2020

PFAS – Frequently Asked Questions

SWRCB - DIVISION OF WATER QUALITY

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BACKGROUND

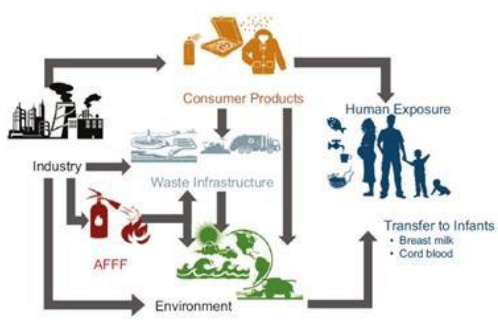
What are per- and polyfluoroalkyl substances (PFAS)?

Per- and polyfluoroalkyl substances (PFAS) are a large group of human-made substances that do not occur naturally in the environment and are resistant to heat, water, and oil. PFAS have been used extensively in surface coating and protectant formulations due to their unique ability to reduce the surface tension of liquids [1]. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are two types of PFAS that are no longer manufactured or imported into the United States [2]; however, there could be some imported goods containing trace amounts of these substances[3].

Other PFAS goods and materials are still produced and used in the United States [4]. PFAS are persistent in the environment, can accumulate within the human body over time, and are toxic at relatively low concentrations [5]. Exposure to unsafe levels of PFOA/PFOS may result in adverse health effects including developmental effects to fetuses during pregnancy, cancer, liver effects, immune effects, thyroid effects, and other effects (such as cholesterol changes)[6]. PFOA and PFOS were found in the blood of nearly all people tested in several national surveys[7], [8]. According to the Center for Disease Control (CDC), blood levels of both PFOS and PFOA have steadily decreased in U.S. residents since 1999-2000[9].

How are people exposed to PFOA, PFOS and other PFAS?

PFAS can be introduced into the body by eating or drinking contaminated food or liquid (including water), breathing in or touching products treated with PFAS, such as carpets or clothing [10]. Exposure to PFOA and PFOS is generally dominated by the ingestion of food [11]. Food can be contaminated by the migration of PFAS from packaging [12], and some foods such as fish, meat, eggs and leafy vegetables may contain PFAS due to bioaccumulation and crop uptake [13].Contaminated drinking water has led to high levels of exposure to PFOA, PFOS, and other PFAS for some populations residing



Potential major exposure pathways of PFAS to humans.
Figure from Sunderland et. al. (2019)

near manufacturing facilities[14]. Workers in facilities that make or use PFAS can be exposed to higher amounts of these chemicals and have higher levels in their blood [15].

Infants may be exposed to PFAS through breastfeeding [16]. However, the benefits of breastfeeding are well known and generally outweigh potential risks from transfer of chemicals [17], but you can talk with your doctor if you have concerns.

Where are PFOA, PFOS and other PFAS found in the environment?

PFAS, especially PFOS and PFOA, have been detected in air, water, and soil in and around manufacturing facilities; however, these releases have been declining since companies began phasing out the production and use of several PFAS in the early

2000s[18].Due to their chemical structure, PFAS are very stable in the environment and are resistant to breaking down.

Some PFAS are volatile and can be carried long distances through the air, which may lead to contamination of soils and groundwater far from the source of the PFAS emission [19]. PFAS have been detected in many parts of the world, including oceans and the Arctic, indicating that long-range transport is possible[20].

How does PFAS get into drinking water?

The four major sources of PFAS are: fire training/fire response sites, industrial sites, landfills, and wastewater treatment plants/biosolids[10].PFAS can get into drinking water when products containing them are used or spilled onto the ground or into lakes and rivers[21]. Once in groundwater, PFAS are easily transported large distances and can contaminate drinking wells [10]. PFAS in the air can also end up in rivers and lakes used for drinking water[10]. Additional information regarding the fate and transport of PFAS in the environment may be found on the Interstate Technology Regulatory Council.

Are PFAS still being produced in the United States?

