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Lessons Learned from States and Challenges Ahead in Setting State-Level Per- and Polyfluoroalkyl Substances (PFAS) Standards

WHITE PAPER

Association of State Drinking Water Administrators

Supported by the ASDWA State PFAS MCLs Group

asdwa
Association of State Drinking Water Administrators

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Glossary

ACRONYM	FULL PHRASE
ACT	Accelerated Column Testing
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	Best Available Technologies
CMDP	Compliance Monitoring Data Portal
CSF	Cancer Slope Factor
DEP SAB	New Jersey Department of Environmental Protection Science Advisory Board
DWQI	New Jersey's Drinking Water Quality Institute
DWQC	New York's Drinking Water Quality Council
EBCTs	Empty Bed Contact Times
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EJ	Environmental Justice
EPI Center	American Association for the Advancement of Science (AAAS) Center for Scientific Evidence in Public Issues
EPTDS	Entry Point To The Distribution System
FRB	Field Reagent Blank
FTE	Full-Time Employee
GAC	Granular Activated Carbon
HBV	Health-Based Values
HBGV	Health-Based Guidance Values (used by Minnesota)
ITRC	Interstate Technology and Regulatory Council
IX	Ion Exchange
LHA	Lifetime Health Advisory
LOAEL	Lowest Observed Adverse Effects Level
LRAA	Locational Running Annual Average
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MPART	Michigan PFAS Action Response Team
MRL	Minimal Risk Level (used by ATSDR for non-cancer health effects)
NF	Nanofiltration
NPDWR	National Primary Drinking Water Regulation
NTNCs	Non-Transient, Non-Community water systems
PFAS	Per- and polyfluoroalkyl substances, also known as "forever chemicals"
PFOA and PFOS	Perfluorooctanoic Acid and Perfluorooctane Sulfonate
SDWA	Safe Drinking Water Act
RfDs	Reference Doses
RL	Minimum Reporting Level or Reporting Limit (used by EPA and states for analytical methods)
NOAEL	No Observed Adverse Effects Level
PWS	Public Water System
POU/POE	Point of Use or Point of Entry (water treatment device)
RO	Reverse Osmosis
RSC	Relative Source Contribution
RSSCT	Rapid Small-Scale Column Testing
TNCs	Transient Non-Community (TNC) water systems
TOF	Total Organic Fluorine
Toxicokinetic (TK) Model	An Excel-based maternal/infant model developed by the Minnesota Department of Health
UCMR3	Third Unregulated Contaminant Monitoring Rule

Introduction

State and territorial drinking water programs have been challenged over the past several years on how to appropriately address per- and polyfluoroalkyl substances (PFAS)[1] in their states. In response to increasing discoveries of PFAS contamination in drinking water sources, and without a federal enforceable standard for PFAS in drinking water, states that have never developed drinking water standards in the past are now setting state-level maximum contaminant levels (MCLs) for the first time.

Though states would prefer that EPA establish a National Primary Drinking Water Regulation (NPDWR) for PFAS, not all states can wait for EPA. While EPA made the determination to regulate PFOA and PFOS in March 2021[2], the standard Safe Drinking Water Act (SDWA) timeline would allow the Agency until February 2027 to promulgate a NPDWR, unless Congress passes one of the proposed bills to require a two-year (instead of six-year[3]) timeline. However, these actions also do not include other PFAS (beyond PFOA and PFOS) that some states determined are important and have already included, or are planning to include, in their drinking water regulations.

The state standard-setting process is complex and resource intensive. To assist states that are developing MCLs, ASDWA created tools and resources including the "State CEC Rule Development and Management Strategies Toolkit" released in February 2020. While the toolkit broadly addressed the management of contaminants of emerging concern, states needed guidance on PFAS management and regulatory development. ASDWA therefore established a State PFAS MCLs Workgroup in late 2020 to enable states that had already set their own state-level standards to share their experiences and lessons learned with the states that were setting their own state-level standards or exploring the regulatory options under the SDWA. Fifteen states joined this Workgroup and met monthly via Teams meetings from December 2020 through June 2021, to discuss the topics identified in the White Paper:

1. Assessing Health Effects
2. Monitoring and Occurrence
3. Analytical Methods and Lab Capacity
4. Treatment and Compliance Options
5. Benefits, Costs, and Economic Considerations
6. Standard Development - Overarching Rulemaking Process
7. Risk Communications

The primary audience for this White Paper is states that are developing or considering developing PFAS drinking water standards or guidelines. The primary purpose is to assist state drinking water administrators in how they address PFAS by: providing decision-making considerations for the regulatory setting process for each topic; identifying and sharing state challenges during the regulatory development process; showing how states have addressed or overcome challenges; and providing helpful tips and resources from states that have already gone through the process to those that have not. This paper may be useful for other audiences, but a strong understanding of the regulatory development process, state drinking water programs, and PFAS may be necessary.

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[1] Environmental Protection Agency. (2021, April 6). Basic Information on PFAS. EPA. https://www.epa.gov/pfas/basic-information-pfas#health.

[2] https://www.epa.gov/ccl/regulatory-determination-4

[3] https://www.asdwa.org/sdwa-regulatory-development-process/

Overview of Current State PFAS Efforts

States are undertaking different approaches to address PFAS in drinking water. The conditions and drivers that have compelled states to develop state specific PFAS drinking water standards or guidelines vary from state to state. In several states, the Governor or State Legislature has directed the state drinking water program to develop standards. In at least four states a public petition coinciding with further state action has directed the development of standards for PFAS. For other states, the occurrence of PFAS, proactive public health protection, and/or cost-benefit analysis have led states to act. The following chart shows the current PFAS standards and guidelines for select states and EPA's lifetime health advisory level (LHA) as of July 28, 2021.

Table 1: Select PFAS Standards and Guidance Values in the U.S. (in ppt)

Specific PFAS	NH MCLs	NJ MCLs	VTMCL	MI MCLs	MA MCL	NY MCLs	MN Guid.	CA Response Level	CA Notif. Level	IL HA Guid.	CTAdvisory	USEPA LHA
PFOA	12	13	20* combined	8	20* combined	10	35	10	5.1	2	70* combined	70* combined
PFOS	15	14	*	16	*	10	15	40	6.5	14	*	*
PFHxS	18		*	51	*		47			140	*	
PFNA	11	13	*	6	*					21	*	
PFHpA			*		*						*	
PFDA					*							
GenX				370								
PFBS				420			2000	5000	500	2100		
PFBA							7000					
PFHxA				400,000						560,000		

All units are in part-per-trillion (ppt) / Chart date as of July 28, 2021

In addition to the states that have already developed PFAS drinking water MCLs and guidelines, at least six states (Maine, Pennsylvania, Rhode Island, Virginia, Washington, and Wisconsin) are in the process of developing PFAS standards or guidelines. Some states are also taking other non-regulatory approaches and actions to assess and address PFAS in drinking water and more broadly for other media. These approaches and actions include: developing multi-agency PFAS Action Plans and Response Teams; undertaking PFAS sampling programs for drinking water systems and surface water and groundwater sources of drinking water; conducting inventories of facilities that use, have used, or produced PFAS; responding to drinking water contamination throughout the state and across media (e.g., residuals, effluent discharges, landfill leachate, Superfund sites); banning use in products; and working with EPA and the Department of Defense to address site specific PFAS contamination. The ASDWA website and PFAS – Source Water Protection Guide and Toolkit[4] provide more information and examples of state actions to address PFAS contamination, along with a mapping guide of how to identify potential PFAS sources of contamination as part of the source water assessment process.

At least 15 states have a prohibitive law or policy that prevents them from setting state-level drinking water MCLs.[5] In addition, many states lack the capacity or resources to effectively and individually regulate PFAS. Barriers include lack of technical expertise needed for toxicity assessment and standard development; lack of labs certified to test for PFAS in the state, and lack of legislative support and funding. States have also noted the need for more peer-

[4] ASDWA PFAS – Source Water Protection Guide and Toolkit – https://www.asdwa.org/pfas/

[5] Based on a survey of ASDWA members in July 2019.

reviewed science to make informed decisions on whether to establish guidance levels for specific PFAS[6]. Many states, including some of those mentioned above, are waiting for EPA to develop PFAS drinking water regulations and are not moving forward with developing MCLs. However, they are taking other strong steps to protect public health and reduce human exposure to PFAS. The states that are developing or have developed PFAS MCLs at lower levels are concerned that EPA will set higher PFAS MCLs, producing confusion and creating risk communication and implementation challenges for states.

[6] ECOS Standards White Paper - https://www.ecos.org/wp-content/uploads/2021/04/Updated-Standards-White-Paper-April-2021.pdf

1. Assessing Health Effects

State MCLs for PFAS are based on calculated risk assessments for each PFAS analyte by multiplying toxicity and exposure factors to determine health-based values (HBVs). States that are considering or are developing PFAS drinking water regulations or guidelines should consider the following factors and approaches for making these determinations. Assessing health effects is traditionally the first step in the MCL development process.

