

Incorporating PFAS Research into K-12 education and outreach

- Introductions
- An unfolding environmental health issue
 - Challenges & Opportunities: **Think Pair Share**
- Description of three different programs (working at different scales)
- Approaches for incorporating data in educational activities
- Engagement strategies for diverse learners and trainees
- Strategies for showcasing solutions
- Q&A

Incorporating PFAS Research into K-12 education and outreach

Think-Pair-Share: Opportunities

Introduce yourself to a neighbor and then...

- **Discuss** the relevance of PFAS to students in your community
- **Discuss** what you think students should know about PFAS
- **Describe the opportunities** associated with incorporating PFAS content (research, policy, a solutions) into science learning environments (formal and informal)
- **Consider the benefits** of youth learning about this topic

Incorporating PFAS Research into Science Learning Environments

Think-Pair-Share: Challenges

- **Describe the challenges** associated with incorporating PFAS into science learning environments (formal and informal)
- **Consider solutions** to overcome the challenges you've identified
- **Discuss** how you have handled similar challenges in your work, if applicable

Opportunities



PFAS Contamination of
Drinking water

For students:

- Provides **relevance**
 - personal & community
- Brings **science to life**
- Highlights **current example** of interaction between environment and people
- Brings attention to current public health issue and **careers**
- Promotes **systems thinking & critical thinking**

For educators:

- Reflects **current research landscape**
- Showcases the **unfolding nature** of science
- **Reinforces curriculum**
- Promotes use of **science and engineering practices**
- Provides **interdisciplinary connections**

Challenges

PFAS Contamination of
Drinking water

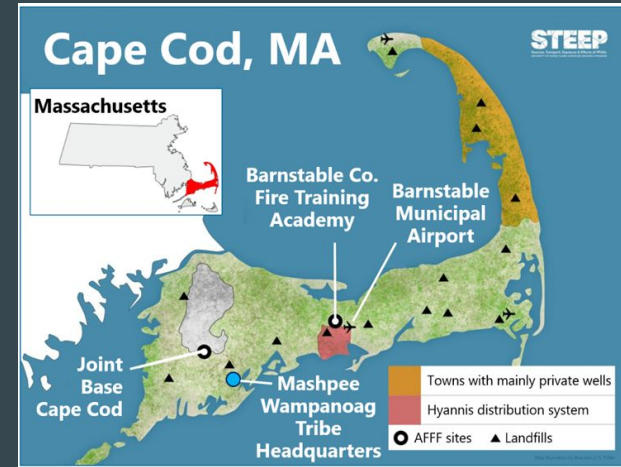


- Unfolding area of scientific research = **uncertainty**
- Addressing a **persistent** environmental problem
- Integrating into instruction
 - Curriculum constraints
 - Teacher content knowledge
 - Classroom resources
- Keeping instructional materials up to date & accurate
 - Evolving regulatory landscape
 - Emerging biomedical research findings (e.g., toxicological studies)
 - Updating curriculum standards

**How are we incorporating PFAS research
into K-12 education and outreach?**

STEEP Superfund Research Program Community Engagement Core

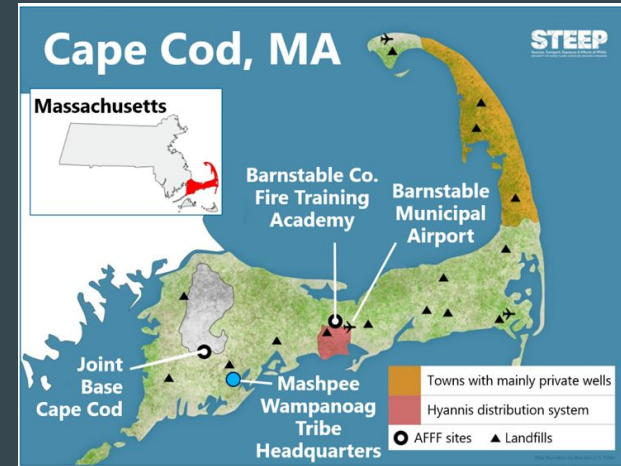
- CEC Co-Leads
 - Laurel Schaider, Silent Spring Institute
 - Emily Diamond, Univ. of Rhode Island
- Partner organizations
 - MA Breast Cancer Coalition
 - Mashpee Wampanoag Tribe
 - Sierra Club Cape Cod Group



STEEP Superfund Research Program Community Engagement Core

Planned activities on Cape Cod, MA

- Engage with local high school teachers and plan classroom learning activities
- Community education events
- Engage with Mashpee Wampanoag Tribe's summer ecology camp for youth
- Work towards water quality summit with high schools across Cape Cod



Engagement with local high school teachers

- Series of meetings with educators from high schools around Cape Cod to gather ideas and teacher preferences
- Classroom presentations with small panel of trainees** on topics including chemistry, env. sciences, and EJ
- Interest in university campus and lab tour from some (not all) teachers

**Trainees = grad students and postdocs funded by NIH grants

Informal community learning opportunities

Falmouth STEAM Fair (K-12 families)

Vote with pompoms quiz

Coloring sheets

STEEP resources





Preserving Our Homelands - Tribal youth summer camp (July 2023)

- 20 participants, grades 5 to 8
- STEEP trainees created activities
- Focus on PFAS and other chemicals in our environment
- **Hands-on activities** to understand how PFAS chemicals are detected in the environment and how they move through our bodies and ecosystems

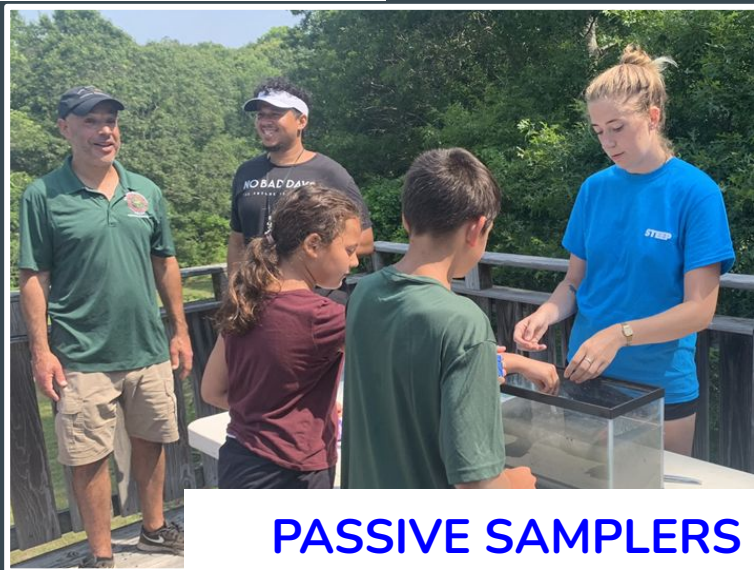




BIOACCUMULATION



DISTRIBUTION IN THE BODY



PASSIVE SAMPLERS



CHROMATOGRAPHY

HOMES WITH PRIVATE WELLS



A



B



C



D



E



F

NEW ACTIVITY FOR AP CHEMISTRY OR ENV SCIENCE CLASSES

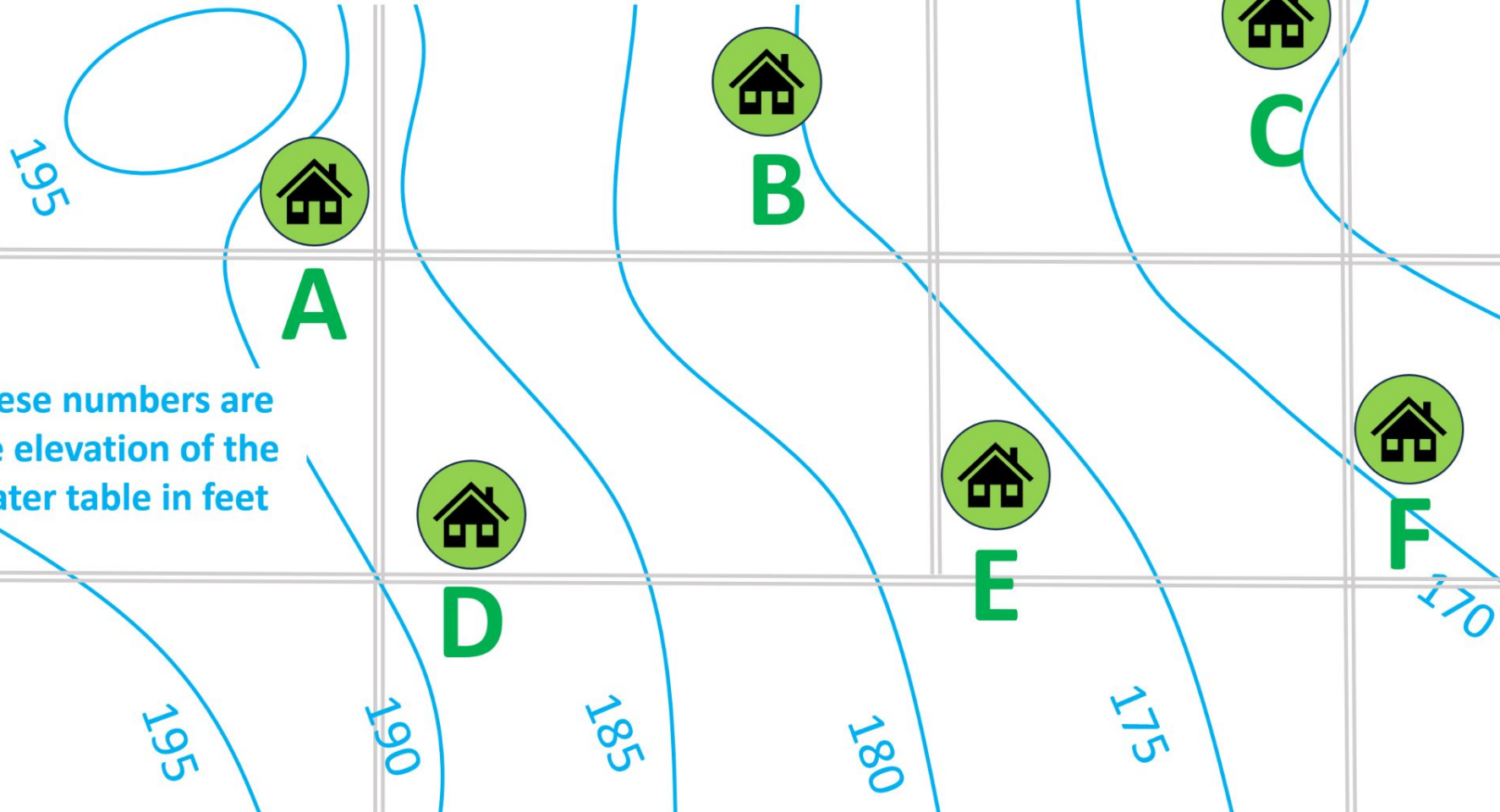
PRIVATE WELL TEST RESULTS

ppt = parts per trillion. ppm = parts per million

	A	B	C	D	E	F
PFOA (ppt)	25	8	32	0.1	18	8
PFOS (ppt)	18	6	25	1.2	208	100
PFHxS (ppt)	9	3	18	0.8	320	150
PFBA (ppt)	115	30	80	0.3	4	2
Nitrate (ppm)	0.4	0.2	13	0.1	1.3	0.7

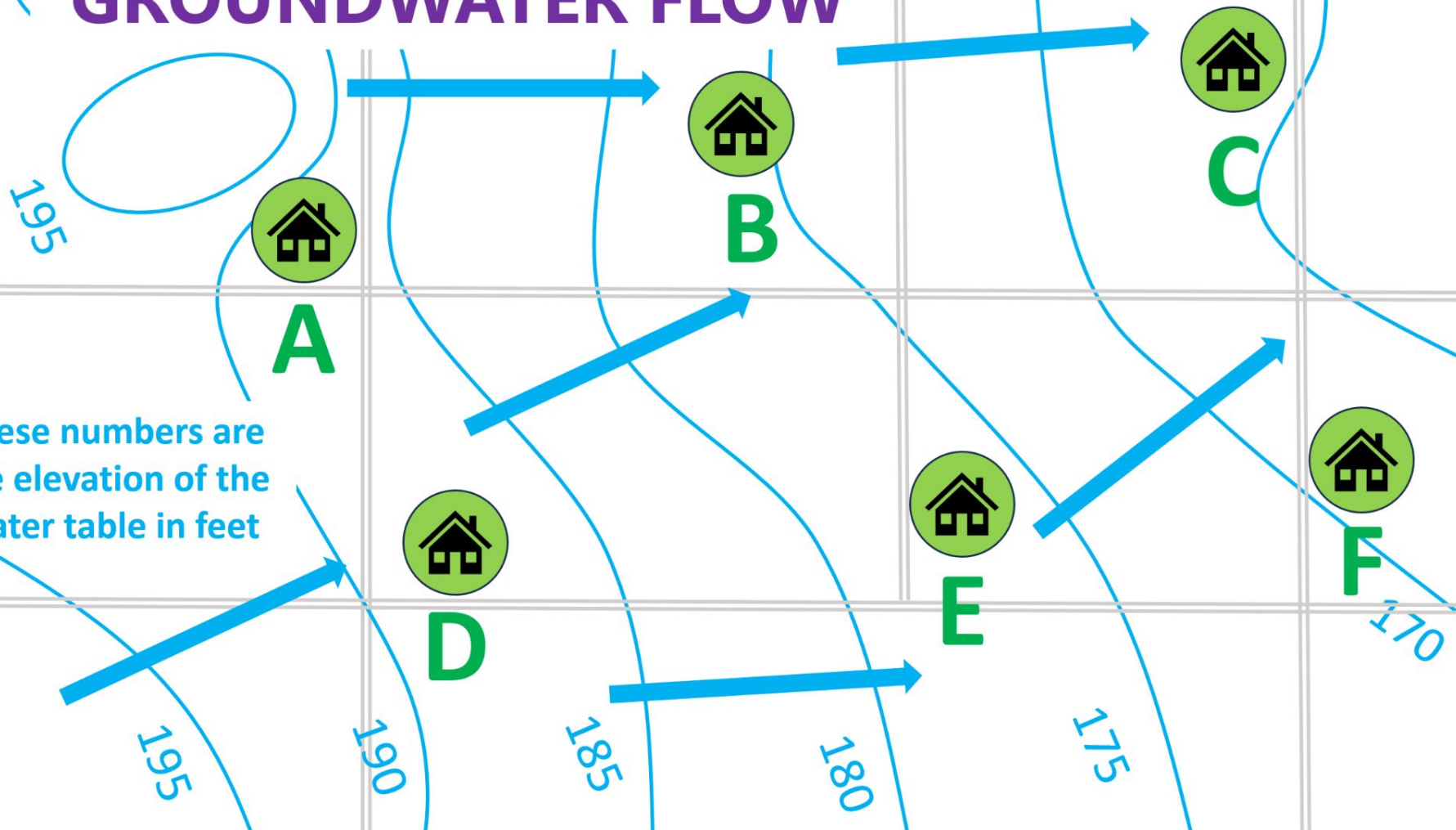
GROUNDWATER FLOW

These numbers are the elevation of the water table in feet



GROUNDWATER FLOW

These numbers are the elevation of the water table in feet



LANDFILL



195



A



B



C

SEPTIC SYSTEMS



D



E



F



FIRE STATION

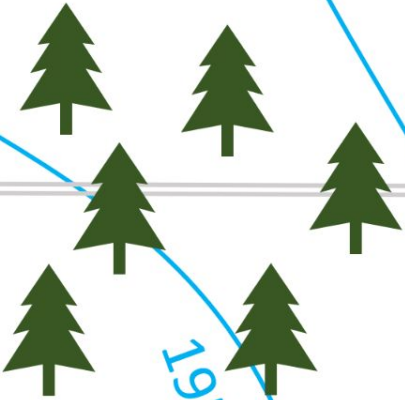
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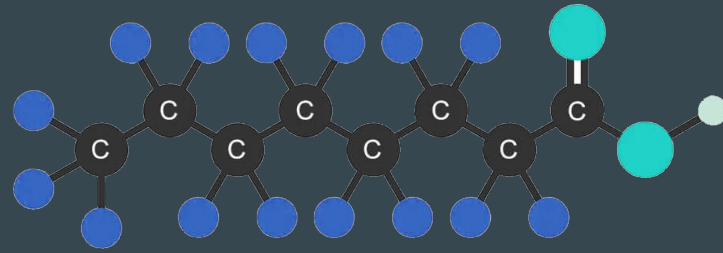
190

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175

170





Introducing North Carolina Teachers to Local PFAS Datasets

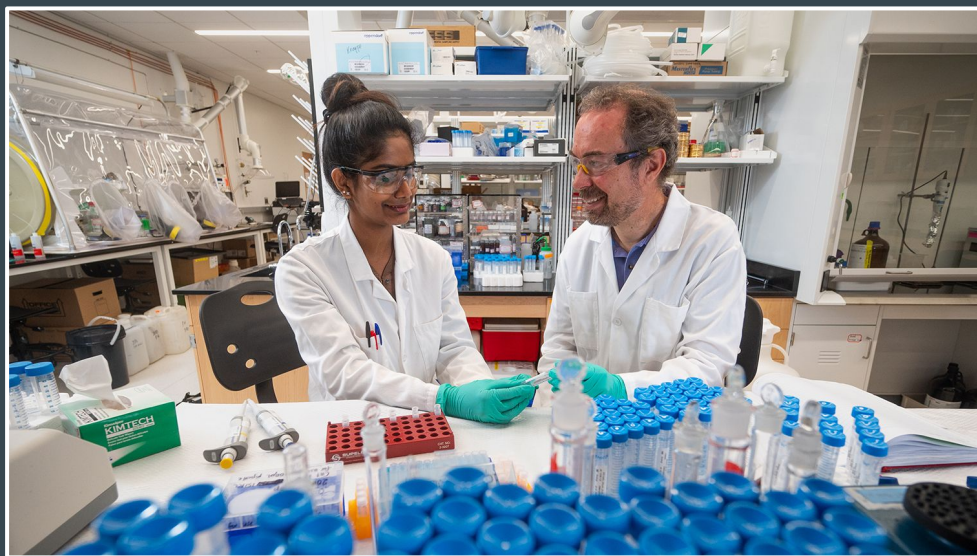


Katy May

Center for Human Health and the Environment
Center for Environmental and Health Effects of PFAS

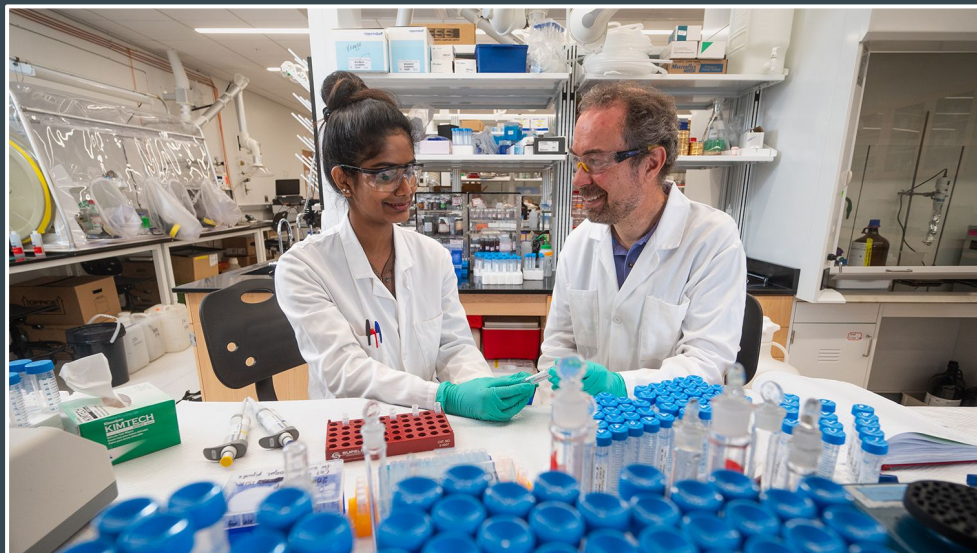
NC STATE

Introducing North Carolina Teachers to Local PFAS Datasets



NC STATE

Introducing North Carolina Teachers to Local PFAS Datasets



NC STATE



Let's Keep it Real:
Real Teaching with Real Data

Calling all 8-12 grade Science Teachers!

Join us **Saturday, March 16**, for a workshop that will guide you through best data practices and how to train your students to work with messy data.

PERKS:

\$ 250 STIPEND



Lead your district in developing lessons with data science skills

Collaborate on developing data science lessons



Engage your students with REAL NC State research data



Connect with colleagues from other districts

NC STATE Data Science Academy

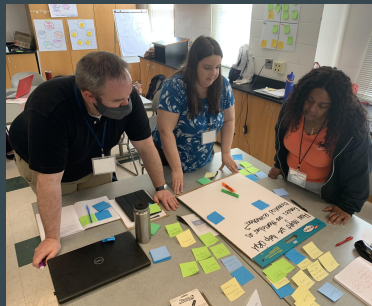
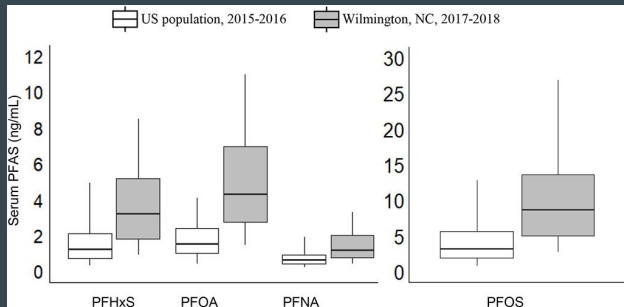
NC STATE UNIVERSITY Center for Human Health and the Environment

NC STATE UNIVERSITY THE SCIENCE HOUSE

Website: <https://go.ncsu.edu/dsak12>

Contact: Taryn Shelton, tshe1to3@ncsu.edu

Bringing PFAS data into the classroom



SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH

Dana Haine, MS, Lynn Chesnut, & Kathleen Gray, PhD

Center for Environmental Health and Susceptibility, UNC Gillings School of Global Public Health
Center for Public Engagement with Science, UNC Institute for the Environment



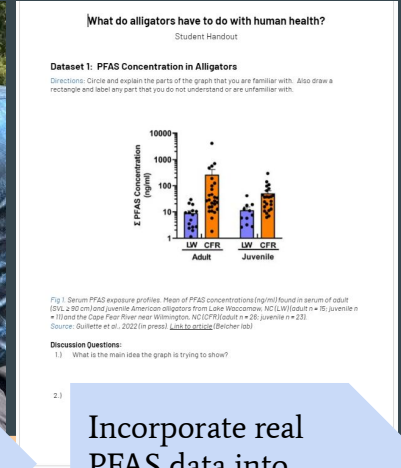
Goal: Develop PFAS-focused lessons that incorporate biomedical research data & promote careers



Meet scientists and interact with real data



Learn about research methods & science practices



Incorporate real PFAS data into lessons

Use design-thinking to co-create standards-aligned lessons (8 teachers, 2022-2024)

Use design-thinking to co-create **three lesson prototypes**



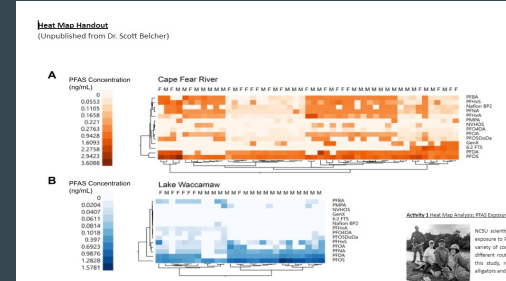
Lesson Plan 1

Alligator Analysis:

A data-driven investigation of PFAS exposure and associated health effects in NC Alligator populations.

This lesson engages students in a data-driven investigation of health outcomes associated with exposure to PFAS, which are a harmful class of widely used chemicals that can be found in everything from drinking water and food crops to cosmetics and food packaging. The standards-aligned activities in this lesson plan feature the cutting-edge research taking place to understand exposure to PFAS and to describe the biological processes behind health outcomes such as autoimmune disease and cancer. These activities use adapted published scientific data for use with diverse learners to address life science standards while conveying important environmental health concepts and promoting biomedical research careers.

Featured articles	This lesson features research from the following peer-reviewed publications:
	<ul style="list-style-type: none"> Activity 1: Gullette, T. C., Jackson, T. W., Gullette, M. P., McCord, J. P., & Belcher, S. M. (2022). Blood Concentrations of Per- and Polyfluoroalkyl Substances are 2 Associated with Autoimmunity-like Effects in the American Alligator. <i>BioRxiv</i>. https://doi.org/10.3388/oxf.2022.10.10.185 Activity 2: Multiple articles, cited in teacher slide deck.
Alignment to standards	AP Biology
	Science Practices <ul style="list-style-type: none"> SP 2 - Analyze visual representations of biological concepts and processes SP 3 - Determine scientific questions and methods SP 4 - Represent and describe data SP 6 - Develop and justify scientific arguments using evidence Learning Objectives <ul style="list-style-type: none"> SY1-1.C IST-3.A - Describe ways that cells can communicate with one another IST-1.N - Describe the mechanisms by which genetic information flows from DNA to RNA to protein IST-1.D - Describe how the phenotype of an organism is determined by its genotype IST-2.D - Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms IST-4.A - Explain how changes in genotype may result in changes in phenotype IST-1.P - Explain the use of genetic engineering techniques in analyzing or



Activity 1: Use Your Analysis: PFAS Exposure in NC Alligators

Name: _____

Instructions: You will create a visual representation of the experimental data, referred to as a heat map, using the following questions as a guide as you view the heat map provided by your teacher:

- Notice that there are two heat maps labeled A and B above. On the topographic map to the right:
 - Draw an orange star to show where samples from the alligators from heat map A were obtained.
 - Draw a blue star to show where samples from the alligators from heat map B were obtained.

Common words: perfluorinated, sulfone, 1,1,1-trichloro-2,2,2-trifluoroethane

How to Strip Scales

Just as you would strip a scale from a fish, you can strip a scale from an alligator. Scales are made of keratin, a protein that is also found in hair and nails. Scales are attached to the skin and can be used to identify the age and sex of an alligator.

Evidence

Dr. Belcher's research team found that alligators with higher PFAS concentrations in their blood had more scales that were shed. This suggests that PFAS exposure may affect the shedding of scales in alligators.

- 1 Exposure to PFAS** (Illustration: A person in a protective suit)
- 2 PFAS enters cells and interacts with DNA** (Illustration: A DNA double helix)
- 3 Changes in gene regulation alters amount of mRNA produced** (Illustration: A DNA strand with arrows pointing to mRNA)
- 4 Changes in mRNA leads to changes in type and/or amount of proteins** (Illustration: A blue protein structure)
- 5 Changes in 'protein landscape' leads to changes in cell structure and/or function** (Illustration: A cell diagram)
- 6 Changes in cell function lead to disease** (Illustration: A person with a red cross on their forehead)

WANTED PFHxS

REWARD


Incorporate:

- PFAS research data
- Science practices
- Inclusive teaching strategies
- Career connections



Goal: Develop PFAS-focused lessons that incorporate biomedical research data & promote careers




Lesson Plan 1

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<p>Alignment to standards</p>	<p style="text-align: center;"><u>AP Biology</u></p> <p>Science Practices</p> <ul style="list-style-type: none"> • SP 2 - Analyze visual representations of biological concepts and processes • SP 3 - Determine scientific questions and methods • SP 4 - Represent and describe data • SP 5 - Evaluate and justify scientific arguments using evidence <p>Learning Objectives</p> <ul style="list-style-type: none"> • ST-1.C • ST-1.A: Describe ways that cells can communicate with one another • ST-1.N: Describe the mechanisms by which genetic information flows from DNA to RNA to protein • ST-1.D: Describe how the phenotype of an organism is determined by its genotype • ST-1.D: Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms • ST-1.A: Explain how changes in genotype may result in changes in phenotype • ST-1.P: Explain the use of genetic engineering techniques in analyzing or

WANTED: PFOA

IMAGE:

KNOWN ALLEYS:

- C₈H₁₅O₂
- perfluorooctanoic acid

HOW TO STAY SAFE:

- Don't wash your & kids' dishes
- Avoid kitchen/laundry water
- Reduce use of non-stick cookware

CRIMES:

Exposure to PFAS can lead to decreased ability to fight off multiple infections as well as leading to ability to produce antibodies that fight off infections.

LEADS to antibodies that fight off infections

CRIMES:

Exposure to PFOA can lead to decrease in ability to fight off multiple infections as well as leading to ability to produce antibodies that fight off infections.

other possible effects on the body

KNOWN SIGHTINGS:

- in drinking tap water
- in water resistant products
- in firefighting foam
- in non-stick cookware
- in dental floss

IF FOUND CONTACT:

Rebecca Gray, Ph.D. Molecular Biologist, Environmental Science & Engineering Research Institute, PFAS exposure & research in advanced health

Co-create lessons

Conduct 2 cycles of piloting in classrooms

Cycle 1: 6 teachers, 2023-2024; Cycle 2: 13 teachers, 2023-2024

How are we incorporating PFAS research data into our science education initiatives?

Our approaches for engaging learners

1. Provide **data interpretation** opportunities
2. Provide **data analysis** opportunity
3. Use **science posters** to anchor discussion of research



Data interpretation lessons

Students work in teams to examine evidence and determine the cause of illness in “Fluffy”, an American Alligator who lives in NC.

See Ya Later Alligator



Science & Engineering Practices (SEPs)



1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and **interpreting data**
5. Using mathematics and computational thinking
6. **Constructing explanations**
7. Engaging in argument from evidence
8. Obtaining, **evaluating,** and **communicating information**

Evidence Cards: See Ya Later Alligator

Print and distribute as students work through each TASK.

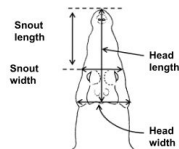


Student Investigation Cards



TASK 1: Fluffy's Measurements

Snout to Vent (SVL): 2.13 m Total Length (TL): 3.66 m
 Head Length (HL): 53.34 cm Tail Girth (TG): 71 cm
 Weight (WT): 181.43 kg
 Observations: Incidence of skin lesions, unhealed and infected wounds
 Sex: Male



TASK 2: Fluffy's Wound Culture (Biomedical Research)

Pathology Report: positive for *Corynebacterium species* bacteria

Figure 1

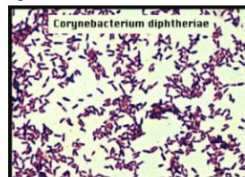


Figure 2



TASK 5: Dataset 1

Figure 7: PFAS in Alligator Serum (NC)

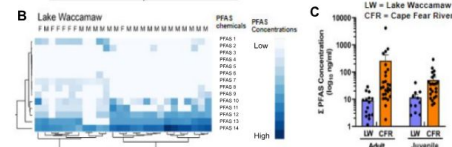
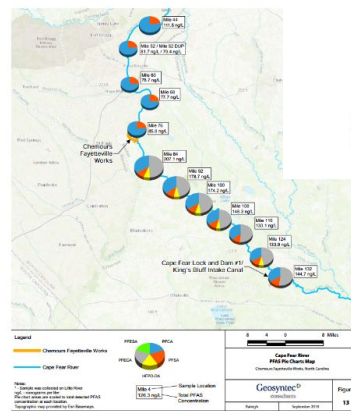


TASK 3: Cape Fear River Basin, Figure 3 (adapted)

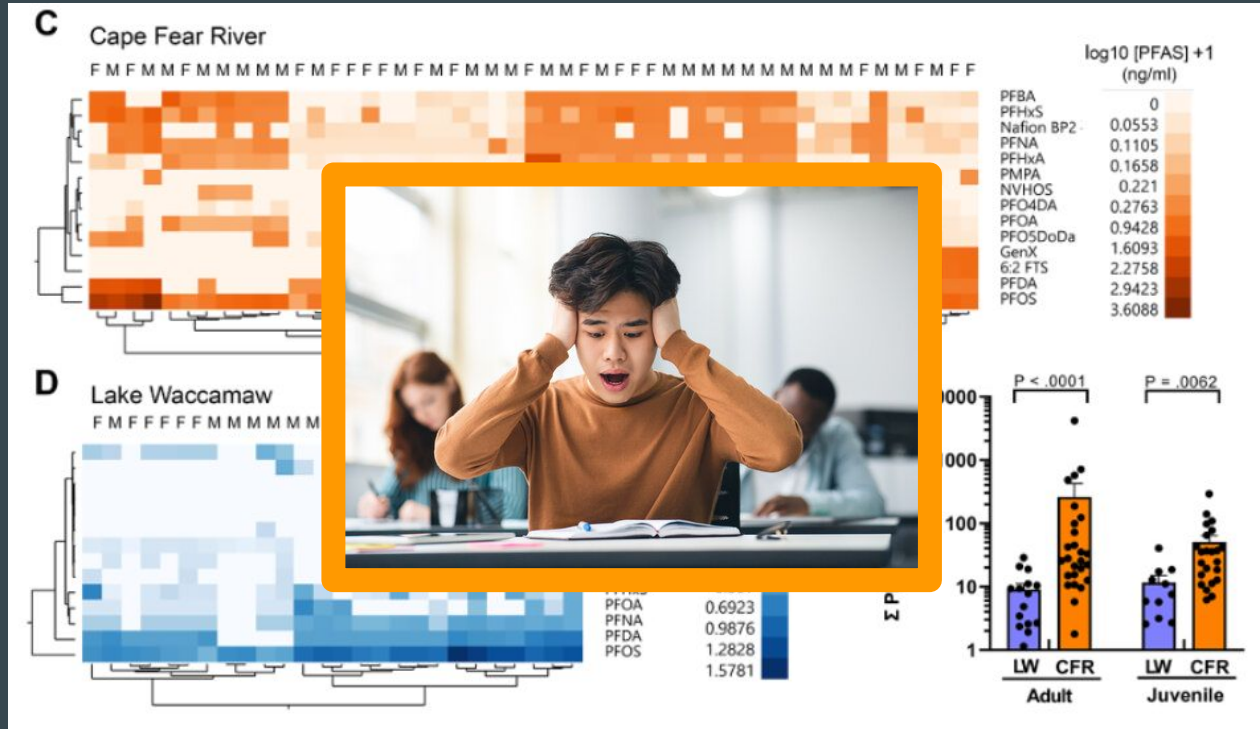


TASK 4: Inferring Map 1

Figure 4: Cape Fear River PFAS Pie Charts

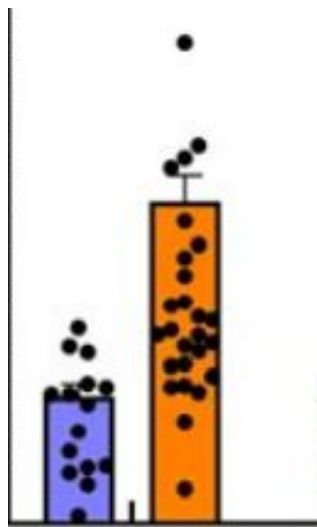


Adapting data to engage learners & promote graph literacy



PFAS in Alligator Serum

Deconstructing graphs



What do you notice?

What do you wonder?

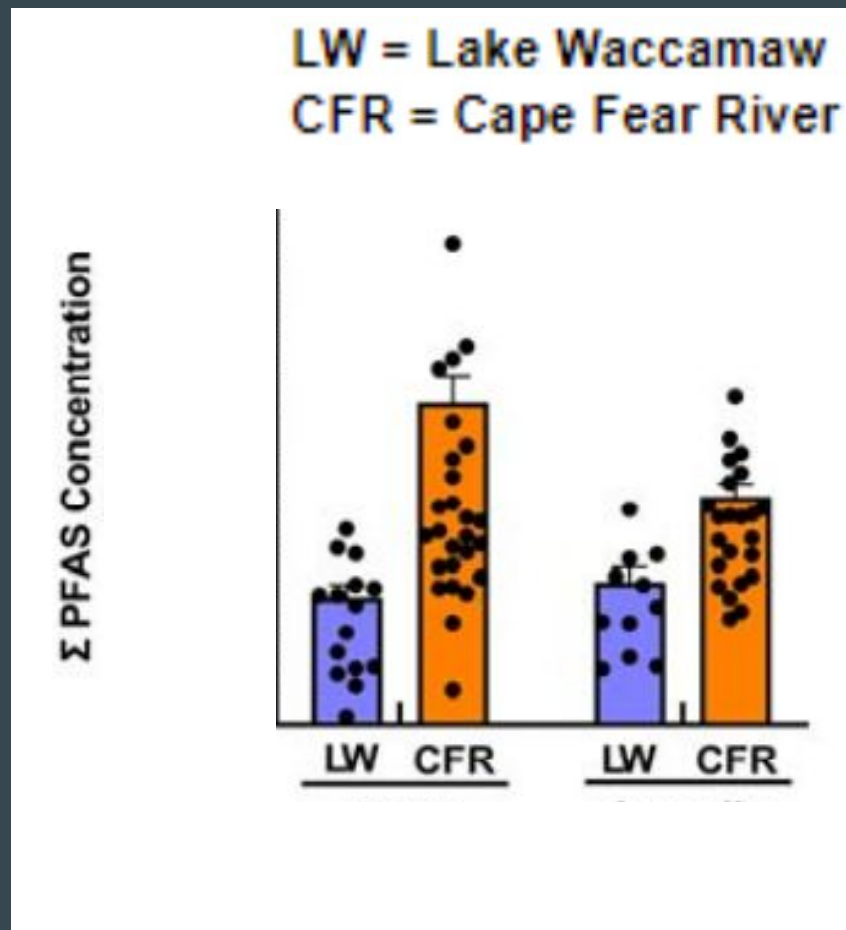
What new information did we just learn?

Are you surprised?

Also see...
slowrevealgraphs.com

PFAS in Alligator Serum

Deconstructing graphs



What do you notice?

What do you wonder?

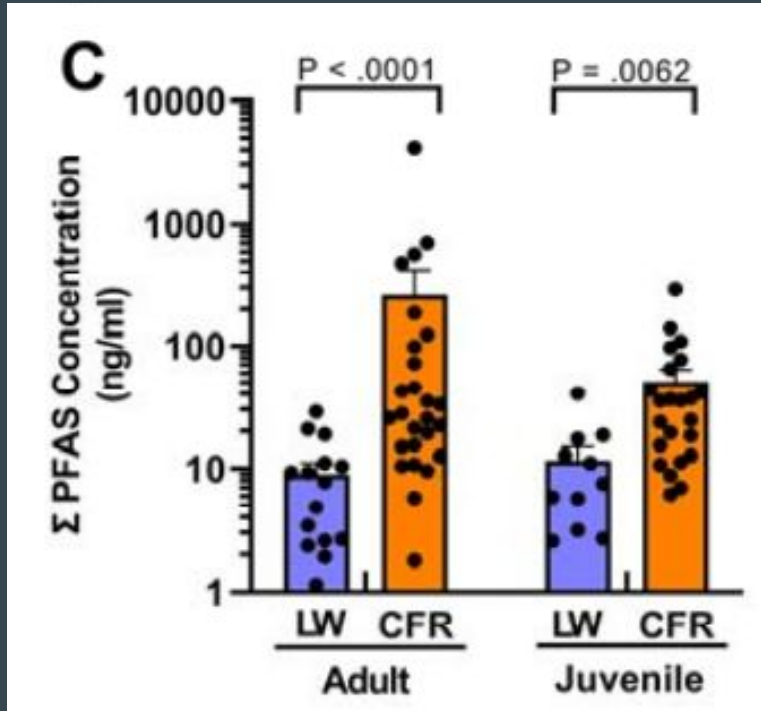
What new information did we just learn?

Are you surprised?

How does this change your understanding of this data representation?

PFAS in Alligator Serum

Promoting graph literacy



1. From what 2 locations were data collected? Why do you think these 2 locations were chosen?

2. What things do you notice about this graph?

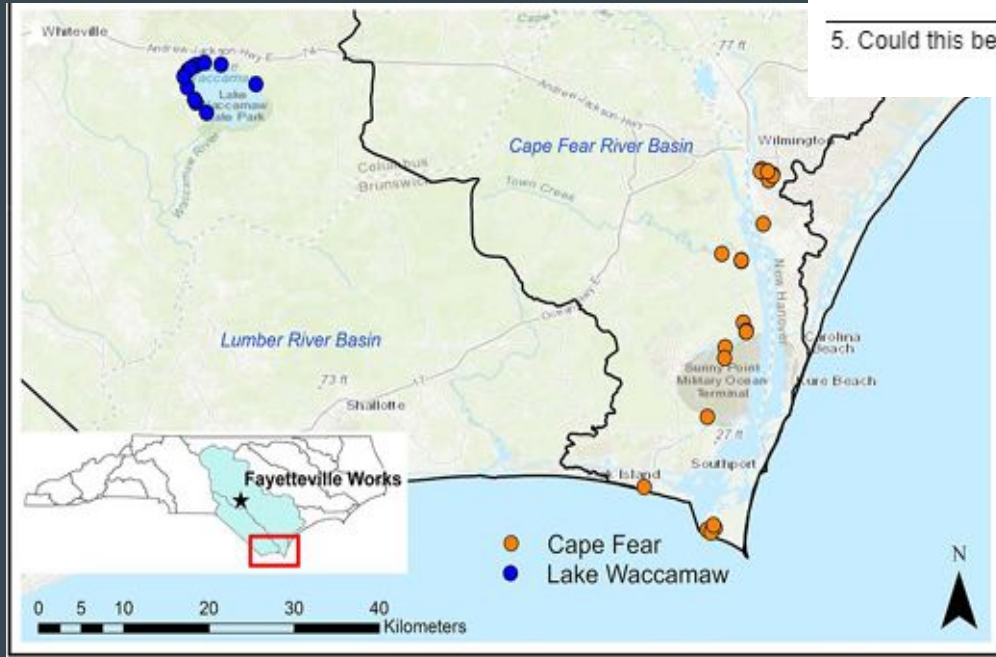
3. Identify points on each graph where you notice higher concentrations of PFAS.

4. Based on your observations, which location has the overall highest contamination of PFAS?

Fig 1. Serum PFAS exposure profiles. Mean of PFAS concentrations (ng/ml) found in serum of adult and juvenile American alligators from Lake Waccamaw (LW), NC (adult n = 15; juvenile n = 11) and the Cape Fear River (CFR) near Wilmington, NC (adult n = 26; juvenile n = 23).

Alligator Sampling Sites

Promoting map literacy



1. Draw a line indicating the location of the Cape Fear River. (Refer to another map if needed)

2. Which color circle indicates a high concentration of PFAS and which color indicates a low concentration of PFAS?

3. Based on the map, in what **specific** areas do you notice the greatest concentrations of PFAS? (You may need to refer to a different map to determine the location/city names.)

4. Could PFAS contamination be the cause of Fluffy's illness? Explain your thoughts.

5. Could this be a larger concern for public health? Explain your thoughts.

What do you notice?

What do you wonder?

Identifying a PFAS source

Promoting map and data literacy

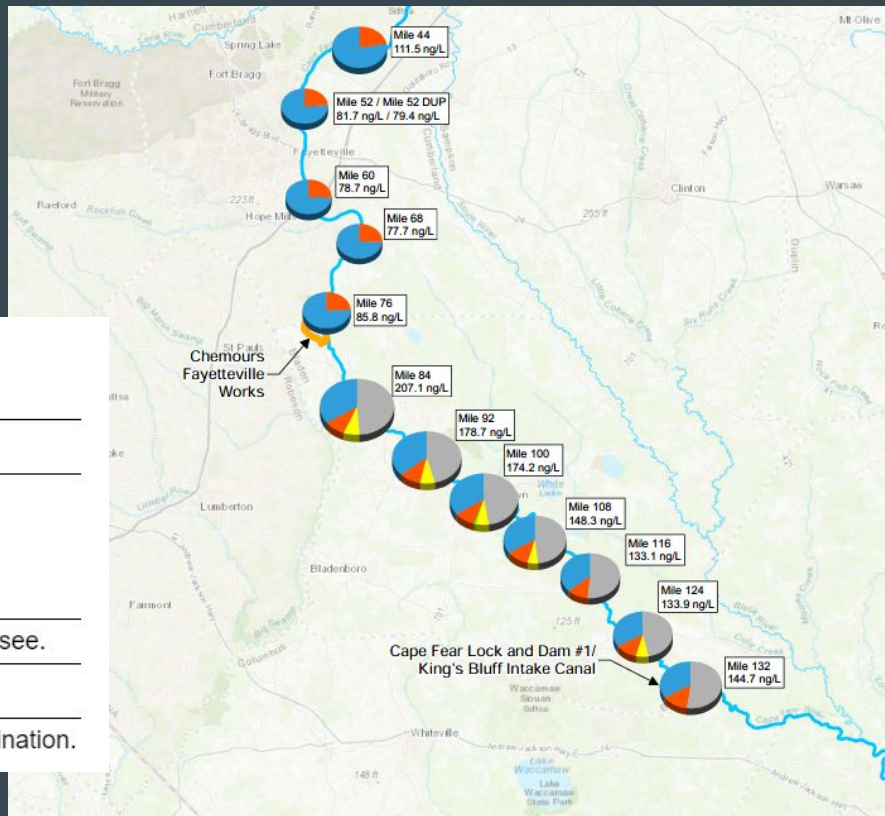
1. What things do you notice about this graph?

2. Draw an arrow in the direction the water is flowing

3. What do you notice about the change in the size of the pie charts?
What does that mean?

4. Circle points where you notice significant changes occurring. Describe what you see.

5. Based on your observations, use a star to identify a major point of PFAS contamination.



Legend

- Chemours Fayetteville Works
- Cape Fear River

Scale: 8 Miles

Cape Fear River PFAS Pie Charts Map
Chemours Fayetteville Works, North Carolina

Geosyntec
consultants

Raleigh | September 2018

Notes:
 * - Sample was collected on Little River
 ng/L - nanograms per liter
 Pie chart areas are scaled to total detected PFAS concentration at each location.
 Topographic map provided by Esri Basemaps.

Sample Location
Mile 4: 126.3 ng/L

Total PFAS Concentration

Figure **13**

Connecting alligator analysis to human health

Promoting graph literacy

Dataset 2

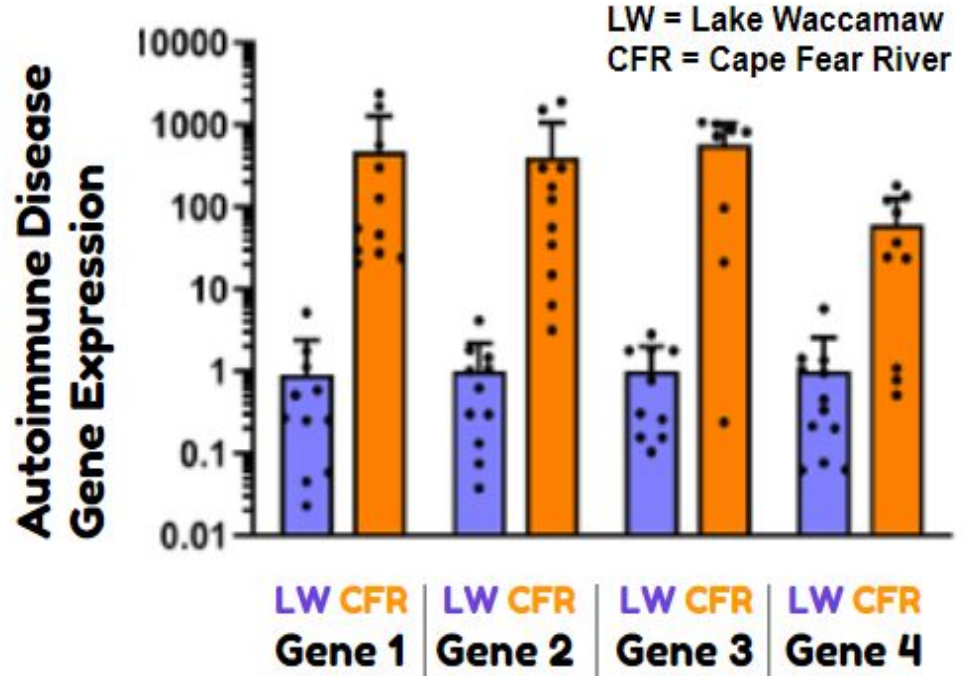
1. What things do you notice about this graph?

2. Identify the **independent** and **dependent** variables on this graph.

3. Research and define what an autoimmune disease is.

4. If overexpression of genes involved in autoimmune disease is bad for an organism's health, which population of alligators is less healthy?

5. How does this data connect to Fluffy the alligator's symptoms?



Lessons showcase PFAS researchers to promote interest in biomedical research careers

Career Trading Cards



My Skills
My skills include photography, I am good with making people smile, and I have a good understanding of technology.

The biomedical career that best matches my skills is Science Graphic Design. I say this because some of the tasks included inside of this career include graphic art, video animation, and taking pictures are things that I have a great interest in, making the job more suit my personality.



MY SKILLS

- A GOOD OBSERVER, PAYS CLOSE ATTENTION TO DETAIL
- DETERMINED, HARD WORKER
- HAVE A STRONG LOVE FOR SCIENCE
- WANTS TO MAJOR IN BIOLOGY
- PRIORITIZE SKINCARE

THE BIOMEDICAL CAREER THAT BEST MATCHES MY SKILL SET IS A COSMETIC TOXICOLOGIST. I ALWAYS CHECK FOR CERTAIN CHEMICALS / INGREDIENTS IN ANYTHING I PUT ON MY BODY, SO TO GO INTO A CAREER HELPING WITH THAT WOULD BE GREAT. I ALSO ALREADY WANT TO MAJOR IN BIOLOGY, AND I ENJOY SCHOOL & LEARNING





Career Investigation



TASK 2.1: Become a Biomedical Researcher

Career Investigation:

List the various careers that might work together to solve the mystery of Fluffy's illness:

Career Profile:

Role:		Average Salary:	
Education Requirements:			
Skills:			

Summarize the Main Job Duties:

PFAS Wanted Posters



WANTED: PFOA

IMAGE:

FC(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(=O)O

KNOWN ALIASES:

- C₈HF₁₅O₂
- Perfluorooctanoic acid

HOW TO STAY SAFE:

- Eat less fast & packaged foods
- Drink filtered/pure water
- Reduce use of non-stick cookware

PRODUCTS THAT CONTAIN PFAS

CRIMES:

IgM
Exposure to PFOA can lead to a decrease in ability to produce antibodies that fight off infections.
[IgM] = an antibody that kills/neutralizes bacteria & viruses

CRIMES:

Exposure to PFOA can lead to decrease in ability to fight off multiple infections at once, especially among younger age groups.

other possible effects on the body

KNOWN SIGHTINGS:

- In drinking / tap water
- In water resistant products
- In firefighting foam
- In non-stick cookware
- In dental floss

IF FOUND CONTACT:

Rebecca Fry
 • Job title: Ph.D. Associate Professor, Environmental sciences & Engineering
 • Research: Investigates links between PFAS exposure & prenatal + childhood health

Crimes & Evidence

How to stay safe

Known sightings

Feature a PFAS Researcher

North Carolina Context: Surface Water Sampling

NC STATE UNIVERSITY

Learning with Data

PFAS Water Contamination Case Study

Taryn Shelton
The Science House
Data Science Academy

Katlyn May
Lacey Brown
Center for Human Health and the Environment
Center for Environmental and Health Effects of PFAS



NC STATE

Topic: Student interactions with Data in the Classroom

Opportunities

- What ways could data enrich my current lessons?

Preps students for data analysis on ACTs

Engagement & relevance

Better understanding of lesson through realistic data

Case Studies

Relevance/Connection to real life

Skills
- Real World Connections
- Teaching critical thinking
- Increase in the lesson
- Go deeper into lesson
- Make better informed decisions
- Read the world like a data scientist
- Purchasing decisions

Analyzing data could teach students critical thinking skills

Data can make real world connections for students



NC STATE

Data Science Overview



NC STATE

PFAS Science Overview

Turning EHS Data Into Classroom Activities

NC STATE UNIVERSITY

Learning with Data

PFAS Water Contamination Case Study

Taryn Shelton
The Science House
Data Science Academy

Katlyn May
Lacey Brown
Center for Human Health and the Environment
Center for Environmental and Health Effects of PFAS

NC STATE

	A	B	C	D	E	F	G	H	I
1	Data File	Nafion byproduct 2 instrument response	Nafion byproduct 2 concentration (ng/L)	Nafion byproduct 2 internal standard instrument response	Comment	Sample collection date	Finished or raw water for WTPs		
2	Method blank	10.4	0.23	1408	DI water that has been processed like a sample (has				
3	0.5 ng/L standard	97.5	0.54	1381	Calibration standard				
4	1 ng/L standard	236.9	1.02	1407	Calibration standard				
5	2 ng/L standard	437.0	1.75	1391	Calibration standard				
6	5 ng/L standard	1270.6	4.78	1367	Calibration standard				
7	10 ng/L standard	1907.3	6.99	1385	Calibration standard				
8	25 ng/L standard	6522.9	23.27	1381	Calibration standard				
9	50 ng/L standard	13736.2	47.80	1388	Calibration standard				
10	100 ng/L standard	27531.8	97.35	1324	Calibration standard				
11	250 ng/L standard	69799.1	254.70	1172	Calibration standard				
12	500 ng/L standard	140571.5	501.06	1059	Calibration standard				
13	1000 ng/L standard	250870.7	883.34	906	Calibration standard				
14	Blank	65.8	414.40	1					
15	QC 25 ng/L	5698.9	20.45	1377	QC=Quality control				
16	QC 250 ng/L	66065.4	220.91	1303					
17	Blank	3.5	2.49	8					
18	Blank	14.9	17.45	4					
19	CFPUA1	10861.3	37.33	1417	CFPUA=Ca	5/16/2017	Finished water		
20	CFPUA1_dup	11408.3	38.72	1433	duplicate sa	5/16/2017	Finished water		
21	CFPUA2	15738.9	52.18	1453		5/18/2017	Raw water		
22	CFPUA3	14717.4	51.36	1381		5/18/2017	Finished water		
23	CFPUA4	11680.0	40.25	1409		5/17/2017	Finished water		
24	CFPUA5	13144.3	45.26	1406		5/17/2017	Raw water		
25	CFPUA6	7811.2	27.13	1413		5/16/2017	Raw water		
26	CFPUA7	21361.5	71.71	1417		5/19/2017	Raw water		
27	Blank	6.4	37.85	1					
28	HWTP1	69.8	0.43	1422	HWTP=Hoff	5/16/2017	Raw water		
29	HWTP2	107.3	0.56	1431		5/17/2017	Raw water		
30	HWTP3	137.4	0.67	1418		5/18/2017	Raw water		
31	HWTP4	192.2	0.85	1446		5/19/2017	Raw water		
32	HWTP5	64.9	0.42	1427		5/17/2017	Finished water		
33	HWTP6	89.7	0.49	1486		5/16/2017	Finished water		
34	HWTP7	111.2	0.56	1504		5/18/2017	Finished water		
35	Blank	31.7	12.56	13					
36	TH1	26478.1	86.13	1449	TH1=Tar He	5/16/2017			
37	TH1_dup	27415.9	86.71	1490	duplicate sa	5/16/2017			
38	TH2	36018.4	115.51	1444		5/18/2017			
39	TH3	29875.1	98.47	1419		5/17/2017			
40	TH4	39487.7	129.21	1403		5/19/2017			
41	Blank	111.1	11.85	47					
42	CC_10ppt_1	2202.3	7.96	1398	CC=Calibration check				
43	CC_250ppt_1	74686.0	254.43	1256					
44	Blank	0.9	1.82	3					
45	EF1	22113.7	71.42	1473	EF=Elwell F	5/17/2017			
46	EF1_dup	22311.9	71.27	1489	duplicate sa	5/17/2017			
47	EF2	19470.1	62.90	1481		5/18/2017			

Nafion_byproduct_2

PFOA



Ready

Accessibility: Investigate

Cleaning up That Data



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Data Wrangling - Tidy Data

- Each row is a single observation,
- Each column is a single variable, and
- Each value is a single cell

rows = observations

columns = variables

cells = values

region	year	population
Toronto	2016	2235145
Vancouver	2016	1027613
Montreal	2016	1823281
Calgary	2016	544870
Ottawa	2016	571146
Winnipeg	2016	321484

region	year	population
Toronto	2016	2235145
Vancouver	2016	1027613
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region	year	population
Toronto	2016	2235145
Vancouver	2016	1027613
Montreal	2016	1823281
Calgary	2016	544870
Ottawa	2016	571146
Winnipeg	2016	321484

Source: [Data Science: A First Introduction](#)

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	A	B	C	D	E	F	G	H	I
1	Data File	Nafion byproduct 2 instrument response	Nafion byproduct 2 concentration (ng/L)	Nafion byproduct 2 internal standard instrument response		Sample collection date	Finished or raw water for WTPs		
2	Method blank	10.4	0.23	1408	DI water that has been processed like a sample (has				
3	0.5 ng/L standard	97.5	0.54	1381	Calibration standard				
4	1 ng/L standard	236.9	1.02	1407	Calibration standard				
5	2 ng/L standard	437.0	1.75	1391	Calibration standard				
6	5 ng/L standard	1270.6	4.78	1367	Calibration standard				
7	10 ng/L standard	1907.3	6.99	1385	Calibration standard				
8	25 ng/L standard	6522.9	23.27	1381	Calibration standard				
9	50 ng/L standard	13736.2	47.80	1388	Calibration standard				
10	100 ng/L standard	27531.8	97.35	1324	Calibration standard				
11	250 ng/L standard	69799.1	254.70	1172	Calibration standard				
12	500 ng/L standard	140571.5	501.06	1059	Calibration standard				
13	1000 ng/L standard	250870.7	883.34	906	Calibration standard				
14	Blank	65.8	414.40	1					
15	QC 25 ng/L	5698.9	20.45	1377	QC=Quality control				
16	QC 250 ng/L	66065.4	220.91	1303					
17	Blank	3.5	2.49	8					
18	Blank	14.9	17.45	4					
19	CFPUA1	10861.3	37.33	1417	CFPUA=Ca	5/16/2017	Finished water		
20	CFPUA1_dup	11408.3	38.72	1433	duplicate sa	5/16/2017	Finished water		
21	CFPUA2	15738.9	52.18	1453		5/18/2017	Raw water		
22	CFPUA3	14717.4	51.36	1381		5/18/2017	Finished water		
23	CFPUA4	11680.0	40.25	1409		5/17/2017	Finished water		
24	CFPUA5	13144.3	45.26	1406		5/17/2017	Raw water		
25	CFPUA6	7811.2	27.13	1413		5/16/2017	Raw water		
26	CFPUA7	21361.5	71.71	1417		5/19/2017	Raw water		
27	Blank	6.4	37.85	1					
28	HWTP1	69.8	0.43	1422	HWTP=Hoff	5/16/2017	Raw water		
29	HWTP2	107.3	0.56	1431		5/17/2017	Raw water		
30	HWTP3	137.4	0.67	1418		5/18/2017	Raw water		
31	HWTP4	192.2	0.85	1446		5/19/2017	Raw water		
32	HWTP5	64.9	0.42	1427		5/17/2017	Finished water		
33	HWTP6	89.7	0.49	1486		5/16/2017	Finished water		
34	HWTP7	111.2	0.56	1504		5/18/2017	Finished water		
35	Blank	31.7	12.56	13					
36	TH1	26478.1	86.13	1449	TH1=Tar He	5/16/2017			
37	TH1_dup	27415.9	86.71	1490	duplicate sa	5/16/2017			
38	TH2	36018.4	115.51	1444		5/18/2017			
39	TH3	29875.1	98.47	1419		5/17/2017			
40	TH4	39487.7	129.21	1403		5/19/2017			
41	Blank	111.1	11.85	47					
42	CC_10ppt_1	2202.3	7.96	1398	CC=Calibration check				
43	CC_250ppt_1	74686.0	254.43	1256					
44	Blank	0.9	1.82	3					
45	EF1	22113.7	71.42	1473	EF=Elwell F	5/17/2017			
46	EF1_dup	22311.9	71.27	1489	duplicate sa	5/17/2017			
47	EF2	19470.1	62.90	1481		5/18/2017			

Nafion_byproduct_2

PFOA

Ready

Accessibility: Investigate

Cleaning up That Data



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TASK 6: Data Wrangling & Cleaning

3c. After sorting, select the entries that list:

- “Calibration standard”
- “Standard”
- “Blank”
- “Method blank”
- “CC=Calibration check”
- “QC=Quality Control”

Right-click and Delete those rows. Do this for both datasets.

	A	B	C	D	E	F	G
1	Data File	Nafion byproduct 2 concentration (ng/L)	Comment	Finished			
5	1 ng/L standard	1.01					
6	10 ng/L standard	6.99	Calibration standard				
7	10 ng/L standard	7.01					
8	100 ng/L standard	97.35	Calibration standard				
9	100 ng/L standard	102.92					
10	1000 ng/L standard	883.34	Calibration standard				
11	1000 ng/L standard	875.35					
12	2 ng/L standard	1.75	Calibration standard				
13	25 ng/L standard	23.27	Calibration standard				
14	25 ng/L standard	23.90					
15	250 ng/L standard	254.70	Calibration standard				
16	5 ng/L standard	4.78	Calibration standard				
17	5 ng/L standard	4.72					
18	50 ng/L standard	47.80	Calibration standard				
19	500 ng/L standard	501.06	Calibration standard				
20	500 ng/L standard	497.09					
21	Blank	414.40					
22	Blank	2.49					
23	Blank	17.45					
24	Blank	37.85					
25	Blank	12.56					
26	Blank	11.85					

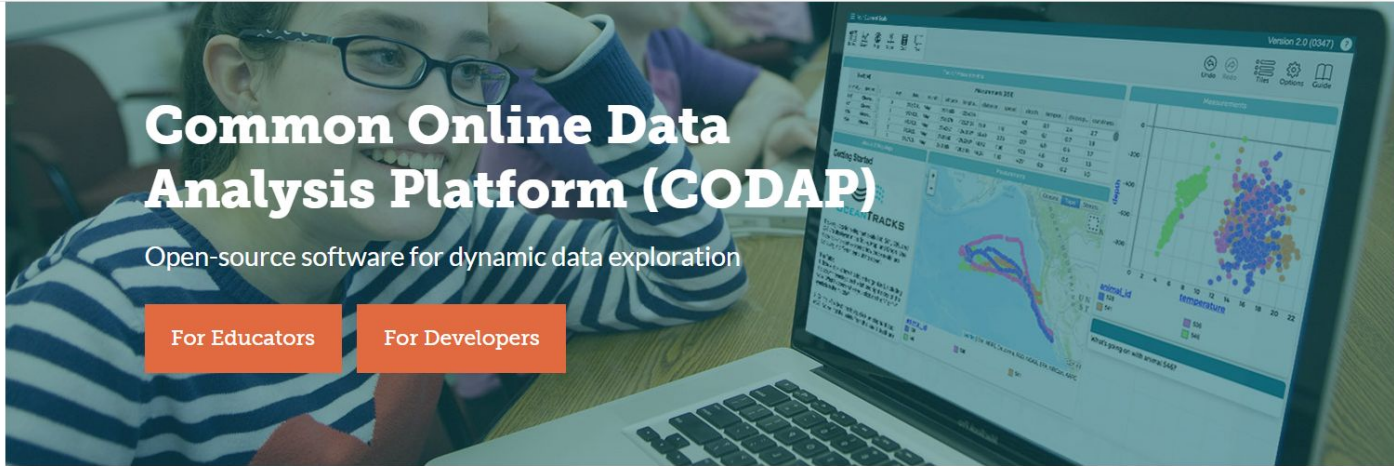
	A	B	C	D	E	F	G	H	I
1	Data File	Nafion byproduct 2 instrument response	Nafion byproduct 2 concentration (ng/L)	Nafion byproduct 2 internal standard instrument response	Comment	Sample collection date	Finished or raw water for WTPs		
2	Method blank	10.4	0.23	1408	DI water that has been processed like a sample (has				
3	0.5 ng/L standard	97.5	0.54	1381	Calibration standard				
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17	Blank	3.5	2.49	8					
18	Blank	14.9	17.45	4					
19	CFPUA1	10861.3	37.33	1417	CFPUA=Ca	5/16/2017	Finished water		
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21	CFPUA2	15738.9	52.18	1453		5/18/2017	Raw water		
22	CFPUA3	14717.4	51.36	1381		5/18/2017	Finished water		
23	CFPUA4	11680.0	40.25	1409		5/17/2017	Finished water		
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27	Blank	6.4	37.85	1					
28	HWTP1	69.8	0.43	1422	HWTP=Hoff	5/16/2017	Raw water		
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30	HWTP3	137.4	0.67	1418		5/18/2017	Raw water		
31	HWTP4	192.2	0.85	1446		5/19/2017	Raw water		
32	HWTP5	64.9	0.42	1427		5/17/2017	Finished water		
33	HWTP6	89.7	0.49	1486		5/16/2017	Finished water		
34	HWTP7	111.2	0.56	1504		5/18/2017	Finished water		
35	Blank	31.7	12.56	13					
36	TH1	26478.1	86.13	1449	TH1=Tar He	5/16/2017			
37	TH1_dup	27415.9	86.71	1490	duplicate sa	5/16/2017			
38	TH2	36018.4	115.51	1444		5/18/2017			
39	TH3	29875.1	98.47	1419		5/17/2017			
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47	EF2	19470.1	62.90	1481		5/18/2017			

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Introducing Teachers to Data Analysis Tools



[About](#) [Forums](#) [Contact](#) [Help](#) [Launch CODAP](#)



Common Online Data Analysis Platform (CODAP)

Open-source software for dynamic data exploration

For Educators

For Developers

CODAP is free educational software for data analysis. This web-based data science tool is designed as a platform for developers and as an application for students in grades 6-14.

Introducing Teachers to Data Analysis Tools

Getting started with CODAP **UNSAVED**

Tables Graph Map Slider Calc Text Plugins

1.02 Getting started with CODAP

You've got data! It appears in a *case table*.

Each row in the table represents a *case* and each column represents an *attribute*.

This data set contains data about mammals. Each case represents a different mammal. The attributes provide information about lifespan, height, and so on.

mammals

cases (27 cases)

in- dex	Mammal	Order	LifeSpan	Height	Mass	Sleep	Speed	H
23	Pig	Artioda...	10	1	192	8	18	la
24	Prongh...	Artioda...	10	0.9	70		98	la
25	Rabbit	Lagomo...	5	0.5	3	11	56	la
26	Red Fox	Carnivora	7	0.8	5	10	48	la
27	Spotted...	Carnivora	25	0.9	70	18	64	la

Using PFAS Data in Codap



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Wrapping Up: Discussions and Extensions

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TASK 8: Communication - What do we do with the insights we have learned from the data?

- You can discuss and argue certain ideas, while realizing that datasets cannot provide pure answers
- ★ Remember:

Data is information - not truth - with error, variability, and degrees of inclusion/exclusion

Moving Forward: Year-long, interdisciplinary cohort

Incorporate and Emphasize:

- PFAS is a complex, multidisciplinary issue
- Biology data (Yoder lab)
- Evolving policy landscape (MCLs)
- Work with education experts

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Let's Keep it Real:

Real Teaching with Real Data

Calling all 8-12 grade Teachers!

Join our year-long cohort and co-design data science lessons to pilot in your classroom! Teachers from ALL subject areas are encouraged to apply.

PERKS:

\$1200 STIPEND

*Spread over the full year



Collaborate on developing data science lessons



Engage your students with REAL NC State research data



Lead your district in developing lessons with data science skills



Connect with colleagues from other districts

NC STATE UNIVERSITY Center for Human Health and the Environment

NC STATE UNIVERSITY THE SCIENCE HOUSE

NC STATE Data Science Academy

Website: <https://go.ncsu.edu/dsak12>

Contact: Taryn Shelton, tshelto3@ncsu.edu

Reverse Science Fair

- Opportunity for high school students to hear from young professional scientists
- Scientists present scientific poster prepared for a conference

STEEP Trainee Emily Kaye describing PFAS-protein binding studies



Falmouth High School REVERSE SCIENCE FAIR!

We are looking for Scientists, Engineers, Undergraduate or Graduate Students, and Post Docs to present their recent scientific research posters to Falmouth High School students. Filling out this form indicates your interest, but does not commit you to presenting. We will send you more information and will confirm your commitment in a later email.



How are we engaging diverse learners?

Discussion

What strategies did you notice from our examples?

What strategies do you use?

How do our programs recruit & engage trainees?



NC State Strategy: Don't Reinvent the Wheel



NC STATE



SCIREN





Strategies to Engage Trainees

- 1) Speed networking
- 2) Curriculum development
- 3) PFAS speakers bureau
- 4) Trainee-focused videos
- 5) Informal interactions

Engaging trainees to **enhance relevance** and **promote awareness** of biomedical research careers

Speed Networking



Whiteboard prompts:

Teachers and trainees **listed relevant identities** that they were comfortable speaking about during networking

Discussion prompts:

Was there a person who opened a door to a career or field of study for you? Can you describe **actions** that person did to help you?

Curriculum Development



Teacher: "Listening to the [researchers] and what they are doing really **helps to make this relevant** for me and the lessons I'll be creating."



Trainee: "I enjoyed getting a direct look into the development of a K-12 lesson plan ... it not only gave me a **better appreciation** for the effort and work that teachers engage in to develop lessons, but also gave me **valuable insight** into ways that I can make my research more palatable to diverse audiences."

PFAS Speakers Bureau



[Jacqueline Bangma](#) is a researcher at the US EPA in Research Triangle Park, NC. She investigates the impact of per- and polyfluoroalkyl substances in both wildlife and the placenta. Dr. Bangma has studied bioaccumulation of PFAS in an undergraduate degree program at the University of South Carolina.



[Ashley Connors](#) is a PhD student in Dr. Jeffrey Yoder's lab at North Carolina State University. She studies how PFAS affects the innate immune system, which engulf and neutralize pathogens in culture and zebrafish models.



[Marissa Blackburn](#) is a nonprofit focused on environmental protection. She is involved in the protection of water resources and leads public water education and has worked in the field for ten years.



[Caroline Coxwell Mohler](#) is a PhD student focuses on making new materials to remove polymeric materials from small molecule tests those materials for PFAS removal.



[Nick Chew](#) is a Postdoc at North Carolina at Chapel Hill and granular sorbent toward providing clean drinking water of-use (POU) level, water POU systems to purify water. He received his PhD from the University of Singapore.



[Michael Davern](#) is a PhD student in Dr. J. Chapel Hill. He works in developing analytical methods to use mass spectrometry to detect PFAS.



[Christian Chung](#) is a graduate student in Environmental Science works as an undergraduate in hydrologic and chemical implications PFAS have on the environment. Chung traveled to Egypt to present at the Framework on Climate Change Convention. He is representing youth, the state of North Carolina and is also highly engaged in campus life at UNC-Chapel Hill the UNC Mixed Asian Student Heritage Organ and EnviroLab.



[Haley Macdonald](#) is a PhD student and a graduate student at the University of North Carolina at Chapel Hill from drinking water. Haley looks at current water and tests these materials to determine novel sorbent that is able to overcome the challenges of PFAS.



[Nnamdi Osalwe](#) is a PhD student in Dr. J. Chapel Hill. His research focuses on how PFAS-related research focuses on how PFAS generate relevant, summarized scores of exposure to PFAS. Part of his research goal is to create dynamic models of environmental exposure to diverse audiences. Part of his research focuses on Environmental and Health Effects of PFAS.



[Brittany Rickard](#) is a PhD student in Dr. J. Chapel Hill. She studies the resistance to platinum-based chemotherapy. ~65% mortality rate. Brittany's lab researches relevant PFAS induce platinum resistance. Based treatment can overcome PFAS-induced resistance.



[Charlotte Robbins](#) is a MSPH student in the Action Clinic at the University of North Carolina at Chapel Hill. She is interested in the well water in communities near the coast. She communicates PFAS risk and concentration. Charlotte supported the Agency for Toxic Substances and Disease Registry's Multi-site Health Study related to PFAS.



[Krystal Taylor](#) is currently a fourth-year student in the Department of Pharmacology and Toxicology. Krystal was born and raised near the birth of the state of North Carolina, so there is no surprise that her research involves looking at the impact of PFAS on the immune system. She hopes to develop a novel protocol to study PFAS and the immune system. Krystal believes the results from that will allow laws and regulations to be implemented to ensure treatment, and access to services.



[Tracey Woodlief](#) is a research faculty at the University of North Carolina at Chapel Hill. She studies the impact of exposure to environmental PFAS as well as within the immune system, her research focuses on novel mechanisms within metabolism, and how they relate to public health. She received her PhD from the University of North Carolina and PhD also from the University of North Carolina.

Teacher: "I think the most effective thing we did that increased [students'] interest in a biomedical career was hearing from Ashley, and **actually having someone come in and talk about what they do.**"

Student: "Thank you so much for sharing your experiences working with Zebra fish to study PFAS. **It was super interesting to learn about real world studies measuring PFAS effects.**"

Trainee-focused videos

<https://go.unc.edu/PFASvideos>



"I think to be good at research you need really good time management and perseverance ... I have really good time management skills because I've been an athlete my whole life and so I think that's definitely helped me figure out how to manage a research schedule while also having a personal life."

Advice tailored to high school students

**Challenges & opportunities of featuring an
unfolding environmental health issue in K-12 &
informal science education**

Discussion

Science is a verb, not a noun:

Address uncertainty and the iterative nature of science

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TASK 8: Communication - What do we do with the insights we have learned from the data?

- You can discuss and argue certain ideas, while realizing that datasets cannot provide pure answers

★ Remember:

Data is information - not truth - with error, variability, and degrees of inclusion/exclusion

Challenging students to think about what to do next

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TASK 9: Data for Social Good

- 1) Compare the data to the [EPA's proposed maximum contamination level \(MCL\) for drinking water](#).
 - a) Note: There are no regulations as of yet for Nafion_BP2
- 2) How can this data be used to create & advocate for policies?
- 3) How can this data be used to create environmental plans?
 - Filtration; Cleanup; Further monitoring; etc
- 4) How can this data be used to plan for human health monitoring?
 - a) What data is missing that you may first need to make this plan?
- 5) How can we use the data to make decisions that can affect the health and well-being of communities?

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Extensions

- Create a public information poster
- Write a 2 minute speech for public comment to your state legislature
- Design your own water quality testing experiment

How are we showcasing solutions?

Solutions



- Technologies for Assessment, Detection, and Treatment
- Environmental Policies & Regulations
- Manufacturers remove PFAS from consumer goods
- Advocacy & informed consumers

PEOPLE!

Environmental Policies & Regulations

North Carolina DEQ Action Strategy for PFAS

June 7, 2022



Clean Cape Fear Co-Founder Emily Donovan talk...



Watch later



Share

THE

ENVIRONMENTAL


TRANSFORMATION

PODCAST



EPISODE 51

Clean Cape Fear Co-Founder Emily Donovan talks about their efforts to address PFAS contamination in their community.

Watch on  YouTube



E.P.A. Says 'Forever Chemicals' Must Be Removed From Tap Water

The rule applies to a family of chemicals known as PFAS that are linked to serious health effects. Water utilities argue the cost is too great.



The new measure will require utilities to reduce PFAS substances in drinking water to near-zero levels. Justin Sullivan/Getty Images



By Lisa Friedman

April 10, 2024

Companies are making progress

KNOW YOUR ENVIRONMENT. PROTECT YOUR HEALTH.



Who We Are ▾ Areas of Focus ▾ Consumer Guides Research News & Insights



Many Companies Market Alternatives for Products that Contain PFAS



Mission

On March 22, 2021, we took out a full-page ad in the New York Times to welcome footwear friends Salomon to the PFC Free club and invite others to join us. **PFAS are a big problem.** So we had to go big.



