Investigation and Treatment of PFAS at a Rurally-Located Naval Airfield

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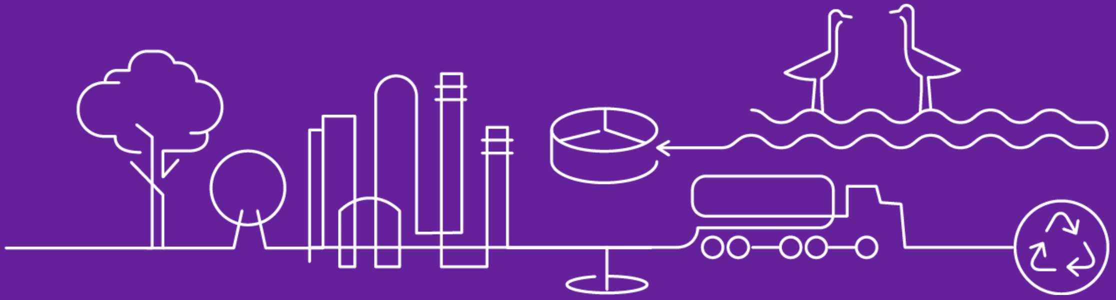

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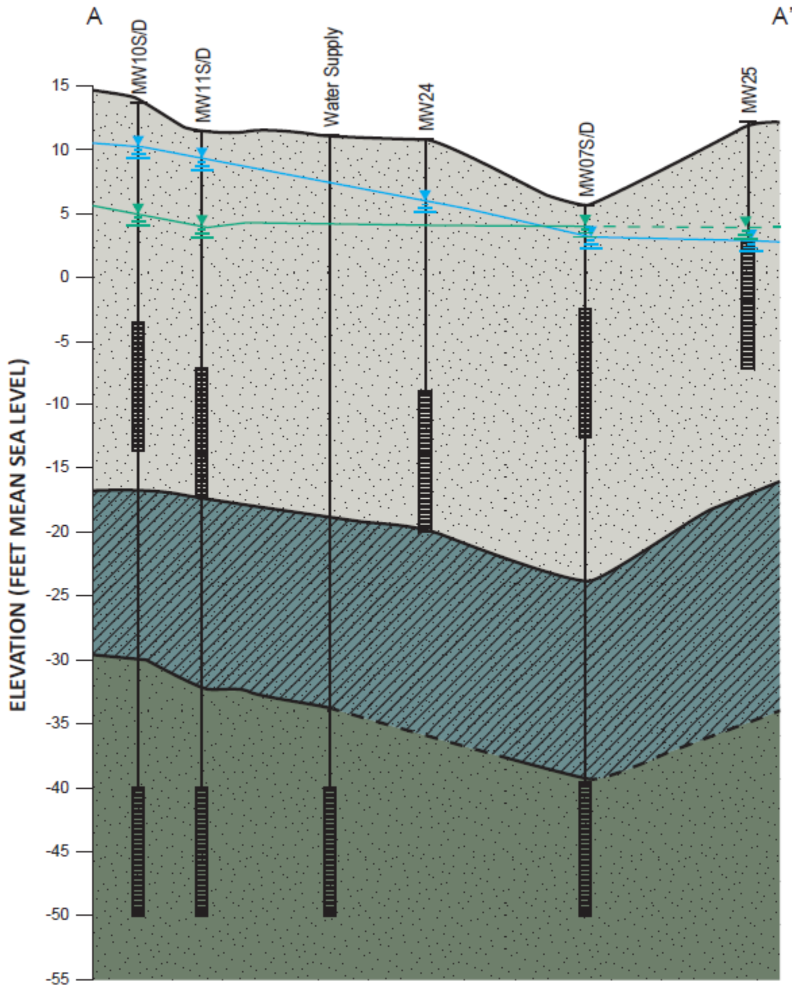
Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds – Battelle 2017

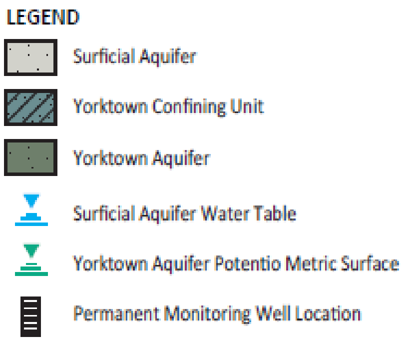
Site History

- Site is an outlying landing field used primarily for touch-and-go's
- Staffed by 40 military personnel, primarily fire-fighters
- Groundwater from two supply wells is used as the only source of water (potable and non-potable) on-base
- Former drinking water treatment involves green sand filters, permanganate oxidation, water softening, and chlorination
- Wastewater is treated with settling in a series of lagoons and subsequently used for spray irrigation on-site
- Residences near the landing field use private wells for potable and non-potable purposes

