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EXAMINING THE PUBLIC HEALTH IMPACTS OF PFAS EXPOSURE

HEARING

BEFORE THE

SUBCOMMITTEE ON CHEMICAL SAFETY,
WASTE MANAGEMENT, ENVIRONMENTAL JUSTICE,
AND REGULATORY OVERSIGHT

OF THE

COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

ONE HUNDRED EIGHTEENTH CONGRESS

SECOND SESSION

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EXAMINING THE PUBLIC HEALTH IMPACTS OF PFAS EXPOSURE

THURSDAY, DECEMBER 5, 2024

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON CHEMICAL SAFETY, WASTE MANAGEMENT,
ENVIRONMENTAL JUSTICE, AND REGULATORY OVERSIGHT,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:34 a.m. in room 406, Dirksen Senate Office Building, Hon. Jeff Merkley (chairman of the subcommittee) presiding.

Present: Senators Merkley, Mullin, Carper, Markey, Wicker.

OPENING STATEMENT OF HON. JEFF MERKLEY, U.S. SENATOR FROM THE STATE OF OREGON

Senator MERKLEY. Good morning, and welcome. This hearing of the Environment and Public Works Subcommittee on Chemical Safety, Waste Management, Environmental Justice and Regulatory Oversight is now underway. The topic is Everyday Exposure: Examining PFAS Pollution and its Impacts on Human Health.

In 1980, when President Carter signed the Superfund into law, he said we had created in this Country great prosperity and a leadership of the entire world with our chemical industry and with the energy industries. But we have neglected to pay part of the cost of that development, and now, of course, we must face that responsibility.

Today, we are here to discuss facing that responsibility, to understand the class of chemicals known as PFAS. Many folks know of PFAS chemicals from brands such as Teflon and Scotch Guard. But there are estimated to be thousands of PFAS chemicals in the use to resist water, stains, and grease. Some of these products include frying pans, furniture, food packaging, work boots, rain coats, microwave popcorn bags, pizza boxes, shampoos, cosmetics, contact lenses, toilet paper, firefighting foam, and the list goes on and on.

In other words, it is impossible to avoid PFAS. The chemicals are so useful for consumer products, because they are durable and they are resistant to typical environmental processes including by water and bacteria. But those very qualities make them an environmental disaster. After decades of use, scientists are finding forever chemicals everywhere.

Rubbing salt into the wound, they are concentrated into biosolids generated by wastewater treatment facilities and subsequently spread on crops as fertilizer, putting PFAS back into the water and food we consume.

The more we learn about various PFAS chemicals, the clearer it becomes that any level of exposure is significant and dangerous. Estimates are that at least 45 percent of U.S. household tap water contains one or more PFAS chemicals.

Two of the best understood PFAS chemicals, PFOA and PFOS, the Environmental Protection Agency has concluded there is no safe level in drinking water. PFAS has been linked to devastating health problems, breast cancer, testicular cancer, liver damage, thyroid disease, colitis, fertility problems, high blood pressure, low birth weight, developmental delays, high cholesterol. So this is a public health challenge, and we want to understand it better.

These chemicals were first developed in the 1940's. By the 1960's, manufacturers like 3M and DuPont knew their products were toxic. In fact, in 1981, DuPont removed female employees from working with PFAS chemicals after eight women gave birth to babies with severe birth defects. But these corporations kept these dangers secret for decades. The public didn't learn about them until they were revealed by a landmark lawsuit in the 1990's. PFAS manufacturers only began phasing out PFAS chemicals in the 2000's after public outcry.

Today, scientists and researchers are revealing the dangers of these chemicals, underscoring the necessary ubiquity of their use, and identifying pollution hotspots that need to be contained or cleaned up. But we need extensive monitoring data to understand the scope, the severity, and the urgency of the problem, and understand how Congress and Federal agencies can protect the public from exposure to these chemicals. Avoiding PFAS poisoning cannot and should not be the responsibility of individual consumers.

Thankfully, we have a panel of experts to help us understand this problem here today. Dr. Laurel Schaidler is a senior scientist at the Silent Spring Institute, where she works to understand the health effects of PFAS exposure. As a result of her research, in 2022, New York State banned PFAS in food packaging, including pizza boxes, pastry boxes, sandwich wrappers, soup cups, and more. Since then, similar bans have passed in 12 more States.

Joining her is Dr. Sue Fenton from North Carolina State University, who specializes in understanding how disease develops from PFAS. Her research is among the most cited toxicology work on PFAS exposure, and she was the first to identify how PFAS affects breast feeding. She previously worked for the Environmental Protection Agency and the National Institute of Environmental Health Sciences at the National Institutes of Health.

And we are joined by Michael Larrañaga, President and Managing Principal of R.E.M. Risk Consultants. He served on the Board of Scientific Counselors for the National Institute of Occupational Safety and Health, and a member of First Responders Advisory Group for the Department of Homeland Security.

Thank you all for being here to share your expertise today. Now I would like to turn this over to our Ranking Member, Senator Mullin.

**OPENING STATEMENT OF HON. MARKWAYNE MULLIN,
U.S. SENATOR FROM THE STATE OF OKLAHOMA.**

Senator MULLIN. Thank you, Mr. Chairman. And thank you to all of our witnesses here. Thank you for your time, and I do appreciate your expertise.

I would like to thank first of course the committee that spent a lot of time doing this. A lot of times we get the credit, but we really know it is the staff that is doing most of the work, right?

I would also like to take the opportunity to introduce and welcome Dr. Larrañaga, who received his undergraduate degree from Oklahoma State University. I have to put a plug there, I have a couple of boys going to school right there, and wrestling. Of course, I also have one at OSU wrestling, too, so I am kind of house divided there.

He also later served as department head of the School for Fire Protection Safety. Almost everyone at some point in the past few years has heard about PFAS, unless you live underneath a rock, which is OK, because likely you would be in a lot better mental health if you did. For those who have not heard of PFAS, those acronyms refer to a group of chemicals first discovered almost 90 years ago that provided immense durability, strength and resilience, which is why PFAS is so commonly used in manufacturing markets today.

Several thousands of PFAS have been manufactured and are used in a variety of industries around the world, including electric vehicle batteries, military and civilian aerospace equipment, semiconductors, linings for piping, surgically implanted medical devices, inhalers, water filtrations, foam touch streams, which all of us use today, solar panels, coatings for steel and concrete bridges, and you name it, they are pretty much involved in it.

So, with so many different types of PFAS used in so many applications, blanket banning PFAS without fully understanding the risks, the differences between the chemicals, would not only suffocate our economy, it would halt innovation. But it would also disproportionately impact low-income and rural communities who already face many other challenges.

One thing I want to make clear is that although it is not nearly as impossible to show that all PFAS directly causes negative health conditions in humans, several studies have shown that significant exposures to certain PFAS can cause adverse health effects. However, as Congress considers PFAS regulations, we must also work to avoid unintentionally harming technological advancements and national security.

I will pause here for a second and say, one thing that Congress seems to do is we overreact. I want to get it right. I live and walk in this world just like everybody else. I have six kids that are growing up in this world. And I expect to be around for a long time and I want my kids to be around and I want my grandkids to be around. So overreaction is not what I want to do here.

But looking for a direction, a healthy direction, and moving in the right path is why you guys are here today. Hopefully you can incite wisdom, leave emotion out of it and put facts in place. And you can help steer us in the right direction.

So once again, thank you for your time. With that, Mr. Chairman, I will yield back.

Senator MERKLEY. Now I would like to turn this over to the Chairman of the entire committee, Senator Carper, and I believe this may be his last hearing.

Senator CARPER. Don't say that.

[Laughter.]

Senator CARPER. Saving the best for last.

Senator MERKLEY. Your last hearing while serving as Chair, and we are delighted to have you here.

**OPENING STATEMENT OF HON. THOMAS R. CARPER,
U.S. SENATOR FROM THE STATE OF DELAWARE**

Senator CARPER. Thank you. It is wonderful to serve with you and our colleagues on this subcommittee.

One of the things we get to do as we come to the end of our tenure in the Senate, we get to give a farewell address. Later this week, actually next week, I have the opportunity, a week or so from today, to give a farewell address. I am going to talk for 3 hours about PFAS that day. Not really.

But I am going to talk a bit next week when I give my farewell address about all that we have accomplished in this room with this committee, with the involvement of the two gentlemen to my right. There are a couple of big issues that we have not been able to resolve. One of those is before us here today.

I like to say, the key to success in life is you just don't give up, never give up. This is an important issue; it is an important issue for us to find common ground and something that is fair and reasonable, but actually provides the protection that we need.

So I am delighted that the last hearing is on one of the toughest issues that we face. I would just urge both of you to make sure that in the next Congress, we don't quit, we find a way to yes. Thanks so much.

Senator MERKLEY. Thank you very much, Chair Carper.

We will now turn to our witnesses' testimony, starting with Dr. Laurel Schaidler.

**STATEMENT OF LAUREL SCHAIER, PH.D., SENIOR SCIENTIST,
ENVIRONMENTAL CHEMISTRY AND ENGINEERING, SILENT
SPRING INSTITUTE**

Ms. SCHAIER. Good morning, Chairman Merkley, Ranking Member Mullin, and members of the committee. My name is Laurel Schaidler. I am a senior scientist at Silent Spring Institute, an independent non-profit research organization investigating links between everyday chemicals and health. We are leaders in researching women's health and breast cancer prevention.

Since 2009, I have led research on how PFAS moves through the environment, how people are exposed and how these chemicals affect our health. Thank you for the invitation to testify today.

PFAS, or forever chemicals, have polluted every corner of the globe. They have been found in the blood of nearly every single American whose blood has been tested. My colleague, Dr. Fenton,

will tell you about the many serious health effects associated with PFAS. I am here to tell you why that is very bad news.

Exposures to PFAS are widespread. They are in our water, our food, consumer products, even in the air and dust in our homes. Although all of us have PFAS in our bodies, some communities and individuals have much higher levels than others.

My main point is this: we need comprehensive strategies to address PFAS contamination, identify and reduce exposures, support impacted communities, and ultimately eliminate unnecessary uses of these harmful communities.

PFAS are used in a wide range of everyday products, like non-stick cookware, stain resistant carpets, and cosmetics. My own research has shown that PFAS are widespread in food packaging and consumer products, like dental floss and children's clothing and furnishings. We have shown that PFAS can migrate out of products and end up in our bodies.

Infants can be highly exposed, since PFAS can cross the placenta and contaminate breast milk. PFAS have also contaminated our environment. Millions of people in the U.S. are drinking tap water containing PFAS, according to testing by the U.S. Geological Survey in 2023.

The most severe contamination is found near industrial facilities and military bases, airports and other locations where aqueous film forming foam, or AFFF, was used. In many other communities, PFAS contamination comes from wastewater treatment plants, landfills, septic systems, and sewage sludge used to fertilize farm land.

Earlier this year, the EPA set standards for six PFAS in drinking water. These standards were set in the low parts per trillion range, much lower than for most other contaminants, underscoring their extreme toxicity. These new standards will go a long way to reducing exposures.

However, they only apply to six individual PFAS, a drop in the bucket compared to the more than 14,000 chemicals classified as PFAS. And they do not protect the 44 million Americans who rely on a private well for their drinking water.

The health and economic costs of PFAS are not evenly distributed. Public water systems serving small communities, particularly in rural areas, need more financial and technical support for testing and treatment. Our research has found that communities with higher proportions of Hispanic and Black residents are more likely to be exposed to PFAS through their drinking water. And PFAS can buildup in fish and shellfish, so tribal communities and subsistence fishers may be especially vulnerable.

PFAS contamination takes a toll on communities. I have heard from anguished parents who feel guilt for having unwittingly exposed their children during pregnancy and breast feeding. I have heard from farmers who have lost their livelihood because their land and livestock were contaminated.

And I have heard from too many people who have lost loved ones to cancer or other diseases that they suspect were caused by PFAS. They face a lifetime of worry about long-term health effects.

Our health care systems have not caught up with this public health crisis. We need better access to PFAS blood testing, as rec-

ommended by a 2022 National Academies report. We need more resources to educate clinicians, such as those developed by our NIH-funded PFAS-REACH study as models for how PFAS blood testing can improve clinical care. New Hampshire now requires insurers to cover the cost of PFAS blood tests, and similar policies are needed nationwide.

To protect public health and the environment, we need to turn off the tap on unnecessary uses of PFAS and develop safer alternatives. Many everyday uses of PFAS are not essential. PFAS in products such as cosmetics, dental floss, and home textiles have no real health or safety benefit. For some other uses, like firefighting foam, safe and effective alternatives already exist.

In 2019, an international panel of experts from the fire engineering industry concluded that fluorine-free foams, which don't contain PFAS, meet the same performance standards as AFFF without long-term pollution risks.

We will never solve this problem if we attempt to address PFAS one at a time. We need comprehensive strategies to address all PFAS, including fluorinated polymers as a class. Production of PFAS can expose workers and nearby communities, and products containing PFAS can contaminate the environment after their disposal.

We need to stop assuming that chemicals are innocent until proven guilty. We are still dealing with costly messes from chemicals manufactured years ago, like DDT and PCBs. Fortunately, we also know that legislation can lead to significant improvements, like substantial declines in children's blood lead levels, and recovery of bald eagles from DDT in recent decades.

We need to act now to address the current PFAS contamination crisis, prevent additional contamination, and protect future generations.

Thank you.

[The prepared statement of Ms. Schaidler follows:]



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**Testimony of Laurel Schaider, Ph.D.
Senior Scientist, Silent Spring Institute**

U.S. Senate Committee on Environment and Public Works
Subcommittee on Chemical Safety, Waste Management,
Environmental Justice and Regulatory Oversight

“Examining the Public Health Impacts of PFAS Exposures”
December 5, 2024

Good morning and thank you Chairman Merkley, Ranking Member Mullin, and Members of this Committee.

My name is Laurel Schaider, and I am a Senior Scientist at Silent Spring Institute. We are an independent non-profit research organization and national leader in investigating links between everyday chemicals and health, with an emphasis on women’s health and breast cancer prevention. I have expertise in environmental chemistry, environmental engineering, exposure science, and community-engaged research and have studied PFAS since 2009. I am currently leading or contributing to three federally funded research studies on per- and polyfluoroalkyl substances (PFAS) to understand how they move through the environment, how humans are exposed, and how they affect our health. Thank you for holding this hearing and for the invitation to testify today about the need for comprehensive strategies to address PFAS contamination, to reduce people’s exposures, and to turn off the tap on the future use and production of PFAS.

PFAS have been called “forever chemicals” because of their extreme persistence in the environment. They have polluted every corner of the globe and have been found in the blood of nearly every single American whose blood has been tested since the 1950s when they first became widely used in consumer products. They have been linked to numerous health effects, even at very low levels of exposure. Some communities and workers have quite high exposures that place them at even greater risk of harm. By understanding exposures, we can find ways to help affected communities, improve clinical care, and ultimately eliminate the unnecessary uses of these harmful chemicals.

PFAS have contaminated the drinking water of millions of Americans

Millions of people in the U.S. are drinking tap water contaminated by PFAS. In 2023, the U.S. Geological Survey (USGS) estimated that at least 45% of the nation’s tap water is contaminated

with PFAS.¹ This number is likely an underestimate since the study only tested for 34 PFAS, whereas there are more than 1,400 individual PFAS used in industry and consumer products.² The highest levels of PFAS in water are often traced to industrial facilities and military bases, airports, and other fire training areas where the use of aqueous film-forming foams (AFFF) released PFAS into groundwater or surface water.³ Increasingly, discharges from wastewater treatment plants, landfills, septic systems, and land-applied biosolids are proving to be even more pervasive contamination sources. Our waste stream contains PFAS because our products contain PFAS, so it is essential to reduce our reliance on products containing PFAS to prevent future contamination.

In April 2024, the U.S. Environmental Protection Agency (EPA) set standards for six PFAS in drinking water. These standards were set at levels in the low parts-per-trillion range, orders of magnitude lower than the parts per billion range for most other contaminants, underscoring their extreme toxicity. EPA had previously set health advisories in 2023 for PFOS and PFOA that were even lower, well below concentrations that can be reliably measured. These new standards will go a long way to preventing exposures from this source. However, the standards apply to only six individual PFAS chemicals, whereas many other PFAS have also been found in U.S. drinking water.⁴ Furthermore, these new standards do not apply to the 44 million U.S. residents who rely on a private well for their drinking water.⁵

PFAS are common in everyday products, contributing to widespread exposures

My research at Silent Spring Institute has shown that PFAS are widespread in drinking water,⁶ food packaging,⁷ diet,⁸ dental floss,⁹ and textile products marketed for children and adolescents.¹⁰ PFAS are widely used in non-stick cookware, stain-resistant carpets and upholstery, waterproof apparel, greaseproof food packaging, and countless other consumer applications, such as car seats,

¹ Smalling KL et al. (2023) Per- and polyfluoroalkyl substances (PFAS) in United States tapwater: Comparison of underserved private-well and public-supply exposures and associated health implications, *Environ. Int.* 178, 108033, <https://doi.org/10.1016/j.envint.2023.108033>.

² Glüge J et al. (2020) An overview of the uses of per- and polyfluoroalkyl substances (PFAS), *Environ. Sci. Proc. Imp.* 22(12): 2345-73, <https://doi.org/10.1039/D0EM000291G>.

³ Hu XC et al. (2016) Detection of poly- and perfluoroalkyl substances (PFASs) in U.S. drinking water linked to industrial sites, military fire training areas and wastewater treatment plants, *Environ. Sci. Technol. Lett.* 3(10): 344-50, <https://doi.org/10.1021/acs.estlett.6b00260>.

⁴ Smalling et al., *Environ. Int.* 178, 108033. Pelch KE et al. (2023) 70 analyte PFAS test method highlights need for expanded testing of PFAS in drinking water, *Sci. Tot. Environ.* 876, 162978, <https://doi.org/10.1016/j.scitotenv.2023.162978>.

⁵ Maupin MA et al. (2014) *Estimated Use of Water in the United States in 2010*, U.S. Geological Survey (Reston, VA).

⁶ Schaidler LA et al. (2014) Pharmaceuticals, perfluorosurfactants, and other organic wastewater compounds in public drinking water wells in a shallow sand and gravel aquifer, *Sci. Tot. Environ.* 468-469: 384-93, <https://doi.org/10.1016/j.scitotenv.2013.08.067>; Schaidler LA et al. (2016) Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer, *Sci. Tot. Environ.* 547: 470-81, [https://doi.org/S0048-9697\(15\)31235-3](https://doi.org/S0048-9697(15)31235-3); Hu et al., *Environ Sci Technol Lett* 3(10): 344-50, <https://doi.org/10.1021/acs.estlett.6b00435>.

⁷ Schaidler LA et al. (2017) Fluorinated compounds in US fast food packaging, *Environ. Sci. Technol. Lett.* 4(3): 105-11, <https://doi.org/10.1021/acs.estlett.6b00435>.

⁸ Susmann HP et al. (2019) Dietary habits related to food packaging and population exposure to PFASs, *Environ. Health Perspect.* 127(10): 107003, <https://doi.org/10.1289/EHP4092>.

⁹ Boronow KE et al. (2019) Serum concentrations of PFASs and exposure-related behaviors in African American and non-Hispanic white women, *J. Expo. Sci. Environ. Epidemiol.* 29(2): 206-17, <https://doi.org/10.1038/s41370-018-0109-y>.

¹⁰ Rodgers KM et al. (2022) How well do product labels indicate the presence of PFAS in consumer items used by children and adolescents?, *Environ. Sci. Technol.* 56(10): 6294-304, <https://doi.org/10.1021/acs.est.1c05175>.

paints, and cosmetics.¹¹ Through our research and other published studies, we know that PFAS in products do not stay in products—the chemicals leach out into our air and dust, and ultimately end up in our bodies.

The prevalence of PFAS in our homes, schools, and workplaces increases our exposure to these toxic chemicals. Indeed, testing by the Centers for Disease Control and Prevention (CDC) has shown that over 99% of people in the U.S. have detectable levels of PFAS in our blood.¹² Infants can be highly exposed since PFAS can cross the placenta and contaminate breast milk.¹³ The levels of some long-chain PFAS in blood have declined in the general population, reflecting the phase-out of manufacturing in the U.S. and elsewhere.¹⁴ However, a 2021 study found that on average around half of organofluorine in blood cannot be accounted for by known PFAS, which means that we are being exposed to other unidentified PFAS for which we cannot assess health risks.¹⁵

PFAS exposures are linked to numerous health effects

PFAS have adverse health impacts on nearly every system in our bodies, and some effects can occur at very low levels of exposure.¹⁶ PFAS are toxic to the liver, thyroid, immune system, and cardiovascular system, adversely impact reproduction and development, and increase risks for several types of cancer. As a breast cancer research organization, we are especially concerned that some PFAS impair mammary gland development, which may increase the risk of breast cancer later in life, the most common cancer among U.S. women and the second leading cause of cancer death for U.S. women.¹⁷ In addition, epidemiological studies have shown that higher PFAS exposures are associated with impaired lactation and reduced duration of breastfeeding.¹⁸ Children

¹¹ Guo Z et al. (2009) *Perfluorocarboxylic acid content in 116 articles of commerce*, National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency (Research Triangle Park, NC), <http://nepis.epa.gov/Exec/Query/PURL.cgi?Dockey=P100EA62.txt>; Whitehead HD et al. (2021) Fluorinated compounds in North American cosmetics, *Environ. Sci. Technol. Lett.* 8(7): 538–44, <https://doi.org/10.1021/acs.estlett.1c00240>; Wu Y et al. (2020) Per- and polyfluoroalkyl substances in paired dust and carpets from childcare centers, *Chemosphere* 251: 126771, <https://doi.org/10.1016/j.chemosphere.2020.126771>; Miller G et al. (2018) *Hidden hazards: Flame Retardant Chemicals & PFAS in Children's Car Seats*. Ecology Center (Ann Arbor, MI) <https://www.ecocenter.org/healthy-stuff/pages/car-seats-2018-report>.

¹² Calafat AM et al. (2019) Legacy and alternative per- and polyfluoroalkyl substances in the US general population: Paired serum-urine data from the 2013–2014 National Health and Nutrition Examination Survey, *Environ. Int.* 131, 105048, <https://doi.org/10.1016/j.envint.2019.105048>; Susmann et al., *Environ. Health Perspect.* 127(10): 107003.

¹³ Zheng G et al. (2021) Per- and polyfluoroalkyl substances (PFAS) in breast milk: Concerning trends for current-use PFAS, *Environ. Sci. Technol.* 55(11): 7510–20, <https://doi.org/10.1021/acs.est.0c06978>; Blake BE and SE Fenton. (2020) Early life exposure to per- and polyfluoroalkyl substances (PFAS) and latent health outcomes: A review including the placenta as a target tissue and possible driver of peri- and postnatal effects, *Toxicol.* 443, 152565, <https://doi.org/10.1016/j.tox.2020.152565>.

¹⁴ Agency for Toxic Substances and Disease Registry (ATSDR). (2023) *PFAS in the U.S. Population*, <https://www.atsdr.cdc.gov/pfas/health-effects/us-population.html>.

¹⁵ Aro R et al. (2021) Organofluorine mass balance analysis of whole blood samples in relation to gender and age, *Environ. Sci. Technol.* 55(19): 13142–51, <https://doi.org/10.1021/acs.est.1c04031>.

¹⁶ Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Perfluoroalkyls (Atlanta, GA 2021); Attina B et al. (2022) Exposure to low-dose perfluorooctanoic acid promotes hepatic steatosis and disrupts the hepatic transcriptome in mice, *Molec. Metabol.* 66, 101602, <https://doi.org/10.1016/j.molmet.2022.101602>.

¹⁷ Tucker DK et al. (2015) The mammary gland is a sensitive pubertal target in CD-1 and C57BL/6 mice following perinatal perfluorooctanoic acid (PFOA) exposure, *Repro. Toxicol.* 54: 26–36, <https://doi.org/10.1016/j.reprotox.2014.12.002>; Kay JE et al. (2022) Chemical effects on breast development, function, and cancer risk: Existing knowledge and new opportunities, *Curr. Environ. Health Rep.* 9(4): 535–62, <https://doi.org/10.1007/s40572-022-00376-2>.

¹⁸ Timmermann CAG et al. (2017) Shorter duration of breastfeeding at elevated exposures to perfluoroalkyl substances, *Repro. Toxicol.* 68: 164–70, <https://doi.org/10.1016/j.reprotox.2016.07.010>; Romano ME et al. (2016) Maternal serum perfluoroalkyl

are a sensitive subpopulation who are especially vulnerable to the harmful effects of PFAS, notably lowered effectiveness of childhood vaccinations, abnormal lipids, reduced kidney function, asthma, and delayed puberty.¹⁹

We must address inequities in PFAS exposures and responses

The health and economic costs of PFAS are not evenly distributed. Public water systems serving small communities, particularly in rural areas, do not have the resources to cover the cost of PFAS testing and treatment and need more federal support. In a study I co-authored, we found that communities with higher proportions of Hispanic/Latino residents and Black residents are more likely to be exposed to harmful levels of PFAS in their drinking water supplies.²⁰ In another study I led as senior author, we found that counties with at least one major PFAS pollution source had higher percentages of Hispanic/Latino residents and Black residents than counties that did not.²¹ These disparities are likely the result of disproportionate siting of sources of PFAS pollution near watersheds serving these communities. Other research has shown that a disproportionate number of low-income households and people of color live within 5 miles of a PFAS-contaminated site.²²

Contamination of local waterways means that PFAS build up in fish and shellfish, particularly long-chain PFAS that are most likely to bioaccumulate.²³ Subsistence fishers and Tribal communities may be especially vulnerable because of their reliance on local food sources. As part of the federally funded STEEP Superfund Research Program, I am working with members of the Mashpee Wampanoag Tribe on Cape Cod to understand how their traditional harvesting of fish and shellfish may increase their exposure to PFAS.

Impacted communities need resources for testing and improved clinical care

Severe contamination takes a toll on communities. I have heard from grassroots activists in dozens of communities across the U.S. I have heard from anguished parents, who feel guilt for having exposed their children without even knowing during pregnancy and breastfeeding. I have heard from farmers who have lost their livelihood because their land has been polluted with these invisible toxic chemicals. And I have heard from too many people who have lost loved ones or endured diseases that they suspect were caused by PFAS. They face a lifetime of uncertainty and questions about possible long-term effects on their health.

substances during pregnancy and duration of breastfeeding, *Environ. Res.* 149: 239-46, <https://doi.org/10.1016/j.envres.2016.04.034>.

¹⁹ Rappazzo KM et al. (2017) Exposure to perfluorinated alkyl substances and health outcomes in children: A systematic review of the epidemiologic literature, *Int. J. Environ. Res. Public Health* 14(7), <https://doi.org/10.3390/ijerph14070691>.

²⁰ Liddie JM et al. (2023) Sociodemographic factors are associated with the abundance of PFAS sources and detections in U.S. community water systems, *Environ. Sci. Technol.* 57(21): 7902-12, <https://doi.org/https://doi.org/10.1021/acs.est.2c07255>.

²¹ Maruzzo AJ et al. (In press) Socioeconomic disparities in exposures to PFAS and other unregulated industrial drinking water contaminants in U.S. public water systems, *Environ. Health Perspect.* DOI: 10.1289/EHP14721.

²² Desikan A et al. (2019) *Abandoned Science, Broken Promises*, Union of Concerned Scientists, <https://www.ucsusa.org/sites/default/files/2019-10/abandoned-science-broken-promises-web-final.pdf>.

²³ Barbo N et al. (2023) Locally caught freshwater fish across the United States are likely a significant source of exposure to PFOS and other perfluorinated compounds, *Environ. Res.* 220, 115165, <https://doi.org/10.1016/j.envres.2022.115165>.

Yet healthcare systems and medical training have not caught up with this emerging tragedy. When residents approach their doctors with questions about PFAS, they are often frustrated when clinicians are unprepared to answer their questions and unable to provide access to PFAS blood testing to evaluate their exposure levels. A crucial 2022 report by the National Academies of Sciences, Engineering, and Medicine (NASEM) highlighted the benefits of offering PFAS blood testing to people with likely exposures and provided guidance for how results of PFAS blood tests can inform clinical care.²⁴ However, accessing PFAS blood testing remains a challenge, since these tests can be expensive and rarely covered by insurance. There is progress on this front; the state of New Hampshire now requires insurers to cover the cost of PFAS blood testing,²⁵ and similar policies are needed nationwide. The NASEM report, as well as guidance documents developed by ATSDR and by our own PFAS-REACH study—a federally funded study started in 2018 to empower communities and understand health effects—can support doctors in using information about PFAS exposure to improve patient care. These resources need to be expanded.

We need to tackle PFAS as a class rather than regulating individually

According to EPA, there are over 14,000 chemical structures classified as PFAS.²⁶ Over 1,400 individual PFAS have been associated with industrial uses and consumer products.²⁷ This means it is simply not possible to evaluate the toxicity of each one and regulate them all individually.

We need to turn off the tap on unnecessary uses of PFAS and to develop alternative products and solutions. Many everyday uses of PFAS are not essential.²⁸ The inclusion of PFAS in products such as cosmetics, dental floss, and home textiles do not represent a benefit for health and safety and lead to unnecessary exposures and environmental contamination. For some other uses, like firefighting foam, effective alternatives already exist²⁹ and their adoption has been prompted in large part by regulatory pressure on industry to develop these alternatives.