The Role of Toxicologists, Health Risk Assessors, and State Advisory Committees: If not already in place, states should evaluate hiring staff or consulting with toxicologists and health risk assessors and consider the value in creating a state drinking water advisory group or committee or engaging experts and stakeholders. While it may require legislative authority to create an advisory group or committee, this type of group provides an opportunity for experts (including toxicologists) and important stakeholders to address questions and provide input where the state may lack personnel and capacity for conducting a thorough health risk assessment process. The role of the toxicologists and advisory committees is to review current human and animal health studies and provide recommendations for MCLGs or MCLs based on calculations for adverse health risks (i.e., toxicity) and relative source contribution for different exposure periods. They can also provide helpful recommendations from their experience when there is a lack of available toxicological data and health effects studies for specific PFAS.

Health Risk Assessments: States have developed different health risk assessments based on the professional judgement of the toxicologists, risk assessors, and advisory groups that are involved in the state process. States with PFAS MCLs have used and considered EPA's toxicity assessments, Reference Doses (RfDs) for non-cancer effects, and Cancer Slope Factors (CSFs) for carcinogenic effects, as well as Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) and toxicological profiles (that have been developed for certain PFAS)[7] as part of their health risk assessment process. The difference between EPA risk assessments[8] and ATSDR's MRLs is that EPA calculates drinking water concentrations for PFAS based on both non-cancer and cancer health risks from exposure during a lifetime, whereas ATSDR calculates MRLs (to be used as a screening level) based on a daily dose unit for exposure to a single substance for only noncarcinogenic effects. EPA and states have also applied additional factors and variations to their health risk assessment calculations for body weight and ingestion rates, that have led to the development of the state MCL concentrations for multiple PFAS, that are different from each other and from EPA's LHA for PFOA and PFOS.

These different state health risk determinations have been made using varying points of departure to correlate a no-observed-adverse-effects level (NOAEL) or lowest-observed-adverse-effects level (LOAEL) from oral exposure based on toxicological (RfDs) and CSFs. They are also based on the use of different scientific human and animal studies and toxicity endpoints to calculate uncertainty factors for RfDs or CSFs that result in differences in the numerical values. Some EPA NPDWRs for other regulated contaminants are calculated using a 10^{-4} (one in ten thousand) CSF, while some state PFAS MCLs are calculated using a 10^{-6} (one in one million) CSF. Because new studies are being published so frequently and the science is rapidly evolving, states are continuing to reconsider these numbers, even after they have set their MCLs.

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[7] ATSDR Toxicological Profile for Perfluoroalkyls, May 2021 - https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf

[8] EPA health effect support document - https://www.epa.gov/ground-water-and-drinking-water/supporting-documents-drinking-water-health-advisories-pfoa-and-pfos

State Experience	New Jersey determined its MCLs for three PFAS (PFOA, PFOS, and PFNA) based on both noncarcinogenic and carcinogenic health effects. The state's Drinking Water Quality Institute[9] reviewed more than 2,000 human and animal health studies as part of this process to achieve the state goal of eliminating all non-carcinogenic adverse health effects resulting from ingestion, within the limits of practicability and feasibility. With respect to carcinogens, the recommended MCLs were determined to meet the state goal that MCLs be set at a level that, within limits of medical, scientific, and technological feasibility, permits cancer in no more than one in one million persons ingesting that chemical over a lifetime.
	California and Illinois also use a CSF of 10^{-6} when determining contaminant limits based on adverse health effects.

Using Health Risk Assessments to set MCLs: State MCLs are based in part on calculated risk assessment factors for potential human health effects. These factors are calculated using toxicity information for each PFAS (either individually or combined) and multiplying the human exposure factor for drinking water, which is calculated by EPA and most states using a default of 20 percent relative source contribution (RSC) when there is inadequate data to justify a different percentage. These calculations may also include considerations for risks to sensitive subpopulations such as fetuses and breastfed infants which EPA is also now considering in the development of its NPDWR for PFAS. States will want to consider these sensitive subpopulations and cumulative toxicity for multiple PFAS when developing HBVs. The following examples provide some information about how states have considered these additional risks.

State Experience	Massachusetts and Vermont developed their MCLs at 20 ppt for sums of multiple PFAS compounds (Vermont includes five, Massachusetts includes six) to address the potential cumulative health risks and building from EPA's health advisory level for PFOA and PFOS which is calculated using a lifetime exposure level for the sum of both compounds. Massachusetts also used a "read-across" process to capture additional PFAS within its additive MCL based on structure and toxicological similarities.
	Minnesota used its Toxicokinetic (TK) Model[10] to incorporate placental and breastmilk transfer to offspring into the derivation of health-based guidance values (HBGVs) for bioaccumulative PFAS. Incorporating the transfer of accumulated PFAS body burden from mother to fetus during gestation and to infants during breastfeeding resulted in lower HBGVs. The model also incorporates elevated intake rates early in life following the period of breastfeeding. Since 2009, Minnesota has incorporated high early life water intake rates, coupled with short-term RfDs to derive short-term HBGVs. In some cases, the short-term infant-based HBGVs are lower than chronic-based drinking water criteria[11], indicating that chronic-based values may not be protective of short-term exposures in highly exposed populations such as formula-fed infants. To address mixtures of chemicals, Minnesota calculates a health risk (hazard) index[12] using an additivity approach for grouping chemicals that affect the same health endpoints (e.g., liver, thyroid, immune system, development). Since PFAS occur in mixtures the health risk (hazard) index approach often results in lowering the acceptable concentrations to a level lower than the individual HBGVs.

[9] New Jersey Drinking Water Quality Institute MCL Recommendations - https://www.state.nj.us/dep/watersupply/g_boards_dwqi.html

[10] Minnesota TK Model - https://www.nature.com/articles/s41370-018-0110-5

[11] Focus on Chronic Exposure for Deriving Drinking Water Guidance Underestimates Potential Risk to Infants - https://www.mdpi.com/1660-4601/15/3/512

[12] Health Risk Limits in Minnesota Rules Part 4717.7880 -https://www.revisor.mn.gov/rules/4717.7880/

Relative Source Contribution (RSC): The RSC is the proportion of the total daily exposure to a contaminant that is attributed to or allocated to tap water (accounting for multi-route exposures) in calculating acceptable levels of a contaminant in water. While a few states have considered different RSCs to address site specific circumstances that may warrant a higher RSC percentage for drinking water, there may be a lack of data at the local level to justify making a change to the default percentage. When developing HBVs for drinking water, states should be prepared to explain why they are using the 20 percent RSC, to address questions by the public and other stakeholders that would potentially want the state to lower the percentage to be "more protective."

Regulating PFAS as Chronic, Sub-chronic, or Acute Contaminants: States with PFAS drinking water regulations are using a few different approaches for monitoring requirements as well as public water system (PWS) regulatory response actions when PFAS is detected above the state MCL. These differences are based on the state's determination to regulate PFAS as chronic, sub-chronic, or acute contaminants. States that are developing PFAS drinking water regulations will want to consider their state risk assessment calculations and other regulatory factors when making determinations about both PWS monitoring and response actions for PFAS MCL violations. Chronic concerns are about avoiding long-term exposure, Acute is short-term or immediate exposure, Sub-chronic is in between.

State Experience	Three of the six states (Michigan, New Hampshire, and New York) that regulate PFAS in drinking water are addressing them as chronic contaminants that require a Tier 2 public notification by PWSs within 30 days. This is based on an exceedance of the PFAS MCL and the determination that this level does not pose an immediate risk to human health.
	Massachusetts and Michigan also require PWSs to issue Tier 3 public notices for PFAS monitoring and reporting violations within one year because it does not have a direct impact on human health.
	Massachusetts uses a sub-chronic (hybrid) approach for MCL violations that requires a Tier 2 response by water utilities, but also includes a "do not drink" advisory for sensitive subpopulations such as infants, pregnant and nursing women and immunocompromised individuals.
	Vermont requires Tier 1 "do not drink" notification within 24 hours of an MCL violation for PFAS as an acute contaminant. This determination is based on exposure to an infant because a bottle-fed infant drinks more water per body weight than an adult woman, the dose to the infant is higher than the dose to the adult woman.

