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Report to Congressional Requesters

September 2022

PERSISTENT CHEMICALS

EPA Should Use New Data to Analyze the Demographics of Communities with PFAS in Their Drinking Water

GAO-22-105135

Highlights of GAO-22-105135, a report to congressional requesters

September 2022

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EPA Should Use New Data to Analyze the Demographics of Communities with PFAS in Their Drinking Water

Why GAO Did This Study

PFAS are a large group of heat- and stain-resistant chemicals first developed in the 1940s. PFAS are used in a wide range of products, including carpet, nonstick cookware, waterproof clothing, and firefighting foam used at airports and military bases. PFAS can persist in the environment for decades. Studies have found that most people in the U.S. have been exposed to PFAS, likely from consuming contaminated water or food. PFAS at certain levels may cause adverse health effects. EPA plans to regulate two PFAS in drinking water, while some states have begun independently testing for and regulating various PFAS.

GAO was asked to examine PFAS contamination in drinking water and related state actions. This report examines, among other things, (1) what recent data from selected states show about the occurrence of PFAS in drinking water, (2) the demographic characteristics of communities in selected states with and without PFAS in their drinking water, and (3) factors that influenced states' decisions to test and develop standards or guidance for PFAS in drinking water. GAO analyzed available state PFAS occurrence data for six states and held discussion groups and interviews with officials from 49 states.

What GAO Recommends

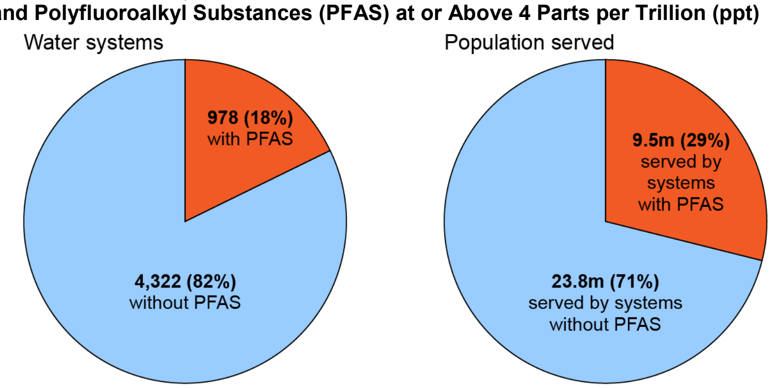
GAO recommends that EPA conduct a nationwide analysis using comprehensive data to determine the demographic characteristics of communities with PFAS in their drinking water. EPA agreed with the recommendation.

View GAO-22-105135. For more information, contact J. Alfredo Gómez at (202) 512-3841 or GomezJ@gao.gov

What GAO Found

Recent drinking water data from six selected states show that at least 18 percent of the states' 5,300 total water systems had at least two per- and polyfluoroalkyl substances (PFAS)—perfluorooctanoic acid and perfluorooctane sulfonate—above the Environmental Protection Agency's (EPA) 2022 interim revised health advisory levels. Over these levels, adverse health effects can occur and EPA plans to regulate these two PFAS in drinking water in 2023. GAO found that 978 water systems had the two PFAS at or above EPA's minimum reporting level of 4 per trillion (ppt)—the lowest level reliably quantified by most laboratories—and above EPA's health advisory levels. These systems served 9.5 million (29 percent) of the total 33 million people served by all the systems (see fig.).

Number of Water Systems and Population Served Across Six Selected States with Two Per- and Polyfluoroalkyl Substances (PFAS) at or Above 4 Parts per Trillion (ppt)



Source: GAO analysis of state data. | GAO-22-105135

Notes: The Environmental Protection Agency plans to regulate these two PFAS: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). GAO examined what recent data show about the occurrence of PFAS in drinking water from these six states: Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, and Vermont.

The demographic characteristics of communities with PFAS in their drinking water varied in the states GAO examined. In Massachusetts, communities with higher percentages of non-White or Hispanic/Latino residents and/or families living in poverty were less likely than other communities to have PFAS in their drinking water. This was the converse situation in New Jersey. According to EPA officials, EPA does not currently have information to determine the extent to which disadvantaged communities are exposed to PFAS in drinking water nationally; however, the agency plans to collect comprehensive, nationwide data. Conducting a nationwide analysis using such data could help EPA understand whether PFAS in drinking water contributes to the cumulative burden of pollution in disadvantaged communities.

According to state officials, public health and PFAS contamination concerns influenced some states' decisions to test and develop enforceable standards or nonenforceable guidance for PFAS in drinking water. As of July 2022, six states set standards and were influenced to do so by public health concerns. When the states set standards, the levels they set were more stringent than EPA's 2016 lifetime health advisory levels. Fourteen additional states developed guidance or began developing standards because of PFAS contamination.

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Abbreviations

EPA	Environmental Protection Agency
GenX chemicals	hexafluoropropylene oxide dimer acid and its ammonium salt
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonic acid
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
ppt	parts per trillion
SDWIS	Safe Drinking Water Information System
UCMR	Unregulated Contaminant Monitoring Rule

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

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Congressional Requesters

Per- and polyfluoroalkyl substances, known as PFAS, are a large group of more than 4,000 synthetic chemicals that have been in use since the 1940s.[1] PFAS are persistent in the environment; resistant to degradation; and some bioaccumulate in humans, animals, and plants to varying degrees.[2] According to the Centers for Disease Control and Prevention, most Americans have PFAS in their blood. Exposure to some PFAS above certain levels may negatively affect human health. For example, the Environmental Protection Agency (EPA) has proposed classifying perfluorooctanoic acid (PFOA) as a likely human carcinogen.[3] Research has found that PFOA is associated with kidney and testicular cancer in certain populations.[4] In June 2022, on the basis of new science, EPA stated that some negative health effects may occur with concentrations of PFOA and perfluorooctane sulfonate (PFOS) in water that are below EPA's ability to detect at this time, and EPA recommended taking steps to reduce exposure.[5]

[1]PFAS are a class of fluorinated organic compounds. According to Environmental Protection Agency documentation, more than 4,700 PFAS may have been manufactured and used in a variety of industries worldwide since the 1940s but of these, fewer than 1,500 are known to have ever been in commerce in the U.S., and fewer than 700 are known to have been commercially active within the last decade.

[2]PFAS can be persistent in the environment for decades or longer, depending on the type of PFAS. Bioaccumulation is defined as the accumulation of a substance—especially a contaminant, such as a pesticide or heavy metal—in a living organism.

[3]In draft documents submitted to EPA's PFAS Science Advisory Board, EPA classified PFOA as a likely human carcinogen. The board supported EPA's conclusion in its August 2022 final report. Should EPA determine that PFOA is a carcinogen, the maximum contaminant level goal for PFOA in drinking water would be set at zero.

[4]See V. Barry et al., "Perfluorooctanoic Acid (PFOA) Exposures and Incident Cancers among Adults Living Near a Chemical Plant," *Environmental Health Perspectives*, vol. 121 (2013): pp. 1313-1318. See also, Joseph J. Shearer et al., "Serum Concentrations of Per- and Polyfluoroalkyl Substances and Risk of Renal Cell Carcinoma," JNCI J Natl Cancer Inst. (2021):113(5) djaa143.

[5]Environmental Protection Agency, *Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA)* (June 2022); and *Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS)* (June 2022).

Due to their heat- and stain-resistant properties, PFAS are used in a wide range of commercial and consumer products. PFAS are found in firefighting foams that suppress petrochemical fires—typically used at airports and on military bases.[6] People are exposed to PFAS primarily through the environment, such as by ingesting contaminated food and drinking water, breathing PFAS-contaminated air, and coming into contact with contaminated soil. Water may become contaminated by PFAS as a result of chemical releases into the air, surface water, or groundwater, from locations such as manufacturing sites, landfills, aviation fire training areas, or wastewater treatment facilities.

Congress has pursued legislation to address PFAS. For example, Congress appropriated $9 billion in fiscal year 2022 through the Infrastructure Investment and Jobs Act that, among other purposes, can be used by water systems to treat for PFAS in drinking water. Of the $9 billion, $6 billion must go to address emerging contaminants, such as PFAS, at water systems that serve disadvantaged communities.[7]

EPA does not yet regulate PFAS in drinking water. In March 2021, EPA announced that it intended to regulate PFOA and PFOS—two of the most widely studied PFAS. According to EPA's *PFAS Strategic Roadmap:*

[6]See our previous work on the Department of Defense's actions to address PFAS in drinking water from the use of firefighting foam at or near military installations: GAO, *Firefighting Foam Chemicals: DOD Is Investigating PFAS and Responding to Contamination, but Should Report More Cost Information*, GAO-21-421 (Washington, D.C.: June 22, 2021); *Drinking Water: Status of DOD Efforts to Address Drinking Water Contaminants Used in Firefighting Foam*, GAO-18-700T (Washington, D.C.: Sept. 26, 2018); and *Drinking Water: DOD Has Acted on Some Emerging Contaminants but Should Improve Internal Reporting on Regulatory Compliance*, GAO-18-78 (Washington, D.C.: Oct. 18, 2017). See also our technology assessment related to PFAS: GAO, *Persistent Chemicals: Technologies for PFAS Assessment, Detection, and Treatment,* GAO-22-105088 (Washington, D.C.: July 28, 2022).

[7]Specifically, the act included $5 billion for water systems to treat for emerging contaminants, such as PFAS. These grants are directed toward water systems that serve disadvantaged communities or populations of fewer than 10,000 people. According to EPA's grant announcement, a "disadvantaged community" is one determined by the state to be disadvantaged under the affordability criteria established by the state under section 1452(d)(3) of the Safe Drinking Water Act or may become a disadvantaged community as a result of carrying out a project or activity under the grant program. The act provided an additional $4 billion through Drinking Water State Revolving Funds for water systems to, among other things, treat emerging contaminants. Of the $4 billion, 25 percent ($1 billion) must go to disadvantaged communities.

EPA's Commitments to Action 2021-2024 (PFAS Strategic Roadmap)[8] and EPA officials, the agency plans to propose a national drinking water rule in the fall of 2022 and to finalize the rule by the end of 2023. In the meantime, many states are testing for PFAS in drinking water, and some have already developed, or are in the process of developing, their own regulatory standards[9] or guidance.[10]

You asked us to examine PFAS contamination in drinking water and related state actions. This report examines (1) what recent data from selected states show about the occurrence of PFAS in drinking water; (2) the demographic characteristics in selected states of communities with and without PFAS in their drinking water; (3) factors that influenced states' decisions to test for PFAS in drinking water, as well as barriers the states encountered; and (4) factors that influenced states' decisions to develop standards or guidance for PFAS in drinking water and barriers the states encountered.

To examine what recent data from selected states show about the occurrence of PFAS in drinking water, we collected data from six states—Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, and Vermont. We selected these states because they had (1) developed standards or guidance for PFAS in drinking water; and (2) collected comprehensive data—that is, data from most or all water systems in the state—that were more recent than data collected under EPA's third Unregulated

[8]Environmental Protection Agency, *PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024* (October 2021).

[9]As of July 1, 2022, six states had enacted or promulgated maximum contaminant levels (MCL) that cumulatively addressed nine different PFAS in drinking water: Massachusetts, Michigan, New Hampshire, New Jersey, New York, and Vermont. Wisconsin promulgated standards that became effective August 1, 2022.

[10]"Standards" refer to enforceable regulations—such as MCLs. "Guidance" refers to narrative guidance, action levels, response levels, or health advisories, etc., that are unenforceable levels set for the maximum concentration of specific PFAS in water and were established to provide guidance to drinking water managers or the public.

Contaminant Monitoring Rule (UCMR) (2013-2015).[11] We then analyzed the occurrence of PFAS in the states' drinking water systems. Specifically, we examined PFAS occurrence in water systems at the following three levels: (1) PFOA or PFOS at or above 4 parts per trillion (ppt)[12]—the minimum reporting level for these two chemicals in EPA's upcoming UCMR5 monitoring cycle (2023-2025), the lowest level reliably quantified by most laboratories, and a level reported in most of the states' data;[13] (2) levels above a state's standard or guidance level;[14] and (3) PFOA, PFOS, or the combination of the two above 70 ppt—EPA's 2016 lifetime health advisory level.[15]

We requested documentation and information from state officials about the completeness, comprehensiveness, and accuracy of their datasets. We then independently assessed the reliability of each dataset. After taking steps to assess the reliability of each state's data, we found all six

[11]According to EPA documentation, there are three types of public water systems: (1) community water systems that supply water to the same population year-round; (2) non-transient non-community water systems that regularly supply water to at least 25 of the same people at least 6 months per year, such as schools, factories, office buildings, and hospitals; and (3) transient non-community water systems that provide water in a place such as a gas station or campground where people do not remain for long periods of time. Unless otherwise noted, we included data from community water systems and non-transient non-community water systems in our scope, which we collectively refer to as "water systems" in this report. For more information on EPA's implementation of the UCMR program, see our previous work: GAO, *Drinking Water: EPA Has Improved Its Unregulated Contaminant Monitoring Program, but Additional Action Is Needed*, GAO-14-103 (Washington, D.C.: Jan. 9, 2014).

[12]One ppt is equivalent to a single drop of water in 20 Olympic-sized swimming pools.

[13]According to EPA documents, EPA establishes the minimum reporting level using data from multiple laboratories performing "Lowest Concentration Minimum Reporting Level" studies to identify their capability. The minimum reporting level is the minimum quantitation level that, with 95 percent confidence, can be achieved by at least 75 percent of the laboratories, assuming the use of good instrumentation and experienced analysts. All six states' datasets measured PFOA and PFOS at or below 4 ppt, with the exception of Ohio, which had minimum reporting levels for the two chemicals at 5 ppt.

[14]Of the states we selected, most states developed standards for more than PFOA and PFOS, and not all states' standards or guidance address the same PFAS. We analyzed levels for only those PFAS for which the states themselves had developed standards or guidance.

[15]Since 70 ppt no longer represents EPA's current health advisory level for PFOA and PFOS, we focus our findings in the report on the other two levels. We include footnotes in the report where we analyzed at the 70 ppt level.

datasets to be sufficiently reliable for describing the occurrence of PFAS in drinking water in the six states.

To examine the demographic characteristics of communities with and without PFAS in their drinking water for two selected states—Massachusetts and New Jersey—we conducted an exploratory analysis using available data from large community water systems. Specifically, we analyzed (1) the PFAS occurrence data collected for the first objective; (2) ZIP code data, where available, for the service areas of states' water systems; and (3) demographic data from the U.S. Census Bureau's 2019 American Community Survey. We chose these two states from the six selected states that had comprehensive PFAS data because EPA had ZIP code data for a sufficiently large number of their water systems' service areas and because they had standards against which we could compare PFAS concentrations.[16]

We selected two core factors from EPA's *EJSCREEN Technical Documentation*[17]—(1) minority (the percentage of the population that identified as non-White or Hispanic/Latino); and (2) low-income (the percentage of families for which their household income was less than, or equal to, twice the federal poverty level). We modified these core factors

[16]We restricted our analysis to states with standards and comprehensive data on PFAS in drinking water, which included Massachusetts, New Hampshire, New Jersey, and Vermont. Our methodology relied upon ZIP code information on water systems' service areas available in EPA's UCMR4 and other sources to estimate the American Community Survey demographic characteristics for each water system. Because UCMR4 did not collect ZIP codes for all small and non-community water systems (only a representative subset of small systems participated in UCMR4), we restricted our analysis to large community water systems. Two of the states—New Hampshire and Vermont—have predominantly small water systems and, thus, could not be assessed using our methodology.

[17]According to EPA documentation, EJScreen is an environmental justice mapping and screening tool that provides EPA with seven demographic indicators, including one core measure related to low-income communities and another related to communities of color. See Environmental Protection Agency, *EJSCREEN Environmental Justice Mapping and Screening Tool EJSCREEN Technical Documentation* (September 2019). EPA uses the demographic indicators of low-income and minority to specify which communities may be more susceptible to environmental pollutants. It should be noted that, for the purposes of their own analyses, states might use different definitions of susceptible, disadvantaged, or overburdened, which might or might not use the same criteria as we used in our analysis and, therefore, might yield different results.

as appropriate for our analysis,[18] to classify whether the communities served by a water system were disadvantaged.[19] Then we used the state-provided PFAS data to determine which water systems had PFAS at what levels. As a result of various data limitations, our findings cannot be generalized to other states or small water systems, and the number of water systems that serve disadvantaged communities is approximate. Additionally, we cannot confirm whether or how individuals are consuming water from their specific water systems. After taking steps to assess the reliability of each of the datasets, we found them to be sufficiently reliable for describing the demographic characteristics of communities with PFAS in their drinking water. For further information about the demographic classifications of water systems, please see appendix I.

To examine factors that influenced states' decisions to test for PFAS in drinking water, factors that influenced states' decisions to develop standards and guidance for PFAS in drinking water, and any barriers they encountered in doing so, we collected information from state officials in 49 states through semistructured interviews and moderated virtual discussion groups. Specifically, for the same states that we selected to examine what recent state data show about the occurrence of PFAS in drinking water, we conducted interviews and analyzed the information to identify themes and develop a summary of the factors that influenced states' decisions. For all other states, we invited officials from each state to participate in moderated discussion groups and analyzed the information we gathered to identify commonly cited factors that influenced

[18]We classified disadvantaged communities as those with significantly higher percentages of the population that identified as non-White or Hispanic/Latino and/or higher percentages of families living in poverty when compared to the respective demographic's statewide average across ZIP codes—ZIP Code Tabulation Areas—in the state. Statistical tests were carried out at the 95 percent confidence level.

