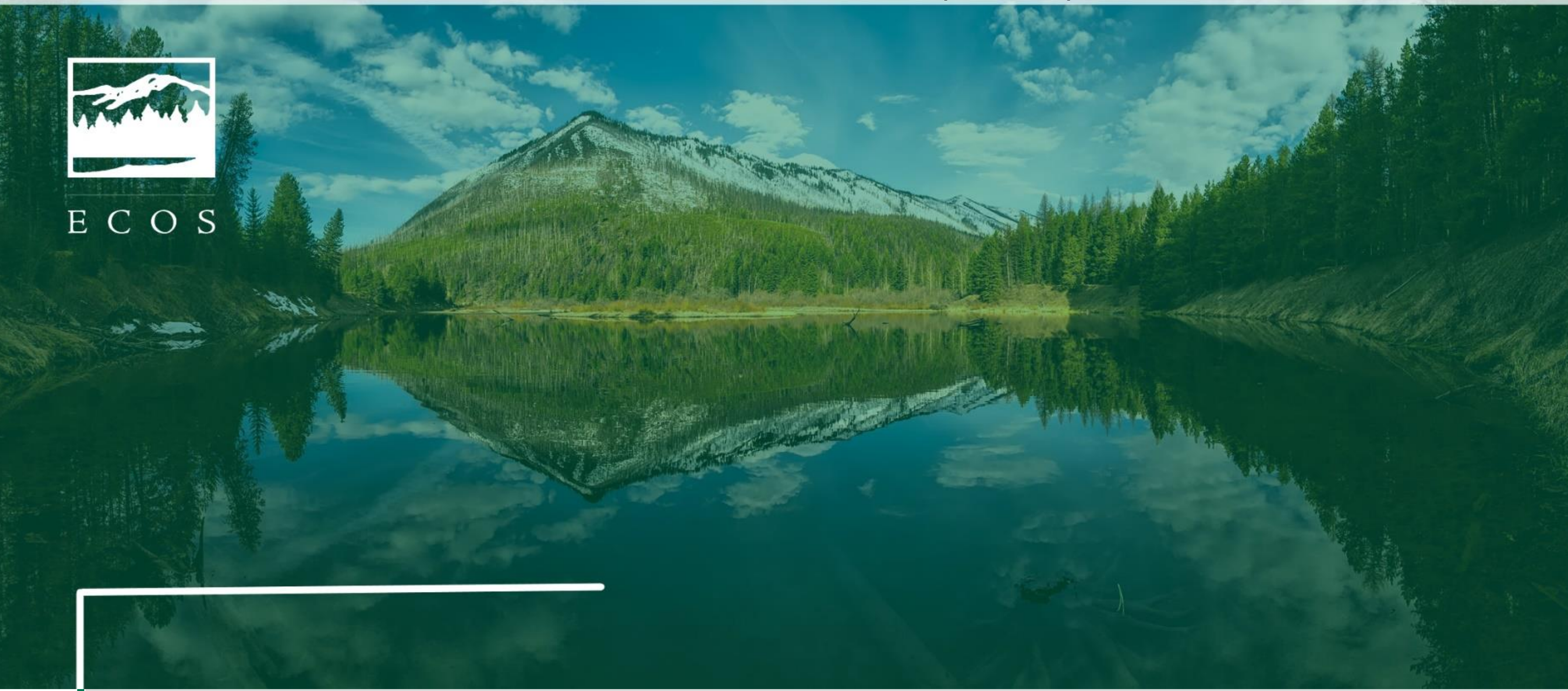
February 2020
Updated April 2021, March 2022, March 2023



Processes & Considerations for Setting State PFAS Standards

By Sarah Grace Hughes, Senior Project Manager, ECOS

Supported by & in conjunction with the ECOS PFAS Caucus

Executive Summary

In recent years, federal, state, and international authorities have established various health-based regulatory values and evaluation criteria for a number of specific per- and polyfluoroalkyl substances (PFAS) in response to growing concerns with contamination. At this time, the U.S. has no federally enforceable PFAS standards, leaving individual states to navigate various avenues for addressing PFAS contamination. Some states have established legally enforceable values for certain PFAS in drinking water, groundwater, surface water, soil, or other environmental media (e.g., drinking water Maximum Contaminant Levels [MCLs]). Other states and regulatory agencies have opted for non-enforceable values such as guidance levels, screening numbers, or advisories that may apply to PFAS for which promulgated standards do not exist.

The Environmental Council of the States (ECOS) in 2019 compiled information on state PFAS standards, advisories, and guidance values (hereinafter referred to as "guidelines"[1]). Sharing data and regulatory approaches helps federal, state, and international authorities avoid unnecessary duplication of efforts, as well as understand and communicate about differences in guidelines. This paper[2] outlines ECOS' findings on state efforts and considerations for future regulatory activities on PFAS.

[1] For the purposes of this paper, the term "guidelines" will apply to both regulatory (enforceable) standards and non-regulatory (non-enforceable) values.
[2] The paper was initially published in February 2020. It was updated with new information and state participants in April 2021, March 2022, and March 2023, and will continue to be updated annually as appropriate.

Table of Contents

Introduction ... 6
Overview of States' PFAS Guidelines ... 9
States without PFAS Guidelines ... 9
States with PFAS Guidelines ... 11
Grouping PFAS ... 12
Individual PFAS ... 12
PFOA & PFOS, Summed ... 14
More than 2 PFAS, Summed ... 15
Evaluating Differences among States' PFAS Guidelines ... 16
Section I. Legislative Considerations ... **17**
Rulemaking Capacities ... 17
Regulating PFAS as Hazardous ... 19
Intra-State PFAS Collaboration ... 22
Impacts of Federal Regulatory & Legislative Uncertainty ... 22
Section II. Risk Assessment ... **24**
Scientific Considerations, Professional Judgment, & Peer Review ... 25
Toxicity Criteria & Methodology ... 25
State Trends on the Basis of Guidelines ... 27
Section III. Risk Management ... **30**
Analytical Methods & Limitations ... 30
Establishing Guidelines ... 34
PFAS Resource (Cost) Issues ... 34
Conclusions ... **37**
State Agency Reports on PFAS Guidelines ... **39**
Appendix A: State Drinking Water PFAS Guideline Criteria ... **41**
Appendix B: State Groundwater PFAS Guideline Criteria ... **50**
Appendix C: State Surface Water PFAS Guideline Criteria ... **60**
Appendix D: State Soil PFAS Guideline Criteria ... **64**
Appendix E: State Air PFAS Guideline Criteria ... **77**
Appendix F: State Fish and Wildlife Consumption PFAS Guideline Criteria ... **80**

List of Acronyms

ACRONYM	FULL PHRASE
ACGIH	American Conference of Governmental Industrial Hygienists
ACWA	Association of Clean Water Administrators
AFFF	Aqueous film-forming foam
APFO	Ammonium perfluorooctanoate
ASDWA	Association of State Drinking Water Administrators
ASTM	ASTM International (formerly American Society for Testing and Materials)
ATSDR	Agency for Toxic Substances and Disease Registry
BMDL	Benchmark dose (lower confidence limit)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIPFPECA	Chloroperfluoropolyether carboxylate
CSF	Cancer slope factor
CTL	Cleanup Target Level
CWA	Clean Water Act
DOD	U.S. Department of Defense
ECOS	Environmental Council of the States
EMEG	Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
ESL	Effect Screening Level
FTE	Full-time employee
FTS	Fluorotelomer sulfonate
GAC	Granular activated carbon
HBV	Health-Based Value
HED	Human equivalent dose
HFPO-DA	Hexafluoropropylene oxide dimer acid
HRL	Health Risk Limit
ISO	International Organization for Standardization
ITRC	Interstate Technology and Regulatory Council
ITSL	Interim Threshold Screening Level
kg	Kilogram
L	Liter
LHA	U.S. EPA Lifetime Health Advisory

LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg	Milligram
MLA	Multi-linear array (SGS Axys method)
MPART	Michigan PFAS Action Response Team
MRL	Minimal risk level
NDAA	National Defense Authorization Act
NEtFOSA	N-ethyl perfluorooctane sulfonamide
NEtFOSAA	N-Ethyl perfluorooctane sulfonamidoacetic acid
NEtFOSE	N-Ethyl perfluorooctane sulfonamidoethanol
NGO	Non-governmental organization
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulation
NRWQC	National Recommended Water Quality Criteria
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutanesulfonic acid
PFDA	Perfluorodecanoic acid
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexane sulfonic acid
PFIB	Perfluoroisobutylene
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFOSA, FOSA	Perfluorooctanesulfonamide
PFUnDA	Perfluoroundecanoic acid
POD	Point of Departure
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
PWS	Public water system
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration

RfD	Reference Dose
RSC	Relative Source Contribution
RSL	Regional Screening Level
RCL	Residual Contaminant Level
SAB	Science Advisory Board
SDWA	Safe Drinking Water Act
SOP	Standard operating procedure
SPE	Solid phase extraction
SPLP	Synthetic precipitation leaching procedure
TOF	Total organic fluorine
TOP	Total oxidizable precursor
TSCA	Toxic Substances Control Act
WAX	Weak anion exchange

Introduction

PFAS are a group of synthetic chemicals used in a wide array of consumer and industrial products since the 1940s. Several decades later, publicly available studies on certain PFAS risks indicated potential human health concerns related to these chemicals. In 2000, 3M announced a voluntary phase-out of certain legacy PFAS (e.g., perfluorooctanoic acid [PFOA], perfluorooctane sulfonate [PFOS], perfluorohexane sulfonic acid [PFHxS]). In 2006, the U.S. Environmental Protection Agency (EPA) initiated the PFOA Stewardship Program, which encouraged eight major chemical manufacturers to eliminate the use of PFOA and similar long-chain[3] PFAS in their products and in the emissions from their facilities.[4] International signatories of the United Nations' Stockholm Convention on Persistent Organic Pollutants treaty voted in 2009 and 2020 to add PFOS and PFOA, respectively, to the list of substances to be eliminated.[5] In 2020, the EPA issued a rule under the Toxic Substances Control Act (TSCA) prohibiting the manufacturing, processing, and/or importing of products containing certain PFAS without prior agency review and approval, and began the process of annually adding certain PFAS to the list of chemicals covered by the Toxics Release Inventory beginning in Reporting Year 2021. In 2022, 3M announced that it will, among other actions, discontinue PFAS manufacturing and the use of PFAS across its products by the end of 2025. Despite these actions, U.S. manufacturers can, with approval, still import PFOA, PFOS, and PFHxS for use in consumer goods, and some U.S. sites are legally required to keep PFAS-containing firefighting foams on-site for emergencies.[6]

U.S. manufacturers have developed numerous PFAS to replace long-chain PFAS such as PFOA, PFOS, and perfluorononanoic acid (PFNA). One example is hexafluoropropylene oxide dimer acid (HFPO-DA) and the HFPO-DA ammonium salt, the two chemical substances that are part of the **GenX** technology developed by Chemours (formerly DuPont), that were developed as PFOA replacements. There are more than 9,000[7] PFAS, some of which the EPA has approved for manufacture and use in the U.S. PFAS pose many problems: they do not break down or, in the case of PFAS that are precursors[8], are converted to terminal PFAS that do not break down, and are very hard to remove and/or destroy with treatment. Therefore, there is a persistent "supply" of PFAS in the environment that maintain their carbon-fluorine chemical structures and potential toxicity, in contrast to many other organic compounds that degrade in the environment over time. Although there have been advances in analytical methods, regulators lack routine analytical methods for PFAS detection and measurement across some environmental media. In addition, limited toxicological data and agreed upon chemical and physical parameters for the majority of PFAS (especially the precursors) are available to define risks to human and ecological receptors. Recently, however, the EPA has added a number of PFAS to the Toxics Release Inventory under Section 313 of the Emergency Planning and Community Right-to-Know Act, a requirement of the 2020 National Defense Authorization Act (NDAA), and has proposed a rule to eliminate an exemption allowing facilities to avoid reporting when PFAS are used at low

[3] Long-chain PFAS are those with carbon chain lengths of 6 or higher for sulfonic acids like PFOS and PFHxS, and carbon chain lengths of 8 or higher for carboxylic acids like PFOA and perfluorononanoic acid (PFNA). In general, perfluoroalkyl acids (sulfonic acids and carboxylates) of all chain lengths do not break down, and long-chain PFAS have been found to bioaccumulate and pose risks to human health and the environment.
[4] **Fact Sheet**, History and Use of Per- and Polyfluoroalkyl Substances (PFAS), Interstate Technology and Regulatory Council (ITRC) (2020). ITRC is a subsidiary of ECOS.
[5] For more information on international PFAS regulations, including the European Union's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) regulation, see the **European Chemicals Agency website**.
[6] The U.S. Department of Defense in January 2023 updated **Military Specifications** (MIL-SPEC), a requirement under the 2020 National Defense Authorization Act, to no longer require the use of fluorinated chemicals. However, the existing performance standard for firefighting foams remains unchanged. Certain airports must remain in compliance by using approved foams that satisfy MIL-SPEC performance requirements.
[7] See U.S. EPA's Master List of PFAS Substances on its **Comptox Chemical Dashboard**
[8] Precursor, as used here, are PFAS, known or unknown, which have the potential to degrade to terminal PFAS that do not break down in the environment.

concentrations. These two efforts should increase regulators' awareness of which PFAS are being manufactured, processed, or otherwise used and at what quantities.

In 2016, the EPA updated its short-term Provisional Health Advisory values for PFOA (400 parts per trillion [ppt]) and PFOS (200 ppt) to a Lifetime Health Advisory (LHA) of 70 ppt for PFOA and PFOS, individually or in combination, in finished drinking water.[9] The EPA stated that this LHA was calculated "to provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water."[10] The LHA is a non-regulatory and non-legally enforceable value, and is intended to provide guidance to federal, state, and municipal governments for addressing PFOA and PFOS contamination in public water systems and private potable wells. In February 2019, the EPA released its **PFAS Action Plan** in which the agency committed to make a "regulatory determination" for PFOA and PFOS under the Safe Drinking Water Act (SDWA). The SDWA requires the EPA to make formal regulatory determinations for at least five contaminants from the most recent drinking water Contaminant Candidate List[11] within five years of the completion of the previous round of regulatory determinations. A positive determination initiates the rulemaking process to establish an enforceable **National Primary Drinking Water Regulation** (NPDWR) (i.e., MCL or Treatment Technique). In January 2021, the EPA announced that it had evaluated more than 11,000 public comments and made a final decision to regulate PFOA and PFOS. This decision was reissued by the new Administration on February 22, 2021. The agency also noted that it intends to fast track evaluation of other PFAS for future drinking water regulatory determinations if necessary data and information are available. In November 2021, the EPA requested that its Science Advisory Board (SAB) review draft scientific documents that support the development of NPDWRs for PFOA and PFOS, as well as a draft document that provides a framework for risk assessment of PFAS mixtures. In the draft documents, the EPA **concludes** that "recent scientific data and new analyses … indicate that negative health effects may occur at much lower levels of exposure to PFOA and PFOS than previously understood and that PFOA is a likely carcinogen." The EPA also has initiated efforts to engage the public on environmental justice considerations for the NPDWR and to obtain input from stakeholders, including small public water systems and state, local, and tribal officials. In June 2022, the EPA **published** interim updated LHAs of 0.004 ppt for PFOA and 0.02 ppt for PFOS, which are based on the draft scientific document mentioned above, as well as final LHAs of 10 ppt for GenX chemicals and 2,000 ppt for PFBS. The EPA stated that these interim LHAs for PFOA and PFOS supersede the 2016 LHA of 70 ppt for the total of the two compounds. In August 2022, the EPA SAB finalized its review of the draft **scientific documents**. The agency has **stated** that the draft scientific basis for its LHAs and NPDWRs for PFOA and PFOS will change in response to the SAB's comments, but that the final LHAs and Maximum Contaminant Level Goals (MCLGs; health-based drinking water concentrations) for these two PFAS are expected to remain below 4 ppt. In the Agency's October 18, 2021 publication of the **PFAS Strategic Roadmap**, the EPA stated that it expected to propose MCLs for PFOA and PFOS in the fall of 2022, with a final rule to follow in late 2023. At the time of this updated publication, the MCLs had not yet been proposed.

In 2021, the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR) finalized **minimal risk levels** (MRLs) for four PFAS: PFOA, PFOS, PFHxS, and PFNA. MRLs are not regulatory values and are not intended to be used as public water or environmental cleanup standards. MRLs are screening tools

[9] In December 2019, the EPA issued **interim guidance** that recommends a screening level of 40 ppt to assess whether the levels of PFOA and/or PFOS present in groundwater at a federal cleanup site may require further investigation. The EPA will use the LHA of 70 ppt as a preliminary remediation goal for contaminated groundwater. While this may be useful to states, many states have their own guidance for PFAS in groundwater.

[10] The **EPA Drinking Water Health Advisories for PFOA and PFOS**

[11] The EPA's **Contaminant Candidate List** (CCL) is a list of contaminants that are currently not subject to proposed or promulgated national primary drinking water regulations, but are known or anticipated to occur in public water systems. It was most recently updated in November 2022 (CCL 5) and includes PFAS as a class, per its structural definition included in the hyperlinked document.

to identify contaminants of concern at hazardous waste sites. If an exposure is below an MRL, it is not expected to result in adverse health effects, whereas an exposure exceeding an MRL warrants further investigation to determine if the exposure might harm human health. Additionally, MRLs are presented in terms of dose (a measurement of exposure in units of milligrams/kilogram/day) and not in terms of concentration (the amount of a substance present in a particular media in units of parts per million [ppm], parts per billion [ppb], or ppt), analogous to Reference Doses (RfDs) developed by the EPA. The ATSDR developed Environmental Media Evaluation Guides (EMEGs) specific to children and adults to convert these dosages into drinking water concentrations that represent about how much water a person can drink each day. Differences among the MRLs, EMEGs, RfDs, and LHAs have resulted in public confusion and emphasize the need for improved risk communication, especially in the news media, to explain that the ATSDR's MRLs and EMEGs and the EPA's RfDs and LHAs are used in different situations and are not/should not be considered "equivalent."

Historically, many states relied on the promulgated standards from federal agencies to regulate chemicals, while other states have had the authority to develop their own standards for contaminants of concern. If no federal standard exists, states may rely on toxicity values from the **EPA Tier 3 Toxicity Value Workgroup document**, the **Regional Screening Levels** list,[12] or similar reference documents. Noting the broad range and complexity of PFAS, the need for cross-media consideration, and the absence of promulgated federal standards, states have taken alternative routes to actively address PFAS across a wide range of programs. At least 27 states[13] have developed draft, proposed, or final health-based regulatory and/or guidance values for several PFAS in drinking water, groundwater, surface water, soil, air, and/or fish and wildlife. These guidelines may significantly differ from the EPA's 2016 and 2022 LHAs and vary from state to state as a result of different legislative and scientific considerations. For example, states may have different mandates (e.g., regulations, policies) that direct them on approaches for the development of human health-based guidelines (e.g., consideration of exposures to sensitive life stages like infants or pregnant women) or require them to use the EPA's toxicity values as the basis for their guidelines. Several states have developed drinking water guidelines for PFOA and PFOS that are lower than the EPA's 2016 LHA of 70 ppt due to considerations of more recent scientific information, more sensitive toxicological endpoints, and/or more stringent exposure parameters. Now, given the EPA's updated interim LHAs which were set at much lower values, most state drinking water guidelines are higher than the interim LHAs. Many states have also developed guidelines for various PFAS in addition to PFOA and PFOS and in environmental media other than drinking water. Other states have adopted the EPA's 2016 LHA for PFOA and PFOS in drinking water and/or groundwater to guide their efforts upon detection of contamination.[14] As of March 2023, none of the states that provided updates to this paper have used the 2022 LHAs for PFOA and PFOS, but several clarified that they are either following the **advice** outlined by the EPA to assess the situation and inform the public about confirmed levels above the new health advisories, that they consider the values but have not used them for decision making or to guide an investigation or cleanup, or that they are waiting for the EPA MCL. Given that the interim LHAs for PFOA and PFOS are well below analytical reporting limits, some states are addressing any detections of PFOA and PFOS.

With a growing body of science to inform standards development, the current absence of a federally enforceable standard, and pressures from the public and legislative bodies to take regulatory action, it is important to know which

[12] In 2022, the EPA added five PFAS (PFOS, PFOA, PFNA, PFHxS, HFPO-DA), for a new total of six PFAS (PFBS was added in 2014 and updated in 2021) to the Regional Screening Levels list. The risk-based values are not cleanup standards but help the EPA determine if further investigations or actions are needed to protect public health and the environment.
[13] Several states in addition to those that completed the ECOS survey are known to have drafted, proposed, or finalized health-based regulatory and/or guidance values for PFAS in various environmental media. They are not included in the facts and figures outlined in this report.
[14] In reference to states that use the 2016 LHA, the health basis for standards for other contaminants of emerging concern may be as low as those for PFAS, but the actual standards for those other contaminants are often higher because they are based on analytical limitations, while the PFAS standards can be set at the 2016 health-based levels.

states are setting guidelines, understand how the guidelines are developed, and be able to educate legislators on differences between state, federal, and other guidelines. This is essential so that states can make informed decisions when establishing their own regulations and/or implementing risk communication practices.

Overview of States' PFAS Guidelines

ECOS surveyed states on their processes, rulemaking requirements, and other considerations for establishing PFAS guidelines (e.g., occurrence of specific PFAS in drinking water sources or other environmental media). ECOS and its working group of state environmental agency officials (the PFAS Caucus) examined responses from 40 states *(Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming).*[15] Below are findings and conclusions from the 40 states that completed the ECOS survey.

States without PFAS Guidelines

13 states *(Alabama, Arizona, Arkansas, Idaho, Kansas, Missouri, Nebraska, Oklahoma, South Carolina, Tennessee, Utah, Virginia, Wyoming)* indicated that they do not have state guidelines.[16]

Reasoning for Not Establishing State PFAS Guidelines:

- 12 states *(Arizona, Arkansas, Idaho, Indiana, Iowa, Kansas, Maryland, Missouri, New Mexico, North Carolina, Oklahoma, Utah)*[17,18] have restrictions that prohibit them from setting a drinking water or groundwater guideline more stringent (i.e., more protective) than a federal standard in at least one environmental medium. This could dissuade a state from setting a PFAS standard (at any level), or from setting a PFAS standard lower than the EPA's LHA in anticipation that a federal MCL may be enacted at a similar level, forcing the state to amend its guideline(s) in a way that appears to "weaken" it.
- Many states lack the capacity or resources to effectively and individually regulate PFAS. Barriers include a lack of one or more of the following: technical expertise needed for toxicity interpretation and standard development, numerical data and established limits for PFAS in various environmental media, labs certified to test for PFAS in the state, cost-benefit analyses (especially to smaller systems), interdependence of programs, legislative support, legal authority, and funding. One state noted it is required to complete an economic impact analysis of treatment, sampling, and analysis before it would be allowed to consider its own guidelines, especially ones that may be more stringent than a federal standard, and therefore it will instead incorporate federal regulations into its state rules to address PFAS.

---

[15] Individual state PFAS websites can be found in the "Overview" section on ECOS' **PFAS Risk Communication Hub**.
[16] These states may use the EPA's 2016 LHA as guidance, remediation goals, action levels, or for regulatory oversight if PFAS contamination is detected. However, they will likely wait for a federal standard before enacting their own state guidelines.
[17] *Indiana, Iowa, Maryland, New Mexico, and North Carolina* are included in this list because they have such a law governing rule-based standards in at least one environmental medium. However, they have a guideline for at least one PFAS analyte, as indicated below. *Iowa* state law prohibits water quality effluent standards from being more stringent than federal standards, but drinking water standards can be more restrictive if certain state law conditions are met (although historically, the state has not adopted drinking water standards for analytes listed in an EPA health advisory).
[18] *North Carolina's* restrictions prohibit setting more stringent standards in drinking water or groundwater. However, the statute does provide exemptions, such as if there is a serious and unforeseen threat to public health, as they pertain only to federal rules, like a MCL under the SDWA.

- There are still limitations to available toxicity data, approved monitoring or analytical methods, and established federal criteria, all of which may contribute to scientific and regulatory uncertainty. Many states noted the need for more peer-reviewed science to make informed decisions on whether to establish guidance levels for some of the PFAS that have been found in their environmental media. States may also have many sites with known contaminants that need to be addressed and must choose to prioritize those over others impacted by emerging contaminants with less available data.

Without their own state-based guidelines, several of these states are still taking actions to inform the public, and to monitor, investigate, and remediate PFAS. Efforts include statewide sampling of public water systems (PWSs) and surface water and groundwater intakes; conducting inventories of facilities that use or have used or produced PFAS; responding to drinking water and fish contamination; notifying local emergency planning committees, fire departments, airports, and industry of the human health and environmental impacts associated with using legacy aqueous film-forming foams (AFFF); sampling potentially-impacted private wells; and forming interagency task forces to coordinate the messaging for and response to PFAS contamination within the state. For example:

- *Alabama* does not currently have any ambient water quality criteria or drinking water standards for any PFAS, but it has begun to include PFAS monitoring and reporting requirements in NPDES permits (new sources and renewals) for certain industry sectors. Based on those results, the state may require facilities to develop and implement a PFAS Minimization Plan to identify and reduce possible PFAS sources in discharge. Alabama has also required all of its public drinking water systems that treat source water to test for PFAS in either 2020 or 2022.
- *Kansas* has also been sampling wastewater from selected municipal wastewater plants around the state and from certain streams with a notable urban presence. The state plans to conduct additional sampling for PFAS in wastewater plants, finished drinking water, streams, and reservoirs in 2023.
- *Missouri* developed a **PFAS webpage** and interactive PFAS map viewer, which is connected to the Safe Drinking Water Information System and reports all public water system PFAS results collected since 2013. The state is collecting occurrence study samples from community and non-community non-transient PWS' with the intent to have PFAS data for all systems by the end of 2025. Missouri is also developing a PFAS dashboard map viewer. By utilizing a variety of data layers, including industry NAICS and SIC codes, Superfund, Federal Facility, and Resource Conservation and Recovery Act (RCRA) sites with PFAS detections, and environmental media sampling, Missouri is identifying potential source locations for exceedances found in public drinking water. The state convened a PFAS workgroup to develop policies and tools related to PFAS, and will provide recommendations by the end of 2023.

Similarly, a few of these states may have changes in guidance based on the federal MCL. *Arizona* noted that it will consider the federal MCL in potentially setting state PFAS water quality standards. *Idaho* said it plans to follow primacy requirements and timelines for adoption once EPA promulgates its final rule, and will include a review and approval by the Board of Environmental Quality and the Idaho Legislature. *Virginia* is evaluating a number of PFAS found in its public drinking water supplies and may consider regulatory action related to monitoring and limits based on the outcome of EPA's PFAS risk assessment and the MCL. States like *Arkansas* and *Utah* specifically noted that they will consider incorporating enforceable federal regulations into their state rules and programs. States with PFAS guidelines also shared thoughts in the March 2023 paper update on how the forthcoming proposal of federally enforceable PFAS standard will impact their current guidelines; see those details on the *Impacts of Federal Regulatory & Legislative Uncertainty* section on page 22.

States with PFAS Guidelines

27 states *(Alaska, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington, Wisconsin)* have a guideline for at least one PFAS in at least one environmental medium.[19]

State guidelines for water and soil specified in ECOS' survey have been incorporated into the ITRC's **PFAS Water and Soil Regulatory and Guidance Values Table**. The table defines which environmental medium each standard applies, as well as whether the values are promulgated or advisory. States may have slightly different definitions of each medium. For example, most states consider drinking water standards to be finished water from the PWSs, but a state may also include groundwater used as drinking water from a private residential well or similar source. ECOS compiled responses based on how the state categorized each medium in the survey and how it defines it generally for the public. For more detailed state-specific definitions, see **state PFAS websites**.

