

Mapping Guide for Per- and Polyfluoroalkyl Substances (PFAS) Source Water Assessments



Association of State Drinking Water Administrators

CADMUS

Table of Contents

1	Introduction	2
2	Assessing Source Water Vulnerability to PFAS	3
	Step 1 – Define Purpose and Goals.....	4
	Step 2 – Map Source Water Locations.....	4
	Step 3 – Map Potential PFAS Source Locations	4
	Step 4 – Map PFAS Monitoring Data.....	4
	Step 5 – Map Watershed and Aquifer Data	5
	Step 6 – Identify Priority Source Waters.....	6
3	PFAS Source Location Data	7
4	PFAS Monitoring Data.....	10
5	Watershed and Aquifer Data	12
	5.1 Surface Water Network and Watersheds Boundaries.....	12
	5.2 Aquifer Boundaries	13
	5.3 Land Cover	14
	5.4 Soil and Geological Attributes.....	14
	5.5 Source Water Mapping	145
6	References	16
	Appendix A: NAICS Codes	18
	Appendix B: State-Specific Databases.....	21

List of Figures

Figure 1.	Diagram of the source water assessment framework.....	3
Figure 2.	PFAS fate and transport diagram for firefighting foams (from ITRC, 2018).	5

List of Tables

Table 1.	Example NAICS codes relevant to PFAS production, storage, and use.....	8
Table 2.	NAICS codes relevant to PFAS production, storage, and use.....	18

1 Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large family of synthetic chemicals that are used in a range of products and industrial processes. Because many PFAS compounds are resistant to heat, oil, grease, and water, they are commonly used in the production of stain-repellent and water-repellent fabrics, nonstick products, polishes, waxes, paints, cleaning products, firefighting foams, and related goods. The properties that make PFAS useful for such products can also contribute to the persistence of PFAS in the environment. Rather than breaking down into component molecules, many PFAS remain intact and accumulate in the soil, air, and water.

Toxicological studies have shown that exposure to PFAS may be harmful to humans and the environment. Ingestion through drinking water poses an array of health risks to humans, including increased cholesterol, low infant birth weights, increased risk of certain cancers, and interference with hormones and the immune system (ATSDR, 2018). States and non-governmental organizations are taking steps to address PFAS in drinking water sources. This includes the completion of a Source Water Assessment (SWA) to evaluate the susceptibility of drinking water sources to PFAS contamination.

This document provides information and guidance for readers interested in undertaking a SWA in order to identify source waters that are vulnerable to PFAS contamination. The guide focuses on the use of Geographic Information System (GIS) data for completing a screening-level assessment of source water vulnerability to PFAS across a state, county, or other region. The guide begins with an overview of the approach to assessing source water vulnerability to PFAS, followed by descriptions of potential data sources to use for the assessment.

Section 2 describes a general framework for completing a GIS-based assessment that includes goal definition; compilation of GIS datasets related to PFAS source locations, PFAS monitoring, and watershed and aquifer characteristics; and synthesis of GIS datasets to identify priority source waters. Since the specific methods of an assessment will depend on its goals and available resources and data, the approach described in Section 2 is not a detailed methodology for acquiring, processing, and analyzing GIS data. Rather, the guide presents an overview of key steps to characterize the relative vulnerability of a group of source waters. Potential national and state datasets to inform the assessment are discussed in Section 3 (PFAS source data), Section 4 (PFAS monitoring data), and Section 5 (watershed and aquifer data).

2 Assessing Source Water Vulnerability to PFAS

GIS data on PFAS source locations, PFAS monitoring results, and environmental characteristics can be combined to complete a screening-level assessment of source water vulnerability to PFAS contamination. Source waters that are identified as vulnerable can be prioritized for targeted monitoring, detailed analysis of PFAS sources, fate, and transport, and source water protection planning. Example assessments of source water vulnerability to PFAS have been completed by state drinking water programs in Arizona (ADEQ, 2018) and Pennsylvania (PADEP, 2019).

This section outlines a general process for completing a screening-level assessment of source water vulnerability to PFAS (Figure 1). Specific methods for a vulnerability assessment will depend on the goals of the assessment and available resources and data. The process described in this section is therefore intended to serve as a framework that can be augmented and customized with detailed data and methods.

