Technical Memorandum

TO:	Kenneth Thiessen, CEG, Oregon Department of Environmental Quality
FROM:	Evelyn Ives, PE, and Christine Kimmel, LHG
DATE:	July 13, 2021
cc:	Cindy Bartlett, RG, Brent Miller, PE, Geosyntec Consultants Deborah Taege, The Boeing Company Jason Hegdahl, Brian Fischer, Cascade Corporation
RE:	**1,4-Dioxane Reconnaissance-Level Investigation Work Plan** **East Multnomah County Cleanup Project** **Portland, Oregon** **ECSI #1479**

Purpose

Landau Associates, Inc. (LAI) has prepared this work plan on behalf of The Boeing Company (Boeing) and Cascade Corporation (Cascade) in support of the ongoing remediation of the East Multnomah County (EMC) Cleanup Project (Site) for the Troutdale Sandstone Aquifer (TSA). Remediation activities for the TSA are implemented jointly by Boeing and Cascade under the Oregon Department of Environmental Quality (ODEQ) Consent Order No. WMCSR-NWR-96-08 (ODEQ 1997). Groundwater remediation has primarily consisted of corrective actions to address dissolved volatile organic compounds (VOCs), primarily trichloroethene (TCE).

On March 17, 2021, ODEQ requested a reconnaissance-level groundwater sampling event for 1,4-dioxane to evaluate whether it is present at concentrations above the ODEQ risk-based cleanup standards (ODEQ 2021) in groundwater. The purpose of this work plan is to propose an investigation to determine the presence or absence of 1,4-dioxane above the applicable screening level in groundwater at the Site.

Well Selection Approach and Sampling Schedule

As requested by ODEQ, a subset of existing groundwater monitoring wells was selected for 1,4-dioxane testing. Wells were selected to represent groundwater quality in identified former VOC source areas, along with wells located upgradient and downgradient of the current dissolved VOC plume in both the Upper TSA and the Lower TSA. Current and historical concentrations of TCE and 1,1,1-trichloroethane (1,1,1-TCA) were considered when selecting representative locations for potential 1,4-dioxane impacts.

A total of six wells were selected for 1,4-dioxane testing; four Upper TSA wells (BOP-61ds, BOP-44ds, CMW-17ds, and CMW-18ds) and two Lower TSA wells (BOP-44dg and CMW-36dg), as shown on Figures 1 and 2.

For each of the selected wells, historical maximum concentrations of 1,1,1-TCA and TCE along with the current extent (as of August 2020) of the TCE plume for the Upper TSA and the Lower TSA are shown in Figures 1 and 2, respectively. Based on the ODEQ-approved monitoring schedule, wells BOP-44(ds,dg) were last sampled in 2017, while wells BOP-61ds, CMW-17ds, and CMW-18ds were last sampled in May 2021. Time versus concentration plots for 1,1,1-TCA and TCE for each proposed sampling location are shown on Figures 3 through 8. The rationale for well selection is presented below:

- **BOP-61ds:** Upper TSA well BOP-61ds was selected because of its location along the western portion of the current dissolved VOC plume with historical concentrations of TCE above the cleanup level (5 micrograms per liter [µg/L]). Historical results for samples collected at BOP-61ds indicate TCE concentrations ranged from a maximum of 28 µg/L detected in 1995 to 16 µg/L in 2000, prior to a general decrease in groundwater elevations when the screen was not saturated due to remedial extraction operations. Since resaturation (from decreased remedial extraction rates) in 2006, TCE concentrations have ranged from 8.7 µg/L in 2015 to 3.51 µg/L in 2021. Reported 1,1,1-TCA concentrations declined from 0.8 µg/L in 1998 to non-detect at the laboratory reporting limit (0.2 to 0.5 µg/L) by 2006.
- **CMW-17ds:** Upper TSA well CMW-17ds was selected as a representative location in the TSA "mound area," where a historical groundwater mound existed prior to groundwater remediation. Groundwater in this portion of the Site has persistently elevated TCE concentrations compared to the rest of the plume. Between 1999 and 2009, active pump and treat operations decreased the groundwater elevation in the mound area to below the well screen depth; therefore, no groundwater sample results are available for this time frame. Prior to this time, the maximum TCE concentration was 220 µg/L (1993). Upon groundwater resaturation, based on ODEQ approved phased shutdown approach of active extraction well operations, TCE concentrations have fluctuated between 30 and 57.7 µg/L. Analytical results for 1,1,1-TCA at CMW-17ds have consistently been non-detect at the laboratory reporting limit (0.5 to 1.0 µg/L) since monitoring began in 1992.
- **CMW-18ds:** Upper TSA well CMW-18ds was selected as a representative location in the mound area of the Site with the highest historical TCE concentrations. As with several Upper TSA wells, active remedial pumping resulted in decreased groundwater elevations and no analytical data available from 1999 to 2009. TCE concentrations prior to the resaturation reported a maximum concentration of 250 µg/L; however, after resaturation, the TCE concentration was 180 µg/L in 2013 before decreasing and fluctuating between 18.1 and 102 µg/L over the last 5 years. Analytical results for 1,1,1-TCA at CMW-17ds have consistently been non-detect at the laboratory reporting limit (0.5 to 1.0 µg/L) since monitoring began in 1992.
- **BOP-44ds and BOP-44dg:** Upper TSA well BOP-44ds and Lower TSA well BOP-44dg were selected as representative locations downgradient of the dissolved VOC plume. The two wells are paired to allow for monitoring of both aquifer zones for potential downward migration of impacted groundwater in Remedy Zone A. Based on ODEQ approval, the two wells were removed from the Site groundwater monitoring plan in 2017 due to TCE concentrations at BOP-44ds decreasing from a maximum concentration of 23 µg/L (1993) to below the cleanup level (2002), and below reporting limits (0.5 to 1.0 µg/L) since 2009. TCE concentrations at

BOP-44dg ranged from 0.99 µg/L to non-detect at the laboratory reporting limits (<0.2 µg/L to <0.93 µg/L). Analytical results for 1,1,1-TCA at BOP-44ds ranged from 0.9 µg/L to non-detect at the laboratory reporting limits (0.2 to 1.0 µg/L). 1,1,1-TCA has consistently been non-detect at the reporting limit (0.2 to 1.0 µg/L) at BOP-44dg since monitoring began in 1993.

- **CMW-36dg:** Lower TSA well CMW-36dg was selected as a representative upgradient location for Remedy Zone A. The maximum historical TCE concentration (1.7 µg/L in 2001) was below the cleanup level prior to decreasing below the laboratory reporting limits (0.5 to 1.0 µg/L) in 2002. Analytical results for 1,1,1-TCA at CMW-17ds have consistently been non-detect at the laboratory reporting limits (0.5 to 1.0 µg/L) since monitoring began in 1997.

The 1,4-dioxane reconnaissance-level sampling event will be conducted during the next routine groundwater sampling event in August 2021. The timing will allow for 1,4-dioxane results to be compared to VOC (e.g., TCE and 1,1,1-TCA) data also collected at that time.

