PFC Distribution at Three Unique Release Sites and the Implications on Characterization Design

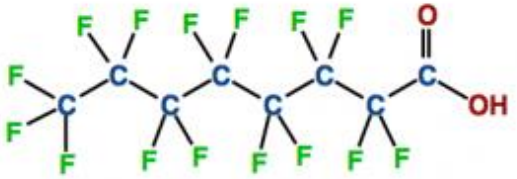
Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies

May 23, 2017

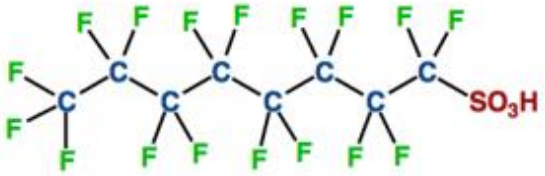
Weston & Sampson℠

What are they?

- PFAs are partial to fully fluorinated, organic compounds 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, and are used as surface-active agents in various high-temperature applications and as a coating on surfaces that contact with strong acids or bases



PFOA - perfluorooctanoic acid



PFOS - perfluorooctanesulfonic acid

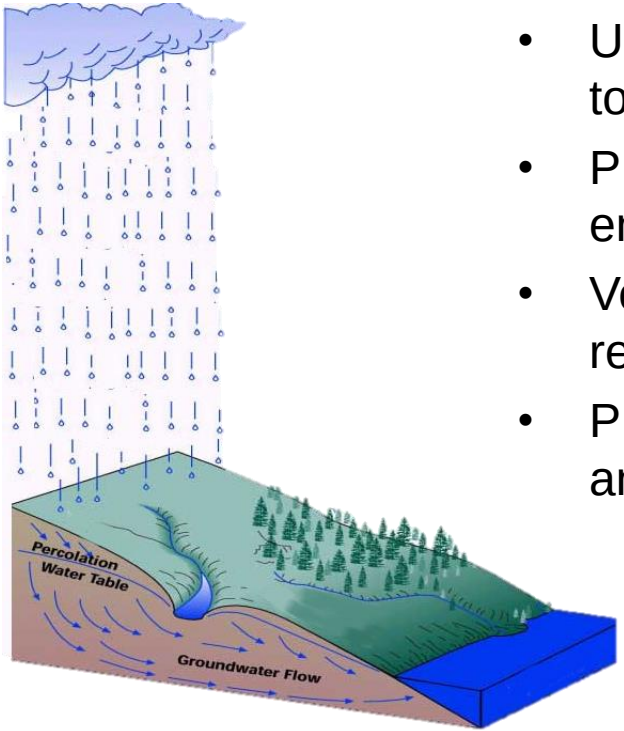
Historic Uses

- 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 fabric
  - Photographic industry/photolithography
  - Semi-conductors
  - Paper and packaging (fast food wrappers)
  - Coating additives (Teflon)
  - Cleaning products
  - Pesticides

Release Sources

- "Traditional" Release Methods
  - Airborne Emissions from Manufacturing Facilities
  - Fire Training Facilities
  - Fire Responses
  - Spills
  - Landfill Disposal
- "Non-Traditional" Releases/Redistribution Methods
  - Land Application of WWTF Sludge
  - On-Site Septic Disposal Fields
  - Irrigation

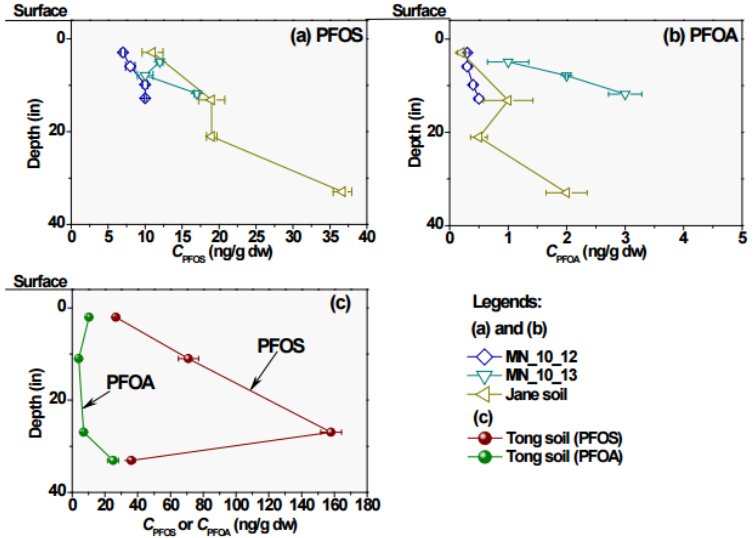
Fate & Transport

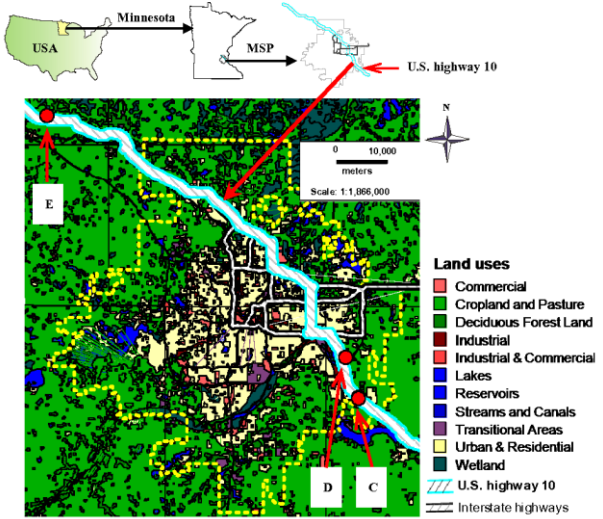


- Use of PFCs in manufacturing can result in releases to air, water, and soil
- PFCs are extremely stable, and persistent in the environment
- Very soluble, low Koc, low vapor pressures and resistant to degradation
- PFCs deposited into/onto soil can be transported to and contaminate groundwater

