PFAS – Why we need to pay attention

Ned Beecher • NEBRA

June 26, 2019

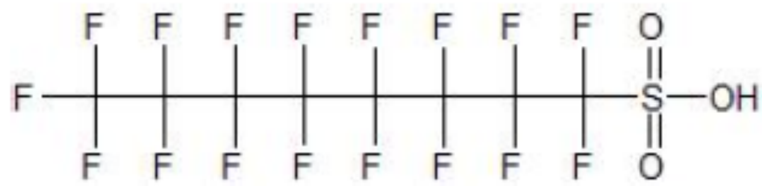
PFAS Sampling & Analysis Training
Franklin, NH

Why are PFAS a hot topic for biosolids?

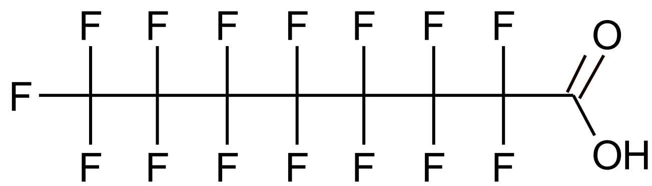
- 2000s → present: Increasing focus on PFOA & PFOS in the environment worldwide. PFOA & PFOS voluntary phase-out by 2015. Industrially-impacted biosolids contamination at Decatur, AL.
- May 2016 → EPA drinking water public health advisory (PHA) - - 70 ng/L (ppt) for PFOA & PFOS combined. Rare ppt PHA.
- State agencies look for sources → literature points to wastewater & residuals as some. (They convey PFAS.)
- Because they reflect modern life, wastewater, biosolids, & other residuals (e.g. from recycle paper mills) contain low microgram/L (ppb) concentrations of PFAS.
- PFOA & PFOS chemistry and persistence → Scant literature shows some leaching to groundwater possible at levels approaching the EPA PHA concentration → Regulators concerned. States' cursory screening sampling & analysis supports some concern. State reactions follow.
- 2107 – 2019: Public & legislative pressure drives efforts to lower the benchmark below EPA's PHA of 70 ppt, which could impact biosolids & residuals management. Pressure mounts to set biosolids screening level.

perfluorinated:

PFOS



PFOA

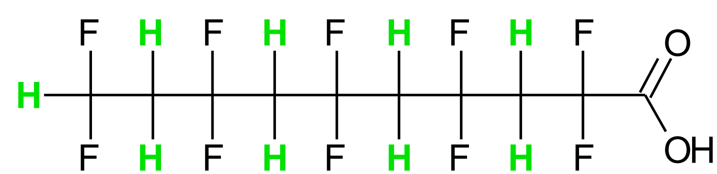


PFAS

an extreme, worst-case CEC

the only *common* trace contaminant of drinking water regulated in ppts

polyfluorinated:

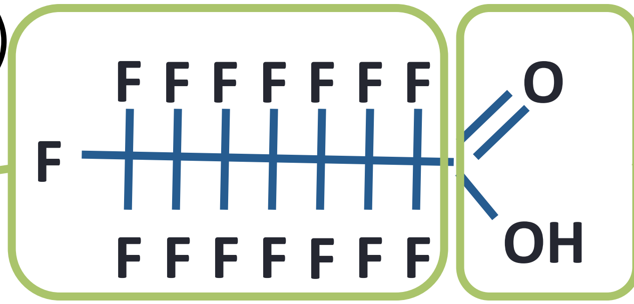


PFAS - The Basics

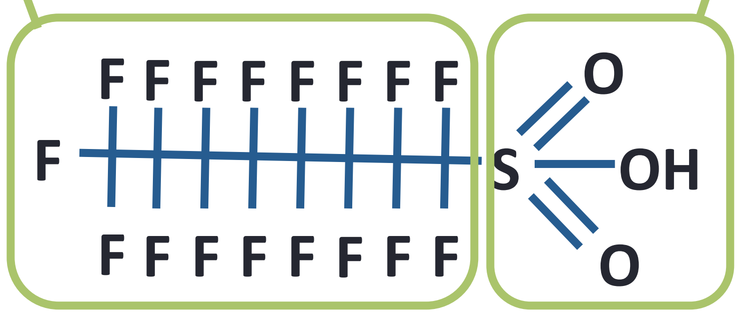
PFAS = Per- and Poly- Fluorinated Alkylated (Fluoroalkyl) Substances includes the subset of PFCs – Perfluorinated Compounds (but PFAS is a better term)

Fluorocarbon tail

- Strong bonds
- Hydrophobic
- Oleophobic
- Varying length



perfluorooctanoic acid (PFOA)



perfluorooctane sulfonic acid (PFOS)

Functional group

- Strong to weak acids
- Hydrophilic

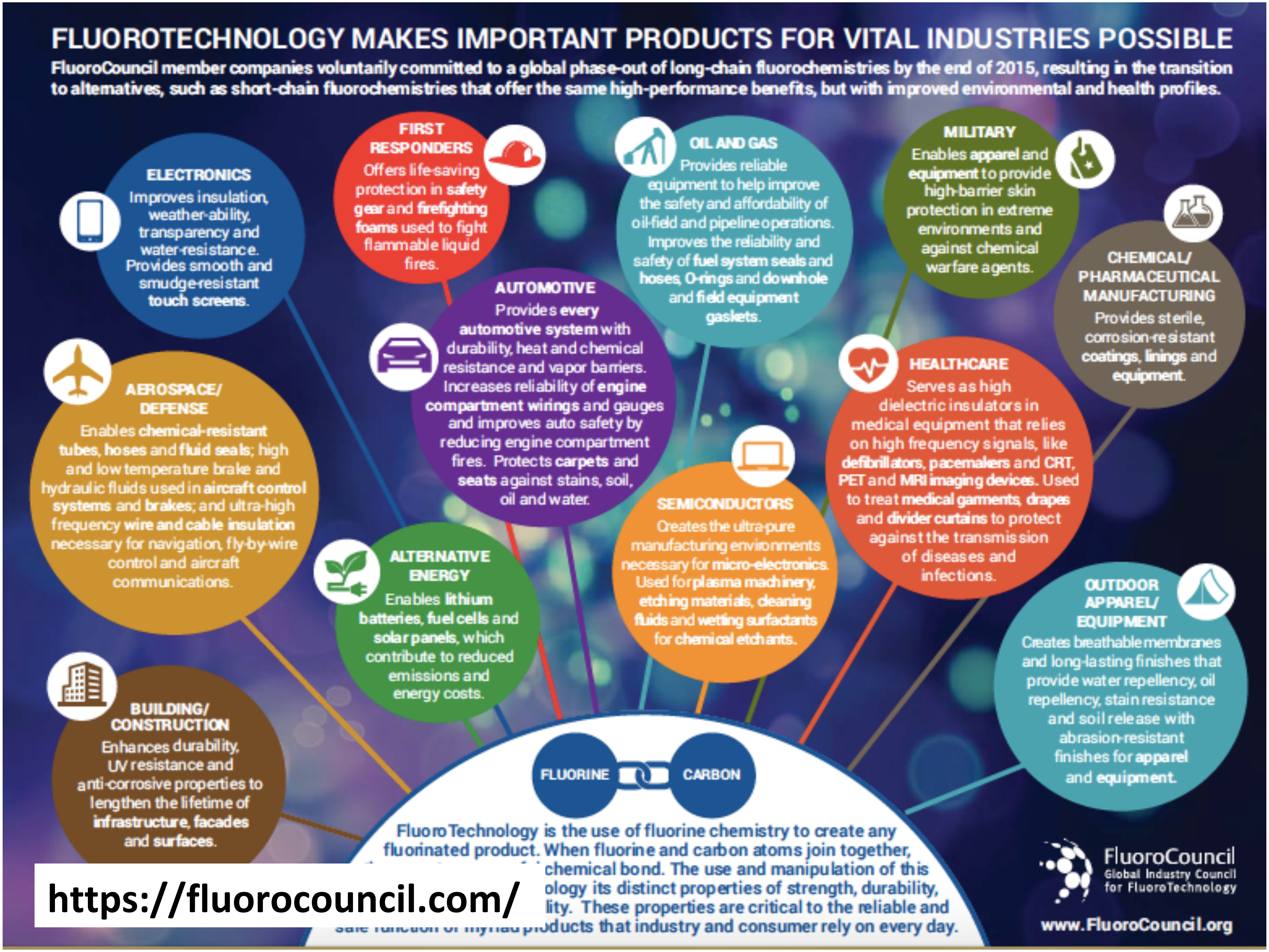
Also Note:
Precursors
& Substitutes –
Gen-X, Adona, et al.

