDE that have been in use over the last few decades. This information will help separate current long-term sources from those that are being phased out.
- Focus source control efforts on business type visits, such as carpet cleaners, as well as basin-focused source tracing.

Dioxin/Furan

- Due to current local focus on PCB, in-depth analysis of sources beyond selected stormwater and CSO basin work will need to be delayed until next biennium when priorities are reassessed.
- Develop a CoC specific list for Ecology Urban Waters inspectors to assist with source investigations.

Lead, Cadmium, Zinc

- Although other CoC take priority for data analysis, we should place high priority on establishing timeframes for QA/QC completion, and develop an internal process for metal results distribution between Ecology Programs and source elimination.
- Consider a focus on carpet cleaners and companies for zinc control measures.
- Consider a focus on recyclers and radiator shops that process older radiators for lead and zinc control measures.
- Because these metals are ubiquitous and often above benchmark values, conducting general activity category visits in addition to source tracing will be useful until priorities change. Urban Waters should utilize current research that identifies those activity categories that provided the best results with least resources to direct business visits.

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Appendices

Appendix A. 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.

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.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

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

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

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 that clear more than 5 acres of land.

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.

Appendix B. Figures and Tables

Figure B-1. Original outfalls with sample locations for additional basin characterization. Erie, CSO 34, and Union are included for reference.