Study of PFOS & PFOA in Soil

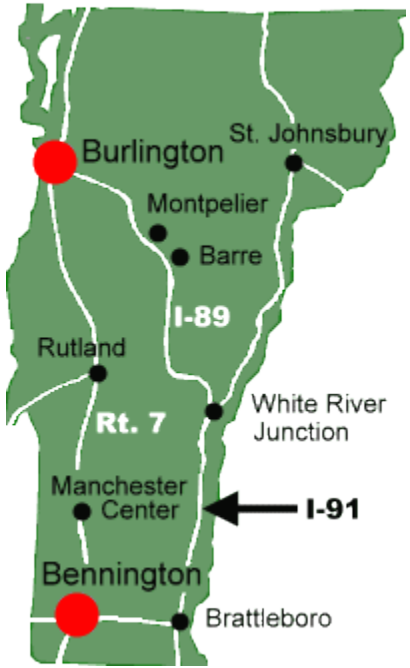
Xiao *et al.* (2013). Transport of Perfluorochemicals to Surface and Subsurface Soils. Center for Transportation Studies, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/148999.





- Sampled several roadside locations near 3M manufacturing plant
- Found that concentration generally increased with depth of sample collection
- Results imply PFOS & PFOA is not contained to “hot spots”

Case Study: Bennington



Case Study: Bennington

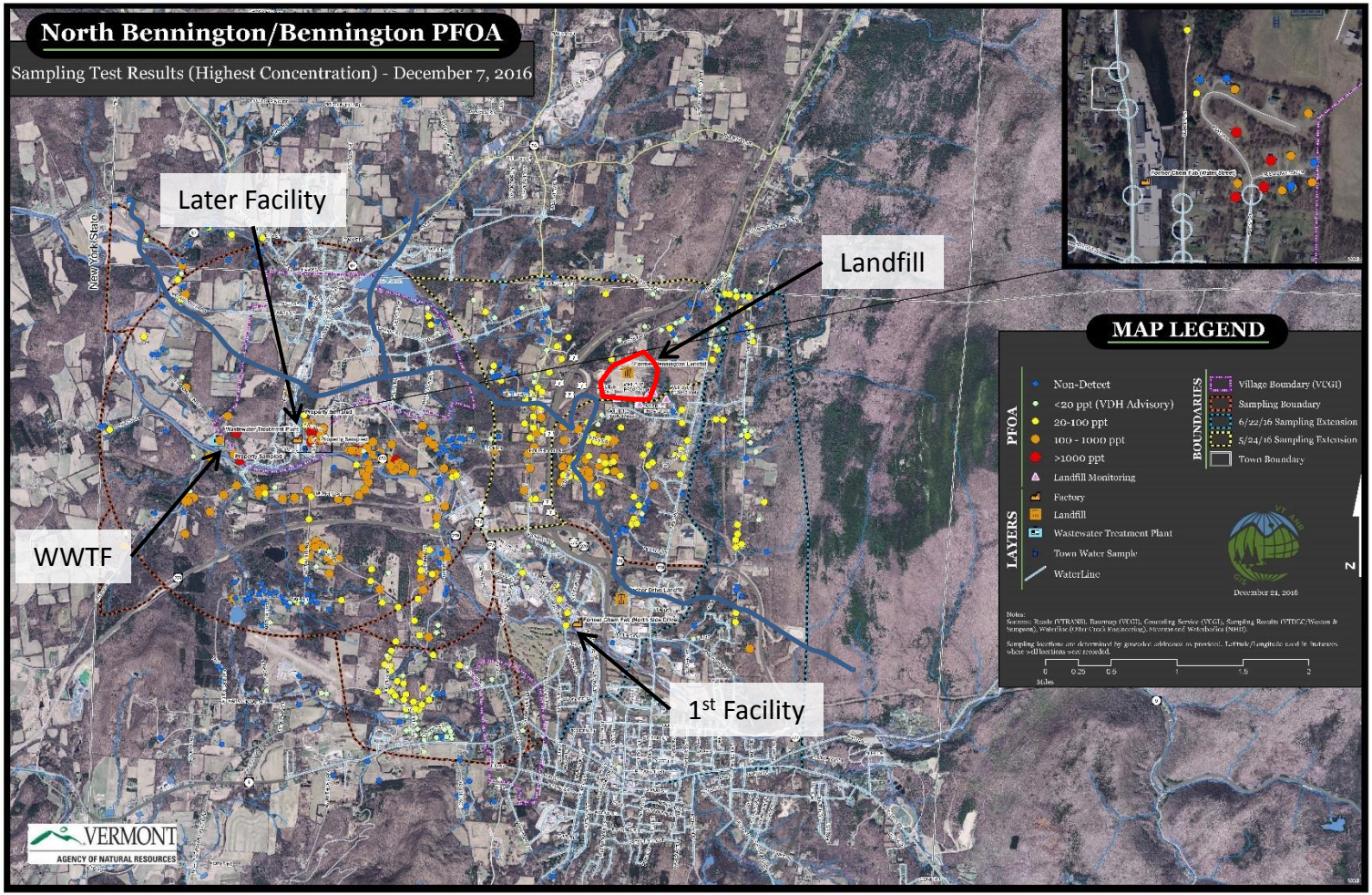
- Industrial Plant operated in North Bennington from 1970 through 2002. During its operation the facility primarily applied PTFE (Teflon) coatings to fiberglass fabrics by dip coating the fabrics in a liquid bath of micron size PTFE particles and various additives (likely including PFOA) followed by ovens to dry and melt the Teflon onto the fabric.
- Surrounding area uses mix of public and private water supplies and wastewater treatment.
- Wastewater at plant is discharged to WWTF
- Plant in valley bottom with rolling hills surrounding
- Relatively thin soil cover over complex bedrock regime
- Vermont Regulatory Limit of 20 ppt

