DEPARTMENT OF
ECOLOGY
State of Washington

Chemicals of Emerging Concern in Pretreated Industrial Wastewater in Northwestern Washington State

Screening Study Results, 2021

August 2022

Publication 22-03-013

Publication Information

This report is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/SummaryPages/2203013.html.

Data for this project are available in Ecology's EIM Database. Study ID: SWON0002.

The Activity Tracker Code for this study is 20-022.

Suggested Citation
Wong, S. 2022. Chemicals of Emerging Concern in Pretreated Industrial Wastewater in Northwestern Washington State: Screening Study Results, 2021. Publication 22-03-013. Washington State Department of Ecology, Olympia.
https://apps.ecology.wa.gov/publications/SummaryPages/2203013.html.

Contact Information

Publications Team
Environmental Assessment Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6764

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

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Shoreline 206-594-0000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Chemicals of Emerging Concern in Pretreated Industrial Wastewater in Northwestern Washington State

Screening Study Results, 2021

by

Siana Wong

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington

Table of Contents

List of Figures and Tables

Acknowledgments

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

- Staff at the sampled facilities for voluntary participation in this study of chemicals of emerging concern.
- SGS AXYS staff for coordination of contract laboratory samples.
- Biniam Zelelow for original scoping and coordination of this project.
- Washington State Department of Ecology staff:
  - Maia Hoffman for coordination with facilities and collaboration on this project.
  - Kristi Floyd for assistance with field sampling.
  - Will Hobbs for original scoping and coordination of this project and for peer review of this report.
  - Manchester Environmental Laboratory staff for coordination and analysis of samples.
  - Jim Medlen, Jessica Huybregts, and Rachel McCrea for review and comments on the report draft.

Abstract

The Washington State Department of Ecology (Ecology) conducted a screening-level study to assess the presence and magnitude of various chemicals of emerging concern (CECs) and lesser-studied chemicals in pretreated industrial wastewater. The wastewater is received by publicly owned treatment works (POTWs) or wastewater treatment plants (WWTPs) in the Puget Sound region. During January through April 2021, we collected whole water samples from nine facilities representing seven different industry types.

Samples were analyzed for:

- Polychlorinated biphenyls (PCBs)
- Polybrominated diphenyl ethers (PBDEs)
- Per- and polyfluoroalkyl substances (PFAS)
- Organophosphate flame retardants (OPFRs)
- Bisphenols
- Alkylphenols
- Semivolatile organic compounds (SVOCs)

Wide ranges in chemical concentrations were found in samples from the nine facilities. Sample concentrations ranged as follows:

- Total PCB: 64–168,000 pg/L
- Total PBDE: 29–3,490,000 pg/L
- Total PFAS: 4–9,840 ng/L
- Total OPFR: 35–29,800,000 ng/L
- Phenolic Compounds
  - Total bisphenol: 225–36,500 ng/L
  - Total alkylphenol: Non-detect–2,430,000 ng/L
- Total SVOC: 21–470,680 µg/L

Overall, the study demonstrated that a number of CECs and other lesser-studied chemicals have the potential to be present in industrial wastewater, sometimes at high concentrations.

Introduction

Background

This study was conducted by Ecology's Environmental Assessment Program (EAP), in coordination with Ecology's Water Quality Program (WQP), during 2021.

The purpose of the study was to conduct screening-level research on the presence and magnitude of several chemicals of emerging concern (CECs) and other lesser-studied chemicals in pretreated industrial wastewaters that are discharged to publicly owned treatment works (POTWs) in the Puget Sound region of Washington State. CECs are natural or synthetic contaminants that may cause ecological or human health effects and are not widely regulated. CECs commonly found in wastewater include pharmaceuticals, personal care products (e.g., synthetic fragrances, antibacterial compounds), plasticizers, food additives, flame retardants, and nanoparticles.

POTWs are designed to treat wastewaters through primary, secondary, and sometimes tertiary, treatment processes. Through these processes, solids, organic matter, and harmful organisms are removed from the wastewaters before the wastewaters can be safely discharged to the environment, most commonly to surface waters. However, POTWs are not intentionally designed to remove many types of pollutants that may be conveyed to the POTW from an industrial facility. Such pollutants may interfere with a POTW's operation, or pass through the POTW untreated. In many cases, while the POTW reduces pollutant concentrations, the chemical of concern may still be present at low concentrations in the treated discharge (Bothfeld 2021).

In the Puget Sound region, protecting the quality of fresh and marine waters is vital for the health of the region's population, economy, quality of life, and iconic wildlife. The Puget Sound Partnership is the state agency that has been leading the region's efforts to restore and protect the Puget Sound. It identified the reduction of toxic chemicals entering the Puget Sound as a top priority. This includes research to better understand sources, transport, and fate of toxics to the Puget Sound (Norton et al. 2011), especially those regarded as CECs (Roberts 2017).

POTWs represent potential pathways of pollutants into Puget Sound (Ecology and Herrera Environmental Consultants, Inc. 2010). While previous research has examined toxic chemicals in the influent and treated effluent of POTWs themselves, we did not find published studies examining a range of toxic chemicals in pretreated industrial wastewater. Data from various pretreated industrial wastewater effluent samples will provide useful information about the types of toxic chemicals and source categories that become inputs to the POTW. Understanding the sources of different types and magnitudes of toxic chemicals that enter POTWs is an important part of addressing toxic chemicals to the Puget Sound.

Pretreatment, or pretreated industrial wastewater, refers to the treatment of industrial or commercial wastewater before being discharged to a POTW. Under the U.S. Environmental

Protection Agency (EPA) National Pretreatment Program, which Ecology has been delegated to implement in Washington, industrial facilities that discharge to POTWs ("industrial users") must comply with specific pretreatment requirements and standards included in an industrial user's State Waste Discharge permit. A permit typically includes self-monitoring and reporting of water quality, following best management practices and complying with prohibited discharge rules.

Parameters of interest for this study were:

- polychlorinated biphenyls (PCBs)
- polybrominated diphenyl ethers (PBDEs)
- per- and polyfluoroalkyl substances (PFAS)
- organophosphate flame retardants (OPFRs)
- phenolic compounds (specifically alkylphenols and bisphenols)
- semivolatile organic compounds (SVOCs)

These parameters were selected because they have previously been detected in wastewaters or wastewater-impacted water bodies in the Puget Sound region, are of interest as a CEC, or there is little information available on their occurrence.

For the remainder of this report, we use the term "CECs" to describe the parameters of interest in this study.

Parameters of Interest

PCBs

Polychlorinated biphenyls (PCBs) are a class of synthetic chemicals composed of two phenyl rings with one to 10 chlorines attached (Figure 1a). There are 209 congeners, which are the different arrangements of chlorine atoms on the benzene rings. PCB mixtures were commercially manufactured in the United States from 1929 until 1979, commonly under the tradename Aroclor. They were used in various industrial applications because of their flame-retardant, electrical insulating, chemically stable, and lubricating properties. Typical applications included electrical and hydraulic equipment, plasticizers in paints, plastics, and rubber, pigments, and dyes. The manufacture of PCBs in the U.S. was banned in 1979 after more was learned about their toxic impacts.

PCB sources include legacy contamination from previous industrial manufacturing and uses, inadvertent production during present-day manufacturing processes, and transport from other geographical areas.

PCBs are considered to be persistent, bioaccumulative, and toxic chemicals (PBTs). While PCBs may be found in surface water at low concentrations, PCBs may accumulate in fish tissue at high concentrations (Limnotech 2016, Rodenburg and Leidos 2017). Exposure to high levels of PCBs may be carcinogenic, and may also affect the immune, reproductive, nervous, and endocrine systems (Davies 2015).

PCBs are widespread in the environment and efforts to understand and control PCB sources are ongoing. To learn more about actions Ecology is taking to address PCBs, visit Ecology's PCBs webpage.

PBDEs

Polybrominated diphenyl ethers (PBDEs) are a class of synthetic chemicals composed of two phenyl rings linked by an oxygen atom, with two to 10 bromines attached (Figure 1b). Like PCBs, there are 209 congeners, and PBDEs are considered to be PBTs

Since the 1970s, PBDEs were used as flame retardants in electronics, plastics, furniture, textiles, and various consumer products. Commercial mixtures of PBDEs include pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE) and decabromodiphenyl ether (decaBDE), with decaBDE being the most globally used (EPA 2017). Because of increasing concerns about their presence and effects in the environment and to human health, penta- and octaBDEs were phased out of U.S. manufacture and import in 2004. In 2009, the EPA subsequently announced voluntary phase-out of decaBDE. In 2011, Washington State banned decaBDE in televisions, computers, and upholstered furniture, provided the identification and approval of safer alternatives.

Pathways of PBDEs into the environment include air emissions from manufacturing processes, recycling PBDE-containing materials, leachate from waste disposal sites, and volatilization or leaching from various products containing PBDEs when they break down (EPA 2017). At high concentrations in animals, there is evidence of carcinogenicity and toxic effects to the nervous, reproductive, and immune systems, liver, pancreas, and thyroid (EPA 2010). In a previous study, PBDEs in juvenile salmonids were detected at levels high enough to potentially cause harmful effects (O'Neill et al. 2015).

To learn about more actions Ecology is taking to address PBDEs in the environment, visit Ecology's flame retardants webpage.

PFAS

Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals composed of a chain of carbon atoms with attached fluorine atoms and a functional group (Figure 1c). There are over 4,700 PFAS compounds known to exist today. Since the 1940s, PFAS have been used in various industrial applications and consumer products because of their resistance to oil, grease, water, and heat. They have been used in non-stick cookware, water-repellant clothing, stain-resistant fabrics and carpets, and fire-fighting foams.

Some PFAS, including perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), are PBTs. Health effects include compromised endocrine, developmental, hepatic and immune systems, increased cholesterol, and increased risk of some cancers (ATSDR 2018). Beginning in 2002, the more commonly used PFOS and PFOA were phased out of production in the U.S. as concerns about their toxicity grew. However, these chemicals were largely replaced with short-chain and other PFAS. While the toxicity of PFOS, PFOA, and short-chain PFAS

have been studied and documented (ATSDR 2018, Sedlak et al. 2018), much less is known about the thousands of other PFAS that continue to be produced to replace those that have been phased out.

For more information on actions Ecology is taking to address PFAS, visit Ecology's PFAS webpage.

OPFRs

Organophosphate flame retardants (OPFRs) are synthetic organic esters of phosphoric acid (Figure 1d). They are used as flame retardants in consumer products such as textiles, electronics, and furniture, as well as in hydraulic fluids, plasticizers, and building and industrial materials. The use of OPFRs expanded as concerns about PBDEs grew. OPFRs are generally thought to be less persistent and bioaccumulative than PBDEs. However, OPFRs have a wide range of properties, and their persistence and toxicity depends on their unique solubility, vapor pressure, and bioconcentration factor (Yang et al. 2019).

Several health effects to humans and animals have been associated with exposure to certain OPFR compounds, including tris(2-chloroethyl) phosphate (TCEP), tributyl phosphate (TnBP), tributoxyethyl phosphate (TBEP), tris(1,3-dichloro-2-propyl) phosphate (TDCP), and tricresyl phosphate (TCP) (ATSDR 2012). Health effects include neurotoxicity, developmental toxicity, disruptions to the reproductive and endocrine systems, and carcinogenicity (Yang et al. 2019). Because of their global use and presence in environmental samples, they are regarded as an emerging contaminant.

Phenolic Compounds

Bisphenols

Bisphenols are a class of synthetic compounds consisting of two phenol groups (Figure 1e). The most common is bisphenol A (BPA), which was first synthesized in 1891, and is used to harden polycarbonate plastics and make epoxy resins. BPA is found in products such as plastic containers, thermal paper (e.g., receipt paper), and some dental and medical devices. It is also found in epoxy resins that are used to make food and beverage can linings, paints, and protective coatings for various industrial applications. Health effects from exposure to BPA include effects to the endocrine, reproductive, developmental, and neural systems. BPA is moderately soluble and biodegradable in the environment. Exposure to BPA can occur through eating food in contact with BPA-containing plastics or other containers (National Center for Biotechnology Information). BPA is more likely to be leached from products when heated at high temperatures.

As concerns about BPA increased in the 1990s, alternatives such as bisphenol S and bisphenol F have increased in use for the manufacture of products containing polycarbonate plastics and epoxy resins (Ben-Jonathan and Hugo 2016, Lehmler et al. 2018). However, there is evidence that the bisphenol alternatives may have similar endocrine-disrupting and toxicological properties as BPA (Rochester and Bolden 2015).

Alkylphenols

Alkylphenols are a class of compounds characterized by the alkylation of phenols (Figure 1f). They are commonly used to make alkylphenol ethoxylates, which are surfactants used in various consumer and industrial products. Nonylphenol ethoxylate is a type of alkylphenol ethoxylate manufactured through the combination of nonylphenol and ethylene oxide. It is widely used to make industrial and commercial detergents, cleaners, emulsifiers, and pesticides. In the environment, nonylphenol ethoxylate will degrade to nonylphenol, which is more persistent and bioaccumulative, and a known estrogenic endocrine disruptor (California Environmental Protection Agency 2009).

SVOCs

Semivolatile organic compounds (SVOCs) are a subgroup of volatile organic compounds that have a higher molecular weight and boiling point than volatile organic compounds. They are used in a wide range of industrial and commercial applications and include a range of different structural compounds, including pesticides, phthalate plasticizers, and flame retardants. People may be exposed to SVOCs through inhalation, ingestion of contaminated foods, or absorption through the skin.

Polycyclic aromatic hydrocarbons (PAHs) are a class of SVOCs consisting of carbon atoms joined together to form multiple rings. They are formed from the incomplete combustion of coal, oil and gas, and plant or animal matter. People may be exposed to PAHs through various pathways, such as breathing PAH contaminated air, eating charred meat, or coming into contact with air, water, or soils near hazardous waste sites (ATSDR 1996). Little is known about human health effects at low exposures. Animal tests have shown that exposure to PAHs may affect the skin, body fluids, immune and reproductive systems, and may be carcinogenic.

For more information on actions Ecology is taking to address PAHs, visit Ecology's PAHs webpage.