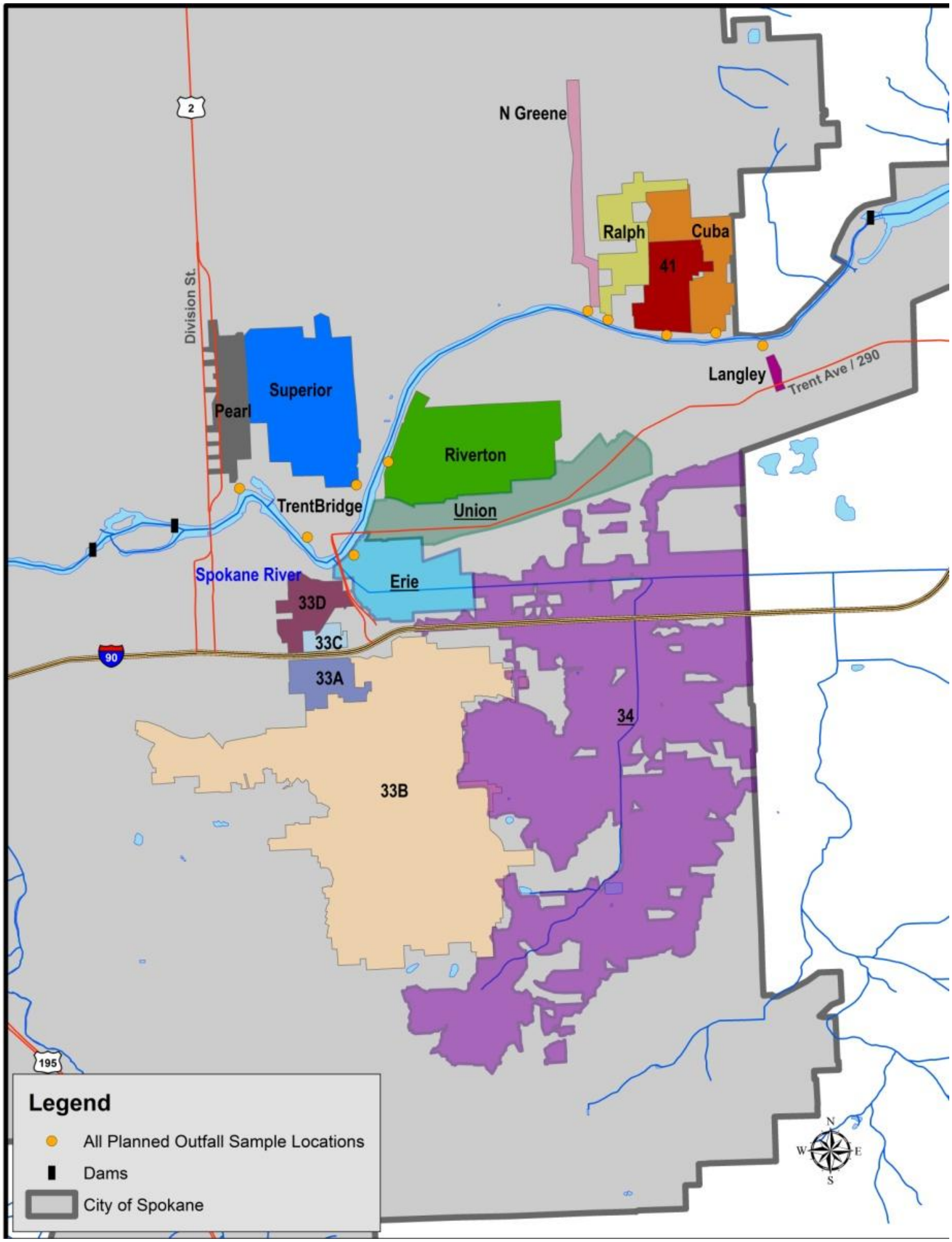
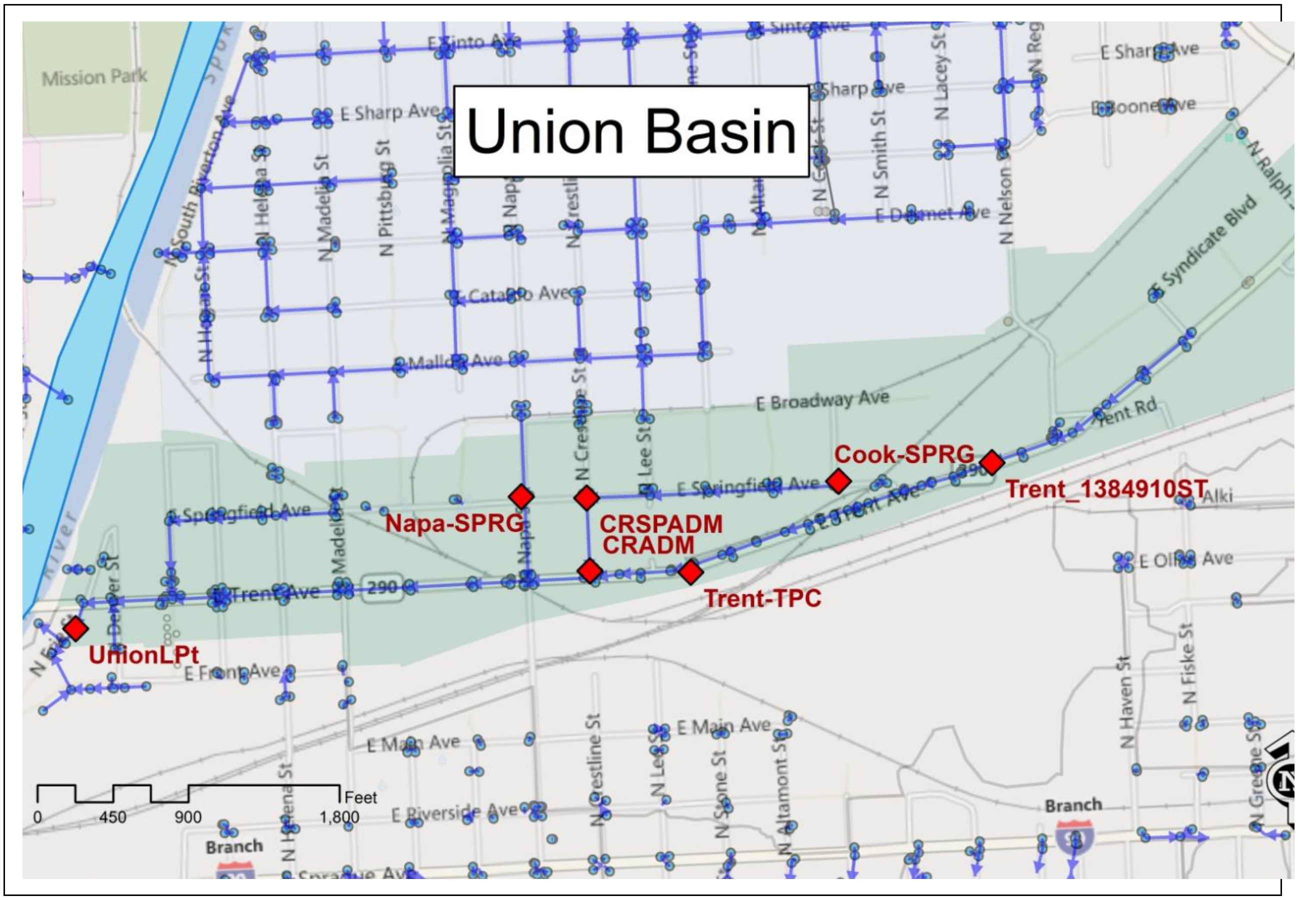
