POLICY BRIEF

Parts per Trillion

An Overview of State PFAS Drinking Water Standards

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Parts Per Trillion: An Overview of State PFAS Drinking Water Standards

Introduction

Perfluoroalkyl substances (PFAS) have been produced and used in the United States for roughly 80 years. Research has shown they are toxic, persistent, and bioaccumulative, and exposure through contaminated drinking water has been linked to several negative health outcomes including various forms of cancer, but there are currently no enforceable federal drinking water standards for any PFAS compounds. It is only in the last two decades or so that federal regulators have started to understand the negative health impacts following decades of industry's failure to disclose internal health impacts studies and knowledge of harms. Regulators at the federal and state level have since started to address this group of human-made chemicals.

State legislation and regulations pertaining to PFAS have increased in recent years in response to cases of contamination across the country coming to light. Affected communities and advocates have fought for greater state level protections and measures to address resulting harms in the absence of enforceable federal regulations. To date, nine states have set their own drinking water standards through a combination of legislative, regulatory, and advisory body actions.

In late 2021, however, the Environmental Protection Agency (EPA) laid out a new PFAS Strategic Roadmap in which it slated the proposal of new federal drinking water standards for two PFAS chemicals—PFOA (perfluorooctanoic acid) and PFOS (perfluorooctanesulfonic acid)—for the fall of 2022.[1] That formal proposal will need to work its way through a lengthy rulemaking process. If finalized, they will represent the first new federal drinking water standards for any contaminant since 1996, when the current process for establishing such standards was enacted.[2] Moreover, since the PFAS Strategic Roadmap was laid out, in June 2022, the EPA revised its interim drinking water advisories (previously set in 2016) for PFOA and PFOS to drastically lower levels.

This brief addresses the history of what we do and don't know about the impacts of PFAS exposure with respect to drinking water. It provides an overview of how testing for unregulated contaminants like PFAS occurs at the federal level, and how the knowledge/ignorance produced through those processes relates to the absence of federal standards.

As states were the first to implement drinking water standards related to PFAS, it can be insightful to understand how these standards were developed. This brief will summarize the implementation of enforceable drinking water standards currently in place across nine states and their development against the backdrop of changes to federal health advisories and regulatory testing data. Ultimately, these cases reflect that, while current state standards fell at or below the EPA's earlier (2016) advisory levels, the EPA's new (2022) interim advisories for PFOA and PFOS are now far below those state standards. These cases also demonstrate that while the EPA has committed to proposing standards for two PFAS compounds, most of these states have set standards for five or more PFAS compounds—with many having set a combined standard. In doing so, however, the time between precipitating events and enacting state standards has generally been lengthy and the enactment of standards has often involved a substantive legislative and not solely regulatory role.

What Are PFOA, PFOS, and PFAS?

PFAS are chemical compounds that have been used since the late 1940s to make a host of industrial and consumer products. The properties of PFAS compounds help produce materials that are nonstick, water repellant, and fire-resistant or suppressive. They are used in or in the process of manufacturing a broad range of widely available products, including: waterproof clothing and outdoor gear, stain repellants and repellant materials like carpets and upholstery, food packaging, cosmetics, electronics, and firefighting foams. They are also a key component in a number of name-brand products like Scotchgard and other Wolverine products, Gore-Tex, Stainmaster, and, perhaps most recognizably, Teflon.

Some of the same characteristics that lend PFAS compounds to these applications also make them harmful to people and the environment. They are known to be toxic, persistent, soluble, and bioaccumulative. Because of these characteristics and their widespread use and disposal, they have become so pervasive that they have been found in the most remote places on earth, including the Arctic,[3] as well as in rainwater[4] and in polar bears.[5] Their persistence is due to their carbon-fluorine bonds—"one of the strongest ever created" according to the National Institutes of Health (NIH).[6] And, they have thusly been dubbed "forever chemicals."[7]

PFOA and PFOS are perhaps the most frequently referenced PFAS compounds given their predominance in highly visible cases of contamination. But, they are just two of the more than 9,000 human-made (or synthetic) compounds[8] in the class of PFAS chemicals.[9]

What We Know and Don't Know About PFAS Toxicity and Prevalence—And Why

With respect to their toxicity, research has demonstrated probable links[10] between PFAS exposure and a number of negative human health outcomes,[11] including ulcerative colitis, thyroid disease, high cholesterol, pregnancy-induced hypertension, testicular cancer, prostate cancer, and kidney cancer, as well as associations with immunosuppression,[12] vaccine suppression,[13] and reduced infant and fetal growth. Recently, the National Academies of Sciences, Engineering, and Medicine issued guidance to policymakers, communities, and clinicians that those with elevated exposure to PFAS be offered medical testing for serum (blood) levels and biomonitoring in cases where those serum levels of PFAS have been associated with adverse impacts.[14]

Chemical manufacturers of PFAS have been aware of some of these impacts going back at least five decades. Manufacturers conducted toxicity studies starting in the 1970s, but those studies were not made public for decades, contributing to the long delay in regulatory oversight.[15] Such "unseen science" was unknown to federal or state regulators until 2000 when discovery documents in a case against DuPont brought them to light and the studies were then sent to the to the EPA.[16, 17] Following, and as a direct result of that case's landmark settlement agreement, large scale studies in communities with PFAS contamination along the Ohio-West Virginia border were conducted that demonstrated probable links between PFAS exposure and a number of the negative impacts noted above.[18]

Even after knowledge of adverse impacts of PFAS exposure was brought to federal regulators, the reliance of regulators on voluntary industry phaseouts,[19] a one-by-one chemical approach to regulation, the industry's production of replacement PFAS chemicals (such as Gen X),[20] and the ability of industry to deem research as confidential business information (CBI) thereby avoiding public disclosure, has meant that PFAS have remained in widespread use and disposal.[21]

PFAS Contamination

Given its diffuse and long-term use, as well as characteristics of persistence and bioaccumulation, human exposure in the United States to PFAS has been nearly ubiquitous. The National Health and Nutrition Examination Survey (NHANES) by the National Center for Health Statistics (NCHS),[22] under the Centers for Disease Control and Prevention (CDC), has found PFAS compounds (including PFOA, PFOS, PFHxS, or perfluorohexane sulfonic acid, and PFNA, or perfluorononanoic acid) in the blood of 97–100 percent of Americans.[23]

Individuals may be familiar with particular cases of drinking water contamination due to their proximity, severity, or notoriety—such as in Decatur, Alabama;[24] Wilmington, North Carolina;[25] Hoosick Falls, New York;[26] Newburgh, New York;[27] Merrimack, New Hampshire;[28] Parkersburg, West Virginia;[29] and Bennington, Vermont.[30] Beyond these more notable cases, understanding the full breadth and depth of PFAS contamination across the United States is challenging. Federal regulators collect information on