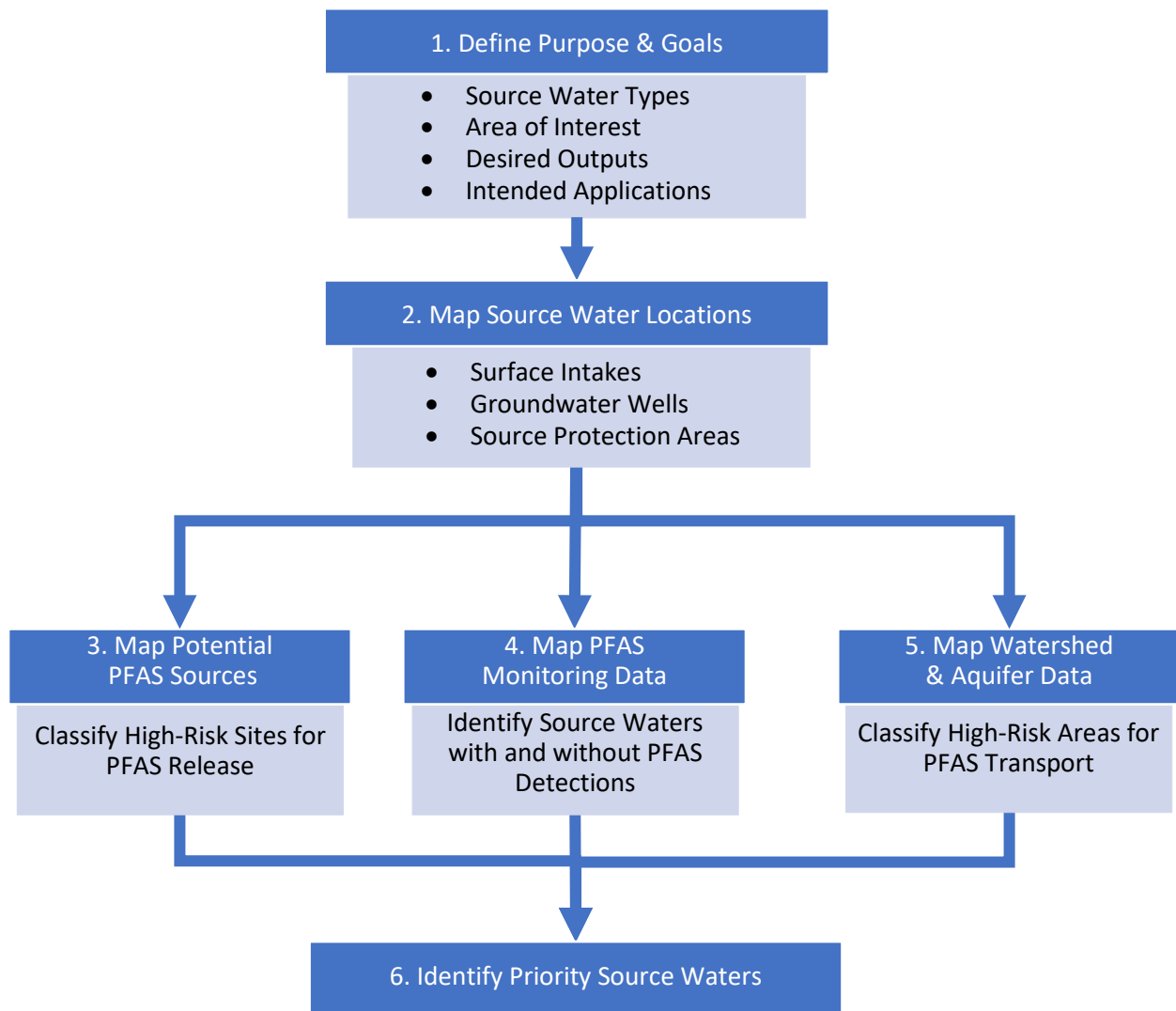


Figure 1. Diagram of the source water assessment framework.

Step 1 – Define Purpose and Goals

An SWA should begin with a definition of the purpose and goals of the effort. The purpose and goals should clearly describe: (1) the types of source waters to be assessed; (2) the area of interest; (3) the desired output of the assessment; and (4) the intended application of results. The types of source waters to assess could include surface water sources and/or groundwater sources and can be further refined based on drinking water system characteristics, such as the size of the population served. The assessment may address the entire state or focus on a single county or other region within the state. Example outputs of interest could include a vulnerability ranking of all source waters in the assessment or a more general grouping of high versus low vulnerability source waters.

Step 2 – Map Source Water Locations

Drinking water wells and surface intakes should be mapped within your area of interest in order to establish the location of the source waters that will be assessed for vulnerability to PFAS contamination. Related data such as source water protection areas (SPAs) can also be mapped during this step to account for areas that have already been identified as important for maintaining source water quality. GIS datasets of wells, intakes, and SPAs are typically maintained by state drinking water programs.

Step 3 – Map Potential PFAS Source Locations

Examples of potential sources of PFAS in the environment include manufacturing facilities for household goods (food packaging, nonstick products, cleaning products, etc.), industrial facilities (chrome plating or electronics manufacturing), airports, military installations, and wastewater treatment plants. The location of these and other potential PFAS sources offers a starting point for evaluating the relative risk of source waters to PFAS contamination.

The US Environmental Protection Agency (EPA) maintains several databases that can be used to map the location of potential PFAS sources. The EPA databases can be supplemented with state-specific sources of information on known or potential PFAS sites. Section 3 provides a detailed review of available data for mapping the location of potential PFAS sources.

After mapping potential PFAS source locations, this step should also include a classification of each point to characterize the relative risk for PFAS release into the environment. High-risk locations could include:

- Sites producing or storing large quantities of PFAS materials;
- Facilities with detected levels of PFAS in wastewater effluent or air emissions; and
- Known locations of PFAS releases such as firefighting foam applications.

The above examples are not inclusive of all potential high-risk locations for PFAS release. Readers should evaluate the different types of PFAS sources within in their datasets and develop a classification method that addresses risk factors that are specific to their study.

Step 4 – Map PFAS Monitoring Data

Water quality monitoring data for source waters and treated drinking water may be available to map locations where PFAS has been sampled. Mapping should include sample points where PFAS detections have occurred and locations where PFAS has been analyzed but not detected. Potential data sources for PFAS monitoring data are discussed in Section 4.

PFAS monitoring data offers two benefits for assessing source water vulnerability. Source waters with PFAS detections can be readily classified as vulnerable and as priorities for follow-up monitoring, analysis, and management. PFAS monitoring data can also be used to validate other datasets in the assessment and to inform the assessment methods. For example, PFAS detections in waters with no nearby PFAS sources could indicate a need to revisit Step 3 to compile additional data on PFAS source locations. When combined with data on watershed and aquifer characteristics, PFAS detections (or lack thereof) can also be used to infer relationships between environmental conditions and PFAS transport.

Step 5 – Map Watershed and Aquifer Data

PFAS contamination can occur through the direct release of PFAS-containing substances into a drinking water source or through the transport of PFAS compounds into source waters via processes such as surface runoff, wind and water erosion, atmospheric deposition, and groundwater recharge. The study of how chemicals move through the environment and partition among different media (water, soil, air, etc.) following release is referred to as fate and transport.

Chemical fate and transport depend on the characteristics of the contaminant and the surrounding environment. Contaminant characteristics include physical and chemical attributes, such as the tendency to dissolve in water versus adhere to soil particles, while example environmental characteristics include soil permeability and conductivity or depth to groundwater. An example conceptual diagram of PFAS fate and transport is displayed in Figure 2. See ATSDR (2018) and ITRC (2018) for a detailed review of fate and transport considerations for PFAS.

Fate and transport modeling is a complex process that is completed as part of site-specific investigations of the vulnerability of source waters to contamination. Due to data, time, and budget constraints, fate and transport modeling is not feasible for a screening-level assessment of PFAS vulnerability across large areas. However, hydrologic and geologic data that are used as inputs to fate and transport models can be applied to approximate the relative potential for PFAS contamination among a group of source waters.