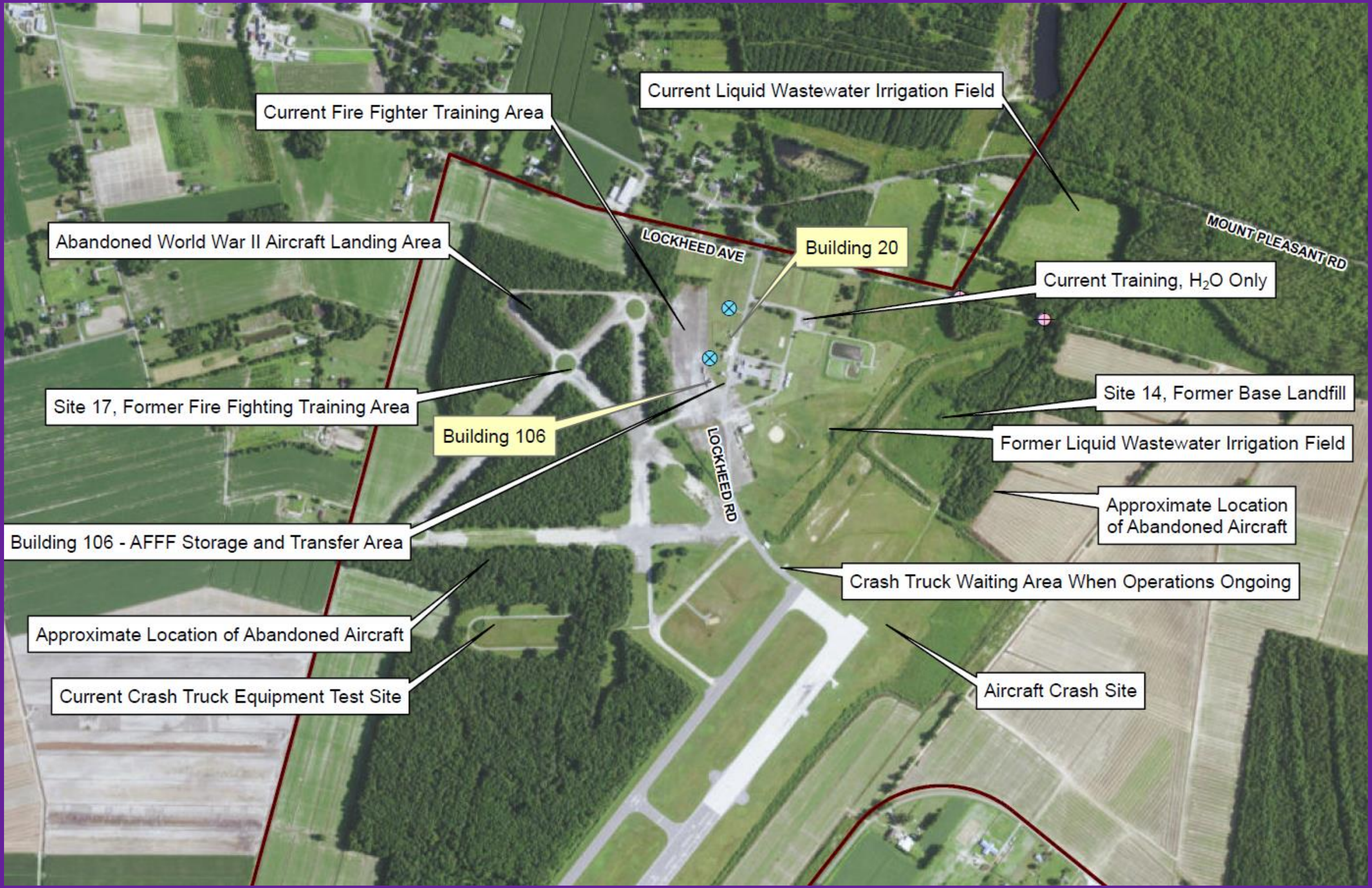
Hydrogeologic Setting

- Surficial aquifer – heterogeneous silty sand to 20-30 feet bgs
- Shallow water table at 2-8 ft bgs
- Yorktown confining unit - ~8-15 feet thick
- Yorktown aquifer - silty-sand >100 ft thick (drinking water aquifer)





