Guide for Investigating Historical and Current Uses of Per- and Polyfluoroalkyl Substances at Department of Energy Sites

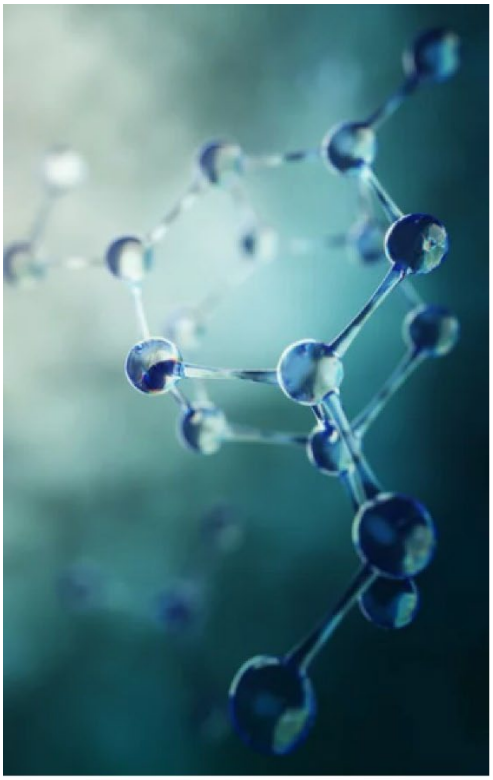

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Table of Acronyms

AFFF	Aqueous Film Forming Foam
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSM	Conceptual Site Model
DoD	Department of Defense
DOE	Department of Energy
DQO	Data Quality Objectives
EMS	Environmental Management System
EPA	Environmental Protection Agency
ESG	Environmental Sampling Guide
FIMS	Facilities Information Management System
HQ	Headquarters
ISO	International Organization for Standardization
ITRC	Interstate Technology and Regulatory Council
OSF	Other Structures and Facilities
PA	Preliminary Assessment
PCC	PFAS Coordinating Committee
PFAS	Per- and Polyfluoroalkyl Substances
PFBS	Perfluorobutanesulfonic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SI	Site Inspection

Guide for Investigating Historical and Current Uses of Per- and Polyfluoroalkyl Substances at Department of Energy Sites

1.0 INTRODUCTION

This Guide outlines a framework for investigating the historical and current use of per- and polyfluoroalkyl substances (PFAS) at U.S. Department of Energy (DOE) owned or operated entities nationwide. The investigative techniques outlined herein are designed to help DOE better understand its past and present uses of PFAS, identify areas of potential releases of PFAS to the environment, and satisfy the goals and objectives presented in the first pillar of DOE's PFAS Strategic Roadmap (USDOE 2022). Specifically, the first pillar of the Roadmap seeks to develop information concerning PFAS uses and environmental releases to characterize and assess the Department's liabilities and risks. To accomplish this, the DOE will focus on identifying the most common sources of PFAS at DOE sites, including: 1) Manhattan Project and Cold War era sources; 2) the use of aqueous film-forming foam (AFFF); and 3) other PFAS uses, disposal, and incidental releases associated with research, operations, and equipment maintenance uses (USDOE 2022).

This Guide addresses Roadmap Action 1.2: Publish DOE guidance on historical and current use searches and expands on the results of Roadmap Action 1.1: Publish Initial Assessment Report. This Guide also supports the execution of expanded DOE records search efforts described in Actions 1.4 and 1.5 of the Roadmap, all of which will inform Action 1.7: Perform site field assessments and Action 1.8: Publish DOE PFAS Updated Status Report. Resulting actions from this Guide should inform the need to conduct environmental sampling which is supported by the Environmental Sampling Guide (Action 1.6: Publish environmental sampling guidance to support determining the nature and extent of PFAS releases at DOE sites following the Data Quality Objectives (DQO) process). See Figure 1 for a visualization of the actions listed in Pillar 1: Understand from the DOE PFAS Strategic Roadmap.

The scope of this Guide focuses on investigative efforts to determine the historical and current use of PFAS, which include emerging contaminants as identified by the Environmental Protection Agency (EPA), and likelihood of release at a DOE site. The DOE definition of the term "Use" of PFAS in this Guide applies to all circumstances associated with the presence of PFAS at DOE sites related to any of the historical and current PFAS uses presented in the document and includes activities such as use in production, operations, maintenance, storage, transportation, disposal, release, spill, or other ancillary activity.

The DOE definition of the term "Use" of PFAS in this Guide applies to all circumstances associated with the presence of PFAS at DOE sites related to any of the historical and current PFAS uses presented in the document and includes activities such as use in production, operations, maintenance, storage, transportation, disposal, release, spill, or other ancillary activity.

Use of this Guide and associated regulatory information will help ensure the employment of a structured and robust PFAS historical and current use investigation that will lead to defensible

results and meet DOE policies and Federal/State regulatory requirements. However, all DOE sites do not comply with the same regulatory framework. Accordingly, the implementation of this Guide should be tailored to meet site-specific circumstances (e.g., Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] sites versus non-CERCLA sites), needs (e.g., site mission), and agreements (e.g., Federal Facility Agreement). As previously mentioned, evidence/results derived from the use of this Guide should be compiled to support site decisions such as environmental sampling.

Figure 1. Applicable Pillar, Objectives, and Actions referenced in this Guide.

Pillar 1: Understand

Goal: Develop information concerning PFAS uses and environmental releases to characterize and assess the Department's liabilities and risks

- **Obj. 1 –** Understand the Manhattan Project and Cold War-era sources and volumes of PFAS used and disposed of, with initial focus on uranium processing operations.
- **Obj. 2 –** Assess Aqueous Film Forming Foam (AFFF) releases to the environment from fire suppression systems, firefighter training operations, and emergencies resulting in AFFF use.
- **Obj. 3 –** Identify other PFAS uses and disposal activities associated with research, operations, and equipment maintenance.
- **Obj. 4 –** Understand the presence of PFAS in drinking water and the environment.
- **Obj. 5 –** Catalogue and track current PFAS inventories and uses.

- **Action 1.1:** Publish "Initial Assessment of PFAS at DOE Sites" (Initial Assessment Report). (Supports all objectives)
  This report is DOE's first broad investigation into the presence of PFAS at DOE sites. Results from this report will inform future data collection activities.
- **Action 1.2:** Publish DOE guidance on historical and current use searches. (Supports all objectives)
  The Preliminary Assessment Report offers a cursory look at historical and current uses. This action will support the execution of expanded DOE records search efforts described in Actions 1.4 and 1.5. This action also supports completion of Action 1.7.
- **Action 1.4:** Complete initial assessment of classified records held at DOE-Germantown and the National Archives-College Park for information regarding PFAS use in nuclear production and research activities in the Manhattan Project and early Cold War. (Supports Objectives 1 and 3)
- **Action 1.5:** Identify relevant records (classified and open) held at DOE sites and Federal Records Centers and complete initial scoping efforts to identify likely PFAS use in historical and current DOE production and research activities. (Supports all objectives)
- **Action 1.6:** Publish environmental sampling guidance to support determining the nature and extent of PFAS releases at DOE sites, following the DQO process. This will establish consistency and robustness when executing site assessments described in Action 1.7. (Supports Objective 4)
- **Action 1.7:** Perform Site field assessments, as appropriate, and provide an annual site-specific status update to the PFAS Coordinating Committee (PCC). (Supports Objective 4)
- **Action 1.8:** Publish DOE PFAS Updated Status Report. (Supports all objectives)

2.0 APPROACH

Some DOE sites either are not comprised of operational facilities; do not have legacy environmental issues; do not generate, store, treat, or dispose of hazardous waste; or have been remediated or cleared of environmental liability. Therefore, it may appear that PFAS are not a concern requiring further attention. Until recently, PFAS were not considered a risk to the environment or human health, so the nature and extent of PFAS contamination may not have been included in prior environmental investigations or waste determinations. Additionally, PFAS sampling and analytical procedures were virtually unavailable. As a result, PFAS point sources may have had years to develop and migrate without detection or characterization.

Some DOE sites either are not comprised of operational facilities; do not have legacy environmental issues; do not generate, store, treat, or dispose of hazardous waste; or have been remediated or cleared of environmental liability. Therefore, it may appear that PFAS are not a concern requiring further attention. However, information used for historical investigations/remediations completed at these sites may have overlooked the potential for PFAS contamination as an emerging contaminant of concern.

For sites lacking an identified source/release; a full understanding of the site timeline; or a general understanding of potential PFAS use, the investigation approach should start with a review of available site information utilizing the resources in this Guide.

DOE recommends utilizing a process similar to the CERCLA Preliminary Assessment (PA) process as the framework for performing a PFAS historical and current use investigation. The main purpose of a PA is to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation (USEPA 2005). The PA generally is an initial compilation of existing information about the site and its surrounding area. Because DOE sites are at various stages of the environmental cleanup process (i.e., pre-and post-Record of Decision), how a PA will fit into the cleanup program will require regulatory coordination. Using the PA process will also allow sites to complete a single assessment and resulting report that can be used to communicate both with DOE-HQ and meet any regulatory requirements.

DOE recommends utilizing a process similar to the CERCLA PA process as the framework for performing a PFAS historical and current use investigation.

If the PA concludes that further investigation is warranted, DOE may conduct a follow-on evaluation process similar to the CERCLA Site Inspection (SI). Alternatively, a federal facility may combine the PA/SI report. The main purpose of the SI is to collect and analyze waste and environmental samples to identify the substances present, determine whether PFAS were released to the environment, and determine whether PFAS have impacted specific targets (USEPA 2005). DOE is developing a companion guide, the PFAS

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Environmental Sampling Guide for DOE Sites (ESG), as referenced in the DOE PFAS Strategic Roadmap, Action 1.6, to be completed by the second quarter of fiscal year 2023. This ESG should be consulted when conducting an SI or similar process. The ESG is intended to provide environmental sampling guidance to support determining the nature and extent of PFAS releases at DOE sites, following the DQO process which will establish consistency and robustness when executing site assessments.

All DOE sites do not comply with the same regulatory framework and the implementation of this Guide should be tailored to meet site-specific circumstances.

DOE recognizes that DOE sites are unique in their mission, regulatory agreements, and their regulatory framework; however, the investigative approach recommended is presented as a potential starting point for sites to address potential PFAS contamination in coordination with their regulatory partners. The PA evaluation process is a dynamic, flexible process that should be tailored to the specific circumstances of individual sites. The site is responsible for the design and execution of the PA and should determine how best to use the flexibility of this process. As conditions are tested and hypotheses are either confirmed or rejected, the investigation should be adjusted. These adjustments involve balancing a wide variety of factors and exercising professional judgment.

If a DOE site is subject to CERCLA cleanup (upon federal regulation of PFAS as a CERCLA hazardous substance), then the historical and current use investigative efforts of PFAS, documented in the final report, should be referenced in the site's CERCLA five-year reviews. Five-year reviews provide an opportunity to evaluate the implementation and performance of a remedy to determine whether it remains protective of human health and the environment. Documentation or reference of the site's PFAS historical and current use investigation in the five-year review allows the regulators a mechanism to concur on the hypotheses and conclusions. If a DOE site has not been subject to a CERCLA cleanup, then the PA process outlined in this Guide should be used as a methodical and defensible approach.

If a DOE site is subject to Resource Conservation and Recovery Act (RCRA) corrective action or cleanup, an alternative approach may be necessary (upon federal regulation of PFAS as a RCRA hazardous waste). EPA states sites that conduct a PA may satisfy some or all the PA reporting requirements through work conducted pursuant to the RCRA corrective action program or state cleanup programs (USEPA 2005). For example, a facility at which a RCRA Facility Assessment (RFA) has been conducted may base its PA on the RFA report. When work conducted under non-CERCLA authorities is the basis for satisfying PA requirements, the facility should demonstrate that all information required for the CERCLA PA is provided. In some instances, it may be appropriate to provide supplemental information to ensure that PFAS at the facility are addressed. This evaluation (PA or RFA) should be provided to the site's regulatory partners and

would provide the basis for determining whether further evaluation is warranted (refer to the ESG for further evaluation guidance).