Of the states that responded to ECOS' survey, the following have different types of guidelines:

Regulatory Standards

- Drinking Water[20]: 11 states *(Maine [interim], Massachusetts, Michigan, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Washington, Wisconsin)*
- Groundwater: 13 states *(Alaska, Colorado, Delaware, Iowa, Massachusetts, Michigan, New Hampshire, New Jersey, New Mexico, Pennsylvania, Rhode Island [in process], Texas, Vermont)*
- Surface Water: Four states *(Michigan, Minnesota [site-specific criteria], New Mexico, Wisconsin)*
- Soil: 12 states *(Alaska, Delaware, Iowa, Massachusetts, Michigan, New Hampshire, New Jersey, New Mexico, Pennsylvania, Texas, Vermont, Wisconsin)*
- Air: Two states *(Michigan, New Hampshire)*
- Other: *California* added PFOA and PFOS as developmental toxicants, PFOA and "PFOS and its salts and transformation and degradation precursors" as carcinogens, and PFNA and its salts as male reproductive toxicants to the Proposition 65 list of chemicals known to cause cancer or reproductive toxicity; *Washington* has regulatory standards for PFAS as halogenated organic compounds in state designated hazardous waste, for PFOA and PFOS in children's products, and regulatory requirements for PFAS in Class B firefighting foams, certain consumer products, and certain food packaging

Advisory Guidelines

- Drinking Water: 13 states *(Alaska, California, Connecticut, Hawaii, Illinois, Indiana, Iowa, Maryland, Minnesota, North Carolina, Oregon, Vermont, Wisconsin)*
- Groundwater: 12 states *(California, Colorado, Connecticut, Florida, Hawaii, Illinois, Indiana, Maine, Minnesota, New York, Washington, Wisconsin)*
- Surface Water: Six states *(Colorado, Florida, Hawaii, Minnesota, Oregon [wastewater], Rhode Island [in process])*
- Soil: Nine states *(California, Connecticut, Florida, Hawaii, Indiana, Maine, Minnesota, New York, Washington)*
- Air: Three states *(Minnesota, New Jersey, Texas)*

[19] These include promulgated or interim rules and advisories (e.g., action and notification levels, cleanup target levels, initiation levels), and may be determined by the state or may be consistent with EPA's 2016 LHA of 70 ppt.
[20] See States with a Final or Proposed MCL (Drinking Water Only) designation below.

- Fish or Wildlife Consumption Advisories[21]: 12 states (*Connecticut [fish], Delaware [in process], Hawaii [in process], Maine [fish, beef, milk, and deer], Maryland [fish], Michigan [fish and deer], Minnesota [fish], New Hampshire [fish], New Jersey [fish], New York [fish], Washington [in process], Wisconsin [fish and deer]*)

States with a Final or Proposed MCL (Drinking Water Only)

- *Delaware* (Proposed for PFOA and PFOS, individually and summed)
- *Massachusetts* (Enacted for six PFAS, individually and summed)
- *Michigan* (Enacted for seven PFAS, individually)
- *New Hampshire* (Enacted for four PFAS, individually)
- *New Jersey* (Enacted for PFOA, PFOS, and PFNA, individually)
- *New York* (Enacted for PFOA and PFOS, individually)
- *Pennsylvania* (Enacted for PFOA and PFOS, individually)
- *Rhode Island* (In process for 6 PFAS)
- *Vermont* (Enacted for five PFAS, individually and summed)
- *Wisconsin* (Enacted for PFOA and PFOS, individually and summed)

Grouping PFAS

Proposed congressional legislation suggested creating a federal MCL for total PFAS, derived by adding the concentration of each PFAS detected in a sample. This total PFAS concentration depends on which analytical methods are used, as different analytical methods detect different suites of PFAS and have different reporting levels. Given that there are more than 9,000 PFAS, most of which have little known information about their toxicities, some regulators and subject-matter experts advise against grouping PFAS as an entire class, while other regulators and experts are considering all of the thousands of PFAS as a class based on common properties such as environmental persistence. Additionally, some state guidelines address PFOA, PFOS, and other specific PFAS individually, while other state guidelines are based on the total concentration of PFOA and PFOS, as the EPA does in its LHA, or on the total concentration of PFOA, PFOS, and several additional specific long-chain PFAS, based on the assumption of similar toxicological and toxicokinetic properties.

States' approaches for grouping PFAS, and the reasoning provided for grouping PFAS under each method, are as follows:

Individual PFAS

- 22 states
  - *Alaska*: Soil and groundwater cleanup levels for PFOA, PFOS
  - *California*: Non-regulatory notification levels and response levels for PFOA, PFOS, PFBS, and PFHxS in drinking water; Non-regulatory environmental screening levels for PFOA, PFOS in soil, groundwater, aquatic habitat, terrestrial habitat, and leaching to groundwater
  - *Connecticut:* Advisory action levels for PFOA, PFOS, PFNA, PFHxS in drinking water; Fish tissue consumption advisories for PFOS in some waterbodies
  - *Delaware:* Proposed MCLs for PFOA, PFOS individually and summed; Hazardous substance screening values reflecting Regional Screening Levels for PFOA, PFOS, PFHxS, PFNA, PFBS, and HFPO-DA in groundwater implemented through its risk-based cleanup program

[21] Advisories apply to fish only, unless otherwise noted.

- *Florida:* Provisional Soil Cleanup Target Levels for PFOA, PFOS; Provisional Irrigation Water Screening Levels for PFOA, PFOS; Surface Water Screening Levels for fish consumption for PFOA, PFOS[22]
- *Hawaii:* Action levels for PFOA, PFOS, PFNA, PFBS, PFHxS, PFHpS, PFDS, PFBA, PFPeA, PFHxA, PFHpA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFOSA, HFPO-DA, 6:2 FTS in drinking water, groundwater, surface water, soil
- *Illinois:* Advisory levels for PFOA, PFOS, PFBS, PFHxS, PFNA, HFPO-DA in drinking water and groundwater
- *Indiana:* Guidance Remediation Screening Levels for PFOA, PFOS, PFBS, PFHxS, and PFNA in drinking water, groundwater, and soil
- *Iowa:* Groundwater and soil standards for PFOA, PFOS, PFBS, PFNA, PFHxS, HFPO-DA; Public notice minimum reporting requirements for PFOA, PFOS in finished drinking water samples above the EPA health advisory
- *Maine:* Screening levels used as remedial action guidelines for PFOA, PFOS, and PFBS in soil and fish, and for PFOS in milk and beef
- *Maryland:* Drinking water advisory level for PFHxS as a requirement for impacted water utilities to provide alternative water to customers;[23] Site-specific fish consumption advisory for PFOS
- *Michigan*: MCLs for 7 PFAS (PFOA, PFOS, PFNA, PFHxA, PFHxS, PFBS, HFPO-DA); Surface Water Quality Standards for PFOA, PFOS, PFBS; Groundwater cleanup criteria for 7 PFAS (PFOA, PFOS, PFNA, PFBS, PFHxA, PFHxS, HFPO-DA); Soil Criteria for Groundwater-Surface Water Interface protection for PFOA (in process of updating), PFOS; Consumption advisories for PFOS in fish and deer tissue; Initial Threshold Screening Levels (ITSLs) for PFOA, PFOS, 6:2 fluorotelomer sulfonate (FTS)
- *Minnesota:* Promulgated Health Risk Limits (HRLs) for PFOA, PFOS, PFBA, PFBS in groundwater[24]; Health-Based Values (HBVs) for PFOA, PFOS, PFBS, PFHxS, PFHxA in groundwater; Rule-based Intervention Limits for PFOA, PFOS, PFBA, PFBS to protect surface water and groundwater at solid waste facilities; Soil Reference Values for PFOA, PFOS, PFBS, PFBA, PFHxS, PFHxA; Site-Specific Water Quality Criteria for PFOA, PFOS, PFBS, PFBA, PFHxS, PFHxA in surface water; Fish Consumption Advice for PFOS; Risk-Based Inhalation Values for PFOA, PFOS, PFHxS, PFBA, PFBS, PFHxA in air
- *New Hampshire:* MCLs and Ambient Groundwater Quality Standards for PFOA, PFOS, PFHxS, PFNA; Soil contact value for PFOA, PFOS, PFHxS, PFNA for evaluating sites[25]; Ambient air limit for APFO; Fish consumption advisories for PFOS in some waterbodies
- *New Jersey:* MCLs and Groundwater Quality Standards for PFOA, PFOS, and PFNA; Interim Specific Groundwater Quality Standard for chloroperfluoropolyether carboxylates (ClPFPECAs); Interim Soil Remediation Standards for PFOA, PFOS, PFNA, GenX; Consumption Advisories in waterbodies where fish have been monitored for PFOS, as well as for PFNA or PFUnDA at some sites; inhalation Reference Concentrations (RfCs) for PFOA, PFOS; screening inhalation RfC for HFPO-DA (GenX)
- *New Mexico:* Groundwater and surface water standards for PFOA, PFOS, PFHxS; soil and tap water screening levels for PFOA, PFOS and its potassium salt, PFBS and its potassium salt, PFNA, PFHxS

---

[22] *Florida* developed Provisional Groundwater and Soil Cleanup Target Levels (CTLs) in accordance with rules 62-780.150 and 62-780.650, Florida Administrative Code. The Provisional CTLs are considered enforceable as they were generated in accordance with the process established in these rules that allows for the development of CTLs.
[23] This may include acquisition of an alternative water source, improvements to the construction of the existing source, connection to another water system, or treatment of the source. If treatment is installed, the system is asked to conduct quarterly monitoring if feasible.
[24] *Minnesota's* Health Risk Limits and Health-Based Values for groundwater are also used as guidance values for drinking water.
[25] Pursuant to state law RSA 485-H:13, the *New Hampshire* Department of Environmental Services is required to initiate rulemaking for Soil Remediation Standards by November 1, 2023 for the four PFAS (PFOA, PFOS, PFHxS, and PFNA) currently regulated in groundwater and drinking water in the state.

- *New York:* MCLs, water quality guidance values, groundwater effluent limitations, interim soil cleanup objectives, and fish advisories for PFOA, PFOS; Chronic annual guideline concentration values for 5 individual PFAS (PFOA and its salts) listed in DAR-1 in ambient air
- *North Carolina:* Non-Regulatory Drinking Water Health Goal for HPFO-DA (GenX)
- *Oregon:* Initiation levels for PFOA, PFOS, PFNA, PFHpA, PFOSA in municipal wastewater effluent
- *Pennsylvania:* MCLs for PFOA, PFOS; Medium-specific concentrations for PFOA, PFOS, PFBS as groundwater and soil cleanup values
- *Texas:* Health-Based Non-Carcinogenic Toxicity Factors and Cleanup Values for 16 PFAS (including PFOA and PFOS) in soil and groundwater; interim short- and long-term Effects Screening Levels (ESLs) for PFOA, PFOS in air permitting; Chronic, non-carcinogenic reference concentrations for nine PFAS in air for remediation
- *Washington:* Action levels for PFOA, PFOS, PFNA, PFHxS, PFBS in drinking water; Preliminary soil and groundwater cleanup levels for PFOA, PFOS, PFNA, PFHxS, PFBS, HFPO-DA (GenX); Fish Consumption Advisory for PFOS; Regulatory standards for PFOA, PFOS in children's products under the Children's Safe Products Act
- *Wisconsin:* Proposed health guidelines for 18 PFAS in drinking water and groundwater; Residual Contaminant Levels (RCLs) for PFOA, PFOS, PFBS in Soil, based upon the EPA Regional Screening Levels (RSLs) web calculator; Fish and wildlife consumption advisories for PFOS

- Reasoning:

  - Risk assessors evaluate PFAS analytes individually in the regulatory determination process. Regulations are therefore based on conclusions that human health effects, analytical limitations, and removal of drinking water contaminants vary among PFAS.
  - Regulations vary based on the presence of PFAS in a state, availability of chemical guidelines used for testing, and ability of available labs to test for and measure that analyte. States with more limited contamination potential and evaluations of health effects may be waiting to see whether the EPA develops a technical basis for grouping PFAS before summing or regulating additional analytes.
  - Toxicologists have more data on the perfluoroalkyl acids (carboxylates and sulfonates) that are a result of the terminal degradation process of PFAS precursors, and less on the PFAS precursors and other non-perfluoroalkyl acids in the same family.
  - Toxicological studies demonstrate differences in the potency and bioaccumulation (i.e., physiological half-lives) among individual PFAS.

PFOA & PFOS, Summed

- Eight states

  - *Alaska*: Drinking water action level for PFOA and PFOS
  - *Delaware:* Proposed MCLs for PFOA, PFOS individually and summed
  - *Florida*: Provisional Groundwater Cleanup Target Level for PFOA and PFOS, individually or combined
  - *Maryland:* Drinking water advisory level for PFOA and PFOS as a requirement for impacted water utilities to provide alternative water to customers.[26]

[26] This also may include acquisition of a new source, improvements to the construction of existing wells, connection to other water systems, or installation of treatment. If a system installs treatment, they are asked to conduct quarterly monitoring to ensure that it is effective. Certain water systems may be asked to conduct semi-annual monitoring depending on the concentrations of PFOA and PFOS.

- *New Mexico:* Groundwater standard for PFOA and PFOS; surface water screening level for PFOA and PFOS implemented through Clean Water Act (CWA) Section 401 conditional certification of a National Pollutant Discharge Elimination System (NPDES) permit
- *Pennsylvania:* Medium-specific concentrations for PFOA and PFOS, individually or summed, as groundwater and soil cleanup values
- *Rhode Island:* Drinking water standard for the sum of PFOA and PFOS
- *Wisconsin*: Drinking water standard for PFOA and PFOS

- Reasoning:
  - Regulating PFOA and PFOS aligns with the EPA's LHA. While the EPA has developed draft toxicity factors for a few other PFAS, PFOA and PFOS remain the only analytes with federal health advisories.
  - Regulating PFOA and PFOS together can streamline processes given their similar characteristics and known toxicities. PFOA and PFOS are the most thoroughly studied of the long-chain PFAS, with a large quantity of publicly available toxicity information available, and are considered hazardous substances or listed as a similar toxicant under some states' laws.

More than 2 PFAS, Summed or Otherwise Grouped

- 13 states
  - *California:* Identification of PFOS and its salts and transformation and degradation precursors as carcinogens, and PFNA and its salts as male reproductive toxicants, under California's Proposition 65 law. Enforcement action can be applied to any compounds within these groups.
  - *Colorado*: Policy interpreting narrative groundwater and surface water quality standards for PFAS sums PFAS constituents based on endpoint toxicity (e.g., PFOA, PFOS, PFNA, and any identified parents are added together based on developmental toxicity; PFHxS and any identified parents are added together based on endocrine toxicity; PFBS and any identified parents are added together based on renal toxicity)
  - *Connecticut:* Advisory groundwater protection criteria, groundwater pollutant mobility criteria (soil leaching to groundwater), and soil direct exposure criteria for the sum of 5 PFAS (PFOA, PFOS, PFNA, PFHxS, PFHpA)
  - *Maine:* Interim drinking water standard for the sum of 6 PFAS (PFOA, PFOS, PFNA, PFHxS, PFHpA, PFDA) for community water systems and non-transient, non-community water systems that are schools or childcare facilities; Screening levels used as groundwater remedial action guidelines for the sum of 5 PFAS (PFOA, PFOS, PFNA, PFHxS, PFHpA)
  - *Massachusetts:* MCL and groundwater cleanup standard for the sum of 6 PFAS (PFOA, PFOS, PFNA, PFHpA, PFHxS, PFDA)
  - *Minnesota*: MN's **Health Risk Limits Rules for Groundwater** require evaluation of exposure to multiple contaminants in groundwater. Hazard ratios are summed across contaminants that affect the same health endpoints. An **Excel-based calculator** has been created to facilitate cumulative assessments. For example, PFOA, PFOS, PFHxS, PFHxA, PFBS, and PFBA all affect the thyroid and the hazard ratios for each of these contaminants would therefore be added together to calculate a multiple contaminant health risk index.
  - *New Mexico:* Narrative groundwater standard implemented through risk assessment guidance that provides for summation of PFOS, PFOA, PFHxS
  - *Oregon:* Health Advisory Levels for PFOA, PFOS, PFNA, and PFHxS in drinking water
  - *Vermont:* MCL and promulgated groundwater standard for the sum of 5 PFAS (PFOA, PFOS, PFNA, PFHpA, PFHxS)

- *Rhode Island:* Legislative requirement to set a MCL, groundwater cleanup standard, and surface water quality action level for the sum of 6 PFAS (PFOA, PFOS, PFHxS, PFNA, PFHxA, PFDA)
- *Washington:* Regulatory standard for the sum of all PFAS in state-designated hazardous waste when halogenated organic compounds are present; Regulatory standards for the sum of all PFAS in certain consumer products under the Pollution Prevention for Health People and Puget Sound Act, Class B firefighting foams, and certain food packaging.
- *Wisconsin:* Proposed groundwater enforcement standard and health advisory limit for the sum of PFOA, PFOS, and four of their precursors (FOSA, NEtFOSA, NEtFOSAA, and NEtFOSE). Wisconsin uses a **hazard index approach** to establish drinking water advisories for PFAS. Hazard quotients for detected PFAS with standards are added and compared to a value of 1.

- Reasoning: Many of the summed PFAS analytes are similar as indicated below:
  - They are long-chain compounds with similar chemical structures (+/- two carbons in chain length) to PFOA and PFOS.
  - They are often found together in the environment and have characteristically similar bioaccumulative patterns and fate and transport mechanisms.
  - Human exposures to these PFAS often are correlated, making it difficult to differentiate the contributions of the individual PFAS to health effects observed in humans.
  - Their toxicity is assumed to be additive based on a substantial body of publicly available data indicating that they cause similar toxicological effects, have long serum half-lives in humans (long-chain PFAS only), and are associated with similar health effects in humans.[27]
  - They have similar limits for lab detection via EPA Method 537.1 (see the *Analytical Methods* section on page 30), and there is a minimal cost difference between analyzing a few or 18 compounds, so regulating and requiring testing for more analytes does not increase the cost and lessens the potential for the need to resample in the future.
  - PFOA, PFOS, PFNA, PFHxS, PFHpA, and PFBS were the six PFAS included in the EPA's third round of the Unregulated Contaminant Monitoring Rule (UCMR3). These PFAS have been researched to the extent that they are regulated individually by some states. PFHpA has minimal toxicity data available and PFDA was not included in UCMR3, but some states regulate both of these PFAS with the other long-chain PFAS based on close structural similarity and their inclusion as analytes in the EPA's analytical methods for drinking water.[28]
  - Regulating more analytes can provide information on conceptual site model development and the potential for PFAS fingerprinting (forensics on the fate and transport of chemicals over time).

Evaluating Differences among States' PFAS Guidelines

One of the most common questions that states are asked to address when communicating risks to the public and co-regulators is why guidelines vary from state to state. Many of the states' derived values typically differ within a factor of two to three, indicating that they are similarly protective; however, this is difficult to communicate with audiences who lack a background in the scientific and regulatory basis for the guidelines. Consequently, communicating the rationale for varying guidelines among state and federal entities remains a challenge.

---

[27] On the other hand, though similar, these PFAS do still present differences (e.g., different levels at which toxicity occurs, different toxicological effects and modes of action) that a state might acknowledge as a reason *not* to group the chemicals, but rather to regulate them individually.
[28] This list of PFAS is expected to expand in 2023-2025 as PWSs will be required under UCMR5 to monitor for all 29 PFAS that are within the scope of EPA methods 537.1 and 533.

States report that deviations among PFAS guidelines are driven by several main factors:

- Differences in professional judgments regarding the choice of the critical study and endpoint, whether animal or human data are used, the method for animal-to-human extrapolation, the uncertainty factors, and exposure parameters such as the Relative Source Contribution. Differences in any one of these choices (described in more detail in the *State Trends for the Basis of Guidelines* section on page 27) will result in different numerical values for the PFAS standard being developed.[29]
- Differences in timing. *When* guidelines are developed and *when* a state looks at the available scientific information affects *what* the guidelines are. While many technically sound guidelines have been developed from older studies, toxicologists and epidemiologists continue to conduct new PFAS research that will provide states with more referential data for deriving values. In this fast-paced field, short timeframes can change what studies relevant to PFAS standard development are available.
- Differences in state legislative or rulemaking requirements. The next section of this paper will explore differences in legislative procedures, but it should also be noted that beyond legislatures, state environmental and health agency programs (e.g., drinking water, surface water, wastewater, remediation, air, and others) have varying priorities or responsibilities in the standard-setting process.
- Differences in state regulatory processes and histories. States have different histories of developing standard methods, enacting regulations, and setting policy, all of which may direct toxicologists to use specific approaches and require protection of certain human life stages/vulnerable populations or other factors. *Minnesota*, for example, is required to evaluate risks to pregnant women and children in its exposure assumptions. *Washington* chose to regulate PFAS as a class in certain consumer products under the Toxic Pollution law, Class B firefighting foams under the Firefighting Agents and Equipment – Toxic Chemical Use law, and certain food packaging under the Packages Containing Metals and Toxics Chemicals law. These factors, coupled with how well a state's standard-setting methods reflect current and evolving science, can greatly affect how guidelines are calculated and what the resulting values are.

Section I. Legislative Considerations

Rulemaking Capacities

ECOS asked states to describe what authorities and processes they had to set PFAS guidelines. Responses indicate that most state guidelines are adopted/enacted through general rulemaking processes outlined in state administrative policies or acts, while some states have bills or statutes specifically targeted to PFAS. Examples of categories of such rulemakings besides those specifically setting PFAS guidelines include:

- Consumer products. The *California* Department of Toxic Substances Control's Safer Consumer Products Program lists PFAS as Candidate Chemicals and evaluates PFAS in consumer products like carpets, rugs, treated textiles, and leathers in accordance with its Safer Consumer Products Regulations. *Colorado* has passed bills banning certain products containing PFAS starting in 2024. *Maine* is requiring all manufacturers intentionally adding PFAS to any product to report such actions to its Department of Environmental Protection by 2023; is banning PFAS in carpets, rugs, and fabric treatments by 2023; and is banning all PFAS in products (unless unavoidable) by 2030. Rulemaking for the implementation of this program will continue into 2023. *Washington* is in the rulemaking process to restrict PFAS as a class in carpets and rugs, furniture and furnishings intended for indoor use, and aftermarket stain and water resistance treatments, and is in the rulemaking process to require reporting of PFAS used in outdoor furniture and furnishings. The *Vermont* legislature in 2021 passed a

[29] An August 2020 **critical review** published in the Society of Environmental Toxicology and Chemistry's online journal discusses some of the toxicity and exposure considerations that lead to similarities and differences among state and federal guidelines.

regulation banning PFAS from certain commercial products, including personal protective equipment, rugs and carpets, and ski wax. *New York* signed into law the Toxic Chemicals in Children's Products Law, which establishes an ingredient disclosure program and prohibits certain chemicals in children's products.

- Food packaging. The *California* Department of Resources Recycling and Recovery adopted several regulations imposing statewide restrictions on PFAS in food packaging, including one that establishes a threshold of 100 ppm total fluorine concentration for "compostable" and "recyclable" food service packaging served at food service facilities that are state-owned, operated on state property, or under contract with the state.[30] *Maine* is prohibiting the use of PFAS in food packaging if safer alternatives are available at comparable cost and function. Rulemaking for the implementation of this program will continue into 2023. Manufacturers of food packaging in *Maryland* must establish a certificate of compliance showing that PFAS was not intentionally added. *Washington* prohibits the use of PFAS in those types of food packaging where available safer alternatives have been identified. In 2021, the *Vermont* legislature passed a regulation banning PFAS in food packaging, and the *Connecticut* legislature passed updates to the state's Toxics in Packaging Law to include a prohibition on intentionally-added PFAS in food packaging, which will go into effect on January 1, 2024. The *Rhode Island* legislature in 2022 similarly passed a regulation prohibiting the sale or promotional distribution of any food packaging containing intentionally-added PFAS beginning in 2024. *New York* enacted the Hazardous Packaging Act, Title II of Article 37 of the state's Environmental Conservation Law, which applies specifically to food packaging with intentionally-added PFAS.
- AFFF. *Arizona* recently revised a statute prohibiting the use of AFFF for training or testing purposes unless those activities are conducted using proper containment, treatment, and disposal measures approved by the state. *California* legislation amended the state Health and Safety Code to prohibit AFFF beginning January 1, 2022; ban AFFF training classes; restrict unused foam disposal; and track sales of and require notice of PFAS in personal protective equipment. *Colorado* has passed bills to prevent further contamination from AFFF. *Indiana* state law IC 36-8-10.7 prohibits the use of PFAS-containing firefighting foam for training purposes and requires containment, treatment, and disposal measures when used for testing purposes. *Maine's* legislature enacted a law in 2021 prohibiting the discharge of firefighting or fire suppressing foam for testing or training to which PFAS have been intentionally added; requiring the reporting of discharges to the state's Department of Environmental Protection; enacting a notice and recall provision; and prohibiting the manufacture, sale, and distribution of intentionally-added PFAS to firefighting foams. Report on the Implementation of an Act to Restrict the use of PFAS Substances in Firefighting Foam was submitted to the 130th Maine legislature on March 2, 2022. In 2018, *Washington* law prohibited the use of AFFF containing intentionally-added PFAS for training purposes. In 2020, under the state's Firefighting Agents and Equipment – Toxic Chemical Use Law, the manufacture, sale, or distribution of AFFF with intentionally-added PFAS was prohibited in most cases. The *Vermont* legislature in 2021 passed a regulation banning PFAS in AFFF. Also in 2021, the *Connecticut* legislature passed a law banning training with Class B firefighting foam containing intentionally-added PFAS effective July 13, 2021, and most other uses effective October 1, 2021. The law also required implementation of an AFFF takeback program for municipal fire services. The AFFF ban allowed a later effective date (October 1, 2023), for airports, and provisions for chemical facilities, oil refineries, and terminals to request a two-year extension for transitioning. *Rhode Island* recently developed draft legislation to require extra measures for storage of AFFF and limiting the use of these foams for training in environmentally-sensitive areas. *New York* enacted restrictions on the sale and use of firefighting equipment containing PFAS. The law also includes a recall provision where manufacturers of restricted Class B firefighting foam must "recall the product, which includes collection, transport, treatment, storage and safe disposal," and that the manufacturers "reimburse the retailer or any other purchaser of the product."
- Air toxics. Since 1997, *New Hampshire's* state air toxics regulation has contained annual and 24-hour inhalation standards for APFO, the ammonium salt of PFOA. Additionally, New Hampshire is required by state statute to write rules and require the installation of best available control technology for PFAS and PFAS precursor air

[30] Total fluorine measurements are a reliable proxy for determining the presence of PFAS in food service packaging.

emissions that may have contributed to ambient groundwater or surface water quality standards. *New York* currently has five PFAS with chronic ambient air concentration values under its state regulations.

- Water sampling and investigation. Many states have or are in the process of enacting laws or taking other steps to require sampling of all statewide PWSs. Additionally, states are sampling and investigating non-drinking water sources. For example, *Maine* is conducting statewide soil and groundwater testing for PFAS at or associated with sludge and septage land application sites and testing landfill leachate, assessing fees for sludge and septage handlers that will go towards PFAS investigation and treatment funds, and coordinating with other agencies on PFAS impacts to active agricultural operations and pesticide uses. *New Jersey* revised its regulations to add PFOA, PFOS, and PFNA to the list of contaminants that must be analyzed in private wells when a residential property is sold and in rental residences served by private wells.
- Land application of residuals (sludge and septage). The 130th *Maine* legislature, in Public Law 2021, Chapter 641, banned the land application of sludge and sludge-derived products beginning August 8, 2022.[31] This does not include all sludges (some sludges are specifically exempt in statute) and it does not ban the licensed land application of septage. While Maine is the only state with a ban on land application, some other states have taken or are considering rulemaking pertaining to PFAS in biosolids, more information for which can be found in ECOS' ***PFAS in Biosolids: A Review of State Efforts & Opportunities for Action***, published in January 2023.

