Removal of PFAS from Groundwater in an Extraction and Treatment System

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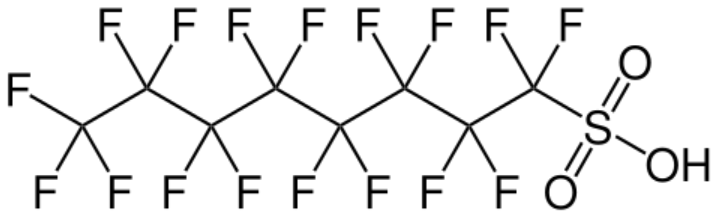
Challenges for Groundwater Treatment

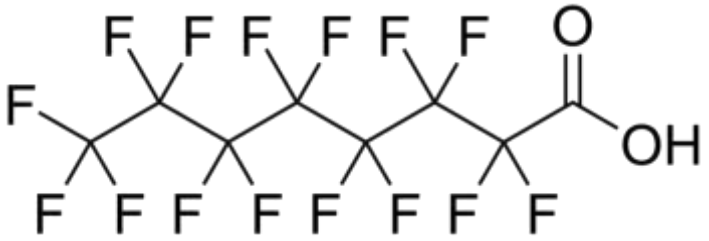
Including:

- Low volatility
- Strength of C-F Bonds
- Polarity
- Hydrophobic/hydrophilic
- Precursor issues – other PFAS present in influent

PFOS



PFOA



Focus on Four PFAS

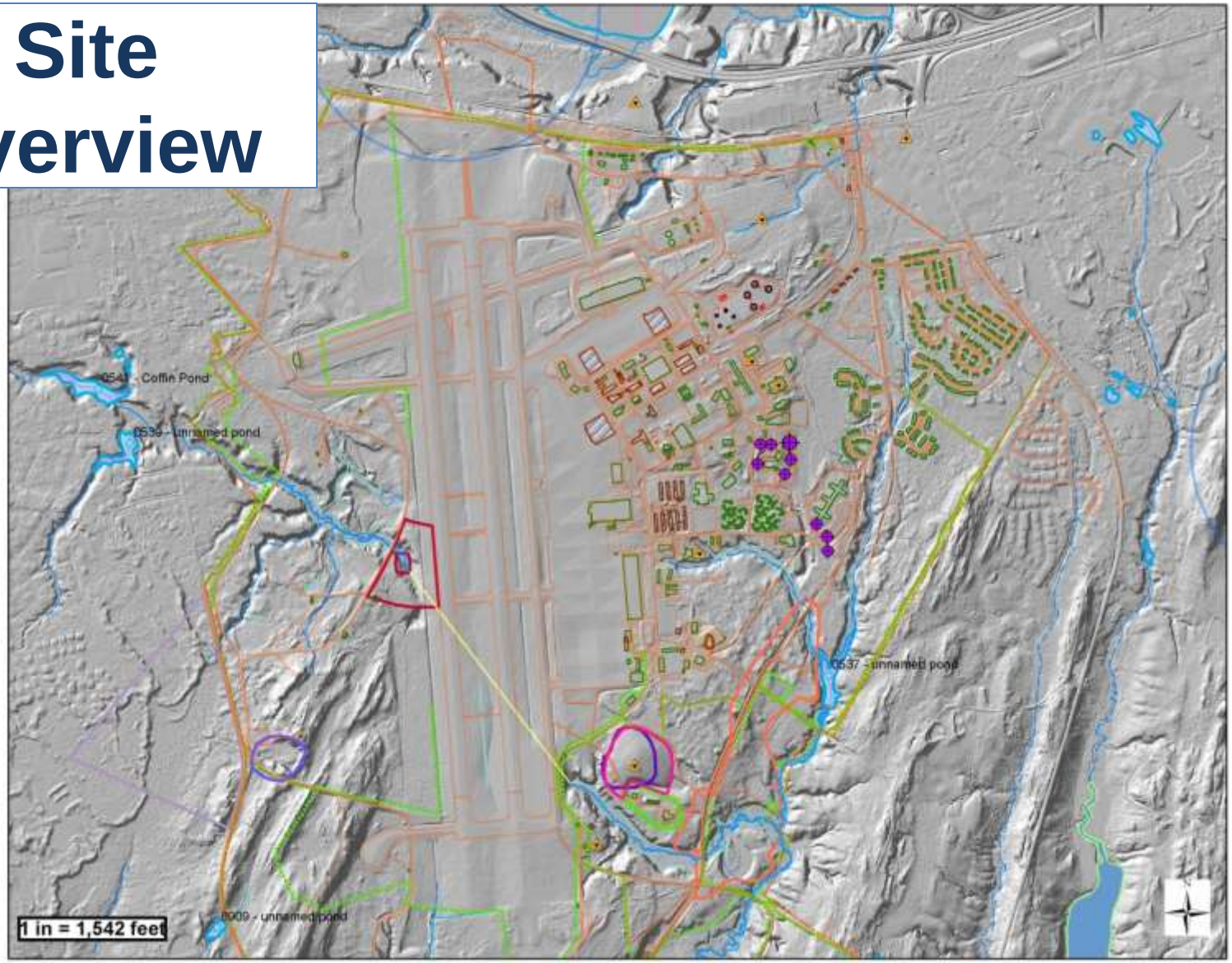
Name	Acronym	Carbon Chain Length	Molecular Weight g/mol
Perfluorooctanoic Acid	PFOA	8	414
Perfluorooctane Sulfonic Acid	PFOS	8	500
Perfluorohexanoic Acid	PFHxA	6	314
Perfluorobutanoic Acid	PFBA	4	214