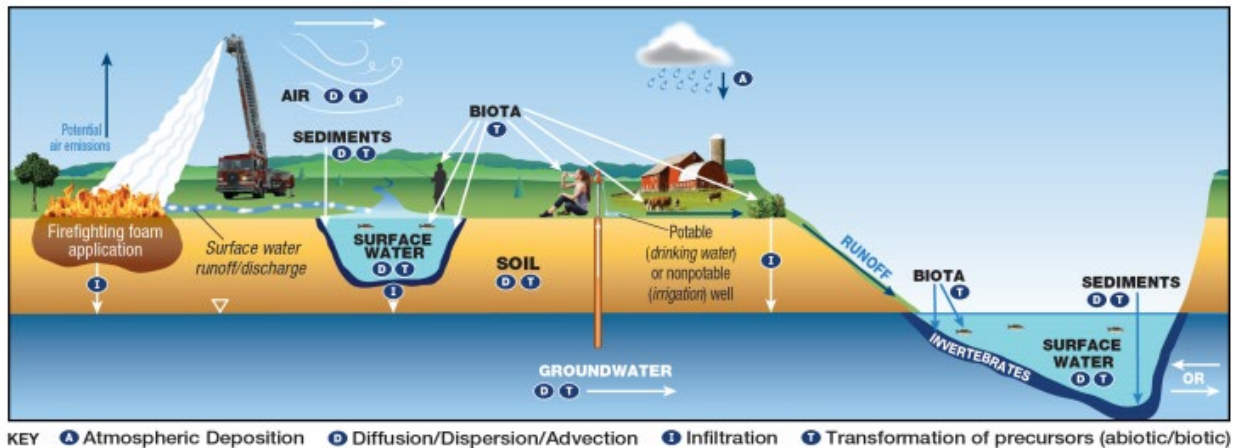


Figure 2. PFAS fate and transport diagram for firefighting foams (from ITRC, 2018).

Section 5 of this document describes potential GIS data on watershed and aquifer characteristics that can be relevant to PFAS fate and transport. The suggested watershed and aquifer datasets address:

- **Surface Water Network and Watershed Boundaries** – The surface water network (streams, rivers, lakes, etc.) and watershed boundaries provide information on flow pathways and flow direction for the transport of PFAS in water. This information can be used to identify surface waters that are located adjacent to, or downstream of, PFAS sources.
- **Aquifer Boundaries** – An understanding of aquifer extent can highlight groundwater supplies that are vulnerable to PFAS contamination, such as aquifers that underlie PFAS source locations.
- **Land Cover** – Land cover characteristics in your area of interest can influence surface runoff and erosion processes that are relevant to PFAS fate and transport. Developed land uses (urban or agricultural cover types) are more prone to surface runoff and erosion compared to natural cover types such as forests and grasslands. PFAS releases in developed areas may therefore be more rapidly transported into nearby waters.
- **Soil and Geological Attributes** – Soil and geological characteristics are key factors for evaluating contaminant transport. Physical attributes of soils and bedrock such as permeability, conductivity, groundwater depth, and chemical attributes such as organic matter content all affect the movement of contaminants in surface runoff and groundwater.

Similar to step 3 (map PFAS source locations), this step should include the identification of areas with high-risk watershed and aquifer characteristics for PFAS transport into source waters. High-risk characteristics could include areas that are prone to surface runoff and erosion or areas with shallow groundwater, high recharge rates, or high subsurface conductivity.

Step 6 – Identify Priority Source Waters

The final step of the assessment process involves overlaying information on PFAS sources, results of PFAS monitoring, and watershed and aquifer characteristics to classify the vulnerability of source waters in your area of interest and identify priority source waters. High-priority status could be assigned based on:

- The detection of PFAS compounds in water quality monitoring data. Threshold concentrations could also be considered to further differentiate high versus low detection levels;
- The presence and number of high-risk PFAS sources upstream of surface water sources or within the recharge area of groundwater sources (i.e., sources with a high-risk of PFAS release into the environment);
- The presence and number of high-risk watershed and aquifer characteristics (i.e., conditions that are conducive to the transport of PFAS from release sites into source waters through surface runoff, groundwater recharge and flow, or soil erosion).

The specific classification methodology applied in this step will depend on the goals of the assessment and available data but can be refined based on initial findings. For example, a preliminary analysis may result in too many high-priority source waters relative to resources available for post-assessment monitoring and management. In such cases, the classification method can be revised to include additional criteria and filters for designating high-priority status.

3 PFAS Source Location Data

As a chemical agent with unique properties, PFAS has been used in a wide variety of industrial processes and commercial products. Because of this widespread occurrence, locating historical and present-day releases of PFAS into the environment requires a broad investigation of potential facilities and release sites. Manufacturing facilities for household goods (such as food packaging, nonstick products, cleaning products, etc.), industrial facilities (such as chrome plating or electronics manufacturing), airports, military installations, and wastewater treatment plants are all examples of potential contamination sources. More information on the uses and life cycle of PFAS is available in *Per- and Polyfluoroalkyl Substances (PFAS) Source Water Protection Guidance: Technical Appendix* (ASDWA, 2020).

A variety of resources are available to help identify possible sources of PFAS contamination. Potential data sources are described below. In addition, readers can refer to recent efforts by states to identify and map PFAS sources to learn more about data sources and methods. These include efforts by the Kansas Department of Health and Environment (KDHE, 2019), Pennsylvania Department of Environmental Protection (PADEP, 2019), and Vermont Agency of Natural Resources (VANR, 2019). The Environmental Working Group has also partnered with Northeastern University to create an interactive national map of known PFAS contamination sites (https://www.ewg.org/interactive-maps/2019_pfas_contamination/map/).