These examples represent only a few of the active state PFAS bills and other regulatory actions prohibiting AFFF for firefighting, regulating food packaging, and requiring PFAS sampling, among other actions. States active in PFAS regulation are typically backed by their legislators, Attorneys General, and other leadership entities that provide funding and direct the environmental agencies to take action on contamination. Such actions include forming task forces for improved coordination (see the *Intra-State PFAS Collaboration* section on page 21), setting guidelines in different media by certain dates (e.g., *Vermont*), or initiating directives or lawsuits against PFAS manufacturers or the DOD (e.g., *Minnesota*, *New Jersey*, *New York*, *New Mexico*).

Enforcement of state regulations is typically a programmatic issue specific to the contaminated medium and is conducted in accordance with rules or policies in effect for each regulatory program (e.g., Superfund and hazardous waste, RCRA, SDWA). Consequently, enforcement efforts for PFAS in drinking water, groundwater, surface water, solid waste, biosolids, and other environmental media are led by the state agency with authority to administer the applicable rules, and would be conducted as directed by program rules, unless specific rules for PFAS have been adopted. A couple of states indicated that they may rely on the state Attorney General for broader authorities or look to primacy agreements with the EPA. Enforcement may occur if a regulatory standard is exceeded, the contamination is considered hazardous, or there is a requirement for assessment and remediation. Some states noted that PFAS enforcement is a challenge without having adequate toxicity data necessary to establish the criteria on which a permit limit or enforcement/remediation action is based.

Regulating PFAS as Hazardous

22 states *(Alaska*, *Arkansas*, *Connecticut*, *Florida*, *Hawaii*, *Indiana*, *Iowa*, *Maine*, *Maryland*, *Massachusetts*, *Minnesota*, *New Hampshire*, *New Mexico*, *New York*, *Pennsylvania*, *Rhode Island*, *Utah*, *Vermont*, *Virginia*, *Washington*, *Wisconsin*, *Wyoming)* noted that they have emergency rulemaking powers that can be invoked in the event of a PFAS contamination event or if a specific PFAS is declared hazardous at the federal level.

Several states also regulate PFAS as hazardous under certain conditions. For example, *Alaska* includes PFOA and PFOS in a list of hazardous substances for which groundwater and soil cleanup levels are set. *Delaware's* Hazardous

[31] This action was taken in response to the detection of PFAS-contaminated milk, resulting from PFAS in the biosolids that were applied to dairy farms in the state.

Substance Cleanup Act lists PFOA, PFOS, PFHxS, PFNA, PFBS, and HFPO-DA as hazardous substances with screening values reflecting Regional Screening Levels in groundwater through a risk-based cleanup program. *New Jersey* added PFNA to the NJ Hazardous Substance List in 2018, and added PFOA and PFOS to the list in 2020. *New York* regulates PFOA and PFOS as hazardous substances under 6 NYCRR Part 597. Although *New Mexico* cannot adopt rules more stringent than the federal government under its Hazardous Waste Act, it can include PFAS in RCRA corrective action permits and take action in response to a PFAS contamination event of which the quantity, concentration, or other characteristics of the waste threaten human health or the environment. In October 2021, the *Washington* Department of Ecology announced that PFAS are hazardous substances under the state's Model Toxics Control Act. Ecology released draft guidance in December 2022 for public review and comment that provides direction on how to address PFAS contamination in the state. *Maine* adopted Public Law, Chapter 117 in June 2021 redefining hazardous substances in the state to be consistent with the definition of CERCLA, including a CERCLA "pollutant or contaminant" which opens the door for PFAS contamination to be considered, evaluated, or managed under Maine's uncontrolled site law. *Minnesota* considers PFAS to be hazardous substances under the Minnesota Environmental Response and Liability Act. *Oregon* is working on a draft strategic plan in 2023 that will include rulemaking options for regulating PFAS as hazardous. Lastly, *Rhode Island* regulates six PFAS as hazardous under state law.

While the federal government has in the past considered designating PFOA and PFOS as hazardous substances, as outlined in the EPA's PFAS Action Plan and considered by Congress for the Fiscal Year 2020 National Defense Authorization Act (NDAA), it was not until recently that the federal government has taken formal steps to move forward with such rulemaking. In its Strategic Roadmap, the EPA proposed to designate certain PFAS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In August 2022, the EPA **proposed** to designate PFOA and PFOS, including their salts and structural isomers, as CERCLA hazardous substances. The proposed rule was open for public comment for 60 days, and a final rule is expected in Summer 2023. If finalized, the designations would require facilities to report on PFOA and PFOS releases that meet or exceed a reportable quantity of one pound or more within a 24-hour period, and would provide the EPA with the statutory authority to investigate, monitor, and respond to PFOA and PFOS releases (or threats of releases) into the environment. It would also require responsible parties to conduct or pay for cleanups to address such releases or threats of releases. The EPA will also issue in winter 2023 an Advance Notice of Proposed Rulemaking on regulating other PFAS under CERCLA, as well as updated guidance on destroying and disposing PFAS by December 2023.

Designating PFAS (PFOA and PFOS, or also including additional analytes) as hazardous substances under CERCLA would have some, though likely different, impacts on states. In previous iterations of this report, *North Carolina* noted that the declaration may provide more information to its rulemaking body. Other states noted that empowering them to act using existing regulatory CERCLA mechanisms allows for an expedited cleanup process and prevents draining already-strained funds for site investigation and characterization. *Kansas* said this definition is what it needs to regulate PFAS and that it cannot set PFAS standards until EPA does, as the state's definition of a hazardous substance is based on its inclusion as a CERCLA hazardous substance, and that it will provide more opportunity to ensure companies evaluate PFAS impacts. Given that the EPA formally proposed a rule in 2022, ECOS asked states in this iteration of the report to share how the rule, if finalized, will affect them and gathered a number of responses:[32]

- *Alaska and Rhode Island* already list PFOA and PFOS as hazardous substances in state regulations so they reported that a CERCLA listing would not have a direct or notable impact. Similarly, *Florida's* definition of a hazardous substance directly incorporates all of the substances listed in CERCLA, so it will automatically

[32] ECOS recognizes that this list of state stances is not comprehensive and there are many different opinions from states and other stakeholders about if and how this rule should be implemented. Some of these states provided formal comments to the EPA.

update if and when EPA finalizes their rule for PFOA and PFOS. *Minnesota* said actions taken at the federal level will not impact the state's current position regarding PFAS as hazardous substances under the Minnesota Environmental Response and Liability Act.

- *Arizona* said the designation would allow additional sites to be investigated and remediated under the state's Water Quality Assurance Revolving Fund, the state's equivalent to the Superfund Law.
- *Arkansas* mentioned that the designation would give the state additional authorities to address the wide-ranging impacts of PFOA and PFOS, but will also undoubtedly lead to new sites being added to State or federal (National Priority List) lists of contaminated sites, exacerbating the staffing issues the state already faces and requiring additional funding to meet the new workload required.
- *Delaware*, which lists six PFAS as hazardous substances under state law, noted that with regard to the potential of regulating other PFAS under CERCLA, listing PFAS as a class would create challenges as analytical methods are not able to detect the majority of PFAS, and the majority of PFAS do not have toxicological data.
- *Indiana* noted it is waiting for the CERCLA designation to be able to regulate PFAS as hazardous in the state and to include PFAS in cleanup considerations.
- *Iowa* said that the CERCLA designation would, at a minimum, affect EPA-Lead Sites and military sites across the state.
- *Maine* said the designation would make the process clear and consistent among states, which is needed for all PFAS requirements. The state did note, however, that there is some concern about the scope and liability once PFOA and PFOS are listed, specifically as to what degree regulated parties will be subject to enforcement (e.g., a farmer or landowner of a previous farm might have as much PFAS contamination from land application of biosolids as that of a manufacturing company – does the EPA plan to treat them both equally under the law?)
- *Oregon* has many more sites under state cleanup authority than under federal CERCLA authority and a state rulemaking will be required to make some PFAS state hazardous substances, so it may pursue that before or after EPA finalizes its rulemaking.
- *Pennsylvania* said that any CERCLA defined or designated hazardous substance is deemed a "hazardous substance" under the state's Hazardous Sites Cleanup Act, which also provides emergency response authority to address releases of nonhazardous substances if deemed imminent or a substantial threat to public health or the environment. The federal CERCLA hazardous substance designation will enhance the state's authority under this Act to pursue responsible parties and provide a legal path for private citizens to file civil actions.
- *South Carolina* said if finalized, the designation will enhance its ability to require assessment and remediation of PFOA and PFOS at release sites in the state.
- *Texas* said it has no concerns.
- *Utah* said the designation would allow the state to include PFAS data collection in the Site Assessment work it conducts in support of the CERCLA process, strengthen the state's ability to require it as part of its site characterizations and remedial action plans for cleanup, and provide a foundation to request investigations and/or monitoring at additional sites.
- *Virginia* said the designation would result in landfill operators revisiting their waste acceptance criteria, likely choosing to limit inbound wastes with known elevated concentrations of PFAS (including filter materials, biosolids, and impacted soils), and that there are potential CERCLA liabilities for past discharges from publicly owned treatment works.

In October 2021, in response to a petition from New Mexico Governor Michelle Lujan Grisham to identify individual PFAS or a class of PFAS as hazardous wastes under RCRA, the EPA **announced** that it also plans to initiate rulemaking for two new actions under the Act. These actions include evaluating existing data to propose adding four PFAS (PFOA, PFOS, PFBS, and GenX) as RCRA Hazardous Constituents under Appendix VIII to ensure they are subject to corrective action requirements, and clarifying in agency regulations that PFAS can be cleaned up through the RCRA Corrective Action Program.

Intra-State PFAS Collaboration

States have varying procedures for designating who regulates PFAS. Many state environmental agencies are coordinating with their health, agriculture, and other state agency counterparts on the state's PFAS response. For example, the *Michigan* PFAS Action Response Team (MPART) was created in 2017 through an executive directive to investigate sources and locations of PFAS and protect drinking water and public health. In 2019, MPART was signed into an executive order as an enduring advisory body of seven state agencies, led by the Michigan Department of Environment, Great Lakes, and Energy. Other states (e.g., *Arizona,* Arkansas, *California*, *Colorado*, *Connecticut*, *Delaware*, *Florida*, *Hawaii*, *Illinois*, *Indiana*, *Iowa*, *Maine*, *Massachusetts*, *Minnesota*, *Missouri*, *New Mexico*, *New York*, *North Carolina*, *Ohio*, *Oregon*, *Pennsylvania*, *Utah*, *Virginia*, *Washington*, *Wisconsin*) have formed similar task forces and action teams charged with recommending PFAS guidelines and/or conducting other statewide PFAS efforts.

Impacts of Federal Regulatory & Legislative Uncertainty

In the original and subsequent publications of this report, ECOS asked states that have already established guidelines about the expected impact of the pending federal MCL or a similarly enforceable federal PFAS standard on their regulations. States responded that they may be required to modify their guidelines to be "no more stringent than" federal requirements, or they may be required to "strengthen" their guidelines so that they are as protective as federal standards. States recognize that this may impact the number of public water systems that need to address PFAS contamination as a result of adjusted standards. At the time, *North Carolina* noted that a federal MCL could affect its groundwater and drinking water programs, *Maryland* acknowledged that a lowered reference dose may impact its fish tissue monitoring work and result in more sites needing to be revisited, and another state noted its concern that a federal MCL may or may not adequately address protection for all populations and impacted communities because MCLs are not strictly risk-based. Numerous states with advisory guidelines expressed their preference for the EPA to have the primary role in setting MCLs, which they argue will facilitate a unified approach to mitigating PFAS contamination in drinking water supplies, as well as federal standards in other media. States recognized, however, the timeline associated with setting a nationwide standard and expressed their intentions to move forward with statewide MCLs or guidance in the interim. When the EPA enacts an enforceable drinking water standard for PFOA and PFOS, some states may need to make challenging management decisions regarding how to adjust their existing guidelines and PFAS response efforts to comply with the federal standard.

Given the much lower interim EPA LHAs for PFOA and PFOS and the forthcoming EPA proposal expected in the coming days for a MCL for the two compounds, ECOS again asked states to share how the previously published considerations, and state guidelines, might change. Some responses are below:[33]

- *Alaska* will adopt the final rule by reference if an MCL or treatment technique is developed.
- *Arkansas* said a MCL would have a tremendous economic impact due to the state's rural water and wastewater infrastructure, and would require the expense of regular sampling and analysis across the state, as well as potential mitigation efforts, which the state does not currently have the capacity to undertake.
- *Delaware* said the creation of MCLs for any individual PFAS would allow the state to create Reporting Values for those PFAS in groundwater.

[33] ECOS recognizes that this list of state thoughts is not comprehensive and there will be more clarity as to how state guidelines will actually change once the EPA has published the proposed rule, allowed time for public comment, and finalized a rule.

- *Florida* is required by state statute to establish Cleanup Target Levels if EPA has not finalized its MCLs by January 1, 2025. The Department of Environmental Protection would then adopt the MCLs for PFOA and PFOS as the groundwater Cleanup Target Levels, allowing the agency to move forward with requiring cleanup at sites that exceed the levels.
- *Hawaii* will present the draft MCLs in its current PFAS guidance and will adopt final, promulgated MCLs into its regulations.
- *Indiana* relies on the EPA RSLs for screening levels, and these will presumably incorporate the MCL.
- *Iowa* intends to propose the adoption of any federal PFAS standard required to maintain delegation of a federal program in the state.
- *Maine* acknowledged that since it has a standard for the sum of six PFAS, there will be regulatory confusion until the state sets an official MCL to account for the differences in which PFAS are covered in the state's guidelines versus PFOA and PFOS under the federal MCL. The state listed a number of potential impacts of a federal MCL to its current efforts, including requirements of PWSs; costs associated with monitoring and treatment; slower laboratory turnaround times; implications of risk communication and what is "safe" if the MCL is set at lower levels than state standards; and shifts in expectations of residents in terms of how funding should be allocated (e.g., to ensure drinking water wells are safe at the lowest levels, if equal funding is allocated to the state's efforts on biosolids); among other considerations.
- *Michigan* will continue to utilize state MCLs until the EPA has fully-enforceable ones, and does not anticipate major changes to the SDWA program.
- *Minnesota* will continue to use its state health-based guidance values in its additivity calculation even after the MCLs are released. If the MCLs are significantly lower than its own values, they would likely be the driver in what values the state uses.
- *New Jersey* will review the proposed MCL before making any decisions.
- *Oregon* uses MCLs as de facto groundwater reference levels, so there will be analysis and possible remediation efforts under several state authorities for sites with groundwater monitoring.
- *Pennsylvania* is supportive of a federal MCL to ensure national consistency, especially since many states do not have the resources to set such limits themselves. In the state, the MCL would be treated like any other new rule – the Department of Environmental Protection would review and evaluate the federal rule to determine if any provisions are more stringent than existing state provisions, and would move forward with a state rulemaking as needed.
- *Rhode Island* said it will continue to implement standards that are protective of human health and the environment, and to refine them as necessary based on new federal, or other, guidance arises.
- *Utah* has not taken a stance on the federal MCL but said any federal action to regulate PFAS will affect most of its state programs, allowing for integration of the new standards into state rules and for regulation of PFAS releases. The MCL would also allow the Department of Environmental Quality to require monitoring and evaluation of these substances in its current and future permits.
- *Vermont* said its regulations may or may not change depending on what the MCL is. The state currently has a standard for five PFAS, individually or summed, in drinking water and noted that that may change, or the state toxicologist may seek a lower number than what the EPA arrives at based on specific endpoints.

In the interim, some states are pursuing other federal regulatory and legislative actions that might make PFAS remediation and regulation more consistent nationwide. In 2019, the bipartisan Congressional PFAS Task Force was established, and has been actively working to educate Members of Congress and their staff about PFAS, craft legislation to address PFAS, and advocate for federal appropriations to clean up PFAS contamination. In October 2020, a coalition of 20 attorneys general sent a letter to Congress outlining states' PFAS-related priorities for the fiscal year 2021 NDAA. In addition to again encouraging Congress to designate PFAS as hazardous substances under CERCLA, these states argued for DOD to meet or exceed the PFOA and/or PFOS standards established in the state in which the military installation is located when those standards are more stringent than federal standards or health advisory levels. These provisions were not included in the final NDAA bill.[34] However, several state governors, including those from *Michigan, Ohio, and Arizona*, have written letters under Section 332 of the fiscal year 2020 NDAA requesting that the DOD amend and/or enter into cooperative agreements with the state environmental agencies to address PFAS contamination resulting from military installation activities. The states cite that natural gradients have caused AFFF-contaminated drinking water, surface water, or groundwater to flow to nearby communities and, as such, argue that the DOD should coordinate with the state to mitigate further migration of PFAS contamination off base, oversee the implementation of state standards, and pay for treatment technologies, among other actions. Additionally, several states in late 2022 sent a joint letter to the Federal Aviation Administration urging the agency to secure federal funding to support airports' efforts to investigate the extent of PFAS contamination and put in place appropriate controls to address the risks posed by PFAS at and around commercial service airports.

Section II. Risk Assessment

State environmental and public health agencies use quantitative risk assessment to develop health-based criteria for PFAS guidelines. The processes for evaluating exposure and developing these criteria are described across several guidance documents produced by the EPA.[35]

At its core, risk assessment is used to develop the human health basis for guidance values or standards by considering the following:

$$\boldsymbol{Toxicity} \times \boldsymbol{Exposure} = \boldsymbol{Risk}$$

Risk is a function of the toxicity of a chemical and a person's exposure to that chemical. The higher one's exposure, the greater the risk; similarly, the more toxic a chemical is, the more risk there is at the same level of exposure. Both variables are fundamental to the resulting calculation of risk.

As described in more detail below, differences among state PFAS guidelines may arise from differences in toxicity factors, which include RfDs for non-cancer effects and Cancer Slope Factors (CSFs) for carcinogenic effects. These toxicity factors are developed based on animal toxicology and/or human epidemiology studies. Choices in the scientific study and toxicity endpoint used, as well as choices made in developing an RfD or CSF from the selected study and endpoint, will result in differences in the numerical values of these toxicity factors. Additionally, a cancer risk level (e.g., 10^{-5}, 10^{-6}) must be selected when using a CSF to develop a health-based criterion, and states may differ as to the cancer risk level used for guidance development.

Different guidelines may also result from variations in exposure factors, which include parameters relating to daily water ingestion, body weight of an individual, duration of exposure, and fraction of total exposure from the medium of concern (e.g., drinking water). As with toxicity factors, state agencies use evidence-based methods to characterize exposure factors.

[34] The **fiscal year 2021 NDAA** did, however, include many PFAS provisions geared towards remediating PFAS contamination and searching for suitable AFFF alternatives. It also ordered the formation of an interagency federal working group to coordinate on research and development.
[35] Examples of these EPA guidance documents include the **Risk Assessment Guidelines**, **Water Quality Standards Handbook**, and **Exposure Factors Handbook** (2011).

Scientific Considerations, Professional Judgment, & Peer Review

In general, states prefer to use peer-reviewed, publicly available toxicity studies that meet risk assessment criteria (e.g., study duration, route of exposure) as the basis for their guidelines. In some cases, states will consider non-peer reviewed reports (e.g., contract lab reports). Regulators review studies to ensure that they were properly conducted and reported, and consider a study's results coupled with its relevance, degree of rigor, and importance to the question at hand. Some states routinely develop their own guidelines for chemicals of interest to their state; however, if the EPA completes this process first, states can review the agency's conclusions and decide whether to use them, saving states the effort of doing this on their own. When EPA values are not available to use, some states refer to ATSDR's MRLs (as they would RfDs) or use health-protective values from other agencies like the American Conference of Governmental Industrial Hygienists (ACGIH).

Toxicity Criteria & Methodology

Regulatory agencies may rely on a chemical-by-chemical approach or grouping approaches for developing PFAS toxicity criteria (e.g., RfDs for non-carcinogens and CSFs for carcinogens). Most states conducting their own evaluations do not rely solely on EPA or ATSDR risk assessments, for which the only published documents are those supporting the EPA's former (2016) and interim (2022) LHAs for PFOA and PFOS, RfDs for PFBA, PFBS, and GenX chemicals, and a draft RfD for PFHxA, and the ATSDR's MRLs for PFOA, PFOS, PFHxS, and PFNA. Performing the scientific analysis needed to effectively regulate PFAS is time consuming, and regulators lack toxicological data needed to develop criteria for some PFAS detected in environmental media.

To develop health-based guidelines, agencies conduct risk assessments, which usually follow this sequence of events:

1. Review available studies (e.g., toxicological, epidemiological) to identify critical endpoints that are sensitive and relevant to humans.

   Scientists generally prefer human epidemiological information as the basis for guidelines when the data are appropriate. Previously, the EPA and most states have concluded that currently available human studies are not appropriate to use as the primary basis for PFAS guidelines. As such, most current federal and state PFAS guidelines are based on laboratory animal study data that are then translated. For PFOA and PFOS, the EPA and some states have identified developmental effects (e.g., decreased pup body weight, thyroid effects [PFOS]; accelerated puberty; delayed ossification, delayed mammary gland development, neurobehavioral and skeletal effects [PFOA]; hepatic [liver] toxicity, immune system suppression [PFOA, PFOS]) as critical endpoints. Critical endpoints can vary from state-to-state based on scientific judgment.

   California is the first (and so far only) state to use human epidemiological data (kidney cancer) to develop a draft drinking water guideline level for PFOA. While it treats PFOS as a carcinogen based on animal data, the California non-cancer health protective concentrations are also based on human data (liver toxicity for PFOA, increased total cholesterol for PFOS). Minnesota is currently re-evaluating its PFOA and PFOS guidance with the intent to use epidemiological data as the basis for updated values. At a federal level, recently, the EPA released draft Reference Doses for PFOA and PFOS, as well as a likely carcinogen descriptor and cancer slope factor for PFOA, that are based on human data and will support MCLGs for the NPDWR. These draft **documents** have been reviewed by the agency's SAB, and the EPA has stated that the draft toxicity factors for

PFOA and PFOS will be revised in response to the SAB's comments.[36] Internationally, the European Food Safety Authority was the first entity to use epidemiological data to derive an "acceptable" dose level in 2018 and 2020.

2. Determine a point of departure (POD), the spot on the dose-response curve from the animal or human study at which toxicologists begin to apply uncertainty factors (UFs) to obtain a dose that should not be associated with adverse effects. PODs can be a No Observed Adverse Effect Level (NOAEL), Lowest Observed Adverse Effect Level (LOAEL), or Benchmark Dose (lower confidence limit; BMDL). BMDL is the preferred POD when available, as it is less dependent on dose selection and sample size.

   Toxicologists typically adjust the POD to account for the much slower excretion rate of PFAS in humans than animals (i.e., calculating human equivalent doses [HEDs] that will result in an equivalent internal dose [serum level] at the POD in animal studies). This dosimetric adjustment can be performed using estimated human clearance values, or the ratio of estimated serum half-lives in humans and animals.[37]

3. Apply UFs to the HED to determine the RfD, an estimate of the daily oral dose at which humans are expected to be without risk from repeated[38] exposure to a chemical, including PFAS. An RfD is expressed as mass of chemical per day on a body weight basis ($mg_{chemical}/kg_{body\ weight}/day$).

   Toxicologists apply UFs of 3 (i.e., the square root of 10, which rounds to 3 if a single such factor is applied; if two such factors are applied, the value equals 10), or 10 to reflect uncertainties associated with the data used. Uncertainties include variability in human sensitivity (intraspecies), extrapolation from animals to humans (interspecies), shorter duration of exposure than the intended timeframe for the RfD in the study used, use of a LOAEL as the POD, and information gaps (i.e., potentially more sensitive effects that have not been studied) in the toxicological database. The UFs are applied selectively for each chemical as appropriate for the toxicity data being used as the basis for the RfD.

   Toxicologists multiply the UFs together to obtain the total UF, and then divide the selected (NOAEL, LOAEL, or BMDL) POD (or as adjusted, the HED) by the total UF. A dosimetric adjustment is then performed to determine the RfD (as shown in the equation below).[39]

$$\frac{\boldsymbol{POD}}{\boldsymbol{Total\ UFs}} \times \boldsymbol{dosimetric\ adjustment\ factor} = \boldsymbol{RfD}$$

---

[36] The European Food Safety Authority has also used epidemiological studies to develop acceptable intake rates of the total of PFOA, PFOS, PFNA, and PFHxS in humans.

[37] The dosimetric adjustment is used to determine the human serum PFAS level expected from a given external (oral) dose, and is how toxicologists account for PFAS bioaccumulation in risk assessment. It can be applied to the POD to develop the HED as described, or applied to the ratio of the POD and Total UFs as shown in the RfD equation below. Both methods are mathematically equivalent and the order of operations does not affect the final result.

[38] The length of exposure to which the toxicity factor is intended to apply can vary depending on the chemical and regulatory agency. For example, in its toxicity values for PFBS and GenX, the EPA characterizes exposure over a lifetime (chronic RfD) or less (subchronic RfD). For the EPA's 2016 LHA for PFOA and PFOS, the RfDs were derived from developmental toxicity studies, where a single exposure at a critical time in development could cause an adverse effect. Thus, EPA recommended that the lifetime LHA be applied to both short-term (e.g., during pregnancy and lactation) and lifetime exposure scenarios. For the EPA's 2022 interim LHA for PFOA and PFOS, the RfDs are based on an effect that occurs from short term exposure in children. The ATSDR uses the term MRL instead of RfD to describe the daily dose of a chemical that is not expected to pose a risk to human health. Its PFAS MRLs are derived for intermediate (14-364 days) exposure.

[39] As stated in footnote 37, the dosimetric adjustment can alternatively be made on the POD to determine a HED, to which the UFs are applied, yielding the same result for the calculated RfD.

When there may be a cancer hazard, the BMDL is used to derive a cancer slope factor (as shown in the equation below).

$$\boldsymbol{CSF = \frac{benchmark\ response}{BMDL}}$$

For example, if the BMDL estimates a lower bound on the dose associated with an increased cancer incidence of five percent, the CSF is 0.05 divided by the BMDL. The CSF can be used to estimate an upper bound on risk for a given level of exposure, or it can be used to derive a health-based guidance level.

4. Combine the RfD with selected exposure parameters to establish a concentration (i.e., standard or guidance value) for PFAS in a specific medium (e.g., drinking water) that is intended to be protective of human health. Exposure assumptions vary among states and can result in different guidelines despite similar RfDs.

   Some states select exposure parameters for subgroups such as pregnant women or children if they are more sensitive for the toxicological effect of concern. Exposure parameters for health-based guidelines include the exposure rate (e.g., amount of drinking water, fish, or soil assumed to be ingested each day) and representative body weights for the target population. Several states use a model that predicts exposure to the developing fetus and breastfed infant from maternal drinking water exposure. For drinking water guidelines (and groundwater guidelines based on drinking water exposure parameters) based on non-cancer effects, states consider the Relative Source Contribution (RSC), which is the percentage of the RfD allocated or allowed to come from drinking water. For example, the EPA's LHAs (2016, and 2022 interim for PFOA and PFOS and final for GenX and PFBS) allow drinking water to contribute only 20 percent of the RfD and other sources can contribute 80 percent, so the RSC is 20 percent. In the absence of adequate data to determine exposure from non-drinking water sources, default assumptions, typically a lower-bound estimate of 20 percent and an upper-bound estimate of 80 percent, may be used as the RSC. Furthermore, scientists are still learning about PFAS sources and extents/impacts of exposure levels; as such, states' assumptions about the RSC may change in the future and affect PFAS guidelines.

State Trends on the Basis of Guidelines

ECOS examined states' calculations and factors applied to oral routes of exposure to PFAS that contributed to their standard setting processes.

