

# PFAS Distribution in Casco & Merymeeting Bays

**Christoph Aeppli**

*Sr Research Scientist, Bigelow Laboratory for Ocean Sciences*





# How we'll spend the next hour

- **Intro:** PFAS in the environment
- PFAS after the 2024 **BNAS Spill**
- **Sources** into Merrymeeting Bay & Casco Bay
- **Q&A**



# Thanks!

- **Friends of Merrymeeting Bay:** Ed Friedman
- **Friends of Casco Bay:** Ivy Fignoca, Heather Kenyon, Mike Doan
- **Bigelow Laboratory:** Hannah Sterling, Caitlyn Olson
- **Funding:** EPA National Estuary Program; Watershed Grant Program

# Chemist

1 1A <b>H</b> Hydrogen 1.008																	18 VIIIA <b>He</b> Helium 4.002602	
3 <b>Li</b> Lithium 6.94	4 2IIA <b>Be</b> Beryllium 9.0122																	10 <b>Ne</b> Neon 20.1797
11 <b>Na</b> Sodium 22.98976928	12 2IIA <b>Mg</b> Magnesium 24.305																	18 <b>Ar</b> Argon 39.948
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955908	22 <b>Ti</b> Titanium 47.867	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938044	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933194	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.630	33 <b>As</b> Arsenic 74.921595	34 <b>Se</b> Selenium 78.971	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.798	
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90584	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90637	42 <b>Mo</b> Molybdenum 95.95	43 <b>Tc</b> Technetium (98)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.90550	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8682	48 <b>Cd</b> Cadmium 112.414	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.710	51 <b>Sb</b> Antimony 121.760	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90447	54 <b>Xe</b> Xenon 131.293	
55 <b>Cs</b> Caesium 132.90545196	56 <b>Ba</b> Barium 137.327	57 - 71 Lanthanoids	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.94786	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.217	78 <b>Pt</b> Platinum 195.084	79 <b>Au</b> Gold 196.966569	80 <b>Hg</b> Mercury 200.592	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98040	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)	86 <b>Rn</b> Radon (222)	
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89 - 103 Actinoids	104 <b>Rf</b> Rutherfordium (267)	105 <b>Db</b> Dubnium (268)	106 <b>Sg</b> Seaborgium (269)	107 <b>Bh</b> Bohrium (270)	108 <b>Hs</b> Hassium (269)	109 <b>Mt</b> Meitnerium (278)	110 <b>Ds</b> Darmstadtium (281)	111 <b>Rg</b> Roentgenium (282)	112 <b>Cn</b> Copernicium (285)	113 <b>Nh</b> Nihonium (286)	114 <b>Fl</b> Flerovium (289)	115 <b>Mc</b> Moscovium (289)	116 <b>Lv</b> Livermorium (293)	117 <b>Ts</b> Tennessine (294)	118 <b>Og</b> Oganesson (294)	

Atomic Number → 1

Symbol ← **H**

Name → Hydrogen

Atomic Weight ← 1.008

State of matter (color of name)  
 GAS LIQUID SOLID UNKNOWN

Subcategory in the metal-metalloid-nonmetal trend (color of background)  
 Alkaline metal Alkaline earth metal Metalloid Noble gas  
 Lanthanide Actinide Polyatomic nonmetal Unknown chemical properties  
 Transition metal Post-transition metal Diatomic nonmetal

57 <b>La</b> Lanthanum 138.90547	58 <b>Ce</b> Cerium 140.196	59 <b>Pr</b> Praseodymium 140.90766	60 <b>Nd</b> Neodymium 144.242	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92535	66 <b>Dy</b> Dysprosium 162.500	67 <b>Ho</b> Holmium 164.93033	68 <b>Er</b> Erbium 167.259	69 <b>Tm</b> Thulium 168.93422	70 <b>Yb</b> Ytterbium 173.045	71 <b>Lu</b> Lutetium 174.9668
89 <b>Ac</b> Actinium (227)	90 <b>Th</b> Thorium 232.0377	91 <b>Pa</b> Protactinium 231.03688	92 <b>U</b> Uranium 238.02891	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (260)