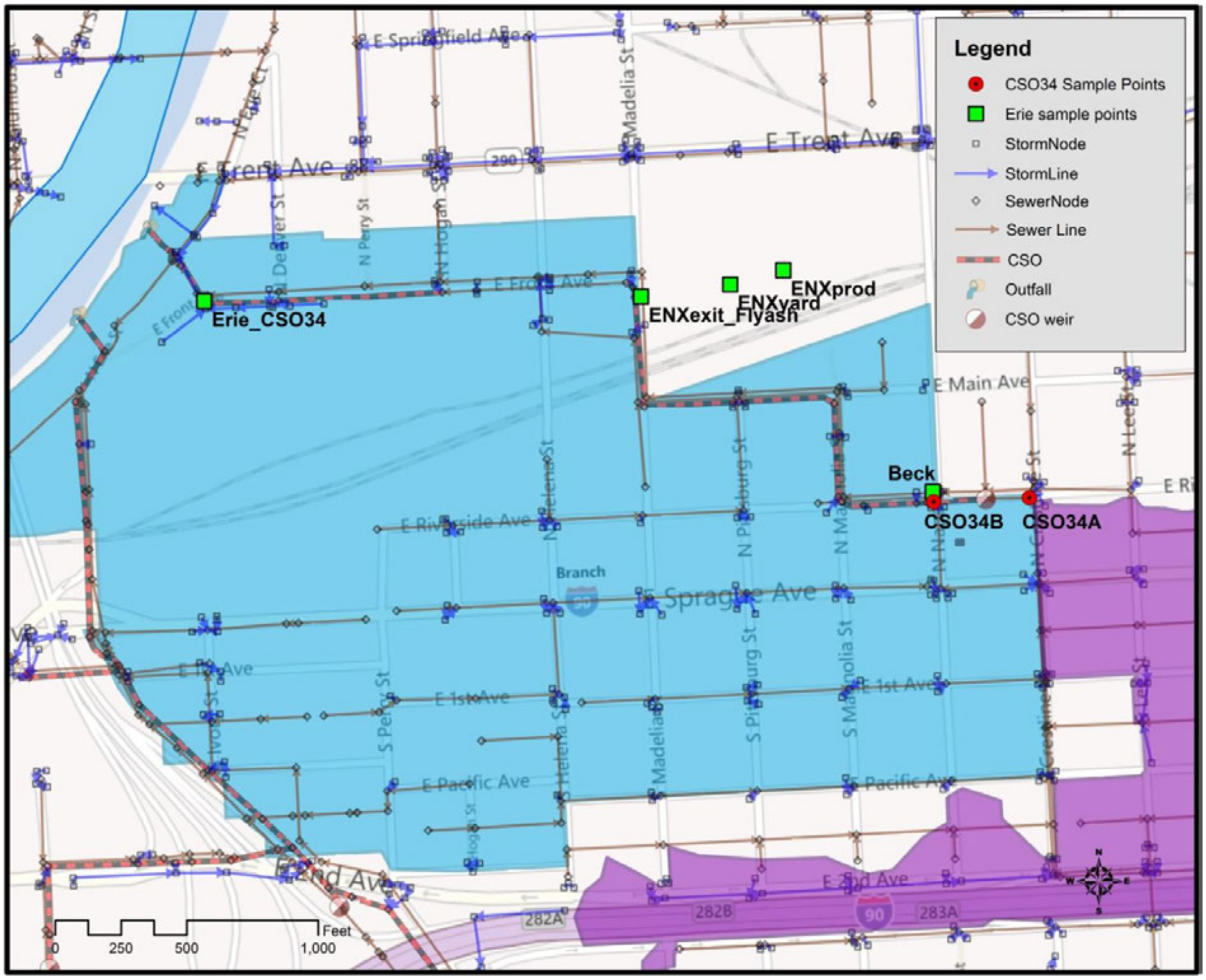


