

# Community Level Biomonitoring for Per and Polyfluoroalkyl Substances (PFAS) in Pennsylvania

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# Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

- ▼ Man-made chemicals
- ▼ Used in protective surfaces and things that have water-repellant coatings
- ▼ PFAS-containing firefighting foam



# ▶ EPA Health Advisory Levels

## **2009 - Provisional Health Advisory Levels (PHAL)**

- 0.4 ug/L for PFOA and 0.2 microgram per liter (ug/L) for PFOS (400 and 200 parts per trillion, respectively)

## **May 2016 - Lifetime Health Advisory Level (LHAL)**

- 70 parts per trillion or 0.07 ug/L for PFOS and PFOA combined.

PFOA - Perfluorooctanoic acid

PFOS - Perfluorooctanesulfonic acid

# Background

- Former Naval Air Warfare Center (NAWC)-  
Warminster Twp. Bucks County (840 acre site)
  - In operation from 1940s-1997
  - Firefighter training activities using foams containing PFAS



# Background

## NAWC

- 2013: PFAS detected in ground water
- 2014: All contaminated public wells taken out of service
- 2015: PFAS found in 93 out of 100 private wells within a 1-3 mile radius
- Private well owners were given bottled water

# Background

- Former Naval Air Station Joint Reserve base and Horsham Air Guard Station (1,200 acre site)
  - In operation from 1920s-2011

## Contamination in two public water systems

- ▀ 2014: Five public wells were taken out of service
- 2016: EPA released LHAL; Additional wells were taken out of service; Private well owners were given bottled water



# ▶ PFAS Exposure in Community

- Levels 21 times higher (1,440 ppt) than EPA's health advisory level (70 ppt) found in a municipal well in one PWS area
- Assumed to have been exposed for a long time - nearly 50 years
- Wide range of exposure:
  - Some municipal wells had no levels of PFAS
  - Some municipal wells had levels of PFAS much higher than national guideline

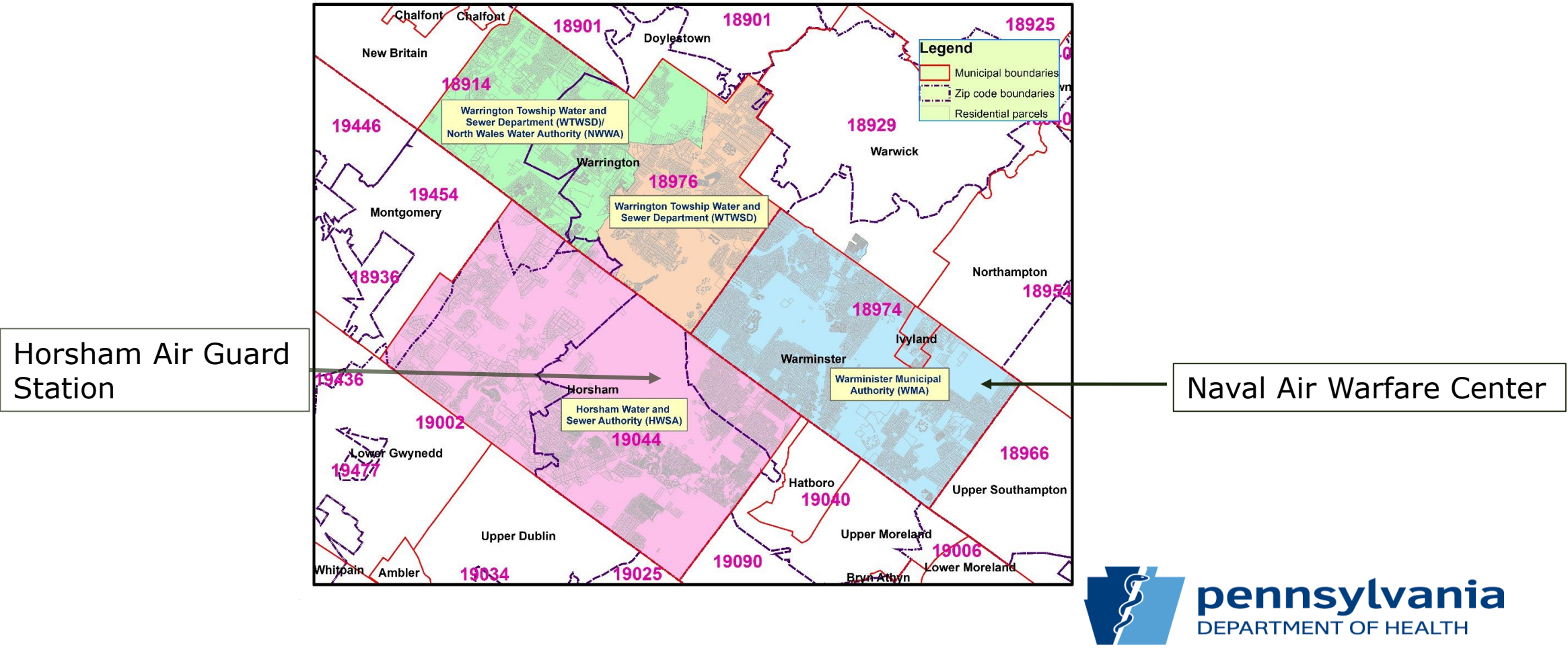
# PEATT Pilot Project

- CDC/ATSDR has developed a toolkit to conduct biomonitoring for PFAS
- Pennsylvania was chosen for the pilot program to evaluate the toolkit
- Feedback from this project
  - ▀ Will be used to improve the toolkit
  - ▀ Will support a larger, national study



# ▶ PFAS Exposure in Southeastern PA

- Affected area = Population of 84,184 (2010 census)



# Participant Selection

- Aimed to select 500 participants
- We mailed eligibility information forms and invitation letters to 600 randomly selected households
- Eligibility form included:
  - ▣ How many in each household?
  - ▣ How many lived there prior to July 1, 2016?
  - ▣ How many willing to participate?