Table 1 below provides a summary of the investigation steps, goals, and process under CERCLA and RCRA.

Table 1. PFAS assessment under federal regulatory authorities

General Environmental Investigation Steps	**Preliminary Assessment (DOE Historical and Current Use Guide)**	Site Screening Investigation (Use DOE ESG, 2023)	Site Risk Assessment Investigation (Use DOE ESG, 2023)
Overarching Investigation Goal	To determine potential for historical use and release of PFAS	To conduct sampling and analysis to evaluate PFAS concentrations and complete a Risk Screening	To conduct sampling and analysis to complete a Baseline Risk Assessment
Level of Data Density and Quality	Low-conceptual	High-quantitative screening	High-quantitative
CERCLA	Preliminary Assessment	Site Inspection (SI)	Remedial Investigation
RCRA	Facility Assessment (RFA)	Facility Investigation (RFI)	
Decision Supported	Determine whether No Further Action or progress to site investigation	Determine whether PFAS impacts and risks warrant: 1. No Further Action 2. Listing on the National Priority List (CERCLA-only) 3. Interim Action (RCRA) or Removal (CERCLA) 4. Risk Assessment	Determine if data sufficient to complete a risk assessment or a feasibility study or remedial alternatives evaluation (RCRA)

DOE sites should refer to the EPA PFAS website (https://www.epa.gov/pfas) for current information on CERCLA or RCRA PFAS regulations and policies. It is expected perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) will be listed as a hazardous substance under CERCLA by summer 2023 (USEPA 2022a). EPA has also begun the process to add PFOA, PFOS, perfluorobutanesulfonic acid (PFBS), and GenX as RCRA Hazardous Constituents and clarify the Corrective Action Program so that emerging contaminants such as PFAS can be cleaned up through the RCRA corrective action process.

Collaboration with site regulatory partners to choose a site-specific PFAS historical and current use investigation process is recommended and should begin before the investigation is initiated. Several states have implemented PFAS investigative and regulatory initiatives. In fact, some DOE sites may have completed initial PFAS investigations and are, or may be, proceeding with follow-on remediation activities, such as Remedial Actions, in response to coordination with their regulatory partners. DOE Site Management, site regulatory partners, and contractor management should be in alignment that the proposed approach and results support future decisions that meet regulatory requirements.

Collaboration with site regulatory partners to choose a site-specific PFAS historical and current use investigation process is recommended and should begin before the investigation is initiated.

It may also be necessary as new information becomes available for a site to amend their PA, for example, if a new PFAS constituent becomes regulated or a new PFAS category specific to DOE is learned. The DOE PFAS Working Group intends to remain a platform for sharing lessons learned, capturing regulatory changes, and updating lists of DOE PFAS categories and associated keywords.

The complexity of PFAS investigations can be attributed to many factors and an experienced investigation team should be employed. The investigative processes described in this Guide require the use of experienced environmental professionals, experts in records management, and other resources as necessary for successful completion. This will ensure that a systematic and acknowledged process was used to develop objective evidence on which to base subsequent conclusions.

3.0 PRELIMINARY ASSESSMENT

Some DOE sites have already conducted PFAS investigations or are in the process of investigating for PFAS in coordination with Federal and State regulators. However, it is prudent that these sites consider the information provided herein to ensure all potential PFAS uses are evaluated before exempting themselves from initiating the process described. The scope of the PA includes collecting readily available information through records research, conducting interviews with personnel, and site reconnaissance. The objective of the PA is to identify areas of interest where a release of PFAS to the environment may have potentially occurred. A release is defined by CERCLA as spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant).

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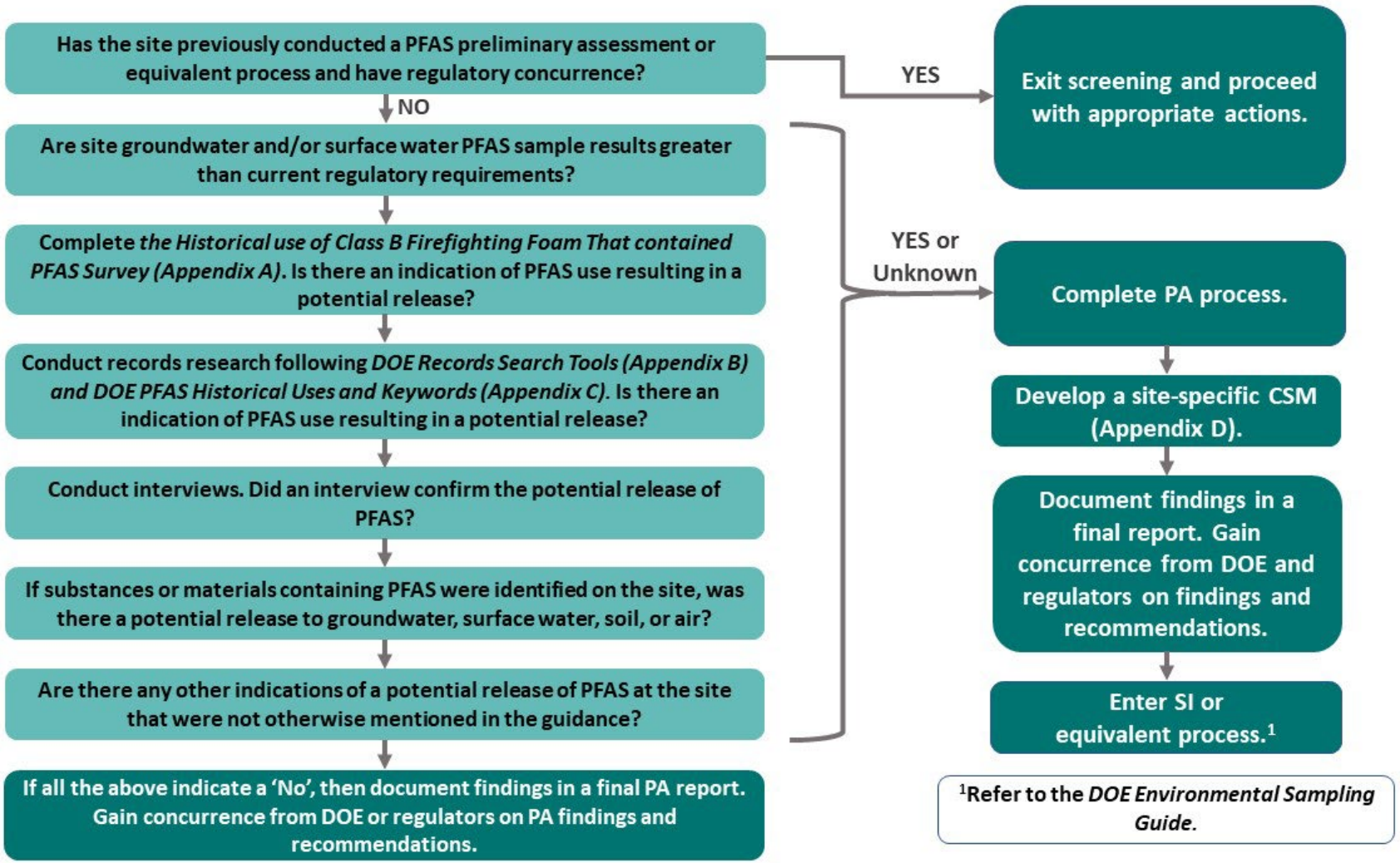
The major PA investigation tasks include gathering information, identifying potential PFAS sources, evaluating the potential for PFAS releases, developing the preliminary conceptual site model (CSM), and writing the final report. The PA process has been institutionalized for many years and EPA guidance is cited in the Reference section of this Guide. DOE's PFAS Preliminary Assessment Screening Flowchart summarizes the process (see Figure 2).

Figure 2. PFAS Preliminary Assessment Screening Flowchart



3.1 Gathering Information

Gathering information is the initial PA activity and informs follow-on activities. Common sources of information may include, but are not limited to, archived files and records; on-site stored files and records; environmental management system (EMS) related information, including compliance and regulatory information; chemical management system files and records; geographic information system files; procurement system files; aerial photographs; and interviews with past and current site employees. Sites may consider evaluating facilities and non-facilities individually to understand the operations lifecycle. Considerations should be given to all departments, such as environmental, operational and maintenance, and emergency response, etc., when gathering information. The information gathering process may include site reconnaissance for ground-truthing purposes to view areas of potential concern, verify verbal or pictorial information, or confirm the existence of structures or features that can help further the site characterization effort.

This Guide focuses on gathering information related to the historical and current use of PFAS. Refer to the EPA website for the definition of PFAS. DOE has developed several important tools to aid in the information gathering process, such as a fire department survey, records search guide, and list of keywords based on use (see Appendices A-C). Sites should gather information regarding the potential use of PFAS using these tools. Due to the experiences and lessons learned from Department of Defense (DoD) and DOE sites that have performed initial investigation efforts, DOE is focusing efforts on the highest potential use areas.

The most well established PFAS use resulting in environmental releases is the use of firefighting foams, specifically AFFF. To determine if the site has historically used firefighting foams, complete the *Department of Energy Historical Use of Class B Firefighting Foam That Contained Per- and Polyfluoroalkyl Substances (PFAS) Survey Questions for DOE Facilities (Appendix A)*. This survey aids in the investigation of the activities most associated with operations, maintenance, and training using AFFF and potential release locations.

The information gathering process will require the search and evaluation of many records and electronic systems. To assist with the search for key records, DOE has developed a *Records Search Tool (Appendix B)*. This tool provides tips for efficiently searching historical and current records in both nonsecure and secure storage, as well as electronic and hard copy.

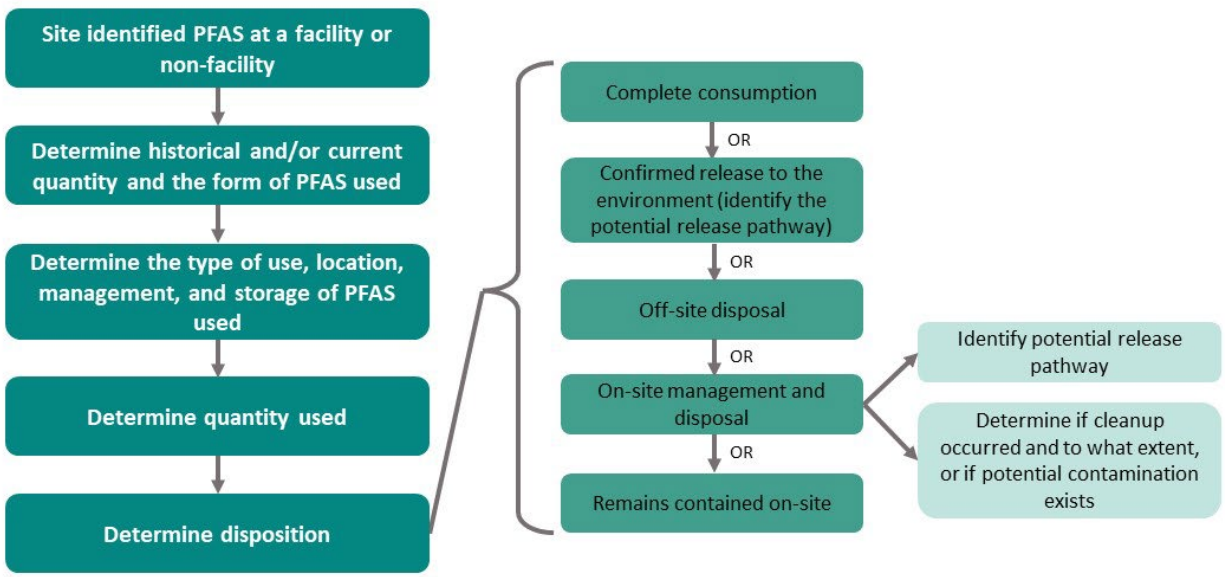
Next, sites should gather information regarding potential uses listed in the *DOE PFAS Historical Uses and Keywords Tool (Appendix C)*. This tool presents a standardized list of common uses at DOE sites that have the potential for a PFAS release. Note that these are an initial set of potential uses and are further categorized, but all sites are unique in their mission over many years; therefore, consideration of other uses (for example, as identified in published literature such as the PFAS overview reports by Glüge et al., 2020 and Gaines et al. 2022) should be

considered when gathering information. Associated with each category is a non-exhaustive list of keywords to assist in records research.