Figure B-2. Union basin sample locations.



*Road data provided by Bing Maps

Figure B-3. Erie basin and CSO 34 sampling locations.



*Road data provided by Bing Maps

Table. B-1 Original outfall basin sampling locations

Catchment	Manhole No.	WRIA	Purpose	Previously Sampled
Pearl_N	1200115ST	57/54	Suspect CoC present	N
Superior_N	1300136ST	57	High in PCB and D/F	Y
Greene_N	1500124ST	57	Suspect CoC present	N
CSO41_N	5603718CD	57	Larger CSO within river reach	N
I05-Langley_S	9029621ST	57	Suspect CoC present	N
I05-Ralph_N	1600124ST	57	Suspect CoC present	N
TrentBridge-WN	1385524ST	57	Suspect CoC present	N
I05-Cuba_N	1700018ST	57	Suspect CoC present	N
Riverton_S	1800130ST	57	High in PCB	Y
CSO33A-D_S	6041269CD	57	Larger CSO within reach	N

Table B-2. Sample location information

Sample ID	Basin	City Manhole Unit Identifier	Latitude	Longitude	Purpose	Location Description
1384910ST (Trent)	Union	1384910ST	47.664	-117.37	Source identification/reduction	Manhole sample on north side of Trent Avenue
AH/FAFB-Sa	NA	0908127CD	47.642712	-117.559591	Interceptor trace	Airway Heights/Fairchild AFB interceptor
AvistaP	Avista	NA	47.673	-117.388	New outfall source	Pipe sample
BECK	Erie	1310008IN	47.658	-117.382	Branch trace/Source Identification	Drywell with overflow next to Riverside/Napa intersection
BrownCB Avg	CSO 33	1391408IN	47.659136	-117.394243	Source Identification	Front St at Freedom Marine yard and Brown's Bldg Supply SW run to manhole and located on street in front of Brown's office bldg on same side of street next to swale
C34 Front	Front	1390318ST	47.660491	-117.392379	Branch trace/Source Identification	Pipe sample
Cochran	Cochran	0501142ST	47.683521	-117.447908	Outfall baseline	Pipe sample
COInt1	NA	NA	47.749494	-117.421327	Interceptor trace	Marion Hay Pump Station manhole. See photos. 10128 N College Rd. Spokane North County (Whitworth) monitoring location.
Cook - SPRG	Union	1376108IN	47.663318	-117.373591	CB trace	Springfield tracing sample
CRSP (SPG/CR)	Union	1394915ST	47.663238	-117.379693	Source reduction	Pipe sample
CRSPADM	Union	1394915ST	47.663238	-117.379693	CR/ADM partial branch catch basin clean out effectiveness	Pipe sample
CSO 10	CSO 10	3080248CD	47.681556	-117.45184	Outfall baseline	Pipe sample
CSO33	CSO33	6041269CD	47.66	-117.394	New outfall	Pipe sample
CSO34A	CSO 34	0701460CD	47.658141	-117.379794	Sewer basin baseline	CSO above weir sample during dry period
CSO34B	CSO 34	0701160CD	47.658142	-117.381278	CSO overflow baseline	CSO 34 Outfall–below weir manhole
ENXexit	Erie	1380508IN	47.660416	-117.385657	Source Identification	As SW enters the city street catch basin

Sample ID	Basin	City Manhole Unit Identifier	Latitude	Longitude	Purpose	Location Description
ENXprod	Erie	NA	47.661	-117383	Source Identification	Product spill along silo base
ENXexit	Erie	NA	47.66	-117.386	Source Identification	SW between silos near loading dock
ENXyard	Erie	NA	47.661	-117384	Source Identification	SW in driveway of yard
ErieLPt	Erie	0700136CD	47.660568	-117.392402	Basin baseline	Pipe sample
Flyash	Erie	1380508IN	47.660416	-117.385657	Branch trace	BNSF owned silo facility
FlyashW	Erie	1380508IN	47.660416	-117.385657	Branch trace	BNSF owned silo facility
FMCB	Front	Private	47.659935	-117.393007	Branch trace	Catch basin sediment from manhole onsite just upstream of city street catch basin in front of Freedom Marine on Front St
GUBP	GUBP	1381348ST	47.663034	-117.398012	Outfall baseline/source identification	Sidewalk outside Gonzaga University baseball field on the corner of E Trent Ave and N Cincinnati St.
Langley	Langley	9029621ST	47.676	-117.344	New outfall	Pipe sample
NAPSPG (NAPA Spg)	Union	1377408IN	47.664	-117.384	Branch trace	Sheet flow sample
NSLFC	NA	NA	47.724	-117.492	Source Identification	Northside Landfill condensate tank
NSLFCBPad	NA	0124820CD	47.724	-117482	Source Identification	Northside Landfill City catch basin pad sump
NSLFL	NA	NA	47.727	-117486	Source Identification	Northside Landfill leachate discharge pipe
NVInt1	NA	1204530CD	47.681453	-117.313232	Interceptor trace	SE of Felts Field. Spokane North Valley Interceptor monitoring location.
NWGreen	NWGreen	1500124ST	47.679051	-117.364469	Outfall baseline	Pipe sample
Pearl	Pearl	1200115ST	47.665922	-117.407399	Outfall baseline	Pipe sample
Ralph	Ralph	1600124ST	47.678	-117.362	New outfall	Pipe sample
River Ext	SVRP aquifer	NA	47.658	-117.411	Source from construction	Dug out pit full of groundwater

