Understanding the occurrence of Per- and polyfluoroalkyl substances (PFAS) in Maryland's Public Drinking Water Sources – Phase 1

Table of Contents

List of Acronyms

CCR – Consumer Confidence Report

CFWS – Confirmation Finished Water Sample

CWS – Community Water System

CWS-WTP – Community Water System Water Treatment Plant

EPA - Environmental Protection Agency

FRB – Field Reagent Blank

HAL – Health Advisory Level

HFPO-DA - Hexafluoropropylene Oxide Dimer Acid

HUC - Hydrologic Unit Code

IFWC – Initial Finished Water Concentration

IFWS – Initial Finished Water Sample

ITRC – Interstate Technology Regulatory Council

MDE - Maryland Department of the Environment

MDH-LA - Maryland Department of Health Laboratories Administration

NTNC - Non-transient Non-Community

PFAS - Per- and polyfluoroalkyl substances

PFBS - Perfluorobutanesulfonic acid

PFHpA - Perfluoroheptanoic acid

PFHxS - Perfluorohexanesulfonic acid

PFNA - Perfluorononanoic acid

PFOA - Perfluorooctanoic acid

POE – Point of Entry

PFOS - Perfluorooctanesulfonic acid

PPT - Parts per Trillion

PWS - Public Water System

SDWA - Safe Drinking Water Act

TCE - Trichloroethylene

TCOW – The City of Westminster

TNC – Transient Non-Community

UCMR 3 - Third Unregulated Contaminant Monitoring Rule

UCMR 5 - Fifth Unregulated Contaminant Monitoring Rule

EPA - United States Environmental Protection Agency

WSP – Water Supply Program

WTP – Water Treatment Plant

Executive Summary

Per- and polyfluoroalkyl substances (PFAS) are a group of human-made chemicals that include Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic Acid (PFOS), Hexafluoropropylene Oxide Dimer Acid (HFPO-DA or 'Gen-X') and over 4,000 other variants. Since the 1940s, PFAS have been used in a wide variety of industrial and commercial processes and products for their surfactant and dispersant properties, chemical and thermal stability, and their ability to resist heat, water, and oil. Common uses of PFAS in consumer products and industrial processes include, but are not limited to: non-stick cooking surfaces, waterproof clothing, stain-resistant carpet, firefighting foams, chemical processing, building and construction, electronics, food packaging coatings, and more.

Certain PFAS are persistent in the environment and human body, meaning they typically do not break down under normal conditions and have the potential to accumulate within the human body. Understanding the occurrence of PFAS in the environment (e.g., air, surface water, groundwater, and land) and the routes of human exposure (e.g., in drinking water and in food sources) are areas of growing science, as environmental and public health professionals seek to better understand the risks to human health posed by PFAS.

Currently, there are no federal regulatory drinking water standards (i.e., Maximum Contaminant Levels (MCLs)) for PFAS. However, the U.S.Environmental Protection Agency (EPA) has issued a Health Advisory Level (HAL) of 70 parts per trillion (ppt) for the sum of the concentrations of the two most studied PFAS compounds, PFOA+PFOS, in drinking water. While non-regulatory, the EPA HAL does provide drinking water customers, even the most sensitive populations, with a margin of protection from lifetime exposure to PFOA+PFOS in drinking water.

In late 2019, the Maryland Department of the Environment (MDE) began to increase its efforts to better understand, communicate, and manage PFAS risks in Maryland through the implementation of MDE's multi-phased approach to assessing PFAS in drinking water sources across the State. This report summarizes the results collected under Phase 1 of MDE's Public Water System (PWS) study for the occurrence of PFAS in State drinking water sources and corrective actions taken.

In Maryland, there are 463 federally regulated Community Water Systems (CWS), which deliver drinking water to the same customers throughout the year. During Phase 1, samples were collected from 129 CWS Water Treatment Plants (CWS-WTPs), serving 59 CWSs, and were monitored for PFAS under EPA Method 537.1 by the Maryland Department of Health Laboratories Administration (MDH-LA). Under Phase 1, approximately 13% of Maryland's federally regulated CWSs were monitored. The 129 CWS-WTPs tested during Phase 1 provide drinking water to 4.3 million people, approximately 70% of Maryland's population.

The 129 CWS-WTPs monitored under Phase 1 were selected for priority sampling based on MDE's evaluation of potential relative risk for PFAS exposure through drinking water. MDE's relative risk priority setting involved considering:

- Consumer potential for long term exposure to PFAS (if present);
- Drinking water source water vulnerabilities to contamination (e.g., surface waters, unconfined and/or semi-confined aquifers); and
- Proximity and relative risk to potential PFAS sources (i.e., CWS source water is located near one or more locations where there is an increased probability of PFAS use and/or release).

Depending upon initial finished water results for PFOA+PFOS, additional actions may have been needed. If results for initial finished water samples measured PFOA+PFOS concentrations greater than the EPA's HAL of 70 ppt, then MDE asked the impacted CWS to immediately take any impacted WTP out of service until additional sample collection and treatment implementation could be conducted.

One finished water sample (i.e.,IFWS) was collected from each of the 129 CWS-WTPs, except for two CWS-WTPs where two finished water samples were collected from each of their WTPs (i.e.,Town of New Windsor and Wakefield Valley). A total of 131 initial finished water samples (IFWS) were collected from the 129 CWS-WTPs. Of the 131 IFWS analyzed:

- 98 IFWSs (~75%) measured quantifiable levels of PFOA+PFOS in finished water
- Two IFWSs (~1.5%) measured PFOA+PFOS greater than the EPA HAL for PFOA+PFOS (70 ppt)
- Two IFWSs (~1.5%) measured PFOA+PFOS between 35 ppt (half EPA HAL) and 70 ppt (EPA HAL)
- 23 IFWSs (~17%) measured PFOA+PFOS levels between 10 ppt and 35 ppt (50% of the HAL)

The highest measured levels of PFOA+PFOS (i.e.,those greater than the EPA's HAL of 70 ppt) were found in samples collected from only two CWS-WTPs withdrawing and treating groundwater from an unconfined aquifer. One of these CWS-WTPs serves the City of Westminster; the other CWS-WTP serves the Town of Hampstead.

When initial sample results from these two water systems measured levels of PFOA+PFOS greater than the EPA's HAL of 70 ppt, MDE worked with each CWS to take the following actions:

- Immediately take the impacted water treatment plant offline until confirmation samples (finished and untreated water samples) were collected;
- Collect additional finished and groundwater samples from each system's impacted treatment plant and groundwater source;
- Issue a Tier II Public Notice to their drinking water customers; and
- If and where feasible, continue to keep the impacted groundwater source offline until proper treatment is in place.