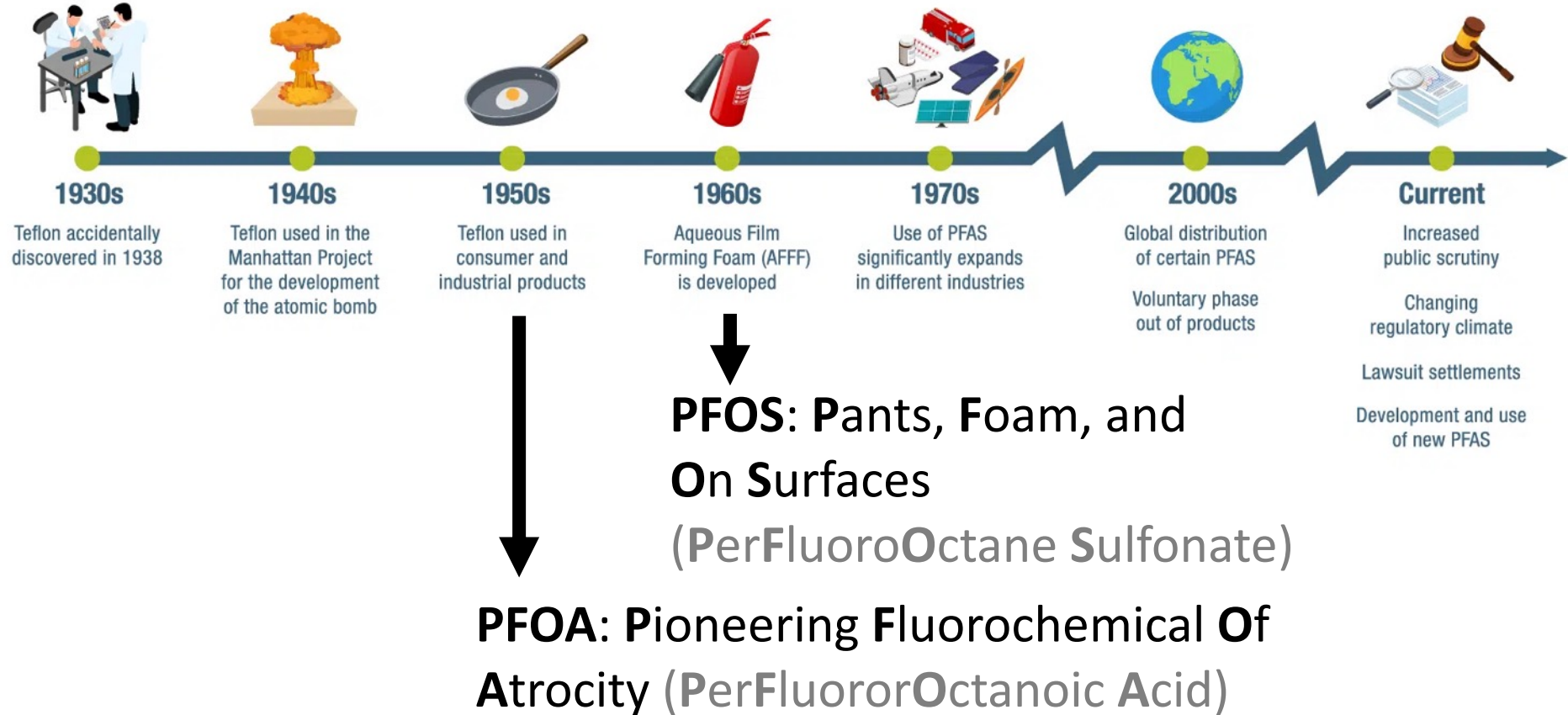


# PFAS: Per- and PolyFluoroAlkyl Substances

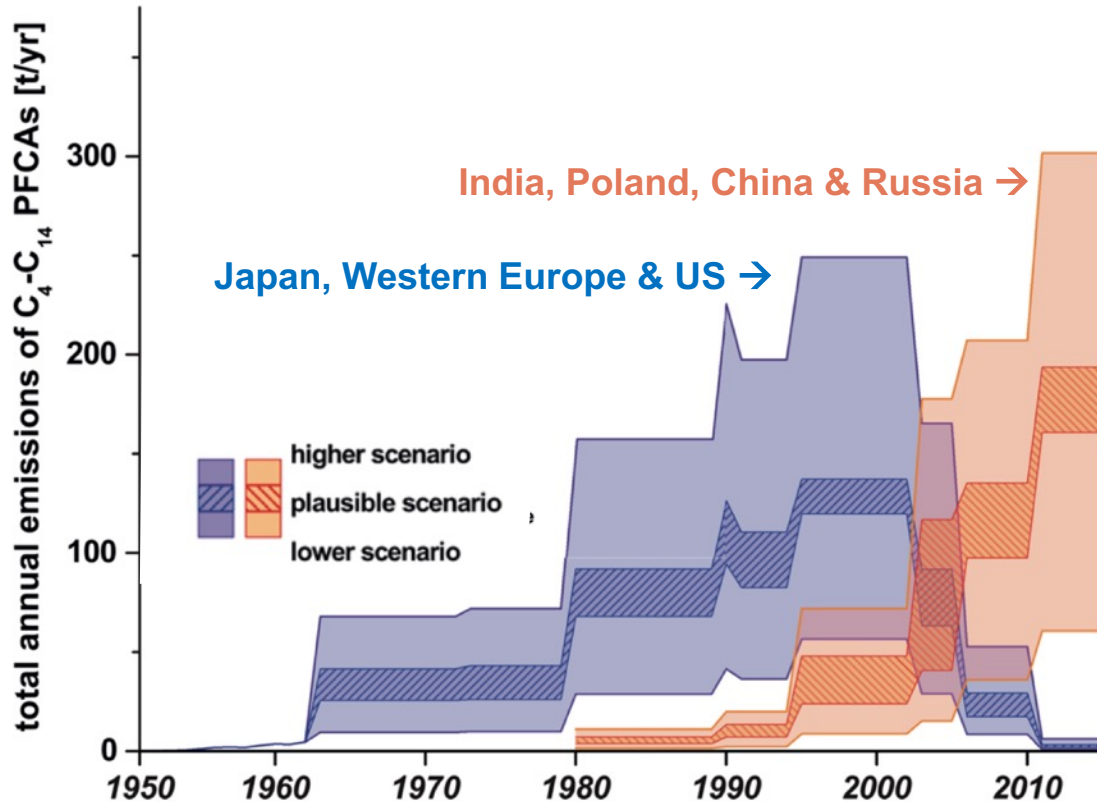


# PFAS Development ...

# ...and Evolution



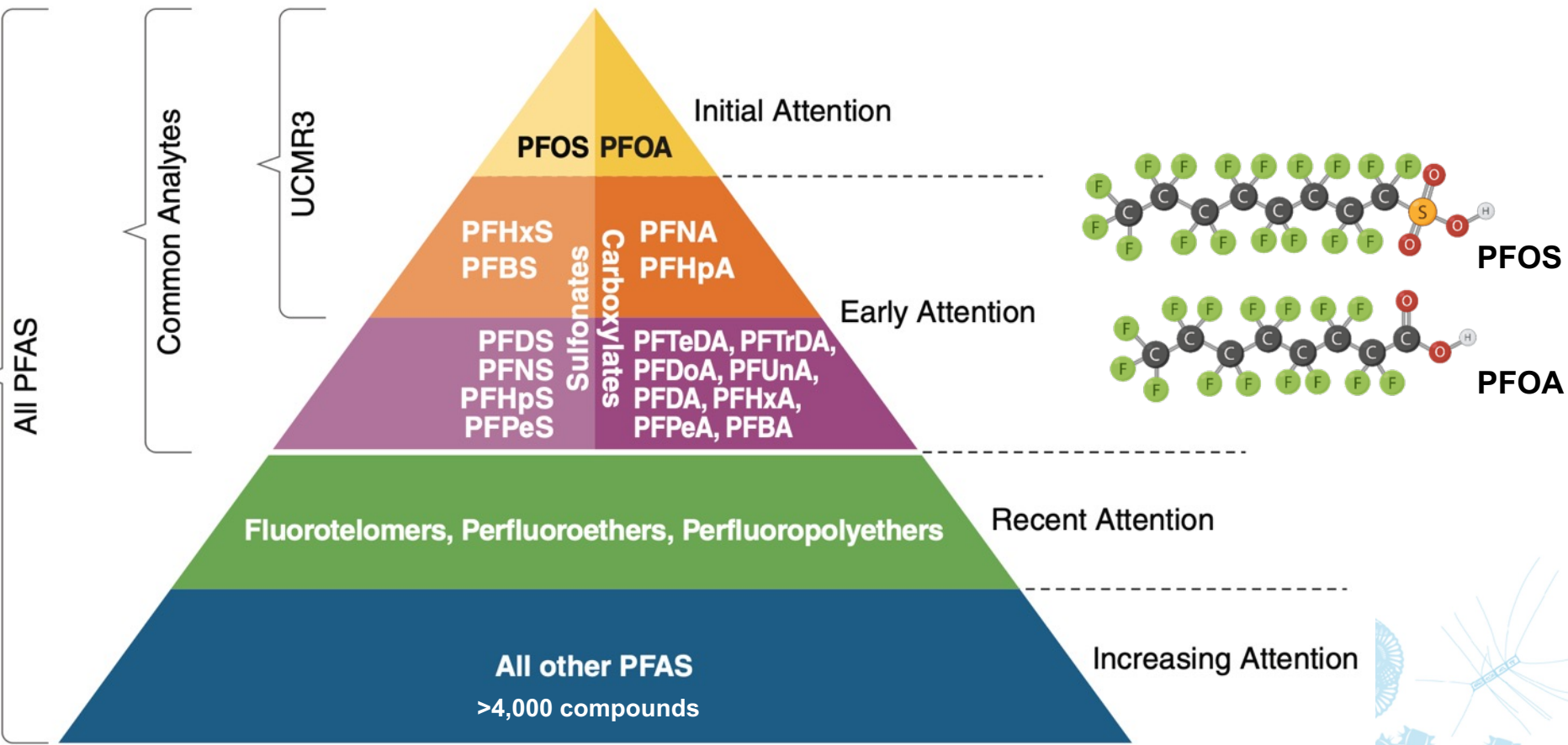
# PFAS Production Worldwide



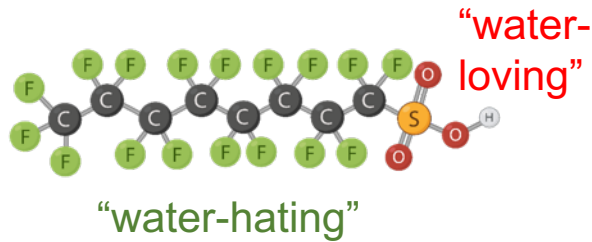
Some countries started banning some PFAS

... but they are still produced.