Site Layout



Current Liquid Wastewater Irrigation Field
Current Fire Fighter Training Area
Abandoned World War II Aircraft Landing Area
LOCKHEED AVE
Building 20
MOUNT PLEASANT RD
Current Training, H_2O Only
Site 14, Former Base Landfill
Site 17, Former Fire Fighting Training Area
Building 106
LOCKHEED RD
Former Liquid Wastewater Irrigation Field
Approximate Location of Abandoned Aircraft
Building 106 - AFFF Storage and Transfer Area
Crash Truck Waiting Area When Operations Ongoing
Approximate Location of Abandoned Aircraft
Current Crash Truck Equipment Test Site
Aircraft Crash Site

Initial PFAS Investigation

- Six UCMR3 PFAS initially evaluated in on-base groundwater and drinking water in December 2015
- Monitoring wells sampled in locations of reported or probable aqueous film forming foam (AFFF) releases and at base boundary:
  - Crash truck test area
  - Former fire-fighting training area
  - Former Base Landfill
  - Crash sites
  - Irrigation spray fields
- Raw groundwater from on-base drinking water supply wells and treated drinking water was tested at various points within the drinking water treatment process

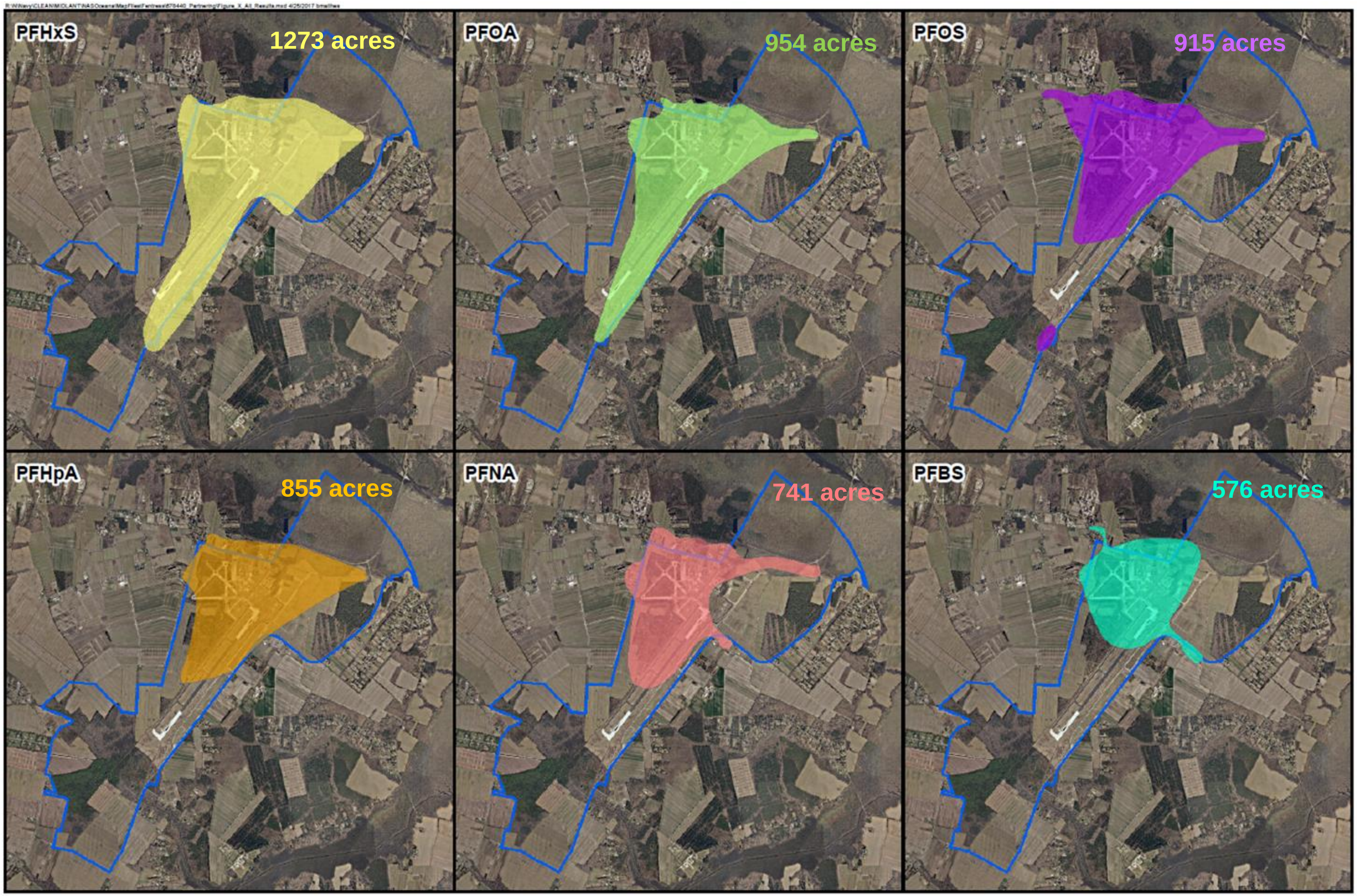
Initial (2015) Investigation Findings - Groundwater

