From: Tom Cambareri <tomcambareri@gmail.com>
Sent: Wednesday, January 16, 2019 9:20 AM
To: Director-DWP, Program (DEP)
Cc: Mark Ells; Daniel Santos; Hans Keijser; Cheryl Osimo; capedeb20@comcast.net; Laurel Schaider; e-info@clf.org
Subject: PFAS PETITION MEETING

Dear Mr. Suuberg,

I am a Hydrogeologist and LSP practicing in the Hyannis area. I managed the Barnstable County Fire Training Academy Immediate Response Action Plan and assisted the DEP-SERO and the Town of Barnstable in dealing with the chaos of the newly discovered PFAS concentrations in groundwater and public water supply wells.

I am writing to support the tack that the Department has taken for PFAS for drinking water protection. The Department has used the EPA Health Advisory of 70 ppt as a surrogate for a MCL to take action and encourage communities to obtain alternative sources of water and/or provide treatment. These actions have protected public health.

In regards to lowering the advisory or MCL to 20 ppt, the Department has not invested adequate research into the overall distribution of PFAS in Air, Soils and Water of the Commonwealth. Based on the work I have been engaged in, I have seen low levels of PFAS in soils and groundwater where there are no obvious upgradient sources. We need to determine overall extent of PFAS sources prior to forcing towns and water suppliers to bear the brunt of the ramifications of a lowered MCL.

I say this because the Department, has not taken forthright action to cease activities at the Barnstable County Fire Training Academy. The BFTA has the highest concentrations of PFAS in groundwater and soils, including the contamination of Flintrock Pond at over 1,000 ppt. The site and its septic system is 1,500 ft directly upgradient of the Hyannis Water Supply wells. The Department has been reluctant to take decisive action and allowed training activities that exacerbate groundwater contamination to continue leaving an EJ community to fend for itself.

I urge the Department to follow through on the adoption of cleanup standards in the MCP for groundwater and soil. As an LSP, we have been hearing about the imminent adoption of these standards by the Department for nearly a year. The Department and the Commonwealth need the MCP standards to strengthen its resolve to apply science based decisions so appropriate actions can be taken to cleanup our most severely contaminated sites.

I also urge the Department to provide formal accounting of discussions with the State Public Safety Officials on the use and standard operating procedures for Fire Fighting foams on Sole Source Aquifers.

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Sent from Mail for Windows 10

From: MatthewBrennan@weymouth.ma.us
Sent: Wednesday, January 16, 2019 9:40 AM
To: Director-DWP, Program (DEP)
Subject: PFAS Petition Feedback

As a member of the Weymouth Health Department, I believe PFAS in drinking water should be regulated by the MA DEP. Previous land use within the Town of Weymouth includes a Navy Base which has caused high levels of PFAS within the environment. Without such regulation, the people's health in these areas affected by PFAS will be negatively impacted.

Matthew Brennan, R.S.
Assistant Health Director

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nebra
North East Biosolids & Residuals Association
Cooperatively promoting the environmentally sound recycling of biosolids and other residuals

Douglas E. Fine
Assistant Commissioner, Bureau of Water Resources
Massachusetts Department of Environmental Protection
One Winter Street
Boston, Massachusetts
delivered by email to: program.director-dwp@mass.gov

January 15, 2019

Greetings,

Thank you for the opportunity to provide feedback regarding the Conservation Law Foundation (CLF) petition regarding establishing treatment technique limits for per- and polyfluorinated alkyl substances (PFAS) in drinking water.

NEBRA and our public wastewater utility members and other members have been tracking and proactively addressing the concerns related to PFAS for the past two years. Because all water is interconnected, we collaborate with numerous water quality professionals and organizations – including drinking water stakeholders. As Massachusetts and other states wrestle with how to address ubiquitous PFAS chemicals in the environment, we are paying close attention to the setting of numerical screening, guidance, and enforcement standards for drinking water, groundwater, surface water, and soils. Because of the ubiquitous use of PFAS and the innumerable sources of releases to the environment, establishing limits in waters and soils can have unintended consequences and costs affecting more than just drinking water systems. It is for this reason that we urge the MA Department of Environmental Protection (MassDEP) to proceed cautiously in response to the CLF petition.

NEBRA is attending the public hearing on this matter, which is being held January 16, 2019. We welcome the opportunity to hear further from CLF and other stakeholders. We concur with CLF's concern about protecting drinking water quality and public health. That is our members' core focus in their work, 24-7-365. However, we also observe the ongoing debate about the level of health impacts of various PFAS chemicals. Clarity and consensus are lacking; for examples, see the 2018 report of the Australian Expert Health Panel (2018) and the levels of uncertainty expressed in ATSDR's Toxicity Profiles (2018) and U. S. EPA's response to the New Jersey Drinking Water Quality Council.

We also note the considerable divergence of responses to PFAS drinking water concerns on the part of other states and jurisdictions. Very few states have set standards; most are applying the U. S. EPA public health advisory level of 70 ppt as they investigate and track this issue. Canada Health just finalized PFOA and PFOS drinking water limits of 200 and 600.

We remain uncertain about the level of urgency around the PFAS issue. Given the considerable and growing attention to this issue, and the phase-out of two of the most ubiquitous and concerning PFAS (PFOA and PFOS), we note that the threats posed by PFAS are already diminishing. Data compiled by federal agencies and states show declining levels of PFOA and PFOS in human blood serum, in wastewater, and in other matrices. Our peak human exposures to at least those two chemicals are in the past.

We concur with and support state actions that focus on the very high levels of PFAS found at sites impacted by direct industrial and fire-fighting discharges, where drinking and other waters are impacted in the hundreds and thousands of parts-per-trillion (ppt) range. Taking proactive, precautionary steps to reduce human exposures and risks from such high levels of PFAS is appropriate. And taking steps to reduce further releases and control sources also make sense. Thus, in the wastewater realm, we support efforts to identify any significant wastewater PFAS discharges and apply industrial pretreatment protocols.

However, we urge caution in attempting to address small-scale PFAS releases and setting numerical standards for drinking water or other waters more stringent than U. S. EPA's public health advisory levels (PFOA + PFOS of 70 ppt). Such actions may have unintended, costly repercussions. Data show that many wastewaters, groundwaters, and surface waters have several to low tens of parts per trillion PFAS. The costs of treatment or remediation of these ubiquitous trace contaminations will be real and significant, if numerical standards are set in the 20 ppt level or lower, as CLF recommends. We are not convinced that there are demonstrable societal and public health benefits of setting such low regulatory or screening levels. And we are concerned that many of the costs of addressing low contamination levels will fall not only on drinking water systems, both public and private, but also on municipal wastewater management systems and other public systems that are already challenged by funding shortfalls and increasing regulatory pressures.

Establishing a treatment technique, which appears to be a flexible process, could focus action on addressing the most egregious contamination issues associated with industrial and fire-fighting releases of PFAS. That would be good. As CLF suggests, this may be preferable to establishing MCLs for individual chemicals. However, an important aspect of setting formal MCLs is that the process includes consideration of feasibility, costs, and benefits. (One feasibility factor of note is the fact that no U. S. EPA-approved analytical method yet exists for waters other than drinking water or for solids). These are important considerations when public funds are being expended, and we urge MassDEP to address them, as the agency takes actions on PFAS.

Finally, we disagree with CLF's recommendation of immediately setting a PFAS drinking water limit at 20 ppt. There remains too much uncertainty on the public health impacts of various PFAS, and numerous conservative, protective, uncertainty factors were already applied in the formal process of establishing U. S. EPA's health advisory level of 70 ppt. Adding more vague uncertainty factors – just out of excess precaution – is unscientific. For the same reasons, we disagree with the concept of lumping all PFAS together. Among the PFAS chemicals, there are significant, known differences in the human half-lives, persistence, bioaccumulation, and other key parameters. Already, MassDEP's combination of five PFAS in its screening level of 70 ppt, adopted in 2018, is random and represents the inclusion, in a non-transparent way, of yet another uncertainty factor in the risk calculation.

We urge MassDEP to consider the feasibility, costs, and benefits of whatever actions are taken to address PFAS in drinking water and other waters and soil. Municipalities and public utilities and ratepayers will likely have to bear a sizable proportion of the costs involved in meeting whatever standards are adopted. MassDEP needs to be aware – upfront – of these costs and the implication for communities around the Commonwealth.

And we urge MassDEP and other stakeholders to put emphasis and take actions on source reductions and controls on uses of any persistent chemicals of concern. Avoiding uses of chemicals of proven public health concern is the most cost-efficient way of reducing risk to public health, protecting drinking water, and protecting wastewater and the environment.

Thank you for this opportunity to provide input. We welcome further discussion and working collaboratively to address the public health concerns and policies related to PFAS.

Sincerely,

Ned Beecher
Executive Director

The North East Biosolids and Residuals Association (NEBRA) is a 501(c)(3) non-profit professional association advancing the environmentally sound and publicly supported recycling of biosolids and other organic residuals in New England, New York, and eastern Canada. NEBRA membership includes the environmental professionals and organizations that produce, treat, test, consult on, and manage most of the region's biosolids and other large volume recyclable organic residuals. NEBRA is funded by membership fees, donations, and project grants. Its Board of Directors are from CT, MA, ME, NH, VT, and Nova Scotia. NEBRA's financial statements and other information are open for public inspection during normal business hours. For more information: http://www.nebiosolids.org.

January 16, 2019

Douglas E. Fine
Assistant Commissioner, Bureau of Water Resources
Massachusetts Department of Environmental Protection
1 Winter Street
Boston, MA 02108

A.M. Yvette DePeiza
Program Director, Drinking Water Program
Bureau of Water Resources
Massachusetts Department of Environmental Protection
1 Winter Street
Boston, MA 02108

Subject: PFAS Petition Feedback

Dear Mr. Fine and Ms. DePeiza:

The LSP Association (LSPA) very much appreciates the opportunity to participate in the process of providing feedback on the "PFAS Petition" submitted to MassDEP by the Conservation Law Foundation and Toxics Action Center. Representatives of the LSPA will attend the meeting and listen carefully to the presentations as we all grapple with the complex public health issues posed by Per- and Polyfluoroalkyl Substances (PFAS). We understand the potential public policy and public health concerns associated with this class of compounds.

The LSPA is the non-profit professional society for Licensed Site Professionals (LSPs), the environmental consultants licensed by the LSP Board of Registration to oversee the investigation and remediation of hazardous waste sites in Massachusetts, and for other professionals (attorneys, laboratory personnel, contractors, etc.) involved in these activities. Through education, dissemination of information, and advocacy, we work to help our nearly 850 members achieve and maintain high standards of practice in overseeing the assessment and remediation of hazardous waste sites. The LSPA works closely with MassDEP's Bureau of Waste Site Cleanup (BWSC) in all aspects of waste site assessment and remediation, we participate in policy development workgroups, and we provide input and comment on draft guidance and regulations.

As MassDEP takes its next steps in the regulation of PFAS, the LSPA will continue to actively participate and share our expertise as a key stakeholder in policy development discussions and workgroups, and provide input and comment on draft guidelines, guidance, and regulations. We agree that, as articulated in the petition, "a robust stakeholder process" should be part of any rulemaking.

Independent of the petition, we encourage MassDEP to take a holistic approach to information sharing and regulation of PFAS across its many programs. The BWSC's invitation of stakeholders, including the LSPA, to this meeting is a good first step. In addition, we recommend that MassDEP approach PFAS through a comprehensive and cohesive regulatory framework, similar to that set forth in the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000). This would include thoughtful consideration not only of drinking water standards and treatment technologies, but also PFAS source reduction and control; methods to define the nature and extent of PFAS contamination; risk-based criteria for groundwater, surface water, soil and sediments; comparative assessment of remediation alternatives; evaluation of the cost effectiveness and financial burden of various approaches, and transparent, effective community relations and risk communication.

Ultimately, we anticipate that an integrated and comprehensive approach to regulating these compounds will be required in order to provide appropriate protection of public health, welfare, and the environment. Thank you again for the opportunity to provide our thoughts in advance of the public meeting.

Sincerely,
LSP Association, Inc.

Marilyn M. Wade, PE, LSP
President

Wendy Rundle
Executive Director

cc:
Commissioner Martin Suuberg, MassDEP
Paul Locke, Assistant Commissioner, MassDEP Bureau of Waste Site Cleanup

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January 16, 2019

Written Comments re: *"Petition for Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per- and Polyfluoroalkyl Substances"*

Dear Commissioner Suuberg,

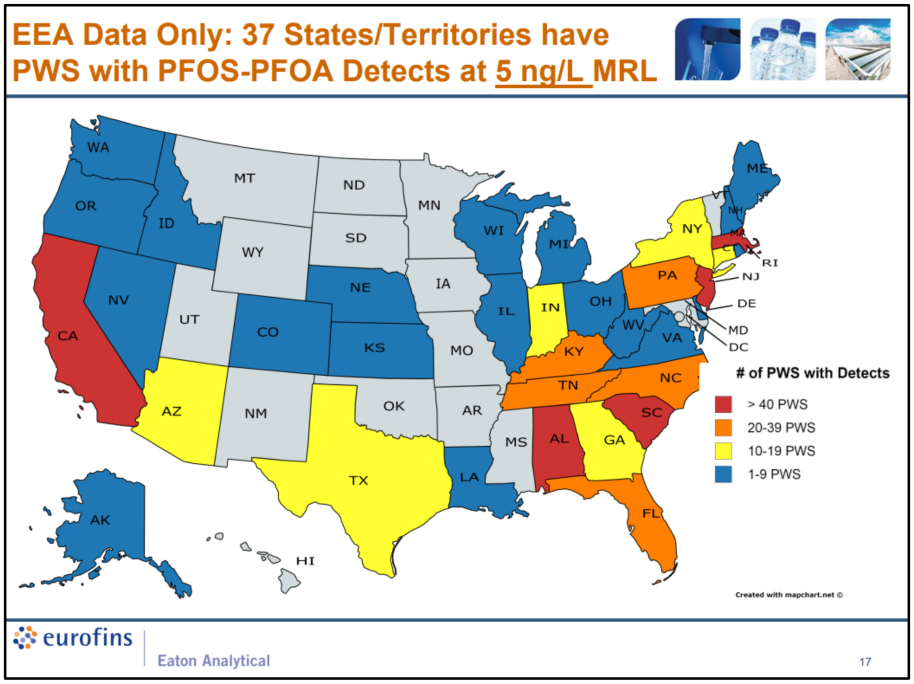
Thank you to the Massachusetts Department of Environmental Protection for hosting today's meeting to discuss the important topic of PFAS drinking water guidelines.

My name is Laurel Schaider and I am a research scientist at Silent Spring Institute, where we have been studying PFASs in drinking water since 2009. I am also part of the research team for the STEEP Superfund Research Program, a collaboration of the University of Rhode Island, Harvard University, and Silent Spring Institute. I would like to share some information and perspectives based on our own research and on approaches used by other states and federal agencies in developing guidelines for PFASs in drinking water.

<u>PFAS contamination of drinking water supplies is widespread, and the full extent of contamination is not yet known.</u> Silent Spring Institute was first to detect PFASs in drinking water on Cape Cod. In our 2010 study of public wells,[1,2] we found PFOS in 40% of the public wells we tested, and the highest levels in the Hyannis Water System. In our 2011 study of private wells,[3,4] we found PFASs in half of the wells we tested throughout Cape Cod, including both legacy PFAS compounds, like PFOS, and newer replacement PFAS compounds, like PFBS and PFHxA.

Across the Commonwealth, the full extent of PFAS contamination in public drinking water supplies is unknown. In the absence of an enforceable standard at the state or federal level, public water supplies are not required to monitor PFASs on a routine basis. From 2013-2015, large public water supplies in Massachusetts, those that serve at least 10,000 customers, were required to test for six PFASs as part of the third cycle of U.S. EPA's Unregulated Contaminant Monitoring Rule. That testing revealed PFASs in five public water supplies, out of the 170 that were tested through this program. However, the reporting limits for the individual PFAS chemicals were relatively high—ranging from 10 to 90 ng/L—well above the lowest levels measurable by some labs, and in some cases higher than drinking water guidelines developed by states. In other words, additional public water supplies in Massachusetts may have PFAS levels that exceed the current Massachusetts ORSG but did not need to be reported.

Indeed, a 2017 re-analysis of the data collected under UCMR by one of the major analytical laboratories, Eurofins Eaton Analytical, found that over 40 public water supplies in

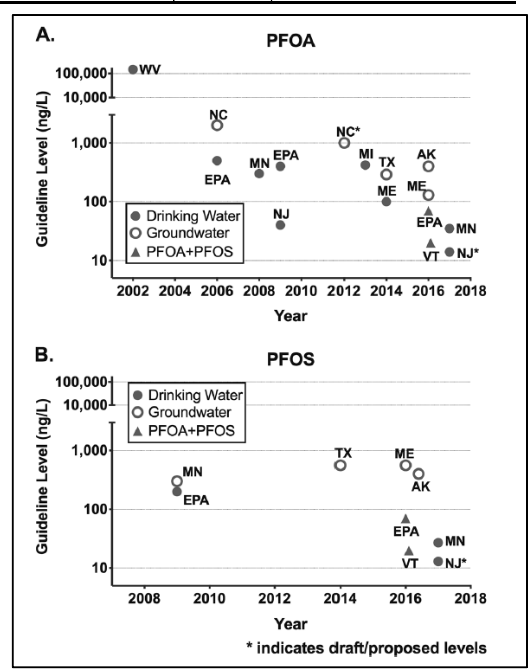


Eurofins Eaton Analytical, which analyzed 30% of samples nationwide tested through EPA's UCMR3 program (2013-2015), reported the number of public water supplies with detectable concentrations of PFOS and PFOS using a method reporting limit of 5 ng/L. According to this re-analysis, over 40 public water supplies in Massachusetts had PFOS or PFOA above this level.

Source: http://greensciencepolicy.org/wp-content/uploads/2017/12/Andy_Eaton_UCMR3_PFAS_data.pdf

Massachusetts had concentrations of PFOS or PFOA over 5 ng/L (see figure above).[5] Having an enforceable drinking water standard would require public water supplies to monitor for PFASs, ensuring that we are not missing water supplies that currently have PFAS contamination, and would detect new contamination in the future.

<u>Other states have developed drinking water guidelines for PFOA, PFOS, and other PFASs lower than EPA's health advisories.</u> Last week, my colleagues and I published a peer-reviewed journal article in the *Journal of Exposure Science & Environmental Epidemiology* that summarizes approaches used by state and federal agencies in developing drinking water guidelines for PFOS and PFOA (provided as an attachment to this letter).[6] At the time we wrote our paper, we found that three states had developed drinking water guidelines for PFOS and PFOA that were lower than EPA's 2016 Lifetime Health Advisory: New Jersey, Vermont, and Minnesota. Since that time, three additional states have also drafted guidelines below the EPA's health advisories. Our analysis revealed that over time, drinking water guidelines generally go down, informed by new scientific findings on PFAS health effects (see figure on right).