# PFAS: 4000+ Compounds

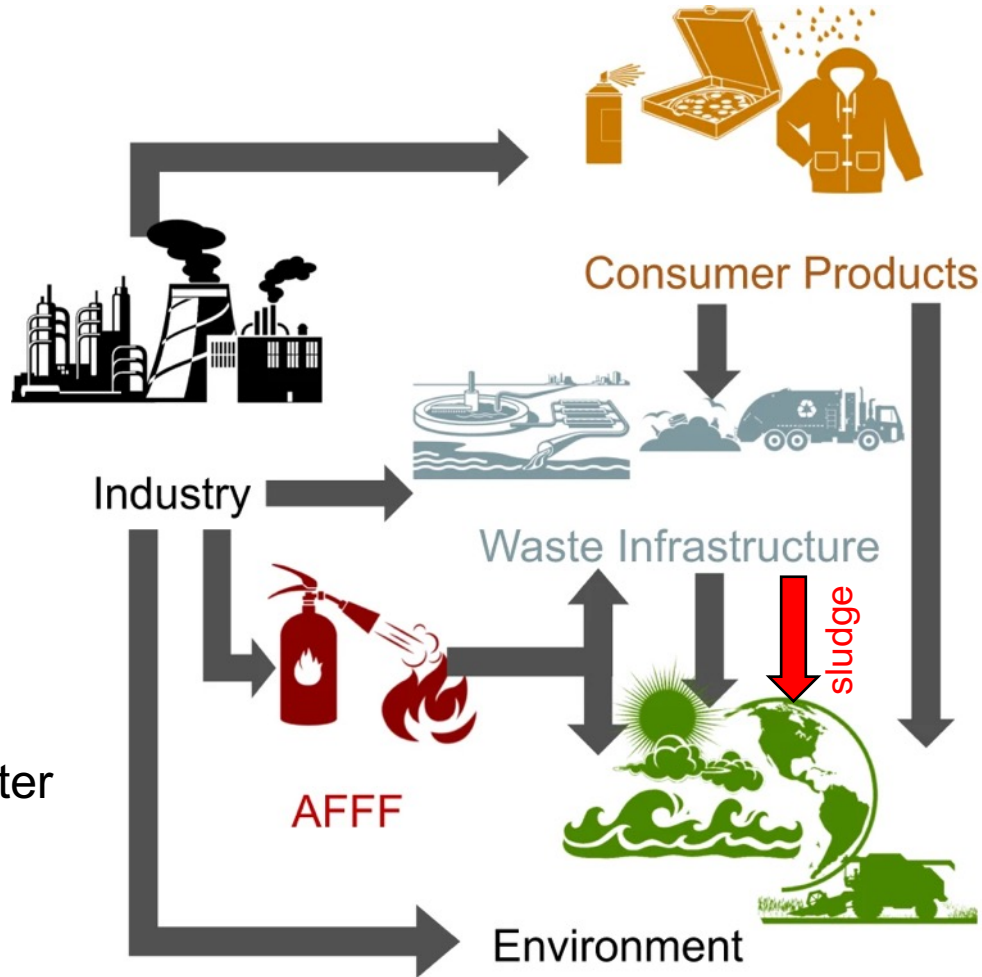


# How Do PFAS Get into the Environment?

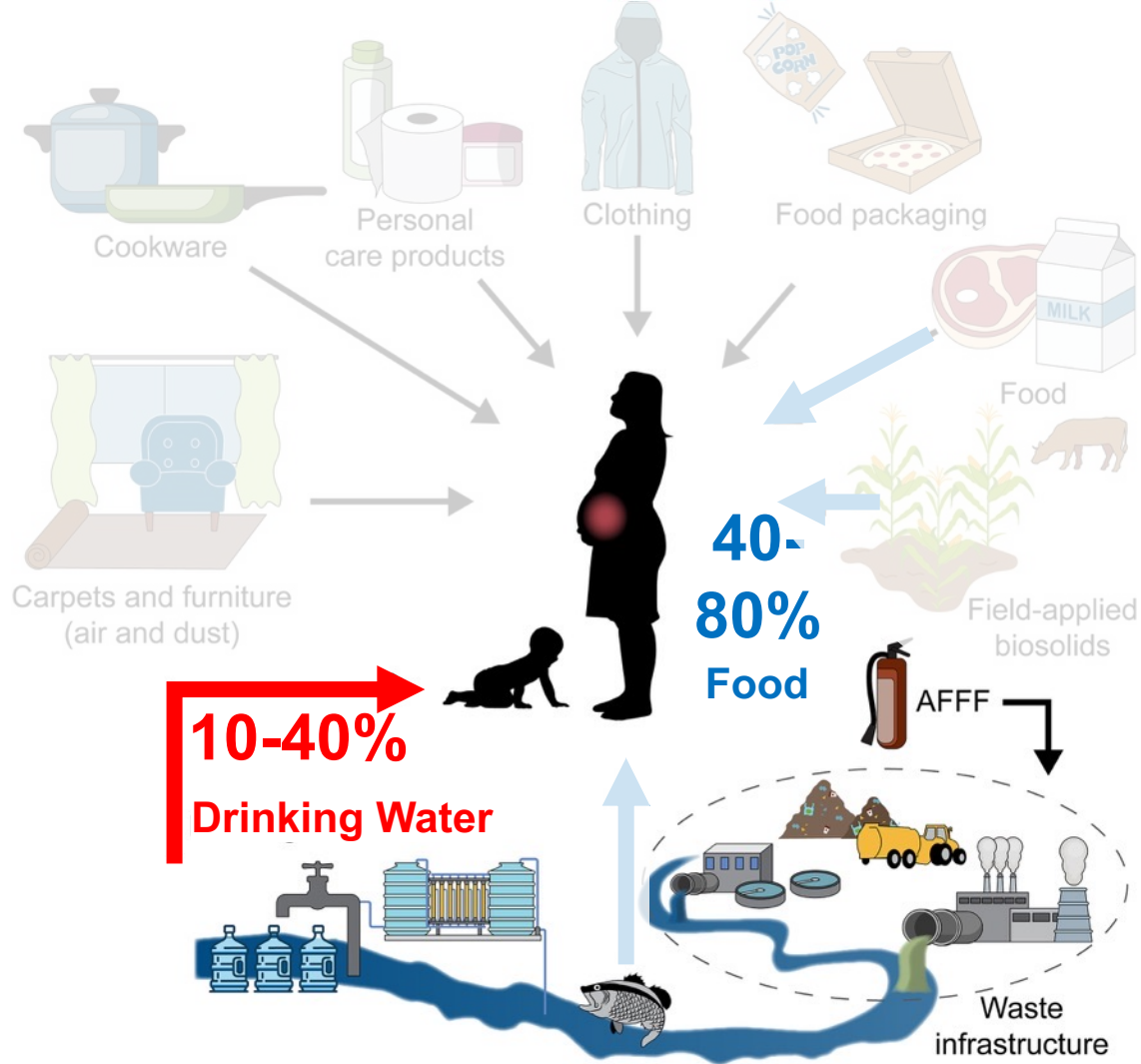


**AFFF:** Aqueous Film-Forming Foams (firefighting foams)

**Sludge** (“biosolids”): Wastewater treatment solids; was used for fertilizing agricultural fields

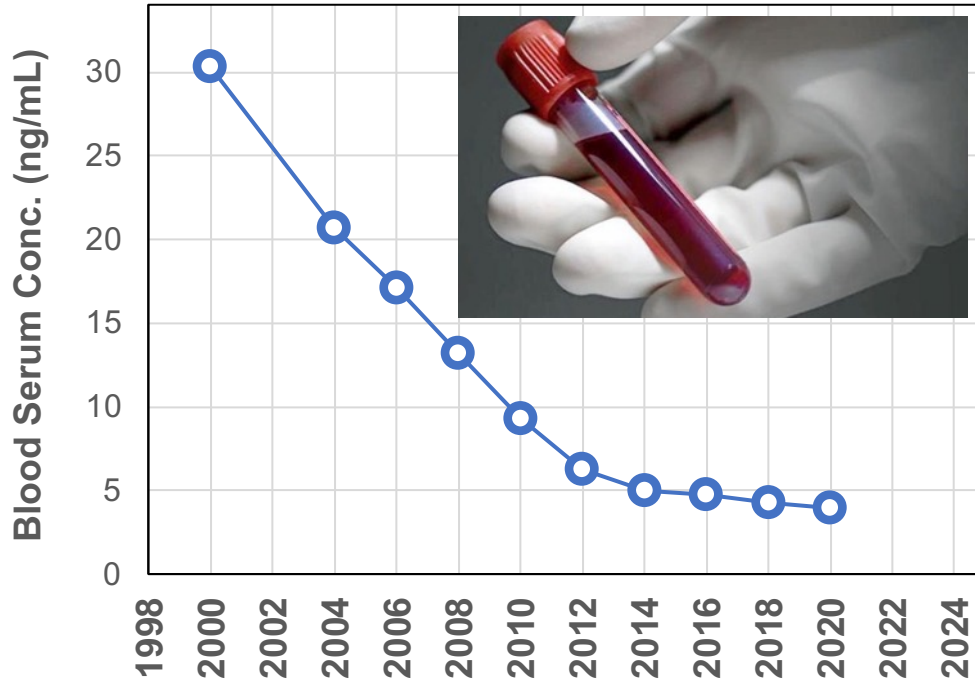


# How Do We Get Exposed to PFAS?



# PFOS in our Blood

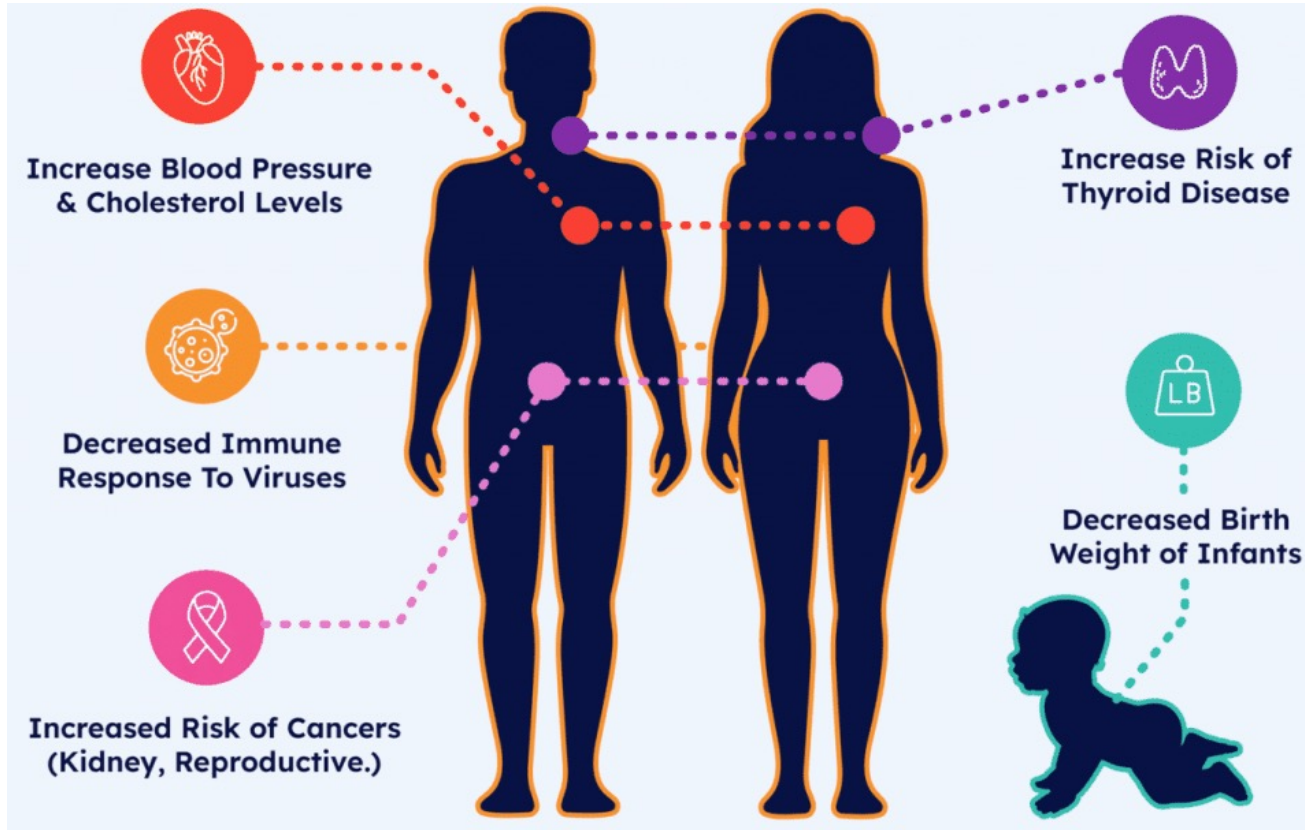
1 ng = 0.000,000,001 g  
one billionth of a gram



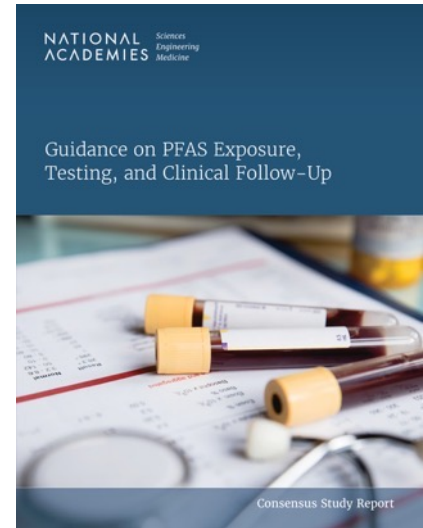
Detected in **>99%**  
of US Population  
(US CDC NHANES study  
2017-2020;  $n=3072$ )

**80% Decrease** in  
Concentration from  
1999 to 2020

# Health Effects of PFAS



Increased risk at serum concentrations **> 20 ng/mL**



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

# PFAS in Drinking Water



## 2023-2025 EPA

15% of large and  
8% of small  
drinking water  
facilities  
> 4 ng/L

\* January 2025 UCMR5 summary

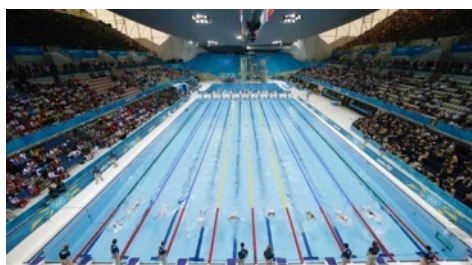


660,000 gal  
2,500,000 L

# 4 ng / L (4 ppt; 0.000,000,004 g per L)

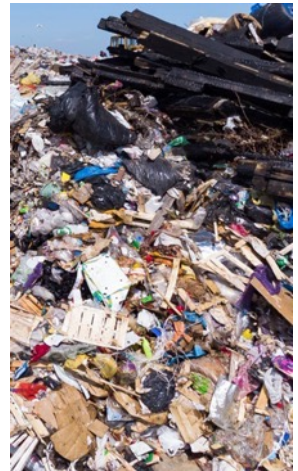
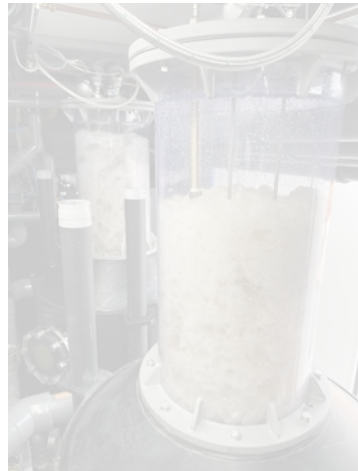
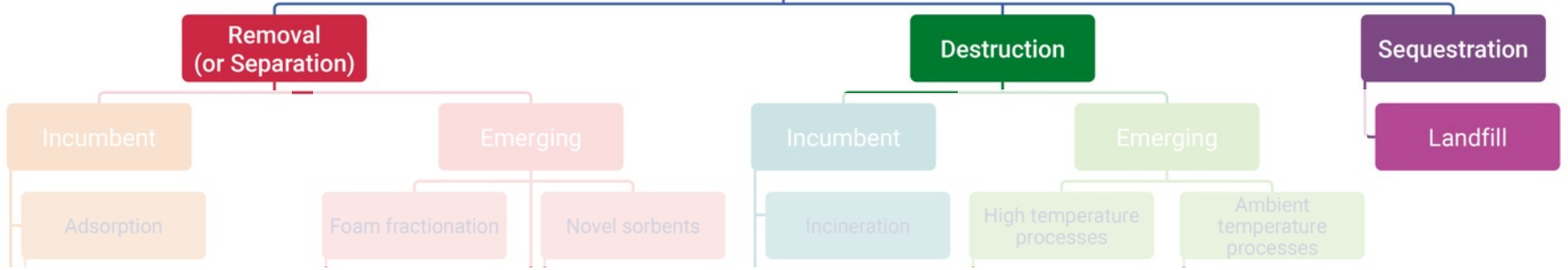