More than 3,000 PFAS compounds identified

Slide courtesy Steve Zemba, Sanborn Head

PFAS - The Basics

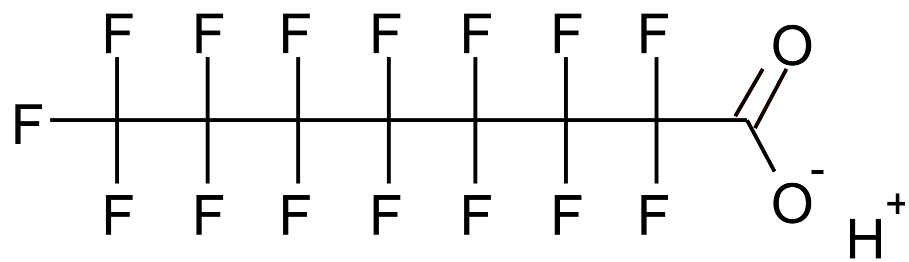
- Water soluble, hydrophobic, lipophobic, bind to proteins
- Persistent − C8 and lower versions do not degrade
- Not volatile, resists photolysis & hydrolysis
- Transport pathways: air deposition, leaching & groundwater, surface water
- Human exposure through drinking water (focus), food & food packaging, indoor dust & product exposure, use of consumer products
- Sorption & solubility differences
- 3000+ varieties, co-contaminants
- Destroyed at ~1000^{o} C
- No natural counterparts



https://fluorocouncil.com/

Long-Chain PFAS

Long-chain = have longer carbon chain lengths and include carboxylic acids C_8 and longer



Long-chain also includes sulfonic acids C_6 and longer

Long-chain compounds are a concern:

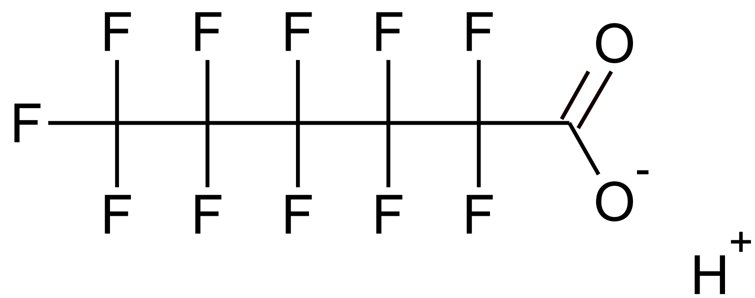
- They bioaccumulate, have long half lives in blood, and are thought to be more toxic
- But, less mobile compared to short chain PFAS.

PFOA human half-life (t½) = 3.8 years

Slide by A. Lindstrom, U. S. EPA, March 2018

Short-Chain PFAS

Short-chain = shorter carbon chain lengths and includes
carboxylic acids C_7 and shorter,
sulfonic acids C_5 and shorter



Short-chain compounds tend have shorter half-lives in blood, but they are more mobile and not easily removed during drinking water treatment.

Perfluorohexanoic acid (PFHxA) human half-life ($t½$) = 32 days.

Slide by A. Lindstrom, U. S. EPA, March 2018

Major sources of PFAS in the environment:

Parkersburg, WV

Cottage Grove, MN

EPA reaches new C8 deal with DuPont

on January 16, 2017 at 4:54 pm

The Washington Works DuPont plant in Parkersburg, West Virginia, on Wednesday, August 5, 2015. Photo: Maddie McGarvey for The Intercept/Investigative Fund

PARKERSBURG, WV — "Less than two weeks before the Obama administration leaves office, the U.S. Environmental Protection Agency on Monday said it had reached a new agreement with DuPont Co. regarding pollution of drinking water in the Mid-Ohio Valley with the toxic chemical C8 from the company's manufacturing plant near Parkersburg.

EPA said in a news release that it had amended its 2009 agreement with DuPont to reflect a lower level of C8 exposure recommended in an EPA health advisory issued last year. While more protective than the previous agreement with DuPont, the new number would allow larger

LAWSUITS CHARGE THAT 3M KN ABOUT THE DANGERS OF ITS CHI

Sharon Lerner

April 11 2016, 9:42 a.m.

FOR DECADES, 3M was the primary producer of C8, or PFOA, and was the sole producer of a related chemical known as PFOS. But while DuPont was caught up in a massive class-action suit over C8, 3M has largely avoided public scrutiny and serious legal or financial consequences for its role in developing and selling these industrial pollutants.

In February, however, a state court in Minnesota, where the company is headquartered, allowed a lawsuit against 3M to move forward. And late last year, lawyers filed a class-action suit in Decatur, Alabama, home to one of 3M's biggest plants. Both lawsuits charge that 3M knew about the health hazards posed by the perfluorinated chemicals it was manufacturing and using to make carpet coating, Scotchgard, firefighting foam, and other products – and that the company knew the chemicals were spreading beyond its sites. With PFCs cropping up in drinking water around the country and all over the world, the two lawsuits raise the possibility that 3M may finally be held accountable in a court of law.

State Attorney General Lori Swanson first filed the lawsuit against 3M on behalf of the people of Minnesota in 2010, claiming that the company polluted more than 100 square miles of groundwater near its plant in Cottage Grove, Minnesota, as well as four aquifers serving as drinking water for some 125,000 people in the Twin Cities. The suit charges that the company piped PFC-polluted wastewater into a stream that flows into the Mississippi River and disposed of it on land near the river, which allowed it to leach into the river.

Based on the company's own research, the complaint argues, 3M "knew or should have known" that PFCs harm human health and the environme[nt] that the chemicals would leach from their disposal sit[es]