3.2 Identify Potential PFAS Sources

An evaluation of data collected during the information gathering process should help sites identify how, and if, the site used PFAS historically or uses it currently. To determine if those uses at facility and non-facility areas had the potential to be sources of a release to the environment, and to determine the need for further investigation, sites should determine the magnitude of PFAS use, management practices, release mechanisms, waste stream quantities, waste disposal practices and locations, and any prior response actions specific to PFAS (including removal actions) (see Figure 3). Real Property identifies a facility as either a Building or Other Structures and Facilities (OSF) as defined in Facilities Information Management System (FIMS [2022]). In addition, any facility that has undergone deactivation and/or decontamination that has not been demolished and excessed per FIMS remains a facility for the purposes of this guide. Non-facility is a location on the site absent of a building or OSF but which demonstrates presence of an activity (i.e., detonation areas, weapons range, area of discharges, decommissioned facility, excessed or archived facility, legacy/remediated site, etc.).

Figure 3. Identify Potential PFAS Sources Flowchart



Sites should also consider the following in this process:

- Inquiry into the operational and ownership history at the site; clear and concise description of past industrial and research operation(s) conducted on site; detailed evaluation of the most recent operations; all raw materials, finished products,

formulations, hazardous substances, and hazardous wastes that contained or may have contained PFAS, that are present, or were historically present, on the site.

- Inquiry into all current and historical wastewater discharges of sanitary and industrial waste and sludge; production processes and their respective wastewater use; water treatment systems such as reuse areas and lagoons; the specific and potential discharge and disposal points.
- How and where materials are or were received and stored on site, as well as overall waste handling and disposal procedures.
- The presence or potential presence of onsite permitted or non-permitted landfills, septic systems, centralized sewer systems, injection wells, floor drains, stormwater drains, industrial waste lines, waste disposal areas and/or burial grounds, or pump and treat systems.
    - The inquiry should include an evaluation of all available waste disposal records for any onsite landfill that describe the nature, quantity, location, and dates of waste placement.
    - Sampling in accordance with the ESG should be considered for leachate and water downgradient due to the potential complexity and uncertainty of inputs.
- Preliminary information about other documented PFAS releases outside the site boundary (i.e., within a 4-mile radius or radius determined by professional judgement). A potential resource of offsite information is Environmental Database Reports. These reports provide environmental risk data (e.g., proximity to schools, drinking water wells, etc.) near a target property such as a DOE site. These reports are valuable because they provide up-to-date information on the areas around DOE sites.

3.3 Evaluation of Likelihood of a Release of PFAS to the Environment

Once a site has determined historical or current PFAS sources with the potential to be released to the environment, the site should determine the likelihood of such a release. The EPA PA summary guides (USEPA 1991 and USEPA 2005) are useful aids for this part of the investigation. These guides are summarized below and tailored to PFAS. Refer to the ESG for discussion on background PFAS or if a PFAS release is identified but cannot be to a source.

3.3.1 Groundwater

PFAS are found in groundwater due to exposure to impacted media (e.g., firefighter training facilities or emergency response sites where AFFF was used, landfill leachate, or biosolids), spills, or other inadvertent releases that leach, infiltrate, and percolate, as well as direct discharge. The assessment of a release of PFAS to groundwater during a PA, if known or suspected, should include the following:

- Evaluation of the likelihood of a release to groundwater of PFAS from a source, based on site and pathway conditions, including considerations such as containment features

- Information on PFAS mobility in groundwater
- Information on local geology and hydrogeology, and associated site characteristics, including:
    - Rock and soil types, porosity, permeability, and seismicity
    - Aquifer(s)
    - Depth to aquifer
    - Groundwater use and regulatory classification of the aquifer
    - Low-permeability or confining layers impeding groundwater movement into or between aquifers
    - Aquifer discontinuities
    - Karst terrain and other preferential flow pathways
    - Infiltration rates
    - Precipitation rates and occurrence of extreme rain events
    - Surface topography
    - Containment and flow-control features (engineered structures such as liners or a leachate collection system), as well as simpler controls such as impermeable surfaces like parking lots and buildings
    - Co-contaminants (i.e., understanding co-solvency)

Use any available analytical data or circumstantial evidence suggesting the presence or absence of PFAS-related groundwater contamination and provide maps of groundwater wells used for monitoring, drinking, or other purposes. The EPA PA Summary Guide (2005) suggests a 4-mile radius of each source at the site be evaluated for the groundwater pathway. It is advised to use professional judgement when determining the appropriate search radius based on site specific needs and circumstances. The assessment of groundwater receptors in a PA should include the following:

- Identification and description of drinking water supply wells located within areas that could be or have been impacted by site contaminant releases
- Identification of public and private drinking water supply wells and systems, including the number of people they serve, and
- Description of groundwater-surface water interactions, especially groundwater discharge to surface water

3.3.2 Surface Water

PFAS are found in surface water due to exposure to impacted media (e.g., aerial deposition, landfill leachate, or biosolids), spills, or other inadvertent releases that runoff, leach, and infiltrate towards water bodies, as well as direct discharge. Surface water contamination may occur because of soil and sediment contamination or through contaminated groundwater seepage.

This section of the PA provides information for documenting the likelihood of exposure to PFAS-contaminated surface water and associated receptors of concern. The EPA PA Summary Guide (2005) suggests 15 miles downstream of points where sources discharge (or may discharge) PFAS to surface water be evaluated. It is advised to use professional judgement when determining the appropriate search distance based on site specific needs and circumstances. The assessment of a release to surface water and receptors of concern during a PA should include the following:

- Understanding of surface topography, drainage patterns, and outfalls, including any permitted under State or Federal pollutant discharge system regulations
- Description of surface water features including naturally occurring perennial water bodies, as well as streams and rivers, lakes, reservoirs, coastal tidal waters, oceans, seeps, marshes, and contiguous wetlands; in arid areas (where the mean annual precipitation is less than 20 inches) these include ephemeral and intermittently flowing waters and vernal pools
- Identification of existing analytical or circumstantial evidence of potential surface water contamination, including previous sampling data of surrounding surface waters or reports on closings (beach, fishing, recreational use) associated with the site
- Identification of foam on surface water
- Identification and description of drinking water intakes that may serve as municipal systems, community systems, or individual residential supplies
- Identification of information on the number of people utilizing drinking water intakes and information on the flow rates of water bodies at or near intakes from local water authorities (e.g., from the Unites States Geological Survey, local municipal and county water authorities, local government agencies)
- Identification of sensitive environments, such as aquatic resources, protected aquatic species, endangered species, fragile natural settings, or other areas, such as those Federally or State designated, with unique or highly valued environmental or cultural features (most commonly these are wetlands)
- Identification of information on fishery use from local fish and game officials, if data from published sources are lacking (fisheries are defined as surface water bodies from which aquatic organisms are taken for consumption purposes)
- Measurements of annual and seasonal flow rates and characteristics for streams and rivers

3.3.3 Soil

PFAS are found in soil and sediment due to atmospheric deposition, exposure to impacted media (e.g., aerial deposition, landfill leachate, groundwater, or biosolids), and direct discharge (e.g., firefighter training with AFFF). Soil and sediment may act as secondary sources of PFAS via

leaching to groundwater and runoff to surface water through leaching, percolation, and erosion processes.

This section of the PA provides information for documenting the likelihood of exposure to areas of PFAS-contaminated soil and associated receptors of concern. The PA should include the following:

- Identification and description of areas of suspected contamination defined by the actual presence of PFAS (i.e., in storage areas, as determined through previous chemical analysis, etc.)
- Identification of known or potential PFAS sources (including in-ground sources such as surface impoundments and landfills, septic systems, centralized sewer systems, wastewater treatment operations, injection wells, floor drains, stormwater drains, industrial waste lines, waste disposal areas and/or dump areas, areas previously subjected to fire-fighting activities, on-ground sources such as contaminated soil and piles, and above-ground sources such as drums and tanks) that are considered areas of potential contamination
- Identification of whether sources have more than two feet of clean cover, or an impenetrable cover, regardless of thickness
- Identification of areas in which surface soil contamination is not readily apparent based upon historical information, a visual survey of the site, and/or surface cover present (such as fill, asphalt, or concrete)
- Visual examination of the area, including sites with areas of cover, paying attention to fill cover that may be eroded or unevenly distributed, and asphalt/concrete with cracks or fissures providing insufficient cover
- Consideration of all information relevant to soil exposure, such as groundwater contamination (which may indicate the presence of surface or subsurface soil contamination unaccounted for by visual examination of the site)
- Identification of extent of release (as this may impact the location of samples, if sampling is deemed necessary)
- Identification of receptors that may be exposed to releases from the source, including workers, public, terrestrial, aquatic resources, and other sensitive resources
- Identification of receptors that may engage in recreational activities on areas of contamination
- Examination and identification of health reports of adverse health effects, suspected releases on adjacent or nearby properties, reports or observations of the site being flooded, overflow of PFAS contaminants to other properties, or reports/observations of windblown substances deposited on nearby properties

3.3.4 Air

The air pathway should only be evaluated if a release to the air is suspected or identified. PFAS are sometimes associated with stack or other air-emission sources and may contribute to regional PFAS concentrations. Certain PFAS are currently found in ambient air, with elevated concentrations observed or expected in urban areas nearest to major emission sources, such as industrial facilities that produce PFAS or use PFAS chemicals or products in manufacturing. Other areas of concern may be in areas where Class B firefighting foams containing PFAS are used or released; waste management facilities, including landfills and wastewater treatment plants; metal plating operations; areas of biosolids production and application; or high temperature applications.

If DOE facilities conducted operations in the past that involved potential PFAS air emissions, the deposition of PFAS onto soil may need to be characterized by soil sampling. Atmospheric transport and deposition from DOE facilities or off-site activities may have resulted in PFAS contamination in terrestrial and aquatic systems near points of significant emissions, contaminating soil, groundwater, and other media of concern, as well as several miles from industrial emission sources.

This section of the PA provides information for documenting releases or suspected releases of PFAS to the air migration pathway and associated receptors of concern. The assessment of a release to air during a PA should include the following:

- Evaluation of the likelihood of release of PFAS to air based on site operations and pathway analysis and description; use any available analytical or circumstantial evidence suggesting release of PFAS contaminants into the air
- Description of wind currents which may cause air releases to disperse in any direction
- Identification of human populations and sensitive environments near the site; determine distance to the nearest regularly occupied on-site or off-site building and identify populations (residents, students, workers, subsistence gatherers), sensitive environments/species (terrestrial and aquatic), and wetlands (USEPA 2005)

3.4 Preliminary Conceptual Site Model

A CSM is a concise written summary and/or graphical representation of what is known or hypothesized about environmental contamination at a site and the relationships among key site information that are pertinent to decision-making. A CSM is a representation of source, release, migration, and potential exposure pathways that evolves over the life cycle of site characterization. It provides a platform for evaluating the data gaps and related uncertainty associated with site history and operations; geology, hydrogeology and hydrology; contaminant sources, release mechanisms and fate and transport; potential receptors and exposure pathways.