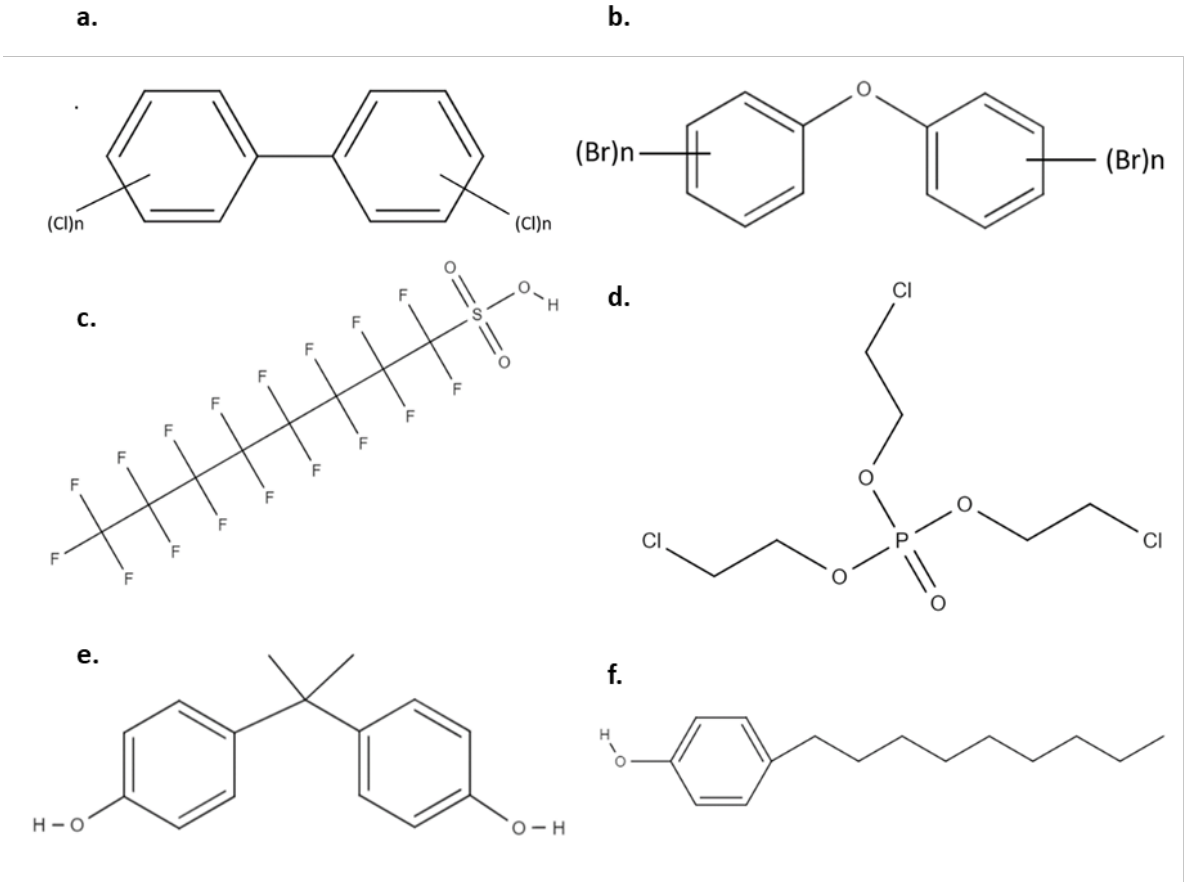

Figure 1. Molecular structure of (a) PCB; (b) PBDE; (c) PFAS, e.g., PFOS; (d) OPFR, e.g., TCEP; (e) bisphenol, e.g., BPA; and (f) alkylphenol, e.g., nonylphenol.

Goals and Objectives

The goal of the study was to screen for the presence and concentration ranges of several CEC classes in industrial wastewaters that are discharged to POTWs.

The objectives were to:

- Sample pretreated effluent during one event from each of nine industrial facilities representing various industry types in the Puget Sound region.
- Analyze the pretreated effluent samples collected from each industrial facility for PCBs, PBDEs, PFAS, OPFRs, bisphenols, alkylphenols, and SVOCs.
- Analyze data and report results.

In coordination with Ecology's Water Quality Program (WQP), Ecology's Environmental Assessment Program (EAP) conducted compliance monitoring at each of the nine industrial facilities as part of WQP's compliance inspection process, as described in the Quality Assurance Project Plan (QAPP) for this study (Wong 2021). The WQP used the results of this compliance monitoring to complete its inspection report for each facility; these are not discussed in this report. The focus of this report is on CEC results.

Although some of the facilities monitor for a subset of certain CEC parameter classes as a condition of their permit, the analytical methods used for this study are different from those required for compliance monitoring. Compliance monitoring must use 40 CFR Part 136-approved analytical methods. This study used alternative Ecology-accredited analytical methods in an effort to quantify selected CECs at lower level concentrations.

Methods

Study Locations

Pretreated industrial wastewaters from each of the nine facilities sampled during this study were received by POTWs that eventually discharge treated water to Puget Sound.

Since this study is a screening-level analysis of CECs in pretreated industrial wastewater and not a focused study of any individual facility, we are not providing the facility names and specific locations, as a courtesy to each business that voluntarily participated in the study. Instead, we use facility site ID codes and the industry type (Table 1).

Table 1. List of the facilities sampled by their Site ID and industry type, and a description of the wastewater sampled from each facility.

Facility Site ID	Type of Industry	Description of Pretreated Industrial Wastewater Sampled
Facility A	Food Processing	Egg processing and cleanup wastewater
Facility B, E	Metal Finishing	Chemical metal finishing process wastewater (acid etch, chromium conversion coating, anodizing, and dyeing)
Facility C	Steel Foundry	Mechanical metal finishing process wastewater (hydroblasting)
Facility D, F	Aerospace/Aircraft Modification	Chemical metal finishing, aircraft cleaning, and painting cleanup process wastewater
Facility G	Landfill	Leachate and catch basin cleanout wastewater
Facility H	Industrial Laundry	Industrial laundry process wastewater
Facility I	Ship Building and Repair	Facility wide wastewater (chemical metal finishing and various industrial wastewater and domestic wastewater)

Field Methods

During January through April 2021, WQP staff sampled each facility once during the facility's normal daily operations.

At each facility, grab samples were collected at the discharge point where compliance monitoring is required by their permit, or a final discharge point where mixed effluent (pretreated industrial wastewater and domestic wastewater) leaves the facility. Grab samples were collected as a one-time discrete sample during a time when the facility was discharging wastewater. The exception was Facility C, which discharges infrequently. At Facility C, the sample was collected from a containment tank that accumulates wastewater until a full batch is eventually discharged.

Wastewater for analysis of CECs was collected using a decontaminated stainless steel transfer container. The decontamination procedure involved a wash with soapy (Liquinox) water and

separate rinses with nitric acid, acetone, hexane, and methanol at Ecology Headquarters prior to sampling, following standard operating procedures in Friese (2014).

At each facility, equipment blank samples were collected first by pouring blank water provided by the laboratory into the clean transfer container, and from the transfer container into the respective sample bottles for each CEC parameter.

Wastewater effluent samples were collected following collection of equipment blank samples. Wastewater from the transfer container was poured into the respective sample bottles for each CEC parameter, following specific procedures determined by the analytical laboratories for each parameter.

The sample bottles were then stored in a cooler on ice until further processing. The samples were shipped on ice to the respective laboratories, along with completed chain of custody forms, as soon as possible after sampling.

Flows from each facility on the date of sampling were used to calculate instantaneous loads. The flows are shown in Table 2.

Table 2. Flows from each of the nine facilities on the dates sampled.

Facility Site ID	Sample Date	Flow (GPD)
A-Food Processing	3/3/2021	32,000
B-Metal Finishing	2/2/2021	1,500
C-Steel Foundry*	2/8/2021	280
D-Aerospace/Aircraft Modification	2/4/2021	2,000
E-Metal Finishing	1/25/2021	1,500
F-Aerospace/Aircraft Modification	3/3/2021	12,934
G-Landfill	3/30/2021	143,400
H-Industrial Laundry	3/9/2021	59,170
I-Ship Building and Repair	4/1/2021	409,300

*Average daily flow value when discharging
GPD = gallons per day

Changes from Original Quality Assurance Project Plan

Two facilities (Facilities G and H in the original QAPP) opted out of participation in the CEC sampling for this 2021 study, so we did not sample these facilities as originally planned. These were replaced by two facilities under the industry types of "Landfill" and "Industrial Laundry."

The original QAPP stated that wastewater would be collected using the sample bottles themselves. Instead, we collected wastewater using decontaminated transfer containers because (1) each facility had different setups for effluent sampling, and (2) the different sizes and shapes of the bottles for different parameters were not amenable to directly sampling the effluent.

Laboratory Methods

Samples were analyzed by SGS AXYS Analytical Services in Sidney, British Columbia, and by Ecology's Manchester Environmental Laboratory (MEL) in Port Orchard, WA. Table 3 summarizes the parameter, respective analytical laboratory, and laboratory method used in this study.

Table 3. List of CEC parameters analyzed in this study.

Parameter	Laboratory	Analytical Method
PCB Congeners	SGS AXYS	EPA 1668
PBDEs	SGS AXYS	EPA 1614
PFAS	SGS AXYS	MLA-110 Rev 02
OPFRs	MEL	EPA 8321B Mod
Alkylphenols	SGS AXYS	SGS AXYS Method MLA-004 Rev 07
Bisphenols	SGS AXYS	SGS AXYS Method MLA-113 Rev 01
SVOCs (BNA with TICs)	MEL	EPA 8270E

BNA = Base/Neutral/Acids
TICs = Tentatively Identified Compounds

PCB and PBDE samples were analyzed by high resolution gas chromatography/high resolution mass spectrometry for the 209 congeners. Target analytes (the individual compounds designated to be tested using the analytical method) for PFAS and SVOCs are provided in Appendix A and B, respectively. Target analytes for OPFRs, alkylphenols, and bisphenols are listed in Tables 7, 8, and 9, respectively.

Ancillary parameters were also collected as supporting data for CEC results. These included total suspended solids (TSS), total organic carbon (TOC), dissolved organic carbon (DOC), and hardness as $CaCO_3$. MEL analyzed all samples for these parameters using methods SM2540D, SM5310B, and SM2340B for TSS, TOC/DOC, and hardness, respectively. Conductivity, pH, and temperature were measured and recorded in the field using a calibrated YSI EXO sonde.

Data Reporting

Total concentrations for CECs were calculated as the sum of target analytes for each CEC group as a way to summarize the data. Data qualified as non-detect (U) were not included in total calculations. Data qualified as an estimate (J) or tentatively identified (NJ) were included in total calculations.

For each CEC group, measurement units were reported as they were reported in the original laboratory results sent by the laboratory (pg/L, ng/L, or µg/L). While it is useful to compare concentrations among samples within each CEC group, comparing concentrations among the different CEC groups is less meaningful.

Instantaneous total loads were also calculated using total concentration results and flow data from each facility to provide an indication of load on the day of sampling (Load = Concentration

x Flow). However, these load calculations do not necessarily represent each facility's average temporal loads. We reported the load results in units of pounds per day (lbs/day) because these units are more commonly used in the wastewater sector.

Quality Assurance/Quality Control

Field and laboratory quality control (QC) samples were collected and assessed against this project's measurement quality objectives (MQOs) to evaluate data quality (Wong, 2021).

QC results are briefly summarized below by parameter group. Table summaries of sample reporting limits for each CEC group are provided in Appendix C. MQO criteria for ancillary parameters (TSS, TOC, DOC, and hardness) were all met and are not summarized. The data validator reports and case narratives provide details about lab data quality and data qualifications; these are available upon request. Recommendations by the data validator for rejection of several data results were accepted. Overall, data were deemed usable to meet study objectives.

PCBs

Field Duplicate: All detected PCB congeners met the target MQO of ≤ 50% relative percent difference (RPD).

Equipment Blank: 79% of congeners were non-detect in the equipment blank. 21% of various congeners were estimated (J-qualified) or tentatively identified (NJ-qualified) in the equipment blank.

Method Blank: 86% of congener results met the target MQO. 14% of the results were qualified as non-detect (U) due to method blank contamination; i.e. > 5 times sample result value.

Laboratory Control Sample (LCS): All spiked congener results met the 60–135% method recovery criteria.

Surrogate Recovery: All surrogate results met the 5–145% recovery criteria.

PBDEs

Field Duplicate: 94% of PBDE congeners met the target MQO of ≤ 50% RPD. The RPD for congeners BDE-071 and 077 was >50%.

Equipment Blank: 98% of PBDE congeners were non-detect in the equipment blank. Congener BDE-203 was tentatively identified in the sample.

Method Blank: 95% of congener results met the target MQO. For samples from Facilities A and C, congeners BDE-047 and -099 were qualified as non-detect due to method blank contamination >5 x sample result value. For Facilities, A, C, and F, congener BDE-209 was also qualified as non-detect due to method blank contamination.

LCS: All spiked congener results met the 50–150% recovery criteria.

Surrogate Recovery: All surrogate results met the 25–150% recovery criteria.

PFAS

Field Duplicate: All detected PFAS analytes met the target MQO of ≤40% RPD.

Equipment Blank: All PFAS analytes were non-detect in the equipment blank.

Method Blank: Approximately 99% of PFAS analyte results met the target MQO. The following sample results were qualified as non-detect due to method blank contamination >5 x sample result value: PFDA in the samples from Facilities A and F; PFDoA in the sample from Facility A; and PFHxS in the sample from Facility H.

LCS: Analyte-specific recovery criteria were met, with the following exceptions for detected results. In samples from Facilities B, C, and E, EtFOSAA recovery was greater than the upper control limit of 140%, indicating potential high bias. Detected EtFOSAA results in the samples were qualified as an estimate (J).

Surrogate Recovery: Recovery criteria were met, with the following exceptions:

- Several labeled compounds were greater than the analyte-specific upper control limit, indicating potential low bias. Detected sample results were J-qualified, and included:
  - 4:2 FTS (Facility D)
  - 6:2 FTS (Facility G, Facility G-Field Duplicate, Facility H, Facility I)
  - 8:2 FTS (Facility G, Facility G-Field Duplicate, Facility F)
- Several labeled compounds were below the analyte-specific lower control limit, indicating potential high bias. Detected sample results were J-qualified, and included:
  - 4:2 FTS (Facility F)
  - PFBA (Facility A)
  - PFPeA (Facility A, Facility F)
  - PFTeDA (Facility A)
- Two labeled compounds were recovered below 20%, and the results were rejected. These included:
  - PFBA (Facility F)
  - N-EtFOSE (Facility H)

OPFRs

Field Duplicate: All OPFR analytes met the target MQO of ≤40% RPD.

Equipment Blank: 7 of 9 OPFR analytes were non-detect in the equipment blank. Phosphoric Acid Tributyl Ester and Phosphoric Acid Triethyl Ester were detected in the equipment blank.

Method Blank: 94% of OPFR analyte results met the target MQO. In several samples, Ethanol, 2-Butoxy-, Phosphate (3:1), Tricresyl phosphate, Tris(2-ethylhexyl) phosphate, Phosphoric Acid Triethyl Ester, Ethanol, 2-Butoxy-, Phosphate (3:1), and Phosphoric Acid Tributyl Ester were qualified as non-detect due to method blank contamination >10 x sample result value.

LCS: OPFR analytes met the 50–150% recovery criteria, with the following exceptions:

- Several analytes were greater than the upper control limit:
  - 2-Ethylhexyl diphenyl phosphate (Facility A, Facility F, Facility H)
  - Ethanol, 2-Butoxy-, Phosphate (3:1) (Facility A, Facility F, Facility H)
  - Tricresyl phosphate (Facility A, Facility F, Facility H)
  - Tris(1,3-dichloroisopropyl)phosphate (Facility B, Facility D, Facility E)
  - Tris(2-ethylhexyl) phosphate (Facility A, Facility F)
  - Tris[2,3-Dibromopropyl]Phosphate (Facility G, Facility H, Facility I)
- One analyte was below the lower control limit:
  - Tris[2,3-Dibromopropyl]Phosphate (Facility C)

Surrogate Recovery: OPFR analytes met the 40–140% recovery criteria, with the following exceptions:

- Several analytes were greater than the upper control limit:
  - Tris(2-chloroisopropyl)phosphate D18 (Facility E)
- Several analytes were below the lower control limit:
  - Carbofuran C13 (Facility H)
  - Triethyl Phosphate D15 (Facility A, Facility B, Facility C, Facility D, Facility D-Field Duplicate, Facility D-Equipment Blank, Facility F, Facility G)
  - Tributyl Phosphate D27 (Facility A, Facility D)
  - Triphenyl Phosphate D15 (Facility D, Facility D-Field Duplicate, Facility G)
  - Tripropyl Phosphate D21 (Facility D, Facility D-Field Duplicate, Facility D-Equipment Blank, Facility F)
  - Tris(2-Chloroethyl) Phosphate D12 (Facility D, Facility D-Field Duplicate)
  - Tris(2-chloroisopropyl)phosphate D18 (Facility D, Facility D-Field Duplicate)
  - Tributyl Phosphate D27 (Facility D-Field Duplicate)
  - Tris(1,3-dichloroisopropyl)phosphate D15 (Facility D-Field Duplicate)

Alkylphenols

Field Duplicate: 3 of 4 alkylphenol analytes met the target MQO of ≤40% RPD. Nonylphenol was >40% RPD.

