

Exposure Assessment Sites

ATSDR utilized a multistep approach to select sites for the PFAS exposure assessments. The process reflects the legislative requirements and the scientific needs of the project. ATSDR drew on a variety of sources to assemble a list of candidate sites. Sources included information from other federal agencies, including DoD, EPA's UCMR3 data, and local water utilities. ATSDR's inclusion criteria for communities were:

- sites that are near a current or former military installation (legislative mandate),
- sites with a completed drinking water exposure pathway for PFOA and/or PFOS above the EPA's lifetime health advisory (LHA) of 70 ppt (we want to get a range of exposures),
- duration of water system contamination (longer exposure duration is preferred),
- sites with a population of potentially exposed persons larger than the required sample size calculated in the protocol (larger population is preferred), and
- sites where no previous CDC/ATSDR sponsored PFAS biomonitoring has occurred.

Other factors affecting selection included how recently PFAS exposure mitigation had been implemented as well as characterization of the complexity of the water distribution system. All systems meeting the above criteria have completed mitigation activities. Other factors being equal, we selected sites where the mitigation has more recently occurred. In addition, we gave sites with a single source water distribution system preference over systems with multiple intakes with varying PFAS contamination. ATSDR also categorized the eligible sites based on the predominant source of drinking water to ensure the exposure assessments included communities served by both public and/or private water systems and private wells. Finally, we strove to select sites from across the country to assure a heterogeneity of exposure conditions and characteristics.

ATSDR used information from the local water utilities to estimate the exposed population for each site. ATSDR evaluated the maximum measured concentrations of PFOA and PFOS combined in drinking water to assess the magnitude of exposure. ATSDR estimated the duration of exposure using information about initial use of AFFF at nearby military installations, service dates for drinking water wells, and information about documented releases of AFFF to surface water. Based on the information available, ATSDR chose sites that included both private well and water system sites and a geographical diversity of sites.

To our knowledge, all municipal systems serving the communities identified as potential exposure assessment sites took steps to reduce concentrations of PFOA and PFOS below 70 ppt between 2014 and 2017. Additionally, the information available for private wells within these communities indicates that either treatment systems were installed, or alternate sources of water provided between 2015 and 2018 in cases where PFOA and PFOS concentrations in private wells exceeded 70 ppt. Exposure to lower levels of PFAS may be ongoing.

No single criterion was the determining factor for site selection. Rather a weight of evidence approach was used to select a set of sites for exposure assessment.

Listed in alphabetical order by county, the sites selected for PFAS exposure assessments are:

- Berkeley County, WV near Shepherd Field Air National Guard Base (Berkeley County)
- El Paso County, CO near Peterson Air Force Base (El Paso County)
- Fairbanks North Star Borough, AK near Eielson Air Force Base (Fairbanks North Star Borough)
- Hampden County, MA near Barnes Air National Guard Base (Hampden County)
- Lubbock County, TX near Reese Technology Center (Lubbock County)
- New Castle County, DE near New Castle Air National Guard Base (New Castle County)
- Orange County, NY near Stewart Air National Guard Base (Orange County)
- Spokane County, WA near Fairchild Air Force Base (Spokane County)

Six of the selected communities (Berkeley County, El Paso County, Hampden County, New Castle County, Orange County, and Spokane County) have water systems that had PFOA + PFOS above 70 ppt. In order to draw generalizable conclusions, the sample frame in these communities will include only water system customers. The other two communities (Fairbanks North Star Borough and Lubbock County) had a large number of private wells with PFOA + PFOS above 70 ppt but no affected municipal systems. The sample frame in these communities will include only households with private wells.

Site-selection parameters for the exposure assessment sites are included below. Note that all of these parameters were estimated based on available information and may be updated as further information is obtained through the exposure assessment process (e.g. may find that a smaller area within a water system received water with PFOA + PFOS over 70 ppt resulting in reduced population estimate). Mitigation year provides the date for each community when mitigation activities were completed and exposure after that date is believed to be below the EPA lifetime health advisory.

The table below summarizes the PFOA/PFOS concentrations measured in each community, the exposed population, the exposure duration, and the mitigation year at the sites selected for exposure assessment. Further details for each site are provided below the table.