Major public health organizations and scientific experts have called for regulating PFAS as a class—restricting all types of PFAS rather than individual PFAS chemicals or subgroups—due to chemical similarities and shared toxicity and persistence. This includes the American Public Health Association³⁰ and a number of expert scientists including Dr. Linda Birnbaum, former head

²⁴ National Academies of Sciences Engineering and Medicine (2022) *Guidance on PFAS Exposure, Testing, and Clinical Follow-Up* (Washington, DC: The National Academies Press). <https://nap.nationalacademies.org/catalog/26156/guidance-on-pfas-exposure-testing-and-clinical-follow-up>.

²⁵ New Hampshire Legislature, Chapter 485-H, Per and Polyfluoroalkyl Substances (PFAS): Funds and Programs, (2020). https://legiscan.com/NH/text/HB1264/id/2194036/New_Hampshire-2020-HB1264-Amended.html.

²⁶ U.S. EPA. (2022) *PFAS Structures in DSSTox* <https://comptox.epa.gov/dashboard/chemical-lists/PFASSTRUCTV5>.

²⁷ Glüge et al., *Environ. Sci. Proc. Imp.* 22(12): 2345-73.

²⁸ Cousins IT et al. (2019) The concept of essential use for determining when uses of PFASs can be phased out, *Environ. Sci. Proc. Imp.* 21(11): 1803-15. <https://doi.org/10.1039/c9em00163h>.

²⁹ IPEN. (2019) *The Global PFAS Problem: Fluorine-free Alternatives as Solutions*, Stockholm Convention COP-9, https://ipen.org/sites/default/files/documents/the_global_pfas_problem-v1_5_final_18_april.pdf.

³⁰ American Public Health Association. (2016) *Reducing Human Exposure to Highly Fluorinated Chemicals to Protect Public Health*, <https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2016/12/21/reducing-human-exposure-to-highly-fluorinated-chemicals>.

of the National Institute for Environmental Health Sciences.³¹ In 2019, the European Union recommended an action plan to eliminate all non-essential uses of PFAS,³² indicating regulatory agencies are already moving in this direction.

These concerns extend to fluorinated polymers—large PFAS molecules built from repeating chemical units—such as polytetrafluoroethylene (PTFE), also known as Teflon. Although industry points to the structural differences between large polymer molecules and smaller non-polymer PFAS like PFOS and PFOA that are most often found in our bodies and environment, fluorinated polymers also raise numerous concerns.³³ Production of fluorinated polymers can expose workers and nearby communities to other PFAS. And products containing fluorinated polymers can contaminate the environment with PFAS after disposal.

We need to reform our chemical regulation system to protect public health

We need to learn from our past mistakes. We keep releasing untested chemicals into the environment, only to find out too late that they are toxic and then we cannot get rid of them or that it is too costly. Our institute was named in honor of Rachel Carson's pivotal 1964 book, *Silent Spring*. She was a visionary who saw the immense threats posed by the chemical industry to human health and ecological systems. But as a society, we have not heeded Rachel Carson's warnings. As she wrote in *Silent Spring*, "If we are going to live so intimately with these chemicals eating and drinking them, taking them into the very marrow of our bones - we had better know something about their nature and their power."

We often do not pay attention to possible harms of chemicals until it is too late. Our regulatory policies often take an innocent until proven guilty approach, and often fail to act until exposures are already widespread and the health effects can no longer be ignored. There is no way to rein chemicals back in once they have been released into the world, especially extremely persistent chemicals like PFAS. Unfortunately, PFAS are just the latest chapter in a long history, after DDT, PCBs, brominated flame retardants, and other extremely persistent synthetic chemicals. We are still dealing with the costly messes from chemicals manufactured decades ago. We also know, however, that government action can have significant impacts—there were substantial declines in children's blood lead levels following the phase out of leaded gasoline and remarkable recoveries of bird of prey populations after DDT was banned. We need to act now to address the enormous challenges of PFAS and truly protect future generations.

³¹ Kwiatkowski CF et al. (2020) Scientific basis for managing PFAS as a chemical class, *Environ. Sci. Technol. Lett.* 7(8): 532-43, <https://doi.org/10.1021/acs.estlett.0c00255>; Blum A et al. (2015) The Madrid Statement on Poly- and Perfluoroalkyl Substances (PFASs), *Environ. Health Perspect.* 123: A107-11, <https://doi.org/10.1289/ehp.1509934>; Birnbaum LS and P Grandjean. (2015) Alternatives to PFASs: Perspectives on the science, *Environ. Health Perspect.* 123: A104-A05, <https://doi.org/10.1289/ehp.1509944>.

³² Council of the European Union (2019). *Towards a Sustainable Chemicals Policy Strategy of the Union*. (Brussels, Belgium). <https://www.consilium.europa.eu/media/40042/st10713-en19.pdf>.

³³ Lohmann R et al. (2020) Are fluoropolymers really of low concern for human and environmental health and separate from other PFAS?, *Environ. Sci. Technol.* 54(20): 12820-28, <https://doi.org/10.1021/acs.est.0c03244>.

Senator MERKLEY. Thank you very much, Doctor.
Now we will turn to Dr. Fenton. Thank you.

STATEMENT OF SUE FENTON, PH.D., DIRECTOR OF THE CENTER FOR HUMAN HEALTH AND THE ENVIRONMENT, PROFESSOR OF BIOLOGICAL SCIENCES, NORTH CAROLINA STATE UNIVERSITY

Ms. FENTON. Good morning, Chairman Merkley, Ranking Member Mullin, Chairman Carper. I am honored to be here for your last round.

Two decades ago, my EPA colleagues and I discovered that newborn mice exposed to PFOA during pregnancy were dying. PFOA caused a dose-dependent decrease in birth weight of mouse pups. But even those that appeared healthy at birth died several days later.

We reported a few years later, for the first time, that PFOA caused deficits in lactation, was transferred across the mouse placenta, was present in the breast milk of mice and women exposed to PFAS, and induced obesity and persistent breast developmental abnormalities during puberty from just a pregnancy exposure.

Around that same time, PFAS and PFOA were voluntarily phased out of the market by the manufacturers. But by then, most Americans had it in their blood. Most of us here today, and I have looked at the room, have been exposed to PFAS as young adults. But a lot of the people sitting behind me were exposed in utero. They may have received up to 40 percent of their mom's body burden of PFAS.

Today, it is likely that all U.S. children are born with a PFAS body burden and we have evidence of that from the CDC testing that is shown in Figure 1 on the screen. For several reasons, children are more vulnerable to the effects of PFAS than adults. Body burdens in children are higher, because they are breast fed. In America, human breast milk levels of PFAS and PFOA are at or above ATSDR's children drinking water screening level for these PFAS.

We don't have a crystal ball to predict the severity of the health effects for this prenatally exposed generation. But scientists like myself are very concerned.

In general, health effects associated with PFAS exposure include many of the things that Senator Merkley described in his opening remarks, and are really nicely summarized in the two documents that I have provided to the committee in your documents, the PFAS report to Congress and a highly cited paper by myself and other PFAS experts.

Senator MERKLEY. Without objection, we will have those entered into the record. Thank you.

Ms. FENTON. Although pregnant women and children are more vulnerable to the effects of PFAS, the 2022 National Academy report only provided clinical guidance for adults. Many new papers have emerged since this guidance was published, including alarming data indicating increased risks of fatty liver disease in children associated with PFAS exposure. Children don't usually have fatty liver disease.

Due to the shorter half life in humans and rodents, GenX was offered by industry as a safer alternative to PFOA. However, my own studies in pregnant mice exposed to equivalent doses of PFOA and GenX finds they have similar health effects, especially fatty liver disease and metabolic disease. Therefore, GenX is not a safer alternative for PFOA.

These toxicities in studies are super important for the people living in contaminated counties of North Carolina who were exposed to GenX in their drinking water and other perchloro ethers for decades. They will likely suffer health effects later in their life.

NC State faculty are engaged with these communities and their families, and they deserve to be followed for health effects, just like the science panel study on the health effects of PFOA many years ago.

Today, women of reproductive age were born between approximately 1992 and 2004, when PFAS and PFOA were at their highest levels in human blood. So the body burdens of these legacy chemicals are high. But these women, of the age that are in this room, are also exposed to emerging chemicals that we know very little about. We can't wait 20 more years to determine the health effects of PFAS exposures that are currently being passed from one generation to the next.

Ongoing studies at federally funded labs across the U.S. are evaluating the effects of replacement PFAS, comparing those to known effects of legacy PFAS. While many studies can be done, we know enough today to say that replacement PFAS are not safe replacements.

I ask this committee to promote the following suggestions to protect public health. Develop new and support current legislation to limit PFAS production and use as much as possible. Require health insurance companies to pay for PFAS testing for susceptible populations, like tribal communities, pregnant women and children.

Empower the National Academy to update clinical guidance on PFAS to include children and pregnant women. Commit NIEHS and NC Cancer Moon Shot funds to develop a longitudinal health study on replacement PFAS exposure communities, especially those that may have been prenatally exposed. Oppose efforts to weaken CERCLA.

Phase out PFAS-containing fire foam. Require companies to provide standards in any purified forms of any PFAS they produce. Fund innovative developmental methods to remove replacement PFAS from drinking water. And require PFAS producers and not taxpayers to fund the development of safe destruction methods that fully capture, mineralize and destroy PFAS.

Please continue to move forward with our efforts to keep PFAS out of our environment. Remember, once it gets there, it takes billions of dollars and decades or generations to get rid of it. Our taxpayer dollars can go to better purposes than PFAS cleanup stemming from lucrative industries.

I do want to say that the current rules that are in place are really a win-win. They are not only removing PFAS, but they are also removing other contaminants that are commingled.

I want to thank you for your time and your influence.

[The prepared statement of Ms. Fenton follows:]



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Testimony of Suzanne (Sue) E. Fenton
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before the

U.S. Senate Committee on Environment and Public Works
Subcommittee on Chemical Safety, Waste Management, Environmental Justice and Regulatory Oversight

December 5, 2024

Good morning, Chairman Merkley, Ranking Member Mullin, and Members of the EPW Committee. Thank you for holding this hearing to examine the public health impacts of PFAS exposures, especially as it pertains to the current generation of young adults, who would have been exposed in utero or as infants and children.

My name is Sue Fenton, and I am the Director of the National Institute of Environmental Health Sciences (NIEHS)-funded Center for Human Health and the Environment at North Carolina State University. I am a reproductive endocrinologist, specialized in developmental origins of adult health, lactation and breast cancer, and have been conducting research on PFAS-induced health effects for the last 2 decades. I led PFAS research at the USEPA up to 2009 and at the NIEHS from 2009-2023, in Research Triangle Park, NC. As you may know, NC is contaminated with both legacy (long-chain PFAS that have been around for a long time and phased out of production – and have left their “legacy” behind) and emerging or data-poor PFAS, often referring to replacement structures, such as GenX and other perfluoroalkyl ethers. Exposure to both legacy and emerging PFAS is known to be associated with widespread human health impacts.

My initial work focused on why newborn mice of mothers exposed during pregnancy were dying from increasing doses of PFOA (a well-known legacy PFAS). We knew that PFOA caused a dose-dependent decrease in birth weight of mouse pups, but even those that appeared healthy at birth died several days later¹. With the help of exceptional analytical chemists at the USEPA and the CDC, by 2009 we had reported for the first time that PFOA transfers across the placenta into the newborn mouse, and is also present in the milk of mice^{2,3} and women⁴. It turned out that the mammary gland was quite sensitive to the effects of PFOA, and it not only decreased the ability of lactating mice to adequately nurse their newborns³, but also caused breast developmental abnormalities during puberty in female offspring which persisted into adult life^{5,6}. In 2022, I worked with international collaborators to publish a systematic review demonstrating that women from all over the world had shortened lactation duration

and difficulty initiating nursing associated with increased PFAS exposures⁷. Additional studies have been published since then showing consistency of PFAS effects on lactation^{8,9}.

Abnormal breast development and impaired ability to breastfeed induce social, health-related, and economic outcomes. Significant health benefits of lactation exist for the mother, whereby the adverse cardiometabolic changes during pregnancy are sort of reset by breastfeeding. In contrast, without breastfeeding, these metabolic changes persist¹⁰. The many benefits of human milk for children are well known, with health benefits such as immune system maturation extending into adulthood^{11,12}. Breastfeeding occurs at no financial cost to the mother and family and is a real asset to those on a strict budget. In contrast, the alternative to breastfeeding is to prepare infant formula and milk, which is typically sold as a powder and reconstituted in water. While this is a wonderful resource to have available, the costs associated with providing infant formula and milk are substantial, and they are not typically monitored for PFAS contaminants.

Now, I want to take a step back. According to internal 3M and Dupont documents discovered through court proceedings, and reported by Environmental Working Group¹³, already in the late 1970s there was evidence that PFOA and PFOS accumulated in the blood of workers. By the early 1980's Dupont workers had evidence of liver damage and female Teflon workers were reassigned due to teratogenic effects in animal studies. By 1984, PFOA was detected in the Little Hocking River by Dupont, but the community was not made aware. The year 2000 is about the time that 3M discovered that PFOS was measurable in polar bears and found in other regions of world where there was no production plant or source of the chemical. EPA requested and 3M agreed to discontinue making PFOS, but it was already in numerous products including aqueous film-forming foam that was used heavily at military and commercial airports and other fire training sites across the U.S. for decades. Production of PFOA and other long-chain chemicals was also largely discontinued in the US by about 2012, again because of the extent of contaminated water sources and the reports of health effects in rodents and humans¹⁴. I tell you this because it is very likely that most of us in this room were exposed to PFAS as young adults or maybe adolescents, but my children, and all children born after ~2000 or so were exposed in utero. I had three children, and based on several papers showing maternal:fetal transfer¹⁵, it is safe to say that my first born received 20-40% of my body burden of PFAS when he was born. The generation that is currently showing disease (such as cancer) due to PFAS exposure, were likely mainly exposed postnatally, potentially as young adults. Yet it is currently theorized that all U.S. children are born with a PFAS body burden, suggesting that impacts from PFAS exposure (both prenatally and postnatally) in this generation could be exacerbated. Supporting this, there are hundreds of peer-reviewed papers demonstrating that low doses of PFAS induce health effects in animals exposed in utero¹⁶.

Sadly, body burdens in children are higher if they are breast fed¹⁷. A 2023 review of available datasets¹⁸ demonstrated that most studies from around the globe reported human milk levels of PFOA and PFOS at or above ATSDR's "children's drinking water screening level" for these PFAS (at or above 21 pg/mL (ppt)). This indicates that breast milk could be a substantial source of legacy PFAS (data available for PFOA, PFOS, PFHxS and PFNA) to the infant. Some studies have also shown PFAS contamination of infant formula and animal milk, neither or which are

monitored regularly for PFAS. Further, there is a risk that infant formula could be reconstituted with contaminated drinking water. Despite the many gaps on the impacts of PFAS contamination on breastmilk and its replacements, breast feeding is still highly recommended due to its many positive qualities.

There are many known effects of PFAS on human health¹⁶, reported in a highly cited review I wrote with the help of many other PFAS experts, such as lower birth weight, liver disease, kidney and testicular cancer, thyroid and reproductive function, cardiometabolic disease (cholesterol, obesity), inadequate immune response, and adverse mammary gland changes. Several of these were noted by the National Academy of Science, Engineering, and Medicine (NASEM) in their Guidance on PFAS Exposure, Testing, and Clinical Follow-Up¹⁹, specifically because they had authoritative or systematic reviews published. One of the health effects agreed upon by NASEM was dyslipidemia, which is a holistic term for changes in cholesterol, triglycerides and other fatty acid changes induced by PFAS in humans and rodents. Dyslipidemia is intricately connected to metabolic disease. This is important when considering the constellation of health effects observed while studying the PFOA replacement chemical, GenX²⁰.

GenX has a much shorter half-life in humans (a month vs years) and rodents), which is why industry promoted it as a safer alternative to PFOA. We tested PFOA and GenX at equivalent doses in pregnant mice and found that although GenX did not accumulate in the livers of offspring, it did increase fatty liver disease in males and females, altered insulin levels, increased body fat mass, and altered lipids²¹. We measured these outcomes at 3 life stages (late childhood, young adult and mature adult) and reported progression of effects over time, all of which were prominent in mature adults. So, despite being cleared from the body more quickly than PFOA, we found GenX to be similarly toxic, and capable of inducing metabolic disease in mice. GenX also caused adverse placental:fetal weight ratios, placental pathology, and increased gestational weight gain in pregnant mothers²⁰. In fact, whole genome analysis of maternal and fetal livers showed the same set of differentially expressed genes for PFOA and GenX²⁶, demonstrating that although the GenX was not measurable in the offspring, the effects were present both at the genomic level and in phenotypes evident later in life²².

Pregnant women and children are more vulnerable to the effects of PFAS; however, the NASEM report provides clinical guidance on adults only— not children. Many new papers have emerged since the NASEM clinical guidance was published, thus the guidance needs to be revisited and updated. For example, new/recent research from multiple cohorts demonstrate that the odds of children having metabolic dysfunction-associated fatty liver disease (MAFLD) or nonalcoholic steatohepatitis (NASH), was significantly increased by various PFAS, including PFHpA, a 7-carbon carboxylic acid²³⁻²⁵. Historically, children do not develop severe liver disease, but cases are rising in the U.S., Europe and China²⁶ and it may be entirely due to inadvertent in utero PFAS exposures. PFHpA also induces platinum-based chemotherapy resistance in ovarian cancer cells²⁷, and adverse pregnancy and other reproductive outcomes²⁸⁻²⁹.

People in communities near active PFAS production are in desperate need of more guidance and protection. For example, the people living in the NC counties between Wilmington and Fayetteville were exposed to GenX for decades in their drinking water. Though they do not have detectable blood levels now, there is no telling the health

effects they will suffer in later life due to their early life and in utero exposures. These communities deserve to be followed for health effects, like the C8 Science Panel³⁰ studied health effects of PFOA many years ago.

PFAS blood testing must be made available to all Americans, and especially for some special populations such as firefighters, elderly, indigenous and rural communities, and women that are pregnant or of reproductive age so they can make informed decisions with their caregivers. Today, women of reproductive age were born between 1992-2004, when PFOA and PFOS were at their highest levels in human blood – so, their body burdens of legacy chemicals are high (relatively speaking). However, based on total organic fluorine studies, they also had exposures to emerging chemicals that we know little about³¹. We cannot wait another 20 years to find out the resulting health effects for those women or their resulting children. Studies at NC State, EPA, and other NIEHS-funded Centers across the U.S. are evaluating the effects of emerging PFAS in cell lines and rodent models, in comparison with “known” effects of legacy PFAS. While more studies are needed to understand some aspects of the health implications, we do know enough to say that replacement PFAS are not safer than the legacy PFAS.

As environmental monitoring and biomonitoring becomes available, efforts should be made to ensure that testing is affordable and accessible. Our Centers at NC State have recently worked with communities in Alamance County where unlined landfills were causing PFAS exposure and the individuals needed blood testing and resources for whole house water filtration, but the county couldn’t help them. Our Center was able to provide blood testing for the exposed neighborhood and helped them to understand their results. Based on those results, the community liaison worked with the NC State Superfund Center focused on PFAS to secure whole house filtration so the families could have PFAS-free water access.

Another way to speed up our knowledge on health effects is to develop novel assays and sensitive methods that are conducive to dried blood strips and other materials that will be easily stored over time. A collaboration between the VA, DoD and NC State (funded through PROMETHEUS and Murtha Cancer Center) is currently developing health effect biomarkers using in vitro activity and molecular assays with dried blood strips, matched with gold standard tests in venous blood. How these biomarkers relate to PFAS exposures of civilian and military firefighters will be determined.

I ask this important Committee to consider and promote the following suggestions to protect public health, today –

1. Urge EPA to adopt a science-based definition of PFAS, as Congress, the DoD, many states, and the international community already have done^{32, 33}. Currently EPA has opted to define PFAS on a case-by-case basis, causing unnecessary confusion, and none of the definitions used so far by EPA are scientifically justified.
2. Develop new and support current legislation to restrict PFAS production and use as much as possible³⁴. New PFAS should not receive expedited TSCA review. If PFAS were comprehensively tested for safety, they would

likely not be approved. Policies like Minnesota's 2023 Amara's Law³⁵ and the EU Universal PFAS restriction provide models for the type of comprehensive action that is needed^{36, 37}.

3. Legislation is needed that requires health insurance companies to pay for PFAS blood testing. The NASEM¹⁹ has already identified populations at risk and recommend this as part of health care follow-up - include civilian and military firefighters, women of reproductive age, children, farmers, indigenous communities living off the land, and others living in polluted areas.
4. Empower NASEM to update their Clinical Guidance on PFAS¹⁹ to include guidance for children and pregnant women and expand the panel's expertise to include immunologist and lactation specialist to the team³⁸.
5. Commit NIEHS and NCI Cancer Moonshot³⁹ funds to develop a longitudinal health study in emerging PFAS exposed communities (GenX, PFMOAA, Nafion Byproducts), especially focused on prenatally exposed individuals.
6. Oppose efforts to weaken CERCLA. This would remove the strong incentives in place that are critical to ensuring all parties exercise due care in handling highly toxic chemicals like PFAS and meet requirements to stop PFAS pollution at its source.
7. Aqueous film forming foam (AFFF) is a highly concentrated source of PFAS contamination. Now that there are MilSpec fluorine free foams, PFAS containing AFFF should be phased out nationally.
8. Laws are needed that require companies to provide standards and purified forms of any PFAS they produce to EPA to allow environmental and toxicological testing and biomonitoring. Currently they are inappropriately being claimed as confidential business information. For example, a PFAS found in firefighting foam⁴⁰ is unavailable for us to purchase and use to test. Short-term animal studies or comparative in vitro screening bioassays could be run to see how they compare with known "bad actors". This is currently a practice in place for pesticides.
9. Support funding to develop novel methods to remove replacement PFAS that are more difficult to remediate from drinking water to help protect communities impacted by proximity to manufacturing plants, such as those in the Cape Fear River basin in NC (e.g., PFMOAA³⁰ and Nafion byproducts⁴¹).
10. PFAS producers – not taxpayers – must fund the development of safe destruction methods that fully capture, mineralize, and destroy PFAS. Require them to work with EPA to break the contamination cycle! None of the disposal options in EPA's Interim Guidance on the Destruction and Disposal of PFAS⁴² fully prevent PFAS wastes from contaminating the environment.

PFAS require a comprehensive approach - we must limit new PFAS coming onto the market while at the same time cleaning up (and destroying) the contamination that has already happened. Thank you so much for your time and your influence. Please continue to move toward removing PFAS from our environment. Remember, once it gets in, it takes billions of dollars and decades (generations) to get rid of it. Taxpayer dollars should be used for better purposes than PFAS cleanup stemming from lucrative industries.

Respectfully submitted,

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*Per- and Polyfluoroalkyl Substances (PFAS)
Federal Research and Development Strategic Plan*

A Report by the
JOINT SUBCOMMITTEE ON ENVIRONMENT, INNOVATION, AND
PUBLIC HEALTH
PFAS Strategy Team
of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

AUGUST 2024

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About the PFAS Strategy Team

Congress directed an Interagency Working Group (IWG) to coordinate federal research on Per- and Polyfluoroalkyl Substances (PFAS) through the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021.¹ In response, OSTP developed the PFAS Strategy Team (PFAS ST) under the Joint Subcommittee on Environment, Innovation, and Public Health (JEEP) in late 2021. The PFAS ST coordinates interagency PFAS research and development activities and supports the development and implementation of the PFAS strategic research plan. The PFAS ST is co-chaired by OSTP, Department of Energy (DOE), and Department of Defense (DOD).

About this Document

The NDAA for FY 2021 directs the PFAS ST to identify all currently federally funded PFAS research and development; to identify scientific and technological challenges that must be addressed to understand and to significantly reduce the environmental and human health impacts of PFAS; to identify cost-effective (1) alternatives to PFAS that are designed to be safer and more environmentally friendly, (2) methods for removal of PFAS from the environment, and (3) methods to safely destroy or degrade PFAS; and to establish goals and priorities for federally funded PFAS research and development that take into

¹ William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, (P.L. 116-283) (hereafter "NDAA for FY 2021") Section 332.

account the current state of research and development. The PFAS ST solicited input from member agencies about ongoing and prospective research and development efforts for PFAS, based on the scientific and technological challenges.

The PFAS Federal Research and Development Strategic Plan provides a federal strategy and implementation plan for addressing the strategic areas identified in the 2023 PFAS Report.² This strategic plan is intended to be a companion document to the 2023 PFAS Report; the first report provided the background on PFAS and context for the development of this strategic plan. The activities described in this document are reviewed through the Office of Management and Budget (OMB) annual budget process and subject to available resources.

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² NSTC PFAS Strategy Team, "Per- and Polyfluoroalkyl Substances (PFAS) Report." March 2023, https://www.whitehouse.gov/ostp/news-updates/2023/03/14/nstc_pfas_report

³ See 17 U.S.C. §105

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Abbreviations and Acronyms

ADME	Absorption, distribution, metabolism, and excretion	NASA	National Aeronautics and Space Administration
AEE	FAA Office of Environment and Energy	NCEH	National Center for Environmental Health
AFFF	Aqueous Film-Forming Foams	NDAA	National Defense Authorization Act
AI	Artificial Intelligence	NIEHS	National Institute of Environmental Health Sciences
ARP	Office of the Associate Administrator for Airports	NIH	National Institutes of Health
ARS	Agricultural Research Service	NIOSH	National Institute for Occupational Safety and Health
ATSDR	Agency for Toxic Substances and Disease Registry	NIST	National Institute of Standards & Technology
BHSO	DOE Brookhaven Site Office	NNSA	National Nuclear Security Administration
CEQ	Council on Environmental Quality	NOAA	National Oceanic and Atmospheric Administration
CDC	Centers for Disease Control and Prevention	NSF	National Science Foundation
CDOC	Chief Data Officer Council	NSTC	National Science and Technology Council
CPSC	Consumer Product Safety Commission	NTA	Non-Targeted Analysis
DHS	Department of Homeland Security	OCE	USDA Office of the Chief Economist
DOC	Department of Commerce	OMB	Office of Management and Budget
DOD	Department of Defense	OSEC	USDA Office of the Executive Secretary
DOE	Department of Energy	OSTP	Office of Science and Technology Policy
DOI	Department of the Interior	PFAS	Per- and polyfluoroalkyl substances
DOT	Department of Transportation	QSAR	Quantitative Structure-Activity Relationship Model
EHSS	DOE Office of Environment, Health, Safety and Security	R&D	Research and Development
EM	DOE Office of Environmental Management	SBA	Small Business Administration
EOP	Executive Office of the President	SC	DOE Office of Science
EPA	Environmental Protection Agency	ST	Strategy Team
FAA	Federal Aviation Administration	USDA	United States Department of Agriculture
FDA	Food and Drug Administration	USGS	United States Geological Survey
FSIS	Food Safety and Inspection Service	VA	Department of Veterans Affairs
GAC	Granulated Activated Carbon		
HHS	Department of Health and Human Services		
IWG	Interagency Working Group		
JEEP	Joint Subcommittee on Environment, Innovation, and Public Health		
ML	Machine Learning		
NAM	New Approach Methodologies		

Executive Summary

President Biden has been clear that every community has the right to clean and safe water and products—free of harmful pollutants. The federal government is committed to delivering clean drinking water, clean air, safe consumer products, and safe food to everyone in America, and particularly to people in communities with environmental justice concerns. This includes reducing the harmful effects of exposure to per- and polyfluoroalkyl substances (PFAS) including certain types of cancer, decreased immune response, decreased birthweight, and increased cholesterol levels. Over the past several years, the Biden-Harris Administration has taken substantial action to accelerate efforts to prevent releases and expand cleanup of PFAS.⁴ In March 2023, the PFAS Strategy Team (PFAS ST) produced a state-of-the-science report that includes gaps and opportunities used for the development of this strategic plan.⁵ In addition, the 2023 PFAS report identified strategic areas of opportunity for future research including sources and pathways of exposure to PFAS; toxicity of PFAS; removal, destruction, and degradation of PFAS; and safer and environmentally friendlier alternatives to PFAS.⁶

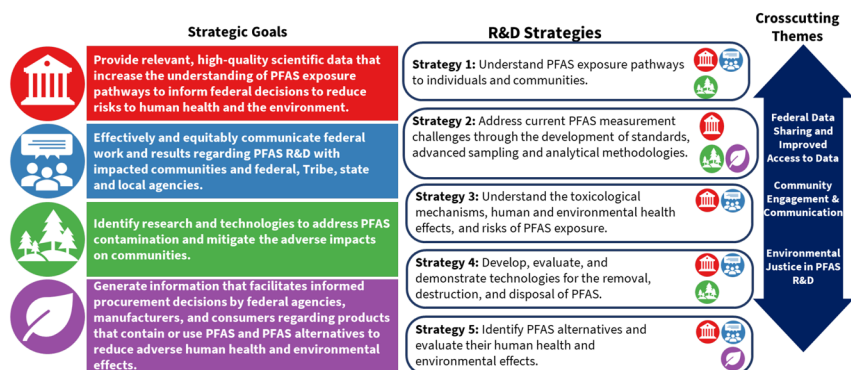


Figure 1. Visual diagram of the strategic goals, R&D strategies and crosscutting themes of the strategic plan.