Sampling and Analytical Procedures

ODEQ approved the transition from low-flow sampling techniques to passive diffusion bag (PDB) samplers based on the results of a site-specific study completed in 2006 (LAI, Prowell Environmental, and Pegasus Geoscience 2006). Groundwater samples for Upper TSA well BOP-61ds have been collected using waterra sampling procedures due to historical low groundwater elevations related to remedial extraction operations. However, groundwater elevations have rebounded in recent years and meet water depth requirements for fully saturated PDBs, which will be utilized for future sampling events starting with the August 2021 event.

PDBs have several advantages compared to low-flow sampling including cost efficiency, the high level of precision, potential for vertical profiling, and low risk of cross-contamination; however, the standard PBD samplers are not appropriate for 1,4-dioxane molecules that are too large to pass through the polyethylene bag membrane. There are several commercially available samplers available for collection of larger molecules like 1,4-dioxane at depth-discrete intervals. The utilization of a snap sampler or HydraSleeve were considered during this evaluation; however, both techniques would require the installation of multiple samplers to analyze for both VOCs and 1,4-dioxane. For simultaneous collection of VOCs and 1,4-dioxane at the same depth, the use of Dual Membrane Passive Diffusion Bag (DMPDB™) samplers is recommended for this investigation. In the event that a DMPDB cannot be deployed or is lost during retrieval, a HydraSleeve sampler will be used to collect the intended sample. HydraSleeve is not a passive diffusion bag sampler and can be filled instantaneously at discrete depths within a well.

DMPBD samplers consist of a 1.75-inch diameter by 22-inch-long hollow tube comprised from two types of permeable membranes. The top 6 inches of membrane is 125-micrometer mesh nylon, and the bottom 16 inches is low-density polyethylene. The top portion of nylon screen allows diffusion of larger molecules including 1,4-dioxane into the sampler. The lower part of the sampler allows

diffusion of VOCs and acts as a reservoir. Chemical constituents that enter through either membrane diffuse vertically and mix within the sampler. As equilibration occurs, the concentration of constituents inside the sampler becomes equal to concentrations outside the sampler in the well to represent aquifer conditions.

The DMPDB is made by EON Products, Inc (EON). and has been used since about 2015. The US Environmental Protection Agency and the US Geological Survey (USGS) have conducted case studies on the sampler's effectiveness, including a comparison between the DMPDB and low-flow sampling techniques (USGS 2020). In particular the USGS conducted a case study at the Kirtland Air Force Base in Albuquerque, New Mexico, by collecting two VOCs (1,2-dibromoethane and benzene). Results from the study indicate good agreement between the two sampling methods with more than 90 percent of the comparison sampling results were within 20 percent relative percent difference (USGS 2020). Bench scale DMPDB testing has been conducted by EON for a wider suite of chemicals, including 1,4-dioxane, and results are included as Attachment 1. Bench scale testing was conducted by hanging a DMPDB sampler in an 8-ft-tall column that was spiked with 1,4-dioxane. After 16 days, control and test samples were collected from the column and DMPDB, respectively. A total of two control samples and six test samples were collected for 1,4-dioxane analysis, and results indicate the test results (concentrations ranged between 3.6 and 4.2 µg/L) are within 14 percent relative difference of the control concentrations (4.2 and 3.7 µg/L).

The DMPDB will be field-filled with laboratory-supplied deionized water and deployed at least 3 weeks prior to sample collection to allow for equilibration in groundwater. The depth of DMPDB deployment will be the same depth of the routinely utilized standard PDBs for comparison against historical VOC concentrations. The planned deployment depths of the DMPDB are listed below:

Selected Well	DMPDB Top Deployment Depth (feet below top of well casing)
BOP-61ds	95.5 (parent) and 98 (duplicate)
CMW-17ds	105
CMW-18ds	111
BOP-44ds	62.3
BOP-44dg	143.5
CMW-36dg	114.4 (parent) and 117 (duplicate)

To meet project quality objectives, a field duplicate sample will be collected from CMW-36dg and BOP-61ds. Due to the volume constraints of the DMPDB, the duplicate samples will be collected by deploying a secondary DMPDB directly below the primary sample depth interval. Two DMPDB field blank sample will also be collected using laboratory provided distilled water. The quality assurance samples will be analyzed for VOCs and 1,4-dioxane by the same analytical methods as the primary

DMPDB sample. Samples will be submitted to the project-approved accredited laboratories: Eurofins Lancaster Laboratories Environmental in Lancaster, Pennsylvania (Boeing managed wells) and Pace National Analytical Laboratory in Mount Juliet, Tennessee (Cascade managed wells). 1,4-Dioxane samples will be analyzed using US Environmental Protection Agency (EPA) Method 8270E with selected ion monitoring (SIM) with a reporting limit of 0.300 µg/L. Analytical results for 1,4-dioxane will be compared to ODEQ risk-based concentrations (RBCs) for groundwater ingestion and inhalation from tap water for the urban residential scenario (2.0 µg/L).

Reporting

Each set of analytical results (collected at Boeing managed and Cascade managed wells) will undergo Stage 2A data verification and validation. Field and analytical laboratory control samples will be used to evaluate data precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity of the analytical results for this investigation. Data Quality Indicators (DQI) and Measurement Quality Objectives (MQO) are presented in Table 1. In the event the RPD exceeds the project-specified MQO of 20 percent the associated results will be qualified as estimated.

The results of the 1,4-dioxane testing will be summarized and submitted to ODEQ in a technical memorandum. If 1,4-dioxane is detected at concentrations greater than the applicable RBC, then next steps will be discussed with ODEQ. Alternately, if 1,4-dioxane results are less than the applicable RBC, no additional sampling for 1,4-dioxane will be recommended.

Limitations

This work plan has been prepared for the exclusive use of EMC for specific application to the East Multnomah County Cleanup Project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of LAI and Geosyntec. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI or Geosyntec, shall be at the user's sole risk. LAI and Geosyntec warrant that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

LANDAU ASSOCIATES, INC.

Evelyn Ives, PE
Associate Engineer

Christine Kimmel, LHG
Senior Associate Geologist

EMW/CBK/EHI/ljl
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Attachments

Figure 1: Selected 1,4-Dioxane Location and Upper TSA Aquifer Trichloroethene Concentrations, August 2020
Figure 2: Selected 1,4-Dioxane Location and Lower TSA Aquifer Trichloroethene Concentrations, August 2020
Figure 3: Selected Volatile Organic Compounds BOP-61(ds)
Figure 4: Selected Volatile Organic Compounds CMW-17(ds)
Figure 5: Selected Volatile Organic Compounds CMW-18(ds)
Figure 6: Selected Volatile Organic Compounds BOP-44(ds)
Figure 7: Selected Volatile Organic CompoundsBOP-44(dg)
Figure 8: Selected Volatile Organic Compounds CMW-36(dg)
Table 1: Sample Collection and Measurement Quality Objectives
Attachment 1: EON Products, Inc. DMPDB Bench Scale Test Results

References

LAI, Prowell Environmental, and Pegasus Geoscience. 2006. Troutdale Sandstone Aquifer Remedial Action, Annual Performance Evaluation, April 1, 2005 through March 31, 2006. Landau Associates, Inc., Prowell Environmental, Inc., and Pegasus Geoscience. June 30.