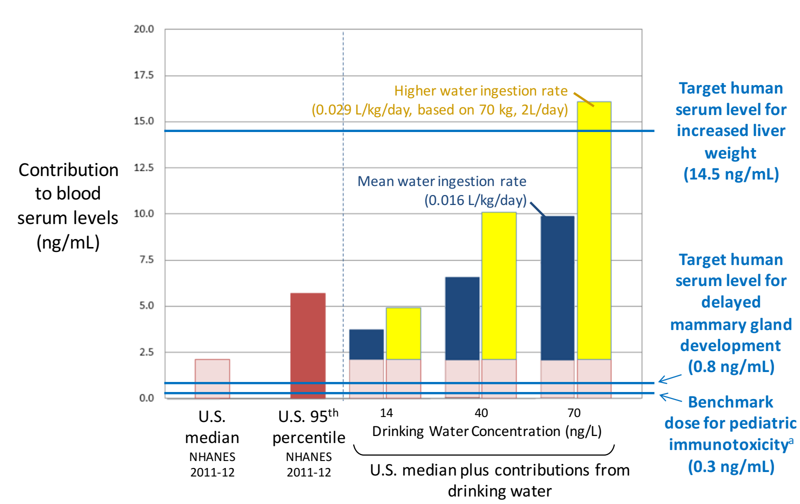
In June 2018, the ATSDR issued an updated draft Toxicological Profile for PFASs, including minimal risk levels for four PFAS chemicals.[7] The minimal risk levels for PFOA and PFOS were 6.7 and 10 times lower, respectively, than the reference doses that the U.S. EPA used in developing its 2016 health advisories.

The current Massachusetts ORSG recommends that public water supplies ensure that the total concentration of five PFAS chemicals does not exceed 70 ng/L. This is more restrictive than EPA's health advisory, which considers just PFOS and PFOA. However, this is less restrictive than approaches developed by New Jersey and Vermont. As an example, the levels of PFOA and PFHpA found in Danvers and Hudson public wells tested through the UCMR testing fall not exceed the Massachusetts ORSG, but would exceed the guidelines in New Jersey and Vermont (see table below).

Water System	PFHpA (ng/L)	PFOA (ng/L)	Above NJ MCL?	Above VT guideline?	Above 70 ng/L for sum of 5 PFASs?
Danvers Well #1	14	22	yes	yes	no
	16	25	yes	yes	no
Hudson Chestnut St.	10	50	yes	yes	no
	10	40	yes	yes	no

New science and sensitive endpoints and populations should be considered in developing drinking water standards. The New Jersey Drinking Water Quality Institute, in developing its recommended maximum contaminant level of 14 ng/L for PFOA, noted that the target human serum level for delayed mammary gland development was 18 times lower than the target level for increased liver weight, and below median serum levels in the U.S.[8] Changes in breast development could have significant public health impact because of the long-term implications for breastfeeding and breast cancer, making this an urgent priority. Research by many scientists has demonstrated that early life environmental exposures can alter mammary gland development, disrupt lactation, and increase susceptibility to breast cancer.[9,10] These findings support the conclusion that assessment of mammary gland development should be incorporated in chemical test guidelines and risk assessment. Although New Jersey's recommended MCL for PFOA is not based on delayed mammary gland development, their MCL does include an uncertainty factor to be protective of this effect as well as other endpoints associated with developmental exposures.

Drinking water contributions to population PFOA exposures



Graph from: New Jersey Drinking Water Quality Institute. *Health-Based Maximum Contaminant Level Support Document: Perfluorooctanoic Acid (PFOA)*. 2017. [a]Grandjean and Budtz-Jorgensen, 2013.

The NJ Drinking Water Quality Institute also modeled how exposures to PFOA in drinking water would increase blood serum concentrations in the population. They estimated that exposure to 70 ng/L PFOA in drinking water (assuming average water consumption rates) would lead to a 4.8-fold increase in blood serum PFOA levels compared to median serum levels in the U.S. based on NHANES. Given the fact that epidemiologic studies have shown effects on children's immune systems (reduced antibody response to vaccines) at serum PFAS levels below average levels in the general population,[11] a drinking water guideline level that will allow exposed communities to have further increases in exposures is not consistent with protecting public health.

To protect public health, MassDEP should establish enforceable standards for drinking water supplies and contaminated sites to facilitate remediation, set maximum drinking water levels that are low enough to not increase blood PFAS levels substantially above background levels, establish surveillance of water supplies with appropriately low reporting limits, and release existing data so that exposed populations are informed and can take action.

Sincerely,

Laurel A. Schaider, Ph.D.
Research Scientist, Silent Spring Institute

References Cited:

1. Schaider, L.; Rudel, R.; Dunagan, S.; Ackerman, J.; Perovich, L.; Brody, J. *Emerging Contaminants in Cape Cod Drinking Water*; Silent Spring Institute: Newton, MA, 2010. http://www.silentspring.org/our-publications/study_reports/emerging-contaminants-cape-cod-drinking-water.
2. Schaider, L. A.; Rudel, R. A.; Ackerman, J. M.; Dunagan, S. C.; Brody, J. G., Pharmaceuticals, perfluorosurfactants, and other organic wastewater compounds in public drinking water wells in a shallow sand and gravel aquifer. *Sci. Tot. Env.* **2014,** *468*, 384-393.
3. Schaider, L.; Ackerman, J.; Rudel, R.; Dunagan, S.; Brody, J. *Emerging Contaminants in Cape Cod Private Drinking Water Wells*; Silent Spring Institute: Newton, MA, 2011. http://silentspring.org/pdf/our_research/Emerging-contaminants-private-wells.pdf.
4. Schaider, L. A.; Ackerman, J. M.; Rudel, R. A., Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer. *Sci. Tot. Env.* **2016,** *547*, 470-481.
5. Eaton, A. *A Further Examination of a Subset of UCMR 3 PFAS Data Demonstrates Wider Occurrence*. 2017; Available at: http://greensciencepolicy.org/wp-content/uploads/2017/12/Andy_Eaton_UCMR3_PFAS_data.pdf (Accessed 20 June 2018).
6. Cordner, A.; De La Rosa, V. Y.; Schaider, L. A.; Rudel, R. A.; Richter, L.; Brown, B., Guideline levels for PFOA and PFOS in drinking water: the role of scientific uncertainty, risk assessment decisions, and social factors. *J Expo Anal Environ Epidemiol* **2019**.
7. Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Perfluoroalkyls: Draft for Public Comment*; U.S. Department of Health and Human Services: 2018. https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf.
8. New Jersey Department of Environmental Protection. *Health-Based Maximum Contaminant Level Support Document: Perfluorooctanoic Acid (PFOA)*; New Jersey Drinking Water Quality Institute, Health Effects Subcommittee: Trenton, NJ, 2017. http://www.nj.gov/dep/watersupply/pdf/pfoa-appendixa.pdf.

9. Rudel, R. A.; Fenton, S. E.; Ackerman, J. M.; Euling, S. Y.; Makris, S. L., Environmental exposures and mammary gland development: State of the science, public health implications, and research recommendations. *Environ. Health Perspect.* **2011,** *119* (8), 1053-1061.
10. Macon, M. B.; Fenton, S. E., Endocrine disruptors and the breast: Early life effects and later life disease. *J. Mammary Gland Biol. Neoplasia* **2013,** *18* (1), 43-61.
11. Grandjean, P.; Budtz-Jørgensen, E., Immunotoxicity of perfluorinated alkylates: Calculation of benchmark doses based on serum concentrations in children. *Environ Health* **2013,** *12*, 35.

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ARTICLE

Guideline levels for PFOA and PFOS in drinking water: the role of scientific uncertainty, risk assessment decisions, and social factors

Alissa Cordner[1] · Vanessa Y. De La Rosa[2,3] · Laurel A. Schaider[2] · Ruthann A. Rudel[2] · Lauren Richter[3] · Phil Brown[3,4]

Received: 30 July 2018 / Revised: 21 October 2018 / Accepted: 12 November 2018

Abstract

Communities across the U.S. are discovering drinking water contaminated by perfluoroalkyl and polyfluoroalkyl substances (PFAS) and determining appropriate actions. There are currently no federal PFAS drinking water standards despite widespread drinking water contamination, ubiquitous population-level exposure, and toxicological and epidemiological evidence of adverse health effects. Absent federal PFAS standards, multiple U.S. states have developed their own health-based water guideline levels to guide decisions about contaminated site cleanup and drinking water surveillance and treatment. We examined perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) water guideline levels developed by the U.S. Environmental Protection Agency (EPA) and state agencies to protect people drinking the water, and summarized how and why these levels differ. We referenced documents and tables released in June 2018 by the Interstate Technology and Regulatory Council (ITRC) to identify states that have drinking water and groundwater guideline levels for PFOA and/or PFOS that differ from EPA's health advisories (HAs). We also gathered assessment documents from state websites and contacted state environmental and health agencies to identify and confirm current guidelines. Seven states have developed their own water guideline levels for PFOA and/or PFOS ranging from 13 to 1000 ng/L, compared to EPA's HA of 70 ng/L for both compounds individually or combined. We find that the development of PFAS guideline levels via exposure and hazard assessment decisions is influenced by multiple scientific, technical, and social factors, including managing scientific uncertainty, technical decisions and capacity, and social, political, and economic influences from involved stakeholders. Assessments by multiple states and academic scientists suggest that EPA's HA is not sufficiently protective. The ability of states to develop their own guideline levels and standards provides diverse risk assessment approaches as models for other state and federal regulators, while a sufficiently protective, scientifically sound, and enforceable federal standard would provide more consistent protection.

Keywords Drinking water · Emerging contaminants · Exposure assessment · Perfluorinated chemicals · PFAS · Risk assessment

Introduction

The mobility, persistence, and widespread use of perfluoroalkyl and polyfluoroalkyl substances (PFAS) have resulted in drinking water contamination globally. PFAS were found in the drinking water of more than 16 million Americans in 33 states [1], and a recent analysis indicates that PFAS-contaminated drinking water is much more widespread than previously reported [2]. Surprisingly, despite this widespread contamination [3], ubiquitous exposure [4], and toxicological and epidemiological evidence of health effects [5–7], there are no federal drinking water standards for any PFAS. Instead of a standard, in 2016 the U.S. Environmental Protection Agency (EPA) released a non-enforceable lifetime health advisory (HA)

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of 70 ng/L for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), individually or combined. Without an enforceable standard, public water systems (PWSs) are not required to routinely test for PFAS or to treat water exceeding EPA HAs, and so no complete assessment of the prevalence of PFAS in U.S. drinking water exists.

In the absence of federal standards, seven U.S. states have adopted or proposed their own health-based drinking water guideline levels or standards for PFOA and/or PFOS, ranging from 13 to 1000 ng/L. There are important regulatory distinctions between terms such as guidelines, advisories, and standards. For this paper, we use "drinking water guideline levels" as a general term to refer to any risk-based water concentration intended to protect from health effects associated with drinking water consumption, along with more precise terms that are used by individual state or federal agencies, including "health advisory level," "maximum contaminant level," or "protective concentration level." (Tables 1 and 2 use the specific term associated with each agency's guideline.)

In this perspective, we compare PFOA and PFOS drinking water guideline levels developed by EPA and seven states, and summarize how and why these levels differ. We aim to provide a useful overview of a rapidly changing regulatory field, identify common factors and decisions that influence guideline development, and examine the importance of social factors. We used tables released by the Interstate Technology and Regulatory Council (ITRC) in June 2018 [8] to identify states with drinking water and groundwater guideline levels for PFOA and/or PFOS that differ from EPA's HAs. These documents serve as a resource for regulatory personnel addressing PFAS contamination and are updated regularly by a team of environmental professionals. We also contacted state health and environmental agencies to identify and confirm current guideline levels. For all guidelines, we reviewed publicly available risk assessment documents and toxicological summaries prepared by regulatory agencies.

We find that the development of PFOA and PFOS guideline levels is influenced by many scientific, technical, and social factors and decisions including: agency management of scientific uncertainty; an evolving understanding of PFAS health effects; decisions about toxicological endpoints and exposure parameters; and the influence of various stakeholders, including regulated industries and affected communities. We document the rationale used by states to develop guideline levels that differ from those set by EPA. Several states have established guideline levels below EPA's HA, suggesting that some regulators and scientists view EPA's approach as not sufficiently protective.

Perfluoroalkyl and polyfluoroalkyl substances: growing concerns

PFAS as a class include an estimated 4730 human-made and commercially available chemicals, polymers, and mixtures containing chains of fluorinated carbon atoms that are widely used in industrial processes and consumer goods [9]. It is not currently possible to accurately track the use of PFAS individually or as a class in the U.S. because companies can claim production volume data as confidential business information and not disclose it publicly or to EPA. Two PFAS are the most well-known and widely studied. PFOA—previously used to manufacture polytetrafluoroethylene (PTFE) for non-stick coatings such as Teflon™, added as an ingredient in firefighting foams, and created as a byproduct of many other chemical processes—was first used to manufacture commercial products in 1949. U.S. manufacturer DuPont began studying PFOA's toxicological and exposure concerns starting in the 1960s [10]. PFOS, previously used in fabric protectors such as Scotchgard™, firefighting foam, and semiconductor devices, has been produced since the 1940s. U.S. manufacturer 3M started measuring fluorine levels in blood samples from workers in the 1970s [11]. In 1997, 3M detected PFOS in workers' blood serum and in samples from U.S. blood banks, intended to represent a control population, and several studies in following years confirmed widespread exposure in the U.S. population [12]. In 2000, 3M announced that it would voluntarily phase out all production of PFOS due to regulatory pressure and concerns over liability [13]. In 2006, following an EPA investigation, eight U.S. chemical manufacturers agreed to phase out all production and use of PFOA and related compounds by 2015 [14]. PFOA and PFOS, both considered long-chain PFAS (perfluorocarboxylic acids with eight or more carbon atoms or perfluorosulfonic acids with six or more carbon atoms [15]), are no longer produced in the U.S., but manufacturing continues in other parts of the world [16] and replacement PFAS are widely used despite growing concerns about persistence, exposure, and toxicity [14, 17–21].

PFAS are important and widespread drinking water contaminants because they are highly persistent, mobile in groundwater, and bioaccumulative [22]. PFAS contamination is often linked to industrial releases, waste disposal and landfill sites, military fire training areas, airports, and other sites where PFAS-containing aqueous film-forming foams (AFFFs) are used to extinguish flammable liquid fuel fires or for firefighter training [1]. Over twenty-five U.S. communities have contaminated water due to releases from manufacturing or industrial waste sites [23], and the Department of Defense (DoD) has identified 401 current or former military sites with known or suspected PFAS contamination, including 126 sites with PFOA or PFOS

Table 1 PFOA drinking water guideline levels

	Advisory level	Critical effect study	Toxicological endpoint	Reference dose	Uncertainty factors	Target population	Water ingestion rate	RSC
U.S. EPA[a], 2016, Health Advisory Level [35]	70 ng/L	Lau et al. [49]	Developmental	20 ng/kg- day	Total = 300 Intraspecies 10, Interspecies 3, LOAEL to NOAEL 10	Lactating woman	0.054 L/kg-day	20%
Alaska DEC[b], 2016, Groundwater cleanup level [89]	400 ng/L	Lau et al. [49]	Developmental	20 ng/kg- day	Total = 300 Intraspecies 10, Interspecies 3, LOAEL to NOAEL 10	Child (0–6 years) residential	0.78 L/day, 15 kg body weight (b.w.)	100%
Maine DEP[b], 2016, Remedial action guideline [90, 91]	130 ng/L	Six studies combined [49, 92–94]	Liver	6 ng/kg-day	Total = 300 Intraspecies 10, Interspecies 3, Database 10	Adult	2 L/day, 70 kg b.w.	60%
Minnesota DOH, 2017, Non-cancer health-based level [95]	35 ng/L	Lau et al. [49]	Developmental	18 ng/kg- day	Total = 300 Intraspecies 10, Interspecies 3, LOAEL to NOAEL 3, Database 3	Infant exposure via breastmilk for 1 year, from mother chronically exposed via drinking water	Derived from internal serum concentrations based on 95% water intake rates and upper percentile breastmilk intake rates	50%
New Jersey DEP, 2017, Maximum contaminant level (recommended) [45]	14 ng/L	Loveless et al. [96]	Liver	2 ng/kg-day	Total = 300 Intraspecies = 10, Interspecies 3, Database 10	Adult	2 L/day, 70 kg b.w.	20%
North Carolina DENR[b], 2012, Interim maximum allowable concentration (proposed) [54]	1000 ng/L	Butenhoff et al. [97]	Liver	N/A	Total = 30 Intraspecies 10, Interspecies 3	Adult	2 L/day, 70 kg b.w.	20%
Texas CEQ[b], 2017, Protective concentration level [81]	290 ng/L	Macon et al. [50]	Mammary Gland	15 ng/kg- day	Total = 300 Intraspecies 10, LOAEL to NOAEL 30	Child (0–6 years) residential	0.64 L/day, 15 kg b.w.	100%
Vermont[a] DEC/DOH, 2016, Primary groundwater enforcement standard [98]	20 ng/L	Lau et al. [49]	Developmental	20 ng/kg- day	Total = 300 Intraspecies 10, Interspecies 3, LOAEL to NOAEL 10	Infant (0–1 year)	0.175 L/kg-day	20%

Note: Adapted from ITRC [8]

CEQ Commission on Environmental Quality, *DEC* Department of Environmental Conservation, *DENR* Department of Environment and Natural Resources (note that NC DENR is now NC DEQ), *DEP* Department of Environmental Protection, *DEQ* Department of Environmental Quality, *DOH* Department of Health, *RSC* Relative Source Contribution

[a]Applies to PFOA and PFOS individually, as well as the sum of PFOA and PFOS

[b]Alaska, Maine, North Carolina, and Texas follow the EPA's HA for public and/or private drinking water

Table 2 PFOS drinking water guideline levels

	Advisory level	Critical effect study	Toxicological endpoint	Reference dose	Uncertainty factors	Target population	Water ingestion rate	RSC
U.S. EPA[a] Office of Water, 2016, Health Advisory Level [35]	70 ng/L	Luebker et al. [99]	Reduced pup body weight	20 ng/kg- day	Total = 30 Interspecies 3, Intraspecies 10	Lactating women	0.054 L/kg-day	20%
Alaska DEC[b], 2016, Groundwater cleanup level [89]	400 ng/L	Luebker et al. [99]	Reduced pup body weight	20 ng/kg- day	Total = 30 Interspecies 10, Intraspecies 3	Child (0–6 years) residential, non-cancer	0.78 L/day, 15 kg b.w.	100%
Maine DEP[b], 2016, Remedial action guideline [91, 100]	560 ng/L	Seacat et al. [101]	Thyroid effects	80 ng/kg- day	Total = 30 Interspecies 3, Intraspecies 10	Adult	2 L/day, 70 kg b.w.	20%
Minnesota DOH, 2017, non-cancer health-based value [102]	27 ng/L	Luebker et al. [99]	Reduced pup body weight	5.1 ng/kg- day	Total = 100 Interspecies 3, Intraspecies 10, Database 3	Lifetime based on internal serum concentration	Derived from internal serum concentrations based on 95% water intake rates and upper percentile breastmilk intake rates	50%
New Jersey DEP, 2017, Maximum contaminant level, draft [103]	13 ng/L	Dong et al. [104]	Immune response	1.8 ng/kg- day	Total= 30 Interspecies 3, Sensitive subpopulations 10	Adult	2 L/day, 70 kg b.w.	20%
Texas CEQ[b], 2017, Protective concentration level [81]	560 ng/L	Zeng et al. [105]	Hippocampus synapse structure	20 ng/kg- day	Total = 100 LOAEL to NOAEL 10, Intraspecies 10	Child (0–6 years) residential	0.64 L/day, 15 kg b.w.	100%
Vermont[a] DEC/DOH, 2016, Primary groundwater enforcement standard [98]	20 ng/L	Luebker et al. [99]	Reduced pup body weight	20 ng/kg- day	Total = 30 Interspecies 3, Intraspecies 10	Infant (0–1 year)	0.175 L/kg-day	20%

Note: Adapted from ITRC [8]

CEQ Commission on Environmental Quality, *DEC* Department of Environmental Conservation, *DEP* Department of Environmental Protection, *DEQ* Department of Environmental Quality, *DOH* Department of Health, *RSC* Relative Source Contribution

[a]Applies to PFOA and PFOS individually, as well as the sum of PFOA and PFOS

[b]Alaska, Maine, and Texas follow the EPA's HA for public and/or private drinking water

levels above EPA's HA, mostly related to AFFF use [24]. In addition to PFOA and PFOS, 57 classes of PFAS have been identified in AFFF and/or AFFF-contaminated groundwater, containing over 240 individual compounds, many of which are poorly characterized in terms of toxicity and environmental fate and transport [25]. Surveillance for PFAS is difficult because of the large number of compounds, many of which lack analytical standards.