# ➤ Participant Selection- Response Rates

- Total households contacted: 600
- Total households responded: 276
- Household level response rate: **46%**
- Number of eligible participants identified: 584 (including 113 kids aged 3-17 years)
- Number of eligible participants who completed the questionnaire and the informed consent form: 305
- Number of eligible participants who completed paperwork **AND** provided blood samples: 235 – from 118 households
- Individual participation rate: **40%** (235 out of 584)
- Household level participation rate: **19.6%** (118 out of 600 contacted)

# ▶ PEATT Pilot Project

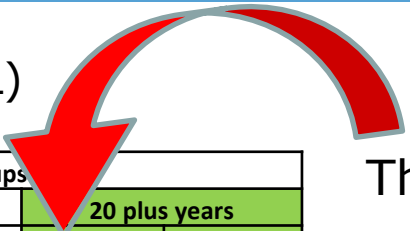
- Weekly clinics in Bucks and Montgomery Counties to draw the blood samples
- From May through September 2018
- 235 samples obtained and sent to Wadsworth Laboratory in the New York State Health Department
- Wadsworth returned all results to DOH, and all 235 participants were notified of their individual results along with information on national and community averages

# ▶ Reading Individual Results (first letter)

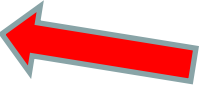
For an ADULT age 20 or older (unit: microgram/L)

PFAS chemicals measured in your blood	Concentration found in your blood	US Population - Age groups					
		3-11 years		12-19 years		20 plus years	
		Geometric mean	95th percentile	Geometric mean	95th percentile	Geometric mean	95th percentile
Perfluorooctanoic acid (PFOA)	3.52	1.92	4.19	1.66	3.47	1.98	5.60
Perfluorooctanesulfonic acid (PFOS)	9.60	3.88	11.00	3.54	9.30	5.22	19.50
Perfluorohexane sulfonic acid (PFHxS)	<b>8.37</b>	0.84	3.12	1.27	6.30	1.36	<b>5.50</b>
Perfluorononanoic acid (PFNA)	0.80	0.79	3.26	0.60	2.00	0.69	2.00
Perfluorobutanesulfonic acid (PFBuS)	ND	*	<0.10**	*	<0.10**	*	<0.10**
Perfluorodecanoic acid (PFDeA)	ND	*	0.37	0.14	0.40	0.19	0.80
Perfluorododecanoic acid (PFDoA)	ND	*	<0.10**	*	0.20	*	0.20
Perfluoroheptanoic acid (PFHpA)	ND	*	0.21	*	0.20	*	0.10
Perfluorooctane sulfonamide (PFOSA)	ND	*	<0.10**	*	<0.10**	*	<0.10**
2-(N-Methyl-perfluorooctane sulfonamido) acetic acid (MeFOSAA)	ND	*	1.02	*	0.60	*	0.60
Perfluoroundecanoic acid (PFUA)	<b>0.95</b>	*	0.28	*	0.20	*	<b>0.50</b>

Your number was in ***italicized bold*** if it exceeded the 95<sup>th</sup> percentile