Sample ID	Basin	City Manhole Unit Identifier	Latitude	Longitude	Purpose	Location Description
Riverton	Riverton	1800130ST	47.668	-117.389	New outfall	Pipe sample
SpWWTPDay	NA	NA	47.696	-117.473	Baseline-12hr composite (6a-6p)	Headworks
SpWWTPNt	NA	NA	47.696	-117.473	Baseline-has duplicate-12hr comp. (6:30p-6:30a)	Headworks
Superior	Superior	1300136ST	47.665797	-117.393402	Outfall baseline	Pipe sample
SVInt	NA	NA	47.653488	-117.346039	Interceptor trace	Monitoring station manhole east of Havana off of 4th Street. 4220 E 4th. See photos. Spokane South Valley Interceptor location.
Trent-TPC	Union	1312308IN	47.661954	-117.377269	CB trace	Trent tracing sample
UnionLPt	Union	1382924ST	47.661479	-117.392200	Basin baseline	Union Basin Outfall – low point manhole
ZeroRez	NA	NA	NA	NA	Carpet cleaner source	Truck wash tank

Table B-3. Ancillary parameter results for Union Basin including TSS, TDS, TOC, DOC, grain size, and turbidity

Sample ID	Collection Date	Matrix	Grain size (% fines = % silt + % clay)	TSS (mg/L)	TDS (mg/L)	TOC (mg/L) or (%)	DOC (mg/L)	Turbidity (ntu)	Season	Storm event Precip. From Felts Field (in)	Location
Upstream Trent Ave Branch											
TRENT-TPC	6/25/2009	sed	**14.59**	NA	NA	**2.88**	NA	NA	Summer	NA	Catch basin
1384910ST (Trent)	1/24/2011	sw	NA	**457**	**1590**	**26.5**	NS	**>1000**	Winter	0.49	Branch
	5/16/2011	sw	NA	**100**	**43**	**11.5**	NS	**184**	Spring	0.29	Branch
Crestline-Springfield Ave Branch											
COOK-SPRG	6/25/2009	sed	**33.62**	NA	NA	NS	NA	NA	Summer	NA	Catch basin
CR/ADM	8/12/2009	sw	NA	**72.5**	**147**	**47.6**	NS	NS	Summer	0.27	Branch

Sample ID	Collection Date	Matrix	Grain size (% fines = % silt + % clay)	TSS (mg/L)	TDS (mg/L)	TOC (mg/L) or (%)	DOC (mg/L)	Turbidity (ntu)	Season	Storm event Precip. From Felts Field (in)	Location
CRSPADM	2/16/2010	sw	NA	**1140**	NS	NS	NS	NS	Winter	No data	Branch
	6/4/2010	sw	NA	**73**	NS	NS	NS	**119**	Spring	0.56	Branch
	7/2/2010	sw	NA	**595**	**54**	**17.2**	**18.5**	**762**	Summer	0.28	Branch
	1/13/2011	sw	NA	NS	NS	NS	NS	NS	Winter	0.33	Branch
	3/28/2011	sw	NA	NS	NS	NS	NS	**>1000**	Spring	No data	Branch
Napa St-Springfield Ave Branch											
NAPA-SPRG	9/9/2010	sw	NA	**970**	NS	**19.9**	NS	**>1000**	Fall	0.06	Branch
	1/24/2011	sw	NA	**737**	NS	**20.9**	NS	**>1000**	Winter	0.49	Branch
	5/16/2011	sw	NA	**1000**	146	**6.1**	NS	**>1000**	Spring	0.29	Branch
	7/29/2011	sed	**30.78J**	NA	NA	**4.24**	NA	NA	Summer	NA	Branch
Union Outfall											
UNIONLPT	6/8/2009	sw	NA	NS	NS	NS	NS	NS	Spring	0.29	Outfall
	10/2/2009	sw	NA	**75**	**139**	**45.9**	**44.1**	NS	Fall	0.11	Outfall
	2/16/2010	sw	NA	**508**	**137**	**64.8**	NS	NS	Winter	0.12	Outfall
	4/29/2010	sw	NA	**177**	**11.5**	**11.5**	**9.1**	**379**	Spring	0.48	Outfall
	9/9/2010	sw	NA	**520**	NS	**19.4**	NS	**939**	Fall	0.06	Outfall
	1/7/2011	sw	NA	**420**	**385**	**21.1**	NS	**698**	Winter	0.19	Outfall
	3/29/2011	sw	NA	**362**	NS	**17.2**	NS	**704**	Spring	0.18	Outfall
	7/13/2011	sw	NA	NS	NS	NS	NS	**321**	Summer	0.42	Outfall