Concern about health effects from PFAS is high because of widespread exposure and documented toxicity. Biomonitoring data from the U.S. Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES), a representative sample of U.S. residents, for 12 PFAS from 1999 to 2014 found four PFAS in the serum of nearly all people tested [4, 26]. These PFAS remain widely detected, although population serum levels have generally declined, especially for PFOS, following the phase-outs of U.S. production [26]. An epidemiological study, funded by a DuPont lawsuit settlement, of 69,000 people in the Mid-Ohio Valley who drank water contaminated with at least 50 ng/L of PFOA for at least one year linked PFOA exposure to high cholesterol, ulcerative colitis, thyroid disease, testicular and kidney cancers, and pregnancy-induced hypertension [6]. Other health effects associated with PFOA and several other PFAS based on epidemiological evidence include decreased vaccine response, liver damage, and decreased birth weight [27, 28]. In animal studies, PFAS have shown a variety of toxicological effects including liver toxicity, suppressed immune function, altered mammary gland development, obesity, and cancer [7, 22]. There is concordance between some of the endpoints identified in studies of animals and humans, most notably suppression of the immune system [29]. While there are sufficient data for risk assessment of PFOA, PFOS, and several other PFAS, most PFAS detected in drinking water lack sufficient data for risk characterization [22, 28].

Drinking water regulation

Public drinking water supplies (PWSs) in the U.S. are regulated under the Safe Drinking Water Act (SDWA), which specifies that EPA is responsible for establishing testing requirements and standards, while states have primary authority to implement and enforce these standards. The SDWA currently regulates over 90 chemical, biological, and radiological contaminants [30]. For most listed contaminants, EPA establishes both a Maximum Contaminant Level Goal (MCLG), a non-enforceable guideline below which no adverse health effects are expected, and a Maximum Contaminant Level (MCL), an enforceable standard for PWSs set as close as feasible to the MCLG while accounting for availability of treatment technologies and cost. PWSs must test for regulated contaminants, which can reveal previously unrecognized contamination, and take any needed action to address violations. Amendments to the SDWA in 1996 removed a requirement for EPA to periodically establish new MCLs and created a more extensive review process, and few additional contaminants have been regulated since 1996 [31]. Private drinking water sources are not regulated under the SDWA. Other laws like the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) and the Clean Water Act govern groundwater and surface water quality, including responses to contaminated water at industrial sites. States often develop health-based water guidelines to support decisions at these sites, including response to contamination in private wells.

EPA has not set MCLs for any PFAS, though they recently announced their intention to "initiate steps to evaluate the need for a maximum contaminant level (MCL) for PFOA and PFOS" [32]. In an unusual move that reflects the political demand for a federal MCL, 25 U.S. Senators signed a letter urging EPA to develop an MCL for PFAS [33]. Establishment of an MCL would increase EPA's authority to address PFAS contamination under the Superfund program [33].

The SDWA also requires EPA to consider additional contaminants for regulation. Every five years, EPA must publish a Candidate Contaminant List (CCL) of contaminants being considered for future standards based on health concerns, prevalence in PWSs, and meaningful opportunities for exposure reduction [34]. No MCLs have been developed for contaminants from the CCL since the SDWA 1996 Amendments were enacted [31]. PFOS and PFOA were added to the third CCL in 2009 and were carried forward to the fourth CCL in 2016. To inform this process, every five years EPA must also develop a list of up to 30 contaminants under the Unregulated Contaminant Monitoring Rule (UCMR) program for which PWSs are required to test on a short-term basis to establish their prevalence. In the third cycle (UCMR3; 2013–2015), six PFAS were analyzed by all large PWSs (serving >10,000 customers) and 800 smaller PWSs [3]. EPA decided not to include any PFAS in UCMR4 (2018–2020).

Under the SDWA, EPA can establish HAs for contaminants without MCLs as guidance for federal, state, and local officials. HAs are intended to represent levels of exposure unlikely to cause adverse health effects, considering both cancer and non-cancer endpoints, and can represent specific durations of exposure (one-day, 10-day, or lifetime). Federal HAs and state guidance values can guide response at contaminated sites if drinking water is affected but do not require PWSs to proactively monitor for these contaminants. In 2016, EPA issued HAs for lifetime PFOA and PFOS exposure [3, 35].

Individual states can also establish their own guidelines and regulations, including MCLs, for drinking water contaminants that are not regulated at the federal level, or they can develop stricter guidelines for contaminants with a federal MCL. There is precedent for states to develop drinking water MCLs for contaminants that do not have federal MCLs (e.g., perchlorate in Massachusetts and methyl tertiary-butyl ether in California) or to develop MCLs that are more stringent than EPA's (e.g., several volatile solvents in New Jersey and California) [36–38]. These state standards and guidelines may apply to PWSs or be used as screening or cleanup levels at contaminated sites (e.g., sites with contaminated groundwater or drinking water). However, some states are precluded by state law from developing their own guidelines or standards, and other states may lack the resources to do so. For instance, Pennsylvania identified lack of funding, technical expertize, and occurrence data as challenges in setting a state standard for PFOA and PFOS [39].

Variation in PFOA and PFOS drinking water guideline levels

In the absence of federal MCLs, multiple states have proposed or adopted drinking water guidelines or standards for PFOA and/or PFOS (Fig. 1). The first PFOA guideline level of 150,000 ng/L was developed in West Virginia in 2002 in response to PFOA-contaminated drinking water near a DuPont facility. In 2006, EPA issued a screening level of 500 ng/L for PFOA for West Virginia sites contaminated by DuPont [40]. In 2009, EPA developed provisional, short-term HAs of 400 ng/L for PFOA and 200 ng/L for PFOS in response to a contaminated site in Alabama. Around the same time, states such as Minnesota and New Jersey developed PFOA guidelines and standards that were lower than the EPA's short-term HA. In 2016, EPA issued a lifetime HA of 70 ng/L for PFOA and PFOS individually or combined [3, 35]. Shortly after, Vermont and Minnesota, building off the EPA's risk assessments, developed state guideline levels that were lower than the EPA HAs. In 2017, New Jersey recommended MCLs of 14 ng/L for PFOA and 13 ng/L for PFOS, which, if adopted, would be the first standards to require surveillance by PWSs for PFOA and PFOS, as well as being the lowest guideline levels in the U.S.

We analyzed fifteen current or proposed water guidelines or standards for PFOA or PFOS that are the most recent guidelines for the EPA and each state: EPA's PFOA and PFOS HAs, seven state guidelines for PFOA, and six state guidelines for PFOS (Tables 1 and 2). Some states (e.g., New Jersey and North Carolina) have older adopted guidelines, as well as newer proposed guidelines that have not yet been formally adopted; in these cases, we analyzed the more recent, proposed guidelines. Some guideline levels apply to individual chemicals, while others are based on the sum of multiple PFAS. For example, the EPA HA applies to PFOA and PFOS combined, and the Connecticut, Massachusetts, and Vermont guidelines refer to the sum of PFOA, PFOS, and three other PFAS [41–43]. Eight states (Colorado, Delaware, Massachusetts, Minnesota, New Jersey, North Carolina, and Texas) have developed guideline levels for PFAS other than PFOA and PFOS. Many other states follow EPA's 70 ng/L HA level and are not included in our analysis or shown in the Figure or Tables.

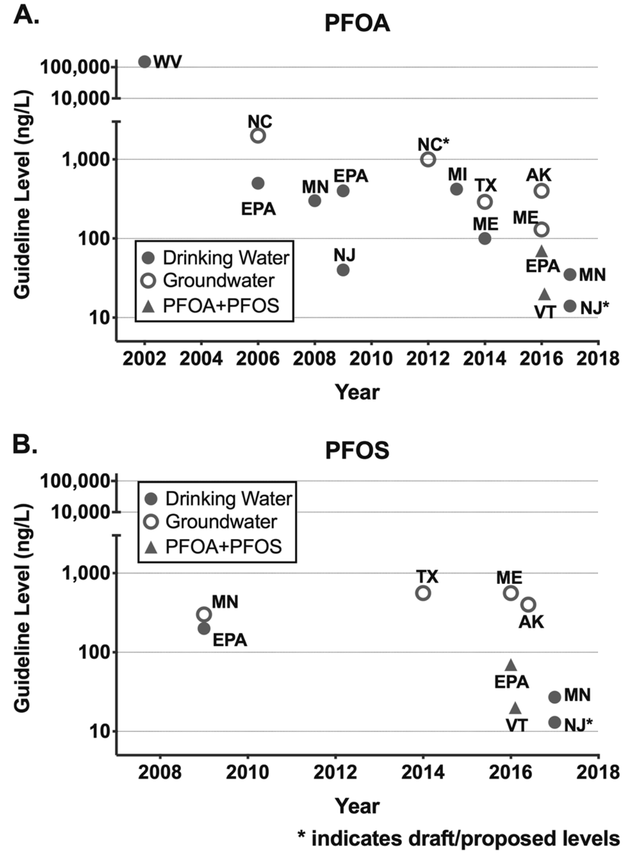

Fig. 1 Timeline of Select PFOA and PFOS Drinking Water Guideline Levels. (**a**) PFOA and (**b**) PFOS water guideline levels have decreased over time. Several states have developed guidelines for PFOA or PFOS individually (circles), while Vermont (VT) and EPA have guidelines that apply to PFOA and PFOS individually or combined (triangles). PFOA and PFOS water guidelines can apply to different water types such as public drinking water (closed circles) or groundwater, e.g., at contaminated sites (open circles)

The most recent proposed state guideline levels for PFOA vary by a factor of 70, from 14 ng/L (New Jersey) to 1000 ng/L (North Carolina; Table 1). For PFOS, the seven guidelines vary by a factor of 43, from 13 ng/L (New Jersey) to 560 ng/L (Maine and Texas; Table 2).

Alaska, Maine, and Texas follow EPA's HA for public and/or private drinking water supplies but have developed higher guideline levels for other contaminated water and site remediation intended to be protective of drinking water exposures from groundwater at those contaminated sites.

PFOA and PFOS health-based risk assessment

Comparing the risk assessments developed by states and EPA to derive these guideline levels highlights the scientific uncertainty and assumptions that underlie these decisions. Tables 1 and 2 summarize critical components of each assessment: toxicological endpoint, critical study, uncertainty factors, target population, and exposure parameters.

Toxicological and dose-response assessments

Risk assessment is used to develop health-based guideline levels. Scientists first review toxicological, epidemiological, and mode of action studies to identify the critical effect, the most sensitive adverse endpoint that is considered relevant to humans. Four of the eight guideline levels for PFOA are based on developmental effects, three are based on liver toxicity, and one is based on mammary gland development effects. Of the seven guideline levels for PFOS, four are based on reduced pup body weight, one is based on thyroid effects, one is based on suppressed immune response, and one is based on developmental neurotoxicity. New Jersey's recommended PFOS MCL, the lowest in the country, is the only assessment to use immune response as the critical endpoint.

The critical effect serves as the starting point for deriving a point of departure (POD), the point on the dose-response curve to which uncertainty factors (UFs) are applied, such as a No Observed Adverse Effect Level (NOAEL) or Lowest Observed Adverse Effect Level (LOAEL). In PFAS assessments, toxicokinetic adjustments were made to account for slower excretion of PFOA and PFOS in humans compared to animals, either by calculating a Human Equivalent Dose based on doses used in animal studies (most states and EPA) or by converting serum levels based on animal studies into serum levels in humans (New Jersey). This is a particularly important consideration for PFAS because of substantial variation in PFAS toxicokinetics among humans and test animals [44]. There are also sex-specific and species-specific differences in the excretion rates of PFAS. For example, PFOA has a very short half-life in female rats (4–6 h) due to rapid excretion [44], which makes the female rat a poor model for studying chronic or developmental effects of PFOA exposure since it is unlikely to reach a steady-state level when administered on a daily basis.

After a POD is derived, UFs are applied to the POD for non-cancer endpoints to estimate a reference dose (RfD), the daily dose expected to be without harm. PFOA and PFOS assessments utilized various UFs to account for: potential differences in sensitivity among people (intraspecies UF) and between humans and animals (interspecies UF); gaps in toxicity data (database UF); and critical effect studies for which the POD was a LOAEL (LOAEL-to-NOAEL UF). UFs were applied differently across PFOA and PFOS assessments. The EPA and all state-based PFOA assessments except for North Carolina have total UFs of 300. North Carolina, the state with the highest proposed PFOA guideline level, has a total UF of only 30 based on intraspecies and interspecies UFs. For PFOS, Texas and Minnesota have total UFs of 100 while other states and the EPA have total UFs of 30. Texas includes a UF for LOAEL-to-NOAEL extrapolation, and Minnesota a database UF to account for potentially more sensitive immune effects.

States and EPA developed guideline levels that are based on a single critical effect but are intended to also be protective of other cancer and non-cancer health outcomes. Though New Jersey's recommended PFOA MCL is based on an RfD for liver toxicity, the state also considered whether the MCL would be protective for cancer endpoints or mammary gland development. Their assessment based on increased incidence of testicular tumors in rats arrived at the same 14 ng/L guideline level [45]. Their assessment based on altered mammary gland development produced a recommended PFOA MCL equivalent to 0.77 ng/L—18 times lower than the RfD used to derive the proposed MCL. This lower MCL was not recommended due to the lack of precedent for mammary gland development as a critical endpoint in risk assessment, although an additional UF of 10 for sensitive effects was applied to protect for this endpoint [45]. Vermont and EPA both calculated PFOA guideline levels for testicular cancer and determined that guideline levels based on the non-cancer endpoints were more protective. Minnesota did not derive a cancer-based PFOA guideline level, instead concluding that existing data were inadequate for assessing carcinogenic potential and that the non-cancer guideline was protective of potential cancer effects. All PFOS guideline levels are based on non-cancer endpoints, with most assessments indicating that cancer endpoints were reviewed and found to be not sufficiently well-studied to establish a cancer-based guideline level.

Exposure assessment

Following the derivation of an RfD, exposure assumptions are used to establish a concentration in drinking water that is intended to be health protective, usually targeted to protect sensitive subgroups such as children. Exposure assessment relies on assumptions about the target population, water ingestion rates, and proportion of the daily dose supplied by drinking water relative to other exposure sources, known as the relative source contribution (RSC). These assumptions may vary based on the type of guideline (e.g., groundwater or drinking water).

In PFOA and PFOS assessments, target populations to be protected differed across states, even among those that used the same critical endpoint and/or had a similar RfD. EPA, Alaska, and Vermont derived the same critical endpoint and RfD for PFOA, yet their guideline levels ranged from 20 ng/L (Vermont) to 400 ng/L (Alaska), a 20-fold difference, because they used different exposure parameters. Vermont and EPA selected different target populations (infants for Vermont, lactating women for EPA), leading to divergent water ingestion rates and consequently different PFOA guideline levels for water. Minnesota's assessment is based on exposure for breastfed and formula-fed infants. Texas assumed that children's water consumption is 0.64 L/day, while Alaska assumed it is 0.78 L/day.

States also differed in their selection of RSC values. Most states and EPA assumed an RSC value of 20% for drinking water, which limits daily exposure from contaminated drinking water to 20% of the RfD so that additional exposures from other sources, such as consumer products or diet, do not push total exposure above the RfD. All other exposure assumptions being equal, lower RSC values correspond to lower drinking water guideline levels. Minnesota and Maine used human biomonitoring studies to derive RSCs for PFOA and PFOS ranging from 20% to 60%. Alaska and Texas used a 100% RSC, meaning that for people drinking water at their guideline, any dietary and consumer product exposures would raise their intake above the RfD. The Alaska and Texas PFOA and PFOS guidelines, which are 4–8 times higher than EPA's HAs, were developed for remediation and clean-up of contaminated sites, and these states use EPA's HAs as limits for PWS drinking water.

Factors contributing to variation in PFAS guideline levels

Considering the most recent adopted or proposed PFOA and PFOS water guideline levels at the federal and state levels, the range of "safe" levels in drinking water spans almost two full orders of magnitude, from 13 to 1000 ng/L. This variation reflects responses to scientific uncertainty in risk assessment, technical decisions and capacity, and social, political, and economic influences from involved stakeholders.