At the time of this publication, both Westminster and Hampstead water systems are currently planning to devise and implement treatment to reduce the concentrations of PFOA+PFOS in order to supplement their drinking water demand.

Due to the fact that PFAS was found in a majority of the samples collected during Phase 1, MDE has moved on to sampling the next phase of CWSs. Results from this next phase, and its corresponding report, are expected to be published late 2021.

In addition to conducting additional drinking water sampling, MDE continues to carefully monitor the EPA's work with regard to PFAS in drinking water. As additional information is published, such as MCLs and toxicity assessments, MDE will take additional actions to reduce unacceptable human health risks with respect to PFAS. MDE will also be working with MDH on risk communication to assist the public, utilities, and homeowners in better understanding PFAS risk and options for mitigating risks associated with these compounds.

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a group of human-made chemicals that include Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic Acid (PFOS), Hexafluoropropylene Oxide Dimer Acid (HFPO-DA or 'Gen-X') and over 4,000 other variants. PFAS have been used in a wide variety of industrial and commercial processes and products since the 1940s. PFAS are used for their surfactant and dispersant properties, chemical and thermal stability, and their ability to resist heat, water, and oil. Common uses of PFAS in consumer products and industrial processes include, but are not limited to: non-stick cooking surfaces, waterproof clothing, stain-resistant carpet, firefighting foams, chemical processing, building and construction, electronics, food packaging coatings, and more (Interstate Technology Regulatory Council (ITRC), 2020).

Certain PFAS are highly persistent and bioaccumulative. Some PFAS (i.e.,polyfluoroalkyl and other precursor molecules) may undergo degradation under normal environmental conditions to more stable PFAS (e.g., perfluoroalkyl acids) (ITRC 2020). PFAS have been detected across the country in various environmental media, including but not limited to: drinking water, fish tissue, surface water and groundwater. Certain PFAS have been very well studied for their impacts on human health (e.g., PFOA+PFOS), while at least seven other PFAS (PFBS, PFBA, PFHxS, PFHxA, PFNA, PFDA and HFPO-DA) are still undergoing toxicological assessments by the Environmental Protection Agency (EPA, 2021).

During 2020, and continuing into 2021, the Maryland Department of the Environment (MDE) has been leading an integrated, multi-agency effort to better understand the presence of PFAS in finished drinking water and drinking water sources across Maryland. In the first phase of this study, MDE partnered with the Maryland Department of Health Laboratories Administration (MDH-LA) to test the occurrence of PFAS in 129 Community Water System Water Treatment Plants (CWS-WTPs) across Maryland starting in September 2020. These 129 CWS-WTPs were selected for initial sampling because they were thought to pose the greatest relative risk of PFAS exposure to drinking water customers. This report presents the results of the completed Phase 1 study of PFAS in Public Water Systems (PWS) in Maryland.

Background

Our understanding of PFAS occurrence, fate, transport, toxicity, treatment methods, analytical techniques, and other PFAS-science topics is rapidly evolving and improving both at State and federal levels. MDE's earliest efforts in 2012-2015 to assess PFAS in drinking water were primarily fueled by federal initiatives, specifically the testing required by EPA under the Third Unregulated Contaminant Monitoring Rule (UCMR 3). That effort in 2012-2015 identified only one PWS in Maryland with quantifiable levels of PFAS above the 2012/2015 PFOA+PFOS limits of detection of 20-40 ppt. Due to increasing understanding of human health risks, public concern surrounding this group of compounds, improved analytical methods and lower limits of detection as well as the identification of these compounds in environmental media across the United States, MDE has made sampling of PWSs for PFAS in Maryland a near term priority. Phase 1 of this effort - sampling of 129 CWS-WTPs - started in September 2020, and sample collection concluded in February 2021.

Concerns about PFAS stem from their widespread occurrence in the environment, their persistence in the environment and in human tissue, and a growing body of evidence that they may affect the immune system, the liver, the endocrine system, and the reproductive system in a variety of ways. Exposure to PFAS can potentially occur through ingestion of foods containing PFAS, through drinking water, through

inhalation, including inhalation of very small particles of PFAS-containing material, and by ingestion of breast milk. However, our understanding of the health effects of many PFAS compounds is still very limited. The uncertainty about the health effects of many PFAS compounds means that conversations between health care providers and people with possible exposures to PFAS can be challenging. The U.S. Agency for Toxic Substances and Disease Registry (ATSDR) has resources for the public and for health care providers on PFAS.

Previous Federal Initiatives Addressing PFAS in Drinking Water

As mentioned above, MDE's earliest PFAS initiatives were federally fueled by the EPA.

Third Unregulated Contaminant Monitoring Rule (UCMR 3)

MDE's first set of data on PFAS occurrence in PWS was a result of the EPA's UCMR 3. Under the 1996 amendment to the Safe Drinking Water Act (SDWA), once every five years the EPA issues a list of 30 compounds to be monitored by PWSs. During UCMR 3, six PFAS were monitored in drinking water between 2012 and 2015. The six PFAS and their Minimum Reporting Limits from this effort are provided in Table 1 below (EPA, Dec. 2016).

PFAS Name	PFAS Acronym	Minimum Reporting Limit (ppt)	Reference Concentration (ppt)
Perfluorooctanesulfonic acid	PFOS	40	70 (combined PFOA+PFOS)
Perfluorooctanoic acid	PFOA	20	70 (combined PFOA+PFOS)
Perfluorononanoic acid	PFNA	20	NA
Perfluorohexane Sulfonic acid	PFHxS	30	NA
Perfluoroheptanoic acid	PFHpA	10	NA
Perfluorobutanesulfonic acid	PFBS	90	NA

Table 1: Six PFAS monitored under UCMR 3

Nationally, in the UCMR 3, PFOA+PFOS were found at 1.2% of PWS at concentrations above 70 ppt for the combined concentrations of PFOA+PFOS (the reference concentration for the study).

In Maryland under UCMR 3, 84 WTPs serving 39 PWSs were sampled, and only one sample from the Harford County Department of Public Works water system had detectable levels of any of the six PFAS. At this system, PFOA was detected, but at a level below the EPA's Health Advisory Level (HAL) for PFOA+PFOS combined at 70 parts per trillion (ppt) published in 2016. Since finding this detection, the system has regularly monitored for PFAS, and reports their findings on their Consumer Confidence Report (CCR). Activated carbon treatment was installed at this system prior to UCMR 3 sampling in 1993 to mitigate Trichloroethylene (TCE) contamination from Aberdeen Proving Grounds. It is suspected that the PFAS found at this system under UCMR 3 shares the same source area as the TCE contamination (i.e.,Aberdeen Proving Grounds) and that this previously installed treatment mitigated some PFAS contamination. Harford County Department of Public Works maintains this treatment system at the

impacted WTP to ensure PFAS levels remain below the EPA's HAL. Additional data on Maryland's PFAS monitoring under UCMR 3 can be accessed here.