[19]In this report, we use the term "disadvantaged" to describe communities that might face barriers in accessing resources owing to factors such as income or race. We recognize that language to describe such communities is in flux and, depending on the circumstance, those communities might also be referenced using a range of terms, such as underserved, vulnerable, susceptible, marginalized, or overburdened by pollution. We chose to use the term "disadvantaged" because the term is used in the Safe Drinking Water Act and agency guidance related to these communities and the water systems that serve them (e.g., EPA's guidance to states for Infrastructure Investment and Jobs Act funding and the Office of Management and Budget's *Interim Implementation Guidance for the Justice40 Initiative*).

states' decisions.[20] When reporting on the results of our discussion groups and interviews, we do not report the numbers of states that reported various factors and barriers. Instead, we present those factors and barriers that were discussed in interviews and that received the majority of the votes in our discussion groups. For example, where we describe the factors that state officials most commonly cited as influencing their state's decision to test for PFAS in drinking water, we refer to the factors that received a majority of the votes (more than 20 votes) on that poll held during the discussion groups. We compared the results of our discussion group analysis to those of our interviews and, where there was concurrence, we present those results together. Where the differences in the groups were apparent, we present those results separately. Appendix I provides further details about our objectives, scope, and methodology.

We conducted this performance audit from April 2021 to September 2022, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

PFAS Pathways into the Environment

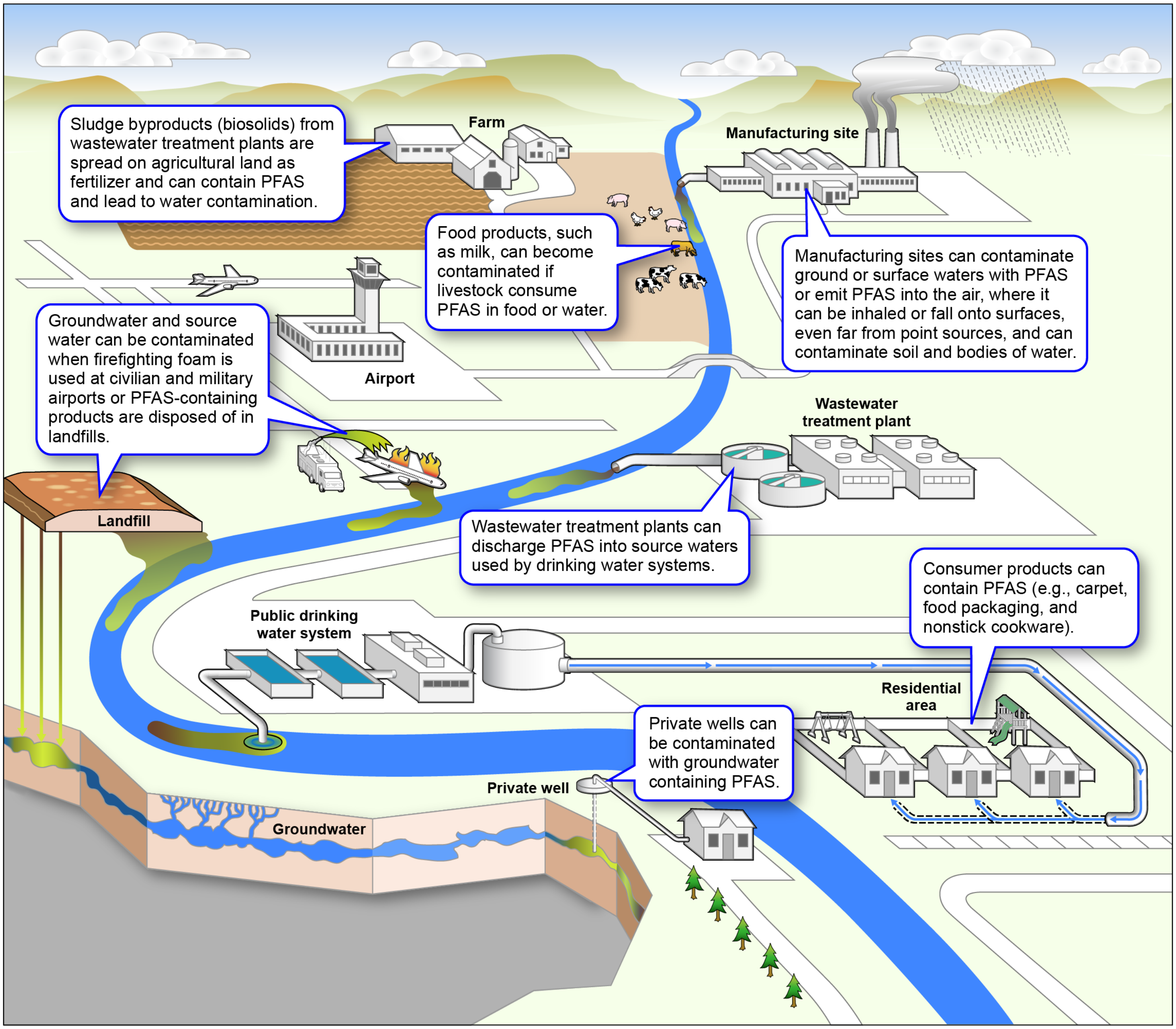
PFAS are used in consumer and industrial products, including carpet, food packaging, nonstick cookware, and certain clothing; and at manufacturing facilities, airports, and military installations. According to scientific literature, some PFAS are pervasive in the environment and bioaccumulate in humans, animals, and plants.[21] PFAS can enter the environment in a number of ways (see fig. 1). For example, firefighting

[20]Our report represents the views of officials from 49 states. Officials from Michigan were not able to participate in our interviews or discussion groups because of ongoing litigation related to their PFAS drinking water regulations. Of the 49 states in our methodology, we held interviews with officials from seven states and collected data from six of them; we held discussion groups with officials from the other 42 states.

[21]M. Clara et al., "Emissions of perfluorinated alkylated substances (PFAS) from point sources—identification of relevant branches," *Water Science & Technology*, vol. 58, no. 1 (2008): pp. 59-66; Agency for Toxic Substances and Disease Registry, *Per- and Polyfluoroalkyl Substances (PFAS) and Your Health: PFAS in the U.S. Population*, accessed March 25, 2020, https://www.atsdr.cdc.gov/pfas/pfas-in-population.html; and National Academies of Sciences, Engineering, and Medicine, *Use and Potential Impacts of AFFF Containing PFASs at Airports* (Washington, D.C.: 2017).

foam can seep into groundwater, as can water (i.e., leachate) that drains from landfills where PFAS-containing materials are disposed. PFAS in biosolids—the sludge byproducts from wastewater treatment plants that are deposited on agricultural lands as fertilizer—can also run off into surface waters, as can PFAS from the discharge of wastewater effluent. Industrial, manufacturing, and waste incineration facilities can emit PFAS into the air, which may also later affect source waters through contaminated rain. While some companies in the U.S. have voluntarily phased out certain PFAS from their production processes and replaced them with chemicals that are generally less bioaccumulative and potentially less toxic, legacy uses and a lack of commercially viable alternatives for certain safety products, such as firefighting foams, have resulted in PFAS contamination across the U.S.

Figure 1: Examples of How Per- and Polyfluoroalkyl Substances (PFAS) Enter the Environment



Source: GAO. | GAO-22-105135

Human Exposure to, and Health Risks from, PFAS

In general, risks of adverse health effects from chemical exposures depend on (1) the level of exposure, which is a combination of how much of the chemical in is the environment and how much contact a person has with it; and (2) how the chemical affects the health of humans, also called toxicity. Risk to human health is a function of both the potential harm to humans from PFAS and the potential exposure to PFAS. Researchers assess PFAS to better understand how harmful specific compounds may be and to determine where PFAS come from, how they move through the environment, and how people are exposed to them.

According to epidemiological research by the Centers for Disease Control and Prevention and others, human exposure to PFAS occurs primarily by ingesting contaminated drinking water and food.[22] Water may become contaminated by PFAS as the result of chemical releases into the air, surface water, or groundwater, from locations such as manufacturing sites, landfills, aviation fire training areas (see fig. 2), or wastewater treatment facilities. Food, including dairy products, may become contaminated by PFAS when livestock, fish, or plants are exposed to PFAS. Additionally, human exposure can also occur by inhaling contaminated air, using products that contain PFAS, and coming into contact with other contaminated media.[23] According to EPA and scientific studies, people can be exposed to PFAS in both their workplaces and homes. Workers can be exposed to PFAS at a workplace that produces or uses PFAS or one that stores or destroys PFAS. Additionally, fetuses can be exposed to PFAS in utero, and nursing mothers can expose their children to PFAS through breastmilk.

[22]Centers for Disease Control and Prevention, *Per- and Polyfluorinated Substances (PFAS) Factsheet*, accessed August 20, 2020, https://www.cdc.gov/biomonitoring/PFAS_FactSheet.html.

[23]Sunderland, "A Review of the Pathways of Human Exposure to Poly- and Perfluoroalkyl Substances (PFASs) and Present Understanding of Health Effects," p. 132; and Centers for Disease Control and Prevention, *Per- and Polyfluorinated Substances (PFAS) Factsheet*.

Figure 2: Firefighters Using Chemical Foam

Source: mushegovdiva/stock.adobe.com. | GAO-22-105135

Since 1999, the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey, also known as NHANES, has measured some PFAS in the blood of a representative sample of Americans.[24] While some blood PFAS levels have declined, the survey has found that most people in the U.S. have been exposed to two of the most widely studied PFAS—PFOA and PFOS.[25] Specifically, from 1999 to 2014, blood PFOA levels have declined by more than 60 percent, and blood PFOS levels have declined by more than 80 percent. However, as PFOA and PFOS are phased out and replaced, people may be exposed to other PFAS.

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[24]The National Health and Nutrition Examination Survey assesses the health and nutritional status of adults and children in the U.S. The survey, which began in the 1960s, combines interviews and physical examinations and determines the prevalence of major diseases and risk factors for diseases. Results are shared online and in scientific and technical journals, and the data are made available to researchers, risk assessors, and regulators around the world.

[25]PFOA and PFOS are known to be persistent, bioaccumulative, and toxic; for example, see Clara, et al., "Emissions of perfluorinated alkylated substances (PFAS) from point sources." See also, Agency for Toxic Substances and Disease Registry, *Per- and Polyfluoroalkyl Substances (PFAS) and Your Health.*

Certain PFAS have been shown to pose hazards to human health. For example, according to some studies, PFAS exposure may reduce antibody responses to vaccines and may reduce resistance to infectious disease such as COVID-19.[26] Further, according to EPA, exposure to PFOA and PFOS over certain levels may have a variety of adverse effects on human health, including effects on fetal development, the immune system, and the thyroid. The two PFAS can also cause liver damage and, in draft documents in late 2021, EPA proposed classifying PFOA as a likely human carcinogen, and EPA's Science Advisory Board supported this classification.[27]

Additionally, according to toxicity assessments that EPA released in 2021 for two other PFAS—perfluorobutane sulfonic acid (PFBS) and its potassium salt, and hexafluoropropylene oxide dimer acid and its ammonium salt (also known as "GenX" chemicals)—these PFAS can also affect human health.[28] For example, in animal studies, following oral exposure, PFBS and its potassium salt showed thyroid, developmental, and kidney effects. Similarly, GenX chemicals showed an association with cancer, as well as effects on the liver, kidneys, immune system, and

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[26]According to the Centers for Disease Control and Prevention, exposure to high levels of PFAS may affect the immune system. There is evidence from human and animal studies that PFAS exposure may reduce antibody responses to vaccines and, as noted, may reduce resistance to infectious disease. Because COVID-19 is a new public health concern, more research is needed to understand how PFAS exposure may affect illness from COVID-19. For more information on the impact of PFAS exposure on the immune system, see P. Grandjean et al., "Estimated exposures to perfluorinated compounds in infancy predict attenuated vaccine antibody concentrations at age 5-years," *J Immunotoxicol.,* vol. 14, no.1 (2017): pp. 188-195; C. Looker et al., "Influenza vaccine response in adults exposed to perfluorooctanoate and perfluorooctanesulfonate," *Toxicol Sci.,* vol. 138, no. 1 (2014): pp. 76-88; and National Toxicology Program, *Monograph on Immunotoxicity Associated with Exposure to Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)* (Research Triangle Park, NC: National Toxicology Program, 2016). https://ntp.niehs.nih.gov/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdf.

[27]Science Advisory Board Report, *Review of EPA's Analyses to Support EPA's National Primary Drinking Water Rulemaking for PFAS* (Aug. 22, 2022).

[28]Environmental Protection Agency, *Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3)*, EPA Document Number EPA/600/R-20/345F (Washington, D.C: 2021); and *Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3) Also Known as "GenX Chemicals,"* EPA Document Number 822R-21-010 (Washington, D.C.: 2021).

reproduction and development, such as increased early deliveries and developmental delays in offspring.[29]

EPA uses toxicity assessments to develop lifetime health advisories. As of July 2022, EPA is in the process of completing toxicity assessments for five additional PFAS.[30]

Federal Actions to Address PFAS

Funding. The federal government has begun taking steps to address PFAS contamination.[31] For example, through the Infrastructure Investment and Jobs Act, EPA will make a total of $9 billion available for fiscal years 2022 through 2026 to address PFAS and other emerging contaminants in drinking water through grants and loans,[32] including $6 billion for small or disadvantaged communities.[33]

Regulatory process to address PFAS in drinking water. The Safe Drinking Water Act authorizes EPA to establish legally enforceable

[29]For more information about GenX chemicals and their health impacts, see the Environmental Protection Agency's October 2021 *Fact Sheet: Human Health Toxicity Assessment for GenX Chemicals* (EPA 822 -F -21-006). https://ntp.niehs.nih.gov/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdfhttps://www.epa.gov/system/files/documents/2021-10/genx-final-tox-assessment-general_factsheet-2021.pdf.

[30]The five PFAS being assessed are perfluorobutanoic acid (PFBA), perfluorohexanesulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorodecanoic acid (PFDA), and perfluorononanoic acid (PFNA). For more information on the status of these assessments, see EPA's Integrated Risk Information System assessment page, https://iris.epa.gov/AtoZ/?list_type=erd.

[31]In addition to drinking water standards developed by state governments, other governments outside of the U.S. have also taken steps to regulate PFAS. For example, the European Union's Drinking Water Directive includes limits of 0.1 µg/l (100 ppt) for the sum of 20 specific PFAS, and 0.5 µg/l (500 ppt) for the total of all PFAS in drinking water.

[32]Under the Safe Drinking Water Act, the federal government contributes some funding to states through EPA's Drinking Water State Revolving Fund program. States use this funding to make low- or no-interest loans to communities to build water and wastewater infrastructure, in addition to other assistance. These loans are repaid with interest, and these funds are then used for future loans. EPA reviews and oversees this program.

[33]According to EPA's announcement for its Emerging Contaminants in Small or Disadvantaged Communities grant program, eligible applications for these funds include disadvantaged communities, which are defined as follows: "disadvantaged community" is one determined by the state to be disadvantaged under the affordability criteria established by the state under section 1452(d)(3) of the Safe Drinking Water Act or may become a disadvantaged community as a result of carrying out a project or activity under the grant program. As with the Drinking Water State Revolving Fund program, each state has statutory discretion to set its own criteria.

standards for water systems—called National Primary Drinking Water Regulations—that generally limit the levels of specific contaminants in drinking water. Specifically, EPA sets standards when it determines that (1) the contaminant is known to occur or there is a substantial likelihood that it will occur in public water systems with a frequency and level of public health concern; (2) a contaminant may have an adverse health effect; and (3) in the sole judgment of the EPA Administrator, regulation of the contaminant presents a meaningful opportunity for health risk reduction for persons served by public water systems.[34] EPA must follow a number of steps when setting these regulatory standards, including:

- **Monitoring unregulated contaminants.** As part of its efforts to assess if a contaminant is known to occur or if there is a substantial likelihood that it will occur in water systems with a frequency and level of public health concern, EPA monitors for unregulated contaminants. Under its UCMR program, EPA requires certain water systems to monitor for specific unregulated contaminants that EPA identifies.[35] EPA previously monitored for some PFAS through its UCMR program. Specifically, during the third UCMR cycle (UCMR3) from 2013 to 2015, EPA required monitoring for six PFAS: PFOA, PFOS, PFBS, perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), and perfluoroheptanoic acid (PFHpA). For UCMR3, EPA required monitoring by all large community and non-transient, non-community water systems serving more than 10,000 people and a nationally representative sample of 800 small water systems selected by EPA.[36] EPA is currently preparing for its fifth UCMR cycle (UCMR5) and will require water systems to monitor for 29 different PFAS between 2023 and 2025. For UCMR5, EPA is expanding monitoring and, subject to available appropriations, all water systems serving more than 3,300 people will be required to monitor. EPA will

[34]42 U.S.C. § 300g-1(b)(1)(A).

[35]Unregulated drinking water contaminants include chemical and microbial substances that are not currently subject to National Primary Drinking Water Regulations under the Safe Drinking Water Act. States may develop standards for some of these contaminants. Under state laws, some state environmental agencies have the authority to regulate additional contaminants or to establish more stringent standards than federal regulations, while others do not have such authorities. See our previous work on EPA's implementation of the UCMR: GAO-14-103.

[36]For purposes of the UCMR3, EPA defined a small water system as one serving 10,000 or fewer people. EPA defined a large water system as one that serves more than 10,000 people.

also select a representative sample of systems with less than 3,300 people.

- **Determining whether to regulate.** After collecting monitoring data on potential contaminants to regulate—through its UCMR program, and considering other sources of occurrence data—and determining the level at which adverse health effects may occur, EPA must then determine whether to regulate any contaminants. If EPA makes a positive determination to regulate a contaminant, the Safe Drinking Water Act requires EPA to propose a National Primary Drinking Water Regulation within 24 months and to finalize that proposed rule within 18 months. In March 2021, EPA published such a determination for PFOA and PFOS in drinking water, indicating that it would begin the process to issue a National Primary Drinking Water Regulation.[37]
- **Establishing goal for regulation.** Next, EPA must communicate at what level a contaminant should be regulated. The Safe Drinking Water Act requires EPA to set a nonenforceable maximum contaminant level goal (MCLG) at which no known or anticipated adverse health effects occur and that allows an adequate margin of safety. The agency intends to issue the proposed MCLGs for PFOA and PFOS in the fall of 2022 and the final MCLGs in the fall of 2023.
- **Setting enforceable standard for regulation.** Once the MCLG is established, EPA generally sets an enforceable standard. In most cases, the standard—the maximum contaminant level—is for water as it leaves the water treatment plant.[38] The MCL generally must be set as close to the MCLG as is feasible using the best technology or other means available, taking costs into consideration. Concurrent with issuing the MCLGs, EPA plans to issue the proposed national drinking water standard for PFOA and PFOS in the fall of 2022 and the final regulatory standard in the fall of 2023. If finalized, the regulations would likely go into effect in 2026.

