

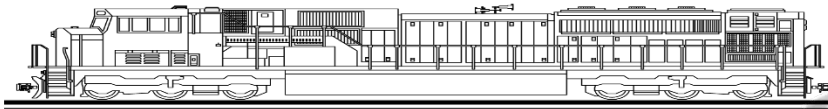
**welcome**

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# Per and Poly Fluoralkyl Substances (PFAS) and the Railroad Industry

19<sup>th</sup> RAILROAD  
ENVIRONMENTAL  
CONFERENCE



# As a Railroad Operations and Compliance Professional – What do I need to know about PFAS?

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# PFAS Emerging Contaminants Presentation Overview

- **PFAS Background**
- **Toxicology and Regulatory status**
- **Treatment Alternatives**
- **What does this mean for the Railroad Industry**
- **Closing Remarks and Questions**



# PFAS Background

# PFAS, PFCs, PFOS and PFOA

- PFAS is the family name
- PFCs are how others refer to your family
- PFOS and PFOA are the most famous family members.

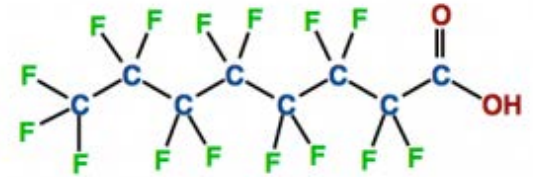
# What is it?

- PFOS and PFOA are fully fluorinated, organic compounds and are the two perfluorinated chemicals (PFCs) that have been produced in the largest amounts within the United States
- PFCs are the family of synthetic chemicals that include long chains of carbon and fluorine
- Have unique lipid- and water-repellent characteristics, PFOS and PFOA are used as surface-active agents in various high-temperature applications and as a coating on surfaces that contact with strong acids or bases

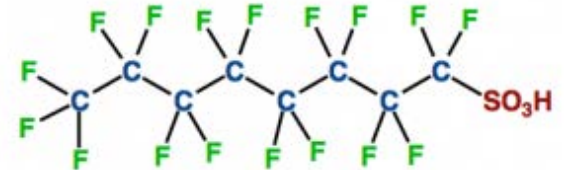


# Occurrence

- Used in fire fighting foams, Aqueous Film-Forming Foam (AFFF)
- Also used in industrial and commercial products including:
  - Textiles and leather products (Gore-Tex, Polartec)
  - Metal plating
  - Stain-resistant carpet
  - Photographic industry and photolithography
  - Semi-conductors
  - Paper and packaging (fast food wrappers)
  - Coating additives (Teflon)
  - Cleaning products
  - Pesticides
- Being voluntarily phased out with EPA input



PFOA - perfluorooctanoic acid

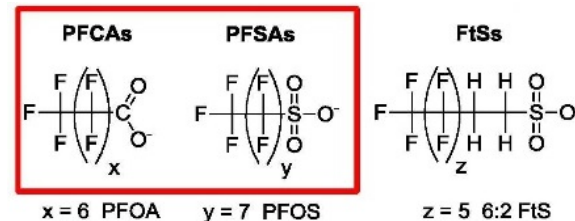


PFOS - perfluorooctanesulfonic acid

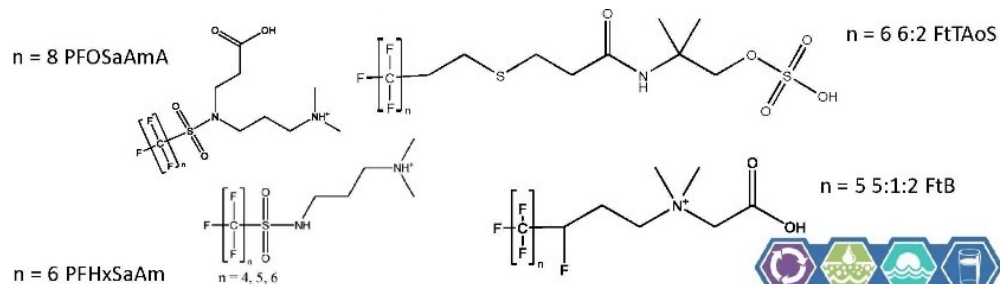
# Composition at AFFF-impacted Sites

Perfluoroalkyl acids (PFAAs)  
present

- Some presumed PFAA precursors



Presumptive PFAA precursors identified  
in AFFF and/or at AFFF-impacted sites:



Schultz et al. 2004 *ES&T*; Place and Field, 2012. *ES&T*; Backe et al., 2013 *ES&T*.