PFAS have been used extensively in surface coating and protectant formulations due to their unique ability to repel oil, grease and water. Major applications have included protectants for paper and cardboard packaging products, carpets, leather products, and textiles that enhance water, grease, and soil repellency, and in firefighting foams[22].

PFAS have also been used as processing aids in the manufacture of nonstick coatings on cookware[22].

Under the PFOA Stewardship Program with the U.S. Environmental Protection Agency (US EPA), eight major PFAS producers have phased out PFOA and other PFAS substances from emissions and products[2]. However, manufacturers are developing replacement technologies in the PFAS family by substituting longer-chain substances with shorter-chain substances such as GenX and ADONA [23]. While less information is available for these shorter-chain substances, studies have shown that they behave in a similar toxicological manner as their longer-chain counterparts [24], [25]. Due to the wide range of chemicals within the PFAS family and the observed similarities in their toxic mode-of-action, efforts are underway to calculate relative potency estimates for chemicals within the PFAS class in order to better inform regulation [26].

To complement the PFOA Stewardship Program, US EPA has issued regulations, known as Significant New Use Rules (SNURs), requiring manufacturers and processors of these chemicals to notify US EPA of new uses of these chemicals before they are commercialized[27]. Specifically, the regulations require that anyone who intends to manufacture (including import) or process any chemicals for uses contained in the SNUR must submit a notification to US EPA at least 90 days before beginning the activity[27].

This provides US EPA with an opportunity to review and, if necessary, place limits on manufacturers or processors who intend to reintroduce or import products with these chemicals.

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HEALTH EFFECTS

How can PFAS affect people's health?

Laboratory studies in animals who were exposed to per- and polyfluoroalkyl substances (PFAS) found links between the chemicals and increased cholesterol, changes in the body's hormones, alterations of the immunologic system, decreased fertility, increased risk of cancer (especially kidney and testicular), low birth weight, delayed puberty onset, and birth defects[1].

Since humans and animals react differently to PFAS, not all effects observed in animals may occur in humans. Although many epidemiology studies have examined the potential of PFAS to result in adverse health effects, most of the studies are cross- sectional in design and do not establish causality. Based on several factors outlined in the report of PFAS by the Center for Disease Control (CDC) including the consistency of findings across studies, the available epidemiology studies suggest associations between PFAS exposure and several health outcomes in humans [1]:

- Pregnancy-induced hypertension/pre-eclampsia (PFOA, PFOS)
- Liver damage, as evidenced by increases in serum enzymes and decreases in serum bilirubin levels (PFOA, PFOS, PFHxS)
- Increases in serum lipids, particularly total cholesterol and low-density lipoprotein (LDL) cholesterol (PFOA, PFOS, PFNA, PFDeA)
- Increased risk of thyroid disease (PFOA, PFOS)
- Decreased antibody response to vaccines (PFOA, PFOS, PFHxS, PFDeA)
- Increased risk of asthma diagnosis (PFOA)
- Increased risk of decreased fertility (PFOA, PFOS)
- Small decreases in birth weight (PFOA, PFOS)

The International Agency for Research on Cancer has classified PFOA as possibly carcinogenic (causing cancer) to humans [2], but it has not evaluated whether other PFAS may also cause cancer. The Department of Health and Human Services has not yet evaluated whether PFOA and other PFAS can cause cancer.

In August 2019, the Office of Health Hazard and Assessment (OEHHA) developed PFOA reference levels in drinking water associated with pancreatic and liver tumors. The level of 0.1 ng/L (nanogram/liter) or parts per trillion (ppt) represents the concentration of PFOA in drinking water that would not pose more than a one in one million cancer risk. OEHHA developed PFOS reference levels in drinking water associated with liver tumors. The level of 0.4 ng/L (nanogram/liter) or parts per trillion (ppt) represents the concentration of PFOS in drinking water that would not pose more than a one in one million cancer risk.

Are PFAS found in people?