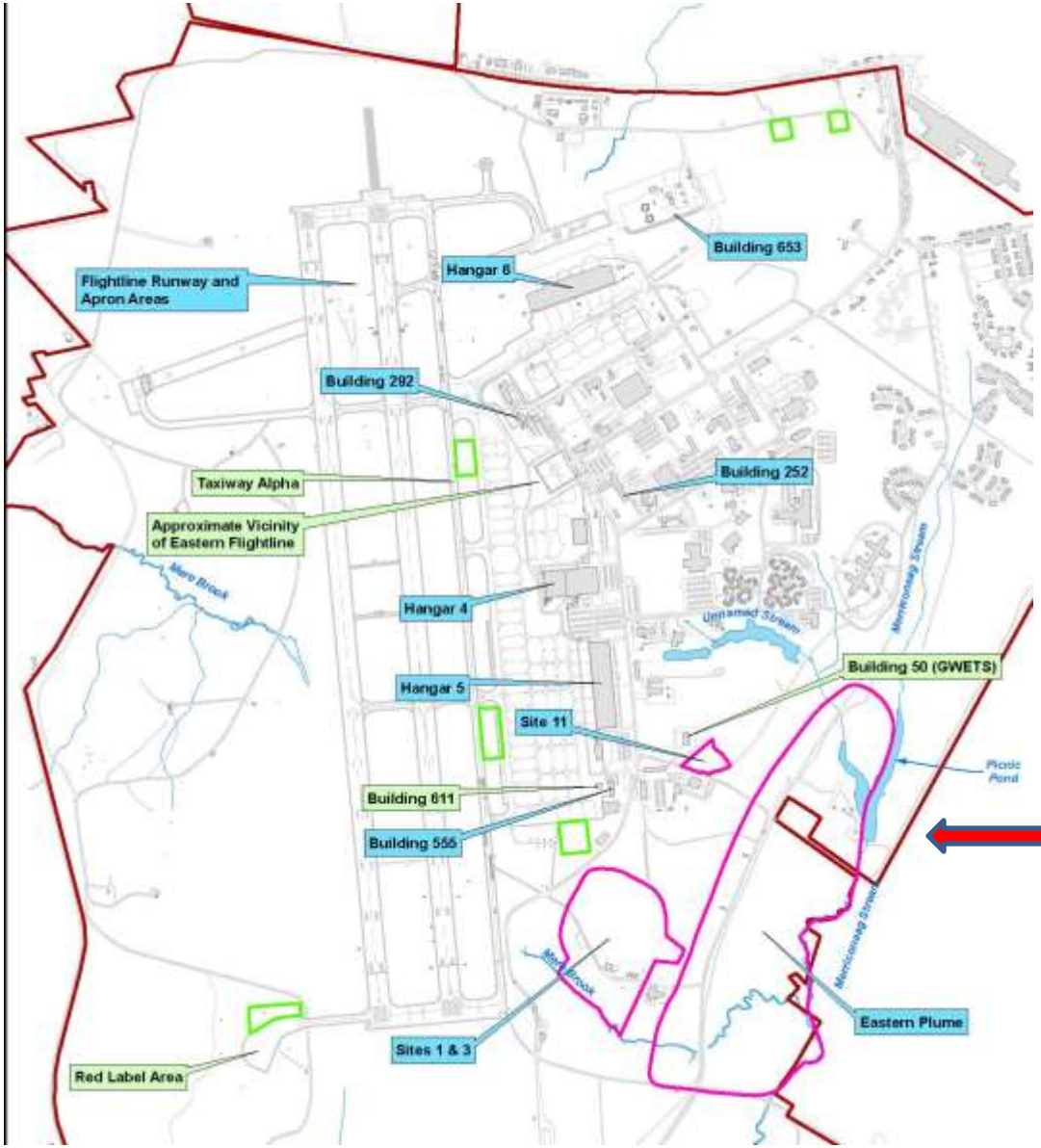
Limited Treatment Options

	Evaluated for Selected C4 – C10 PFAS
< 10% Effective	Ozone, UV, Chlorine Dioxide, Aeration, Permanganate
10 – 90% Effective	Anion Exchange, Granular Activated Carbon (>90% for higher MW PFAS (>=C8), less for lower MW (C4-C6))
> 90% Effective	Nanofiltration, Reverse Osmosis