2022-2024 Program

PFAS Researchers

Scott Belcher, PhD, NCSU
Jamie DeWitt, PhD, ECU
Rebecca Fry, PhD, UNC
Detlef Knappe, PhD, NCSU
Lisa Smeester, PhD, UNC

NIEHS-funded trainees:
Ashley Connors, Michael Davern, Nnamdi Oaskwe, Brittany Rickard, Krystal Taylor, Mikayla Watt

Design Team Teachers

Tabitha Batts-Turner
Andromeda Crowell
Amy Elliott
Daniel Glaze
Clare Matusevich
Taryn Shelton
Abria Vodenichar
Matt Yaeger

IDEA Learners Program

Kathleen Gray, PhD, UNC
Dana Haine, MS, UNC
Lynn Chesnut, PhD, UNC
Jenna Hartley, PhD, UNC
Kelly Ryoo, PhD, UNC
Melissa Troester, PhD, UNC
Rebekah Davis, PhD, NCSU
Janell Miller, NCSU

SEPA SCIENCE EDUCATION
PARTNERSHIP AWARD
SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL



NC STATE Friday Institute for Educational Innovation

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**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI









**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

Advancing Public Health Research to Address PFAS Concerns – Ongoing Initiatives and Next Steps

Rachel D. Rogers, PhD

Senior Health Scientist

National Center for Environmental Health/
Agency for Toxic Substances and Disease Registry

National PFAS Conference

June 11, 2024

Ann Arbor, Michigan

ATSDR's Role in Addressing PFAS

ATSDR actively works to:



Investigate exposure to PFAS and associated health effects



Address community health concerns



Support evidence-based interventions

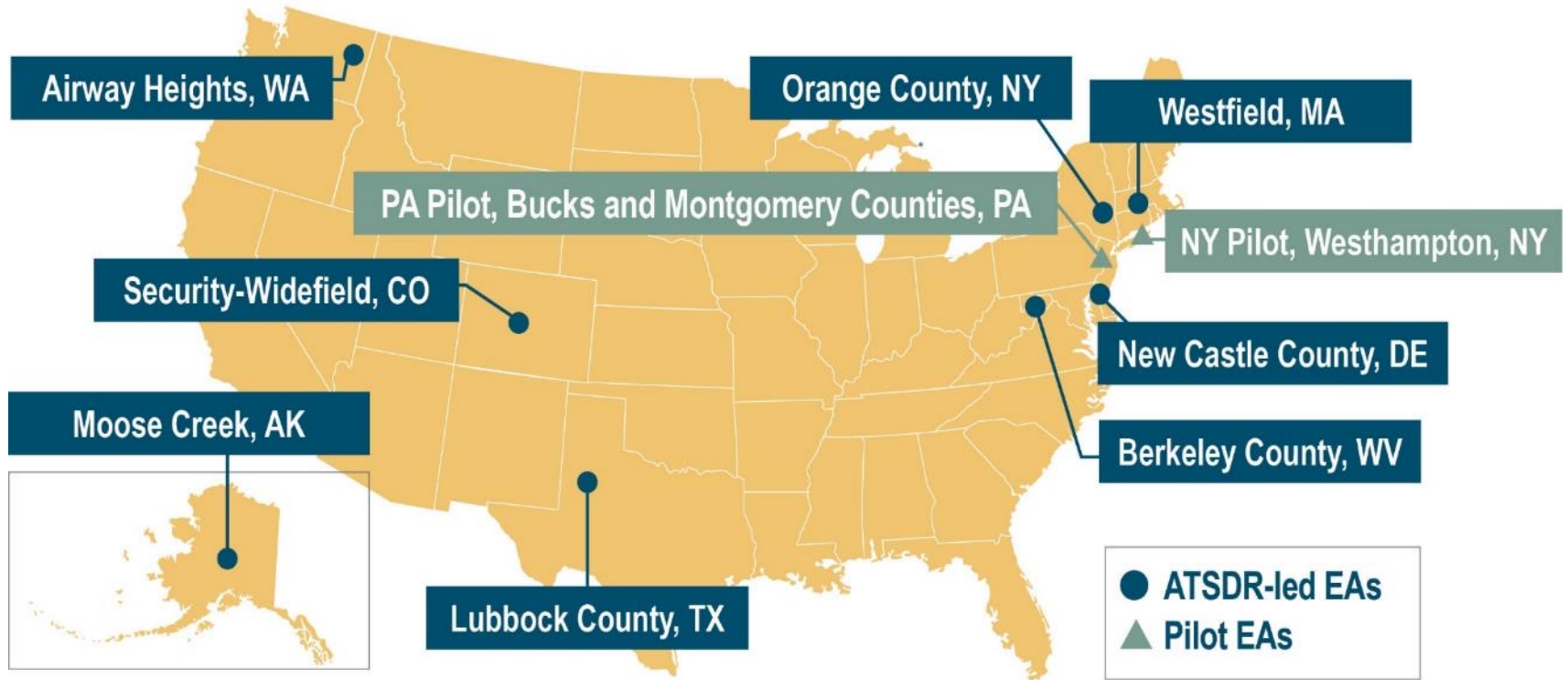


Provide communities and healthcare providers with accurate and timely information

CDC, NCEH, & ATSDR

are helping our local, territorial, tribal, state, and federal partners address human exposure to PFAS and its possible associated health effects.

ATSDR PFAS Exposure Assessments



ATSDR PFAS Exposure Assessments – What Did We Hope To Learn?



- ✓ PFAS levels in the blood and urine of participants



- ✓ How PFAS levels in communities exposed to PFAS through drinking water compare to the general U.S. population

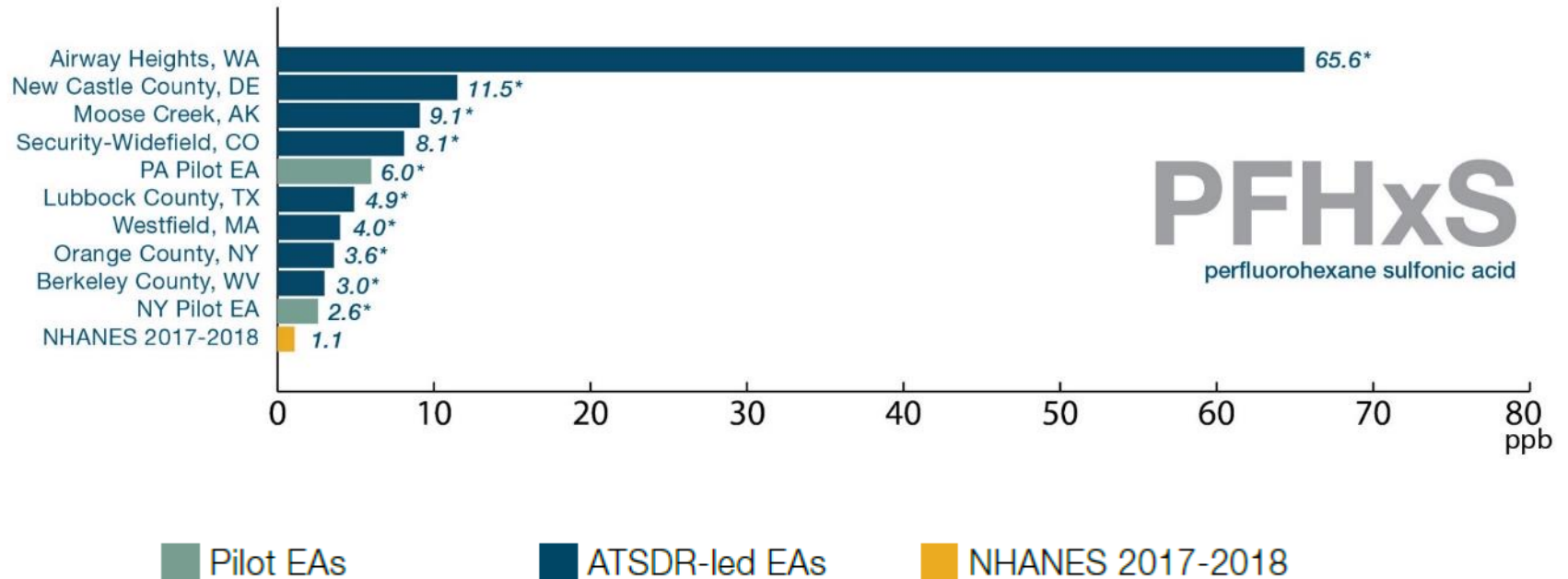


- ✓ The range of PFAS levels we might expect to see in untested people in each community



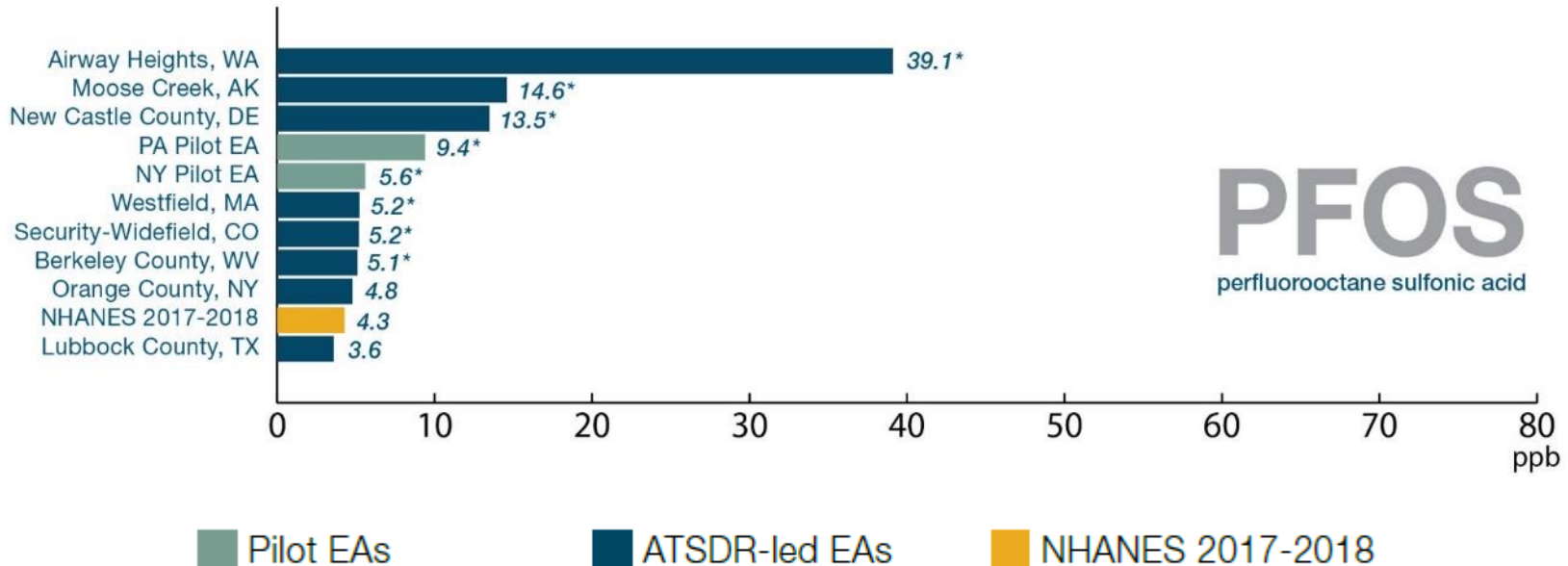
- ✓ What environmental factors might affect PFAS levels in people's bodies

Age-Adjusted Geometric Mean PFHxS Blood Levels are Higher than NHANES 2017-2018 in All Exposure Assessment Communities



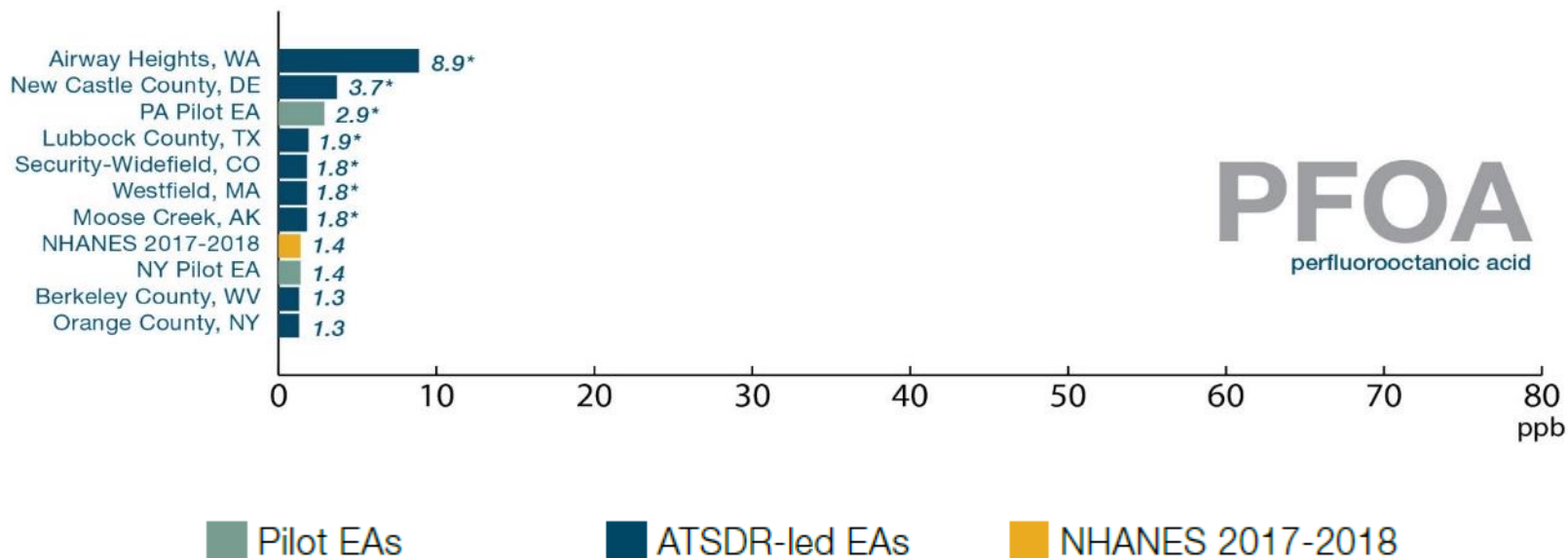
Age-adjusted Geometric Mean PFOS Blood Levels are Higher than NHANES 2017-2018 in Most Exposure Assessment Communities.

PFOS is significantly higher in eight out of ten EA communities.



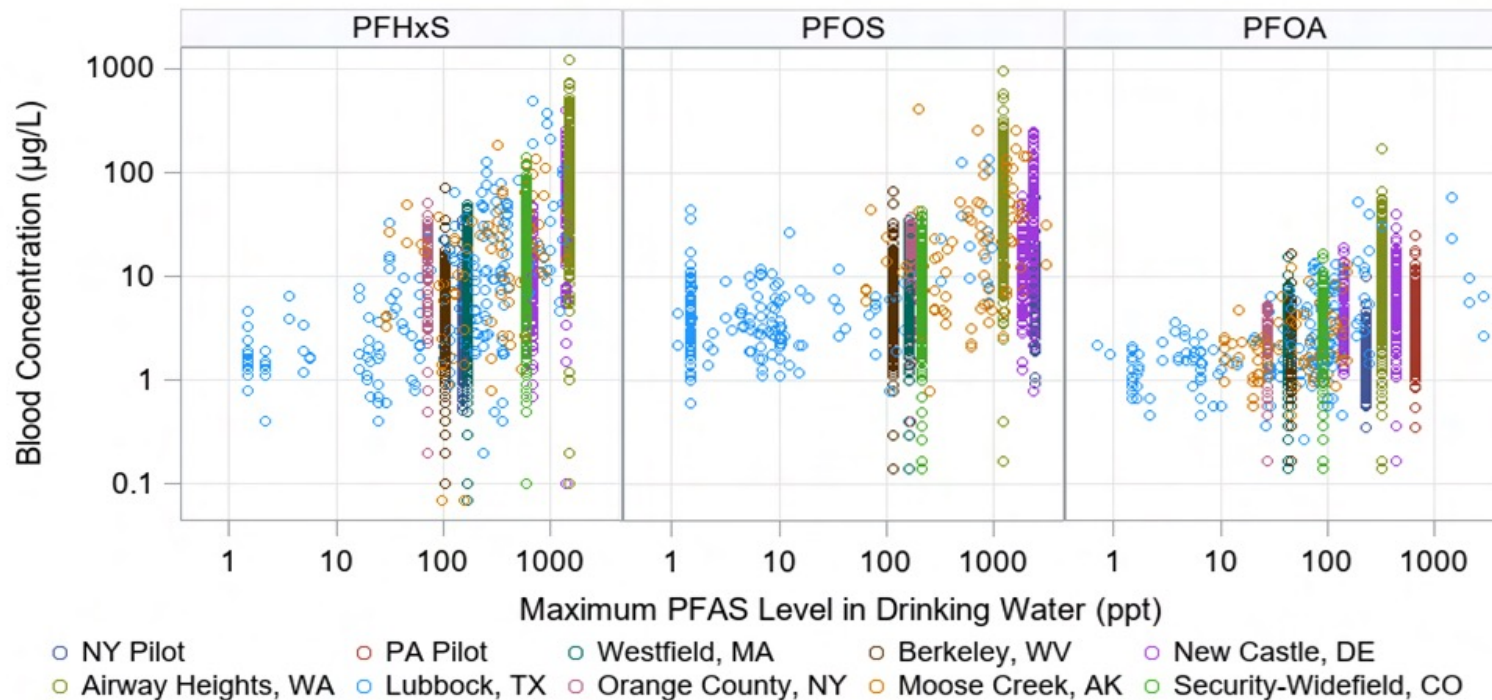
Age-adjusted Geometric Mean PFOA Blood Levels are Higher than NHANES 2017-2018 in Most Exposure Assessment Communities.

PFOA is significantly higher in seven out of ten EA communities.



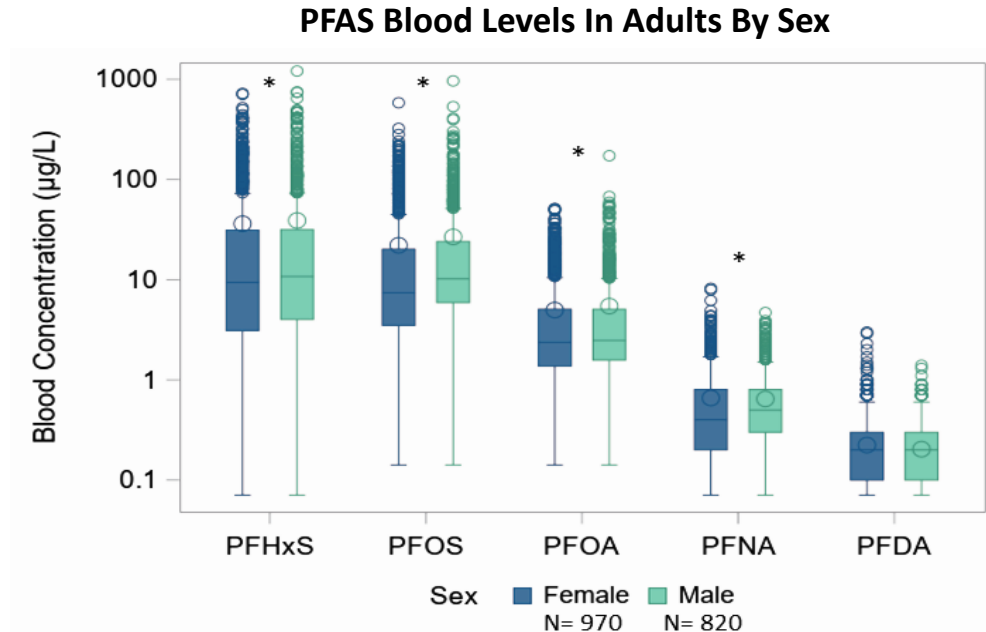
Elevated Blood Levels of PFHxS, PFOS, And PFOA May Result From Past Drinking Water Contamination

Maximum PFAS Level In Drinking Water And Corresponding Blood Levels By Site



Factors Associated With PFAS Blood Levels

- Length of Residency
- Water Consumption
- Use of a Filtration System
- Age
- Sex
- Cleaning Frequency
- Soil Exposure
- Consumption of Locally Grown Produce and Dairy
- Use of Stain Resistant Products
- Childbirth
- Breastfeeding/Formula



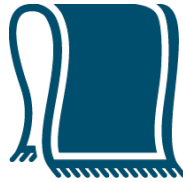
Factors Not Associated with PFAS Blood Levels



Occupation



Blood donation
frequency



Flooring



Fast food
consumption



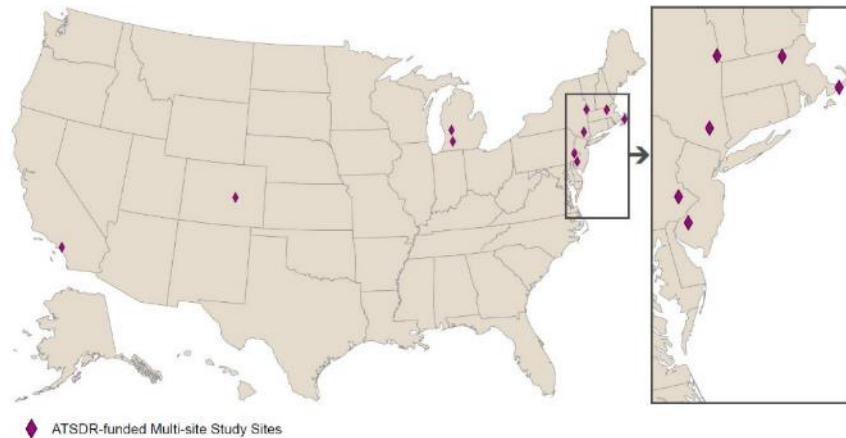
Kidney
disease

Key Recommendations

- Private well owners living in PFAS-affected areas should consider testing for PFAS if testing has not been conducted before.
- Based on test results, private well users should consider installing a home water treatment system.
- Nursing mothers should continue breastfeeding.
- Public water systems should monitor concentrations of PFAS in drinking water and maintain treatment systems to ensure that PFAS levels remain below the existing federal and state guidelines.
- PFAS monitoring results should be shared with community members.
- Bottled water and/or water filtration systems should be provided for households with private wells with PFAS levels above state or federal guidelines unless a alternative source of drinking water that meets all guidelines has been provided.

ATSDR Multisite Study (MSS)

- First major study to look at multiple PFAS at sites across the nation with different exposure levels
- The MSS was authorized through the National Defense Authorization Acts of 2018 and 2019 to provide information about the health effects of PFAS exposure
- Will expand on the pilot health study conducted near Portsmouth, NH (Pease Study)
- Information will inform all communities in the U.S. with PFAS drinking water exposures



Goals of MSS

The MSS investigates the relationship between PFAS exposure and health outcomes across differing populations, expanding our understanding of PFAS and its risks to our health



Intended Insights:

- Relationship between PFAS exposures and health outcomes
- Better understanding of the risk of health effects
- What health effects may be associated with PFAS exposure
- Information on health endpoints and PFAS levels in the blood of participants

MSS Outcomes

The Multi-site Study will assess various health endpoints:

- Lipid metabolism
- Kidney function
- Thyroid disease
- Liver disease
- Glycemic parameters and diabetes
- Immune response



Recruitment and Data Collection

Types of data planned for collection:



Blood sample



Urine Sample



List of medications/supplements



Medical and exposure history



Neurobehavioral information from child participants

The study planned to recruit **2,000 children** and **7,000 adults** from communities exposed to PFAS contaminated drinking water.

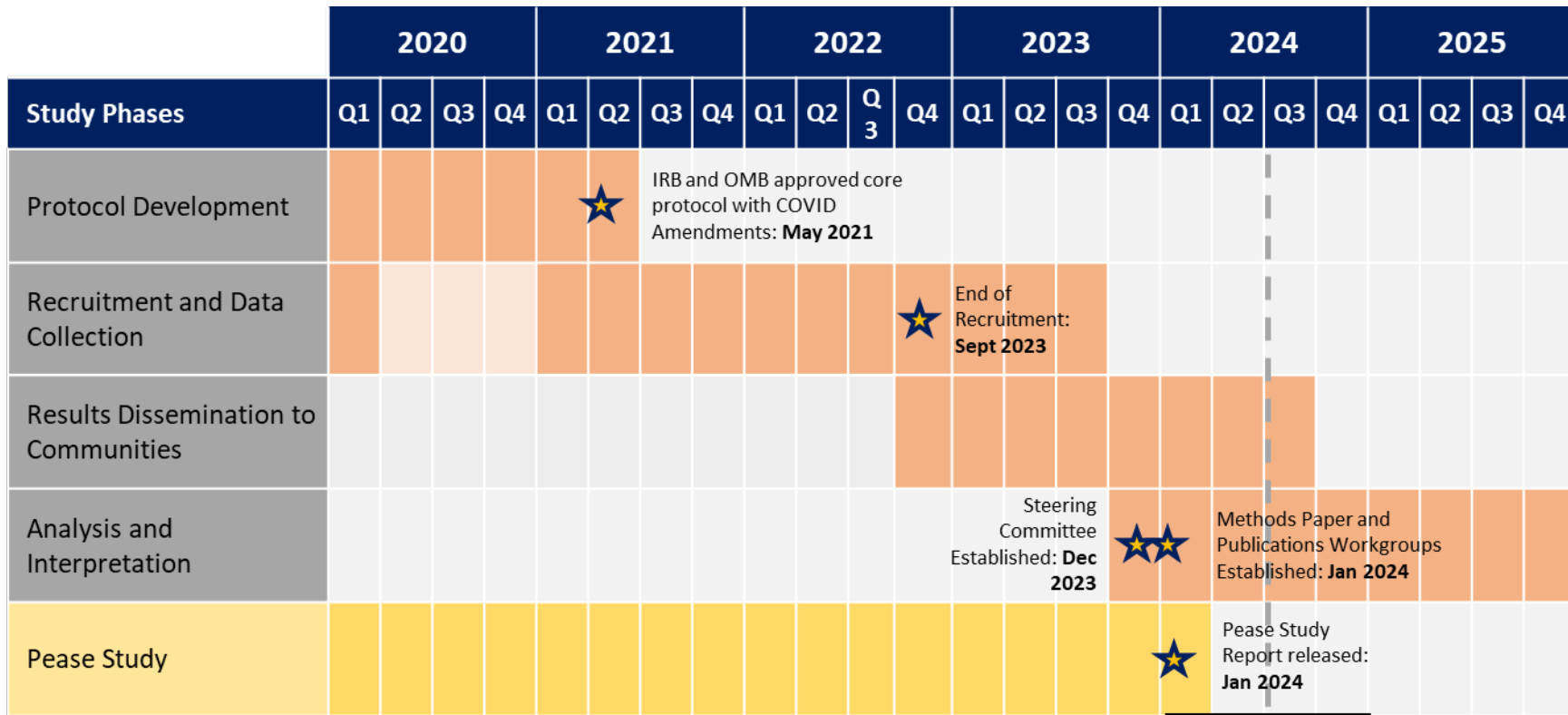
Combined Pease and MSS Final Recruitment Numbers

		Adult Participants		Child Participants		
Site	Launch	Questionnaire Only	All Study Activities	Questionnaire Only	Questionnaire and Body Measurements/ Blood Draw Only	All Study Activities (includes NBT)
California	12/2021	586	518	71	51	28
Colorado	11/2021	979	925	190	141	122
Massachusetts	10/2021	695	689	99	90	48
Michigan	08/2021	445	423	42	27	19
New Jersey	07/2021	829	777	103	88	68
New York	12/2021	508	468	55	44	20
Pennsylvania	10/2021	1455	1252	125	89	53
Pease	10/2019	811	776	201	183	129
SUBTOTAL (MSS ONLY)		5,497	5,025	685	530	358
TOTAL (MSS + PEASE)		6,308	5,828	886	713	487

**Total Completed Questionnaires:
7,194**

Total Completed Participants: 6,315

MSS Study Timeline



WE ARE HERE

★ Key Milestones

Pease Study Data - Adults

Per- and Polyfluoroalkyl Substance Serum Concentrations in Adult Pease Study Participants in 2019-2021 Compared with NHANES 2017-2018 and New Hampshire (NH) Biomonitoring Program.

PFAS	Pease Exposed 2019-2021 ^a		Pease Referent 2019-2021 ^a		NHANES 2017-18			NH Biomonitoring Program (2015-2017) ^b	
	n	Geometric Mean (95% CI)	n	Geometric Mean (95% CI)	n	Geometric Mean (95% CI)	p-value for Difference (Pease Exposed v. NHANES 2017-2018) ^c	n	Geometric Mean (95% CI)
PFOS (µg/L)	676	5.04 (4.74, 5.35)	100	3.97 (3.47, 4.54)	1700	4.45 (4.10, 4.83)	0.035	1181	8.9 (8.5, 9.3)
PFOA (µg/L)	676	1.93 (1.85, 2.03)	100	1.70 (1.52, 1.90)	1700	1.45 (1.35, 1.56)	<0.001	1181	3.0 (2.9, 3.2)
PFNA (µg/L)	676	0.48 (0.45, 0.50)	100	0.51 (0.46, 0.57)	1700	0.41 (0.37, 0.47)	<0.001	1181	0.7 (0.7, 0.7)
PFHxS (µg/L)	676	3.21 (2.97, 3.48)	100	1.79 (1.50, 2.15)	1700	1.11 (1.02, 1.21)	<0.001	1181	4.3 (4.1, 4.6)
PFDA (µg/L)	676	0.19 (0.18, 0.20)	100	0.19 (0.17, 0.21)	1700	0.20 (0.18, 0.21)	0.027	-	-
PFUnDA (µg/L)	676	0.15 (0.15, 0.16)	100	0.16 (0.14, 0.18)	1700	0.13 (0.12, 0.14)	<0.001	-	-
MeFOSAA (µg/L)	676	0.10 (0.10, 0.11)	100	0.13 (0.11, 0.14)	1700	0.13 (0.12, 0.14)	<0.001	-	-

^aExposed - Pease participants who consume contaminated water, Referent - Pease participants who did not consume contaminated water.

^b includes results from adult participants (n ≥20 years) from Daly et al., 2018.

^cBolded values are considered to be statistically significantly different at an alpha of 0.05.

Pease Study Data - Children

Per- and Polyfluoroalkyl Substance Serum Concentrations in Child Pease Study Participants in 2019-2021 Compared with NHANES 2017-2018

PFAS	Pease Exposed 2019-2021 ^a		Pease Referent 2019-2021 ^a		NHANES 2017-2018		
	n	Geometric Mean (95% CI)	n	Geometric Mean (95% CI)	n	Geometric Mean (95% CI)	p-value for Difference (Pease Exposed v. NHANES 2017-2018) ^b
PFOS (µg/L)	172	3.06 (2.78, 3.38)	8	2.00 (1.61, 2.05)	229	2.53 (2.18, 2.93)	<0.001
PFOA (µg/L)	172	1.47 (1.38, 1.57)	8	1.38 (1.02, 1.85)	229	1.13 (1.04, 1.22)	<0.001
PFNA (µg/L)	172	0.31 (0.28, 0.34)	8	0.20 (0.10, 0.39)	229	0.37 (0.30, 0.46)	0.539
PFHxS (µg/L)	172	1.82 (1.61, 2.05)	8	1.10 (0.69, 1.76)	229	0.80 (0.70, 0.90)	<0.001
PFDA (µg/L)	172	0.14 (0.13, 0.15)	8	0.12 (0.08, 0.19)	229	0.15 (0.13, 0.17)	0.988
PFUnDA (µg/L)	172	0.09 (0.08, 0.10)	8	0.11 (0.07, 0.17)	229	0.10 (0.09, 0.10)	0.156
MeFOSAA (µg/L)	172	0.11 (0.10, 0.12)	8	0.09 (0.06, 0.12)	229	0.14 (0.13, 0.15)	0.091

^aExposed - Pease participants who consume contaminated water, Referent - Pease participants who did not consume contaminated water.

^bBolded values are considered to be statistically significantly different at an alpha of 0.05.

Communicating Results

CDC/ATSDR laboratories will analyze blood samples for PFAS, and clinical laboratories will analyze blood samples for health endpoints. We will ultimately:



Publish combined results and share the final report findings at a community information session



Host a Q&A session for all community members



Host experts to answer questions

CDC/ATSDR's *PFAS: Information for Clinicians*

- Released in January 2024.
- Provides clinicians information for engaging patients to help them understand their exposures, how they may reduce exposure, and navigate decisions around PFAS blood testing and clinical testing.
- Responds to community requests for greater provider awareness of PFAS concerns and actions that can be taken to address PFAS exposures.

Health Effects Information



Increases in
cholesterol levels



Decreases in birth
weight



Lower antibody
response to vaccines



Pregnancy-
induced
hypertension and
preeclampsia



Kidney and
testicular cancer



Changes in liver
enzymes

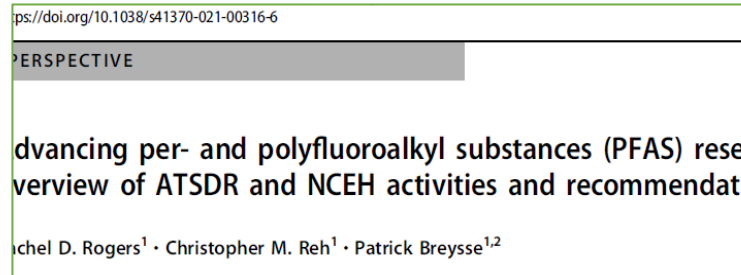
Main Messages for Outreach

- Clinicians can help their patients understand their unique risks, reduce PFAS exposures, and navigate PFAS blood testing and clinical testing.
- PFAS exposure should be reduced whenever possible. Steps to reducing exposure can be identified through taking an exposure history.
- PFAS blood testing should be done in consideration of:
 - an individual's exposure history
 - results of PFAS testing from the patient's water supply, food sources, or other exposure routes
 - whether results can inform exposure reduction and health promotion
- Patients and clinicians can discuss the potential risks and benefits of using PFAS blood testing results to guide clinical management.

Next Steps – Exposure

Exposure:

- How can identification of individuals and communities exposed to PFAS be improved?
- What is the contribution of non-drinking water sources (food, air, soil, dust) to PFAS exposure?
- What are the implications of a person's PFAS exposure for exposure to their nursing infant and what does PFAS in human milk mean for their children's health?

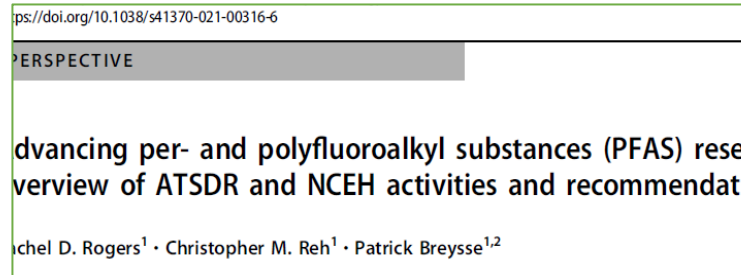


<https://pubmed.ncbi.nlm.nih.gov/33795841/>

Next Steps – Toxicology

Toxicology:

- What are the critical windows of exposure, toxicokinetic, and toxicodynamic properties of individual (including less-studied and emerging) PFAS and PFAS mixtures?
- How does chemical structure affect the physical, chemical, and biological behavior of PFAS?
- How can PFAS be grouped according to their toxicological profiles?



<https://pubmed.ncbi.nlm.nih.gov/33795841/>

Next Steps – Human Health

Additional epidemiological studies could contribute to filling data gaps for the following:

1. PFAS (or groups of PFAS) most likely to be associated with which health effects;
2. Understanding of the relative effects of varying levels of exposure for those associations;
3. How health effects vary by route of exposure;
4. What factors (such as age and underlying health conditions) increase susceptibility to the effects of PFAS on various health outcomes;
5. What measurable intermediate biomarkers of effect in exposed humans can lead to better understanding of biological mechanisms leading to disease;
6. What public health and medical interventions are most effective in alleviating health effects following PFAS exposure; and,
7. The influence of different PFAS mixtures and co-occurring exposures (chemical and nonchemical) on PFAS-associated health effects.

Thank you!

**Never doubt that a small group of thoughtful,
committed citizens can change the world;
indeed, it's the only thing that ever has.**

Margaret Mead

For more information, contact NCEH/ATSDR

1-800-CDC-INFO (232-4636)

TTY: 1-888-232-6348 www.atsdr.cdc.gov www.cdc.gov

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry.



ATSDR



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

PFAS LIFE

Tobyn McNaughton

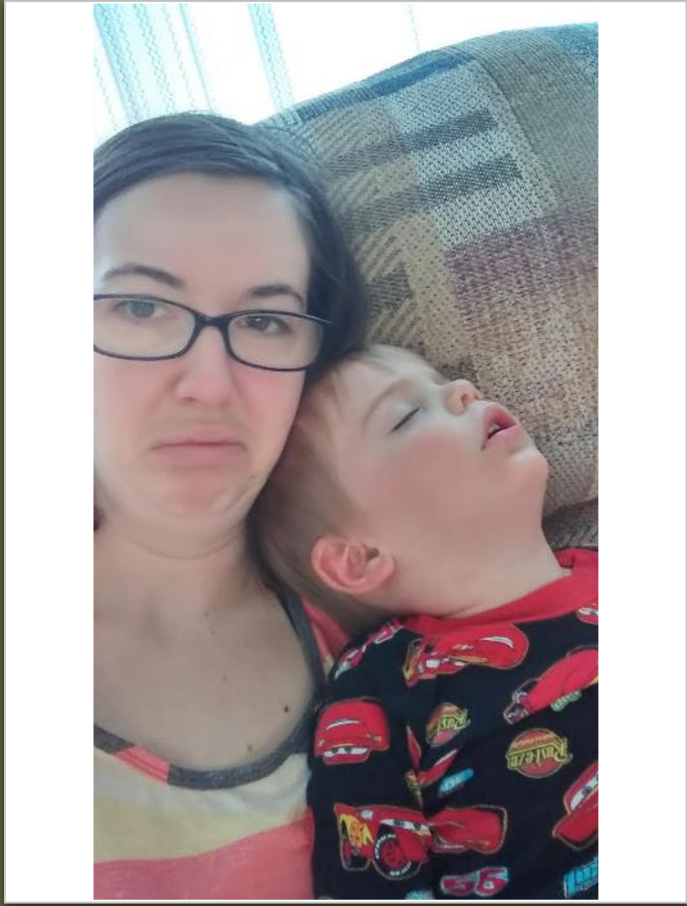






Jack









Jack McNaughton

Born : 2016

Belmont, MI

**Initial PFAS level in
blood: 484,000 ppt**

**Source: House St.
Dumpsite**

PFAS levels in Belmont boy's blood 50 times higher than national average



By: Rebecca Russell

Posted at 10:24 PM, Jan 10, 2018

and last updated 10:25 PM, Jan 10, 2018

BELMONT, Mich. -- A family who lives near an old Wolverine Worldwide

Lab Sample: 1701617-01 Date Analyzed: 21-Dec-1

VAL - PFAS

Analyte	Conc. (ng/mL)	Reporting Limit (ng/mL)
PFHxS	223	2.08
PFOA	241	2.08
PFOS	19.4	0.417
PFNA	1.03	0.417
PFDA	Not Detected	0.417
PFOSA	Not Detected	0.417
PFUnA	Not Detected	0.417
EtFOSAA	Not Detected	0.417
MeCF	Not Detected	0.417

BOY'S RESULTS: "UNBELIEVABLE" CONTAMINATED WATER



3M, Wolverine settle pollution lawsuit with Michigan family

Updated: Feb. 21, 2020, 4:43 p.m. | Published: Feb. 21, 2020, 4:07 p.m.



Seth and Tobyn McNaughton and their son, Jack, 2, at their home in Plainfield Township on Monday, March 5, 2018. (Neil Blake | MLive.com)

408 shares

By Garret Ellison | gellison@mlive.com

GRAND RAPIDS, MI – Wolverine World Wide and 3M have settled a lawsuit with a Michigan family [whose drinking water was poisoned](#) by toxic fluorochemicals that were in manufacturing waste dumped near their home





Thank you

togreen55@gmail.com



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

PFAS and Genetic Risk Factors for Hepatocellular Carcinoma (HCC)

Jesse Goodrich, PhD

Assistant Professor

Division of Environmental Health

Keck School of Medicine, University of Southern California

jagoodri@usc.edu

PFAS and Genetic Risk Factors for Hepatocellular Carcinoma (HCC)

*Plus: the importance of examining the health
effects of PFAS in diverse populations*

Jesse Goodrich, PhD

Assistant Professor

Division of Environmental Health

Keck School of Medicine, University of Southern California

jagoodri@usc.edu

Hepatocellular Carcinoma (HCC): An Epidemic

Hepatocellular carcinoma



Fourth leading cause of cancer death globally¹

Predominate form of liver cancer¹

Etiology



Non-alcoholic fatty liver disease



Viral hepatitis



Alcoholic fatty liver disease

Racial/Ethnic Disparities in HCC

- HCC rates are increasing in most groups in the USA, but there are differences by race/ethnicity
- HCC rates are increasing fastest in Hispanic populations compared to Blacks and non-Hispanic whites (Ajayi et al., *Curr Hepatol Rep.*, 2020)
- It is essential to examine how environmental factors, such as PFAS, may impact HCC risk differentially based on race or ethnicity

Overview: PFAS and Fatty Liver Disease

HEPATOLOGY 


ORIGINAL

Prenatal Exposure to Perfluoroalkyl Substances Associated with Increased Susceptibility to Liver Injury in Children

Nikos Stratakis, David V Conti, Ran Jin, Katerina Margetaki, Damaskini Valvi, Alexandros P. Siskos, Léa Maitre, Erika Garcia, Nerea Varo, Yinqi Zhao, Theano Roumeliotaki, Marina Vafeladi, Jose Urquiiza, Silvia Fernández-Barrés, Barbara Heude, Xavier Basagana, Maribel Casas, Serena Fossati, Regina Gražulevičienė, Sandra Andrušaitytė, Karan Uppal, Rosemary R. McEachan, Eleni Papadopoulou, Oliver Robinson, Line Småstuen Haug, John Wright, Miriam B. Vos, Hector C. Keun, Martine Vrijheid, Kiros T. Berhane, Rob McConnell, Lidada Chatzi  ... See fewer authors 

First published: 01 August 2020 | <https://doi.org/10.1002/hep.31483>



Perfluoroalkyl substances and severity of nonalcoholic fatty liver in Children: An untargeted metabolomics approach 

Ran Jin^a, Rob McConnell^a, Clöff Catherine^b, Shujing Xu^a, Douglas I. Walker^{c,d,1}, Nikos Stratakis^a, Dean P. Jones^a, Gary W. Miller^{a,2}, Cheng Peng^a, David V. Conti^a, Miriam B. Vos^{b,c,3}, Leda Chatzi^{b,c,3}

 Environmental Health Perspectives

Vol. 130, No. 4 | Review

Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis

 is companion of 

Invited Perspective: PFAS and Liver Disease: Bringing All the Evidence Together

Elizabeth Cossetto^{EE}, Sarah Rock, Nikos Stratakis, Sandra P. Eikel, Douglas I. Walker, Damaskini Valvi, Dora Cserbik, Todd Jenkins, Stavra A. Xanthakos, Rohit Kohli, Stephanie Sisley, Vasilis Vasilidou, Miznele A. Le Merrill, Hugo Rosen, David V. Conti, Rob McConnell, and Leda Chatzi

Toxicologic Pathology
Volume 43, Issue 4, June 2015, Pages 558-568
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<https://doi.org/10.1177/0192623114558463>

 journals

Perfluorooctanoic Acid (PFOA)-induced Liver Lesions in Two Strains of Mice Following Developmental Exposures: PPAR α Not Required

Adam J. Filgo^{1,2}, Erin M. Quist^{2,3,4}, Mark J. Hoenerhoff⁴, Amy E. Brix⁵, Grace E. Kissling⁶, and Suzanne E. Fenton²

PFAS can impact fatty liver disease, an important risk factor for the development of HCC

Epidemiological Studies Linking Blood PFAS and Liver Cancer

Eriksen et al., J Natl Cancer Inst, 2009 (Danish Cancer Registry):

- Number of Liver Cancer Patients: 67, Northern European
- PFAS assessed: 2 (PFOA and PFOS)
- Findings: No association between PFOA/PFOS and liver cancer

Goodrich et al., JHEP Reports, 2021 (The Multiethnic Cohort Study):

- Number of Liver Cancer Patients: 50, Predominately Hispanic/Japanese American
- PFAS assessed: 6 (PFOA, PFOS, PFHxS, PFNA, PFUnDA, PFDA)
- Findings: High PFOS levels associated with higher HCC risk

Cao et al., Chemosphere, 2022 (Zhejiang, China, Cross Sectional):

- Number of Liver Cancer Patients: 203, Predominately Chinese
- PFAS assessed: 12 (PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFBS, PFHxS, PFOS, 6:2 Cl-PFES, 8:2 Cl-PFES)
- Findings: PFOS associated with higher liver cancer risk

Increasing evidence suggests that PFAS may increase HCC risk, but longitudinal human studies with large sample sizes are lacking, and it is unclear how other risk factors may impact this risk

Increasing Evidence Links PFAS With HCC Risk, But Gaps Remain

- Existing studies:
 - Have small sample sizes and/or are cross-sectional
 - Examine a limited set of PFAS
 - Lack diverse populations
 - Don't examine how other HCC risk factors, such as race/ethnicity or genetics may alter susceptibility

To address these gaps, we are currently working on a follow-up study to our previous study in the Multiethnic Cohort Study (MEC)



The Multiethnic Cohort Study

Understanding ethnic differences in cancer to prevent it in all populations



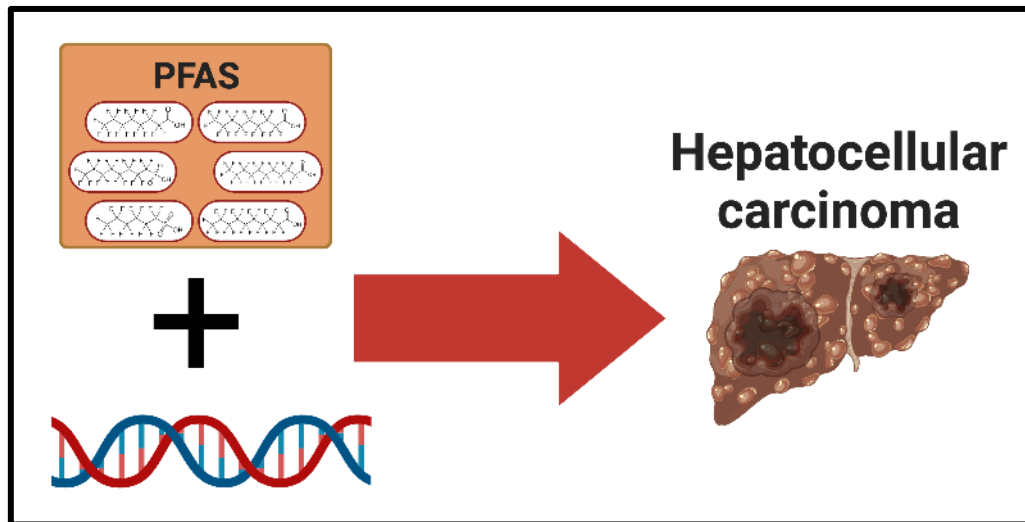
Multiethnic
cohort

Nested case
control study

- >200,000 participants from Southern California and Hawaii
- Goal: to create an ethnically diverse cancer cohort
- Five ethnic groups targeted: African Americans, Latinos, Japanese, whites, Hawaiians
- Incident cancer cases were identified over 20+ years using the SEER registry

Study Design: PFAS Screening, Interactions with HCC risk factors

- **Sample Size:** 240 HCC Cases, 240 Matched Controls:
 - Cases and controls matched by birth year, date of blood collection (+/- 6 months), sex, race/ethnicity, fasting status, and study area.
- **Expanded set of PFAS:** Untargeted PFAS screening (measured through the Human Health Exposure Analysis Resource, HHEAR, Project #: 2020-00500)
- **Goal:** Examine how PFAS interact with other risk factors, including genetics, to increase HCC risk



Wendy Setiawan, PhD



Leda Chatzi, MD,
PhD



Hongxu Wang, M.S.

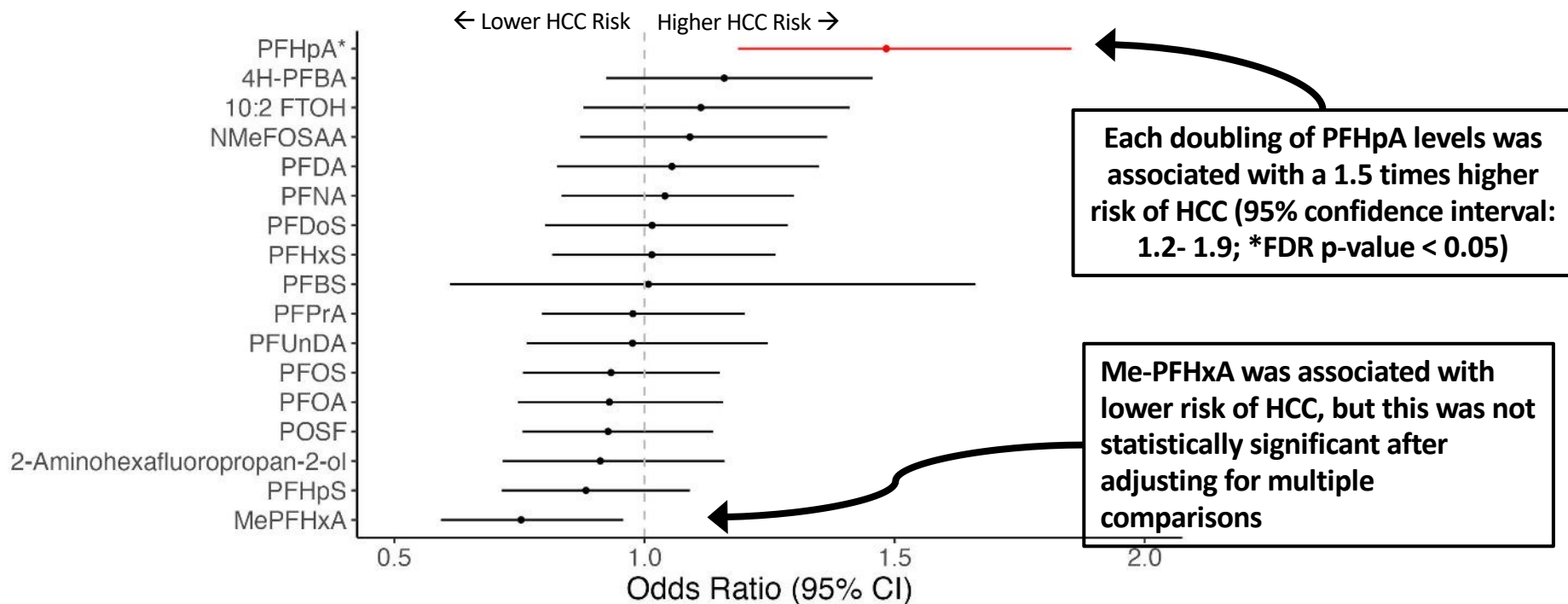
Methods: Untargeted PFAS Assessment: Suspect Screening

- **New analytical method** using liquid-chromatography-high resolution mass-spectroscopy (LC-HRMS) was used to assess a large number of PFAS chemicals
- **Strengths:**
 - Greater number of PFAS assessed: 17 detected
 - Provides information for future targeted assays
- **Limitations:** Relative concentrations limit the ability to generalize to other populations

Study Population

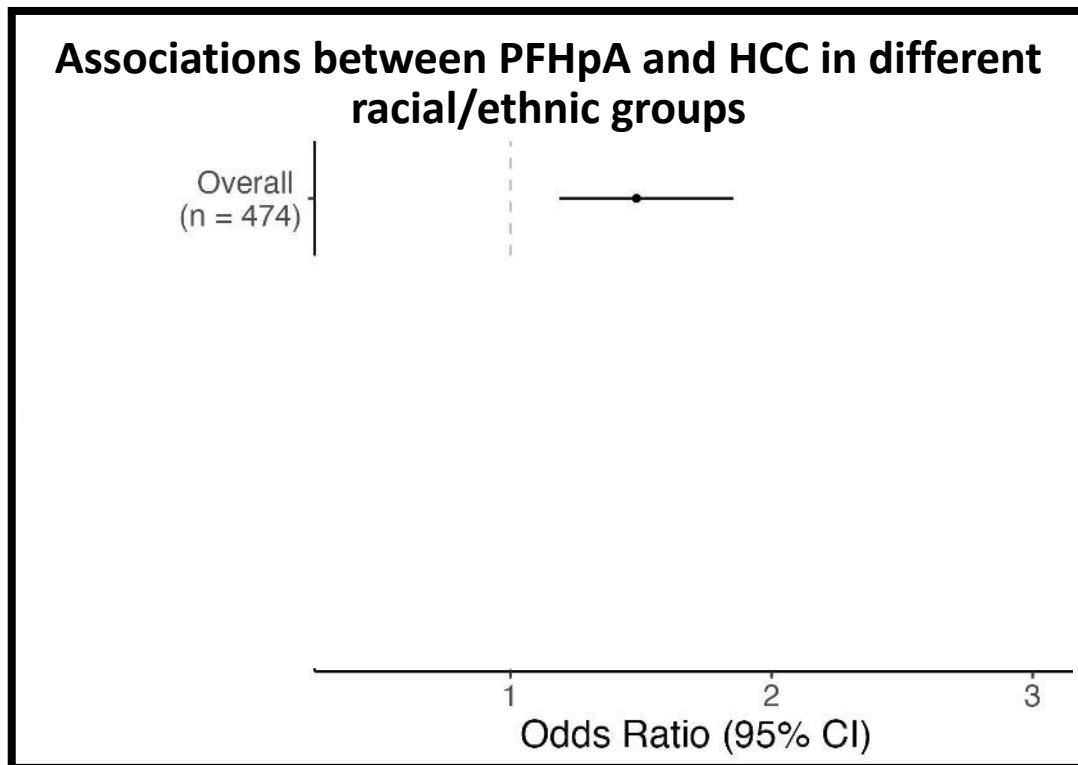
	Control	HCC Case
Sample Size	240	240
Age at blood draw, mean, (SD)	68.4 (7.39)	68.4 (7.48)
History of Diabetes, n (%)	19 (7.9%)	53 (22.1%)
BMI(kg/m²)		
<25	83 (34.6%)	55 (22.9%)
25-30	110 (45.8%)	105 (43.8%)
≥30	47 (19.6%)	77 (32.1%)
<i>Missing</i>	0 (0%)	3 (1.3%)
Alcohol intake (g/day)		
0	114 (47.5%)	118 (49.2%)
<12	70 (29.2%)	65 (27.1%)
≥12	56 (23.3%)	57 (23.8%)
Smoking status		
<i>Never</i>	94 (39.2%)	68 (28.3%)
<i>Former</i>	114 (47.5%)	121 (50.4%)
<i>Current</i>	29 (12.1%)	45 (18.8%)
<i>Missing</i>	3 (1.3%)	6 (2.5%)
Race/ethnicity		
<i>White</i>	24 (10.0%)	24 (10.0%)
<i>African American</i>	26 (10.8%)	26 (10.8%)
<i>Japanese American</i>	92 (38.3%)	92 (38.3%)
<i>Latino</i>	81 (33.8%)	81 (33.8%)
<i>Native Hawaiian</i>	17 (7.1%)	17 (7.1%)

RESULTS Associations Between Plasma PFAS and HCC Risk



RESULTS PFHpA and HCC Risk by Race/Ethnicity

- In all participants, each doubling of PFHpA was associated with a 1.5 times higher risk of HCC
- However, when rerunning this analysis stratified by race/ethnicity, we saw that this association was being driven by Latino, Japanese American, and to a lesser degree, African American populations

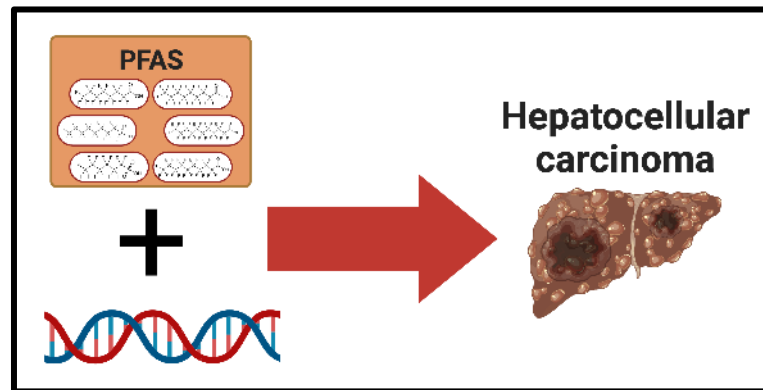


What drives differences in PFAS susceptibility between groups?

Other Environmental Risk Factors? Genetic susceptibility? Both?

Potential contributing factor: Genetic Risk

- *PNPLA3* is a gene that plays a role in lipid metabolism in the liver
- *PNPLA3*-I148M genetic variant:
 - Strongest individual genetic risk factor for HCC (Hassan et al., 2013)
 - Higher prevalence in individuals of Hispanic/Latino or Japanese American ancestry (~40-50%) compared to African American (~10%) or Northern European ancestry (~20%; Romeo et al., 2009)

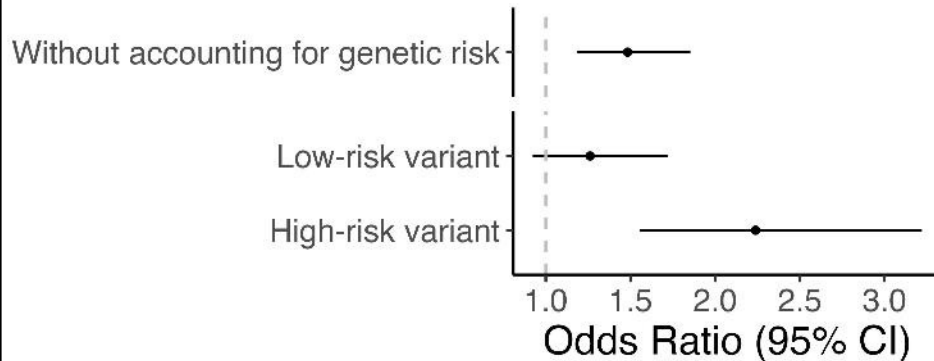


Hypothesis: Individuals with the *PNPLA3*-I148M variant would be more susceptible to PFHpA exposure because both impact hepatic lipid metabolism

RESULTS Interactions Between PFHpA and *PNPLA3*-I148M Variant

- **If we don't account for this genetic variant:**
Each doubling of PFHpA increases HCC risk by 1.48 (1.19, 1.85)
- **For people with high-risk polymorphism:** PFHpA increases HCC risk by 2.24 (1.56, 3.22).
- **For people with low-risk polymorphism:** PFHpA only increases HCC risk by 1.26 (0.92, 1.72).
- These findings were after accounting for genetic ancestry

Associations of PFHpA levels with HCC risk overall (not accounting for genetic risk), and in individuals with and without the *PNPLA3*-I148M high risk genetic variant



Summary and Discussion

- These results are the first to demonstrate that genetic factors may interact with PFAS exposure to increase risk of HCC
- Although not the case with many genetic variants, the *PNPLA3*-I148M variant is more common in individuals of Latino/Hispanic and Japanese American ancestry
- This raises the possibility that *PNPLA3*-I148M may play a role in our results demonstrating that PFHpA was only associated with HCC risk in individuals self-identifying as Latino/Hispanic or Japanese American.
- Our work demonstrates how critical it is to include diverse populations when studying the health effects of PFAS (especially on the liver)

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**NATIONAL
PFAS
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JUNE 9-12, 2024 • ANN ARBOR, MI



PFAS, EPIGENETICS, AND FIREFIGHTER HEALTH

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UNIVERSITY OF MICHIGAN

DEPT. OF ENVIRONMENTAL HEALTH SCIENCES

Overview

What is epigenetics?

Link between PFAS, epigenetics, & health

PFAS and epigenetics in firefighters

PFAS and Cancer

International Agency for Research on Cancer (IARC) named PFOA a group 1 carcinogen in 2023 and PFOS a group 2b ('possible carcinogen')

	PFOA	PFOS
IARC GROUP	Group 1 Carcinogenic to humans	Group 2B Possibly carcinogenic to humans
EVIDENCE	Sufficient evidence for cancer in animals and strong mechanistic evidence in exposed humans: Epigenetics Immunosuppression	Strong mechanistic evidence in exposed humans: Epigenetics Immunosuppression
LIMITED EVIDENCE	Limited evidence for cancer in humans (nasopharyngeal carcinoma and testicular cancer)	
MAIN USES	Historically, production of fluoropolymers and stain-, oil-, and water-resistant surface treatments. Today, uses are limited by the Stockholm Convention and other regulations.	Historically, manufacture of electric and electronic parts, stain-, oil-, and water-resistant surface treatments, and firefighting foams. Today, uses are limited by the Stockholm Convention and other regulations.
EXPOSURES	General population, mainly by contaminated drinking-water and food, and potentially consumer products. Workers producing and using fluorochemicals.	General population, mainly by contaminated drinking-water and food, and potentially consumer products. Workers producing and using fluorochemicals, and firefighters.

Firefighting and Cancer

IARC named firefighting a group 1 carcinogen in 2023

Epigenetics as a mechanism

International Agency for Research on Cancer
World Health Organization

IARC MONOGRAPHS VOL. 132: OCCUPATIONAL EXPOSURE AS A FIREFIGHTER

Occupational exposure as a firefighter is **carcinogenic to humans (Group 1)** on the basis of **sufficient evidence for cancer in humans**

GROUP 1 GROUP 2A GROUP 2B GROUP 3

The IARC Monographs classification indicates the level of certainty that an agent can cause cancer (*hazard identification*)

Higher level of certainty Lower level of certainty

Cancer types with **sufficient evidence** for cancer in humans:

Mesothelioma Bladder cancer

Cancer types with **limited evidence** for cancer in humans:

Colon cancer Prostate cancer Testicular cancer Melanoma of the skin Non-Hodgkin lymphoma

Strong mechanistic evidence in exposed firefighters

Genotoxicity Epigenetic alterations Oxidative stress Chronic inflammation Modulation of receptor-mediated effects

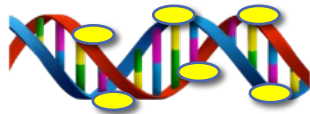
Exposures of firefighters include combustion products, diesel exhaust, building materials, asbestos, chemicals, shift work, ultraviolet radiation

Firefighters respond to various types of fire

Structure Wildland Vehicle

Genetics vs. Epigenetics

Genome

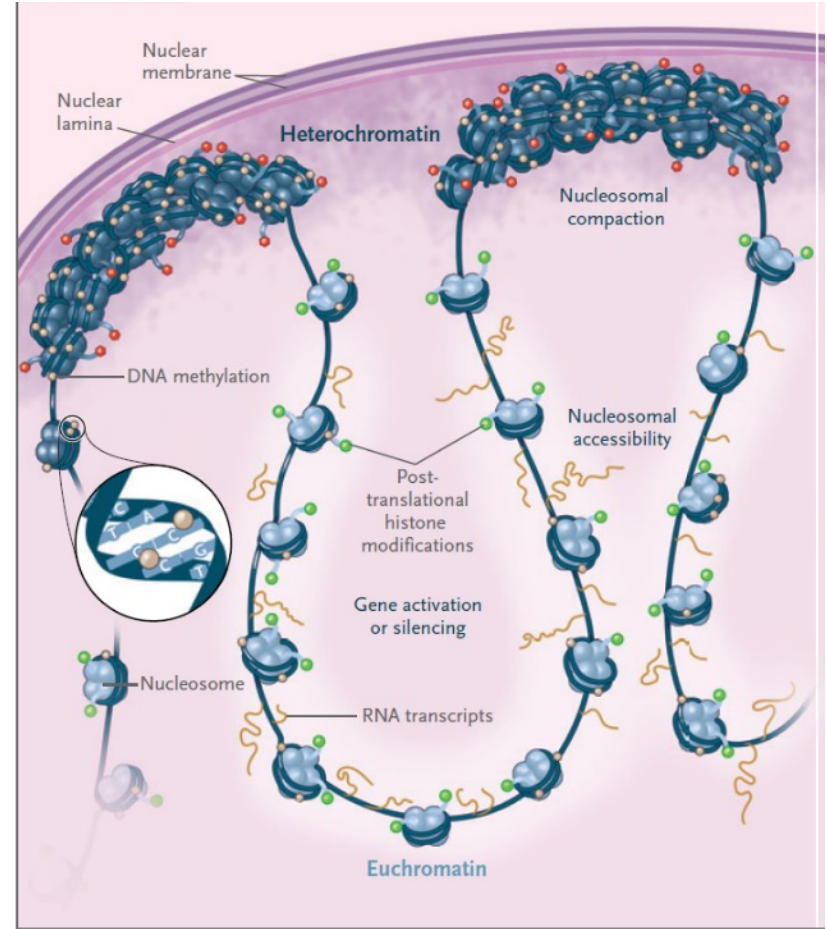


Epigenome



Epigenetics: Definition

Heritable (and potentially *reversible*) changes in gene function that occur without a change in the sequence of nuclear DNA

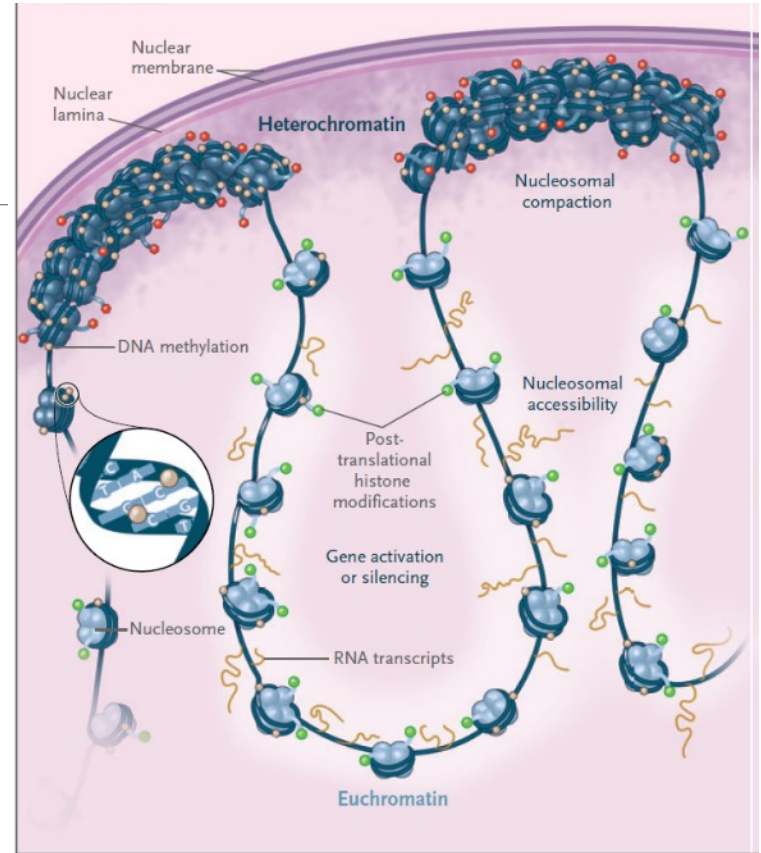


Types of Epigenetic Modifications

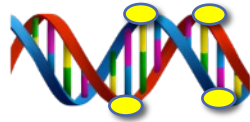
DNA Methylation

Histone Modifications

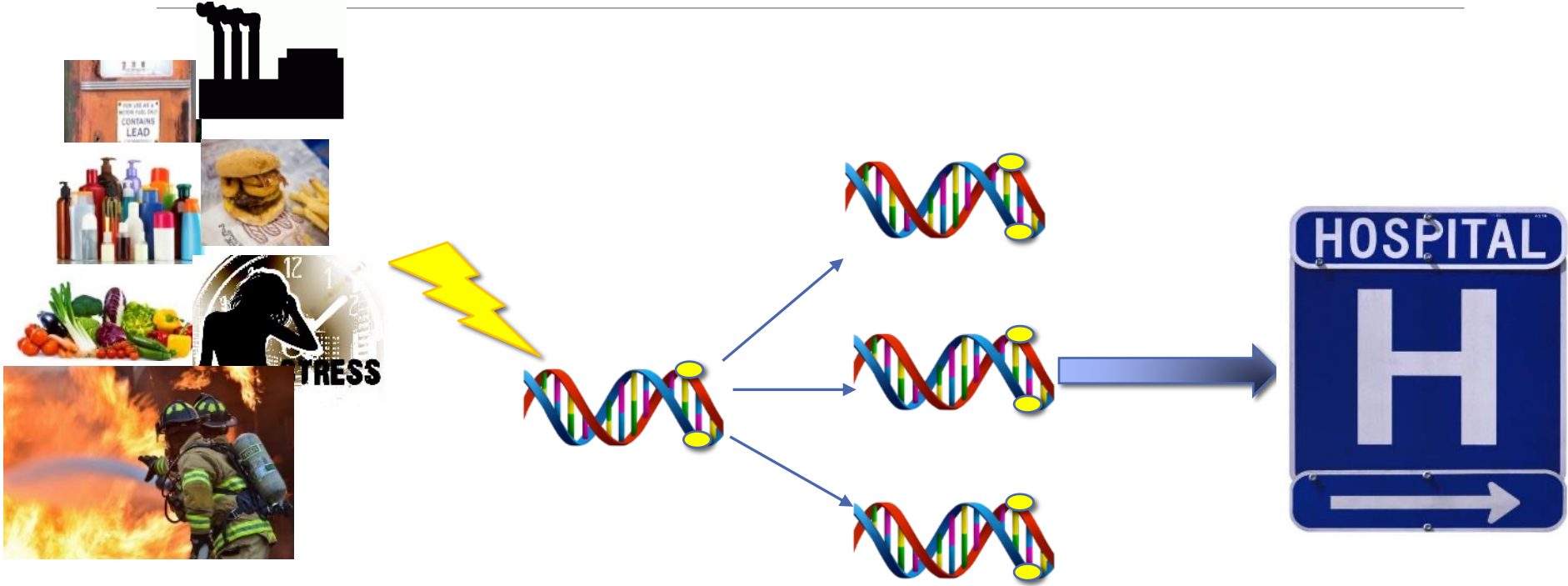
Non-coding RNA (including micro-RNAs)



What can go wrong with the epigenome?



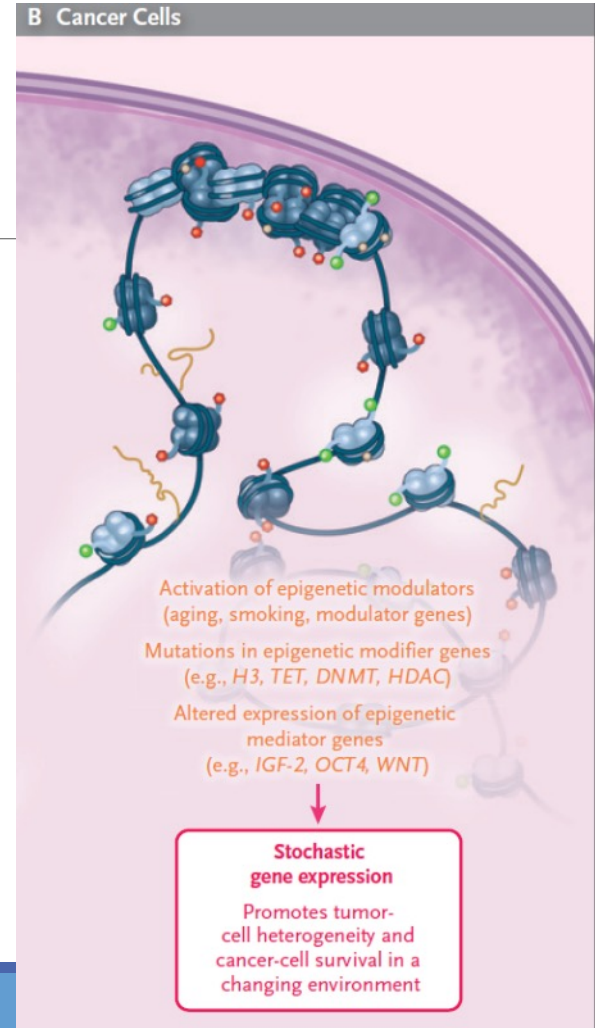
Environmental Exposures Impact the Epigenome



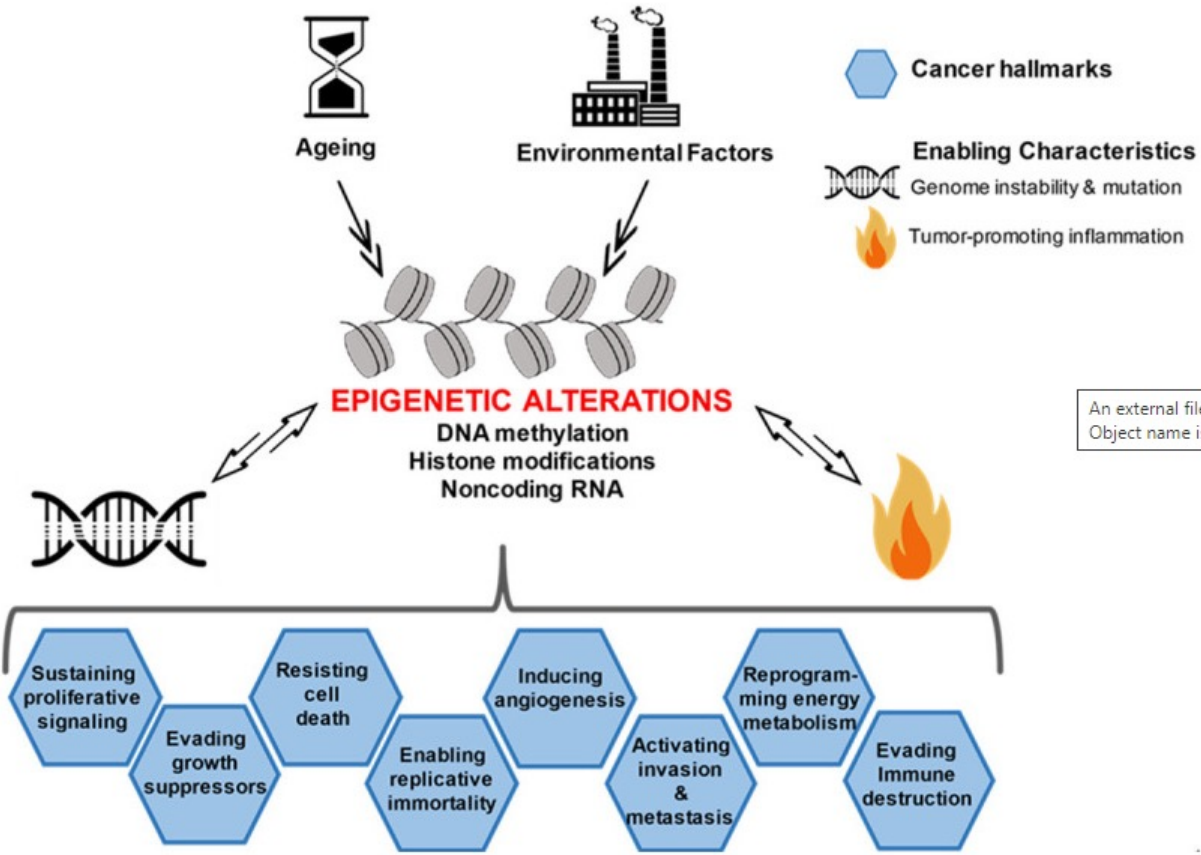
Cancer Epigenome

Cancer is an 'epigenetic disease'

Epigenetic profiles are widely altered in cancerous cells compared to healthy cells



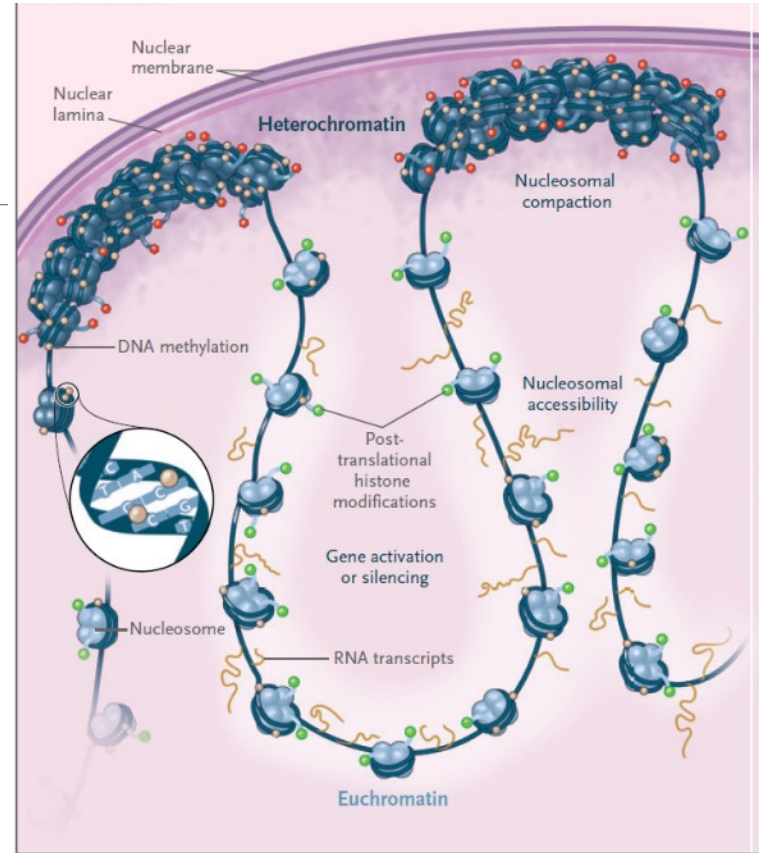
Epigenetic Changes Contribute to the Hallmarks of Cancer



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Object name is ajc

Epigenetics and Health

- Epigenetic dysregulation implicated in
 - Cardiovascular disease
 - Neurological disorders
 - Developmental disorders
 - Aging
 - Autoimmune diseases
 - And more



What do we know so far?

PFAS and firefighting in general are linked to cancers and other adverse health outcomes.

Epigenetic alterations underlie cancers and other adverse health outcomes.

A growing body of evidence links PFAS exposures to epigenetic alterations, especially DNA methylation, in experimental models and human studies.

PFAS and Firefighters



FIRE FIGHTER CANCER COHORT STUDY (FFCCS)

MISSION

To conduct community-engaged research with the fire service to advance firefighter cancer control and prevention, as well as evaluation and prevention of other health conditions.

TARGET GOAL

10,000 firefighters enrolled and followed over 30 years.

FIRE SERVICE

PARTNERSHIP

Fire Service Oversight and Planning Board and firefighter research champions in each research project.



BIOLOGICAL SAMPLES

Collect blood, urine, and other biological samples at enrollment, every two years, and as needed after exposures. Report back results to firefighters.