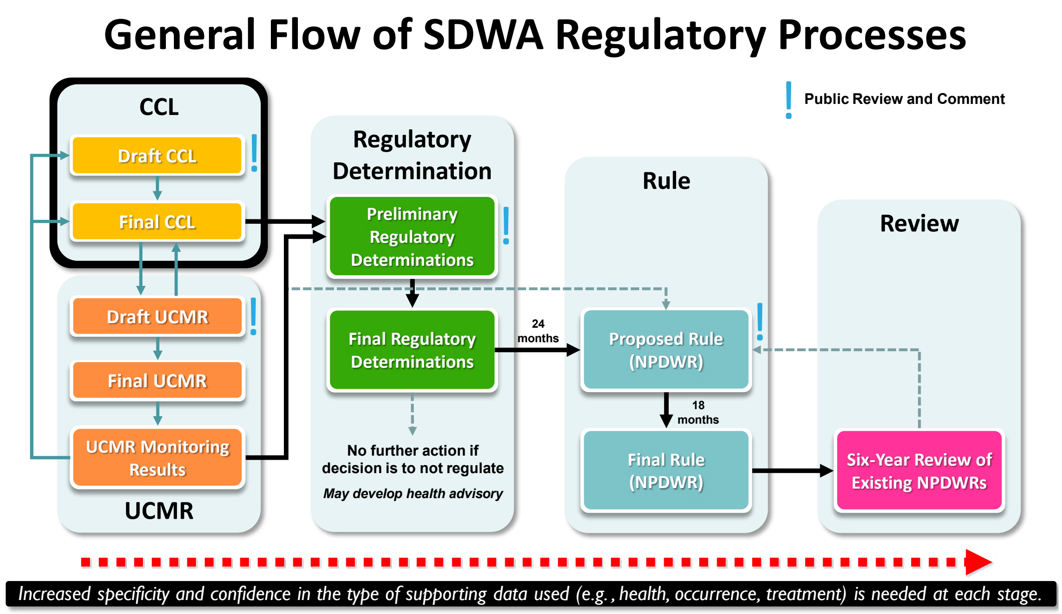
PFAS through a variety of environmental data systems related to manufacturing and importation, handling and use, chemical releases or spills, and water contamination.[31] But these datasets are not synthesized for broader analysis and individually they provide a limited picture of where PFAS are and how significant the breadth of contamination may be.

Regulatory Process for Safe Drinking Water Act Determinations

Overview of the Federal Drinking Water Regulation Process

The Safe Drinking Water Act (SDWA) of 1974 underpins the federal requirements for testing of drinking water systems for unregulated contaminates and the establishment of new standards. Under the SDWA's current regulatory process, established in 1996, potential contaminants are added to the Contaminant Candidate List (CCL) based on considerations related to both potential health impacts and frequency of occurrence in water systems.[32] Once added to the list, the contaminants are subject to further evaluation through additional research and data collection.

FIGURE 1. **Safe Drinking Water Act Process—EPA Presentation on UCMR 4, 2017**



SOURCE: "The Fourth Unregulated Contaminant Monitoring Rule (UCMR 4)," (PowerPoint presentation presented at public meeting and webinar, Office of Ground Water and Drinking Water, US Environmental Protection Agency, April 12, 2017), https://www.epa.gov/sites/default/files/2017-05/documents/ucmr4-presentation-april2017.pdf.

The CCL is published roughly once every five years. Once the list is finalized, the EPA is required to make a determination on whether or not to regulate at least five contaminants on the list. The determination to regulate a potential contaminant from the CCL is made based on three criteria: the contaminant may have an adverse health impact on people; it is known or is substantially likely to occur with frequency in water systems to a degree of public concern; and regulation would "present a meaningful opportunity for health risk reductions."[33] In 2009, for example, the CCL included 116 contaminants, from which the decision was made to *not* regulate four of those contaminants and to gather additional research on one further contaminant (Table 1).

Number of Contaminants on CCLs, UCMRs, and Receiving Regulatory Determinations

The contaminant candidate list and these determinations often involve a secondary process, known as the Unregulated Contaminates Monitoring Rule (UCMR). During the UCMR process, testing is conducted to produce data on the occurrence of potential contaminants in water systems across the country (Figure 1). It is only after such occurrence data are available that a regulatory determination will be made. As a result of this lengthy and narrowing process, only around 90 contaminants out of a universe of over 85,000 potential contaminants have been regulated under the SWDA since it was established in 1974, and not one has been newly regulated since 1996 (Table 1).

TABLE 1. **Number of Contaminants on CCLs, UCMRs, and Receiving Regulatory Determinations**

	First	Second	Third	Fourth	Fifth
CCL	1998	2005	2009	2016	2021
	60 Contaminants	51 Contaminants	116 Contaminants	109 Contaminants	78 Contaminants + 3 Chemical Groups
UCMR	1999	2007	2012	2016	2021
	26 Contaminants	25 Contaminants	30 Contaminants	30 Contaminants	30 Contaminants (29 of which are PFAS)
Regulatory Determination	2003	2008	2016	2021	2026
	9 Not Regulated	11 Not Regulated	4 Not Regulated; 1 Needs Further Research	2 to be Regulated (PFOA and PFOS); 6 Not Regulated	TBD

SOURCE: Undated from *Safe Drinking Water Act (SDWA) Regulatory Development Process* (Arlington , VA: Association of State Drinking Water Administrators, 2019), https://www.asdwa.org/wp-content/uploads/2019/05/ASDWA-SDWA-Regulatory-Development-Process-FactSheet-2019.pdf.

PFAS and the SWDA Regulatory Process

The EPA first added PFAS compounds to the Third Unregulated Contaminants Monitoring Rule (UCMR 3) in 2012. That testing was carried out between 2013 and 2015 and included the six PFAS compounds: PFOA, PFOS, PFNA, PFHxS, PFHpA, and PFBS. That UCMR testing focuses on public water systems and testing was limited to large water systems serving over 10,000 people and a sample of smaller systems across the country.[34] UCMR testing does not collect data from private wells which 15 million households rely on for their drinking water.[35] The issue of PFAS contamination has dominantly been framed with respect to public drinking water systems and policy responses have addressed drinking water standards. But groundwater—which has its own standards—provides the source for drinking water for an estimated 115 million people in the United States, with 43 million relying on private wells that are much less regulated than public water systems.[36]

While those receiving their water through public systems ultimately have their drinking water tested to meet existing drinking water standards regardless of where it comes from, federal and state regulations for drinking water don't necessarily coincide with groundwater standards. Only a subset of states have established such standards or guidance for groundwater systems with respect to PFAS. But drinking water standards at the state and federal level typically exclude private wells that rely on groundwater from regulatory requirements, including testing for "emerging" contaminants under the UCMR.

As a result, UCMR testing does not include a comprehensive sample of all drinking water. These factors meant that, in New York, for example, there are an estimated 800,000 private wells serving somewhere between approximately 2 million to a reported 6.4 million people that did not have their drinking water source tested for PFAS contaminants under UCMR 3, in addition to many small water systems serving under 10,000 people.[37, 38] A recent study by the United States Geological Survey (USGS) across sixteen states found that PFAS were detected in 60 percent of wells serving public water systems and 20 percent of wells serving individual households.[39]

The reporting requirements for UCMR 3 testing also meant that detections only needed to be reported to the EPA if they exceed certain levels.[40] These levels are chosen with respect to establishing practical quantitation limits (or PQLs) based on existing lab capacity and through lowest concentration minimum reporting level (LCMRL) studies.[41] These studies are used to calculate a reporting level that, with a 95 percent confidence, 75 percent of laboratories can achieve. The UCMR 3 established the reporting levels of PFOA at 20 parts per trillion (ppt) and PFOS at 40 ppt. Although some of the labs used for the UCMR 3 had the technical ability to test down to 15 ppt, other labs were able to test down to 2.5 ppt reliably, but they were not required to report these findings.[42]

Not requiring reporting below a threshold results in the exclusion of important information and ultimately creates ignorance about the scale and severity of contamination. Since the UCMR 3, multiple states have set standards below the reporting levels established in that process. For example, New York set a standard of 10 ppt each for PFOA and PFOS but the reporting of levels between 10 ppt and 20 ppt for PFOA or 40 ppt for PFOS was not required under UCMR 3. If the UCMR testing processes required the reporting of any detection, regardless of the level, policymakers would have a better understanding of the prevalence of PFAS contamination, even if our technical capacity meant that we would not have the same ability to test to those lower levels for every single system.