Publication of the EPA's HALl for PFOA+PFOS

In 2016, the EPA published its HAL of 70 ppt for the combination of PFOA+PFOS. This health advisory was based on the agency's assessment of the latest peer-reviewed toxicity data available at that time. The HAL is not a federal regulatory limit; it is a level that provides technical information or guidance to drinking water system operators, State and local officials, and drinking water customers. Generally, the EPA develops HALs for contaminants that can cause human health effects and occur in drinking waters, but these levels are non-enforceable limits under the federal SDWA. The HAL for PFOA+PFOS of 70 ppt combined was determined by EPA to provide drinking water customers, even the most sensitive populations, with a margin of protection from lifetime exposure to PFOA+PFOS in drinking water. When PFOA+PFOS are found in drinking water, the combination of these two compounds' concentrations are compared to the EPA HAL (EPA, Nov. 2016).

Recent Federal Initiatives Addressing PFAS in Drinking Water

PFAS to be Monitored under the Fifth Unregulated Contaminant Monitoring Rule

In January 2021, the EPA announced the inclusion of 29 PFAS under the Fifth Unregulated Contaminant Monitoring Rule (UCMR 5). The PFAS listed under UCMR 5 encompasses the analytes covered by both EPA Methods 537.1 and 533, which are the EPA's most recent validated analytical method for measuring PFAS in drinking water (EPA, Mar. 2021).

EPA's Regulatory Determination for PFOA+PFOS

In February 2021, the EPA issued their final regulatory determination for PFOA+PFOS, two compounds under the Fourth Contaminant Candidate List . With these final regulatory determinations for PFOA+PFOS, the EPA will move forward with their rulemaking process to develop and issue national primary drinking water regulations and Maximum Contaminant Levels (MCLs) for these two PFAS. This regulatory determination indicates that EPA will conduct further analysis, scientific review, and provide additional opportunities for public comments. Additionally, the EPA's regulatory determination outlines different avenues the agency is considering to evaluate additional PFAS, including considering PFAS as groups (EPA, Feb. 2021). In general, MCLs take around three years to develop after their regulatory determination. MDE continues to track EPA's publications on PFOA, PFOS, and other PFAS. As more information is publicized, MDE willadjust their approach to managing PFAS in State drinking water sources.

Maryland's Public Water Systems

In Maryland, there are approximately 3,257 PWSs regulated under the SDWA. These systems are divided into three categories, which are described below.

- **Community Water Systems (CWS)-** a PWS serving the same population year-round. These systems serve at least 25 people at their primary residences. In Maryland, there are about 463 CWSs serving ~2million people per day.

- **Transient Non-Community (TNC)**- These systems provide water to 25 people or more for at least 60 days out of the year. These systems do not serve the same 25 people continuously and not on a regular basis. Examples of TNC systems include gas stations and campgrounds. In Maryland, there are about 2,235 TNC systems.
- **Non-transient Non-Community (NTNC)-** These systems regularly supply water to at least 25 of the same people at least six months out of the year, but not year-round. Examples of NTNC systems include schools and office buildings. In Maryland, there are about 559 NTNC systems.

In Maryland, 85% of the State's population (~5.1 million people) is served by a PWS. The vast majority of Maryland's PWS customers (~70%) are served by PWSs that withdraw water from surface water sources (i.e.,reservoirs and rivers) while ~15% of PWS customers are served by groundwater sources (i.e.,water from unconfined, semi-confined, or confined aquifers).

The other ~15% of Maryland citizens (~900,000 people) obtain water from a well that they own. Private well users can be found in every county within Maryland.

Monitoring Approach

In September 2020, MDE initiated Phase 1 of the PFAS study to evaluate the occurrence of PFAS in PWS. During this phase, 129 Community Water System Water Treatment Plants (CWS-WTPs) were sampled and tested for all 18 PFAS analytes listed under EPA Method 537.1. (see Table 3 for list of analytes). Collectively these systems provide drinking water to an estimated 4.3 million people (i.e.,approximately 70% of Maryland's population).

These sites were identified by MDE using readily available information as having the highest potential relative risk for PFAS contamination. Relative risk is defined as a combination of the estimated degree of threat (i.e.,potential PFAS source type, number of potential sources and proximity to drinking water sources), vulnerability (i.e.,source waters from surface water or groundwater in unconfined or semi-confined aquifers), and the frequency a system's customers receive their drinking water (i.e.,customers receiving water from the same CWS every day).

Site Selection Criteria

The Phase 1 CWS-WTPs were selected based on the following factors:

- Consumer potential for long term exposure to PFAS (if present);
- CWS source water vulnerabilities to contamination (e.g., surface waters, unconfined and/or semi-confined aquifers); and
- Proximity and relative risk to potential PFAS sources (i.e., CWS source water is located near one or more locations where there is an increased probability of PFAS use and/or release).

In addition to the above selected criteria, 11 reference sites were also chosen so that MDE would be able to compare the 129 targeted sites to sites not expected to be at risk of PFAS contamination (e.g., 75% forested and no known proximity to potential PFAS sources or releases). Figure 1 illustrates the locations of water sources potentially at highest relative risk for PFAS contamination. These sources then enter their respective treatment plants from which Phase 1 finished water samples were collected. Figure 1 also indicates locations of reference sites to be sampled during this phase.

