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Frequently Asked Questions: Perfluorinated Compounds (PFC)/ Perfluoroalkyl Substances (PFAS)

FOR INTERNAL DON USE ONLY

Approved by:
DASN(E)

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SOURCE OF INFORMATION

The information used for compiling the perfluorinated compound (PFC) or perfluoroalkyl substances (PFAS) Frequently Asked Questions (FAQs) in this document are based on two main sources:

- 1) Readily available materials and references from various Federal Agencies such the U.S. Environmental Protection Agency (EPA), the National Institute of Environmental Health Sciences (NIEHS), the National Toxicology Program (NTP), the Agency for Toxic Substances and Disease Registry (ATSDR), and the Center for Disease Control and Prevention (CDC).
- 2) Policy, guidance, manuals, and technical correspondence with the Department of the Navy (DON) and subject matter experts (SMEs) from DASN(E), NAVSEA, NAVSUP, CNIC, NAVFAC, BUMED, NMCPHC, and USMC.

For the purpose of the FAQs, the terms PFC and PFAS are synonymous and can be used interchangeably. References are provided only on the information originated from outside DON.

GENERAL

What is PFC or PFAS?

Perfluorinated compounds (PFC) or perfluoroalkyl substances (PFAS) are a class of man-made chemicals. PFC/PFAS have been used for many years to make products that resist heat, stains, grease and water. For example, PFC/PFAS may be used to keep food from sticking to cookware, to make sofas and carpets resistant to stains, to make clothes and mattresses more waterproof, and may also be used in some food packaging, as well as in some firefighting materials. Because they help reduce friction, they are also used in a variety of other industries, including aerospace, automotive, building and construction, and electronics. Commercial and consumer products containing PFC/PFAS were first introduced in the 1950s.

What are some different terminology being used to describe PFC/PFAS?

Perfluorinated Compounds (PFCs) or Perfluoroalkyl substances (PFAS) are a family of hundreds of human-made chemicals as described above. The two best known groups of this family of chemicals are the perfluorocarboxylic acids (PFCAs), which include perfluorooctanoic acid (PFOA), and the perfluorosulfonates (PFSAs), which include perfluorooctane sulfonate (PFOS). Other common PFC/PFAS are listed in the table below.

List of Common PFC/PFAS and Their Abbreviations

Compound	Acronym	Chemical Abstracts Service Registry Number (CAS No.)
Perfluorocarboxylic acids (PFCAs)		
Perfluorobutanoic acid	PFBA	375-22-4
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorosulfonates (PFSAs)		

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Perfluorobutane sulfonate	PFBS	375-73-5
Perfluorodecane sulfonate	PFDS	335-77-3
Perfluoroheptane sulfonate	PFHpS	375-92-8
Perfluorohexane sulfonate	PFHxS	432-50-7
Perfluorooctane sulfonate	PFOS	1763-23-1
Perfluorooctane sulfonamides		
Perfluorooctane sulfonamide	PFOSA	754-91-6
2-(N-Methyl-perfluorooctane sulfonamido) acetic acid	Me-PFOSA-AcOH	2355-31-9
2-(N-Ethyl-perfluorooctane sulfonamido) acetic acid	Et-PFOSA-AcOH	2991-50-6

How have PFC/PFAS been used?

Due to their unique properties, PFC/PFAS have been used in many industrial and consumer products. PFC/PFAS have been used to make non-stick surfaces on cookware and waterproof coatings for textiles and paper products. They are a key ingredient in many products that must flow freely, including paints, cleaning liquids, and fire-fighting foams. PFC/PFAS have been used in hundreds of ways across almost all industrial sectors, some of which are listed in the table below.

Common Uses of PFC/PFAS

Consumer Products	Industrial Uses
Cookware (Teflon®, Nonstick)	Engineering Coatings
Food Containers or Package such as french fry boxes, pizza boxes, hamburger wrappers, and microwave popcorn bags	Medical Devices
Personal Care Products (Shampoo, Dental Floss)	Fire-Fighting Foam (AFFF)
Cosmetics (Nail Polish, Eye Makeup)	Insect Baits
Paints and Varnishes	Printer and Copy Machine Parts
Stain Resistant Chemicals (Scotchguard®)	Oil Production
Water Resistant Apparel (Gore-Tex®)	Textiles, Upholstery, Apparel and Carpets
Cleaning Products	Paper and Packaging
Electronics	Rubber and Plastics

Are PFC/PFAS still being produced?

PFC/ PFAS may broadly be separated into two categories: short-chain and long-chain. Long-chain PFC/PFAS, including PFOS and PFOA, contain more carbon atoms than short-chain PFC/ PFAS. In general, short-chain PFC/PFAS are still being produced worldwide, but the production of long-chain PFC/PFAS has greatly declined over the past 15 years. For example, the largest U.S. manufacturer of PFOS voluntarily stopped producing it in 2002. However, other countries still produce PFOS, and it can be imported into the United States in limited quantities. In 2006, EPA and major companies in the PFC/PFAS industry launched the 2010/2015 PFOA Stewardship Program. Companies participating in the program committed to stop producing PFOA and related chemicals by 2015.

As companies have stopped producing long-chain PFC/PFAS, short-chain PFC/PFAS have replaced them in many cases. Short-chain PFC/PFAS have many of the same unique properties as long-chain PFC/PFAS.

Comment [DTB1]: Note that this was a voluntary program, so not sure that there was a complete halt in production as of 2015.