- Detections of PFAS in both aquifers, focus is on PFOS/PFOA
- Exceedances of the 2009 USEPA Provisional Health Advisory (PHA) of PFOA (0.4 µg/L) and PFOS (0.2 µg/L) in Surficial Aquifer monitoring wells:
  - **Crash Truck Test Area**
    - PFOS – 11 µg/L
    - PFOA – .0.32 µg/L
  - **Fire-fighting Training Area**
    - PFOS – 3.0 µg/L
    - PFOA – 0.320 µg/L
  - **Facility boundary wells**
- Yorktown Aquifer Monitoring Wells – detections but no exceedances
- Base water supply (raw water and finished drinking water) samples exceeded PHAs

Follow-on Investigations – Groundwater and Drinking Water

- Conceptual Site Model (CSM) developed to assess need to test off-site drinking water
- Off-base private wells within 0.5 mile of wells with concentrations exceeding 25% of the PHA were sampled
  - Two downgradient properties exceeded the PHA
  - Based on step outs and establishment of the lifetime health advisory (L-HA), 6 properties exceeded the L-HA
  - 52 wells on 49 properties ultimately sampled
- Installation and sampling of new wells and sampling of existing on-base wells for better delineation
  - Monitoring wells sampled to date: 47
  - Concentrations of up to 49 µg/L (PFOS) and 6 µg/L (PFOA) at old tank site
- Deep double-cased environmental well concentrations were in most cases less than the health advisory level
- Straight-drilled deep water supply wells exceeded the health advisory in many cases

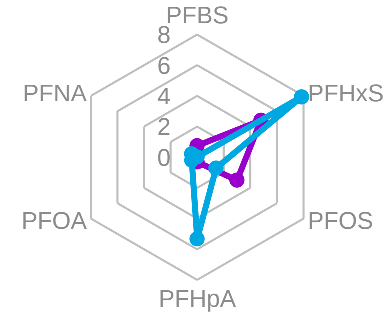
Plume Extents – 6 UCMR3 PFAS



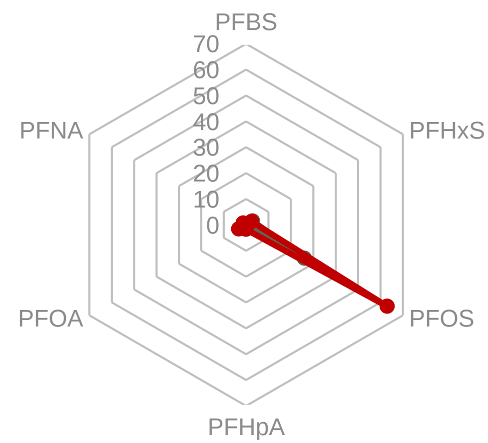
Primary and Secondary Source Evaluation

- Soil sampling completed to assess primary and secondary source areas:
  - Areas where fire-fighting training activities were conducted
  - Irrigation sprayfields
- Sludge evaluation to determine if liner replacement would be necessary once the upgraded drinking water treatment system was functional
  - From wastewater storage lagoon

