PFAS Overview: Chemistry, Method Options, and Sampling

ENTHALPY ANALYTICAL

a Montrose Environmental Group company

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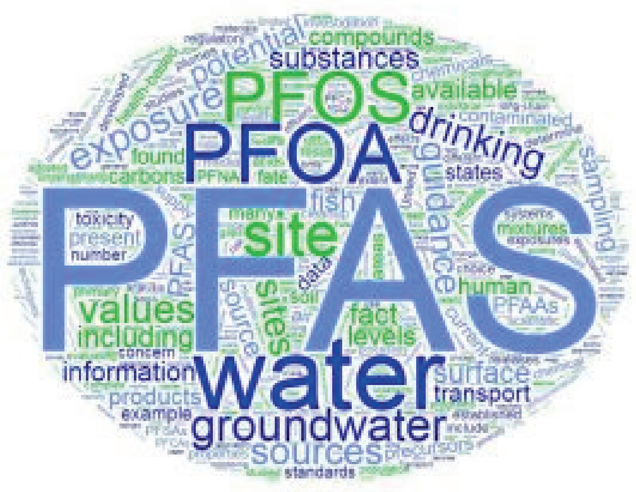
Technical Program Manager

Overview

- PFAS- What…Where…Why
- Method Options
- Sampling Techniques
- Conclusion



PFAS-

What...

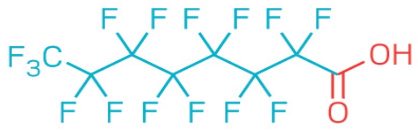
Where...

Why...

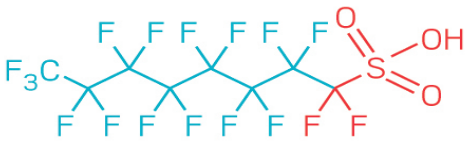
PFAS (Per & Polyfluorinated Alkyl Substances)

Longer Chains & Strong Bonds C8

Perfluorinated

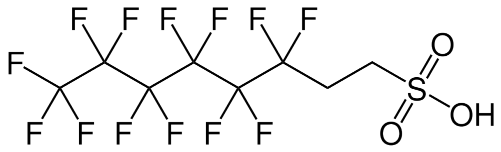


**Perfluorooctanoic acid,
PFOA,
CAS 335-67-1**



**Perfluorooctane
sulfonic acid,
PFOS,
CAS 1763-23-1**

Polyfluorinated

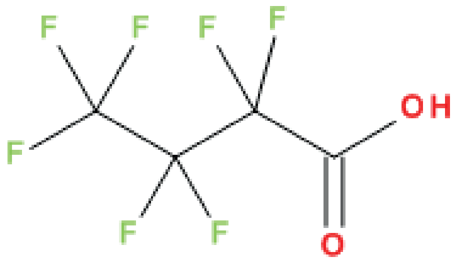


6:2 FTS

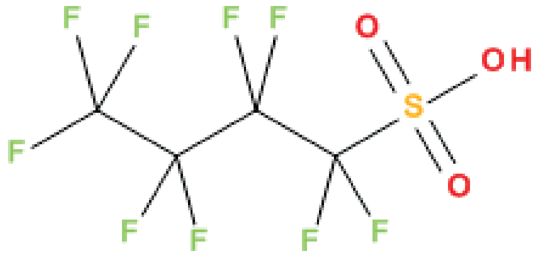
Replacement Compounds

C4 & C6

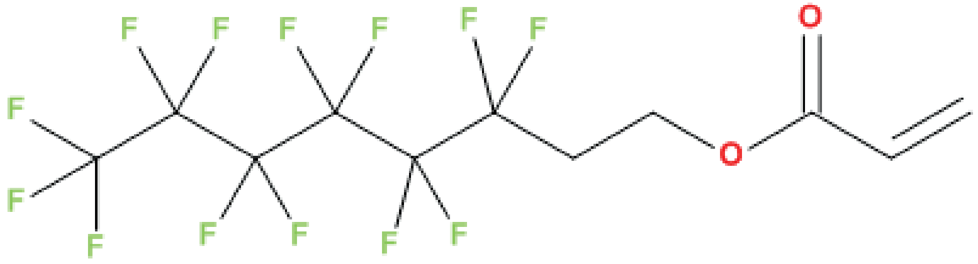
- Industry Claims they are safer
- Precursors are still longer chain C8
- PFBA- food packaging and film
- PFBS- surfactants/repellents, metal plating, pesticides, and flame retardants



PFBA



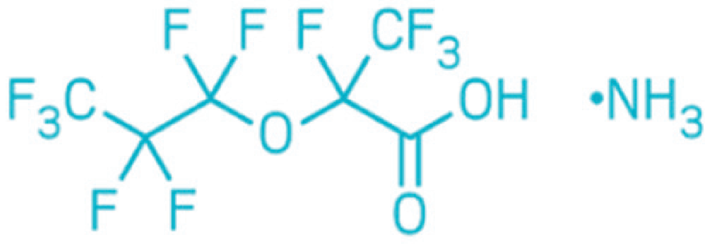
PFBS



6:2 Fluorotelomer acrylate

Gen X 2009 Dupont

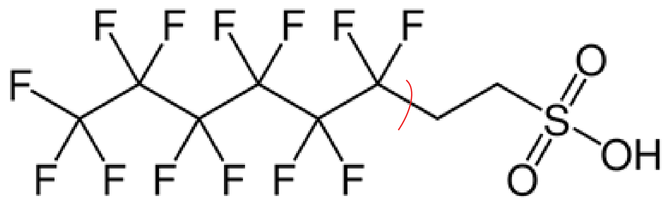
PFOA Replacement Compound



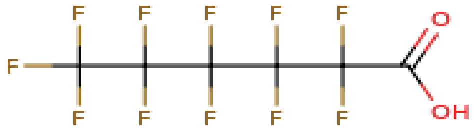
GenX

Degradation Products

Does not bioaccumulate



6:2 FTS (C8)



PFHxA (C6)

PFHxS (C6)

Liver and Kidney Toxicity
Skin Irritation

https://nasf.org/wp-content/uploads/2019/04/Summary-of-Toxicology-Studies-on-6-2-FTS-and-Detailed-Technical-Support-Documents.pdf

May Influent/Effluent WWTP

Compounds	Influent	Effluent	Δ
6:2 FTS	1840 ppt	105 ppt	- 1735
PFHxA	19.9 ppt	70.8 ppt	+ 50.9
PFHxS	8.3 ppt	5.35 ppt	- 2.95

Mass Balance….Where did it go?

PFAS

Uses

- AFFF
- Household Products(Teflon)
- Cosmetics
- Food Wrappers (PFPeA)
- Stain Resistant/Water Proofing

PFOA C8

PFOS (perfluorooctane sulfonate)

Discovery & Manufacturing History

Table 2-1. Discovery and manufacturing history of select PFAS

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production	Protective Coatings					
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)
Pre-Invention of Chemistry /			Initial Chemical Synthesis / Production			Commercial Products Introduced and Used		

Notes:
1. This table includes fluoropolymers, PFAAs, and fluorotelomers. PTFE (polytetrafluoroethylene) is a fluoropolymer. PFOS, PFOA, and PFNA (perfluorononanoic acid) are PFAAs.
2. Refer to Section 3.4.
3. The dominant manufacturing process is shown in the table; note, however, that ECF and fluorotelomerization have both been, and continue to be, used for the production of select PFAS.

Sources: Prevedouros et al. 2006; Concawe 2016; Chemours 2017; Gore-Tex 2017; US Naval Research Academy 2017

INTERSTATE TECHNOLOGY REGULATORY COUNCIL ITRC

Health Concerns

PFOA/PFOS most studied…

- Reproductive/development issue
- Increased Cholesterol
- Infant birth rate
- Cancer (PFOA)
- Thyroid hormone effects (PFOS)

EPA Health Advisory Timeline for PFAS

Three Factors That Affect Standards:

- Reference Dose,
- Relative Source Contribution
- Consumption Rate

Change in Reference Concentrations: PFOS and PFOA

- ***EPA Provisional* Health Advisory**, 2009
  - *Short-term* adverse health effects
  - PFOS: 200 ppt PFOA: 400 ppt

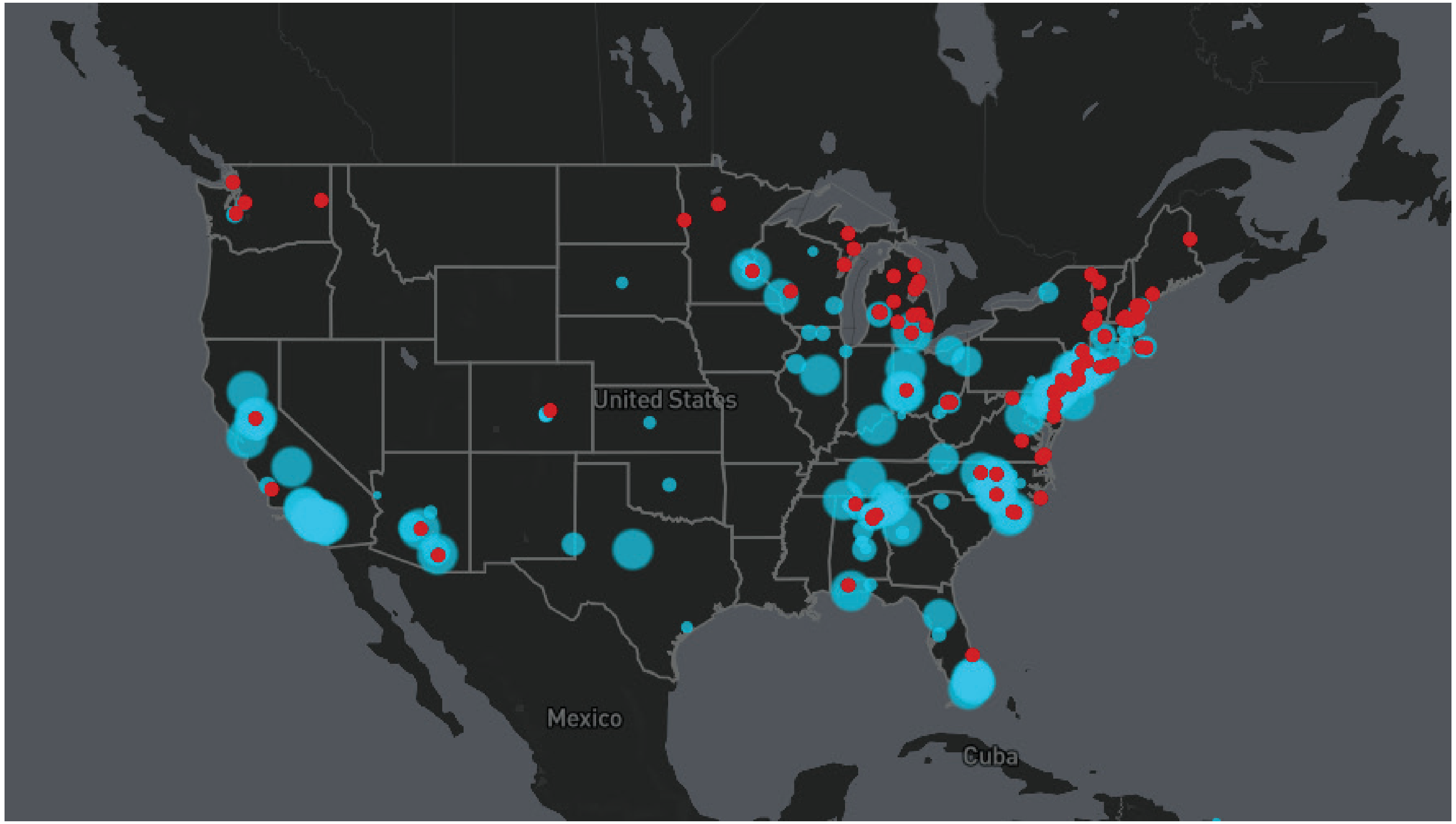
- **EPA Health Advisory**, May 19, 2016
  - *Long-term* adverse health effects
  - PFOS + PFOA: 70 ppt

EPA United States Environmental Protection Agency

FACT SHEET
PFOA & PFOS Drinking Water Health Advisories

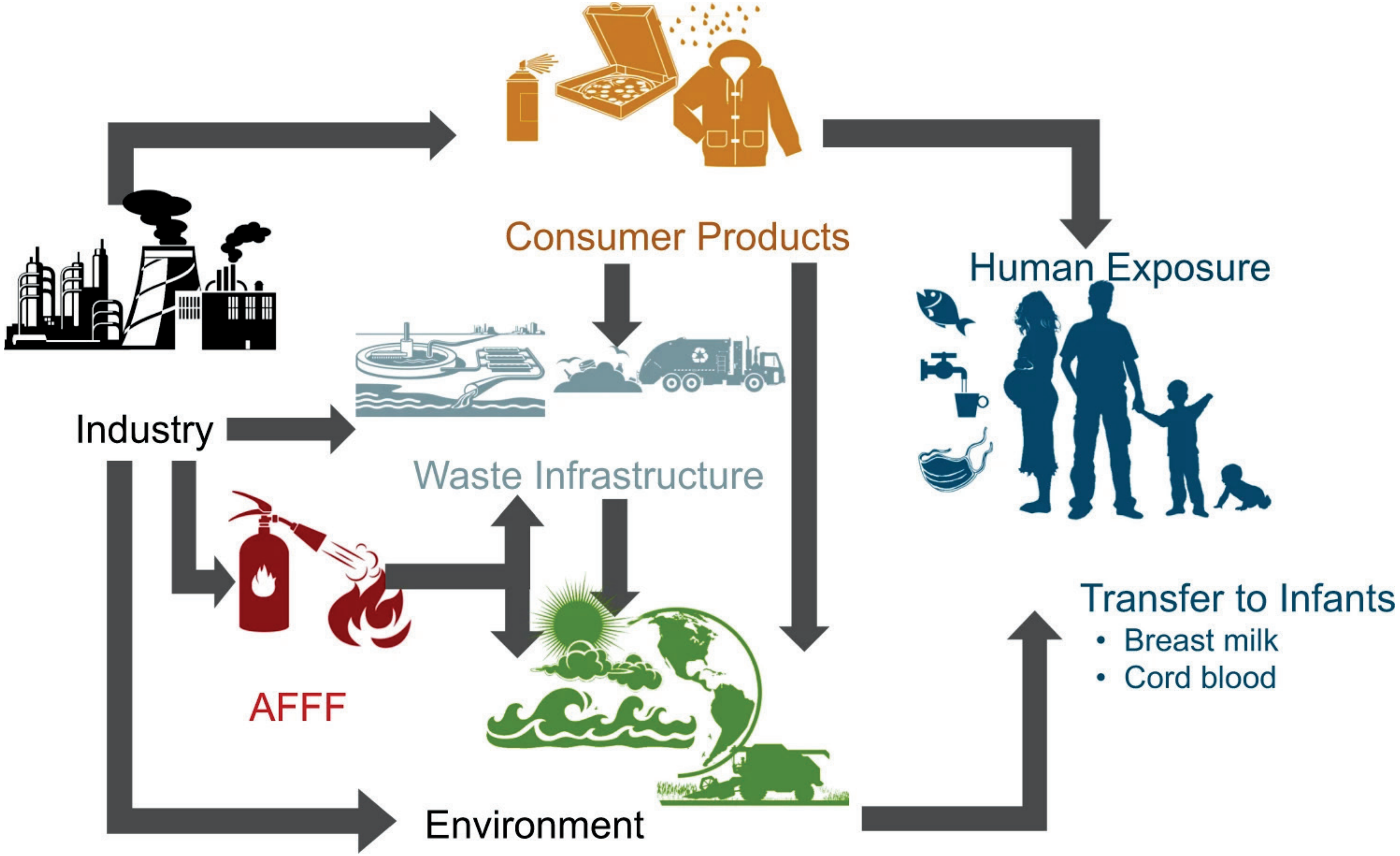
Where are they….

April 2018

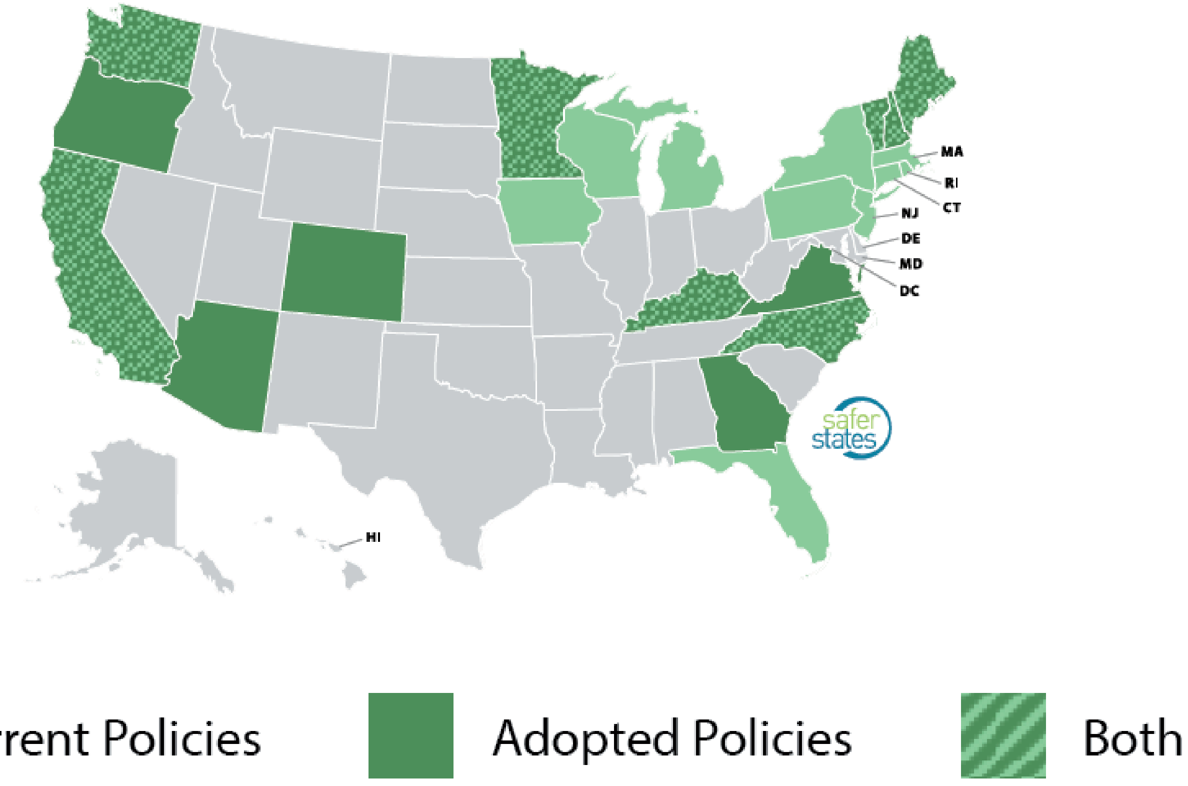


https://www.northeastern.edu/environmentalhealth/mapping-the-expanding-pfas-crisis/

Exposure to Humans



63 current policies in 18 states
22 adopted policies in 13 states



http://www.saferstates.com/toxic-chemicals/pfas/

State PFAS Water Regulation Overview

- **Sixteen states** have promulgated rules or guidance values for PFAS in groundwater, drinking water, surface water or effluent (AK, CA, CO, FL, IA, MA, MI, MN, MT, NH, NJ, NC, OR, RI, TX, VT).
- **Thirteen states** regulate PFAS in drinking water through a Maximum Contaminant Level (MCL), screening level, and / or action level, as of August 6, 2020 (AK, CA, CT, DE, MA, MI, MN, NV, NJ, NC , OH, RI, and VT)
  - MCLs range from 5 ppt to 70 ppt.
  - Eleven states have pending legislation that would require the jurisdiction to set and enforce a MCL for PFAS and other chemicals in drinking water (AZ, DE, IL, IN, OH, PA, SC, VA, WA, WV, WI)
  - Other states are awaiting formal drinking water limits from the EPA at the federal level.
- **Fourteen states** have banned or proposed to ban the use of PFAS in fire-fighting foam used for testing and training purposes (AK, CO, CT, IL, IA, MI, MD, MA, NC, NY, VT, VA)

Method Options

Method Options

Matrix Dependent

- EPA 537/537.1- Drinking Water, Required for demonstrating compliance, 18 compounds, but only a few states accredit
- EPA 533- Drinking Water, Isotope Dilution, 25 compounds
- EPA 8327- direct inject, screening method water high RL, poor accuracy/precision, few calibration points, 24 compounds
- Isotope Dilution– Isotope Dilution, largest number of quality requirements, wide variety of matrices/compunds, and most accurate.

Isotope Dilution

And its many names

- Modified 537/537.1
- PFAS by LC/MS/MS
- PFAS by Table B-15
- PFAS by DOD QSM Table B-15

DOD QSM Table B-15

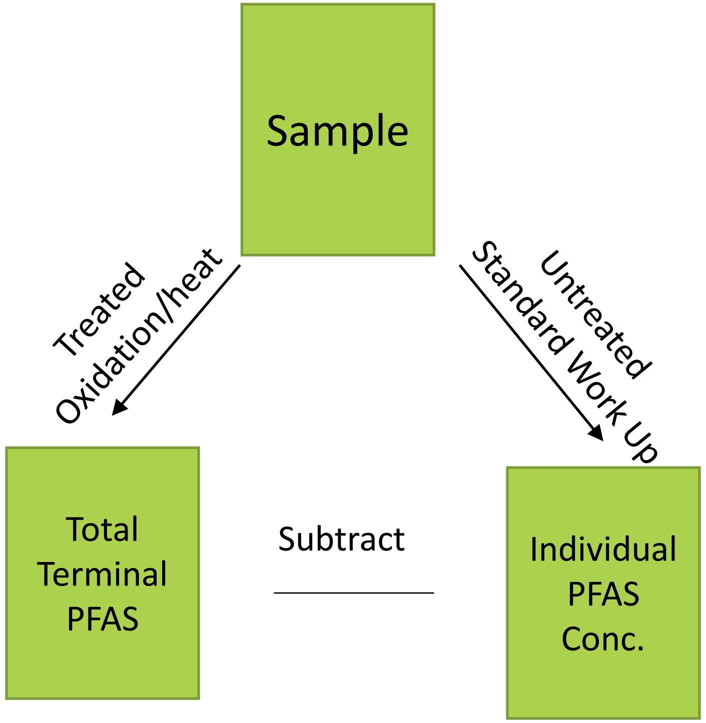
Highlights of Quality Requirements

- Requirements that Improve PFAS Analysis
  - Two ions monitored for each compound – reduces false positives
  - Method blanks to ensure a lack of contamination in sample results
  - Instrument blanks assess and prevent carryover to ensure a lack of contamination in sample results
  - Calibration criteria to ensure accuracy within ~30% of reported values
  - Low level accuracy confirmation with each analytical sequence

- Requirements that work against Isotope dilution
  - Labeled standard recoveries measured by area and required to be within 50% of calibration – why use isotope dilution?
  - Matrix spikes & matrix spike duplicates – not necessary in isotope dilution

TOPS (Total Oxidizable Precursor Assay)

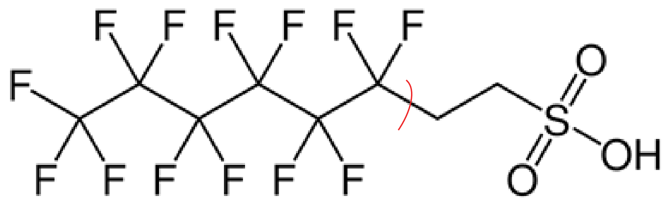
- Worst Case Estimate PFAS Composition
- Speeds up potential environmental oxidation that might occur over many years. Lab oxidation takes less than a day.
- Helpful in remediation testing as well as waste water treatment facilities.
- Used in AFFF analysis frequently.
- Assumptions are made- 1) all non-targeted PFAS will be converted to targeted PFAS 2) 100% of the PFAS will be oxidized 3) all compounds oxidize similarly



The difference if any is presumed to be due to the oxidation of precursors

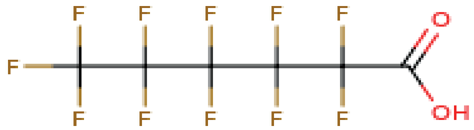
Degradation Products

Does not bioaccumulate

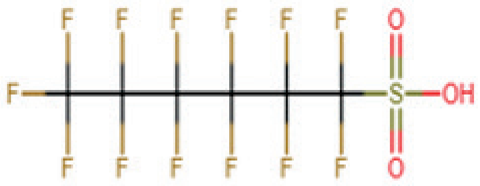


6:2 FTS (C8)

Liver and Kidney Toxicity
Skin Irritation

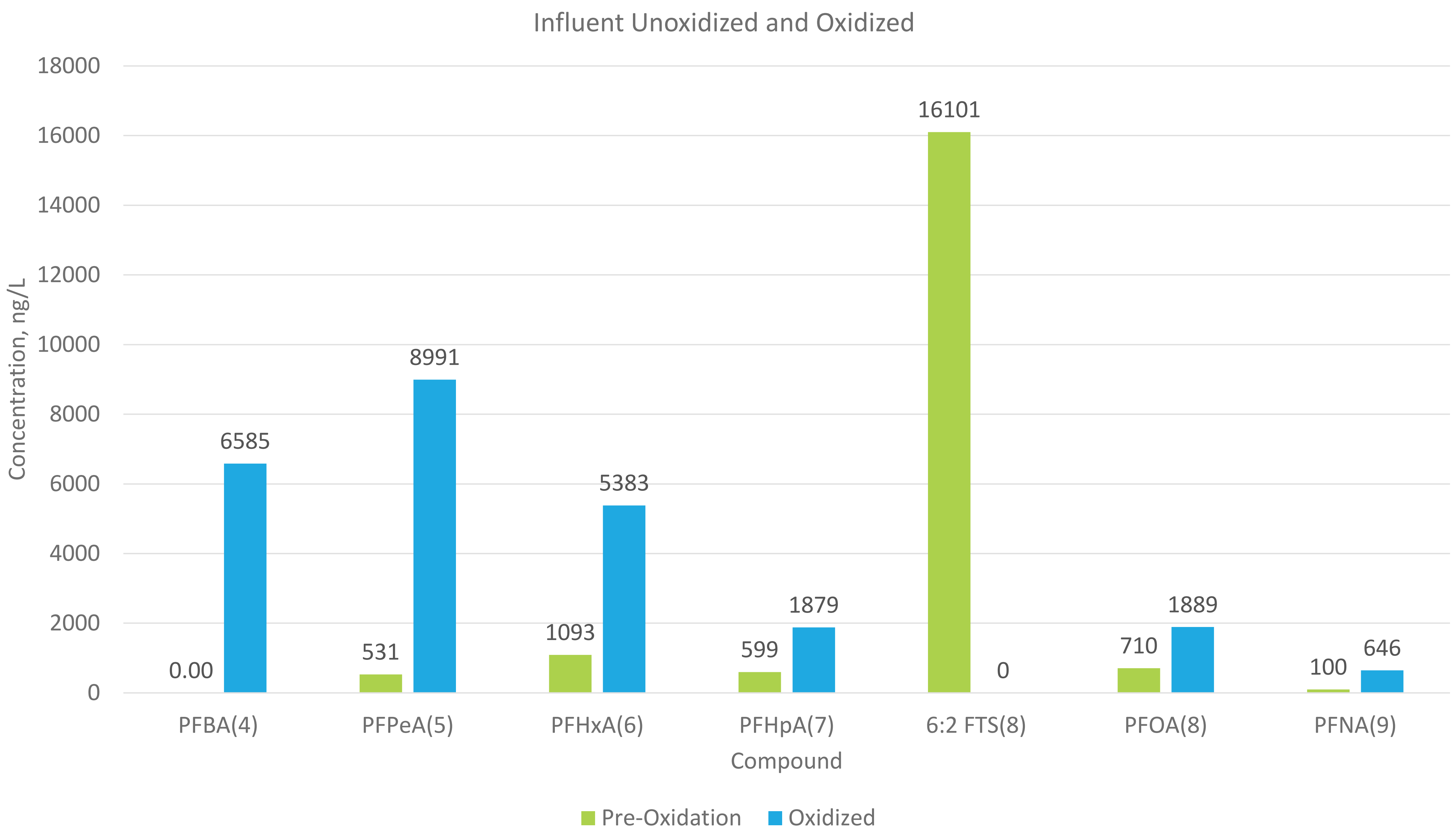


PFHxA (C6)



PFHxS (C6)

https://nasf.org/wp-content/uploads/2019/04/Summary-of-Toxicology-Studies-on-6-2-FTS-and-Detailed-Technical-Support-Documents.pdf


Influent Unoxidized and Oxidized
Concentration, ng/L
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.00
6585
531
8991
1093
5383
599
1879
16101
0
710
1889
100
646
PFBA(4)
PFPeA(5)
PFHxA(6)
PFHpA(7)
6:2 FTS(8)
PFOA(8)
PFNA(9)
Compound
Pre-Oxidation
Oxidized

Tabulated Influent Results

	Pre-Oxidation			
	Influent 1	Influent 2	Influent 3	Average
Compounds	ng/L	ng/L	ng/L	ng/L
PFBA(4)	0.00	0.00	0.00	0.00
PFPeA(5)	0.00	792	802	531
PFHxA(6)	1073	1100	1107	1093
PFHpA(7)	669	574	553	599
6:2 FTS(8)	17465	16596	14243	16101
PFOA(8)	765	697	668	710
PFNA(9)	100	85	116	100
ΣPFAS	20072	19843	17490	19134

	Post-Oxidation			
	Influent 1	Influent 2	Influent 3	Average
Compounds	ng/L	ng/L	ng/L	ng/L
PFBA(4)	7963	5736	6056	6585
PFPeA(5)	10753	7987	8233	8991
PFHxA(6)	6361	4929	4861	5383
PFHpA(7)	3070	2568	0	1879
6:2 FTS(8)	0	0	0	0
PFOA(8)	2270	1748	1649	1889
PFNA(9)	759	631	548	646
ΣPFAS	31177	23598	21347	25373

Average Difference = 6,239 ppt
Represents unknown precursors and it is a lower limit on the precursor content (This assumes that 100% of 6:2 FTS converted to a measured PFAS)

The complete removal of 6:2 FTS also indicates oxidation was driven to completion

TOF (Total Organic Fluorine)

- What is it? Measurement of all fluorine in a sample that can be attributed to organic chemicals. There are nearly zero naturally occurring chemicals with organic fluorine. The mast majority of organic fluorine is PFAS.
- There are 3 common ways to measure combustion-Ion Chromatography is the most common
- The measurement is very non-specific. You will get an amount of organic fluorine but it does not tell you what chemical it specifically came from. Total Organic Fluorine can't be used to correlate toxicity.
- How do we measure it? Combustion Ion Chromatography. We measure Total Fluorine by combustion. Then we measure inorganic fluorine per a common IC procedure. This is done on the same instrument. Then the organic fluorine is obtained by subtracting inorganic from the total fluorine.

Sampling Techniques

Your Outfit

What not to wear….

- Wear Clean Clothes
- Cotton Clothing
- Use Powder Free Nitrile Gloves
- Avoid Sunscreens, Make-up, and Lotions
- No Perfumes/Cologne
- No Dry Fit Clothing, Gortex, or Water-Proof Clothing
- Don't eat out there

Common Sources of Laboratory Contamination

Samples should be collected in high density polyethylene (HDPE) containers pre-washed with methanol.

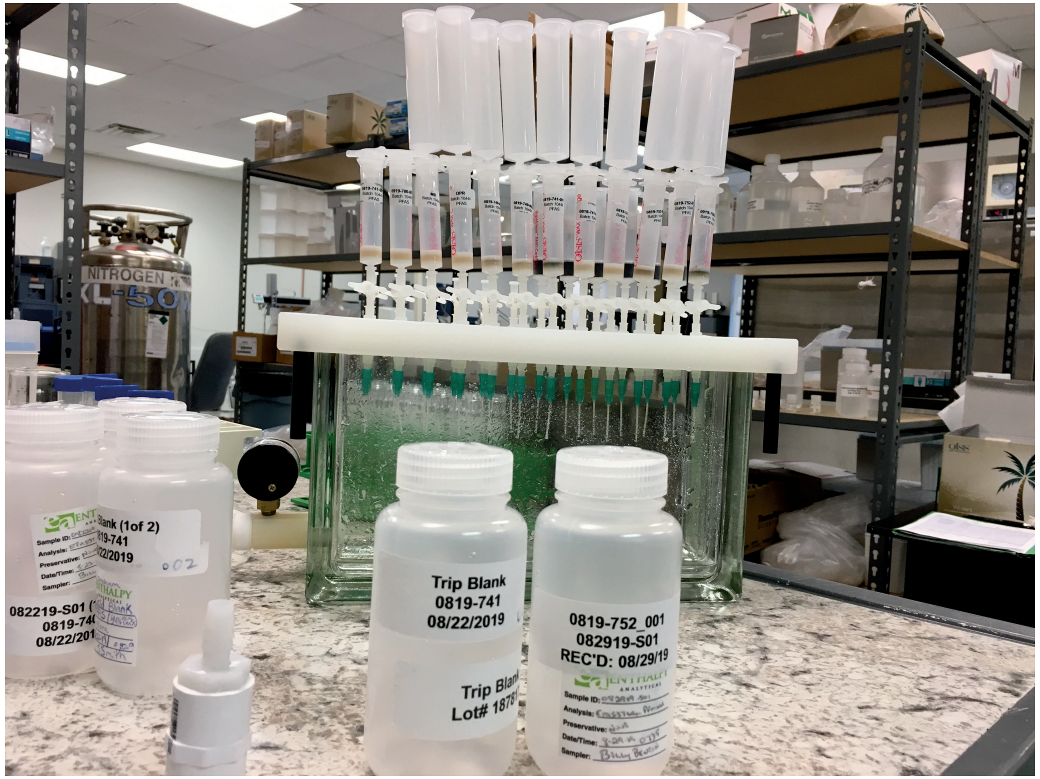
Common sources of laboratory contamination that <u>should be avoided</u> include:

- Aluminum foil
- Glass transfer pipettes
- Glass autosampler vials
- Vial caps with Teflon seals
- Pipette tips labelled as “low retention”
- Blue Ice

Sampling Options

What questions am I looking to answer…

- Analytes to Measure
- Reporting Limits
- Trip Blank-prepped by lab
- Field Blank-prepared by you in the field
- Report Type



Grab Sampling

WWTP/Surface Waters etc.

- Use HDPE Containers Provided/Stainless Dipper
- Wash Hands and Wear Nitrile Gloves
- Pre-label with Ball Point Pen
- Waste Twice Then Collect
- Collect in Duplicate

USA Blue Book Part# 55295

Decontamination

PFAS Free Water (We can test your Milli Q/DI Systems)

Raw Water/Finished Water/Wells

Usually Clean Environment

Finished Water

Raw Water

Soils, Sediments, and Solids Sampling

NY Department of Environmental Conservation

- Acceptable equipment- Stainless Steel Spoon, stainless steel bowl, steel hand auger or shovel without coatings
- Decontamination- A 2 step process is most stringent. 1) detergent Alconox is acceptable 2) PFAS free water rinse
- Surface Soil 0-6 inches stainless steel spoon
- Shallow sub surface 6-36 inches dig hole with shovel then collect with pre-cleaned auger or spoon
- Sample should be placed in a stainless steel bowl and mixed by rolling the material in the middle until homogeneous. Then transfer to sample containers.
- Avoid contact with foil or PTFE.

Packing Your Sample

What to do and extra precautions….

- Place in Secondary Container (Zip Lock)
- Use Wet Ice-Do Not Use Blue Ice
- Can Refrigerate Until Shipped or Picked Up

- Can Bag Each Sample Location Separately
- We Can Supply Labeled Bags If You Like
- Can Bag Your Wet Ice
- Make Copies of Your COC

A Few Extras

What we have learned…

- Influent sampling is difficult
- True duplicates are tough
- Think about particulate
- Rotate your sampling schedule
- Think about nearby industries
- We can add analytes

Questions?
Call me for your PFAS Testing Needs!

- Lindsay Boone
  - lboone@enthalpy.com
  - 910.544.6077

Emerging Contaminants: PFAS in NPDES Permits

Ethan R. Ware, Esq.

WILLIAMS MULLEN

Per–and–polyfluoroalkyl Substances

"PFAS" = Active Priority to EPA

NOTE: PFAS breaks down to PFOA/PFOS

Overview

- EPA Action Plan
- NPDES Permits
- Class Actions

EPA PFAS Action Plan February 2019

A. Drinking Water

- M533/537.1 – 29 Chemicals
- Proposed Rule: PFOA/PFOS (December 2019)

[Document 1]

B. Cleanup Levels (December 2019)

- EPA Screening Level: 40 ppt
- EPA Drinking Water Advisory: 70 ppt

[Document 2]

C. Destruction standards (July 2020)

- Incineration
- MSW or HW Landfills
- UIC

[Document 3]

D. Hazardous Substances

"Working on Proposed Rule" to be Hazardous Substance.

CERCLA 302.4, Table 1.

E. Ancillary Actions

- Final Rule: 172 PFAS on TRI (June 2020)
- Final Rule: PFAS Products banned (July 2020)
- Enforcement: 15 cases …Primarily North Carolina in Region 4

Recommendations for NPDES Permits

- "Address point source discharges of PFAS"
- CWA 402

Question: Reasonable potential to violate what WQS?

[Document 4]

EPA Recommendation 1: Permit Requirements

A. Monitoring – if “PFAS expected”

- Data – Similar Facilities
- Stored/Used
- Products/Byproducts

B. Phased Approach

- After EPA Methods Published

NOTE: Must be part of 40 CFR 136

C. Best Management Practices

- Release at Plant
- Process Water

QUESTION: What are BMPs for PFAS?

EPA Recommendation 2: Storm Water

- SWP3
- “Control Measures”
- Inspections

SWP3 Requirements

- Identify Sources
- Monitor
- Control Releases = “maximum extent practicable”

Max Extent Practicable (MEP):

- Location-by-location
- Receiving waters
- Watershed
- Locations

EPA Recommendation 3: Information

- Permit Compendium
- “Clear, specific, measurable”

EPA Deadlines

June 2021 ……………………….. Build-out Permit Compendium

- Permit Terms/Conditions
- BMP/Sampling
- Not Limits…yet

Third Quarter 2021 NPDES …. Permit Examples

CONTACT: Craig Hasterleve (Region 4)

North Carolina Assistance

- Cape Fear River – Testing
- Input to DEQ “Interim Health Goal”
- Assistance NPDES Permitting

June 2017

EPA Recommendation No. 4: Permit Limits

North Carolina Permit Process

- 99% Removal Efficiency--Groundwater
- Influent/Effluent Testing
- Process water (No Discharge)

NOTE: September 2019

.

Treatment Systems

1. Influent Oxidation, Coagulation, and pH Adjustment
2. Ultrafiltration
3. G.A.C. Absorption

EPA: “[These] have not been…effective in removing PFAS.” “[PFAS] Action Plan”, p. 29

WQBELs: PFAS Limits

"When EPA develops PFAS criteria or the State adopts standards…."
[Id.]

PFAS Indicator Limits

HFPO-DA = 60 ppt

PFMOAA = 850 ppt

PMPA = 54 ppt

RULE: PFAS Limits to Come…

[Document 5]

EPA Advanced Notice of Proposed Rulemaking

Organic Chemicals, Plastics and Synthetic Fibers Point Source

[86 Fed. Reg. 14560 (March 17,2021)]

Please note: This presentation contains general, condensed summaries of actual legal matters, statutes and opinions for information purposes. It is not meant to be and should not be construed as legal advice. Individuals with particular needs on specific issues should retain the services of competent counsel.

EPA Soliciting Information

1. PFAS Manufacturers
2. PFAS Formulators

PFAS Manufacturers

"Produce PFAS compounds or precursors through…electrochemical fluorination and telomerization."

NOTE: Six Facilities

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PFAS Formulators

"Use raw PFAS feedstock"

- Produce Goods
- Intermediary products

NOTE: "Ten Facilities"—None in S.C.?

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2. EPA Interim Strategy

Consumer Goods

"Weather-proof caulking"

Intermediary Products

"Grease proof coatings for [food packaging]"

Purpose of Rulemaking

1. Correct Collected Information
2. "Soliciting Information and data"

Stated Goal: "Developing new or revised ELGs"

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Clean Water Act

PFAS: "Nonconventional Pollutant"

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Technology–Based Controls

Existing Facilities

1. Best Practicable Control
2. Best Available Treatment Economically Achievable
3. Pretreatment Standards

OCPSF Focus

1. OCPSF Manufacturers
2. Pulp/Paper
3. Textiles/Carpet
4. Airports

NOTE: A3F Fire Retardants

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Sources of Information

1. DMRs
2. NPDES
3. TRI 2021
4. Manufacturers
5. TSCA/CDR/Pubic Sources

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Requested Information

1. Identity of PFAS Formulators
2. SIC/NAICS
3. PFAS Compounds Used
4. Monitoring/Treatment/Process
5. Analytical Methods

Ultimate Goal:

Revise 40 CFR 414

1. Waste Treatment Options
2. Water Pollution Control
3. Chemicals, Plastics, Synthetics

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What to do now?

1. Rule is Proposed
2. Am I OCPSF (Part 414)?
3. If So, Am I a Formulator?

Covered Facility: File Comments

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DHEC Strategy

Assess Impacts in Waters of the State

(Draft Document)

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External Peer Review Groups

NGOs – 16

Industry – 3

Gov’t Research – 5

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Potential PFAS Sources

- Defense/Energy
- PFAS Manufacturing
- Landfills
- Airports/Fire Fighting
- Industry/Refineries

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Industry Groups

- OCPSF– 65
- Pulp/Paper—11
- Textiles—68
- Airport/POTW-- 240

Target Watersheds

- Broad River
- Catawba River
- Saluda River

…among others.

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…But Wait…There is More!!

Multi-District Litigation by Public Utilities for Cleanup of Rivers, Streams, and POTWs

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Liability: Citizen Suits

"A3F MDL" : 800 Complaints

A3F = Aqueous Film Forming Foam

MDL = Multi-district Litigation

Two Groups Plaintiffs: A3F Exposure

A. Fireman – Personal Injury

B. POTW – Remediation Costs

Defendants

- 3M
- DuPont/Chemours
- Tyco/Chemguard

….AND

A3F Products

- Toll Manufacturers – “Components”
- Distributors
- Wholesale/Retail

QUESTION: Are Tollers included as “Formulators”?

Source Areas: Fire Training

- Water/Foam Discharge
- Water/Foam Stormwater
- Water/Foam Wastewater Treatment

3. Class Action

- Influent exposure
- Influent treatment/discharge
- Product

…and the POTW discharge.

Causes of Action

- Product Liability (Strict)
- Nuisance
- Negligence
- Fail to Warn

Question: Will Plaintiff lawyers stop at manufacturers?

Question: Must SEC be informed?

Conclusions

1. EPA Has an Action Plan

2. New Permit Limits: Information Gathering…

3. Will A3F MDL Push Timing?

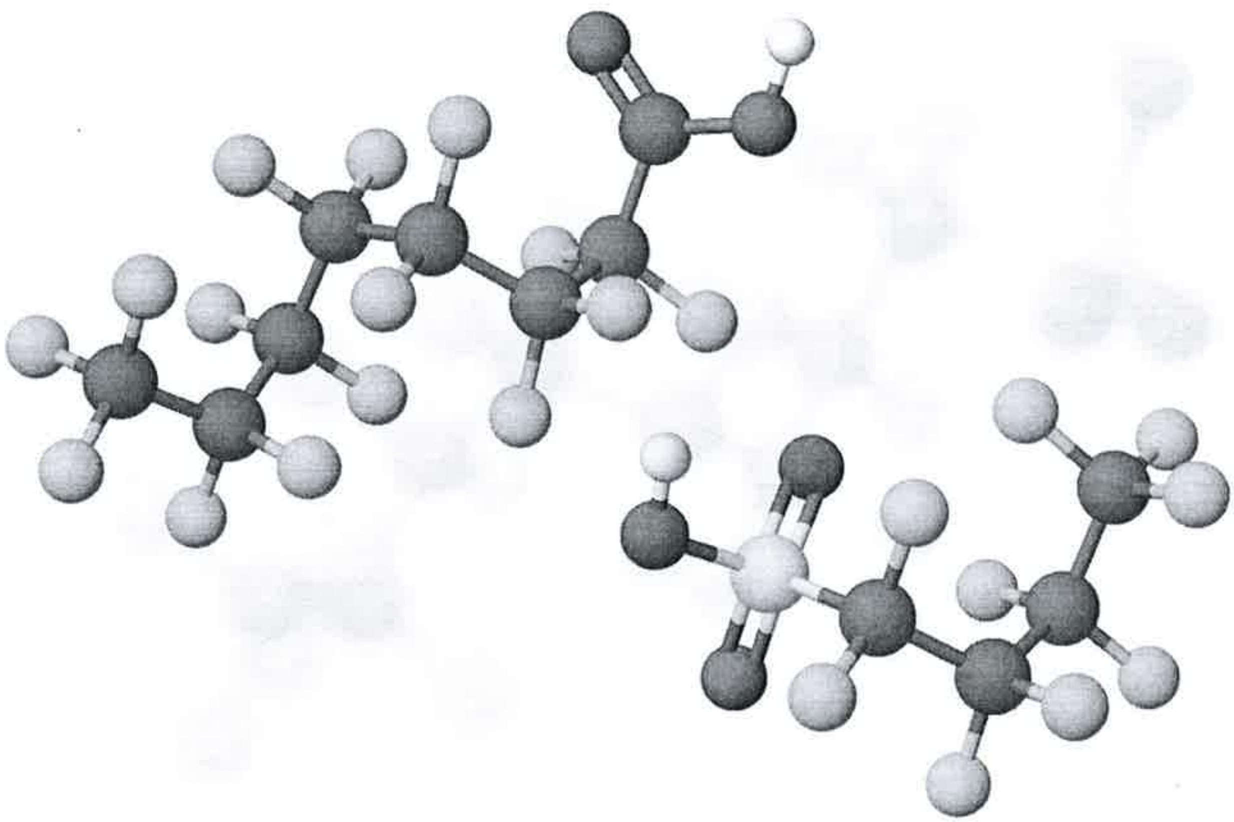
NEXT STEPS

1. Investigate PFAS
2. Respond to Information Requests
3. File Comments to EPA Guidance

United States Environmental Protection Agency

EPA 823R18004 | February 2019 | www.epa.gov/pfas

EPA's Per- and Polyfluoroalkyl Substances (PFAS) Action Plan



U.S. Environmental Protection Agency

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List of Acronyms

ACRONYM	FULL PHRASE
ASDWA	Association of State Drinking Water Administrators
ASTHO	Association of State and Territorial Health Officials
ASTSWMO	Association of State and Territorial Solid Waste Management Officials
ATSDR	Agency for Toxic Substances and Disease Registry
CAA	Clean Air Act
CCL	Contaminant Candidate List
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
CWS	Community Water System
DoD	Department of Defense
DWSRF	Drinking Water State Revolving Fund
ECOS	Environmental Council of States
ELGs	Effluent Limitations Guidelines
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
GenX	Gen X Chemicals (i.e., HFPO dimer acid and its ammonium salt), also known as (2,3,3,3-tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid (CASRN 13252-13-6) or hexafluoropropylene oxide (HFPO) dimer acid and 2,3,3,3-tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoate (CASRN 62037-80-3) or HFPO dimer acid ammonium salt)
HA	Health Advisory
HERO	Health and Environmental Research Online
HFPO	Hexafluoropropylene Oxide
HTT	High Throughput Toxicity Testing
HTTK	High Throughput Toxicokinetic
HUD	Department of Housing and Urban Development
ITRC	Interstate Technology and Regulatory Council
KDHE	Kansas Department of Health and Environment
LCPFAC	Long-Chain Perfluoroalkyl Carboxylate
LGAC	Local Government Advisory Committee
MCL	Maximum Contaminant Level
MDEQ	Michigan Department of Environmental Quality
NIST	National Institute of Technology

NPDES	National Pollutant Discharge Elimination System
NTP	National Toxicology Program
OECD	Organization for Economic Cooperation and Development
PFCA	Perfluoroalkyl Carboxylic Acid
PFAS	Per- and Polyfluoroalkyl Substances
PFBS	Perfluorobutane Sulfonic Acid
PFBA	Perfluorobutanoic Acid
PFHpA	Perfluoroheptanoic Acid
PFHxS	Perfluorohexane Sulfonic Acid
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PMN	Premanufacture notice
ppt	Parts per Trillion
PWSs	Public Water Systems
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SNUN	Significant New Use Notice
SNURs	Significant New Use Rules
TSCA	Toxic Substances Control Act
UCMR	Unregulated Contaminant Monitoring Rule
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WCIT	Water Contaminant Information Tool

I. Executive Summary

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic chemicals that have been in use since the 1940s. PFAS are found in a wide array of consumer and industrial products. PFAS manufacturing and processing facilities, facilities using PFAS in production of other products, airports, and military installations are some of the contributors of PFAS releases into the air, soil, and water. Due to their widespread use and persistence in the environment, most people in the United States have been exposed to PFAS. There is evidence that continued exposure above specific levels to certain PFAS may lead to adverse health effects (USEPA 2016a, 2016b, ATSDR 2018a).