This is also discussed with better fidelity on p.17 under “What is being done to prevent the risk of exposure to PFC/PFAS?” It might be worth coordinating the language between these two sections.

Some (but not all) short-chain PFC/PFAS do not remain in the body as long as long-chain PFC/PFAS. As a result, they are thought to be a less-toxic alternative to long-chain PFC/PFAS. However, the toxicity and environmental impacts of short-chain PFC/PFAS have not been thoroughly researched, and more research is needed to demonstrate their safety.

What are the more commonly known PFC/PFAS?

PFC/PFAS are a class of chemicals; 8 are better known than the others: PFOA (perfluorooctanoic acid), PFOS (perfluorooctane sulfonate), PFHxS (perfluorohexane sulfonate), PFOSA (perfluorooctane sulfonamide), PFNA (perfluorononanoate), PFDeA (perfluorodecanoate), Et-PFOSA-AcOH 2 [(N-ethyl-perfluorooctane sulfonamido) acetate], and Me-PFOSA-AcOH 2 [(N-methyl-perfluorooctane sulfonamido) acetate]. Scientists know the most about PFOA and PFOS. Less is known about the other PFC/PFAS.

References on PFC/PFAS General Information

- NIEHS PFCs Factsheet:
http://www.niehs.nih.gov/health/materials/perflourinated_chemicals_508.pdf
- How EPA manages PFAS under TSCA: <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/and-polyfluoroalkyl-substances-pfass-under-tsca>
- ATSDR:
<http://www.atsdr.cdc.gov/HAC/pha/deatur/Blood%20PFC%20Testing%20and%20Health%20Information.pdf>

USES WITHIN DON/MILITARY

What are the uses of materials that contain PFC/PFAS within the Department of the Navy (DON)?

Within DON's operations, PFC/PFAS are most commonly associated with aqueous film-forming foam (AFFF), but can also be contained in some other materials (e.g. degreaser vapor suppression) and wastes/mixed wastes. Additional information is provided below regarding release mechanisms.

What are the advantages of AFFF?

Aqueous film-forming foam (AFFF) is used for extinguishing Class B (flammable liquid) fuel fires. A key feature is the formation of an aqueous film with low surface tension between the foam layer and the fuel surface that prevents the escape of flammable vapors. The film and foam layers work in combination to exclude oxygen from the fuel surface, and the water content of the foam provides a cooling effect.

What are the advantages of Military Specification (MILSPEC) AFFF over non-MILSPEC AFFF?

Some of the advantages of MILSPEC AFFF include: quicker fire extinguishment times; a requirement for compatibility with both seawater and freshwater; a requirement for compatibility with PKP dry chemical (used in portable extinguishers); performance requirements for half and quintuple strength tests (for demonstrated viability when incorrectly proportioning); and the capability to intermix MILSPEC AFFFs from different manufacturers.

Comment [DTB2]:

Point for consideration:
The AFFF FAQs on this page and the next contain plenty of discussion on why MILSPEC AFFF is better than non-MILSPEC AFFF. The underlying tone is almost such that it's hinting that the PFOS/PFOA problem solely belongs to MILSPEC AFFF. We may want to point out that older formulations of non-MILSPEC AFFF may also contain PFCs of concern. According to information provided by the Film Forming Foam Coalition (FFFC), the foam manufacturers started reformulating the non-MILSPEC foams before the MILSPEC foams due to non-MILSPEC foam having a larger share of the commercial foam market. That being said, I do not know if there are trace-PFOA concerns with the newer non-MILSPEC formulations. I'm sure some are some that are fluorine-free, but there may also be products using short-chain PFC formulations that may contain trace PFOA contamination.

Why does the Navy and Marine Corps use Military Specification (MILSPEC) aqueous film forming foam (AFFF)?

MILSPEC qualified AFFF was developed specifically to rapidly extinguish Class B fires where shipboard/aviation fuels and ordnance may be present in critical fire scenarios such as flight decks and where aircraft movement, fueling and weapons loading occur in very close proximity. The allowable times for fire extinguishment are much more stringent for a MILSPEC AFFF than a non-MILSPEC (i.e. UL 162 qualified) AFFF. One example is the 50 square foot pan fire where a MILSPEC AFFF is required to extinguish the fire in 50 seconds, but a UL162 non-MILSPEC AFFF is allowed 180 seconds.

What types/classes of AFFF extinguishing agent(s) are currently specified and available?

Military Specification (MILSPEC) AFFF is currently specified and available in two types (3% and 6%). 3% is intended to be mixed 3 parts concentrate to 97 parts water. 6% is intended to be mixed 6 parts concentrate to 94 parts water.

Does DON still use AFFF that contains PFOS and/or PFOA?

3M ceased manufacturing AFFF with PFOS (this formulation also included about 1-2% PFOA) in 2002. However, legacy 3M AFFF remains in some DON systems and inventory. DON is in the process of identifying these locations and preparing to remove this AFFF for proper disposal/destruction. AFFF produced after 2002 may also contain PFOA and/or precursor PFC/PFAS, which can degrade to PFOA. DON is in the process of testing the newest formulations of AFFF to verify whether there are trace amounts of PFOA and, if so, at what level. Once PFOA free formulations can be identified and certified to meet MILSPEC performance criteria, old stocks will be replaced with these newer, safer formulations.

RELEASES AND BEHAVIOR OF PFC/PFAS IN THE ENVIRONMENT

What are PFCs release mechanisms into the environment?