Dickenson and Higgins, Water Research Foundation, 2016

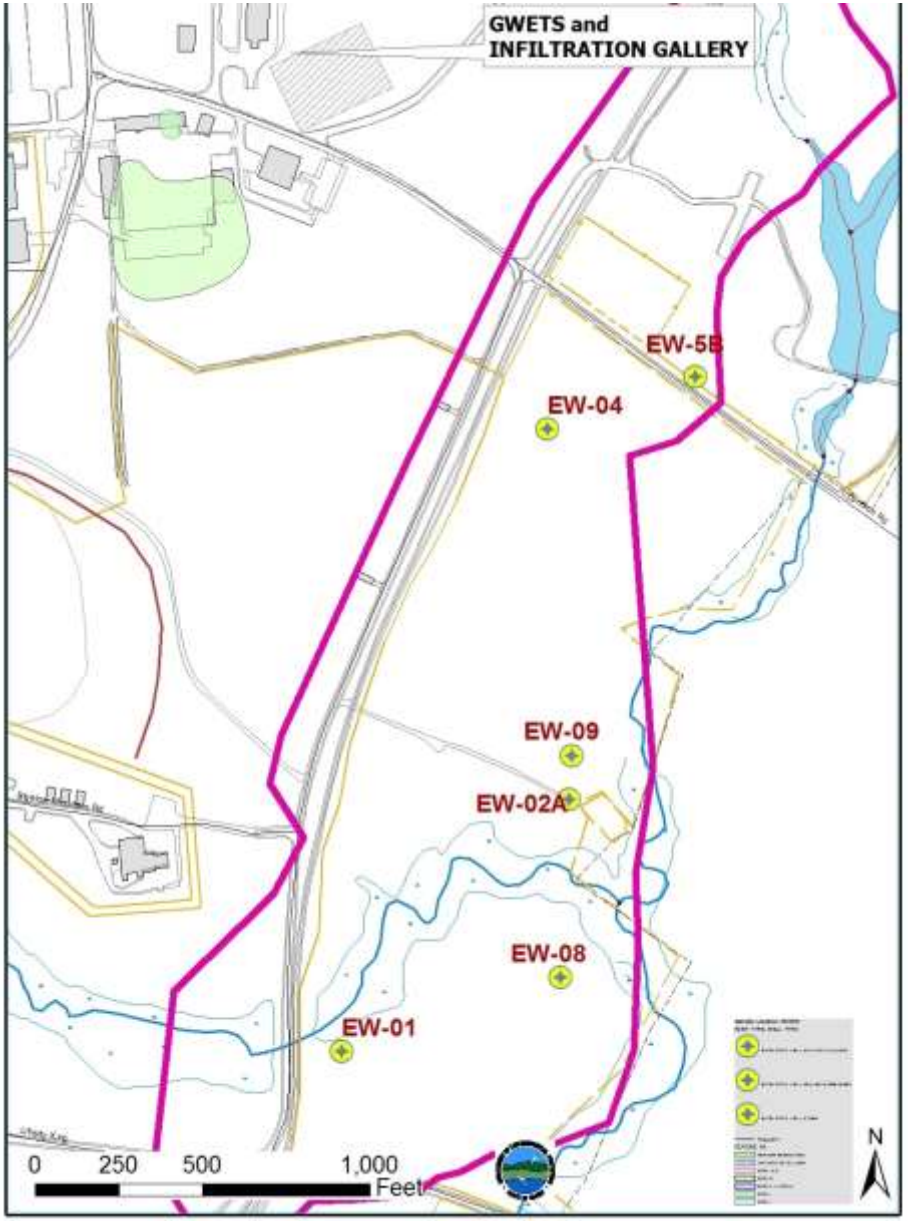
Site Overview





Multiple potential sources related to AFFF

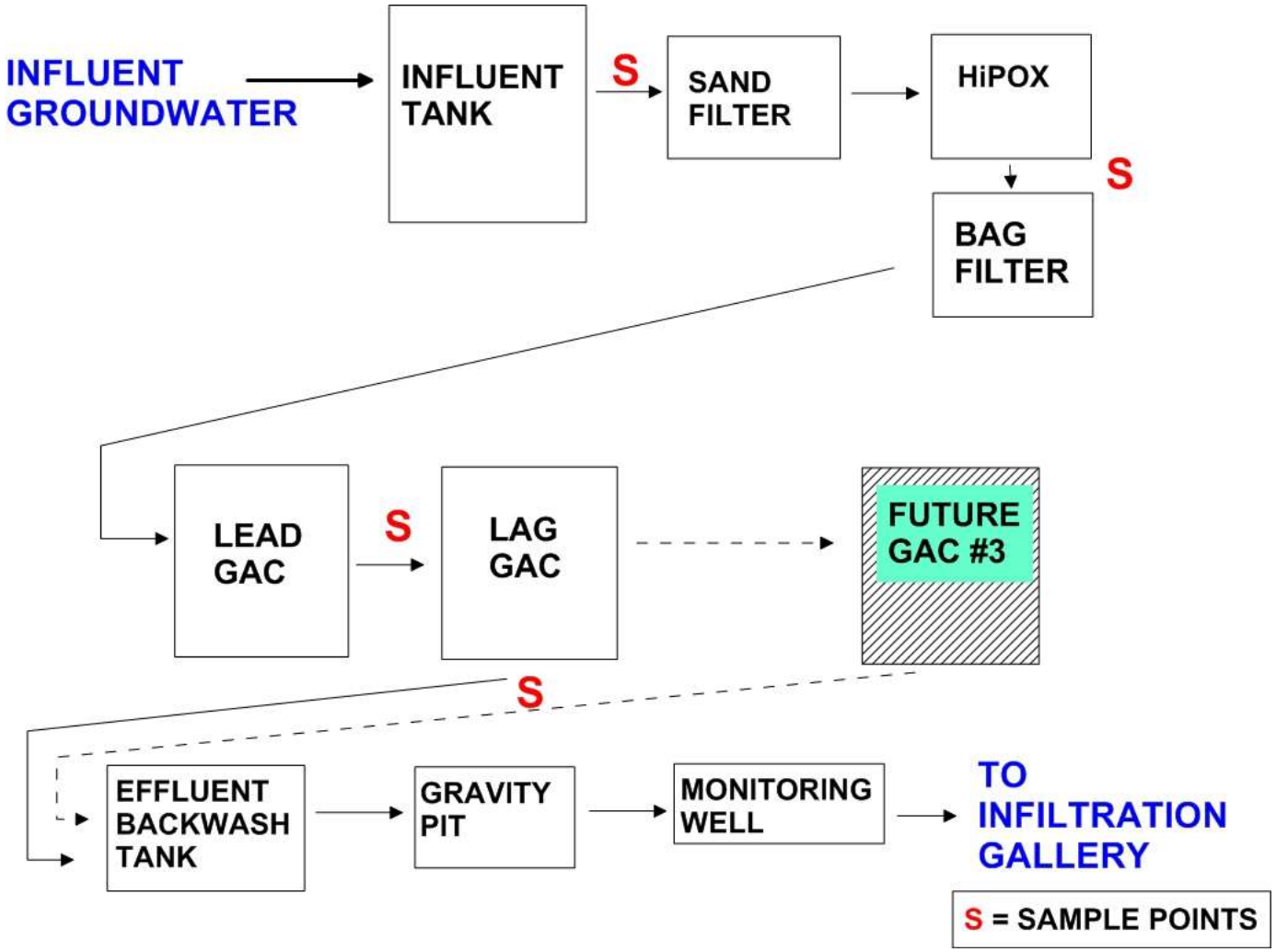
Plume targeted by pump and treat system



GWETS NETWORK:

- 5 Extraction Wells
- Total flow ~55 GPM
- 2.2 million gal/mo
- Operational 1995
- Designed for chlorinated solvent plume, adapted for PFAS

GWETS system configuration

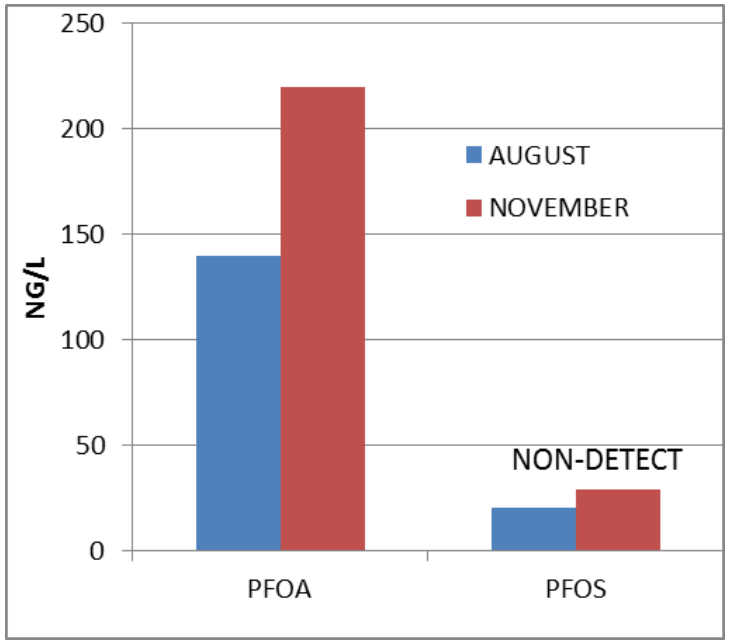


2014-2015 Basewide Groundwater Concentrations

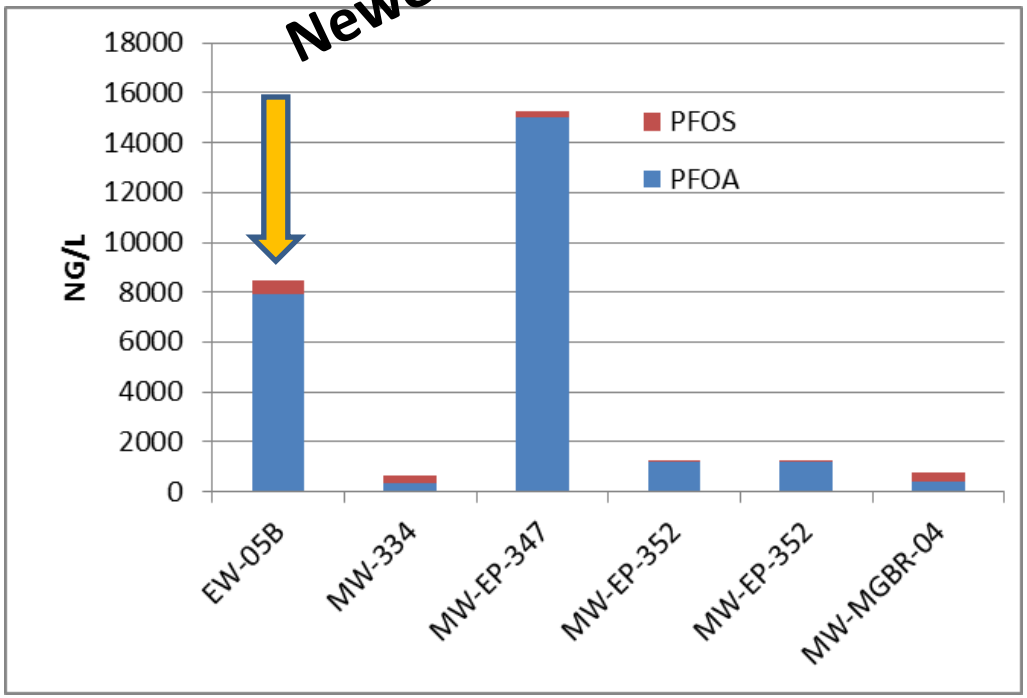
- PFBA ND – 3,640 ng/L
- PFBS ND – 20,400 ng/L
- PFHxA ND – 9,720 ng/L
- PFHxS ND – 25,300 ng/L
- PFOA ND – 6,600 ng/L
- PFOS ND – 24,000 ng/L
- PFPA ND – 4,250 ng/L