As I've discussed in my previous research, taken together these characteristics of the UCMR have resulted in the production of "incommensurate science" or ignorance that is structurally produced through regulatory science and that results in water contamination being relatively invisible compared to its actual occurrence and leaves many communities with drinking water contamination in the dark.[43] New York State addressed some of these regulatory shortfalls through state expansion of testing requirements under the Emerging Contaminants Monitoring Act which set up a parallel state program to the federal UCMR that includes testing of all water systems,[44] and the Clean Water Infrastructure Act of 2017; state regulatory testing now also includes smaller water systems serving over 3,300 people.[45] Federally, a similar rule was finalized by the EPA in December 2021 to include systems serving between 3,300 and 10,000 people in the Fifth Unregulated Contaminants Monitoring Rule (UCMR 5) testing, to the extent lab capacity and funding are available.[46] In New York, this change means that, although under UCMR 4 just 151 larger water systems were included in testing, 313 could now be included under UCMR 5 (with the addition of those smaller public water systems sampled).[47]

The UCMR 5 testing, which will take place from 2023-2025, will also test water systems for a broader array of 29 PFAS, including those six PFAS from the UCMR 3 once again, but at lower reporting levels.[48, 49] PFOA and PFOS reporting levels, for example, will now be 4 ppt each. This has occurred alongside the development and use of testing methods that can address more compounds, greater understanding around how PFAS are typically found together in the environment, and their similar traits and shared characteristics with respect to replacement compounds.[50]

While we await new federal proposals for standards, which will then need to go through a multi-year rulemaking process, these changes to the testing and reporting process have begun and will begin to take effect. Further, changes to other environmental data and reporting systems such as the Toxic Release Inventory, in combination with those to the UCMR, and implementation of the state level standards discussed below will also begin to give communities a better—if still uneven—sense of their potential exposure to PFAS.[51] In the interim, work by researchers and advocates has further sought to identify where PFAS contamination has occurred in (and beyond) drinking water systems and estimate how many people it may impact. In a re-analysis of EPA data conducted by Eaton Analytics, one of the labs used in the UCMR 3, researchers found that while the federal reporting requirement for PFOA and PFOS resulted in detections in 1.0 percent and 0.8 percent of samples respectively, lowering the reporting level to 2.5 ppt would result in detections of 23.5 percent and 20.5 percent of samples, respectively.[52] The advocacy organization Environmental Working Group considered that data, including detections of PFAS below the agency's reporting levels, and found that more than 200 million people living in the United States may be affected by PFAS contamination.[53] Further research at Northeastern University's PFAS Project Lab has mapped over 1,750 sites of known contamination across the country, as well as thousands of potential or presumed sites of contamination through a new conceptual approach to integrating available datasets.[54, 55]

Federal Standards and Advisories on PFAS

The federal government sets drinking water regulations or enforceable standards under the Safe Drinking Water Act. When setting new standards, regulators are required to consider the economic impacts of potential regulations in their rule making process. And, as such, enforceable standards do not solely reflect health-based guidance and goals.

The EPA can alternatively issue health advisories for contaminants, which act as guidance to states but are not enforceable or required. These advisories can designate levels on a short-term or lifetime basis, and are national in scope, though more localized guidance is sometimes issued.

In 2009, the EPA issued a provisional health advisory for short-term exposure to contaminated drinking water of 400 ppt for PFOA and 200 ppt for PFOS.[56] This provisional advisory followed the conclusion of testing in local drinking water systems and on agricultural sites in Decatur, Alabama—where sewage sludge from a local wastewater treatment plant had been applied from 1996-2008.[57] The wastewater treatment plant routinely processed wastewater from facilities that manufactured PFOA and other PFAS chemicals.

In January 2016, in response to the public discovery of PFAS contamination in drinking water in Hoosick Falls, New York, the EPA then indicated it was developing a lifetime advisory level for PFOA and recommended that those with private wells whose water was over 100 ppt not use their water for drinking or cooking.[58] This recommendation was specific to that locality and did not act as broader guidance.

In May 2016, the EPA then published a national health advisory level of 70 ppt combined for PFOA and PFOS for lifetime exposure.[59] In June 2018, however, the federal Agency for Toxic Substances and Disease Registry (ATSDR), part of the Department of Health and Human Services, released a report on the "Toxicological Profile for Perfluoroalkyls."[60] That report reviewed the health risks associated with exposure and identified provisional levels (referred to as minimum risk levels or MRLs) significantly lower than those reference doses used to calculate the EPA's 70 ppt combined advisory.

The EPA then made explicit commitments, in February 2019[61, 62] and in July 2021, to establishing enforceable standards for PFOA and PFOS in drinking water.[63] Under the "PFAS Strategic Roadmap" released in October 2021, the EPA planned to propose those drinking water standards in the fall of 2022.[64]

More recently, in June 2022, the EPA released updated interim drinking water health advisories for PFOA and PFOS, replacing those set in 2016.[65] The agency also issued two new final health advisories for PFBS (perfluorobutane sulfonic acid) and its potassium salt at 2,000 ppt and HFPO (hexafluoropropylene oxide) and its ammonium salt also known as "Gen X" chemicals at 10 ppt. The updated interim advisories for PFOA and PFOS were drastically lower than the previous 70 ppt combined advisory, at 0.004 ppt and 0.02 ppt respectively.[66] Given the level of reliable detection PFOA and PFOS is generally at or above 2 ppt, and the EPA itself considers this level 4 ppt each, any detection of these PFAS in water systems will exceed these (orders of magnitude) lower federal interim advisory levels.[67] Levels that also, crucially, fall below all of the enforceable state standards currently in place.

Enforceable State Standards

States can set standards for drinking water at whatever levels they deem protective of public health, as they are as protective as any existing federal standards. In the absence of federal standards, nine states impacted by PFAS contamination have established their own enforceable standards for drinking water. These standards vary in terms of which PFAS compounds they include, whether or not they are combined standards, and what exact levels are set. While many of these standards have ultimately been put in place through existing state regulatory processes by agencies, some state legislatures have intervened directly or indirectly in that process.

New Jersey's Drinking Water Quality Institute was the first to recommend or propose an enforceable standard in 2015 for perfluorononanoic acid (PFNA), which was then finalized in 2018. Since then, a handful of other states have also established enforceable standards for PFAS in drinking water. These include: Maine (interim), Massachusetts, Michigan, New Hampshire, New Jersey, New York, Rhode Island (interim), and Vermont. Pennsylvania has also recently proposed but not yet finalized a standard for PFOA (14 ppt) and PFOS (18 ppt).[68] Other states have established action, response, advisory, guidance, or notification levels, as in California, but do not have enforceable drinking water standards or maximum contaminant levels (MCLs).[69] In this section, we outline the precipitating events, process through which standards were set, and what those standards are in each of these states.

State PFAS Drinking Water Standards

In the process of setting such standards, while the same bodies of research are generally being considered, standards often differ across states somewhat with respect to setting individual levels for the same contaminant. For example, the two states with PFHxS standards, Michigan and New Hampshire, have levels of 51 ppt and 18 ppt respectively, and the specific standard for PFOS across all of these states ranges from 10 ppt in New York to 16 ppt in Michigan. Furthermore, while all of the current standards are well below both the EPA initial 2009 health advisory (for 200 ppt PFOS and 400 ppt PFOA) and the EPA's 2016 advisory (of 70 ppt for PFOA and PFOS combined), they are all well above the EPA's recently revised interim 2022 advisory levels of .004 ppt for PFOA and .02 for PFOS, as well as 10 ppt for Gen X (a replacement PFAS compound)—with the exception of Michigan's standard for PFBS which is lower than the EPA's advisory of 2,000 ppt. Given those differences and their potential implications for setting standards that are protective of public health, existing state standards should be reconsidered. Many of the regulatory agencies in these states have already noted that given the EPA's interim levels, state standards may be subject to further review.