Equipment Blank: All alkylphenol analytes were non-detect in the equipment blank.

Method Blank: No alkylphenol analytes were qualified due to method blank contamination >5 x sample result value.

LCS: All analytes met the analyte-specific recovery criteria.

Surrogate Recovery: All surrogate results met the analyte-specific recovery criteria.

Bisphenols

Field Duplicate: All bisphenol analytes met the target MQO of ≤40% RPD.

Equipment Blank: All bisphenol analytes were non-detect in the equipment blank.

Method Blank: No bisphenol analytes were qualified due to method blank contamination >5 x sample result value.

LCS: All bisphenol analytes met the analyte-specific recovery criteria.

Surrogate Recovery: Recovery criteria were met, with the exceptions listed below:

- Several labeled compounds were greater than the analyte-specific upper control limit, indicating potential low bias. Detected sample results were J-qualified, and included:
  - Bisphenol S (Facility D)
  - Bisphenol F (Facility D)
- Several labeled compounds were below the analyte-specific lower control limit, indicating potential high bias. Detected sample results were J-qualified, and included:
  - Bisphenol S (Facility B, Facility B-Field Duplicate, Facility B, Facility B-Equipment Blank, Facility S)
  - Bisphenol F (Facility F, Facility H, Facility I)
  - Bisphenol A (Facility G, Facility H, Facility I)

The sample from Facility D was extracted outside of the 7-day holding time. Non-detected results (Bisphenol B, E, and AF) were rejected, and detected results were qualified J.

SVOCs

Field Duplicate: 97% of SVOC analytes met the target MQO of ≤40% RPD. 1,4-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester and dimethyl phthalate had > 40% RDP.

Equipment Blank: 2 of 80 SVOC analytes were tentatively identified in the equipment blank (Oleic Acid and an Unknown Hydrocarbon).

Method Blank: The target MQO was met with one exception. Bis(2-Ethylhexyl) Phthalate in one sample (Facility C) had a sample result that was qualified as non-detect due to method blank contamination > 5 x sample result value. Except for Tris(2-chloroethyl) phosphate (TCEP), analytes from the phthalate group were the only SVOC analytes with qualified detections in the method blank.

LCS: All SVOC analytes met analyte-specific recovery criteria.

Surrogate Recovery: SVOC analyte results met the 40–140% recovery criteria, with the following exceptions:

- Several surrogate analytes were greater than the upper control limit:
  - 2-Fluorobiphenyl (Facility A, Facility C, Facility D)
  - 2-Nitrophenol-D4 (Facility F)
  - 4,6-Dinitro-2-methylphenol-D2 (Facility H)
- Several surrogate analytes were below the lower control limit:
  - 4-Chloroaniline-D4 (Facility B, Facility D, Facility E, Facility E-Equipment Blank, Facility F, Facility G, Facility H)
  - 4,6-Dinitro-2-methylphenol-D2 (Facility D, Facility E-Equip Blank)
  - 4-Methylphenol-D8 (Facility A, Facility D, Facility H)
  - 2-Nitrophenol-D4 (Facility H)
  - 4-Nitrophenol-D4 (Facility A, Facility D, Facility F, Facility H)
  - 4-Methylphenol-D8 (Facility H)
  - Nitrobenzene-D5 (Facility D, Facility H)
  - Phenol-D5 (Facility D)
  - 2,4-Dichlorophenol-D3 (Facility A)
  - 2-Chlorophenol-D4 (Facility A, Facility H, Facility I)
  - 2-Fluorophenol (Facility A, Facility H)
  - Acenaphthylene-D8 (Facility A, Facility H)
  - Bis(2-Chloroethyl)Ether-D8 (Facility A, Facility F, Facility G, Facility H, Facility I)
  - Phenol-D5 (Facility A, Facility H)
  - Fluorene-D10 (Facility F)
  - Terphenyl-D14 (Facility I)

Results

PCBs

PCBs were detected in samples from all nine facilities, with total PCB (sum of 209 congeners) concentrations ranging from 64–168,000 pg/L (Table 4). The Industrial Laundry (Facility H) sample had the highest total PCB concentration, followed by the Landfill (Facility G) and Aerospace/Aircraft Modification (Facility D) samples. Estimated instantaneous total PCB loads were highest at the Industrial Laundry and Landfill facilities. The two lowest total PCB concentrations and loads were observed at the Metal Finishing (Facility E) and Steel Foundry (Facility C) facilities.

In many of the samples, the penta- and hexa- homolog groups comprised a large proportion of the total PCB (Figure 2). Within the penta- group, PCB-118 and several co-elutions were frequently detected at the highest relative concentrations (PCB-110/115, PCB-090/101/113, PCB-093/095/098/100/102, and PCB-090/101/113). Within the hexa- group, several co-elutions (PCB 129/138/160/163, PCB 147/149, and PCB-153/158) had the highest relative concentrations among samples.

Within the di- group, PCB-011 was detected at the highest relative concentration in samples from Facilities H, D, and B.

Table 4. Total PCB concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low.

Facility Site ID	Total PCB Concentration (pg/L)	Total PCB Instantaneous Load (lbs/day)
H-Industrial Laundry	168,000	0.0000828
G-Landfill	36,500	0.0000435
D-Aerospace/Aircraft Modification	14,100	0.000000235
I-Ship Building and Repair	3,740	0.0000128
B-Metal Finishing	1,490	0.0000000186
F-Aerospace/Aircraft Modification	438	0.0000000472
A-Food Processing	258	0.0000000687
C-Steel Foundry	165	0.000000000384
E-Metal Finishing	64	0.000000000803

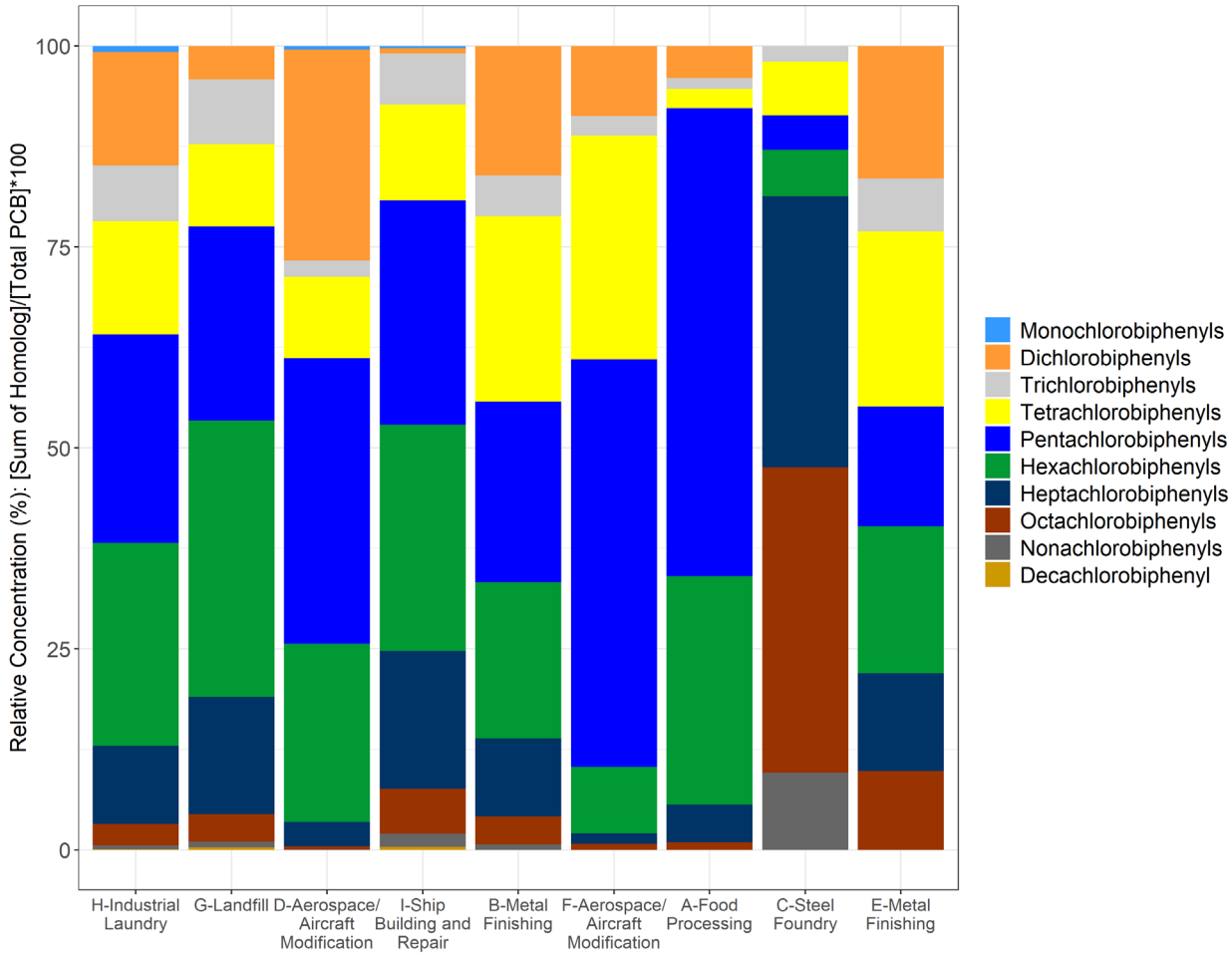

Figure 2. Relative PCB homolog concentrations in wastewater from the nine sampled facilities.

Organized left to right by the total concentration from high to low (Table 4).

PBDEs

PBDEs were detected in samples from all nine facilities, with total PBDE (sum of 209 congeners) concentrations ranging from 29–3,490,000 pg/L (Table 5). The Industrial Laundry (Facility H) sample had the highest total PBDE concentration, followed by the Aerospace/ Aircraft Modification (Facility D) and Landfill (Facility G) samples. Estimated instantaneous total PBDE load was highest at the Industrial Laundry facility, followed by the Landfill and Ship Building and Repair (Facility I) facilities.

The tetra-, penta- and deca-BDE homolog groups were most represented among all of the samples (Figure 3). BDE-209, -047, and -099 were the most frequently detected congeners, with BDE-209 being the dominant congener in the samples. In the three samples with the lowest BDE-concentrations in this study (Facility A, C, and F), BDE-209 was detected and was the dominant congener in the sample; however, the result was qualified as non-detect due to method blank contamination >5 x the sample result value (Figure 4). Similarly, BDE-047 and -099 were

detected in the samples from Facilities A and C, but the result was qualified as non-detect due to method blank contamination.

Frequent detections of nona-BDE congeners across samples is also notable. BDE-206 and -207 were detected in samples from Facilities A and C, but the result was qualified as non-detect due to method blank contamination.

Overall, the congener pattern across the nine industrial samples was fairly consistent, regardless of concentration and industry type. This pattern deviated in samples with lower total PBDE concentrations (Facilities A, C, and F), in which frequently detected congeners were qualified as non-detect due to method blank contamination.

Table 5. Total PBDE concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low.

Facility Site ID	Total PBDE Concentration (pg/L)	Total PBDE Instantaneous Load (lbs/day)
H-Industrial Laundry	3,490,000	0.00172
D-Aerospace/Aircraft Modification	167,000	0.00000278
G-Landfill	104,000	0.000124
I-Ship Building and Repair	13,400	0.0000457
E-Metal Finishing	9,200	0.000000115
B-Metal Finishing	4,110	0.0000000514
F-Aerospace/Aircraft Modification	471	0.0000000507
C-Steel Foundry	52	0.000000000122
A-Food Processing	29	0.00000000767

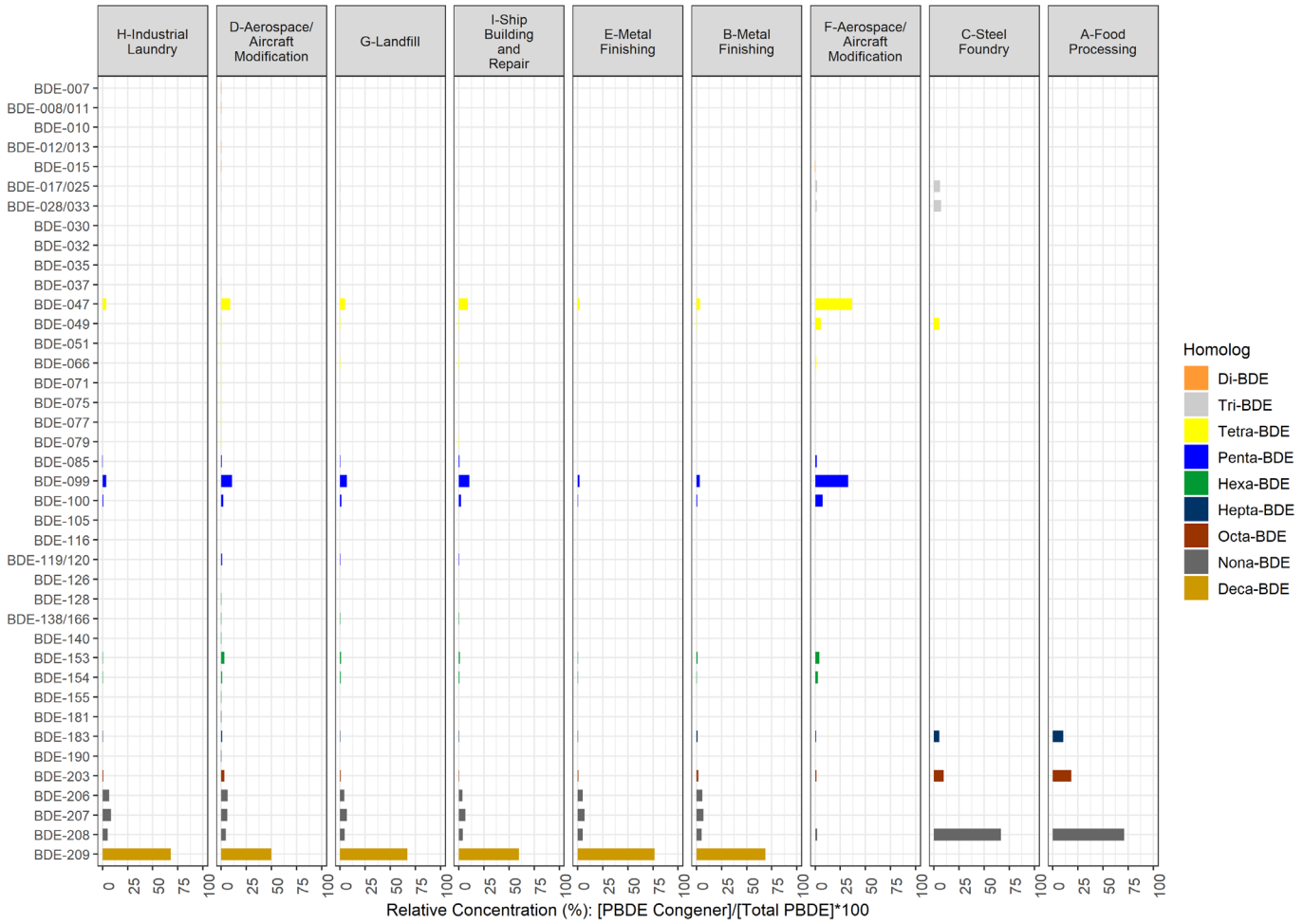

Figure 3. Relative PBDE congener concentration in wastewater from the nine sampled facilities. Organized left to right by the total concentration from high to low (Table 5).