2012 Initial Data, GWETS / Wells in Eastern Plume

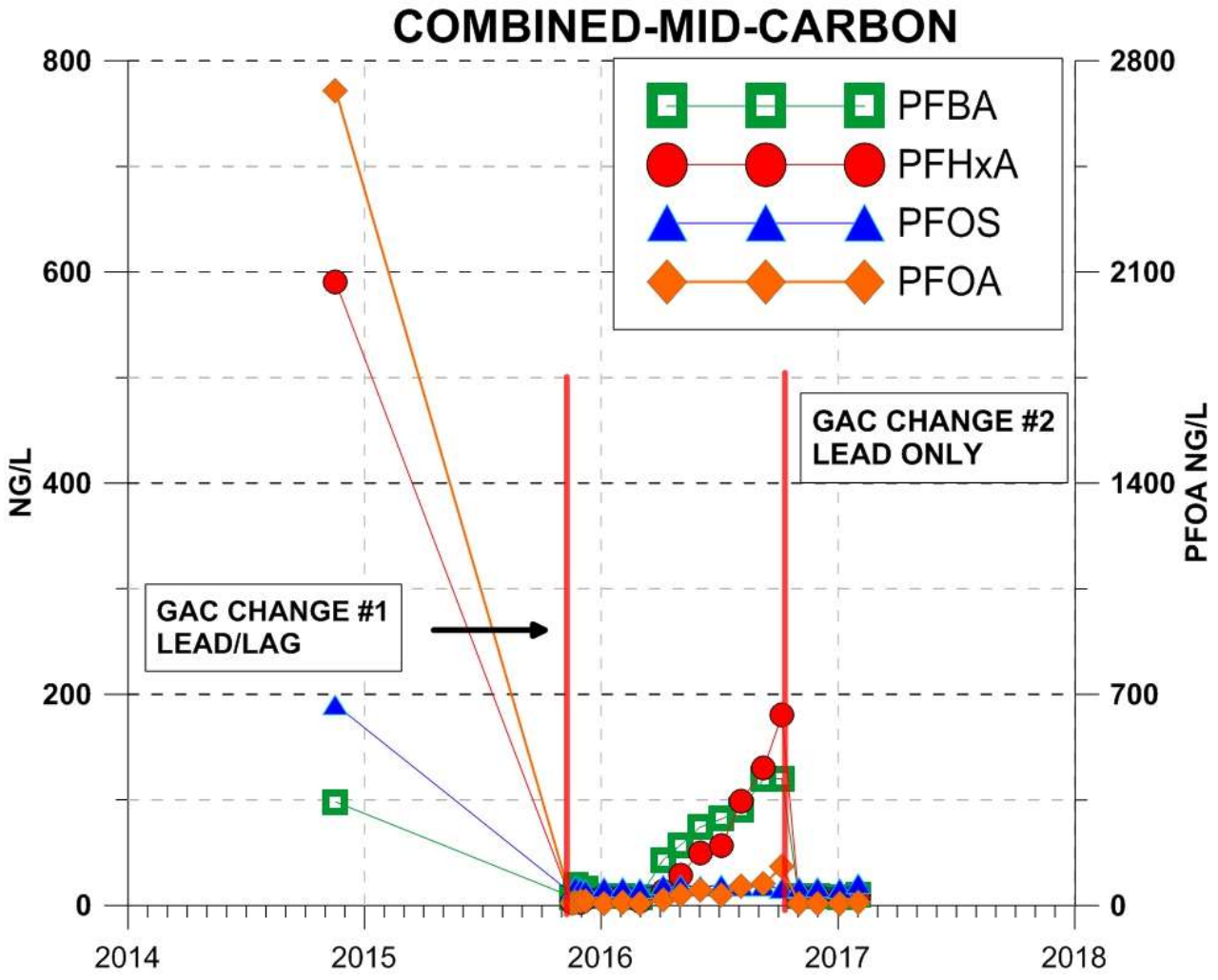
GWETS Effluent



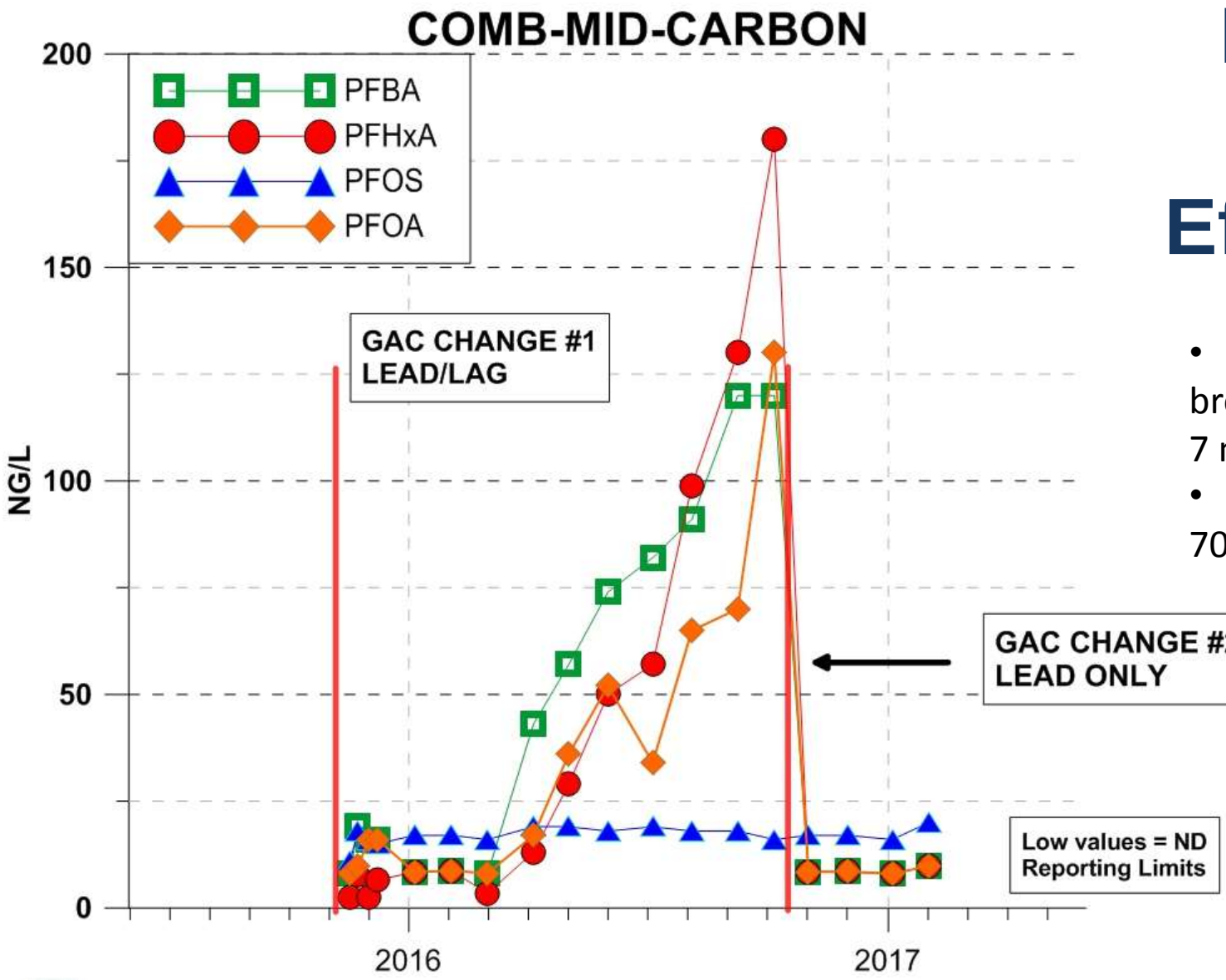
Newest Extraction Well



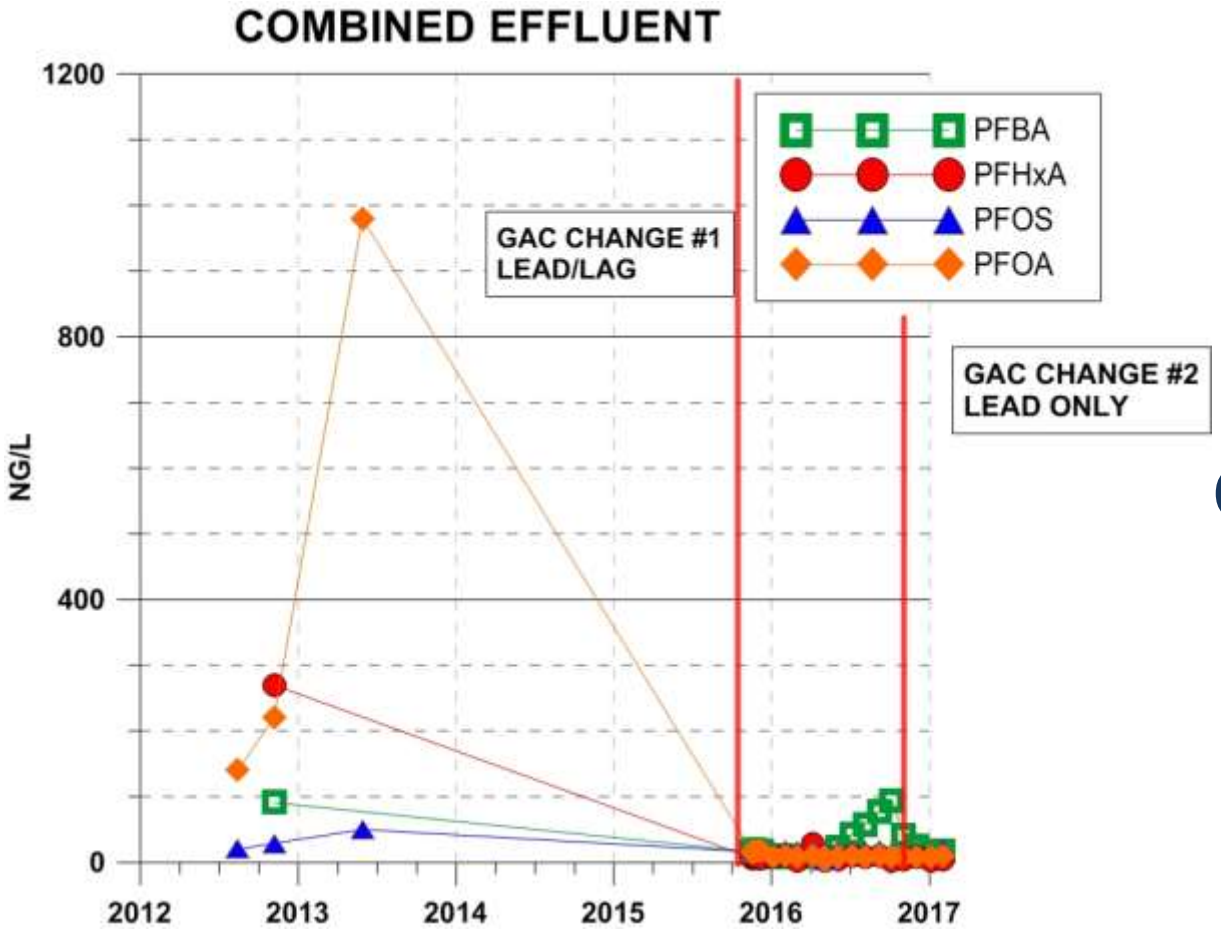
Lead GAC effluent data