The EPA will continue to partner with other federal agencies, states, tribes, and local communities to protect human health and, where necessary and appropriate, to limit human exposure to potentially harmful levels of PFAS in the environment. The EPA is leading the national effort to understand PFAS and reduce PFAS risks to the public through implementation of this Action Plan and through active engagement and partnership with other federal agencies, states, tribes, industry groups, associations, local communities, and the public.

Key EPA Actions Addressing PFAS-Related Challenges

- **Expand toxicity information for PFAS**
- **Develop new tools to characterize PFAS in the environment**
- **Evaluate cleanup approaches**
- **Develop guidance to facilitate cleanup of contaminated groundwater**
- **Use enforcement tools to address PFAS exposure in the environment and assist states in enforcement activities**
- **Use legal tools such as those in TSCA to prevent future PFAS contamination**
- **Address PFAS in drinking water using regulatory and other tools**
- **Develop new tools and materials to communicate about PFAS**

Throughout recent engagements, the EPA heard clearly the public's desire for immediate action to address potential human health and economic impacts from PFAS in the environment.

This Action Plan describes the EPA's approach to identifying and understanding PFAS, approaches to addressing current PFAS contamination, preventing future contamination, and effectively communicating with the public about PFAS. The Action Plan describes the broad actions the EPA has underway to address challenges with PFAS in the environment, including next steps on the four PFAS management actions the EPA announced at the May 2018 National Leadership Summit. The four actions announced at the Summit were:

- Initiating steps to evaluate the need for a maximum contaminant level (MCL) for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS);
- Beginning the necessary steps to propose designating PFOA and PFOS as "hazardous substances" through one of the available federal statutory mechanisms[1];
- Developing groundwater cleanup recommendations for PFOA and PFOS at contaminated sites;
- Developing toxicity values or oral reference doses (RfDs)[2] for GenX chemicals[3] and perfluorobutane sulfonic acid (PFBS).

In addition to these significant actions, the EPA's PFAS Action Plan identifies more short-term and long-term actions that are currently being implemented to understand and address PFAS. Short-term actions include:

- Developing new analytical methods and tools for understanding and managing PFAS risk;
- Promulgating Significant New Use Rules (SNURs) that require EPA notification before chemicals are used in new ways that may create human health and ecological concerns; and
- Using enforcement actions to help manage PFAS risk, where appropriate.

Short-term actions are generally taking place or expected to be completed within two years. The Action Plan also sets out long-term regulatory and research approaches the EPA will pursue to reduce exposures and to understand the potential human health and environmental risks associated with PFAS. Actions classified as long-term, such as multi-step research initiatives or regulatory actions, are generally expected to take more than two years. Some long-term actions may result in intermediate steps and products that can help to reduce PFAS exposures and protect public health.

Ecological risks are of great concern to many stakeholders due to the widespread distribution and persistence of PFAS in the environment and the wide variety of PFAS chemicals for which environmental fate and transport is currently uncharacterized. While this Action Plan focuses mainly on human health, characterizing potential ecological impacts and risks are important areas of work for the EPA.

Table 1 below summarizes the key actions the EPA is taking to assist states, tribes, and communities in addressing PFAS. These activities are intended to address challenges identified though stakeholder input

[1] There are multiple statutory mechanisms available to designate PFAS as CERCLA hazardous substances, including CERCLA, RCRA, TSCA, CWA, and CAA.

[2] A reference dose is an estimate of the amount of a chemical a person can ingest daily over a lifetime (chronic RfD) or less (subchronic RfD) that is unlikely to lead to adverse health effects.

[3] hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt

during the PFAS National Leadership Summit, multiple community engagements, and through the public docket (see Appendices B and C for summaries of stakeholder input).

In addition to the highlighted action items in Table 1, the EPA continues to make progress on developing tools and expanding the body of scientific knowledge needed to understand and effectively manage risk from PFAS, including developing PFAS analytical methods, evaluating treatment and remediation techniques for PFAS, understanding the exposure from various environmental media, and evaluating human health impacts of additional PFAS. These activities are described in more detail in Appendix A.

Table 1. Key PFAS-Related Challenges and Planned and Ongoing EPA Actions

Stakeholder Concern or Challenge	EPA Action(s)	Purpose	Anticipated Timeframe
EPA Priority Actions			
Regulatory uncertainty (e.g., MCL) for PFAS in drinking water	Propose a national drinking water regulatory determination for PFOA and PFOS, highlighting key information gathered by the Agency and our partners to date and additional data needs.	Provide the opportunity for the public to comment on and contribute to the information the EPA may consider related to the regulation of PFAS in drinking water.	2019
Hold responsible parties accountable for PFAS releases into the environment	The EPA has initiated the regulatory development process for listing PFOA and PFOS as CERCLA hazardous substances.	Listing PFOA and PFOS as CERCLA hazardous substances would provide additional authority to address PFOA and PFOS, including the ability to require responsible parties to carry out and/or pay for response actions.	Ongoing Started 2018
Provide guidance for groundwater cleanup actions at contaminated sites	Develop interim cleanup recommendations to address groundwater contaminated with PFOA and PFOS.	Recommendations will provide a starting point for making site-specific cleanup decisions. These recommendations may be considered for federal facility and private-party cleanup under CERCLA, RCRA corrective action programs, and state cleanup programs, where appropriate.	Anticipated 2019
Increase understanding about potential human health impacts of additional PFAS	Finalize draft toxicity assessments for GenX chemicals and PFBS; develop additional PFAS toxicity values for PFBA, PFHxA, PFHxS, PFNA, and PFDA.	Finalized toxicity assessments can be combined with specific exposure information by government and private entities to help characterize potential public health risks associated with exposure to these chemicals.	Final toxicity assessments for PFBS and GenX chemicals in 2019; Draft toxicity assessments for five additional PFAS in 2020

Stakeholder Concern or Challenge	EPA Action(s)	Purpose	Anticipated Timeframe
Expand knowledge about whether new PFAS chemicals entering commerce are safe	Use new statutory requirements added by the Frank R. Lautenberg Chemical Safety for the 21st Century Act to review new PFAS and issue supplemental proposed Significant New Use Rules (SNUR on PFAS).	New chemical reviews under TSCA ensure that unreasonable risks are addressed prior to commercialization. The issuance of SNURs for existing PFAS chemicals prohibits new uses for these chemicals until the EPA determines whether the significant new use presents an unreasonable risk and takes appropriate actions as required by TSCA to address any unreasonable risk.	Ongoing Started in 2016
Short-Term Actions			
Understanding and Addressing PFAS Toxicity and Occurrence			
Establish and curate a clearinghouse of chemical information for PFAS	The EPA's CompTox Chemistry Dashboard has been updated to include several curated lists of PFAS chemicals with links to known chemical, physical, and other properties.	Provide simple access to a comprehensive array of up-to-date information for PFAS of interest.	Ongoing
Expand analytical methods to accurately test for additional PFAS in drinking water	Expand the current drinking water Method 537 to include GenX chemicals and additional PFAS; develop a new drinking water method for additional short-chain PFAS not measured by Method 537.	Improved and/or additional methods would help stakeholders and the EPA accurately test, analyze, and quantify a broader suite of PFAS in their drinking water, including GenX chemicals and other short-chain PFAS.	Method 537.1 completed November 2018; additional methods in 2019
Test for PFAS and PFAS precursors in media other than drinking water	Develop and validate methods for other water matrices (wastewater, surface waters, groundwater), solids (soil, sediment, biosolids, fish tissue), and air (ambient, stack emission, off-gases).	Provide additional methods for stakeholders and the EPA to identify the presence of PFAS in concentrations of concern for media other than drinking water.	2019 – 2021
Coordination across federal agencies with common interests in PFAS toxicity	Participate in a cross-federal-agency working group on PFAS information gathering and sharing.	Better leverage federal investments and reduce redundancies. Provide states, tribes, and communities with consistent cross-federal information for making decisions.	2019

Stakeholder Concern or Challenge	EPA Action(s)	Purpose	Anticipated Timeframe
Identifying and Addressing PFAS Exposures			
Additional robust treatment and remediation technologies for PFAS in the environment	Conduct additional research to identify performance and costs associated with treatment and remediation approaches to address PFAS in the environment, along with any potential unintended consequences associated with specific technologies.	Identify new/additional treatment and remediation options that can be used to address PFAS contamination.	2019
Information about drinking water treatment effectiveness and costs for different PFAS	Incorporate the latest research results for additional PFAS into the EPA's online drinking water treatability database.	Support stakeholders in selecting the most effective drinking water treatment approaches to address concerns with PFAS in the environment.	Ongoing
Hold responsible parties accountable for PFAS releases into the environment	Employ an enforcement strategy that relies first on state and local authorities and utilizes federal authorities as appropriate where, for example, state and local authorities are not available or responsible parties do not address PFAS voluntarily.	Support communities that have PFAS releases by using federal enforcement authorities, where relevant and appropriate.	Ongoing
Understand sources and concentrations of PFAS in the environment	Partner with ECOS to build an interactive map to provide users with easy access to publicly available data on potential PFAS sources and occurrence.	Enable states, tribes, and communities to use the best available data to guide PFAS management decisions.	2019
Risk Communication and Engagement			
Coordinated messaging on PFAS across the federal government	Participate in and coordinate with an interagency PFAS risk communication workgroup to develop consistent communication materials that can be used across the federal government and are informed by the best available science.	Ensure coordinated messaging from the federal government is provided to the states, tribes, and local communities.	Ongoing Start 2019
Communication materials that can be used to inform the public of concerns related to PFAS	Work with other federal agencies, states, and tribes to develop a risk communication toolbox that includes materials and messaging for federal, state, tribal, and local partners to use with the public.	Provide states, tribes, local officials, and utilities with communication tools that convey clear and consistent messages to the public.	2019

Stakeholder Concern or Challenge	EPA Action(s)	Purpose	Anticipated Timeframe
Long-Term Actions			
Increase knowledge about PFAS releases	Explore data availability for listing PFAS chemicals to the Toxics Release Inventory (Section 313 of the Emergency Planning and Community Right-to-Know Act).	Make information about PFAS releases reported by industrial and federal facilities available. This information may be helpful to inform decision-making by communities, government agencies, companies and others.	Start 2019
Reduce PFAS releases into ambient waters and sources of drinking water	Determine if available data and research support the development of Clean Water Act Section 304(a) ambient water quality criteria for human health for PFAS.	When adopted by states and tribes as water quality standards, criteria can be used to set permit limits on discharges to a waterbody and to determine if a waterbody requires cleanup to protect human health and aquatic life.	2021
Hold responsible parties accountable for PFAS releases into the environment	Examine available information and beginning in 2019 seek additional information from industry to explore identification of industrial sources that may warrant potential regulation through national ELGs to be described in preliminary ELG plan 14 (2019).	ELGs require that a technology-based, minimum level of control be applied to any NPDES permit for direct discharge to waters or be directly applicable for indirect dischargers.	Start 2019
Characterize potential health impacts from a broader set of PFAS	Generate PFAS toxicology data through new approaches such as high throughput screening, computational toxicology tools, and chemical informatics for chemical prioritization, screening, and risk assessment.	Inform a more complete understanding of PFAS toxicity for the large set of PFAS chemicals without conventional toxicity data and allow prioritization of actions to potentially address groups of PFAS.	Ongoing
Develop more drinking water occurrence data for a broader group of PFAS	The EPA will propose nationwide drinking water monitoring for PFAS under the next UCMR monitoring cycle utilizing newer methods available to detect more PFAS chemicals and at lower minimum reporting levels (MRLs) than previously possible in earlier monitoring.	Monitoring results will improve understanding of the frequency and concentration of PFAS occurrence in finished U.S. drinking water.	Anticipated 2020
Develop a PFAS data inventory and best practices for contributing data	Develop a data standards best practice that allows sharing of soil, air, water, fish tissue, and other PFAS monitoring data.	Provide a way to share PFAS testing results for media other than drinking water that facilitates integration and easy access and use of PFAS data.	Start 2019

Stakeholder Concern or Challenge	EPA Action(s)	Purpose	Anticipated Timeframe
Access ecological risk information to protect ecosystems	Identify sensitive and susceptible species; synthesize information on bioaccumulation in organisms and food chains; where appropriate develop benchmarks and thresholds for ecological toxicity.	Enable action to protect aquatic ecosystems; establish cleanup levels for contaminated sites; protect recreational and cultural values, such as hunting and fishing.	2022
Understand potential for atmospheric transport of PFAS	Incorporate PFAS information into the EPA atmospheric models to understand the potential for atmospheric fate and transport of PFAS.	Enable risk managers to understand the full range of potential PFAS exposure pathways so that they can prioritize appropriate action.	2022

II. Introduction

Many Americans are concerned about potential health impacts from exposure to per- and polyfluoroalkyl substances (PFAS) in the environment. Over the last decade, there has been a move to the manufacture and use of PFAS that may be less bioaccumulative and may be less likely to cause adverse health effects in humans and the environment. However, contamination from legacy PFAS and uncertainty regarding the safety of newer, alternative, PFAS compounds in the environment are a continuing concern for the federal government, states, tribes, and local communities. The EPA is leading efforts with our federal, state, tribal, and community partners to better characterize and mitigate risks related to the presence of PFAS in the environment. The Agency will work with partners to accomplish these goals through pollution prevention, characterization and remediation of contamination in the environment, evaluation of human health and ecological risks, reducing exposures, development of treatment and remediation technologies, dissemination of risk communication materials, identification of safer alternatives, and use of enforcement authorities and regulatory approaches as appropriate.

This PFAS Action Plan identifies EPA-led short-term actions, longer-term research, and potential regulatory approaches designed to reduce the risks associated with PFAS in the environment. In carrying out this Action Plan, the EPA intends to work closely with its federal partners, states, tribes, and local communities. The challenges associated with PFAS cross multiple environmental media and many potential sources. Effective collaboration among all stakeholders is key to successful characterization, communication, and mitigation of concerns associated with PFAS in the environment. The EPA has heard the concerns expressed by the public through a recent series of EPA-sponsored community engagement meetings and through public comments submitted to the EPA through an open docket. The EPA will work with states, tribes, communities, and other federal agencies to take appropriate steps to protect human health and limit risks from PFAS in the environment. Through implementation of this Action Plan and active engagement with other federal agencies, international organizations, states, tribes, industry groups, associations, local governments, communities, and the public, the EPA will lead the national effort to understand and reduce PFAS risks to the American people. As the EPA learns more about PFAS and the risks they may pose, the Agency may update this Action Plan to reflect that new information.

III. PFAS Identification and Actions Previously Taken by the EPA

The term PFAS refers to per- and polyfluoroalkyl substances. PFAS are a very large group of synthetic chemicals that includes PFOA, PFOS, PFBS, perfluorononanoic acid (PFNA), hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt (referred to as GenX chemicals), and thousands of other compounds (USEPA 2018a). Due to their strong carbon-fluorine bonds, many PFAS can be very persistent in the environment with degradation periods of years, decades, or longer under natural conditions (Beškoski et al. 2018, Kallenborn 2004, Luo et al. 2015, Parsons et al. 2008, Frömel and Knepper 2010). Differences associated with chain length, chemical structure, and chemical functional groups incorporated into individual PFAS have important implications for mobility, fate, and degradation within the environment, as well as uptake, metabolism, clearance, and toxicity in humans, plants, and other animals. There is evidence that exposure to certain PFAS in the environment can lead to adverse human health effects (ATSDR 2018a, USEPA 2016a, USEPA 2016b). PFOA and PFOS, two of the most widely studied PFAS, have been detected in the blood serum of up to 99% of samples collected between 1999 and 2012 in a population that is representative for the U.S. More recent studies suggest blood levels of PFOA and PFOS have been decreasing since some U.S. manufacturers voluntarily phased out production beginning in 2000[4](ATSDR 2018a, USEPA 2016a, USEPA 2016b, CDC 2018). Measured body concentrations of other PFAS, including replacement PFAS, are showing different patterns (Kato et al. 2011, Olsen et al. 2008, USEPA 2018b). For example, PFNA in women of child-bearing age increased between 1999-2000 and 2007-2008, while perfluorohexane sulfonic acid (PFHxS) was relatively constant (USEPA 2013). However, because these results are based on a broad national survey, they do not depict the exposure distribution for those who live near PFAS-contaminated sites or people who work in

[4] The PFOA Stewardship Program began in 2006. PFOS was phased out by 3M between 2000 and 2002.

occupations that use PFAS. There are many PFAS in wide use for which more information regarding their presence, toxicity and mobility in a variety of environmental media is needed.

Stakeholder Concerns

At the PFAS National Leadership Summit, at community engagement events across the country, and through comments submitted to the docket, the EPA has heard about the many challenges communities are facing with PFAS. The EPA heard that effective collaboration is needed at the federal and state levels to compile and reconcile different information sources, better understand exposure impacts, enhance monitoring approaches, and to develop additional information on PFAS. Stakeholders and decision makers have emphasized the need to accelerate the understanding of PFAS toxicity and the impacts of PFAS to ecosystems as well as the need to expand the availability of analytical methods to detect and characterize exposures of concern.

At these events, the EPA also heard many challenges associated with addressing PFAS including:

- Cost burden and affordability concerns for PFAS-impacted communities and utilities, especially for the cost and operating requirements associated with treatment and remediation technologies;
- Lack of hazardous substance listings, precluding the use of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) cleanup orders and cost recovery for PFAS;
- Lack of enforceable numeric standards;
- Lack of multi-media sampling methods;
- Confusion about different health values from various authorities; and
- Information gaps on how to safely handle PFAS-containing waste byproducts, biosolids, treatment plant residuals, and materials containing PFAS.

Overarching Challenges for PFAS Management

Understanding the scope of PFAS exposure including sources, pathways, populations exposed, and levels of exposure is critical to effectively characterizing the potential human health and environmental risks associated with these compounds. Other unknown and undiscovered PFAS likely exist within the environment as impurities or byproducts of chemical production or as a result of environmental degradation and transformation processes. Health and occurrence data and validated analytical methods are available for certain PFAS (e.g., PFOA and PFOS). However, for most PFAS there is limited or no toxicity information. While validated EPA drinking water measurement methods are available for 18 PFAS today, including PFOA and PFOS, and more are in development, we lack validated analytical methods for national environmental measurements and assessment of exposure for hundreds of other PFAS. Additional challenges to remediation and cleanup include PFAS occurrence as mixtures with other contaminants. There are continuing research needs related to the development of PFAS destruction technologies. Additional tools and information would improve risk characterization, cleanup options, and management decisions. Knowledge of PFAS impacts on human health and the environment is advancing, and the EPA and other organizations are collaborating to generate research and consider new scientific information as it becomes available. To effectively manage PFAS-related exposures and human health risks when they have been identified, decision makers must consider the potential sources, available technology and if necessary, the regulatory authorities and enforcement tools that may allow federal agencies, states, tribes, and local governments to address PFAS exposure in the environment.

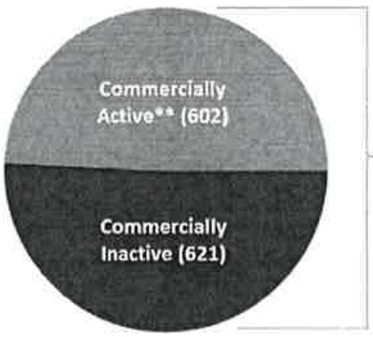
Federal, state, tribal, and local government, communities, and public and private entities will need to partner on developing and implementing management approaches, policies, and solutions to efficiently use limited resources to address PFAS-related risks. While better understanding and reducing the risks posed by PFAS is an important EPA priority, it is not the only public health or environmental challenge faced by our communities. Leveraging resources and partnering is important to ensure the availability of resources to address other priority environmental and public health issues.

While the EPA is evaluating options for development of the most appropriate regulatory programs and tools to address PFAS risks, the EPA also plans to actively lead and support PFAS management efforts using nonregulatory means and enforcement, where appropriate, in partnership with many stakeholders, to protect public health and the environment.

PFAS Use

Over 4,000 PFAS may have been manufactured and used in a variety of industries worldwide since the 1940s (OECD 2018, Guelfo et al. 2018). The EPA's Toxic Substances Control Act (TSCA) Chemical Substance Inventory lists over one thousand PFAS, of which approximately half are known to be commercially active within the last decade. Many PFAS are chemically and thermally stable and demonstrate resistance to heat, water, and oil (Rahman et al. 2014). These properties have made PFAS useful in a variety of consumer products and industrial processes, including firefighting foams, chemical processing, building/construction, aerospace, electronics, semiconductor and automotive industries, stain- and water-resistant coatings (e.g., carpets and rain repellent clothing), food packaging, and in waxes and cleaners (USEPA 2009). Due to their desirable chemical properties for consumer goods, PFAS are widely used in commercial products and can be found in almost every U.S. home and business. All eight companies participating in the EPA's PFOA Stewardship Program voluntarily phased out long-chain PFAS in favor of shorter-chain replacements, which are generally less bioaccumulative and potentially less toxic (Ritter 2010). Previously produced items and imported items may still contain longer-chain PFAS such as PFOA or PFOS (USEPA 2018b). Some replacement PFAS are capable of degrading to PFOA or other long-chain PFAS. Recent research suggests that additional factors aside from chain length may affect the bioaccumulation potential and toxicity of individual PFAS (ITRC 2018a, Ng et al. 2014).

PFAS on the TSCA Inventory*



1,223 Total Compounds

EPA Actions

- **MARCH 2002:** Significant New Use Rule (SNUR) requiring notification to the EPA before any future manufacture (including import) of 13 PFAS chemicals
- **DECEMBER 2002:** SNUR for additional 75 PFAS chemicals
- **OCTOBER 2007:** SNUR for additional 183 PFAS chemicals
- **JANUARY 2010:** Amendment of Polymer Exemption Rule to exclude certain PFAS polymers
- **2010-2015:** PFOA Stewardship Program—reduce long-chain PFAS emissions and product content by 95%; by 2015 reduce long-chain PFAS emissions and product content by 100%. All participating companies met the program goals.
- **OCTOBER 2013:** SNUR for additional PFAS chemicals
- **JANUARY 2015:** Proposed SNURs for additional PFAS chemicals

* The TSCA Inventory is a list of chemical substances approved for U.S. commerce. The original Inventory was compiled from substances reported under the 1978 TSCA Inventory Reporting Rule, and substances have been added since via a commenced Premanufacture Notice.

** Substances on the TSCA Inventory currently designated as commercially active are those reported under the retrospective reporting requirements of the TSCA Inventory Notification (Active/Inactive) rule. These substances were in U.S. commerce at some point between June 2006 and June 2016.

Routes of Exposure

People are exposed to PFAS through the use of consumer products, through occupational exposure, and/or through consuming contaminated food or contaminated drinking water (Fromme et al. 2009). Potential pathways of significant human PFAS exposure include (USEPA 2018a, ATSDR 2018b, Fromme et al. 2009, Ghisi et al. 2018, McGoldrick and Murphy 2016, Stahl et al. 2014, Franko et al. 2012):

- Drinking water from public water and private water systems, typically localized and associated with a release from a specific facility (e.g., manufacturer, processor, landfill, wastewater treatment, or facilities using PFAS-containing firefighting foams);
- Consumption of plants and meat from animals, including fish that have accumulated PFAS;
- Consumption of food that came into contact with PFAS-containing products (e.g., some microwaveable popcorn bags and grease-resistant papers);
- Use of, living with, or otherwise being exposed to commercial household products and indoor dust containing PFAS, including stain- and water-repellent textiles (including carpet, clothing and footwear), nonstick products (e.g., cookware), polishes, waxes, paints, and cleaning products;
- Employment in a workplace that produces or uses PFAS, including chemical production facilities or utilizing industries (e.g., chromium electroplating, electronics manufacturing, or oil recovery); and
- In utero fetal exposure and early childhood exposure via breastmilk from mothers exposed to PFAS.

Potential Human Health Impacts

The majority of research on the potential human health risks of PFAS are associated with oral (ingestion) exposure. Limited data exist on health effects associated with inhalation or dermal exposure to PFAS. Most available toxicity data are based on laboratory animal studies. There are also several human epidemiological studies of PFOA and PFOS. Exposure to some PFAS above certain levels may increase risk of adverse health effects. While many of the same effects are observed for the family of PFAS chemicals, it appears that different adverse effects may be dominant in different PFAS. Depending on the PFAS, increased risks observed in some animal studies include developmental effects to fetuses during pregnancy and infants (e.g., low birth weight, altered puberty, skeletal variations), cancer (e.g., testicular, kidney), liver effects (e.g., tissue damage), immune effects (e.g., changes in antibody production and immunity), thyroid effects related to developmental outcomes, and other effects (e.g., cholesterol changes) (USEPA 2016a, USEPA 2016b). The EPA plans to continue evaluating toxicity information for PFAS; critical information may come from investigating whether exposure to structurally similar PFAS results in similar health effects. Currently, long-chain PFAS are generally thought to present greater toxicity in humans than shorter-chain PFAS (Ritter 2010, Eschauzier et al. 2012), though the toxicities of short-chain PFAS have generally been less thoroughly studied (Danish EPA 2015). Additionally, short-chain PFAS are as persistent in the environment as their longer-chain analogues and are highly mobile in soil and water (Bergström 2014). Due to increasing global production and use, environmental and human exposure to short-chain PFAS is expected to increase over time (Wang et al. 2013). Differences in mobility, fate and persistence in the environment, as well as treatability in environmental media across the complex family of PFAS are expected to contribute to differences in potential exposures and resulting health risks in humans.

History of the EPA's PFAS Actions

The EPA has been actively engaged in preventing risks associated with PFAS. Several statutes provide the EPA with the authority to address PFAS, including TSCA, the Safe Drinking Water Act (SDWA), and CERCLA. This section provides an overview of previous actions the EPA has taken to address PFAS.

Toxic Substances Control Act (TSCA)

Under TSCA, the EPA has broad authority to issue regulations designed to gather health/safety and exposure information on, require testing of, and control exposure to chemical substances and mixtures. TSCA gives the EPA authority to require reporting, record-keeping, and testing of chemical substances and mixtures, and protect against unreasonable risks to human health and the environment from existing chemicals. Among other things, section 5 of TSCA allows the EPA to issue SNURs that require notice to the Agency before chemical substances and mixtures are manufactured (including imported) or processed for significant new uses.

The EPA has used various strategies under TSCA to better understand and reduce exposures to PFAS. For example, in early 2000, the EPA worked with the 3M Company to support the company's voluntary phase-out and elimination of PFOS production and use. As a result of the EPA's 2010/2015 PFOA Stewardship Program, eight major chemical manufacturers and processors agreed to phase out the use of PFOA and PFOA-related chemicals in their products and emissions from their facilities. All companies met the PFOA Stewardship Program goals by 2015. Through the EPA's work under TSCA, the Agency has also issued various SNURs to require manufacturers (including importers) and processors of certain PFAS chemicals to notify the EPA at least 90 days before starting or resuming significant new uses of these chemicals. This notification would require the EPA to review the significant new use, make a risk determination under section 5, and take appropriate regulatory action based on that risk determination. In 2015, the EPA proposed the most recent SNUR on PFAS to complement the long-chain PFAS phaseout under the 2010/2015 PFOA Stewardship Program by requiring manufacturers (including importers) of PFOA and certain PFOA-related chemicals, including as part of articles, and processors of these chemicals to notify the EPA at least 90 days before starting or resuming new uses of these chemicals. Upon receipt of the notice and prior to any "significant new use" activity commencing, TSCA mandates that the EPA review the potential health and environmental effects, make an affirmative determination on the risks, and take actions necessary to eliminate those risks, as appropriate. The EPA is considering the public comments received on the 2015 proposed SNUR as well as the new statutory requirements added by the Frank R. Lautenberg Chemical Safety for the 21st Century Act as it works to issue a supplemental proposed SNUR on PFAS for the manufacture (including import) of certain long-chain perfluoroalkyl carboxylate (LCPFAC) chemical substances, including as part of categories of certain articles, and the processing of these chemicals.

Safe Drinking Water Act (SDWA)

Section 1412 of the SDWA requires the EPA to publish a list of contaminants known or anticipated to occur in public water systems which may require regulation under the Safe Drinking Water Act (the Contaminant Candidate List). The EPA included PFOA and PFOS on the fourth Contaminant Candidate List (USEPA 2018c). The EPA worked with states and public water systems to characterize the occurrence of six PFAS in the nation's drinking water by including them in the third Unregulated Contaminant Monitoring Rule (UCMR), published in 2012 under the SDWA. The EPA uses the UCMR to collect data for contaminants that are suspected to be present in drinking water and do not have standards set under the SDWA. The EPA collected data for six PFAS in the UCMR: PFOA, PFOS, PFBS, PFNA, PFHxS, and perfluoroheptanoic acid (PFHpA). From 2013-2015, drinking water samples were collected and analyzed in nearly 5,000 public water systems across the nation, accounting for approximately 80% of the U.S. population served by public water systems (USEPA 2016c). The EPA plans to use these monitoring results and other information in the next step in the SDWA regulatory determination process as described below. In addition to the regulatory process, the SDWA provides authority for the Agency to publish drinking water Health Advisories (HAs) which are non-enforceable, health-based drinking water levels. In 2016, the EPA released lifetime Health Advisories for two PFAS (PFOA and PFOS). These Health Advisories provide the public, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water. Health Advisories are non-enforceable and non-regulatory and provide technical information to state agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination (USEPA 2016a, USEPA 2016b).

Furthermore, pursuant to section 1431(a) of the SDWA, the EPA has authority to take actions the Agency deems necessary to protect public health when a contaminant, whether regulated or not, is present in or likely to enter a public water system or an underground source of drinking water, and "may present an imminent and substantial endangerment to the health of persons." This authority enables the EPA to respond to emergency conditions and conditions where contamination threatens public health. This section 1431 authority is distinct from the process to establish National Primary Drinking Water Regulations under section 1412 of the SDWA. The EPA has used its authority under section 1431 to issue orders that require persons who have caused or contributed to PFAS contamination to take actions as may be necessary to protect the health of persons, including actions that reduce or prevent exposures.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA, commonly known as Superfund, provides the federal government with authority to respond to releases and threatened releases of hazardous substances, and, if they may present an imminent and substantial endangerment, pollutants and contaminants. CERCLA section 104(e) also provides authority to investigate a site to determine whether hazardous substances, pollutants or contaminants have been or may be released. If there is a release of a hazardous substance, parties responsible for the release may be ordered to respond under CERCLA and/or may be liable under CERCLA for the costs of responding to those releases. PFOA and PFOS are considered CERCLA pollutants or contaminants, not hazardous substances. Thus, federal response/cleanup authority exists where the federal agency with CERCLA authority has made a determination that the PFOA or PFOS release may present an imminent and substantial danger to public health or welfare. In addition, the EPA has initiated the regulatory development process to designate PFOA and PFOS as CERCLA "hazardous substances", which would extend CERCLA order and cost recovery authorities to address communities affected by PFOA and PFOS contamination.

The EPA supports federal agencies, states, tribes, and local communities by coordinating with others to identify exposures, developing methods in order to measure PFAS in the environment, and supporting cleanup efforts where PFAS has been identified as a risk to human health, including working with other federal partners and using enforcement tools where necessary. Where the EPA finds that there may be an imminent and substantial endangerment to public health or welfare related to PFAS contamination, the Agency will consider using its response authority under CERCLA section 104 or utilizing its enforcement authorities such as the SDWA section 1431 or Resource Conservation and Recovery Act (RCRA) section 7003.

Consistent with CERCLA, the Agency for Toxic Substances and Disease Registry (ATSDR) recently released draft toxicological profiles for multiple PFAS, which included Minimal Risk Levels (MRLs). ATSDR's MRLs for four PFAS substances (i.e., PFOA, PFOS, PFHxS, and PFNA), when finalized, are intended to serve as screening tools to help public health professionals to determine areas and populations potentially at risk for exposure and can be used as a mechanism to identify hazardous waste sites that are not expected to cause adverse health effects (ATSDR 2018a). The EPA will continue to partner with ATSDR to better understand and communicate risks to human health from PFAS.

IV. Reducing PFAS Exposures: What the EPA Is Doing to Ensure the Problem Is Not Exacerbated

Understanding PFAS in Commerce

Risk Management for PFAS under TSCA

The EPA has the responsibility for reviewing new chemical substances before they enter commerce. The EPA's TSCA New Chemicals program functions as a "gatekeeper" to help manage the potential risk to human health and the environment from chemicals new to the marketplace. TSCA requires the EPA to make risk determinations on new industrial chemicals and provides the EPA with a range of regulatory options to address risks. The EPA has reviewed hundreds of new chemical substitutes for PFOA, PFOS, and other long-chain PFAS under TSCA since 2000. In many cases, the EPA has used its authority under TSCA to impose restrictions on these substances—as well as requiring companies to generate data on physical and chemical properties, environmental fate, toxicokinetics, acute toxicity, irritation and sensitization, repeated dose toxicity,

EPA Priority Action

ACTION: New SNUR on PFAS chemicals.

PURPOSE: In 2015 the EPA proposed the most recent SNUR on PFAS chemicals to complement the long-chain PFAS-phaseout under the 2010/2015 PFOA Stewardship Program.

NEXT STEPS: The EPA is considering the public comments received as well as the new statutory requirements added by the Frank R. Lautenberg Chemical Safety for the 21st Century Act as it works to issue a supplemental proposed SNUR on PFAS.

genotoxicity, reproductive/developmental toxicity, and cancer—as conditions for allowing the substances on the market.

Anyone who plans to manufacture or import a new PFAS chemical substance for a non-exempt[5] commercial purpose must first provide the EPA with notice, known as a premanufacture notice (PMN). The EPA must review and make an affirmative determination on the PMN. For purposes of TSCA, if a chemical is on the TSCA Inventory, the substance is considered an existing chemical substance in U.S. commerce. Any chemical that is not on the Inventory is considered a new chemical substance.

The EPA is required under TSCA to review PMNs in a 90-day period with the goal of identifying whether there are unreasonable risks and applying appropriate controls to mitigate risks where identified. The EPA uses an integrated approach that draws on knowledge and experience across disciplinary and organizational lines to identify releases and exposures and evaluate concerns regarding health and environmental effects. The EPA evaluation includes an assessment of occupational exposures and facility releases to land, water, and air. The EPA then evaluates the impacts of these releases on environmental receptors (primarily aquatic) as well as to the general population, including susceptible populations. The EPA also conducts, when relevant, an assessment of non-workplace exposures such as those experienced by persons using a specific commercial or consumer product containing a chemical (e.g., paints, cleaners). Product use scenarios used to assess risk may include, as appropriate, assessment of 'bystanders' (i.e., persons not actually using the product, but within the exposure vicinity) and subsequent impacts on environmental receptors. As required by TSCA, these evaluations are risk based and consider both hazard and exposure.

By the end of the review period, the EPA must make one of five determinations under TSCA:

1. Insufficient information to perform a reasoned evaluation;
2. Insufficient information and may present unreasonable risk;
3. Not likely to present an unreasonable risk;
4. Presents an unreasonable risk; or
5. Potential for substantial release/exposure.

More information on the EPA's review and decision-making processes is available on the EPA's website at: https://www.epa.gov/reviewing-new-chemicals-under-toxic-substances-control-act-tsca.

The EPA can designate through rulemaking certain new uses of a chemical as significant new uses. Anyone who plans to manufacture or import a chemical substance for a use that has been designated by the EPA as a significant new use must first provide the EPA with notice, known as a significant new use notice (SNUN). The EPA must review and make an affirmative determination on the notice before that new use can commence, if at all. The EPA has already designated significant new uses for more than 400 PFAS chemicals, including for certain PFAS substances that have been through the new chemical review

[5] Certain manufacture of chemical substances is excluded or exempt from full PMN notification requirements, including small quantities of substances manufactured solely for research and development, substances manufactured for test marketing, substances manufactured in low-volumes, and substances manufactured with low releases or low exposures. Some of these exemptions (e.g., the Low Volume Exemption) require submission of an application to the EPA for review and potential action.

process but have not yet been commercialized, and for certain PFAS substances used in manufacturing (including importing) and processing of carpets or for treating carpet.

The Agency proposed in 2015 a Significant New Use Rulemaking for Long-Chain Perfluoroalkyl Carboxylate and Perfluoroalkyl Sulfonate Chemical Substances that would require manufacturers (including importers) of PFOA and certain PFOA-related chemicals, including as part of articles, and processors of these chemicals to notify the EPA at least 90 days before starting or resuming new uses of these chemicals in any products. The Agency plans to follow up on the 2015 SNUR.

Depending on the outcome of its review and determination, under TSCA the EPA may take actions on a new PFAS or significant new PFAS use, ranging from imposing restrictions or limitations (e.g., use restrictions, production volume cap, limitation on releases to water, etc.) to an outright prohibition on manufacture to ensure that the substance does not present an unreasonable risk. For example, if the EPA determines that there is insufficient information to perform a reasoned evaluation or that the chemical may present an unreasonable risk, the EPA may issue an order under TSCA that eliminates the potential for unreasonable risk. The EPA can also require the submitter to conduct testing to better understand whether or to what extent the chemical presents risks. Nearly all TSCA new chemicals orders issued by the EPA are consent orders negotiated with the submitter of the notice. Because these orders are binding only on the original PMN submitter for that substance, the EPA typically also issues a Significant New Use Rule that requires notice to the EPA by any manufacturer or processor who wishes to manufacture or process the chemical in a way other than described in the terms and conditions contained in the order.

Over the decades, and in particular since the beginning of the phase-out of long-chain PFAS in 2006 under the PFOA Stewardship Program, the EPA's new chemicals program has developed significant experience in reviewing PFAS substances before they enter the market. More than 300 PMN or SNUN submissions for PFAS substances have been reviewed by the EPA since the beginning of the PFOA Stewardship Program, of which about 200 were regulated by the EPA, typically under a section 5(e) Order. Similarly, more than 300 Low Volume Exemption Applications have been reviewed by the EPA during this period, most of which were granted based on restrictions/controls in the original or amended submissions.

With the restrictions the EPA has imposed on many of these chemicals, together with the data the EPA required to be generated, the TSCA new chemicals program is an important contributor to helping ensure the safe use of PFAS in commerce.

PFAS and the Toxics Release Inventory

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) created the TRI Program. The TRI Program's mission is to provide the public with information about TRI chemicals, including releases, other waste management (e.g., recycling), and pollution prevention from TRI-reporting facilities. The TRI Program is another tool the EPA may use to understand the releases of PFAS by industrial and federal facilities. TRI tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery and treatment. A "release" of a chemical means that it is emitted to the air or water or placed in some type of land disposal. The information submitted by facilities is compiled in the Toxics Release Inventory. TRI helps support informed decision-making by companies, government agencies, non-governmental organizations, and the public.

Currently, no PFAS chemicals are included on the list of chemicals required to report to TRI; however, the EPA is considering whether to add PFAS chemicals. In considering listing, the EPA must determine whether data and information are available to fulfill the listing criteria and the extent and utility of the data that would be gathered. For example, hazard data required for TRI listing may be readily available for certain PFAS chemicals, but not others. In addition, in considering if TRI will provide useful information to stakeholders, the EPA also will consider if those PFAS are still active in commerce. The process for listing includes notice and comment rulemaking to list PFAS chemicals for reporting prior to adding these chemicals to the TRI for annual reporting.

V. Understanding PFAS Toxicity to Develop Recommendations and Standards

The EPA is working to understand and address PFAS toxicity through development of human health toxicity assessments on long- and short-chain PFAS. This and other research using advanced toxicological methods will provide a better understanding of PFAS toxicity, including methods for assessing groups of PFAS with similar toxicities and exposures. Toxicity information can be used to provide health protective recommendations and standards for cleanup of environmental media.

The EPA's Actions to Develop Human Health Toxicity Information on PFAS

In 2016, the EPA issued a non-regulatory lifetime Health Advisory (HA) of 70 parts per trillion (ppt) for individual and combined PFOA and PFOS in drinking water. Additional information on the Health Advisories for PFOA and PFOS can be found at https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos. The EPA has made it a priority to produce a new toxicity assessment for GenX chemicals and an updated toxicity assessment for PFBS to facilitate hazard characterization and future risk management decisions. The EPA made

EPA Priority Action

ACTION: The EPA is developing toxicity values for GenX chemicals and PFBS.

PURPOSE: Industry has phased out the use of PFOS and PFOA in favor of shorter-chain PFAS such as GenX chemicals and PFBS. Toxicity values for these replacement chemicals will help inform risk management decisions of federal agencies, states, and tribes to protect human health.

NEXT STEPS: The EPA plans to release final toxicity values for GenX chemicals and PFBS in 2019. Toxicity values for five other PFAS are under development.

draft toxicity assessments for GenX chemicals and PFBS available for public comment in 2018 and expects to issue final toxicity assessments for these two compounds in 2019. Concurrently, the EPA plans to generate additional PFAS toxicity data through *in vitro* high throughput toxicity testing (HTT) and high throughput toxicokinetic (HTTK) assays to inform hazard effects characterization and promote prioritization of chemicals for further *in vivo* testing (Judson et al. 2009, Kavlock and Dix 2010). Generating HTT and HTTK data will improve our understanding of PFAS toxicity and potential human health effects for PFAS compounds for which there is currently limited health-related information and can help to inform Agency and stakeholder decision-making regarding human health risk and remediation levels across the broad landscape of PFAS compounds. In the near term, the EPA intends to also continue to use public peer-reviewed available toxicity information to work towards the development of additional PFAS toxicity assessments for perfluorobutanoic acid (PFBA), perfluorohexanoic acid (PFHxA), PFHxS, PFNA, and perfluorodecanoic acid (PFDA).

Groundwater Cleanup Recommendations for PFOA and PFOS

The EPA is developing Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS to support site-specific cleanup efforts. When finalized, the guidance will provide interim recommendations at sites being evaluated and remediated under the EPA's CERCLA federal cleanup program or at federal-led RCRA corrective action sites. The information and recommendations in this guidance may also be useful for other federal agencies, states, tribes, or other regulatory authorities (e.g., approved state RCRA corrective action programs).

Addressing PFAS in Drinking Water through Standards

The EPA is committed to following the Safe Drinking Water Act process for evaluating drinking water standards for PFAS, including an MCL for PFOA and PFOS. That process involves determining: (1) whether a contaminant may have adverse health effects; (2) whether a contaminant is found in public water systems with a frequency and at levels of concern; and (3) whether, in the sole judgment of the Administrator, there is a meaningful opportunity for health risk reduction through a national drinking water regulation. This process includes a formal rulemaking, engagement with the EPA's National Drinking Water Advisory Council, and extensive public participation. These requirements are expressly prescribed under the Safe Drinking Water Act to ensure scientific integrity and transparency for the regulation of contaminants in public water systems.

EPA Priority Action

ACTION: The EPA is developing interim recommendations for addressing groundwater contaminated by PFOA and PFOS.

PURPOSE: These recommendations will assist the EPA, other federal agencies, states, and tribes in developing and implementing cleanup goals for PFOA and PFOS under CERCLA.

NEXT STEPS: The groundwater cleanup recommendations will be released for public comments prior to finalization.

Certain PFAS have been shown to cause adverse health effects at sufficient exposures, and the EPA is continuing to gather and analyze data regarding the frequency and levels of occurrence of the sampled PFAS. Under the third Unregulated Contaminant Monitoring Rule (UCMR3) program the EPA collected data for six PFAS. From January 2013 through December 2015, samples were collected nationally by all public water systems (PWSs) serving more than 10,000 people, as well as from 800 representative PWSs serving 10,000 or fewer people. Additional information can be found at the EPA's UCMR3 website https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule (USEPA 2016c). The EPA found that 1.3 percent of the PWSs monitored under UCMR3 had measured concentrations of PFOA and PFOS that were greater than the EPA's lifetime HA (lifetime HA limit of 70 ppt or 0.07µg/L) (USEPA 2016a, USEPA 2016b).

Using the occurrence information from UCMR3 and other relevant information, the EPA will propose a regulatory determination for PFOA and PFOS in 2019 for public comment. A regulatory determination is the next step in the SDWA process for developing a national primary drinking water regulation. The Agency also recognizes that there is additional information that the EPA should evaluate regarding PFAS other than PFOA and PFOS, including new monitoring and occurrence data, recent health effects data, and additional information to be solicited from the public, which will inform the development of a national drinking water regulation for a broader class of PFAS in the future.