Appendices A-F of this report include tables of state toxicological information and exposure assumptions for setting guidelines in drinking water, groundwater, surface water, soil, air, and fish and wildlife. Some of the trends in the data are summarized below:

***Critical Studies and Endpoints*:** This is a critical first step in the process, as it indicates the most sensitive health effect identified for which toxicologists are protecting (e.g., fetal/infant growth delays, thyroid dysfunction, infertility, alterations in liver function, and/or impaired immune function). Ten states indicated that they use the EPA's preferred critical studies (e.g., Lau et al. [2006] for the PFOA LHA and Luebker et al. [2005] for the PFOS LHA) and pharmacokinetic model for developing a toxicity factor (i.e., EPA modeled average animal serum levels at the POD). States also use a variety of critical studies and endpoints based on which PFAS they are evaluating. As discussed in the *Human-to-Animal Extrapolation Methods* section on page 29, state approaches may differ from the EPA methodology in that the POD is based on serum PFAS levels measured at the end of the animal study rather than serum levels predicted using the EPA pharmacokinetic model.

Points of Departure: The choice of POD depends on the dose response data for the critical endpoint being used as the basis for risk assessment. As previously mentioned, BMDL is the preferred POD when available as it is less dependent on the dose selection and sample size than the NOAEL or LOAEL. If a BMDL cannot be derived, the NOAEL is preferred. If there is no NOAEL in the study (i.e., effects occur at all doses), the LOAEL is used. Twelve states and the EPA use the LOAEL and NOAEL PODs for PFOA and PFOS in drinking water. Other states indicated that they use a combination of PODs depending on which PFAS they are examining, with LOAEL the most commonly used for PFOA and NOAEL the most commonly used for PFOS. Five states reported using a BMDL for various PFAS in drinking water.

Uncertainty Factors: States use a variety of combinations for UFs that differ based on the study used. Some states reported applying a total UF of 300 for PFOA (with a UF of 3 for interspecies; 10 for intraspecies; and other UFs for extrapolation from LOAEL to NOAEL, database limitations, duration of exposure [i.e., subchronic to chronic extrapolation], and/or sensitive developmental endpoints), and a total UF of 30 (with a UF of 3 for interspecies and 10 for intraspecies) for PFOS. Some states have applied higher UFs depending on their interpretations of the relevant scientific data. UFs selected for other PFAS vary.

Exposure Parameters:

- ***Populations at Risk***: States including *Michigan*, *Minnesota*, *New Hampshire*, *Pennsylvania*, *and Washington* use Minnesota's model (Goeden et al. [2019]) to predict fetal and infant exposure from transplacental transfer, breastmilk, and prepared formula for certain PFAS. This model applies the upper-percentile age-adjusted drinking water ingestion rates in the 95th percentile for pregnant women and formula-fed infants, and the upper-percentile ingestion rate for breast-fed infants. Other states account for populations that may be at increased risk by considering their higher intake rates, with infants and lactating women consuming more than typical adults when adjusted for body weight. Examples include, but are not limited to, a 0-1 year old body weight-adjusted drinking water intake rate of 0.175 L/kg/day *(Vermont)*, a 10 kg body weight adjusted drinking water intake rate of 0.1 L/kg/day *(Wisconsin)*, or a lifetime average drinking water intake rate of 0.053 L/kg/day that accounts for increased water consumption relative to body weight at young ages *(California)*, as compared to the default adult upper percentile water consumption rate (0.029 L/kg/day) *(New Jersey)*. The EPA's LHA assumed the drinking water ingestion rate of the 90th percentile of lactating women to be 0.053 L/kg/day. Several states look at fish consumption rates as well when developing surface water quality criteria and fish consumption advisories; these advisories are more stringent for high-risk populations (e.g., infants, children, pregnant and lactating women, women of childbearing age) in some states (e.g., *Delaware*, *New Jersey*, *Pennsylvania*). Overall, target populations and RSCs differed among states, even if those states used the same critical endpoint or a similar RfD. The different exposure parameters resulted in different final guidelines.[40]

- ***Relative Source Contribution***: Fourteen states reported using the default value for the RSC of 20 percent (as the EPA does in its LHAs for PFOA and PFOS) for various PFAS in drinking water, indicating that they allow 20 percent of the RfD to come from drinking water and 80 percent to come from other sources of exposure. *Four states* use a chemical-specific RSC of 50 percent in their drinking water guidelines. Some of these states base their guidelines on the higher exposure to breastfed infants predicted by the Goeden et al. (2019) model; in these states, the RSC of 50 percent is specific to infants. *Wisconsin* does not use an RSC for PFAS in surface water, but uses a less conservative RSC of 80 percent for PFAS in other media, meaning 80 percent of the RfD comes from the source (e.g., drinking water) and only 20 percent is allocated to exposure to all other sources like diet or consumer products. *Alaska*, *Iowa*, *and Wisconsin* do not use an RSC (i.e., an RSC of 100 percent) in groundwater; at that guideline, exposures from other sources would raise the intake above the RfD.

[40] Some states develop groundwater standards based on the assumption that groundwater is used as drinking water, so the ingestion rates/exposure assumptions used for drinking water standards are applied to the groundwater standards.

Washington's uses the subtraction method and biomonitoring data to define the aggregate exposure from all other PFAS sources, resulting in a variety of RSCs used to inform its drinking water action levels depending on the PFAS and the target population. For example, it uses an RSC of 20 percent for PFBS; an RSC of 50 percent for PFOA, PFNA, and PFHxS; and an RSC of 50 percent for infants and 20 percent for adults exposed to PFOS. Several states reported that the **EPA Decision Tree** (2000) is helpful in establishing an RSC.

Human Epidemiological Data**:** Twelve states *(California, Connecticut, Florida, Hawaii, Illinois, Massachusetts, Michigan, New Hampshire, New Jersey, North Carolina, Washington, Wisconsin)* reported considering both animal and human epidemiological data to support their selections of critical endpoints from animal toxicity studies and guide their risk assessments.[41] *California* used human epidemiological data to derive its proposed slope factor for PFOA and its non-cancer guidance levels for PFOA and PFOS.

Human-to-Animal Extrapolation Methods**:** Human toxicity values for PFAS are primarily based on laboratory animal studies and rely on various approaches to account for the much longer half-lives in humans than in animals. Toxicologists consider the interspecies half-life difference in most PFAS risk assessments because the same daily dose of a PFAS results in a higher internal dose (blood serum PFAS level) in humans because of their slower excretion rate. In general, the serum PFAS levels from animal studies are converted to HEDs by applying a chemical-specific clearance factor (based on human half-life and volume of distribution) that relates serum levels to human-administered doses. The interspecies UF is reduced from the default value of 10 to 3 when these approaches are used since interspecies pharmacokinetic differences have already been accounted for.

Seven states *(Alaska, Colorado, Connecticut, Maine, Massachusetts, Vermont, Wisconsin)* reported using the EPA approach (used in its derivation of the LHA for PFOA and PFOS), which estimates the HED using modeled serum concentrations at the POD in the animal study as the internal dose metric. A few other states, including *New Jersey, New Hampshire, and California*, use measured serum concentrations at the end of the dosing period in the animal study as the POD. *Washington* reported using ATSDR's modeled serum concentration when it was available for PFOA and PFNA, and measured serum concentrations at the end of the dosing period for when PFOS and PFHxS. For PFBS, it used the administered dose, not the serum level. *Connecticut* reported using a variety of approaches, including EPA's modeled serum concentration for PFOA, ATSDR's time-weighted average serum concentrations for PFNA and PFHxS, and the measured serum concentration at the end of the dosing period for PFOS.

Carcinogenicity**:** 18 states *(Alaska, Arkansas, California, Connecticut, Delaware, Florida, Hawaii, Illinois, Indiana, Massachusetts, Minnesota, New Hampshire, New Jersey, North Carolina, Pennsylvania,*[42] *Vermont, Washington, Wisconsin)* reported that they consider carcinogenicity as well as non-cancer endpoints in their evaluations. 12 of those states *(Alaska, Arkansas, California, Connecticut, Delaware, Florida, Hawaii, Illinois, New Jersey, Pennsylvania, Vermont, Wisconsin [PFOA only])* quantify cancer risk with a slope factor and a cancer risk level of 1 in 100,000 ($1\text{x}10^{-5}$) or 1 in 1,000,000 ($1\text{x}10^{-6}$).[43] *California* uses cancer as the critical endpoint for PFOA (pancreatic and liver cancer in male rats)

[41] As with any risk assessment, human epidemiology is considered, at a minimum, to support using an animal study. Only one state (*California*) has relied on the human epidemiological data as the quantitative basis of an RfD derivation, based on effects that are supported by animal studies, for its proposed non-cancer drinking water guidance levels for PFOA and PFOS (see footnote 44). The current draft EPA Reference Doses for PFOA and PFOS are also based on human epidemiological data.
[42] *Pennsylvania* considers cancer-based toxicity values in calculating its medium-specific concentrations for PFOS, but not for PFOA or PFBS. Additionally, toxicologists from Drexel University's PFAS Advisory Group, which made recommendations on the MCL to the state's Department of Environmental Protection, determined that existing evidence did not support a cancer risk endpoint for drinking water.
[43] Cancer risk levels used in risk assessments are policy choices that vary among states and may be specified in a state's legislation or regulation.

and PFOS (liver cancer in male rats) for their guidance level, as does *Illinois* for PFOA. *California* uses human kidney cancer data in its current draft guideline for PFOA.[44]

Section III. Risk Management

Once their toxicologists assess potential health or ecological risks, states take steps to manage those risks and protect public health. This includes analyzing PFAS samples, establishing guidelines, and addressing resource issues. This could also include deciding whether to address PFAS individually or as a group (see the *Grouping PFAS* section on page 12), deciding not to act based on their conclusions of the assessed risks, or looking at broader impacts of managing PFAS such as issuing discharge permits and availability of treatment removal technologies.

Analytical Methods & Limitations

States use a variety of methods to test for PFAS in different media. The most widely used is **EPA Method 537.1** (2018/2020, applies to 18 PFAS in drinking water), which 31 *states (Alaska, Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Vermont, Virginia, Washington, Wisconsin)* report using. [45] This method supersedes **EPA Method 537** (2009, applies to 14 PFAS in drinking water); it analyzes the same 14 PFAS as EPA Method 537, which was used for UCMR3 analysis, and adds four other replacement PFAS, including HFPO-DA (GenX). Both methods are designed for drinking water with low total suspended or dissolved solids. Samples are prepared by using a solid phase extraction technique.

Some labs perform modifications to these methods such as using isotope dilution, using a weak anion exchange (WAX) solid-phase extraction (SPE) cartridge, or not evaporating samples to dryness. These changes allow labs to analyze a greater number of analytes in additional matrices and may also allow for lower reporting limits, increased recovery, or greater accuracy. For example, 19 states *(Alaska, Arizona, Connecticut, Delaware*[46]*, Indiana, Maine, Minnesota, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Pennsylvania, South Carolina, Texas, Utah, Vermont, Virginia, Wisconsin)* reported that they allow modifications to EPA Method 537.1 for non-drinking water media. Methods can be applied to analyze one, some, or all applicable PFAS for which the methods apply, depending on which PFAS a state considers.

Other methods and criteria for PFAS analysis include:

- **EPA Method 533**: *Alaska, Arizona, California, Hawaii, Idaho, Iowa, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, South Carolina, Texas, Virginia, and Washington* allow labs to use this drinking water method.[47] Published in 2019, this isotope dilution method uses a WAX SPE cartridge to improve

[44] *California*'s current draft guideline is a Public Health Goal, which serves as the scientific basis for future regulatory standard (MCL) setting. The previous guidance levels for PFOA and PFOS, based on cancer observed in animal studies, were notification level recommendations.
[45] In the previous publications of this report, two states *(Florida, New Hampshire)* reported using this method, and nine states *(Alaska, Arizona, Connecticut, Indiana, Maine, Massachusetts, New Jersey, New Mexico, New York, Texas)* reported using both this method and EPA Method 537.
[46] *Delaware* uses a unique modification to this method, called 537(M) DNREC REM, for 37 PFAS in non-drinking water media.
[47] *Oregon* specifies that it now recommends EPA Method 537.1 for drinking water, per EPA. And *Washington* said EPA Method 533 is the most common drinking water test method used in the state.

recoveries of 25 short-chain[48] and long-chain PFAS. The method targets 25 PFAS, including all 14 PFAS from EPA Method 537 and 11 PFAS unique to this method. Additional isotope labeled stable standards can be added into this method.

- **EPA Solid Waste (SW)-846 Method 8327:** *Illinois* uses this method for surface water, groundwater, and wastewater; *Minnesota* has begun to receive results for stormwater and wastewater samples analyzed for PFAS using this method; *Virginia* accepts this method; and *Alaska* allows this method to be used, although it notes it is not the method of choice. This direct injection method for non-drinking water aqueous samples was developed in 2019 for 24 target analytes, 14 of which are also found in EPA Method 537.1. While sensitivity was found in multi-laboratory validation to measure PFOA and PFOS below the EPA's 2016 LHA levels for drinking water, this method does not yet provide low-level detection (i.e., single ng/L) and is only intended for testing of non-potable waters. The U.S. Department of Defense (DOD) published a memo stating that this method does not meet its needs to support decision-making and advises its use for screening purposes only. The final version of this method was published in July 2021.
- **EPA SW-846 Method 8321B**: *Washington* has used this method for fish tissue.
- **DEP SOP LC-001-3**: *Florida* is NELAC Institute (TNI)-certified for its own Department of Environmental Protection standard operating procedure (SOP) method for PFAS in surface water, groundwater, wastewater, soil, and other solids. DEP SOP LC-001-3 references the EPA method 8321B and incorporates isotope dilution mass spectrometry consistent with EPA draft Method 1633 to report 36 PFAS analytes.
- **DOD Quality Systems Manual** Version 5.1 or later (i.e., 5.2, 5.3, 5.4): *Alaska*, *California*, *Colorado*, *Hawaii*, *Maine*, *New Hampshire*, *North Carolina*, *Rhode Island*, *Virginia*, *and Washington* use some or all of the versions of this method for consideration as additional guidance and quality control requirements or at DOD sites. *Washington* recommends, and in some cases requires, in their Quality Assurance Project Plans that labs use a method that is compliant with the DOD Quality Systems Manual PFAS criteria when analyzing samples.
- Total Oxidizable Precursor (TOP) Assay: *Connecticut* uses this assay for groundwater, surface water, AFFF, and fluorine-free foam; *Hawaii* uses it for soil and groundwater; *Maine* uses it for all matrices; *New Hampshire* accepts it for soil and groundwater under its waste programs; *New York* uses it for soil and groundwater; *Pennsylvania* uses it for surface water; *Rhode Island* accepts this method; *Vermont* uses it for soil and groundwater; and *Washington* has used it for surface water and sediments.
- **EPA SW-846 Method 1312**, Synthetic Precipitation Leaching Procedure (SPLP): *New Hampshire* accepts this method for soil analysis under its waste programs; *New York* uses it for soil; *Vermont* uses it for soil and sludge; and *Virginia* accepts this method.
- SGS Axys Analytical, SOP **MLA 110**: *Connecticut and New Hampshire* use this method for fish tissue; *Hawaii* uses it for soil and groundwater; *Maine* uses it for all matrices; *Minnesota* uses it for water/effluent, soil/sediment, biosolids, and tissue; *New York* uses it for biota; *Pennsylvania* uses it for surface water; *Vermont* uses it for sludge; and *Washington* has used it for groundwater, surface water, effluent, sediments, and tissue.
- **ISO 25101**: *New York* uses this method for drinking water.
- As long as the method meets program requirements and project objectives, some states defer to each lab's preferred methods[49]: seven states *(Maine and Wisconsin [all matrices except drinking water, requires use of isotope dilution where isotopes are commercially available], Minnesota [drinking water], New Hampshire, New Jersey, New York, and Texas [remediation]).*

[48] Short-chain PFAS are those with carbon chain lengths of 5 or lower for sulfonic acids like PFBS, and carbon chain lengths of 7 or lower for carboxylic acids like PFHxA.
[49] State agencies have method performance expectations that they use to approve labs and determine whether or not the lab's own method is considered suitable by state program standards.

Several methods were not final when ECOS conducted the survey[50], so it is unknown if or which states may already use them:

- **Draft Method 1633**: The DOD and the EPA partnered to produce this single-laboratory validated method for analyzing 40 PFAS in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. The method can be used in various applications, such as providing a consistent PFAS method tested in a wide variety of wastewaters and containing all required quality control procedures under the CWA for NPDES permits. The DOD noted that as of December 31, 2021, all new contracts and task orders shall require the use of this method for analyzing PFAS in matrices other than drinking water. In September 2021, the EPA posted the draft method on its website and encouraged review and feedback from laboratories and regulatory authorities. This review resulted in a more refined and current second draft of the method, released in June 2022. Both the DOD and the EPA are supporting a multi-laboratory validation study of the procedure, which is expected to be completed in 2023 and will help the EPA finalize the method and add formal performance criteria. In the meantime, many states now use or accept this method, including *Alabama (non-drinking water media), Arizona (non-drinking water media), Alaska, Colorado (biosolids, wastewater), Hawaii, New Hampshire, New Jersey (non-potable water, solid and chemical materials), New York (all non-drinking water media), Oregon (all non-drinking water media), South Carolina, Utah, Virginia, and Washington (non-potable water, solid and chemical materials matrices).* Other states plan to use this method once finalized, including *Delaware*.[51]
- **Draft Method 1621**: The EPA is developing a method for the determination of Adsorbable Organic Fluorine (AOF) in aqueous matrices by combustion ion chromatography. The CWA method will be used as a screening method to measure organofluoride compounds from PFAS and non-PFAS fluorinated compounds such as pesticides and pharmaceuticals. The result is reported as the concentration of fluoride in the sample. *Arkansas* said it proposes to use this method.
- SW-846 Isotope Dilution Methods: The EPA is developing these methods under RCRA for analyzing PFAS in solid waste under RCRA. The agency's goal is to publish a 1600 series CWA method (i.e., Draft Method 1633) and SW-846 guidance methods for preparation, cleanup, and analysis using the same validation studies. The methods are similar, but CWA methods are written in a more prescriptive manner than the SW-846 guidance methods. A state noted that isotope dilution is the gold standard for quantitation and is the only method that corrects results for potential matrix effects, and another state mentioned that this is particularly true when stable labeled internal standards are available for all analytes in an analytical method.
- **EPA Other Test Method (OTM)-45**: This method will be used to test for 50 specific PFAS at stationary sources, as well as identify other PFAS that may be present in the air sample, which will help improve emissions characterizations and inform the need for further testing. *New Hampshire* reported using this method twice at one of its facilities and OTM-45 will be the required test method for stack tests in the future.
- The EPA is developing a number of source emission methods for measurements from industrial and combustion/incineration sources. The EPA will apply what they learn in the source sampling (stack testing) efforts to ambient measurement techniques anticipated in 2022-2024.
- Some states and the EPA are considering validating supplemental analysis (e.g., Total Organic Fluorine [TOF] and TOP assays) to more completely characterize total PFAS in various media including consumer and industrial products.
- Some states are utilizing non-targeted analysis data for identification of unknown site-related PFAS.
- Other federal agencies beyond the EPA and the DOD have developed methods, which are available on their websites.
    - Centers for Disease Control and Prevention **Laboratory Procedure Manual - Matrix: Serum**

---

[50] Additional information on EPA PFAS methods is available on their analytical methods development and sampling research **webpage**.
[51] In its January 2023 **report** on PFAS in biosolids, ECOS referenced which states use or plan to use Draft Method 1633 for analyzing biosolids samples. States not included in these lists may be included in the biosolids report.

- U.S. Department of Agriculture **Screening, Determination, and Confirmation of PFAS by UPLC-MS-MS** and **Evaluation of Blood and Tissue PFAs Levels in Unintentionally Contaminated Dairy Animals**
- U.S. Food and Drug Administration **PFAS Methods**
- U.S. Geological Survey **PFAS in Source Waters and Treated Public Water Supplies** and **Sampling Groundwater for PFAS**

Challenges that confound PFAS analysis include:

- There are decreasing detection levels for several PFAS (e.g., the interim LHAs for PFOA and PFOS which are below current detection levels for laboratories), making reporting of health-based limit exceedances and development of standards at health-based levels challenging.
- There are few low-level detection methods that are applicable to most PFAS in complex media, and there is a lack of a TOF method with detection limits in the low nanograms per liter range.
- Sample collection and analytical interference/contamination due to the presence of PFAS in common consumer products, sampling equipment, and lab materials can create challenges concerning quality control procedures in the laboratories.
- Matrix effects can interfere with accurate PFAS quantitation, as natural biological components and coexisting chemicals are often present in environmental samples but not in the solvent standards, leading to a difference in instrument response for equal concentrations in standards and samples.
- There are new challenges associated with many lesser studied PFAS. For example, there is a lack of analytical standards and stable isotope-labeled internal standards, which help optimize method accuracy, for many emerging PFAS. Several PFAS have also been found to be diprotic (meaning the molecule contains two acid functional groups which can cause multiple charged states) or to be early eluting PFAS (meaning the compounds elute too quickly from the high-performance liquid chromatography columns), and therefore many require lower mass spectrometer source temperatures and capillary voltage for ionization for optimum instrument signal and enhanced analytical accuracy. In addition, trifluoroacetic acid (TFA, a common environmental contaminant) interferes in the analysis of early elutes by suppressing the ionization of other coeluting PFAS. Lastly, several PFAS have been found to contain isomer forms (with more isomer forms present with increasing PFAS chain length), complicating analysis.
- There are financial and time constraints for existing lab methods. The *Minnesota* Department of Health reports that the turnaround time for their samples is 45 days and each water sample costs more than $300. *Maine* said its water and soil samples take about 28 days (depending on the backlog) and cost about $200 and $275 per water and soil sample, respectively. *North Carolina* reports that that samples it sends to a laboratory with a two-week turnaround time costs $300, and *Wisconsin* has observed costs between $275 and $500 for most matrices and a two-week turnaround. *New York* reports that pricing for Draft Method 1633 analysis can double the cost of modified EPA Method 537.1.
- There are different and sometimes inconsistent laboratory procedures for non-EPA approved methods. Not every state has a state lab, and some labs are government contracted or private. Each could result in different costs, time constraints, and sampling procedures. State agencies verify labs for use based on their own criteria.
- There are concerns about sample consistency among states and federal agencies. The *Hawaii* Department of Health requires the collection and testing of at least 10 grams of "**Multi Increment**" samples for testing for PFAS in soil, sediment, and biosolids, in accordance with the state's **Technical Guidance Manual**. While this can increase the cost for analyzing samples, the state says the practice is more reliable than the EPA laboratory methods, which require 0.5 grams of soil or other particulate matter from a discrete sample for testing. Hawaii noted that advancements in science and data collection since the EPA established their methods warrant a review of standard procedure across all laboratories.

ECOS recommends conferring with other states and using resources like the ITRC's **Sampling and Analytical Methods fact sheet**, or the Association of State Drinking Water Administrators' (ASDWA) **PFAS Laboratory Testing Primer** for guidance on selecting an analytical method, finding a qualified laboratory, specifying PFAS analytes and reporting limits, understanding sample collection procedures, and interpreting testing results and variability.

Establishing Guidelines

States consider the health-based criteria from risk assessment and other technical factors in the establishment of their guidelines. Some states' risk assessment approaches and conclusions have resulted in the development and adoption of PFAS guidelines that are lower than guidelines for most other contaminants. Scientific considerations that may contribute to these values include:

- PFAS cause toxicological effects at very low doses.
- Risk assessments account for the higher bioaccumulation of certain PFAS in humans than in animals. The same dose given to a human will result in a much higher blood serum level than in a lab animal.
- Low levels of certain PFAS in blood serum are associated with human health effects, and some states will consider how much a certain level in drinking water will increase blood serum PFAS levels. Even low levels of PFAS in drinking water can cause considerable increases in blood serum PFAS levels.
- As mentioned in footnote 14, the health basis for standards for other contaminants of emerging concern may be as low as those for PFAS, but the final guideline is set at the analytical quantitation levels, which may be up to several orders of magnitude higher than the health-based levels. For PFAS, analytical quantitation levels are very low, such that the final standard or guidance can be set at the health-based criterion.

Additionally, some states are required to perform a cost-benefit analysis in setting their final standards.

PFAS Resource (Cost) Issues

19 states *(Alaska, Arkansas, California, Delaware, Illinois, Indiana, Iowa, Maine, Massachusetts, Michigan, New Jersey, New Mexico, New York, North Carolina, Pennsylvania, Rhode Island, Virginia, Washington, Wisconsin)* have conducted, are required by a state or federal law to conduct, or plan to consider costs or conduct cost-benefit analyses to define the economic impact of establishing guidelines for certain PFAS. Some states (e.g., *Idaho*, *New Mexico*, *North Carolina*, *Pennsylvania*) require a cost-benefit analysis as part of their administrative procedures for developing MCLs or water quality criteria, or release compliance costs through rulemaking (*New York*). In December 2022, *Washington* **published** a preliminary cost-benefit analysis as part of a proposed rulemaking to restrict PFAS in some consumer products and require reporting in others. Other states (e.g., *New Jersey*) are not required to conduct a cost-benefit analysis prior to adopting guidelines into state regulation but factor costs into decision-making. One state noted that the operations and management costs for treatment (e.g., Granular Activated Carbon [GAC]) are detrimental to its and others' budgets, especially for small public water systems that perform carbon changeouts regularly to ensure no arsenic MCL exceedances or other background factors when undergoing PFAS treatment procedures.[52]

11 states *(Arkansas, California, Connecticut, Iowa, Maine, Michigan, Minnesota, New Jersey, New Mexico, Pennsylvania, South Carolina)* have conducted cost estimates for some PFAS efforts. Some actions may fall under a state's normal agency programmatic activity; others require more staff and time. For example:

[52] Small public water systems usually contain contaminants other than PFAS, including arsenic, manganese, nitrate, or bacteria that present health risks and are naturally occurring or originate from nearby land uses. Effectiveness of PFAS treatment will depend on how often filters are replaced and what levels of these other contaminants are present in the system. See more **here**.

- *Arkansas* has estimated the cost to assess the status of PFAS in its surface waters at approximately $1.5 million over about five years, excluding costs associated with personnel and with costs incurred during the first year exceeding $550,000. The state said additional costs would be incurred to during the standards development and rulemaking process, and that it is required to conduct an economic impact analysis to the regulated community before initiating rulemaking to establish PFAS standards.
- *California* has FTEs dedicated to enforcement of the regulation but does not consider FTEs for rule development in its cost estimates. In 2020, *Connecticut* estimated it needed $5 million to implement a 5-year statewide monitoring plan to study surface water and fish tissue (not including staff time); $75,000 to evaluate influent and effluent PFAS values at approximately 30 publicly owned treatment works for 1 year; and $90,000 to support the development of a geographic information system for risk assessment of groundwater, surface water, and drinking water.
- *Iowa* estimates contract costs for two rounds of PFAS sampling from 2021 to 2022 to total $350,000; staffing costs for 0.5 FTEs for PFAS sampling and 2 FTEs for combined leadership and staff time related to PFAS issues in the state to total $350,000; and annual travel costs to total $25,000 per year.
- The *Maine* Department of Environmental Protection (Maine DEP) has expended almost $6 million from July 1, 2018 through November 15, 2022 on personnel expenses related to PFAS. Spending exponentially increased once the Maine legislature added 11 full-time employees (FTEs) and 6 limited period positions, as well as $20 million to fund soil and groundwater sampling and install/maintain drinking water filtration systems for private drinking water wells impacted by PFAS from the land application of residuals.[53] The Maine Department of Agriculture spent just over $2.5 million in FY 2022. Four new positions and an additional $3 million were provided by the Maine legislature in the 2022 Supplemental Budget for PFAS programming related to Agriculture. In addition, the PFAS Fund, 7 MRSA § 320-L was created to address PFAS contamination impacting agriculture, and authorized a PFAS Advisory Committee to oversee use of a $60 million fund. The Maine Center for Disease Control and Prevention added 2 new positions for both its environmental health and toxicology program and its drinking water program to assist with the implementation of public health aspects of contamination, and the Maine Department of Inland Fisheries and Wildlife added 1 new position and obtained $842,774 from the Maine legislature in support of better understanding impacts of PFAS to fish and wildlife.
- In 2021, *Michigan* allocated $23.4 million and 131,296 staff hours to implement **PFAS activities**.
- *New Jersey* utilized five FTEs for PFAS standard-setting efforts.
- *New Mexico* estimated 2020 and 2021 drinking water sampling efforts to total $1.2 million, and the state legislature has authorized $4 million for communities in two counties to plan, design, and construct improvements to water systems with PFAS contamination.
- *Pennsylvania's* MCL rulemaking required a cost-benefit analysis. The state provided an in-depth cost-estimate chart of costs to the regulated community (i.e., public water systems) for the first four years, including total estimated annual treatment costs, as well as comparisons of costs and benefits for compliance monitoring, treatment, performance monitoring, and other costs associated with state health advisories, MCLs, and MCLGs for PFOA and PFOS. Pennsylvania said its Department of Environmental Protection's Bureau of Safe Drinking Water has also incurred considerable costs to move forward with the MCL rulemaking, including toxicology contracts of $180,367 for year one and $250,000 for year two; sampling plan lab costs of $361,151; sampling plan travel costs to collect samples of $12,000, and personnel costs of about $1,150,000, totaling about $1,953,518 for MCL development.