# Where is it?

- Airports
- Air Force Bases and Naval Facilities
- Fire Fighting Academies
- Manufacturing Facilities
- Bulk Storage of AFFF or product



# Former Firefighter Training Areas (FTAs)

What do we *really* know about poly- and perfluoroalkyl substances (PFASs) at these sites?

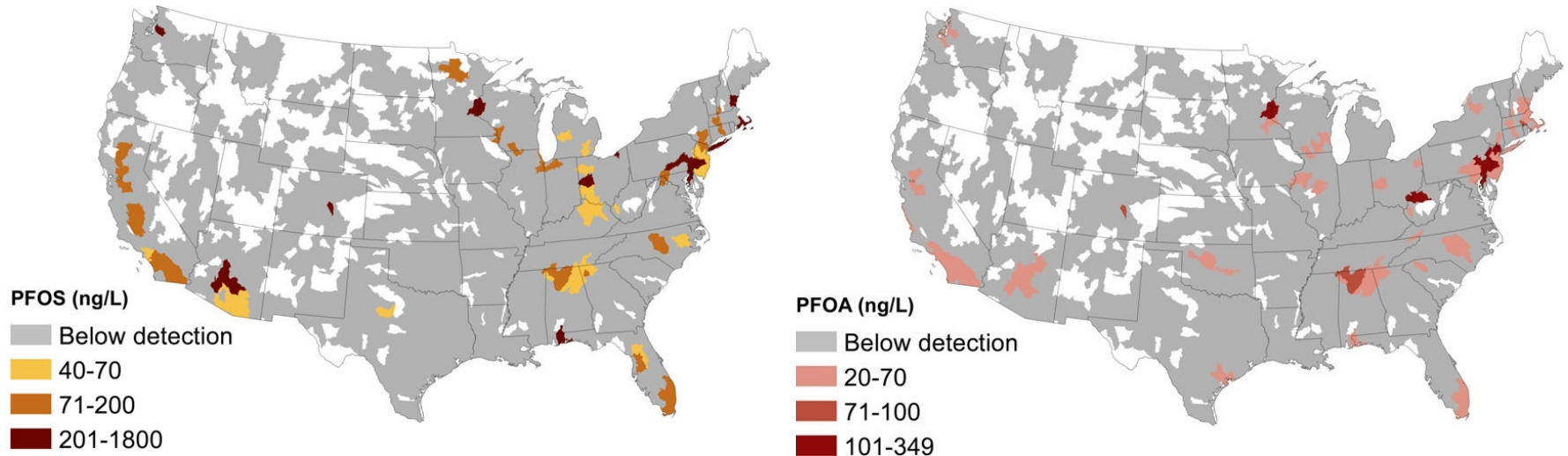


Likely present at *all* sites where aqueous film forming foam (AFFF) was used

- Composition?
- Spatial distribution?

