PFAS Primer

What are PFAS and where do they come from?

PFAS refers to per- and polyfluoroalkyl substances, a family of manmade chemicals used in industry and consumer products worldwide since the 1950s to manufacture stain-resistant, water-resistant, and non-stick products. PFAS have been used in common consumer products (e.g., non-stick cookware, coatings, food packaging, water-repellent clothing, stain-resistant fabrics and carpets, some cosmetics, leather goods, ski and snowboard waxes, and products that resist grease, water, and oil). Certain types of firefighting foam known as aqueous film-forming foams or AFFFs (historically used by U.S. military, local fire departments, and airports to fight oil and gasoline fires) may contain PFAS. (MassDEP, ATSDR and CDC).

Of the thousands of PFAS compounds, the most commonly studied are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). The next most commonly studied PFAS are perfluorohexane sulfonic acid (PFHxS) and perfluorononanoic acid (PFNA). PFOA and PFOS have been phased out of production and use in the U.S., but other countries may still manufacture and use them. New kinds of PFAS are continually being developed and used in consumer and industrial products. Some of these may have properties similar to the existing PFAS, and some may be less persistent in the environment. There are few scientific studies on new PFAS, so more research is necessary to discover whether they may pose a health concern (ATSDR and CDC).

Where are PFAS found and how do they get there?

PFAS are water-soluble, and PFAS in drinking water is an important emerging issue nationwide (and worldwide). PFAS from some firefighting foams, manufacturing sites, landfills, spills, deposition from factories, release from wastewater treatment systems—including septic systems—and other releases can seep into surface soils. During production and use, PFAS can migrate into the soil, water, and air. From there, PFAS can leach into groundwater or surface water and can contaminate drinking water. PFAS has been found in rivers, lakes, fish, and wildlife. Most PFAS (including PFOA and PFOS) do not break down easily and remain in the environment for a long time. They are widely detected in soil, water, air, and food. Some can accumulate in the food chain. Exposure can occur when someone uses certain products that contain PFAS, eats food containing PFAS, or drinks water containing PFAS. When ingested, some PFAS accumulate in the body and concentrations of PFAS may increase to a level where health effects could occur. (MassDEP, ATSDR and CDC).

Because of their widespread use and their persistence in the environment, PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and in the environment. Some PFAS can build up in people and animals with repeated exposure over time (ATSDR and CDC).

Potential health effects of PFAS

Many scientific studies have been published about PFAS exposure and health effects. While it is always difficult to show that specific substances directly cause health conditions in humans, scientific studies have shown that exposure to some PFAS in the environment may be linked to harmful health effects in humans and animals. More research is needed to better understand the health effects of PFAS exposure (ATSDR and CDC).

While scientists and regulators are still working to study health effects of exposures to PFAS, scientific studies so far indicate that elevated levels of certain PFAS in the blood may cause a variety of harmful health effects, such as:

- Developmental effects in fetuses and infants (e.g., small decreases in infant birth weights);
- Effects on the thyroid, liver, and kidneys (e.g., changes in liver enzymes);
- Increased cholesterol levels;
- Effects on certain hormones and the immune system;
- Decreased vaccine response in children;
- Increased risk of high blood pressure or pre-eclampsia in pregnant women;
- Some studies suggest a cancer risk in people exposed to higher levels (e.g., increased risk of kidney or testicular cancer). (MassDEP, ATSDR and CDC).

Human exposure to per- and polyfluoroalkyl substances is a public health concern resulting in the national Centers for Disease Control (CDC), National Center for Environmental Health (NCEH), and the Agency for Toxic Substances and Disease Registry (ATSDR) providing assistance to local, territorial, tribal, state and federal partners. Over the last decade, interest in PFAS has been growing. ATSDR and state health partners are investigating exposure to, and possible health effects associated with, PFAS in more than 30 communities across the U.S. At this time, scientists are still learning about the health effects of exposures to mixtures of different PFAS (ATSDR and CDC).

How can human exposure occur?

Exposure can occur when someone uses certain products that contain PFAS, eats food containing PFAS (including food from food packaging that contains PFAS), or drinks water containing PFAS. When ingested, some PFAS can accumulate in the body and concentrations of PFAS may increase to a level where health effects could occur. (MassDEP, ATSDR and CDC). Exposure can occur in the following ways:

- Drinking contaminated municipal water or private well water;
- Eating fish caught from water contaminated by PFAS (PFOS, in particular);
- Accidentally swallowing contaminated soil or dust;
- Using some consumer products such as non-stick cookware, stain-resistance carpeting, and water-repellant clothing.
- Eating food that was packaged in material that contains PFAS, e.g., fast food burger and sandwich wrappers, greaseproof bags used for fries, and molded-fiber compostable bowls and trays (Consumer Reports) .