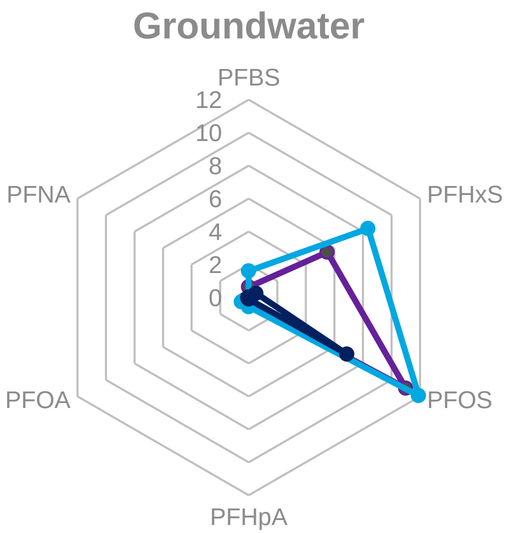
Groundwater

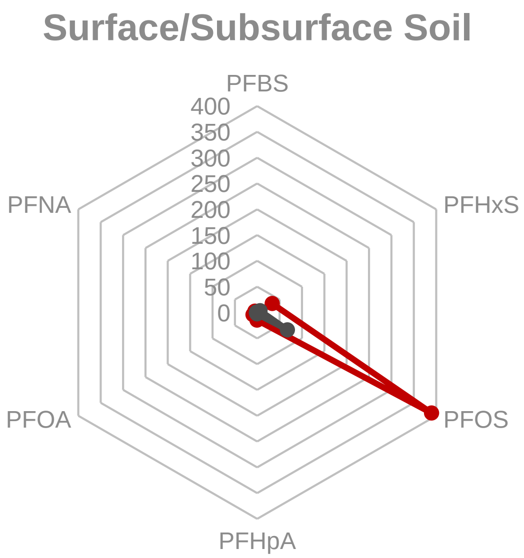


Surface/Subsurface Soil



units: µg/L and µg/kg





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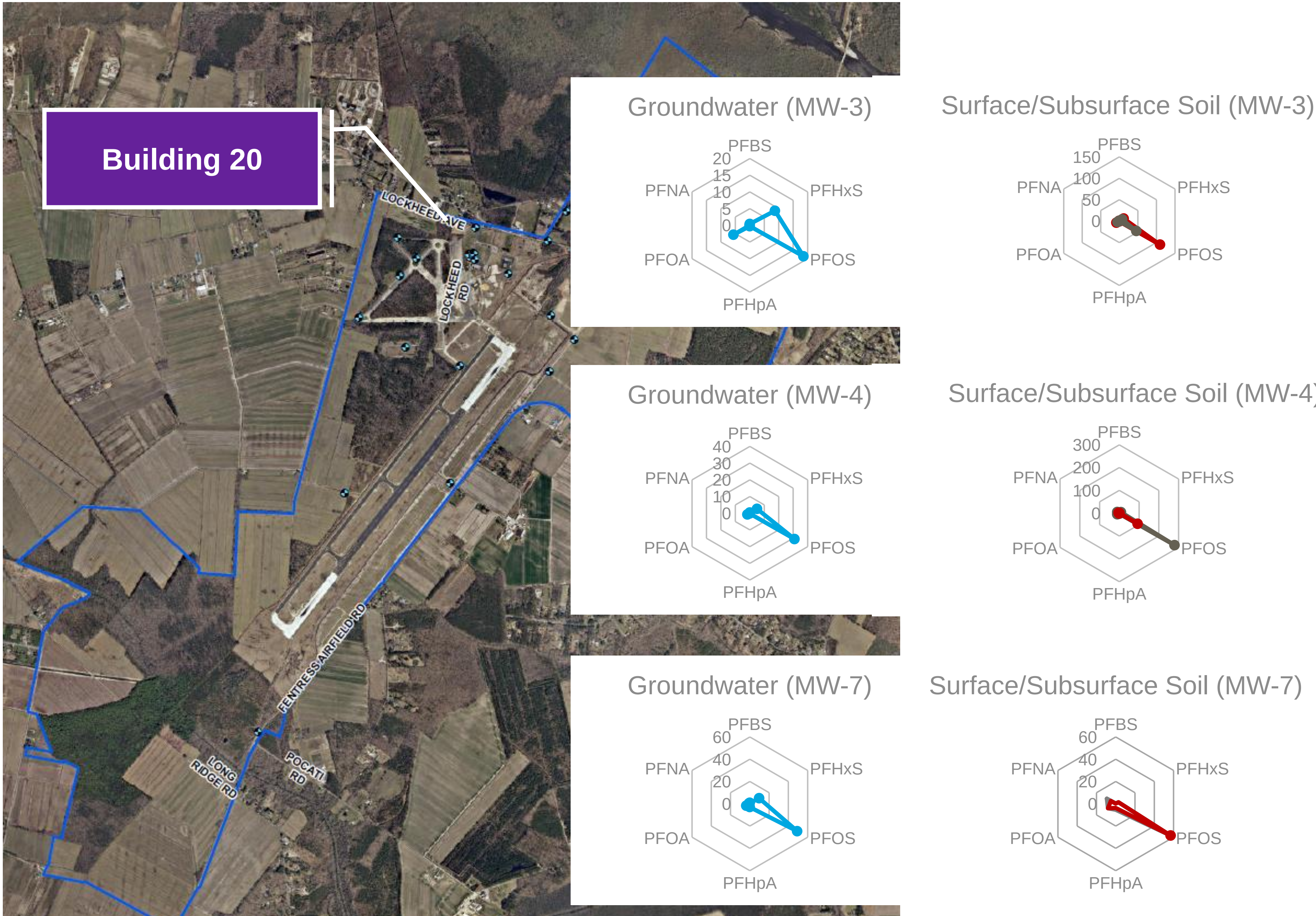