Health guidance for unsafe levels of contaminants in drinking water. EPA issues health advisories to provide information on contaminants not subject to drinking water regulations, including those that can cause

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[37]As EPA notes in its 2021 *PFAS Strategic Roadmap*, the agency is also evaluating additional PFAS and considering regulatory actions to address groups of PFAS.

[38]An MCL is the maximum permissible level of a contaminant in drinking water delivered to any user of a water system. When there is no reliable method that is economically and technically feasible to measure a contaminant at concentrations to indicate that there is not a public health concern, EPA sets a treatment technique, rather than an MCL. A treatment technique is an enforceable procedure or level of technological performance that public water systems must follow to ensure control of a contaminant.

adverse human health effects and that are known or anticipated to occur in drinking water. These advisories are nonenforceable and nonregulatory and provide technical information on the health risk of identified but unregulated chemicals to drinking water system managers, government officials, and others with primary responsibility for overseeing water systems. Health advisories may offer a margin of protection by defining a level of drinking water concentration at or below which exposure is not anticipated to lead to adverse health effects. However, as we have previously reported, there are several factors that could hamper efforts by officials to use the health advisories in a timely and effective manner to protect public health. These factors include limited comprehensive data on the occurrence of unregulated contaminants and widespread state and local government budget constraints.[39]

In May 2016, EPA issued two lifetime health advisories for PFOA and PFOS at 70 ppt individually or summed.[40] In June 2022, EPA issued interim, revised, substantially lower health advisories of less than 1 ppt for both chemicals, with PFOA at 0.004 ppt and PFOS at 0.02 ppt.[41] The updated advisory levels, which are based on new science and consider lifetime exposure, indicate that some negative health effects may occur with concentrations of PFOA or PFOS in water that are near zero and below EPA's ability to quantify at this time. These health advisory levels will remain in place until EPA establishes a National Primary Drinking Water Regulation for the two chemicals. Additionally, in June 2022, EPA

[39]GAO, *Safe Drinking Water Act: EPA Should Improve Implementation of Requirements on Whether to Regulate Additional Contaminants*, GAO-11-254 (Washington, D.C.: May 27, 2011).

[40]Environmental Protection Agency, *Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)* (May 2016); and *Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)* (May 2016).

[41]Environmental Protection Agency, *Interim Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)* (June 2022); and *Interim Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)* (June 2022).

issued final health advisories for two other PFAS—PFBS and GenX chemicals—at 2000 ppt and 10 ppt, respectively.[42]

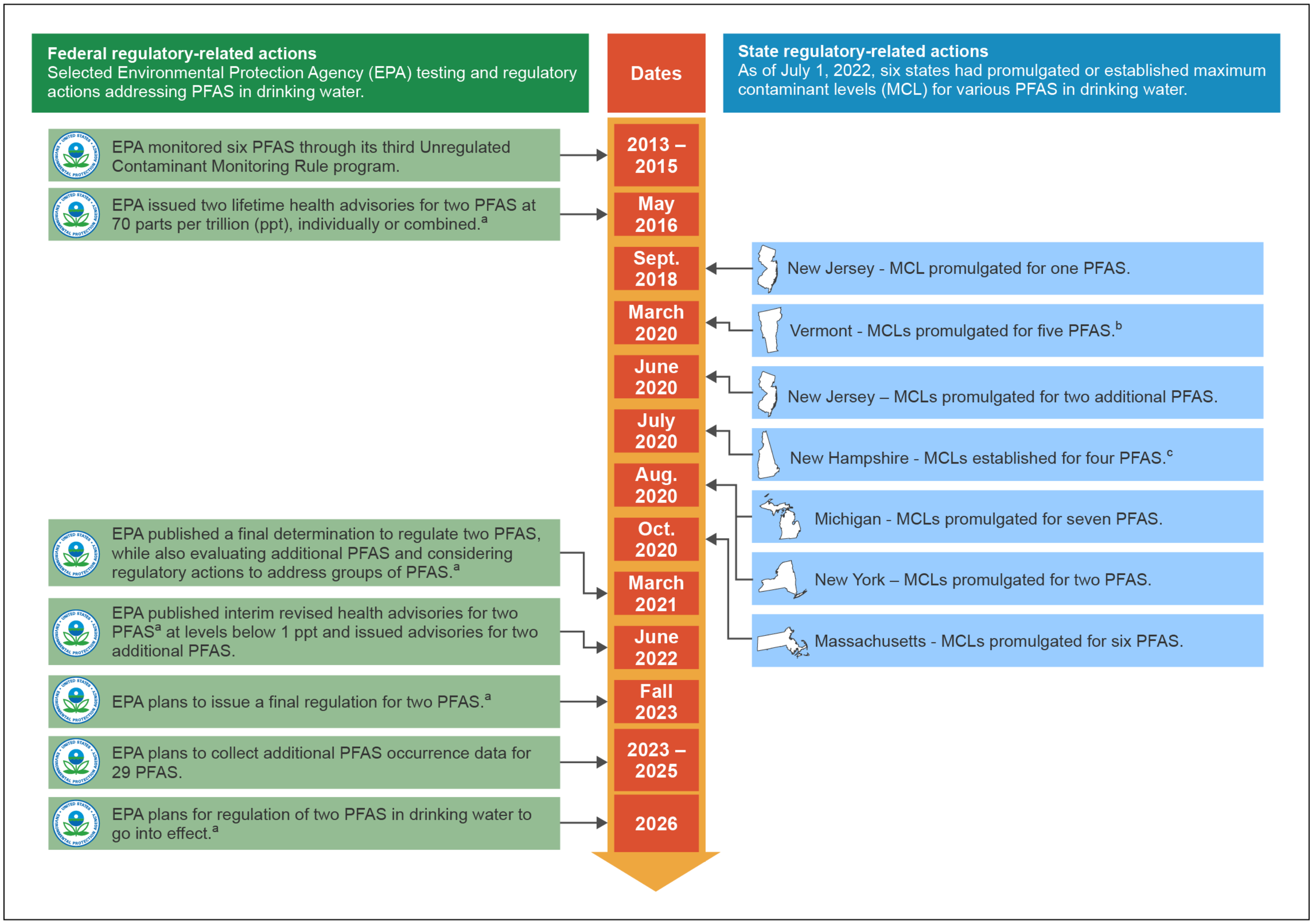
State Actions to Address PFAS

At the state level, efforts to address PFAS have resulted in states developing a variety of enforceable standards and nonenforceable guidance for PFAS in drinking water.[43] Since 2018, some states have adopted their own drinking water standards—as enforceable MCLs—which are more stringent than EPA's 2016 lifetime health advisories for PFOA and PFOS and often include additional PFAS (see fig. 3). Under the Safe Drinking Water Act, EPA generally delegates primary enforcement responsibility for water systems to states and Indian tribes if they meet certain requirements. So even when there is a promulgated federal standard, states may choose to adopt standards that are more stringent.

[42]According to EPA's Drinking Water Health Advisories for GenX and PFBS, in chemical and product manufacturing, GenX is considered a replacement for PFOA, and PFBS is considered a replacement for PFOS. Environmental Protection Agency*, Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid and HFPO Dimer Acid Ammonium Salt, Also Known as "GenX Chemicals"* (June 2022); and *Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid and Related Compound Potassium Perfluorobutane Sulfonate* (June 2022).

[43]For more information on what states have done to develop nonenforceable guidance for PFAS in drinking water, see the subsection in this report titled "The States That Developed Guidance or Began Developing Standards Were Influenced to Do So by PFAS Contamination."

Figure 3: Timeline of Federal and State Regulatory-Related Actions Addressing Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water



Source: GAO analysis of state information. | GAO-22-105135

[a]Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

[b]Vermont established interim MCLs by law in May 2019. These were then superseded by the final MCLs promulgated in March 2020.

[c]New Hampshire developed MCLs for four PFAS in rules that went into effect on October 1, 2019, but were prevented from being enforced, by litigation from December 2019 through 2020. The state legislature enacted the same standards in law in July 2020, and the litigation associated with the rules ended.

[d]Perfluorobutane sulfonic acid (PFBS) and its potassium salt and hexafluoropropylene oxide dimer acid and its ammonium salt (GenX chemicals).

As of July 1, 2022, six states had enacted or promulgated MCLs for nine different PFAS in drinking water: Massachusetts, Michigan, New Hampshire, New Jersey, New York, and Vermont. For example, New Jersey adopted drinking water standards of 14 ppt for PFOA and 13 ppt for PFOS and PFNA.[44] All six states with MCLs have standards that are stricter than EPA's 2016 nonenforceable drinking water lifetime health advisory of 70 ppt for PFOA and PFOS—the health advisory levels that were current at the time the states set their MCLs. Further, five of the six states regulate more PFAS than PFOA and PFOS (see table 1 below).

Table 1: Per- and Polyfluoroalkyl Substances (PFAS) Regulated by States in Drinking Water, as of July 1, 2022

	PFAS								
State	**GenX**	**PFBS**	**PFDA**	**PFHpA**	**PFHxA**	**PFHxS**	**PFNA**	**PFOA**	**PFOS**
Massachusetts	○	○	●	●	○	●	●	●	●
Michigan	●	●	○	○	●	●	●	●	●
New Hampshire	○	○	○	○	○	●	●	●	●
New Jersey	○	○	○	○	○	○	●	●	●
New York	○	○	○	○	○	○	○	●	●
Vermont	○	○	○	●	○	●	●	●	●

Legend:
● = yes
○ = no

GenX = hexafluoropropylene oxide dimer acid and its ammonium salt

PFBS = perfluorobutane sulfonic acid and its potassium salt

PFDA = perfluorodecanoic acid

PFHpA = perfluoroheptanoic acid

PFHxA = perfluorohexanoic acid

PFHxS = perfluorohexane sulfonic acid

PFNA = perfluorononanoic acid

PFOA = perfluorooctanoic acid

PFOS = perfluorooctane sulfonate

Source: GAO analysis of state information. | GAO-22-105135

[44] N.J. Admin. Code § 7:10-5.2(a)(5)(i)–(iii).

At Least 18 Percent of Water Systems from the Six Selected States Had PFAS above EPA's Health Advisory Levels

Recent drinking water data from six states—Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, and Vermont—show that at least 18 percent of the states' water systems had PFOA or PFOS above EPA's 2022 interim revised health advisory levels.[45] Specifically, 978 of 5,300 water systems had these PFAS at or above 4 ppt, thereby exceeding EPA's revised health advisories of 0.004 ppt for PFOA and 0.02 ppt for PFOS. These systems with PFAS at or above 4 ppt served 29 percent of the systems' total populations. Further, 7 percent of the 5,300 water systems had PFAS above states' standards or guidance levels, and those systems served 18 percent of the systems' total populations. Overall, for the six states, the data show that PFAS occurred in more small water systems than large systems; however, PFAS occurred in a higher percentage of large systems, which also served a higher percentage of the population.

PFAS Occurred above EPA's 2022 Health Advisory Levels in at Least 18 Percent of States' Water Systems, Which Served 29 Percent of the Systems' Total Populations

In June 2022, EPA released interim revised health advisories for PFOA and PFOS, which, at 0.004 ppt for PFOA and 0.02 ppt for PFOS, were significantly lower than EPA's 2016 levels of 70 ppt individually or summed for the two chemicals. According to our analysis of recent available data that measured PFOA and PFOS at or above 4 ppt, we found that across all six selected states—Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, and Vermont[46]—PFOA and/or PFOS

[45]The percentage of water systems above EPA's 2022 interim revised health advisory levels could be higher than 18 percent because, while five of the six states in our study measured PFOA and PFOS at or below 4 ppt, analytical limitations in the datasets prevented us from reporting on PFAS levels below 4 ppt. (i.e. for Ohio, the minimum reporting levels were 5 ppt for PFOA and PFOS.) As a result, our analysis does not include water systems that had PFAS between EPA's interim revised health advisory levels (0.004 ppt for PFOA and 0.02 ppt for PFOS) and 4 ppt. Further, not all water systems were monitored for PFAS in these states, meaning additional water systems could have PFAS.

[46]We analyzed data from six states that had (1) collected recent comprehensive data on PFAS in drinking water—that is, data from most or all water systems in the state; and (2) developed either standards (MCLs) or guidance levels for PFAS.

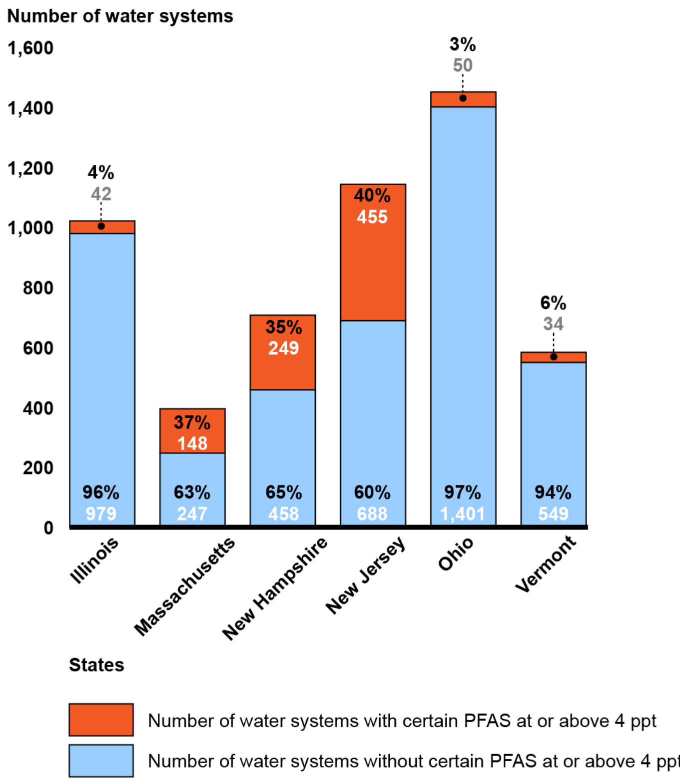
occurred in 978 (18 percent) of the total 5,300 water systems.[47] Among individual states, the percentage of water systems with PFAS and the population served by water systems varied. For example, of the six states, New Jersey, Massachusetts, and New Hampshire had the highest percentage of water systems with PFOA and/or PFOS occurrence at or above 4 ppt, at approximately 40 percent, 37 percent, and 35 percent,[48] respectively. By contrast, Vermont, Illinois, and Ohio had the lowest percentage of PFAS occurrence at or above 4 ppt, with rates of approximately 6, 4, and 3 percent,[49] respectively (see fig. 4).

[47]We also analyzed the six states' data for PFOA and PFOS occurrences above 70 ppt—EPA's previous (2016) health advisory level. We found that across the six states, only 29 systems (less than 1 percent) of all 5,300 systems had these PFAS above 70 ppt. Water systems with these PFAS above 70 ppt served approximately 71,000 people or 0.2 percent of the total 33 million people served by all 5,300 systems. According to officials from Illinois, the one water system in Illinois with PFAS above 70 ppt has since sealed up the contaminated wells, and the population is now being served by another municipal water system. According to a Massachusetts official, because the data represent PFAS occurrence in water systems after January 1, 2020, they do not fully represent all PFAS that have occurred above 70 ppt in Massachusetts' drinking water. Specifically, the official noted that these data do not capture water systems that tested for and subsequently treated PFOA and PFOS before 2020.

[48]According to New Hampshire officials, because these data represent PFAS occurrence in water systems after October 1, 2019, they do not fully represent the PFAS that have occurred in drinking water across New Hampshire. Specifically, officials noted these data do not capture water systems that tested for and subsequently treated PFAS between 2016 and October 1, 2019. Further, according to the officials, around half of the population of New Hampshire gets their drinking water from wells, and many of those wells have PFAS but are not represented in these data.

[49]According to officials from Ohio, the minimum reporting level for PFOA and PFOS in their dataset was 5 ppt. Therefore, these results include any water system with PFAS that occurred at or above 5 ppt but do not capture those between 4 and 5 ppt. Further, according to these officials, some of their water systems sell treated drinking water wholesale to other water systems. Consequently, populations are likely underrepresented here, as this analysis only considered the population served by the wholesale water system. If any wholesale water system had PFAS, the actual affected population would include both the population served by the wholesale water system itself, plus the population served by all the water systems that purchased water from the original system.