Site Name	Maximum Measured PFOA+PFOS Concentration	Estimated Exposed Population	Estimated Exposure Duration	Estimated Mitigation Year
Berkeley County, WV	124 ppt	1,866	35 years	2016
El Paso County, CO	1,370 ppt	14,072	46 years	2017
Fairbanks North Star Borough, AK	2,980 ppt	750	34 years	2015
Hampden County, MA	203 ppt	7,665	45 years	2016
Lubbock County, TX	2,900 ppt	885	47 years	2018
New Castle County, DE	2,740 ppt	7,382	43 years	2014
Orange County, NY	197 ppt	28,000	27 years	2016
Spokane County, WA	1,520 ppt	6,200	46 years	2017

Berkeley County, WV

The City of Martinsburg has two water sources: a well (Big Spring Plant) and a spring (Kilmer Spring). Both sources had PFOA+PFOS concentrations that exceeded the LHA, though contamination was only consistently found in the Big Spring Plant well. The maximum reported concentration of PFOA+PFOS was 124 ppt.¹ The City of Martinsburg was the primary public water system affected by PFOA/PFOS contamination in Berkeley County. This water system serves approximately 15,000 people; however, the subset of this population in the high pressure zone likely had the highest exposure levels. The estimated population in the high pressure zone, served by the Big Spring Plant well, was 1,866 based on 2010 census data.² AFFF was used, and presumably released, at Shepherd Field Air National Guard Base from the 1980s until 2007.³ The Big Spring Plant well is located 1 mile downgradient of the base, and Kilmer Spring is located 4 miles downgradient.³ PFOA and PFOS were first detected in the system's sources in February 2014.⁴ The first mitigation measures were implemented in May 2016, resulting in an estimated exposure duration of 35 years.⁵

El Paso County, CO

PFOS or PFOA were detected in most of Security's and Widefield's drinking water wells as well as in an interconnection zone for the Fountain system. The maximum PFOA+PFOS concentration observed in Security's system was 1,370 ppt and the maximum in Widefield was 246 ppt.⁴ The primary exposed population live within specific zones of the distribution systems serving the cities of Security and Widefield. Each system serves a mixture of groundwater and surface water to approximately 19,000 people each. The zones most impacted by PFOA/PFOS contamination primarily received groundwater. The estimated 2010 population within the areas of greatest impact are: 5,670 residents in zone 1 of the Security system and 8,363 residents in combined zones 1, 2, and 3 of the Widefield system.⁶ PFOS and PFOA were also detected at the City of Fountain entry point to distribution system from the Fountain Valley Authority. The maximum PFOA+PFOS concentration detected in Fountain drinking water was 140 ppt.⁴ The Fountain interconnect part of the drinking water system that was affected serves around 39 individuals.⁶ AFFF was used, and presumably released, at Peterson Air Force Base from 1970 until 2005.⁷ The first PFOA/PFOS sampling for water systems in this area occurred in 2014 during UCMR3, which revealed widespread detection. Each water system began mitigation immediately and reduced most exposures below the LHA by 2017, resulting in an estimated exposure duration of 46 years.^{8,9,10}

Fairbanks North Star Borough, AK

ATSDR obtained well sampling data that indicated the maximum PFOA+PFOS concentration in private wells in this community was 2,980 ppt.¹¹ Residents with private wells in the community of Moose Creek were the primary off-base population affected by PFOA/PFOS contamination in Fairbanks North Star Borough near Eielson Air Force Base. Water from nearly every private well tested off-base (170 out of 174) during a recent sampling effort had PFOA+PFOS concentrations greater than the LHA¹¹. ATSDR estimates that 750 off-base residents were affected.¹² AFFF was used, and presumably released, at Eielson Air Force Base from the 1980s until 2010.¹³ In May 2015, the Air Force began sampling private wells in the Moose Creek community immediately downgradient of the base.¹⁴ In June 2015, the first results indicated that PFOS was detected in every well sampled and PFOS concentrations exceeded the LHA in more than 90 percent of the samples. The Air Force immediately began providing bottled water to affected well owners. An additional time critical remediation action was initiated to continue monitoring private wells in the area and to allow for the installation of point-of-use granulated activated carbon filters or potable water storage tanks.¹⁵ The estimated PFOA+PFOS exposure duration for private well owners is 34 years.