Lead GAC Effluent

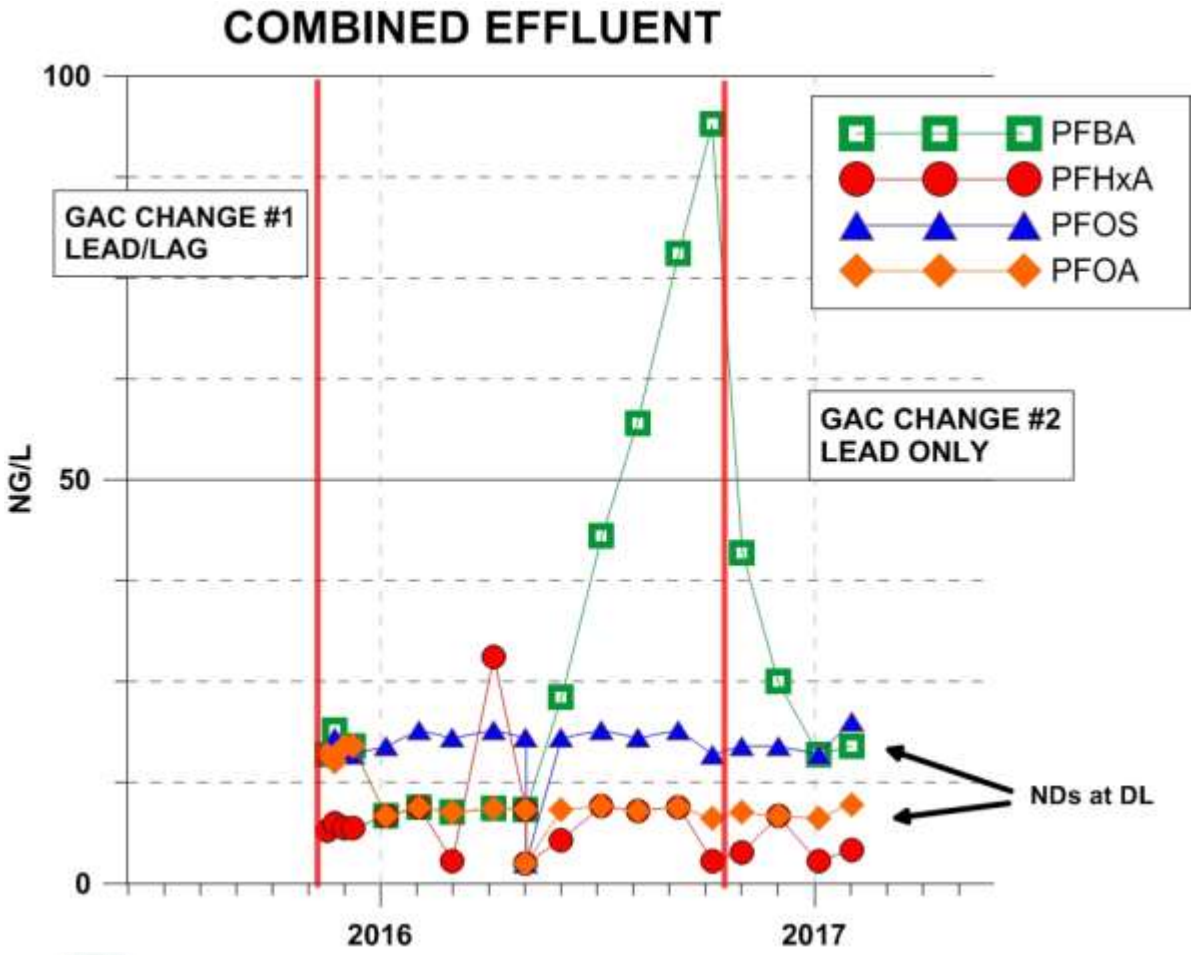


- Short-chain breakthrough at 7 months
- PFOA > EPA HA of 70 ng/L at ~ 1 yr



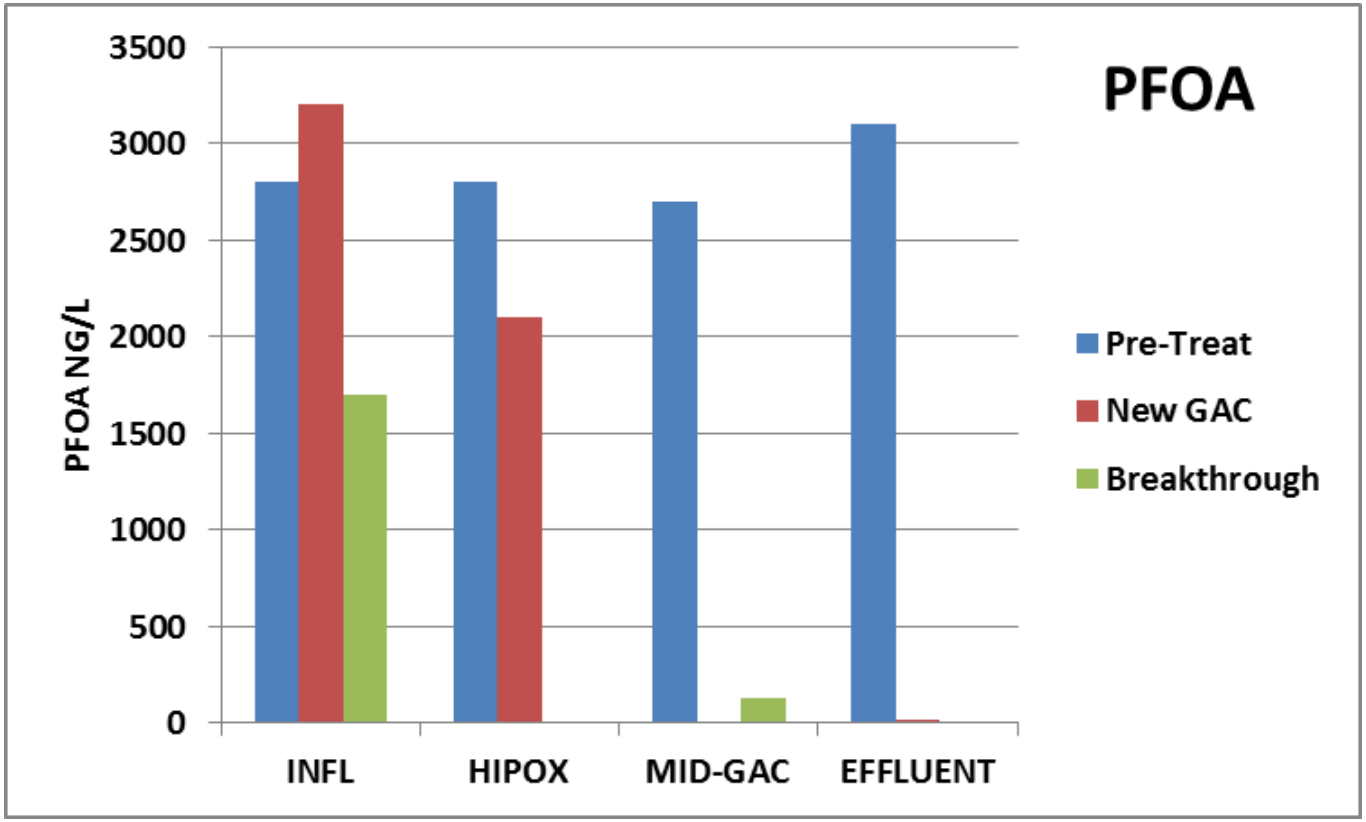
Decreased "recycling" effect compared to pre-changeout