Figure 4: Number and Percentage of Water Systems in Six Selected States with Occurrences of Two Per- and Polyfluoroalkyl Substances (PFAS) at or Above 4 Parts per Trillion (ppt)



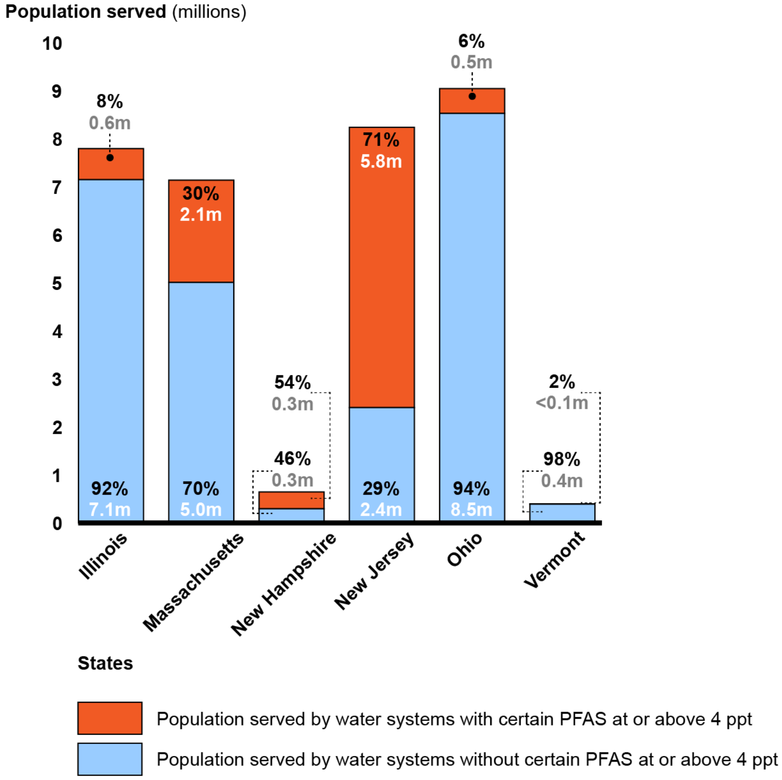
Source: GAO analysis of state data. | GAO-22-105135

Note: We analyzed the two PFAS that the Environmental Protection Agency plans to regulate: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

These water systems with PFOA and/or PFOS at or above 4 ppt in six states served approximately 9.5 million (29 percent) of the total 33 million people served by all 5,300 systems. New Jersey, New Hampshire, and Massachusetts had the highest percentages of their populations served by water systems with PFAS occurrences at or above 4 ppt: 71 percent (5.8 million people) in New Jersey; 54 percent (349,518 people) in New

Hampshire; and 30 percent (2.1 million people) in Massachusetts (see fig. 5).[50]

Figure 5: Population Served by Water Systems in Six Selected States with Occurrences of Two Per- and Polyfluoroalkyl Substances (PFAS) at or Above 4 Parts per Trillion (ppt)



Source: GAO analysis of state data. | GAO-22-105135

Note: We analyzed the two PFAS that the Environmental Protection Agency plans to regulate: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

[50]According to officials from Illinois, some water systems in the state sell treated drinking water wholesale to other water systems. Consequently, if any wholesale water systems had PFAS, the actual affected population would include both the population served by the wholesale water system itself, plus the population served by all the water systems that purchased water from the original system. Therefore, the affected population could be higher than we have reported here.

PFAS Occurred above States' Standards or Guidance Levels in 7 Percent of Water Systems, Which Served 18 Percent of the Systems' Total Populations

The six states included in our analysis developed their own standards or guidance for nine different PFAS. While there was some variation in the specific PFAS and levels included in the states' standards and guidance, all six states included three particular PFAS: PFOA, PFOS, and PFNA (see table 2).

Table 2: Six States' Maximum Contaminant Level (MCL) or Guidance Levels for Various Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water

State	MCL or guidance	Levels in parts per trillion (ppt)
Illinois	Guidance	1. perfluorobutane sulfonic acid (PFBS) and its potassium salt - 2,100 ppt 2. perfluorohexanoic acid (PFHxA) - 560,000 ppt 3. perfluorohexane sulfonic acid (PFHxS) - 140 ppt 4. perfluorononanoic acid (PFNA) – 21 ppt 5. perfluorooctanoic acid (PFOA) – 2 ppt 6. perfluorooctane sulfonate (PFOS) – 14 ppt
Massachusetts	MCL	*20 ppt individually and summed for six PFAS*: 1. perfluorodecanoic acid (PFDA) 2. perfluoroheptanoic acid (PFHpA) 3. PFHxS 4. PFNA 5. PFOA 6. PFOS
New Hampshire	MCL	1. PFHxS – 18 ppt 2. PFNA – 11 ppt 3. PFOA – 12 ppt 4. PFOS – 15 ppt
New Jersey	MCL	1. PFNA – 13 ppt 2. PFOA – 14 ppt 3. PFOS – 13 ppt
Ohio	Guidance	1. Hexafluoropropylene oxide dimer acid and its ammonium salt (GenX chemicals) – 700 ppt[a] 2. PFBS - 140,000 ppt[a] 3. PFHxS - 140 ppt 4. PFNA - 21 ppt 5. PFOA - 70 ppt, individually or summed with PFOS 6. PFOS - 70 ppt, individually or summed with PFOA

State	MCL or guidance	Levels in parts per trillion (ppt)
Vermont	MCL	*20 ppt individually and summed for five PFAS:* 1. PFHpA 2. PFHxS 3. PFNA 4. PFOA 5. PFOS

Source: GAO analysis of information from state laws, regulations, and guidance. | GAO-22-105135

Note: As of July 1, 2022, six states had developed standards for PFAS in drinking water. As of December 2021—when we spoke with officials from the remaining states—14 had developed guidance or were in the process of developing guidance or standards for PFAS in drinking water.

[a]On March 11, 2022, in response to updated human health toxicity information from the Environmental Protection Agency (EPA), Ohio's EPA revised its guidance levels for GenX chemicals and PFBS in drinking water. Specifically, Ohio reduced the guidance level for GenX chemicals from 700 ppt to 21 ppt, and for PFBS from 140,000 ppt to 2,100 ppt.

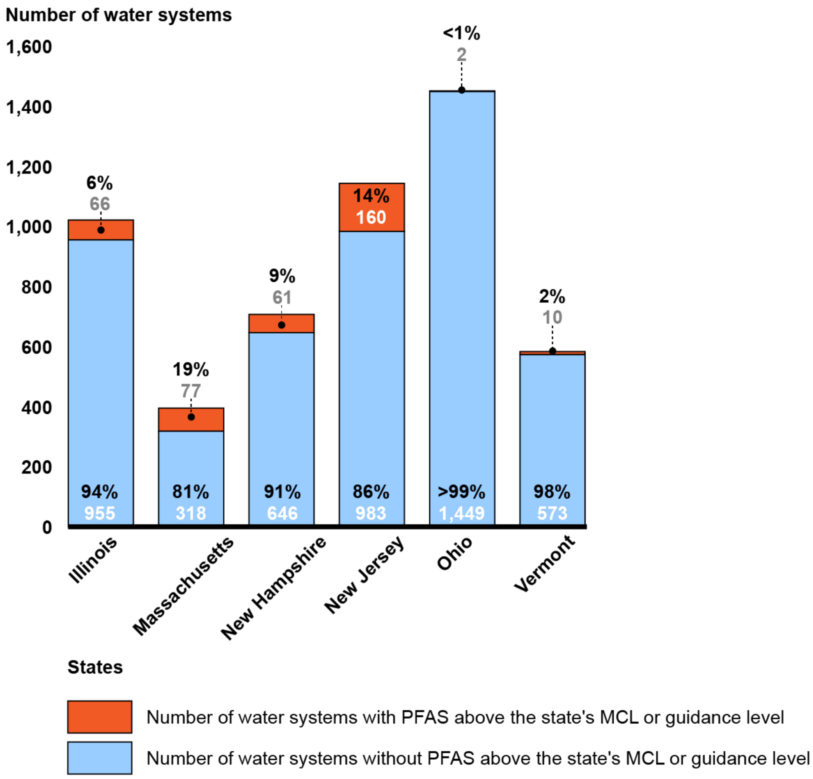
For each of the six states, we analyzed how many water systems had PFAS occurrences, for any PFAS, above the level for which the state itself had developed standards or guidance. For example, Illinois developed guidance for six PFAS, including a guidance level for PFOS of 14 ppt. Accordingly, the results of our analysis identified any water system in Illinois in which PFOS occurred above 14 ppt, or any water system in Illinois in which any of the other five PFAS occurred above the state's guidance levels. Across all six states, we found that one or more PFAS occurred above an individual state's standard or guidance level in 7 percent (376) of the states' total of 5,300 water systems. These 376 water systems served 18 percent (approximately 6 million) of the approximately 33 million total population served by the systems in all six states.

Across the states, the percentage of water systems with PFAS occurrences above the state's standard or guidance level ranged from less than 1 percent to as much as 19 percent. For most of the six states, the percentage of water systems with PFAS occurrences above the state's standard or guidance level was below 10 percent. Specifically, Ohio had the lowest rate—less than 1 percent—of water systems with PFAS above the state's guidance level.[51] Additionally, less than 10 percent of the water systems in Vermont, Illinois, and New Hampshire had PFAS occurrences above their state's standard or guidance levels, with occurrences in approximately 2, 6, and 9 percent of these states'

[51]However, Ohio also had guidance levels that were higher than the other six states for PFBS, PFOA, and PFOS.

systems, respectively. New Jersey[52] and Massachusetts had the highest percentages of water systems with PFAS occurrences above their states' standards, at approximately 14 and 19 percent, respectively (see fig. 6).

Figure 6: Number of Water Systems with Occurrences of Per- and Polyfluoroalkyl Substances (PFAS) Above the State's Maximum Contaminant Level (MCL) or Guidance Level, in Six Selected States



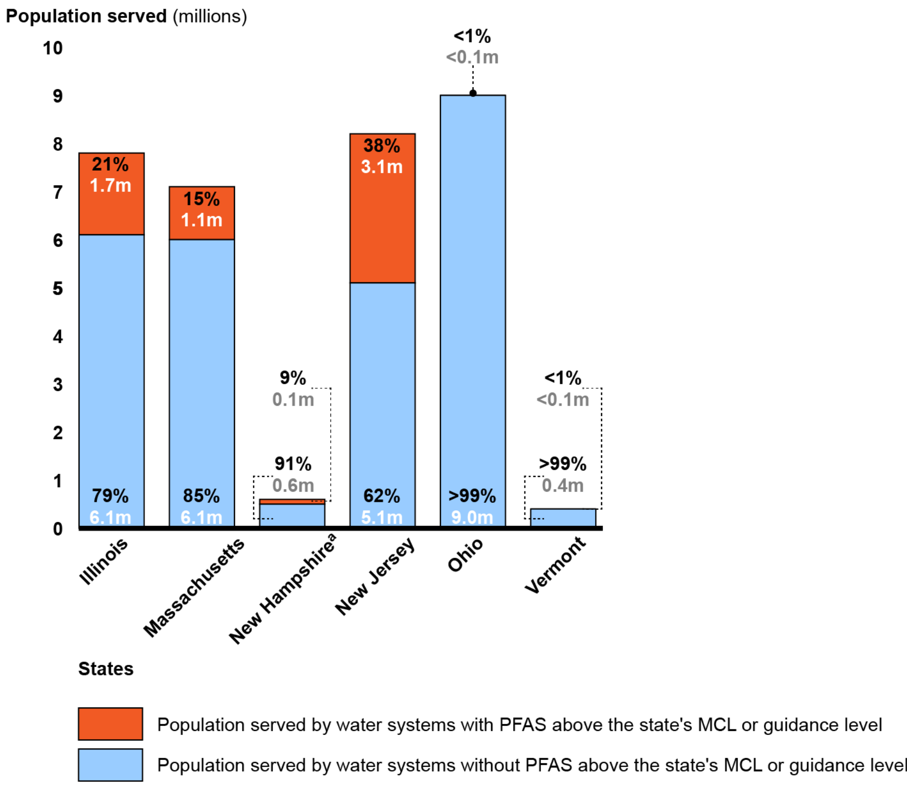
Source: GAO analysis of state data. | GAO-22-105135

Note: Each state developed standards or guidance for different PFAS, at different levels. For each state, we analyzed the number of water systems that did and did not have PFAS occurrences above the level for which the state itself had developed standards or guidance.

[52]According to New Jersey officials, because these data represent PFAS occurrence in water systems after January 1, 2020, they might not fully represent the PFAS that have occurred in drinking water across New Jersey. Specifically, the officials noted that these data do not capture water systems that tested for and subsequently treated or changed water sources before New Jersey's MCLs were set in 2018 (PFNA) and 2020 (PFOA and PFOS). Additionally, according to the officials, it should be noted that many water systems with PFAS detections in the dataset used for this report have since taken action to reduce PFAS levels.

Additionally, the size of the populations served by the water systems in the six selected states varied, as did the percentage of the population served by water systems that had PFAS occurrences above their state's standard or guidance level. For example, the total population served by the water systems in our analysis for Vermont—the smallest population in our analysis—was less than 400,000 people. By contrast, at more than 9 million people, Ohio had the largest population served by the water systems in our analysis. Because of the varying percent of water systems with occurrences above each state's standard or guidance level and the array of population sizes served by the states' water systems, the percentage of the population served by water systems with PFAS above the state's standard or guidance level also varied greatly. This variation in population served by systems with PFAS occurrences above their state's standard or guidance level ranged from less than 1 percent in Vermont and Ohio to approximately 21 percent in Illinois and 38 percent in New Jersey (see fig. 7).

Figure 7: Population Served by Water Systems in Six Selected States with Occurrence of Per- and Polyfluoroalkyl Substances (PFAS) Above the State's Maximum Contaminant (MCL) Level or Guidance Level



Source: GAO analysis of state data. | GAO-22-105135

Note: Each state developed standards or guidance for different PFAS, at different levels. For each state, we analyzed the population served by water systems with and without PFAS above the state's standard or guidance level.

[a]According to New Hampshire officials, per data collected from 2016 through 2019—prior to the enactment of the state's MCL on October 1, 2019—more than 200,000 people were served by water systems with PFAS.

Finally, as noted previously, EPA plans to regulate two chemicals in drinking water—PFOA and PFOS.[53] For the six selected states, all developed standards or guidance that address these two PFAS and at least one more PFAS, while three of the states' standards or guidance

[53]EPA is also evaluating additional PFAS and considering regulatory actions to address groups of PFAS.

address six PFAS. Our analysis found that although other PFAS were detected in states' PFAS occurrence data, for four of the six states, PFOA and PFOS made up over 70 percent of the PFAS found across all water systems.[54] (See app. II for more information.)

PFAS Occurred in More Small Water Systems, but PFAS Occurred in a Higher Percentage of Large Systems, and Those Systems Served a Higher Percentage of the Population

Across the six states, there were more small systems than large ones—of the 5,300 systems, 4,799 (91 percent) were small. We found that PFAS occurred in more small water systems than large ones at the two levels we analyzed—at or above 4 ppt and above a state's standard or guidance level. However, a higher percentage of large water systems had PFAS occurrence at each of the levels. Furthermore, these large systems served a higher percentage of the total population served by the six states' water systems.

Specifically:

- **At or above 4 ppt.** Across the six states, 37 percent of the large water systems had PFOA or PFOS at or above 4 ppt, compared to 16 percent of the small water systems. Cumulatively, the large systems with these PFAS served approximately 8.6 million people (30 percent of the total population served by large systems), while the small systems served approximately 850,000 (19 percent of the total population served by small systems).
- **Above the state's standard or guidance level.** Similarly, 20 percent of the large water systems had PFAS above states' standards or guidance levels, whereas 6 percent of the small water systems did. Cumulatively, the large water systems with these PFAS served approximately 5.6 million people (19 percent of the total population served by large systems), while the small ones served approximately 352,000 (8 percent of the total population served by small systems). (See table 3.)

[54]PFOA and PFOS made up 38 percent of the PFAS in Illinois and nearly 49 percent in Ohio.

Table 3: Number and Percentage of Water Systems and Population Served Across Six Selected States with Occurrence of Per- and Polyfluoroalkyl Substances (PFAS), by PFAS Level and System Size

	Number and percentage of water systems			Number and percentage of population served		
PFAS level	**Total**	**Small**	**Large**	**Total**	**Small**	**Large**
At or above 4 parts per trillion (ppt)[a]	978	791	187	9,485,541	853,144	8,632,397
	18%	16%	37%	29%	19%	30%
Above states' standards or guidance levels[b]	376	274	102	5,902,782	351,806	5,550,976
	7%	6%	20%	18%	8%	19%
Total	**5,300**	**4,799**	**501**	**33,256,953**	**4,528,815**	**28,728,138**
	100%	**100%**	**100%**	**100%**	**100%**	**100%**

Source: GAO analysis of state data. | GAO-22-105135

Note: Small water systems serve 10,000 or fewer people, while large ones serve more than 10,000 people.

[a]For our analysis of PFAS occurrence at or above 4 ppt, we analyzed the two PFAS that the Environmental Protection Agency plans to regulate: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

[b]Each state developed standards or guidance for different PFAS, at different levels. For each state, we analyzed the number of water systems that had PFAS occurrences above the level for which the state itself had developed standards or guidance.

The Demographics of Communities with PFAS in Drinking Water Varied, but EPA Has Not Analyzed the Cumulative Burden on Disadvantaged Communities

In our exploratory analysis examining data for large community water systems in Massachusetts and New Jersey, we found that the demographic characteristics of communities with PFAS in their drinking water varied.[55] Specifically, we found a substantial relationship between PFAS occurrence and communities' demographic characteristics, but the relationship differed by state. Further, we found that EPA has not analyzed whether PFAS in drinking water contributes to the cumulative burden of pollution in disadvantaged communities.

In its *EJSCREEN Technical Documentation*, EPA defined two core factors that characterize disadvantaged communities: (1) minority (the percentage of the population that identified as non-White or Hispanic/Latino); and (2) low-income (the percentage of families for which their household income was less than or equal to twice the federal poverty level). We classified disadvantaged communities as those with statistically significant higher percentages of the population that were minority and/or low-income,[56] when compared to the respective demographic's statewide averages across ZIP codes.[57]

In Massachusetts, we found that disadvantaged communities were less likely than other communities to have PFAS in their drinking water at both levels we reviewed—that is, at or above 4 ppt, or above Massachusetts' standard (MCL).[58] For example, approximately 27 percent of water

[55]Community water systems supply water to the same population year-round. We limited our analysis to large water systems—those serving more than 10,000 people—because geospatial data (service area ZIP codes) were not uniformly available for small systems. We chose these two states from the six selected states in our first objective that had comprehensive PFAS data because EPA had service area ZIP code data for a sufficiently large number of their water systems and because the state had standards (i.e., MCLs) against which we could compare PFAS concentrations.

[56]We classified disadvantaged communities as those with significantly higher percentages of the population that identified as non-White or Hispanic/Latino and/or higher percentages of families living in poverty when compared to the respective demographic's statewide average across ZIP codes—ZIP Code Tabulation Areas—in the state. Statistical tests were carried out at the 95 percent confidence level.