Table B-4. Ancillary parameter results for Erie Basin and CSO 34 including TSS, TDS, TOC, DOC, and turbidity

Sample ID	Date	DOC (mg/L)	TDS (mg/L)	Turbidity (ntu)	TOC (mg/L) or (%)	TSS (mg/L)	Season	Sample Type	Note
Madelia Street									
ENXexit	5/27/2010	NS	NS	>1000	NS	NS	Spring	sw	
ENXprod	5/27/2010	NS	NS	NA	NS	NS	Spring	solid	
ENXsilo	5/27/2010	NS	NS	>1000	NS	NS	Spring	sw	
ENXyard	5/27/2010	NS	NS	>1000	NS	NS	Spring	sw	
Flyash	2/3/2010	NS	NS	NA	0.16	NS	Winter	sed	
	2/3/2010	NS	NS	NA	NS	165	Winter	sw	
Erie Basin Outfall									
ErieLPt	10/2/2009	39.8	168	NS	38.9	157.5	Fall	sw	
	2/16/2010	42.5	179	NA	42.5	147	Winter	sw	
ErieLPt/ CSO34B	6/8/2009	NS	NS	NA	NS	NS	Spring	sw	ErieLPt with CSO34 overflow
	1/13/2011	NS	477	NA	15.3	253	Winter	sw	
CSO 34 above weir-sewer only									
CSO34A	7/15/2010	NS	NS	NA	45.1	NS	Summer	sa	
CSO 34 below weir during overflow									
CSO34B	6/8/2009	104	461	NA	103	229	Spring	cso	
	10/23/2009	NS	NS	NA	NS	NS	Fall	cso	
	4/22/2010	15.5	97	NA	19.4	471	Spring	cso	
	1/13/2011	NS	577	NA	14.05	289	Winter	cso	
C34Front stormwater									
C34Front	6/8/2009	13.5	39	NS	13.9	7	Spring	sw	
	3/29/2011	NS	NS	26	NS	22	Spring	sw	

Table B-5. Ancillary parameter results for additional outfall sample locations and C34Front including TSS, TDS, TOC, DOC, and turbidity

Sample ID	Date	Turbidity (ntu)	TOC (mg/L)	TSS (mg/L)	TDS (mg/L)	Storm event Precip. from Felts Field (in)	Sample Type
AvistaP	5/10/2011	NS	**3.1**	**1U**	NS	NA	sw
Cochran	10/14/2009	NS	**16.2**	**82**	**56**	0.35	sw
	10/23/2009	NS	**13.9**	**58**	**52**	0.75	sw
	10/26/2009	NS	**29.9**	**37**	**40**	0.62	sw
CSO 10	10/23/2009	NA	**30.9**	**51**	**30**	0.75	cso
CSO33	7/13/2011	NA	**26.5**	**75**	**121**	0.42	cso
GUBP	4/22/2010	**115**	**13.9**	**71**	**31**	0.27	sw
Langley	7/19/2011	**432**	**68.2**	**304**	**112**	0.08	sw
NWGreen	10/14/2009	NS	**19**	**80**	**86**	0.35	sw
	10/23/2009	NS	**42.9**	**134**	**67**	0.75	sw
	10/26/2009	NS	**9.8**	**68**	**47**	0.62	sw
Pearl	10/14/2009	NS	**33.8**	**37**	**83**	0.35	sw
	10/23/2009	NS	**14.7**	**73**	**36**	0.75	sw
	10/26/2009	NS	**18**	**37**	**44**	0.62	sw
Ralph	4/21/2011	**201**	**14.7**	**NS**	NS	0.01	sw
Riverton	5/16/2011	**179**	**13.7**	**81**	**41**	0.39	sw
Superior	10/14/2009	NS	**26.4**	**47**	**87**	0.35	sw
	10/23/2009	NS	**27.1**	**53**	**65**	0.75	sw
	10/26/2009	NS	**28.5**	**38**	**66**	0.62	sw