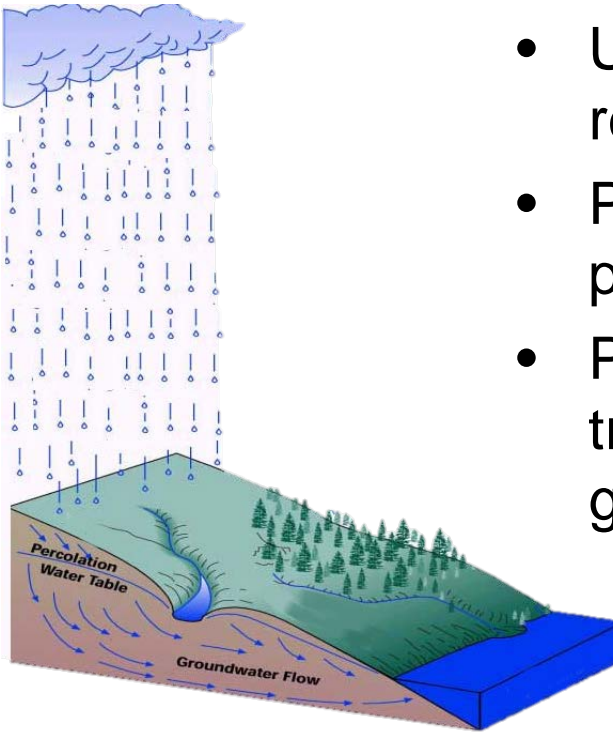
# PFOS & PFOA in Public Drinking Water

Xindi C. Hu et al. Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants. *Environmental Science & Technology Letters* **2016** 3 (10), 344-350. DOI: 10.1021/acs.estlett.6b00260



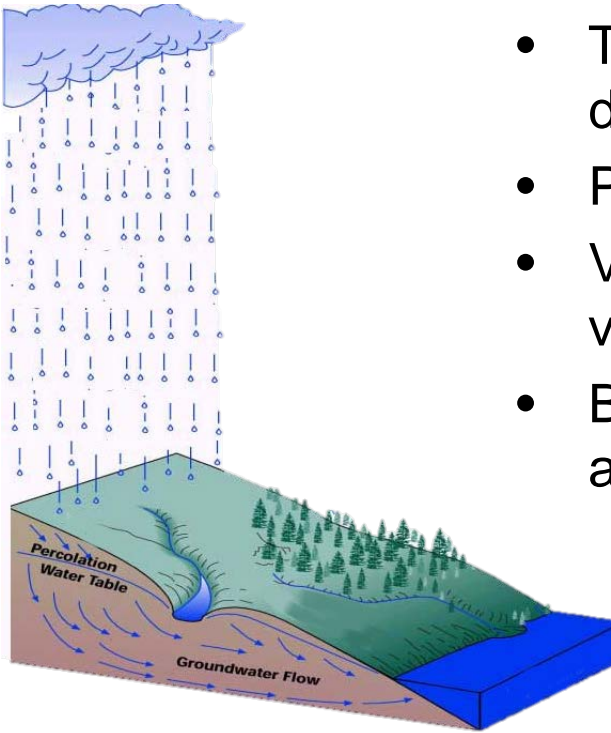
# Fate & Transport

- Use of PFOA in manufacturing can result in releases to air, water, and soil
- PFOA released to air is readily adsorbed to particles and settles to the ground
- PFOA deposited into/onto soil can be transported to and contaminate groundwater



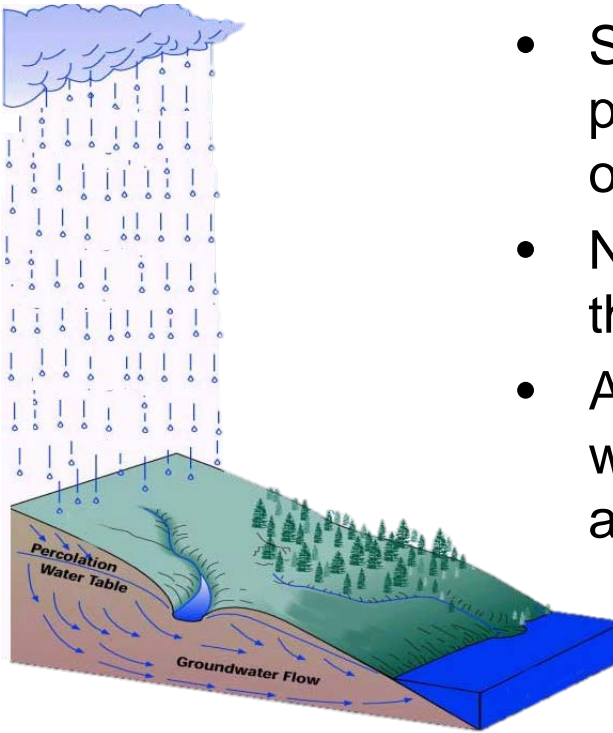
# Fate & Transport

- Travels advectively with water flow (e.g. dissolved)
- Poor adsorption but may trap in clays
- Very resistant to biodegradation and therefore very persistent
- Binds to protein thus found in blood streams and bound to biosolids in wastewater effluent