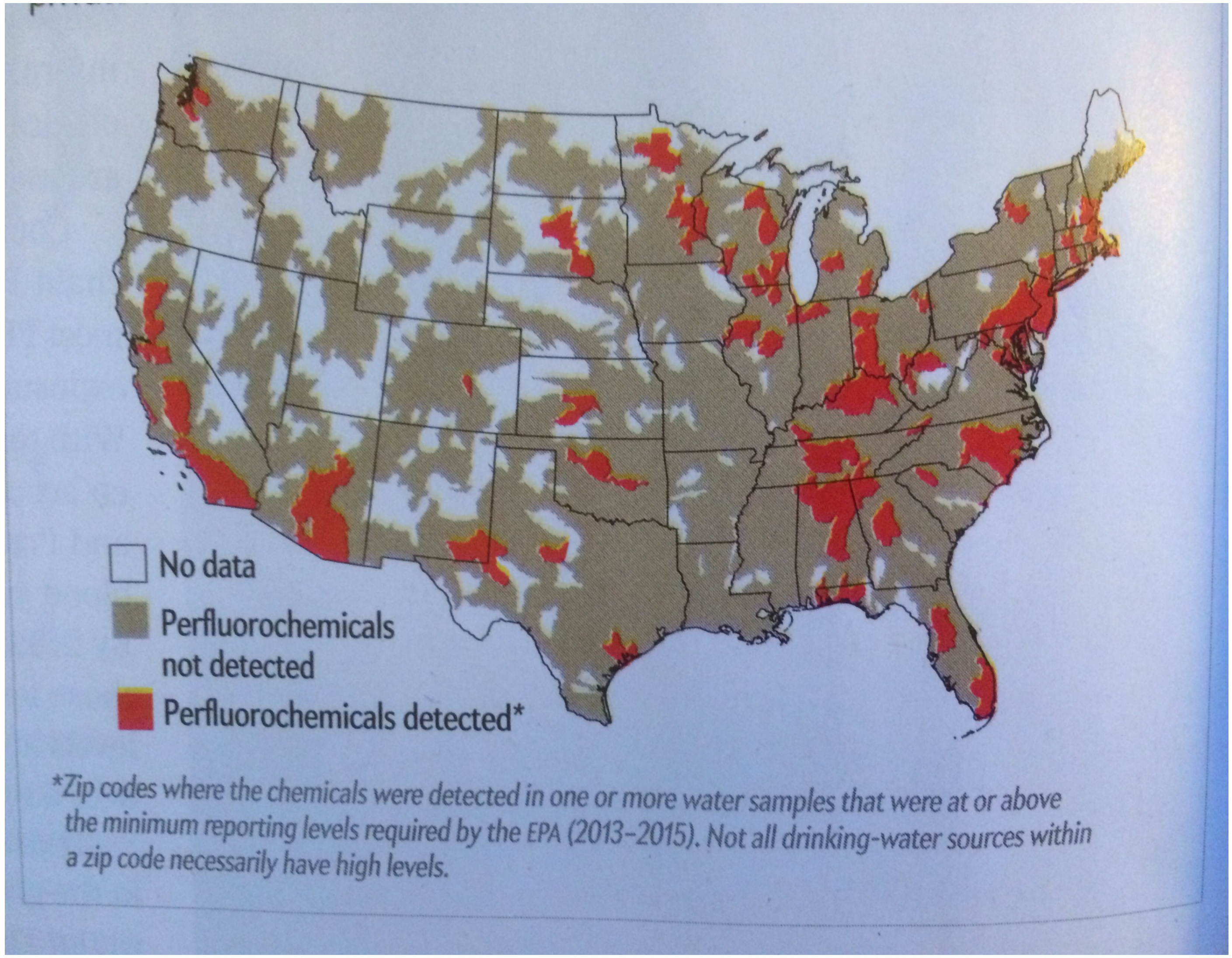
Major source of PFAS in the environment:

AFFF, Pease AFB, NH

All the white is AFFF
(PFAS-containing foam)

https://www.youtube.com/watch?v=8W_zJfJGhSI&feature=youtu.be

Known U. S. PFAS hot spots, 2016. More found since.



Wastewater & biosolids mirror modern life.

- If they contain any feedstocks from society, they contain PFAS from our modern environments. We know this now, because of advances in analytical chemistry.



Typical biosolids are part of "ambient background" levels of PFAS.

There are a few cases of large industrial inputs to WWTFs & biosolids; those are industry point sources – not typical.

Source: Dr. Bradley Clarke, RMIT, Per- and polyfluoroalkyl substances (PFAS) in Australia, Dec. 2017 slide presentation to Water Research Australia

Interstate Technology Regulatory Council's (ITRC) fact sheets

Helpful resources

http://pfas-1.itrcweb.org/

INTERSTATE TECHNOLOGY & REGULATORY COUNCIL

Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances

1 Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large group of compounds used in non stick coatings, textiles, paper products, some firefighting foams, and many other products. These compounds have many manufacturing and product applications because they repel oil and water, resist temperature extremes, and reduce friction. PFAS include compounds that vary in molecular weight and can have multiple structures and functional groups. Over the years, manufacturing and use of these compounds has resulted in their presence in the environment. More information about the manufacturing history and use of PFAS, including the two major production processes, electrochemical fluorination (ECF) and telomerization, is included in the *History and Use* fact sheet.

The scientific community is rapidly recognizing the environmental and health effects of PFAS. Some of the perfluoroalkyl acids (PFAAs), such as perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS), are mobile, persistent, and bioaccumulative, and are not known to degrade in the environment (USEPA 2003b; ATSDR 2015a; NTP 2016; Concawe 2016). USEPA has compiled an online resource for PFAS information that includes guidance on policy, chemistry and behavior, occurrence, toxicology, site characterization, and remediation technologies (USEPA 2017h). The National Groundwater Association (NGWA) has also published a resource on PFAS that includes information about fate and transport (NGWA 2017).

ITRC has developed a series of fact sheets that summarize the latest science and emerging technologies regarding PFAS. This fact sheet describes:

- four major sources of PFAS (fire training/fire response sites, industrial sites, landfills, and wastewater treatment plants/biosolids)
- processes that influence the fate and transport of PFAS from these sources in the environment (partitioning, transport, and abiotic and biotic transformation)
- processes that affect PFAS concentrations in air, surface water, groundwater, soil and sediment, and biota (plants, invertebrates, fish, and humans)

Understanding the fate and transport of a chemical in the environment is fundamental to the investigation and remediation of any contaminated site. This fact sheet focuses on how the unique chemical and physical properties of PFAS affect their behavior in the environment.

2 Major Sources of PFAS

There are four major sources of PFAS: fire training/fire response sites, industrial sites, landfills, and wastewater treatment plants/biosolids. Other point and diffuse sources of PFAS exist, and may be significant locally, but generally are expected to be small by comparison to these main four sources. This section provides a general discussion of the fate and transport processes associated with each source. Figures 1 through 3 illustrate conceptual site models (CSMs) for these four sources. Sections 3 and 4 provide specific details on the processes and media identified in the CSMs. See the *History and Use* fact sheet for information on PFAS uses, applications, and releases from each of these sources. Information about risk assessment, and human and ecological receptors is included in the *Site Characterization Considerations, Sampling Precautions and Laboratory Analytical Methods* fact sheet.

2.1 Fire Training/Fire Response Sites

Aqueous film-forming foams (AFFFs) are commercial surfactant solutions used for several decades by the U.S. military, civilian airports, and other facilities to extinguish hydrocarbon fires. In 1969, the U.S. Department of Defense (DOD) issued military specification Mil-F-24385, which dictates the performance of all AFFFs (with performance standards referred to as "Mil-Spec"). Once an AFFF was shown to perform to MIL-F-24385 requirements, the product was listed on the U.S. military's AFFF Qualified Product Listing (QPL). Since July 1, 2006, the Federal Aviation Administration has required Part 139 certified airports purchase only AFFF that is Mil-Spec compliant (FAA 2006, 2016; 14 CFR 139.317).

Multiple AFFF formulations have been produced over the years, and the exact composition of any given AFFF used or manufactured in any given year is highly variable (Backe, Day, and Field 2013). The fluorosurfactants in AFFF formulations can either be produced using the electrochemical fluorination (ECF) process or the fluorotelomerization process. Both ECF-derived and telomer-derived AFFF contain highly diverse mixtures of PFAS (Barzen-Hanson et al. 2017). The ECF process results in a PFAS mixture dominated by perfluoroalkyl acids (PFAAs)—both perfluoroalkyl sulfonate (PFSA) and perfluoroalkyl carboxylate (PFCA) homologues, while the fluorotelomerization process produces AFFF formulations dominated by polyfluorinated compounds with lesser amounts of PFAAs (Houtz et al. 2013). ECF-based AFFF formulations were voluntarily phased out of production in the United States in 2002, but DOD reportedly has

1

the level of PFAS health risk?

There is debate. That is not ours to figure out. But we are commenting to ensure no rush to judgment without good science.

PFAS Health Effects – Summary 1

Animal toxicity

- Causes liver, immune system, developmental, endocrine, metabolic, and neurobehavioral toxicity
- PFOA and PFOS caused tumors in chronic rat studies.