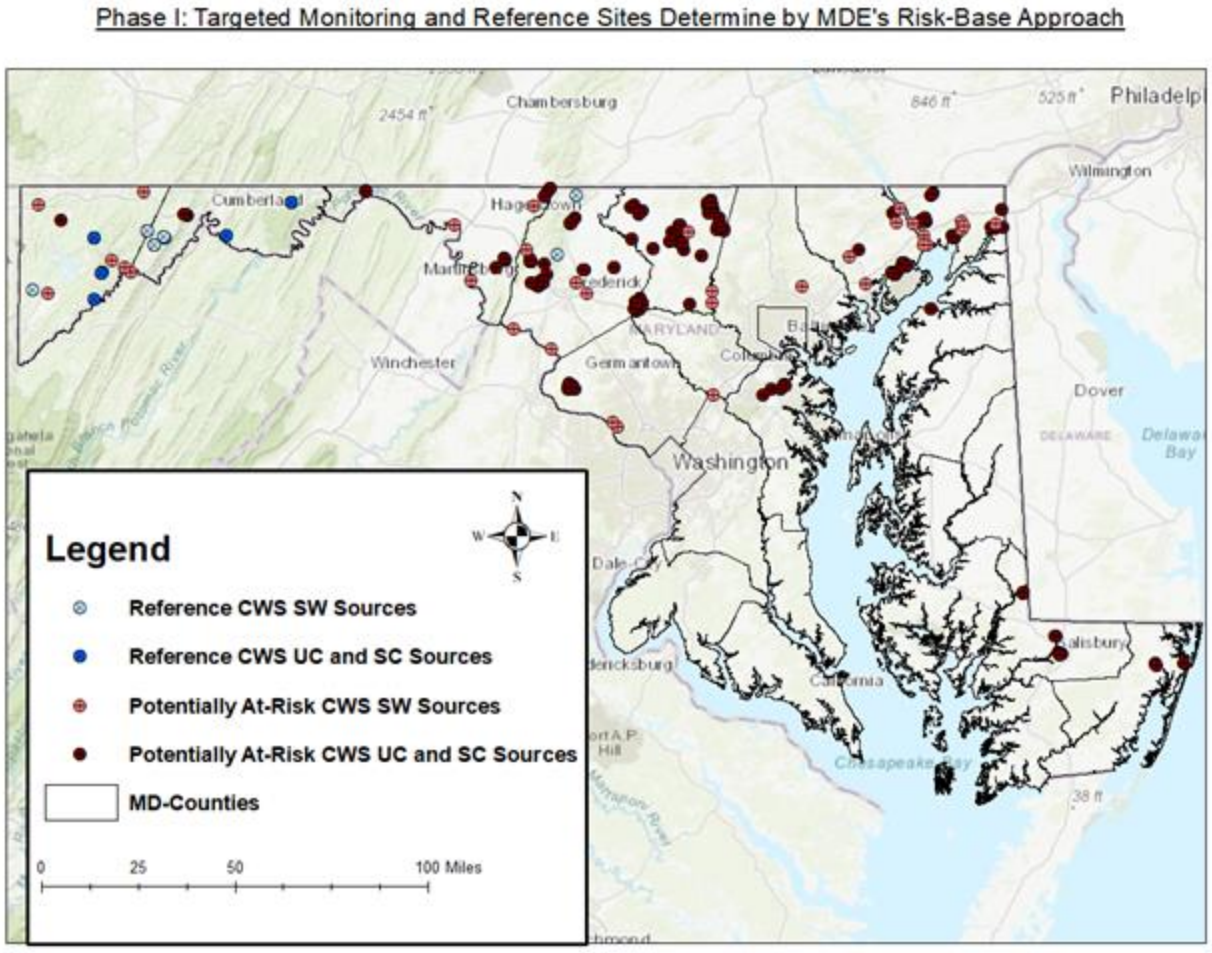

Figure 1: Locations of Untreated Drinking Water Sources to be sampled under Phase 1

"Potentially At-Risk" here means these sources are of higher priority and potential relative risk than others based on the criteria previously discussed.

What are the differences between Community Water Systems, Water Treatment Plants, and Raw Water Sources?

Community water systems (CWSs) supply drinking water to the same population year-round. To be considered a CWS, a system must provide drinking water to at least 25 of the same people or 15 service connections. In Maryland, the majority of CWSs provide some form of treatment depending on their water source. Some systems have multiple treatment plants while some blend all their sources into one treatment plant.

Under Phase 1, 131 finished water samples were collected from 129 CWS WTPs representing 59 CWSs.

Importance of focusing first on Community Water Systems

In Maryland, ~5.2 million people receive their drinking water from 463 regulated CWSs. A single CWS can serve from 25 to more than 1.8 million people. The EPA HAL of 70 ppt for PFOA+PFOS is based on longer term exposures, not a single or short-term event. Due to the large number of people served by

CWS and the risk assessment endpoint being chronic risk, the initial phase of PWS sampling for PFAS focused on CWS.

What makes a Community Water System's Source Water "vulnerable?"

Maryland's 463 CWSs either withdraw from surface or groundwater, or, in some cases, a combination of both. Maryland's groundwater-based drinking water sources include waters from unconfined , semi-confined , and confined aquifers. In Maryland, the majority of CWS are dependent on one or a combination of these sources. Depending on the type or location of a source water, vulnerability of a CWS to contaminated source water ranges from less vulnerable because they are naturally protected, to very vulnerable and susceptible to external influences. For example, CWS using groundwater from a confined aquifer are expected to be more naturally protected from contamination than other sources; however, waters from surface water and unconfined and/or semi-confined aquifers are generally expected to be more vulnerable.

Integrating Information on Potential Sources of PFAS into Priority-Setting

To identify the highest priority CWS that use surface and groundwaters from unconfined and semi-confined aquifers for monitoring, MDE considered the proximity, number, and type of potential sources of PFAS to these systems' untreated surface and groundwater sources. MDE mapped over 2,000 potential sources of PFAS in Maryland. The potential sources include military installations, fire training areas, airports, landfills, manufacturing facilities, and wastewater treatment plants. MDE then created a 1,000-foot buffer around each potential source of PFAS. If one or more of these 1,000-foot buffers intersected a CWS' source water protection area(s), then that CWS untreated source was considered as potentially at-risk for PFAS contamination. The number and types of PFAS sources intersecting with each CWS source protection area was recorded throughout this process. These potentially at-risk CWS sources were then correlated to which WTP they serve.

Based on these criteria, 129 CWSs WTPs were identified as the highest priority for initial finished drinking water sampling.

To determine where to sample first (i.e., which of the 129 CWSs WTPs to sample first), MDE further prioritized this list by assessing which PFAS sources presented a higher potential for PFAS release. For example, MDE believed that military installations, fire-training areas, or other types of sites with known historical usage of aqueous film forming foams could present a larger potential risk to drinking water sources than other potential PFAS sources. These 129 CWS WTPs treat approximately 230 raw water sources and provide treated waters to 59 CWS.