The development of an accurate CSM is vital to the project and site decision-making process. CSM development is an iterative process over the project life cycle.

Information resulting from the use of this Guide and from existing DOE Site data will aid in the development of a site-specific preliminary CSM for each area of interest showing potential source and release locations. The preliminary CSM will then support the justification for environmental sampling if necessary. A generic preliminary CSM graphic for PFAS is included as an example in Appendix D. At the end of the PA, the CSM will be used to identify all areas of interest where PFAS are likely to have been released to an environmental media that require further evaluation in the SI process.

3.5 Final Report

At the completion of the PA, a narrative report that meets the site's specific regulatory needs should be prepared. This report summarizes what is known about the site, what is assumed or inferred, the activities conducted during the PA, all researched information and findings, a preliminary CSM, and recommendations for sites moving to the Site Inspection phase. Facilities and non-facilities that are determined to require further evaluation per Figure 2 should reference DOE's PFAS ESG for SI or equivalent process guidance. This report can be referenced to update other documentation from regulatory drivers as appropriate. Reference materials (e.g., figures, maps, photos, QA/QC data) should accompany the PA Narrative Report. Example outlines for the Narrative Report are presented in U.S. EPA guidance (USEPA 2005).

The DOE Site management, appropriate external regulators, and contractor management should be confident that the final narrative report provides the basis for any path forward and meeting existing and future regulatory requirements.

The DOE Site management, appropriate external regulators, and contractor management should be confident that the final narrative report provides the basis for any path forward and meeting existing and future regulatory requirements. Submit the report to the DOE PFAS Coordinating Committee (PCC) for the Updated Status Report (Roadmap, Action 1.8) and external regulators, as appropriate.

4.0 OTHER CONSIDERATIONS

All DOE sites are required to implement and maintain an EMS that meets the requirements of the International Organization for Standardization (ISO) 14001 Environmental Management Systems International Standard. If site characterization activities reveal that PFAS are a hazardous substance that were unevaluated, a review of the site's EMS should be undertaken to determine if they pose new risks and liabilities that require the establishment of a new environmental aspect in accordance with Pillar 2 of the DOE Roadmap: "Safeguard the health and well-being of our employees by minimizing the exposure to PFAS and addressing PFAS releases." In addition, appropriate environmental objectives should be considered in accordance with the ISO standard.

5.0 KEY SOURCES OF INFORMATION

Much of the information in this Guide was supplied by external resources. Emerging contaminants like PFAS create a collaborative need where shared resources build the body of knowledge and aid in informed decision making. Below is a list of key resources available for sites to access and become familiar with before beginning records searches.

- DOE Office of Sustainable Environmental Stewardship (EHSS-21) maintains departmental PFAS information, such as the PFAS Strategic Roadmap and the PFAS Initial Assessment, on the DOE PFAS website. Continue to monitor this website for future PFAS information and resources. https://www.energy.gov/pfas.
- EPA operates an extensive website with basic PFAS information, EPA actions to address PFAS, and additional detailed tools and resources. https://www.epa.gov/pfas. Additionally, EPA has numerous guidance and information documents on CERCLA PA and RCRA Facility Assessments.
- The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition working to reduce barriers to the use of innovative environmental technologies and approaches so that compliance costs are reduced and cleanup efficacy is maximized. ITRC hosts a thorough, widely recognized library of technical resources, guidance, and training materials on PFAS. For example, there is a Quick Explainer Video on PFAS History and Use as well as a Longer PFAS Training Module Video on Production, Uses, Sources and Site Characterization. ITRC also offers an expansive PFAS Technical and Regulatory Guidance Document which is updated regularly. https://pfas-1.itrcweb.org/
- Host states can be sources of information, depending on how advanced they are in addressing PFAS as emerging contaminants. Several DOE sites are engaged in PFAS investigations initiated by their host states such as Brookhaven National Lab and Rocky Flats Site. These sites are proceeding in accordance with federal facility agreements, state regulations, or alternative agreements made. Benchmarking with these DOE sites can be beneficial.
- DoD has a mature PFAS investigation program. However, most of their investigations have focused exclusively on AFFF. Their investigations follow the CERCLA PA process. Much of their information is publicly available on DoD websites. https://denix.osd.mil/dod-pfas/

Federal Resources

- Agency for Toxic Substances and Disease Registry
- Food and Drug Administration
- National Institutes of Environmental Health Sciences
- United States Army Per- and Polyfluoroalkyl Substances
- United States Air Force, Civil Engineer Center
- United States Air Force Administrative Record

- United States Navy
- USDOE National Nuclear Security Administration
- Strategic Environmental Research and Development Program – Environmental Security Technology Certification Program PFAS Initiative

Other State Resources

- Association of State Drinking Water Administrators
- Environmental Council of the States
- Environmental Research Institute of the States
- National Academy of Sciences

6.0 REFERENCES

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USDOE 2022, *PFAS Strategic Roadmap: DOE Commitments to Action 2022-2025*.

USDOE 2023, *Department of Energy PFAS Environmental Sampling Guide*.

USEPA 1991, Guidance for Performing Preliminary Assessments Under CERCLA, OSWER 9345.0-01A.

USEPA 2005, Federal Facilities Remedial Preliminary Assessment Summary Guide.

USEPA 2022, "PFAS Strategic Roadmap: EPA's Commitment to Action 2021-2024." https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024

Guide for Investigating Historical and Current Uses of Per- and Polyfluoroalkyl Substances at Department of Energy Sites

APPENDICES

Appendix A – Historical Use of Class B Firefighting Foam That Contained PFAS: Survey Questions for DOE Facilities

Department of Energy Historical Use of Class B Firefighting Foam[1] Containing Per- and Polyfluoroalkyl Substances (PFAS):

Survey Questions for DOE Facilities

1. Does the site currently have, or did it previously have, a fire department?[1]

Yes ☐ **No ☐** **Unknown ☐**

If yes, *please note**:***

a. Date range of operation:
b. Number of fire department facilities located on site:
    I. Are any of the facilities operated by other agencies (e.g., U.S. Forest Service, local municipal fire department)?
c. Have the fire department facilities always been at the same location(s)?
d. Are engineering and other documents available related to firehouse construction and supporting utilities (e.g., locations of floor drains, stormwater, and sanitary systems) for each facility?
e. Are incident reports for emergency responses and firefighter training available for review (e.g., documents maintained at the fire department or by fire protection engineers, chemical inventory records, Safety Data Sheets, procurement records, or photographs of firefighting or firefighter training activities taken by site photographers)?
    I. For what years are records available? [2]
f. Other relevant information:

[1] **Class B firefighting foam** for the purpose of this document includes aqueous film forming foam (AFFF), alcohol resistant aqueous film forming foam (AR-FFFF), film-forming fluoroprotein foam (FFFP), alcohol resistant film-forming fluoroprotein foam (AR-FFFP), and fluoroprotein foam (FP).

[1] Fire Department – an emergency response organization, equipped and trained to fight fires. This includes established fire departments and formal employee-based Emergency Response Organizations that have support from a neighboring municipality.

[2] A useful starting timeframe would be 1964 when firefighting foam that contained PFAS became readily available.

If no, *please note:*

g. Is the site protected by a municipal fire department?
h. Are there incident reports related to municipal fire departments responding to on-site fires?
i. Are records available that document municipal firefighters conducting on-site training?
j. Other relevant information:

Former DOE Facilities:

k. For former DOE facilities (e.g., Mound) that have been redeveloped for commercial/private business use, who is currently providing fire protection for the site and is Class B foam being used or stored at the facility?

2. Has Class B fire suppression foam (also referred to as Aqueous Film Forming Foam, High Expansion Foam, or Low Expansion Foam) ever been stored and/or used at the fire department facility, at an on-site firefighting training facility, or at a building protected by a fire suppression system?

Yes ☐ No ☐ Unknown ☐

If no, please describe in section 2a, what was done to confirm that Class B foam was never stored or used at the site. *There is no need to answer the remaining questions*.

a. Explanation:

If yes, please answer all questions below:

b. How many locations (i.e., at more than one firehouse or support facility)?
c. Method of storage (e.g., in original containers, storage tanks on fire apparatus):
d. Range of dates for storage and use:
e. If foam concentrate was stored in fire apparatus holding tanks, were the foam delivery systems routinely tested and at what frequency?
    I. If testing occurred, where would the foam be discharged? Was foam discharged to ditches, stormwater catch basins or other conveyances?
    II. What was done with unused foam when the tanks and lines had to be emptied and flushed?

III. Is information available regarding where emergency vehicles were washed, maintained, or tested? Including spray nozzle refractory test locations?
IV. If firefighting equipment/apparatus that contained Class B foam was decommissioned/sent to surplus, were the foam holding tanks drained and flushed, and where would this occur?

f. Is information available on the manufacturer(s), types, and quantities of Class B foam stored or quantities used over the years?
g. Other relevant information:

If unknown, has the facility started to investigate whether Class B foam was ever stored or used at the site?

h. Explanation:

3. Is Class B fire suppression foam currently used or stored at the fire department or other facility (e.g., centralized emergency services storage facility or a facility protected by a fixed fire suppression system)?

Yes ☐ No ☐ Unknown ☐

If yes, please note for each location or system:

a. Manufacturer and type of Class B foam:
b. Date of purchase:
c. Quantity:
d. % PFOS/A in foam concentrate:
e. Method of storage (e.g., in original containers, storage tanks on fire apparatus):
f. Is information on the types and quantities of foam in storage being tracked using the site's chemical management system?
g. Other relevant information:

4. Has Class B fire suppression foam ever been used for training purposes at the facility?

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Did/does the training occur at a dedicated firefighter training area/facility?
    I. Location(s):
    II. Dates or frequency of training:

b. Did/does training occur at other on-site areas (e.g., fuel storage or research facilities)?
    I. Location(s):
    II. Dates or frequency of training:
c. Was foam ever released for firefighting demonstration purposes (for outside agencies, employees, or employee-family events) in areas not normally used for training?
d. Manufacturer and type of Class B foam used:
e. Quantity of foam used:
f. Is/was the foam used for training containerized for treatment/disposal?
g. Was foam released in areas where it could infiltrate soil, or enter stormwater drainage or sanitary systems?
h. Other relevant information:

5. Has Class B fire suppression foam ever been used for firefighting or other emergency responses at the facility? This includes emergency foam releases at facilities that have fixed fire suppression systems that used Class B foam.

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Dates and locations:
b. Manufacturer and type of Class B foam used:
c. Quantity of foam used:
d. Could the foam have infiltrated nearby soils, entered exterior stormwater drainage systems, interior drainage systems, or sanitary systems?
e. As part of a mutual aid response, did an outside fire department use Class B foam at the site? Is information available on where the event(s) occurred, and the type and quality of foam that was used?
f. Other relevant information:

6. Has the facility ever been responsible for the use of Class B fire suppression foam for training or emergency response that occurred at an off-site area or facility?

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Use of Class B foam for an emergency response as part of a mutual aid to another fire department?
    l. Dates and locations where foam was used:
b. Was Class B foam used at an off-site regional firefighter training facility?
    l. Are training records available?
c. Other relevant information:

7. Was there ever an accidental spill or leak of Class B fire suppression foam?

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Dates and locations:
b. Manufacturer and type of Class B foam used:
c. Quantity of foam spilled/leaked:
d. Could the foam have infiltrated nearby soils, entered exterior stormwater drainage systems, interior drainage systems, or sanitary systems?
e. Other relevant information:

8. Does/did the facility have fixed fire suppression systems for buildings, aircraft hangars, research facilities, or other which use/used Class B fire suppression foam?