EXPOSURE DATA

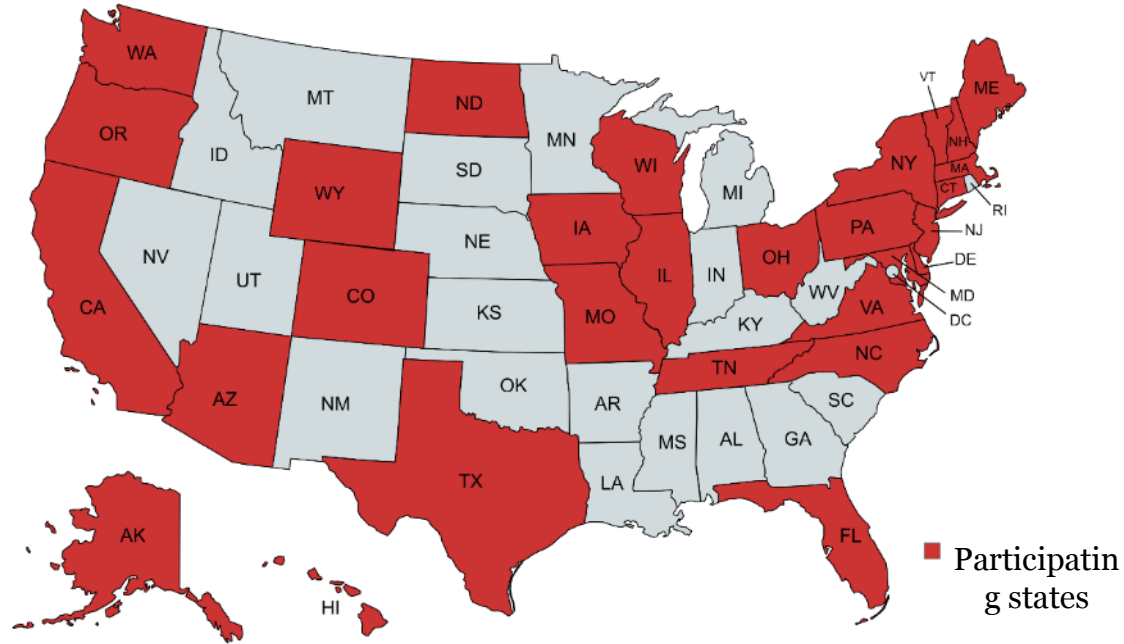
Collect exposure data from firefighters at the fireground, during training activities, and at other locations.

DATA INTEGRATION

Integrate exposure, biological and health survey data through a centralized data center.

FFCCS Enrollment (as of March 2024)

- >5,000 total participants
- >100 departments
- 29 states
- Incumbents & recruits
- >900 women firefighters
- >700 volunteer firefighters
- >500 wildland firefighters
- ~200 airport firefighters




PFAS Research with the FFCCS

1. > 200 structural firefighters



PFAS

2. 100 incumbent and 50 new recruit firefighters



PFAS

2 years

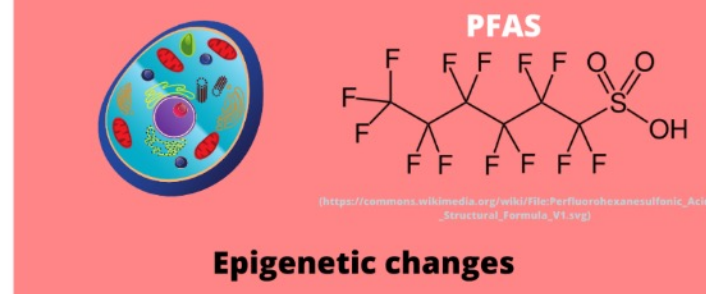
3. ~200 ARFF firefighters



PFAS

ARFF RESCUE 345

4. *In vitro* and chronic human toxicity



PFAS

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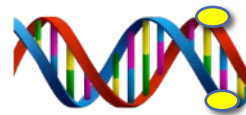
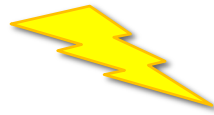
(https://commons.wikimedia.org/wiki/File:Perfluorohexanesulfonic_Acid_Structural_Formula_V1.svg)

Epigenetic changes

PFAS and Epigenetics in Firefighters: Research Question #1



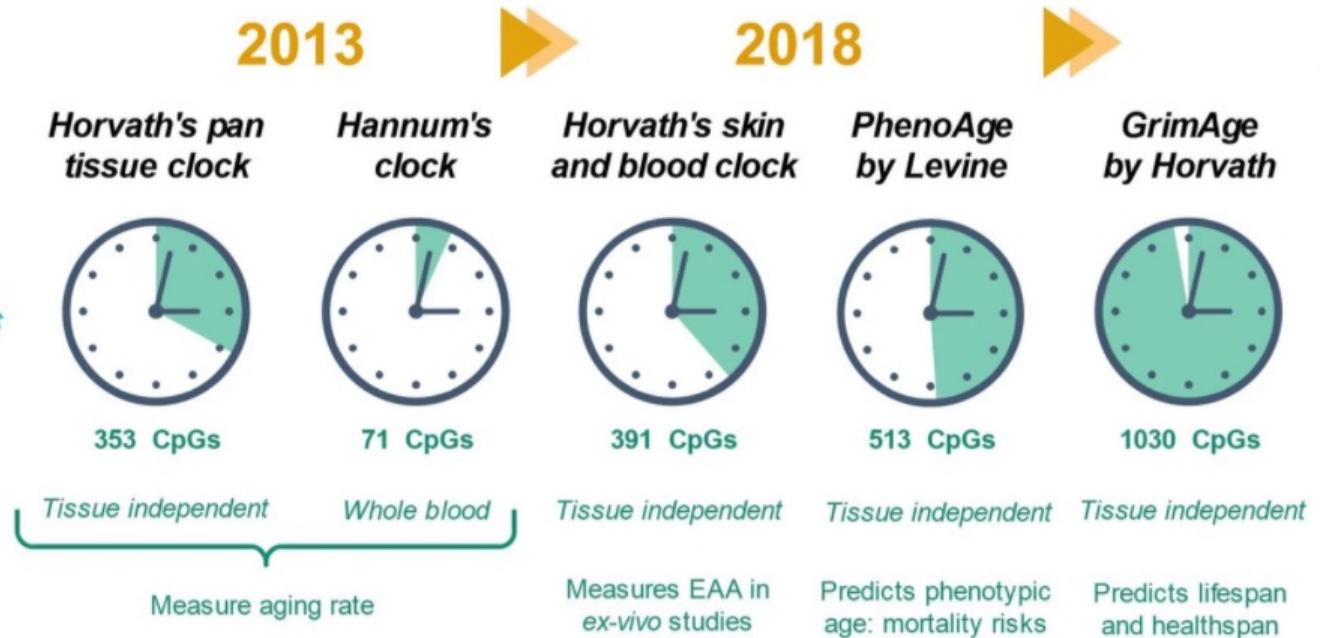
Do exposures to PFAS accelerate epigenetic age?



Epigenetic Age: A Marker of Biological Age

DNA methylation at certain regions is predictive of age

‘Epigenetic clocks’ have been developed from DNA methylation data that approximate biological aging





Serum PFAS Concentrations among Structural Firefighters

Abbreviation	Full Name	% Above LOD	Geometric Mean	95% CI
PFHxS	perfluorohexane sulfonate	100	2.50	(2.29, 2.74)
n-PFOA	linear perfluorooctanoate	100	1.79	(1.68, 1.89)
Sb-PFOA	sum of branched isomers of perfluorooctanoate	31.0	<LOD	<LOD
n-PFOS	linear perfluorooctane sulfonate	100	4.02	(3.74, 4.32)
Sm-PFOS	sum of perfluoromethylheptane sulfonate isomers	100	2.06	(1.91, 2.23)
PFNA	perfluorononanoate	98.5	0.44	(0.41, 0.48)
PFDA	perfluorodecanoate	99.0	0.23	(0.22, 0.25)
PFUnDA	perfluoroundecanoate	66.0	0.12	(0.11, 0.13)
MeFOSAA	2-(N-methyl-perfluorooctane sulfonamido) acetate	27.9	<LOD	<LOD



Results: Some PFAS chemicals were linked to accelerated epigenetic age (in blue)

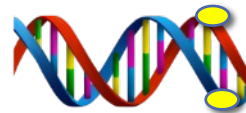
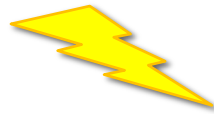
PFAS	IEAA	EEAA	Horvath	Hannum	PhenoAge	SkinBlood Clock	GrimAge
PFHxS	0.77 (0.5)	1.05 (0.44)	0.93 (0.5)	0.97 (0.4)	0.58 (0.57)	1.13 (0.4)	0.49 (0.27)
n-PFOA	2.12 (0.71)	1.57 (0.63)	2.28 (0.71)	1.45 (0.58)	1.62 (0.82)	1.71 (0.58)	0.16 (0.39)
Sb-PFOA	0.63 (0.69)	0.09 (0.60)	0.70 (0.69)	0.08 (0.56)	0.23 (0.78)	0.49 (0.55)	-0.3 (0.36)
n-PFOS	0.8 (0.68)	0.83 (0.6)	1.04 (0.68)	0.77 (0.55)	-0.36 (0.77)	0.46 (0.55)	0.65 (0.36)
Sm-PFOS	1.69 (0.65)	0.97 (0.57)	1.85 (0.64)	0.89 (0.53)	-0.18 (0.74)	0.88 (0.53)	0.6 (0.34)
PFNA	0.03 (0.64)	-0.11 (0.56)	0.09 (0.64)	-0.1 (0.52)	-0.73 (0.72)	-0.34 (0.51)	-0.18 (0.34)
PFDeA	-0.63 (0.7)	-0.18 (0.61)	-0.43 (0.7)	-0.16 (0.57)	-0.6 (0.79)	-0.71 (0.56)	-0.91 (0.36)
PFUA	0.09 (0.62)	-0.72 (0.54)	0.03 (0.62)	-0.67 (0.5)	-0.47 (0.7)	-0.57 (0.5)	-0.76 (0.33)
MEFOSAA	0.45 (0.67)	-0.87 (0.59)	0.47 (0.67)	-0.81 (0.54)	-0.69 (0.76)	-0.27 (0.54)	0.32 (0.36)

Color Key
+ association, p<0.05
+ association, p>0.05
- association, p>0.05
- association, p<0.05

PFAS and Epigenetics in Firefighters: Research Question #2



Are PFAS exposures associated with DNA methylation and at which genes? Are these genes in pathways relevant to cancer, immune function, or other disease states?



Results: PFAS and DNA Methylation

PFAS	Significant CpG Sites ($p < 9e^{-8}$)	Significant regions of consecutive CpG sites
PFHxS	0	0
n-PFOA	0	0
Sb-PFOA*	1 (<i>CAPN12</i>)	1
n-PFOS	1 (<i>RAD1</i>)	1
Sm-PFOS	0	0
PFNA	0	59
PFDA	2 (<i>TUBD1</i> & intergenic)	2
PFUnDA*	1 (<i>LOC339529</i>)	1
MeFOSAA*	0	0

Associations between PFAS concentrations and total DNA methylation levels at >740,000 CpG sites (individually and in regions)

*Modeled as categorical (detect vs. not)

Results: PFAS were linked to altered DNA methylation at specific genes



- Genes involved in cancer processes:
 - snoRNAs, the oncogene *POU5F1*, and more (*CAPN12*, *RAD1*, *DDR1*, *RAB37*, *PASK*, *RGS7*, *RAPGEF1*, *MIPOL1*, *TNFAIP8L3*, *PCAT18*)
- Genes involved in immune function:
 - *IL32*, *SLFN12*, *CCL8*, and more

Take Home Points

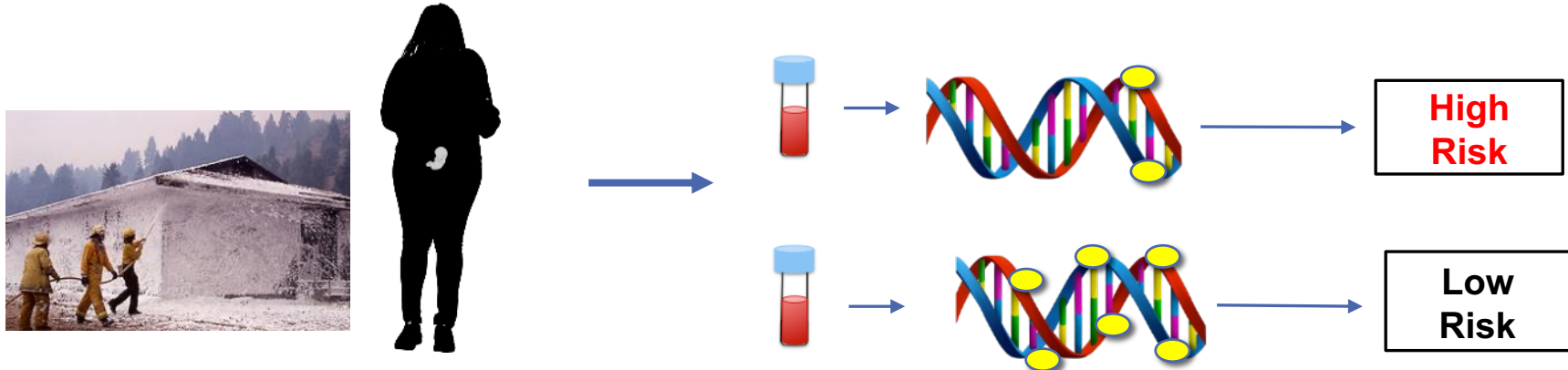
Epigenetics modifications are responsive to environmental exposures and contribute to development of many diseases.

PFAS are associated with accelerated epigenetic and gene-specific total DNA methylation (in firefighters)

Utility of Epigenetic Biomarkers

Research on exposures and epigenetics may inform:

- Risk assessment of potential hazardous substances
- Understanding of mechanisms of toxicity
- Development of prevention/intervention strategies to protect health



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Darin Wallentine

Jeff Hughes

Charles Popp

A photograph of firefighters in full gear, including helmets and oxygen tanks, standing in front of a large fire. The scene is filled with bright orange and yellow flames and thick smoke. The firefighters are seen from behind, looking towards the fire.

Fire Fighter Cancer Cohort Study

<https://ffccs.org>



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Targeting Mechanisms by which PFAS Induce Platinum Resistance in Ovarian Cancer

Brittany Rickard, Ph.D.

6/11/2024

National PFAS Conference



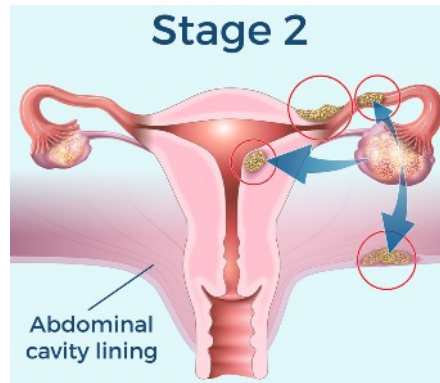
SCHOOL OF
MEDICINE

Overview of Ovarian Cancer

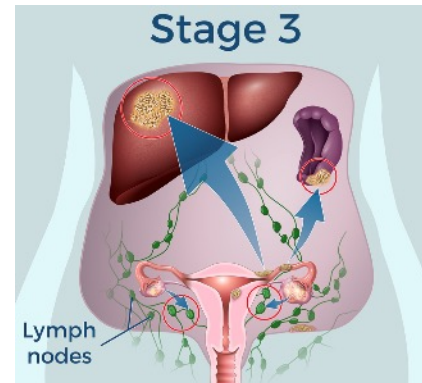
- Ovarian cancer is the most lethal gynecologic malignancy with a mortality rate of ~65%
 - In 2024, 19,680 new cases are expected, while 12,740 patients will succumb to the disease¹
- High lethality rate results from lack of early detection methods resulting in advanced-stage diagnoses



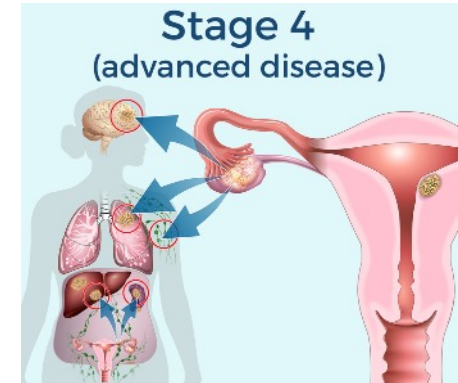
5-year survival: 89%



5-year survival: 71%



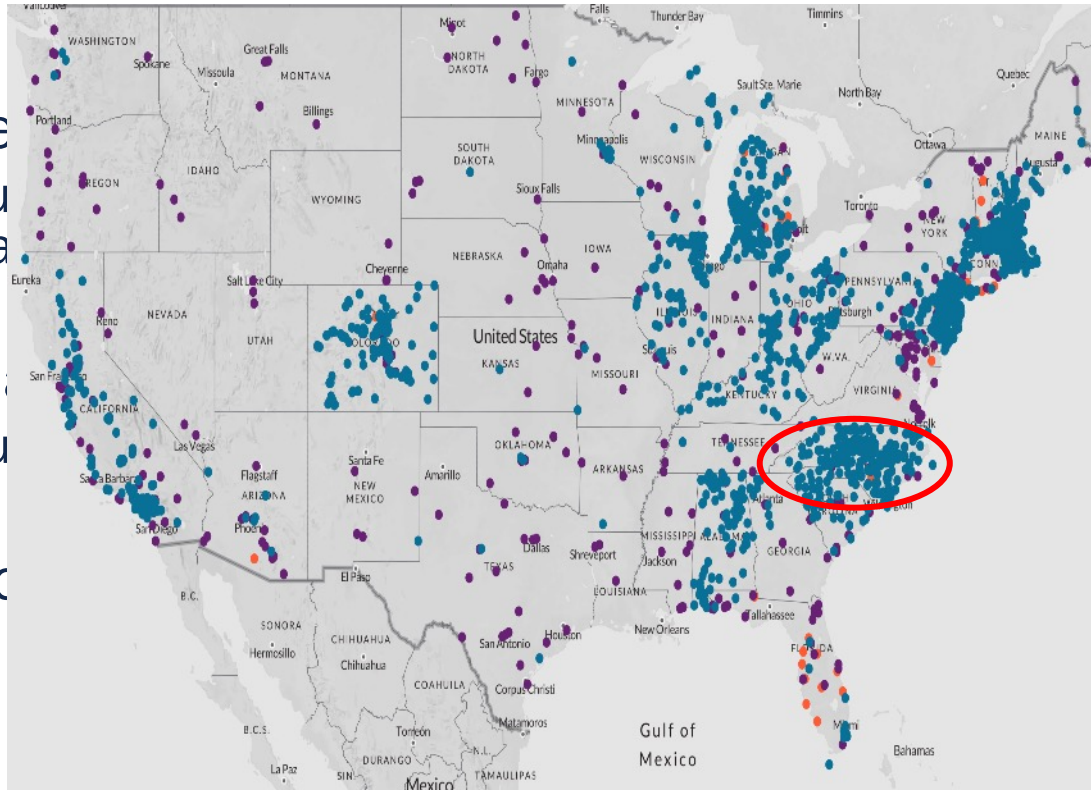
5-year survival: 41%



5-year survival: 20%

Environmental Contaminants Influence Therapy Response

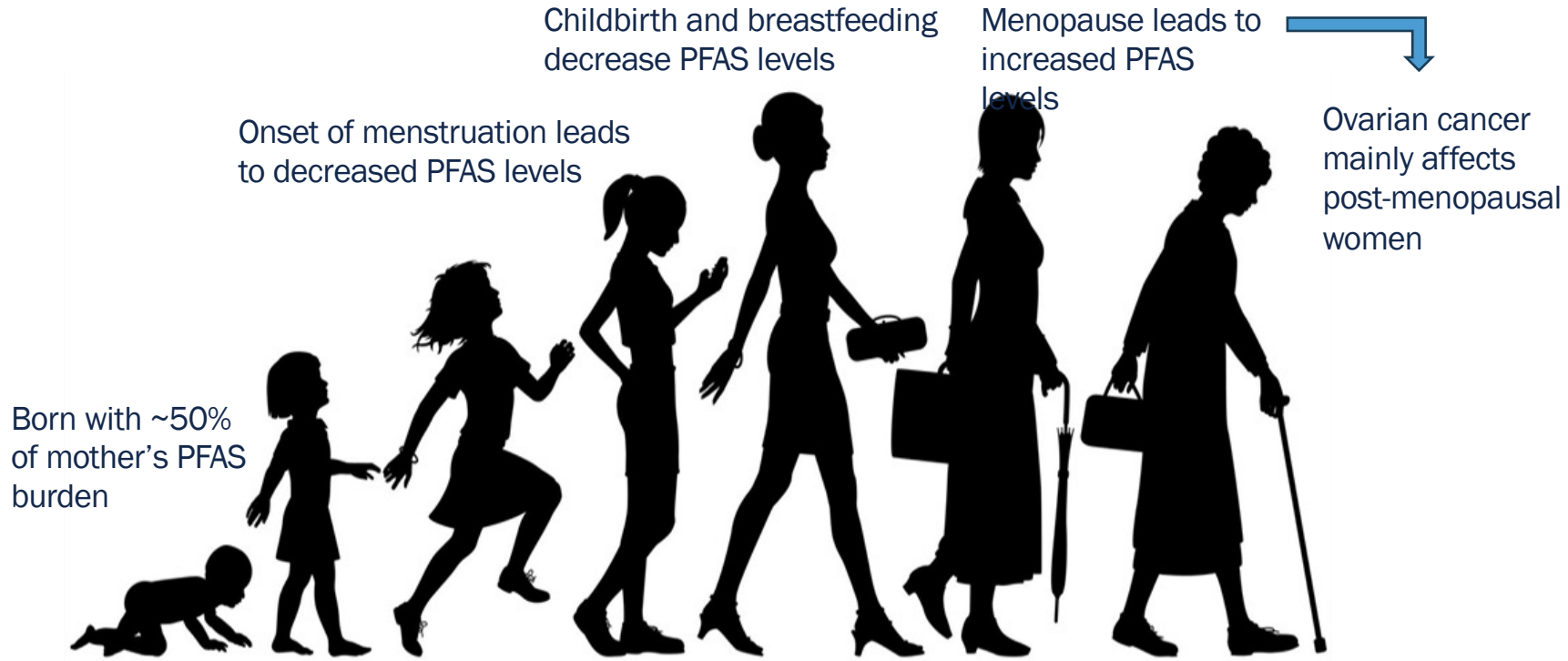
- Bisphenol A
- Industrial solvents
- Phthalates
- Industrial byproducts
- Perfluorinated compounds



stine in

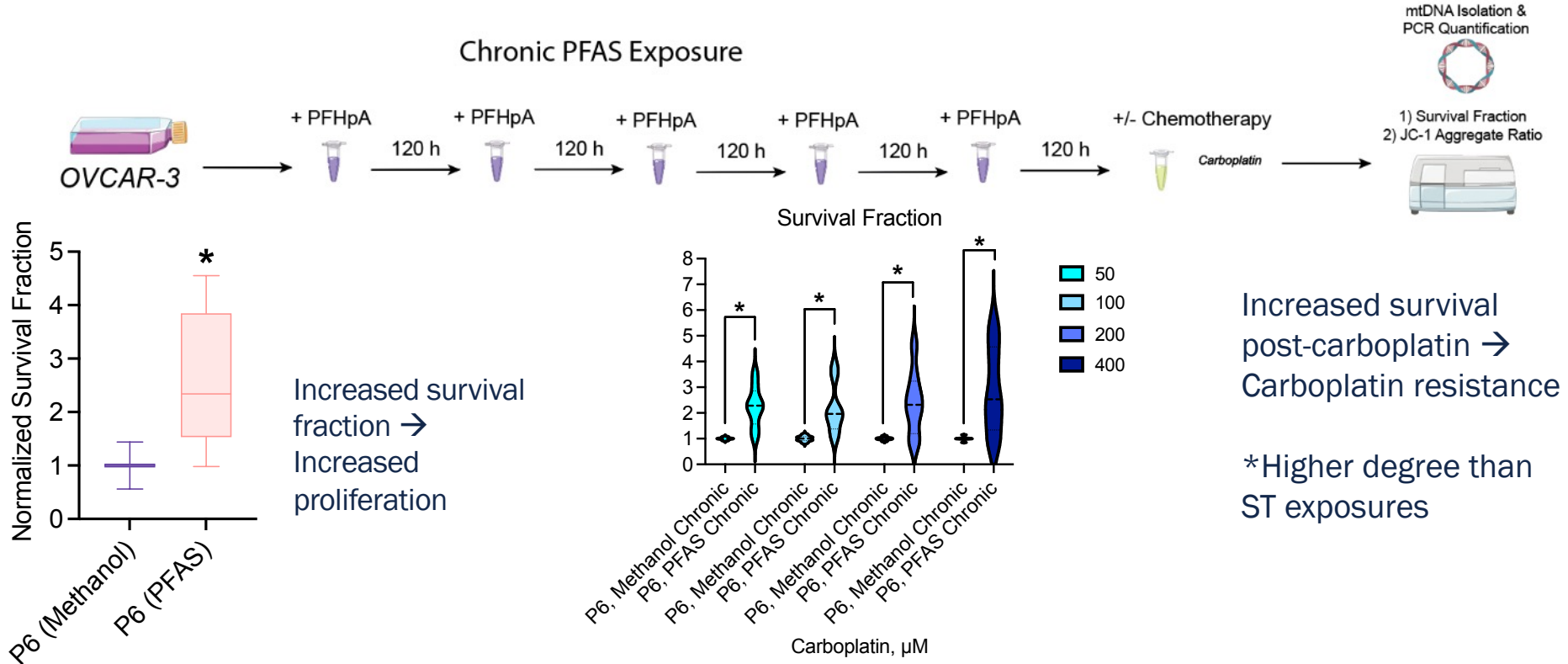
Endocrine Disrupting Chemicals (EDCs)

PFAS Levels Change Over a Woman's Lifetime

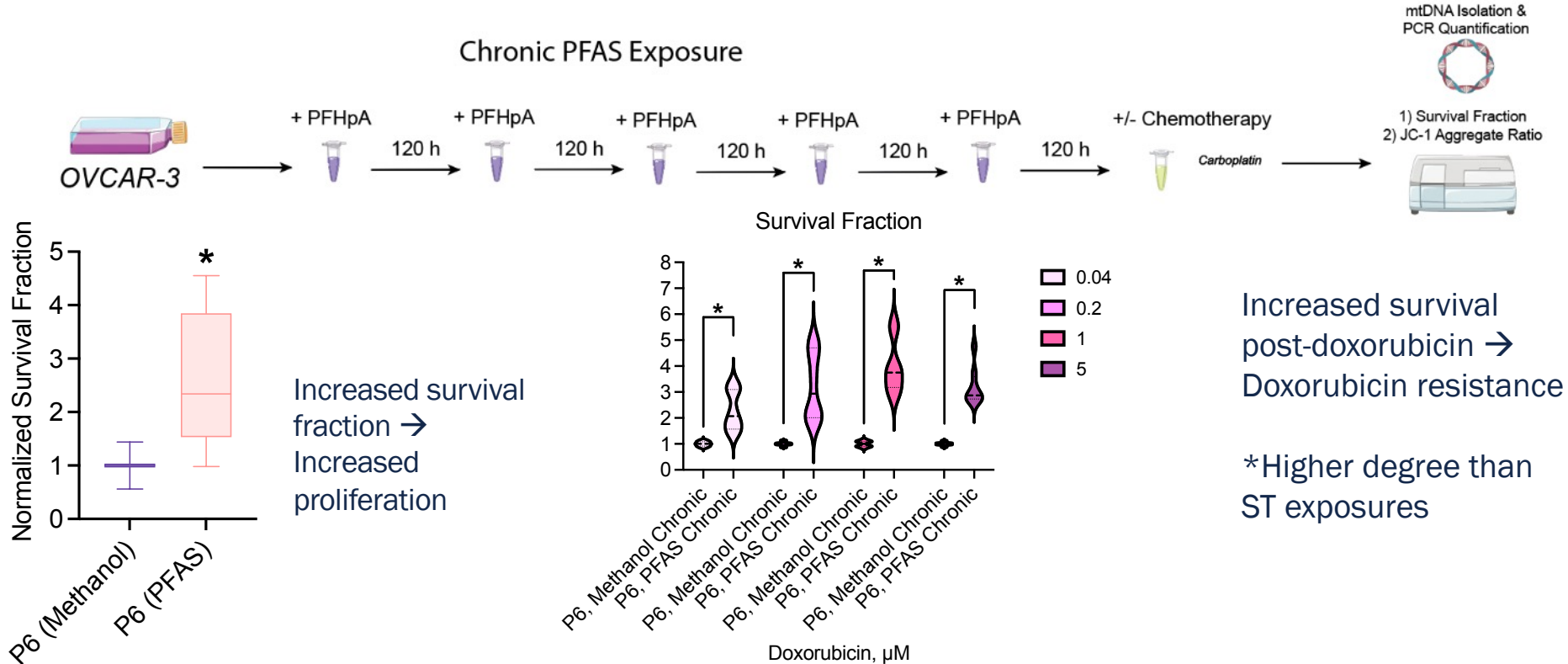


¹ Rickard et al. Int. J. Mol. Sci. (2022)

Chronic Exposure of Ovarian Cancer Cells to PFAS (PFHpA)



Chronic Exposure of Ovarian Cancer Cells to PFAS (PFHpA)



What We Know So Far...

- ✓ PFAS impact female reproductive health
- ✓ Select PFAS induce chemotherapy resistance

? Mechanism of chemoresistance

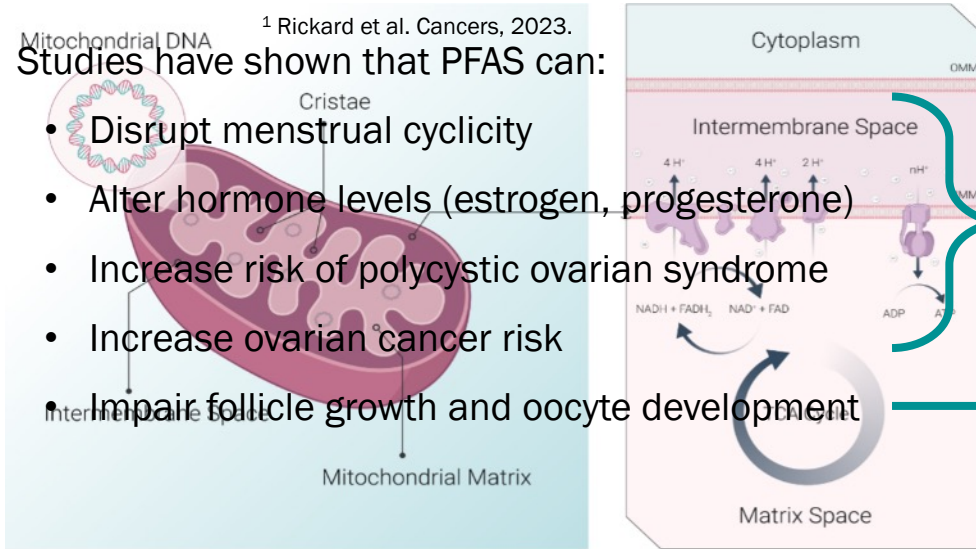
? Treatment approach for PFAS-induced chemoresistance

Target Organelles of PFAS in the Ovary

¹ Rickard et al. *Cancers*, 2023.

Studies have shown that PFAS can:

- Disrupt menstrual cyclicity
- Alter hormone levels (estrogen, progesterone)
- Increase risk of polycystic ovarian syndrome
- Increase ovarian cancer risk
- Impair follicle growth and oocyte development



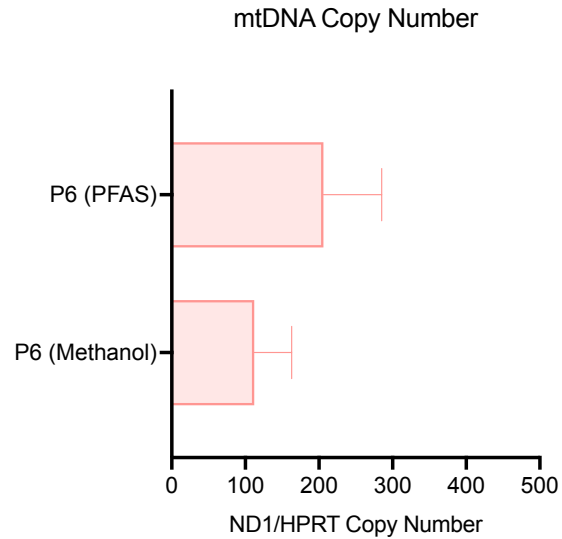
- Mitochondrial functions
 - Energy production (ATP)
 - Oxidative stress homeostasis
 - Regulation of apoptosis
- Mechanism unknown
- Disrupts mitochondrial respiration

¹ Ding et al. *Human Reproduction Update*. 2020

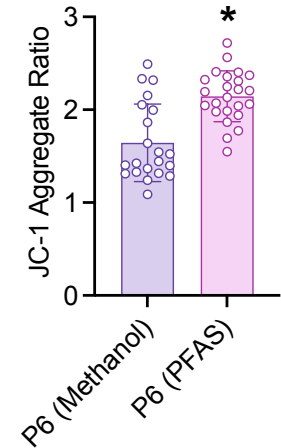
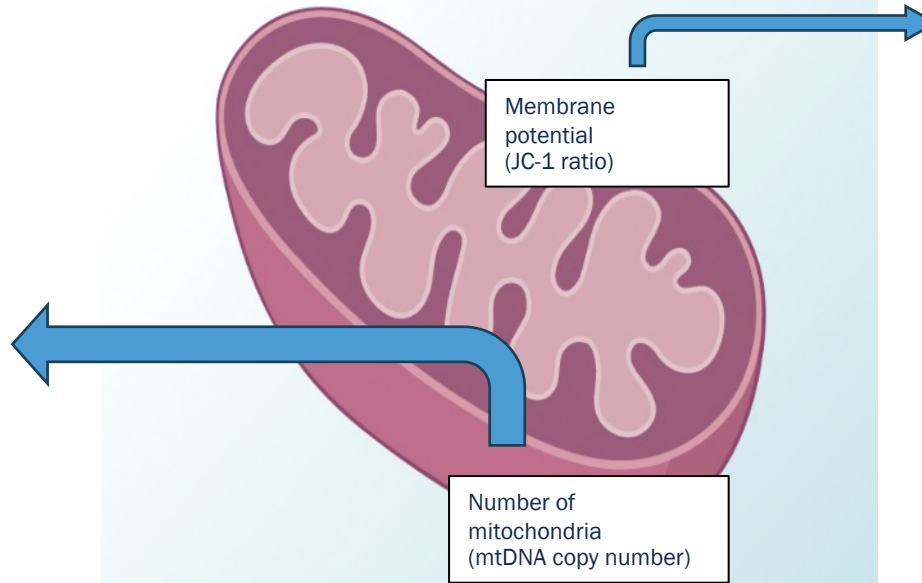
² Andrieux et al. *Int. J. Mol. Sci.* 2021

³ Lopez-Arellano et al. *Environ Toxicol.* 2018

Chronic Exposure of Ovarian Cancer Cells to PFAS (PFHpA)



Increased mtDNA copy number →
aggressive, chemoresistant tumors



Increased membrane potential →
enhanced mitochondrial functioning

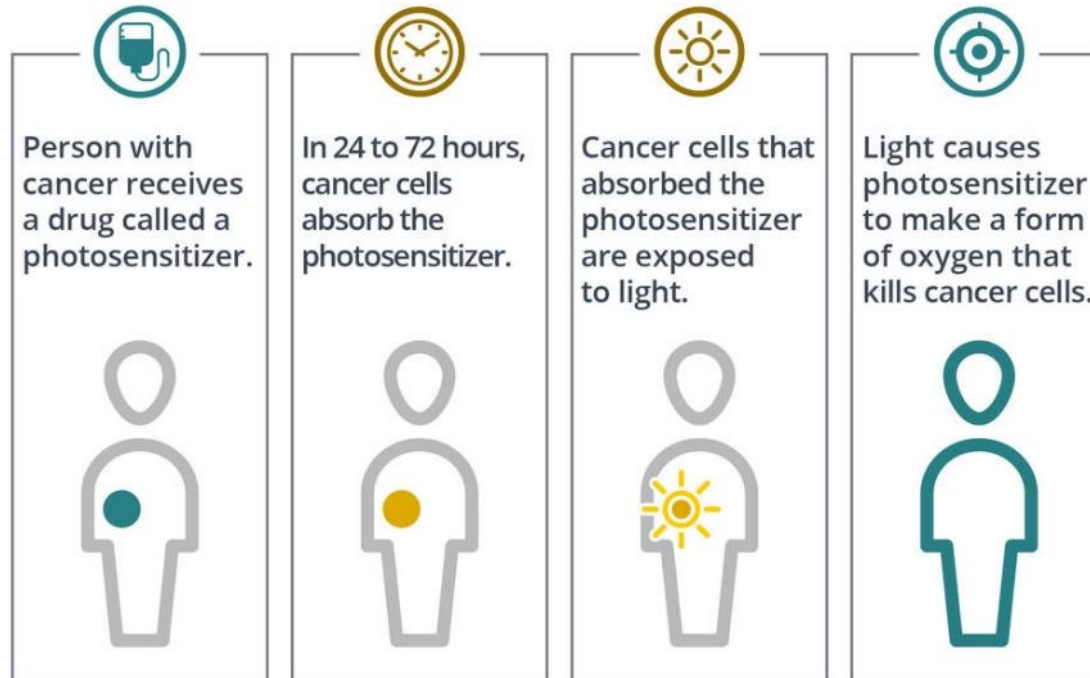
What We Know So Far...

- ✓ PFAS impact female reproductive health
- ✓ Select PFAS induce carboplatin resistance
- ✓ PFAS target mitochondria in ovarian cancer cells

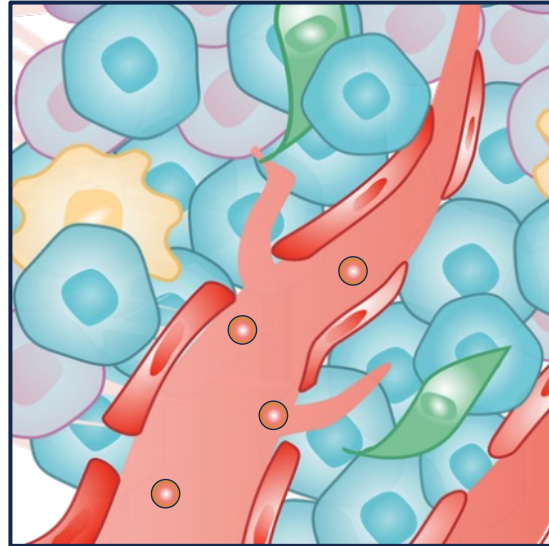
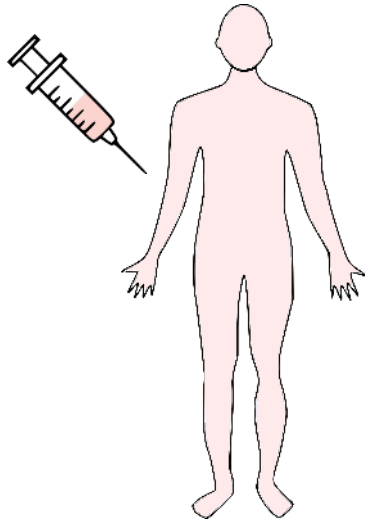
? Treatment approach for PFAS-induced chemoresistance

Targeting PFAS-Induced Effects on Mitochondria with Photodynamic Therapy (PDT)

PHOTODYNAMIC THERAPY



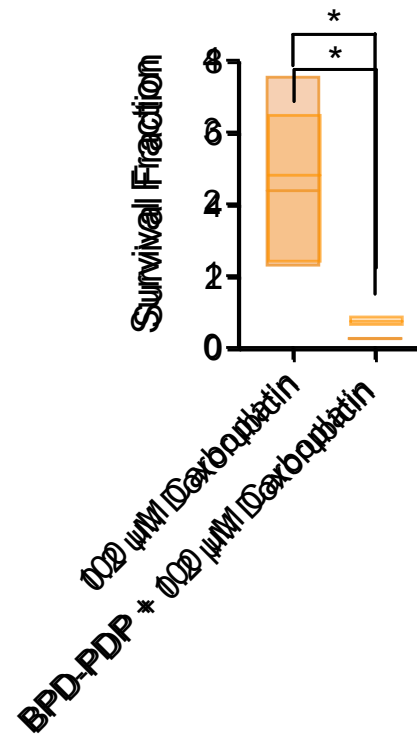
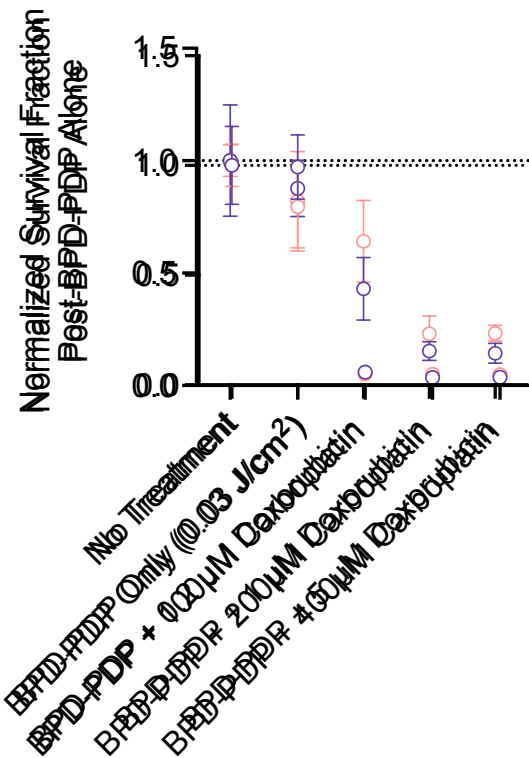
PDT Overcomes Tumor Microenvironmental Barriers



- **↑ vessel leakiness**
(Snyder, Cancer Res, 2003)
- **↓ solid stress**
(Sano, ACS Nano, 2013)
- **↓ mitochondrial integrity**
(Kessel, Photochem Photobiol, 2014)

PDT has been shown to decrease tumor microenvironmental barriers and enhance chemotherapy efficacy.

PDP + Platinum for PFAS-Induced Platinum-Resistant Ovarian Cancer



What We Know So Far...

- ✓ PFAS impact female reproductive health
 - ✓ Select PFAS induce chemoresistance
- ✓ PFAS target mitochondria in ovarian cancer cells
- ✓ Photodynamic priming effectively overcomes PFAS-induced chemoresistance

Experimental Aims:

- Evaluate effects of chronic PFAS exposures in 3D ovarian cancer cultures and mouse models of ovarian carcinomatosis
 - Additional mitochondrial endpoints
 - Determine PDT efficacy
 - Examine patient serum and ascites samples for PFAS, correlate with platinum response status
-

Big Picture:

- Promote clinical integration of PFAS blood testing for women prior to receiving chemotherapy
 - Prevent failure on chemotherapy
- Promote clinical integration of mitochondria-localized PDT for the treatment of platinum-resistant ovarian cancer

Acknowledgements

Rizvi Lab Members:

- Marta Overchuk, Ph.D.
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Imran Rizvi, Ph.D.



Sue Fenton, Ph.D.





**SCHOOL OF
MEDICINE**



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI



CLEAN WATER COMMUNITY HEALTH WATERSHED RESTORATION

Jennifer Rawlison



Jen@NewburghCleanWaterProject.org



www.NewburghCleanWaterProject.org

Newburgh



NEWBURGH: An Environmental Justice Community

- **De-Industrialized City - over a century of corporate pollution**
Dupont, General Electric, Global Oil, and many others
- **BIPOC - 50% Latinx, 30% Black, 20% White**
- **Redlining - Discriminatory Practice**
- **Urban Renewal & Displacement**
- **Aging infrastructure**





**Family homestead lost to NYS eminent domain in effort to expand
Stewart Airport in the 60s & 70s
*(8,657 acres seized - over 1,500 people displaced)***

Early Birth & Lead



Marta

**4 ½ Weeks Premature
Elevated Lead Levels**



Nicole

Elevated Lead Levels

Newburgh residents fear health effects of toxic water

Blood testing to show extent of PFOS contamination

Leonard Sparks Times Herald-Record

Published 6:47 p.m. ET Oct. 22, 2016 | Updated 6:47 p.m. ET Oct. 22, 2016



2016 Public Disclosure



Understanding Lake Washington

- Reservoir is outside our jurisdiction
- At least 12 PFAS chemicals detected
- Drinking water supply left unusable
- City of 30K - *Poisoned without our knowledge or consent*







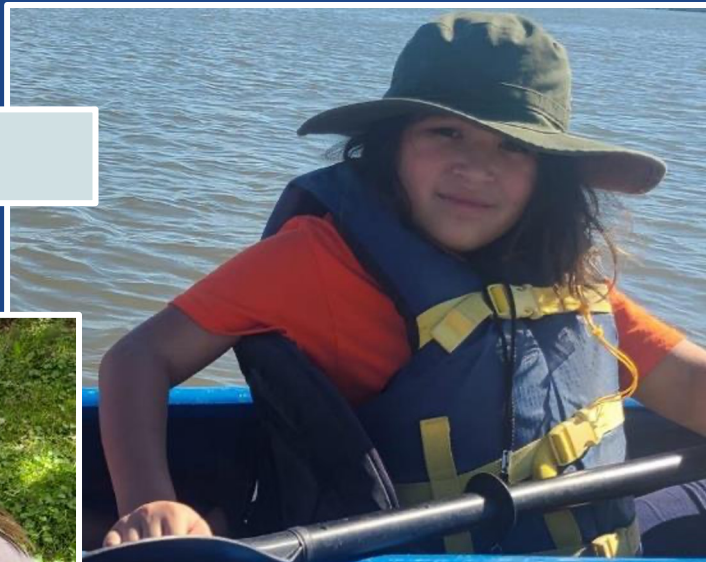


Marta

*** PFHxS ***

*** PFOS * PFOA * PFNA ***

PFAS EXPOSED

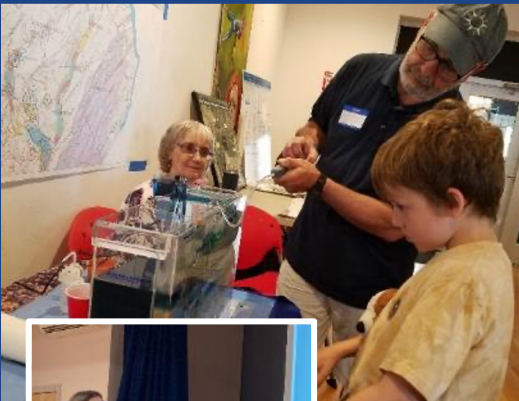


Nicole

*** PFOS * PFHxS ***

*** PFOA * PFNA ***





Clinician Guidance





RESTORED WATERSHED

Advocacy
& Hope

HEALTH PROTECTIVE REGULATIONS

COMPREHENSIVE
PROTECTIONS
OF WATER SOURCES

BIO-MONITORING &
SUPPORTIVE CARE

JUSTICE

FULL REMEDIATION

Thank You!





CLEAN WATER COMMUNITY HEALTH WATERSHED RESTORATION

Jennifer Rawlison



Jen@NewburghCleanWaterProject.org



www.NewburghCleanWaterProject.org



NATIONAL PFAS CONFERENCE

JUNE 9-12, 2024 • ANN ARBOR, MI

Moving Forward with the NASEM Guidance on PFAS

Kevin C. Elliott

Professor

Lyman Briggs College,

Department of Fisheries and Wildlife,

and Department of Philosophy

Michigan State University



NATIONAL *Sciences*
ACADEMIES *Engineering*
Medicine

Guidance on PFAS Exposure, Testing, and Clinical Follow-Up



Consensus Study Report

Overview

- Principles for decision making under uncertainty
 - Autonomy
 - Justice
- Key elements of the NASEM clinical guidance
- Need for clinician education



I. Principles for Decision Making under Uncertainty

Statement of Task

ATSDR and the National Institute of Environmental Health Sciences (NIEHS) asked the National Academies of Sciences, Engineering, and Medicine to form an ad hoc committee to advise on PFAS testing and clinical care for patients exposed to PFAS. The Statement of Task asked the committee to

- develop principles for biological testing and clinical evaluation, given substantial scientific uncertainty about the health effects or the value of such measures in informing care,
- review the human health literature for the health effects of PFAS, and
- characterize human exposure pathways and develop principles for exposure reduction.

(p. 4)

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- characterize human exposure pathways and develop principles for exposure reduction.

(p. 4)



BOX S-1

Principles for Decision Making Under Uncertainty Used in This Report

Proportionality: Decisions should balance plausible harms and benefits proportionally, meaning that the harms and benefits are considered together and weighed based on a qualitative assessment of their potential likelihoods and magnitudes.

Justice: Decisions should be informed by an emphasis on promoting justice, including by balancing benefits and harms fairly across the population of at-risk individuals, advancing health equity, and respecting human rights. In addition, justice requires consideration of sociohistorical context, stakeholders, existing structural inequalities, and issues of agency (the power a community has to advocate for itself in conflicts).

Autonomy: Decisions should be based on informed decision making by individuals and reflect respect for their values.

Feasibility: Decisions should take into account resource availability, including follow-up services.

Adaptability: Decisions should respond to new information about harms, benefits, and other relevant considerations (e.g., health equity and feasibility).

BOX S-1

Principles for Decision Making Under Uncertainty Used in This Report

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Adaptability: Decisions should respond to new information about harms, benefits, and other relevant considerations (e.g., health equity and feasibility).

Autonomy

- “In the clinical setting, these principles converge under the principle of autonomy; thus, shared, informed decision making between clinician and patient is the practical way to incorporate the principles into a clinical encounter.” (p. 5)
- Recommendation 5.2: Clinicians should offer PFAS testing to patients likely to have a history of elevated exposure. In all discussions of PFAS testing, clinicians should describe the potential benefits and harms of the testing and the potential clinical consequences (such as additional follow-up), related social implications, and limitations of the testing so patient and clinician can make a shared, informed decision.

BOX S-2
Potential Harms and Benefits of PFAS Testing

Potential Harms

- Fear of blood draw
- Small risk of injury or infection at draw site
- Difficulties in interpreting results
- Stress or concern about the health effects of exposure
- Decreased property values resulting from identifying property contamination
- Social isolation
- Clinical consequences from medical follow-up as a result of exposure

Potential Benefits

- Increased awareness of exposure so it can be reduced
- Empowerment of communities to respond to contamination
- Relief from the stress of not knowing one's exposure level
- Identification of the potential risk for health conditions associated with PFAS exposure, informing subsequent preventive care
- Help in monitoring whether efforts to reduce exposure are working through the conduct of baseline and follow-up tests

Why Autonomy?

- “In response to uncertainty, some public health professionals may wish to avoid acting as soon as science determines the risks of an exposure for fear that the association is not a true one and that acting too quickly could lead to inappropriate and costly public health measures (Boffetta et al., 2008). On the other hand, some may fear that if society waits for more certain evidence, meaningful action will be delayed (Blair et al., 2009).” (p. 41)
- “The committee understood that when evidence is incomplete, dangers can be associated both with taking action *and with failing to act...*” (p. 41, italics added)
- So reasonable people can weigh these dangers differently

Why Autonomy?

- “The committee also observed gaps in the evidence for many health effects, whereby the evidence was *inadequate* or *insufficient* to determine associations.” (p. 85-86, italics in original)
- “It is critical to recognize that an assessment of *inadequate* or *insufficient* evidence does not mean there is no significant and important association between PFAS exposure and the outcome under consideration. [It means that we just don’t have enough information to be able to tell.] (p. 86, italics in original)





<u>Category of Association</u>	<u>What Does it Mean?</u>
 Sufficient Evidence of an Association	<ul style="list-style-type: none">• Based on strong evidence, there is high confidence that there is an association between exposure to PFAS and the health outcome. It is unlikely that the association is due to chance or bias.
 Limited or Suggestive Evidence of an Association	<ul style="list-style-type: none">• Based on limited evidence, there is moderate confidence that there is an association between exposure to PFAS and the health outcome. It is possible that the association is due to chance or bias.
 Inadequate or Insufficient Evidence to Determine an Association	<ul style="list-style-type: none">• Based on inconsistent evidence, a lack of evidence, or evidence of insufficient quality of an association between exposure to PFAS and the health outcome, no conclusion can be made about a potential association.
 Limited or Suggestive Evidence of No Association	<ul style="list-style-type: none">• Based on at least limited evidence, there is at least moderate confidence that there is NO association between PFAS and the health outcome.

FIGURE S-5 Categories of association used in this report.

Why Autonomy?

- In addition to the lack of evidence, there can be legitimate disagreements about how to interpret the available evidence
- “The committee acknowledges that other expert and lay communities might draw different conclusions about PFAS health risks, either by including different lines of evidence or by making alternative judgments when assessing the available evidence” (p. 86)
- “This is one of the reasons that the committee emphasizes the importance of patient autonomy and shared decision making...” (p. 86)

Justice

- “Testing for PFAS, although expensive, offers an opportunity to identify people who may need to reduce their PFAS exposure and are at increased risk of certain health outcomes. It is important to recognize, however, that race, age, and other social and demographic characteristics already have disadvantaged many patients with respect to accessing clinical preventive services, such as PFAS testing. The disadvantage would be compounded as PFAS testing services should be linked to counseling on steps to mitigate exposure and its impacts.
- Therefore, encouraging testing primarily among people with relatively stable access to care could have the unintended effect of aggravating disparities in exposure to PFAS absent a funded, national PFAS testing program with a counseling component.” (p. 14)



II. Key Clinical Guidance

Statement of Task

ATSDR and the National Institute of Environmental Health Sciences (NIEHS) asked the National Academies of Sciences, Engineering, and Medicine to form an ad hoc committee to advise on PFAS testing and clinical care for patients exposed to PFAS. The Statement of Task asked the committee to

- develop principles for biological testing and clinical evaluation, given substantial scientific uncertainty about the health effects or the value of such measures in informing care,
- review the human health literature for the health effects of PFAS, and
- characterize human exposure pathways and develop principles for exposure reduction.

The Statement of Task asked the committee to recommend

- options and considerations to guide decision making for PFAS testing in a patient's blood or urine,
- PFAS concentrations that could inform clinical care of exposed patients, and
- appropriate patient follow-up and care specific to PFAS-associated health endpoints for those patients known or suspected to be exposed to PFAS.

Statement of Task

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NASEM Guidance

PFAS Exposure: Clinical Follow-Up

- Clinicians should offer PFAS testing to patients who are likely to have a history of elevated exposure. In all discussions of PFAS testing, clinicians should describe the potential benefits and harms of PFAS testing and the potential clinical consequences (such as additional follow-up), related social implications, and limitations of the testing so patient and clinician can make a shared, informed decision.
- If testing is done the clinician should compare its results with the chart below and discuss treatment accordingly.

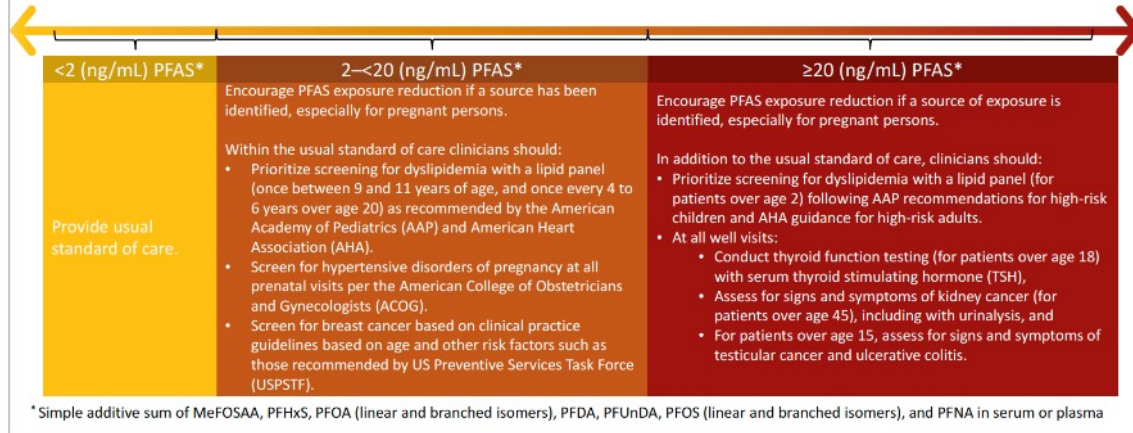


FIGURE 6-1 Clinical guidance for follow-up with patients after PFAS testing.

Other Sources of Guidance

TABLE 7-1 Description of PFAS Clinical Guidance Documents

Clinical Guidance Document	Description of Content	Strengths of Document
<i>How to Conduct a Clinical Visit with Patients Concerned About PFAS</i> (PEHSU, 2021)	Includes a numbered list of five strategies for clinicians to use in discussing PFAS exposure with concerned patients and provides some detail on how to apply them. Also provides some references to other materials with further detail.	Focuses on empathy and shared decision making and the potential need for exposure reduction. Offers advice only for overall approaches to navigating discussions with patients, and directs clinicians to supplementary Pediatric Environmental Health Specialty Units (PEHSUs) and Agency for Toxic Substances and Disease Registry (ATSDR) resources.
<i>PFAS Exposure: Information for Patients and Guidance for Clinicians to Inform Patient and Clinician Decision Making: For Clinicians</i> (PFAS-REACH, 2021)	Summarizes clinical services recommended by other trustworthy groups for adults and children with above-average PFAS exposure. Categorizes information by type of service—laboratory tests, exams, or counseling topics	Accessible summary of material produced by others. Does not claim to provide rigorous analysis of others' findings. Does provide more information than the PEHSU document in an accessible format.

Updating the Guidance

Recommendation 7-3: The Agency for Toxic Substances and Disease Registry (ATSDR) should develop a process for updating its PFAS guidance that adheres to criteria for making guidelines trustworthy, such as being based on a thorough, transparent, unbiased review of the evidence and being developed by a knowledgeable panel of experts free from strong biases and conflicts of interest. A review of the evidence on the health effects of PFAS should be completed by an authoritative neutral party every 2 years, and the clinical guidance should be updated every 5 years or sooner if warranted by the evidence on the health effects of PFAS. Clinicians and members of communities with elevated PFAS exposure should be engaged to inform the problem and review updated guidance.



III. Clinical Education

Clinical Education

- “From a clinical perspective, providers need a better working knowledge of environmental health and chemical exposures. At the committee’s town halls, speakers described their frustration with trying to obtain medical care from practitioners who were unfamiliar with PFAS and did not understand the environmental health contexts of the communities in which they practiced.
- At the town hall on April 7, 2021, Hope Grosse said:
 - When I would go to the doctors and tell them about some of the exposures of over 50 chemicals that I was exposed to, the doctors would laugh and say no. Clearly, they didn’t have any information about environmental components [of disease]. They made me feel small; they made me feel stupid and embarrassed even just asking the question.” (p. 160)

Clinical Education

- “The 1991 Institute of Medicine (IOM) report *Addressing the Physician Shortage in Occupational and Environmental Medicine: Report of a Study* notes that all levels of medical education, from undergraduate to graduate and continuing education programs, provide limited, if any, training in occupational and environmental medicine. The report recommends that occupational and environmental medicine concepts be introduced early and continuously during medical education (IOM, 1991).” (p. 160)
- “Decades later, however, Green-McKenzie and colleagues (2021) found that only 70 percent of medical students had heard of occupational and environmental medicine, and most of them had received only one lecture on the topic.” (p. 160)

Conclusions

- Principles for decision making under uncertainty
 - Autonomy
 - Justice
- Key elements of the NASEM clinical guidance
- Need for clinician education

References:

- Blair, A., R. Saracci, P. Vineis, P. Cocco, F. Forastiere, P. Grandjean, M. Kogevinas, D. Kriebel, A. McMichael, N. Pearce, M. Porta, J. Samet, D. P. Sandler, A. S. Costantini, and H. Vainio. 2009. Epidemiology, public health, and the rhetoric of false positives. *Environmental Health Perspectives* 117(12): 1809–1813.
- Boffetta, P., J. K. McLaughlin, C. La Vecchia, R. E. Tarone, L. Lipworth, and W. J. Blot. 2008. Falsepositive results in cancer epidemiology: A plea for epistemological modesty. *Journal of the National Cancer Institute* 100(14):988–995.
- IOM (Institute of Medicine). 1991. *Addressing the physician shortage in occupational and environmental medicine: Report of a study*. Washington, DC: National Academy Press.
- Green-McKenzie, J., U. Savanoor, H. Duran, C. Jones, D. Vearrier, P. Malak, E. Emmett, and F. Shofer. 2021. Outcomes of a survey-based approach to determine factors contributing to the shortage of occupational medicine physicians in the United States. *Journal of Public Health Management & Practice* 27(3 Suppl): S200–S205.
- National Academies of Sciences, Engineering, and Medicine. 2022. *Guidance on PFAS Exposure, Testing, and Clinical Follow-Up*. Washington, DC: The National Academies Press.
- PEHSU (Pediatric Environmental Health Specialty Unit). 2021. How to conduct a clinical visit with patients concerned about PFAS exposure. https://deohs.washington.edu/pehsu/sites/deohs.washington.edu/pehsu/files/PFAS%20Clinical%20Visit%20tips%20for%20clinicians_AK_Jan%202021.pdf (accessed June 30, 2022).
- PFAS-REACH (PFAS Research, Education, and Action for Community Health). 2021. PFAS exposure: Information for patients and guidance for clinicians to inform patient and clinician decision making—For people in PFAS-impacted communities. https://wordpress.silentspring.org/wpcontent/uploads/2021/06/PFAS-REACH-Medical-screening-guidance_PFAS-impactedcommunities.pdf



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PFAS and Health Care Providers in northeastern North Carolina: What Should we Know??

David N Collier, MD, PhD, FAAP

Professor of Pediatrics

Brody School of Medicine, East Carolina University

Co-Director Translational Research Support Core

Center for Human Health and the Environment

NC State University



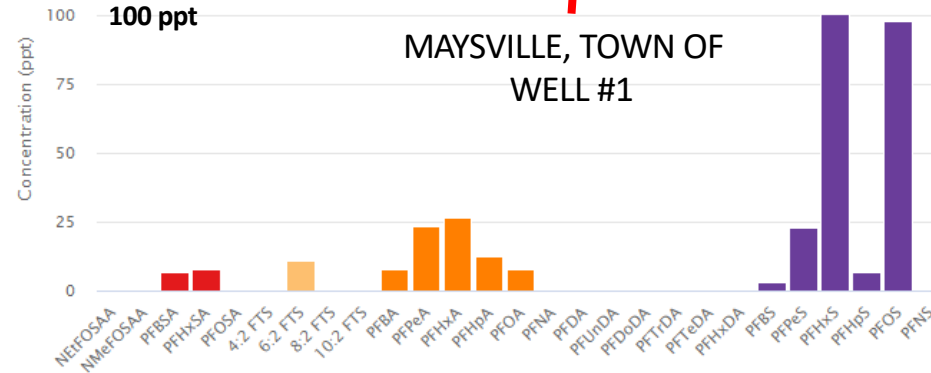
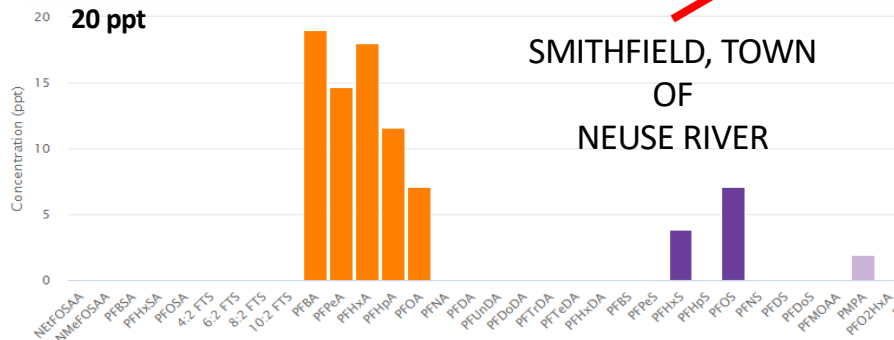
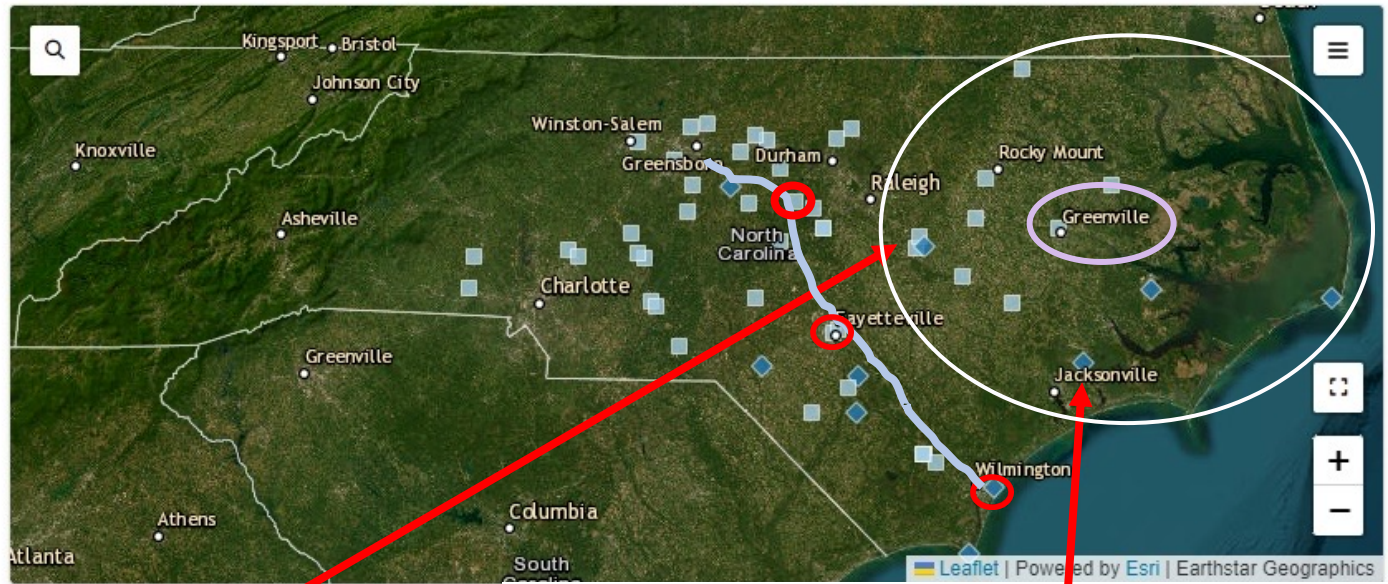
PFAS and Health Care Providers in northeastern North Carolina: What Should we Know?



- PFAS landscape in NC.
- What are the risks?
- Current recommendations.
- Moving forward.

Fayetteville Works/Chemours fluoroether production facility
(Vaughn Haggerty Star News June 7, 2017)

Sites in North Carolina Exceeding Proposed PFAS National Primary Drinking Water Regulation Guidelines.



Evidence for Health Effects?

Human Studies:

Cross Sectional

Longitudinal

Interventional



Mechanistic Studies

Animal Studies

Blinded Randomized
Controlled Trials

Longitudinal

Cross Sectional

National Academies of Sciences, Engineering and Medicine 2022.

Guidance on PFAS Exposure, Testing, and Clinical Follow-up.

Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>

- An ad hoc committee appointed by the National Academies of Sciences, Engineering, and Medicine (the National Academies) **will consider current evidence regarding human health effects of the most widely studied per- and polyfluoroalkyl substances** (PFAS).
- The National Academies will provide the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry (CDC/ATSDR) and the National Institute of Environmental Health Sciences (NIEHS) an **objective and authoritative review of current evidence regarding human health effects of those PFAS being monitored in the CDC's National Report on Human Exposure to Environmental Chemicals.**

Review Limited to 7 PFAS Species Included in CDC's National Report.

National Academies of Sciences, Engineering and Medicine 2022. *Guidance on PFAS Exposure, Testing, and Clinical Follow-up*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>

TABLE S-1 PFAS Species Currently Included in the Centers for Disease Control and Prevention's National Report on Human Exposure to Environmental Chemicals

Abbreviated Name	# Carbons	Full Name	CAS Registry No.
MeFOSAA	C8	Methylperfluorooctane sulfonamidoacetic acid	2355-31-9
PFHxS	C6	Perfluorohexanesulfonic acid perfluorohexane sulfonic acid	355-46-4
n-PFOA (linear isomer), Sb-PFOA (branched isomers)	C8	Perfluorooctanoic acid	335-67-1*
PFDA	C10	Perfluorodecanoic acid	335-76-2
PFUnDA	C11	Perfluoroundecanoic acid	2058-94-8
n-PFOS (linear isomer), Sm-PFOS (branched isomers)	C8	Perfluorooctanesulfonic acid	1763-23-1*
PFNA	C9	Perfluorononanoic acid	375-95-1

NOTES: CAS = Chemical Abstracts Service. * = CAS number refers to linear isomer only. Previous survey years have also included perfluorobutane sulfonic acid (PFBS), perfluoropentanoic acid (PFpA), perfluorododecanoic acid (PFDoDA), perfluorooctane sulfonamide (FOSA), and 2-(N-ethyl-perfluorooctane sulfonamido)acetate (EtFOSAA), according to Patrick N. Breyse's presentation to the committee on February 4, 2021.

Guidance on PFAS Exposure, Testing, and Clinical Follow-up: Evidence Reviewed.

- Authoritative Reviews
 - C-8 Science Panel reports (latest 2012)
 - European Food Safety Authority (EFSA) (latest 2013)
 - Organization for Economic Co-Operation and Development (OECD) (2013)
 - International Agency for research on Cancer (IARC) (search complete 2014)
 - U.S. Environmental Protection Agency (EPA) (search complete 2015)
 - National Toxicology Program (NTP) (search complete 2016)
 - Agency for Toxic Substances and Disease Registry (ATSDR) (search complete 2018)
- Review of Systematic Reviews
 - 26 high quality SRs evaluated using “AMSTAR-2”
- Review of recent epidemiologic studies
 - 139 high quality studies published after 2017 and not included in above reviews
- Evidence Synthesis
 - Framework based on “Hill considerations”
 - Animal studies included in ATSDR and Systematic Reviews aided in interpretation of human studies

Category of Association and Health Outcomes With Increased Risk Associated with PFAS Exposure.

National Academies of Sciences, Engineering and Medicine 2022. *Guidance of PFAS Exposure, Testing, and Clinical Follow-up*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>

+ + Sufficient Evidence of an Association

- Decreased antibody response (adults and children)
- Dyslipidemia (adults and children)
- Decreased infant and fetal growth
- Increased risk of kidney cancer (adults)

+ Limited or Suggestive Evidence of an Association

- Increased risk breast cancer (adults)
- Liver enzyme alterations (adults and children)
- Increased risk pregnancy-induced hypertension (gestational hypertension and preeclampsia)
- Increased risk testicular cancer (adults)
- Thyroid disease and dysfunction (adults)
- Increased risk ulcerative colitis (adults)

? Inadequate or Insufficient Evidence to Determine an Association

- Limited or Suggestive Evidence of NO Association

Category of Association and Health Outcomes With Increased Risk Associated with PFAS Exposure. –contd.

+ + Sufficient Evidence of an Association

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? Inadequate or Insufficient Evidence to Determine an Association

- **Immune effects** (other than reduced antibody response and ulcerative colitis)
- **Cardiovascular outcomes** (other than dyslipidemia)
- **Development outcomes** (other than reduced birthweight)
- **Cancers** (other than kidney, breast and testicular)
- **Reproductive effects** (other than hypertensive disorders of pregnancy)
- **Hepatic effects** (other than liver enzyme levels)
- **Renal effects**, such as kidney disease
- **Respiratory effects, Hematological effects, Musculoskeletal effects, Neurological effects**

Health Concern	C8 Study N = 69,000	Systematic Review 2018	Critical Review 2020	NASEM (PFAS as a class)	ATSDR
*Hypercholesterolemia	Yes	Sufficient Evidence	Strong	Sufficient Evidence	Evidence of (PFOA, PFOS, PFNA, PFDA)
*Thyroid disease/dysfunction	Yes	Inconsistent	Definitively	Limited or Suggestive	No consistent evidence of
*Changes in liver enzymes		Inconsistent	Emerging	Limited or Suggestive	Evidence of (PFOA, PFOS, PFHxS)
*Suppressed immune response	(yes)	Limited Evidence	Strong	Sufficient Evidence	Evidence of (PFOA, PFOS, PFNA, PFDA)
*Ulcerative colitis	Yes	Inconsistent	Probable	Limited or Suggestive	No consistent evidence of
*Increased uric acid		Limited Evidence	Effect underestimated		
*Decreased GFR		Limited Evidence	Likely causes		
Chronic kidney disease		Limited Evidence	Accumulating evidence		
Impaired sperm motility & #		Inconsistent	Ample evidence		
Time-to-pregnancy		Inconsistent	Increased (reversible)		
Preeclampsia/PIH	Yes	No	Probably linked	Limited or Suggestive	Evidence of (PFOA, PFOS)
*Lower birthweight		PFOS only	Prospective (reversible)	Sufficient Evidence	Evidence of (PFOA, PFOS)
Kidney cancer	Yes	Limited Evidence	Accumulating evidence	Sufficient Evidence	Evidence of (PFOA)
Testicular cancer	Yes	Limited Evidence	Evidence	Limited or Suggestive	Evidence of (PFOA)
Breast cancer				Limited or Suggestive	No consistent evidence of



< 2 ng/mL	2- <20 ng/mL	≥ 20 ng/mL
Adverse health outcome not expected	Potential for adverse health effects, especially for sensitive populations (pregnant women, children).	Increased risk of adverse health effects
2% US	89% US in 2017-18	9% US in 2017-2018



< 2 ng/mL	2- <20 ng/mL	≥ 20 ng/mL
Adverse health outcome not expected	Potential for adverse health effects, especially for sensitive populations (pregnant women, children)	Increased risk of adverse health effects
Usual Standard of Care	<p>Encourage PFAS reduction if source known, especially for pregnant persons.</p> <p>Within Usual Standard Care:</p> <ul style="list-style-type: none">• Prioritize screening for dyslipidemia with lipid panel: once between age 9-11 yr. and every 4-6 yr. > age 20 yr. per AAP and AHA.• Screen for hypertensive d/o pregnancy at all prenatal visits per ACOG.• Screen for breast cancer following CPGs based on age and risk factors as recommended by USPSTF.	<p>Encourage PFAS reduction if source known, especially for pregnant persons.</p> <p><u>In Addition to Usual Standard of Care:</u></p> <ul style="list-style-type: none">• Prioritize screening for dyslipidemia with lipid panel for patients <u>age > 2 yr.</u> following AAP and AHA recommendations for <u>high-risk</u> children and adults, respectively.• At All Well Visits:<ul style="list-style-type: none">• Conduct thyroid function* testing (patients > age 18) with serum TSH level• Assess for S/Sx kidney cancer (patients over age 45) including with urinalysis• Assess S/Sx of testicular cancer and ulcerative colitis* (patients over age 15)

Who Should be tested? NASEM Recommendations for

Clinicians.

National Academies of Sciences, Engineering and Medicine 2022. *Guidance on PFAS Exposure, Testing, and Clinical Follow-up*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>

- “Clinicians should offer PFAS blood testing to patients who are likely to have a history of elevated exposure to PFAS” based on.....
 - Ingestion of contaminated water and foods such as vegetables, fish, game, dairy from contaminated soil or water
 - Food contact materials used in packaging
 - Ingestion of dust containing PFAS
 - Inhalation in people living near fluorochemical plants or incinerators
 - Transfer to fetus via placenta and infant in early life via contaminated formula or breastmilk.
- Clinicians should:
 - Determine if/how their patients may be exposed
 - Advise appropriate consultation if occupationally exposed
 - Advise filtering their water if PFAS levels in drinking water are elevated
 - Advise patients residing in areas with known PFAS contamination that PFAS can be present in fish, wildlife, meat and dairy.
 - Discuss infant feeding and steps that can be taken to lower sources of exposure to PFAS.