Human health effects associated with PFC(s) in the general population and/or communities with contaminated drinking water include:

- ↑ cholesterol
- ↑ uric acid
- ↑ liver enzymes
- ↓ birth weight
- ↓ vaccine response
- Thyroid disease
- Osteoarthritis
- Diabetes
- Testicular and kidney cancer
- Pregnancy-induced hypertension
- Ulcerative colitis
- Effects in young adulthood from prenatal exposures
  - *Obesity in young women.*
  - ↓ *sperm count in young men.*

Slide by A. Lindstrom, U. S. EPA, March 2018

PFAS Health Effects – Summary (2)

- Toxicity of PFOA & PFOS and other PFAS have uncertainties
  - Epidemiological studies and laboratory animal studies have not shown consistent and conclusive findings
  - Cancer incidence studies in NY, NH, and MN not indicative of PFAS effects
  - If PFAS is causing health effects, the effects appear to be subtle
  - Current risk-based standards/guidelines for PFOA and PFOS are protective (e.g. EPA's PHA, Health Canada's numbers)
- Reasons for concern
  - PFAS in drinking water elevates PFAS in blood
  - Little data for PFAS other than PFOA and PFOS; unknowns → caution

Slide courtesy Steve Zemba, Sanborn Head *from EPA*

Sources of PFAS Exposure for Humans

- Best documented source is contaminated drinking water near industrial production facilities or waste disposal e.g., Cottage Grove, Minnesota; Parkersburg, West Virginia; Dalton, Georgia; Decatur, Alabama; Arnsberg, Germany; Osaka, Japan *Lindstrom et al. 2011, Environ. Sci. & Technol. (45) 8015 – 8021*
- Food is also implicated in many studies, especially fish from contaminated waters, items contaminated by food packaging, and breast milk *Fromme et al. 2009, Inter. J. Hyg. & Envr. Heath (212) 239-270; Mogensen et al. 2015 , Environ. Sci. & Technol. (49) 10466 - 10473*
- House dust may also be an important route of exposure – especially for children who ingest relatively higher levels of dust via hand-to-mouth activity *Shoeib et al. 2011, Environ. Sci. & Technol. (45) 7999 - 8005*
- Workplace exposures significant for some sectors: manufacturing or services making or directly using PFAS, apparel sales, waste treatment *Nilsson et al. 2013 Environ. Sci.: Processes Impacts, 15, 814-822*

Slide by Mark Strynar, U. S. EPA October 17, 2017

Findings of the Australian Health Expert Panel – quite a contrast to current level of high concern in some of U. S.

- Limited evidence
- Associations with several health outcomes, in particular: increased cholesterol, increased uric acid, reduced kidney function, altered markers of immunological response, levels of thyroid and sex hormone levels, later menarche and earlier menopause, and lower birth weight.
- Differences between those with the highest and lowest exposures are generally small, with the highest groups generally still being within the normal ranges for the whole population.
- There is no current evidence that supports a large impact on an individual’s health. In particular, there is no current evidence that suggests an increase in overall cancer risk.
- Possible association with an increased risk of two uncommon cancers (testicular and kidney)… evidence is very weak, inconsistent
- The evidence does not support any specific biochemical or disease screening, or health interventions, for highly exposed groups (except for research purposes).

US Environmental Protection Agency PFOA Stewardship Program

In January 2006, USEPA started this program to help minimize impact of PFOA in the environment

Eight major international companies have agreed to participate (including 3M, DuPont, Asahi Glass, Daikin)

Agreement to voluntarily reduce factory emissions and product content of PFOA and related compounds* on a global basis by 95% no later than 2010

Agreement to work toward total elimination of emissions and product content of these compounds by 2015

Based on emissions and content determinations made for 2006

* Includes PFOA, precursor chemicals that can break down to PFOA, higher homologues (C9 and larger)

Slide by A. Lindstrom, U. S. EPA, March 2018

US Environmental Protection Agency Health Advisories

Health Advisory levels for PFOS and PFOA in drinking water

PFOS alone = 70 ng/L
PFOA alone = 70 ng/L
PFOS + PFOA = 70 ng/L

remember 70 ppt

"Protective" long term (chronic) exposure level

* Some experts calling for further reduction in these standards to be truly protective for long term exposures

PFOS = 1 ng/L PFOA = 1 ng/L

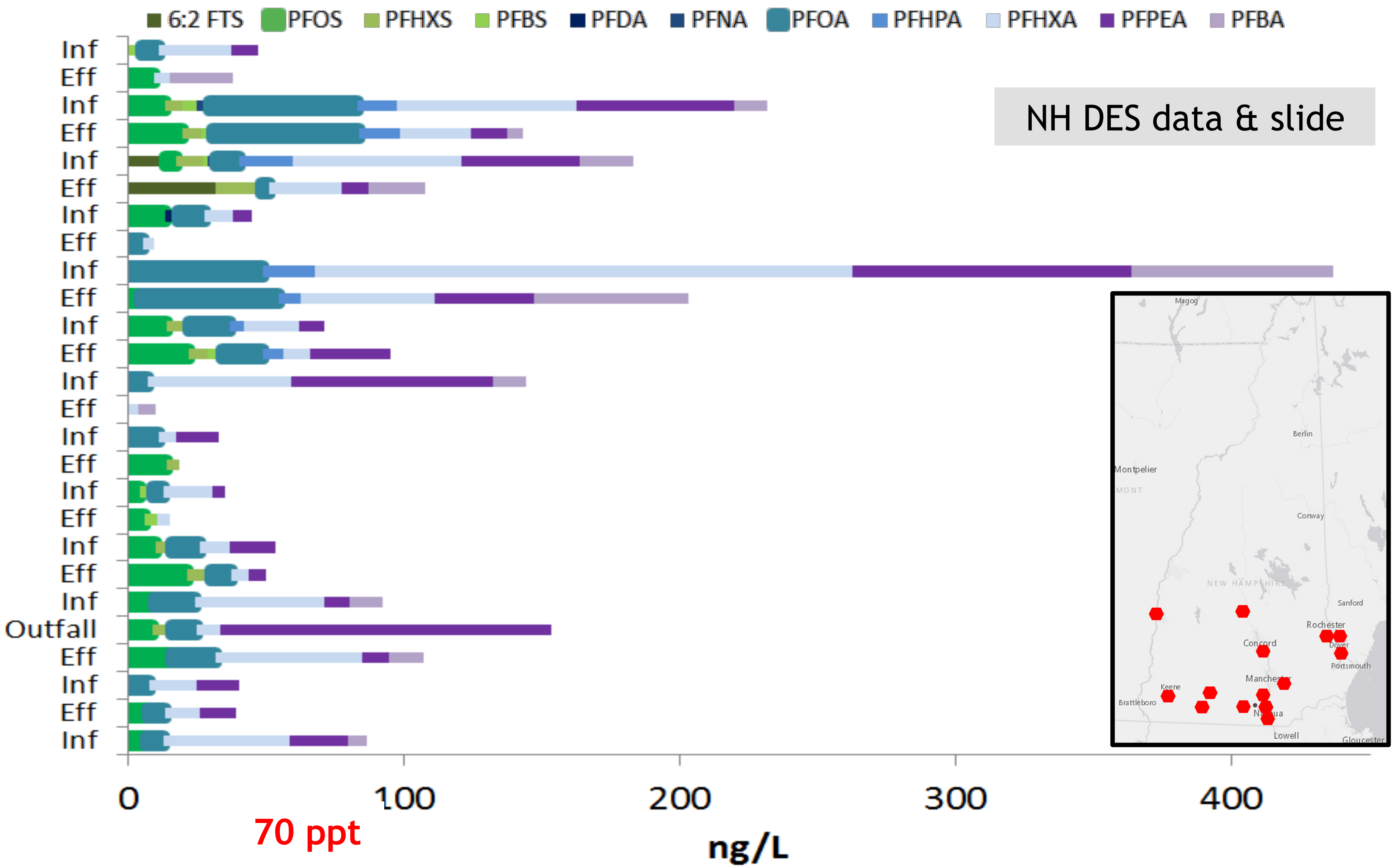
* Immunotoxicity of perfluorinated alkylates: calculation of benchmark doses based on serum concentrations in children Grandjean, P ; Budtz-Jorgensen, E ;Environmental Health (12:35) DOI: 10.1186/1476-069X-12-35, APR 19 2013