Table B-6. Ancillary parameter results for sanitary sewer sample locations including TSS, TDS, TOC, and DOC

Sample ID	Collection Date	TOC (mg/L)	DOC (mg/L)	TSS (mg/L)	TDS (mg/L)
AH/FAFB	6/3/2009	**130**	**103**	**154**	**422**
SVINT	6/10/2009	**140**	**130**	**180**	**422**
NCoInt1	6/17/2009	**114**	**100**	**124**	**499**
NVInt1	6/17/2009	**85.9**	**74.7**	**101**	not enough sample
SpWWTPDay	7/15/2009	**58.3**	**38**	**166**	**388**
SpWWTPNt (Avg)	7/15/2009	**56.8**	**39**	**190**	**366**
CSO34A	7/15/2010	**45.1**	NS	NS	NS

Appendix C. Metals data

Table C-1. Erie basin and CSO 34 metals data in µg/L with hardness

Location	Collection Date	Anti-mony	Ar-senic	Bery-llium	Cad-mium	Chro-mium	Cop-per	Lead	Mer-cury	Nic-kel	Sele-nium	Silver	Thal-lium	Zinc	Hardness (mg/L)
CSO 34 below weir during overflow															
CS034B	6/8/2009	**0.88**	**6.93**	**0.18**	**0.36**	**8.26**	**61.0**	**10.7**	0.006 U	**7.37**	**0.84**	**0.79**	0.002 U	**153**	NS
	10/23/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	68.3
	4/22/2010	**2.80**	**4.99**	**0.28**	**0.46**	**17.0**	**42.4**	**28.8**	0.050 U	**8.04**	**0.54**	**0.42**	**0.16**	**234**	93.7
	1/13/2011	**1.44**	**4.27**	10 U	**0.29**	**7.9**	**26.2**	**7.14**	**0.054**	**5.02**	**2.83**	**0.24**	0.1 U	**119**	351
Erie Basin Outfall															
ERIELPT	10/2/2009	**3.67**	**3.95**	**0.18**	**0.57**	**14.6**	**47.5**	**37**	0.050 U	**16.9**	0.50 U	**0.11**	0.10 U	**311**	71.7
	2/16/2010	**2.54**	**5**	**0.24**	**0.57**	**12.3**	**38**	**52.9**	0.059	**9.19**	0.5 U	**0.16**	0.1 U	**237**	65.7
ERIELPT/ CSO34B	6/8/2009	**3.33**	**6.75**	**0.29**	**0.98**	**21.4**	**74.3**	**39.6**	**0.969**	**11.9**	**1.05**	**2.75**	0.002 U	**374**	NS
	1/13/2011	**1.44**	**4**	10 U	**0.33**	**7.85**	**24.1**	**9.6**	0.05 U	**4.93**	**2.39**	**0.2**	0.1 U	**121**	313

Appendix D provides definitions for all data flags used in this project.

Table C-2. Additional outfall metals data in µg/L with hardness

Sample ID	Collection Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc	Hardness (mg/L)
AvistaP	5/10/2011	**0.31**	**2.32**	0.10U	0.10U	**0.71**	**9.40**	**0.19**	0.050U	0.10U	0.50U	0.10U	0.10U	**6.5**	**98.0**
Cochran	10/14/2009	**1.56**	**1.69**	0.1U	**0.2**	**13.6**	**16.7**	**13.7**	0.05U	**3.72**	0.50U	0.10U	0.10U	**93.5**	**25.8**
	10/23/2009	**1.29**	**1.46**	0.1U	**0.16**	**52.5**	**15.5**	**12.4**	0.05U	**4.8**	0.50U	0.10U	0.10U	**78.2**	**19.3**
	10/26/2009	**1.17**	**1.19**	0.1U	**0.16**	**9.03**	**12.8**	**12.9**	0.05U	**2.54**	0.50U	0.10U	0.10U	**73.7**	**15.3**
CSO 10	10/23/2009	**1.42**	**1.75**	0.1U	**0.2**	**12**	**16**	**17.9**	0.05U	**3.42**	0.50U	0.10U	0.10U	**87.2**	**13.9**
CSO33	7/13/2011	**3.78**	**2.29**	0.1U	**0.23**	**12.2**	**26.5**	**10.4**	0.05U	**4.92**	0.50U	0.10U	0.10U	**114**	**49**
GUBP	4/22/2010	**2.87**	**1.42**	0.1U	**0.27**	**30.4**	**22.4**	**9.61**	0.05U	**4.22**	0.50U	0.10U	0.10U	**162**	**17.7**
Langley	7/19/2011	**1.62**	**4.54**	0.1U	**0.42**	**12.7**	**29.1**	**27**	0.05U	**9.61**	0.50U	**0.19**	**0.1**	**280**	**46.4**
NWGreen	10/14/2009	**2.87**	**2.24**	0.1U	**0.33**	**9.75**	**25**	**14.2**	0.05U	**5.72**	0.50U	0.10U	0.10U	**177**	**39.9**
	10/23/2009	**3.64**	**2.94**	**0.14**	**0.47**	**12.9**	**33.9**	**23.6**	0.05U	**7.65**	0.50U	0.10U	0.10U	**257**	**38**

