

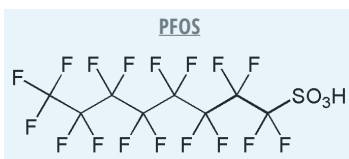
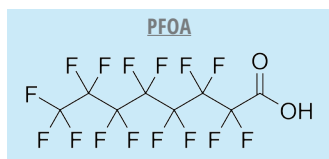
# Perfluorinated Compounds

## Prevalence and Assessment in Drinking Water

### What are PFCs?

Perfluorinated Compounds (PFCs), also referred to as perfluorinated alkyl substances (PFASs), are a large group of environmentally persistent manufactured chemicals used in industrial applications and consumer products. PFCs are very stable, slow to degrade in the environment, and can lead to potential adverse health effects in humans and wildlife. Animal studies show that increased exposure to high concentrations of PFCs may cause abnormal endocrine activity, and reproductive and developmental problems.

Several compounds fall under the umbrella of PFCs, including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). The U.S. Environmental Protection Agency (EPA) and many states have provided guideline concentrations for PFOA and PFOS in source or drinking waters. In May of 2016, the EPA released lifetime health advisories for PFOA and PFOS that are based on adverse developmental health effects to the most sensitive populations: fetuses during pregnancy and breastfed infants. EPA recommends that drinking water containing PFOA or PFOS individually or in combination at concentrations greater than 0.070 µg/L (70 ng/L) should undergo further testing and efforts to limit exposure.



PFCs can be clustered into two groups – “long-chain” and “short-chain” PFCs. “Long-chain” PFCs, which include PFOA and PFOS, typically are designated as perfluoroalkyl sulfonic acids containing ≥6 carbons and perfluoroalkyl carboxylic acids with ≥8 carbons. Short-chain PFCs, which have less than 6 carbon molecules, can be degradation by-products of long-chain PFCs or independent PFC compounds. Long- and short-chain PFCs have been identified in drinking water and are categorized as contaminants that should be monitored. “Long-chain” PFCs are of particular concern because they are more difficult to degrade and more likely to persist in the environment.

Currently there are no enforceable federal drinking water limits for PFCs. Elevated levels of PFCs should be reported to your state’s primary agency to determine the course of action. While there are numerous PFCs identified to date, the EPA has only required monitoring of the following PFCs as contaminants with suspected presence in drinking water under the Unregulated Contaminant Monitoring Rule 3 (UCMR 3).

Primary PFCs Found in Drinking Water	Source of PFC
<b>Long-Chain</b>	
Perfluorooctanoic acid (PFOA)	Nonstick Surfaces
Perfluorooctane sulfonate (PFOS)	Fabric Protection , Firefighting Foam
Perfluorononanoic acid (PFNA)	Surfactant Used for Plastic Production
<b>Short-Chain</b>	
Perfluorohexane Sulfonic Acid (PFHxS)	Firefighting Foam
Perfluorohexanoic Acid (PFHxA)	Degradation Product of PFHxS
Perfluorobutanesulfonic Acid (PFBS)	Stain Repellent; Replacement for PFOS

### Presence of PFCs in Drinking Water Supplies

PFCs are highly soluble in aquatic environments and can dissolve into water from various sources. Due to their chemical and biological stability, PFCs are difficult to degrade via biodegradation, photolysis, or hydrolysis. They are most often found near industry discharge points where they have been used. Surface water sources of PFCs include aqueous film forming foam (AFFF) runoff from firefighting activities, industrial factory runoff, and wastewater treatment plant discharges. Groundwater sources include landfill leachate, plumes from AFFF use, and runoff from land application of wastewater biosolids.

In the United States, source waters including lakes, rivers, tributaries, and groundwater have been found to have low ng/L levels of PFCs. The chemical species of PFC present in source waters is also of interest to water researchers since the toxicity is closely related to the form of PFC found. Data collected as part of the EPA’s UCMR 3 illustrates that PFOS and PFOA are the most frequently detected PFC compounds in finished drinking waters .

Removal of PFCs from source waters depends on water treatment variables such as influent concentration and treatment techniques. Conventional treatment has been shown to be largely ineffective at removal of PFCs, but studies show up to a 90% removal of PFCs is possible with certain advanced treatment techniques like activated carbon filtration, high pressure membrane filtration, or anion exchange.

# Perfluorinated Compounds

Prevalence and Assessment in Drinking Water

## Occurrence of PFCs in Public Water Systems (PWSs)

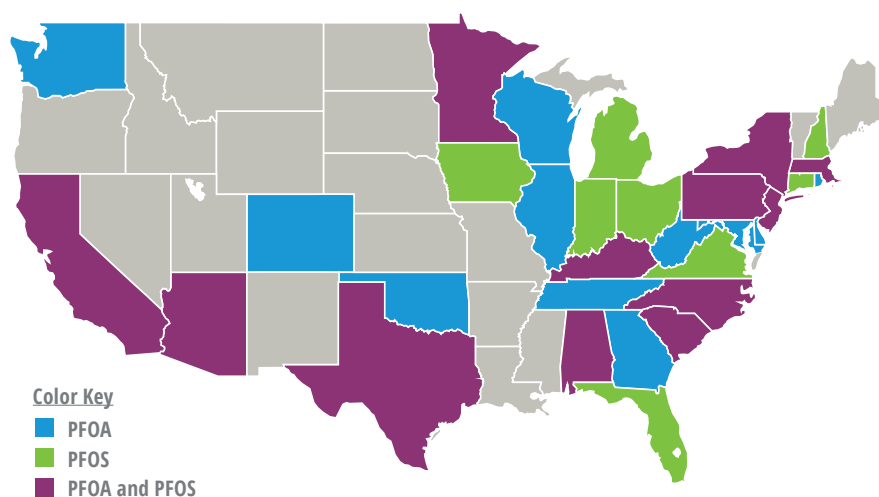
Compound	EPA Lifetime Health Advisory (LHA) Concentration (µg/L)* (2016)	UCMR 3 Minimum Reporting Level (MRL) (µg/L)*	% of PWSs with Results ≥ MRL*	% of PWSs with Results > LHA*
PFOS	0.070	0.040	0.30%	0.90%
PFOA	0.070	0.020	0.09%	0.30%
PFNA	N/A	0.020	--	--
PFHxS	N/A	0.030	--	--
PFHpA	N/A	0.010	--	--
PFBS	N/A	0.090	--	--