PFAS

PFAS were detected at all nine facilities, with total PFAS concentrations (sum of 40 PFAS analytes) ranging from 4–9,840 ng/L (Table 6). The two Aerospace/Aircraft Modification samples (Facilities F and D) had the highest total PFAS concentrations, both >9,000 ng/L. The highest PFOA concentrations were also observed in the two Aerospace/Aircraft Modification samples at 703 and 212 ng/L. The highest PFOS concentrations were observed in the Metal Finishing (Facility E) and Industrial Laundry (Facility H) samples at 65 and 25 ng/L, respectively.

Table 6. Total PFAS concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low. Values in parentheses indicate the detection limit.

Facility Site ID	Total PFAS (ng/L)	Total PFAS Instantaneous Load (lbs/day)	PFOS (ng/L)	PFOA (ng/L)
F-Aerospace/Aircraft Modification	9,840	0.00106	3	212
D-Aerospace/Aircraft Modification	9,430	0.000157	4	703
G-Landfill	503	0.000601	19	89
A-Food Processing	353	0.0000941	nd (<0.19)	nd (<0.19)
H-Industrial Laundry	190	0.0000938	25	7
E-Metal Finishing	105	0.00000131	65	1
I-Ship Building and Repair	37	0.000125	17	4
B-Metal Finishing	7	0.0000000837	nd (<0.198)	nd (<0.221)
C-Steel Foundry	4	0.00000000855	nd (<0.194)	nd (<0.194)

nd = non-detect

Estimated instantaneous total PFAS loads were highest in the Aerospace/Aircraft Modification (Facility F) and the Landfill (Facility G) samples, followed by samples collected from Aerospace/Aircraft Modification (Facility D) and Ship Building and Repair (Facility I). The lowest total PFAS concentrations and loads were observed in the Steel Foundry facility (Facility C) and Metal Finishing (Facility B) samples.

Across samples, the perfluorocarboxylic acids (PFCAs)—in particular PFBA, PFPeA, PFHxA, PFHpA, and PFOA—generally had more detections and higher relative concentrations than other PFAS groups (Figure 4). Among the perfluorosulfonic acids (PFSAs), PFOS, PFBS, and PFHxS had the highest relative concentrations and detection frequencies. In the Metal Finishing (Facility E) and Shipbuilding and Repair (Facility I) samples, PFOS had the highest relative concentration among all PFAS analytes.

PFAS precursor compounds, including the fluorotelomer and perfluorooctane sulfonamide/sulfonamido compounds, were less frequently detected and had lower relative concentrations. The exceptions were 6:2 FTS and 5:3 FTCA in some samples. For example,

6:2 FTS had the highest relative concentration in the two Aerospace/Aircraft Modification samples and the Industrial Laundry sample.

The following PFAS analytes were not detected in any samples: PFNS, PFESA, PFMBA, NFDHA, N-MeFOSA, N-EtFOSA, N-MeFOSE, N-EtFOSE, GenX, ADONA, F53B Major, and F53B Minor.

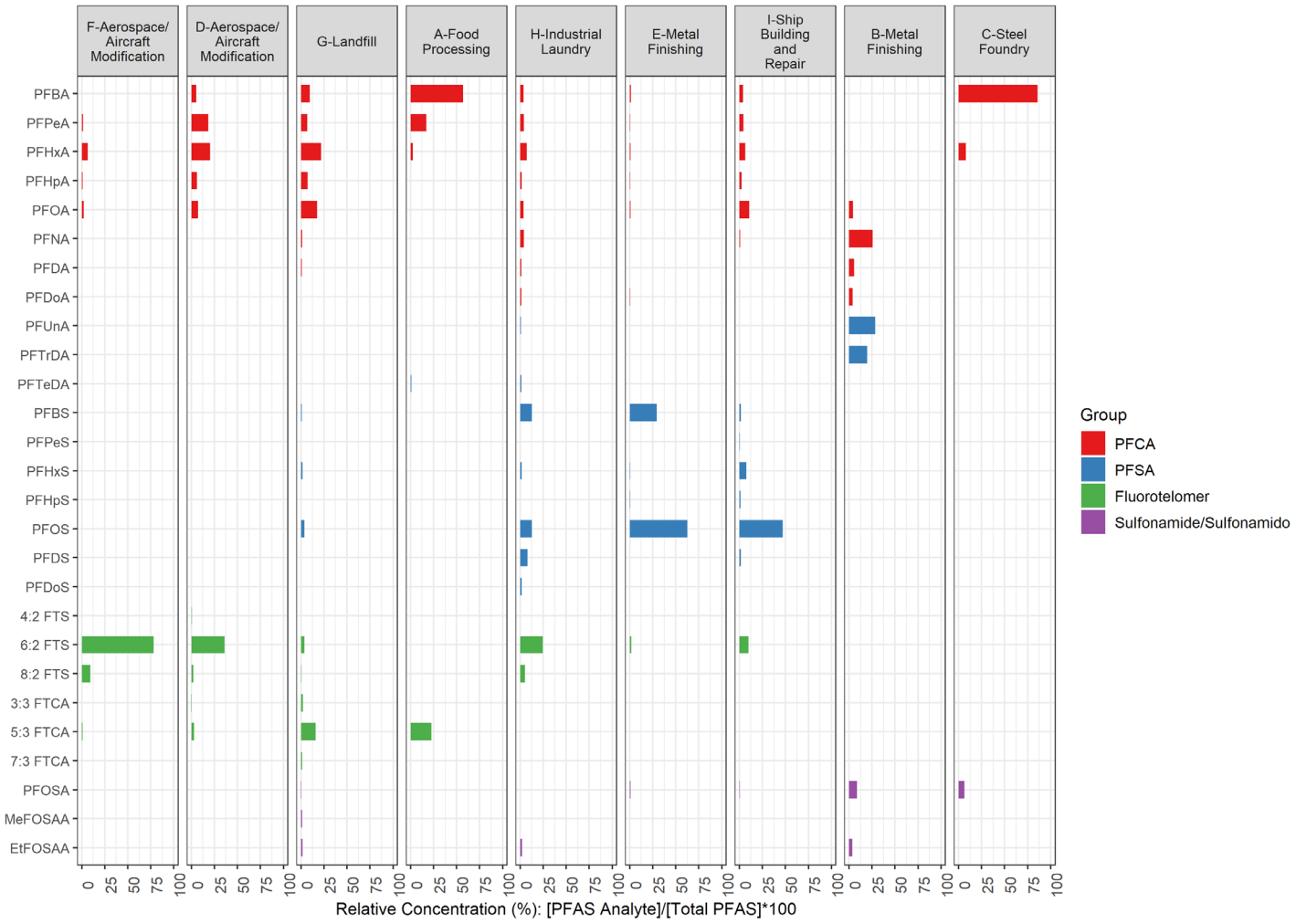

Figure 4. Relative PFAS analyte concentrations in wastewater from the nine sampled facilities

Organized left to right by the total concentration from high to low (Table 6).
Analytes that were not detected in any samples are not included in this plot.
PFCA = perfluorocarboxylic acid.
PFSA = perfluorosulfonic acid.

OPFRs

Total OPFR (sum of 12 OPFR analytes) concentrations ranged from 35–29,800,00 ng/L (Table 7). The highest total OPFR concentration was observed in the Aerospace/Aircraft Modification (Facility D) sample, followed by the Industrial Laundry (Facility H) sample. In these two samples, the analyte tri-n-butyl phosphate (TnBP) comprised almost all of the total OPFR. The discharge from those two facilities also had the highest estimated instantaneous total OPFR load.

Detections and concentrations of the different OPFR analytes varied across samples. The analytes with the highest observed concentrations were TnBP, tricresyl phosphate (TCP), and ethanol, 2-butoxy-, phosphate (3:1) (TBEP). Tris(2-chloroisopropyl)phosphate (TCIPP) and tris(2-chloroethyl) phosphate (TCEP) were also frequently detected at high concentrations, relative to this study. The analytes with the lowest OPFR concentrations across samples were tripropyl phosphate (TPP) and V6, which had concentrations <250 ng/L.

Table 7. OPFR concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low. Values in parentheses indicate the reporting limit. Values qualified as U or UJ indicate that the analyte was detected above the reporting limit, but the result was qualified as non-detect for other reasons.

Facility	Total OPFR Concen-tration (ng/L)	Total OPFR Instantan-eous Load (lbs/day)	EHDPP	TBEP	TCEP	TCIPP	TCP	TDBPP	TDCIPP	TEHP	TEP	TnBP	TPP	V6
-Aerospace/ Aircraft Modification	29,800,000	0.497	531	5,480	238	23,900	6,090	nd (<5.03)	nd (<5.03)	65	169	29,800,000	127	84
H-Industrial Laundry	4,120,000	2.03	7,410	138,000	1,920	5,350	94,500	13,800	1,960	22,900	612	3,830,000	nd (<174)	nd (<174)
F-Aerospace/ Aircraft Modification	38,500	0.00415	nd (<0.5)	632	35,000	1,090	nd (<1)	nd (<5)	135	nd (<0.5)	15	1,630	4	9
E-Metal Finishing	13,400	0.000167	10	12.4 (U)	nd (<0.172)	2,090	1.91 (U)	nd (<5.32)	73	0.57 (U)	11,200	31	nd (<0.532)	nd (<0.532)
I-Ship Building and Repair	7,910	0.027	nd (<0.543)	5,530	1,720	252	84	nd (<5.43)	69	8	10	16	nd (<0.543)	223
G-Landfill	3,000	0.00358	189	379	384	1,050	97	64	177	83	465	79	nd (<0.521)	29
C-Steel Foundry	400	9.33E-07	1	111	nd (<0.192)	213	20	19	15	21	3.03 (UJ)	15 (U)	nd (<0.51)	nd (<0.51)
A-Food Processing	171	0.0000455	nd (<0.495)	7.88 (U)	112	51	nd (<0.99)	nd (<4.95)	nd (<4.95)	nd (<0.495)	8	5.86 (UJ)	nd (<0.495)	nd (<0.495)
B-Metal Finishing	35	4.33E-07	3	nd (<0.61)	nd (<0.192)	29	nd (<0.61)	nd (<6.1)	1.22 (U)	1.22	30	nd (<0.61)	nd (<0.61)	nd (<0.61)

nd = non-detect

EHDPP = 2-Ethylhexyl diphenyl phosphate

TBEP = Ethanol, 2-Butoxy-, Phosphate (3:1)

TCEP = Tris(2-chloroethyl) phosphate

TCIPP = Tris(2-chloroisopropyl)phosphate

TCP = Tricresyl phosphate

TDBPP = Tris[2,3-Dibromopropyl]Phosphate

TDCIPP = Tris(1,3-dichloroisopropyl)phosphate

TEHP = Tris(2-ethylhexyl) phosphate

TEP = Triethyl phosphate

TnBP = tri-n-butyl phosphate

TPP = Tripropyl Phosphate

Alkylphenols

Total alkylphenols (sum of 4 analytes) ranged from 79–2,430,000 ng/L among the nine facilities sampled (Table 8). The highest concentrations were observed in the Aerospace/Aircraft Modification (Facility D) sample, followed by samples from the Metal Finishing (Facility E) and Aerospace/Aircraft Modification (Facility F) facilities. The highest estimated instantaneous total alkylphenol load was observed in the Ship Building and Repair (Facility I) sample, followed by the Aerospace/Aircraft Modification (Facility D) sample. Alkylphenols were not detected in the Food Processing (Facility A) sample.

4-Nonylphenol was detected at 8 facilities, while 4-nonylphenol monoethoxylate and 4-nonylphenol diethoxylate were present in samples from 6 facilities. 4-n-octylphenol was not detected in any samples.

Table 8. Alkylphenol concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low. Values in parentheses indicate the detection limit.

Facility Site ID	Total Alkyl-phenols (ng/L)	Total Alkylphenol Instantaneous Load (lbs/day)	4-Nonylphenol (ng/L)	4-Nonylphenol monoethoxylate (ng/L)	4-Nonylphenol diethoxylate (ng/L)	4-n-Octylphenol (ng/L)
D-Aerospace/Aircraft Modification	2,430,000	0.0404	1,360,000	533,000	534,000	nd (<91.7)
E-Metal Finishing	65,900	0.000823	816	6,270	58,800	nd (<1.15)
F-Aerospace/Aircraft Modification	50,300	0.00542	19,400	17,400	13,500	nd (<7.55)
I-Ship Building and Repair	36,600	0.125	3,800	17,200	15,600	nd (<4.91)
H-Industrial Laundry	19,400	0.00955	8,220	7,400	3,760	nd (<109)
G-Landfill	3,290	0.00000119	2,210	788	290	nd (<3.29)
B-Metal Finishing	454	0.00000567	454	nd (<28.2)	nd (<6.03)	nd (<1.41)
C-Steel Foundry	79	0.000000184	79	nd (<6.98)	nd (<13.7)	nd (<0.67)
A-Food Processing	0	0	nd (<79.3)	nd (<25.9)	nd (<5.47)	nd (<3.41)

Bisphenols

Total bisphenol concentrations ranged from 225–36,500 ng/L among the nine sampled facilities (Table 9). The highest total concentrations were observed in the Industrial Laundry (Facility H) sample, followed by the Aerospace/Aircraft Modification (Facility D) sample. The highest estimated instantaneous total bisphenol load was observed at the Industrial Laundry facility, followed by the Landfill (Facility G) and Ship Building and Repair facility (Facility I).

Bisphenol A was the only bisphenol analyte detected in all nine samples. Bisphenol A was the dominant bisphenol analyte in all of the samples except for the Landfill, in which bisphenol S was the dominant bisphenol. Bisphenols S and F were detected in most samples. Bisphenols B and E were not detected in any sample.

Table 9. Bisphenol concentrations and estimated instantaneous loads in wastewater from the nine sampled facilities.

Organized by total concentration values from high to low. Values in parentheses indicate the detection limit.

Facility Site ID	Total Bisphenols (ng/L)	Total Bisphenol Instantaneous Load (lbs/day)	Bisphenol A (ng/L)	Bisphenol AF (ng/L)	Bisphenol B (ng/L)	Bisphenol E (ng/L)	Bisphenol F (ng/L)	Bisphenol S (ng/L)
H-Industrial Laundry	36,500	0.0180	21,700	19	nd (<4.05)	nd (<9.54)	363	14,400
D-Aerospace/ Aircraft Modification	12,400	0.000206	11,100	Rej	Rej	Rej	932	319
B-Metal Finishing	1,610	0.0000201	1,580	nd (<3.94)	nd (<3.94)	nd (<9.84)	nd (<9.84)	33
F-Aerospace/ Aircraft Modification	1,370	0.000148	1,200	nd (<3.85)	nd (<3.85)	nd (<28.9)	171	nd (<2.41)
G-Landfill	1,180	0.00141	127	nd (<3.66)	nd (<6.97)	nd (<9.15)	nd (<13.8)	1,050
I-Ship Building and Repair	312	0.00106	263	nd (<3.8)	nd (<3.8)	nd (<9.5)	12	36
C-Steel Foundry	241	0.00000056	178	nd (<3.71)	nd (<3.71)	nd (<9.27)	63	nd (<2.32)
A-Food Processing	227	0.0000606	210	nd (<3.86)	nd (<3.86)	nd (<9.66)	nd (<9.66)	17
E-Metal Finishing	225	0.00000281	203	nd (<3.92)	nd (<3.92)	nd (<9.8)	12	10

nd = non-detect
Rej = Result rejected

SVOCs

The occurrence and concentrations of SVOC analytes varied across the nine samples (Figures 5 and 6). Benzoic acid and phenol were detected in 6 of 9 samples, and were the most frequently detected SVOC analytes measured. The highest SVOC analyte concentration observed was benzyl alcohol (363,000 µg/L; Figure 6), followed by benzoic acid (63,400 µg/L), both in the Aerospace/Aircraft Modification (Facility D) sample.