⁴ White House Council on Environmental Quality, "Biden-Harris Administration Progress on Per- and Polyfluoroalkyl Substances: Steps Taken and Ongoing Actions." March 2023, <https://www.whitehouse.gov/wp-content/uploads/2023/03/CEQ-PFAS-Report-March-2023.pdf>

⁵ NSTC PFAS Strategy Team, "Per- and Polyfluoroalkyl Substances (PFAS) Report." March 2023, https://www.whitehouse.gov/ostp/news-updates/2023/03/14/nstc_pfes_report (hereafter referred to as the "2023 PFAS Report")

⁶ In this strategic plan, the PFAS ST identified five R&D strategies that address the four strategic priority areas found in the 2023 PFAS report.

Based on the four strategic areas presented in the 2023 PFAS Report, the PFAS ST identified four strategic goals that will drive federal research and development (R&D) efforts regarding PFAS:

1. Provide relevant, high-quality scientific data that increase the understanding of PFAS exposure pathways to inform federal decisions that reduce risks to human health and the environment;
2. Effectively and equitably communicate federal work and results regarding PFAS R&D through engagement with impacted communities and federal, Tribal, state and local agencies;
3. Identify research and technologies to address PFAS contamination and mitigate the adverse impacts on communities; and
4. Generate information that facilitates informed procurement decisions by federal agencies, manufacturers, and consumers regarding products that contain or use PFAS and PFAS alternatives to reduce adverse human health and environmental effects.

Within the strategic research areas, the PFAS ST has identified five R&D strategies that address the identified knowledge gaps. The five R&D strategies are:

1. Understand PFAS exposure pathways to individuals and communities;
2. Address current PFAS measurement challenges through the development of standards, advanced sampling and analytical methodologies;
3. Understand the toxicological mechanisms, human and environmental health effects, and risks of PFAS exposure;
4. Develop, evaluate, and demonstrate technologies for the removal, destruction, and disposal of PFAS; and
5. Identify PFAS alternatives and evaluate their human health and environmental effects.

In addition to the four strategic goals, there are specific themes that cut across most or all of the R&D strategies, including federal data sharing and improved access to data, community engagement and communication, and environmental justice in PFAS R&D. These crosscutting themes should be considered in all R&D activities.

This report presents the goals, objectives, and tasks for PFAS R&D for the next five years that, through interagency coordination, would further the federal government's actions to protect Americans from the harmful effects of PFAS.

I. Introduction

Background

PFAS are a group of chemicals that have unique characteristics due to their chemical structure that contributes to their persistent, bioaccumulative, and/or toxic properties. Certain PFAS may pose significant risks to human and environmental health. Through the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (Public Law 116-283), Congress instructed the Office of

Science and Technology Policy (OSTP) Director to coordinate interagency research and development regarding PFAS.

In March 2023, the PFAS ST, formed under the National Science and Technology Council (NSTC), released a report on the federal landscape regarding PFAS R&D.⁷ The 2023 PFAS Report provided a review of the state of the science related to PFAS research and development. The report identified four strategic areas for PFAS research: sources and pathways of exposure to PFAS; toxicity of PFAS; removal, destruction, and degradation of PFAS; and safer and environmentally friendlier alternatives to PFAS.

Driven by these areas of opportunity, the PFAS ST has developed this strategic plan, which identifies priority goals that align with the R&D objectives for the federal government to address PFAS knowledge gaps.

Scope of the PFAS R&D Strategic Plan

The focus of this strategic plan is on R&D objectives and implementation tasks that fulfill the strategic areas identified by the 2023 PFAS Report. The aim of these activities is to provide the best-available science for evidence-based policymaking. The strategic plan incorporates both near-term and long-term objectives, which can be achieved through intramural and extramural research. As the NDAA for FY 2021 instructs the PFAS ST to revisit this strategic plan every three years, the R&D strategies are intended to be broad and flexible to incorporate future innovation in PFAS research and emerging knowledge on PFAS.

The objectives and their respective tasks aim to inform federal and non-federal researchers about opportunities for future research. Tasks are written to provide flexibility for agencies and their programs to use their unique expertise and capabilities to address identified R&D needs. Some of the identified objectives and tasks align with ongoing R&D programs within federal agencies, but others will require new R&D program development.

There is a wide range of chemical structures that could exist under the definition of PFAS, including precursor compounds that transform into different PFAS. In addition, there are opportunities for federal agencies to prioritize PFAS individually or by defined categories according to chemical structure, physical-chemical properties, toxic effects, occurrence, use, or other characteristics. In addition, some PFAS have relatively more data available than others with regards to their physical, chemical, and toxicological properties, and therefore understudied PFAS may be more relevant for specific objectives and tasks. As individual federal agencies have different scopes and priorities, they will need to identify their own priority PFAS of concern or categories of PFAS relevant to specific agency activities. The scope of this strategic plan is to provide research that supports the development of individual agency PFAS priorities and enable interagency alignment of these priorities.

Crosscutting Themes for Interagency PFAS R&D

In addition to the four strategic goals, there are specific themes that cut across most or all of the R&D strategies. These crosscutting themes should be considered in all relevant R&D activities.

⁷ 2023 PFAS Report

Federal Data Sharing and Improved Access to Data

A key component of interagency coordination on PFAS R&D activities is the sustained sharing of data among federal agencies and with the research community; the general public; and state, local, Tribal, and territorial governments. Types of shared data for PFAS could include, but are not limited to, physical and chemical properties; computational models for PFAS mixtures (exposure and toxicity); analytical method parameters and performance; environmental and human health monitoring results; toxicological testing results; epidemiological investigation data; risk assessment data; removal, treatment, and destruction technology parameters and performance; and exposure mitigation technology parameters and performance. In addition, artificial intelligence (AI) and machine learning (ML) models that develop *in silico* approaches to PFAS characterization and risk assessment can be used to improve efforts in PFAS R&D.

Interagency data sharing increases efficiency and reduces duplication of efforts by individual federal agencies. Through interagency data and information sharing, federal agencies can prevent inadvertent repetition of research studies and data, and provide pathways for new research that builds from previous studies and result in the most efficient utilization of federally sponsored PFAS research funding. To encourage the efficient exchange of data among federal agencies, the barriers to meaningful communication need to be lowered. Recommendations to lower these barriers for interagency data sharing have been presented by the Chief Data Officer Council (CDOC) Data Sharing Working Group, and include developing expedited agreement processes for interagency data sharing; improving awareness of available federal data; and improving federal data trustworthiness.⁸ Incorporation of the recommendations by individual federal agencies and cooperation with guidance bodies, such as the CDOC, will enhance efforts to exchange relevant PFAS data among federal agencies.

In addition, high-quality data produced by federal agencies are valuable for the broader research community. Creating open-source databases and other data sources that provide PFAS data in accordance with Findable, Accessible, Interoperable and Reusable (FAIR) Principles,⁹ while ensuring privacy and confidentiality requirements related to data use are in accordance with federal law, will allow non-federal researchers to access and utilize the unique data, creating the opportunity to elevate ongoing and future research programs. A more automated, curated, transparent, and accountable federal data-sharing framework ensure scientific data can made available to inform decisions to reduce and/or prevent PFAS contamination and minimize risks to human health and the environment.

Community Engagement and Communication

Often PFAS studies, such as environmental monitoring and human biomonitoring studies, have results that are relevant to communities. Federal agencies should create timely opportunities to meaningfully engage impacted communities in the identification of research needs and study designs, addressing any possible barriers to such participation. In addition, agencies can provide context (including scientific uncertainties) and continued support after the results are shared, and collaboratively identify corrective actions (if needed). It is vital that information be shared in accessible language.

⁸ Chief Data Officer Council, Data Sharing Working Group. "Data Sharing Working Group Findings & Recommendations." https://resources.data.gov/assets/documents/2021_DSWG_Recommendations_and_Findings_508.pdf

⁹ GO FAIR Initiative, "FAIR Principles." <https://www.go-fair.org/fair-principles/>

Agencies should collaboratively develop communication approaches and tools for engaging impacted communities for input on their concerns in the identification of research needs and for the dissemination of R&D results and findings concerning PFAS exposure and the associated risks and health effects. This includes dissemination of high-quality information on potential sources of PFAS exposure; clinical guidance concerning PFAS exposure, risk-based recommended limits for exposures to different media, health effects, and the health care needs of those exposed; development, maintenance, and use of PFAS methodologies and databases for the purpose of determining shared ontologies and data integration; and the risks and benefits of the use of PFAS alternatives. Finally, communication strategies should incorporate multiple modes of communication (e.g., email updates, public meetings, fact sheets, science briefs, and social media) and address the communication needs of the impacted communities.

Environmental Justice in PFAS R&D

PFAS exposure through environmental contamination can disproportionately affect sensitive, or highly exposed, populations and lifestyles. Addressing PFAS exposure to vulnerable populations and communities with environmental justice concerns is essential for advancing environmental justice. Within the scope of the PFAS R&D strategy, it is important that federal agencies understand the impact of their research on communities, so federal agencies can use this information to accelerate ways to prevent, mitigate, and address the impacts of PFAS in these communities and advance environmental justice. These efforts should include specific funding opportunities focused on environmental justice considerations regarding PFAS. In addition, these efforts should provide meaningful engagement for communities with environmental justice concerns and Tribal nations to align data collection and research strategies that support the needs of these communities. Finally, federal efforts should advance the priorities articulated in the Environmental Justice Science, Data, and Research Plan.¹⁰

For PFAS monitoring and biomonitoring studies, mindful use of environmental justice tools, such as EJScreen,¹¹ the Climate and Economic Justice Screening Tool,¹² and the Agency for Toxic Substances and Disease Registry (ATSDR) Environmental Justice Index,¹³ can be used to provide socioeconomic and environmental information to understand the affected community, and how the study results may or may not represent other populations or communities.

II. Research and Development Strategy

Strategy 1: Understand PFAS exposure pathways to individuals and communities

PFAS are ubiquitous in outdoor and indoor environments due to their extensive uses, persistence in the environment, and limited prior control of PFAS releases due to a lack of data and technology. To

¹⁰ NSTC Environmental Justice Subcommittee, “Environmental Justice Science, Data, and Research Plan.” July 2024, <https://www.whitehouse.gov/wp-content/uploads/2024/07/NSTC-EJ-Research-Plan-July-2024.pdf>

¹¹ Environmental Protection Agency, “EJScreen: Environmental Justice Screening and Mapping Tool.” <https://www.epa.gov/ejscreen>

¹² Council on Environmental Quality, “Climate and Economic Justice Screening Tool.” <https://screeningtool.geoplatform.gov/>

¹³ Agency for Toxic Substances and Disease Registry, “Environmental Justice Index.” <https://www.atsdr.cdc.gov/placeandhealth/eji/index.html>

understand the prevalence of PFAS in our environment and how humans and biota can be exposed to PFAS, researchers need a more complete characterization of the presence, identity, and concentration of individual PFAS in the environment, including background (e.g., atmospheric deposition) levels. Studies are necessary for supporting a data-driven understanding of risks posed by PFAS exposure. In addition, the fate and behavior of PFAS in the environment is critical to fully characterizing a PFAS release. Developing models that accurately predict the fate and behavior of PFAS where there are limited model training data is important. Finally, studies will inform the occurrence and concentrations of PFAS in humans, biota, and the environment. With this more complete picture of pathways of exposure, there will be a better understanding of the extent of PFAS exposures and the locations of potentially highly exposed populations; this understanding can inform clean-up activities and identify specific technology needs for PFAS removal, destruction, and disposal.

Objective 1.1: Further evaluate occurrence, identity, and concentrations of PFAS in various environmental media to understand the extent of potential exposure routes and inform quantitative exposure assessments for risk assessment.

Previous studies have contributed to the understanding of the extent of PFAS contamination in the environment.¹⁴ However, expansion of studies to conventionally understudied exposure sources and pathways, as well as the analysis of ongoing national drinking water studies, are necessary to understand where PFAS exposure occurs. Additionally, many individual studies of PFAS occurrence and distribution associated with local or regional sources have been conducted. However studies providing a better understanding of the distribution of PFAS in environmental media (atmospheric media, drinking water, surface and groundwater, sediment, soil, and marine media) for the United States in its entirety are needed and are now beginning to be determined. To understand the extent of PFAS contamination and human exposure, it is important that researchers develop and improve analytical methods to detect additional PFAS of concern, which is the scope of Strategy 2. Mixtures of PFAS in the environment occur from single-event releases (e.g., aqueous film-forming foam (AFFF) release during firefighting events), continued point-source discharges, and additional sources of PFAS, which have the potential for human and environmental exposure. Finally, occurrence and exposure efforts should consider potential disproportionate impact on specific populations and special exposure scenarios for potentially susceptible lifestages, such as fetal or early childhood development.

Task 1.1.1: Enhance environmental ambient sampling and analysis efforts for PFAS, including atmospheric emissions and deposition and transport, drinking water, groundwater, and both freshwater and marine surface waters and their associated sediments. This should include a long-term, national-scale environmental ambient PFAS monitoring study to include PFAS levels in soil, air, atmospheric wet/dry deposition, surface waters, and groundwater.

Task 1.1.2: Further characterize potential PFAS exposures in the built environment, including schools, workplaces, and other indoor/household environments. This would include the co-occurrence and use of consumer products and understanding the lifecycle of products with regard to PFAS exposure.

¹⁴ Evich MG, Davis MJB, McCord JP, Acrey B, Awkerman JA, Knappe DRU, Lindstrom AB, Speth TF, Tebes-Stevens C, Strynar MJ, Wang Z, Weber EJ, Henderson WM, Washington JW. Per- and polyfluoroalkyl substances in the environment. *Science*. 2022 Feb 4;375(6580). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8902460/>

Task 1.1.3: Develop and support additional food product sampling and analysis for PFAS, including foods grown or raised in areas with water contamination; animal/livestock feed ingredients; general population dietary items; fish, wildlife, and plants related to subsistence and cultural practices of Tribal populations and other communities, developing fetuses, infants, or children; and food packaging and processing. Develop reference materials in food to support agricultural research.

Task 1.1.4: Support and expand food and animal/livestock feed production sampling and analysis for PFAS to include rural and urban soils, aquaculture systems, areas using reclaimed/reuse water, areas using contaminated groundwater, domestic sludge, and biosolids- and compost-impacted soils.

Task 1.1.5: Initiate studies regarding PFAS co-exposure and potential interactions with other contaminants (including other PFAS) in environmental samples, such as nano- and microplastics, petroleum constituents, metals, pesticides, and pharmaceuticals.

Task 1.1.6: Characterize exposures from previously unstudied or understudied sources of PFAS and their contribution to overall PFAS exposures for a comprehensive understanding of the breadth of PFAS exposures across the United States. This could include studies to understand the behavioral drivers of PFAS exposure.

Task 1.1.7: Develop and strengthen federal partnerships with state, local, and Tribal communities, territories, and private industries, for long-term understanding of PFAS exposures, including PFAS-impacted environments in communities with environmental justice concerns.

Task 1.1.8: Advance analytical and computational techniques for source attribution of PFAS contamination, including forensic methods and source contamination databases and modeling tools.

Objective 1.2: Characterize the bioaccumulation, biotic and abiotic transformation, and food web behavior of individual and mixtures of PFAS.

Given their unique physical and chemical properties,¹⁵ certain PFAS are known to bioaccumulate and persist in humans and the environment. Some PFAS can be mobile in the environment and have been detected around the world, including in remote regions. The fate and behavior of PFAS, individually and as mixtures, in the environment can influence the assessment of health risks posed by acute and chronic exposures. The potential hazards of PFAS biomagnification in the food web remain a subject of great interest given the widespread detection of PFAS in environmental systems. Laboratory- and field-based research in the bioaccumulation and persistence of PFAS is needed to understand the potential fate, transportation, and distribution of PFAS in the environment and contribute to the cumulative assessment of health risks, including the uptake of PFAS by agricultural commodities. Research to better characterize the fate, transportation, and distribution of PFAS in the environment and in humans is necessary. Data regarding the empirical and *in silico* determination of the properties of PFAS can be

¹⁵ : E. Kissa, Fluorinated Surfactants and Repellents, Marcel Dekker AG, 2001.

helpful for identifying potential chemically similar substitutes for read-across of toxicological data when there are gaps for targeted PFAS.

Task 1.2.1: Initiate and continue studies of the physical-chemical properties of PFAS and mixtures of PFAS. Such studies are needed to support the identification of fate and transport parameters, degradation rates, media absorption and adsorption, abiotic and biotic transformation and degradation, agricultural uptake, and other parameters useful for predicting movement of PFAS through the environment.

Task 1.2.2: Expand ongoing research to understand bioavailability, bioaccumulation, and biomagnification of PFAS and mixtures of PFAS in aquatic (estuarine, fresh, and marine), terrestrial, and avian species, and their movement within agricultural lands and the food and feed webs.

Task 1.2.3: Develop and support AI/ML techniques, and other computational modeling efforts to identify or address knowledge gaps with regards to PFAS degradation rates, media absorption and adsorption, abiotic and biotic transformation and degradation, and other parameters, including the properties and behaviors of mixtures of PFAS.

Objective 1.3: Develop and implement studies to understand PFAS exposure in humans and wildlife.

Exposure and biomonitoring studies are critical to increasing our understanding of PFAS exposure in humans and wildlife and identifying interventions to reduce exposures. Studies that identify PFAS in the environment can inform the need for, and design of, biomonitoring studies. Biomonitoring studies are important for understanding what PFAS people are exposed to and how these PFAS behave in human systems. This includes enhancing our understanding of the absorption, distribution, metabolism, and elimination (ADME) of PFAS in humans and wildlife. Less-characterized exposure scenarios, such as lactational transfer and consumer product exposure, should be explored through these studies. Studies that include both the collection of environmental exposure information and biomonitoring can best characterize the effects of the exposure on PFAS levels in the body, expanding on existing knowledge.

Task 1.3.1: Investigate additional pathways and routes of exposure, such as direct contact, dermal absorption, oral ingestion, and inhalation from indoor and outdoor environments (residential, consumer, and occupational exposures).

Task 1.3.2: Investigate pathways and routes of exposure for domestic and wild animals, including uptake, bioaccumulation, and biomagnification within domestic and wild animals and potential transfer to human exposure routes.

Task 1.3.3: Develop and support biomonitoring programs related to PFAS exposure of the general population, including studies that examine routes of PFAS exposure or transfer, such as lactational transfer.

Task 1.3.4: Develop and support biomonitoring programs that aim to identify occupational sources and types of exposures among disproportionately exposed populations, including firefighters and other workers with potentially high exposure to PFAS.

Task 1.3.5: Develop and support biomonitoring programs to study communities that may have environmental justice concerns near significant sources of PFAS contamination with a focus on susceptible populations and lifestyles. These studies can enhance awareness of potential disproportional impacts and provide data relevant to advancing environmental justice.

Task 1.3.6: Develop and support studies of PFAS exposures in indoor environments through collection of dust, air, consumer products, and other media where biomonitoring may also be conducted.

Strategy 2: Address current PFAS measurement challenges through the development of standards, advanced sampling and analytical methodologies

The analysis of PFAS in the environment,¹⁶ biological samples,¹⁷ and consumer products¹⁸ has driven the understanding of the fate and transport of PFAS contamination and sources of human exposure. There have been increasing numbers of PFAS that have been identified, often due to novel detection in samples or because of emerging toxicological information. This creates a moving target for PFAS analytical methods. In addition, advanced analytical techniques, like non-targeted analysis (NTA),¹⁹ require a different approach to the identification and quantification of PFAS in environmental and biological samples. Occurrence and prevalence of novel PFAS identified through NTA coupled with expanded toxicological data can focus resources on the expansion of targeted analytical methods and availability of analytical-grade standards and certified reference materials. This approach would address the most critical needs for evaluating human and ecological exposures, modeling fate and transport, and contaminated site assessment and cleanup. To achieve this end, reference methods and materials are needed to standardize the use of NTA for PFAS identification.

In addition, there is a significant need for analytical methodologies that are capable of precise and accurate measurement of PFAS at very low levels. Novel analytical methods must be developed, or existing methods may require modifications, to accommodate additional analytes as the list of targeted PFAS expands, technology advances, and insight into toxicological effects of PFAS emerges. Current sampling and analytical techniques should be routinely re-evaluated to ensure they continue to support their intended use.

¹⁶ Evich MG, Davis MJB, McCord JP, Acrey B, Awkerman JA, Knappe DRU, Lindstrom AB, Speth TF, Tebes-Stevens C, Strynar MJ, Wang Z, Weber EJ, Henderson WM, Washington JW. Per- and polyfluoroalkyl substances in the environment. *Science*. 2022 Feb 4;375(6580). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8902460/>

¹⁷ U.S. Centers for Disease Control and Prevention, "Biomonitoring Data Tables for Environmental Chemicals." https://www.cdc.gov/exposurereport/data_tables.html

¹⁸ DeLuca NM, Angrish M, Wilkins A, Thayer K, Cohen Hubal EA. Human exposure pathways to poly- and perfluoroalkyl substances (PFAS) from indoor media: A systematic review protocol. *Environ Int*. 2021 Jan;146:106308. <https://pubmed.ncbi.nlm.nih.gov/33395950/>

¹⁹ NTA is an analytical chemistry technique with the objective to identify unknown chemicals in samples without existing analytical standards.

Objective 2.1: Further improve targeted and non-targeted analytical methods for identifying, detecting, and quantifying PFAS in a variety of sample types.

Existing targeted analytical methods can identify and quantitate a limited number of PFAS in environmental media and other media. Targeted methods are currently limited by the number of available analytical reference standards for PFAS. With thousands of possible PFAS in the environment, analytical reference standards need to be quickly developed and measurement methods adjusted, or new methods created, to effectively prioritize further characterization of PFAS in the environment and in humans. Continued improvement of routine, targeted methodologies are needed to reduce detection levels, and to refine parameters of complex PFAS samples. Reference methods and standards are needed for NTA of PFAS.

Task 2.1.1: Develop and validate targeted methods for PFAS analysis, and refine methods to expand targeted PFAS analyte lists and reduce detection limits to better evaluate and manage risk through monitoring of PFAS in environmental and other media.

Task 2.1.2: Streamline workflows and build capacity (training, instrumentation, software) to support method development and implementation of NTA for PFAS in environmental and other media.

Task 2.1.3: Develop analytical methods to fill knowledge gaps on the occurrence, distribution, fate, and transport of PFAS, including zwitterionic, cationic, neutral, ultra-short-chain PFAS, and fluoropolymers (including side-chain fluoropolymers and fully fluorinated polymers) in various environmental media. This work will include identifying sources of analytical standards for these PFAS.

Task 2.1.4: Develop and improve analytical methods for measuring PFAS in biological samples, including human tissue, plants, and domestic and wild animals.

Task 2.1.5: Support the coordination, completion, and sharing of PFAS sampling, sample handling, and processing protocols for various matrices based on real-world studies and data to promote consistent, representative, and accurate sample collection and analysis. This work can include the development of high-throughput methods that utilize automated technologies, such as online solid-phase extraction.

Task 2.1.6: Develop and support ongoing targeted and non-targeted analytical methodologies for the analysis of blood/serum samples, dried blood spots, and human milk. Continue to support the use of archived specimens and passive sampling devices to monitor historical and current human exposure.

Task 2.1.7: Develop and refine analytical methods and data collection methods to evaluate PFAS content, migration, and emissions from consumer, commercial, and industrial products, and their impact on workplace and indoor environments.

Task 2.1.8: Develop testing programs and methods related to quantifying PFAS content, migration, and emissions in animal/livestock feed, food and food packaging, indoor exposure (dust, home/office materials), workplace settings, and consumer products.

Task 2.1.9: Expand reference materials, analytical standards, and data for the measurement of PFAS in different environmental and biological materials to enhance accurate identification and quantification of PFAS by targeted and non-targeted analytical methods.

Task 2.1.10: Develop and validate targeted and non-targeted analytical methods for the measurement of transformation products of PFAS to assess degradation and destruction technologies.

Objective 2.2: Advance the science of total fluorine and PFAS summations with method-defined analyses and protocols.

Currently, approaches to quantifying all PFAS in a material are limited. In addition, a variety of PFAS have been identified or are suspected to be present in environmental samples that cannot be quantified with today's standardized PFAS analytical methods. The inability to make quantitative measurements of total PFAS content is a potentially large source of uncertainty in managing exposure risk. To bridge this gap, there is a significant need for aggregate measurements (e.g., total fluorine and total organic fluorine content) and precursor mass balance approaches (e.g., total oxidizable precursors assay), which account for known and unknown PFAS that may be present in a material. Examination of the benefits and limitations of various method-defined total fluorine and mass balance approaches is necessary to implement such measures in regulatory and environmental health decision-making. To guide science-based decision-making, it will be important to understand the benefits and limitations of various method-defined total fluorine and mass balance approaches.

Task 2.2.1: Develop and validate methods for total fluorine and PFAS mass balance approaches, including those for total oxidizable precursors, adsorbable organic fluorine, extractable organic fluorine, total organic fluorine, and total fluorine that are applicable to a variety of matrices and types of PFAS precursors.

Task 2.2.2: Expand reference materials and data for the measurement of aggregate PFAS or total organic fluorine content in different environmental and biological materials.

Objective 2.3: Foster the development of new technologies for efficiently measuring and identifying, quantifying, and modeling PFAS occurrence in the environment.

While targeted methods using existing and well-developed instrumentation exist, the ability to collect, extract, and analyze samples can be time-consuming and costly. There is a significant need for new technologies to measure total PFAS, as well as individual PFAS and their classes, efficiently and in a cost-effective manner. Reference materials and data underpin the accuracy and precision of analytical results, which are required of any new technologies developed and provide a benchmark for understanding measurement performance. Further, while predictive models can be used to understand PFAS occurrence, fate, transport, and distribution in the environment, the models must be trained by high-quality data to produce the best results.

Task 2.3.1: Develop and validate real-time, rapid, and remote PFAS screening methods using analytical sensors, PFAS proxies, passive sampling devices, and other novel technologies for the detection of PFAS in media.

Task 2.3.2: Develop and validate methods for evaluating PFAS leaching potential from various media into the environment or humans.

Task 2.3.3: Develop and validate AI/ML tools to predict occurrence and estimated movement of PFAS in media. Tools and data sets can include breakdown or degradation products of PFAS materials that generate other PFAS.

Strategy 3: Understand the toxicological mechanisms, human and environmental health effects, and risks of PFAS exposure.

The 2023 PFAS Report noted that it is impractical to assess the human and environmental hazards posed by each of the numerous PFAS that may exist in the environment using an individual, chemical-by-chemical approach. There are additional challenges to traditional experimental approaches, such as limited availability of appropriate analytical tests and standards, background levels, intrinsic physicochemical properties, and the lack of access to confidential business information. A holistic systems approach to understanding the risk of PFAS was proposed in the 2023 PFAS Report, leveraging new approach methodologies (NAMs), high-throughput technologies, and different data streams (i.e., human health studies, ecotoxicology, *in silico* models, and epidemiology studies).

Objective 3.1: Further characterize the toxicological mechanisms of action regarding PFAS exposure in humans, wildlife, and domestic animals.

While PFOA and PFOS are arguably the most thoroughly studied PFAS in the scientific literature, numerous efforts to better understand the overall toxicity of these and many other PFAS are currently underway worldwide.^{20,21,22} Ongoing efforts are largely focused on the potential for PFAS to cause a variety of adverse changes in human health, but adverse effects at the ecosystem level, including health effects on animals, are also of great concern. Understanding PFAS' toxicity to humans and the environment is a challenge due to PFAS' varying structures and properties and the lack of available toxicity data. There are several efforts underway to explore class-based or grouping strategies, as they relate to understanding and categorizing PFAS toxicological mechanisms and human health effects. Real-world exposure to PFAS in humans and the environment most often occurs as a complex mixture, as opposed to one PFAS in isolation.²³ These approaches may help to address issues including the lack of data, limited resources, and the cumulative risk posed by exposure to PFAS mixtures.

Task 3.1.1: Advance the development of NAMs, including high-throughput technologies that produce quantitative data, to provide faster assessment of PFAS hazard in multiple taxa, under multiple exposure conditions, and with individual and mixtures of PFAS. This should complement traditional toxicity testing methods to characterize long-term impacts on growth,

²⁰ U.S. Environmental Protection Agency, "Integrated Risk Information System." <https://www.epa.gov/iris>

²¹ Codex Alimentarius Commission, Codex Committee on Contaminants in Food, 16th Session, April 2023. https://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FMeetings%252FCX-735-16%252FCRDs%252Fcf16_CRD05x.pdf

²² European Food Safety Authority, "Risk to human health related to the presence of perfluoroalkyl substances in food." <https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2020.6223>

²³ U.S. Centers for Disease Control and Prevention, "Biomonitoring Data Tables for Environmental Chemicals." https://www.cdc.gov/exposurereport/data_tables.html

reproduction, carcinogenicity, neurodevelopment, chronic adverse health effects, and multi-generational effects.

Task 3.1.2: Develop scientifically supported classification schemes for PFAS with respect to adverse impacts on human health and the environment.

Task 3.1.3: Develop and support research regarding the human toxicity and ecotoxicity testing of PFAS as mixtures with PFAS and other co-occurring chemicals.

Task 3.1.4: Develop and support empirical and modeling approaches to quantify human and wildlife toxicokinetics of PFAS in support of human and wildlife exposure assessment. This can include the use of PFAS monitoring data to develop physiologically-based toxicokinetic models and biologically-based dose-response models.

Task 3.1.5: Develop and apply AI/ML tools for the characterization of common toxicological mechanisms and health effects resulting from PFAS exposure, including the potential classification of PFAS by toxicological mechanism and/or health effects.