Hampden County, MA

Four out of eight drinking water supply wells in the Westfield Water Department's (WWD) system had PFOA+PFOS levels greater than the LHA. Exceedances occurred for Wells #1, #2, #7, and #8, and the highest PFOA+PFOS concentration of 203 ppt occurred at Well #7.⁴ The Westfield Water Department was the primary public water system affected by PFOA/PFOS contamination. In 2018, the system served approximately 42,000 people.¹⁶ However, the population of greatest concern are those who live north of the Westfield River and were served drinking water from the East Mountain Tank. ATSDR estimates this population to be approximately 7,665 individuals.^{17,18} Barnes Air National Guard Base used AFFF for fire training and suppression between 1970 and the early 2000s; and AFFF was used in on-site emergency response vehicles until 2016.¹⁹ After EPA lowered the LTHA in May 2016, WWD's drinking water exceeded the advisory, and mitigation measures were immediately implemented. Some examples include:

- Wells #7 and #8 were removed from service in December 2015 and January 2016, respectively. Both wells are expected to remain inactive, except for sampling.²⁰
- A water restriction was put in place during the summer of 2016 that restricted all non-essential water use (e.g., lawn irrigation, car washing) to 3 days per week.²¹ This restriction ensured that WWD would have enough water capacity to support customers' essential needs, without having to resort to using potentially contaminated emergency sources.
- Wells #2 was disconnected from the water system in September 2016 due to PFAS contamination, though the well remained active to meet critical supply needs. A drinking water health advisory was issued for residents in the affected area.²²

The estimated PFOA+PFOS exposure duration for the population served by drinking water north of the Westfield River from the Westfield Water Department is 45 years.

Lubbock County, TX

ATSDR obtained well sampling data from DoD that indicated the maximum PFOA+PFOS concentration in private wells was 2,900 ppt.¹¹ Two permanent resident populations had drinking water contaminated with PFAS at levels exceeding EPA's LHA, Texas Commission on Environmental Quality's (TCEQ's) Protective Contamination Levels (PCLs), or both health-based screening values. One population is 108 residents served by a small water system at the Pecan Grove Mobile Home Park.²³ The other population is an estimated 777 residents served by contaminated private wells.^{24,25} In the absence of data to suggest otherwise, ATSDR assumed former Reese Air Force Base started using AFFF in 1970.²⁶ AFFF was used at the former Reese AFB until the 1997 base closing.²⁷ The Air Force began testing for PFAS in November 2017, at which point contamination was observed at many off-base private drinking water wells. Mitigation began in 2018 and implementation of mitigation measures is an ongoing process, as affected homes have been typically offered bottled water in the short term and drinking water treatment systems as a longer-term solution.²⁸ Some examples include:

- In January 2018, media accounts indicated that 93 private wells near Reese AFB had been sampled, 77 had received results, 15 exceeded the LTHA, and 5 exceeded a PCL but not the LTHA.^{29,30} As soon as PFAS were detected above the LTHA or PCL, the Air Force provided bottled water to the affected residences.
- By August 2018, the Air Force had reportedly sampled 450 private wells; 185 of them had PFAS water concentrations that exceeded the LTHA, the PCL, or both values; and 77 of these wells had been equipped with treatment in the form of granulated activated carbon filters with polymer resins.³¹

Communication with EPA and TCEQ indicated that at least 120 private wells are currently equipped with treatment systems. The estimated PFOA+PFOS exposure duration for private well owners is 47 years.