Breakthrough indicated by PFBA at effluent and mid-carbon points

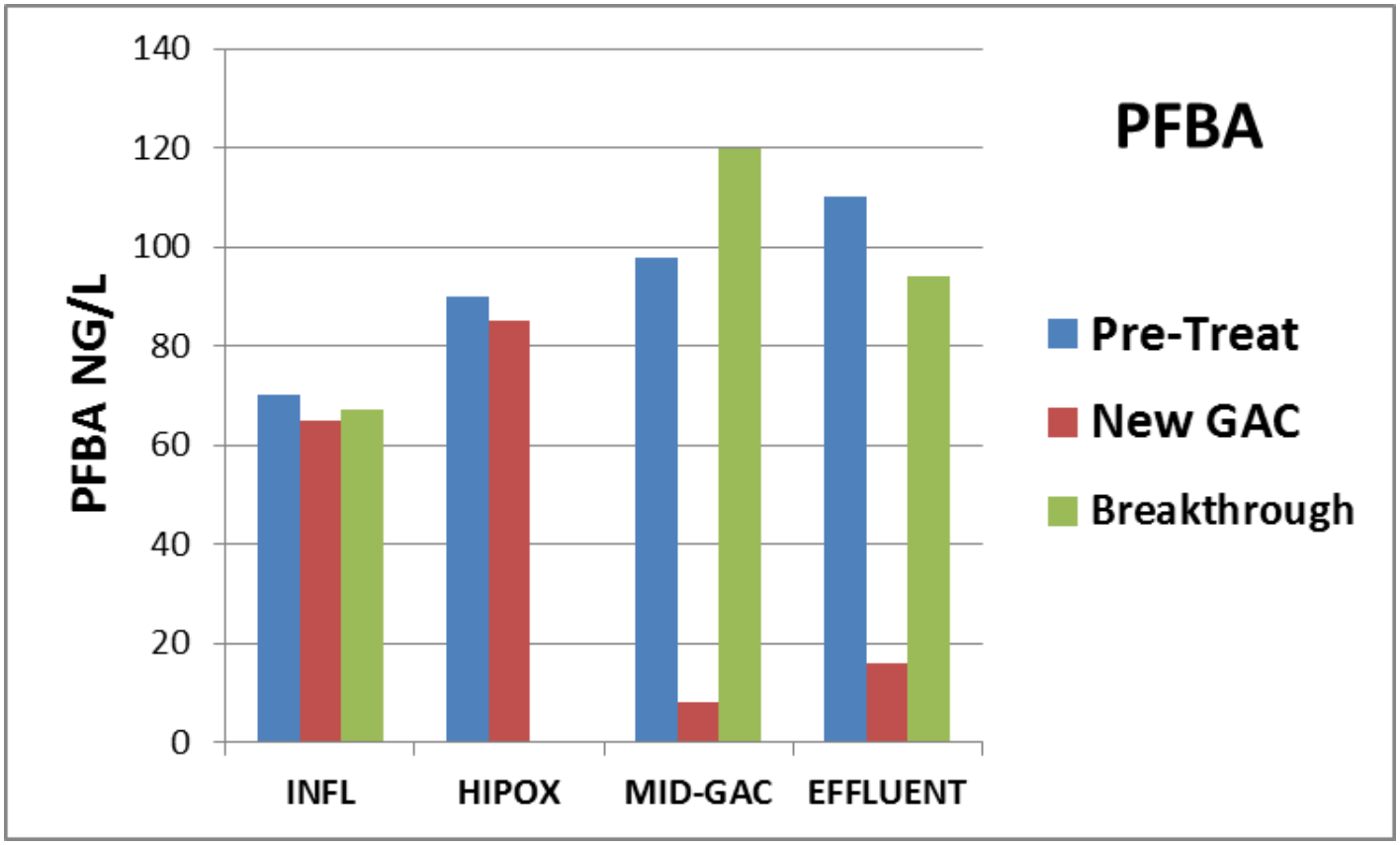


PFBA breakthough after lag carbon vessel nearly matches breakthrough at GAC mid-point

PFOA through the GWETS



PFBA through GWETS



Conclusions – Next Steps

- GAC is effective at this site, with monitoring for breakthrough
- Similar to other sites and laboratory studies, shorter chain/lighter molecular weight >> break through longer chain/higher molecular weight PFAS
- Calculate most cost-effective carbon once new lead vessel reaches breakthrough

- Thanks to:
- U.S. Navy BRAC Program Management Office for the use of the data for this presentation

- QUESTIONS?

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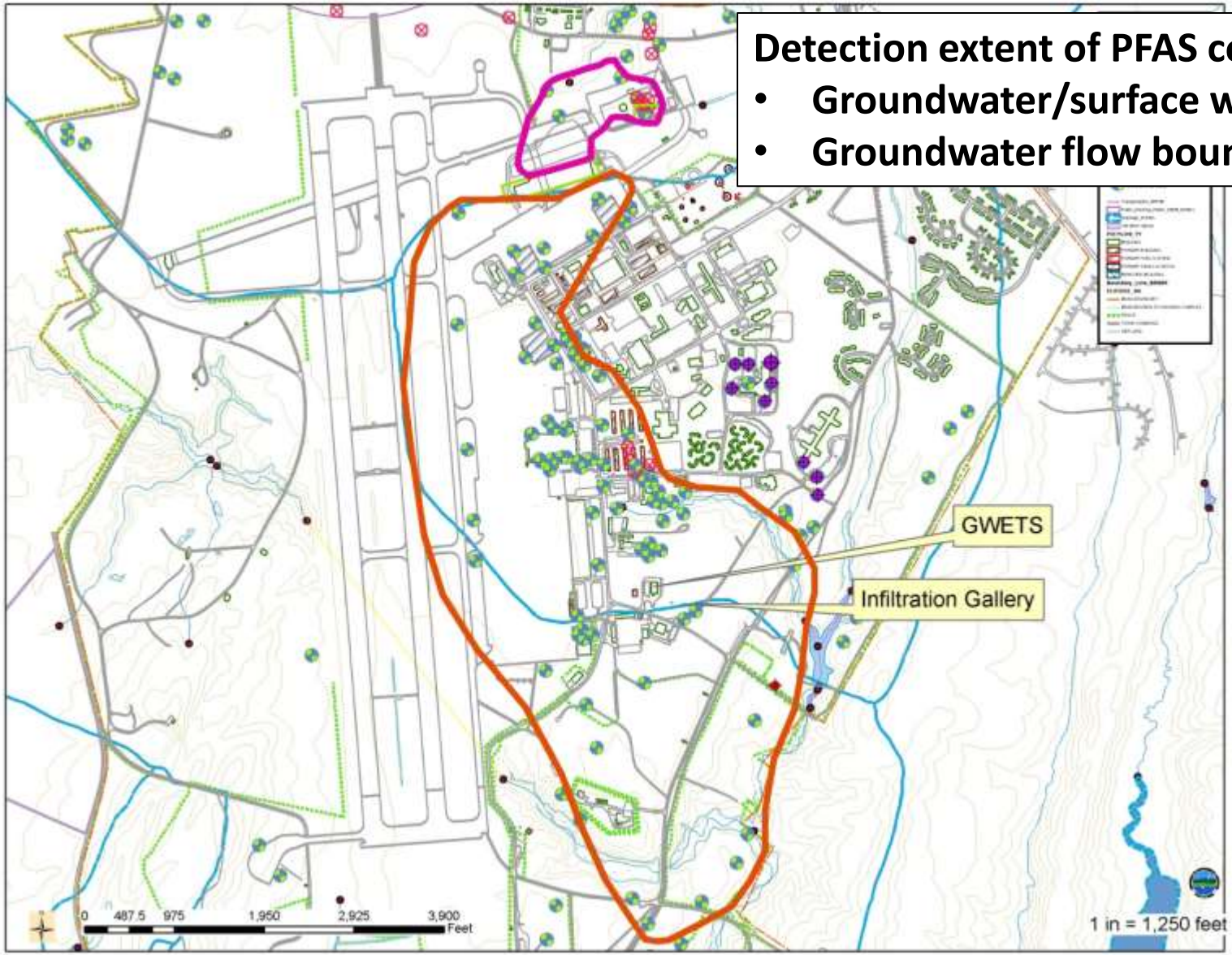
EXTRA SLIDES