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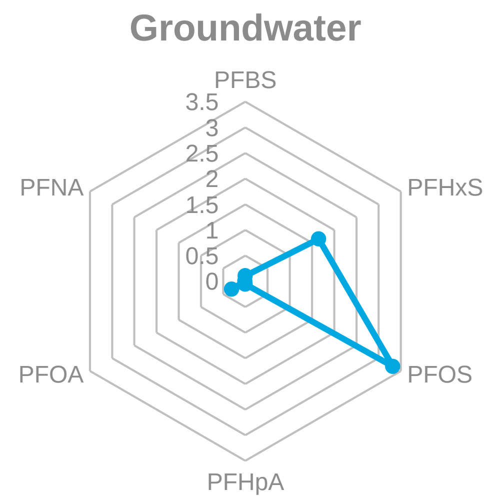

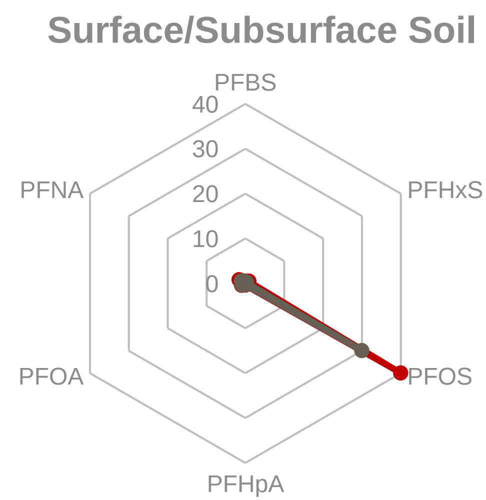

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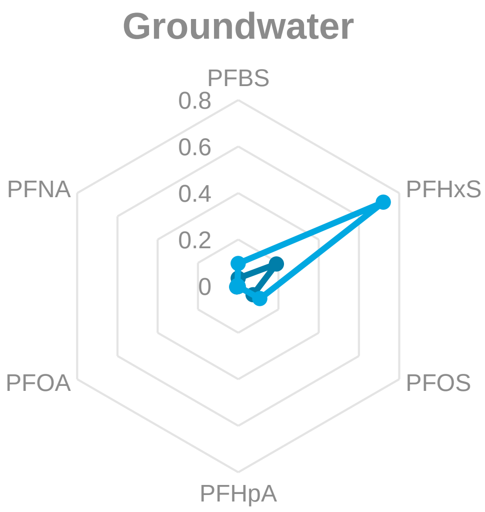