New Castle County, DE

Two water systems in this community, Artesian Water and Municipal Services Commission (MSC), had PFOA+PFOS concentrations above the LHA. The highest concentration measured in the Artesian Water system was 1,940 ppt⁴, and the highest concentration measured in MSC was 2,740 ppt.³² Contamination was more widespread in the MSC system. ATSDR estimates at least 7,382 people across two different water systems were exposed to PFOA/PFOS at concentrations above the LHA. This includes 5,500 people in the City of New Castle served by the Municipal Services Commission (MSC) water system³³ and 1,882 people served by the Artesian Water system^{34,35}. The estimated exposed population served by the Artesian Water system is a small fraction of the overall population (211,494) in this system's service area. In the absence of data to suggest otherwise, ATSDR assumed New Castle ANGB started using AFFF in 1970.³⁶ PFOA and PFOS were first detected in the MSC system in the Frenchtown Road and School Lane Road wells in September 2009.³⁷ On June 2, 2014, Artesian Water received notice that samples collected under UCMR3 at their Wilmington Manor 3 Treatment plant exceeded the provisional health advisory for PFOS. The system immediately shut down the two affected wells and removed the facility from service.^{38,39} According to MSC, all groundwater wells were inactivated on August 6, 2014, and MSC began purchasing all of its water from Artesian Water.³⁷ A GAC filtration system was installed on MSC's wells in December 16, 2014, after which the system began using its groundwater wells again. The estimated PFOA+PFOS exposure duration to customers served by Artesian Water and MSC is 43 years.

Orange County, NY

Multiple sampling events conducted in Washington Lake (the primary source of the City of Newburgh's drinking water) and finished water in the water system show PFOA+PFOS contamination greater than the LHA. PFOA+PFOS concentrations observed in the drinking water between 2013 and 2016 ranged from 165 ppt to 197 ppt.⁴ All drinking water in the Newburgh City supply is treated at the system's water treatment plant before being pumped to the system's service area. This configuration likely results in all customers receiving drinking water containing the same PFAS contamination levels. The City of Newburgh was the primary public water system affected by PFOA/PFOS contamination in Orange County. This water system serves approximately 28,000 residents.^{16,40} Stewart Air National Guard Base previously used AFFF in its fire suppression system, both for training and emergency response. According to information that state officials provided to ATSDR, the base used AFFF "for fire suppression in aircraft hangars between about 1988 and 2009."⁴¹ The first PFOA/PFOS detection in Washington Lake occurred in a sample collected on December 30, 2013.⁴ Drinking water in this system continued to be contaminated above the LHA until May 2, 2016, after which the water system began using an uncontaminated surface water as its primary water source.⁴² The estimated PFOA+PFOS exposure duration to customers served by the City of Newburgh 27 years.

Spokane County, WA

Three out of eight active drinking water supply wells in the Airway Heights system had PFOA+PFOS levels greater than the LHA. Exceedances occurred for wells #1, #4, and #9, and the highest PFOA+PFOS concentration of 1,520 ppt occurred at Well #9.^{11,43} These three wells account for a majority of the system's total drinking water capacity.⁴⁴ The City of Airway Heights was the primary public water system affected by PFOA/PFOS contamination in Spokane County. According to Air Force officials, AFFF used for on-base fire training and to

extinguish fires from aircraft crashes at two sites caused PFAS groundwater contamination in the area.⁴⁵ This water system serves approximately 6,200 residents and 792 non-residential customers.⁴⁶ Fairchild AFB used AFFF for fire training from the 1970s through 1991.⁴⁷ Airway Heights' drinking water supply wells are located approximately 1 mile downgradient from the base boundary. The first PFOA/PFOS detection in the Airway Heights water system occurred in a sample collected in May 2017.¹¹ The water system immediately implemented mitigation measures, which appear to have reduced tap water contamination levels to below the LHA. On May 16, 2017 the Air Force informed the City of Airway Heights that water sampled from three wells (#1, #4, and #9) had PFOA/PFOS concentrations above the LTHA.⁴⁸ The three wells were immediately inactivated. Airway Heights advised customers not to drink or cook with city water, and city firefighters provided bottled water to residents.⁴⁹ The estimated PFOA+PFOS exposure duration to customers served by the City of Airway Heights is 46 years.

Potential New Exposure Assessment Sites

If resources become available to conduct additional exposure assessments, we will use inclusion criteria similar to those above with the exception of the need to be near current or former military site, and allowing for the potential to evaluate sites with species other than PFOA or PFOS in drinking water. These include:

- sites with a completed drinking water exposure pathway for PFOA and/or PFOS, or an emergent PFAS species, above the EPA's lifetime health advisory (LHA) of 70 ppt (we want to get a range of exposures),
- duration of water system contamination (longer exposure duration is preferred),
- sites with a population of potentially exposed persons larger than the required sample size calculated in the protocol (larger population is preferred), and
- sites where no previous CDC/ATSDR sponsored PFAS biomonitoring has occurred.