[53] Maine also obtained an additional $5 million through the American Recovery Program to be used by the Maine DEP for providing clean drinking water to residents with PFAS impacted private drinking wells, as well as to the Maine Department of Agriculture, Conservation and Forestry, for two FTEs and $10 million to coordinate with Maine DEP on investigation of PFAS in active agricultural operations. A breakdown of spent and projected costs on Maine DEP's soil and groundwater investigation is available in the Status of Maine's PFAS Soil and Groundwater Investigation at Sludge and Septage Land Application Sites report, **published** on January 13, 2023. Maine is also utilizing support for litigation through its Attorney General's Office.

- In 2022, the *South Carolina* legislature appropriated $10 million to mitigate drinking water that has been impacted by PFAS. The state's Department of Health and Environmental Control will also use carry-forward dollars from the previous year for additional personnel costs to support the Bureau of Water's strategies due to the amount of time spent on additional projects.

A couple of states noted that PFAS have required a somewhat swift and significant rebalancing of staff member projects; for example, a state may have difficulty hiring new employees to fill the previous positions of those now assigned to work on PFAS, or a state's other projects may fall by the wayside due to the demand of this issue.

Incurred costs extend beyond those for regulating PFAS and should factor in expenditures for: initial investigations to determine whether and to what degree there are PFAS releases or contaminated media; removal methods for contaminated media; disposal or long-term storage of AFFF; lab certification process development and equipment acquisition; chemical analysis; method-specific staff training; liabilities and legal fees; risk communication; water utilities (which may be passed on to consumers); and tracking the fate and transport of PFAS once they are released from an active source to the environment, requiring (re)sampling and treatment. For example, *Florida* has appropriated funding to assess and remediate PFAS at state-owned fire training facilities, as well as to assist homeowners with private wells that have PFAS-related contamination. Also, the *Maine* legislature set aside $3.2 million in its 2022 supplemental budget to help fund the startup of laboratories to analyze for PFAS.[54] Many states, with and without PFAS guidelines, have, are currently, or are planning to sample all public water systems, requiring a large amount of resources, not including the money required to remediate contamination when it is discovered. *Minnesota* is still calculating its costs (the total for past, ongoing, and potential future PFAS efforts will be estimated in its pending PFAS report), but noted that an industrial facility in the state allocated about $750,000 to retrofit its operations where PFAS were used and had contaminated a nearby waterbody. *New Jersey* estimates that the average cost for lab analysis is $300 per PFAS sample at each point of entry, and that this cost is expected to decrease as additional laboratories are certified for PFAS analysis and as market competition increases. The state also estimates that the cost of installing PFAS-specific GAC treatment for a PWS treating one million gallons per day (serving about 10,000 people) ranges from $500,000 to $1,000,000, with estimated operating costs of approximately $80,000 per year. New Jersey notes that operating costs could increase depending on the number of wells requiring treatment and the level of contamination. Given PFAS ubiquity, the ability for precursors (e.g., fluorotelomers) to transform to perfluoroalkyl acids and complicate site models, and complex transport mechanisms, especially at the air-water interface, states will need to use more resources to test process-based conceptual site models and fully understand the size and source of PFAS plumes.

States identified several cost implications of regulating PFAS:

- Resource availability is driven by dedicated government appropriations. For most states, resources to investigate and address PFAS come from existing program budgets (i.e., no new funds). Agencies in some states like *Colorado* and *Michigan* have received funding from bills signed by their Governors, and *Connecticut* regulators received $2 million in bond funding to support the development and implementation of an AFFF take-back program, limited private well sampling, and treatment where needed. *Wisconsin* allocated $1 million in their 2021-2023 biennial budget for a firefighting foam collection and disposal program. But these exemplify state-specific resources based on legislative priorities. Other states have received funding from settlements with PFAS manufacturers to use on regulation and/or restoration of contaminated sites, or rely on grant funding options to support PFAS regulations.
- Resource disparity exists. States with the fewest resources to address PFAS may be more significantly impacted by PFAS than others. Similarly, they may only have resources to address PFAS-related risks that are most

[54] Two facilities have been awarded grants through this program, and it is anticipated that the laboratories will need some time before they will be fully operational.

studied in existing science and most salient among the public, rather than addressing risks unique to that state. The complexities of PFAS scientific information also create a barrier to understanding risk in a public forum.
- Data gaps prevent confident decision-making on how resources are used to address PFAS. States want to develop regulations based on a sound understanding of the problem in their state and to be able to communicate that understanding to their constituents. However, various factors – the lack of information on the sources and fates of PFAS, how they can be removed from drinking water and aquifers, and resulting waste management issues – create barriers to state time and financial investment.

In November 2021, President Biden signed into law the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law. The law provides $550 billion over fiscal years 2022 to 2026 in new federal investment in infrastructure, including $5 billion to help communities address emerging contaminants like PFAS in drinking water. In early 2023, the EPA announced the availability of the first $2 billion of the funding, which will be allocated to states and territories through the agency's Emerging Contaminants in Small or Disadvantaged Communities Grant Program, to prioritize infrastructure and source water treatment for pollutants and to conduct water quality testing. A number of states and territories have already been allotted some of the funding, and states hope to receive more to continue to work on these challenging issues.

A few states identified the need for water quality-based effluent limits, as well as the need for a cost conversation through national MCL or National Recommended Water Quality Criteria (NRWQC) processes, as many states do not have the resources to regulate PFAS on their own. These are SDWA and CWA processes driven by the EPA and involving states as co-regulators, and are one example of how the EPA is assessing potential changes to its regulatory processes to better respond to contaminants of emerging concern and be more inclusive of state priorities.[55] Additionally, a couple of states mentioned needing final federal 304(a) criteria or better cost information to implement surface water quality standards.

Conclusion

ECOS asked states to list considerations and unanswered questions that will affect their PFAS guidelines in the future. States noted that the biggest questions for state PFAS regulations will be:

- How can regulators apply or develop guidelines to PFAS in less-explored media (e.g., food and agriculture, fish tissue, biosolids, landfills, foam, and air emissions), if at all?
- How can labs detect lower concentrations of PFAS for media other than drinking water?
- What new information on sensitive human subpopulations, bioaccumulation in fish and shellfish, etc. will affect PFAS regulation?
- How will shifting use and chemistries of PFAS that have yet to be addressed complicate the responses? How many PFAS exist but are unknown to regulators due to confidentiality from manufacturers, etc.?
- How will developing information about PFAS migration from soil into animal feed, food crops, etc. affect the need for guidance values and state actions in response?
- How will regulatory approaches for soil (for protection of groundwater) change based on the results of ongoing research into better understanding PFAS sorption and leaching?
- What analytical approaches and health effects data will be available to develop guidelines for replacement PFAS?
- What will happen to current and pending state guidelines when federally enforceable standards (MCLs, NRWQCs) are enacted?

[55] For more information on states' recommendations for contaminants of emerging concern, see the Association of Clean Water Administrators (ACWA) and ASDWA joint **Recommendations Report for Contaminants of Emerging Concern**.

- What kinds of new science are needed to more effectively regulate PFAS individually or as mixtures? How will more occurrence data help to better understand PFAS in various media including wastewater and biosolids, private drinking water supplies, soils, air, fish tissue, and surface water?
- How will guidelines affect PFAS management/cleanup liability, disposal, and other considerations? For example, what will be the impact of designating PFAS as hazardous substances or regulating discharges through the NPDES and remediation programs? Who will pay for mitigation or remediation? What role does pollution prevention play in prohibiting PFAS in consumer goods from passing through regulated facilities and entering the environment?
- How can PFAS be effectively remediated and/or disposed of, especially once designated as a hazardous substance or waste? How will data on PFAS disposal through landfills, wastewater treatment, composting, plant uptake, etc. be utilized for proper management?
- How can we effectively prioritize and harmonize policies that focus on managing upstream processes to prevent downstream contamination (e.g., mandates that will minimize or eliminate the presence of PFAS/PFOS in compost, biosolids, and consumer products)?
- How does the presence of PFAS/PFOS in packaging and organic products impact the faith of consumers and policy makers to move forward with a circular economic model?
- How do we ensure that new chemicals developed to replace PFAS do not end up having similar or greater impacts on public health and the environment?
- How will funding from the Bipartisan Infrastructure Law continue to be allocated to states to monitor, remediate, and regulate PFAS contamination? And what other funding mechanisms can be made available for states to initiate pilot or other projects for PFAS treatment, concentration, and destruction technologies, among other activities?
- How can state and federal agencies better coordinate effective risk communication messaging?
- What considerations should be made for the compliance costs of drinking water providers that will be passed to their customers, especially those in disadvantaged communities?
- What is the impact of PFAS discharges from multiple onsite wastewater treatment systems (septic fields) on local groundwater quality and what is the role of states in addressing such non-point source contamination, which ends up contaminating nearby private drinking water wells?
- How can regulators utilize the lessons learned from dealing with PFAS to assist with or prevent additional emerging contaminant issues?

PFAS pose complex challenges that are new (e.g., drinking water contamination is not a major issue for other persistent, bioaccumulative, and toxic chemicals) and especially daunting. Their unique characteristics include mobility; persistence in the environment and the human body; toxicity to animals and human health effects at low doses; a lack of toxicological data for most PFAS detected in the environment and used in commerce; ubiquitous detection in human blood; and technical obstacles for remediation. These challenges are compounded by regulatory and policy developments that vary by state and are uncertain at the federal level. There is also heightened public pressure for swift risk management, encouraged through social media and news reports. For example, there have been large settlements of high-profile lawsuits (e.g., $850 million from 3M to Minnesota in 2018, $671 million from DuPont to plaintiffs in West Virginia and Ohio in 2017). Advocacy groups have convened community events and produced films inspired by PFAS contamination in cities like Parchment, Michigan; Decatur, Alabama; and Parkersburg, West Virginia. And public data from the UCMR3 reported that PFAS were detected in water supplies serving 16.5 million people in the U.S. and that more than six million people consumed water with PFAS concentrations above the EPA's 2016 LHA of 70 ppt for the total of PFOA and PFOS in 2015.[56] These numbers are

[56] Hu et al., 2016. "Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants." *Environmental Science & Technology Letters*, vol. 3, no. 10, 2016, pp. 344-350. *ACS Publications*, **https://doi.org/10.1021/acs.estlett.6b00260**.

expected rise as PWSs monitor for 29 PFAS - including the six included in UCMR3, with lower Reporting Levels - under UCMR5 in 2023-2025.

A few states followed the emerging scientific information on, evaluated occurrence of, and developed guidelines for PFAS for many years before they were widely known to the public. Some states are actively responding to the recent events mentioned above by establishing programs and guidelines to regulate PFAS-contaminated sites. Other states are aware of PFAS as a contaminant of emerging concern and addressing it as they can. Given these variations in state action and public knowledge of the issue, risk communication is going to be an increasingly important function. Additionally, regulators need more transparency about the uses of existing PFAS, the ongoing development of new PFAS by industry, and PFAS approval by the EPA under statutes like TSCA. As states seek to independently regulate PFAS, it is critical to coordinate with and learn from other states that have established and are establishing their own guidelines.

This compilation of state-developed PFAS guidelines is a moving target, as regulators are acting quickly to develop and/or update guidelines for PFAS in various environmental media. Some states are waiting to set guidelines until the EPA establishes a federally enforceable MCL. Other states have established guidance at levels below the EPA's 2016 LHA and/or for PFAS other than PFOA and PFOS, indicating that some regulators and toxicologists view the existing federal approach[57] as insufficiently protective. As stated earlier, however, the EPA's current draft toxicity assessments for PFOA and PFOS are much more stringent than almost all state assessments for these two PFAS. As not all states completed the survey (including some states known to have developed guidelines) and there will likely continue to be state standard setting at concentrations below the EPA's 2016 LHA and for PFAS other than PFOA and PFOS, ECOS hopes to compile additional information in the future.

This white paper is not intended to be a comprehensive compendium of state PFAS regulations. Rather, it aims to lay the foundation for states to dig deeper into the issue. ECOS hopes this paper will serve as a basis for future conversations, and encourages state-to-state, state-federal, and state-NGO partnerships and collaboration. In June 2020, the ASDWA published a **toolkit** of modules on assessing state resources, characterizing health impacts, identifying treatment, analyzing costs and benefits, and other considerations surrounding PFAS in source water. ECOS is also compiling a spreadsheet of PFAS that states monitor for, including those for which the state does not have guidelines. The spreadsheet will be available on ECOS' **PFAS webpage** and will be updated as often as states submit new data. ECOS encourages states to use this white paper in combination with its additional PFAS resources, the ASDWA's numerous reports, the ITRC **fact sheets** and **Technical/Regulatory Guidance document**, and other relevant documents to fully understand the current status on PFAS regulation.

State Agency Reports on PFAS Guidelines

These reports/resources were provided by state environmental and health agencies that responded to the ECOS survey. For a full list of individual state PFAS websites with information on how they developed their guidelines and on other PFAS efforts, see ECOS' **PFAS webpage** or the "Overview" section of ECOS' **PFAS Risk Communication Hub**.

- **Arizona**
- **Alaska**
- **California**[58]
- **Colorado**

[57] I.e., its process as a whole, or in its choice of critical studies or factors for calculation.
[58] *California*'s resources are listed as individual reports and documents which, in addition to the report linked above, include that on **PFBS notification level guidance**, **PFHxS notification level guidance**, **PFOA and PFOS proposed guidance based on human data**, **PFOS and precursor cancer hazard identification**, **PFOA hazard identification**, and **PFNA male reproductive toxicity**.

- Connecticut
- Delaware
- Florida
- Hawaii
- Illinois
- Indiana
- Iowa
- Maine
- Maryland
- Massachusetts
- Michigan
- Minnesota
- New Hampshire
- New Jersey
- New York
- North Carolina
- Oregon
- Pennsylvania
- South Carolina
- Texas
- Utah
- Vermont
- Virginia
- Washington
- Wisconsin

Appendix A: State Drinking Water PFAS Guideline Criteria

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
CA	PFOA	0.0051 (based on health-based reference level of 0.1 ppt for cancer effects, 2 ppt for non-cancer effects [liver])	Animals (mice/liver, rats/cancer)	Li et al., 2017; NTP, 2018	Hepatotoxicity in female mice; Cancer (pancreatic and liver) in male rats	20	LOAEL (0.97 mg/L)		300	3	10	3			3		Lifetime average of 0.053 L/kg/day	Oral ingestion as significant route of exposure		https://www.waterboards.ca.gov/pfas/ https://oehha.ca.gov/water/notification-level/notification-level-recommendations-perfluorooctanoic-acid-pfoa https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/PFOA_PFOS.html
	PFOS	0.0065 (based on health-based reference level of 0.4 ppt for cancer effects, 7 ppt for non-cancer effects [immune system])	Animals (mice/liver, rats/cancer)	Dong et al., 2009 Butenhoff et al., 2012	Immunotoxicity in male mice; Cancer (liver, structural similarity to PFOA) in male rats	20	NOAEL (0.674 mg/L)		30	3	10						Lifetime average of 0.053 L/kg/day			https://oehha.ca.gov/water/notification-level/notification-level-recommendations-perfluorooctanoic-acid-pfoa
	PFHxS	0.003 (based on recommended health-protective concentration of 0.002 for thyroid effects)	Animals (rats)	NTP, 2019	Decreased total thyroxine (T4)	20	$BMDL_{1SD}$ (28.6 mg/L)	0.00243	1,000	√10	10		√10	10		0.0000024	0.237 L/kg-day	0-6 month infant drinking water intake rate		https://oehha.ca.gov/media/pfhxsnl031722.pdf
	PFBS	0.5	Animals (mice)	Feng et al., 2017	Reduction of thyroid hormone, pregnant mice	20	$BMDL_{1SD}$ (22 mg/kg-day)	0.06	100	3	10		3			0.0006	0.237 L/kg-day	0-6 month infant drinking water intake rate		https://oehha.ca.gov/media/downloads/water/chemicals/nl/pfbsnl011321.pdf
	PFOA	(Proposed Public Health Goal) 0.007 × 10-3 (based on human kidney cancer)	Humans (kidney cancer)	Shearer et al., 2021; Vieira et al., 2013	Cancer (kidney) in humans		CSF (0.0026 per ng/kg-day)										Lifetime average of 0.053 L/kg-day	Oral ingestion as significant route of exposure		https://oehha.ca.gov/sites/default/files/media/downloads/crnr/pfoapfosphgdraft061021.pdf

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
CA	PFOA	(Proposed Health-Protective Concentration for noncancer effects) 0.003 (based on increased risk of liver damage)	Humans (increased risk of liver damage)	Gallo et al., 2012	Liver enzymes in human serum exceeding clinically based reference levels used by the International Federation of Clinical Chemistry and Laboratory Medicine	20	NOAEC (9.8 ng/ml)	9.8 ng/ml	√10		√10					0.00087	Lifetime average of 0.053 L/kg-day	Oral ingestion as significant route of exposure		https://oehha.ca.gov/sites/default/files/media/downloads/crnr/pfoapfosphgdraft061021.pdf
	PFOS	(Proposed Public Health Goal) 0.001 (based on cancer effects in animals)	Animals (liver and pancreatic tumors in rats)	Butenhoff et al., 2012	Cancer (liver and pancreatic) in rats		CSF (15.6 per mg/kg-day)										Lifetime average of 0.053 L/kg-day	Oral ingestion as significant route of exposure		
	PFOS	(Proposed Health-Protective Concentration for noncancer effects) 0.002 (based on increased total cholesterol)	Humans (increased total cholesterol)	Steenland et al., 2009	Total cholesterol levels in humans exceeding clinical reference level published by the American Heart Association	20	LOAEC (16.4 ng/ml)	16.4 ng/ml	10		√10	√10				0.00064	Lifetime average of 0.053 L/kg-day	Oral ingestion as significant route of exposure		
CT	PFOA	0.016	animal (mice)	Lau et a (2006)	Developmental Effects	50	LOAEL: 38 mg/L (animal serum)		1000	3	10	10			3	4.50E-06	0.143 L/kg-d	Infant (0-1 yr) average BW and 95th percentile intake rate	Infants; also protective of pregnant and lactacting women	
	PFOS	0.010	animal (mice)	Dong et al (2009)	Immune Suppression	50	NOAEL: 0.67 mg/L (animal serum)		30	3	10					2.90E-06	0.143 L/kg-d	Infant (0-1 yr) average BW and 95th percentile intake rate	Infants; also protective of pregnant and lactacting women	
	PFNA	0.012	animal (mice)	Das et al (2015)	Developmental Effects	50	NOAEL: 6.8 mg/L (animal serum)		300	3	10		10			3.40E-06	0.143 L/kg-d	Infant (0-1 yr) average BW and 95th percentile intake rate	Infants; also protective of pregnant and lactacting women	
	PFHxS	0.049	animal (rats)	Butenhoff et al (2009)	Thyroid Effects	50	NOAEL: 73.2 mg/L (animal serum)		300	3	10		10			1.40E-05	0.143 L/kg-d	Infant (0-1 yr) average BW and 95th percentile intake rate	Infants; also protective of pregnant and lactacting women	

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
HI	PFOA$^-$	0.006	ATSDR (2021)		Based on noncarcinogenic effects	20										0.54 L/kg/day				https://health.hawaii.gov/heer/files/2020/12/PFASs-Techncal-Memo-HDOH-Dec-2020.pdf
	PFOS$^-$	0.004	ATSDR (2021)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFNA$^-$	0.006	ATSDR (2021)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFBS$^-$	0.600	USEPA 2021a		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFHxS$^-$	0.04	ATSDR (2021)		Based on	20										0.54 L/kg/day				
	PFHpS$^-$	0.020	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFDS$^-$	0.020	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFBA$^-$	7.6	MNDOH (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFPeA$^-$	0.800	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFHxA$^-$	1.0	USEPA (2022)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFHpA$^-$	0.040	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFDA$^-$	0.004	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFUnDA$^-$	0.010	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFDoDA$^-$	0.013	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFTrDA$^-$	0.013	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFTeDA$^-$	0.130	Zeilmaker et al. (2018)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	PFOSA$^-$	0.024	Texas CEQ (2016)		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	HFPO-DA$^-$	0.006	USEPA 2021b		Based on noncarcinogenic effects	20										0.54 L/kg/day				
	6:2 FTS	0.780	MIDOE (2020, 2021)		Based on noncarcinogenic effects	20														

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
IL	PFOA	0.002 (MRL)	Animals (Rats/Cancer)	NTP 2018. TR-598	Liver/Pancreatic Tumors	20	LOAEL (0.97 mg/L)		300	3	10	3		chronic	3		2	Duration: 30 years Frequency: 350 days/year	Average Adult	
	PFOS	0.014	Animals (Rats/ Developmental)	Luebker et al. 2005	Decreased body weight/Delayed eye opening	20	NOAEL (0.1 mg/kg-day)	0.000515	300	3	10	1		chronic	3	0.000002	2	Lifetime	Average Adult	https://www2.illinois.gov/epa/topics/water-quality/pfas/Pages/pfas-statewide-investigation-network.aspx
	PFBS	2.1	Animals (Mice/ Endocrine)	Feng et al. 2017	Decreased thyroid levels	20	$BMDL_{0.5SD}$	0.095	300	3	10	1		chronic	1	0.0003	2	Lifetime	Average Adult	
	PFHxS	0.14	Animals (Rats/Endocrine)	Butenhoff et al 2009	Thyroid follicular damage	20	NOAEL (1 mg/kg-day)	0.0047	300	3	10	1		chronic		0.00002	2	Lifetime	Average Adult	
	PFNA	0.021	Animals (Mice/ Developmental)	Das et al. 2015	Decreased body weight/developmental delays	20	NOAEL (1 mg/kg-day)	0.001	300	3	10	1		chronic	2	0.000003	2	Lifetime	Average Adult	
	HFPO-DA	0.021	Animals (Mice/ Developmental)	DuPont-18405-1037, 2010	Reproductive effects and developmental delays	20	NOAEL (1 mg/kg-day)	0.01	3000	3	10	1	10	chronic	2	0.000003	2	Lifetime	Average Adult	
IN	PFOA	0.06		EPA RSL Tables					400											
	PFOS	0.04		EPA RSL Tables																
	PFBS	6		EPA RSL Tables																
	PFHxS	0.4		EPA RSL Tables																
	PFNA	0.06		EPA RSL Tables																
MA	PFOS, PFOA, PFNA, PFHpA, PFHxS, PFDA	0.020*	Animals	Multiple	Based on mulitple endpoints and evidence of effects below EPA PODs for PFOA and PFOS; including: immunotoxicity, hepatotoxicity, thyroid effects, developmental effects.	20; to account for dietary and other exposures to PFAS subgroup addressed as well as potentially higher infant exposures.	NOAEL for PFOS, LOAEL for PFOA, equivalent to EPA values.	Equivalent to EPA values for PFOA and PFOS	1000 for PFOA, 100 for PFOS	3	10	10 for PFOA	3 for both PFOA and PFOS			$5x10^{-6}$ based on PFOS and PFOA value, which is applied to subgroup based on similarity in chemical strutures, toxicities, long serum half-lives.	0.054 L/kg/day (same as EPA value used in LHA derivation)	Body weight and water intake of lactating women (same as EPA value used in LHA derivation)	Lactating and pregnant women; fetus; nursing infants	https://www.mass.gov/lists/development-of-a-pfas-drinking-water-standard-mcl
MD	PFOA, PFOS	0.07*																		
	PFOA, PFOS	0.035*																		
	PFHxS	0.14																		

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
ME	PFNA, PFHxS, PFHpA,	0.02*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)		EPA (2016)											
MI	PFOA	0.008	Animals (mice)	Onishchenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeltal alterations	50	LOAEL		300	3	10	3	3	1		3.9×10^{-6}	95th percentile			Health-Based Drinking Water Value Recommendations for PFAS in Michigan Report https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Reports/2019-Health-Based-Drinking-Water-Value-Recommendations-PFAS-MI.pdf?rev=1779be946a5c41439f1db4f3eeaec4ec&hash=36D3B1EA9C1E40CD83AE2A198759C2
	PFOS	0.016	Animals (mice)	Dong et al., 2009	Immunotoxicity and Hepatotoxicity	50	NOAEL		30	3	10	1	1	1		2.89×10^{-6}	95th percentile			
	PFNA	0.006	Animals (mice)	Das et al., 2015	Reduced pup body weight	50	NOAEL		300	3	10	1	10	1		2.2×10^{-6}	95th percentile			
	PFHxA	400	Animals (rats)	Klaunig et al., 2015	Renal effects	20	BMDL		300	3	10	1	10	1		8.3×10^{-2}	3.353			
	PFHxS	0.051	Animals (rats)	NTP 2018 Tox-96 Report	Thyroid effects	50	BMDL		300	3	10	1	10	1		9.7×10^{-6}	95th percentile			
	PFBS	0.42	Animals (mice)	Feng et al., 2017	Thyroid effects	20	BMDL		300	3	10	1	10	1		3×10^{-4}	1.106			
	GenX	0.37	Animals (mice)	DuPont 18405-1037, 2010	Reduced pup body weight, Hepatotoxicity	20	BMDL		300	3	10	1	3	3		7.7x10-5	3.353			
MN	PFOA (Short-term, Subchronic and chronic)	0.035	Animals (mice)	Lau et al., 2006	Developmental and liver effects, kidney effects, Immunotoxicity	20 for older children and adults, 50 for infants/young children	38 mg/L serum concentration	0.0053	300	3	10	3	3			1.8×10^{-5}	95th percentile	Half-life 840 days; placental transfer 87%, 5.2% breastmilk transfer	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfoa.pdf
	PFOS (Short-term, Subchronic and chronic)	0.015	Animals (mice)	Dong et al., 2011	Immunotoxicity, adrenal, developmental effects, liver effects, thyroid effects	20 for older children and adults, 50 for infants/ young children	2.36 mg/L serum concentration	0.000307	100	3	10		3			3.1×10^{-6}	95th percentile	Half-life 1241 days; placental transfer 40%; 1.7% breastmilk transfer	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfos.pdf
	PFBA (Short-term, Subchronic and chronic)	7 [Short-term value was lower than calculated subchronic and chronic values. Therefore all durations set to short-term]	Animals (rats)	NOTOX, 2007 and Butenhoff, 2007	Liver effects, Thyroid effects	50	3.01 mg/kg/day	0.38	100	3	10		3			3.8×10^{-3}	95th percentile	Half-life 72 hrs; placental transfer ND; breastmilk transfer ND	Infants and Adults	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfba2summ.pdf
	PFBS	0.1	Animals (rats)	NTP 2019	Thyroid effects	50	6.97 mg/kg-d	0.0084	100	3	10		3			8.40E-05	95th percentile	Human half-life 1050 hours	Adults	Perfluorobutane Sulfonate (PFBS) Toxicological Summary, March 2022 https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfbssummary.pdf