EPA Priority Action

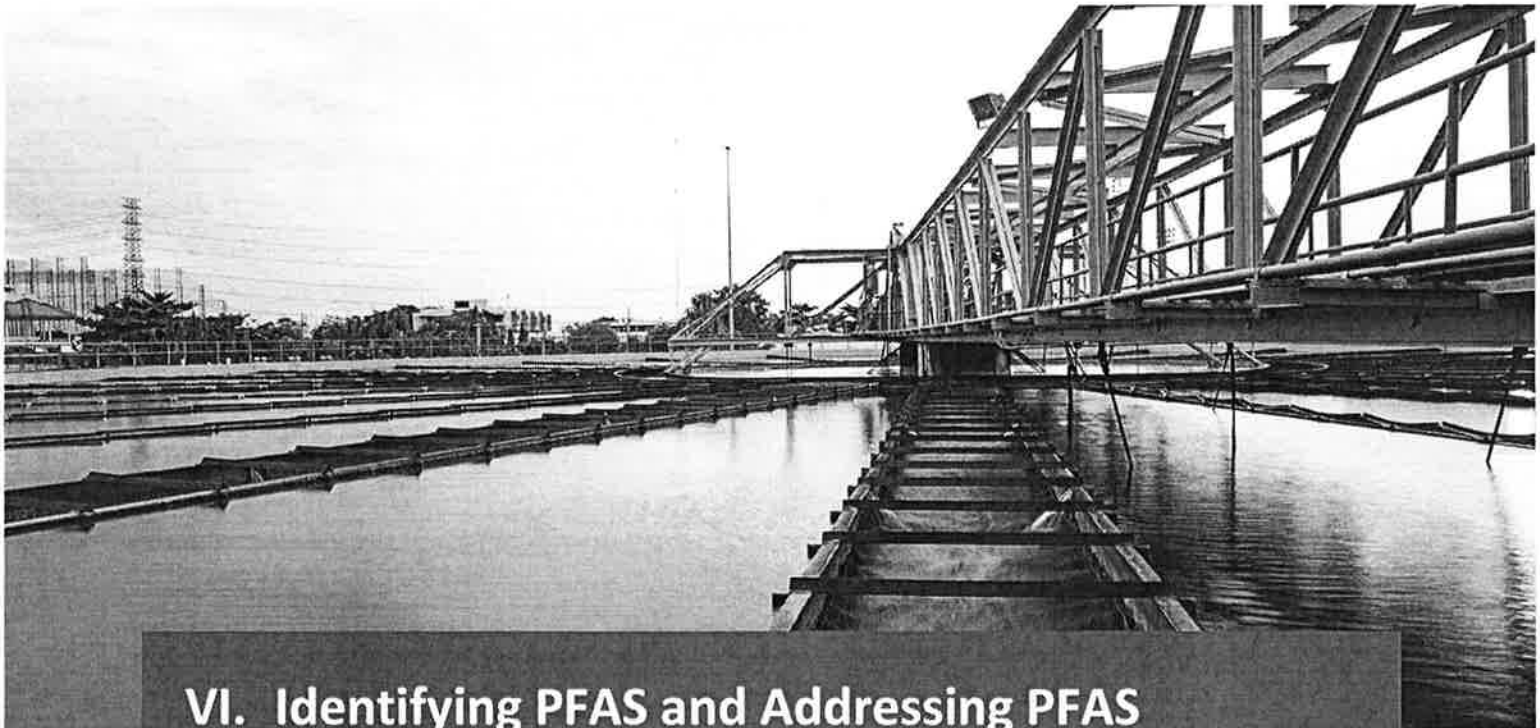
ACTION: The EPA is committed to proposing a regulatory determination for PFOA and PFOS. In addition, the EPA is committed to proposing additional PFAS for the next round of unregulated contaminant monitoring.

PURPOSE: This is the next step in the SDWA process and will enable the EPA to obtain additional information on PFOA, PFOS, and other PFAS compounds to inform regulatory action.

NEXT STEPS: In 2019, propose a regulatory determination for PFOA and PFOS highlighting key information gathered by the Agency to date. The EPA will invite the public to comment on the Agency's efforts to date, including recommending additional information the Agency should consider in its regulatory determination.

The EPA also intends to propose nationwide drinking water monitoring for PFAS under the next UCMR monitoring cycle utilizing newer methods available to detect different PFAS and at lower minimum reporting levels (MRLs) than previously possible in earlier monitoring. As part of this process, the EPA intends to solicit pre-proposal stakeholder input in 2019 and issue a proposed drinking water monitoring rule (UCMR5) in 2020.

In addition to the available UCMR data, the EPA plans to evaluate the extensive occurrence information for PFAS in source and drinking waters recently collected by some states, and which other states intend to collect in the future. The Agency has also heard extensive concerns from the public about PFAS that were not monitored as a part of the UCMR3 effort. Within the proposed regulatory determination federal register notice for PFOA and PFOS, the EPA plans to highlight the information that is known by the Agency and invite the public to provide additional information that the EPA can consider, including information from additional data sources related to sampling of additional water systems and for a broader suite of PFAS. Based on this and other information (including UCMR finished water data), the EPA will make a final determination for PFOA and PFOS, and as appropriate, other PFAS and take the appropriate next regulatory steps under the SDWA. In the interim, the Agency intends to prioritize prevention and remediation programs to support local communities currently facing PFAS challenges and will exercise its SDWA authorities where necessary and appropriate.



VI. Identifying PFAS and Addressing PFAS Exposures in Affected Communities

The EPA is focused on identifying and addressing PFAS exposures in order to protect people and communities from exposures to PFAS that present an adverse health risk, especially for the most vulnerable members of the exposed population. Additionally, the EPA is focused on providing tools and information to support federal agencies, states, tribes, and local communities to address PFAS in the environment. This work involves coordinating with others to identify exposures, developing methods in order to measure PFAS in the environment, and supporting cleanup efforts where PFAS has been identified as a risk to human health, including working with other federal partners and using enforcement tools where necessary. Where the EPA finds that there may be an imminent and substantial endangerment to public health related to PFAS contamination, the Agency will consider using its response authority under CERCLA section 104 or utilizing its enforcement authorities such as the SDWA section 1431 or RCRA section 7003.

Work with States, Tribes, and Local Governments on Identifying Exposures

Identifying PFAS is the first step in understanding if PFAS exposure may be of concern to a community. PFAS exposure in the general population occurs primarily through consumption of food that has been stored or cooked in materials containing PFAS, eating contaminated food grown in or collected from contaminated soil or water (Ghisi et al. 2018), eating contaminated meat from animals (e.g., fish), contact with household products contact through contaminated soil and dust (Shoeib et al. 2005), or drinking water that has been contaminated with PFAS. Drinking water contamination is typically localized and associated with a specific source of PFAS (for example, an industrial facility where these chemicals were produced or used to manufacture other products; or an airfield, military base, or petroleum or chemical facility at which PFAS containing foams were used for firefighting or training

(USEPA 2018a, Hu et al. 2016, Guelfo et al. 2018)). In addition to the monitoring conducted by the EPA and states as part of the UCMR program (monitored for six PFAS), some states have taken additional steps to understand the occurrence of PFAS contamination in communities with potential PFAS exposures from current or historical activities. In addition, some states have conducted sampling and monitoring more broadly to identify locations with PFAS contamination. These steps include sampling drinking water—either in large water systems that serve multiple communities, private potable wells potentially impacted by releases, or sites where PFAS-containing materials are known to have been used—to gather important baseline data on the presence of PFAS in the environment. A number of environmental monitoring activities are also ongoing to measure and assess trends of PFAS in air, water, fish, wildlife, and sediment. In addition, some states are conducting biomonitoring studies to measure the levels of PFAS in people (ASTHO 2018). States can also consider updating their source water assessments to account for potential PFAS risks based on monitoring results or known sources of contamination. The EPA is working with our partners to develop and disseminate sampling, measurement, and treatment tools to help stakeholders concerned about PFAS in their communities to implement actions to prevent and mitigate harmful human exposures to PFAS.

Many stakeholders have questioned the extent and magnitude of PFAS contamination across the United States. To help fill these information gaps, the EPA intends to compile baseline, publicly available, PFAS environmental data into a visual map. Mapping tools can be used to show known or potential PFAS contamination sources and related information. The EPA may also specify sites of interest to environmental monitoring, such as wildlife refuges and fisheries, as well as additional impacted environmental media (for example, air or soil). These efforts can be used to help assess environmental trends in PFAS concentrations and serve as one source of information for local and regional authorities.

The EPA is also exploring how to coordinate sampling, data sharing, and data evaluation across environmental media and biota to provide online tools that can provide information about PFAS detections for government and public users. The EPA plans to work with state partners to develop data sharing standards so that testing results (either government sampling results or public testing) can be shared in a way that is accessible and useful. The EPA will explore development of a PFAS inventory and data plan. The EPA intends to play a lead role in distributing tools that provide the public with an integrated look at what is known about PFAS detections.

Development of Field and Laboratory Methods to Measure PFAS in the Environment

When available, validated analytical methods for measuring PFAS and PFAS precursors in multiple environmental media enable a more accurate understanding of PFAS occurrence and exposures. This information in turn helps the EPA's effort to focus toxicity studies on the most prevalent PFAS exposures in the environment. With the information produced using validated analytical methods, decision makers can also understand the extent of PFAS contamination and better design and execute remediation and treatment. The EPA recently released an expanded drinking water Method 537.1 to include additional PFAS, including GenX chemicals. Longer-term efforts include the development and multi-lab validation of methods (e.g., SW-846, 40 CFR Part 136) for complex water matrices (e.g., wastewater, surface waters, groundwaters), solids (e.g., soil, sediment, biosolids, fish tissues), air (e.g., ambient, stack emission, off-gases), and other PFAS in drinking water not currently captured by Method 537. In addition, the EPA continues to collaborate with others to refine and apply high resolution mass spectrometry (HRMS) analytical methods for discovery and identification of additional PFAS in environmental media (McCord et al. 2018, Newton et al. 2017, Strynar et al. 2015). These efforts will support federal partners, states, tribes, and other stakeholders in site assessment and remediation and help characterize the broader environmental occurrence and potential exposure to PFAS compounds in drinking water and other impacted environmental media. For more information on the EPA research plans related to PFAS, please see Section VII.

Risk Assessment Definitions

RESEARCH: The EPA conducts laboratory and field observations, compiles and synthesizes information, and develops models and tools in order to understand toxicity, exposure, treatment, and remediation.

HAZARD IDENTIFICATION & DOSE-RESPONSE ASSESSMENTS: The EPA determines whether exposure to a contaminant (e.g., PFAS) has the potential to cause harm to humans and/or ecological systems, and if so, under what circumstances.

EXPOSURE ASSESSMENTS: The EPA models or measures contamination (e.g., in drinking water) and predicts how people and ecological systems can come in contact with a contaminant, along with the size and characteristics of the population exposed (including the most vulnerable) to estimate exposure.

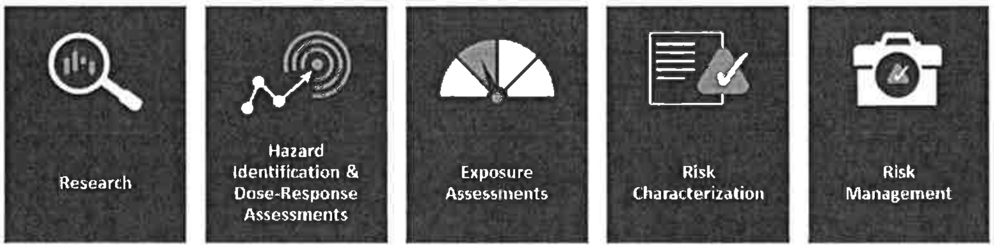
RISK CHARACTERIZATION: The EPA works to integrate the previous steps to create a comprehensive picture of potential PFAS risks, considering hazard, dose-response, and exposure information.

RISK MANAGEMENT: The EPA applies information attained in the previous steps to develop, analyze, and compare options and identify the most appropriate treatment, remediation, or policy response, including how to best exchange information about health or environmental risks among various stakeholders.

Utility of Additional Exposure Information on PFAS

Applying new analytical methods for discovering and measuring PFAS in the environment would enable a better understanding of the sources, types of PFAS, and the exposure pathways which bring PFAS into contact with people and ecosystems. This information could be used to prioritize PFAS for toxicity testing and to facilitate assessment of the relative importance of different pathways (how much PFAS exposure is via food, water, dust, or other media/pathways). This information, combined with more knowledge about PFAS toxicity, could enable stakeholders to identify the PFAS exposures which are of greatest relevance and potential impact to humans and ecosystems, enabling them to prioritize their management efforts and allocate their resources to achieve the maximum reduction in risk. For more information on the EPA's research efforts related to risk assessment, please see Section VII.

EPA Actions and the Risk Assessment Framework



<table>
<tr><td>Risk Assessment Framework</td><td>Research</td><td>Hazard Identification & Dose-Response Assessments</td><td>Exposure Assessments</td><td>Risk Characterization</td><td>Risk Management</td></tr>
<tr><td>EPA's PFAS Action Plan</td><td>• Develop PFAS analytical methods.
• Research treatment and remediation technologies.
• Evaluate human health and ecological impacts.</td><td>• Drinking Water Health Advisories for PFOA/PFOS.
• Toxicity assessments for PFAS including GenX chemicals and PFBS, and then for five other PFAS.</td><td>• UCMR monitoring for PFAS in drinking water.
• Predictive models to enable PFAS exposure assessments.
• Develop mapping tool to identify potential PFAS exposures.</td><td colspan="2">• Interim recommendations for addressing groundwater contaminated with PFOA and PFOS.
• Propose a national drinking water preliminary regulatory determination for PFOA and PFOS.
• Significant New Use Rules (SNURs) under TSCA.
• Initiated the regulatory development process for listing PFOA and PFOS as CERCLA "hazardous substances".
• Continued technical assistance to impacted communities.
• Use enforcement authorities as appropriate.
• Develop risk communication toolbox for PFAS.</td></tr>
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Mitigating PFAS Exposures

To prevent adverse effects to human health and the environment both now and in the future, the EPA is prioritizing short-term exposure prevention and long-term cleanup goals. The EPA will work with federal, state, tribal, and local agencies to employ appropriate authorities, when necessary, to address or prevent PFAS contamination. Potential federal enforcement, regulatory, and response authorities include, for example, the SDWA; RCRA sections 3004(u) and (v); 3005; 3008(h); 3013; and TSCA sections 5, 6, 7, and 8. Additionally, the EPA will continue to develop tools and provide information to support decision-making on mitigating PFAS exposures.

Hazardous Substance Listing for PFAS

EPA Priority Action

ACTION: The EPA has initiated the regulatory development process for listing PFOA and PFOS as CERCLA "hazardous substances" using available statutory mechanisms.

PURPOSE: A "hazardous substance" designation under CERCLA provides more options for the federal government to facilitate use of response and enforcement authorities.

In addition to short-term exposure prevention, the EPA will continue to provide technical assistance on site-specific PFAS challenges across the country, including using CERCLA and other authorities, as appropriate, to investigate sites when needed. The EPA is also developing Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS to support site-specific cleanup efforts (see section V). An important long-term action for federal agencies, states, tribes, communities, and the public is the development of additional tools to facilitate cleanup of PFAS-contaminated sites and recover cleanup costs from responsible parties. In order to augment the EPA's ability to use its CERCLA federal response authority, the EPA is moving forward with how best to designate PFOA and PFOS as CERCLA "hazardous substances" using one of the available statutory mechanisms. Following the PFAS Summit in May 2018, the EPA began an intensive effort to examine the statutory options that could be used to designate PFOA and PFOS as CERCLA hazardous substances. This effort included consideration of the benefits and challenges, as well as the timing and criteria for each available option. There are several statutory authorities available to define PFOA and PFOS as CERCLA hazardous substances, including CERCLA, RCRA, TSCA, Clean Water Act (CWA), and the Clean Air Act (CAA). The EPA is initiating the regulatory development process for listing PFOA and PFOS as CERCLA hazardous substances.

Tools to Mitigate PFAS in Our Nation's Waters

The EPA will continue to work towards providing impacted communities with the tools they need to mitigate risks from PFAS. To further support communities in making decisions about mitigating exposures from drinking water, the EPA intends to continue to update the Drinking Water Treatability Database for PFAS, including treatability and cost information for different technologies and additional PFAS of concern. The treatability database presents information on the control of contaminants in drinking water through treatment processes such as activated carbon, ion exchange, and high-pressure membranes. The treatability database allows utilities, emergency responders, regulators, and other stakeholders access to comprehensive information gathered in a single location. The EPA is also conducting bench-, pilot-, and full-scale experiments to identify performance and cost of treatment (both capital and operations and maintenance), along with potential unintended consequences of employing specific technologies. Better understanding the capabilities of available treatment technologies will further enable the removal of PFAS in drinking water.

Several states are taking actions related to PFAS, including product labeling and consumer products laws, chemical action plans, listing select PFAS as hazardous wastes or designating select PFAS as hazardous substances through state-specific authorities, and developing standards and guidance values to limit concentrations of PFAS in groundwater or drinking water (ITRC 2018b). PFAS can be considered pollutants under the Clean Water Act, and states can use National Pollutant Discharge Elimination System (NPDES) permits to control discharges from point sources containing PFAS into receiving waters, including sources of drinking water. To support states in managing their water quality, the EPA will evaluate development of ambient water quality criteria under section 304(a) of the Clean Water Act to facilitate state permitting efforts, if adequate data are available.

Parties responsible for PFAS releases, states, and utilities have acted to reduce exposure to PFAS in drinking water from community water systems and private wells through the installation of treatment systems, providing connections to public water systems, point-of-use filters, point-of-entry treatment systems, or through the provision of bottled water. Conventional drinking water treatment technologies (coagulation, flocculation, clarification, filtration, and disinfection) have not been found to be effective in removing PFAS. Technologies have been found to remove longer-chain PFAS, such as PFOA and PFOS, from drinking water including activated carbon adsorption, ion exchange resins, and high-pressure membranes (Rahman et al. 2014, Eschauzier et al. 2012, Flores et al. 2013). These technologies can be used in drinking water treatment facilities, in point-of-entry systems to treat all the potable water that enters a home or other building, or at the point-of-use of potable water, such as in a kitchen sink (USEPA 2018d). The EPA is currently working to better understand the efficacy of commercially available point-of-use and point-of-entry treatment applications for PFAS. In some cases, these treatment technologies can result in considerable cost to utilities or homeowners within communities that have been impacted by PFAS. Concerns continue to be expressed by communities regarding the potential for ongoing exposure to PFAS that are less well characterized or are less amenable to measurement and/or removal using existing treatment technologies.

Each state administers the Drinking Water State Revolving Fund (DWSRF) to provide low-interest loans for drinking water infrastructure and technical assistance to publicly-owned community water systems (CWSs), privately-owned CWSs, and non-profit non-CWSs to facilitate compliance with national primary drinking water regulations or to significantly further the health protection objectives of the SDWA (USEPA 2018d, USEPA 2018e). Under the SDWA, states may set aside up to up to 31% of their DWSRF capitalization grant to fund state programs and third parties to provide assistance and build the capacity of drinking water systems. DWSRF set-asides can fund laboratory or testing equipment for research or contamination prevention. In addition, states with a synthetic organic chemical monitoring waiver program can use the DWSRF to assist with special-purpose monitoring, including PFAS, at local systems that have not yet tested for PFAS (USEPA 2017).

A detailed understanding of the sources of PFAS contamination can help communities impacted by PFAS with the development of long-term solutions. Common sources of PFAS include groundwater plumes associated with areas where fire-fighting foam was used, wastewater effluent or air emissions from industrial facilities where PFAS are manufactured or used, and landfills, including leachate, where materials with high levels of PFAS have been disposed. If a source (or sources) can be identified, then actions can be taken to remediate, reduce or divert the source, or address exposure. As part of the EPA's statutorily-required Effluent Guidelines planning process, the EPA has reviewed readily-available information about PFAS surface water discharges to identify industrial sources that may warrant further study for potential regulation through national Effluent Limitation Guidelines and Standards (ELGs).

Based on the very limited amount of data available, the EPA has identified several industries that are likely to be discharging PFAS in their wastewater and will begin a more detailed study to evaluate the potential for PFAS presence in their wastewater discharges. As part of this study, the EPA plans to gather more detailed information for the following point-source categories: organic chemicals, plastics, synthetic fibers, pulp and paper, textiles, and airports.

Work with Federal Partners

The EPA continues to collaborate with federal agencies to address challenges associated with PFAS. As part of interagency cross-coordination efforts, additional actions may be taken by other agencies to mitigate existing PFAS exposures. The EPA is working with other federal partners, through outreach on EPA PFAS products such as the GenX chemicals and PFBS toxicity assessments as well as the Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS. The EPA plans to collaborate with other agencies on PFAS-related research, for example on toxicology studies of a broad number of PFAS with the National Institute of Environmental Health Sciences (NIEHS) National Toxicology Program (NTP). Additionally, the EPA will also work with other federal agencies such as the Food and Drug Administration (FDA), as appropriate, to support efforts regarding PFAS-related food safety issues. The EPA plans to continue coordinating with other federal agencies, such as ATSDR, FDA, and the United States Department of Agriculture (USDA), to ensure we are providing clear and consistent risk communications. The EPA also plans to work with federal partners, such as the Department of Defense (DoD) at military sites or USDA with respect to agriculture, to reduce PFAS exposures. DoD activities at military sites have included, for example, identifying the extent of PFAS contamination of drinking water sources as a result of releases from DoD facilities, ensuring that, where such contamination has occurred, communities at or near DoD facilities are not reliant on drinking water above the EPA's Health Advisory value for PFOA or PFOS.

VII. Research, Development and Technical Assistance for Addressing PFAS-Related Public Health Questions

Research, Development, and Technical Assistance

Problem Scoping and Formulation

The science needed to protect public health and the environment from PFAS exposure cuts across many applications and disciplines. The risk assessment/risk management paradigm provides a useful means to assess the state of the science available for informing decisions, and to identify gaps in knowledge needed to address the highest priority issues. *Risk assessment,* the integration of PFAS exposure and toxicity information, helps to determine if, when, and where risk exists (probability of harm) to human health or the environment from PFAS, considering both toxicity and exposure. *Risk management* involves solving a PFAS problem once it has been properly identified and characterized, considering available scientific tools and data, as well as economic, legal, social, technological, and policy factors.

The EPA's initial scoping of information available to decision makers for assessing and managing PFAS risks revealed deficiencies in all key areas of the risk paradigm:

- **Hazard and Toxicity:** There are many PFAS of potential concern to the public that may be found in the environment. Most of these PFAS lack sufficient toxicity data to inform our understanding of the potential for adverse human or ecological effects.
- **Exposure:** Information for many PFAS sources, fate and transport, and human and ecological exposure is sparse, both spatially and temporally.

- **Treatment and Remediation:** There is little information on effective methods and costs for treating or removing PFAS from drinking water, groundwater, wastewater, air, soils, and sediments.
- **Science Communication:** Stakeholders lack easy access to the growing body of technical information that can assist them in applying PFAS science to their specific problems and communicating to their constituents.

The EPA's research program will focus on an integrated set of research activities aimed at filling gaps in our current ability to conduct sound risk assessment and risk management activities. This research program is designed to address these data gaps and enable stakeholders to begin making effective decisions for identifying and mitigating risk from PFAS in the environment, as mentioned in Section VI.

The EPA's PFAS research plan consists of ***near term*** (<2 years) and ***long term*** (>2 years) research activities in four areas:

- What are the human health and ecological effects of exposure to PFAS?
- What are the significant sources, fate and transport pathways, and exposures to humans and ecosystems?
- What are the costs and effectiveness of different methods for removing and remediating PFAS in the natural and built environment?
- How does the EPA support stakeholders in using science to protect public health and the environment?

While the activities highlighted in this section are planned to be completed on a longer-term time horizon, many of these efforts will have visible interim milestones and may produce shorter-term products. Many different entities have an interest in—and are actively conducting—research to address PFAS, and so there is a substantial opportunity to advance PFAS science by effective coordination and collaboration amongst these entities. The EPA is committed to leading federal action to protect human health and the environment and to coordinating and cooperating with state and other federal agencies, academia, industry, and non-government organizations to build a body of best available science in the areas described below and to support policy and management decisions and actions by all stakeholders.

Research Area 1: *What are the human health and ecological effects of exposure to PFAS?*

One of the main research needs is a better understanding of the potential human health and ecological hazards from exposure to PFAS. Characterizing hazards through the development of hazard and dose-response assessments capitalizes on existing scientific information where available. For data-poor PFAS, an integrated approach to testing and assessment includes the use of existing hazard information, where available, coupled with data and information generated from new advances in computational and high throughput toxicology and ecotoxicology. These efforts will help the Agency develop toxicity values for additional PFAS, as discussed in Section V.

Research to advance our understanding of human health and ecological effects of PFAS will consist of three complementary lines of work:

- **Development of human health toxicity values where suitable data are available.** The EPA plans to develop cancer and noncancer toxicity values for PFAS where sufficient health effects data currently exist, are publicly available, and adequately support human health toxicity value derivation. The EPA will use established risk assessment guidelines and methods to develop standard toxicity values, such as oral reference doses (RfDs), inhalation reference concentrations (RfCs), oral cancer slope factors (CSFs), and cancer inhalation unit risks (IURs). These assessments will undergo interagency consultation, public comment, and independent external peer-review prior to finalization. The EPA currently has published toxicity assessments for PFOA and PFOS. ***In the near term*** the EPA plans to complete toxicity assessments for GenX chemicals and PFBS. The Agency has begun work on assessments for PFBA, PFHxA, PFHxS, PFDA, and PFNA. The EPA intends to coordinate with federal partners, including ATSDR, on prioritizing and conducting future PFAS toxicity assessments. The EPA will build on work by universities, industry, and other government agencies who are conducting and publishing the peer-reviewed toxicological and epidemiological studies needed to support toxicity assessment.

- **Using computational toxicology approaches to fill in gaps.** For the many PFAS for which published peer-reviewed data are not currently available, the EPA plans to use new approaches such as high throughput and computational approaches to explore different chemical categories of PFAS, to inform hazard effects characterization, and to promote prioritization of chemicals for further testing. These data will be useful for filling gaps in understanding the toxicity of those PFAS with little to no available data. ***In the near term***, the EPA intends to complete assays for a representative set of 150 PFAS chemicals, load the data into the CompTox Chemicals Dashboard for access, and provide peer-reviewed guidance for stakeholders on the use and application of the information. ***In the long term***, the EPA will continue research on methods for using these data to support risk assessments using New Approach Methods (NAMs) such as read-across and transcriptomics, and to make inferences about the toxicity of PFAS mixtures which commonly occur in real world exposures. The EPA plans to collaborate with NIEHS and universities to lead the science in this area and work with universities, industry, and other government agencies to develop the technology and chemical standards needed to conduct this research.

- **Ecological toxicity.** Ecological toxicity information is also needed by stakeholders to inform risk assessment and management to protect ecosystems, animals, and plant resources they support, and ultimately the human benefits that stem from these resources, including, for example, the prevention of potential PFAS risks associated with consuming game animals and fish. ***In the long term***, the EPA plans to work to identify species which are sensitive or susceptible to PFAS exposure; gather and synthesize information on bioaccumulation of PFAS in organisms and food chains; and, where indicated, develop benchmarks and thresholds for ecological toxicity. The EPA plans to collaborate with the United States Geological Survey (USGS), United States Army Corps of Engineers (USACE), and universities to lead the science in this area.

Research Area 2: *What are the sources, fate and transport pathways, and exposures to humans and ecosystems?*

The diversity of the PFAS family of chemicals enables the use of PFAS for many diverse industrial processes and end use products, which in turn means there are numerous potential sources and pathways by which PFAS can move from a source through the environment. Understanding this complexity is necessary to understand PFAS exposure. The EPA plans to address this complexity through two lines of research and development:

- **New analytical methods.** Developing, validating, and applying new analytical methods for discovering and measuring PFAS in air, water, and soil will enable a better understanding of the specific subsets of PFAS that exist in the environment, as well as the exposure pathways that potentially bring those PFAS into contact with people and ecosystems. This will enable the creation of datasets to better understand fate and transport pathways and to identify cases where exposures exceed thresholds of concern. ***In the near term***, the EPA plans to develop, validate, and publish reliable sampling and laboratory analytical methods to detect, identify, and quantify PFAS in different environmental media (including drinking water, groundwater, wastewater, air, and soil) and in other kinds of samples (e.g., plant and animal tissue), as needed. This includes analytical methods for known PFAS of concern, as well as methods to identify and detect new, currently unknown, PFAS in the environment. ***In the long term,*** the EPA will continue to prioritize, develop, and validate analytical methods for emerging PFAS of concern. The EPA plans to collaborate with USGS, DoD, National Institute of Standards and Technology (NIST), FDA, and private industry to lead the science in this area and rely on universities and industry to develop the technology needed to enable new analytical methods.

- **Exposure assessment.** Exposure information enables decision makers to prioritize the PFAS exposures that are of greatest relevance and impact to human health and the environment, enabling them to prioritize management actions and allocate resources to achieve the maximum reduction in risk. ***In the near term***, the EPA plans to develop a mapping tool to house public datasets of known PFAS source and occurrence data, and tools to analyze PFAS exposure through multiple routes (via water, food, inhalation, or dermal contact). ***In the long term***, the EPA intends to build predictive models to enable PFAS exposure assessment from site-specific to national in scope, to better understand where and how PFAS move through the environment to impact people and ecosystems, and to estimate how much PFAS reaches people via air, water, food, and other pathways. The EPA plans to collaborate with the Department of Housing and Urban Development (HUD), ATSDR, and other federal agencies, as appropriate, to lead the science in this area.

Research Area 3: *What are the costs and effectiveness of different methods for removing and remediating PFAS in the natural and built environment?*

Current technology and approaches for treating or removing chemical contaminants from air, water, and soil are not always effective for PFAS. Better information is needed on the costs and effectiveness of different treatment systems for different PFAS of concern, as well as the development of new treatment technologies that are less expensive, easier to operate, and more sustainable than existing technologies. The EPA is addressing this information need through two related lines of research:

- **Drinking water treatment.** The EPA is evaluating treatment technologies for removal of PFAS from drinking water. States, public water utilities, communities, and federal facilities will benefit by having treatment technology guidance and accurate cost numbers for the treatment of PFAS in drinking water. ***In the near term***, the EPA plans to evaluate performance, cost, and potential unintended consequences of drinking water treatment technologies for different PFAS in small, medium, and large systems. The Agency plans to place data in the EPA's online Drinking Water Treatability Database and associated cost models. The EPA plans to collaborate with states, federal agencies, public water utilities, and private industry to lead the science in this area and will work closely with universities and industry who are developing the treatment technology advances needed to support this research.

- **Contaminated site cleanup.** The complexity of PFAS sources and uses means there are multiple ways that specific sites can become contaminated by PFAS. Examples include improper dumping or disposing of PFAS-contaminated waste, accidental or intentional spills of PFAS-containing products such as firefighting foam, or leaking of PFAS in leachate from landfills. This can result in the contamination of soils, sediments, groundwaters, and surface waters. ***In the near term***, the EPA plans to evaluate the effectiveness and cost of existing treatment and remediation technologies for a variety of PFAS-contaminated sites and develop and test new technologies and approaches for cleaning up PFAS contamination. The EPA plans to collaborate with DoD, states, industry, and non-government organizations to lead the science in this area and work closely with universities and industries developing the treatment technology advances needed to support this research.

Research Area 4: *How does the EPA support stakeholders in using science to protect public health and the environment?*

Stakeholders have varying levels of knowledge and expertise for using the science products that will result from the EPA's research. Part of the research process therefore involves communication of the Agency's research in multiple ways to make the science usable to all stakeholders. This communication needs to include the proper context and any applicable limitations inherent in the work. This may also include applying tools in collaboration with stakeholders through technical assistance. The EPA plans to conduct two lines of work in support of stakeholders.

- **Science communication.** PFAS are of interest to a variety of stakeholder groups. It is important that the EPA maintain suitable communication with each of these groups and facilitate access to new research products as they become available. ***In the near and long term***, the EPA plans to facilitate access to the research products described in this plan via multiple avenues, including publications, reports, online tools and databases, fact sheets, workshops, webinars, and summaries describing our science. The EPA plans to make this information readily available using the EPA PFAS website as the main point of access. The EPA intends to collaborate with states, tribes, and communities to lead work in this activity.
- **Technical assistance.** In certain cases, the EPA provides technical advice, assistance, and collaboration to state, tribal, federal, and community partners in a manner consistent with the Agency's goal of Cooperative Federalism. These technical assistance activities inform cost-efficient and cost-effective risk management decisions by the EPA and its partners, as well as help to advance the science through applied research. ***In the near and long term***, the EPA plans to continue to prioritize engagement in these activities.

VIII. Risk Communication and Engagement

Risk communication and engagement are critical for the EPA to effectively support communities across the country that are addressing PFAS issues. The EPA is actively working to enhance the way in which agencies communicate about potential human health risks that may be associated with these chemicals. PFAS are a complex group of chemicals that can differ in terms of how they are used, how people are exposed, and how they potentially impact public health and ecosystems. There is a lack of definitive scientific information about many chemicals in the PFAS family, making it challenging to communicate with the public about their associated health risks. The EPA also supports the efforts of other federal partners to develop information related to PFAS. Other agencies may issue different values based on factors such as their own statutory, regulatory, or case-specific analyses and exposure assumptions. The EPA continues to take concrete steps, in cooperation with our federal, state, and tribal partners, to communicate how the efforts of the EPA and other federal, state, and tribal agencies help to protect public health and the environment from risks related to PFAS.

Importance of Effectively Communicating PFAS Information to the Public

At the National Leadership Summit and throughout the community engagements, the EPA heard how important it is to communicate effectively with the public and to be transparent in sharing what is known and unknown in a timely manner. The EPA heard that speaking with one voice and providing consistent messaging across federal, state, tribal, and local authorities helps to build trust and ensures that the public has a clear understanding of any PFAS issues that need to be addressed. The EPA also heard that it is important to clearly explain the actions the Agency is taking, as well as the specific concerns that those actions are intended to address. Other comments submitted to the EPA highlighted how important it is to provide information to stakeholders as quickly as possible, while also taking into account the high levels of uncertainty that surround these chemicals. Appendix B provides additional discussion about feedback from the community engagements and information submitted to the PFAS docket.

The EPA's Goals and Actions on PFAS Risk Communication

PFAS are of significant interest to a diverse set of stakeholders. Clear and consistent communication from all information sources will help stakeholders determine the most appropriate PFAS risk management approach and help the public understand the response. Through this Action Plan, the EPA's goal is to work with other agencies to:

1. Enhance the public's understanding of PFAS by providing clear and consistent information;
2. Enhance the public's understanding of the regulatory processes available to address PFAS and the different standards established for PFAS;
3. Build trust with the public as we work together to address these chemicals; and
4. Provide the public with an understanding of the uncertainties associated with PFAS measurement, exposure, and toxicity, and the importance of considering these uncertainties when identifying effective risk management actions.

For communities directly impacted by PFAS, the EPA plans to:

1. Work in coordination with other federal agencies and local, state, and tribal governments on clearly communicating PFAS information;
2. In support of responses to PFAS found in communities, work with the community to identify the lead agency and explain the role of each agency involved. Establish contact points responsible for managing community questions;
3. Communicate pathways of exposure and what is being done to mitigate exposure through those pathways;
4. Enhance the public's understanding of the potential human health effects associated with PFAS exposure; and
5. Provide information on tangible steps individuals can take on their own to manage risk.

To best support and leverage the efforts of other federal partners, the EPA is committing in the short-term to convene a federal interagency PFAS risk communication workgroup to ensure, as appropriate, collaborative interagency action and consistent messaging on PFAS toxicity that is informed by the best available science. In addition, the EPA plans to enhance communications with the public on PFAS through the following actions:

1. In 2019, develop a risk communication toolbox that includes materials and messaging for federal, state, tribal and local partners to use to inform the public, as they deem appropriate.
2. Continue to listen to and engage with the public; and

3. Continue to support states, tribes, and local officials who have purview in protecting the environment and public health, including the Environmental Council of States (ECOS), the Association of State and Territorial Health Officials (ASTHO), the Association of Clean Water Administrators (ACWA), the Association of State Drinking Water Administrators (ASDWA), the National Tribal Toxic Council, and the Association of State and Territorial Solid Waste Management Officials (ASTSWMO).

Information Needed by Stakeholders to Effectively Communicate About PFAS

Effective communication at the federal, state, tribal, and local level begins by clearly summarizing what is known and unknown about PFAS, with a focus on the key questions with which the public is most concerned. The EPA will help to advance these efforts by continuing its work with other agencies to develop a risk communication toolbox that will include the following:

- Key messages
- Questions and answers
- Infographics
- Fact sheets
- Sample language/template for potential notifications
- Sample communication materials
- Links to available data sources and tools

The EPA will make available materials and informational fact sheets on the EPA's PFAS webpage as part of the risk communication toolbox and, as necessary, will continuously update the information as the science around PFAS evolves. To find the complete set of tools, visit: https://www.epa.gov/pfas/pfas-communication-and-outreach-tools.

Stakeholder Engagement on PFAS

The EPA conducted extensive public outreach in the development of the PFAS Action Plan, including gathering diverse perspectives through the May 2018 National Leadership Summit, direct engagement with the public in impacted communities in five states, engagement with tribal partners, and roundtables conducted with community leaders near impacted sites (USEPA 2018f). The EPA also obtained recommendations from the Local Government Advisory Committee (LGAC), a chartered policy committee comprised of elected and appointed local officials. In addition, the Agency reviewed approximately 120,000 comments in the public docket that was specifically established to gather input for the Action Plan.

Through these engagements, a broad range of stakeholders provided input to the EPA about ongoing PFAS challenges facing states, tribes, and local communities, as well as specific actions needed from the EPA and state regulators in order to protect the public from PFAS in the environment. Key public priorities include the need for identification and remediation of known sources of contamination; source water protection for drinking water supplies; resources to support effective communication with the public; long-term policy solutions; reliable, enforceable, and actionable standards and risk information; validated and cost effective analytical and sampling methods and tools; treatment solutions; enforcement strategies to reduce the cost burden on citizens; and coordination among all parties involved in mitigation and response. The Agency received comments identifying the importance of developing and relying on the best available science even if that means not rushing to implement regulatory actions in the near term. Stakeholders also emphasized the need to balance the potential cost and burden associated with managing PFAS with the costs and benefits of addressing other competing public health and environmental protection priorities such as the presence of lead in community water systems. Among other things, the LGAC recommended using existing funding tools, such as the State Revolving Funds to address PFAS, prioritizing PFAS-related risk communication activities, developing new methods and certification programs, and using risk-based approaches to address PFAS contamination issues, being mindful that clean and safe water are valued by every American citizen. The EPA plans to continue to seek feedback from stakeholders on actions to address PFAS.

National Leadership Summit

Over 220 participants, including senior officials from 40 states, 3 tribes, Guam, Northern Marianas Islands, 13 federal agencies, congressional staff, and dozens of associations, industry groups, and non-governmental organizations.

Community Outreach

Over 1,000 participants at 7 locations, including community engagements in New Hampshire, Pennsylvania, Colorado, North Carolina, and Kansas; engagement with tribes at the Tribal Lands and Environment Forum and the Saginaw Chippewa Tribe; and a roundtable in Michigan.

Public Docket

Approximately 120,000 comments received.

Information for Individuals Concerned about PFAS

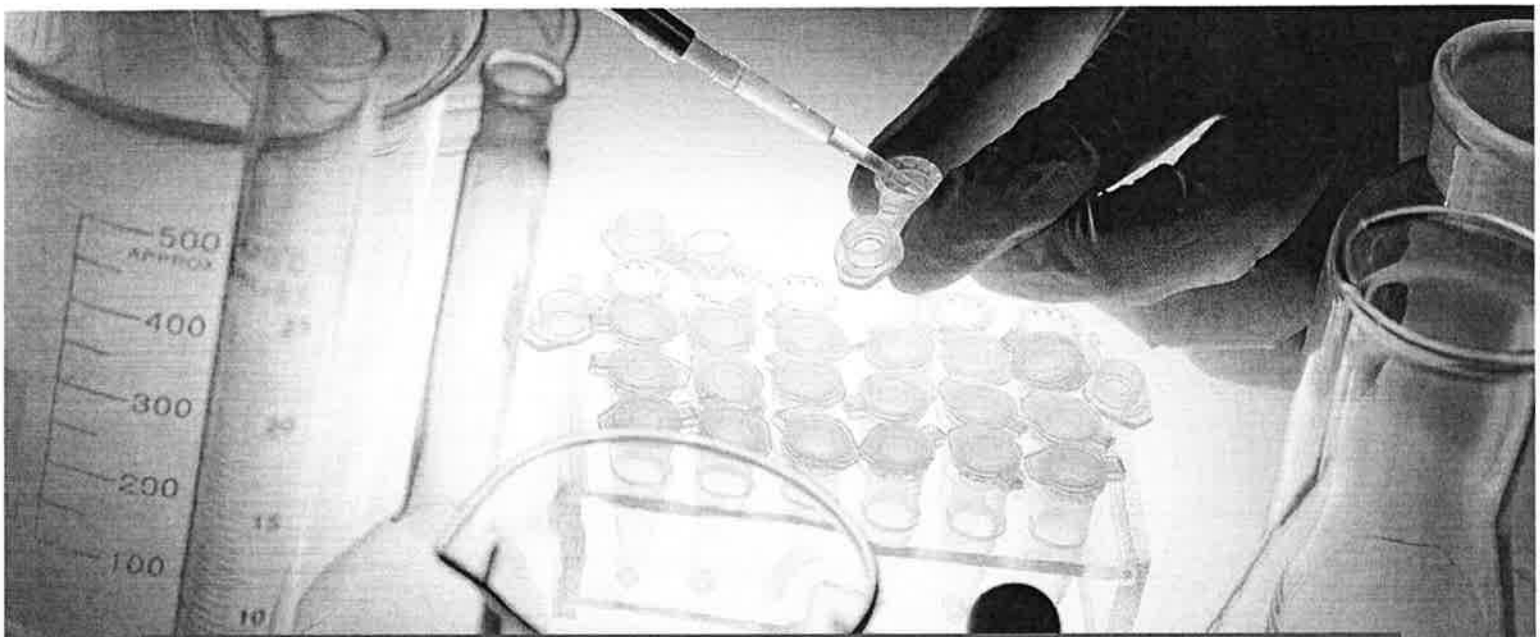
Individuals in communities that are served by a public water system can contact their local water supplier to ask for information on any PFAS monitoring the utility may have conducted. Members of the public are also encouraged to request a copy of their drinking water Consumer Confidence Report. While there are currently no federal drinking water regulations for PFAS, this report provides useful information on other regulated contaminants found in local drinking water. If owners of drinking water wells not regulated by the SDWA (i.e., private potable wells) have reason to believe their well may contain PFAS (e.g., due to proximity to a known contamination site or probable source of PFAS), they could consider contacting their state or local health department for further guidance. Owners may also consider well testing to learn about PFAS that may be in their drinking water. For more information about well testing, please visit https://www.epa.gov/privatewells/protect-your-homes-water. The EPA recommends contacting your state for a list of laboratories that are certified to test for PFAS using EPA Method 537. If you find PFAS in your drinking water, certain PFAS can be reduced or removed through the use of in-home point-of-use or point-of-entry water filters. It is important to keep in mind that any in-home treatment device should be certified by an independent party, currently available for PFAS (NSF 2018), and should be properly maintained to ensure that the treatment system remains effective over time.

For those concerned about food (plant or animal) collected from an environment that may contain PFAS, the EPA recommends contacting your local health department. All 50 states and some U.S. territories and tribes have fish consumption advisory programs to protect people from potential human health risks of eating contaminated fish caught in local waters. However, due to the limited sampling at this time, few locations have information specific to PFAS. In some states, pollutant levels in certain types of fish and shellfish collected from contaminated bodies of water have led to health-based consumption advisories for some PFAS, particularly PFOS (USEPA 2016d, State Impact Pennsylvania 2018, State of Michigan 2018). The EPA maintains a national database of fish and shellfish advisories issued by states where the public can find information on safe consumption guidelines (https://fishadvisoryonline.epa.gov/General.aspx) and for the most up to date information links to state and tribal fish consumption advisory websites (https://fishadvisoryonline.epa.gov/Contacts.aspx).

IX. Conclusion

In addition to the four priority actions the EPA announced at its May 2018 National Leadership Summit, this Action Plan highlights the many activities that the EPA plans to lead in collaboration with federal, state, tribal, and local partners to understand, communicate, and take steps to effectively manage potential concerns associated with the presence of PFAS in the environment. Where deemed appropriate and necessary, the EPA will prioritize preventing environmental contamination and identifying approaches that reduce the costs of PFAS management faced by local communities. Efforts discussed in this plan are also intended to encourage the use of safer PFAS formulations and/or PFAS alternatives and limit PFAS discharges, releases, and emissions. Where PFAS contamination in the environment has already occurred, the Agency will facilitate remediation efforts by providing groundwater cleanup recommendations and initiating the regulatory development process for listing certain PFAS as hazardous substances. For those cases where cleanup actions are necessary to prevent exposure to contaminated environmental media, the Agency is evaluating active management and treatment options and evaluating available treatment technologies. The EPA is also proposing a national drinking water regulatory determination for PFOA and PFOS in 2019 for public comment. The Agency will also gather and evaluate additional information that may inform the development of a national drinking water regulation for a broader class of PFAS in the future. The EPA is committed to working with other federal agencies, states, tribes, and local communities to coordinate and advance how we respond to PFAS concerns throughout the country.

The EPA is taking a leadership role to ensure that instances where PFAS pose risk to human health or the environment are identified and quickly addressed. The EPA plans to work in close coordination with multiple entities, including other federal agencies, states, tribes, local governments, water utilities, industry, and the public. This PFAS Action Plan highlights key EPA PFAS-related activities and reinforces the EPA's commitment to better understand potential impacts from a broad suite of PFAS, and, where necessary, take steps to reduce any risks they may pose to public health and the environment.



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Appendix A: EPA PFAS Activities

Appendix A contains a detailed list of completed and ongoing PFAS activities at the EPA. This list is not intended to be exhaustive of all the EPA's activities on PFAS.