[57]The number of water systems that serve disadvantaged communities is approximate, because of uncertainties in the underlying data, including the lack of information on the precise boundaries of drinking water systems' service areas and sampling error in the demographic estimates from the American Community Survey, and because of the lack of a single standard for determining which communities are disadvantaged and which are not. By ZIP codes here, we are referring to ZIP Code Tabulation Areas. ZIP Code Tabulation Areas are generalized geographic representations of U.S. Postal Service ZIP code service areas. Statistical comparisons for each demographic characteristic were determined at the 95 percent confidence level. Please see app. I for more details.

[58]We also examined the data at the 70 ppt level, but the small number of water systems with PFAS at that level did not allow us to draw conclusions about whether disadvantaged communities were more or less likely than other communities to have PFAS in their drinking water.

systems in disadvantaged communities had PFAS occurrence at or above 4 ppt, compared to approximately 52 percent of systems in other communities. The water systems with PFAS at or above 4 ppt in disadvantaged communities served approximately 574,000 people, whereas the water systems in other communities with PFAS served approximately 1.3 million people. Similarly, disadvantaged communities were less likely than other communities to have PFAS in their drinking water at Massachusetts' MCL of 20 ppt for six PFAS individually or summed (see table 4).

Conversely, in New Jersey, disadvantaged communities were more likely than other communities to have PFAS in their water at both levels that we reviewed. For example, approximately 78 percent of the water systems in disadvantaged communities had PFAS in their water at levels at or above 4 ppt, compared to approximately 58 percent of systems in other communities. The water systems with PFAS at or above 4 ppt in disadvantaged communities served approximately 4.6 million people, whereas the water systems in other communities with PFAS served approximately 1.4 million people. Similarly, disadvantaged communities were more likely than other communities to have PFAS in their drinking water at New Jersey's MCLs of 14 ppt for PFOA, 13 ppt for PFOS, and 13 ppt for PFNA (see table 4).

Table 4: Water Systems with Per- and Polyfluoroalkyl Substances (PFAS) at or Above 4 Parts per Trillion (ppt) or Above the State's Maximum Contaminant Level (MCL), by Community Type and Size of Population Served

		Number and percentage of water systems			Number and percentage of population served		
PFAS level	Type of community[a]	Total	Above PFAS level	Rate	Total (in millions)	Above PFAS level (in millions)	Rate
Massachusetts							
At or above 4 ppt	Disadvantaged	**55**	15	27%	**3.5**	0.6	16%
At or above 4 ppt	Not disadvantaged	**100**	52	52%	**2.5**	1.3	52%
>MCL	Disadvantaged	**55**	9	16%	**3.5**	0.3	9%
>MCL	Not disadvantaged	**100**	26	26%	**2.5**	0.7	28%
New Jersey							
At or above 4 ppt	Disadvantaged	**59**	46	78%	**5.4**	4.6	86%
At or above 4 ppt	Not disadvantaged	**102**	59	58%	**2.7**	1.4	53%
>MCL	Disadvantaged	**59**	21	36%	**5.4**	2.7	50%
>MCL	Not disadvantaged	**102**	21	21%	**2.7**	0.5	18%

Source: GAO analysis of state, U.S. Census Bureau's American Community Survey (2019), and Environmental Protection Agency data. | GAO-22-105135

Notes: For our analysis of PFAS levels at or above 4 ppt, we limited our analysis to perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

Numbers for population served are rounded. However, the rates of population served are calculated prior to rounding.

Massachusetts' MCL is 20 ppt individually or summed for six PFAS: PFOA, PFOS, perfluorohexane sulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), and perfluorodecanoic acid (PFDA).

New Jersey's MCL covers three PFAS: PFOA at 14 ppt, PFOS at 13 ppt, and PFNA at 13 ppt.

The number of water systems that serve disadvantaged communities is approximate, because of uncertainties in the underlying data, including the lack of information on the precise boundaries of drinking water systems' service areas and sampling error in the demographic estimates from the American Community Survey, and because of the lack of a single standard for determining which communities are disadvantaged and which are not.

[a]We classified disadvantaged communities as those with significantly higher percentages of the population that identified as non-White or Hispanic/Latino and/or higher percentages of families living in poverty when compared to the respective demographic's statewide average across ZIP codes—ZIP Code Tabulation Areas—in the state.

Our exploratory analysis of available data shows that for the two states, the demographic characteristics of communities with PFAS in their drinking water varied and that there was a substantial relationship between PFAS occurrence and communities' demographic characteristics. In its *PFAS Strategic Roadmap*, EPA states that it will "conduct research to understand how PFAS contribute to the cumulative burden of pollution in communities with environmental justice concerns."

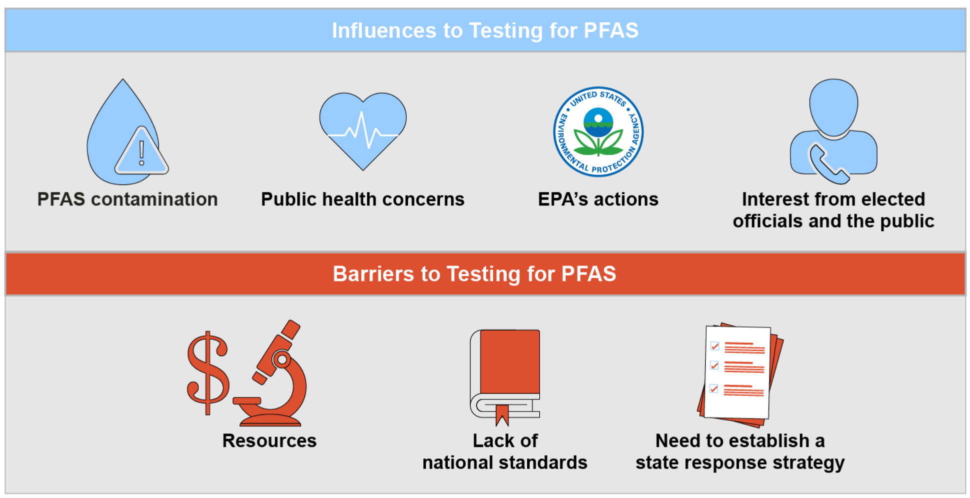
Additionally, EPA further states in the same document that the agency will collect more data and develop new methodologies to understand how nonenvironmental stressors, such as systemic socioeconomic disparities, can exacerbate the impacts of pollution exposure. However, EPA does not currently have information to determine the extent to which disadvantaged communities across the country are affected by PFAS in drinking water. As a result, EPA cannot conduct research to understand how PFAS may contribute to the cumulative burden of pollution in communities nationwide.

According to agency officials we interviewed, EPA's Office of Water is conducting an analysis to understand the demographics of communities with PFAS in their drinking water and to examine changes in PFAS exposure under different regulatory scenarios as the office develops the agency's planned national drinking water standards for PFOA and PFOS. The results are not yet publicly available. However, this analysis will rely upon currently available data from a limited number of states and is not intended to inform an understanding of how PFAS contribute to the cumulative burden of pollution in communities across the country. In its upcoming UCMR5 cycle—which will require water systems to collect data between 2023 and 2025—EPA plans to collect nationwide data on the occurrence of 29 different PFAS, as well as ZIP code data for water systems' service areas, including for small systems serving 3,300-10,000 people. These data could be used to conduct an analysis similar to ours and could provide additional information about PFAS exposure in communities served by small water systems, as well as communities across the country. Conducting this nationwide analysis—using comprehensive data from UCMR5 or elsewhere—would allow EPA to better understand how PFAS contribute to the cumulative burden of pollution affecting disadvantaged communities.

Public Health and PFAS Contamination Concerns Influenced States' Decisions to Test for PFAS in Drinking Water, and States Cited Various Barriers to Testing

States tested for PFAS in drinking water after officials became aware of public health concerns related to PFAS contamination and because of known or suspected PFAS contamination in their state. Officials from 48 states reported that their state tested for PFAS in water or plans to begin such testing in the next 12 months.[59] According to these officials, most states that are testing for PFAS are doing so in drinking water.[60] State officials also cited various barriers to testing, including resources and a lack of national standards (see fig. 8).

Figure 8: Influences and Barriers to State Testing for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water, According to State Officials



Source: GAO analysis of state information. | GAO-22-105135

Factors That Influenced State Decisions to Test for PFAS in Drinking Water

State officials reported—either in discussion groups or interviews—several factors that influenced their state's decisions to test for PFAS in drinking water. The two most commonly cited factors that influenced state's decisions to test for PFAS in drinking water were the following:

- **Public health concerns.** State officials cited public health as one of the most common factors influencing their state to test for PFAS in drinking water. For example, one official said that their state's testing

[59]We collected information on state testing for PFAS in drinking water through discussion groups and interviews with officials from 49 states. The state of Michigan was not able to participate because of ongoing litigation.

[60]Some states also reported testing for PFAS in other types of water, including raw water from groundwater and surface water sources.

was driven by health concerns documented by state toxicologists in a state chemical action plan for persistent, bioaccumulative, and toxic chemicals, such as PFAS. As the state became more aware of the health concerns these chemicals posed, officials decided to establish a testing program to assess the geographic extent of PFAS throughout the state.

- **Known PFAS contamination in the state.** State officials reported that they began testing after they became aware of PFAS contamination identified through testing by other entities, such as EPA or the Department of Defense. For example, an official from one state said that EPA's UCMR3 results included their state's PFAS occurrence data from 2017, which led the state to start its own sampling program to assess whether contamination was more widespread than previously reported. Similarly, an official from another state reported that their state's UCMR3 results indicated a high concentration of PFAS in drinking water near an Air Force base. Because the results led to concerns that other areas might be similarly contaminated from firefighting foam, the state began broadly testing at lower detection levels than had been possible for UCMR3. A third state official reported that their state had a number of military bases where testing identified PFAS contamination. The state decided to continue testing water to determine the extent and degree of contamination in other areas of the state.

Officials also cited other factors that influenced their states to test, including EPA's actions and interest from elected officials and the public about the health impacts from PFAS.

- **EPA's actions.** According to state officials, states received funding from EPA to pay for testing, which influenced their decision to test for PFAS in drinking water. For example, one state official reported that their state used a grant from EPA to pay for equipment, which allowed them to overcome the cost of testing. Additionally, state officials said that EPA having taken steps toward promulgating national drinking water standards for PFOA and PFOS influenced their state's decision to begin testing before any such standards are set. Specifically, an official from one state reported that because EPA was moving forward on setting standards for PFOA and PFOS, they started testing for PFAS in drinking water to help prepare their local water systems to comply with the anticipated standards.
- **Interest from elected officials and the public.** According to state officials, interest from elected officials—including state legislatures and executive branches—as well as the public led to testing for PFAS

in drinking water in their state. For example, officials from one state reported that their governor pushed for testing, while officials from another reported that their legislature demonstrated interest in testing. State officials also reported public awareness of PFAS as a factor that influenced their decision to begin testing. According to one state official, local environmental justice groups created public awareness about the health effects of PFAS, which led the state government to act, including beginning testing.[61]

Barriers to Testing for PFAS

State officials identified various barriers to testing, including:

- **Resources.** State officials frequently cited resources—both financial and nonfinancial—as a barrier that their state encountered to testing for PFAS. Specifically, officials mentioned financial resource barriers, including lack of funding for conducting testing and time limits for spending funds. For example, one state official reported that testing can cost around $500 per sample, which is a challenge for some systems.[62] Another state official reported that even when they receive funding to pay for testing, the timelines for spending the funds do not have the flexibility they need for their contract process. Further, state officials cited nonfinancial resource barriers to testing, such as supply chain issues, state procurement process challenges, and the lack of needed technology or staff. For example, one state official reported being the only person on the state's PFAS team and having to travel up to 5 hours to collect a single test sample. Another state official reported contracting with a private lab for PFAS testing because their state lab has limited capabilities; however, the official said the process of finding interested labs to apply for the contract took 5 months.
- **Lack of national standards.** State officials frequently cited the lack of national drinking water standards as a barrier that their state encountered to testing for PFAS. Specifically, state officials said that they needed EPA to promulgate national drinking water standards for PFAS because their state lacks the authority to require water systems to test for PFAS in drinking water. The officials stated that without

[61]State officials infrequently reported other factors that influenced their state's decision to test, including awareness building by interest groups and other states taking action or sharing data.

[62]As we have previously reported, the cost to analyze samples is a challenge, according to academic experts and agencies. For example, one academic expert cited a contract laboratory's cost of up to $500 per sample, and instrumentation for mass spectrometry can initially cost over $500,000 to acquire and set up, plus over $250,000 a year to maintain and operate. For more information, see GAO-22-105088.

national standards, their states must rely on voluntary testing by water systems. In particular, officials from states that had not developed guidance for PFAS in drinking water and were not in the process of developing standards stated that the lack of national standards was the most important barrier to their state testing for PFAS in drinking water.

- **Lack of a state response strategy.** State officials frequently reported that before they conducted testing, they needed to first establish a state response strategy to address PFAS occurrence. Such a strategy might include identifying treatment options, and how to communicate risks to the public, as proactive steps to facilitate public understanding about the implications of testing results. For example, one state official reported that their state did not want to test for PFAS without first developing a plan for how to communicate to the public about what the testing results mean for communities impacted by PFAS contamination. Consequently, their state established a working group that is creating such a plan. Developing a state response strategy for addressing PFAS was the most frequently cited barrier to testing reported by officials from the states that have already developed guidance for PFAS in drinking water or are developing standards.[63]

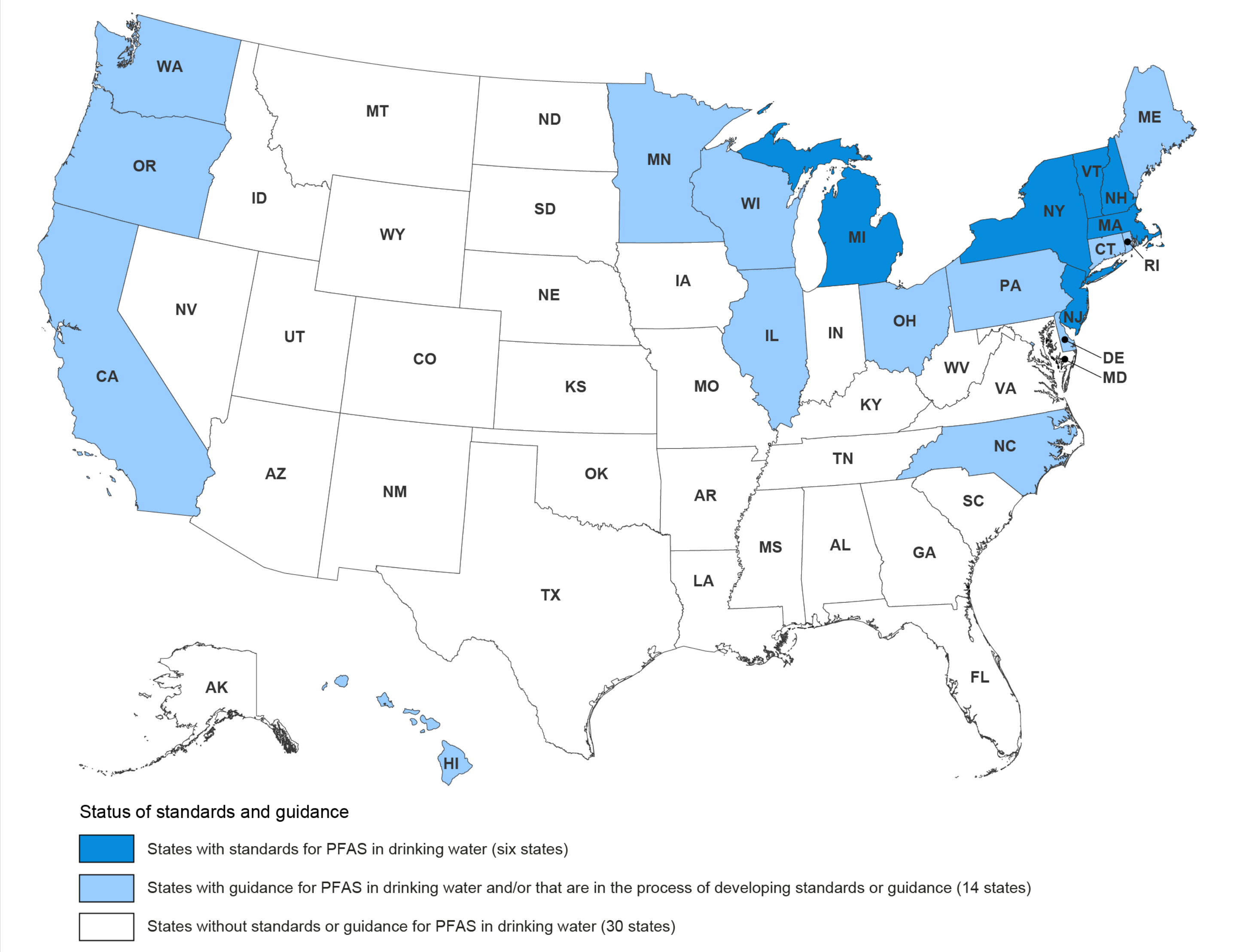
Some States Decided to Develop Standards and Guidance Because of Public Health and PFAS Contamination Concerns, While Others Are Waiting for National Standards

As of July 2022, six states had set enforceable standards for PFAS in drinking water and, as of December 2021, 14 states had developed nonenforceable guidance or were in the process of developing standards (see fig. 9).[64] According to officials from these states, their states were influenced to do so by public health concerns—including liver toxicity and harm to pregnant women and infants—and known PFAS contamination. Thirty states have not set standards or guidance for PFAS in drinking water and were not in the process of doing so, and officials most frequently reported that their states are waiting for EPA to set national PFAS drinking water standards.

[63]State officials also infrequently cited other barriers to testing for PFAS in drinking water, including the complexity of PFAS science and the lack of an analytical method to test for a specific PFAS of concern.

[64]We collected information on state regulation of PFAS in water through discussion groups and interviews with officials from 49 states. The state of Michigan—which has set regulations for PFAS in drinking water—was not able to meet with us because of ongoing litigation.