Reference Sites

In addition to the 131 initial finished water samples to be collected during Phase 1, MDE collected "baseline" samples from 11 WTPs serving CWS withdrawing from surface, unconfined, and semi-confined raw water sources to determine PFAS levels in locations not expected to have proximal PFAS sources. These reference sites are located in hydrologic unit code 12 (HUC-12) watersheds with 75% or more forested cover with no PFAS sources within 1,000 feet of their protection areas. HUC watersheds are delineated by the U.S>Geological Survey. HUC watersheds are a hierarchical system differentiated by the number of digits in groups of two (e.g., HUC-8, HUC-10, HUC-12). HUC-12 watersheds are local

sub-watershed level delineations. More information on HUC delineations can be found here: enviroatlas.epa.gov/enviroatlas/DataFactSheets/pdf/Supplemental/HUC.pdf .

Follow-Up Sampling and Corrective Actions

MDE developed and implemented a framework to guide its decisions as to additional sampling and corrective actions, based on initial finished water results.

This framework was developed using the EPA's HAL, MDE's regulatory procedures, and the potential for underreporting of PFAS during analysis. For this effort, MDE utilized the EPA's HAL of 70 ppt for total PFOA+PFOS concentration as an action level. If initial and follow-up samples measured PFOA+PFOS concentrations equal to or greater than 70 ppt, then MDE and the respective system would take a number of actions, which are outlined in Table 2. Using the general approach MDE has used in the past for responding to monitoring results for any compounds where an MCL exists, if initial and follow-up samples measured PFOA+PFOS concentrations between 35 ppt (half the action level) and 70 ppt, the system and MDE would take the actions outlined in Table 2. To account for analytical variability and the potential for underreporting of PFAS, MDE assumed a potential underreporting of 20% of PFAS during analysis. Due to this, if an initial finished water sample measured total PFOA+PFOS between 28 and 35 ppt, then a confirmed finished water sample would be collected from the water treatment plant (Association of State Drinking Water Administrators, 2021).

Initial Finished Water Concentration (IFWC) (PFOA+PFOS)	Actions taken by MDE	Actions taken by Water System
IFWC ≥ 70 ppt	System is notified of results. MDE requests the system to immediately take the impacted WTP offline if practicable until follow-up sampling (by MDE) can be conducted. MDE/MDH collected and tested confirmation finished water sample within seven days. MDE/MDH collected and tested sample(s) from respective untreated water source(s). Encourage water systems to submit results from any additional monitoring efforts.	System to issue Tier II Public Notification (PN) if results are confirmed. Take the impacted WTP offline (if feasible). ● If not feasible to keep the impacted WTP offline indefinitely, explore alternate options such as implementing treatment or alternate water sources. ● If WTP is taken offline, a system to plan how to address the elevated PFOA+PFOS concentrations. ● If sources are needed in the future, then the system should plan to implement proper treatment to ensure that PFOA+PFOS concentrations remain below the EPA's HAL of 70 ppt. ● Once treatment is in place, the system shall monitor the impacted WTP quarterly. If sources are not needed then the system should consider abandoning the source. Systems to collect and test additional samples throughout their distribution systems. Systems should also investigate potential sources of PFAS within their source protection area(s). Yearly monitoring should be conducted at all points of entry to the distribution system (if feasible).
35 < IFWC < 70 ppt	System is notified of results. MDE/MDH to collect and test the confirmation finished water sample. MDE/MDH to collect and test sample(s) from respective untreated water source(s).	Using the EPA SDWA general approach for monitoring results for compounds with MCLs, the system is required to conduct semi-annual monitoring at impacted WTP(s)(if feasible). System encouraged to conduct additional yearly monitoring at all points of entry to their distribution system (if feasible). Encouraged to share any results with MDE.
28 < IFWC < 35 ppt	System is notified of results. MDE/MDH to collect and test confirmation finished water samples because 28 ppt is within the range of analytical variability of 35 ppt.	If confirmed to be 28 ppt or less, encouraged to conduct yearly monitoring. (If follow-up monitoring is found to be 35 ppt to less than 70 ppt, using the EPA SDWA general approach for monitoring results for compounds with MCLs, the system is asked to conduct semi-annual monitoring at impacted WTP(s)(if feasible).

		System encouraged to conduct additional yearly monitoring at all points of entry to their distribution system (if feasible). Encouraged to share any results with MDE.
IFWC < 28 ppt	System is notified of results.	Encouraged to conduct yearly monitoring. Encouraged to share results with MDE.

Table 2: Follow-up actions taken by MDE and water systems, dependent upon initial finished water concentrations.

Sample Collection and Analysis

Once systems were notified that they were to be sampled in Phase 1, initial and confirmation finished water samples were collected at the identified WTPs' points of entry (POE) to each system's distribution system. When necessary, sampling of untreated sources took place at the respective well(s) being treated.

Sample Collection

Initial and confirmation finished water samples were collected at each of the identified WTPs POE to their system's distribution system. Untreated water samples were collected at the source. All untreated source water samples were collected at wells with raw taps. Samples were collected in 250-mL high density polypropylene bottles with polypropylene screw on caps and preserved with Trizma.

No untreated surface water samples were needed during Phase 1 as PFOA+PFOS levels in CWS relying on surface water sources did not exceed 28 ppt. If needed, then equipment blanks would be tested prior to sample collection of untreated surface water sources.

Sample Analysis

MDE collected and delivered samples to the MDH-LAto be tested under EPA Method 537.1. Table 3 below reports the Minimum Detection Limits (MDLs) and Minimum Reporting Levels (MRLs) that MDH-LA was able to achieve with each PFAS analyte. Developing these below 1 ppt MDLs took MDH-LA months of repeated work to get the MDLs to these low levels.

Analyte	Minimum Detection Limits (MDL) (ppt)	Minimum Reporting Level (MRL) (ppt)
PFBS	0.29	1.00
PFHxA	0.31	1.00
PFHpA	0.33	2.00
PFHxS	0.29	1.00
PFOA	0.30	1.00
PFNA	0.43	2.00
PFOS	0.27	2.00
PFDA	0.25	1.00
PFUdA	0.27	1.00
N-MeFOSAA	0.67	3.00
N-EtFOSAA	0.68	2.50

PFDoA	0.45	2.00
HFPO-DA ('GenX')	0.34	1.00
ADONA	0.30	1.00
9Cl- PF3ONS	0.34	2.00
11Cl-PF3OUdS	0.36	2.00
PFTrDA	0.53	2.00
PFTA	0.28	1.00

Table 3: MDLs and MRLs for the eighteen (18) PFAS listed under EPA Method 537.1. (Provided by the MDH Laboratories Administration- Division of Environmental Services.)

MDLs are determined by analyzing seven replicates at 1 ppt over three days following EPA Method 537.1, sec 9.2.8. MRLs are determined by analyzing seven replicates at the proposed MRL concentration following EPA Method 537.1, sec 9.2.6.