Task 3.1.6: Support research to further understand mechanism of action of PFAS toxicity, advance development of adverse outcome pathways, and understand the impact of PFAS mixture toxicities when evaluating cumulative health effects.

Objective 3.2: Understand the occurrence of adverse human health outcomes from PFAS exposure.

PFAS exposure is ubiquitous, and most people have measurable levels in their blood.²⁴ People with occupational exposure and communities with contaminated drinking water typically have higher blood levels of PFAS. Characterizing risks associated with such exposures can be challenging due to the wide range of potential health effects, the co-occurrence of PFAS and other chemicals, and differing exposures, and population and lifestage susceptibility (either due to higher sensitivity among individuals or lifestages to the adverse effects of PFAS exposure or from disproportionately higher levels of PFAS contamination). Nevertheless, epidemiological studies can contribute to better understanding of the effects of PFAS mixtures, understudied adverse health outcomes, exposure routes, biomarkers of exposure and/or effect, modulating factors, and health and medical interventions.

Task 3.2.1: Develop and support epidemiological studies on the effect of PFAS exposure on adverse health outcomes, including longitudinal cohort studies, nested case-control, and case-cohort studies. Rigorous study design would minimize bias and consider the role of relevant factors, such as social determinants of health, susceptible populations, vulnerable windows of exposure, and the effect of mitigation measures.

Task 3.2.2: Develop and support epidemiological studies designed to identify communities near significant sources of PFAS contamination that may have environmental justice concerns, including occupationally exposed populations and populations, communities, and/or lifestages that are more susceptible to PFAS exposure or adverse health outcomes.

²⁴ U.S. Centers for Disease Control and Prevention, "Biomonitoring Data Tables for Environmental Chemicals." https://www.cdc.gov/exposurereport/data_tables.html

Task 3.2.3: Explore the development of a federal data-sharing strategy to use interagency toxicological and epidemiological data to determine human health endpoints of concern from PFAS exposure.

Task 3.2.4: Develop and support studies that evaluate the efficacy and effectiveness of clinical and non-clinical interventions to reduce the risk of adverse health consequences in persons exposed to PFAS. This may include treatment of humans with high PFAS blood concentrations and interventions to reduce the severity of adverse health outcomes related to PFAS exposure.

Objective 3.3: Support hazard identification and risk assessment for PFAS exposure to humans and ecosystems.

Federal agencies should align efforts to identify health hazards and develop risk assessment approaches for PFAS for their use in human and environmental health risk assessment. These might include models of PFAS mixture use, systematic reviews, or weight of evidence evaluations. Currently, federal toxicity and risk assessments exist for select PFAS; further supporting these efforts through alignment of federal research and increased interagency data sharing could address research needs and data gaps. This can include work regarding populations and taxa that have disproportionate exposure and/or adverse health effects. Interagency communication of these models and their results will support agency risk characterization and risk management processes, which include development of risk mitigation strategies.

Task 3.3.1: Develop aligned interagency data infrastructure and data requirements for interagency sharing of data regarding toxicological models (such as NAMs), hazard identification, exposure assessment, and dose-response studies in support of risk assessments.

Task 3.3.2: Develop aligned interagency approaches to inform, and obtain feedback from, affected communities, scientists, and other stakeholders on the human and environmental risks of PFAS exposure that includes PFAS mixture assessments and systematic reviews.

Task 3.3.3: Develop classification strategies that enable grouping of PFAS by hazard identification, exposure assessment, and dose-response studies in support of risk assessments.

Strategy 4: Develop, evaluate, and demonstrate technologies for the removal, destruction, and disposal of PFAS

The safe and environmentally friendly removal, destruction, and disposal of PFAS can be challenging because of the large number of PFAS, the stability of the carbon-fluorine bond, and the goal of reducing the PFAS contamination levels to those that are protective of human and environmental health. Collaborative research and engagement among industry, governments, and the public will help reach this objective. The 2023 PFAS Report identified many technologies for the removal, destruction, and

disposal of PFAS, ranging from novel to field-ready technologies. Individual agencies have provided guidance on recommended techniques for destruction and disposal.^{25,26}

New research is needed to advance these technologies to field-ready technologies. In addition, removal, destruction, and disposal technology developers should consider tailored treatments for specific exposure pathways (e.g., air, water, soil, or biosolids) to find solutions for specific exposure pathways identified in the previous goals and objectives. Media-specific technologies should consider effectiveness (e.g., soil cleanup thresholds to allow for agricultural production) and be implementable (e.g., cost effective) for the targeted media. This research can include *in situ* immobilization strategies that reduce the impact of PFAS contamination. This goal aims to support the 1) continued development of novel, more efficient and effective technologies, and 2) implementation of technologies for field-scale removal, destruction, and/or disposal of PFAS-contaminated materials.

Objective 4.1: Develop and evaluate technologies for PFAS removal, destruction, and disposal.

To address the need to develop new, environmentally friendly technologies to mitigate, sequester, or remove PFAS contamination from environmental matrices, federal agencies should continue to support research in the development, characterization, and economic costs of these new technologies. Beyond the current use of granular activated carbon (GAC) and ion exchange resin adsorption to remove PFAS from water, new technologies may prove efficient for PFAS removal from water and other contaminated materials. In addition to continued research into an effective and efficient means of PFAS incineration, several other PFAS destruction technologies are being researched, including novel technologies for removal and destruction of PFAS in environmental and biological matrices. Also, the technologies for addressing PFAS-contaminated agricultural lands and commodities should be considered, as agricultural systems present a unique challenge due to the potential for widespread, low-level contamination at farms and migration of PFAS from commodities and livestock to the food system. Current PFAS treatment technologies under development include feed and water additives, composting, molecular biology-based tools, and novel chemistries for destruction in biological matrices.

Interagency coordination of novel removal, destruction, and disposal technologies, including development, scientific, and socio-economic evaluation, and other relevant data and models, would enable efficient development and alignment of agency policies.

Task 4.1.1: Characterize and assess materials and membranes for novel adsorption, separation, concentration, and stabilization technologies, including biotechnology-based removal and destruction techniques.

Task 4.1.2: Continue to support the foundational research that advances technologies for the destruction of PFAS by both thermal and non-thermal approaches.

²⁵ DOD, "Interim Guidance on Destruction or Disposal of Materials Containing Per- and Polyfluoroalkyl Substances in the United States" July 11, 2023. https://www.acq.osd.mil/eie/ee/ecc/pfas/docs/news/Memorandum_for_Interim_Guidance_on_Destruction_or_Disposal_of_Materials_Containing_PFAS_in_the_U.S.pdf

²⁶ USEPA, "Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials That Are Not Consumer Products." April 16, 2024. <https://www.epa.gov/pfas/interim-guidance-destroying-and-disposing-certain-pfas-and-pfas-containing-materials-are-not>

Task 4.1.3: Support research regarding the treatment of PFAS-contaminated agricultural lands and commodities that are protective of human health and the environment, cost-effective, and implementable.

Task 4.1.4: Generate high-quality data regarding PFAS properties to enable AI/ML tools to assist in the development of novel removal, destruction, and disposal technologies.

Task 4.1.5: Continue research efforts focused on demonstrating performance and destruction efficiency of thermal treatment, by characterizing emissions (including products of incomplete combustion), residual waste streams, and optimal operating conditions (e.g., temperatures and residence times) needed for full mineralization of PFAS.

Task 4.1.6: Develop and assess removal technologies using renewable or waste materials, such as biological and agricultural waste materials.

Objective 4.2: Support the implementation of technologies for PFAS removal, destruction, and disposal.

To support technology implementation, decision-makers need data on performance, cost, and optimization parameters, especially when multiple technologies are combined in a treatment train. Ideally, the data would be generated through field-scale demonstration projects or during full-scale implementation under a range of operating conditions, including (but not limited to) a wide range of PFAS, a range of water qualities and flow rates, and a range of PFAS-containing materials (e.g., AFFF, PFAS-contaminated biosolids). Performance data should include data on all process output, including solids, air emissions, and water discharges. Further, technologies that show significant promise would benefit from validation at full-scale implementation and an analysis of the economic cost of implementation.

Task 4.2.1: Coordinate individual agency efforts and partnerships with non-federal facilities (e.g., drinking water treatment facilities, waste management facilities) to determine optimal combination of field-scale technologies for PFAS removal, destruction, and disposal.

Task 4.2.2: Engage with potential users to understand and lower the barrier to field-scale implementation of PFAS removal, destruction, and disposal technologies.

Task 4.2.3: Support the implementation of removal and destruction technologies that apply to discharge and releases at the point of manufacturing.

Task 4.2.4: Develop and implement models to evaluate technology performance, short-term and long-term costs, energy demands, scalability, and the composition of treated materials that are released to the environment.

Task 4.2.5: Further develop and optimize sorbent reactivation technologies to increase sorbent capacity to remove PFAS and prevent PFAS emissions from the reactivation process.

Task 4.2.6: Develop, model, and test the effectiveness and economic cost of removal, destruction, and disposal technologies at differing scales, such as low volumes of high concentrations (e.g., landfill leachate) and high volumes of low concentration (e.g., widespread irrigation water or soil contamination in agricultural systems).

Strategy 5: Identify PFAS alternatives and evaluate their human health and environmental effects.

PFAS alternatives largely fall into two categories: functional alternatives, which involve technical or engineering solutions to reduce the need for PFAS-containing materials, and chemical alternatives, which involve the replacement of PFAS with alternatives with lower toxicity and lesser persistence that impart a similar function in the manufacturing process or finished product. To identify potential alternatives, the federal government should better understand the uses of PFAS in products and in the supply chain, the criticality of the uses, and physical and chemical properties required for those uses. Generally, prioritization for replacement of PFAS-containing materials and products can be determined by individual federal agencies and/or through interagency coordination, based on their own assessment of the critical and essential uses of these materials.

The development and/or identification of cost-effective and more sustainable alternatives that are functionally or chemically equivalent to those made with PFAS depends on the type of product, its application, and associated human and ecological hazard in comparison to the PFAS being replaced.²⁷ R&D efforts to identify and reduce the use of PFAS have been conducted by a variety of government, industry, and academic institutions using literature, database, and quantitative structure-activity relationship models (QSARs); toxicological evaluations of PFAS alternatives; and transition to new products that have reduced adverse effects on human health and the environment. As new functional and chemical alternatives are developed, it will be essential that the below objectives be revisited and revised regularly to incorporate advances in technology. In addition, there are research opportunities to understand and innovate in the area of recycling and the circular economy of PFAS-containing materials, which is discussed by the NSTC Sustainable Chemistry Strategy Team's landscape report.²⁸

Objective 5.1: Review current resources and products for PFAS alternatives.

As part of the effort to identify and evaluate sustainable PFAS alternatives, it will be important to apply sustainable chemistry principles and incorporate an essential use concept as a rapid pathway toward effective management and/or phase out of hazardous PFAS-containing products; this can include the continued use of PFAS-containing products that must continue to be used, particularly when the costs and risks of product replacement to national security are substantial.²⁹ Thorough reviews of publicly available literature and databases and toxicity/hazard databases can be used to inform federal program activities directed at the development of PFAS alternatives, as well as an understanding of the performance and human health and environmental risk trade-offs of PFAS alternatives. However, not all uses of PFAS are known or reported in publicly accessible formats. Therefore, additional research is needed to identify which products contain or are made using PFAS. Federal agencies should work with academic and industrial researchers to identify and scale-up novel alternative processes and chemicals. There have been regulatory and policy actions where federal agencies are encouraged to

²⁷ For the definition of sustainable, see the NSTC report on sustainable chemistry: Office of Science and Technology Policy National Science and Technology Council Sustainable Chemistry Strategy Team, "Sustainable Chemistry Report: Framing the Federal Landscape," August 2023, <https://www.whitehouse.gov/ostp/news-updates/2023/08/02/nstc-sustainable-chemistry-report/> (hereafter the "NSTC SC Report")

²⁸ NSTC SC Report

²⁹ NSTC SC Report

transition to products that do not contain PFAS and suppliers that do not use PFAS.³⁰⁻³¹ The identification and transition to suppliers of PFAS alternatives should be expedited to mitigate potential supply chain risks without impact to critical infrastructure, national security, and public health.

Task 5.1.1: Engage with academic and private sector industrial researchers to support the development of novel, less toxic alternative chemistries and processes for sustainable PFAS alternatives.

Task 5.1.2: Identify and evaluate critical and essential uses of PFAS within individual agencies and sectors.

Task 5.1.3: Develop an interagency-aligned evaluation framework for prioritizing research on specific PFAS alternatives that includes considerations regarding sustainability, performance; viability and timeframe to transition; dependency on foreign sources of materials; criticality of the current product to national security, critical infrastructure, climate change mitigation and public health; and criticality of the need for a replacement product or process.

Task 5.1.4: Perform reviews of the research on current PFAS alternatives in all commercial and governmental (e.g., defense) sectors, including the performance differences between products.

Task 5.1.5: Support research that lowers the barrier for federal agencies to transition to sustainable PFAS alternatives.

Task 5.1.6: Support research to advance sustainable manufacturing and circularity of PFAS-based processes and products to preserve current critical and essential uses, which will enable an orderly transition to PFAS alternatives in critical manufacturing sectors that are dependent on PFAS.

Objective 5.2: Perform chemical characterization, product evaluation, and risk assessment of alternatives to current PFAS-containing products and processes.

An ideal PFAS alternative product or process would have less human health or environmental risks than current PFAS-containing products and processes. In order to prevent the possibility of a regrettable substitution of PFAS, there should be a thorough assessment of alternatives utilizing all available data regarding physical-chemical properties, material performance characteristics, predicted biological activity, and use and production estimates to provide insight on the viability and safety of PFAS alternatives.³² A holistic approach should be implemented in understanding the properties and risk of PFAS alternatives, as a PFAS alternative may have lower environmentally hazardous properties (e.g., less persistent), but be more hazardous to human health (e.g., greater acute toxicity and more flammable). In addition, PFAS alternatives characterization should include a focus on the most likely exposure routes of both PFAS and the evaluated alternatives, as their properties may result in different

³⁰ United States Department of Defense, "Department of Defense Announces Prohibition in DFARS on Certain PFOS and PFOA Procurement." September 28, 2022, <https://www.defense.gov/News/Releases/Release/Article/3172591/departments-of-defense-announces-prohibition-in-dfars-on-certain-pfos-and-pfoa-p/>

³¹ Office of Management and Budget, "Memorandum for the heads of Executive Departments and Agencies: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability." December 8, 2021, <https://www.whitehouse.gov/wp-content/uploads/2021/12/M-22-06.pdf>

³² The substitution of a chemical or material with another chemical or material that is more harmful to human and/or environmental health.

exposure routes, for example: a more volatile PFAS alternative may be an inhalation hazard while the less volatile PFAS product is an ingestion hazard.

Task 5.2.1: Develop a database of the current commercial inventory of alternative materials and products with relevant chemical and toxicological information, manufacturer production capacity, and performance comparison of the alternatives to PFAS-containing materials and products.

Task 5.2.2: Continue to assess human health and environmental effects posed by alternative materials and products for use in comparison to other product formulations, including PFAS-containing product formulations.

III. Conclusions

Successful implementation of this strategic plan will help strengthen and advance the state of the science to successfully address regulatory, scientific, and mitigation gaps and disproportionate exposure, contamination, and toxicity regarding PFAS. While outside of the scope of this report, the PFAS ST recognizes there are additional research needs that should be further explored through intramural and extramural research, including the socio-economic effect of PFAS contamination and remediation on specific populations, such as communities with environmental justice concerns firefighters, and farmers, and medical interventions to prevent or reduce the severity of adverse health outcomes related to PFAS exposure. The NDAA requires this strategic plan to be updated every three years; therefore, these areas could be considered in future updates of this plan.

The PFAS ST will support interagency coordination during the implementation of this strategic plan, continue to engage with external stakeholders—including state, local, Tribal, and territorial communities, academia, and industry—to identify PFAS R&D needs and solutions, and will assess and revise this strategic plan as technology and information changes.

FIGURE 1. Data from NHANES reports on serum PFOS in the U.S. population (from [Biomonitoring Data Tables for Environmental Chemicals | CDC](#)).

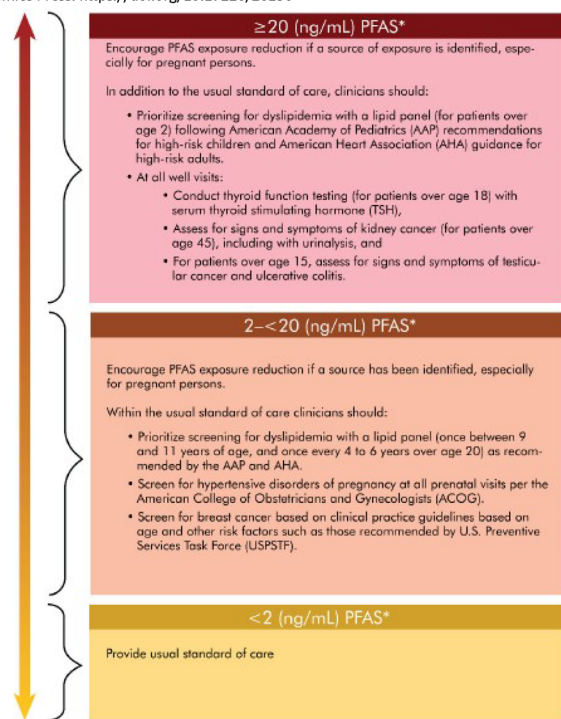
Serum Perfluorooctane sulfonic acid (PFOS) (2011 – 2018)

Sum of linear and branched PFOS isomers

Geometric mean and selected percentiles of serum concentrations (in µg/L) for the U.S. population

Demographic Categories	Survey (Years)	Geometric Mean (95% CI)	50th Percentile (95% CI)
Total population	11-12	6.31 (5.84-6.82)	6.53 (5.99-7.13)
Total population	13-14	5.01 (4.53-5.54)	5.30 (4.90-5.70)
Total population	15-16	4.72 (4.40-5.07)	4.80 (4.40-5.30)
Total population	17-18	4.25 (3.90-4.62)	4.30 (3.80-4.90)
Age 6-11 years	13-14	4.18 (3.70-4.72)	4.00 (3.44-4.57)

FIGURE 2. Clinical guidance on PFAS blood levels for impacted communities. From: National Academies of Sciences, Engineering, and Medicine. 2022. Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>



* Simple additive sum of MeFOSAA, PFHxS, PFOA (linear and branched isomers), PFDA, PFUnDA, PFOS (linear and branched isomers), and PFNA in serum or plasma

FIGURE S-6 Clinical guidance for follow-up with patients after PFAS testing.

NOTE: MeFOSAA = methylperfluorooctane sulfonamidoacetic acid; PFDA = perfluorodecanoic acid; PFHxS = perfluorohexane sulfonic acid; PFNA = perfluorononanoic acid; PFOA = perfluorooctanoic acid; PFOS = perfluorooctanesulfonic acid; PFUnDA = perfluoroundecanoic acid.

Senator MERKLEY. Thank you very much.

I am going to defer to Senator Carper.

Senator CARPER. Thanks so much. I will just take another minute, if I could. There are a number of other committees that are meeting right now, with hearings. It is not like they are postponing everything until the last day or the last week, there is just a lot of important stuff that we need to be dealing with. This is certainly one of them. I am going to slip off to be at my other committee and try to participate in those hearings.

The words of my father, as I sit here, come back to mind. My dad used to say the hardest things to do are sometimes the most important things to do. This is a hard thing to do, but it is also a really important one. My mother used to say, if you think you can, or you think you can't, you are right. If you think you can or you think you can't, you are right.

A couple of years ago, at a hearing right here in this room, sitting, Michael, where you are sitting, was a fellow named Rob Wallace, a close friend of Senator John Barrasso from Wyoming. He was here for a hearing. He had been nominated by Donald Trump for a senior position in the Department of Interior. Rob Wallace said to us that day in his testimony, the bipartisan solutions are lasting solutions. Bipartisan solutions are lasting solutions.

So I would just say, as I prepare to weigh anchor and set sail into the sunrise in a week or so that I hope that Senator Mullin, you and Chairman Merkley can somehow do what the rest of us have been unable to do, and that is to come to the right solution here. If you think you can or you think you can't, you are right. And I think you can.

Thank you all very much.

Senator MERKLEY. Senator Carper, thank you for the many quotes you have instilled in our minds. That is certainly one of them: if you think you can or you think you can't, you are right. Another is, it is not that hard, just do more of what works and less of what doesn't.

Senator CARPER. Find out what works and do more of that. There you go.

Senator MERKLEY. And if you want to go fast, go alone. If you want to go far, go together. So thank you for these words of wisdom over the years.

Senator CARPER. I will be gone but not forgotten. That is a plus.

Senator MERKLEY. That is right.

Dr. Larrañaga, welcome.

STATEMENT OF MICHAEL D. LARRAÑAGA, PH.D., P.E., PRESIDENT AND MANAGING PRINCIPAL, R.E.M. RISK CONSULTANTS

Mr. LARRAÑAGA. Thank you, Chairman Merkley, Ranking Member Mullin, and Chairman Carper.

I am testifying here today on behalf of the American Industrial Hygiene Association, the association for scientist professionals committed to preserving occupational and environmental health in the workplace and community.

One of the headlines I want you to remember from my testimony today is that the use of PFAS chemicals is vital to the critical infra-

structure of the United States. We must manage these chemicals responsibly and balance their use against the risk of using proposed alternatives.

The use of PFAS is indeed critical, not only in the sense that our critical infrastructure provides a backbone for the U.S. Government to ensure our security, but also in the sense that our critical infrastructure is vital to maintaining the American way of life. For example, PFAS as described earlier in this hearing are used in the manufacture of semiconductors and electronics, medical equipment, pharmaceuticals, herbicides, insecticides, plastics, airplanes, automobiles, buildings, and thousands of other applications that we rely on every day.

One aspect of my job is to assist companies in identifying alternatives for PFAS-containing firefighting foams. This is no easy task, as the PFAS containing aqueous film forming foam, or AFFF, is by far the best firefighting foam available. Companies are spending millions of dollars, sometimes per facility, to transition away from AFFF to fluorine-free foams. And the U.S. Government is doing the same.

Our critical infrastructure stakeholders are replacing their AFFF fire suppression systems at great cost with less capable fluorine-free foams. It is important to note that the historical legacy AFFF foams using long-chain PFAS, you may have heard of these as CA foams, are no longer produced, sold or imported into the United States. We as a country are no longer recklessly disposing of mass volumes of chemicals containing PFAS directly into the environment.

Modern AFFF formulations that meet the 2019 military specification contain trace amounts of PFOA or PFOS. Just to put that into perspective, the 2019 Intercontinental Terminals Fire in Deer Park, Texas, released 132, almost 133 pounds of air emissions per hour during the first 24 hours, eventually releasing more than 16 million pounds of toxic air emissions. Responding fire departments attempted to extinguish the fire with fluorine-free foams, and the fire burned for 51 hours.

During the 51st hour, PFAS-containing AFFF was applied, and the fire was extinguished 13 hours later. During those 13 hours of AFFF application, the use of the modern military spec AFFF foam would have resulted in about 30 ounces of PFOA or PFOS introduced into the environment, or about two and a half of these coffee cups.

So the risk versus reward calculation here is this: is it better for the environment and surrounding communities to be exposed to 16 million pounds of toxic air emissions, which is 30 ounces of PFOA or PFOS? Had MilSpec AFFF been applied initially, the fire would have likely only burned for a couple of hours, if that, and we could have avoided releasing millions of pounds of toxic emissions into the air, most likely with a couple of ounces of long-chain PFAS released.

According to Dwight Williams of the industrial firefighting team that extinguished the fire, the fire could not have been extinguished without the use of AFFF. In addition, there were 51 hours of fluorine-free foam application and fluorine-free foams are not

without their own toxicological drawbacks, being more toxic to certain types of aquatic life than AFFF.

Another example is the chemical fire in Rockton, Illinois. It was brought under control in 3 hours with the use of AFFF, when officials required the fire department to stop the application of AFFF for environmental concerns. The chemical fire then burned for another eight and a half days, generating 21 million pounds of air emissions which could have been avoided.

The fluorine-free foams are simply not as effective at attacking complex fires that occur in industrial facilities, onboard ships, or during an airplane crash, for that matter. Major airports are transitioning away from AFFF to fluorine-free foams, and the Department of Defense is doing the same in all but the most critical applications.

I am sitting here today to tell you that if my family and I are aboard a jetliner that crashes, please soak us in AFFF. Why? Because jetliner fires are dangerous. Fire moves exceedingly fast and AFFF is simply superior at putting out fires.

It is important to recognize that AIHA and I recognize the toxicological properties inherent in these PFAS, and in no way encourages the improper use or disposal. AIHA supports the responsible management of these chemicals. However, we recommended a balanced and commonsense approach to chemical management and regulation, whereby the implementation of the risk versus reward calculus includes the assessment of the consequences of requiring the use of alternatives, removing these chemicals from the marketplace, and regulating these chemicals as an entire class instead of health and risk-based frameworks.

In summary, the use of PFAS chemicals is vital to the critical infrastructure of the United States. We must manage these chemicals responsibly and balance their use against the risk of alternatives.

On behalf of myself and the AIHA, thank you all for the opportunity to provide feedback on this important topics.

[The prepared statement of Mr. Larrañaga follows:]



HEALTHIER WORKPLACES | A HEALTHIER WORLD

Senate Subcommittee on Chemical Safety, Waste Management,
Environmental Justice, and Regulatory Oversight of the Senate
Environment and Public Works Committee
Hearing entitled “*Examining the Public Health Impacts of PFAS
Exposure*”

Thursday, December 5, 2024
9:30 AM in SD-406

My name is Michael Larrañaga, and I am testifying on behalf of the American Industrial Hygiene Association (AIHA), the association for scientists and professionals committed to preserving occupational and environmental health in the workplace and community. I am a graduate and former Professor and Department Head of the Oklahoma State University School of Fire Protection and Safety. In addition, I am Founding Scholar of Innovation and Creativity for the Advanced Thinking in Homeland Security think tank at the Naval Postgraduate School’s Center for Homeland Defense and Security.

This is one of the headlines I want you to remember from my testimony: The use of PFAS chemicals are vital to the critical infrastructure of the United States. We must manage these chemicals responsibly and balance their use against the risk of using proposed alternatives.

The use of PFAS is indeed critical from the standpoint of critical infrastructure. Not only in the sense that our critical infrastructure provides the backbone for the U.S. government to ensure our security, but also in the sense that our critical infrastructure is vital to maintaining the American way of life. For example, PFAS chemicals are used in the manufacture of semiconductors, electronics, medical equipment, pharmaceuticals, herbicides, insecticides, plastics, airplanes, automobiles, buildings, and in thousands of other applications that we rely on every day.

One aspect of my job is to assist companies in identifying alternatives for PFAS containing firefighting foams. This is no easy task, as the PFAS-containing Aqueous Film Forming Foam, or A triple F, is by far the best firefighting foam available. Companies are spending millions of dollars per facility to transition away from AFFF to Fluorine Free Foams, and the U.S.

government is doing the same. Our critical infrastructure stakeholders are replacing their AFFF fire suppression systems, at great cost, with less capable Fluorine Free Foam systems.

It is important to note that the historical, or legacy, AFFF foams using long-chain PFAS – you may have heard of these as C-8 foams – are no longer produced, sold, or imported in the United States. And we, as a country, are no longer recklessly disposing of mass volumes of chemicals containing PFAS directly into the environment.

Modern AFFF formulations that meet the 2019 military specification contain trace amounts of PFAS. Just to put that into perspective, the 2019 Inter-Continental Terminals Fire in Deer Park, Texas released 132,700 lbs of air emissions per hour during the first 24 hours, eventually releasing 16,000,000 pounds of toxic air emissions (See Photo on p. 1 in Appendix). Responding fire departments attempted to extinguish the fire with Fluorine Free Foams, and the fire burned for 51 hours. During the 51st hour, PFAS-containing AFFF was applied, and the fire was extinguished 13 hours later. During those 13 hours of AFFF application, the use of a modern military spec AFFF foam would have resulted in about 30 ounces of PFOA or PFOS, introduced into the environment (See calculation on p. 2 in Appendix).

So the risk vs. reward calculation here is this: Is it better for the environment and surrounding communities to be exposed to 16 million pounds of toxic air emissions or to the 30 ounces of PFOA or PFOS? Had mil-spec AFFF been applied initially, the fire would have likely only burned for a couple of hours and we could have avoided releasing millions of pounds of toxic emissions into the air, most likely with a couple of ounces of long-chain PFAS released. According to Dwight Williams of the industrial firefighting team that extinguished the fire, the fire could not have been extinguished without the use of AFFF.

In addition, there were 51 hours of Fluorine Free Foam application, and Fluorine Free Foams are not without their own toxicological drawbacks, being more toxic to certain types of aquatic life than AFFF. As an example, the Chemtool fire in Rockton, Illinois was brought under control in 3 hours using AFFF when officials required the fire department to stop the application of AFFF. The Chemtool fire then burned for another 8 1/2 days, generating 21 million pounds of air emissions, which could have been avoided.

The Fluorine Free Foams are simply not as effective at attacking complex fires that occur in industrial facilities, onboard ships, or during an airplane crash for that matter. Major airports are transitioning away from AFFF to Fluorine Free Foams, and the Department of Defense is doing the same in all but the most critical applications. I am sitting here today to tell you that if

my family and I are aboard a jetliner that catches fire, I beg of you, please...shower us in AFFF. Why? Because jetliner fires are dangerous and AFFF is simply superior at putting out fires. See p. 3 in Appendix.