Tool/Activity	Purpose	Timeframe
Preventing PFAS Exposures: What is EPA doing to reduce risks from PFAS?		
Significant New Use Rule; Final Rule and Supplemental Proposed Rule: Perfluoroalkyl Sulfonates (67 FR 11008)	The EPA published a SNUR to require notification to the EPA before any future manufacture (including import) of 13 PFAS chemicals specifically included in the voluntary phaseout of PFOS by 3M that took place between 2000 and 2002.	Completed March 2002
Significant New Use Rule: Perfluoroalkyl Sulfonates (67 FR 72854)	The EPA issued a SNUR for 75 PFAS, requiring manufacturers and importers to notify the EPA at least 90 days before starting the manufacture or importation of these chemical substances for the significant new uses described.	Completed December 2002
2010/2015 EPA PFOA Stewardship Program	The EPA launched 2010/2015 PFOA Stewardship Program with eight companies in 2006 to reduce PFAS emissions and product content by 95%; by 2015 reduce PFAS emissions and product content by 100%. All participating companies met the program goals.	Ongoing Started in 2006
Premanufacture Notification Exemption for Polymers; Amendment of Polymer Exemption Rule to Exclude Certain Perfluorinated Polymers (75 FR 4295)	The EPA published a final rule that amended the Polymer Exemption Rule to no longer exclude from eligibility polymers that include any one or more of the following: PFAS, PFAC, or perfluoroalkyl moieties that are covalently bound to either a carbon or sulfur atom where the carbon or sulfur atom is an integral part of the polymer molecule. Compliance date was January 27, 2012.	Completed May 2012
Significant New Use Rules: Perfluoroalkyl Sulfonates and Long-Chain Perfluoroalkyl Carboxylate Chemical Substances (78 FR 62443)	The EPA amended a SNUR to designate as a significant new use PFAS that have completed the new chemical review process under TSCA but have not yet commenced production or import and processing. The EPA also finalized a SNUR to designate as a significant new use LCPFAC chemical substances used in manufacturing (including importing) and processing of carpets or for treating carpet.	Completed October 2013
Significant New Use Rules: Long-Chain Perfluoroalkyl Carboxylate and Perfluoroalkyl Sulfonate Chemical Substances Proposed Rule (80 FR 2885)	The EPA proposed a SNUR for LCPFAC chemical substances that would require manufacturers (including importers) of PFOA and PFOA-related chemicals, including as part of articles, and processors of these chemicals to notify the EPA at least 90 days before starting or resuming new uses of these chemicals in any products. The EPA plans to follow up on the 2015 SNUR.	Completed January 2015

Tool/Activity	Purpose	Timeframe
New Chemicals Program Review of Alternatives for PFOA and Related Chemicals	The EPA has reviewed hundreds of new chemical substitutes for PFOA, PFOS, and other long-chain PFAS under the EPA's New Chemicals Program since 2000. The EPA reviews the new substances to identify whether the range of toxicity, fate, and bioaccumulation issues that have caused past concerns with perfluorinated substances may be present, as well as any issues that may arise by new chemistries, to ensure that the new chemical may not present an unreasonable risk to health or the environment. One outcome of the EPA's review of a PMN for a new chemical substance or review of a SNUN is the issuance of an order under section 5(e) of TSCA. Most TSCA section 5(e) Orders issued by the EPA are Consent Orders that are negotiated with the submitter of the notification.	Ongoing Started 2000
Understanding and Addressing PFAS Toxicity: What is the EPA doing to advance the science to support New Benchmarks?		
Lifetime Health Advisories for PFOA and PFOS	The EPA released lifetime health advisories (HAs) and health effects support documents for PFOA and PFOS. The EPA's HAs, which are not regulations, identify the concentration of PFOA and PFOS in drinking water at or below which adverse health effects are not anticipated to occur over a lifetime of exposure.	Completed May 2016
List of available scientific literature on toxicity for 31 PFAS of interest loaded to the HERO database	The EPA updated the Health and Environmental Research Online (HERO) database with available scientific literature (as of August 2017) on PFAS toxicity to detail which scientific studies the EPA has collected.	Completed April 2018
PFAS Chemical Library	Development of a chemical library of PFAS standards (pure samples of PFAS) to support consistent research and method development across the EPA.	Completed April 2018
Provide states access to GenX chemicals data	Provide states access to test data obtained under TSCA authority for information on GenX chemicals (acid and salt).	Completed March 2018
Information on Transcriptomic and *in vitro* assay toxicity testing (Tier 0 and Tier I)	Generate and publish first approximation toxicity and toxicokinetic data from the larger universe of PFAS compounds, in order to make inferences about which subcategories of PFAS might be of highest toxicological concern and thus prioritized for further near-term investigation. These data will also be useful for enabling read-across activities for PFAS with little to no available data. Tests will include a battery of transcriptomic *in vitro* assays (toxicity and kinetics) implemented by the EPA and the NTP.	Anticipated 2019
Tier II PFAS testing	Conduct Tier II *in vivo* toxicity testing for a subset of prioritized compounds based upon data provided from Tier I testing.	Anticipated 2019

Tool/Activity	Purpose	Timeframe
Tri-Services Ecological Risk Assessment Work Group	The EPA Ecological Risk Assessment Forum has a joint work group with the DoD Tri-Services Environmental Risk Assessment Work Group (TSERAWG) to develop ecological risk assessment screening values for PFAS. The DoD has an interagency agreement between the Air Force Civil Engineering Center and the Department of Energy (DOE) Argonne National Laboratory for the development of screening values for PFAS compounds. The PFAS screening values will be available for use at CERCLA sites and RCRA facilities.	Ongoing
Tools and data for evaluating ecotoxicity effects	Identify sensitive and susceptible taxa, synthesize information on bioaccumulation in organisms and food chains, and develop benchmarks and thresholds for ecological toxicity.	Anticipated 2022
Toxicity assessments for additional PFAS	Development of additional peer-reviewed PFAS toxicity assessments for PFBA, PFHxA, PFHxS, PFNA, and PFDA to support stakeholders.	Anticipated 2020
Toxicity assessments for GenX chemicals and PFBS	Provide toxicity assessments to stakeholders for GenX chemicals and an updated PFBS assessment. Both assessments underwent independent peer-review and review by federal partners prior to public comment.	Draft completed November 2018 Finalize 2019
Update Chemistry Dashboard with Information for Additional PFAS	The CompTox Chemicals Dashboard provides users with information on chemical structures, experimental and predicted physicochemical and toxicity data, and additional links to relevant websites and applications. The EPA updated the Dashboard with additional PFAS.	Completed March 2018
Water Contaminant Information Tool (WCIT) Profiles for PFOA and PFOS	Contaminant Profiles for two PFAS, PFOS and PFOA, to be added to the EPA's Water Contaminant Information Tool.	Completed December 2018
CWA Effluent Guidelines Planning PFAS Review	Through the Clean Water Act Effluent Guidelines Planning process, the EPA is examining readily-available information about PFAS surface water discharges to identify industrial sources that may warrant further study for potential regulation through Effluent Limitation Guidelines.	Ongoing
Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS	The EPA anticipates releasing interim cleanup recommendations to address groundwater contaminated with PFOA and/or PFOS to support stakeholders in their remediation efforts.	Anticipated 2019
Evaluation of CWA 304(a) Ambient water quality criteria for PFAS	The EPA is evaluating available data and research to support development of Clean Water Act Section 304(a) Ambient water quality criteria for PFAS.	Anticipated 2022

Tool/Activity	Purpose	Timeframe
Identifying and Addressing PFAS Exposures: What is the EPA doing to help identify communities with potential PFAS impacts, remediate PFAS exposures, and monitor compliance?		
Method Development	The EPA developed Method 537 for measuring PFOA, PFOS, and 12 other PFAS in drinking water to support the Unregulated Contaminant Monitoring Rule.	Completed 2009
Method Development	The EPA expanded Method 537 to measure four additional short-chain PFAS, including HFPO-DA (GenX chemicals) and ADONA. Method 537.1 is available on the EPA's website.	Completed November 2018
Method Development	Validated Direct Injection Method (SW-846) for quantifying 24 PFAS in surface, ground, and waste water matrices (non-drinking water) and solids (e.g., soil and sediment).	Anticipated 2019
Method Development	Validated Isotope Dilution Method (SW-846) for quantifying 24 PFAS in surface, ground, and waste water matrices (non-drinking water) and solids (e.g., soil and sediment).	Anticipated 2019
Method Development	New validated analytical method for PFAS in drinking water focusing on short-chain PFAS which cannot be measured by Method 537.1.	Anticipated 2019
Method Development	Method for sampling and analyzing PFAS in factory stack air emissions.	Anticipated 2020
Method Development	Testing and developing additional methods for possible refinement, including methods to quantify PFAS precursors; Total Organic Fluorine for a general PFAS detection method; and refinement of non-targeted high-resolution mass spectrometry approaches for suspect screening and novel PFAS discovery.	Ongoing
PFAS Geospatial Analytical Tool	Working with states and other federal partners, the EPA is evaluating how to best develop and maintain a GIS resource to consolidate and present PFAS data to inform analysis and understanding of PFAS sources and occurrence in the environment.	Anticipated 2019
Modeling atmospheric fate and transport of PFAS	Incorporate PFAS information into the EPA air models (e.g., the Community Multiscale Air Quality modeling system, AERMOD atmospheric dispersion model) to inform understanding of the potential and significance of atmospheric transport of PFAS.	Anticipated 2022
Unregulated Contaminant Monitoring Rule 3 for Public Water Systems	The third UCMR required monitoring for 30 contaminants (28 chemicals and two viruses) between 2013 and 2015 using analytical methods developed by the EPA, consensus organizations, or both. The purpose of UCMR3 was to collect occurrence data for contaminants suspected to be present in drinking water, but that do not have regulatory standards set under the SDWA. Six PFAS compounds were included in the UCMR3: PFOS, PFOA, PFNA, PFHxS, PFBS, and PFHpA. Of these six compounds, PFOA and PFOS were found in the greatest number of samples, and 1.3% of the public water systems sampled had results that exceeded the reference dose (lifetime HA limit of 70 ppt or 0.07μg/L).	Completed 2013-2015

Tool/Activity	Purpose	Timeframe
Unregulated Contaminant Monitoring Rule 5	The EPA intends to propose nationwide drinking water monitoring for PFAS under the next UCMR monitoring cycle utilizing newer methods available to detect more PFAS and at lower minimum reporting levels (MRLs) than previously possible in earlier monitoring.	Anticipated 2020-2025
Drinking Water Treatability Database-Update for Additional PFAS	Users can utilize the database to identify effective drinking water treatment processes for PFOA, PFOS, and additional PFAS chemicals. This database is continually updated as additional information becomes available.	Ongoing Updated September 2018
Research for Drinking Water Treatment	Conduct bench-, pilot-, and full-scale experiments to discern performance and cost of treatment (both capital and operations and maintenance), along with potential unintended consequences of employing specific technologies. Following a literature review for data gap identification, granular activated carbon and ion exchange treatment technologies will be tested under varying water qualities.	Anticipated Fall 2019
Treatability Cost Models	Updated drinking water PFAS treatability cost models.	Ongoing Updated September 2018
Evaluation of commercially Point-of-Use (POU) and Point-of-Entry (POE) home treatment systems	Investigate commercially available reverse osmosis and granular activated carbon units that can serve households in a point-of-use or point-of-entry applications for 6 PFAS included in UCMR3.	Completed 2018
Evaluation of treatment technologies for contaminated sites	A series of studies evaluating effectiveness and cost of different combinations of treatment train approaches for remediating contaminated sites.	2021
Fourth Contaminant Candidate List (CCL)	The EPA is required by the Safe Drinking Water Act to publish a list of contaminants known or anticipated to occur in public water systems which may require regulation under the Safe Drinking Water Act. The EPA included PFOA and PFOS on the fourth Contaminant Candidate List (the most recent CCL list).	2016
Fourth Regulatory Determination Process	The EPA is working on the Fourth Regulatory Determination process in which the EPA determines whether to regulate at least five contaminants on the CCL and issue final regulatory determinations after considering public input. The EPA is evaluating available information to determine if contaminants on the CCL, including PFOA and PFOS, meet the three criteria for regulation in accordance with the SDWA: (1) whether a contaminant may have adverse health effects; (2) whether a contaminant is found in public water systems with a frequency and at levels of concern; and (3) whether, in the sole judgment of the Administrator, there is a meaningful opportunity for health risk reduction through a national drinking water regulation.	Ongoing Anticipated 2019

Tool/Activity	Purpose	Timeframe
Collection of Great Lakes Environmental PFAS data	The EPA collects and analyzes environmental samples, including whole fish tissue, sediment, air, and water, to determine concentrations and trends of PFAS in the Great Lakes and occurrence in fish tissue.	Ongoing
Evaluate PFAS exposure through fish consumption	Evaluate temporal and demographic patterns of PFAS exposure and the relationship with fish consumption, in the U.S. general population.	Anticipated 2019
Fish Tissue Contamination Studies	To ensure that communities are aware of levels of PFAS in fish they may consume, continue to analyze PFAS in edible fish tissue as part of the National Rivers and Streams Assessment and the Great Lakes portion of the National Coastal Condition Assessment, and include PFAS in the revised list of target analytes that states may consider including in their fish and shellfish contaminant monitoring and advisory programs.	Ongoing
CERCLA Hazardous Substance Listing	The EPA has initiated the regulatory development process for listing PFOA/PFOA as CERCLA hazardous substances.	Ongoing
Scoping biosolids risk assessment for PFOA/PFOS	The EPA is in the early scoping stages of risk assessment for PFOA and PFOS in biosolids to better understand the implications of PFOA and PFOS in biosolids to determine if there are any potential risks.	Anticipated 2020
Identifying PFAS Risks from Chromic Acid Etch Facilities	The EPA's Office of Research and Development and Region 5 are collaborating on a study to characterize PFAS fume suppressants used at chromic acid etch facilities. Both Minnesota and Michigan have identified high levels of PFOS releases from these facilities, even after PFOS was phased out of the fume suppressant products in 2015. Region 5 is assessing if the current PFOS releases are the result of legacy use of PFOS fume suppressants or related to the replacement chemical formulations.	Ongoing
Identify PFAS sources, concentrations, uses, locations, and exposure routes most likely to pose threats to human health and the environment	Continue to make Toxic Substances Control Act (TSCA) data available where possible; identify sources, uses, and locations; develop information on potential high-impact locations; work with states to develop consistent sampling protocols.	Ongoing
Need to integrate data from multiple sources to better understand the presence of PFAS in the environment	Develop data sharing standards that allows states, tribes, communities, public water systems, and other organizations to contribute data about PFAS testing in a consistent manner.	Ongoing

Tool/Activity	Purpose	Timeframe
EPA TSCA section 5(e) order for GenX Chemicals	In 2009 the EPA entered into a Consent Order under TSCA section 5(e) with Dupont (now Chemours) that imposes requirements on the manufacture, processing, use, and disposal of GenX chemicals. Among other requirements, the Consent Order restricts the releases of the GenX chemicals by requiring the recapture of 99% of the chemicals. It also requires certain worker personal protective equipment as well as certain studies to be performed.	Ongoing
TRI listing for PFAS chemicals	Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) created the TRI Program. The TRI Program is another tool EPA may use to understand the releases of PFAS by industrial and federal facilities. Currently, no PFAS chemicals are included on the list of chemicals required to report to TRI; however, the EPA is considering whether to add PFAS chemicals. In considering listing, the EPA must determine whether data and information are available to fulfill the listing criteria and the extent and utility of the data that would be gathered. In addition, in considering if TRI will provide useful information to stakeholders, the EPA also will consider if those PFAS are still active in commerce. The process for listing includes notice and comment rulemaking to list PFAS chemicals for reporting prior to adding these chemicals to the TRI for annual reporting.	Ongoing

Tool/Activity	Purpose	Timeframe
Regions 1 and 3: Safe Drinking Water Act Section 1431 Emergency Orders to Department of Defense	2014 order to Navy at Warminster (PA) NPL Site directing the Navy to address high levels of PFOS discovered in three drinking water supply wells at and off the Warminster Naval Warfare Center where the elevated levels were four times the provisional health advisory level (which was 200 ppt for PFOS and 400 ppt for PFOA) in one case: Where levels in finished drinking water are above the HA for PFOA or PFOS, the Order required the Navy to provide a permanent drinking water supply as soon as practicable, but in no event later than 6 months after execution of the order. 2015 order to Air Force and Air National Guard at Horsham Air Guard Station/Willow Grove (PA) NPL Site (2015): The order directs the Air Guard/Air Force to treat two onsite public water supply wells and supply treatment to any private well found to exceed the provisional health advisory for PFOS in drinking water. Sampling confirmed that the Guard portion of the facility is also (like the Navy portion from Willow Grove) a source of PFOS offsite migration. The order covers long term treatment for private homes and also for short- and long-term public water supply concerns. 2015 order to Air Force for Contamination at Pease Air Force Base (NH) NPL Site: The order directs the Air Force to address contamination from perfluorinated compounds in drinking water at Pease Air Force Base including a number of actions to address the partial loss of the city's water supply attributed to firefighting foams used at the Base. The PFAS contamination resulted in the shutdown of one public water supply well, and two others could have been impacted if action were not taken to control PFAS migration. Under the order, the Air Force will restore contaminated groundwater in the Pease aquifer.	Ongoing
Annex 3, Chemicals of Mutual Concern, of the Great Lakes Water Quality Agreement	The goal of Annex 3 under the Canada-United States Great Lakes Water Quality Agreement (GLWQA) is to reduce the anthropogenic release of chemicals of mutual concern into the waters of the Great Lakes. In 2016, PFOS, PFOA, and LC-PFCAs—or collectively, PFAS—were designated as chemicals of mutual concern. In designating PFAS as a chemical of mutual concern, Canada and the United States have agreed that they may pose a threat to the Great Lakes. An Annex 3 binational strategy for PFAS is under development.	Anticipated September 2019
Belmont and Rockford, Michigan	The EPA is coordinating with the State of Michigan by overseeing a federal CERCLA time-critical removal action focused on hazardous substances at the Wolverine World Wide (Wolverine) Tannery and House Street Disposal Site and providing technical assistance to MDEQ while it responds to PFAS contamination of residential wells from Wolverine's former Tannery, shoe factory, and disposal locations in the Rockford area.	Ongoing

Tool/Activity	Purpose	Timeframe
Regions 3 and 5: Amendment to 2009 Safe Drinking Water Act Section 1431 Emergency Order on Consent with DuPont and Chemours	In 2009, the EPA issued a 1431 order on consent to Chemours' Washington Works Facility that contaminated sources of drinking water in WV and OH primarily via air deposition from the Facility. That order was amended in 2017, incorporating the Lifetime Health Advisory and requiring DuPont and Chemours to offer treatment, connection to a PWS, or bottled water to people on public or private water systems with PFOA levels above 70 ppt. In 2018, at the EPA's request, Chemours has also voluntarily sampled numerous private and PWSs for GenX chemicals.	Ongoing
Region 4 coordination of assistance to North Carolina Department of Environmental Quality (NCDEQ) – Chemours Fayetteville Works Facility	Region 4 has provided ongoing support to the NCDEQ as it has responded to GenX chemicals in the Cape Fear River and Fayetteville area. • Analytical testing via ORD-RTP and Region 4 Science and Ecosystem Support Division labs (testing of raw & finished water in the Cape Fear, rainwater, and air emissions stack testing for GenX chemicals and 22 other PFAS compounds) • Technical input as the state established its interim health goal • Coordinated treatment technique assistance for water systems • Technical assistance with NPDES permitting related matters and air emissions control.	Ongoing Started June 2017
Grant Funding Opportunity: National Priorities: Per- and polyfluoroalkyl substances	The EPA solicited proposals for EPA-G2018-ORD-A1 that included the below desired research areas: • Short-chain PFAS (C4 to C7) • PFAS found as residuals from manufacturing processes • Alternatives for long-chain PFAS (≥ C8) such as per- and poly-fluoroethers • PFAS generated through environmental chemical transformation	Ongoing Completed June 2018
Technical Support	The EPA will continue to assist states and tribes in bringing on PFAS analytical capabilities.	Ongoing

Tool/Activity	Purpose	Timeframe
Risk Communication and Engagement: What is the EPA doing to provide consistent and accurate information and guidance to the public?		
Clearinghouse of PFAS information for states, tribes and local communities	The EPA compiled information from a wide range of sources on measurement, health impacts, and treatment and remediation technologies. The EPA continues to update this site as additional information becomes available.	Ongoing Started 2018
Engagement with states and stakeholders	Ongoing robust engagement effort with states, tribes, local communities, utilities, industry, and the public. Extensive outreach in 2018 included: • 5/22-5/23/2018: PFAS National Leadership Summit • 6/25-26/2018: Exeter, NH (Region 1 wide) Community Engagement • 7/25/2018: Horsham, PA Community Engagement • 8/7-8/2018: Colorado Springs, CO Community Engagement • 8/14/2018: Fayetteville, NC Community Engagement • 8/13/2018: Spokane WA, PFAS session at the Tribal Lands and Environment Forum meeting • 9/5/2018: Leavenworth, KS Community Engagement • 10/4-5/2018: Michigan site visits, Kalamazoo, MI Roundtable	Completed October 2018
EPA Region 7 participation in Kansas PFAS Monitoring Plan Advisory Committee	Region 7 to serve on Kansas Department of Health and Environment Per- and Polyfluoroalkyl Substance Monitoring Plan Advisory Workgroup for drinking water. The KDHE requested the EPA's participation to serve in an advisory capacity on a monitoring plan to be developed with the focus on drinking water.	Started Fall 2018
EPA Region 7 updates on PFAS for states and tribes	Activated the EPA Region 7 Science Council with state representation which will also include a PFAS update on a quarterly basis. The EPA Region 7's Regional POC for PFAS will also update our tribal representatives at the Regional Tribal Operation Committee meetings.	Started March 2018
Federal Remediation Technologies Roundtable Meeting	One-day interagency technical meeting meant to identify and discuss the emerging science behind PFAS characterization and remedial technologies. Technical presentations also remotely broadcasted. Primarily federal agency participation.	Completed November 7, 2018
Internal EPA regional coordination network	Activated internal EPA regional coordination network with representation from all regions and program offices to further support rapid dissemination of information in order to better support states, tribes, and local communities.	Started February 2018
Internal EPA regional coordination for cleanup programs	Created an internal EPA regional coordination group for cleanup programs with representation from all regions to further support rapid dissemination of information in order to better support states, tribes, and local communities.	Started Summer 2016

Tool/Activity	Purpose	Timeframe
Internal EPA Region 7 team	Activated internal EPA Region 7 network with representation from all programs further support rapid dissemination of information in order to better support states, tribes, and local communities.	Started February 2018
Quarterly Meetings with Region 10 Environmental and Health Departments	Region 10 quarterly conference calls with Region 10 PFAS contacts in state environmental and health departments to share information and discuss issues and topics of mutual interest.	Ongoing
Webinar on PFAS State case studies	Webinar showcasing PFAS risk communication activities by states; developed in coordination with ECOS and ASTHO.	Completed June 2018

Appendix B: Summary of PFAS National Leadership Summit and Community Engagements

In 2018, the EPA held a series of public community engagement events that brought together the EPA and state officials, federal partners, local speakers, community groups, and citizens to share perspectives and help inform future Agency actions for managing PFAS. Following the PFAS National Leadership Summit, these sessions continued EPA's commitment to foster an ongoing dialogue with stakeholders to address PFAS.

The National Leadership Summit included representatives from over 40 states, tribes, and territories; 13 federal agencies; congressional staff; associations; industry groups; and non-governmental organizations to engage in discussions about PFAS monitoring, risk characterization, near-term actions, and risk communications strategies. Key perspectives emphasized by participants during the summit included interest in:

1. An expansion of monitoring and sampling in the environment supported by sources of funding;
2. Continued advancement of the understanding of PFAS compounds, potential toxicity, and further development of analytical methods;
3. Increased understanding of exposures beyond drinking water;
4. Robust near-term action while long term actions are completed;
5. Identifying opportunities for collaboration and coordinated data sharing efforts among partners; and
6. Continued public engagement and development of risk communication resources.

The Community Engagements included panel discussions on the current state of science and potential risks posed by PFAS, as well as state and local actions towards 1) Identifying PFAS; 2) PFAS Risk Communications; and 3) Identifying Solutions for PFAS. Following the panel discussions, members of the public shared input and personal stories. During the community listening sessions, the EPA interacted with over 1,000 members of the public and heard from approximately 200 citizens in Exeter, New Hampshire; Horsham, Pennsylvania; Colorado Springs, Colorado; Fayetteville, North Carolina; and Leavenworth, Kansas.

The EPA developed summaries for the PFAS National Leadership Summit and each of the community engagements that can be found on EPA's PFAS webpages: https://www.epa.gov/pfas/pfas-national-leadership-summit-and-engagement and https://www.epa.gov/pfas/pfas-community-engagement.

Appendix C: Summary of Docket Comments

Background

Following the PFAS National Leadership Summit, the EPA requested input from the public on how the Agency can best help states, tribes, and communities facing PFAS challenges. The EPA has considered these comments in the development of this PFAS Action Plan and will continue to be informed by these comments as the Agency plans its next steps.

Docket Process and Summary of Submissions

The EPA opened the docket on PFAS, OW-2018-0270, from May 2, 2018 to September 28, 2018 and received approximately 120,000 comments via Regulations.gov. The docket comments are summarized below according to the themes requested by the EPA. The docket is available at: https://www.regulations.gov/docket?D=EPA-HQ-OW-2018-0270.

1. Obtaining information on ongoing efforts to characterize risks from PFAS and develop monitoring and treatment/cleanup techniques;
2. Informing specific near-term actions, beyond those already underway, that are needed to address challenges currently facing states and local communities;
3. Developing risk communication strategies to address public concerns with PFAS; and
4. General comments.

All comments were reviewed, categorized, and used to support the development of the PFAS Action Plan. The majority of comments received, approximately 97%, were from the public from across the United States representing rural and urban communities. Public citizen comments generally included a request for the EPA and the federal government to assist in managing PFAS in their community, concern for the health of their families and themselves, specific requests for action in managing and limiting PFAS in the environment, a desire to see PFAS removed at the source, a desire for responsible parties to pay for cleanup, and a universal expression for the right to have access to clean and healthy water.

Approximately 2.5% of comments were submitted by organizations, members of Congress, industry, water associations, governmental organizations at all levels, and not-for-profit organizations. The comments generally included support for the development of the PFAS Action Plan, an expression of the need for regulatory action, the need for science-based decisions, a desire for better communication regarding the Agency's planned activities, a request for the EPA to use regulatory authorities to manage PFAS, and a coordinated response from the federal government.

The following information is intended to provide an overview summary of the comments received in the public docket within each theme and is not meant to be comprehensive. Comments provided to the EPA are available in the docket at the link provided above.

Characterize Risks from PFAS and Develop Monitoring and Treatment/Cleanup Techniques

- Undue burden placed on communities and private well owners. Concerns on the costs to the taxpayer associated with treatment of PFAS in water, purchasing bottled water, point-of-use filters, and/or the cost associated with health care stemming from potential PFAS exposure.
- Desire for responsible parties to pay for the cost of cleanup/treatment and monitoring.
- Requests that the EPA consider the cost of treatment in the rulemaking process.
- Federal prioritization of PFAS compounds for additional study and effort.
- Concern on the movement of PFAS through groundwater and the potential for contamination to spread.
- Need for more science-based research and method development to monitor PFAS.

Near-term Actions Needed to Address Challenges Currently Facing States and Local Communities

- Desire for the EPA to use its regulatory authority to regulate PFAS and provide regulatory certainty.
- List PFAS as hazardous substances.
- Develop groundwater cleanup values in a way that encourages site-specific solutions and allow for use of available resources.
- Request for better risk communication and education from the public on health effects, more research on PFAS, identification of PFAS in media other than drinking water, and prevention of industrial releases of PFAS.
- Develop consistent and enforceable standards, including a maximum contaminant level for PFAS that is based on best-available and current science. Some members of the public expressed support for lowering EPA's Health Advisory Level.
- Follow up or expanded water testing and/or blood testing in local communities.
- Concern with the UCMR detection levels (too low and not representative of PFAS presence) and requests to expand the list of PFAS for future UCMR efforts.
- Need for funding for the federal, state, tribal, and local governments to adequately address PFAS.
- Regulate PFAS at the source; prevent PFAS from entering commerce and prevent releases into the environment.
- Concern that families and communities located near military installations are disproportionally affected by PFAS.
- Concern from site-specific contamination, including GenX chemicals.
- Make available technical assistance and funding to individual households and private well owners to address PFAS. Communities need assistance in determining the extent of their contamination.
- Need for new analytical methods to achieve lower detection limits, identify additional PFAS, and monitor in media other than water.

- Need any guidance developed by the EPA to be scalable, with special emphasis for small and tribal communities.

Risk Communication Strategies to Address Public Concern with PFAS

- Concern regarding the quality and accessibility of information from the EPA and other federal agencies. Desire to have information on: the proximity of a community to a PFAS source; the potential exposure of communities to individual and mixtures of PFAS; products that contain PFAS; guideline, standard, and method development process; and access to technical resources such as data, methods, and research.
- Need for a clear and concise communication plan from the EPA to inform the public and stakeholders regarding the risk of PFAS exposure and related the EPA activities (both ongoing and planned).
- Concern on the unknown human health effects from PFAS exposure, the cost of health insurance and mental health coverage from exposure and stress of exposure, and the possible health effects from PFAS exposures.
- Request for comprehensive testing of PFAS in drinking water and blood and communication of risk information in a clear and concise manner that is easy for the public to understand.
- Concern on the lack of risk communication for PFAS in food, such as fish and shellfish.
- Need for a comprehensive risk communication strategy that includes stakeholders and allows for the opportunity for the public to provide comments and questions.

General Comments

- Request the EPA exercise its regulatory authority to limit the use and manufacture of PFAS due to health concerns from exposure from air, water, and food.
- Commenters at community engagements provided both support and appreciation for the opportunity to participate, in addition to implying frustration at feeling excluded from presenting information to the panelists.
- Commenters provided personal accounts of PFAS exposure in their local community and the health and financial impacts of that exposure.
- Encourage the EPA to abide by its mission to protect human health and the environment by ensuring all citizens are provided healthy and clean drinking water and air.

Appendix D: Other Reference Materials

EPA Resources

- EPA's Webpage for Per- and Polyfluoroalkyl Substances (PFAS): https://www.epa.gov/pfas
- Information on the EPA Community Engagement Sessions on PFAS: https://www.epa.gov/pfas/pfas-community-engagement
- Information on the National Leadership Summit on Per- and Polyfluoroalkyl Substances (PFAS): https://www.epa.gov/pfas/pfas-national-leadership-summit-and-engagement
- PFAS National Leadership Summit and Engagement Federal Public Input Docket: https://www.regulations.gov/ – enter docket number: OW-2018-0270
- Drinking Water Health Advisories for PFOA and PFOS: https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos
- Third Unregulated Contaminant Monitoring Rule: https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule
- Contaminant Candidate List 4: https://www.epa.gov/ccl/contaminant-candidate-list-4-ccl-4-0
- EPA Drinking Water Laboratory Method 537 Q&A: https://www.epa.gov/pfas/epa-drinking-water-laboratory-method-537-qa
- Research on Per- and Polyfluoroalkyl Substances (PFAS): https://www.epa.gov/chemical-research/research-and-polyfluoroalkyl-substances-pfas
- EPA Actions to Address PFAS: https://www.epa.gov/pfas/epa-actions-address-pfas
- EPA 2010/2015 PFOA Stewardship Program: https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program
- Drinking Water Treatability Database: https://iaspub.epa.gov/tdb/pages/general/home.do
- Case Studies on State-Level Risk Communication of PFAS (EPA and ECOS collaboration): https://www.ecos.org/documents/state-level-risk-communication-of-pfas-and-habs/

Additional Resources (Non-EPA Materials)

- ATSDR Webpage Per- and Polyfluoroalkyl Substances (PFAS) and Your Health: https://www.atsdr.cdc.gov/pfas/
- ATSDR Overview of Perfluoroalkyl and Polyfluoroalkyl Substances and Interim Guidance for Clinicians Responding to Patient Exposure Concerns: https://www.atsdr.cdc.gov/pfc/docs/pfas_clinician_fact_sheet_508.pdf
- ToxFAQs™ for Perfluoroalkyls: https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1116&tid=237
- Toxicological Profile for Perfluoroalkyls: https://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237
- CDC Per- and Polyfluorinated Substances (PFAS) Factsheet: https://www.cdc.gov/biomonitoring/PFAS_FactSheet.html

- CDC National Report on Human Exposure to Environmental Chemicals: https://www.cdc.gov/exposurereport/index.html
- Interstate Technology Regulatory Council (ITRC) PFAS website: https://pfas-1.itrcweb.org/
- ITRC PFAS fact sheets: https://pfas-1.itrcweb.org/fact-sheets
- Per- and Polyfluoroalkyl Substances (PFAS) Laboratory Testing Primer for State Drinking Water Programs and Public Water Systems: https://www.asdwa.org/wp-content/uploads/2018/10/ASDWA-PFAS-Lab-Testing-Primer-10-10-18-Final.pdf

Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS

Fact Sheet

Overview

On December 19, 2019, EPA issued Interim Recommendations for Addressing Groundwater Contaminated with Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonate (PFOS) that can be used at sites under federal cleanup programs. Federal agencies and states have asked EPA to provide guidance on this issue, and EPA is following through on its commitment. It is important to note that these are "interim recommendations," and the agency will continue to evaluate new scientific information on PFAS. Addressing PFAS is an active and ongoing effort for the agency, and issuing these interim recommendations is a priority action under EPA's PFAS Action Plan.

EPA's interim recommendations will help protect public health in communities across the country by providing clear and consistent guidance for cleanup sites being evaluated and addressed under federal cleanup programs, including CERCLA or Superfund and corrective action under the Resource Conservation and Recovery Act (RCRA). This information is based on EPA's current scientific understanding of per- and polyfluoroalkyl substances (PFAS) toxicity. EPA acknowledges that scientific information on these compounds continues to evolve. As part of the PFAS Action Plan, EPA is developing and assessing toxicity information, test methods, laboratory methods, analytical methods, exposure models, and treatment methods, among other research efforts to improve our knowledge about this class of chemicals. EPA anticipates considering additional recommendations for addressing other PFAS at a future date as we advance our knowledge of these other substances.

EPA's Action

EPA is prioritizing public health impacts by focusing on addressing groundwater that is a current or potential source of drinking water. The guidance recommends:

- Using a screening level of 40 parts per trillion (ppt) to determine if PFOA and/or PFOS is present at a site and may warrant further attention.
    - Screening levels are risk-based values that are used to determine if levels of contamination may warrant further investigation at a site.
- Using EPA's PFOA and PFOS Lifetime Drinking Water Health Advisory level of 70 ppt as the preliminary remediation goal (PRG) for contaminated groundwater that is a current or potential source of drinking water, where no state or tribal MCL or other applicable or relevant and appropriate requirements (ARARs) are available or sufficiently protective.
    - PRGs are generally initial targets for cleanup, which may be adjusted on a site-specific basis as more information becomes available.

2

Public Input

During the 45-day public comment period, the agency received nearly 300 public comments that included a wide range of perspectives on the draft interim recommendations. A number of commenters suggested using values that were higher than the recommended screening level and PRG and others suggested using values that were lower. Since 2016, EPA has determined that drinking water concentrations of PFOA and PFOS of 70 ppt or lower offer a margin of protection for all individuals throughout their lives from adverse health effects resulting from exposure to PFOA and PFOS in drinking water. EPA also believes 70 ppt is appropriate for use as a Preliminary Remediation Goal (PRG) for CERCLA purposes as a first step in the process of developing cleanup levels at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site.

Commenters suggested EPA should consider including additional PFAS in the recommendations. Under the PFAS Action Plan, the agency is evaluating other available toxicity information, including efforts to understand how to address a larger number of PFAS. The agency anticipates considering additional recommendations for addressing other PFAS at a future date when the results of research outlined the PFAS Action Plan are available.

How will EPA apply these recommendations?

These recommendations are for sites being evaluated and addressed under federal cleanup programs, including CERCLA or Superfund and corrective action under the Resource Conservation and Recovery Act (RCRA). The recommendations in this guidance may also be useful for state, tribal, or other regulatory authorities (e.g., federal facility cleanup programs, approved state RCRA corrective action programs); though, many states have promulgated state standards that may be considered ARARs under CERCLA. This guidance document does not impose any requirements and shall not by itself be considered binding on any party. Rather, the sources of authority and requirements for addressing groundwater contamination regarding a particular situation are the relevant statutes, and as appropriate, regulations.

The interim recommendations and additional information can be found at:
https://www.epa.gov/pfas/interim-recommendations-addressing-groundwater-contaminated-pfoa-and-pfos

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Background on the PFAS Action Plan

PFAS are a large group of man-made chemicals used in consumer products and industrial processes. In use since the 1940s, PFAS are resistant to heat, oils, stains, grease, and water—properties which contribute to their persistence in the environment.

The agency's PFAS Action Plan is the first multi-media, multi-program, national research, management, and risk communication plan to address a challenge like PFAS. The plan responds to the extensive public input the agency received during the PFAS National Leadership Summit, multiple community engagements, and through the public docket. The PFAS Action Plan outlines the tools EPA is developing to assist states, tribes, and communities in addressing PFAS.

EPA is taking the following highlighted actions:

Highlighted Action: Drinking Water

- EPA is committed to following the national primary drinking water regulation rulemaking process as established by the Safe Drinking Water Act (SDWA).
- EPA has sent the proposed regulatory determination for PFOA and PFOS to the Office of Management and Budget for interagency review.
- The agency is also gathering and evaluating information to determine if regulation is appropriate for other chemicals in the PFAS family.

Highlighted Action: Cleanup

- On December 19, 2019, EPA issued *Interim Recommendations for Address Groundwater Contaminated with PFOA and PFOS*, which provides cleanup guidance for federal cleanup programs (e.g., CERCLA and RCRA) that will be helpful to states and tribes.
- EPA will follow through on the regulatory development process for listing perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) as hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

Highlighted Action: Monitoring

- EPA will propose nationwide drinking water monitoring for PFAS under the next UCMR monitoring cycle.

Highlighted Action: Toxics

- EPA has issued an advanced notice of proposed rulemaking that would allow the public to provide input on adding PFAS to the Toxics Release Inventory toxic chemical list.
- A supplemental proposal to ensure that certain persistent long-chain PFAS chemicals cannot be manufactured in or imported into the United States without notification and review under TSCA is currently undergoing interagency review at the Office of Management and Budget.

Highlighted Action: Surface Water Protection

- EPA is exploring data availability and research to support the development of Clean Water Act human health and aquatic life criteria for certain PFAS, as data allows.
- EPA is examining available information about PFAS released into surface waters by industrial sources to determine if additional study is needed for potential regulation.

Highlighted Action: Biosolids

- EPA is in the early scoping stages of risk assessments for PFOA and PFOS in biosolids to understand any potential health impacts.

Highlighted Action: Research

- On November 22, 2019, EPA announced availability of $4.8 million in funding for new research on managing PFAS in agriculture.
- EPA continues to compile and assess human and ecological toxicity information on PFAS to support risk management decisions.
- EPA continues to develop new methods to test for additional PFAS in drinking water. The agency is also validating analytical methods for surface water, ground water, wastewater, soils, sediments and

biosolids; developing new methods to test for PFAS in air and emissions; and improving laboratory methods to discover unknown PFAS.
- EPA is developing exposure models to understand how PFAS moves through the environment to impact people and ecosystems.
- EPA continues to assess and review treatment methods for removing PFAS in drinking water.
- EPA is working to develop tools to assist officials with the cleanup of contaminated sites.

Highlighted Action: Enforcement
- EPA uses enforcement tools, when appropriate, to address PFAS exposure in the environment and assists states in enforcement activities.
- EPA has already taken actions to address PFAS, including issuing Safe Drinking Water Act orders and providing support to states. *See examples in the PFAS Action Plan.*

Highlighted Action: Risk Communications
- EPA will work collaboratively to develop a risk communication toolbox that includes multi-media materials and messaging for federal, state, tribal, and local partners to use with the public.

A full summary of EPA's action to address PFAS can be found in the PFAS Action Plan: https://www.epa.gov/pfas/epas-pfas-action-plan

Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances

INTERIM GUIDANCE FOR PUBLIC COMMENT
DECEMBER 18, 2020

3

Tables

Abbreviations

AFFF	aqueous film-forming foam
ARFF	aircraft rescue firefighting
BEA	Bureau of Economic Analysis
BDL	below detection limit
BLS	Bureau of Labor Statistics
BOHP/UV	petitjeanite ($Bi_3O(OH)(PO_4)^2$) microparticle ultraviolet
C	Celsius
CAA	Clean Air Act
C_2F_6	hexafluoroethane
C_3F_8	octafluoropropane
CaF_2	calcium fluoride
C&D	construction and demolition
CaO	calcium oxide
$Ca(OH)_2$	calcium hydroxide
CDR	Chemical Data Reporting
CEPCI	Chemical Engineering Plant Cost Index
CF_4	carbon tetrafluoride
CFR	Code of Federal Regulations
CHF_3	fluoroform
CIC	combustion–ion chromatography
CI/MS	chemical ionization mass spectrometry
CKD	cement kiln dust
DoD	Department of Defense
DOE	Department of Energy
DRE	destruction and removal efficiency
EIA	Energy Information Administration
EJ	environmental justice
EPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
F	Fahrenheit
FAA	Federal Aviation Administration
FBC	fluidized bed combustor
FF	fabric filter
FML	flexible membrane liner
FTIR	Fourier transform infrared spectrometry
FTOH	fluorotelomer alcohol
FY 2020 NDAA	National Defense Authorization Act for Fiscal Year 2020
GAC	granular activated carbon
GCCS	gas collection and control system
GDP	gross domestic product
GHGRP	Greenhouse Gas Reporting Program

SDA	spray dryer absorber
SDWA	Safe Drinking Water Act
SERDP	Strategic Environmental Research and Development Program
SSI	sewage sludge incinerator
STAR	Science to Achieve Results
TOF	total organic fluorine
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
UF	ultrafiltration
UIC	underground injection control
U.S.C.	United States Code
USDW	underground source of drinking water
VOC	volatile organic compound
WWTP	wastewater treatment plant
XPS	X-ray photo-electron spectroscopy

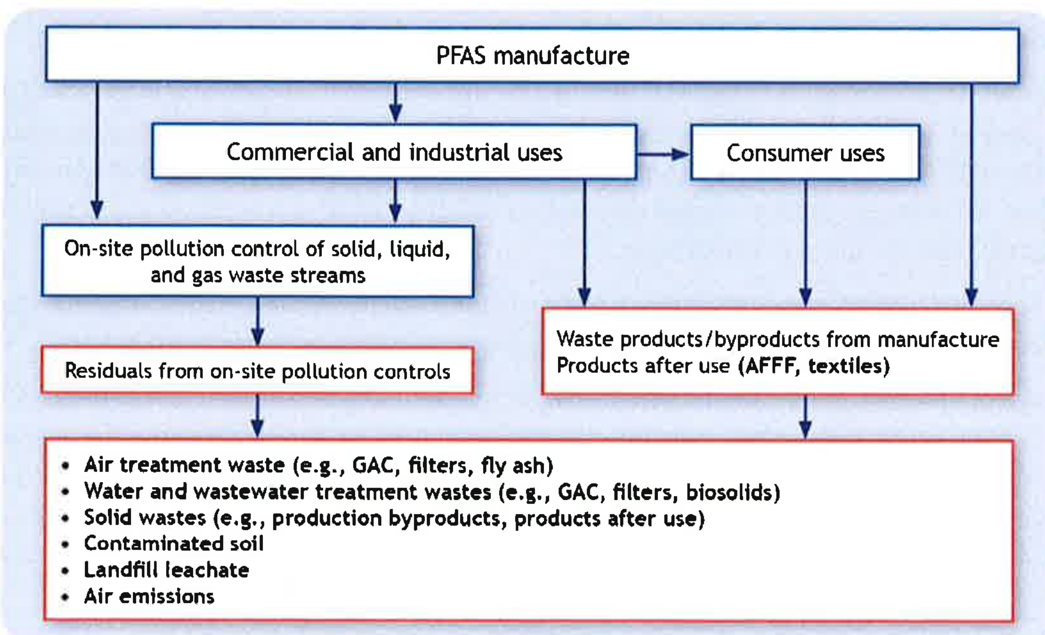
into the environment should destruction or disposal be required at this time. However, there remain several important data gaps, which this document describes.

Consistent with the FY 2020 NDAA, it is organized as follows:

- Section 2: Description of PFAS-Containing Materials Identified in the FY 2020 NDAA
- Section 3: Technologies for the Destruction and Disposal of PFAS and PFAS-Containing Materials
- Section 4: Considerations for Potentially Vulnerable Populations Living Near Likely Destruction or Disposal Sites
- Section 5: Planned Research and Development on Destruction and Disposal Technologies for PFAS and PFAS-Containing Materials

1.b.i PFAS and PFAS-containing materials identified in the FY 2020 NDAA

Section 7361 of the FY 2020 NDAA (see Figure 1-1) lists six types of PFAS-containing materials. Although the information included in this guidance would probably be suitable for other types of PFAS and PFAS-containing materials, this guidance addresses destruction and disposal for these six material types, which are described in more detail in Section 2. PFAS are either manufactured in the United States or imported, and then used (as an input or in a formulation) as processing aids or components of commercial and consumer products. Figure 1-2 shows conceptually how these activities could result in material streams that are in the intended scope of this interim guidance. A more global illustration of how PFAS-containing materials may be released to and migrate through the environment is presented in Figure 4-1.



Note: The red-outlined portions of this figure show where the FY 2020 NDAA material types occur in the course of manufacture, use, and disposal of PFAS and PFAS-containing materials that are within the scope of this interim guidance.

Figure 1-2. Generation of PFAS materials identified in the FY 2020 NDAA.

1.c Destruction and disposal technologies addressed in this interim guidance

PFAS are managed in non-hazardous and hazardous waste treatment and disposal systems. As shown in Table 1-1, this interim guidance focuses on three destruction and disposal technologies: thermal treatment, landfilling, and underground injection. Other current PFAS waste management options are not discussed, as they are not in the intended scope of this guidance described in Section 1.b.ii. The land application of biosolids and other wastes (e.g., pulp and paper sludges) containing PFAS, for example, does not meet the Section 1.b.ii goal of PFAS destruction or control of PFAS migration into the environment.

Table 1-1. Destruction and Disposal Technologies Discussed in This Guidance, with Examples of PFAS-Containing Materials

Destruction and Disposal Technology, by Physical Phase of Materials	Examples of PFAS-Containing Materials (Within the Scope of the FY 2020 NDAA) That Could Be Managed Using These Technologies
Solid phase: Landfill disposal Thermal treatment	• Drinking water, groundwater, and wastewater treatment residuals o Biosolids o Spent granular activated carbon (GAC) o Ion exchange resins o Filters o High-pressure membranes • Air waste stream treatment residuals o Spent GAC o Fly ash • Contaminated soil • End-of-life products (e.g., textiles)
Liquid phase: Underground injection Thermal treatment	• Landfill leachate • Aqueous film-forming foam • End-of-life products (e.g., spent cleaning solvents) • Pollution control residuals (e.g., concentrates) from PFAS production and use
Gas phase: Thermal treatment	• Landfill gas • Emissions from manufacture, use, or destruction

1.d Summary of destruction and disposal interim guidance

The FY 2020 NDAA requires that EPA publish interim guidance on the destruction and disposal of PFAS and PFAS-containing materials. This document contains guidance that is based on currently available research and information and is responsive to the scope of the FY 2020 NDAA. Most significantly, it provides the best up-to-date information on potential releases during the destruction and disposal of PFAS and PFAS-containing materials and identifies data gaps to be filled that can inform future EPA guidance.

This interim guidance presents background information on the manufacture and uses of PFAS, as well as solid, liquid, and gas waste streams containing PFAS, including those materials identified in the FY 2020 concentrations for these materials. EPA encourages the manager of PFAS-containing materials, the hazardous waste combustion facility, and the state to work together with EPA to develop and implement protocols for monitoring, emission testing, and data sharing. While developing and implementing these protocols is not a precondition, EPA considers it a key step and requests assistance in obtaining more information to inform research efforts and future guidance. EPA is very interested in collaborating on these protocols.