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Locations of systems:
b. Dates the systems were in service:
c. Are records available on the design of the fire suppression systems?
d. Manufacturer and type of Class B foam used:
e. Quantity of foam used:
f. Are there records related to acceptance testing/commissioning, and the routine testing of the systems?
    l. How often are/were the systems tested?
g. Was foam ever released in response to a fire at the facility?
h. Was foam released inside protected structures, and could the foam have entered interior drainage systems?

l. Where do interior drainage systems discharge into (e.g., sanitary or stormwater systems)?

i. Was the foam released outside, and could the foam have infiltrated nearby soils or enter stormwater drainage?

j. Other relevant information:

9. Does/did the facility have procedures for handling Class B fire suppression foam that has reached its expiration date?

Yes ☐ No ☐ Unknown ☐

If yes, please note:

a. Foam was/is containerized for disposal:
b. Foam was/is used for training:
c. Foam was/is disposed on-site (e.g., released to ground or landfill):
d. Could the foam have infiltrated nearby soils, entered stormwater drainage, or have been released to interior drainage systems (e.g., floor drains at the firehouse)?
e. Other relevant information:

10. Has the site tested environmental or treatment system samples for PFAS in areas where Class B fire suppression foam had been used for training, released during fire suppression system testing/maintenance, or used for emergency response?

Yes ☐ No ☐ Unknown ☐

If yes, please note the types of monitoring conducted and whether PFAS have been detected in the samples:

a. Groundwater:
b. Soils:
c. Surface water:
d. Sanitary treatment system:
e. Groundwater treatment systems:
f. Other monitoring:

11. What is the general level of confidence in the site's ability to document all relevant information related to Class B foam release locations and quantities?

Very Confident ☐ Confident ☐ Not Confident ☐

Appendix B – DOE Records Search Tool

Department of Energy Records Search Tool for Investigating Per- and Polyfluoroalkyl Substances (PFAS)

A successful effort to identify relevant records (classified and open) held at DOE sites and Federal Records Centers (FRCs) requires extensive resources and the involvement of a variety of subject matter experts.

The Program Records Official (PRO) for Departmental elements, who has program and field site oversight, budgetary, and signature authority to approve records issues for the program and serves as the program liaison with the Departmental Records Officer, should be involved with ensuring that PFAS record searches are conducted by qualified records staff at each DOE site.

Records management personnel should also work closely with other subject matter experts in identifying potentially responsive records, including historians, archivists, and other staff who possess historical knowledge about the site.

This *DOE Records Search Tool* is designed to provide some guidance in conducting records searches and includes a reporting tool for sites to complete, *U.S. Department of Energy Records Documenting Historical Uses of Per- and Polyfluoroalkyl Substances (PFAS) Survey Questions for DOE Facilities*, below.

Types of Records to Search

To characterize and understand historical and current uses of PFAS, both on-site and off-site records should be consulted. This includes analog and electronic records, and both classified and unclassified material. Potentially responsive records can come in a variety of forms, as specified in the survey below.

Conducting Records Searches

All analog and electronic records searches should employ the *DOE PFAS Historical Uses and Keywords Tool (Appendix C)*. Given that PFAS have been used for decades but were not referred to as PFAS for much of that time, identification of these chemicals can be a challenge, and finding information about their use and disposal can be even more difficult. On the other hand, because PFAS are so ubiquitous and the terms used to refer to them in historical records can be so broad and non-specific, using the general keywords provided by the guide will almost certainly result in hundreds, if not thousands, of "hits" that are not directly responsive to the inquiry.

One approach to this challenge is to begin by separately documenting results from one or more searches, using chemical and trade names to more clearly identify the quantity of records that are likely to provide information about specific PFAS historic use and disposal. For example, if you are conducting a search of records using the list of keywords for uranium enrichment and plutonium production, you could begin by recording the number of documents for each category in the chemical and/or trade name list:

Chemical and Trade Names	# of documents
C-2144	27
C616	12
Chlorotrifluoroethylene	43
Du Pont (manufacturer)	234
Kellex	278
Perfluoroheptane (C7 F16)	32
Perfluoro-1,3-dimethylcyclohexane (also CAS No. 335-27-3)	4
Perfluorinated dimethylcyclohexane (also C8 F16 or C-816)	7
Polytetrafluoroethylene (PTFE)	46
Symalit	59
Teflon	3

A secondary search using PFAS Specific Terms will provide you with a volume of records that are likely to be responsive:

PFAS Specific Terms	# of documents
Fluorolube	7
MFP (also MFP-10)	12
Perfluoro	18
Perfluorinated polymers	2
Special chemicals	5

The list of general terms in Appendix C, *DOE PFAS Historical Uses and Keywords Tool*, is designed to drill deeper to identify PFAS-related records that may not be as easy to find. The general

terms can be so broad, however, that they could result in search results that are unmanageable without identifying the context for those specific records or establishing the likelihood that they may be related to PFAS historic use or disposal. With the general terms below, for example, if you are conducting a search for "acid" in the site's database, it may be helpful to look at the subject of adjacent files, dates for those files, or the collection title or heading. It may also be helpful to combine search terms to try to narrow results and increase the likelihood that results may be responsive, or to use other available search operators.

Acid	Insulator
Coating	Lubricant
Coolant, cooling medium	Membrane filtration (MFL)
Corrosion, corrosive, anti-corrosive	Oil
Fluor or fluoro	Sealant
Gaseous diffusion operations	Tubing
Gaseous diffusion report	UF_6 Separation/Diffusion
Gasket	Valve
Grease	Valve packing
Heavy fluorocarbon	Wax
Membrane filtration (MFL)	

Record searches using the broader general keywords above may, nevertheless, provide more substantive results when completing initial scoping efforts to identify likely PFAS use in historical and current DOE production and research activities. In the case of uranium enrichment, for example, the most informative records relating to historical use initially came from gaseous diffusion project reports. A preliminary search of the archives at Headquarters (HQ) resulted in no hits for any of the chemical names and PFAS specific terms, and very little for trade names and most of the general terms. Searching for "gaseous diffusion" resulted in a report describing the use of PFAS during the Manhattan Project.

Consultation with Technical Subject Matter Experts

Technical subject matter experts should be consulted before and after conducting records searches. Interviews have proven to be invaluable in identifying both potentially responsive records, as well as site-specific key words to use when searching those records. As many of the records identified are likely to include technical information, subject matter experts will also be needed to review the records identified by the search to determine their responsiveness.

Working with Classified Records

Sites with classified records should work closely with their classification offices to review potentially responsive material for declassification. For sites without classification offices, the Office of Classification at DOE-HQ should be consulted.

Survey Questions

To determine if a site has historically used and disposed of PFAS, complete the *U.S. Department of Energy Records Documenting Historical Uses of Per- and Polyfluoroalkyl Substances (PFAS) Survey Questions for DOE Facilities* below.

U.S. Department of Energy Records Documenting Historical uses of Per- and Polyfluoroalkyl Substances (PFAS):

Survey Questions for DOE Facilities

1. **Does the facility have on-site *analog* records that may document historical uses of PFAS?**

   Yes ☐ No ☐

   If yes, *please note:*

   a. Date range of records:
   b. Location of records facilities:
      I. Are any of the facilities operated by contractors?
   c. What is the approximate volume of records?
   d. Are the records indexed?
      I. If yes, at the folder level or individual level?
      II. Are the indexes available in electronic form for searching?

2. **Does the facility have *electronic* records that may document historical uses of PFAS?**

   Yes ☐ No ☐ Unknown ☐

   If yes, *please note:*

   e. Date range of records:
   f. What is the approximate volume of records?
   g. Are the records indexed?
      I. If yes, at the folder level or individual level?

3. **Are there *off-site* records that may document historical uses of PFAS at the facility?**

   Yes ☐ No ☐ Unknown ☐

   If yes, *please note:*

   h. Date range of records:
   i. Location of records facilities:
   j. What is the approximate volume of records?

k. Are the records in analog or electronic format?
l. Are the records indexed?
    I. If yes, at the folder level or individual level?
    II. Are the indexes available in electronic form for searching?

4. Do the following types of records exist for the facility?

Records Types	Yes	No	Analog	Digital	On-Site	Off-Site
Accident investigations						
CERCLA and other regulatory historical documents						
Chemical Management Systems and chemical inventories						
Department of Labor personnel exposure records						
Engineering drawings and systems documentation						
Fire department or emergency management records						
Historic American Buildings Survey (HABS)/ Historic American Engineering Record (HAER) reports and related records						
Landfill records						
Organizational charts that identify roles and positions/responsibilities to identify records of individuals involved with PFAS use and disposal						
Photograph collections						
Production, processes, and operations records related to common practices involving PFAS, identified in Appendix B: *DOE Records Search Tool*						
Purchasing records related to chemicals						
Records of individuals involved with PFAS use and disposal						
Spill and release reports						
Waste and Environmental Management Systems						
Waste manifests						
Weapons records/inventories						

5. **Have you conducted keywords searches for *on-site* records using Appendix C *DOE PFAS Historical Uses and Keywords Tool?***

   Yes ☐ No ☐

6. **Have you conducted keywords searches for off-site records using Appendix C *DOE PFAS Historical Uses and Keywords Tool?***

   Yes ☐ No ☐

7. **After conducting a keywords search using Appendix C, *DOE PFAS Historical Uses and Keywords Tool*, were you able to identify any potentially responsive records for any of the following categories of keywords?**

Category	Yes	No
General PFAS Terms		
Category 1: AFFF		
Category 2: Wastewater Treatment Plants and Landfills		
Category 3: Uranium Enrichment, Plutonium Production, and Nuclear Operations		
Category 4: Metal Plating Processing		
Category 5: Explosives, Munitions, and Weapons		
Category 6: Electronics Manufacturing		
Category 7: Equipment Fuel/Maintenance		
Category 8: Well Drilling		
Category 9: Pesticides		
Category 10: Laboratory		
Category 11: Other		

8. **Using Appendix C, *DOE PFAS Historical Uses and Keywords Tool*, what volume of potentially responsive records exist for the following categories of keywords?**

Category	Volume of Records
General PFAS Terms	
Category 1: AFFF	
Category 2: Wastewater Treatment Plants and Landfills	
Category 3: Uranium Enrichment, Plutonium Production, and Nuclear Operations	

Category	Volume of Records
Category 4: Metal Plating Processing	
Category 5: Explosives, Munitions, and Weapons	
Category 6: Electronics Manufacturing	
Category 7: Equipment Fuel/Maintenance	
Category 8: Well Drilling	
Category 9: Pesticides	
Category 10: Laboratory	
Category 11: Other	

9. Has a technical expert reviewed the records to determine their responsiveness?

Yes ☐ **No ☐**

10. If yes, has the technical expert determined that there are responsive records that describe or quantify the historic use of PFAS in any of the following categories?

Category	Yes	No
General PFAS Terms		
Category 1: AFFF		
Category 2: Wastewater Treatment Plants and Landfills		
Category 3: Uranium Enrichment, Plutonium Production, and Nuclear Operations		
Category 4: Metal Plating Processing		
Category 5: Explosives, Munitions, and Weapons		
Category 6: Electronics Manufacturing		
Category 7: Equipment Fuel/Maintenance		
Category 8: Well Drilling		
Category 9: Pesticides		
Category 10: Laboratory		
Category 11: Other		

11. Does the facility have any classified records that are potentially responsive in describing or quantifying history use of PFAS?

Yes ☐ **No** ☐

If yes, have those records been searched using Appendix C, *DOE PFAS Historical Uses and Keywords Tool*?

Yes ☐ **No** ☐

Are potentially responsive classified records under declassification review?