This is the NHANES average

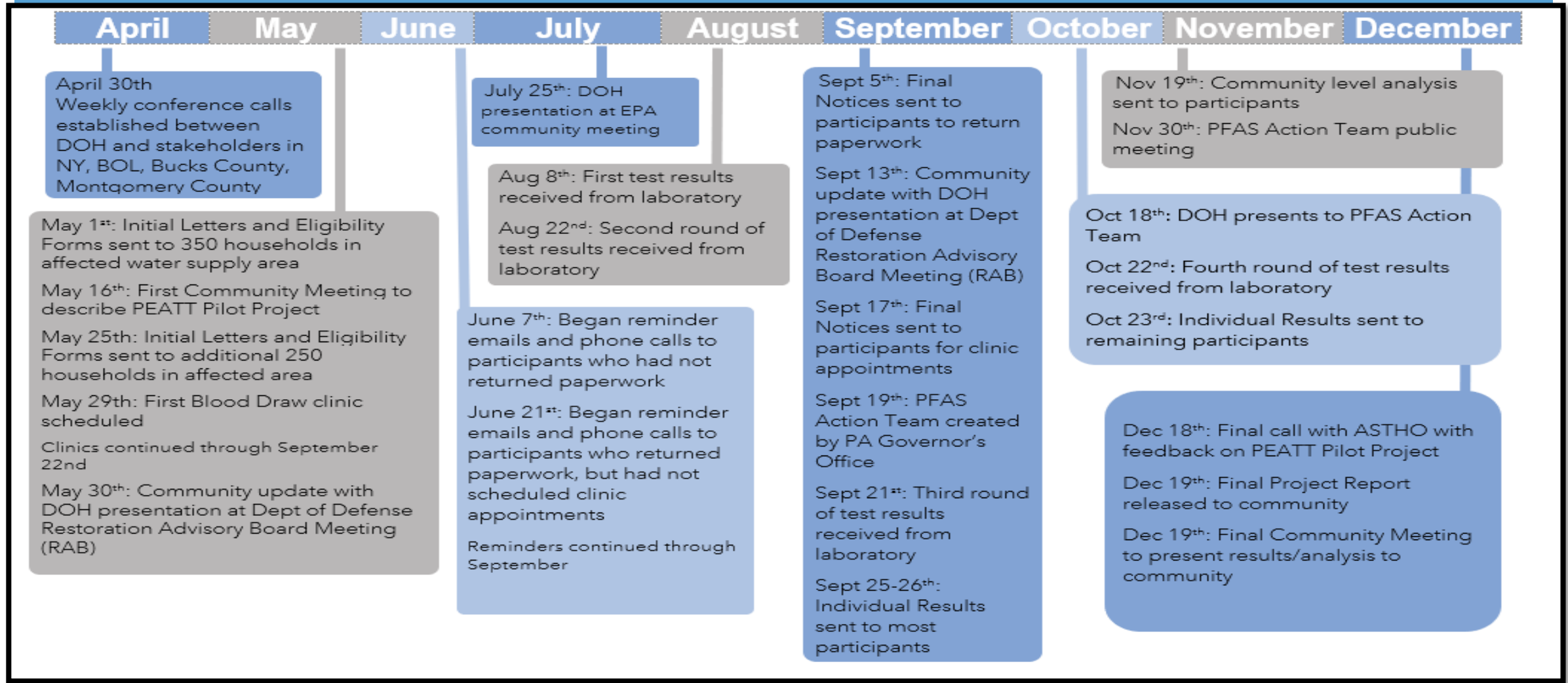


95% of population is below this number

ND or \* means "non detect"- levels are so tiny they cannot be detected

**Above results from NHANES 2013-2014, except PFOSA which is from 2011-2012.**

# PEATT Pilot Project Timeline



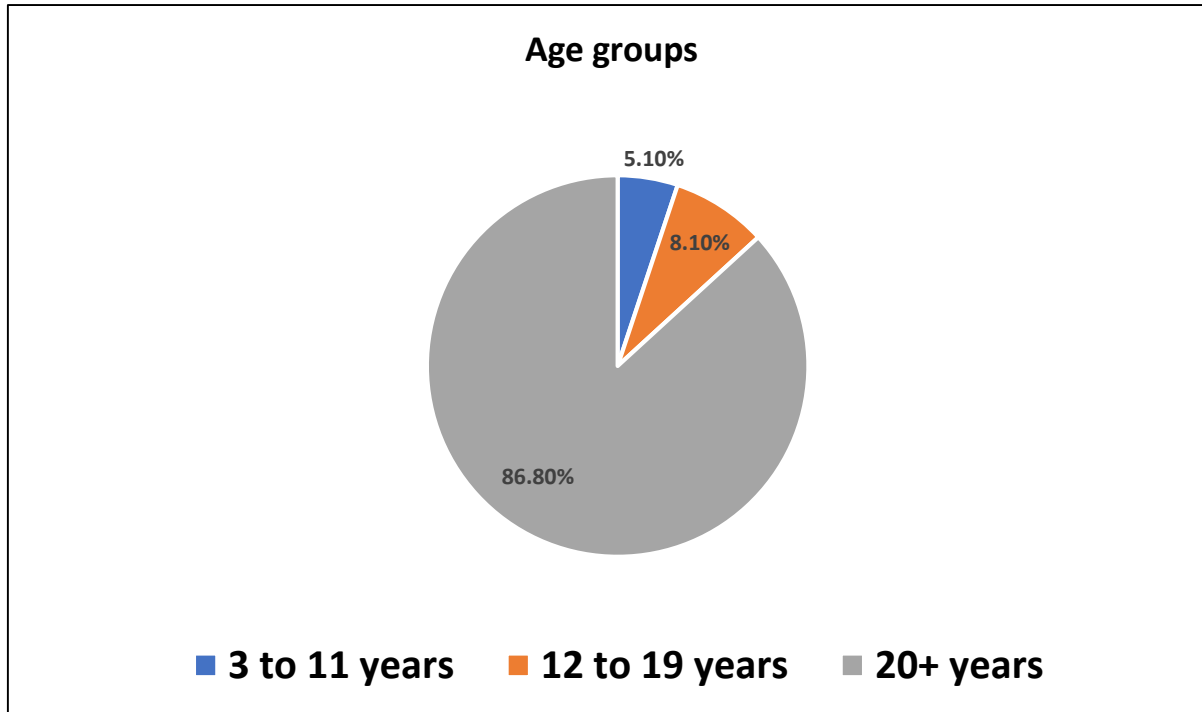
# PEATT Project Demographics - Comparison

	Study Participants (%)	Community (%)	U.S. (%)
<b>Age</b>			
Under 12 years	5.1	14.9	15.8
12 to 19 years	8.1	10.9	11.2
20+ years	86.8	74.2	73.0
<b>Sex</b>			
Male	44.3	48.8	49.2
Female	55.7	51.2	50.8
<b>Race/Ethnicity</b>			
Hispanic or Latino	0	5.1	16.3
White	94.5	85.6	63.7
Black	0	3.0	12.2
Asian	0.4	4.8	4.7
Other	5.1	1.5	3.0
<b>Education Level (18+ years old)</b>			
Lower than College	20.6	34.7	40.5
Some College or more	74.2	65.3	59.5
Other	5.3	0.0	0.0