5. **Hazardous waste combustors.** These would include commercial incinerators, cement kilns, and lightweight aggregate kilns, subject to the considerations outlined in this guidance.

6. **Other thermal treatment.** This would include carbon reactivation units, sewage sludge incinerators, municipal waste combustors, and thermal oxidizers, subject to the considerations outlined in this guidance.

This document describes a suite of technologies within the three categories noted above: thermal treatment (destruction), landfilling (disposal), and underground injection (disposal). The following have been found to have the greatest potential within each category to control migration of PFAS to the environment if used to destroy or dispose of PFAS-containing materials, based on the available information analyzed for this guidance document:

1. **Hazardous waste combustion** technologies (commercial incinerators, cement kilns, and lightweight aggregate kilns) can potentially achieve temperatures and residence times sufficient to break apart the PFAS contained in the waste stream being thermally treated. Permitted hazardous waste facilities have stringent regulatory controls on temperatures and other important operating parameters to achieve a 99.99 percent destruction efficiency for other (non-PFAS) organic chemicals. Key uncertainties include the lack of PFAS-specific information on these facilities. EPA currently has no emission characterizations from these sources when they burn PFAS, and is working to develop measurement methodologies as well as gather information to conclude whether potential products of incomplete combustion (PICs) are adequately controlled. EPA recognizes that PICs are formed (even for nonfluorinated compounds); however, based on the unique characteristics of fluorine combustion chemistry, it needs to be determined whether thermal treatment devices and their associated post-combustion control devices are controlling fluorinated PICs. Additional research is needed to minimize or eliminate data gaps or current uncertainties. By the time of the next update to this guidance (within the next 3 years), EPA expects to complete sufficient research to address data gaps. EPA will then make a more informed recommendation on disposal of PFAS compounds and PFAS-containing substances using incineration.

2. **Hazardous waste or municipal solid waste landfills** are available, feasible, and effective, to varying degrees, disposal options for PFAS and PFAS-containing materials. Permitted hazardous waste landfills employ the most extensive set of environmental controls (e.g., double liner systems with leachate collection and leak detection) and practices (e.g., extensive record keeping) that are currently available for the containment of PFAS waste (see Table 3-4) and as a result would be more effective at minimizing PFAS migration into the environment than other landfill types. Modern municipal solid waste landfills, when constructed with appropriate controls (e.g., liner system and leachate and gas collection and management systems), can also control the migration of PFAS into

guidance in less than 3 years if research results become available that would allow the Agency to issue more specific guidance on PFAS destruction and disposal.

replacements and alternative chemistries. However, uses of these chemical substances continue by companies that did not participate in the PFOA Stewardship Program. Long-chain PFAS and their precursors may still be produced as unintentional byproducts and may persist in facility emissions and as product impurities in small quantities (3M Company, 1999; Boucher et al., 2019; Lehmler, 2009; Kissa, 2001). Furthermore, information on the toxicity and environmental fate and transport of alternative PFAS chemistries is limited (Sun et al., 2016; Wang et al., 2014).

In the 2016 CDR full dataset, primary manufacturers reported manufacturing (including importing) about 25,600 metric tons of PFAS at 38 sites in 2015. This represents the aggregate production volume for PFAS produced and imported into the United States, across all industries. Although the aggregate production volume might not include all PFAS sources (for instance, a specific chemical or site may not meet reporting obligations), it provides a proxy quantity of all PFAS domestically produced and imported.

PFAS might be released into the environment at every step in the production process, including synthesis, polymerization, application, transport, usage, and waste stream management and disposal (3M Company, 2000b). Table 2-1 lists important PFAS uses and the resulting solid, liquid, and gas waste streams for primary and secondary manufacturers of PFAS-containing materials and certain service sectors as indicated by industry, national and global inventories, and research. However, this list is not exhaustive or representative of all current uses, applications, recovery and recycling practices, or treatment technologies that could affect the volume and characteristics of the resulting waste streams. EPA recognizes the need for continued research to better characterize the multi-media PFAS-containing materials targeted for destruction or disposal, as discussed in Section 5.a.

2.a.i Solid phase wastes

Primary manufacturing and secondary industrial use of PFAS can generate solid waste streams with PFAS-containing materials (OECD, 2011, 2015). For example, some PFAS synthesis processes can produce tars consisting of high-molecular-weight byproducts that are either fully or partially fluorinated. These byproducts may be recycled back into the process, disposed of in a hazardous waste landfill, or incinerated (3M Company, 2000a, 2000b). Solid wastes may also be produced as fly ash or spent GAC resulting from PFAS incineration and other treatment processes.

Other important solid-phase wastes include sludges and biosolids (see Section 2.c) that result from stabilizing or treating process waters and wastewaters, either on-site or at a municipal wastewater treatment plant (WWTP) that receives influent from industrial sources (Venkatesan & Halden, 2013). In addition to solids produced via treatment, spent water treatment media (such as ion exchange resins) are part of this waste stream (see Section 2.e). Other direct industrial sources of solid wastes containing PFAS include intentional residuals, such as cuttings and fibers from textile manufacturing (see Section 2.d), and materials unintentionally produced outside of product specification. The concentrations and composition of PFAS in solid wastes generated from primary and secondary industrial sources vary by facility and depend on factors such as facility- or industry-specific production processes and the types and quantities of PFAS produced or used (ITRC, 2020).

Table 2-1. Examples of PFAS Waste Streams by Industry Type

Industry Type	Uses	Examples of Waste Streams[a]			Notes
		Solid	Liquid	Gas	
Primary chemical manufacturing	PFAS synthesis, feedstocks for primary products, feedstocks for secondary users, processing aids (fluoropolymers)	Process byproducts (tars), sludges/ biosolids, off-spec materials,[b] treatment residuals (GAC/anion exchange resins), spill residues (replacement and legacy), *particulate emissions*	Degraded/stabilized process wastes, wastewater effluent, *stack emissions condensate*	Stack emissions, fugitive volatiles	3M Company (1999, 2000b)
Secondary Manufacturing (Industry Users of PFAS-Containing Materials)[c]					
Adhesives manufacturing	Component of solvent- and water-based adhesives, rubber to allow bonding to steel, and urea-formaldehyde adhesive resins for wood particleboard bonding	*Used filter media and filter residues, residues of cured adhesives, empty containers, used shop rags (from cleaning), contaminated soil (from spill cleanup residues)*	*Residues of liquid adhesives, off-spec products,[b] contaminated wastewater (from spill cleanup residues)* *For cleaning: equipment startup, cleaning, and flushing wastes; spent cleaning solvents; and contaminated wastewater*	Stack emissions, fugitive volatiles	ASC (n.d.), RadTech International North America (2010)

Industry Type	Uses	Examples of Waste Streams[a]			Notes
		Solid	Liquid	Gas	
Metal plating/ fabrication	Used as a surfactant, wetting agent, and mist suppressing agent; as a wetting agent fume suppressant for chromium plating and chromium anodizing; as a dispersion product used to coat metals; as a blocking agent for aluminum foil; in plating baths; and to treat metal surfaces	*Off-spec products*[b]	Spent plating or etching baths, rinse water effluent, liquid residues from empty containers, and spills	Stack emissions, fugitive volatiles	3M Company (1999), U.S. EPA (2009b)
Oil and gas drilling/ extraction/ refinery/ support	Component of chemical barrier used for containing oil spills Used as a surfactant for recovery in oil/gas recovery wells, a jet fuel/hydrocarbon solvent, and in hydraulic oils Used as a gasoline/petroleum product evaporation inhibitor in storage tanks in the following forms: a floating layer of cereal grains treated with PFAS, an aqueous layer containing PFAS		Applied product[d] (oil spills, oil and gas recovery wells), *liquid residues from empty containers, and spills*		UNEP (2011), Kissa (2001)
Paint/coating manufacturing	Component of coatings, paints, varnishes, dyes, ink jet printer inks, and ski waxes	*Pigment dust*	*Unused paint products, off-spec products,[b] liquid residues from empty containers, and spills*	*Fugitive volatiles, atomized paint*	Waste Management and Research Center (1992)
Paper products/ packaging manufacturing	Waterproofing/greaseproofing for products including food contact paper (plates, popcorn bags, pizza boxes, food containers, wraps), non-food contact applications (folding cartons, carbonless forms, masking papers)	Dusts; *solids coated with PFAS from processing, sampling, quality assurance; off-spec products*[b]	Spillage, cleanup, and releases during opening, rinsing, and cleaning of PFAS totes	Fugitive volatiles	U.S. EPA (2009a)
Pesticide/ fertilizer/ other agriculture chemical manufacturing	Pesticide and herbicide additive	*Particulate emissions*	*Liquid residues from empty containers, spills, off-spec products,[b] cleaning of equipment, and process wastewaters*	*Fugitive volatiles*	World Bank Group (1998)

Industry Type	Uses	Examples of Waste Streams[a]			Notes
		Solid	Liquid	Gas	
Semiconductor manufacturing	Etching solutions for photolithography, glass etching, plastics etching, fused silica, aluminum; liquid etchant in photo mask rendering		Spent plating or etching baths, PFOA residues from photoresist developers associated with semiconductor liquid waste streams, liquid residues from empty containers, and spills Photoresists and antireflective coatings stripped off from semiconductor devices before shipment are present in waste solvent streams	Photoresists and antireflective coatings stripped off from semiconductor devices before shipment are present in waste gas streams	Bowden et al. (2002), Tremblay (2015)
Building and construction materials manufacturing	Component of cement and primers used to coat cement mortar; used in wire and cable insulation and coatings for wood particleboards	*Cuttings and debris, off-spec materials*[b]	*Wastewater effluent*		Buck et al. (2012), FluoroCouncil (2019), U.S. EPA (2009a)
Mining industry	Surfactant for recovery of metals from ores; used in ore flotation to separate metal salts from soil, electrowinning of metals, and nitrogen flotation to recover uranium	Contaminated rock from applied product[d]	Applied product[d]		ITRC (2020)
Medical uses	Video endoscopes; catheters; saline solutions for in vitro diagnostics; treatment/coatings for textiles such as hospital gowns, curtains, drapes; dialysis machines	*Laboratory/medical solid wastes (tubing, filters, films, etc.)*			FluoroCouncil (2019), Posner (2012)
Cosmetics and personal care product manufacturing	Used in cosmetics, hair conditioning formulations, hair creams, and toothpaste	*Off-spec materials*[b]	*Wastewater effluent*		Danish EPA (2018), FluoroCouncil (2019), Schultes et al. (2018)

2.b Aqueous film-forming foam

AFFFs are a group of PFAS-containing fire extinguishing agents for low-flashpoint hydrocarbon fuel fires (Tuve et al., 1964). AFFFs are intended for use where a significant flammable liquid fire hazard exists (FFFC, 2016).

AFFFs are based on synthetic fluorosurfactants that provide unique low-surface tension and positive spreading coefficient characteristics. When mixed with water and applied, AFFFs form an aqueous film and a foam solution to coat the liquid fuel, seal fuel vapor, and reduce oxygen availability, extinguishing the fire and preventing burnback (FFFC, 2016; SERDP, 2020; Sheinson et al., 2002).

Until application, AFFF is managed as a concentrated product containing less than 2 percent PFAS fluorosurfactants by weight for a typical 3 percent AFFF concentrate (ITRC, 2020) and is stored in either fixed, structural dispensing systems, such as those in hangars and aboard vessels, or in mobile, vehicle-based systems (i.e., aircraft rescue firefighting [ARFF] vehicles) (Field et al., 2017). Reserve AFFF concentrate inventory may be stored in hangars or warehouses. The amount of AFFF concentrate in the finished foam varies by manufacturer and application circumstances, but is usually between 1 and 6 percent, meaning the fluorosurfactants are diluted to less than a fraction of a percent (FFFC, 2016; ITRC, 2020).

A 2004 inventory estimated that there were 4.6 million gallons of legacy PFOS-containing AFFF in the United States (Darwin, 2011). Frequency of use for firefighting, training, or testing; transfers between locations; and other factors determine rates of AFFF inventory depletion. However, AFFF's characteristically long shelf life means little disposal due to expiration should occur (FFFC, 2016), increasing the possibility that legacy PFOS-containing AFFF concentrate remains in service or reserve inventories.

In the United States, AFFF and associated systems are or have been in service at federal facilities, civil airports, and oil refineries. Civilian fire departments also use or have used AFFF. The U.S. Department of Defense (DoD) is working to identify areas of active and former installations where PFOS- or PFOA-containing AFFFs have been used (Darwin, 2011; DoD, 2020). As of the end of FY 2019, the scope of this assessment of potential PFAS use or release has grown to comprise a more comprehensive inventory of DoD and National Guard installations, beyond just those with potentially significant historical AFFF use (DoD, 2020).

The FY 2020 NDAA prohibits any land-based fluorinated AFFF use effective October 1, 2024, or sooner, if the Secretary of Defense deems it practicable. DoD issued policy in January 2016 to discontinue land-based AFFF training and testing activities. Since then, DoD has managed any mission-critical AFFF use in response to an emergency event as a spill response to mitigate impacts to the environment (DoD, 2019, 2020). DoD, among other entities, is also investing in research and development for fluorine-free AFFF alternatives (SERDP, 2020).

Examples of AFFF users and locations in the United States are listed in Table 2-2. Note that the list of sources in the table is non-exhaustive.

AFFF User	Locations	Comments
Oil refineries and processing facilities	• Oil refineries and related facilities (e.g., storage facilities)	• Little information is available about AFFF in this sector, though published industry guidelines recommend AFFF for pipeline emergencies • Survey-based data suggest this sector is the second largest consumer of AFFF after federal agencies • Sources: Darwin (2011); Noll & Hildebrand (2016)
Ships and other vessels	• Ships and other marine vessels, including the U.S. Coast Guard	• Little information is available about AFFF quantities on ships • There has been a shift towards non-fluorinated AFFF for some uses including testing and training, though the Coast Guard has indicated that certain uses (e.g., required inspections) must continue to use fluorinated AFFF • Source: U.S. EPA (2020e)

[a] An exception exists for airports with low departure traffic and serving aircraft less than 90 feet in length. See 14 Code of Federal Regulations (CFR) 139.317 for more information (FAA, 2006).

Fate and transport of PFAS in AFFF after use depends on the release circumstances and chemical-specific properties. Though sometimes classified as incidental releases (Thalheimer et al., 2017), equipment failure, accidental releases, or operator error can result in substantial leaks (Anderson et al., 2016; Resolution Consultants, 2016; Leidos, 2016).

Engineering controls (such as dikes, barriers, or basins) may be installed at facilities with significant flammable liquid hazards to contain foam solution and runoff for later disposal (FFFC, 2016). Where such hazards do not significantly exist, or installed engineering controls are otherwise not practicable, firefighting personnel may as part of their response block sewer drains or deploy portable dikes as containment measures (FFFC, 2016). Runoff can then be pumped out and impacted environmental media removed for disposal (ITRC, 2020). Construction and demolition (C&D) debris originating from facilities where AFFF was historically released may also be a source of PFAS in landfills and groundwater (Solo-Gabriele et al., 2020).

Though subject to site-specific characteristics and conditions, studies demonstrate AFFF use at airports is a source of PFAS in soil and groundwater (Ahrens et al., 2015; Dauchy et al., 2017b; Høisæter et al., 2019). Further, PFAA precursors from original AFFF concentrate products may transform in the environment to more mobile products over time (Houtz et al., 2013), expanding plumes long after AFFF use is discontinued.

2.c Soils and biosolids

As required by Clean Water Act Section 405(d), EPA established requirements for the final use or disposal of sewage sludge when it is (1) applied to land as a fertilizer or soil amendment; (2) placed in a surface disposal site, including sewage sludge-only landfills; or (3) incinerated. The regulation at 40 CFR of PFAS in soils). Both direct and indirect soil impacts might also occur via the atmospheric deposition of PFAS adsorbed to particulates released from stack emissions and atmospheric transformation products of volatile precursors, respectively (Davis et al., 2007; Dreyer et al., 2009; Schenker et al., 2008). Remediation wastes such as soils excavated during the cleanup of sites or during decommissioning of facilities where PFAS was manufactured, used, or applied may contain diverse mixtures of PFAS in elevated concentrations.

2.d Textiles, other than consumer goods, treated with PFAS

Because PFAS can repel oil, water, and stains, the textile industry uses these chemicals in a broad range of textile products other than consumer goods (apparel or household textiles). For example:

- PFAS can be used to treat outdoor equipment such as tents and sails (UNEP, 2011).
- Technical or occupational textiles, such as protective clothing for firefighters, can be treated with PFAS or woven from fluoropolymers (OECD, 2013).
- Medical garments can be treated with fluorinated polymers (OECD, 2013).
- Fluoropolymers can be spun into fibers and used to make sailcloth and fabric for fire suppression needs (Tokarsky & Uy, 2003).
- PTFE can be woven to make architectural fabrics such as roofs, and can also be used to coat fiberglass for tensile structures or long-life structures (Fabric Architect, 2020).
- Textiles made from fiberglass coated with or saturated with PFAS are used for high-temperature or corrosive industrial environments. Kevlar and perfluoroplastic composite textiles are used for similar industrial environments (Robco, 2020).

Examples of typical PFAS-containing waste streams generated from textiles include discarded industrial or commercial textiles (such as apparel, carpets, or personal protective equipment), solids coated with PFAS from cuttings and shearings, and fugitive volatiles from spray applications of textile surface treatments. The destruction and disposal technologies used for these waste streams include landfill disposal and thermal treatment. (For examples of industrial waste streams from the textiles/apparel manufacturing industry, see Table 2-1.)

2.e Spent water treatment materials

Although novel technologies for removing PFAS from drinking water sources and groundwater are being developed, current processes known to be effective are activated carbon, anion exchange resins, and high-pressure membranes (reverse osmosis [RO] and nanofiltration [NF]) (U.S. EPA, 2016a, 2016b). This section discusses the residual streams of these three processes (see Section 3 for discussions on treatment and disposal considerations and costs, and Section 5 for discussions of research needs for more novel treatments).

PFAS can desorb off the resin if the resin comes into contact with a water stream whose counter ions can displace the PFAS. The resulting leachate concentrations will vary tremendously depending on conditions.

2.e.iii High-pressure membranes (reverse osmosis and nanofiltration)

High-pressure membranes are extremely effective for removing many PFAS from water to a high degree (Crone et al., 2019; U.S. EPA, 2020d). Because the process is based on a rejection phenomenon, water treatment with high-pressure membranes creates a waste stream with potentially high concentrations of PFAS that needs to be treated and disposed. These waste streams also have high concentrations of salts, other contaminants, and dissolved organic matter.

Treatment of the concentrate residual stream can be challenging and the cost is likely high, similar to those for landfill leachates, ion exchange spent regenerates, and waters from highly contaminated sites. Many variables could affect the cost of treating these waste streams. At this time, there is no obvious treatment technology choice, especially given that the concentrated retentate stream is typically 20 percent of flow (Baruth, 2005). This represents a sizeable flow, especially for large membrane treatment systems, such as those used by large municipalities (e.g., treating 20 million gallons per day [4 million gallons per day concentrate flow]). This large-volume flow would prevent the use of batch treatment processes, which have higher efficiencies because they can process the water multiple times before discharge.

2.f Landfill leachate containing PFAS

Landfill leachate (discussed in more detail in Section 3.b.iii) is the effluent formed by rainwater percolating through waste in landfills. Leachate generation may continue even after a landfill's closure period, as a result of inherent liquids in the waste or if the cap system fails. There are different types of solid waste landfills characterized by the wastes managed, which also dictate the environmental controls employed. MSW and hazardous waste landfills are typically required to collect the liquid leachate captured within the landfill liner and subsequently manage or treat the leachate. While PFAS concentrations in different landfill leachates have been documented (see Table 3-5 in Section 3.b), there are no monitoring or reporting requirements at the federal level for PFAS in landfill waste or leachate. Thus, existing treatment methods are being used to process leachate irrespective of PFAS concentrations.

Landfill leachate can be treated on-site or off-site. The most prevalent off-site management approach is to export leachate to a WWTP where it is mixed with wastewater and treated. However, as noted in Section 2.a.ii, conventional wastewater treatment technologies are generally unable to treat or control PFAS (Schultz et al., 2006). Other off-site treatment methods include incineration and underground injection control (see Sections 3.a and3.c, respectively). The on-site leachate treatment technologies employed at landfills are explored in Table 3-4 in Section 3.b.i. Some management approaches and treatment technologies represent significant pathways for PFAS release. Unlined impoundments, release to constructed wetlands, and land applications can release PFAS and potentially contaminate groundwater. Additional research is needed to determine the efficacy of landfill leachate treatments for PFAS (see Section 5).

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compounds thermally decompose and the resulting halogen atoms recombine with available hydrogen. For this interim guidance, PFAS destruction is defined as the complete severing of all carbon-fluorine bonds in a PFAS molecule. Severing all carbon-fluorine bonds results in conversion to carbon dioxide, hydrogen fluoride (HF), and other compounds. HF and some of the other products of combustion can be removed in pollution control devices.

This section focuses on the viability of thermal treatment of PFAS, discussing:

- The types of thermal treatment units that manage PFAS-containing waste and their ability to effectively destroy PFAS.
- The potential for environmental releases during these thermal treatment operations.
- PFAS monitoring methods relevant to these thermal treatment operations.
- Uncertainties and unknowns associated with thermally treating PFAS-containing waste, including the ability to effectively measure and monitor thermal treatment performance.
- Operating costs and commercial availability for the thermal treatment operations known to handle PFAS-containing waste.

3.a.i Types of thermal treatment

The following subsections describe the types of thermal treatment devices potentially capable of treating PFAS-containing waste streams identified in Section 2.a, with a focus on design and operation parameters that are important for destroying PFAS. These include hazardous waste combustors (HWCs), non-hazardous waste combustors, carbon reactivation units, and thermal oxidizers. Waste incinerators are typically classified by the type of waste that they combust.

3.a.i.1 Hazardous waste combustors

HWCs are hazardous waste incinerators (HWIs), cement kilns, LWAKs, boilers, and hydrochloric acid production furnaces that burn hazardous waste.[1,2] Two types of HWCs that have treated PFAS waste in the United States are commercial[3] incinerators and LWAKs. Initial studies suggest that cement kilns may be effective at treating PFAS waste (see Section 3.a.ii).

All HWIs, LWAKs, and cement kilns are subject to Resource Conservation and Recovery Act (RCRA) and Clean Air Act (CAA) permitting requirements that provide additional regulatory oversight and include operating requirements and emission limitations to safely and effectively treat regulated hazardous contaminants that may not be required for non-permitted facilities. These types of HWCs are subject to CAA Title V permitting requirements, and to maximum achievable control technology standards pursuant to Section 112 of the CAA that include emission limitations for metals, dioxin/furans,

[1] Hazardous waste is regulated pursuant to Resource Conservation and Recovery Act authority. See 42 U.S.C. 6903. The regulatory definition is found in 40 CFR 261.3. PFAS is currently not a listed or characteristic hazardous waste, but a PFAS-containing waste may meet the regulatory definition of hazardous waste if PFAS is mixed with a listed hazardous waste or if a PFAS-containing mixture exhibits a hazardous characteristic (e.g., corrosivity or another characteristic stemming from the material that is mixed with PFAS).
[2] Hazardous-waste-burning cement kilns and LWAKs are a small subset of the total cement kiln and LWAK universe—i.e., most kilns do not burn hazardous waste.
[3] Commercial thermal treatment units primarily treat waste received from other facilities.

treat hazardous waste. Cement kilns use either electrostatic precipitators or baghouses to collect particulate and metal emissions, referred to as cement kiln dust (CKD). Portions of the CKD can be fed back into the kiln as a raw material feed or be used in other industries as neutralizers or additives, but usually the excess CKD is land-disposed. Add-on acid gas air pollution control devices, such as wet or dry scrubbers, are typically not used: the high alkaline content of the raw material feeds already prevents or minimizes the formation and release of acid gases by providing for "in situ" absorption of chlorine and other halogens and sulfur.

3.a.i.1.3 Hazardous-waste-burning lightweight aggregate kilns

There is one LWAK facility operating in the United States that burns hazardous waste. LWAKs thermally process raw material (clay, shale, and slate) in slightly inclined, rotating furnaces to produce a coarse aggregate used in lightweight concrete products. In hazardous-waste-burning LWAKs, liquid wastes are either blended directly with conventional fuels burned in the hot end of the kiln or pumped separately into the hot end flame. High combustion gas flame temperatures (above 1,650°C [3,000°F]) and kiln gas residence times (over 2 seconds) are used to destroy hazardous organics. Kiln exhaust gases leave the cold upper end of the kiln at a temperature from 205°C to 540°C (400°F to 1,000°F). LWAKs use FFs to control dust contained in the exhaust gas. The collected dust can be recycled back into the kiln (at the hot or cold end) or mixed into the lightweight aggregate product. Some LWAKs also use wet or dry scrubbing for acid gas emissions control.

3.a.i.2 Carbon reactivation units

Carbon reactivation units or "furnaces" use high temperatures to thermally desorb contaminants from GAC, which allows for the carbon to be used again. Over a dozen large-scale companies and utilities in the United States reactivate sizeable quantities of GAC. In all, these entities operate about 17 commercial furnaces (Roskill Information Services Ltd., 2017). Four of these commercial furnaces operate under RCRA permits and applicable air permits. RCRA permits provide additional regulatory oversight and include operating requirements and emission limitations to safely and effectively treat the hazardous contaminants, which may not be required for non-RCRA-permitted carbon reactivation furnaces. Due to these additional safeguards, RCRA-permitted furnaces may operate under conditions more conducive to destroying PFAS and controlling related PICs. This discussion focusses on RCRA-permitted furnaces because EPA has more design and operational information on these devices as a result of the RCRA permitting process. Reactivation[5] of spent carbon is generally carried out in multiple-hearth (or "multi-hearth") or rotary kiln furnaces, although fluidized bed and infrared furnaces are also options. While the furnace designs vary, they all use high temperatures and residence times designed to eliminate the adsorbed contaminants and return the carbon to a virgin state for reuse.

During reactivation, spent GAC is typically exposed to drying, desorption, pyrolysis, and oxidation as it moves through the furnace.

- The drying stage eliminates moisture via evaporation and occurs when hot combustion gases ranging from 100°C to 110°C (212°F to 230°F) contact the carbon.

[5] "Reactivation" refers to a regeneration process that requires high temperatures. Regeneration also includes low-temperature processes, including those using brines, solvents, oxidants, biological treatment, etc. These processes may not be as effective as reactivation for GAC (AWWA, 2018); therefore, they are not considered for this discussion.

The basic multi-hearth furnace is a vertical cylinder divided into zones. The sludge is dried at temperatures from 425°C to 760°C (800–1,400°F). Sludge combustion occurs as the temperature is increased to about 925°C (1,700°F) in successive zones. The gas residence times are typically 4 or 5 seconds. Emission controls on multiple hearths can include wet scrubbers, wet electrostatic precipitators, afterburners, and regenerative thermal oxidizers.

An FBC consists of a vertically oriented outer steel shell with nozzles designed to deliver fluidizing air at the base of the furnace within a refractory-lined grid. Air is injected into the furnace to fluidize the sludge and the sand. The combustion of the sludge occurs at temperatures between 750°C and 925°C (1,400–1,700°F). The gas residence times are typically 2 to 5 seconds. Emission controls on FBCs can include venturi scrubbers, multicyclones, FFs, activated carbon injection, and carbon bed absorbers.

3.a.i.3.2 Municipal waste combustors

There are 193 MWC units operating in the United States (Michaels & Krishnan, 2018). Three main classes of technologies are used to combust MSW: mass burn, refuse-derived fuel (RDF), and modular combustors. Mass burn and RDF combustors are the predominant designs.

With mass burn units, the MSW is combusted without any preprocessing other than removal of items too large to go through the feed system or hazardous materials, such as pressurized containers. In a typical mass burn combustor, refuse is placed on a grate that moves the waste through the combustor. The grates typically have three sections. On the initial grate section, referred to as the drying grate, the moisture content of the waste is reduced before ignition. The second grate section, referred to as the burning grate, is where most of the active burning takes place. The third grate section, referred to as the burnout or finishing grate, is where remaining combustibles in the waste are burned. Typical combustion temperatures for mass burn units can range from 800°C to 1,100°C (1,500°F to 2,012°F) (Reddy, 2016).

RDF combustors burn waste that has been processed to varying degrees to raise its heating value and provide a more uniform fuel. Most boilers designed to burn RDF use spreader stokers and typically operate at around 680°C (1,250°F). RDF-fired FBCs typically operate at bed temperatures around 815°C (1,500°F).

Residence times of gases within MSW combustors vary from unit to unit, depending on design and operational factors such as furnace volume, excess combustion air percentage, whether flue gas recirculation is employed, and combustor operating load parameters (Scavuzzo et al., 1990; Themelis & Reshadi, 2009). Overall combustion air residence times have been calculated in the 7–10 second range for a small sampling of MWC design loads (Themelis & Reshadi, 2009), with an approximate residence time at temperature above 980°C (1,800°F) of about 2 seconds at full combustor load (Scavuzzo et al., 1990).

Emission controls on MWCs can include spray dryer or dry sorbent injection, electrostatic precipitator or FF, selective or non-selective catalytic reductions, and activated carbon injection.

3.a.i.4 Thermal oxidizers

Thermal oxidizers are used to destroy volatile organic compounds (VOCs) and organic hazardous air pollutants (HAPs) from liquid and gaseous process streams at a manufacturing or production facility.

The stability of perfluorinated radicals and their propensity to recombine present the potential for the creation of PFAS PICs distinctive from the original fluorinated compounds. These reactions are promoted by partial combustion caused by insufficient temperatures, time, and turbulence. Many PFAS are composed of very stable fluorinated carbon chains and relatively weak non-fluorinated functional groups. Often, the functional group is easily removed, allowing the fluorinated chain to react with other radicals and create a variety of compounds, which complicates the determination of DREs and the identification of PICs (Wang et al., 2015). In addition, the presence of catalytic surfaces, often metals, may promote further reaction and PIC formation in post-combustion regions. PFAS PICs may be smaller in molecular weight than the original species or larger in molecular weight when formed via the recombination of two large radicals.

Incinerator designs vary, resulting in differing operational and waste feed approaches (see Section 3.a.i). HWIs typically operate at very high average temperatures and employ auxiliary primary and secondary flames. MWCs typically operate at lower temperatures, and often do not employ auxiliary primary or secondary flames. SSIs vary in design, often operating as dryers with very low temperatures. Even within the same incinerator, wastes can be introduced at different locations and experience different time, temperature, and mixing histories. PFAS introduced into a hazardous waste rotary kiln incinerator's main burner, along with auxiliary fuel, may experience very different conditions than the same waste introduced to the kiln as contained charges with solid wastes. These factors are expected to affect PFAS destruction and PIC formation. Limited studies have investigated the influence of various factors on PFAS destruction and PIC formation (see Section 3.a.viii).

Carbon reactivation systems can degrade PFAS even at the lower temperatures (150°C–700°C) (302°F–1,292°F) seen in bench-scale research studies. Experimental data suggest that thermal destruction of PFAS will occur in two stages: during reactivation of the GAC, then when the offgas is introduced into a high-temperature zone as high as 1,000 °C (Forrester, 2018; Watanabe et al., 2016, 2018; Xiao et al., 2020). Carbon reactivation systems, with the concomitant use of offgas incineration (i.e., afterburners) and gas scrubbing units, can destroy PFAS without significant environmental releases, or without PFAS remaining on the reactivated carbon. However, as discussed elsewhere in this interim guidance, more work is needed for confirmation particularly with regard to reactor conditions, differing carbons, and PICs.

Thermal oxidizers have historically not been designed with destruction of PFAS as the primary focus, so most currently installed thermal and catalytic oxidizers may not be optimized for PFAS destruction. Thermal oxidizers are being employed to destroy PFAS-containing liquid and gaseous streams, but the data are insufficient to allow conclusions on the overall efficiency of thermal oxidizers in PFAS destruction. EPA is currently unaware of any catalytic oxidizers being used specifically for the destruction of PFAS, particularly in light of their site-specific design and optimization. Though the efficacy of thermal and catalytic oxidizers in destruction of PFAS is currently unknown, a properly optimized thermal oxidizer can readily achieve a DRE of 99.99 percent of VOCs.

In addition to incinerators and thermal oxidizers, cement kilns are also used for the destruction of hazardous wastes. Cement kilns operate at very high temperatures (exceeding 1,800°C [3,270°F]), exhibit very large gas and solid residence times, and have the added advantage of providing a caustic environment for halogen reaction and acid neutralization. A cement kiln in Australia has received an

A thermal oxidizer with a potential for HF emissions typically uses a wet scrubber integrated with the oxidizer to control HF emissions. Hot flue gas exiting from the oxidizer is cooled rapidly in a quenching unit, and HF (which has high water solubility) is removed by the quenching water. The cooled flue gas then flows up through a multistep wet scrubbing tower for further HF removal by scrubbing water. Flue gas is scrubbed by a sodium hydroxide solution to neutralize the residual HF as the final scrubbing step. After exiting the tower, flue gas is emitted through a stack. All effluents, including those from the quenching unit and scrubber tower, are mixed with a $Ca(OH)_2$ solution in a reactor where calcium is combined with fluorine and precipitation of water-insoluble calcium fluoride (CaF_2) occurs. After dewatering, dry CaF_2 is sent to a landfill for disposal (see Section 3.b) or used to produce fluorine gas for new PFAS production, and wastewater is discharged from the plant after it is treated by activated carbon to remove trace fluorinated contaminants. Rapid cooling of hot flue gas is known to be effective in reducing catalytic reformation of chlorinated PICs such as dioxins during cooling of incineration flue gas.

A thermal oxidizer equipped with a quenching unit to treat PFAS-containing wastes may also limit catalytic reformation of fluorinated PICs if they are actually formed in the oxidizer. Those PICs may be subsequently transferred into the liquid phase in the wet scrubber, which could then be partitioning between solid CaF_2 and water in the precipitator, with most of the PICs retained in water then removed by activated carbon adsorption. EPA is not aware of peer-reviewed studies for measuring levels of fluorinated contaminants remaining in both the treated scrubber water stream and the dry CaF_2 stream. Such measurements could be useful for evaluating the potential environmental impacts of byproducts and residuals generated from thermal oxidation of PFAS-containing wastes.

Spray dryer absorber (SDA) technology has been applied to control emissions of halogen acids including HCl and HF from both MWCs and HWIs. This semi-dry scrubbing process is designed to inject an alkaline slurry, typically lime, to control acid and fly ash. Water in the fine slurry droplets is vaporized by heat carried by the flue gas, and drying lime in droplets neutralizes the halogen acids simultaneously in this two-phase reaction process. The cooled flue gas carries the dried acid neutralization product downstream to a particle collection device, typically an FF. PAC may also be injected into flue gas upstream of the FF to control emissions of mercury and chlorinated dioxins/furans from both MWCs and HWIs. Fly ash, dried acid neutralization product, and PAC are captured by the FF. The SDA/FF with PAC injection flue gas cleaning train produces no scrubber water. The addition of lime (a calcium compound) into the flue gas is known to be effective for forming CaF_2 through hydro-defluorination of PFOS at a moderate temperature of about 350°C (660°F) (Wang et al., 2015); this suggests the SDA may provide a potential co-benefit of controlling fluorinated PICs. The injection of PAC upstream of the FF subsequently may create another potential co-benefit for capturing fluorinated PICs. Studies evaluating PFAS mitigation via SDA/FF with PAC injection (e.g., see research activities in Section 5) will help develop data on this potentially viable technology option.

3.a.iv Potential for releases for thermal treatment technologies

Thermal treatment devices used to treat PFAS-containing waste (see Section 3.a.i for descriptions of these devices) are located in both rural and populated areas throughout the United States. Two possible sources of potential PFAS emissions from thermal treatment are the stack emissions and subsequent management of scrubber water and bottom ash/fly ash. As previously discussed, emissions from including poor retention or chemical conversion of the PFAS during sampling and poor recovery during sample preparation prior to chemical analysis (Arp & Goss, 2008).

Ambient sampling for semivolatile PFAS roughly follows the high-volume air sampling protocol described in EPA compendium method TO-13a (U.S. EPA, 1999) or National Atmospheric Deposition Program (NADP) approaches for wet and dry deposition sampling (NADP, 2020). High-volume air samples collect both water-soluble PFAS acids and salts and water-insoluble telomer alcohols. NADP sampling has focused on condensable and particulate-bound targeted PFAS captured in polypropylene buckets to evaluate deposition due to rain.

Current method development and evaluation for stationary source air emissions is based on EPA SW-846 Method 0010—modified to include collection of both targeted and nontargeted PFAS in a single sampling system. Sampling includes heated or stack temperature probe extraction of emission gases followed by collection on filters, XAD sorbent media, and aqueous impingers. EPA plans to release Other Test Method 45 (OTM-45), *Measurement of Selected Poly- and Perfluorinated Alkyl Substances from Stationary Sources,* based on this method development.

These field procedures collect samples that are subsequently transported to a laboratory for extraction and analysis. Analysis procedures include established water methods for targeted compounds and/or non-targeted analysis (NTA) for unknown PFAS. High-resolution mass spectrometry can be used for both targeted analysis and NTA. Qualitative identification of PFAS by NTA reveals PICs/degradants formed during the thermal treatment of PFAS-contaminated media (Aleksandrov et al., 2019; McCord & Strynar, 2019; Newton et al., 2020). NTA, used to identify unknown PFAS, currently relies on high-resolution mass spectrometry, which generates qualitative information about the molecular formula of unknown PFAS. NTA is a critical component of thermal treatment emissions characterizations because it provides the only definitive approach for identifying unknown PFAS or PICs.

3.a.v.2 Gaseous volatile PFAS sampling and analysis

Volatile PFAS targets and thermal treatment byproducts from ducted emissions or in ambient air have been sampled using a variety of whole gas sample collection approaches, such as Tedlar® bags and SUMMA canisters, as well as sorbent traps and cryogenic solvents. Issues such as sample reactivity, breakthrough volumes, and quantitative transfer to the analysis instrument complicate these approaches. Direct instrumental methods to measure volatile PFAS can suffer from lack of sensitivity compared with extractive methods that allow concentration prior to analysis. To develop more sensitive methods to measure volatile fluorocarbon compounds, EPA has investigated the use of SUMMA canisters for targeted and nontargeted volatile PFAS as well as PICs at multiple-source emissions tests, including a thermal treatment facility for AFFF-contaminated soil (U.S. EPA, 2020b). SUMMA canisters have been used to sample source emissions and perform targeted measurements for PFAS including TFE, HFP, E1, E2, 4:2 FTOH, and 6:2 FTOH. NTA has also been performed on the same samples. EPA and private sector investigators have used specialized commercial sorbent traps and Tedlar bags in laboratory-scale thermal destruction and ambient volatile PFAS measurement of targeted and non-targeted PFAS (Wang et al., 2013, 2015; Yamada et al., 2005).

can be adequately characterized. EPA recognizes that PICs are inevitable (even for nonfluorinated compounds); however, based on the unique characteristics of fluorine combustion chemistry, it needs to be determined whether thermal treatment devices are adequately controlling fluorinated PICs. Research efforts will address several issues. For example, are the operating temperatures at these various thermal treatment devices adequate to completely destroy PFAS? Can surrogate DRE or TOF indicators be used as reliable indicators to ensure potential PICs are being controlled? Can catalysts be used to enhance PFAS destruction efficiency? EPA and others continue to research these complex and important issues. See Section 5 for a summary of planned research activities specific to thermal treatment of PFAS.

3.a.vii Treatment costs and commercial availability

Section 3.a.i describes the commercial availability of thermal treatment devices. The United States has about 22 commercial hazardous waste combustion facilities[8] in operation; over a dozen large-scale, commercial carbon reactivation companies with about 17 furnaces; 193 MSW incineration units; and 170 SSIs.

Costs associated with treating contaminated media using thermal treatment include operation and maintenance costs of the treatment technology, capital costs, waste transport costs (if applicable), and costs associated with regulatory compliance. Breakdowns of these costs for the thermal treatment units described in this guidance were not readily available. However, operating costs for commercial treatment units are reflected in the amounts these facilities charge to thermally treat the waste streams they receive. This cost can be characterized by a cost charged per ton to treat specific types of waste. Waste transport costs are also important to consider, because some commercial treatment options could involve transporting large volumes of waste over large distances.

Treatment of contaminated media in hazardous waste combustion devices, such as incinerators, involves costs associated with the high energy consumption needed to maintain elevated temperatures, as well as the regulatory and permitting costs associated with treating, handling, and storing these waste streams. Table 3-1 summarizes estimated costs to incinerate different types of hazardous waste, and Table 3-2 summarizes the costs to incinerate different types of non-hazardous waste. These estimates in Table 3-1 were used to assess costs and impacts of CAA regulations issued in 2005 (U.S. EPA, 2005a), acknowledging these costs likely have changed over the years. Halogenated waste streams are generally more expensive to treat, and costs are also influenced by whether the waste is a liquid, sludge, or gas.

[8] This includes commercial incinerators, cement kilns, and LWAKs that are permitted to burn hazardous waste.

waste treatment permits. These incinerators may have lower operating costs due to fewer permitting requirements. Several factors affect costs for thermal treatment of contaminated soils, including soil type (e.g., clay content, particle size, moisture content, pH), type and concentration of contaminants that affect the necessary operating temperature, type of emission treatment needed, and type and frequency of maintenance needs such as changeout of filters or carbon (U.S. EPA, 2001). As a result of all these factors, the cost associated with incineration of remediation wastes vary and are site-specific. Ex situ incineration costs ranging from $168 to $3,256 per metric ton (normalized to 2019 dollars from 2016 dollars using the BEA GDP deflator [BEA, 2020]) have been reported (Ding et al., 2019; Vidonish et al., 2016).

With respect to carbon reactivation units, financial considerations favor the reactivation of spent GAC as opposed to disposal of the spent media and replacement with virgin media. The analysis is complex and a number of issues need to be considered at the site level, such as those that affect costs (cost of energy, shipping, labor, construction, operation, sampling, etc.) and those that affect other matters (practicality, public versus private ownership, contract availability, regional reactivation availability, offgas permitting, public opinion, etc.). Table 3-3 contains example costs per weight of media for various disposal options. These data are derived from unit costs developed for EPA's work breakdown structure drinking water treatment cost models (Khera et al., 2013; U.S. EPA, 2020a). They are intended to reflect typical conditions and are based on estimates from multiple vendors. However, they do not account for site- or project-specific factors that could affect the cost of media replacement and disposal. Therefore, these unit costs are presented as examples only, to illustrate the tradeoffs between disposal options.

As seen in Table 3-3, thermal reactivation of GAC costs less, at $1.41 per pound, than disposing of spent GAC and replacing it with virgin carbon. This is due to the higher cost of virgin media ($1.88/pound versus $1.21/pound for reactivated) (normalized to 2019 dollars from 2018 dollars using the BEA GDP deflator [BEA, 2020]). Although the reactivation procedure results in the loss of a certain percentage of carbon, incorporating this factor does not change the general conclusion that reactivation is a lower-cost option. For example, the reactivation costs in the table incorporate a conservative estimate of 30 percent loss and remain lower than the replacement and disposal costs. Therefore, it is expected that entities treating PFAS-contaminated waters with GAC, as well as GAC manufacturers, will desire to reactivate their media.

Table 3-3. Example Disposal/Reactivation Costs for Spent GAC for Drinking Water Treatment (Derived from U.S. EPA, 2020a)

Method	Cost of Disposal ($/Pound of Media)	Cost of Disposal Plus Replacement Media ($/Pound of Media)[a]
Reactivated GAC—off-site	$0	$1.41
Disposal via landfill	$0.04	$1.92
Disposal via incineration	$0.36	$2.24

[a] Cost per pound is in 2018 dollars. Costs were normalized to 2019 dollars using the BEA GDP deflator for waste management and remediation services using a base year of 2002 (BEA, 2020). For GAC, on-site reactivation is possible. However, the utility or site would have to have ample workforce, managerial, and financial (both capital and operating) resources to justify this choice. It is likely to be cost-effective only for very large facilities and would require consideration of other factors including availability of land and public opinion. Due to the complex analysis needed, a full comparison of off-site versus on-site is beyond the scope of this document.

carbon reactivation furnaces of various designs to ensure optimal destruction of PFAS, and an understanding of how thermal treatment influences the physical and chemical properties of GAC (in ways that can affect GAC's adsorption behavior and sorption capacity for PFAS).

Research and testing of PFAS destruction performance within MWCs is extremely limited, primarily comprising laboratory and pilot-scale studies (Aleksandrov et al., 2019; Taylor et al., 2014). For example, the Aleksandrov et al. study uses a pilot-scale rotary MWC with afterburner chamber combusting PTFE granules added to wood pellets (also firing natural gas) to assess whether the PTFE is destroyed or reformed as PFAS. This study looked at a half-load scenario of 870°C (1,600°F) with a 4-second residence time and a full-load scenario of 1,020°C (1,870°F) for a 2.7-second residence time. There were 31 PFAS compounds analyzed for within the flue gas samples collected, assumed to represent a broad range of PFAS. While the laboratory and pilot-scale studies conclude that MSW incineration of PTFE is not a significant source of PFAS, the laboratory thermal reactor and the pilot incinerator used in these studies may not be representative of the design of MWC units operating in the United States presently. For example, the pilot-scale unit in the Aleksandrov et al. study is a rotary combustion chamber followed by an upflow afterburner. No MWC units operating in the United States have a similar configuration. In addition, while several PFAS species were analyzed for in these studies, it is important to note that there are far more PIC species possible, and no studies have thoroughly evaluated the types and quantities of PICs.

As noted earlier in this section, research (Wang et al., 2013) has investigated PFAS interactions with CaO and $Ca(OH)_2$ at moderate temperatures (200°C–900°C [390°F–1,650°F]) both with and without sewage sludge. These experiments were conducted in a laboratory (i.e., combustion in a crucible within a muffle furnace) and found that these calcium species exhibit a pseudo-catalytic effect promoting PFAS destruction and fluorine capture at relatively low temperatures. The study did not investigate the evolution of PICs during the thermal treatment process. While this study shows promising results for the use of catalysts resulting in PFAS destruction and fluorine capture at low temperatures, along with the potential for full-scale application (since lime is occasionally added to sewage sludge to control odor at SSIs), it is important to note that, as with the MWC studies described above, there are caveats for applying these results to real-world design and operation of SSI and the lack of robust information on PIC formation.

More research is needed to address these issues and develop reliable measurement techniques. Section 5 summarizes EPA's continuing PFAS research, as well as a general proposal to collaborate with stakeholders to address these uncertainties promptly.