Figure 9: Status of State Standards and Guidance for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water



Source: GAO analysis of state information. | GAO-22-105135

Note: As of July 1, 2022, six states had developed standards for PFAS in drinking water. As of December 2021—when we spoke with officials from the remaining states—14 had developed guidance or were in the process of developing guidance or standards for PFAS in drinking water.

The States That Set Standards Were Influenced to Do So by Public Health Concerns, and Their Levels Are More Stringent Than EPA's 2016 Health Advisory Levels

Six states have set enforceable standards for PFAS in drinking water.[65] State officials from five of those states reported several factors that influenced their state's decision to set standards, including:

- **Public health concerns.** Public health concerns were the most common factor that influenced states' decisions to set standards for PFAS in drinking water, according to state officials. For example, one state official reported that PFAS are unique and of particular concern because they are persistent, bioaccumulative, highly water soluble, and toxic. This concern led the state to implement standards to prevent public exposure to PFAS in drinking water. Officials from another state reported that, in 2020, they set maximum levels lower than EPA's 2016 health advisory because of concerns about liver toxicity and immunotoxicity.
- **State requirements.** State officials reported that they set standards because they were required to do so by the state legislature, a council, or an action plan. For example, officials from one state reported that their state legislature passed a law identifying PFOS and PFOA as priority emerging contaminants in drinking water and, as a result, the state health department was required to set standards.
- **Lack of national standards.** State officials reported that the lack of national standards influenced their state to set standards for PFAS in drinking water. For example, officials from one state reported that they had set standards because EPA had not and that their state might not have set their own standards if a national standard were in place.

The six states' standards are more stringent than EPA's 2016 health advisory levels for PFOA and PFOS, which was the current national health advisory at the time that these states developed their standards.[66] Most of these states also developed standards for additional PFAS (see table 5). Some officials told us that EPA's 2016 health advisory level of 70 ppt was not sufficiently protective of human health, and the officials set standards below 70 ppt because they used different health information than EPA. For example, some states assessed the risks of PFAS using more recent data than EPA used for its 2016 health advisories, or they

[65]As of July 1, 2022, six states had set standards for PFAS in drinking water: Massachusetts, Michigan, New Hampshire, New Jersey, New York, and Vermont. Michigan had standards but was not able to speak with us because of ongoing litigation.

[66]On June 15, 2022, EPA issued interim revised health advisories of 0.004 ppt for PFOA and 0.02 ppt for PFOS. However, at the time when each of these six states developed their standards, EPA's 2016 health advisory of 70 ppt individually or summed was still current.

used other data, such as exposure data from formula-fed or breast-fed infants that suggested that vulnerable subpopulations could face negative health consequences at lower levels of exposure than originally reported. Additionally, five of the states set standards for additional PFAS beyond PFOA and PFOS. State officials said that the main reason for a more comprehensive set of PFAS was that they found sufficient toxicological evidence to support additional standards. In 2022, EPA revised its health advisory levels for PFOA and PFOS to be more protective of human health. According to officials from three states, they may revise their standards to lower values as a result.

Table 5: Per- and Polyfluoroalkyl Substances (PFAS) Chemicals and Levels Regulated by States with Drinking Water Standards, in Parts per Trillion (ppt)

PFAS	MA[a]	MI	NH	NJ	NY	VT[a]
hexafluoropropylene oxide dimer acid and its ammonium salt (GenX chemicals)	-	370	-	-	-	-
perfluorobutane sulfonic acid (PFBS) and its potassium salt	-	420	-	-	-	-
perfluorodecanoic acid (PFDA)	20	-	-	-	-	-
perfluoroheptanoic acid (PFHpA)	20	-	-	-	-	20
perfluorohexanoic acid (PFHxA)	-	400,000	-	-	-	-
perfluorohexane sulfonic acid (PFHxS)	20	51	18	-	-	20
perfluorononanoic acid (PFNA)	20	6	11	13	-	20
perfluorooctanoic acid (PFOA)	20	8	12	14	10	20
perfluorooctane sulfonate (PFOS)	20	16	15	13	10	20

Source: GAO analysis of information from state laws and regulations. | GAO-22-105135

[a]Levels for this state are individually or summed. For example, in Massachusetts, a water system has PFAS above the state standard if a single PFAS is above 20 ppt, or if the sum of the six PFAS for which Massachusetts has standards is above 20 ppt.

The States That Developed Guidance or Began Developing Standards Were Influenced to Do So by PFAS Contamination

Officials from the 14 states that have developed nonenforceable guidance or are in the process of developing standards cited other factors that influenced their decisions to do so, including:

- **Known PFAS contamination in the state.** Knowledge of existing contamination was the most commonly cited factor that influenced states' decisions to develop standards or guidance for PFAS. For example, one state official reported that the discovery of PFAS in drinking water supplies in their state led to the state creating an emerging contaminant program. The program looks proactively at unregulated contaminants and allows the state to set guidance values for the contaminants. An official in another state said that when their state collected data for chemicals that EPA regulates, they also chose to collect data on all volatile organics because it was no additional cost to them. Once they had collected occurrence data on unregulated contaminants, they created a process for regulating the contaminants, which they are using to develop standards for PFAS.

- **Interest from elected officials and the public.** State officials also commonly cited interest from the public, their state legislature, or their state executive branch as a factor that influenced their state's decision to develop guidance or to begin developing standards. For example, one state official stated that support from the legislative and executive branches was essential to their state starting to develop standards for PFAS in drinking water. Specifically, they said because most states do not have unregulated contaminant programs and instead use EPA's standards, states might not develop their own programs without the interest of, and support from, elected officials.

States Encountered Various Barriers in the Process of Developing Standards or Guidance

State officials we interviewed from five of the six states with standards and the 14 states that have developed guidance or are in the process of developing standards reported encountering various barriers in the process of developing their standards or guidance, including:[67]

- **Resources.** State officials reported encountering both financial and nonfinancial resource barriers to developing standards or guidance. Specifically:
  - Financial resource barriers that states encountered included costs associated with sampling, testing, water treatment, and staff. For example, three state officials reported that the costs of testing or treatment for water systems were a concern if the state developed standards for PFAS in drinking water. Further, an official from one state reported that the state rulemaking process requires an economic analysis. They added that the rulemaking could not proceed if the economic analysis showed that the new standard would cost the state or the regulated community more than $10 million dollars in a 2-year period.
  - Nonfinancial resource barriers included supply chain issues, limited lab capacity, and lack of technology or personnel. For example, one state official reported that to store water quality information, the state needed a particular database that required additional staff to construct. Another state official reported that

[67]Officials from Michigan were not able to participate in our interviews or discussion groups because of ongoing litigation related to their PFAS drinking water regulations.

their state experienced difficulty hiring the toxicologists and economists necessary to identify appropriate health-protective levels to use in the development of standards.

- **Need for federal technical assistance.** State officials identified the need for federal technical assistance as a barrier to developing standards or guidance for PFAS. Specifically, officials from one state reported that they needed additional scientific and toxicological information on PFAS, as well as assistance from EPA with things such as public notices and enforcement strategies.
- **Legal challenges to standards.** Officials we spoke with from five states with standards identified legal challenges as a barrier to developing standards for PFAS in drinking water. This included the need to address active legal challenges, as well as the need to prepare for potential legal challenges. According to officials from one state, having robust standards that were established through a rigorous rulemaking process can help them withstand legal challenges.
- **Complexity of PFAS science.** Officials we spoke with from the 14 states that have developed guidance or are in the process of developing standards specifically cited the complexity of PFAS science as a barrier to doing so. For example, one state official noted that the lack of scientific consensus was a barrier to developing standards or guidance because it meant that the state was required to evaluate a large body of scientific and industry information on PFAS to determine what was applicable to the state. Another state official reported that a few days before their state's guidance went into effect, EPA released new toxicity information that would lower their state's values; the state found the rapidly changing information a challenge to developing its own guidance.[68]

[68]State officials also infrequently cited other barriers that influenced their state's decision to develop guidance or begin developing standards, including (1) lack of state legislative interest in, or direction for, regulation or guidance; (2) lack of resources for enforcement and water treatment; and (3) lack of information on where in the state PFAS have been used.

Various Factors Influenced States' Decisions to Not Set PFAS Drinking Water Standards or Guidance, Including Waiting for EPA to Set National Standards

Thirty states have not set standards or guidance for PFAS in drinking water. The factors that influenced these states' decisions not to set standards or guidance included:

- **Waiting for EPA to set national PFAS drinking water standards.** State officials most frequently reported that they were waiting on EPA to promulgate national PFAS drinking water standards. The lack of national standards for PFAS was the most frequently reported factor that influenced the 30 states that have not set standards or guidance. The state officials reported that their states are waiting for EPA because they wanted to avoid potentially creating conflicting regulatory levels with other states or with eventual national standards. For example, one state official stated that even if their state had the resources to create its own PFAS standards, they would recommend that the state not do so because they did not believe that drinking water should be regulated through a patchwork of state standards. Similarly, another state official stated that a patchwork of varying standards across the country confuses consumers and makes it harder to communicate about health risks.
- **Resources.** State officials frequently reported that their state lacked resources to set standards or guidance values for PFAS in drinking water. For example, one state official reported that while some of the larger states have the resources—such as staffing and in-house expertise—to set their own standards, most states do not have sufficient resources to set their own standards. Another state official reported that because their state does not have the resources necessary to fully develop standards for PFAS, their state commonly adopts EPA's standards "as is."
- **State law or policy.** State officials frequently indicated that their state had laws or policies that prohibited the state from developing standards or guidance. Specifically, officials told us that these laws or policies prevented the states from developing standards that were more stringent than EPA's standards.
- **Complexity of PFAS science.** State officials frequently stated that, because of the complexity of PFAS science, they did not have sufficient technical expertise in their state to determine the level at

which there would be no known or expected risks to health from PFAS in drinking water.[69]

Conclusions

The Centers for Disease Control and Prevention previously found that PFAS are present in the blood of nearly all Americans. Our analysis found that nearly 30 percent of the population in six states has PFAS in their drinking water at levels above what EPA considers safe. Further, our analysis of limited available data found that the relationship between PFAS occurrence in drinking water and communities' demographic characteristics differed by state—leaving unresolved whether disadvantaged communities are more likely to have PFAS in their drinking water.

In its *PFAS Strategic Roadmap*, EPA outlined a number of broad-ranging actions to address PFAS, including regulating two PFAS in drinking water and conducting research to understand how PFAS may contribute to the cumulative burden of pollution in communities with environmental justice concerns. According to officials, as EPA develops its national drinking water standards, the agency is conducting an analysis to characterize the demographics of populations served by water systems with PFAS over levels of concern. EPA is also evaluating anticipated changes in PFAS exposure via drinking water for population groups of concern, under different regulatory scenarios. However, the analysis will rely upon currently available data from a limited number of states and is not intended to analyze the cumulative burden of pollution in communities.

While not a prerequisite for pursuing actions to address PFAS in drinking water, conducting a nationwide analysis to identify which communities have unsafe levels of PFAS in their drinking water could help EPA determine the extent to which PFAS contribute to the cumulative burden of pollution on particular communities. Specifically, some disadvantaged communities may have less PFAS in their drinking water than other communities; however, as noted in the *PFAS Strategic Roadmap*, disadvantaged communities might experience multiple pollution sources in addition to nonenvironmental stressors, such as systemic socioeconomic disparities, that can exacerbate the impacts of pollution exposure. Thus, information from such an analysis could be used as a

[69]State officials also infrequently cited factors that influenced their state's decision not to develop guidance or begin developing standards, including (1) no known PFAS contamination in the state; (2) lack of legislative interest in, or direction for, standards or guidance; (3) lack of funding for enforcement or treatment; and (4) current state guidance sufficient for the state's needs.

tool by states, EPA, and others to ensure adequate protection from PFAS in disadvantaged communities.

Recommendation for Executive Action

The EPA Administrator should conduct a nationwide analysis using comprehensive data—such as the forthcoming fifth Unregulated Contaminant Monitoring Rule data—to determine the demographic characteristics of communities with PFAS in their drinking water. (Recommendation 1)

Agency Comments

We provided a draft of this report to EPA for review and comment. In written comments provided by EPA (reproduced in app. IV), EPA agreed with our findings and concurred with our recommendation. EPA also provided technical comments, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 19 days from the report date. At that time, we will send copies to the appropriate congressional committees and the Administrator of the Environmental Protection Agency. In addition, the report will be available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or GomezJ@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.

J. Alfredo Gómez
Director, Natural Resources and Environment

List of Requesters

The Honorable Tom Carper
Chairman
Committee on Environment and Public Works
United States Senate

The Honorable Gary C. Peters
Chairman
The Honorable Rob Portman
Ranking Member
Committee on Homeland Security and Governmental Affairs
United States Senate

The Honorable Ron Johnson
Ranking Member
Permanent Subcommittee on Investigations
Committee on Homeland Security and Governmental Affairs
United States Senate

The Honorable Mikie Sherrill
Chairwoman
Subcommittee on Environment
Committee on Science, Space, and Technology
House of Representatives

The Honorable Haley Stevens
Chairwoman
Subcommittee on Research and Technology
Committee on Science, Space, and Technology
House of Representatives

The Honorable Lizzie Fletcher
House of Representatives

Appendix I: Objectives, Scope, and Methodology

In this report, we examine (1) what recent data from selected states show about the occurrence of per- and polyfluoroalkyl substances (PFAS) in drinking water; (2) the demographic characteristics of communities with and without PFAS in their drinking water in selected states; (3) factors that influenced states' decisions to test for PFAS in drinking water, as well as barriers the states encountered; and (4) factors that influenced states' decisions to develop standards or guidance for PFAS in drinking water, and barriers the states encountered.

For the first objective, to examine recent data from selected states on PFAS occurrence in drinking water, we selected states from which to report data by identifying those states that had independently collected comprehensive data—that is, data from most or all water systems[1] in the state—that were more recent than the Environmental Protection Agency's (EPA) third Unregulated Contaminant Monitoring Rule (UCMR) nationwide data (2013-2015). We did so by first identifying which states had enacted maximum contaminant levels (MCL)—as states with MCLs required their water systems to conduct compliance monitoring once the regulations went into effect. Next, we identified states that had developed guidance for PFAS levels in drinking water, since the state might have conducted comprehensive preliminary testing as they developed their guidance.[2]

Through this process, we identified nine states that potentially met our two selection criteria. The nine states were: Illinois, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Rhode Island, and Vermont. From October 2021 through December 2021, we confirmed with officials from the remaining 41 states that they did not have both comprehensive data and standards or guidance. Since the status of state

[1]According to Environmental Protection Agency (EPA) documentation, there are three types of public water systems: (1) community water systems that supply water to the same population year-round; (2) non-transient non-community water systems that regularly supply water to at least 25 of the same people at least 6 months per year, such as schools, factories, office buildings, and hospitals; and (3) transient non-community water systems that provide water in a place such as a gas station or campground where people do not remain for long periods of time. We included in our scope data from community water systems and non-transient non-community water systems, which we collectively refer to as "water systems" in this report.

[2]"Guidance" refers to narrative guidance, action levels, response levels, or health advisories, etc., that are unenforceable levels set for the maximum concentration of specific PFAS in water and that were established to provide guidance to drinking water managers or the public.

PFAS regulations is in constant flux, our universe of in-scope states was current as of July 2022.

We then interviewed state officials to obtain information about the comprehensiveness of their state's PFAS occurrence data. We were unable to interview officials from Michigan because of ongoing related litigation. Officials from New York declined to be interviewed or provide data but did provide written responses to our questions about why they tested for and regulated PFAS in drinking water. In our interview with officials from Rhode Island, we learned that the state had collected comprehensive data on PFAS in raw, untreated water, not in drinking water; we subsequently excluded them from our scope. During our interviews with officials from the remaining six states, officials confirmed that they had (a) collected comprehensive data on PFAS in drinking water in their state[3] and (b) set either MCLs or guidance levels—thus meeting our selection criteria.

For the six remaining states that met our criteria—Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, and Vermont—we sought their input on which data to analyze. We then either requested their PFAS occurrence data or downloaded the publicly available data from their websites based on the state's recommendation for the relevant data for our analysis.

To determine if an individual water system had a PFAS occurrence, we analyzed the data to determine if any water system sample, at any point-of-entry into the distribution system and at any point in the dataset's time frame, exceeded any of the three levels we planned to analyze. Some water systems had multiple samples, at multiple points-of-entry, over multiple dates. For our analysis, we sought to determine if a water system had PFAS over a certain level at any point within the dataset's time frame for any sample taken. Therefore, our results represent a snapshot in time. It is possible that a water system that detected PFAS in the past no longer has PFAS because the system switched sources of raw water—thereby potentially eliminating PFAS from its finished drinking water—or

[3]At the time we collected their data, Illinois had only collected PFAS occurrence data from community water systems. They did not collect data from non-transient non-community water systems, which make up approximately 19 percent of the state's water systems, according to EPA data.

installed treatment after detecting PFAS. Thus, our results might not represent the current condition at each water system.

We analyzed the occurrence of PFAS in drinking water for each state's water systems at the following three levels: (1) perfluorooctanoic acid (PFOA) or perfluorooctane sulfonate (PFOS) at or above 4 parts per trillion (ppt)—the minimum reporting level for these two chemicals for EPA's upcoming fifth UCMR monitoring cycle (2023-2025),[4] the lowest level reliably quantifiable by most laboratories, and a level reported in most of the states' data;[5] (2) levels above each state's standard or guidance level;[6] and (3) PFOA, PFOS, or the combination of the two above 70 ppt—EPA's 2016 lifetime health advisory level. We also evaluated the water systems for PFAS occurrence by water system size to determine if more small systems (those serving 10,000 or fewer persons) or large systems (those serving more than 10,000 persons) reported PFAS occurrences.[7]

During the course of our analysis, we made a number of methodological decisions to ensure comparable results across the various datasets. For example, because each state enacted its standard at a different time, we assessed each state's data for different time frames.[8] For states with

[4]According to EPA documents, EPA establishes the minimum reporting level using data from multiple laboratories performing "Lowest Concentration Minimum Reporting Level" studies to identify their capability. The minimum reporting level is the minimum quantitation level that, with 95 percent confidence, can be achieved by at least 75 percent of the laboratories, assuming the use of good instrumentation and experienced analysts.