While we were reasonably certain that, for sites near military bases, water mitigation had already occurred - this may not be the case for non-military sites. Sites where exposure has not been mitigated will be given preference. When exposure has been mitigated, site selection will favor sites with more recent mitigation activities. In addition, sites with a single source water distribution system will be given preference over systems with multiple intakes with varying PFAS concentrations. If possible, additional sites will include both water distribution systems and communities served primarily by private wells. In communities served by private wells, preference will be given to communities with well characterized groundwater plumes. Finally, we will continue to select sites from across the country to assure a heterogeneity of exposure conditions and characteristics. No single criterion will be the determining factor for site selection. Rather a weight of evidence approach will be used to select a set of sites for exposure assessment.

- ¹ https://www.heraldmillmedia.com/news/tri_state/west_virginia/martinsburg-mayor-says-city-s-water-is-safe/article_fc57b80e-1eac-11e6-acb0-139390330886.html
- ² 2010 Census data for high pressure zone, Big Springs water filtration plant (electronic communication, GRASP 12/6/2019)
- ³ Final Perfluorinated Compounds Preliminary Assessment Site Visit Report. West Virginia Air National Guard Base Eastern West Virginia Regional Airport, Martinsburg, West Virginia, December 2015.
- ⁴ EPA UCMR3 data
- ⁵ <http://cityofmartinsburg.org/water-and-wastewater-system-information/>
- ⁶ 2010 Census data, (electronic communication, GRASP 11/13/2018)
- ⁷ Revised Final Preliminary Assessment Report for Perfluorinated Compounds at Peterson Air Force Base El Paso County, Colorado, November, 2016
- ⁸ [Engineering Evaluation and Cost Analysis Non-Time Critical Removal Action Widefield WSD, CO](#) prepared by Tehama for USACE, June 2018
- ⁹ [Engineering Evaluation and Cost Analysis Non-Time Critical Removal Action Security Water District, CO](#) prepared by Tehama for USACE, May 2018
- ¹⁰ [Engineering Evaluation and Cost Analysis Non-Time Critical Removal Action City of Fountain, CO](#) prepared by Tehama for USACE, June 2018
- ¹¹ electronic communication from DoD, November 28, 2018
- ¹² Interim Proposed Plan for Long Term Water Supply, Community of Moose Creek, Alaska April 2018. https://www.eielson.af.mil/Portals/40/documents/Moose_Creek/Final%20Moose%20Creek%20Interim%20Proposed%20Plan.pdf?ver=2018-04-16-191123-360
- ¹³ Final Preliminary Assessment Report for Perfluorinated Compounds at Eielson Air Force Base Alaska. Air force Civil Engineering Center. December 2015
- ¹⁴ https://www.eielson.af.mil/Portals/40/documents/Moose_Creek/AFD-151130-026.pdf?ver=2016-01-07-092845-813
- ¹⁵ Action Memorandum for a Time-Critical removal Action of Perfluorooctanesulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Contaminated Drinking Water at Moose Creek by Eielson Air Force Base, Alaska. November 2015.
- ¹⁶ County SDWIS.
- ¹⁷ ATSDR calculated this estimate by approximating the water system area that receives water from the East Mountain Tank. The 2010 Census data indicates that 7,665 residents live in census tract 8125 (north of the Westfield River). ATSDR estimates this population received drinking water from the East Mountain Tank.
- ¹⁸ Population, Housing Units, Area, and Density: 2010 - County -- Census Tract, 2010 Census Summary File 1. U.S. Census Bureau, 2010 Census. Accessed from <https://factfinder.census.gov>.
- ¹⁹ Draft SI Report Barnes. <https://cswab.org/wp-content/uploads/2018/07/Barnes-Air-National-Guard-Base-Site-Inspection-WRAFT-2018-MA.pdf>
- ²⁰ Notice of Revisions to Drinking Water Health Advisory Levels. Westfield Water Department. May 27, 2016. <https://www.cityofwestfield.org/DocumentCenter/View/4643/Westfield-Advisory---PFOA-May-2016?bidId=>
- ²¹ Water Use Restrictions Announcement. Westfield Water Department. June 2016. <https://www.cityofwestfield.org/DocumentCenter/View/4645/Water-Restriction-June-2016?bidId=>
- ²² Notice of Drinking Water Health Advisory Level Exceedance for Well #2. Westfield Water Department. September 16, 2016. <https://www.cityofwestfield.org/DocumentCenter/View/4644/Drinking-Water-Health-Advisory-September-2016?bidId=>
- ²³ County Safe Drinking Water Information System, 2013
- ²⁴ estimate was calculated by multiplying the number of affected residents (300 homes) by the average household size in Lubbock County, per recent Census data
- ²⁵ <https://www.census.gov/quickfacts/fact/table/lubbockcountytexas/POP060210>
- ²⁶ https://www.afcec.af.mil/Portals/17/documents/BRAC/Reese/180820_Reese_PFOS-PFOA%20Factsheet_FINAL.pdf?ver=2018-10-17-161344-773
- ²⁷ Final Preliminary Assessment Report for PFCs at Former Reese Air Force Base, TX and Terry County Auxiliary Airfield, TX, January 2016.
- ²⁸ <http://ramar.worldnow.com/story/37307033/20-water-wells-contaminated-at-former-reese-air-force-base>
- ²⁹ <https://www.amarillo.com/news/texas-news/2018-01-21/water-well-contamination-detected-near-former-reese-air-force-base>
- ³⁰ <http://ramar.worldnow.com/story/37307033/20-water-wells-contaminated-at-former-reese-air-force-base>
- ³¹ <https://www.census.gov/quickfacts/fact/table/lubbockcountytexas/POP060210>
- ³² written communication, FOIA Request pertaining to PFAS Information Response. City of New Castle, Delaware. November 14, 2018.
- ³³ written communication, MSC Water System Overview - 2018. City of New Castle, Delaware. November 14, 2018.