3.a.ix References for Section 3.a

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3.b.i Types of landfills

Landfills are typically classified by ownership status and by the type of solid waste they are permitted to receive, which determines the types of environmental controls they must employ. Depending on the type of waste disposed of, a landfill could be subject to regulation and permitting under RCRA, the CAA, and/or the Toxic Substances Control Act (TSCA). RCRA regulates two types of landfills: Subtitle C facilities receive hazardous waste, while Subtitle D landfills are primarily intended for the management of non-hazardous waste and can include MSW landfills, industrial non-hazardous waste landfills, C&D waste landfills, and coal combustion residual landfills. The requirements determine how the landfill must be constructed, operated, maintained, monitored, and closed when it reaches its final capacity.

Although categories and environmental controls vary from state to state, the following categories of landfills exist in most states and tend to have similar environmental controls within each category:

- Hazardous waste.
- MSW.
- Ash monofill.
- Industrial.
- C&D debris.

Table 3-4 compares some of the environmental controls required by landfill types as defined under RCRA Subtitles C and D. The landfill categories differ in how they are constructed, operated, monitored, and closed, reflecting the different types of waste they are allowed to receive. Subtitle C hazardous waste landfills are permitted to receive hazardous wastes, which has been evaluated and determined to pose potential risk to humans and the environment and therefore has the most stringent environmental controls in place; Subtitle D landfills that receive non-hazardous and non-putrescible waste tend to have environmental controls commensurate with the waste they receive. These controls can vary from state to state; for example, certain small MSW landfills in arid or remote locations are exempt from both design and groundwater monitoring requirements.

Table 3-4. Required Environmental Controls by Landfill Type

Landfill Type	Federally Regulated Under	Bottom Liner and Leachate Collection System	Gas Collection System	Final Cover
Hazardous waste	RCRA Subtitle C	Yes (double liner or better)	No	Flexible membrane liner (FML) cap
MSW	RCRA Subtitle D 40 CFR part 258 CAA 40 CFR parts 60 and 63	Yes (composite liner or better)	Yes	FML cap
Ash monofills	RCRA Subtitle D 40 CFR part 257	Yes (composite liner or better)	No	Clay cap
Industrial	RCRA Subtitle D 40 CFR part 257	Varies by state, from no liner requirement to composite liner	No	Varies by state, from no requirements to FML cap
C&D debris	RCRA Subtitle D 40 CFR part 257	Varies by state, from no liner requirement to composite liner	No	Varies by state, from no requirements to FML cap

Landfill type	Country	Mean PFAS Range (ng/L)	References
Ash monofill	USA	BDL–742	Solo-Gabriele et al., 2020
C&D debris landfill	USA	BDL–4,630	Solo-Gabriele et al., 2020

BDL = below detection limit; ng/L = nanograms per liter

3.b.i.4 Industrial landfills

Industrial landfills receive solid wastes from industrial operations (non-municipal). Industrial landfills are often designed to manage specific waste streams (e.g., furnace slag, fly ash, and plastics). The designs of industrial landfills vary widely, based on the characteristics of the waste they receive. Requirements for environmental controls at these landfills also vary state to state. Depending on the waste types and size of the landfill, some states do not require a liner. If a liner is required, a membrane cap is often also required. Due to the variability in control technologies, industrial landfills may not be an effective disposal option for managing uncontrolled releases of PFAS. Some waste types received at industrial landfills, including plastics and materials with polishes or coatings, are associated with high concentrations of PFAS (OECD, 2013).

3.b.i.5 Construction and demolition landfills

C&D landfills receive waste from construction, renovation, and demolition projects, and other material that may be considered inert. The exact list of materials for these types of landfills varies by state, but the wastes are generated in high volumes. The requirements for environmental controls at these landfills vary widely from state to state, ranging from no liner to a required composite liner. If a liner is required, a membrane cap could also be required. GCCSs are not required in C&D landfills due to low levels of putrescible waste received compared to MSW landfills. A GCCS may sometimes be necessary to remediate a specific issue, typically related to gases generated from the decay of drywall. Due to variability in control technologies and the potential lack of monitoring, C&D landfills are unlikely to manage the uncontrolled release of mobile PFAS; however, it is likely that C&D landfills receive some PFAS-containing wastes (e.g., building materials and carpeting with fluoropolymer coatings) (OECD, 2013; Solo-Gabriele et al., 2020).

3.b.ii Ability of engineered landfill components to contain PFAS

PFAS are emitted from landfills via two possible routes: landfill leachate and LFG. Landfill leachate is the liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste. LFG is the result of the natural decomposition of organic material in landfills. LFG is composed of roughly 50 percent methane, 50 percent carbon dioxide, and a small amount of nonmethane organic compounds (NMOCs).

Existing efforts to manage contaminants in landfills focus on controlling leachate and gaseous emissions. As shown in Figure 3-1, landfills constructed with environmental controls (bottom liner, leachate collection system, gas collection system, and final cover system, among other controls) manage the release of contaminants into the environment.

The uses of the engineered landfill controls shown in Figure 3-1 vary by landfill type due to the variation in types of waste accepted, operating practices, site conditions, and federal and state regulations.

type of clay used in liners, and found PFAS did not significantly compromise the performance of bentonite liners (Li, 2011). While the performance of clay liners may not be affected drastically, there is currently no research on the long-term stability of FML in the presence of PFAS.

3.b.ii.2 Landfill gas collection system

Landfills use GCCSs to manage gas from decomposing organic waste. A GCCS consists of a network of perforated pipes sunken into the waste. These "gas wells" are connected to a central blower that pulls gas from the wells. Despite collection technologies, gas can still migrate both through the surface of the landfill and underground through the bottom of the landfill. The gas produced by MSW landfills contains a high level of methane that is usually burned off at the site via flares or for energy recovery.

As noted in Section 3.b.iv.1, research has found that soluble PFAS with relatively high vapor pressures can be emitted into the atmosphere via the gas generated at landfills (Ahrens et al., 2011; Hamid et al., 2018; Wang et al., 2020; Weinberg et al., 2011). Direct LFG sample evaluation for PFAS concentrations is currently being researched by EPA. The effects of flaring on gaseous PFAS have not been demonstrated. See Section 5 for potential research needs.

3.b.ii.3 Final cover system

After a regulated landfill has reached its expected capacity, it must be capped with a cover system. This system consists of some combination of soil and membrane liners and is primarily intended to reduce infiltration of rainwater into the landfill to minimize leachate generation. It also helps increase the efficiency of the GCCS and reduce uncontrolled gas emissions. Synthetic liners and caps are more effective at controlling migration of PFAS than earthen covers. Earthen covers are more subject to wet/dry cycles and cracking and are more likely to result in uncontrolled LFG emissions, which could contain PFAS (Ahrens et al., 2011; Tian et al., 2018; Wang et al., 2020; Weinberg et al., 2011).

3.b.ii.4 Other environmental controls and monitoring systems

Landfills control solid waste and corresponding pollutants through containment. Because of their many and varied uses, PFAS enter solid waste landfills as part of the general municipal waste stream, with industrial waste, or in other PFAS-containing solid wastes (e.g., solidification waste).

In addition to the major infrastructure discussed above, solid waste landfills implement other practices and systems. In active landfill cells, daily application of a cover material like soil or other inert waste covers exposed solid waste. Daily cover reduces leachate generation, gas emissions, and direct exposure to humans and wildlife. Access control for a landfill site, such as a fence, is typically also required, to reduce the chance of direct human and ecological exposure to waste. Extensive monitoring networks are generally required to measure the landfills impact on surface water, groundwater, and air. RCRA Subtitle C requires all hazardous waste landfills to install groundwater monitoring wells. See Section 3.b.iii for landfill controls.

3.b.iii Leachate discharge controls

3.b.iii.1 Leachate characteristics

Landfill leachate is the liquid effluent primarily generated through the percolation or infiltration of rainwater through waste. Leachates often contain high concentrations of biodegradable and non-

(e.g., ammonia). The use and effectiveness of leachate management strategies in removing or destroying PFAS during treatment varies (and, as noted in Section 3.b.vii, methods to quantify effectiveness are still under development). Leachate treatment technologies can be largely categorized into physiochemical processes, physical processes, biological processes, natural processes, and other management methods, as grouped in Table 3-6. Considering that leachate contains a variety of chemicals, a combination of physiochemical treatment processes can be used to narrowly target specific parameters for pre-treatment, or as part of a multi-step treatment strategy.

Table 3-6. Existing Landfill Leachate Treatment Technologies for PFAS Removal or Destruction

Treatment Technology	Treatment Mechanism	Pros for PFAS Treatment	Cons for PFAS Treatment	References
Physiochemical Processes				
GAC	Adsorption	• Familiar technology • Effective for long-chain PFAS	• Secondary treatment required • Short-chain PFAS breakthrough • Potential secondary release • Cost	McCleaf et al. (2017), Pan et al. (2016), Ross et al. (2018)
PAC with coagulation	Adsorption	• Effective for long-chain PFAS	• Secondary treatment required • Costly for high-volume leachate • Potential secondary release	Bao (2014), Pan et al. (2016)
Polymeric adsorption	Adsorption	• Tailor for specific compounds	• Secondary treatment required • Potential secondary release	Liu (2017)
Ion exchange resin	Ion exchange adsorption	• Specified for certain compounds • More effective than GAC for long-chain compounds	• Secondary treatment required • Less effective for short-chain PFAS • Potential secondary release	Dickenson & Higgins (2016), McCleaf et al. (2017), Ross et al. (2018)
Zeolite	Ion exchange adsorption	• Inexpensive	• Secondary treatment required • Low surface area compared to GAC • Unknown reaction with short-chain PFAS	Chiang et al. (2017), Ochoa-Herrera & Sierra-Alvarez (2008)

Treatment Technology	Treatment Mechanism	Pros for PFAS Treatment	Cons for PFAS Treatment	References
Deep well injection	Containment	• Potential solution for PFAS concentrate	• Dependent on site geology • Regulatory approval	ITRC (2018)
Incineration	Thermal destruction	• PFAS destruction	• Potential secondary emissions • Regulatory approval	ITRC (2017), Yamada et al. (2005)
Solidification	Containment	• Co-location with landfill • Reduces PFAS mobility	• Consumes air space in landfill • Unrealistic for large leachate volume	*None identified*
Biological Processes				
Activated sludge process sequencing; batch reactor; anaerobic; digestor; membrane bioreactor	Biological processes	*Limited data available*	• Limited by high concentrations of non-biodegradable organic matter	Ross et al. (2018), Saez et al. (2008), U.S. EPA (2020a)
Natural Processes				
Constructed wetlands; aerated ponds; phyto-remediation; land application	Environmental release	*N/A*	• Direct release of PFAS	U.S. EPA (2020a)

3.b.iii.3 Leachate management and treatment technologies

Membrane treatments separate compounds from the leachate using mechanical filtration and pressure. Leachate passes through selective membranes (such as RO, NF, UF, and MF membranes) that divide it into two parts: permeate (which has passed through the membrane) and concentrate (which has not). The permeate and concentrate can then be treated as independent streams. The primary difference between these membranes is the pore size, which in turn affects the operating pressure and removal efficiency for different types of contaminants. RO is the most commonly used type of membrane for leachate treatment, while NF, UF, and MF are generally used in combination with other treatment technologies including RO. RO and NF are known to be effective in concentrating some PFAS, but UF and MF have pores that are too large to limit the migration of most water-bound PFAS across the filtration membrane. Membrane fouling and a large amount of concentrate generation are two of the major drawbacks observed in implementing the membrane treatment system for landfill leachate and may be further complicated by high concentrations of PFAS (Dickenson & Higgins, 2016; ITRC, 2018; Ross et al., 2018).

PFAS releases to air. Commercial evaporators operated through the heat generated by the LFG combustion or other fuel sources are sometimes used at landfills. Exhaust gases emitted from the evaporators may be exposed to high temperatures, but those temperatures may not be high enough or last long enough to destroy PFAS (see Section 3.a).

3.b.iv Landfill gas emission controls

3.b.iv.1 Landfill gas characteristics

Under the anaerobic conditions that dominate landfill environments, organic waste (e.g., food waste, paper, cardboard) decomposes and generates LFG. LFG in MSW landfills consists mostly of methane and carbon dioxide. In most landfills where gas is collected, it is burned for energy or to destroy the methane and other organic chemicals it contains. Even at sites that actively collect LFG, a fraction of the LFG is emitted directly to the environment through the landfill surface and other routes. These uncontrolled emissions are referred to as fugitive losses.

Research has found that soluble PFAS with relatively high vapor pressures can be emitted into the atmosphere via the gas generated at landfills (Ahrens et al., 2011; Hamid et al., 2018; Wang et al., 2020; Weinberg et al., 2011), but direct LFG sample evaluation for PFAS concentrations is currently being researched by EPA. See Section 5 for details.

Unlike waste in MSW landfills, the C&D landfill waste that contributes most to LFG production is generally dominated by gypsum drywall (Yang et al., 2006). Gypsum drywall results in C&D LFG largely consisting of hydrogen sulfide, a highly pungent gas, with a smaller fraction of methane. Because C&D landfills generate a lower volume of gas than MSW landfills, LFG from C&D landfills is not collected and is often emitted to the environment without treatment.

3.b.iv.2 On- and off-site management of landfill gas

LFG collection and management are regulated under the CAA through National Emission Standards for Hazardous Air Pollutants (NESHAP) and the New Source Performance Standards (NSPS) programs. After collection, LFG can be managed on-site and burned using a flare. There are two basic types of flares common at MSW sites: open (candlestick) and enclosed flares. LFG can also be managed off-site, where it is usually piped from the landfill site to a nearby gas-fired system to generate heat or power.

On-site open flares must operate in accordance with key parameters for exit velocity and flare diameter for non-assisted flares (in 40 CFR 60.18). Additionally, a heat-sensing device must be installed to indicate continuous flame presence (but no specific temperature level). A landfill with an enclosed flare must demonstrate a maximum 20 parts per million by volume (ppmv) NMOC outlet or 98 percent reduction in NMOC with a one-time performance test and operating parameters set during the test for the requisite flare temperature and flow rate.

Combustion temperatures and duration may prove to be critical factors for destruction of PFAS in LFG. While on-site flare systems average 850°C (1,550°F) (U.S. EPA, 2008), engine and boiler systems may run cooler and have a lower destructive potential for PFAS (as indicated in the EPA boiler database). See Section 3.a for a more complete discussion on conditions required for PFAS destruction.

3.b.vii Uncertainties/unknowns

EPA plans to conduct further research on PFAS within landfills, including the potential for PFAS to migrate to leachate or LFG without adequate controls. As with thermal treatment, EPA lacks detailed information on the amounts and concentrations of PFAS and precursor compounds in wastes that are landfilled. There has not been enough research to determine what percent of PFAS can be expected to remain within the confines of landfills, with the many combinations of technology and operating parameters that exist across the thousands of landfills in the United States. Sampling and analytical methodologies must continue to be developed to quantify potential PFAS flows out of landfills, an effort that may be complicated by the long lifespan of some PFAS. Additionally, as detailed above, the efficacy of treatment options for PFAS captured by leachate and LFG systems is not well understood and is in some cases intrinsically entwined with WWTP and thermal treatment options. EPA continues to research these complex and important issues. Refer to Section 5 for a summary of EPA and DoD's planned research activities specific to landfill containment, wastewater treatment, and thermal treatment of PFAS.

3.b.viii Treatment costs

The United States has more than 2,600 MSW, around 1,000 stand-alone C&D debris, and at least 169 industrial (reporting to the Greenhouse Gas Reporting Program [GHGRP]) landfills in operation (U.S. EPA, 2020b, n.d.; DHS, 2017). Costs associated with containing PFAS in landfills are associated with tipping fees (gate rates) at landfills, which help pay for operation and maintenance, capital investment, and costs associated with regulatory compliance. The costs associated with sending PFAS wastes to landfills are difficult to assess because the available data are largely associated with general tipping fees for MSW on a per-ton basis.

Table 3-7, on the next page, presents the average tipping fees for one short ton of waste at an MSW landfill. The range of costs varies widely by state and region, with a lowest average state-level rate at $29.82 in Kentucky and the highest in the contiguous United States at $110 in Rhode Island; Alaska and Hawaii both have even higher rates. All regions have seen these rates increase over the 4-year period from 2016 to 2019. The national average 2019 tipping fee for MSW was $55.36, while C&D debris disposed of in MSW landfills was slightly lower at $54.04 (EREF, 2019). These costs are not reflective of any additional surcharges leveled for wastes associated with high PFAS concentrations. Hazardous waste, ash monofill, and industrial landfills are often explicitly designed and built for specific waste streams, and their costs vary widely from site to site.

Associated with the tipping fees is the cost burden associated with treating the leachate, which can also contain PFAS. The 2000 EPA rulemaking that led to the Landfill Effluent Guidelines identified 1,989 landfills, generating a median daily flow of 5,620 gallons of leachate (U.S. EPA, 2000). Lang et al. (2017) estimated 16.1 billion gallons of leachate generated in 2013, not including leachate recirculated in landfills. Similar to the cost of landfilling PFAS waste, the associated treatment of PFAS-laden leachate is difficult to assess because the available data are associated with typical industrial wastewater generators or typical landfill leachate. These data currently do not include specific information on extra treatment considerations that may be required by an NPDES permit or by an industrial user permit for a discharge into a POTW to control the release of PFAS.

Table 3-8. Average State-Level Wastewater Treatment Prices for Large Industrial Consumers with an 8-Inch Wastewater Meter (DOE, 2017)

State	2016 Volume Charge per kGal[a]
Alabama	$7.51
Alaska	$7.49
Arizona	$2.88
Arkansas	$1.63
California	$3.61
Florida	$5.57
Georgia	$5.11
Illinois	$2.64
Kansas	$4.77
Louisiana	$6.04
New Mexico	$2.39
North Carolina	$4.00
Pennsylvania	$4.00
South Carolina	$2.12
Tennessee	$8.39
Texas	$4.79
Utah	$4.57
Virginia	$2.88
Washington	$18.45
Wisconsin	$3.53
Average	$5.05

a Cost per thousand gallons (kGal) is assumed to be in 2016 dollars. Costs were normalized to 2019 dollars using the BEA GDP deflator (BEA, 2020) for utilities using a base year of 2016.

Leachate treatment at POTWs has been reported between $33 and $125 per gallon depending on treatment method (Kremen, 2020). This cost does not represent any additional burdens associated specifically with PFAS treatment. Cost estimates were also identified for two on-site leachate treatments that were previously indicated as potential treatment options for leachate containing PFAS: RO and activated carbon.

A membrane bioreactor with RO is expected to provide treatment at $64 to $95 per 1,000 gallons for typical landfill leachate, while activated carbon may possibly provide treatment as low as $5.40 per 1,000 gallons using activated carbon with a sequencing batch reactor (Kremen, 2020). Again, though, neither of these ranges accounts for the additional burdens that may be associated with a PFAS-laden leachate (Cunningham, 2019). See Section 3.a (specifically Table 3-3) on thermal treatment for costs specifically associated with the regeneration or disposal of GAC.

3.b.x References for Section 3.b

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3.c Underground injection

Like landfills, underground injection wells are a feasible and effective, to varying degrees, disposal option that normally should minimize migration of PFAS into the environment. Unlike landfills, underground injection wells are only suited for disposal of liquids. A waste stream in the form of PFAS-containing fluids would currently be handled similarly to non-hazardous industrial and hazardous wastes that are injected deep into geologic formations. The limited number of wells currently receiving PFAS, as well as location, waste transportation, and associated costs, may significantly limit the type and quantity of PFAS-related liquid waste streams appropriate for underground injection.

3.c.i Types of wells

Underground injection is generally defined as the subsurface emplacement of fluids through a well. Under the Safe Drinking Water Act (SDWA), EPA is authorized to regulate the permitting of injection wells—including construction, operation, monitoring, and proper closure—for the purpose of protecting underground sources of drinking water (USDWs). Underground injection control (UIC) regulations are found in 40 CFR parts 144 to 148.

EPA's UIC program shares information for owners and operators of injection wells, regulators, and the public about safe injection well operations to prevent the contamination of USDWs. Under the UIC program, EPA regulates the permitting of the following well types:

- **Class I** wells are deep injection wells injecting into geologic formations below the lowermost USDW and are further subdivided into four categories: municipal wastewater, radioactive waste, hazardous waste, and non-hazardous industrial waste disposal wells (see Figure 3-2).
- **Class II** wells are used for injection activities associated with oil and gas production and hydrocarbon storage.
- **Class III** wells are solution mining wells used to inject fluids for the purposes of dissolving and extracting minerals.
- **Class IV** wells, with limited exceptions, have been banned by EPA since 1984 and were used to inject hazardous or radioactive waste into or above geologic formations containing USDWs.
- **Class V** wells include injection wells that are not included in Classes I, II, III, IV, or VI. EPA has identified multiple subtypes including stormwater drainage wells, septic system leach fields, and agricultural drainage wells.
- **Class VI** wells are used to inject and geologically sequester carbon dioxide.

Figure 3-2. Class I well.

- Continuous monitoring and periodic monitoring and testing requirements.
- Appropriate well closure and plugging.

Specific components of these requirements are discussed further below.

3.c.ii.2 Class I non-hazardous industrial and hazardous waste wells

Underground injection to Class I non-hazardous industrial and hazardous waste wells reduces the potential risks of human exposure to injected materials, avoiding discharge to surface and shallow groundwater and generating little or no air emissions. When injected into non-hazardous industrial or hazardous waste Class I wells, fluids are placed below the lowermost USDW. The area into which wastes are injected is referred to as the injection zone. Injection zones of Class I wells typically range from 1,700 to over 10,000 feet in depth (U.S. EPA, 2001). Injection zones are porous and permeable geologic formations. They are separated from USDWs by one or more confining layers of impermeable rock. The confining layer(s) prevent injected fluids from migrating vertically into a USDW.

Class I wells are sited in geological areas that are conducive to injection operations. Siting considerations include ensuring that injected fluids will not migrate through natural fractures and faults from the injection zone into USDWs. Likewise, well operators are required to demonstrate the absence of non-natural pathways (e.g., abandoned wells) or other nearby active wells that could allow for movement of injected fluids into USDWs, within a prescribed area surrounding the well (known as the area of review). In addition to the safeguards offered by siting, engineering, and operating requirements, well design and construction requirements incorporate redundant safety features, and construction materials are "corrosion-resistant and compatible with the wastewater and the formation rocks and fluids into which they come in contact" (U.S. EPA, 2001). Class I wells might also use multiple strings of well casing, inject through tubing set on a packer, and be constructed with adequate cement alongside the entire well string to ensure appropriate protection of any USDWs.

Permitted underground injection of fluids through Class I non-hazardous industrial and hazardous waste wells ensures that injected fluids are confined and cannot enter USDWs—the pathway of concern for this waste disposal technology. In its 2001 study of risks associated with Class I wells, EPA stated that the "probability of Class I well failures, both non-hazardous and hazardous, has been demonstrated to be low. In the unlikely event that a well would fail, the geology of the injection and confining zones serves as a final safety net against movement of wastewaters to USDWs" (U.S. EPA, 2001).

Injection well operators invest millions of dollars in the permitting, construction, and operation of wells. Development of Class I non-hazardous industrial and hazardous waste wells is a resource-intensive process, with the geologic limitations noted previously. In addition, siting requirements limit the areas in the country where Class I wells can be located (see Section 3.c.iv). The typical construction cost to develop a Class I well has been estimated at $4 million to $6 million (deSilva, 2019). Routine operation and maintenance costs include those to address requirements for extensive mechanical integrity testing, monitoring, and periodic submission of permit/no-migration petitions.

3.c.ii.3 Additional requirements for Class I hazardous waste wells

Class I hazardous waste wells are highly protective of USDWs and avoid active seismic areas. The 1984 Hazardous and Solid Waste Amendments to RCRA prohibited land disposal of hazardous waste,

Table 3-9. Inventory of Permitted Class I Non-Hazardous and Hazardous Waste Wells in the United States (FY 2018; Source: EPA)[9]

Location of Wells		Number of Wells	
EPA Region	State/Tribe	Class I Non-Hazardous	Class I Hazardous
4	Florida	251	1
4	Kentucky	1	0
4	Seminole Tribe	3	0
4	Mississippi	8	5
5	Illinois	9	2
5	Indiana	0	4
5	Michigan	31	7
5	Ohio	5	12
6	Arkansas	8	3
6	Louisiana	17	19
6	New Mexico	6	0
6	Oklahoma	6	0
6	Osage Nation	1	0
6	Texas	92	77
7	Kansas	56	8
7	Nebraska	10	0
8	Colorado	16	0
8	North Dakota	8	0
8	Wyoming	85	0
10	Alaska	23	0

Class I well capacity is limited, which may affect the costs associated with deep well injection. A presentation in 2019 placed the cost for deep well injection at approximately $0.18 to $0.25 per gallon (deSilva, 2019). As mentioned above, the typical construction cost to develop a Class I well has been estimated at $4 million to $6 million (deSilva, 2019).

3.c.iii.1 Class I non-hazardous industrial waste wells

Non-hazardous industrial waste wells are located across 19 states, though the majority are in five states—Texas, California, Louisiana, Kansas, and Wyoming. Disposal to this type of well requires well operators to apply and receive permit modifications and assess long-term consequences of accepting new waste streams. Although current Class I injection wells may have limited capacity for PFAS-containing fluids, many of them are used for specific purposes and disposal of waste generated on-site. To accept PFAS-containing fluids, well permits would have to be modified to recognize that the facility is accepting waste from other entities and authorize the facility to inject modified waste streams.

Well operators must also weigh considerations around capacity to accept additional volumes of waste and compatibility of PFAS-containing waste streams with the well material, the geochemistry of the injection formation and formation fluids, and the properties of other injected wastes.

[9] EPA's inventory of Class I non-hazardous waste wells consists of all non-hazardous waste wells, including municipal and industrial waste wells.

- The geochemical properties of the injection zone.

Understanding of the long-term fate and transport properties of PFAS (including precursors) in the injection zone is currently limited. Studies have shown wide ranges in PFAS chemical properties, and these can be altered by mixture effects and interactions with co-contaminants. This creates uncertainty in predictions of PFAS contaminant migration and longevity in the injection zone. For disposal of PFAS in Class I hazardous waste wells, these uncertainties need to be considered in the development of the required no-migration petition.

3.c.vi Summary

As noted above, Class I (non-hazardous industrial or hazardous waste) wells are well suited for the management of PFAS waste material. Permitted underground injection of fluids through Class I non-hazardous industrial and hazardous waste wells ensures that injected fluids are confined and cannot enter USDWs—the pathway of concern for this waste disposal technology. Research on the long-term fate and transport of PFAS (including precursors) to predict migration potential in the injection zone could support future permits.

3.c.vii References for Section 3.c

deSilva, V. (2019). *PFAS in landfill leachate.* *http://www.mowastecoalition.org/resources/Documents/2019%20conference/MWCC2019%20-deSilva%20(SCS)%20-PFAS-July%2016,%202019.pdf*

Marine, F. (2020). *Class I UIC wells to manage PFAS in wastewaters.* http://www.gwpc.org/sites/default/files/event-sessions/Marine%20-%20Class%20I%20PFAS.pdf

McCurdy, R. (2011). *Underground injection wells for produced water disposal.* *https://www.epa.gov/sites/production/files/documents/21_McCurdy_-_UIC_Disposal_508.pdf*

U.S. EPA (Environmental Protection Agency). (2001). *Class I Underground Injection Control Program: Study of risks associated with Class I underground injection wells* (EPA 816-R-01-007). *https://www.epa.gov/sites/production/files/2015-07/documents/study_uic-class1_study_risks_class1.pdf*

U.S. EPA (Environmental Protection Agency). (2015). *Requirements for all Class I wells and class I hazardous waste wells.* *https://www.epa.gov/sites/production/files/2015-10/documents/page_uic-class1_summary_class1_reqs_508c.pdf*

U.S. EPA (Environmental Protection Agency). (2016). *Class I industrial and municipal waste disposal wells.* *https://www.epa.gov/uic/class-i-industrial-and-municipal-waste-disposal-wells*

Usher, K. H. (2019, July 26). Landfill was responsible for PFAS in Cadillac wastewater. *Cadillac News.* *https://www.cadillacnews.com/news/landfill-was-responsible-for-pfas-in-cadillac-wastewater/article_2ae7a3c8-3193-5b8a-8ddf-6d695c3438c5.html*

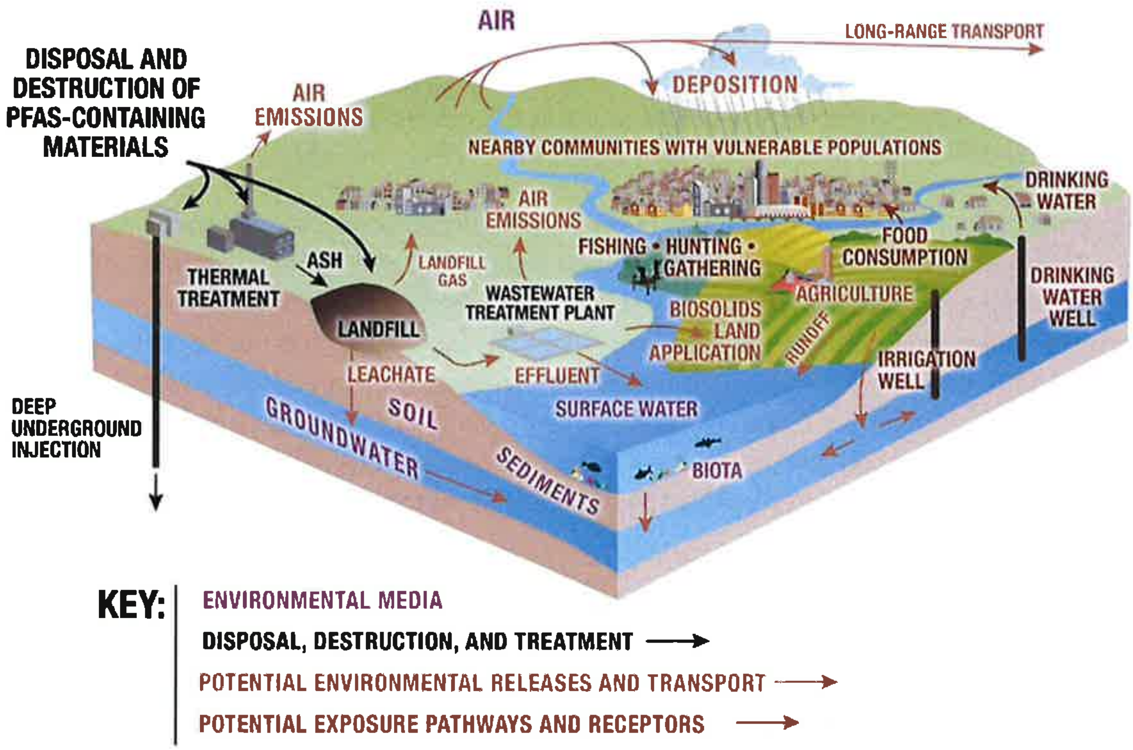

Figure 4-1. Conceptual model providing examples of potential releases from destruction and disposal of PFAS-containing materials, which the technologies covered in this guidance could help to control.[10]

Risk assessment and communication are important tools to protect communities and the environment from potential releases of harmful substances. Risk assessments are performed when a facility is being sited, or when there is a change in permit status (U.S. EPA, 2015a). Tools from the risk assessment process may also be useful when considering whether a facility is an appropriate option for receiving PFAS-containing waste. Risk communication and community engagement are important for building trust and addressing concerns about potential releases. EPA has developed resources for assessing, managing, and communicating environmental risks, including guidance and tools available to stakeholders and the public. These resources are summarized in Section 4.c.

4.b Potentially vulnerable populations

Considering vulnerability and susceptibility in risk assessment can help protect populations at greatest risk.

- "Susceptibility" refers to the likelihood of being affected by a chemical or pollutant. Intrinsic (biological) and extrinsic (exposure-related) factors can influence a person's susceptibility to pollutants, or a population's. That is, different individuals and populations might have different susceptibilities.

[10] Figure 4-1 provides examples of possible releases and exposures that could be associated with destruction and disposal of PFAS-containing materials, but it is not intended to be exhaustive.

Many of these cross-cutting issues are related to environmental justice (EJ) concerns, which encompass the disproportionate exposure and impacts associated with environmental releases. EPA has defined "potential EJ concerns" as "the actual or potential lack of fair treatment or meaningful involvement of minority populations, low-income populations, tribes, and indigenous peoples" (U.S. EPA, 2015b, 2016c). In practice, vulnerability in this context can be considered as "disproportionate impacts on minority populations, low-income populations, and/or indigenous peoples" (U.S. EPA, 2015b, 2016c).

The following sections provide examples of different factors that may contribute to vulnerability to PFAS.

4.c PFAS and vulnerability

There is evidence that exposure to certain PFAS can lead to adverse health outcomes in humans. If humans, or animals, ingest certain PFAS (by eating or drinking food or water than contains PFAS), the PFAS are absorbed, and can accumulate in the body. PFAS stay in the human body for long periods of time. As a result, as people get exposed to PFAS from different sources over time, the level of PFAS in their bodies may increase to the point where they suffer from adverse health effects (U.S. EPA, 2020b).

Research on the two most well-studied PFAS (PFOA and PFOS) demonstrates that they can cause reproductive and developmental, liver and kidney, and immunological effects in laboratory animals (U.S. EPA, 2020b). Both chemicals have caused tumors in animal studies. The most consistent findings from human epidemiology studies are increased cholesterol levels among exposed populations, with more limited findings (U.S. EPA, 2020b) related to:

- Infant birth weights.
- Effects on the immune system.
- Cancer (for PFOA).
- Thyroid hormone disruption (for PFOS).

People with pre-existing conditions, such as liver or kidney disease or immunocompromised status, may be more susceptible to certain PFAS that may target these systems.

Children may be particularly vulnerable to certain PFAS exposures, as they can be both more exposed and more sensitive to health effects. Children drink more water, eat more food, and breathe more air per pound of body weight than adults, which can increase their exposure to PFAS in food and the environment. Breast milk from mothers with PFAS in their blood and formula made with water containing PFAS can expose infants to PFAS, and it may also be possible for children to be exposed in utero during pregnancy. Young children who crawl on floors and put objects or hands in their mouths may have a higher risk of exposure to PFAS in household dust or cleaning products (U.S. EPA, 2018, 2019a). Because of these cross-cutting biological, physiological, and exposure factors, children may be more sensitive to the effects of chemicals such as certain PFAS.

EPA developed drinking water health advisories for PFOA and PFOS to be protective of adverse developmental effects to fetuses during pregnancy or to breastfed infants, which are the groups most sensitive to the potential harmful effects of PFOA and PFOS (U.S. EPA, 2016a, 2016b).

A particularly useful document that presents technical approaches and methods to help analysts (including economists, risk assessors, and others) analyze potential EJ concerns is the *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (U.S. EPA, 2016c). Although it is designed for regulators, it is broadly useful to external analysts and stakeholders.

- *https://www.epa.gov/environmentaljustice/technical-guidance-assessing-environmental-justice-regulatory-analysis*

For considerations in assessing risks to children, refer to the EPA *Framework for Assessing Risks of Environmental Exposure to Children:*

- *https://cfpub.epa.gov/ncea/risk/hhra/recordisplay.cfm?deid=22521*

For information on exposure considerations for identified potentially vulnerable and highly exposed populations in the quantitative and/or qualitative assessment of risk, refer to EPA's ExpoBox:

- *https://www.epa.gov/expobox/exposure-assessment-tools-lifestages-and-populations-highly-exposed-or-other-susceptible#fac*

For considerations of tribal and indigenous lifeways, refer to these tools:

- EPA memo on traditional ecological knowledge: *https://semspub.epa.gov/src/document/11/500024668*
- Amendments to Superfund Hazard Ranking System guidance incorporating Native American traditional lifeways: *http://semspub.epa.gov/src/document/11/175862*

For PFAS, which can reside in the human body for months to years, it is particularly important to consider toxicokinetics in the risk assessment using physiologically based pharmacokinetic (PBPK) modeling. For information on available PBPK models for PFAS, refer to the health effects support documents for PFOA and PFOS and EPA's guidance on the use of PBPK modeling in risk assessment:

- *https://www.epa.gov/ground-water-and-drinking-water/supporting-documents-drinking-water-health-advisories-pfoa-and-pfos*
- *https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=157668*

4.d.iii Considerations for community engagement

In certain cases, community engagement is required under law. For example, facilities must hold public meetings before submitting part B RCRA permit applications (U.S. EPA, 2013a), and in some cases EPA's policy is to consult and coordinate with tribes (U.S. EPA, 2013b). Community engagement is not merely a matter of meeting requirements, though. It can also have the following benefits under this guidance: reaching out to the community before accepting PFAS-containing waste for destruction or disposal will help build trust and support for operations and can reduce the likelihood of negative reactions stemming from unresolved concerns.

Meaningful community engagement typically includes two key elements:

U.S. EPA (Environmental Protection Agency). (2015a). *RCRA's critical mission & the path forward.* https://www.epa.gov/sites/production/files/2015-09/documents/rcras_critical_mission_and_the_path_forward.pdf

U.S. EPA (Environmental Protection Agency). (2015b). *Guidance on considering environmental justice during the development of regulatory actions.* https://www.epa.gov/environmentaljustice/guidance-considering-environmental-justice-during-development-action

U.S. EPA (Environmental Protection Agency). (2016a). *Drinking water health advisory for perfluorooctane sulfonate (PFOS)* (EPA 822-R-16-004). https://www.epa.gov/sites/production/files/2016-05/documents/pfos_health_advisory_final_508.pdf

U.S. EPA (Environmental Protection Agency). (2016b). *Drinking water health advisory for perfluorooctanoic acid (PFOA)* (EPA 822-R-16-005). https://www.epa.gov/sites/production/files/2016-05/documents/pfoa_health_advisory_final_508.pdf

U.S. EPA (Environmental Protection Agency). (2016c). *Technical guidance for assessing environmental justice in regulatory analysis.* https://www.epa.gov/environmentaljustice/technical-guidance-assessing-environmental-justice-regulatory-analysis

U.S. EPA (Environmental Protection Agency). (2018). *Children are not little adults!* https://www.epa.gov/children/children-are-not-little-adults

U.S. EPA (Environmental Protection Agency). (2019a). *About the Office of Children's Health Protection (OCHP).* https://www.epa.gov/aboutepa/about-office-childrens-health-protection-ochp

U.S. EPA (Environmental Protection Agency). (2019b). *Guidelines for human exposure assessment* (EPA/100/B-1/001). https://www.epa.gov/risk/guidelines-human-exposure-assessment

U.S. EPA (Environmental Protection Agency). (2020a). *Exposure assessment tools by lifestages and populations—highly exposed or other susceptible population groups.* https://www.epa.gov/expobox/exposure-assessment-tools-lifestages-and-populations-highly-exposed-or-other-susceptible

U.S. EPA (Environmental Protection Agency). (2020b). *Basic information on PFAS.* https://www.epa.gov/pfas/basic-information-pfas#main-content

3. **Research to measure and assess the effectiveness of existing methods for PFAS disposal, improve existing methods, and/or develop new methods for PFAS disposal (referenced in Sections 2.e, 2.f, and 3.b).** This includes better understanding of the environmental persistence, mobility, fate, and transport of different PFAS-containing materials, waste streams, and sources (e.g., AFFF, textiles, biosolids, landfill leachate) under different disposal conditions (e.g., landfills, deep well injection, material separation) to ensure that PFAS sequestered or stabilized in material streams have no opportunity to reenter the environment.

While EPA's research has been delayed by COVID-19 and by public concerns about EPA collecting data in communities, research is proceeding. Status and updates on EPA's PFAS research are available at *https://www.epa.gov/chemical-research/status-epa-research-and-development-pfas*.

5.b Current federal research and development activities

EPA and DoD are currently the primary federal agencies engaged in research and development of PFAS destruction and disposal; they coordinate efforts and external partnerships to ensure coverage, leverage opportunities and resources, and avoid duplication of effort. They also coordinate with other federal and state agencies doing research in this area.

- EPA presently supports a research program focused on end-of-life management of PFAS-containing materials, primarily by thermal treatment (as referenced in Section 3.a), advanced oxidation processes, wastewater, and landfills (as referenced in Sections 2.f and 3.b). **Thermal treatment research** focuses on understanding and modeling the behavior of PFAS under a range of thermal conditions (e.g., temperature, residence time, turbulence, exposure to flame, effect of catalysts) to better understand the conditions required to defluorinate PFAS, thereby informing selection of appropriate thermal treatment for various PFAS-containing materials. EPA is also studying the **behavior of PFAS and non-PFAS byproducts** that may result from incomplete thermal treatment (e.g., thermal PICs) and subsequently move through different emission control processes. This research informs the consequences of incomplete thermal treatment in terms of these treatment byproducts and the secondary waste streams generated by control processes and will help inform selection of viable control technology options. It includes methods for **sampling and analyzing PFAS in air emissions and ambient air** to enable monitoring of the environment and testing effectiveness of PFAS control technologies.

  EPA scientists are also examining the fate of PFAS during **wastewater treatment operations** and the **disposal of wastewater residuals** (e.g., sludges and biosolids). This research also examines the **benefits of pretreatment technologies** to treat PFAS in high-strength waste streams prior to disposal via wastewater, separation, and destruction technologies. Finally, EPA is examining the **presence and management of PFAS in different landfill types** and **controlling emissions and discharges**. This research effort includes the evaluation of the effectiveness of leachate treatment technologies to manage PFAS.

  EPA also supports partnerships through extramural vehicles such as the *Science to Achieve Results* (STAR) competitive grant program and the *Small Business Innovation Research* (SBIR) program, both of which have provided funding in recent years to develop and commercialize approaches and technologies to advance the practice of PFAS destruction and disposal.

advanced methods such as **high-resolution mass spectrometry** for targeted analysis for known PFAS and nontargeted analysis to discover and document unknown PFAS (e.g., thermal PICs). This research builds on existing EPA expertise and methods for aqueous, solid, and air media (e.g., modifying the existing Modified Method 5 sampling trains to characterize air emissions). Characterizing air emissions requires expansion of method applicability to complex mixtures of byproducts and PICs. EPA will publish a draft Other Test Method 45 by the end of 2020, which will include measurement of semivolatile targeted compounds. EPA is also evaluating and developing other sampling and measurement tools to characterize performance of these technologies, such as **TOF analysis** using **CIC** and **FTIR techniques** to measure the broader suite of compounds with carbon–fluorine moieties without identifying specific chemicals. These tools, in combination with more traditional targeted measurements, have a role in characterizing sources, evaluating the fate and transport of PFAS, and monitoring the destruction and disposal approaches used to manage PFAS.

- **Fundamental understanding of PFAS thermal treatment.** EPA is researching the **incineration conditions** (e.g., temperature, residence time, reactor configuration, turbulence) needed to fully defluorinate PFAS. This includes **testing different catalysts** (e.g., calcium and aluminum) that can be added during incineration or used in separate unit operations to defluorinate more effectively and at lower temperatures. Research is also looking at whether **free fluorine can be controlled**. Results will be incorporated into **databases and models** to enable users to make predictions for different PFAS materials under different disposal conditions.

  This work is being done in bench- and pilot-scale facilities and will enable material managers to **determine the thermal conditions** needed to dispose of different materials (e.g., hazardous waste, MSW, AFFF). It will include assessing the **effectiveness of air pollution control technologies** such as afterburners, baghouses, and scrubbers. This information can then be applied to the current universe of incinerators, industrial oxidizers, and other thermal treatment facilities. EPA will use the thermodynamic and kinetic dataset to **add fluorine chemistry to existing computational fluid dynamic models** for reacting combustion environments to predict potential PFAS destruction and PIC formation in incinerator environments of practical interest.

- **Effectiveness of full-scale PFAS incineration operations.** EPA is partnering with real-world facilities to understand the **operational effectiveness of commercial PFAS thermal treatment**, including HWIs, GAC regeneration facilities, SSIs, municipal waste incinerators, thermal oxidizers, and facilities that thermally treat soils and solid waste contaminated by PFAS. This research involves characterizing the untreated waste inputs, sampling at various stages during treatment, and sampling the stack emissions in order to characterize the efficacy of the treatment process and understand the ultimate fate of the PFAS during treatment.

- **PFAS destruction toolkit.** EPA has established a PFAS Innovative Treatment Team (PITT) to expeditiously identify, review, and test novel (as referenced in Section 2.e) but readily available solutions for destroying PFAS in media and wastes. Such solutions may include traditional destruction methods (e.g., common incineration processes) and novel technologies that might, involve **non-traditional thermal treatment, photolysis, hydrolysis, catalysis, or bioremediation**. For example, EPA recently announced the Innovative Ways to Destroy PFAS Challenge (U.S. EPA, 2020), which challenges problem-solvers to identify a non-thermal way of destroying PFAS in concentrated measuring and modeling PFAS fate and transport to better understand the potential for exposures and opportunities for management interventions to break exposure pathways. Better understanding of risk is also critical to setting benchmarks and thresholds for deciding when destruction or disposal efforts are needed, and when the results can be deemed to be successful. A better understanding of risk will enable risk managers to make informed decisions about the tradeoffs between different risk management solutions, leading to better environmental outcomes.

5.d Longer-term EPA research and development initiatives

The following activities are on a longer-term (3+ years) trajectory, including technologies in pioneering stages of early development:

- **Continuous monitoring technology for PFAS in source and ambient air.** This will include mobile/portable measurement and sensor devices to enable fenceline monitoring and discovery of any fugitive emissions in PFAS destruction and disposal operations.
- **Atmospheric fate, transport, and deposition of PFAS.** It is known that many PFAS are emitted to the atmosphere either by design or by accident, but little is known about the chemical transformations that occur, or about the distribution, dispersion, deposition, and potential for remobilization into the atmosphere. EPA is applying proven atmospheric pollution models to enable predictions about fate, transport, and deposition of PFAS in the air (as referenced in Section 3.a).
- **New and innovative technologies for destroying and disposing of PFAS.** Technology development from proof of concept to full-scale demonstration and validation requires significant time and resources and is most effectively achieved by partnering across government, academia, and industry. These ongoing partnerships are coordinating research to accelerate the most promising new technologies and approaches for the end-of-life disposal of PFAS. EPA and its partners are developing and evaluating innovative technologies such as **electron beam treatment** for aqueous and solid wastes, **cold vapor plasma technologies** for liquid wastes, **oxidative and reductive catalysts, higher-efficiency and reactive sorbents, mechanochemical ball milling, supercritical water oxidation, pyrolysis/gasification, electrochemical oxidation, stabilizing agents**, and **thermal catalysts**. In addition, EPA is developing **cost and performance models** for existing and innovative technologies to compare technologies on a cost and efficacy basis. These models will also allow for the optimization of treatment operations and treatment trains for PFAS. Continued development of the most promising innovative technologies also requires industry partners that have the experience and resources to commercialize these technologies and provide the capacity and the costing to make these viable solutions to this complex problem.

5.e Data and information needs to inform future guidance updates

There are many stakeholders with interests in destruction and disposal of PFAS, and many of these stakeholders have generated data and other information that, if made available, could greatly enhance the speed at which EPA can refine and extend this guidance. EPA is always seeking to partner with entities that have information to share. The following discussion identifies the most critical information gaps where information from outside entities might help to strengthen future guidance.