CDC scientists measured PFAS in the blood serum (the clear portion of blood) of 98% of participants aged 12 years and older who took part in the National Health and Nutrition

Examination Survey (NHANES) since 1999, indicating widespread exposure to PFAS in the U.S. population [3]. Median PFOA serum levels of 45,276 non- occupationally exposed individuals residing in southeastern Ohio and West Virginia who were exposed to PFOA via contaminated drinking water were approximately 6 times greater than the median concentration of the general population [3], [4].

Due in large part to the phasing out of certain PFAS compounds by the US EPA's PFOA Stewardship Program [5], serum levels of PFOA and PFOS in the general population of the United States have decreased dramatically in recent years [3]. For example, the geometric mean concentrations of PFOA and PFOS in the general population were 5.2 and 30.4 micrograms per liter (or parts per billion, ppb), respectively, in 1999–2000, but have decreased to 1.56 ppb (PFOA) and 4.72 ppb (PFOS) in 2015–2016 [3].

Learn more about the US EPA's actions on PFAS at https://www.epa.gov/pfas. Learn more about the California State Water Board's actions on PFAS at https://www.waterboards.ca.gov/pfas/.

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[1] Out of 12 PFAS measured, four PFAS (PFOS or perfluorooctanesulfonate, PFOA or perfluorooctanoic acid, PFHxS or perfluorohexane sulfonic acid, and PFNA or perfluorononanoic acid) had detection frequencies in serum of greater than 98% of people tested.

REGULATORY

What are the per-and polyfluroalkyl substances (PFAS) safe drinking water levels?

In May 2016, the United States Environmental Protection Agency (US EPA) issued a lifetime health advisory (LHA) for PFOA and PFOS in drinking water, advising municipalities that they should notify their customers of the presence of levels over 70 nanograms per liter (or parts per trillion) in community water supplies. The LHA is the level, or amount, calculated to offer a margin of protection against adverse health effects to the most sensitive populations. The LHA level is 70 (ppt) for PFOA and PFOS individually or combined. Currently, the US EPA has not set health advisory levels for the other PFAS chemicals.

In June 2018, the California Office of Environmental Health Hazard Assessment (OEHHA) recommended interim notification levels for PFOA (based on liver toxicity, as well as cancer risks) and for PFOS (based on immunotoxicity). OEHHA made these recommendations following its review of currently available health-based advisories and standards and supporting documentation. After independent review of the available information on the risks, the California State Water Resources Control Board's Division of Drinking Water (DDW) established interim notification levels.

In August 2019, OEHHA provided updated information on health-impacts. Based on this updated information, DDW established notification levels at concentrations of 6.5 ppt for PFOS and 5.1 ppt for PFOA, consistent with OEHHA's recommendations.

What is California doing?

A summary of California regulatory agency's actions regarding PFAS is provided below.

California State Water Board – Division of Drinking Water

Pursuant to Health and Safety Code section 116400, DDW has issued orders to public water systems requiring testing for PFOA, PFOS and certain other PFAS chemicals in March 2019. Public water system wells were selected that were adjacent to locations such as airports with fire training and response areas, and municipal solid waste landfills. Targeted testing is underway to identify the extent of contamination of drinking water sources in California. A list of public water systems and sources that are required to be sampled can be found at State Water Board's DDW website (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/pfos_and_pfoa/pfas_watersystemorders.pdf)

More water system data will be requested in the area of other types of sources in 2019, including industrial sites. The assessment of this data will be used to determine data information gaps. Additional and more assessment will be required in the coming years.

AB 756 authorizes the State Water Board to more broadly order water systems to monitor for PFAS and report their detections.

In August 2019, California's Division of Drinking Water established notification levels for perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) (6.5 parts per trillion for PFOS and 5.1 parts per trillion for PFOA), as well as a single health advisory response level which offers a margin of protection for all persons throughout their life from adverse health effects resulting from exposure to PFOA and PFOS in drinking water. Notification levels are a nonregulatory, precautionary health-based measure for concentrations in drinking water that warrant notification and further monitoring and assessment. Public water systems are encouraged to test their water for contaminants with notification levels, and in some circumstance may be ordered to test. If the systems do test, they are required to report exceedances to their governing boards and the State Water Board and are urged to report this information to customers.