ODEQ. 1997. TSA Remedy Order on Consent, WMCSR-NWR-96-08, February 14.

ODEQ. 2021. Letter: Request for Reconnaissance-Level Groundwater Sampling for 1,4-Dioxane at Cascade Corporation Fairview, Oregon Facility. ECSI #1479. From Kenneth Thiessen, Oregon Department of Environmental Quality, to Jason Hegdahl, Cascade Corporation. March 17.

USGS. 2020. Passive Sampling of Groundwater Wells for Determination of Water Chemistry: Chapter 8 of Section D. Water Quality, Book 1. Collection of Water Data by Direct Measurement. US Geological Survey.

BOP-44ds	TCE	1,1,1-TCA
August 2020	ND (a)	ND (a)
Maximum	23	0.3

BOP-61ds	TCE	1,1,1-TCA
August 2020	3.51	ND
Maximum	28	0.8

CMW-17ds	TCE	1,1,1-TCA
August 2020	35.6 (a)	ND (a)
Maximum	220	ND

CMW-18ds	TCE	1,1,1-TCA
August 2020	59.7 (a)	ND (a)
Maximum	250	ND

BOP-44ds
BOP-20ds < 0.20
EW-3 < 0.20
BOP-61ds 3.2
BOP-65ds 0.23
BOP-62ds 1.00
BOP-66ds 0.71
BOP-31ds < 0.20
VMW-L < 0.500
VMW-M 14.2
CMW-17ds 48.4
VMW-C 5.85
VMW-A 5.09
VMW-B 18.7
VMW-N 19.3
VMW-H 0.619
VMW-G 4.79
VMW-K 1.26
VMW-D 7.86
BOP-13ds 2.0
VMW-J2 58.9
CMW-18ds 96.6
VMW-F < 0.500
CMW-20ds < 0.500
VMW-E 34.5
VMW-I 53.9
CMW-19ds 1.29
CMW-10ds 13.2
45
25
5

Legend

- Upper TSA Monitoring Well
- Upper TSA Trichloroethene Countour (µg/L)
- Inferred Upper TSA Trichloroethene Countour (µg/L)
- Unsaturated Area
- Structure
- Boeing Property Boundary
- Cascade Corporation Property Boundary

Notes

CMW-10ds = Monitoring Well Location ID
13.2 = TCE Concentration (µg/L)

Maximum values are reported for locations with field duplicates and/or multiple depths.
If analyte was not detected, the minimum reporting limit was shown.

Figure modified by Landau Associates on 5/28/2021 to include well BOP-44ds

Graphic notes for MW-18ds, BOP-44ds, and MW-17ds
(a) BOP-61ds, MW-17, and MW-18 were last sampled in May 2021 while BOP-44ds last sampled in August 2017

500 250 0 500 Feet

Selected 1,4-Dioxane Location and Upper TSA Aquifer Trichloroethene Concentrations August 2020

East Multnomah County

Geosyntec consultants

Figure **1**

PNG0564S | April 2021

SantaBarbara-01\Data P:\GIS\PNG\0564_CascadeProjects\2020\TSA 2020 Annual Report\Fig5-2a_Upper_TSA_Aquifer_TCE_Contours_2020-08.mxd (Author: GCallin) 20210408

BOP-44dg	TCE	1,1,1-TCA
August 2020	ND (a)	ND (a)
Maximum	0.93	ND

BOP-44dg

CMW-36dg	TCE	1,1,1-TCA
August 2020	ND	ND
Maximum	1.7	ND

CMW-36dg
< 0.500

BOP-23dg
1.0

EW-23
1.71

EW-8
1.41

BOP-61dg
3.7

EW-13
0.75

BOP-31dg
2.9

CMW-25dg
< 0.500

CMW-24dg
(EW-5)
< 0.500

EW-12
2.21

CMW-14Rds
< 0.500

CMW-22dg
< 0.500

EW-16
< 0.500

D-17ds
40.7

EW-1
< 0.500

D-17dg
4.38

EW-14
6.54

EW-2
11.0

BOP-13dg
0.39

5

25

40

Legend

- Lower TSA Monitoring Well
- Extraction Well
- Decomissioned or No Longer Monitored Monitoring Well
- Lower TSA Trichloroethene Countour (µg/L)
- Inferred Upper TSA Trichloroethene Countour (µg/L)
- Structure
- Boeing Property Boundary
- Cascade Corporation Property Boundary

Notes

D-17dg = Monitoring Well Location ID
4.38 = TCE Concentration (µg/L)
(U) = Upper interval at long screened well location
(L) = Lower interval at long screened well location

Maximum values are reported for locations with field duplicates and/or multiple depths.
If analyte was not detected, the minimum reporting limit was shown.
*D-17dg value not used in contouring due to the greater D-17ds concentration.

Figure modified by Landau Associates on 5/28/2021 to include well BOP-44dg

Graphic note for BOP-44dg
(a) Latest sample collected August 2017

N

500 250 0 500 Feet

Selected 1,4-Dioxane Location and Lower TSA Aquifer Trichloroethene Concentrations August 2020
East Multnomah County

Geosyntec consultants

PNG0564S	April 2021	Figure 2

SantaBarbara-01\Data P:\GIS\PNG0564 - Cascade\Projects\2020\TSA 2020 Annual Report\Fig5-2b Lower TSA Aquifer TCE Contours 2020-08.mxd (Author: GCatlin) 20210409