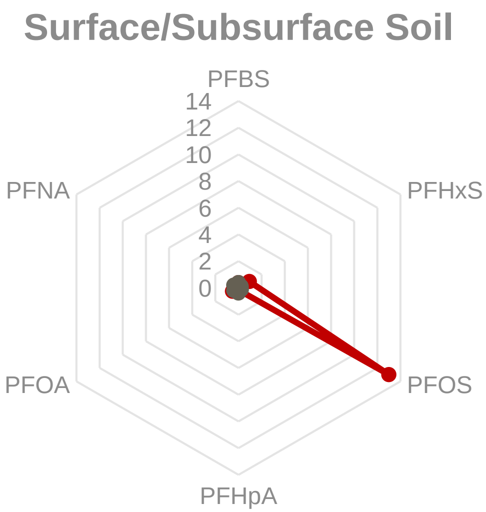

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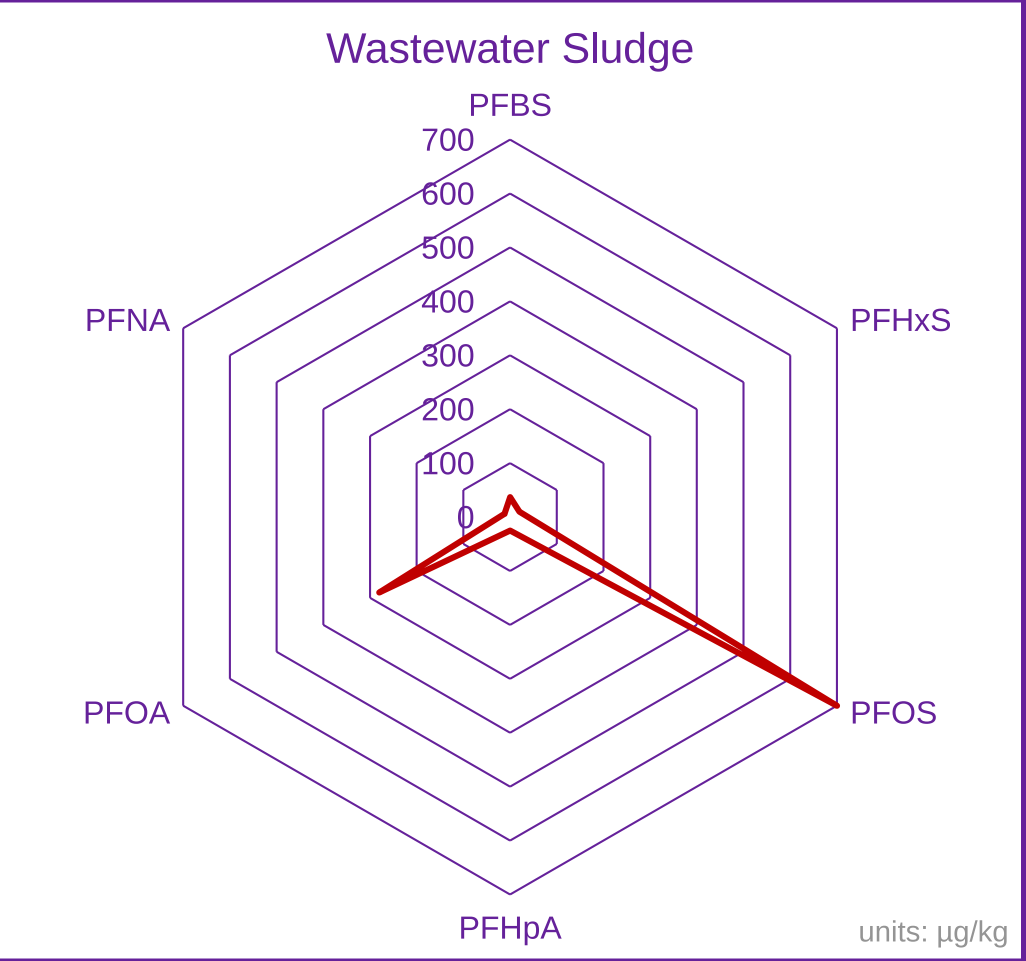
Sludge Testing Results

- Highest PFAS concentrations found within sludge of storage lagoon
- Liner replaced ~1 year prior to collection of sludge sample
- PFOS dominates, with lower levels of PFOA observed



Follow-on Investigations and Rapid Response Actions, On-base and Off-base Drinking Water

- Base personnel supplied with bottled water
- Water filling station established by local municipality for concerned residents during off-base groundwater sampling
- Residences with exceedances of the PHA and subsequently the L-HA (PFOA + PFOS > 0.070 µg/L) were immediately supplied with bottled water when results were received (6 properties)

Evaluation of Drinking Water and Wastewater Systems

Drinking water system

- Used Total Oxidizable Precursor (TOP) assay to assess precursor mass
- TOP assay PFOA values higher than non-TOP assay PFOA in raw water
- PFOA was greater after permanganate/greensand filter treatment, indicating oxidative transformation of precursors
- PFOS levels remained fairly consistent throughout treatment system and were relatively consistent between non-TOP and TOP samples

Wastewater system

- PFOS levels remained fairly consistent throughout treatment system
- PFOA levels declined slightly through treatment process
- TOP assay suggested some precursor mass remains throughout

Water and Wastewater Treatment Approach

GAC selected to treat potable water and wastewater because:

- Removes the target compounds very well
- In routine use for PFAS, readily available
- PFAS destroyed by incineration during GAC regeneration

