

A Field Demonstration Study: Activated Carbon-Based Amendment Used to Remediate PFAS Source Soil and Groundwater at a Northern Michigan Airfield



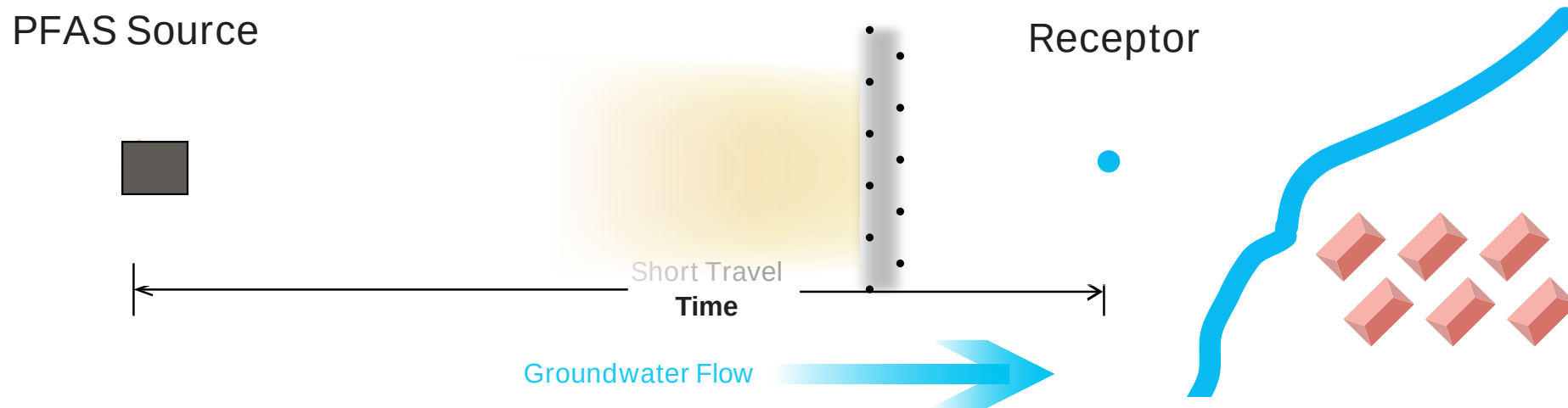
Ryan E. Moore
Vice President - PFAS Programs

Overview

- Introduction
- PFAS Remediation
- Groundwater
- Vadose Soil
- Summary



PFAS Enhanced Retention (PER)



- **Risk managed through PER**
- **CAC Application**-Increase retention mechanisms to meet remediation goals