1 Pinch of Salt  
into 10 Olympic-  
sized Swimming  
Pools



# PFAS Removal

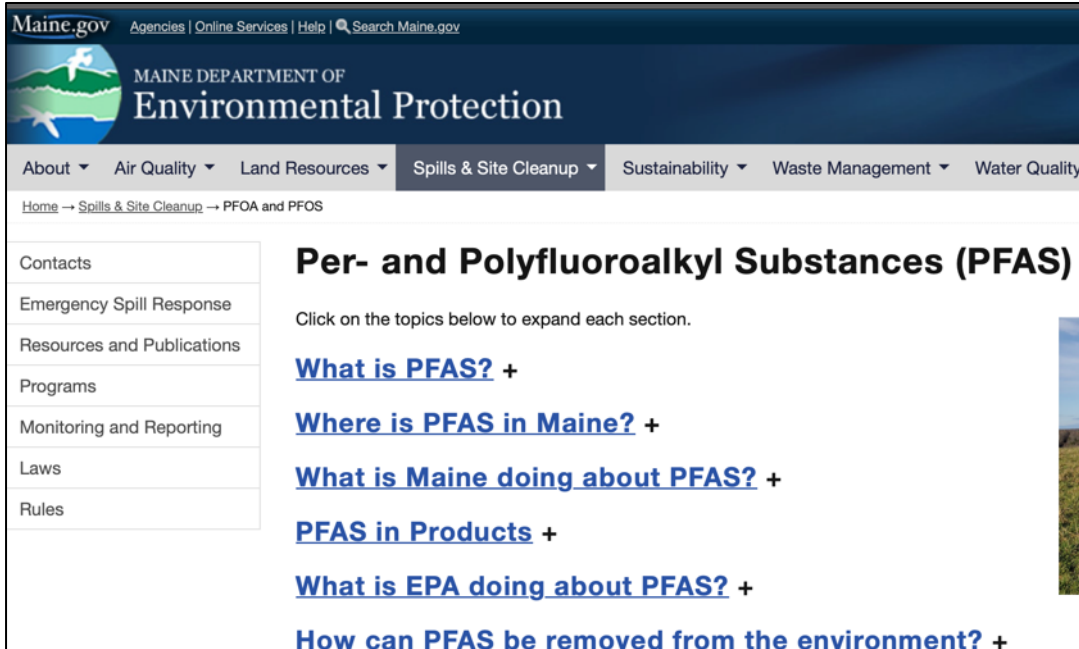
## PFAS Treatment Technologies for Contaminated Water



# What Can I Do?

## Get Information

<https://www.maine.gov/dep/spills/topics/pfas/>



The screenshot shows the Maine Department of Environmental Protection website. The header includes the Maine.gov logo and navigation links for Agencies, Online Services, Help, and Search. The main title is "MAINE DEPARTMENT OF Environmental Protection". The navigation menu includes About, Air Quality, Land Resources, Spills & Site Cleanup (selected), Sustainability, Waste Management, and Water Quality. The breadcrumb trail is "Home → Spills & Site Cleanup → PFOA and PFOS".

### Per- and Polyfluoroalkyl Substances (PFAS)

Click on the topics below to expand each section.

- [What is PFAS? +](#)
- [Where is PFAS in Maine? +](#)
- [What is Maine doing about PFAS? +](#)
- [PFAS in Products +](#)
- [What is EPA doing about PFAS? +](#)
- [How can PFAS be removed from the environment? +](#)

## Use PFAS-Free Product



# Reduce Exposure

## PFAS Water Sampling for Homeowners

### Can I sample my own water?

Sampling your drinking water for per- and polyfluoroalkyl substances (PFAS) can be challenging due to the prevalence of PFAS in consumer products such as water-resistant clothing, boots, gloves, sunscreen, lotions, cosmetics, and food packaging. All of these products may contain PFAS and can contaminate samples. To ensure a quality, representative sample, make sure your sample area is free of any PFAS-containing material.

### How much does it cost?

The cost of PFAS analysis typically ranges between \$250 and \$500, depending on the laboratory.

### Can I be reimbursed?

The DEP will reimburse the cost of this testing up to a certain amount only if sampling was conducted in general accordance with the DEP's sampling guidance, a Maine-accredited and DEP-approved laboratory was used, you provide the laboratory results to the DEP for review, and the source of PFAS can be tied to a DEP-licensed sludge or septage land application site or other remediation-type site as verified by the DEP.

### How do I find a laboratory?

Maine does not have in-state laboratories accredited to conduct PFAS testing. The DEP has compiled a list of Maine Laboratories that will subcontract for these services. [Maine Laboratories that Subcontract Residential](#)

### What do I ask for from the lab?

1. Explain that you want to self-test your own drinking water for PFAS.
2. Ask for "Method 537.1, modified with isotope dilution." The compound list should include a list of 28 PFAS.

**Note: To prevent contamination of your sample, make sure your hands are free of lotion and thoroughly washed. Do not wear waterproof clothing. Use nitrile gloves.**

3. Ask that the laboratory reports include all quality control information. This is generally referred to as a "Level 2 Report."
4. Ask the laboratory for an [electronic deliverable data \(EDD\)](#) in DEP's latest format. This is important if you wish to seek reimbursement.



## Recreational Freshwater Fish Anglers

STATE OF MAINE  
Department of  
Health and Human Services

Hotlines | Contact Us | Online Services | Privacy

Search MECDC SEARCH

Maine Center for Disease Control & Prevention

About Us | Diseases & Conditions | Healthy Living | Services | Data & Reports | Vital Records | Health Professionals

Home → Healthy Living → Health and Safety → Food Safety → Fish and Seafood

### Fish and Seafood

Fish are an important part of a healthy diet. However, some freshwater fish have PFAS, mercury, PCBs, and dioxins in them. The Maine Center for Disease Control and Prevention is responsible for recommending safe eating guidelines for fish based on the presence of chemicals ([MSRA 22 B 1696 I](#)). Follow the guidelines below.

- Mercury in Fish Guidelines
- PFAS in Fish Guidelines

Fish tested in several locations found levels of per- and polyfluoroalkyl substances (PFAS) above Maine CDC's recommended levels for regular consumption. Exposure to certain PFAS chemicals has been associated with:

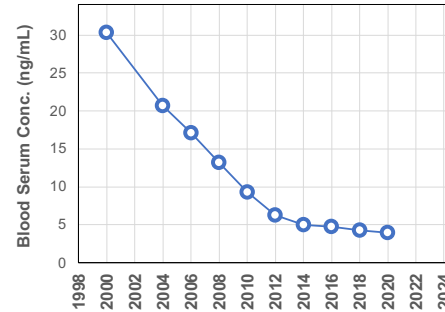
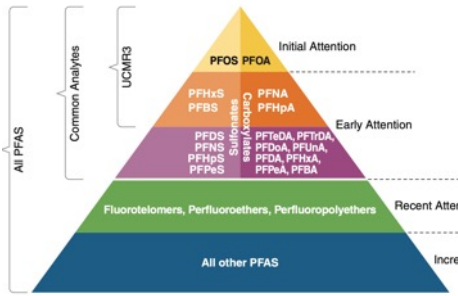
- changes in liver and kidney function
- changes in cholesterol levels
- decreased immune response to vaccines in children
- complications during pregnancy
- increased risk of kidney cancer and possibly testicular cancer

Healthy Living
Women, Infants, and Children (WIC) Nutrition
Oral Health
Maternal and Child Health
Substance Use and Behavioral Health
Health and Safety
Drinking Water Safety
Food Safety
Food Related Illnesses
Fish and Seafood
Preparing for Emergencies

<https://www.maine.gov/dhhs/mecdc/healthy-living/health-and-safety/food-safety/fish-and-seafood>

<https://www.maine.gov/dep/spills/topics/pfas/>

# Key Takeaways



Many different compounds. **Not all are equally “bad”**

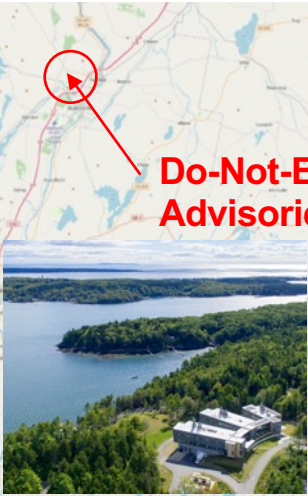
Detected and can have health effects at low doses. **What is the level of concern?**

**Regulation works** (for PFAS that are regulated...). But it takes time

**Remediation technology** exists for water and wastewater

# Monitoring PFAS in Casco Bay





**Do-Not-Eat  
Advisories for Fish**

**August 2024  
AFFF Spill  
50k gal foam**

**Bigelow** | Laboratory for  
Ocean Sciences

**Portland ME**

**Casco Bay Estuary**



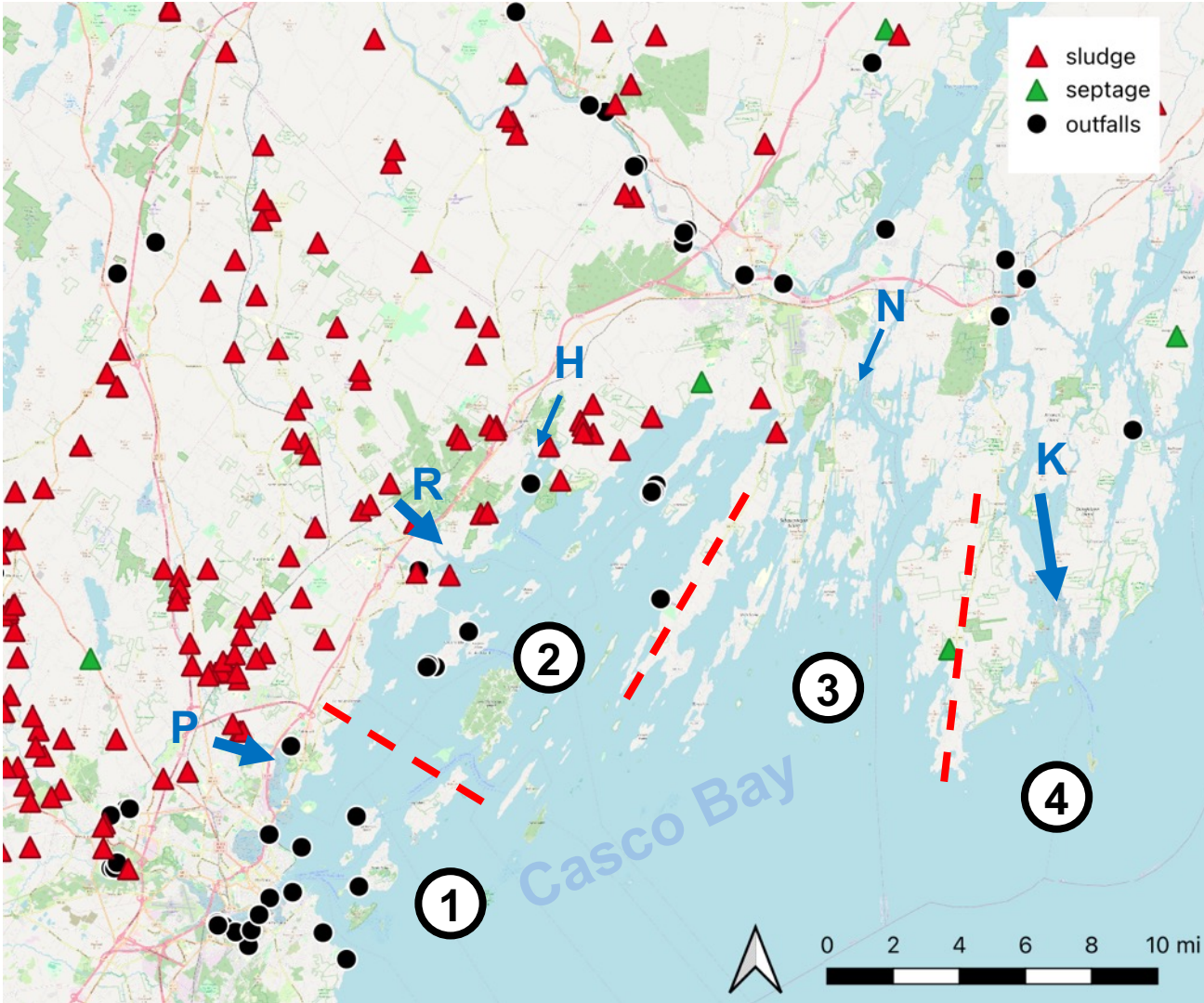
## PFAS in estuarine and coastal environments