Some products that may contain PFAS include:

- Some grease-resistant paper, fast food containers/wrappers (Consumer Reports) microwave popcorn bags, pizza boxes, and candy wrappers;
- Nonstick cookware;
- Stain-resistant coatings used on carpets, upholstery, and other fabrics;
- Water-resistant clothing;
- Cleaning products;
- Personal care products (shampoo, dental floss) and cosmetics (nail polish, eye makeup);
- Paints, varnishes, and sealants. (ATSDR and CDC).

Research has suggested that exposure to PFOA and PFOS from today's consumer products is usually low, especially when compared to exposures from contaminated drinking water. However, the U.S. Food and Drug Administration now prohibits a few PFAS compounds in food packaging, and Maine, Washington and New York have passed restrictions on PFAS in food packaging (Consumer Reports; National Law Review).

Studies have shown that only a small amount of PFAS can get into your body through your skin. Therefore, showering and bathing in water containing PFAS should not increase exposure. Washing dishes in water containing PFAS should not increase exposure (ATSDR and CDC).

Workers involved in making or processing PFAS and PFAS-containing materials are more likely to be exposed than the general population. Workers may be exposed to PFAS by inhaling them, getting them on their skin, and swallowing them, but inhaling them is the most likely route for exposure (ATSDR and CDC).

The ATSDR and CDC state that babies born to mothers exposed to PFAS can be exposed during pregnancy and while breastfeeding. However, nursing mothers should continue to breastfeed for the following reasons:

- Breastfeeding is good for the health of both infants and mothers;
- The American Academy of Pediatrics states that "although a number of environmental pollutants readily pass to the infant through human milk, the advantages of breastfeeding continue to greatly outweigh the potential risks in nearly every circumstance."
- Scientists continue to do research in this area. Based on current science, the benefits of breastfeeding outweigh the risks for infants exposed to PFAS in breastmilk. To weigh the risks and benefits of breastfeeding, mothers should contact their doctors (ATSDR and CDC).

Reducing exposure to PFAS

The ATSDR and CDC recommend that you can lower your exposure to PFAS in these ways (ATSDR and CDC):

- If your drinking water is contaminated above levels specified by the EPA or your state government, use an alternate water source for drinking, preparing food, cooking,

brushing teeth, and any other activity when you might swallow water. If you do not know if your water is contaminated, ask your local health department.

- Avoid eating contaminated fish. Check with your local or state health and environmental quality departments for fish advisories in your area and follow the advisories (MassDPH guidance on fish consumption).
- Even though recent efforts to remove PFAS have reduced the likelihood of exposure, some products may still contain them. If you have questions or concerns about products you use in your home, contact the Consumer Product Safety Commission at (800) 638-2772.
- Because PFAS are at low levels in some foods and in the environment (air, water, soil, etc.), completely eliminating exposure is unlikely.
- The discovery of PFAS in food packaging, such as greaseproof containers and compressed fiber bowls and trays, and the fact that several states prohibit the use of PFAS in food packaging, suggests that consumers should consider avoiding or minimizing consumption of food from such food packaging whenever possible (Consumer Reports; National Law Review).

Can PFAS be removed from drinking water?

Yes. There are three different water treatment technologies that have been tested for their ability to remove or reduce concentrations of PFAS in drinking water: granular activated carbon (GAC), ion exchange resins, and high-pressure membranes (EPA-PFAS treatment technologies). GAC has been most studied, but all three methods are effective at removing PFAS, depending on the kinds of PFAS present, amounts of other contaminants in the water, flow rate, length of time, and other factors described by EPA. All three methods can be used in drinking water facilities, water systems in hospitals and individual buildings, and in homes at the point of entry or point of use (e.g., sink or faucet). GAC is a commonly used water treatment method that utilizes activated carbon to adsorb a wide variety of contaminants, including natural and manmade organic compounds, taste and odor compounds, and metals. For more information on PFAS treatment technologies, visit the EPA webpage on PFAS treatment (EPA-PFAS treatment technologies). The Massachusetts Department of Environmental Protection also provides information on water treatment technologies that can be used by homeowners on private wells and others to remove PFAS (MassDEP-private wells).