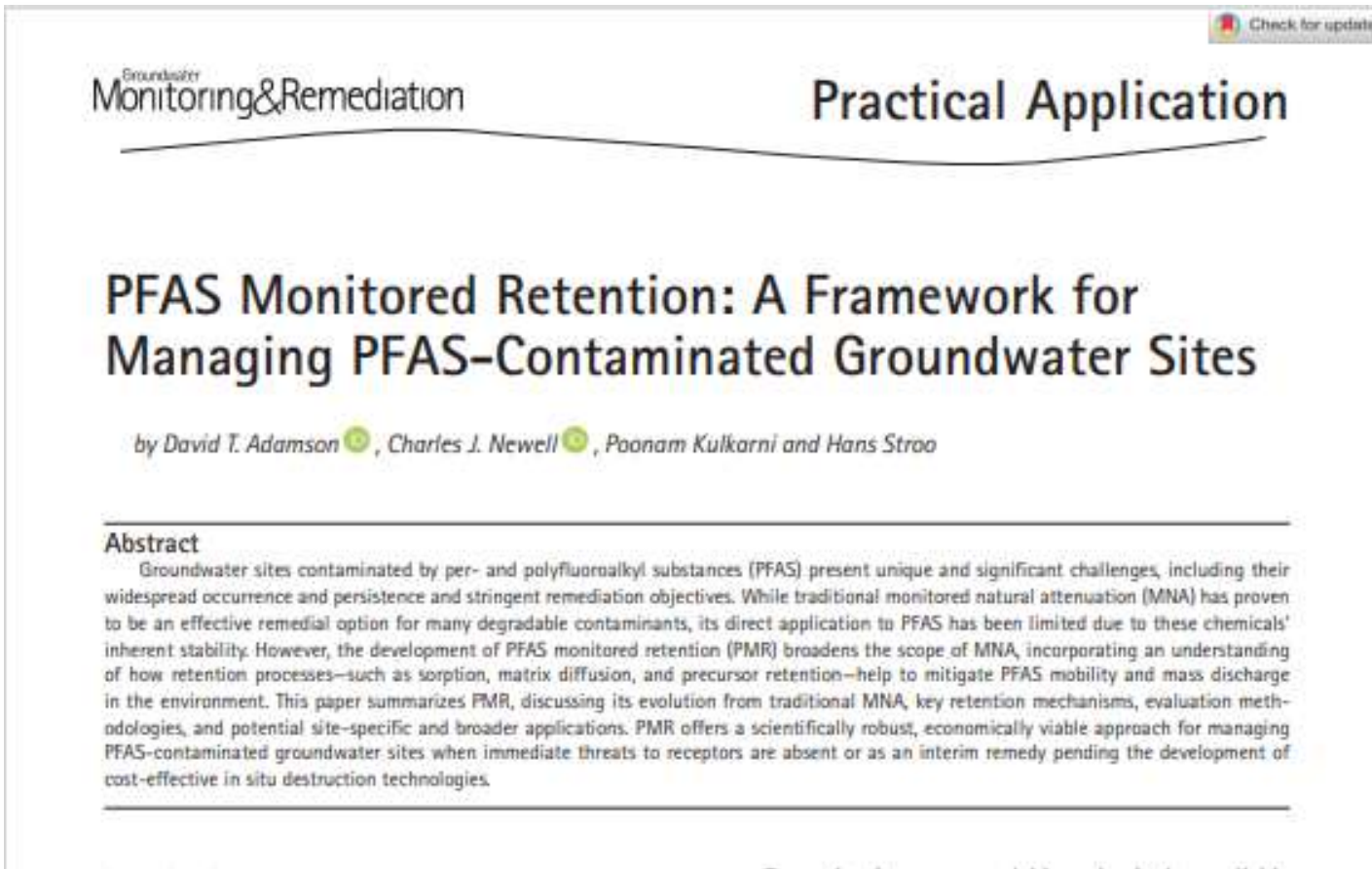
1. Source area stabilization

- Preventing further discharge
- Avoiding further plume development

2. Permeable Retention Barrier

- Stopping further plume propagation

PFAS Monitored & Enhanced Retention



Grayling Army Airfield



Case Study: Groundwater Pilot Test

Site Details

October 2018
Application

GW Velocity	~250 ft/yr
Vertical Treatment Interval	15'-27' bgs.
Injection Points	9
Soil Type	Coarse, Medium to Fine Sand with Clay at 27' bgs
Sensitive Receptors	Residences, Surface water bodies, Property Boundary
Contaminants of Concern	8 µg/L PCE and 130 ng/L Total PFAS, Primarily PFOS & PFHxS



***In Situ* Remediation using Colloidal Activated Carbon**

- Form of Activated Carbon
- Particle Sizes 1 – 2 μm
- Suspended as a colloid in a polymer solution
- Distributes Widely Under Low Pressure
- Provides extremely fast sorption sites
- Converts underlying geology into purifying filter
- Patented Technology