It's important to emphasize that AIHA and I recognize the toxicological properties inherent in these PFAS and in no way encourage their improper use and disposal. AIHA supports the responsible management of these chemicals. However, we recommend a balanced and common sense approach to chemical management and regulation whereby the implementation of a risk vs. reward calculus includes the assessment of the consequences of a) requiring the use of alternatives, b) removing these chemicals from the market and c) regulating these chemicals as an entire class rather than based on health- and risk-based frameworks.

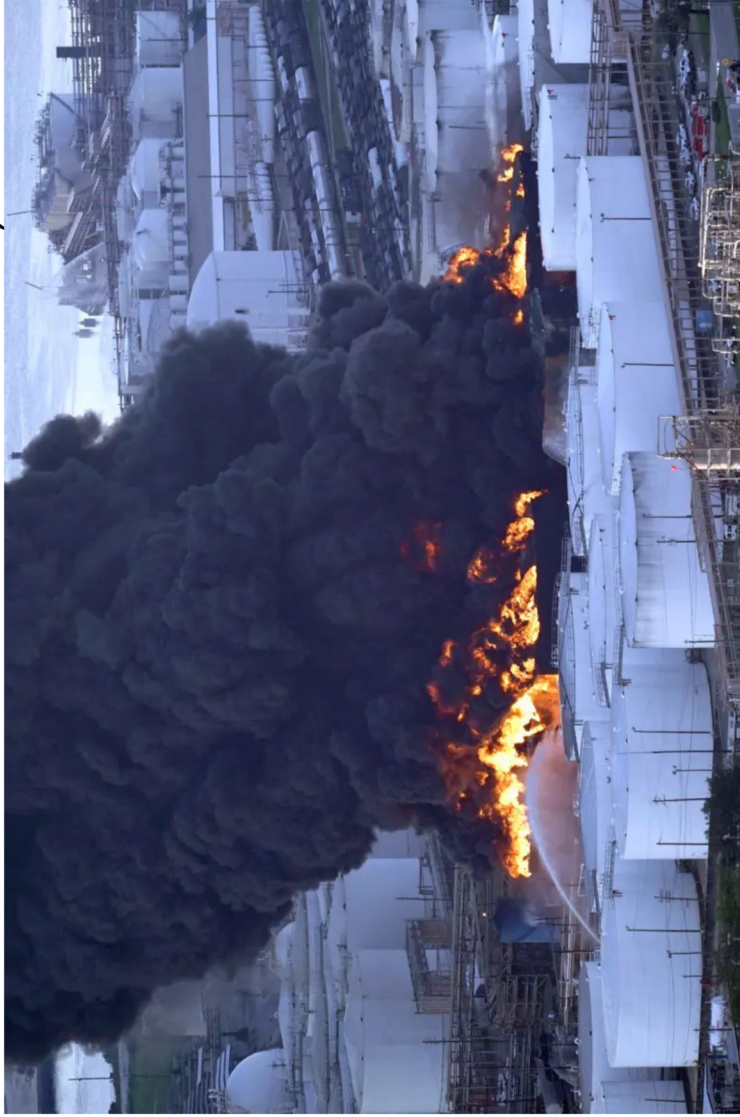
In summary, the use of PFAS chemicals is vital to the critical infrastructure of the United States. We must manage these chemicals responsibly and balance their use against the risk of using proposed alternatives.

I'm happy to answer any questions you may have.

On behalf of myself and AIHA, thank you all for the opportunity to provide feedback on this important topic.

Appendix – Supporting Documentation

ITC Deer Park Fire March 18, 2019

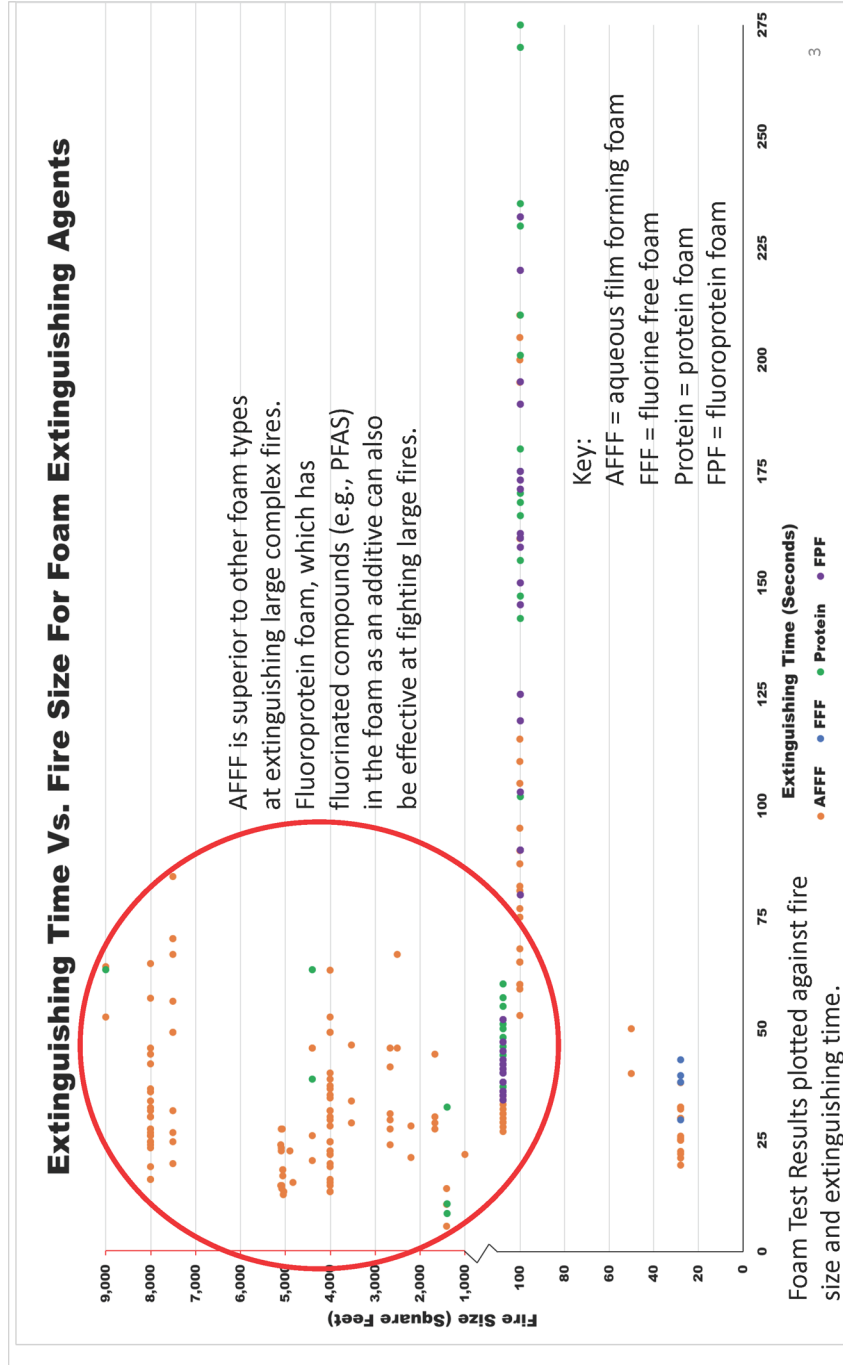


Source: Houston Public Media; David J. Phillip/AP

PFOA or PFOS Content in ITC Fire AFFF

AFFF MilSpec (2019) Permits 800 ppb PFOA or PFOS

- **Gallons of Concentrate Used:** 140,000 gallons
- **PFOA or PFOS Content in AFFF:** $(140,000 \text{ gallons concentrate}) * (800 \text{ ppb})$
 $= (140,000 \text{ gallons of AFFF}) * (0.0000008)$
 $= 0.112 \text{ gallons of PFOA or PFOS}$
- **PFOA & PFOS Content :** $0.112 \text{ gallons} \times 2$
 $= 0.224 \text{ gallons (~30 oz) of PFOA \& PFOS}$





January 9, 2025

From: Michael Larrañaga, PhD, PE, CIH, FAIHA
President and Managing Principal
R.E.M. Risk Consultants

To: Chairman Jeff Merkley and Ranking Member Markwayne Mullin
Senate Committee on Environment and Public Works
Subcommittee on Chemical Safety, Waste Management, Environmental Justice, and
Regulatory Oversight

RE: Hearing Entitled "*Examining the Public Health Impacts of PFAS Exposures*"
December 5, 2024 - Questions for the Record for Dr. Larranaga

Dear Chairman Merkley and Ranking Member Mullin,

Thank you for providing me the opportunity to testify before the Senate Committee on Environment and Public Works Subcommittee on Chemical Safety, Waste Management, Environmental Justice, and Regulatory Oversight regarding the public health impacts of PFAS exposures. I am writing in response to Chairman Merkley's questions sent to me on December 19, 2024. Chairman Merkley's questions are presented followed by my response:

1. Most Americans have been exposed to PFAS from a variety of sources including our water, our food, or the air we breathe. PFAS is also used in the manufacture and wiring of technology products. What, if any, is the human health exposure to PFAS used in products like smartphones?
 - a. What is the exposure to workers handling PFAS chemicals during the manufacturing process?

Response: I do not have the data sufficient to provide an answer to this question.

2. At the hearing, I was interested to hear that alternatives to PFAS chemicals could make machinery and semiconductors heavier. Please provide more information on how replacing PFAS with alternative chemicals in semiconductors, airplanes, or other technologies can make products and machines heavier.



Response: To answer this question, I must first provide some background on a some of the reasons that the use of PFAS and fluoropolymer substances permit the manufacture of small, efficient, reliable, and long-life products in every sector of the economy. (e.g., semiconductors, medical devices, lubricants). The carbon-fluorine bond inherent to these substances is the strongest bond known in organic chemistry, provides the following properties.

- Superior operation at extreme high and low temperatures.
- Superior friction reduction
- Ultra-high insulative, fire, and flame retardant properties per unit mass.
- Superior chemical corrosion resistance.
- Excellent ultraviolet light resistance.
- Ultra-pure surface properties.
- Significantly increased reliability, durability, and lifespan.

These properties permit the use of smaller amounts, and hence lower weights, of materials in products or items where weight and size are critical, such as aircraft, spacecraft, lubricants, semiconductors, printed circuit boards, electronic equipment, medical equipment, medical devices and implants, electrical wiring, batteries, electrical windmills, solar panels, data transmission components, automobiles, smartphones, computers, and an unquantifiable number of other applications.

These properties also permit the manufacture of high-quality safety critical components in aircraft, spacecraft, industrial controls, advanced weaponry, communication networks (e.g., Internet), signals intelligence systems, medical devices (e.g., pacemakers, ventilators, heart-lung machines, magnetic resonance imaging devices, insulin pumps, and robotic surgery machines), and in a variety of other applications.

These properties have played an important role in nanotool manufacturing, facilitating the achievement of Moore's Law, permitting increasingly greater computer processing power in decreasingly smaller configurations for applications in almost every aspect of modern society.



To summarize, the properties inherent to PFAS and fluoropolymers permit the manufacture of increasingly small components used in everyday society. The removal of PFAS and fluoropolymer substances from the marketplace would result in the opposite: increasingly larger configurations for products with poorer quality, reliability, performance, and shorter lifespans.

Thank you for the opportunity to provide this response.

Sincerely yours,

A handwritten signature in blue ink that reads "Michael Larrañaga".

Michael Larrañaga, PhD, PE, CIH, FAIHA

President and Managing Principal – R.E.M. Risk Consultants, LLC

Editor-in-Chief – *Journal of Occupational and Environmental Hygiene*, the research journal of the American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists.

Senator MERKLEY. We are delighted to have you share that information on foam, and I almost feel like we need a separate hearing to examine the complexities of the risk-reward that you have referred to.

Today, we are primarily focused on consumer products that people come in contact with. I want to start simply by, when a lot of people hear about PFAS, they hear Teflon. The most common thing in our homes that has Teflon, as far as I am aware, are no-stick pans like this one. Is it correct, I will direct this to you, Dr. Schaidler, is this PFAS? And is this a simple case of, we could just simply retire these pans? Does some of this forever non-stick Teflon get into our blood and our children's blood when we use these pans?

Ms. SCHAIER. Thank you, Senator, for the question. Yes, there are still frying pans that are made with Teflon. Teflon is a long polymer, PFAS. In the production of Teflon, smaller PFAS molecules are used and put together to make the long polymers and other PFAS are used as processing aids.

So frying pans are what I would consider a non-essential use of PFAS. We certainly have other ways to make cookware without the use of these toxic chemicals for everyday uses. There are concerns about PFAS exposures through the use of cookware, because the smaller PFAS molecules can come off of that cookware and expose people. There are also concerns about the life cycle. So in communities where Teflon is manufactured, with local environmental contamination and exposures among workers. Then at the end of a product's useful life span, those PFAS ultimately can end up in landfills or emissions from incinerators.

Senator MERKLEY. So we have various agencies that evaluate the risk to our citizens of different products. If this is non-essential and it presents a health risk, why do we still have Teflon coated pans being sold to the public?

Ms. SCHAIER. I think that is a great question. I think because industry has been able to make the case that newer PFAS are less bio accumulative in peoples' bodies, that they are still acceptable to use. But I would argue that the newer replacement PFAS that are in use, as Dr. Fenton described, are not safe. And in cases like cookware, we should find alternatives to PFAS, because they are simply not an essential use.

Senator MERKLEY. Dr. Fenton, you referred in your testimony to GenX. People listening to that hear "Generation X." But that wasn't at all what you were referring to. You were referring to a chemical replacement. Can you explain a little bit about that?

Ms. FENTON. Sure, I would be happy to. I am talking about HFPO-DA. It is a dimer acid, affectionately called GenX. There is more than one, multiple chemicals. The one thing really important about the GenX work that we have done is that when we saw the health effects in the animal studies that we have done, we couldn't measure it in their blood anymore. But we know we gave it to them.

So at early life stages, or right before birth, we know we could measure it in the blood of the animals. But the people living in the areas that have been affected by GenX for decades, you can't meas-

ure it in their blood either anymore. We know that if you are exposed, the health effects can still happen.

Senator MERKLEY. When you referred to the mice studies that you were looking at, those were PFAS studies. But there have been similar studies on GenX?

Ms. FENTON. Yes, there are, Jane Hoppin, for example, at NC State University, and others, are doing biomonitoring studies to look at many of the replacement PFAS that are known to be in the water in the Cape Fear River Basin, and have been there for decades, like I said.

Senator MERKLEY. Dr. Schaider, I have read in the past that microwave popcorn packages, like this one here, have non-stick surfaces, but that it's PFAS. Is that true? Is there PFAS in our microwave popcorn packages?

Ms. SCHAIER. Thank you for the question, Senator. Testing that Silent Spring Institute led in 2017 found that PFAS are common, were common in fast food packaging. Other studies found that microwave popcorn bags also contained PFAS as a grease-proof agent.

In the meantime, some States have put in place bans on PFAS in food packaging. Then most recently, earlier this year, the FDA announced that PFAS are no longer allowed in paper food packaging as grease-proofing agents. So my understanding is that microwave popcorn and other paper-based food packaging should no longer have PFAS. I am not sure about imported food packaging, and how much testing and enforcement there is for imported food packaging.

Senator MERKLEY. So in these cases where PFAS has been replaced, what has it been replaced by, and is that equally dangerous?

Ms. SCHAIER. In some cases, the solutions to PFAS in food packaging are a simple replacement. In our study of fast food packaging, we found about half of wrappers did contain PFAS and half did not. I would be happy to provide some additional information about what the replacement chemicals are.

But my understanding is that the replacements, other non-PFAS food additives would not be as persistent or pose the same health risks.

Senator MERKLEY. I have heard that paraffin, palm oil wax, and coconut wax are often used as a replacement for PFAS in food packaging. Are those dangerous to our health?

Ms. SCHAIER. Those would be safer alternatives than PFAS.

Senator MERKLEY. In the States that have—I see I am over my initial time here. I am going to yield to my colleague, but we may have time to go through several rounds of questions.

Senator Mullin?

Senator MULLIN. Thank you so much. It is not like we have a lot of people waiting in line, so I wasn't too worried about you going long on that. But I do appreciate you looking at the time.

Ma'am, we were talking about what is in food packaging, in the popcorn and the non-stick pans, which, the consumers are the ones who want to buy those pans, because cast iron is hard to deal with. For a guy that doesn't cook at all except Spam, I know how that sounds, but yes, I am the guy that likes Spam, OK? I am the one

that buys that stuff, because it is the only thing I cook at my house up here in D.C.

I also want to bring to everybody's notice, it is also on all of our touch screens, right? PFAS is in everyone's. So by using our touch screens, by using our phones, which everybody here has, and every one of our schools are giving them out for, that is how they are doing their homework now and doing their work at school. Is this contaminating our kids, too, every time they use the phone, every time they do their work at school?

Ms. SCHAUER. Thank you for that question, Senator. I am not aware of studies that have looked at the extent of PFAS coming off of phones and touch screens. I wonder about that with my own children as well.

But I do worry about the potential for PFAS to come off of products and end up in people's bodies.

Senator MULLIN. I bring that up because the pan, you are talking about the food, but the Teflon is designed to stay there. I mean, these, if you look at my phone, which you can't see, I don't even replace it every time I crack my phone, because I know I am going to drop it the next day. But it cracks up, we see them crack up, it is constantly on our head, it is constantly on our fingers, we are constantly using our fingers.

So I don't know how this isn't the same as using the pan. I mean, I am serious. If you are talking about contamination, how does it transfer from one place to the next if it is not transferring by touch? And I say that because we don't know. And so when we are moving forward to put a ban on PFAS, one, what are we going to replace it with? I don't think coconut wax is going to replace these touch screens, right?

When we start talking about insulating cups, I will leave the names out of them, but my kids drive me nuts with all these stupid insulating cups every time they get in my truck. It is like some fad that they carry. And it drives me nuts. But everyone one of those insulated cups for the most part have PFAS in them, right?

Ms. SCHAUER. Yes.

Senator MULLIN. So what is it, at what level do we stop, and what level is it contaminated, which level is it isn't? Is it just on the disposable side of it, that we are not disposing of it right?

These are questions that we need to talk about. Because it is something that we use in our everyday life that we have to be careful about. Yes, ma'am, go ahead.

Ms. FENTON. If I might, Senator Mullin, I want to suggest a couple of things here. Yes, these are all ways that we could be exposed. We do know that PFAS can be dermally absorbed, so, through your skin. Some can be dermally absorbed. They are water soluble. So they are going to go into your skin.

But this may not be the most prominent way that we are being exposed. I want to suggest that we do spend some time talking about PFAS in foods, foodstuffs, drinking water. Because those are major pathways of ingestion and exposure for all Americans.

So there are some new work coming out of East Carolina University and NC State showing that produce grown in our State is contaminated with PFAS, just because of the soil that they are being grown in. Now, that is a shame. I hope that we can get to a place

where we can get rid of the PFAS in the ground that the dairy cattle may eat the grass from that ground and our children could eat those blueberries.

But making sure we have clean drinking water and food that is not contaminated with PFAS is a really major win.

Senator MULLIN. I would ask on, what exactly are we talking about with the health risks that it is exposing to? Because most of that which you are talking about, because plumbing is my background, and I also carry a C license, operating license for water treatment plants and wastewater treatment plants.

Most of it is delivered through the water system from irrigation. But what we actually don't know is what harm it is actually causing, what is the long-term effects. We are identifying PFAS as there, but it is like we are putting the cart before the horse. We are saying that it is there, so it must cause some type of issue.

But there is not enough study to actually say it is causing these issues. I just want to be cautious. I don't want to overreact. And I am not getting into all my questions, because I want to talk about semiconductors, too, sir, but I am running out of time. We will circle back on this.

The whole point I am trying to make right here is, we all see that it is everywhere. It is everywhere. But I don't think we are even close to knowing the exact studies of if it is harmful and if it is, which direction is it harmful? At what point is it harmful? Is it just at the manufacturing stage? Is it in the raw form in itself? And so, yes, ma'am, you can finish, and I will go over my time.

Ms. FENTON. I actually have a good answer for that. Many of the PFAS that we are talking about today don't change form. So it would be whatever, the PFOA, for instance, if you are exposed to PFOA, that is what is in your blood, and that is what stays in your blood. It is not easily removed from the body.

We do know that many, a good handful of PFAS, we do know the health effects. I have put on the docket two really good reviews of the health effects of PFAS. One was written by Federal employees working across the entire base of the Federal Government, anybody who worked with anything with PFAS was on this committee that wrote the PFAS Report to Congress. Numerous health effects, both in humans and toxicology studies and ecology studies, are in there.

Also, some colleagues of mine wrote specific, targeted areas that have the biggest weight of evidence for health effects of PFAS. And those do include cancer, birth weight reduction of newborn infants. So specifically for the newborn infant issue—

Senator MULLIN. I am sorry, I am almost 2 minutes over time. I apologize.

Ms. FENTON. So for the newborn infants, we can estimate the amount of decrease in their birth weight by the amount of increase in the PFAS in the mom's blood. There is a direct correlation.

Senator MULLIN. I am over time. We will get back to you, we will circle back around.

Senator MERKLEY. We are going to turn to Senator Wicker.

Senator WICKER. Thank you very much. I am intrigued by the pronunciation of this substance. So since the last witness says PFAS, I will say PFAS. Some people say PFAS.

I want to nail something down, if I can. Is there a category of PFAS, and I will ask this to you, Dr. Larrañaga, that is not harmful as compared to a type of PFAS that is? And here is where I am going. There is a rather far-reaching definition of PFAS as “any compound containing at least one fully fluorinated carbon atom.”

I am told by some people that this combines a type of PFAS that is OK, and not harmful, with a type that is. And that the type of PFAS that is not harmful is used in 95 percent of our ammunitions, and a number of very, very important things to our economy, not to include national defense. So if the panel, starting with Dr. Larrañaga, would discuss that, I would appreciate it.

Mr. LARRAÑAGA. Thank you, Senator. It is my understanding that the fluoropolymer substances like PTFE, for example, that is used in many of our defense systems, 95 percent of our ammunition has a similar type of polymer chemical, almost all of our weapons systems have these types of chemicals. And that the PFAS of concern did not come out of those, for bioavailability, so they aren’t available to the body for absorption.

Senator WICKER. Although they do contain one fully fluorinated carbon atom?

Mr. LARRAÑAGA. Yes, sir.

Senator WICKER. They do not propose, they do not comprise a harmful substance?

Mr. LARRAÑAGA. That is correct. One of the issues is, that could be caused if you are heating them. If you are heating them far above the temperature that they are rated for, that could happen.

Senator WICKER. For example?

Mr. LARRAÑAGA. For example, a pan. That is a complete use where we could remove that from the marketplace without any adverse effect to our infrastructure or defense.

Senator WICKER. OK, so are we, should we be concerned that certain domestic suppliers will not be able to meet the demand for very important products as they continue to fight over this definition?

Mr. LARRAÑAGA. Yes, sir. If we were to ban as a country all PFAS chemicals with a broad brush, it would affect our supply chain that would lead directly to our military, public health, and all these critical infrastructure sectors. One example is the guidance systems on airplanes and ships and a lot of other drones and things like that use semiconductors that, in which PFAS was used to create those semiconductors. In addition, the wiring, the insulation on the wiring has PFAS-containing chemicals as insulators to the wiring.

If we were to broadly brush these into a regulator where we couldn’t use them anymore, airplanes would have to get heavier, they would carry less people, they would carry less cargo, and they would become a lot heavier. So what that would mean is, we would be burning a lot more carbon to move the same amount of cargo or people.

Senator WICKER. And public health would not be any better off?

Mr. LARRAÑAGA. Public health would not be better off, because you would be increasing the amount of air pollution that you put into the environment, which ends up in our oceans anyway.

Senator WICKER. OK, well, let me ask, Mr. Chairman, to at this point enter into the record a report on critical per and polyfluoroalkyl substance use.

Senator MERKLEY. Without objection.
[The referenced information follows:]

Report on Critical Per- and Polyfluoroalkyl Substance Uses

**Pursuant to Section 347 of the James M. Inhofe National Defense Authorization Act for
Fiscal Year 2023 (Public Law 117-263)**



August 2023

Office of the Assistant Secretary of Defense for Energy,
Installations, and Environment

Office of the Assistant Secretary of Defense for Industrial
Base Policy

The estimated cost of this report or study for the Department of Defense is approximately \$83,000 in Fiscal Year 2023. This includes \$47,900 in expenses and \$45,100 in DoD labor.
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Appendix

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Acronyms

AFFF	Aqueous film forming foam
AIM Act	American Innovation and Manufacturing Act of 2020
CMRMP	Chemical and Material Risk Management Program
DoD	Department of Defense
ECTFE	Ethylenechlorotrifluoroethylene
EPA	U.S. Environmental Protection Agency
EU	European Union
F3	Fluorine-free foam
FY	Fiscal Year
HFCs	Hydrofluorocarbons
HFOs	Hydrofluoroolefins
Li-ion	Lithium-ion
MCMEU	Mission-critical military end use
MilDep	Military Department
NDAA	National Defense Authorization Act
NDT	Non-destructive testing
OASD(IBP)	Office of the Assistant Secretary of Defense for Industrial Base Policy
ODASD(E&ER)	Office of the Deputy Assistant Secretary of Defense for Environment and Energy Resilience
OECD	Organisation for Economic Co-operation and Development
PA&T	Policy, Analysis, & Transition
PFA	Perfluoroalkoxy alkanes
PFAA	Perfluoroalkyl acid
PFAS	Per- and polyfluoroalkyl substances
polyFAA	Polyfluoroalkyl acid
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene fluoride
SOTA	State-of-the-Art
SOTP	State-of-the-Practice
U.S.	United States
USS	United States Ship
UV	Ultraviolet

I. Introduction

Section 347(a) of the James M. Inhofe National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2023 (Public Law 117-263) directs the Secretary of Defense, in consultation with the Defense Critical Supply Chain Task Force (i.e., the Office of the Assistant Secretary of Defense for Industrial Base Policy (OASD(IBP))) and the Chemical and Material Risk Management Program (CMRMP) of the Office of the Assistant Secretary of Defense for Energy, Installations, and Environment (OASD(EI&E)), to submit to the Committees on Armed Services of the House of Representatives and the Senate a report outlining the uses of per- and polyfluoroalkyl substances (PFAS) that are critical to the national security of the United States. This report focuses on critical uses in the sectors outlined in the February 2022 Department of Defense (DoD) report titled *Securing Defense-Critical Supply Chains* and sectors of strategic importance for domestic production and investment to build supply chain resilience.

PFAS are common chemicals used across DoD. Most weapons platforms incorporate PFAS, and PFAS are found throughout the defense industrial base in roles supporting mission critical component production and supply. PFAS uses may be direct, where a PFAS is a constituent in a consumable item or is incorporated into an article (e.g., end item), or indirect, where a PFAS is used to formulate another chemical or is part of a manufacturing process. These uses and processes are necessary to the production of key components of the defense industrial base, such as microelectronic chips and lithium-ion (Li-ion) batteries.

PFAS are chemically quite stable, and many are water and oil repellent, heat resistant, and/or stain resistant, often leading to non-stick surfaces on various materials. Examples of applications of PFAS are in plastics, o-rings, gaskets, lubricants, coolants, and fabrics. DoD is reliant on the critically important chemical and physical properties of PFAS to provide required performance for the technologies and consumable items and articles which enable military readiness and sustainment. Losing access to PFAS due to overly broad regulations or severe market contractions would greatly impact national security and DoD's ability to fulfill its mission, and impact domestic defense industrial base manufacturing and supply.

This report provides details on what is currently known about direct and indirect mission critical PFAS uses that could impact mission readiness if the substances are no longer available. It also highlights the challenges and costs related to finding and qualifying equal or improved performing alternatives to existing PFAS materials in sectors of strategic importance to DoD. It is important to note that the information contained in this report is limited to what was available at the time of its drafting. As such, the information presented represents a fraction of the mission critical PFAS uses due to a lack of knowledge of the complete chemical composition in consumables and articles (e.g., end items)¹. In addition, there is significant uncertainty regarding

¹ A consumable is defined as "an item of supply or an individual item (except explosive ordnance and major end items of equipment) that is normally expended or used up beyond recovery in the use for which it is designed or

the presence of PFAS in products that make up a complex value chain. A more complete understanding of PFAS essential uses would require an extensive and complex evaluation of the market, a gap analysis of current requirements for manufacturer-provided product information, and illumination of the value chain of products.

II. Definitions

For purposes of this report, the terms used within section 347(a) of the NDAA for FY 2023 are defined in the following sub-sections.

II.1 Per- and Polyfluoroalkyl Substances

There is currently no consensus definition of PFAS as a chemical class.² Congress did not define PFAS within section 347(a) of the NDAA for FY 2023 for purposes of this report.³ While there is no consensus definition, regulators in the European Union (EU) and the United States have proposed, but not yet adopted, different chemical-structure-based (rather than hazard- or risk-based) definitions. In anticipation of the most stringent future regulatory actions, DoD used the definition put forward by the Organisation for Economic Co-operation and Development (OECD) in its 2021 report, *Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance*,⁴ for collecting data and developing this report. OECD states “The term ‘PFASs’ is a broad, general, non-specific term, which does not inform whether a compound is harmful or not, but only communicates that the compounds under this term share the same trait for having a fully fluorinated methyl or methylene carbon moiety.” OECD cautions that this definition should not be used in deciding how to group and manage PFAS in regulatory actions; however, future PFAS legal and regulatory frameworks may disregard the OECD caution and seek to restrict the use of PFAS based on chemical structure.

intended. An end item is the “final combination of end products, component parts, or materials that is ready for its intended use, e.g., ship, tank, mobile machine shop, or aircraft.” *DoD Supply Chain Terms and Definitions* (February 21, 2023). https://www.acq.osd.mil/log/LOG_SD/policy_vault.html/DoD_Supply_Chain_Terms_and_Definitions.pdf.