# Fate & Transport

- Since PFCs found in water, soil, and consumer products, it is also found in the blood and tissue of organisms worldwide
- Nearly all people have some level of PFCs in their blood
- Although health effects from exposure are not well understood, the EPA has identified PFOA and PFOS as 'Emerging Contaminants'





# Exposure Should Be Decreasing

- Manufacturers in US began phasing out PFOA production and PFOA usage in 2002.
- Stockpiles of AFFF containing long chain PFCs are slowly decreasing
- PFOA concentrations in blood serum decrease once exposure stopped

# Toxicology and Regulatory Status

# Response to PFAS: Toxicology Studies and Regulations

- EPA tasked with toxicology and risk
- Of ~23 PFAS compounds of concern only PFOA and PFOS have health advisory levels

## Additional Information:

EPA Contaminant Candidate List (CCL) available at: <https://www.epa.gov/ccl>

EPA Unregulated Contaminant Monitoring Rule (UCMR3) available at: <https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule>

Provisional Health Advisory (PHA) Levels: <https://www.epa.gov/sites/production/files/2015-09/documents/pfoa-pfos-provisional.pdf>

PFOA (Perfluorooctanoic acid) = 0.4 µg/L

PFOS (Perfluorooctane sulfonate) = 0.2 µg/L

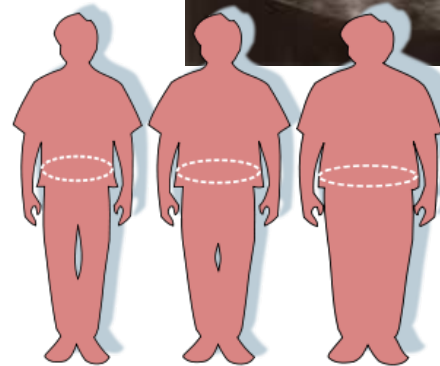
# PFAS Toxicology



- Toxicology poorly known
- Possible link to diabetes, weight gain
- In 2006, the EPA Science Advisory Board suggested that PFOA are “likely to be carcinogenic to humans” (pancreatic, liver and kidney cancers)
- PFOS exposure also associated with cancers
- Potential developmental, reproductive and other systemic effects
- Bioaccumulation at different rates per species