Case Study: Bennington

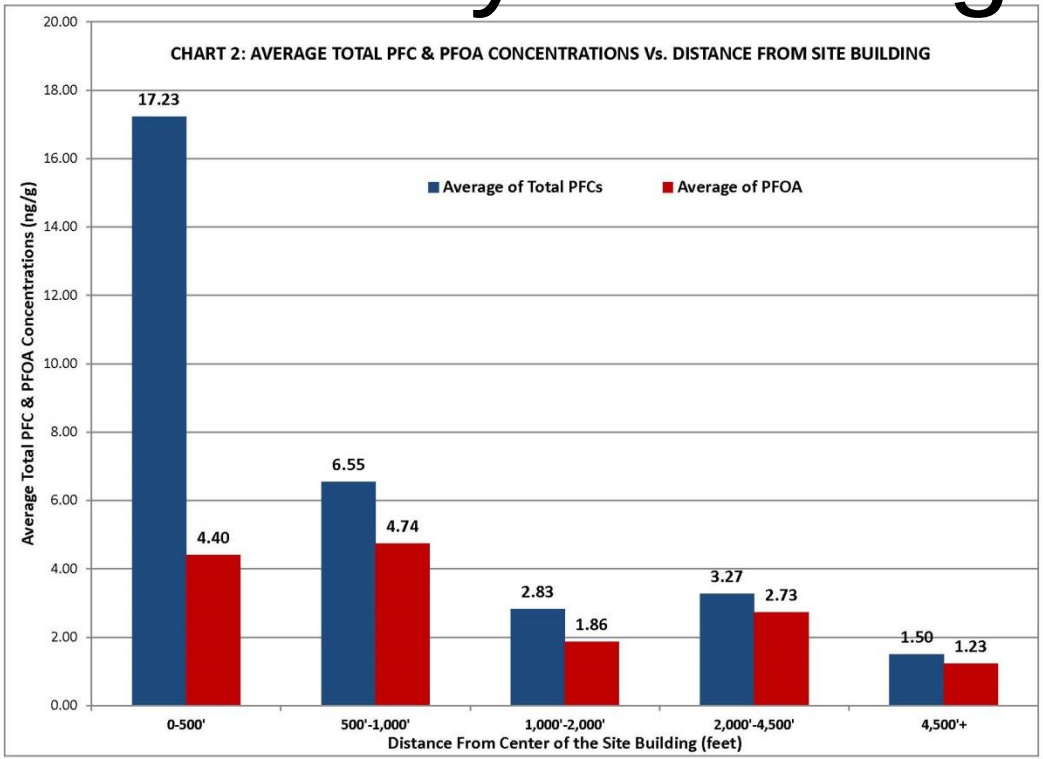
- Impacted Media
  - Shallow Water Supply Wells
  - Deep Water Supply Wells
  - Shallow Soils
  - Surface Waters
  - Sediment
  - Fish
  - WWTF and Domestic Sludges

Case Study: Bennington

- Potential Sources and Redistribution Methods.
  - Air discharge from manufacturing facility
  - Spills/dumping
  - Contaminated Wastewater discharge to WWTF
    - Pass through to receiving stream
    - Sludge from WWTF spread on farm fields throughout area in 1980's
    - Sludge from WWTF disposed of in local landfill
    - Sludge from WWTF composted and sold in neighboring state
  - Waste materials disposed of in local landfill
  - Contaminated private water supply discharge and pass through to on-site disposal fields
  - Land application of livestock manure from locations with contaminated water supply


North Bennington/Bennington PFOA
Sampling Test Results (Highest Concentration) - December 7, 2016
Later Facility
Landfill
WWTF
1st Facility
MAP LEGEND
PFOA
Non-Detect
<20 ppt (VDH Advisory)
20-100 ppt
100 - 1000 ppt
>1000 ppt
Landfill Monitoring
LAYERS
Factory
Landfill
Wastewater Treatment Plant
Town Water Sample
WaterLine
BOUNDARIES
Village Boundary (VCGI)
Sampling Boundary
6/22/16 Sampling Extension
5/24/16 Sampling Extension
Town Boundary
December 21, 2016
VERMONT
AGENCY OF NATURAL RESOURCES