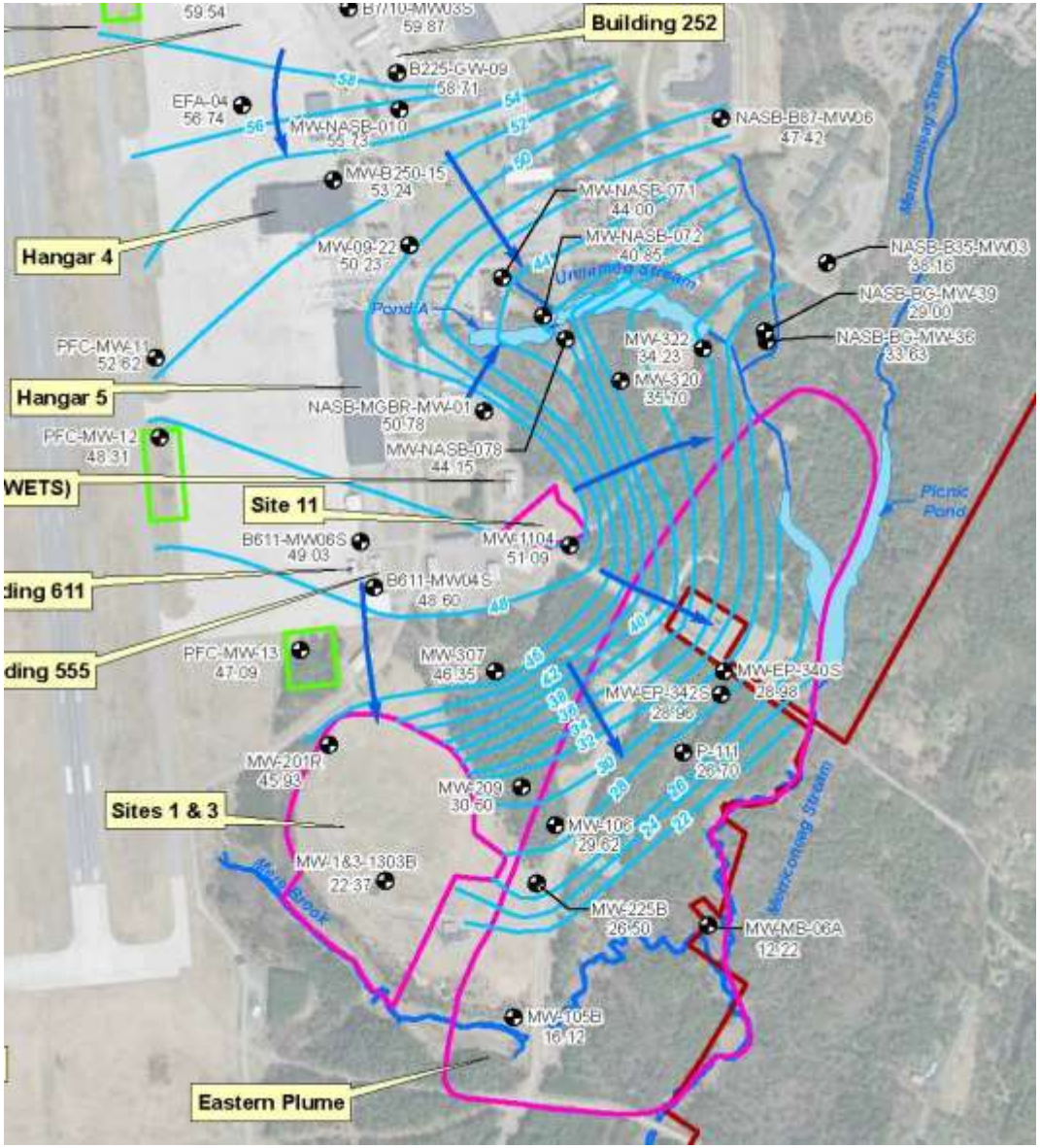
PFAS sources

Fire training exercises, emergency crash response, system malfunctions, equipment maintenance involving AFFF



Detection extent of PFAS controlled by:

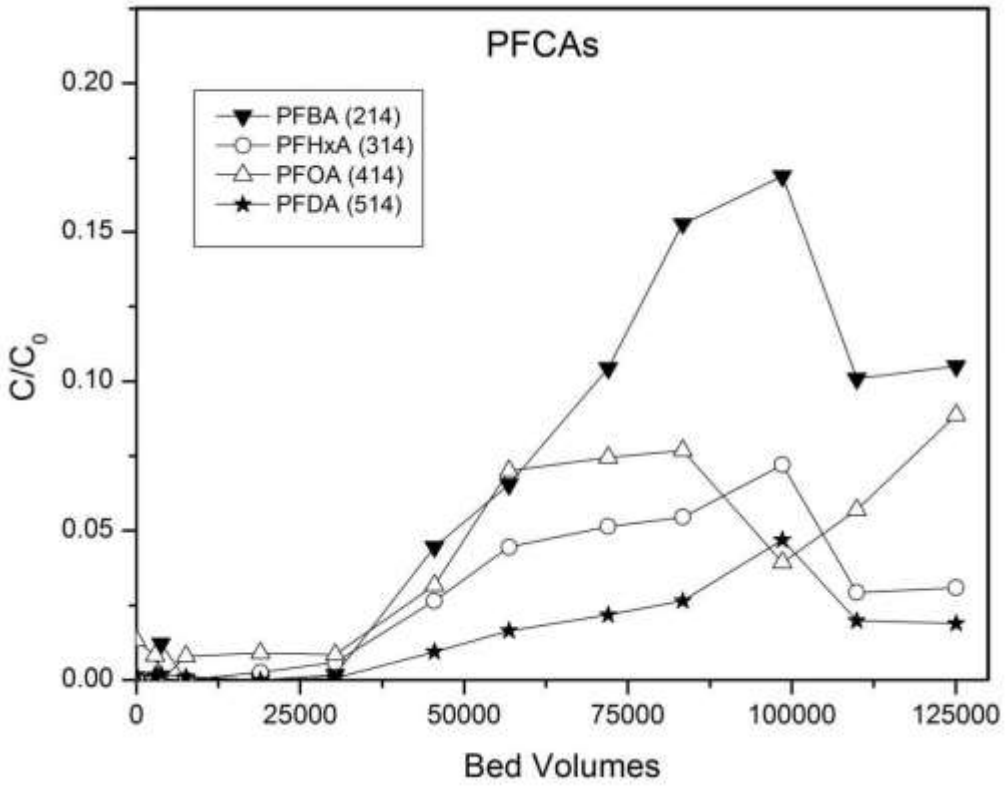
- **Groundwater/surface water divide**
- **Groundwater flow boundaries**