TABLE 2. **State PFAS Drinking Water Standards**

Type of Level or Standard	Group Name	Year	State or Agency	PFOS (ppt)	PFOA (ppt)	PFNA (ppt)	PFHxS (ppt)	PFHxA (ppt)	PFBS (ppt)	PFHpA (ppt)	PFDA (ppt)	GenX or HFPO	Combined	Groundwater or Private Well Standards
Guidance or Advisory Level	EPA Health Advisory	2016	EPA	X	X								70 ppt for PFOS and PFOA	In 2019, EPA issued interim recommendations for groundwater cleanup programs that included a screening level of 40 ppt combined for PFOA and PFOS and a preliminary remediation goal of 70 ppt combined, mirroring the agency's drinking water guidance.
Standard or MCL	Combined Standard	2019	Vermont	X	X	X	X			X			20 ppt for 5 PFAS: PFOS, PFOA, PFNA, PFHxS, PFHpA	The state has the same groundwater standards as drinking water standards.
Standard or MCL	Combined Standard	2020	Massachusetts	X	X	X	X			X	X		20 ppt for 6 PFAS: PFOS, PFOA, PFNA, PFHxS, PFHpA, PFDA	The state has the same groundwater standards as drinking water standards.
Standard or MCL	More than PFOA and PFOS	2020	Michigan	16	8	6	51	400,000	420			370		Same as the state's drinking water standards (for water used as drinking water).
Standard or MCL	More than PFOA and PFOS	2020	New Hampshire	15	12	11	18							The state has the same groundwater standards as drinking water standards.
Standard or MCL	More than PFOA and PFOS	2020	New Jersey	13	14	13								The state has the same groundwater standards as drinking water standards. It has also established private well testing requirements for PFOA, PFOS, and PFNA through regulation under the state's Private Well Testing Act.
Standard or MCL	PFOA and PFOS only	2020	New York	10	10									The state's Department of Environmental Conservation proposed guidance values in 2021 for PFOA and PFOS in ground and surface water of 6.7 ppt and 2.7 ppt respectively.
Standard or MCL—Interim	Combined Standard	2021	Maine	X	X	X	X			X	X		20 ppt for 6 PFAS: PFOS, PFOA, PFNA, PFHxS, PFHpA, PFDA	
Standard or MCL—Interim	Combined Standard	2022	Rhode Island	X	X	X	X			X			20 ppt for 5 PFAS: PFOS, PFOA, PFNA, PFHxS, PFHpA	Enacting legislation directs the Department of Health to set groundwater standards by 2024 alongside finalizing drinking water standards.

TABLE 2. **State PFAS Drinking Water Standards, cont.**

Type of Level or Standard	Group Name	Year	State or Agency	PFOS (ppt)	PFOA (ppt)	PFNA (ppt)	PFHxS (ppt)	PFHxA (ppt)	PFBS (ppt)	PFHpA (ppt)	PFDA (ppt)	GenX or HFPO	Combined	Groundwater or Private Well Standards
Standard or MCL	EPA Guidance	2022	Wisconsin	X	X								70 ppt for PFOS and PFOA	In February 2022, the Natural Resources Board voted against a proposed groundwater standard.
Guidance or Advisory Level	EPA Health Advisory—Interim for PFOA and PFOS	2022	EPA	0.02	0.004				2,000			10 ppt		
Proposed Standard	More than PFOA and PFOS	2020 proposed	Washington	15	10	14	70		860					
Proposed Standard	More than PFOA and PFOS	2020 proposed	Illinois	14	21	21	140		140,000				21 ppt combined for PFOA and PFOS only	
Proposed Standard	Combined Standard and Individual Standards	2022 proposed	New York	X	X	X (10 ppt)	X (10 ppt)			X (10 ppt)	X (10 ppt)		10 ppt individual and 30 ppt combined for 6 PFAS: PFOS, PFOA, PFNA, PFHxS, PFHpA, PFDA	

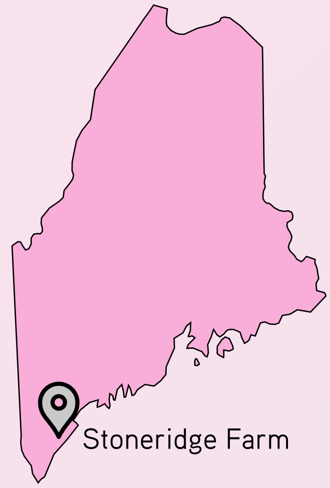
PFOS—Perfluorooctanesulfonic acid.
PFOA—Perfluorooctanoic acid.
PFNA—Perfluorononanoic acid.
PFHxS—Perfluorohexane sulfonate.
PFHxA—Perfluorohexanoic acid.
PFBS—Perfluorobutanesulfonic acid.
PFHpA—Perfluorohepatanoic acid.
PFDA—Perfluorodecanoic acid.
"Gen X or HFPO—Hexafluoropropylene oxide.

These differing standards can be understood as a reflection of the choices of variables within the underlying calculations for[70] endpoints,[71] vulnerable populations,[72] relative source contribution,[73] and uncertainty factors. As Maine's PFAS Task Force stated:

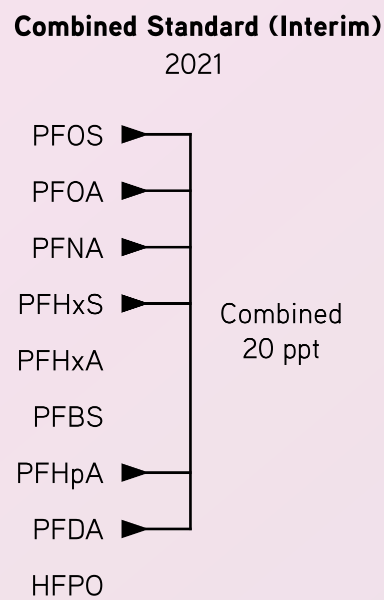
> Despite looking at mostly the same toxicity information as EPA, nearly all of these agencies, including ATSDR, have adopted or proposed toxicity values as much as 10-fold lower with differences largely a consequence of divergent views on which animal studies and which toxic effects to rely on, as well as divergent views on the appropriate application of uncertainty factors.[74]

Different choices across agencies are sometimes discussed by public health practitioners in terms of professional judgement and can be at least partially explained, as discussed in previous work,[75] with respect to epistemic cultures of public health (within a given state's public health and/or environmental health agency staff or advisory body) and their relative inclination towards a precautionary stance.[76, 77]

Maine



Discovery of Contamination: Maine's Department of Environmental Protection (DEP) began testing for PFAS in fish in 2013 near former military sites.[78] In 2016, the EPA's UCMR 3 testing results reflected PFAS contamination in the Kennebunk, Kennebunkport, and Wells Water District.[79] Further testing determined that residential wells on the nearby Stoneridge Farm were also contaminated and still further testing determined that that contamination impacted the milk produced by cows on the farm at levels testing up to 690 ppt. The contamination was linked to the use of biosolids (or sewage sludge) from facilities that processed paper mill waste to help add nutrients to the soil.[80] The use of biosolids on agricultural land has been broadly supported through federal environmental health policies under the Clean Water Act (Part 503) over the last few decades, which determined the reuse of waste materials as beneficial so long as it met certain criteria including testing for contaminants.[81] However, as with the UCMR process, the assessment of new contaminants over time has been "incomplete" according to the EPA's Office of Inspector General.[82] Paper mill waste has more broadly been found to contain PFAS, given its use in paper products, which also include food packaging.[83] Since the initial discovery, other Maine farmers have discovered PFAS contamination, jeopardizing their health and livelihoods.[84, 85] Given the agriculture focus of these precipitating events, Maine developed rules related to the use of solid waste and screening for biosolids ahead of and alongside those for drinking water, alongside soil and crop specific action levels and screening values.[86]

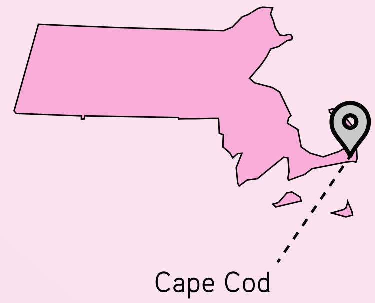


Regulation and/or Legislation: According to the state DEP, as of 2019, the agency had "more than 30,000 records for 28 different PFAS at 245 locations across the State." Remedial Action guidelines developed by DEP in conjunction with the state's Department of Health and Human Services recommended the replacement of drinking water supplies for levels above 70 ppt for PFOA and PFOS combined, based on the EPA's toxicity values.