- Receive cumulative inputs from diverse sources
- PFAS sources & fate remain understudied
- Limited data on PFAS.

# Study Area: Casco Bay

## Potential PFAS Sources

- 1) Stormwater & Industrial effluent
- 2) Agricultural runoff from **sludge spreading sites**
- 3) BNAS superfund site
- 4) Kennebec & Androscoggin **River** (runoff, WWTP)



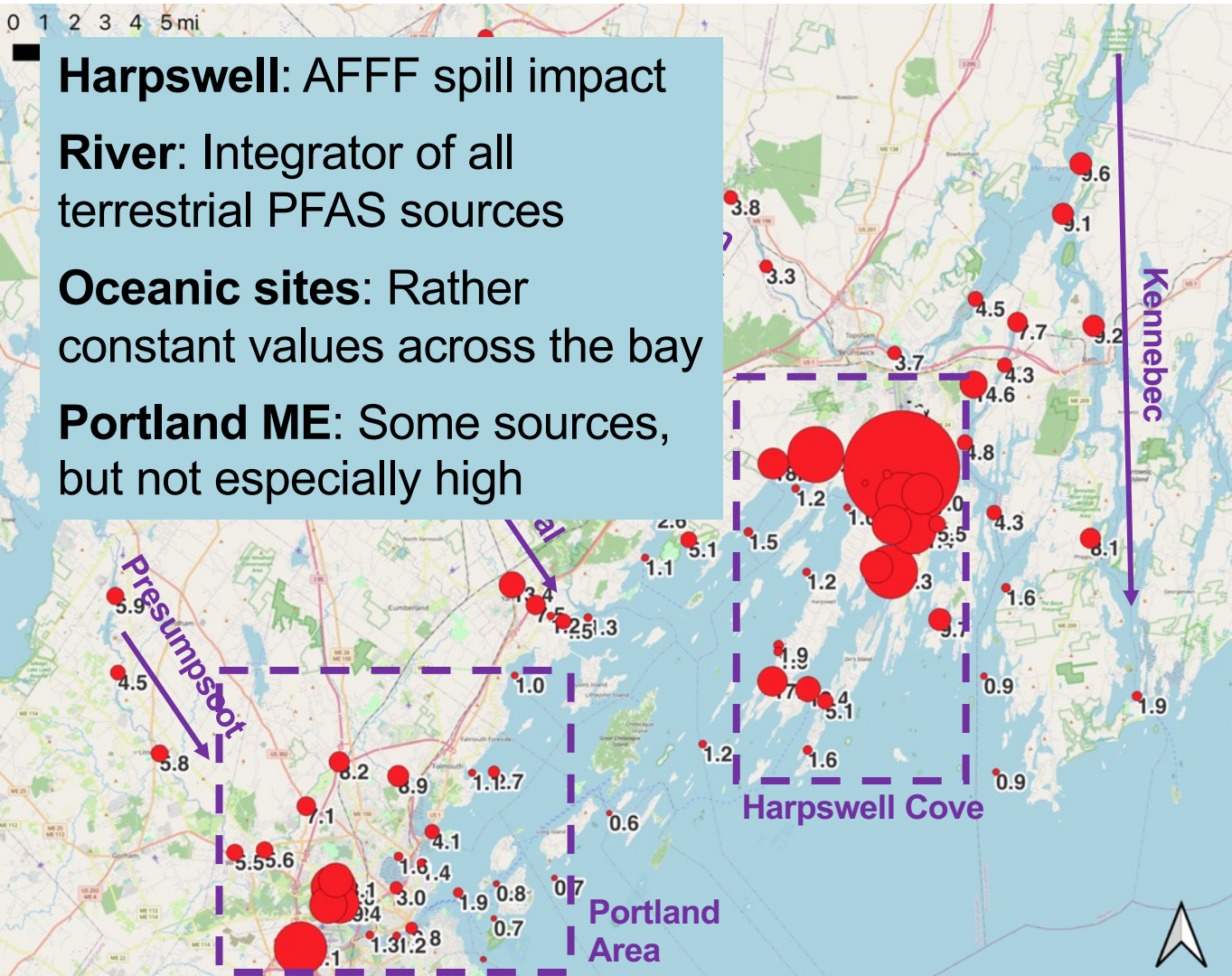


**Harpswell:** AFFF spill impact

**River:** Integrator of all terrestrial PFAS sources

**Oceanic sites:** Rather constant values across the bay

**Portland ME:** Some sources, but not especially high



# Results Overview

**Sept 9-13, 2024**  
Sum of 8 PFAS (ng/L)

**Method EPA 1633**  
Isotope dilution  
40 PFAS compounds  
Bigelow PFAS Facility  
[www.bigelow.org/pfas](http://www.bigelow.org/pfas)

**Most 8 commonly detected**  
PFOS, PFOA  
PFHxS  
PFHxA, PFHpA, PFNA  
FOSA, 6:2FTS

# PFAS after AFFF Spill

**Portland Press Herald**

WEATHER:  
Partly sunny  
with showers  
High 68  
Details, D5

\$3.00  
Tuesday,  
August 20, 2024

pressherald.com



*Shawn Patrick Ouelletto/Staff Photographer*

Firefighting foam blows through the air as workers try to clean up from a massive accidental discharge Monday at Brunswick Executive Airport. The foam filled a hangar big enough for two 747s and spilled out into the parking lot.

## Forever chemicals spew from foam spill at Brunswick airport

A malfunctioning fire suppression system discharged 1,600 gallons of firefighting foam at the former Naval Air Station. It was 4 to 5 feet deep in some places, workers said.

By **PENELOPE OVERTON**  
*Staff Writer*  
**KRISTIAN MORAVEC**  
*The Times Record*

A fire suppression system malfunctioned inside a large airport hangar at the former Brunswick Naval Air Station ear-



# 8/19/2024 PFAS Spill

**Portland Press Herald**  
\$3.00 Tuesday, August 20, 2024  
pressherald.com

WEATHER: Partly sunny with showers High 68 Low 68 Details, D6



Shawn Patrick Ouellette/Staff Photographer

Firefighting foam blows through the air as workers try to clean up from a massive accidental discharge Monday at Brunswick Executive Airport. The foam filled a hangar big enough for two 747s and spilled out into the parking lot.

## Forever chemicals spew from foam spill at Brunswick airport

A malfunctioning fire suppression system discharged 1,600 gallons of firefighting foam at the former Naval Air Station. It was 4 to 5 feet deep in some places, workers said.

By **PENELOPE OVERTON**  
Staff Writer  
**KRISTIAN MORAVEC**  
The Times Record

A fire suppression system malfunctioned inside a large airport hangar at the former Brunswick Naval Air Station ear-