PFAS on Cape Cod

On Cape Cod, PFAS has been found in groundwater and private and public water supply wells in Barnstable. PFAS6 has been detected in public water supply wells in Barnstable, Bourne, Chatham, Dennis, Falmouth, Mashpee, Sandwich, and Yarmouth—all but one of these met the new state drinking water limit for PFAS6 of 20 parts per trillion except one public water supply system—Yarmouth. PFAS has been detected in 21 freshwater ponds and lakes in the town of Barnstable, and in five rivers on the south side of the Cape. Known sources of PFAS on Cape Cod include AFFFs used at the Barnstable County Fire/ Rescue Training Academy (BCFTA) in Barnstable and Joint Base Cape Cod (JBCC), as well as potential sources of PFAS such as airports, landfills, municipal wastewater biosolids, and private septic systems (USGS, URI

STEEP Program, Silent Spring, and published Consumer Confidence Reports for drinking water in 2021).

The discovery of PFAS in 21 freshwater ponds in Barnstable in 2020 confirmed fears that the ponds are likely experiencing PFAS contamination through their connection to PFAS-contaminated groundwater. The additional discovery by scientists from Harvard, USGS, and URI that PFAS were present in five rivers (Childs River, Quashnet River, Mill Creek, Marstons Mills River, Mashpee River, and Santuit River) also showed that PFAS was widespread in surface water downgradient of JBCC and other unknown sources (Harvard Gazette).

In November 2021, the Massachusetts Department of Public Health issued a fish consumption advisory for six ponds on Cape Cod due to elevated levels of PFAS found in fish tissues. As of July 2022, the same six ponds had fish consumption advisories due to PFAS (MassDPH fish consumption advisories for PFAS). The six ponds were: Johns Pond in Mashpee, Flax Pond (Picture Lake) in Bourne, Jenkins and Grews Ponds in Falmouth, and Mashpee Pond and Wakeby Pond in Mashpee. MassDPH also posted information on the advisories and on fish consumption from freshwater ponds with PFAS fish consumption advisories (MassDPH-PFAS in fish; MassDPH guidance on fish consumption).

Scientific research and monitoring

The University of Rhode Island STEEP program ("Sources, Transport, Exposure, and Effects of PFAS") is funded by the National Institute of Health Sciences to conduct research into human and environmental impacts of PFAS (URI STEEP Program). Together with partners from universities, agencies and organizations, the URI STEEP program has developed a comprehensive program that provides information on PFAS on Cape Cod and elsewhere. Other scientific research agencies (USGS), universities, towns, organizations, and state and federal agencies are conducting research to understand the extent of PFAS contamination of groundwater and surface waters (e.g., Silent Spring; Harvard Gazette; Northeastern University).

PFAS Regulatory Timeline

This section summarizes the federal and state regulatory timeline for regulation of PFAS in drinking water and contaminated sites. Note that in the Commonwealth of Massachusetts, only six PFAS compounds are regulated; the National Institutes of Health (NIH) report that there are more than 4,700 PFAS compounds.

May 2016: EPA issued a lifetime drinking water Health Advisory (HA) of 0.070 microgram per liter (ug/L) or 70 parts per trillion (ppt) for any combination of PFOA and PFOS (EPA drinking water health advisories-pfoa-pfos).

June 2018: MassDEP extended the EPA Health Advisory of 70 parts per trillion to include three additional related PFAS chemicals—perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), and perfluoroheptanoic acid (PFHpA). The Massachusetts value of 70 parts per trillion is called a MassDEP Office of Research and Standards Guideline (ORSG) and is a maximum recommended level for drinking water.

February 14, 2019: EPA announced a comprehensive nationwide PFAS action plan (EPA PFAS Roadmap). 1) EPA plans to move ahead with drinking water MCL for PFOA and PFOS and by the end of 2019 will propose a regulatory determination, the next step in the Safe Drinking Water Act process of establishing an MCL. 2) Cleanup: EPA has already begun the regulatory development process of listing PFOA and PFOS as hazardous substances and will issue interim groundwater cleanup recommendations for sites contaminated with PFOA and PFOS. 3) Enforcement: EPA will use available enforcement tools to address PFAS exposure in the environment and assist states in enforcement activities. 4) Monitoring: EPA will propose to include PFAS in nationwide drinking water monitoring under the next Unregulated Contaminant Monitoring Program. EPA will also consider PFAS for listing in the Toxics Release Inventory to help EPA identify where these chemicals are being released. 5) Research: EPA will develop new analytical methods for use in drinking water, soil, and groundwater and will conduct research in treatment options to remove PFAS from contaminated sites. 6) Risk communication: EPA will work across the agency and interagency to develop a PFAS risk communication toolbox.