Different phthalate analytes were detected among the samples. The highest phthalate concentrations observed were bis(2-Ethylhexyl) Phthalate in the Industrial Laundry (Facility H) sample (~125 µg/L) and Di-N-Butylphthalate in the Steel Foundry (Facility C) sample (~60 µg/L) (Figure 5).

Among the nine facilities, PAH analytes were primarily present in the Landfill (Facility G) sample, with concentrations <1 µg/L.

The lowest concentrations of all SVOCs were generally observed in the samples from the Landfill, Metal Finishing, Steel Foundry, and Food Processing facilities (Facilities G, E, C, and A, respectively; Figures 5 and 6). In general, occurrences of the 154 target SVOC analytes were variable based on analyte and facility.

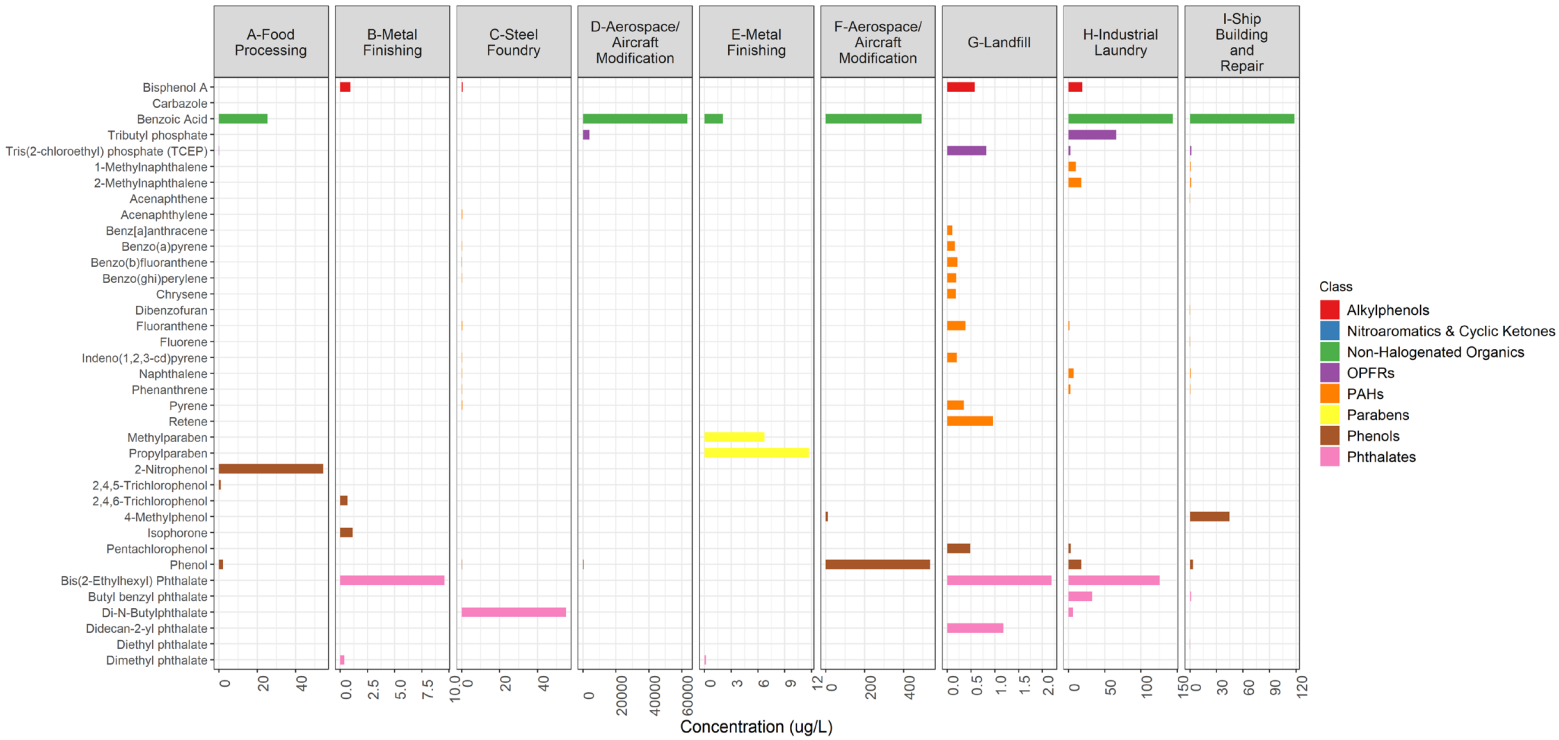

Figure 5. Concentrations of SVOC analytes in wastewater at the nine sampled facilities.

Grouped by several common chemical classes. Note the differences in scale at the bottom.

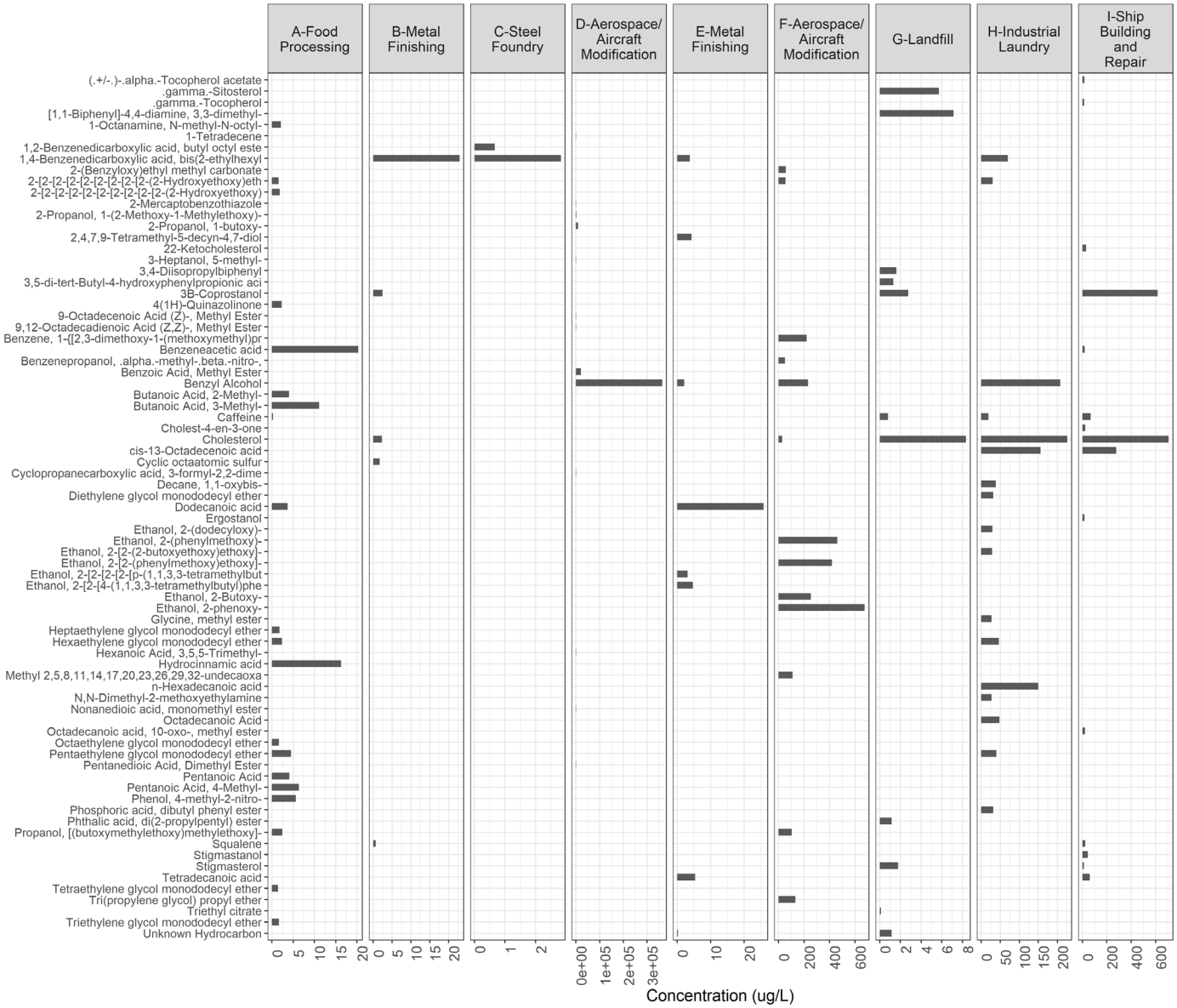

Figure 6. Concentrations of other SVOC analytes not categorized in Figure 5.

Note the differences in scale at the bottom.

Ancillary Parameters

Results for ancillary parameters are provided in Table 10.

Table 10. Results for ancillary parameters.

Facility Site ID	DOC (mg/L)	TOC (mg/L)	Hardness (mg/L as CaCO3)	TSS (mg/L)	Tempe-rature (°C)	Specific Conductance (µS/cm)	pH
A-Food Processing	249	277	96.2	124	19.6	1,242	9.77
B-Metal Finishing	13.4	17.2	64	6,520	22.8	660	9.46
C-Steel Foundry	1.87	2.91	57.8	9	4.5	163	8.02
D-Aerospace/ Aircraft Modification	1,290	1,330	334	8	17.8	1780	7.82
E-Metal Finishing	31.1	35	16.9	67	8.21	655	8.7
F-Aerospace/ Aircraft Modification	170	166	11.5	30	14	5,017	7.85
G-Landfill	11.3	13.8	248	628	8.73	1,078	7.6
H-Industrial Laundry	530	860	2.2	1,172	32.6	1,308	7.99
I-Ship Building and Repair	27.7	35.8	1,670	54	13.5	17,171	7.72

Discussion

A summary of total concentrations for each CEC group from each facility is provided in Table 11. Various CECs in this screening study—PCBs, PBDEs, PFAS, OPFRs, alkylphenols, and bisphenol A—were detected in samples from all nine facilities with wide concentration ranges.

Table 11. Total CEC concentrations in samples collected from all nine facilities.

Facility Site ID	Total PCB (pg/L)	Total PBDE (pg/L)	Total PFAS (ng/L)	Total OPFR (ng/L)	Total Alkylphenol (ng/L)	Total Bisphenol (ng/L)	Total SVOC (µg/L)
Facility A-Food Processing	258	29	353	171	0	227	178
Facility B-Metal Finishing	1,490	4,110	7	35	454	1,610	22
Facility C-Steel Foundry	165	52	4	400	79	241	61
Facility D-Aerospace/Aircraft Modification	14,100	167,000	9,430	29,800,000	2,430,000	12,400	470,680
Facility E-Metal Finishing	64	9,200	105	13,400	65,900	225	70
Facility F-Aerospace/Aircraft Modification	438	471	9,840	38,500	50,300	1,370	3,845
Facility G-Landfill	36,500	104,000	503	3,000	3,290	1,180	40
Facility H-Industrial Laundry	168,000	3,490,000	190	4,120,000	19,400	36,500	1,663
Facility I-Ship Building and Repair	3,740	13,400	37	7,910	36,600	312	2,121

Summary of CECs

In comparing the samples across industry types, the Industrial Laundry tended to have among the highest instantaneous loads and concentrations of the various CECs, particularly for PCBs, PBDEs, OPFRs, and bisphenols A and S. The presence of flame retardants in laundry wastewater has been documented in prior studies. For example, Schreder and Guardia (2014) concluded from their study of a suite of flame retardants (including PBDEs and various OPFRs) in residential household dust, laundry wastewater, and receiving POTWs, that laundry wastewater could be a primary source to the receiving wastewater treatment plants (WWTPs). Their study suggested the primary mechanism is flame retardants escaping from household products and collecting onto household dust and clothes, which then become washed off into the wastewater stream when laundered.

Although the study by Schreder and Guardia (2014) looked at domestic wastewater, the general mechanism by which flame retardants might make their way to the POTW could be applicable to industrial processes as well.

The sample from the Landfill also tended to have high CEC concentrations and loads in this study, particularly for PCBs, PBDEs, and PFAS. The occurrence of CECs in landfill leachate has

been well documented in previous studies (Li et al. 2012, Masoner et al. 2014, Propp et al. 2021). It is thought that products containing the chemicals are disposed of in landfills, and because many of these chemicals do not break down easily in the environment, they continue to exist in the landfills for many years, or exit the landfill as leachate which is commonly directed to a POTW.

PCBs

Although the manufacture of PCBs has been largely banned in the United States since 1979, they still exist in some products and equipment developed before the ban, and can still be found as inadvertently created compounds in many consumer products. In this study, PCBs were present at higher concentrations in samples from several facilities as compared to treated effluent samples from POTWs. For example, Ecology and Herrera (2010) observed total PCB concentrations in samples of treated discharge from six Puget Sound POTWs ranging roughly from 100–10,000 pg/L. Total PCB concentrations in industrial discharges to the POTW from this study ranged from 64–168,000 pg/L. The high concentrations from several of the industrial discharges suggest that legacy contamination or inadvertent production of PCBs (Ecology and Herrera 2010, Rodenburg et al. 2014) from the facilities remains a source to the receiving POTWs.

PBDEs

Although some PBDEs have been phased out of U.S. production (e.g., pentaBDEs), they were observed at higher concentrations in samples from several of the facilities as compared to treated effluent samples from POTWs. Ecology and Herrera (2010) observed total PBDE concentrations in samples of treated discharge from 10 Puget Sound POTWs ranging from about 8,600–135,000 pg/L. In this study, total PBDE concentrations ranged from 29–3,490,000 pg/L in the industrial samples. The dominance of three congeners (BDE-047, -099, and -209) found in this study was also observed in POTW samples from Ecology and Herrera (2010), comprising 69–82% of the total PBDE loadings from each of the POTWs sampled. This study highlighted the dominance of BDE-209 in the industrial samples, which alone comprised about 50–77% of the total PBDE.

PFAS

The highest total PFAS concentrations were found in the Aerospace/Aircraft Modification samples (Facilities F and D). Compared to other samples taken during this study, these samples were characterized by the relatively high contribution of 6:2 FTS to the total PFAS. 6:2 FTS is used as an alternative to PFOS and PFOA as an active ingredient in fire-fighting foams, as well as a mist suppressant in chrome plating (Bao et al. 2021).

OPFRs

OPFR concentrations were highest in the Aerospace/Aircraft Modification and Industrial Laundry samples, with the primary constituent being tri-n-butyl phosphate. Major uses of tri-n- butyl phosphate in industrial applications include: serving as a component of aircraft hydraulic fluid and brake fluid; a de-foaming agent in detergent solutions, ethylene glycol-borax antifreeze solutions, and latex paints; a foaming and corrosion inhibitor in chromium plating; and a wetting agent in textile and adhesive manufacturing.

Alkylphenols

Alkylphenols (4-nonylphenol and 4-nonylphenol ethoxylates) were detected at all facilities except for the Food Processing facility, again with a wide range in concentration.