DDW also has requested that OEHHA develop public health goals (PHGs) for both PFOA and PFOS, the next step in the process of establishing regulatory standards, known as maximum contaminant levels (MCLs), in drinking water. Other chemicals in the broader group of per- and polyfluoroalkyl substances (PFAS) may be considered later, either individually or grouped, as data permits.

On February 6, 2020, the DDW and Waterboards reduced the levels of PFOA and PFOS in drinking water that trigger responses by local water systems. The DDW and Waterboards set the new response levels to 10 ppt for PFOA and 40 ppt for PFOS based on a running four quarter average.

California State Water Board – Division of Water Quality

In coordination with DDW, the Division of Water Quality issued state-wide Water Code 13267 Orders to 226 locations (30 commercial airports and 196 municipal solid waste landfills), potential source areas of PFAS. Data from these investigations will continue to be collected until early 2020. More investigation data will be requested in the area of other types of PFAS sources in 2019, including industrial sites. Additional and more assessment will be required in the coming years.

California Office of Environmental Health Hazard Assessment

In November 2017, OEHHA added PFOA and PFOS under Proposition 65, which requires manufacturers to disclose the presence of these chemicals as a potential carcinogenic compound in materials in which they are present. Documentation supporting OEHHA's determination that the criteria for administrative listing have been satisfied for PFOA and PFOS is available on OEHHA's website (https://oehha.ca.gov/).

Department of Toxic Substances Control

The Department of Toxic Substances Control (DTSC) included food packaging as a product category in the Safer Consumer Products 2018-20 Work Plan due to concerns regarding exposure to PFAS and other chemicals included in food packaging, including the migration of PFAS from food packaging into packaged foods, becoming indirect food additives.

On February 15, 2018, DTSC released its Product-Chemical Profile on Carpets and Rugs with PFASs, documenting potential exposures and harm from these products. The Priority Product listing regulation triggers requirements that manufacturers look for safer alternatives. The process to make the requirements into regulations is likely to begin in the spring of 2019. The latest information about PFAS in the Safer Consumer Products program can be found on DTSC's website. (https://dtsc.ca.gov/scp/carpets-and-rugs-with-perfluoroalkyl-and-polyfluoroalkyl-substances-pfass/)

California Air Resources Board

In June 2018, California Air Resources Board (CARB) began a rulemaking effort to amend the Hexavalent Chromium Airborne Toxic Control Measure for Chrome Plating and Chromic Acid Anodizing Operations (Chrome Plating ATCM).Throughout this process, CARB staff is collecting information and soliciting input on ways to further reduce emissions of hexavalent chromium from chrome plating and chromic acid anodizing operations, and to address concerns about potential health and environmental impacts of PFAS-containing chemical fume suppressants. More information about CARB is available on CARB's website (https://ww2.arb.ca.gov/).

California Department of Public Health - Biomonitoring

Biomonitoring California's Scientific Guidance Panel designated PFAS as a program priority. Its California Regional Exposure (CARE) study includes 12 PFAS chemicals and is analyzing sources of exposures in the Asian Pacific Islander Community Exposure projects. More information about Biomonitoring in California is provided on the Biomonitoring in California's website (https://biomonitoring.ca.gov/).

DRINKING WATER

What is a notification level?

A notification level is a nonregulatory, precautionary health-based measure for concentrations of chemicals in drinking water that warrant notification and further monitoring and assessment. Public water systems are encouraged to test their water for contaminants with notification levels. If the systems test, they are required to report exceedances to their governing boards and are urged by the State Water Board to report this information to customers.

Establishing notification levels based on current health studies is an initial step toward setting regulatory standards for these chemicals in drinking water. The Water Board's investigation of a broader group of PFAS chemicals in water systems and groundwater will help inform this process.