² *Per- and Polyfluoroalkyl Substances (PFAS) Report: A Report by the Joint Subcommittee on Environment, Innovation, and Public Health*, Per- and Polyfluoroalkyl Substances Strategy Team of the National Science and Technology Council, March 2023.

³ Congress previously defined PFAS in the NDAA for FY 2021 for purposes of establishing the interagency working group to coordinate federal activities related to PFAS research and development. Section 332(g)(1) defines PFAS broadly as (A) man-made chemicals of which all of the carbon atoms are fully fluorinated carbon atoms; and (B) man-made chemicals containing a mix of fully fluorinated carbon atoms, partially fluorinated carbon atoms, and nonfluorinated carbon atoms. William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. 116-283 (2021).

⁴ “PFASs are defined as fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF₃) or a perfluorinated methylene group (–CF₂–) is a PFAS.” OECD, *Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance* (Series on Risk Management No. 61), July 9, 2021. [https://one.oecd.org/document/ENV/CBC/MONO\(2021\)25/En/pdf](https://one.oecd.org/document/ENV/CBC/MONO(2021)25/En/pdf).

The figure below provides an overview of the PFAS groups based on the OECD definition. This very broad definition encompasses more than 38,000 individual PFAS chemicals.⁵ DoD uses are represented in each major category of PFAS (i.e., perfluoroalkyl acids (PFAAs) and polyfluoroalkyl acids (polyFAAs)), PFAA precursors, and other PFAS (e.g., fluoropolymers, fluoroelastomers).

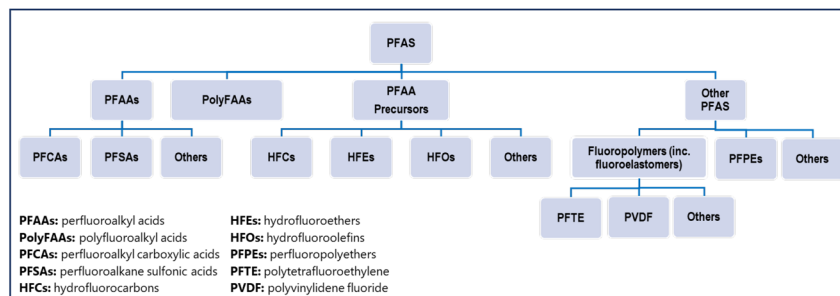


Figure: Overview of PFAS Groups (refined from OECD 2021)

II.2 Critical to the National Security

Congress did not define “critical to the national security of the United States” within section 347(a) of the NDAA for FY 2023. The term “mission-critical military end use (MCMEU),” however, is defined in regulations promulgated by the U.S. Environmental Protection Agency (EPA) under the American Innovation and Manufacturing Act of 2020 (AIM Act).⁶ The AIM Act addresses the phasedown of production and consumption of hydrofluorocarbons (HFCs) (e.g., regulated substances). MCMEUs are “[t]hose uses of regulated substances by an agency of the Federal Government responsible for national defense that have a direct impact on mission capability, as determined by the U.S. Department of Defense, including, but not limited to uses necessary for development, testing, production, training, operation, and maintenance of Armed Forces vessels, aircraft, space systems, ground vehicles, amphibious vehicles, deployable/expeditionary support equipment, munitions, and command and control systems.”⁷

The MCMEU definition focuses on *regulated substances*. As with HFCs, PFAS are undergoing increased regulation. But in addition to regulation, market forces can directly impact mission capability by limiting DoD’s ability to source and use PFAS and PFAS-containing

⁵ Williams, et al. 2022. Assembly and Curation of Lists of Per- and Polyfluoroalkyl Substances (PFAS) to Support Environmental Science Research. *Front. Environ. Sci.* 10:850019. doi:10.3389/fenvs.2022.850019.

⁶ 42 U.S. Code 7675.

⁷ See 40 Code of Federal Regulations 84.3, “Phasedown of Hydrofluorocarbons” (October 5, 2021).

products. The most recent example is 3M's decision to phase out production of PFAS and PFAS-containing products by 2025.⁸

For purposes of data collection and report development, DoD used the MCMEU definition with the recognition that both market forces and increased regulation can have a direct impact on mission capability.

II.3 Sectors Considered

Section 347(a) of the NDAA for FY 2023 directs DoD to focus this report on critical PFAS uses in the four focus areas identified in DoD's February 2022 report *Securing Defense-Critical Supply Chains*.⁹ The four focus areas—kinetic capabilities, energy storage and batteries, microelectronics, and castings and forgings—have critical supply chain vulnerabilities posing the most pressing threats to national security. In addition, this report focuses on semiconductors—a sector of strategic importance for domestic production and investment to build supply chain resilience—and strategic and critical minerals. These areas are described as:

- **Kinetic capabilities:** Current missiles systems and advanced and developing missile capabilities, including hypersonic weapons technology, as well as directed energy weapons.
- **Energy storage and batteries:** High-capacity batteries, with a particular focus on lithium batteries.
- **Microelectronics and semiconductors:** State-of-the-Practice (SOTP) and legacy microelectronics, State-of-the-Art (SOTA) microelectronics, and semiconductors.
- **Castings and forgings:** Metals or composites developed into key parts and manufacturing tools through high-intensity processes.
- **Strategic and critical minerals:** Minerals to supply U.S. military, industrial, and essential civilian national emergency needs, with emphasis on those that are not produced in sufficient quantities in the United States.

III. Data Collection Methodology

Data collection efforts for this report were led by the CMRMP of the ODASD(E&ER) and the OASD(IBP) and included engagement with the DoD Components and Military Departments (MilDeps), industry, and industry associations.

⁸ "3M to Exit PFAS Manufacturing by the End of 2025" (December 20, 2022). <https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025>.

⁹ Securing Defense-Critical Supply Chains: An Action Plan Developed in Response to President Biden's Executive Order 14017 (February 2022). <https://media.defense.gov/2022/Feb/24/2002944158/-1/-1/1/DOD-EO-14017-REPORT-SECURING-DEFENSE-CRITICAL-SUPPLY-CHAINS.PDF>.

III.1 CMRMP Data Call

In March 2023, the CMRMP asked the DoD Components and MilDepts to provide information about its critical uses of PFAS, to include use of neat PFAS, use of PFAS-containing products, the functionality provided by the PFAS, specific uses and applications, and availability of alternatives (if known).

III.2 Additional Industry Engagement

The CMRMP held engagement sessions with various industries and industry associations to obtain information about the PFAS and PFAS-enabled products that they (or their member industries) manufacture and how DoD uses those products. The CMRMP shared this information with the DoD Components and MilDepts to inform their data collection efforts.

III.3 OASD(IBP) Industry Sector Data Collection Process

The Kinetic Capabilities Team at Policy, Analysis, & Transition (PA&T), OASD(IBP), engaged with PA&T Industry Sector leads and their industry partners to identify PFAS uses that are critical to U.S. national security. These sectors include Kinetic Capabilities, Energy Storage and Batteries, Microelectronics and Semiconductors, Castings and Forgings, and Strategic and Critical Materials. The Sector leads identified PFAS uses in industry, operation, manufacturing, processes, components, parts, and materials. They also discussed how and where losing access to PFAS could have significant mission readiness impacts and what they could do or are doing to mitigate those impacts.

IV. Results

DoD's known critical uses of PFAS are summarized in the following sub-sections, organized by focus area, and in the Appendix. The complexities in dissecting the defense industrial base value chain and supply chain dependencies, in addition to the lack of transparency in chemical and material content data, prevented the CMRMP from gathering comprehensive data on all critical PFAS uses.

Critical PFAS uses were identified in almost every major weapon system category including but not limited to fixed wing aircraft (trainers, fighters, bombers, transports, refuelers, ground support, unmanned, and associated support equipment); rotary wing aircraft (attack, transports, heavy lifts, search-and-rescue, and associated support equipment); surface ships (combat, destroyers, aircraft carriers, cutters, landing crafts); submarines; missiles (air-to-air, ground-to-air, air-to-ground, ballistic); torpedo systems; radar systems; and battle tanks, assault vehicles, and infantry carriers.

IV.1 Kinetic Capabilities

Kinetic capabilities represent a direct use of PFAS, as PFAS are found in a variety of applications across the DoD munitions portfolio. About a dozen fluoropolymers, including

fluoroelastomers, are ingredients in polymer bonded explosives, pyrotechnics, and propellant components used in munitions, decoy flares, and chaff. They serve as high temperature resistant binders and resins. These uses, which represent some of the few purely military PFAS applications, include:

- Unique binder materials specifically developed for use in the energetic portion of conventional and strategic weapons platforms.
- Fluoroelastomers, such as Viton™, used as a binder in explosive and booster charge formulations integrated into many DoD munitions.
- Fluoropolymers, such as Teflon™, used in pyrotechnics and as a material used in the manufacture of munitions for a variety of missile systems.

PFAS are used in a variety of applications during energetics processing and testing. Currently, non-PFAS alternatives do not exist for most of these applications, and the likelihood of developing alternatives for these uses is estimated to range from moderate to almost impossible. If available, alternatives require multi-year processes and cost program offices millions of dollars to requalify every missile system that used the material, even if products are similar.

IV.2 Energy Storage and Batteries

Impacts to national security from PFAS applications in energy storage and battery applications are indirect. Manufacturers use fluoropolymers (e.g., polytetrafluoroethylene (PTFE)) and polyFAAs in multiple subcomponents in modern Li-ion batteries. They serve as heat transfer materials or insulation and provide weather resistance and ultraviolet (UV) light resistant functionalities to final components. Military applications rely on Li-ion battery technologies that are largely innovated in the civilian sector. Manufacturers use PFAS in the electrolyte solutions, cathode binders, and separator coatings; and, to a lesser extent, PFAS are found in casing materials and gaskets due to their deterioration resistance properties.

PFAS materials also play an important role in battery manufacturing. Filters and other components of manufacturing equipment are essential to battery production. The battery industry's ability to make products for a broad range of commercial and military applications would be greatly impacted if PFAS were no longer available for use in these components. The significant time and money needed to identify and qualify alternatives as replacements would cause ripple effects throughout the economy as consumers and users absorb the additional cost.

Fully eliminating PFAS from energy storage in the U.S. economy would likely take more than 10 years. Energy storage is a broad issue for U.S. industrial competitiveness as well as an important part of Federal initiatives around combating climate change. DoD is not the primary consumer of batteries in the United States, but battery supply chain issues would impact the ability to produce missiles and field military vehicles that increasingly rely on batteries.

IV.3 Microelectronics and Semiconductors

The semiconductor industry produces the chips that drive modern electronic devices. The microelectronics packaging and assembly industry integrates these chips into the electronic products used every day across the defense enterprise. In the semiconductor industry, fluoropolymers, fluoroelastomers, polyFAAs, and other fluorochemicals are used in a number of applications and at every stage of semiconductor fabrication. These uses include etching materials (photoresists), etching coolants, masks in photolithography processes, packaging materials that provide heat dissipation for the chip, and cleaning gases at various stages in the microchip production process. Examples of specific PFAS in the semiconductor industry include polyvinylidene fluoride (PVDF; a fluoropolymer), ethylenechlorotrifluoroethylene (ECTFE; a fluoropolymer), FKM/FFKM (fluoroelastomers), and perfluoroalkoxy alkanes (PFAs).

One significant use of PFAS in semiconductor manufacturing is during the photolithography process, where the patterns that define the microchip circuitry are developed onto bare silicon surfaces. Manufacturers use photolithography specialty formulations containing fluorinated compounds in various steps of this process to ensure final chip quality and reduce the probability of defects. PFAS are ideal for these purposes due to their low surface tension and compatibility with other chemicals. The PFAS materials used in these processes are typically no longer present in the finished product, except in some specific applications, such as imaging chips used in cameras, displays, and some medical devices.

Similar to the energy storage industry, PFAS are essential for semiconductor manufacturing equipment and factory infrastructure. The exceptional combination of heat and chemical resistance and chemical inertness allows fluoropolymers to be used both in equipment components (e.g., tubing, gaskets, containers, filters) and lubrication (e.g., various oils and greases). These same properties are also needed to ensure the functioning of the surrounding infrastructure.

In wider microelectronics applications, PFAS remain key industrial materials in applications that integrate microchips into electronic products, such as printed circuit boards. PTFE and PFA base laminate materials are currently used in many radio frequency (RF) and microwave circuits, as they provide unique properties related to isolating RF and microwave signals. Identifying and qualifying potential replacement materials will require significant time, particularly for use in fielded systems. There currently are no available drop-in replacement materials for a PTFE designed printed board. Lack of access to PTFE laminate will necessitate the redesign and requalification of the printed board, the assembly, and potentially the system.

Several PFAS-containing vapor phase soldering and flux removal products are used in the manufacture of printed circuit boards. Vapor phase soldering is used primarily for printed board assembly when there is a high thermal mass, in combination with advanced technologies such as fine-pitch features, or when there are temperature sensitive components used. Alternative materials are not currently identified and would need to be evaluated for performance

and safety. New equipment may be required to implement new vapor phase soldering liquids. PTFE cable jackets are used in printed circuit board and other electronic systems in connectors and wire. PTFE has unique properties as a wire insulator including fire, smoke, and chemical resistance to mitigate the risk of wire exposure in harsh environments. PTFE can withstand 450°C and is used widely in products that have been developed to meet MilSpec applications. Manufacturers also use fluoropolymers as electronics sealants and encapsulants to protect microelectronic components from degradation due to environmental, chemical, or UV-light exposure. Vapor degreasing solvents, used in a variety of cleaning processes during microelectronics production, contain hydrofluorocarbons (HFCs) and hydrofluoroolefins (HFOs), which, in many cases and in the broadest sense, are defined as PFAS. These materials impart fire suppression properties to the degreasing solvent, creating safer manufacturing environments for workers.

Currently, no alternatives to PFAS have been identified that can provide the functional properties required for photolithography or some applications in semiconductor manufacturing equipment. Even if alternative chemicals and technologies were discovered today, due to the extremely complex qualification process throughout the value chain, it would take another 15 years to deploy them in high-volume manufacturing. Therefore, continued access to PFAS is a prerequisite for high-volume and advanced semiconductors. Lack of continued access to PFAS could lead to an inability to produce and supply semiconductor manufacturing technology.

Replacing most PFAS uses in semiconductor fabrication would require industry-wide re-tooling and other process innovations, at a minimum. Some might be achievable within 10 years, but many would not. As stated above, there are some PFAS uses for which no alternatives are known. For these uses, it may be necessary to invent novel chemistries and processes. Replacing PFAS in semiconductor fabrication could be a 25-year effort and may not succeed in all respects if alternatives cannot be identified or qualified at the microchip level.

Consideration must also be given to the resultant impact on DoD programs. It is highly probable that manufacturers would need to change semiconductor manufacturing processes to accommodate PFAS replacements. This change has the potential to result in the costly requalification of specific components. For example, radiation hardened microelectronics applications typically mandate requalification if a manufacturer substantively alters the fabrication process, which can easily exceed \$10 million; many programs lack intrinsic funding for requalification.

IV.4 Castings and Forgings and Strategic and Critical Minerals

Specialty fluorochemical gases and fluids are used for advanced metalworking, casting, and fabrication due to the temperature and wear resistance functionalities they provide. These gases and fluids are used in the production of advanced metal parts throughout U.S. industry, including military-specific parts. Requiring a move to PFAS-free alternatives in under 10 years may make construction using certain alloys impossible and require returning to previous methods

of construction leading to lower performance, shorter life, and higher weight of constructed parts.

In both the casting and forging and strategic and critical minerals industries, loss of access to PFAS is an indirect threat to national security and a potential source of significant disruption to supply chains vital to the DoD mission. These industries depend on PFAS in products used during normal business operations. A product used as a liquid cold spray in castings and forgings or coolant in drilling operations for critical minerals may contain PFAS, but the product user would not know that PFAS are present until the product is discontinued. Both industries are at risk of losing critical capabilities with little warning, as there are limited requirements for companies to provide composition information for the materials used to create the products they sell to DoD or on the commercial market. The risk for these industries is particularly high, even if the probability is low, because there may be no warning for critical product obsolescence and no ability to develop and qualify alternatives in a timely fashion.

PFAS are also contained in mold release chemicals and release films typically used in composite manufacturing processes. Loss of access of PFAS would impact the commercial composites manufacturing industry and, indirectly, the DoD who is reliant on the commercial industry for applications.

Mold release chemicals are applied to mold hardware to prevent the composites from strongly adhering to the mold hardware during cure. The mold release chemicals typically contain PFAS chemicals or a PTFE polymer spray. Peel plies are used to prevent attachment of vacuum bag materials and other disposable molding materials to the composite part and to impart a textured surface to the molded component to improve adhesion in secondary bonding or painting. Peel plies are typically made of non-PFAS polymers, such as polyamides and polyesters; however, to prevent adhesion of the composite to the peel ply, PFAS modification (most commonly) or silicone modification is done to the fabric. Additionally, if high cure temperatures are required, PTFE and PVDF peel plies are typically used. Polymer release films are similar to peel plies but are generally used with composite resins that need to release gasses during cure. Many of these release films are polyethylene, polypropylene, or other polyolefins and work well for many applications; however, certain applications (typically higher temperature curing systems) require use of fluoropolymers, such as PTFE, PVDF, and others. Pre-preg release film is used to keep individual layers of pre-pregs (e.g., fabrics that are pre-impregnated with a fully curable, mixed resin system during manufacture) separated from each other within the rolls of materials that are prepared and transported for use in composites manufacturing facilities. Fluoropolymer release films are generally used to ensure the releasability of the release film during composite layup. Silicones are also useable for this application but are generally not used because of the low rigidity of silicone films.

IV.5 Additional Mission Critical PFAS Uses

Mission critical PFAS uses extend beyond the five industries discussed to this point. DoD identified a range of additional critical uses for which the potential risk of supply chain

disruption would undercut not only mission readiness but the U.S. economy. These uses are discussed in more detail in the following sub-sections.

IV.5.1 Refrigeration and Air Conditioning, Cooling, and Electronics Thermal Control

Most refrigerants used in civil and military cooling and refrigeration applications can be classified as PFAS. Many next-generation refrigerant alternatives adopted by U.S. industry (and U.S. households) between now and the end of 2025 are also PFAS. Under the AIM Act and EPA technology transition regulations, the U.S. economy is in the process of switching from one set of PFAS-classified refrigerants (e.g., HFCs) to a new generation of refrigerants (e.g., HFOs), which are also, in the broadest definitions, considered to be PFAS. Known non-PFAS alternatives (e.g., hydrocarbon or ammonia alternatives) pose flammability, toxicity, or high-pressure concerns. The same PFAS that are used in quantities of several hundred million pounds per year throughout the U.S. economy for cooling applications are used in much smaller quantities (i.e., a fraction of one percent) for military cooling and military thermal control of all kinds.

IV.5.2 Fire Suppression in Naval Vessels, Aircraft and Ground Combat Vehicles

Fluorochemical specialty gases are used in “clean agent” fire suppression in naval vessels, aircraft, and ground combat vehicles. Most known clean agent, low-corrosion, low-weight, low-toxicity alternatives will likely be classified as PFAS, broadly defined.

Since the advent of regulations against halogenated agents, Naval vessels commonly utilize an HFC clean agent in compartments subject to flammable/combustible liquid fuel fires such as engine modules and hazardous material storage spaces. For new U.S. Naval ship designs, the Navy continues to move to alternate fire suppression technologies (e.g., water mist) where suitable, however limited use of HFC remains for those spaces where the alternatives are not appropriate. For existing ship HFC uses, there is no “drop-in” replacement for these HFC agents.

Well over 10 million pounds of PFAS fire suppressants are installed in civil aircraft engine, cargo compartment, and lavatory fire suppression systems, and in hand-held aircraft fire extinguishers, worldwide. This includes halons (which meet PFAS definitions but are frequently excluded from draft PFAS regulations because they are separately covered by ozone depleting substance regulations) and all currently implemented aviation replacements for halons. In 2022, Working Paper 96 presented at the 41st Assembly of the International Civil Aviation Organization recommended considering PFAS use in aircraft fire suppression an essential use in prospective PFAS regulations to maintain progress in replacing halons.¹⁰

¹⁰ International Civil Aviation Organization (ICAO), Working Paper 96: Aircraft Halon Replacement, A41-WP/96, 28 July 2022. https://www.icao.int/Meetings/a41/Documents/WP/wp_096_en.pdf.

IV.5.3 Aqueous Film Forming Foam

Mission critical ocean-going vessels employed by DoD and the Military Services continue to use aqueous film forming foam (AFFF) containing PFAS for combating Class B (flammable/combustible liquid) fuel spill fires. U.S. Navy ships are required to use AFFF qualified to MIL-PRF-24385. MIL-PRF-24385 qualified AFFF provides the capability to rapidly control and extinguish shipboard fires. AFFF is critical for fire emergencies on flight decks where aircraft movement, fueling, launch/recovery, and weapons loading occur, and substantial risk exists for loss of aircraft, ship, and life if a fire is not rapidly controlled and extinguished.

Past flight deck fires, such as those that occurred on the United States Ship (USS) FORRESTAL, USS ENTERPRISE, and USS NIMITZ, all demonstrate the potential for such catastrophic events to occur. The risk of devastating loss of life and warfighting capability in incidents such as these, and the more recent fire emergency which resulted in the loss of the USS BONHOMME RICHARD, necessitates the use of the most effective firefighting agents available.

Beyond the potential for the immediate loss of life and impacts to operational capability that can result from an uncontrolled fire on a warship, the defense industrial base has limitations with respect to repairing or delivering replacement national security assets, including ordnance, aircraft, and ships. It could take a decade or longer to replace large amphibious assault ships and aircraft carriers.

Currently available fluorine-free foams (F3s) have significant limitations compared to AFFF that preclude their use on DoD ocean-going vessels, including the U.S. Navy fleet. Those limitations include reduced firefighting performance; chemical and physical properties that make them unsuitable for use with existing ship firefighting foam storage and delivery systems; and cross-agent compatibility issues. There are currently no equivalent, fully performing firefighting alternatives to AFFF for shipboard use.

DoD continues to sponsor research and development for F3 technologies to address these limitations, with the goal that continued technology improvements will support efforts toward a future path for use on ships. To date, DoD has invested approximately \$45.8M since 2017 toward the development and qualification of F3 technologies.

Until such time that a capable F3 alternative is found, the safety and survivability of naval ships and crew from shipboard fires depends on the continued availability of MilSpec AFFF products and their PFAS-containing constituents, which were formulated, tested, qualified, and implemented in order to save lives and military assets.

IV.5.4 Lines, Hoses, O-Rings, Seals and Gaskets, Tapes, and Cables and Connectors

Dozens of different fluoropolymers (e.g., PVDF, ECTFE, PTFE) and fluoroelastomers (e.g., FKM/FFKM) are critical to modern UV-resistant, ozone-resistant, weather-resistant,

temperature-resistant, high pressure-resistant, chemical-resistant “rubberized” fuel lines. They are also key materials in hoses, tubing, hydraulic system lines, O-rings, seals and gaskets, tapes, and cables and connectors widely used in civil and military aircraft, space systems, vehicles, weapon systems, utility systems, and other applications. Alternatives are not as resistant to embrittlement and break-down and have a much shorter useful life, leading to more frequent part replacement, which is not feasible for space or satellite uses.

IV.5.5 Electronic/Dielectric Fluids

Fluorochemicals are found in electronic and dielectric fluids that are used in civil and military radars and high-power electronics and electrical system/utility system components because of their dielectric and heat transfer properties. Industry and DoD have repeatedly investigated alternatives for these applications. Known alternatives have high global warming potential (e.g., sulfur hexafluoride) or may pose health/environmental risks (e.g., the polychlorinated biphenyls banned by the U.S. Toxic Substances Control Act and the Stockholm Convention on Persistent Organic Pollutants). Examples of PFAS-containing electronic/dielectric fluids used by DoD include 3M™ Fluorinert™ Electronic Liquids FC-40, FC-72, FC-770, and FC-3283.

IV.5.6 Advanced Oils, Greases, Fluids, and Lubricants

PFAS are used in many advanced turbine engine oils, greases, fluids, and lubricants due to their wear- and heat-resistant properties. These uses are common throughout the most demanding applications in the U.S. civil transportation, industrial, and space sectors. Analogous PFAS-containing oils, lubricants, and fluids are used in military critical ground, sea, air, and space applications. Previous generations of oils, fluids, and lubricants approached, but did not equal, the performance of PFAS additives that have become more prevalent in high performance oils, greases, fluids, and lubricants over the past 20 years.

Castrol Braycote 640AC is an example of a PFAS-containing grease, designed to be oxidizer and propellant compatible for use in aerospace vehicles, spacecraft, rocket and aircraft engines, and associated ground support equipment, oxygen equipment, and transport equipment. Braycote 640AC is typically used to lubricate threaded fasteners, connectors, valves, gaskets, elastomers, and bearings. Perfluorinated greases, in general, exhibit excellent shelf lives due to their intrinsic inertness.

Two additional examples of PFAS-containing greases used by DoD (and original equipment manufacturers and the maintenance, repair, and overhaul industry) are NYCO GREASE GN25013 and NYCO GREASE GN617. PTFE is used as a thickener in both products and perfluoropolyether is used as the base stock for GN617.

IV.5.7 Precision Cleaning Fluids

Fluorochemicals are used in precision cleaning applications, including the cleaning of sensitive oxygen systems in civil and military aerospace.

IV.5.8 Degreasing/Cleaning Fluids

The MilDeps reported the use of PFAS-containing degreasing/cleaning products and contact cleaners (e.g., 3M™ Novec™ Engineering Fluids, 3M™ Novec™ Contact Cleaners, 3M™ Novec™ Contact Cleaner/Lubricant) in vapor degreasing and flux removal.

The Army reported the use of FCC2 Enhanced Fiber Connector Cleaner and Preparation Fluid, which contains butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy, for cleaning fiber optic connectors in secure link manager assemblies and primary modem assemblies.

The MilDeps reported the use of fluorinated non-destructive testing (NDT) solvent cleaner/remover for precleaning before NDT and for removing excess surface penetrant from an inspection area before applying developer during liquid penetrant testing.

The MilDeps also reported that PFAS-containing degreasers are used to effectively remove grease, oil, tar, and other substances from military equipment to increase its operating efficiency. These degreasers leave no residue, have no flash or fire point, and serve as an alternative to legacy solvents (e.g., n-propyl bromide, trichloroethylene, tetrachloroethylene).

IV.5.9 Adhesives

The MilDeps reported the use of the following adhesives, which contain PFAS: 3M™ Super Foam Fast Spray Adhesive 74-Orange, 3M™ Hi-Strength Spray Adhesive 90 (aerosol), and 3M Scotch-Weld Epoxy Adhesive DP420 Off-White, Part A.

IV.5.10 Insulation and Foam Blowing

Fluorochemicals are components of insulation and foam blowing products used in civil and military aircraft and space vehicles/rocket motors.

IV.5.11 Resins for Specialty Materials

Fluoropolymers are used in resins for specialty high-temperature or weather-/UV-resistant composites due to their temperature-, pressure-, wear-, and chemical-resistance properties. Fluoropolymers are also used in high cleanable, high weathering and chemical resistant coatings for military assets. Many aircraft topcoats contain fluoropolymer resins due to their UV and chemical resistance properties. PFAS are not actually in the coatings themselves but are used in fluoropolymer resin manufacturing.

Moving to alternatives in under 10 years may require a return to previous methods of parts construction which produced shorter life and higher weight composites with lower performance characteristics.

IV.5.12 Specialty Filters and Membranes

Fluoropolymers are used in specialty filters and membranes (e.g., aviation filters) due to their temperature-, pressure-, and wear-resistance properties. PFAS are also found in several air filtering masks and air filtering respirators used by DoD.

IV.5.13 Fabrics, Fabric Liners, and Fabric Barriers

A variety of textiles used in uniform clothing and footwear items, tents, and duffle bags are treated with PFAS to repel water and oils while providing durability to laundering, UV light exposure, and temperature cycling. The main PFAS used on textiles are fluoropolymers, such as PTFE and short chain PFAS, known as C6 or C4 chemistries. PFAS can be incorporated as an additive mixed into individual fibers or sprayed as a coating onto finished fabrics during manufacturing or after sale and are present in/on textiles in two forms: a non-polymerized compound that can be washed out or evaporated or as a molecule integrated into a fluorine free polymer network via covalent bonds. The MilDeps reported the use of PFAS in chemical, biological, radiological, and nuclear protective equipment (the Uniform Integrated Protection Ensemble Family of Systems) and in a number of uses within health care communities.

Coretech, the biological protective fabric lining used on the Joint Biological Agent Decontamination System, includes a barrier layer for biological protection during the decontamination of aircraft. The barrier layer contains PFAS.

IV.5.14 Customized Applications

Customized applications like gyroscope suspension fluids and analytic gases and fluids for thermometric and other sensors use specialty fluorochemicals because of their pressure-resistant, wear-resistant, and temperature control properties. These applications require very small quantities of specialty PFAS and are particularly susceptible to disruptions in PFAS supply chains due to challenges in attracting manufacturers to develop low-volume commodities.