U.S. EPA (Environmental Protection Agency). (2020). *Innovative Ways to Destroy PFAS Challenge.* *https://www.epa.gov/innovation/innovative-ways-destroy-pfas-challenge*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER

MEMORANDUM

SUBJECT: Recommendations from the PFAS NPDES Regional Coordinators Committee *Interim Strategy for Per- and Polyfluoroalkyl Substances in Federally Issued National Pollutant Discharge Elimination System Permits*

FROM: David P. Ross, Assistant Administrator

DAVID ROSS — Digitally signed by DAVID ROSS Date: 2020.11.22 22:43:00 -05'00'

TO: Regional Administrators
Regions 1–10

The purpose of this memorandum is to transmit recommendations developed by a workgroup comprised of U.S. Environmental Protection Agency (EPA or Agency) Headquarters and Regional contacts. By transmitting these recommendations, I am also seeking your support in ensuring the recommendations encompassed in this interim strategy for Per- and Polyfluoroalkyl Substances (PFAS) in federally issued National Pollutant Discharge Elimination System (NPDES) permits are implemented.

EPA's Office of Water (OW) is currently leading multiple actions in the PFAS Action Plan that will help the Agency better understand and effectively manage risk from exposure to PFAS. These OW-led actions include developing analytical methods for detecting PFAS in drinking water and other environmental media, evaluating PFAS treatment techniques, understanding PFAS exposure from various environmental media, and evaluating statutory and regulatory mechanisms to manage adverse human health and environmental impacts from PFAS exposure. OW has made outstanding progress in each of these areas since the Action Plan was announced in February 2019. Among the important work underway are efforts to address point source discharges of PFAS in accordance with Clean Water Act (CWA) Section 402 NPDES permits.

While OW's work is advancing, a need for an interim strategy to address point source discharges of PFAS in EPA-issued NPDES permits has been identified. On February 6, 2020, the workgroup was established to develop an interim NPDES permitting strategy to address PFAS in EPA-issued CWA Section 402 permits. The workgroup was charged with exploring options on how to address these pollutants while the CWA framework for potentially regulating PFAS discharges pursuant to the NPDES program is under development. The workgroup's goal was to develop a strategy that would serve to guide the Agency's CWA NPDES permitting approach on an interim basis across the EPA Regions as informed by input from our state partners. Each of the ten EPA Regions appointed a representative to the workgroup.

4

To develop potential recommendations for an interim PFAS NPDES strategy, the workgroup conducted a thorough review of the NPDES permitting process, with a specific focus on PFAS in the context of permitting. This included examining CWA Section 402 authorities and permit writing practices to understand where unregulated contaminants, such as PFAS, may fit into the permit development process; analyzing existing state-issued NPDES permits with PFAS monitoring requirements (identified through EPA's NPDES Integrated Compliance Information System (ICIS)) to understand the prescribed analytical methods for detecting PFAS, monitoring frequency, and detection benchmarks in current permits; and obtaining input and perspectives from state partners.

Workgroup Recommendations:

1) **Include permit requirements for phased-in monitoring and best management practices, as appropriate, taking into consideration when PFAS are expected to be present in point source wastewater discharges.**

The workgroup recommends that EPA NPDES permit writers consider incorporating permit requirements for monitoring PFAS at facilities where PFAS are expected to be present in point source wastewater discharges. The PFAS that could be considered for monitoring are those that will be part of EPA's multi-lab validated wastewater analytical method. This recommendation is consistent with EPA's 2010 NPDES Permit Writers Manual,[1] Section 6.2.1.5, "Pollutants Otherwise Expected to be Present in the Discharge." This section of the NPDES Permit Writer's Manual notes that there may be pollutants for which neither the discharger nor the permitting authority have monitoring data, but because of the raw materials stored or used at the facility, products or byproducts of the facility operation, or available data and information from similar facilities, the permit writer has a strong basis for expecting that the pollutant could be present in the discharge.

The workgroup also recognizes the need for reliable and accurate analytical methods and resulting data when considering the incorporation of monitoring provisions into NPDES permit requirements. The workgroup recommends a phased approach to any potential PFAS monitoring provision, such that monitoring requirements are triggered at a time after EPA's multi-lab validated methods are made available to the public. OW expects to have a multi-lab validated PFAS analytical method available for detecting certain PFAS in wastewater and several other matrices in 2021. EPA water quality methods are developed with particular attention to accuracy and precision and have been through single- and multi-lab validation. Generally, the permitting authority requires the use of methods approved at 40 CFR Part 136 for compliance with such monitoring requirements. If no approved methods are available at 40 CFR Part 136, then the permitting authority has discretion to specify the use of suitable methods.

The workgroup also recommends permit writers consider and incorporate best management practices when appropriate to control or abate the discharge of PFAS where authorized for both direct and indirect dischargers.[2]

[1] *See* EPA-833-K-10-001, September 2010.

[2] For industrial NPDES and stormwater NPDES discharges, 40 CFR 122.44(k). For POTW NPDES discharges, 40 CFR 403.8(f)(1)(iii)(B)(3).

2) **Include permit requirements for phased-in monitoring and stormwater pollutant control, as appropriate, taking into consideration when PFAS are expected to be present in stormwater discharges.**

The workgroup recommends consideration of pollutant control measures in municipal separate storm sewer system (MS4) and industrial stormwater permits when PFAS are expected to be present in stormwater discharges. In addition, the workgroup recommends a phased approach to incorporating monitoring in these permits, as described above, when deemed appropriate by the permit writer.

MS4 permits generally require permittees to implement traditional stormwater controls necessary to reduce the discharge of pollutants from MS4s to the "maximum extent practicable" and to make progress towards achieving other water quality objectives.[3,4] MS4 permits typically require controls that focus on programs to reduce pollutant discharges through public education and outreach, illicit discharge detection and elimination, construction site stormwater runoff control, and pollution prevention measures. Additional requirements may be necessary to address specific pollutants of concern for specific water quality problems in receiving waters. In the same way, where PFAS are pollutants of concern, NPDES authorities may consider using these traditional controls to reduce PFAS discharges in stormwater.

Industrial stormwater permits generally require permittees to implement stormwater controls necessary to reduce the discharge of pollutants from industrial activities and to achieve applicable water quality standards. Typically, industrial permittees develop stormwater pollution prevention plans (SWPPPs), implement stormwater control measures to meet permit effluent limits, and conduct inspections and monitoring, where applicable. Where PFAS are pollutants of concern, NPDES authorities may consider using these general types of controls to reduce PFAS discharges in stormwater.

3) **Information sharing on permitting practices and the development of a permitting compendium, an information sharing platform, and continuation of the workgroup.**

Knowledge sharing and development of a common understanding of issues is helpful for emerging permitting topics in the NPDES program. Such actions help to establish best practices and communities of technical knowledge. The workgroup recommends building on the work that has already started on PFAS-specific communication, knowledge sharing, capacity-building, and training at the federal and state levels.

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[3] CWA Section 402(p)(3)(B)(iii) provides that "[p]ermits for discharges from municipal storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." The Phase II stormwater regulations at 40 CFR 122.34(a) further specify that small MS4s permits "must include permit terms and conditions to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act."

[4] To recognize the importance of flexibility in establishing conditions based on the "maximum extent practicable" (MEP) standard and of optimizing reductions in stormwater pollutants on a location-by-location basis, "EPA has intentionally not provided a precise definition of MEP to allow maximum flexibility in MS4 permitting." 64 FR 68754 (Dec. 8, 1999). In establishing MEP-based permit requirements, EPA suggests consideration of "such factors as conditions of receiving waters, specific local concerns, and other aspects included in a comprehensive watershed plan. Other factors may include MS4 size, climate, implementation schedules, current ability to finance the program, beneficial uses of receiving water, hydrology, geology, and capacity to perform operation and maintenance." *Ibid.*

Permitting Compendium

The NPDES program has promoted the development and publishing of permitting compendia to share information. These compendia present examples of different permitting approaches that EPA identifies in a nationwide review of NPDES permits in a specific programmatic area. Current permitting compendia are located at https://www.epa.gov/npdes/municipal-sources-resources. A PFAS permitting compendium would build on the initial evaluation of permits conducted to date and would serve as a source of information for states and EPA to learn about practices being adopted in NPDES permits to address PFAS across the nation. Consistent with other compendia, EPA would update the document as new information is received and make it available on its website.

Information Sharing Platform

As PFAS information relevant to the NPDES program becomes available, the workgroup believes it would be beneficial to establish a mechanism for information sharing to facilitate frequent and timely communication with the states and our partners. The workgroup recommends that OW encourage utilizing the EPA's NPDES Permit Writers' Clearinghouse to share information on PFAS relevant to permitting.[5] The Clearinghouse is a searchable database containing resources such as permits, templates, and webinars that are shared by NPDES authorities. It is primarily populated and used by permitting authorities and practitioners.

Continuation of the Workgroup

The NPDES PFAS workgroup has provided a forum for robust discussion on PFAS in the context of CWA Section 402 permitting. This resulted in valuable insights from key stakeholders at the EPA regional and state levels. As work on PFAS evolves, this workgroup can serve as an ongoing source of NPDES permitting knowledge and practice through continued collaboration with state permitting authorities.

The workgroup recommends PFAS-specific communication, knowledge sharing, capacity-building, and training opportunities through the following deliverables:

Deliverable	Timeline
Build-out relevant NPDES permitting information on the EPA PFAS website and NPDES Permit Writers' Clearinghouse.	June 2021
Publish a PFAS permitting compendium that provides examples of permit conditions that have been developed and issued by states and EPA.	Third Quarter 2021
Host quarterly meetings of the Regional Coordinators workgroup.	Beginning January 2021
Broadcast two webinars for states and EPA Regions on relevant PFAS topics.	First Quarter 2021
Work with the Association of Clean Water Administrators (ACWA) to organize 2nd state listening session.[6]	First Quarter 2021

[5] https://ofmpub.epa.gov/apex/pwc/f?p=206:1:186468836250::NO:::

[6] The first state listening session was held on March 18, 2020.

cc: Andrew Sawyers, Director, Office of Wastewater Management
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Glenn Curtis and Diane Huffman, R7
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EPA United States Environmental Protection Agency

News Releases from Headquarters › Water (OW)

New Interim Strategy Will Address PFAS Through Certain EPA-Issued Wastewater Permits

11/30/2020

Contact Information:
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WASHINGTON (November 30, 2020) — Aggressively addressing per- and polyfluoroalkyl substances (PFAS) in the environment continues to be an active and ongoing priority for the U.S. Environmental Protection Agency (EPA). Today, the agency is announcing two important steps to address PFAS. First, EPA issued a memorandum detailing an interim National Pollutant Discharge Elimination System (NPDES) permitting strategy for addressing PFAS in EPA-issued wastewater permits. Second, EPA released information on progress in developing new analytical methods to test for PFAS compounds in wastewater and other environmental media. Together, these actions help ensure that federally enforceable wastewater monitoring for PFAS can begin as soon as validated analytical methods are finalized.

"Better understanding and addressing PFAS is a top priority for EPA, and the agency is continuing to develop needed research and policies," **said EPA Administrator Andrew Wheeler**. "For the first time in EPA's history, we are utilizing all of our program offices to address a singular, cross-cutting contaminant and the agency's efforts are critical to supporting our state and local partners."

"Managing and mitigating PFAS in water is a priority for the Office of Water as we continue our focus on meeting 21st century challenges," **said EPA Assistant Administrator for Water David Ross.** "These actions mark important steps in developing the underlying science and permitting techniques to address PFAS in wastewater where the discharge of these chemicals may be of concern."

EPA's interim NPDES permitting strategy for PFAS provides recommendations from a cross-agency workgroup on an interim approach to include PFAS-related conditions in EPA-issued NPDES permits. EPA is the permitting authority for three states (Massachusetts, New Hampshire, New Mexico), the District of Columbia, most U.S. territories including Puerto Rico, Indian Country, and certain federal facilities. The strategy advises EPA permit writers to consider including PFAS monitoring at facilities where these chemicals are expected to be present in wastewater discharges, including from municipal separate storm sewer systems and industrial stormwater permits. The PFAS that could be considered for monitoring are those that will have validated EPA analytical methods for wastewater testing, which the agency anticipates being available on a phased-in schedule as multi-lab validated wastewater analytical methods are finalized. The agency's interim strategy also encourages the use of best management practices where appropriate to control or abate the discharge of PFAS and includes recommendations to facilitate information sharing to foster adoption of best practices across states and localities.

In coordination with the interim NPDES permitting strategy, EPA is also providing information on the status of analytical methods needed to test for PFAS in wastewater. EPA is developing analytical methods in collaboration with the U.S. Department of Defense to test for PFAS in wastewater and other environmental media, such as soils. The agency is releasing a list of 40 PFAS chemicals that are the subject of analytical method development. This method would be in addition to Method 533 and Method 537.1 that are already approved and can measure 29 PFAS chemicals in drinking water. EPA anticipates that multi-lab validated testing for PFAS will be finalized in 2021. For more information on testing method validation, see https://www.epa.gov/cwa-methods.

Background

EPA continues to make progress under its PFAS Action Plan to protect the environment and human health, including:

Highlighted Action: Drinking Water

- In December 2019, EPA accomplished a key milestone in the PFAS Action Plan by publishing a new validated method to accurately test for 11 additional PFAS in drinking water. Method 533 complements EPA Method 537.1, and the agency can now measure 29 chemicals.
- In February 2020, EPA took an important step in implementing the agency's PFAS Action Plan by proposing to regulate PFOA and PFOS drinking water.
- EPA also asked for information and data on other PFAS substances, as well as sought comment on potential monitoring requirements and regulatory approaches.
- In November 2020, EPA issued a memo detailing an interim National Pollutant Discharge Elimination (NPDES) permitting strategy for PFAS. The agency also released information on progress in developing new analytical methods to test for PFAS compounds in wastewater and other environmental media.

Highlighted Action: Cleanup

- In December 2019, EPA issued *Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS*, which provides guidance for federal cleanup programs (e.g., CERCLA and RCRA) that will also be helpful to states and tribes.
  - The recommendations provide a starting point for making site-specific cleanup decisions and will help protect drinking water resources in communities across the country.
- In July 2020, EPA submitted the Interim Guidance on the Destruction and Disposal of PFAS and Materials Containing PFAS to OMB for interagency review. The guidance would:
  - Provide information on technologies that may be feasible and appropriate for the destruction or disposal of PFAS and PFAS-containing materials.
  - Identify ongoing research and development activities related to destruction and disposal technologies, which may inform future guidance.

- EPA is working on the proposed rule to designate PFOA and PFOS as hazardous substances under CERCLA. In the absence of the rule, EPA has used its existing authorities to compel cleanups.

Highlighted Action: Monitoring

- In July 2020, EPA transmitted the Unregulated Contaminant Monitoring Rule 5 (UCMR 5) proposal to the Office of Management and Budget (OMB) for interagency review. EPA anticipates proposing nationwide drinking water monitoring for PFAS that uses new methods that can detect PFAS at lower concentrations than previously possible.

Highlighted Action: Toxics

- In September 2019, EPA issued an advanced notice of proposed rulemaking that would allow the public to provide input on adding PFAS to the Toxics Release Inventory toxic chemical list.
- In June 2020, EPA issued a final regulation that added a list of 172 PFAS chemicals to Toxics Release Inventory reporting as required by the National Defense Authorization Act for Fiscal Year 2020.
- In July 2020, EPA issued a final regulation that can stop products containing PFAS from entering or reentering the marketplace without EPA's explicit permission.

Highlighted Action: Scientific Leadership

- EPA continues to compile and assess human and ecological toxicity information on PFAS to support risk management decisions.
- EPA continues to develop new methods to test for additional PFAS in drinking water.
- The agency is also validating analytical methods for surface water, groundwater, wastewater, soils, sediments and biosolids; developing new methods to test for PFAS in air and emissions; and improving laboratory methods to discover unknown PFAS.
- EPA is developing exposure models to understand how PFAS moves through the environment to impact people and ecosystems.
- EPA is working to develop tools to assist officials with the cleanup of contaminated sites.
- In July 2020, EPA added new treatment information for removing PFAS from drinking water.

Highlighted Action: Technical Assistance

- Just as important as the progress on PFAS at the federal level are EPA efforts to form partnerships with states, tribes, and local communities across the country.
- EPA has provided assistance to more than 30 states to help address PFAS, and the agency is continuing to build on this support.
- These joint projects allow EPA to take the knowledge of its world-class scientists and apply it in a collaborative fashion where it counts most.

Highlighted Action: Enforcement

- EPA continues to use enforcement tools, when appropriate, to address PFAS exposure in the environment and assist states in enforcement activities.
- EPA has already taken actions to address PFAS, including issuing Safe Drinking Water Act orders and providing support to states. *See examples in the PFAS Action Plan.*

- To date, across the nation, EPA has addressed PFAS in 15 cases using a variety of enforcement tools under SDWA, TSCA, RCRA, and CERCLA (where appropriate), and will continue to do so to protect public health and the environment.

Highlighted Action: Grants and Funding

- Under this Administration, EPA's Office of Research and Development has awarded over $15 million through dozens of grants for PFAS research.
- In May 2019, EPA awarded approximately $3.9 million through two grants for research that will improve the agency's understanding of human and ecological exposure to PFAS in the environment. This research will also promote a greater awareness of how to restore water quality in PFAS-impacted communities.
- In September 2019, EPA awarded nearly $6 million to fund research by eight organizations to expand the agency's understanding of the environmental risks posed by PFAS in waste streams and to identify practical approaches to manage potential impacts as PFAS enters the environment.
- In August 2020, EPA awarded $4.8 million in funding for federal research to help identify potential impacts of PFAS to farms, ranches, and rural communities.

Highlighted Action: Risk Communications

- EPA is working collaboratively to develop a risk communication toolbox that includes multimedia materials and messaging for federal, state, tribal, and local partners to use with the public.

Additional information about PFAS can be found at: www.epa.gov/pfas

LAST UPDATED ON NOVEMBER 30, 2020

Fact Sheet
NPDES Permit No. NC0089915

Permit Writer/Email Contact: sergei.chernikov@ncdenr.gov
Date: February 12, 2020
Division/Branch: NC Division of Water Resources / NPDES Complex Permitting
Fact Sheet Template: Version 09Jan2017

Permitting Action:
☐ Renewal
☐ Renewal with Expansion
☒ New Discharge
☐ Modification (Fact Sheet should be tailored to mod request)

Note: A complete application should include the following:
- For New Dischargers, EPA Form 2A or 2D requirements, Engineering Alternatives Analysis, Fee
- For Existing Dischargers (POTW), EPA Form 2A, 3 effluent pollutant scans, 4 2nd species WET tests.
- For Existing Dischargers (Non-POTW), EPA Form 2C with correct analytical requirements based on industry category.

Complete applicable sections below. If not applicable, enter NA.

1. Basic Facility Information

Facility Information	
Applicant/Facility Name:	The Chemours Company / Chemours Fayetteville Works
Applicant Address:	1007 Market Street, Wilmington, DE 19899
Facility Address:	22828 NC Highway 87 W, Fayetteville, NC 28306-7332
Permitted Flow:	1.58 MGD
Facility Type/Waste:	MAJOR Industrial
Facility Class:	II
Treatment Units:	influent oxidation, coagulation, and pH adjustment, ultrafiltration, granular activated carbon (GAC) adsorption
Pretreatment Program (Y/N):	N/A
County:	Bladen
Region:	Fayetteville

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From time-to-time the Middle Cape Fear River has experienced flooding conditions which are documented to cause a significant increase in water levels below Lock and Dam #3, consistent with the location of proposed Outfall 003. During these events a backwater condition propagates upstream in the "Old Outfall 002 Stream". Historical observation indicates that the Old Outfall 002 Stream levels can rise significantly (consistent with the flooded Cape Fear River levels) and would be expected, at times, to be equal to or significantly greater than the invert elevation of the treatment system intake dam and associated pumping system. During these flooded backwater conditions elevated sediment load and reduced flow velocity gradients are expected to cause significant sediment deposition within the collection dam and pumping structure. The sediment load may cause failure of the pumping and treatment system during the flooded backwater condition. Requirement for treatment shall be suspended during these force majeure flooding events and be allowed 48 hours after the backwater stream level falls below the invert of the intake collection dam to safely maintain the influent collection structure and re-initiate collection and treatment. The triggering Cape Fear River flood elevations; event documentation and notification requirements; and procedure for treatment cessation and safe restart shall be included in the approved Dam Operation and Maintenance Plan.

This proposed treatment system will consist of the following components:

1) Influent Oxidation, Coagulation & pH Adjustment

This treatment system includes an influent oxidation/coagulation /pH adjustment tank for pretreatment of the ultrafiltration (UF) feed (pH adjustment/oxidation/coagulation). The pH adjustment will be done using sodium hydroxide. Additional iron oxidation will be done with sodium hypochlorite. Poly-aluminum chloride (PAC) will be used for coagulation and contribute to help maintain the UF membranes. Partially treated water will be conveyed to the UF units via dual booster pumps. Safety Data Sheets (SDSs) are attached for the chemicals to be utilized at the wastewater treatment system.
Iron hydroxide particles precipitated in the oxidation process and total suspended solids (TSS) will be coagulated and settled in the tank. The settled solids will be transferred by a solids transfer pump to a weir tank (back pulse waste recycle tank) and filtered in downstream removal processes (thickener and rotary-fan filter press).

2) Ultrafiltration

This design includes UF pretreatment before the GAC stage. The UF will perform the role of solids removal upstream of the GAC units. The UF will provide an absolute barrier to solids at 0.04 - 0.1 μm range. Per the manufacturing vendor, the UF membrane will provide additional TOC removal as well.
The UF back pulse waste recycle will be captured in a weir tank to allow solids to settle and then will be recycled through the system after being pumped back to the influent oxidation/coagulation /pH adjustment tank. The settled solids in the weir tank (the back-pulse waste recycle tank) will be drawn off by a sludge pump and filtered in downstream removal processes (thickener and rotary-fan filter press).

The UF units will intermittently need to be cleaned with a low concentration of citric acid. The cleaning solution will be captured in a Clean-In Place (CIP) tank and neutralized in it. Following neutralization, the CIP water will be recycled through the treatment system after being pumped back by CIP neutralization pumps to the influent oxidation/coagulation /pH adjustment tank.

3) Granular Activated Carbon (GAC) Adsorption

Based on GAC adsorption studies, the PFAS removal required to meet discharge requirements (per the Consent Order), is expected to be accomplished using GAC adsorption. The system design for this application includes a total of six (6) 12' diameter x 5' diameter straight side vessels in a three (3) pass configuration capable of swapping lead/middle/lag. Each GAC vessel can hold up to 20,000 lbs. of GAC. The GAC beds will be sluiced out upon exhaustion and the new bed sluiced back into the vessel. The GAC vessels have backwashing capability. Sizing, quantities and configuration may be modified during process optimization.

Summer 7Q10 (cfs):	467 (17.14 – used in limit calculations to account for dilution, the number is based on the modeling)
Winter 7Q10 (cfs):	603
30Q2 (cfs):	900
Average Flow (cfs):	4220
IWC (% effluent):	12.5% (based on the model, see item 6)
303(d) listed/parameter:	No, the segment is not listed on the 2018 303(d) list
Subject to TMDL/parameter:	Yes – State-wide Mercury TMDL implementation.
Sub-basin/HUC:	Outfall 002: 03-06-16 /
USGS Topo Quad:	Duart

3. Effluent Data Summary

N/A – New Discharge

This is a new permit for the collection and treatment of contaminated dry weather flow in a channel leading to the Cape Fear River. Previously, DuPont used this channel to discharge process wastewater and referred to it as "Old Outfall 002".

4. Instream Data Summary

Instream monitoring may be required in certain situations, for example: 1) to verify model predictions when model results for instream DO are within 1 mg/l of instream standard at full permitted flow; 2) to verify model predictions for outfall diffuser; 3) to provide data for future TMDL; 4) based on other instream concerns. Instream monitoring may be conducted by the Permittee, and there are also Monitoring Coalitions established in several basins that conduct instream sampling for the Permittee (in which case instream monitoring is waived in the permit as long as coalition membership is maintained).

If applicable, summarize any instream data and what instream monitoring will be proposed for this permit action: As part of the Consent Order (Paragraph 11(d)), Chemours is required to sample its intake, discharge (Outfall 002), and a multitude of additional on-site locations for PFAS compounds. These sampling efforts are detailed in the Updated PFAS Characterization Plan, dated May 1, 2019. This plan and the sampling locations were conditionally approved by DWR on June 19, 2019.

Chemours' existing NPDES permit, NC0003573, has instream monitoring requirements for temperature, dissolved oxygen, and conductivity on a weekly basis to evaluate the effects of its discharge on the receiving stream. Chemours is a member of the Middle Cape Fear Basin Association, with upstream coalition station B8290000 (approximately 1 mile upstream of Outfall 002) and downstream coalition station B8302000 (approximately 4 miles downstream of Outfall 002). As part of this permit, instream monitoring for PFAS compounds will be required.

Is this facility a member of a Monitoring Coalition with waived instream monitoring (Y/N): Y

It should be noted that the model produced an effective summer 7Q10 (7Q10s) value of 17.14 cfs. This is a very conservative assumption, as it is substantially lower than the USGS estimate of 467.0 cfs for the 7Q10s. Because the CORMIX model provides a very high level of protection for the receiving stream and the downstream water users, the effective 7Q10s was be used in the Reasonable Potential Analysis (RPA) for Outfall 003.

If applicable, describe any mixing zones established in accordance with 15A NCAC 2B.0204(b): N/A.

Oxygen-Consuming Waste Limitations

Limitations for oxygen-consuming waste (e.g., BOD) are generally based on water quality modeling to ensure protection of the instream dissolved oxygen (DO) water quality standard. Secondary TBEL limits (e.g., BOD= 30 mg/l for Municipals) may be appropriate if deemed more stringent based on dilution and model results.

If permit limits are more stringent than TBELs, describe how limits were developed: See "Dilution and Mixing Zones" Section above.

Ammonia and Total Residual Chlorine Limitations

Limitations for ammonia are based on protection of aquatic life utilizing an ammonia chronic criterion of 1.0 mg/l (summer) and 1.8 mg/l (winter). Acute ammonia limits are derived from chronic criteria, utilizing a multiplication factor of 3 for Municipals and a multiplication factor of 5 for Non-Municipals.

Limitations for Total Residual Chlorine (TRC) are based on the NC water quality standard for protection of aquatic life (17 ug/l) and capped at 28 ug/l (acute impacts). Due to analytical issues, all TRC values reported below 50 ug/l are considered compliant with their permit limit.

Describe any proposed changes to ammonia and/or TRC limits for this permit renewal: The facility conducted a comprehensive evaluation of the dry weather flow in the creek bed (channel) and submitted results on the EPA Form 2D to the Division. The analysis indicates that there is no ammonia or TRC.

Reasonable Potential Analysis (RPA) for Toxicants

If applicable, conduct RPA analysis and complete information below.

The need for toxicant limits is based upon a demonstration of reasonable potential to exceed water quality standards, a statistical evaluation that is conducted during every permit renewal utilizing the most recent effluent data for each outfall. The RPA is conducted in accordance with 40 CFR 122.44 (d) (i). The NC RPA procedure utilizes the following: 1) 95% Confidence Level/95% Probability; 2) assumption of zero background; 3) use of ½ detection limit for "less than" values; and 4) stream flows used for dilution consideration based on 15A NCAC 2B.0206. Effective April 6, 2016, NC began implementation of dissolved metals criteria in the RPA process in accordance with guidance titled *NPDES Implementation of Instream Dissolved Metals Standards*, dated June 10, 2016.

A reasonable potential analysis was conducted on effluent toxicant data provided by the facility in the permit application. Pollutants of concern included toxicants with positive detections and associated water quality standards/criteria. Based on this analysis, the following permitting actions are proposed for this permit:

- Effluent Limit with Monitoring. The following parameters will receive a water quality-based effluent limit (WQBEL) since they demonstrated a reasonable potential to exceed applicable water quality standards/criteria: Silver and Cobalt.

Other WQBEL Considerations

If applicable, describe any other parameters of concern evaluated for WQBELs:

The Technology Based Effluent Limits were the guiding criteria used to develop permit limitations for HFPO-DA, PFMOAA, and PMPA.

When EPA develops PFAS criteria or the State adopts standards for any of the compounds generated by Chemours, the Division will conduct a reasonable potential analysis and reopen the permit to include the new limits, if they are more stringent than the TBELs.

If applicable, describe any special actions (HQW or ORW) this receiving stream and classification shall comply with in order to protect the designated waterbody.

If applicable, describe any compliance schedules proposed for this permit renewal in accordance with 15A NCAC 2H.0107(c)(2)(B), 40CFR 122.47, and EPA May 2007 Memo.

If applicable, describe any water quality standards variances proposed in accordance with NCGS 143-215.3(e) and 15A NCAC 2B.0226 for this permit renewal: N/A.

7. Technology-Based Effluent Limitations (TBELs)

Describe what this facility produces: This is a surface/groundwater remediation permit for the Chemours facility that produces organic chemicals.

List the federal effluent limitations guideline (ELG) for this facility: N/A.

If the ELG is based on production or flow, document how the average production/flow value was calculated: N/A.

For ELG limits, document the calculations used to develop TBEL limits: N/A.

If any limits are based on best professional judgement (BPJ), describe development: N/A.

Document any TBELs that are more stringent than WQBELs: Initially, HFPO-DA and PFMOAA were chosen as the two PFAS compounds that would be used to indicate reductions of Total PFAS in the remediated surface water. As additional studies have been performed since the Consent Order, PMPA has been added as an indicator parameter since the laboratory experiments demonstrated its low affinity for GAC absorption. Therefore, TBELs for HFPO-DA, PFMOAA, and PMPA were calculated while recognizing the Consent Order's requirement that the treatment system removes at least 99% of HFPO-DA and PFMOAA.

The 99% removal is also consistent with the NPDES permitting procedure for establishing BAT for waste streams that don't have promulgated Effluent Guidelines.

The facility provided an Engineering Report on Wastewater Treatability. The Report demonstrated that the proposed GAC system is able to remove 99% of the total Table 3+ PFAS compounds (as listed in NPDES permit application) present in the wastewater based on current analytical reporting limits and influent concentrations. The GAC system showed that when indicator compounds PFMOAA, PMPA, and HFPO-DA are removed at the rate of 99%, the Total Table 3+ compounds (as listed in NPDES application) were also removed at the rate of 99% based on current analytical detection levels.

Data provided in the application showed dry weather baseflow to have influent concentrations for the two indicator parameters at 6.0 μg/L for HFPA-DA, 85 μg/L for PFMOAA, and 5.4 μg/L for PMPA. This was based on a single 24-hour composite influent sample. The dry weather flow (baseflow) will be treated

If applicable, describe the results of the antidegradation review, including the Engineering Alternatives Analysis (EAA) and any water quality modeling results: The facility provided an EAA to justify the chosen disposal alternative for this new discharge; the complete EAA document can be found within the application in DWR's Laserfiche files.

The facility reviewed the following available alternatives: Connection to the Existing Publicly Owned Treatment Works (POTW), Land Application, Wastewater Reuse in the Facility, Trucking Offsite, and Direct Discharge.

Connection to the existing POTW was not available since the nearest Rockfish Creek Water Reclamation Facility refused to accept this wastewater. Reuse is currently not a feasible option, because, including but not limited to, - the Consent Order requires Chemours to accelerated reduction of PFAS contamination in the Cape Fear River and downstream water intakes within a two-year period, and it would be difficult for Chemours to implement this in an accelerated manner. Chemours may evaluate this alternative more closely in the future.

The Present Value Costs for the next 20 years was calculated for the following alternatives using an EPA discount factor of 3.5%; the Costs are presented below:

Land Application – $86,000,000
Wastewater Reuse in the Facility - $69,600,000 (includes riparian restoration; Concerns with this alternative include the riparian damage and distance from the capture dam to the facility)
Trucking Offsite - $8,710,000,000
Direct Discharge- $67,000,000

As compared to other alternatives, and in accordance with 15A NCAC 2H .0105(c)(2), the Engineering Alternatives Analysis provided justification for a direct discharge to surface water alternative and indicated that the direct discharge is the most environmentally sound alternative selected from all reasonably cost-effective options.

9. Antibacksliding Review

Sections 402(o)(2) and 303(d)(4) of the CWA and federal regulations at 40 CFR 122.44(l) prohibit backsliding of effluent limitations in NPDES permits. These provisions require effluent limitations in a reissued permit to be as stringent as those in the previous permit, with some exceptions where limitations may be relaxed (e.g., based on new information, increases in production may warrant less stringent TBEL limits, or WQBELs may be less stringent based on updated RPA or dilution).

Are any effluent limitations less stringent than previous permit (YES/NO): N/A. This is a new permit.

If YES, confirm that antibacksliding provisions are not violated: N/A.

10. Monitoring Requirements

Monitoring frequencies for NPDES permitting are established in accordance with the following regulations and guidance: 1) State Regulation for Surface Water Monitoring, 15A NCAC 2B.0500; 2) NPDES Guidance, Monitoring Frequency for Toxic Substances (7/15/2010 Memo); 3) NPDES Guidance, Reduced Monitoring Frequencies for Facilities with Superior Compliance (10/22/2012 Memo); 4) Best Professional Judgement (BPJ). Per US EPA (Interim Guidance, 1996), monitoring requirements are not considered effluent limitations under Section 402(o) of the Clean Water Act, and therefore anti-backsliding prohibitions would not be triggered by reductions in monitoring frequencies.

Parameter	**Current Permit**	**Proposed Change**	**Basis for Condition/Change**
Total Phosphorus	N/A (new permit)	Monthly Effluent Monitoring Only	State WQ Rule, 15A NCAC 2B .0500
Conductivity	N/A (new permit)	Monthly upstream/downstream Monitoring Only	State WQ Rule, 15A NCAC 2B .0500
Toxicity Test	N/A (new permit)	Chronic limit, 12.5% effluent	WQBEL. No toxics in toxic amounts. 15A NCAC 2B.0200 and 15A NCAC 2B.0500
Total Hardness	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Selenium	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Silver	N/A (new permit)	MA 0.48 µg/L DM 2.01 µg/L	State WQ standard, 15A NCAC 2B .0200
Total Cobalt	N/A (new permit)	MA 23.9 µg/L DM 23.9 µg/L	State WQ standard, 15A NCAC 2B .0200
Total Cadmium	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Copper	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Cyanide	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Lead	N/A (new permit	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Total Thallium	N/A (new permit)	Quarterly Effluent Monitoring Only	State WQ standard, 15A NCAC 2B .0200
Mercury	N/A (new permit)	Quarterly Effluent Monitoring Only	2012 State TMDL and NPDES Implementation Guidance.
Electronic Reporting	N/A (new permit)	Required	In accordance with EPA Electronic Reporting Rule 2015.

MGD – Million gallons per day, MA – Monthly Average, DM – Daily Max

In order to reduce PFAS loading to the Cape Fear River, this Permit requires the treatment of dry weather base flow from a contaminated stream. This stream, often referred to as "Old Outfall 002," was used to discharge process wastewater from the facility prior to June 2012, when the process wastewater discharge was relocated to the current outfall location (permit NC0003573) above Lock and Dam #3 in the Cape Fear River. The treated stream base flow, covered in this permit, will be discharged from Outfall 003 which will be located downstream of the capture dam, and will flow from the channel into the Cape Fear River below Lock and Dam #3. The flow from Outfall 003 must be treated to remove at least 99% of the PFAS in the stream. This removal efficiency will be demonstrated through measurements of indicator parameters HFPO-DA (GenX), PFMOAA, and PMPA. The issuance of this permit will allow Chemours to begin remediation of the stream and without the permit, the contaminated surface water will continue to discharge to the Cape Fear River untreated.

SELC Comments

Comment:
Technology-based effluent limits must be based on the reductions achievable by the technology.

Response:
The DEQ has used professional judgement and experience in establishing Technology Based Effluent Limits for GenX, PMPA, and PFMOAA after evaluation of all data presented in the engineering report.

1). Review of the Engineering Report and Addendum to the Report indicates that the effluent concentrations of indicator PFAS compounds (PFMOAA and HFPO-DA) are highly variable depending on the type of the GAC used and other factors. PFMOAA concentration varies from <10.6 ng/L to 31,059 ng/L and HFPO-DA varies from <11.7 ng/L to 4,622 ng/L. Such a significant variation shows that even under tightly controlled laboratory conditions the treatment technology must be optimized for the facility to meet the permit limits, which are much closer to the lower end of the identified range of the effluent concentrations (60 ng/L for HFPO-DA and 850 ng/L for PFMOAA). Moreover, these numeric standards serve as a backstop to the requirement that Chemours control PFAS indicator parameters at an overall efficiency of 99%.

2). The study performed by the consultants was conducted under predictable and controlled laboratory conditions on a small scale during a short time period. When this technology is implemented in the field, there will be additional complications that could have a negative impact on the performance, including: variation in temperature (daily and seasonal); variations in the influent pH, volume, TSS, oxidation-reduction potential, additional chemical compounds impacting GAC, etc. Additional difficulties might be encountered during scaling-up the technology from the lab to the field.

3). In addition, the facility will encounter substantial treatment difficulties as the influent concentration of the PFAS compounds decreases. Consistent removal of 99% of the compounds in the influent becomes more difficult as the wastewater coming to the treatment system becomes less polluted. The DEQ has observed these difficulties with numerous facilities and parameters.

Comment:
The Permit Cannot Allow for Less Than 99 Percent Removal of PFAS.

Response:
The Permit does not currently allow for less than 99% removal of PFAS. As the concentration of the PFAS compounds in the influent decreases, the ability of the treatment system to remove contaminants also decreases. This statement is true for the vast majority of the contaminants. Therefore, the permit provides the facility an opportunity to request revisions to the permit condition that require 99% removal efficiency. The DEQ will evaluate such a request and make a decision based on the available data. Even if such a request is granted, the numeric effluent limits will be maintained. These numeric limitations represent Technology Based Effluent Limits and they will not be violated by changing removal efficiency requirements.

Comment:
DEQ Must Do More.

Response:
This comment is outside of the issues related to the subject permit.

CFPUA and Brooks Pierce Comments

Comment:
Chemours' draft NPDES Permit would allow the discharge of 1.5 million gallons per day of wastewater resulting from a proposed treatment system for old Outfall 002 with a total concentration of 954 ppt of GenX, PFMOAA, and PMPA. There is no limit on the total mass of these compounds that can be discharged. CFPUA objects to excessive concentration of these compounds that can be discharged and failure to limit the mass that can be discharged.

Response:
The DEQ is not authorizing the discharge of any additional wastewater into the Cape Fear River. Rather, this permit requires the removal of PFAS from a contaminated stream that is already discharging into the Cape Fear River.

The DEQ established permit limits that are based on the engineering evaluation of the treatment system that controls PFAS pollutants. The Clean Water Act requires that DEQ protects the receiving stream from the toxic impacts of the effluent. The toxic impact evaluation relies on the concentration-based water quality standard promulgated by the state and concentration-based water quality criteria promulgated by the EPA. To achieve this goal, the Draft Permit contains concentration-based limits. The mass-based limits are typically implemented when the Federal Effluent Guidelines exist for a particular industry or as a result of the TMDL. There are no applicable Federal Effluent Guidelines or TMDLs here.

Comment:
CFPUA objects to the high limits set for the three compound listed and the absence of limits on the remaining Full Suite of PFAS compounds.

Response:
The Engineering Report provided by the facility clearly demonstrates that chosen indicator parameters represent the most difficult PFAS compounds to be treated because they are the short-chained molecules and if they are removed at 99% rate the other PFAS compounds will also be removed at 99% rate or higher.

Hence, by imposing 99% removal efficiency on these indicator parameters the DEQ also imposes 99% removal efficiency on all PFAS compounds contained in the effluent.

out, about once every 3-6 months. This backwash water will be discharged to the weir tank to allow solids to settle as described above.

The permit allows the facility to discharge wastewater only after treatment and when it meets effluent limits. These conditions apply to the backwash.

Comment:
The removal efficiency is to be calculated only monthly, even though samples are collected twice per month. CFPUA objects to this permit only requiring calculation of removal efficiency once per month.

Response:
The removal efficiency calculation is based on the long-standing implementation structure of the Clean Water Act that requires monthly submission of the Discharge Monitoring Reports. It allows for the time needed for sample shipment and analysis.

Comment:
CFPUA believes the discharge to the Cape Fear River should be limited to the same 70/10 analysis that applies to what is considered safe water that is being withdrawn by neighboring groundwater users.

Response:
Effluent limits and other conditions in the permit are based on the federal and state NPDES regulations and surface water standards.

Environment North Carolina Comment

Comment:
NCDEQ should consider including conditions with more stringent limits.

Response:
The DEQ believes that the proposed limits adequately represent the ability of the treatment system to remove PFAS compounds. This conclusion is based on limited available data. DEQ will re-evaluate these limits after the long-term performance data are collected.

Chemours Comments

Comment:
The effluent limits and 99% removal efficiency requirement for PMPA are arbitrary and not provided for in the Consent Order.

Response:
The Consent Order identifies PFMOAA and GenX as "indicator parameters" that are intended to be reflective of reductions in all PFAS at the facility. In addition, the Renewal Application submitted by Chemours clearly stated that "Treatment testing demonstrated that other PFAS compounds in the Table 3+ and EPA Mod 537 Max analyses were removable by at least 99% when PFMOAA and HFPO-DA are removed by 99%". Furthermore, to the extent the permit imposes requirements in addition to those set forth in the Consent Order, the DEQ has the legal authority to go above and beyond the terms of the Order

Comment:
The daily maximum effluent limits for PFAS indicator parameters should not be set equal to the monthly average effluent limits.

Response:

NPDES Implementation of Instream Dissolved Metals Standards – Freshwater Standards

The NC 2007-2015 Water Quality Standard (WQS) Triennial Review was approved by the NC Environmental Management Commission (EMC) on November 13, 2014. The US EPA subsequently approved the WQS revisions on April 6, 2016, with some exceptions. Therefore, metal limits in draft permits out to public notice after April 6, 2016 must be calculated to protect the new standards - as approved.

Table 1. NC Dissolved Metals Water Quality Standards/Aquatic Life Protection

Parameter	Acute FW, µg/l (Dissolved)	Chronic FW, µg/l (Dissolved)	Acute SW, µg/l (Dissolved)	Chronic SW, µg/l (Dissolved)
Arsenic	340	150	69	36
Beryllium	65	6.5	---	---
Cadmium	Calculation	Calculation	40	8.8
Chromium III	Calculation	Calculation	---	---
Chromium VI	16	11	1100	50
Copper	Calculation	Calculation	4.8	3.1
Lead	Calculation	Calculation	210	8.1
Nickel	Calculation	Calculation	74	8.2
Silver	Calculation	0.06	1.9	0.1
Zinc	Calculation	Calculation	90	81

Table 1 Notes:

1. FW= Freshwater, SW= Saltwater
2. Calculation = Hardness dependent standard
3. Only the aquatic life standards listed above are expressed in dissolved form. Aquatic life standards for Mercury and selenium are still expressed as Total Recoverable Metals due to bioaccumulative concerns (as are all human health standards for all metals). It is still necessary to evaluate total recoverable aquatic life and human health standards listed in 15A NCAC 2B.0200 (e.g., arsenic at 10 µg/l for human health protection; cyanide at 5 µg/L and fluoride at 1.8 mg/L for aquatic life protection).

Table 2. Dissolved Freshwater Standards for Hardness-Dependent Metals

The Water Effects Ratio (WER) is equal to one unless determined otherwise under 15A NCAC 02B .0211 Subparagraph (11)(d)

Metal	NC Dissolved Standard, µg/l
Cadmium, Acute	WER*{1.136672-[*ln* hardness](0.041838)} · *e*^{0.9151 [*ln* hardness]-3.1485}
Cadmium, Acute Trout waters	WER*{1.136672-[*ln* hardness](0.041838)} · *e*^{0.9151[*ln* hardness]-3.6236}
Cadmium, Chronic	WER*{1.101672-[*ln* hardness](0.041838)} · *e*^{0.7998[*ln* hardness]-4.4451}
Chromium III, Acute	WER*0.316 · *e*^{0.8190[*ln* hardness]+3.7256}
Chromium III, Chronic	WER*0.860 · *e*^{0.8190[*ln* hardness]+0.6848}
Copper, Acute	WER*0.960 · *e*^{0.9422[*ln* hardness]-1.700}

- Receiving stream classification

2. In order to establish the numeric standard for each hardness-dependent metal of concern and for each individual discharge, the Permit Writer must first determine what effluent and instream (upstream) hardness values to use in the equations.

   The permit writer reviews DMR's, Effluent Pollutant Scans, and Toxicity Test results for any hardness data and contacts the Permittee to see if any additional data is available for instream hardness values, upstream of the discharge.

   If no hardness data is available, the permit writer may choose to do an initial evaluation using a default hardness of 25 mg/L (CaCO3 or (Ca + Mg)). Minimum and maximum limits on the hardness value used for water quality calculations are 25 mg/L and 400 mg/L, respectively.

   If the use of a default hardness value results in a hardness-dependent metal showing reasonable potential, the permit writer contacts the Permittee and requests 5 site-specific effluent and upstream hardness samples over a period of one week. The RPA is rerun using the new data.

   The overall hardness value used in the water quality calculations is calculated as follows:

   Combined Hardness (chronic)

   $$= \frac{(\text{Permitted Flow, cfs} * \text{Avg. Effluent Hardness, mg/L}) + (\text{s7Q10, cfs} * \text{Avg. Upstream Hardness, mg/L})}{(\text{Permitted Flow, cfs} + \text{s7Q10, cfs})}$$

   The Combined Hardness for acute is the same but the calculation uses the 1Q10 flow.

3. The permit writer converts the numeric standard for each metal of concern to a total recoverable metal, using the EPA Default Partition Coefficients (DPCs) or site-specific translators, if any have been developed using federally approved methodology.

EPA default partition coefficients or the "Fraction Dissolved" converts the value for dissolved metal at laboratory conditions to total recoverable metal at in-stream ambient conditions. This factor is calculated using the linear partition coefficients found in *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit from a Dissolved Criterion* (EPA 823-B-96-007, June 1996) and the equation:

$$\frac{C_{diss}}{C_{total}} = \frac{1}{1 + \{ [K_{po}] [ss^{(1+a)}] [10^{-6}] \}}$$

Where:

ss = in-stream suspended solids concentration [mg/l], minimum of 10 mg/L used,

7. When appropriate, permit writers develop facility specific compliance schedules in accordance with the EPA Headquarters Memo dated May 10, 2007 from James Hanlon to Alexis Strauss on 40 CFR 122.47 Compliance Schedule Requirements.

8. The Total Chromium NC WQS was removed and replaced with trivalent chromium and hexavalent chromium Water Quality Standards. As a cost savings measure, total chromium data results may be used as a conservative surrogate in cases where there are no analytical results based on chromium III or VI. In these cases, the projected maximum concentration (95th %) for total chromium will be compared against water quality standards for chromium III and chromium VI.