Scientific decisions

Differences between water guidelines in part reflect responses to scientific uncertainty. As described above, health risk assessment requires many assumptions and estimates in order to predict a safe exposure for humans. These include identifying critical effects, addressing inter-species and intra-species variation, quantifying other uncertainties, and selecting exposure parameters. Many areas of toxicity and exposure research on PFAS have not achieved scientific consensus so risk assessors make diverse choices.

Another important consideration in these and future assessments is the consideration of epidemiological evidence. Many of the assessments noted that effects in human studies were consistent with the critical effect in animal studies, giving greater confidence to the assessment. However, all of the assessments used dose-response data from animal studies as a basis for their drinking water levels. New Jersey assessments compared their target PFOS serum level of 23 ng/mL with the midrange of serum levels in epidemiological studies that reported effects (6–27 ng/mL) and with U.S. serum levels (median 5 ng/mL, 95%ile 19 ng/mL, from 2013–2014 NHANES) [46]. Based on this comparison, New Jersey recognized the need to minimize any additional exposures from drinking water since the population is already approaching effect levels from the epidemiological studies and risk-based exposure limits. While risk assessors generally expect their approaches to produce exposure levels that will be protective for exposed humans, PFOS immune effects in children are reported at lower exposures than the EPA's drinking water advisory levels [46]. A recent assessment used epidemiological data to propose a drinking water guideline of 1 ng/L to prevent additional increases in serum PFOS levels [47]. Several other endocrine disrupting compounds show effects in humans at exposures below EPA risk-based exposure limits, including di-(2-ethylhexyl) phthalate (DEHP) and polybrominated diphenyl ethers (PBDEs) [48].

The number of peer-reviewed scientific articles on PFAS has increased dramatically since 2000, while federal and state PFAS drinking water guideline levels have generally decreased over this time (Fig. 1). This demonstrates a common phenomenon: initial risk assessments based on limited data are often shown not to be health protective once more complete data become available. For PFOA and PFOS, the tightening of the guidelines is largely not due to new toxicology studies, but rather to improved exposure research, advances in analytical measurement technologies, improved biomonitoring and toxicokinetic data, and epidemiological findings. For example, both of EPA's PFOA HAs, the 2009 provisional HA for short term exposure and the 2016 lifetime HA for chronic exposure, are based on developmental effects from the same mouse study [49], but different exposure parameters and toxicokinetic assumptions led to a much lower HA in 2016. Seven of the eight PFOA assessments, all released between 2012 and 2017, use critical endpoints from studies published in 2006 or earlier. EPA's assessments are also influential: once EPA derived RfDs for the 2016 HAs, states such as Minnesota and Vermont used these RfDs along with different decisions about exposure parameters, resulting in lower guideline levels.

The most sensitive toxicological endpoints—altered mammary gland development and suppressed immune function—were not the basis for EPA's PFOA and PFOS HAs. However two states, Texas and New Jersey, did use these endpoints as the basis for their PFOA Protective Concentration Level (PCL) and PFOS MCL, respectively. Although in utero PFOA exposure has been shown to alter mammary gland development in rodents [50, 51], this specialized endpoint is not routinely evaluated in regulatory toxicity studies and there is limited precedent for using it in risk assessment [52, 53]. To the best of our knowledge, altered mammary gland development has never been used as a critical endpoint for the basis of any federal regulatory risk assessment in the United States.

Texas based their PFOA PCL on altered mammary gland development from a full gestational study in mice since this endpoint showed a dose response. Texas determined this RfD to be protective of increased liver weight effects observed in several other studies. New Jersey's PFOA assessment did not use mammary gland changes as the critical effect but did recognize that it was most sensitive and included an additional UF for database uncertainty related to mammary gland effects. Minnesota identified delayed mammary gland development as a co-critical effect, but did not include additional UFs. North Carolina and EPA cited uncertainty related to variation in response between mouse strains, inconsistent methods across studies, and questions about toxicokinetics as challenges for using this endpoint [35, 54], though risk assessments commonly rely on endpoints for which there is substantial intra- and interspecies variation in sensitivity. Most notably, EPA discounted effects on mammary gland development because these alterations were not associated with decreased lactation function and the mode of action for mammary gland development effects is not well described. Though EPA was reluctant to consider the changes adverse, a substantial body of scientific work suggests that altered mammary gland development is likely to influence later breast cancer risk [53]. New research to better characterize these associations is important because many endocrine disruptors alter mammary gland development if exposure occurs in utero or early in life. Routine assessment of mammary gland development in toxicity studies of endocrine disruptors will be informative and improve understanding of these changes and reduce uncertainty for future risk assessments.

New Jersey used decreased plaque forming cell response (suppressed immune function) as the basis for their PFOS MCL, noting also the consistency between this effect and decreased vaccination response in epidemiological studies. Minnesota identified suppressed immune function as a co-critical effect and included a database UF of 3 for immunotoxicity. While the EPA indicated a concern for adverse immune effects, it chose not to use suppressed immune function as the basis for the PFOS HA because a "lack of human dosing information and lack of low-dose confirmation of effects in animals for the short-duration study precludes the use of these immunotoxicity data in setting the RfD" [35]. The New Jersey assessment includes a rebuttal of EPA's decision, noting that EPA has used this endpoint as a basis for RfDs for other chemicals [46].

Social, political, and economic influences

While risk assessments such as these PFAS water guidelines are presented as being based solely on scientific considerations, this process is also influenced by political, social, and economic factors [55–59]. For PFAS, much like other high-value products such as tobacco, the landscape of what is scientifically known and unknown about their health and environmental impacts is influenced by the context of knowledge production. Internal industry documents reveal a broad "science-based defense strategy" to "command the science" on PFAS, ranging from suspected influence on state environmental protection agencies in the case of West Virginia, to the selective peer review publication of internal research, to paying academic scientists to influence the peer-review process [10, 60, 61].

PFAS manufacturing companies have influenced PFAS water guidelines in both overt and subtle ways. For example, in 2001 EPA and West Virginia Department of Environmental Protection (WVDEP) learned that DuPont scientists had found high levels of PFOA in regional drinking water. The following year, DuPont collaborated with WVDEP and a state-appointed C8 Assessment Toxicity Team to develop a screening level of 150,000 ng/L, despite numerous conflicts of interest and DuPont's own internal guideline of 1000 ng/L [10, 62].

Economically invested corporations have indirectly influenced the development of PFAS drinking water guideline levels through the strategic production and dissemination of industry-friendly research, a well-documented pattern in environmental health [63]. Recent litigation by the State of Minnesota Attorney General against 3M revealed internal correspondence between the company and academic scientists paid as consultants. In one instance, an academic scientist hired by 3M wrote in private emails that he intentionally described his work reviewing articles for publication as "literature reviews" in order to avoid a paper trail to 3M, bragged about rejecting an article on PFAS health effects, and offered to pass unpublished articles to peer reviewers recommended by 3M, clear violations of scientific norms [60].

Industry sponsorship of toxicological research and risk assessments can also influence the developments of guidelines through the "funding effect" in which funding source influences published outcomes [64–66]. Studies or assessments funded by a company or industry that benefits financially from the product under investigation are less likely to identify risks and more likely to demonstrate efficacy (or ambiguity), while the opposite is true of studies funded by government agencies or independent parties. Of the eight critical studies used to derive PFOA ($n = 5$) or PFOS ($n = 3$) guidelines, five were conducted by PFAS manufacturers (3M or DuPont), two were conducted by the U.S. government (EPA or NIEHS), and one was conducted by academic researchers with funding from the Chinese government. North Carolina's PFOA guideline, the highest in the country, heavily references a risk assessment conducted by industry consultants [67]. However, the small number of PFAS guidelines prevents any quantitative analysis of funding effects. Risk assessments, which rely on many assumptions to estimate human exposure and toxicity in the absence of data, are more vulnerable to funding effects. For example, a 2009 PFOA risk assessment funded by DuPont and 3M identified 880 ng/L as "a reliable, albeit conservative" level for an MCL, over 12 times higher than the EPA HA [67].

Industry-funded research may also influence the overall landscape of PFAS research because it is selectively produced and shared [10]. For example, most research conducted by chemical companies is never published or made public, even when disclosure could be useful for assessing chemical risk. Major PFAS manufacturers have repeatedly violated information disclosure requirements under the Toxic Substances Control Act (TSCA) Section 8(e) by not disclosing information on substantial risks related to PFAS in production [68, 69]. This practice has resulted in multimillion dollar fines and also delayed the production of science on environmental and human health effects of PFAS by decades [70, 71]. Today, PFAS manufacturers commonly assert that information on production quantities, use in consumer goods, and chemical identity is confidential business information, creating barriers for scientists and regulators seeking to prevent harmful exposures.

Unlike some states where limited regulatory appetite and strong industry and political influence may slow progress on protecting public health by establishing drinking water exposure limits, other states have developed more protective and scientifically sound PFAS guideline levels in response to significant public and community pressure. After communities in Vermont learned of water contamination, social pressure led to state guidelines for PFOA and PFOS that were lower than EPA's [72]. In contrast, North Carolina, home to a major Chemours PFAS manufacturing facility, has not updated their PFOA interim maximum allowable concentration of 2000 ng/L, the highest in the United States, despite a 2012 proposal that this guideline be lowered to 1000 ng/L. North Carolina recently developed the nation's first drinking water provisional health goal for GenX (hexafluoropropylene oxide dimer acid), a PFOA replacement, following discovery of widespread contamination in local rivers that are used for drinking water [73]. This example demonstrates that local pollution concerns can motivate states to develop guidelines or standards without waiting for federal precedent. Legislators at the state and federal level may play an increasing role going forward. Recent examples include a legislatively proposed 5 ng/L level for PFOA and PFOS in Michigan and pressure from 25 U.S. Senators on EPA to develop a PFAS MCL [33, 74].

Discussion and conclusion

The wide range of PFOA and PFOS guidelines—up to 70-fold difference between states—as well as the lack of enforceable MCLs and deference by many states to EPA's HA of 70 ng/L have significant public health implications. Our finding that some states have taken additional steps beyond federal action in evaluating and/or regulating PFAS is consistent with states taking more health-protective action on other chemicals, including flame retardants and bisphenol A [75, 76].

EPA's HAs do not require ongoing monitoring by PWSs or treatment of water that exceeds the HAs, though in practice many other entities use the HA to make remediation decisions. If MCLs existed for PFAS, regulators would have greater authority to take action at contaminated sites under CERCLA, and DoD sites would be able to move forward with remediation of contaminated sites [33]. In addition, given the toxicity, persistence, and mobility of PFAS, systematic screening of PWSs is a logical approach to protect public health. Some states, including Michigan and Washington, are testing PWSs for certain PFAS [77, 78], and New Jersey's recommended MCLs would require routine testing. In the absence of MCLs, guidelines are applied only after contamination is discovered by other mechanisms, for example, when residents seek water testing near known industrial sites. Public and regulatory awareness of PFAS water contamination has benefited from nationwide testing initiatives, including EPA's UCMR testing and DoD identification of PFAS-contaminated military sites. The recently authorized nationwide study on PFAS exposure at military sites may be particularly useful in raising awareness and potentially supporting further regulatory action [79].

Regulatory and scientific attention to PFAS has focused on PFOA and PFOS, but the scope of potential PFAS contamination is much broader. While there are data available to support risk assessment for several additional PFAS, including perfluorobutyrate (PFBA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), and GenX, there are no studies on prevalence, exposure, and toxicity for many other PFAS, or even analytical methods to detect them [22]. PFAS as a class are generally persistent and mobile, and the few that have been adequately tested share some toxic effects and exposure characteristics with PFOA and PFOS [14, 18–21, 80]. The lack of information and potential scope of the contamination poses significant challenges for protecting public health. The fact that several guideline levels, including EPA's HAs, apply to the total concentration of multiple PFAS suggests that regulatory agencies are attentive to PFAS as a class, not just as individual compounds. In the absence of toxicity data on individual chemicals, regulators could use well-characterized PFAS as analogues for deriving RfDs and guideline levels, or could develop methods to regulate PFAS as a class, although this would involve additional assumptions and uncertainties. Texas developed PCLs for 16 PFAS, deriving RfD values for PFAS with limited toxicity data using well-characterized PFAS as surrogates [81]. Relative potency estimates have been used in other chemical classes, such as polycyclic aromatic hydrocarbons and dioxins, and are being explored for PFAS [82]. Some existing regulations treat all long-chain PFAS similarly. The U.S. Food and Drug Administration (FDA) has restricted all long-chain PFAS as a class [55, 83], and EPA's PFOA Stewardship Program includes PFOA and all "precursor chemicals that can break down to PFOA, and related higher homologue chemicals" [84]. The similarities between many PFAS in terms of chemical structure and exposure potential, combined with potential differences in toxicity and the long time required to gather sufficient data, further raise the importance of limiting manufacture and use of PFAS before they become exposure concerns.

EPA-validated drinking water testing protocols exist for 18 PFAS (EPA Method 537), though validated methods are lacking for other PFAS and other media, such as groundwater. It is difficult to understand why EPA has not included any PFAS in the fourth cycle of UCMR testing, despite significant data gaps regarding the extent of drinking water contamination with other PFAS and the need for surveillance using lower detection limits [85]. The focus of current water screening and treatment efforts solely on removing PFOA and PFOS is concerning because carbon filtration designed to remove long-chain PFAS is less effective at removing short-chain PFAS and PFAS transformation products likely present in AFFF-contaminated water [86] and at PFAS production sites [21].

Our review of PFAS drinking water guideline levels highlights opportunities to extend risk assessment methods to include some important endpoints such as mammary gland development and immune function. Reports of immunosuppression in children with exposures within the exposure range prevalent in the general population have raised concern that EPA's HAs are not adequately protective, since modeling indicates that consumption of drinking water at 70 ng/L would substantially increase PFOA and PFOS blood levels above current U.S. background levels [47]. Additionally, New Jersey's PFOA assessment estimated that the RfD for mammary gland changes is below median blood levels in the general population [45]. Grandjean and Clapp [47] proposed that a drinking water concentration of 1 ng/L for PFOA and PFOS would not be expected to lead to an increase in population-level blood serum levels above current U.S. averages.

Our analysis also highlights opportunities to consider epidemiological data more carefully in conjunction with toxicological and exposure data. Despite a relatively robust epidemiological literature for PFOA and PFOS, only New Jersey showed how their target blood level was in the range of exposures in human studies that show effect on vaccine response. New Jersey also used human biomonitoring data to illustrate that even small increases in exposure are problematic because current exposure levels are near levels associated with health effects [22]. However, the environmental co-occurrence of multiple PFAS is a challenge for using epidemiological data to develop guideline levels for individual PFAS [87]. Considering information from human biomonitoring and epidemiology adds important context to the risk assessment process.

The scientific and regulatory landscape on PFAS continues to evolve rapidly. Advances in analytical methods and decreased cost of measuring certain PFAS in water and other media broaden the ability of PWSs, regulatory and health agencies, academics, and nonprofits to identify water contamination. In June 2018, the Agency for Toxic Substances and Disease Registry (ATSDR) released a draft Toxicological Profile that derived minimal risk levels (MRLs), which are similar to RfDs, for intermediate duration exposure (15–364 days) of four PFAS routinely measured in NHANES [28]. The MRL values for PFOA (3 ng/kg/day) and PFOS (2 ng/kg/day) are 6.7 and 10 times lower than the RfDs EPA used to develop its 2016 HAs and similar to those developed by New Jersey, though they are based on different studies and endpoints. The release of this report became surrounded in controversy amidst suggestions that months earlier, EPA and other government officials sought to delay its release, citing concerns about public reaction [88], and demonstrates how political and economic factors can affect the timely development of health-protective guidelines.

In the absence of enforceable, nationwide water standards for PFAS, some states have developed more health-protective and scientifically sound guidelines. This may create or exacerbate public health disparities because not all states have the resources to develop guideline levels. The ability of states to develop their own guideline levels and standards provides diverse risk assessment approaches as models for other state and federal regulators, while a sufficiently protective, scientifically sound, and enforceable federal standard would provide more consistent protection.

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Compliance with ethical standards

Conflict of interest The authors declare they have no conflict of interest.