Field Reagent Blanks

Field Reagent Blanks (FRB) are an aliquot of reagent water that is placed in a sample container in the laboratory and treated as a normal sample from shipment to the sampling site, exposure to sampling site conditions, storage, preservation and analytical procedures. FRBs are used to determine if contaminating method analytes or other interferences are present in the field environment. All ~150 FRBs tested under Phase 1 had no detectable limits of PFAS.

Results: PFOA+PFOS

A total of 153 samples were tested under the first phase of the study. This number includes: initial finished water, confirmation finished water, untreated water, and reference site samples. Table 4 provides an overview of the initial finished water results from the 131 IIFWSs collected from the 129 CWS-WTPs. Full results tables can be found on MDE's Water Supply Program PFAS Webpage.

Action Level Thresholds Finished Water Concentrations PFOA+PFOS(ppt)	Number of IFWS	Number of CWSs*	Primary Water Source being Treated
≥70 ppt	2	2	Groundwater
35 ppt – 70 ppt	2	2	Groundwater
28 ppt – 35 ppt	1	1	Groundwater
10 ppt – 28 ppt	22	13	Groundwater/Surface Water
< 10 ppt	71	35	Groundwater/Surface Water
Non-Detect	33	30	Groundwater/Surface Water

Table 4: Overview of Phase 1 CWS-WTPs Initial Finished Water Results.

* The total for the "Number of CWSs" column does not add up to the total 59 CWSs previously mentioned. This is because a single CWS may have multiple WTPs falling within multiple action level threshold categories.

Table 5 below provides an overview of the findings for sampling conducted at initial, follow up, and reference sites.

PFOA+PFOS Concentrations (ppt) (x)	Initial Finished Water Concentration (# IFWS)	Confirmation Finished Water Concentrations (# CWS-WTP Samples)	Follow-Up Untreated Water Sample Concentrations (# Untreated Samples)	"Reference" Site Concentrations (#CWS-WTP Samples)
x = ND	33	-	-	11
x < 10	71	-	1	-
10 ≤ x < 28	22	2	1	-
28 ≤ x < 35	1	-	-	-
35 ≤ x < 70	2	1	1	-
x ≥ 70	2*	1	2	-
Total	131	4	5	11

Table 5: Phase 1 initial, follow up and reference sites' results overview for PFOA+PFOS.

*The City of Westminster (TCOW) submitted results from PFAS testing, which they undertook earlier in 2020, and shared with MDE on October 16, 2020. The results indicated levels of PFOS exceeding EPA's 70 ppt HAL. Upon receiving these results, MDE collected a finished water sample and a groundwater sample from the impacted WTP/well. MDE did not collect a confirmation finished water sample from this WTP because of the prior sampling by TCOW . This is explained further in section 3.4.1.

Appendix 1 outlines PFOA+PFOS detections in the initial samples collected during this Phase. In addition to these 131IFWSs, two untreated groundwater sources were collected from the Town of Hampstead. More information on these untreated groundwater samples is described below under the "*Town of Hampstead PFAS Test Results"* section. The results from these two untreated groundwater samples are not included in any of the finished water tables, figures, or percentages. These tables and figures reflect the finished drinking water sample results, unless stated otherwise.

If a water system's initial sample exceeded the thresholds discussed earlier in this report, then additional samples were collected from the system. Information for specific systems requiring additional sampling is discussed in the sections below.

Results: Systems with PFOA+PFOS in Initial Finished Water Samples greater than 70 ppt

Two CWSs were found to have PFOA+PFOS levels in initial finished water samples (IFWS) at concentrations greater than the 70 ppt EPA HAL. Those CWS-WTPs serve the City of Westminster and the Town of Hampstead.

City of Westminster PFAS Test Results

On October 16, 2020, MDE received from the City of Westminster results from previous PFAS testing, which indicated the presence of PFOS and PFHxS in their finished drinking water from TP06 (treating VoTech Well 8). In response to these results, MDE asked Westminster to take the source offline and prioritized sampling the system; MDE took samples at the Westminster CWS-WTPs on October 20. A

finished water sample and an untreated groundwater sample were tested from Votech Well 8. Results confirmed elevated levels of PFOA+PFOS in both the finished and source water. Table 6 summarizes MDE's findings from TP06: VoTech Well 8

Water Sample Type	**PFOA+PFOS Concentration (ppt)**
Finished Water Sample	154.96
Untreated Well 8	193.46

Table 6: Finished and Untreated Water Sample Results - City of Westminster TP06: VoTech Well 8

In response to these elevated levels of PFAS, MDE required the City of Westminster to take the following actions:

- Continue to keep the VoTech Well 8 offline until an alternate option is in place (i.e.,implementing proper treatment, acquiring an alternate water source to supplement demand, etc.)(if feasible).
- Issue a Tier II Public Notice (PN) to their impacted drinking water customers.
- In the event Well 8 is needed and treatment is in place, conduct quarterly monitoring at the treatment plant.
- Collect additional samples throughout the distribution system, including storage tanks.
- Conduct annual sampling at all POE to the distribution system (if feasible).
- Investigate potential source of PFAS existing in the Well 8's wellhead protection area.
- Continue to report any results collected from aforementioned monitoring and investigative measures.

At the time of this report's publication, Well 8 remains offline.

Finished water samples were collected from nine additional WTPs serving the City of Westminster (TP01, TP02, TP03, TP04, TP05, TP07, TP08, TP09, and TP10). PFAS were detected in these samples, but below the 28 ppt threshold for PFOA+PFOS.

Town of Hampstead PFAS Test Results

On November 4, 2020, MDE collected IFWSs from five Town of Hampstead WTPs: TP02, TP05, TP08, TP12, and TP13. Five additional finished water samples were collected the following week from: TP03, TP07, TP09, TP10, and TP11. On November 17, 2020, MDE received results from the Town's first set of finished water samples (i.e.,those collected the week of November 4. 2020). These results indicated elevated levels of PFOA+PFOS at TP08. MDE alerted the Town of these concentrations at TP08, and required the Town of Hampstead to shut off the WTP until follow-up sampling could be conducted on November 20. Table 7 below summarizes MDE's findings from sampling at TP08.