Facility Registry Service

<https://www.epa.gov/frs>

The Facility Registry Service (FRS) is an EPA database of facilities, sites, and places of environmental interest that are subject to EPA regulations. Users can search for specific facilities by name, or search for all facilities within a specific state, tribe, or region. The FRS draws from an array of national datasets, including the National Pollutant Discharge Elimination System (NPDES), Toxics Release Inventory (TRI), Superfund Enterprise Management System (SEMS), etc., as well as state environmental databases. Query results include facility names, addresses, latitude and longitude, and downloadable geospatial information.

Facilities in the FRS can be filtered by North American Industry Classification System (NAICS) code. The NAICS is a system for categorizing businesses. It was designed for statistical purposes and for comparing economic data across North America. Companies select the NAICS code which best describes their primary business activity, and government agencies use these codes to classify industry information. The NAICS classification scheme replaces the older Standard Industrial Classification (SIC) system. Table 1 shows a sample list of NAICS codes that may indicate primary or secondary manufacturing of PFAS. See Appendix A for a more complete list of relevant NAICS codes for PFAS source assessment.

When searching for possible contamination locations with NAICS codes, it is important to note that companies select a single NAICS code to describe their business activities. For large corporations, where only a subset of the business manufactures or uses PFAS, the chosen code may not reflect this activity. Furthermore, addresses associated with NAICS code entries may be for corporate offices, and not necessarily the manufacturing facilities themselves. When investigating possible contamination sites, researchers should confirm that the given address is for the correct facility.

SIC codes are still referenced in some databases and industry publications. Although SIC is an older system and its categories capture less detail, it is still possible to conduct searches for facilities using SIC codes.

Table 1. Example NAICS codes relevant to PFAS production, storage, and use.

NAICS Code	Description
332813	Electroplating, Plating, Polishing, Anodizing, and Coloring
313320	Fabric Coating Mills
325199	Plasticizers (i.e., basic synthetic chemicals) manufacturing
325211	Plastics and synthetic resins regenerating, precipitating, and coagulating
325613	Finishing agents, textile and leather, manufacturing
333242	Micro-lithography equipment, semiconductor, manufacturing
334413	Wafers (semiconductor devices) manufacturing
322220	Bags (except plastics only) made by laminating or coating combinations of purchased plastics, foil and paper
315280	Coats, waterproof (e.g., plastics, rubberized fabric, similar materials), rubberizing fabric and manufacturing coats
326113	Sheet, plastics, unlaminated (except packaging), manufacturing
332812	Coating of metal and metal products with plastics for the trade
336411	Aircraft Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing

Chemical Data Reporting

<https://www.epa.gov/chemical-data-reporting>

Under the Toxic Substances Control Act's (TSCA) Chemical Data Reporting (CDR) Rule, manufacturers and importers are required to report information to EPA on the chemicals they produce domestically or import into the United States. EPA makes this information publicly available via downloadable Microsoft Access or CSV files. Users can search by specific chemical, or the entire PFAS group of compounds. The CDR reports include addresses of the chemical's manufacturers, as well as whether it is used in commercial or consumer products. The most recent round of CDR reporting was completed in 2016.

Wastewater Discharge Monitoring Reports

<https://echo.epa.gov/tools/data-downloads/icis-ntpdes-dmr-and-limit-data-set>

<https://echo.epa.gov/>

All NPDES permit holders are required to submit Discharge Monitoring Report (DMR) data either to the states or directly to EPA. DMR reports include information on the NPDES permit conditions for each surface water discharge site, as well as the measured values for each monitored pollutant. DMR datasets can be downloaded from the EPA website by state for each reporting year, or they can be searched by city/zip code or facility name using EPA's Enforcement and Compliance History Online (ECHO) tool. The ECHO tool allows users to view all of the NPDES permit holders within a specific area on a map. While PFAS chemicals themselves are reported for only some industrial permit holders, facilities discharging effluent in general are still possible sources of surface and groundwater contamination.

Integrated Compliance Information System for Air

<https://www.epa.gov/enviro/icis-air-search>

The EPA Integrated Compliance Information System for Air (ICIS-AIR) contains compliance and monitoring data for permitted sources of air pollution, including specific information on industrial plant components. Accessed through the Envirofacts database, users can search ICIS-AIR by facility name, geographic location, pollutant, or SIC/NAICS code. This information can be used to identify facilities that may be releasing PFAS into the air.

Wastewater Treatment Facilities

<https://catalog.data.gov/dataset/epa-facility-registry-service-frs-wastewater-treatment-plants>

Due to their ubiquity in consumer goods, PFAS compounds commonly end up in the waste stream. Wastewater treatment facilities are possible sources of contamination because conventional treatment techniques do not effectively remove PFAS compounds from wastewater. The locations of wastewater treatment facilities can be accessed via datasets such as the FRS, but locational information is also available from EPA's geospatial data catalog.

Superfund National Priorities List Sites

<https://www.epa.gov/superfund/superfund-national-priorities-list-npl>

The EPA Superfund cleanup process includes the maintenance of a National Priorities List (NPL) of sites needing environmental remediation. It includes the locations of federal and non-federal facilities where PFAS has been detected, among other contaminants. Each entry includes a location and background information on the site, including the source and estimated extent of the contamination. The NPL is not an exhaustive list because PFAS compounds are not currently classified as hazardous substances, but it does include sites where PFAS contamination has been identified or is suspected.

US Military Sites

<https://www.denix.osd.mil/derp/home/documents/aqueous-film-forming-foam-report-to-congress/>

In 2017, the Department of Defense (DoD) issued the Aqueous Film Forming Foam Report to Congress, which details the DoD PFAS sampling efforts at military sites that provide drinking water. The report lists 393 former and current military installations with known or suspected releases of PFAS. This list may expand pending military confirmation of additional sites.

State-Specific Data Sources

Many states maintain their own databases of regulated facility information and environmental permit monitoring data. Appendix B contains a list of such databases. Your state may have also undertaken initiatives to develop supplemental information on potential PFAS source locations. For example, the New Hampshire Department of Environmental Services has distributed letters and surveys to local fire departments to compile information on the past use of firefighting foams (NHDES, 2017). Such information should be incorporated into a database of potential PFAS source locations.