The primary release mechanisms of PFC/PFAS to the environment within DON's operations consist of uses, non-point and point source releases such as spills and leaks, training activities, emergency responses, and testing of PFC/PFAS containing material and wastes. Potential release mechanisms of PFC/PFAS into the environment include:

1. Uses of AFFF containing PFC/PFAS in the following activities:
 - a. Firefighting and crash response vehicle testing where AFFF is discharged and not completely collected for proper disposal
 - b. Fire training exercises such as flooding a fire pit or other built facility or structure with flammable liquids (e.g. jet fuel), igniting the fluids, and subsequently extinguishing the fire with AFFF where the liquid is not completely contained and collected for proper disposal
 - c. Crash crew training exercises where releases occur from spraying AFFF at training sites and the liquid is not completely contained and collected for proper disposal
 - d. Hangar system operations, testing, and flooding; releases may occur from improper capture and disposal of AFFF in and around the hangars where the foam migrated to and was thus released the ground or into draining channels or ditches
 - e. Responses to class B or fuel fires or spills and there was no containment of the liquids for proper disposal
 - f. Emergency response actions such as crash sites (aircraft, vehicle, and others)

2. Uses of material containing PFC/PFAS in the following industrial operation:
 - a. Plating shops – PFC/PFAS are sometimes contained in materials used in the vapor suppression system; releases could result from improper capture or disposal of material around floor drains, foundation cracks, and outdoor soil or ditch areas
3. Storage, handling, or disposal of PFC/PFAS contained in AFFF and materials or wastes
 - a. Release from improper filling of storage tanks, firefighting trucks, or crash response vehicles
 - b. Release from spills and leaks from storage tanks and piping
 - c. Releases from landfills or burn areas where the materials or wastes were/are disposed

DON POLICIES & APPROACH ON PFC/PFAS

What is the DON strategy to managing PFC/PFAS?

DON is implementing a comprehensive strategy to manage and address PFC/PFAS issues in the following areas:

- 1) Drinking water on DON installations: DON has sampled all on installation drinking water systems in compliance with the EPA unregulated contaminant monitoring rule (UCMR3) requirements and DON policy. DON has also reviewed EPA UCMR3 data for all installations that buy water from these public water systems. All installations where testing has been conducted are currently receiving safe drinking water.
- 2) Impacted public and private drinking water off installation: DON has been proactive in identifying locations where PFOA or PFOS may have migrated to off installation drinking water sources. Where ever EPA lifetime health advisory levels have been exceeded, DON has provided alternative, safe water.
- 3) DON cleanup program: DON is conducting installation-wide assessments to identify all potential PFOA and PFOS release sites and will prioritize future site investigations and remediation based on potential risk to drinking water sources.
- 4) AFFF: DON is identifying for removal and destruction all legacy 3M PFOS (and PFOA) containing AFFF. DON is testing current AFFF formulations to determine whether there are trace levels of PFOA in these formulations, and once PFOA free MILSPEC qualified formulations are identified, these will replace existing stocks.

How many installations throughout the DON have sampled for PFOA and PFOS in the U.S.?

Per EPA Unregulated Contaminant Monitoring Rule (UCMR3) requirements, Navy was required to sample at 17 installations and Marine Corps was required to sample at 7 installations within the United States. None of the following systems exceeded the EPA Health Advisory (HA) for PFOS and PFOA:

Navy:

- Joint Base Pearl Harbor-Hickam - HI
- Naval Base Guam - GU
- Naval Support Activity (NSA) Norfolk Naval Shipyard – VA
- Naval Station (NAVSTA) Norfolk – VA

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- Naval Station (NAVSTA) Great Lakes - IL
- Joint Expeditionary Base (JEB) Little Creek-Fort Story West - VA
- Naval Air Station (NAS) Patuxent River – MD
- NSA Washington – DC (Navy Yard)
- Joint Base Anacostia - Bolling – DC
- Naval Base Kitsap - Bangor – WA
- Naval Base Kitsap - Bremerton – WA
- Naval Air Station (NAS) Whidbey Island – WA
- NAS Jacksonville – FL
- NAS Pensacola – FL
- NAVSTA Mayport – FL
- NAS Lemoore – CA
- Naval Construction Battalion Center (NCBC) Port Hueneme – CA

Marine Corps:

- Marine Corps Base (MCB) Camp Pendleton - Camp Pendleton (North and South)-CA
- Marine Corps Air Station (MCAS) Cherry Point - Marine Corps Air Station Cherry Point-NC
- MCB Hawaii - Marine Corps Base Hawaii-HI
- MCB Quantico - Quantico Marine Base Mainside-VA
- MCB Camp Lejeune - USMC Lejeune (Hadnot Point and Holcomb Blvd) - NC
- MCAS New River - USMC Lejeune New River Air Station-NC
- Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms - USMC Twentynine Palms-CA

The individual results can be found on EPA's website: <http://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule>

DON policy further required sampling at installations where there was a known or suspected release of PFC/PFAS with a potential to impact drinking water sources. This required Navy to sample 10 additional installations and Marine Corps to sample 1 additional installation within the United States.