Clinical Evaluation and Management: ATSDR Recommendations

[ATSDR] Agency for Toxic Substances and Disease Registry. 1/18/2024. PFAS Information for Clinicians.
U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

- Clinicians should “help address (patient’s) concerns by actively listening”
- Obtain a PFAS exposure history:
 - Assess water, dietary and consumer product exposure
 - Proximity to factories, airports, military bases, wastewater treatment plants, farms using sewage sludge, landfills, incinerators
 - Occupational or recreational exposures
 - FC manufacturing, firefighting foams, ski wax, other PFAS-containing materials
 - Past exposures
 - Pre- and peri-natal
 - PFAS testing and results
- Work to reduce exposure:
- Consider ordering PFAS blood levels through CLIA-certified commercial clinical laboratory
- Clinical Management
 - No specific health-based screening recommendations based on PFAS levels – follow usual standards care
 - No approved medical treatments to remove PFAS from the body

RCT: Effect of Plasma and Blood Donations on Levels of Perfluoroalkyl and Polyfluoroalkyl Substances in Firefighters in Australia

POPULATION

279 Men, 6 Women



Fire Rescue Victoria staff with serum perfluorooctane sulfonate (PFOS) levels ≥ 5 ng/mL

Mean age, 53 y

INTERVENTION

285 Individuals



95 Whole-blood donation

Whole-blood donation every 12 wk for 1 y for total of up to 5 donations **470 ml per donation**

95 Plasma donation

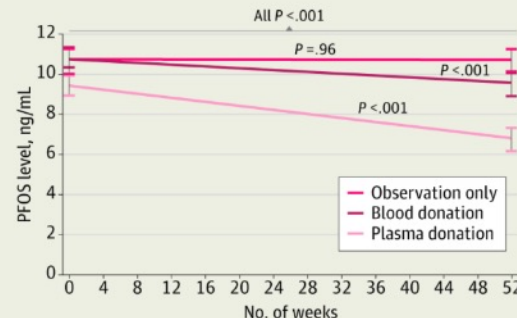
Plasma donation every 6 wk for 1 y for a total of up to 9 donations **800 ml per donation**

95 Observation

Observation alone

FINDINGS

PFOS and PFHxS levels were reduced significantly more by plasma and blood donations compared with observation alone



Mean PFOS level change

Blood group: -1.1 ng/mL (95% CI, -1.53 to -0.70; $P < .001$)

Plasma group: -2.9 ng/mL (95% CI, -3.57 to -2.30; $P < .001$)

Observation: -0.01 ng/mL (95% CI, -0.49 to 0.48; $P = .96$)

Mean PFHxS level change

Blood group: -0.1 ng/mL (95% CI, -0.43 to 0.17; $P = .54$)

Plasma group: -1.1 ng/mL (95% CI, -1.59 to -0.70; $P < .001$)

Observation: 0.4 ng/mL (95% CI, -0.01 to 0.71; $P = .06$)

SETTINGS / LOCATIONS



Victoria, Australia

PRIMARY OUTCOME

Changes in serum perfluorohexane sulfonate (PFHxS) and PFOS levels after 12 mo of donations

OFFICE OF RESEARCH & INNOVATION
VICE CHANCELLOR
Mladen Vouk



IAB EAB SAB

DIRECTOR
Sue Fenton

DEPUTY DIRECTOR
David Aylor

ADMINISTRATIVE CORE

PROGRAM MANAGER
Michico James (MJ)

DATA MANAGER
Nathan Dunn

BIOINFORMATICS SENIOR RESEARCH SCHOLAR
Dereje Jima

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PILOT PROJECT PROGRAM

CO-DIRECTOR
Hong Wang

CO-DIRECTOR
Carolyn Mattingly

CENTER MEMBERS

CAREER DEVELOPMENT PROGRAM

DIRECTOR
Jeff Yoder

RESEARCH INTEREST GROUPS (RIGs)

BEHAVIOR & NEUROSCIENCE

CO-LEADS
Kurt Marsden, Natalia Duque-Wilckens

WATER & EMERGING CHALLENGES

CO-LEADS
Detleff Knappe, Ayse Ercumen

CLIMATE CHANGE & AIRBORNE CONTAMINANTS

CO-LEADS
Vijay Sivaraman, Sinan Sousan

GENES, ENVIRONMENT & PRECISION HEALTH

CO-LEADS
Shobhan Gaddameedhi, Michael Cowley

ENVIRONMENTAL HEALTH DISPARITIES

CO-LEADS
Jennifer Richmond-Bryant, Cathrine Hoyo

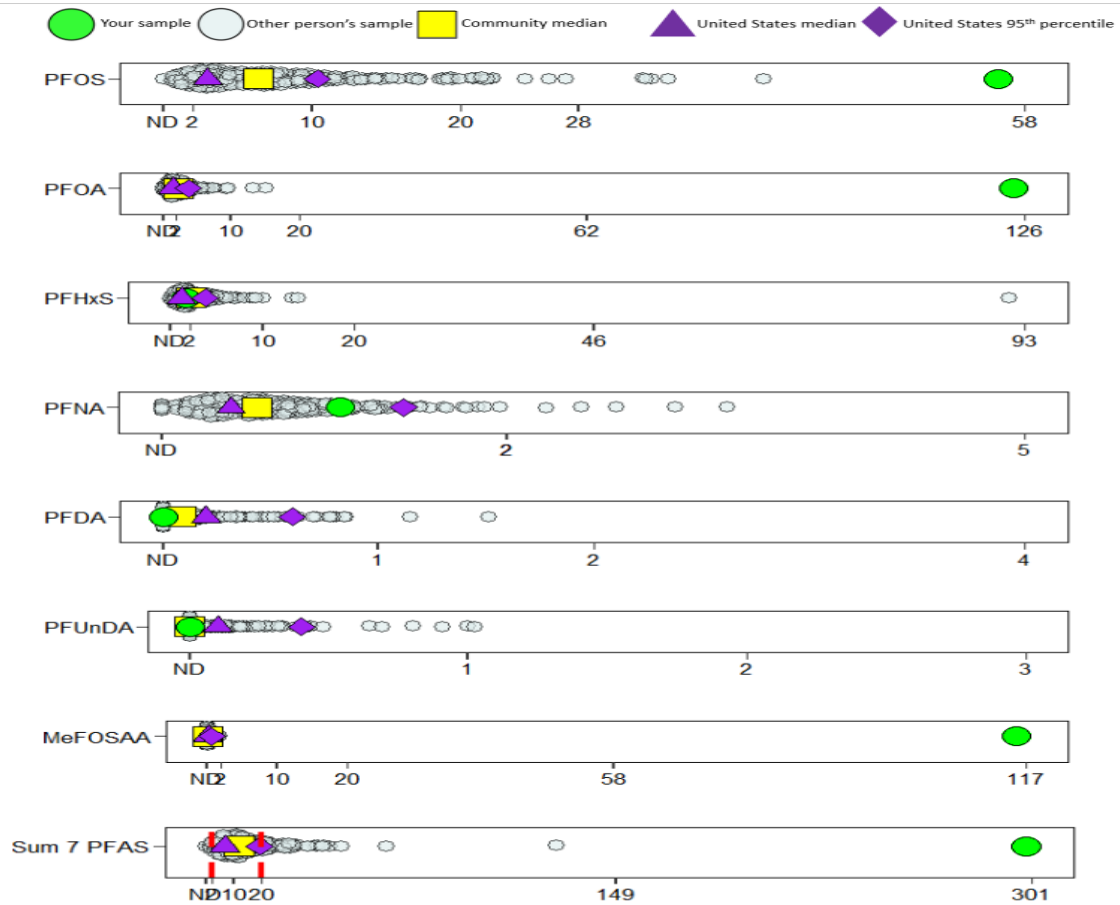
• Translational Partnerships

- North Carolina Central University
- NC-DHHS Division of Public Health
- Brody School of Medicine
- NC-AHEC Eastern Area Health Education Center
- Adapt/Develop Continuing Medical Education (CME) programming with regional relevance.
- Deliver CME and practice support
- Support/facilitate testing



References and Acknowledgements

- Well and surface water data were prepared by Drs L Ferguson and D. Knappe within the North Carolina PFAS Testing Network, supported by an award from the North Carolina Collaboratory with funding appropriated by the North Carolina General Assembly. The statements, findings, conclusions and recommendations are those of the author(s) and do not necessarily reflect the views of the North Carolina PFAS Testing Network. <https://ncpfastnetwork.com/data/#>
- Kotlarz N. *et al.* **Measurement of Novel, Drinking Water-Associated PFAS in Blood from Adults and Children in Wilmington, North Carolina.** *Environmental Health Perspectives* 2020;128:0770051-12. available @ <https://doi.org/10.1289/EHP6837>
- C8 Science Panel Website www.c8sciencespanel.org/prob_link.html
- [NASEM] National Academies of Sciences, Engineering, and Medicine. 2022. **Guidance on PFAS Exposure, Testing, and Clinical Follow-Up.** Washington, DC: The National Academies Press. Available from: <https://nap.nationalacademies.org/catalog/26156/guidance-on-pfas-exposure-testing-and-clinical-follow-up>
- [ATSDR] Agency for Toxic Substances and Disease Registry. 1/18/2024. **PFAS Information for Clinicians.** U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. <https://www.atsdr.cdc.gov/pfas/resources/pfas-information-for-clinicians.html>
- Gasiorowski R, Forbes MK, Silver G, et al. **Effect of Plasma and Blood Donations on Levels of Perfluoroalkyl and Polyfluoroalkyl Substances in Firefighters in Australia: A Randomized Clinical Trial.** *JAMA Netw Open.* 2022;5(4):e226257. doi:10.1001/jamanetworkopen.2022.6257
- GenX Study – Jane Hoppin (PI) Nadine Kotlarz, Detlef Knappe,
- Center for Human Health and the Environment - Sue Fenton (PI), Rob Smart,



Serum PFAS ng/mL



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

Translating PFAS Research into Health Protective Action



Courtney Carignan, Ph.D.
Michigan State University

National PFAS Conference
June 11, 2024



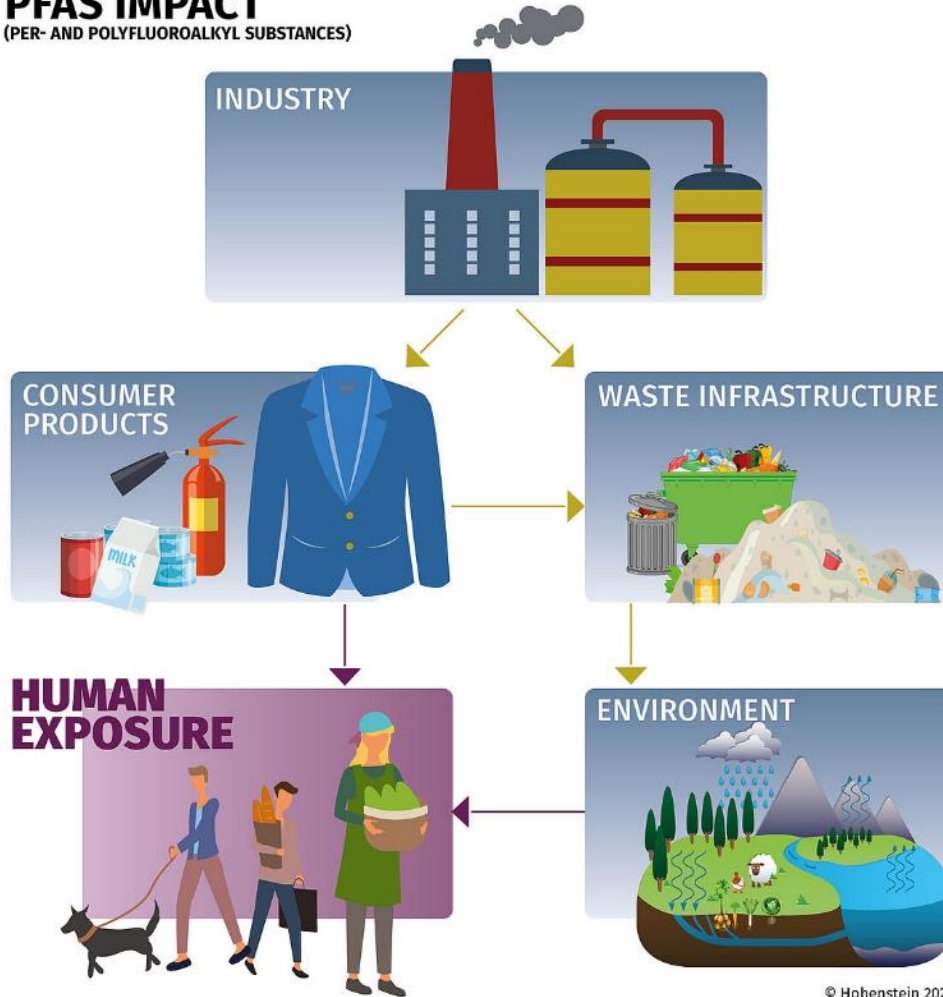
Outline

1. Child Immune Effects as a basis for Regulatory Decision Making
2. Improving Access to PFAS Blood Testing
3. Clinical Guidance & Medical Screening
4. Clinician Outreach & Training

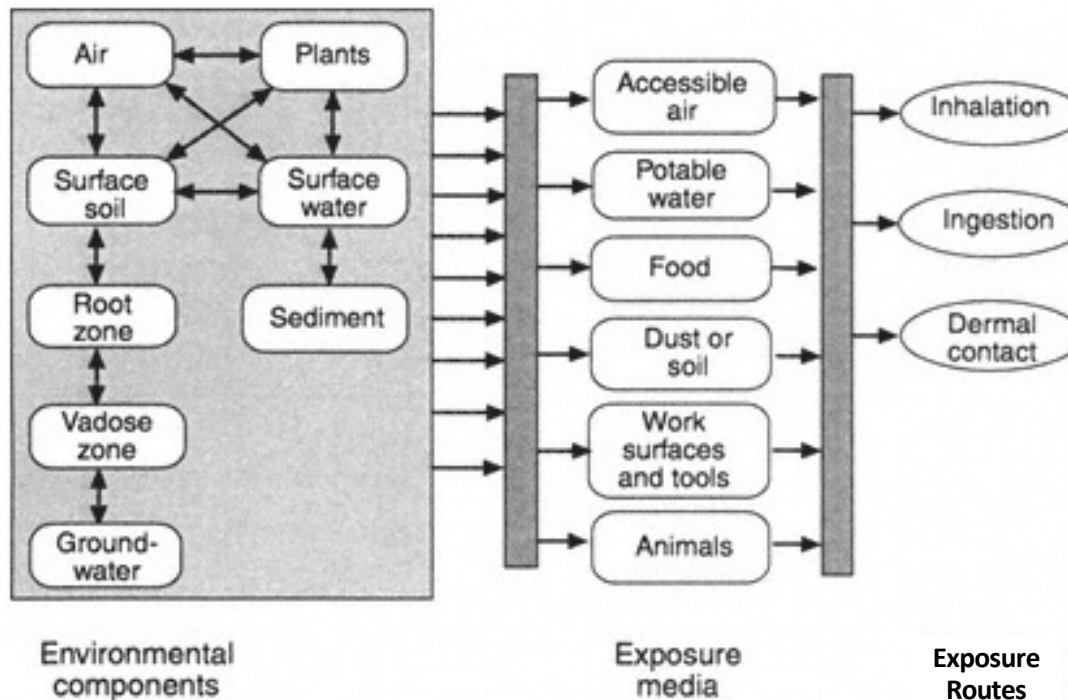


PFAS IMPACT

(PER- AND POLYFLUOROALKYL SUBSTANCES)



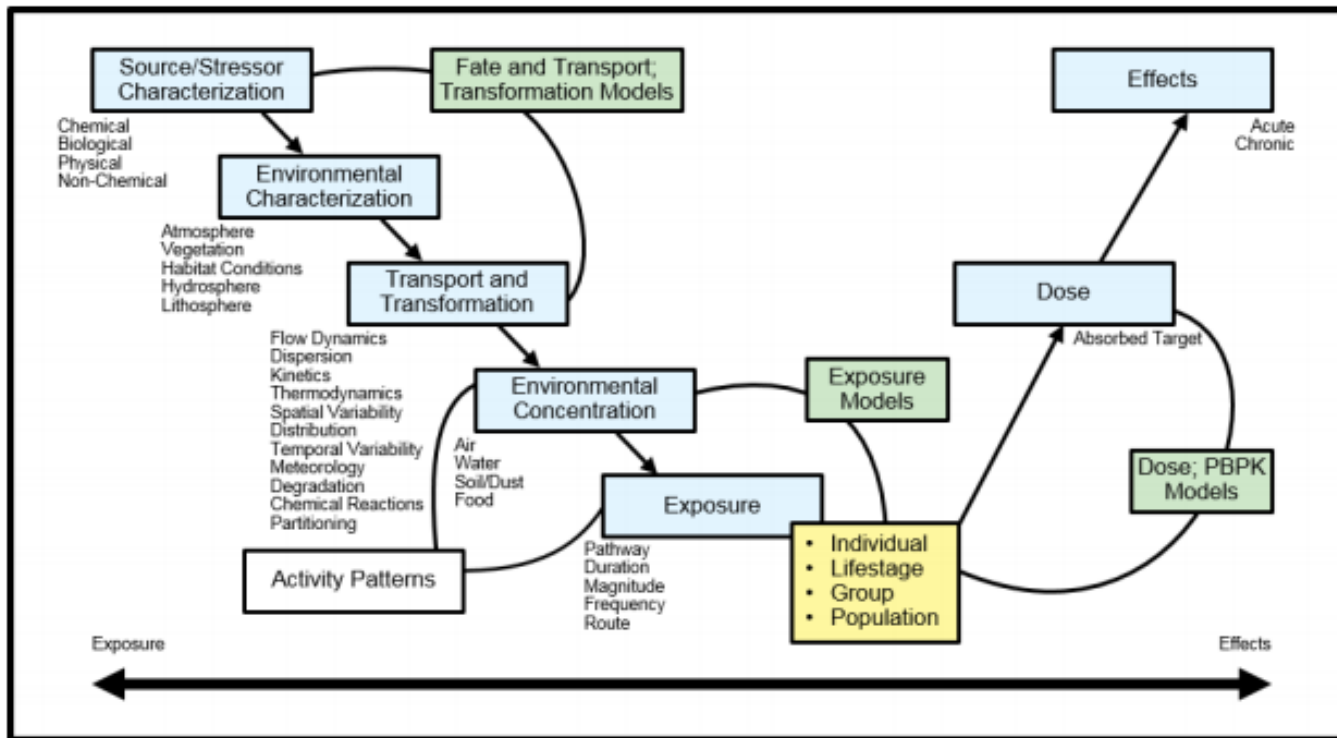
Exposure Pathways



National Academies Press (2000)



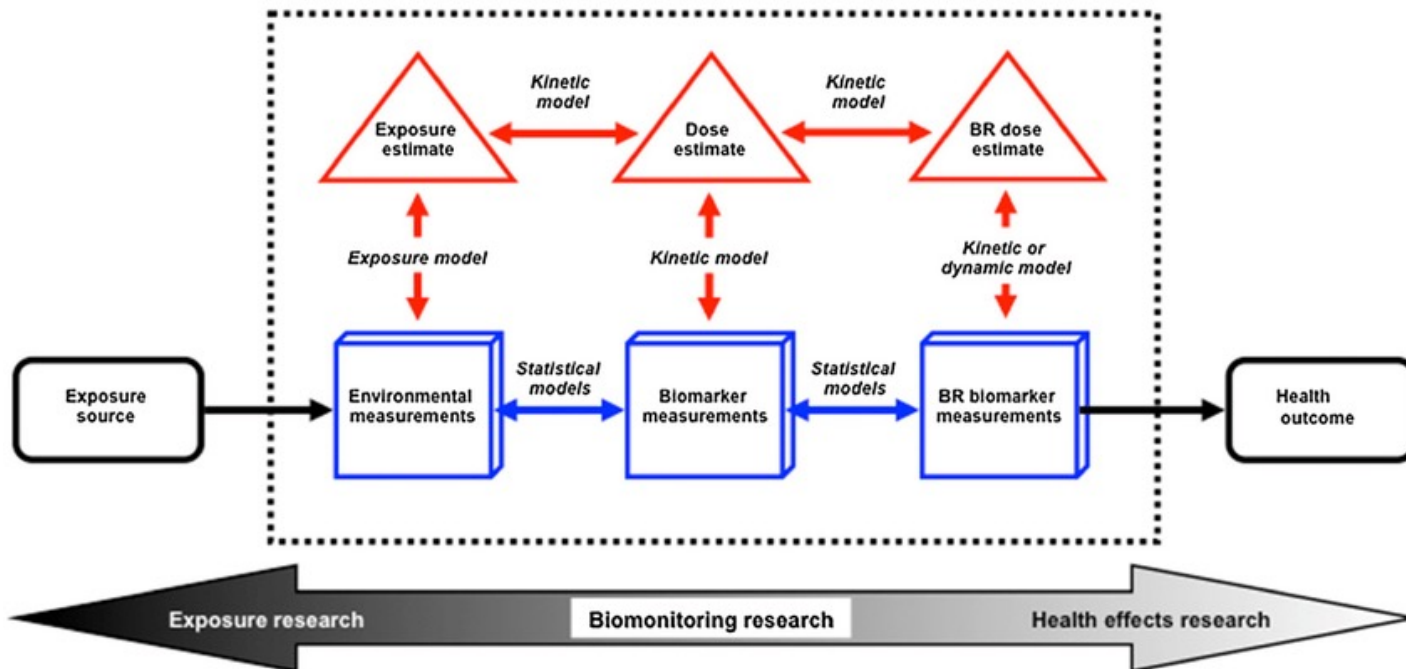
Source to Outcome Continuum



Note: PBPK = physiologically based pharmacokinetic

Adapted from NRC (1983); NRC (1997)

Source to Outcome Continuum



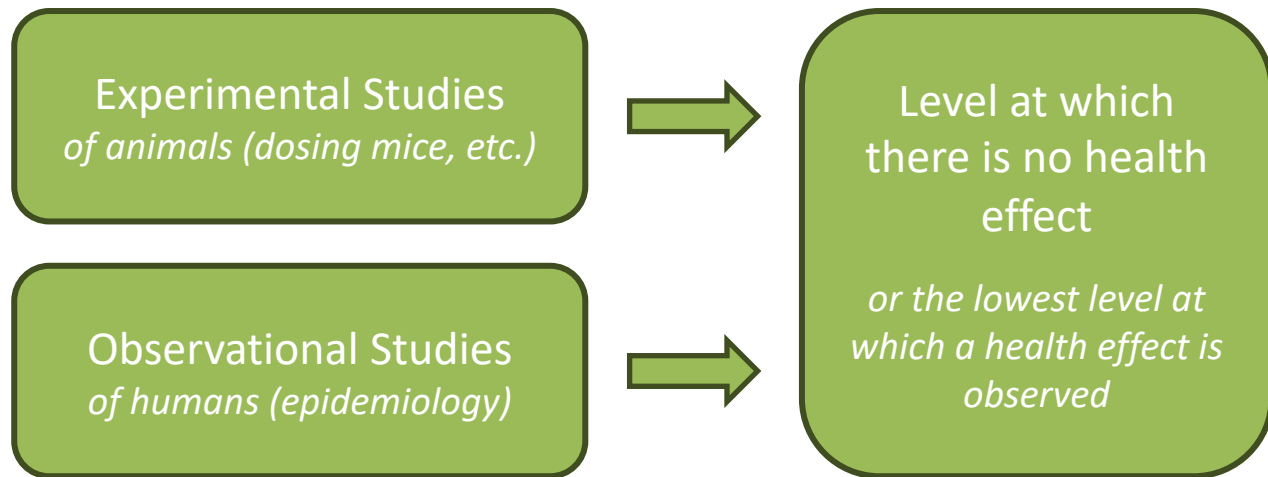
How much exposure to a chemical is safe?

- Many chemicals have a level below which there is little to no risk, called a threshold.
- Some (e.g., nutrients) improve health at a low level, but can be harmful at high levels
- Some chemicals (e.g., lead) have effects at such low doses the exposure goal is zero.
- To best protect the entire population, studies must consider whether there is a time in the lifespan that is more sensitive to such chemicals – this is often pre-conception through early life.



How do you determine toxicity without dosing people?

There will always be some level of uncertainty.



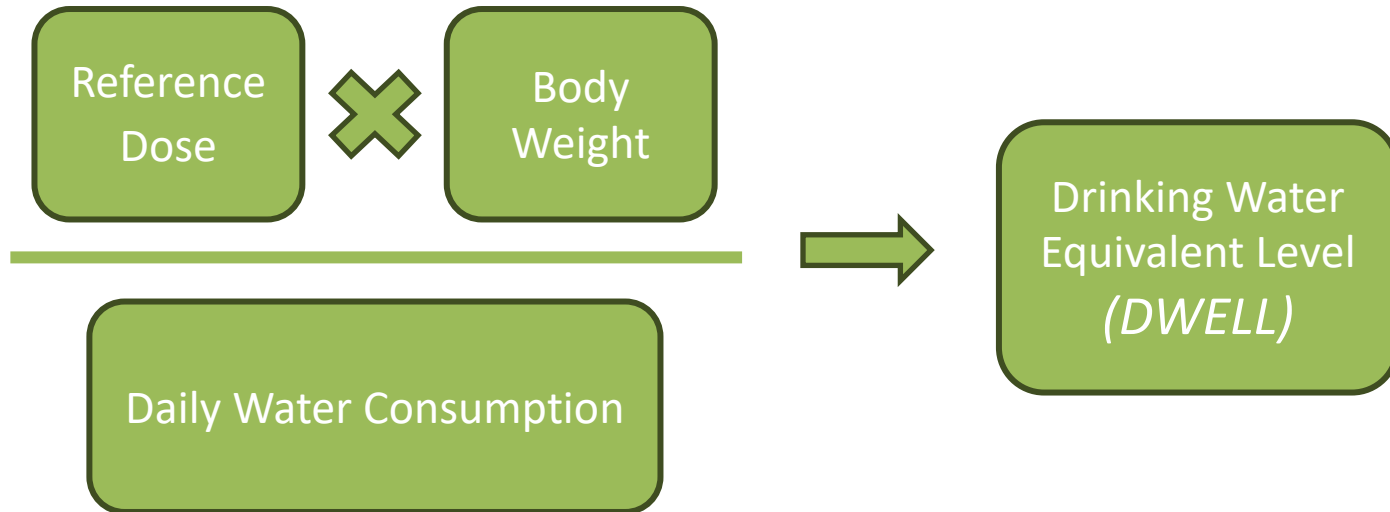
How do you determine what level is likely safe?

Apply uncertainty factors to calculate a 'reference dose'



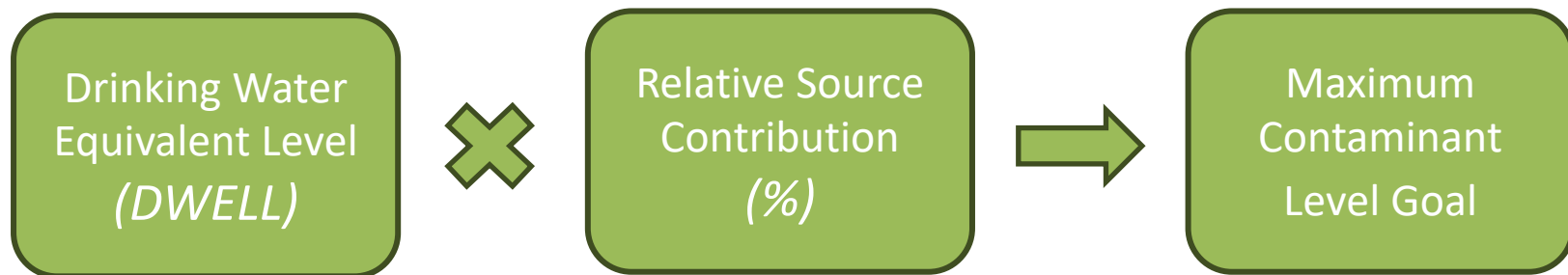
How do you determine what level is likely safe in water?

Step 1: Use algebra to integrate exposure to calculate DWELL



How do you determine what level is likely safe in water?

Step 2: Essentially subtract out non-water exposure.

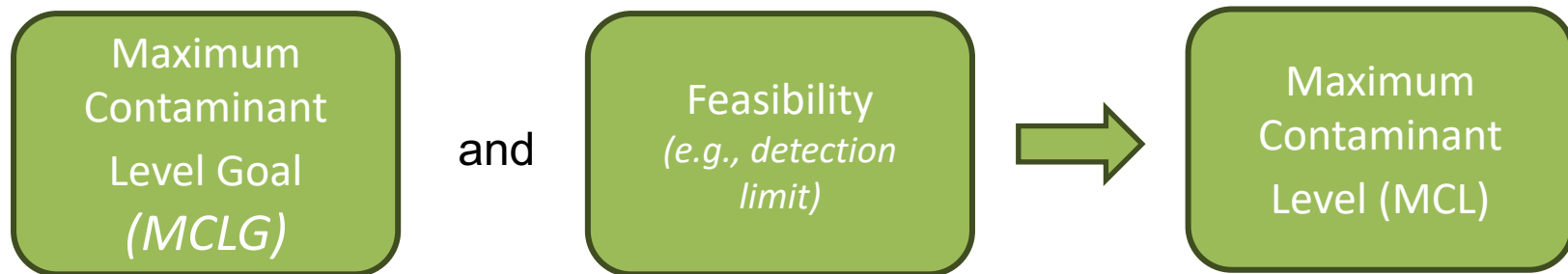


Relative Source Contribution: Percentage of total drinking water exposure for the general population after considering other exposure routes (e.g., food, soil, air, dust)



How is this safety goal implemented?

EPA sets an enforceable MCL by considering feasibility



More detail: epa.gov/sdwa/how-epa-regulates-drinking-water-contaminants

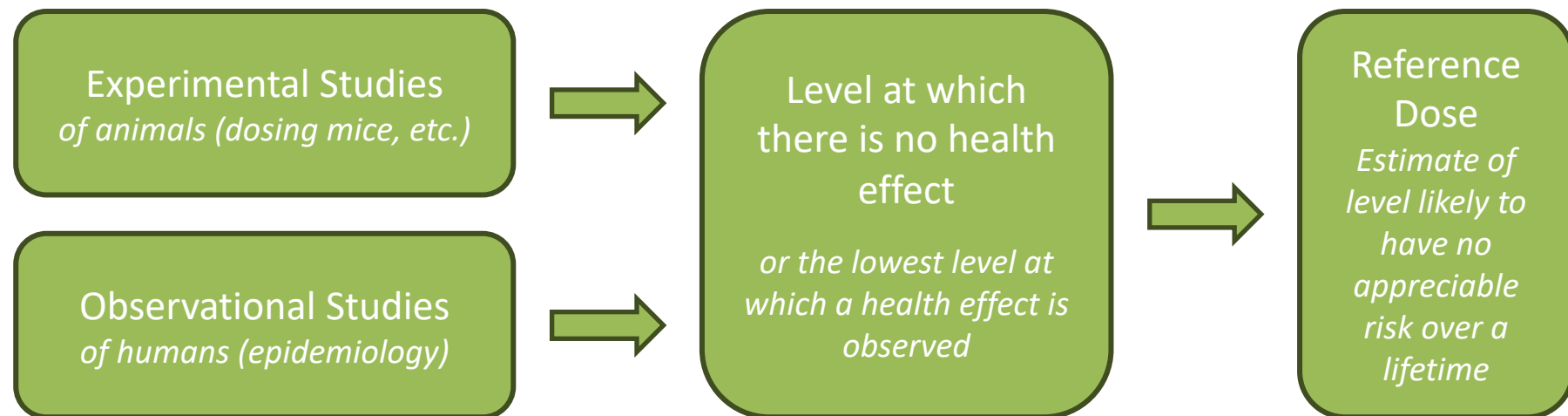


EPA PFAS MCLs

EPA'S PROPOSED MCLS FOR PFAS		simplelab
Compound	Proposed MCLG	Proposed MCL (enforceable levels)
PFOA	Zero	4.0 PPT (also expressed as ng/L)
PFOS	Zero	4.0 PPT (also expressed as ng/L)
PFNA	1.0 (UNITLESS) Hazard Index	1.0 (UNITLESS) Hazard Index
PFHxS		
PFBS		
*HFPO-DA		
HFPO-DA = commonly referred to as GenX Chemicals PPT = parts per trillion		
Sources: WHO, United States Geological Survey (USGS)		

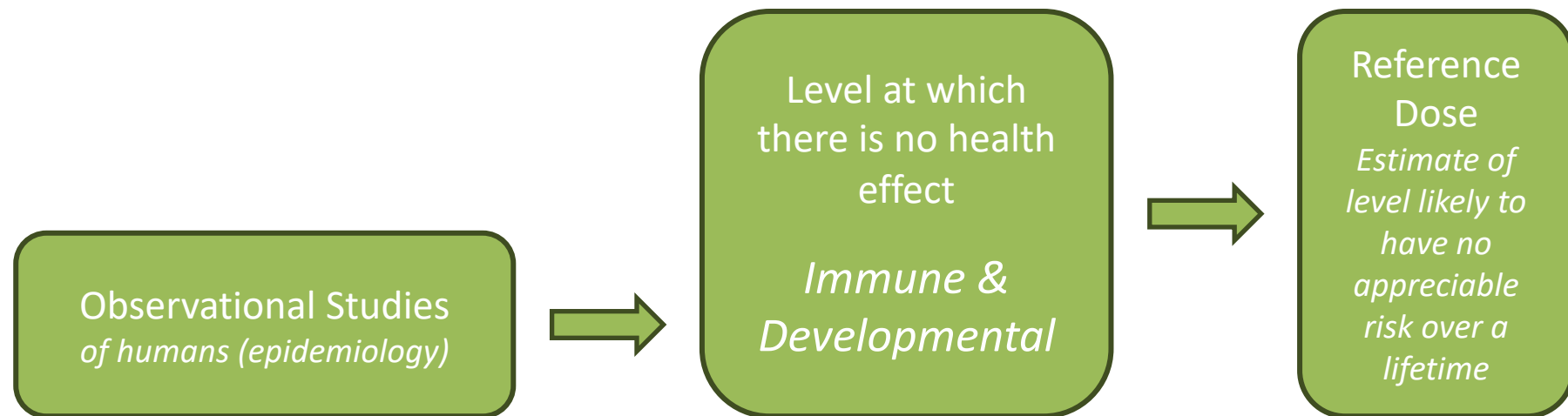
Determining Reference Dose for PFOA, PFOS, etc.

Comparing effect levels across studies – which is lowest?

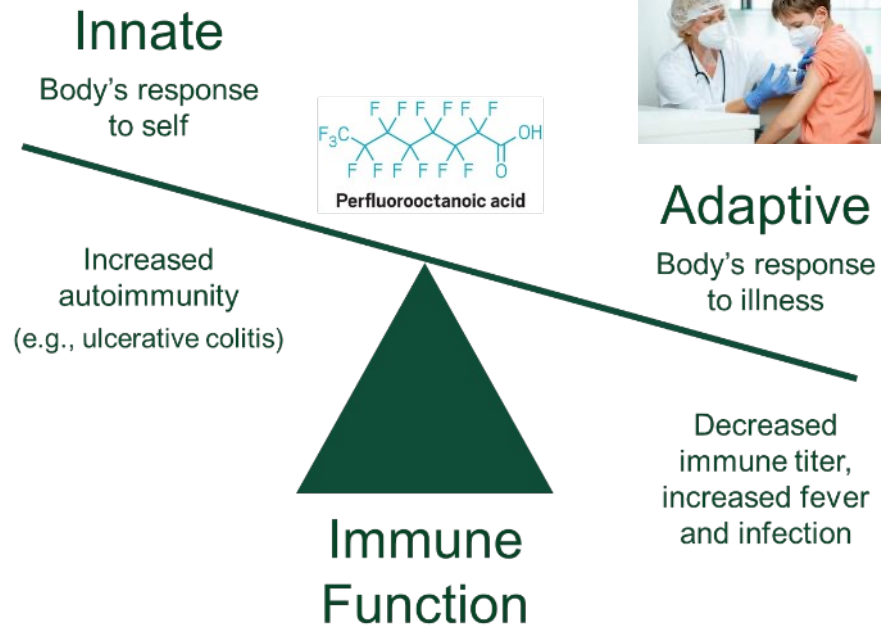


Determining Reference Doses for PFOA and PFOS

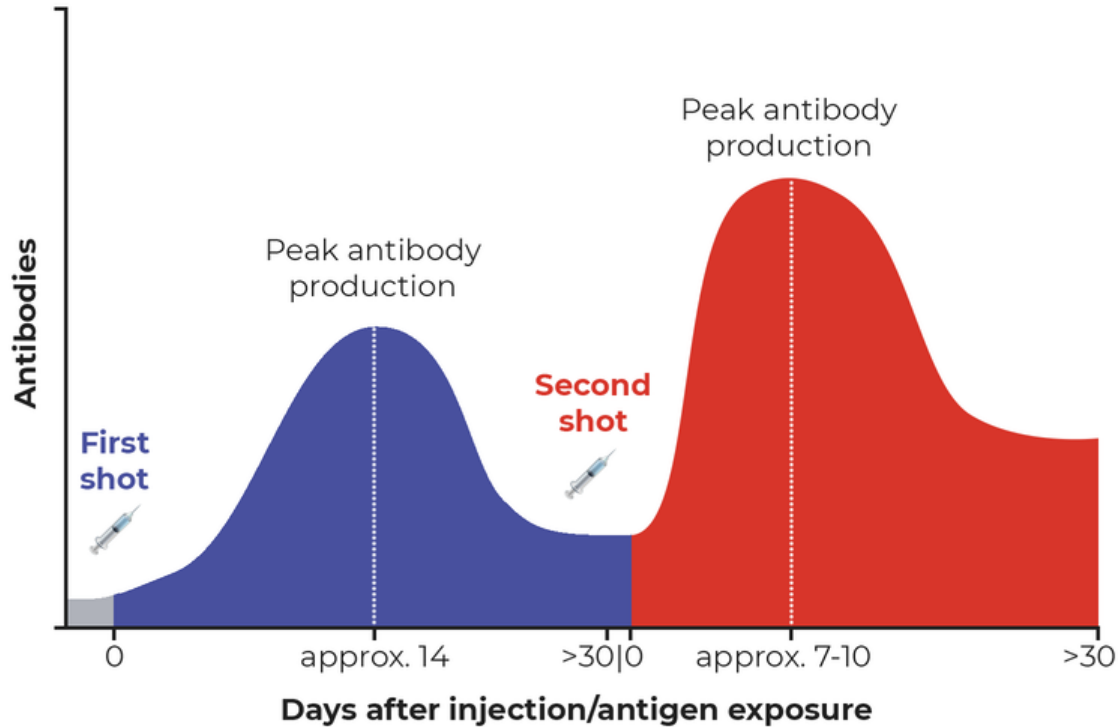
Comparing effect levels across studies – which is lowest?



Immune Disruption



How does a second vaccination dose improve your immune response?





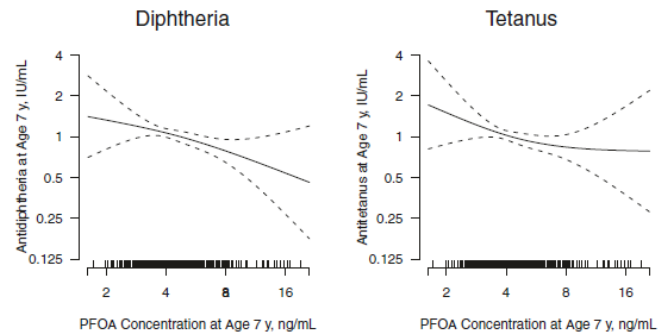


Fig. 3 Associations between PFAS and antibody concentrations at age 7 years. Dose–response functions are modeled by generalized additive models with cubic smoothing spline with 3 degrees of freedom, adjusted for age, sex, and booster vaccination type. The dashed lines indicate the 95 % confidence intervals. The spikes on the horizontal line indicate individual observations

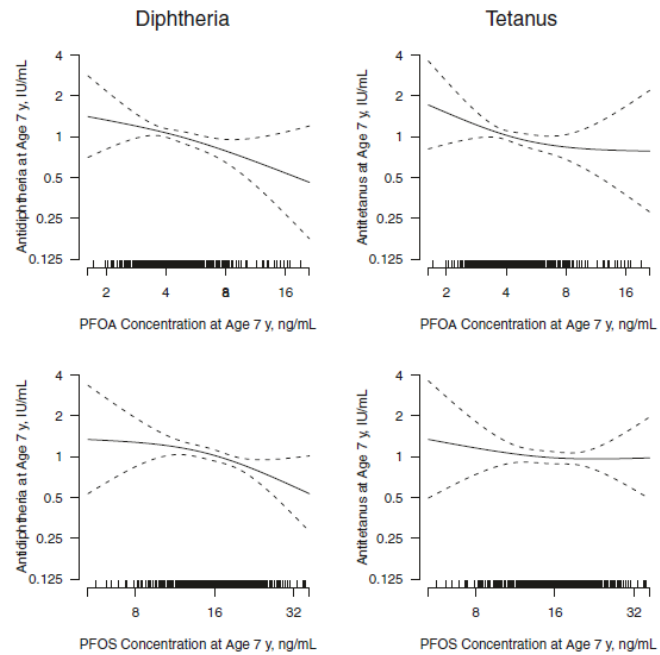


Fig. 3 Associations between PFAS and antibody concentrations at age 7 years. Dose–response functions are modeled by generalized additive models with cubic smoothing spline with 3 degrees of freedom, adjusted for age, sex, and booster vaccination type. The dashed lines indicate the 95 % confidence intervals. The spikes on the horizontal line indicate individual observations

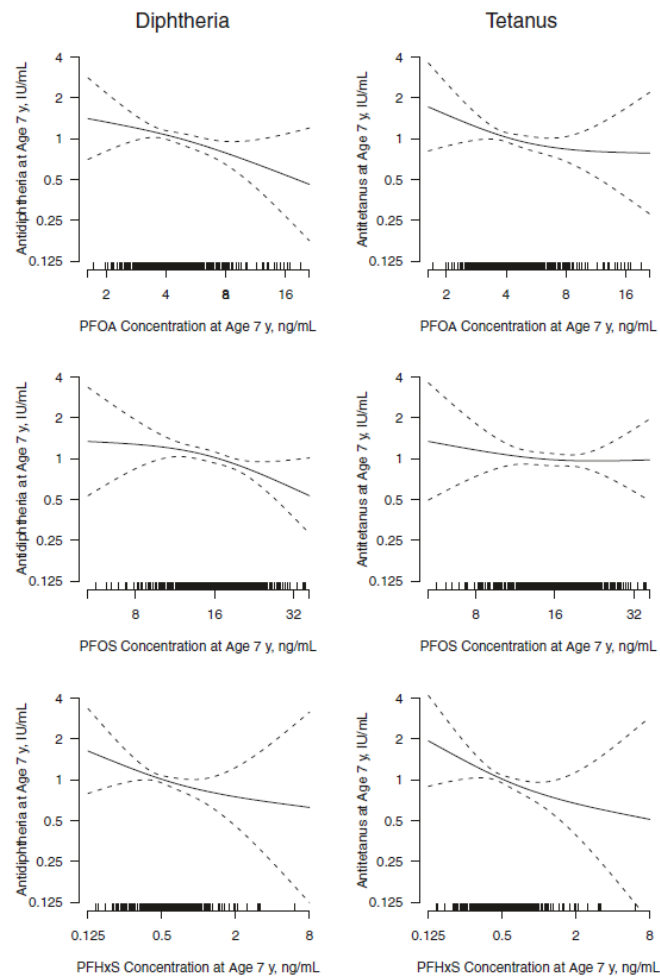


Fig. 3 Associations between PFAS and antibody concentrations at age 7 years. Dose–response functions are modeled by generalized additive models with cubic smoothing spline with 3 degrees of freedom, adjusted for age, sex, and booster vaccination type. The dashed lines indicate the 95 % confidence intervals. The spikes on the horizontal line indicate individual observations

More Frequent Fevers and Infections



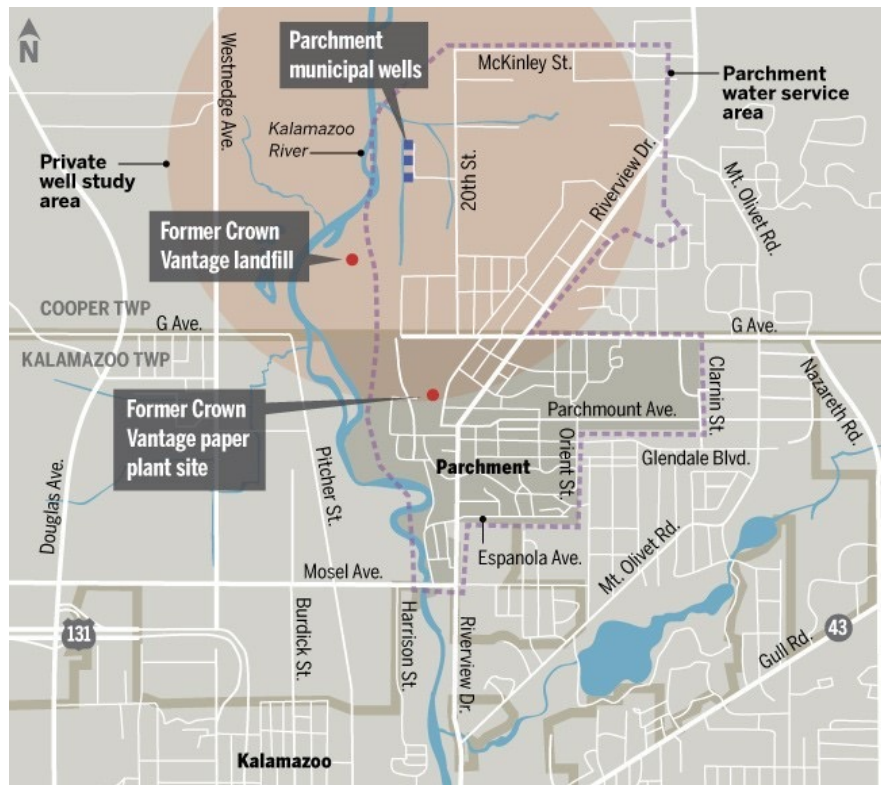


Jul 06, 2020

Op-ed: PFAS chemicals—the other immune system threat

"This global pandemic is scary for everyone and it's even scarier knowing your family has been exposed to chemicals that may hurt the immune system."

Jamie Dewitt , Phil Brown , Courtney Carignan , Shaina Kasper , Laurel Schaider , Cheryl Osimo and Maia Fitzstevens



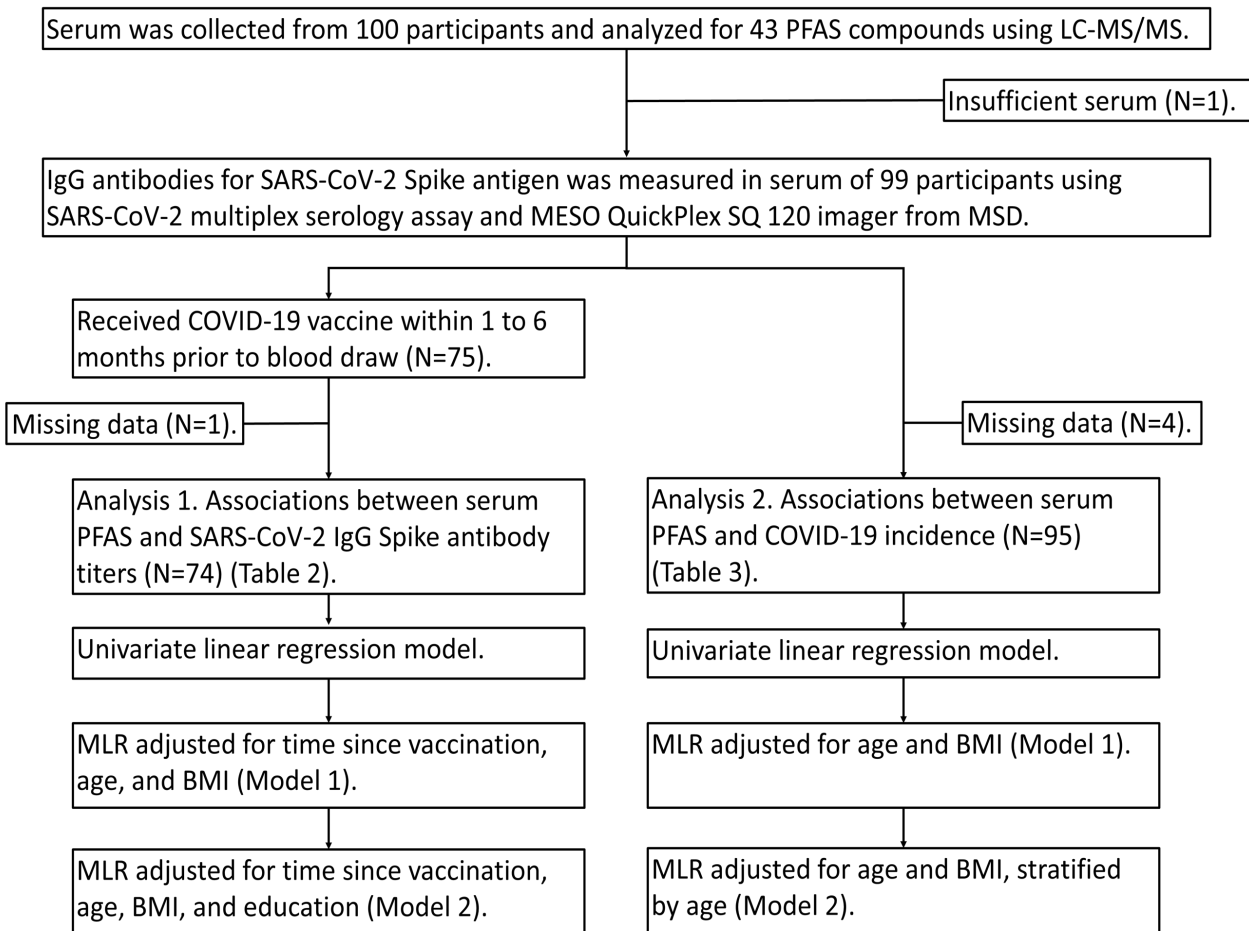
Michigan Cohort

- PFAS contamination discovered in 2018
- >1600 ppt PFAS in water
- Live in study area and drank the impacted water
- 130 enrolled (2020-2021)
- 100 provided venous





Rachel
Bauer



Geometric mean serum PFAS concentrations (95th percentile) (µg/L)

Exposure Group	ΣPFAS	PFOS	PFOA	PFHxS	PFNA	PFHpS
This Study (n=74)	22.08* (166)	7.47* (58)	4.25* (72)	2.49* (16)	0.35 (1.3)	0.31 (3.1)
General Population ^a	10.03 (28)	4.23 (15)	1.41 (3.8)	1.07 (3.7)	0.41 (1.4)	0.22 (1.0)

^aAdult general population serum concentrations in 2017-2018 (NHANES); *Statistically significant $\alpha \leq 0.05$.



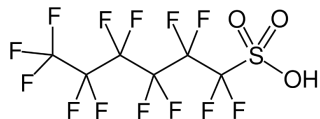
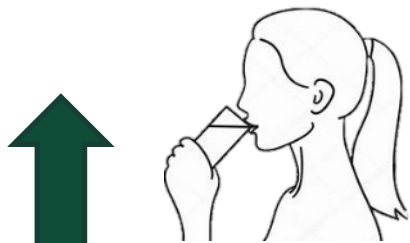
Associations of COVID-19 IgG spike antibody in Serum

PFAS Compound	Detection Frequency	Univariate		Model 1 ^a		Model 2 ^b	
		β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
Σ PFAS		-0.22 (-0.46, 0.03)	0.08	-0.22 (-0.45, 0.01)	0.07	-0.24 (-0.48, 0.001)	0.05
PFOS	100%	-0.18 (-0.4, 0.04)	0.11	-0.18 (-0.38, 0.03)	0.10	-0.19 (-0.4, 0.03)	0.09
PFOA	98%	-0.09 (-0.24, 0.06)	0.25	-0.09 (-0.23, 0.05)	0.21	-0.1 (-0.26, 0.05)	0.17
PFHxS	100%	-0.33 (-0.58, -0.07)	0.01	-0.32 (-0.55, -0.08)	0.01	-0.35 (-0.59, -0.10)	0.007
PFNA	72%	-0.15 (-0.56, 0.25)	0.45	-0.04 (-0.44, 0.36)	0.85	-0.04 (-0.44, 0.37)	0.85
PFHpS	99%	-0.16 (-0.37, 0.05)	0.13	-0.15 (-0.35, 0.04)	0.12	-0.17 (-0.38, 0.03)	0.10

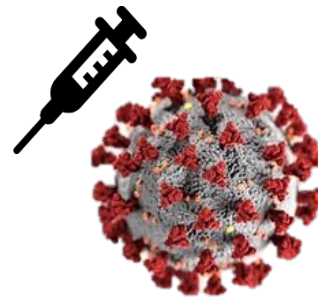
β , Beta estimate; CI, Confidence limits; ^aMultiple linear regression adjusted for time since COVID-19 vaccination, age, and body mass index; ^bMultiple linear regression adjusted for time since COVID-19 vaccination, age, body mass index, and education.



Higher Serum PFHxS was Associated with Lower COVID-19 Vaccine Antibodies in a Community with Elevated PFAS Exposure



**PFAS
Exposure**



**COVID-19
Vaccine Titer**



[Expert Blog](#)

PFAS Blood Tests: Needed but Denied

Guest blog by Andrea Amico, a PFAS community leader from Portsmouth, NH. She is passionate about advocating for answers and action on behalf of PFAS impacted communities nationwide.

February 18, 2020



Dr. Anna Reade

Director, PFAS Advocacy, Environmental Health

SHARE THIS PAGE

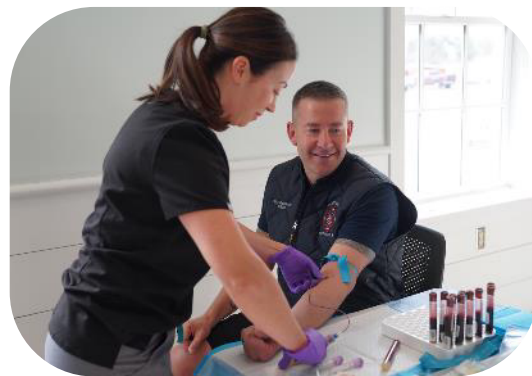


Andrea Amico is a PFAS community leader from Portsmouth, NH. She is passionate about advocating for answers and action on behalf of PFAS impacted communities nationwide. | TEDx Talks <https://www.youtube.com/watch?v=-3wspAVJ6Ps>

PFAS Blood Testing

Blood Tests allow people to:

- Better understand and mitigate their personal exposures
- Share with their doctor as a risk factor and consider medical screening. Note that doctor should also put firefighter occupation in record as a risk factor. Both can improve more timely detection and treatment of health problems.



PFAS Blood Testing

Blood Tests do not:

- Directly link exposure with disease
- Quantify personal risk
- Predict future health effects

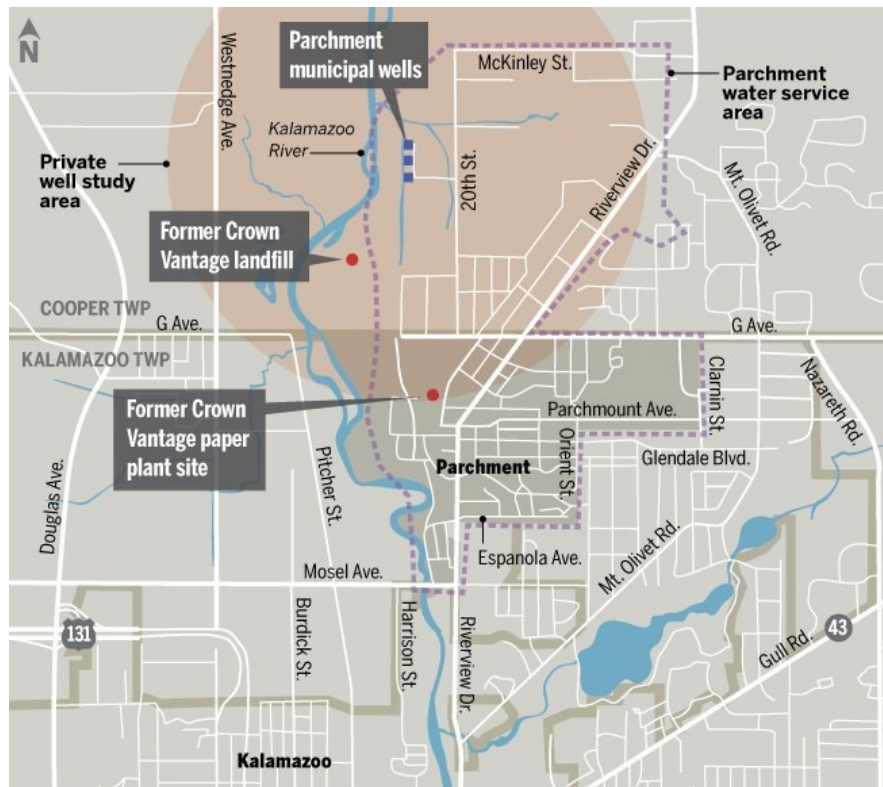


Population Inference of Risk

Kidney cancer example:

- Odds Ratio = 2 among those with elevated PFAS in drinking water
- If general population odds is 1 in 64
- Doubling of odds is 1 in 32
- Expect 2-fold higher incidence in comparable populations
- Kidney cancer has many risk factors: Individual risk will vary



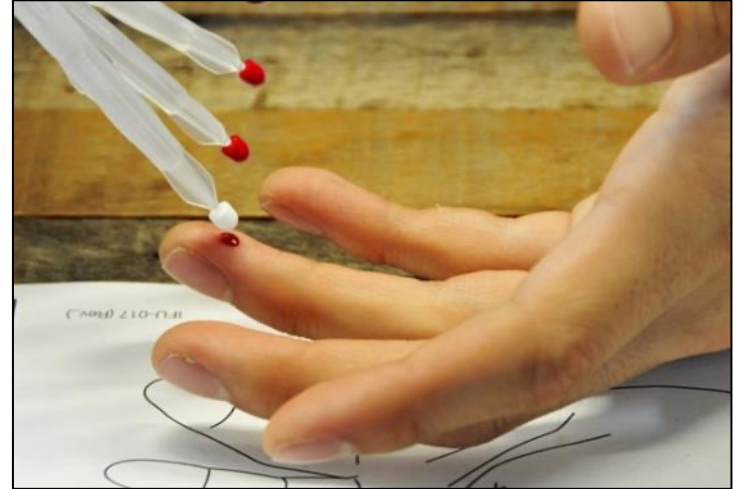


Michigan Cohort

- PFAS contamination discovered in 2018
- Live in study area and drank the impacted water
- 130 enrolled (2020-2021)
- 100 provided venous blood
- 53 provided VAMS



New Self-Collected PFAS Blood Test



<https://empowerdxc.com/products/product/pfas-exposure-test>



New test improves access to blood test for legacy PFAS.
Available from empowerDX for \$299.



Self-Collection Blood Test for PFASs: Comparing Volumetric Microsamplers with a Traditional Serum Approach

Courtney C. Carignan,* Rachel A. Bauer, Andrew Patterson, Thep Phomsopha, Eric Redman, Heather M. Stapleton, and Christopher P. Higgins



Cite This: <https://doi.org/10.1021/acs.est.2c09852>

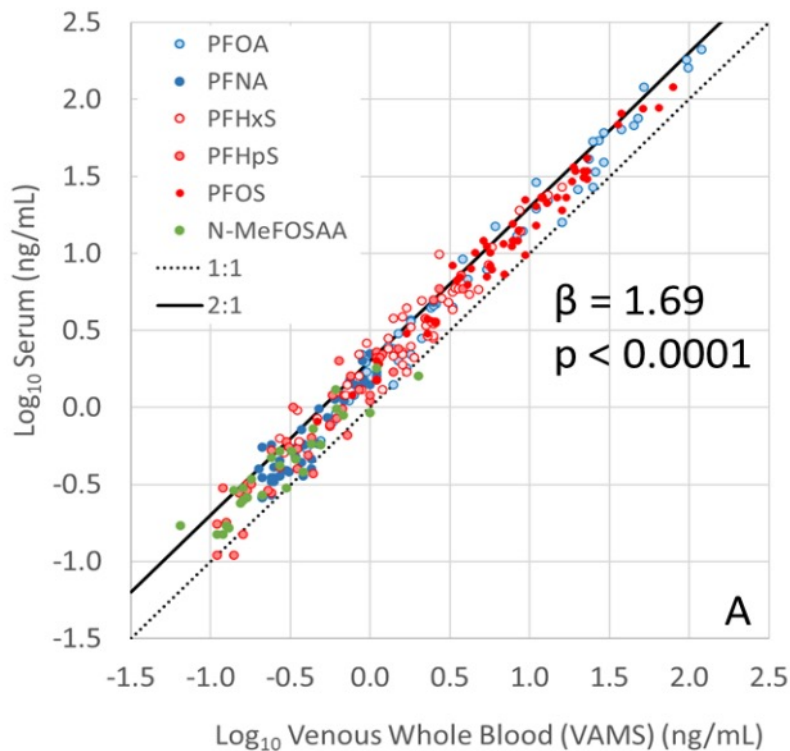


Read Online

2023 57 (21), 7950-7957

Found the test works well for measuring legacy PFASs among those exposed.

Significant Association Between Methods



- PFAS results from new VAMS method significantly associated with blood draw/serum method.
- As VAMS uses capillary whole blood, interpretation requires conversion to serum equivalent.

Works well for measuring legacy PFASs.

Full report is free online. Click around prompts.

Guidance on PFAS Testing and Health Outcomes

SHARE [f](#) [t](#) [in](#) [✉](#)



- About
- Announcement
- Publications
- Description

Per- and polyfluoroalkyl substances (PFAS) are chemicals that contaminate many communities in the United States. Our expert committee will examine the health outcomes associated with the most widely studied PFAS and make recommendations to the CDC on who, when, how, and what to test, as well as the risks of testing.

[Provide feedback on this project](#)

SUBSCRIBE FOR UPDATES
FROM BEST

<https://www.nationalacademies.org/our-work/guidance-on-pfas-testing-and-health-outcomes>

The PFAS Exchange

An online resource center about PFAS contaminants in drinking water—helping communities understand their exposures and take action to protect their health.



What's My Exposure?

Information from your blood report

PFOA (in blood) --
Perfluorooctanoic acid

Value: 0.85
Unit: ng/mL

PFOS (in blood) --
Perfluorooctane sulfonic acid

Value: 7.6
Unit: ng/mL

PFHxS (in blood) --
Perfluorohexane sulfonic acid

Value: 2.7
Unit: ng/mL

PFNA (in blood) --
Perfluorononanoic acid

Value: 0.84
Unit: ng/mL

Generate report

 **PFAS Exchange**
www.pfas-exchange.org

> PFOS (Perfluorooctane sulfonic acid)

Your result: 7.6 µg/L (You entered this as: 7.6 ng/mL)

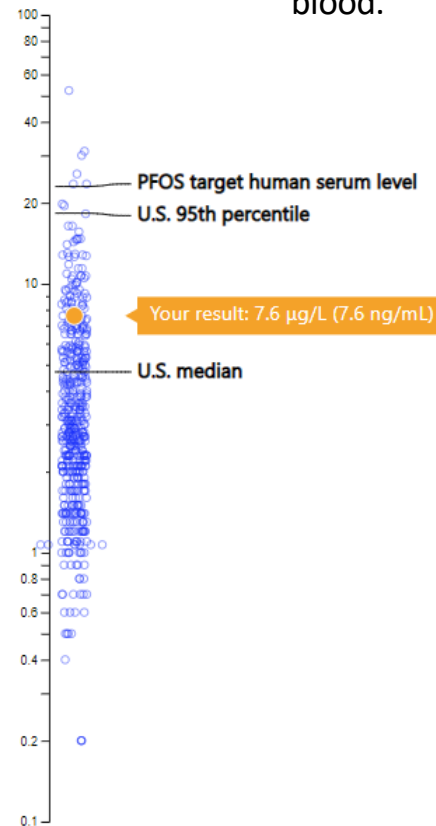
✔ Your result was **below** the U.S. 95th percentile of 18.3 ng/mL (18.3 µg/L)

⚠ Your result was **above** the U.S. median of 4.7 ng/mL (4.7 µg/L)

Graph legend

- People in a representative sampling of Americans
- PFOS level in my blood
- Benchmarks from a representative sampling of Americans and from other PFAS exposure studies

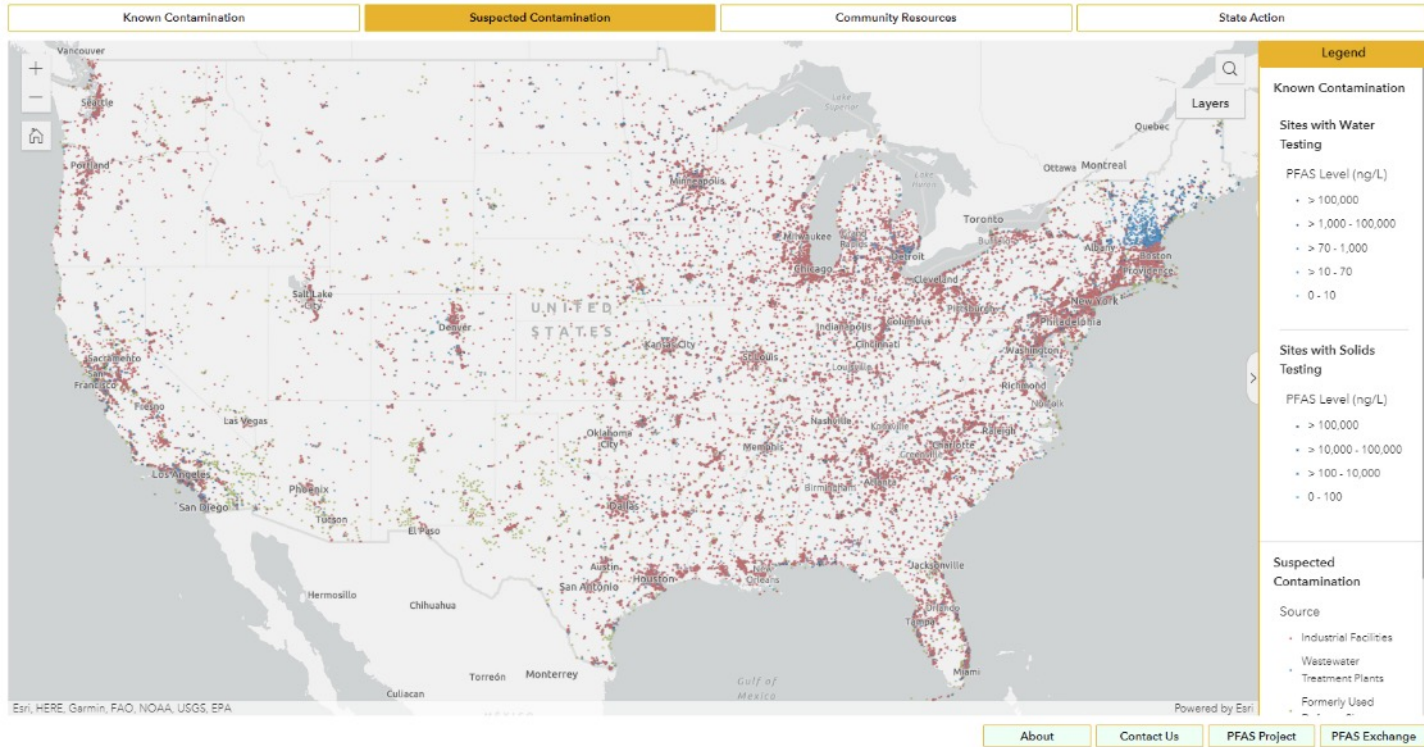
This online tool can help interpret PFAS levels in water and blood.



The PFAS Exchange

An online resource center about PFAS contaminants in drinking water—helping communities understand their exposures and take action to protect their health.





Resources

Because PFAS are so ubiquitous in the environment and exposures are so widespread, it's important for people to be informed. Below are resources to help you make decisions to protect your health.



Fact Sheets

Health Monitoring

- Medical Screening Guidance – for people in PFAS-impacted communities
- Medical Screening Guidance – for clinicians
- Vaccine Response and PFAS Exposure – for people in PFAS-impacted communities
- PFAS Blood Testing: What You Need to Know
- Information About Blood Testing Laboratories – for individuals


pfas-exchange.org

How do I get a PFAS blood test?

Your doctor may be able to order a PFAS blood test. Providers should use ICD-10 diagnosis code Z13.88, and if ordering a test through Quest, they should use Test Code 39307 and CPT code 82542. Let your provider know you prefer a lab that measures both linear and branched isomers and a comprehensive panel that includes many compounds (see explanation on next page).

Blood testing fact sheet has codes for doctor

If your doctor cannot order the test, ask if they can help with a blood draw. Either way, you can contact a lab directly to request the test.

How do I find a lab?

Several labs in North America currently offer PFAS blood testing to individuals: [AXYS Analytical](#), [EmpowerDX](#), and [Eurofins](#). AXYS and Eurofins measure PFAS in blood serum, and EmpowerDX offers a home finger-prick test. [NMS Labs](#) does not offer tests to directly to individuals, but does provide blood testing to other entities, including Quest and LabCorp that do offer testing to individuals through clinicians.

For information about price, specific chemicals tested, and lab requirements, see our online guide (bit.ly/pfas-blood-test).

A note about litigation

If you are considering legal action, consult a lawyer before testing your blood. Discovery of PFAS in blood may start the clock on a statute of limitations that could prevent you from litigating in the future. Note that certain documentation may be required in legal settings, so you may need a blood draw (rather than a finger-prick) by a phlebotomist who can serve as a documented witness.

Blood draw vs. finger-prick tool

- Most labs require a **blood draw** by a phlebotomist so they can test a large amount of your blood. This has been preferred for many years, is well studied, and may have legal benefits.
- EmpowerDX (part of Eurofins) offers a **finger-prick tool** that allows you to collect a sample at home and will test your whole blood. Note that if PFAS levels in your blood are low, this test may be less likely to detect the PFAS.

Limitations you may encounter

- Health insurance may not cover costs.
- The maximum number of PFAS that can be tested is around 40. This is a small number compared to the thousands of PFAS that exist.


Resources

Because PFAS are so ubiquitous in the environment and exposures are so widespread, it's important for people to be informed. Below are resources to help you make decisions to protect your health.



Fact Sheets

Health Monitoring


- 
- Medical Screening Guidance – for people in PFAS-impacted communities
 - Medical Screening Guidance – for clinicians
 - Vaccine Response and PFAS Exposure – for people in PFAS-impacted communities
 - PFAS Blood Testing: What You Need to Know
 - Information About Blood Testing Laboratories – for individuals

pfas-exchange.org

Medical Screening Guidance

PFAS-Impacted People

Their Clinicians

 **PFAS-REACH**
PFAS Research, Education, and Action for Community Health

PFAS Exposure: Information for patients and guidance for clinicians to inform patient and clinician decision making
For people in PFAS-impacted communities

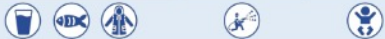
Purpose
This guidance document is intended for people living in communities with contaminated water or who have had some other source of substantial exposure to PFAS. This guidance document is not targeted to those at average risk from PFAS.

What is medical screening?
Medical screening is the testing for early signs of disease. Screening for certain conditions or subclinical changes may be advised for those who have or have had known elevated exposure to PFAS. Medical screening may identify early indicators of disease and allow you to work with your clinician to determine next steps.

What are PFAS?
Per- and polyfluoroalkyl substances (PFAS) are a large group of over 9,000 human-made chemicals, exposure to which has been associated with several serious health effects. They are extremely resistant to breakdown, highly mobile in the environment, and have contaminated hundreds of drinking water supplies. PFAS have been found in the blood of over 99% of Americans and some PFAS can remain in the body for years.

How can I be exposed to PFAS?


At home	At work	Early in life
<ul style="list-style-type: none">Drinking contaminated waterEating food contaminated from environmental sources or from processing and packagingUsing stain- and water-resistant products, grease-proof food packaging, nonstick cookware, and many other consumer products	<p>Some people, such as firefighters and those in chemical production and application industries, may be exposed to products containing PFAS at work.</p>	<p>PFAS can cross the placenta and accumulate in breast milk, so children can be exposed in the womb and during early life through breastfeeding.</p>



How are PFAS regulated in drinking water?

- PFAS are not regulated under the U.S. Environmental Protection Agency's Safe Drinking Water Act. This means there are no federally enforceable standards and public water suppliers are not required to routinely test or treat for PFAS under federal law.
- In 2016, the U.S. Environmental Protection Agency established a non-enforceable Lifetime Health Advisory of 70 parts per trillion (ppt) for PFOA and PFOS (two of the most common PFAS chemicals) individually or combined, for municipal drinking water. Some scientists and regulators think this advisory is not sufficiently protective of human health.
- As of April 2021, 12 states have adopted more stringent, and in some cases enforceable, drinking water guidelines. The [PFAS Exchange](#) provides more information about national and state drinking water guidelines. Some states have established guidelines for additional PFAS chemicals, down to 10–20 ppt.
- The Northeastern University [Contamination Site Tracker](#) has documented hundreds of contaminated sites in the U.S., with more sites being added as testing continues.

This fact sheet is a product of the PFAS-REACH (Research, Education, and Action for Community Health) study. PFAS-REACH is funded by the National Institute of Environmental Health Sciences (Grant No. R01ES028311). June 2022

 **PFAS-REACH**
PFAS Research, Education, and Action for Community Health

PFAS Exposure: Information for patients and guidance for clinicians to inform patient and clinician decision making
For clinicians

About this guidance document

The guidance summarized here is to help inform discussion and decision making for physicians and their patients. Many of the tests and screenings noted are part of basic primary care annual appointments. In 2019, the American Medical Association (AMA) resolved to support research and policy to address the effects of PFAS exposure.

We based the following suggestions for medical screening tests on those previously developed and implemented for a PFAS-impacted community as well as peer-reviewed research and scientific assessments using weight of evidence approaches from:

- Agency for Toxic Substances and Disease Registry (2021)
- Centers for Disease Control and Prevention (2019)
- CB Science and Medical Panels (2005–2013)
- European Environment Agency (2019)
- International Agency for Research on Cancer (2017)
- National Toxicology Program (2016)

These recommendations are for those living in communities with contaminated water or who are exposed to other sources of PFAS that substantially increases their internal burden of PFAS. These recommendations are not targeted to those with average levels of PFAS exposure.

Guidance for adult patients

Laboratory tests

- Lipid panel (cholesterol, LDL, HDL, triglycerides).** PFAS exposure has been associated with higher total and LDL cholesterol and fatty liver.
- Liver function tests,** such as ALT, AST, and GGT. PFAS exposure has been associated with higher-than-normal liver function tests, as well as hepatotoxicity including hepatocyte and liver architecture damage.
- Serum creatinine and urine protein and urine albumin.** PFAS exposure is associated with chronic kidney disease and kidney cancer. An important note for researchers is that there is enhanced excretion of PFAS in moderate-to-severe kidney disease, especially if there is albuminuria. Reduced serum PFAS concentrations for those individuals introduces a bias towards the null if not controlled for in epidemiologic studies.
- Thyroid tests,** such as TSH with or without FT4. PFAS exposure has been associated with thyroid disease.

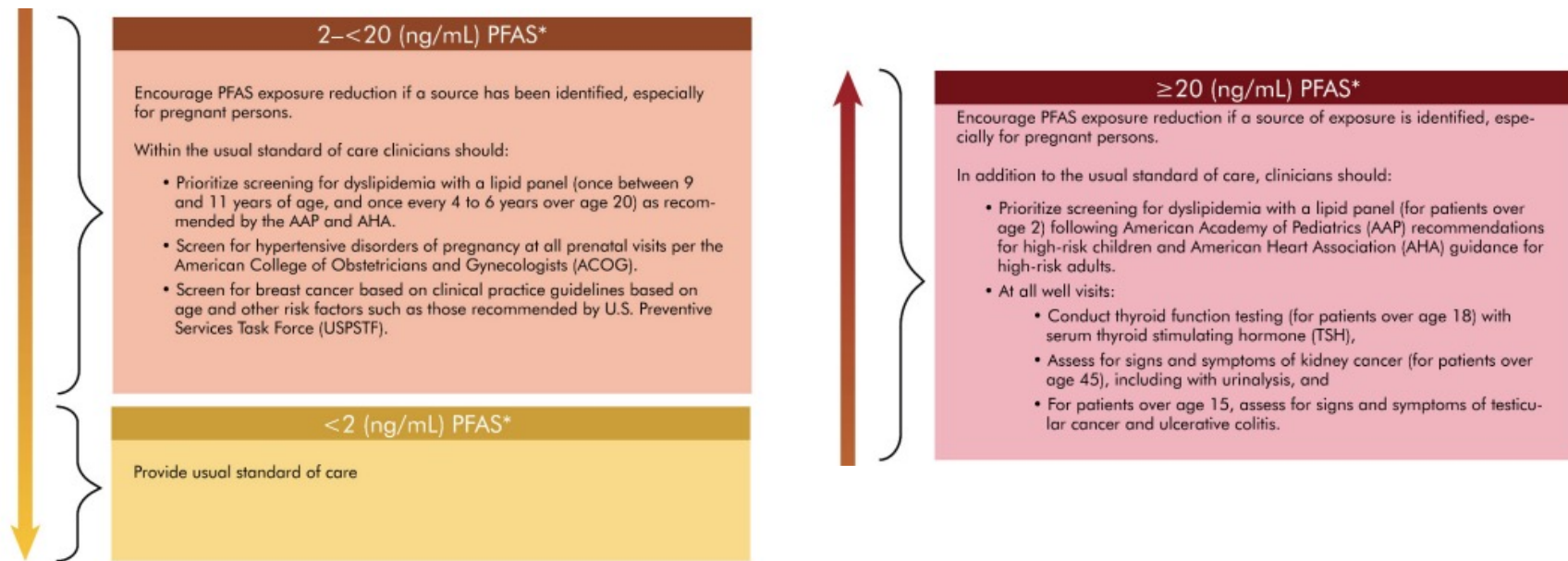
Clinical examinations

- Regular testicular examinations.** Exposure to high levels of PFAS has been associated with increased risk of testicular cancer.