Resource Documents	ASDWA State CEC Rule Development and Management Strategies Toolkit Module 2: Characterize Health Effects
	ECOS Standards White Paper Section II: Risk Assessment, and Appendix A: State Drinking Water PFAS Guideline Criteria
	ITRC PFAS Health Effects Guidance
	EPA Human Health Risk Assessments
	CDC ATSDR PFAS Health Effects
	Nordic Council of Ministers - The cost of inaction: A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS
	Perfluorooctanoic acid and low birth weight: Estimates of US attributable burden and economic costs from 2003 through 2014 High Levels of PFAS in Breast Milk: May 2021

State Advisory Committee Links

- Massachusetts – Safe Drinking Water Act Advisory Committee, Laboratory Advisory Committee and Health Effects Advisory Committee
- Michigan – PFAS Action Response Team: Science Advisory Workgroup
- New York - Drinking Water Quality Council
- New Jersey - Drinking Water Quality Institute

State Resource Document Links

- Minnesota - Chronic Exposure for Drinking Water Guidance Underestimates Potential Risk to Infants
- Minnesota - Toxicokinetic Model for PFAS Water Guidance
- Massachusetts - PFAS: An Updated Subgroup Approach to Groundwater and Drinking Water Values
- Massachusetts - regulating PFAS as a sub-chronic contaminant (See 22.07G)
- New Hampshire - MCL Derivation Document
- Wisconsin - Setting Groundwater Standards to Protect Public Health
- New York - Recorded presentation on derivation begins at about 15 minutes
- Rhode Island - PFAS Regulatory Technical Support Document - DRAFT
    - The cost benefit analysis is included.
- Michigan - Health-Based Drinking Water Value Recommendations for PFAS

2. Monitoring and Occurrence

As part of the regulatory development process, PFAS sampling will help states determine if these compounds are being detected in both drinking water sources and finished drinking water, and if there is a high chance for occurrence at PWSs where PFAS are determined to be a public health concern, as determined by the HBVs. Occurrence information informs the assessment of the population being exposed and the levels of exposure. States with and without MCLs are implementing different types of PFAS sampling programs. States with PFAS MCLs have also established different monitoring requirements for different types of PWSs, and then require increased sampling or allow reduced sampling frequencies depending on whether specific PFAS are detected and at what level.

State Drinking Water PFAS Sampling Program Design for States without MCLs: The level of funding allocated for state PFAS drinking water sampling will likely determine the extent of sampling that a state can do. The ASDWA PFAS – Source Water Protection Toolkit provides a framework for states to consider targeted finished water sampling at PWSs and specific drinking water sources that are potentially vulnerable and in proximity of known PFAS contamination sites. This information can be used in conjunction with UCMR3 data for the six PFAS that were monitored to assist with the design of a more limited and targeted sampling program to inform the development of state PFAS MCLs. Though, the use of UCMR3 data has limited applicability due to the high Minimum Reporting Levels or Reporting Limits (RLs) for each PFAS (e.g., PFOS at 40 ppt and PFOA at 20 ppt) compared to some of the current state RLs at 2 ppt.

State PFAS Sampling to Determine Sources and Likely Occurrence: In addition to sampling at PWS entry points to the distribution system (EPTDS) for state MCL compliance determinations, states both with and without PFAS MCLs are also sampling the PWS raw water sources, private wells, and/or other media to help determine where PWSs may be impacted, find sources of PFAS contamination, and target remediation actions.

State Experience	California's 2019-2020 statewide PFAS investigation is being coordinated with multiple state agencies to include sampling of PWS wells, landfills, airports, chrome platers, and at publicly owned treatment works (POTWs). The state's 2021 PFAS investigation will expand to include refineries and bulk fuel terminals, private wells, watersheds, and DoD sampling along with sampling of PWS wells around impacted installations.
	Massachusetts, in partnership with the USGS, just completed a statewide sampling effort in rivers that found widespread PFAS contamination13 and has an ongoing private well sampling effort.[14]

Initial Monitoring: The states with MCLs have developed their requirements using a volatile organic compound or synthetic organic compound (VOC or SOC) framework that typically starts with four quarters of initial sampling at each EPTDS for their community and non-transient non-community water systems (NTNCs).

State PFAS MCL Monitoring Requirements: States that are developing PFAS MCLs will want to consider how states with current MCLs have designed their sampling requirements. Following are examples of the different protocols these states are using for their monitoring requirements.

[13] Massachusetts statewide river sampling - https://www.mass.gov/doc/pfas-in-massachusetts-rivers-presentation/download

[14] Massachusetts private well sampling - https://www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas-in-private-well-drinking-water-supplies-faq

State Experience	System Types • Vermont requires community and NTNC systems to sample for PFAS. Transient non-community (TNC) systems may be directed to sample if they are located in an area with a documented PFAS issue. • Massachusetts also requires TNCs to take one sample to help characterize statewide occurrence and could be required to conduct corrective actions under existing authority if, based on a system-specific health assessment, they find levels of concern, typically above the state's MCL. • New York requires TNCs to sample if they are determined to be vulnerable to PFAS contamination by the state.
	Repeat/Reduced Sampling • Massachusetts requires confirmation sampling for the first detection of any PFAS, and subsequent detections above 10 ppt until the PWS is placed on monthly monitoring. PWSs are required to sample monthly when determining compliance with the MCL. PWSs that install PFAS treatment will monitor quarterly. PWSs that routinely detect PFAS below the MCL will monitor annually. Routine monitoring is the same as for SOCs. Monitoring waivers are offered both during the initial quarterly monitoring (waiving the third and fourth quarter) and routine monitoring (anticipated to waive monitoring in two Compliance Periods within each Compliance Cycle). The online monitoring flowchart provides a visual display of this process.[15] • New Hampshire requires confirmation sampling if detection is at or above 50 percent of the MCL and there is no history of detections. If the sample result is below the detection level for the first two quarters, then the PWS can request a waiver for the last two quarters and reduce frequency to triennial monitoring if the average is below 50 percent of the MCL. • New York allows PWSs with detection below the MCL to reduce frequency to annual sampling after two quarterly samples from a groundwater source and four quarterly samples from a surface water source. • Vermont allows PWSs with non-detects to reduce sampling frequency to every three years and for three rounds of sampling at a three-year frequency, non-detects can reduce frequency to six years. PWSs with detection below 15 ppt (the MCL is 20 ppt (summed) for five PFAS) can reduce frequency to annual sampling.

State Compliance Determinations: Compliance determinations are based on monitoring results and vary from state to state (e.g., annual average vs. one sample with repeat then average). Section 4 of this document also includes more information about treatment and compliance options.

Occurrence - General Observations and Trends to Consider from ASDWA's Survey: ASDWA conducted a member survey on PFAS drinking water sampling and occurrence in April 2021[16] and a short summary of the survey results is provided in the following state experience table. States that are considering or planning to develop MCLs may want to consider some of the survey findings to target and analyze samples for specific compounds. However, it is important to understand that these data cannot be extrapolated to represent nationally statistical data for other states or for the whole country. Analyzing occurrence data across states is not straightforward: states use different method detection limits and minimum reporting levels/limits, and also sample both raw and finished drinking water.

[15] Massachusetts DEP Community and NTNC PWS PFAS Monitoring Flowchart - https://www.mass.gov/doc/pfas-monitoring-flowchart-for-public-water-suppliers-com-and-ntnc/download

[16] ASDWA PFAS Sampling and Detection Survey Summary - http://www.asdwa.org/wp-content/uploads/2021/04/ASDWA-PFAS-Sampling-and-Detection-Survey-Summary.pdf

<table>
<tr><td rowspan="6">State Experience</td><td>The states that responded to the ASDWA survey said they are using EPA Methods 537, 537.1 and 533, as well as some proprietary methods.</td></tr>
<tr><td>The states that used EPA Methods 537/537.1 and 533 did not all analyze the samples for the full number of compounds that can be detected using the methods.</td></tr>
<tr><td>For Methods 537/537.1
• PFOA and PFOS were detected by all 14 states that provided data.
• Four other compounds (PFBS, PFHpA, PFHxS, and PFHxA) were detected by all but one of the states that sampled for them.
• PFDA, PFNA, and NMeFOSAA were found by more than half of the states that sampled for them.</td></tr>
<tr><td>For Method 533
• Of the six states that used Method 533, PFBA was detected by 3 states and PFPeA was detected by 2 states.
• The other compounds (NFDHA, 8:2FTS, PFEESA, PFHpS, 4:2FTS, PFMPA, PFMBA, 6:2FTS, and PFPeS) were not detected.</td></tr>
<tr><td>Three states used proprietary methods and detected as least one of four other PFAS (FOSA, PFOSA, PFTeDA, and PFUDA) for at least one water system source in their state.</td></tr>
<tr><td>Many states noted the co-occurrence of contaminants in sample results.
• Minnesota observed the highest concentrations for PFBA (average results >18 ppt), the lowest concentrations were observed for PFBS, PFOSA, PFNA, and PFHpA (average 0-2 ppt).</td></tr>
</table>

Data Sharing, Transparency, and Public Engagement: States that are conducting sampling have found that publicly sharing the results of their PFAS sampling data, providing clear communications about their response actions, and conducting stakeholder engagements when PFAS are detected at levels above the MCLs, guidance, or health advisory levels, has been extremely helpful for ensuring state accountability and public knowledge transfer. To do this, states must also consider data system needs to support complexity in monitoring and compliance approaches (see Section 6 for more information on reporting and data management), as well as GIS needs to support website mapping tools. While some states have data release policies that do not allow specific latitude/longitude coordinates of sample locations to be shared publicly, general reporting of PFAS levels is still attainable. The states that have developed websites with GIS maps and tools to share sampling results with the public and increase transparency provide good examples for how to share state data and what actions to take with the public.