Navy:

- NAS Oceana – VA (Naval Auxiliary Landing Field (NALF) Fentress)
- Weapon Station (WPNSTA) Earle Colts Neck (MSC Fire School) – NJ
- Naval Shipyard (NSY) Portsmouth – NH (NAA Cutler – ME)
- NSA South Potomac – VA (Naval Surface Warfare Center Division (NAVSURFWARCEMDIV) Dahlgren)
- Naval Base Kitsap - WA (NAVUNSEAWARCEMDIV KEYPORT)
- NSA Mid-South – TN
- NAS Kingsville – TX
- NAS Whiting Field Milton – FL
- NAS Whiting Field Milton (Naval Outlying Field Choctaw) – FL

- NCBC Gulfport – MS

Marine Corps:

- Marine Corps Logistic Base (MCLB) Albany—GA

Only NALF Fentress had PFOA or PFOS detected above the EPA lifetime HA in drinking water and alternative water was immediately provided upon receipt of sample results. Earle Colts Neck (MSC Fire School) had PFC/PFAS detected in ground water monitoring wells associated with an environmental restoration site, but not in the Navy drinking water supply.

Where does DON's past use of PFC/PFAS currently impact public and/or private drinking water system/wells?

DON is currently mitigating the PFC/PFAS drinking water contamination at two BRAC installations (Naval Air Station Joint Reserve Base, Willow Grove and Naval Air Warfare Center, Warminster, PA) and two active installations (NALF Fentress and Earle Colts Neck). If drinking water exposures exceeding the HAs, DON immediately eliminates the exposure by disconnecting the affected system and providing an alternate drinking water (new connection or bottled water).

DON is managing the long-term mitigation of the contamination source areas under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Department of Defense Environmental Restoration Program (DERP), and the Navy Environmental Restoration Program (NERP), similar to other regulated contaminants.

Further details on DON's actions at the affected installations can be found in:

- Naval Air Warfare Center, Warminster:
http://www.bracpmo.navy.mil/brac_bases/northeast/former_warfare_center_warminster.html
- Naval Air Station Joint Reserve Base, Willow Grove:
http://www.bracpmo.navy.mil/brac_bases/northeast/reserve_base_willow_grove.html
- Naval Auxiliary Landing Field, Fentress:
http://www.cnmc.navy.mil/fentressinfo/regions/cnrma/installations/nas_oceana/om/environmental_support/NALF_fentress_drinking_water.html
- Earle Colts Neck:
http://www.cnmc.navy.mil/regions/cnrma/installations/nws_earle/om/environmental_support/nws_earle_msc_ffs_drinking_water.html

REGULATORY FRAMEWORKS

What are the regulatory standards for PFC/PFAS?

Currently, PFC/PFAS are classified as unregulated or “emerging” contaminants, which have no Safe Drinking Water Act (SDWA) regulatory standards or routine water quality testing requirements.

PFC/PFAS are being studied by the EPA to determine if regulation is needed. On 19 May 2016, the EPA's Office of Water issued health advisory levels (HAs) for two PFC/PFAS, perfluorooctane sulfonate (PFOS) - Publication EPA 822-R-16-004 and perfluorooctanoic acid (PFOA) – EPA 822-R-16-005. Health advisory levels are not regulatory standards. They are health based concentrations above which the EPA

recommends action should be taken to reduce exposure. The EPA HA levels are 0.07 parts per billion (ppb) for both PFOS and PFOA, additively.

For more information on how EPA manages the unregulated or “emerging” contaminants refer to:

UCMR - <https://www.epa.gov/dwucmr/learn-about-unregulated-contaminant-monitoring-rule>

Drinking water health advisory for PFOS and PFOA - <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>

What are health advisory levels?

Health advisory levels identify the concentration of a contaminant in drinking water at which adverse health effects are not anticipated to occur over specific exposure durations (e.g., 1 day, 10 days, a lifetime). HAs serve as informal technical guidance to assist federal, state, and local officials, and managers of public or community water systems in protecting public health when emergency spills or other contamination situations occur. An HA document provides information on the environmental properties, health effects, analytical methodology, and treatment technologies for removing drinking water contaminants.

How did EPA set the drinking water health advisory levels for PFOS and PFOA?

EPA used a factor called the Relative Source Contribution (RSC) in calculating the lifetime health advisory levels for PFOS and PFOA to account for non-water exposures. From a national perspective, the dominant source of human exposure to PFOS and PFOA is expected to be from the diet (food and water); indoor dust from carpets and other sources is also an important source of exposure, especially for children. The HA was calculated using a RSC of 20%, which allows for other PFOS and PFOA exposure sources (e.g., dust, diet, air) to make up 80% of the dose of exposures (RfD).

More information on the EPA method for calculating a health advisory level is available from the EPA Document EPA-822-B-00-004, *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health 2000*, October 2000 and the EPA's Webpage for Drinking Water Health Advisory for PFOS and PFOA (<https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>).

Why is the EPA issuing a health advisory for PFOS + PFOA (combined) that exceed a reference value of 70 parts per trillion (ppt; 0.070 micrograms per liter)?

Please refer to EPA.

What do parts per billion (ppb) and parts per trillion (ppt) concentrations in drinking water mean in simple terms?

Parts per billion (ppb) and parts per trillion (ppt) are the most commonly used terms to describe very small amounts or trace levels of contaminants in our drinking water.

One ppb is the equivalent of one drop of impurity in 500 barrels of water or 1 cent out of \$10 million.

One ppt is the equivalent of one drop of impurity in 500,000 barrels of water -or- traveling 6 inches out of a 93 million-mile journey toward the sun.

Why is there not an advisory number for other PFC/PFAS (except PFOA and PFOS)?

There is not enough toxicological data available for most other PFC/PFAS to determine advisory levels. That said, some states have screening levels for other PFC/PFAS.