V. Conclusions

This report summarizes known direct and indirect uses of PFAS that are critical to the national security of the United States, but it is not comprehensive. Also highlighted are the challenges and costs related to finding and qualifying alternatives to existing PFAS materials in sectors of strategic importance to DoD. The information contained in this report is limited to what was available at the time of its drafting. As such, the information presented represents a fraction of the mission critical PFAS uses due to a lack of transparency in the chemical composition in consumables and articles. In addition, there is significant uncertainty regarding the presence of PFAS in products that make up a complex value chain. A more complete understanding of PFAS essential uses would require an extensive and complex evaluation of the market, a gap analysis of current requirements for manufacturer-provided product information, and illumination of the value chain of products.

PFAS are critical to DoD mission success and readiness and to many national sectors of critical infrastructure, including information technology, critical manufacturing, health care, renewable energy, and transportation. DoD relies on an innovative, diverse U.S. industrial economy. Most of the structurally defined PFAS are *critical to the national security of the United States*, not because they are used exclusively in military applications (although a few are) but because of the civil-military commonality and the potentially broad civilian impact. This report provides details on what is currently known about direct and indirect mission critical PFAS uses that could impact mission readiness if the substances are no longer available.

Emerging environmental regulations focused on PFAS are broad, unpredictable, lack the specificity of individual PFAS risk relative to their use, and in certain cases will have unintended impacts on market dynamics and the supply chain, resulting in the loss of access to mission critical uses of PFAS. These market responses will impact many sectors of U.S. critical infrastructure, including but not limited to the defense industrial base. Collectively, international and U.S. regulatory actions to manage PFAS' environmental impacts and identify and eliminate PFAS from the market, and the resulting market changes, pose risks to DoD operations and the defense industrial base supply chain. In addition, impacts to the global PFAS supply chain will present risks to the DoD Foreign Military Sales program and to North Atlantic Treaty Organization interoperability.

The Department will continue to oversee coordinated lines of effort to expeditiously identify essential uses of PFAS, prioritize actions according to vulnerabilities to national security, and address mission readiness associated with the potential loss of access to PFAS. Actions include:

- Implementing DoD PFAS policy directing the DoD Components and MilDeps to determine the PFAS content in DoD weapon systems, to the extent feasible, and enabling continued access to mission critical uses, while encouraging safe use by DoD personnel and adoption of PFAS-free alternatives.
- Engaging with industry to identify PFAS content in other materials commonly used within the DoD to assess potential obsolescence risks and potential PFAS alternatives.
- Engaging with industry and federal agencies during routine meetings to assess obsolescence risks, mission criticality, and potential PFAS alternatives.
- Investing in research, development, and qualification efforts required to demonstrate conformance with Military Standards or Specifications.
- Collaborating across the Federal Government to develop a long-term research plan for the most challenging applications where it will take a decade or more to find viable replacements.
- Investing in research to support advanced manufacturing approaches by improving purification, deconstruction technologies, scale-up of sustainable materials design and manufacturing, and circularity for the most critical and irreplaceable PFAS.

Concurrent with efforts to identify essential uses of PFAS, the Department is phasing out non-essential and non-critical PFAS uses in accordance with NDAA requirements where there is no mission impact (e.g., in food packaging, cookware, furniture, personal protective firefighting equipment). Additionally, per the 2023 U.S. Government Accountability Office (GAO) recommendations,¹¹ the Department is developing an approach to implement the April 2023 prohibition for military exchange resale procurements. The Department is also updating DoD Instruction 4105.72, *Procurement of Sustainable Goods and Services*, to include procedures specifically targeted to implementing the provisions of Executive Order 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*, with respect to limiting the procurement of items containing PFAS.

Eliminating PFAS from non-essential uses is an important step toward addressing public concerns and protecting human health and the environment. Mission critical PFAS uses provide significant benefits to the framework of U.S. critical infrastructure, and national and economic security. DoD will consider future policy actions to manage non-essential and essential PFAS uses and will implement these actions with the intent of protecting human health and the environment while ensuring no adverse impacts to U.S. critical infrastructure and national security.

If future PFAS legal and regulatory frameworks ignore the OECD caution on the use of its PFAS definition and seek to broadly restrict the use of PFAS based on chemical structure, there could be extensive economic, industrial competitiveness, and quality-of-life impacts to U.S. society. The PFAS universe is structurally and physiochemically diverse and subgroups of PFAS may be more or less stable, persistent, and/or bioaccumulative compared to well-studied PFAS such as perfluorooctane sulfonate and perfluorooctanoic acid.¹² Congress and the Federal regulatory agencies should avoid taking a broad, purely “structural” approach to restricting or banning PFAS. It is critical that future laws and regulations consider and balance the range of environmental and health risks associated with different individual PFAS, their essentiality to the U.S. economy and society, and the availability of viable alternatives.

¹¹ U.S. Government Accountability Office (GAO). Persistent Chemicals: Actions Needed to Improve DoD’s Ability to Prevent the Procurement of Items Containing PFAS. GAO-23-105982. April 2023.

¹² EPA Framework for Estimating Noncancer Health Risks Associated with Mixtures of Per- and Polyfluoroalkyl Substances (PFAS) (Public Review Draft), EPA-822-P-23-003 (March 2023).

Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Kinetic Capabilities				
Fluoropolymers (e.g., Teflon™)	Ingredients in binders and resins used in PBX, pyrotechnics, and propellant components that are used in a variety of applications across the DoD munitions portfolio.	High temperature resistance	NA*	NA
Fluoroelastomers (e.g., Viton™)				
PFAS	Used in energetic slurry processing.	Enables high levels of mixing between key energetic components.	NA	NA
Fluorinated performance fluids (e.g., 3M™ Fluinert™ fluids)	Enable energetics laboratory research. Are critical for developing and transitioning new energetic materials.	NA	NA	NA
Energy Storage and Batteries				
Fluoropolymers (e.g., polytetrafluoroethylene (PTFE))	Multiple subcomponents in modern Li-ion batteries: electrolyte solutions, cathode binders, separator coatings, casing materials, and gaskets.	Serve as heat transfer material or insulation. Provide weather-resistance, UV light-resistance, and deterioration-resistance properties.	NA	Fully eliminating PFAS from energy storage in the U.S. economy would likely take 10+ years.
Polyfluoroalkyl acids (PolyFAAs)				
PFAS	Battery manufacturing: filters and other components essential to production.	NA	Possibly available	Time and cost to identify and qualify alternatives would be significant and have ripple effects throughout the economy.
Microelectronics and Semiconductors				
Fluoropolymers	Semiconductor fabrication: etching materials and masks in photolithography processes; cleaning gases.			
Fluoroelastomers		Dielectric, heat transfer, and insulation functionalities.	Currently no alternatives to PFAS for photolithography.	NA
PolyFAAs				
Other PFAS				

Report on Critical Per- and Polyfluoroalkyl Substance Uses

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Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Fluoropolymers	Semiconductor manufacturing equipment and factory infrastructure: equipment components (e.g., tubing, gaskets, containers, filters) and lubrication (various oils and greases).	Heat and chemical resistance, and chemical inertness.	Currently no alternatives for some applications in semiconductor manufacturing equipment. Replacing most PFAS uses in semiconductor fabrication would require industry-wide re-tooling and other process innovations. Some might be achievable within 10 years, but many would not.	Development of alternatives for some uses may require the invention of novel chemistries and processes. Due to the extremely complex qualification process, it would take another 15 years to deploy alternatives, once developed, in high-volume manufacturing. Replacing PFAS in semiconductor fabrication could be a 25-year effort and may not succeed in all respects if alternatives cannot be identified or qualified at the microchip level. Replacing PFAS has the potential to initiate costly requalification of specific components. Example: microelectronics applications typically mandate requalification if a manufacturer substantively alters the fabrication process, which can easily exceed \$10 million.

Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
PTFE	Microelectronics applications: base laminate materials used in many RF and microwave circuits.	Provide unique properties related to isolating RF and microwave signals. Used in radar, antenna, guidance systems, 5&G infrastructure, and other network/transmission applications.	There is no drop in alternative material. Any material replacement for fielded systems would require redesign of the printed board and potentially the electronic system to account for material property differences. Fielded systems that have been redesigned may require requalification.	Developing and/or identifying suitable alternative materials and qualifying them could be a forward-looking action for all future DoD systems. This however does not address sustainment of existing systems. There will continue to be a need to have PTFE laminate materials available for system sustainment until all systems currently designed with PTFE are retired.
PFAS	Manufacture of printed circuit boards (PCBs); vapor phase solder and flux remover products.	Vapor phase soldering process is used for PCB assemblies with high thermal mass, fine-pitch structures, and temperature-sensitive components to minimize risk to materials, structures and components. The material stability and flame retardant qualities are well suited for the enclosed high temperature operation of the process.	It is unknown if there are suitable materials that can be used, however it is likely that current equipment may need to be replaced or modified to accommodate the replacement materials.	Developing and evaluating new materials could take 5 years or more. Equipment replacement would add time and have a cost impact.
PTFE	PCBs; cable jackets used in PCB connectors.	Used because it has excellent fire, smoke, and chemical resistance. Wide temperature range -200 to 260°C constant use and up to 450°C for peak exposure.	It is unknown if there are suitable replacement materials for all of the applications for PTFE wire jacket material. PTFE is higher cost than some other wire jacket materials. When it is selected for use there are typically no other suitable replacement materials.	Qualification of alternatives will be both costly and time consuming. Many materials will require new UL or other certification body approval before they can be implemented. Many current products are MilSpec certified.

Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Castings and Forgings and Strategic and Critical Minerals				
Specialty fluorochemical gases and fluids	Advanced metalworking, casting, and fabrication processes used in the production of advanced metal parts throughout U.S. industry, including military-specific parts.	Temperature and wear resistance.	NA	Moving to alternatives in under 10 years may require returning to previous construction methods and may make construction using certain alloys impossible.
PTFE, PVDF, other PFAS	Mold release chemicals and release films typically used in composite manufacturing processes.	Prevent composites from strongly adhering to mold hardware.	NA	NA
Refrigeration and Air Conditioning, Cooling, Electronics Thermal Control				
HFOs	Next-generation refrigerant alternatives (to HFCs) used in civil and military cooling and thermal control applications.	NA	Known non-PFAS alternatives (e.g., hydrocarbon or ammonia alternatives) pose flammability, toxicity, or high-pressure concerns.	NA
Fire Suppression in Aircraft and Ground Combat Vehicles				
Fluorochemical specialty gases	"Clean agent" fire suppression in aircraft and ground combat vehicles.	NA	Most known clean agent, low-corrosion, low-weight, low-toxicity alternatives will likely be classified as PFAS, broadly defined.	NA
Aqueous Film Forming Foam (AFFF)				
PFAS	AFFF use to combat Class B (flammable/combustible liquid) fuel spill fires on mission critical ocean-going vessels employed by DoD and the Military Services.	MIL-PRF-24385 qualified AFFF provides the capability to rapidly control and extinguish shipboard fires.	Current F3s have significant limitations compared to AFFF that preclude their use on DoD ocean-going vessels, including the U.S. Navy fleet.	NA

Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Lines, Hoses, O-Rings, Seals and Gaskets, Tapes, and Cables and Connectors				
Fluoropolymers (e.g., PVDF, ECTFE, PTFE)	Critical to modern "rubberized" fuel lines. Key materials in hoses, tubing, hydraulic system lines, O-rings, seals and gaskets, tapes, and cables and connectors widely used in civil and military aircraft, space systems, vehicles, weapon systems, utility systems, and other applications.	Functionalities include UV-resistance, ozone-resistance, weather-resistance, high temperature-resistance, high pressure-resistance, and chemical resistance.	Alternatives are not as resistant to embrittlement and break-down and have a much shorter useful life, leading to more frequent part replacement, which is not feasible for space or satellite uses.	NA
Fluorelastomers (e.g., FKM/FFKM)				
Electronic/Dielectric Fluids				
Fluorochemicals	Used in electronic and dielectric fluids used in civil and military radars, high-power electronics, and electrical system/utility system components.	Provide dielectric and heat transfer properties.	Industry and DoD have repeatedly investigated alternatives in these applications. Known alternatives have high global warming potential (e.g., sulfur hexafluoride) or may pose health/environmental risks (e.g., the polychlorinated biphenyls).	NA
Advanced Oils, Greases, Fluids, and Lubricants				
PFAS	Used in many advanced turbine engine oils, greases, fluids, and lubricants common throughout the U.S. civil transportation, industrial, and space sectors. Analogous oils, lubricants, and fluids are used in military critical ground, sea, air, and space applications.	Wear- and heat-resistant properties. Perfluorinated greases exhibit excellent shelf lives due to their intrinsic inertness.	Previous generations of oils, fluids, and lubricants approached, but did not equal, the performance of PFAS additives that have become more prevalent in high performance oils, greases, fluids, and lubricants over the past 20 years.	NA

Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Precision Cleaning Fluids				
Fluorochemicals	Precision cleaning applications such as cleaning of sensitive oxygen systems in civil and military aerospace.	NA	NA	NA
Degreasing / Cleaning Fluids				
PFAS	Degreasing/ cleaning products and contact cleaners used in vapor degreasing and flux removal.	NA	NA	NA
	Non-destructive testing solvent cleaner/remover used for precleaning and for removing excess surface penetrant before applying developer during liquid penetrant testing.	NA	NA	NA
	Degreasers used to effectively remove grease, oil, tar, and other substances from military equipment to increase its operating efficiency.	Leaves no residue, has no flash or fire point, and serves as an alternative to chlorinated solvent-based cleaners (e.g., 1,1,1-trichloroethane).	NA	NA
	Connector cleaner and preparation fluid used for cleaning fiber optic connectors in secure link manager assemblies and primary modem assemblies.	NA	NA	NA
Insulation and Foam Blowing				
Fluorochemicals	Components of insulation and foam blowing products used in civil and military aircraft and space vehicles/rocket motors.	NA	NA	NA

Report on Critical Per- and Polyfluoroalkyl Substance Uses

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Appendix: Summary of Known Mission Critical PFAS Uses

PFAS	Application	Functionality	Availability of Alternatives	Time Frame / Cost to Develop and Qualify Alternatives*
Resins for Specialty Composites				
Fluoropolymers	Resins for specialty high-temperature or weather-/UV-resistant composites.	Temperature-, pressure-, wear-, and chemical-resistance properties.	NA	Moving to alternatives in under 10 years may require a return to previous methods of parts construction and an acceptance of lower performance, shorter life, and higher weight composites.
Specialty Filters and Membranes				
Fluoropolymers	Used in specialty filters and membranes (e.g., aviation filters); and in air filtering masks and air filtering respirators used by DoD.	Temperature-, pressure-, and wear-resistance properties.	NA	NA
PFAS				
Fabrics, Fabric Liners, Fabric Barriers				
PFAS	- Fabrics used in a variety of uniform clothing and footwear items, tents, and duffle bags. - Reported use in chemical, biological, radiological, and nuclear protective equipment. - Used in the biological protective fabric lining used in the Joint Biological Agent Decontamination System.	Water and oil repellency.	NA	NA
Customized Applications				
Specialty fluorochemicals	Used in customized applications like gyroscope suspension fluids and analytic gases and fluids for thermometric and other sensors.	Pressure-resistant, wear-resistant, and temperature control properties.	NA	NA

* NA = no information provided through data collection efforts.

Report on Critical Per- and Polyfluoroalkyl Substance Uses

Senator WICKER. Thank you. If other members—my time has expired but I am sure other members of the panel would like to respond.

Senator MERKLEY. I think that is an invitation, if anybody else wanted to followup on his question.

Ms. SCHAUER. Thank you for your question, Senator Wicker. To my knowledge, there are no PFAS that I would consider completely safe. Different PFAS have different chemical structures and different toxicity. We know a lot about PFOS, PFOA, and a handful of other PFAS chemicals that are frequently found in drinking water supplies, and in people's blood. There are newer PFAS replacement chemicals that are more mobile in the environment. We have been studying them for a shorter amount of time, but as Dr. Fenton said, they raise many of the same health concerns.

When we talk about fluorinated polymers, like PTFE, those are large molecules and they are less likely to enter our cells and may not have the same type of toxicity. As Dr. Larrañaga said, if you overheat those, though, they can produce toxic fumes. For instance, in your home, if you overheat a Teflon pan, those fumes can be really toxic for pet birds. I can't imagine that they are good for our health, either.

I would add another important point, though, that fluorinated polymers don't occur by themselves. Polymers are produced from shorter PFAS chemicals that are stitched together, and products containing a fluorinated polymer also contain a mixture of different PFAS chemicals. So we never are exposed to just one PFAS at a time.

So even fluorinated polymers raise concerns about exposures among workers and fluoropolymer production facilities and in the communities, for instance, in North Carolina, that Dr. Fenton described, in the communities around those facilities where drinking water, soil, sediment can be contaminated.

Then at the end of a product's useful life span, there are concerns about disposal, what happens to those PFAS after we throw away products that contain PFAS. If they are incinerated, there are concerns about air emissions and what that might mean for communities around incinerators that are often environmental justice communities. Or putting them in a landfill could lead to slow release from landfills over time as well.

In terms of the different types of uses of PFAS, I would point to the essential uses framework, which I think provides a really nice path forward for identifying where we can start making reductions in PFAS use now. It is certainly easier to take PFAS out of a Teflon pan.

Another common use I would point to are dental flosses. Oral-B Glide dental floss, which is made with Teflon, we are putting Teflon in our mouth. To me that is a non-essential use that we could absolutely do away with right now. If we are talking about critical infrastructure, cell phones, semiconductors, those might take longer to find alternatives to phaseout their use.

Senator WICKER. That statement is very much appreciated, the last sentence.

It seems that I have mispronounced your name, Larrañaga?

Mr. LARRAÑAGA. Yes, sir.

Senator WICKER. OK, I have done better.

Mr. LARRAÑAGA. Thank you. First of all, Teflon dental floss is absolutely necessary. My teeth are packed so tight that that is the only thing I can get in there.

[Laughter.]

Mr. LARRAÑAGA. We agree that we shouldn't improperly dispose of PFAS-containing materials. But let me give you an example of how important PFAS chemicals are. The firefighting foams that we are replacing the PFAS-containing AFFF with contain fluorinated polymers.

So if we were to remove these chemicals from the marketplace with a broad brush, we would be left without the ability to fight these large fires, even if we have to fight them in a compromised fashion, because these new foams are not as effective as AFFF.

Ms. FENTON. Can I comment, please?

Senator Wicker, I read just last night a document from the Federal Aviation Administration that there are two MilSpec AFFF, they are on the QPL, right now. We do have safe replacements. I know at least they have listed two, and they were considering a third one.

So although it seems ominous, especially for the defense systems, some of the microcomputers, things like that, to replace something that seems essential, we are being successful at it. Someone, in fact, one of the companies that makes the QPL PFAS-free foam is a company that made AFFF foam. So they are doing it. They are still making money, they are still building their industry, and they are using their imagination and their experts to make a safer product.

So I do think it is doable, and it is happening already. I just want to leave you with that impression.

Senator WICKER. Thank you, Mr. Chairman, for that indulgence, and perhaps witnesses can supplement their answers for the record.

Senator MERKLEY. Thank you very much, Senator.

I want to go back to a point you made, Dr. Fenton, about understanding the major pathways of human contamination. There are probably plenty of places where PFAS is, and it may be the insulation on wires, that may have a very low impact on human health, especially if they are hidden behind a wall on an aircraft.

But as I understand it, the main things you are identifying are PFAS that is in our food and in our water. On the food side, the mention was about biosolids, and what we are talking about is in the human waste that is then repurposed as fertilizer. So it is interesting that when some PFAS goes through our bodies and doesn't stay in our blood, it finds its way back into our food. And maybe the second time around, it has an impact.

So I really want to focus on those major sources of contamination that affects our health. You noted one aspect of that, studies that really focused on holding other factors constant. There is lower birth weight in humans who have a higher exposure to PFAS. I assume this is by taking blood samples.

Ms. FENTON. Yes.

Senator MERKLEY. So does this hold constant, all the other factors, like cigarette smoking is associated with lower birth weight,

is this an area that we really have a pretty clear understanding of an impact?

Ms. FENTON. Yes, sir, thank you for the question.

There are dozens of studies that have shown consistent effects from PFAS-associated decreases in birth weight. Those are epidemiological studies that take into consideration all the things that you were just mentioning, smoking, poor nutrition, socioeconomic status, even the BMI of the mother. They take those many variables into consideration when they do the analysis in the studies. They are controlled for, so those are things that they control for.

Senator MERKLEY. OK, so we see this in human studies. But then you also mentioned mice studies. In the mice studies, they show the same thing. You mentioned mice that, I think you called them pups, is that the correct term?

Ms. FENTON. Yes.

Senator MERKLEY. And that we have seen the same effects. So we have both the human studies and the laboratory studies reinforcing each other?

Ms. FENTON. Correct. In fact, the University of California San Francisco did a systematic review of all the studies that had shown birth weight outcomes in mouse studies, and at the time, all the studies that had shown birth weight outcomes in human studies. They reviewed them both altogether.

So when I say a systematic review, that is all the information that is available in the literature.

Senator MERKLEY. So lower birth weight can be an indication of other things, but maybe not the immediate highest concern. But it is an indication of something that is going on. But you mentioned some very specific things, like breast development abnormalities. Is that in humans or is that in mice, or both?

Ms. FENTON. I first reported it in mice, and since then, there have been nine studies in women showing that PFAS and PFOA specifically and a few other handful of other PFAS are associated with women not being able to nurse their children. So they have a shorter duration of lactation, is the specific term they are using in these papers.

And this is not just in the U.S. Several of these studies are from other countries. Several are from the U.S. They are showing very consistent—

Senator MERKLEY. I want to keep this moving. How about other diseases where the studies have shown a significant correlation? For example, you mentioned fatty liver disease. I don't even know what that is, but maybe you are about to tell me. Also, are there other things? Do they show higher cancer rates, for example, for breast cancer or prostate cancer?

Ms. FENTON. Yes. So some of the things that we have in common are thyroid disease. Definitely changes in fatty liver. Fatty liver is when, and you can tell if a person has fatty liver from their clinical enzymes. When you go to the doctor and they say they are going to do a liver panel on you, you can tell if you have some adverse outcomes in your liver based on those clinical, easy to acquire outcomes. You do a blood draw and they can tell you then.

But the fat that is accumulating in the liver can lead to non-reparable damage to the liver. That would be like steatosis, when the

liver can become fibrous. Once that happens, it is not reversible. Whereas fatty liver is reversible.

Senator MERKLEY. So if you were to name the top four health concerns, would they be the ones you have just mentioned? Or what would the top four health concerns be that there is clear studies associated with higher PFAS?

Ms. FENTON. Birth outcomes, one. Metabolic disease.

Senator MERKLEY. Birth outcomes, meaning miscarriages? Meaning stillborn? Or simply the lower weight?

Ms. FENTON. Smaller birth weight. And there is really good evidence that links smaller birth weight to long-term adverse health outcomes. There are thousands of papers that link it to that. This is not just a PFAS issue. Anything, like poor nutrition, cigarette smoking, anything that causes lower birth weight can lead to adverse outcomes later in life, long-term.

So definitely birth outcomes. The thyroid disease is a big deal. Immune suppression I would say is one of the biggest issues. And we do know that PFAS suppresses the ability of the body to properly respond to a vaccination. This is really important in our children. And if children are given PFAS in their breast, from their mom, this really brings home a very important point. We want moms to breast feed their babies because they provide to the baby immunoglobulins in the milk that help the little infant develop their immune system. But if PFAS are inhibiting that proper production of a proper immune system, this can lead to long-term immune problems for the person.

Senator MERKLEY. Thank you.

Senator Mullin?

Senator MULLIN. How many different forms of PFAS is there?

Ms. FENTON. A lot.

Ms. SCHAIER. The number seems to keep changing. The most recent—

Senator MULLIN. Thousands?

Ms. SCHAIER [continuing]. estimate by EPA is over 14,000.

Senator MULLIN. OK, so I just, I know, have we ever been able to identify which PFAS is causing this problem? Just yes or I don't know.

Ms. SCHAIER. Yes.

Senator MULLIN. So we can specifically look at those and maybe be able to separate those from the other ones. Because I mean, when you are talking about immune shots, right, every needle out there has Teflon on it. That's what the plunger is able to slide up and down in. And so when they are getting injections, you are getting shots, it is Teflon. I am just saying that it is literally everywhere. And I don't know how you can possibly think we are going to ban PFAS if we don't look for what the alternative is going to be. And there is 14,000 and counting different forms of PFAS.

And I go back to my original statement, is, at which form, because you are creating it, so it is a chemical that you are creating, at which form or which deterioration does it become harmful? Where is the curve? Is it at the final product or the curve going down?

I know you have a lot to say about it, but I have to move. I am just bringing the question to mind, because we are talking about

the effects but we are not talking about when it actually takes place.

I want to talk about semiconductors, and I need to send something for the record. Mr. Chairman, I would like to submit for the record a letter emphasizing the critical role certain PFAS play in manufacturing for the semiconductor industry.

Senator MERKLEY. Without objection, so ordered.

[The referenced information follows:]



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The Honorable Jeff Merkley
Subcommittee on Chemical Safety, Waste
Management, Environmental Justice, and
Regulatory Oversight
Committee on Environment and Public Works
United States Senate

The Honorable Markwayne Mullin
Subcommittee on Chemical Safety, Waste
Management, Environmental Justice, and
Regulatory Oversight
Committee on Environment and Public Works
United States Senate

Dear Chairman Merkley and Ranking Member Mullin:

On behalf of SEMI, the industry association serving the global semiconductor design and manufacturing supply chain, I write to offer comments on the use of Per- and Polyfluoroalkyl Substances (PFAS) by the semiconductor industry. These comments explore the essential role of PFAS in semiconductor manufacturing and the need for a balanced approach to PFAS policy to ensure health and environmental safety while enabling innovation. SEMI and its members are grateful for the opportunity to provide this input to the Committee on Environment and Public Works (the Committee).

SEMI represents more than 530 member companies in the United States and over 3300 companies worldwide reflecting the full range of the country's semiconductor industry, including design automation and semiconductor intellectual property (IP) suppliers, device manufacturers, equipment makers, materials producers, and subcomponent suppliers. SEMI member companies are the foundation of the \$2 trillion global electronics industry, and this vital supply chain supports 350,000 high-skill and high-wage jobs across the United States.

Semiconductors are the heartbeat of modern technology, found in everything from smartphones and computers to medical devices and defense systems. Their production is critical to economic prosperity and national security, and is thus a major driver of the domestic and global economy. In recent years, governments worldwide have also recognized the strategic importance of semiconductor manufacturing and its significant contributions to economic prosperity and modern life. The disruptions caused by the pandemic highlighted the vulnerabilities in global supply chains, prompting calls for greater domestic production. Government initiatives, such as those authorized and funded by the *CHIPS and Science Act*, are collectively investing hundreds of billions of dollars in the semiconductor industry in response to supply shortages and the expanding importance of semiconductors across all economic sectors.

SEMI wants to specifically draw attention to the importance of the semiconductor industry to digital healthcare through products such as medical microelectronics and medical devices. Microchips and semiconductors are at the heart of our modern healthcare economy, providing patients with lifesaving medical support, from drug delivery devices like a continuous glucose monitor, or clinical uses, such as a ventilator or pacemaker. These devices are thoroughly regulated by the Food and Drug Administration to provide patients with the care they need, and devices such as these are reliant upon fluoropolymers.



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Manufacturing Complexity and Role of PFAS

Creating semiconductors is a complex process, involving thousands of intricate steps. State-of-the-art technology nodes require over 2,000 processing steps, utilizing specialized equipment and materials, all of which collectively cost billions of dollars. Due to their extremely small feature size, the devices (chips) are highly sensitive to any source of contamination.

Various types of PFAS are essential to the semiconductor manufacturing process because they have low surface tension, high heat and chemical resistance, high thermal stability, radiation stability, favorable electrical characteristics, compatibility with other chemicals, purity, and other properties that enable them to fulfill the unique demands of semiconductor manufacturing. Fluoropolymers, fluorochemicals, and fluorinated gases are all used by the industry to meet many needs within the manufacturing process and can be found in virtually every segment of the value chain. In short, the semiconductor manufacturing process is enormously dependent on fluorine chemistry in a variety of use cases, the majority of which currently have no viable alternatives.

Understanding PFAS

Many PFAS serve a wide array of critical functions across a variety of sectors, including personal protective equipment, civil and military aerospace applications, specialty gases, clean energy generation, and battery manufacturing, just to name a few. These perfluorinated compounds are designed to resist breakdown under extremes of temperature and wear to be effective for their intended use.

SEMI member companies continue to pursue R&D aimed at identifying alternative compounds, but this is a decades-long endeavor that must account for fundamental challenges in materials and chemistry. The unique nature of the carbon-fluorine bonds, among the strongest known to chemists, make PFAS and PFAS-containing materials difficult, and in some cases impossible, to replace while maintaining the same performance metrics. Applying a universal restriction or classification to all PFAS is scientifically unjustified and would be as catastrophic to modern society as removing all insects from agriculture because some are problematic.

Not all PFAS are the same and they should not be treated as such from a legislative or regulatory perspective. The PFAS group includes thousands of substances in many sub-groups: polymers and non-polymers; solids, liquids, and gases; persistent and non-persistent; highly reactive and inert; mobile and insoluble; and toxic and nontoxic. Frequently, efforts to address important health and environmental topics use the broad term PFAS when they are most interested in a distinct sub-group of PFAS like perfluoroalkyl acids such as PFOA.