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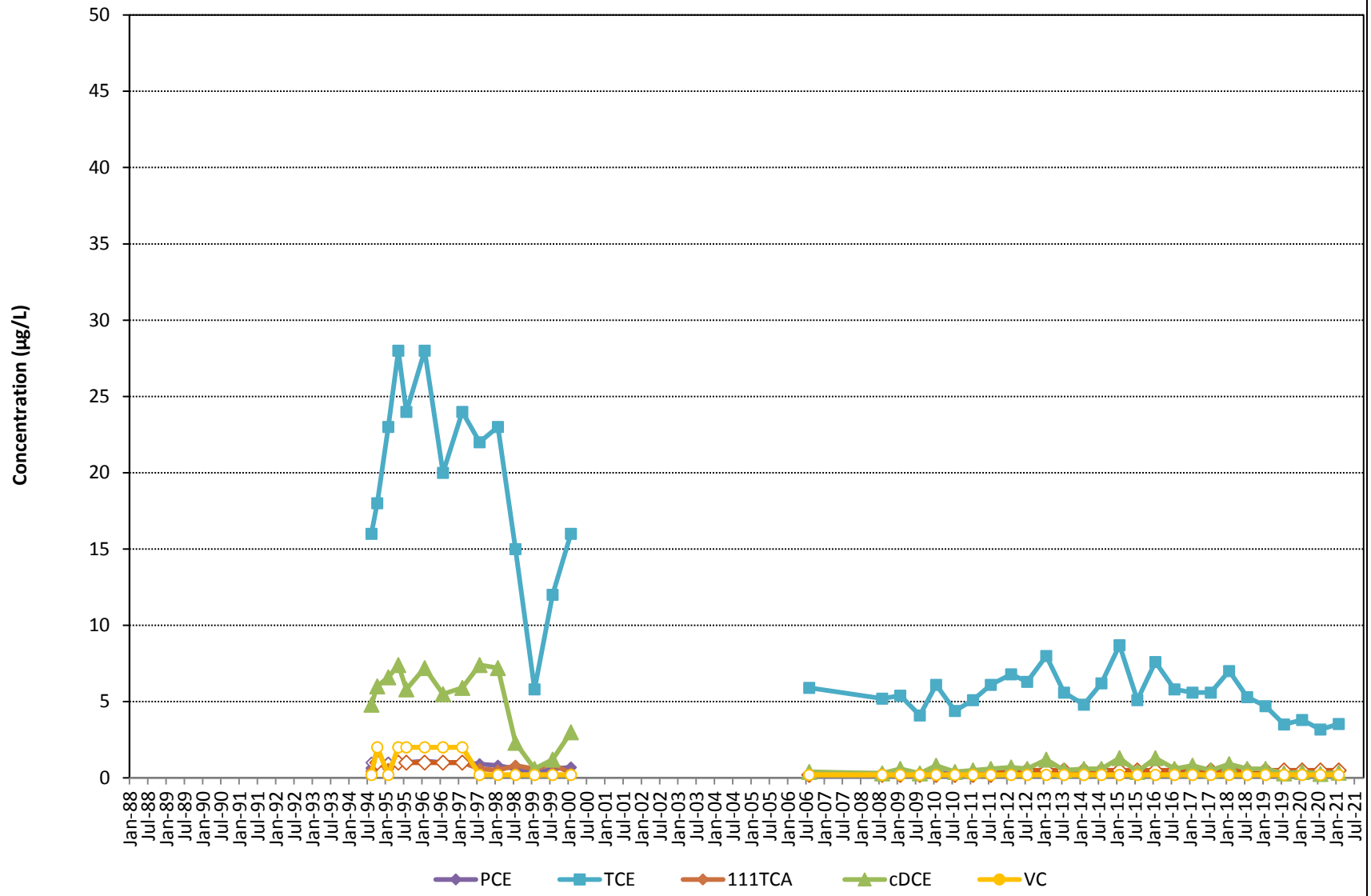

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Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds BOP-61(ds)**	Figure 3

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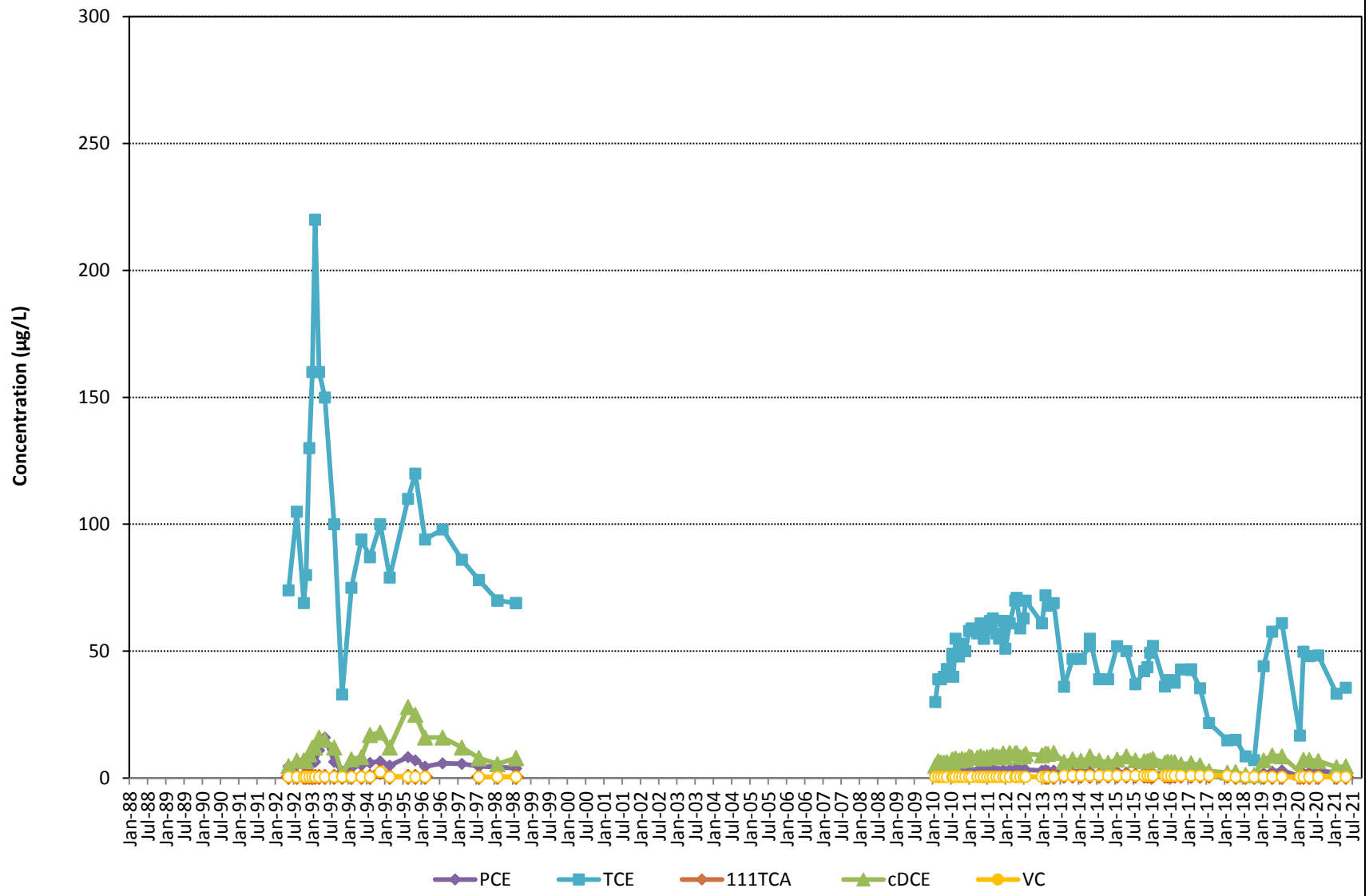

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Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds CMW-17(ds)**	Figure 4