Table C-3. Union basin metals data in µg/L with hardness

Location	Collection Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc	Hardness (mg/L)
Upstream Trent Ave Branch															
1384910ST Trent	1/24/2011	**3.74**	**17**	10 U	**1.28**	**23**	**58.9**	**38.9**	**0.061**	**16.2**	5 U	**0.21**	0.1 U	**453**	1720
	5/16/2011	**2.18**	**2.59**	**0.12**	**0.33**	**11.9**	**25.1**	**35.8**	0.05U	**5.73**	0.5U	0.1U	0.1U	**149**	24.3
Napa St-Riverside Ave. Branch															
NAPA-SPRG	9/9/2010	**3.89**	**14.4**	**1.45**	**2.97**	**37.2**	**527**	**833**	**0.178**	**26.5**	5.00 U	**1.32**	**0.39**	**752**	85.4
	1/24/2011	**3.1**	**13.4**	**10 U**	**1.51**	**29.9**	**152**	**180**	**0.071**	**21.2**	5 U	**0.37**	**0.12 J**	**582**	798
	5/16/2011	**5**	**18.3**	**1.29**	**3.15**	**49.9**	**842**	**1090**	**0.196**	**37.2**	**1.12 J**	**1.31**	1 U	**820**	120
Union Basin Outfall															
UNIONLPT	10/2/2009	**2.48**	**2.77**	**0.13**	**0.36**	**13.5**	**31.5**	**28.2**	0.050 U	**5.77**	0.50 U	0.10 U	0.10 U	**153**	46.2
	2/16/2010	**3.57**	**11.2**	1 U	**1.9**	**30.4**	**112**	**221**	**0.157**	**24.1**	**0.77**	**0.4**	**0.28**	**632**	81.9
	4/29/2010	**2.88**	**3.4**	**0.2**	**0.48**	**14.5**	**38.2**	**41.5**	0.05 U	**7.81**	0.5 U	0.1 U	**0.11 J**	**249**	44.1
	9/9/2010	**2.47 J**	**6.25**	**0.42**	**1.04**	**23.7**	**68.2**	**113**	**0.130**	**12.8**	0.50 U	**0.32**	**0.20**	**410**	51.3
	1/7/2011	**2.55**	**6.11**	10.0U	**1.05**	**17.1**	**44.1**	**40.7**	0.050U	**12.2**	**1.71**	0.10U	0.10U	**338**	279
	3/29/2011	**2.4**	**5.26**	1 U	**0.73**	**16.7**	**67.4**	**98.8**	**0.052**	**12.4**	0.5 U	**0.18**	0.1 U	**265**	58
	6/8/2009	**2.27**	**4.22**	**0.23**	**0.68**	**38.2**	**46.7**	**53.4**	0.006 U	**26.7**	**0.56**	**0.13**	0.002 U	**240**	NS
	6/8/2009	**2.27**	**4.21**	**0.23**	**0.68**	**20.2**	**43.1**	**54.3**	0.006 U	**8.73**	**0.64**	**0.13**	0.002 U	**238**	NS

Table C-4. Opportunistic sample metals data in µg/L with hardness

Location	Collection Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc	Hardness (mg/L)
C34Front	6/8/2009	**0.66**	**0.59**	0.02 U	0.003 U	**2.02**	**7.58**	**1.07**	0.006 U	**4.88**	0.11 U	0.02 U	0.002 U	**43.9**	NS

Appendix D provides definitions for all data flags used in this project.

Appendix D. Laboratory Data Flag Definitions

U	-	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	-	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
NJ	-	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
N	-	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
B	-	Certain target compounds were detected in the laboratory blank. These congeners were also detected in some of the samples. Where the sample concentration was less than five times the blank concentration, the sample result was flagged with a "B" by the contract laboratory.