References on PFC/PFAS Regulatory Framework

- How EPA manages the unregulated or “emerging” contaminants under UCMR:
<https://www.epa.gov/dwucmr/learn-about-unregulated-contaminant-monitoring-rule>
- Drinking water health advisory for PFOS and PFOA
 - <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>
 - <https://www.epa.gov/ground-water-and-drinking-water/supporting-documents-drinking-water-health-advisories-pfoa-and-pfos>
- States:
 - California Department of Public Health - <http://www.biomonitoring.ca.gov/>
 - Michigan Department of Community Health
Former Wurtsmith Air Force Base, Iosco County -
http://www.michigan.gov/mdhhs/0,5885,7-339-71551_2945_5105-285528--00.html
 - Minnesota Department of Health -
<http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/>
 - New Hampshire Department of Health and Human Services -
<http://www.dhhs.nh.gov/dphs/pfcs/pfc-resources.htm>
 - New Jersey Department of Health -
http://www.nj.gov/health/eohs/pfc_in_drinkingwater.shtml
http://www.nj.gov/health/eohs/drinking_water.shtml

HEALTH EFFECTS

How do PFCs behave in our body?

Because of their widespread use, most people in the United States have some PFC/PFAS in their body. PFC/PFAS are not stored in body fat. Once the PFC/PFAS are in a person's body, it takes about two to four years before those PFC/PFAS levels go down by half, even if no more is taken in.

More information is available from ATSDR and the U.S. EPA.

Reference ATSDR:

<http://www.atsdr.cdc.gov/HAC/pha/decaturn/Blood%20PFC%20Testing%20and%20Health%20Information.pdf>

Why are PFC/PFAS of possible concern?

Since their introduction in the late 1940s, PFC/PFAS have entered and spread throughout the environment. Many PFC/PFAS, including PFOS and PFOA, breakdown slowly in the environment and can travel long distances over time. PFOS, PFOA and other PFC/PFAS have been found in animals in the Arctic and Antarctic, far removed from known sources of the chemicals. Because of their frequent use and presence in the environment, most people in the United States and in the industrialized world have measurable amounts of PFC/PFAS in their blood (at levels measured in microgram per liter (ug/l)). In addition, PFOS, PFOA and other PFC/PFAS can build up and remain in the human body. Once in the body, it can take a long time for them to leave. As a result of this bio-persistence and widespread detection, many people are concerned about the potential impacts of PFC/PFAS on human health.

Comment [DTB3]: I think the EPA guidance used µg/l vice ug/l. I think both are acceptable for micrograms, but thought I'd point out the difference.

Research is currently ongoing to evaluate the potential health impacts of PFOS, PFOA, and other PFC/PFAS. In many animal studies, exposure to PFC/PFAS has been shown to cause changes in the function of the liver, thyroid, pancreas, and hormone levels. The impacts of PFC/PFAS in humans are less well understood and considered uncertain, though studies of exposed populations have shown possible links between PFC/PFAS and some harmful health effects.

What is known about the possible health effects of PFC/PFAS?

Scientists are not sure about the possible health effects of human exposure to PFC/PFAS. PFOS, PFOA, PFHxS and PFNA have been more widely studied than other PFC/PFAS. For the most part, studies have found that animals exposed to PFC/PFAS have shown changes in the function of the liver, thyroid, pancreas, and hormone levels. However, scientists are not sure how animal data applies to human exposure, because PFC/PFAS behave differently in humans than they do in animals and may be harmful in different ways.

PFC/PFAS build up and remain in the human body and the amount reduces very slowly over time. So scientists and doctors are concerned about their effects on human health. While the evidence is inconclusive, according to the Agency for Toxic Substances and Disease Registry (ATSDR) some studies in humans have shown that certain PFC/PFAS may be associated with developmental delays in the fetus and child, including possible changes in growth, learning, and behavior, decreased fertility and changes to the body's natural hormones, increased cholesterol, changes to the immune system, increased uric acid levels, changes in liver enzymes, and prostate, kidney, and testicular cancer. More research is needed to confirm or rule out possible links between health outcomes of potential concern and exposure to PFC/PFAS.

Additional reference is available on: http://www.atsdr.cdc.gov/pfc/health_effects_pfcs.html and <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>.

How likely are PFC/PFAS to cause cancer?

Researchers and regulators continue to evaluate the likelihood of PFC/PFAS causing cancer. Neither the U.S. Environmental Protection Agency (EPA) nor the National Toxicology Program has made a final statement about the ability of any PFC/PFAS to cause cancer. However, both agencies are currently evaluating the cancer potential of PFOA. EPA is evaluating the cancer potential of PFOS. ATSDR and EPA have identified possible association of certain PFC/PFAS with prostate, kidney, and testicular cancer.

Additional reference is available on: http://www.atsdr.cdc.gov/pfc/health_effects_pfcs.html and <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>.

What do we know about the effect of PFC/PFAS mixtures?

At this time, there is not enough information to evaluate the health effects of exposures to mixtures of PFC/PFAS. We do not currently know how mixtures of PFC/PFAS may interact with the body, and few studies have compared the health effects of different mixtures of PFC/PFAS.

What are the potential health effects of PFC/PFAS exposure in children?

Over the past few years, researchers have begun to examine the possible effects of PFC/PFAS exposures in children. Studies have shown that newborns can be exposed to PFC/PFAS through breast milk. Young children may be exposed to PFC/PFAS through food and water, similarly to adults. In addition, young children have a higher risk of exposure to PFC/PFAS through carpet cleaners and similar products, due to

time spent lying and crawling on floors in their early years. As a result, most children in industrialized nations have at least some level of PFC/PFAS in their blood.