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
MN	term, Subchronic and chronic)	0.047	Animals (rats)	NTP, 2018	Thyroid effects, Liver effects	children and adults, 50 for infants/	32.4 mg/L	0.00292	300	3	10		10			$9.7x10^{-6}$	95th percentile	placental transfer 70%; breastmilk transfer 1.4%	Fetus and Breastfeeding Infants	mn.us/communities/environment/risk/docs/guidance/gw/pfhxs.pdf
	PFHxA (Short-term, Subchronic and chronic)	0.2 [Short-term value was lower than calculated subchronic and chronic values. Therefore all durations set to short-term]	Animals (rats)	NTP, 2019	Developmental & Thyroid effects	20 for all durations	25.9 mg/kg/day	0.0958	300	3	10		10		decreased body weight	$3.2x10^{-4}$ (short-term), 0.00015 (subchronic & chronic)	95th percentile	Half-life 32 days *[TK model was not used. Placental transfer 2.26; breastmilk transfer- No data]*	General Population	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfhxa.pdf
NC	GenX	0.14	Animals (mice)	DuPont-24459, 2008; DuPont-18405-1037, 2010	Hepatotoxicity	20	0.1 mg/kg/day (NOAEL)		1000	10	10			10		0.0001	1.1 L/day (95th percentile infant)	Bottle-fed infants of median weight	Infants	https://epi.dph.ncdhhs.gov/oee/pfas/NC%20DHHS%20Health%20Goal%20Q&A.pdf
NH	PFOA	0.012	Animals (mice)	Loveless et al., 2007	Hepatotoxicity	50	BMDL10		100	3	10		3			$6.1x10^{-6}$	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFOS	0.015	Animals (mice)	Dong et al., 2011	Immunosuppression	50	NOAEL		100	3	10		3			$3x10^{-6}$	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFNA	0.011	Animals (mice)	Das et al., 2015	Hepatotoxicity	50	BMDL10		100	3	10		3			$4.3x10^{-6}$	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFHxS	0.018	Animals (mice)	Chang et al., 2018 and Ali et al., 2019	Infertility	50	BMDLSD		300	3	10		3	3		$4x10^{-6}$	95th percentile	MDH Model	Fetus and Breastfeeding Infants	https://pubmed.ncbi.nlm.nih.gov/31487490/
NJ	PFOA	0.014	Animals (mice)	Loveless et al., 2006	Hepatotoxicity	20	BMDL		300	3	10				10	$2x10^{-6}$	2 (70 kg body wt)	Default adult	Infants	https://www.state.nj.us/dep/watersupply/pdf/pfoa-appendixa.pdf
	PFOS	0.013	Animals (mice)	Dong et al., 2009	Immunotoxicity	20	NOAEL		30	3	10					$1.8x10^{-6}$	2 (70 kg body wt)	Default adult	Infants	https://www.state.nj.us/dep/watersupply/pdf/pfos-recommendation-appendix-a.pdf
	PFNA	0.013	Animals (mice)	Das et al., 2015	Hepatotoxicity	50	BMDL		1000	3	10		3	10				200:1 serum: drinking water ratio		https://www.state.nj.us/dep/watersupply/pdf/pfna-health-effects.pdf

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
NY	PFOA	0.01																		
	PFOS	0.01			Liver, developmental, immune, thyroid effects															
OR	PFOA, PFOS, PFNA, PFHxS	0.03*														0.000017 (PFOA), 0.0000041 (PFOS), 0.0000034 (PFNA), 0.0000057 (PFHxS)		Short- and long-term exposures	All persons, including sensitive populations	https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/OPERATIONS/Pages/PFAS.aspx
PA	PFOA	0.014		Koskela, et al., 2017, Onishchenko, et al., 2011	Developmental effects		LOAEL and NOAEL (8.29 mg/L)		300										Children and women of childbearing age	
	PFOS	0.018		Dong, et al., 2011	Immunotoxicity effects		LOAEL and NOAEL (2.36 mg/L)		100										Children and women of childbearing age	
RI	PFOA, PFOS	0.07*																		
VT	PFOA, PFOS, PFHxS, PFHpA, PFNA	0.02*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)		EPA (2016)								0.175 L/kg/day		0-1 year old	
WA	PFOA	0.01	Animals (Mice)	Koskela et al., 2016	Skeletal effects (developmental)	50	LOAEL (8.29 mg/L maternal serum)	0.000821	300	3	10	1	10	1	1	0.000003	MDH transgenerational toxicokinetic model (Goeden et al 2019)	12 months breast feeding (1st 6 months = exclusive BF); 95th percentile DW ingestion by lactating women and infants in 1st year, then 90th percentile age-specific DW ingestion rates > 1 years old.	Fetus, infants	331-673.pdf (wa.gov)
	PFOS	0.015	Animals (Mice)	Dong et al., 2011 (with support by Dong et al., 2009)	Immune effects	20 adults; 50 infants	NOAEL (2.36 mg/L serum concentration)	0.000307	100	3	10	1	3	1	1	0.0000031	MDH transgenerational toxicokinetic model (Goeden et al 2019)	Limiting population was adults at 90th percentile drinking water intake over chronic period. Infants also modelled for 12 months breast feeding (1st 6 months = exclusive BF); 95th percentile DW ingestion by lactating women and infants in 1st year, then 90th percentile age-specific DW ingestion rates > 1 years old.	Adults, fetus, infants	331-673.pdf (wa.gov)

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
WA	PFNA	0.009	Animals (mice)	Das et al. 2015	Reduced pup weight and developmental delays	0.5	NOAEL (6.8 mg/L serum concentration)	using half-life estimate of 3.52 years	300	3	10	1	10	1	1	0.0000025	transgenerational toxicokinetic model (Goeden	feeding (1st 6 months = exclusive BF); 95th percentile DW	Fetus, infants	331-673.pdf (wa.gov)
	PFHxS	0.065	Animals (rats)	NTP, 2018	Thyroid hormone level reduction	50	BMDL (32.4 mg/L serum concentration)	0.00292	300	3	10	1	10	1	1	0.0000097	MDH transgenerational toxicokinetic model (Goeden et al 2019)	12 months breast feeding (1st 6 months = exclusive BF); 95th percentile DW ingestion by lactating women and infants in 1st year, then 90th percentile age-specific DW ingestion rates > 1 years old.	Fetus, infants	331-673.pdf (wa.gov)
	PFBS	0.345	Animals (mice)	Feng et al., 2017	Thyroid hormone level reduction (developmental)	20	BMDL (22.1 mg/kg/day)	0.095	300	3	10	1	10	1	1	0.0003	0.174 L/kg/day	95th percentile water intake rate for birth - 1 year old.	Infants	331-673.pdf (wa.gov)
WI	PFOA	0.02 (combined)*	Animals (mice)	Lau et al., 2006	Developmental (reduced ossification)	100	LOAEL		300	10	3	10								https://www.dhs.wisconsin.gov/water/gws.htm
	PFOS	0.02 (combined)*	Animals (mice)	Luebker et al., 2005	Reduced pup body weight	100	NOAEL		30	3	10				10			1 (10 kg body wt)	Gestation and infancy (including breastfeeding)	
	FOSA, NEtFOSA, NEtFOSAA, NEtFOSE	0.02 (combined)*	PFOA and PFOS Precursor		Combined standard for PFOS, PFOA, FOSA, NEtFOSE, NEtFOSA, and NEtFOSAA	100												Combined		https://www.dhs.wisconsin.gov/water/gws-cycle11.htm
	PFTeA	10	Animals (rats)	Hirata-Koizumi et al., 2015	Body weight	100	NOAEL (1 mg/kg/day)		1000	10	10	1	10	1	1		0.001	1		
	PFHxA	150	Animals (rats)	Klaunig, 2015	Clinical effects	100	NOAEL (15 mg/kg/day)		1000	10	10	1	10	1	1		0.015	1		
	PFUnA	3	Animals (rats)	Takahashi et al., 2014	Body weight	100	NOAEL (0.3 mg/kg/day)		1000	10	10	1	10	1	1		0.0003	1		
	PFDoA	0.5	Animals (rats)	Shi, 2009	Body weight and testosterone levels	100	NOAEL (0.05 mg/kg/day)		1000	10	10	1	10	1	1		$5x10^{-5}$	1		
	PFBA	10	Animals (rats)	van Otterdyk, Buttenholf 2012b	Hemotoxicity, hepatotoxicity, and thyroid toxicity	100	BMDL (MN) (3 mg/kg/day)		3000	10	10	1	10	3	1		0.001	1		
	PFBS	450	Animals (rats)	Lieder, 2009b	Nephrotoxicity	100	BMDL (MN) (45 mg/kg/day)		1000	10	10	1	10	1	1		0.045	1		

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
WI	PFNA	0.03	Animals (mice)	Das, 2015	Reproductive toxicty	100	NOAEL (1 mg/kg/day)	0.0011	300	3	10	1	1	1	10		$3x10^{-6}$	1		https://www.dhs.wisconsin.gov/water/gws-cycle11.htm
	PFDA	0.3	Animals (mice)	Harris and Birnbaum 1989	Deveolpmental (Fetal growth)	100	NOAEL (0.03 mg/kg/day)		1000	10	10	1	10	1	1		$3x10^{-5}$	1		
	PFHxS	0.04	Animals (rats)	Cheng, 2018	Developmental and repoductive toxicity (Maternal and fetal growth)	100	NOAEL (0.3 mg/kg/day)		300	3	10	1	10	1	1		$4x10^{-6}$	1		
	PFODA	400	Animals (rats)	Hirata-Koizumi., 2012	Body weight	100	NOAEL (40 mg/kg/day)		1000	10	10	1	10	1	1		0.04	1		
	Gen X	0.3	Animals (mice)	Dupont, 2010b	Nephrotoxicity and hepatotoxicity	100	NOAEL (0.1 mg/kg/day)		3000	10	10	1	10	3	1		$3x10^{-5}$	1		
	DONA	3	Animals (rats)	Gordon, 2011	Hemotoxicity and hepatotoxicity	100	NOAEL (1 mg/kg/day)		3000	10	10	1	10	3	1		0.0003	1		

*= Advisory level is based on the total of more than one PFAS

Appendix B: State Groundwater PFAS Guideline Criteria

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
AK	PFOA	0.4	Animals (mice)	Lau et al., 2006	Decreassed ossification of pup proximal phalanges, accelerated preputial separation	None (but does not include an RSC in cleanup level calculations, so essenitally use an RSC of 100)	EPA (2016)		EPA (2016)								EPA (2016)	0.78	Residential exposure for 6 yrs old child receptor	Child	http://dec.alaska.gov/media/7543/20180201_pccl.pdf
	PFOS	0.4	Animals (mice)	Luebker et al., 2005	Reduced pup body weight	None (but does not include an RSC in cleanup level calculations, so essenitally use an RSC of 100)	EPA (2016)		EPA (2016)								EPA (2016)	0.78	Residential exposure for 6 yrs old child receptor	Child	http://dec.alaska.gov/media/7543/20180201_pccl.pdf
CO	PFOA, PFOS, PFNA	0.07*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)		EPA (2016)								EPA (2016)	EPA (2016)	EPA (2016)	EPA (2016)	
	PFBS	400	Animals (mice)	EPA RSL	EPA RSL	EPA RSL	EPA RSL		EPA RSL								EPA RSL	EPA RSL	EPA RSL	EPA RSL	
	PFHxS	0.7	Animals (mice)																		
CT	PFOA, PFOS, PFHxS, PFHpA, PFNA	0.07*																			CT DEEP Remediation and Groundwater Protection Criteria

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
DE	PFOA	6 ng/L (water), 0.019 mg/kg (soil)																	Risk-based		Proposed HSCA screening levels derived from November 2022 EPA RSLs
	PFOS	4 ng/L (water), 0.013 mg/kg (soil)																			
	PFHxS	39 ng/L (water), 0.13 mg/kg (soil)																			
	PFNA	6 ng/L (water), 0.019 mg/kg (soil)																			
	PFBS	600 ng/L (water), 1.9 mg/kg (soil)																			
	HFPO-DA	6 ng/L (water), 0.023 mg/kg (soil)																			
FL	PFOA	0.07	Animals (mice)	Lau et al., 2006	Decreassed ossification of pup proximal phalanges, accelerated preputial separation	20	EPA (2016)		300	3		10			10		$2x10^{-5}$	0.054 L/kg/day		Prengant/ lactating women	
	PFOS	0.07	Animals (mice)	Luebker et al., 2005	Decreased offspring body weight	20	EPA (2016)		30	3					10		$2x10^{-5}$	0.054 L/kg/day		Prengant/ lactating women	
HI	PFOA^{-}	0.006 (drinking water [DW] toxicity), 8.5 (chronic aquatic [CA] toxicity), 120 (acute aquatic																			Applicable to groundwater that is a current or potential drinking water resource, where the surface water body is located within 150 meters of a release site. See other action levels and more information: https://health.hawaii.gov/heer/guidance/ehe-and-eals/
	PFOS^{-}	0.004 (DW), 1.1 (CA), 31 (AA)																			
	PFNA^{-}	0.006 (DW) 8.0 (CA) 8.0 (AA)																			
	PFBS^{-}	0.600 (DW), 130000 (CA), 130000 (AA)																			
	PFHxS^{-}	0.040 (DW), 10 (CA), 10 (AA)																			

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
HI	PFHpS$^-$	0.020 (DW) 0.020 (CA) 0.020 (AA)																			Applicable to groundwater that is a current or potential drinking water resource, where the surface water body is located within 150 meters of a release site. See other action levels and more information: https://health.hawaii.gov/heer/guidance/ehe-and-eals/
	PFDS$^-$	0.020 (DW) 0.020 (CA) 0.020 (AA)																			
	PFBA$^-$	7.6 (DW) 830 (CA) 830 (AA)																			
	PFPeA$^-$	0.800 (DW) 0.800 (CA) 0.800 (AA)																			
	PFHxA$^-$	1.0 (DW), 6300 (CA) 48000 (AA)																			
	PFHpA$^-$	0.040 (DW) 0.040 (CA) 0.040 (AA)																			
	PFDA$^-$	0.004 (DW) 10 (CA) 10 (AA)																			
	PFUnDA$^-$	0.010 (DW) 0.010 (CA) 0.010 (AA)																			
	PFDoDA$^-$	0.013 (DW) 20 (CA) 20 (AA)																			
	PFTrDA$^-$	0.013 (DW) 0.013 (CA) 0.013 (AA)																			
	PFTeDA$^-$	0.130 (DW) 0.130 (CA) 0.130 (AA)																			
	PFOSA$^-$	0.024 (DW) 0.024 (CA) 0.024 (AA)																			
	HFPO-DA$^-$	0.006 (DW) 0.006 (CA) 0.006 (AA)																			
	6:2 FTS	0.780 (DW) 260 (CA) 11,000 (AA)																			

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
IA	PFOA	0.000004															1.5E-09				EPA
	PFOS	0.00002															7.9E-09				EPA
	PFBS	2															0.0003				EPA
	PFHxS	0.14															0.00002				ATSDR
	PFNA	0.021															0.000003				ATSDR
	HFPO-DA	0.01															0.000003				EPA/PPRTV
IL	PFOA	0.002 (MRL)	Animals (rats)	NTP 2018. TR-598	Cancer (Liver/Pancreatic Tumors)	20	LOAEL (0.97 mg/L)		300	3	10	3		chronic	3			Child: 0.78 L/day Adult: 2.5 L/day	Child Duration: 6 years Frequency: 350 days/year Adult Duration: 20 years Frequency: 350 days/ year	Child and Adult Exposure	https://pcb.illinois.gov/Cases/GetCaseDetailsById?caseId=17099
	PFOS	0.0077	Animals (rats)	Luebker et al. 2005	Developmental (Decreased body weight/Delayed eye opening)	20	NOAEL (0.1 mg/kg-day)	0.000515	300	3	10	1		chronic	3		0.000002	0.78	Child age 0-6 years	Child and Adult Exposure	
	PFBS	1.2	Animals (mice)	Feng et al. 2017	Endocrine (Decreased thyroid levels)	20	$BMDL_{0.5SD}$	0.095	300	3	10	1		chronic	1		0.0003	0.78	Child age 0-6 years	Child and Adult Exposure	
	PFHxS	0.077	Animals (rats)	Butenhoff et al 2009	Endocrine (Thyroid follicular damage)	20	NOAEL (1 mg/kg-day)	0.0047	300	3	10	1		chronic			0.00002	0.78	Child age 0-6 years	Child and Adult Exposure	
	PFNA	0.012	Animals (mice)	Das et al. 2015	Developmental (Decreased body weight/ developmental delays)	20	NOAEL (1 mg/kg-day)	0.001	300	3	10	1		chronic	2		0.000003	0.78	Child age 0-6 years	Child and Adult Exposure	
	HFPO-DA	0.012	Animals (mice)	DuPont-18405-1037, 2010	Developmental (Reproductive effects/ developmental delays)	20	NOAEL (1 mg/kg-day)	0.01	3000	3	10	1	10	chronic	2		0.000003	0.78	Child age 0-6 years	Child and Adult Exposure	
IN	PFOA	0.06		EPA RSL Tables					400												
	PFOS	0.04		EPA RSL Tables																	
	PFBS	6		EPA RSL Tables																	
	PFHxS	0.4		EPA RSL Tables																	
	PFNA	0.06		EPA RSL Tables																	

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
MA	PFOS, PFOA, PFNA, PFHpA, PFHxS, PFDA	0.020*	Animals	Multiple	Based on mulitple endpoints and evidence of effects below EPA PODs for PFOA and PFOS; including: immunotoxicity, hepatotoxicity, thyroid effects, developmental effects.	20; to account for dietary and other exposures to PFAS subgroup addressed as well as potentially higher infant exposures.	NOAEL for PFOS, LOAEL for PFOA, equivalent to EPA values.	Equivalent to EPA values for PFOA and PFOS	1000 for PFOA, 100 for PFOS	3	10	10 for PFOA	3 for both PFOA and PFOS				$5x10^{-6}$ based on PFOS and PFOA value, which is applied to subgroup based on similarity in chemical strutures, toxicities, long serum half-lives.	0.054 L/kg/day (same as EPA value used in LHA derivation)	Body weight and water intake of lactating women (same as EPA value used in LHA derivation)	Lactating and pregnant women; fetus; nursing infants	https://www.mass.gov/lists/development-of-a-pfas-drinking-water-standard-mcl
ME	PFOA	750 (construction worker)																			
	PFOS	750 (construction worker)																			
	PFBS	400 (residential), 100,000 (construction worker)																			
	PFOS, PFOA, PFNA, PFHxS, PFHpA	0.07* (residential)																			
MI	PFOA	0.008	Animals (mice)	Onishchenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeltal alterations	50	LOAEL		300	3	10	3	3	1			$3.9x10^{-6}$	95th percentile			Health-Based Drinking Water Value Recommendations for PFAS in Michigan Report: https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Reports/2019-Health-Based-Drinking-Water-Value-Recommendations-PFAS-MI.pdf?rev=1779be946a5c41439f1db4f3eeaec4ec&hash=36D3B1EA9C1E40CD83AE2A198759C23F
	PFOS	0.016	Animals (mice)	Dong et al., 2009	Immunotoxicity and Hepatotoxicity	50	NOAEL		30	3	10	1	1	1			$2.89x10^{-6}$	95th percentile			
	PFNA	0.006	Animals (mice)	Das et al., 2015	Reduced pup body weight	50	NOAEL		300	3	10	1	10	1			$2.2x10^{-6}$	95th percentile			
	PFHxA	400	Animals (rats)	Klaunig et al., 2015	Renal effects	20	BMDL		300	3	10	1	10	1			$8.3x10^{-2}$	3.353			
	PFHxS	0.051	Animals (rats)	NTP 2018 Tox-96 Report	Thyroid effects	50	BMDL		300	3	10	1	10	1			$9.7x10^{-6}$	95th percentile			
	PFBS	0.42	Animals (mice)	Feng et al., 2017	Thyroid effects	20	BMDL		300	3	10	1	10	1			$3x10^{-4}$	1.106			
	GenX	0.37	Animals (mice)	DuPont 18405-1037, 2010	Reduced pup body weight, Hepatotoxicity	20	BMDL		300	3	10	1	3	3			7.7x10-5	3.353			

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
MI	PFOA (GSI for drinking water source)	0.066	Animals (mice)	Onischenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeletal alterations		LOAEL		300	3	10	3	3	1			3.88×10^{-6}	2			https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values
	PFOA (GSI)	0.17	Animals (mice)	Onischenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeletal alterations		LOAEL		300	3	10	3	3	1			3.88×10^{-6}	0.01			
	PFOS (GSI for drinking water source)	0.011	Animals (primates)	Seacat et al., 2002	Decreased body weight, hepatotoxicity, thyroid effects		NOAEL		30	3	10	1	1	1			1.37×10^{-5}	2			https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values
	PFOS (GSI)	0.012	Animals (primates)	Seacat et al., 2002	Decreased body weight, hepatotoxicity, thyroid effects		NOAEL		30	3	10	1	1	1			1.37×10^{-5}	0.01			https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values
	PFBS (GSI for drinking water source)	8.3	Animals (mice)	Feng et al., 2017	Thyroid effects		BMDL		300	3	10	1	10	1			1.13×10^{-3}	2			https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-
	PFBS (GSI)	670	Animals (mice)	Feng et al., 2017	Thyroid effects		BMDL		300	3	10	1	10	1			1.13×10^{-3}	0.01			
MN	PFOA (Short-term, Subchronic and chronic)	0.035	Animals (mice)	Lau et al., 2006	Developmental and liver effects, kidney effects, Immunotoxicity	50	38 mg/L serum concentration	0.0053	300	3	10	3	3				1.8×10^{-5}	95th percentile	Half-life 840 days; placental transfer 87%, 5.2% breastmilk transfer	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfoa.pdf
	PFOS (Short-term, Subchronic and chronic)	0.015	Animals (mice)	Dong et al., 2011	Immunotoxicity, adrenal, developmental effects, liver effects, thyroid effects	20 for older children and adults, 50 for infants/ young children	2.36 mg/L serum concentration	0.000307	100	3	10		3				3.1×10^{-6}	95th percentile	Half-life 1241 days; placental transfer 40%; 1.7% breastmilk transfer	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfos.pdf
	PFBA (Short-term, Subchronic and chronic)	7 [Short-term value was lower than calculated subchronic and chronic values. Therefore all durations set to short-term]	Animals (rats)	NOTOX, 2007 and Butenhoff, 2007	Liver effects, Thyroid effects	50	3.01 mg/kg/day	0.38	100	3	10		3				3.8×10^{-3}	95th percentile	Half-life 72 hrs; placental transfer ND; breastmilk transfer ND	Infants and Adults	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfba2summ.pdf

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
MN	PFBS (Short-term, subchronic, and chronic)	0.1 [Short-term value was lower than calculated subchronic and chronic values. Therefore all durations set to short-term]	Animals (rats)	NTP 2019	Thyroid effects	50%	6.97 mg/kg-d	0.0084	100	3	10		3				8.40E-05	95th percentile	Human half-life 1050 hours	Adults	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfbssummary.pdf
	PFHxS (Short-term, Subchronic and chronic)	0.047	Animals (rats)	NTP, 2018	Thyroid effects, Liver effects	20 for older children and adults, 50 for infants/ young children	32.4 mg/L	0.00292	300	3	10		10				9.7x10^{-6}	95th percentile	Half-life 1935 days; placental transfer 70%; breastmilk transfer 1.4%	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfhxs.pdf
	PFHxA (Short-term, Subchronic and chronic)	[Short-term value was lower than calculated	Animals (rats)	NTP, 2019	Developmental & Thyroid effects	20 for all durations	25.9 mg/kg/day	0.0958	300	3	10		10		decreased body weight	(short-term), 0.00015 (subchronic & chronic)	95th percentile	days *[TK model was not used. Placental*	General Population		https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pfhxa.pdf
NH	PFOA	0.012	Animal (mice)	Loveless et al., 2007	Hepatotoxicity	50	BMDL10		100	3	10		3				6.1x10^{-6}	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFOS	0.015	Animal (mice)	Dong et al., 2011	Immunosuppression	50	NOAEL		100	3	10		3				3x10^{-6}	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFNA	0.011	Animal (mice)	Das et al., 2015	Hepatotoxicity	50	BMDL10		100	3	10		3				4.3x10^{-6}	95th percentile	MDH Model	Fetus and Breastfeeding Infants	
	PFHxS	0.018	Animal (mice)	Chang et al., 2018 and Ali et al., 2019	Infertility	50	BMDLSD		300	3	10		3	3			4x10^{-6}	95th percentile	MDH Model	Fetus and Breastfeeding Infants	Ali, et al., 2019 https://pubmed.ncbi.nlm.nih.gov/31487490/
NJ	PFOA	0.014	Animals (mice)	Loveless et al., 2006	Hepatotoxicity	20	BMDL		300	3	10				10		2x10^{-6}	2 (70 kg body wt)	Default adult		Note: MCLs for PFOA, PFOS, and PFNA are also used as Groundwater Quality Standards.
	PFOS	0.013	Animals (mice)	Dong et al., 2009	Immunotoxicity	20	NOAEL		30	3	10						1.8x10^{-6}	2 (70 kg body wt)	Default adult		
	PFNA	0.013	Animals (mice)	Das et al., 2015	Hepatotoxicity	50	BMDL		1000	3	10		3	10					200:1 serum: drinking water ratio		

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
NJ	Chloroperfluoropolyether carboxylates (ClPFPECAs)	0.002	Animals (rats)	RTC. 2016. Posted at https://www.nj.gov/dep/dsr/13-week-oral-toxicity-study-in-rats-	Hepatotoxicity	20	BMDL		3000	3	10		10	10			2.8×10^{-7}	2.4 (80 kg body wt)			Ground Water Quality Standard https://www.state.nj.us/dep/wms/bears/gwqs.htm and https://www.nj.gov/dep/dsr/supportdocs/
NM	PFOA	0.07*																			
	PFOS	0.07*																			
	PFHxS	0.07*																			
NY	PFOA	0.01																			
	PFOS	0.01																			
PA	PFOA	0.07																			
	PFOS	0.07																			
	PFBS	10 (residential), 29 (non-residential)																			
TX	PFBA	24	Animals (male rats)	Butenhoff et al., 2012	hepatocellular hypertrophy and decreased total thyroxine (T4)		5.4 mg/kg-d (BMDL10 for hepatocellular hypertrophy) and 6 mg/kg-d (NOAEL for decreased total thyroxine)	1.15 mg/kg-d (hepatocellular hypertrophy) and 1.27 mg/kg-d (decreased total thyroxine)	1000	3	10		3	10			1x10-3	See the equations and input values in §350.74 of the Texas Risk Reduction Program (TRRP) rule		residents (adult, child)	TRRP rule website https://www.tceq.texas.gov/remediation/trrp
	PFBuS	34	Animals (mice)	Leider et al., 2009, York et al., 2002	Systemic Toxicity		NOAEL (60 mg/kg/d)		42600	1	10		10	3			1.4×10^{-3}				
	PFPeA	0.093	Animals (mice)	Surrogate: PFHxS	Hematotoxicity		NOAEL (0.3 mg/kg/d)		78900	1	10	3	10				3.8×10^{-6}				
	PFHxS	0.093	Animals (mice)	Hoberman and York, 2003	Hematotoxicity		NOAEL (0.3 mg/kg/d)		78900	1	10	3	10				3.8×10^{-6}				
	PFHxA	12	Animals (pregnant rats)	Loveless et al., 2009	decreased offspring body weight in neonatal male and female rats		10.62 mg/kg-d (BMDL5)	0.048 mg/kg-d	100	3	10		3				5x10-4	See the equations and input values in §350.74 of the Texas Risk Reduction Program (TRRP) rule		residents (adult, child)	TRRP rule website https://www.tceq.texas.gov/remediation/trrp
	PFHpA	0.56	Animals (mice)	Surrogate: PFOS	Neurodevelopment		NOAEL (0.6 mg/kg/d)		26300	1	10	10	1				2.3×10^{-5}				