April 2019: MassDEP proposed draft amendments to the state's hazardous waste cleanup regulations (the Massachusetts Contingency Plan or MCP) that include groundwater and soil cleanup standards for six PFAS. The proposed groundwater cleanup standard (GW-1) that is used or may be used for drinking water is 20 ppt for six PFAS: the 5 compounds noted above, plus perfluorodecanoic acid (PFDA). MassDEP accepted comments on the draft MCP regulation until July 19, 2019.

December 27, 2019: MassDEP filed proposed regulatory changes to regulate six PFAS in drinking water as part of the state's drinking water regulations at 310 CMR.22.0 PFAS Amendments Public Notice, Section 22.07G: Per- and Polyfluoroalkyl Substances Monitoring and Analytical Requirements (MA drinking water regulations).

January 2020: MassDEP held public hearings to present proposed new drinking water regulations for six PFAS compounds (MA proposed regulations).

June 12, 2020: MassDEP promulgated regulatory requirements for laboratory certification to perform PFAS testing, at 310 CMR 42.00 (MA lab certification).

October 2020: Following a public comment period, MassDEP promulgated a new drinking water regulation and Maximum Contaminant Level (MCL) of 20 ng/L (nanograms per liter, or parts per trillion) for the sum of six per- and polyfluoroalkyl substances (called PFAS6). The new drinking water regulations are part of the state's drinking water regulations at 310 CMR 22.0 and apply to community water systems (year-round residential customers and non-transient, non-community water systems [e.g., schools, daycares, larger businesses of 25+ employees]). The new regulations required PFAS monitoring to begin on 1/1/21 for public water suppliers serving more than 50,000 individuals, on 1/1/21 for public water suppliers serving more than 10,000 and 50,000 or fewer individuals, and on 10/1/21 for public water suppliers serving 10,000 or fewer individuals. Monitoring is required if PFAS is detected monthly. A PFAS violation occurs when the average of all monthly samples collected over a quarter exceeds the MCL (310 CMR 22.07G(10). The regulations are posted at: MA drinking water regulations. (While private

wells are not covered by the regulations, MassDEP is conducting free testing of a limited number of private wells focusing on communities where 60% or more of residents are served by private wells (MassDEP-private wells).

January 2021: New state regulations limiting the concentrations of six PFAS compounds (aka PFAS6) in drinking water became effective (310 CMR 22.07G). The new PFAS6 limit is 20 nanograms per liter (aka 20 parts per trillion (ppt)) based on the average of the monthly samples over a quarter. Sampling locations are located at every entry point to the distribution system. If any one sampling location is in violation, then the PWS is considered in violation. If any sample result would cause the quarterly average to exceed the PFAS6 MCL, the PWS is immediately in violation and begins compliance actions. All confirmed detections of PFAS6 greater than 20 ppt require public education. A summary is provided at **MassDEP PFAS Drinking Water Regulation Quick Reference Guide**).

October 18, 2021: The White House announced a nationwide plan to combat PFAS pollution, beginning with the EPA launching a program ("PFAS Roadmap") to control PFAS sources, hold polluters accountable, ensure science-based decision making, and address impacts on disadvantaged communities (White House). A total of eight federal agencies will take steps to address PFAS, including EPA, DOD, FDA, USDA, DHS, DHHS (ATSDR and CDC), and FAA, as well as the White House Council on Environmental Quality.

December 2022: The U.S. EPA is developing a proposed national drinking water regulation for PFOA and PFOS in drinking water. Additional PFAS compounds are being considered. EPA anticipates finalizing the rule by the end of 2023. The anticipated rule will include both enforceable limits (MCLs) and goals (MCLGs). For more information, visit https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas.

Conclusions

PFAS research, regulation and management continue to move at a fast pace. On December 7, 2021, Governor Charlie Baker announced $1.3 million in funding to help 12 public water supplies to address PFAS contamination in their systems (see **MA funding**). The Barnstable Centerville-Osterville-Marstons Mills (COMM) public water system was one of the 12 public water suppliers to receive funding. This was the first round of state funding for PFAS; for more information on state grants to address PFAS, visit **MA Water Resources Grants**. Scientific research and monitoring of PFAS continues. In January 2021, public water systems in Massachusetts were required to meet a new state drinking water standard for PFAS6 (MA drinking water regulations). EPA is developing a national drinking water rule that would include both enforceable limits and goals.

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