Case Study: Bennington

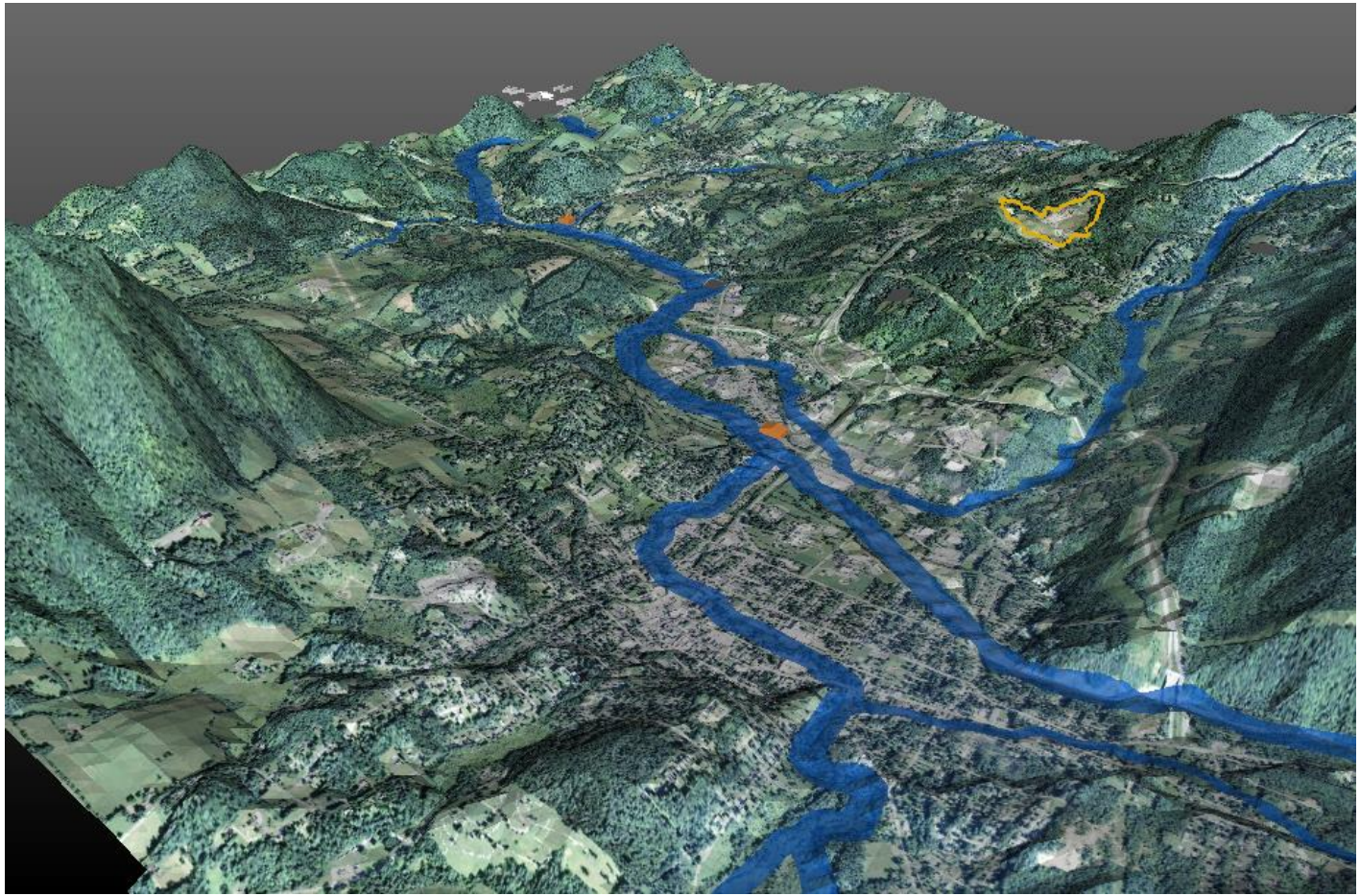


C.T. Male Assoc.

Case Study: Bennington

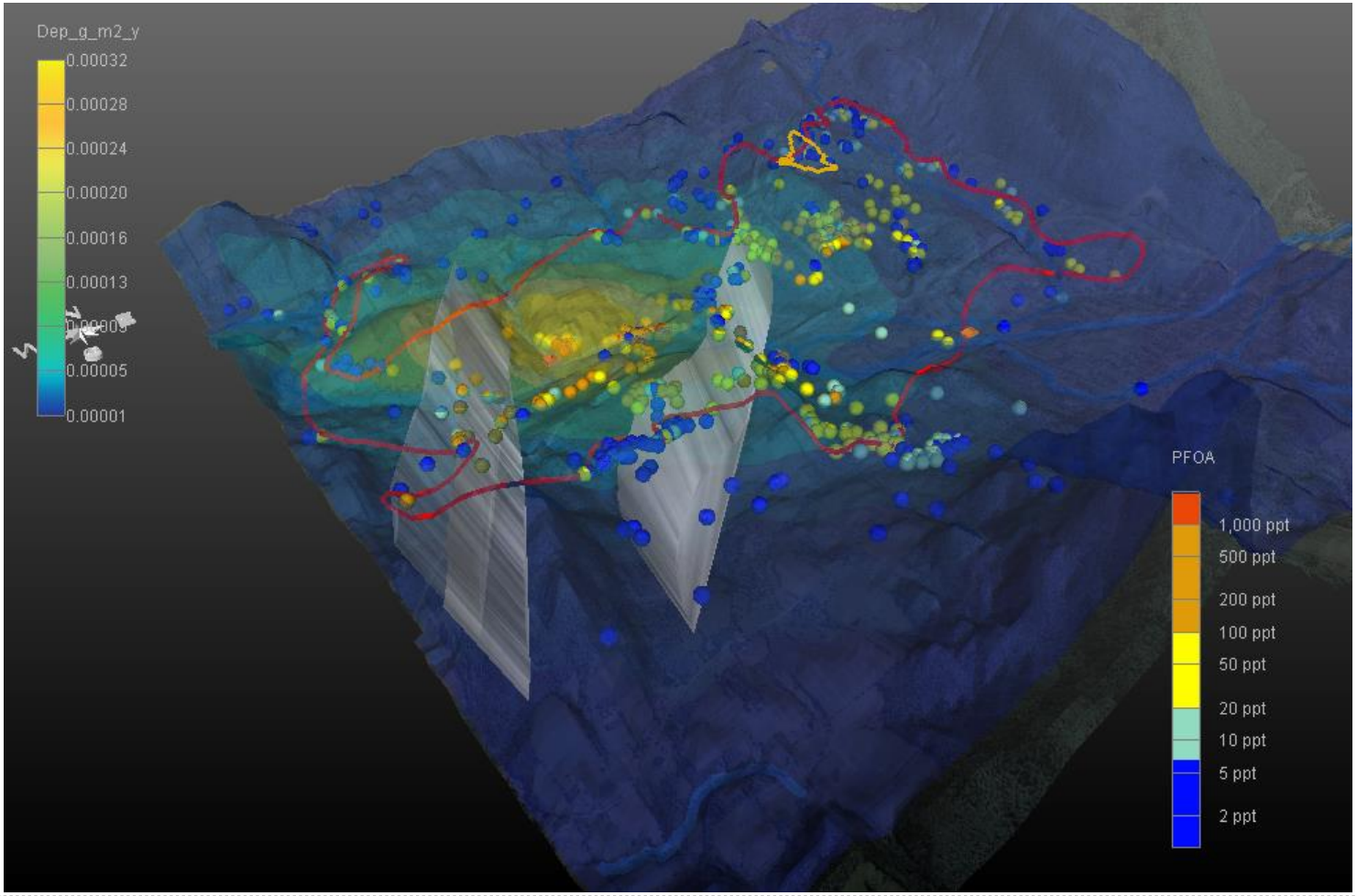
	Solid (ng/g)	Leachate (ng/L)
WWTF Sludge	7.5	66
Composted Sludge	ND/<0.9	61
Residential	69	430
VTDEC Screening/Std	300	20