Yes ☐ **No** ☐

Appendix C – DOE PFAS Historical Uses and Keywords Tool

Department of Energy Per- and Polyfluoroalkyl Substances (PFAS) Historical Uses and Keywords Tool

This guide is intended to provide a non-exhaustive but standardized list of common uses at the Department of Energy (DOE) that have the potential for a per- and polyfluoroalkyl substances (PFAS) release and can be used when performing a preliminary assessment (PA) and/or site inspection (SI), or similar site research process. Uses are categorized and are generally listed as a hierarchy of highest to least likelihood of a potential PFAS release. However, in some categories, the PFAS concentrations may have been used in a de minimis application, depending on the site. Associated with each category are a non-exhaustive list of keywords to assist in records research. It is suggested to use any combination of the provided keywords to generate records research results (e.g., fire + suppressant). The records researcher should also keep in mind the potential for keywords to incorporate alternate spellings, either on the source documents or the records entries (misspellings and typographical errors, as well as spelling variations such as DuPont vs. Du Pont, 3M vs. 3-M, etc.). Figure C-1 outlines the step-by-step process for using the appendix.

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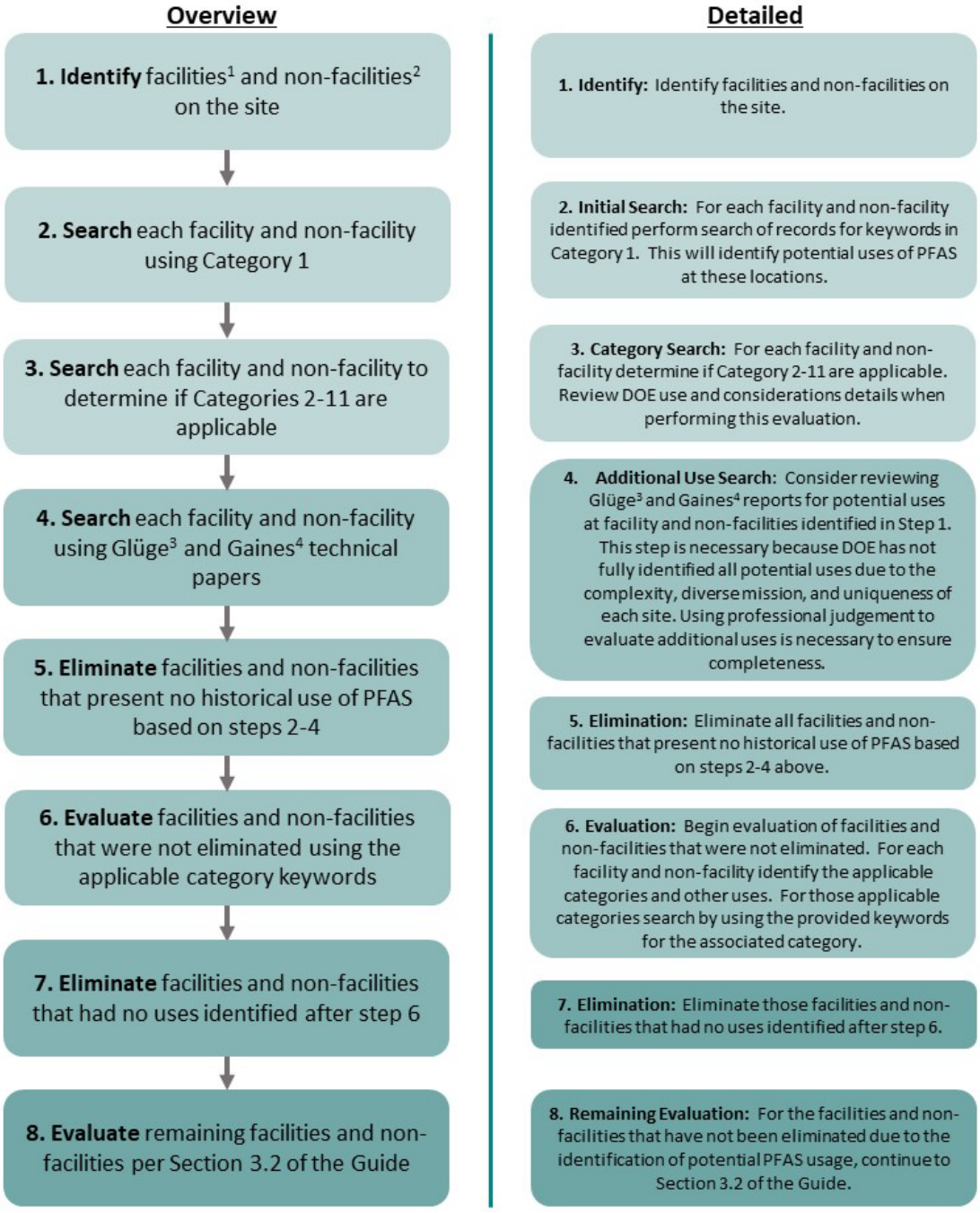
Figure C-1. Using *DOE PFAS Historical Uses and Keywords Tool* Flowchart



[1]Facility is either a Building or Other Structures and Facilities (OSF) as defined in FIMS. Any facility that has undergone deactivation and/or decontamination that has not been demolished and/or excessed per FIMS remains a facility for the purposes of this guide.

[2]Non-facility is a location on the site absent of a building or OSF but which demonstrates presence of an activity (i.e., detonation areas, weapons range, area of discharges, decommissioned facilities, excessed or archived facility, legacy/remediated sites, etc.).

[3]Glüge, J., Scheringer, M., Cousins, I. T., DeWitt, J. C., Goldenman, G., Herzke, D., ... & Wang, Z. "An overview of the uses of per-and polyfluoroalkyl substances (PFAS)." Environmental Science--processes & Impacts 22.12 (2020): 2345-373.

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Guide for Investigating Historical and Current Uses of Per- and Polyfluoroalkyl Substances at Department of Energy Sites

General PFAS Terms

DOE Use & Considerations: General and common terms to aid in records and chemical management research. The list below is intended to reflect the likelihood of a search return by group; the terms are then alphabetized within the group. Additional information on chemicals can be found at (but not limited to) EPA's CompTox Chemicals Dashboard, EPA's Chemical and Products Database (CPDat), the Office of Chemical Safety and Pollution Prevention (OCSPP), and Safety Data Sheets (SDSs).

Keywords:

General and Common Terms			
Chemical Names	C-216 (conditioning agent)	PFOA (also CAS No. 1763-23-1)	PFBA (also CAS No. 375-22-4)
	C-270 (sealant)	PFOS (also CAS No. 335-67-1)	Perfluoroalkyl Acid (PFAA)
	C-2144 or $C_{21}F_{44}$ (lube oil)	PFDA (also CAS No. 335-76-2)	Perfluoroalkyl carboxylic Acid (PFCA)
	C8 or C-8	PFNA (also CAS No. 375-24-4)	Perfluoroalkyl sulfonic acid (PFSA)
	Hexafluoropropylene oxide dimer acid (HFPO-DA)	PFHxA (also CAS No. 307-24-4)	Perfluoroalkyl phosphonic acid (PFPA)
	K-416 (polymer)	PFHxS (also CAS No. 355-46-4)	Perfluoroalkyl phosphonic acid (PFPIA)
	MFL (CF2-CFCl)		
Trade Names	ADONA	Linde Air Products, Inc.	Teflon (Tef) (polymer D-29)
	GenX or Gen-X	Scotchgard	
Manufacturers/ Companies	3M	BASF Corporation	DuPont
	AGC Chemical Company	Buckeye	F2 Chemicals
	Angus	Chemguard	Fire Services Plus, Inc. (FSP)
	Ansul	Chemours Company	National Foam
	Arkema	Clariant	Solvay Solexis
	Asahi	Daikin Industries	Tyco
Common Terms	Conditioning agent	High-corrosivity	Perfluorooctyl
	Fluor or fluoro[3]	High-heat	Polyfluoroalkyl

General and Common Terms			
	Fluorinated chemical (also florinated, fluorinated)[3]	High-pressure	PFAS
	Fluorinated surfactant[3]	Hydrophobic	Plastic
	Fluorochemical	Lube oil	Polymer
	Fluorothene	Oleophobic	Long-chain
	Fluoroprotein	Organofluorine	Short-chained
	Fluorosurfactant	Perfluoroalkyl	Straight-chain
	Fluorosulfonate	Perfluorocarbon	Branched-chain
	Forever chemical	Perfluorooctanoic	

2021 PFAS Integrated Risk Information System (IRIS) Assessments	
PFAS Name	**CAS**
perfluorodecanoic acid (PFDA)	335-76-2
perfluorononanoic acid (PFNA)	375-95-1
perfluorohexanoic acid (PFHxA)	307-24-4
perfluorohexanesulfonic acid (PFHxS)	355-46-4
perfluorobutanoic acid (PFBA)	375-22-4

Third Unregulated Contaminant Monitoring Rule (UCMR) Listed PFAS	
PFAS Name	**CAS**
perfluorooctanesulfonic acid (PFOS)	1763-23-1
perfluorooctanoic acid (PFOA)	335-67-1
perfluorononanoic acid (PFNA)	375-95-1
perfluorohexanesulfonic acid (PFHxS)	355-46-4
perfluoroheptanoic acid (PFHpA)	375-85-9
perfluorobutanesulfonic acid (PFBS)	375-73-5

Fifth Unregulated Contaminant Monitoring Rule (UCMR) Listed PFAS	
PFAS Name	**CAS**
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9
9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4
hexafluoropropylene oxide dimer acid (HFPO DA)	13252-13-6
nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6
perfluorobutanoic acid (PFBA)	375-22-4
perfluorobutanesulfonic acid (PFBS)	375-73-5

[3] Terms from lessons learned that were successful in records search.

Fifth Unregulated Contaminant Monitoring Rule (UCMR) Listed PFAS	
PFAS Name	**CAS**
1H,1H, 2H, 2H-perfluorodecane sulfonic acid (8:2FTS)	39108-34-4
perfluorodecanoic acid (PFDA)	335-76-2
perfluorododecanoic acid (PFDoA)	307-55-1
perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7
perfluoroheptanesulfonic acid (PFHpS)	375-92-8
perfluoroheptanoic acid (PFHpA)	375-85-9
1H,1H, 2H, 2H-perfluorohexane sulfonic acid (4:2FTS)	757124-72-4
perfluorohexanesulfonic acid (PFHxS)	355-46-4
perfluorohexanoic acid (PFHxA)	307-24-4
perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1
perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5
perfluorononanoic acid (PFNA)	375-95-1
1H,1H, 2H, 2H-perfluorooctane sulfonic acid (6:2FTS)	27619-97-2
perfluorooctanesulfonic acid (PFOS)	1763-23-1
perfluorooctanoic acid (PFOA)	335-67-1
perfluoropentanoic acid (PFPeA)	2706-90-3
perfluoropentanesulfonic acid (PFPeS)	2706-91-4
perfluoroundecanoic acid (PFUnA)	2058-94-8
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9
perfluorotetradecanoic acid (PFTA)	376-06-7
perfluorotridecanoic acid (PFTrDA)	72629-94-8

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Category 1: Fire Training Facility, Fire Department, AFFF

DOE Use & Considerations: Search terms for use in conjunction with the *Historical Use of Class B Firefighting Foam That Contained PFAS Survey Questions for DOE Facilities (Appendix A).*

Keywords:

Chemical and/or Trade Names	3M	Forafac	Perfluorooctanesulfonyl fluoride (POSF)
	Angus	Lightwater	PFOA (also CAS No. 335-67-1)
	Ansul	MIL-F-24385F	PFOS (also CAS No. 1763-23-1)
	Ansulite	MIL-PRF-24385	SURLFON
	Buckeye	National Foam	Tridol
	Chemguard	Perfluorinated carboxylic acid (PFCA)	Tyco
	Fire Services Plus, Inc. (FSP)	Perfluoroketone	UL Standard 162
	FireAde		
PFAS Specific Terms	Aqueous film-forming foam (AFFF)	FFFP (film-forming fluoroprotein foam)	Fluoroprotein
	Class B	Fluor or fluoro	Fluorotelomer
General Terms	Aqueous fire	Fire fighting/firefighting	Hangar
	Aqueous firefighting	Fire Suppression System (FSS)	High-expansion foam
	Crash Area	Fire training area (FTA)	Low-expansion foam
	Film-forming	Firefighter training	Nozzle Testing
	Fire	Firefighting foam	Suppression
	Fire department	Foam	

Category 2: Wastewater Treatment Plants and Landfills

DOE Use & Considerations: Influent to wastewater treatment plants; discarded granular activated carbon and filter membranes from water treatment; centralized waste treatment landfills (consider if the landfill is lined or unlined and has a leachate collection system); septic systems; centralized sewer systems; injection wells; floor drains; stormwater drains; industrial waste lines; and Cold War releases. Research in these areas should be considered, and/or sampling should be conducted in accordance with the ESG, of leachate and water from the systems or downgradient from the systems due to the complexity and uncertainty of inputs to the system. General terms are not provided for this category, with the exception of a few landfill and treatment plant terms, as the potential contributors are too vast and can include a combination of other categories presented in this tool.