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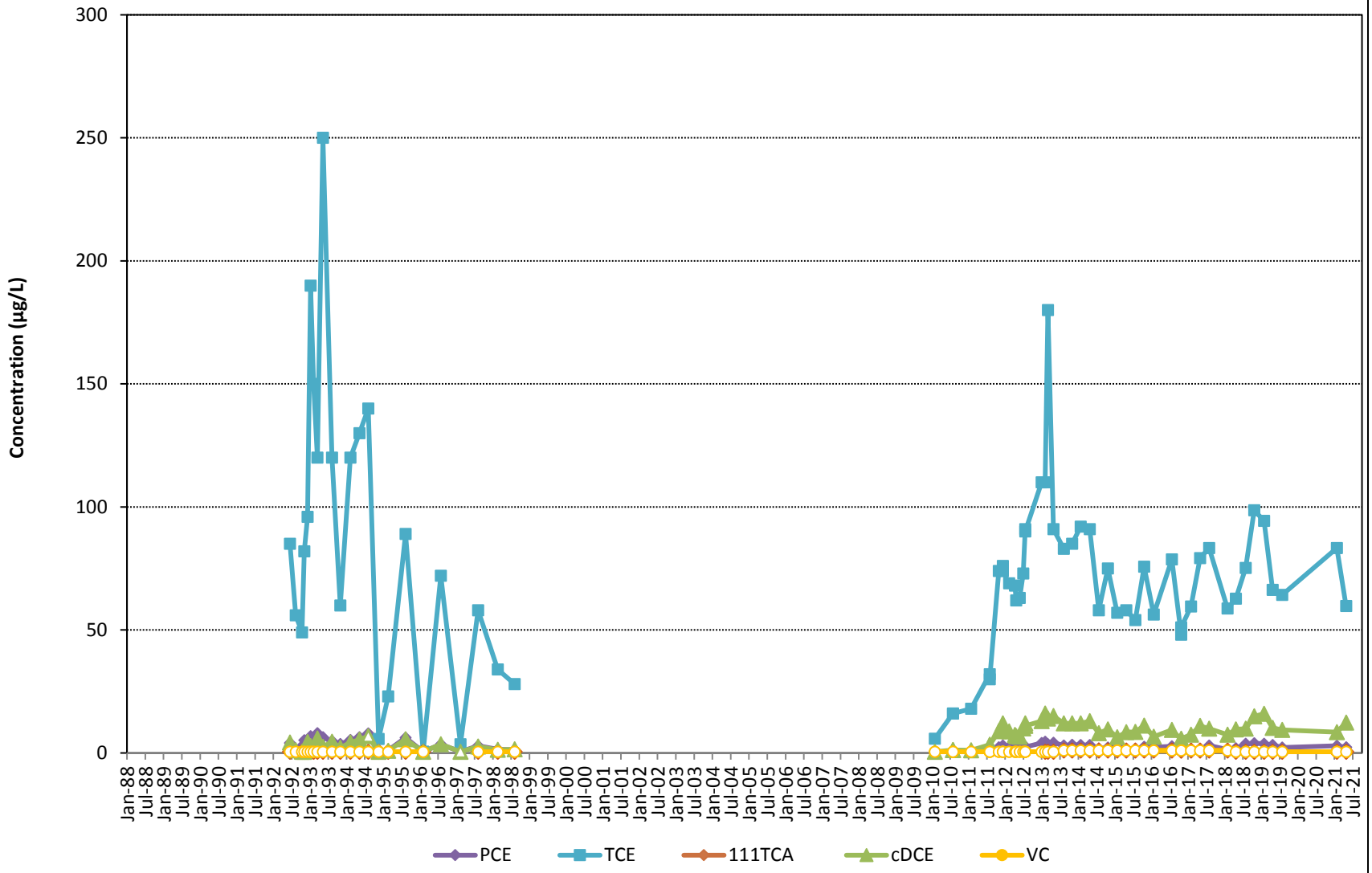

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Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds CMW-18(ds)**	Figure 5

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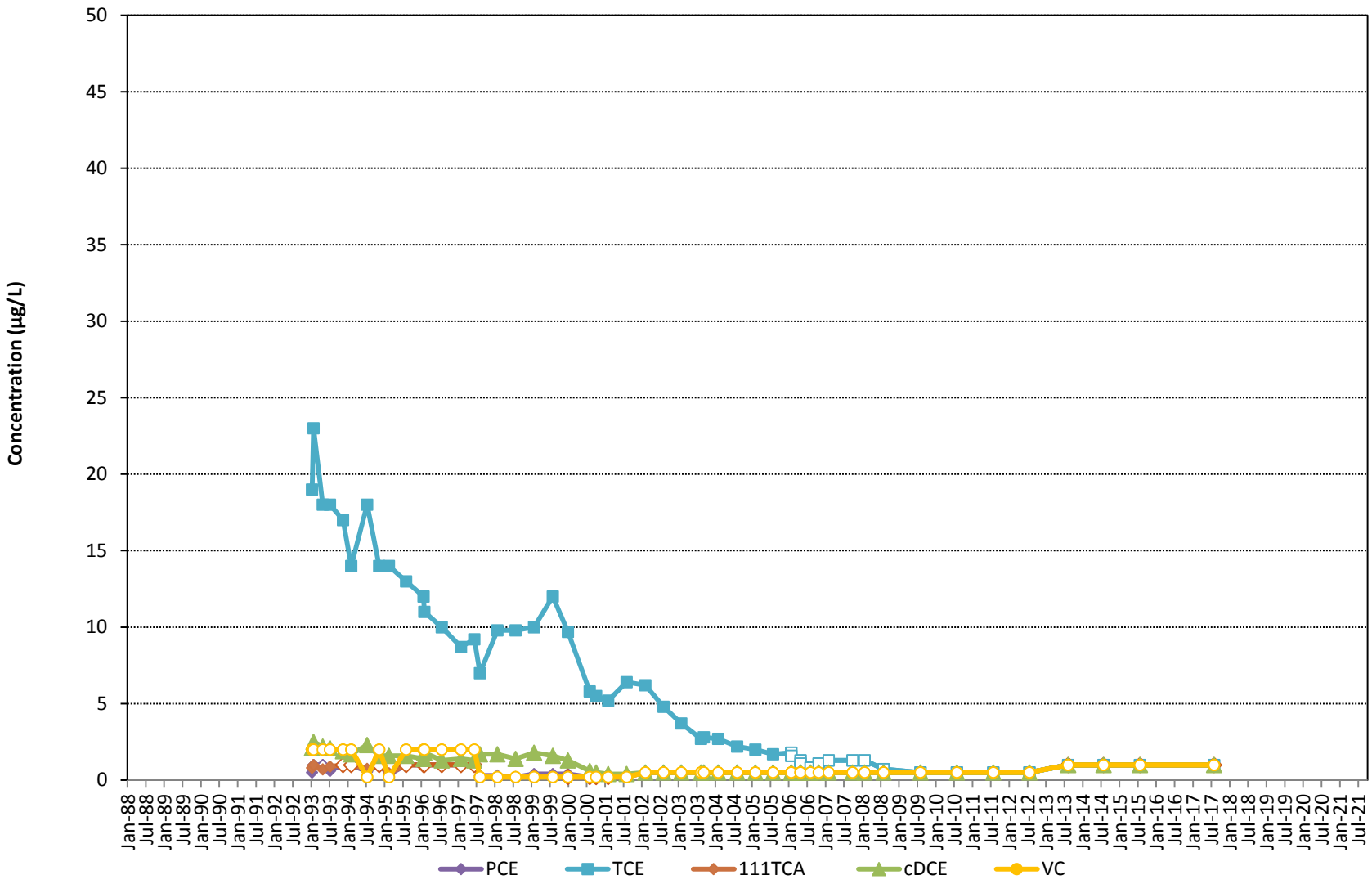

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Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds BOP-44(ds)**	Figure 6