In May 2016, the United States Environmental Protection Agency (US EPA) issued a lifetime health advisory for PFOS and PFOA for drinking water, advising municipalities that they should notify their customers of the presence of levels over 70 parts per trillion in community water supplies. US EPA recommended that customer notifications include information on the increased risk to health, especially for susceptible populations.

On July 13, 2018, DDW established an interim notification level of 14 parts per trillion (ppt) for PFOA and 13 ppt for PFOs and a single response level of 70 ppt for the combined concentrations of PFOA and PFOS.

In August 2019, DDW evaluated updated health-impact information provided by OEHHA. Based on this, DDW revised the notification levels to 6.5 parts per trillion for PFOS and 5.1 parts per trillion for PFOA.

What is a response level?

A response level is a nonregulatory, precautionary health-based measure that is set higher than a notification level and represents a recommended level that water systems consider taking a water source out of service or provide treatment if that option is available to them.

In May 2016, the United States Environmental Protection Agency (US EPA) issued a lifetime health advisory for PFOS and PFOA for drinking water, advising municipalities that they should notify their customers of the presence of levels over 70 parts per trillion in community water supplies. US EPA recommended that customer notifications include information on the increased risk to health, especially for susceptible populations.

On July 13, 2018, DDW established an interim notification level of 14 parts per trillion (ppt) for PFOA and 13 ppt for PFOs and a single response level of 70 ppt for the combined concentrations of PFOA and PFOS.

On February 6, 2020, the DDW and Waterboards reduced the levels of PFOA and PFOS in drinking water that trigger responses by local water systems. The DDW and Waterboards set the new response levels to 10 ppt for PFOA and 40 ppt for PFOS based on a running four quarter average.

What is a public health goal?

A public health goal (PHG) is a level of a contaminant in drinking water that does not pose a significant health risk. A PHG reflects the risk from long-term exposure to a contaminant and should not be used to estimate risks from short-term or acute exposure. Developed by OEHHA, PHGs are not regulatory requirements, but instead represent non-mandatory goals.

What is a maximum contaminant level?

Maximum contaminant levels (MCLs) are health-protective drinking water standards to be met by public water systems. MCLs consider not only health risks from exposure to a chemical, but factors such as detectability and treatability, as well as costs of treatment to reduce a chemical's presence in drinking water. Health & Safety Code §116365(a) (https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&secti on Num=116365) requires the State Water Board to establish a contaminant's MCL at a level as close to its PHG as is technically and economically feasible, placing primary emphasis on the protection of public health.

How do we establish maximum contaminant levels?

The first goal of the State Water Board is to establish an MCL as close as possible to the PHG. This is a complex task that involves consideration of many factors, including the following:

- What different contaminant levels are found throughout water systems in California?
- What are the population sizes that are being affected?
- What technology is available to treat our water?
- What is the cost of the treatment to treat and monitor our water?
- What amount of health benefit is achieved at each increment?

Establishing an MCL is a public process that follows the Administrative Procedures Act.

PFOA and PFOS Notification Levels:

In May 2016, the United States Environmental Protection Agency (US EPA) issued a lifetime health advisory for PFOS and PFOA for drinking water, advising municipalities that they should notify their customers of the presence of levels over 70 parts per trillion (ppt) in community water supplies. US EPA recommended that customer notifications include information on the increased risk to health, especially for susceptible populations.

On July 13, 2018, the State Water Board established an interim notification level of 14 ppt for PFOA and 13 ppt for PFOS and a single response level of 70 ppt for the combined concentrations of PFOA and PFOS.

In August 2019, the State Water Board evaluated updated health-impact information provided by OEHHA. Based on this, the State Water Board revised the notification levels to 6.5 parts per trillion for PFOS and 5.1 parts per trillion for PFOA. The single health advisory response level (for the combined values of PFOS and PFOA) remained at 70 ppt.

On February 6, 2020, the State Water Board reduced the levels of PFOA and PFOS in drinking water that trigger responses by local water systems. The State Water Board set the new response levels to 10 ppt for PFOA and 40 ppt for PFOS based on a running four quarter average.