[5]Ohio's minimum detection level for PFOA and PFOS was 5 ppt. Consequently, results for Ohio only represent water systems with occurrences above 5 ppt. For all other states, results for the two chemicals were at least as low as 4 ppt.

[6]All of our selected states developed standards or guidance for more than PFOA and PFOS, and not all states' standards or guidance address the same PFAS. We analyzed only those PFAS for which the states themselves had developed standards or guidance.

[7]According to EPA documents, more than 97 percent of the nation's 156,000 water systems are small systems that serve 10,000 or fewer persons. Our analysis of the six states also showed that the majority of water systems in each state were small.

[8]We analyzed data for the following time frames: Massachusetts (January 2, 2020, to November 8, 2021); New Hampshire (January 4, 2021, through October 4, 2021); New Jersey (January 2, 2019, to September 28, 2021); and Vermont (January 6, 2020, through August 1, 2021).

guidance, we analyzed state-wide PFAS testing data that were collected to assess PFAS occurrence in the state.[9]

For our analysis of PFAS levels above a state's standard, we did not seek to represent the number of water systems in a given state that violated the state's MCL or guidance level. Our methodology is different from how the states assess whether water systems have exceeded their state's MCL or guidance level. For example, states determine compliance based on a running annual average at a sampling point and may require another sample to be taken—a confirmation sample—if a water system's sample exceeds the state's standard for a specific PFAS. The states must then average the confirmation sample with the original sample. In our analysis, we analyzed confirmation samples identical to the initial samples.

Additionally, in cases where a water system's sample result included a qualifier, we contacted state officials to determine whether to include or exclude those samples. If a nonzero concentration was detected but was below the minimum reporting level, we considered the concentration to be zero for the purposes of our analysis. Further, we excluded any systems that states identified as inactive. For four of the six states, we did not seek to identify the number of people served by water systems that purchased their water from wholesalers.[10] As a result, as noted by officials from a couple of states, our data may underrepresent the number of people served by water systems with PFAS.[11]

To assess the reliability of the states' datasets, we requested documentation and information from state officials about their dataset's completeness, comprehensiveness, and accuracy. We then independently assessed the reliability of each dataset based on those three criteria. We did so by (1) reviewing written answers to our questions about data reliability; (2) conducting routine testing of the dataset, as appropriate; and (3) interviewing agency officials knowledgeable about the data. In our interviews and follow-up correspondence, we asked officials about the types of water systems required to sample; the sample

[9]We analyzed data for the following time frames: Illinois (September 28, 2020, to January 5, 2022) and Ohio (December 19, 2019, to December 15, 2021).

[10]In support of our analysis of demographic characteristics of communities with PFAS in their drinking water in Massachusetts and New Jersey, we identified water systems that purchased their water from wholesalers and confirmed with state officials, as necessary.

[11]Even if an individual is served by a water system with PFAS, they might not be consuming the drinking water.

collection process; minimum reporting levels; data entry practices; data quality control practices; and limitations, if any, that officials thought we should take into consideration before reporting the data.

Additionally, we requested information on the methods used by the laboratories that analyzed the samples. According to state officials, their PFAS drinking water samples were analyzed by state-approved laboratories that were generally required to use EPA-validated drinking water methods 533, 537, and 537.1.[12] Further, according to the officials, all analytical results met their quality control criteria, and those results that did not were removed from the datasets we analyzed.

Finally, in consultation with EPA, we determined that EPA's data showed that the six states had approximately 7,800 water systems, while our state-provided data had 5,300. The following differences existed between the two datasets: (1) Illinois did not have data for its more than 400 non-transient non-community systems; (2) some states only required wholesalers to test for PFAS and did not require the water systems purchasing water from the wholesalers to also test;[13] and (3) not all systems that were required to test had tested by the time we received the state's data. While our data do not contain results for all water systems in the six states, our analysis covers 78 percent of the six states' populations (approximately 33 million of the approximately 43 million people). After taking these steps to assess the reliability of each state's data, we found all six datasets to be sufficiently reliable for describing the occurrence of PFAS in drinking water. If appropriate, we note, in the text of the report, qualifications related to individual datasets.

For the second objective, to determine the demographic characteristics of communities with and without PFAS in their drinking water in selected states, we conducted an exploratory statistical and geospatial analysis. To conduct this analysis, we (1) selected a universe of water systems in two states, (2) identified data sources for water systems and community demographics, (3) compiled ZIP codes served by water systems, (4) classified water systems based on community demographic characteristics, (5) assessed the relationship between community

[12]According to officials from New Jersey, laboratories could use any analytical method that met the state's threshold levels, but most used EPA Method 537 or 537.1.

[13]According to EPA data, the six states had 60 wholesale water suppliers.

disadvantage and PFAS concentrations, and (6) tested the reliability of our estimates to account for uncertainties.

1. Selected a universe of water systems in two states

We selected large community water systems to analyze in two states—Massachusetts and New Jersey—because they (1) were among the six selected states from our first objective that had comprehensive PFAS data, (2) had a sufficient number of water systems with associated service area ZIP codes, and (3) had MCLs against which we could compare PFAS concentrations.[14] We selected large water systems because they were the only water systems for which EPA had comprehensive ZIP code information to approximate service areas, as described in the next section. We selected water systems defined as large either in EPA's fourth UCMR data, generated in December 2015, or in EPA's Safe Drinking Water Information System (SDWIS), which we obtained for the fourth quarter of 2021. Our final dataset contained 329 water systems in the two states.[15] Because our analysis focused on large community water systems in two states, the results are not generalizable to other types of water systems or to other states. Smaller systems, other types of water systems, or water systems in other parts of the country may produce different results.

2. Identified data sources for water systems and community demographics

[14]We restricted our analysis to states with MCLs and comprehensive data on PFAS in drinking water, which included Massachusetts, New Hampshire, New Jersey, and Vermont. Our methodology relied upon ZIP code information on water systems' service areas available in EPA's UCMR4 and other sources to estimate the American Community Survey demographic characteristics for each water system. Because UCMR4 did not collect ZIP codes for all small and non-community water systems (only a representative subset of small systems participated in UCMR4), we decided to restrict our analysis to large community water systems. Two of the states—New Hampshire and Vermont—have predominantly small water systems and, thus, could not be assessed using our methodology, thereby leaving us with Massachusetts and New Jersey for which to conduct our analysis.

[15]We removed water systems from our analysis that distributed wholesale water, unless they appeared in the UCMR4 data that contains ZIP code data for service areas.

To classify water systems as being disadvantaged or not disadvantaged, we identified relevant datasets from EPA, the U.S. Census Bureau and New Jersey.[16] Specifically:

- **EPA's SDWIS:** To determine basic characteristics of drinking water systems, we used EPA's SDWIS data from the fourth quarter of 2021. These characteristics included the estimated number of people served by the system, whether the system was classified as a community water system, whether the system was a wholesale provider, and the address of the administrative contact of the system.
- **EPA's UCMR4:** To identify ZIP codes served by community water systems, we used data from EPA's UCMR4 program, for which water system operators reported the ZIP codes that they served.[17]
- **U.S. Census Bureau's 2019 5-year American Community Survey estimates:** To estimate the demographic characteristics of communities, we used estimates and the associated margins of error at the 95 percent confidence level for the (1) total number of families, (2) total population, (3) number of families below the federal poverty level during the past 12 months,[18] and (4) number of people identifying as non-White or Hispanic/Latino. We selected (3) and (4) because they are related to two core factors identified in EPA's

[16]In this report, we use the term "disadvantaged" to describe communities that might face barriers in accessing resources because of factors such as income or race. We recognize that language to describe such communities is in flux and, depending on the circumstance, those communities might also be referenced using a range of terms, such as underserved, vulnerable, susceptible, marginalized, or overburdened by pollution. We chose to use the term "disadvantaged" because the term is used in the Safe Drinking Water Act and agency guidance related to these communities and the water systems that serve them (e.g., EPA's guidance to states for Infrastructure Investment and Jobs Act funding and the Office of Management and Budget's *Interim Implementation Guidance for the Justice40 Initiative*).

[17]UCMR4 data included all public water systems that EPA defined as large—that is, those serving more than 10,000 people—and a random sample of small water systems as of December 2015.

[18]References to the "federal poverty level" in this report are based on the Census Bureau's poverty threshold, which follows the Office of Management and Budget's Directive 14. According to the Census Bureau, it uses a set of money income thresholds that vary by family size and composition to detect who is in poverty. If a family's total income is less than that family's threshold, then that family, and every individual in it, is considered to be in poverty.

EJSCREEN Technical Documentation.[19] To characterize low-income populations, EPA uses the percentage of the population in households with income below twice the poverty level and notes that there is rationale and precedent for alternatively calculating the percentage below the poverty level itself. We obtained these estimates for the Census Bureau's ZIP Code Tabulation Areas, which are geographical units that approximate the boundaries of U.S. Postal Service ZIP codes. We also obtained cartographic boundary shapefiles[20] of the Zip Code Tabulation Areas, Census Places, and Census Tracts from the Census Bureau.

- **New Jersey Department of Environmental Protection Bureau of Geographic Information System Data:** To assess the reliability of our primary estimates, we used a spatial data frame of the service area boundaries for public water systems for New Jersey, the one state we examined where geospatial data were available.[21]

To assess the reliability of these datasets, we interviewed agency officials and reviewed database documentation. To assess the reliability of our estimates of community disadvantage, which were based on these data, we then also conducted electronic checks and sensitivity analyses, as described below. Using these steps, we determined that these data sources were sufficiently reliable for our purposes after conducting additional analytical steps, as described below.

[19]According to EPA documentation, EJScreen is an environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic indicators. See EPA, *EJSCREEN Environmental Justice Mapping and Screening Tool EJSCREEN Technical Documentation* (September 2019). It should be noted that, for the purposes of their own analyses, states might use different definitions of disadvantaged or overburdened, which might or might not use the same criteria as we used in our analysis and, therefore, might yield different results.

[20]Cartographic boundary shapefiles allow data to be mapped and analyzed geographically. Census Places include Census Incorporated Places, such as cities and towns, and Census Designated Places, which are named areas with concentrated population that do not have a municipal government. Census Tracts are statistical subdivisions whose boundaries follow geographic features, such as streams, highways, railroads, and legal boundaries, and that generally contain between 1,200 and 8,000 people.

[21]https://gisdata-njdep.opendata.arcgis.com/datasets/njdep::purveyor-service-areas-of-new-jersey/about.

3. Compiled ZIP codes served by water systems

To approximate water systems' service areas, we compiled ZIP code data from various sources. We primarily used UCMR4 to identify the ZIP codes that system operators reported for their water system service areas. UCMR4 contained a total of 897 ZIP codes for 301 of the 329 water systems we selected; however, it did not contain ZIP codes for 28 water systems. For these water systems, we used the ZIP codes for the administrative address in SDWIS and verified that the name of each water system matched the name of the town in which the administrative address was located. For three water systems, we found that the names did not match, and we identified ZIP codes inside of the service areas from the water system websites. We added these 28 ZIP codes to the 897 ZIP codes we had identified in UCMR4, for a total of 925 ZIP codes.

To assess the completeness of the ZIP codes service areas for each water system, we compared the estimated number of people served by each water system to the estimated total population count in the ZIP codes associated with that system. We flagged water systems where the number of people served was substantially greater than the total population count in the ZIP codes.[22] For the number of people served by each water system, we used the fourth quarter of 2021 estimates in SDWIS. For the total population count in the associated ZIP codes, we used the American Community Survey total population estimates for the corresponding ZIP Code Tabulation Areas. Through this process, we identified 44 water systems that served substantially more people than lived in the associated ZIP codes.

We then identified potentially missing ZIP codes for these 44 water systems by taking two steps. First, we overlaid the ZIP Code Tabulation Area boundaries for each water system with the Census Place boundaries. Second, we reviewed the websites for individual water systems to determine whether they served the overlapping Census Place. For water systems that did serve the overlapping Census Place, we identified the additional ZIP Code Tabulation Areas located inside of the Census Place that were not already contained in our ZIP code data. Through this process, we identified 38 additional ZIP codes for 12 water

[22]We defined a "substantial difference" as being greater than the total population count in the median ZIP code in the two states, which was 9,376.

systems. Our final dataset contained 857 ZIP codes for 329 water systems.[23]

4. Classified water systems based on community demographic characteristics

To approximate community demographic characteristics, we estimated the percentage of families living below the federal poverty level and the percentage of the population identifying as non-White or Hispanic/Latino. These characteristics corresponded to the two core measures of poverty and minority that EPA uses in its *EJScreen Technical Documentation*. To do this, we aggregated all of the ZIP Code Tabulation Areas associated with each water system and calculated a single estimate for each characteristic.[24] To classify water systems as disadvantaged, we compared these estimates to the average ZIP Code Tabulation Area in each state. In the average ZIP Code Tabulation Area in Massachusetts, approximately 5.9 percent of families were below the federal poverty level, and approximately 18.8 percent of people identified as non-White or Hispanic/Latino. In New Jersey, these rates were 6.0 percent and 33.7 percent, respectively.

We classified water systems as disadvantaged if they were significantly higher, at the 95 percent confidence level, than the thresholds for either of the two demographic characteristics because this measure could be reliably calculated across the range of water systems in the data we analyzed. However, this measure is not the only measure of community disadvantage that could be calculated, and other measures in other settings may produce different results.

The number of water systems that are or are not disadvantaged is approximate because of uncertainties in the underlying data, including the lack of information on the precise boundaries of drinking water systems' service areas and sampling error in the demographic estimates from the American Community Survey, and because of the lack of a single

[23]We removed ZIP codes that either did not correspond to ZIP Code Tabulation Areas, such as those that represented Post Office boxes, or that corresponded to ZIP Code Tabulation Areas that did not have any families counted in the American Community Survey.

[24]We calculated margins of error at the 95 percent confidence level.

standard for determining which communities are disadvantaged and which are not.

5. Assessed the relationship between community disadvantage and PFAS concentrations

We then compared, within these water systems, classifications of community disadvantage and the occurrence of PFAS in each state's water systems. We made these comparisons at two levels of PFAS occurrence: (1) whether a water system reported PFOA or PFOS at or above 4 ppt—the minimum reporting level for these two chemicals for EPA's upcoming UCMR5 monitoring cycle and a level reported in most of the states' data; and (2) whether a water system had any PFAS at levels above its state's MCL.[25] For each state and each level of PFAS occurrence, we compared occurrence rates in the group of water systems classified as disadvantaged against the group classified as not disadvantaged and reported these results in the body of this report. This comparison included 316 water systems, rather than the 329 for which we obtained demographic estimates, because 13 of the water systems in our demographic analysis did not have corresponding PFAS occurrence data.

6. Tested the reliability of our estimates to account for uncertainties

As previously discussed, ZIP codes may not precisely correspond to service areas for all of the water systems in our data. For example, a water system may serve the entirety of one ZIP code but only a portion of another, or systems operators may not report all of the ZIP codes they serve to UCMR4. Because of these uncertainties, we took additional steps to assess the reliability of our estimates. First, we compared the total population count in the core ZIP Code Tabulation Areas[26] to the estimated number of people served by the water system to determine

[25]We also examined the data at the 70 ppt level, but the small number of water systems with PFAS at that level did not allow us to draw conclusions about whether disadvantaged communities were less likely than other communities to have PFAS in their drinking water.

[26]We refer to "core" ZIP Code Tabulation Areas as the ZIP Code Tabulation Areas that correspond to the ZIP codes that we obtained for each water system from UCMR4, SDWIS, and our geospatial analysis.

whether the estimates were substantially different.[27] Because the number of people served by the water system is an estimate submitted by water systems, we constructed this estimation interval with a 20 percent caliper.[28] We used this caliper to account for potential sources of uncertainty, such as changes in population over time and imperfect information submittals to EPA from water system operators. On the basis of these tests, the estimated total population count in the core ZIP Code Tabulation Areas was not substantially different from the estimated number of people served by the water system for 183 of the 316 (58 percent) of the water systems in our analysis of PFAS occurrence. For these water systems, we determined that classifying the water system as disadvantaged or not disadvantaged based on the core ZIP Code Tabulation Areas was sufficient.

For the remaining 133 water systems (42 percent), the estimated total population count in the core ZIP Code Tabulation Areas was substantially different from the estimated number of people served by the water system. As a result, we were less confident that demographic estimates based on the core ZIP Code Tabulation Areas represented the demographic characteristics for these water systems. To account for this uncertainty, we constructed a range of demographic estimates for each of these water systems. We did this by delineating four alternative configurations of contiguous ZIP Code Tabulation Areas where the total population count most closely matched the total number of people served by the water system. For each water system, these four configurations included those with (1) the highest percentage of families living below the federal poverty level, (2) the highest percentage of people identifying as non-White or Hispanic/Latino, (3) the lowest percentage of families below

[27]To do so, we used 95 percent confidence intervals for the total population count in the core ZIP Code Tabulation Areas and an estimation interval for the total number of people served by the water system. American Community Survey estimates are based on data from a sample survey and refer to the period 2015-2019, while SDWIS estimates are based on data submitted by water systems as of the fourth quarter of 2021; therefore, any differences between these population definitions or estimation methods could lead to differences in population counts.

[28]For each water system, we defined a caliper width, which we used to construct an estimation interval, as +/- 20 percent of the estimated number of people served by that water system. For example, the estimation interval for a water system serving approximately 10,000 people was between 8,000 and 12,000 people.

the poverty level, and (4) the lowest percentage of people identifying as non-White or Hispanic/Latino.[29]

Overall, the majority of water systems in our analysis of PFAS concentrations had either comparable total populations or comparable alternative configurations. We recalculated the relationship between community disadvantage and PFAS concentrations using alternative classifications for water systems with inconsistent classifications. We found that the specific quantitative estimates of the relationship between community disadvantage and PFAS occurrence changed, but the general direction and magnitude of the relationship remained unchanged.[30] We concluded that this was sufficient for us to reliably assess the relationship between community disadvantage and PFAS concentrations.