Resource Documents	ASDWA PFAS web page – includes some state sampling maps and information under "State PFAS Sampling Maps - Action Plans – Resources"
	ASDWA PFAS SWP Guide and Toolkit - Mapping Guide
	ASDWA State CEC Rule Development and Management Strategies Toolkit Module 3: Characterize Occurrence - see "Questions to Consider" (on page 32)
	California YouTube video on a machine learning approach to analyze where occurrence may or may not be prevalent - from the October 2020 Water Board meeting.
	California PFAS Map Tool with Site Investigation and Drinking Water Test Results.
	California Statewide PFAS Results for Drinking Water and Non-Drinking Water - GeoTracker PFAS Map
	Colorado PFAS Action Plan Fact Sheet and 2020 Sampling Plan Website
	Massachusetts Energy & Environmental Affairs Data Portal: Search Drinking Water for Contaminant Group = "PFAS" or for individual compounds under Chemical Name.
	Massachusetts PWS Story Map
	Michigan PFAS Site Investigation web page and PFAS Action Response Team Public Meeting Calendar
	Minnesota PFAS Interactive Map for Private Well Monitoring
	New Hampshire PFAS Investigation website and GIS maps and data and PWS test results
	North Carolina Gen-X Sampling Study Website
	North Carolina PFAS Testing Network
	Ohio PFAS Public Water System Testing
	Pennsylvania Statewide Sampling Plan Final Results
	South Carolina PFAS Sampling Results for Surface Water-Sourced Drinking Water Systems

3. Analytical Methods and Lab Capacity

States are using a variety of approaches to work with labs, analyze PFAS samples, and ensure quality control of lab reports. States that have MCLs have adapted these approaches over time based on the likelihood of specific compounds to be present in drinking water; the availability and capacity of labs to analyze for those compounds; and their cumulative experience from receiving and reviewing lab reports with PFAS sample results. These elements have helped the states determine which PFAS they wanted to test for; what protocols and procedures are working (and not working) and allowed them to adjust these processes to maximize the use of resources and make them more efficient, while still ensuring that they get accurate and necessary PFAS sample results for implementing the MCLs. For more complete information on all of these topics, please refer to the ASDWA PFAS Laboratory Testing Primer[17].

Analytical Methods

EPA Developed Analytical Methods for Drinking Water: EPA Methods 537, 537.1 and 533 can analyze drinking water samples for a total of 29 compounds. Method 537 can test for 14 PFAS, Method 537.1 can test for 18 PFAS, and Method 533 can test for 25 PFAS (inclusive of 14 of the 18 PFAS in EPA 537.1, plus 11 more PFAS). These are the primary methods states are using to sample PWSs for PFAS at the entry point to the distribution system to determine compliance with MCLs. Most states that are conducting sampling are using EPA Method 537.1, though some states have begun using Method 533 since it was published in November of 2018, either exclusively or in combination with Method 537.1 to test for the different PFAS. It is also important to note that the some of the states with PFAS MCLs do not always analyze the samples for the full number of compounds that can be detected using the methods, and sometimes will only analyze for the compounds with specific MCLs or a subset of compounds within the method that have known occurrence.

State Considerations for PFAS Sampling and Methods

States that have not yet begun to sample or are developing PFAS MCLs will want to consider which PFAS they want to test for based on known occurrence of PFAS through other sampling efforts such as UCMR3, the type of PFAS that the military, firefighting agencies, or industries have used in proximity to the drinking water sources, and which EPA method(s) are able to analyze for those compounds.

Other Analytical Methods for Additional PFAS, Raw Water and Other Media: While other methods (besides the EPA methods above) are not being used by states with PFAS MCLs for drinking water compliance purposes, a few states are using them to sample for additional compounds and they are also sampling raw water sources and other media to better understand occurrence and where PWSs may be impacted by PFAS.

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[17] ASDWA PFAS Laboratory Testing Primer for State Drinking Water Programs and Public Water Systems - https://www.asdwa.org/wp-content/uploads/2021/02/ASDWA-PFAS-Lab-Testing-Primer-FINAL-02032021.pdf

State Experience	California is requiring analytical laboratories to follow the Department of Defense's Quality System Manual (Table B-15) (Version 5.1 or later) for the testing and reporting of PFAS in non-drinking water matrices (e.g. groundwater, wastewater, biosolids).
	Minnesota is using method SGS AXYS METHOD MLA-110 Rev 02 that has been validated and accredited by DoD to sample for a total of 36 compounds and to sample raw water sources.
	North Carolina used a university-developed method to test for 48 compounds in 15 different media as part of its PFAS Testing Network and also conducted non-targeted and suspect screening analyses for raw water samples using high-resolution mass spectrometry to assess the presence and relative abundance of PFAS beyond the 48 compounds based on a list of 7,267 known PFAS molecules and an additional 41,629 predicted chemical and biological transformation products of PFAS.
	Wisconsin is using a proprietary method that was developed by the Wisconsin State Laboratory of Hygiene at the University of Wisconsin to sample for 33 compounds, because EPA Method 537 was not sufficient to test for the PFAS of interest to the state.

Total Organic Fluorine (TOF) Method: The TOF method is still being validated and can be used to conduct non-targeted analysis (similar to North Carolina) for an initial screening of all organic fluorinated compounds that may be present in the water and ensure that potentially significant contaminants are not being missed. For this reason, no states are using the TOF method for PFAS MCL compliance. There are differing state opinions on the use of TOF because of the need for additional research on how to interpret and use the results, public expectations, and the burden/cost to respond to potentially unknown contaminants. The reporting level for commercial labs analyzing for TOF is relatively high (500 ppt) when compared to analytical methods for PFAS.

Lab Capacity, Accreditation, and Reporting

Lab Capacity: State drinking water programs are using state labs as well as both in-state and out-of-state commercial laboratories for PFAS sampling. The states that have issued Requests for Proposals (RFPs) for lab contracts have been able to negotiate reduced costs for shipping and analysis of samples based on the volume of samples and the number of compounds that are tested for. While EPA expects to expand lab capacity before UCMR5 monitoring begins in 2023, some labs may currently have a longer turnaround time of two weeks or more to provide sample results. States will want to consider these factors when deciding which labs to use for MCL compliance determinations. More information on costs is provided in Section 5 on Benefits, Costs, and Economic Considerations.

Lab Accreditation: Each state should have a list of approved or accredited laboratories that can analyze drinking water for PFAS. If a state has not established a list, qualified laboratories can be identified using: the National Environmental Laboratory Accreditation Program[18], the Department of Defense accredited labs search[19] or EPA's certified labs website[20].

Lab Reporting Reviews for Quality Assurance/Quality Control (QA/QC): Staff in different states are conducting different levels of quality control reviews for lab reports, even when labs are certified by the state. The Level 2 and Level 3 reviews of lab reports that some states have conducted to ensure QA/QC can be very complicated and time

[18] National Environmental Laboratory Accreditation Program - https://nelac-institute.org/content/NELAP/index.php

[19] Department of Defense accredited labs search - https://www.denix.osd.mil/edqw/accreditation/accreditedlabs/

[20] EPA's certified labs website - https://www.epa.gov/dwlabcert/contact-information-certification-programs-and-certified-laboratories-drinking-water

consuming. While some states have accredited labs that submit data electronically and have had just a few problems with obvious errors, other states have identified a variety of problems with labs submitting data that does not meet QA/QC requirements and that should be disqualified. And while some states with significant amounts of data from statewide sampling have gotten consistently accurate results, even with the QC flags, other states that are just starting to do sampling are more concerned and have rejected large amounts of data from labs with data flags/qualifiers. This is because some lab results are not meeting all the method requirements and the lab SOPs are deficient or invalid. States should decide ahead of time how qualified data will be handled.

State Consideration for Surrogate Recovery

Many QA/QC issues with lab reports seem to stem from a surrogate recovery problem and it may help to associate each surrogate with specific target analytes. Then if a surrogate fails, it only affects the associated target analytes.

Minimum Reporting Levels/Limits (RLs): At least six states (Massachusetts, Michigan, Illinois, Vermont, and New Hampshire) have RLs of 2 ppt for their PFAS MCL sampling requirements. However, other states have set or are considering RLs in the 5-6 ppt range to ensure QA/QC criteria can be met. Many commercial labs are achieving RLs of less than 1 ppt. PFAS health studies are rapidly evolving and are looking at low-level exposure. Some states have determined that PFAS health advisory concentrations in drinking water should be based on the additive effect of PFAS (i.e., combined rather than individual PFAS). Obtaining water quality results with lower RLs will improve the data's utility if a new health guidance or standard is developed based on the additive effects of PFAS.