Counseling topics

- Vaccine response.** There is currently no consensus on re-vaccinating patients with low vaccine titer when tested a month following vaccination (e.g., Tdap, MMR); more research is needed.
- Home blood pressure monitoring during pregnancy.** PFAS are associated with elevated blood pressure during pregnancy and with preeclampsia.
- Breastfeeding.** Babies can be exposed to PFAS during pregnancy since PFAS can cross the placenta. PFAS chemicals also accumulate in breast milk. However, the benefits of breastfeeding are clear, and include benefits to maternal as well as child health. There is insufficient evidence to recommend against breastfeeding based on maternal PFAS exposure.

Clinical Guidance for Follow-up with Patients after PFAS Testing



* Simple additive sum of MeFOSAA, PFHxS, PFOA (linear and branched isomers), PFDA, PFUnDA, PFOS (linear and branched isomers), and PFNA in serum or plasma

National Academies of Sciences, Engineering, and Medicine. 2022. Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26156>



National Academies Medical Screening Guidance

Advises tests in typical physical plus a little more

≥ 20 (ng/mL) PFAS*

Encourage PFAS exposure reduction if a source of exposure is identified, especially for pregnant persons.

In addition to the usual standard of care, clinicians should:

- Prioritize screening for dyslipidemia with a lipid panel (for patients over age 2) following American Academy of Pediatrics (AAP) recommendations for high-risk children and American Heart Association (AHA) guidance for high-risk adults.
- At all well visits:
 - Conduct thyroid function testing (for patients over age 18) with serum thyroid stimulating hormone (TSH),
 - Assess for signs and symptoms of kidney cancer (for patients over age 45), including with urinalysis, and
 - For patients over age 15, assess for signs and symptoms of testicular cancer and ulcerative colitis.

* Simple additive sum of MeFOSAA, PFHxS, PFOA (linear and branched isomers), PFDA, PFUnDA, PFOS (linear and branched isomers), and PFNA in serum or plasma

<https://www.nationalacademies.org/our->



Jun 29, 2021

Improved medical screening in PFAS-impacted communities to identify early disease

People highly exposed to PFAS often face significant hurdles in getting screened for potential health effects from the exposure. That needs to change.

[Isabella Raponi](#) , [Phil Brown](#) and [Alissa Cordner](#)



Credit: Zach Vessels/Unsplash

Op-ed: Arming doctors with knowledge about PFAS pollution

A new course and report on PFAS-related health effects can empower patients, promote life-saving screening and help tackle the continued devastating health effects of PFAS chemicals.

by Courtney Carignan and Esmé Getto and Phil Brown and Laurel Schaidler and Andrea Amico and Emily Donovan and Alissa Corder

December 05, 2022



PFAS-REACH Fact Sheets and Resources

PFAS Exposure and Health

- [How to Reduce Your Exposure to PFAS](#)
- [How Can PFAS Affect Your Health](#)
- [PFAS and the Immune System: What Do We Know?](#)

PFAS in Drinking Water

- [PFAS in Drinking Water: What You Should Know](#)
- [PFAS: A Word About Drinking Water Guidelines](#)

Health Monitoring

- [Medical Screening Guidance – for people in PFAS-impacted communities](#)
- [Medical Screening Guidance – for clinicians](#)
- [Vaccine Response and PFAS Exposure – for people in PFAS-impacted communities](#)
- [PFAS Blood Testing: What You Need to Know](#)
- [Information About Blood Testing Laboratories – for individuals](#)

Webinar

- [“Non-stick Nuisance: Medical Monitoring for PFAS” – Health Education and Guidance on PFAS Exposure](#)



Resources for Clinicians

A comprehensive set of resources for medical and health professionals, including our 2022 Continuing Medical Education Course.

Resources for Clinicians

Because PFAS are so ubiquitous in the environment and exposures are so widespread, it's important for clinicians to be informed. Below are resources to help guide you in your practice.

Video: Health Education and Guidance on PFAS Exposure

This presentation highlights the importance of increasing clinical knowledge and understanding among healthcare providers for patients with potential risk factors and/or concerns about PFAS exposure. The presentation discusses individual risk factors and teaches the audience current federal recommendations for screening, as well as other protocols for assessing PFAS exposure and prevention and follow up approaches where research and research findings may be involved and/or unclear. The presentation promotes knowledge and competence for understanding and recognizing likely PFAS environmental exposures and preventing further exposure.



Nonstick Nuisance: Medical Monitoring for PFAS

Watch later Share

PFAS-REACH
PFAS Research, Education, and Action for Community Health

PFAS Project Lab

MICHIGAN STATE UNIVERSITY

SILENT SPRING INSTITUTE
Research for Environment and Human Health

NANTUCKET COTTAGE HOSPITAL
NANTUCKET COMMUNITY HEALTH CENTER

TESTING FOR PFAS

NANTUCKET PFAS ACTION GROUP

Watch on YouTube

New Clinician Training CME

Developed by our PFAS REACH team in collaboration with project partners. Features leading experts in PFAS toxicology, occupational medicine and pediatric environmental medicine.



Linda Birnbaum



National Institute of
Environmental
Health Sciences



Alan Ducatman



Elizabeth Friedman



Courtney Carigan



Phil Brown



Laurel
Schaider



New Clinician Training CME

Includes presentations by project partners and personal stories from people impacted by PFAS contamination. Produced by communication professionals.



Andrea Amico



Sandy Wynn-Stelt



Ayesha Khan



Jamie Honkawa



Beyond PFAS

Industrial Chemicals in Virtually Every U.S. Pregnant Woman

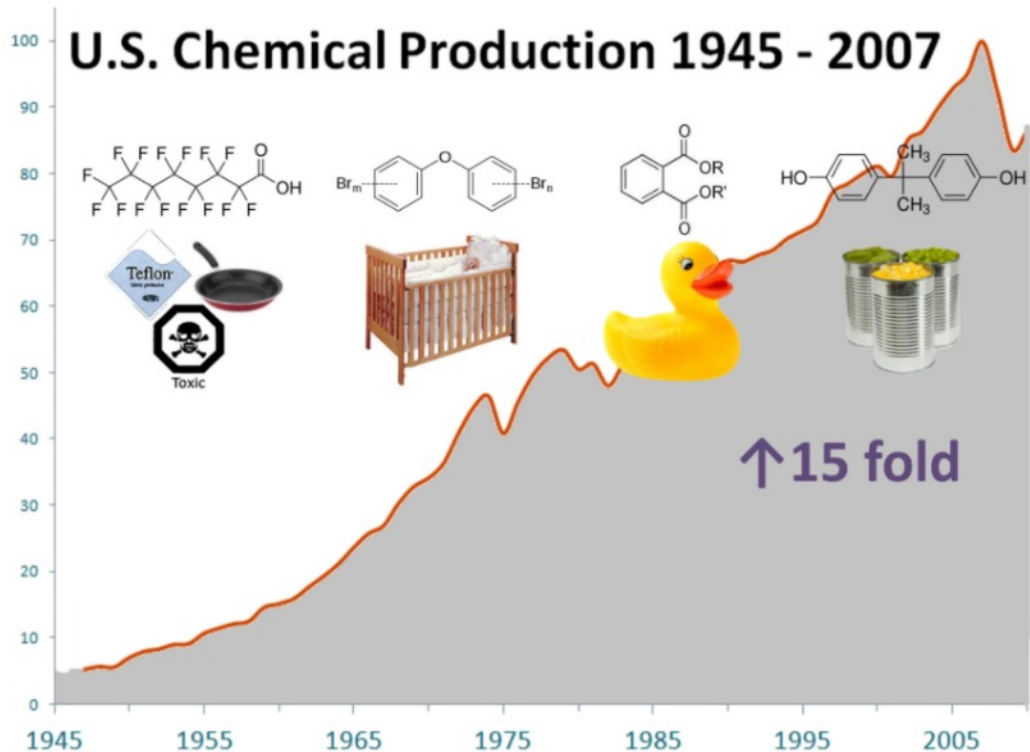
43

industrial chemicals found
in pregnant women

	Perchlorate	PCB-170
	1-Hydroxypyrene	PCB-153
	3-Hydroxyphenanthrene	PCB-146
	2-Hydroxyphenanthrene	PCB-118
	1-Hydroxyphenanthrene	PCB-110
	1-Naphthol	PCB-105
	2-Naphthol	PCB-101
	2-Hydroxyfluorene	PCB-99
	3-Hydroxyfluorene	PCB-74
	9-Hydroxyfluorene	PCB-66
	Mono-(3-carboxypropyl) phthalate (MCPP)	PCB-52
	Mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP)	PCB-49
	Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP)	PCB-44
	Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	PCB-28
	Mono-ethyl phthalate (MEP)	PBDE-153
	Mono-n-butyl phthalate (MnBP)	PBDE-100
	Mono-isobutyl phthalate (MIBP)	PBDE-47
	Mono-benzyl phthalate (MBzP)	Perfluorononanoic acid (PFNA)
	Benzophenone-3	Perfluorooctane sulfonic acid (PFOS)
	Hexachlorobenzene	Perfluorooctanoic acid (PFOA)
	p,p' - Dichlorodiphenyldichloroethene (DDE)	PCB-138 and -158
	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	



Source: University of California, San Francisco, Program on Reproductive Health and the Environment



Federal reserve data on chemical production is only offered as relative production, which is unit-less. A specific reference year is chosen and values are calculated relative to that year's production. In this particular data set 2007 is the reference year and is assigned a value of 100.

Data from: U.S. Federal Reserve Board, Division of Research and Statistics



Roadmap to strengthen chemical policy

The Problem



Chemical production is rising dramatically and impacting global health



EPA's regulatory process can't keep up



Low wealth and communities of color bear disproportionate chemical burden

The system fails to protect people from harmful chemicals

The Solution



To protect people's health, EPA must **strengthen** use of **science** in 5 ways:

- 1 Make industry pay for data collection 
- 2 Declare lack of data does not mean lack of risk 
- 3 Better identify and protect populations in harm's way 
- 4 Don't assume safety thresholds for population-wide exposures 
- 5 Account for conflicts of interest in risk assessments 

EPA can protect people better if chemical regulations rely on the best science

Carignan Lab

Graduate Team:

Rachel Bauer

Ankita Bhattacharya

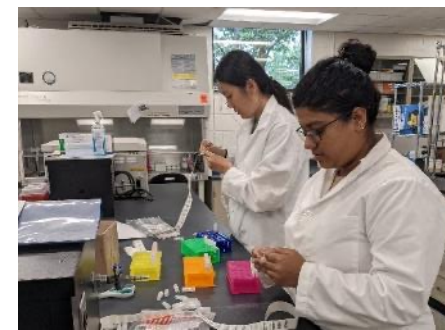
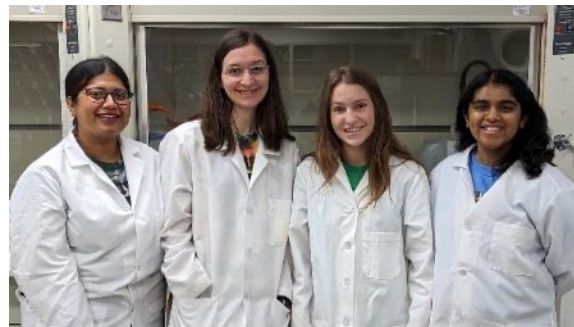
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Acknowledgements – Blood Test Study

Study Participants

Michigan State University

Rachel Bauer

Colorado School of Mines

Chris Higgins

Duke University

Heather Stapleton

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Andrew Patterson

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Study Participants

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Maia Fitzstevens

Testing for Pease

Andrea Amico

Massachusetts Breast Cancer Coalition

Cheryl Osimo

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PFAS-REACH is a partnership of Silent Spring Institute, Northeastern University, and Michigan State University, funded under grant R01ES028311.



Thank You!

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**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

CLEAN CAPE FEAR

ENDING PFAS SACRIFICE ZONES

A COMMUNITY PERSPECTIVE ON ENGAGING
THE UNITED NATIONS HUMAN RIGHTS COUNCIL

2024 National PFAS Conference | Ann Arbor, MI | June 11, 2024

Emily Donovan, Jessica Cannon, Harper Peterson,
Rebecca Trammell, Kyle Horton, Kirk deViere

www.cleancapefear.org



“ ”

***The control of what happens to
one's own body [] is fundamental to
human rights law...***

UN Special Rapporteur



BY THE NUMBERS

FAYETTEVILLE WORKS

1980 began making PFAS

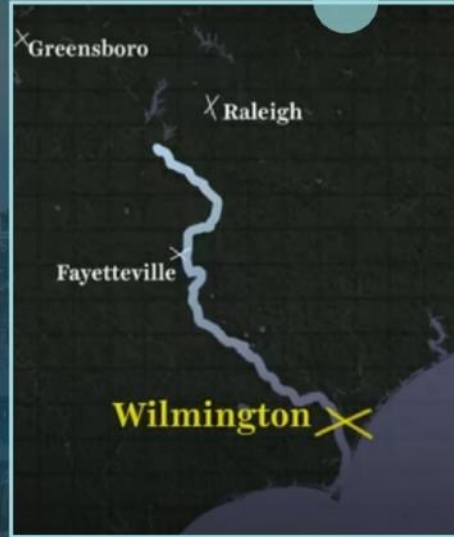
300 distinct PFAS released into river

8 counties contaminated

500,000 public water users impacted

10,000 private well owners in distress

DUPONT & CHEMOURS: 60 YEARS OF DECEIT



NORTH CAROLINA'S PFAS SACRIFICE ZONE

FAYETTEVILLE WORKS

- 2008: DuPont knew severity of 5.4 million pounds of PFAS released each year in NC.
- 2009: DuPont fails to notify EPA of GenX releases for past 24 years.
- 2015: DuPont offloads PFAS liability onto spinoff Chemours.
- 2018: Chemours fails to accurately report air emissions to NCDEQ and knowingly fails to control PFAS air emissions until legally required by 2019 Consent Order.
- 2023: Chemours seeks expansion permit from NCDEQ to make more PFAS.

RESPONDING TO THE THREAT



Protest at Chemours Information Meeting



Berkeley Environmental Law Clinic Site Visit

NORTH CAROLINA'S PFAS SACRIFICE ZONE

UNHRC BEGINS FACT-FINDING PROCESS



Source: <https://spcommreports.ohchr.org/>

Source: <https://spcommreports.ohchr.org/>

UN Allegation Letters Sent:
United States, Netherlands, Chemours, Corteva, & DuPont

Response Letters Received as of June 8, 2024:
Netherlands, Chemours, Corteva, & DuPont

UN EXPERTS CALL OUT DUPONT & CHEMOURS



The screenshot shows the United Nations Human Rights Office website. At the top left is the United Nations logo and the text "United Nations". To its right is the United Nations Human Rights logo and the text "UNITED NATIONS HUMAN RIGHTS OFFICE OF THE HIGH COMMISSIONER". A "Donate" button and a search icon are in the top right. A navigation bar contains links for "What are human rights?", "Topics", "Countries", "Instruments & mechanisms", "Latest", "About us", and "Get Involved". Below the navigation bar, the page is titled "Latest / Media Center". Underneath, it says "PRESS RELEASES | SPECIAL PROCEDURES". The main headline reads: "US companies DuPont and Chemours generated extensive contamination with toxic 'forever chemicals' in North Carolina: UN experts". The date "21 February 2024" is displayed at the bottom left of the article preview.

“The UN experts also expressed grave concern at reports that Chemours had applied to the North Carolina Department of Environmental Quality for an air permit to expand its PFAS production.”

Source: www.ohchr.org, February 21, 2024

PFAS DEFINITIONS MATTER

More comprehensive testing commissioned by The Guardian found PFAS air emissions over 30 times above state required testing.

America's dirty divide

A North Carolina PFAS factory claims its emissions fell by 99.99%. A Guardian test reveals otherwise

Chemours and state regulators say the Fayetteville Works plant has reduced air emissions, but we found levels of 'forever chemicals' as much as 30 times higher than state tests

by [Tom Perkins](#) with photographs by Justin Cook

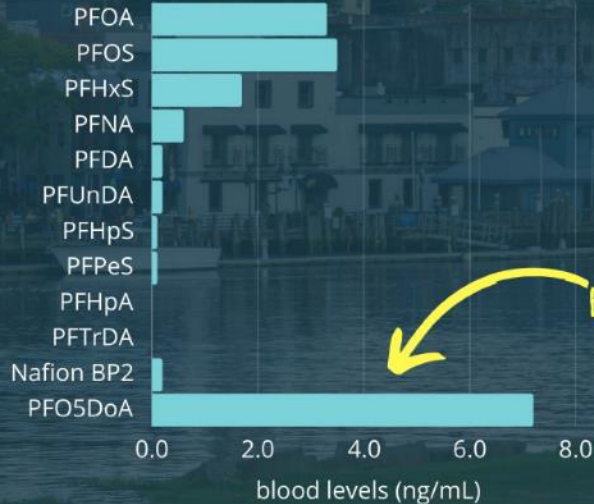


Photo: Justin Cook

In fact, regulators use three separate legal definitions of “PFAS” in the consent order, which opens the door for Chemours to make claims that are legally true but likely do not line up with reality.

EPA OVERLY FAVORS CHEMICAL INDUSTRY BY DELAYING PROPER REGULATIONS OF PFAS

2020 GenX Exposure Study Participant Brunswick County



EPA says not a PFAS but
in residents blood



Source: The Intercept, August 1, 2022

EPA Office of
Chemical Safety &
Pollution Prevention



Source: The Intercept, July 2, 2021



HISTORIC FIRST STEPS

In April 2024, EPA finalized first-ever federal drinking water standards for 6 PFAS including GenX. EPA also designated PFOA & PFOS as hazardous substances under CERCLA.

CLEAN CAPE FEAR

BUSINESS-RELATED HUMAN RIGHTS ABUSES

WHAT WE STILL NEED:

EPA should regulate all PFAS as a class and designate PFAS as a class of hazardous substances under both CERCLA and RCRA.

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US HEALTH & ENVIRONMENTAL REGULATORS SHOULD PROVIDE INFORMATION NECESSARY TO PREVENT HARM AND SEEK REPARATION



We have the statistical power!

- 130,000** ppt total PFAS consumed regularly
- 300** distinct PFAS released into drinking water
- 37** years of peak exposures
- 500,000** public water users impacted

Community rally supporting efforts to bring large-scale human epidemiological studies to our region.

www.cleancapefear.org

CLEAN CAPE FEAR

BUSINESS-RELATED HUMAN RIGHTS ABUSES

**IN NORTH CAROLINA,
THE TIME LIMIT FOR
FILING A PERSONAL
INJURY CASE IS
THREE YEARS.**



www.cleancapefear.org

CLEAN CAPE FEAR

BUSINESS-RELATED HUMAN RIGHTS ABUSES

US ENFORCEMENT & LEGAL ACTIONS HAVE BEEN INADEQUATE

- 2018 NCDEQ fined Chemours \$13 million--1% of yearly profits for nearly 40 years of PFAS contamination.
- 2005 US EPA fined DuPont \$10.5 million for 23 years of failing to report PFOA toxicity and releases.

www.cleancapefear.org

BUSINESS

Agreement calls for Chemours to pay \$13 million, provide drinking water

Steve DeVane sdevane@fayobserver.com
Published 7:39 p.m. ET Nov. 21, 2018 | Updated 2:53 p.m. ET Nov. 22, 2018



The state Department of Environmental Quality, Chemours and Cape Fear River Watch requires the company to pay \$13 million and provide drinking water to homes near its worsted levels of GenX. (The Fayetteville Observer/The Fayetteville Observer) Source: Fayetteville Observer, November 21, 2018

EPA United States Environmental Protection Agency

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Newsroom

You are here: [EPA Home](#) » [All News Releases By Date](#) » EPA Settles PFOA Case Against DuPont for Largest ...

All News Releases By Date

EPA Settles PFOA Case Against DuPont for Largest Environmental Administrative Penalty in Agency History

Release Date: 12/14/2005
Contact Information:
Contact: Dave Ryan, 202-564-4355 / ryan.dave@epa.gov

(Washington, D.C.-Dec. 14, 2005) DuPont will pay \$10.25 million -- the largest civil administrative penalty EPA has ever obtained under any federal environmental statute -- to settle violations alleged by EPA over the company's failure to comply with federal law. Under the settlement, filed with the Agency's Environmental Appeals Board, DuPont is also committing to \$6.25 million for Supplemental Environmental Projects (SEPs).

The settlement, which still must be approved by the EAB, would resolve DuPont's violations related to the synthetic chemical Perfluorooctanoic Acid (PFOA) under provisions of both the Toxic Substances Control Act (TSCA) and the Resource Conservation and Recovery Act (RCRA).

Source: US EPA Archives, December 14, 2005

STOP GREENWASHING & QUIT REWARDING BAD ACTORS WITH FEDERALLY FUNDED GRANTS

Chemours and Partners Selected for \$60M in U.S. Department of Energy Grants to Support Continued Advancement of Global Hydrogen Economy

— PRESS RELEASE
Published March 23, 2024

Source: Chemours, March 20, 2024

Cummins will receive \$17.9 million to lead a project developing a new proton exchange membrane electrolyzer design to reduce hydrogen manufacturing costs. The corporation will also be involved in a \$10 million project led by the Chemours to improve Nafion membrane-based electrolyzers and the lifespan of proton exchange membrane electrolyzers.

Source: E&E News, March 13, 2024 "DOE awards \$750M for 'clean' hydrogen technology."

NORTH CAROLINA'S PFAS SACRIFICE ZONE

HOW TO REMEDY BUSINESS-RELATED HUMAN RIGHTS ABUSES IN NC

Deny Chemours expansion plan air permit.

Regulate PFAS as a class using broad definition of PFAS.

Designate PFAS as a class under CERCLA & RCRA

Fund large-scale human epidemiological studies in NC.

Federally remove civil and criminal statutes of limitations.

Create detoxification strategies based on human rights.

Create stronger deterrent strategies.

Stop energy transition disinformation and reward Green Chemistry.



CLEAN CAPE FEAR

**BE A ROB BILOTT
IN A DUPONT &
CHEMOURS WORLD**

People power always wins.

www.cleancapefear.org



Amy Shands
1978 - 2022



Sarah McLaughlin
1974 - 2022



Chris Mathis
1970 - 2023

**The
Guardian**

America's dirty divide

Cancer fears plague residents of US region polluted by 'forever chemicals'

Exposure to harmful PFAS remains almost impossible to escape - particularly for the people of the Cape Fear River basin

by Tom Perkins with photographs by Allison Joyce



Tom Kennedy
1971 - 2022



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI



PFAS and Liver Disease: Translating the Knowledge from Epidemiological and Experimental Studies into Public Health Action

Lida Chatzi, MD, PhD
USC Keck School of Medicine

PFAS National Conference
June 11, 2024

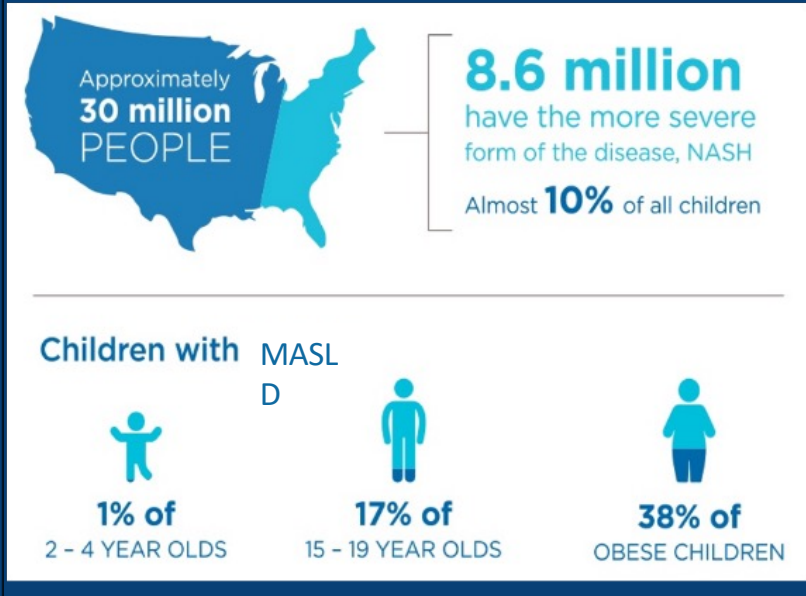


Keck School of Medicine of USC
Department of Population and
Public Health Sciences

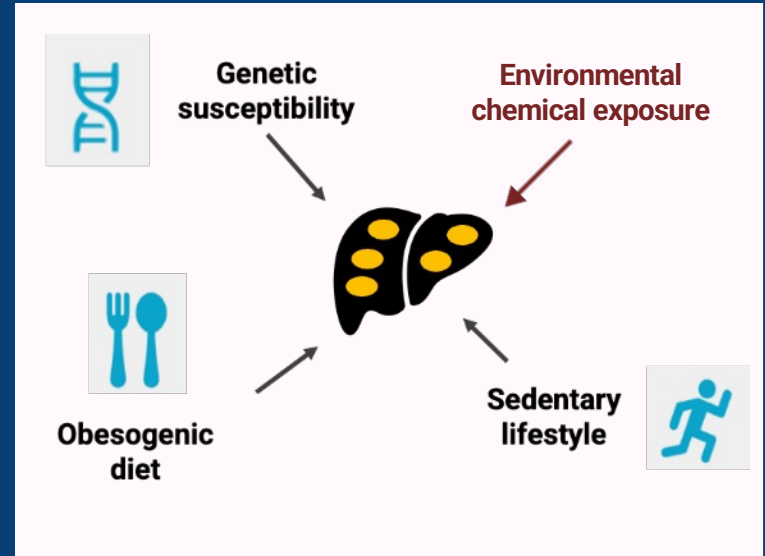
METABOLIC DYSFUNCTION-ASSOCIATED STEATOTIC LIVER DISEASE

An epidemic

MASLD Prevalence in the U.S



Traditional MASLD Risk Factors

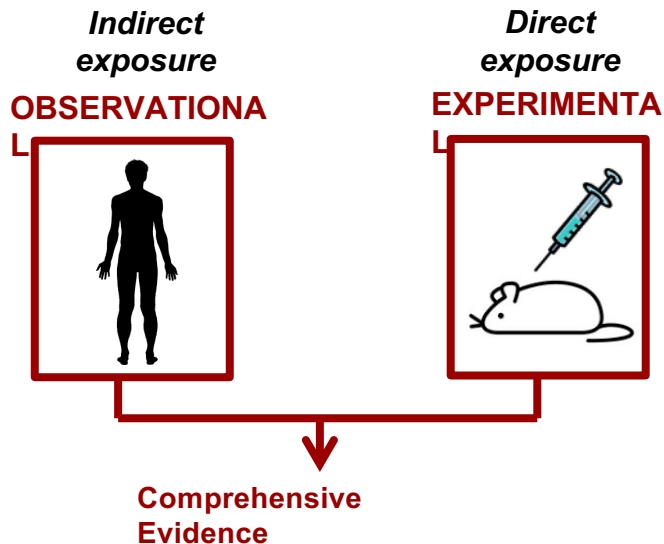


EMERGING EVIDENCE PFAS and MASLD

ehp Environmental Health Perspectives

Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis

Elizabeth Costello,^{1,*} Sarah Rock,^{1,*} Nikos Stratakis,¹ Sandra P. Eckel,¹ Douglas I. Walker,^{2,3} Damaskini Valvi,²
Dora Cserbik,³ Todd Jenkins,⁴ Stavra A. Xanthakos,⁵ Rohit Kohli,^{4,6} Stephanie Sisley,⁷ Vasilis Vasiliou,⁸
Michele A. La Merrill,⁹ Hugo Rosen,¹⁰ David V. Coniti,¹ Rob McConnell,¹ and Leda Chatzi¹



RESULTS

- Human Studies N=25
- Animal Studies N=86
- Long chain PFAS associated with **increased risk for liver injury** in both human (*increased liver enzymes*) and animal studies (*histopathological changes*)

ORIGINAL

Prenatal Exposure to Perfluoroalkyl Substances Associated with Increased Susceptibility to Liver Injury in Children

Nikos Stratakis, David V Conti, Ran Jin, Katerina Margetaki, Damaskini Valvi, Alexandros P. Siskos, Léa Maitre, Erika Garcia, Nerea Varo, Yinqi Zhao, Theano Roumeliotaki, Marina Vafeiadi, Jose Urquiza, Silvia Fernández-Barrés, Barbara Heude, Xavier Basagana, Maribel Casas, Serena Fossati, Regina Gražulevičienė, Sandra Andrušaitytė, Karan Uppal, Rosemary RC. McEachan, Eleni Papadopoulou, Oliver Robinson, Line Småstuen Haug, John Wright, Miriam B. Vos, Hector C. Keun, Martine Vrijheid, Kiros T. Berhane, Rob McConnell, Lidada Chatzi  ... See fewer authors 

First published: 01 August 2020 | <https://doi.org/10.1002/hep.31483>

RESEARCH ARTICLE | ARTICLES IN PRESS, 100550

Exposure to perfluoroalkyl substances and risk of hepatocellular carcinoma in a multiethnic cohort

Jesse A. Goodrich   • Douglas Walker • Xiangping Lin • Hongxu Wang • Tiffany Lim • Rob McConnell • David V. Conti • Lida Chatzi • Veronica Wendy Setiawan  • Show less • Show footnotes

Open Access • Published: August 08, 2022 • DOI: <https://doi.org/10.1016/j.jhepr.2022.100550>



Papers of the Year 2020/2022



ELSEVIER

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Perfluoroalkyl substances and severity of nonalcoholic fatty liver in Children: An untargeted metabolomics approach

Ran Jin^a, Rob McConnell^a, Cioffi Catherine^b, Shujing Xu^a, Douglas I. Walker^{c,d,1}, Nikos Stratakis^a, Dean P. Jones^c, Gary W. Miller^{d,2}, Cheng Peng^a, David V. Conti^a, Miriam B. Vos^{b,e,3}, Leda Chatzi^{a,*,3}




Vol. 130, No. 4 | Review

Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis

 is companion of 

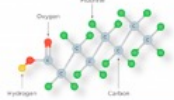
Invited Perspective: PFAS and Liver Disease: Bringing All the Evidence Together

Elizabeth Costello , Sarah Rock, Nikos Stratakis, Sandrah P. Eckel, Douglas I. Walker, Damaskini Valvi, Dora Cserbik, Todd Jenkins, Stavra A. Xanthakos, Rohit Kohli, Stephanie Sisley, Vasilis Vasilioiu, Michele A. La Merrill, Hugo Rosen, David V. Conti, Rob McConnell, and Leda Chatzi

- **Mechanisms are unknown**
 - How PFAS interfere with liver metabolism
 - Which cells are affected by PFAS exposure
- **Models available for PFAS study**
 - Animal models do not recapitulate human disease
 - Human studies require years of follow-up
 - *In vitro* studies only use single cell types
- **Data integration**
 - Current studies do not integrate *in vitro* or *in vivo* datasets with human data
- **Others**
 - Impact of PFAS withdrawal is not known
 - Potential harmful effects of PFAS degradation byproducts are unclear

A COMPLEX PROBLEM

Per- and Polyfluoroalkyl Substances



- > 7,000 chemicals
- Strong carbon fluorine bonds
- Bioaccumulation
- Detection in 99% of US adults

SOURCES OF EXPOSURE



ACCUMULATION & TOXICITY



RESEARCH & SOLUTIONS



Multidisciplinary Translational Approach

- Understand PFAS contamination, toxicity, and mechanisms
- Develop innovative methods of remediation and treatment
- Co-design community-driven prevention strategies
- Translate findings and prevention strategies to public, clinical community, and policy makers



Discover Associations:
Human Studies



Understand Biology:
Experimental Studies

PFHpA alters lipid metabolism & increases the risk of MASLD: an integration of human and experimental data



Lucy Golden, PhD
Professor of Medicine
USC



Ana Marette-Garcia, PhD
Asst. Professor of Medicine
USC

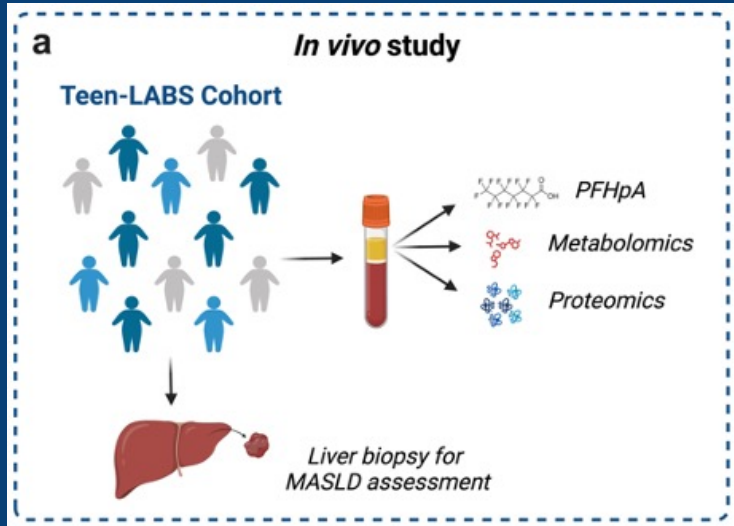


Matthew Salomon, PhD
Asst. Professor of Medicine
USC



Brittney Baumert, PhD MPH
Postdoctoral Scholar
USC

HUMAN STUDY

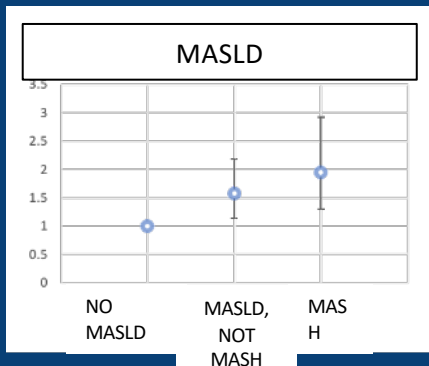


Examine the effects of plasma PFAS concentrations on **histologically-diagnosed MASLD** and **severity of hepatic steatosis** in a bariatric surgery cohort of obese adolescents (TeenLABS).

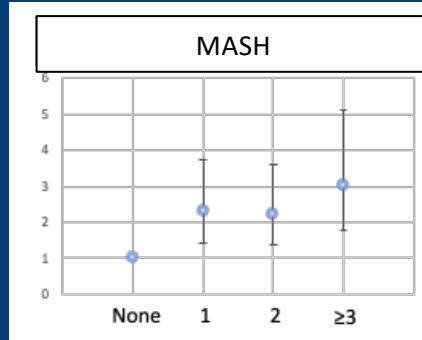
Teen-LABS

- N=220 adolescents
- 17.1 years

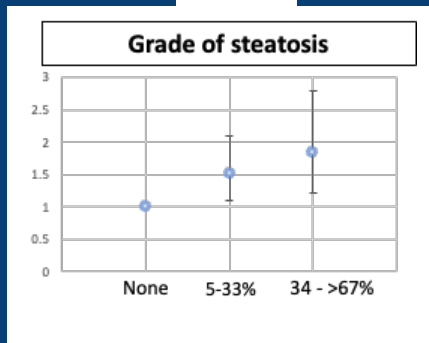
HUMAN STUDY PFHpA and MASLD Progression



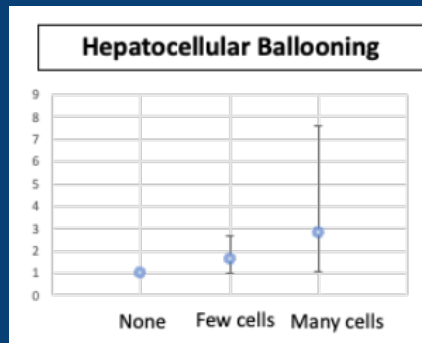
MASLD	OR	95% CI
No MASLD	--	--
MASLD, not NASH	1.6	(1.1, 2.2)
NASH	1.9	(1.3, 2.9)



MASH	OR	95% CI
None	--	--
1	2.3	(1.4, 3.7)
2	2.2	(1.3, 3.6)
≥3	3.0	(1.8, 5.1)



Steatosis	OR	95% CI
None	--	--
5-33%	1.5	(1.1, 2.1)
34- >67%	1.8	(1.2, 2.8)



Ballooning	OR	95% CI
None	--	--
Few balloon cells	1.6	(1.0, 2.6)
Many balloon cells	2.8	(1.1, 7.6)

EXPERIMENTAL STUDY

3D liver spheroids model

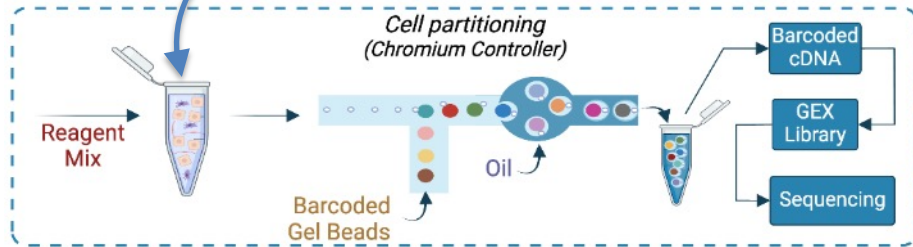
(co-culture of hepatocytes and other NPCs from multi-donors)

**PFOS, PFOA, PFNA,
PFHpA, and PFHxS**

4 μ M of each, 20 μ M in total
(lean media)

7 or 14
days

Spheroid cells
dissociation



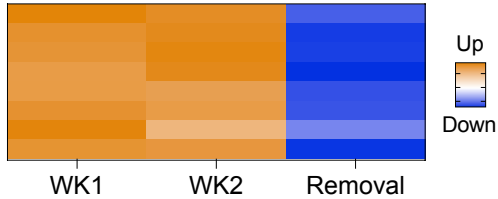
10x Genomics Single-Cell RNA-sequencing (kit 3' v3.1)

Aim 1: Identify the hepatic biological pathways impacted by short and chronic exposures to PFHpA and PFAS mixtures commonly found in human plasma and drinking water.

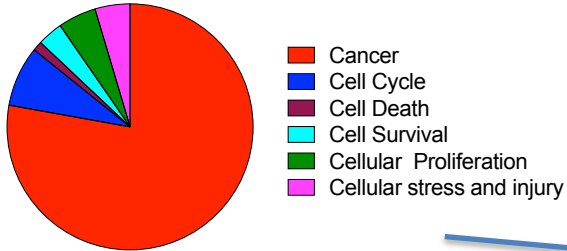
Aim 2: Test if PFAS removal can reverse or attenuate the harmful effects of PFAS exposure.

EXPERIMENTAL STUDY Preliminary Results

Gene Expression and Protein Translation



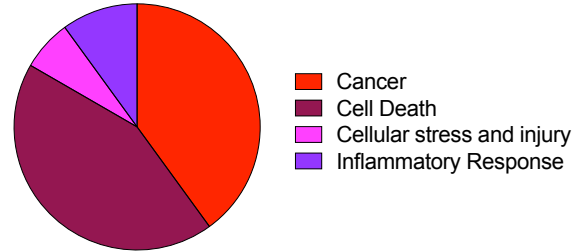
1 week of exposure



Hepatic effects

↑ Fibrosis ↑ Necrosis

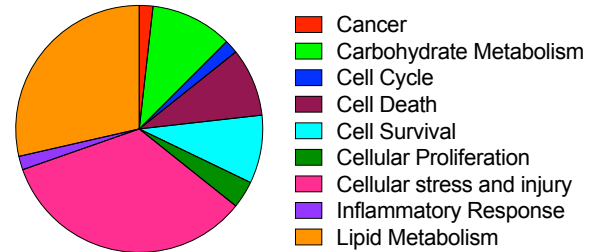
2 weeks of exposure



Hepatic effects

↑ Inflammation ↑ Necrosis
↑ Steatosis ↑ HCC

1 week of exposure + 1 week of recovery



Hepatic effects

↑ Cell proliferation ↑ Hepatotoxicity

Adaptation to PFAS exposure

Normalization of liver functions

Discover Associations - - -

Understand Biology - - -

Integrate Multiomics - - -

*Community-Engaged,
Solutions-Oriented*
Public Health Action

Community Engagement Team



Max Aung, PhD, MPH
Assistant Professor, USC



Liz Costello, PhD
Postdoctoral Scholar,
USC



Sherlock Li, PhD
Postdoctoral Scholar,
USC



Tamar Galindo, MPH
Research Coordinator, USC



Shudi Pan, ScM
PhD Student, USC



Tomás Manea
Undergraduate Student, USC

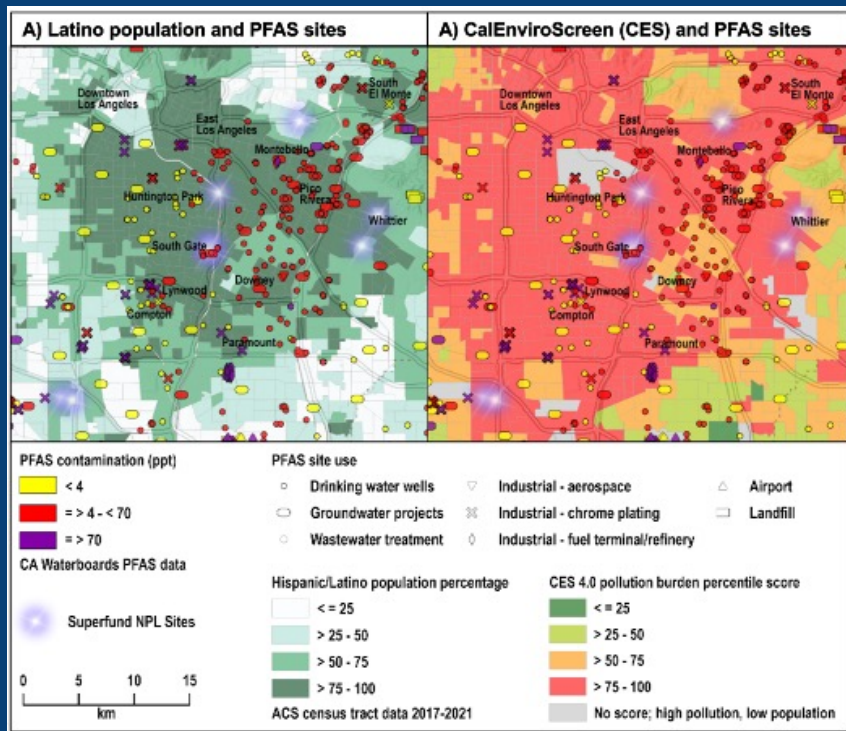


Dominic Pak
Undergraduate Student,
USC



Nico Gentile
Undergraduate Student
Loyola Marymount University

COMMUNITY ENGAGEMENT Water Contamination in EJ LatinX Communities



East and Southeast communities in Los Angeles

- Latino Population: 90%
- High PFAS and top 10th percentile of environmentally burdened communities in CA
- Close proximity to point sources of PFAS (metal plating facilities, bulk fuel refineries)
- Proportions of Hispanic/Latino residents were **1.5–2 times greater** among community water systems (CWS) with detectable PFAS (>5 ng/L)

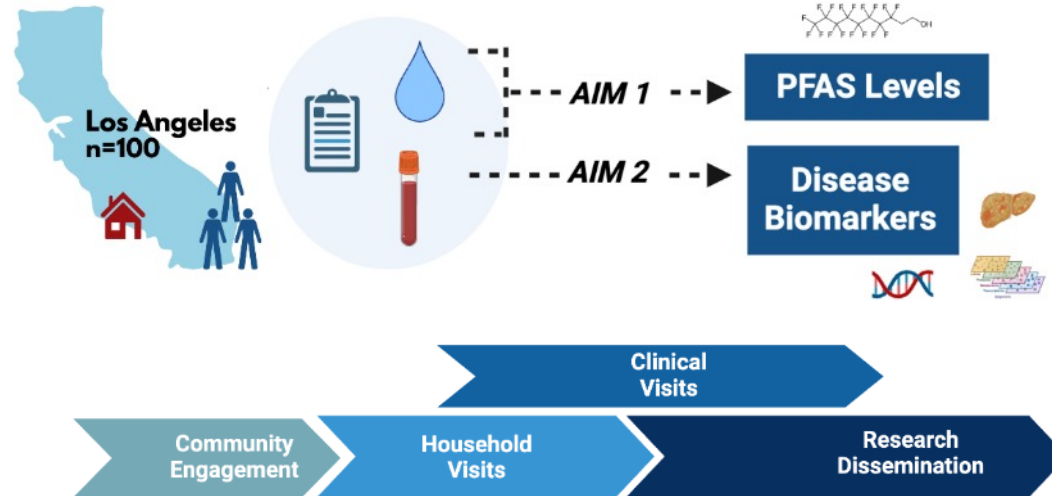
PFAS ACT Addressing the PFAS drinking water crisis in Southern California

Project Aims:

Aim 1: Exposure assessment on 100 participants, measuring targeted PFAS in drinking water, dust, and plasma samples

Aim 2: Estimate associations between individual PFAS compounds and clinical biomarkers of liver injury, lipid homeostasis, and related metabolomic pathways

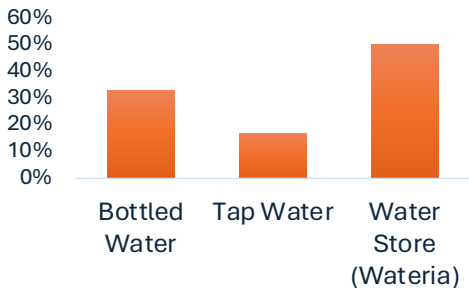
Solutions-Oriented Approach: Provide **EpicWater Filters** to all participating households



Demographics

- 100% Hispanic/Latino
- Mean age: 48 yrs old
- 65% live in an apartment building with 5 or more units

Source of Drinking Water



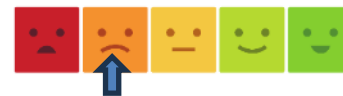
80% still use tap water to cook

80% of those who selected "tap water" as their primary source of drinking water utilize a filter (faucet or fridge)

Perceptions of Tap Water

When asked on a scale of 1 through 5, how strongly do you agree or disagree with the following:

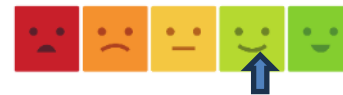
It is safe to drink the water from my tap.



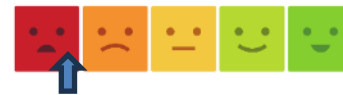
I am satisfied with the taste of my tap water.



It is safe to drink the water from my tap only if I use a water filter.



If there is something wrong with the quality of my tap water, I know who to contact to resolve the issue.



I trust my tap water company to provide me with safe drinking water.



ACKNOWLEDGEMENTS

University of Southern California

- Max Aung, PhD
- Liz Costello, PhD
- Sherlock Li, PhD
- Tamar Galindo, MPH
- Rob McConnell, MD
- David Conti, PhD
- Ana Maretti, PhD
- Brittney Baumert, PhD
- Jesse Goodrich, PhD
- Lucy Golden, PhD

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R21 ES028903;

U01HG013288

5P30ES007048-23; 5P30DK048522-24,

USC President's Sustainability Research Award

ISGlobal, Barcelona

- Martine Vrijheid, PhD
- Nikos Stratakis, PhD

Emory University

- Douglas Walker, PhD
- Dean Jones, PhD

Mount Sinai

- Damaskini Valvi, MD, PhD

Harvard

- Philippe Grandjean, PhD





QUESTIONS?

Lida Chatzi, MD, PhD
Population and Public Health Sciences
USC Keck School of Medicine



Keck School of Medicine of **USC**
Department of Population and
Public Health Sciences



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

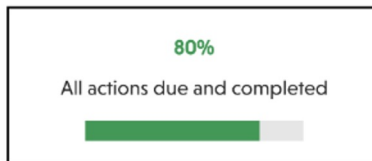


National PFAS Conference

SCOTT FABER
SENIOR VP, GOVERNMENT AFFAIRS, EWG



Environmental Protection Agency



Protecting water, air and food from PFAS



Eliminating unnecessary PFAS uses



Cleaning up historic PFAS pollution

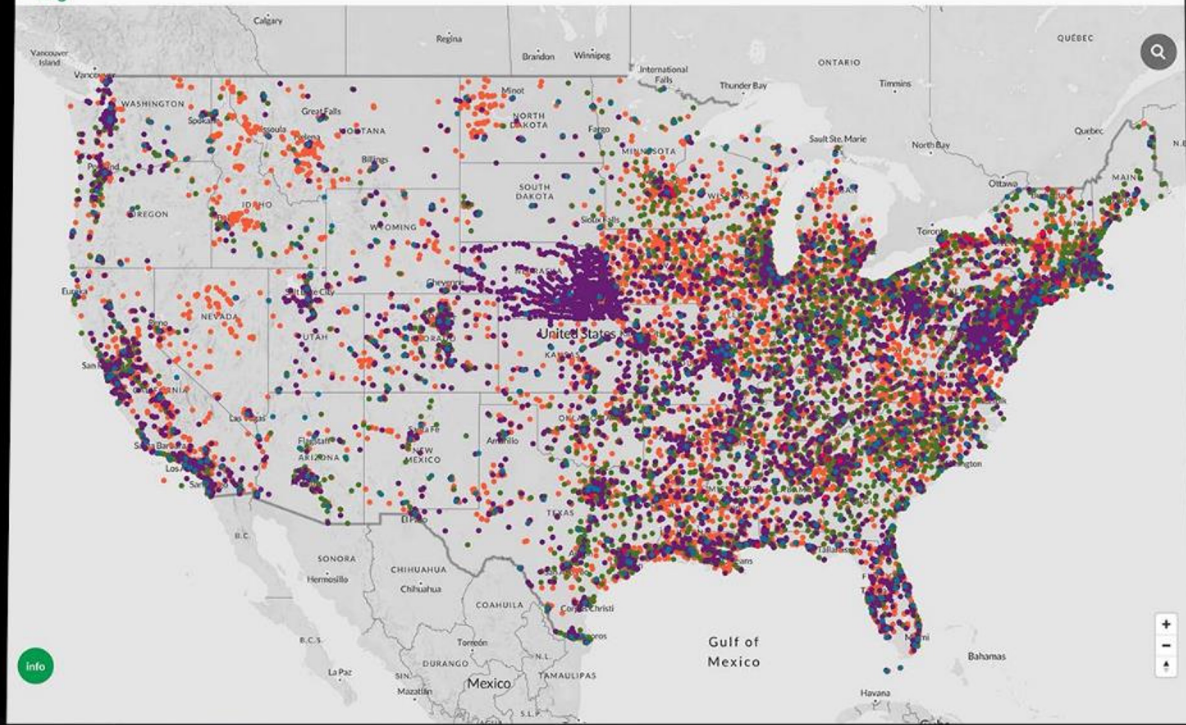


PFAS science and solutions



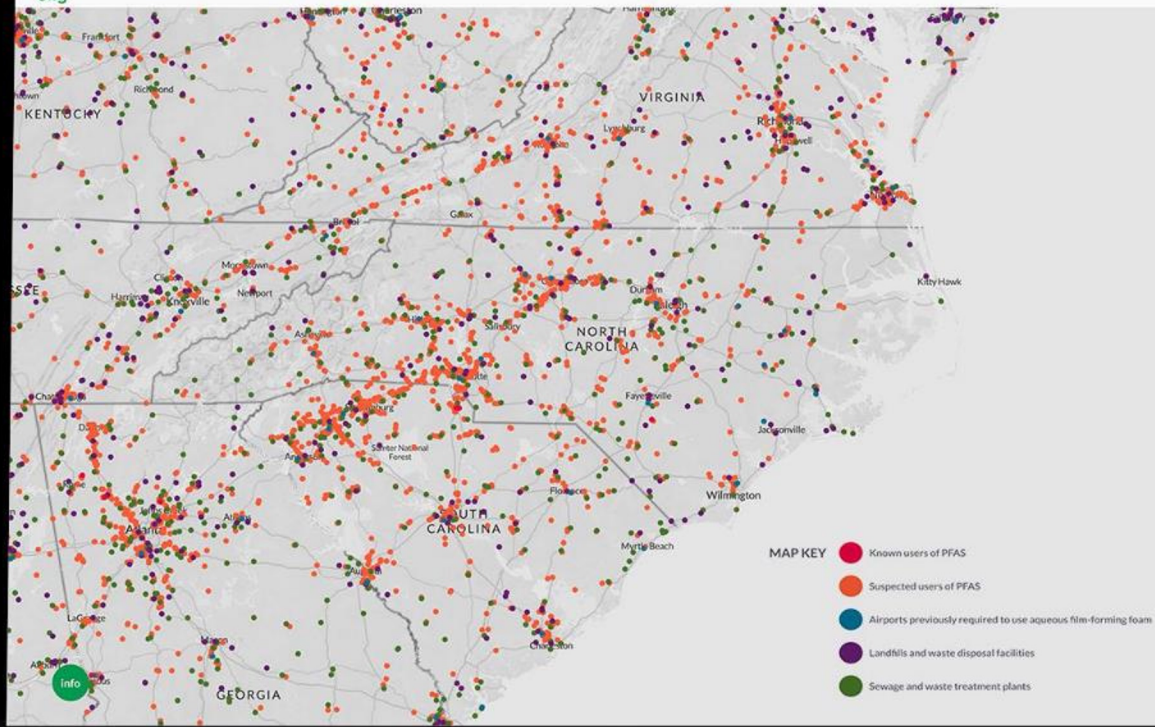


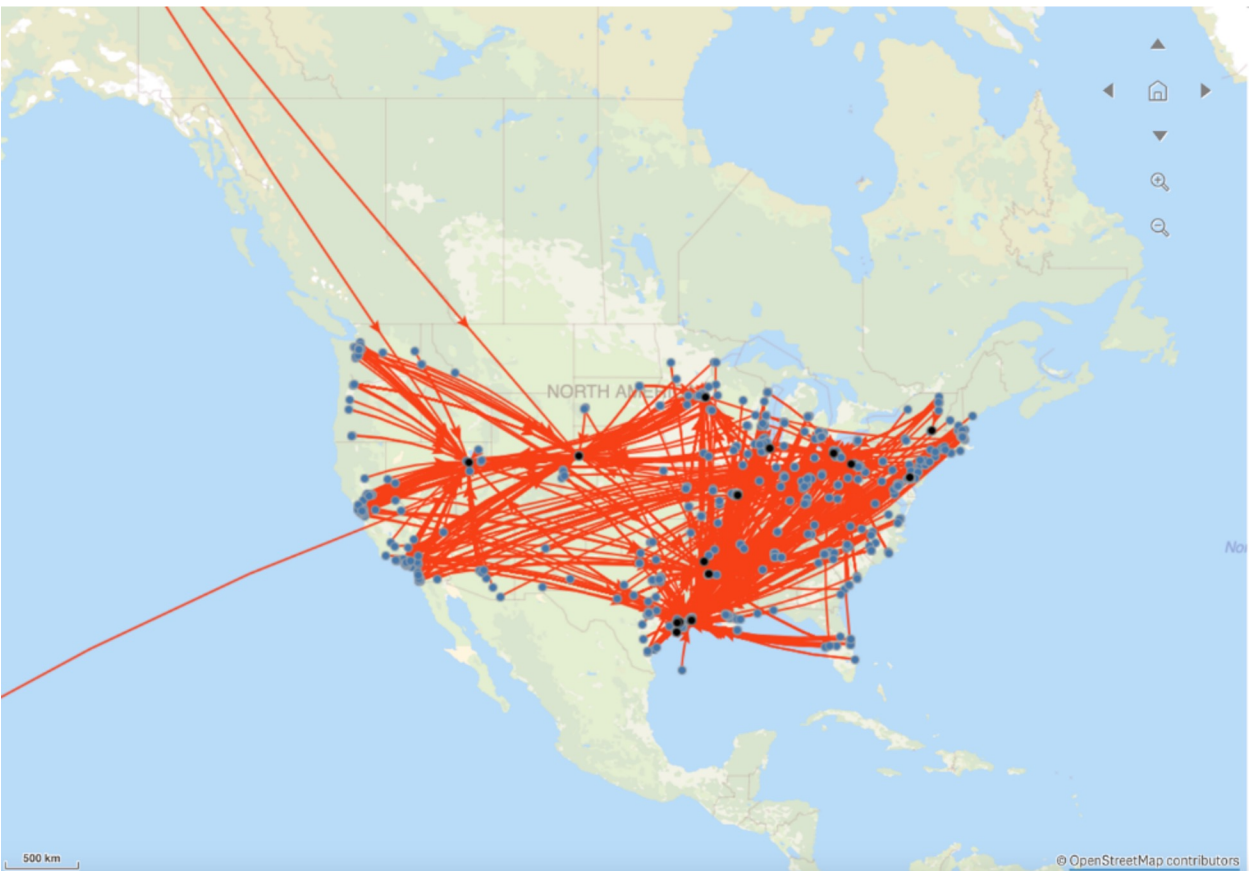
Suspected industrial discharges of PFAS

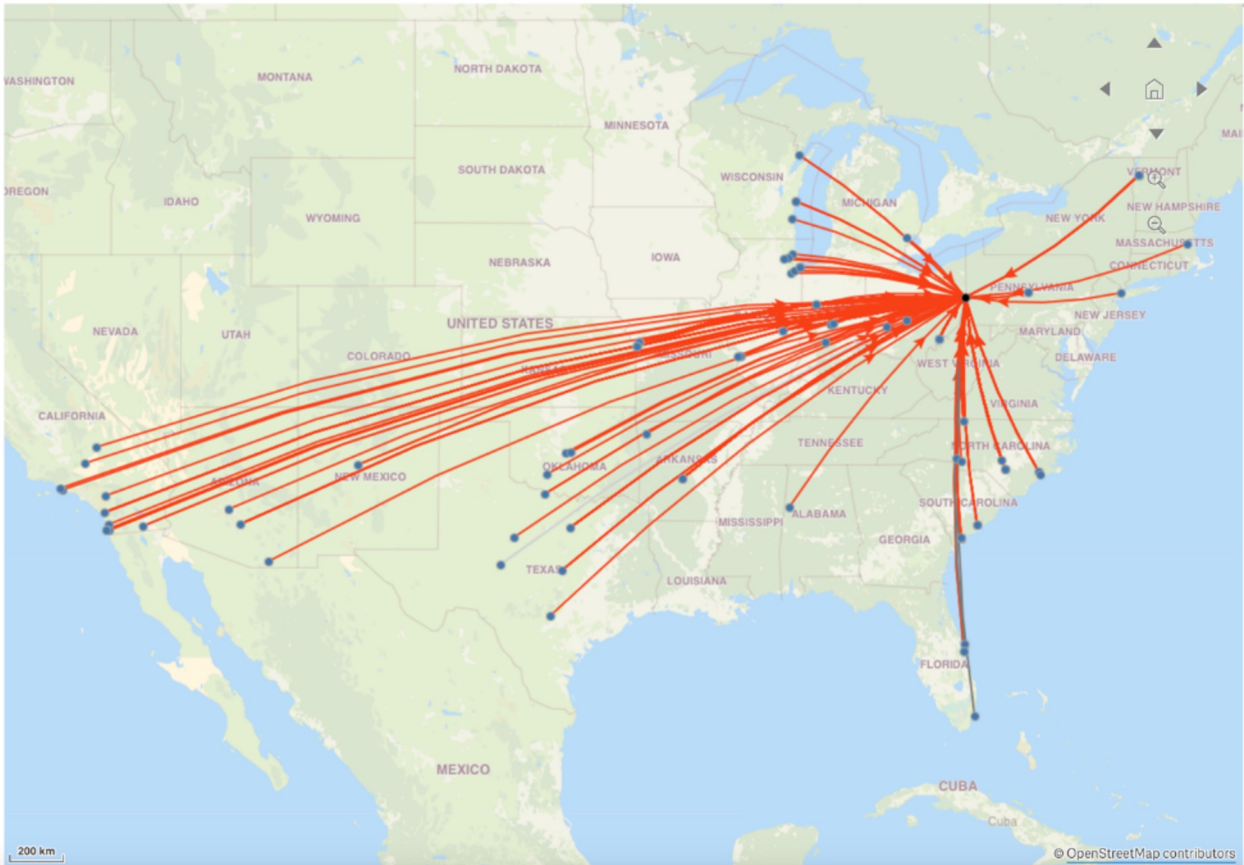


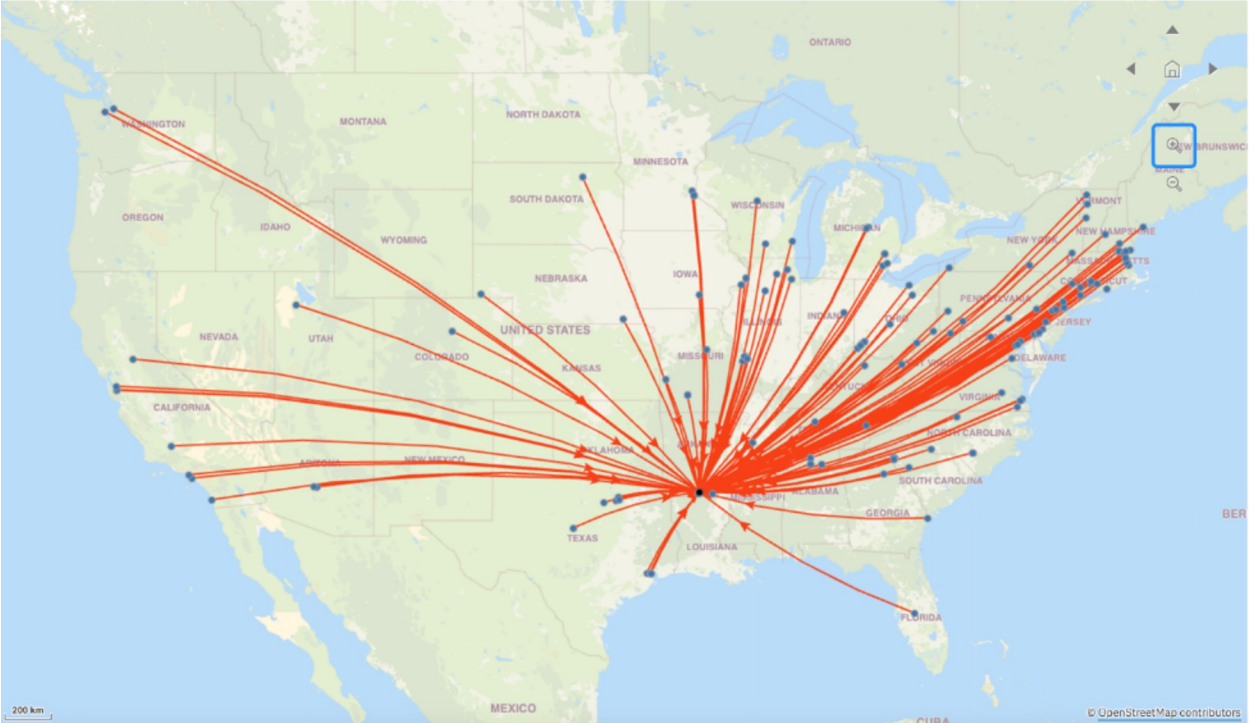


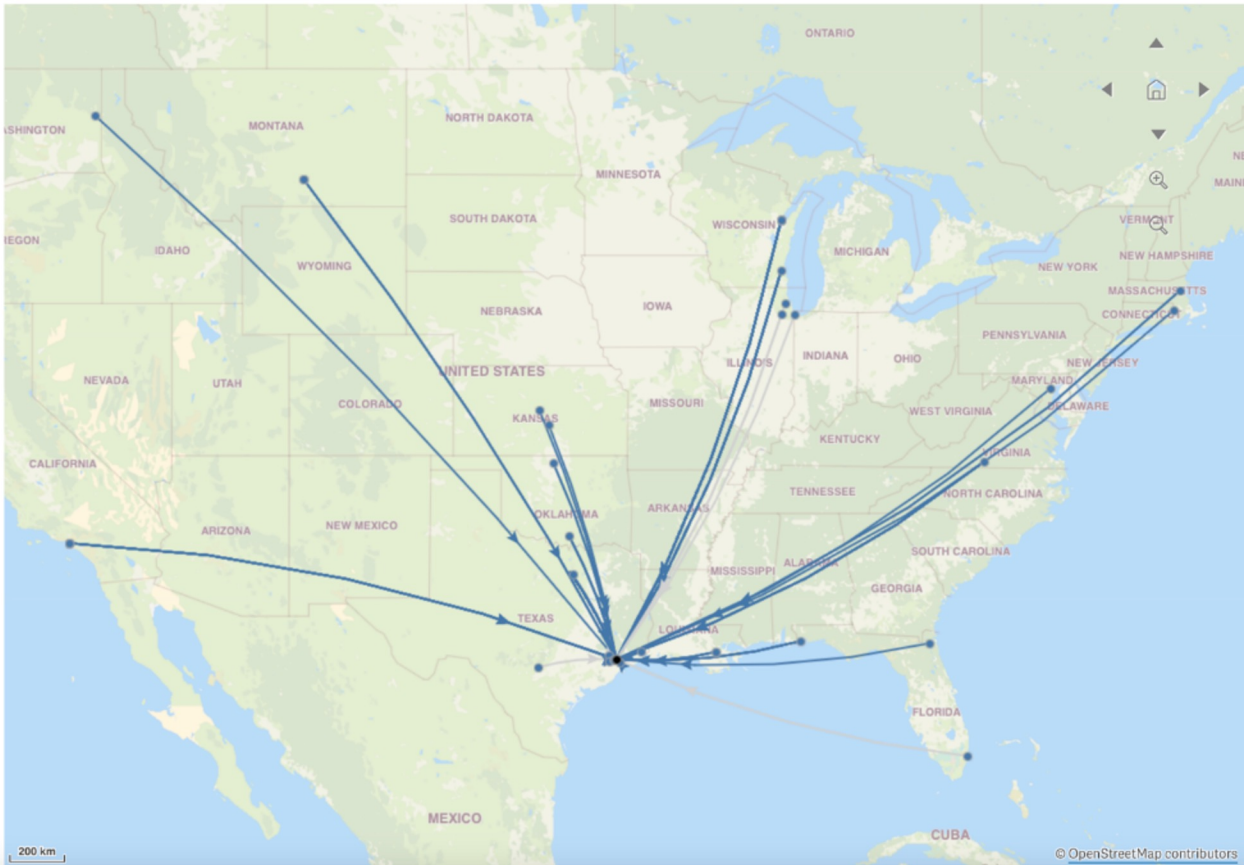
Suspected industrial discharges of PFAS

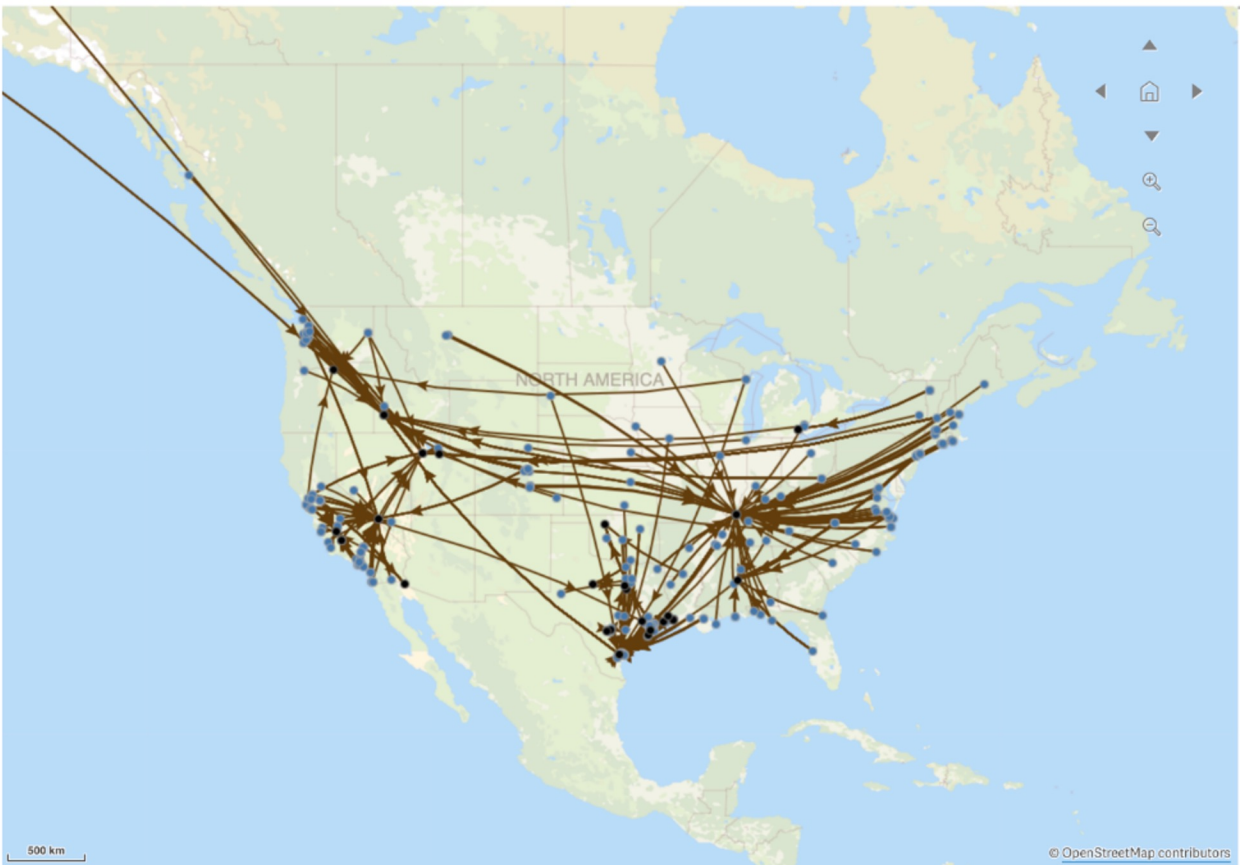


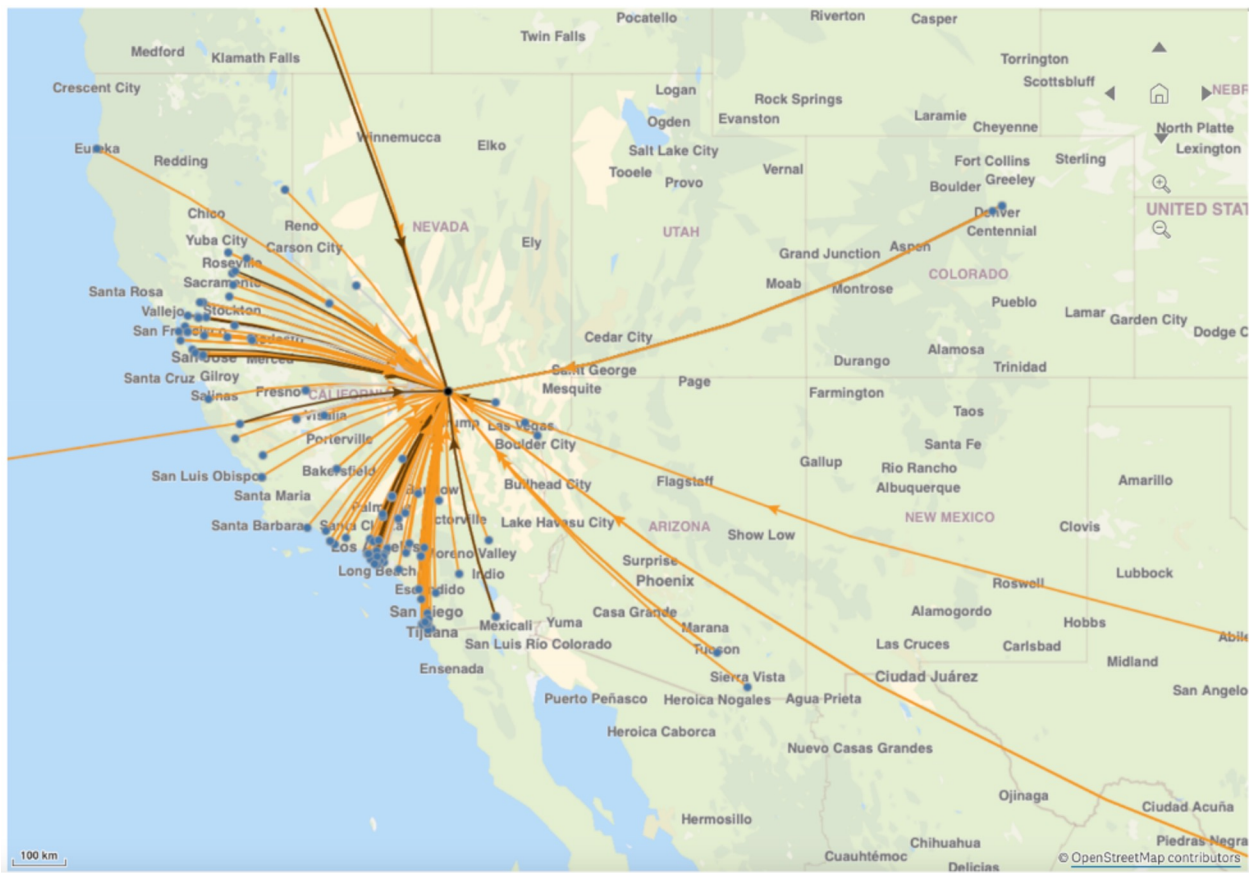


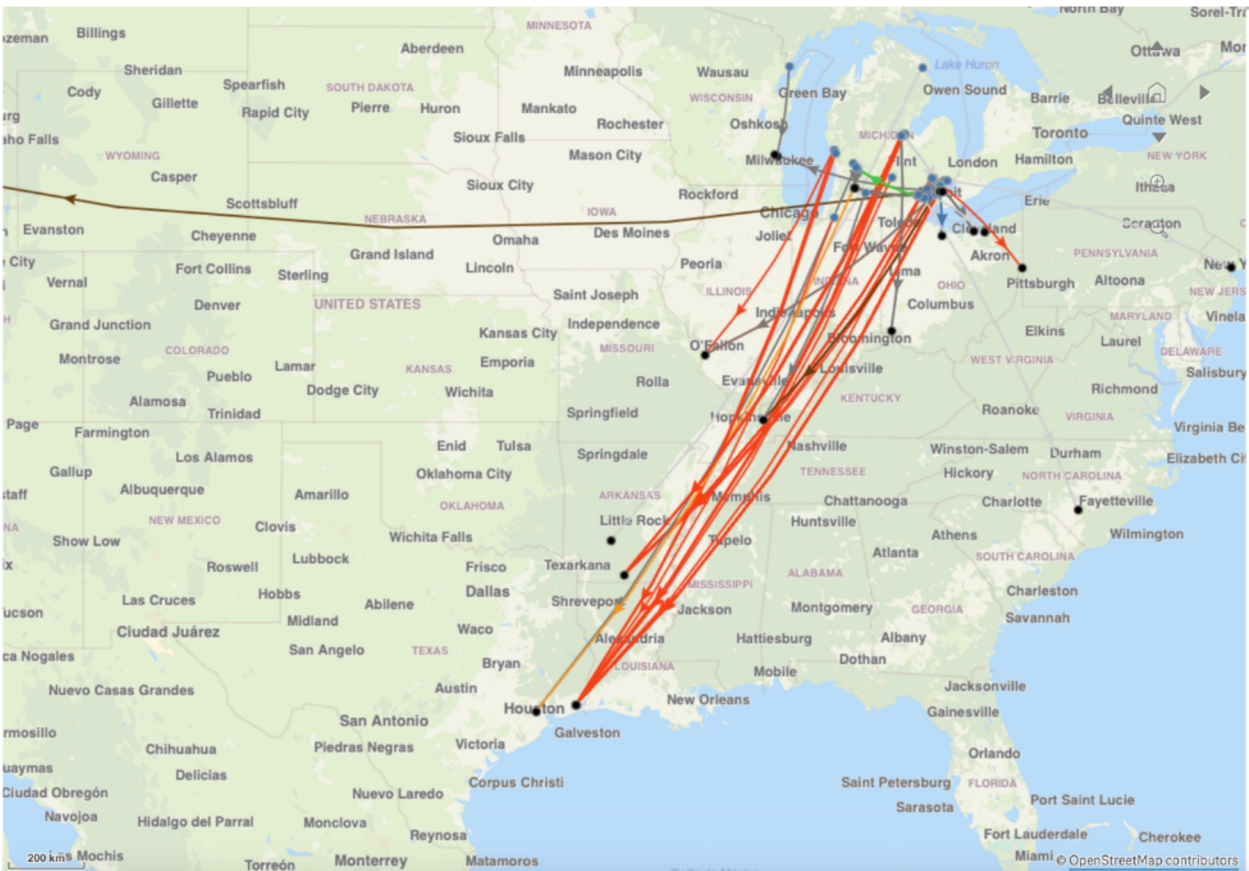


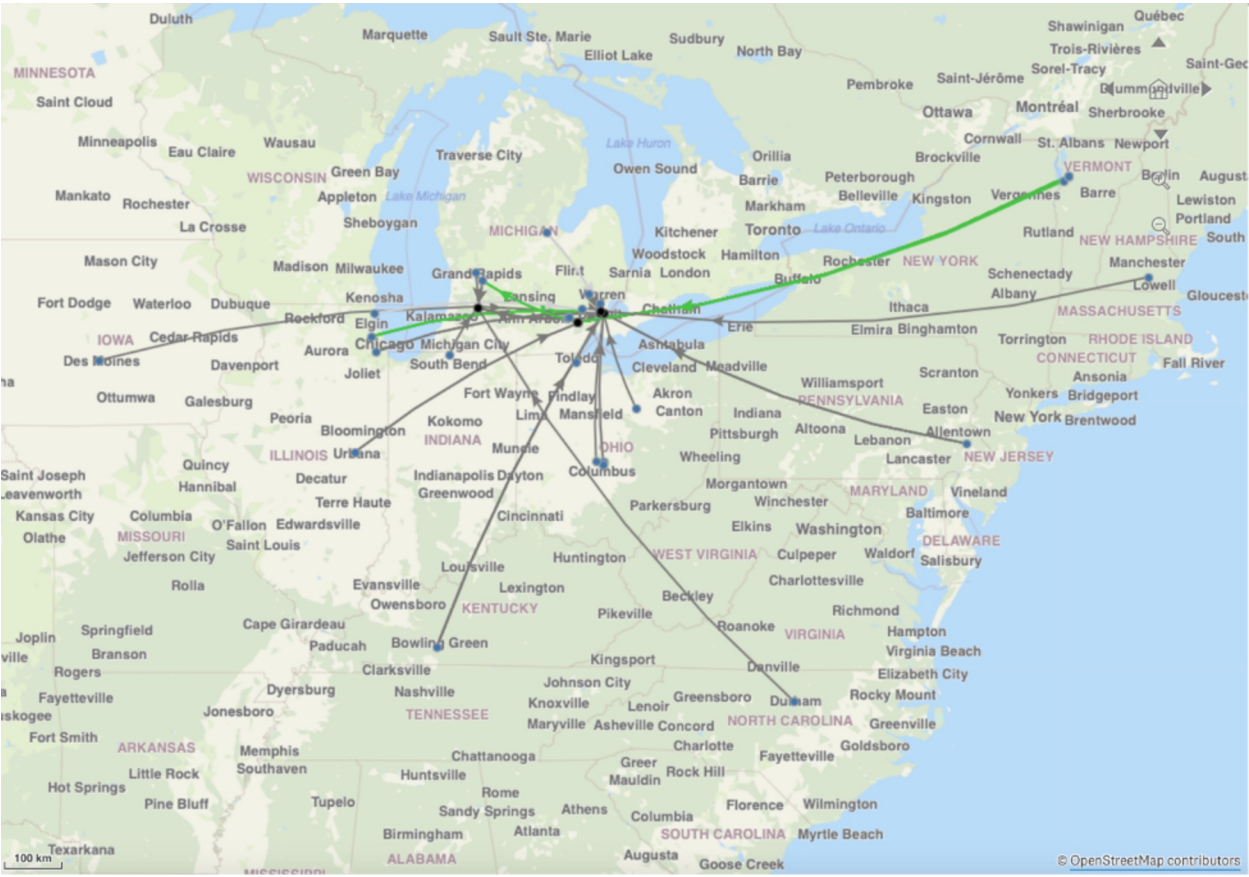


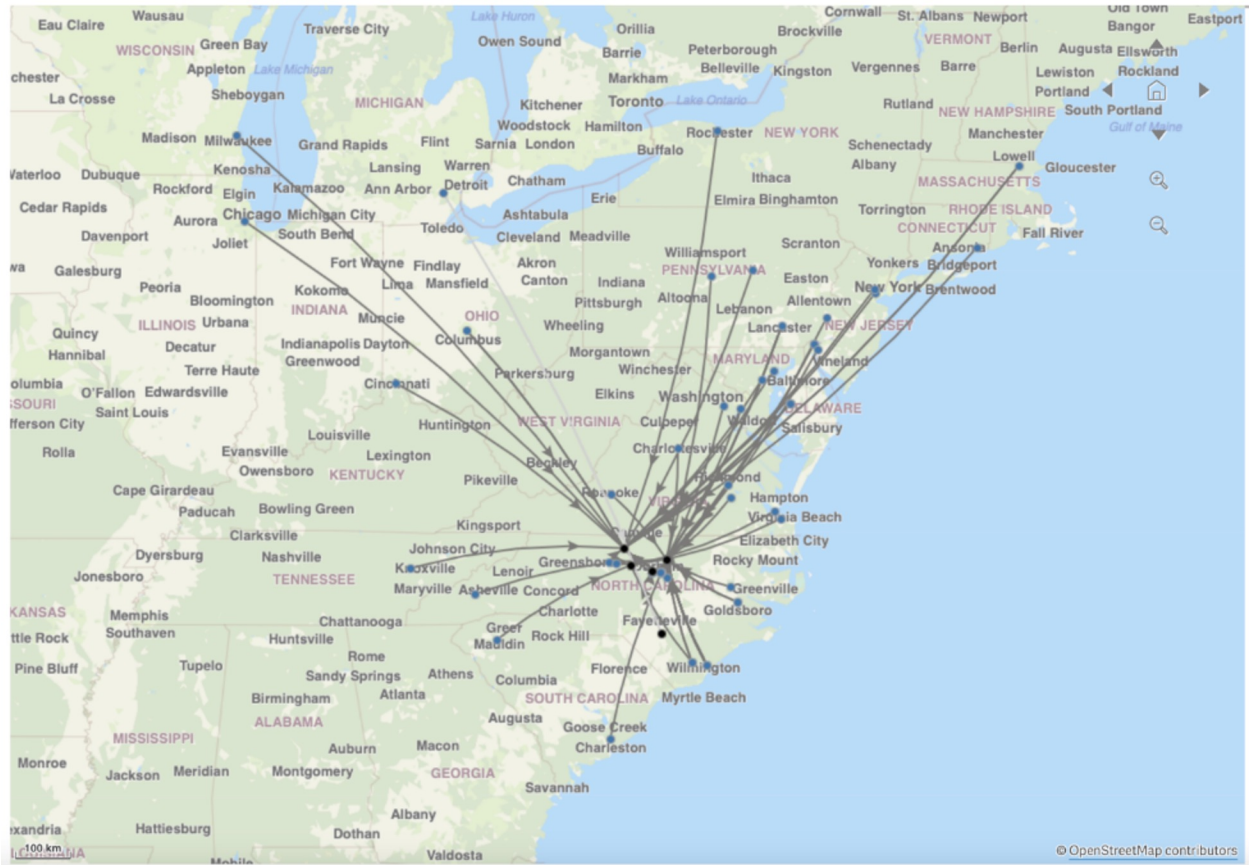












More needs to be done

- Turn off the tap.
- End needless uses.
- Clean up our food.
- Properly manage hazardous wastes.
- Clean up “hot spots.”