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References

1. Hu XC, Andrews D, Lindstrom AB, Bruton TA, Schaider LA, Grandjean P, et al. 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. 2016;3:344–50.
2. Eaton AA. Further Examination of a Subset of UCMR 3 PFAS Data Demonstrates Wider Occurrence. 2017. http://greensciencepolicy.org/wp-content/uploads/2017/12/Andy_Eaton_UCMR3_PFAS_data.pdf.
3. U.S. EPA (Environmental Protection Agency). Third Unregulated Contaminant Monitoring Rule. 2016. https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-.
4. CDC (Centers for Disease Control and Prevention). Per- and Polyfluorinated Substances (PFAS) Factsheet. 2017. https://www.cdc.gov/biomonitoring/PFAS_FactSheet.html.
5. ATSDR (Agency for Toxic Substances and Disease Registry). Draft Toxicological Profile for Perfluoroalkyls; U.S. Department of Health and Human Services. 2015. https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf.
6. C8 Science Panel. The Science Panel Website. 2017. http://www.c8sciencepanel.org/.
7. Lau C. Perfluorinated compounds: an overview. in toxicological effects of perfluoroalkyl and polyfluoroalkyl substances, In: DeWitt J, editors. Switzerland: Springer International Publishing; 2015.
8. ITRC (Interstate Technology and Regulatory Council), ITRC PFAS Regulations, Guidance and Advisories Fact Sheet. In ITRC PFAS Regulations Section 5 Tables, Ed. 2017.
9. OECD (Organisation for Economic Cooperation and Development). Toward a New Comprehensive Global Database of Per- And Polyfluoroalkyl Substances (PFASs): Summary Report on Updating the OECD 2007 List of Per- and Polyfluoroalkyl Substances (PFASs); OECD Environment Directorate, Environment, Health and Safety Division: Paris, France. 2018. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO(2018)7&doclanguage=en.
10. Lyons C. Stain-resistant, Nonstick, Waterproof, and Lethal: The Hidden Dangers of C8. Westport: Praeger; 2007.
11. 3M. Environmental and Health Assessment of Perfluorooctane Sulfonic Acid and its Salts. 2003. http://multimedia.3m.com/mws/media/370351O/3m-pfos-risk-assessmt-2003.pdf.
12. State of Minnesota. Civil Action No. 27-CV-10-28862, State of Minnesota, et al. v. 3M Company. Expert Report of Philippe Grandjean, MD, DMSc. Prepared on behalf of Plaintiff State of Minnesota; State of Minnesota District Court for the County of Hennepin Fourth Judicial District. 2017.
13. U.S. EPA. EPA and 3M announce phase out of PFOS. 2000. https://yosemite.epa.gov/opa/admpress.nsf/0/33aa946e6cb11f35852568e1005246b4.
14. U.S. EPA. PFOA Stewardship Program Baseline Year Summary Report. 2017. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/pfoa-stewardship-program-baseline-year-summary-report.
15. Buck RC, Franklin J, Berger U, Conder JM, Cousins IT, Voogt PD, et al. Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. Integr Environ Assess Manag. 2011;7:513–41.
16. Wang ZY, DeWitt JC, Higgins CP, Cousins IT. A never-ending story of per- and polyfluoroalkyl substances (PFASs)? Environ Sci Technol. 2017;51:2508–18.
17. Danish Environmental Protection Agency. Short-chain Polyfluoroalkyl Substances (PFAS): A literature review of information on human health effects and environmental fate and effect aspects of short-chain PFAS; (Environmental Project No. 1707). Danish Ministry of the Environment: Copenhagen. 2015. https://www2.mst.dk/Udgiv/publications/2015/05/978-87-93352-15-5.pdf.
18. Perez F, Nadal M, Navarro-Ortega A, Fabrega F, Domingo JL, Barcelo D, et al. Accumulation of perfluoroalkyl substances in human tissues. Environ Int. 2013;59:354–62.
19. Rae J, Craig L, Slone T, Frame S, Buxton L, Kennedy G. Evaluation of chronic toxicity and carcinogenicity of ammonium 2, 3, 3, 3-tetrafluoro-2-(heptafluoropropoxy)-propanoate in Sprague–Dawley rats. Toxicol Rep. 2015;2:939–49.
20. Rosenmai AK, Taxvig C, Svingen T, Trier X, van Vugt-Lussenburg BMA, Pedersen M, et al. Fluorinated alkyl substances and technical mixtures used in food paper-packaging exhibit endocrine-related activity. Andrology. 2016;4:662–72.
21. Sun M, Arevalo E, Strynar MJ, Lindstrom AB, Richardson M, Kearns B, et al. Legacy and emerging perfluoroalkyl substances are important drinking water contaminants in the Cape Fear

River Watershed of North Carolina. Environ Sci Technol Lett. 2016;3:415–19.
22. Post GB, Gleason JA, Cooper KR. Key scientific issues in developing drinking water guidelines for perfluoroalkyl acids: Contaminants of emerging concern. PLoS Biol. 2017;15: e2002855.
23. SSEHRI (Social Science Environmental Health Research Institute). PFAS Contamination Site Tracker. 2018. https://pfasproject.com/pfas-contamination-site-tracker/.
24. Sullivan M. Addressing Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). Office of the Secretary of Defense. 2018.
25. Barzen-Hanson KA, Roberts SC, Choyke S, Oetjen K, McAlees A, Riddell N, et al. Discovery of 40 classes of per- and polyfluoroalkyl substances in historical aqueous film-forming foams (AFFFs) and AFFF-impacted groundwater. Environ Sci Technol. 2017;51:2047–57.
26. CDC. Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables Atlanta, GA. 2015. http://www.cdc.gov/exposurereport.
27. Grandjean P, Andersen EW, Budtz-Jørgensen E, Nielsen F, Mølbak K, Weihe P, et al. Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. J Am Med Assoc. 2012;307:391–7.
28. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Perfluoroalkyls: Draft for Public Comment; U.S. Department of Health and Human Services: 2018. https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf.
29. DeWitt JC, Blossom SJ, Schaider LA. Exposure to per- and polyfluoroalkyl substances leads to immunotoxicity: Epidemiological and toxicological evidence. J Expo Sci Environ Epidemiol. 2018. https://doi.org/10.1038/s41370-018-0097-y.
30. U.S. EPA. Drinking Water Contaminants: Standards and Regulations; 2017; https://www.epa.gov/dwstandardsregulations.
31. Roberson JA. What's next after 40 years of water regulations? Environ Sci Technol. 2011;45:154–60.
32. U.S. EPA. Historic EPA Summit Provides Active Engagement and Actions to Address PFAS. 2018. https://www.epa.gov/newsreleases/historic-epa-summit-provides-active-engagement-and-actions-address-pfas.
33. Reed J, Stabenow D, Warren E, Durbin R, Manchin J, Harris K, et al. Letter from United States Senators to EPA Administrator Scott Pruitt [letter]. 13 April 2018. https://drive.google.com/file/d/1LgpWUVI-wfvSW90LtTzjymSNm_BAZTj1/view. Accessed 10 May 2018.
34. U.S. EPA. Drinking Water Contaminant Candidate List (CCL) and Regulatory Determination. 2017. https://www.epa.gov/ccl.
35. U.S. EPA. Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS). Office of Water document 822-R-16-004; U. S. EPA: Washington, DC. 2016.
36. Massachusetts Department of Environmental Protection. Code of Massachusetts Regulations Title 310, 22.06: Inorganic Chemical Maximum Contaminant Levels, Monitoring Requirements and Analytical Methods. 2006. https://www.mass.gov/files/documents/2016/08/vb/perchlorate-310cmr22-07282006.pdf.
37. New Jersey Department of Environmental Protection. Health-Based Maximum Contaminant Level Support Document: Perfluorooctanoic Acid (PFOA) (Public Review Draft); New Jersey Drinking Water Quality Institute, Health Effects Subcommittee: Trenton, NJ. 2016. p. 475. https://www.state.nj.us/dep/watersupply/pdf/dw-standards.pdf.
38. California State Water Resources Control Board. Maximum Contaminant Levels and Regulatory Dates for Drinking Water, U.S. EPA vs California. 2018. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/ccr/MCLs EPA vsDWP-2018-10-02.pdf.
39. PADEP (Pennsylvania Department of Environmental Protection). State MCL Considerations. 2018. http://www.dep.pa.gov/Citizens/My-Water/drinking_water/Perfluorinated%20Chemicals%20%E2%80%93PFOA%20and%20PFOS%20%E2%80%93%20in%20Pennsylvania/Pages/Establishing-a-State-MCL.aspx.
40. U.S. EPA. Long-Chain Perfluorinated Chemicals (PFCs) Action Plan; U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics: Washington, D.C. 2009. https://www.epa.gov/sites/production/files/2016-01/documents/pfcs_action_plan1230_09.pdf.
41. Connecticut Department of Public Health. Drinking Water Action Level for Perfluorinated Alkyl Substances (PFAS). 2016. http://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/eoha/Toxicology_Risk_Assessment/DrinkingWaterActionLevelPerfluorinatedAlkylSubstances-PFAS.pdf?la=en.
42. MADEP (Massachusetts Department of Environmental Protection). Massachusetts Department of Environmental Protection Office of Research and Standards Final Recommendations for Interim Toxicity and Drinking Water Guidance Values for Perfluorinated Alkyl Substances Included in the Unregulated Chemical Monitoring Rule 3; 2018. https://www.mass.gov/files/documents/2018/06/11/pfas-ors-ucmr3-recs_0.pdf.
43. Vermont Department of Health. Drinking Water Health Advisory for Five PFAS (per- and polyfluorinated alkyl substances); Burlington, VT. 2018. http://www.healthvermont.gov/sites/default/files/documents/pdf/ENV_DW_PFAS_HealthAdvisory.pdf.
44. Lau C, Anitole K, Hodes C, Lai D, Pfahles-Hutchens A, Seed J. Perfluoroalkyl acids: a review of monitoring and toxicological findings. Toxicol Sci. 2007;99:366–94.
45. NJDWQI (New Jersey Drinking Water Quality Institute). Maximum Contaminant Level Recommendation for Perfluorooctanoic Acid in Drinking Water, Basis and Background; 2017. http://www.nj.gov/dep/watersupply/pdf/pfoa-recommend.pdf.
46. NJDWQI (New Jersey Drinking Water Quality Institute). Health-based Maximum Contaminant Level Support Document: Perfluorooctane Sulfonate (PFOS); 2018. p. 257. https://www.state.nj.us/dep/watersupply/pdf/pfos-recommendation-appendix-a.pdf.
47. Grandjean P, Clapp R. Perfluorinated alkyl substances: emerging insights into health risks. New Solut. 2015;25:147–63.
48. National Academies of Sciences Engineering and Medicine. Application of Systematic Review Methods in an Overall Strategy for Evaluating Low-Dose Toxicity from Endocrine Active Chemicals. Washington, DC: National Academies Press; 2017.
49. Lau C, Thibodeaux JR, Hanson RG, Narotsky MG, Rogers JM, Lindstrom AB, et al. Effects of perfluorooctanoic acid exposure during pregnancy in the mouse. Toxicol Sci. 2006;90:510–8.
50. Macon MB, Villanueva LR, Tatum-Gibbs K, Zehr RD, Strynar MJ, Stanko JP, et al. Prenatal perfluorooctanoic acid exposure in CD-1 mice: low-dose developmental effects and internal dosimetry. Toxicol Sci. 2011;122:134–45.
51. White SS, Stanko JP, Kato K, Calafat AM, Hines EP, Fenton SE. Gestational and chronic low-dose PFOA exposures and mammary gland growth and differentiation in three generations of CD-1 mice. Environ Health Perspect. 2011;119:1070–6.
52. Makris SL. Current Assessment of the Effects of Environmental Chemicals on the Mammary Gland in Guideline Rodent Studies by the US Environmental Protection Agency (US EPA), Organisation for Economic Co-operation and Development (OECD), and National Toxicology Program (NTP). Environ Health Perspect. 2011;119:1047–52.
53. Rudel RA, Fenton SE, Ackerman JM, Euling SY, Makris SL. Environmental exposures and mammary gland development: State of the science, public health implications, and research recommendations. Environ Health Perspect. 2011;119:1053–61.

54. NCSAB (North Carolina Science Advisory Board). Recommendation to the Division of Water Quality for an Interim Maximum Allowable Concentration for Perfluorooctanoic Acid (PFOA) in Groundwater. 2012. http://daq.state.nc.us/toxics/risk/sab/ra/.
55. Cordner A, Richter L, Brown P. Can Chemical Class Approaches Replace Chemical-by-Chemical Strategies? Lessons from Recent US FDA Regulatory Action on Per- And Polyfluoroalkyl Substances. Environ Sci Technol. 2016;50:12584–91.
56. Frickel S, Moore K. The new political sociology of science. Madison: University of Wisconsin Press, 2006.
57. Joyce K. Is Tuna Safe? A sociological analysis of federal fish advisories. In: Zuber S, Newman M, editors. Mercury pollution: a transdiciplinary treatment. Boca Raton: CRC Press; 2011; pp. 71–100.
58. Krimsky S, Golding D. Social theories of risk. Praeger: Westport, CT, 1992.
59. NRC (National Research Council). Science and decisions: advancing risk assessment. Washington, DC: The National Academies Press, 2009; p 422.
60. Lerner S. Lawsuit Reveals How Paid Expert Helped 3M "Command the Science" on Dangerous Chemicals. The Intercept. 2018.
61. Gaffney T. Perfluorooctanoic Acid (PFOA); US EPA: Washington, DC. 2003.
62. Bilott R. Re: In the Matter of: E.I. du Pont de Nemours and Company [letter]. 20 January 2015. https://www.hpcbd.com/EPA-WVDEP-Letter.pdf. Accessed 31 Jan 2018.
63. Michael D. Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health. New York: Oxford University Press, 2008.
64. Krimsky S. The funding effect in science and its implications for the judiciary. J L Pol'Y. 2005;8:43–68.
65. Smith R. Medical journals are an extension of the marketing arm of pharmaceutical companies. PLoS Med. 2005;2:364–6.
66. Vom Saal FS, Hughes C. An extensive new literature concerning low-dose effects of bisphenol A shows the need for a new risk assessment. Environ Health Perspect. 2005;113:926–33.
67. Tardiff RG, Carson ML, Sweeney LM, Kirman CR, Tan YM, Andersen M, et al. Derivation of a drinking water equivalent level (DWEL) related to the maximum contaminant level goal for perfluorooctanoic acid (PFOA), a persistent water soluble compound. Food Chem Toxicol. 2009;47:2557–89.
68. Grandjean P. Delayed discovery, dissemination, and decisions on invervention in environmental health: a case study on immunotoxicity of perfluorinated alkylate substances. Environ Health. 2018;17:62.
69. U.S. Congress. Toxic Substances Control Act; (15 USC2601-2692). 1976.
70. U.S. EPA. E.I. DuPont de Nemours and Company PFOA Settlements. 2005. https://www.epa.gov/enforcement/ei-dupont-de-nemours-and-company-pfoa-settlements.
71. Richter L, Cordner A, Brown P. Non-stick science: sixty years of research and (In)action on fluorinated compounds. Soc Stud Sci. 2018;48:691–714.
72. Schuren A. Role of state and federal agencies. Presentation at highly fluorinated compounds: social and scientific discovery. Boston, MA. 2017.
73. Hagerty V. Could 140 ng/L limit for GenX increase? Star News Online. 2018.
74. State of Michigan. House Bill 5375, 2017. https://www.legislature.mi.gov/documents/2017-2018/billintroduced/House/htm/2017-HIB-5375.htm.
75. Cordner A, Brown P. A multisector alliance approach to environmental social movements: Flame retardants and chemical reform in the United States. Environ Sociol. 2013;1:69–79.
76. Vogel S. Is It Safe? BPA and the Struggle to Define the Safety of Chemicals. Berkeley: University of California Press, 2013.
77. Michigan Environmental Quality Agency. Michigan embarks on statewide study of PFAS in water supplies. 2018. https://www.michigan.gov/som/0,4669,7-192-47796-468979--,00.html.
78. Interim Chemical Action Plan for Per- and Polyfluorinated Alkyl Substances; (Publication 18-04-005). Department of Ecology State of Washington and Washington State Department of Health: 2018; https://fortress.wa.gov/ecy/publications/documents/1804005.pdf.
79. U.S. Congress. Consolidated Appropriations Act. H.R.1625. U. S. Congress.
80. Danish Ministry of the Environment. Short-chain Polyfluoroalkyl Substances (PFAS): a literature review of information on human health effects and environmental fate and effect aspects of short-chain PFAS; 2015; https://www2.mst.dk/Udgiv/publications/2015/05/978-87-93352-15-5.pdf.
81. TCEQ (Texas Commission on Environmental Quality). Toxicological Evaluation of perfluoro compounds; 2016; https://www.tceq.texas.gov/assets/public/implementation/tox/evaluations/pfcs.pdf.
82. Zeilmaker MJ, Fragki S, Verbruggen EMJ, Bokkers BGH, Lijzen JPA. Mixture exposure to PFAS: A Relative Potency Factor approach; National Institute for Public Health and the Environment: Bilthoven, The Netherlands. 2018; https://www.rivm.nl/dsresource?objectid=6ca2deab-9e68-4457-986f-cbaa1dad2a4f&type=pdf&disposition=inline.
83. U.S. FDA (U.S. Food and Drug Administration). Indirect food additives: Paper and paperboard components. 2016-28116; Food and Drug Administration Department of Health and Human Services. 2016.
84. U.S. EPA. Fact Sheet: 2010/2015 PFOA Stewardship Program. 2015. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program.
85. Eaton A. Perfluorinated Compounds Monitoring in Response to the U.S. EPA Health Advisories; 2017; http://greensciencepolicy.org/wp-content/uploads/2017/12/Andy_Eaton_UCMR3_PFAS_data.pdf.
86. Xiao X, Ulrich BA, Chen BL, Higgins CP. Sorption of poly- and perfluoroalkyl substances (PFASs) relevant to aqueous film-forming foam (AFFF)-impacted groundwater by biochars and activated carbon. Environ Sci Technol. 2017;51:6342–51.
87. National Toxicology Program. Systematic Review of Immunotoxicity Associated with Exposure to Perfluorooctanoic Acid (PFOA) or Perfluorooctane sulfonate (PFOS); Office of Health Assessment and Translation, Division of the National Toxicology Program, National Institute of Environmental Health Sciences: Research Triangle Park, NC. 2016.
88. Snider A. White House, EPA headed off chemical pollution study. Politico. 2018.
89. AKDEC (Alaska Department of Environmental Conservation). Interim Technical Memorandum: Comparing DEC cleanup levels for Perfluorooctane Sulfonate (PFOS) and Perfluorooctonoic Acid (PFOA) to EPA's Health Advisory Levels; 2016; https://dec.alaska.gov/spar/csp/pfas-contaminants.
90. MeCDC (Maine Center for Disease Control and Prevention). Maximum Exposure Guideline for Perfluorooctanoic Acid in Drinking Water; 2014; http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/wells/documents/pfoameg.pdf.
91. MeCDC (Maine Center for Disease Control and Prevention). Human Health Risk-Based Screening Levels for Perfluoroalkyl Compounds; 2016.
92. Butenhoff JL, Gaylor D, Moore J, Olsen G, Rodricks J, Mandal J, et al. Characterization of risk for general population exposure to perfluorooctanoate. Regul Toxicol Pharmacol. 2004;39:363–80.