Nomenclature in Lab Reports: ASDWA developed the Technical Bulletin for Labs[21] to address the issues some states have had with labs using inconsistent names for the same PFAS and their associated CAS numbers. This bulletin provides recommendations for labs to ensure that they are not incorrectly and interchangeably using anionic (salt) and acid form names (e.g., perfluorooctane sulfonate (PFOS) and perfluorooctanesulfonic acid (PFOS) are not the same) in their lab reports.

Field Reagent Blanks (FRBs): EPA Methods 533, 537 and 537.1 require one FRB for every sample set at each site (samples collected from the same sample site and at the same time). Analysis of the FRB is required only if a Field Sample contains a method analyte or analytes at or above the RL. The FRB is processed, extracted and analyzed in exactly the same manner as a Field Sample.

State Considerations for FRBs

States have differing opinions on EPA method requirements and are using a variety of approaches for collecting and analyzing FRBs. While some states are strictly following the EPA's methods and agree with the FRB requirements, other states do not strictly follow them and would prefer that the EPA methods do not require FRBs. For example, New Hampshire and Minnesota have seen very low risk for site contamination in FRBs and would like the FRB requirement to be revisited. This is because EPA's FRB requirement is a huge burden on water systems, states, and labs - in that it increases the costs by using triple the number of containers, shipping volume and shipping costs; as well as extraction and analytical costs for the FRBs (especially if the majority of samples have detections). This is because the FRB comes in two bottles, one full and one empty, and the water is transferred between the two at the sample site. The FRBs also increase the costs for the methods that will be passed onto the clients/projects because the number of sites/samples that can be collected and submitted will be significantly reduced and can create lab capacity problems. In addition, it makes it more difficult for labs to track and ensure the field blanks associated with PFAS detections are analyzed within method hold times, or risk invalidating the sample results. That being said, in

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[21] ASDWA Technical Bulletin to Laboratories Reporting PFAS Analysis - https://www.asdwa.org/wp-content/uploads/2020/10/ASDWA-PFAS-Lab-Reporting-Technical-Bulletin-FINAL-101420-1.pdf

some states with PFAS MCLs, quality control rejections have often been tied to a laboratory not being able to demonstrate that the FRB (or lab blank) was non-detect down to one third of the RL, as required by the method.

Potential FRB Solutions: Some states are doing FRBs in batches rather than collecting FRBs for each sample set at every sample site as the EPA Methods require, and other states are only analyzing FRBs if the samples have detections for the PFAS with MCLs. If samples have detections, re-sampling to confirm, which would take longer for a state to confirm detections, may be better and less burdensome than doing FRBs for every sample site.

Resource Documents	ASDWA PFAS Laboratory Testing Primer for State Drinking Water Programs and Public Water Systems – February 2021
	ASDWA Technical Bulletin to Laboratories Reporting PFAS Analysis Using EPA Methods 533, 537, or 537.1 – October 2020
	ASDWA State CEC Rule Development and Management Strategies Toolkit Module 4: Identify Analytical Methods (see pages 40-45)
	EPA PFAS Drinking Water Laboratory Methods
	EPA Analytical Methods for Drinking Water: Lowest Concentration Minimum Reporting Level (LCMRL) Calculator
	ITRC PFAS Guidance: Sampling and Analytical Methods

4. Treatment and Compliance Options

States that are developing PFAS MCLs will need to establish a compliance determination process and response framework to ensure public health is protected from the risks associated with PFAS in drinking water when detected at or above the state specific MCL for individual compounds (or a sum of compounds). Protocols for compliance and treatment must include considerations for: confirming PFAS sample results; requiring public notice and response actions for short-term fixes and long-term solutions; using alternative water sources, and ensuring effective treatment for removing PFAS based on the site specific factors such as the PWS size, existing treatment, source water quality, the presence of different PFAS compounds and their associated detection levels, cost and availability of appropriate treatment technologies and equipment, and the capacity of the PWS to operate it.

Compliance Determinations and Response Actions

Sampling Location/Frequency and Compliance Determinations: States with PFAS MCLs are using different compliance determination processes based on the state's monitoring requirements and protocols for confirming sample results (e.g., locational running annual average (LRAA), one sample with repeat then average, or one sample with a confirmation). However, like the EPA NPDWRs, immediate MCL violations can occur before the end of the monitoring period if a high level of the contaminant is detected in a sample before the end of the monitoring period. Following are how the states with MCLs are making their compliance determinations.

State Experience	New Hampshire and New Jersey use the LRAA.
	Michigan also uses the LRAA. If confirmation sampling is required, the confirmation result(s) will be averaged with the first result.
	Massachusetts uses a quarterly average of three monthly results.
	Vermont compares the results with the MCL: If the PWS is on quarterly monitoring, they use the last two sample results. If the PWS if not on quarterly monitoring, they require a confirmation sample when above 20 ppt, and average the two sample results.
	New York uses the average of the initial sample and between one and three follow up samples collected within 30 days of the initial sample.

Emergency, Short- and Long-term Regulatory Response Actions: States will need to consider public notice, education, and health effects language, and community engagement requirements along with emergency, short-term, and long-term response actions for PWSs that have detected PFAS at or above the state MCLs. Section 1 on Health Effects provides additional information on Tier 1 and Tier 2 regulatory response actions for PFAS as an acute, sub-acute and chronic contaminant. When more time is needed to implement a permanent solution, such as installing treatment, emergency and short-term response actions may also include providing bottled water, distributing bulk-hauled water, providing an alternate source of water (e.g., vending unit) or distributing POU/POE devices to an impacted community. Both short-term and long-term solutions can include taking wells offline, connecting to another PWS or alternative water source (if available), blending sources or changing an existing blend, or installing temporary treatment in advance of a permanent treatment solution.

State Experience	Michigan and Massachusetts do not include a specific timeline for enforcement in their PFAS drinking water regulations, but Massachusetts does have general language in their regulations allowing the state to establish a schedule for compliance that may include interim measures a PWS must take.
	Michigan negotiates an enforceable timeline with the PWS based on their ability to lower the PFAS level (by installing treatment or changing their source) as part of a compliance agreement.
	Massachusetts requires PWSs to provide another source of water (e.g., bottled water) or an onsite vending unit for the community to get water until the PWS is able to lower the level of PFAS in their drinking water.

State Review and Approval of Treatment: States should review existing resources and case studies, and consult with other states, universities, PWSs and consultants when considering PWS treatment technology options for PFAS. The selection and approval of treatment technologies and protocols must include considerations for the specific PWS size and circumstances such as existing treatment; source water quality; the presence of multiple PFAS compounds and their associated detection levels and MCLs; the cost and availability of appropriate technologies and equipment; and capacity of the PWS to purchase, operate, maintain, and manage waste disposal or media regeneration for the treatment technology. The PWS will need to demonstrate that the treatment technology and operation will effectively and reliably remove the specific PFAS compounds to the level necessary to comply with the state MCL and ensure public health protection. State pilot testing of treatment options will help inform decision-making to consider treatment technology effectiveness, as well as costs.

Treatment Technologies

Research and recommendations on treatment technologies and protocols are continuing to evolve as more PWSs have begun using them and more studies are being conducted to evaluate the treatability of additional PFAS compounds and new technologies. However, there are three types of treatment technologies that are considered most effective for removing PFAS from drinking water, and most commonly allowed by the states with MCLs.

Granular Activated Carbon (GAC): GAC has been widely used and is proven to effectively treat long-chain PFAS (such as PFOS, PFOA, and PFNA) in drinking water. However, more studies are needed to confirm GAC treatment effectiveness for shorter chain PFAS or to identify complementary technologies/materials to supplement GAC removal capability. Rapid small-scale column testing (RSSCT) and accelerated column testing (ACT) are useful for evaluating treatability and determining initial design parameters. Larger scale pilot demonstrations are recommended to establish site-specific design parameters such as adsorption bed depth; GAC consumption rate to meet a given treatment objective; empty bed contact times (EBCTs); projections of breakthrough (based on bed volumes treated); and corresponding change-out frequency/costs[22].

Ion Exchange (IX) Resin: Single-use and regenerable IX resin systems are also being used and have been demonstrated to reduce concentrations for many PFAS, though longer chain PFAS may be adsorbed better than shorter chain compounds. The efficiency of IX for removing PFAS depends upon the source water chemistry and co-contaminant concentrations (including organic and inorganic compounds) that may significantly reduce the IX PFAS removal capacity and may also require pretreatment. For example, removing co-contaminants such as uranium and arsenic may require additional treatment and pretreatment if iron is present to reduce fouling. Conversely, IX treatment may also be more cost effective if it can be used for simultaneous compliance to remove co-occurring contaminants rather than adding another type of treatment. States should consider requiring pilot studies to ensure effective PFAS removal, and consider costs for incinerating, disposing, or regenerating spent resins.

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[22] ITRC PFAS Treatment Technologies - https://pfas-1.itrcweb.org/12-treatment-technologies/

Reverse Osmosis (RO): RO has been used to remove large chain PFAS, sometimes in combination with nanofiltration (NF). However, the high cost of RO treatment systems, along with the need for pretreatment and the need to dispose of the concentrated waste stream prohibits the use of RO for most PWSs.