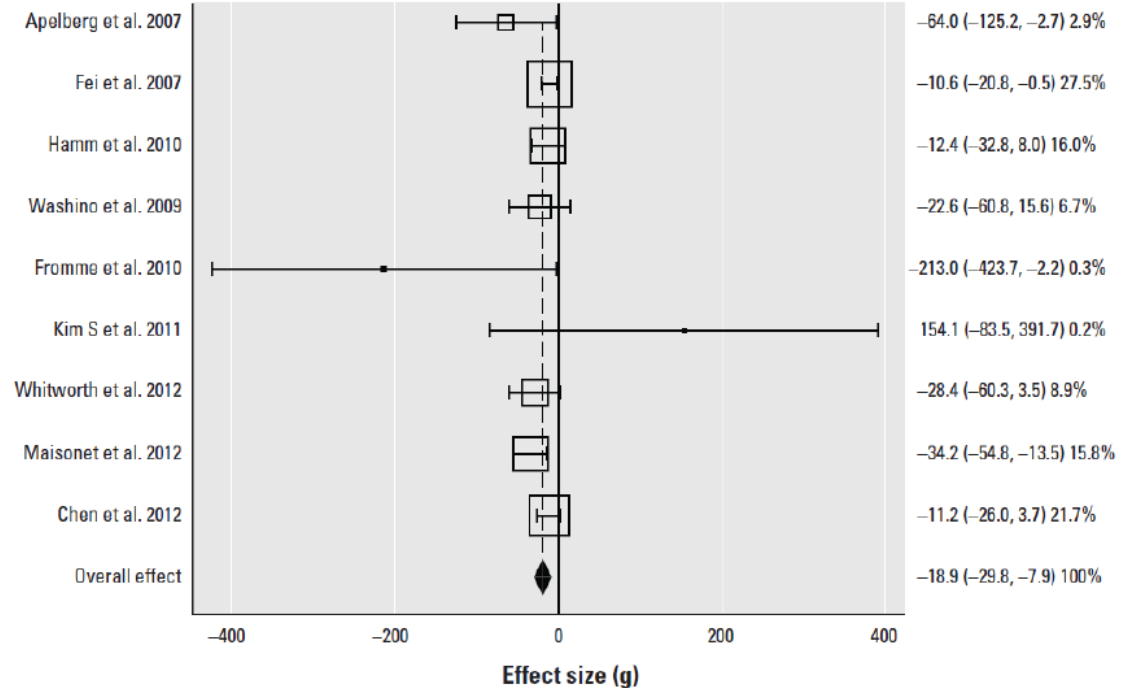
# Health Effects in Humans

- Fetal growth
- Child/adult adiposity
- Breastfeeding
- Others



# Health Effects: Fetal growth

- PFOA exposure associated reduced birthweight
- Possibly effects from PFOS exposure



Source: Brown University<sup>22</sup>

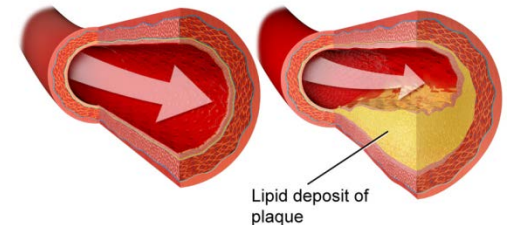
# Child/Adult Adiposity

- Adiposity is related to fat levels
- PFAS exposure initially results in lower birthweight
- However, pre-natal exposure associated with higher BMI/WC at 20 years of age
  - BMI = Body Mass Index, WC = waste circumference
- Increased obesity/adiposity are related to cardio-metabolic disease including:
  - High blood pressure
  - Triglycerides
  - LDL
  - Insulin resistance
  - Central Adiposity – abdominal fat



Normal Artery

Narrowing of Artery



Coronary Artery Disease

# Breastfeeding

## Reduced Milk Production:

- PFAS exposure during pregnancy associated with decreased breastfeeding/lactation duration:
  - Doubling in PFOA associated with 0.5 month reduction in exclusive breastfeeding duration
- Animal studies indicate PFAS limit breast development and lactation

## Transfer of PFAS to Infant:

- If mother exposed to PFAS: breastmilk, umbilical cord blood and amniotic fluids also contaminated
- At birth infants have same serum level as mother, in first months PFAS level increases in infants from breastmilk/formula produced with impacted drinking water
- Infant intake of PFAS 13 to 16 times greater than adults
- Public health experts recommend continued breastfeeding and mothers reduce/minimize PFAS exposure



Person	PFOA (ng/kg/d)	PFOS (ng/kg/d)
Infant	4.3	8.7
Adult	0.26	0.62

Source: Brown University<sup>22</sup>



# Other Health Effect

**Wide Range of Other Health Effects from PFAS observed in animal and/or human studies:**

- Skeletal variation – reduced bone growth
- Testicular and kidney cancer
- Persistent liver effects – tissue damage
- Immune effects (e.g., antibody production and immunity)
- Thyroid effects
- Accelerated puberty (observed in animal studies)



# Development of EPA Health Advisory Level



Based on Toxicological Data

$$\text{RfD} = \text{NOAEL} / (\text{UF} \times \text{MF})$$

*Reference Dose (RfD): Estimated daily exposure to the human receptor that is likely to be without an appreciable risk of deleterious effects during a lifetime. (mg/kg/day)*

*NOAEL: No observed adverse effect level. If NOAEL isn't established, LOAEL (lowest) is sometimes used. (mg/kg/day).*

*UF: Uncertainty factor to err for safety in relating animal studies to sensitive human populations.*

*MF: Modifying factor*

EPA select RfD of 20 ng/kd/day based on animal studies showing reduced ossification and accelerated puberty (in males) for PFOA and based on decreased pup body weight for PFOS.