Testing in California Drinking Water

From 2013 to 2015, the US EPA, under the Unregulated Contaminant Monitoring Rule (UCMR 3), required all large water systems (i.e., water systems serving over 10,000 people) nationwide to collect and analyze more than 12,000 drinking water samples for PFOS and PFOA. In addition, some water systems serving less than 10,000 people reported approximately 400 drinking water results for PFOS and PFOA. This occurrence data identified 36 sources with PFOS detections and 32 sources with PFOA detections. A summary of the findings for California is available on the EPA website (https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule).

In March 2019, the Division of Drinking Water issued Health and Safety Code 116400 Orders to 600 water system sites, and nearly 250 locations such as airports with fire training and response areas, and municipal solid waste landfills are being reported to the State Water Boards and will continue to be collected until into early 2020. More water system data will be requested in the area of other types of sources in 2019, including industrial sites. The assessment of this data will be used to determine data information gaps. Additional and more assessment will be required in the coming years.

Testing Methods in California Drinking Water

Some analytical methods using liquid chromatography-mass spectrometry-electrospray ionization methods (LC/MS/ESI) can achieve reporting limits for PFOA and PFOS at the nanogram per liter (ng/L) level. For the UCMR 3 monitoring program, LC/MS/MS-EPA Method 537 (rev 1.1) was required with minimum reporting limits of 20 ng/L and 40 ng/L for PFOA and PFOS, respectively. In November 2018, revised US EPA Method 537.1 was published that can detect PFOA, PFOS, and 16 other per-and polyfluorinated alkyl substances. Compliance with the recently changed NLs to 5.1 ng/L (PFOA) and 6.5 ng/L (PFOS) will require reporting limits lower than what can be achieved with US EPA Method 537. US EPA Method 537.1 is reported to be able to achieve lowest concentration minimum reporting levels (LCMRL) of 0.82 ng/L (PFOA) and 2.7 ng/L

(PFOS). An LCMRL is defined as the lowest true concentration for which the future recovery is predicted to fall, with 99% confidence, between 50 and 150% recovery of the matrix spike (US EPA, Method 537.1, 2018).

Further information regarding PFAS in drinking water may be found at the Division of Drinking Water PFOA/PFOS webpage (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/PFOA_PFOS.html).

If a water system detects PFOA or PFOS in the source water, what is required to be done?

When chemicals are found at concentrations greater than their notification levels in drinking water that is provided to consumers, certain noticing requirements and recommendations apply. DDW recommends that the water system inform its customers and consumers about the presence of the chemical, and about health concerns associated with exposure to it.

To provide consumer notice, the utility may use its annual Consumer Confidence Report, a separate mailing, or other method. DDW strongly recommends that a water system provide annual notification if a source that exceeds a notification level continues to be used.

When chemicals exceed their response levels in drinking water, DDW recommends that water systems consider taking a water source out of service or provide treatment if that option is available to them. Under AB 756, drinking water sources with PFAS levels above the response level are either to be taken out of service or the water system must provide public notice of the exceedance level.

How will results of the PFAS sampling be made public?

All chemical compounds required to be sampled by public water systems are to be included in the annual Consumer Confidence Report required by Health and Safety Code section116455.

The State Water Board will also provide a map of the sampling completed to date by the end of the summer 2019. The map along with a spreadsheet of all available data will be made available to the public.

PFAS LABORATORY TESTING & SAMPLING

What are the testing methods for PFAS?

Some analytical methods using liquid chromatography-mass spectrometry-electrospray ionization methods (LC/MS/ESI) can achieve reporting limits for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) at the nanogram per liter (ng/L) or parts per trillion, ppt) level. For the US EPA’s Third Unregulated Contaminant Monitoring Rule (UCMR 3) study, LC/MS/MS-EPA Method 537 (rev 1.1) was required with minimum reporting limits of 20 ng/L and 40 ng/L for PFOA and PFOS, respectively [1], [2].

In November 2018, revised US EPA Method 537.1 was published that can detect PFOA, PFOS, and 16 other per- and polyfluorinated alkyl substances (PFAS) [3].