4 PFAS Monitoring Data

This section describes potential sources of water quality monitoring data for surface water, drinking water, and groundwater. Although PFAS compounds are not yet routinely analyzed as part of water quality monitoring programs, even limited sample data can highlight source waters where PFAS has been detected and provide insight into relationships between PFAS source locations, environmental characteristics, and contamination of source waters.

Safe Drinking Water Information System

<https://www.epa.gov/ground-water-and-drinking-water/safe-drinking-water-information-system-sdwis-federal-reporting>

The Safe Drinking Water Information System (SDWIS) federal data warehouse contains information on every public water system, including their service area, the number of people served, and the characteristics of their source water. It also includes violation and enforcement information, which states report to EPA. As of February 2020, there are no Maximum Contaminant Levels (MCLs) for drinking water established for PFAS compounds, so detections of PFAS above the EPA health advisory level will not be reported in this database. However, SDWIS may still be useful for establishing public water system (PWS) locations and gathering basic information about them.

Unregulated Contaminant Monitoring Rule Database

<https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule#3>

Under the Unregulated Contaminant Monitoring Rule (UCMR) program, every five years EPA develops a list of 30 contaminants for which select PWSs are required to monitor. The third UCMR cycle (UCMR3) took place between 2013 and 2015 and included monitoring for several PFAS compounds. In many PWSs, these compounds were detected at levels above the EPA health advisory. All data are available for download from EPA.

Water Quality Portal

<https://www.waterqualitydata.us/>

The Water Quality Portal (WQP) is a collaborative data service provided by EPA, the US Geological Survey (USGS), and the National Water Quality Monitoring Council. The WQP combines water quality monitoring data from multiple national databases, including the EPA STOrage and RETrieval (STORET) Data Warehouse and the USGS National Water Information System (NWIS). The data available from are primarily collected from surface waters and groundwater wells. The STORET database contains water quality monitoring data generated by water resource management groups across the country, including states, tribes, watershed groups, other federal agencies, volunteer groups, and universities. The NWIS database contains extensive current and historical water data collected by USGS from over 1 million sites across the nation.

State-Specific Data Sources

Many states maintain their own databases of drinking water, surface water, and groundwater samples collected by state agencies and local partners. Such databases should be queried as part of the compilation of PFAS monitoring data to include in the assessment of source water vulnerability.

Readers should also take advantage of any previous or ongoing efforts to evaluate and map PFAS monitoring data within their state. Examples include reviews of PFAS monitoring data in Kentucky (KDEP, 2019), Maine (MDEP, 2019), and North Dakota (NDDEQ, 2019) and mapping efforts in California (https://www.waterboards.ca.gov/pfas/#general_info) and New Hampshire (<http://nhdes.maps.arcgis.com/apps/View/index.html?appid=66770bef141c43a98a445c54a17720e2>).

5 Watershed and Aquifer Data

This section describes potential GIS data on watershed and aquifer characteristics that can be relevant to PFAS fate and transport. The watershed and aquifer datasets described in this section address:

- Surface Water Network and Watershed Boundaries – the surface water network (streams, rivers, lakes, etc.) and watershed boundaries provide information on flow pathways and flow direction for the transport of PFAS in water. This information can be used to identify surface waters that are located adjacent to or downstream of PFAS sources.
- Aquifer Boundaries – An understanding of aquifer extent can highlight groundwater supplies that are vulnerable to PFAS contamination, such as aquifers that underlie PFAS source locations.
- Land Cover – Land cover characteristics in your area of interest can influence surface runoff and erosion processes that are relevant to PFAS fate and transport. Developed land uses (urban or agricultural cover types) are more prone to surface runoff and erosion compared to natural cover types such as forests and grasslands. PFAS releases in developed areas may therefore be more rapidly transported into nearby waters.
- Soil and Geological Attributes – Soil and geological characteristics are key factors for evaluating contaminant transport. Physical attributes of soils and bedrock such as permeability, conductivity, and groundwater depth, and chemical attributes such as organic matter content all affect the movement of contaminants in surface runoff and groundwater.
- Source Water Mapping – State and water system source water assessment maps can use multiple data sets and GIS mapping layers to add locations with potential for PFAS contamination and assess the vulnerability of drinking water sources.

5.1 Surface Water Network and Watersheds Boundaries

NHDPlus

<https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution>
<http://www.horizon-systems.com/nhdplus/>

NHDPlus is a comprehensive national dataset of surface hydrology. NHDPlus expands on the National Hydrography Dataset (NHD), a geospatial layer of the US surface water drainage network (rivers, streams, canals, lakes, ponds, and coastlines) maintained by the USGS. The NHDPlus dataset includes: map layers of the location of surface water features from the NHD; enhanced information on stream network navigation; an elevation-based drainage area for each stream network feature (termed catchments); catchment characteristics including mean annual precipitation, mean annual temperature, and mean annual runoff, etc.; and flow direction, flow accumulation, and elevation rasters.

NHDPlus also includes map layers of watershed boundaries from the national Watershed Boundary Dataset (WBD) maintained by the USGS and the Natural Resource Conservation Service (NRCS). The WBD is a seamless, national dataset for mapping watershed boundaries. The WBD is comprised of hydrologic units that represent the areas of the landscape that drains to discrete points on the surface water network. Hydrologic unit boundaries are determined based on topographic, hydrologic, and other relevant landscape characteristics. The watershed of a given point of interest may be represented by a single hydrologic unit or by multiple contiguous hydrologic units.

A medium resolution version of NHDPlus with surface water features mapped at a scale of 1:100,000 scale or better was initially released in 2006 and updated in 2012 (<http://www.horizon-systems.com/NHDPlus/index.php>). In 2019, a high resolution version of NHDPlus was released by USGS with surface water features mapped at a scale of 1:24,000 scale or better (<https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution>).

StreamStats

<https://streamstats.usgs.gov/ss/>

StreamStats is a web-based GIS application maintained by USGS that can be used to select any location along a stream network and delineate the upstream drainage area boundary and obtain pre-calculated basin characteristics. The drainage area boundary delineated by StreamStats can be downloaded as a polygon and used in desktop GIS applications.