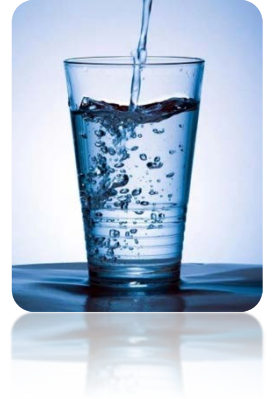
# New USEPA Lifetime Health Advisory

May 19, 2016

- PFOS and PFOA, combined or individually  
70 parts per trillion (PPT)



# Prior Advisory Levels



- Former USEPA pHA:
  - PFOA (Perfluorooctanoic acid) = 0.4  $\mu\text{g/L}$  or 400 ppt
  - PFOS (Perfluorooctane sulfonate) = 0.2  $\mu\text{g/L}$  or 200 ppt
- Various states had set different limits:
  - ME, MA, NH, NY – (health advisory levels) –100 ppt (0.1  $\mu\text{g/L}$ )
  - VT DOH has established a PFOA health level of 20 ppt (0.02  $\mu\text{g/L}$ )
  - VT and NY – has declared it a hazardous substance allowing funds to be applied

# State Standards and Guidelines

Numerical Limits for PFOA and PFOS as of September 2016 (ng/L, or ppt)			
State(s)	PFOA	PFOS	Combined
VT	20	-	20
NJ	40*	-	-
ME	60	100	-
AL, CA, CO, DE, FL, MA, NH, NY, RI	70	70	70
MN	300	300	-
TX	300	600	-
AK, IL	400	200	-
MI	420	11	-
WV	500	-	-
NC	2000	-	-

\*NJ Proposing 14 ppt

# Exposure From Non-drinking Water Sources

- USEPAs calculated conservative reference dose in drinking water is of 0.02 ng/kg-d assumed 20% of exposure from drinking water.
- Where does the other 80% of exposure come from?



# Evolving Landscape

- New and changing toxicological data
- Improved analytical testing has allowed for detection limits in parts per trillion range