US EPA Method 537.1 is reported to be able to achieve lowest concentration minimum reporting levels (LCMRL) of 0.82 ng/L (PFOA) and 2.7 ng/L (PFOS). An LCMRL is defined as the lowest true concentration for which the future recovery is predicted to fall, with 99% confidence, between 50 and 150% recovery of the matrix spike.

Laboratories have developed proprietary modified methods of US EPA Method 537, which have been adapted to account for additional media (wastewater, sludge, soil, sediments, tissue, etc.). These methods use LC-MS/MS with isotopically labeled standards to calculate recovery. Analyte lists currently vary from 24-39 PFAS compounds.

Are labs accredited by the California Environmental Laboratory Accreditation Program to test for PFAS?

The California Environmental Laboratory Accreditation Program (ELAP) accredits environmental laboratories that analyze environmental samples for regulatory purposes/compliance. In July 2018, ELAP began offering accreditation for US EPA Method 537 revision 1.1 (method is limited to 14 PFAS compounds in potable water samples) and US EPA Method 537.1 in September 2018.

As of April 3, 2019, ELAP's website posted the announcement for PFAS analysis for non-drinking water matrices. Based on qualified laboratories accredited by the Department of Defense to use the proprietary LC-MS/MS with isotopically labeled standard methods as specified in Table B-15 of Quality Systems Manual version 5.1 (or later)[4], California ELAP will certify up to 38 PFAS analytes.

Further information on labs accredited by ELAP to analyze PFAS (drinking water and non-drinking water matrices) may be found on the ELAP website: (https://www.waterboards.ca.gov/drinking_water/certlic/labs/).

What sample containers or other materials will I need for testing?

The laboratory that you choose should provide sampling materials for you to use, which will include PFAS-free sample bottles. It is important to use these for sample collection. Many laboratories only accept samples returned in their sample containers and may qualify your test results from any other container; it is highly recommended you only use the materials sent from the lab that have been verified to be PFAS-free.

General sampling guidance for non-drinking water and drinking water samples is provided on the Waterboard's PFAS website (https://www.waterboards.ca.gov/pfas/).

As a public water system customer, how can I sample my water for PFAS?

Sampling and testing require strict adherence to sampling procedures and care to avoid errors or misleading test results. DDW recommends you contact your water system for assistance. If the water system cannot assist you, DDW recommends using an accredited laboratory. (Laboratory map: https://www.waterboards.ca.gov/drinking_water/certlic/labs/)

References

[1]J. Shoemaker, P. . Grimmett, and B. K. Boutin, “Method 537. Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS). Version 1.1.” USEPA, 2009.

[2]US Environ. Prot. Agency, “Revisions to the Unregulated Contaminant Monitoring Regulation (UCMR 3) for public water systems. A proposed rule by the Environmental Protection Agency. March 3. No. 2011-4691,” Fed Regist, vol. 76, no. 42, pp. 11713–37, 2011.

[3]J. Shoemaker and D. Tettenhorst, “Method 537.1: Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).,” U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington, DC, 2018.

[4]Department of Defense (DoD), “DoD Quality Systems Manual Version 5.1,” 2017.

TREATMENT & REMEDIATION

What treatment techniques are used to reduce per- and polyfluoroalkyl (PFAS) levels in drinking water?

Most conventional water treatment techniques (i.e. coagulation/sedimentation/filtration, chlorination, ozonation, UV/H2O2) are ineffective for reducing PFAS levels in drinking water Several treatments have shown to be effective in the removal of PFAS from drinking water. Promising techniques include granular activated carbon (GAC), powdered activated carbon (PAC), high pressure membranes (reverse osmosis/nanofiltration) and ion exchange resin.

Activated carbon treatment is the most studied treatment for PFAS removal. Activated carbon is commonly used to adsorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals in drinking water treatment systems.