5.2 Aquifer Boundaries

Principal Aquifers of the US

https://water.usgs.gov/GIS/metadata/usgswrd/XML/aquifers_us.xml

This USGS map layer contains polygons depicting the boundaries of principal aquifers of the conterminous United States, Hawaii, Puerto Rico, and the US Virgin Islands. A principal aquifer is a regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable water. The map layer was developed as part of the USGS Ground Water Atlas of the United States mapping effort (<https://water.usgs.gov/ogw/aquifer/atlas.html>).

Aquifers of Alluvial and Glacial Origin

<https://water.usgs.gov//ogw/aquifer/map.html>

This USGS map layer represents the extent of alluvial and glacial aquifers above the southern extent of glaciation in the US. Aquifers are mapped in Maine, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New Jersey, New York, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Illinois, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, North Dakota, and Montana. The map layer was developed as part of the USGS Ground Water Atlas of the United States mapping effort (<https://water.usgs.gov/ogw/aquifer/atlas.html>).

Sole Source Aquifers

<https://catalog.data.gov/dataset/national-sole-source-aquifer-gis-layer>

This map layer represents the boundaries of aquifers designated as sole source aquifers by EPA. A sole source aquifer is the sole or principal source of drinking water for a geographic region with no reasonably available alternative drinking water sources should the aquifer become contaminated.

State-Specific Aquifer Data

State drinking water, geologic, or natural resource agencies often maintain state-specific map layers of aquifer boundaries. The maps may include the extent of all aquifers in the state or focus on a particular subarea of interest. Examples include aquifer boundary datasets produced by the Massachusetts Bureau of Geographic Information (<https://docs.digital.mass.gov/dataset/massgis-data-aquifers>), the New York State Department of Environmental Conservation (<https://www.dec.ny.gov/lands/36118.html>), and the

South Dakota Department of Environment and Natural Resources
(<http://www.sdgs.usd.edu/currentprojects/aquifer.aspx>).

5.3 Land Cover

National Land Cover Dataset

<https://www.mrlc.gov/data/nlcd-2016-land-cover-conus>

The National Land Cover Dataset (NLCD) is comprised of several raster datasets depicting land use and land cover across the continental US at 30-meter pixel resolution. The NLCD Land Cover raster classifies the landscape into 16 different cover types, such as deciduous forest, grasslands, and high-intensity developed cover. Other components of the NLCD include percent imperviousness, tree canopy cover, and land cover change over time.

National Wetlands Inventory

<https://www.fws.gov/wetlands/data/Mapper.html>

The National Wetlands Inventory (NWI) is produced by the US Fish and Wildlife Service. The NWI geospatial dataset consists of polygons depicting wetland locations with classification codes denoting the type of each wetland. The classification codes distinguish different wetland system types (riverine, estuarine, etc.), water regimes (e.g., permanently flooded versus seasonally flooded) and vegetation types. The information stored in the NWI on wetland system type and water regime can help to distinguish portions of the landscape with high hydrological connectivity between surface and groundwater.

State-Specific Land Cover Data

High resolution land cover data may be available from state geographic and natural resource agencies, local municipalities (counties, towns, etc.), or partner organizations. Examples include map layers of land cover with 1 meter pixel resolution for Delaware (<https://catalog.data.gov/dataset/high-resolution-land-cover-state-of-delaware-2014>) and Iowa (<https://geodata.iowa.gov/dataset/high-resolution-land-cover-iowa-2009>).

5.4 Soil and Geological Attributes

Soil Survey Data

<https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/geo/>

The US Department of Agriculture (USDA) NRCS maintains several GIS datasets produced from soil surveys that have been completed across the nation. Each dataset varies in resolution and completeness but consist of map layers of soil unit boundaries with tables storing attributes for each soil unit, such as hydraulic conductivity, erosivity, or depth to groundwater. The datasets include:

- Digital General Soil Map of the United States (STATSGO2) – a coarse-scale depiction of soil data across the US. Created by generalizing more detailed soil survey maps (see https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629);
- Soil Survey Geographic Geodatabase (SSURGO) – a fine-scale depiction of soil data created from detailed information from soil surveys (see https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627);

- Gridded National Soil Survey Geographic Database (gNATSGO) – a combination of the best-available soil data created by combining the STATSGO2 and SSURGO datasets (see <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcseprd1464625>).

State Geologic Map Compilation Geodatabase

https://mrddata.usgs.gov/geology/state/USGS_SGMC_Metadata.xml

The USGS State Geologic Map Compilation (SGMC) geodatabase provides a seamless spatial database of geologic characteristics of the conterminous US. The geodatabase contains polygons representing distinct geologic units and attribute tables containing basic information on each geologic unit (name, description, age) and standardized lithology for the state geologic units.

State-Specific Soil and Geologic Data

State geologic and natural resource agencies often maintain a variety of datasets depicting soil and geologic attributes. For example, the Michigan Department of Environment, Great Lakes, and Energy, (formerly Michigan Department of Environmental Quality) produced a map layer of estimated annual groundwater recharge for each public land survey section in Michigan (<http://gis-michigan.opendata.arcgis.com/datasets/estimated-groundwater-recharge>), the California Department of Water Resources produces several datasets describing groundwater depth throughout the state (<https://gis.water.ca.gov/app/gicima/>), and the Pennsylvania Department of Conservation and Natural Resources has produced a map of karst features (sinkholes, surface depressions, surface mines, or cave entrances) that have been cataloged in Pennsylvania (<https://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=3073>).

5.5 Source Water Mapping

Drinking Water Mapping Application to Protect Drinking Water Sources (DWMAPS)

<https://www.epa.gov/sourcewaterprotection/drinking-water-mapping-application-protect-source-waters-dwmaps>

DWMAPS is an online mapping tool that can help states and water utilities update their source water assessments and protection plans in concert with other state and local mapping tools. DWMAPS can be used to locate drinking water providers, potential sources of contamination, and polluted waterways as well as information on protection projects and Source Water Collaborative initiatives in their area. DWMAPS includes many of the data layers provided in this section and more including: Sole Source Aquifers, Land Cover, Facilities Permitted to Discharge to Water, Facility Registry Service (FRS), Watershed Boundaries (HUC12), and the National Hydrography Dataset.