Researchers are studying whether childhood PFC/PFAS exposures may be linked to effects on the immune system, asthma, and behavioral effects. However, as with studies in adults, the evidence linking PFC/PFAS to health effects in children is inconclusive. Researchers acknowledge that the findings of many of the studies linking PFC/PFAS and health effects in children are limited and that more studies are needed. As a result, it is too soon to state whether or not there are special concerns for children.

If my child is sick, who will take responsibility? How do I get my child help?

For questions about health care, you should consult your health care provider.

I drank the water, will I get sick?

ATSDR says they cannot predict whether or not you will get sick. Whether someone will or will not develop health problems from exposure to any contaminant depends on several factors, including

- How much exposure you received
- How long you were exposed
- When you were exposed (e.g., as a fetus, a child, or an adult)
- Your genes
- Any other exposures to environmental or occupational hazards you have received during your lifetime
- Your lifestyle—for example, your diet, your tobacco or alcohol use, and your physical activity
- Illness you may have had from other causes, and medications you have taken during your lifetime.

References on PFC/PFAS Health Effects

- ATSDR: http://www.atsdr.cdc.gov/pfc/health_effects_pfc.html
- EPA: <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>

EXPOSURE AND BIOMONITORING

How are people exposed to PFC/PFAS?

PFC/PFAS are man-made, so there are no natural sources in the environment. However, PFC/PFAS can be found near areas where they are manufactured or where products containing PFC/PFAS are often used. PFC/PFAS can travel long distances, move through soil, seep into groundwater, or be carried through air. Because they are stable chemicals and move so easily in the environment, PFC/PFAS have been found in soil, sediment, and water samples far away from where they were made or used. Potential sources of PFC/PFAS in the environment may include industrial sources, areas where PFC/PFAS are used frequently, and consumer products. Listed below are places where they can be found.

- Public water systems and drinking water wells, soil, and outdoor air near industrial sources or areas with frequent PFC/PFAS use.
- Indoor air in spaces that contain carpets, textiles and other consumer products treated with PFC/PFAS to resist stains.

- Surface water (lakes, ponds, etc.) and run-off from areas where aqueous (water-based) film-forming firefighting foam (AFFF) is often used, such as military or civilian airfields.
- Locally caught fish from contaminated bodies of water.
- Food items sold in the marketplace.
- Consumer products.

Consuming contaminated food and water is thought to be the main way people are exposed to PFC/PFAS. PFC/PFAS have been measured in waterbodies used for drinking water around the world, and PFC/PFAS have been found in a variety of commercial food items. Due to their ability to build up in the body, even small amounts of PFC/PFAS consumed regularly can result in measurable levels of PFC/PFAS in exposed people. Other potential sources of PFC/PFAS include everyday items such as non-stick coatings on cookware, grease-resistant paper used for foods, and stain resistant coatings on carpets, upholstery, and other fabrics; however PFOA and PFOS are no longer used in most of these products.

Workers involved in making or processing PFC/PFAS are more likely to be exposed to PFC/PFAS than the general population. Workers may be exposed to PFC/PFAS by inhaling them, getting them on their skin, and swallowing them; however, inhalation is the most likely route for exposure.

Additional information on exposure to PFC/PFAS can be found in

http://www.atsdr.cdc.gov/pfc/sources_of_exposure.html

Is my drinking water safe if it comes from a private well?

Private wells can be contaminated with PFC/PFAS. If your water contains PFOA and PFOS, you can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water. Routine showering or bathing will not likely cause a significant exposure. Studies have shown very limited absorption of PFC/PFAS through the skin. Many PFC/PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while bathing or showering is not likely to be a major pathway.

Are there PFC/PFAS in foods?

Various studies have examined the concentrations of PFC/PFAS in different food items available for purchase in the marketplace. In general, the concentration of PFC/PFAS in commercially available food items is low. Items in which low levels of PFC/PFAS have been detected include potatoes, canned vegetables, eggs, sugars, preserved foods, beef, fish, milk and microwave popcorn. PFC/PFAS can be transferred to vegetables and other plants from contaminated soil and water, though the uptake, distribution and storage properties of individual plants can vary. Cattle, poultry, and other animals can be exposed through the consumption of feed contaminated with PFC/PFAS or through the ingestion of contaminated drinking water, which in turn can lead to the contamination of food items produced from these animals. In addition, the non-stick coatings on many items used to cook or store food may function as a source of PFC/PFAS contamination in prepared foods. Numerous modeling studies have suggested that the contamination of food with PFC/PFAS at low levels is the most likely source of non-occupational exposures for the general population in industrialized nations without contaminated drinking water supplies. In their review article of exposure pathways for PFC/PFAS, Fromme et al. suggest that over 90% of exposures to PFAS in the general population (without contaminated water supplies) may come through food consumption.

The consumption of fish is thought to be a major pathway for PFC/PFAS exposure for both the general population and for people living near PFAS contaminated waters. Typically, elevated concentrations of PFC/PFAS in fish are found near areas involved in the production or manufacture of PFC/PFAS. In a

review article by Fromme et al., PFAS concentrations in fish from waters known to be contaminated with PFC/PFAS tended to be in the 10s to 100s of nanograms PFC/PFAS per gram fish tissue (ng/g), while concentrations in fish not near a known PFC/PFAS source ranged from nondetect to the low 10s of ng PFC/PFAS /g fish tissue. Both PFOS and PFOA are believed to bioaccumulate in fish, with the result that fish higher up the food chain can accumulate significant concentrations of the chemicals. In general, however, PFOS accumulates at a higher rate than PFOA.