Thank you

Know what's in the water you are drinking.

ewg.org/tapwater



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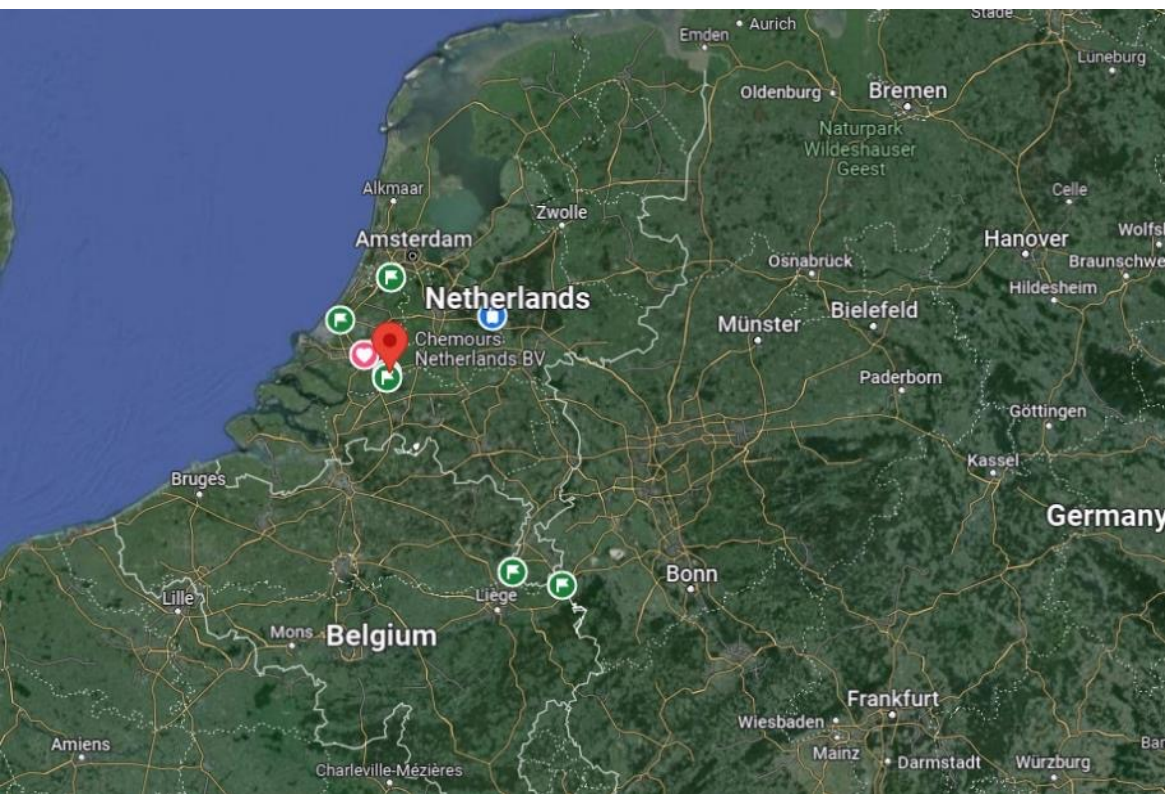
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Lawful but awful ?

DuBtde Nemous – Chemous
Dodech, the Netherlands

Prof. dr. Lieselot Bisschop

Department of Law, Society & Crime
Erasmus School of Law
Rotterdam, the Netherlands
Bisschop@law.eur.nl



Dodect, the Netherlands

DuBnde Nemous Nederland (1962-2014)

a.k.a. Dodectwerk

Chemours (since 2015)

Which chemicals

Ezafus

Legenda 

Stippellijnen (globale ligging*)

-  Binnen deze lijn advies: wissel eten van groenten en fruit uit de tuin af met de winkel; buiten deze lijn geen beperkingen
-  Binnen deze lijn wordt eten uit eigen moestuin afgeraden, bij teelt in bakken geen slootwater gebruiken voor irrigatie

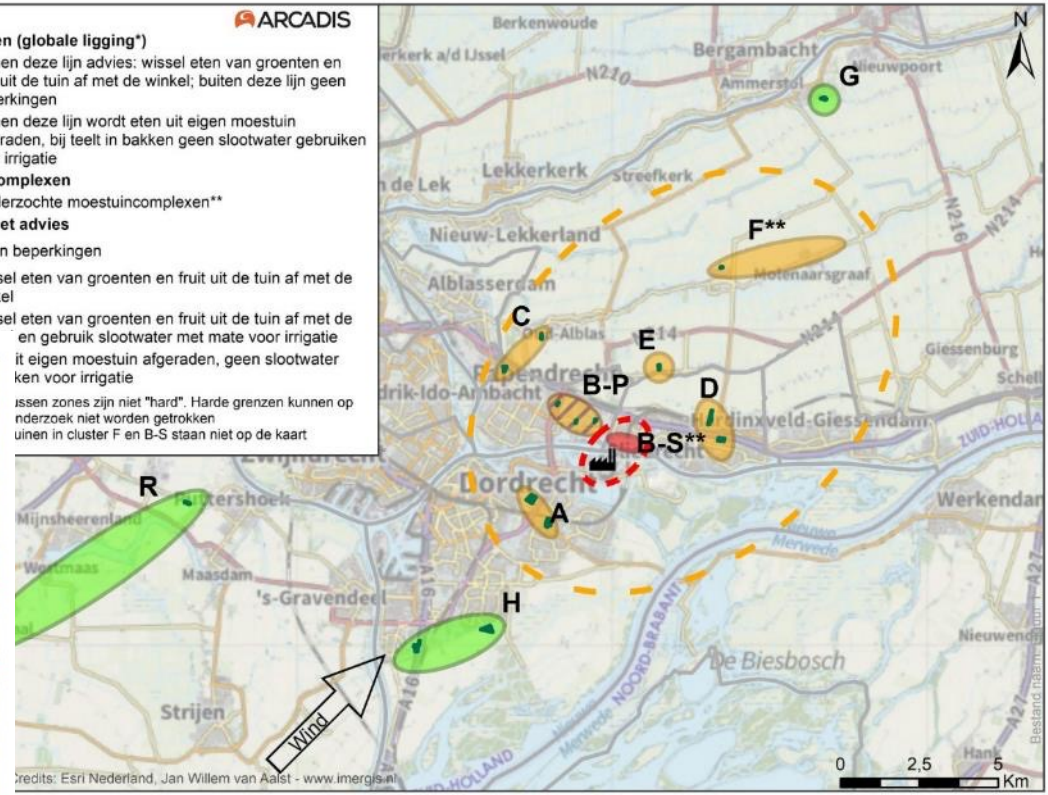
Moestuincomplexen

-  Onderzochte moestuincomplexen**

Clusters met advies

-  Geen beperkingen
-  Wissel eten van groenten en fruit uit de tuin af met de winkel
-  Wissel eten van groenten en fruit uit de tuin af met de winkel en gebruik slootwater met mate voor irrigatie
-  it eigen moestuin afgeraden, geen slootwater gebruiken voor irrigatie

issen zones zijn niet "hard". Harde grenzen kunnen op nederzocht niet worden getrokken
uinen in cluster F en B-S staan niet op de kaart



Figuur 1 Ligging van de locaties (groene symbolen) waar eieren zijn verzameld in de acht gemeenten (zie Tabel 1 op de volgende pagina). Het rode symbool is de positie van het chemiebedrijf Chemours in Dordrecht. N.B.: Er staan minder dan 30 bolletjes op de kaart omdat enkele locaties dicht bij elkaar liggen.

Erasmus

Retracing the steps: a history of waste since 1962

Erasmus

Erasmus

Erasmus

Erasmus

Where does the waste go according to the EU WSR registry?

2019 *Failure to remove and store Gen-X containing waste (factory in Italy went bankrupt): penalty payment*

2019-2022 IT permits 57 reports with (potential) PAS obtaining ab to Under
(Belgium)

2022 IT ~~oks~~ permit for reports & then einbs (2023.9.1 until
2024.8.31) for appeals

2020: IT report permit for FRD902 (period 2020.09.01-2021.8.31) to
Fille

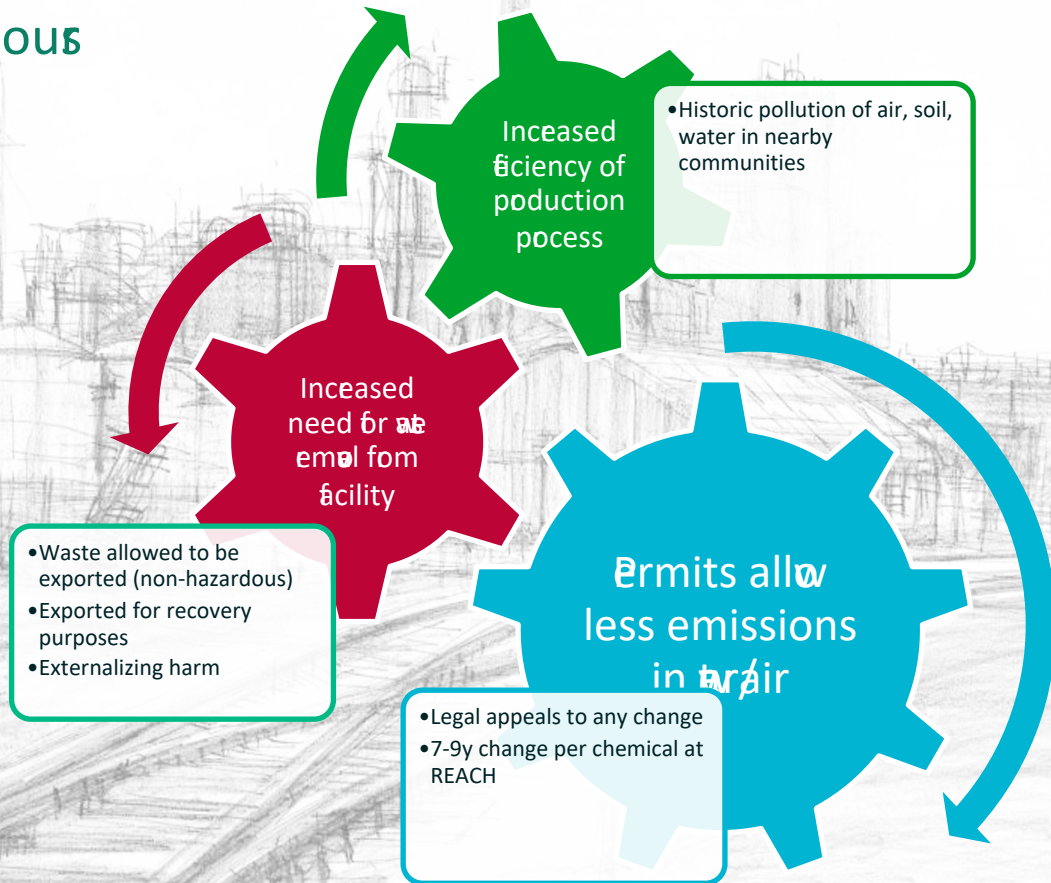
2023 Permit to report 2 million kg of HFPO-A to Fille



Lawful but awful ?

DuBois Nemours – Chemours
Dordrecht, the Netherlands

National PAS Conference
Ann Arbor MI (USA)
10-12 June 2024





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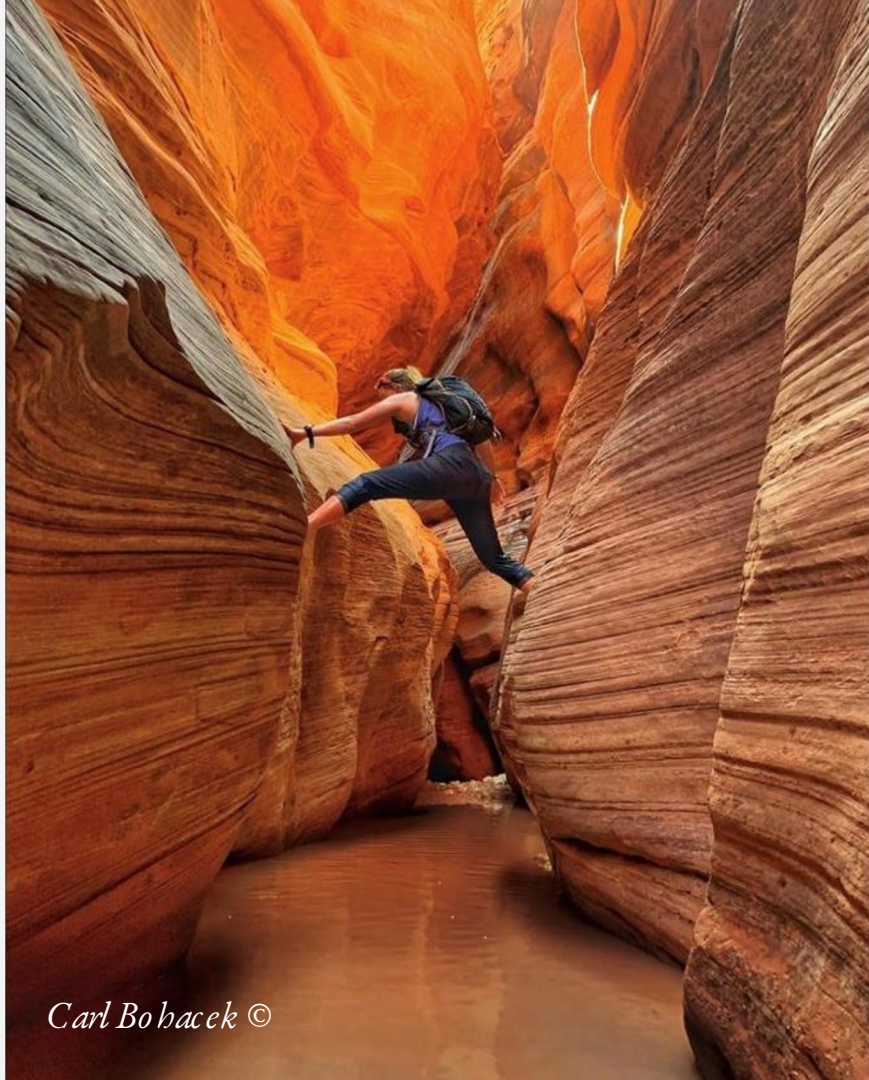
*At the Bench Inside 3M, 1997-
2001*

Or

*Toxic Gaslighting: How 3M
Executives Convinced a Scientist
the Forever Chemicals She Found
in Human Blood Were Safe
(propublica.org, 20May2024)*

Or

*You Make Me Sick
([The New Yorker](#), 20May2024)*



Carl Bohacek ©

Buckskin Gulch, UT



Lulealven, Sweden

Matthias Andresson ©



Loreto, Mexico



Carl Bohacek ©

Ely, MN



Carl Bohacek ©

Fairy Falls, Stillwater, MN



Carl Bohacek ©

Confluence, Prescott, WI



by Sharon Lerner, photography by Haruka Sakaguchi, special to ProPublica

May 20, 6 a.m. EDT

A REPORTER AT LARGE

HOW 3M DISCOVERED, THEN CONCEALED, THE DANGERS OF FOREVER CHEMICALS

The company found its own toxic compounds in human blood—and kept selling them.

By Sharon Lerner
May 20, 2024



Toxic Gaslighting: How 3M Executives Convinced a Scientist the Forever Chemicals She Found in Human Blood Were Safe



1/7/24

MANUFACTURING DOUBT, 3M's Ethical PFAS Debacle, Part III: Controlling the Narrative

[Read More](#)



10/2/23

UNDONE SCIENCE, 3M's PFAS Ethical Debacle, Part IIb: PFOS Environmental Contamination

[Read More](#)



9/29/23

UNDONE SCIENCE, 3M's PFAS Ethical Debacle, Part IIa: PFOS Carcinogenicity

[Read More](#)



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THE IRONY DOESN'T ESCAPE ME

- A CAUTIONARY TALE

Denise Trabbic-Pointer, BS, MS,
CHMM Emeritus



MY WORKPLACE LEARNING CURVE

Total trust and oblivious. I worked with Teflon blending 3 months in summer of 1976 and then dispersions from 1977 to 1986. I was not removed or restricted from working around Teflon, ever.

Continued education, workplace health and expanded corporate responsibilities

Pivotal moment #2. Guilt – Betrayal, Anger.
Technical expertise sharing, cleaning up the mess and community advocacy



In 1981 DuPont removed women of child-bearing age from Teflon mfg. and sends them back in in 2004

Beginning realization and pivotal moment #1, union activism and engagement

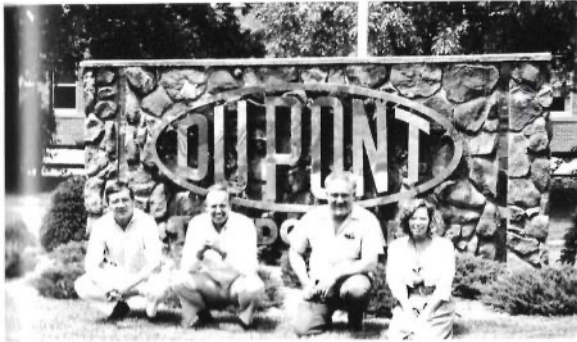
Global environmental management, global site legacy clean-up, dawning realization of the scope and impact of our global operations

DUPONT TOLEDO SITE HISTORY

In the mid-60's we began to produce the non-stick coating Teflon™. Our site was the sole supplier of Teflon™ for food contact until 1985.

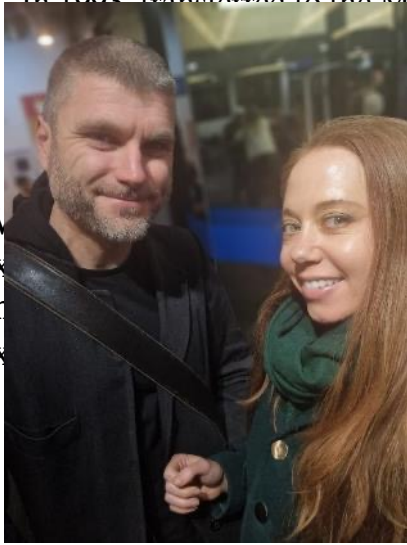
By the early '50s, all stone mills and floor paste mixers were removed and replaced by steel ball and pebble mills. The open varnish kettle stacks were no longer required and have been replaced by closed resin kettles. In 1952, the major production items were "Dulux" automotive finish and Hi-bake refrigerator whites. There were approximately 400 employees on the site at this time.

In 1957, the site experienced a potentially dangerous and disastrous situation—a tornado that destroyed one of the four original smokestacks. In the mid-60's we began to produce Teflon™. Our site was the sole supplier of Teflon™ for food contact until 1985. A new finished product warehouse was completed. It replaced a service garage, and many other buildings. The "Blizzard of '78" crippled the entire Midwest, including the Toledo site.



WORK HISTORY AND KEY FAMILY IMPACTS

- First 16 years – Teflon® blending, Paint filling, Dispersions mfg., Quality Control Lab, Environmental
 - Had both daughters C-Section while in filling and dispersions areas. Daughter #1 – non-malignant fluid removed at age 2-1/2, preeclampsia when pregnant, and daughter born prematurely weighing 20 oz; Daughter #2 – malignant colon pullups and must have annual colonoscopy and biopsy.
- While at Toledo and in about 1987, became the local union health & safety rep. In 1990 became a Health Technician, continue union activity
- In 1993 transferred to the Mt Clemens Plant as the Occupational Health Manager and soon picked up the role of a union rep.
- From 1987 until retirement (32 years), I monitored people and spent most of my time in our green room. I worked with employees, hazmat and fire brigade, local fire departments on the hazards and toxicology of the materials they would encounter. I was often called “Dr Death” because of my insistence that they properly



When my own exposure was impacting my children’s health and was sitting in me just waiting to be diagnosed with cancer. Of all people, my years of education, my research into the impacts of asbestos, and my care for employee and responder exposure and it never occurred to me that my own exposure was impacting my children’s health.

The Irony Doesn’t Escape Me

MY CAUTIONARY TALE

Genetic conditions

- Migraine (neurologist)
- Macular degeneration (retinal specialist)

Diagnosed Illnesses and Specialists

- Two Autoimmune conditions:
 - Lichen Sclerosis (gynecologist)
 - Vitiligo (dermatologist)
- Keratinizing Squamous Metaplasia (KSM) of the Bladder (rare) – 1/5th the size of a normal bladder due to years of infection. Characterized by the urologist as “weird” and likely from workplace exposure. KSM cells are considered pre-cancerous and there is no treatment – only periodic procedure and biopsy (urologist)
- Recent early signs and symptoms of kidney disease, including a November 2023 trip to the emergency room

MY CAUTIONARY TALE

What I've Learned

- With all the years of education and experience and preaching to people about chemical health hazards and personal protection, it did not protect me from what I didn't know.
- Don't assume that because you know the hazards and how to protect yourself that you are safe
- Never too old to learn – Never too old to do something about it
- Those agencies like ATSDR, CDC, NIOSH, OSHA and associations like AIHA and ACGIH that I always trusted so completely are not being at all proactive with learning more about workplace exposure to PFAS or to setting acceptable limits. NIOSH is starting by asking for companies to “volunteer” but where have they all been? Infuriating and frustrating

Thanks to Ecology Center, I know that my and my oldest daughter's PFAS blood levels are now within “normal” ranges. But the PFAS was doing its harm for many intervening years. There still is no silver bullet for those that know now they have high levels of PFAS in their blood but testing for PFAS in potentially impacted people's blood and working to find a chelation therapy is essential.



THANK YOU

Denise Trabbic-Pointer | dtrabbicpointer@gmail.com

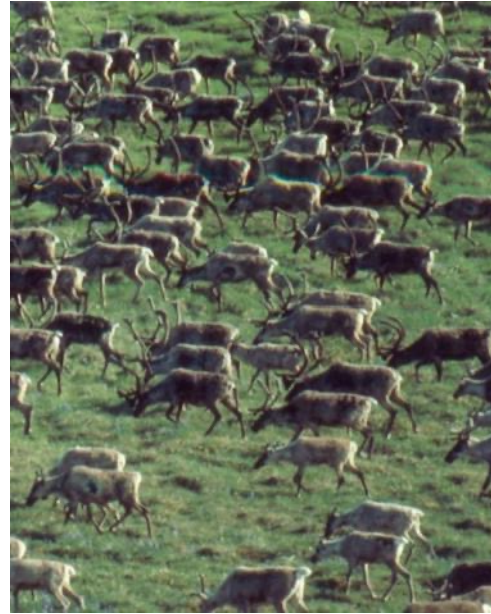




**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

National PFAS Conference
Workers Rights and Protections
June 12, 2024
Tim Whitehouse



ABOUT PEER

- Protecting Whistleblowers
- Shining the Light
- Improving Governance
- Building Networks

- Founded in 1992
 - 12 staff. Staff in 6 states.
 - All our work is pro bono
 - Our financial support comes from foundations, individuals, and case settlements



Credit: Caught Between Conscience and Career





No Workers Rights and Protections

There are no special worker safety precautions for PFAS

No Public Knowledge

PFAS Statistics

- 1,344 PFAS currently on the TSCA Inventory (666 active)
 - This does not include environmental degradants, by-products, or impurities
- Approx. 700 Low Volume Exemptions granted
 - not listed on the Inventory

Source: PEER
FOIA

There is no way for the public to know what kind of review, if any, these PFAS underwent

Over 12,000 PFAS and the ability to test for only about 40



Almost nothing is known about the scope of the problem

"People whose work involves the making or processing of PFAS and PFAS-containing materials are more likely to be exposed than the general population. Workers may be exposed by touching or swallowing PFAS or PFAS-containing materials or by breathing in associated dust, aerosols, or fumes."

<https://www.atsdr.cdc.gov/pfas/health-effects/exposure.html#:~:text=Workers.dust%2C%20aerosols%2C%20or%20fumes>

Industry Sectors that May be Handling PFAS

Industry	Count	Active
Oil and Gas	45,000	29,719
Waste Management	35,682	21,103
Chemical Mfg	11,619	7,191
Metal Coating	10,727	6,866
Petroleum	8,340	4,829
Electronics Industry	7,863	4,460
Plastics and Resins	7,668	4,976
Mining and Refining	6,603	779
Metal Machinery Mfg	6,072	3,956
Printing	4,941	2,830
Airports	3,596	2,184
Textiles and Leather	3,089	1,575
Paints and Coatings	2,992	1,870
Paper Mills and Proc	2,403	1,729
Cleaning Product Mfg	2,179	1,106
National Defense	2,149	1,401
Industrial Gas	1,183	760
Fire Protection	861	243
Glass Products	785	503
Furniture and Carpe	546	234
Airports (Part 139)	536	518
Fire Training	510	7
Consumer Products	485	301
Cement Mfg	399	265

Source: EPA PFAS Tracker



Workers are not properly notified



By design and neglect
Safety Data Sheets do not
contain needed information

New and Emerging Issues

Industry will continue to push the use of PFAS

Example: Refrigeration. **Worker safety issues are unknown, but TFA is of concern**

Driven by profit margins, U.S. chemical manufacturers continue to push refrigerants that worsen not only global warming but also contain PFAS.

Europe is embracing eco-friendly alternatives that possess the power to cool without contributing to the climate crisis and using PFAS.



Impact of Refrigerants Fact Sheet #2 (V.1)
Refrigerants: Real GWP and PFAS

Refrigerant / Brand Name	Type	Composition	IPCC AR4 (2007)		IPCC AR6 (2021)		PFAS
			GWP 100 years	Real GWP 20 years	GWP 100 years	Real GWP 20 years	
R143a	HFC	100% R143a	4470	5990	5810	7640	Yes
R125	HFC	100% R125	3500	6350	3740	6740	Yes
R134a	HFC	100% R134a	1430	3830	1530	4140	Yes
R32	HFC	100% R32	650	2330	771	2690	No
R404A Freon 404A	HFC	44% R125 / 4% R134a / 52% R134a	3922	6010	4728	7208	Yes
R407A Freon 407A	HFC	20% R32, 40% R125, 40% R134a	2102	4538	2262	4890	Yes
R410A Freon 410A	HFC	50% R125 / 50% R32	2075	4340	2255	4715	Yes
R407C Freon 407C	HFC	23% R32 / 25% R125 / 52% R134a	1768	4115	1908	4457	Yes
R452A Opteon XP44	HFC/ HFO	11% R32 / 59% R125 / 30% R1234yf	2137	4003	2292	4273	Yes
R449A Opteon XP40	HFC/ HFO	24.3% R32 / 24.7% R125 / 25.7% R134a / 25.3% R1234yf	1390	3119	1504	3383	Yes
R484A Solstice N40	HFC/ HFO	26% R32 / 26% R125 / 21% R134a / 7% R1234ze / 20% R1234yf	1379	3062	1494	3321	Yes
R448C Opteon XP20	HFC/ HFO	20% R32 / 20% R125 / 29% R134a / 31% R1234yf	1245	2847	1346	3087	Yes
R452B Opteon XL55	HFC/ HFO	67% R32 / 7% R125 / 26% R1234yf	681	2006	779	2275	Yes
R454B Opteon XL41	HFC/ HFO	68.9% R32 / 31.1% R1234yf	448	1606	531	1854	Yes
R513A Opteon XP10	HFC/ HFO	44% R134a / 56% R1234yf	629	1686	673	1823	Yes
R450A Solstice N13	HFC/ HFO	42% R134a / 58% R1234ze	601	1611	643	1742	Yes
R454C Opteon XL20	HFC/ HFO	78.5% R1234yf / 21.5% R32	140	502	166	580	Yes
R455A Solstice L40X	HFC/ HFO	75.5% R1234yf / 21.5% R32 / 3% R744	140	502	166	580	Yes
R744	Natural	CO ₂	1	1	1	1	No
R600a	Natural	Isobutane	<1	<1	<1	<1	No
R290	Natural	Propane	<1	<1	<1	<1	No
R1270	Natural	Propylene	<1	<1	<1	<1	No
R717	Natural	NH ₃	0	0	0	0	No
R718	Natural	H ₂ O	0	0	0	0	No
R729	Natural	Air	0	0	0	0	No

<https://www.theguardian.com/environment/2024/may/01/rapidly-rising-levels-of-tfa-forever-chemical-alarm-experts>



Workers Need

- PFAS defined as a class
- PFAS banned except for essential uses
- Comprehensive standards for PFAS across all major environmental statutes (e.g. air, water, hazardous waste, clean up, and reporting)
- Reforms at EPA's Office of Chemical Safety and Pollution Prevention
- OSHA standards
- Complete Transparency
- Political Support



Thank you!

Tim Whitehouse

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202-265-7337





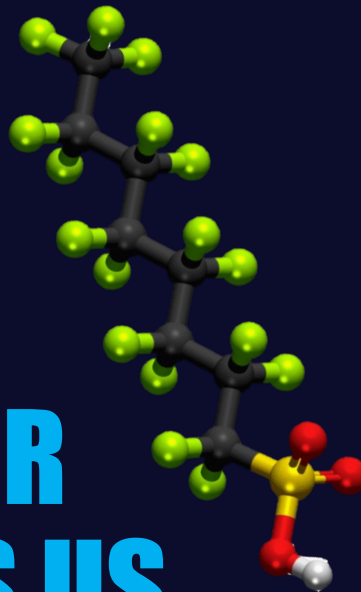
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INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

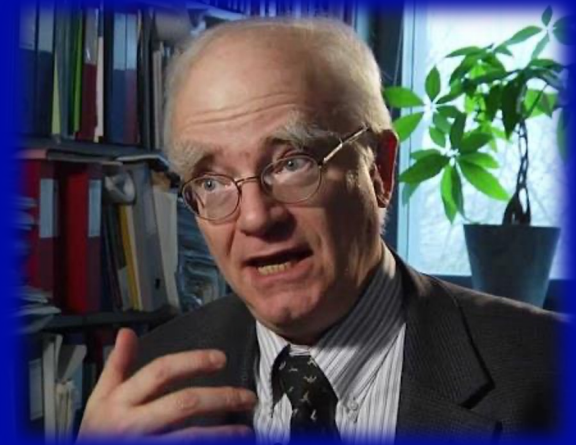
PFAS & FIRE FIGHTERS: GOING WHEREVER THE FIGHT TAKES US



June 11, 2023

“

It's frustrating to be an environmental health researcher and spend years and years to characterize the exposures and the adverse health effects of these [PFAS] compounds, only to discover that most of that information was already known but had been kept secret.”



Head of Environmental Medicine Research Unit at the [University of Southern Denmark](#) and adjunct professor of environmental health at [Harvard School of Public Health](#)

— **Philippe Grandjean**



HOW ARE FIRE FIGHTERS SUPPOSED TO EVALUATE THE SCIENCE ?

Acknowledgment—The authors would like to thank Laura Hoch and Joel Tickner of the University of MA Lowell for comments on this manuscript; Yasuhiko Matsuoka of AGC Chemicals Americas, Inc.; Mary MaloneyHuss, Greg Hannon, Paul Fisher, David Einum, Catherine Parmeter and Terry Zitzelberger of **W.L. Gore** for technical assistance; John Jones of W.L. Gore for chemical analyses; Terrie Stike of **W.L. Gore** for manuscript preparation. We would also like to thank the editors and reviewers for their comments to improve this paper.

Disclaimer—BJ Henry, JP Carlin, and JA Hammerschmidt are employees of **W.L. Gore**, a global manufacturer of products made with fluoropolymers. RC Buck and LW Buxton are employees of The **Chemours** Company, a global manufacturer of fluoroproducts. O Hernandez, former Director of the Risk Assessment Division in the USEPA Office of Pollution Prevention and Toxics, is an employee of Bergeson and Campbell, a **W.L. Gore contractor**. J Seed, former Deputy Director of the Risk Assessment Division in the USEPA Office of Pollution Prevention and Toxics, is an independent risk assessment **consultant to W.L. Gore**. H Fiedler is a professor of Chemistry at the MTM Research Centre in the School of Science and Technology at Örebro University in Örebro, Sweden. Hernandez and Seed were retained and **compensated by W.L. Gore & Associates, Inc.**, to assist in writing this paper. **W.L. Gore & Associates, Inc.**, the **Chemours** Company, and the MTM Research Centre School of Science and Technology, Örebro University, Örebro, Sweden donated data and employee time to support this work.

Data Accessibility—All data and information used in this manuscript have been made available in tabulated form (Tables 1–4) by the authors and are included in the paper and the Supplemental Data.

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Are fluoropolymers polymers of low concern?

Integrated Environmental Assessment and Management — Volume 14, Number 3—pp. 316–334

316

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Critical Review

A Critical Review of the Application of Polymer of Low Concern and Regulatory Criteria to Fluoropolymers

Barbara J Henry,*† Joseph P Carlin,† Jon A Hammerschmidt,† Robert C Buck,‡ L William Buxton,‡ Heidelore Fiedler,§ Jennifer Seed,|| and Oscar Hernandez#

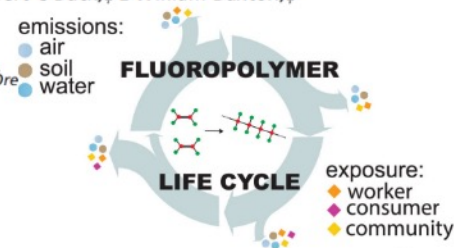
***W.L. Gore & Associates, Elkton, Maryland, USA**

†**Chemours Company, Wilmington, Delaware, USA**

‡**MTM Research Centre School of Science and Technology, Örebro University, Örebro, Sweden**

§**Risk Assessment Consultant, Alexandria, Virginia, USA**

#**Bergeson & Campbell, Washington, DC, USA**



PFAS EXPOSURE

FIRE FIGHTER PFAS EXPOSURES

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PFAS WITHIN FIRE FIGHTERS FROM AFFF

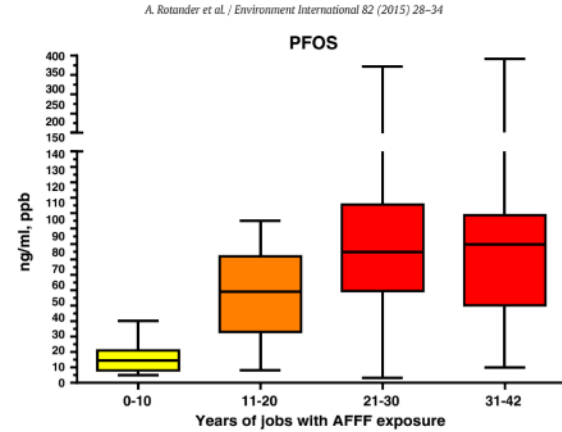
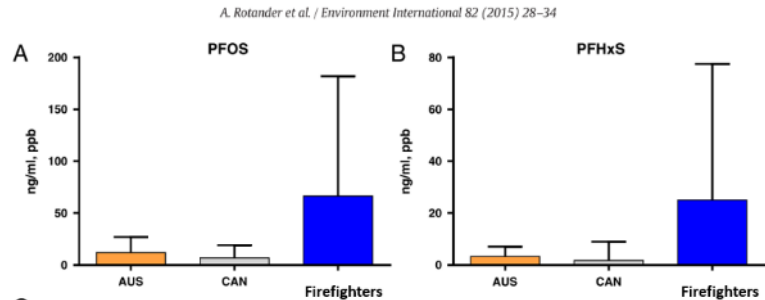


Fig. 2. PFOS serum concentrations (ng/ml, serum, y-axis) in 149 firefighters in relation to number of years of jobs with AFFF exposure (x-axis). The lines in the boxes indicate median concentrations, the outside of the boxes the 25th and 75th percentiles, and the whiskers min and max concentrations.



PFAS from turnout gear

Studies done by **Peaslee**, **Muensterman**, **Carignan** and **NIST** all prove that the same PFAS which cause illnesses and negative health outcomes are shed from turnout gear:

- PFDoA
- PFNA
- PFDA
- PFHxS
- PFOA
- PFOS
- HFPO-DA
- PFUnA
- FTOH
- FTMAc
- EtFOSE
- PFPeA
- PFBA
- PFHxA
- PFBS
- FOSA
- PFDODA

Transformation of Precursors to PFAAs

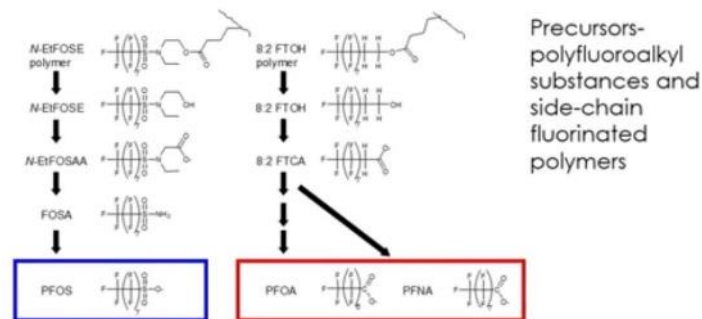


Figure courtesy of C. Higgins

Module 5: Fate and Transport

<http://www.itrcweb.org/>

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INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

NIST 2024

- Abrasion increased summed PFAS concentrations for all textile types
- Laundering produced changes in summed PFAS concentrations across all textiles
- When exposed to elevated temperatures (260 degrees C), summed PFAS concentrations were higher than in the equivalent unstressed textiles.
- Changes in summed PFAS concentration after exposure to elevated temperatures were largely due to changes in 6:2 FTMAC and 6:2 FTOH concentrations.
- The observation of higher summed volatile PFAS concentrations after exposure to elevated temperatures could indicate their production from the degradation of fluorinated polymers.
- Health Canada are investigating the liberation of volatile PFAS from turnout gear when heated.
- Their methods include heating the thermal liner to 38° C, the moisture barrier to 76° C, and the outer shell to 100° C.



Per- and Polyfluoroalkyl Substances in Firefighter Turnout Gear Textiles Exposed to Abrasion, Elevated Temperature, Laundering, or Weathering

Andrew C. Maizel
Andre Thompson
Meghanne Tighe
Samuel Escobar Veras
Alix E. Rodowa
Ryan Falkenstein-Smith
Bruce Benner
Kathleen Hoffman
Michelle Donnelly
Olivia Hernandez
Nadine Wetzler
Trung Ngu
Jessica Reiner
Benjamin Place
John Kucklick
Catherine Rimmer
Rick D. Davis

This publication is available free of charge from:
<https://doi.org/10.6028/NIST.TN.2260>

Pathways for PFAS

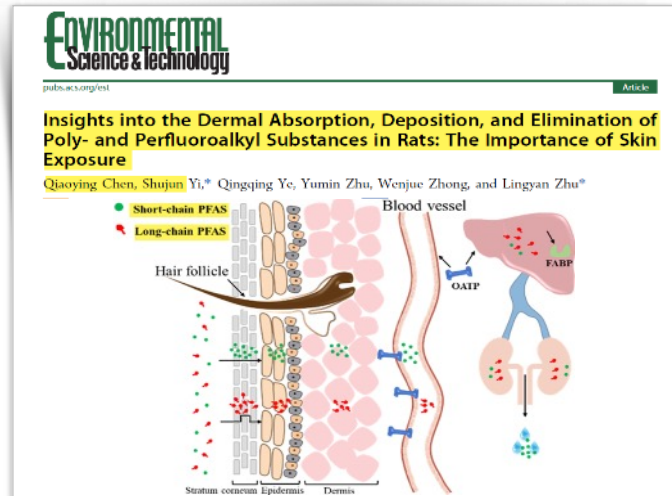


Full length article

Transdermal absorption of $^{13}\text{C}_4$ -perfluorooctanoic acid ($^{13}\text{C}_4$ -PFOA) from a sunscreen in a male volunteer – What could be the contribution of cosmetics to the internal exposure of perfluoroalkyl substances (PFAS)?

Klaus Abraham, Bernhard H. Monien

German Federal Institute for Risk Assessment (BfR), Department of Food Safety, 10589 Berlin, Germany



J. Toxicol. Environ. Health A, 2012;75(1):50-62. doi: 10.1080/15287394.2011.615108.

Dermal penetration potential of perfluorooctanoic acid (PFOA) in human and mouse skin.

Franko J, Meade BJ, Frasch HF, Barbero AM, Anderson SE.

Author information

Abstract

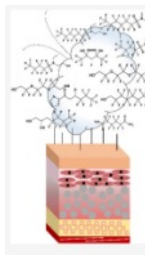
Recent data, using a murine model, have indicated that dermal exposure to perfluorooctanoic acid (PFOA) induces immune modulation, suggesting that this may be an important route of PFOA exposure. To investigate the dermal penetration potential of PFOA, serum concentrations were analyzed in mice following topical application.

Statistically significant and dose-responsive increases in serum PFOA concentrations were identified. In vitro dermal penetration studies also demonstrated that PFOA

Published in final edited form as:
Food Chem Toxicol. 2023 January ; 171: 113515. doi:10.1016/j.fct.2022.113515.

Systemic toxicity induced by topical application of perfluoroheptanoic acid (PFHpA), perfluorohexanoic acid (PFHxA), and perfluoropentanoic acid (PFPeA) in a murine model

Lisa M. Weatherly,
Hillary L. Shane,
Ewa Lukomska,
Rachel Baur,
Stacey E. Anderson



Evaluating Neutral PFAS for Potential Dermal Absorption from the Gas Phase

John C. Kissel,^{||} Ivan A. Titaley,*^{||} Derek J. Muensterman, and Jennifer A. Field

Cite This: Environ. Sci. Technol. 2023, 57, 4951–4958

Read Online

neutral PFAS gave calculated D/I ratios >5 , indicating that direct transdermal absorption may be an important exposure pathway compared to inhalation. Data on consumer products or indoor air is needed

from 9-600 ng m^{-3} , followed by 8:2 FTOH. Concentrations of volatile PFAS from air, carpet and dust were closely related to each other, indicating that carpets and dust are major sources of FTOHs in air. Nonetheless, air posed the largest exposure risk of FTOHs and biotransformed perfluorinated alkyl acids (PFAA) in young children. This research highlights inhalation of indoor air as an important exposure pathway and the need for further reduction of precursors to PFAA.

Morales-McDevitt et al. 2022

but not volatile PFAS (e.g., 6:2 FTOH). Thus, inclusion of volatile PFAS in WPEM is recommended. Given the thermal transformation of nonvolatile PFAS (e.g., 6:2 diPAP) that occurred under the temperatures of a GC inlet (280 °C), firefighters entering burning structures painted with PFAS-containing may experience exposure to FTOHs. Research is

Cahuas et al. 2022



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

IAFF.ORG

TURNOUT GEAR IS POINTED TO BE THE SOURCE

- PFOS, PFOA, PFHxS, perfluorononanoic acid, and diPAP were **significantly higher in dust from fire stations** than from homes
- PFOS, PFOA, PFHxS, PFNA, and 6:2 diPAP were **significantly higher in fire station dust** than in residential dust
 - **Hall et al. 2020** –
- Compared to station living rooms, **turnout gear locker rooms had higher dust levels of total fluorine**
 - **Young et al. 2022** –



Previous PFAS fire fighter studies

Gaussian graphical modeling of the serum exposome and metabolome reveals interactions between environmental chemicals and endogenous metabolites

Vincent Bessonneau^{1,2}, Roy R. Gerona³, Jessica Trowbridge⁴, Rachel Grashow¹, Thomas Lin¹, Heather Buren⁵, Rachel Morello-Frosch^{4,7} & Ruthann A. Rudel^{1,2}

Given the complex exposures from both exogenous and endogenous sources that an individual experiences during life, exposome-wide association studies that interrogate levels of small molecules in biospecimens have been proposed for discovering causes of chronic diseases. We conducted a study to explore associations between environmental chemicals and endogenous molecules using Gaussian graphical models (GGMs) of non-targeted metabolomics data measured in a cohort of **California women firefighters** and office workers. GGMs revealed many exposure-metabolite associations, including that exposures to mono-hydroxyisobutyl phthalate, ethyl paraben and 4-ethylbenzoic acid were associated with metabolites involved in steroid hormone biosynthesis, and **perfluoroalkyl substances were linked to bile acids—hormones that regulate cholesterol and glucose metabolism—and inflammatory signaling molecules**. Some hypotheses generated from these findings were confirmed by analysis of data from the National Health and Nutrition Examination Survey. Taken



Persistent organic pollutants including polychlorinated and polybrominated dibenzo-*p*-dioxins and dibenzofurans in firefighters from Northern California



Susan D. Shaw^{1,2,3*}, Michelle L. Berger³, Jennifer H. Harris³, Se Hun Yun⁴, Qian Wu^{5,6}, Chunyang Liao⁶, Ariene Blum⁴, Anthony Stefani⁴, Kurunthachalam Kannan^{5,6}

¹Marine Environmental Research Institute, Center for Marine Studies, P.O. Box 1052, Ilwaco, OR 97101, USA

²Wadsworth Center, New York State Department of Health, Albany, NY 12201, USA

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⁴Green Science Policy Institute, University of California, Berkeley, CA 94705, USA

⁵San Francisco Firefighters Cancer Prevention Foundation, 1139 Mission St., San Francisco, CA 94101, USA

ARTICLE IN PRESS

Clarity et al. *Environmental Health* (2021) 20:97
<https://doi.org/10.1186/s12940-021-00778-z>

Environmental Health

RESEARCH

Open Access



Associations between polyfluoroalkyl substance and organophosphate flame retardant exposures and telomere length in a cohort of women firefighters and office workers in San Francisco

Cassidy Clarity¹, Jessica Trowbridge^{1,2}, Roy Gerona³, Katherine Ona^{4,5}, Michael McMaster^{4,5}, Vincent Bessonneau^{6,7}, Ruthann Rudel⁸, Heather Buren⁶ and Rachel Morello-Frosch^{1,2*}

terms found in firefighter serum.
in firefighter serum.
tional exposure to deca-BDE.
to smoke during firefighting.

ORIGINAL ARTICLE

OPEN

Biomonitoring in California Firefighters Metals and Perfluorinated Chemicals

Dina Dobraca, MPH, Leslie Israel, DO, MPH, Sandra McNeel, DVM, Robert Voss, MS, Miaomiao Wang, PhD, Ryszard Gajek, PhD, June-Soo Park, PhD, Suhash Harwani, PhD, Frank Barley, PhD, Jianwen She, PhD, and Rupali Das, MD, MPH

Evidence was challenged

Exposure to Perfluoroalkyl Substances in a Cohort of Women Firefighters and Office Workers in San Francisco

Jessica Trowbridge, Roy R. Gerona, Thomas Lin, Ruthann A. Rudel, Vincent Bessonneau, Heather Buren, and Rachel Morello-Frosch*

MIND & BODY. RESEARCH, SCIENCE & ENVIRONMENT

Women firefighters face high exposure to toxic ‘forever chemicals’

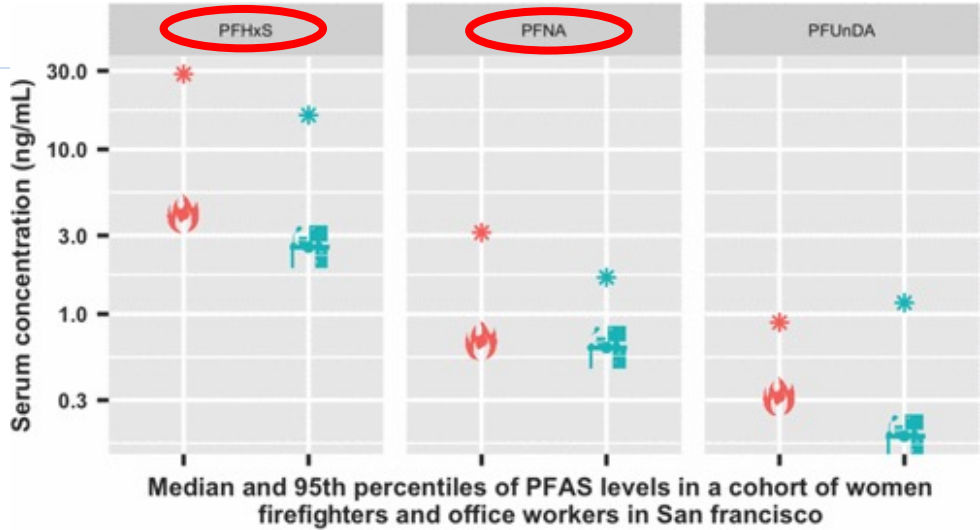
By Kara Manko, February 26, 2020



Maiko Bristow, a firefighter and EMT with the San Francisco Fire Department, is part of a long-term investigation into female firefighter's risk of breast cancer. (UC Berkeley photo by Brittany Hoses-Suall)

San Francisco's women firefighters are exposed to higher levels of certain toxic PFAS chemicals than women working in downtown San Francisco offices, shows a new study led by researchers at the University of California, Berkeley, the University of California, San Francisco, and Silent Spring Institute.

Per- and polyfluoroalkyl substances (PFAS) are used in grease- and water-resistant coatings and can be found in fabrics, furniture and food packaging, but also notably in firefighting foam and turnout gear. These "forever chemicals," which don't easily break down in the environment, have been linked to a variety of cancers and are known to interfere with immune function, endocrine function and breast development.



"PFAS in firefighters were consistent with those in office workers."

– Paul Chrostowski

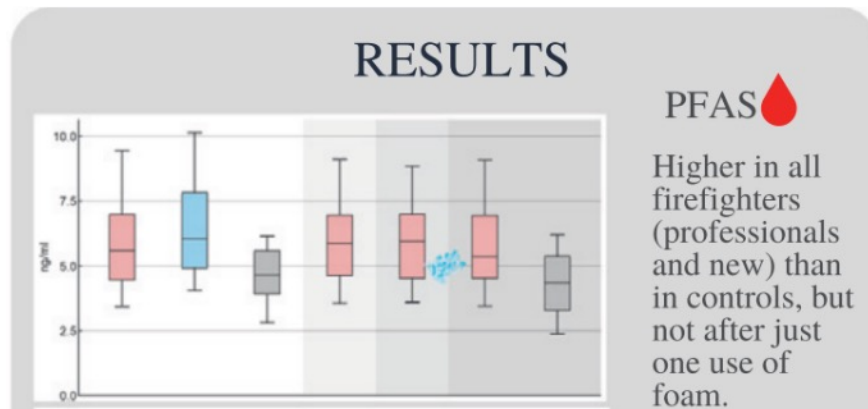
"Chrostowski chose to ignore parts of the paper that are inconvenient... It is a misrepresentation of what our study did and the results we found."

- Rachel Morello-Frosch



Czech fire fighter study

“The firefighting occupation and firefighting training lead to increased PFAS and PAH levels in firefighters. Health-based HBM-I and HBM-II values for PFOS and PFOA were exceeded in several participants: thus, there is a need to minimize such exposure and to conduct further monitoring.”



The exposure of Czech firefighters to perfluoroalkyl substances and polycyclic aromatic hydrocarbons: CELSPAC – FIREexpo case-control human biomonitoring study



Katarína Řiháčková^a, Aleš Pindur^{a,b,c}, Klára Komprdová^a, Nina Páležová^a, Jiří Kohoutek^a, Petr Šenk^a, Jana Navrátilová^a, Lenka Andrášková^a, Ludmila Šebejová^a, Richard Hůlek^a, Mazen Ismael^a, Pavel Čupr^{a,*}



Gene and epigenetic alteration

Do PFAS exposures accelerate biological aging (approx. by 7 epigenetic age markers)?

PFAS	IEAA	EEAA	Horvath	Hannum	PhenoAge	SkinBlood Clock	GrimAge
PFHxS	0.77 (0.5)	1.05 (0.44)	0.93 (0.5)	0.97 (0.4)	0.58 (0.57)	1.13 (0.4)	0.49 (0.27)
n-PFOA	2.12 (0.71)	1.57 (0.63)	2.28 (0.71)	1.45 (0.58)	1.62 (0.82)	1.71 (0.58)	0.16 (0.39)
Sb-PFOA	0.63 (0.69)	0.09 (0.60)	0.70 (0.69)	0.08 (0.56)	0.23 (0.78)	0.49 (0.55)	-0.3 (0.36)
n-PFOS	0.8 (0.68)	0.83 (0.6)	1.04 (0.68)	0.77 (0.55)	-0.36 (0.77)	0.46 (0.55)	0.65 (0.36)
Sm-PFOS	1.69 (0.65)	0.97 (0.57)	1.85 (0.64)	0.89 (0.53)	-0.18 (0.74)	0.88 (0.53)	0.6 (0.34)
PFNA	0.03 (0.64)	-0.11 (0.56)	0.09 (0.64)	-0.1 (0.52)	-0.73 (0.72)	-0.34 (0.51)	-0.18 (0.34)
PFDeA	-0.63 (0.7)	-0.18 (0.61)	-0.43 (0.7)	-0.16 (0.57)	-0.6 (0.79)	-0.71 (0.56)	-0.91 (0.36)
PFUA	0.09 (0.62)	-0.72 (0.54)	0.03 (0.62)	-0.67 (0.5)	-0.47 (0.7)	-0.57 (0.5)	-0.76 (0.33)
MEFOSAA	0.45 (0.67)	-0.87 (0.59)	0.47 (0.67)	-0.81 (0.54)	-0.69 (0.76)	-0.27 (0.54)	0.32 (0.36)



Color Key
+ association, p<0.05
+ association, p>0.05
- association, p>0.05
- association, p<0.05

Effect estimates (se) for association between each PFAS and each epigenetic age indicator, adjusting for age, gender, race, cell types, and batch. **P<0.05 in bold.**

Goodrich et al., in preparation



HEALTH EFFECTS

REDUCED OVARIAN RESERVE IN FIRE FIGHTERS

Article

Anti-Müllerian Hormone Levels among Female Firefighters

Samantha Davidson¹, Sara Jahnke², Alesia M. Jung^{1,3}, Jefferey L. Burgess^{3,4}, Elizabeth T. Jacobs^{1,4}, Dean Billheimer¹ and Leslie V. Farland^{1,4,5,*}

Abstract: Female firefighters have occupational exposures which may negatively impact their reproductive health. Anti-müllerian hormone (AMH) is a clinical marker of ovarian reserve. We investigated whether AMH levels differed in female firefighters compared to non-firefighters and whether there was a dose-dependent relationship between years of firefighting and AMH levels. Female firefighters from a pre-existing cohort completed a cross-sectional survey regarding their occupational and health history and were asked to recruit a non-firefighter friend or relative. All participants provided a dried blood spot (DBS) for AMH analysis. Linear regression was used to assess the relationship between firefighting status and AMH levels. Among firefighters, the influence of firefighting exposures was evaluated. Firefighters ($n = 106$) and non-firefighters ($n = 58$) had similar age and BMI. Firefighters had a lower mean AMH compared to non-firefighters (2.93 ng/mL vs. 4.37 ng/mL). In multivariable adjusted models, firefighters had a 33% lower AMH value than non-firefighters ($-33.38\% \Delta$ (95% CI: $-54.97, -1.43$)). Years of firefighting was not associated with a decrease in AMH. Firefighters in this study had lower AMH levels than non-firefighters. More research is needed to understand the mechanisms by which firefighting could reduce AMH and affect fertility.



Citation: Davidson, S.; Jahnke, S.; Jung, A.M.; Burgess, J.L.; Jacobs, E.T.; Billheimer, D.; Farland, L.V. Anti-Müllerian Hormone Levels among Female Firefighters. *Int. J. Environ. Res. Public Health* **2022**, *19*, 5981. <https://doi.org/10.3390/>

Mullerian Inhibiting Substance inhibits cervical cancer cell growth via a pathway involving p130 and p107

Thanh U. Barbie*, David A. Barbie[†], David T. MacLaughlin*, Shyamala Maheswaran*, and Patricia K. Donahoe*^{††}

*Pediatric Surgical Research Laboratories, Massachusetts General Hospital and Harvard Medical School, Boston, MA 02114; and ^{††}Cancer Center, Massachusetts General Hospital, Charlestown, MA 02129

Contributed by Patricia K. Donahoe, October 24, 2003

“Mullerian Inhibiting Substance (MIS) inhibits the growth of epithelial ovarian cancer cells”



Fire fighters have higher serum concentrations of PFAS

These PFAS cause:

- Lung cancer
- Prostate cancer
- Endometriosis
- Decreased antibody response
- Pregnancy-induced hypertension
- Miscarriage
- Elevated total cholesterol
- Low birth weight
- Placental dysfunction
- Age at menopause
- Menstrual irregularities
- Reduced fertility

Article

Prevalence and Predictors of Per- and Polyfluoroalkyl Substances (PFAS) Serum Levels among Members of a Suburban US Volunteer Fire Department

Judith M. Graber^{1,2,4}, Taylor M. Black², Nimit N. Shah³, Alberto J. Caban-Martinez³, Shou-en Lu^{1,2}, Troy Brancard³, Chang Ho Yu⁴, Mary E. Turyk², Kathleen Black², Michael B. Steinberg⁴, Zhihua Fan⁴ and Jeffrey L. Burgess⁷

PFAS chemicals in serum differed between members of a large suburban volunteer fire department and the general US population, including that **PFDoA** was detected in 80% of study subjects but in none of the NHANES participants in the 2017–2018 cycle. As well, we observed significantly higher serum levels of **PFNA**, **PFDA**, and **PFDoA**. Our observation that mean PFDA serum concentrations were significantly elevated in these volunteer firefighters compared to NHANES participants is notable. It is consistent with a 2015 biomonitoring study of 101 California career firefighters that reported their **PFDA** levels were three times higher than those in NHANES participants.

ORIGINAL ARTICLE

Perfluoroalkyl Substances and Metabolic Syndrome in Firefighters

A Pilot Study

David B. Leary, DO, MPH, Mari Takazawa, PhD, Kurunthachalam Kannan, PhD, and Naila Khalil, MBBS, MPH, PhD, CPH

Results: PFASs serum concentrations were 18% to 74% higher in FF than the general population



Continuing research confirms the causal association with increased forms of cancer

The association between per- and polyfluoroalkyl substances (PFASs) and brain, esophageal, melanomatous skin, prostate, and lung cancer using the 2003–2018 US National Health and Nutrition Examination Survey (NHANES) datasets

Jinyoung Moon^{a,b,c,1}, Yongseok Mun^{d,*}

This study found that exposure to PFHxS, PFOA/PFOS, PFOA/PFHxS, PFOS/PFNA, and PFOS/ PFNA was linked to cancers of the brain, esophagus, melanomatous skin, prostate, and lung, respectively.

4. Discussion

In this study, the OR of brain cancer for one unit increase in ln (PFHxS) was 8.16 (95 % CI 2.98–68.89). The OR of esophageal cancer for one unit increase of ln (PFOA) and ln (PFOS) were 5.10 (95 % CI 1.18–17.34) and 3.97 (95 % CI 1.24–11.42), respectively. The OR of melanoma for one unit increase of ln (PFOA) and ln (PFHxS) were 1.65 (95 % CI 1.07–2.58) and 1.55 (95 % CI 1.07–2.25), respectively. The OR of prostate cancer for one unit increase of ln (PFOS) and ln (PFNA) were 1.21 (95 % CI 1.00–1.48) and 1.27 (95 % CI 1.00–1.62), respectively. The OR of lung cancer for one unit increase of ln (PFOS) and ln (PFNA) were 2.62 (95 % CI 1.24–5.83) and 2.38 (95 % CI 1.00–5.52), respectively.

Fire fighter cancer rates:

Skin cancer – Incidents 56% higher, Lee et al. (2020), Mortality 73% higher, Howe and Burch (1990)

Prostate cancer – Incidents 28% higher, LeMasters et al. (2006), Mortality 30% higher, IARC (2010)

Brain cancer – OR 35% higher, Bates et al. (2007)

Esophageal cancer – OR 48% higher, Bates et al. (2007)

Lung cancer – RR 8-43% higher, Navarro et al. (2019)



Fire fighters are more than 2x as likely to miscarry

Pregnancy, childbirth, and puerperium outcomes in female firefighters in Korea

Juha Park¹, Yeon-Soon Ahn², and Min-Gi Kim^{1*}

¹Department of Occupational and Environmental Medicine, Dankook University Hospital, Cheonan, Korea
²Department of Prevention Medicine and Institute of Genomic Cohort, Yonsei Wonju College of Medicine, Wonju, Korea

Results: The study population included 1,766 female firefighters. Total follow-up duration was 9,659 person-years. Compared to the general female population, the female firefighters' SARs were higher in all admissions for PCPOs (SAR, 1.92; 95% CI: 1.79–2.05); pregnancy and abortive outcomes (SAR, 1.56; 95% CI: 1.12–2.12); other maternal disorders predominantly related to pregnancy (SAR, 2.65; 95% CI: 1.99–3.46); maternal care related to the fetus, amniotic cavity, and possible delivery problems (SAR, 2.13; 95% CI: 1.74–2.57); labor and delivery complications (SAR, 1.55; 95% CI: 1.15–2.06); delivery (SAR, 1.94; 95% CI: 1.80–2.08); and complications predominantly related to puerperium (SAR, 4.68; 95% CI: 2.02–9.23).

Conclusion: The results of this study showed high SARs in all and specific subcategories of PCPOs in female firefighters.

Keywords: Pregnancy and puerperium outcomes; Reproductive health; Female; Firefighters

Maternal and Child Health Journal
<https://doi.org/10.1007/s10995-018-2468-3>



Maternal and Child Health Among Female Firefighters in the U.S.

Sara A. Jahnke¹ · Walker S. C. Poston¹ · Nattinee Jitnarin¹ · Christopher K. Haddock¹

ter (27.0%). When age standardized with two separate studies, the rate of spontaneous abortion was more than twice as high as the published rates in both Andersen et al. (2000) (13.5 vs. 29.1%) and Slama et al. (2005) (9.5 vs. 27.1%). Our

RESEARCH

Open Access



Occupational factors and miscarriages in the US fire service: a cross-sectional analysis of women firefighters

Alesia M. Jung^{1*}, Sara A. Jahnke¹, Leslie K. Dennis^{1,3}, Melanie L. Bell¹, Jefferey L. Burgess¹, Nattinee Jitnarin², Christopher M. Kaipust² and Leslie V. Farland^{1,4}

High rates of ALL adverse pregnancy and birth outcomes



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

Congenital heart defects

REVIEW

Review of recent epidemiological studies on paternal occupations and birth defects

S-E Chia, L-M Shi

The main findings reported by recent epidemiological studies on paternal occupations and birth defects are reviewed, and the main limitations associated with these studies discussed. Epidemiological studies on paternal occupations and birth defects were reviewed for the period 1989 to 1999 inclusive. Systematic searches were made with search engines with related keywords.

There were several common paternal occupations that were repeatedly reported to be associated with birth defects. These paternal occupations were janitors, painters, printers, and occupations exposed to solvents; fire fighters or firemen; and occupations related to agriculture. The common weaknesses in most of these studies include inaccurate assessment of exposures,

Paternal occupation of fire fighter was identified by linkage between a cohort of Metropolitan Toronto fire fighters, and live born cardiac congenital anomalies were retrieved from the Canadian Congenital Anomalies Surveillance System.

Gestational exposure to perfluoroalkyl substances and congenital heart defects: A nested case-control pilot study

Yanqiu Ou^{a,1}, Xiaowen Zeng^{b,1}, Shao Lin^{c,*}, Michael S. Bloom^d, Fengzhen Han^e, Xiaohua Xiao^f, Hui Wang^e, Rosemary Matala^c, Xiaohong Li^g, Yanji Qu^a, Zhiqiang Nie^a, Guanghui Dong^{b,*}, Xiaoqing Liu^{a,*}

Conclusion: These exploratory findings suggested that gestational exposure to most PFAS, especially linear **PFOS, 6 m-PFOS, PFDA, and PFDaA, was associated with greater risks for septal and conotruncal defects.**



TAKING ACTION

U.S. Legislative advances

AMENDED IN ASSEMBLY MARCH 21, 2024
CALIFORNIA LEGISLATURE—2023–24 REGULAR SESSION

ASSEMBLY BILL

No. 2408

Introduced by Assembly Member Haney

February 12, 2024



(d) Commencing July 1, 2026, any person, including a manufacturer, shall not manufacture or knowingly sell, offer for sale, distribute for sale, or distribute for use in this state, and no person shall use in this state, firefighter personal protective equipment containing intentionally added PFAS chemicals.



HOUSE No. 4486

The Commonwealth of Massachusetts

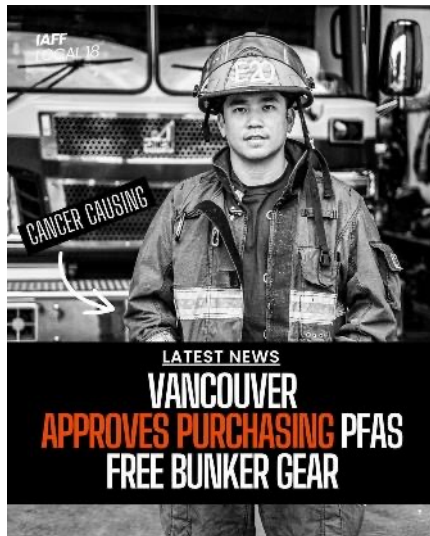
In the One Hundred and Ninety-Third General Court
(2023-2024)

An Act to protect Massachusetts public health from PFAS.

(b) (1) A manufacturer or other person that sells firefighting personal protective equipment containing PFAS to any person, local government or state agency shall provide written notice to the purchaser at the time of sale: (i) that the firefighting personal protective equipment contains PFAS; (ii) the reason PFAS are added to the equipment; and (iii) the specific PFAS within the product listed by chemical name and abbreviated name.



From Capitol Hill to the Court House



General President Edward Kelly thanks President Joe Biden for his remarks at the U.S. Legislative Conference in March.



- Currently **36 states are considering 450 PFAS-related bills.**

- **30 state A.G.'s** have initiated or are strongly considering filing suit against PFAS manufacturers.



WHAT IS THE FUTURE OF THE AMERICAN FIRE SERVICE ?



PFAS IS AN ATTACK ON THE GENERATIONAL FIRE FIGHTERS WHO ARE VITAL FOR RECRUITMENT & RETENTION



You hear a **lot** of stories
about fathers and sons, but
**there were never any
mother and daughters,
so it is really
something special.**

LISA MALLOY
RETIRED FIRE CAPTAIN
KANSAS CITY, MO LOCAL 42





THANK YOU!

ANY QUESTIONS ?



Neil McMillan

IAFF
nmcmillan@iaff.org



**NATIONAL
PFAS
CONFERENCE**

JUNE 9-12, 2024 • ANN ARBOR, MI

PFAS and Health

Alan Ducatman, MD, MS

Professor emeritus, West Virginia University

aducatman@hsc.wvu.edu

Moderator **Elizabeth Friedman, MD, MPH.** Children's Mercy Hospital, Kansas City, and Region 7 PEHSU

Co-coordinator, **Sherry Homan** Epidemiologist, Region 7 PEHSU



Declarations including COI

- ▶ Contributed to Design; Led Participant Health communications for “C8 Health Project” in contaminated water districts, WV and Ohio beginning 2005
- ▶ Participate as paid and unpaid consultant to communities seeking medical monitoring benefits following PFAS water contamination
- ▶ Assisting attorneys for State of North Carolina (affected by PFAS contamination from a chemical industry source)

Goals: Information for PFAS-Affected Communities



Aims:

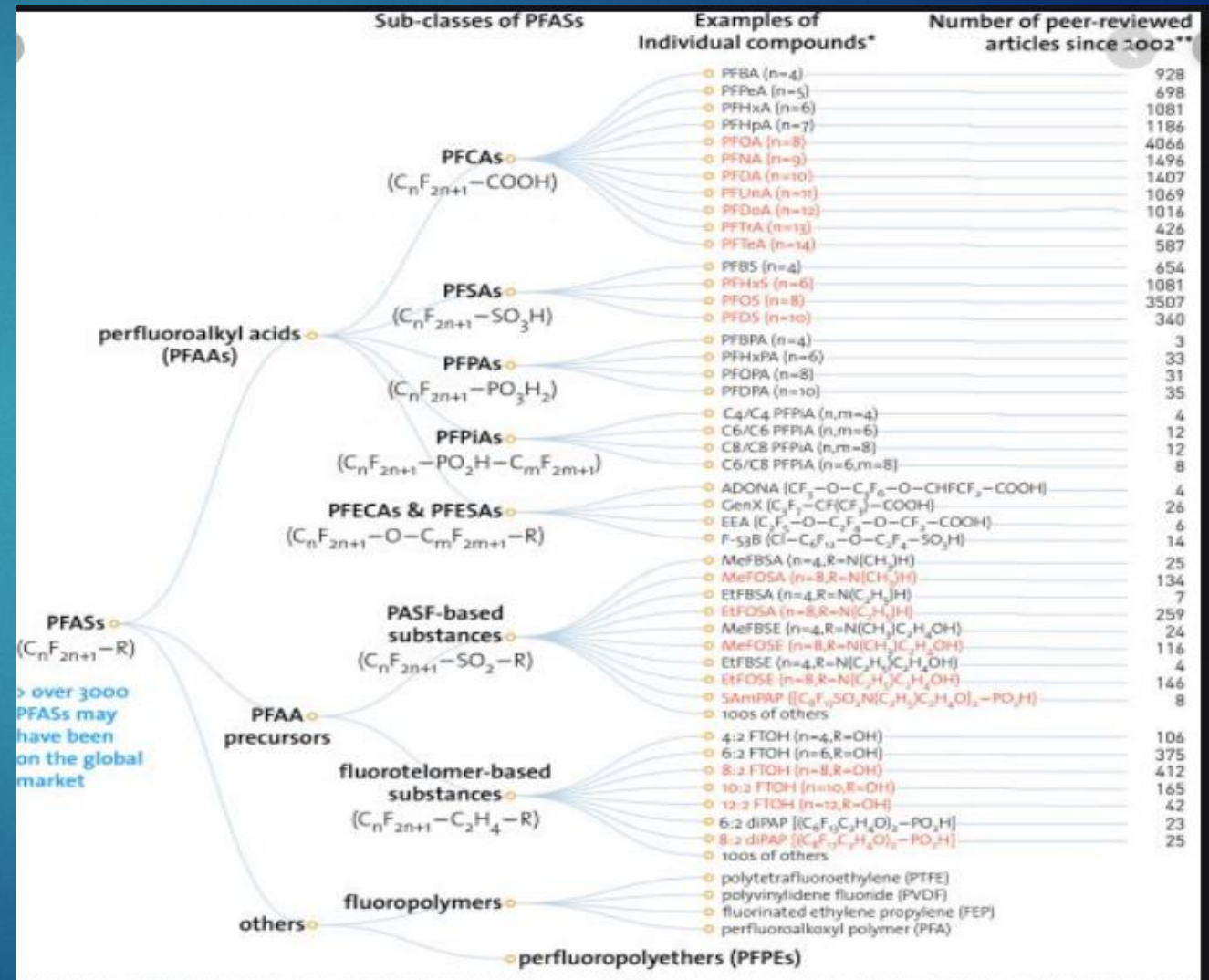
- ▶ Sources (another visual example)
- ▶ Health Communications
- ▶ Health Outcomes and Addressing Patient &/or Community Concerns



A Large Family Tree

Per- and polyfluoroalkyl substances (PFAS)

- ▶ Aliphatics with ≥ 1 fully fluorinated carbon
- ▶ Many have little health information, a few have a lot of health information
- ▶ Many not detected by current methods (except as total fluorine)
- ▶ We know the most about perfluoroalkyl acids (PFAAs) such as PFOA, PFOS, and PFNA



Array of Historic Sources, Uses

- ▶ **Surfactants/Dispersants**; Industrial manufacturing Aid in numerous commercial products
- ▶ Food packaging (including pet food, food preparation bags such as microwave popcorn, take-out, pizza box, frozen food container)
- ▶ Medical device (including coatings for stents)
- ▶ Home barrier insulation and specialty paints – future spray on roof applications proposed
- ▶ Specialty Paper coatings
- ▶ Treatments for Fabrics and Carpets, Outdoor wear and Leather
- ▶ Adhesives (including carpet backing)
- ▶ Ski wax, bike lube
- ▶ Electronics, solar panels, elastomeric coating for electrical cables
- ▶ Cleaners, treatments: gun cleaners, chain cleaners, engine coaters, auto detailing, piano tuning (2 uses)
- ▶ Hydraulic fracturing lubricant and tracer technology
- ▶ Chrome plating and photolithography
- ▶ **AFFFs** – most prevalent source in groundwater and drinking water, may contain a complex mixture, and each batch can vary to meet a standard (“MilSpec”)
- ▶ Shaving, cosmetics, flosses

Array of Historic Sources, Uses



A 50 minute presentation on uses and sources would still leave out many that are in all of our homes.