6 References

Agency for Toxic Substances & Disease Registry (ATSDR). 2018. *Toxicological Profile for Perfluoroalkyls*.

Retrieved from <https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf>

Arizona Department of Environmental Quality (ADEQ). 2018. *Arizona's Public Water System Screening for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) Final Report*. Retrieved

from: http://static.azdeq.gov/wqd/reports/pfoapfosepareport_final.pdf

Association of State Drinking Water Administrators (ASDWA). 2020. *Draft Per- and Polyfluoroalkyl Substances (PFAS) Source Water Protection Guidance: Technical Appendix*.

Interstate Technology and Regulatory Council (ITRC). 2018. *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*. Retrieved from [https://pfas-1.itrcweb.org/wp-](https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_fate_and_transport_3_16_18.pdf)

[content/uploads/2018/03/pfas_fact_sheet_fate_and_transport_3_16_18.pdf](https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_fate_and_transport_3_16_18.pdf)

Kansas Department of Health and Environment (KDHE). 2019. *Final statewide inventory of potential perfluoroalkyl substances (PFAS) sites in Kansas*. Retrieved from

http://www.kdheks.gov/pws/documents/PFAS_Inventory_Report.pdf

Kentucky Department for Environmental Protection (KDEP). 2019. *Evaluation of Kentucky Community Drinking Water for Per- & Poly-Fluoroalkyl Substances*. Retrieved from

<https://eec.ky.gov/Documents%20for%20URLs/PFAS%20Drinking%20Water%20Report%20Final.pdf>

Maine Department of Environmental Protection (MDEP). 2019. *Maine PFAS Data (2007 - 2019)*.

Retrieved from <https://www.maine.gov/dep/spills/topics/pfas/PFAS-all-results-9.23.2019.pdf>

North Dakota Department of Environmental Quality (NDDEQ). 2019. *North Dakota Statewide 2018 Per- and Polyfluoroalkyl Substances (PFAS) Presence/Absence Survey*. Retrieved from

https://deq.nd.gov/Publications/MF/PFAS_Report.pdf

New Hampshire Department of Environmental Services (NHDES). 2017. *Information on Class B*

Firefighting Foam and Potential PFCs and Request for Notification of Use. Retrieved from

<https://www4.des.state.nh.us/nh-pfas-investigation/wp-content/uploads/2017/08/pfas-classb-foam-20170509.pdf>

Pennsylvania Department of Environmental Protection (PADEP). 2019. *PFAS Sampling Plan Phase 1: Plan*

to Prioritize Sampling of Public Water Systems (PWS) 2019 – 2020. Retrieved from

http://files.dep.state.pa.us/Water/DrinkingWater/Perfluorinated%20Chemicals/BSDW%20PFAS%20Sampling%20Plan_Phase%201_April%202019.pdf

Vermont Agency of Natural Resources (VANR). 2019. *Per and Polyfluoroalkyl Substances (PFAS)*

Statewide Sampling Plan. Retrieved from

<https://anrweb.vt.gov/PubDocs/DEC/PFAS/Sampling/PFAS-sampling-plan-07162019-Final.pdf>

Appendix A: NAICS Codes

The North American Industry Classification System (NAICS) is a system for categorizing businesses. It was designed for statistical purposes and for comparing economic data across North America. Companies select the six-digit NAICS code which best describes their primary business activity, and government agencies use these codes to classify industry information. The NAICS classification scheme replaced the older and less specific Standard Industrial Classification (SIC) system.

Potential sources of PFAS contamination can be located by searching for facilities with specific NAICS codes. Table A1 shows a list of NAICS codes for businesses and industries that may be primary or secondary sources of PFAS. Note that NAICS codes are broad categories that may contain manufacturers of products unrelated to PFAS; the specific sub-categories that are relevant to PFAS are indicated in the table. This code list was informed by efforts undertaken by states in recent years to identify and map PFAS sources (ASDWA, 2020).

Table 2. NAICS codes relevant to PFAS production, storage, and use.
Sub-categories within a code are marked with an asterisk (*).

NAICS Code	Description
Construction	
238320	Electrostatic painting, on site, contractors*
238330	Wood floor finishing (e.g. coating, sanding)*
Manufacturing	
313110	Fiber, yarn, and thread mills
313210	Broadwoven fabric mills
313220	Narrow fabric mills and Schiffli machine embroidery
313320	Waterproofing apparel, fabrics and textile products (e.g., oiling, rubberizing, waxing, varnishing)*
	Plastics coating of textiles and apparel*
314910	Textile bag and canvas mills
315210	Aprons, waterproof (including rubberized fabric, plastics), cut and sew apparel contractors*
315280	Coats, waterproof (e.g., plastics, rubberized fabric, similar materials), rubberizing fabric and manufacturing coats*
315990	Bibs and aprons, waterproof (e.g., plastics, rubber, similar materials), rubberizing fabric and manufacturing bibs and aprons*
316110	Upholstery leather manufacturing*
316210	Footwear manufacturing
	Footwear leather or vinyl upper with rubber or plastic soles, manufacturing*
316998	All other leather good and allied product manufacturing
	Transmission belting, leather, manufacturing*
322110	Pulp mills
322121	Paper (except newsprint) mills
322130	Paperboard mills