Slide by A. Lindstrom, U. S. EPA, March 2018

PFAS data

wastewater, biosolids, facilities, soils

Wastewater Assessments



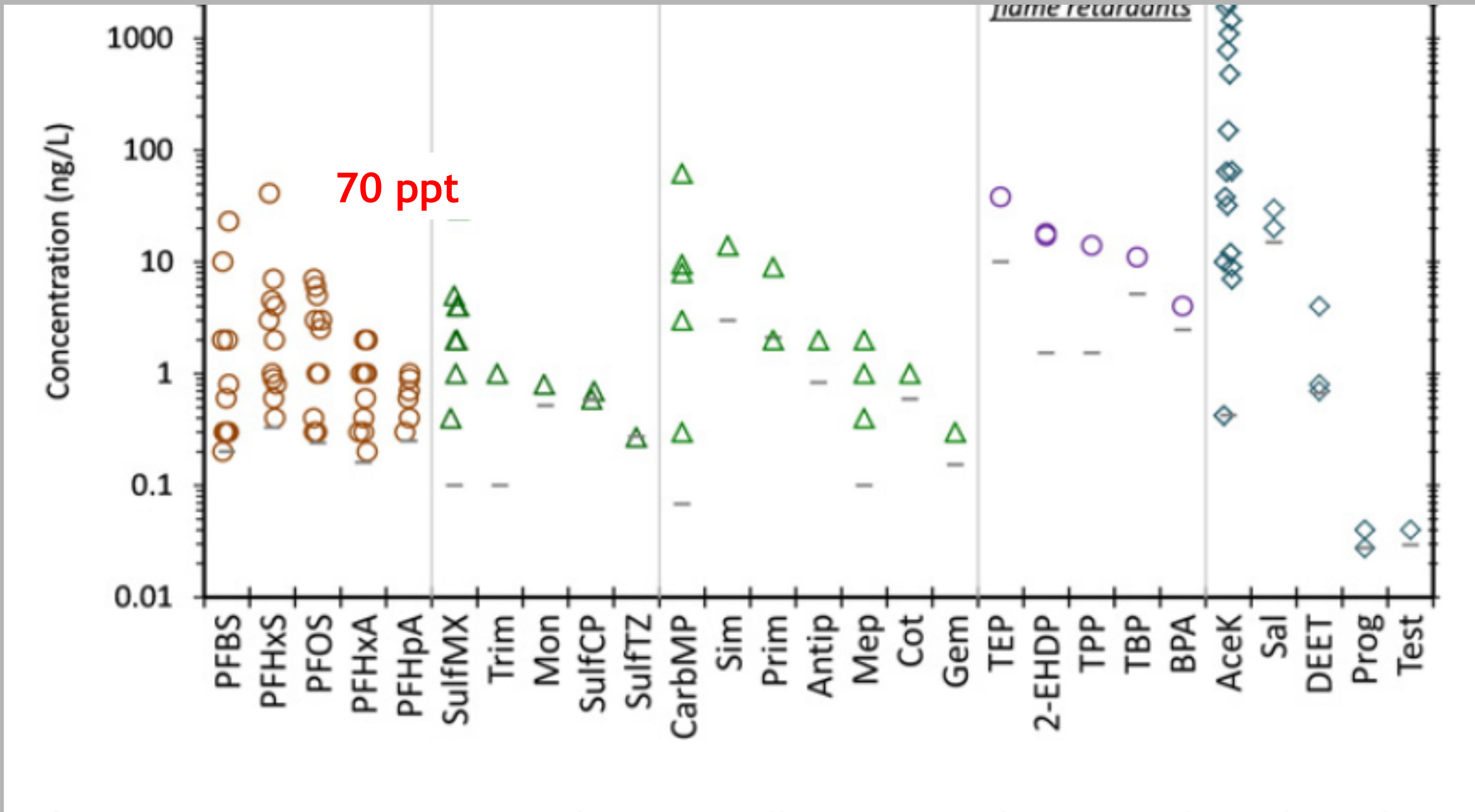
Northeast states evaluate locally…

PFAS in wastewater - ppb

(presence further confirmed, 2017 NH DES data)

	PFBA C4	PFHPA C7	PFHXS C6-S	PFHXA C6	PFNA C9	PFOA C8	PFOS C8	PFPEA C5
Small City Influent	13	<4	<4	7	<4	6	6	5
Small City Effluent	7	<4	<4	46	<4	6	7	21
Mid-size City Influent	<9.6	7	7	10	<4.8	15	22	29
Mid-size City Effluent	<9.6	5	8	20	<4.8	15	14	9
Municipality with industrial impacts Influent	56	8	<4	49	<4	50	4	36
Municipality with industrial impacts Effluent	73	19	<4	195	<4	49	<4	101

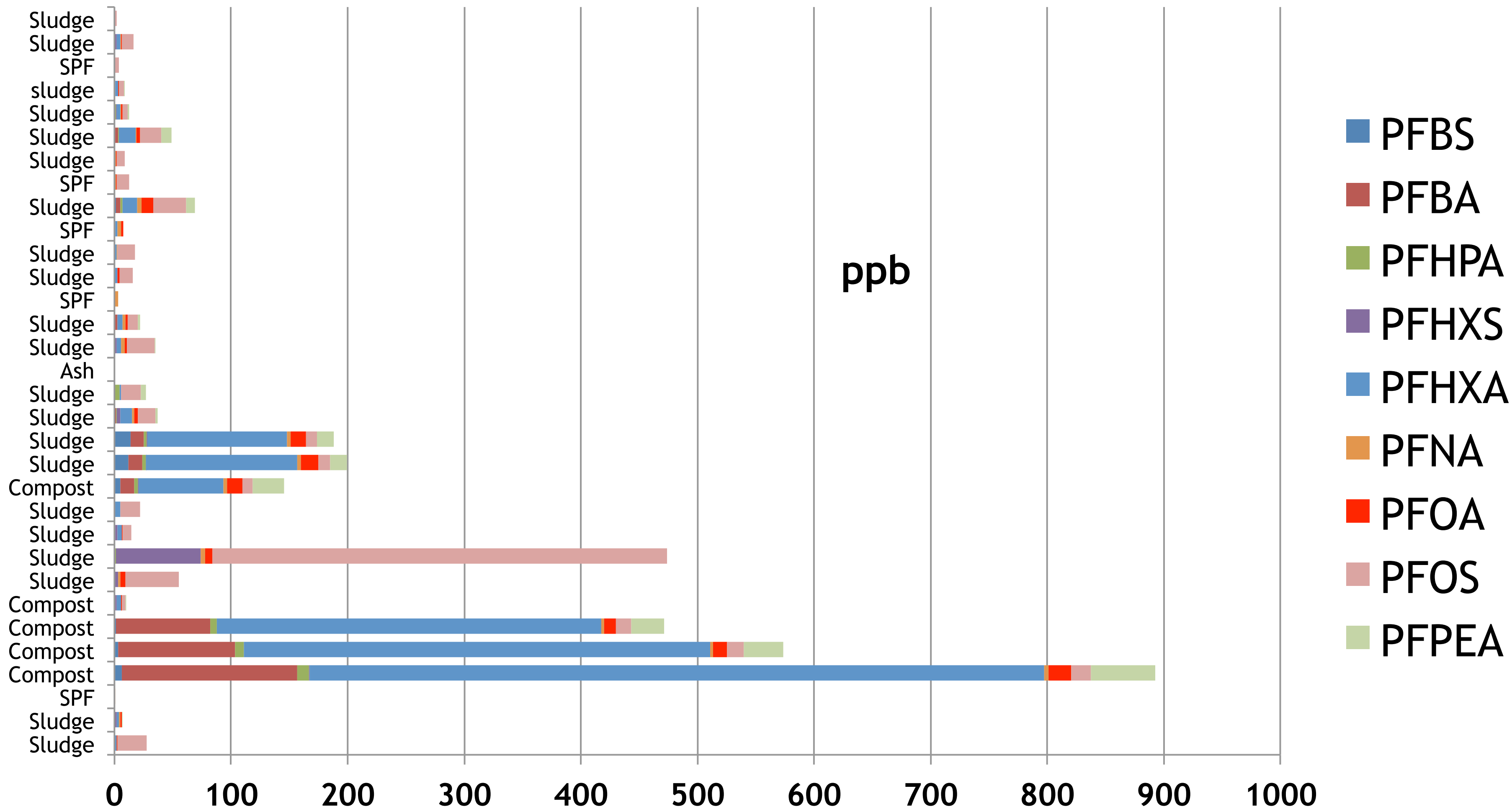
Cape Cod Groundwater
impacted by septic systems