Water Sample Type	**PFOA+PFOS Concentration (ppt)**
IFWS	249.3
CFWS	240.37
Untreated Well 24	283.7
Untreated Well 25	9.42

Table 7: Finished and Untreated Water Sample Results - Town of Hampstead TP08: Wells 24 +25

In response to these elevated levels of PFAS, MDE required the Town of Hampstead to take the following actions:

- Continue to keep the WTP offline until an alternate option is in place (i.e.,implementing proper treatment, acquiring an alternate water source to supplement demand, etc.)(if feasible).
- Issue a Tier II Public Notice to their impacted drinking water customers.
- In the event that the wells are needed and treatment is in place, conduct quarterly monitoring at the treatment plant.
- Collect additional samples throughout the distribution system, including storage tanks.
- Conduct annual sampling at all POE to the distribution system (if feasible).
- Investigate potential source of PFAS existing in the Well 24's wellhead protection area.
- Continue to report any results collected from aforementioned monitoring and investigative measures.

Additional drinking water samples were collected from the Town's TP14, Well 33, and Well 36 on January 21, 2021, as a request by the Town. PFAS was not detected in Well 33, but was measured in the samples from TP14 and Well 36 at levels below MDE's action levels.

At the time of this report's publication, TP08 remains offline, and the Town is exploring treatment options to bring the plant back online to supplement water demand.

Results: Systems with PFOA+PFOS in Initial Finished Water Samples between 35 and 70 ppt.

Two CWS—in the towns of Thurmont and Poolesville were found to have IFWSs for PFOA+PFOS between 35 ppt and 70 ppt. These samples were collected from the Town of Thurmont's TP06 and the Town of Poolesville's TP03. MDE has established 35 ppt of PFOA+PFOS combined as a value that triggers semi-annual monitoring. Although there are no current SDWA MCLs for PFOA+PFOS, MDE has used the SDWA approach for the triggering of semi-annual monitoring. This approach requires semiannual monitoring when measured concentrations are found to be present in concentrations of 50% or more of the MCL. Since the EPA HAL for PFOA+PFOS is 70 ppt, MDE chose to establish 35 ppt combined levels of PFOA+PFOS as the trigger level for semi-annual monitoring.

Town of Thurmont PFAS Test Results

The Town of Thurmont's TP06, which treats the Town's Well 8 had measured PFOA+PFOS concentrations above the 35 ppt threshold,but below the 70 ppt action level. Based on MDE's response protocol, a CFWS and untreated water sample were collected from the Town's TP06. Table 8 below outlines the results from this sampling.

Water Sample Type	**PFOA+PFOS Concentration (ppt)**
IFWS	46.9
CFWS	45.5
Untreated Well 8	46.85

Table 8: Initial and Follow-Up sampling results - Town of Thurmont TP06 (Well 8)

Two other IFWSs were collected from the Town of Thurmont (TP03, TP05). These samples measured below the 28 ppt threshold for PFOA+PFOS. The system has been notified of their results and as requested by MDE, are planning to semi-annually monitor for PFAS at TP06.

Town of Poolesville PFAS Test Results

The Town of Poolesville's TP03, which treats the Town's Well 3, had measured PFOA+PFOS concentrations between 35 and 70 ppt. Based on MDE's response protocol, aCFWS and untreated water samples were collected from the Town's TP03. Table 9 below outlines the results from this sampling.

Water Sample Type	PFOA+PFOS Concentration (ppt)
IFWS	38.24
CFWS	25.42
Untreated Well 3	24.26

Table 9: Initial and Follow-Up Sampling Results - Town of Poolesville TP03 (Well 3)

Seven other IFWSs were collected from the Town of Poolesville (TP05, TP06, TP08, TP10, TP11, TP12, and TP13). These samples were all below the 28 ppt threshold for PFOA+PFOS. The variability in results seen between the initial and confirmation finished water samples was unexpected. As a result and out of an abundance of caution, MDE has requested and the system plans to monitor PFAS at this location semiannually.

At the time of this report's publication, one of the Town's WTPs (TP02) is currently offline. MDE plans to coordinate with the Town to collect samples at this location once it is in operation.

Ten additional IFWSs were collected from the Town: TP02, TP03, TP05, TP07, TP09, TP10, TP11, TP12, TP13, and TP14. PFAS were detected in these samples, but below the 28 ppt threshold for PFOA+PFOS. In addition to these IFWSs, MDE collected two additional untreated groundwater samples from Wells 33 and 36 as the Town is planning on bringing these sources online. PFAS were not detected in Well 33. Some PFAS were detected in Well 36, but below the 28 ppt threshold.

Results: Systems with PFOA+PFOS in Initial Finished Water Samples between 28 and 35 ppt

One CWS—in the Town of Elkton –was found to have PFOA+PFOS in an IFWS at levels greater than 28 ppt but less than 35 ppt. As a result, MDE took a CFWS from the Town's WTP to confirm that the level of PFOA+PFOS in their finished water is below 35 ppt. Table 10 indicates the levels of PFOA+PFOS in the Town of Elkton's TP02.

Finished Water Sample Type	PFOA+PFOS Concentration (ppt)
IFWS	29.78
CFWS	27.22

Table 10: Initial and Confirmation Finished Water Sample Results from the Town of Elkton's TP02.

Four additional IFWS were collected from the Town. These levels were all below the 28 ppt threshold. Since collection and analysis, the Town has been informed of their results and encouraged to conduct yearly monitoring at their TP02.

Results: Systems with PFOA+PFOS in Initial Finished Water Samples Less Than 28 ppt

Fifty four of the 59 CWS tested in Phase 1 (91.5% of the tested CWS) had IFWSs that contained PFOA+PFOS combined at concentrations below 28 ppt.

MDE established 28 ppt as a threshold concentration for the triggering of additional actions (i.e verification sampling to ensure that the actual concentrations of PFOA+PFOS in finished water were not at 35 ppt or greater). At the time of publication, these systems have been notified of their results. MDE has encouraged systems with measurable PFOA+PFOS levels (confirmed to be below 28 ppt combined) to continue to monitor for PFAS at their WTPs and report any further findings.

Results: Other PFAS Measured during Phase 1

In addition to PFOA+PFOS, other PFAS were detected intermittently throughout the study. Other PFAS detected include: PFBS, PFDA, PFHpA, PFHxS, PFHxA, and PFNA. Table 11 below outlines the percent detection of these compounds for all 153 water samples collected.

PFAS	Number of Samples Detected	Total Number of Samples*	Percent Detection (%)	Range of Detections (ppt) in Initial Finished Water Sample
PFBS	98	153	64.05	1.08 – 21.29
PFDA	1	153	0.65	1.08 – 1.08
PFHpA	40	153	26.14	2.00 – 12.30
PFHxS	74	153	48.37	1.00 – 123.18
PFHxA	93	153	60.78	1.06 – 25.95
PFNA	7	153	4.58	2.27 – 10.16
PFOS	62	153	40.52	2.05 – 235
PFOA	106	153	69.28	1.02 – 23.98

Table 11: Percent Detection and Range of Detections for Other PFAS Measured during Phase 1

* 153 samples were collected in total under Phase 1. This number includes initial and confirmatory finished water samples, untreated groundwater samples, and samples collected at the study's 11 reference sites.