93. Perkins R, Butenhoff JL, Kennedy GL, Palazzolo M. 13-week dietary toxicity study of ammonium perfluorooctanoate (APFO) in male rats. Drug Chem Toxicol. 2004;27:361–78.
94. Sibinski LJ, Allen JL, Erickson EE. Two-year oral (diet) toxicity/carcinogenicity study of fluorochemical FC-143 in rats. Experiment No. 0281CR0012; 3M Company/Riker Laboratories, Inc: St. Paul, MN. 1983.
95. MDH (Minnesota Department of Health). Health Based Guidance for Water Health Risk Assessment Unit–Toxicological Summary for: Perfluorooctanoate; 2017; http://www.health.state.mn.us/divs/eh/risk/guidance/gw/pfoa.pdf.
96. Loveless S, Finlay C, Everds NF, SR, Gillies P, O'Connor J, Powley C, et al. Comparative responses of rats and mice exposed to linear/branched,linear, or branched ammonium perfluorooctanoate (APFO). Toxicology. 2006;220:203–17.
97. Butenhoff JL, Costa G, Elcombe C, Farrar D, Hansen K, Iwai H, et al. Toxicity of ammonium perfluorooctanoate in male cynomolgus monkeys after oral dosing for 6 months. Toxicol Sci. 2002;69:244–57.
98. Vose S. Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) Vermont Drinking Water Health Advisory [letter]. https://anrweb.vt.gov/PubDocs/DEC/PFOA/PFOA%20-%20PFOS%20Health%20Advisories/Vermont/PFOA_PFOS_HealthAdvisory_June_22_2016.pdf. Accessed 6 June 2018.
99. Luebker D, York R, Hansen K, Moore J, Butenhoff JL. Neonatal mortality from in utero exposure to perfluorooctanesulfonate (PFOS) in Sprague-Dawley rats: Dose-response and biochemical and pharmacokinetic parameters. Toxicology. 2005;215:149–69.
100. MeCDC (Maine Center for Disease Control and Prevention). Maine Center for Disease Control and Prevention Maximum Exposure Guidelines for Drinking Water; 2011. http://www.maine.gov/dhhs/mecdc/environmentalhealth/eohp/wells/documents/megprocedures2011.pdf.
101. Seacat A, Thomford P, Hansen K, Olsen GW, Case M, Butenhoff JL. Subchronic toxicity studies on perfluorooctanesulfonate potassium salt in cynomolgus monkeys. Toxicol Sci. 2002;68:249–64.
102. MDH (Minnesota Department of Health). Health Based Guidance for Water Health Risk Assessment Unit-Toxicological Summary for: Perfluorooctane Sulfonate; 2017. http://www.health.state.mn.us/divs/eh/risk/guidance/gw/pfos.pdf.
103. NJDWQI (New Jersey Drinking Water Quality Institute). Health-Based Maximum Contaminant Level Support Document: Perfluorooctane Sulfonate (PFOS); 2017. https://www.nj.gov/dep/watersupply/pdf/health-based-mcl-pfos.pdf.
104. Dong G, Zhang Y, Zheng L, Liu W, Jin Y, He Q. Chronic effects of perfluorooctanesulfonate exposure on immunotoxicity in adult male C57BL/6 mice. Arch Toxicol. 2009;83:805–15.
105. Zeng HL,YY, Zhang L, Wang Y, Chen J, Xia W, Lin Y, et al. Prenatal exposure to perfluorooctanesulfonate in rat resulted in long-lasting changes of expression of synapsins and synaptophysin. Synapse. 2011;65:225–33.

CLEAN WATER ACTION

My name is Maureo Fernández y Mora and I am the Drinking Water Advocate for Clean Water Action, Massachusetts.

Clean Water Action is a national organization founded in 1972, in order to pass the Clean Water Act. Our mission is to protect our environment, health, economic well-being and community quality of life. We have over 500,000 members nationally and 37,000 in Massachusetts.

I am here today to offer testimony on the issue of PFAS in drinking water. Clean Water Action thanks both Conservation Law Foundation and Toxics Action Center for their diligence in highlighting the urgency of this issue as well as the need for strong regulatory action to ensure that communities are not further endangered. We would also like to thank DEP, in addition to their recent efforts on PFAS which included the expansion of ORS guidelines to three additional PFAS class chemicals, for advising communities to expedite PFAS reduction in cases of contamination, advising mothers and children not to drink contaminated water, and for their commitment to transparent and public process. MA can be a leader on addressing PFAS chemicals in drinking water and on curbing all releases of these chemicals into the environment. We point out that leadership will also be needed by the U.S. Environmental Protection Agency, which is virtually non-existent during the current federal government shut down.

As noted in this petition, the health effects of PFAS were well known among industry insiders as far back as the 1980's. Still, industry polluters, negligent consumer products, and chemically reliant military and firefighting exercises have continued; and with it, so has water contamination across the country. A number of cancer, reproductive, and developmental risks have been linked to PFAS exposure.

However, despite its well established presence and impacts on public health, communities often face this issue alone and with little support. In the absence of PFAS regulation, community members have little access to information of the safety of the water they depend on, and municipalities have little guidance as to how to move forward when, and only if, PFAS contamination is discovered.

In this regard, Massachusetts has the opportunity to be a national leader in the fight for clean drinking water. Massachusetts DEP has already laid the groundwork to be such a leader. The recent expansion of the ORS Guideline based off of EPA's current federal advisory for PFOA and PFOS to include PFNA, PFHsX, PFHpA demonstrates that Massachusetts is not going to wait for Federal standards to catch up both to science and demonstrated community suffering.

However, it cannot be emphasized enough that in a world where chemical companies are going so far as to leave new PFAS chemicals unpatented, and therefore untraceable until impact has occurred, a chemical by chemical approach is futile. Instead, DEP must act based off of what we know: that while the individual composition of different PFAS chemicals are distinct and constantly multiplying, they share in common

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devastating health impacts particularly for pregnant and nursing women and young children. Therefore, MA-DEP should pursue a class-based approach to PFAS drinking water standards. Otherwise, regulators, communities, and advocates will always be at a disadvantage with industry as it continues to churn out thousands of unregulated toxic chemicals.

As noted in this petition, this is not a new concept. The EPA made the decision to regulate haloacetic acid byproducts as a class when, as is also true with PFAS, the public health impact of these byproducts was so well established that the absence of complete information about individual acids was less important than the opportunity to reduce public exposure to the entire class of harmful chemicals.

A class approach may also inform efforts to address the upstream uses of PFAS chemicals – for example in food packaging and other consumer products. So far, manufacturers have relied on the sheer multitude of individual chemicals to avoid regulation and responsibility. We must make sure that polluters are held responsible for creating, using, and discharging the chemicals into the environment in the first place. Those responsible for drinking water source contamination and other releases need to be held accountable. Regulators and elected officials need to make sure that whenever possible, polluters pay.

In conclusion, a statewide conversation about PFAS is urgent and largely overdue. While recent DEP initiatives like expanding the ORSG to five PFAS chemicals in total, publishing recommendations pertaining to PFAS consumption for sensitive subgroups like pregnant and nursing mothers and their young children, and advising public water suppliers to take expeditious action in lowering the levels of these five designated PFAS chemicals demonstrate the seriousness of the situation, it does not yet adequately provide a path forward for ensuring the safety of Massachusetts residents. Moving forward will depend on, as called for in the petition, a robust stakeholders process. Clean Water Action endorses all creative thinking as different stakeholders continue to find the best solutions for this ongoing issue.

For our part, Clean Water Action recommends:

Continuing these public processes so that everyone has the chance to take part in establishing best practices for the monitoring, regulation, and treatment of PFAS.

DEP identifying and connecting communities with all possible strategies and funding for effective drinking water treatment, including polluter payback whenever possible.

Establishing a class based approach to regulation so that advocates and consumers can address PFAS contamination based off of what is most important: public health.

Finally, the drinking DEP Drinking Water Program should work with all other DEP offices and appropriate state agencies to address PFAS chemicals in order to prevent release into the environment. Such action could include surface water quality standards, pre-treatment industrial user standards, and land application limits as described in the petition.

We look forward to continuing to participate in these vital conversations.

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mwwa
massachusetts water works association
www.masswaterworks.org

January 16, 2019

Martin Suuberg, Commissioner
Massachusetts Department of Environmental Protection
One Winter Street, 2nd Floor
Boston, MA 02108

RE: CLF Petition for Rulemaking for Per- and Polyfluoroalkyl Substances

Dear Commissioner Suuberg:

Massachusetts Water Works Association (MWWA) is submitting the following written testimony regarding the Conservation Law Foundation's (CLF) petition to the Massachusetts Department of Environmental Protection (MassDEP) for rulemaking to establish a Treatment Technique Drinking Water Standard for Per- and Polyfluoroalkyl Substances (PFAS) or, as an alternative, a Maximum Contaminant Level (MCL). MWWA is a non-profit membership organization representing over 1,200 drinking water professionals throughout the Commonwealth of Massachusetts. MWWA members are committed to protecting public health and providing a safe and sufficient supply of drinking water to consumers. Our Public Water Systems are operated by licensed professionals who work each and every day to provide this essential service.

MWWA firmly believes that any new drinking water standard must be developed through a transparent process that:

- Relies on a strong scientific foundation
- Involves key stakeholders
- Evaluates the cost-benefit of the proposal, and
- Evaluates the effectiveness of the regulatory action in achieving better health outcomes

With respect to emerging contaminants such as PFAS, it is particularly important for MassDEP to take a deliberative approach, as our understanding of the health risks of these substances is continually evolving. We offer the following comments outlining our concerns with the CLF petition.

water works pride
massachusetts water works association po box 1064, acton, ma, 01720 978 263-1388 (fax) 978 263-1376

A Treatment Technique Standard for PFAS is not appropriate
MWWA is concerned with CLF's request that MassDEP develop a Treatment Technique standard. A Treatment Technique is warranted when it is not economically or technologically feasible to ascertain an appropriate level for establishing a MCL. While setting individual MCLs for each of the more than 3,000 distinct PFAS compounds would not be feasible, establishing a MCL for PFAS as a class based on the best available, peer-reviewed science should be achievable. The Safe Drinking Water Act already regulates some contaminants (HAAs, THMs) as a class of compounds. The major issue with a Treatment Technique approach is the establishment of a trigger requiring implementation of a prescribed treatment process. The process of finding the right trigger level is quite similar to the MCL process, so why not pursue the MCL?

Further, MWWA believes a Treatment Technique standard for drinking water puts the onus and cost solely on the public water supplier. Treating contaminated water at the source does not prevent the continued contamination of the Commonwealth's aquifers and surface waters. Regulatory controls need to be put in place to prevent PFAS from contaminating our water supplies. Such controls should include, but may not be limited to, regulations to prevent the manufacturing and use of PFAS, setting pre-treatment standards for industrial users, setting limits for land application of sludges, controlling air emissions and establishing groundwater standards for site cleanup.

Why is it Normally EPA's Role to Set Drinking Water Standards?
Setting drinking water standards involves a multi-step process. The toxicity level of the substance or contaminant must be determined. The prevalence of the substance must be evaluated. The ability to reliably detect and quantify the substance must be determined. The feasibility of treating to remove the substance must be evaluated. The cost to the affected parties must be assessed. The benefits to the environment and human health of reaching the standard must be quantified.

The United States Environmental Protection Agency (EPA) is responsible for oversight of the Safe Drinking Water Act and is tasked with setting drinking water quality standards on a national basis. MassDEP has been delegated the authority (otherwise known as primacy), to oversee the Safe Drinking Water Act in Massachusetts. The issue of emerging contaminants is one to which EPA pays close attention. For public health protection, the EPA has a rigorous process for evaluating contaminants of concern in drinking water and deciding whether regulation is warranted. EPA employs experts who derive protective health-based standards (e.g., toxicologists and health risk assessors), economists who produce cost and benefit analysis, and chemists and engineers who can determine lab and treatment capabilities.

EPA regularly mandates water systems of a certain size to test for substances on their Contaminant Candidate List (CCL) through the Unregulated Contaminant Monitoring Rule (UCMR). This process allows EPA to assess the prevalence of a substance throughout the country. There were several PFAS substances included in the last round of the UCMR sampling (UCMR 3). EPA has committed to developing a national strategy to deal with PFAS and it has begun that process. We urge MassDEP to review the comments submitted by American Water Works Association (AWWA)[1] to EPA during the public comment period on the national strategy; MWWA supports the approach suggested by AWWA.

MWWA has always believed that it is in the best interest of the public for EPA to take the lead on setting standards, so there is a consistent protocol and messaging for all water suppliers across the nation. In the past, Massachusetts has imposed regulatory controls on Perchlorate and Manganese before the national process was complete. Jumping out ahead of the EPA puts Massachusetts water suppliers in the untenable position of complying with standards of uncertain value and places a burden on the water suppliers before the public health benefits have been completely evaluated. When states act independently and have differing standards for particular substances, it also causes confusion and concern among the public. MWWA suggests that MassDEP closely follow the EPA process and implement standards only after the scientific and public health merits of doing so have been methodically and carefully considered.

Occurrence of PFAS in Consumer Products

PFAS can be found in a number of products that consumers use daily. Although PFOA and PFOS have been phased out of production in the United States, there are now many thousands of alternative PFAS in use. Numerous products containing PFAS are imported into the country. When considering the levels often found in drinking water and the amount of water actually consumed, drinking water may only be a small fraction of the overall human exposure to PFAS. MassDEP should identify all other points of exposure for PFAS and publicize a list of products along with the typical levels found in those products. Of course, the best way to reduce overall exposure to PFAS is to remove them from products in the marketplace. However, in the interim, public education may be a more effective tool for reducing a person's exposure.

Analytical Capability does not Automatically Translate to Risk

It is important to note that advances in analytical techniques have allowed laboratories to detect substances at lower and lower levels. Substances found at low levels do not always correlate to health impacts. There needs to be robust toxicological studies conducted on the health impacts of PFAS at the levels being detected. MWWA urges MassDEP to conduct a thorough evaluation of existing toxicological studies and perhaps fund future studies to better understand how these levels impact human health.

The Difference between Drinking Water Guidelines and MCLs

In June 2018, the Massachusetts Office of Research and Standards (ORS) issued a Guideline (ORSG) of 70 parts-per-trillion (ppt) for the sum of 5 long-chain PFAS compounds. The five compounds include perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), and perfluoroheptanoic acid (PFHpA). MWWA has previously expressed concern regarding MassDEP's use of an ORSG to regulate water systems. The ORSG process is less robust than the process EPA uses to set an

[1] https://www.awwa.org/Portals/0/AWWA/Government/20180820_AWWA_Comments_PFAS_Plan.pdf?ver=2018-08-22-181340-493

MCL, does not require rulemaking and lacks transparency and public scrutiny. MWWA believes that if MassDEP intends to regulate PFAS in water systems, MassDEP should do so through the formally established MCL process.

What if MassDEP chooses to set an MCL for PFAS?

If MassDEP chooses to develop an MCL for PFAS, the process must be dictated by science. It must also consider the effectiveness of treatment and the cost impacts for all sizes of water systems. In other words, a thorough cost-benefit analysis must be done as is required by the Safe Drinking Water Act. The final MCL should be based not only on health impacts, but also economic impacts of treatment, public health benefits to be derived. It must consider uncertainties in analysis of health risk, evaluation of health benefits from treatment and related costs. We are especially concerned about the impact to small water systems, as they have more limited technical and financial resources at their disposal. MassDEP needs to pay special attention to how any action they take will affect these small systems.

It is imperative that the MCL process be a public process with input from the regulated community. We understand that ORS would be the ones tasked with developing the recommendation for the MCL. These meetings should be publicly posted and open to interested stakeholders. MWWA suggests that a subgroup of utilities and water system consultants be convened to advise ORS throughout the process. Our members have a wealth of knowledge and expertise and could provide valuable input. MWWA would be happy to coordinate such a group to work with MassDEP. It is also important that that this be a deliberative process with no prescribed deadline, although we encourage MassDEP to move the process expeditiously.

Concerns in Sampling and Lab Capability

MassDEP must also provide strong guidance on sampling protocols. Given the widespread use of PFAS in consumer products, it is very important to ensure that there is no cross-contamination of a sample. Given that PFAS are being detected at the part-per-trillion range, it's not inconceivable that, if precautions are not taken, a sample could be contaminated by other conditions in the environment. For example, Teflon tape is known to contain PFAS; because Teflon is used widely in water supply, care must be taken in sampling for PFAS. The State of Michigan has developed very comprehensive sampling guidance[2] that MassDEP could look toward.

In its deliberation, MassDEP must evaluate the capacity of laboratories to handle the additional samples that will be taken. Massachusetts does not currently accredit labs for testing PFAS compounds, so it must develop an accreditation program and also certify the method that labs will be using to analyze for PFAS compounds. MassDEP needs to consult with the Lab Advisory Committee on these issues.

[2] https://www.michigan.gov/pfasresponse/0,9038,7-365-86510_87154-469832--,00.html

Effect on Massachusetts Water Suppliers of Shifting Standards

Several water suppliers in the state are already grappling with PFAS contamination. These suppliers are currently either treating their water, or making significant investments to design and build treatment facilities based on the current EPA Health Advisory and ORSG. MassDEP stated in the fall of 2018 that ORS would be reviewing the ORSG in light of new information. MassDEP should understand that changes in the drinking water standard for PFAS may cause changes in design. For those water suppliers who are in the design process, changes in the standard could entail significant costs. Public Water Systems already committed to construct or operate new treatment facilities based on the current health advisory should be given substantial leeway and ample opportunity to make further changes in treatment to meet a new MCL without risk of violation notice or enforcement action.

Role of the Bureau of Waste Site Cleanup and Industry

As we mentioned at the beginning of our comments, PFAS must be tackled on multiple fronts. We understand that MassDEP's Bureau of Waste Site Cleanup (BWSC) has been discussing developing cleanup standards for PFAS. We urge MassDEP to continue this process as it is important to identify specific areas where PFAS has been found, the general types of industry and human activity associated with PFAS and identify the responsible parties contributing to that contamination. As treatment options are expensive, it is unfair to expect water system ratepayers alone to bear the burden of the costs associated with treatment. A clean up standard must be consistent with any established drinking water standard so that cost recovery can be pursued.

Closing

Thank you for the opportunity to provide these comments. We would ask MassDEP to reject the petitioners request to create a Treatment Technique standard for PFAS. Public water suppliers keenly understand the importance of ensuring that the drinking water that reaches its customers meet Safe Drinking Water Act requirements. The water suppliers work hard each day to meet these goals and satisfy their customers' expectations. The issue of emerging contaminants is a challenging one. Our members will be tasked with meeting any standards set; therefore, we must determine what the risk exposure is and then, when and if the science dictates, move towards standards that will achieve desired public health outcomes. EPA is developing a national strategy for PFAS and it is important for MassDEP to follow that process closely. We look forward to working collaboratively with MassDEP as this process moves forward.

Sincerely,

JA Pederson

Jennifer A. Pederson
Executive Director

PACE

People of Ayer Concerned About the Environment

Presentation to Massachusetts Department of Environmental Protection
One Winter Street, Boston, MA 02108

Re: Petition for Rulemaking to establish a treatment technique Drinking Water Standard for Per- and Polyfluoroalkyl Substances.
January 14, 2019

From: Laurie S. Nehring, President of PACE
35 Highland Ave., Ayer MA 01432

Good Morning.
My name is Laurie Nehring.
I am a resident of Ayer, and here to represent *People of Ayer Concerned About the Environment* (or PACE). PACE is a local environmental watchdog group, focusing on environmental risks affecting the small town of Ayer.

We are here today because we urgently need the Massachusetts Department of Environmental Protection to step forward and establish an <u>enforceable standard</u> for addressing the <u>entire class of PFAS's</u> (Per-fluorinated Alkyl Substances) threatening public drinking water supplies in The Commonwealth.

This is far more than the interim guidance value established by the Mass DEP's Office of Research and Standards, which recommends limiting five of the PFAS chemicals to a total of 70 ppt. This is helpful but it has no teeth, and does not address the constant flow of newly invented forms of PFAS's used in industry. We urgently need a legally binding standard that towns can depend upon <u>and plan around</u> and citizens can used to bring suit, if need be, to force protective measures be taken in their towns.