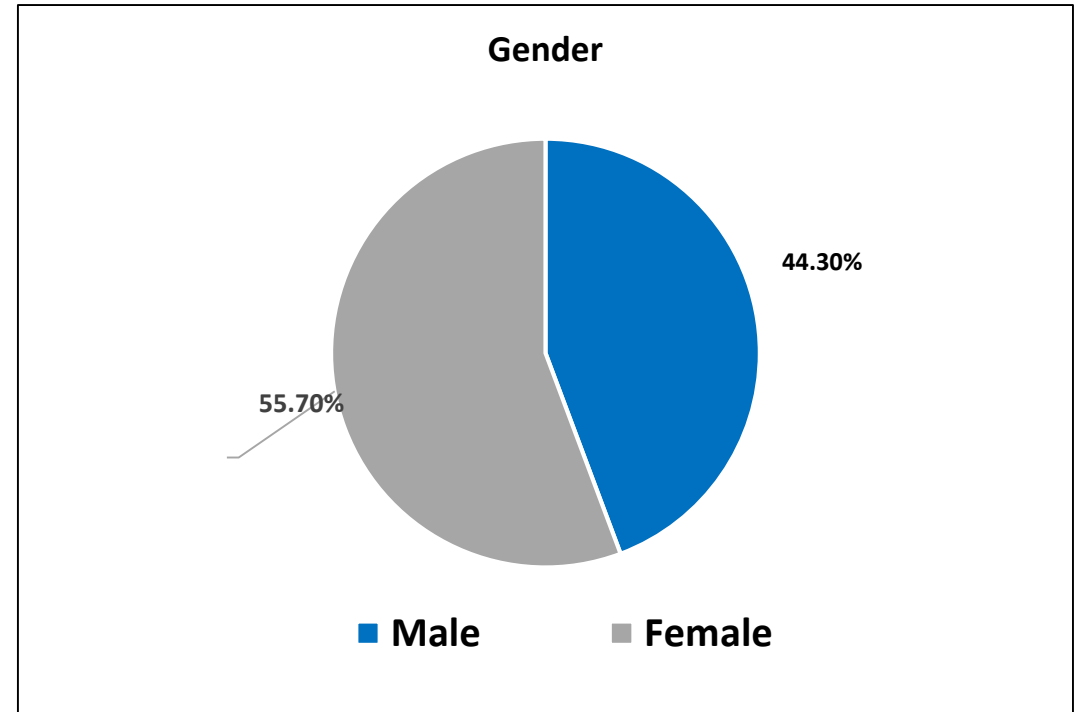
Study group determined by water service area, community determined by Warrington, Warminster, Horsham Twps., and Ivyland Borough

# Study Demographics

Mostly adults 20+ years old



More females than males

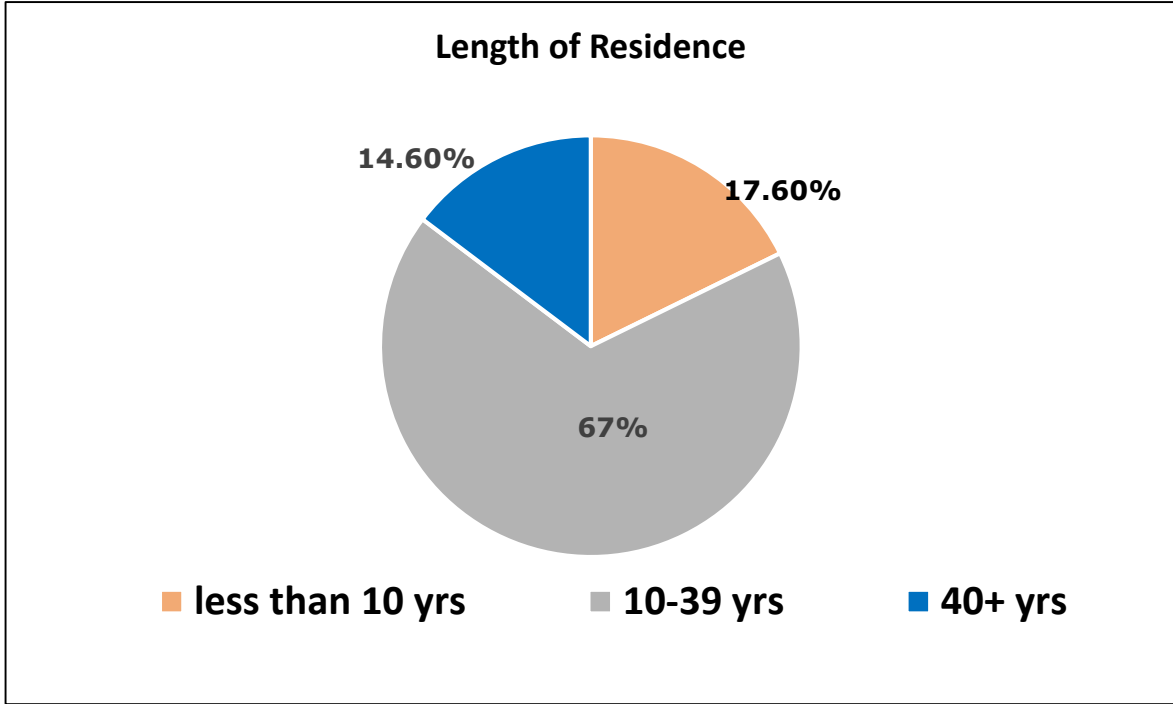


- Average age – 49 years
- 66 percent had college education or higher
- 12 percent were ever employed on a military base