State Considerations for Best Available Technologies (BATs)

All of the six states with MCLs allow PWSs to use GAC for PFAS treatment as a BAT. However, New Hampshire does not specify a BAT in its rule and Massachusetts will allow GAC, PAC, IX, NF, and RO. In addition, the states of Massachusetts and Michigan allow PWS variances for exceeding the MCL if they are using a BAT.

Treatment Differences: Comparing different treatment options will help inform decision-making. States developing MCLs will want to consider which treatment technology will be most effective, and how will it be operated to treat for one or more long-chain versus short-chain PFAS with different detection levels that will result in different breakthrough curves from differences in EBCT. States may also need to develop design and construction standards for approving treatment technologies. For example, IX has greater capacity, faster kinetics, and lower EBCT compared with GAC, resulting in smaller vessel size and potentially less frequent media change-out. However, GAC may be more cost effective due to the rising costs for IX resin media and disposal.

Residuals Handling and Disposal: States will want to consider the different residuals handling and disposal costs and implications for different types of treatment based on volume and frequency. These costs and implications include considerations for moving PFAS contamination from one media to another. For example, disposal at landfills may also cause PFAS contamination in groundwater from leaching. In addition, while spent GAC media may be less expensive if it is regenerated through incineration. Further research needs to be conducted on air emissions from incineration that has the potential to cause PFAS contamination in surface water from air deposition[23].

Treatment Equipment Availability Delays and Costs: Due to COVID, material and construction costs across the country have increased significantly and caused delays in the delivery of PFAS water treatment systems. See Section 5 for additional information on Benefits, Costs, and Economic Considerations.

Resource Documents	Effectiveness of point-of-use/point-of-entry systems to remove per- and polyfluoroalkyl substances from drinking water
	EPA Website on Drinking Water Treatment Technologies – August 2018: General information on using activated carbon, ion exchange, and high-pressure membranes.
	EPA Drinking Water Treatability Database (TDB)
	EPA Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials
	ITRC PFAS Guidance – Treatment Technologies
	ASDWA Webinar: PFAS Treatment Options and Considerations for Drinking Water Utilities – October 2018: With four vendors (TIGG, Calgon, Evoqua, Purolite)
	New Jersey Recommendations for PFAS Drinking Water Treatment Options – June 2015: This document developed by the New Jersey Drinking Water Quality Institute Treatment Subcommittee provides drinking water treatment options for removing PFOA, PFOS, and PFNA, as well as some short case studies with treatment information and costs from a few water utilities. There are two addendums dated August 2016 and November 2017 to the original document that update information about treatment and the case studies.

[23] EPA Interim Guidance on Destroying and Disposing of PFAS - https://www.asdwa.org/wp-content/uploads/2021/02/EPA-HQ-OLEM-2020-0527-0002_Interim-PFAS-Disposal-Guidance.pdf

5. Benefits, Costs, and Economic Considerations

Benefit, cost, economic impacts, and affordability analysis requirements for developing drinking water regulations vary from state to state depending on the state laws and administrative procedures. These requirements lay the foundation for the state to make a final MCL determination based on an evaluation of the benefits and costs of the PFAS regulation for the state government, the PWSs, the public, and the economy, and then provide an explanation of why the benefits outweigh or justify the costs. States with PFAS MCLs have not all been required to conduct a benefit-cost analysis and those that have, may not have had to conduct the same extensive full-scale benefit, cost, and economic analyses that EPA conducts for SDWA regulations. Some states also have Advisory Committees (e.g., Massachusetts, Michigan, and New York) that play a role in reviewing the benefits and costs and recommending PFAS MCLs at specific levels. Some states with PFAS MCLs used qualitative statements to describe the benefits and costs in their regulatory development process when data or health studies were insufficient to quantify specific outcomes such as health care treatment costs, loss of income, and associated indirect benefits and costs, as well as avoided costs by limiting exposure to the PFAS being regulated. A few examples of different types of required state analyses include Michigan's Regulatory Impact Statement and Cost-Benefit Analysis [24] and Massachusetts' Regulatory Review Checklist[25].

Human Health Benefits: Human health benefits can be derived from estimates for the number of people protected from exposure to different levels of individual PFAS, or sums of multiple PFAS in their drinking water based on the calculated health risk assessments (Section 1) and expected occurrence (Section 2). Benefit analysis may also be affected by uncertainty or safety factors. For example, if uncertainty factors lead to a range of MCLs from 10 to 70 ppt or more for certain PFAS, and actual health effects are only expected at much higher values, the benefits for the lower MCL values may be determined differently. However, because reliable quantitative data from human epidemiological studies of PFAS at the low background levels resulting from drinking water exposure is very limited, some states have provided a qualitative narrative to describe the benefits. The following examples highlight some of the differences between states that have developed or are developing PFAS MCLs in using and estimating benefits.

State Experience	Rhode Island's benefits analysis included health considerations for cholesterol, low birthweight, and breast milk. The state used CDC ATSDR cholesterol effects information to estimate costs of cholesterol medications and hospitalization for heart attacks at $9.2 million dollars. The state also estimated benefits for differences in infant mortality for one death at $9 million but did not include immune system benefits because they were not able to quantify it.
	New York did not estimate health benefits as part of its regulatory development process. However, the state Drinking Water Quality Council recommended the PFAS MCLs based on its review of relevant data and information.
	New Hampshire cited general information about known PFAS health effects and included references to a few scientific articles in its benefits analysis, while noting that the Office of the Attorney General concluded this information was sufficient to meet the state's regulatory requirements based on the lack of available comprehensive data for quantifying the benefits of its PFAS MCL for four compounds.

[24] Michigan's Regulatory Impact Statement and Cost-Benefit Analysis - https://rb.gy/34adaj

[25] Massachusetts' Regulatory Review Checklist - https://www.mass.gov/doc/regulation-review-checklist/download

State Administrative Costs: States will want to estimate the costs for staff positions (FTEs), training, regulatory implementation and compliance needs, funding and assistance for sampling and treatment, as well as any potential savings for the agency promulgating the rule. This includes staff time, as well as contract assistance and database (technology) funding needs for tracking sampling and compliance. Depending on how the state program is structured, some states will also need to consider resources and costs for local health departments that may directly oversee or implement the PFAS rule for their local PWSs by processing sample results or issuing enforcement communications. Some states with PFAS MCLs did not receive any additional funding and have not been able to fill new FTEs and/or existing vacancies to implement their PFAS MCLs. These states have had to divert staff time and resources from other necessary activities that has essentially compounded the resource burden on the program.

State Experience	Rhode Island prepared a supplemental budget request of $859,000 to implement their future PFAS drinking water regulation. This included 4.5 FTEs - two environmental scientists, two engineers and O.5 FTE for legal support, as well as funding for community outreach through a contract with the University of Rhode Island, and new laboratory equipment. However, the whole state drinking water program was only staffed at 64 percent of the needed positions at the time of the budget request and implementation of a PFAS regulation at an MCL of 20 ppt or lower is not expected to be sustainable without additional staff.
	New York used existing resources for rule development, implementation, compliance, and plan review.
	Massachusetts was able to hire 5 FTEs (one per office) to assist with PFAS regulatory implementation, but the DWP did not receive this position in every office as some offices chose to assign their position to the waste site cleanup program.

State Sampling and Lab Costs: State costs for shipping and analysis of PWS samples for PFAS vary considerably from state to state. States with PFAS MCLs and states that have conducted sampling programs have also had to have staff spend a considerable amount of time reviewing lab reports for quality control (see Section 3 for more information on lab reporting reviews for QA/QC). Some states have obtained lower lab costs using different approaches and requirements. States that have issued RFPs have had some success in obtaining lower lab costs due to the competitive factor in competing for the contract. Some states have elected to only have the labs analyze the samples for the regulated PFAS compounds to lower the costs, even though the lab methods can analyze for more. Requirements for conducting analysis of every FRB versus requiring analysis only for confirming detections, in batches or not at all, has also been helpful for some states to obtain lower the lab costs.

State Experience	New Hampshire issued an RFP for lab testing and was able to secure a contract with a $150 cost per sample without running FRBs for every sample. The state estimated a total initial sampling costs of $1,102,500 - $2,836,000 and annual sampling costs at $174,257 - $444,409.
	Massachusetts has 12 labs that are analyzing samples and the costs are approximately $250 - $350 per sample with FRBs.
	New York costs per sample range from $350 to $400 using Method 533.

Costs for Water Systems: States that have completed a comprehensive statewide PFAS sampling program and have occurrence data are better able to estimate the total amount of capital and operating costs for PFAS treatment needed for all PWSs in the state. States without statewide occurrence data may be able to extrapolate data from a smaller subset of sample results in their state, or from other states with statewide occurrence data based on the areas with known or expected PFAS contamination sources. These cost estimates should also account for those systems that are able and will choose to blend, interconnect with another system, or take contaminated wells offline rather than install treatment. These estimates should also consider the cost of spent media regeneration or disposal and the associated potential environmental impacts. Having a responsible party pay for treatment in a litigation case may also offset treatment costs for some PWSs.