The highest concentrations of alkylphenols (4-nonylphenol and 4-nonylphenol ethoxylates) were found in the Aerospace/Aircraft Modification (Facilities D & F), Metal Finishing (Facility E), Ship Building and Repair, and Industrial Laundry samples. In a study of treated effluent from five Puget Sound POTWs, 4-nonylphenol influent concentrations ranged from non-detect to 400 ng/L (Lubliner et al. 2010). The occurrence of 4-nonylphenol has been frequently detected in POTW influent and treated effluent worldwide (Mao et al. 2012).

Bisphenols

Bisphenol A has also been frequently detected in POTW influent and treated effluent. Bisphenol A concentrations ranged from non-detect to 44,000 ng/L in a study of five Puget Sound WWTPs (Lubliner et al. 2010). The occurrence of bisphenol A in the industrial samples may be attributable to its widespread use in various industrial applications (Mohapatra et al. 2011).

Study Limitations

Overall, this study was a small representation of industry types that discharge to POTWs in the Puget Sound region. The sampling of a range of different CEC parameters from different industry types provided valuable data and information. However, results from this study do not necessarily reflect all individual industrial users within the industry types represented in this study. Furthermore, the results represent one grab sample collected from each facility on one given day. It is possible that concentrations and loads exhibit temporal variability; however, we did not evaluate this. Because of the limited scope, an assessment of relative loads and load contributions to the receiving POTWs over the longer term is difficult to make. In addition, many other industry types in the study area have the potential to carry measurable amounts of CECs in their wastewater discharges; these were not evaluated in this study.

Conclusions

This screening-level study demonstrated that CECs (PCBs, PBDEs, PFAS, OPFRs, alkylphenols, bisphenol A) are present in quantifiable concentrations in industrial discharges to the receiving POTWs. Wide ranges in CEC concentrations were observed in industrial discharge samples collected from nine facilities that represented seven different industry types. The study documented analyte concentrations within each class of CECs, which may be useful for identifying origins and mechanisms by which the CECs enter into the wastewater stream. While limited in scope, the screening-level study overall provided unique and valuable results.

Recommendations

Results of this 2021 study support the following recommendations for additional research:

- A comprehensive evaluation of CECs in industrial wastewaters could include:
  - Time series sampling at each facility. This would help to assess variability and make more accurate evaluations of load contribution over a longer time period.
  - Addition of other major industry types in the Puget Sound region that discharge to POTWs. Sampling of more than one facility per industry type would also help in assessing whether there are any patterns based on industry type.
  - Sampling of concurrent POTW influent and treated effluent would provide information to assess load contributions to the receiving POTWs.
- Sampling of CECs from non-industrial wastewater sources, such as households, would be useful in assessing relative CEC load contributions originating from industrial and domestic wastewaters. For example, based on results from the Industrial Laundry sample, domestic/household laundering could be an important pathway by which flame retardants enter the wastewater stream. However, it is unclear whether the result from this study is specific to the facility sampled, certain industrial laundry processes that are used, or general laundering.
- Working with industrial users to identify specific origins, processes, and pathways by which CECs enter their wastewater discharges would inform actions to prevent or minimize the introduction of CECs into the industrial wastewater.

References

ATSDR [Agency for Toxic Substances and Disease Registry]. 1996. ToxFAQs™ for Polycyclic Aromatic Hydrocarbons (PAHs). Agency for Toxic Substances and Disease Registry, Atlanta, GA. https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=121&tid=25

ATSDR [Agency for Toxic Substances and Disease Registry]. 2018. Toxicological Profile for Perfluoroalkyls. https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf.

Bao, Y., S. Deng, G. Cagnetta, J. Huang, and G. Yu. 2021. Role of Hydrogenated Moiety in Redox Treatability of 6:2 Fluorotelomer Sulfonic Acid in Chrome Mist Suppressant Solution. *Journal of Hazardous Materials*, 408(10):124875.

Ben-Jonathan and Hugo. 2016. Bisphenols Come in Different Flavors: Is "S" Better Than "A" Endocrinology, 157(4):1321–1323. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4816743/

Bothfeld, F. 2021. Contaminants of Emerging Concern and Wastewater Treatment. Publication 21-10-006. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/2110006.html

California Environmental Protection Agency. 2009. Toxicological Profile For Nonylphenol. Office of Environmental Health Hazard Assessment, Integrated Risk Assessment Branch. http://www.opc.ca.gov/webmaster/ftp/project_pages/MarineDebris_OEHHA_ToxProfiles/Nonylphenol%20Final.pdf

Davies, H. 2015. PCB Chemical Action Plan. Publication 15-07-002. Washington State Department of Ecology, Olympia, WA. https://apps.ecology.wa.gov/publications/documents/1507002.pdf

Ecology and Herrera Environmental Consultants. 2010. Summary Technical Report, Control of Toxic Chemicals in Puget Sound, Phase 3: Loadings from POTW Discharge of Treated Wastewater. Publication 10-10-057. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/summarypages/1010057.html.

EPA. 2010. An Exposure Assessment of Polybrominated Diphenyl Ethers. United States Environmental Protection Agency, National Center for Environmental Assessment, Washington, DC. EPA-600-R-08-086F.

EPA. 2017. Technical Fact Sheet – Polybrominated Diphenyl Ethers (PBDEs). United States Environmental Protection Agency. EPA 505-F-17-015. https://www.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant_perchlorate_january2014_final_0.pdf.

Friese, M. 2014. Standard Operating Procedure EAP090, Version 1.1: Decontaminating Field Equipment for Sampling Toxics in the Environment. Revised by J. Medlen. Recertified February 2017. Washington State Department of Ecology, Olympia.

Lehmler, H-J, B. Liu, M. Gadogbe, and W. Bao. 2018. Exposure to Bisphenol A, Bisphenol F, and Bisphenol S in U.S. Adults and Children: The National Health and Nutrition Examination Survey 2013–2014. *ACS Omega*, 3(6):6523–6532. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6028148/.

Li, B., M.N. Danon-Schaffer, L.Y. Li, M.G. Ikonomou, and J.R. Grace. 2012. Occurrence of PFCs and PBDEs in Landfill Leachates from Across Canada. *Water, Air, and Soil Pollution*, 223:3365–3372. https://www.informea.org/sites/default/files/imported-documents/UNEP-POPS-POPRC12FU-SUBM-PFOA-Canada-27-20161209.En.pdf.

LimnoTech. 2016. 2016 Comprehensive Plan to Reduce Polychlorinated Biphenyls (PCBs) in the Spokane River. Prepared for the Spokane River Regional Toxics Task Force. http://srrttf.org/wp-content/uploads/2016/04/2016_Comp_Plan_Final_Approved.pdf

Lubliner, B., M. Redding, and D. Ragsdale. 2010. Pharmaceuticals and Personal Care Products in Municipal Wastewater and their Removal by Nutrient Treatment Technologies. Publication 10-03-004. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1003004.html

Mao, Z., X. Zheng, Y. Zhang, X. Tao, Y. Li, and W. Wang. 2012. Occurrence and Biodegradation of Nonylphenol in the Environment. *International Journal of Molecular Sciences*, 13(1):491–505. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3269700/

Masoner, J., D.W. Kolpin, E.T. Furlong, I.M Cozzarelli, J.L Gray, and E.A. Schwab. 2014. Contaminants of Emerging Concern in Fresh Leachate from Landfills in the Conterminous United States. *Environmental Science: Processes and Impacts*, 16(10). https://www.researchgate.net/publication/264676430_Contaminants_of_emerging_concern_in_fresh_leachate_from_landfills_in_the_conterminous_United_States

Mohapatra, D.P., K. Brar, R.D. Tyagi, and R.Y. Surampalli. 2011. Occurrence of Bisphenol A in Wastewater and Wastewater Sludge of CUQ Treatment Plant. *Journal of Xenobiotics*, 1(1). https://www.researchgate.net/publication/216344153_Occurrence_of_bisphenol_A_in_wastewater_and_wastewater_sludge_of_CUQ_treatment_plant

Norton, D., D. Serdar, J. Colton, R. Jack, and D, Lester. 2011. Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007-2011. Publication No. 11-03-055. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/documents/1103055.pdf

O'Neill, S., A.J. Carey, J.A. Lanksbury, L.A. Nielwolny, G. Ylitalo, L. Johnson, and J.E. West. 2015. Toxic contaminants in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) migrating through estuary, nearshore and offshore habitats of Puget Sound. Washington Department of Fish and Wildlife, Olympia, WA. Report No. FPT 16-02. https://wdfw.wa.gov/publications/01796

Propp, V.R., A.O. De Silva, C. Spencer, S.J. Brown, S.D. Catingan, J.E. Smith, and J.W. Roy. 2021. Organic Contaminants of Emerging Concern in Leachate of Historic Municipal Landfills. *Environmental Pollution*, 276(1). https://www.sciencedirect.com/science/article/pii/S026974912100052X

Roberts, T. 2017. Toxics Projects in Puget Sound, 2011-2018, Funded by the NEP Toxics and Nutrients Prevention, Reduction, and Control Cooperative Agreement. Publication No. 17-03-003. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/documents/1703003.pdf

Rodenburg, L.A. and Leidos. 2017. Green-Duwamish River Watershed: PCB Congener Study: Phase 2 Source Evaluation. Prepared for Washington State Department of Ecology, Toxics Cleanup Program. https://apps.ecology.wa.gov/gsp/CleanupSiteDocuments.aspx?csid=1643

Rochester, J.R. and A.L. Bolden. 2015. Bisphenol S and F: A Systematic Review and Comparison of the Hormonal Activity of Bisphenol A Substitutes. *Environmental Health Perspectives*, 123(7):643–650. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4492270/

Sedlak, M., R. Sutton, A. Wong, and D. Lin. 2018. Per and Polyfluoroalkyl Substances (PFASs) in San Francisco Bay: Synthesis and Strategy. RMP Contribution 867. San Francisco Estuary Institute, Richmond CA. 130 pages.

Schreder, E.D. and M.J. La Guardia. 2014. Flame Retardant Transfers from U.S. Households (Dust and Laundry Wastewater) to the Aquatic Environment. *Environmental Science and Technology*, 48(19):11575–83. https://www.researchgate.net/publication/266682899_Flame_Retardant_Transfers_from_US_Households_Dust_and_Laundry_Wastewater_to_the_Aquatic_Environment

Wong, S. 2020. Quality Assurance Project Plan: Sampling of Pretreated Industrial Wastewater in Northwestern Washington State. Publication 20-03-119. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/2003119.html

Yang, J., Y. Zhao, M. Li, M. Du, X. Li, and Y. Li. 2009. A Review of a Class of Emerging Contaminants: The Classification, Distribution, Intensity of Consumption, Synthesis Routes, Environmental Effects and Expectation of Pollution Abatement to Organophosphate Flame Retardants (OPFRs). *International Journal of Molecular Sciences*, 20(12):2874. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6627825/.

Glossary, Acronyms, and Abbreviations

Glossary

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella.

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process.

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.

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis.

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.

Equipment blank: A blank used to obtain information on contamination introduced during sample collection.

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples.

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples.

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 neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is 10 times more basic than one with a pH of 7.

Publicly Owned Treatment Works: A municipal or public service district treatment system.
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.

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

[Abs(a-b)/((a + b)/2)] * 100

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples.

Acronyms and Abbreviations

BPA	Bisphenol A
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
OPFR	Organophosphate flame retardant
PBDE	Polybrominated diphenyl ether
PBT	Persistent, bioaccumulative, and toxic substance
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluoroalkyl substance
POTW	Publicly Owned Treatment Works
QAPP	Quality assurance project plan
RPD	Relative percent difference
SOP	Standard operating procedures
SVOC	Semivolatile organic compound
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
mg	milligram
mg/L	milligrams per liter (parts per million)
ng/L	nanograms per liter (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
µg/L	micrograms per liter (parts per billion)
µS/cm	microsiemens per centimeter, a unit of conductivity

Appendices

Appendix A. List of Target PFAS Analytes

Individual Compounds	Compound Group
Perfluorobutanoate (PFBA)	Perfluoroalkyl acids (PFAAs)
Perfluoropentanoate (PFPeA)	Perfluoroalkyl acids (PFAAs)
Perfluorohexanoate (PFHxA)	Perfluoroalkyl acids (PFAAs)
Perfluoroheptanoate (PFHpA)	Perfluoroalkyl acids (PFAAs)
Perfluorooctanoate (PFOA)	Perfluoroalkyl acids (PFAAs)
Perfluorononanoate (PFNA)	Perfluoroalkyl acids (PFAAs)
Perfluorodecanoate (PFDA)	Perfluoroalkyl acids (PFAAs)
Perfluoroundecanoic (PFUnA)	Perfluoroalkyl acids (PFAAs)
Perfluorododecanoate (PFDoA)	Perfluoroalkyl acids (PFAAs)
Perfluorotridecanoate (PFTrDA)	Perfluoroalkyl acids (PFAAs)
Perfluorotetradecanoate (PFTeDA)	Perfluoroalkyl acids (PFAAs)
Perfluorobutane Sulfonate (PFBS)	Perfluoroalkyl acids (PFAAs)
Perfluoropentane sulfonate (PFPeS)	Perfluoroalkyl acids (PFAAs)
Perfluorohexane sulfonate (PFHxS)	Perfluoroalkyl acids (PFAAs)
Perfluoroheptane sulfonate (PFHpS)	Perfluoroalkyl acids (PFAAs)
Perfluorooctane sulfonate (PFOS)	Perfluoroalkyl acids (PFAAs)
Perfluorononane sulfonate (PFNS)	Perfluoroalkyl acids (PFAAs)
Perfluorodecane sulfonate (PFDS)	Perfluoroalkyl acids (PFAAs)
Perfluorododecane sulfonate (PFDoS)	Perfluoroalkyl acids (PFAAs)
4:2 fluorotelomer sulfonate (4:2 FTS)	Precursors
6:2 fluorotelomer sulfonate (6:2 FTS)	Precursors
8:2 fluorotelomer sulfonate (8:2 FTS)	Precursors
N-Methylperfluorooctanes sulfonamido acetate (N-MeFOSAA)	Precursors
N-Ethylperfluorooctane sulfonamido acetate (N-EtFOSAA)	Precursors
Perfluorooctane Sulfonamide (PFOSA)	Precursors
N-Methylperfluorooctane sulfonamide (N-MeFOSA)	Precursors
N-Ethylperfluorooctane sulfonamide (N-EtFOSA)	Precursors
N-Methylperfluorooctane sulfonamidoethanol (N-MeFOSE)	Precursors
N-Ethylperfluorooctane sulfonamidoethanol (N-EtFOSE)	Precursors
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoate (HFPO-DA; GenX)	Replacement PFAS
Dodecafluoro-3H-4,8-dioxanonanoate (ADONA)	Replacement PFAS
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate (9Cl-PF3ONS) (F53B Minor)	Replacement PFAS
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate (11Cl-PF3OUdS) (F53B Major)	Replacement PFAS