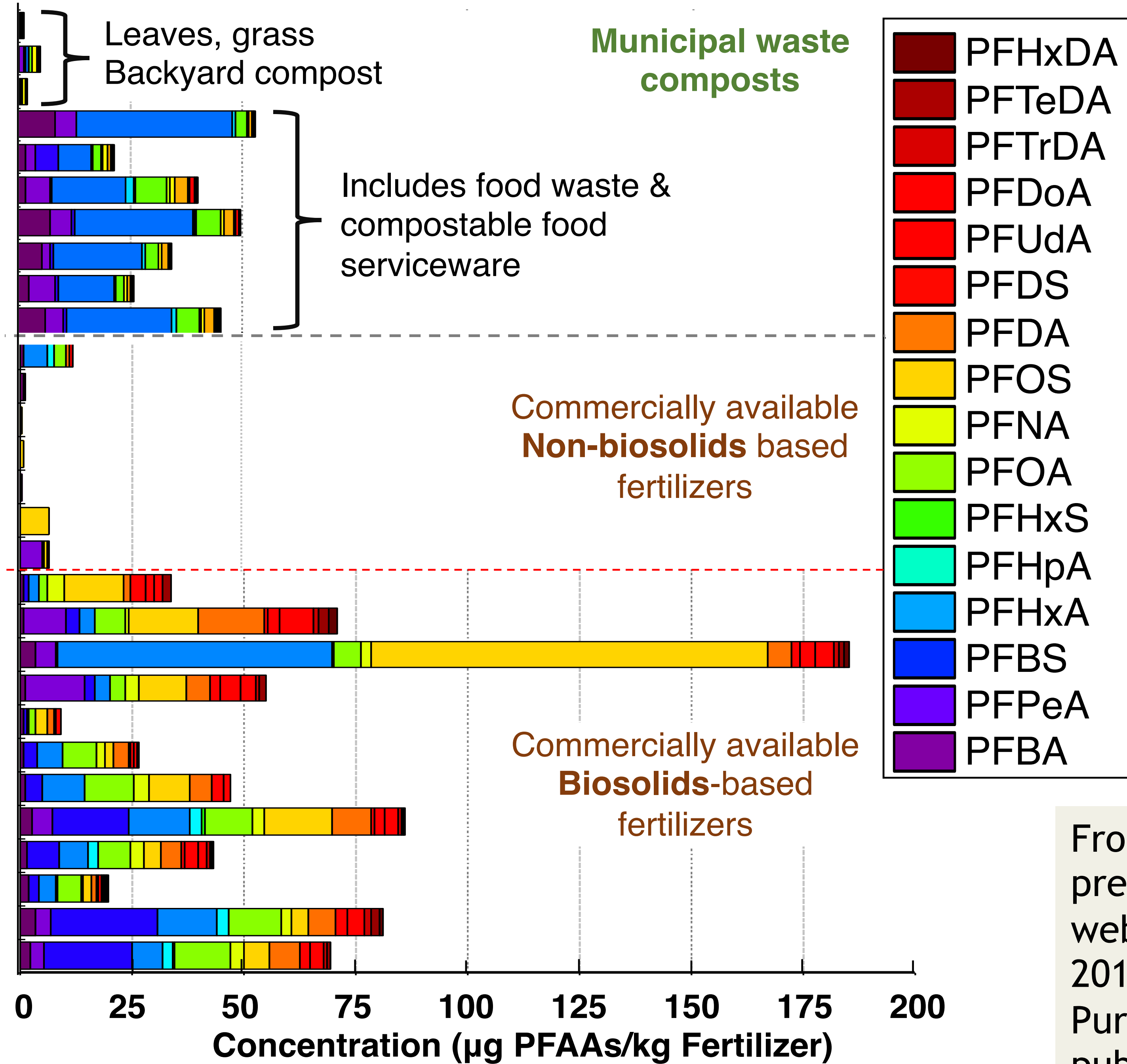
* Schaider et al., 2016. Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer. *Sci. Total Environ.*

Residuals Assessments

NH DES data & slide



70 ppt



From Kim-Lazcano – presentation for USCC webinar, Jan. 18, 2019. © Kim-Lazcano, Purdue Univ. Data in publication.

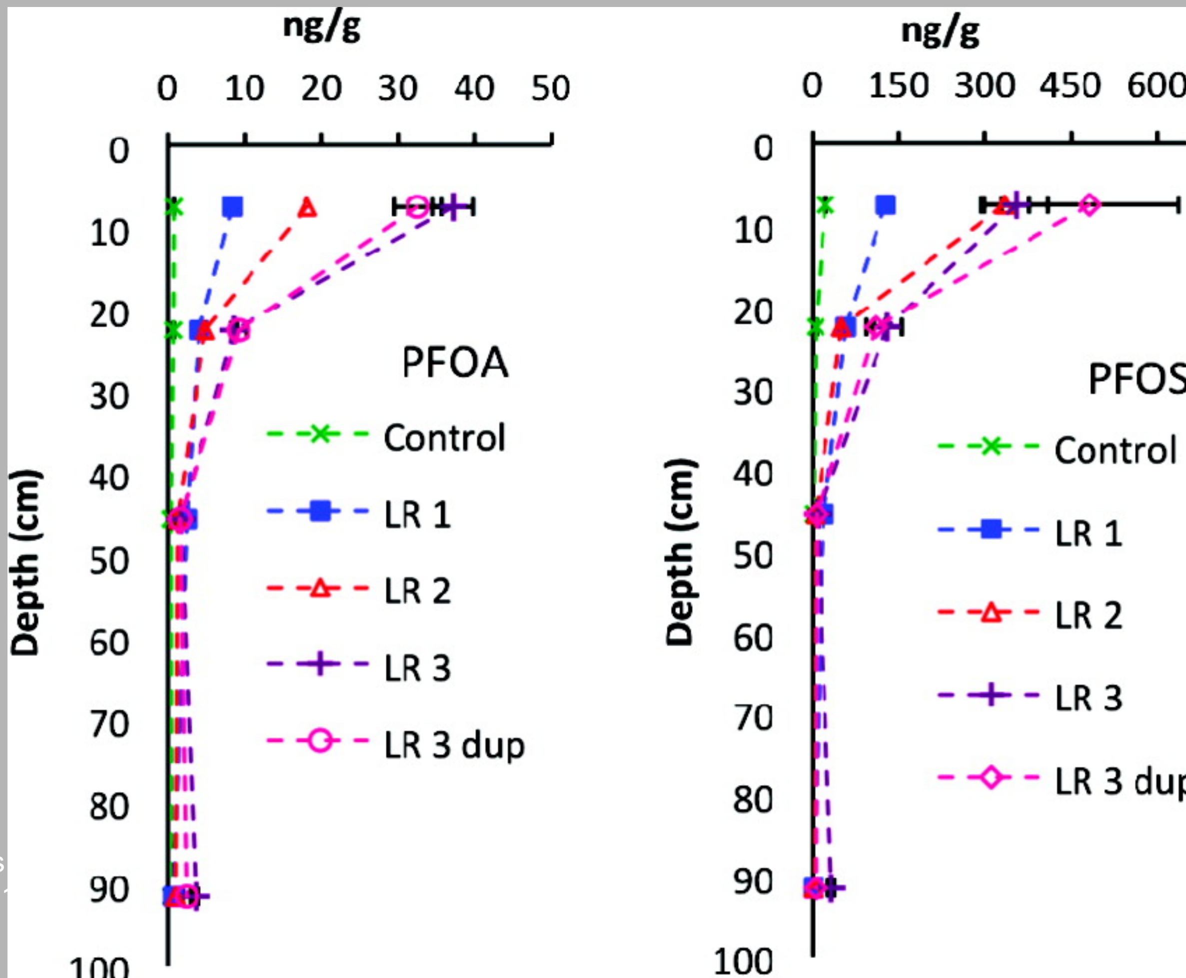
A residuals compost facility…

Regulatory response in March 2017 drives recycle paper mill residuals to landfill and composting business to laying off workers.