A review of leading journals such as Science and Nature consistently reveals new and exciting technologies, for which some per- and polyfluoroalkyl substance plays a role.

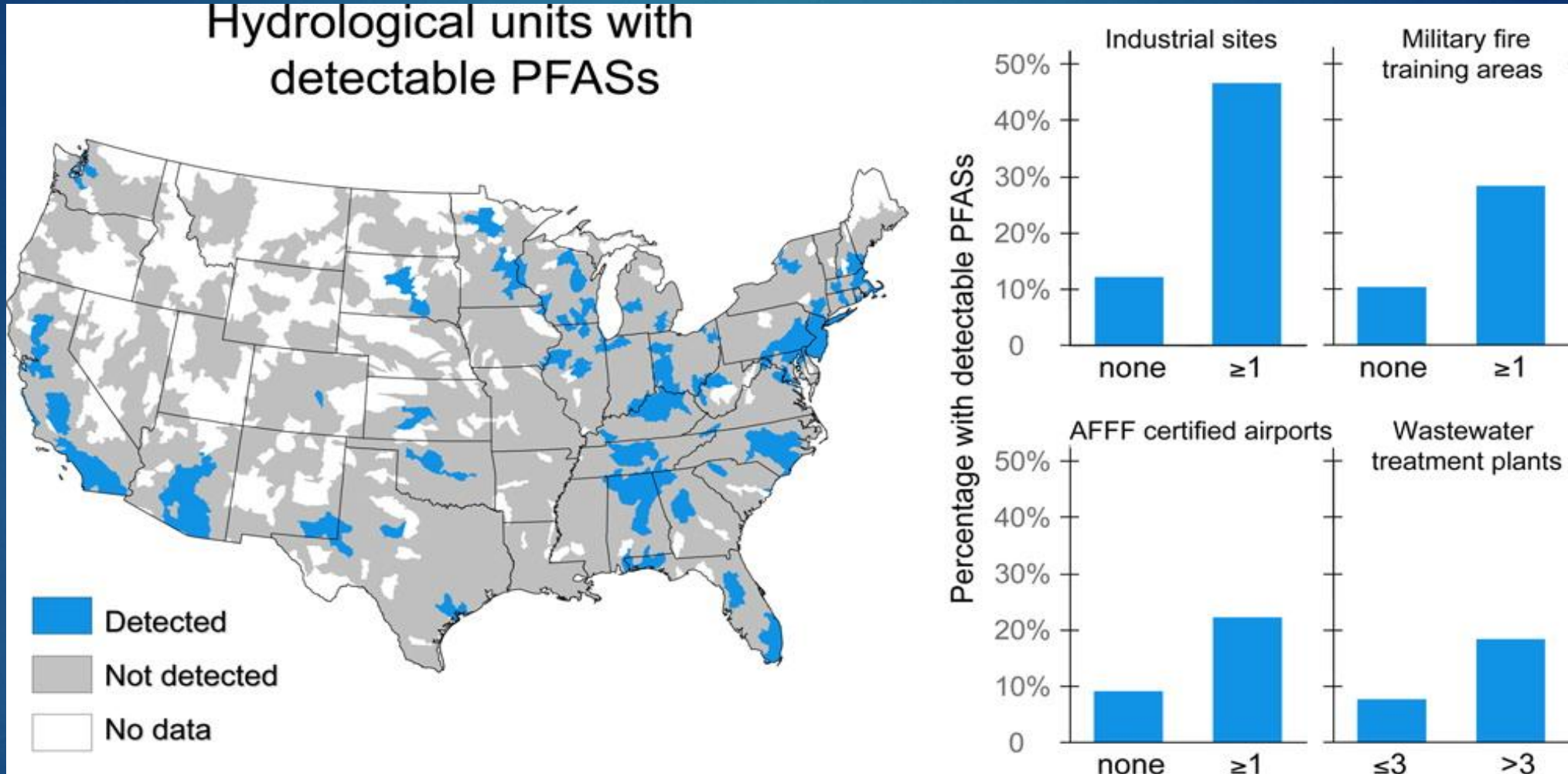


Useful to think of “essential uses” (important product, no substitute technology) vs “nonessential sources” which include both replaceable uses and thoughtless uses (EX: where does shaving cream go when we are done with it. Where is lipstick and lip balm applied)? Slippery slope of essential vs. products such as microchips depending on photolithography techniques.

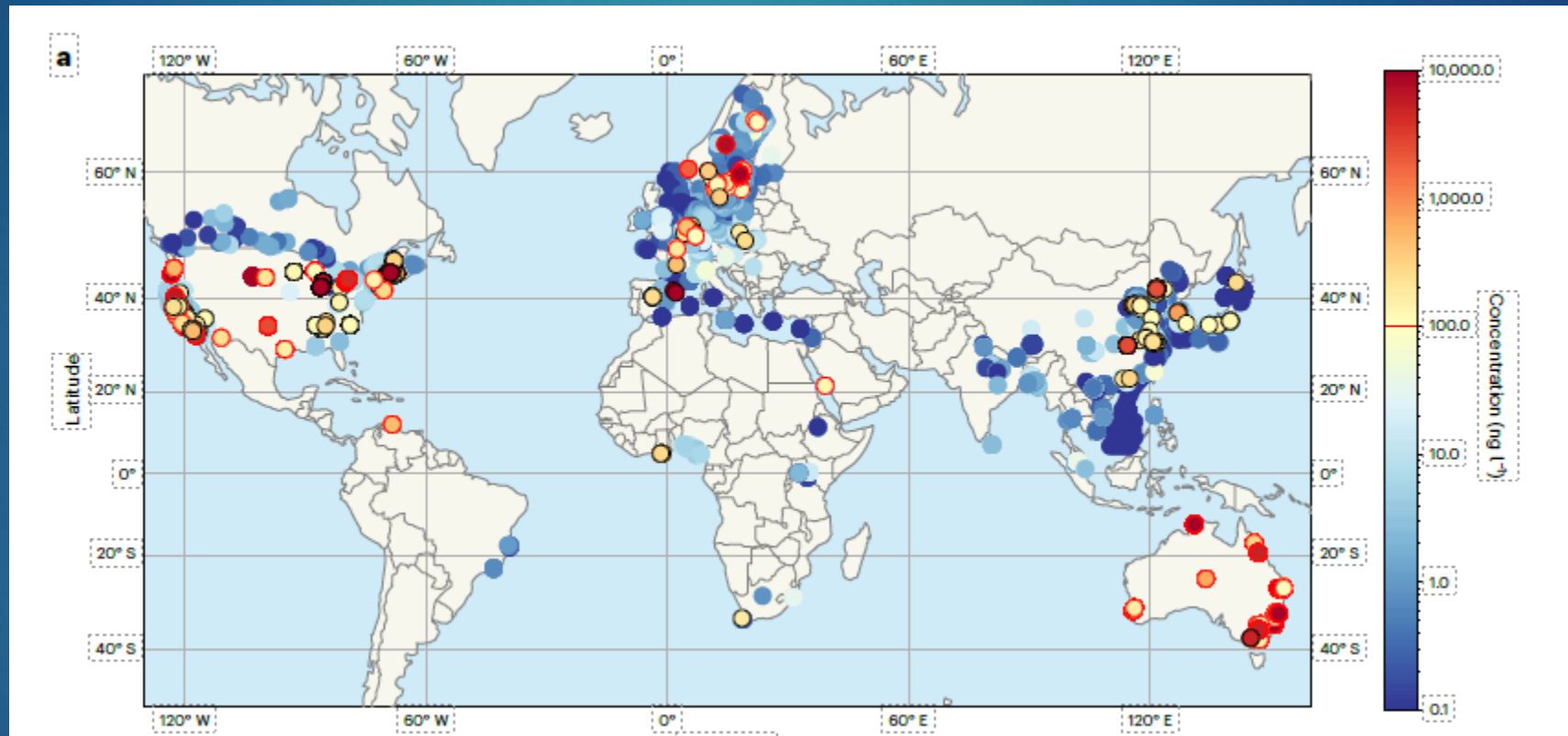


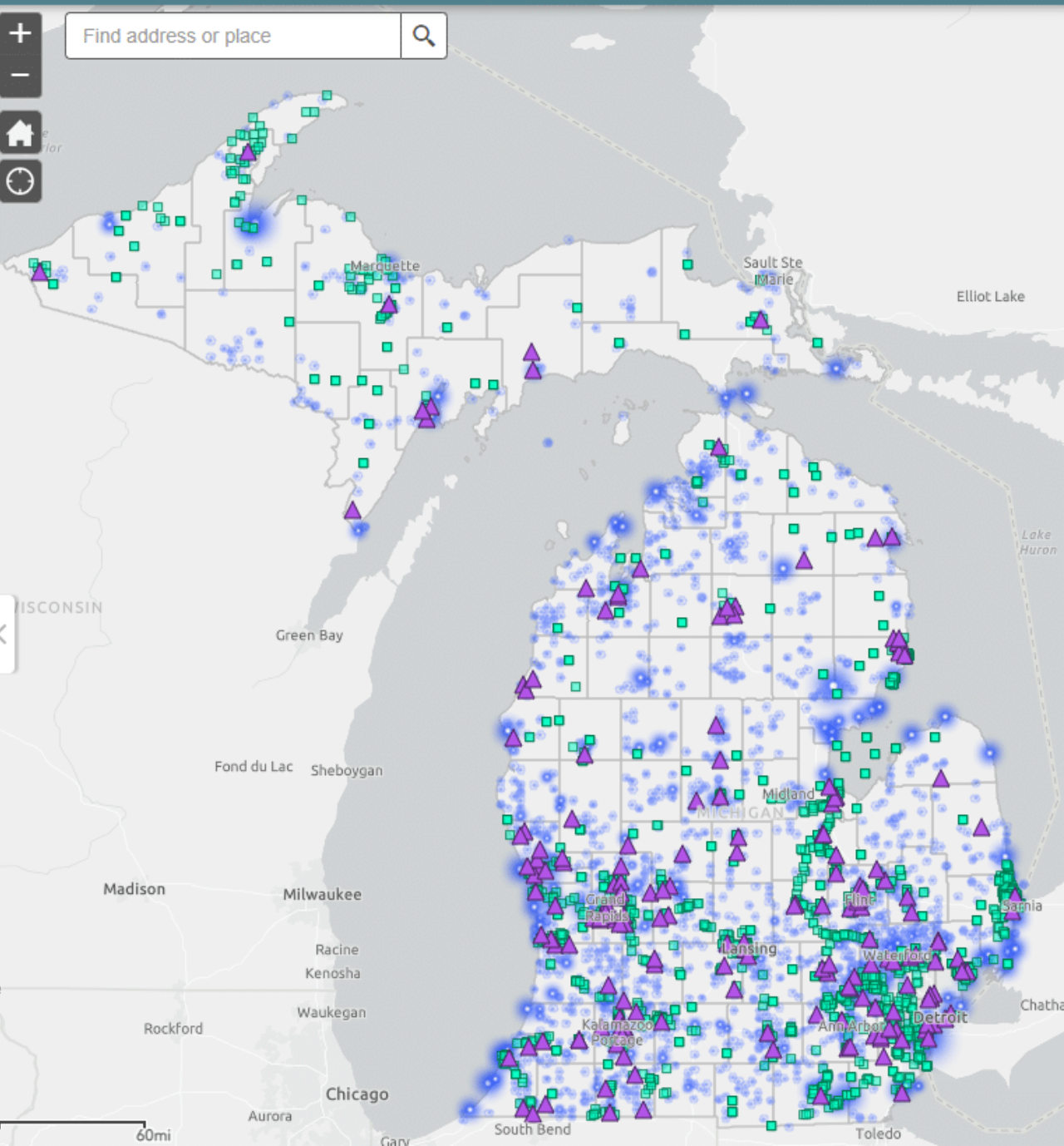
Migrate in air, through soil to water, in water, hard to filter, and “forever.”

> 6 Million Americans with Impacted Water 2016



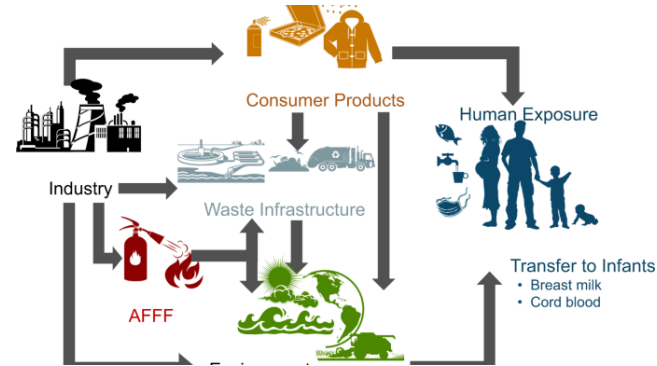
International





Michigan

- ▶ Task one – Measure
 - ▶ Michigan is a national leader
- ▶ Task 2 – Intervene as needed
- ▶ Federal regulations published last month
- ▶ Where do well-owners fit?



Many species affected (companion animal image from NC Health News, story by Greg Barnes, 2021)



Common Patient Concerns

Health Outcomes

- ▶ **Cancer**
- ▶ Human development
- ▶ Birth defects, developmental delays
- ▶ Transgenerational exposure, pregnancy timing or choosing to breastfeed or failing to breastfeed
- ▶ Infertility (reduced fecundity)
- ▶ Lipids, liver
- ▶ Stress (property value, maintenance of filtration equipment, guilt concerning children or family)

Primary & Secondary Prevention

- ▶ Our help for water sources and water filtration
 - ▶ Public health role: influence entities perceived as uncaring
- ▶ Breast Feeding and Pregnancy Timing - honest advice includes unknowns
- ▶ Decrease Health Risk, Screen for Outcomes (Community medical monitoring)
- ▶ Remove Internal Contamination
- ▶ Volunteer as Regular blood donor
- ▶ Take a bile acid sequestrant such as ¿cholestyramine?

Active approaches to enhanced excretion with clinical trial support

- ▶ Cholestyramine or similar bile acid sequestrants, especially for PFOS. Old fashioned modestly effective drug for lipids. Safe but unpleasant
- ▶ Regular phlebotomy. Results not as impressive, also works. Plasmapheresis works better
- ▶ Both work, and they are relatively safe, but there is no proof of net benefits.
- ▶ Image from Public Health England Abstract. Article by Ducatman et al in Environ Toxicol Pharmacol PMID 33819618

TABLE 3. Association between Cholestyramine use and PFAS levels

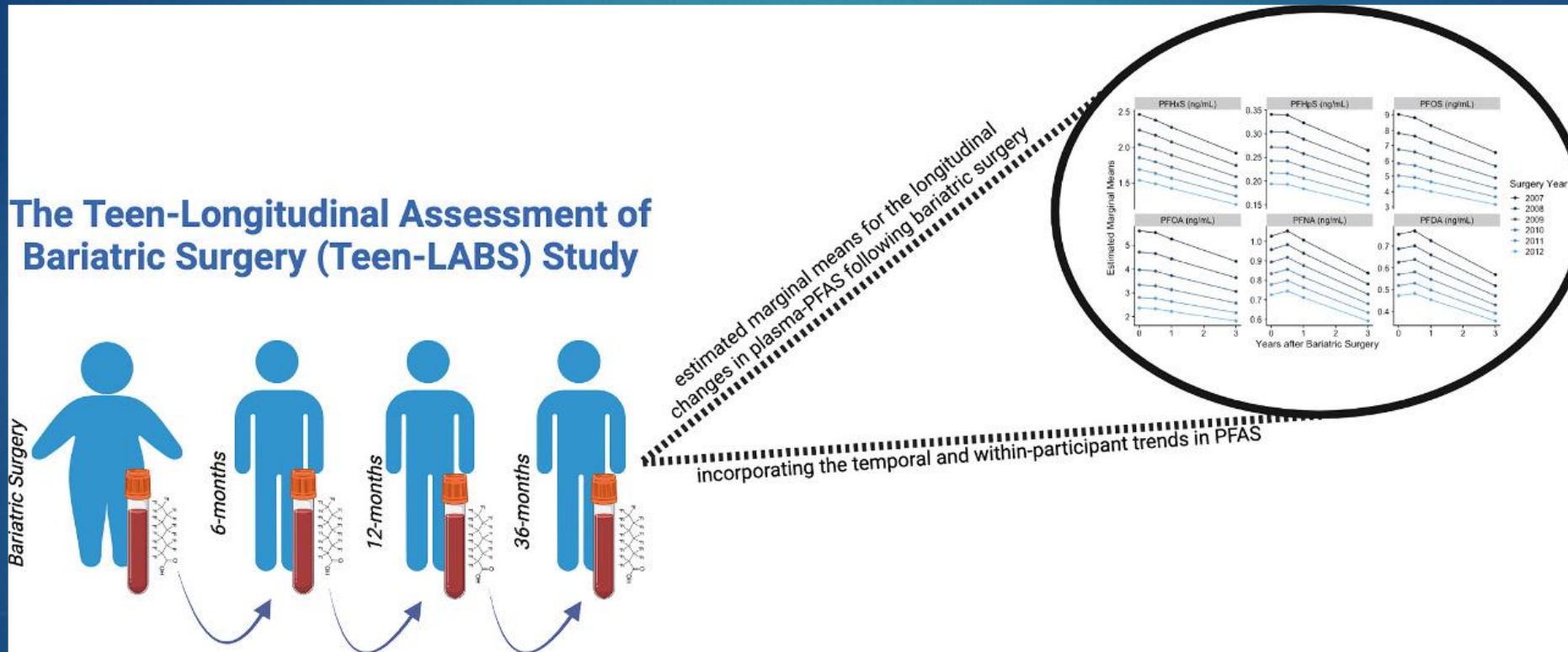
Cholestyramine	Sample size	Unadjusted geometric mean ratio (95% CI)	Multivariable adjusted* geometric mean ratio (95% CI)
PFHxS			
Non-users	56136	1 (referent)	1 (referent)
Users	36	0.38 (0.29-0.49)	0.43 (0.33-0.56)
p-value		0.00	0.00
PFOA			
Non-users	56136	1 (referent)	1 (referent)
Users	36	0.723 (0.48-1.09)	0.55 (0.41-0.74)
p-value		0.12	0.00
PFOS			
Non-users	56136	1 (referent)	1 (referent)
Users	36	0.07 (0.05-0.08)	0.07 (0.05-0.08)
p-value		0.00	0.00
PFNA			
Non-users	56136	1 (referent)	1 (referent)
Users	36	0.38 (0.32-0.44)	0.39 (0.33-0.46)
p-value		0.00	0.00

* Adjusted for age, gender, body mass index, water district, and estimated glomerular filtration rate.

Bariatric surgery (serum PFAS was not the indication)

From Baumert BO, et al (ISC group) in STOTEN

<https://doi.org/10.1016/j.scitotenv.2024.172840>



Reproductive Age Women Have Lower PFAS

- ▶ Menstruation
- ▶ Transplacental
- ▶ Breast Feeding

Image from Zheng et al.

<https://doi.org/10.1016/j.scitotenv.2021.152446>





C8 Science Panel 2005-13
(PFOA-contaminated water,
N=69,030, and literature review)

There are now > 2000 peer review papers concerning this chemical class, human exposures, and health effects

▶ “Probable Link” Findings

- **Hypercholesterolemia¹**
- Thyroid Disease²
- Ulcerative Colitis²
- **Testicular Cancer¹**
- Kidney Cancer¹
- Pregnancy-induced Hypertension

1. Substantially Increased Evidence since 2015

2. Nuances since 2015

Examples of Outcomes other than probable links that have become clearer since the Science Panel Deliberated

Liver Disease

Hyperuricemia

California Basis for PFAS Health Goals

	PFOA	PFOS
Health Effects in Humans	<ul style="list-style-type: none">• Kidney cancer• Liver toxicity• Immune system toxicity• Increases in cholesterol• Suggestive evidence of preeclampsia	<ul style="list-style-type: none">• Increases in cholesterol• Immune system toxicity• Suggestive evidence of preeclampsia
Health Effects in Animals	<ul style="list-style-type: none">• Liver, pancreatic, and testicular cancer• Liver toxicity• Immune system toxicity• Thyroid toxicity• Developmental and reproductive toxicity	<ul style="list-style-type: none">• Liver and pancreatic cancer• Liver toxicity• Immune system toxicity• Thyroid toxicity• Developmental and reproductive toxicity



PFAS health outcomes evidence taxonomy

Substantial (“Sufficient*”)

Multiple Populations and different study designs

Findings pertain to populations with a wide range of exposure (less focus on all high or all low)

Dose response

Unifying Experimental evidence such as histopathology and plausible pathways

Moderate (“Limited*”)

Population Evidence but in fewer populations

Experimental: Mechanistic or histologic data less rich

*** Clinicians less commonly use the scientific designations of federal agencies such as “Limited.”**
Clinicians may mis understand “Limited” to mean a negative statement about evidence.

At or above (“Limited*”)

Population evidence only.

Few studies

More Conflicting outcomes

Less Indication of Mechanisms or Parallel findings in experimental settings.

PFAS Outcome Examples – my View

Strong Evidence

Immunotoxicity, ↓ vaccine uptake

Lipids /Sterol interference, Associated Codeable conditions and longitudinal diagnoses and medications

Kidney cancer

Liver Functions and liver toxicity

Thyroid Alterations/Binding proteins

Uric Acid - Hyperuricemia/Gout

Substantial Evidence

Breast Feeding, diminished capability

Fecundity/Fertility male

Insulin Resistance/Diabetes

Kidney Disease

Osteoporosis

Preeclampsia/PIH

Testicular Cancer

Ulcerative colitis

Birthweight

Some or conflicting evidence

Asthma, Allergy

Cardiovascular/BP

Childhood adiposity

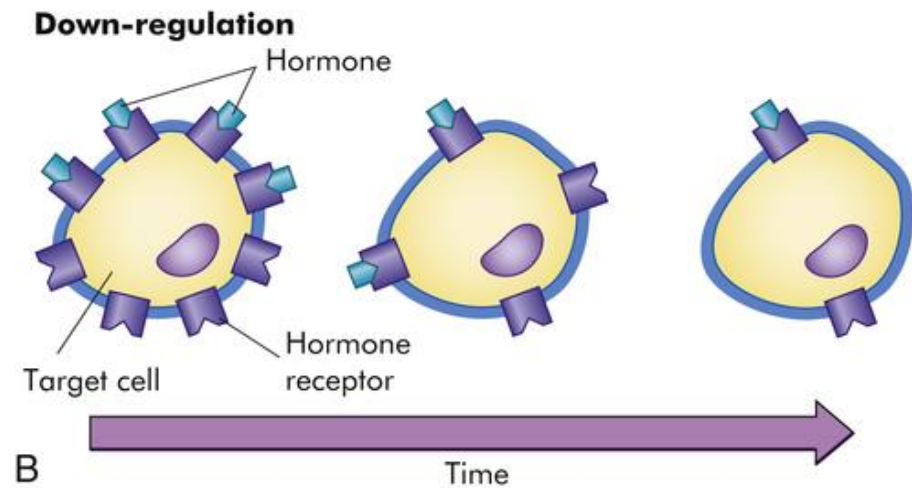
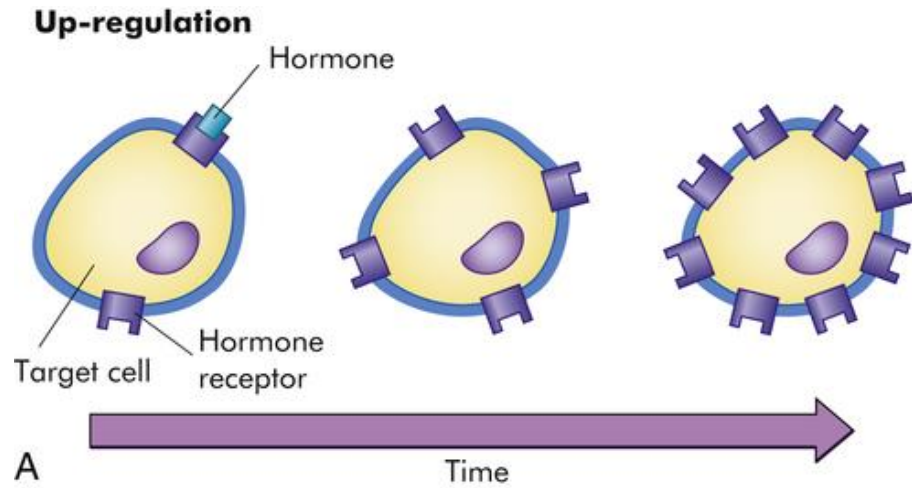
Fecundity/Fertility

Liver cancer & Breast cancer

Infections, notably in early childhood

Thyroid disease- autoimmune

Developmental: Intrauterine Growth Retardation (IUGR/SGA), Preterm birth



Why:

Signaling, our bodies “think” these are messages to “up- or down-regulate” cell function.

Membrane effects and reactive oxygen species

Health communications and (inadvertent) obfuscation

Science Terms Serve the Comfort level of Scientists

Sufficient evidence

Moderate evidence or limited evidence (a very wide range in practice)

Other such as some evidence, conflicting

Major misunderstandings around some of these terms, especially “limited evidence.”

Clinicians communicating with patients or communities should try to avoid terms which can be mistranslated to be dismissive

More useful terms are

Near certain

Substantial

More Likely than not

Unsure, uncertain

Epidemiology invariably has some conflicting evidence, there are guidelines for interpretation

I would like to think one of our papers influenced this topic at the agency level... ..

COMMENTARY: Official health communications are failing PFAS-contaminated communities. Alan Ducatman, Jonas LaPier, Rebecca Fuoco, and Jamie C. DeWitt <https://doi.org/10.1186/s12940-022-00857-9>

Example of historical, problematic PFAS Health Communications



“Scientists are still studying the health effects of exposure to PFAS. Although more research is needed, some studies in people have shown that certain PFAS may affect health.”

and

“PFAS have not been proven to cause any specific illnesses in humans. ...To date there is not enough information available to definitively say what, if any, health effects may be caused by exposure to PFAS.”

PFAS Health Communications Improving

- ▶ There is still a tendency to dismiss hard evidence, but it is much better than it was
- ▶ Regulatory and research agencies are understaffed for many roles, including PFAS. Formal external reviews can help. In addition, external vigilance and feedback concerning messages and actions is part of the process.



Based on the outcomes, some communities in US have received Medical Monitoring benefits



This process is dependent on many factors, and some of the barriers are outside of the realm of science or medicine. Clean water is primary prevention. Medical monitoring is secondary or tertiary prevention.

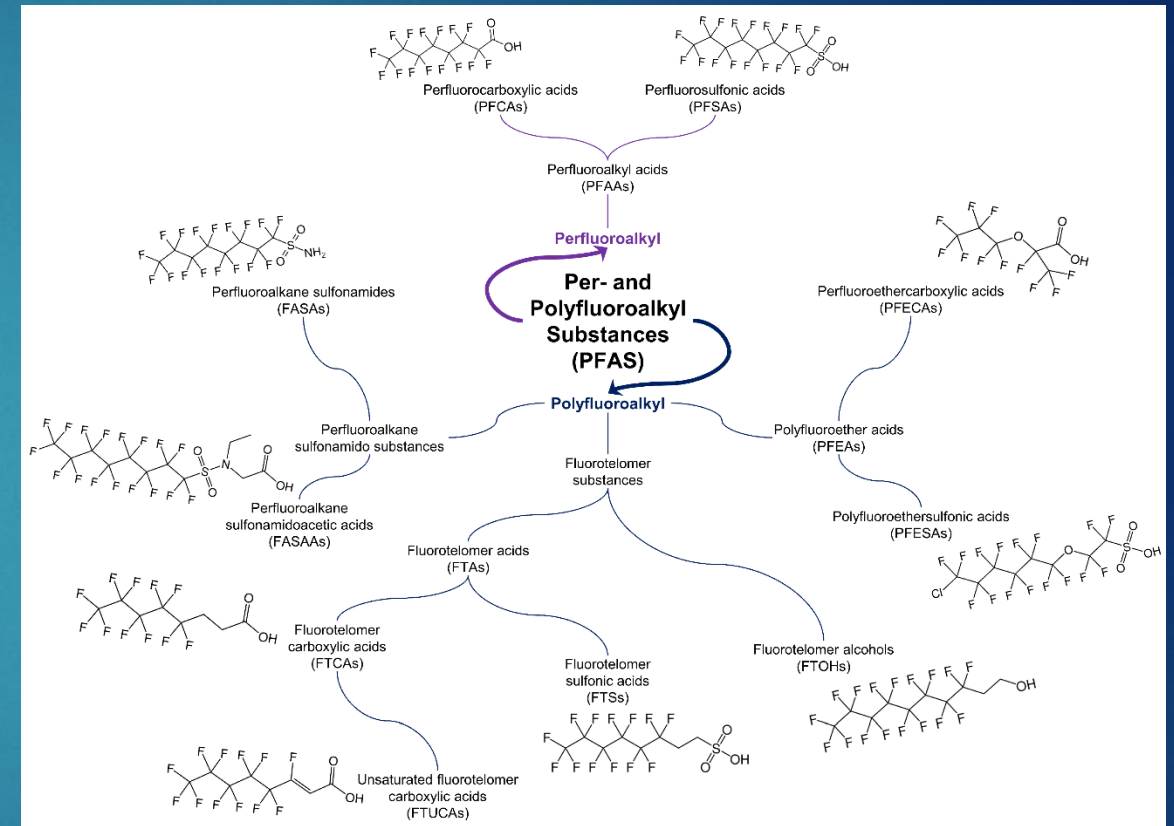
- ▶ An Example: Michigan Supreme Court 2005. The outcome boils down to something like this: One must be harmed before one can seek redress from risk. (The goal of medical monitoring is early detection and prevention mitigation.)
- ▶ In contrast, Adjacent communities in Vermont and New York, and an eligible group in Ohio/WV are eligible to receive ongoing medical monitoring ingoing programs.

Health Effects Knowledge mostly Limited to “Legacy” Compounds (hundreds in use)

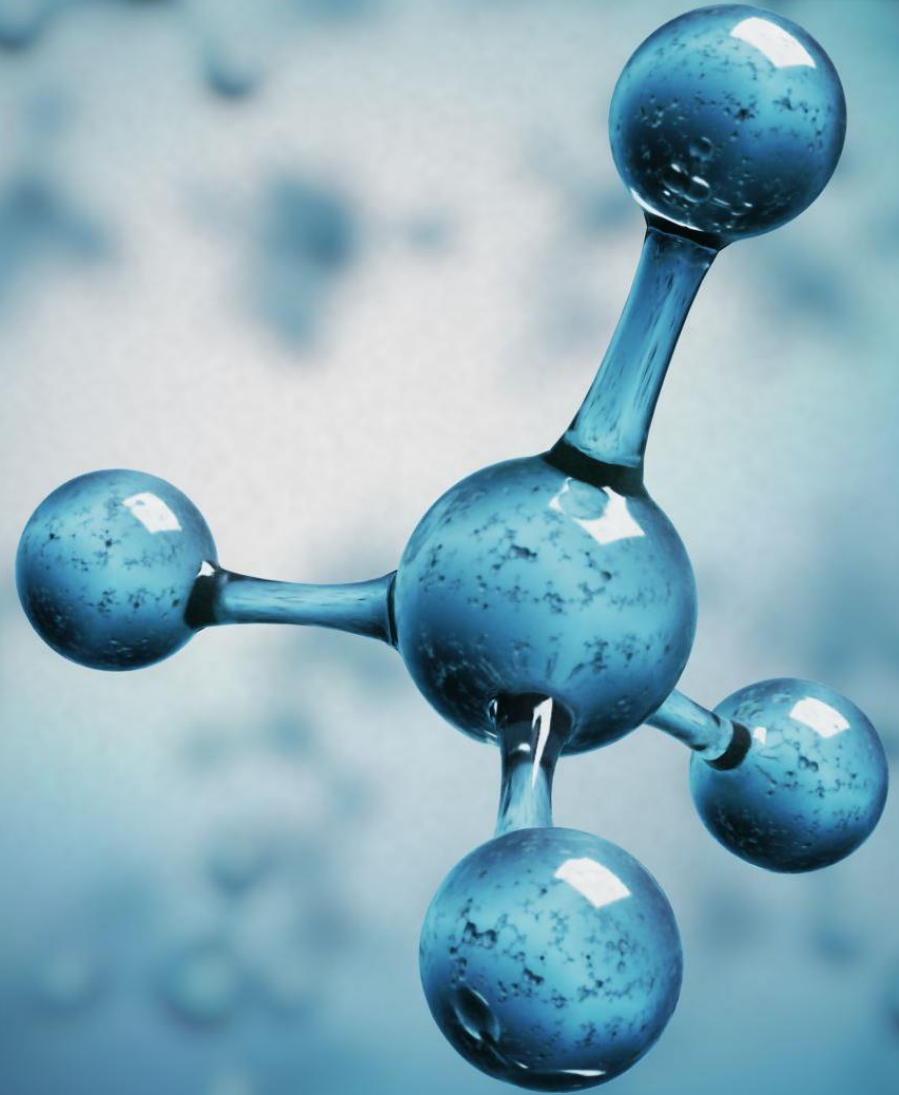
“Replacement compounds”

- ▶ Tend to have shorter half-lives
- ▶ Therefore, a “hope” is lower toxicity.
- ▶ Also, harder to study in humans
- ▶ Trade secrets, expensive “off-target” analysis
- ▶ Toxicology studies mostly not encouraging
- ▶ Even faster moving in water and harder to filter

Graphic: Brase RA et al. *Int. J. Mol. Sci.* 2021, 22(3), 995; <https://doi.org/10.3390/ijms22030995>

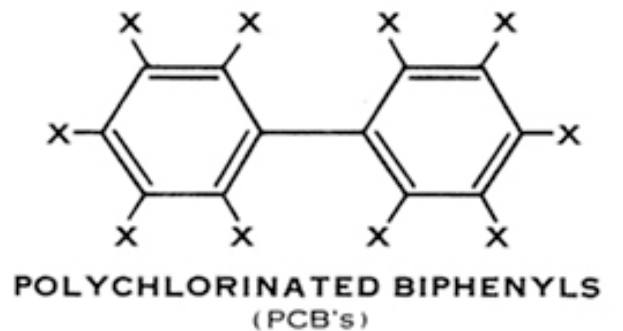


We still do not know much about so many of the replacement compounds. In studies to date, the physiology is not necessarily different (but internal doses may be different).



Perspective – somehow given the choice between exposure to “legacy” PFAS and.....

- ▶ Industry responses to health knowledge concerning legacy compounds
- ▶ Substitutions – We have information about 4-6 PFAS. Many (not all) of the substitutes are still PFAS
- ▶ It is hoped but uncertain that these are not “regrettable”
- ▶ Trade secrecy so its harder to find what is there
- ▶ Public research limited to End Products, and not including process contaminants
- ▶ Redefinitions of PFAS



PFAS “legacy,” “replacement,” & thoughts for the future

- ▶ The replacements tend to have shorter half-lives, and the toxicology varies with the specific compound (and can be discouraging to read).
- ▶ Replacement compounds tend to migrate even more than the legacy compounds and are most often even harder (and more expensive) to filter . They are sprinters, and can spread in rain
- ▶ We hope they are safer. Hope is a weak approach to public policy for something this expensive.



Health Communication Challenges - the 'Stockholm Syndrome' decision makers caught in the middle

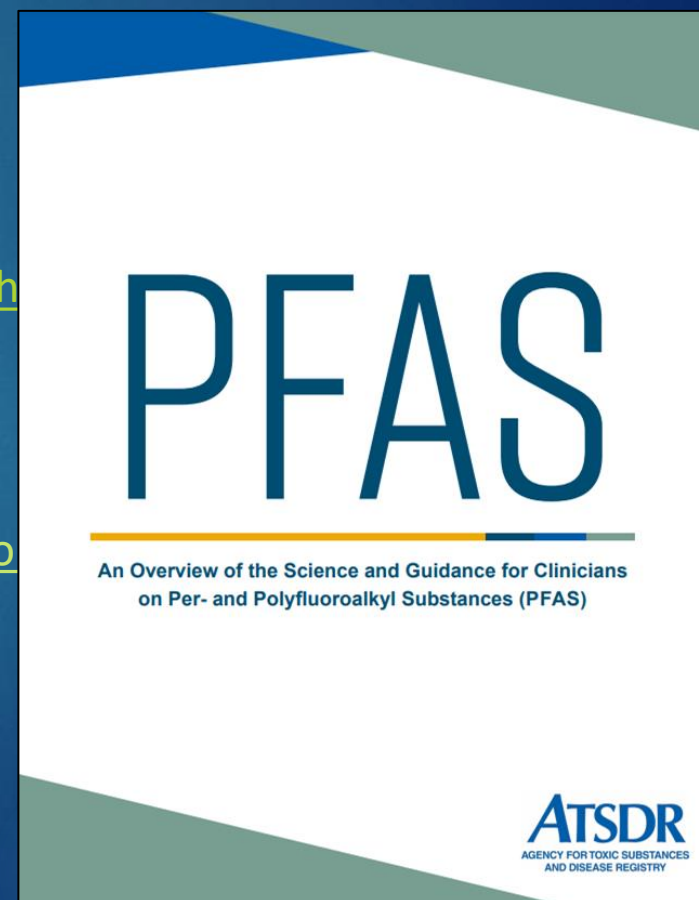


Water utility managers and others (i.e. state agencies) can be “caught in the middle”

- Worried about another large task
- Have (In)sufficient funds to do the tasks
- Water managers typically not trained in Chronic Disease Epidemiology and in Toxicology
- Recognize that acknowledging the problem implies costs that will be passed to their budgets/ consumers/ taxpayers

CLINICAL SCREENING & MEDICAL MONITORING (Recommendations)

- ▶ **NASEM (National Academies of Sciences, Engineering & Medicine)**
 - ▶ <https://nap.nationalacademies.org/resource/26156/interactive>
- ▶ **ATSDR (Agency for Toxic Substances and Disease Registry)**
 - ▶ <https://www.atsdr.cdc.gov/pfas/resources/pfas-information-for-clinicians.h>
- ▶ **PFAS-REACH (Research, Education and Action for Community Health)**
 - ▶ <https://www.pfas-exchange.org/resources/>
- ▶ **C8 Study**
 - ▶ http://www.c-8medicalmonitoringprogram.com/docs/med_panel_educatio



MOST RECENT SCREENING GUIDANCE

NASEM

Lipids

Thyroid

Breast Cancer

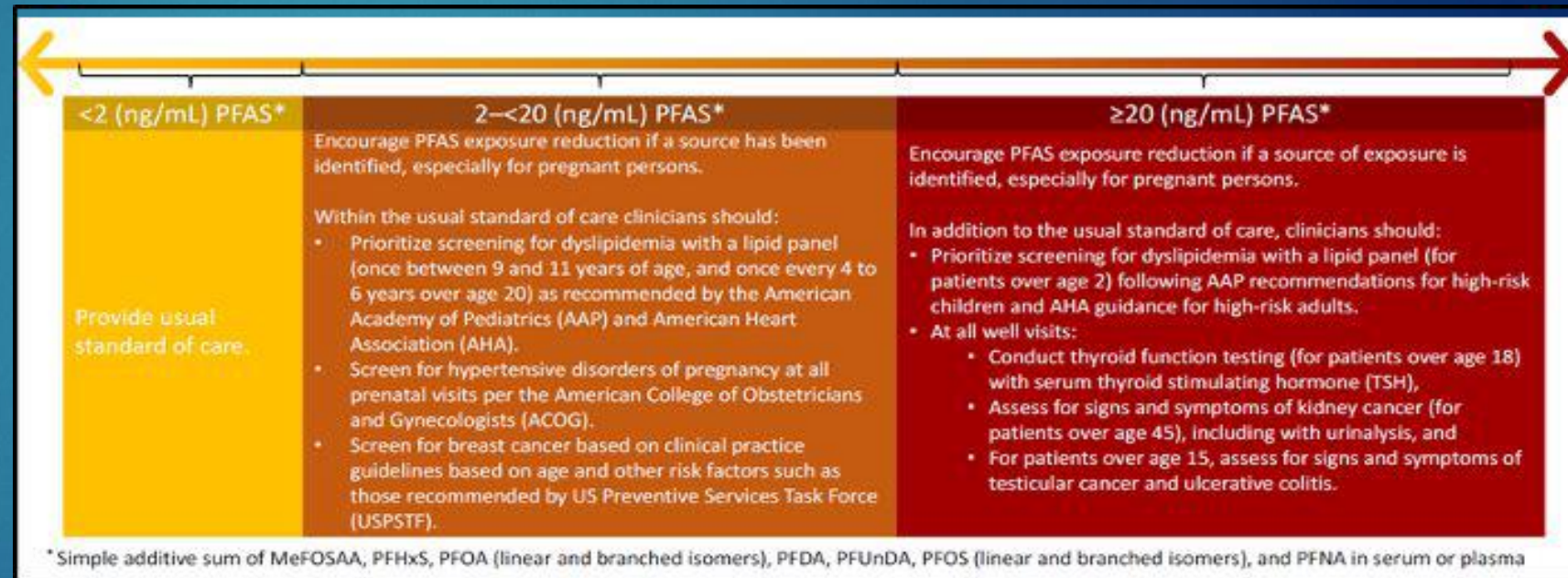
Kidney Cancer

Testicular Cancer

Ulcerative colitis

Pregnancy associated HTN

(+) Counsel on breastfeeding and other topics



NASEM. 2022. "Guidance on PFAS Exposure, Testing, and Clinical Follow-Up"



<2 (ng/mL) PFAS*

Provide usual
standard of care.

2–<20 (ng/mL) PFAS*

Encourage PFAS exposure reduction if a source has been identified, especially for pregnant persons.

Within the usual standard of care clinicians should:

- Prioritize screening for dyslipidemia with a lipid panel (once between 9 and 11 years of age, and once every 4 to 6 years over age 20) as recommended by the American Academy of Pediatrics (AAP) and American Heart Association (AHA).
- Screen for hypertensive disorders of pregnancy at all prenatal visits per the American College of Obstetricians and Gynecologists (ACOG).
- Screen for breast cancer based on clinical practice guidelines based on age and other risk factors such as those recommended by US Preventive Services Task Force (USPSTF).

≥20 (ng/mL) PFAS*

Encourage PFAS exposure reduction if a source of exposure is identified, especially for pregnant persons.

In addition to the usual standard of care, clinicians should:

- Prioritize screening for dyslipidemia with a lipid panel (for patients over age 2) following AAP recommendations for high-risk children and AHA guidance for high-risk adults.
- At all well visits:
 - Conduct thyroid function testing (for patients over age 18) with serum thyroid stimulating hormone (TSH),
 - Assess for signs and symptoms of kidney cancer (for patients over age 45), including with urinalysis, and
 - For patients over age 15, assess for signs and symptoms of testicular cancer and ulcerative colitis.

* Simple additive sum of MeFOSAA, PFHxS, PFOA (linear and branched isomers), PFDA, PFUnDA, PFOS (linear and branched isomers), and PFNA in serum or plasma

ATSDR Recommendations (WHAT YEAR WERE THE NEWEST FLUFFFY RECS?)

INSERT NEWEST ATSDR RECOMMENDATIONS

PFAS REACH

Lipids

Thyroid

Uric acid

Testicular Cancer

Liver function studies

Pregnancy associated HTN

Kidney disease (creatinine)

Kidney Cancer (urine albumin/creatinine)

(+) Counsel on breastfeeding and vaccine response



PFAS Exposure: Information for patients and guidance for clinicians to inform patient and clinician decision making

For clinicians

About this guidance document

The guidance summarized here is to help inform discussion and decision making for physicians and their patients. Many of the tests and screenings noted are part of basic primary care annual appointments. In 2019, the American Medical Association (AMA) resolved to support research and policy to address the effects of PFAS exposure.

We based the following suggestions for medical screening tests on those previously developed and implemented for a PFAS-impacted community as well as peer-reviewed research and scientific assessments using weight of evidence approaches from:

- Agency for Toxic Substances and Disease Registry (2021)
- Centers for Disease Control and Prevention (2019)
- CB Science and Medical Panels (2005-2013)
- European Environment Agency (2019)
- International Agency for Research on Cancer (2017)
- National Toxicology Program (2016)

These recommendations are for those living in communities with contaminated water or who are exposed to other sources of PFAS that substantially increases their internal burden of PFAS. These recommendations are not targeted to those with average levels of PFAS exposure.

Guidance for adult patients

Laboratory tests

- **Lipid panel (cholesterol, LDL, HDL, triglycerides).** PFAS exposure has been associated with higher total and LDL cholesterol and fatty liver.
- **Liver function tests,** such as ALT, AST, and GGT. PFAS exposure has been associated with higher-than-normal liver function tests, as well as hepatotoxicity, including hepatocyte and liver architecture damage.
- **Serum creatinine and urine protein and urine albumin.** PFAS exposure is associated with chronic kidney disease and kidney cancer. An important note for researchers is that there is enhanced excretion of PFAS in moderate-to-severe kidney disease, especially if there is albuminuria. Reduced serum PFAS concentrations for those individuals introduces a bias towards the null if not controlled for in epidemiologic studies.
- **Thyroid tests,** such as TSH with or without FT4. PFAS exposure has been associated with thyroid disease.

Clinical examinations

- **Regular testicular examinations.** Exposure to high levels of PFAS has been associated with increased risk of testicular cancer.

Counseling topics

- **Vaccine response.** There is currently no consensus on revaccinating patients with low vaccine titer when tested a month following vaccination (i.e., Tdap, MMR); more research is needed.
- **Home blood pressure monitoring during pregnancy.** PFAS are associated with elevated blood pressure during pregnancy and with preeclampsia.
- **Breastfeeding.** Babies can be exposed to PFAS during pregnancy since PFAS can cross the placenta. PFAS chemicals also accumulate in breast milk. However, the benefits of breastfeeding are clear, and include benefits to maternal as well as child health. There is insufficient evidence to recommend against breastfeeding based on maternal PFAS exposure.

How do the expert
recommendations compare?
I cannot find the table that compares
the different sets of
recommendations

EXPOSURE PREVENTION FOR INDIVIDUALS

How can I avoid PFAS exposure?

PFAS exposures are widespread, so it is difficult to avoid PFAS entirely. However, you can take steps to reduce your personal exposure going forward:

- If you know or suspect PFAS to be in your drinking water, you can use a filter to lower the levels. Visit the PFAS Exchange's [drinking water fact sheet](#) to learn more about where to find a lab to test your water for PFAS, and resources to find filters for removing PFOA and PFOS in your drinking water.
- Avoid stain-resistant carpets, treatments, and waterproofing sprays. Green Science Policy Institute's [PFAS Central](#) maintains a current list of PFAS-free products.
- Avoid take-out containers and other food packaging that may contain PFAS by eating more fresh foods and home-cooked meals.

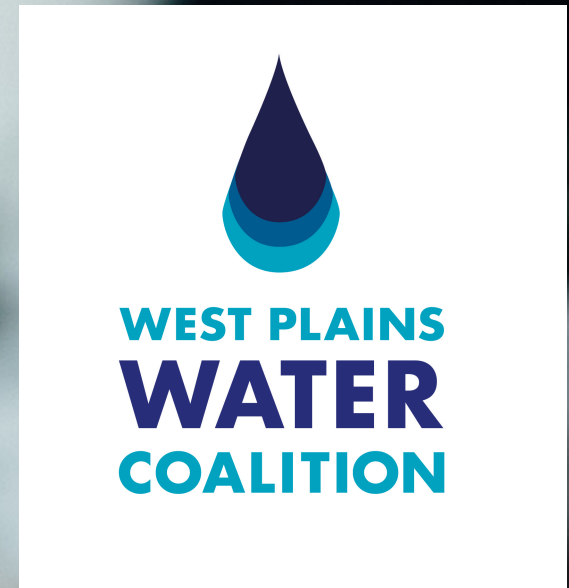
For more suggestions, visit the PFAS Exchange's [exposure reduction tips](#) and download Silent Spring Institute's [Detox Me smartphone app](#).

POLICY, REGIONAL & FEDERAL INVOLVEMENT

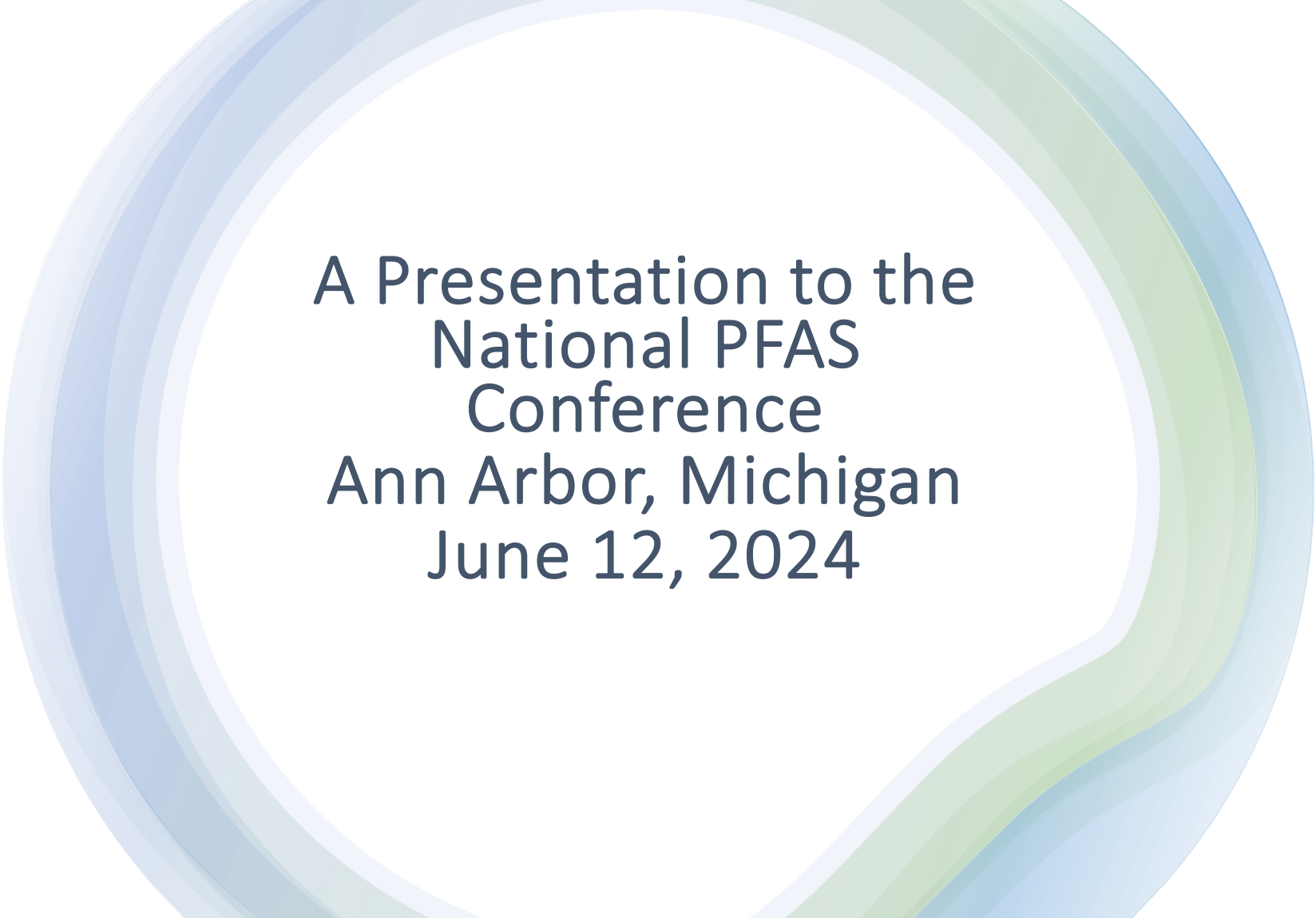
- EPA – recommendations
- States and local – varies
- ATSDR – research and health guidances
- NASEM – recent recommendations



Mapping Neighborhood PFAS



Neighbors Working
Together
To Solve Our Water
Crisis



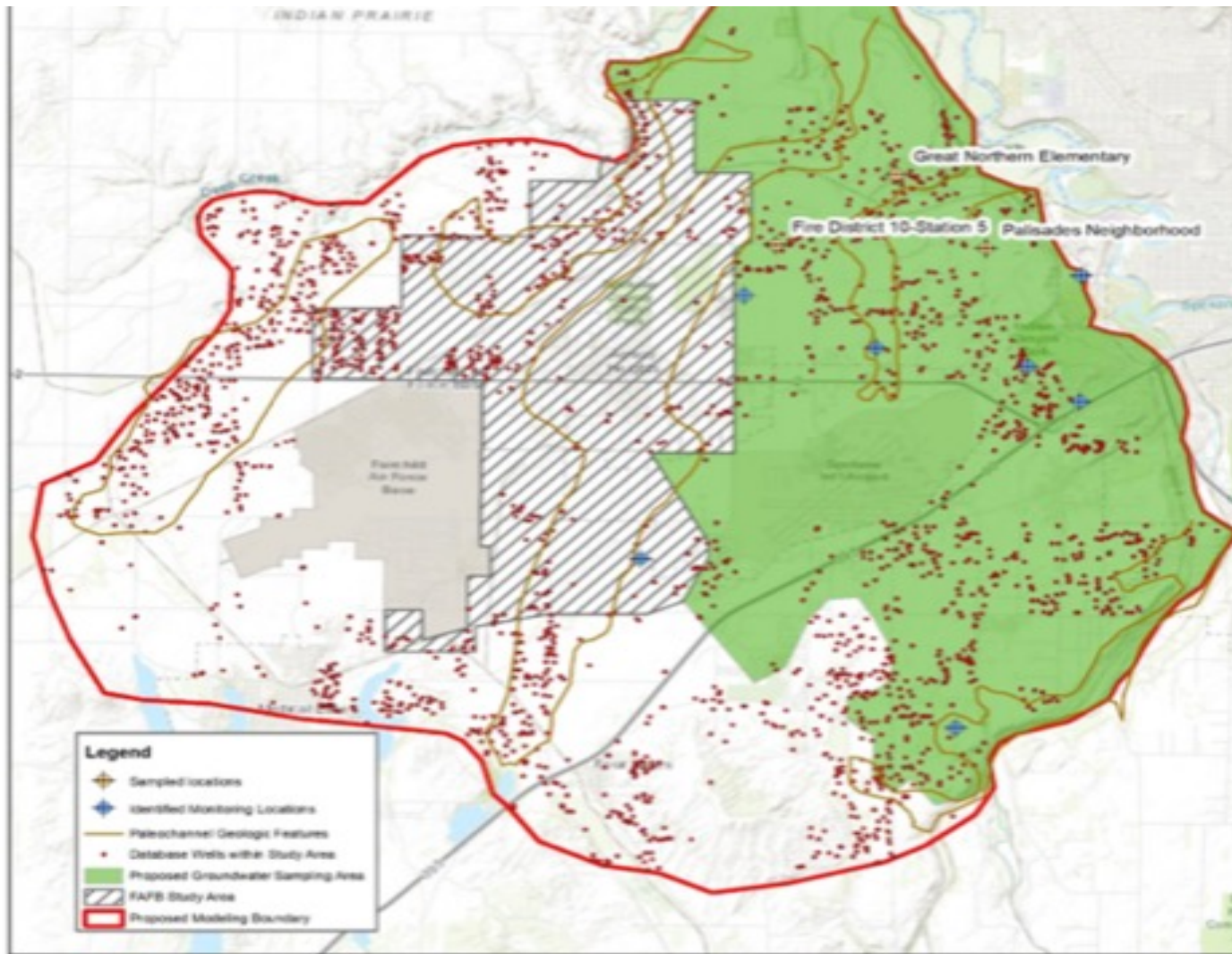
A Presentation to the
National PFAS
Conference
Ann Arbor, Michigan
June 12, 2024

John Hancock

Founder and President
West Plains Water Coalition
Spokane Washington

Hancock@westplainswater.org



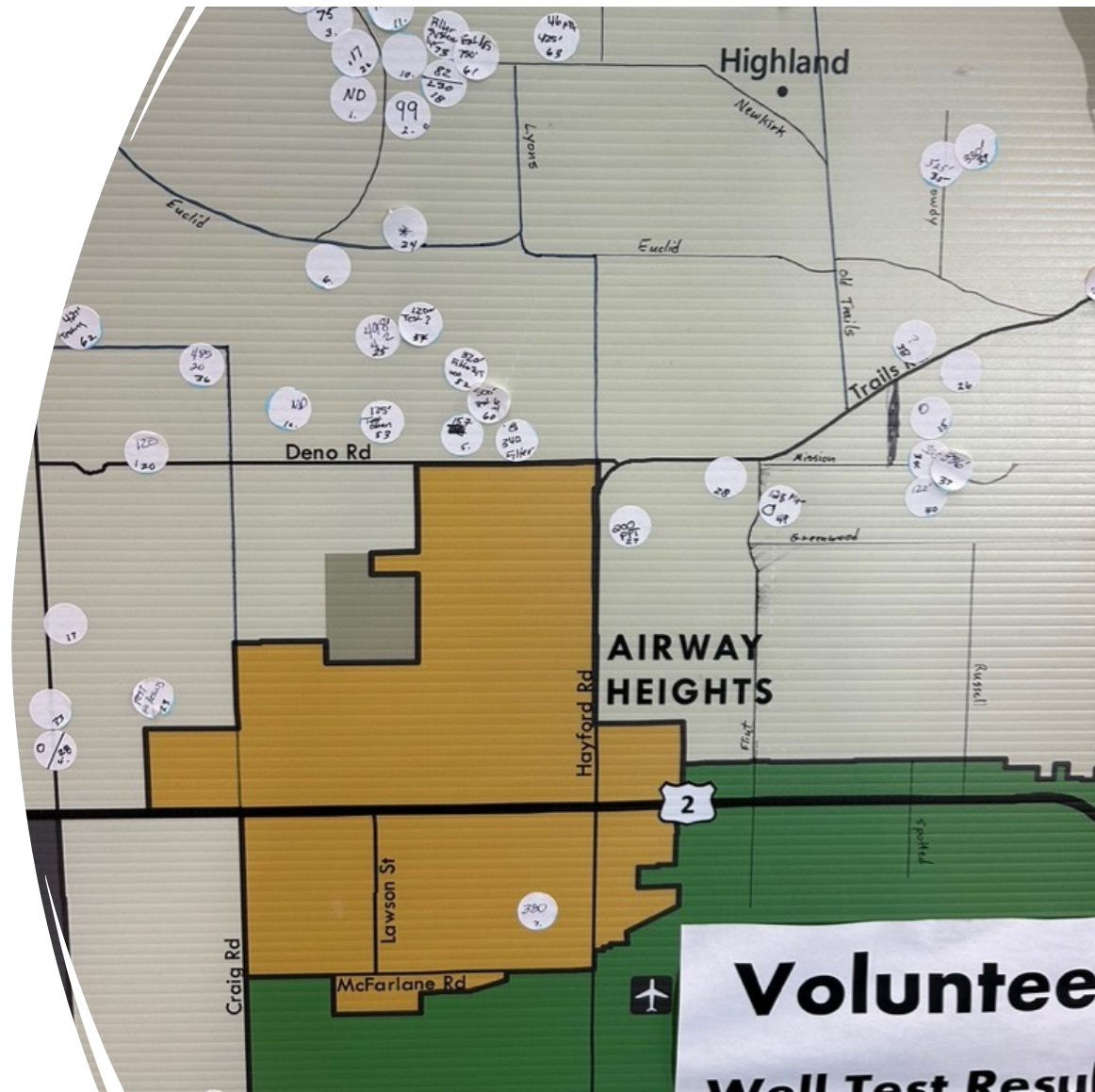


Source:
Pritchard
Et al

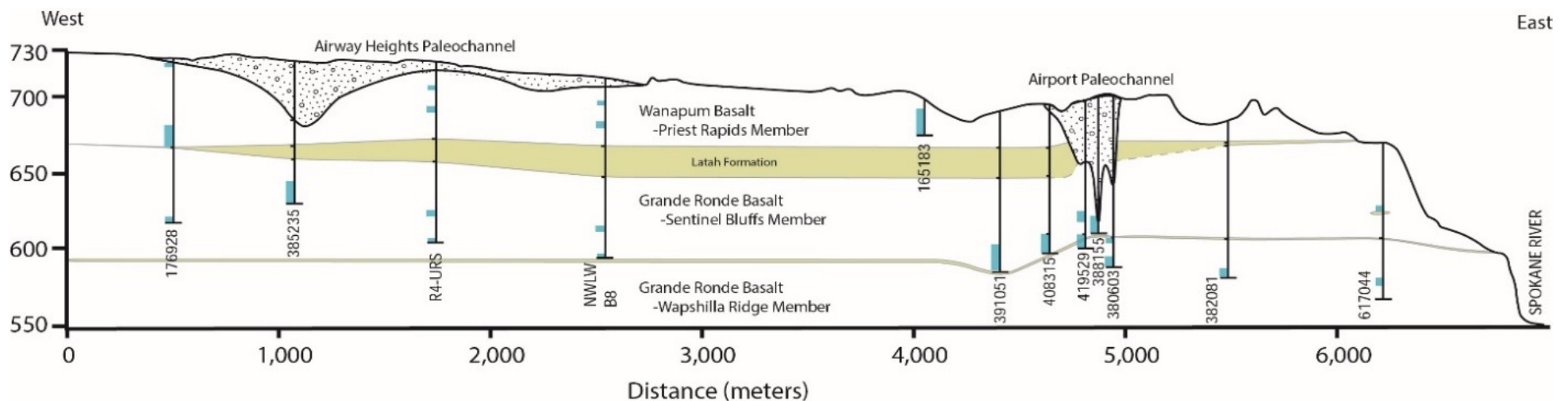
Figure 1: Map of the West Plains of eastern Washington. Fairchild Air Force Base (FAFB) is a site of documented AFFF use with BEAS levels of over 5,000 ppb. The study site of FAFB BEAS delineation is outlined in a dashed blue line. The Great Northern

Coalition's Startup Mapping Spring 2023

PFAS Test Results
from self-purchased
Or
Air Force Sampling



West Plains Cross Section, showing Paleochannels



showing the general stratigraphy and basaltic aquifers, interbeds of the Latah Formation that can be either aquifers or aquicludes and the Quaternary Paleochannels that may allow for cross-contamination between aquifers.

*Water wells with Washington State Department of Ecology Well ID #'s.
(Modified from Pritchard et al., 2020).*

PFAS on Spokane's West Plains

Sources, Pathways, and Wells At Risk

(December 2023)



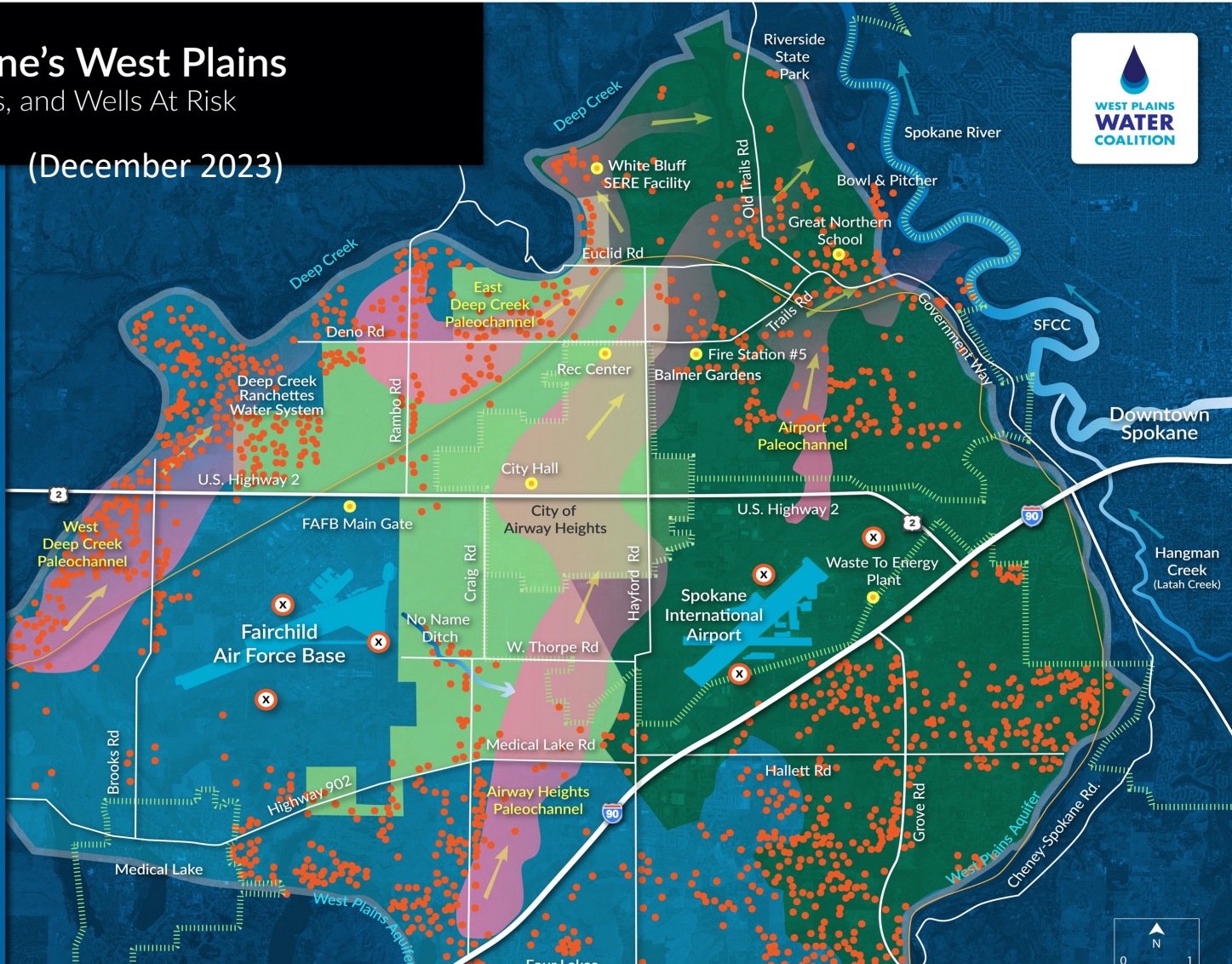
- ✕ PFAS Source Sites
- Private Wells At Risk (icons: see all corresponding citations below)
- Landmarks
- ▭ Underground Paleochannels
- ▭ Fairchild Test Zone
- ▭ Pritchard Ecology Study Area
- ▭ West Plains Aquifer
- Roads
- Railroads
- Subsurface Water Flow
- Surface Water Flow
- ▭ Municipal Water Boundary

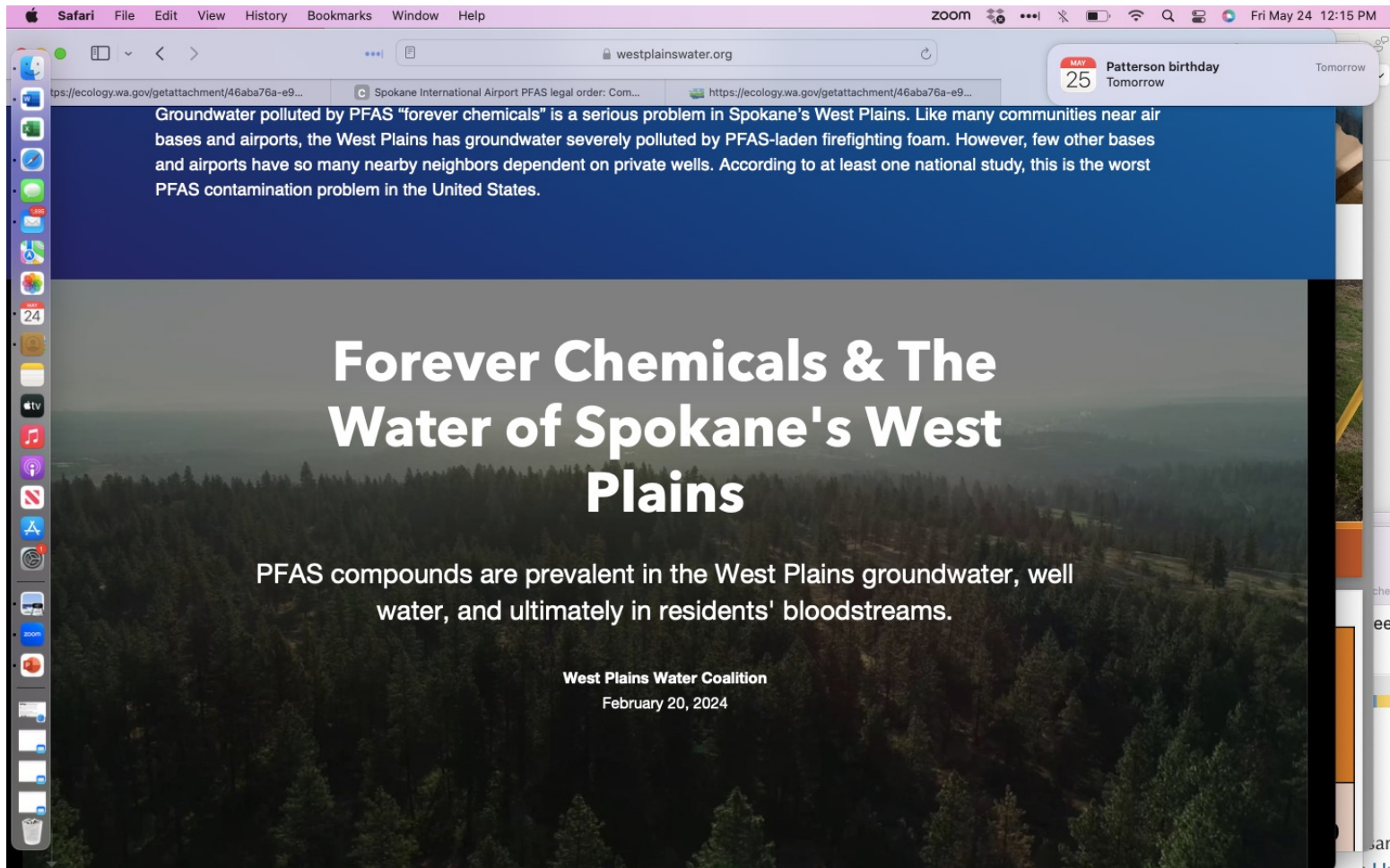
Paleochannels

Paleochannels are inactive streambeds that have been filled in with gravel and sand over time. The permeability in the paleochannel allows for groundwater to move faster than in the surrounding basalt towards Deep Creek and the Spokane River.

Citations

- Well locations from WA Ecology's database: <https://apps.wa.ecology.wa.gov/WellConstruction/Map/WCLSWebMap/TextSearch.aspx>
- Aquifer boundary based on reports by Chad Pritchard, Michael Hamilton, and others.
- Alternative Groundwater Supply Assessment, City of Airway Heights Water System, File #6615-011-00, 2021
- How the West Plains Aquifer feeds the Spokane River Aquifer: <https://www.spokanecounty.org/1227/SVRP-Aquifer-Home>
- Airport PFAS Source Sites**
 - AECOM, Monitoring Well Installation and Groundwater Monitoring for Perfluorinated Chemicals, report dated December 12, 2017.
 - SES, Limited Assessment of Electric Avenue Waste Disposal/Fire Pit Training Area, report dated April 23, 2019. <https://apps.ecology.wa.gov/cleanupsearch/site/16774>
- Fairchild PFAS Source Sites**
 - https://www.fairchild.af.mil/Portals/23/documents/PFOS_P-OA/03_PFO5-PFOA%20Fact%20Sheet_161109.pdf?ver=2017-05-17-32035-187
 - Fairchild detail at: <https://www.fairchild.af.mil/Information/Restoration/>





Online @ westplainswater.org

- All 16
 - Data Visualization 13
 - Interactive Maps 13
 - Story Maps 9
 - Cartography 2
 - Pro Bono 2
- Date Name



FOREVER CHEMICALS ♥ 1

Data Visualization, Interactive Maps, Story Maps

Firefighting foam has been rinsed from the hangars directly into groundwater and residents' wells for decades in West Plains, and people here test at 56x the national average for these toxins.



AMAZON RIVER DOLPHINS ♥ 1

Data Visualization, Interactive Maps, Story Maps

WINNER: ESRI's 2023 StoryMap of the Year! See the StoryMap describing the research efforts of Fernando Trujillo and the Omaha Foundation, alongside the National Geographic Society, and their conservation work studying Amazon river dolphins.



SHAPE OUR WATER ♥ 1

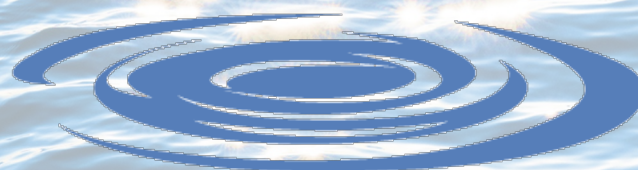
Data Visualization, Interactive Maps, Story Maps

Water has shaped the land and the people of Seattle, and this is the story of how SPU will manage drainage and wastewater systems for the benefit of all communities into the future.



"Blue Water GIS took a mammoth task of years of data and made a legacy."

-Jason Corbett,
Bat Conservation International



Blue Water GIS

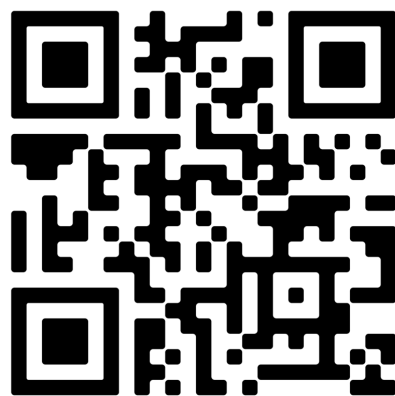
WINNER
Esri StoryMap of
the Year,
2022 and 2023

Cartography. Data Visualization. Storytelling.

Creating an Impact with Your Data

A small, family-owned firm born out of a passion for understanding and conserving our natural world.

We've been clarifying data into compelling stories and beautiful maps since 2009.



SCAN TO LEARN MORE

Other featured clients include...

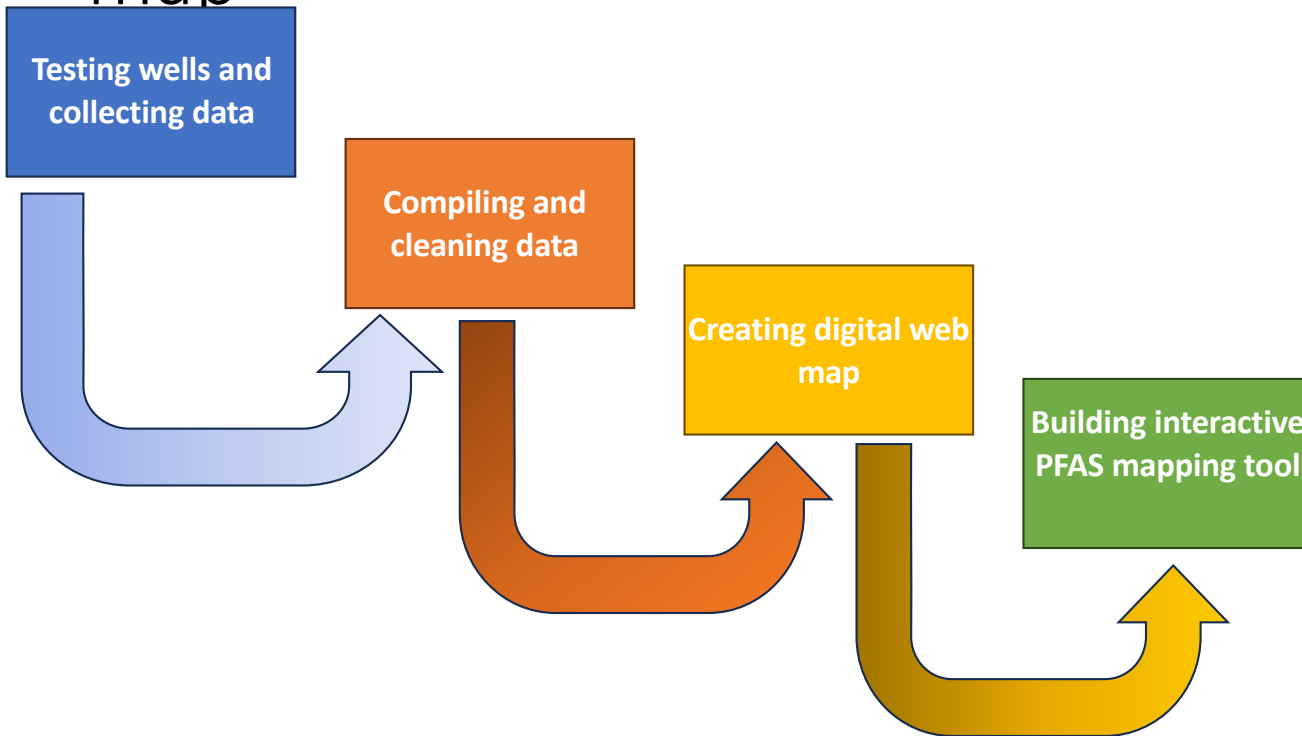
- National Geographic
- The Nature Conservancy
- Washington State Department of Ecology
- Brightstorm
- Wild Bird Trust
- Seattle Public Utilities

Creating the PFAS Heat Map

Using ArcGIS online to visualize
the PFAS Contamination on the
West Plains



From field testing to the digital map



1.