Keywords:

Chemical and/or Trade Names	Hexafluoropropylene oxide dimer acid (HFPO DA) (Gen X)
	PFOA (also CAS No. 335-67-1)
	PFOS (also CAS No. 1763-23-1)
	PFDA (also CAS No. 335-76-2)
	PFNA (also CAS No. 375-24-4)
	PFHxA (also CAS No. 307-24-4)
	PFHxS (also CAS No. 355-46-4)
	PFBA (also CAS No. 375-22-4)
	PFBS (also CAS No. 375-73-5)
General Terms	Biosolids
	Sludge disposal
	Wastewater treatment facility sludge

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Category 3: Uranium Enrichment, Plutonium Production, Nuclear Operations

DOE Use & Considerations: Fluoroplastic used in the handling of highly corrosive liquids and reactive uranium derivatives; coolant; spent fuel extraction processes; valve and ultracentrifuge bearing lubricants in uranium hexafluoride (UF6) enrichment including, but not limited to, Manhattan Project and Cold War liquid waste discharges; research and development, production, surveillance, and testing and recovery of nuclear materials.

Keywords:

Chemical and/or Trade Names	C-216 (conditioning agent)	Fluorothene (polymer of F 1113)	Perfluoro-1,3-dimethylcyclohexane (also CAS No. 335-27-3)
	C-270 (sealant)	Hydrogen Perfluorobutyric Acid (also Perfluorobutyric acid, Heptofluorobutyric acid, Perfluorobutanoic Acid)	Perfluorinated dimethylcyclohexane (also C8 F16 or C-816)
	C-2144 (approximate formula $C_{21}F_{44}$, lube oil)	K-416 (polymer)	Polytetrafluoroethylene (PTFE)
	C616 (process gas prompting PFAS use)	Kellex	Polychlorotrifluoroethylene (also Kel-F, MFP-10, P-10)
	Calcium Perfluorobutyrate (also Trichloroheptofluorobutane, Heptafluorotricholorbutane)	MFL (also CF_2-CFCl)	Symalit
	Chlorotrifluoroethylene	MW Kellogg	Teflon (or Tef) (polymer D-29)
	Du Pont (manufacturer)	Perfluoroheptane (C7 F16)	
PFAS Specific Terms	Fluor or fluoro	Heavy fluorocarbon	Perfluoro
	Fluorolube	MFP (also MFP-10)	Perfluorinated polymers
General Terms	Acid	Gasket	Sealant
	Coating	Grease	Septa
	Coolant, cooling medium	Lubricant	Special chemicals
	Corrosion, corrosive, anti-corrosive	Membrane filtration (MFL)	Tubing
	Gaseous diffusion operations	Insulator	UF_6 Separation/Diffusion
	Diaphragms	Oil	Valve

	Ferrules	o-ring	Valve packing
	Gaseous diffusion report	PCB Impregnated Gaskets	Wax

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Category 4: Metal Plating Processing

DOE Use & Considerations: Treatment of metal surfaces; surfactant, wetting agent, and mist-suppressing agent in metal plating, especially chrome; fluorinated surfactant used in chrome plating bath.

Keywords:

Chemical and/or Trade Names	1H,1H, 2H, 2H-perfluorooctane sulfonic acid (6:2FTS)	Femetrol-140	Perfluoroalkane carbonyl fluoride (PACF)
	Ankor (wetting agent)	Fluorad	Perfluoroalkane sulfonyl fluoride (PASF)
	Benchmark (manufacturer)	Fluorotelomer sulfonic acid (FTSA)	Perfluoroalkyl acid (PFAA)
	Brite Guard	Fluorotenside-248	Perfluorooctanesulfonic acid (PFOS)
	Clepo (chrome mist control)	Forafac	Perfluoropolyether (PFPE)
	Ethone (manufacturer)	Fumetrol (mist suppressant)	SurTec 960
	F-53B (11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid [11Cl-PF3OUdS or F-53B Minor], 9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS or F-53B Major])	MacDermid (manufacturer)	
PFAS Specific Terms	Fluor or fluoro	Fluoropolymer	Surfactant (also fluorinated surfactant)
General Terms	Steel	Fume suppressant	Tin (Sn)
	Alkaline zinc	High-corrosivity	Tin-plating
	Chrome or chrome plating	High-heat	Wetting agent
	Chromium (Cr)	High-pressure	Zinc (Zn)
	Copper (Cu)	High temperature lubricant	Plating bath
	Defoam	Mist-supress; mist-suppressant	Foam dampening

	De-mister	Plating Process Systems	Chrome-plating
	Nickel-plating	Nickel (Ni)	Surfactant
	Etching	Plating	

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Category 5: Explosives, Munitions, and Weapons

DOE Use & Considerations: Improvement in performance and stability of military explosives, ordnances, and weapons; binder, plasticizer, oxidizer, mold release agent, and plastic in explosives, munitions, pyrotechnics, ammunition, and weapons; pyrotechnic oxidizer and use in infrared tracking flares (1950s); thermoplastic in warheads and ammunition; fluoropolymer rubber to reduce the likelihood of an unplanned explosion due to shock; stabilizer in clean rooms; quality assurance testing and acceptance of weapons reserve materials; information and research repository in boned stores for weapons reserve or war reserve.

Keywords:

Chemical and/or Trade Names	Magnesium, Teflon, Viton (MTV)	PBX (plastic-bonded explosive or polymer- bonded explosive)	Perfluorinated carboxylic acid (PFCA)
	Vinylidene fluoride	Teflon (or Tef) (polymer D-29)	Hexafluoropropylene
	Hexafluoropropylene copolymer	Viton (also Viton-A)	PCTFE
	Kel-F	Polytetrafluoroethylene (PTFE)	RDX
	OXY-461		
PFAS Specific Terms	Fluoropolymer	Fluorocarbon pyrolant	Perfluorocarbon
General Terms	Ammunition	Munition	Thermoplastic
	Binder	Munition constituent (RDX, TNT, HMX, TATB)	Ordnance
	Incendiary	Oxidizer	Pyrotechnic
	Infrared flare	Igniter pyrolant	Oxidizer

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Category 6: Electronics Manufacturing

DOE Use & Considerations: Electronics and circuit board manufacturing; lubricant for magnetic tapes and disks; fluoropolymer in cables and wires; coating inside and outside of electronic devices to protect from moisture and corrosion; cleaning of components; battery electrolytes and dielectric and heat-exchanging fluid (1950s); semiconductor to reduce surface tension and reflectivity of etching solutions; manufacturing, testing, research and development of weapons components (i.e. circuit board).

Keywords:

Chemical and/or Trade Names	Chemours	HFE-7100	Perfluoro 2-butyltetrahydrofuran (CAS No. 335-36-4)
	Dow	HFE-7200	PFOA (also CAS No. 335-67-1)
	Fluorinert	Nafion	Polyvinylidene difluoride (PVDF)
	Flutec	Novec	Teflon (or tef) (polymer D-29)
PFAS Specific Terms	Fluoropolymer	Perfluoro	6:2 FTS
General Terms	Battery	Electrochemical fluorination	Lubricant
	Brine cooling	Etching	Photoresist
	Capacitors	Flame retardant	Plating agent
	Circuit board	Fluorotelomerization	Semiconductor
	Coolant	Functional fluid	Surfactant
	Coolant fluid	Immersion cooling	Wetting agent
	Direct contact cooling	LCDs	
	Electroplating	Lithium-ion battery	

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Category 7: Equipment Fuel/Maintenance

DOE Use & Considerations: Large fuel storage areas; industrial waste lines; industrial maintenance; parts with PTFE Coatings.

Keywords:

Chemical and/or Trade Names	Perfluoroelastomer	Perfluorooctanesulfonic acid (PFOS)	Teflon (or Tef) (polymer D-29)
	Perfluorooctanoic acid (PFOA)	Polytetrafluoroethylene (PTFE)	
PFAS Specific Terms	Aqueous film-forming foam or Aqueous firefighting foam (AFFF)		
General Terms	Brake pad	Fuel tank	Motor pool
	Car wash	Garage	Oil storage
	De-greaser	Gas storage	Vehicle maintenance
	Fire suppression system (FSS)	Grease	Vehicle wash areas
	Fuel line	Hydrazine	Wiper Fluid
	Fuel storage	Lubricant	

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Category 8: Well Drilling

DOE Use & Considerations: Drilling fluid; drilling foaming agent; proprietary blend of grout, bentonite, cement, or concrete used in well construction; proprietary blend of fuel, oil, and grease used in well construction; bladder pumps and tubing with Teflon coating installed in wells.

Keywords:

Chemical and/or Trade Names	CAS No. 29117-08-6	PFOS (also CAS No. 1763-23-1)	Polytetrafluoroethylene (PTFE)
	PFOA (also CAS No. 335-67-1)	Teflon (or Tef) (polymer D-29)	
General Terms	Cement	Drilling foam	Non-foamed fluid
	Concrete	Fuels	Oils
	De-foam	Grease	PTFE bladder
	Drilling fluid	Grout	PTFE tubing

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Category 9: Pesticides

DOE Use & Considerations: General insecticide/pesticide around facilities (mechanism of insecticidal activity appears to be suffocation of the insect by the adsorbed PFAS); aerosol for mosquito control. Additional information on individual pesticides can be found at the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Pesticide Product and Label System.

Keywords:

Chemical and/or Trade Names	Anvil 10+10 (1975-current)	Flubendiamide (2008-2016)	Pyrifluquinazon (2013-current)
	Broflanilide	Flursulamid	Sulfuramid (1987-2008)
	EL-499	Nifluridide	Super-Arinosu-Korori
	Griffin (manufacturer)	Novaluron (first registered 2013)	Perfluoroalkyl phosphonic acids
	Li-PFOS (1999-2002)	Noviflumuron	Fluorotelomer alcohol (FTOH)
	Lithium perfluorooctane sulfonate	PFOA (also CAS No. 335-67-1)	Vectobac; Vectobac 12AS
General Terms	Ant insecticide	Phosphinic	Wetting agent
	Anti-foam	Phosphonic	Adulticide
	Dispersant	Roach insecticide	Larvicide
	Mosquito insecticide		

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Category 10: Laboratory

DOE Use & Considerations: Equipment and chemicals used in the laboratory; equipment includes (but not limited to) tubing, plastic beakers, flasks, funnels, cylinders, stopcocks, test tubes, rotameters, seals, personal protective equipment; chemicals used in a research and development laboratories can be vast.