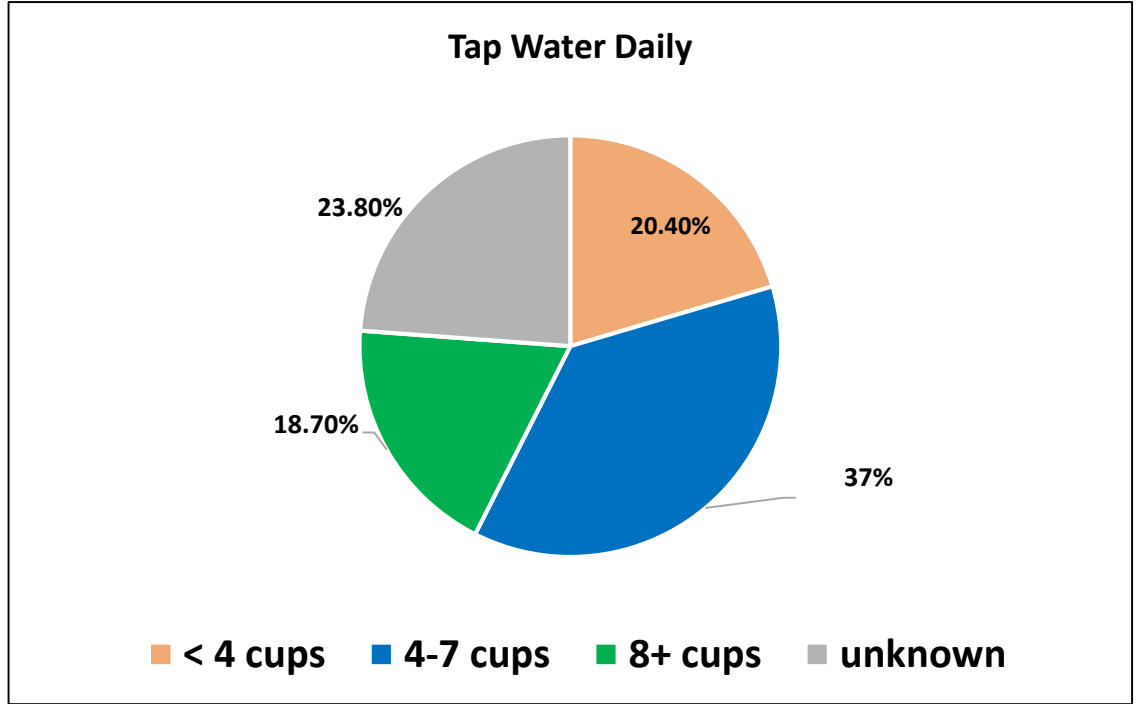


# Study Demographics

Most are long-term residents (>10 years)



Estimated Tap Water Consumed Daily



- 82 percent used public water

# 11 PFAS tested for

Perfluorobutanesulfonic acid (PFBS)

Perfluoroheptanoic acid (PFHpA)

Perfluorohexanesulfonic acid (PFHxS)

Perfluorononanoic acid (PFNA)

Perfluorooctanoic acid (PFOA)

Perfluorooctanesulfonic acid (PFOS)

Perfluorodecanoic acid (PFDeA)

Perfluoroundecanoic acid (PFUA)

Perfluorododecanoic acid (PFDoA)

Perfluorooctane sulfonamide (PFOSA)

2-(N-Methyl-perfluorooctane sulfonamido) acetic acid (MeFOSAA)

# ▶ PFAS Detected

- Tested for 11 PFAS compounds
  - ▣ Four compounds were commonly detected
    - ▣ PFOS in 235 participants (100%)
    - ▣ PFHxS in 233 participants (99.1%)
    - ▣ PFOA in 232 participants (98.7%)
    - ▣ PFNA in 185 participants (78.7%)
  - ▣ All four detected in 79 percent of participants

# ▶ PFAS Detected

- Of the remaining seven compounds-
  - ▣ PFDeA was found in 14 participants
  - ▣ MeFOSAA was found in nine participants
  - ▣ PFUA in eight participants
  - ▣ PFHpA in one participant

# ▶ Serum PFAS Levels (ug/L)

Four most commonly found PFAS:

PFAS Compound	Community Results (n=235)				NHANES Results (2013-2014)	
	Average	95% Confidence Interval	Median	Range	Average	95% Confidence Interval
PFOA	<b>3.13</b>	2.81-3.50	3.06	0.55-24.8	<b>1.94</b>	1.76-2.14
PFOS	<b>10.24</b>	8.86-11.83	9.86	1.02-105.00	<b>4.99</b>	4.50-5.52
PFHxS	<b>6.64</b>	5.51-7.99	6.61	0.54-116.00	<b>1.35</b>	1.20-1.52
PFNA	<b>0.74</b>	0.67-0.80	0.76	0.50-2.56	<b>0.68</b>	0.61-0.74