<u>Background:</u>
For more than 22 years, PACE's primary focus has been overseeing the environmental remediation projects at the former Fort Devens, a Superfund Site, which directly abuts and impacts our town. My bookshelves at home overflow with copies of CERCLA reports addressing groundwater and soil contamination by arsenic, lead, TCE (a dry-cleaning solvent used to clean parachutes), and the cleanup of numerous dumps, accidental spills, and fires

Unfortunately, both the Ayer DPW and Devens have detected PFAS's in the raw drinking water that exceeds the current EPA Health Advisory of 70 ppt.

So now, we must also deal with the impact of these substances in our drinking water.

We know that the source of these PFAS's is the former Fort Devens. They were released into the soil and groundwater as a result of the use of fire-fighting foam at Fort Devens during practices and during the large Warehouse fire. Because it travels easily in groundwater, it reached key wellheads.

At the Grove Pond wells in Ayer, DPW found 490 ppt; at the McPherson well in Devens it was above 4,000 ppt. A level of **39,000 ppt** was found at a monitoring well at the Moore Army Airfield training area.
As a temporary fix, both Ayer and Devens have had to shut down highly productive wells. Last spring, Ayer residents voted to install a $4.2 Million water treatment system to remove the PFAS's as the long-term solution.

[This was a unanimous Town Meeting vote, btw –which demonstrates how important it is to our residents to proactively protect our health!].

Currently, our DPW Superintendent and Board of Selectpersons are in the process of designing a very complex water treatment system, with design criteria based on a 20 ppt treatment system goal for 5-long chain of PFAS compounds.

However, because of unclear and evolving requirements from EPA and MassDEP, this process is very stressful. There is urgency in getting the treatment plant running – but a lack of clarity of what cleanup standards must we meet? The public health and financial impacts of any future rule changes on Ayer, and indeed, on every community in the Commonwealth, are significant.

We have studied the US EPA, Drinking Water Health Advisory for PFAS. It is not sufficient. An Advisory is not enforceable and does not allow the polluter to be held as a responsible party. Case in point, In August 2018, The Secretary of Defense submitted a response letter to the Region I EPA Regional Administrator about Ayer and Devens' PFAS contamination. It states that Ayer's actions were "voluntary" and the EPA Guidance is "non-binding". The Secretary states:

> "While we understand it is the EPA's preference that Army provide funding to support the voluntary actions taken by the Ayer and Devens water systems.. even though the finished water is below the LHA, DOD must follow existing laws and regulations that govern our funding and activities. DOD does not have authority to fund the water systems' action until a need for remedial action is established under CERCLA."
>
> "

MassDEP's Office of Research and Standards for the **Interim Toxicity and Drinking Water Guidance Values for Per-fluorinated Alkyl Substances** has recommended a more conservative value than the US EPA, combining the values of five significant PFAS compounds together, in any combination, the sum of their concentrations should be compared to 70ppt. As we have stated, this Guidance value needs to become enforceable.

In addition, we must consider that today, there are now over 3000 PFAS compounds, with more being invented every year. We agree with the Petitioners, that the family of ALL PFAS compounds must be considered together, as a sum total. Since they are chemically similar, we must assume the have similar toxic effects on humans

We urgently need MassDEP to establish a MCL for the entire family of related PFAS substances found in drinking water as the most efficient and effective long-term solution.

Many other states and other countries HAVE already established legal exposure limits. We cannot wait for the Federal Government to resolve this issue. We respectfully request that this be a key priority for this department.

In closing, we want to express our sincere appreciation for the support of Commissioner Martin Suuberg in working with the Army and the EPA Region I to address the PFAS contamination issue in Ayer. We recognize the complexities involved and appreciate the hard work being done by everyone.

Thank you,

Laurie Nehring
35 Highland Ave.
Ayer, MA 01432
978.772.9749

January 15, 2019

The Honorable Martin Suuberg
Commissioner
Massachusetts Department of Environmental Protection
One Winter Street, 2nd Floor
Boston MA

RE: Conservation Law Foundation and Toxics Action Center to the Department of Environmental Protection regarding Petition for Rulemaking to Establish a Drinking Water Standard for Per-and Polyfluoroalkyl Substances.

Dear Commissioner, Suuberg:

I request that MassDEP establish an enforceable standard such as a MCL that are protective of public health for all Per-and Polyfluoroalkyl Substances as a class and not individually. I also urge MassDEP to initiate a rulemaking for a treatment technique standard for the PFAS class. The standards should be protective of the most vulnerable populations.

I drank the public water for 30 plus years while I worked in Hyannis. I have had increasingly complicated problems with my thyroid over this time period. Ultimately, I had it removed. After a biopsy found cancer cells. The medical literature includes thyroid problems associated with PFAS exposures. Mine may be such a case. In any event the drinking water needs to be as protective as feasible of public health. We owe it to the public which in Hyannis includes a large social justice group.

It's not just about PFOA and PFOS.

There are between 3,000 and 5,000 different PFAS compounds used in numerous products and industrial processes. While PFOA and PFOS are the most commonly known PFAS, EPA and other scientists have raised concerns that other chemicals in the PFAS class of compounds are likely to pose similar health risks due to similarities in chemical structure.

PFAS are everywhere.

PFAS have been found in drinking water, ground water, and surface waters throughout New England. The more sampling that is performed, the more contamination is discovered.

For example: Groundwater in Barnstable, Massachusetts has been particularly susceptible to the spread of PFAS because of the town's location in an outwash plain with permeable soil. Due to multiple sources of PFAS, there is an ongoing threat of contamination to the sole source aquifer that provides drinking water for all Cape Cod residents. Drinking water supplied to the Town of Ayer has been and continues to be contaminated with PFAS, and in Weymouth, Massachusetts, PFAS has been detected in groundwater near the site of the former Naval Air Station. A study of the Joint Base in Bourne, Massachusetts includes surface water reports showing PFAS contamination above the EPA Health Advisory level.

We need a class-based approach

Drinking water standards are often a numeric limit on the amount of a chemical that is allowed in a public water supply (i.e. maximum contaminant levels or MCLs). However, the unique characteristics of the PFAS class pose a public health threat that cannot be adequately addressed with the establishment of an MCL for one or a few PFAS chemicals.

Instead of spending years or decades developing individual MCLs for each PFAS chemical, state agencies should develop a procedure that requires public water systems to install the best available drinking water treatment technologies where PFAS levels are or may be unsafe. That procedure may also to require public water systems to utilize a safe alternative water supply when the threat of PFAS is present.

Adopting a treatment technique drinking water standard for the PFAS class in lieu of establishing MCLs for thousands of PFAS chemicals will not only better protect public health on a much shorter timeline, but will require far fewer Agency resources and could provide significant co-benefits for public health. The same technologies that are effective in PFAS treatment are effective in removing a host of other dangerous chemicals. Thus, a treatment technique will save cities and towns money in the long run.

Thank you for your attention to this important public health matter.

Sincerely,

Stephen Seymour
179 Plum street
West Barnstable, MA 02668

BOSTON OFFICE
Toxics Action Center
294 Washington St, #500
Boston, MA 02108

January 16, 2019

Written Comments re: "Petition for Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per- and Polyfluoroalkyl Substances" *submitted to MassDEP in October 2018 by the Conservation Law Foundation and Toxics Action Center*

My name is Mary Jones and I am a Community Organizer for Toxics Action Center, covering Western Massachusetts and leading our work supporting communities on the front lines of PFAS contamination in the state.

At Toxics Action Center, we believe everyone has a right to clean air and clean water and we work side by side with communities facing pollution threats. From working with communities that have been contaminated by PFAS, I have seen first-hand the toll that overlooking these chemicals has taken in places like Westfield and Barnstable. Our primary motivation in submitting this petition is to safeguard public health for the people of Massachusetts and protect our right to clean water.

To do that, the state must address PFAS as a class of chemicals. As you know, exposure to PFAS through drinking water, even in incredibly small quantities, has been linked to adverse health effects such as reproductive cancers, kidney disorders and autoimmune diseases, just to name a few. As as our knowledge of the PFAS class expands, the scientific community is finding these health effects at lower and lower exposure levels and consistently across the array of thousands of PFAS chemical compounds. In short, the more we know about the PFAS class, the worse we understand this group of 5,000+ chemicals to be as a whole.

We see the treatment technique standard as a promising way treat PFAS as a class, get out in front of this emerging public health crisis, and protect clean drinking water in the Commonwealth.

This treatment technique based on PFAS as a class would require public water systems to install best available treatment technologies or utilize safe water supply alternatives where overall PFAS levels are or may be unsafe. MassDEP should set a treatment technique drinking water standard that will limit PFAS exposure to health protective levels including for infants, children, and the most vulnerable populations-- we suggest 1 ppt. Adopting a treatment technique standard is an opportunity for MassDEP to maximize its impact as it would streamline MassDEP's regulatory response to PFAS as a class and get clean water to affected communities as fast as possible.

The state of Massachusetts needs strong regulations to spur more testing for PFAS across the state because we know that communities like Barnstable, Ayer, Westfield, Devens, Martha's Vineyard and more are just the tip of the iceberg. We know that this dangerous class of chemicals have been released from manufacturing facilities, used fire trainings, and dumped in landfills across Massachusetts for decades. Once released, PFAS are extremely persistent in the environment and accumulate in the human body. The time to act is now.

This is why I am asking MassDEP to move forward on establishing a treatment technique drinking water standard for PFAS as a class. Alternatively, MassDEP should immediately start the process to setting a MCL for the PFAS as a class.

I want to close by saying that this petition, which is about proactively finding and treating PFAS contamination to stop exposure to the class of PFAS, is just one step in rectifying this crisis. We also need MassDEP's vigilance to stop the continued release of PFAS into the environment and for MassDEP to work with other agencies and impacted communities to find relief from harm caused by these chemicals and find justice for lives lost from PFAS contamination.

Respectfully submitted by
Mary Jones

Mary M. Jones
Community Organizer for Western Massachusetts
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Cape Alliance for Pesticide Education
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Non-Toxic Strategies for a Sustainable Cape Cod

January 16, 2019

The Honorable Martin Suuberg
Commissioner
Massachusetts Department of Environmental Protection
One Winter Street, 2nd Floor
Boston, MA 02108

Subject: Comment on Petition for Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per-and Polyfluoroalkyl Substances

Dear Commissioner Suuberg:

Thank you for providing us this opportunity to comment on the "Petition for Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per-and Polyfluoroalkyl Substances".

In the absence of federal MCL's and due to the ever-expanding discovery of a variety of PFASs in the Commonwealth-including my community of Barnstable--it is incumbent upon MA DEP to adopt enforceable drinking water standards for per- and polyfluoroalkyl substances (aka PFASs) as a class.

Regulatory and scientific attention to PFAS has focused on PFOA and PFOS, but the scope of current and future PFAS contamination is much broader. EPA and other scientists have raised concerns that compounds in the PFAS class of chemicals are likely to pose similar health risks due to similarities in chemical structure. However, once in the drinking water, this vast assortment of PFASs are not targeted for elimination; just the 2 most popular flavors-PFOS and PFOA. How is that protective of the public health? To truly ensure the public health, PFASs should be regulated as a class.

Regulating similar compounds as a class of chemicals has some earlier precedent. EPA has applied a similar concept in establishing an MCL for a group of disinfection byproducts (HAA5) though it did not have sufficient information on each individual chemical. EPA promulgated a group MCL even in the absence of complete information about each individual chemical in the class in order to better protect public health. That approach makes sense with PFASs as well. It also makes economic sense in that each of the 3,000 + (and growing) PFAS compounds do not have to be assessed singly when they have close chemical and toxicological similarities. There are already some existing federal regulations that treat all long-chain PFASs similarly. The U.S. Food and Drug Administration (FDA) has restricted all long-chain

PFAS as a class, and EPA's PFOA Stewardship Program includes PFOA and all "precursor chemicals that can break down to PFOA".

This is DEP's meaningful opportunity to reduce exposure of MA citizens to all per- and polyfluorinated chemicals. Seize it! Continued inaction re: enforceable MCL's for PFAS As A Class has significant public health implications for us all. A heavy burden already falls on communities like Hyannis and Westfield that have been exposed to an indeterminate number and variety of PFASs-- For Decades, jeopardizing personal health and livelihood into future generations. A heavier burden yet falls on our firefighters have gotten PFAS overdoses from their heroic firefighting activities, their turn out gear, and, in our village of Hyannis, from the water they drink. The heaviest burden impacts breast-fed infants as PFASs easily accumulate in human breast milk and bioaccumulate to worrying levels. For human infants, protein-rich breast milk appears to be the major source of PFAS exposure. Children who were partially breast-fed also had significant, but lower, increases in PFAS levels over time. In some cases, by the end of breast feeding, children's blood levels of PFASs exceeded that of their mothers'. This has significant implications for the Hyannis community -an EPA-designated Environmental Justice Community- and its children's future health.

Regulating PFASs (thousands of them), chemical by chemical, is not protective of public health, is inefficient and costly, and will translate into decades more exposure for the PFAS-exposed Hyannis community and others similarly exposed. Given the absence of federal protections, Massachusetts should fulfill their obligation to protect the health of its citizens by establishing an MCL for the per-and polyfluorinated chemicals as a class-without delay.

Sue Phelan, Director

GreenCAPE

West Barnstable, MA 02668

508.494.0276

www.GreenCAPE.org

January 17, 2019

The Honorable Martin Suuberg
Commissioner
Massachusetts Department of Environmental Protection
One Winter Street, 2nd Floor
Boston, MA 02108

Dear Commissioner Suuberg,

Thank you to the Massachusetts Department of Environmental Protection for hosting yesterday's meeting to discuss the important topic of PFAS drinking water guidelines. On behalf of the STEEP Superfund Research Program at the University of Rhode Island, we are grateful to be able to submit written comments to the **Petition for Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per-and Polyfluoroalkyl Substances** filed by the Conservation Law Foundation and Toxics Action Center.

We are co-directors and project leaders of the STEEP (Sources, Transport, Exposure & Effects of PFASs) Superfund Center, a collaboration of the University of Rhode Island, Harvard University, and Silent Spring Institute, funded by the National Institute of Environmental Health Sciences (NIEHS) Superfund Research Program. STEEP's team members contribute decades of interdisciplinary experience in developing methods for chemical detection in the environment, determining health impacts of chemical compounds and where in the body these compounds accumulate, training the next generation of scientists, engaging communities to improve well water quality and awareness, and communicating complex science to a variety of audiences.

1. We strongly support the petition filed by the Conservation Law Foundation and Toxics Action Center that MassDEP ought to act on PFASs.

2. We concur that PFASs are widespread in the Massachusetts environment. Across the Commonwealth, the full extent of PFAS contamination in public drinking water supplies is yet unknown due to the limited extent of monitoring efforts. Thus, in the absence of an enforceable standard at the state or federal level, public water supplies are not required to monitor PFASs on a routine basis. From 2013-2015, large public water supplies in Massachusetts, those that serve at least 10,000 customers, were required to test for six PFASs as part of the third cycle of U.S. EPA's Unregulated Contaminant Monitoring Rule. That testing revealed PFASs in five public water supplies, out of the 170 that were tested through this program. However, the reporting limits for the individual PFAS chemicals were relatively high—ranging from 10 to 90 ng/L—well

STEEP is funded by the Superfund Research Program, National Institute of Environmental Health Sciences under award number P42ES027706.

above the lowest levels measurable by some labs, and in some cases higher than drinking water guidelines developed by some states. In other words, additional public water supplies in Massachusetts may have PFAS levels that exceed the current Massachusetts ORSG but did not need to be reported.

3. We agree that there are serious health concerns arising from the exposure of the general public to PFASs.
   This has already been shown by our own epidemiological research on the Faroe Islands, where exposure to PFASs has been linked to suppressed antibody response to vaccines (1).

4. We concur that MassDEP ought to act to protect public health from exposure to PFASs. STEEP research is focusing on risks to human health from early-life exposures that may occur during pregnancy or through breastfeeding, especially in communities where PFAS contamination of the drinking water has resulted in accumulation of the substances in women, who then pass on the PFASs to the next generation. As adverse effects on the next generation, e.g., on the development of the immune system, may have long-term adverse health implications, we believe that a substantial amount of precaution would be appropriate to protect the most vulnerable part of the population. As an example, STEEP researchers used the EPA procedures to provide a basis for decisions on reference doses (RfDs) for the five most commonly detected long-chain PFASs. These calculations suggest that PFAS concentrations in drinking water should not exceed 1 ng/L, a level that can be detected by modern chemistry methods.

5. We strongly support the setting of MCLs for at least the 5 main PFASs as a sum approach. However, we note that there are many more PFASs of concern; some examples are given below:
   Beyond the 5 PFASs MA is currently targeting, there is ample evidence that MRLs ought to be considered for PFDA (C10), PFUnDA (C11), and PFDoDA (C12). In addition to the continual exposures to these compounds, the health effects and toxicokinetic behavior all indicate a similarity in behavior to PFNA. That is, C10-C12 PFCAs exhibit similar behavior:

   - **Toxicokinetic behavior:** Absorption of orally administered C10-C12 PFCAs is estimated to be >95% based on animal data. Elimination of C10-C12 PFCAs decreases with longer carbon chains as indicated by longer half-lives reported in both human and animal studies. Mother-child transfer efficiencies for these compounds are often greater than PFNA as indicated by the low maternal-fetal and maternal-infant ratios reported in the recent ATSDR toxicological profile on PFASs.

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- **Animal toxicity:** Toxicity for C10-C12 PFCAs appears similar to that of PFNA when comparing endpoints.
- **Human toxicity:** As noted in the recent ATSDR toxicological profiles on PFASs, PFDA, PFUnDA, and PFDoDA have been linked with thyroid disorders and adverse birth outcomes. PFDA and PFUnDA have been linked with serum lipid outcomes, neurodevelopmental outcomes and prostate cancer. PFUnDA and PFDoA have been linked to suppressed antibody response to vaccines, decreases in childhood growth in human. PFDA has been linked with male reproductive outcomes, and adverse pregnancy outcomes. PFUnDA has been linked to diabetes.

In addition, emerging research demonstrates that select shorter-chain alternatives may bioaccumulate to the same extent or to a greater degree than legacy compounds such as PFOA or PFOS (2-6). Pharmacokinetic models suggest that shorter-chain alternatives may be equally toxic compared to legacy compounds after adjusting for differences in toxicokinetics (7).