Collecting PFAS Test Data

- Water sources suspected of contamination were tested for PFAS
- The West Plains Water Coalition began compiling test results from community members

WEST PLAINS WATER COALITION



2.

Collecting PFAS Test Data

- The West Plains Water Coalition worked with Blue Water GIS to clean the test results
- Results were uploaded to live Google Sheet with automatic updates as more tests are added

Blue Water GIS



3.

Creating Digital Web Map

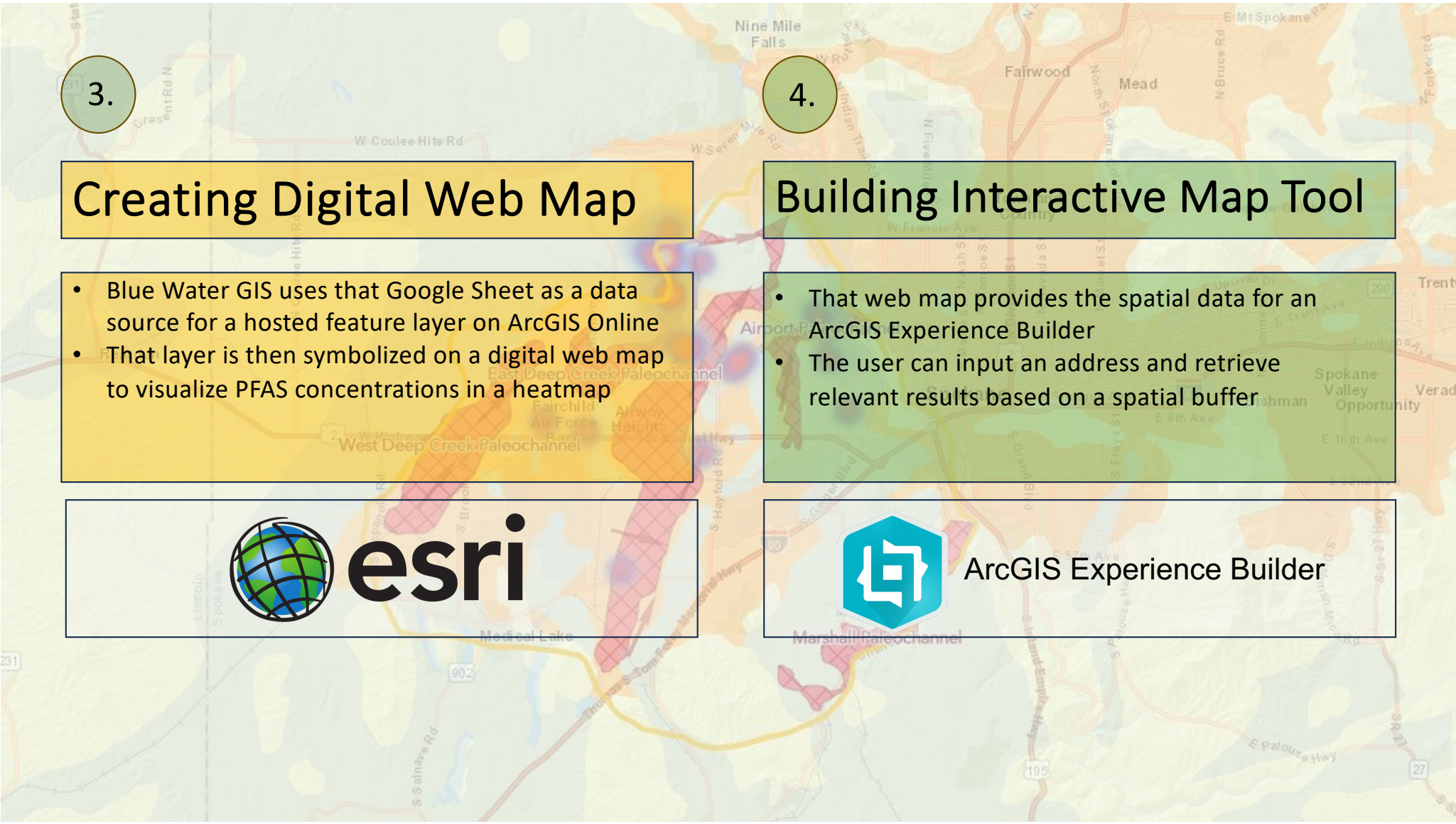
- Blue Water GIS uses that Google Sheet as a data source for a hosted feature layer on ArcGIS Online
- That layer is then symbolized on a digital web map to visualize PFAS concentrations in a heatmap



4.

Building Interactive Map Tool

- That web map provides the spatial data for an ArcGIS Experience Builder
- The user can input an address and retrieve relevant results based on a spatial buffer






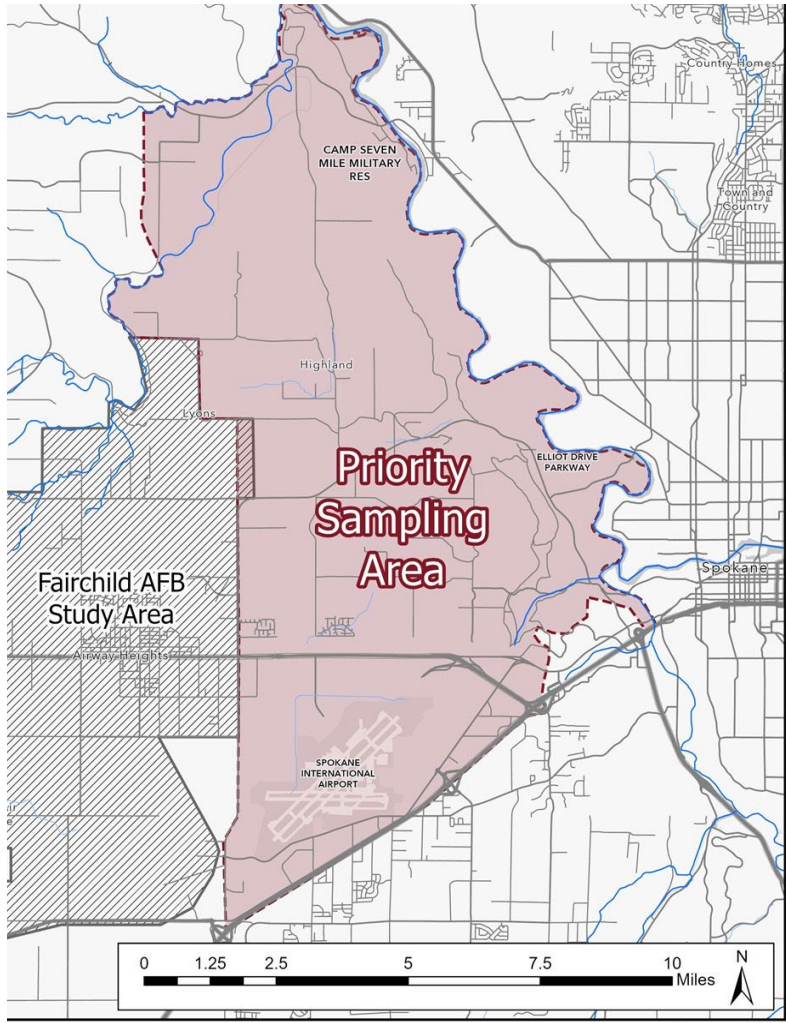
Community Update

NE West Plains

PFAS Sampling

5/21/24





Photos from March 2024 NE West Plains Sampling Effort
 Photo Source: U.S. EPA

Sample Result Type	Number of locations	Percent of locations
Wells that don't have PFAS	91	30%
Wells with PFAS below drinking water standards	44	14%
Wells with PFAS above drinking water standards	172	56%
Total	307	100%

2024 Northeast West Plains Drinking Water Sample Results Table

Station ID: [REDACTED]

Reported State Well ID: [REDACTED]

Sample Number: [REDACTED]

Reported Well Depth: [REDACTED]

Sample Date: [REDACTED]

Well Address: [REDACTED]

Sample Media: Drinking Water

Well Latitude, Longitude: [REDACTED]

Sample Analysis: EPA Method 533: Determination of PFAS Substances in Drinking Water

Analyte	Abbreviation	CAS	Site-Specific Action Level	Your Sample Results
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4 ^a	190
Perfluorooctanoic acid	PFOA	335-67-1	4 ^a	29
Perfluorononanoic acid	PFNA	375-95-1	9 ^b	2.8
Perfluorohexanesulfonic acid	PFHxS	355-46-4	10 ^a	160
Perfluorobutanesulfonic acid	PFBS	375-73-5	345 ^b	14
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	10 ^a	1.8 U

Summary of PFAS Levels by Quarter Section

Results from March 2024 West Plains Sampling Event

- No PFAS found
- PFAS found below drinking water standards
- At least one PFAS compound found at levels 1 to 5 times the drinking water standard
- At least one PFAS compound found at levels 5 to 10 times the drinking water standard
- At least one PFAS compound found at levels 10 to 20 times the drinking water standard
- At least one PFAS compound found at levels more than 20 times the drinking water standard

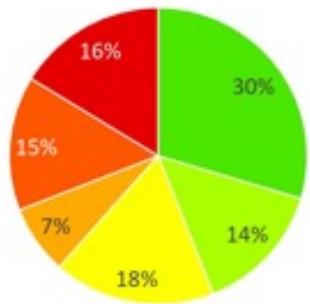
Number of Samples Collected



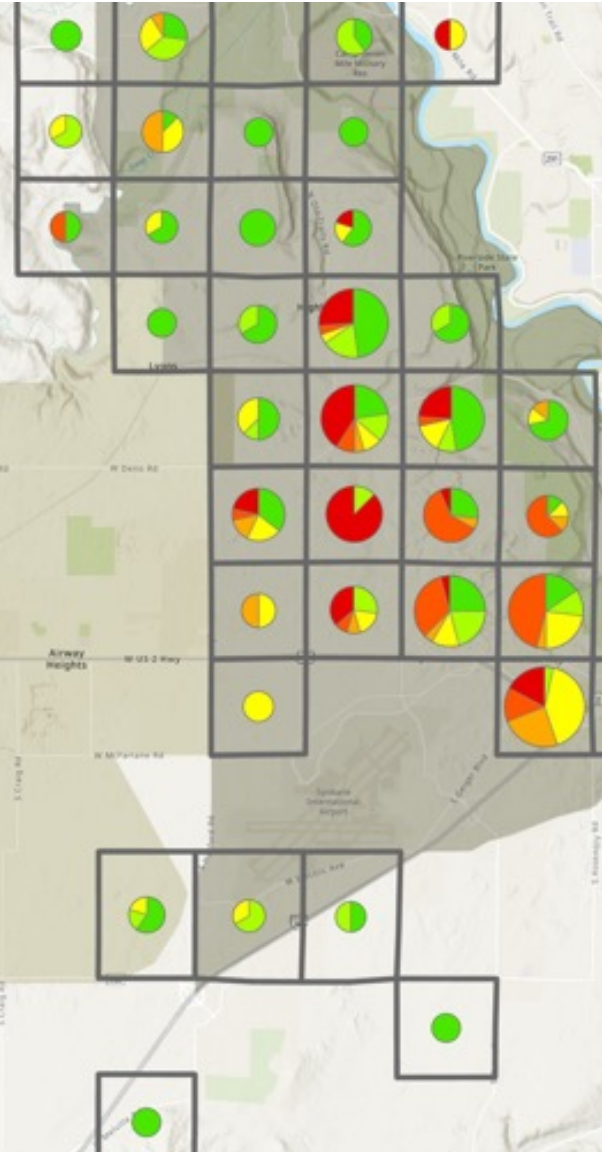
Map Shading

- EPA Sampling Area
- Fairchild AFB Study Area

PFAS Levels in 307 Wells Sampled



0 2 4 8 12 16



QUESTIONS?



WestPlainsWater.org

Introduction

- Name
- Your position and where you work
- What brings you here?



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POLICY INSTITUTE

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A Healthier Future

GreenSciencePolicy.org

The Madrid Statement on Highly Fluorinated Chemicals



“We call on the international community to cooperate in limiting the production and use of PFASs and in developing safer non-fluorinated alternatives.”

Signed by 230 scientists from 40 countries

2015: *Environmental Health Perspectives*

2015-2016

The Opinion Pages | OP-ED COLUMNIST

The New York Times

Chemicals in Your Popcorn?

JUNE 4, 2015



Nicholas Kristof

What do a pizza box, a polar bear and you have in common?

All carry a kind of industrial toxicant called poly- and perfluoroalkyl substances, or PFASs, that do two things: They make life convenient, and they also appear to increase the risk of cancer.

These Chemicals in Pizza Boxes and Carpeting Last Forever

More than 200 scientists around the world document the threats of perfluorinated compounds and call for more government control.

By Lindsey Konkel, National Geographic
PUBLISHED MAY 01, 2015



The Intercept

THE TEFLON TOXIN

DuPont and the Chemistry of Deception



Sharon Lezner

Aug. 11 2015, 3:35 p.m.



133

Home

The New York Times Magazine

The Lawyer Who Became DuPont's Worst Nightmare

Rob Bilott was a corporate defense attorney for eight years. Then he took on an environmental suit that would upend his entire career — and expose a brazen, decades-long history of chemical pollution.

By NATHANIEL RICH JAN. 6, 2016



Letter from NY Department of Health to US EPA



Department of
Environmental
Conservation

Department
of Health

January 14, 2016

The Honorable Gina McCarthy
Administrator
USEPA Headquarters
William Jefferson Clinton Building
1200 Pennsylvania Avenue, N. W.
Mail Code: 1101A
Washington, DC 20460

Dear Administrator McCarthy:

We write to you to request that EPA take vigorous action to address the presence of perfluorooctanoic acid (PFOA) in drinking water and groundwater. Respectfully, we ask that EPA:

- lower its provisional health advisory of 400 parts per trillion (ppt) for PFOA drinking water to take into account the most current scientific evidence;
- act expeditiously to adopt a protective maximum contaminant level for PFOA;
- expeditiously list PFOA as a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) to facilitate the cleanup of contaminated groundwater and other media; and
- review the remaining uses of PFOA under the Toxic Substances Control Act and curtail it whenever less toxic alternatives are available.

Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaidler,^{*,†} Simona A. Balan,[‡] Arlene Blum,^{§,||} David Q. Andrews,[⊥] Mark J. Strynar,[#] Margaret E. Dickinson,[∇] David M. Lunderberg,[∇] Johnsie R. Lang,[○] and Graham F. Peaslee[@]

[†]Silent Spring Institute, Newton, Massachusetts 02460, United States

[‡]California Department of Toxic Substances Control, Sacramento, California 95814, United States

[§]Green Science Policy Institute, Berkeley, California 94709, United States

^{||}Department of Chemistry, University of California at Berkeley, Berkeley, California 94720, United States

[⊥]Environmental Working Group, Washington, D.C. 20009, United States

[#]National Exposure Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, United States

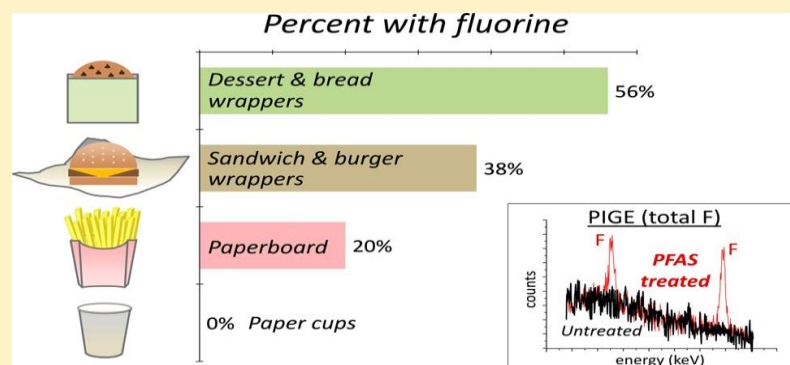
[∇]Chemistry Department, Hope College, Holland, Michigan 49423, United States

[○]Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee 37831, United States

[@]Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, United States

S Supporting Information

ABSTRACT: Per- and polyfluoroalkyl substances (PFASs) are highly persistent synthetic chemicals, some of which have been associated with cancer, developmental toxicity, immunotoxicity, and other health effects. PFASs in grease-resistant food packaging can leach into food and increase dietary exposure. We collected ~400 samples of food contact papers, paperboard containers, and beverage containers from fast food restaurants throughout the United States and measured total fluorine using particle-induced γ -ray emission (PIGE) spectroscopy. PIGE can rapidly and inexpensively measure total fluorine in solid-phase samples. We found that 46% of food contact papers and 20% of paperboard samples contained detectable fluorine (>16 nmol/cm²). Liquid chromatography/high-resolution mass spectrometry analysis of a subset of 20 samples found perfluorocarboxylates, perfluorosulfonates, and other known PFASs and/or unidentified polyfluorinated compounds (based on nontargeted analysis). The total peak area for PFASs was higher in 70% of samples (10 of 14) with a total fluorine level of >200 nmol/cm² compared to six samples with a total fluorine level of <16 nmol/cm². Samples with high total fluorine levels but low levels of measured PFASs may contain volatile PFASs, PFAS polymers, newer replacement PFASs, or other fluorinated compounds. The prevalence of fluorinated chemicals in fast food packaging demonstrates their potentially significant contribution to dietary PFAS exposure and environmental contamination during production and disposal.



CNN @CNN Follow

Researchers found fluorinated chemicals in one-third of the fast food packaging they tested, according to a report cnn.it/2jWU6Rw



RETWEETS 237 LIKES 205

6:20 AM - 1 Feb 2017

47 237 205

Washington Post @washingtonpost Follow

Researchers find "another reason" to avoid fast food: Chemicals in the packaging



Researchers find 'another reason' to avoid fast food: Chemicals in the packa...
Substances with links to health problems have been found in wrappers and containers, where they can leach into food.
washingtonpost.com

RETWEETS 141 LIKES 106

Mother Jones @MotherJones Follow

The Nasty Ingredient in Fast-Food Wrappers
mojo.ly/2jCPzA4



RETWEETS 19 LIKES 22

5:09 AM - 1 Feb 2017

19 22

United States Senate
WASHINGTON, DC 20510

March 9, 2017

Mr. Daniel S. Schwartz
Chief Executive Officer
Restaurant Brands International Inc.
226 Wycroft Road,
Oakville, Ontario L6K 3X7,
Canada

Dear Mr. Schwartz:

We write to inquire about Burger King's use of potentially harmful fluorinated chemicals in food wrappers, bags, boxes, or other kinds of food packaging. Per and polyfluoroalkyl substances (PFASs) represent a class of chemicals sometimes used in fast food packaging to prevent grease and sauces from seeping through packaging. These chemical compounds have been

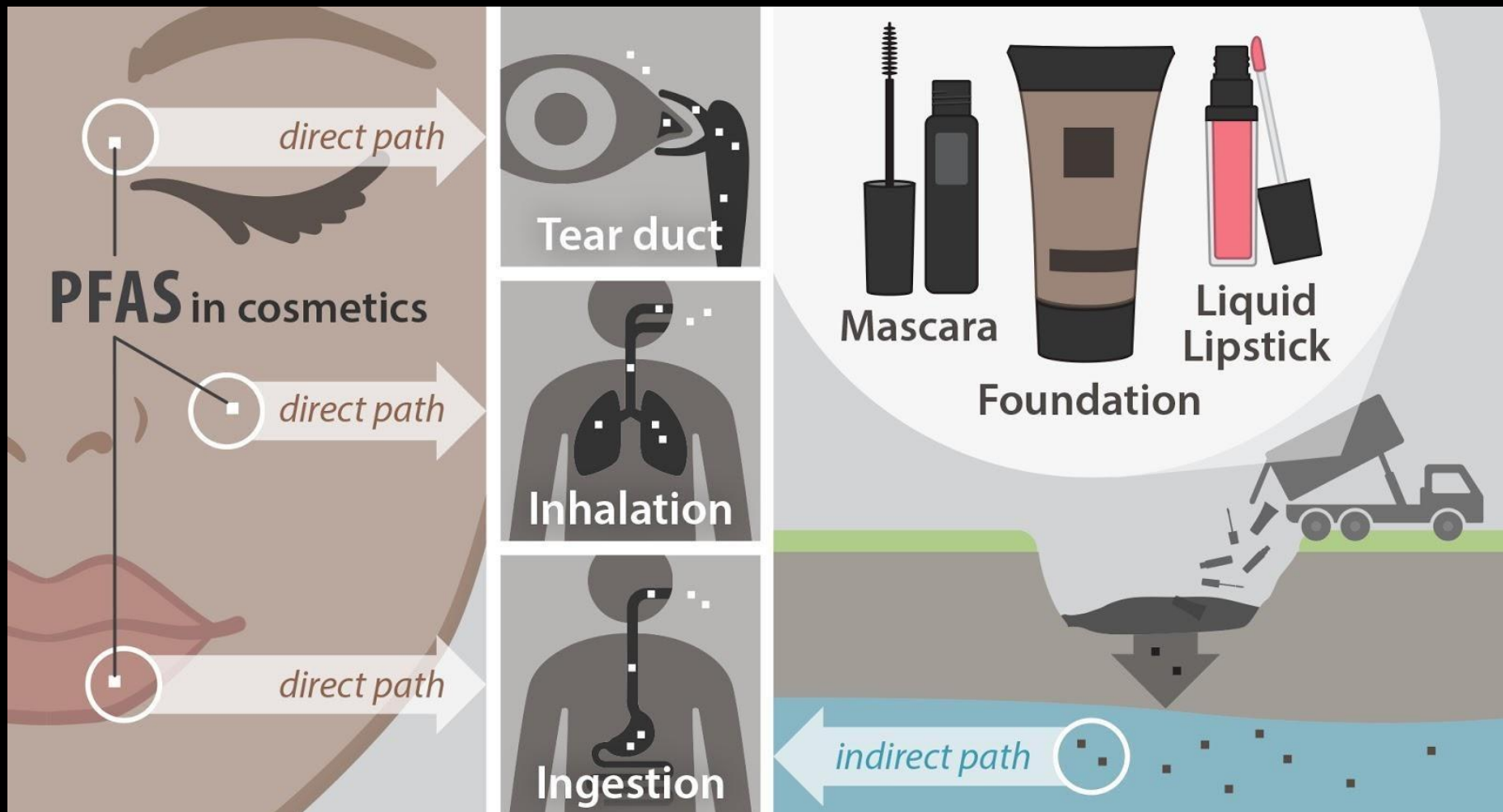
Food Packaging Regulation

Bans passed:

- 2018 - Washington State
- 2019 – Maine, Denmark
- 2020 – San Francisco, New York State
 - US NDAA : no PFAS in military meals-ready-to-eat (MREs)
- 2021 – Minnesota, Connecticut, California,
- 2022 – Maryland, Hawaii, Colorado, Netherlands
- 2023 – Rhode Island, Vermont



Fluorinated compounds in North American cosmetics



California AB2771 PFAS-Free Cosmetics Act

September 30, 2022

Bans all-the whole class- PFAS from being intentionally added to beauty & personal care products sold in California from January 1, 2025.



Per- and Polyfluoroalkyl Substances in North American School Uniforms

September 21, 2022, *ES&T*



Found high levels of PFAS in all stain-resistant uniforms tested.

PFAS Banned in California Textiles

September 30, 2022



Co-sponsored by NRDC, Breast Cancer Prevention Partners, and Clean Water Action,

Authored by Assembly Member Phil Ting..

Green Science Policy Communications Strategy

[GreenSciencePolicy.org/our-work/communications-strategy/](https://www.GreenSciencePolicy.org/our-work/communications-strategy/)

Study	Journal	Year	Downloads
Flame retardants in baby products	<i>ES&T</i>	2011	30,202
PFAS in U.S. drinking water	<i>ES&T Letters</i>	2016	77,552
PFAS in fast food packaging	<i>ES&T Letters</i>	2017	50,291
Managing PFAS as a chemical class	<i>ES&T Letters</i>	2020	71,266
PFAS in cosmetics	<i>ES&T Letters</i>	2021	128,100

Science & Communication Strategy



Available on our website:

- Six short videos from experts
- Communications plan worksheet
- Press release template
- Embargo tip sheet

greensciencepolicy.org/news-events/events/science-and-communication-strategy-workshop

Green Science Policy Communications Strategy

GreenSciencePolicy.org/our-work/communications-strategy/

- Collaborate with expert authors at multiple institutions.
- Select research topic to support policy in public interest.
- Publish open access.
- After acceptance, select a publication date for maximum impact (Two weeks or more in the future).
- Compose release in accessible language with a “hook”.
- Query journalists & then share embargoed release & paper.
- Educate journalists & establish relationships.
- Hope it is not a big news day.
- Utilize paper to affect change.



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PFASCentral.org

SixClasses.org

Sign up for our monthly e-newsletter

How can you use communication strategy to advance your project?

- (What is your pitch? What makes it newsworthy? Why should people care? Who are you trying to reach and what is the call-to-action?)
- Group with time keeper
- Think about your pitch & write 5 minutes
- Report back each **ACTIVE LISTENING** 3 minutes
- Discussion of each 2 minutes
- Group report back and discussion

What's Your Pitch?



Choose a timekeeper for your group



write down a news pitch for an upcoming project (What makes it newsworthy? Why should people care? Who are you trying to reach and what is the call-to-action?)



Each person gets **3 minutes** to share their pitch with the rest of the group and receive **2 minutes** of feedback. Remember to practice active listening.

Commitments

Name

Partners

To help create the future I envision,
during the next month I will:

1.

2.

3.

National PFAS Conference 2024

Weds June 12, 2:30-4:30

Community Driven Health Surveys workshop summary

[Brief notes from workshop presentation](#)

[Quick epidemiology 101](#)

[Overview of two PFAS community health studies in NPCC communities](#)

[Discussion Guide for Breakouts - Items to consider when planning a health survey](#)

Brief notes from workshop presentation

This session is designed to cover the types of community surveys that people can do without the intense funding and expertise required for academic-initiated epidemiology studies. Community-initiated studies are not designed to be able to answer the question about the relationship between PFAS and other contaminants and any specific health outcome. But they can be very powerful tools to build local awareness of potential health impacts, get visibility to community concerns, and lay the groundwork for political priorities like medical monitoring, local fish/water advisories, or more detailed medical studies.

In this way community health studies are similar to community-led environmental monitoring efforts which have been successfully used to draw attention of regulators, federal agencies, and health experts to local pollution hotspots.

We note that these types of community surveys can be difficult and provoke different types of discomfort... either from academics who've been trained to dive deep and use more robust statistical methods (and be cautious about drawing conclusions), or by place-based leaders who are aware that there isn't often a quick and efficient remedy for communities with historic PFAS exposure.

In general addressing the crisis posed by PFAS chemicals has required a lot of detective work - by scientists, regulators, journalists and people living in contaminated places. Scientists have learned important things by studying highly exposed populations (in the Faroes, Parkersburg

WV and now a variety of US locations where NPCC members live, in studies hosted by the US government or universities). Studying PFAS exposure is very difficult due to the incredible number of health impacts that appear to be related in experimental animal studies. And while we know a bit more about the longer-chain PFAS chemicals, the currently used, “shorter chain” PFAS could have additional impacts. We expect this information to grow and become more conclusive over time.

Epidemiology 101

In general, environmental diseases are easier to study if they cause a rare and specific health outcome. For example mesothelioma is an unusual cancer related almost exclusively to asbestos exposure. Asbestos causes a lot more cases of lung cancer and non-cancerous lung disease, but these weren't conclusively linked until much later due to high rates of lung diseases and lung cancer in the American population.

1. General tenants of cause and effect
 - a. Easy for limited chemical exposure group and rare outcome (asbestos)
 - b. Harder when everyone is exposed to chemical and for common and multifactorial outcomes (ex cholesterol)
 - c. Also hard for diseases that might not be formally diagnosed (ex thyroid function, cognitive impairment, immune system suppression)
 - d. No group with zero PFAS exposure
2. Case-control study
 - a. Match people with exposure and people without exposure.
 - b. Compare blood levels, biological markers or disease diagnosis
3. “Ecological study”
 - a. Examine disease rates in a given area
 - b. Needs a comparison population to say if observed disease rates are elevated in the study area
 - c. Need to account for qualities of the community (sex ratio, age, health status)
4. Long history of community disappointment in attempting to study the environmental “causes” of cancer cluster or disease outbreaks

Overview of two PFAS community health studies in NPCC communities

Loreen Hackett - Hoosick NY - Goal - a community effort to ground-truth a local government study that reported no excess of cancer in the local community, looking only at diseases associated with PFAS in the large C8 Health Study

- a. Survey results from about 400 residents - took 6 months to collect. Partnership with Bennington College.
- b. Higher numbers of illnesses identified through community study - (41% more kidney cancer, 4 new testicular cancer during study period - 9 overall, 230 cases of thyroid disease)
- c. Overall - lots of work. Fairly simple survey question. Powerful reminder that government data sets for diseases like cancer, which is specifically tracked in national registries, can underestimate the burden of disease in a population
- d. Also as a reminder - if the contaminated area isn't carefully delineated then you have highly exposed people living in your comparison group - what happened to Liz who moved slightly outside the known plume area in El Paso County CO. This means comparing rates of a disease like kidney cancer for a community vs its neighboring county could be flawed by design and not find an elevated risk even if it existed.

Laurene Allen - Merrimack NH - co-led a community health survey that asked about health conditions broadly and compared disease rates in newer and older residents of the area. The results of this study were published in a scientific journal

<https://ehjournal.biomedcentral.com/articles/10.1186/s12940-019-0513-3>

- e. This community-initiated health study grew to incorporate formal epidemiology support and some statistical analysis of self-reported diseases rates between newer and longer-time residents of the contaminated area
- f. Study included 596 people, 213 households ~2% of town pop

Findings:

- 1) for YOUTH - elevated incidence of developmental, autoimmune and kidney disorders among those < 18 years of age;
- 2) for WOMEN -elevated levels of health concerns, **multiple health concerns, autoimmune disorders, and reproductive disorders among women,**
- 3) for WORKERS- elevated levels of **health concerns, multiple health conditions, cardiovascular, respiratory, reproductive, and liver disorders** in those with industrial occupational exposures, and;

4) for LONG-TIME RESIDENTS elevated incidence of **health concerns, cardiovascular, and developmental disorders** among those who have been living in Merrimack for a long time versus newer residents.

These results only represent those exposed to PFAS contamination with no comparison to the control population, hence it is not possible to conclude from this analysis if the people in this community experience disproportionately higher health concerns compared to a less-exposed, control population.

Discussion Guide for Breakouts - Items to consider when planning a health survey

1. When first planning a study
 - a. Compiling a group of people who are interested in helping design or implement a study
 - b. Determining area of interest
 - c. Identifying groups of people in your community that need to be represented racial/ethnic groups, linguistic isolation, cultural practices - fish and game and wild food consumption, home gardeners
 - d. considering methods of inclusion of marginalized/under-represented groups - contact and consult individual people/leaders *at this phase*. Ask for input about questions/concerns and outreach strategies. Adjust questions and goals as needed based on this feedback.

2. Setting project goals

Goals - awareness among community members, awareness for local government/medical providers, visibility of community impacts, building a cohesive narrative/conversation about impacts and needs.

Scope - How many people is the target? How long are you willing to take to reach this number?

What types of format of data gathering (web/phone based survey vs one on one interview (at event, in person, or via phone)

Can you simplify tool in order to reach more people, option for follow up?

3. Explaining scope to the public and managing community expectations about the results of a survey
4. Mechanics of a health study - program you use, managing data, determining who will analyze data and who will have access (how you will protect anonymity)
5. PFAS health outcomes - which to ask about, how to ask? - important remember to make it clear that you are only asking about illness diagnosed since moving to impacted area
 - a. Consider if/how you would use this information
 - b. Open ended vs yes/no questions
 - c. Place for "other concerns/effects"
6. PFAS exposure - How to ask or characterize? Water, wild foods, home garden, occupation
7. Do you include a non-exposure group, or low exposure group? - challenge of statistics and reporting bias (people who are unhealthy or concerned are more likely to report every concern thoroughly while people who are presently healthy or unconcerned will be less detailed)
8. Privacy and consent
How to ask/explain to individuals (can someone report on health impacts for a family member? Neighbor? child?) Will you contact people directly based on knowledge or recommendation?

Who has access to survey info - small number of people, data set up to be secure

How will you talk about specific people's health information?
9. Will you allow people to withdraw their information from the study, or withdraw their consent for you and others to talk about their illness?
10. Outreach/data gathering/
What materials would you give people who participate? FAQ
11. Data interpretation
12. Publicity of findings and audience you will communicate the results to (decision makers, politicians, journalists, etc.)

PFAS and Community Mapping Workshop

2024 National PFAS Conference

Ann Arbor, MI

12 June



PFAS Project Lab
Northeastern University



WEST PLAINS  **WATER COALITION**

Workshop Outline

Mapping for Community Health - History, environmental health research, and best practices

Kimberly Garrett – Northeastern University PFAS Project Lab

Mapping Tribal Communities - PFAS Impacts and Challenges for South Carolina's Tribal Nations

Cheryl Cail – Waccamaw Indian People

Mapping Neighborhood PFAS - Neighbors working together to solve our water crisis

John Hancock – West Plains Water Coalition

Questions and Conversation

How have you used maps to convey environmental information?

About Me

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She/They

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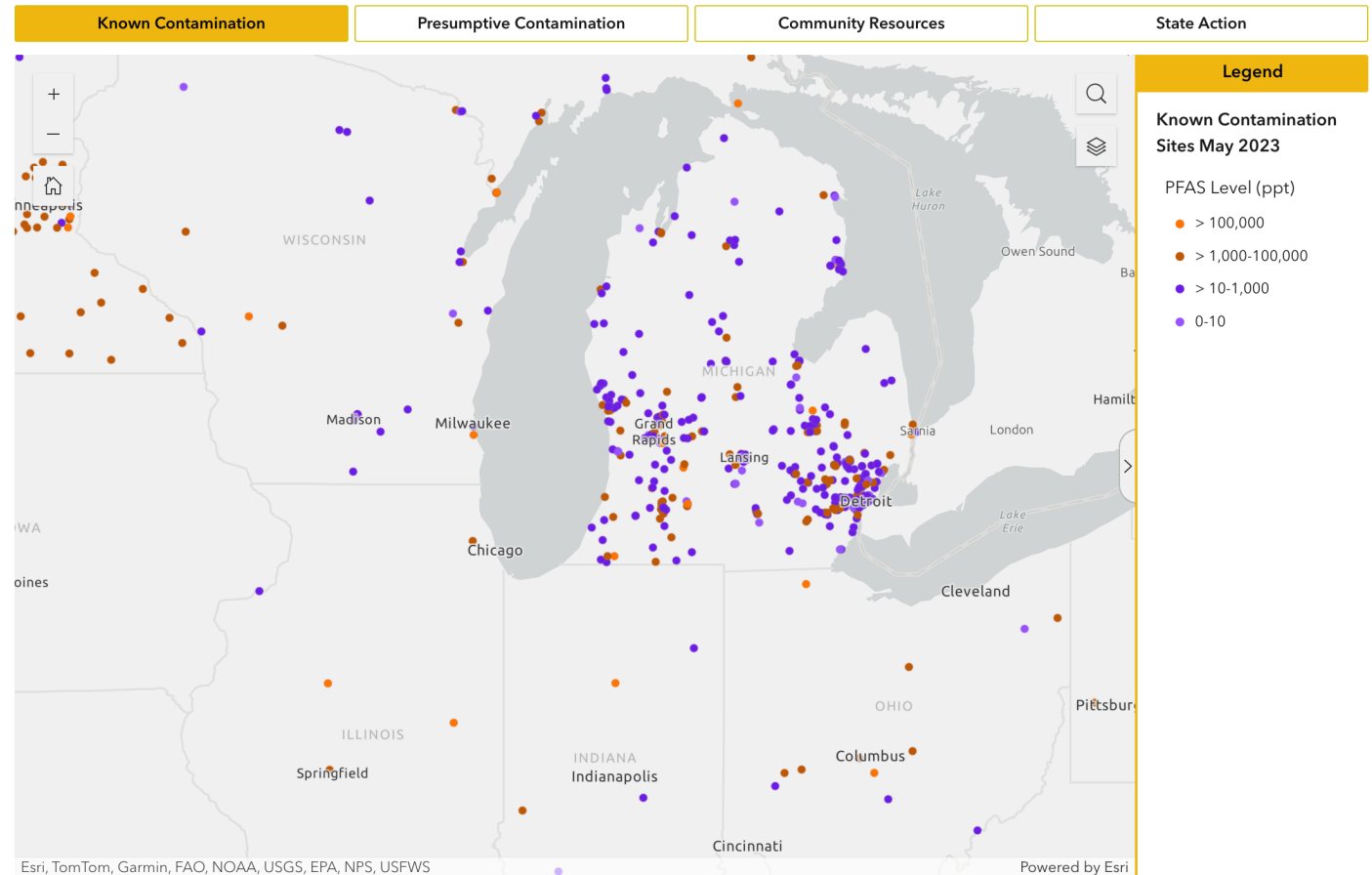
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NIH 2-T32-ES023769-06 and R01ES028311
NSF SES-1827817 and SES-2120510

PFAS Sites and Community Resources



www.pfasproject.com/pfas-sites-and-community-resources

Maps as Methods in Public Health

Who?

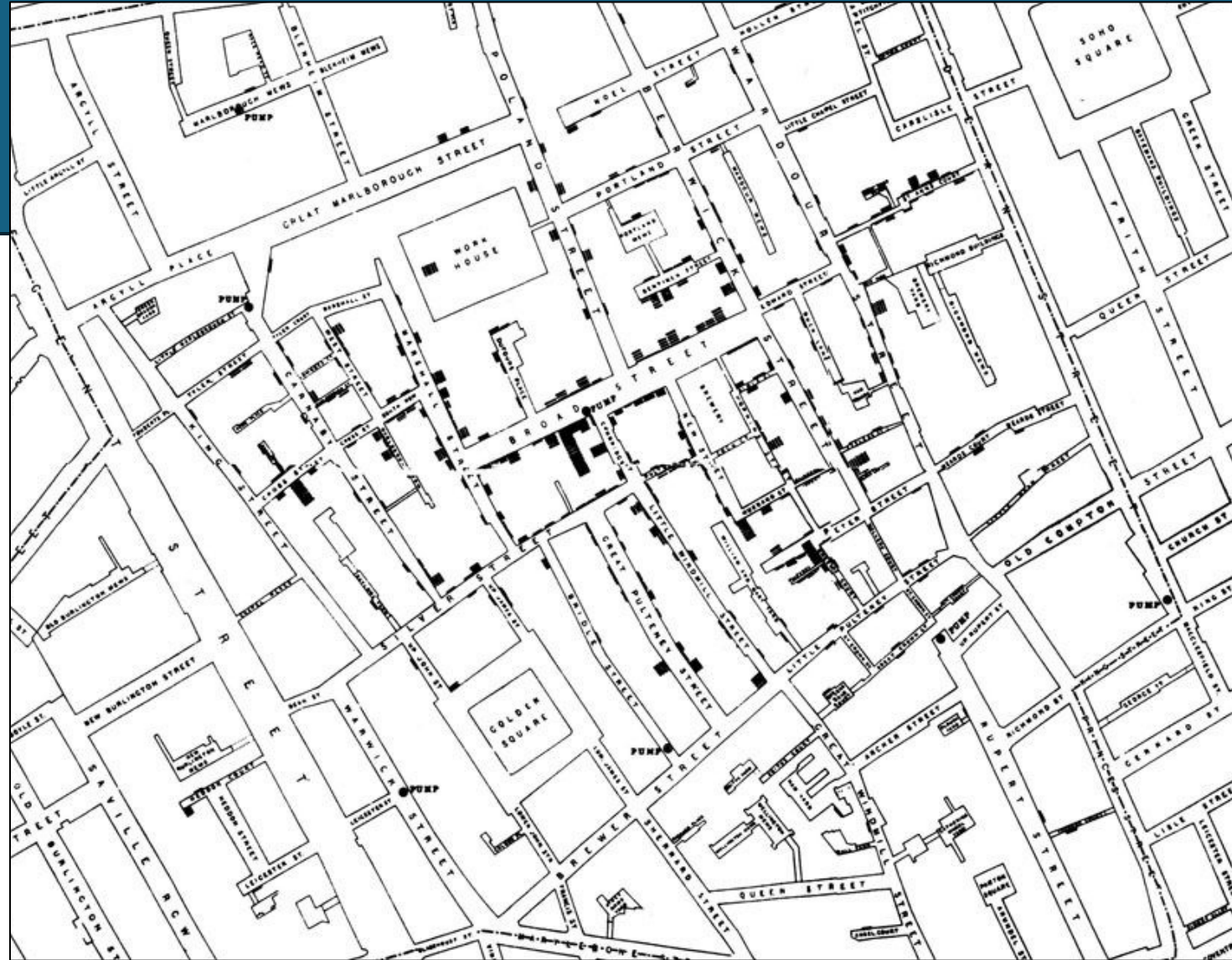
When?

Where?

- **Spatial analysis:** quantitative assessment of geospatial data
 - Are health outcomes clustered in space?
 - Where are exposures highest?
 - Are there associations between exposures, demographics, and health outcomes?
- Public health data is often mapped in **spot** and **area maps**.

Spot Maps

- Spatial model showing case residence or exposure location as a single point
- ✓ Show geographic case distribution
- ✓ Can inform source identification
- ✓ Accessible method for community science
- X Do not show disease risk
- X Do not account for population density
- X Incomplete data leads to underestimation

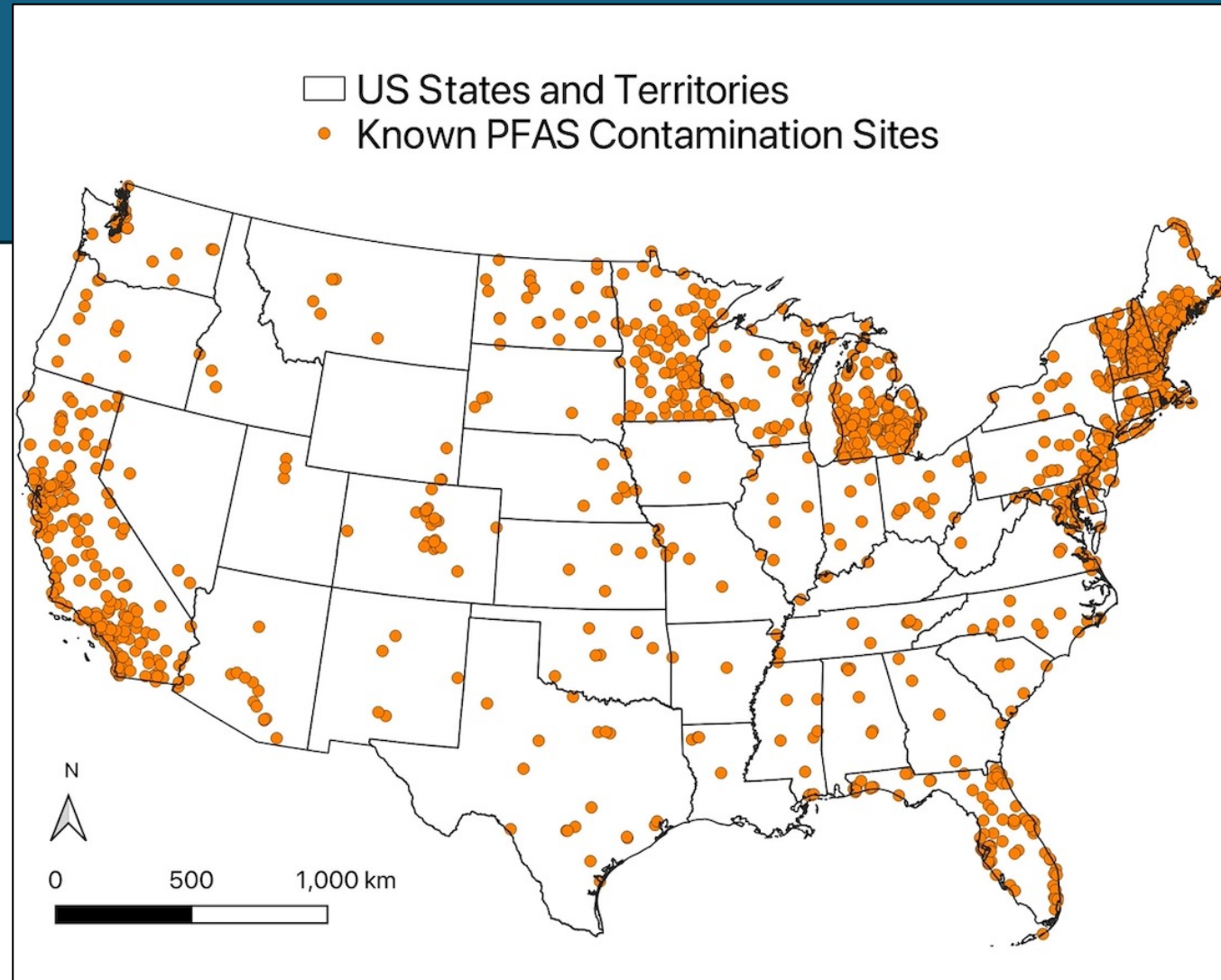


John Snow's 1854 map of a London cholera outbreak



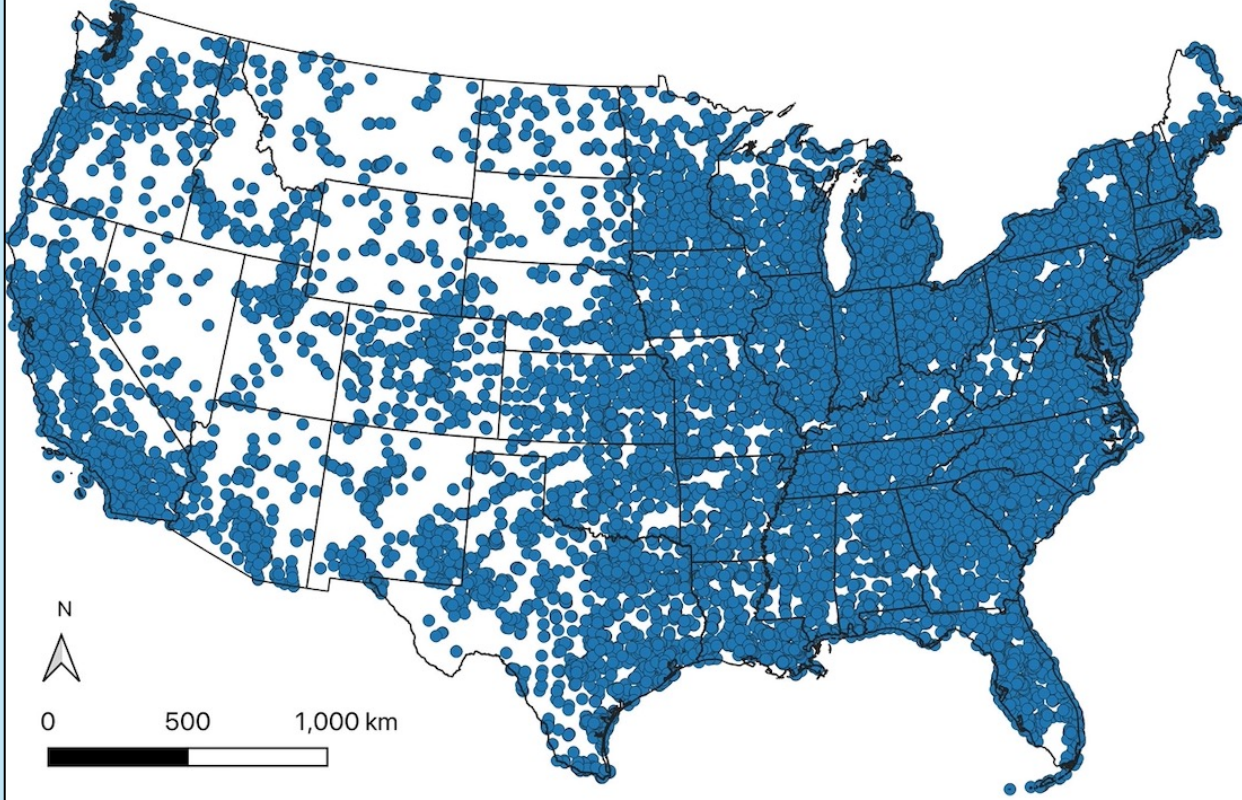
Beware of Bias!

- Known PFAS Contamination Sites were identified using publicly available testing data from
 - State environmental agencies
 - Department of Defense
- How would you allocate remediation resources based on this map?

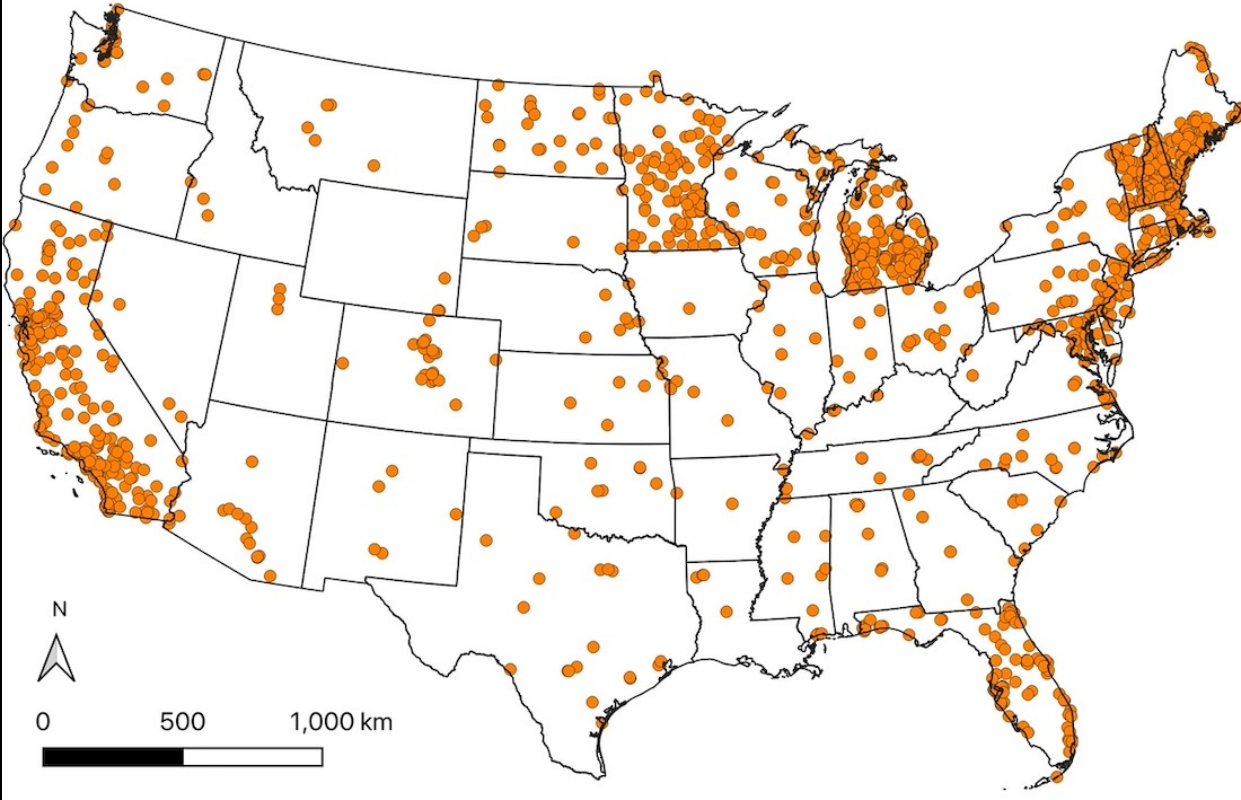


The PFAS Project Lab's Known PFAS Contamination Site Tracker
(Salvatore et al., 2022)

- US States and Territories
- Presumptive PFAS Contamination Sites



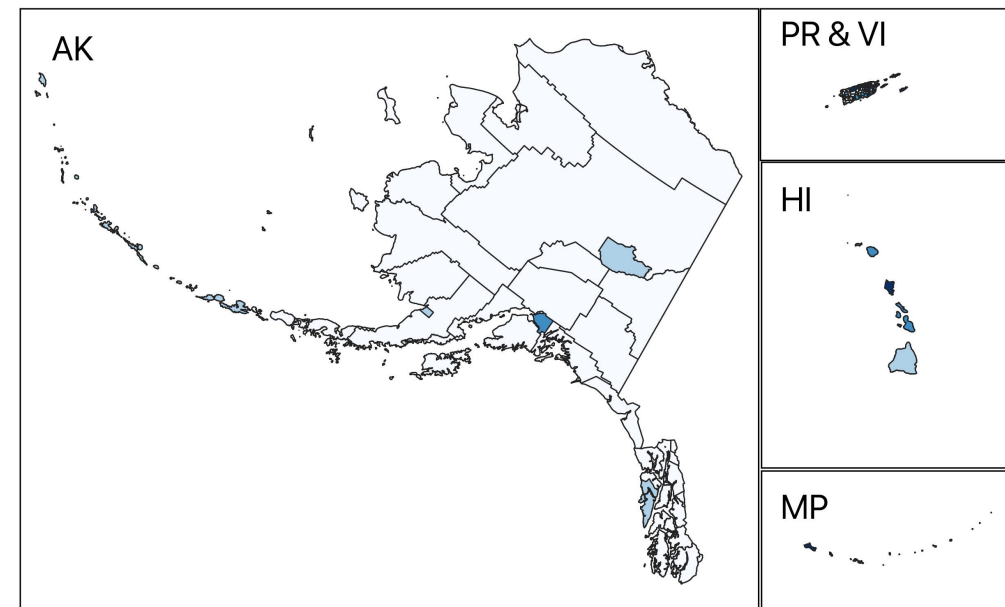
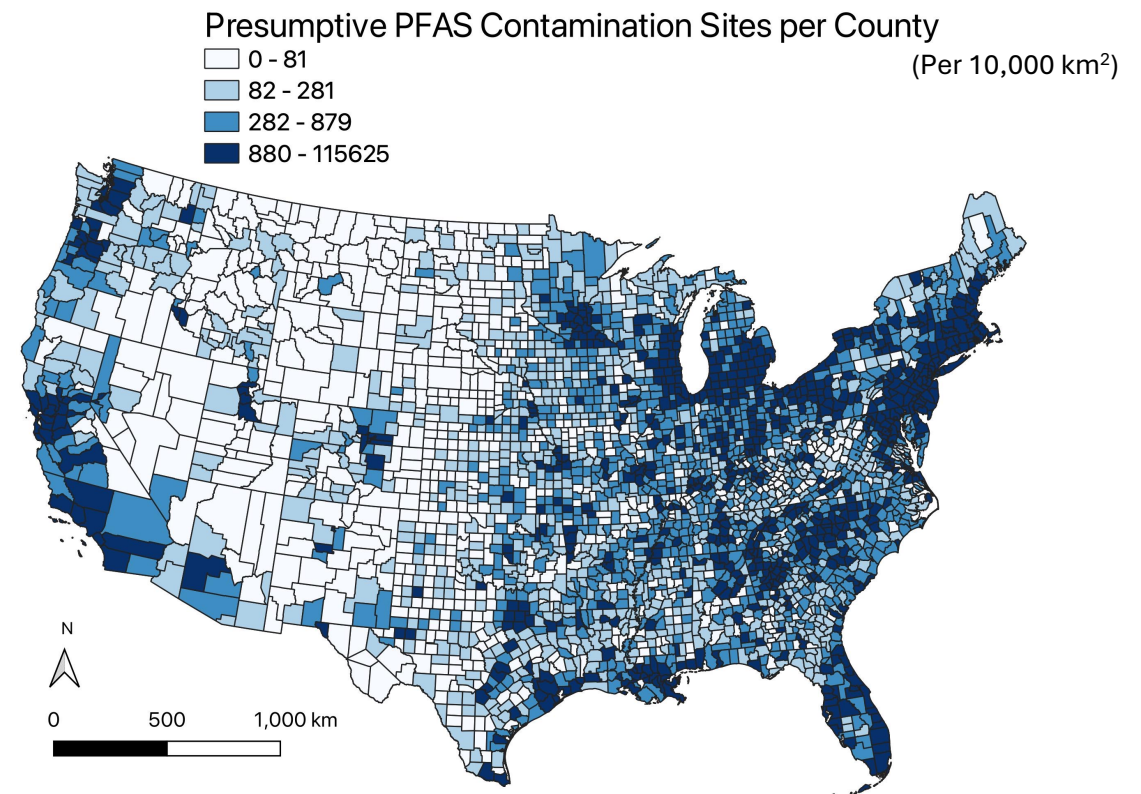
- US States and Territories
- Known PFAS Contamination Sites



The PFAS Project Lab's Known and Presumptive PFAS Contamination Site Models (Salvatore et al., 2022)

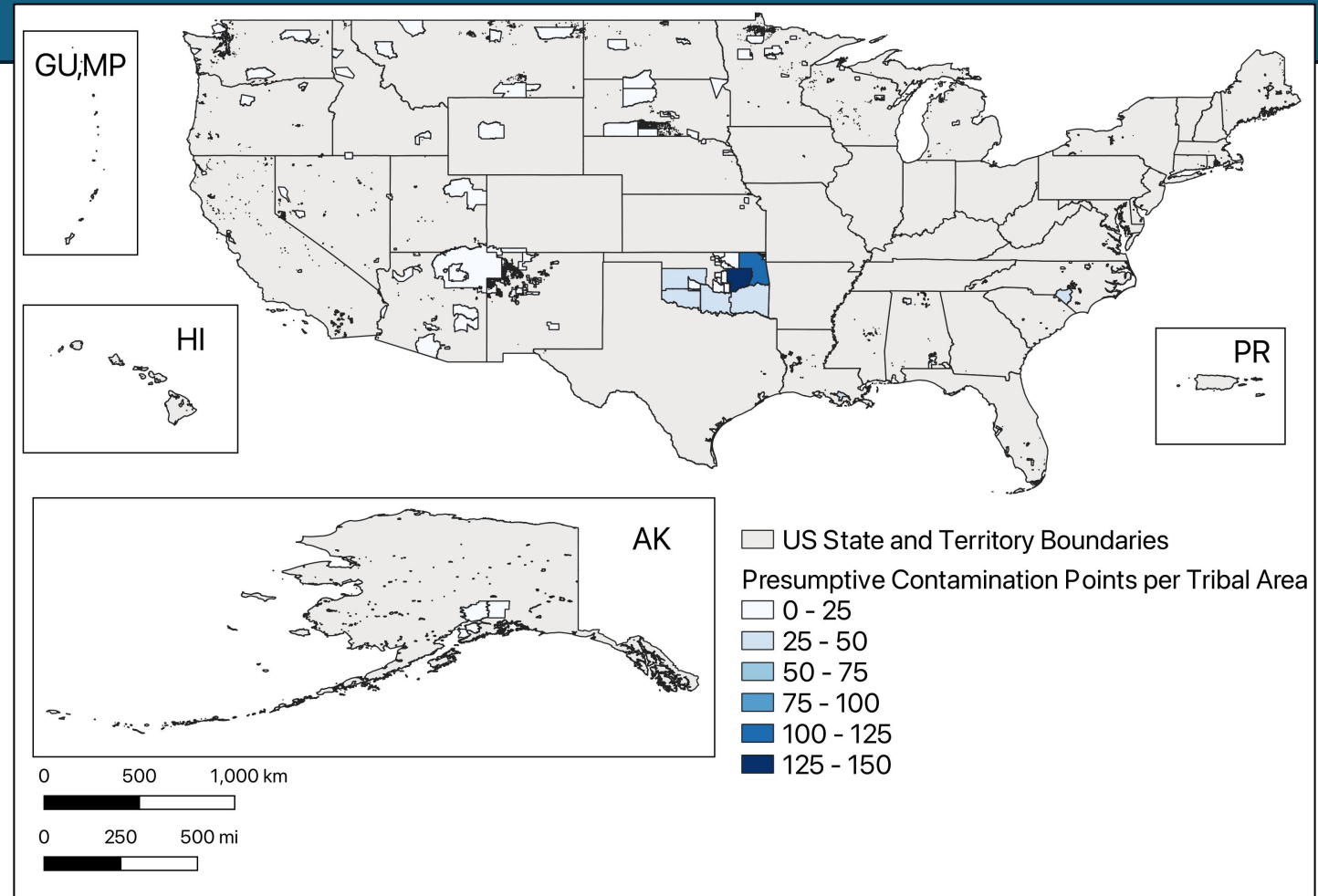
Area Maps

- Spatial model showing multi-dimensional public health data including disease incidence rates and spatial distribution of disease risk
- ✓ Show trends
- ✓ Can account for multiple variables
- ✓ Can communicate risk
- X Limited by geographic units
- X Correlation \neq causation



Critical Cartography

- Maps aren't neutral.
 - Relationships with colonialism and land ownership
 - What's included? What's excluded?
- Cartographic perspective
- Technicians vs *geographers*
- Data sovereignty



Community Mapping & Civic Science

Asset Mapping

Lay Mapping

Agent-based Mapping

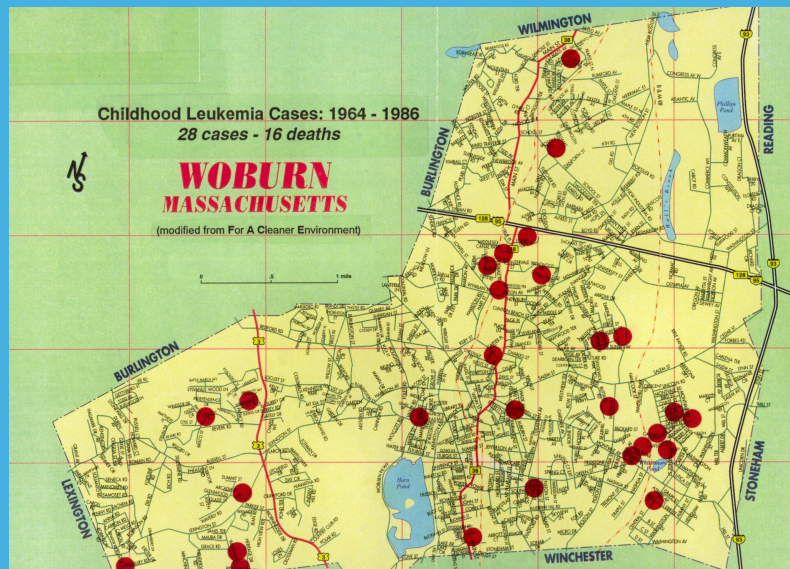
Participatory Mapping

Whose is the cartographic
perspective?

Who owns the data?

Community-led Mapping & Environmental Health

- Hanford, WA
- Woburn, MA
- Long Island, NY
- Love Canal, NY



Love Canal community illness map (Ploughman 2009).

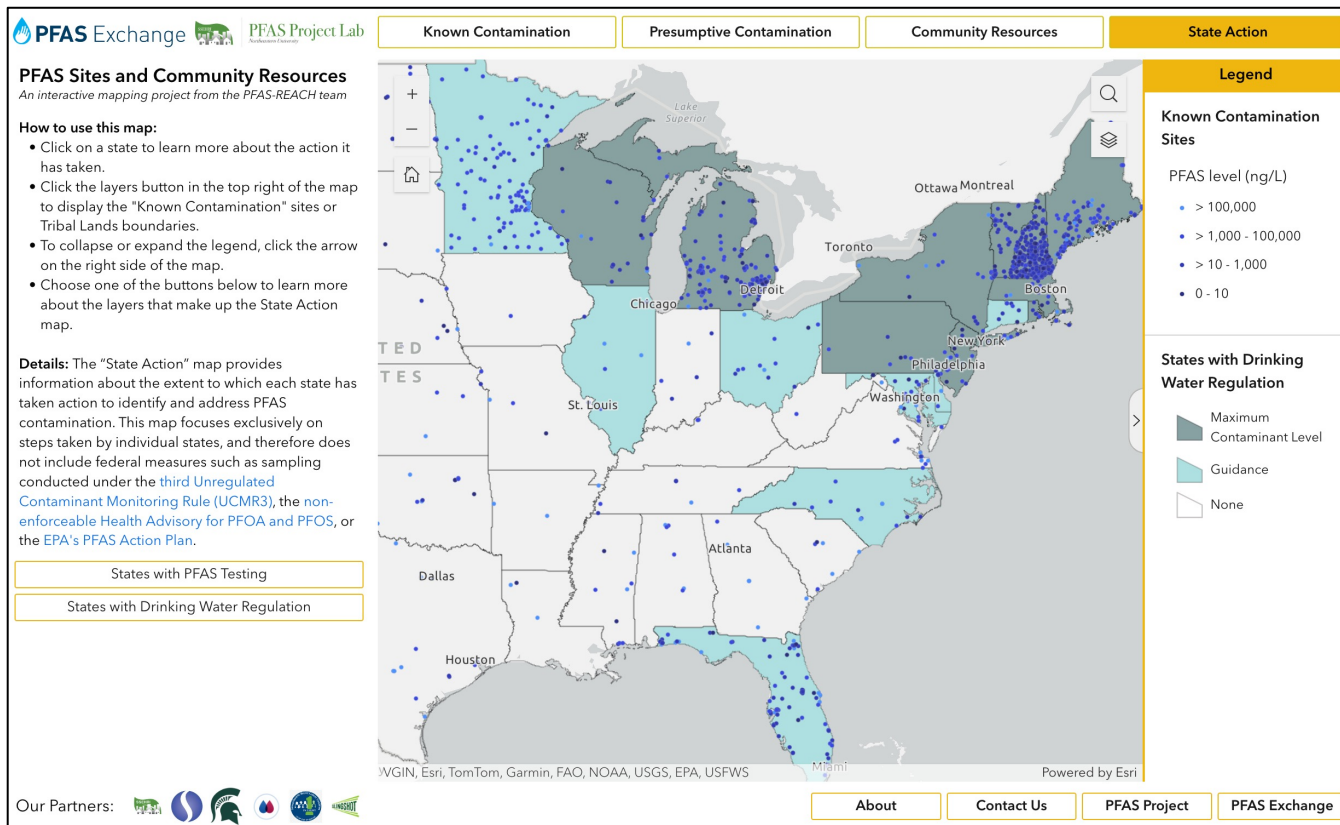
Mapping Tools

- **Pen and paper**
- Accessible, low-cost
- Limited accuracy
- Difficult to translate to virtual resources



Love Canal community illness map (Ploughman 2009).

Mapping Tools



- **Geographic Information Systems (GIS):** a variety of computer programs that enable management, analysis, and visualization of *geolocated* data
- Allow for detailed analyses and visualization
 - Built-in analysis tools
- Require technical training
- Can be expensive (QGIS is open-access)

The PFAS Project Lab Known PFAS Contamination dataset overlaying state PFAS action tracker (PFAS Project Lab,2023)

Photovoice and Story Mapping

- Showing *and* telling
 - What is most important to you?
 - How does contamination appear in your life?
 - What do you wish others knew about this issue?
- Example: Women's photovoice in Appalachian coal communities:



"Ginseng"

Ginseng grows wild in the hills of West Virginia. This piece of ginseng was found in [my community]. It weighed 7 ounces. It might not sound like much, but it isn't something one can find very often....more like once in a lifetime, if you're fortunate. In 2007, one could sell ginseng for around \$800.00 per pound. A piece this size would sell for well over \$1000.00. There is a difference between wild ginseng and cultivated ginseng. It was estimated that this particular piece was over 100 years old!



"Please Pass the Bottle Bill!"

This picture was taken [in my community] after a rain. As you can see, trash piles up against our bridges almost anytime it rains. Look at all those bottles! The biggest part of the trash we see piled up by our bridges is pop bottles and water bottles. This is really nasty to look at, and all this trash is also very hard on the wildlife in our area. If we had a bottle deposit in our state, a lot of this wouldn't be here. I would really like to see our state pass the Bottle Bill this year.



"Coal Slurry Injection Site"

This pipe is where the coal companies injected coal slurry (waste) into an old underground coal mine for storage. There are many sites like this throughout the mountains, and no one knows they are there unless they happen upon them while four-wheeling. This site is directly above my home. If it ever breaks loose, the damage will be devastating. No one has ever contacted us to inform us that this slurry injection was taking place so close to our house.



"The Changing of the Water Filter"

This photo shows what a new water filter should look like (white one) and after only three months (black one), it has become unthinkably black from something lurking in the well. My Dad says it looks like pure coal slurry water -- he should know, as he worked at a coal tippie for many years and saw first-hand what it looked and smelled like.

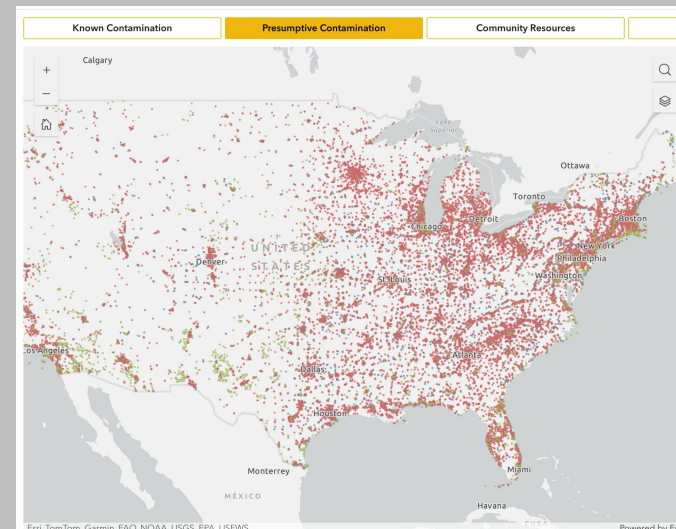
Resources

QGIS

A Free and Open Source Geographic Information System



www.qgis.org



www.pfasproject.com/pfas-sites-and-community-resources/



pubs.acs.org/journal/estlcu



Letter

Presumptive Contamination: A New Approach to PFAS Contamination Based on Likely Sources

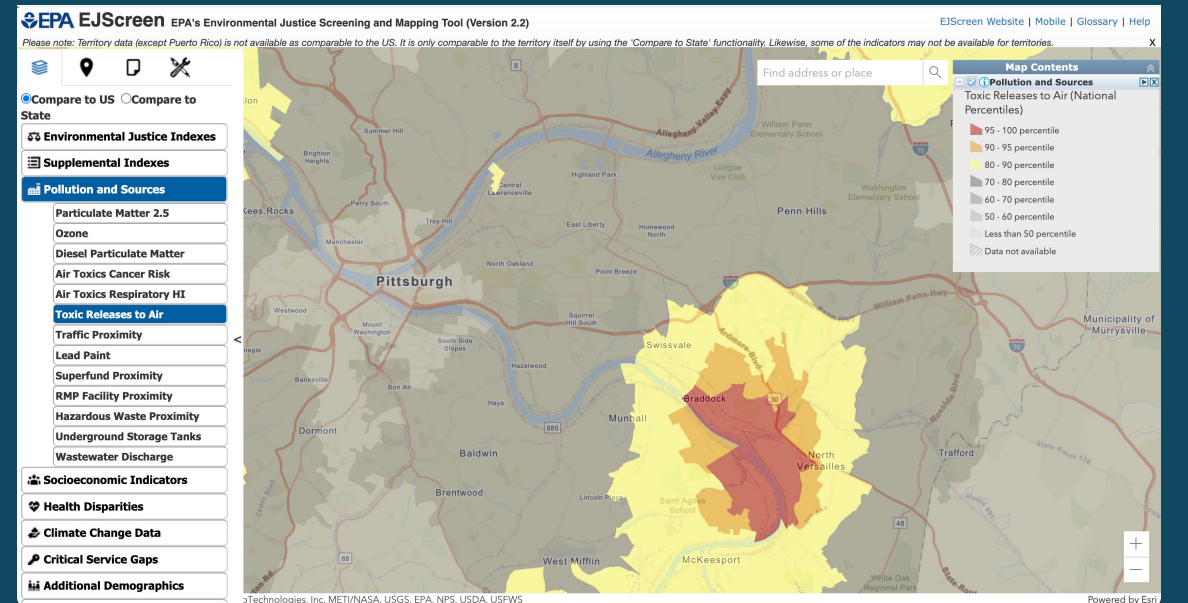
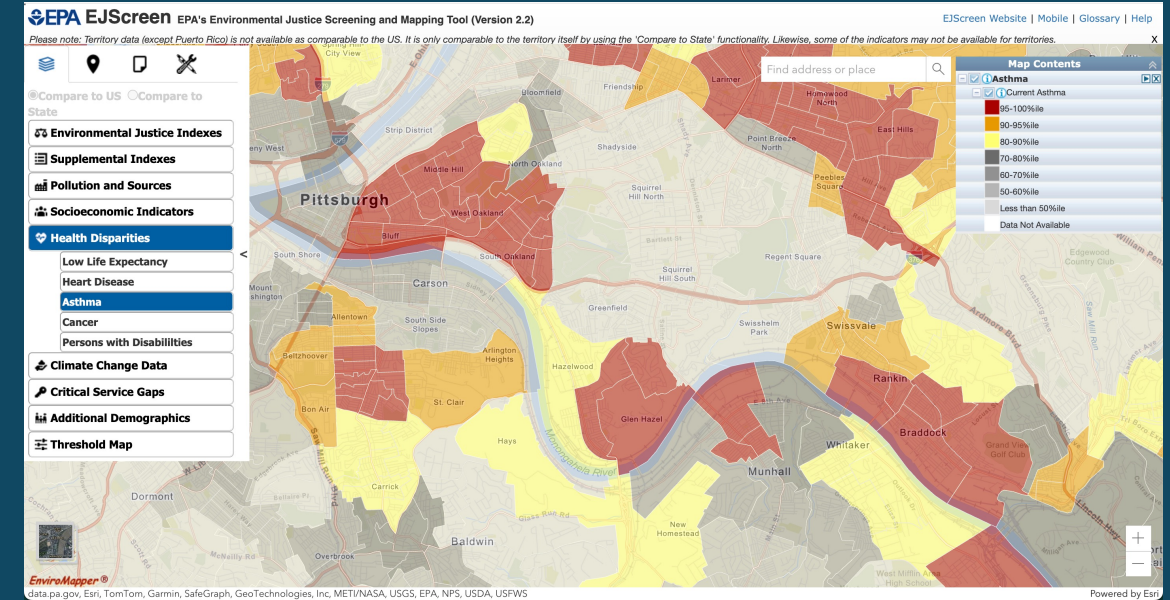
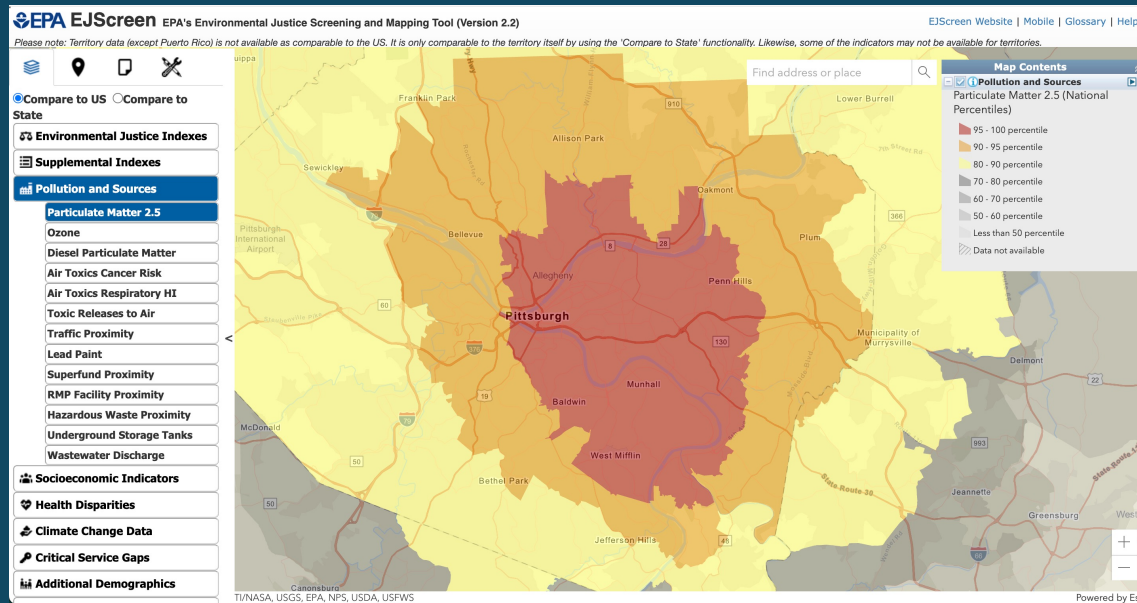
Derrick Salvatore, Kira Mok, Kimberly K. Garrett, Grace Poudrier, Phil Brown, Linda S. Birnbaum, Gretta Goldenman, Mark F. Miller, Sharyle Patton, Maddy Poehlein, Julia Varshavsky, and Alissa Cordner*

Cite This: <https://doi.org/10.1021/acs.estlett.2c00502>

[Read Online](#)

EPA EJ Screen

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



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