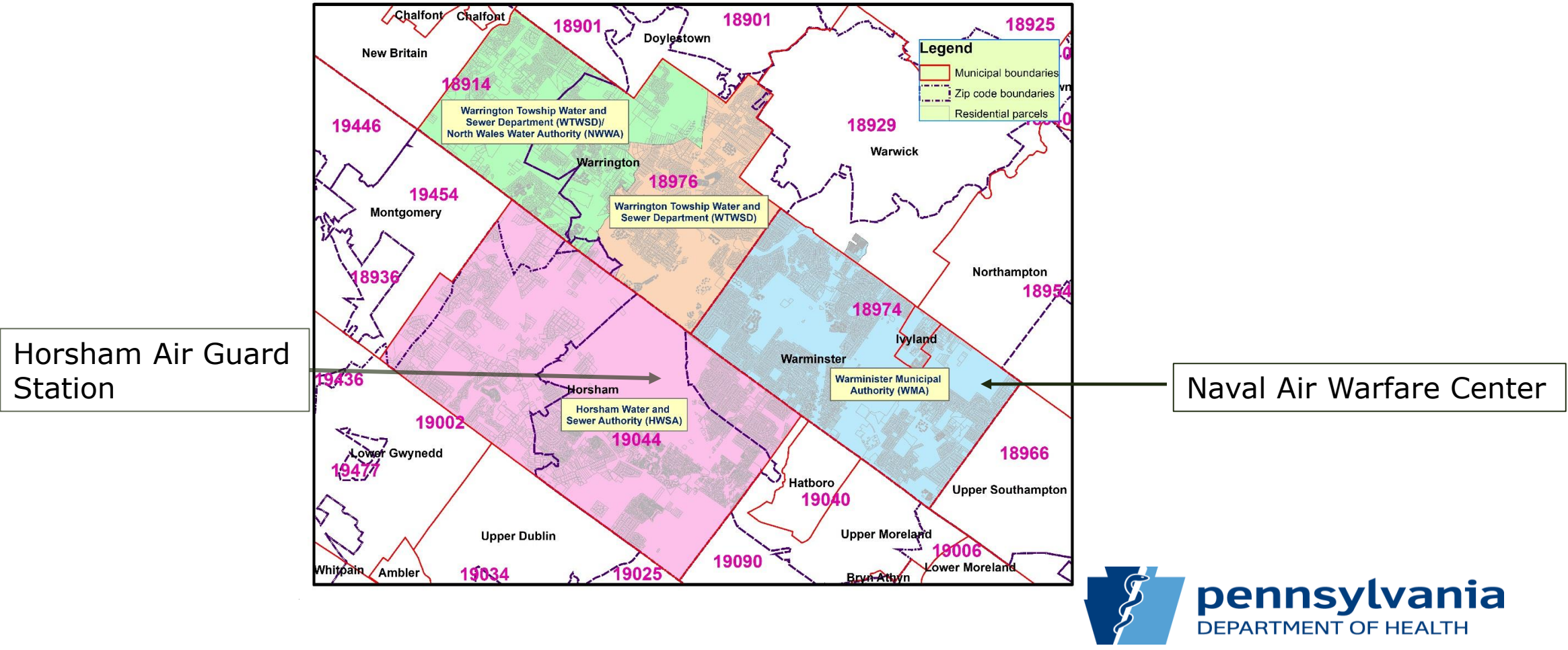
Range excludes <LOD

# ▶ Serum PFAS Levels – Univariate Analyses

- ▣ Age
- ▣ Male gender
- ▣ Residence time
- ▣ BMI
- ▣ Private well use
- ▣ Quantity of tap water consumed
- ▣ Water service area's proximity to military base

# ▶ PFAS Exposure in Southeastern PA

- Affected area = population of 84,184 (2010 census)



# Serum PFAS Levels (ug/L) by Public Water System (PWS) Area- Current Address

PFAS Compound	HWSA (n=69)		WMA (n=98)		WTWSD (n=41)		WTWSD/NWWA (n=27)	
	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.
PFOA	<b>3.69</b>	2.99-4.56	<b>3.17</b>	2.71-3.71	<b>3.35</b>	2.62-4.29	<b>1.78</b>	1.44-2.20
PFOS	<b>12.38</b>	9.47-16.19	<b>10.06</b>	8.06-12.57	<b>11.47</b>	8.69-15.15	<b>5.65</b>	4.17-7.67
PFHxS	<b>8.81</b>	6.28-12.37	<b>6.98</b>	5.32-9.16	<b>6.56</b>	4.61-9.33	<b>2.72</b>	1.72-4.30
PFNA	<b>0.79</b>	0.68-0.92	<b>0.72</b>	0.62-0.84	<b>0.78</b>	0.66-0.94	<b>0.59</b>	0.51-0.67

Significant difference in levels of all four PFAS ( $P \leq 0.05$  for all) among PWS areas

WTWSD/NWWA had lower serum PFAS levels

Includes all drinking water sources



# Serum PFAS Levels (ug/L ) - Private Well Users – Current Address

PFAS Compound	HWSA (n=1)		WMA (n=10)		WTWSD (n=3)		WTWSD/NWWA (n=6)	
	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.
PFOA	<b>7.78</b>	7.78-7.78	<b>3.23</b>	2.30-4.55	<b>4.87</b>	2.43-9.79	<b>2.33</b>	1.27-4.28
PFOS	<b>23.60</b>	23.60-23.60	<b>12.59</b>	8.36-18.97	<b>15.94</b>	7.19-35.33	<b>7.55</b>	5.86-9.74
PFHxS	<b>25.90</b>	25.90-25.90	<b>8.05</b>	4.48-14.47	<b>11.75</b>	8.99-15.35	<b>2.29</b>	0.99-5.28
PFNA	<b>1.44</b>	1.44-1.44	<b>0.76</b>	0.58-0.99	<b>0.96</b>	0.68-1.35	<b>0.69</b>	0.37-1.31