9. Effluent hardness sampling and instream hardness sampling, upstream of the discharge, are inserted into all permits with facilities monitoring for hardness-dependent metals to ensure the accuracy of the permit limits and to build a more robust hardness dataset.

10. Hardness and flow values used in the Reasonable Potential Analysis for this permit included:

Parameter	Value	Comments (Data Source)
Average Effluent Hardness (mg/L) [Total as, $CaCO_3$ or (Ca+Mg)]	25.0	Default value
Average Upstream Hardness (mg/L) [Total as, $CaCO_3$ or (Ca+Mg)]	25.0	Default value
7Q10 summer (cfs)	17.14	CORMIX model, 8:1dilution
1Q10 (cfs)	14.16	RPA calculation
Permitted Flow (MGD)	1.58	Design flow of treatment system

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 414

[EPA–HQ–OW–2020–0582; FRL 10019–06–OW]

RIN 2040–AG10

Clean Water Act Effluent Limitations Guidelines and Standards for the Organic Chemicals, Plastics and Synthetic Fibers Point Source Category

AGENCY: Environmental Protection Agency (EPA).

ACTION: Advance notice of proposed rulemaking.

SUMMARY: The U.S. Environmental Protection Agency (EPA or Agency) is initiating further data collection and analysis to support potential future rulemaking, under the Clean Water Act (CWA), relating to the effluent limitations guidelines, pretreatment standards and new source performance standards applicable to the Organic Chemicals, Plastics and Synthetic Fibers (OCPSF) point source category to address discharges from manufacturers of per- and polyfluoroalkyl substances (PFAS) and is considering revising the same for formulators of PFAS. PFAS are a group of man-made organic chemicals. Some PFAS compounds are persistent in the environment and in the human body. Analysis of animal studies and human epidemiological research suggest that exposure above certain levels to some PFAS may be associated with adverse human health effects. The Agency has identified several industries with facilities that are likely to be discharging PFAS in their wastewater, including OCPSF manufacturers and formulators. This advance notice of proposed rulemaking (ANPRM) provides for public review and comment on the information and data regarding PFAS manufacturers and formulators that EPA has collected to date. EPA is requesting public comment on the information and data presented in this ANPRM. EPA is also soliciting additional information and data regarding discharges of PFAS from these facilities to inform future revisions to the wastewater discharge requirements that apply to the OCPSF point source category.

DATES: Comments must be received on or before May 17, 2021.

ADDRESSES: You may send comments, identified by Docket ID No. EPA–HQ–OW–2020–0582, by any of the following methods:

- *Federal eRulemaking Portal: https://www.regulations.gov/* (our preferred method). Follow the online instructions for submitting comments.
- *Mail:* U.S. Environmental Protection Agency, EPA Docket Center, Office of Water, Office of Science and Technology Docket, Mail Code 28221T, 1200 Pennsylvania Avenue NW, Washington, DC 20460.
- *Hand Delivery or Courier (by scheduled appointment only):* EPA Docket Center, WJC West Building, Room 3334, 1301 Constitution Avenue NW, Washington, DC 20004. The Docket Center's hours of operations are 8:30 a.m.–4:30 p.m., Monday–Friday (except Federal Holidays).

Instructions: All submissions received must include the Docket ID No. for this rulemaking. Comments received may be posted without change to *https://www.regulations.gov/*, including any personal information provided. For detailed instructions on sending comments and additional information on the rulemaking process, see the "Public Participation" heading of the **SUPPLEMENTARY INFORMATION** section of this document. Out of an abundance of caution for members of the public and our staff, the EPA Docket Center and Reading Room are closed to the public, with limited exceptions, to reduce the risk of transmitting COVID–19. Our Docket Center staff will continue to provide remote customer service via email, phone, and webform. We encourage the public to submit comments via *https://www.regulations.gov/* or email, as there may be a delay in processing mail and faxes. Hand deliveries and couriers may be received by scheduled appointment only. For further information on EPA Docket Center services and the current status, please visit us online at *https://www.epa.gov/dockets.*

FOR FURTHER INFORMATION CONTACT: Ms. Samantha Lewis, Engineering and Analysis Division, Office of Science and Technology, Office of Water; telephone number: 202–566–1058; email address: *lewis.samantha@epa.gov.*

I. Public Participation

A. Written Comments

Submit your comments, identified by Docket ID No. EPA–HQ–OW–2020–0582, at *https://www.regulations.gov* (our preferred method), or the other methods identified in the **ADDRESSES** section. Once submitted, comments cannot be edited or removed from the docket. EPA may publish any comment received to its public docket. Do not submit to EPA's docket at *https://www.regulations.gov* any information you consider to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. If you wish to submit such information, consult the person listed for additional information in the preceding **FOR FURTHER INFORMATION CONTACT** section. Multimedia submissions (audio, video, etc.) must be accompanied by a written comment. The written comment is considered the official comment and should include discussion of all points you wish to make. EPA will generally not consider comments or comment contents located outside of the primary submission (*i.e.*, on the web, cloud, or other file sharing system). For additional submission methods, the full EPA public comment policy, information about CBI or multimedia submissions, and general guidance on making effective comments, please visit *https://www.epa.gov/dockets/commenting-epa-dockets.*

EPA is temporarily suspending its Docket Center and Reading Room for public visitors, with limited exceptions, to reduce the risk of transmitting COVID–19. Our Docket Center staff will continue to provide remote customer service via email, phone, and webform. We encourage the public to submit comments via *https://www.regulations.gov/* as there may be a delay in processing mail and faxes. Hand deliveries or couriers will be received by scheduled appointment only. For further information and updates on EPA Docket Center services, please visit us online at *https://www.epa.gov/dockets.*

EPA continues to carefully and continuously monitor information from the Centers for Disease Control and Prevention (CDC), local area health departments, and our Federal partners so that we can respond rapidly as conditions change regarding COVID–19.

B. Supporting Information

This notice is supported by documents that are contained in the public docket. EPA has prepared an index of these materials to aid in the public's review and comment. The index can be identified by searching the docket for DCN OCPSF00116.

II. General Information

A. Does this action apply to me?

Entities potentially affected by any rulemaking following this notice include:

Category	Example of regulated entity
Industry	PFAS Manufacturers. PFAS Formulators.

This section is not intended to be exhaustive, but rather provides a guide regarding entities likely to be regulated by any future rulemaking activities following this notice. Other types of entities that are not included in the examples above could also be regulated. PFAS manufacturers are facilities that produce PFAS compounds or precursors through processes including, but not limited to, electrochemical fluorination (ECF) and telomerization. Facilities that manufacture PFAS are currently regulated under EPA's national Effluent Limitations Guidelines and Standards (ELGs) for the OCPSF category (40 CFR part 414). EPA has also gathered more limited information about PFAS formulators. PFAS formulators are facilities that are the primary customers of the PFAS manufacturers, and that use raw PFAS feedstock to (a) produce commercial or consumer goods (*e.g.*, weather-proof caulking), or (b) as intermediary products for use in the manufacture of commercial goods (*e.g.*, a grease-proof coating for a pizza box).

If you still have questions regarding the applicability of any future rulemaking activities following this notice to a particular entity, please consult the person listed for additional information in the preceding **FOR FURTHER INFORMATION CONTACT** section.

B. What is the purpose of this notice?

As part of EPA's statutorily required Effluent Guidelines planning process, EPA has reviewed readily available information about PFAS surface water discharges to identify industrial sources that may warrant further study for potential regulation through national ELGs. Based on the limited data available at the time, in February of 2019, EPA published the PFAS Action Plan, in which it identified several industries with facilities that are likely to be discharging PFAS compounds in their wastewater and EPA began a more detailed study to evaluate the potential for PFAS presence in their wastewater discharges. Through the PFAS Multi-Industry Study, described in EPA's Preliminary Effluent Guidelines Program Plan 14, EPA gathered a range of information about PFAS manufacturers and formulators, as well as the potential discharges of PFAS from these facilities (further details on these efforts are provided in Section V below). PFAS manufacturers are facilities that produce PFAS compounds or precursors through processes including, but not limited to, ECF and telomerization. Facilities that manufacture PFAS are currently regulated under EPA's national ELGs for the OCPSF category (40 CFR part 414). EPA has also gathered some information about PFAS formulators. PFAS formulators are facilities that are the primary customers of PFAS manufacturers, and that use raw PFAS feedstock to (a) produce commercial or consumer goods (*e.g.*, weather-proof caulking), or (b) as intermediary products for use in the manufacture of commercial goods (*e.g.*, a grease-proof coating for a pizza box). EPA's data set for formulators is more limited than for manufacturers, as the Agency has identified little publicly available information on these facilities and their potential discharges.

This notice provides for public review and comment on the information that EPA has collected to date on PFAS discharges from both PFAS manufacturers and formulators. In addition, as detailed in Section V below, EPA is soliciting additional information and data regarding PFAS manufacturers and formulators, including wastewater characteristics and treatability. EPA will use any information and data received to inform potential next steps, which could include developing new or revised ELGs for these categories of dischargers. Because formulators may be subject to national ELGs outside of the OCPSF category, future EPA actions to address PFAS discharges from these facilities may include revisions to ELGs other than the ELGs that apply to the OCPSF category or proposal of a new ELG.

III. Background

A. Clean Water Act

Among its core provisions, the Clean Water Act (CWA) prohibits the discharge of pollutants from a point source to waters of the United States, except as authorized under the CWA. Under CWA Section 402, 33 U.S.C. 1342, discharges may be authorized through a National Pollutant Discharge Elimination System (NPDES) permit. The CWA outlines a dual approach for establishing discharge limits for these permits: (1) Technology-based effluent limitations that establish a floor of performance for categories of dischargers, and (2) water quality-based effluent limitations that are established where technology-based effluent limitations are insufficient to meet applicable state water quality standards (WQS) or site specific water quality goals. The CWA authorizes EPA to establish national technology-based ELGs and new source performance standards for discharges to waters of the United States from categories of point sources (such as industrial, commercial, and public sources). These national ELGs are used by state permitting authorities to establish technology-based effluent limitations for NPDES permits.

The CWA also authorizes EPA to promulgate nationally applicable pretreatment standards that control pollutant discharges from sources that discharge wastewater indirectly to waters of the United States through Publicly Owned Treatment Works (POTWs), as outlined in Sections 307(b) and (c) of the CWA, 33 U.S.C. 1317(b) and (c). EPA establishes national pretreatment standards for pollutants in wastewater from such indirect dischargers shown to pass through, to interfere with, or to be otherwise incompatible with POTW operations. Pretreatment standards are designed to ensure that wastewaters from indirect industrial dischargers are subject to similar levels of treatment as direct dischargers in the same industrial category. See CWA Section 301(b), 33 U.S.C. 1311(b).

Technology-based effluent limitations in NPDES permits are derived from effluent limitations guidelines (CWA Sections 301 and 304, 33 U.S.C. 1311 and 1314) and new source performance standards (CWA Section 306, 33 U.S.C. 1316) promulgated by EPA. Where EPA has not promulgated an applicable ELG or new source performance standard, technology-based effluent limitations are based on the best professional judgment (BPJ) of the permitting authority. Additional limitations are also required in a permit where necessary to meet WQS. CWA Section 301(b)(1)(C), 33 U.S.C. 1311(b)(1)(C). The ELGs are established by EPA regulation for categories of industrial dischargers and are based on the degree of control that can be achieved using various levels of pollution control technology, as specified in the CWA (*e.g.*, Best Practicable Control Technology Currently Available (BPT), Best Conventional Pollutant Control Technology (BCT), Best Available Technology Economically Achievable (BAT); see below).

The EPA promulgates national ELGs for industrial categories for three classes of pollutants: (1) Conventional pollutants (total suspended solids (TSS), oil and grease, biochemical oxygen demand (BOD_5), fecal coliform, and pH), as outlined in CWA Section 304(a)(4), 33 U.S.C. 1314(a)(4), and 40 CFR 401.16; (2) toxic pollutants (*e.g.*, toxic metals such as arsenic, mercury, selenium, and chromium; toxic organic pollutants such as benzene, benzo-a-pyrene, phenol, and naphthalene), as outlined in CWA Section 307(a), 33 U.S.C. 1317(a); 40 CFR 401.15 and 40 CFR part 423, appendix A; and (3) nonconventional pollutants, which are those pollutants that are not categorized as conventional or toxic (*e.g.*, ammonia-N, phosphorus, and total dissolved solids (TDS)). PFAS compounds fall into the category of nonconventional pollutant, as they are not defined as a toxic or conventional pollutant in the CWA or the Code of Federal Regulations (CFR).

B. Effluent Guidelines Program

EPA establishes ELGs based on the performance of well-designed and well-operated control and treatment technologies. EPA is not to base technology-based requirements on their effects on the receiving water. See *Weyerhaeuser Co.* v. *Costle,* 599 F.2d 1011, 1028, 1042 (D.C. Cir. 1978).

There are four levels of technology-based controls applicable to direct dischargers and two levels of controls applicable to indirect dischargers. These are described in detail below as general background information:

1. Best Practicable Control Technology Currently Available (BPT)

Consistent with the CWA, EPA establishes effluent limitations based on BPT by reference to the average of the best performances of facilities within the industry, grouped to reflect various ages, sizes, processes, or other common characteristics. EPA promulgates BPT effluent limitations for conventional, toxic, and nonconventional pollutants. In specifying BPT, EPA looks at a number of factors. EPA first considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of equipment and facilities, the processes employed, engineering aspects of the control technologies, any required process changes, non-water quality environmental impacts (including energy requirements), and such other factors as the Administrator deems appropriate. See CWA Section 304(b)(1)(B), 33 U.S.C. 1314(b)(1)(B).

2. Best Conventional Pollutant Control Technology (BCT)

The 1977 amendments to the CWA require EPA to identify additional levels of effluent reduction for conventional pollutants associated with Best Conventional Pollutant Control Technology (BCT) for discharges from existing industrial point sources. In addition to other factors specified in Section 304(b)(4)(B), 33 U.S.C. 1314(b)(4)(B), the CWA requires that EPA establish BCT limitations after consideration of a two-part "cost reasonableness" test. EPA explained its methodology for the development of BCT limitations on July 9, 1986 (51 FR 24974). Section 304(a)(4) designates the following as conventional pollutants: BOD_5, TSS, fecal coliform, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as a conventional pollutant on July 30, 1979 (44 FR 44501; 40 CFR 401.16).

3. Best Available Technology Economically Achievable (BAT)

BAT represents the second level of control for direct discharges of toxic and nonconventional pollutants. As the statutory phrase intends, EPA considers technological availability and the economic achievability in determining what level of control represents BAT. CWA Section 301(b)(2)(A), 33 U.S.C. 1311(b)(2)(A). Other statutory factors that EPA must consider in assessing BAT are the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the process employed, potential process changes, non-water quality environmental impacts (including energy requirements), and such other factors as the Administrator deems appropriate. CWA Section 304(b)(2)(B), 33 U.S.C. 1314(b)(2)(B); *Texas Oil & Gas Ass'n* v. *EPA,* 161 F.3d 923, 928 (5th Cir. 1998). The Agency retains considerable discretion in assigning the weight to be accorded each of these factors. *Weyerhaeuser Co.,* 590 F.2d at 1045. Generally, EPA determines economic achievability based on the effect of the cost of compliance with BAT limitations on overall industry and subcategory (if applicable) financial conditions. BAT is intended to reflect the highest performance in the industry, and it may reflect a higher level of performance than is currently being achieved based on technology transferred from a different subcategory or category, bench scale or pilot studies, or foreign facilities. *Am. Paper Inst.* v. *Train,* 543 F.2d 328, 353 (D.C. Cir. 1976); *Am. Frozen Food Inst.* v. *Train,* 539 F.2d 107, 132 (D.C. Cir. 1976). BAT may be based upon process changes or internal controls, even when these technologies are not common industry practice. See *Am. Frozen Food Inst.,* 539 F.2d at 132, 140; *Reynolds Metals Co.* v. *EPA,* 760 F.2d 549, 562 (4th Cir. 1985); *Cal. & Hawaiian Sugar Co.* v. *EPA,* 553 F.2d 280, 285–88 (2nd Cir. 1977).

One way that EPA may consider differences within an industry when establishing BAT limitations is through subcategorization. The Supreme Court has recognized that the substantive test for subcategorizing an industry is the same as that which applies to establishing fundamentally different factor variances—*i.e.*, whether the plants are different with respect to relevant statutory factors. See *Chem. Mfrs. Ass'n* v. *EPA,* 870 F.2d 177, 214 n.134 (5th Cir. 1989) (citing *Chem. Mfrs. Ass'n* v. *NRDC,* 470 U.S. 116, 119–22, 129–34 (1985)). Courts have stated that there need only be a rough basis for subcategorization. See *Chem. Mfrs. Ass'n,* 870 F.2d at 215 n.137 (summarizing cases).

4. Best Available Demonstrated Control Technology/New Source Performance Standards (NSPS)

NSPS reflect "the greatest degree of effluent reduction" that is achievable based on the "best available demonstrated control technology" (BADCT), "including, where practicable, a standard permitting no discharge of pollutants." CWA Section 306(a)(1), 33 U.S.C. 1316(a)(1). Owners of new facilities have the opportunity to install the best and most efficient production processes and wastewater treatment technologies. As a result, NSPS generally represent the most stringent controls attainable through the application of BADCT for all pollutants (that is, conventional, nonconventional, and toxic pollutants). In establishing NSPS, EPA is directed to take into consideration the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements. CWA Section 306(b)(1)(B), 33 U.S.C. 1316(b)(1)(B).

5. Pretreatment Standards for Existing Sources (PSES)

Section 307(b) of the CWA, 33 U.S.C. 1317(b), authorizes EPA to promulgate pretreatment standards for discharges of pollutants to POTWs. PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or otherwise are incompatible with the operation of POTWs. Categorical pretreatment standards are technology-based and are analogous to BPT and BAT effluent limitations guidelines, and thus the Agency typically considers the same factors in promulgating PSES as it considers in promulgating BPT and BAT. The General Pretreatment Regulations, which set forth the framework for the implementation of categorical pretreatment standards, are found at 40 CFR part 403. These regulations establish pretreatment standards that apply to all non-domestic dischargers. See 52 FR 1586 (January 14, 1987).

6. Pretreatment Standards for New Sources (PSNS)

Section 307(c) of the CWA, 33 U.S.C. 1317(c), authorizes EPA to promulgate PSNS at the same time it promulgates NSPS. As is the case for PSES, PSNS are designed to prevent the discharge of any pollutant into a POTW that interferes with, passes through, or otherwise is incompatible with the POTW. In selecting the PSNS technology basis, the Agency generally considers the same factors it considers in establishing NSPS, along with the results of a pass-through analysis. Like new sources of direct discharges, new sources of indirect discharges have the opportunity to incorporate into their operations the best available demonstrated technologies. As a result, EPA promulgates pretreatment standards for new sources based on best available demonstrated control technology for new sources. See *Nat'l Ass'n of Metal Finishers* v. *EPA*, 719 F.2d 624, 634 (3rd Cir. 1983).

C. Summary of the Existing OCPSF ELGs

The OCPSF ELGs (40 CFR part 414) were originally promulgated in 1987, and then amended in 1989, 1990, 1992, and 1993. The OCPSF category includes more than 1,000 chemical facilities producing over 25,000 end products. These include such products as benzene, toluene, polypropylene, polyvinyl chloride, chlorinated solvents, rubber precursors, rayon, nylon, and polyester. The OCPSF industry is large and diverse with complex operations and processes. Some plants produce chemicals in large volumes through continuous chemical processes, while others produce only small volumes of "specialty" chemicals through batch chemical processes.

Only a small subset of the facilities that are currently regulated under the OCPSF ELGs manufacture or formulate PFAS. Although the OCPSF ELGs may apply to PFAS manufacturers and formulators, the OCPSF ELGs do not establish effluent limitations or pretreatment standards for any PFAS compounds. Rather, the revision to the OCPSF ELGs would address PFAS discharges from PFAS manufacturers and formulators.

IV. The EPA's PFAS Multi-Industry Study and Identification of PFAS Manufacturers and Formulators for Potential Regulation

As described in the Preliminary Effluent Guidelines Program Plan 14 (Preliminary Plan 14), published in October 2019, EPA conducted an initial examination of readily available public information about PFAS surface water discharges to identify industrial sources that may warrant further study. The Preliminary Plan 14 docket (EPA–HQ–OW–2018–0618) includes a summary of the information EPA reviewed and a report with a more thorough description of our review activities. Based on this initial review, EPA decided to conduct further studies to better understand and document facilities discharging PFAS compounds to surface waters and to POTWs. This was introduced in the Preliminary Plan 14 as the PFAS Multi-Industry Study.

The goals of the PFAS Multi-Industry Study are to identify industries and specific facilities producing or using PFAS compounds; quantify—to the best of EPA's ability—the amounts of PFAS being discharged; identify PFAS control practices and treatment technologies; document PFAS removal efficiency in wastewater; and estimate costs associated with PFAS treatment systems. EPA identified the following industrial point source categories as the primary focus of this study: OCPSF manufacturers; pulp and paper manufacturers; textiles and carpet manufacturers; and commercial airports.[1]

For the OCPSF manufacturers, EPA reviewed numerous data sources and identified six PFAS manufacturers and ten likely PFAS formulators. EPA is not sure that the ten facilities that it identified as "likely" PFAS formulators are actually PFAS formulators due to limited data available at this time. We discuss each of these data sources in greater detail below.

EPA reviewed 2019 Discharge Monitoring Reports (DMRs) and obtained PFAS data for six PFAS manufacturers and three likely PFAS formulators (the other seven facilities do not report PFAS compounds in their DMRs or they do not have DMRs because they are indirect dischargers). These nine facilities combined reported a total of 17 PFAS compounds in their discharges. Based on the DMRs, effluent data detected a total of 15 PFAS compounds, and concentrations ranged from non-detect to 777 parts per billion (ppb). The "2019 Monitoring Period Level DMR PFAS Data" (DCN OCPSF00030) includes additional information on the compounds that were monitored, and the concentration ranges reported in DMRs.

EPA reviewed NPDES permits for these PFAS manufacturers and formulators to evaluate whether their permits contain effluent limitations or monitoring requirements for PFAS compounds. One current NPDES permit in West Virginia contains effluent limitations for two PFAS compounds (Perfluorooctanoic acid (PFOA) and Hexafluoropropylene oxide dimer acid (HFPODA) that go into effect on September 1, 2021. Another facility in North Carolina is under a consent decree with requirements for no discharge of PFAS process wastewater. See DCN OCPSF00079 for consent decree. The North Carolina facility is currently hauling all PFAS process wastewater off-site for disposal. The consent decree went into effect on February 25, 2019 and ends on January 31, 2023. This North Carolina facility reported detections of PFOA for 9 of 12 reporting periods in 2019 DMRs, including periods after February 2019. Four of the other PFAS manufacturers and formulators have PFAS monitoring requirements, and no effluent limitations, in their NPDES permits. Two Alabama facilities and one Illinois facility are operating under expired, administratively continued NPDES permits. The NPDES permit materials collected and reviewed are available as DCNs OCPSF000008 to OCPSF00025.

EPA also reviewed the Toxics Release Inventory (TRI), which is managed by EPA's Office of Chemical Safety and Pollution Prevention (OCSPP) and tracks annual environmental waste management, including releases, of 767 individually listed chemicals and 33 chemical categories from industrial facilities that manufacture, process, or otherwise use these chemicals in amounts above their applicable reporting thresholds. Release of a TRI chemical refers to an emission to air, discharge to water, or placement in some type of land disposal. EPA has not yet received any information or data pertaining to the release of PFAS compounds through TRI reporting. However, the National Defense Authorization Act for Fiscal Year 2020 added 172 PFAS compounds to the TRI. TRI reporting for these PFAS will be due to EPA by July 1, 2021, for calendar year 2020 data. For additional information on the addition of 172 PFAS to TRI, see *https://www.epa.gov/toxics-release-inventory-tri-program/list-pfas-added-tri-ndaa*.

EPA reviewed data from the Toxic Substances Control Act (TSCA) Inventory, which lists chemicals manufactured (including imported) or processed in the United States. The TSCA Inventory, managed by the Office of Pollution Prevention and Toxics (OPPT) within OCSPP, currently lists more than 86,000 chemicals, of which approximately half are currently in

[1] Military bases and airports are not included in the scope of this study.

commerce or "active." For PFAS specifically, the TSCA Inventory lists over one thousand compounds, of which approximately half are known to be commercially active within the last decade. The TSCA Inventory by itself cannot be used to identify dischargers.

EPA also reviewed the Chemical Data Reporting (CDR) database, which compiles information collected under a TSCA Section 8(a) rule that requires chemical manufacturers (including importers) to provide EPA with production, import, and customer use information about chemicals in commerce. Manufacturers and importers must report to the CDR database if they meet certain annual volume thresholds, typically 25,000 pounds, but 2,500 pounds for chemicals subject to certain TSCA actions. EPA matched the chemicals in the 2016 CDR data (the most recent year available) [2] against EPA's Cross-Agency Research List [3] and identified 118 PFAS compounds in the CDR database. See DCN OCPSF00032 for "2016 nonCBI CDR Data for PFAS Compounds" and DCN OCPSF00003 for "EPA's CompTox Cross Agency PFAS List." Using this list of CDR PFAS compounds, EPA summed the reported production volumes to calculate a total PFAS production and importation volume of approximately 608 million pounds for 2015. See DCN OCPSF00033 for "Review of 2015 non-CBI CDR Data for PFAS Compounds." The CDR database contains data identifying which facilities produced PFAS compounds, but does not have any information on PFAS discharges. The six PFAS manufacturing facilities that reported 2019 DMR data also appear in the CDR data as domestic manufacturers of 76 separate PFAS compounds. An additional 55 facilities appear in the CDR dataset; however, EPA has no corresponding data on their potential PFAS discharges. The deadline for the CDR data for the 2020 reporting cycle is in January 2021. Additional PFAS-related data submitted by CDR sites can be assessed shortly thereafter.

EPA collected and reviewed 15 treatment technology technical articles from a range of sources including EPA publications, federal, state, and local government publications, PFAS manufacturers, and non-governmental organizations (NGOs). Through these articles, EPA identified eight potential technologies that can remove PFAS from wastewater. These include granular activated carbon, reverse osmosis filtration, and ion exchange. A full list of available technologies that EPA has identified to date is included in DCN OCPSF00096.

EPA began stakeholder outreach in July 2019 by meeting with stakeholders to collect, on a voluntary basis, additional information such as supplementary effluent data, information on PFAS compounds being produced/used and discharged, and any information about treatment technologies being used, along with their effectiveness and costs, to augment the available information EPA reviewed. This information gathering effort was performed under the Multi-Industry Study noted above. The information provided by stakeholders is included in DCN OCPSF00042–OCPSF00078.

EPA met with the FluoroCouncil of the American Chemistry Council,[4] the primary trade association that represents PFAS manufacturers and formulators, and its members. See DCN OCPSF00054 for meeting notes. They provided EPA with technical literature concerning PFAS terminology and classification, a list of short chain fluorotelomers studies, an economic assessment of the U.S. fluoropolymer industry, and the names of contacts at entities that they identified as the sole three PFAS manufacturing companies in the United States. These three manufacturers (with a total of six facilities) mirrored the six facilities for which EPA found DMR data and an additional facility for which EPA received internal monitoring data.

EPA met with representatives of one company that operates multiple facilities that manufacture PFAS in West Virginia, New Jersey and North Carolina. They provided EPA with a copy of the presentation they gave during their meeting with the Agency, a copy of a New Jersey facility's NPDES permit, data for an internal outfall at that facility, a document addressing PFAS concerns at a North Carolina facility, and technical literature on fluoropolymers of low concern. See DCN OCPSF00061 for meeting notes and DCNs OCPSF00062 to OCPSF00064 for materials provided.

EPA met with representatives of one company that operates multiple facilities that manufacture PFAS in Alabama, Illinois and Minnesota. Representatives of this company provided EPA with a PFAS production history in addition to current PFAS product categories, wastewater process flow diagrams, copies of their NPDES permits, documentation for a direct injection analytical method, sampling data for both PFAS manufacturing facilities and a formulating facility, and related published literature. See DCN OCPSF00042 for meeting notes and DCNs OCPSF00043 to OCPSF00052 for materials provided.

EPA met with representatives of another PFAS manufacturing facility in Alabama. See DCN OCPSF00065 for meeting notes.

EPA spoke to a representative of another company who stated that the company does not produce PFAS compounds in the United States. EPA learned that this company imports products from international manufacturing facilities and other manufacturers both inside and outside of the United States. Those materials are further processed at a domestic facility in Pennsylvania. See DCN OCPSF00060 for meeting notes. EPA is not aware of any PFAS discharge data from this facility, but EPA is requesting additional information regarding these and similar operations through this notice.

EPA made attempts to contact the other PFOA/PFOS Stewardship Program *https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program*) companies but did not receive any additional information. EPA continues to coordinate with manufacturers to obtain additional information, including a list of PFAS compounds they manufacture, documentation for the analytical methods they use to analyze PFAS in waste streams, and PFAS analytical data collected from source water, process water, and effluent at their facilities.

EPA spoke with representatives of the Michigan Department of Environment, Great Lakes, & Energy (MI EGLE). Michigan EGLE provided EPA with sampling data for 30 direct discharging facilities and 633 indirect discharging facilities across 44 industrial categories, mostly for PFOA and PFOS. See DCN OCPSF00067 for direct discharging data and DCN OCPSF00068 for indirect discharging data provided by MI EGLE.

Four of these facilities were likely PFAS formulators based on the concentrations of PFAS in discharges and the operations of the facilities. EPA also reviewed an investigation report

[2] The information for the CDR is collected every four years from manufacturers (including importers). The 2016 CDR data contains information reported in 2016 and covering 2012 to 2015. *https://www.epa.gov/chemical-data-reporting/basic-information-about-chemical-data-reporting#what*.

[3] EPA's Cross-Agency Research PFAS list, from the CompTox Chemicals Dashboard, is a manually curated listing of mainly straight-chain and branched PFAS compiled from various internal, literature and public sources by EPA researchers and program office representative (*https://comptox.epa.gov/dashboard*).

[4] The FluoroCouncil of the American Chemistry Council has disbanded since EPA last spoke to them.

from EPA's Region 3, looking for potential PFAS sources in Goose Creek, Pennsylvania. From this report, EPA was able to identify another likely PFAS formulator. See DCN OCPSF00038 for report and communications.

V. Request for Further Information on PFAS Manufacturers and Formulators

A. PFAS Manufacturers

EPA has identified six facilities (Alabama, North Carolina, West Virginia, New Jersey, Illinois) in the United States that currently manufacture PFAS compounds and have an associated wastewater discharge.

Throughout the course of EPA's PFAS Multi-Industry Study, the Agency worked collaboratively with stakeholders to obtain information regarding facilities that manufacture and formulate fluorochemicals in the United States. EPA appreciates the information that these entities have provided to the Agency to date.[5] This information has greatly increased the Agency's understanding of current manufacturing facilities, their operations, their production of fluorochemicals, their wastewater generation activities, and their wastewater treatment activities. After reviewing the information received to date, EPA is inviting stakeholders to review this information and provide comment and is seeking additional information and data to inform EPA's next steps.

Specifically, EPA is requesting the following information and data regarding PFAS manufacturers:

1. The identity of or suggestions for how to identify any other facilities in the United States currently manufacturing PFAS.

2. Descriptions of the manufacturing processes being employed at PFAS manufacturing facilities, including process flow diagrams.

3. Information and data on the specific PFAS compounds that are currently being produced (including as byproducts) at these facilities (including the product name, CAS number and class of each compound), the quantities that are being produced, the customers or industries that are purchasing these materials, and the quantities of materials sold to various customers. For sales, EPA is also interested in knowing the quantities of PFAS compounds that are exported outside of the United States.

4. Identification of the wastewater streams at manufacturing facilities that contain PFAS (*e.g.*, process wastewater, cooling water, contaminated stormwater, wastewater from aqueous scrubbers or air pollution control equipment, off-specification products, equipment cleaning wastewater, spills and leaks), their volumes, characteristics, the identity (including CAS Number), and concentrations of PFAS compounds in those individual waste streams.

5. Information and data on the current wastewater treatment and management practices (including pollution prevention and product recovery practices) being utilized at existing PFAS manufacturers. Specific information requested includes descriptions of the treatment technologies, their size and flow rate, process flow diagrams, capital and operation and maintenance costs, treatment chemical utilization, and residuals generation and management. If wastewater storage ponds are used to hold PFAS wastewater, EPA also requests a description of the ponds, including purpose, age, capacity, design, wastewater characteristics, whether they are lined or unlined, and whether they have discharge outfalls.

6. If manufacturers are not treating PFAS containing wastewater onsite, EPA is requesting information on the management or disposal practices being utilized (*e.g.*, zero liquid discharge, disposal wells, transfer to off-site centralized waste treatment facilities or transfer to POTWs), the volumes of wastewaters being managed via different practices, the name and location of the facilities receiving wastewaters, and their associated costs.

7. Information and data on future planned process changes at existing PFAS manufacturing facilities, any plans to change or phase-out manufacture of specific fluorinated compounds or to increase or decrease production of specific compounds, and any planned major upgrades to existing manufacturing facilities or construction of new PFAS manufacturing facilities in the United States. EPA is also requesting information regarding any potential changes in PFAS manufacturing processes, pollution prevention practices or chemicals used as PFAS substitution, or use and cost of specific technologies that can reduce the quantity of PFAS in wastewater from PFAS manufacturing operations.

8. EPA has collected existing publicly available DMR data and monitoring data from known manufacturers, as well as data from TRI and CDR databases, as indicated in the docket. These DMRs contain data on only a subset of the total PFAS that are potentially present in discharges from these facilities. EPA requests additional monitoring data (see DCN OCPSF00115 for suggested data format and fields) on PFAS compounds in wastewater discharges from PFAS manufacturing facilities. Since there is currently no CWA-approved analytical method promulgated for analysis of PFAS compounds in wastewater, EPA requests that monitoring data that is submitted include information on the analytical methods used as well as associated information and data that can be used by EPA to determine the quality of the data. EPA also requests comment on whether additional PFAS compounds or precursors that are not reported in DMRs are found in wastewater discharges from these facilities, and the quantities of such PFAS compounds, precursors, and other organofluoride compounds found in untreated and treated wastewaters from these facilities. In addition to data on individual compounds, EPA is also particularly interested in data that would provide the total quantity of organofluorides present, such as would be provided by a Total Organic Fluorine (TOF) analysis or other assays.

9. In addition to treatment technologies being used at the six known PFAS manufacturing facilities, EPA is requesting additional information and data regarding treatment and destruction technologies for PFAS in industrial wastewater, including data on their performance, costs (both capital and operation and maintenance), and the types, quantities and management practices for any treatment residuals that are generated. Data from laboratory, bench, pilot, and full-scale facilities are requested. EPA also requests comment on the 15 treatment technology articles included in the docket.

10. Analytical methodologies used to monitor wastewater at PFAS manufacturing facilities, including in house SOPs and method performance data, including lists of specific PFAS compounds being monitored, and any aggregate procedures (*e.g.*, adsorbable or extractable organic fluorine by combustion ion chromatography).

11. Any studies that have been conducted concerning environmental or human health impacts (*e.g.*, toxicity, risk, fate and transfer, cross media) of PFAS discharges from PFAS manufacturers.

B. PFAS Formulators

EPA has identified limited publicly available information regarding the universe of PFAS formulators. To date, EPA has identified ten facilities (in Ohio, Virginia, Michigan, Minnesota, Pennsylvania and New Jersey) that are

[5] These data and information are contained in the docket supporting this notice.

potential formulators, but requests additional details regarding formulator facilities.

As with manufacturers, EPA is interested in obtaining additional information and data regarding discharges of PFAS from formulators in order to inform the Agency's decision-making regarding the need for new or revised ELGs for these types of facilities. EPA is requesting the following information and data from PFAS formulators:

1. Identification of all known PFAS formulators in the United States.

2. Descriptions of the manufacturing processes occurring at formulating facilities, including descriptions of how PFAS compounds are utilized at these facilities.

3. The SIC or NAICS codes of formulating facilities.

4. Information and data on the PFAS compounds that are currently being used at these facilities (including the product name, CAS number and class of each compound), the quantities that are being used, the quantities that are being sold or transferred for further processing or as materials for incorporation into finished products, and the customers or industries that are purchasing these materials and products.

5. Information on whether PFAS is being imported by formulators from outside the United States, and if any formulators are exclusively utilizing imported PFAS.

6. The locations and number of formulating facilities, as well as whether process wastewater associated with PFAS formulating is being discharged at these facilities.

7. Whether facilities have current monitoring requirements for PFAS or other fluorocarbons.

8. Information and data on the current wastewater treatment and management practices (including pollution prevention and product recovery practices) being utilized at existing PFAS formulators. Specific information requested includes descriptions of the treatment technologies, their size and flow rate, process flow diagrams, capital and operation and maintenance costs, treatment chemical utilization, and residuals generation and management. If wastewater storage ponds are used to hold PFAS wastewater, provide a description of the ponds including purpose, age, capacity, design, wastewater characteristics, whether they are lined or unlined, and whether they have discharge outfalls.

9. For facilities that discharge process wastewater, whether facilities are subject to national ELGs, and if so, identification of the applicable part(s) and subpart(s) (*e.g.*, 40 CFR 414 Subpart H) and the wastewater discharge permit identification numbers. EPA is also requesting copies of NPDES permits and fact sheets (or statement of basis) for direct discharging facilities, and copies of control agreements for indirect discharging facilities.

10. Process flow diagrams showing where wastewater is generated.

11. Identification of the wastewater streams at formulating facilities that contain PFAS (*e.g.*, process wastewater, cooling water, contaminated stormwater, wastewater from aqueous scrubbers or air pollution control equipment, off-specification products, equipment cleaning wastewater, spills and leaks), their volumes, characteristics, and concentrations of PFAS compounds in those individual waste streams.

12. If formulators are not treating PFAS containing wastewater onsite, EPA is requesting information on the management or disposal practices being utilized (*e.g.*, zero liquid discharge, disposal wells, transfer to off-site centralized waste treatment facilities or transfer to POTWs), the volumes of wastes being managed via different practices, and their associated costs.

13. Information and data on future planned process changes at formulators, any plans to change or phase-out use of specific fluorinated compounds or to increase or decrease production of specific compounds, and any planned major upgrades to existing formulating facilities or construction of new formulating facilities in the United States.

14. EPA has collected existing publicly available DMR data and monitoring data from potential PFAS formulators, as well as data from TRI and CDR databases, as indicated in the docket. These DMRs contain data on only a subset of the total PFAS that are potentially present in discharges from these facilities. EPA requests additional monitoring data (see DCN OCPSF00115 for suggested data format and fields) on PFAS compounds in wastewater discharges from PFAS formulating facilities. Since there is currently no CWA-approved analytical method promulgated for analysis of PFAS compounds in wastewater, EPA requests that monitoring data that is submitted include information on the analytical methods used as well as associated information and data that can be used by EPA to determine the quality of the data. EPA also requests comment on whether additional PFAS compounds or precursors that are not reported in DMRs are found in wastewater discharges from these facilities, and the quantities of such PFAS compounds, precursors and other organofluoride compounds found in untreated and treated wastewaters from these facilities. In addition to data on individual compounds, EPA is also particularly interested in data that would provide the total quantity of organofluorides present, such as would be provided by a Total Organic Fluorine (TOF) analysis or other assays.

15. EPA is interested in information regarding any potential changes in PFAS formulating processes, pollution prevention practices or product substitution, or use and cost of specific technologies that can reduce the quantity of PFAS in wastewater from PFAS formulating operations.

16. Analytical methodologies used to monitor wastewater at PFAS formulating facilities, including in house SOPs and method performance data, including lists of specific PFAS compounds being monitored, and any aggregate procedures (*e.g.*, adsorbable or extractable organic fluorine by combustion ion chromatography).

17. Any studies that have been conducted concerning environmental or human health impacts (*e.g.*, toxicity, risk, fate and transfer, cross media) of PFAS discharges from formulators.

VI. Statutory and Executive Order Reviews

Under Executive Order 12866, titled *Regulatory Planning and Review* (58 FR 51735, October 4, 1993), this is a "significant regulatory action" "because the action raises novel legal or policy issues." Accordingly, EPA submitted this action to the Office of Management and Budget (OMB) for review under Executive Order 12866, and any changes made in response to OMB recommendations have been documented in the docket for this action. Because this action does not propose or impose any requirements, other statutory and Executive Order reviews that apply to rulemaking do not apply. Should EPA subsequently determine to pursue a rulemaking, EPA will address the statutes and Executive Orders that apply to that rulemaking.

EPA welcomes comments and/or information that would help the Agency to assess any of the following: The potential impact of a rule on small entities pursuant to the Regulatory Flexibility Act (RFA) (5 U.S.C. 601 *et seq.*); potential impacts on federal, state, or local governments pursuant to the Unfunded Mandates Reform Act (UMRA) (2 U.S.C. 1531–1538); federalism implications pursuant to Executive Order 13132, entitled *Federalism* (64 FR 43255, November 2, 1999); availability of voluntary consensus standards pursuant to Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law 104–113; tribal implications pursuant to Executive Order 13175, entitled *Consultation and Coordination with Indian Tribal Governments* (65 FR 67249, November 6, 2000); environmental health or safety effects on children pursuant to Executive Order 13045, entitled *Protection of Children from Environmental Health Risks and Safety Risks* (62 FR 19885, April 23, 1997); energy effects pursuant to Executive Order 13211, entitled *Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use* (66 FR 28355, May 22, 2001); Paperwork burdens pursuant to the Paperwork Reduction Act (PRA) (44 U.S.C. 3501); or human health or environmental effects on minority or low-income populations pursuant to Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629, February 16, 1994). The Agency will consider such comments during the development of any subsequent rulemaking.

List of Subjects in 40 CFR Part 414

Environmental protection, Chemicals, Plastics materials and synthetics, Waste treatment and disposal, Water pollution control.

Jane Nishida,

Acting Administrator.

[FR Doc. 2021–05402 Filed 3–16–21; 8:45 am]

BILLING CODE 6560–50–P

DEPARTMENT OF HEALTH AND HUMAN SERVICES

42 CFR Part 100

RIN 0906–AB24

National Vaccine Injury Compensation Program: Revisions to the Vaccine Injury Table

AGENCY: Health Resources and Services Administration (HRSA), Department of Health and Human Services (HHS).

ACTION: Notice of proposed withdrawal; request for comments.

SUMMARY: HHS proposes rescinding the final rule entitled "National Vaccine Injury Compensation Program: Revisions to the Vaccine Injury Table," published in the **Federal Register** on January 21, 2021. That final rule, if it were to go into effect, would amend our regulations by removing Shoulder Injury Related to Vaccine Administration (SIRVA), vasovagal syncope, and the new vaccines category (Item XVII) from the Vaccine Injury Table (Table). HHS seeks comments on this proposed rescission.

DATES: The final rule published January 21, 2021, at 86 FR 6249, delayed February 23, 2021, at 86 FR 10835, is proposed to be withdrawn. Written comments and related material to this proposed withdrawal must be received on or before April 16, 2021.

ADDRESSES: You may submit written comments electronically by the following method: *Federal eRulemaking Portal: http://www.regulations.gov.* Follow the instructions on the website for submitting comments.

Instructions. Include the HHS Docket No. HRSA–2021–0001 in your comments. All comments received will be posted without change to *http://www.regulations.gov.* Please do not include any personally identifiable or confidential business information you do not want publicly disclosed.

FOR FURTHER INFORMATION CONTACT: Please visit the National Vaccine Injury Compensation Program's website, *https://www.hrsa.gov/vaccinecompensation/,* or contact Tamara Overby, Acting Director, Division of Injury Compensation Programs, Healthcare Systems Bureau, HRSA, Room 08N146B, 5600 Fishers Lane, Rockville, MD 20857; by email at *vaccinecompensation@hrsa.gov;* or by telephone at (855) 266–2427.

SUPPLEMENTARY INFORMATION: This is a notice of proposed rulemaking by which HHS proposes to rescind the final rule titled "National Vaccine Injury Compensation Program: Revisions to the Vaccine Injury Table," (final rule), January 21, 2021, 86 FR 6249, delayed February 23, 2021, 86 FR 10835, which, if it were to go into effect, would amend the provisions of 42 CFR 100.3 by removing Shoulder Injury Related to Vaccine Administration (SIRVA), vasovagal syncope, and the new vaccines category (Item XVII) from the Table.

I. Background and Purpose

The National Childhood Vaccine Injury Act of 1986, title III of Public Law 99–660 (42 U.S.C. 300aa–10 *et seq.*) (Vaccine Act), established the National Vaccine Injury Compensation Program (VICP) to ensure an adequate supply of vaccines, stabilize vaccine costs, and establish and maintain an accessible and efficient forum for individuals found to be injured by certain vaccines to be compensated. The Vaccine Act has been amended several times since 1986.

Petitions for compensation under this Program are filed in the United States Court of Federal Claims (Court), with a copy served on the Secretary, who is the "Respondent." The Court, acting through judicial officers called Special Masters, makes findings as to eligibility for, and the amount of, compensation. To be found entitled to an award under the VICP, a petitioner must establish a vaccine-related injury or death, either by proving that a vaccine actually caused or significantly aggravated an injury (causation-in-fact) or by demonstrating the occurrence of what has been referred to as a Table injury. That is, a petitioner may show that the vaccine recipient suffered an injury of the type enumerated in the regulations at 42 CFR 100.3—the Vaccine Injury Table—corresponding to the vaccination in question, and that the onset of such injury took place within a time period also specified in the Table. The Table is accompanied by, among other provisions, the Qualifications and Aids to Interpretation (QAI), which defines the injuries and conditions listed on the Table. If these criteria are met, the injury is presumed to have been caused by the vaccination, and the petitioner is entitled to compensation (assuming that other requirements are satisfied), unless the respondent affirmatively shows that the injury was caused by some factor other than the vaccination (*see* 42 U.S.C. 300aa–11(c)(1)(C)(i), 300aa–13(a)(1)(B)), and 300aa–14(a)). Currently, cases are often resolved by negotiated settlements between the parties and approved by the Court. In such situations, HHS and the Court have not concluded, based upon review of the evidence, that the vaccine caused the alleged injury.

Revisions to the Table are authorized under the Vaccine Act (42 U.S.C. 300aa–14(c)–(e)). The Vaccine Act prohibits the Secretary of HHS from proposing a revision to the Table "unless the Secretary has first provided to the [Advisory] Commission [on Childhood Vaccines] a copy of the proposed regulation or revision, requested recommendations and comments by the Commission, and afforded the Commission at least 90 days to make such recommendations" (42 U.S.C. 300aa–14(d)). Further, once the proposed revision is published, the Secretary must afford the public at least 180 days of public comment (42 U.S.C. 300aa–14(c)(1)).

HHS added SIRVA and vasovagal syncope to the Table in March 2017, following an extensive, multi-year process that involved nine HHS workgroups, including HRSA and the