Appendix B. List of Target SVOC Analytes

(.+/-.)-.alpha.-Tocopherol acetate	22-Ketocholesterol	9-Octadecenoic Acid (Z)-, Methyl Ester	Chrysene	Hexachlorobenzene	Phenanthrene
.gamma.-Sitosterol	2-Chloronaphthalene	Acenaphthene	cis-13-Octadecenoic acid	Hexachlorobutadiene	Phenol
.gamma.-Tocopherol	2-Chlorophenol	Acenaphthylene	Cyclic octaatomic sulfur	Hexachlorocyclopentadiene	Phenol, 4-methyl-2-nitro-
[1,1-Biphenyl]-4,4-diamine, 3,3-dimethyl-	2-Mercaptobenzothiazole	Anthracene	Cyclopropanecarboxylic acid, 3-formyl-2,2-dime	Hexachloroethane	Phosphoric acid, dibutyl phenyl ester
1,2,4-Trichlorobenzene	2-Methylnaphthalene	Benz[a]anthracene	Decane, 1,1-oxybis-	Hexaethylene glycol monododecyl ether	Phthalic acid, di(2-propylpentyl) ester
1,2-Benzenedicarboxylic acid, butyl octyl este	2-Methylphenol	Benzene, 1-{[2,3-dimethoxy-1-(methoxymethyl)pr	Dibenzo(a,h)anthracene	Hexanoic Acid, 3,5,5-Trimethyl-	Propanol, [(butoxymethylethoxy) methylethoxy]-
1,2-Dichlorobenzene	2-Nitroaniline	Benzeneacetic acid	Dibenzofuran	Hydrocinnamic acid	Propylparaben
1,2-Diphenylhydrazine	2-Nitrophenol	Benzenepropanol, .alpha.-methyl-.beta.-nitro-,	Didecan-2-yl phthalate	Indeno(1,2,3-cd)pyrene	Pyrene
1,3-Dichlorobenzene	2-Propanol, 1-(2-Methoxy-1-Methylethoxy)-	Benzo(a)pyrene	Diethyl phthalate	Isophorone	Retene
1,4-Benzenedicarboxylic acid, bis(2-ethylhexyl	2-Propanol, 1-butoxy-	Benzo(b)fluoranthene	Diethylene glycol monododecyl ether	Methyl 2,5,8,11,14,17,20,23,26,29,32-undecaoxa	Squalene
1,4-Dichlorobenzene	3,3'-Dichlorobenzidine	Benzo(ghi)perylene	Dimethyl phthalate	Methylparaben	Stigmastanol
1-Methylnaphthalene	3,4-Diisopropylbiphenyl	Benzo(k)fluoranthene	Di-N-Butylphthalate	N,N-Dimethyl-2-methoxyethylamine	Stigmasterol
1-Octanamine, N-methyl-N-octyl-	3,5-di-tert-Butyl-4-hydroxyphenylpropionic aci	Benzoic Acid	Di-N-Octyl Phthalate	Naphthalene	Tetradecanoic acid
1-Tetradecene	3B-Coprostanol	Benzoic Acid, Methyl Ester	Dodecanoic acid	n-Hexadecanoic acid	Tetraethylene glycol monododecyl ether
2-(Benzyloxy)ethyl methyl carbonate	3-Heptanol, 5-methyl-	Benzyl Alcohol	Ergostanol	Nitrobenzene	Tri(propylene glycol) propyl ether
2,3,4,6-Tetrachlorophenol	3-Nitroaniline	Bis(2-chloro-1-methylethyl) ether	Ethanol, 2-(dodecyloxy)-	N-Nitrosodi-n-propylamine	Tributyl phosphate
2,3,5,6-Tetrachlorophenol	4(1H)-Quinazolinone	Bis(2-Chloroethoxy)Methane	Ethanol, 2-(phenylmethoxy)-	N-Nitrosodiphenylamine	Triclosan
2,4,5-Trichlorophenol	4,6-Dinitro-2-Methylphenol	Bis(2-Chloroethyl)Ether	Ethanol, 2-[2-(2-butoxyethoxy)ethoxy]-	Nonanedioic acid, monomethyl ester	Triethyl citrate
2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Bis(2-Ethylhexyl) Phthalate	Ethanol, 2-[2-(phenylmethoxy)ethoxy]-	Octadecanoic Acid	Triethylene glycol monododecyl ether
2,4,7,9-Tetramethyl-5-decyn-4,7-diol	4-Chloro-3-Methylphenol	Bisphenol A	Ethanol, 2-[2-[2-[2-[p-(1,1,3,3-tetramethylbut	Octadecanoic acid, 10-oxo-, methyl ester	Tris(2-chloroethyl) phosphate (TCEP)
2,4-Dichlorophenol	4-Chloroaniline	Butanoic Acid, 2-Methyl-	Ethanol, 2-[2-[4-(1,1,3,3-tetramethylbutyl)phe	Octaethylene glycol monododecyl ether	Unknown Hydrocarbon
2,4-Dimethylphenol	4-Chlorophenyl-Phenylether	Butanoic Acid, 3-Methyl-	Ethanol, 2-Butoxy-	Oleic Acid	
2,4-Dinitrophenol	4-Methylphenol	Butyl benzyl phthalate	Ethanol, 2-phenoxy-	Pentachlorophenol	
2,4-Dinitrotoluene	4-Nitroaniline	Caffeine	Fluoranthene	Pentaethylene glycol monododecyl ether	
2,6-Dinitrotoluene	4-Nitrophenol	Carbazole	Fluorene	Pentanedioic Acid, Dimethyl Ester	
2-[2-[2-[2-[2-[2-[2-[2-[2-(2-Hydroxyethoxy)eth	4-nonylphenol	Cholest-4-en-3-one	Glycine, methyl ester	Pentanoic Acid	
2-[2-[2-[2-[2-[2-[2-[2-[2-(2-Hydroxyethoxy)	9,12-Octadecadienoic Acid (Z,Z)-, Methyl Ester	Cholesterol	Heptaethylene glycol monododecyl ether	Pentanoic Acid, 4-Methyl-	

Appendix C. Summary of Sample Detection and Reporting Limits for CEC Analytes

C- 1. Sample detection limits (EDL) and reporting limits (LOQ) for PCB congeners.

Values represent Minimum – Maximum (Median) of nine samples.

PCB Congener	Detection Limit (EDL), pg/L	Reporting Limit (LOQ), pg/L	PCB Congener	Detection Limit (EDL), pg/L	Reporting Limit (LOQ), pg/L
PCB-001	0.519 - 41.5 (0.5665)	31.1 - 36.7 (32.9)	**PCB-055**	0.584 - 17.9 (0.9435)	31.1 - 36.7 (32.9)
PCB-002	0.519 - 26.6 (0.5665)	31.1 - 36.7 (32.9)	**PCB-056**	0.577 - 17.8 (0.944)	31.1 - 36.7 (32.9)
PCB-003	0.519 - 21.4 (0.5665)	31.1 - 36.7 (32.9)	**PCB-057**	0.538 - 16.3 (0.882)	31.1 - 36.7 (32.9)
PCB-004	3.11 - 10.5 (5.79)	31.1 - 36.7 (32.9)	**PCB-058**	0.561 - 17.5 (0.9175)	31.1 - 36.7 (32.9)
PCB-005	2.06 - 8.18 (3.64)	31.1 - 36.7 (32.9)	**PCB-059/062/075**	0.519 - 1.02 (0.5595)	31.1 - 36.7 (32.9)
PCB-006	1.89 - 7.3 (3.24)	31.1 - 36.7 (32.9)	**PCB-060**	0.562 - 17.6 (0.9235)	31.1 - 36.7 (32.9)
PCB-007	1.94 - 7.51 (3.29)	151 - 179 (160)	**PCB-061/070/074/076**	0.519 - 16.3 (0.849)	50.8 - 60 (53.65)
PCB-008	1.78 - 6.68 (2.965)	36.3 - 42.9 (38.35)	**PCB-063**	0.526 - 16.4 (0.862)	31.1 - 36.7 (32.9)
PCB-009	1.84 - 7.19 (3.195)	31.1 - 36.7 (32.9)	**PCB-064**	0.519 - 0.984 (0.5595)	31.1 - 36.7 (32.9)
PCB-010	1.9 - 7.32 (3.195)	31.1 - 36.7 (32.9)	**PCB-066**	0.538 - 16.3 (0.867)	31.1 - 36.7 (32.9)
PCB-011	1.99 - 7.76 (3.475)	166 - 196 (175)	**PCB-067**	0.519 - 14.3 (0.764)	31.1 - 36.7 (32.9)
PCB-012/013	1.98 - 7.9 (3.515)	31.1 - 36.7 (32.9)	**PCB-068**	0.519 - 16 (0.825)	31.1 - 36.7 (32.9)
PCB-014	1.91 - 7.55 (3.37)	31.1 - 36.7 (32.9)	**PCB-072**	0.526 - 16.5 (0.854)	31.1 - 36.7 (32.9)
PCB-015	2.18 - 9.8 (3.87)	31.1 - 36.7 (32.9)	**PCB-073**	0.519 - 1.04 (0.5595)	31.1 - 36.7 (32.9)
PCB-016	0.551 - 0.891 (0.765)	31.1 - 36.7 (32.9)	**PCB-077**	0.649 - 19 (1.0405)	31.1 - 36.7 (32.9)
PCB-017	0.519 - 0.775 (0.636)	31.1 - 36.7 (32.9)	**PCB-078**	0.548 - 16.9 (0.898)	31.1 - 36.7 (32.9)
PCB-018/030	0.519 - 0.64 (0.5665)	36.3 - 42.9 (38.35)	**PCB-079**	0.519 - 14 (0.725)	31.1 - 36.7 (32.9)
PCB-019	0.519 - 0.98 (0.6725)	31.1 - 36.7 (32.9)	**PCB-080**	0.519 - 15.5 (0.799)	31.1 - 36.7 (32.9)
PCB-020/028	0.519 - 2.34 (0.576)	35.3 - 41.6 (37.25)	**PCB-081**	0.649 - 19.2 (1.001)	31.1 - 36.7 (32.9)
PCB-021/033	0.519 - 2.28 (0.5785)	31.1 - 36.7 (32.9)	**PCB-082**	0.623 - 6.42 (0.8515)	31.1 - 36.7 (32.9)
PCB-022	0.519 - 2.58 (0.587)	31.1 - 36.7 (32.9)	**PCB-083/099**	0.606 - 6.24 (0.813)	31.1 - 36.7 (32.9)
PCB-023	0.519 - 2.51 (0.587)	31.1 - 36.7 (32.9)	**PCB-084**	0.639 - 6.58 (0.877)	31.1 - 36.7 (32.9)
PCB-024	0.519 - 0.612 (0.5565)	31.1 - 36.7 (32.9)	**PCB-085/116/117**	0.519 - 4.78 (0.6645)	31.1 - 36.7 (32.9)
PCB-025	0.519 - 2.03 (0.5595)	31.1 - 36.7 (32.9)	**PCB-086/087/097/109/119/125**	0.537 - 5.09 (0.693)	31.1 - 36.7 (32.9)
PCB-026/029	0.519 - 2.41 (0.587)	31.1 - 36.7 (32.9)	**PCB-088/091**	0.558 - 5.75 (0.7885)	31.1 - 36.7 (32.9)
PCB-027	0.519 - 0.612 (0.552)	31.1 - 36.7 (32.9)	**PCB-089**	0.606 - 6.24 (0.836)	31.1 - 36.7 (32.9)
PCB-031	0.519 - 2.29 (0.571)	31.1 - 36.7 (32.9)	**PCB-090/101/113**	0.537 - 5.09 (0.7035)	31.1 - 36.7 (32.9)
PCB-032	0.519 - 2.28 (0.5745)	31.1 - 36.7 (32.9)	**PCB-092**	0.589 - 6.07 (0.781)	31.1 - 36.7 (32.9)
PCB-034	0.519 - 2.51 (0.587)	31.1 - 36.7 (32.9)	**PCB-093/095/098/100/102**	0.556 - 5.73 (0.777)	31.1 - 36.7 (32.9)
PCB-035	0.519 - 2.56 (0.587)	31.1 - 36.7 (32.9)	**PCB-094**	0.625 - 6.43 (0.8685)	31.1 - 36.7 (32.9)
PCB-036	0.519 - 2.37 (0.587)	31.1 - 36.7 (32.9)	**PCB-096**	0.519 - 1.55 (0.5565)	31.1 - 36.7 (32.9)
PCB-037	0.551 - 2.88 (0.655)	31.1 - 36.7 (32.9)	**PCB-103**	0.551 - 5.33 (0.712)	31.1 - 36.7 (32.9)
PCB-038	0.519 - 2.29 (0.581)	31.1 - 36.7 (32.9)	**PCB-104**	0.519 - 1.12 (0.57)	31.1 - 36.7 (32.9)
PCB-039	0.519 - 2.32 (0.587)	31.1 - 36.7 (32.9)	**PCB-105**	0.742 - 7.61 (1.073)	31.1 - 36.7 (32.9)
PCB-040/041/071	0.524 - 1.35 (0.619)	31.1 - 36.7 (32.9)	**PCB-106**	0.588 - 6.25 (0.935)	31.1 - 36.7 (32.9)
PCB-042	0.524 - 1.43 (0.658)	31.1 - 36.7 (32.9)	**PCB-107**	0.627 - 6.66 (0.9215)	31.1 - 36.7 (32.9)
PCB-043	0.524 - 1.71 (0.7745)	31.1 - 36.7 (32.9)	**PCB-108/124**	0.681 - 7.23 (1.0395)	31.1 - 36.7 (32.9)
PCB-044/047/065	0.519 - 1.22 (0.5905)	76.8 - 90.6 (81.1)	**PCB-110/115**	0.519 - 4.39 (0.63)	31.1 - 36.7 (32.9)
PCB-045/051	0.524 - 1.37 (0.619)	31.1 - 36.7 (32.9)	**PCB-111**	0.519 - 4.33 (0.6315)	31.1 - 36.7 (32.9)
PCB-046	0.524 - 1.57 (0.705)	31.1 - 36.7 (32.9)	**PCB-112**	0.519 - 4.19 (0.614)	31.1 - 36.7 (32.9)
PCB-048	0.524 - 1.39 (0.625)	31.1 - 36.7 (32.9)	**PCB-114**	0.727 - 7.67 (1.056)	31.1 - 36.7 (32.9)
PCB-049/069	0.519 - 1.2 (0.5845)	31.1 - 36.7 (32.9)	**PCB-118**	0.713 - 7.44 (1.067)	65.3 - 77.2 (69.05)
PCB-050/053	0.524 - 1.33 (0.609)	31.1 - 36.7 (32.9)	**PCB-120**	0.519 - 4.15 (0.6095)	31.1 - 36.7 (32.9)
PCB-052	0.524 - 1.31 (0.602)	52.9 - 62.5 (55.9)	**PCB-121**	0.519 - 4.59 (0.6285)	31.1 - 36.7 (32.9)
PCB-054	0.519 - 1.15 (0.5975)	31.1 - 36.7 (32.9)	**PCB-122**	0.709 - 7.54 (1.0795)	31.1 - 36.7 (32.9)
PCB-123	0.753 - 7.97 (1.132)	31.1 - 36.7 (32.9)	**PCB-184**	0.519 - 2.86 (0.5665)	31.1 - 36.7 (32.9)
PCB-126	0.782 - 8.6 (1.17)	31.1 - 36.7 (32.9)	**PCB-186**	0.519 - 3.16 (0.587)	31.1 - 36.7 (32.9)