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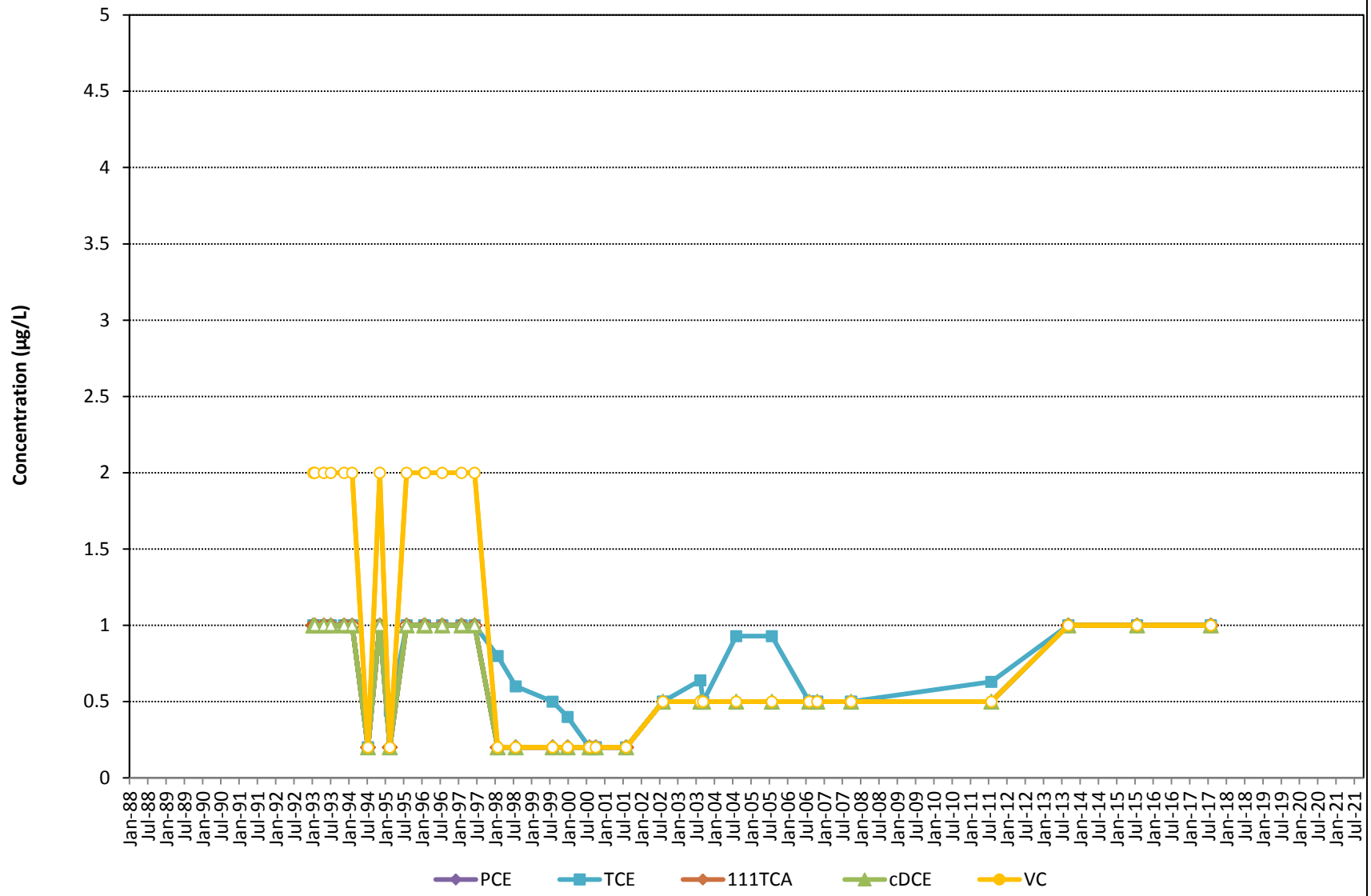

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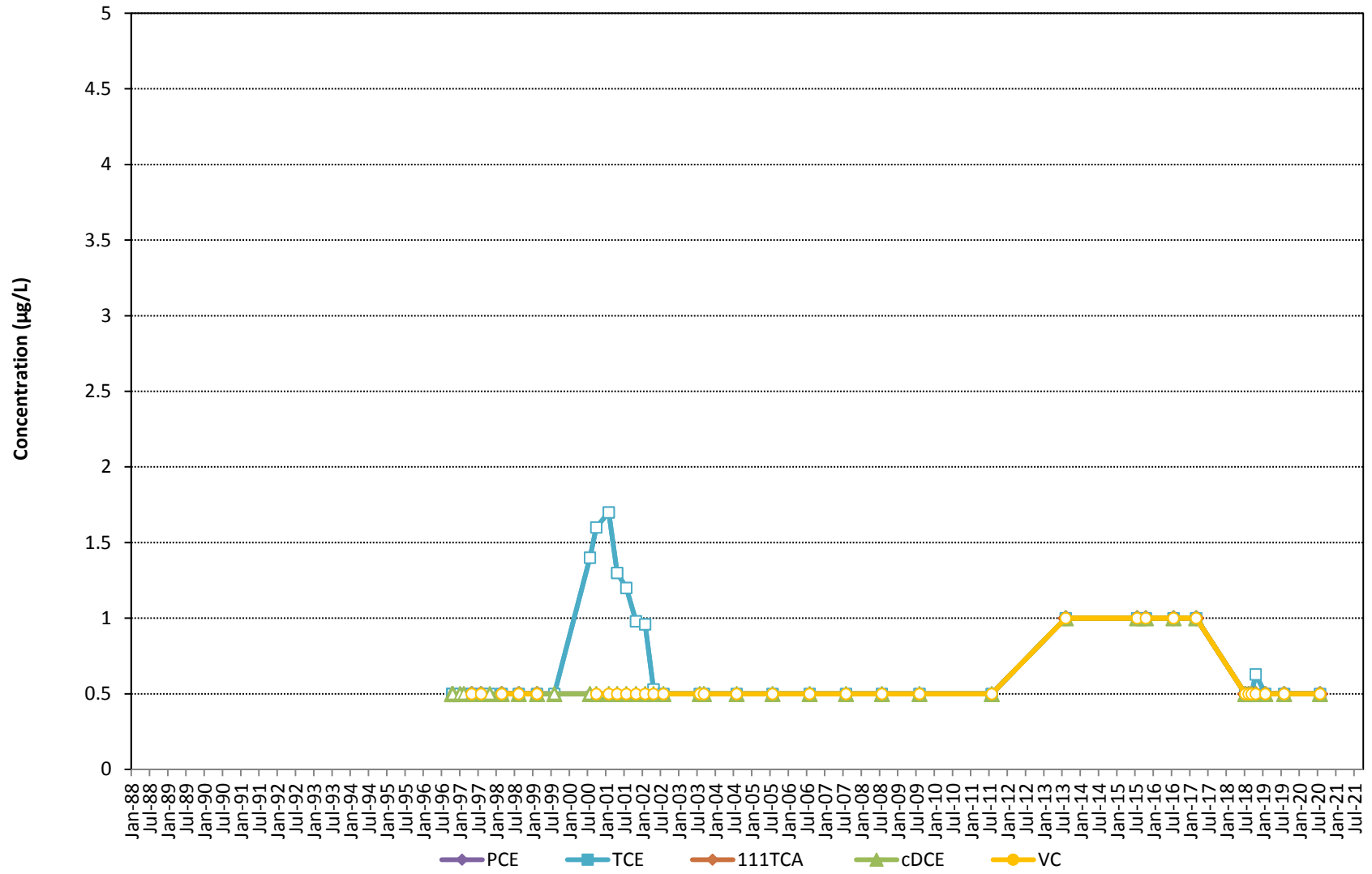
Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds BOP-44(dg)**	Figure 7