- ³⁴ estimate was calculated by multiplying 822 customers by the average household size in City of New Castle.
- ³⁵ <https://www.census.gov/quickfacts/newcastlecitydelaware>
- ³⁶ FINAL Perfluorinated Compounds Preliminary Assessment Site Visit Report. Delaware Air National Guard Base, New Castle, Delaware, January 2016.
- ³⁷ EPA R3, Final DANG SI report 2018
- ³⁸ Final POLREP New Castle County Airport Removal Assessment. USEPA. June 2018.
- ³⁹ Drinking Water Notice. "Artesian's Wilmington Manor 3 Treatment Plant detected levels of PFOS Above Provisional Health Advisory" June 12, 2014
- ⁴⁰ https://www.dec.ny.gov/docs/remediation_hudson_pdf/newburghpfoswashlkwtrshd.pdf.
- ⁴¹ electronic communication, *Requested Info, Stewart ANGB, Newburgh NY*. William Gilday. June 20, 2018
- ⁴² https://www.dec.ny.gov/docs/remediation_hudson_pdf/newburghpfostimeline.pdf.
- ⁴³ The City of Airway Heights Consumer Confidence Report, 2017
- ⁴⁴ Sentry Internet, Washington State Department of Health, Division of Environmental Health, Office of Drinking Water. Accessed in November 2018. <https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx>
- ⁴⁵ <http://www.spokesman.com/stories/2017/may/03/testing-confirms-chemical-contamination-in-residen/>
- ⁴⁶ Sentry Internet, Washington State Department of Health, Division of Environmental Health, Office of Drinking Water <https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx>
- ⁴⁷ Final Preliminary Assessment Report for Perfluorinated Compounds at Fairchild Air Force Base, Spokane, Washington, September 2015
- ⁴⁸ [EPA] U.S. EPA Environmental Protection Agency. 2018. The Safe Drinking Water Information System (SDWIS). Accessed in November 2018.
- ⁴⁹ <http://www.spokesman.com/stories/2017/may/16/airway-heights-residents-warned-not-to-drink-tap-w/>