\*4,864 reporting PWSs - Data from EPA UCMR 3

### Preferred PFC Analytical Method

<b>Standard Name</b>	EPA 537 Rev. 1.1
<b>Method Name</b>	LC/MS/MS
<b>Interferences</b>	<ul style="list-style-type: none"> <li>Humic and/or fulvic materials</li> <li>Laboratory supplies containing PFCs</li> <li>Chlorine</li> </ul>
<b>Sampling Equipment</b>	250 mL Polypropylene bottles with polypropylene screw caps, nitrile gloves
<b>Sample Preservation</b>	A preservation reagent, Trizma® is recommended for buffering and removal of free chlorine
<b>Sample Standardization</b>	A field blank sample is required per site
<b>Sample Holding Time</b>	14 days with sample chilling as described in Section 8.4
<b>Extract Holding Time</b>	28 days with described preservation and storage in Section 8.5
<b>Reporting Limit</b>	0.5 to 1 ng/L for primary PFCs

### PFOA and PFOS Occurrence



Source: Map created from data collected by Eurofins Eaton Analytical

## Sampling and Measurement of PFCs

While no special equipment is required for sampling stable PFC compounds in water, special care should be taken during the sampling and transport process to avoid contamination from PFC coated clothing, sampling materials and storage containers. Grab samples are collected in polypropylene bottles and shipped in coolers with ice packs to the selected laboratory for PFC measurement. The analysis typically costs \$300 - \$350 per sample when completed by a commercial laboratory.

Sampling location should be based on the water utility's source waters and distribution system design. In general, samples should be gathered from multiple surface waters, unconfined wells,

or semi confined groundwater wells. Occurrence of PFCs should be examined first in finished water sources to confirm presence of PFCs. If PFCs are detected in finished water, raw water should be screened. Treatment of PFCs through conventional water treatment has not been shown to be very effective, but blending of water sources may reduce the amount of PFCs measured in finished waters. The presence of chlorine, other PFCs, humic acids, fulvic acids, or organic acids in the water sample may cause measurement interference, but interferences can be removed through sample preparation.

The analytical method for measuring PFCs is EPA 537 Rev. 1.1 which uses solid phase extraction

followed by liquid chromatography with tandem mass spectrometry (LC/MS/MS). This approach, also cited by the International Standards Organization (ISO) and the American Society for Testing and Materials (ASTM), has proven highly accurate for a range of fourteen PFCs, including the PFCs listed above.

While most PFCs show a single concentration peak on an LC/MS/MS chromatogram, PFOS produces linear and branched isomers, showing two concentration peaks. The method combines the isomers for quantification. There is speculation that this phenomenon exists for PFHxS and PFBS, but this has not been confirmed to date.

### References

\*Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). U.S. Environmental Protection Agency, Mar. 2014.

\*Perfluorinated Chemicals (PFCs): Perfluorooctanoic Acid (PFOA) & Perfluorooctane Sulfonate (PFOS). Association of State and Territorial Solid Waste Management Officials, 1101 17th Street, NW, Suite 707 Washington, DC 20036, Information Paper, Aug. 2015.

L. Cummings, A. Matarazzo, N. Nelson, F. Sicksel, and C. Storms, "Recommendation on Perfluorinated Compound Treatment Options for Drinking Water," New Jersey Drinking Water Quality Institute, Treatment Subcommittee, Jun. 2015.

E. Dickenson and C. Higgins, "Treatment Mitigation Strategies for Poly- and Perfluoroalkyl Substances," Water Research Foundation, 6666 West Quincy Avenue, Denver, CO 80235, Web Report 4322, 2016.

L. Bonnette, B. J. Boros-Russo, A. Dillon, E. Apalinski, J. Berchtold, K. Fell, B. Hamill, M. Ferko, and B. Wilk, "Determination of Perfluorooctanoic Acid (PFOA) in Aqueous Samples," New Jersey Department of Environmental Protection Division of Water Supply, Trenton, N.J., Jan. 2007.

\*Occurrence Data for the Unregulated Contaminant Monitoring Rule," U.S. Environmental Protection Agency, May 2016, [Online]. Available: <https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule>. [Accessed 19-April-2016].

EPA, "Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)." [Online]. Available: [https://pub.epa.gov/si/public\\_record\\_report.cfm?dirEntryID=198984&sampleSearch=1&searchAll=EPAN%25F000%25FR-08%25F002+](https://pub.epa.gov/si/public_record_report.cfm?dirEntryID=198984&sampleSearch=1&searchAll=EPAN%25F000%25FR-08%25F002+) [Accessed 06-May-2016].