- Increased detections
- **CONFUSION ABOUNDS**

# Treatment Alternatives



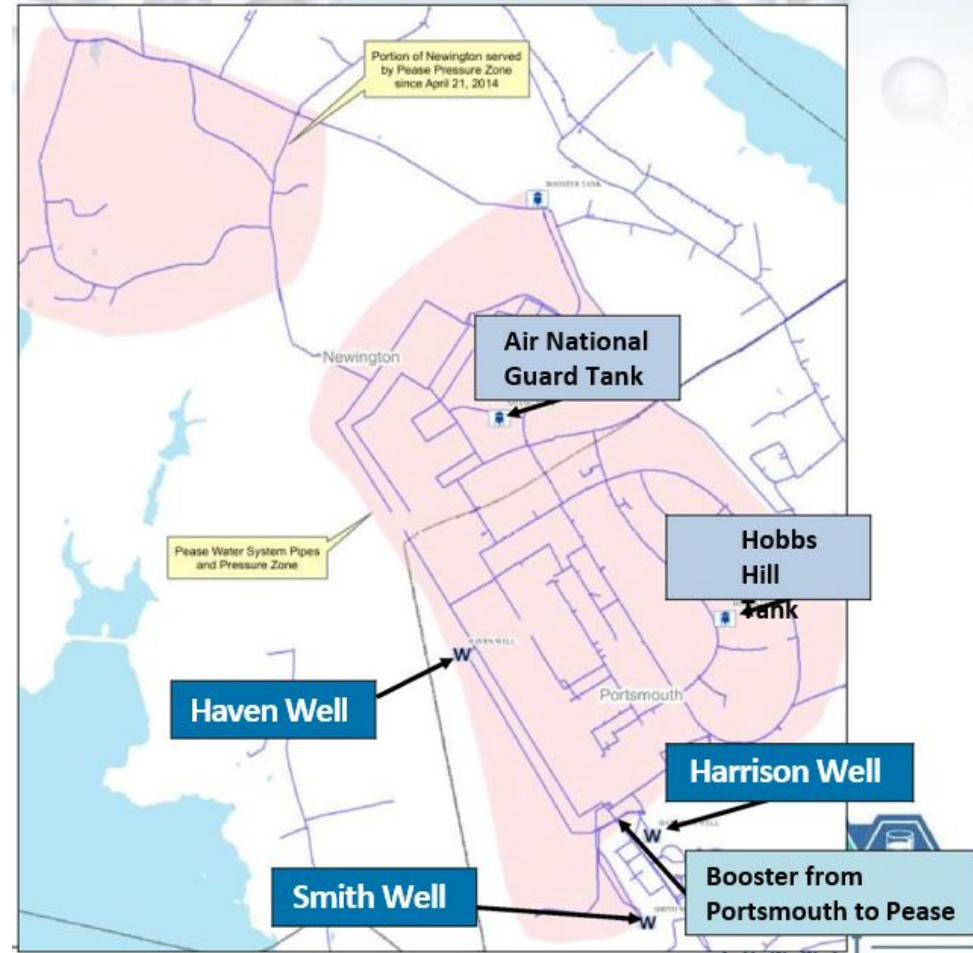
# Treatment

- Low Flow – Resins showing promise
- Higher Flow - Carbon

# Case Study: Pease

# Pease Tradeport Water System

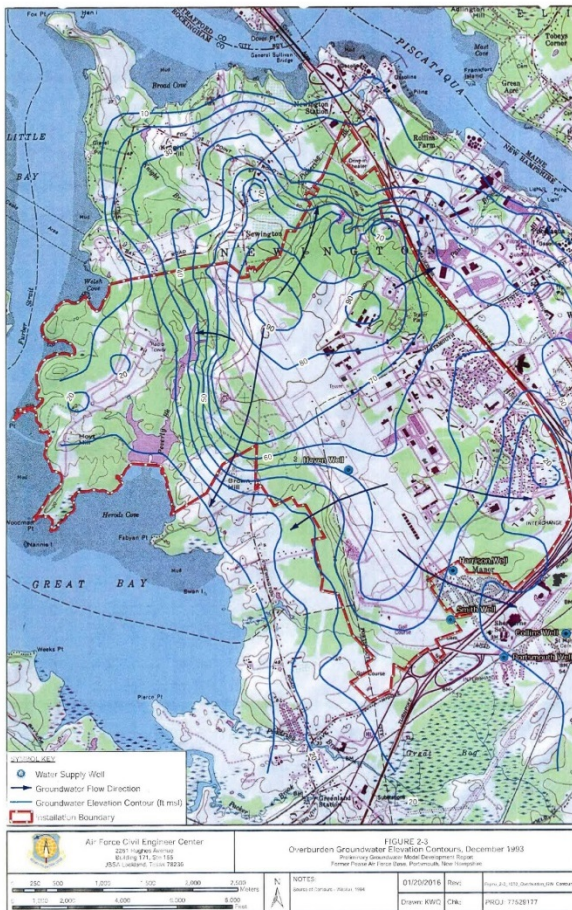
- 3 Wells
- 2 Storage Tanks
- Booster from Portsmouth to Pease
- 30 Miles of water main
- 0.4 to 1.0 Million Gallons per Day Usage



# Haven Well

- Installed in 1875 (Haven Springs)
- Pease Air Base: 1956 to 1992
- PDA/Portsmouth: 1992 to 2014
- 500 GPM pump





Courtesy of AMEC

# Pease Airbase Closure - Superfund

- Eleven Record of Decisions (ROD) - Superfund cleanup completed between 1993 and 1997.
- All remedial design and construction activities for the Base have also been completed.
- Operation and maintenance (O&M) and long-term monitoring (LTM) activities conducted
- Haven Well had an extensive monthly monitoring program to track any potential contaminants nearing the well.

# Chronology of Events

EPA requests Air Force to Sample for PFCs

- May 2012 – EPA Federal Facilities Restoration and Reuse Fact Sheet on Emerging Contaminants lists PFOA and PFOS
- Film Forming Foam (AFFF) used for firefighting:
  - PFOA – Perfluorooctanoic Acid
  - PFOS – Perfluorooctane Sulfonate
- May 2012 – EPA's Unregulated Contaminant Monitoring Rule 3 lists PFCs

# Haven Well Shutdown

## Chronology of Events

- April 2014 – City Contacted by EPA regarding their request that Air Force sample the Pease Wells for PFCs
- Air Force Consultant sampled all three Pease wells in mid-April 2014 for PFCs
- May 12, 2014 – City staff are notified that PFC levels in Haven Well exceeded the EPA's Health Advisory Standard for PFOS – 2.5 ug/L (Preliminary Health Advisory = 0.2 ug/L)
- May 12, 2014 - Haven Well is shut down
- Since May 12, 2014 - Pease water system is supplemented with water from Portsmouth's water system (50% of demand supplied by Portsmouth)