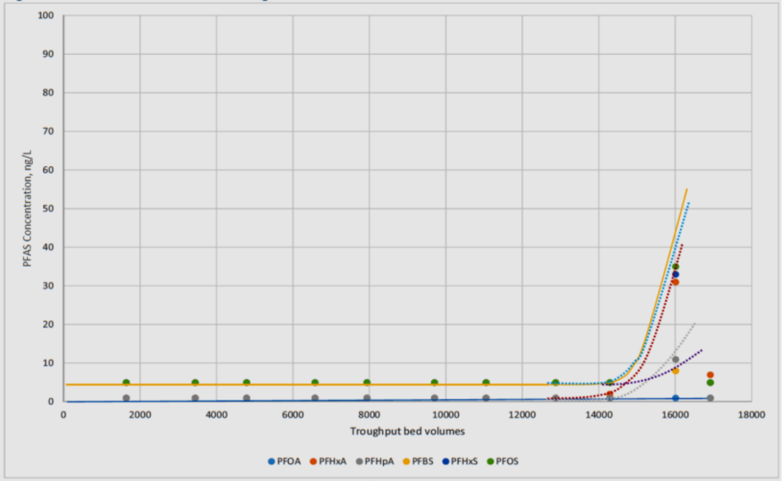
Drinking Water

- Multiple GACs isotherm tested with Rapid Small Scale Column Testing
- For finished drinking water, breakthrough occurred at >16,000 bed volumes

Wastewater

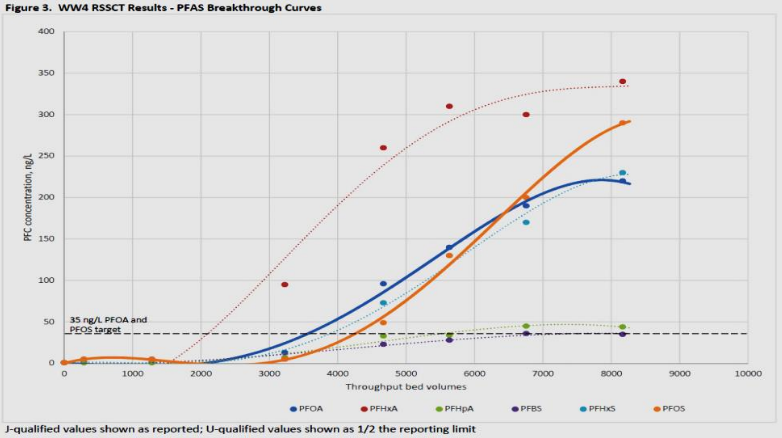
- Tested alum and ferric sulfate pretreatment at multiple doses, 50 mg/L alum selected
- Alum pretreatment reduced concentrations of PFOA (22%) and PFOS (56%)
- Breakthrough for wastewater considerably sooner than for drinking water due to total organic carbon (TOC)

Figure 2. DE2 RSSCT Results - PFAS Breakthrough Curves



J-qualified values shown as reported; U-qualified values shown as 1/2 the reporting limit.

Figure 3. WW4 RSSCT Results - PFAS Breakthrough Curves



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Treatment Systems/System Retrofits

Drinking water systems

- Designed GAC systems on- and off-base using Filtrasorb 600
- System installations in progress

Wastewater system

- Designed GAC system using Filtrasorb 400
- Operating successfully, removing PFOS and PFOA to non-detect levels

General Conclusions and Take-aways - Characterization

- Releases came from a number of different aviation fire fighting sources with significant migration in groundwater, particularly for PFHxS
- Concentrations in groundwater well above L-HAs
- Significant redistribution occurred as a result of irrigation spraying of contaminated wastewater
- Deeper aquifer was impacted by straight drilling wells through the confining unit and pumping
- PFOS was the dominant compound in surface and subsurface soil and in wastewater sludge
- Dominant compounds varied in groundwater depending on source area

General Conclusions and Take-aways - Remediation

- Oxidizable precursors resulted in increases in PFOA concentrations following permanganate/greensand filter treatment in drinking water
- Bench-testing confirmed Filtrasorb 600 bituminous GAC as most effective treatment for drinking water
- Bench-testing confirmed alum was an adequate flocculant for high TOC wastewater effluent
- Bench-testing confirmed Filtrasorb 400 bituminous GAC as most effective treatment for pre-treated wastewater
- Continuing releases from the spray irrigation system were mitigated through GAC treatment of wastewater
- Impacts to current drinking water receptors were successfully mitigated through bottled water supply and subsequent GAC treatment

Thank you!

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