Compare to 70

Some PFAS leach in soil

Sepulvado et al; *Environ. Sci. Technol.* 2011, 45, 8106-8112



Concentrations … g/ha, LR 1 = 553
Mg/ha, LR 2 = 1 …

.

A few biosolids around the U.S. are impacted at levels raising regulatory concern when an industry discharges large amounts of PFAS to a sewer.
Solution: Apply pretreatment and source control.

- Decatur, AL (2000s)
- Lapeer, MI (2017)
- Maine farm (2019) – issue is not municipal biosolids

Large majority of biosolids average ~2 – 30 ng/g or ppb for each PFAS.

PFAS regulations are impacting biosolids land application now… …the latest in Maine:

Maine imposes moratorium… testing for PFAS required for all biosolids to be land applied

- https://www.nebiosolids.org/maine-dep-disrupts-biosolids-recycling
- Maine DEP pressured by media event & news coverage that inaccurately focused on municipal biosolids.
- Maine DEP data at that Farm show:
  - PFOS is the issue; it likely came from industrial source in 1980s
  - Very unusual occurrence
  - Would not be an issue if in Canada (200 ppt PFOA / 600 ppt PFOS)

ME DEP requiring testing of biosolids… based on flawed screening values:

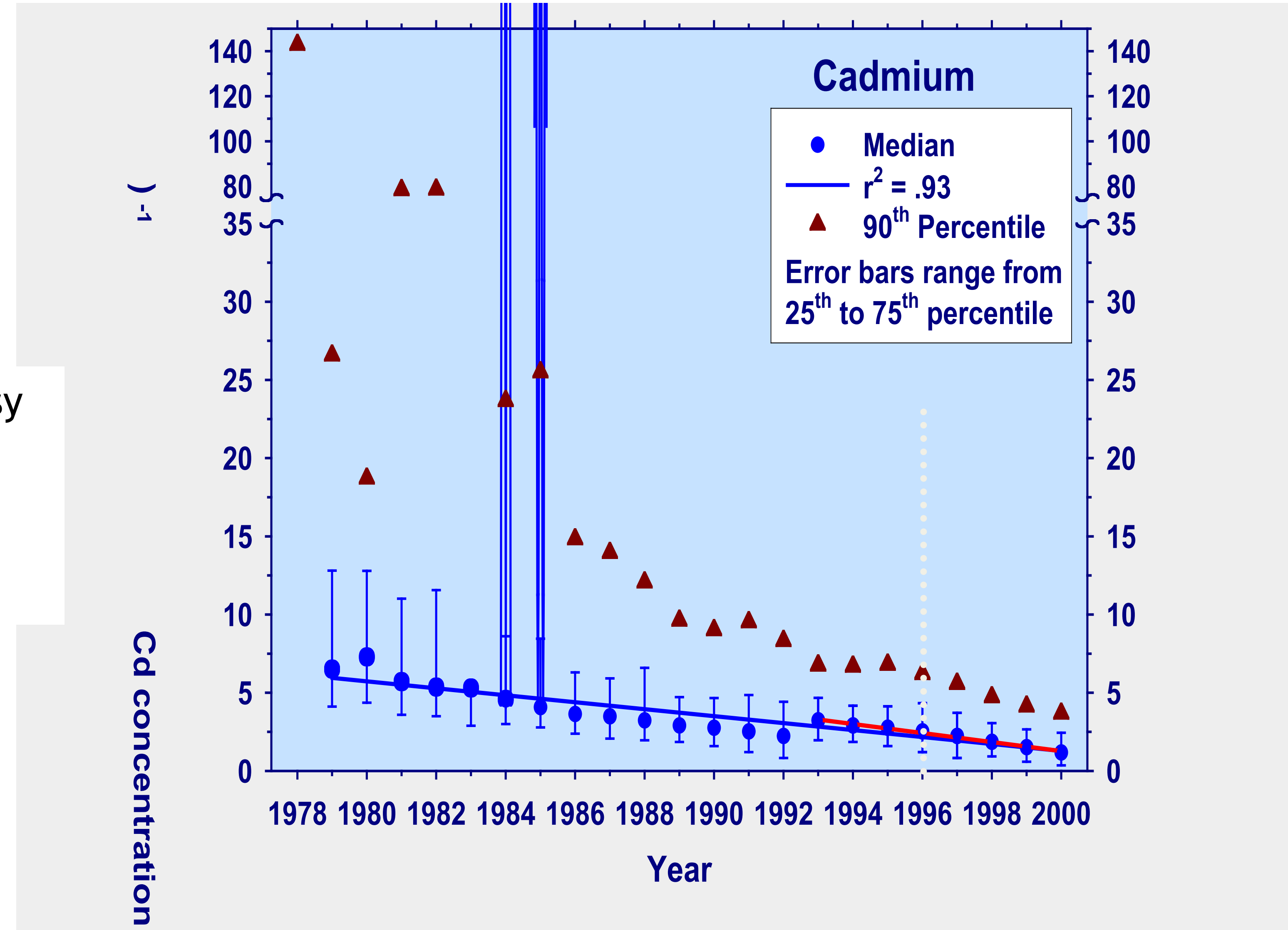
- Only 1 or 2 of 44 biosolids tested met Maine DEP's inappropriate screening values for PFOA (2.5 ppb) and PFOS (5.2 ppb).
- 2/3 of biosolids amended soils tested exceed the screening values. DEP: no more land application on those fields.
- NEBRA & others argued strongly to DEP 2017-2018 that their leaching-to-groundwater risk modeling & numbers were inappropriate for biosolids.
- Only AK & NY have tried such risk modeling; NY came up with 72 ppb as a screening value applied to paper mill residuals in one permit situation.
- Have engaged experts to develop science-based modeling with field validation.