# The Trigger

Sample Location	Collection Date	Perfluorobutane sulfonate	Perfluorodecanoic acid	Perfluorododecanoic acid	Perfluoroheptanoic acid	Perfluorohexane sulfonate	Perfluorohexanoic acid	Perfluorononanoic acid	Perfluorooctane sulfonate (PFOS)	Perfluorooctanoic acid (PFOA)	Perfluoropentanoic acid	Perfluoroundecanoic acid
PHA (µg/L)		--	--	--	--	--	--	--	0.2	0.4	--	--
HAVEN	16-Apr-14	0.051	0.0049 J	ND	0.12	0.83	0.33	0.017	2.5	0.35	0.27	ND
HAVEN	14-May-14	0.051	0.0043 J	ND	0.12	0.96	0.35	0.017	2.4	0.32	0.26	ND
HARRISON	16-Apr-14	0.002 J	ND	ND	0.0046 J	0.036	0.0087	ND	0.048	0.009	0.0079	ND
HARRISON	14-May-14	0.0019 J	ND	ND	0.0042 J	0.032	0.01	ND	0.041	0.0086	0.0084	ND
SMITH	16-Apr-14	0.00094 J	0.0044 J	0.012	0.0025 J	0.013	0.0039 J	ND	0.018	0.0035 J	0.0035 J	0.017
SMITH	14-May-14	0.00087 J	ND	ND	0.002 J	0.013	0.004 J	ND	0.015	0.0036 J	0.0034 J	ND

## Notes:

Grey text indicates the parameter was not detected.

2.5 indicates concentration above PHA

J - estimated value

all results in µg/L

ND - non detect

PHA - Provisional Health Advisory

-- indicates no established PHA

# The Response

- Data Collection
- Forensic Analysis
- Health Information
- Water System Operational Changes
  - Existing Supplies
  - Alternative Supplies
  - Treatment Options
- Public Outreach









# Implications for the RR Industry

- Fire Fighting Foam – Aqueous Film Forming Foam (AFFF)
  - Post derailment assessments / impacts
  - Regulatory Endpoint
- Due diligence assessments
- Facility Compliance

# Post Derailment Response

- Over excavate soil in immediate vicinity of application
- Nearby Receptors?  
Private Wells





# Case Study – Hanscom Field

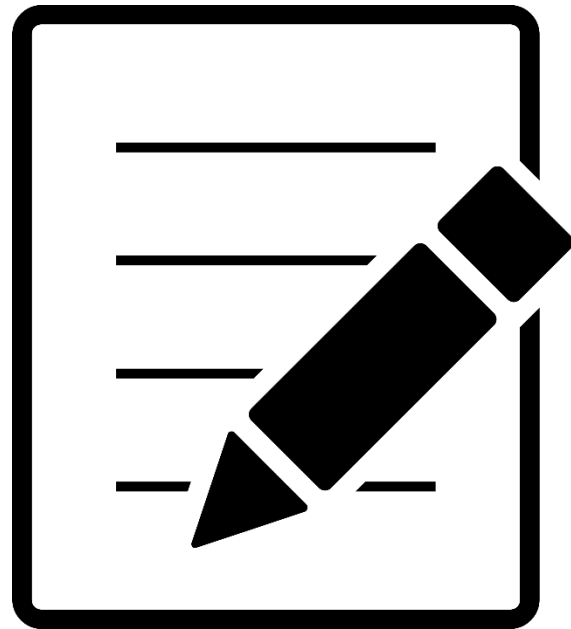
- Post Crash Response
- Jetfuel and PFCs
- Stream and Soil Impacts
- Nearby receptors





# ASTM Due Diligence

- Potential for PFCs considered a Recognized Environmental Condition?
- The standard of care currently does not seem to address PFAS, however watch this space.



# Storage at Facilities / Facility Compliance

- Check AFFF supply with Manufacturer
- Double containment
- Receptors near facility
  - Private wells
  - Regulatory framework
  - Community Right to Know



# Closing Remarks

- This is a rapidly evolving topic
- Implications for RR operations
  - Storage,
  - Transportation,
  - Emergency Response and
  - Compliance
- May reopen older sites

# Questions?



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