Industry Leadership and Request for Engagement

The semiconductor industry is committed to complying with existing regulations, and actively works to promote environmental protection in the design, manufacture, and use of its products, and prioritizes practices aimed at ensuring health and safety throughout the semiconductor supply chain.¹ SEMI

¹ Many SEMI member companies participate in the Semiconductor PFAS Consortium, a coalition of semiconductor industry stakeholders working together to collect the technical data needed to formulate a science-based approach to PFAS. Specific activities include gathering and vetting PFAS-use information; conducting socioeconomic impact analyses; providing tools for tracking and reducing PFAS use; identifying R&D needs; and developing technical reports, position papers, and presentations. More information is available at <https://www.semiconductors.org/pfas/>.



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member companies have proactively taken steps to collaborate on material detection capabilities, abatement and destruction technology, circularity (recycling, reuse, and repurpose), and alternatives. However, significant technical challenges remain to be overcome in finding alternatives for many PFAS use-cases in semiconductor applications due to the unique characteristics that PFAS provide to the industry.

SEMI members remain available to offer recommendations and industrial insight to the Committee and believe that a more targeted and multi-pronged approach to addressing PFAS concerns should be adopted. In particular, SEMI members urge the Committee to:

1. Support PFAS legislation and regulations that effectively empower authorities to implement risk-based analysis and emission controls while ensuring access to chemicals that are vitally important to the production of semiconductors. All proposed policies should account for the fact that developing alternatives to critical applications of PFAS within the semiconductor industry is a decades-long process.
2. Support research and development (R&D) with programs that leverage industry and academic expertise to develop enhanced detection, monitoring, control, and abatement capabilities; investigate potential PFAS alternatives; and overcome technical challenges associated with developing and implementing alternative substances and related manufacturing processes.

SEMI is committed to balancing the need for environmental protection and the sustainability of semiconductor manufacturing operations, which is a complex challenge. As such, SEMI has endeavored to intensify collaboration across the industry, academia, and like-minded governments on a range of policy issues relevant to the semiconductor industry through forums such as the SEMI International Policy Summit (SIPS). Specific to PFAS, SEMI convenes SIPS as a platform for working with policymakers across the world to identify opportunities and challenges to accelerate R&D related to PFAS while promoting a more globally coordinated, risk-based approach to PFAS regulation.

SEMI is grateful for the opportunity to engage with the Committee on this matter and is available to meet at your convenience to further elaborate on the issues outlined above.²

We remain available should you have any questions or would like to discuss our position,

Sincerely

Ajit Manocha
President and CEO
SEMI

CC: Chairman Thomas Carper
Ranking Member Shelley Moore Capito

² Additionally, more information about SEMI's positions on PFAS can be found in comments submitted to the Committee regarding draft PFAS legislation in July 2023.

Senator MULLIN. Dr. Larrañaga, is that close?

Mr. LARRAÑAGA. Yes, sir.

Senator MULLIN. OK. Given your experience in leading risk assessments in the semiconductor industry, what are the potential impacts of blanket regulatory ban on PFAS in this sector?

Mr. LARRAÑAGA. So there are several impacts in this sector, one being the fabs which are tremendously expensive that build semiconductors would have to retool. In order to do precision manufacturing at the nano scale, at least currently with the technologies we have, PFAS are required. There is no way to do it without PFAS with the level of precision that is necessary to make a semiconductor chip.

If we were not to be able to make those semiconductor chips, a couple of things would happen. One, our chips would have to become larger. Two, they would be less efficient and less capable as well as being less durable. Meanwhile, our competitors, China and other countries, would be increasing their computing power at the same time we would be decreasing our computing power.

So from a semiconductor perspective, it is very important that we are able to use PFAS in this industry.

Senator MULLIN. So basically what I am hearing is that it could greatly disrupt the supply chain?

Mr. LARRAÑAGA. It would tremendously disrupt the supply chain, yes, sir.

Senator MULLIN. Pointing out to other things that are involved with PFAS, many life-saving medications containing PFAS substances are antidepressants, autoimmune drugs, certain essential cancer treatments, and even Lipitor contains PFAS. I just point that out once again, it is literally everywhere.

Sir, do you agree that this indicates that not all PFAS have the same impact on human health and therefore should be treated differently based on each chemical's properties and risk profile?

Mr. LARRAÑAGA. Yes, sir, I do believe that the different PFAS chemicals will have different chemical properties and that we should look at them individually based on health risk frameworks.

Not only medications, but actually medical instruments, like the semiconductors, they would have to get larger. Imagine a pacemaker inserted into someone's chest would have to become larger, also, because the PFAS chemicals that are used in the circuitry or on the wiring and in the actual chips that are used, the brain of the pacemaker. So those would have to become larger as well.

So it has these—banning these as an entire class has these long-reaching effects that would affect our public health and health care at large.

Senator MULLIN. So what we are searching for here is instructions or direction on as we are looking for policy, how do we approach regulating it? And I think that is the question that we could tackle to some degree, if you have thoughts, short, because I am a little over time. But for all of you guys, what is the best way for us to tackle this?

I know, Chairman Merkley, he is being thoughtful in this direction, which I appreciate. We understand not one size fits all, in my opening statement. We want to make sure that we don't overreact. So just really quickly if you could, what are your thoughts?

Ms. FENTON. Senator, if I could, I think that there are essential uses, potentially. And potentially, we are not exposed to the products very often. But we may be exposed to the waste. I want to just mention that.

Proper disposal of the waste in these industries is super important. Because if you think about it, think about how few people may actually ever touch a semiconductor or put their fingers on the wiring that my colleague is talking about. But the waste coming from the industries that make them go into water bodies, go into the air that we all breathe.

Senator MULLIN. So focus on the waste. I think that was kind of a point I made before, at which level does it become harmful.

Ms. FENTON. Yes. And to your point earlier, when you think about the classes of PFAS that might cause health effects, the current regulation that is in place from the EPA will remove the compounds that cause, that we know already cause some of these health effects. So if we can keep that regulation in place, it will take those PFAS out of water, out of air.

Senator MULLIN. The problem is that some of those compounds, it is taking away from the critical needs that we already have. Some of the compounds to which they are referring to, the EPA, it is, what is it taking out of the industry that we are using every single day that is critical of our life.

And so to some degree, I do feel like the EPA, not some degree, the EPA in its direction I think overreacted. Do I have time to look for that response, too, sir? You are the chairman.

Senator MERKLEY. Why don't we come back after Senator Markey?

Senator MULLIN. Oh, sorry, sir. I didn't know you were here. I will yield back.

Senator MERKLEY. Senator Markey?

Senator MARKEY. Thank you, Mr. Chairman. Thank you for having this very important hearing.

Dr. Schaidler, thank you for your years of service in women's health space. My wife was a two-star admiral in charge of all women's health in America. So I appreciate your service.

Recent reports and studies show that soils examined show that hazardous waste incinerators have elevated levels of PFAS. These incinerators are disproportionately in disadvantaged communities. Toxic PFAS emissions get into the atmosphere when they can hurt children, pregnant women, agriculture soil, air.

Can continuous monitoring of any air emissions protect our communities from being exposed to PFAS coming from hazardous waste incinerators?

Ms. SCHAIER. Thank you for that question, Senator Markey. I think the concerns about incineration of PFAS are really critical to consider. I appreciate your raising concerns about environmental justice and the communities that live around incinerators.

There are new, improving methods for how we measure PFAS. I think it is important if there is going to be incineration of PFAS-containing materials that we are carefully monitoring for the full suite of PFAS that are there.

But I have concerns about incineration and what that might mean for exposures among people living in these communities. I

think those kinds of life cycle issues are really why we need to be really judicious when we are creating these highly persistent chemicals that really don't break down.

Senator MARKEY. Thank you.

Dr. Schaider, firefighters protect us from harmful fires. But we need to help protect them from being harmed by the gear they wear, which is full of PFAS. So firefighters are just walking around covered in PFAS. We need to protect our protectors from cancer clusters in firehouses.

Dr. Schaider, is it true that PFAS in firefighters' turnout gear and firefighting foams can harm their health?

Ms. SCHAIDER. Thank you for that question as well. There is a huge concern right now among firefighters about their exposures to PFAS. As you said, that can come from the firefighter turnout gear, which has typically had a PFAS Teflon layer.

Senator MARKEY. Are there alternatives?

Ms. SCHAIDER. There are alternatives, and actually, our State of Massachusetts just instituted a ban on PFAS in firefighter turnout gear. So I am proud of our State for advancing that. I think it is an example of when we set a goal to reduce exposures and protecting firefighters' health, it is critically important that new research and development can provide solutions, so that we are keeping our protectors safe but also not exposing them to toxic chemicals.

Senator MARKEY. I agree. And I think it is something that we should think about on a national level, because, well, obviously so many of our firefighters do die from cancer. We want to make sure that we give them the protections which they deserve.

The Agency for Toxic Substances and Disease Registry conducted an exposure assessment in Westfield, Massachusetts, one of the 10 cities included in the Centers for Disease Control and Prevention's PFAS Exposure Assessment. While random households were invited to participate, the data collected was not fully shared with the public.

Dr. Schaider, do you agree that more data transparency would be helpful to allow the public to understand their exposures, risks and pathways?

Ms. SCHAIDER. Thanks for that question. I know that the ATSDR has released summary statistics for the results of blood testing that they conducted in Westfield. I am not familiar with the specifics.

Senator MARKEY. Should that be made fully available?

Ms. SCHAIDER. Certainly the summary statistics of how people, in the blood levels that they tested in Westfield residents, how those compare to the general population, what is the median level, what is the 95th percentile, those summary statistics have been made available. I am not familiar with the specifics of the extent of data released.

Senator MARKEY. Yes.

Ms. SCHAIDER. But I in general think that having more information about exposures among the general population and exposed communities is helpful.

Senator MARKEY. Yes, we would want to ensure that there is total access to the information about the safety of breastfeeding for PFAS-exposed mothers, especially considering the potential health

risks to children. So it would be, I think, a very important thing that we could do.

The EPA's updated draft PFAS disposal guidance document acknowledges that performance and testing data are needed to validate PFAS, destruction by incineration as opposed to other novel ways of getting rid of PFAS in our environment.

Dr. Fenton, do you believe that attempting standard incineration of PFAS can lead to more dangerous PFAS compounds released into our environment?

Ms. FENTON. Thank you for the question, Senator. We certainly know that incineration can lead to release into the environment. What I suggested earlier in my comments was that funding innovative ways to mineralize these compounds, or re-use what is being released from the incineration might be useful down the road. I do think there is a place that we can fund innovation yet, and work toward a place where we are not releasing fluorine carbon compounds into the environment.

Senator MARKEY. With your indulgence, Mr. Chairman?

Senator MERKLEY. Go ahead.

Senator MARKEY. Dr. Fenton, do you believe that the failure of PFAS manufacturers to provide reference standards to the EPA has hindered the agency's ability to establish accurate drinking water standards for PFAS? Has this lack of cooperation hurt communities across the United States?

Ms. FENTON. Sir, it has affected how quickly and how efficiently we can provide strong data, high quality data, on health effects. It has affected me personally; it has affected my colleagues. The confidential business information in some of the PFAS mixtures has really hindered our progress in understanding the health effects.

That is probably the No. 1 issue that I have had to deal with, is the inability to get standards for some of the new compounds that we would like to study in North Carolina, in particular.

Senator MARKEY. Thank you. It is absolutely critical.

I had my first date with my wife 40 years ago, in two more months, Mr. Chairman. And she was explaining to me, her mother had died from breast cancer. And she was explaining to me that her interest in medicine was driven by that, and having to go to the Stanford Hospital day after day, it was a girl with her mother for the treatment.

But what she explained to me was this, that Japanese women contract breast cancer at only one-third the rate of American women. But Japanese women contract breast cancer at the same rate as American women in the first generation that they live in America. Meaning that we are doing something to ourselves with our environment, what we put into our food, what we put into our water, what we put into the air. We do it to ourselves. And it causes a much higher level of cancers in our society.

So we just can't deny these statistical realities when we compare ourselves to the rest of the world. While manufacturers might want to just continue business as usual, the impact has been felt by the families, the women, the children, in our society, the firefighters who get exposed and ultimately succumb to the diseases.

I thank you so much for this very important hearing.

Senator MERKLEY. Thank you very much, Senator.

I notice that when we have a conversation about, and testimony about, well, PFAS in our food and water is causing bad health effects, often the response is, oh, but wait, it is on other things in our environment like insulated wire in an airplane or coating a solar panel, to try to distract us, essentially, from the fundamental question of the pathways in which we are affected, and how it can be removed in those pathways that are affecting human health.

So this is not a conversation about banning a class of chemicals. It is a conversation about finding the ways that we are affected and eliminating those effects to improve human health.

I think it is a very good point you made, however, Dr. Fenton, that the waste that happens from other portions of the industry may well find its way back into our bodies, even if the initial product is not one where we are touching or around. One of those products is stain-resistant carpet. I remember when the ads came out about, oh, you can drop all kinds of things on the carpet and it just beads up, and so forth. Is that a PFAS treatment? I am thinking about our little babies crawling around on the carpet. Is that a risk to our babies' health?

Ms. SCHAUER. I would say absolutely yes. We do know that stain-resistant carpets treated with Scotch Guard or Stainmaster contain PFAS. And there is ample evidence that the chemicals don't stay in the product. There have been studies that have made links between people who have stain-resistant carpets in their house and levels of PFAS in their blood.

Also I have concerns about children who are more vulnerable, spend more time close to the ground, spend more time with their hands in their mouth. We know that PFAS can get through our skin, but also can be transferred by hand to mouth contact in children who are more vulnerable to those harmful health effects.

So we know that having these products in our home increases our exposure. And I think one point that is important to keep in mind, and Senator Mullin had asked about all these different ways that we can be exposed, all those cumulative exposures add up. We can be exposed from food and water and consumer products.

Some pathways of exposure are easier to turn off now, and I think we should grab that low-hanging fruit and reduce exposures where we can. Other pathways may be more challenging. But we should work, in general, to reduce our exposures to PFAS and reduce our reliance on these problematic chemicals.

Senator MERKLEY. I have kind of been assuming that areas where you have higher abrasion may produce more particles that find their way into our bodies. Maybe that is wrong. But for example, I think about carpets, we are walking on them, there is abrasion, there is carpet dust. That carpet dust, those fibers that have PFAS on them because they are stain resistant or spill resistant now are easily breathed in and therefore have a pathway to get into our bodies.

I have thought about the Teflon pans, and I have seen many Teflon pans where the coating has essentially been worn off from stirring things in the pan. And of course, you noted that heat can be a factor as well.

It seems a lot more of a risk than, say, a coating on my phone, where one, I can put a plastic cover over that coating, so I am not

touching it. But even if I am, there is not the abrasion involved and I am guessing that the transfer of PFAS through my thumb might be far lower.

So our goal here is to figure out and understand better where the highest levels of transfer, as you call it, low-hanging fruit, that can have an impact. But my assumption about abrasion, is that a reasonable way to think about some of this?

Ms. SCHAUER. I think that is one. One way to think about, I think a lot about how we actually get exposed to the PFAS and how do the chemicals and the products get into our bodies. So certainly, abrasion of products and fibers ending up in dust, we don't think about dust as a harmful chemical exposure pathway. But the dust in our homes is one way that we can be exposed to toxic chemicals. It is sort of a repository for toxic chemicals in homes.

Also, there are certain PFAS chemicals that are volatile. So some of the PFAS that we are talking about in water are polar, they tend to stay in water. But other PFAS chemicals, like fluorotelomer alcohols are volatile, so they can actually come off of products and end up in the air in our homes. Then we breathe them in.

Fluorotelomer alcohols are an example of a precursor. So we think of PFAS, PFOA, those chemical structures basically don't change unless you heat them at very high temperatures. Other chemicals like these fluorotelomer alcohols are what we call precursors. So in our bodies, over time and in the environment, they can be transformed into PFAS or PFOA or these other very stable PFAS.

So that is another way we can be exposed, is through these volatile PFAS, that we do measure in indoor air and we do see that homes with PFAS-containing products have higher levels in air and dust.

Senator MERKLEY. So the question we might be asking when we hear that there is PFAS on our cell phone is, is that a volatile version. I will ask that for the record. I will have my team followup.

I want to note that you all mentioned cosmetics. Why would cosmetics contain PFAS? And cosmetics certainly produce dust, if you will, that we breathe in. Is there any rational reason to have PFAS in cosmetics?

Ms. FENTON. They do it for waterproofing. It is like waterproof mascara and waterproof foundation that you would put on your face. It is meant to last all day.

Senator MERKLEY. Is that absorbed through the skin? Because now you are applying something directly to a significant area of skin. Is that a much higher risk than some other sources?

Ms. FENTON. Like all sources, it is how often you are exposed to it. So if you are wearing it every day as an individual, yes, you probably would have substantial exposure from that. But you can make personal choices, like you can make a personal choice not to have Scotch Guarded upholstery or mattresses or carpeting or cosmetics.

Senator MERKLEY. But the thing is, Dr. Fenton, that citizens assume when they don't see a warning on it, it doesn't say, this carpet has Scotch Guard that will reduce your stains but also beware that your children may breathe in a whole lot of PFAS that may

have health impacts. They don't put warnings on them. This is where we are relying upon every citizen to be educated, like each of you have doctorates, and make individual choices. That is why we have public policy, and that is why we are struggling with this.

Of course, I have never used stain-resistant mascara—what did you call it?

Ms. FENTON. Waterproof mascara.

[Laughter.]

Senator MERKLEY. I have never used mascara. I had no idea there was PFAS in it. But I am sure I can see a reason for that. Do we have studies that show cosmetics as you are describing, incorporating these water-resistant qualities, result in PFAS in the blood? Is it a pathway of concern?

Ms. SCHAUER. I am not aware of specific studies that have looked at that question. But I think we know enough about how these chemicals can come out of products. As Dr. Fenton mentioned, they can be absorbed through our skin.

I don't know that we need to do a study for every single product to show what percent of that PFAS ends up in our blood. I would take more of a precautionary approach, because we know that if chemicals are in products, at least some portion of that will end up in our bloodstream. And if we are talking about waterproof mascara, that is really not an essential use. I think that is an easy one to point out.

We often say that you shouldn't need a chemistry degree to go shopping for products for your family. I think it is unfair to expect that consumers will know all the different types of harmful chemicals that they should avoid. As the mother of a 'tween daughter who is getting into makeup, it is impossible to think that every person needs to know about these toxic chemicals. I think people rightfully expect that the government is protecting their health.

Senator MERKLEY. That not always is the case.

So my last question is really about the April EPA drinking water regulations for six PFAS chemicals. I think these are the regulations that were being referred to before. The level that they set is very, very low, like parts per trillion. I am used to parts per million or billion, but I have never seen a parts per trillion before.

But now imagine that you are providing the water to a municipality. And you test and you go, oh, gosh, we have our water, the groundwater is contaminated with PFAS, we are pulling it out of the ground or whatever. Is it possible to really, is there any real cost-effective way to pull this PFAS, the parts per trillion, out of our drinking water?

Ms. FENTON. Yes.

Senator MERKLEY. OK, tell us about that.

Ms. FENTON. Granular activated charcoal systems, large volume systems, have been implemented in multiple cities across the United States already. Because as you know, 11 States already had PFAS regulations on the books, only 11. So this Federal law now protects all States at a level that is safe.

So 11 States have already figured out how to do this, and they are doing it. Some of them are doing it without increasing the water bill to their constituents.

Senator MERKLEY. So we have a cost-effective way to get this out of our water.

Ms. FENTON. Yes.

Senator MERKLEY. Since water, you have all mentioned, is a major pathway, that is a real positive to accomplish that.

Ms. FENTON. Right.

Ms. SCHAUER. It is cost-effective, but there are economies of scale. So that works really well when you are a large water system, the cost per person decreases. But for small water systems with a small customer base, these systems are hugely expensive.

For instance, on Hyannis, on Cape Cod in Massachusetts, where we have been studying PFAS for a number of years, there are only 14,000 customers. All of their public wells were contaminated by PFAS and they have had to spend tens of millions of dollars to install granular activated carbon to remove the PFAS. I don't think it is fair for the ratepayers to foot that bill. I would like to see more pathways for the chemical industries who created the chemicals and profited from them to be responsible for the cleanup.

Senator MERKLEY. Polluter pays, is your principle.

Ms. SCHAUER. Yes.

Senator MERKLEY. Well, this is a really interesting and important conversation that we are having. Obviously, it is a very complicated one. So I really appreciate your bringing your expertise to bear, and hopefully it will cause others who are listening go, oh, we need to explore this further and think about how do we capture that low-hanging fruit.

Should we be labeling things that warn individuals about the effects? Should we simply be, in certain products, and maybe it is the stain-resistant carpet saying no, that the health risk far outweighs any value, or so forth?

There is a lot to followup on. I really appreciate your contributions and expertise.

Ms. FENTON. Senator, could I suggest for the record that what you brought up about the policies on the labeling would be enormously useful to all Americans. If we knew which consumer products had PFAS in them, we could make better choices. We could change things. We could have some say by ourselves in our exposures.

Senator MERKLEY. Let's followup on that question. Because one of the things that is in my head is I heard about lots of things that have PFAS I had no idea about, whether it is medical equipment or a screen of a cell phone. But there may be categories where that labeling is more important because the pathways of contamination are more significant. Maybe it is cosmetics, maybe it is carpet, I don't know.

We will look to your expertise to help guide us. My team will keep wrestling with it. So thank you for that point.

In closing, thank you again. We have heard that the scientific community is deeply concerned about the public's exposure to toxic PFAS chemicals. We have heard about the impact, both observed from human studies and from studies on mice, that the health effects are very significant, and therefore a topic we should continue to explore how to reduce this risk dramatically for our citizens.

I ask unanimous consent from all my colleagues who are still at the table here to approve submissions for the record that they might like to make, including any letters they would like to submit or articles or other material.

[The referenced information follows:]

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January 9, 2025

The Honorable Jeff Merkley

Frm. Chair, Subcommittee on Chemical Safety, Waste Management,
 Environmental Justice, and Regulatory Oversight
 Committee on Environment and Public Works

The Honorable Markwayne Mullin

Frm. Ranking Member, Subcommittee on Chemical Safety, Waste
 Management, Environmental Justice, and Regulatory Oversight
 Committee on Environment and Public Works

Re: Comments for the Record: 12/5/24 Hearing Examining the Public Health
 Impacts of PFAS

Dear Members of the Subcommittee on Chemical Safety, Waste
 Management, Environmental Justice, and Regulatory Oversight:

The National Association of Clean Water Agencies (NACWA) appreciates the opportunity to provide comments following the Subcommittee's December 5th hearing on the public health impacts of PFAS. NACWA is the national voice for more than 350 public wastewater and stormwater utilities around the country. NACWA recognizes the critical importance of addressing PFAS contamination concerns and supports federal policies that promote effective, science-based solutions to protect public health and the environment.

Given the growing public concern and scientific understanding surrounding PFAS, NACWA was encouraged by the Subcommittee's attention to the public health impacts of PFAS. We appreciate that the Subcommittee, and the full Environment and Public Works Committee, has given serious consideration to PFAS throughout this Congress.

While the December hearing put a critical light on public health concerns on PFAS, there were gaps in the discussion connecting consumer product use, management and disposal options, and water systems. Clean water utilities are characterized as pathways of PFAS releases rather than passive receivers of PFAS from upstream sources.

NACWA believes it is critically important to recognize how PFAS chemicals enter the environment, what role public clean water agencies can play, the limitations they face in tackling PFAS contamination, and the potential impacts to water customers. Clean water agencies do not produce or profit from PFAS but rather receive it through wastewater streams. Countless

consumer products known to contain PFAS ultimately contribute to contamination in wastewater and wastewater treatment byproducts. By the time PFAS reaches a clean water agency or enters the water environment, it has been released from our homes, businesses, and communities. This reality underscores that source control must be at the forefront of our nation's efforts to reduce PFAS exposure.

Clean water agencies also have limited control over the influent they receive. Specifically, they can act as co-regulators through a pretreatment program, implementing standards for certain industrial users to protect utility infrastructure or to reduce pollutant levels discharged by nondomestic wastewater sources. EPA has not currently set any pretreatment standards for PFAS but is actively working to do so for certain industrial categories. Once complete, this will offer clean water agencies that have these industries in their service areas a new tool to reduce industrial PFAS being discharged to their utilities.

However, clean water agencies have no control over the domestic discharges they receive. Domestic wastewater can contain PFAS washed off from consumer goods, textiles, and our bodies. Therefore, it is not possible for a clean water agency to fully reduce PFAS loading to their system.

The call for "proper disposal" of PFAS-containing materials heard in the hearing must be grounded in the reality that clean water utilities have limited control over the PFAS they receive. NACWA urges the Subcommittee to emphasize source control and producer responsibility to address PFAS contamination comprehensively and not leave the public bearing the disposal burden.

Source control is also critical given that, at present, there are no effective treatment technologies that can eliminate PFAS at scale considering the volume of influent managed by a public wastewater agency. We are hopeful that destruction technologies continue to advance in the coming years and strongly support the Committee's continued efforts to advance PFAS destruction technology as a federal priority.

Given the above considerations, NACWA is also focused on ensuring that polluters, not the public, pay for PFAS remediation. We are greatly concerned about the unintended consequences of EPA's designation of certain PFAS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in the absence of statutory liability protections for passive receivers.

S. 1430, the *Water Systems PFAS Liability Protection Act*, would provide a targeted exemption for water systems from PFAS liability under CERCLA to ensure that polluters, not the public pay – while still holding water systems accountable for complying with requirements under the Clean Water Act, Safe Drinking Water Act, and other environmental statutes. NACWA urges Congress to continue working to pass S.1430 to ensure water systems in communities around the country are not unjustly held liable.

In conclusion, NACWA appreciates the Subcommittee's continued leadership in examining the public health impacts of PFAS exposures, and we look forward to continuing to work with the 119th Congress

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January 9, 2025
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to develop effective policies that address PFAS risks and allow public clean water agencies to continue effectively protecting public health and the environment.

Sincerely,

A handwritten signature in black ink, appearing to read "Danielle Cloutier".

Danielle Cloutier, PhD
Director, Legislative Affairs
National Association of Clean Water Agencies (NACWA)



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December 13, 2024

U.S. Senate
Committee on Environment and Public Works
410 Dirksen Senate Office Building
Washington, D.C. 20510

**Re: Senate Environment and Public Works Subcommittee on Chemical Safety
Hearing, "Examining the Public Health Impacts of PFAS Exposures"**

Senators Carper and Capito,

Thank you for the opportunity for AGC Chemicals Americas, Inc., to submit comments on the December 5, 2004 Senate Environment and Public Works Subcommittee on Chemical Safety hearing titled, "[Examining the Public Health Impacts of PFAS Exposures](#)."

AGC Chemicals Americas manufactures and supplies a range of specialized industrial chemicals and materials, including resins, coatings, films and membranes, that are incorporated into a wide range of products essential to the daily lives of Americans and businesses. Many of these materials are comprised of fluoropolymers. Although fluoropolymers fall within the extremely broad definition of "PFAS," they are very unlike the PFAS chemicals that have been found in drinking water, groundwater and biosolids, such as PFOA and PFOS. Unlike those PFAS chemicals of concern, fluoropolymers are not soluble in water, are not bioavailable and do not present toxicity concerns associated with PFAS chemicals of concern. In fact, peer-reviewed studies demonstrate that fluoropolymers satisfy internationally-recognized criteria for being "Polymers of Low Concern," which are deemed to have insignificant environmental and human health impacts.

Fluoropolymers also possess a unique combination of properties such as their durability, resistance to heat, harsh chemicals, and extreme weather that make them critical to the performance of a wide range of products and technologies, such as semiconductors, fuel cells, wind turbines, printed circuit boards, coated wires, batteries, aircraft components, vehicle engines, manufacturing equipment, medical devices and prosthetics, and scientific and laboratory equipment. This unique combination of properties underlies the irreplaceability of fluoropolymers in a wide range of applications, including those noted above. The unmatched performance of fluoropolymers across multiple areas of performance means that, for most applications attempting to substitute other materials for fluoropolymers will result in a loss of

reliability and durability that in many instances will have negative effects on health, safety and the environment as well as negative economic impacts.

As the committee considers how best to address PFAS we would urge the committee to not take a one-size fits all approach. Instead, the committee should ensure that any PFAS regulations or limitations going forward are focused on those PFAS chemicals that present risks and exclude fluoropolymers and products containing fluoropolymers.

Sincerely,

A handwritten signature in blue ink, appearing to read 'C. Correnti', with a long horizontal line extending to the right.

Christopher F. Correnti
President and CEO
AGC America, Inc.

A handwritten signature in blue ink, appearing to read 'A. El Kassmi'.

Ahmed El Kassmi, Ph.D
Director, Product Stewardship & Regulatory Affairs
AGC Chemicals Americas, Inc.

Senator MERKLEY. And if any of them wish to submit written questions for the record, that is allowed through the close of business on December 19th of this year. We will compile those questions; we will send them out to you all. And your replies, if you can get them back to us by January 9th, it would be very helpful, so it can be timely and close out the record.

So without hearing any objection to that, that is the plan. This hearing is adjourned.

[Whereupon, at 11:05 a.m., the hearing was adjourned.]