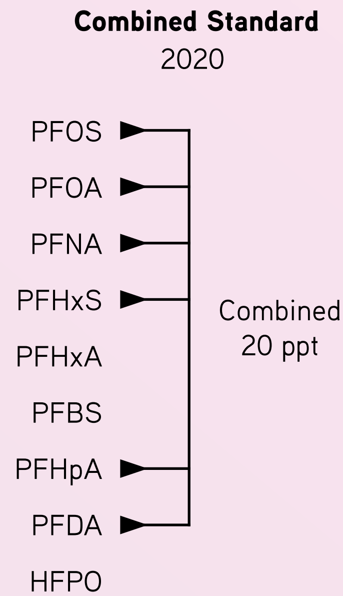
In June 2021, the governor signed SP 64, which set an interim drinking water standard and directed the state Department of Health and Human Services to develop a final rule.[87] The interim standard was for 20 ppt combined for six PFAS, including: PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA. This standard was in line with the 20 ppt combined standard set in Massachusetts for the same six PFAS (as discussed below) in 2020, and similar to that set in Vermont in 2019, though that did not include PFDA in its combined standard. It was also followed more recently by Rhode Island which set the same standard in 2022.

Massachusetts

Discovery of Contamination: In 2009, the Silent Spring Institute conducted tests of nine public water systems on Cape Cod as part of its broader efforts to understand elevated incidence of breast cancer in that area.[88] The Cape's 200,000 year-round residents and 500,000 summer residents rely on a sole-source aquifer for their drinking water.[89] Those initial tests were focused on the impacts of potential wastewater contamination on drinking water supplies, including pharmaceuticals and other chemicals that might be endocrine disrupters. Just two of the 92 chemicals tested for were fluorinated chemicals—PFOA and PFOS. Both were detected, with PFOS being one of the three most frequently detected chemicals, and the study's authors noted the Barnstable Municipal Airport as a potential source. Follow up tests in 2011 of private drinking water wells in the area included other PFAS compounds that were detected—PFBS, PFHpA, PFHxA, and PFHxS.[90] Further reports identified local military bases, firefighting training locations, landfills, wastewater biosolids, and septic systems as sources.[91]



Under the EPA's UCMR 3, testing of certain public water systems across Massachusetts was conducted between 2013–15 (as in other states), which detected PFAS in water systems in Hudson, Hyannis, Mashpee, Middleton, and Westfield.[92]



Regulation and/or Legislation: In 2018, Massachusetts Department of Environmental Protection (MassDEP) issued PFAS guidelines for five PFAS chemicals.[93] These guidelines were that:

> "1) consumers in sensitive subgroups (pregnant women, nursing mothers and infants) not consume water when the level of the five PFAS substances, individually or in combination, is above 0.070 micrograms per liter (µg/L) or 70 parts per trillion (ppt); and,
>
> 2) public water suppliers take steps expeditiously to lower levels of the five PFAS, individually or in combination, to below 70 ppt for all consumers."

In 2019, MassDEP then began drafting regulations, which were finalized in October 2020. Those regulations established the standard of 20 ppt combined for six PFAS: PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA; the same standard is used for groundwater.[94] As of July 2022, 88 cities and towns in the state contained public water systems contaminated with PFAS at levels that exceed the Massachusetts standard.[95] In 2020, the state legislature also appointed the PFAS Interagency Task Force. The Task Force issued its final report in April 2022 with recommendations that included (among other things) expanding groundwater standards to additional PFAS, and evaluating the need for groundwater and surface water discharge permits and pretreatment requirements.[96]

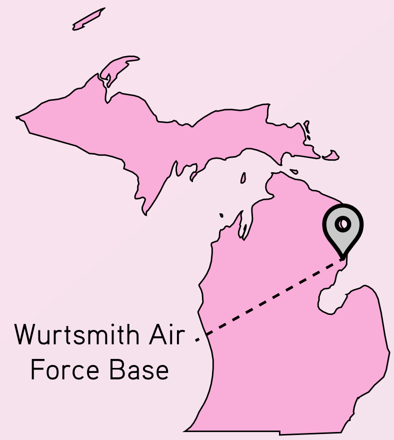
Michigan

Discovery of Contamination: In 2010, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) found PFAS contamination around the closed Wurtsmith Air Force Base in Oscoda, Michigan. Those soil and groundwater tests reflected contamination levels up to 1.2 million ppt. In 2012, Robert Delaney, a specialist at EGLE warned the agency about concerns of broader PFAS contamination in the state, issuing a 93-page report. That report wasn't made public until 2017.[97]

In the interim, the UCMR 3 testing results were published. While the results for Michigan showed just two water systems with detections over the 2016 federal advisory level, it reflected dozens more systems, collectively serving nearly 1.9 million people, with detections of PFOA and PFOS (in addition to further detections of other PFAS).

Regulation and/or Legislation: In 2017, then Governor Rick Snyder formed an interagency PFAS task force, the Michigan PFAS Action Response Team (MPART), and initiated statewide testing of all public water systems and certain additional systems.[98] That testing concluded in 2019 and found that "PFAS below 10 parts per trillion (ppt) were detected in 7 percent of systems tested. PFAS levels between 10 and 70 ppt were detected in 3 percent of systems tested."

In March 2019, EGLE began the process of creating an MCL.[99] In April 2019, MPART formed a Science Advisory Workgroup to assist EGLE with the rulemaking process by recommending health-based values for PFAS in drinking water. The Michigan Environmental Rules Review Committee (ERRC) unanimously voted to move forward with formal rulemaking in November 2019 and in August 2020 the state finalized new drinking water standards.



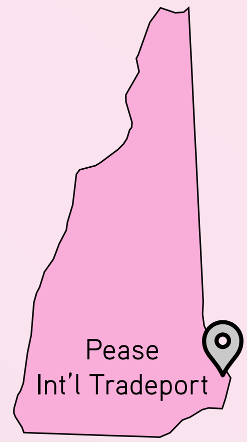
More than PFOA and PFOS
2020

PFOS	16 ppt
PFOA	8 ppt
PFNA	6 ppt
PFHxS	51 ppt
PFHxA	400,000 ppt
PFBS	420 ppt
PFHpA	
PFDA	
HFPO	370 ppt

New Hampshire

Discovery of Contamination: In May, 2014, the US Air Force notified the state's Department of Environmental Services (NHDES) and Department of Health and Human Services (NH DHHS) that PFAS had been detected in wells on the Pease International Tradeport that supply the city of Portsmouth's water at levels of 2500 ppt PFOS, 350 ppt PFOA, and 960 ppt PFHxS.[100] In 2016, residents in and around the town of Merrimack also learned that their public drinking water wells were contaminated drawing from the local facilities for the Saint-Gobain Performance Plastics company.[101] Later analysis of cancer incidence data further found "significantly higher risk" of certain forms of cancer associated with PFAS exposure for local residents.[102]