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
TX	PFOS	0.56	Animals (mice)	Zeng et al., 2011	Neurodevelopment		NOAEL (0.6 mg/kg/d)		26300	1	10	10	1				$2.3x10^{-5}$				
	PFOA	0.29	Animals (mice)	Macon et al., 2011	Mammary gland development		NOAEL (0.3 mg/kg/d)		24300	1	10	30	1				$1.2x10^{-5}$				
	PFOSA	0.29	Animals (mice)	Surrogate: PFOA	Mammary gland development		NOAEL (0.3 mg/kg/d)		24300	1	10	30	1				$1.2x10^{-5}$				
	PFNA	0.29	Animals (mice)	Fang et al., 2010	Spleen Cell Death		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
	PFDeA	0.37	Animals (mice)	Kawashima et al., 1995	Hepatotoxicity		NOAEL (1.2 mg/kg/d)		81000	1	10		10	10			$1.5x10^{-5}$				
	PFDS	0.29	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
	PFUA	0.29	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
	PFDoA	0.29	Animals (mice)	Shi et al., 2007	Reduced Body Weight		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
	PFTrDA	0.29	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
	PFTeDA	0.29	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)		81000	1	10		10	10			$1.2x10^{-5}$				
VT	PFOA, PFOS, PFHxS, PFHpA, PFNA	0.02*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)		EPA (2016)									0.175 L/kg/day		0-1 year old	
WA	PFOA	10 ng/L																			
	PFOS	15 ng/L																			
	PFNA	9 ng/L																			
	PFHxS	65 ng/L																			
	PFBS	345 ng/L																			
	HFPO-DA (GenX)	24 ng/L																			

State	PFAS	State	PFAS	State	Endpoint	RSC (%)	POD	HED (mg/kg/day)	UFs								RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
									Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints/ Subpopulations	Modifying Factor					
WI	PFOA	0.02 (combined)*	Animals (mice)	Lau et al., 2006	Developmental (reduced ossification)	100	LOAEL		300	10	3	10									https://www.dhs.wisconsin.gov/water/gws.htm
	PFOS	0.02 (combined)*	Animals (mice)	Luebker et al., 2005	Reduced pup body weight	100	NOAEL		30	3	10				10			1 (10 kg body wt)	Gestation and infancy (including breastfeeding)		
	FOSA, NEtFOSA, NEtFOSAA, NEtFOSE	0.02 (combined)*	PFOA and PFOS Precursor		Combined standard for PFOS, PFOA, FOSA, NEtFOSE, NEtFOSA, and NEtFOSAA	100												Combined			https://www.dhs.wisconsin.gov/water/gws-cycle11.htm
	PFTeA	10	Animals (rats)	Hirata-Koizumi et al., 2015	Body weight	100	NOAEL (1 mg/kg/day)		1000	10	10	1	10	1	1		0.001	1			
	PFHxA	150	Animals (rats)	Klaunig, 2015	Clinical effects	100	NOAEL (15 mg/kg/day)		1000	10	10	1	10	1	1		0.015	1			
	PFUnA	3	Animals (rats)	Takahashi et al., 2014	Body weight	100	NOAEL (0.3 mg/kg/day)		1000	10	10	1	10	1	1		0.0003	1			
	PFDoA	0.5	Animals (rats)	Shi, 2009	Body weight and testosterone levels	100	NOAEL (0.05 mg/kg/day)		1000	10	10	1	10	1	1		$5x10^{-5}$	1			
	PFBA	10	Animals (rats)	van Otterdyk, Buttenholf 2012b	Hemotoxicity, hepatotoxicity, and thyroid toxicity	100	BMDL (MN) (3 mg/kg/day)		3000	10	10	1	10	3	1		0.001	1			
	PFBS	450	Animals (rats)	Lieder, 2009b	Nephrotoxicity	100	BMDL (MN) (45 mg/kg/day)		1000	10	10	1	10	1	1		0.045	1			
	PFNA	0.03	Animals (mice)	Das, 2015	Reproductive toxicty	100	NOAEL (1 mg/kg/day)	0.0011	300	3	10	1	1	1	10		$3x10^{-6}$	1			
	PFDA	0.3	Animals (mice)	Harris and Birnbaum 1989	Deveolpmental (Fetal growth)	100	NOAEL (0.03 mg/kg/day)		1000	10	10	1	10	1	1		$3x10^{-5}$	1			
	PFHxS	0.04	Animals (rats)	Cheng, 2018	Developmental and repoductive toxicity (Maternal and fetal	100	NOAEL (0.3 mg/kg/day)		300	3	10	1	10	1	1		$4x10^{-6}$	1			
	PFODA	400	Animals (rats)	Koizumi., 2012	Body weight	100	NOAEL (40 mg/kg/day)		1000	10	10	1	10	1	1		0.04	1			
	Gen X	0.3	Animals (mice)	Dupont, 2010b	Nephrotoxicity and hepatotoxicity	100	NOAEL (0.1 mg/kg/day)		3000	10	10	1	10	3	1		$3x10^{-5}$	1			
	DONA	3	Animals (rats)	Gordon, 2011	Hemotoxicity and hepatotoxicity	100	NOAEL (1 mg/kg/day)		3000	10	10	1	10	3	1		0.0003	1			

*= Advisory level is based on the total of more than one PFAS

Appendix C: State Surface Water PFAS Guideline Criteria

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	POD	UFs					RfD (mg/kg/day)	Drinking Water Intake Rate (L/day)	Resources & Notes
							Total	Interspecies	Intraspecies	LOAEL to NOAEL	Duration of Exposure (i.e., Subchronic to Chronic)			
CO	PFOA, PFOS, PFNA	0.07*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)					EPA (2016)	EPA (2016)	
	PFBS	400	Animals (mice)	EPA RSL	EPA RSL	EPA RSL	EPA RSL					EPA RSL	EPA RSL	
	PFHxS	0.7	Animals (mice)											
FL	PFOA	0.5										$2x10^{-5}$		Screening levels derived through a Probabilistic Risk Assessment https://floridadep.gov/sites/default/files/PFOA_PFOS_Human_Health_Surface_Water_Prob_Risk_Assessment.pdf
	PFOS	0.01										$2x10^{-5}$		
HI	$PFOA^-$	0.006 (drinking water [DW] toxicity), 8.5 (chronic aquatic [CA] toxicity), 120 (acute aquatic [AA] toxicity)											0.54 L/kg/day	Drinking water action levels applied if aquatic toxicity action levels not available; chronic aquatic toxicity action level also used as acute aquatic toxicity action level if latter not available. Refer to technical memorandum for additional detail: https://health.hawaii.gov/heer/guidance/ehe-and-eals/
	$PFOS^-$	0.004 (DW), 1.1 (CA), 31 (AA)												
	$PFNA^-$	0.006 (DW) 8.0 (CA) 8.0 (AA)												
	$PFBS^-$	0.600 (DW), 130000 (CA), 130000 (AA)												
	$PFHxS^-$	0.040 (DW), 10 (CA), 10 (AA)												
	$PFHpS^-$	0.020 (DW) 0.020 (CA) 0.020 (AA)												
	$PFDS^-$	0.020 (DW) 0.020 (CA) 0.020 (AA)												
	$PFBA^-$	7.6 (DW) 830 (CA) 830 (AA)												

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	POD	UFs					RfD (mg/kg/day)	Drinking Water Intake Rate (L/day)	Resources & Notes
							Total	Interspecies	Intraspecies	LOAEL to NOAEL	Duration of Exposure (i.e., Subchronic to Chronic)			
HI	PFPeA$^-$	0.800 (DW) 0.800 (CA) 0.800 (AA)												Drinking water action levels applied if aquatic toxicity action levels not available; chronic aquatic toxicity action level also used as acute aquatic toxicity action level if latter not available. Refer to technical memorandum for additional detail: https://health.hawaii.gov/heer/guidance/ehe-and-eals/
	PFHxA$^-$	1.0 (DW), 6300 (CA) 48000 (AA)												
	PFHpA$^-$	0.040 (DW) 0.040 (CA) 0.040 (AA)												
	PFDA$^-$	0.004 (DW) 10 (CA) 10 (AA)												
	PFUnDA$^-$	0.010 (DW) 0.010 (CA) 0.010 (AA)												
	PFDoDA$^-$	0.013 (DW) 20 (CA) 20 (AA)												
	PFTrDA$^-$	0.013 (DW) 0.013 (CA) 0.013 (AA)												
	PFTeDA$^-$	0.130 (DW) 0.130 (CA) 0.130 (AA)												
	PFOSA$^-$	0.024 (DW) 0.024 (CA) 0.024 (AA)												
	HFPO-DA$^-$	0.006 (DW) 0.006 (CA) 0.006 (AA)												
	6:2 FTS	0.780 (DW) 260 (CA) 11,000 (AA)												
MI	PFOA (drinking water source)	0.066	Animals (mice)	Onischenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeletal alterations	LOAEL	300	3	10	3	1	3.88×10^{-6}	2	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values 3x Database uncertainty factor included in Total UF
	PFOA	0.17	Animals (mice)	Onischenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeletal alterations	LOAEL	300	3	10	3	1	3.88×10^{-6}	0.01	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values 3x Database uncertainty factor included in Total UF
	PFOS (drinking water source)	0.011	Animals (primates)	Seacat et al., 2002	Decreased body weight, hepatotoxicity, thyroid effects	NOAEL	30	3	10			1.37×10^{-5}	2	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	POD	UFs					RfD (mg/kg/day)	Drinking Water Intake Rate (L/day)	Resources & Notes
							Total	Interspecies	Intraspecies	LOAEL to NOAEL	Duration of Exposure (i.e., Subchronic to Chronic)			
MI	PFOS	0.012	Animals (primates)	Seacat et al., 2002	Decreased body weight, hepatotoxicity, thyroid effects	NOAEL	30	3	10			1.37×10^{-5}	0.01	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values
	PFBS (drinking water source)	8.3	Animals (mice)	Feng et al., 2017	Thyroid effects	BMDL	300	3	10			1.13×10^{-3}	2	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values 10x Database uncertainty factor included in Total UF
	PFBS	670	Animals (mice)	Feng et al., 2017	Thyroid effects	BMDL	300	3	10			1.13×10^{-3}	0.01	https://www.michigan.gov/egle/about/organization/Water-Resources/assessment-michigan-waters/rule-57-water-quality-values 10x Database uncertainty factor included in Total UF
MN	PFOS	0.37 ng/g (fish tissue) 0.00005 ug/L (surface water)	Animals (mice)	Dong et al., 2011	Immunotoxicity, adrenal, developmental effects, liver effects, thyroid effects	Based on MDH toxicity assessment						3.1×10^{-6}		For more information visit the MPCA site-specific water quality criteria webpage: https://www.pca.state.mn.us/business-with-us/site-specific-water-quality-criteria
	PFBS	0.14 (Class 1/2A/2Bd) 0.35 (Class 2B/2D)	Animals (rats)	NTP 2019	thyroid (endocrine)	Based on MDH toxicity assessment						8.40E-05		
	PFBA	5.7 (Class 1/2A/2Bd) 10 (Class 2B/2D)	Animals (rats)	NOTOX 2007	developmental, hematological (blood) system, hepatic (liver) system, thyroid (endocrine)	Based on MDH toxicity assessment						2.90E-03		
	PFHxS	0.020 (Class 1/2A/2Bd) 0.036 (Class 2B/2D)	Animals (rats)	NTP 2018	hepatic (liver), thyroid (endocrine)	Based on MDH toxicity assessment						9.70E-06		
	PFHxA	0.22 (Class 1/2A/2Bd) 0.95 (Class 2B/2D)	Animals (rats)	Loveless et al. 2009	developmental, hepatic (liver) system, respiratory system, thyroid (endocrine)	Based on MDH toxicity assessment						1.50E-04		
	PFOA	0.025 (Class 1/2A/2Bd) 0.088 (Class 2B/2D)	Animals (mice)	Lau et al. 2006	developmental, hepatic (liver), immune, pancreas, renal (kidney), thyroid (endocrine)	Based on MDH toxicity assessment						1.80E-05		

State	PFAS	Guideline Level (ug/L)	Toxicity Data	Critical Effect Study	Endpoint	POD	UFs					RfD (mg/kg/day)	Drinking Water Intake Rate (L/day)	Resources & Notes
							Total	Interspecies	Intraspecies	LOAEL to NOAEL	Duration of Exposure (i.e., Subchronic to Chronic)			
NM	PFOA, PFOS	0.07*												
	NEtFOSAA, NMeFOSAA, PFBS, PFDA, PFDoA, PFHpA, PFHxS, PFHxA,													Coverage under EPA's 2021 MSGP in NM requires monitoring and analyzing for 18 PFAS compounds using modified EPA Method 537.1. Only PFOA + PFOS are used for screening.
OR	PFOA	24												Note: The Oregon wastewater initiation levels were adopted into rule (OAR 340-045-0100, Table A) in 2011. The PFAS are 5 chemicals on a list of 118 persistent priority pollutants for water that Oregon DEQ developed in response to state legislation. Municipal wastewater treatment plants with effluent exceeding initiation levels are required to develop a pollution prevention plan that becomes a part of their NPDES permit. The list and associated initiation levels were developed in consultation with a science advisory committee.
	PFOS	300												
	PFNA	1												
	PFOSA	0.2												
	PFHpA	300												
WI	PFOS	0.008	Animals (rats)	Luebker et al. 2005	Reduced pup body weight gain	0.00051 (NOAEL)	30	3	10	1	1	0.00002		This criterion applies to waters that contain fish or are connected to waters that contain fish. The Technical Support Document for this rule can be found at: https://dnr.wisconsin.gov/sites/default/files/topic/SurfaceWater/WY-23-19PFOS-PFOA_TechSupportDoc.pdf
	PFOA	0.02	Animals (mice)	Lau et all. 2006, Kieskam et al. 2018	Reduced ossification at birth in pups exposed during gestation	0.00054 mg/kg-d (HED from pharmacokinetic modeling)	300	10	3	10	1	0.00002	1	The 20 ppt criterion applies to surface waters that are used as a source of drinking water, while the 95 ppt criterion applies to all other surface waters. The Technical Support Document for this rule can be found at: https://dnr.wisconsin.gov/sites/default/files/topic/SurfaceWater/WY-23-19PFOS-PFOA_TechSupportDoc.pdf. The Scientific
	PFOA	0.095											0.21	

*= Advisory level is based on the total of more than one PFAS

Appendix D: State Soil PFAS Guideline Criteria

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
AK	PFOA	2.2 in Arctic Zone, 1.6 under 40" zone, 1.3 over 40" zone, 0.003 migration to groundwater	Animals (mice)	Lau et al., 2006	Decreased ossification of pup proximal phalanges, accelerated preputial separation	100	EPA (2016)	EPA (2016)									Residential exposure for 6 yrs old child receptor	Child	http://dec.alaska.gov/media/7543/20180201_pccl.pdf
	PFOS	2.2 in Arctic Zone, 1.6 under 40" zone, 1.3 over 40" zone, 0.0017 migration to groundwater	Animals (mice)	Luebker et al., 2005	Reduced pup body weight	100	EPA (2016)	EPA (2016)									Residential exposure for 6 yrs old child receptor	Child	http://dec.alaska.gov/media/7543/20180201_pccl.pdf
CT	PFOA, PFOS, PFHxS, PFHpA, PFNA	1.35 (residential), 41 (industrial/ commercial), 1.4 ug/kg (GA pollutant mobility criteria), 14 ug/kg (GB pollutant mobility criteria)															Residential and industrial/ commercial are for direct exposure criteria		
FL	PFOA	1.3 (residential), 25 (industrial/ commercial), 0.002 (leachability) Soil Cleanup Target Levels	Animals (mice)	Lau et al., 2006	Decreased ossification of pup proximal phalanges, accelerated preputial separation	20	5.3x10^-3 mg/kg/day	300	3		10			10	$2x10^{-5}$	0.054 L/kg/day	Children- 200 mg/day, worker- 50 mg/day, oral	Children ages 0-6	
	PFOS	1.3 (residential), 25 (industrial/ commercial), 0.007 (leachability) Soil Cleanup Target Levels	Animals (mice)	Luebker et al., 2005	decreased weight	20	5.1x10^-4 mg/kg/day	30	3					10	$2x10^{-5}$	0.054 L/kg/day	Risk target level of 10^-6 and hazard quotient of 1	Children ages 0-6	

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
HI	$PFOA^{-}$	0.0038 (residential), 0.17 (industrial/commercial), 0.00018 (dw leaching to gw), 0.25 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.	Children ages 0-6	Applicable to soil where potentially impacted groundwater is a current or potential drinking water resource and where the surface water body is located within 150 meters
	$PFOS^{-}$	0.0025 (residential), 0.11 (industrial/commercial), 0.00075 (dw leaching to gw), 0.20 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	$PFNA^{-}$	0.0038 (residential), 0.17 (industrial/commercial), 0.0011 (dw leaching to gw), 1.4 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	$PFBS^{-}$	0.38 (residential), 17 (industrial/commercial), 0.0031 (dw leaching to gw), 260 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	$PFHxS^{-}$	0.025 (residential), 1.1 (industrial/commercial), 0.0037 (dw leaching to gw), 0.93 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	$PFHpS^{-}$	0.013 (residential), 0.56 (industrial/commercial), 0.0041 (dw leaching to gw), 0.0041 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	$PFDS^{-}$	0.013 (residential), 0.56 (industrial/commercial), 0.013 (dw leaching to gw), 0.013 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
HI	PFBA^{-}	4.8 (residential), 210 (industrial/commercial), 0.099 (dw leaching to gw), 11 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFPeA^{-}	0.51 (residential), 23 (industrial/commercial), 0.0031 (dw leaching to gw), 0.0031 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFHxA^{-}	0.63 (residential), 28 (industrial/commercial), 0.0033 (dw leaching to gw), 21 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFHpA^{-}	0.025 (residential), 1.1 (industrial/commercial), 0.00029 (dw leaching to gw), 0.00029 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFDA^{-}	0.0025 (residential), 0.11 (industrial/commercial), 0.00048 (dw leaching to gw), 1.2 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFUnDA^{-}	0.006 (residential), 0.28 (industrial/commercial), 0.0045 (dw leaching to gw), 4.5 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFDoDA^{-}	0.008 (residential), 0.38 (industrial/commercial), use lab test for leaching to gw				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFTrDA^{-}	0.008 (residential), 0.38 (industrial/commercial), use lab test for leaching to gw				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
HI	PFTeDA`	0.084 (residential), 3.8 (industrial/commercial), use lab test for leaching to gw				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	PFOSA`	0.015 (residential), 0.68 (industrial/commercial), 50 (dw leaching to gw), 50 (non-dw leaching to gw)				20											Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	HFPO-DA`	0.0038 (residential), 0.17 (industrial/commercial), 0.000012 (dw leaching to gw), 0.000012 (non-dw leaching to gw)															Noncancer HQ =0 0.5, RSC = 20% and USEPA RSL default exposure parameter values. SESOIL leaching model.		
	6:2 FTS	0.49 (residential), 22 (industrial/commercial), 0.12 (dw leaching to gw), 41 (non-dw leaching to gw)																	
IA	PFOA	35													1.5E-09			Residential	EPA
	PFOS	0.00048													7.9E-09			Residential	EPA
	PFBS	18													0.0003			Residential	EPA
	PFHxS	1.6													0.00002			Residential	ATSDR
	PFNA	0.18													0.000003			Residential	ATSDR
	HFPO-DA	0.18													0.000003			Residential	EPA/PPRTV
IN	PFOA	0.3 Residential, 3 Commercial Industrial, 5 Excavation Worker	EPA RSL														Res direct contact exposure duration of 250 days/year, or 100000 mg/kg; others vary		
	PFOS	0.2 Residential, 2 Commercial Industrial, 3 Excavation Worker	EPA RSL														Res direct contact exposure duration of 250 days/year, or 100000 mg/kg; others vary		

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
IN	PFBS	30 Residential, 300 Commercial Industrial, 500 Excavation Worker	EPA RSL														Res direct contact exposure duration of 250 days/year, or 100000 mg/kg; others vary. See https://www.in.gov/idem/files/nrpd_waste-0046-r2_attch.pdf		
	PFHxS	2 Residential, 20 Commercial Industrial, 30 Excavation Worker	EPA RSL														Res direct contact exposure duration of 250 days/year, or 100000 mg/kg; others vary		
	PFNA	0.3 Residential, 3 Commercial Industrial, 5 Excavation Worker	EPA RSL														Res direct contact exposure duration of 250 days/year, or 100000 mg/kg; others vary		
MA	PFOA	0.720 ug/kg	Based on soil background data; 90th percentile.																Note: Method 1 standards. Based on 90th percentile value of soil background data set from Vermont soils.
	PFOS	2.000 ug/kg	Based on soil background data; 90th percentile.																
	PFNA	0.320 ug/kg	Based on soil background data; 90th percentile.																
	PFHxS	0.300 ug/kg	Based on soil background data; 90th percentile.																
	PFHpA	0.500 ug/kg	Based on soil background data; 90th percentile.																
	PFDA	0.30 ug/kg	Based on soil background data; 90th percentile.																

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
ME	PFOA	groundwater), 1.7 (residential), 22 (commercial worker), 4.9 (park user), 5.7 recreator sediment, 5.1 (construction worker),																	
	PFOS	groundwater), 1.7 (residential), 22 (commercial worker), 4.9 (park user), 5.7 recreator sediment, 5.1 (construction worker),																	
	PFBS	groundwater), 1,700 (residential), 22,000 (commercial worker), 4,900 (park user), 5,700 recreator sediment, 51,000 (construction																	
MI	PFOS	2.4x10^{-4}	Animals (primates)	Seacat et al., 2002	Decreased body weight, hepatotoxicity, thyroid effects		NOAEL	30	3	10	1	1	1		1.37x10^{-5}				Table 2: Soil - Residential https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/RRD/Remediation/Rules---Criteria/table-2-soil-residential.pdf?rev=83f3560a75ca41c4b89013dc932455e5&hash=9FED789A3710738F909B80D1B2788238
	PFOA	10	Animals (mice)	Onischenko et al., 2011 and Koskela et al., 2016	Neurobehavioral effects and skeletal alterations		LOAEL	300	3	10	3	1	1		3.88x10^{-6}				Table 2: Soil - Residential, 3x Database UF included in Total UF https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/RRD/Remediation/Rules---Criteria/table-2-soil-residential.pdf?rev=83f3560a75ca41c4b89013dc932455e5&hash=9FED789A3710738F909B80D1B2788238

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
MN	PFOA	0.24 (res/rec) 3.0 (com/ind)	Animals (mice)	Lau et al. 2006	Developmental, liver, immune, kidney	20%	38 mg/L serum concentration	300	3	10	3	3			1.80E-05		Residential/ Recreational, Commercial/ Industrial	Children and adults	Refer to MPCA website for the most up-to-date soil reference values (SRVs) https://www.pca.state.mn.us/business-with-us/cleanup-guidance-and-assistance
	PFOS	0.041 (res/rec) 0.54 (com/ind)	Animals (mice)	Dong et al. 2011	Developmental, liver, thyroid, immune, adrenal	20%	2.36 mg/L serum concentration	100	3	10		3			3.10E-06		Residential/ Recreational, Commercial/ Industrial	Children and adults	
	PFBA	49 (res/rec) 250 (com/ind)	Animals (rats)	NOTOX 2007	Liver, thyroid, developmental, blood	20%	6.9 mg/kg/day	300	3	10		10			2.90E-03		Residential/ Recreational, Commercial/ Industrial	Children and adults	
	PFBS	1.1 (res/rec) 15 (com/ind)	Animals (rats)	NTP 2019	Thyroid	20%	6.97 mg/kg/day	100	3	10		3			8.40E-05		Residential/ Recreational, Commercial/ Industrial	Children and adults	
	PFHxS	0.13 (res/rec) 1.6 (com/ind)	Animals (rats)	NTP 2018	Liver, thyroid	20%	32.4 mg/L serum concentration	300	3	10		10			9.70E-06		Residential/ Recreational, Commercial/ Industrial	Children and adults	
	PFHxA	1.9 (res/rec) 24 (com/ind)	Animals (rats)	Loveless et al. 2009	Liver, respiratory	20%	22.5 mg/kg/day	300	3	10		10			1.50E-04		Residential/ Recreational, Commercial/ Industrial	Children and adults	
NH	PFOA	0.2 (residential), 1.3 (maintenance worker)				0.2									$6.1x10^{-6}$		Residential (young child), Maintenance worker (outdoor)		https://www4.des.state.nh.us/nh-pfas-investigation/wp-content/uploads/PFAS-DCRB-value-121119.pdf
	PFOS	0.1 (residential), 0.6 (maintenance worker)				0.2									$3x10^{-6}$		Residential (young child), Maintenance worker (outdoor)		https://www4.des.state.nh.us/nh-pfas-investigation/wp-content/uploads/PFAS-DCRB-value-121119.pdf
	PFHxS	0.1 (residential), 0.9 (maintenance worker)				0.2									$4x10^{-6}$		Residential (young child), Maintenance worker (outdoor)		https://www4.des.state.nh.us/nh-pfas-investigation/wp-content/uploads/PFAS-DCRB-value-121119.pdf
	PFNA	0.1 (residential), 0.9 (maintenance worker)				0.2									$4.3x10^{-6}$		Residential (young child), Maintenance worker (outdoor)		https://www4.des.state.nh.us/nh-pfas-investigation/wp-content/uploads/PFAS-DCRB-value-121119.pdf

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
NJ	PFOA	Interim Soil Remediation Standard - Ingestion-Dermal Exposure Pathway. Residential - 0.13; Non-residential-1.8.	Animals (mice)	Loveless et al., 2006	Hepatotoxicity		BMDL	300	3	10				10	$2x10^{-6}$ https://www.state.nj.us/dep/watersupply/pdf/pfoa-appendixa.pdf		Assumed dermal absorption fraction is 0.1		https://www.nj.gov/dep/srp/guidance/rs/soil_ingestion_pathway_factsheet.pdf https://www.nj.gov/dep/srp/guidance/rs/interim_soil_ia_rl_rs.html
	PFOS	Interim Soil Remediation Standard - Ingestion-Dermal Exposure Pathway. Residential - 0.11; Non-residential-1.6.	Animals (mice)	Dong et al., 2009	Immunotoxicity		NOAEL	30	3	10					$1.8x10^{-6}$ https://www.state.nj.us/dep/watersupply/pdf/pfos-recommendation-appendix-a.pdf		Assumed dermal absorption fraction is 0.1		
	PFNA	Interim Soil Remediation Standard - Ingestion-Dermal Exposure Pathway. Residential - 0.047; Non-residential-0.67.	Animals (mice)	Das et al., 2015	Hepatotoxicity		BMDL	1000	3	10		3	10		$7.4x10^{-7}$ https://www.state.nj.us/dep/watersupply/pdf/pfna-health-effects.pdf		Assumed dermal absorption fraction is 0.1		
	HFPO-DA and its ammonium salt (GenX)	Interim Soil Remediation Standard - Ingestion-Dermal Exposure Pathway. Residential - 0.23; Non-residential-3.9.	Animals (mice)	DuPont 18405-1037,2010; NTP, 2019	Hepatotoxicity		BMDL	3000	3	10			10	10	$3x10^{-6}$ https://www.epa.gov/system/files/documents/2021-10/genx-chemicals-toxicity-assessment_tech-edited_oct-21-508.pdf		No dermal absorption is assumed.		
	PFOA	Interim Soil Remediation Standard - Migration to Ground Water. Area of concern/site specific using SPLP.																	https://www.nj.gov/dep/srp/guidance/rs/soil_migration_gw_pathway_factsheet.pdf https://www.nj.gov/dep/srp/guidance/rs/interim_soil_ia_rl_rs.html
	PFOS	Interim Soil Remediation Standard - Migration to Ground Water. Area of concern/site specific using SPLP.																	
	PFNA	Interim Soil Remediation Standard - Migration to Ground Water. Area of concern/site specific using SPLP.																	