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Boeing Portland Gresham, Oregon	**Selected Volatile Organic Compounds CMW-36(dg)**	Figure 8

Table 1
Sample Collection and Measurement Quality Objectives
1,4-Dioxane Reconnaissance-Level Investigation Work Plan
East Multnomah County Cleanup Project
Gresham, Oregon

DQI	QC Sample or Activity Used to Assess MQO	MQO	Frequency	Sampling or Analytical DQI
Water Samples Analyzed for 1,4-dioxane by EPA 8270E SIM				
Representativeness	Cooler Temperature	< 6°C	All project samples	S
Bias	Surrogates	Recoveries within laboratory-specified control limits	All project and QA samples	A
Accuracy	LCS/LCSD	Recoveries within laboratory-specified control limits	1 per 20 samples or one per analytical batch (per laboratory)	A
Precision	LCS/LCSD and MS/MSD	RPDs within laboratory-specified control limits	1 per 20 samples or one per analytical batch (per laboratory)	A
Method performance for matrix, bias	MS/MSD	Recoveries within laboratory-specified control limits	1 per analytical batch (per laboratory)	A
Precision	Field Duplicates	RPD <20% (Approximate)	1 per 20 samples or one per analytical batch (per laboratory)	S&A
Bias/Contamination	Bag Blank	Target analytes not detected at concentrations > 1/2 the RL	1 per sampling event (per laboratory)	S&A
Bias/Contamination	Method Blank	Target analytes not detected at concentrations > 1/2 the RL	1 per analytical batch (per laboratory)	A
Analytical Completeness	Number of usable (not rejected) results out of total number of results	90%	NA	S&A
Field Completeness	Number of samples collected out of planned samples	95%	NA	S

Abbreviations and Acronyms:

°C = degrees Celsius
% = percent
A = analytical
DMPDB = Dual-Membrane Passive Diffusion Bag
DQI = data quality indicator
EPA = US Environmental Protection Agency
LCS = laboratory control spike
LCSD = laboratory control spike duplicate
MQO = measurement quality objective
MS = matrix spike
MSD = matrix spike duplicate
NA = not applicable
QA = quality assurance
QC = quality control
RL = reporting limit
RPD = relative percent difference
S = sampling
SIM = selected ion monitoring

ATTACHMENT 1

EON Products, Inc. DMPDB Bench Scale Test Results

EON PRODUCTS INC.

Dual Membrane PDB Bench Test Results

In addition to successful side by side field testing, the Dual Membrane Passive Diffusion Samplers (DMPDBs) have been subject to a series of controlled Bench-Test studies to determine the correlation between the concentration of representative compounds in a sample acquired by the DMPDB and the concentration of those compounds in the fluid surrounding the sampler. For each Bench-Test, an 8-inch diameter by 8-foot tall test chamber was filled with water and spiked with the referenced compounds. DMPDBs were installed in the chamber and left in place for the indicated residence time to allow for diffusion of analyte molecules into the sampler. At the designated time, control samples were then taken of the fluid in the chamber through a discharge port. The DMPDBs were then removed and the contents discharged into lab bottles. A second control sample was taken from the chamber after the DMPDBs were sampled as a quality and repeatability check, and the controls and samples were sent to a certified lab for analysis. The control and DMPDB sample results are shown in the tables below.

Method: 524.2 - Volatile Organic Compounds (GC/MS) or Method: 8260B - Volatile Organic Compounds (GC/MS)	Control (ug/L)		Dual Membrane PDB (ug/L) Residence Time: 18 Days								
Sample ID>	**3MC-11**	**3MC-21**	**3U4-21**	**3U4-31**	**3U4-11**	**3M4-21**	**3M4-31**	**3M4-11**	**3L4-21**	**3L4-31**	**3L4-11**
1,1,1-Trichloroethane	6.7	6.0	6.7	6.5	6.6	6.5	6.4	6.7	6.3	6.6	6.7
1,1,2-Trichloroethane	15.0	14.0	16.0	15.0	15.0	15.0	15.0	16.0	15.0	16.0	16.0
1,1-Dichloroethane	21.0	19.0	21.0	21.0	21.0	21.0	20.0	21.0	20.0	21.0	21.0
1,1-Dichloroethene	2.6	2.3	2.5	2.5	2.6	2.7	2.4	2.6	2.5	2.5	2.6
1,2,4-Trimethylbenzene	3.1	2.8	3.0	3.0	3.0	3.1	3.0	3.0	2.9	3.1	3.1
1,2-Dichloroethane	16.0	15.0	17.0	16.0	16.0	16.0	16.0	17.0	16.0	17.0	17.0
1,2-Dichloropropane	5.0	4.6	5.0	4.9	5.0	5.0	4.9	5.1	4.8	5.1	5.0
1,3,5-Trimethylbenzene	2.8	2.6	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.9	2.8
2-Butanone (MEK)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
qualifier	U	U	U	U	U	U	U	U	U	U	U
4-Methyl-2-pentanone (MIBK)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
qualifier	U	U	U	U	U	U	U	U	U	U	U
Acetone	15.0	11.0	6.1	7.0	5.0	8.7	8.2	8.9	6.6	7.3	8.4
qualifier			J	J	U	J	J	J	J	J	J
Benzene	7.0	6.4	6.8	6.7	7.1	7.0	6.6	6.9	6.6	6.9	6.9
Chloroethane	32.0	29.0	32.0	31.0	32.0	32.0	31.0	32.0	30.0	32.0	32.0
cis-1,2-Dichloroethene	8.2	7.7	8.4	8.0	8.5	8.5	8.1	8.3	7.9	8.3	8.4
Ethylbenzene	13.0	12.0	13.0	13.0	13.0	13.0	12.0	13.0	12.0	13.0	13.0
Isopropyl alcohol	61.0	310.0	25.0	25.0	31.0	25.0	25.0	25.0	25.0	25.0	25.0
qualifier			U	U	J	U	U	U	U	U	U

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Dual Membrane PDB Bench Test Results