Regulation and/or Legislation: That year, NHDES established ambient groundwater quality standards of 70 ppt combined for PFOA and PFOS. In January 2019, NHDES initially proposed maximum contaminant levels for drinking water and ambient groundwater standards of 38 ppt PFOA, 70 ppt PFOS, 70 ppt PFOA and PFOS combined, 85 ppt PFHxS, and 23 ppt PFNA.[103] Those levels were revised downward following further external research, advocacy, and concerns from resident groups like Testing for Pease and Merrimack Citizens for Clean Water, and the state legislature, to 12 ppt PFOA, 15 ppt PFOS, 18 ppt PFHxS, and 11 ppt PFNA.[104] The adoption of those rules was delayed, however, as the Merrimack County Superior Court issued an injunction after it found that NHDES had failed to consider the cost and benefits of the proposed rules. In June and July of 2020, the state legislature passed and then Governor Sununu signed into law a bill that established the levels proposed by NHDES as enforceable standards.[105, 106]



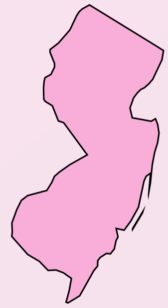
More than PFOA and PFOS
2020

PFOS	15 ppt
PFOA	12 ppt
PFNA	11 ppt
PFHxS	18 ppt
PFHxA	
PFBS	
PFHpA	
PFDA	
HFPO	

New Jersey

Discovery of Contamination: New Jersey was the first state to conduct broader testing of water systems for PFOA and PFOS in 2006 at 23 drinking water sources near facilities that used, handled, stored, or manufactured PFAS.[107] Of those systems, 65 percent detected PFOA and 30 percent detected PFOS. Expanded testing by the New Jersey Department of Environmental Protection (NJDEP) in 2009 and 2010 revealed similarly common detections and reflected contamination in water systems by other, typically multiple, PFAS chemicals. The EPA's UCMR 3 nationwide testing from 2013–15 further reflected that occurrences of PFOA and PFNA were "much more frequent in NJ than nationally," while PFOS was "somewhat more frequent."[108]

Regulation and/or Legislation: In 2014, the commissioner of the Department of Environmental Protection then requested that the state's Drinking Water Quality Institute (DWQI) recommend MCLs for PFNA, PFOA, and PFOS. The following year (2015), the DWQI recommended to the Department an MCL of 13 ppt PFNA, and that year, the NJDEP issued an interim groundwater quality standard of 10 ppt PFNA (those standards were later adopted in 2018). In 2017, the DWQI then recommended additional MCLs for PFOA of 14 ppt and for PFOS of 13 ppt (adopted in 2020). In addition, under the 2002 New Jersey Private Well Testing Act, as of December 2021, private wells at homes being sold in the state must be tested for PFOA, PFOS, and PFNA. Testing following the adoption of the MCLs in 2020, revealed that water systems serving over 500,000 residents were contaminated with PFAS at levels above the new standards.[109]



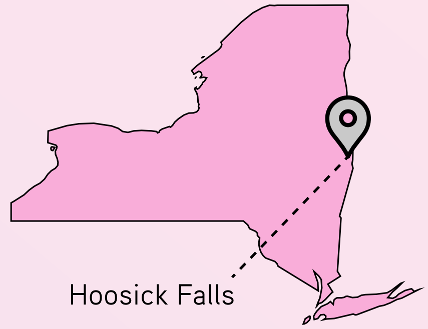
More than PFOA and PFOS
2020

PFOS	13 ppt
PFOA	14 ppt
PFNA	13 ppt
PFHxS	
PFHxA	
PFBS	
PFHpA	
PFDA	
HFPO	

New York

Discovery of Contamination: Like New Jersey, New York State agencies began testing for PFOA and PFOS in the early 2000s. In 2006, the Department of Health published results for PFOA, PFOS, PFHS, and PFOSA in the state's surface waters, as well as fish and birds, and measured their occurrence in certain wastewater systems. Those studies found that "PFOS, perfluorooctanoic acid (PFOA), and perfluorohexanesulfonate (PFHS) were ubiquitous in NYS waters" and that PFOA, for example, was present in wastewater effluents at levels of 58–1,050 ppt.[110] In 2014, PFOA contamination in the village of Hoosick Falls came to light following testing by a resident and local physician. When the village's own testing of the public water supply came back later that year, the primary well being used for drinking water had a level of 540 ppt of PFOA. At the time, in New York, PFAS fell under an umbrella drinking water regulation for unspecified organic contaminants of 50,000 ppt. Broader public awareness in New York of that contamination followed news reports in late 2015.[111] In January 2016, Region II EPA officials had advised residents not to drink or use the water if it tested at 100 ppt of PFOA or higher.[112] This temporary guidance supplanted the EPA's then short-term 400 ppt health advisory level.

Regulation and/or Legislation: Between 2016 and 2017 the state legislature and governor enacted more than a half dozen laws related to PFAS and water contamination. Those included the establishment of the Drinking Water Quality Council (DWQC) to make recommendations to the Department of Health, and the Emerging Contaminants Monitoring Act, which directed the Department to include PFOA and PFOS (as well as 1,4-Dioxane) on a list of "emerging contaminants" within one year.[113] All public water systems in New York would be required to test for the list of emerging contaminants and notify the public if contamination exceeded notification levels set by the Department of Health. In December of 2018, the DWQC then voted to recommend MCLs of 10 ppt each for PFOA and PFOS. In August 2020, those MCLs were then finalized by the Department of Health. In 2021, the legislature then passed and the (new) governor signed into law a further bill directing the Department of Health to issue the first list of emerging contaminants within 180 days of enactment (as the list had not been promulgated following the 2017 law).[114, 115] The initial list would include 23 PFAS, with an additional four PFAS to potentially be included on the subsequent list. In October of 2022, following the EPA's (2022) revised interim health advisory levels of .004 ppt for PFOA and .02 for PFOS, the Department of Health proposed its first list of emerging contaminants including 19 PFAS, as well as new individual MCLs of 10 ppt each for PFNA, PFHxS, PFHpA, and PFDA and a new combined MCL of 30 ppt for six PFAS (PFOA, PFOS, PFNA, PFHxS, and PFDA).



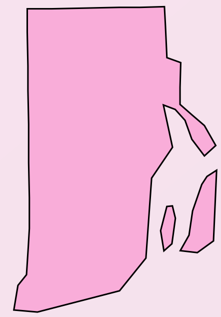
PFOA and PFOS Only
2020

PFOS	10 ppt
PFOA	10 ppt
PFNA	
PFHxS	
PFHxA	
PFBS	
PFHpA	
PFDA	
HFPO	

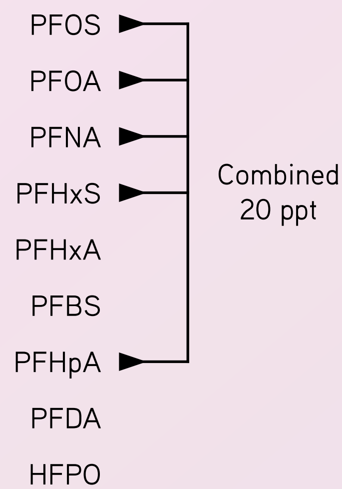
Rhode Island

Discovery of Contamination: Rhode Island is the latest state to adopt standards for drinking water for PFAS. In 2019, the state Department of Health (DOH) tested drinking water systems and found that 44 percent of those systems had some level of PFAS contamination, with 13 systems over 20 ppt and one over 70 ppt.[116, 117] That same year, data analyzed by the advocacy organization the Environmental Working Group also reflected PFAS in drinking water systems and sites in Rhode Island impacting 93,500 residents.[118]