6. We full agree that PFASs ought to be treated as a class of chemicals, rather than be regulated one at a time.
Shorter-chain alternatives replacing legacy PFASs continue being produced and show widespread environmental occurrence. Perfluoroalkyl ether carboxylic acids (i.e. HFPO-DA or "GenX"), polyfluoroalkyl carboxylic acids, and polyfluorinated alkanesulfonates and sulfates persist in air, surface water, and drinking water downstream from release sources (8-12). The scientific community has repeatedly acknowledged similar physicochemical characteristics linking >4,000 PFASs and has suggested PFASs be considered and regulated as a group or as subgroups (13-15).

Thank you, once again, for inviting our comments. We support the petition for MassDEP to act on PFASs.

Dr. Rainer Lohmann
STEEP Director
Professor of Oceanography
University of Rhode Island

Dr. Philippe Grandjean
STEEP Co-Director
Professor of Environmental Health
Harvard University

Dr. Laurel Schaider
STEEP Co-PI, Community Engagement
Research Scientist
Silent Spring Institute

NIH NIEHS STEEP is funded by the Superfund Research Program, National Institute of Environmental Health Sciences under award number P42ES027706.

1. Grandjean P, Andersen EW, Budtz-Jørgensen E, Nielsen F, Mølbak K, Weihe P, et al. Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. Journal of the American Medical Association. 2012;307(4):391-7.
2. De Silva AO, Spencer C, Ho KCD, Al Tarhuni M, Go C, Houde M, et al. Perfluoroalkylphosphinic acids in Northern Pike (Esox lucius), Double-Crested Cormorants (Phalacrocorax auritus), and Bottlenose Dolphins (Tursiops truncatus) in relation to other perfluoroalkyl acids. Environ Sci Technol. 2016;50(20):10903-13.
3. Gomis MI, Wang ZY, Scheringer M, Cousins IT. A modeling assessment of the physicochemical properties and environmental fate of emerging and novel per- and polyfluoroalkyl substances. Sci Total Environ. 2015;505:981-91.
4. Liu YW, Ruan T, Lin YF, Liu AF, Yu M, Liu RZ, et al. Chlorinated polyfluoroalkyl ether sulfonic acids in marine organisms from Bohai Sea, China: Occurrence, temporal variations, and trophic transfer behavior. Environ Sci Technol. 2017;51(8):4407-14.
5. Pan YT, Zhang HX, Cui QQ, Sheng N, Yeung LWY, Guo Y, et al. First report on the occurrence and bioaccumulation of hexafluoropropylene oxide trimer acid: An emerging concern. Environ Sci Technol. 2017;51(17):9553-60.
6. Shi YL, Vestergren R, Zhou Z, Song XW, Xu L, Liang Y, et al. Tissue distribution and whole body burden of the chlorinated polyfluoroalkyl ether sulfonic acid F-53B in crucian carp (Carassius carassius): Evidence for a highly bioaccumulative contaminant of emerging concern. Environ Sci Technol. 2015;49(24):14156-65.
7. Gomis MI, Vestergren R, Borg D, Cousins IT. Comparing the toxic potency in vivo of long-chain perfluoroalkyl acids and fluorinated alternatives. Environ Int. 2018;113:1-9.
8. Gebbink WA, van Asseldonk L, van Leeuwen SPJ. Presence of emerging per- and polyfluoroalkyl substances (PFASs) in river and drinking water near a fluorochemical production plant in the Netherlands. Environ Sci Technol. 2017;51(19):11057-65.
9. Kaboré HA, Duy SV, Munoz G, Meite L, Desrosiers M, Liu JX, et al. Worldwide drinking water occurrence and levels of newly-identified perfluoroalkyl and polyfluoroalkyl substances. Sci Total Environ. 2018;616:1089-100.
10. Newton S, McMahen R, Stoeckel JA, Chislock M, Lindstrom A, Strynar M. Novel polyfluorinated compounds identified using high resolution mass spectrometry downstream of manufacturing facilities near Decatur, Alabama. Environ Sci Technol. 2017;51(3):1544-52.
11. Pan YT, Zhang HX, Cui QQ, Sheng N, Yeung LWY, Sun Y, et al. Worldwide distribution of novel perfluoroether carboxylic and sulfonic acids in surface water. Environ Sci Technol. 2018;52(14):7621-9.
12. Sun M, Arevalo E, Strynar MJ, Lindstrom AB, Richardson M, Kearns B, et al. Legacy and emerging perfluoroalkyl substances are important drinking water contaminants in the Cape Fear River Watershed of North Carolina. Environ Sci Technol Lett. 2016;3(12):415–9.
13. Wang Z, Cousins IT, Scheringer M, Hungerbühler K. Fluorinated alternatives to long-chain perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkane sulfonic acids (PFSAs) and their potential precursors. Environ Int. 2013;60:242-8.

STEEP is funded by the Superfund Research Program, National Institute of Environmental Health Sciences under award number P42ES027706.

14. Wang Z, Cousins IT, Scheringer M, Hungerbuehler K. Hazard assessment of fluorinated alternatives to long-chain perfluoroalkyl acids (PFAAs) and their precursors: Status quo, ongoing challenges and possible solutions. Environment international. 2015;75:172-9.

15. Wang ZY, DeWitt JC, Higgins CP, Cousins IT. A never-ending story of per- and polyfluoroalkyl substances (PFASs)? Environ Sci Technol. 2017;51(5):2508-18.

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STEEP is funded by the Superfund Research Program, National Institute of Environmental Health Sciences under award number P42ES027706.

From: rdelaney@chelmsfordwater.com [mailto:rdelaney@chelmsfordwater.com]
Sent: Thursday, January 17, 2019 2:04 PM
To: Director-DWP, Program (DEP)
Cc: 'Todd Melanson'; 'Jennifer Pederson'
Subject: PFAS Petition Feedback

MassDEP,

The Chelmsford Water District supports the comments submitted by Massachusetts Water Works Association relative to the petition filed by Conservation Law Foundation. The Chelmsford Water District hopes that MassDEP takes a deliberative approach to any future rulemaking with respect to PFAS compounds.

Sincerely,

Robert J. Delaney
Superintendent
Chelmsford Water District
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WOODARD & CURRAN

Via Electronic Mail

January 17, 2019

Mr. Martin Suuberg, Commissioner
Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108

Re: CLF Petition for Rulemaking for Per- and Polyfluoroalkyl Substances (PFAS)

Dear Commissioner Suuberg:

Woodard & Curran is submitting the following written comments to assist the Massachusetts Department of Environmental Protection (MassDEP) in considering a response to the Conservation Law Foundation's (CLF's) petition for rulemaking dated October 25, 2018.

We greatly appreciate the opportunity to provide these comments on this important issue and applaud and support MassDEP's tremendous responsibility and efforts to protect public health and the environment.

In the continued effort to balance the protection of public health and the costs associated with achieving compliance with new regulations, I respectfully ask that the Department consider the following facts as they pertain to PFAS:

- The Environmental Protection Agency has issued a highly protective Lifetime Health Advisory of 70 parts per trillion. Quoting from EPA…*"To provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water, EPA has established the health advisory levels at 70 parts per trillion."* Based on the EPA's process, this threshold is based on peer-reviewed science. EPA made a series of conservative assumptions in their determination, including an assumed ingestion rate more than double the ingestion rate typically used to establish MCLs and health advisories.
- Both EPA and MassDEP have a clear and defined process for the setting of Maximum Contaminant Levels (MCLs) in drinking water. That process involves an evaluation of suspected health risks, cost-benefit analysis, available analytical methods, and treatment technologies.
- Studies to date are inconclusive regarding cause and effect, and most list "associations", or "potential associations". In the case of PFAS, the majority of related studies have been conducted in rodents. Epidemiological and primate studies have often contradicted the rodent study findings and many did not indicate a "dose-response" relationship where one would expect to see more effect at higher doses relative to lower doses.
- Evidence of carcinogenicity is also inconsistent or inconclusive. A 2018 Australian Expert Health Panel Study which performed a "meta-analysis" of numerous available studies indicated "limited or no evidence for any link to human disease". (ATSDR, 2018; Starling et al., 2014)
- According to the Agency for Toxic Substances and Disease Registry (ATSDR) and Centers for Disease Control and Prevention (CDC), across the US human blood levels for PFAS have gone down significantly since phase-out of consumer products containing these compounds began, indicating the likely predominant contribution to body burdens of PFAS from consumer products versus drinking water. (ATSDR, 2018; CDC NHANES, 2017)

- While treatment technologies exist for the removal of these substances from drinking water, there will be significant cost associated with the construction of new treatment facilities as well as the ongoing operation and maintenance of these processes. Regardless of the technology selected, each will produce a waste stream (spent resin/GAC, membrane reject, etc.) that will require further handling, treatment and ultimate disposal or destruction.

We believe that those charged with the development of appropriate standards for PFAS, and other future or emerging contaminants, consider the multiple pathways of exposure and scientifically evaluate incremental benefits in conjunction with feasibility and costs. Regulatory limits should be based on sound science and fact, using peer-reviewed literature and toxicity studies with a preference to epidemiological studies and meta-analysis of those studies.

While treatment technologies such as granular activated carbon, ion-exchange, membranes/reverse osmosis, and various newer, proprietary systems may be capable of reducing PFAS to low, part per-trillion-levels, each of these comes at a significant cost. Public health protection is the foremost responsibility of water supply professionals and the regulatory community. However, limits should not be established based only on the fact that extremely low levels of these compounds can be detected by laboratory analysis, or on our ability to remove them with advanced treatment systems. The lower the limit, the higher the cost. Financial resources are also necessary to protect public health, and every dollar spent on achieving increasingly stringent PFAS limits is one that can't be used to rehabilitate antiquated infrastructure, update aging treatment systems, and replace distribution piping systems that are, in many cases, over 100 years old.

I respectfully ask that the State's process for the determination of an appropriate maximum contaminant level be based in scientific fact, sound estimates of adverse health effects, and consider cost to the communities and their rate payers. I presented many of the above points during oral testimony at MassDEP's petition hearing on January 16, 2019. I am very thankful for that opportunity and certainly hope to have similar future engagement. We look forward to working collaboratively with MassDEP through the rulemaking process and would be happy to discuss our comments if you have any questions.

Sincerely,

WOODARD & CURRAN

Robert S. Little, PE
Drinking Water Practice Leader

RSL/rsl

CITY OF WESTFIELD, MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS
28 Sackett Street, Westfield, MA 01085-3572
(413) 572-6243

David Billips
Director

January 17, 2019

Martin Suuberg, Commissioner
Massachusetts Department of Environmental Protection
1 Winter Street, 2nd Floor
Boston, MA 02108

Dear Commissioner Suuberg;

The City of Westfield would like to submit the following written testimony regarding the petition hearing held at MassDEP Boston on Wednesday January 16, 2019. Conservation Law Foundation's petition calls for the establishment of a standard Treatment Technique for systems effected by PFAS contamination. Westfield is a stakeholder with four of the cities eight public drinking water wells impacted.

It is the opinion of the City that "one size fits all" approaches are not beneficial in this situation. Among the processes advocated for was reverse osmosis. Two major concerns exist with this technology. First and foremost is the volume of waste generated. For every 100 gallons treated approximately 30 gallons is a concentrated waste stream. This waste stream would be difficult if not impossible to negotiate for Westfield, and likely other water systems as well. There is no city sewer in the location of two of the impacted wells, and even if there was the city wastewater treatment plant is not set up to remove PFAS from wastewater. This likely means pass-through of the plant and highly negative impact on the receiving stream, the Westfield River. This would also mean millions of gallons of water would be wasted each week. Secondly, reverse osmosis is highly energy intensive. The inefficiency of production, wasting 30% of all water produced, coupled with the high cost of energy, makes it wasteful of both funding and resources while the operating budget is already stressed to the limit.

There was mention at the petition hearing of an alternative source from an adjacent city. This is not a feasible solution given the condition of the greater than 100 year old water line that Westfield would have to utilize. It is also cost prohibitive and would only yield 2 million gallons of water a day. Each of the four impacted wells is capable of this volume individually. Other communities around the Commonwealth are likely facing similar constraints with their sources as well.

The City is presently in the process of building two granulated activated carbon (GAC) treatment facilities for the four wells impacted. The Owen District Road plant (wells 7 & 8) should be fully functional by June of this year and will have the capacity to treat four million gallons of water a day. The Dry Bridge Road plant is at 30% design and plans are to send out bid documents later this calendar year. The City, in conjunction with CDM Smith, did extensive bench scale testing before design to prove out the technology and identify any constituents that might interfere with the process. This showed that the water in Westfield is an excellent candidate for the type of treatment chosen, GAC, based on the individual characteristics identified. There is also a temporary GAC plant in operation at drinking water well 2. This plant has been operational for months and shows no breakthrough of PFAS, further proving the technology works.

In closing the City of Westfield would like to thank the DEP Western Region for support and guidance in this challenging time. The City has been proactive throughout this process and will continue to follow DEP guidelines to address this challenging matter.

Very truly yours,

David Billips
Director of Public Works

Chelmsford Water District

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January 16, 2019

To: Yvette DePeiza, Program Director
MassDEP/BWR Drinking Water Program

Ms. DePeiza,

I am writing to you in response the Conservation Law Foundation's petition in regards to the Rulemaking to Establish a Treatment Technique Drinking Water Standard for Per- and Polyfluoroalkyl Substances. While we all agree in keeping our populations safe through protecting the drinking water that they rely on, as a drinking water professional and a certified water operator of the State of Massachusetts, I have some real concerns over this petition in what it means for the drinking water utilities within the Commonwealth. First and foremost, given the level of these Per- and Polyfluoroalkyl substances existing currently in our everyday life I find that just treating drinking water and not addressing the sources of the contaminations we will not achieve the true protection we are all looking for. This also is seems to be in direct conflict with MA DEP actions in regards to other contamination issues historically. Additionally, I would like to see what levels of contamination is from actual exposure to all products such as textiles including clothes, carpets and furniture and the many other everyday products containing these compounds versus the consumption of drinking water before it is required to treat this family chemical compounds.

Having some background in analytical chemistry I would like to see a report on whether sampling error has been ruled out in any positive and to have specific sampling procedures listed to prevent sample contamination in any proposed regulatory rule before we go forward in this direction. Given my understanding of the analytical industry, I have strong reservations about the lack of a clear, identifiable and prescribed method for the detection of these compounds and the lack of analytical capabilities to detect most of the members of this class of chemicals. If testing of all the Commonwealth's drinking water utilities is under taken, there are strong reservations as to the availability of sufficient lab capacity to actually meet this level of testing. I find it difficult to recommend the costs of this treatment when we cannot truthfully identify the exact extent of the level of contamination that exists.

With the amount of money that the treatment of these compounds requires to build and operate, I strongly recommend that Massachusetts DEP, look to and wait for the fully toxicology studies to be completed, so that we can as an industry can truly judge the danger and not base decisions on theoretical calculations on the risks that they pose. The dollar values being required to be committed by local municipalities without this full evaluation are not something we can ignore.

Our industry and communities are currently struggling to meet current regulatory and infrastructure needs financially and this could add an unattainable burden on the industry and our communities. I would like to see a robust Cost Benefit Analysis done prior to committing this family of compounds to a required treatment in drinking water. Keeping in mind that it goes far beyond the safety of the drinking itself. We must consider that the sustainability of any community

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Ronald W. Wetmore
John G. Harrington

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financially is its ability to supply municipal services at a financially viable and sustainable level. I strongly feel that this petition if enacted as is has a strong possibility of adversely affecting the economy of the entire Commonwealth without any assurance it will reduce any health risks to our communities. This should all be part of your deliberations. Thank you for allowing me the ability to comment of this topic

Sincerely

Todd A Melanson
Environmental Compliance Manager, Chelmsford Water District
MWWA member and Mass Certified Water Operator

CC: Jennifer Pederson, Director Mass Water Works Association

MassDEP received the following comment via email from multiple individuals. A list of persons who sent this comment appears on the following page.

-----Original Message-----

To: Suuberg, Martin (DEP)
Subject: PFAS Petition Comments: Set a Strong Standard

Martin Suuberg
MassDEP

RE: PFAS Petition Comments: Set a Strong Standard

Per- and polyfluoroalkyl substances (PFASs), the toxic class of chemicals found in drinking water across the country and here in Massachusetts, requires urgent attention and strong action by MassDEP to protect the health of Massachusetts residents. I am writing to urge MassDEP to treat these chemicals as a class and set a treatment technique drinking water standard that will limit PFAS to 1 ppt in Massachusetts drinking water.

PFASs have been found in water in Ayer, Barnstable, Hyannis, Yarmouth, Westfield, Devens, Danvers, Hudson, Sherborn, Bedford, Weymouth and Martha's Vineyard and likely many more towns and cities across the state. These chemicals are highly toxic, even in small concentrations, and just a drop in a swimming pool has been linked to many serious health problems including kidney disorders, cancers, reproductive disorders, immune system problems, and more.

This toxic crisis needs to be addressed urgently. First, PFAS must be regulated as a class. There are between 3,000 and 5,000 different kinds of PFAS chemicals, and regulating each one individually would take years or decades. Scientists believe that all these chemicals pose similar health risks due to their chemical structure, so MassDEP must take action now to prevent further harm to Massachusetts residents.

Second, MassDEP should set a treatment technique drinking water standard that will limit PFAS to 1 ppt to remove unsafe levels of the toxic chemicals from Massachusetts drinking water thoroughly and safely. MassDEP should also require public water systems to use a safe alternative water supply when PFAS is detected.

We need strong regulations to require more testing and remediation. Massachusetts residents deserve to know that the water we drink is safe from toxic chemicals. As more and more towns test for PFAS, more of the toxics are being discovered. MassDEP has the chance to set a standard that will protect people across the state and take care of this crisis at once.

I urge you to make the right decisions now and protect our water, health and future.

Sincerely,

The following persons submitted the foregoing comment to MassDEP.

Allie Astor
Michael Basmajian
Sylvia Broude
Max Ciarlone
Henrietta Cosentino
Nicholas Friese, Fund for the Public Interest
Tesla Gibby
George Herr
Jordan Hurley
Shaina Kasper, Toxics Action Center
Natalie Kassabian
Josh Kratka, National Environmental Law Center
Heather Kunst
Kelsey Lamp
Isabella Maestri, Fund for the Public Interest
Johanna Neumann
Jennifer Newman, The Public Interest Network
Bethany Nguyen, Fund for the Public Interest
Michael O'Reagan
Nathan Proctor
Emily Reid, Fund for the Public Interest
Maureen Rickenbacker
Ruthy Rickenbacker
Megan Stokes
Nancy Strong
Shawna Upton
Emily Van Auken
Winston Vaughan