Keywords:

Chemical and/or Trade Names	Perfluoro kerosene-L (2-Methyl-2-butene) (CAS No. 513-35-9)	PFNA (also CAS No. 375-24-4)	Polytetrafluoroethylene (PTFE)
	PFOA (also CAS No. 335-67-1)	PFHxA (also CAS No. 307-24-4)	Teflon (or Tef) (polymer D-29)
	PFOS (also CAS No. 1763-23-1)	PFHxS (also CAS No. 355-46-4)	Trifluoroacetic acid
	PFDA (also CAS No. 335-76-2)	PFBA (also CAS No. 375-22-4)	Viton (also Viton-A)
PFAS Specific Terms	Fluroelastomer	Fluoropolymer	
General Terms	Beaker (plastic)	Personal protective	Stopcock
	Cylinder	Pipe dope	Teflon tape
	Degasser	PPE	Test Tube
	Flask	PVDF Membrane	Tubing
	Liquid Chromatography	Rotameter	Tyvek
	Mass spec standard	Solvent	

Category 11: Other

DOE Use & Considerations: Listed below are other general consumer categories that have the potential to contribute to centralized waste treatment landfills via disposition, and centralized wastewater treatment plants via floor drains, stormwater drains, or industrial waste lines. If one of the categories was manufactured on an industrial scale at a DOE Site, then additional research should be considered.

- Textiles that repel water, oil, and stains (apparel, carpets, upholstery, technical textiles for high temperature or corrosive environments);
- Plastics (adhesives, filter membranes, pump tubing, gaskets, valve seats, parts with PTFE coatings, etc.);
- Paper and cardboard for both food and non-food use;
- Industrial and consumer cleaning products;
- Coatings (waxes, paints, inks, varnishes or polishes used for cleaning floors, anti-mist/anti-fog spray, building coating, waterproofing);
- Refrigerants ("Sealant" (liquid), "dummy gas", coolant);
- Building and construction materials (architectural membranes, greenhouses, cement additive, cable and wire, OSB and wood insulation material, sealing foam, façade materials, polystyrene, air conditioning).
- Plumbing (tubing lined with or constructed of Teflon or PTFE; threaded pipes, valves, etc. assembled using Teflon tape or pipe dope)

Keywords:

Textiles	Fiberglass	Kevlar	Stain resistant
	Flame resistant	Oil-repellant	Water repellent
	Flame retardant	Oleophobic	Waterproof
	Hydrophobic	Scotchgard	
Plastics	Adhesive	Flame retardant	Rubber
	Anti-stick	Fuel Cells	Seals
	Cable Insulation	Gaskets	Teflon (or Tef) (polymer D-29)
	Electrolyzer membrane	Plastic beakers	Tubing
	Filter membranes	Resin	
Paper and Packaging	Anti-stick	Fluorotelomer alcohol (FTOH)	Perfluoropolyether
	Fluorinated polymer	Oil resistant	Takeout dishware
	Gore-Tex		

	Fluoroalkyl	Perfluoroalkane sulfonyl fluoride	Water resistant
	Fluorotelomer	Perfluorocarboxylic acids (PFCAs)	
Cleaning	3M Novec	Perfluoroalkane	Solvent
	Alkaline cleaner	Perfluorocarboxylic acids (PFCAs)	Stain resistant
	Automobile wax	Perfluorocycloalkane	Surfactant
	Carpet cleaner	Polish	Window cleaner
	HFE-7100/HFE-7200	Shampoo	
Coatings	Antiadhesion	Anti-tacking	PTFE
	Anti-blocking	Flame retardant	Stain resistant
	Anti-corrosive	Fluoro-surfactant	SURFLON
	Anti-fog spray	Ink	Varnish
	Anti-mist spray	Non-stick	Wax
	Antistatic	Paint	Wetting agent
	Anti-stick	Polyvinylidene difluoride (PVDF)	
Refrigerants	Coolant	Dummy gas	Sealant
	Daikin Industries	Fluid	
Building and Construction	Air filter	Façade materials	Polyvinyl fluoride (PVF)
	Architectural membranes	Greenhouses	Roofing and roof fabrics
	Cable and wire	OSB and wood insulation material	Sealing foam
	Cement	Polystyrene	Siding
	Concrete	Polytetrafluoroethylene (PTFE)	

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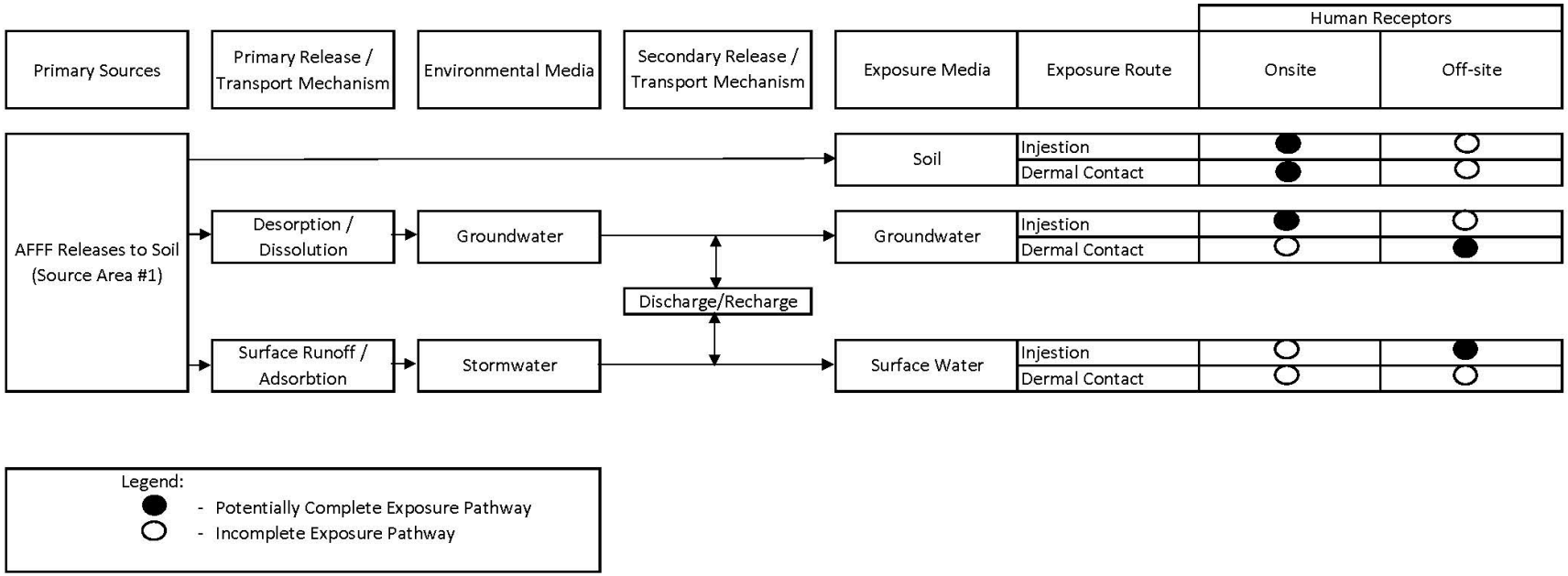
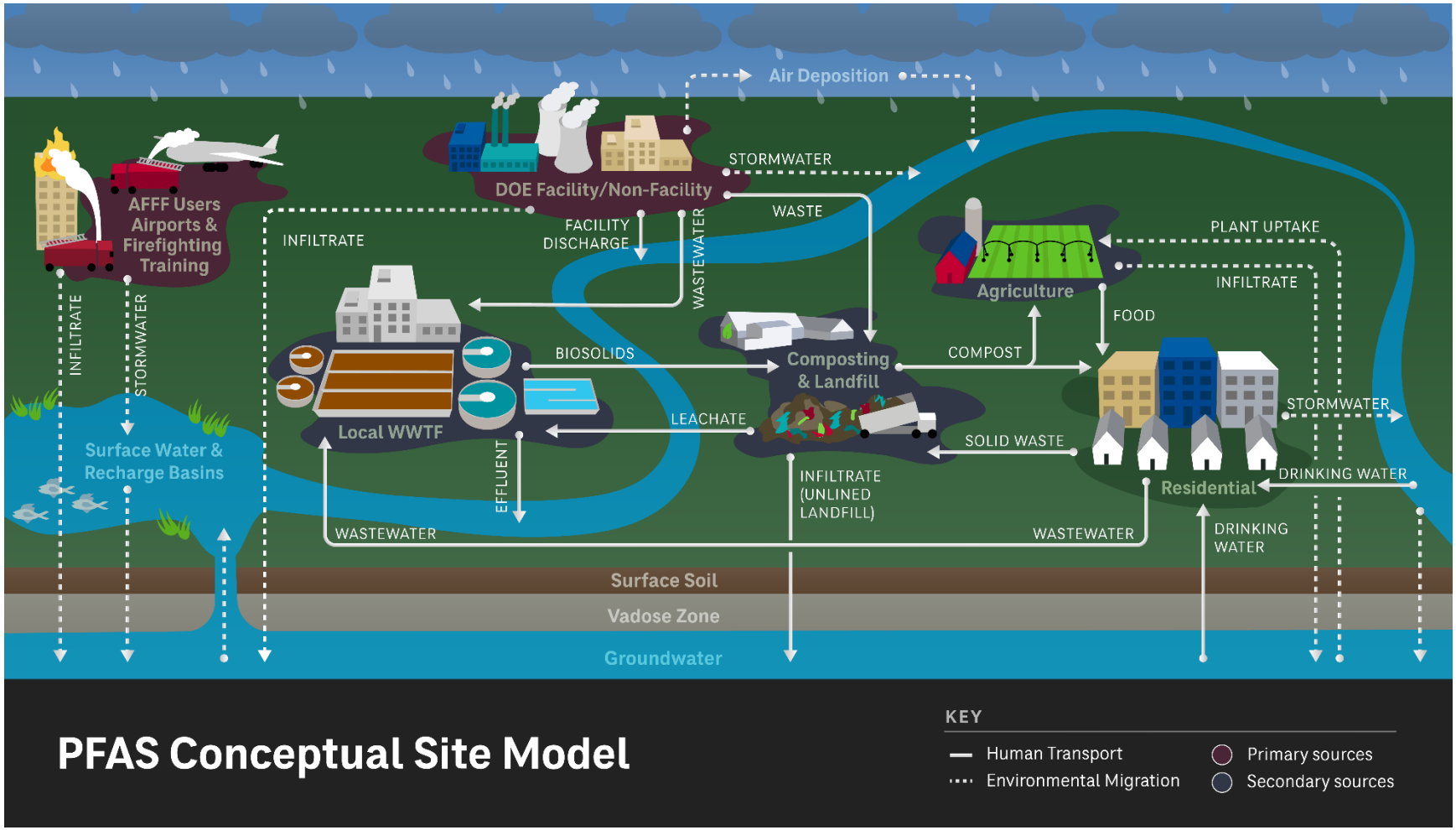
Appendix D – Preliminary CSM Example

Conceptual Site Model (CSM) Example




Air Deposition
AFFF Users Airports & Firefighting Training
DOE Facility/Non-Facility
STORMWATER
WASTE
FACILITY DISCHARGE
WASTEWATER
INFILTRATE
PLANT UPTAKE
Agriculture
INFILTRATE
FOOD
INFILTRATE
STORMWATER
BIOSOLIDS
Composting & Landfill
COMPOST
Local WWTF
LEACHATE
SOLID WASTE
STORMWATER
Surface Water & Recharge Basins
EFFLUENT
INFILTRATE (UNLINED LANDFILL)
Residential
DRINKING WATER
WASTEWATER
WASTEWATER
DRINKING WATER
Surface Soil
Vadose Zone
Groundwater
PFAS Conceptual Site Model
KEY
Human Transport
Environmental Migration
Primary sources
Secondary sources