Land Application of WWTF and Residential Septage Occurred Throughout the Area for Years



amec foster wheeler

Weston & Sampson℠



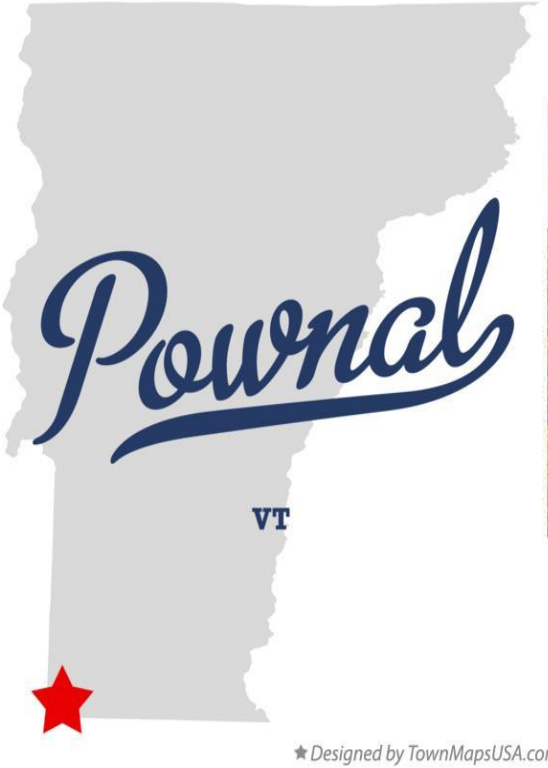
amec foster wheeler

Weston & Sampson

Case Study: Bennington

- Airborne Release Dominates Initial Distribution of Contaminants
- Multiple Methods of Redistribution Exist
  - Domestic Septic System Discharges
  - WWTF Discharge
  - Waste Disposal in Landfill
  - Sludge Spreading
- Residual “Source” Remains in Shallow Soils Throughout Area
- “Recycling”/Redistribution is Major Confounding Factor in Impact