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
NM	PFOS & Salt	18.5 (residential), 374 (industrial/ occupational), 80.7 (construction worker)																	20.6.2.4103.A of the New Mexico Administrative Code, implemented in conjunction with NMED's 2019 Risk Assessment Guidance
	PFOA	18.5 (residential), 374 (industrial/ occupational), 80.7 (construction worker)																	
	PFNA	18.5 (residential), 374 (industrial/ occupational), 80.7 (construction worker)																	
	PFBS & Salt	18.5 (residential), 374 (industrial/ occupational), 80.7 (construction worker)																	
	PFHxS	12.3 (residential), 24.9 (industrial/ occupational), 5.38 (construction worker)																	
NY	PFOA	0.66 ug/kg (unrestricted), 6.6 ug/kg (residential), 33 ug/kg (restricted residential), 500 ug/kg (commercial), 600 ug/kg (industrial), 1.1 ug/kg (protection of groundwater)																	
	PFOS	0.88 ug/kg (unrestricted), 8.8 ug/kg (residential), 44 ug/kg (restricted residential), 440 ug/kg (commercial), 440 ug/kg (industrial), 3.7 ug/kg (protection of groundwater)																	

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
PA	PFOA	4.4 (residential), 64 (non-residential)																	
	PFOS	4.4 (residential), 64 (non-residential)																	
	PFBS	66 (residential), 960 (non-residential)																	
TX	PFBA	0.067	Animals (male rats)	Butenhoff et al. 2012	hepatocellular hypertrophy and decreased total thyroxine (T4)		5.4 mg/kg-d (BMDL10 for hepatocellular hypertrophy) and 6 mg/kg-d (NOAEL for decreased total thyroxine)	1.15 mg/kg-d (hepatocellular hypertrophy) and 1.27 mg/kg-d (decreased total thyroxine)	1000	3	10		3	10		1x10-3			Note: Residential GWSoiling PCLs (0.5 acre source area) https://www.tceq.texas.gov/downloads/toxicology/pfc/pfcs.pdf/view. Direct contact residential soil comparison values are also available in Texas but are typically higher than the soil values that are protective of groundwater, which are the values listed in this table.
	PFBuS	0.11	Animals (mice)	Leider et al., 2009, York et al., 2002	Systemic Toxicity		NOAEL (60 mg/kg/d)	42600	1	10		10	3		1.4×10^{-3}				
	PFPeA	0.00032	Animals (mice)	Surrogate: PFHxS	Hematotoxicity		NOAEL (0.3 mg/kg/d)	78900	1	10	3	10			3.8×10^{-6}				
	PFHxS	0.002	Animals (mice)	Hoberman and York, 2003	Hematotoxicity		NOAEL (0.3 mg/kg/d)	78900	1	10	3	10			3.8×10^{-6}				
	PFHxA	0.063	Animals (pregnant rats)	Loveless et al. 2009	decreased offspring body weight in neonatal male and female rats		10.62 mg/kg-d (BMDL5)	0.048 mg/kg-d	100	3	10		3			5x10-4			

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
TX	PFHpA	0.0046	Animals (mice)	Surrogate: PFOS	Neurodevelopment		NOAEL (0.6 mg/kg/d)	26300	1	10	10	1			2.3x10^{-5}				Note: Residential GWSoiling PCLs (0.5 acre source area) https://www.tceq.texas.gov/downloads/toxicology/pfc/pfcs.pdf/view. Direct contact residential soil comparison values are also available in Texas but are typically higher than the soil values that are protective of groundwater, which are the values listed in this table.
	PFOS	0.05	Animals (mice)	Zeng et al., 2011	Neurodevelopment		NOAEL (0.6 mg/kg/d)	26300	1	10	10	1			2.3x10^{-5}				
	PFOA	0.003	Animals (mice)	Macon et al., 2011	Mammary gland development		NOAEL (0.3 mg/kg/d)	24300	1	10	30	1			1.2x10^{-5}				
	PFOSA	0.92	Animals (mice)	Surrogate: PFOA	Mammary gland development		NOAEL (0.3 mg/kg/d)	24300	1	10	30	1			1.2x10^{-5}				
	PFNA	0.0031	Animals (mice)	Fang et al., 2010	Spleen Cell Death		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
	PFDeA	0.022	Animals (mice)	Kawashima et al., 1995	Hepatotoxicity		NOAEL (1.2 mg/kg/d)	81000	1	10		10	10		1.5x10^{-5}				
	PFDS	0.04	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
	PFUA	0.018	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
	PFDoA	0.034	Animals (mice)	Shi et al., 2007	Reduced Body Weight		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
	PFTrDA	0.061	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
	PFTeDA	0.11	Animals (mice)	Surrogate: PFDoA	Reduced Body Weight		NOAEL (1 mg/kg/d)	81000	1	10		10	10		1.2x10^{-5}				
VT	PFOA, PFOS, PFHxS, PFHpA, PFNA	1.22*	Animals (mice)	EPA (2016)	EPA (2016)	20	EPA (2016)	EPA (2016)								0.175 L/kg/day			

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
WA	PFOA	6.30E-05																	Soil CUL protective of groundwater - vadose zone contamination.
	PFOS	1.70E-04																	
	PFNA	8.00E-05																	
	PFHxS	4.10E-04																	
	PFBS	1.80E-03																	
	HFPO-DA	1.00E-04																	
	PFOA	4.00E-06																	Soil CUL protective of groundwater - saturated zone contamination.
	PFOS	9.90E-06																	
	PFNA	4.80E-06																	
	PFHxS	2.60E-05																	
	PFBS	1.20E-04																	
	HFPO-DA	7.20E-06																	
	PFOA	0.24																	Soil CUL protective of the direct contact pathway for unrestricted land use (Method B).
	PFOS	0.24																	
	PFNA	0.2																	
	PFHxS	0.78																	
	PFBS	24																	
	HFPO-DA	0.24																	
	PFOA	11																	Soil CUL protective of the direct contact pathway for industrial land use (Method C).
	PFOS	11																	
	PFNA	8.8																	
	PFHxS	34																	
	PFBS	1,100																	
	HFPO-DA	11																	

State	PFAS	Guideline Level (mg/kg, unless otherwise specified)	Toxicity Data	Critical Effect Study	Endpoint	RSC (%)	POD	UFs							RfD (mg/kg/day)	Drinking Water Intake Rate (L/day unless otherwise specified)	Exposure assumptions	Target Populations	Resources & Notes
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)	Sensitive Developmental Endpoints					
WI	PFOA	1.26 (residential), 16.4 (composite [industrial] worker)		EPA RSL Tables									26 yrs, 350 days/yr, 24 hrs (residential), 25 yrs, 250 days/yr, 8 hrs (composite worker)		$2x10^{-5}$		Vary through life (residential), 80 kg wt, 100 mg/day intake (composite worker) THQ=1, cancer risk 1x10-6, other default assumptions	Residential, Composite Worker	EPA RSL calculator
	PFOS	1.26 (residential), 16.4 (composite [industrial] worker)		EPA RSL Tables									26 yrs, 350 days/yr, 24 hrs (residential), 25 yrs, 250 days/yr, 8 hrs (composite worker)		$2x10^{-5}$		Vary through life (residential), 80 kg wt, 100 mg/day intake (composite worker) THQ=1, cancer risk 1x10-6, other default assumptions	Residential, Composite Worker	EPA RSL calculator
	PFBS	19 (residential), 246 (composite [industrial] worker)		EPA RSL Tables									26 yrs, 350 days/yr, 24 hrs (residential), 25 yrs, 250 days/yr, 8 hrs (composite worker)		$3x10^{-4}$		Vary through life (residential), 80 kg wt, 100 mg/day intake (composite worker) THQ=1, cancer risk 1x10-6, other default assumptions	Residential, Composite Worker	EPA RSL calculator

*= Advisory level is based on the total of more than one PFAS

Appendix E: State Air PFAS Guideline Criteria

State	PFAS	Guideline Level ($\mu g/m^3$)	Toxicity Data	Critical Effect Study	Endpoint	POD	HED (mg/kg/day)	UFs						RfD (mg/kg/day)	Route-to-Route Extrapolation	Exposure Parameters	Target Populations	Resources
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)					
MN	PFOS (st, sc, c)	0.011	Animals (mice)	Dong et al., 2011	Adrenal, Developmental, Hepatic (liver) system, Immune, Thyroid	2.36 mg/L serum conc	0.000307	100	3	10		3		0.0000031	RfD (mg/kg-d) x (70 kg/20 m3-d) x (1000 µg/mg)	inhalation rate per day of 20m3/d and average body weight of 70kg	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/air/pfos.pdf
	PFHxS (st, sc, c)	0.034	Animals (rat)	NTP, 2018	Hepatic (liver) system, Thyroid	32.4 mg/L serum conc	0.00292	300	3	10		10		0.0000097	RfD (mg/kg-d) x (70 kg/20 m3-d) x (1000 µg/mg)	inhalation rate per day of 20m3/d and average body weight of 70kg	Fetus and Breastfeeding Infants	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/air/pfhxs.pdf
	PFBA (st, sc, c)	10	Animals (rat)	NOTOX, 2007 and Butenhoff, 2007	st -liver and thyroid; sc and c - Developmental, blood system, liver system, Thyroid	st = 3.01 sc = 6.9 c = 6.9	st = 0.38 sc = 0.86 c = 0.86	st =100 sc = 300 c = 300	st = 3 sc = 3 c = 3	st = 10 sc = 10 c = 10		st = 3 sc = 10 c = 10		st = 0.0038 sc = 0.0029 c = 0.0029	RfD (mg/kg-d) x (70 kg/20 m3-d) x (1000 µg/mg)	inhalation rate per day of 20m3/d and average body weight of 70kg	Infants and Adults	https://www.health.state.mn.us/communities/environment/risk/docs/guidance/air/pfba.pdf
	PFBS (st, sc, c)	0.3	Animals (rats)	NTP, 2019	Thyroid	6.97 mg/kg-d	0.0084	100	3	10		3		0.000084 - st, 0.00054 - sc, 0.00018 - c	RfD((mg/kg-d) x (70 kg/20 m3-d) x (1000 ug/mg)			https://www.health.state.mn.us/communities/environment/risk/docs/guidance/air/pfbs.pdf
	PFHxA	1 (short-term), 0.5 (subchronic and chronic)	Animals (rats)	NTP, 2019; Loveless et al., 2009	Developmental, thyroid - st; hepatic (liver) system, respiratory system - sc	22.5 mg/kg	0.0958 - st, 0.045 - sc, c	300	3	10		3 - st, 10 - sc, c		0.00032 - st, 0.00015 - sc, c	RfD((mg/kg-d) x (70 kg/20 m3-d) x (1000 ug/mg)			https://www.health.state.mn.us/communities/environment/risk/docs/guidance/air/pfhxa.pdf
	PFOA (st, sc, c)	0.063	Maternal animals	Lau et al., 2006; EPA, 2016	Developmental, Hepatic (Liver) system, Immune system, and Renal (Kidney) system, Pancreas, and Thyroid	38 mg/L serum concentration	0.0053	300	3	10	3	3		0.000018	RfD((mg/kg-d) x (70 kg/20 m3-d) x (1000 ug/mg)			Air Toxciological Summary Sheet June 2022 (state.mn.us)

State	PFAS	Guideline Level (µg/m³)	Toxicity Data	Critical Effect Study	Endpoint	POD	HED (mg/kg/day)	UFs						RfD (mg/kg/day)	Route-to-Route Extrapolation	Exposure Parameters	Target Populations	Resources
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)					
MI	PFOA (initial threshold screening level; ITSL)	0.07	Animals (mice)	EPA, 2016; Butenhoff et al., 2004; Lau, 2006	Acute, Reproductive/ Developmental		0.0053; 0.0064	300	3	10	10		2 generations +developmental	$2x10^{-5}$	Air Value (ITSL) = RfD x 70kg/20m³	Continuous over time period= 24 hours	Sensitive indivuals	http://www.deq.state.mi.us/aps/downloads/ATSL/335-67-1/335-67-1_24hr_ITSL.pdf
	PFOS (initial threshold screening level; ITSL)	0.07	Animals (rats)	EPA, 2016; Luebker et al., 2005	Acute, Reproductive/ Developmental		0.00051	30	10	3			2 generations +developmental	$2x10^{-5}$	Air Value (ITSL) = RfD x 70kg/20m³	Continuous over time period= 24 hours	Sensitive indivuals	http://www.deq.state.mi.us/aps/downloads/ATSL/1763-23-1/1763-23-1_24hr_ITSL.pdf
	6:2 FTS	1	Animals (rats)	ECHA, 2020; Rat, subchronic, oral	Cardiac	NOAEL 5 mg/kg	1.18	3000	3	10		10	10	0.00039	Air Value (ITSL) = RfD x 70kg/20m³	Continuous over time period= annual (chronic)	Sensitive indivuals	http://www.deq.state.mi.us/aps/downloads/ATSL/27619-97-2/
NH	APFO (CAS #3825-26-1; 24-hr Ambient Air Limit)	Regulatory Level 0.05	Animals (rats)	ACGIH TLV	Acute, Reproductive/ Developmental													
	APFO (CAS #3825-26-1; Annual Ambient Air Limit)	Regulatory Level 0.024	Animals (rats)	ACGIH TLV	Acute, Reproductive/ Developmental													
NJ	PFOA (Reference Concentration)	0.007	Animals (mice)	Loveless et al., 2006	Hepatotoxicity	BMDL		300	3	10			10	$2x10^{-6}$	Reference Concentration = RfD x 70kg/20m³	30 day averaging time	Infants and Adults	Based on route-to-route extrapolation from RfD (2 ng/kg/day) used for NJ MCL https://www.state.nj.us/dep/watersupply/pdf/pfoa-appendixa.pdf
	PFOS (Reference Concentration)	0.006	Animals (mice)	Dong et al., 2009	Immunotoxicity	NOAEL		30	3	10				$1.8x10^{-6}$	Reference Concentration = RfD x 70kg/20m³	30 day averaging time	Infants and Adults	Based on route-to-route extrapolation from RfD (1.8 ng/kg/day) used for NJ MCL https://www.state.nj.us/dep/watersupply/pdf/pfos-recommendation-appendix-a.pdf
	HFPO-DA (GenX) (Screening Reference Concentration)	0.01	Animals (mice)	DuPont 18405-1037, 2010; NTP, 2019.	Hepatotoxicity	BMDL		3000	3	10		10	10	$3x10^{-6}$	Reference Concentration = RfD x 70kg/20m³		Infants and Adults	Based on route-to-route extrapolation from EPA RfD (3 ng/kg/day) https://www.epa.gov/system/files/documents/2021-10/genx-chemicals-toxicity-assessment_tech-edited_oct-21-508.pdf

State	PFAS	Guideline Level (µg/m³)	Toxicity Data	Critical Effect Study	Endpoint	POD	HED (mg/kg/day)	UFs						RfD (mg/kg/day)	Route-to-Route Extrapolation	Exposure Parameters	Target Populations	Resources
								Total	Interspecies	Intraspecies	LOAEL to NOAEL	Database Limitation	Duration of Exposure (i.e., Subchronic to Chronic)					
TX	PFBA	3.50E+00	Animals (male rats)	Butenhoff et al., 2012	hypertrophy and decreased total thyroxine (T4)	d (BMDL10 for hepatocell	(hepatocellular hypertrophy) and 1.27	1000	3	10		3	10	1x10-3	Reference Concentration = RfD x 70kg/20m^3			
	PFBS	4.90E+00	Animals (mice)	Leider et al., 2009, York et al., 2002	Systemic Toxicity	NOAEL (60 mg/kg/d)		42600	1	10		10	3	1.40E-03	Reference Concentration = RfD x 70kg/20m^3			
	PFHxS	1.30E-02	Animals (mice)	Hoberman and York, 2003	Hematotoxicity	NOAEL (0.3 mg/kg/d)		78900	1	10	3	10		3.80E-06	Reference Concentration = RfD x 70kg/20m^3			
	PFOS	8.10E-02	Animals (mice)	Zeng et al., 2011	Neurodevelopment	NOAEL (0.6 mg/kg/d)		26300	1	10	10	1		2.30E-05	Reference Concentration = RfD x 70kg/20m^3			
	PFOA	4.10E-03	Animals (mice)	Macon et al., 2011	Mammary gland development	NOAEL (0.3 mg/kg/d)		24300	1	10	30	1		1.20E-05	Reference Concentration = RfD x 70kg/20m^3			
	PFOSA	4.10E-03	Animals (mice)	Surrogate: PFOA	Mammary gland development	NOAEL (0.3 mg/kg/d)		24300	1	10	30	1		1.20E-05	Reference Concentration = RfD x 70kg/20m^3			
	PFNA	2.80E-02	Animals (mice)	Fang et al., 2010	Spleen Cell Death	NOAEL (1 mg/kg/d)		81000	1	10		10	10	1.20E-05	Concentration = RfD x 70kg/20m^3			
	PFDA	5.30E-02	Animals (mice)	Kawashima et al., 1995	Hepatotoxicity	NOAEL (1.2 mg/kg/d)		81000	1	10		10	10	1.50E-05	Reference Concentration = RfD x 70kg/20m^3			
	PFDoA	4.20E-02	Animals (mice)	Shi et al., 2007	Reduced Body Weight	NOAEL (1 mg/kg/d)		81000	1	10		10	10	1.20E-05	Reference Concentration = RfD x 70kg/20m^3			

*= Advisory level is based on the total of more than one PFAS

Appendix F: State Fish and Wildlife Consumption PFAS Guideline Criteria

State	Media	PFAS	Guideline Level (unit specified)	Frequency	Target Populations	Resources & Notes
AL	Fish	PFOS	>156 ppb	1 meal per week	General Population	
	Fish	PFOS	>800 ppb	Do Not Eat	General Population	
CT	Fish and Shellfish	PFOA, PFOS	<20 ppb	No consumption advice (unlimited consumption)	General Population	
	Fish and Shellfish	PFOA, PFOS	20 to <40 ppb	No more than 1 meal per week	General Population	
	Fish and Shellfish	PFOA, PFOS	40 to <159 ppb	No more than 1 meal per month	General Population	
	Fish and Shellfish	PFOA, PFOS	≥159 ppb	Do Not Eat	General Population	
MD	Fish and Shellfish	PFOS / PFOA	< 24.0 ppb	No limit	General "High Risk" Populations	Rfd from 2016 EPA Drinking Water Health Advisory for PFOS and PFOA
	Fish and Shellfish	PFOS / PFOA	> 24.0 - 27.2 ppb	8	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 27.2 - 31.4 ppb	7	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 31.4 - 37.1 ppb	6	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 37.1 - 45.3 ppb	5	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 45.3 - 58.3 ppb	4	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 58.3 - 81.6 ppb	3	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 81.6 - 136.0 ppb	2	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 136.0 - 408.0 ppb	1	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 408.0 ppb	Avoid	General "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	< 21.2 ppb	No limit	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 21.2 - 24.0 ppb	8	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 24.0 - 27.7 ppb	7	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 27.7 - 32.7 ppb	6	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 32.7 - 40.0 ppb	5	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 40.0 - 51.4 ppb	4	Women "High Risk" Populations	

State	Media	PFAS	Guideline Level (unit specified)	Frequency	Target Populations	Resources & Notes
MD	Fish and Shellfish	PFOS / PFOA	> 51.4 - 71.9 ppb	3	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 71.9 - 119.9 ppb	2	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 119.9 - 359.7 ppb	1	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 359.7 ppb	Avoid	Women "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	< 12.2 ppb	No limit	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 12.2 - 13.8 ppb	8	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 13.8 - 16.0 ppb	7	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 16.0 - 18.9 ppb	6	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 18.9 - 23.1 ppb	5	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 23.1 - 29.7 ppb	4	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 29.7 - 41.5 ppb	3	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 41.5 - 69.2 ppb	2	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 69.2 - 207.6 ppb	1	Children "High Risk" Populations	
	Fish and Shellfish	PFOS / PFOA	> 207.6 ppb	Avoid	Children "High Risk" Populations	
ME	Fish	PFOS	3.5 ppb	1 8-oz meal/week	General Population	
	Fish	PFOS	14 ppb	1 8-oz meal/month	General Population	
	Fish	PFOS	60 ppb	3 8-oz meals/year	General Population	
	Deer, Turkey	PFOS	3.5 ppb	1 8-oz meal/week	Adults	
	Deer, Turkey	PFOS	1.7 ppb	1 3-oz meal/week	Children	
	Deer, Turkey	PFOS	15 ppb	1 8-oz meal/month	Adults	
	Deer, Turkey	PFOS	7.5 ppb	1 3-oz meal/month	Children	
	Milk	PFOS	0.21 ppb	76.7 g/kg/day	Children, 1-2 years old	
	Beef	PFOS	3.4 ppb	4.7 g/kg/day	Children, 1- 6 years old	

State	Media	PFAS	Guideline Level (unit specified)	Frequency	Target Populations	Resources & Notes
MI	Fish	PFOS	≤9 ppb	16 meals per month	All Populations	
	Fish	PFOS	>9-13 ppb	12 meals per month	All Populations	
	Fish	PFOS	>13-19 ppb	8 meals per month	All Populations	
	Fish	PFOS	>19-38 ppb	4 meals per month	All Populations	
	Fish	PFOS	>38-75	2 meals per month	All Populations	
	Fish	PFOS	>75-150	1 meal per month	All Populations	
	Fish	PFOS	>150-300	6 meals per year	All Populations	
	Fish	PFOS	>300 ppb	Do Not Eat	All Populations	
	Deer	PFOS	>300 ppb	Do Not Eat	All Populations	
MN	Fish	PFOS	<10 ppb	4 meals per week	Men, Boys Age 15 and Over, and Women Not Planning to Become Pregnant* (*there is already more stringent advice in place for Pregnant Women, Women Who Could Become Pregnant, and Children Under Age 15 due to statewide mercury concentrations)	Statewide guidance for some species based on PFOS; others are 1 meal per week based on mercury or PCB levels, see Fish Consumption Guidance - MN Dept. of Health (https://www.health.state.mn.us/communities/environment/fish/index.html)
	Fish	PFOS	>10-20 ppb	2 meals per week	Men, Boys Age 15 and Over, and Women Not Planning to Become Pregnant* (*there is already more stringent advice in place for Pregnant Women, Women Who Could Become Pregnant, and Children Under Age 15 due to statewide mercury concentrations)	Best Practice for Perfluorooctane Sulfonate (PFOS) Guidelines (https://www.health.state.mn.us/communities/environment/fish/docs/consortium/bestpracticepfos.pdf) Fish Consumption Guidance - MN Dept. of Health (https://www.health.state.mn.us/communities/environment/fish/index.html)
	Fish	PFOS	>20-50 ppb	1 meal per week	All Populations	
	Fish	PFOS	>50-200 ppb	1 meal per month	All Populations	
	Fish	PFOS	>200 ppb	Do Not Eat	All Populations	
NJ	Fish	PFOS	0.56 ng/g; ppb	Unlimited (based on daily)	General and High Risk Populations	
	Fish	PFOS	3.9 ng/g; ppb	1 meal per week	General and High Risk Populations	
	Fish	PFOS	17 ng/g; ppb	1 meal per month	General and High Risk Populations	
	Fish	PFOS	>17 ng/g; ppb	Do Not Eat	High Risk Population	
	Fish	PFOS	51 ng/g; ppb	1 meal every 3 months	General Population	
	Fish	PFOS	204 ng/g; ppb	1 meal per year	General Population	

State	Media	PFAS	Guideline Level (unit specified)	Frequency	Target Populations	Resources & Notes
NJ	Fish	PFOS	>204 ng/g; ppb	Do Not Eat	General Population	
	Fish	PFNA	0.23 ng/g; ppb	Unlimited (based on daily)	General and High Risk Populations	
	Fish	PFNA	1.6 ng/g; ppb	1 meal per week	General and High Risk Populations	
	Fish	PFNA	6.9 ng/g; ppb	1 meal per month	General and High Risk Populations	
	Fish	PFNA	>6.9 ng/g; ppb	Do Not Eat	High Risk Population	
	Fish	PFNA	21 ng/g; ppb	1 meal every 3 months	General Population	
	Fish	PFNA	84 ng/g; ppb	1 meal per year	General Population	
	Fish	PFNA	>84 ng/g; ppb	Do Not Eat	General Population	
	Fish	PFOA	0.62 ng/g; ppb	Unlimited (based on daily)	General and High Risk Populations	
	Fish	PFOA	4.3 ng/g; ppb	1 meal per week	General and High Risk Populations	
	Fish	PFOA	19 ng/g; ppb	1 meal per month	General and High Risk Populations	
	Fish	PFOA	>19 ng/g; ppb	Do Not Eat	High Risk Population	
	Fish	PFOA	57 ng/g; ppb	1 meal every 3 months	General Population	
	Fish	PFOA	226 ng/g; ppb	1 meal per year	General Population	
	Fish	PFOA	>226 ng/g; ppb	Do Not Eat	General Population	
	Fish	PFUnDA	0.40 ng/g; ppb	Unlimited (based on daily)	General and High Risk Populations	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	2.8 ng/g; ppb	1 meal per week	General and High Risk Populations	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	12.0 ng/g; ppb	1 meal per month	General and High Risk Populations	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	>12.0 ng/g; ppb	Do Not Eat	High Risk Population	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	36.6 ng/g; ppb	1 meal every 3 months	General Population	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	146 ng/g; ppb	1 meal per year	General Population	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf
	Fish	PFUnDA	>146 ng/g; ppb		General Population	https://dep.nj.gov/wp-content/uploads/dsr/pfunda-fish-consumption-trigger.pdf

State	Media	PFAS	Guideline Level (unit specified)	Frequency	Target Populations	Resources & Notes
NY	Fish	PFOS	<50 ppb	4 meals per month	General Population	
	Fish	PFOS	>50-200 ppb	1 meal per month	General Population	
	Fish	PFOS	>50 ppb	Do Not Eat	Sensitive Population	
	Fish	PFOS	>200 ppb	Do Not Eat	General Population	
WA	Fish	PFOS	<1.8 ng/g	No Advisory	General Population	
	Fish	PFOS	1.8-2.3 ng/g	8 meals per month	General Population	
	Fish	PFOS	2.4-4.7 ng/g	4 meals per month	General Population	
	Fish	PFOS	4.8-9.4 ng/g	2 meals per month	General Population	
	Fish	PFOS	9.5-28.2 ng/g	1 meal per month	General Population	
	Fish	PFOS	<28.2 ng/g	Do Not Eat	General Population	
WI	Fish	PFOS	10-50 ppb	1 meal per week	All Populations	
	Fish	PFOS	50-200 ppb	1 meal per month	All Populations	
	Fish	PFOS	>200 ppb	Do Not Eat	All Populations	
	Wildlife	PFOS	10-50 ppb	1 meal per week	All Populations	
	Wildlife	PFOS	50-200 ppb	1 meal per month	All Populations	
	Wildlife	PFOS	>200 ppb	Do Not Eat	All Populations	