WTWSD/NWWA had lower serum PFAS levels

# Serum PFAS Levels (ug/L ) - Public Water Users - Current Address

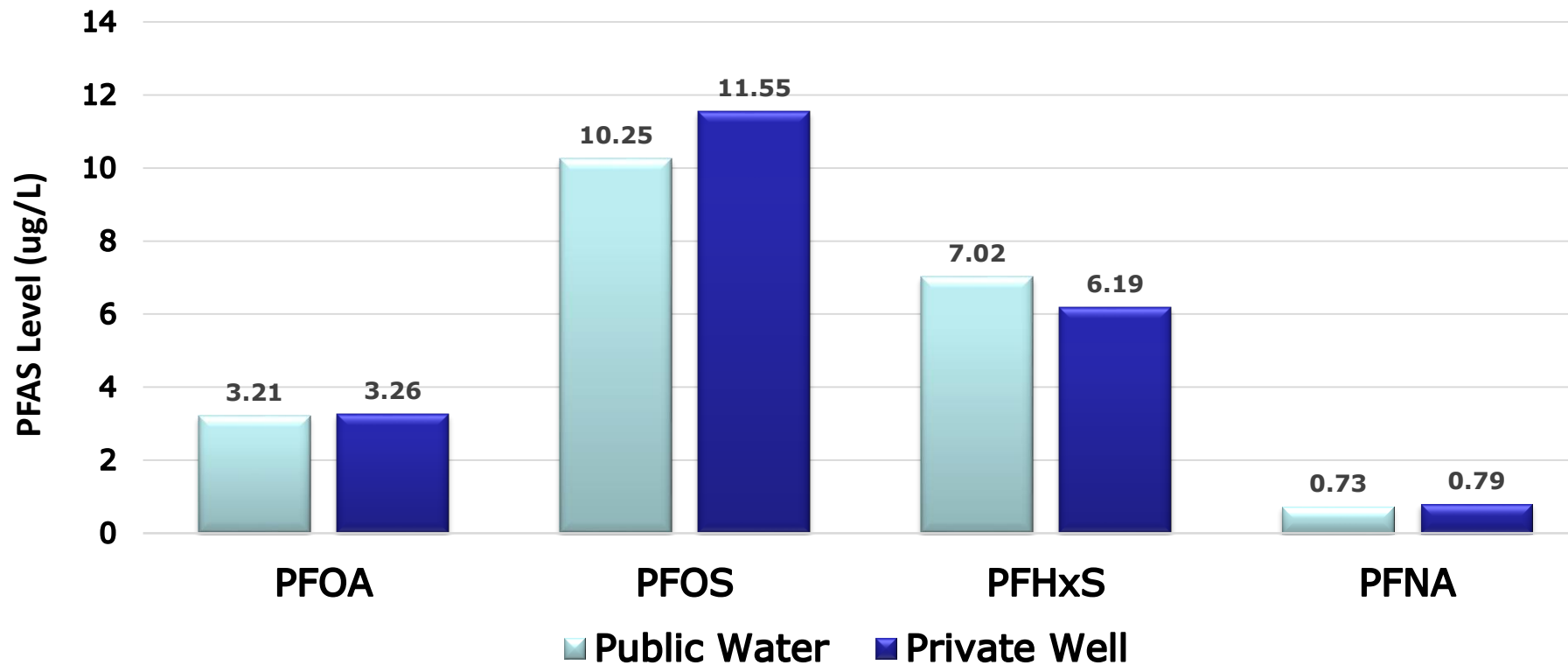
PFAS Compound	HWSA (n=61)		WMA (n=83)		WTWSD (n=31)		WTWSD/NWWA (n=18)	
	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.	Average	95% C.I.
PFOA	<b>3.65</b>	2.89-4.60	<b>3.24</b>	2.73-3.84	<b>3.63</b>	2.76-4.78	<b>1.63</b>	1.25-2.11
PFOS	<b>12.17</b>	9.03-16.39	<b>10.06</b>	7.89-12.83	<b>12.39</b>	9.08-16.91	<b>4.53</b>	3.51-5.85
PFHxS	<b>8.90</b>	6.11-12.96	<b>7.19</b>	5.31-9.73	<b>7.69</b>	5.41-10.92	<b>2.42</b>	1.55-3.79
PFNA	<b>0.76</b>	0.65-0.89	<b>0.72</b>	0.60-0.85	<b>0.81</b>	0.66-0.99	<b>0.56</b>	0.51-0.61

Significant difference ( $P \leq 0.05$ ) in levels of all four PFAS compounds

WTWSD/NWWA had lower serum PFAS levels

# ▶ Serum PFAS Levels (ug/L) by Water Source - Public vs. Private Well

Overall, private well users had slightly higher levels of PFOA, PFOS, and PFNA than public water users, but not PFHxS



Public well (n=193), Private well (n=20)

Differences in levels not statistically significant ( $P > 0.05$  for all)

# Serum PFAS Levels and Self-Reported Health Conditions

- Elevated cholesterol was the most frequently reported health condition
- Those reporting elevated cholesterol also had higher PFAS levels (all four compounds)
- Those reporting endocrine disruption had higher levels of PFOA and PFHxS
- Those with cancer had higher levels of PFOA and PFNA

# Multivariate Analysis (n=204)

- Demographic characteristics:
  - Age
  - Gender
  - Education
- Exposure characteristics:
  - Water source at current address
    - HSWA, WMA, WTWSD, WTWSD/NWWA, private well, other
  - Quantity of water consumed at current address
  - Total length of residence in the study area
  - Employment information - ever employed on a base in the area
- Health information:
  - Health status
  - BMI

# ▶ Multivariate Analysis

- Serum PFAS (PFOA, PFOS, PFHxS and PFNA) levels were positively associated with total length of residence in the study area.
- Those who lived in the area for 10 years or more had higher PFAS serum levels compared to those who lived in the area less than 10 yrs.).