Case Study: Pownal

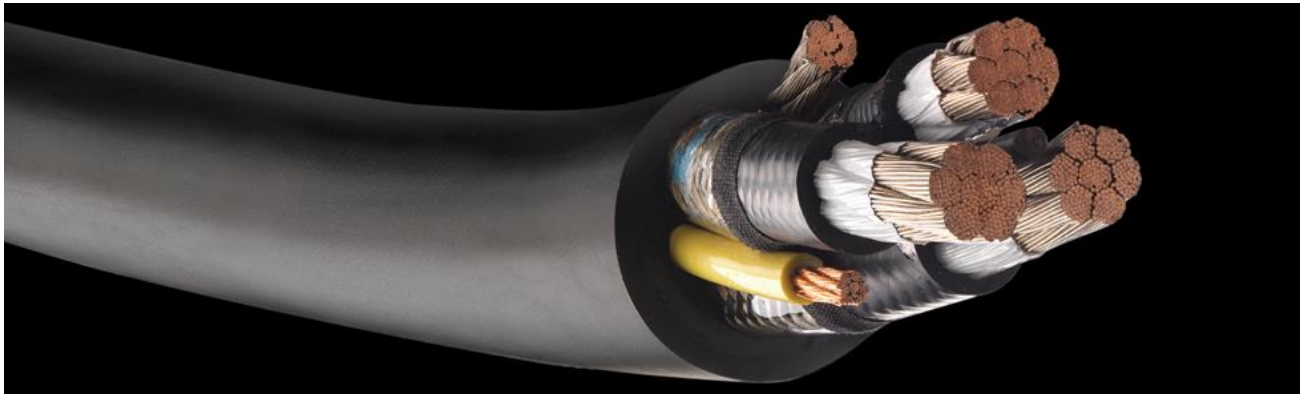


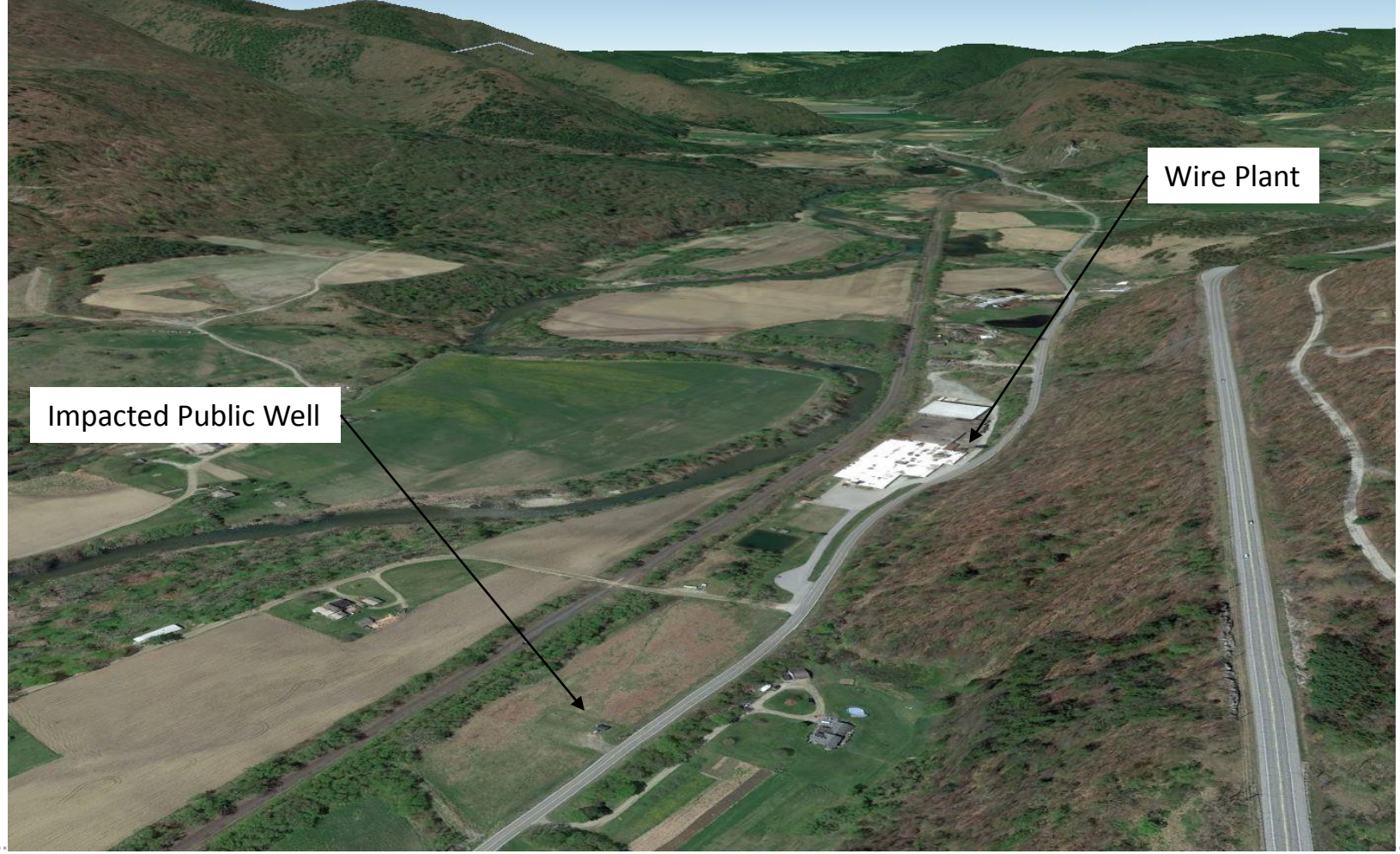
Case Study: Pownal

- Industrial Plant operated in Pownal from 1948 through 1986. During its operation the facility primarily applied PTFE (Teflon) coatings to wire for the automotive industry.
- Surrounding area uses mix of public and private water supplies and wastewater treatment.
- Public Water Supply Well located 250 meters away
- Plant in valley bottom with rolling hills surrounding
- Relatively thick, sand and gravel aquifer

Case Study: Pownal

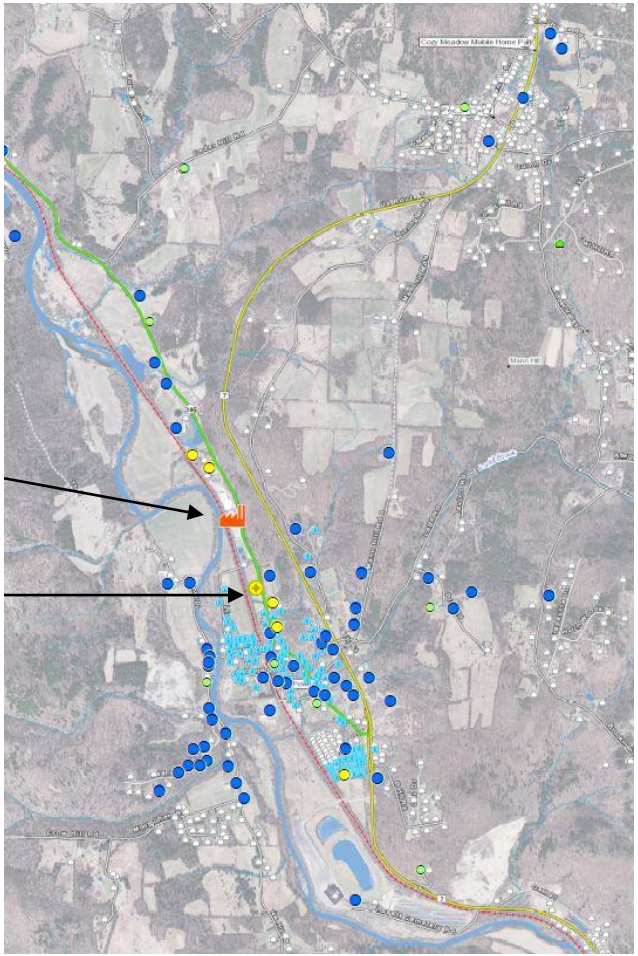
- Potential Sources and Redistribution Methods.
  - Spills/Dumping from manufacturing facility
  - Minimal air discharge
  - Contaminated wastewater discharge to WWTF
  - Waste materials disposed of in illegal landfill




Wire Plant
Impacted Public Well

Wire Plant

Impacted Public Well



Case Study: Pownal

- Terrestrial Releases Dominate Initial Distribution of Contaminants
- Contaminant Migration Appears Dominated by “Predictable” Hydrogeology
- Minimal Methods of Redistribution Exist
  - Active Water Supply Well Causing Flow “Upgradient”
  - WWTF Discharge
  - Waste Disposal in ad hoc Landfill
  - Sludge Spreading?
- Residual “Source” Remains in Shallow Soils Throughout Plant Area