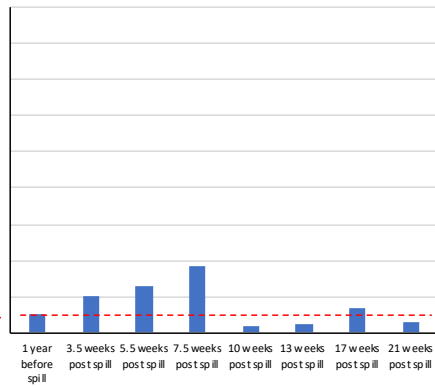
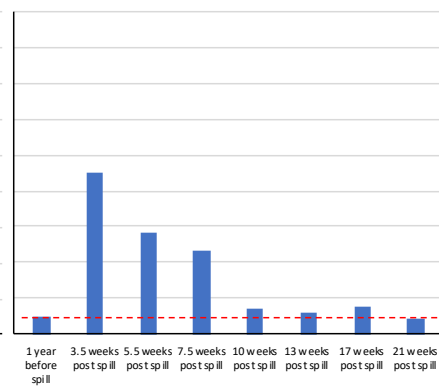
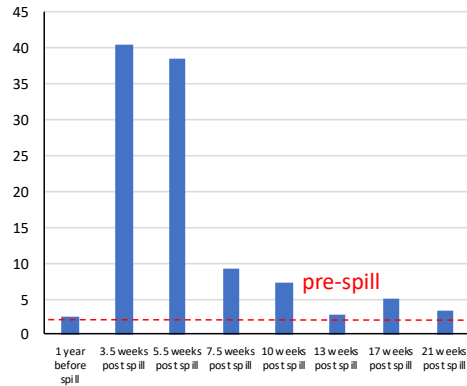
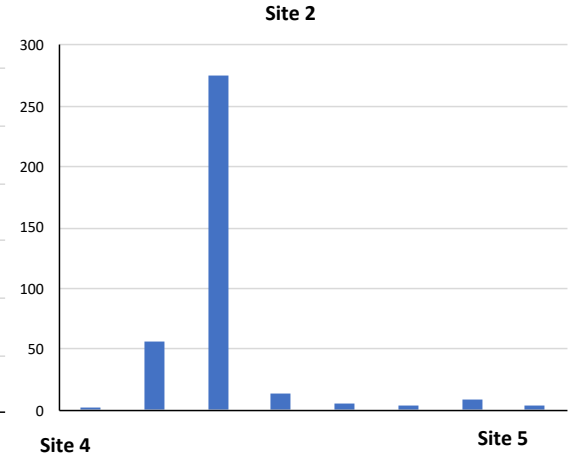
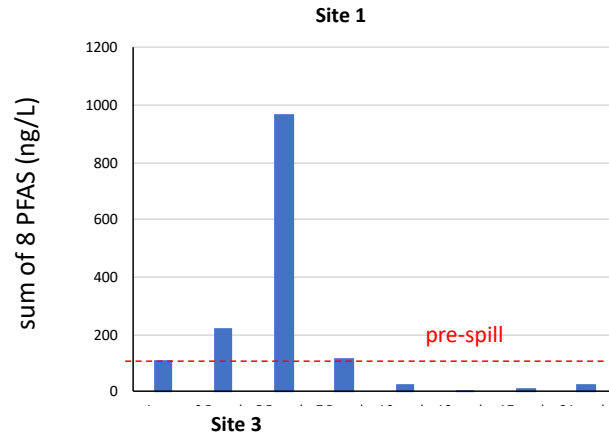
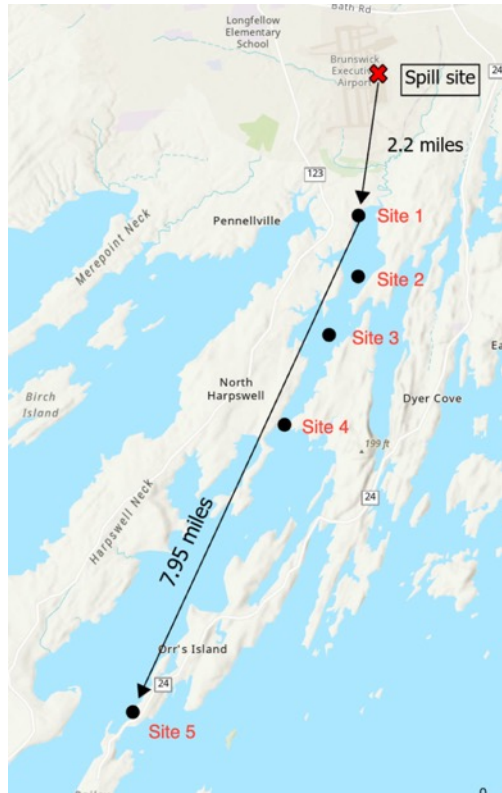
Former Brunswick Naval Air Station (**BNAS**)

Malfunctioning fire suppression system

**1,450 gal.** of aqueous film-forming foam (AFFF) mixed with **50,000 gal.** of water

**Largest AFFF spill in ME,** and the 6<sup>th</sup> in the U.S. in the past 30 years

# AFFF Impact: Harpswell Cove Transect



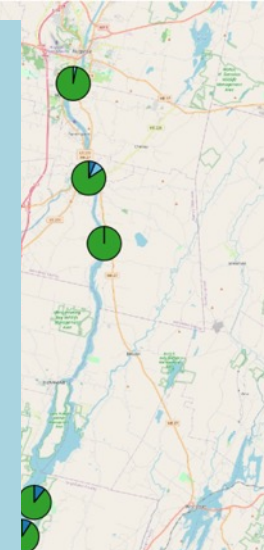
Concentrations at “pre-spill” levels after 3-4 months

**River – Ocean – AFFF:**  
three distinct source profiles

**Rivers:** Short-chain PFAS

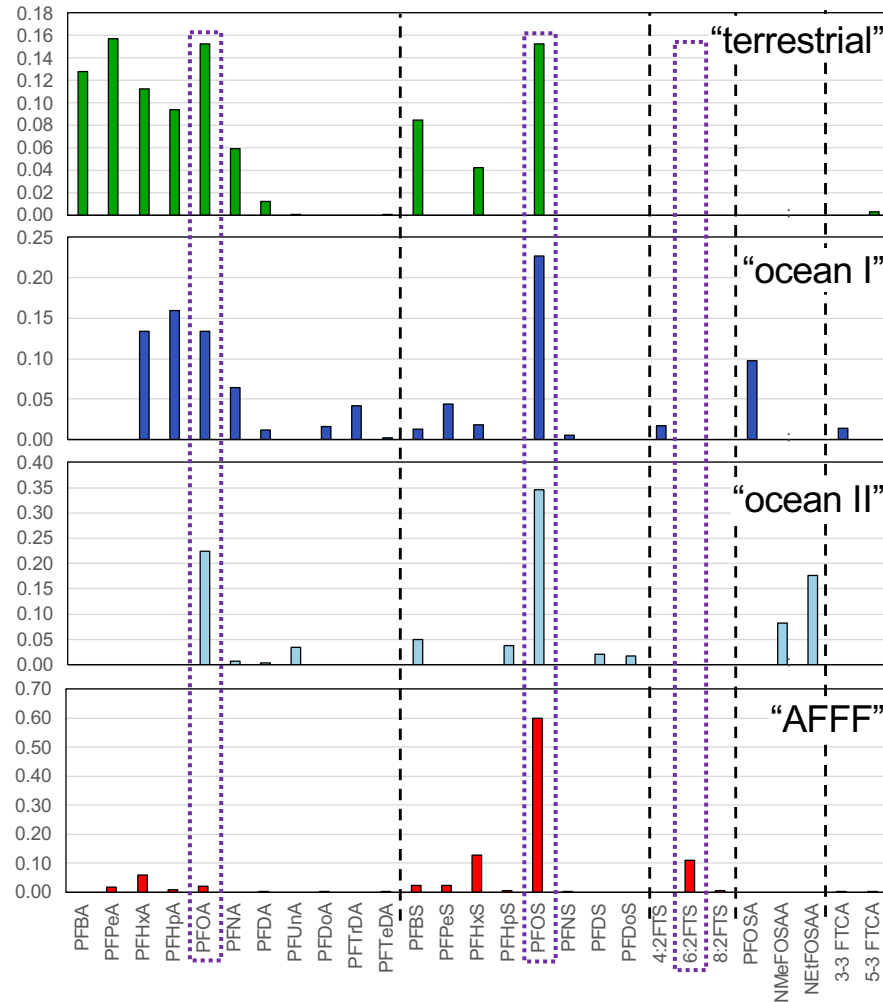
**Ocean:** Sulfonamides (less prevalent in river samples)

**AFFF profile:** Matches spilled product (6:2 FTS)

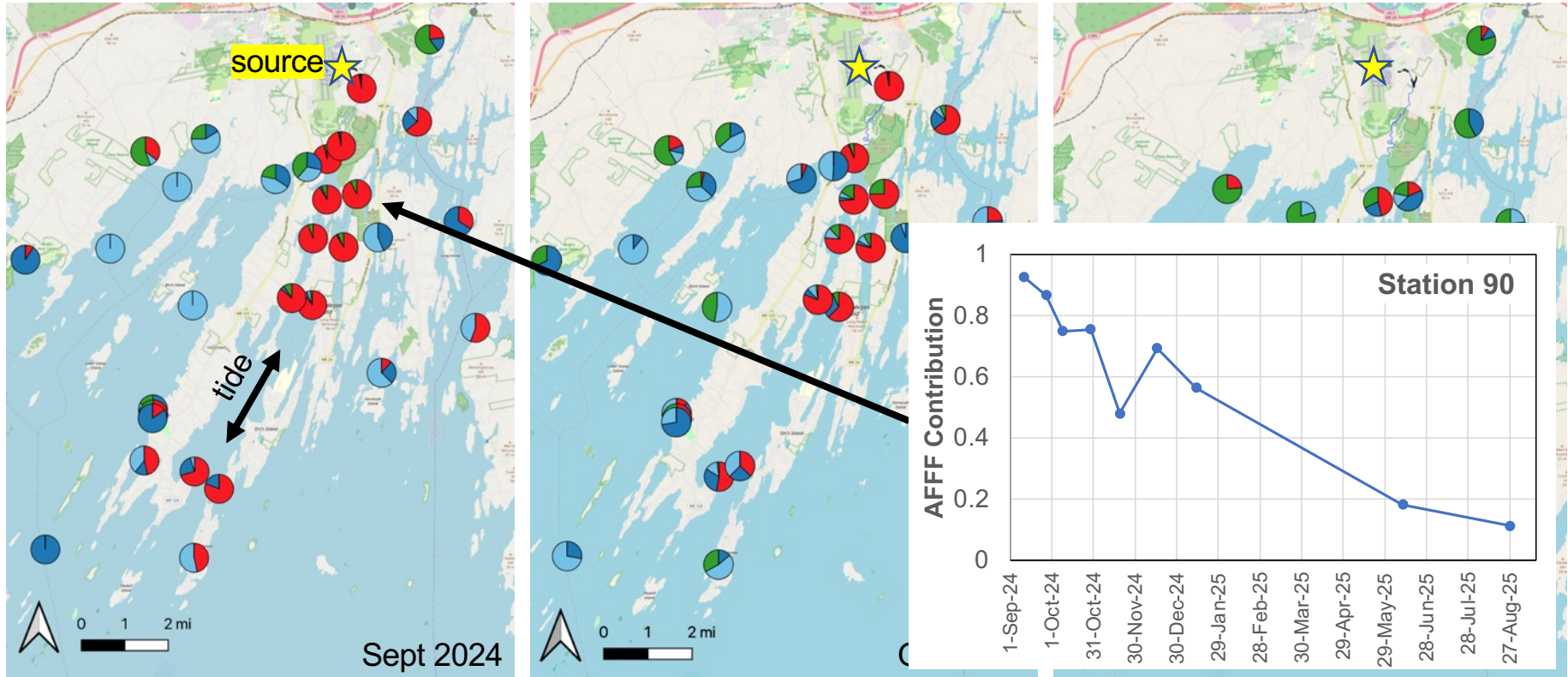


Sept 9-13, 2024

## Source Profiles



# Tracking of spill-related PFAS into Casco Bay



Dynamic AFFF source contribution over time. Decreasing AFFF signal over time.