Is it safe to swim in municipal pools?

Currently, there are no known studies demonstrating that recreational exposures to PFC/PFAS-contaminated waters are harmful to human health. Many PFC/PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while swimming or bathing is not likely to be a major pathway. PFC/PFAS are not easily absorbed through skin, and drinking a small amount while swimming is not expected to result in a significant exposure.

Is it safe to swim recreational waters?

Exposure to PFC/PFAS could occur through contact with contaminated surface waters. Currently, however, there are no known studies demonstrating that recreational exposures to PFC/PFAS-contaminated waters are harmful to human health. Many PFC/PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while swimming or bathing is not likely to be a major pathway. Additionally, PFC/PFAS are not easily absorbed dermally, and drinking a small amount while swimming is not expected to result in a significant exposure.

What is being done to prevent the risk of exposure to PFC/PFAS?

The greatest source of exposure reduction to the general population has come from the voluntary phase-out of many PFC/PFAS by the companies that produce them. The first voluntary reduction came from the 3M Company in 2002, when they agreed to stop the production of PFOS and related chemicals. Later, the eight leading manufacturers of PFOA agreed to a voluntary phase-out of PFOA through the EPA's 2010/2015 PFOA Stewardship Program. Both of these programs have contributed to a significant reduction in PFC/PFAS levels (particularly PFOS) in the blood of the general population since the early 2000s.

At specific locations, many sites contaminated with PFC/PFAS are being treated and monitored for the risk of further contaminant movement. Other efforts have focused on increasing awareness of PFC/PFAS contamination and on ways to reduce the risk of exposure. For instance, health departments in Minnesota, Michigan, Alabama, and other states have issued "Do not eat" fish advisories for fish caught from PFC/PFAS-contaminated waterways. In addition, a variety of state and federal agencies are informing the public about PFC/PFAS contamination through public service announcements and other messaging.

Are there methods to show whether people have been exposed to PFC/PFAS?

Various methods are available for testing if people have been exposed to PFC/PFAS. One method, known as biomonitoring, involves measuring how much of a chemical is present in the human body. Levels of a contaminant in the body suggest that some level of exposure occurred. However, the presence of chemicals in the blood or other body tissue does not automatically mean that harmful health effects will occur. Scientists do not currently know whether and at what levels many contaminants, including PFC/PFAS, in the blood could lead to harmful effects.

More information on biomonitoring can be found on http://www.atsdr.cdc.gov/pfc/docs/biomonitoring_101_5-16-16_508.pdf.

Should people concerned about exposures to PFC/PFAS get themselves tested?

ATSDR does not advise individuals to be tested for PFC/PFAS exposure. Although specific PFC/PFAS can be measured in serum (blood), the measurements must be done in specialized laboratories and are expensive. Further, a serum PFC/PFAS concentration does not provide diagnostic or treatment information, and cannot predict future health effects. It does not indicate when exposure occurred or the source of the exposure, although it may be suggestive.

It is important to keep in mind that most Americans have serum concentrations of one or more specific PFC/PFAS, especially PFOS/PFOA. Serum PFC/PFAS measurements are most helpful as part of a carefully designed research study.

References on Exposure and Biomonitoring

- http://www.atsdr.cdc.gov/pfc/sources_of_exposure.html
- http://www.atsdr.cdc.gov/pfc/docs/biomonitoring_101_5-16-16_508.pdf

WHAT TO DO IF YOU HAVE BEEN EXPOSED?

What can people do to reduce their risk of exposure to PFC/PFAS?

PFC/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 (air, water, soil, etc.). Therefore, completely preventing exposure to PFC/PFAS is unlikely, and no effective recommendations can be made for entirely reducing individual exposures in the general population. However, if you live near known sources of PFC/PFAS contamination, you can take steps to reduce your risk of exposure to PFC/PFAS.

For example, numerous states have issued advisories cautioning consumers to either stop or limit eating fish from waters contaminated with PFOS or other PFC/PFAS. Check with your state public health and environmental quality departments for any advisories in place in your area and to learn the types and local sources of fish that are safe to eat.

If your water contains PFOA and PFOS, you can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water. Routine showering or bathing in this water should not be a problem. Studies have shown very limited absorption of PFC/PFAS through the skin. Many PFC/ PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while bathing or showering is not likely to be a major pathway.

A variety of consumer products, including non-stick coatings on cookware and coatings on clothing, carpets, and paper packaging, have contained different types of PFC/PFAS in the past. While recent efforts to remove long-chain PFC/PFAS from many of these products have reduced the likelihood of exposure to long-chain PFAS, exposure to short-chain PFC/PFAS may still be possible through modern consumer products. However, research has suggested that exposure from consumer products is usually low, especially when compared to the impact of exposure in contaminated drinking water or contaminated food such as fish.

You can contact CDC/ATSDR for updated information on this topic at 1-800-CDC-INFO. If you have questions or concerns about the products you use in your home, contact the Consumer Product Safety Commission at (800) 638-2772.

Is it safe to take a shower or bath?

Routine showering or bathing will not likely cause a significant exposure. Studies have shown very limited absorption of PFC/PFAS through the skin. Many PFC/PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while bathing or showering is not likely to be a major pathway.

Are taking showers safer than taking a bath?