Total Length of Residence	PFOA percent higher	PFOS percent higher	PFHxS percent higher	PFNA percent higher
10-19 yrs	22.5%	<b>89.1%</b>	49.8%	17.3%
20-29 yrs	27.7%	<b>66.0%</b>	<b>67.6%</b>	5.8%
30-39 yrs	38.9%	<b>77.9%</b>	65.4%	<b>46.1%</b>
40+ yrs	<b>55.4%</b>	<b>124.3%</b>	<b>171.8%</b>	17.0%

Bold = statistically significant ( $p \leq 0.05$ )

# Multivariate Analysis

- In general, PFAS levels were higher the closer the water source was to the military base.
- Water sources were compared to the source farthest from the military bases (WTWSD/NWWA reference group):

Drinking water source	PFOA percent higher	PFOS percent higher	PFHxS percent higher	PFNA percent higher
HWSA	<b>157.4%</b>	<b>168.5%</b>	<b>257.2%</b>	<b>33.6%</b>
WMA	<b>104.5%</b>	<b>88.5%</b>	<b>137.4%</b>	15.3%
WTWSD	<b>94%</b>	<b>98.7%</b>	<b>113.9%</b>	10.4%
Other (bottled water, unknown)	<b>78.1%</b>	<b>97.84%</b>	77.2%	<b>29.6%</b>
Private Well	<b>105.9%</b>	<b>101.24%</b>	97.9	<b>38.6%</b>

Bold= statistically significant (p ≤ 0.05)  
 WTWSD/NWWA reference group

# Multivariate Analysis

- Average PFHxS serum levels 32% higher in men
- Average PFHxS serum levels 35% higher in employed than never employed in study area (self-reported)
- Average PFOA serum level of participants consuming 4 to 7 cups of tap water daily was 29% higher than participants consuming 0 to 3 cups daily
- Average serum levels of PFOA, PFOS and PFNA increased with participant age



# Summary

- 4 PFAS compounds were consistently detected (PFOA, PFOS, PFHxS and PFNA)
- 75%, 81%, 94% and 59% of the study participants had levels exceeding the national average for PFOA, PFOS, PFHxS and PFNA respectively
- Serum levels associated with:
  - ▣ Receiving water from select public water systems
  - ▣ Total length of residence in the study area
  - ▣ Age of the study participants
  - ▣ Employment in the study area
  - ▣ Quantity of daily tap water consumption

# ▶ PA-Specific Changes to PEATT

- Sample Selection
  - Used eligibility information form because of exposure cut-off date
  - Modified Consent/Assent form
- Questionnaires
  - Questionnaires had to be reworded to reflect past exposure
  - Questions had to be added considering multiple residences
  - Excluded questions on other sources of exposure (soil, fish, food)
- Created detailed instructions for collection, handling, storage, and shipment of samples
- Modified results letter: Initial and final letters

# ▶ Recommendations

- Selection Process
  - ▣ Option to include volunteer participants and special categories of exposure (i.e. veterans)
  - ▣ Create initial eligibility form to determine number of participants in a household. This facilitates sending the correct number of forms to a household, along with return postage-paid envelopes
- Questionnaires
  - ▣ Need to accommodate for long duration of exposure
  - ▣ Fewer open-ended questions and more structured, multiple choice questions for health conditions

# Recommendations

- Participant Drop-out
  - ▣ Paper questionnaire visually overwhelming- consider online survey options with built-in “skips” to lessen the perceived burden
  - ▣ Streamline the participation process- possible online scheduling for clinics
  - ▣ Consider visiting nurses/teams to collect information
  - ▣ Possible tokens of appreciation
- Results Process
  - ▣ Letter templates complete for information and numbers, but limited in psychological comfort for those with high levels

# Communicating the Risks of PFAS

- Cancer Data Review (1985–2013) with Addendums 1 and 2
  - A review of cancer incidence rates in Horsham, Warminster and Warrington
- Fact sheets
  - PFAS FAQs
- Presented at 5 PFAS community meetings including the Willow Grove Air Station Restoration Advisory Board meetings
- Participated in Medical Grand Rounds in hospitals
- Always available to answer citizen emails and phone calls

# Communicating the Risks of PFAS

- PEATT Pilot Project gave some residents the chance to find out about their own individual exposures.
- PEATT Pilot Project recruitment letter sent to 600 households
  - ▀ Included information on the limitations of interpreting the results of PFAS biomonitoring
- Results letters included information to share with physicians
- Responded to several media inquiries

# ▶ PFAS Responses - Pennsylvania

## PFAS Action Team

Governor's Executive Order in September 2018

Members:

- Secretaries of
  - Department of Environmental Protection
  - Department of Health
  - Department of Military and Veteran Affairs
  - Department of Community and Economic Development
  - Department of Transportation
  - Department of Agriculture AND
  - State Fire Commissioner

# ▶ PFAS Action Team - Functions

- Ensure drinking water is safe
- Identify impacted locations and develop response protocols for identified sites
- Engage stakeholders to develop site-specific plans
- Reduce risk to drinking water from potential sources
- Establish a site to inform and educate the public about PFAS
- Explore funding avenues for remediation efforts
- Engage with academic institutions, public health and environmental remediation experts



# ▶ PFAS Responses - Pennsylvania

- Regular participation in DoD's Restoration Advisory Board Community meetings
- Participation in Environmental Exposure Assessment Efforts in Other DoD Sites
- Participation in PEATT Expansion Project
- Multi-site National Health Study

# Our Partners

- Centers for Disease Control and Prevention (CDC)
- Association of State and Territorial Health Officials (ASTHO)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- Bucks County Health Department
- Montgomery County Health Department
- New York State Health Department Laboratory

# PEATT Pilot Project Team

- Dr. Sharon Watkins
- Dr. Anil Nair
- Dr. Marshal Ma
- Susan Schrack Wood
- Dr. Farhad Ahmed

# Contact Information

Should you have any questions, feel free to contact us at [env.health.concern@pa.gov](mailto:env.health.concern@pa.gov) or by phone at 717-787-3350

For more information:

<https://www.health.pa.gov/topics/envirohealth/Pages/PFAS.aspx>

THANK YOU!

Questions?