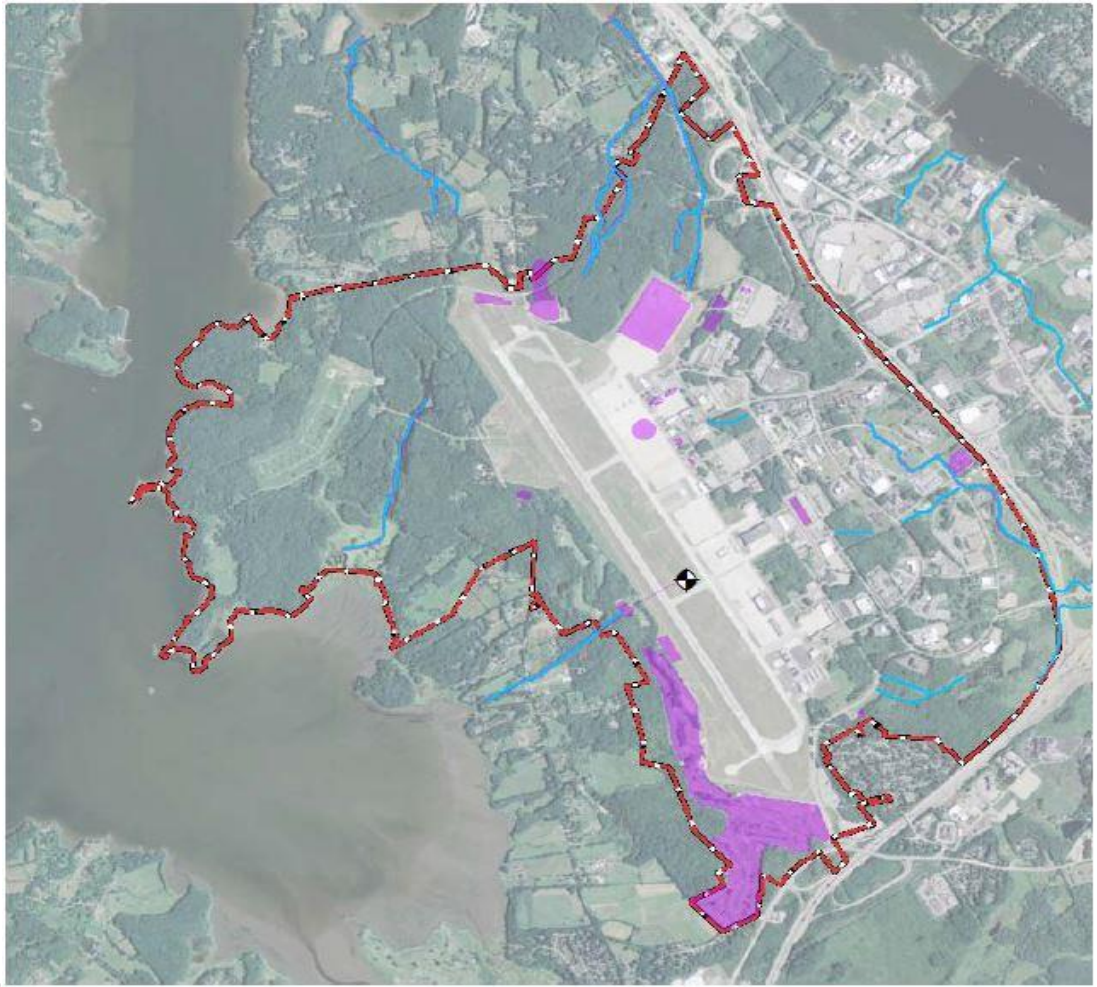
Case Study: Pease

Case Study: Pease

- Pease Tradeport was a Strategic Air Command facility and US Air Force base until 1991.
- AFFF utilized in training and crash responses.
- PFOA, PFOS and precursors identified along with fuels and chlorinated solvents.
- Numerous high producing sand and gravel water supplies for Tradeport and Portsmouth, NH located on-site.
- Now home to a golf course, a commercial airport, and more than 250 businesses employing some 9,500 workers
- Unique aquifer