NAICS Code	Description
	Paperboard coating, laminating, or treating in paperboard mills*
	Leatherboard (i.e., paperboard based) made in paperboard mills*
322212	Folding paperboard box manufacturing
322220	Coating purchased papers for packaging applications*
	Leatherboard (i.e., paperboard based) made from purchased paperboard*
	Waxed paper*
322230	Notebooks (including mechanically bound by wire or plastics) made from purchased paper*
324110	Paraffin waxes made in petroleum refineries*
325199	Plasticizers (i.e., basic synthetic chemicals) manufacturing*
325510	Water repellent coatings for wood, concrete and masonry manufacturing*
325520	Pipe sealing compounds manufacturing
325611	Soap and other detergent manufacturing
325612	Polish and other sanitation good manufacturing
325613	Surface active agent manufacturing
325620	Toilet preparation manufacturing
325998	Foundry core oil, wash, and wax manufacturing*
326111	Trash bags, plastics film, single wall or multiwall, manufacturing*
326112	Packaging film, plastics, single web or multiweb, manufacturing*
326113	Photographic, micrographic, and x-ray plastics, sheet, and film (except sensitized), manufacturing*
326119	Motor vehicle moldings and extrusions, plastics, manufacturing*
326150	Cushions, carpet and rug, urethane and other foam plastics (except polystyrene), manufacturing*
32619	Other plastics product manufacturing
32629	Other rubber product manufacturing
332215	Nonstick metal cooking utensils*
33281	Coating, engraving, heat treating, and allied activities
332812	Hot dip galvanizing metals and metal products for the trade*
	Coating of metal and metal products with plastics for the trade*
	Powder coating metals and metal products for the trade*
332813	Chrome plating metals and metal products for the trade*
333241	Bakery ovens manufacturing*
333242	Semiconductor making machinery manufacturing*
333318	Cooking equipment (i.e., fryers, microwave ovens, ovens, ranges) commercial-type manufacturing*
33351	Metalworking machine manufacturing
333517	Chemical milling machines, metalworking, manufacturing*
334413	Semiconductor memory chips manufacturing*
334419	Rectifiers, electronic component-type (except semiconductor), manufacturing*

NAICS Code	Description
334515	Semiconductor test equipment manufacturing*
335210	Ovens, portable household-type (except microwave and convection ovens), manufacturing*
335220	Microwave ovens (including portable), household-type, manufacturing*
335999	Semiconductor high-voltage power supplies manufacturing*
336412	Aircraft turbines manufacturing*
339114	Dental wax manufacturing*
339920	Sporting and athletic goods manufacturing
Waste Management and Remediation Services	
561990	Firefighting services as a commercial activity*
562111	Solid waste collection
562112	Hazardous waste collection
562119	Other waste collection
562211	Hazardous waste treatment and disposal
562212	Solid waste landfill
562213	Solid waste combustors and incinerators
562219	Other nonhazardous waste treatment and disposal
562991	Septic tank and related services
Educational Services	
611519	Fire fighter training schools*
Public Administration	
922160	Fire protection

Appendix B: State-Specific Databases

The following list of state databases contribute to the EPA Facility Registry Service (see <https://www.epa.gov/frs/frs-data-sources> for additional descriptions of each source). In general, the databases store information on permitted facilities within each state and may include additional data such as results of water quality monitoring. Interested readers should contact appropriate state agencies for more information.

- Arizona Unified Repository for Informational Tracking of The Environment (AZURITE)
- CA-California Environmental Reporting System (CA-CERS)
- California - Department of Toxic Substances Control-EnviroStor System (DTSC-ENVIROSTOR)
- California Enviroview (CA-ENVIROVIEW)
- California - Hazardous Waste Tracking System - Datamart (HWTS-DATAMART)
- California - Solid Waste Information System (CASWIS)
- Cherokee Nation Facility Registry System (CNFRS)
- Coeur D'Alene Facility Location Program (CDAFLP)
- Connecticut - Site Information Management System (SIMS)
- Delaware - Delaware Environmental Navigator (DEN)
- Florida - Fiesta Data Maintenance (FDM)
- Georgia - Geographic Environmental Information Management System (GEIMS)
- Hawaii - Environmental Health Warehouse (HI-EHW)
- Idaho - Department of Environmental Quality (IDDEQ)
- Illinois - Agency Compliance and Enforcement System (ACES)
- Indiana - Facility Registry System (IN-FRS)
- Indiana -Tools for Environmental Management and Protection Organizations (IN-TEMPO)
- Iowa - Department of Natural Resources Environmental Facilities Database (IDNR-EFD)
- Kansas - Facility Profile (KS-FP)
- Kentucky - Tools for Environmental Management and Protection Organizations (KY-TEMPO)
- Louisiana - Tools for Environmental Management and Protection Organizations (LA-TEMPO)
- Maine - Environmental Facility Information System (ME-EFIS)
- Maryland - Environmental Permit Service Center (MD-EPSC)
- Maryland - Resource Conservation and Recovery Act Information System (MD-RCRA)
- Maryland - Tools for Environmental Management and Protection Organizations (MD-TEMPO)
- Minnesota - Permitting, Compliance, And Enforcement Information Management System (MN-DELTA)
- Mississippi - Tools for Environmental Management and Protection Organizations (MS-ENSITE)
- Missouri - Department of Natural Resources (MO-DNR)
- Montana - Consolidated Environmental Data Acquisition and Retrieval System (MT-CEDARS)
- Navajo Nation Environmental Management System (NNEMS)
- Nebraska Department of Environmental Quality (NDEQ)
- Nevada Facility Profile (NV-FP)
- New Hampshire - Department of Environmental Services (NH-DES)
- New Jersey - New Jersey Environmental Management System (NJ-NJEMS)
- New Mexico - Tools for Environmental Management and Protection Organizations (NM-TEMPO)

- New York - Facility Information System (FIS)
- North Carolina - Facility Identification Template for States (NC-FITS)
- North Dakota - Facility Profile (ND-FP)
- Ohio - Core (OH-CORE)
- Oklahoma - Facility Management System (OK-FMS)
- Oregon - Department of Environmental Quality (OR-DEQ)
- Pennsylvania – Environmental, Facility, Application, and Compliance Tracking System (PA-EFACTS)
- Rhode Island - Permits, Licenses and Other Vital Environmental Records (RI-PLOVER)
- Salt River Pima-Maricopa Indian Community Environmental Management System (SRPMICEMS)
- South Carolina - Environmental Facility Information System (SC-EFIS)
- Texas - Texas Commission on Environmental Quality - Agency Central Registry (TX-TCEQ ACR)
- Utah - Common Identifier Mechanism (CIM)
- Virginia - Comprehensive Environmental Data System (CEDS)
- Washington - Facility / Site Identification System (WA-FSIS)
- Wisconsin Environmental System Registry (WI-ESR)
- Wyoming - Industrial Siting Division (ISD)