Method: 524.2 - Volatile Organic Compounds (GC/MS) or Method: 8260B - Volatile Organic Compounds (GC/MS)	Control (ug/L)		Dual Membrane PDB (ug/L) Residence Time: 18 Days								
Sample ID>	3MC-11	3MC-21	3U4-21	3U4-31	3U4-11	3M4-21	3M4-31	3M4-11	3L4-21	3L4-31	3L4-11
Methylene Chloride	7.0	6.5	7.0	6.8	6.9	6.9	6.9	7.0	6.7	7.1	7.1
m-Xylene & p-Xylene	4.5	4.0	4.4	4.5	4.6	4.5	4.3	4.6	4.3	4.6	4.6
Naphthalene	2.5	2.3	2.4	2.5	2.6	2.4	2.5	2.4	2.4	2.5	2.5
o-Xylene	5.7	5.3	5.8	5.7	5.8	5.9	5.7	5.9	5.5	5.9	5.8
Tetrachloroethene	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
qualifier	J	J	J	J	J	J	J	J	J	J	J
Toluene	3.9	3.6	3.8	3.8	4.0	3.9	3.7	3.8	3.7	3.9	3.8
trans-1,2-Dichloroethene	6.4	5.8	6.2	6.2	6.4	6.4	6.0	6.3	6.0	6.2	6.3
Trichloroethene	2.3	2.0	2.1	2.2	2.2	2.2	2.1	2.2	2.1	2.2	2.2
Xylenes, Total	10.0	9.3	10.0	10.0	10.0	10.0	10.0	11.0	9.8	10.0	10.0

Method: 522 - 1,4 Dioxane (GC/MS SIM)	Control Result (ug/L)		Dual Membrane Passive Diffusion Sampler Result (ug/L) Residence Time: 16 Days					
Sample ID>	2MC-12	2MC-22	2M4-12	2U4-12	2M4-22	2M4-32	2M4-42	2L4-12
1,4-Dioxane	4.2	3.7	3.6	3.8	4.0	4.2	3.8	3.8

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Dual Membrane PDB Bench Test Results

Method: 200.8-1994 R5.4 - Metals (ICP/MS)	Control (ug/L)		Dual Membrane Passive Diffusion Sampler (ug/L) Residence Time: 23 Days								
Sample ID>	3MC-24	3MC-14	3U4-14	3U4-24	3U4-34	3M4-14	3M4-24	3M4-34	3L4-14	3L4-24	3L4-34
Aluminum	97.0	96.0	94.0	93.0	96.0	99.0	97.0	94.0	96.0	94.0	93.0
Arsenic	25.0	24.0	22.0	22.0	22.0	22.0	23.0	22.0	23.0	22.0	22.0
Cadmium	30.0	30.0	29.0	28.0	29.0	29.0	30.0	29.0	29.0	28.0	28.0
Chromium	67.0	65.0	62.0	61.0	63.0	63.0	65.0	61.0	64.0	61.0	62.0
Lead	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	100.0	110.0

Method: 537 (modified) - Fluorinated Alkyl Substances			Residence Time 21 Days				
PFAS	Laboratory (ng/L)		Control Samples (ng/L)		DMPDB Samples (ng/L)		
Sample ID>	RL	MDl	4MC-16	4MC-26	4M4-16	4M5-16	4U5-16
6:2-Fts	1.75	0.87	29	30	28	30	28
Perfluoro-Octanesulfonate	1.75	0.35	18	20	20	21	19
Perfluorobutanesulfonic Acid	0.87	0.26	36	36	34	33	34
Perfluoroheptanoic acid	0.87	0.35	27	28	29	30	26
Perfluorohexanesulfonic Acid	1.75	0.35	29	27	24	27	26
Perfluorohexanoic acid	1.75	0.35	30	31	31	31	30
Perfluorooctanoic acid	0.87	0.26	37	35	33	35	36
Perfluoropentanoic acid	5.3	1.8	30	30	30	29	29

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Dual Membrane PDB Bench Test Results

Method: 537 (modified) - Fluorinated Alkyl Substances			Residence Time 41 Days							
PFAS	Laboratory (ng/L)		Control Samples (ng/L)		DMPDB Samples (ng/L)					
Sample ID>	RL	MDl	4MC-36	4MC-46	4M5-16	4L5-26	4U4-16	4MR-16	4L4-16	4M5-26
6:2-Fts	1.75	0.87	25	23	23	21	20	22	21	21
Perfluoro-Octanesulfonate	1.75	0.35	18	17	18	20	17	18	17	16
Perfluorobutanesulfonic Acid	0.87	0.26	30	28	29	29	28	28	29	26
Perfluoroheptanoic acid	0.87	0.35	24	23	23	21	22	22	22	23
Perfluorohexanesulfonic Acid	1.75	0.35	23	23	25	23	23	22	25	23
Perfluorohexanoic acid	1.75	0.35	29	29	27	27	29	26	26	28
Perfluorooctanoic acid	0.87	0.26	32	33	32	32	29	33	29	31
Perfluoropentanoic acid	5.3	1.8	25	25	24	24	23	24	24	25

Method: 537 (modified) - Fluorinated Alkyl Substances			Residence Time: 21 Days										
PFAS	Laboratory (ng/L)		Control Samples (ng/L)		DMPDB Samples (ng/L)								
Sample ID>	RL	MDL	5MC-16	5MC-26	5U4-16	5U5-16	5U5-26	5L4-16	5L5-16	5L5-26	5M4-16	5M5-16	5M5-26
Perfluorobutanoic acid (PFBA)	1.9	0.33	1.3	1.0	1.4	1.2	1.3	1.3	1.4	1.2	1.1	1.4	1.3
qualifier			J B	J B	J B	J B	J B	J B	J B	J B	J B	J B	J B
Perfluorooctanoic acid (PFOA)	1.9	0.81	10	10	9.8	9.8	11	9.8	10	11	9.7	10	9.9
Perfluorooctanesulfonic acid (PFOS)	1.9	0.51	6.5	5.9	5.9	14	6.3	5.8	8.3	6.1	7.3	6.1	6.0
Perfluoropentanoic acid (PFPeA)	1.9	0.47	7.5	7.4	7.6	6.7	7.3	6.9	7.7	7.9	6.7	8.1	7.3
Perfluorohexanoic acid (PFHxA)	1.9	0.55	8.6	8.2	9.1	9.2	8.9	8.5	8.8	8.6	9.0	8.8	8.4
Perfluoroheptanoic acid (PFHpA)	1.9	0.24	7.4	7.0	7.0	7.0	7.0	7.0	7.2	7.0	7.4	6.6	7.1
Perfluorobutanesulfonic acid (PFBS)	1.9	0.19	8.8	8.9	8.2	10	8.9	8.5	9.1	9.3	8.9	8.8	9.5
Perfluorohexanesulfonic acid (PFHxS)	1.9	0.16	7.3	7.5	7.2	7.3	7.0	7.3	7.5	7.3	7.5	7.3	7.2
qualifier			B	B	B	B	B	B	B	B	B	B	B
6:2 FTS	19	1.9	7.2	6.6	7.3	7.1	6.4	6.7	7.1	7.1	6.7	6.1	6.3
qualifier			J	J	J	J	J	J	J	J	J	J	J

***See Qualifier Information, Next Page**

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Dual Membrane PDB Bench Test Results

Qualifier	Qualifier Description
B	Compound was found in the blank and sample.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

QC Method Blank	Result	Qualifier	RL	MDL	Unit
Perfluorobutanoic acid (PFBA)	0.476	J	2.0	0.35	ng/L
Perfluorohexanesulfonic acid (PFHxS)	0.357	J	2..0	0.17	ng/L

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