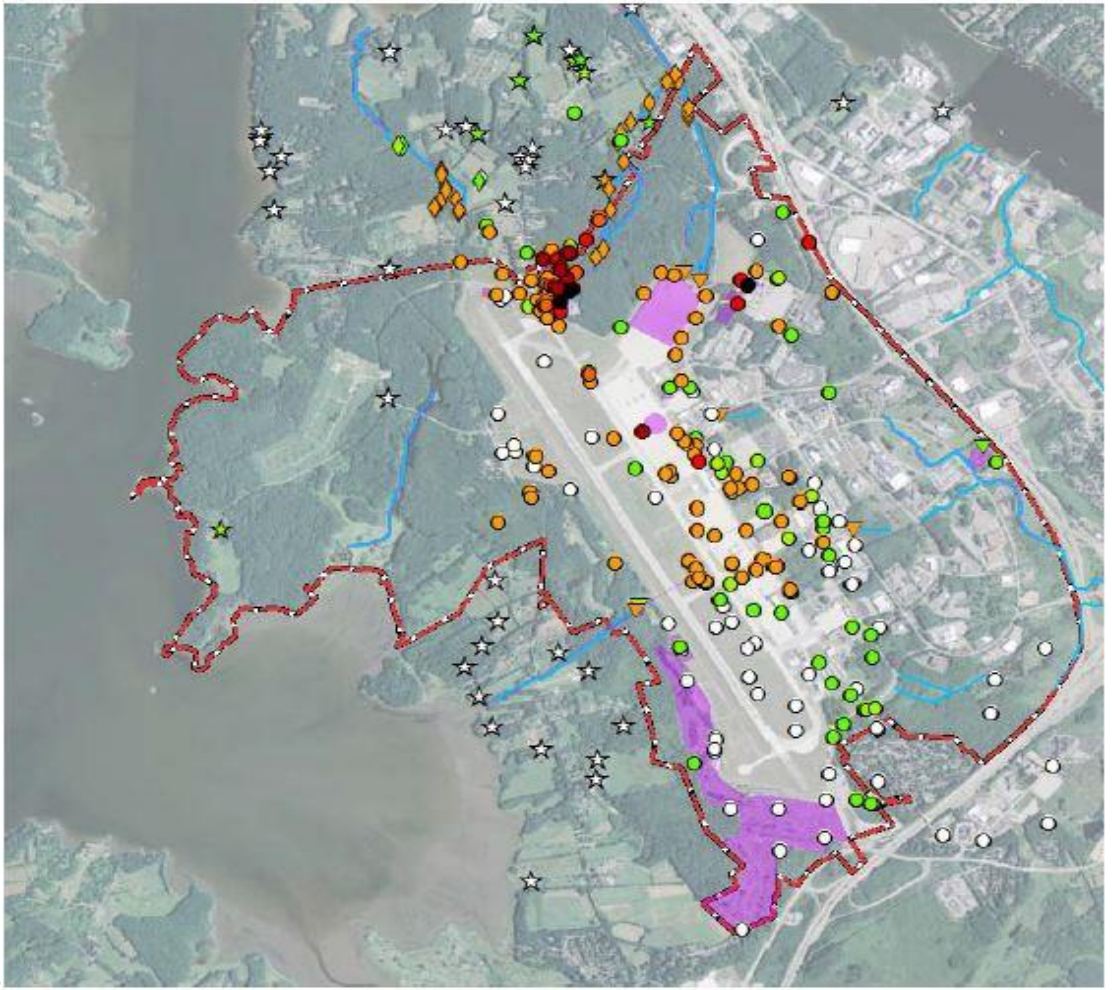
Pease Tradeport

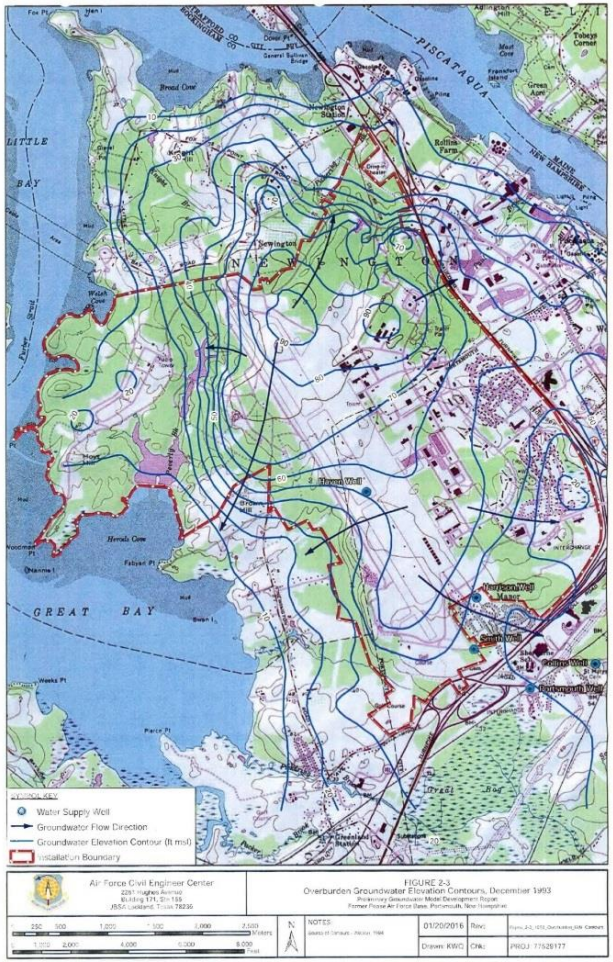
- Potential Source Locations
  - Fire Training
  - Fire Fighting Equipment Testing
  - Crash Sites
- Redistribution Methods
  - Stormwater System Discharges to Beneath Entire Base Water
  - Supply Well Operations
  - Supply Well Pumping Test Discharge
  - Golf Course Irrigation



Pease Tradeport

- PFAS identified throughout facility and beyond.
  - Shallow soils
  - Deep Soils
  - Groundwater
  - Surface Water





Courtesy of AMEC

Case Study: Pease

- Detailed research into previous AFFF use areas necessary to identify potential source and redistribution locations
- Extensive assessment of multiple source and discharge locations necessary.
- Despite known AFFF use areas, complex hydrogeology and multi-component contaminant plumes made for difficult prediction of plume locations.

Characterization Design Implications

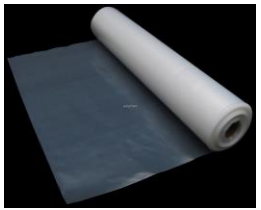
- Detailed research into previous PFAS uses MUST be performed to identify all potential source and distribution methods into a Conceptual Site Model.
  - Volume and types of PFAS and precursors utilized
  - Manufacturing processes
    - application and drying methods
    - AFFF use/training locations
  - Storage, transfer, and waste disposal areas
  - Wastewater treatment and disposal
    - On Site or WWTF
    - Sludge disposal
  - Potential dumping and landfilling areas

Characterization Design Implications

- CSM must address geologic and hydrogeologic conditions assuming little to no retardation of PFAS occurs.
  - Sorption on soils and associated organic carbon is minimal compared to most “traditional” contaminants.
  - Highest soil concentrations likely to be between ground surface and groundwater at airborne deposition locations.
  - Sufficient contaminant mass to cause groundwater contamination above regulatory limits may exist, despite a lack of quantifiable concentrations in solids (soil, sludge, manure).
  - Redistribution mechanisms can be a dominant method of PFAS mass transport into long ranging areas surrounding the “source” location. Potential redistribution methods must be part of the initial CSM.
  - Anticipate an impacted area much larger than expected. (Kilometers not meters)

Characterization Design Implications

- Field characterization methods must be PFAS specific.
  - Most regulatory standards/advisory concentrations are in the part per trillion. Very few molecules of PFAS in a sample can result in exceedances
    - Many “traditional” assessment materials have/had PFAS associated with them
      - Rite in the Rain Notebooks
      - Gore Tex and similiar rainwear
      - Teflon liners in sample jar tops
      - Teflon tubing, pump seals


  - Frequent sample duplicates, field and equipment blanks are essential.
  - Soil/Solid analyses utilizing SPLP type extraction may be necessary to define risk to groundwater.
  - Sites with AFFF and/or multiple PFAS used should consider alternative analysis methods to determine “total” PFAS presence. (Total Oxidizable Precursor Assay).

Questions?