# PFAS in Kennebec and Androscoggin







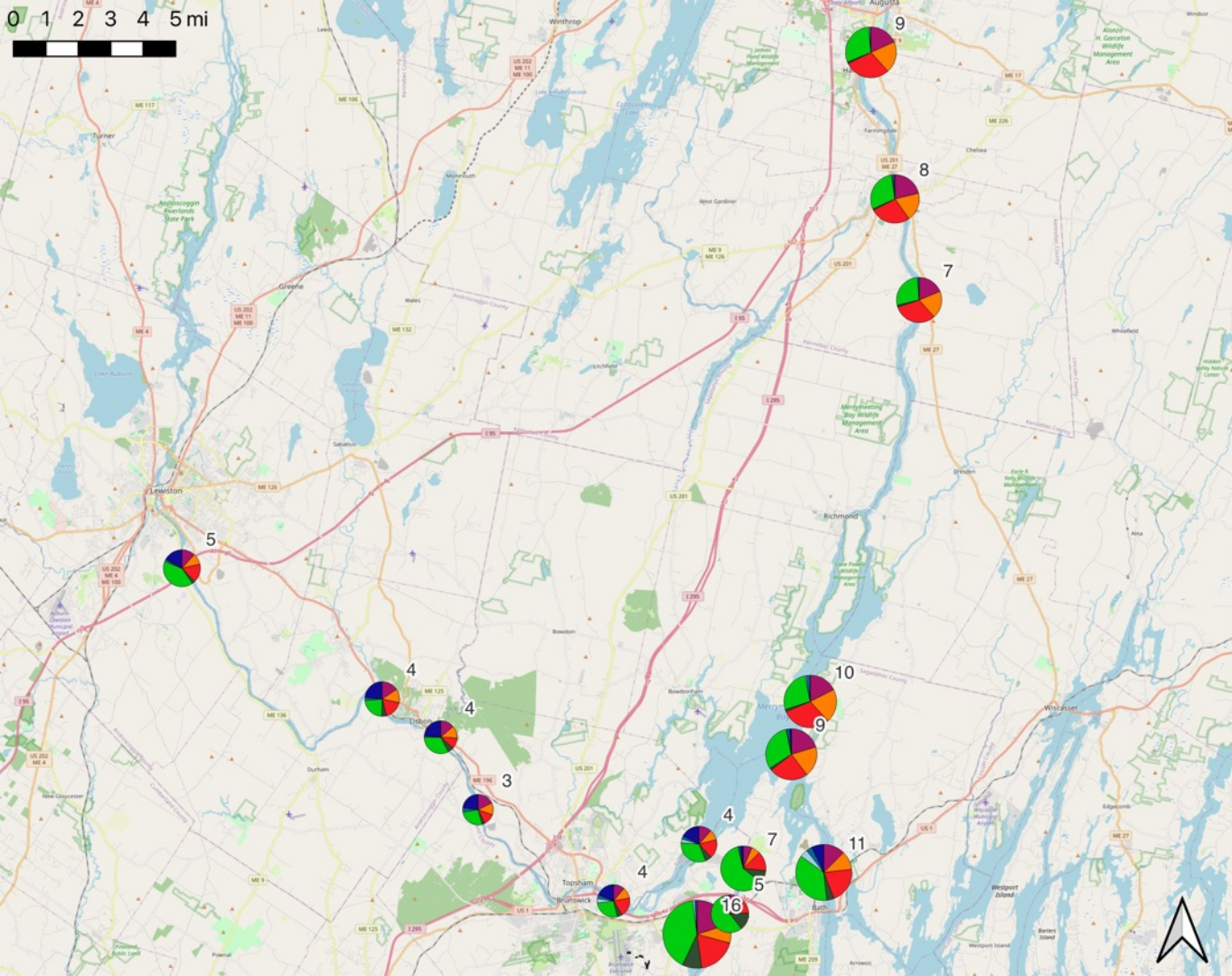




0 1 2 3 4 5mi



# September 2024

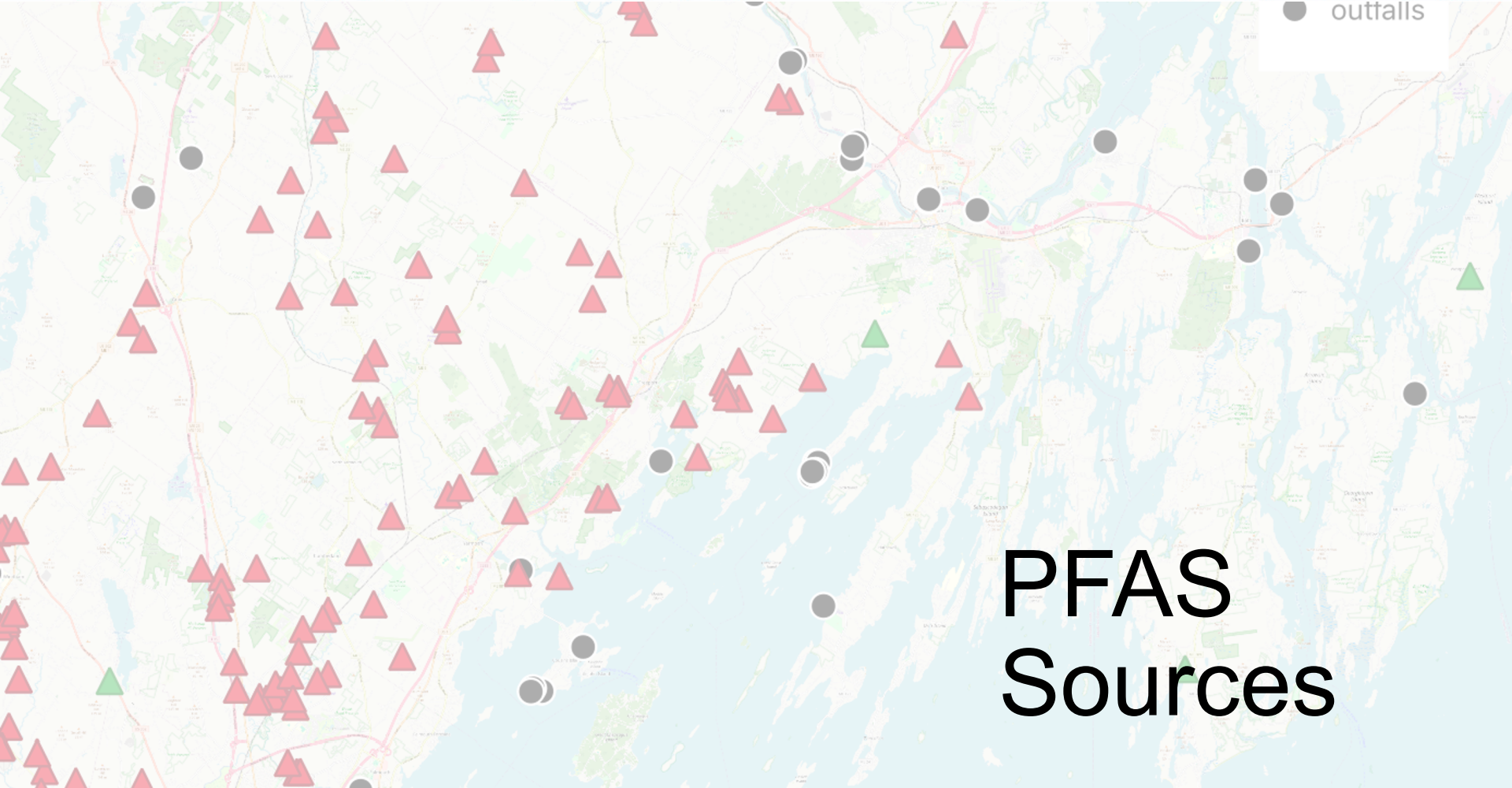


- station
- PFHxA
- PFHpA
- PFOA
- PFHxS
- PFOS
- 6:2FTS
- PFOSA
- NETFOSAA



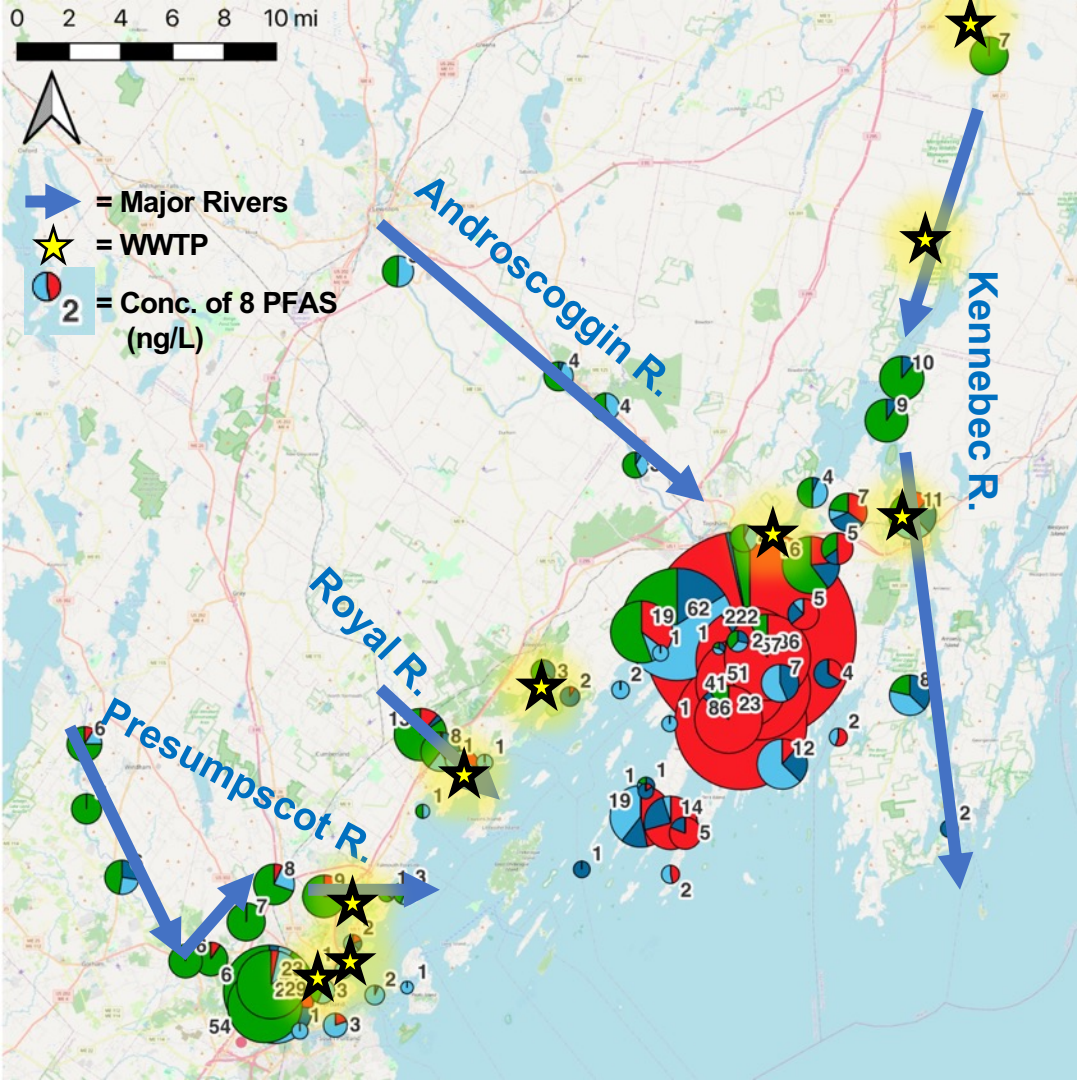






● outfalls

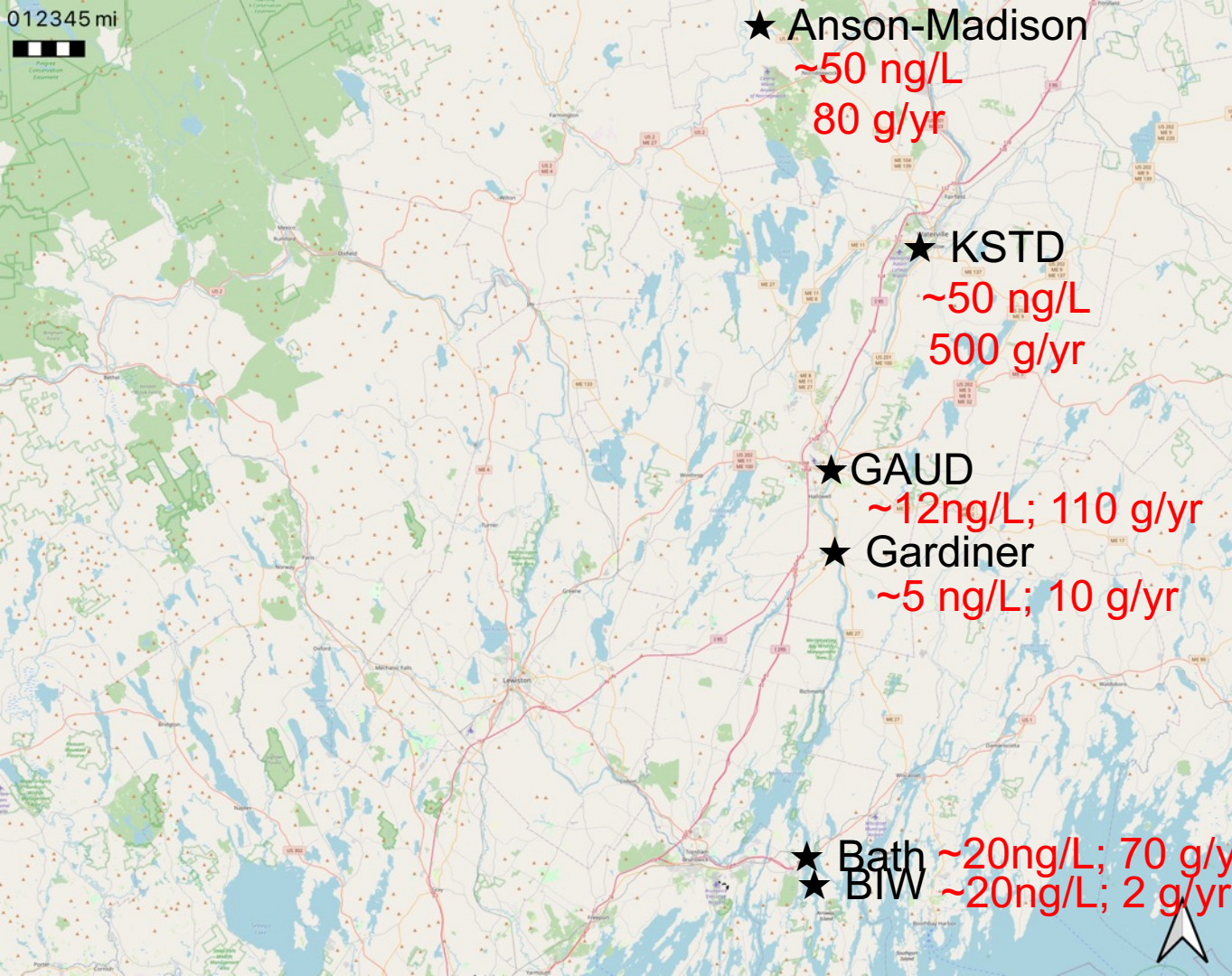
# PFAS Sources



# How important are sources for the input of PFAS into the estuary?

- **AFFF spill** input: Spilled amount as max (20 kg PFOS)
- **Rivers**: Annual flow x [PFOS]
- **WWTP into Bay**: 5 WWTP are discharging into the Bay
- **WWTP into Rivers**: 6 larger facilities into Kennebec River

012345 mi



★ Anson-Madison  
~50 ng/L  
80 g/yr

★ KSTD  
~50 ng/L  
500 g/yr

★ GAUD  
~12ng/L; 110 g/yr

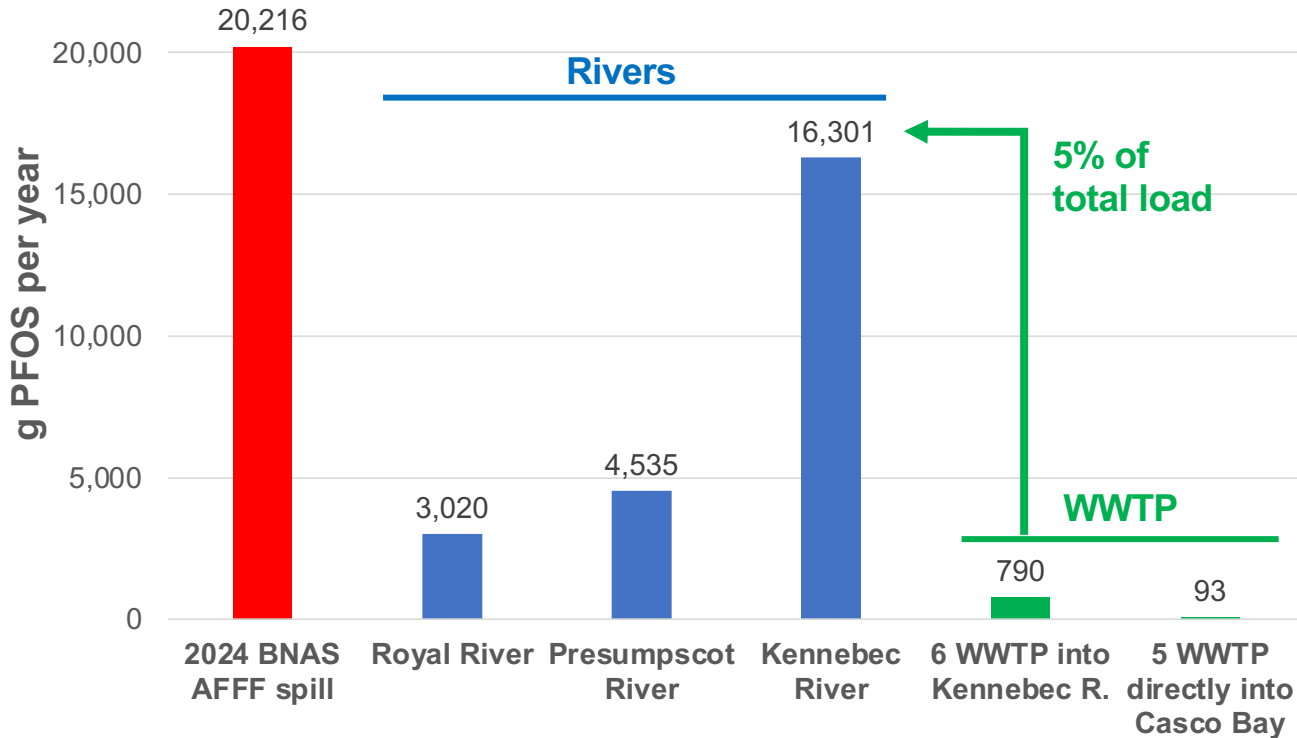
★ Gardiner  
~5 ng/L; 10 g/yr

★ Bath ~20ng/L; 70 g/yr  
★ BIW ~20ng/L; 2 g/yr

# ME-DEP PFAS Data on WWTP Effluent

ng/L PFOS in  