PCB Congener	Detection Limit (EDL), pg/L	Reporting Limit (LOQ), pg/L	PCB Congener	Detection Limit (EDL), pg/L	Reporting Limit (LOQ), pg/L
PCB-127	0.592 - 6.29 (0.951)	31.1 - 36.7 (32.9)	**PCB-187**	0.519 - 3.67 (0.587)	43.6 - 51.4 (46)
PCB-128/166	0.519 - 9.39 (0.989)	31.1 - 36.7 (32.9)	**PCB-188**	0.519 - 2.29 (0.587)	31.1 - 36.7 (32.9)
PCB-129/138/160/163	0.519 - 9.31 (0.9895)	61.2 - 72.3 (64.65)	**PCB-189**	0.519 - 7.84 (0.649)	31.1 - 36.7 (32.9)
PCB-130	0.519 - 11 (1.255)	31.1 - 36.7 (32.9)	**PCB-190**	0.519 - 2.96 (0.587)	31.1 - 36.7 (32.9)
PCB-131	0.519 - 11.5 (1.21)	31.1 - 36.7 (32.9)	**PCB-191**	0.519 - 2.81 (0.5845)	31.1 - 36.7 (32.9)
PCB-132	0.519 - 12.3 (1.235)	31.1 - 36.7 (32.9)	**PCB-192**	0.519 - 2.89 (0.587)	31.1 - 36.7 (32.9)
PCB-133	0.519 - 11.6 (1.165)	31.1 - 36.7 (32.9)	**PCB-194**	0.519 - 6.18 (0.63)	31.1 - 36.7 (32.9)
PCB-134/143	0.519 - 11.8 (1.205)	31.1 - 36.7 (32.9)	**PCB-195**	0.519 - 6.78 (0.6565)	31.1 - 36.7 (32.9)
PCB-135/151/154	0.519 - 3.41 (0.688)	31.1 - 36.7 (32.9)	**PCB-196**	0.519 - 3.43 (0.7055)	31.1 - 36.7 (32.9)
PCB-136	0.519 - 2.77 (0.6065)	31.1 - 36.7 (32.9)	**PCB-197/200**	0.519 - 2.23 (0.6045)	31.1 - 36.7 (32.9)
PCB-137	0.519 - 10.7 (1.095)	31.1 - 36.7 (32.9)	**PCB-198/199**	0.519 - 3.52 (0.7205)	31.1 - 36.7 (32.9)
PCB-139/140	0.519 - 10.7 (1.075)	31.1 - 36.7 (32.9)	**PCB-201**	0.519 - 2.51 (0.6)	31.1 - 36.7 (32.9)
PCB-141	0.519 - 10.3 (1.033)	31.1 - 36.7 (32.9)	**PCB-202**	0.519 - 2.1 (0.637)	31.1 - 36.7 (32.9)
PCB-142	0.519 - 11.9 (1.18)	31.1 - 36.7 (32.9)	**PCB-203**	0.519 - 3.39 (0.697)	31.1 - 36.7 (32.9)
PCB-144	0.519 - 3.5 (0.698)	31.1 - 36.7 (32.9)	**PCB-204**	0.519 - 2.4 (0.6)	31.1 - 36.7 (32.9)
PCB-145	0.519 - 2.85 (0.6235)	31.1 - 36.7 (32.9)	**PCB-205**	0.519 - 8.44 (0.602)	31.1 - 36.7 (32.9)
PCB-146	0.519 - 9.65 (1.012)	31.1 - 36.7 (32.9)	**PCB-206**	1.4 - 5.15 (2.545)	37.3 - 44.1 (39.45)
PCB-147/149	0.519 - 10.7 (1.0495)	31.1 - 36.7 (32.9)	**PCB-207**	1 - 3.53 (1.765)	31.1 - 36.7 (32.9)
PCB-148	0.519 - 3.53 (0.7055)	31.1 - 36.7 (32.9)	**PCB-208**	1.03 - 3.49 (1.825)	31.1 - 36.7 (32.9)
PCB-150	0.519 - 2.72 (0.6105)	31.1 - 36.7 (32.9)	**PCB-209**	0.551 - 1.74 (0.8295)	31.1 - 36.7 (32.9)
PCB-152	0.519 - 2.62 (0.5695)	31.1 - 36.7 (32.9)			
PCB-153/168	0.519 - 8.48 (0.9025)	62.2 - 73.5 (65.75)			
PCB-155	0.519 - 1.51 (0.57)	31.1 - 36.7 (32.9)			
PCB-156/157	0.519 - 10.3 (1.09)	31.1 - 36.7 (32.9)			
PCB-158	0.519 - 7.24 (0.766)	31.1 - 36.7 (32.9)			
PCB-159	0.519 - 7.87 (0.8105)	31.1 - 36.7 (32.9)			
PCB-161	0.519 - 7.55 (0.8255)	31.1 - 36.7 (32.9)			
PCB-162	0.519 - 8.28 (0.8375)	31.1 - 36.7 (32.9)			
PCB-164	0.519 - 7.45 (0.867)	31.1 - 36.7 (32.9)			
PCB-165	0.519 - 9.46 (0.9515)	31.1 - 36.7 (32.9)			
PCB-167	0.519 - 8.7 (0.8535)	35.3 - 41.6 (37.25)			
PCB-169	0.519 - 25 (0.9485)	31.1 - 36.7 (32.9)			
PCB-170	0.519 - 4.42 (0.6455)	31.1 - 36.7 (32.9)			
PCB-171/173	0.519 - 3.87 (0.587)	35.3 - 41.6 (37.25)			
PCB-172	0.519 - 3.47 (0.587)	31.1 - 36.7 (32.9)			
PCB-174	0.519 - 3.73 (0.587)	31.1 - 36.7 (32.9)			
PCB-175	0.519 - 3.7 (0.587)	31.1 - 36.7 (32.9)			
PCB-176	0.519 - 2.94 (0.5735)	31.1 - 36.7 (32.9)			
PCB-177	0.519 - 4.02 (0.587)	31.1 - 36.7 (32.9)			
PCB-178	0.519 - 3.87 (0.587)	40.5 - 47.8 (42.75)			
PCB-179	0.519 - 2.92 (0.5645)	31.1 - 36.7 (32.9)			
PCB-180/193	0.519 - 4.03 (0.587)	46.7 - 55.1 (49.3)			
PCB-181	0.519 - 3.73 (0.587)	31.1 - 36.7 (32.9)			
PCB-182	0.519 - 3.55 (0.587)	31.1 - 36.7 (32.9)			
PCB-183/185	0.519 - 3.75 (0.587)	31.1 - 36.7 (32.9)			

C- 2. Sample detection limits (EDL) and reporting limits (LOQ) for PBDE congeners.

Values represent Minimum – Maximum (Median) of nine samples.

PBDE Congener	Detection Limit (EDL), pg/L	Reporting Limit (LOQ), pg/L
BDE-007	1.56 - 33.5 (4.805)	52.6 - 534 (55.4)
BDE-008/011	1.21 - 26.2 (3.735)	52.6 - 534 (55.4)
BDE-010	1.69 - 39.2 (5.39)	52.6 - 534 (55.4)
BDE-012/013	1.09 - 23.9 (3.35)	52.6 - 534 (55.4)
BDE-015	1.09 - 20.9 (2.955)	52.6 - 534 (55.4)
BDE-017/025	1.87 - 38.2 (4.155)	63.2 - 641 (66.45)
BDE-028/033	1.86 - 34.5 (4.135)	63.2 - 641 (66.45)
BDE-030	1.88 - 42.1 (4.35)	63.2 - 641 (66.45)
BDE-032	1.54 - 32.6 (3.465)	63.2 - 641 (66.45)
BDE-035	1.34 - 25.4 (2.98)	63.2 - 641 (66.45)
BDE-037	1.24 - 23.7 (2.74)	63.2 - 641 (66.45)
BDE-047	1.53 - 21.7 (2.79)	52.6 - 534 (55.4)
BDE-049	2.26 - 32.8 (3.835)	52.6 - 534 (55.4)
BDE-051	1.64 - 23.8 (2.72)	52.6 - 534 (55.4)
BDE-066	2.52 - 36.6 (4.235)	52.6 - 534 (55.4)
BDE-071	2.26 - 32.7 (3.865)	52.6 - 534 (55.4)
BDE-075	1.83 - 26.5 (2.96)	52.6 - 534 (55.4)
BDE-077	1.45 - 21.3 (2.535)	52.6 - 534 (55.4)
BDE-079	1.71 - 24.8 (2.79)	52.6 - 534 (55.4)
BDE-085	1.93 - 334 (5.11)	52.6 - 534 (55.4)
BDE-099	1.58 - 228 (3.87)	52.6 - 534 (55.4)
BDE-100	1.15 - 199 (3.03)	52.6 - 534 (55.4)
BDE-105	2.48 - 413 (6.405)	52.6 - 534 (55.4)
BDE-116	3.33 - 547 (8.505)	52.6 - 534 (55.4)
BDE-119/120	2.47 - 394 (6.19)	52.6 - 534 (55.4)
BDE-126	1.36 - 226 (3.405)	52.6 - 534 (55.4)
BDE-128	2.35 - 682 (15.525)	52.6 - 534 (55.4)
BDE-138/166	2.4 - 309 (5.265)	52.6 - 534 (55.4)
BDE-140	1.88 - 256 (4.26)	52.6 - 534 (55.4)
BDE-153	2.46 - 233 (5.1)	52.6 - 534 (55.4)
BDE-154	1.17 - 192 (2.675)	52.6 - 534 (55.4)
BDE-155	1.54 - 203 (3.42)	52.6 - 534 (55.4)
BDE-181	2.82 - 491 (5.265)	52.6 - 534 (55.4)
BDE-183	2.16 - 361 (3.955)	52.6 - 534 (55.4)
BDE-190	4.51 - 744 (8.2)	52.6 - 534 (55.4)
BDE-203	3.71 - 2000 (9.555)	52.6 - 534 (55.4)
BDE-206	6.01 - 939 (10.6)	52.6 - 534 (55.4)
BDE-207	6.91 - 1370 (13.35)	52.6 - 534 (55.4)
BDE-208	9.1 - 1500 (15.85)	52.6 - 534 (55.4)
BDE-209	31.3 - 956 (56.25)	526 - 5340 (554)

C- 3. Sample detection limits (EDL) and reporting limits (LOQ) for PFAS analytes.

Values represent Minimum – Maximum (Median) of nine samples.

PFAS Analyte	Detection Limit (EDL), ng/L	Reporting Limit (LOQ), ng/L
11Cl-PF3OUdS	0.752 - 6.65 (0.775)	3 - 26.6 (3.09)
3:3 FTCA	0.751 - 6.64 (0.774)	3.09 - 3 (26.6)
4:2 FTS	0.751 - 6.64 (0.774)	3.09 - 3 (26.6)
5:3 FTCA	4.69 - 41.5 (4.84)	19.3 - 18.8 (166)
6:2 FTS	0.677 - 34 (0.709)	2.78 - 1.44 (71.7)
7:3 FTCA	4.69 - 41.5 (4.84)	19.3 - 18.8 (166)
8:2 FTS	0.751 - 6.64 (0.786)	3.1 - 3 (26.6)
9Cl-PF3ONS	0.753 - 6.65 (0.776)	3 - 26.6 (3.09)
ADONA	0.751 - 6.64 (0.774)	3 - 26.6 (3.09)
EtFOSAA	0.188 - 1.66 (0.197)	0.751 - 6.64 (0.773)
HFPO-DA	0.713 - 6.31 (0.735)	2.85 - 25.2 (2.94)
MeFOSAA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
N-EtFOSA	0.469 - 4.15 (0.484)	1.88 - 16.6 (1.93)
N-EtFOSE	1.4 - 12.4 (1.45)	5.63 - 49.8 (5.755)
N-MeFOSA	0.216 - 1.91 (0.223)	0.864 - 7.63 (0.889)
N-MeFOSE	1.88 - 16.6 (1.94)	7.51 - 66.4 (7.73)
NFDHA	0.375 - 3.32 (0.387)	1.5 - 13.3 (1.55)
PFBA	0.751 - 6.64 (0.78)	3 - 26.6 (3.095)
PFBS	0.188 - 1.66 (0.197)	0.751 - 6.64 (0.773)
PFDA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFDoA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFDoS	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFDS	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFEESA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFHpA	0.188 - 1.66 (0.198)	0.751 - 6.64 (0.773)
PFHpS	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFHxA	0.188 - 3.21 (0.241)	0.751 - 6.64 (0.773)
PFHxS	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFMBA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFMPA	0.375 - 3.32 (0.387)	1.5 - 13.3 (1.55)
PFNA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFNS	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFOA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFOS	0.188 - 1.66 (0.197)	0.751 - 6.64 (0.773)
PFOSA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFPeA	0.375 - 3.32 (0.393)	1.5 - 13.3 (1.55)
PFPeS	0.189 - 1.67 (0.211)	0.751 - 6.64 (0.773)
PFTeDA	0.189 - 1.66 (0.197)	0.751 - 6.64 (0.773)
PFTrDA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)
PFUnA	0.188 - 1.66 (0.194)	0.751 - 6.64 (0.773)

C- 4. Sample detection limits (MDL) and reporting limits (LLOQ) for OPFR analytes.

Values represent Minimum – Maximum (Median) of nine samples.

OPFR Analyte	Detection Limit (MDL) ng/L	Reporting Limit (LLOQ) ng/L
2-Ethylhexyl diphenyl phosphate	0.252 - 88.7 (0.268)	0.495 - 174 (0.526)
Ethanol, 2-Butoxy-, Phosphate (3:1)	0.416 - 146 (0.452)	0.495 - 174 (0.5375)
Phosphoric Acid Tributyl Ester	0.151 - 38300 (0.162)	0.495 - 126000 (0.532)
Phosphoric Acid, Triethyl Ester	0.12 - 42.2 (0.129)	0.495 - 174 (0.532)
Tricresyl phosphate	0.141 - 49.5 (0.149)	0.503 - 348 (0.543)
Tripropyl Phosphate	0.276 - 96.9 (0.29)	0.495 - 174 (0.521)
tris(1,3-dichloroisopropyl)phosphate	2.83 - 995 (2.98)	4.95 - 1740 (5.21)
Tris(2-chloroethyl) phosphate (TCEP)	0.034 - 138 (0.282)	0.0862 - 250 (0.51)
tris(2-chloroisopropyl)phosphate	5.75 - 2020 (6.18)	24.8 - 8710 (26.6)
Tris(2-ethylhexyl) phosphate	0.138 - 48.4 (0.146)	0.495 - 174 (0.526)
Tris[2,3-Dibromopropyl]Phosphate	4.7 - 1650 (4.94)	4.95 - 1740 (5.21)
V6	0.283 - 99.6 (0.298)	0.495 - 174 (0.521)

C- 5. Sample detection limits (EDL) for alkylphenol analytes.

Values represent Minimum – Maximum (Median) of nine samples.
Reporting limits not available.

Alkylphenol Analyte	Detection Limit (EDL) ng/L
4-n-Octylphenol	0.67 - 109 (3.35)
4-Nonylphenol diethoxylates	5.47 - 1280 (44.5)
4-Nonylphenol monoethoxylates	6.98 - 2360 (56.45)
4-Nonylphenols	4.49 - 385 (28.55)

C- 6. Sample detection limits (EDL) and reporting limits (LOQ) for bisphenol analytes.

Values represent Minimum – Maximum (Median) of nine samples.

Bisphenol Analyte	Detection Limit (EDL) ng/L	Reporting Limit (LOQ) ng/L
Bisphenol A	3.92 - 698 (16.6)	3.66 - 19.2 (3.855)
Bisphenol AF	3.66 - 3.94 (3.85)	3.66 - 3.94 (3.85)
Bisphenol B	3.71 - 6.97 (3.92)	3.66 - 3.94 (3.85)
Bisphenol E	9.15 - 28.9 (9.66)	9.15 - 28.9 (9.66)
Bisphenol F	9.27 - 63 (9.83)	9.15 - 28.9 (9.73)
Bisphenol S	2.29 - 23.8 (2.43)	2.29 - 23.8 (2.43)