State Experience	
	New Hampshire estimated its initial PWS treatment costs at S65,046,987 - $142,822,885 and the annual operation and maintenance costs at $6,914,552 - $13,444,963. This is based on a high annual estimate of $0.35 per gallon, or $0.000959 per gallon per day for treatment.
	Michigan included the benefits of GAC treatment in its analysis due to the ability to regenerate the spent GAC media through incineration and preventing further PFAS contamination, rather than disposing of it in a landfill, and therefore moving it from one media to another.
	Rhode Island completed a study of the engineering options and capital and operating costs for controlling PFAS at MCLs of 2, 10, 20, 35 and 70 ppt. The costs were based on two rounds of PWS sample results estimated to be negligible at potential MCLs of 70 and 35, and range from $6,335,000 at 20 ppt, to $32,312,000 at 10 ppt, and $67,783,000 at 2 ppt.
	New York estimated PWS treatment costs based on occurrence for capital and operation and maintenance for MCLs of 4, 10, 20, and 36 ppt. The state originally estimated a total cost of $760 billion for capital costs for its final MCLs (see Table 2).

Table 2: New York PFOA/PFOS Occurrence and Treatment Cost Summary for Community Systems

Target MCL (ppt)	Estimated Percent Community Water Systems Requiring Treatment	Estimated Number of Community Water Systems Requiring Treatment	Total Statewide Estimated Capital Cost*	Total Statewide Estimated Annual O&M Cost
4	40 percent	1,125	$1,500,000,000	$78,000,000
10	23 percent	645	$855,000,000	$45,000,000
20	14 percent	410	$544,000,000	$29,000,000
36	10 percent	276	$366,000,000	$19,000,000

**Cost estimates assume $1,325,000 capital cost per treatment system, weighted based on number of small (2,513), mid-size (180), and large (156) community water systems in NYS*

Economic Impacts: States developing PFAS MCLs will want to consider the human health and environmental benefits and costs for PWSs and businesses in the economic impact analysis for their PFAS MCL. States can derive the economic impacts for their PFAS rule by estimating the occurrence of PFAS throughout the state and then using PWS information and statistical data to calculate the extent of the impacts for different subsets of PWSs. This analysis should include costs the state will incur to assist or pay for PWS sampling and treatment, versus the costs the PWSs and their customers will pay. This analysis often provides narrative descriptions of the benefits and calculations of the impacts to different sizes of PWSs and businesses, and particularly for those in small communities. States may then include the associated actions the state plans to take to ensure funding or SRF loans are available for its largest and most economically viable PWSs, as well as the additional assistance and funding the state will provide for small PWSs and businesses that will see the highest level of economic impacts.

State Experience	Massachusetts secured $28.4 million in two supplemental budgets in 2020 to support water infrastructure investment and PFAS testing including providing $5 million for two rounds of grants for reimbursement or new costs for planning and design of PFAS treatment systems and $2 million for a new round of grants to offset the costs of emergency response (e.g. bottled water, interconnections) to MCL violations.
	New York is providing $200 million for grants to cover capital costs.
	States may also be required to provide information about environmental benefits, business growth and job creation in their economic analysis. For example, Michigan included the qualitative benefits in its analysis for "…general improvement to the PWSs and to water quality, creation of jobs, and increased community goodwill through better service to customers."

State Considerations for Affordability Analysis and Environmental Justice

Affordability analysis assesses impacts to small, disadvantaged, and environmental justice (EJ) communities, and/or rural areas that are many times unable to afford expensive PFAS treatment. States can use their PWS information and statistical and economic data, along with disadvantaged and EJ community criteria, metrics, data or maps to calculate the extent of the impacts for this subset of PWSs and the households and communities they serve. States are using these indicators to ensure inclusion of additional impacts as well as state funding and assistance needs in their analysis.

Resource Documents	EPA Guidelines for Preparing Economic Analyses
	New Hampshire Comments and Responses on PFAS Rules (see costs starting on page 89)
	New Jersey Rule Proposal for PFNA and 1,2,3-TCP (see Economic Impact on pages 33-38)
	Michigan Regulatory Impact Statement and Cost-Benefit Analysis
	Massachusetts Executive Order 562 Regulation Review Checklist (page 4)
	Massachusetts PFAS Small Business Impact Statement
	ASDWA State CEC Rule Development and Management Strategies Toolkit Module 6: Characterize Benefits, Costs, and Economic Considerations

6. Standard Development - Overarching Rule Making Process

Combined, each of the sections in this document discuss the relevant topics for states to consider when developing PFAS MCLs. This section focuses on the overarching rulemaking process that brings these pieces together. The states that have developed PFAS MCLs have both some similarities and differences in their rulemaking drivers, requirements, and decision-making processes. These factors, along with the state specific circumstances such as occurrence of PFAS and the associated impacts to communities as well as state capacity, have resulted in differences among states in terms of the PFAS compounds they are regulating, and the way their rules are structured.

State PFAS Regulatory Drivers: Different drivers have led states to consider and make determinations to develop PFAS MCLs and have influenced the structure of the final regulation. These have included directives from political leadership, legislative mandates, administrative actions, and/or legal petitions. For example, the Michigan and Wisconsin[26] PFAS MCLs were driven by a Directive from the Governor. Vermont and New Hampshire's MCLs, and Virginia's current efforts to develop PFAS MCLs were driven by state legislation. In the New England states (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), the Conservation Law Foundation (CLF) filed petitions for rulemaking that coincided with further actions by some of the states (e.g., Massachusetts and Rhode Island) to develop PFAS MCLs. Though the petition was directed at these states to establish a treatment technique drinking water standard for PFAS (as a class), none of them (or any other states) have so far elected to establish a treatment technique for a class of PFAS instead of an MCL for specific PFAS. A treatment technique rule can potentially be used to remove other PFAS during treatment for which there may or not be analytical methods available to measure the level of each PFAS or total PFAS, and where there is not enough health effects or occurrence information to determine a Maximum Contaminant Level Goal (MCLG) or to set an enforceable MCL.

State Experience	Massachusetts was asked as part of the regulatory petition to set a treatment technique requiring three sequential treatment processes (one of which was experimental), though the state never considered it to be a viable option. The rationale in the state's formal response to the petition[27] was that a treatment technique would be cost prohibitive for small systems and would seek to regulate thousands of substances for which little or no health information exists, and for which limited treatment information exists to identify processes that would be effective across the entire class.

PFAS MCLs and Drinking Water Sources: States that are developing PFAS MCLs and are conducting sampling of raw water sources may be directed (or also want) to consider opportunities within their program to address water quantity and quality issues, as well as coordination with other state programs or authorities to address potential PFAS contamination and other emerging contaminants in surface water and groundwater sources of drinking water.

[26] Directive from the Governor in Wisconsin - https://widnr.widen.net/content/d4vyg9qqwj/pdf/EM_PFASActionPlan.pdf

[27] Massachusetts Letter in Response to CLF Petition for Rulemaking (see pages 8-9) - https://www.mass.gov/doc/massdep-action-on-petition-to-establish-a-treatment-technique-drinking-water-standard/download

For example, Wisconsin has proposed groundwater standards for PFOA, PFOS and 16 additional PFAS.[28] New Hampshire developed and promulgated ambient groundwater quality standards for PFAS concurrently with its drinking water MCLs and New York developed and promulgated a regulation for 1,4-Dioxane. While the development of PFAS MCLs may be just one piece of the state's actions to assess and address PFAS, state drinking water programs can also help inform these broader state efforts.

Regulatory Development Process and Approach: The amount of time it took for most of the states to develop their PFAS MCLs and then promulgate them is approximately 18 months. The administrative procedures are somewhat different in each state but include the basic steps and decision-making processes covered in each section of this document, as well as the additional actions discussed in this section. Some of these processes are based on internal and external capacity for both making decisions to develop the PFAS MCLs and ensuring that the state is able to effectively implement the rules.

Role of State Committees: Different types of advisory committees and workgroups consisting of people with expertise in different areas play an important role in the development of state PFAS MCLs. New Jersey, New York, Michigan, and Massachusetts relied on these groups of individuals in different capacities to review the most current data and scientific information and provide recommendations for different aspects of their PFAS rules including health effects, analytical methods, treatment options, and/or which PFAS to regulate at specific MCLs. For example, New Jersey's Drinking Water Quality Institute (DWQI) and New York's Drinking Water Quality Council (DWQC) were both established by state statute to provide recommendations for developing and implementing MCLs for emerging contaminants in drinking water. Massachusetts and Michigan also relied on different groups of experts to inform their PFAS MCL development and implementation processes.