effluent;  
and estimated  
annual load of  
PFOS into the  
Kennebec

# Estimation: Annual PFOS Mass Flow in Casco Bay



**AFFF spills** can be a large (and preventable) source of PFOS

**Rivers** integrate many terrestrial sources

Considered **WWTPs** account for a small fraction of PFOS input

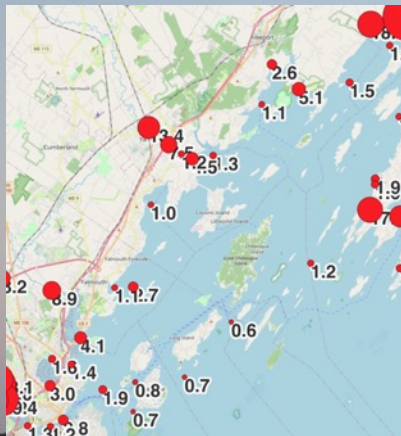
**Unidentified sources:** agricultural runoff, old landfills, other diffuse sources (groundwater? atmospheric deposition?)

# Summary

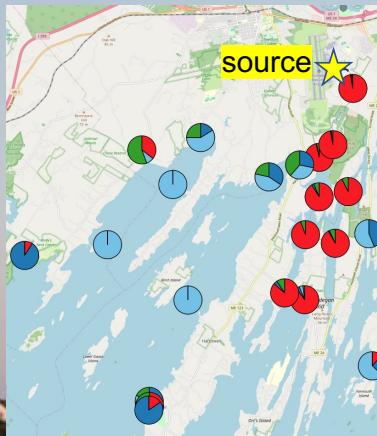
Funding



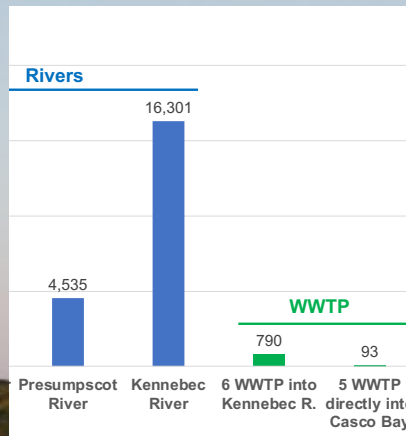
National Estuary Coastal  
Watershed Grant Program



prevalent at low  
concentrations



tracking AFFF-  
related PFAS



WWTP minor  
input in bay

Coffee with the  
Casco BAYKEEPER

March 25  
8 am

[www.cascobay.org](http://www.cascobay.org)

# Thanks for your Attention!

[caepli@bigelow.org](mailto:caepli@bigelow.org)