We further assessed the reliability of our estimates by conducting a separate analysis of community demographics in New Jersey using the shapefile of water system boundaries that was available for that state. Specifically, we overlaid water system boundaries onto Census Tract boundaries and selected Census tracts that fell within water system boundaries.[31] We classified whether water systems were or were not disadvantaged by aggregating demographic data at the Census Tract level, rather than at the level of ZIP Code Tabulation Area, for the 158 water systems in New Jersey with both water system boundaries and PFAS occurrence data. We found that our classifications of water system disadvantage were identical for 138 of the 158 (87 percent) water systems. Similar to our analysis described above, we reassessed the relationship between community disadvantage and PFAS occurrence and

[29]For water systems that served fewer people than lived in the core ZIP Code Tabulation Areas, we selected these configurations from among the core ZIP Code Tabulation Areas. For water systems that served more people than lived in the core ZIP Code Tabulation Areas, we selected these configurations from among the adjacent ZIP Code Tabulation Areas. We then reclassified whether water systems were or were not disadvantaged based on American Community Survey data for each of these four configurations, rather than on the core ZIP Code Tabulation Areas.

[30]For some water systems, we were unable to calculate a range of demographic estimates based on alternative configurations. Our sensitivity analysis for Massachusetts examining the 14 water systems where this occurred found that any uncertainty in whether they served disadvantaged communities would not alter the general relationship between community disadvantage and PFAS.

[31]Census tracts are generally smaller than ZIP Code Tabulation Areas and, therefore, are more geographically precise.

found that the specific quantitative estimates changed but that the general direction and magnitude of the relationship remained unchanged.

For the third and fourth objectives, we examined factors that influenced states' decisions to test and develop standards for PFAS in drinking water, as well as any barriers they encountered. We collected information from state officials in semistructured interviews and moderated virtual discussion groups. Specifically, for the states that we interviewed for our first objective, in addition to our data-related questions, we also asked questions about the factors that influenced the states to test for and regulate PFAS. We analyzed the information we obtained from our interviews to identify themes and to develop a summary of the factors that influenced states to test and regulate, as well as barriers they encountered. One analyst coded the interviews for content related to the questions and summarized the results into themes, and a second analyst confirmed the coding and the results.

For the remainder of the states (42), officials from each state participated in moderated virtual discussion groups, where the officials identified factors that influenced their state's decisions to test and, if appropriate, to develop standards for PFAS in drinking water, as well as any barriers they encountered.[32] We divided the states into four discussion groups based on their regulatory status—three groups of states without standards or guidance, and one group of states that had established guidance for PFAS in drinking water or were in the process of developing standards. Prior to assigning states to the discussion groups, we conducted email outreach to officials in each state to identify the correct contact and to confirm basic information about the state's regulatory status. We asked the states to confirm whether their states had standards or guidance and whether the state was testing for PFAS in drinking water.

We developed questions and polls to guide the discussions and to gather information on state activities. We identified initial lists of factors and barriers based on industry publications and interviews with states. We pretested some of the technical questions with a subject matter expert from the Association of State Drinking Water Administrators. We used an experienced moderator to lead the group discussions. Using a nominal group technique methodology—a technique designed to establish group consensus through using multivoting or list reduction—each discussion

[32]Officials from Michigan were not able to participate in our interviews or discussion groups because of ongoing litigation related to their PFAS drinking water regulations.

group was allowed to suggest modifications to a list of options presented to the group for various questions, which were then voted on by the group. For example, one group asked that a question option regarding legislative branch interest in regulation of PFAS be expanded to include the executive branch as well. Those modifications were applied for that group and then incorporated for use in subsequent discussion groups. Following the modifications suggested by each group, participants were able to vote on the three options they believed were most important. They also voted to select the most important option from a list of the most popular options from the previous vote. In the case of major modifications, we emailed the edited questions to the participants in previous groups for written responses to ensure that the information collected was consistent across the groups. We captured the information provided in the groups via the Zoom polling function, note takers, and audio transcription. If a participant was not able to attend a portion of the group, we obtained written responses from them.

We tabulated the results of these votes across the groups to identify frequently cited factors and barriers, and combined some similar factors into groups. However, the use of nominal group technique resulted in slight differences in the questions and lists of options addressed to each group. Further, the factors and barriers we identified may be related in complex ways because of the interrelated set of influences that states must consider when making decisions about how to address PFAS. Therefore, we discuss the factors and barriers that received the majority of the votes, but we do not report specific tabulations for each factor. For example, where we describe the factors that state officials most commonly cited as influencing their state's decision to test for PFAS in drinking water, we are referring to the factors that received a majority of the votes (more than 20 votes) on that poll. Where appropriate, we broke the responses out by subcategories of respondents, such as a state's regulatory status, to identify differences between groups. We compared the results of our discussion group analysis to those of our interviewees and, when there was concurrence, we present those results together. Where the differences in the groups are significant, we present those results separately.

We conducted this performance audit from April 2021 to September 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

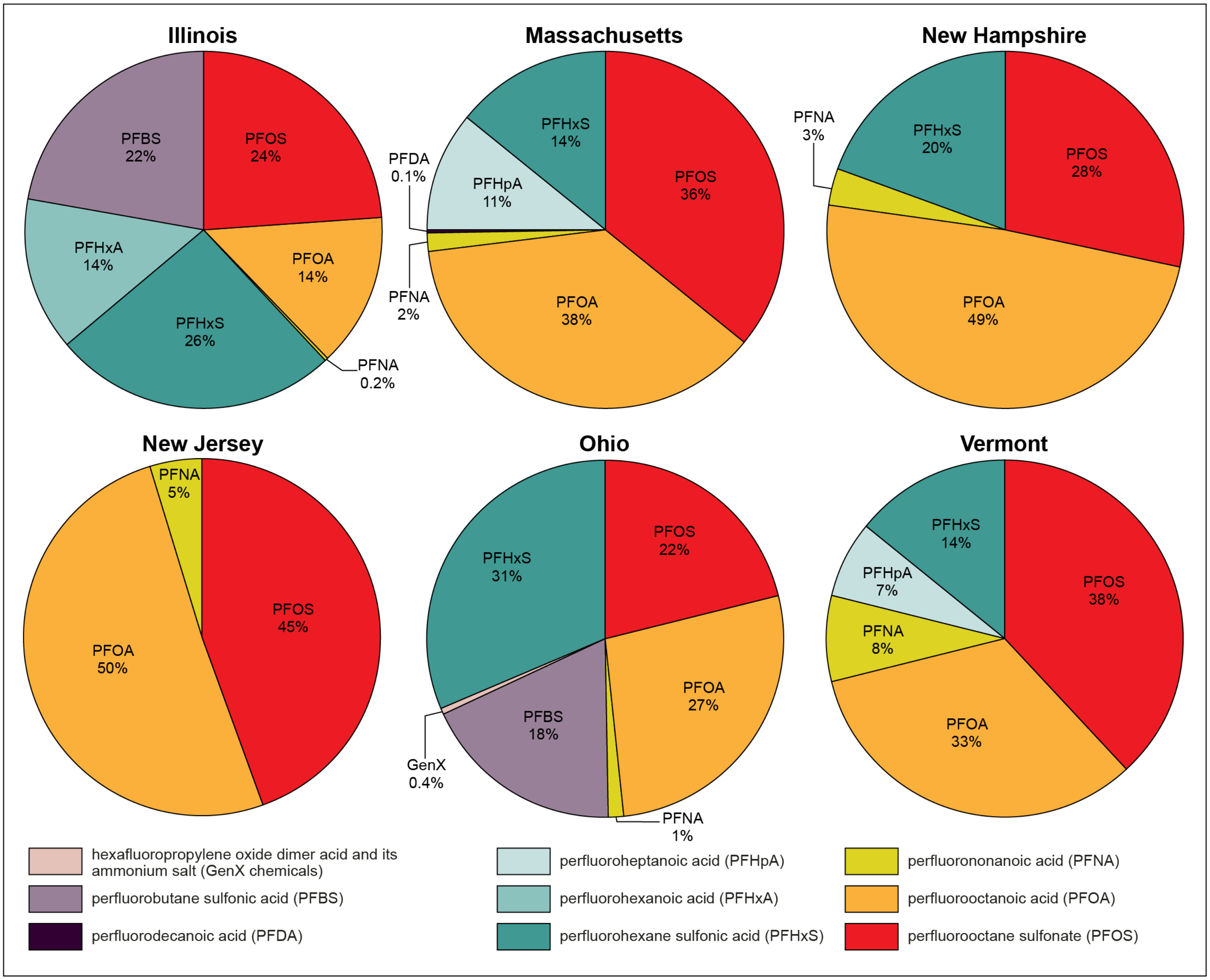
Appendix II: Proportion of Different Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water for Selected States

A number of states have tested for and developed standards or guidance for drinking water for individual per- and polyfluoroalkyl substances (PFAS) in response to a number of factors, including known or suspected occurrences of drinking water contamination by certain PFAS. For our first objective, we analyzed data from six selected states, each of which developed standards or guidance for specific PFAS (see table 2 for a list of the PFAS). To assess the proportion of individual PFAS in drinking water for which each state had developed standards or guidance, we summed all of the PFAS levels found in each water system's samples for all water systems in each state. We then calculated the proportion of the sum attributable to each PFAS in a given state (see fig. 10).

As each state developed standards or guidance for different PFAS, each state is presented separately, and the proportions for each state are not directly comparable to the other states. For example, a state may appear to have less of a particular chemical if that state monitors a greater number of PFAS. Further, if a particular PFAS was tested for more frequently—such as for confirmation samples—it may appear more frequently in the data.[1] Finally, some states had relatively high minimum reporting levels for particular PFAS, which affect the data. For example, Ohio's minimum reporting level for hexafluoropropylene oxide dimer acid and its ammonium salt (also known as "GenX" chemicals) is 25 parts per trillion, and so PFAS occurrences below that level would not be represented in the state's data.

[1]A confirmation sample occurs when PFAS is detected in a water system at levels exceeding the state's standard and the state requires the water system to test one or more additional samples to verify the level of PFAS in the system.

Figure 10: Proportion of Different Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water for Selected States, by Type



Source: GAO analysis of state data. | GAO-22-105135

Note: Totals may not sum to 100 because of rounding.

Appendix III: Examples of Resources Related to PFAS in Drinking Water in Selected States

States have conducted various actions related to addressing per- and polyfluoroalkyl substances (PFAS) in drinking water, including developing standards or guidance for contaminants and creating resources for the public. In our first objective, we analyzed data from six states. Table 6 provides state resources for the public created by these selected states.

Table 6: Examples of Resources Related to PFAS in Drinking Water in Selected States

State	State resources for the public
Illinois	Illinois Environmental Protection Agency • PFAS website http://www2.illinois.gov/epa/topics/water-quality/pfas/Pages/default.aspx • PFAS sampling network http://illinois-epa.maps.arcgis.com/apps/dashboards/d304b513b53941c4bc1be2c2730e75cf • PFAS statewide health advisory http://www2.illinois.gov/epa/topics/water-quality/pfas/Pages/pfas-healthadvisory.aspx • Process to establish maximum contaminant levels for PFAS in Illinois http://www2.illinois.gov/epa/topics/water-quality/pfas/Pages/pfas-mcl.aspx
Massachusetts	Massachusetts Department of Environmental Protection • PFAS website http://www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas • PFAS drinking water regulations quick reference guide http://www.mass.gov/doc/per-and-polyfluoroalkyl-substances-pfas-drinking-water-regulations-quick-reference-guide/download • Drinking water regulations https://www.mass.gov/regulations/310-CMR-22-the-massachusetts-drinking-water-regulations • Fact Sheet - *PFAS in Drinking Water: Questions and Answers for Consumers* http://www.mass.gov/doc/massdep-fact-sheet-pfas-in-drinking-water-questions-and-answers-for-consumers/download • Data portal https://eeaonline.eea.state.ma.us/portal#!/home • PFAS in private well drinking water supplies: frequently asked questions (FAQ) https://www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas-in-private-well-drinking-water-supplies-faq
New Hampshire	New Hampshire Department of Health and Human Services • PFAS website https://www.dhhs.nh.gov/programs-services/environmental-health-and-you/poly-and-fluoroalkyl-substances-pfas • PFAS blood testing and community exposure data portal https://wisdom.dhhs.nh.gov/wisdom/topics.html?topic=pfas-blood-testing-and-community-exposure New Hampshire Department of Environmental Services • New Hampshire PFAS response https://www4.des.state.nh.us/nh-pfas-investigation/

State	State resources for the public
New Jersey	New Jersey Department of Environmental Protection • PFAS website http://nj.gov/dep/pfas/drinking-water.html • New Jersey public water systems with PFAS occurrences https://njems.nj.gov/DataMiner/RUN_REPORT_SP.aspx?RN=Public+Water+Systems+with+PFAS+MCL+Violations • Emerging contaminants http://www.nj.gov/dep/srp/emerging-contaminants/ New Jersey Department of Health • PFAS fact sheet http://www.nj.gov/health/ceohs/documents/pfas_drinking%20water.pdf
Ohio	Ohio Environmental Protection Agency • PFAS in drinking water website http://epa.ohio.gov/monitor-pollution/pollution-issues/per-and-polyfluoroalkyl-substances-pfas • PFAS action plan interactive dashboard and map http://arcg.is/0OvHaK • PFAS action plan for drinking water http://epa.ohio.gov/monitor-pollution/pollution-issues/pfas-action-plan • PFAS in drinking water fact sheet http://epa.ohio.gov/static/Portals/28/documents/pfas/PFAS-in-Drinking-Water.pdf
Vermont	Vermont Department of Environmental Conservation • PFAS website http://dec.vermont.gov/water/drinking-water/water-quality-monitoring/pfas • Searchable database of PFAS monitoring results https://anrweb.vt.gov/DEC/DWGWP/SearchWS.aspx • PFAS and drinking water information page http://dec.vermont.gov/water/drinking-water/pfas • Draft PFAS response plan http://dec.vermont.gov/sites/dec/files/PFAS/Draft-Final-PFAs-Response.pdf Vermont Department of Health • PFAS guidance http://www.healthvermont.gov/environment/drinking-water/perfluoroalkyl-and-polyfluoroalkyl-substances-pfas-drinking-water

Sources: State officials and state websites. | GAO-22-105135

Appendix IV: Comments from the Environmental Protection Agency

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

OFFICE OF WATER

Mr. Alfredo Gómez
Director
Natural Resources and Environment
U.S. Government Accountability Office
Washington, D.C. 20548

Dear Mr. Gomez:

Thank you for the opportunity to review and comment on GAO's draft report, "PERSISTENT CHEMICALS: EPA Should Analyze the Demographics of Communities with PFAS in Their Drinking Water" Report # GAO-22-105135. The purpose of this letter is to provide the U.S. Environmental Protection Agency's (EPA's) response to the draft report findings, conclusions, and recommendation. Through technical comments enclosed with this letter, EPA is also providing additional information for GAO to consider including in the final report.

Recommendation 1: *The EPA Administrator should conduct a nationwide analysis using comprehensive data – such as the forthcoming fifth Unregulated Contaminant Monitoring Rule data – to determine the demographic characteristics of communities with PFAS in their drinking water.*

EPA Response: EPA agrees with this recommendation. A key action included in the PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 (hereafter referred to as "the Roadmap") is to undertake nationwide monitoring for PFAS in drinking water through the fifth cycle of the Unregulated Contaminant Monitoring Rule (UCMR 5). The UCMR 5 will collect finished water data on 29 PFAS from: all large public water systems serving more than 10,000 people, all medium size public water systems serving between 3,300 and 10,000 people (contingent on appropriations) and a representative number of small public water systems serving fewer than 3,300 people. This information will improve EPA's ability to conduct state and local assessments of contamination including analyses of potential environmental justice impacts.

A key principle in the Roadmap is to prioritize protection of disadvantaged communities. As part of that work, EPA is working to collect more data and develop new methodologies to understand PFAS exposure pathways in disadvantaged communities. GAO's analysis in the draft report is helpful in assessing PFAS occurrence and community demographic characteristics using currently available data, but GAO correctly notes that limitations in current data limit GAO's ability to fully resolve important questions related to PFAS and drinking water in disadvantaged communities. Conducting national level analyses with complete UCMR 5 data, including by looking at the potential impacts on disadvantaged communities, will help EPA better understand national-level risks from 29 PFAS and whether PFAS in drinking water disproportionately impact disadvantaged communities. We welcome GAO's recommendation, which reinforces these priorities in the Roadmap and will enable the Agency to more effectively ensure that disadvantaged communities have equitable access to solutions.

EPA appreciates the opportunity to review the draft report. If you have questions or need further information, please contact Nizanna Bathersfield at Bathersfield.Nizanna@epa.gov or 202-564-2258.

Sincerely,

BENITA BEST-WONG Digitally signed by BENITA BEST-WONG Date: 2022.09.21 16:01:19 -04'00' For

Radhika Fox
Assistant Administrator

Attachment: Technical comments

cc: Benita Best-Wong, OW
Nizanna Bathersfield, OW
Matthew Klasen, OW
Jennifer McLain, OGWDW
Yu-Ting Guilaran, OGWDW
Eric Burneson, OGWDW
Crystal Rodgers-Jenkins, OGWDW
Greg Carroll, OGWDW
Karen Wirth, OGWDW
EPA GAO Liaison Team

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Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

J. Alfredo Gómez, (202) 512-3841 or gomezj@gao.gov.

Staff Acknowledgments

In addition to the individual named above, Diane Raynes (Assistant Director), Tanya Doriss (Analyst-in-Charge), Adrian Apodaca, Mark Braza, Antoinette Capaccio, John Delicath, Kathryn Fledderman, Claudia Hadjigeorgiou, Andrew Stavisky, Courtney Tepera, and Sonya Vartivarian made key contributions to this report.

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Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548

Strategic Planning and External Liaison

Stephen J. Sanford, Managing Director, spel@gao.gov, (202) 512-4707
U.S. Government Accountability Office, 441 G Street NW, Room 7814, Washington, DC 20548