State Experience	Massachusetts' SDWA Advisory Committee and Laboratory Certification Office's Laboratory Advisory Committee were not established formally though they both exist to provide a forum for interacting with the regulated community and interested stakeholders. Additionally, its Health Effects Advisory Committee works with their Office of Research and Standards to inform toxicological reviews.
	Michigan set its MCLs for seven PFAS based on the Michigan PFAS Action Response Team (MPART) Science Advisory Workgroup recommendations that considered the latest scientific data available. Many alternatives discussed dealt with changes to the timing and logistics of the new requirements, levels of the MCLs, testing protocols, sampling frequency to capture seasonal variations, applicability of the new rules, laboratory capacity concerns, reporting limit concerns, and public notification requirements. The state wrote and modified the rules where these concerns and suggestions provided less ambiguity in the rules and provided better, more reasonable public health protection. Following is the Michigan PFAS rulemaking timeline and steps for promulgation.

[28] Wisconsin proposed PFAS groundwater standards - https://dnr.wisconsin.gov/topic/Groundwater/NR140.html

Table 3: Michigan PFAS Rulemaking Timeline

Month	Event
March 2019	Governor Whitmer's Directive to Promulgate Rules
April – June 2019	MPART Science Advisory Workgroup Develops Health Based Values
July 2019	Stakeholder Listening Sessions
August – February 2020	EGLE drafts rules, conducts stakeholder meetings, open public comment period, and finalizes proposed rules
February 2020	Environmental Rules Review Committee approves final proposed rules
March 2020	Final proposed rules submitted to Joint Committee on Administrative Rules
August 3, 2020	Rules promulgated

Stakeholder Engagement: Stakeholder engagement is a key component of the rule development and implementation process and is often being conducted virtually. States that have developed MCLs have held multiple forums for engagement with different audiences throughout the process - before, during, and after their PFAS MCLs were developed and finalized. These engagements have included forums with regulatory agencies, PWSs, Labs, consultants, environmental advocates, citizens, and others. Conducting public meetings before and during the rule development process and including a public comment period provides an opportunity for the state to understand the viewpoints and concerns of stakeholders and sets the stage for key stakeholders and the public to support the state's decision-making process for the development of the rule because they have provided input. Once the final rule is promulgated, it is helpful to continue to host meetings on the implementation of the rule in affected communities with both local officials and the public, and separately with the PWSs and with the state advisory committees.

State Considerations for Stakeholder Engagement

States developing PFAS MCLs will want to consider holding separate stakeholder meetings with different audiences. It is particularly helpful to hold meetings with the public after typical workday hours and at locations accessible by public transit and within affected communities. States should also be prepared to hear about health impacts from the public and answer general PFAS questions that are not directly related to developing a PFAS MCL such as where they come from and if there are exposure concerns from other media, as well as questions about banning PFAS products, conducting clinical testing, and/or funding response and remediation actions. States should also be prepared to potentially receive several thousand public comments on their State PFAS MCLs (e.g., Michigan received 3,400) that also raise these questions and concerns.

State Regulatory Structure: The process states used to develop their PFAS MCLs included considerations for which PFAS to regulate and whether to develop MCLs for individual PFAS with specific MCLs, for the sum of PFAS as a group, or to develop a treatment technique for multiple PFAS. Four of the six states with PFAS MCLs (Michigan, New Hampshire, New Jersey, and New York) have developed them for individual compounds and two states (Vermont and Massachusetts) have developed MCLs for sums of PFAS. There are no states yet that have elected to develop a treatment technique for their PFAS rule. Section 1 on Health Effects and in Section 4 on Treatment and Compliance Options also discuss information relevant to state decision-making processes on these topics. New Jersey Department of Environmental Protection Science Advisory Board (DEP SAB) PFAS case study[29] also provides a more detailed analysis for using these different regulatory structures. Some key considerations for determining the structure include using occurrence data from sampling efforts and other studies to determine which

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[29] New Jersey DEP SAB Report (see Appendix D (page 43)) *Case Study: Can PFAS be Grouped and Addressed Based on Common Toxicity and/or Removal by the Same Treatment Technology?* - https://www.nj.gov/dep/sab/sab_cec.pdf

PFAS are present, if there are cumulative health effects, and which treatment method will work best and be most effective for removing each PFAS to achieve the MCL.

Rule Implementation: To implement their PFAS MCLs, states have provided a variety of trainings and resources for PWSs. Due to COVID-19, states are conducting virtual trainings for PWSs, as well as providing recorded videos on different topics such as sampling instructions to address concerns with cross contamination. States have also provided guidance on interpreting lab reports, and similar to other SDWA rules, have developed reference guides and public notification templates for their PWSs, as well as language to include in the PWS Consumer Confidence Reports (CCRs) for violations, PFAS sources, and health effects.

Staggered Monitoring and Compliance Schedules: Due to concerns about laboratory capacity and staff resources, some states have staggered their PFAS MCL monitoring and compliance schedules to start implementation with the largest PWSs first. Michigan and Massachusetts are also conducting one-time monitoring at TNC systems, and Massachusetts and New York allow grandfathering for initial monitoring. Other states allow reduced monitoring after at least two quarters of sample results with no or low detections of the regulated PFAS. Creating a monitoring flowchart can be a helpful way to ensure your regulation covers all the pathways for compliance tracking. See Section 2 (Occurrence) for more information on monitoring and Section 4 (Treatment and Compliance Options) for more information on compliance.

Reporting and Data Management: States that have conducted sampling and developed PFAS MCLs have developed websites with maps and dashboards that show PFAS sample results and have endeavored to be transparent with the public about where PFAS has been found and at what levels. Creating IT infrastructure for displaying the results on their website and additionally providing for electronic lab reporting and compliance tracking can be a huge cost and resource burden for states. While some states have been able to modify their IT programs or Compliance Monitoring Data Portal (CMDP) to create a PFAS compliance database, states that use SDWIS have had to create whole new IT systems.

State Considerations for Reporting and Data Management

The states that have created databases or enhanced their IT systems have also added new fields to capture elements of PFAS testing that have not been common in other SDWA monitoring such as the minimum reporting levels. Enabling electronic reporting from certified labs via formatted text files (bulk upload) and allowing for other submissions directly from PWS staff and operators via web-forms can reduce the burden on state staff. States will also want to consider if additional inputs are needed to address particular state issues. For example, Massachusetts requires labs to attach a full (pdf) report so that staff can evaluate the quality control for each sample.

Resource Documents	Illinois PFAS Statewide Health Advisory
	New Hampshire PFAS Rules and Amendments, Summary of Comments/Responses on Initial Proposals
	Michigan Rulemaking Process Overview
	Massachusetts PFAS Drinking Water Regulations Quick Reference Guide
	Massachusetts – Development of a PFAS Drinking Water Standard (MCL) (https://www.mass.gov/lists/development-of-a-pfas-drinking-water-standard-mcl)
	Massachusetts Drinking Water Regulations
	Massachusetts Public Notification Forms and Templates
	New Jersey DWQI Recommendations for PFOS, PFOA, and PFNA
	ASDWA website: State PFAS MCLs and Guidance Levels, PFAS Sampling Maps - Action Plans - Resources
	ASDWA State CEC Rule Development and Management Strategies Toolkit Modules 1,7, and 8
	ECOS Standards White Paper
	Conservation Law Foundation State PFAS Petitions

7. Risk Communication

One of the greatest challenges for states is risk communication about PFAS. Being transparent about state actions and providing data and information on websites with maps and dashboards is helpful for states to be transparent with the public about where PFAS has been found and at what levels. There are a few helpful resources that have been developed to help states with PFAS risk communication such as the Interstate Technology and Regulatory Council (ITRC) and the AAAS Center for Scientific Evidence in Public Issues (EPI Center) Risk Communication Guides (see Resource Documents).

Public communication, transparency, and stakeholder engagement are important for creating and maintaining trust with all stakeholders. States developing PFAS MCLs should be prepared to speak with the public, with PWSs, and other stakeholders and discuss how they landed on key decisions for their drinking water rule. Developing key messages can build understanding for why the state's MCLs are different from other states and EPA. It is also helpful to have answers prepared about how the toxicology analysis led to decisions for developing the rule monitoring framework, as well as public education and public notice, and making compliance determinations.

Providing as much information as possible will help the public understand what they need to know for their own safety. This information should include: the potential health impacts (including heightened impacts for sensitive subpopulations); how the state used safety and uncertainty factors to develop more protective MCLs compared to the actual levels where health effects are observed in humans and animals; and what the public can do to reduce their risks. Sharing information and engaging with public health officials as well as public health providers also ensures that they have necessary and consistent information to communicate with their stakeholders and patients.

Resource Documents	Michigan: Understanding Risk: What's Behind the (PFAS) Numbers
	ASDWA State CEC Rule Development and Management Strategies Toolkit Risk Communication Section
	ITRC PFAS Risk Communication, training video, and Fact Sheet
	AAAS EPI Center Addressing PFAS in Drinking Water: Risk Communications Guide for Local and State Leaders
	Video by the Cape Fear Public Utility Authority in North Carolina about new PFAS treatment and costs is a of good example of risk communication and public outreach.