Generalized Groundwater Flow

Surficial Geology

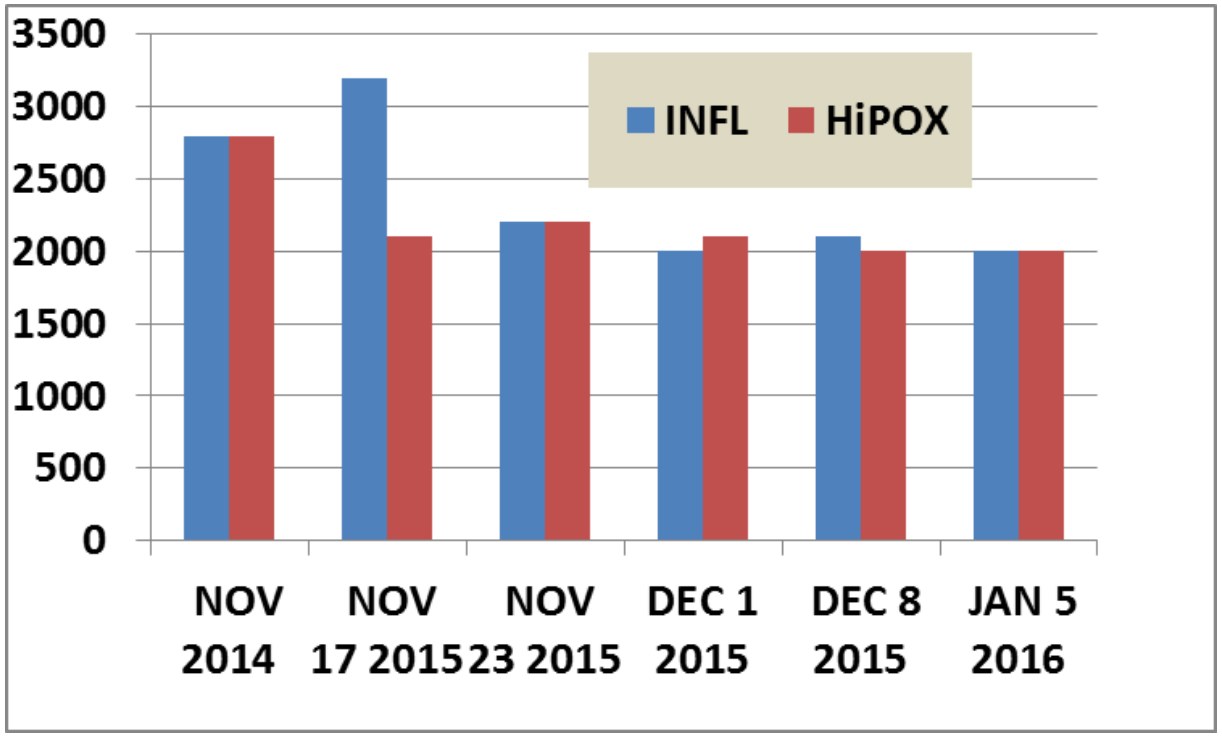
Bench-scale testing



Breakthrough for similar carbon
Lighter molecular weight
PFAS > higher
molecular weight PFAS

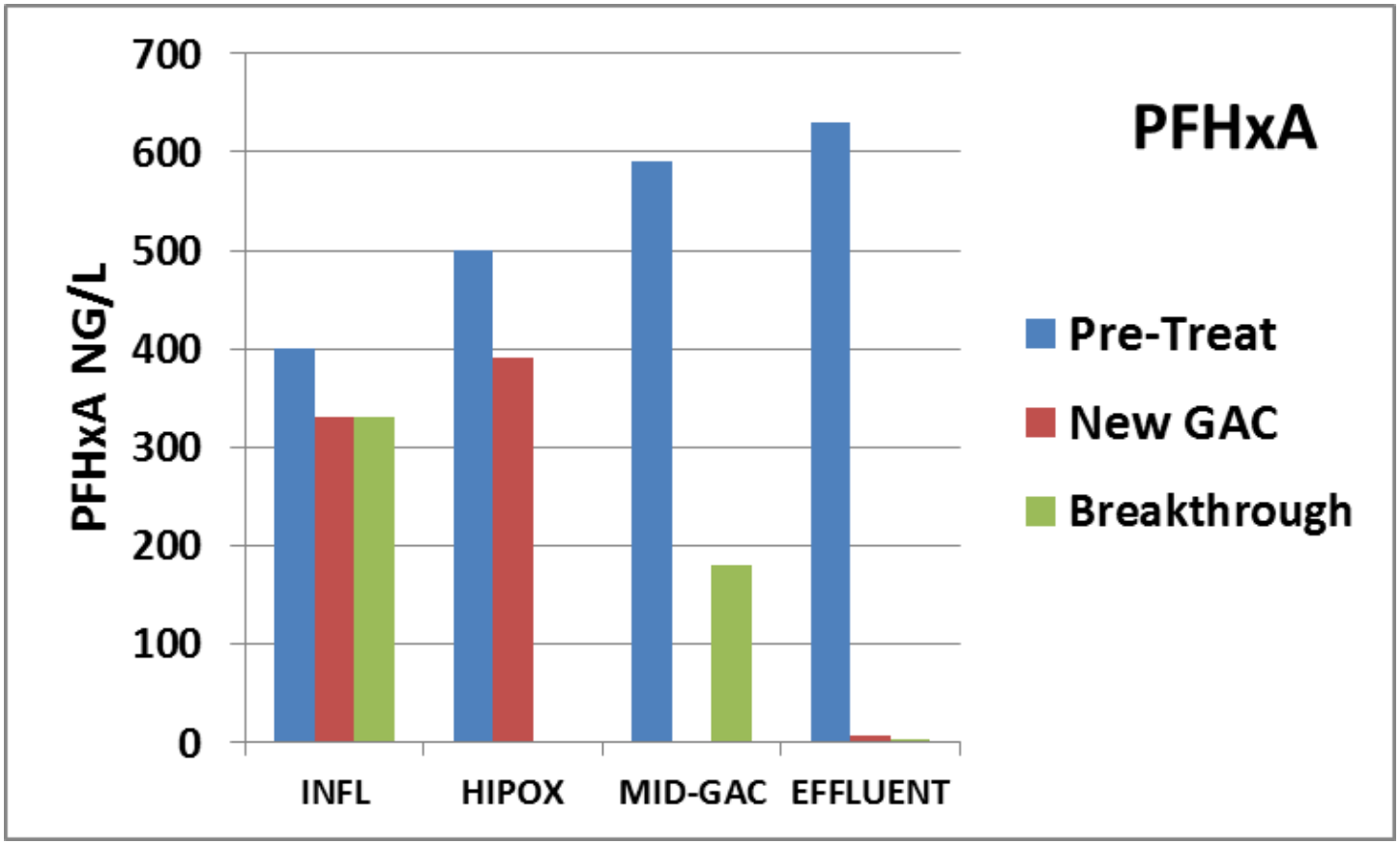
Dickenson and Higgins, 2016, Water Research Foundation

Impact of Oxidation Unit - PFOA



Oxidation did not have significant or consistent effect on PFOA

PFHxA through GWETS



Influent Changes During GAC Changeouts