No. Neither routine showering or bathing are a significant source of exposure. Studies have shown very limited absorption of PFC/PFAS through the skin. Many PFC/PFAS including PFOS and PFOA are essentially non-volatile, such that inhalation while bathing or showering is not likely to be a major pathway.

Should I filter my tap water before drinking?

ATSDR does not currently recommend any specific point-of-use filters for drinking water because the effectiveness and proper use of these devices has not been established. If your water contains PFOA and PFOS at level that exceed the health advisory levels of 0.07 ppb (combined), you can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water.

Should I drink bottled water?

If your water contains PFOA and PFOS, you may reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water. It is safe to shower and bathe in PFC/PFAS- contaminated water. However, bottled water is not tested for the presence of PFC/PFAS, so we don't know if PFC/PFAS may be present in these sources as well.

Can I do laundry and wash dishes with tap water?

Yes. Doing laundry or washing dishes is not likely to pose a significant exposure to PFC/PFAS.

How do I eliminate PFC/PFAS from my body if I have been exposed?

There are no medical interventions that will remove PFC/PFAS from the body. The best intervention is to stop the source of exposure.

Is there treatment for people who have been exposed to PFC/PFAS?

ATSDR does not recommend any specific treatments for people who have been exposed to PFC/PFAS. If PFC/PFAS are detected in your water, or if you or family members have signs or symptoms that you think are caused by PFC/PFAS exposure, discuss your concerns with your family's health care provider.

If I am pregnant, is it safe to drink tap water?

If the EPA's Long Term Health Advisory levels are exceeded, pregnant women may wish to seek an alternative drinking water source until levels of PFOA and PFOS in the drinking water are reduced. You can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water.

If I am pregnant, should I filter my tap water before drinking?

ATSDR does not currently recommend any specific point-of-use filters for drinking water because the effectiveness and proper use of these devices has not been established. If your water contains PFOA and

PFOS, you can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water.

If I am pregnant should I only drink bottled water?

If the EPA's Long Term Health Advisory levels are exceeded, pregnant women may wish to seek an alternative drinking water source until levels of PFOA and PFOS in the drinking water are reduced. You can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water. Bottled water is not tested for the presence of PFC/PFAS.

Is it safe to breastfeed?

Breastfeeding is linked with numerous health benefits for both infants and mothers. At this time, it is recommended that nursing mothers continue to breastfeed. The science on the health effects of PFC/PFAS for mothers and babies is evolving. However, given the scientific understanding at this time, the benefits of breastfeeding outweigh any known risk. To better weigh the risks and benefits of breastfeeding, please talk to your child's pediatrician.

Extensive research has documented the broad and compelling advantages of breastfeeding for infants, mothers, families, and society. Some of the many benefits include immunologic advantages, lower obesity rates, and greater cognitive development for the infant as well as a variety of health advantages for the lactating mother.

Even though a number of environmental pollutants readily pass to the infant through human milk, the advantages of breastfeeding continue to outweigh the potential risks in nearly every circumstance.

I am using powdered formula to feed my baby, is it safe to use tap water to mix the formula or should I use bottled water?

If the EPA's Long Term Health Advisory levels are exceeded, caregivers preparing bottles for infants may wish to seek an alternative water source, or use formula that does not require adding water until levels of PFOA and PFOS in the drinking water are reduced. However, at this time, we don't know how much risk-reduction, if any, will occur through the use of alternate water sources. You can reduce exposure by using an alternative or treated water source for drinking, food preparation, cooking, brushing teeth, and any activity that might result in ingestion of water. Bottled water is not tested for the presence of PFC/PFAS, so we don't know if switching to bottled water will provide any health benefit.

References on What To Do If You Have Been Exposed?

- http://www.atsdr.cdc.gov/pfc/health_effects_pfc.html
- <https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos>

WHAT FEDERAL ACTION IS BEING TAKEN?

What Federal Agencies are conducting actions related to PFC/PFAS?

The U.S.EPA, the National Institute of Environmental Health Sciences (NIEHS), the National Toxicology Program (NTP), the Agency for Toxic Substances and Disease Registry (ATSDR), and the Center for Disease Control and Prevention (CDC), among others, are jointly or individually conducting various studies and researches associated with health effects of PFCs/PFAS.

Information and resources on PFC/PFAS can be found on:

Last Updated: June 10, 2016

ATSDR: <http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1117&tid=237> (Draft ATSDR profile of the toxicity of PFOS and PFOA), <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=1115&tid=237>, and <http://www.atsdr.cdc.gov/pfc/index.html>

CDC: http://www.cdc.gov/biomonitoring/PFCs_FactSheet.html

NTP: <http://ntp.niehs.nih.gov/files/PFOAConcept.pdf>

EPA: http://www.epa.gov/fedfac/pdf/emerging_contaminants_pfos_pfoa.pdf

How many public water systems will this effect for systems that service more than 10,000 people?

Based on preliminary evaluation of the Third Unregulated Contaminated Monitoring Rule (UCMR3) database, we expect approximately 63 municipal water systems to have concentrations of PFOA and PFOS above 0.07 $\mu\text{g/L}$.

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Will public water systems that serve less than 10,000 people have PFOS + PFOA (combined) concentrations that exceed a reference value of 70 parts per trillion (ppt; 0.070 micrograms per liter)?

It is conceivable that smaller water systems will have detections of PFOA and PFOS that exceed the 0.07 $\mu\text{g/L}$ health advisory level. This is especially true for systems near identified sources.

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