PFAS – we have to figure this out

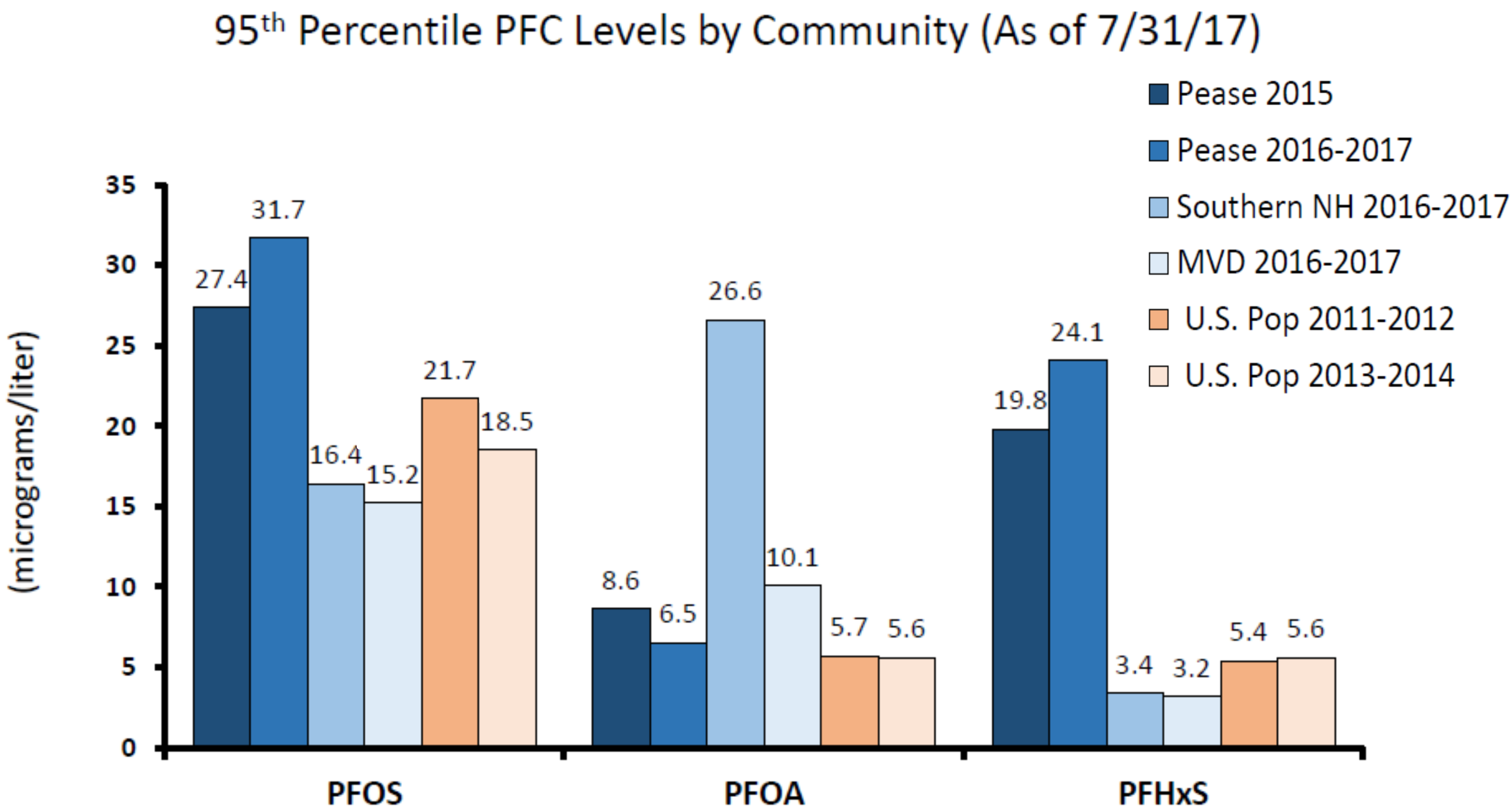
1. Wastewater contains PFAS in 1s to 10s of ppts. Biosolids contain PFAS in 1s to 10s ppbs. Even food waste composts are in the 1s ppbs+ range.
2. Some states (e.g. NH) are creating <u>low</u> drinking water & groundwater & other standards for the two prominent PFAS – PFOA & PFOS – in the 10s of parts per trillion (e.g. VT's 20 ppt). Some are scrutinizing other PFAS too.
3. Because PFAS are persistent and can leach some, biosolids may convey traces of PFOA and PFOS (and precursors) to surface or groundwater at levels relevant to these <u>low</u> advisory levels or standards.
4. State regulatory overreactions – very low numerical standards for waters & soils – can lead to significant disruptions and eroded confidence in wastewater, septage, biosolids, residuals, & composts.

Pretreatment works… (e.g. it worked for cadmium)

Slide courtesy of Richard Stehouwer, PhD, Penn State Univ.



Phase-out of PFOA & PFOS worked:
Human blood testing in NH & nationwide



https://www.dhhs.nh.gov/media/pr/2017/10102017-pfc-findings.htm

Summary: Wastewater & biosolids convey PFAS, but…

PFAS are ubiquitous. Even wastewater & biosolids with no industrial inputs have 1's to 10's parts per billion (ppb*). Wastewater & biosolids are not sources, but transfer routes for PFAS.

Presence does not necessarily mean risk. For wastewater & biosolids, there is no dermal, inhalation, or ingestion risk. The indirect pathway of leaching to waters (groundwater) is the only possible human health concern, and that will depend on the endpoint screening levels set for ground- and surface waters.

Data for biosolids sites show groundwater impacts directly under several worst-case-scenario legacy biosolids sites, but minimal to no exceedance of EPA's health advisory levels in drinking water. Biosolids & soils bind longer-chain PFAS.

PFOA & PFOS are at lower levels in modern wastewater & biosolids than in the past, due to phase-outs. Wastewater & biosolids returning to the environment today are conveying significantly less PFOA & PFOS (~1/10th).

Data are inadequate for robust modeling of leaching potential from biosolids applied to soils. Most states recognize this. There are no approved EPA analytical methods for PFAS in anything but drinking water. Efforts are underway for regional &/or national studies to address data gaps.

Environmental impacts: Wastewater & biosolids have contained PFAS for 50+ years – including PFOA & PFOS at higher levels than today. Bioassays of uses of effluent & biosolids have not found significant negative impacts, only benefits.

How much will society – your municipality & state – spend chasing trace PFAS in waste streams & the environment? And what is the public health benefit compared to use of those resources elsewhere? Prioritize the obvious, highly-impacted industrial & military sites. Careful thinking is needed as screening levels & standards are set.

Best practical option: Phase out any PFAS that are particularly toxic, persistent, &/or bioaccumulative. This is the proven, most-effective way to reduce potential risk.. But we will not get to zero PFAS in wastewater and biosolids and the environment anytime soon.

*1 ppb = 1 sec. in 31.7 years / 1 ppt = 1 sec. in 31,700 years

Interim best management –

See:

Best Management Practices – PFAS and Biosolids and Residuals

The regulatory requirements and best management practices (BMPs) routinely followed by professionals managing biosolids, residuals, digestates, and composts also reduce any potential risk of PFAS leaching from land application programs. Leaching to groundwater and/or surface water is the *only* potential significant risk from PFAS in these materials. Here's what you can do, even as research and understanding continue to advance:

- *Continue to apply biosolids, residuals, and composts (including Class A / EQ) in accordance with the agronomic rate. This controls the amount of any traces of chemicals thus conveyed to the environment, including PFAS. Healthy soils break down and sequester most trace chemicals. Limited research shows that longer-chain PFAS, such as PFOA and PFOS, are more likely to be bound in the soil; shorter chain PFAS leach more easily.*
- *Near surface waters, maintain reasonable setback distances and create/maintain vegetated buffers. Setbacks protect against nutrient pollution of waters and also protect against any trace PFAS migration to surface water.*
- *Evaluate potential sources of PFAS in wastewaters, biosolids, residuals, digestates, and compost. Look upstream for industries that use any of these chemicals. Evaluate waste streams, such as landfill leachate, which may convey PFAS. Sample and test and consider reducing any significant industrial inputs of PFAS. Sampling and testing for PFAS is challenging. NEBRA has sampling and analysis guidance. Consult experts and understand the limitations of PFAS lab analysis.*
- *Consider testing your program's biosolids, residuals, digestate, and/or compost products for PFOA and PFOS and other PFAS. Be careful, because these chemicals are everywhere and the analytical levels (ppt) are challenging, especially when testing solids. Be a savvy lab customer and proceed thoughtfully.*
- *Honestly communicate with your residuals management employees and customers (farmers, landowners) about traces of chemicals – including PFAS – in various media, including biosolids, residuals, composts, digestates, animal manures, and soils. Honor their questions and address them as best you can. Offer to provide further information. See NEBRA info and contact NEBRA for assistance, if needed (https://www.nebiosolids.org/resources/#/microconstituents/).*
- *Communicate with regulatory agencies and monitor research and the development of legislation and regulation. Discourage jurisdictions from setting regulatory standards for drinking water, groundwater, surface waters, and soils without careful consideration of the implications for management of wastewater and the uses of biosolids, residuals, digestates, and composts. Very low standards may create severe impediments and significant costs to municipalities and ratepayers.*
- *Support targeted, practical field research on PFAS in residuals and soils.*
- *Support societal efforts to reduce the use of PFAS – at least any persistent, bioaccumulative (e.g. longer-chain) versions. Support source reduction and pollution prevention.*

Screenshot

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THANK YOU!

Biosolids compost for my raspberries… still using it, even though I know it has PFAS in it. The benefits far outweigh the risks :)

Thank you.

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