Maryland Department of the Environment (MDE) Public Water System (PWS) Study for Per- and Polyfluoroalkyl Substances (PFAS) in State Drinking Water Sources – Phase 2

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List of Acronyms

11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid
ADONA	4,8-dioxa-3H-perfluorononanoic acid
ATSDR	Agency for Toxic Substances and Disease Registry
CWS	Community Water System
EPA	Environmental Protection Agency
FRB	Field Reagent Blank
HAL	Health Advisory Level
HFPO-DA	Hexafluoropropylene oxide-dimer acid (aka 'GenX')
IGWS	Initial Groundwater Sample
IPOE	Initial Point of Entry Sample
IWS	Initial Water Sample
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDE	Maryland Department of the Environment
MDH-LA	Maryland Department of Health - Laboratories Administration
MDH-MRLs	MDH Minimal Reporting Levels
MDL	Minimum Detection Limits
N-EtFOSAA	N-ethyl perfluorooctanesulfonamidoacetic acid
N-MeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid
NPDWR	National Primary Drinking Water Regulations
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutyrate
PFBS	Perfluorobutanesulfonic acid
PFDA	Perfluorodecanoic acid
PFDoA	Perfluorododecanoic acid
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PFTA	Perfluorotetradecanoic acid
PFTrDA	Perfluorotridecanoic acid
PFUnA	Perfluoroundecanoic acid
ppt	Parts Per Trillion
PWS	Public Water System
SAB	Scientific Advisory Board
UCMR3	Third Unregulated Contaminant Monitoring Rule
WTP	Water Treatment Plant

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Executive Summary

PFAS (Per- and polyfluoroalkyl substances) are a group of human-made chemical compounds that include Perfluorooctanoic Acid (PFOA or 'C8'), Perfluorooctanesulfonic Acid (PFOS), Hexafluoropropylene Oxide Dimer Acid (HFPO-DA or 'Gen-X') and over 9,000 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, and food packaging coatings.

In late 2019, the Maryland Department of the Environment (Department or MDE) began to increase its efforts to better understand, communicate, and reduce PFAS risks in Maryland through the implementation of MDE's multi-phased approach to assessing PFAS in drinking water sources across the state. Phase 1 of this effort spanned from September 2020 to February 2021. The report and results from this phase are available on MDE's PFAS webpage. As a result of the findings of Phase 1, MDE continued with Phase 2 of its Public Water System (PWS) study from March through May 2021. This report summarizes the results collected under Phase 2 of MDE's PWS study for the occurrence of PFAS in state drinking water sources.

Currently, there are no National Primary Drinking Water Regulations (NPDWR) for PFAS in drinking water. However, the U.S. Environmental Protection Agency (EPA) issued a Health Advisory Level (HAL) for PFOA+ PFOS. MDE is currently using this HAL as its primary action level threshold until a Maximum Contaminant Level (MCL) is formally adopted by the EPA. Additionally, the EPA is moving forward with regulating PFOA and PFOS in drinking water. In November 2021, the EPA forwarded several documents to its Scientific Advisory Board (SAB) to review as it progresses with setting NPDWRs for PFOA and PFOS. These documents include draft frameworks for developing Maximum Contaminant Level Goals (MCLGs) for PFOA and PFOS, and other human health related information. The EPA indicated that an updated HAL may be in place by fall 2022.

During Phase 2 of MDE's study, 167 initial water samples (IWS) were collected. Whenever possible, these initial samples consisted of untreated groundwater; however, discrete sampling of untreated water sources was not always possible. Under Phase 2, 159 initial groundwater samples (IGWS) and eight (8) initial point of entry (IPOE) samples were collected. Point of entry, here, refers to the location where treated water enters a water system's distribution system. The sources from which these samples were drawn provide drinking water to 65 community water systems (CWS). All samples were tested for 18 PFAS under EPA Method 537.1 by the Maryland Department of Health Laboratories Administration (MDH-LA). Under Phase 2, approximately 14% of Maryland's federally regulated CWSs were monitored. The 65 CWSs tested under Phase 2 provide drinking water to approximately 81,000 people (or about 1.3% of Maryland's population). Between the sampling conducted under phases 1 and 2, MDE has tested drinking water for PFAS in water that is provided to over 70% of the population of Maryland.

The 167 IWS tested under Phase 2 were identified by MDE as being the next priority group for sampling after the Department's completion of Phase 1 sampling. Phase 2 IWS were selected based on:

- Consumer potential for long term exposure to PFAS (if present) (i.e., CWS customers);

- Drinking water source water vulnerabilities (e.g., surface waters, and groundwater from unconfined and semi-confined aquifers).
- Interest by MDE in confirming that groundwater from confined aquifers is less likely to be impacted by PFAS; and
- Proximity and relative risk to potential PFAS sources (i.e., CWS source water is located within 1 mile of one or more potential sources of PFAS).

Of the 167 IWS tested under Phase 2, 26 of these samples withdraw groundwater from confined aquifers. In general, the confining units of clay associated with confined aquifers are thought to provide a level of natural protection to the groundwater within them. In comparison to groundwater from unconfined and semi-confined aquifers, groundwater within confined aquifers is less likely to be impacted by external influences, including PFAS. MDE selected these 26 sites to obtain some data in order to test the hypothesis that PFAS should not be present in confined aquifers. The remaining 141 IWS were collected from wells or springs that withdraw water from unconfined and/ or semi-confined aquifers. Table 1 describes these three aquifer types.

Aquifer Type	Description
Confined	An aquifer below the land surface that is saturated with water with layers of impermeable material above and below the aquifer
Semi-Confined	An aquifer that is partially overlain by a rock formation, which has low permeability, through which water can pass only slowly to recharge the aquifer
Unconfined	An aquifer which is not overlain by a confining layer, but has a confining layer at its bottom

Table 1: Aquifer descriptions

Depending on concentrations of PFOA+ PFOS measured in the IWS, certain actions - such as additional monitoring and reporting - may have been needed to be taken by MDE or an impacted water utility. A full list of actions to be taken by MDE and/or impacted water utilities depending on initial concentrations of PFOA and PFOS can be found in the “Monitoring Approach'' section of this report.

MDE staff intended on collecting one unfinished groundwater sample from each untreated water source. However due to the water treatment plant design of certain systems, discrete sampling of individual groundwater sources was not always possible. Due to this, in certain instances, an untreated, combined sample consisting of two or more groundwater sources or an initial point of entry (IPOE) sample was collected. The corresponding Phase 2 results table (Appendix A) denotes which initial samples contain water from individual or combined unfinished groundwater sources. The table also denotes which samples were IPOE samples.

Table 2 below outlines the number of IGWS and IPOE samples collected from both unconfined and semi confined and confined aquifer sources and their ranges of detection for PFOA+ PFOS.

Sample Type	Number of Samples Collected	Range of detection for PFOA+ PFOS
IGWS withdrawing from an unconfined or semi-confined aquifer	137	ND – 36.92
IGWS withdrawing from a confined aquifer	22	Non-Detect (ND)
IPOE withdrawing from an unconfined or semi-confined aquifer	4	ND - 28.20
IPOE withdrawing from a confined aquifer	4	ND

Table 2: Overview of range of detections for PFOA and PFOS based on sample type.

Of the 137 IGWS withdrawing from an unconfined or semi-confined aquifer:

- 71 IGWS measured quantifiable levels of PFOA+ PFOS (~51.82%)
- 66 IGWS did not detect PFOA+ PFOS (~48.18%)
- One (1) IGWS measured quantifiable levels of PFOA+ PFOS between 35 and 70 ppt (~0.73%)
- One (1) IGWS measured quantifiable levels of PFOA+ PFOS between 28 and 35 ppt (0.73%)
- 13 IGWS measured quantifiable levels of PFOA+ PFOS between 10 and 28 ppt (9.49%)
- 56 IGWS had detectable levels of PFOA+ PFOS, but were below 10 ppt (40.88%)

Two (2) out of the four (4) IPOE samples withdrawing from an unconfined or semi-confined aquifer did not detect PFAS. The two (2) IPOE samples with detectable limits of PFOA+ PFOS are listed below:

- (MD0220204) Gateway Village M.H.P.: PFOA+ PFOS = 28.2 ppt
- (MD0120210) R&R Estates: PFOA+ PFOS = 8.02 ppt

PFOA, PFOS, and the other 16 PFAS monitored were not detected in any of the IPOE or IGWS withdrawing from confined aquifers. Additionally, no samples under Phase 2 measured PFOA+ PFOS above the EPA HAL of 70 ppt.

Due to PFOA+ PFOS being detected in a little over 50% of the IGWS and IPOE samples withdrawing from unconfined and semi-confined aquifers, MDE plans to continue monitoring of additional CWS. Results from this next phase (Phase 3), and its corresponding report are expected to be published in late 2022/early 2023.

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 EPA moves forward to issue final MCLs or new HALs, MDE will take additional actions as needed to reduce 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

PFAS (Per- and polyfluoroalkyl substances) are a group of human-made chemical compounds that include Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic Acid (PFOS), Hexafluoropropylene Oxide Dimer Acid (HFPO-DA or 'Gen-X') and over 9,000 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 and food packaging coatings.

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). 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, PFBS, and HFPO-DA), while at least five other PFAS (PFBA, PFHxS, PFHxA, PFNA, and PFDA) are still undergoing toxicological assessments by the U.S. Environmental Protection Agency (EPA).

Continuing the drinking water initiatives started in 2020, the Maryland Department of the Environment (Department or MDE) leads an integrated, multi-agency effort to better understand the presence of PFAS in finished drinking water and drinking water sources across Maryland. In the second phase (Phase 2) of this study, MDE continued its partnership with the Maryland Department of Health Laboratories Administration (MDH-LA) to test the occurrence of PFAS in 167 initial water samples (IWS) from 65 community water systems (CWSs) across the state from March 2021 to May 2021. These drinking water sources were selected based on their geological setting and proximity to potential sources of PFAS. This report presents the results of the completed Phase 2 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 topics is rapidly evolving and improving both at the state and federal levels. 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 about their potential negative impacts on the immune system, liver, endocrine system and reproductive system. Exposure to PFAS can potentially occur through many routes, including drinking water, through ingestion of certain foods, through inhalation, and by ingestion of breast milk. However, our understanding of the health effects of many PFAS is still very limited. The uncertainty about the health effects of many PFAS means that conversations between healthcare 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.

While initial PFAS work was primarily fueled by federal initiatives such as the Third Unregulated Contaminant Monitoring Rule (UCMR3), MDE has made substantial progress on integrating PFAS management into a number of the programs. Additional information concerning MDE's previous drinking water work can be accessed on the Department's PFAS webpage.

Monitoring Approach

In March 2021, MDE initiated the second phase of its PWS study to evaluate the occurrence of PFAS in drinking water. During this phase, a total of 167 initial water samples (IWS) were collected and tested for the 18 PFAS analytes listed under EPA Method 537.1 by MDH-LA. These drinking water sources provide drinking water to 65 CWSs. Collectively, these 65 CWS provide drinking water to approximately 81,0000 people, or approximately 1.3% of Marylanders.

One hundred and forty-one (141) of the 167 sites were identified by MDE using readily available information to identify drinking water sources that may be at a higher relative risk for PFAS. Relative risk during this study is defined as a combination of the estimated degree of threat (i.e., proximity of potential PFAS sources to drinking water supplies), drinking water source 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: Groundwater Samples from Unconfined and Semi-Confined Aquifers

Due to the large number of people served by CWS and PFAS risk assessments associated with chronic oral ingestion (i.e., drinking PFAS-containing water), MDE chose to maintain its focus on CWS for Phase 2. Additionally, due to the detections found during Phase 1, MDE chose to maintain its focus on drinking water being withdrawn from unconfined and/or semi-confined aquifers. To assess the proximity of drinking water supplies to potential sources of PFAS, MDE expanded its PFAS search radius from 1,000 feet (i.e., as seen in Phase 1) to 1 mile.

The Phase 2 groundwater sources were selected based on the following factors:

- Resident potential for long term exposure to PFAS if present (i.e., residents served by CWS).
- CWS source water vulnerabilities (i.e., groundwater from unconfined and/or semi-confined aquifers); and
- Proximity to potential PFAS sources (i.e., CWS drinking water source is located within *1 mile* of one or more potential sources of PFAS).

Under Phase 2 of this study, a total of 141 of the 167 IWS consist of groundwater withdrawn from an unconfined or semi-confined aquifer. Of these 141 IWS, 137 are initial groundwater samples (IGWS) and four (4) are initial point of entry (IPOE) samples. These drinking water sources provide drinking water to 58 CWS. These 58 CWSs provide drinking water to approximately 39,136 Marylanders. Three additional CWS – the Town of Chestertown, Town of Hurlock, and Walston Mobile Home Park (MHP) - utilize both unconfined and confined sources of drinking water. These three systems provide drinking water to an additional 7,715 Marylanders.

Select Sampling of Groundwater Sources Withdrawing from Confined Aquifers

In addition to the selection criteria listed above, 26 of the 167 IWS were collected, consisting of groundwater withdrawn from confined aquifers. In addition to the Town of Chestertown, Town of Hurlock, and Walston MHP, these sources provide drinking water to an additional four (4) CWSs and are in close proximity to potential sources of PFAS. These 4 additional CWS provide drinking water to approximately 34,231 Marylanders. These samples were collected to test MDE's hypothesis that groundwater within confined aquifers is more "naturally protected" from external influences (i.e., PFAS)

than their unconfined and semi-confined counterparts. Due to this, MDE believes that PFAS should not be present in these confined groundwater sources. Table 3 below outlines information pertaining to these 26 IWS.

System Number	System Name	Number of IWS Collected (withdrawn from a confined aquifer)	Population Served	Comments	IGWS or IPOE Sample*
MD0020042	U.S. NAVAL ACADEMY	2	8,700	Close proximity to potential sources of PFAS	IGWS
MD0080058	NAVAL SUPPORT FACILITY, INDIAN HEAD	3	3,321	Close proximity to potential sources of PFAS	IPOE
MD0180022	PATUXENT NAVAL AIR STATION (NAVFAC-WASH)	16	22,000	Close proximity to potential sources of PFAS	IGWS
MD0140002	CHESTERTOWN	2	5,400	Close proximity to potential sources of PFAS; other unconfined samples scheduled to be collected from system	IGWS
MD0090005	TOWN OF HURLOCK	1	2150	Close proximity to potential sources of PFAS; other unconfined sample scheduled to be collected from system	IGWS
MD0220216	CEDARHURST MOBILE HOME PARK	1	220	Close proximity to potential sources of PFAS; other unconfined samples scheduled to be collected from system but offline at time of sample collection	IPOE
MD0220217	WALSTON MHP	1	165	Close proximity to potential sources of PFAS; other unconfined samples scheduled to be collected from system	IGWS

Table 3: Systems withdrawing from confined aquifers monitored under Phase 2.

* Discrete sampling of MD0080058 unfinished water sources was not possible. As a result, MDE field staff collected initial point of entry samples (IPOE) from each of the systems water treatment plants active at the time of sample collection.

Follow-Up Sampling and Corrective Actions- Total PFOA+ PFOS

Depending on the concentrations of PFOA+ PFOS, additional action may have been needed at a particular CWS. Similar to MDE's response process under Phase 1, MDE continued to implement certain actions should IWS results exceed 28, 35, or 70 parts per trillion (ppt) for Total PFOA+ PFOS concentrations. Table 4 summarizes the actions to be taken by MDE at an impacted utility should their IWS results exceed one of these thresholds.

Thresholds PFOA+ PFOS Concentrations (ppt)	**MDE Action(s) - after receipt of initial results**	**Utility Action(s) – after results received**
28 ppt	Collect and test confirmation finished and unfinished water samples (if feasible) *	- Encouraged to conduct yearly monitoring - Encouraged to share results with MDE
35 ppt	Collect and test confirmation finished and unfinished water samples (if feasible) *	- (If feasible) Conduct semi-annual monitoring at impacted Water Treatment Plant (WTP) - (If feasible) Conduct yearly sampling at other POEs - Encouraged to share results with MDE
70 ppt	Request impacted WTP/ source taken offline Collect and test confirmation finished and unfinished water samples (if feasible) *	- Issue Tier II Public Notification - (If feasible) system to take impacted WTP offline - (If source is needed and feasible) explore treatment options or acquiring alternate water sources - (If treatment installed and feasible) conduct quarterly monitoring - Encouraged to share results with MDE

Table 4: MDE's response to exceedances of certain thresholds for PFOA + PFOS

* Collecting follow-up finished and unfinished water samples may not always be feasible. Feasibility is determined by system design, activity status of drinking water sources, and other factors.

Follow-Up Sampling: Results for Individual PFAS Exceeding 10 ppt

In addition to the thresholds mentioned above, MDE implemented a threshold concentration that would trigger verification sampling whenever any individual PFAS measured above 10 ppt. In the event that any one (1) of the 18 PFAS analyzed were detected at 10 ppt or higher, MDE scheduled follow up sampling and testing of the respective drinking water source. During these follow-up sampling events, a repeat sample was collected at the respective sampling location alongside a field blank. Under Phase 2, field blanks were not collected with every investigative sample to increase analytical capacity. In the future as the EPA moves forward to establish NPDWRs for PFOA, PFOS, or other PFAS, MDE intends to use these data to help determine the need for any corrective actions at water utilities. Additional information on field blanks and their use during Phase 2 can be reviewed in the "Field Reagent Blanks," section later in this document.

Sample Collection and Analysis

MDE field staff intended on collecting one unfinished groundwater sample from each untreated water source. However, due to the water treatment plant design of certain systems, discrete sampling of individual groundwater sources was not always possible. Due to this, in certain instances, an untreated, combined sample consisting of two or more groundwater sources or an initial point of entry (IPOE) sample was collected. The corresponding Phase 2 results table (Appendix A) denotes which initial samples contain water from individual or combined unfinished groundwater sources. The table also denotes which initial samples were point of entry samples.

Samples were collected in 250-mL high density polypropylene bottles with polypropylene screw on caps and preserved with Trizma. Samples were collected at a rate of 24 sites per week. IGWS were collected at the system's untreated water taps. In the event follow-up sampling of finished drinking water was needed, a sample was collected at the system's respective water treatment plant (WTP) POE.

Sample Analysis

MDE collected and delivered samples to the MDH-LA to be tested under EPA Method 537.1. Appendix B contains the Minimum Detection Limits (MDLs) and Minimum Reporting Levels (MDH-MRLs) MDH-LA was able to achieve for each PFAS analyte. Developing these sub-1 ppt MDLs took MDH-LA months of repeated work to achieve.

Field Reagent Blanks

Field Reagent Blanks (FRB) are aliquots of reagent-grade water that originate in the laboratory and are transferred to sample bottles immediately prior to sample collection. FRB are treated as a normal sample during shipment to the sampling site, exposure to sampling conditions, storage, preservation, and analytical procedures. FRBs are used to determine if contaminating method analytes or other interferences are present in the field environment.

Under Phase 1, an FRB was collected alongside each finished drinking water sample collected. PFAS were not detected in any of the FRBs collected under Phase 1, raising confidence that PFAS contamination due to sampling procedures is a rare, or non-existent, event. Under Phase 2, FRBs were not collected with every IWS as a means to increase analytical capacity and preserve resources.

FRBs were collected for one of three reasons.

The first purpose for collecting an FRB was as a random quality check. The frequency of when such spot tests would occur was dictated by when the sampling schedule of 24 sites per week (set by MDH-LA) could not be met. For example, in some instances, previously scheduled groundwater sources may not have been in service at the time of sample collection. During these cases, a supplemental FRB was collected in its place. In other instances, the 24-sample site per week threshold could not be met due to scheduling conflicts. During these instances, an FRB was collected alongside other groundwater samples. A total of five (5) supplemental FRBs were collected under Phase 2. PFAS was not detected in any of these FRBs.

The second purpose for collecting an FRB was for potential follow up sampling events. In the event that an IWS measured any individual PFAS greater than 10 ppt, MDE would schedule that source to be resampled alongside an FRB. This process is summarized below:

- MDE Field Services Program collects IWS from one (1) of the 167 Phase 2 sites;
- MDH-LA analyzes IWS and reports results back to MDE;
- If results indicated that one (1) of the 18 PFAS analytes monitored was detected at a concentration greater than 10 ppt, MDE would schedule resampling of the groundwater source along with the collection of an FRB and submit both for analysis; and
- MDH would analyze and report the follow up sampling to MDE.

A total of seven (7) 10 ppt follow up FRBs were analyzed. PFAS was not detected in any of these FRBs.

The third instance FRBs collection occurred was during any necessary finished water collections. In the event an IWS exceeded the 28 ppt threshold for PFOA+ PFOS, MDE scheduled the impacted groundwater source and its corresponding WTP to be sampled. During these events, one (1) groundwater sample, one (1) finished water sample, and one (1) FRB sample were collected, when feasible. A total of three (3) drinking water FRBs were analyzed. PFAS was not detected in any of these FRBs.

MDE concurred with MDH-LA's recommendation to collect FRBs only in the event of one (1) of the three (3) scenarios described above to allow for quicker completion of Phase 2.

Equipment Blanks

Equipment blanks are collected by pouring analyte free (i.e., PFAS-free) water over and/or through decontaminated field sampling equipment prior to the collection of environmental samples. Equipment blanks assess the adequacy of equipment decontamination and potential cross-contamination of sampling equipment. Under Phase 2, one (1) equipment blank was collected at Rocky Gap Mobile Home Park (MD0010215) to assist with sample collection from the system's well #3. PFAS were not detected in the equipment blank sample.

Results: Total PFOA+ PFOS Concentrations

Under Phase 2, MDE and MDH collected and analyzed IWS from 167 sites. MDE field staff intended to collect one (1) unfinished groundwater sample from each of these sites. However, due to WTP design, this was not always feasible. Due to this, a combined unfinished water sample (i.e., consisting of two or more drinking water sources) or IPOE sample was collected in some instances as denoted in Appendix A.

One (1) groundwater sample was collected from each well, and depending on the initial groundwater concentration, follow up sampling and analysis may have been warranted. Table 5 below provides an overview of the study results. None of the 167 IGWS, or follow up samples, measured PFOA+ PFOS greater than the EPA's Health Advisory of 70 ppt.

Concentration of PFOA+ PFOS in ppt (ppt) (x)	Number of Initial Groundwater Samples (IGWS)	Number of Initial Point of Entry Samples (IPOE)	Number of Repeat Unfinished Groundwater Samples	Number of Follow-Up POE Samples
X = ND	87*	6**	---	---
X < 10	56	1	3	---
10 ≤ X < 28	13	--	3	---
28 ≤ X < 35	1	1***	--	1***
35 ≤ X < 70	1	--	2	2
X ≥ 70	---	--	---	---
Total Number of Samples	159	8	8	3

Table 5: Overview of Phase 2 Results

* This number includes the 22 IGWS withdrawing from confined aquifers – all of which did not detect PFOA, PFOS, or any of the other PFAS when tested.

** 4 of the IPOE samples collected consist of groundwater from a confined aquifer– all of which did not detect PFOA, PFOS, or any of the other PFAS when tested.

*** This number represents a sample collected from Gateway Village Mobile Home Park's common header, consisting of groundwater from wells 1 and 2. For this report, these samples will be referred to as POE samples.

Figure 1 below stratifies results of PFOA+ PFOS across the sites sampled during this phase.

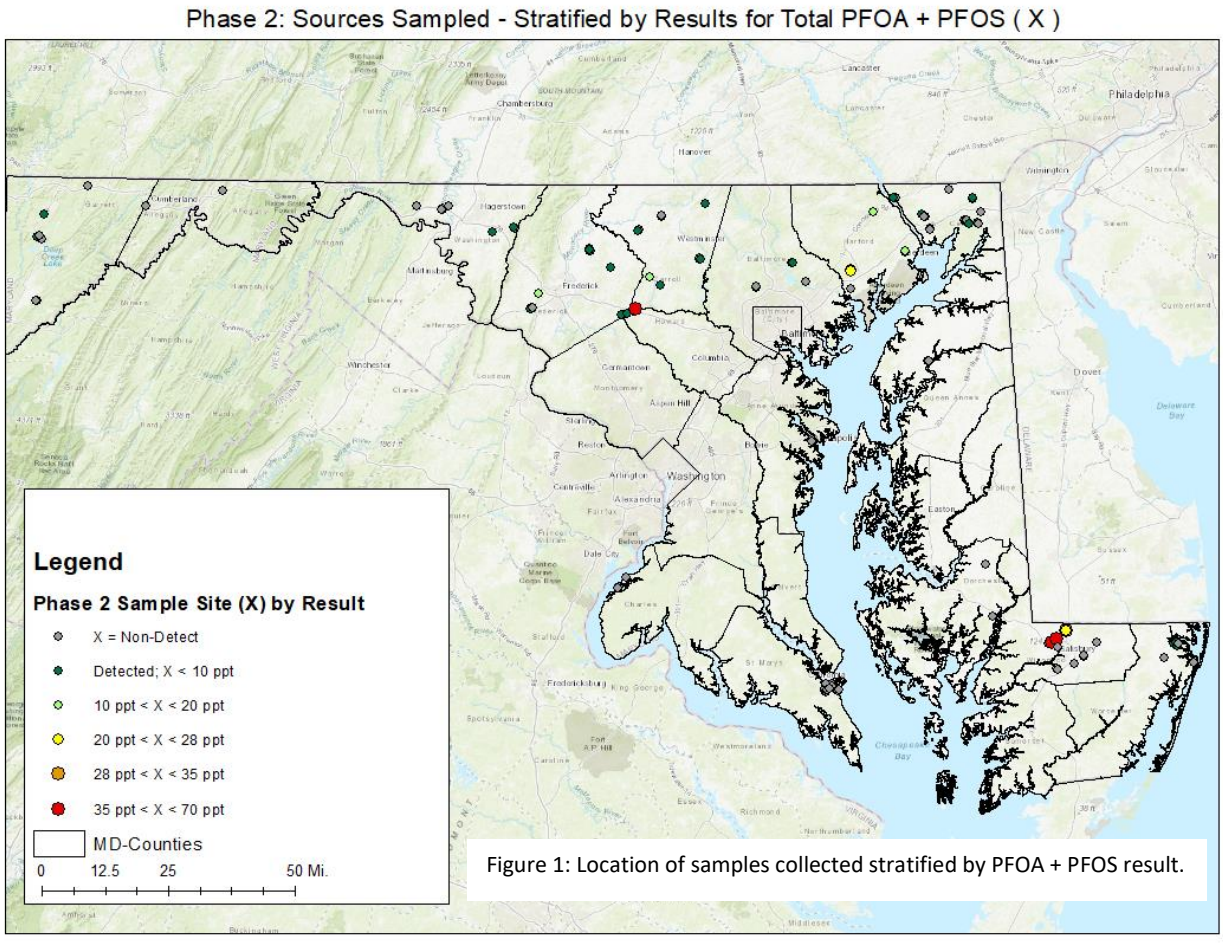

Figure 1: Location of samples collected stratified by PFOA + PFOS result.

Results: Systems with Initial PFOA+ PFOS Concentrations between 35 and 70 ppt

Under Phase 2, only one (1) IWS measured PFOA+ PFOS between 35 and 70 ppt. This was at Naylor Mill Village Mobile Home Park's (MHP) (MD0220221) WELL 2 WI810405.

Following the previously discussed follow-up sampling framework, MDE collected additional samples from the system. These results are outlined in Table 6 below.

Water Sample Type	PFOA+ PFOS Concentration ppt	Date Collected
Groundwater Sample: WELL 2 WI810405 (Initial)	36.92	4/14/2021
Groundwater Sample: WELL 2 WI810405 (Follow Up)	35.75	5/12/2021
Finished Drinking Water Sample: TP01 w/ Field Blank (FB)	35.45 ND (FB)	5/12/2021

Table 6: Naylor Mill Village (MHP) initial and follow up sample results for PFOA+ PFOS

Due to the levels of PFOA+ PFOS found at this system, MDE requested the system conduct semi-annual monitoring of its finished drinking water – if feasible. MDE also encourages the system to share any additional monitoring results to keep the Department apprised of the most recent PFAS occurrence data.

Results: Systems with Initial PFOA+ PFOS Concentrations between 28 and 35 ppt

Under Phase 2, two (2) IGWS measured PFOA+ PFOS concentrations between 28 and 35 ppt. These samples were collected at Twin Arch MHP (MD0060218) and Gateway Village M.H.P. (MD0220204).

Results: MD0060218 Twin Arch PFOA+ PFOS

An initial groundwater sample was collected from Twin Arch's Well 1 on March 11, 2021. Table 7 below outlines the results from the initial and repeat sampling at this system.

Water Sample Type	PFOA+ PFOS Concentration ppt	Date Collected
Groundwater Sample: WELL 1 (Initial)	30.59	3/11/2021
Groundwater Sample: WELL 1 (Follow Up)	43.23	3/30/2021
Finished Drinking Water Sample: TP01 w/ Field Blank (FB)	42.74 ND (FB)	3/30/2021

Table 7: Twin Arch MHP initial and follow-up sampling results for PFOA + PFOS

Due to PFOA+ PFOS concentrations fluctuating between MDE's sampling events at Twin Arch, MDE requested the system conduct semi-annual monitoring of its finished drinking water – if feasible. MDE also encourages the system to share any additional monitoring results to keep the Department apprised of the most recent PFAS occurrence data.

Results: MD0220204 Gateway Village Mobile Home Park (MHP) PFOA+ PFOS

An IWS was collected from Gateway Village MHP on April 29, 2021. The sample was collected from the system's CH01: Pumphouse for Wells 1 and 2. Table 8 below outlines the results from the initial and repeat sampling at this system. Gateway Village MHP (MD0220204).

Water Sample Type	PFOA+ PFOS Concentration ppt	Date Collected
CH01: Pumphouse for Wells 1 and 2 (Initial)	28.20	4/29/2021
CH01: Pumphouse for Wells 1 and 2 (Follow Up) with Field Blank (FB)	27.49 ND (FB)	5/12/2021

Table 8: Gateway Village MHP initial and follow-up sampling results for PFOA+ PFOS

As there is no formal treatment plant at this system, these samples can count toward either POE or unfinished water samples. For the purposes of this report, these samples will be considered as POE samples. In MDE's communication with this system, the Department encouraged Gateway Village MHP to regularly monitor their finished drinking water for PFAS and keep MDE apprised of their results. PFAS were not detected in the field blanks collected at these systems.

Results: Systems with Initial PFOA or PFOS Concentrations between 10 and 28 ppt

Four (4) IGWS from three (3) CWS measured either PFOA or PFOS greater than 10 ppt, individually. Following the previously discussed follow-up sampling framework, MDE collected additional unfinished groundwater samples and field blanks from the systems. Table 9 below summarizes the results from the initial and repeat samples.

PWSID	PWS Name	Impacted Source	PFOA or PFOS >10 ppt	Initial Result (ppt)	Repeat Sample Result (ppt)	Repeat Sample Result – Field Blank (ppt)
MD0220008	Fruitland	WELL 3 WI950364	PFOS	10.15	6.40	ND
MD0120014	Lakeside Vista	WELL 2 (CORNUS WAY) HA047742	PFOS	12.96	12.35	ND
MD0120014	Lakeside Vista	WELL 3 (VERBENA DRIVE) HA813096	PFOS	13.74	source inactive during repeat sample collection	source inactive during repeat sample collection
MD0220204	Gateway Village M.H.P.	Combined sample: WELL 1 WI736523/ WELL 2 WI730126	PFOA PFOA	14.95 (PFOS) 13.25 (PFOA)	14.00 (PFOS) 13.49 (PFOA)	ND

Table 9: Initial and follow-up results for sites with PFOA or PFOS measuring greater than 10 ppt

In MDE's communication with these systems, the Department encouraged the respective systems to regularly monitor their finished drinking water for PFAS and keep MDE apprised of their results. PFAS were not detected in the field blanks collected at these systems.

Results: Select Systems withdrawing from Confined Aquifers

Of the 167 IGWSs collected under Phase 2, a total of 26 samples contained groundwater from confined aquifers. PFAS were not detected in any of these groundwater samples.

Results: Other PFAS Detections

In addition to PFOA and PFOS, other PFAS were detected during this study. These compounds include: 9Cl-PF3ONS, PFBS, PFHpA, PFHxS, and PFHxA.

Table 10 below outlines the percent detection of these compounds in the 137 IGWS withdrawing from unconfined and semi-confined aquifers that were collected during this study.

PFAS	Number of Samples Detected	Total Number of Initial Groundwater Samples	Percent Detection (%)	Range of Detections in Initial Water Sample (ppt)	Toxicity Information Available?
PFOA	70	137	51.09	1 – 14.79	2016 EPA HAL
PFBS	69	137	50.36	1.05-17.08	Tox. Assessment for PFBS(EPA)
PFHxA	63	137	45.98	1.06-11.62	Forthcoming (EPA)
PFHxS	46	137	33.57	1.07-28.60	ATSDR MRL Forthcoming (EPA)
PFOS	39	137	28.46	2.02-30.31	2016 EPA HAL
PFHpA	30	137	21.89	2.02-5.87	N/A
9Cl-PF3ONS	1	137	0.73	2.78-2.78	N/A

Table 10: Overview of occurrence of other PFAS in IGWS withdrawing from unconfined or semi-confined aquifers and their toxicity information (if available).

Of the four (4) IPOE samples consisting of groundwater withdrawn from unconfined or semi-confined aquifers, only two (2) of the samples had quantifiable levels of PFOA, PFOS and other PFAS. Table 11 outlines these findings.

PFAS	IPOE Concentration Measured at Gateway Village MHP (MD0220204) (ppt)	IPOE Concentration Measured at R&R Estates (MD0120210) (ppt)	Toxicity Information Available?
PFOS	14.95	4.7	2016 EPA HAL
PFOA	13.25	3.32	2016 EPA HAL
PFBS	8.89	3.32	Tox. Assessment for PFBS(EPA)
PFHpA	4.61	ND	N/A
PFHxS	3.85	2.05	ATSDR MRL Forthcoming (EPA)
PFHxA	5.13	2.29	Forthcoming (EPA)

Table 11: Overview of other PFAS detected in IPOE samples withdrawing from unconfined or semi-confined aquifers and their toxicity information (if available).

Similar to the PFOA+ PFOS findings, the other 16 PFAS monitors were also not detected in the IGWS (22) and IPOE (4) samples withdrawing from confined aquifers.

Current toxicity information on additional PFAS (i.e., not including PFOA and PFOS), is limited. Earlier in 2021, the EPA released toxicity information for two additional compounds: HFPO-DA and PFBS. HFPO-DA has not been detected in any of the samples collected under Phases 1 and 2 of MDE's PWS study. At this time, MDE does not consider HFPO-DA to be impacting Maryland's drinking water sources. While PFBS has been detected in approximately 50% of samples collected under Phase 2, detections are not at concerning levels based on EPA's toxicity assessment for the compound (linked above).

Additionally, the ATSDR established Minimal Risk Levels (ATSDR-MRLs) for two additional compounds PFHxS and PFNA. ATSDR-MRLs are screening levels established by the ATSDR to help identify environmental exposures that may have negative impacts on human health. If an exposure is below the ATSDR-MRL, it is not expected to result in adverse human health effects. PFHxS has been detected throughout Phase 2, but at levels below the ATSDR-MRL. PFNA was not detected during Phase 2.

MDE continues to monitor federal work regarding PFAS regulations, toxicity assessments, and other actions. As updates occur, MDE may use this additional information to help guide further actions to reduce exposures to PFAS through drinking water routes of exposure.

Results: Systems with Initial Sample Measuring Other PFAS Concentrations greater than 10 ppt

Five (5) initial water samples measured at least one (1) of the 18 PFAS greater than 10 ppt. Following the previously discussed follow-up sampling framework, MDE collected additional unfinished groundwater samples and field blanks from the systems. Table 12 below summarizes the results from the initial and repeat samples.

PWSID	PWS Name	Impacted Source	Individual PFAS > 10 ppt	Initial Result (ppt)	Repeat Sample Result (GW)(ppt)	Repeat Sample Result (FB)(ppt)
MD0030011	Sunnybrook	SUNNYBROOK 2 BA040885	PFBS	11.87	8.17	ND
MD0100040	Mill Bottom (Samhill)	SAM HILL 1 LARSON LANE FR881435	PFBS	17.08	15.10	ND
MD0210015	Mount Aetna	MT AETNA NEW WELL 2 WA950159	PFHxS	17.57	source inactive during repeat sample collection	source inactive during repeat sample collection
MD0070213	WHISPERING PINES MOBILE HOME PARK	WHISPERING PINES 1 CE730101	PFHxS PFHxA	14.15 (PFHxS) 11.58 (PFHxA)	12.16 (PFHxS) 10.79 (PFHxA)	ND
MD0070213	WHISPERING PINES MOBILE HOME PARK	WHISPERING PINES 2 CE730323	PFHxS PFHxA	13.71 (PFHxS) 11.62 (PFHxA)	12.36 (PFHxS) 11.00 (PFHxA)	ND

Table 12: Overview of individual PFAS measuring greater than 10 ppt in IWS.

In MDE's communication with these systems, the Department encouraged each respective systems to regularly monitor their finished drinking water for PFAS and keep MDE apprised of their results. PFAS were not detected in the field blanks collected at these systems.

Conclusions: Phase 2 Public Water System Study

The goal of Phase 2 of MDE's PWS study was to understand and effectively manage the occurrence of PFAS in Maryland's public drinking water sources. Key conclusions from this study are included below. These conclusions are based on 1) the initial concentrations from the 167 IWS tested, and 2) total concentrations of PFOA+ PFOS.

Of the 137 IGWS withdrawing from an unconfined or semi-confined aquifer:

- 71 IGWS measured quantifiable levels of PFOA+ PFOS (~52%)
- 66 IGWS did not detect PFOA+ PFOS (~48%)

- One (1) IGWS measured quantifiable levels of PFOA+ PFOS between 35 and 70 ppt (ppt) (~0.73%)
- One (1) IGWS measured quantifiable levels of PFOA+ PFOS between 28 and 35 ppt (~0.73%)
- 13 IGWS measured quantifiable levels of PFOA+ PFOS between 10 and 28 ppt (~9.49%)
- 56 IGWS had detectable levels of PFOA+ PFOS, but were below 10 ppt (~40.88%)

Two (2) out of the four (4) IPOE samples withdrawing from an unconfined or semi-confined aquifer did not detect PFAS. The two (2) IPOE with detectable limits of PFOA+ PFOS are listed below:

- (MD0220204) Gateway Village MHP: PFOA+ PFOS = 28.20 ppt
- (MD0120210) R&R Estates: PFOA+ PFOS = 8.02 ppt

PFOA, PFOS, and the other 16 PFAS monitors were not detected in any of the IPOE or IGWS withdrawing from confined aquifers. Additionally, no samples under Phase 2 measured PFOA+ PFOS above the EPA HAL of 70 ppt.

Additional conclusions can be made about the other 16 PFAS monitored under Phase 2 (i.e., not including just PFOA+ PFOS). The conclusions below are based on the 137 IGWS withdrawing from unconfined and semi-confined aquifers and the concentrations of Total PFAS (not including PFOA or PFOS).

- 11 of the 18 PFAS were not detected under Phase 2 monitoring (i.e., 11Cl-PF3OUdS, ADONA, HFPO-DA, N-EtFOSAA, N-MeFOSAA, PFDA, PFDoA, PFNA, PFTA, PFTrDA, and PFUnA).
- 60 IGWS did not detect other PFAS (~43.80%)
- 77 IGWS measured quantifiable levels of other PFAS (~56.20%)
- 51 IGWS measured Total PFAS between the limits of detection and 10 ppt (~37.23%)
- 25 IGWS measured Total PFAS between 10 and 35 ppt (~18.25%)
- One (1) IGWS measured Total PFAS between 35 and 70 ppt (~0.73%)
- No IGWS measured Total PFAS greater than 70 ppt.

Of the four (4) IPOE samples withdrawing from unconfined or semi-confined aquifers, only two (2) IPOE samples had detectable levels of other PFAS, as listed in Table 11 earlier. While the IGWS and IPOE samples withdrawing from unconfined and semi-confined aquifers did detect other PFAS, the levels of detections found were below levels of concern based on available toxicity information. Additionally, the 26 IWS consisting of groundwater withdrawn from confined aquifers, PFOA, PFOS, and other PFAS were not detected.

Implications of Updates to the EPA HAL

In November 2021, the EPA submitted draft documents to its SAB for review. The draft documents contain information on the health effects of PFOA and PFOS, and their submission to the SAB for review indicates the EPA's progress in setting NPDWRs for the compounds by Fall 2023. These documents can be viewed in the SAB's webpage linked here.

The EPA also indicated that once the SAB's review of the documents is complete, it may update the existing 2016 EPA HAL (expected: Fall 2022). MDE anticipates that this updated HAL may be lower than the existing HAL. Hypothetically if the HAL were to reduce to 10 ppt for PFOA+ PFOS, then MDE may need to revisit their management of three (3) CWSs previously mentioned in this report (i.e., Naylor Mill Mobile Home Park, Twin Arch Mobile Home Park, and Gateway Village Mobile Home Park). An

additional nine (9) CWS may also be impacted by future updates to the HAL should it be reduced to 10 ppt for PFOA+ PFOS. These systems can be found in Appendix A in the “PFOA+ PFOS: 10 < X < 28 ppt” section.

MDE continues to monitor federal activity regarding promulgation of NPDWRs, updated toxicity assessments, and other actions. As new information becomes available, MDE plans to use this information to help determine whether further action is needed to reduce the risks of PFAS through drinking water routes of exposure.