Regulation and/or Legislation: In January 2020, members of the state legislature introduced a bill (H7216) to set an interim combined drinking water standard of 20 ppt for six PFAS and to direct the Department of Health to then finalize a standard.[119] In February 2020, at a hearing on that bill and related legislation, DOH staff stated that draft regulations would be released that May. The bill was then held for further study.[120] It was later reported that the governor's office was reviewing two potential proposals by DOH as of November 2020, of either a 10 ppt or 20 ppt combined standard (that was also weighted for certain compounds), that took into account technological availability of testing and filtration technologies as well as the costs involved.[121] Finally, in June 2022, a similar bill (H7223) was passed setting a combined standard for five PFAS compounds of 20 ppt.[122]

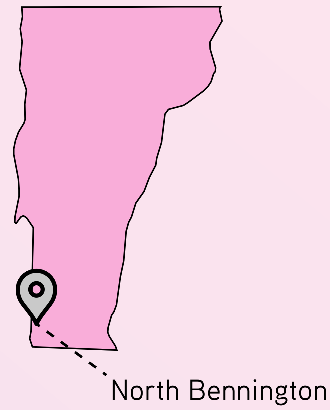


Combined Standard (Interim)
2022



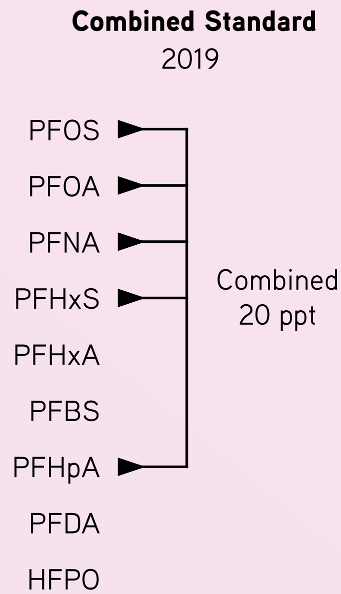
Vermont

Discovery of Contamination: Following news of the contamination in Hoosick Falls, New York, in early 2016, a North Bennington, Vermont resident emailed lawmakers concerning the ChemFab plant in town that was owned by the same company that had impacted Hoosick Falls: Saint-Gobain Performance Plastics.[123] State testing that followed found local wells with levels of PFOA from 40 ppt to 2,880 ppt.[124] Further state testing also revealed contamination in other Vermont communities such as Pownal, the site of another plant where PFAS was used.[125]



Regulation and/or Legislation: In March and April 2016, the state Department of Health issued drinking water health advisories of 20 ppt each for PFOA and PFOS, respectively.[126] In June 2016, the state Department of Health then revised the health advisory to 20 ppt for PFOA and PFOS combined.[127] And, in July 2018, the department further revised the health advisory to 20 ppt for the sum of five PFAS, including PFOA, PFOS, PFHxS, PFHpA, and PFNA.[128]

In 2019, the state legislature passed, and Governor Scott signed, Act 21,[129] directing the testing of water systems,[130] establishing the combined health advisory level as an interim drinking water standard, and directing the state Agency for Natural Resources to propose rulemaking.[131] The Agency adopted the new combined standard for five PFAS in February 2020.



Wisconsin

Discovery of Contamination: Neighboring Marinette and Peshtigo, Wisconsin, were the first known sites of PFAS contamination in the state. That contamination stemmed from the local manufacturing, testing, and discharge of products at sites owned and operated by Tyco Fire Products (previously Ansul Co.) and its parent company Johnson Controls Inc., which produced and tested firefighting foams for roughly 60 years.[132] The company learned from soil and well testing in 2013 of the contamination and only later notified local residents in 2017 that it believed that contamination extended beyond its facilities.[133] The sites represent the largest areas of investigation in the state at 17 square miles, with groundwater contamination at levels up to 254,000 ppt PFOA and 64,000 ppt PFOS.[134, 135]

Regulation and/or Legislation: In August 2019, then Governor Tony Evers directed the Department of Natural Resources to promulgate standards for PFAS.[136] In January 2020, the Natural Resources Boards then approved the development of those standards. In February 2022, members of the Natural Resources Board initially voted down a lower regulatory proposal by the state's Department of Natural Resources for a 20 ppt combined standard as well as one to regulate PFAS in groundwater, voting instead to adopt a standard of 70 ppt for PFOA and PFOS combined in drinking water; that rule was adopted in June 2022.[137, 138, 139]

EPA Guidance
2022

PFOS — PFOA: Combined 70 ppt

PFNA

PFHxS

PFHxA

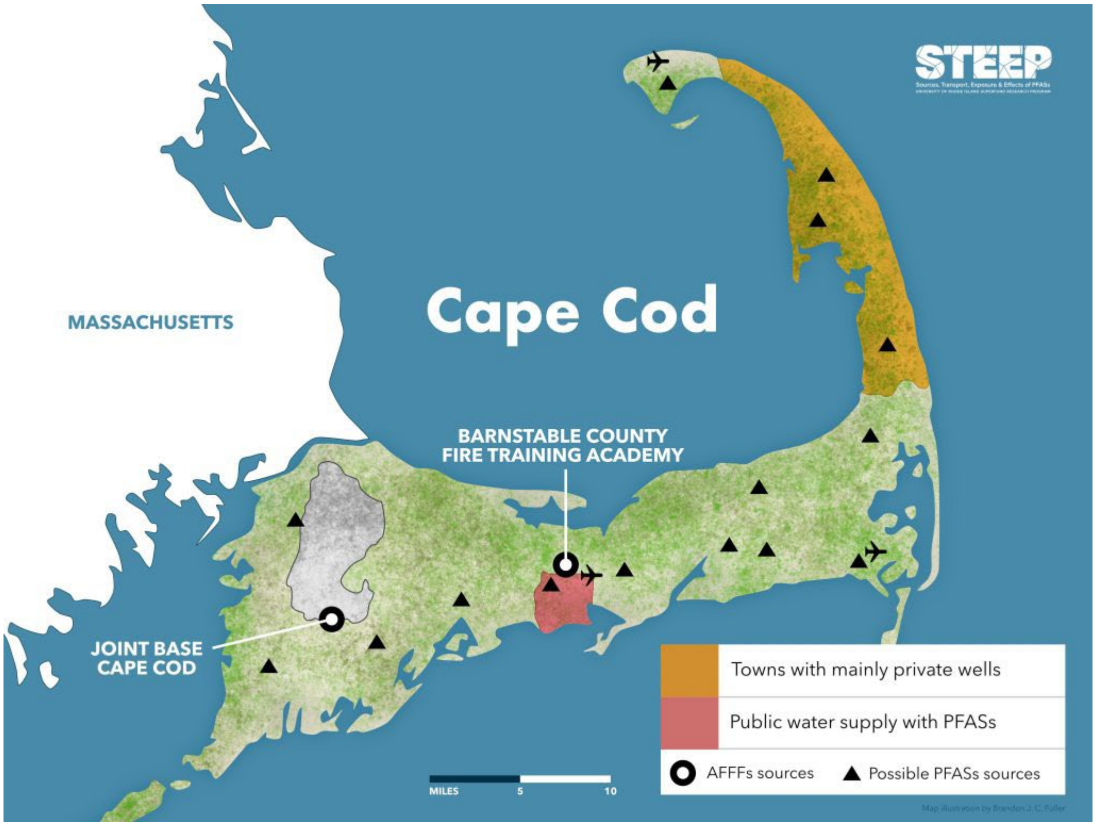
PFBS

PFHpA

PFDA

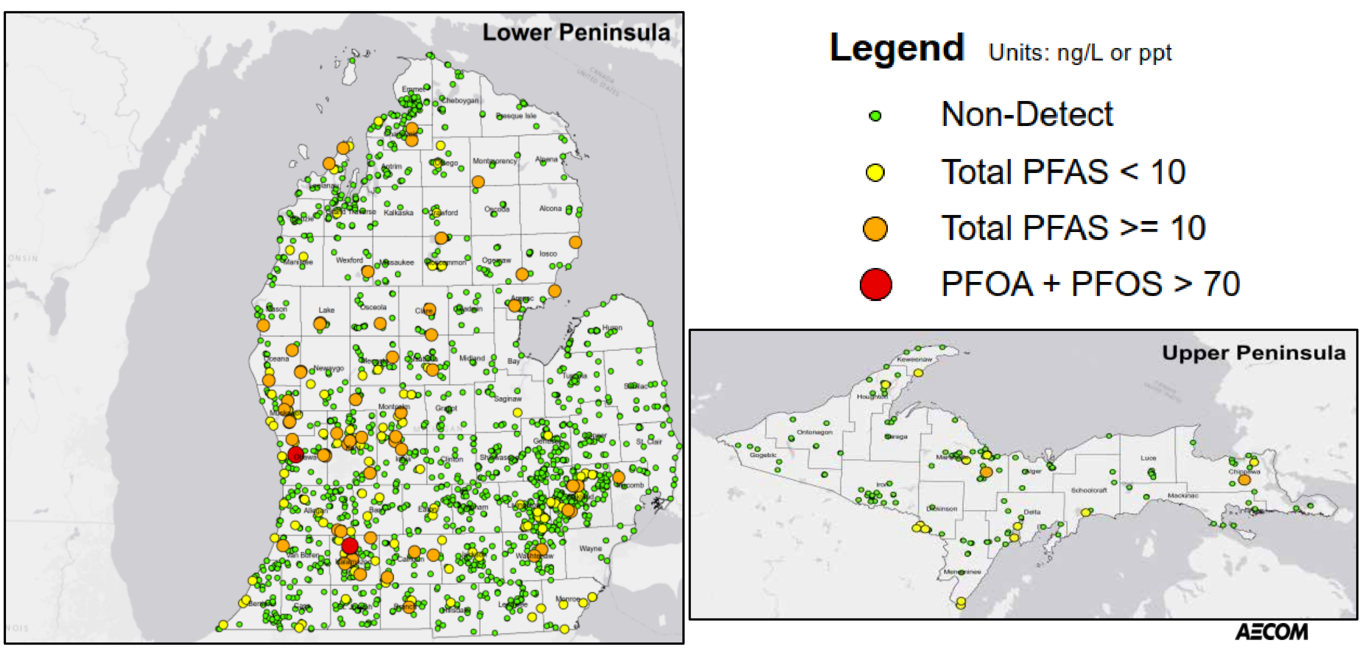
HFPO

FIGURE 2. **University of Rhode Island STEEP**



SOURCE: "Cape Cod," Sources, Transport, Exposure & Effects of PFAS (STEEP), accessed October 17, 2022, https://web.uri.edu/steep/communities/cape-cod/.

FIGURE 3. **Michigan UCMR 3 Test Results for PFOA and PFOS**



SOURCE: **John Cuthbertson and Dorin Bogdan,** "Statewide PFAS Sampling of Public Water Supplies in Michigan" (PowerPoint presentation presented at the Great Lakes Environmental Remediation & Redevelopment Conference, October 17, 2019), https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Events/glerrc/PFAS-Statewide-Sampling-Cuthbertson.pdf.

Analysis and Conclusions

Across the first nine states to have enforceable drinking water standards for PFAS compounds, we can begin to see a few potential patterns pertaining to the length of time to enact standards, the process through which they were established, which PFAS those standards addressed, and if they did so individually or in combination.

- More often than not, the time between precipitating events and enacting standards has been lengthy, with the shortest time reflected in these cases being four years and most taking six or more years.
- The enactment of state standards has generally involved a substantive legislative role to either directly set standards or interim standards, or to direct state agencies and advisories bodies to do so.
- Most of these states have ended up setting standards for five or more PFAS and those doing so have generally set a combined standard for a group of PFAS chemicals. Most of these states have also issued similar groundwater standards or criteria, though they have not issued private well testing requirements.
- While all these state standards fall at or below the EPA's earlier 2016 advisory levels, the EPA's interim 2022 advisories for PFOA and PFOS are far below all of the standards that states now have in place. Some states have noted the need to reconsider standards in light of the new advisories.

The time from precipitating event to the enactment of enforceable drinking water standards spanned anywhere from four to 14 years across these states, but was typically at least six years. This reflects that the path to changing state PFAS drinking water regulations is not a rapid one. At the time of some of the earlier precipitating events discussed here, however, there had been no statewide testing efforts to detect contamination. All states now have the results of at least some statewide drinking water testing from the UCMR 3 with which to begin to understand the occurrence of certain PFAS in their drinking water systems even if that testing has important limitations.

All of the standards discussed have been enacted in the past few years, which may further reflect that broader scientific, public, and political consensus may be at a tipping point. Given the existing state standards and broader availability of testing and research on impacts, however, one might expect that any future rulemaking at the state level will not be quite as lengthy. Indeed, Vermont, which first found PFAS contamination relatively recently in 2016, took the shortest length of time to develop standards (just four years, with interim advisory levels being developed within a year of discovery). That said, there are still states without standards that have had known cases of contamination stemming back much longer—as in the case of Decatur, Alabama[140]—demonstrating, in part, that the availability of testing and mounting scientific evidence of negative health impacts have not alone been enough to result in new rulemaking or laws establishing state PFAS drinking water standards.

While the enactment of standards in all of the states to date has involved the regular agency rulemaking processes in some way, over half of these cases (Maine, New Hampshire, New York, Rhode Island, and Vermont) reflect that state legislatures have played substantial roles in enacting standards. In New Hampshire, the role was very direct with the legislature setting standards through a bill's text. This approach was taken because standards previously developed by the state Department of Environmental Services were challenged through court cases. Vermont's legislature likewise had more direct involvement, establishing interim drinking water standards and directing the state's Agency for Natural Resources to then go through the rulemaking process to finalize standards. New York's legislative role on the other hand was less direct in some ways, though still substantial. In that case, the legislature established an advisory body and an attendant testing and recommendation process for 'emerging' contaminants for the Department of Health and further directed the department to go through the rulemaking process within certain timelines.

While earlier federal and state advisories have typically addressed PFOA and PFOS, state standards reviewed in this report generally include more PFAS compounds. In five of the nine cases (Maine, Massachusetts, Michigan, Rhode Island, and Vermont), states set standards for five or more compounds. And, saliently, in four of those five cases (Maine, Massachusetts, Rhode Island, and Vermont), they established a combined standard or combined interim standard. While the states considered here have generally developed similar groundwater standards or criteria to their drinking water standards, most have not included requirements or standards for private wells to be tested. Even as some states have offered resources upon request or testing for residents with private wells in certain areas, this absence of regulation leaves tens of millions of people excluded from public health protections afforded to their neighbors on public water systems.

All nine states with enforceable drinking water standards have standards orders of magnitude higher than the EPA's 2022 interim health advisory levels for PFOA and PFOS. In addition to those states, many states have been deferring to the EPA'S 2016 health advisory levels as guidance, which are likewise orders of magnitude higher than the new interim levels. If new federal rulemaking for PFOA and PFOS drinking water standards are proposed as promised this fall, the states that do not currently have standards may await the finalization of that rule or try to align state rulemaking with it. If, and as that happens, we'll be updating this work to reflect new developments.

"Winooski River in Montpeilier, VT, USA," by Michael Calore is licensed under CC BY-2.0, https://commons.wikimedia.org/wiki/File:Montpelier_VT_-_Winooski_River.jpg.

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