Adsorption is both the physical and chemical process of accumulating a substance, such as PFAS, at the interface between liquid and solids phases. Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants may adsorb. Activated carbon (GAC) is made from organic materials with high carbon contents such as wood, lignite, and coal; and is often used in granular form called **granular activated carbon (GAC)**.

GAC has been shown to effectively remove PFAS from drinking water when it is used in a flow through filter mode after particulates have already been removed. GAC works well on longer-chain PFAS like PFOA and PFOS, but shorter chain PFAS like Perfluorobutanesulfonic acid (PFBS) and Perfluorobutyrate (PFBA) do not adsorb as well.

Another type of activated carbon treatment is **powdered activated carbon (PAC)** which is the same material as GAC, but it is smaller in size- powder like. Because of the small particle size, PAC cannot be used in a flow through bed, but can be added directly to the water and then removed with the other natural particulates in the clarification stage (conventional water treatment or low-pressure membranes - microfiltration or ultrafiltration). Used in this way, PAC is not as efficient or economical as GAC at removing PFAS.

Another treatment option is **anion exchange treatment**, or resins. Ion exchange resins are made up of highly porous, polymeric material that is acid, base, and water insoluble. The tiny beads that make up the resin are made from hydrocarbons. There are two broad categories of ion exchange resins: cationic and anionic. The negatively charged cationic exchange resins (CER) are effective for removing positively charged contaminants and positively charged anion exchange resins (AER) are effective for removing negatively charged contaminants, like PFAS. Ion exchange resins are like tiny powerful magnets that attract and hold the contaminated materials from passing through the water system. Negatively charged ions of PFAS are attracted to the positively charged anion resins. AER has shown to have a high capacity for many PFAS; however, it is typically more expensive than GAC. Of the different types of AER resins, perhaps the most promising is an AER in a single use mode followed by incineration of the resin. One benefit of this treatment technology is that there is no need for resin regeneration so there is no contaminant waste stream to handle, treat, or dispose.

Like GAC, AER removes 100 percent of the PFAS for a time that is dictated by the choice of resin, bed depth, flow rate, which PFAS need to be removed, and the degree and type of background organic matter and other contaminants.

High-pressure membranes, such as nanofiltration or reverse osmosis (RO), are extremely effective at removing PFAS. RO membranes are tighter than nanofiltration membranes Research shows that these types of membranes are typically more than 90 percent effective at removing a wide range of PFAS, including shorter chain PFAS. With both high-pressure membrane types, approximately 80 percent of the feedwater, the water coming into the membrane, passes through the membrane to the effluent (treated water). Approximately 20 percent of the feedwater is retained as a high-strength concentrated waste. A high-strength waste stream at 20 percent of the feed flow can be difficult to treat or dispose, especially for a contaminant such as PFAS. High pressure membranes may be best suited as a point of use technology for a homeowner, since the volume of water being treated is much smaller and the waste stream could be disposed of more easily with less cause for concern.

Treatment & Remediation Table

	Granular Activated Carbon (GAC)	Powdered Activated Carbon (PAC)	Anion Exchange Resin (PFAS Selective)	High Pressure Membranes (Reverse Osmosis or Nanofiltration)
Short-Chain PFAS (i.e. PFBA) Removal	Moderately Effective	Not Effective	Moderately Effective	Effective
Long-Chain PFAS (i.e. PFOA, PFOS) Removal	Very Effective	Moderately Effective	Very Effective	Effective
Co-contaminant Removal	Very Effective	Not Effective	Moderately Effective	Very Effective
Relative Cost ($-$$$$)	$-$$	$$	$$$	$$$$
Disposal Requirements	Difficult	Difficult	Difficult	Difficult
Challenges	Desorption can diminish effectiveness when influent concentrations are variable; fate of PFASs during thermal regeneration not understood	Performance dependent on activated carbon properties and background water matrix	Performance dependent on resin properties; background water matrix effects unexplored	High energy requirement; membrane fouling; concentrate needs to be managed

- ITRC fact sheet: Naming Conventions and Physical and Chemical Properties of PFAS (https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_naming_conventions__3_16_18.pdf)