Currently no further action is being required when PFAS besides PFOA+PFOS are found. Once the EPA completes their toxicity assessment for seven additional PFAS (by 2023), MDE will review these data

relative to EPA's toxicity assessments and take further action as needed. As more toxicological information is published for these additional PFAS, MDE may need to revisit systems having quantifiable levels of these other PFAS and require additional actions as needed.

Conclusions: Phase 1 Public Water System Study

One of the primary goals of this initial sampling effort was to identify and reduce unacceptable PFAS exposure risk by assessing the occurrence of PFOA+PFOS in those CWS that MDE identified as having the highest relative risk. Other objectives of the study included obtaining information to better understand what PFAS are present in CWS in Maryland, at what concentrations, and in what locations. Key conclusions from this study are included below. These conclusions are based on 1) the initial finished water concentrations from the 131 initial finished water samples tested, and 2) total concentrations of PFOA+PFOS.~75% of IFWSs tested had quantifiable levels of PFOA+PFOS (98 IFWSs).

- ~96% of IFWSs tested had less than 28 ppt combined PFOA+PFOS concentrations, which is well below the EPA HAL of 70 ppt (126 IFWSs).
- ~25% of the IFWSs tested did not detect PFOA+PFOS (33 IFWSs).
- Only one1 IFWS measured PFOA+PFOS between 28 ppt and 35 ppt (~0.76% of all IFWSs)
- Only two IFWSs measured PFOA+PFOS between 35 and 70 ppt (~1.5% of all IFWSs).
- Only two IFWSs measured PFOA+PFOS greater than 70 ppt (~1.5% of all IFWSs)
- All CWS-WTPs with combined PFOA+PFOS levels above 28 ppt treated groundwater sources.
- PFOA+PFOS were not detected in any of the study's reference sites.

Additional conclusions can be made about the 18 PFAS compounds monitored under Phase 1 (not just PFOA+PFOS). These conclusions are listed below and are based on the initial finished water samples tested (i.e.,total of 131 IFWSs).

- ~77% of all IFWSs had quantifiable levels of one or more of the 18 measured PFAS compounds in finished water (i.e.,101 IFWSs).
- ~1.5% of IFWSs measured total PFAS levels over 300 ppt (i.e.,2 IFWSs).
- ~7.6% of IFWSs tested measured total PFAS between 35 and 100 pptt (i.e.,10 IFWSs).
- ~32% of IFWSs tested measured total PFAS between 10 and 35 ppt (i.e.,42 IFWSs).
- ~35% of IFWSs tested measured quantifiable levels of total PFAS between the limits of detection and 10 ppt (i.e.,47 IFWSs).
- ~22% of the IFWSs did not detect any PFAS when tested (i.e.,30 IFWSs).
- No new PFAS (i.e.,GenX and ADONA) were measured in any of the 153 total water samples tested.
- In addition to the 30 IFWSs previously mentioned, no PFAS compounds were detected at the study's 11 reference sites.

Completion of Phase 1 of the PFAS study provides important information on the prevalence of PFAS in Maryland drinking water and drinking water sources, and insights into where PFAS is most likely to be found.

Based on the overall results of 96% of IFWSs tested (serving a total of 4.26 million people) being below the 28 ppt PFOA+PFOS threshold MDE has set as a trigger level for further monitoring, we can cautiously

draw a conclusion that the vast majority of CWS in Maryland do not appear to be impacted by levels of PFOA+PFOS above the EPA HAL of 70 ppt.

It is also worth noting that the CWS with the highest concentrations of PFOA+PFOS appear to be mostly in the areas west of I-95/fall line in the Piedmont and Fractured rock formation/aquifers where groundwater is more susceptible to contamination. This theory does, however, require additional investigation. For example, while PFAS compounds were not detected in Harford County DPW's finished water from their Perryman WTP, the groundwater from these coastal plain wells is treated with activated carbon. Further sampling at these and other wells within the coastal plain is needed to better understand PFAS presence in the eastern regions of the State.

Additionally, having approximately 75% of all initial finished water samples tested with quantifiable levels of PFAS suggests that PFAS use and/or disposal is resulting in the movement of PFAS into drinking water in Maryland. It also appears that PFAS in Maryland's drinking water is not impacted by newer PFAS technologies such as GenX and ADONA. GenX and ADONA were not detected in any of the water samples analyzed during Phase 1. This is something MDE will continue to monitor as it proceeds with additional CWS sampling.

In general, Phase 1 results suggest that further investigation is necessary. As a result, MDE is initiating an expanded second phase of sampling, focusing on additional CWSs located proximate to potential sources of PFAS release as well as areas identified from the first phase of PFAS sampling that merit further consideration. In addition, MDE and MDH will discuss an outreach and communications strategy focused on providing information about PFAS to the public and in particular to health care providers who may be asked about PFAS risks.

Works Cited

Association of State Drinking Water Administrators (ASDWA). "Per- and Polyfluoroalkyl Substances (PFAS) Laboratory Testing Primer for State Drinking Water Programs and Public Water Systems." *Per- and Polyfluoroalkyl Substances (PFAS),* ADWA, Feb. 2021, asdwa.org/pfas/.

"EPA Takes Action to Address PFAS in Drinking Water." EPA, Environmental Protection Agency, 22 Feb. 2021, epa.gov/newsreleases/epa-takes-action-address-pfas-drinking-water.

ITRC "PFAS - Per- and Polyfluoroalkyl Substances." *PFAS Per and Polyfluoroalkyl Substances*, Interstate Technology Regulatory Council, Sept. 2020, pfas-1.itrcweb.org/.

EPA. *Fifth Unregulated Contaminant Monitoring Rule*, United States Environmental Protection Agency, 11 Mar. 2021, epa.gov/dwucmr/fifth-unregulated-contaminant-monitoring-rule.

EPA. *PFOA & PFOS Drinking Water Health Advisories*. US Environmental Protection Agency, Nov. 2016, https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos.

EPA. "Third Unregulated Contaminant Monitoring Rule." *Monitoring Unregulated Drinking Water Contaminants*, United States Environmental Protection Agency, 9 Dec. 2016, www .epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule.