DNREC DIVISION OF
WASTE AND HAZARDOUS
SUBSTANCES

Subject: Policy for Sampling and Evaluation
of Per- and Poly- Fluoroalkyl Substances (PFAS)
in Soil, Groundwater, and Surface Water

HAC Review: March 31, 2023
Issued: July 2, 2018
Revised: May 30, 2023

6/5/2023
Timothy T. Ratsep, Director

INTRODUCTION

This policy adopts the standard practice for the investigation of per- and polyfluoroalkyl substances (PFAS) at sites within the programs administered by the Department of Natural Resources and Environmental Control (DNREC) Division of Waste and Hazardous Substances (WHS). This includes programs under the Hazardous Substances Cleanup Act (HSCA), including, but not limited to the Brownfields Program (BP), the Voluntary Cleanup Program (VCP) and, HSCA State Lead/Enforcement. This policy also may, as determined by due diligence or the Department, include sites or facilities regulated by the Resource Conservation and Recovery Act (RCRA), and Leaking Underground and Aboveground Storage Tank Corrective Action Program.

What are PFAS?

PFAS have been manufactured since the 1940s and are readily used in thousands of daily commercial and residential products for their stain, water, oil, grease-repellant, and heat resistant properties. In the past 20 years, PFAS have been discovered to have a persistent, bioaccumulative, and toxic nature in humans and the environment. Due to the extremely stable nature of a carbon-fluorine bond, PFAS do not readily break down in either the human body or the environment. Further, PFAS chemicals persist indefinitely in the environment and do not readily metabolize in humans (ASTDR, 2022). Exposure to PFAS has been associated with reproductive and developmental effects, along with effects on liver function, and the endocrine and immune systems. The typical route of potential exposure to PFAS for humans is through ingestion of food, household dust, or water (ITRC, 2022 A).

PFAS are a group of thousands of synthetic chemicals constructed of a partially or fully fluorinated carbon “tail” and polar functional “head.” The carbon tail consists of at least two carbons and can be linear or branched. The functional head is typically either carboxylic or sulfonic acids. PFAS are divided into polymer and non-polymer groups. Both the polymer group and the polyfluorinated subgroup of non-polymers, are known as precursors, and typically have one or more bonds between carbon and hydrogen, or other less stable bonds. That less stable bond can break off leaving behind the stable non-polymer perfluorinated PFAS known as perfluoroalkyl acids (PFAA) or “terminal PFAS” (ITRC, 2022 B). The two most studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), both are terminal PFAS and have been classified as “emerging contaminants” by the US EPA (ITRC, 2022 C).

PFAS may be listed under different chemical names depending on its form. For example, the acronym PFOA may refer to its anionic form, the acid form, or of one its salts (ITRC, 2022 B). While each form is chemically unique, for the purposes of this policy, the PFAS acronym will generally refer to all its forms. The anionic form is commonly found in environmental samples; however, laboratories commonly report PFOA as an acid. The laboratories are actually measuring the anionic form in environmental samples (ITRC, 2022 B). For risk assessments, selecting the correct form may be necessary to evaluate the risk of exposure. The anionic and acid forms generally have the same screening values; however, the salt form may be different. The acid/anionic form will apply to a majority of sites, while the salt form may only apply to select sites.

Statement of Purpose

The purpose for developing this policy is to provide guidance for site investigations and risk evaluations. This policy applies to programs authorized by the Hazardous Substances Cleanup Act. The policy may extend to facilities regulated under other programs if due diligence indicates a release or the imminent threat of a release of PFAS. The goal is of this policy is to:

- Ensure investigations are conducted in a manner that delineates the extent of the PFAS contamination in all environmental media at sites or facilities that have confirmed PFAS releases or are suspected of PFAS contamination;
- Ensure uniform investigation and risk assessment procedures so PFAS cleanups can be completed in a consistent and verifiable fashion;
- Consider PFAS at remediation sites or facilities in the same manner as other hazardous substances.

Authority

Under 7 *Del. C.* § 9104(b)(2) of HSCA the Secretary may establish procedures to investigate a release of hazardous substances. Further, 7 Del. Admin. C. § 1375-2.0, Delaware's *Regulations Governing Hazardous Substance Cleanup*, promulgated pursuant to HSCA, defines "hazardous substance" as, among other things, "(d) any substance included in the HSCA screening level table that will be updated semiannually." The Secretary has included certain PFAS compounds on the HSCA screening level table based on the presence of a risk to public health, welfare, or the environment if released into the environment. Therefore, those PFAS compounds must be accounted for by investigations of hazardous substances.

The HSCA screening level table includes the chemicals listed by the United States Environmental Protection Agency (USEPA) with Regional Screening Levels (RSLs) and chemicals that are used, stored in a regulated vessel, transported to, or otherwise present at a facility permitted or regulated by WHS. The HSCA screening level table may also include emerging contaminants which are those pollutants where a perceived, potential, or real threat to human health, welfare, and the environment may exist without a well-defined understanding of the risk posed, and such contaminants (ITRC, 2022 A). The most up to date HSCA screening level table can be found on DNREC's webpage.[1]

Applicability to Sites

A site investigation that includes sampling and analyzing soil, groundwater, and/or surface water for presence of PFAS compounds shall compare the concentrations to the applicable HSCA screening levels. An exceedance of the screening level at a site will require further evaluation of PFAS risk at that site. An evaluation of potential risk to human health from exposure to surface water will be required when PFAS is detected in surface water.

INVESTIGATION

This policy applies to the environmental investigation of facilities within the programs administered by WHS at any point in the remedial process. Similar to other contaminants found during the process, PFAS compounds should be addressed through an investigation to identify potential source areas, transport methods, and the risk the contaminant poses to human health and the environment.

Initial Investigation

The addition of certain PFAS compounds to the HSCA screening level table establishes a requirement to conduct PFAS sampling in soil, groundwater, and surface water when a release or imminent threat of a release is identified under HSCA. The determination for sampling will be conducted under All Appropriate Inquiry (AAI) requirements as defined in 7 Del. Admin. C. § 1375-2.1 of known or suspected areas of current or historical primary or secondary sources outlined in **Table 1**. Tertiary sources can also be considered if there is proper documentation for the inclusion of PFAS sampling at the property, adjoining property, or facility. However, tertiary sources are listed in this policy to assist in the development of a Conceptual Site Model (CSM) during the investigation phase of any site. In the instances where wellhead protection areas (WHPA) overlap the targeted sampling areas, the public well(s) associated with that WHPA shall also be sampled for PFAS as part of the investigation.

The American Society for Testing and Materials (ASTM) maintains a standard practice on Phase I Environmental Site Assessments (ESAs) document number E1527. The standard outlines how to identify Recognized Environmental Conditions (RECs) at subject properties or adjoining properties. The current version of the standard views PFAS contamination as "non-scope" in a Phase I ESA. However, jurisdictions which define certain PFAS compounds as hazardous substances can require PFAS contamination as in-scope of work (ASTM, 2021). Delaware is a jurisdiction that classifies certain PFAS as a hazardous substance through HSCA. If during the review for a Phase I ESA an environmental professional determines PFAS containing substances are likely present at the subject property or an adjoining property, they should list PFAS contamination as a REC for the subject property. If PFAS is listed as a REC in the Phase I ESA, the Phase II ESA should also sample for, at a minimum, PFAS compounds listed in the HSCA screening level table in the media identified in the Phase I ESA and those results compared to HSCA screening levels.

---

[1] https://documents.dnrec.delaware.gov/dwhs/remediation/HSCA-Screening-Level-Table-Guidance.pdf

Potential Responsible Parties (PRPs) and/or Certified Brownfield Developers should also consult the WHS PFAS webpage[2] for the most up to date information regarding PFAS investigations and potential areas of known PFAS contamination. The information provided on the webpage may be updated as new information is discovered about the occurrence of PFAS in Delaware.

Table 1- PFAS Source Determination

Primary Sources: Facilities that produced PFAS compounds for distribution to applicators or to other manufacturers.		
Facilities	**Material or Application Type**	**Media to Sample**
PFAS Production (Facilities that manufactured PFAS)	Chemical plants, Aqueous film-forming foam (AFFF) manufacturers, waterproofing (hydrophobic) agents, anti-stick coatings, paints, anti-friction agents, melt-resistance wiring, lipophobic coatings, surfactants, waterproof-breathable fabrics, waxes (including ski wax) aviation hydraulic fluids	The selected media to sample shall be based on the conceptual site model developed for your site. The location, depth, and selected media should be presented in a Sampling Analysis Plan for your facility. Surface soil (0 to 6 inches), shallow soil (0 to 2 feet), and deep soil (>2 feet), groundwater, surface water, and sediment sampling shall conform with established Standard Operating Procedures (SOPs) established by DCNRE-WHS. Storm water conveyances could include pipes, basins, ponds, or tax ditches.
PFAS Applicators (Facilities that used PFAS or PFAS-containing materials in the manufacturing process including process equipment or applied PFAS to products at their facilities.)	Textiles, leather, carpeting, upholstery, floor finishes (waxes), paints, anti-misting agents, vehicular coatings, and waxes (including ski wax), paper making, photolithography, semiconductor manufacturing, and an access-controlled facility of AFFF use (including, but not limited to airports, fire stations, firefighting academies, military installations, refineries, bulk petroleum storage facilities)	
Secondary Sources: Facilities that handled, used, or processed PFAS-containing items. These sources could have unintentionally released PFAS into the environment.		
Waste Management Facilities	Permitted landfills, unpermitted or uncontrolled landfills (dumps), sewage treatment plants, public water treatment plants, waste transfer facilities, recycling centers, incinerators, crematoriums, auto salvage yards	In addition to the guidance above, landfills may also require leachate sampling if applicable. Sewage treatment plants may also require effluent sampling.
Cleaning Facilities	Car washes, dry cleaners, carpet cleaners	
Tertiary Sources: Known application of a secondary source or consumer product waste.		
Biosolid applicators (From sewage/treatment sludges) and spray irrigation	Agricultural fields or beneficial waste storage/processing facilities	Sampling may not be required at these sites as many may be exempted from HSCA.
Septic Systems	Residential or commercial systems	

---

[2] http://de.gov/pfas

Residential style (ex: Nursing home), Schools, or Commercial/Office facility	Run-off or residual waste from a PFAS-containing substance (floor wax, carpet cleaning, fabric treatments)	If sampling is completed at these sites, the sampling should be complete with the same guidance presented above.
Emergency Response Locations	Emergencies in which AFFF was applied (fires, accidents, training for emergencies at uncontrolled access sites)	

Compiled from: ITRC (Interstate Technology & Regulatory Council). 2022. PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1. Washington, D.C.: Interstate Technology & Regulatory Council, PFAS Team. https://pfas-1.itrcweb.org/.

Facility Evaluation

Sites being evaluated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in cooperation with the USEPA may also be evaluated for PFAS during the Preliminary Assessment (PA) and/or Site Inspection (SI). Sites being evaluated under the Brownfield Development Program, RCRA, Underground Storage Tank program, Above Ground Storage Tank program, or VCP may not necessarily have a Phase I ESA or Phase II ESA completed on the subject property. In those instances, DNREC may ask for a PFAS evaluation to be performed at the site based on operational history and proximity to primary and secondary sources.

Due to PFAS potentially being released at facilities regulated under other programs (UST, AST, RCRA), an evaluation of PFAS should be considered at these facilities as well. This would save parties remediating facilities under those programs time and money to include PFAS in their evaluation in concert with those investigations.

Determining Media to Sample

This policy focuses on acquiring data related to exposure to environmental media that may contain PFAS. For projects described in **Table 1** above, PRPs and/or Certified Brownfield Developers shall collect appropriate data to satisfy AAI from each respective WHS Programs and report the findings in writing to WHS. If regulated PFAS are detected above HSCA screening levels, those compounds may become Contaminants of Potential Concern (COPCs) for the project. Samples should be analyzed with an approved method for detecting PFAS compounds as outlined in the Analytical Method Section.

Appropriate Analytical Methods

The current analytical methods used to determine the presence of PFAS in drinking water are USEPA Method 537.1 and Method 533. These methods were designed to be used for finished (drinking) water samples due to the low probability of interference from particulate matter in finished drinking water. USEPA Method 533 is effective at capturing short-chained PFAS that were not reliably detected with Method 537.1. A modified method (Method 537 Modified) is used for samples collected from groundwater or surface water, where there is a high probability of particulate matter in the water sample (Shoemaker et. al, 2008, Revised 2015). The modified method can also be used for soil, sediment, and fish tissue. The method detection limit for these methods is sufficient to measure regulated PFAS at levels below the HSCA screening levels and capture other PFAS compounds which do not currently have a HSCA screening level. The modified method of analysis is not typically part of the standard suite of contaminants requested for analysis, therefore the method must be requested from the laboratory.

Available Methods and Limitations

Listed below are some of the available analytical methods for PFAS which have been used at facilities in Delaware. See **Table 2** for a complete list of PFAS analytes tested with each method. The referenced analytical methods should follow the Standard Operating Procedures for Chemical Analytical Programs (SOPCAP) under HSCA. The HSCA analytical program is a performance-based program which means that any method or a hybrid method can be used as long as the results are defensible and meet the data quality objectives (DQOs) established in the SOPCAP or the analytical work plan.

EPA Method 537.1

EPA Method 537.1 is a solid phase extraction (SPE) liquid chromatography-tandem mass spectrometry (LC-MS/MS) method used exclusively for drinking water (DW) samples. This is because at the time of publication, the only media of concern for potential risk was ingestion via DW. EPA Method 537.1 detects the presence of 18 select PFAS analytes with a Method Detection Limit (MDL) of 0.53 nanograms per liter (ng/L) to 6.3 ng/L (EPA, 2020). The original EPA Method 537 was published in 2008 and accounted for 14 select PFAS analytes. Between 2013 and 2015, the EPA conducted their Third Unregulated Contaminant Monitoring Rule (UCMR3) to monitor contaminants in public water systems (PWS). Included in UCMR3, were six PFAS that were analyzed using EPA Method 537 with the results published in 2017. In 2018, this method was revised to the current EPA Method 537.1 which incorporated an additional 4 analytes (totaling 18) such as the “replacement” PFAS hexafluoropropylene oxide dimer acid (HFPO-DA commonly called “GenX”) and 4,8-Dioxa-3H-perfluorononanoic acid (ADONA) (EPA, 2020). This method comes with key limitations. It does not allow for other media (i.e., surface water, soil, biosolids) to be analyzed for PFAS. It’s also limited in its ability to capture short chain PFAS and excludes all fluorotelomers (FTs). FTs can be signatures of common PFAS sources such as Aqueous Film Forming Foam (AFFF), otherwise known as firefighting foam (ITRC, 2022 D).

EPA Method 533

EPA Method 533 is a SPE LC-MS method published in 2019, for the detection of 25 select PFAS analytes in DW with an MDL of 1.4 ng/L to 13 ng/L (EPA, 2022 A). This method employs isotope dilution to improve the measurement accuracy by accounting for matrix interference and instrument bias while testing. In lieu of the fact EPA Method 533 was published to complement EPA Method 537.1 as it focuses on the “short chain” PFAS not analyzed via EPA Method 537.1, EPA Method 533 can also only be used for samples collected from DW. Despite this limitation, when used in conjunction with EPA Method 537.1, 29 unique PFAS can be effectively measured in DW.

EPA Method 1633

As of this policy update, EPA Method 1633 is still a draft PFAS analytical method. This method tests for 40 PFAS compounds in several different media. The EPA released the draft of Method 1633 in 2021. This method will have the benefit of detecting the presence of PFAS in biosolids, surface water , groundwater , wastewater, animal tissue, soil, and sludge. EPA Method 1633 will employ isotope dilution to allow for more accurate and precise calibration, expanded matrices (media), and fewer false positives. Because this method is still in the draft phase, there are very few accredited laboratories able to run this method. It is very likely that EPA Method 1633, when finalized, will be approved for use regarding military sites before its approved for residential locations (EPA, 2022 B). At the time of drafting this policy, demand for this method is low, resulting in high costs to run this method. In addition, of the 40 labeled PFAS analytes, only 24 have isotopically labeled internal standards which raises concern regarding the accuracy and measurement of the 16 analytes without isotopically labeled internal standards (ITRC, 2022 D). EPA Method 1633 is classified as a performance-based analysis that allows for modifications in the future. This method may become the universal standard for PFAS analysis in the future due to its comprehensive list of analytes tested, variety of media analyzed, and testing accuracy.

Total Oxidizable Precursors Assay (TOP Assay)

TOP Assay is a comprehensive analysis technique for PFAS that uses chemical oxidation with heat activated persulfate to transform PFAS precursors to perfluoroalkyl carboxylic acids (PFCAs), GenX, and 11Cl-PF3OUdS (F-53B Minor) and 9Cl-PF3ONS (F-53B Major). TOP Assay is effective for facilities where little information about the site is known, and for sites where the only PFAS of concern are PFOA and PFOS. This analysis method is not included in the standard EPA Method 537.1 but can be included in a modified EPA Method 537, meaning the reported analytes and their accuracy are lab specific. This allows a laboratory to detect PFAA precursors and approximate the transformation of precursors into PFAAs. TOP Assay can also cause larger chain PFAA to oxidize into shorter chain PFAAs, yet some data suggests TOP Assay may under report precursors (ITRC, 2022 E). TOP Assay is not without limitations. As mentioned, TOP Assay has been suggested to under report PFAS precursors. To run this method, each sample is halved which raises the MDL for each analyte by a factor of two.

Method 537 Modified

This is a modified version of EPA Method 537.1, to determine the presence and concentrations PFAS analytes in soil, groundwater, surface water, tissue samples, and other media. The MDL of 537M currently available through the State-contracted laboratory is 0.19 ng/L to 2.5 ng/L, noticeably lower than either EPA Method 533 or EPA Method 537.1 (Eurofins, 2022). Alternatively, TOP Assay can be used to obtain the analytes included in 537M. The cost of running a sample through a modified Method 537 varies since it is a lab specific method. The customized list of analytes, the lower detection limits, the variety of media able to be analyzed, and the ability to compare results to a TOP Assay should make 537M the preferred analytical method for samples collected from a facility.

In addition, DNREC-WHS has a list of 37 PFAS analytes that are included in 537M. The list, named “DNREC REM” was established by WHS during State-led PFAS studies and investigations. The 37 PFAS analytes were selected as being the most reliably detected PFAS compounds by our contracted lab. The analytes included were primarily based on detection frequency in Delaware, risk associated with each analyte, and the lab’s ability to return the most consistent, accurate results with a low MDL. While method 537 Modified “DNREC REM” is recognized by our current contract laboratory, the DNREC REM list (See **Table 2**) must be supplied to the HSCA-approved laboratory to ensure the 37 listed PFAS analytes are reported in the final analytical report from the lab when this method is selected by a PRP.

Table 2- PFAS Compounds Reported by the Analytical Methods in This Policy

Analyte	Acronym	CAS#	EPA 537.1	EPA 533	EPA 1633	537M DNREC REM
11Cl-PF3OUdS	F-53B Minor	763051-92-9	x	x	x	x
9Cl-PF3ONS	F-53B Major	756426-58-1	x	x	x	x
4:2 fluorotelomer sulfonic acid	4:2 FTS	757124-72-4		x	x	x
6:2 fluorotelomer sulfonic acid	6:2 FTS	27619-97-2		x	x	x
8:2 fluorotelomer sulfonic acid	8:2 FTS	39108-34-4		x	x	x
5:3 fluorotelomer carboxylic acid	5:3 FTCA	914637-49-3			x	x
6:2 fluorotelomer carboxylic acid	6:2 FTCA	53826-12-3				x
6:2 fluorotelomer alpha, beta-unsaturated carboxylate	6:2 FTUCA	70887-88-6				x
3-Perfluoropropyl acid	3:3 FTCA	356-02-5			x	
3-Perfluoroheptyl Propanoic acid	7:3 FTCA	812-70-4			x	
Pentafluoropropionic acid	PPF Acid or (PFPrA)	422-64-0				x
Perfluorobutanoic acid	PFBA	375-22-4		x	x	x
Perfluoropentanoic acid	PFPeA	2706-90-3		x	x	x
Perfluorohexanoic acid	PFHxA	307-24-4	x	x	x	x
Perfluoroheptanoic acid	PFHpA	375-85-9	x	x	x	x
Perfluorooctanoic acid	PFOA	335-67-1	x	x	x	x
Perfluorononanoic acid	PFNA	375-95-1	x	x	x	x
Perfluorodecanoic acid	PFDA	335-76-2	x	x	x	x
Perfluoroundecanoic acid	PFUnA	2058-94-8	x	x	x	x
Perfluorododecanoic acid	PFDoDA	307-55-1	x	x	x	x
Perfluorotridecanoic acid	PFTrDA	72629-94-8	x		x	x
Perfluorotetradecanoic acid	PFTeDA	376-06-7	x		x	x
Perfluorobutanesulfonic acid	PFBS	375-73-5	x	x	x	x
Perfluoropentanesulfonic acid	PFPeS	2706-91-4		x	x	x
Perfluorohexanesulfonic acid	PFHxS	355-46-4	x	x	x	x
Perfluoroheptanesulfonic acid	PFHpS	375-92-8		x	x	x
Perfluorooctanesulfonic acid	PFOS	1763-23-1	x	x	x	x
Perfluorononanesulfonic acid	PFNS	474511-07-4			x	
Perfluorodecanesulfonic acid	PFDS	335-77-3			x	
Perfluorododecanesulfonic acid	PFDoDS	79780-39-5			x	
N-methyl perfluorooctane sulfonamido acetic acid	N-MeFOSAA	2355-31-9	x		x	x
N-ethyl perfluorooctane sulfonamido acetic acid	N-EtFOSAA	2991-50-6	x		x	x
Perfluorooctanesulfonamide	PFOSA or FOSA	754-91-6			x	
N-Methylperfluorooctanesulfonomide	N-MeFOSA	31506-32-8			x	
N-Ethylperfluorooctanesulfonomide	N-EtFOSA	4151-50-2			x	

N-Methylperfluorooctanesulfonamidoethanol	N-MeFOSE	24448-09-7			x	
N-Ethylperfluoroctanesulfonamidoethanol	N-EtFOSE	1691-99-2			x	
Hexafluoropropylene oxide Dimer acid	HFPODA or (GenX)	13252-13-6	x	x	x	x
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	x	x	x	x
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5		x	x	x
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1		x	x	x
Perfluoro-2-methoxyacetic acid	PFMOAA	674-13-5				x
Perfluoro-3,6-dioxaheptanoic acid	NFDHA or (PFECA B)	151772-58-6		x	x	x
Perfluoro-3,5-dioxahexanoic acid	PFO2HxA	39492-88-1				x
Perfluoro-3,5,7-trioxaoctanoic acid	PFO3OA	39492-89-2				x
Perfluoro-2-ethoxyethanesulfonic acid	PFEESA or (PES)	113507-82-7		x	x	x
Hydro-PS Acid	(None)	749836-20-2				x

PFAS Consideration in the Sampling and Analysis Plan

The evaluation of PFAS during a Remedial Investigation (RI), brownfield investigation (BFI), or equivalent under other programs, will require PFAS-specific provisions in the Sampling and Analysis Plan (SAP). The SAP will outline the number of samples, approximate locations, and media to be collected for sampling based on the CSM. The SAP shall also outline standard practices for handling PFAS samples and all protocols to be followed by samplers. Please refer to the SAP template and sampling Standard Operating Procedures (SOPs) on DNREC's webpage for additional guidance.[3] Other elements of the SAP shall include quality control and quality assurance measures, the type of laboratory analysis, and data quality objectives for the final analytical data package. Project officers will prepare a SAP for any State-led PFAS projects.

The reporting of additional PFAS analytes, while not required under HSCA laws, can be useful in determining source areas, identifying the age of the plume, identifying additional compounds that may become hazardous substances, and applying the data collect from an individual facility to data collected state-wide.

SCREENING ANALYTICAL RESULTS

When a remediation project has obtained all the PFAS analytical data, the results are compared to the HSCA screening levels for all appropriate PFAS compounds. Please consult the DNREC Remediation Section webpage for the latest HSCA screening levels for PFAS.

Soil

The soil screening levels are based upon the soil ingestion pathway. However, projects may also consider the leaching of PFAS from contaminated soil to groundwater. Many PFAS will readily leach into groundwater as water percolates through the vadose zone (ITRC, 2022 C). It is recommended that remediation projects that evaluate soil contamination and the leaching of PFAS to groundwater should consult their respective WHS project officer for additional guidance (See Risk Assessment section below).

---

[3] https://dnrec.alpha.delaware.gov/waste-hazardous/remediation/laws-regs-guidance/

Groundwater

The screening levels for groundwater are based upon the ingestion pathway. Even if the future use of the project does not intend to use the groundwater for a drinking water resource, the groundwater should still be evaluated for the drinking water pathway as the water may be used for this purpose outside of the project area. As stated in the policy previously, some of the key properties of PFAS; persistent, bioaccumulative, and toxic nature in humans plus the highly mobility of certain PFAS in groundwater necessitate the urgency of evaluating PFAS in groundwater (ITRC, 2022 C). Please refer to DNREC guidance for private well evaluation for additional information on protecting drinking water resources.

Surface Water

The WHS project officers shall determine if the surface water at the project site is used as a drinking water resource. DNREC's *Guidance for Human Health Risk Assessments under HSCA* states that surface water should be compared to the appropriate groundwater HSCA screening levels for human health. Contaminated surface water also serves as a pathway for PFAS exposure to aquatic life. PFAS can bioaccumulate in aquatic biota, impacting these resources. Steps should be taken to mitigate any discharge of PFAS, either directly or through diffuse groundwater seepage, to the surface waters of Delaware.

RISK EVALUATION

As with other contaminants, the potential risk from PFAS should be evaluated following DNREC's risk assessment guidance, or other approved methods as appropriate under certain programs. The main driver of human health risk for PFAS is the ingestion pathway. For soils, the ingestion route comes from the direct or indirect ingestion of soil. Examples of indirect ingestion of soil include dust or harvesting of plants in a garden within the shallow soil zone. For deep soil, the soil to groundwater pathway can also be considered. Certain PFAS have a higher tendency to leach into groundwater. Higher-carbon PFAAs ($>C_8$) tend to be less soluble and will not readily leach into percolating groundwater (ITRC, 2022 C). Further, the amount of free organic carbon in the soil also controls the amount of PFAS passing into groundwater (Guelfo and Higgins, 2013). Additional studies have demonstrated that over 95% of the PFOS and PFOA mass in soil is retained after 5 years in the environment (Baduel, Paxman, and Mueller, 2015). The long-term presence of certain PFAS in soil may contribute to persistent groundwater plumes (ITRC, 2022 C).

The persistence of PFAS in subsurface soils can create long-term groundwater plumes that will exceed regulatory values since those values are extremely low (ng/L). The remediation of PFAS soil contamination will result in the elimination of persistent groundwater plumes, reducing the need for treatment of groundwater for drinking and improving the surface water quality in Delaware. DNREC-WHS on a site-specific basis may consider evaluating the soil to groundwater pathway if relevant site-specific data supporting the soil to groundwater pathway is demonstrated. If a PRP would like to consider a soil to groundwater pathway evaluation on a site-specific basis, all information on how it will be assessed should be approved prior to including the assessment within reports. Other fate and transport considerations to evaluate may also include overland flow to surface water and diffuse discharge from groundwater aquifers to surface water. These evaluations are performed on a site-by-site basis.

In groundwater, the risk of ingestion through contaminated drinking water is currently the main risk driver of PFAS. However, there is on-going research into dermal absorption and inhalation of PFAS contaminated water. If groundwater is being used for purposes other than for drinking, then other routes of exposure via dermal adsorption and inhalation could also be a potential risk. If the groundwater is used for other purposes, WHS will consider the well's use. For example, closed-loop geothermal wells would not present a groundwater ingestion risk. A domestic irrigation well could potentially be an ingestion risk depending upon how the water is delivered to the irrigation system. However, the pumping of PFAS contaminated water as an agricultural well may pose other risks. The same questions would apply to large-scale irrigation wells. The industrial and commercial use of the groundwater would have to be evaluated on a case-by-case basis and include a plan on how the process water is used and ultimately disposed. These wells are also typically classified as miscellaneous public water systems and would require the assistance of DNREC to aid in their evaluation.

Small-scale observation, monitoring, and dewatering of groundwater wells would not be considered an ingestion risk since these wells are not utilized as potable water sources. Any PFAS-contaminated groundwater removed from these wells should have a treatment and disposal plan to handle the purged water. See table below for groundwater risk drivers for DNREC-permitted wells.

Potential Risk for Permitted Wells

Well Type	Ingestion Risk	Dermal Adsorption Risk	Inhalation Risk
Public Well	Y	Y	P
Domestic Well	Y	Y	P
Observation Well	N/A	P	P
Monitoring Well	N/A	P	P
Agricultural Well	P	P	P
Irrigation Well	N/A	Y	P
Dewatering Well	N/A	P	P
Closed-loop Geothermal	N/A	N/A	N/A

Y = Pathway open
N/A = No pathway/pathway closed
P = Potential pathway, can be mitigated with permit restrictions

As more information becomes available regarding the potential risk via other exposure routes from PFAS, this information will be incorporated into DNREC's *Guidance for Human Health Risk Assessments under HSCA* and the *Vapor Intrusion Pathway Guidance*. The availability of new information from contaminates of potential ecological concern (COPECs) with regard to sediments will be addressed in the *Guidance for Ecological Risk Assessments under HSCA* as applicable.

REPORTING

All information and data collected during the course of an investigation should be documented in the appropriate reports submitted to WHS. Additional plans or reports to support PFAS sampling may be required so DNREC can provide guidance and comment and WHS concurrence on the data collection process to ensure data are collected in accordance with HSCA regulations, or other applicable regulations.

PFAS lab electronic data deliverables (EDDs) should be submitted to WHS. The shared data can be used to help develop a deeper understanding of the nature and extent of PFAS in Delaware. The information can assist PRPs in the future with identifying potential sources and plumes of PFAS.

ADOPTION

This policy is adopted on the date of the Director's signature with implementation to begin on that date. All CSMs and SAPs submitted to DNREC-WHS on or after the implementation date must fully comply with the policy. Any adoption of additional PFAS compounds by USEPA as a hazardous substance under CERCLA will supersede the scope of this policy in accordance with 7 *Del. C.* § 9103(15)(b). This policy is in effect for 3 years following the implementation date. Prior to the expiration date, the policy will be re-evaluated to determine if the policy should be modified or rescinded. These decisions are at the discretion of the WHS Director.

References

ASTDR (2022), Per- and Polyfluoroalkyl Substances (PFAS) and Your Health. Agency for Toxic Substances and Disease Registry. Centers for Disease Control and Prevention, November 1, 2022. https://www.atsdr.cdc.gov/pfas.

ASTM (2021), Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process. Standard E1527, ASTM International. West Conshohocken, PA.

Baduel, C., Paxman, C. J., and Mueller, J. F. (2015), Perfluoroalkyl Substances in a Firefighting Training Ground (FTG), Distribution and Potential Future Release. *Journal of Hazardous Materials.* v:296 (1), 46-53

EPA (2020), Shoemaker, J. AND Dan Tettenhorst. Method 537.1 Determination of Selected Per- and Polyflourinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). U.S. Environmental Protection Agency, Washington, DC, 2020.

EPA (2022 A)**,** Environmental Protection Agency. (n.d.) “EPA PFAS Drinking Water Laboratory Methods” EPA, 2022, Web. 26 April 2022.

EPA (2022 B), Environmental Protection Agency. (n.d.) “CWA Analytical Methods for Per- and Polyfluorinated Alkyl Substances (PFAS)” EPA, 2022, Web. 19 January 2023.

Guelfo, J. L. and Higgins, C. P. (2013), Subsurface Transport Potential of Perfluoroalkyl Acids at Aqueous Film-Forming (AFFF)-Impacted Sites. *Environmental Science & Technology* v:47 (9), 4164-4171

ITRC (2022 A), History and Use of Per- and Polyfluoroalkyl Substances (PFAS) found in the Environment. Interstate Technology and Research Council, June 2022. ITRC On-line Fact Sheets, https://pfas-1.itrcweb.org/fact-sheets/

ITRC (2022 B), Naming Conventions for Per- and Polyfluoroalkyl Substances (PFAS). Interstate Technology and Regulatory Council, June 2022. ITRC On-line Fact Sheets, https://pfas-1.itrcweb.org/fact-sheets/

ITRC (2022 C), Per- and Polyfluoroalkyl Substances Technical and Regulatory Guidance. Interstate Technology and Regulatory Council, Washington, D.C. June 2022.

ITRC (2022 D), Aqueous Film-Forming Foam (AFFF). Interstate Technology and Regulatory Council, June 2022. ITRC On-line Fact Sheets, https://pfas-1.itrcweb.org/fact-sheets/

ITRC (2022 E), Sampling Precautions and Laboratory Analytical Methods of PFAS. Interstate Technology and Regulatory Council, June 2022. ITRC On-line Fact Sheets, https://pfas-1.itrcweb.org/fact-sheets/

Shoemaker, J.A., P. Grimmett, and B. Boutin, (2008) Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). U.S. Environmental Protection Agency, Washington, DC, Revised: October 7, 2015.