Clark County Local Source Control Partnership Monitoring, Findings and Recommendations 2017

DEPARTMENT OF ECOLOGY
State of Washington

April 2018

Publication No. 18-03-018

Publication information

This report is available on the Department of Ecology's website at
https://fortress.wa.gov/ecy/publications/SummaryPages/1803018.html

Data for this project are available at Ecology's Environmental Information Management (EIM) website EIM Database. Search Study ID JMED0001.

The Activity Tracker Code for this study is 17-002.

Contact information

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology – https://ecology.wa.gov

Location of Ecology Office	Phone
Headquarters, Lacey	360-407-6000
Northwest Regional Office, Bellevue	425-649-7000
Southwest Regional Office, Lacey	360-407-6300
Central Regional Office, Union Gap	509-575-2490
Eastern Regional Office, Spokane	509-329-3400

Cover photo: Stormwater sampling at NE Minnehaha Street (photo by Medlen 2017).

Clark County Local Source Control Partnership Monitoring Findings and Recommendations, 2017

by

James Medlen

Toxics Studies Unit
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

WRIAs

- 27 – Lewis
- 28 – Salmon and Washougal

HUC numbers

- 17080001 – Lower Columbia River - Sandy
- 17080002 – Lewis River
- 17080003 – Lower Columbia River - Clatskanie

This page is purposely left blank

Table of Contents

List of Figures

List of Tables

Abstract

During March to June 2017, Local Source Control (LSC) staff from the Washington State Department of Ecology and the Clark County Public Works Clean Water Division worked in partnership to identify and prioritize sites for Municipal Separate Stormwater Sewer System (MS4) screening and analysis. Screening targeted a broad range of toxic chemicals.

Screening levels were compared to thresholds based on Washington State water quality criteria, existing data trends, and other studies in the United States. To better identify high priority clean-up areas, a scoring system was developed. Sites that exceeded (were above) thresholds were assigned one point per exceedance, regardless of the magnitude at which a threshold was exceeded. This approach was developed to consider "lines of evidence" to prioritize sites for outreach in order to reduce the effects of pollutants from impacting the health of humans, aquatic organisms, and the ecosystem.

Screening found elevated levels of metals, PAHs and phthalates, flame retardants, PCBs, lube oil and grease, and PFAAs in the study area's commercial drainages.

Based on the findings, study sites were ranked from highest to lowest priority for follow-up actions. Outreach activities to small businesses in the study area should be implemented based on their priority ranking. Seven sites were prioritized for further study:

1. Salmon Creek Tributary
2. Lower Salmon Creek @ Hwy 99 and NE 102nd
3. Crystal Creek Apartments, Minnehaha Drive
4. Burnt Bridge Creek MS4 Tributary @ St Johns and Minnehaha Street
5. Whipple Creek NE 10th and NE 149th Street
6. Cougar Canyon Creek
7. Minnehaha Corporate Park

Recommendations for these sites include the following: diversion or reduction of off-site runoff through best management practices (BMPs), additional investigation and monitoring of drainage areas, and possible outreach to larger, non-permitted industrial areas.

Acknowledgements

The author of this report thanks the following people for their contributions to this study:

- Clark County
  - Rod Swanson
  - Bob Patterson

- Washington State Department of Ecology staff *(alphabetical by last name)*
  - Joel Bird
  - Andy Bookter
  - Chad Brown
  - Randy Coots
  - Brandee Era-Miller
  - Tom Gries
  - Will Hobbs
  - Bill Kammin
  - Jake Kleinknecht
  - Patrick Lizon
  - Brandi Lubliner
  - Callie Mathieu
  - Melissa McCall
  - Vince McGowan
  - Peggy Morgan
  - Dale Norton
  - Tanya Roberts
  - Nancy Rosenbower
  - Debby Sargeant
  - Rian Sallee
  - Kari Trumbull
  - Saskia Van Bergen
  - Leon Weiks
  - Siana Wong
  - Ken Zarker

Introduction

In 2007, the Washington State Legislature allocated funding to establish the Local Source Control (LSC) partnership, a technical assistance program that helps small quantity generators[1] manage and reduce toxics to prevent pollution and protect water quality.

The Washington State Department of Ecology (Ecology) funds and supports LSC specialists throughout the state to provide technical and regulatory assistance to small businesses. LSC assistance is being applied towards preventing spills, identifying illicit wastewater discharges, correcting problems with oil/water separators, ensuring storm drains are protected, and protecting employees through properly storing and labeling chemicals and hazardous waste.

Originally, the LSC partnership was limited to the Puget Sound basin and the Spokane River basin. In an effort to create a statewide program, LSC was expanded by the Legislature in 2015 to include the Columbia River basin. With expansion into this basin, the Legislature requested Ecology establish a monitoring program in partnership with local jurisdictions to determine pollutant control effectiveness of LSC. In 2017, Ecology worked with Clark County partners to help design and implement the first toxics screening study in Clark County to serve as a pilot study.

The pilot study consists of three phases:

- Phase I - Pollutant Screening.
- Phase II - Before After Control Impact (BACI) Study.
- Phase III - Hot-Spot Identification and Prioritization for Future Source Investigation.

Details of each phase can be found in the programmatic Quality Assurance Project Plan (QAPP) (Medlen, 2017). Toxics were chosen for monitoring based on their persistence and potential to negatively impact Washington State's surface water designated uses.

This monitoring report presents the study's Phase I pollutant screening findings. Phase I is key in eliminating parameters from the study that are not detected in the Municipal Separate Stormwater Sewer System (MS4), freeing up resources for those parameters that are found. Monitoring Phases II and III will be added as an addendum to this study report.

Clark County has cooperatively participated as a partner in this MS4 pollutant screening study to help the region and the state better understand MS4 concentrations and also locations of toxic pollutants in commercial land-use drainages.

This report does not seek to determine regulatory compliance with NPDES permit requirements but instead is solely focused on providing partners with resources to identify toxic hot-spots for pollution-reduction outreach.

---

[1] Facilities generating less than 220 pounds of dangerous waste or less than 2.2 pounds of highly toxic waste in a month.

Study Design

From March through June 2017, Ecology's LSC program sampled commercial drainages in unincorporated Clark County's stormwater conveyance system to screen for the presence of toxic chemicals (NPDES Phase I MS4). The QAPP (Medlen, 2017) details the study design for this project. Both stormwater and sediment were collected from Clark County's stormwater conveyance system in representative local drainages.

Sediment samples from stormwater conveyance systems were collected to:

- Determine screening concentrations of MS4 toxic chemicals (toxics).
- Identify and prioritize potential problem pollutants and drainages.
- Draft recommendations for future source control and monitoring.

Monitoring Sites and Sampling Frequency

The LSC program identified seven core monitoring sites in commercial drainages most suitable for sediment and stormwater sampling of stormwater conveyance systems. Selected sites are primarily commercial business drainage areas with less than 50% residential land use. Site-selection criteria are detailed in the program's QAPP (Medlen, 2017). The number of sites was increased from 7 to15 during the sediment phase to assess conditions upstream and downstream of target areas.

Sediment samples were collected during two stormwater and three sediment sampling events during the monitoring season, March through June 2017. Stormwater samples were collected during qualifying storm events of > 0.2 inches of rain. Sediment samples were collected during qualifying dry-weather events, defined as an antecedent dry period with < 0.02 inches of rain within a 48-hour period.

Table 1 summarizes the dates of stormwater and sediment monitoring events.

Table 1. Stormwater monitoring event data.

Date	Type	# of Sites	Weather	Precipitation Accumulation[2]
27-Mar-17	Stormwater	6[1]	Wet	0.69 inches
24-Apr-17	Stormwater	7	Wet	1.01 inches
9-May-17	Sediment	7	Dry	-
7-Jun-17	Sediment	9	Dry	-
21-Jun-17	Sediment	15	Dry	-

[1] 6 of 7 sites monitored near end of storm (SC_TRIB site not flowing)

[2] Precipitation accumulation in previous 24 hours

Table 2 lists monitoring site locations. The QAPP (Medlen, 2017) includes drainage area maps of each site.

Table 2. Site locations core and upstream and downstream.

Monitoring Site	Description	Latitude	Longitude
Core Monitoring - Stormwater + Sediment Sites			
BB_STJOHNSMINN	MS4 Ditch to Cold Creek	45.6673072830001	-122.636334065
CC_CAPT	Cold Creek Stormwater Detention Basin	45.6690013320001	-122.645028289
CC_NE85	Cougar Canyon Creek	45.6841654190001	-122.669689143
LR_NW3RDCT	Tributary to Whipple Creek	45.7259377950001	-122.678027496
LS_NE102	Tributary to Salmon Creek	45.6958321910001	-122.656969032
WC_NE10NE149	NE 10th and NE 49th US Whipple Creek	45.7297667450001	-122.661878502
SC_TRIB	Boat yard	45.7064144490001	-122.650794708
Upstream-and-Downstream Monitoring - Sediment Sites			
Dollar_DS	Dollar Corner downstream of NE 72nd Ave	45.779625922	-122.601119478
Dollar_US	Dollar Corner upstream of NE 219th St	45.7803444460001	-122.598299211
LS_NE102_USNE116	Tributary to Salmon Creek D/S LS_NE102	45.7053566000001	-122.654431783
MINN_CORP	Minnehaha Business Park	45.6682691170001	-122.629484084
QMB	Quail Meadow Basin	45.723149479	-122.671989926
SC	Bank of Salmon Creek D/S Foot Bridge and U/S of I5	45.706140342	-122.653181157
SC_SWIM	Outside of Swim Area Salmon Creek	45.7071354490001	-122.657455374
SC_TRIB_DS	Slough down slope of SC_TRIB	45.706487323	-122.651089974

D/S: downstream U/S: upstream

The following monitoring site descriptions provide more detail on location, drainage, and access:

- **SC_TRIB (Salmon Creek Tributary)** - This outfall drains the back lot of Pacific Boatland, a boat dealer located at 11704 NE Hwy 99 Vancouver, WA 98686. The drain receives surficial drainage from a portion of the street along NE Klineline Road.

- **LS_NE102 (Lower Salmon Creek @ Northeast 102nd) -** This site is located in a gully, tributary to Salmon Creek. Access is through a homeless encampment at the top of the gully slope behind the detention pond, located on the north side of NE 102nd Street (across the street from the nursery).

- **CC_CAPT (Crystal Creek Apartment)** - This site is a stormwater detention basin, located on the grounds of the Crystal Creek Apartment complex, at 2600 NE Minnehaha St Vancouver, WA 98665. Monitoring is conducted at the downstream end of the culvert on the west side of the main apartment complex entrance road.

- **BB_STJOHNSMINN (Burnt Bridge @ St. Johns and Minnehaha)** - This site is located on the corner of St. Johns and Minnehaha Street is a small ditch which drains the commercial area adjacent to NE Minnehaha Street upstream (east) of Hwy 99.

- **WC_NE10NE149 (Whipple Creek @ Northeast 10th and Northeast 149th)** - The Whipple Creek site is located on NE 10th Ave, north of NE 149th Ave, upstream of the 10th Ave road culvert crossing.
- **CC_NE85th (Cougar Canyon Creek @ Northeast 85th)-** This Cougar Canyon Creek site is monitored at the upstream inlet of the culvert at Hazel Dell Avenue, south of NE 85th Street.
- **MINN_CORP (Minnehaha Corporate Park) -** This site is located on 4200 NE Minnehaha Street. The sediment sample site is at the inlet to the corporate park's grass swale and detention basin. The detention basin treats runoff from the site through bio-filtration before entering the Minnehaha Street v-ditch and ultimately the Columbia River.
- **LR_NW3RDCT –** The Chinook Park unnamed tributary to Whipple Creek site is located 50 feet upstream of the footbridge stream crossing, accessed through the Brook Run neighborhood cul-de-sac on NW 7th Place.
- **Dollar_DS (Dollar Corner downstream) -** This site is located upstream of the NE Rodda Road Crossing and downstream of NE 72nd AVE at Dollar Corner in Clark county Washington.
- **Dollar_US (Dollar Corner upstream)-** This site is located 50 feet upstream of the Highway 502 stream crossing which runs adjacent to the back lot of Fast Auto Wrecking, 21919 NE 72nd Avenue suite B, Battle Ground, WA 98604 at Dollar Corner in Clark County Washington.
- **LS_NE102_USNE116 (Lower Salmon Creek Northeast 102nd U/S of Northeast 116th) -** Access to the site is at the end of NE 116th Street. The monitoring site is located upstream of the Interstate 5 Freeway before flowing underground in a culvert which outfalls to Salmon Creek under the Interstate 5 bridge.
- **QMB (Quail Meadows Basin) -** This Quail Meadows Detention Basin site is located to the west side of the Salmon Creek Indoor Sports center at 110 NW 139th ST Vancouver, WA 98685. The basin drains to Quail Meadows and downstream to Salmon Creek.
- **SC (Salmon Creek) -** This site is located on the left bank of Salmon Creek, 300 feet upstream of Interstate 5 and 10 feet downstream of the Salmon Creek Park trail footbridge.
- **SC_SWIM (Salmon Creek swim area)** - This site is west of the swim area located in Salmon Creek Park off the concrete revetment bank.
- **SC_TRIB_DS (Salmon Creek Tributary downstream) -** This site is down slope in the receiving water slough of the outfall that drains the back lot of Pacific Boatland, a boat dealer located at 11704 NE Hwy 99, Vancouver, WA 98686.

Figure 1 is a map showing the study areas monitoring sites. Appendix E displays more detailed maps of these areas. In addition, the QAPP (Medlen, 2017) includes detailed drainage area maps.

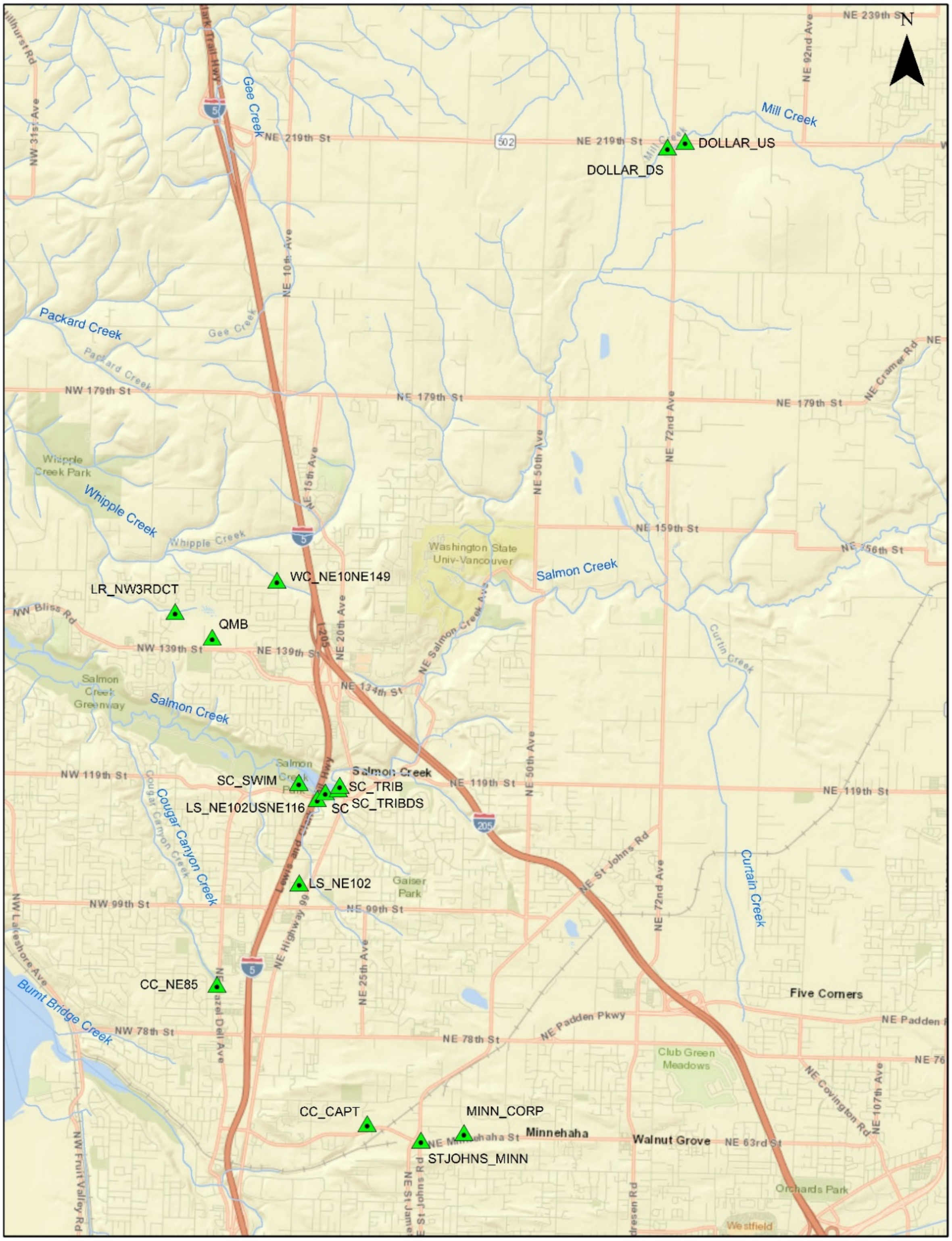

Figure 1. Location of study areas.

Monitored Parameters

The program monitored for persistent toxics and indicator parameters in support of the LSC partnership's goal to reduce their sources. Parameters of interest were chosen based on the following criteria:

- Chemicals of Emerging Concern - Parameters recently targeted for their persistent and toxic effects on the environment and have been found ubiquitously in the environment.
- Results from stormwater and sediment conveyance system status and trends monitoring under Clark County's NPDES Phase I permit area, as well as regional studies and investigations.
- Project stakeholder input, including Clark County Clean Water Division and Ecology's Hazardous Waste and Toxics Reduction Program, regarding analytes of concern and scope of work.
- Clark County's Phase I Municipal Permit requirements for stormwater and sediment conveyance system monitoring parameters. Parameters were refined through review of the Western Washington NPDES Phase I Permit Final S8.D Data Characterization, 2009-2013 findings (Hobbs et al., 2015).

Table 3 displays the number of sampling events and frequencies for each parameter. Appendix C, Table C-1, shows the potential toxic effects on aquatic organisms by parameter monitored. Appendix D describes the monitored parameters.

Table 3. Monitoring dates and number of parameters for stormwater and sediment.

Parameter	Number of Stormwater Sites Sampled		Number of Sediment Sites Sampled		
	27-Mar-17	**24-Apr-17**	**9-May-17**	**7-Jun-17**	**21-Jun-17**
Conventionals [1]	6	7	7	9	15
Nutrients[2]	6	7	7	9	15
Total Metals[3]	6	7	7	9	15
Dissolved Metals[3]	6	7	7	9	15
PAHs[3]	6	7	7	9	15
Phthalates[3]	6	7	7	9	15
Petroleum Hydrocarbons[3]	6	7	7	9	15
PCBs (209 congeners) [3]	6	7	7	9	15
PCBs (Aroclors) [3]	0	0	0	9	15
Flame Retardants[3]	6	7	7	9	15
Perfluoroalkylated Acids Substances[3]	6	7	7	9	15
Pesticides[3]	0	0	0	9	15

[1] Includes pH, conductivity, temperature, and total dissolved solids (TDS).
[2] Includes ammonia, nitrate-nitrite as N, ortho-phosphate, total persulfate nitrogen, total phosphorous.
[3] Too numerous to list; see *Results* section.

Table 4 summarizes the matrices sampled and if the parameter group was analyzed in the field or laboratory. For a detailed description of parameters, see Appendix D.

Table 4. Parameter groups and matrices sampled.

Parameter	Matrix		Analysis	
	Stormwater	Sediment	Field	Laboratory
pH	X	X	X[1]	X[1]
Conductivity	X		X	
Temperature	X		X	
Total Dissolved Solids	X		X	
Oil and Grease	X	X		X
Total Suspended Solids	X			X
Total Organic Carbon	X	X		X
Total Volatile Solids		X		X
Petroleum Hydrocarbons	X	X		X
Nutrients	X			X
Metals	X	X		X
Semi-volatile Organics	X	X		X
Flame Retardants	X	X		X
PCBs	X	X		X
Pesticides	X	X		X
PFAAs	X	X		X

[1] Sediment pH analyzed in laboratory, stormwater in field

Methods

This section describes the methods used to collect, analyze, and assess stormwater and sediment conveyance system samples. Field measurements and sample collection and preparation followed methods detailed in the QAPP (Medlen, 2017) and standard operating procedures (SOPs) referenced in the QAPP.

Collecting Field Parameters

Field measurements were taken using an Oakton Waterproof PCTestr 35 multiparameter tester. The instrument was calibrated using the manufacturer's calibration standards and protocols before each monitoring event. Calibration results were recorded and reviewed to verify equipment met quality assurance (QA) standards.

Conductivity, pH, temperature, and total dissolved solids (TDS) were measured using the multiparameter tester. Measurements were taken at all sites during both storm events, with the exception of SC_TRIB, which had no flow during the 3-27-2017 event (near the end of the storm).

Collecting Laboratory Parameters

Laboratory methods are described in Appendix B. Chain of Custody forms were completed and submitted during all sample events. For a complete list of parameter groups monitored, see Table 3. QA results are summarized in the "Quality Assurance" section of this report.

Stormwater Samples

Stormwater samples were collected during qualifying storm events of > 0.2 inches of rain over the course of a storm event. A storm event was temporally defined as an event that met the 0.2 inches and had continuous rain up to the sample event.

Laboratory parameters were collected as a grab sample using sample collection bottles provided by the lab. A combination of a sample pole and nitrile gloved hands were used to collect samples.

All bottles, filters, and sample preservatives were provided by Ecology's Manchester Environmental Laboratory (MEL).

Samples were subcontracted out to SGS AXYS laboratory to be analyzed for PCBs and per-fluorinated compounds for two stormwater events and one sediment event. Backup samples were taken in the field to provide sufficient volume for lab duplicates and in case bottles were damaged in route to the lab. SGS AXYS labs provided pre-cleaned and proofed bottles for all sampling events.

Dissolved metals samples were filtered in the field using a hand pump and 0.45µm filter and collected in 500mL bottles with acid preservative. Orthophosphate was filtered in the field through a syringe with a 0.45µm filter and collected in a 125mL amber poly bottle with acid preservative.

Sediment Samples

Sediment samples were collected during qualifying dry weather events, defined as an antecedent dry period of less than .02 inches of precipitation within a 48-hour period.

Sediment samples were collected at the sample site, or immediately downstream of the effluent's discharge if sampling occurred at a perched engineered pipe. The top layer of instream sediment deposition was grabbed using pre-cleaned and decontaminated stainless steel spoons and bowls. Several aliquots were taken at each site and composited into the stainless steel bowl. Samples were mixed/homogenized by spoon in the field and carefully distributed into sample bottles provided by the laboratory.

Reporting Methods and Assessment Criteria

Sites were prioritized for future outreach through a simple scoring system. The system is based on existing water quality standards and also studies used to establish thresholds or levels of concentrations. Each exceedances of a threshold gives one point to the monitoring site. Each point is considered a "line of evidence," indicative of an elevated parameter. Sites are ranked based on their scores. Sites with higher scores are prioritized for outreach. The *Recommendations* section of this report summarizes scoring for each site.

The study's small sample size is not conducive to conducting statistical analysis for spatial trends or summaries of median or mean concentrations. As a conservative approach, maximum concentrations for both stormwater and sediment were used for comparison to thresholds. These thresholds included Washington State receiving water quality standards, sediment quality objectives, MS4 permit data, and other studies queried through EIM[2] and through personal communication.

Receiving Water Quality Standards

When available, receiving water quality standards (acute criteria) were used as a threshold for comparison with sample results. These standards provide a baseline for comparison when parameters of interest are elevated in the MS4 and potentially detrimental to receiving water quality.

Washington State Sediment Management Standards

Washington's sediment management standards were used as a threshold when available to assess sediment data. Washington has developed two sets of objectives for evaluating sediment quality:

[2] Ecology's Environmental Information Management database

(1) a sediment *screening* objective, which is used to screen sediment and determine if a site is impaired enough to warrant clean-up, and (2) a sediment *clean-up* objective criterion used to determine when a site's contaminated sediment has been cleaned up sufficiently to meet a safe level.

This study uses the more conservative sediment clean-up objectives as a threshold for evaluating monitoring data. As mentioned earlier in the report, the intent of this study is to identify areas where toxics are present, in hopes of reducing impacts to the environment.

Western Washington MS4 Permit Data Characterization

When receiving water quality standards were not available for comparison, screening results were compared to the 2009-2013 Western Washington NPDES Phase I Stormwater Permit Data Characterization; see Appendix G, Table G-1 (Hobbs et al., 2015). The 75th percentile data (third quartile) at commercial land-use sites were chosen, using best professional judgement, as a threshold for comparison and considered a conservative estimate.

Other Studies for Comparison

Other studies were used for reference, in particular for parameters of emerging concern with no developed standards. Ecology's EIM database was used to query Ecology studies on perfluorinated compounds. The Minnesota Department of Pollution Control provided a study for comparison of PFAAs results (Crane, 2017).

In general, the 75th percentile of reviewed data was used as a threshold to determine when sites had elevated concentrations of parameters and to assign points using the scoring system. Maximum values for some data sets were used as a threshold, in lieu of the 75th percentile, mainly when data sets for comparison were less robust.

Quality Assurance

This section summarizes quality assurance (QA) practices for both field collection and laboratory procedures during this 2017 LSC study. For additional details, such as copies of case narratives, contact the report author.

Field

Samples were collected and prepared following standard operating procedures (SOPs) for field sampling as referenced in the program's QAPP (Medlen, 2017). Hand held multi-parameter probes were calibrated before sampling events and were found to meet all measurement quality objectives (MQOs).

Laboratory

All data were reviewed by the report author. All data were found to meet the data quality objectives outlined in the QAPP (Medlen, 2017). Some of the project data have been qualified due to concerns with data quality but are acceptable as qualified and reported. A stage 4 data validation, using manual review of the raw data and verification of reported results with the electronic data output from the instrument, were conducted by the QA Coordinator at Manchester Environmental Laboratory. A detailed table showing whether laboratory MQOs were met can be found in Appendix A.

Replicates and blanks were taken in the field to ensure that field collection and sample handling procedures were consistent and not contaminating samples. Field blanks were analyzed and found to be non-detects 89% of the time. Triphenyl phosphate was detected in the field blank associated with the 3/27/2017 stormwater event sample. Dissolved zinc was detected in the blank associated with the 4/24/2017 stormwater sample.

The majority of field replicates (96%) met relative percent difference (RPD) targets. The 4% that did not meet targets were dissolved titanium and lead reported for the 3/27/2017 stormwater event. A detailed table summarizing field replicates and blank results can be found in Appendix A, Table A-2.

Results

This section summarizes stormwater and sediment screening results. Lab analysis results are displayed graphically using the maximum value of concentrations found at each site.

A summary table following each graph provides the threshold criteria used and also assigns a score as discussed in the *Methods* section. Scoring was not conducted for field measurements, conventional parameters, and parameter groups not detected.

Field Measurements

Field measurements were obtained during storm events at each site. Tables 5 and 6 present field measurement results. The pH and temperature results during these sample events did not exceed (met) Water Quality Standards.

Table 5. Stormwater field measurements using handheld probe, 3/27/2017

Sites	pH	Conductivity uS/cm	TDS mg/L	Temperature C°
CC_CAPT	7.18	126.4	89.8	9.4
BB_STJOHNSMINN	7.32	126.3	89.7	11.1
CC_NE85	7.63	153.8	109.0	10.0
LS_NE102	7.75	138.0	98.0	10.8
WC_NE10NE149	NA	NA	NA	NA
LR_NW3RDCT	7.40	134.8	95.5	10.5

Table 6. Stormwater field measurements using handheld probe, 4/24/2017

Sites	pH	Conductivity uS/cm	TDS mg/L	Temperature C°
CC_CAPT	7.45	10.1	7.15	9.9
BB_STJOHNSMINN	7.18	129.5	91.9	10.3
CC_NE85	7.60	73.3	52.1	10.2
LS_NE102	7.71	50.6	36.2	11.1
SC_TRIB	7.35	16.0	11.3	12.6
WC_NE10NE149	7.45	65.2	46.3	11.1
LR_NW3RDCT	7.45	122.0	86	11.3

Laboratory Results

This section describes laboratory results for both storm-event and sediment sampling.

Conventional Parameters

The laboratory analyzed sediment pH. A handheld probe was used to measure stormwater pH in the field (Tables 5 and 6).

Currently, there are no standards or criteria related to many of the conventional parameters monitored in this project. Conventional parameters were monitored because they serve as ancillary data for toxics by documenting characteristics of the water or sediment that may influence the uptake and impact toxics have on aquatic organisms.

pH

Over the course of three sediment monitoring events, sediment pH ranged from 6 to 7.4 (Table 7).

Table 7. pH analysis for all sediment sampling events.

Site	Date		
	5/9/2017	6/7/2017	6/21/2017
CC_CAPT	6.5	6.4	6.5
BB_STJOHNSMINN	6.5	6.4	6.3
CC_NE85	7.1	7.1	6.8
LS_NE102	6.7	7.0	7.1
WC_NE10NE149	6.8	6.6	6.4
LR_NW3RDCT	7.2	7.3	7.1
SC_TRIB	6.7	6.7	6.4
Dollar_US			6.5
Dollar_DS			6.1
LS_NE102_USNE116		7.3	7.0
SCTRIB_DS		6.7	
QMB			6.5
SC_SWIM			7.4
SC			6.0
MINN_CORP			6.2

Gray cells: Monitoring sites upstream and downstream of core sites not monitored for.

Hardness

Hardness concentrations were measured during both stormwater monitoring events, 3/27/2017 and 4/24/2017. Hardness was measured as an ancillary parameter in determining when metals concentrations exceeded (did not meet) dissolved metals criteria.

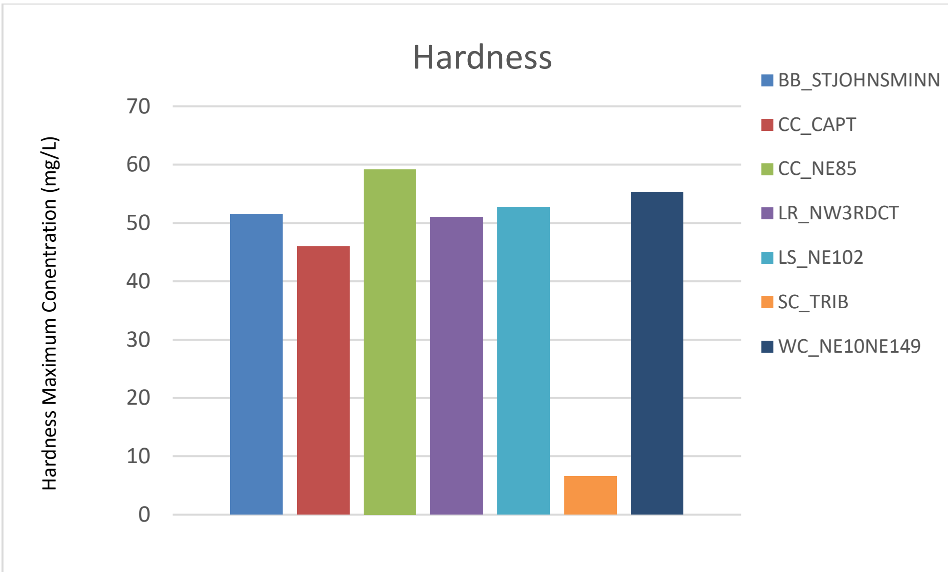

Figure 2. Hardness concentrations.

Oil & Grease

Oil & grease were not detected at any site during storm event sampling, 3/27 and 4/24/2017.

Total Suspended Solids (TSS)

Table 8 describes TSS results for stormwater samples. Results ranged from 2 to 295 mg/L. The site LSNE102 had the highest TSS concentrations during the 4/24/2017 storm event.

Table 8. TSS concentrations for core site stormwater monitoring, 3/27 and 4/24/2017.

Date	Stormwater - Total Suspended Solids, mg/L						
	CC_CAPT	BB_STJOHNSMINN	CC_NE85	LS_NE102	WC_NE10NE149	LR_NW3RDCT	SC_TRIB
3/27/2017	14	2	4	5	11	5	NA
4/24/2017	11	5	54	295	95	42	39

Total Organic Carbon (TOC)

Table 9 describes TOC stormwater concentrations for each site. Concentrations of TOC ranged from 2.65 to 6.24 mg/L.

Table 9. TOC concentrations for core site stormwater monitoring, 3/27 and 4/24/2017.

Date	Stormwater - Total Organic Carbon (mg/L)						
	CC_CAPT	BB_STJOHNSMINN	CC_NE85	LS_NE102	WC_NE10NE149	LR_NW3RDCT	SC_TRIB
3/27/2017	3.14	2.65	4.36	2.89	2.86	3.37	NA
4/24/2017	3.29	3.32	4.86	4.07	5.51	6.24	3.45

Table 10 describes sediment concentrations of TOC. Sediments in the study area consisted of 0.66% to 13.3% TOC.

Table 10. Percent TOC for sediment monitoring sites, 5/9, 6/7, and 6/21/2017.

Site	Date		
	5/9/2017	6/7/2017	6/21/2017
CC_CAPT	13.3	8.91	9.97
BB_STJOHNSMINN	10.3	8.99	7.07
CC_NE85	1.78	1.85	2.67
LS_NE102	1.75	0.66	1.44
WC_NE10NE149	1.55	5.66	3.7
LR_NW3RDCT	1.66	2.26	1.1
SC_TRIB	12	13.6	12.4
Dollar_US			1.04
Dollar_DS			0.66
LS_NE102_USNE116		0.67	2.32
SCTRIB_DS		9.11	
QMB			10.3
SC_SWIM			0.8
SC			2.22
MINN_CORP			3.43

Gray shaded cells – Monitoring sites up and downstream of core sites not monitored for.

Total Volatile Solids (TVS)

Table 11 presents TVS results calculated for all sediment samples. Results ranged from 1.71% to 10.9%.

Table 11. Percent TVS for sediment monitoring sites, 5/9, 6/7, and 6/21/2017.

Site	Date		
	5/9/2017	6/7/2017	6/21/2017
CC_CAPT	5.91	4.53	5.35
BB_STJOHNSMINN	4.8	6.06	4.59
CC_NE85	3.17	2.74	4.21
LS_NE102	3.18	2.26	2.57
WC_NE10NE149	3.34	5.88	4.41
LR_NW3RDCT	4.05	8.9	2.75
SC_TRIB	10.1	9.34	10.9
Dollar_US			2.84
3Dollar_DS			3.08
LS_NE102_USNE116		1.71	4.1
SCTRIB_DS		3.81	
QMB			7.57
SC_SWIM			1.82
SC			3.16
MINN_CORP			6.06

Gray shaded cells – Monitoring sites upstream and downstream of core sites not monitored for.

Hydrocarbons

Diesel and Gasoline

Diesel and gasoline were not detected during stormwater sampling on 3/27/17 and 4/24/17. Diesel was not detected in sediments. Gasoline was not monitored for in sediment due to its volatile nature and short residency time in sediment.

Lube Oil

Lube oil, a heavier weight hydrocarbon than diesel, was detected at elevated levels in sediment across the study area. Lube oil is associated with motor oil and auto/machinery lubricants. Figure 3 shows maximum concentrations of lube oil throughout the study area.

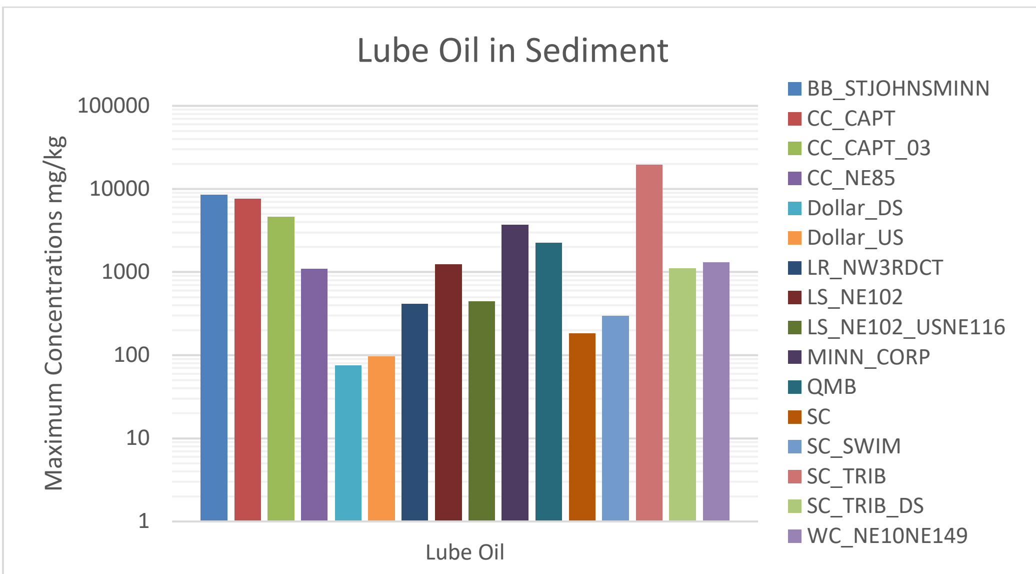

Figure 3. Maximum concentrations of detected lube oil in sediment for all sites (mg/kg), 5/9, 6/7, and 6/21/2017.

Nutrients

In Stormwater

In general, nutrients were detected at low levels at all sites. There are currently no Washington State water quality criteria for nitrogen or phosphorous in stormwater. All sites met the acute Washington State Water Quality Standards for ammonia-nitrogen. Figure 4 displays nutrient results for all sites.

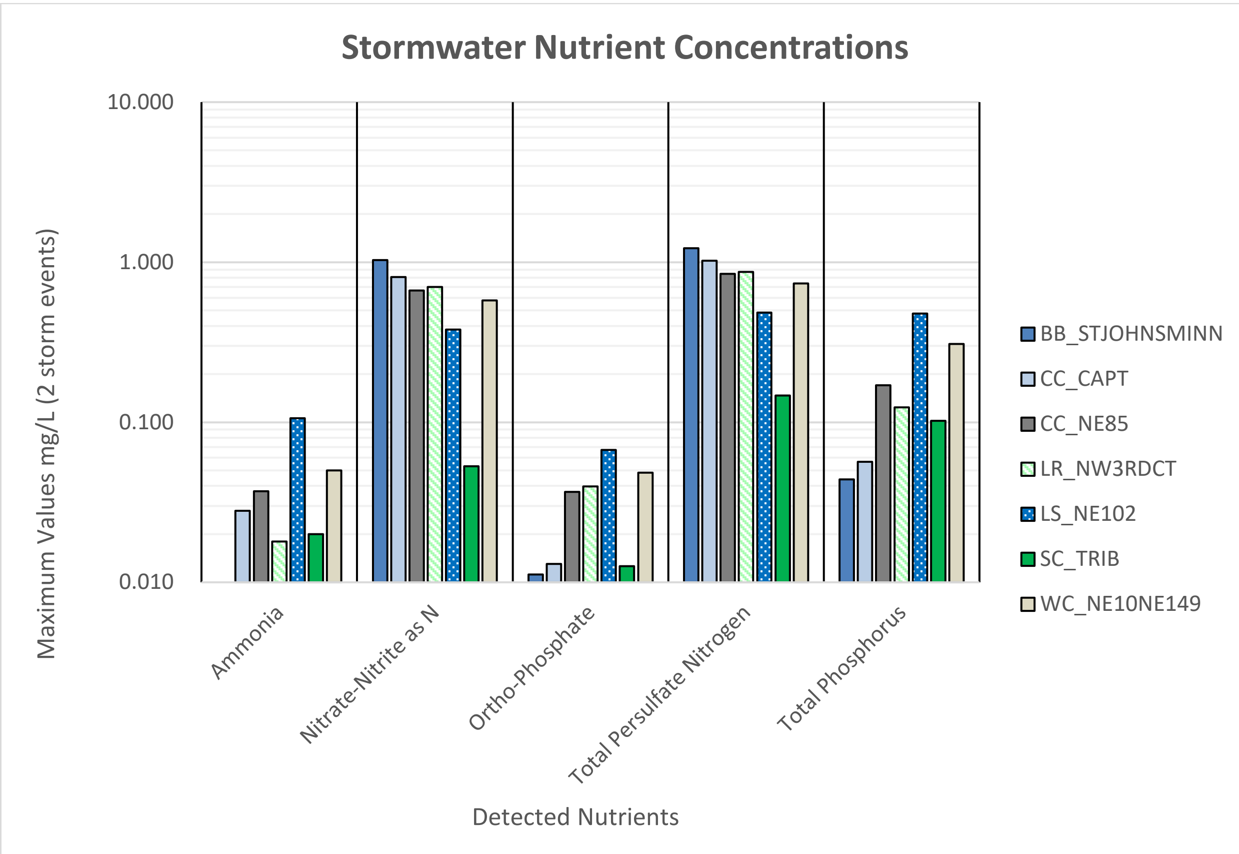

Figure 4. Maximum concentrations of detected nutrients in stormwater for core sites (mg/L), 3/27 and 4/24/2017.

Metals

Total and Dissolved Metals in Stormwater

Stormwater was sampled for both total and dissolved metals on 3/27 and 4/24 at core sites. Maximum concentrations of total and dissolved metals are described in Figures 5 and 6, respectively. The 75^{th} percentile threshold from the 2009-2013 *Western Washington NPDES Phase I Stormwater Permit Data Characterization* study is included to (1) provide a comparison and a cut-off point for concentrations of concern and (2) prioritize source control activities. Copper, lead, and zinc exceeded thresholds for the 75^{th} percentile (Table 11).

In addition, dissolved metals were compared to Washington State's acute aquatic life criteria. Dissolved metals met all criteria with the exception of site SC_TRIB exceeding acute criteria for zinc and copper on the 4-24-2017 storm event. Currently, total metal concentrations in surface water have no state criteria.

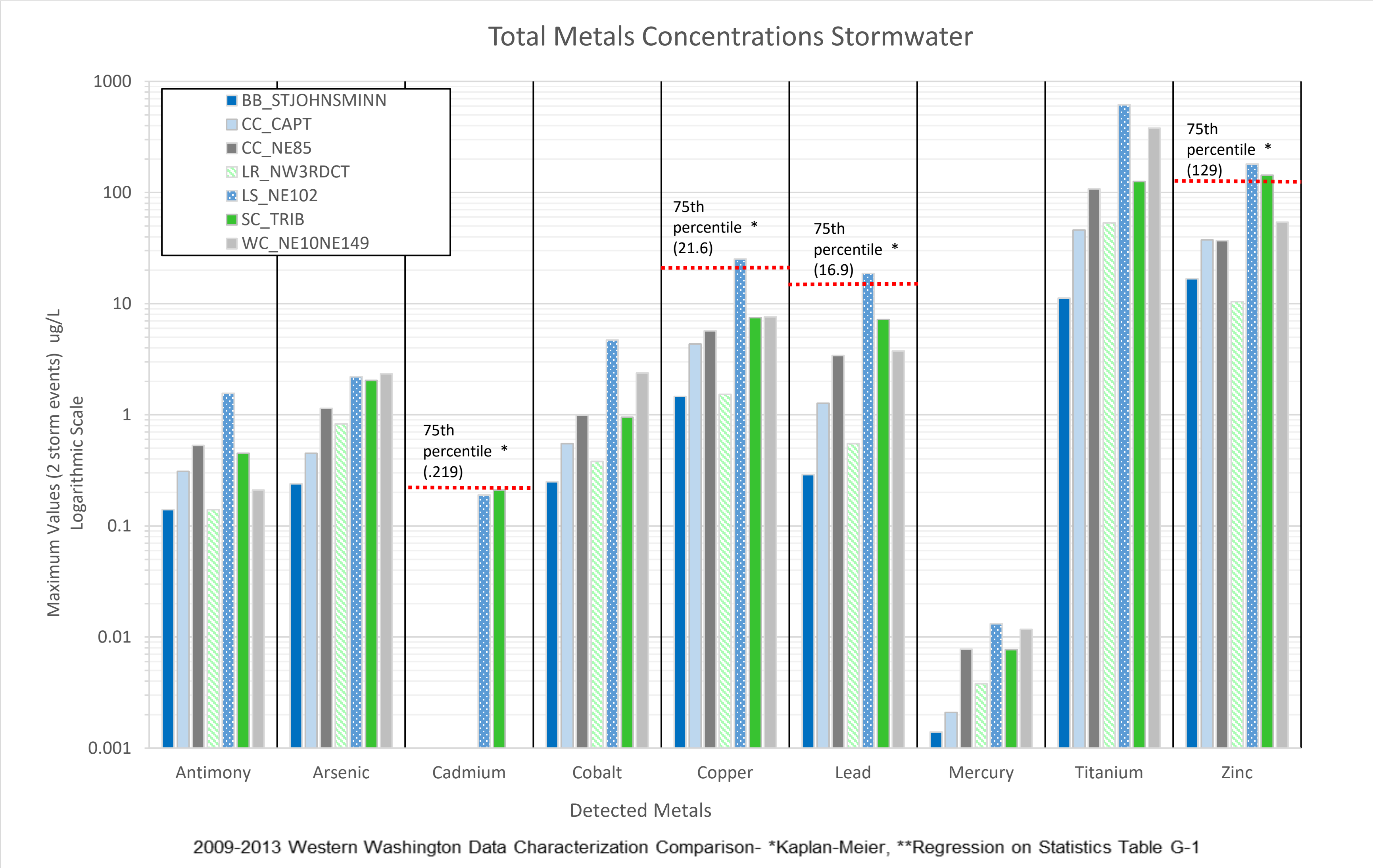

Figure 5. Maximum concentrations of detected total metals in stormwater for core sites (ug/L), 3/27 and 4/24/2017.

Table 12. Comparison and scoring of total metals in stormwater (ug/L), 3/27 and 4/24/2017.

Orange highlighted cells indicate a result above the threshold

Parameters	Antimony	Arsenic	Cadmium	Cobalt	Copper	Lead	Mercury	Titanium	Zinc	Score **
75th percentile*	-	-	0.219	-	21.6	16.9	-	-	129	
BB_STJOHNSMINN	0.14	0.24	ND	0.25	1.46	0.29	0.0014	11.2	16.7	0
CC_CAPT	0.31	0.45	ND	0.55	4.33	1.27	0.0021	45.9	37.4	0
CC_NE85	0.53	1.14	ND	0.99	5.7	3.42	0.0078	108	36.8	0
LR_NW3RDCT	0.14	0.83	ND	0.38	1.53	0.55	0.0038	53.4	10.4	0
LS_NE102	1.56	2.2	0.19	4.7	25.2	18.7	0.0132	616	181	3
SC_TRIB	0.45	2.04	0.21	0.95	7.48	7.2	0.0077	126	143	1
WC_NE10NE149	0.21	2.34	ND	2.37	7.59	3.76	0.0117	380	54.2	0

ND = non-detect

* 2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics.

** Exceedance of compared values = 1 point per exceedance.

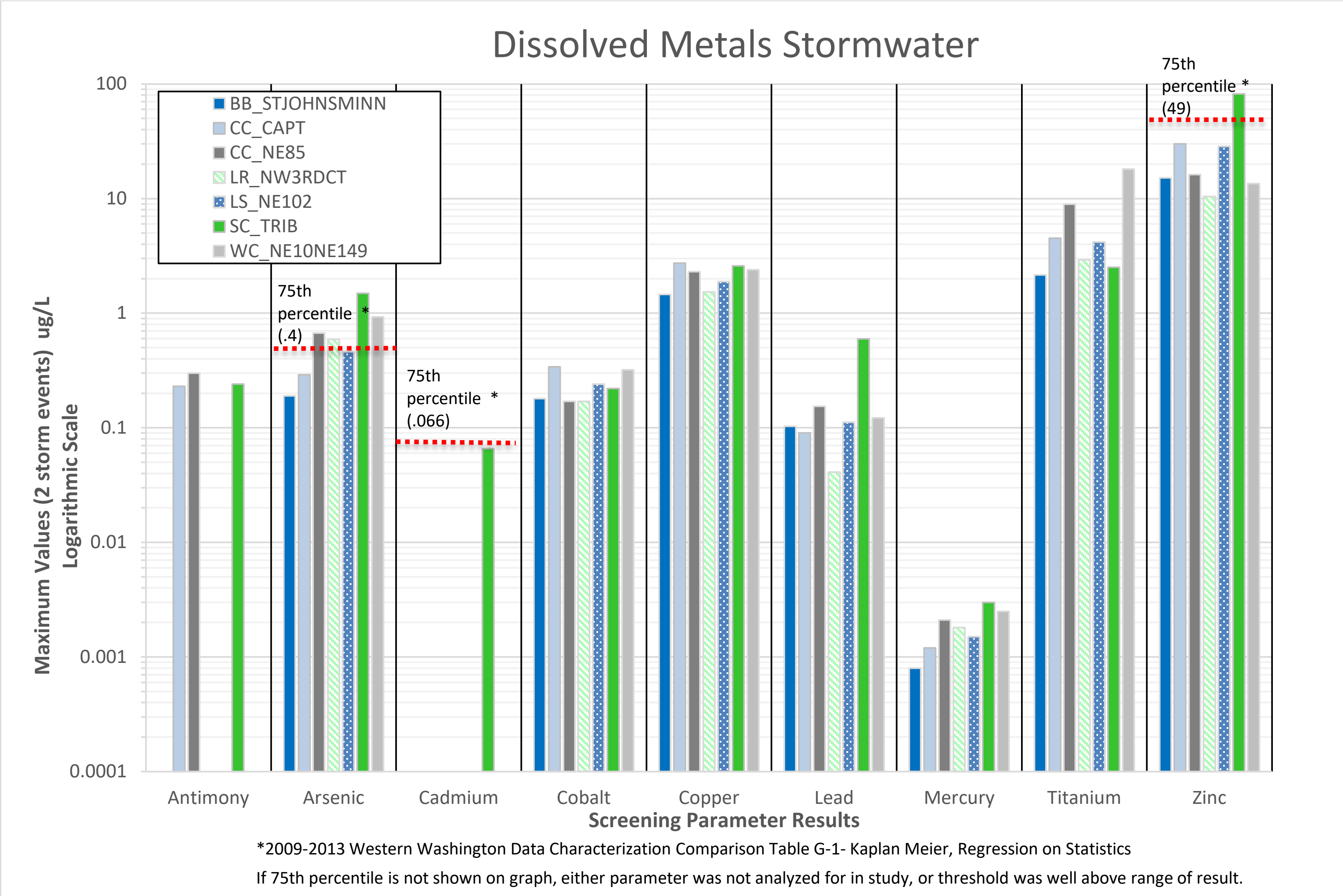

Figure 6. Maximum concentrations of detected dissolved metals in stormwater for core sites (ug/L), 3/27 and 4/24/2017.

Table 13. Comparison and scoring of dissolved metals in stormwater (ug/L), 3/27 and 4/24/2017.

Orange highlighted cells indicate a result above the threshold

Parameters	Antimony	Arsenic	Cadmium	Cobalt	Copper	Lead	Mercury	Titanium	Zinc	Score**
75th percentile*	-	0.4	0.066	-	***	-	-	-	49,***	
BB_STJOHNSMINN	ND	0.19	ND	0.18	1.46	0.103	0.0008	2.16	15.2	0
CC_CAPT	0.23	0.29	ND	0.34	2.73	0.09	0.0012	4.52	30	0
CC_NE85	0.3	0.67	ND	0.17	2.3	0.154	0.0021	8.92	16.2	1
LR_NW3RDCT	ND	0.59	ND	0.17	1.53	0.041	0.0018	2.92	10.4	1
LS_NE102	ND	0.46	ND	0.24	1.89	0.112	0.0015	4.17	28.5	1
SC_TRIB	0.24	1.49	0.066	0.22	2.58 ***	0.596	0.003	2.51	82***	3
WC_NE10NE149	ND	0.93	ND	0.32	2.4	0.122	0.0025	18.1	13.5	1

ND = non-detect.
* 2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics.
** Exceedance of compared values = 1 point per exceedance.
*** Exceeds WA State Acute Metals Criteria for Receiving Waters.

As seen in Table 13 and Figure 6, Arsenic exceeds the 75th percentile threshold comparison.

Copper and zinc were found to exceed acute metals criteria for receiving water and are not displayed in Figure 5 but are included in Table 13. Hardness at the SC_TRIB site was found to be very low, which contributed to the copper and zinc exceedances.

Metals in Sediment

Sediments were analyzed for total metals. Maximum concentrations of total metals in sediment were compared to Washington State's Sediment Management Standards Clean-up Objective levels as a conservative approach.

Figure 7 shows exceedances of sediment management standards clean up objectives for arsenic, cadmium, and silver. Due to lack of sediment objectives or other useful data for comparison for antimony, titanium, and cobalt, these metals were omitted from the graph. Table 14 summarizes all metal parameters analyzed.

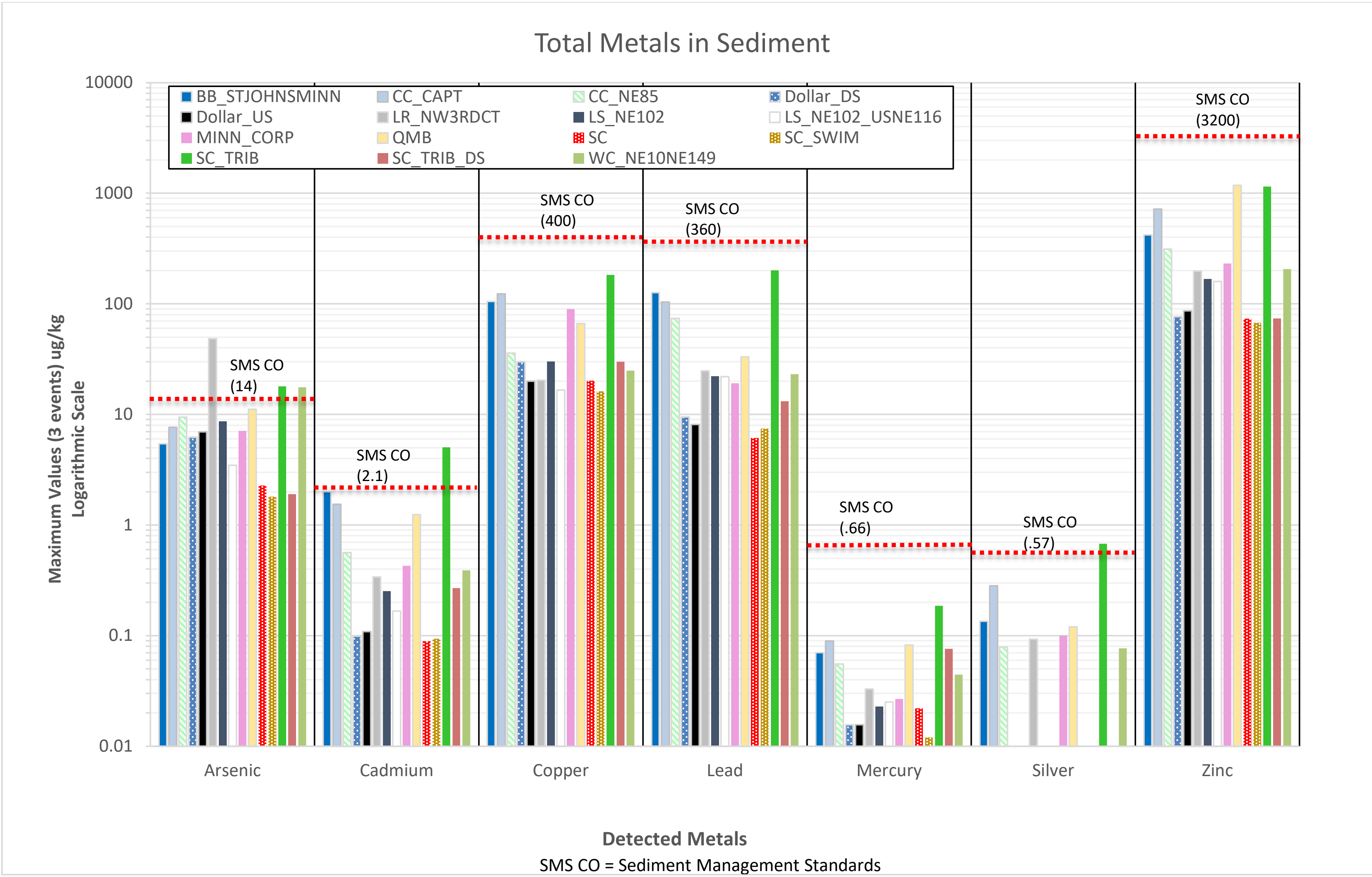

Figure 7. Maximum concentrations of detected total metals in sediment for core sites (ug/kg), 5/9, 6/7, and 6/21/2017.

Table 14. Comparison and scoring of total metals in sediment (ug/kg), 5/9, 6/7, and 6/21/2017.

Orange highlighted cells indicate a result above the threshold

Parameter	Antimony	Arsenic	Cadmium	Cobalt	Copper	Lead	Mercury	Silver	Titanium	Zinc	Score**
Sediment Mgmt CO*	-	14	2.1	-	400	360	0.66	0.57	-	3200	
BB_STJOHNSMINN	3.97	5.42	2.01	17.2	105	126	0.0704	0.135	2130	421	0
CC_CAPT	4.05	7.64	1.54	19.9	123	104	0.0896	0.283	2120	719	0
CC_NE85	1.06	9.45	0.562	18.2	35.8	73.7	0.0555	0.079	1960	312	0
Dollar_DS	0.405	6.24	0.099	13.6	30	9.52	0.0156	ND	1030	76.6	0
Dollar_US	0.319	6.96	0.109	15	20	8.09	0.0156	ND	833	86.3	0
LR_NW3RDCT	3.36	48.3	0.34	22.4	20.4	24.8	0.0328	0.093	1630	198	1
LS_NE102	0.672	8.67	0.253	23	30.1	22.1	0.0229	ND	1890	168	0
LS_NE102_USNE116	0.42	3.47	0.167	11.2	16.6	21.9	0.0251	ND	1510	159	0
MINN_CORP	1.38	7.12	0.428	29.4	89.7	19.1	0.0268	0.1	2000	231	0
QMB	3.06	11.1	1.24	37.8	66.4	33.2	0.0824	0.12	1760	1180	0
SC	0.193	2.28	0.089	9.43	20.2	6.13	0.022	ND	1240	73.3	0
SC_SWIM	0.148	1.81	0.094	11.5	16.2	7.45	0.012	ND	1920	67.4	0
SC_TRIB	5.48	18	5.04	11.5	183	201	0.186	0.678	1910	1150	3
SC_TRIB_DS	0.394	1.9	0.27	10.5	29.9	13.2	0.0759	ND	1580	73.6	0
WC_NE10NE149	0.518	17.6	0.389	16.6	24.9	23.1	0.0443	0.077	1780	206	1

ND = non-detect

* Based on Sediment Cleanup Objectives Chemical Criteria (Sediment Management Standards Chapter 173-204 WAC, Table VI (ECY, 2013)

** Exceedance of compared values = 1 point per exceedance

As seen in Table 14, arsenic, cadmium, and silver exceeded Sediment Management Standards Clean-up Objectives.

Semi-Volatile Organics (Phthalates and PAHs)

Stormwater

Semi-volatile organics (phtahalates and PAHs) stormwater screening results were compared to the 75th percentile threshold value from the Phase 1 characterization study (Hobbs et al., 2015).

Stormwater was screened for six phthalate compounds. Of the six parameters, three were detected: Bis (2-Ethylhexyl) phthalate (1 site), Di-N-Butylphthalate (2 sites), and Dimethyl phthalate (2 sites).

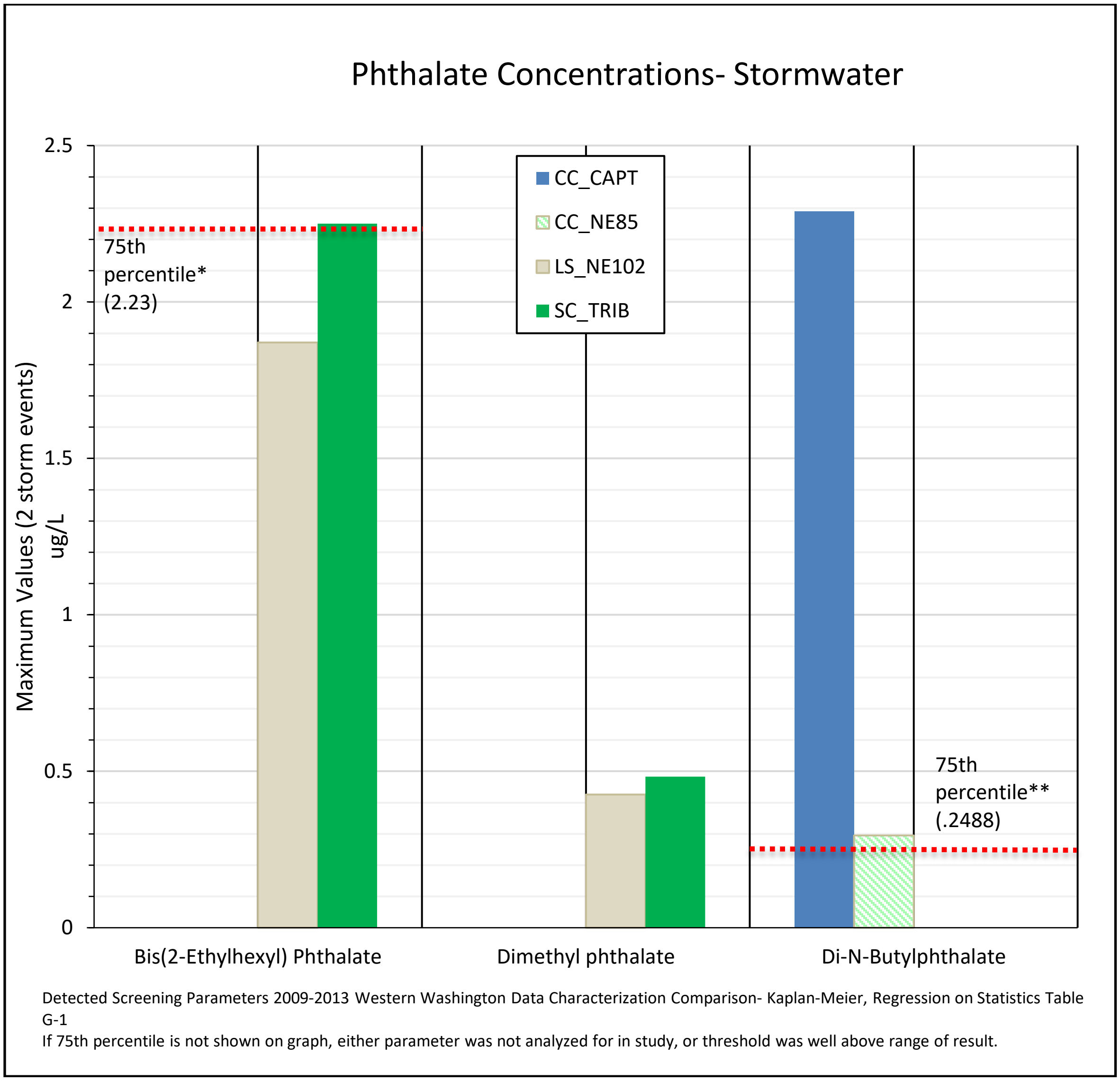

Figure 8. Maximum concentrations of detected phthalates in stormwater for core sites (ug/L), 3/27 and 4/24/2017.

Figure 8 presents the maximum concentrations of phthalates in stormwater and compares the 75th percentile threshold values established by the 2009-2013 data characterization. Results are summarized in Table 15.

Table 15. Comparison and scoring of phthalates in stormwater (ug/L), 3/27 and 4/24/2017.

Orange highlighted cells indicate a result above the threshold

Parameter	Bis(2-Ethylhexyl) Phthalate	Dimethyl phthalate	Di-N-Butylphthalate	Score**
75th percentile*	2.23	-	0.2488	
BB_STJOHNSMINN	ND	ND	ND	0
CC_CAPT	ND	ND	2.29	1
CC_NE85	ND	ND	0.295	1
LR_NW3RDCT	ND	ND	ND	0
LS_NE102	1.87	ND	ND	0
SC_TRIB	2.25	ND	ND	1
WC_NE10NE149	ND	ND	ND	0

* 2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics.
** Exceedance of compared threshold values = 1 point per exceedance
ND = non-detect.

As seen in Table 15, Bis(2-Ethylhexyl) Phthalate and Di-N-Butylphthalate exceeded the 75th percentile threshold comparison values.

Stormwater was screened for 16 priority pollutants of PAHs. A summary of results can be found in Figures 9 and 10 and Tables 16 and 17 summarize screening findings**.**

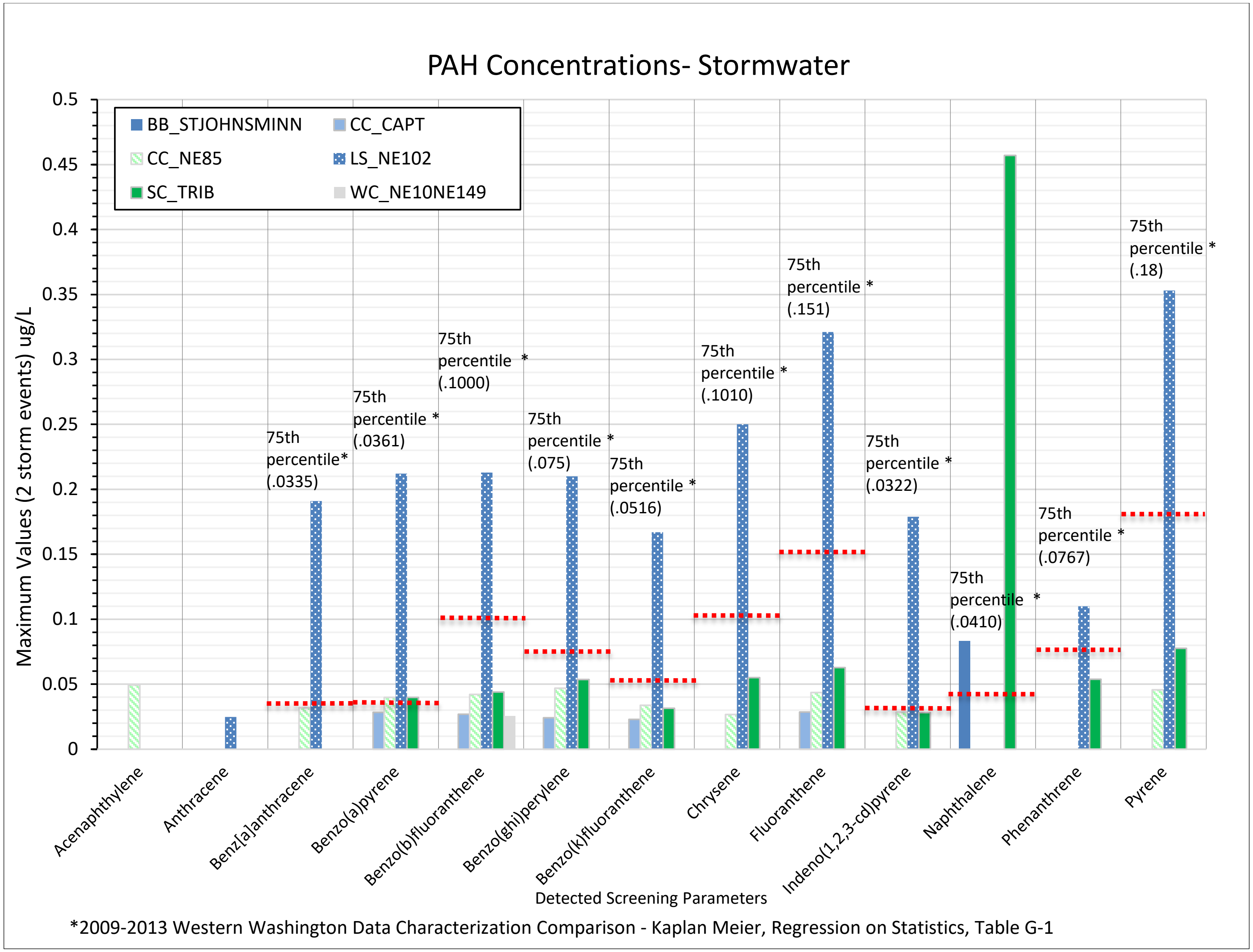

Figure 9. Maximum concentrations of detected PAHs in stormwater for core sites (ug/L), 5/9, 6/7, and 6/21/2017.

Thirteen of 16 PAH parameters were detected in the screening area. PAH concentrations were compared to the 2009-2013 Western Washington MS4 Permit Data Characterization. In general, maximum concentrations in the project area were within the 75th percentile. The site LS_NE102 was an exception, with PAHs detected above the 75th percentile for almost all PAH parameters. The site SC_TRIB also had a large spike of naphthalene. Results are displayed in Figure 8 and summarized in Table 16.

Table 16. Comparison and scoring of PAHs in stormwater (ug/L), 5/9, 6/7, and 6/21/2017.

Orange highlighted cells indicate a result above the threshold

Parameter	Acenaphthylene	Anthracene	Benz[a]anthracene	Benzo(a)pyrene	Benzo(b)-fluoranthene	Benzo(ghi) - perylene	Benzo(k)-fluoranthene	Chrysene	Fluoranthene	Indeno(1,2,3-cd) pyrene	Naphthalene	Phenanthrene	Pyrene	Score ***
75th percentile**	-	-	0.0335	0.0361	0.1	0.075	0.0516	0.101	0.151	0.0322	0.04	0.0767	0.18	
BB_STJOHNSMINN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.083	ND	ND	1
CC_CAPT	ND	ND	ND	0.0283	0.027*	0.0242*	0.023*	ND	0.0286*	ND	ND	ND	ND	0
CC_NE85	0.049	ND	.03*	0.0398*	0.042*	0.0469*	0.034*	0.0266*	0.0436*	0.029*	ND	ND	0.046*	1
LS_NE102	ND	0.025*	0.19	0.212	0.213	0.21	0.17	0.25	0.321	0.18	ND	0.11	0.35	10
SC_TRIB	ND	ND	ND	0.0399*	0.044*	0.0537	0.032*	0.0551	0.0627	0.028*	0.46	0.0539	0.078	2

ND = non-detect

*Estimated Positively Identified (J).

**2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics.

***Exceedance of compared values = 1 point per exceedance.

Sediment

Semi-volatile organics in sediment were compared to the 2009-2013 Western Washington MS4 Permit Data Characterization 75th percentile of results for both phthalates and PAHs. Bis(2-ethylhexyl)phthalate at 2 sites, di-n-octyl phthalate at 3 sites, and naphthalene (PAH) at 7 sites exceeded the 75th percentile values.

Sediment Management Standards Clean-up Objectives were also reviewed and compared to screening results. Clean-up objectives were found to be lower in concentration than the 75th percentile values for several phthalate parameters. Bis(2-ethylhexyl)phthalate at 9 sites, di-n-octyl phthalate at 3 sites, butyl benzyl phthalate at 1 site, and total PAHs at 1 site exceeded sediment clean-up objectives.

Sediment clean-up objectives were available for several individual phthalate parameters. Clean-up objectives are available for Total PAHs. PAHs were summed at each site and compared to the Total PAH threshold of 17,000 ug/Kg.

Figure 10 and Table 17 compare the threshold established by evaluation of sediment objectives and 75th percentile values.

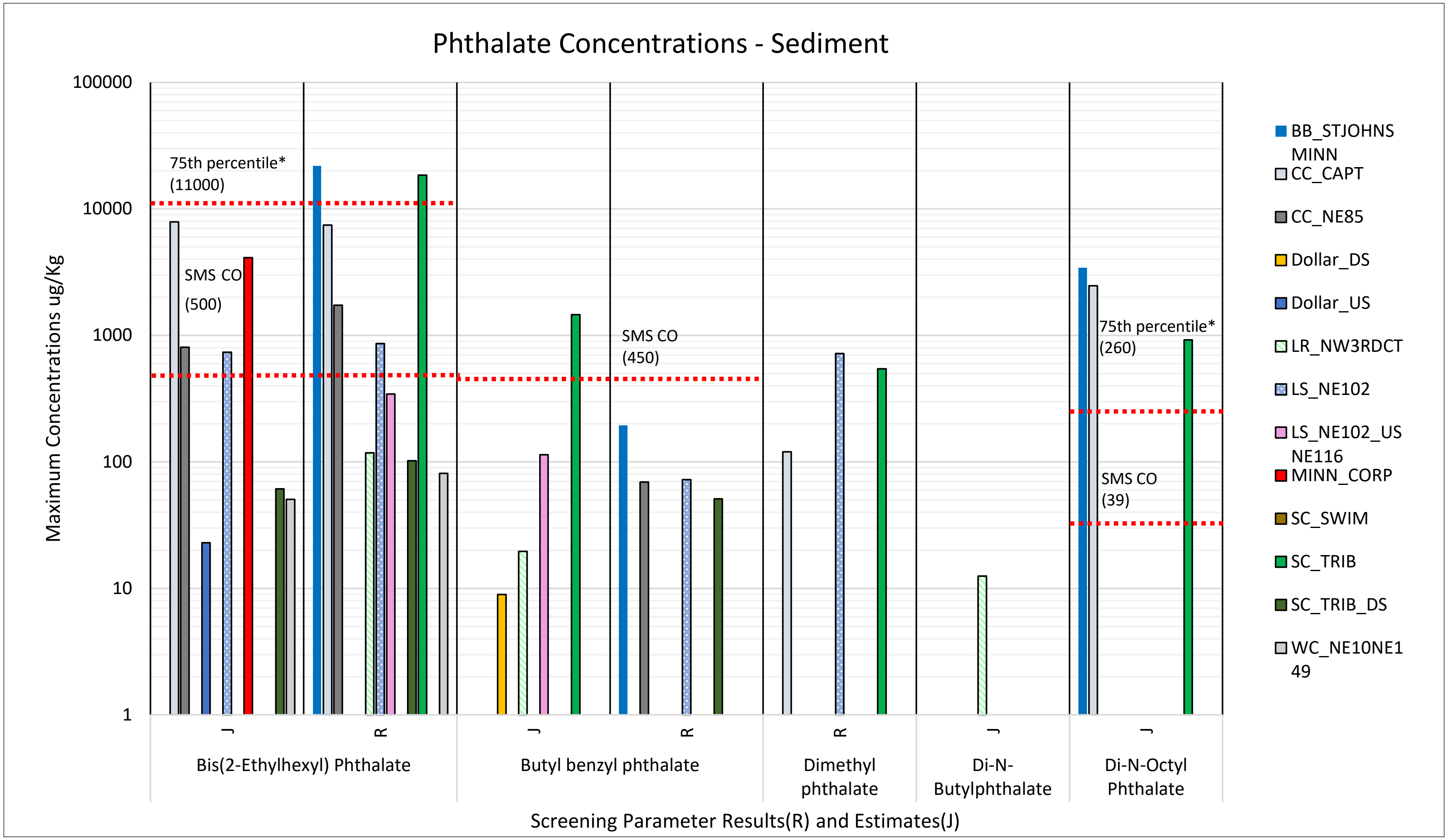

Figure 10. Maximum concentrations of detected phthalates in sediment for all sites (ug/Kg), 5/9, 6/7, and 6/21/2017.

As seen in Figure 10 and summarized in Table 17, Bis(2-Ethylhexyl) Phthalate was the most ubiquitous phthalate compound exceeding threshold comparison values at several sites.

Table 17. Comparison and scoring of phthalates in sediment (ug/L), 5/9, 6/7, and 6/21/2017.

Orange highlighted cells indicate a result above the threshold

Parameters	Bis(2-Ethylhexyl) Phthalate		Butyl benzyl phthalate		Dimethyl phthalate	Di-N-Butylphthalate	Di-N-Octyl Phthalate	Score*
Qualifier****	Res	J	Res	J	Res	J	J	
Sediment Objectives**	500		-		-	380	39	
75th Percentile***	11,000		450		-	51	260	
BB_STJOHNSMINN	21800	-	195	-	ND	-	3420	2
CC_CAPT	7460	7890	ND	-	120	-	2470	2
CC_NE85	1730	805	69.5	-	ND	-	ND	1
Dollar_DS	ND	-	ND	8.97	ND	-	ND	0
Dollar_US	ND	23	ND	-	ND	-	ND	0
LR_NW3RDCT	118	-	ND	19.6	ND	12.5	ND	0
LS_NE102	863	737	72.4	-	718	-	ND	1
LS_NE102_USNE116	344	-	ND	114	ND	-	ND	0
MINN_CORP	ND	4110	ND	-	ND	-	ND	1
SC_SWIM	102	-	51.1	-	ND	-	ND	0
SC_TRIB	18500	-	ND	1460	545	-	923	3
SC_TRIB_DS	ND	61.1	ND	-	ND	-	ND	0
WC_NE10NE149	81.2	50.6	ND	-	ND	-	ND	0

ND = non-detect, *Exceedance of compared values = 1 point per exceedance (one point per parameter per site in the event 2 qualifiers exceed compared value).
** Based on Sediment Cleanup Objectives Chemical Criteria (Sediment Management Standards Chapter 173-204 WAC, Table VI (ECY, 2013).
***2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics.
**** Res = Result, J= Estimate Positively Identified.

Due to the large parameter set for PAHs, only Naphthalene was graphed in Figure 11, as it was the only 75th percentile threshold exceedance. Naphthalene was detected at all sites and was found at elevated concentrations at 7 sites.

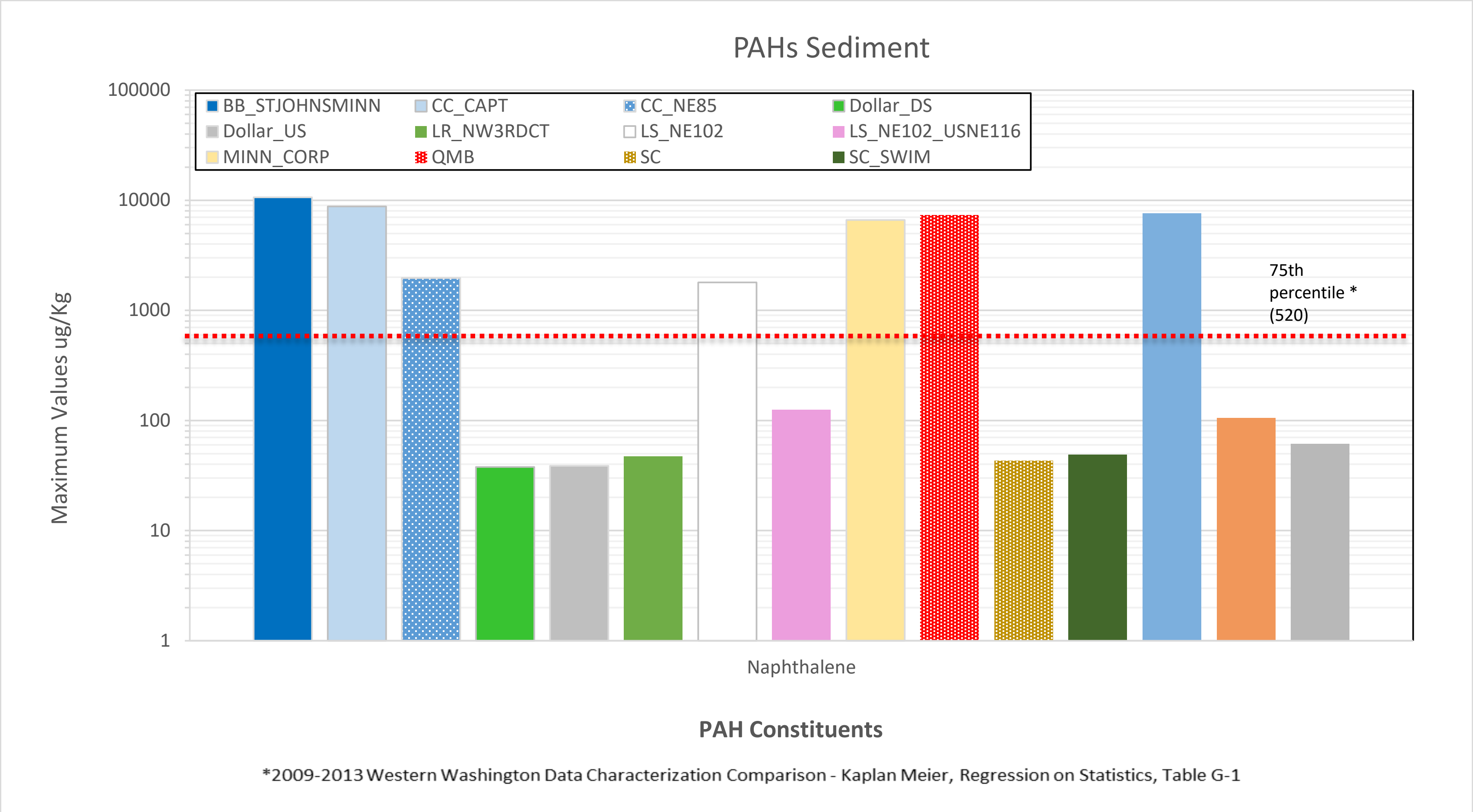

Figure 11. Maximum concentrations of detected PAHs in sediment for all sites (ug/kg), 5/9, 6/7, and 6/21/2017.

Orange highlighted cells indicate a result above the threshold.

The concentrations of detected PAHs were summed and compared to sediment clean-up objectives. As seen in Table 18, the PAH sediment management standard clean-up objective was exceeded once at site LS_NE102.

Table 18. Comparison and scoring of PAHs in sediment (ug/kg), 5/9, 6/7, and 6/21/2017.

Parameters	Acenaphthene	Anthracene	Benz[a] anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(ghi) perylene	Benzo(k) fluoranthene	Carbazole	Chrysene	Dibenzo(a,h)a nthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd) pyrene	Naphthalene	Phenanthrene	Pyrene	Retene	Total PAHs	Score*
Sediment Objectives**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17,000	
75th Percentile***	1,000	6,000	28,000	31,000	17,000	24,000	13,000	-	34,000	9,100	67,000	2,000	18,000	520	30,000	56,000	-	-	
BB_STJOHNSMINN	ND	ND	129	ND	ND	ND	ND	ND	232	ND	368	ND	ND	10600	150	405	ND	11884	1
CC_CAPT	ND	ND	223	ND	ND	ND	ND	ND	510	ND	598	ND	ND	8800	224	909	294	11558	1
CC_NE85	ND	32.1	165	172	783	ND	783	ND	750	ND	1380	ND	88.3	1970	165	1020	300	7608.4	1
Dollar_DS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	37.8	ND	ND	ND	37.8	0
Dollar_US	ND	ND	34.9	24.1	27.1	ND	29.1	ND	31.5	ND	34.9	ND	21	38.6	ND	35.5	ND	276.7	0
LR_NW3RDCT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	47	ND	ND	79.4	126.4	0
LS_NE102	25.8	208	1540	1910	2170	1240	2040	200	2130	558	2240	35.3	1270	1790	755	2800	ND	20912.1	2
LS_NE102_USNE116	ND	ND	82.7	88.6	97.5	48.3	97.3	ND	89.6	ND	138	ND	106	125	40.2	132	ND	1045.2	0
MINN_CORP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6600	ND	ND	ND	6600	1
QMB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7340	ND	ND	ND	7340	1
SC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	43	ND	ND	ND	43	0
SC_SWIM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	48.8	ND	ND	ND	48.8	0
SC_TRIB	ND	ND	ND	ND	ND	ND	ND	ND	336	ND	261	ND	ND	7600	ND	487	ND	8684	1
SC_TRIB_DS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	106	ND	ND	ND	106	0
WC_NE10NE149	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	61	ND	ND	1390	1451	0

ND = non-detect
* Exceedance of compared values = 1 point per exceedance
** Based on Sediment Cleanup Objectives Chemical Criteria (Sediment Management Standards Chapter 173-204 WAC, Table VI (ECY, 2013)
*** 2009-2013 Western Washington Data Characterization Comparison Table G-1- Kaplan Meier, Regression on Statistics

Flame Retardants

Stormwater

For comparison of stormwater results, a combination of data collected in this study and results from Ecology's EIM database was ranked into percentiles. In general, the 75th percentile was used as a cut-off point for concentrations of concern (see Figure 12).

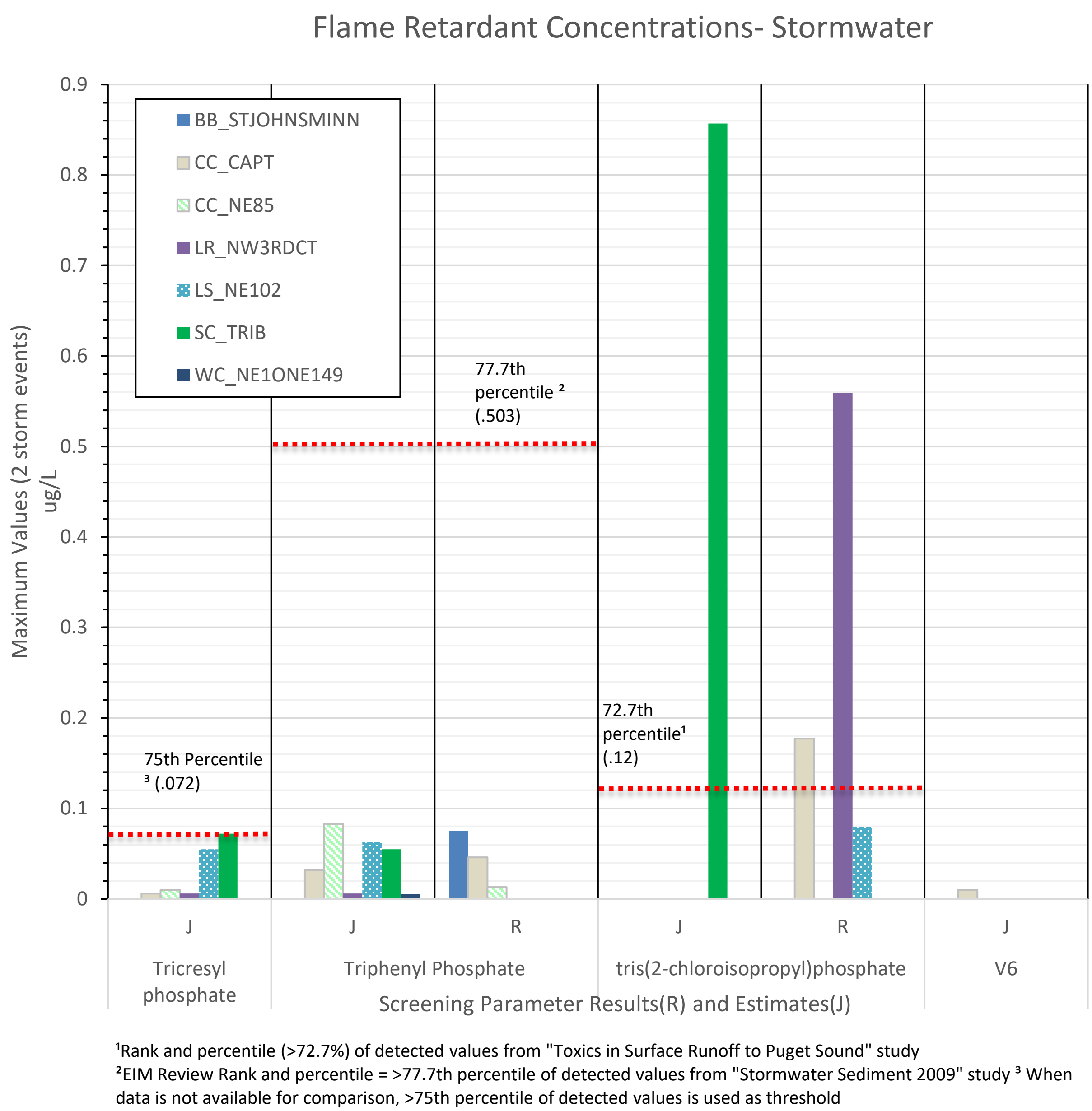

Figure 12. Maximum concentrations of detected flame retardants in stormwater for core sites (ug/L), 3/27 and 4/24/2017.

As seen in Figure 12 and Table 19, 4 of the 9 monitored flame retardants were detected in stormwater, including tricresyl phosphate, triphenyl phosphate, tris(2-chloroisopropyl) phosphate, and V6. Tricresyl phosphate at 1 site and tris(2-chloroisopropyl) phosphate at 3 sites exceeded percentile thresholds used to compare data results.

Table 19. Comparison and scoring of flame retardants in stormwater (ug/L), 3/27 and 4/24/2017.

Orange highlighted cells indicate a result above the threshold

Parameter	Tricresyl phosphate	Triphenyl phosphate		Tris(2-chloroisopropyl) phosphate		V6	Score**
Qualifier*	J	R	J	R	J	J	
EIM Data Review	-	0.503[2]		0.12 [1]		NA	
75th percentile [3]	0.072	-		-			
BB_STJOHNSMINN	-	0.075	-	ND	-	-	0
CC_CAPT	0.006	0.046	0.032	0.177	-	0.01	1
CC_NE85	0.01	0.013	0.083	ND	-	-	0
LR_NW3RDCT	0.006	ND	0.006	0.559	-	-	1
LS_NE102	0.055	ND	0.063	0.079	-	-	0
SC_TRIB	0.072	ND	0.055	ND	0.857	-	2
WC_NE10NE149	-	ND	0.005	ND	-	-	0

ND = non-detect
* Screening Parameter Results(R) and Estimated Positively Identified (J)
** Exceedance of compared values = 1 point per exceedance
[1] Rank and percentile (>72.7%) of detected values from "Toxics in Surface Runoff to Puget Sound" study
[2] Rank and percentile (>77.7%) of detected values from "Strom Surface Water EPA Grant 2008-2009" study
[3] When data are not available for comparison, data are ranked into percentiles, and values >75th percentile are given 1 point.

Sediment

For comparison of flame retardant sediment results, a combination of data collected in this study and previous study results in EIM was ranked into percentiles. In general, the 75^{th} percentile was used as a cut-off point for concentrations of concern (see Figure 13).

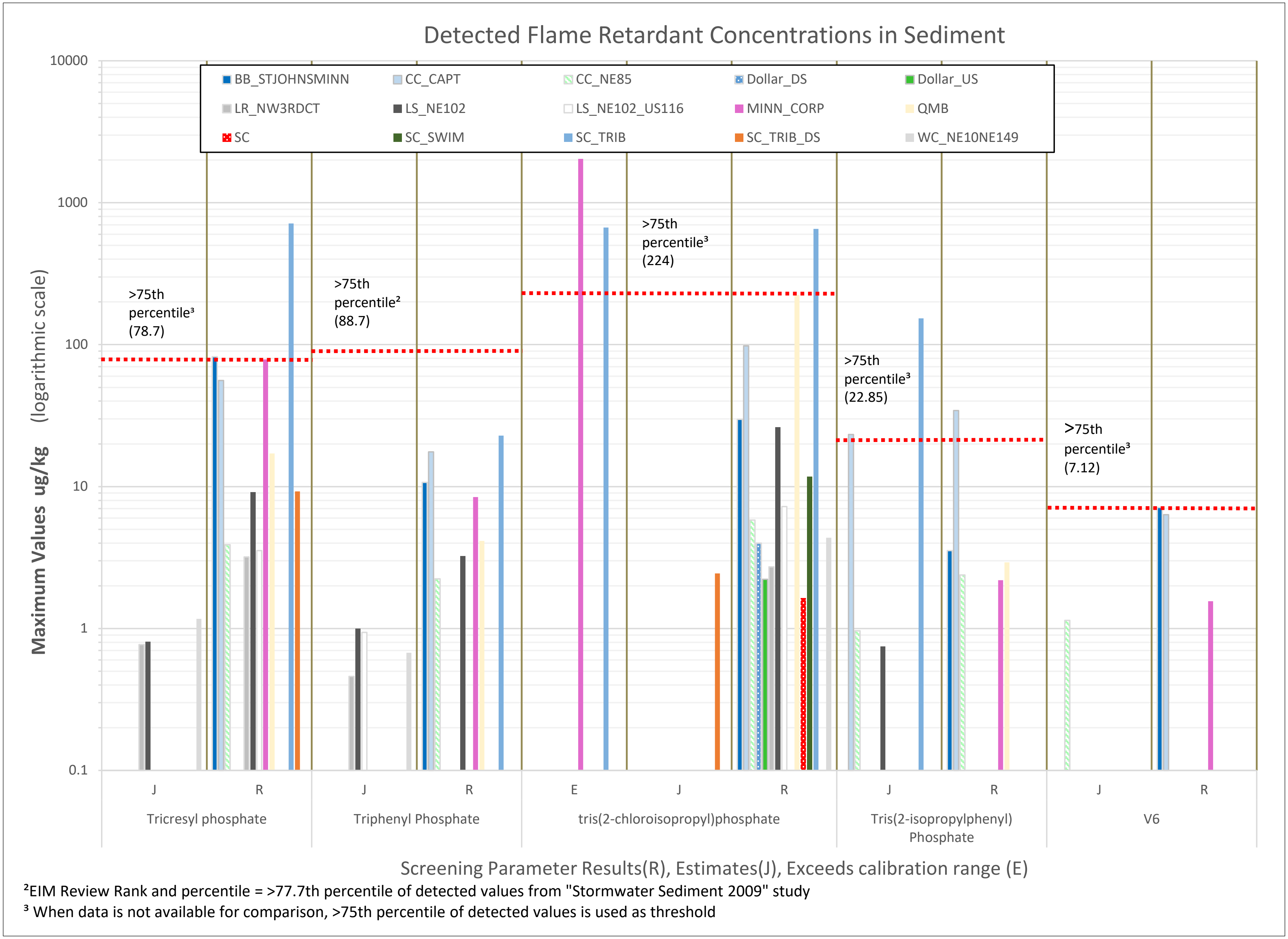

Figure 13. Maximum concentrations of detected flame retardants in sediment for all sites (ug/kg), 5/9, 6/7, and 6/21/2017.

As seen in Figure 13 and Table 20, 5 of the 9 screened flame retardants were detected in sediment, including tricresyl phosphate, triphenyl phosphate, tris(2-chloroisopropyl) phosphate, tris(2-isopropylphenyl) phosphate, and V6.

Table 20. Comparison and scoring of flame retardants in sediment (ug/kg), 5/9, 6/7, and 6/21/2017.

Orange highlighted cells indicate a result above the threshold

Parameters	Tricresyl phosphate		Triphenyl phosphate		Tris(2-chloroisopropyl) phosphate			Tris(2-isopropylphenyl) phosphate		V6		Score**
Qualifier*	Res	J	Res	J	Res	E	J	Res	J	Res	J	
EIM Data Review	NA		88.7[2]		ND[1]			NA		NA		
75th percentile [3]	78.7		-		224			22.85		7.12		
BB_STJOHNSMINN	82.1	-	10.717	-	29.8	-	-	3.54	-	7.12	-	2
CC_CAPT	55.9	-	17.57	-	97.95	-	-	28.85	23.3	6.35	-	1
CC_NE85	3.89	-	2.237	-	5.81	-	-	-	2.38	-	1.14	0
Dollar_DS	ND	-	ND	-	4	-	-	ND	-	ND	-	0
Dollar_US	ND	-	ND	-	2.22	-	-	ND	-	ND	-	0
LR_NW3RDCT	3.19	0.771	0.459	-	2.715	-	-	ND	-	ND	-	0
LS_NE102	9.14	0.809	3.245	1	26.3	-	-	0.747	0.747	ND	-	0
LS_NE102_US116	3.54	-	-	0.938	7.23	-	-	ND	-	ND	-	0
MINN_CORP	78.7	-	8.45	-	-	2040	-	2.19	-	1.56	-	2
QMB	17.1	-	4.14	-	224	-	-	2.92	-	ND	-	1
SC	ND	-	ND	-	1.64	-	-	ND	-	ND	-	0
SC_SWIM	ND	-	ND	-	11.8	-	-	ND	-	ND	-	0
SC_TRIB	714.667	-	22.9	-	654.5	669	-	-	153	ND	-	3
SC_TRIB_DS	9.24	-	ND	-	-	-	2.44	ND	-	ND	-	0
WC_NE10NE149	1.17	-	-	0.675	4.37	-	-	ND	-	ND	-	0

ND = non-detect

* Screening Parameter Results (Res) and Estimated Positively Identified (J).

** Exceedance of compared values = 1 point per exceedance

[1] EIM data review of 2 studies: Puget Sound Toxics Loading Analysis: Characterization of Toxic Chemicals in Puget Sound and Major Tributaries, 2009-10 and Squalicum Creek Stormwater Pilot Total Maximum Daily Load

[2] EIM Review Rank and percentile = >77.7th percentile of detected values from "Stormwater Sediment 2009" study

[3] When data are not available for comparison, >75th percentile of detected values is used as threshold.

PCBs (209 Congeners)

Stormwater

When comparing PCB results across sites, results show PCBs at one order of magnitude greater between sites. Results were reported as estimated values (J - detected, but below reporting limit).

Total PCB concentrations in stormwater were compared to Washington State aquatic life freshwater acute and chronic criteria (2.0 and .014 ug/L respectively). Stormwater concentrations were found to be well below acute and chronic criteria (Figure 14).

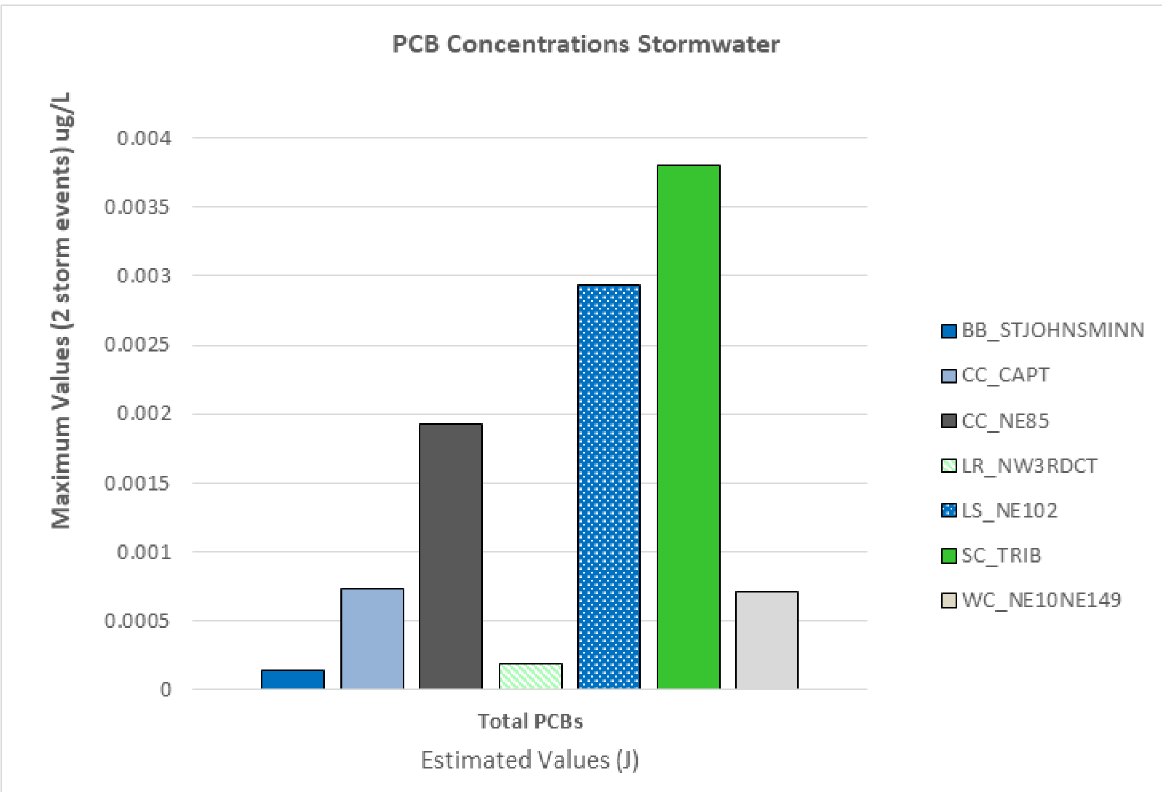

Figure 14. Maximum concentrations of detected PCBs (209 congeners) in stormwater for core sites (ug/L), 3/27 and 4/24/2017.

Sediment

PCB concentrations in sediment were well below Washington State sediment clean-up objectives of 110 ug/kg, based on Aroclor PCBs. The highest concentration found was at the SC_TRIB site at 58,100 pg/g which is equivalent to 58.1 ug/kg (Figure 15).

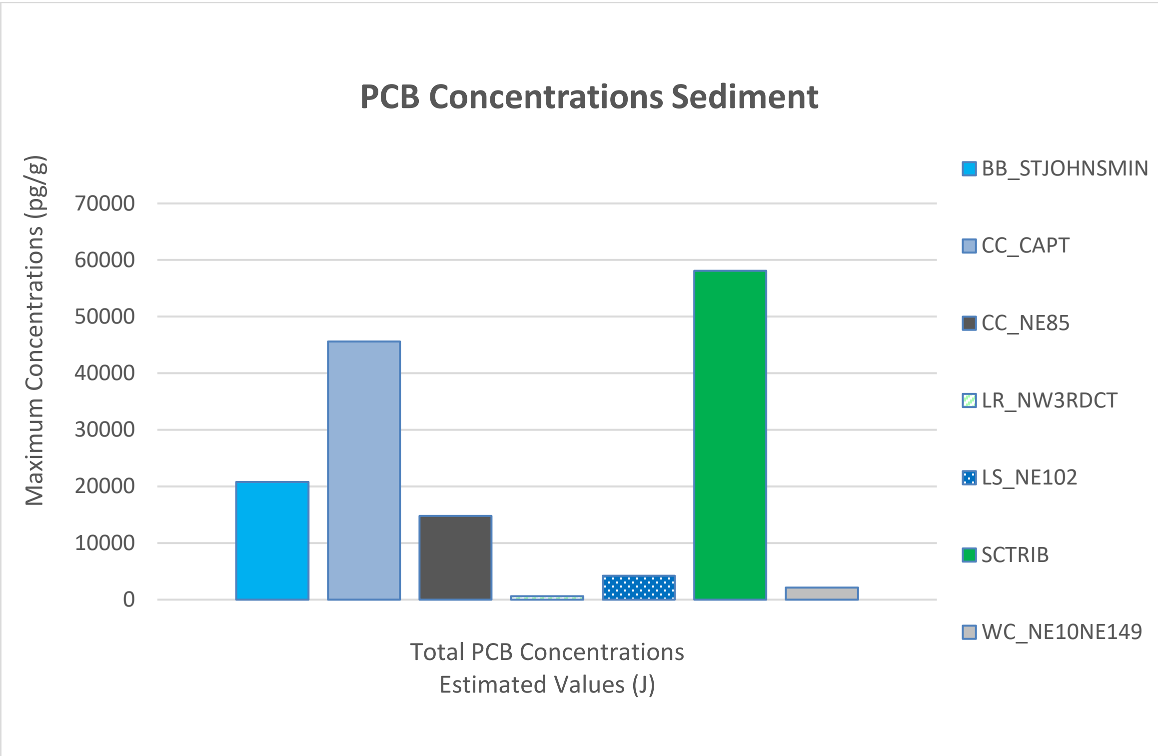

Figure 15. Maximum concentrations of detected PCBs (209 congeners) in sediment for core sites (pg/g), 5/9/2017.

PCBs Sediment (Aroclors)

Sediments for all core, upstream, and downstream sites were analyzed for PCB Aroclors. As seen in Figure 16, maximum PCB concentrations in sediment were well below Washington State sediment clean-up objectives of 110 ug/Kg, based on a total sum of Aroclor PCBs.

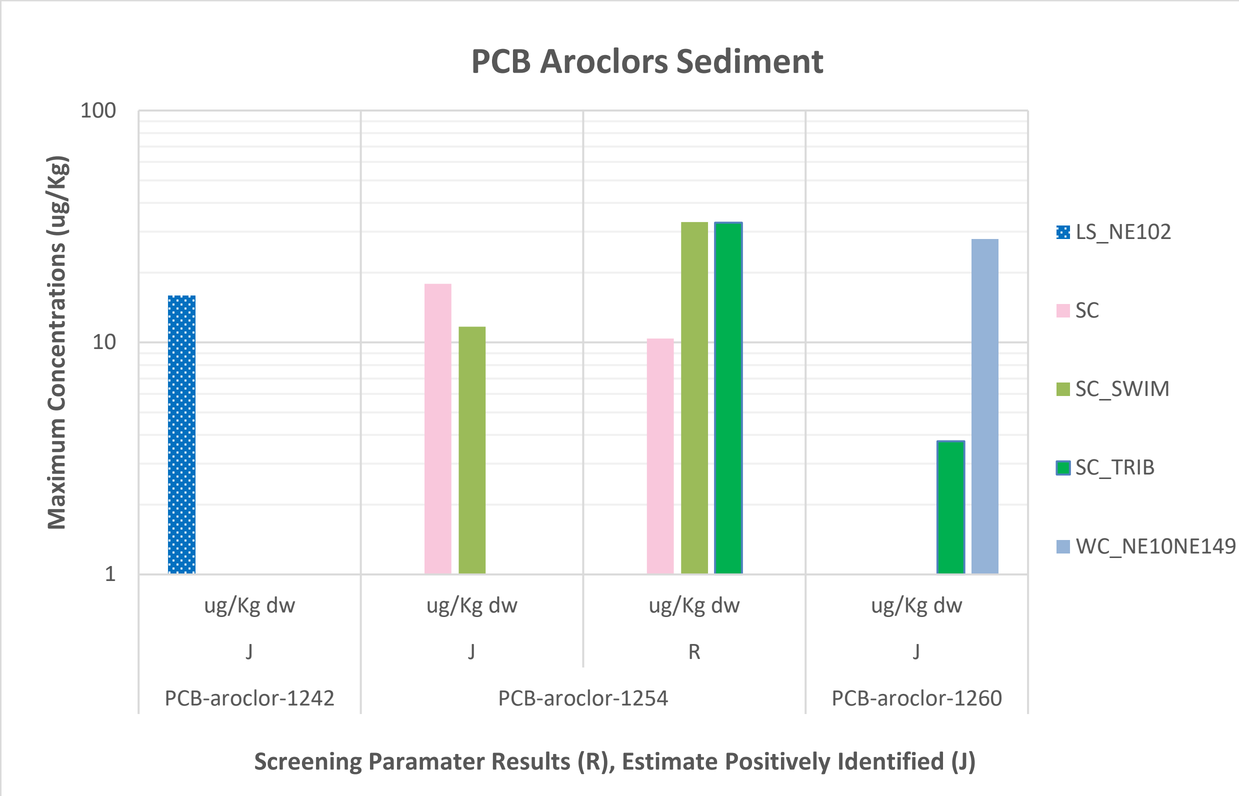

Figure 16. Maximum concentrations of detected PCB Aroclors in sediment for core sites (ug/kg), 6/21/2017.

Pesticides

Sediment

Additional analysis was conducted to characterize concentrations of organochlorine pesticides in sediment. Due to high concentrations of hydrocarbons (lube oil) at several sites, matrix interferences made extraction of samples for analysis difficult and limited the quantity of qualified results.

Sediments from the June 7 and 21 sample events were processed for analysis of legacy pesticides. A legacy chemical is one that remains for a long time in the environment after being introduced and can persist even after being phased out or banned. Organochlorine pesticides were detected at low levels.

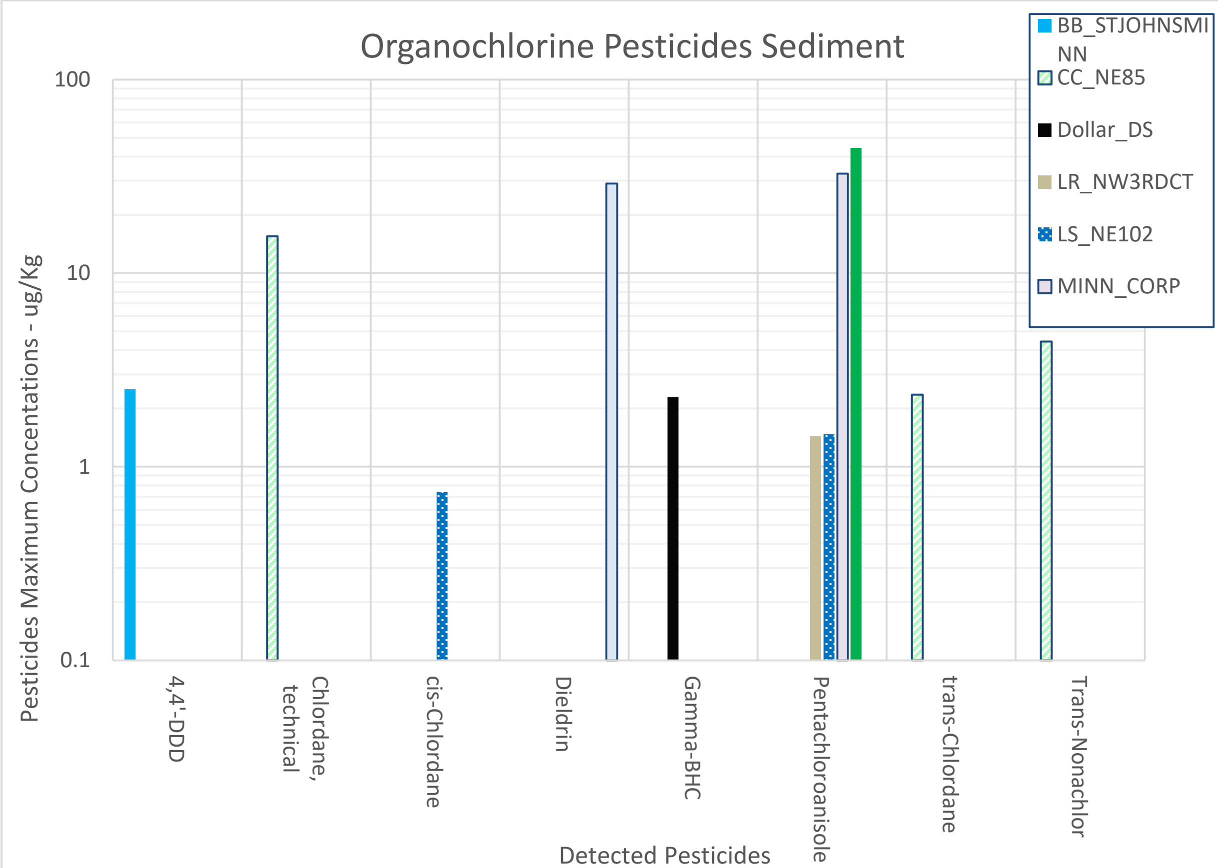

Figure 17. Maximum concentrations of detected organochlorine pesticides in sediment for core sites (ug/kg), 6/21/2017.

Sediment analyzed for pesticides were below Washington State sediment clean-up objectives. Figure 16 displays maximum values for detected pesticides, all of which are related to the historic use of organochlorine pesticide. Figure 17 displays results from detected pesticide concentrations.

Perfluoroalkyl Acids (PFAAs)

Stormwater

Mean values from the recent study, “Survey of Per- and Poly-Fluoroalkyl Substances (PFAAS) in Rivers and Lakes” (Mathieu and McCall 2016), were reviewed and used as a threshold for comparison with MS4 screening values. The Mathieu and McCall study included sampling of ambient waters and wastewater treatment plant effluent impacted waters. Standards for PFAAs have not been developed in Washington State.

As seen in Figure 18 and Table 21, all 12 PFAAs screened for were detected at nearly every site in the screening study.

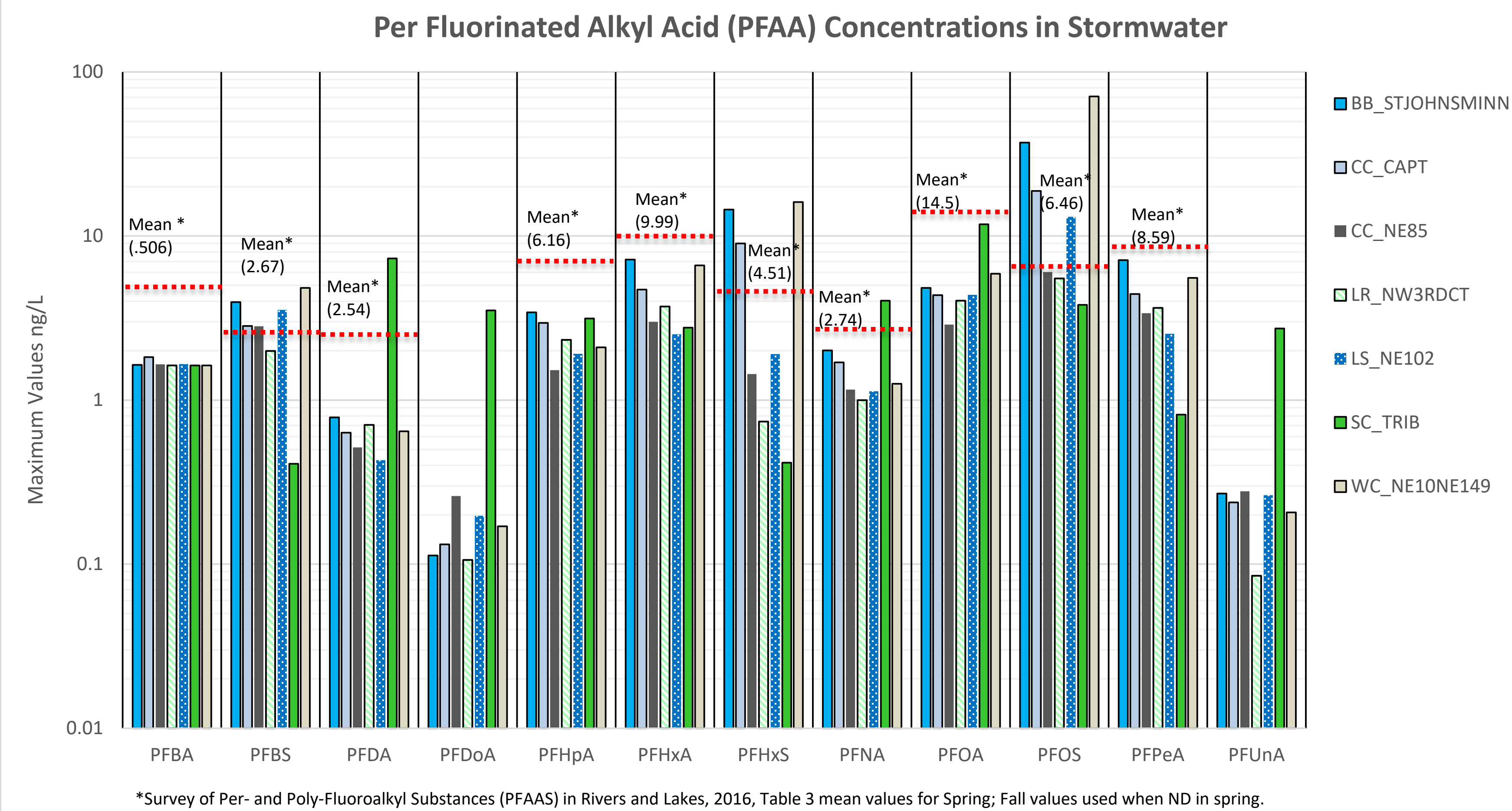

Figure 18. Maximum concentrations of detected PFAAS in stormwater for core sites (ng/g), 3/27 and 4/24/2017.

As seen in Table 21, a comparison of concentrations shows that 6 of 7 sites in the screening area exceeded the mean concentration thresholds for PFBS, PFDA, PFHxS, PFNA, and PFOS. In addition, the study found detectable concentrations of perfluorinated compounds in all samples.

Table 21. Comparison and scoring of PFAAs in stormwater (ng/g), 3/27 and 4/24/2017.

Orange highlighted cells indicate a result above the threshold

Parameter	PFBA	PFBS	PFDA	PFDoA	PFHpA	PFHxA	PFHxS	PFNA	PFOA	PFOS	PFPeA	PFUnA	Total PFAAs	Score*
Mean Reference **	5.06	2.67	2.54	ND	6.16	9.99	4.51	2.74	14.5	6.46	8.59	ND	-	
BB_STJOHNSMIN	1.64	3.96	0.785	0.113	3.42	7.18	14.5	2.01	4.82	37.1	7.12	0.27	81.278	3
CC_CAPT	1.83	2.83	0.634	0.132	2.95	4.72	9.02	1.7	4.37	18.8	4.43	0.238	49.824	3
CC_NE85	1.65	2.82	0.516	0.26	1.52	3	1.44	1.16	2.89	6.03	3.39	0.278	23.304	1
LR_NW3RDCT	1.63	1.99	0.707	0.106	2.33	3.72	0.739	1	4.04	5.52	3.64	0.085	23.877	0
LS_NE102	1.66	3.55	0.43	0.197	1.92	2.52	1.91	1.13	4.38	13.1	2.54	0.263	31.94	1
SCTRIB	1.63	0.409	7.29	3.52	3.15	2.76	0.415	4.03	11.8	3.8	0.816	2.73	40.72	2
WC_NE10NE149	1.63	4.83	0.645	0.17	2.1	6.63	16.1	1.26	5.89	71	5.56	0.207	114.392	3

ND = non-detect

* Exceedance of compared values = 1 point per exceedance.

** (Ecology 2017), Survey of Per- and Poly-Fluoroalkyl Substances (PFAS) in Rivers and Lakes, 2016, Table 3 **mean** values for Spring; Fall values used when ND in spring.

Sediment

Maximum values extracted from a 2009 stormwater pond sediment monitoring study were used as a threshold for comparison with MS4 screening values. The 2009 study was conducted by Dr. Judy Crane, Minnesota Pollution Control Agency (Crane, 2017). It should be noted that the Minnesota study has not been published, and raw validated data were used to establish thresholds for comparison. In addition, the data used for comparison was from a stormwater detention pond (stormwater conveyance system); due to a lack of data, the Minnesota study is being used as a threshold estimate.

Sediment objectives for PFAAs have not been developed in Washington State. A comparison of concentrations shows that 6 of 7 sites in the screening area exceeded the mean concentration thresholds for PFDA, PFDoA, PFHxS, PFOS, PFPeA, and PFUnA.

As seen in Figure 19 and summarized in Table 22, 10 of 12 PFAAs parameters screened for were detected using low level analysis at more than half the sites in the screening study.

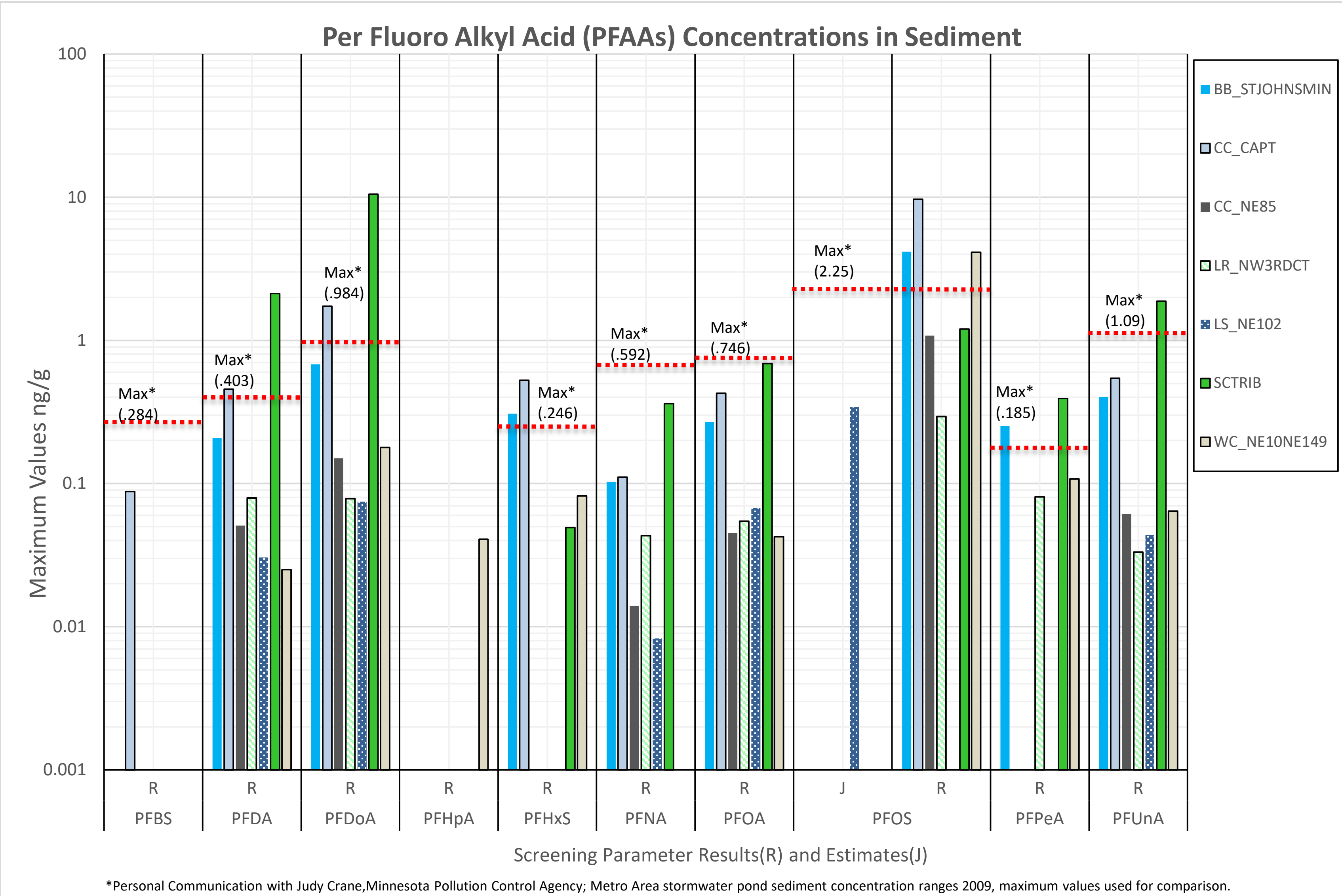

Figure 19. Maximum concentrations of detected PFAAs in sediment for core sites (ng/g), 5/9/2017.

Table 22. Comparison and scoring of PFAAs in sediment (ng/g), 5/9/2017.

Orange highlighted cells indicate a result above the threshold

PFAAs	PFBA	PFBS	PFDA	PFDoA	PFHpA	PFHxA	PFHxS	PFNA	PFOA	PFOS		PFPeA	PFUnA	Total PFAAs	Score*
Qualifier	U	Res	Res	Res	Res	Res	Res	Res	Res	Res	J	Res	Res	-	
Maximum Conc.**	0.432	0.284	0.403	0.948	ND	ND	0.246	0.592	0.746	2.25		0.185	1.09	7.176	
BB_STJOHNSMIN	ND	ND	0.209	0.682	ND	0.454	0.307	0.103	0.27	4.16	-	0.252	0.403	6.84	3
CC_CAPT	ND	0.0878	0.457	1.73	ND	0.53	0.527	0.111	0.428	9.68	-	ND	0.543	14.0938	4
CC_NE85	ND	ND	0.0508	0.15	ND	ND	ND	0.014	0.045	1.08	-	ND	0.0615	1.4013	0
LR_NW3RDCT	ND	ND	0.0793	0.0784	ND	0.0765	ND	0.0432	0.0545	0.294	-	0.0807	0.0332	0.7398	0
LS_NE102	ND	ND	0.0305	0.0748	ND	0.0425	ND	0.0083	0.0677	ND	0.343	ND	0.0437	0.6105	0
SCTRIB	ND	ND	2.12	10.5	ND	0.198	0.0492	0.362	0.69	1.2	-	0.392	1.88	17.3912	4
WC_NE10NE149	ND	ND	0.025	0.179	0.0409	0.0923	0.0819	ND	0.0426	4.13	-	0.108	0.0641	4.7638	1

ND = non-detect

* Exceedance of compared values = 1 point per exceedance.

** Personal communication with Judy Crane, Minnesota Pollution Control Agency; Metro Area stormwater pond sediment concentration ranges 2009 (maximum concentration used for comparison).

Res = Result

J = Estimated Value

Discussion

Funding, resources, and conflicting priorities often play a role in determining how and if toxic chemicals (toxics) are addressed. By prioritizing areas impacted by multiple toxics, greater reductions in toxics can occur with the funding and resources available.

To better identify high priority clean-up areas, a scoring system was developed. The scoring is based on a point system developed by comparing study data to numeric targets such as the Washington State Water Quality and Sediment Standards as well as the 75th percentile threshold values from a regional stormwater characterization data set.

Each exceedance of a standard, or threshold, assigns 1 point to the associated site. Scores help determine which sites and associated drainage areas should be prioritized for further investigation and outreach. Table 23 displays scores based on monitoring sites and results in order of priority.

Table 23. Cumulative Priority Score for all monitoring sites based on exceedance of threshold comparison concentrations.

Site	Nutrients		Metals (total and dissolved)		PAH and Phthalates		Flame Retardants		PCBs		Pesticides	PFAAs		Totals
	SW	SED	SW	SED	SW	SED	SW	SED	SW	SED	SED	SW	SED	
SC_TRIB	0	0	4	2	3	4	2	3	0	0	0	2	4	24
LS_NE102	0	0	4	0	10	3	0	0	0	0	0	1	0	18
CC_CAPT	0	0	0	0	1	3	1	1	0	0	0	3	4	13
BB_STJOHNSMINN	0	0	0	0	1	3	0	2	0	0	0	3	3	12
CC_NE85	0	0	1	0	2	2	0	0	0	0	0	1	0	6
WC_NE10NE149	0	0	1	1	0	0	0	0	0	0	0	3	1	6
MINN_CORP	0	0	0	0	0	2	0	2	0	0	0	0	0	4
LR_NW3RDCT	0	0	1	1	0	0	1	0	0	0	0	0	0	3
QMB	0	0	0	0	0	1	0	1	0	0	0	0	0	2
Dollar_DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dollar_US	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LS_NE102_US116	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC_SWIM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC_TRIB_DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seven Monitoring Sites Prioritized for Further Investigation and Outreach

1. Salmon Creek Tributary

Score = 24

This SC_TRIB outfall drains the back lot of Pacific Boatland, a boat dealer located at 11704 NE Hwy 99 Vancouver, WA 98686. The drain receives surficial drainage from a portion of the street along NE Klineline Road and is used as a drain in the back lot. Pollutant sources from this site could be defined as point sources. The site has the most localized and confined drainage area in the study.

The boat dealer has worked to protect the drain (through recommendation of Clark County's LSC outreach program) by installing an oil absorption boom around the drain's perimeter.

Figure 20. **Google Earth street-view photo of back lot drain inlet.**

Samples taken at the outfall had the highest concentrations of toxics in sediment and stormwater for the study area. The site showed elevated levels of metals, PAHs and phthalates, flame retardants, lube oil and grease, and PFAAs. Also, PCBs were detected at the site.

Figure 21. Dry weather reconnaissance of drain inlet, 9-7-2017.

Figure 22. Stormwater event effluent from outlet to hillside and Salmon Creek.

2. Lower Salmon Creek @ Hwy 99 and NE 102nd

Score = 18

This LS_NE102 site is located in a gully, tributary to Salmon Creek, and receives upstream runoff from a variety of land uses. The drainage area is predominantly residential, commercial, transportation (roads), and open space land use. In addition, a large homeless encampment was observed at the top of the gully slope behind the detention pond, located on the north side of NE 102nd Street (across the street from the nursery).

The site showed elevated levels of metals, PAHs and phthalates, and PFAAs. PAH levels were the highest in the study area.

Figure 23. Looking upstream at culvert tributary, 4-24-2017.

3. Crystal Creek Apartments, Minnehaha Drive

Score = 13

The CC_CAPT site is a stormwater detention basin, located on the grounds of the Crystal Court Apartment complex, 2600 NE Minnehaha St Vancouver WA 98665. The basin receives runoff from upstream commercial, industrial, open space, residential, and transportation (roads) land use.

Toxics screening at the site found elevated levels of PAHs and phthalates, flame retardants, and PFAAs in stormwater and sediment samples.

CC_CAPT had the highest score for PFAAs; the second highest was located upstream at the BB_STJOHNSMINN site.

Figure 24. Looking downstream from above at the CC_CAPT site at detention basin culvert inlet.

4. Burnt Bridge Creek MS4 Tributary @ St Johns and Minnehaha Street

Score = 12

The BB_STJOHNSMINN site, located on the corner of St Johns and Minnehaha Street, is a small ditch which drains the commercial area adjacent to NE Minnehaha Street upstream (east) of Hwy 99. The drainage area is dominated by residential, open space, commercial, and transportation land use.

Figure 25. Looking downstream at St. Johns and Minnehaha Culvert site.

This site is located upstream of the CC_CAPT site, and similar types of toxics were detected. Toxics found include PAHs and phthalates, flame retardants, and PFAAs in stormwater and sediment samples.

5. Whipple Creek @ NE 10th and NE 149th Street

Score = 6

The Whipple Creek site (WC_NE10NE149) is located on NE 10th Ave, north of NE 149th Ave, upstream of the 10th Ave road culvert crossing. Elevated toxics detected at the site include metals and PFAAs.

Figure 26. Looking downstream at WC_NE10NE149 site and culvert running under NE 10th Street

6. Cougar Canyon Creek

Score = 6

The CC_NE85th site is at the upstream inlet of the culvert at Hazel Dell Avenue, south of NE 85th Street. The site receives runoff primarily from the upstream apartment complex and commercial area.

Elevated toxics at the site include metals, PAHs and phthalates, and PFAAs.

Figure 27. Looking downstream at site and culvert crossing under Hazel Dell Avenue.

7. Minnehaha Corporate Park

Score = 4

The MINN_CORP site is located on 4200 NE Minnehaha Street. The site was monitored only for sediment during 1 event to gather more data upstream of the CC_CAPT and BBSTJOHNS_MINN sites. The sediment sample was taken at the inlet to the corporate park's grass swale and detention basin. The basin treats runoff onsite through biofiltration, before entering the Minnehaha Street v-ditch and ultimately the Columbia River.

Elevated levels of PAHs, phthalates, and flame retardants were found in the detention basin's influent sediment.

Figure 28. Detention basin inlet.

Considerations

Concentrations of parameters detected in the study area were within the range of results found in similar monitoring studies (e.g., *Western Washington NPDES Phase I Stormwater Permit: Final Data Characterization 2009-2013)*. Only the upper percentiles of data sets reviewed (>75th percentile), or water quality and sediment standards adopted by the State of Washington, were considered for comparison. This study is limited by the few data points collected; however, the few data collected were compared to an extensively monitored data set from similar settings (land use).

The primary purpose of this study was to screen for parameters in order to better understand the most effective range and approach for identifying priority sites in need of outreach. The goal is that partners will use the study's findings to determine where to spend resources to curb small commercial business discharges.

Evaluation of Target Parameters

For future phases of the project, monitoring will exclusively target sediment as a sampling matrix. During this first phase of the project, it was found that stormwater was (1) difficult to target due to the logistics of timing events and (2) not representative of the entire storm. Sediment, which will be targeted in the dry season, will be looked at for future monitoring efforts.

Future phases of the project will use similar analytical methods for sediment; however, high resolution PCB and PFAAs work will not be contracted out. Instead, MEL will provide the analyses. Rather than using the 209 congener list, PCB Aroclors will be monitored for because the levels of Aroclors detected were within the method's range of detection.

All other parameters, in addition to partner-proposed parameters, will be monitored for in future phases of the project, with the exception of gasoline range hydrocarbons. Under the NW-GX test, gasoline was not detected in stormwater, and should not be expected to be detected in sediment, due to gasoline's volatile nature.

Recommendations

Based on these 2017 monitoring results, the following recommendations are made. These are listed in order of priority for action, with the highest priority sites listed first.

- **SC_TRIB** - Clark County should consider diverting the drain to the sanitary sewer system for wastewater treatment. The feasibility of diverting the drain is dependent on the types of wastewater being generated. Also, best management practices (BMPs), such as conducting pollution-generating activities in a contained area, would help decrease toxic chemicals (toxics) from entering the drain.

- **LS_NE102** - Additional monitoring should be conducted upstream of the commercial area (Yard 'n Garden Land and Harley Davidson Dealership) to better characterize and trace the sources of toxics, in particular PAHs.

- **CC_CAPT** - Local Source Control (LSC) outreach and source monitoring should be implemented to identify potential sources of PFAAs, flame retardants, and phthalates at commercial areas upstream/above Highway 99 in the drainage basin. Based on current parameters, the LSC program chiefly looks at small commercial business discharges. A discussion with partners should be planned to consider other types of small business discharges (e.g. industrial).

- **BB_STJOHNSMINN** - Recommendations for the CC_CAPT site are also being made for this site in order to plan and conduct outreach in commercial areas upstream of the site.

- **CC_NE85** - Additional research should be conducted at commercial areas upstream of the site in the drainage area. A list of businesses with an inventory of potential chemical use should be compiled. After research, targeted monitoring should be conducted to determine if sources of toxics can be found.

- W**C_NE10NE149** - Additional research should be conducted at commercial/industrial facilities in the drainage area upstream of this site. A list of businesses with an inventory of potential chemical use should be compiled. After research, targeted monitoring should be conducted to determine if sources of PFAAs can be found.

- **MINN_CORP** - An assessment of the types of activities in the corporate park should be considered to determine toxics being used. Additional monitoring at the inlet and the outlet of the detention basin is recommended to better characterize toxics levels.

References

Crane, J., 2017. Personal communication with Judy Crane, Minnesota Pollution Control Agency; Metro Area stormwater pond sediment concentration ranges 2009, maximum values used for comparison.

Ecology, 2013. Sediment Management Standards, WAC 173-204-563 Sediment clean-up levels based on protection of the benthic community in freshwater sediment. Washington State Department of Ecology, Lacey, WA. Found on-line at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-204

Ecology, 2017. Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC. Washington State Department of Ecology, Lacey, WA. Publication No. 06-10-091. https://fortress.wa.gov/ecy/publications/SummaryPages/0610091.html

Ecology, 2017. Environmental Information Management Database. Washington State Department of Ecology. Accessed October and November 2017. Found online at: EIM Database.

Hobbs, W., B. Lubliner, N. Kale, and E. Newell, 2015. Western Washington NPDES Phase I Stormwater Permit: Final Data Characterization 2009-2013, Washington State Department of Ecology, Olympia, WA. Publication No. 15-03-001. https://fortress.wa.gov/ecy/publications/SummaryPages/1503001.html

Mathieu, C. and M. McCall, 2016. Survey of Per- and Poly-Fluoroalkyl Substances (PFAS) in Rivers and Lakes, 2016, Table 3 mean values for Spring; Fall values used when ND in spring. Environmental Assessment Program, Toxics Studies Unit, Washington State Department of Ecology. Publication No. 17-03-021. https://fortress.wa.gov/ecy/publications/documents/1703021.pdf

Medlen, J., 2017. Quality Assurance Project Plan, Columbia River Basin (Clark County WA) Local Source Control Monitoring for Toxics: Phase I – Screening Study. Environmental Assessment Program, Toxics Studies Unit, Washington State Department of Ecology. Publication No. 17-03-102. https://fortress.wa.gov/ecy/publications/SummaryPages/1703102.html

Appendices

Appendix A. Quality Assurance

Table A-1. MQO Evaluation

Parameter Group	Parameter	Matrix / Sampling Dates	Laboratory Control Standards %Recovery	Pass?	Duplicate Samples RPD	Pass?	Matrix Spikes % Recovery	Pass?	Matrix Spike-Duplicates RPD%	Pass?	Surrogate %Recovery	Pass?
Stormwater Analysis												
Conventionals	Total Suspended Solids	3/27 and 4/24	80-120	Yes	± 20	NA	NA	NA	NA	NA	NA	NA
	Conductivity		80-120		± 20		NA		NA	NA	NA	NA
	Oil and Grease		78-114		NA	NA	78-114	Yes	NA	NA	NA	NA
Nutrients	TP, -PO4, NH3-N, NO2-, NO3-, TPN	3/27 and 4/24	80-120	Yes	± 20	Yes	75-125	Yes	NA	NA	NA	NA
Metals - Total (t) and Dissolved (d)	Zn, Pb, Cu[2], Cd, Hg, Ag, Ti, Sb, Ar, Co	3/27 and 4/24	85-115	Yes	± 20	Yes	75-125	Mostly	75-125	Yes	NA	NA
Polycyclic Aromatic Hydrocarbons	EPA 16 priority PAHs	3/27 and 4/24	10-150	Yes	40	Yes	18-150	Yes	40	Yes	surrogates[1]	Yes
Phthalates	Bis(2-Ethylhexyl) Phthalate	3/27 and 4/24	23-183	Yes	40	Yes	34 - 149	Yes	40	Yes	surrogates[1]	Yes
	Butyl benzyl phthalate											
	Diethyl phthalate											
	Dimethyl phthalate											
	Di-N-Butylphthalate											
	Di-N-Octyl Phthalate											
Petroleum Hydrocarbons	NWTPH-Dx	3/27 and 4/24	70 - 130	Yes	40	Yes	NA	NA	NA	NA	50-150	Yes
	NWTPH-GX										70-130	
Polychlorinated Biphenyls (PCBs)	209 congeners	3/27 and 4/24	50-150	Yes	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF

Parameter Group	Parameter	Matrix / Sampling Dates	Laboratory Control Standards %Recovery	Pass?	Duplicate Samples RPD	Pass?	Matrix Spikes % Recovery	Pass?	Matrix Spike-Duplicates RPD%	Pass?	Surrogate %Recovery	Pass?
Flame Retardants	TBB, V6, IPTPP, TCPP, TBPH, TPhP, Dechlorane Plus, TCPP, BTBPA, DBDPE	3/27 and 4/24	50-150	Yes	≤50	Yes	50-150	Yes	50-150	Yes	50-150	Mostly[5]
Perfluoroalkyl Substances (PFAS)	PFBA, PFPeA, PFBS, PFOS, PFHxA, PFHpA, PFNA, PFOA, PFDA, PFUnA, PFOSA, PFDoA	3/27 and 4/24	70-130	Yes	<40	Mostly[4]	NAF	NAF	NAF	NAF	50-150	Yes

NA = Not applicable, NAF = Not analyzed for, LCS = Laboratory Control Sample, MS and MSD = Matrix Spike and Matrix Spike Duplicate, TP = Total Phosphorous, -PO4 = Orthophosphate, NH3-N = Ammonia as Nitrogen, NO2- = Nitrite, NO3 - = Nitrate, TPN = Total Persulfate Nitrogen, Zn = Zinc, Pb = Lead, Cu = Copper, Cd = Cadmium, Hg = Mercury, Ag = Silver, Ti = Titanium, Sb = Antimony, Ar = Arsenic, Co = Cobalt, PAH = Polycyclic Aromatic Hydrocarbon, NWTPH-DX = Total Petroleum Hydrocarbon Diesel, NWTPH-GX = Total Petroleum Hydrocarbon Gasoline, PAH = Polycyclic Aromatic Hydrocarbons

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

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

[1] Surrogates and percent recovery limits include: 2-Fluorobiphenyl (30-115%), Dimethylphthalate-D6 (50-150%), Acenapthylene-D8 (50-150%), Fluorene-D10 (50-150%), Anthracene-D10 (50-150%), Pyrene-D10 (50-150%), Terphenyl-D14 (18-137%), Benzo(a)pyrene-D12, (50-150%)

[2] Dissolved Copper for sample site BB_STJOHNSMINN on 4/24 was higher than associated total copper

[3] Matrix spike for fluoranthene exceeded the upper control limits.

[4] A RPD >40% was observed for PFOSA for the duplicate 1705054-04 (LS_NE102). The concentrations of PFOSA had duplicate runs were <5x the detection limits. Data were not qualified on this basis.

[5] ISTD recovery exceeded QC limits for Tricresyl Phosphate, Triphenyl Phosphate, tris(2-chloroisopropyl)phosphate and V6, flagged as J (estimate)

Parameter Group	Parameter	Matrix / Sampling Dates	Laboratory Control Standards %Recovery	Pass?	Duplicate Samples RPD%	Pass?	Matrix Spikes % Recovery	Pass?	Matrix Spike-Duplicates RPD%	Pass?	Surrogate %Recovery	Pass?
Sediment Analysis												
Conventionals	Percent solids	5/9, 6/7, 6/[2]1	NA	NA	± 20	Yes	NA	NA	NA	NA	NA	NA
	Total organic carbon		75-120	Yes	± 20	Yes						
	Grain size		NA	NA	NA	NA						
	Total volatile solids		NA	NA	± 20	No[2]						
Metals - Total (t)	Zn, Pb, Cu, Cd, Hg, Ag, Ti, Sb, Ar, Co	5/9, 6/7, 6/21	85-115	Yes	± 20	Yes	75-125	Mostly [3,4,5]	± 20	Mostly [3,4,5]	NA	NA
Polycyclic Aromatic Hydrocarbons	EPA 16 priority PAHs	5/9, 6/7, 6/21	50-150	Yes	40	Yes	50-150	Some[6]	40	Some[6]	surrogates[1]	Some[6]
Phthalates	Bis(2-Ethylhexyl) Phthalate	5/9, 6/7, 6/21	50-150	Yes	40	Yes	50-150	Some[6]	40	Some[6]	surrogates[1]	Some[6]
	Butyl benzyl phthalate											
	Diethyl phthalate											
	Dimethyl phthalate											
	Di-N-Butylphthalate											
	Di-N-Octyl Phthalate											
Petroleum Hydrocarbons	NWTPH-Dx	5/9, 6/7, 6/21	70 - 130	Yes	40	Yes	NA	NA	NA	NA	50-150	Yes
Polychlorinated Biphenyls (PCBs)	209 congeners	5/9, 6/7, 6/21	50-150	Yes	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF

Parameter Group	Parameter	Matrix / Sampling Dates	Laboratory Control Standards %Recovery	Pass?	Duplicate Samples RPD%	Pass?	Matrix Spikes % Recovery	Pass?	Matrix Spike-Duplicates RPD%	Pass?	Surrogate %Recovery	Pass?
Flame Retardants	TBB, V6, IPPP, TCPP, TBPH, TPhP, Dechlorane Plus, TCPP, BTBPA, DBDPE	5/9, 6/7, 6/21	50-150	Mostly [7]	≤50	Mostly [10]	50-150	Mostly [8]	30-130	Mostly [9]	50-150	Yes
Perfluoroalkyl Substances (PFAS)	PFBA, PFPeA, PFBS, PFOS, PFHxA, PFHpA, PFNA, PFOA, PFDA, PFUnA, PFOSA, PFDoA	5/9, 6/7, 6/21	70-130	Yes	<40	Yes	NAF	NAF	NAF	NAF	40-150	Yes

NA = Not applicable, NAF = Not analyzed for, LCS = Laboratory Control Sample, MS and MSD = Matrix Spike and Matrix Spike Duplicate, TP = Total Phosphorous, -PO4 = Orthophosphate, NH3-N = Ammonia as Nitrogen, NO2- = Nitrite, NO3 - = Nitrate, TPN = Total Persulfate Nitrogen, Zn = Zinc, Pb = Lead, Cu = Copper, Cd = Cadmium, Hg = Mercury, Ag = Silver, Ti = Titanium, Sb = Antimony, Ar = Arsenic, Co = Cobalt, PAH = Polycyclic Aromatic Hydrocarbon, NWTPH-DX = Total Petroleum Hydrocarbon Diesel, PAH = Polycyclic Aromatic Hydrocarbons

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

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

[1] Surrogates and percent recovery limits include: 2-Fluorobiphenyl (30-115%), Dimethylphthalate-D6 (50-150%), Acenapthylene-D8 (50-150%), Fluorene-D10 (50-150%), Anthracene-D10 (50-150%), Pyrene-D10 (50-150%), Terphenyl-D14 (18-137%), Benzo(a)pyrene-D12, (50-150%).

[2] TVS RPD was high and failed QC limits.

[3] Samples collected 5-9-2017: All matrix spike recoveries were within the acceptance limits except for lead, mercury, titanium, and zinc. One MS recovery for lead exceeded recovery limits and two for Mercury were less than acceptance limits. All MS recoveries for titanium and zinc were not calculated; the standard spiking level was insufficient for the native concentration in the source samples and no action was taken.

[4] For the 6-21-2017 collection analysis, all matrix spike recoveries were within acceptance limits except for titanium and zinc; both MS/MSD recoveries for sample 03 Titanium, were outside of the acceptance limits and one of the MS/MSD recoveries for sample 03 was outside of the acceptance limits. The standard spiking level was insufficient for the elevated concentration in the source sample therefore recoveries were not evaluated

[5] For the 6-7-2017 sample event, all MS recoveries met acceptance limits except for lead, titanium, and zinc; MS/MSD for Lead sample 01 was outside of acceptance limits and qualified as estimate; MS recoveries for titanium and zinc not calculated because standard spiking level was insufficient for native concentrations.

[6] Dilutions were required due to black and oily extracts, some dilutions exceeded surrogate spikes and could not be calculated. Dilutions for MS/MSD also exceeded the amount spiked so percent recoveries and RPDs could not be calculated or reported

[7] LCS recovery limits exceeded QC limits 7 times for Bis(2-ethylhexyl) tetrabromophthalate

[8] MS recovery exceeded recovery limits for 2-ethylhexyl-2,3,4,5-tetrabromobenzoate 5-9-2017

[9] 5-9-2017 exceeded MSD RPD limits for Dechlorane Plus

[10] 5-9-2017 LCS Dup RPD limits exceeded for 2-ethylhexyll-2,3,4,5-tetrabromophthalate and Bis (2-ethylhexyl) tetrabromophthalate

Table A-2. Field QA

Site	Collection Date	Parameter	Fraction	QA Type	RPD	Pass?
CC-CAPT-B	3/27/2017	1,2-bis(2,4,6-Tribromophenoxy)ethane	Total	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB)	Total	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Antimony	Dissolved	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Arsenic	Dissolved	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	Bis(2-ethylhexyl)tetrabromophthalate (TBPH)	Total	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Cadmium	Dissolved	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Cobalt	Dissolved	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Copper	Dissolved	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	Dechlorane Plus	Total	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Lead	Dissolved	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Silver	Dissolved	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Titanium	Dissolved	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	Tricresyl phosphate	Total	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	Triphenyl Phosphate	Total	Field Blank	ND	NO
CC-CAPT-B	3/27/2017	Tris(2-chloroisopropyl)phosphate	Total	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	Tris(2-isopropylphenyl) Phosphate	Total	Field Blank	ND	YES
CC-CAPT-B	3/27/2017	V6	Total	Field Blank	ND	YES
CC_CAPT-FB	4/24/2017	Zinc	Dissolved	Field Blank	ND	NO
CC-CAPT-R	3/27/2017	1,2-bis(2,4,6-Tribromophenoxy)ethane	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB)	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Ammonia	Total	Field Replicate	100%	YES
CC-CAPT-R	3/27/2017	Antimony	Dissolved	Field Replicate		YES
CC_CAPT-R	4/24/2017	Antimony	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Antimony	Total	Field Replicate	5%	YES

Site	Collection Date	Parameter	Fraction	QA Type	RPD	Pass?
CC_CAPT-R	4/24/2017	Antimony	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Arsenic	Dissolved	Field Replicate	8%	YES
CC_CAPT-R	4/24/2017	Arsenic	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Arsenic	Total	Field Replicate	6%	YES
CC_CAPT-R	4/24/2017	Arsenic	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Bis(2-ethylhexyl)tetrabromophthalate (TBPH)	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Cadmium	Dissolved	Field Replicate	ND	YES
CC_CAPT-R	4/24/2017	Cadmium	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Cadmium	Total	Field Replicate	ND	YES
CC_CAPT-R	4/24/2017	Cadmium	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Cobalt	Dissolved	Field Replicate	3%	YES
CC_CAPT-R	4/24/2017	Cobalt	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Cobalt	Total	Field Replicate	3%	YES
CC_CAPT-R	4/24/2017	Cobalt	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Copper	Dissolved	Field Replicate	10%	YES
CC_CAPT-R	4/24/2017	Copper	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Copper	Total	Field Replicate	3%	YES
CC_CAPT-R	4/24/2017	Copper	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Dechlorane Plus	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Lead	Dissolved	Field Replicate	150%	NO
CC_CAPT-R	4/24/2017	Lead	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Lead	Total	Field Replicate	0%	YES
CC_CAPT-R	4/24/2017	Lead	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Nitrate-Nitrite as N	Total	Field Replicate	5%	YES
CC-CAPT-R	3/27/2017	Ortho-Phosphate	Dissolved	Field Replicate	3%	YES

Site	Collection Date	Parameter	Fraction	QA Type	RPD	Pass?
CC-CAPT-R	3/27/2017	Silver	Dissolved	Field Replicate	ND	YES
CC_CAPT-R	4/24/2017	Silver	Dissolved	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Silver	Total	Field Replicate	ND	YES
CC_CAPT-R	4/24/2017	Silver	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Titanium	Dissolved	Field Replicate	315%	NO
CC_CAPT-R	4/24/2017	Titanium	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Titanium	Total	Field Replicate	1%	YES
CC_CAPT-R	4/24/2017	Titanium	Total	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Total Persulfate Nitrogen	Total	Field Replicate	2%	YES
CC-CAPT-R	3/27/2017	Total Phosphorus	Total	Field Replicate	2%	YES
CC-CAPT-R	3/27/2017	Tricresyl phosphate	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Triphenyl Phosphate	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Tris(2-chloroisopropyl)phosphate	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Tris(2-isopropylphenyl) Phosphate	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	V6	Total	Field Replicate	ND	YES
CC-CAPT-R	3/27/2017	Zinc	Dissolved	Field Replicate	1%	YES
CC_CAPT-R	4/24/2017	Zinc	Dissolved	Field Replicate	0%	YES
CC-CAPT-R	3/27/2017	Zinc	Total	Field Replicate	0%	YES
CC_CAPT-R	4/24/2017	Zinc	Total	Field Replicate	0%	YES

Appendix B. Laboratory Methods

Table B-1. Laboratory Methods Stormwater

Analyte Group	Analyte	Sample Matrix	Expected Concentration	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Stormwater							
Conventionals	Total Suspended Solids	Stormwater	N/A	1.0 mg/L	Gravimetric, Dried 103-105C	N/A	SM2540D
	Hardness as CaCO3	Stormwater	N/A	.33 (mg CaCO3)	EPA 200.7	N/A	EPA 200.7
	Oil and Grease	Stormwater	N/A	5.0 mg/L	N/A	N/A	EPA Method 1664
Metals total (t) and dissolved (d)	Zinc (Zn)	Stormwater	<5.0-421 µg/L	5 ug/L (t) and 1 ug/L (d)	EPA 200.8	N/A	EPA Method 200.8 (ICP/MS)
	Lead (Pb)	Stormwater	<.1-101µg/L	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Copper (Cu)	Stormwater	<5.0-70 µg/L	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Cadmium (Cd)	Stormwater	< .2 -1.0 µg/L	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Silver (Ag)	Stormwater	N/A	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Titanium (Ti)	Stormwater	N/A	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Antimony (Sb)	Stormwater	N/A	.2 ug/L (t) and (d)	EPA 200.8	N/A	
	Arsenic (As)	Stormwater	N/A	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Cobalt (Co)	Stormwater	N/A	5 ug/L (t) and (d)	EPA 200.8	N/A	
	Mercury (Hg)	Stormwater	N/A	.05 ug/L (t) and (d)	EPA Method 245.1	N/A	EPA Method 245.1
Nutrients	Total P	Stormwater	0.01 – 10 mg/L	.005 mg/L	N/A	N/A	SM 4500
	Ortho P	Stormwater	0.01 – 5.0 mg/L	.003 mg/L	N/A	N/A	SM 4500
	NH3	Stormwater	<0.01 – 30 mg/L	.1 mg/L	N/A	N/A	SM 4500
	NO3/NO2	Stormwater	<0.01 – 30 mg/L	.1 mg/L	N/A	N/A	SM 4500
	TPN	Stormwater	mg/L	0.01	SM 4500PI	SM 4500PI	SM 4500PI

Analyte Group	Analyte	Sample Matrix	Expected Concentration	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Persistent Organic Compounds	Polychlorinated Biphenyls (209)	Stormwater	N/A	Varies by congener pg/L	DCM	Chromatographic	EPA Method 1668C
	Flame Retardants	Stormwater	N/A	Varies by species	N/A	EPA 3620, 3665	EPA Method 1614
	PFAS	Stormwater	<1.0-1,000 ng/L	Varies by species ng/L	SPE Cartridge	SPE Cartridge	AXYS MLA-110 LC-MS/MS; isotopic dilution
Petroleum Hydrocarbons	Diesel	Stormwater	280 - 4800 µg/L	.05 ug/L	NWTPH-Dx	NWTPH-Dx	NWTPH-Dx
	Gasoline	Stormwater	N/A	.05 ug/L	NWTPH-Gx	NWTPH-Gx	NWTPH-Gx
Semivolatile Organic Compounds	PAHs	Stormwater	<.1-.8µg/L	.05 ug/L	N/A	EPA 3630C	EPA Method 8270 D
	Phthalates	Stormwater	<.1ug/L-6 ug/L	.2-.5 ug/L	N/A	EPA 3630C	EPA Method 8270 D

Table B-2. Laboratory Methods Sediment

Analyte Group	Analyte	Sample Matrix	Expected Concentrations	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Sediment							
Conventionals	Percent solids	Sediment	N/A	N/A	N/A	N/A	SM 2540G (PCT)
	Total Organic Carbon (TOC)	Sediment	N/A	0.1%	N/A	N/A	PSEP (1986)
	Grain size	Sediment	<20% - >80% silt and sand	N/A	N/A	N/A	Sieve and Pipette (ASTM 1997)
	pH	Sediment	NA	NA	NA	NA	EPA 9045
	Total Volatile Solids (TVS)	Sediment	NA	NA	NA	NA	SM 2540G
Metals	Zinc (Zn)	Sediment	< 5 .0 - 541 mg/kg	5.0 mg/kg	EPA 3050B	N/A	SW6020A
	Lead (Pb)	Sediment	< 0.1 - 74.0 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Copper (Cu)	Sediment	< 0.1 - 90.0 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Cadmium (Cd)	Sediment	< 0.1 - 1.20 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Silver (Ag)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Titanium (Ti)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Antimony (Sb)	Sediment	N/A	0.2 mg/kg	EPA 3050B	N/A	
	Arsenic (As)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Cobalt (Co)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Mercury (Hg)	Sediment	< 0.005 - .05 mg/kg	0.005 mg/kg	EPA 245.5	N/A	EPA 245.5
Persistent Organic Compounds	Polychlorinated Biphenyls (209)	Sediment	N/A	20 ng/kg	EPA 3541	EPA 3620, 3665	EPA 1668C
	Flame Retardants	Sediment	N/A	2 ng/kg	EPA 3541	EPA 3620, 3665	EPA 1614
	PFAS	Sediment	<.5-1,000 ng/g	0.5 -1.0 ng/g	NA	NA	LC-MS/MS; isotopic dilution
Petroleum Hydrocarbons	NWTPH-Dx	Sediment	N/A	25.0-100.0 mg/kg	NWTPH-Dx	NWTPH-Dx	NWTPH-Dx

Analyte Group	Analyte	Sample Matrix	Expected Concentrations	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Semivolatile Organic Compounds	Phthalates	Sediment	<12 - 1600 ug/kg	12.5-125 ug/kg	EPA 3541	EPA 3630C	EPA 8270 D
	PAHs	Sediment	NS	12.5-50 ug/kg	N/A	EPA 3630C	EPA 8270 D

Appendix C. Potential Impacts to Organisms by Monitored Parameter

Table C-1. Parameters Monitored for and Potential Impacts to Organisms

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
Conventionals	Total Suspended Solids	Stormwater	Indicator for metals. High concentrations can impair aquatic life: temperature, low DO, photosynthesis, degraded habitat, and fish health.	Natural processes and anthropogenic soil disturbances.
	Conductivity	Stormwater	Indicator of pollution.	Various; indication of dissolved solids (ions).
	pH	Stormwater+Sediment	pH >8 and pH <6 : increase toxic metals availability for aquatic life uptake, cause fish kills, invasive species promotion, and aquatic life reproduction impairment.	Combustion of fossil fuels.
	Hardness as CaCO3	Stormwater	Indicator used to calculate dissolved metals criteria.	Natural, underlying geology of water body.
	Percent solids	Sediment	Indicator	Percent non-organic material in sediment sample.
	Total organic carbon	Sediment	Indicator; high levels could indicate toxics compounds.	Amount of carbon in an organic compound.
	Grain size	Sediment	Indicator	Grain size for determination of toxics adsorption.
Hexane Extractable Material	Oil and Grease	Stormwater + Sediment	Indicator of spills or poor BMPs	Includes animal and vegetable based oils
Nutrients	Total Phosphorous	Stormwater	Too much can lead to eutrophication (algal growth) anoxic conditions for aquatic life.	Human and animal waste, fertilizers, laundry, cleaning, industrial and commercial effluents.

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
	Orthophosphate	Stormwater		Inorganic phosphate due to urban run-off.
	Ammonia (NH3)	Stormwater		Toxic as free ammonia (NH3) to aquatic life.
	Nitrite (NO2-)	Stormwater		NH3 is nitrified into NO2-
	Nitrate (NO3-)	Stormwater		NO2- is converted to NO3- by nitrobacters.
	Total Kjeldahl Nitrogen (TKN)	Stormwater	TKN + NO3 +NO2 = Total N	See above.
Metals - Total (t) and Dissolved (d)	Zinc	Stormwater (t,d) +Sediment	Juvenile and adult salmonid gill and olfactory sub-lethal effects and mortality in higher concentrations.	Galvanized roofs, manufacturing processes, automobiles.
	Lead	Stormwater (t,d) +Sediment		Manufacturing, combustion of coal and oil, and waste incineration.
	Copper	Stormwater (t,d) +Sediment		Automobiles, rooftops, anti-fouling paints.
	Cadmium	Stormwater (t,d) +Sediment		Phosphate fertilizers, zinc production, sewage sludge.
	Mercury	Stormwater (t,d) +Sediment		Combustion of coal, metal processing, atmospheric deposition.

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
	Silver [1]	Stormwater (t,d) +Sediment	As nano-particles; ability to travel and bioaccumulate throughout the ecosystem and threaten aquatic and terrestrial populations of microbes at the corner stone of many ecosystems. Ultimate effects still unknown…	Sunscreen, textiles, cleaning products, personal care products, food, paints.
	Titanium [1]	Stormwater (t,d) +Sediment		
	Antimony[3]	Stormwater (t,d) +Sediment	Experimental evidence demonstrates induction of lung tumors in rats following inhalation of antimony trioxide.	Antimony compounds are used in the manufacturing of pigments, paints, glass, pottery, and enamels. Antimony is common at low percentages in metal alloys and as a synergistic to flame retardants.
	Arsenic[3]	Stormwater (t,d) +Sediment	Arsenic exposure has been linked to lung cancer, bladder cancer, skin cancer, and cancers at several other sites in the body.	Historically inorganic arsenic compounds were used in wood preservatives, other pesticides, medicines, metal alloys, and paint pigments.
	Cobalt [3]	Stormwater (t,d) +Sediment	Inhalation of cobalt compounds can induce lung and other cancers in rats and mice.	Cobalt is used in alloys, pigments, and fertilizers; as a drying agent in paints, varnishes and inks; a component in porcelain enamel; and as a catalyst in synthesizing polyester and other materials.

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
Polycyclic Aromatic Hydrocarbons (PAHs)	Acenaphthene	Stormwater +Sediment	Persistent, toxic, carcinogenic, and mutagenic properties detrimental to aquatic and terrestrial life.	Wood burning, asphalt roads, automobile exhaust, cigarette smoke, coal, coal tar, wildfires, agricultural burning, residential wood burning, volcanoes, municipal and industrial waste incineration.
	Acenaphthylene	Stormwater +Sediment		
	Anthracene	Stormwater +Sediment		
	Benz[a]anthracene	Stormwater +Sediment		
	Benzo(a)pyrene	Stormwater +Sediment		
	Benzo(b)fluoranthene	Stormwater +Sediment		
	Benzo(ghi)perylene	Stormwater +Sediment		
	Benzo(k)fluoranthene	Stormwater +Sediment		
	Chrysene	Stormwater +Sediment		
	Dibenzo(a,h)anthracene	Stormwater +Sediment		
	Fluoranthene	Stormwater +Sediment		
	Fluorene	Stormwater +Sediment		
	Indeno(1,2,3-cd)pyrene	Stormwater +Sediment		
	Naphthalene	Stormwater +Sediment		
	Phenanthrene	Stormwater +Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
	Pyrene	Stormwater +Sediment		
Phthalates[3]	Bis(2-Ethylhexyl) Phthalate	Stormwater+Sediment	Endocrine disruptor, carcinogenic to humans and aquatic and terrestrial life.	Plasticizer in production of plastics, industrial uses. Found in many consumer products.
	Butyl benzyl phthalate	Stormwater+Sediment		
	Diethyl phthalate	Stormwater+Sediment		
	Dimethyl phthalate	Stormwater+Sediment		
	Di-N-Butylphthalate	Stormwater+Sediment		
	Di-N-Octyl Phthalate (DnOP)	Stormwater+Sediment		
Petroleum Hydrocarbons	NWTPH-Dx	Stormwater + Sediment	Harmful effects on the central nervous system.	Petroleum and natural gas production, fuel stations, leaky USTs (Dx and Gx), non-point source roadway runoff.
	NWTPH-Gx	Stormwater		
Polychlorinated Biphenyls (PCBs)	209 congeners	Stormwater +Sediment	PCBs have been demonstrated to cause cancer, as well as a variety of other adverse health effects on the immune system, reproductive system, nervous system, and endocrine system.	Transformers and capacitors, electrical equipment, oil, fluorescent light ballasts, cable insulation, thermal insulation material, adhesives and tapes, oil-based paint, and caulking.
Flame Retardants	Polybrominated diphenyl ethers (PBDEs)	Stormwater + Sediment		Flame retardants used in building materials,

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
	Isopropylated triphenyl phosphate (IPTPP)	Stormwater + Sediment	Detrimental to brain development in animals and can cause estrogen and thyroid hormone disruption.	electronics, furnishings, motor vehicles, airplanes, plastics, polyurethane foams, and textiles.
	Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester (TBB)	Stormwater + Sediment		
	Bis (2-ethylhexyl) tetrabromophthalate (TBPH)	Stormwater + Sediment		
	Tris(1-chloro-2-propyl) phosphate (TCPP)	Stormwater + Sediment		
	Triphenyl phosphate (TPP)	Stormwater + Sediment		
	V6 (V6)	Stormwater + Sediment		
Perfluoroalkyl Substances (PFAS)[2]	Perfluorobutane sulfonate (PFBS)	Stormwater+Sediment	Bioaccumulative (especially longer chain) and very persistent in the environment. Found across all matrices: air, water, sediment, and animal tissue. Animal tests show that PFOA can cause tumors and neonatal death and toxic effects on the immune, liver, and endocrine systems.	Water resistant textiles, fire-fighting foam, consumer products and major commercial and industrial discharges.
	Perfluorohexane sulfonate (PFHxs)	Stormwater+Sediment		
	Perfluorooctane sulfonate (PFOS)	Stormwater+Sediment		
	Perfluorohexanoic acid (PFHxA)	Stormwater+Sediment		
	Perfluoroheptanoic acid (PFHpA)	Stormwater+Sediment		
	Perfluorooctanoic acid (PFOA)	Stormwater+Sediment		
	Perfluorononanoic acid (PFNA)	Stormwater+Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Source(s)
	Perfluorodecanoic acid (PFDA)	Stormwater+Sediment		
	Perfluorundecanoic acid (PFUnA)	Stormwater+Sediment		
	Perfluorododecanoic acid (PFDoA)	Stormwater+Sediment		

[1] Monitoring of metals to detect total concentrations; end goal to identify problematic areas that could be linked to nano-particle pollution.

[2] Source: (Furl and Meredith, 2008)

[3] Source (CHCC, 2016)

Appendix D. Monitored Parameters

Field Parameters

- **pH –** pH below 6 and above 8.5 can cause fish kills, invasive species promotion, and aquatic life reproduction impairments. Low pH levels (acidic) are caused by the combustion of fossil fuels. pH along with hardness is used to calculate receiving water quality criteria for dissolved metals.
- **Conductivity –** Indicator of pollution by measuring the conductance of ions in dissolved solids.
- **Temperature –** Temperature is important for salmon rearing and spawning, as well as vital instream biological processes.
- **Total Dissolved Solids –** TDS is the concentration of dissolved salts/solids. High dissolved solids equates to high conductivity.

Laboratory Parameters

- **Oil and Grease** – Petroleum based hydrocarbons and fatty compounds of animal or vegetable origins
- **Total Suspended Solids** – Organic and inorganic compounds undissolved and suspended in water >.45µm in size
- **Total Organic Carbon** – Total amount of organic carbon found in stormwater and sediment, used to normalize organics and determine the bio-availability of metal pollutants
- **Total Volatile Solids –** Indicates the percentage of organic materials found in sediment, which could be indicative of pollutants

Petroleum Hydrocarbons

Hydrocarbons in the form of diesel, oil & grease, and gasoline were analyzed for in stormwater. Diesel and oil & grease were also analyzed for in sediment. Gasoline was omitted from sediment analysis due to its volatile state, making it difficult to detect in sediments at low concentrations.

Nutrients

Nutrients were only analyzed for in stormwater. Nutrients were added to the monitoring parameter list due to the presence of a nursery in one of the targeted drainages. Nutrient parameters include:

- **Ammonia** – Unionized ammonia (NH_3), most toxic form of nitrogen
- **Nitrite-Nitrate** – Nitrites are formed when ammonia is nitrified by bacteria. Nitrites are converted to nitrates/plant nutrients by bacteria called nitrobacters
- **TPN (Total Persulfate Nitrogen)** – The organic portion of nitrogen used to calculate total nitrogen
- **Orthophosphate** – Amount of reactive phosphorous available for algae and plant growth

- **Total Phosphorous –** This includes the sum of all phosphorous forms orthophosphate (fertilizers and bioavailable forms), condensed phosphates (inorganic industrial), and organic phosphates

Metals

Stormwater samples were analyzed for the following total recoverable and dissolved metals: antimony, arsenic, cadmium, cobalt, copper, lead, mercury, silver, titanium, and zinc. Dissolved metals, defined as metals in the range of <.45 µm (pore size), were analyzed to determine bio-availability to aquatic life. “Total metals” is the sum of all metals associated with particulates concentrated in a sample, and includes the dissolved fraction.

In general, metals are dispersed from the built urban landscape from a variety of sources. The following is a summary of the potential sources of each metal analyzed for in the project’s samples:

- **Antimony -** Used in the manufacturing of pigments, paints, glass, pottery, and enamels. Also used at low percentages in metal alloys and as a synergistic in flame retardants.
- **Arsenic -** Wood preservatives, pesticides, medicines, metal alloys, and paint pigments.
- **Cadmium -** Chiefly used in rechargeable nickel-cadmium batteries. Used to a lesser extent in pigments, coatings, alloys, and electronics. During the past few decades, cadmium use has transitioned from consumer to industrial uses and is currently being phased out.
- **Cobalt -** Cobalt is used in alloys, pigments, and fertilizers; as a drying agent in paints, varnishes, and inks; a component in porcelain enamel; and as a catalyst in synthesizing polyester and other materials.
- **Copper -** Automobile brake pads, rooftops, antifouling paints, and water supply lines.
- **Lead -** Manufacturing, combustion of coal and oil, waste incineration.
- **Mercury -** Coal combustion, metal processing, atmospheric deposition.
- **Silver and Titanium -** Primarily tested to screen for the potential of nano-particles in the environment. Silver and titanium nano-particles are used in sunscreens, textiles, cleaning products, personal care products, food, paints, as well as numerous other applications.
- **Zinc -** Galvanized materials, manufacturing processes, automobiles.

Semi-volatile Organics

Semi-volatile organics were analyzed for in both stormwater and sediment, and include phthalates and polycyclic aromatic hydrocarbons (PAHs). The following is a general description of both:

Phthalates – Phthalates are used as a plasticizer in the production of plastics and in various industrial processes and applications. They are also ubiquitous in consumer products. A description of phthalates detected in the screening area during stormwater events follows:

- **Bis (2-Ethylhexyl) Phthalate (DEHP)** - DEHP is a high production volume chemical and is used widely as a plasticizer in PVC.
- **Butyl Benzyl Phthalate (BBP)** - Used as a plasticizer in vinyl foams (floor tiles, traffic

cones, fake leather, etc.).

- **Dimethyl Phthalate** - Dimethyl Phthalate has many uses which include insect repellents, plastics, lacquers, molding powders, and solid rocket propellants.
- **Di-N-Butylphthalate -** A commonly used plasticizer, also used in printing inks and adhesives.
- **Di-N-Octyl Phthalate -** Used to keep plastics soft and more flexible.

Polycyclic Aromatic Hydrocarbons (PAHs)

In general, PAHs are organic compounds containing only hydrogen and carbon. They are found in coal and tar deposits, and are created through the incomplete combustion of organic materials. The following PAHs were detected in stormwater and/or sediment screening samples. A description of each detected parameter based on its most common source is listed below:

- **Acenaphthylene -** Used in the manufacturing of plastics and as a pesticide/fungicide.
- **Anthracene** - Component of coal tar.
- **Benzo(a)anthracene** - Constituent of tobacco smoke.
- **Benzo(a)pyrene** - Found in coal tar, cigarettes, and grilled foods.
- **Benzo(b)fluoranthene -** Found in gasoline exhaust, coal tar, and soot.
- **Benzo(g,h,i)perylene** - Used to make dyes, plastics, pesticides, explosives, and drugs.
- **Benzo(k)fluoranthene -** Released through the incomplete combustion of organic materials (fossil fuels).
- **Carbazole -** Used to make dyes.
- **Chrysene -** Natural constituent of coal tar.
- **Dibenzo(a,h)anthracene -** Found in gasoline exhaust, coal tar, and soot.
- **Fluoranthene –** Originally isolated from coal tar pitch. Incomplete combustion of fossil fuels.
- **Fluorene -** Incomplete combustion of fossil fuels.
- **Indeno(1,2,3-cd)pyrene -** A component of gasoline engine exhaust and cigarette smoke.
- **Naphthalene –** Used in the production of vinyl chloride, insecticide, and as dispersants in plaster, concrete, rubber and multiple other uses. Most abundant single component in coal tar.
- **Phenanthrene -** Used to make dyes, plastics, pesticides, explosives, and drugs.
- **Pyrene -** Used for making dyes and dye precursors.
- **Retene -** Found in wood-waste combustion and crude oil.

Flame Retardants

Flame retardants were selected for monitoring due to their toxicity to the environment and frequent use in consumer products. Currently, state water and sediment standards have not been developed for flame retardants. The study monitored for a total of 9 (2 brominated and 7 halogenated and/or phosphate-based) flame retardant parameters.

Much of the previous work around the nation has been focused on looking at concentrations of PBDEs in drinking water. Little to no data for MS4 stormwater and sediment have been collected to date to look at halogenated (contains chlorine atoms "chloro") or phosphate-based flame retardants in stormwater.

Several brominated flame retardants, such as PBDEs, have been phased out due to health concerns and replaced with other halogenated or phosphate-based retardants. Analysis of stormwater did not detect brominated parameters, but did detect the following halogenated and/or phosphate-based flame retardant parameters:

- **Tris(2-chloroisopropyl) phosphate (TCPP) –** Halogenated phosphate used in polyurethane manufacturing
- **Tricresyl Phosphate (TCP)-** Phosphate used as a plasticizer
- **Tris(2-isopropylphenyl) Phosphate (IPTPP) –** Phosphate used as a fire retardant, also known as "Firemaster 550"
- **Triphenyl Phosphate (TPhP) –** Phosphate used widely as fire retardant and plasticizer
- **2,2-bis(chloromethyl)propane-1,3-diyltetrakis(2-chloroethyl) bisphosphate (V6) –** Halogenated phosphate used as a flame retardant applied to polyurethane foam, commonly found in furniture and automobiles

PCBs

Polychlorinated biphenyls, or PCBs, are a group of human made chemicals containing hydrogen, carbon, and chlorine atoms. PCBs were originally formulated for use in paints, electrical equipment, surface coatings, ink, flame retardants, adhesives, and surface coatings. PCBs are extremely stable and persistent in the environment. They have been associated with numerous negative health effects on aquatic and terrestrial life.

Aroclors are formulations of PCB congeners developed for use in the United States.
Of the Aroclors tested, Aroclor 1242, Aroclor 1254, and Aroclor 1260 were detected in sediments.

Near the end of the sample collection effort in June 2017, additional analysis was conducted on previously collected sediments to better characterize parameters of interest. Due to the high concentrations of hydrocarbons at several of the sites, matrix interferences made extraction of samples for analysis difficult, and limited the quantity of qualified results.

Washington State currently implements an aquatic life and human health consumption criteria for PCBs in freshwaters of the state. Results were compared to the chronic aquatic life criteria (.03 ug/L) and showed that samples did not exceed this criteria.

Sediments from the sample events on June 7 and 21, were processed for analysis of pesticides and PCBs.

Legacy Pesticides

Near the end of the sample collection effort in June 2017, additional analysis was conducted on sediments to better characterize parameters of interest. Due to the high concentrations of hydrocarbons at several of the sites, matrix interferences made extraction of samples for analysis difficult and limited the quantity of qualified results.

Sediments from the sample events on June 7, and 21, were processed for analysis of pesticides and PCBs.

- **4,4 – DDD (Dichlorodiphenyldichloroethane) –** Very persistent and potentially carcinogenic organochlorine insecticide; 4,4 – DDD is a breakdown metabolite of DDT.
- **Chlordane, technical –** Organochlorine insecticide was banned for use in 1983, except as a termite pesticide, which was shortly banned after in1988. Chlordane is resistant to degradation in the environment and has significant health effects on organisms.
- **cis-Chlordane –** Isomer of chlordane.
- **Dieldrin –** Originally formulated as an alternative to DDT in the 1940's, it has been chiefly used as a pesticide in soils and to control mosquitoes. Though banned in the US, developing countries still use it as an insecticide on crops, textiles, and wood. Dieldrin is very persistent and toxic to organisms.
- **Gamma-BHC –** Also known as Lindane, this chemical has been used as an insecticide for agricultural and for human parasites (scabies, lice). Like all other members in the organochlorine family, it is extremely persistent and may be a carcinogen.
- **Pentachloroanisole –** Main degradation product of pentachlorophenol (PCP) and pentachloronitrobenzene, which are used as herbicides, insecticides, fungicides, algaecide, anti-fouling paint, and wood treatment. Highly toxic and persistent.
- **Trans-Chlordane –** Isomer of chlordane.
- **Trans Nonachlor –** Isomer of nonachlor, a chemical found in chlordane.

PFAAs

Perfluoroalkyl acids (PFAAs) were selected for monitoring due to their persistence and toxicity in the environment, and potential bioaccumulation in organisms. PFAAs are used in a variety of applications in modern day products, from non-stick pans to hydraulic fluids in machinery. Currently, state water and sediment standards have not been developed for PFAAs, and very little to no data has been collected to screen for concentrations in MS4s at the time of this report.

This study monitored for the most commonly used PFAA parameters and breakdown products, and detected a majority of them throughout the screening area. The following is a description of each detected parameter and its use before making its way into the environment:

- **Perfluorobutanoate (PFBA) –** Production ended in 1998 by 3M, was chiefly used for photographic film.
- **Perfluorobutanesulfonic acid (PFBS) –** Used in the replacement for Scotchguard, a

persistent phased out chemical in 2003 used to repel staining of apparel and other household fabrics.

- **Perfluorodecanoic acid (PFDA) –** Breakdown product of stain and grease-proof coatings on food packaging, couches, and carpets.
- **Perfluorododecanoic acid (PFDoA) –** Breakdown product of stain and grease-proof coatings on food packaging, couches, and carpets.
- **Perfluoroheptanoic acid (PFHpA) –** Breakdown product of stain and grease-proof coatings on food packaging, couches, and carpets.
- **Perfluorohexanoic acid (PFHxA) –** PFHxA is the primary replacement for PFOA and other long-chain perfluorinated compounds.
- **Perfluorohexane sulfonic acid (PFHxS) –** Replacement for PFOS, used as a stain or water repellent in footwear, bags & luggage, leather, clothing, upholstery, etc.
- **Perfluorononanoic acid (PFNA) –** Used as a surfactant in the production of polyvinylidene fluoride, a high-grade thermal plastic used in piping, wire insulation, lithium ion batteries, and high-end semi-conductor applications (medical and defense industries) and various other uses.
- **Perfluorooctanoic acid (PFOA) –** Manufactured since the 1940s in high quantities, has been found in industrial waste, stain resistant garments and carpets, carpet cleaning soaps, water, food, and cookware (Teflon).
- **Perfluorooctane sulfonate (PFOS) –** Was the key ingredient in Scotchguard made by 3M, a water and stain repellent (phased out in 2003). Used widely in fire-fighting foams, paints, waxes, polishes, varnishes, cleaning products, and various other applications.
- **Perfluoro-n-pentanoic acid (PFPeA) –** Breakdown product of stain and grease-proof coatings on food packaging, couches, and carpets.
- **Perfluoroundecanoic acid (PFUnA) –** Breakdown product of stain and grease-proof coatings on food packaging and household products.

Appendix E. Site Maps

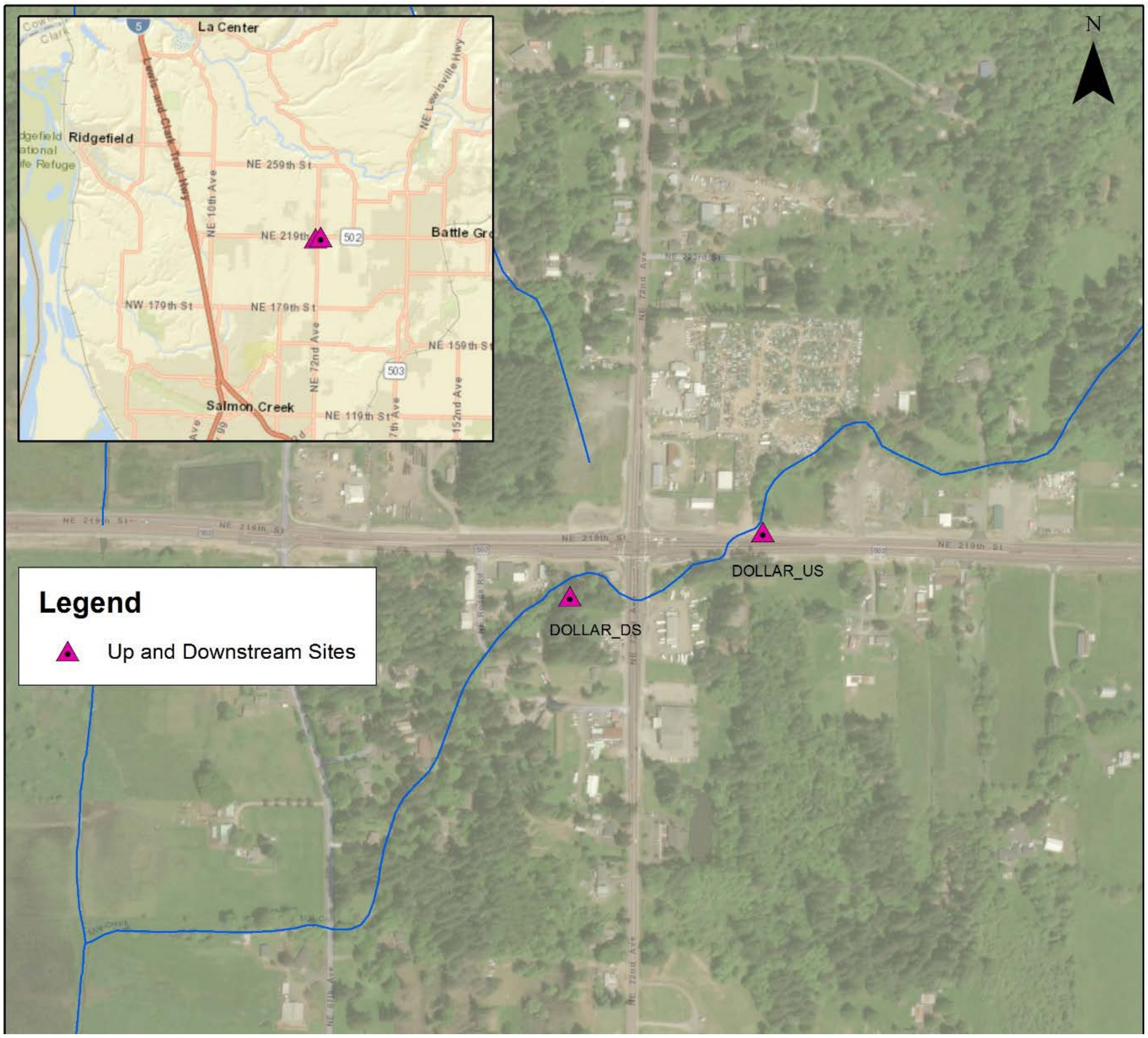

Figure E-1. Northern Study Area Sites

Figure E-2. Central Study Area Sites

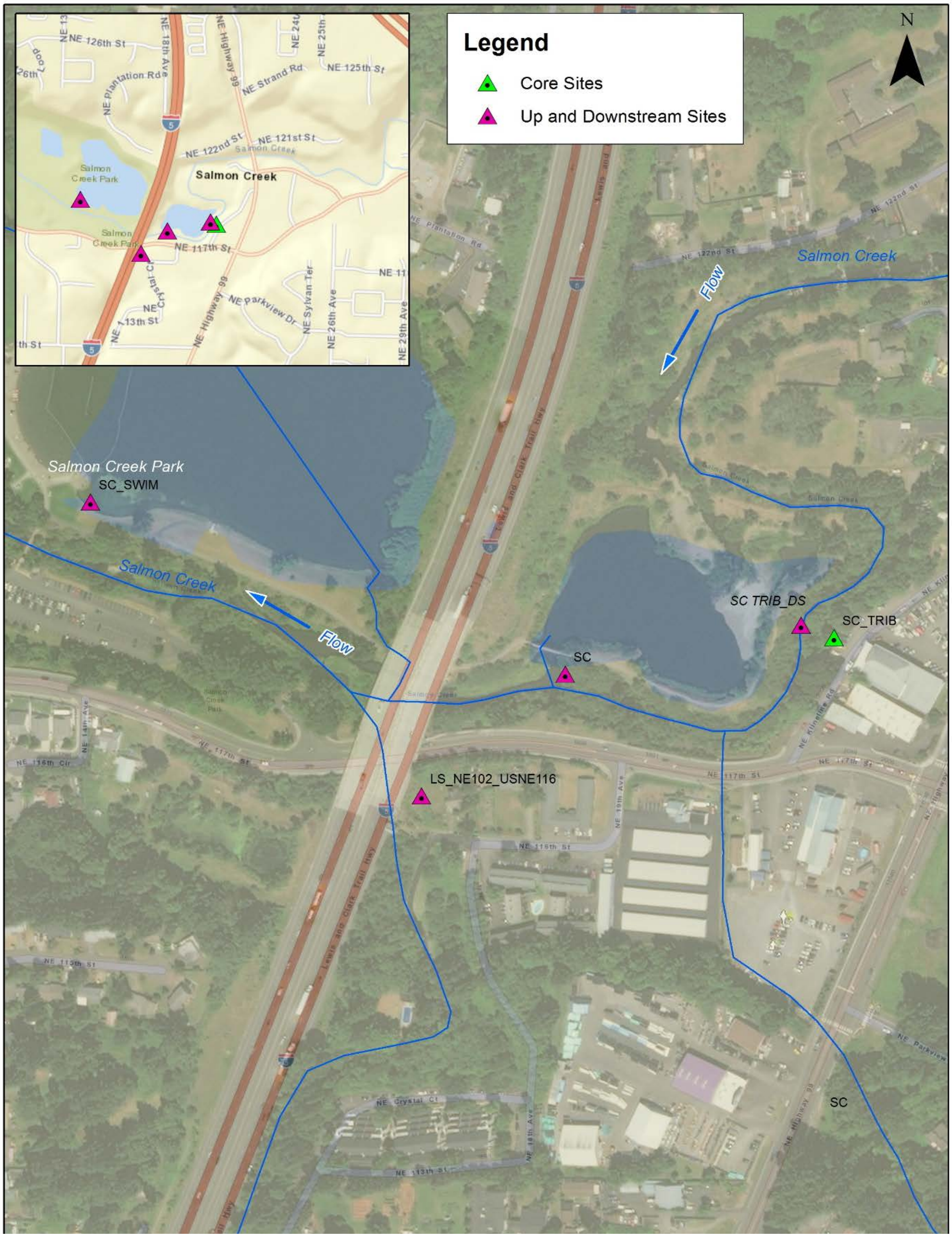

Figure E-3. Salmon Creek Park Study Area Sites

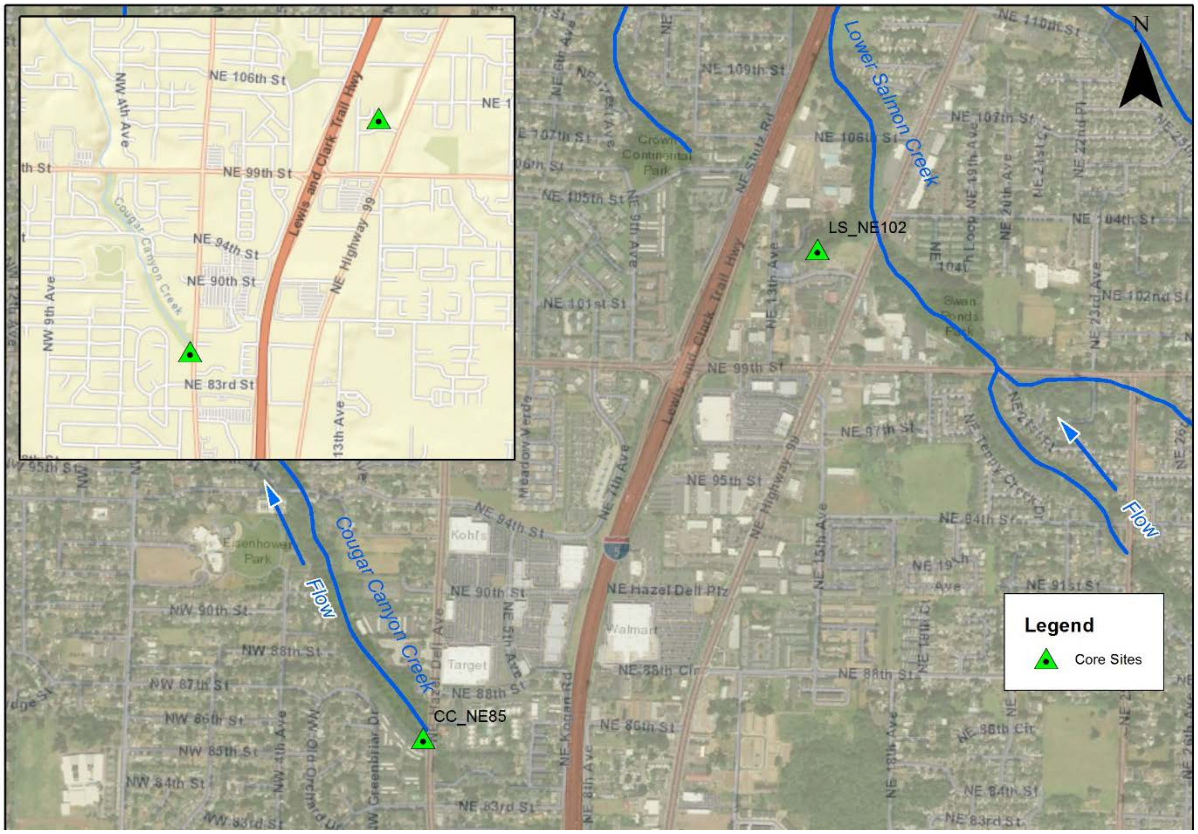

Figure E-4. Hazel Dell Study Area Sites

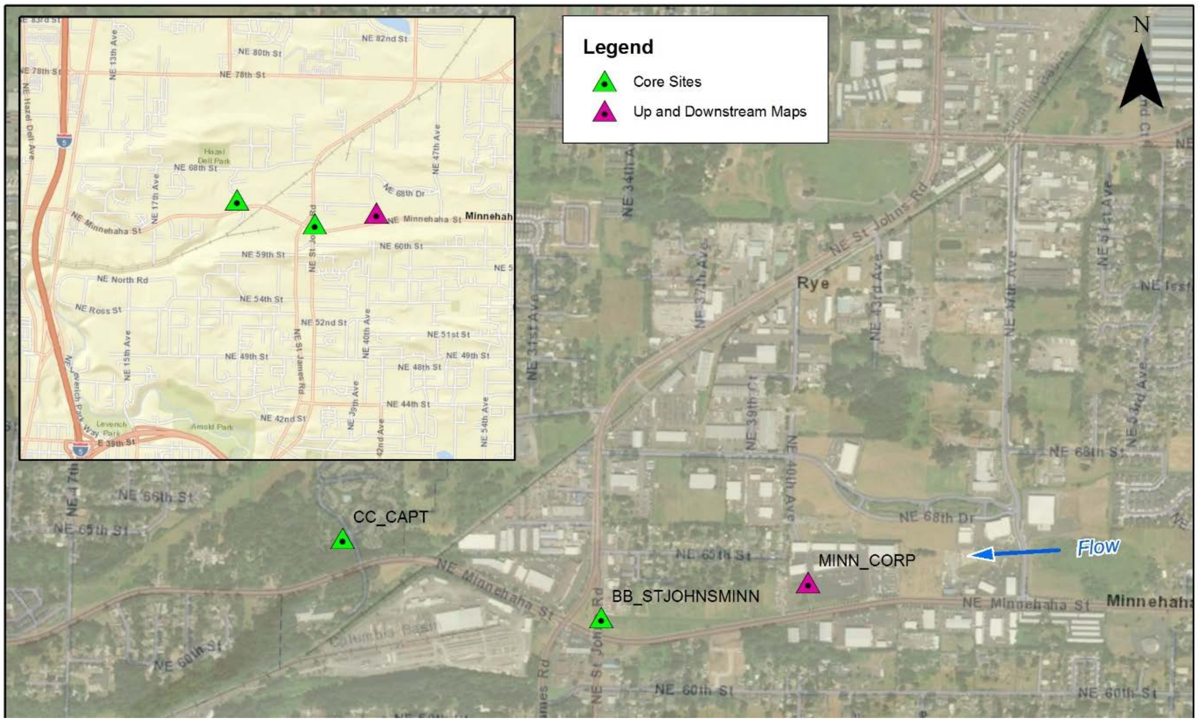

Figure E-5. NE Minnehaha Street Study Area Sites

Appendix F. Glossary, Acronyms, and Abbreviations

Glossary

Anthropogenic: Human-caused.

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.

Effluent: An outflowing of water from a natural body of water or from a man-made structure. For example, the treated outflow from a wastewater treatment plant.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking, reissuing, terminating, monitoring, and enforcing permits, as well as 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, a nonpoint source is any unconfined and diffuse source of contamination. Legally, a nonpoint source is 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 where more than 5 acres of land have been cleared.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

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, as well as from gravel roads and parking lots.

Toxics: Toxic chemicals.

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 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.

75th percentile: A statistical number obtained from a distribution of a data set, above which 25% of the data exists and below which 75% of the data exists.

Acronyms and Abbreviations

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
LSC	Local Source Control
MS4	Municipal Separate Storm Sewer System
MQO	Measurement quality objective
MS4	Municipal Separate Stormwater Sewer System
NPDES	(See Glossary above)
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PFAs	Perfluoroalkyl substances
PFAAs	Perfluoroalkyl acids
RSD	Relative standard deviation
SOP	Standard operating procedure
SRM	Standard reference materials
TDS	Total dissolved solids
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
dw	dry weight
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
mg	milligram
mgd	million gallons per day
mg/d	milligrams per day
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mg/L/hr	milligrams per liter per hour
mL	milliliters
mole	an International System of Units (IS) unit of matter
ng/g	nanograms per gram (parts per billion)
ng/Kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
ug/g	micrograms per gram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ug/L	micrograms per liter (parts per billion)
um	micrometer
umhos/cm	micromhos per centimeter
uS/cm	microsiemens per centimeter, a unit of conductivity