PLUME **STOP**
Liquid Activated Carbon



The REGENESIS Process



PlumeForce Modeling



Design Verification Testing

Mass Flux Vertical Profiling



Design Revision



Injection

Distribution Verification



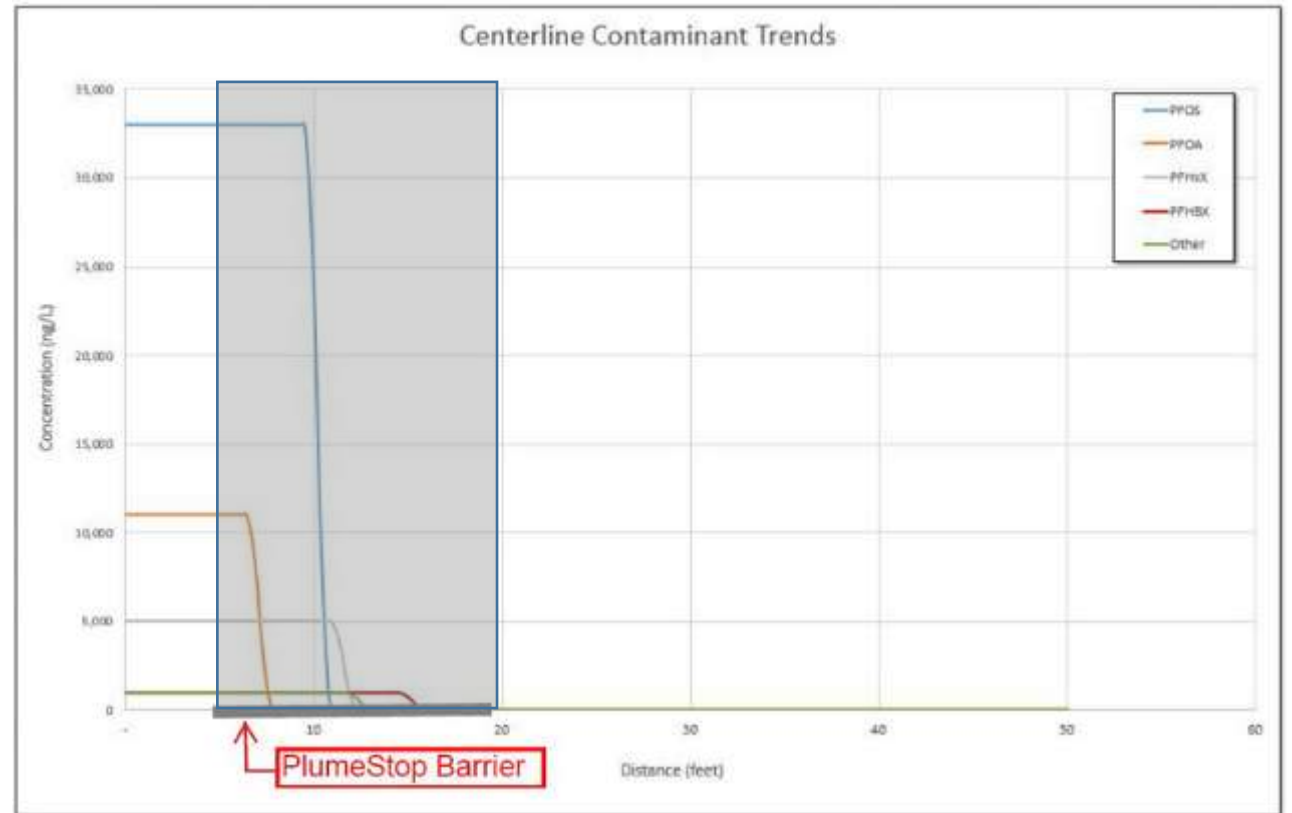
Technical Review of Performance

Design Process-PlumeForce

Barrier lifespan modelled on isotherms, dynamic sorption

Dose based on:

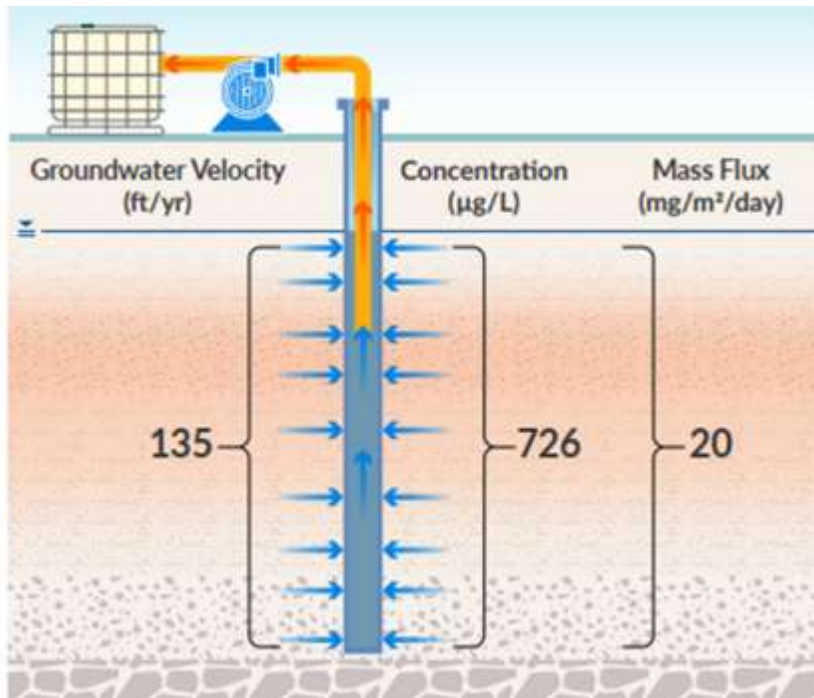
- **Site Specific Data**
- **Target contaminant flux**
- **Competitive sorption**
 - Other contaminants
 - Natural organics



Contaminant Flux Measurement

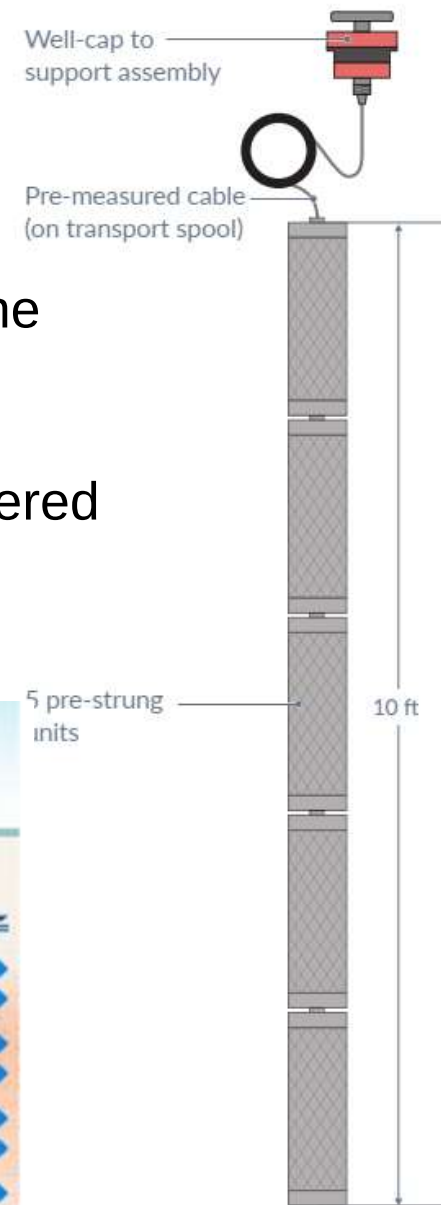
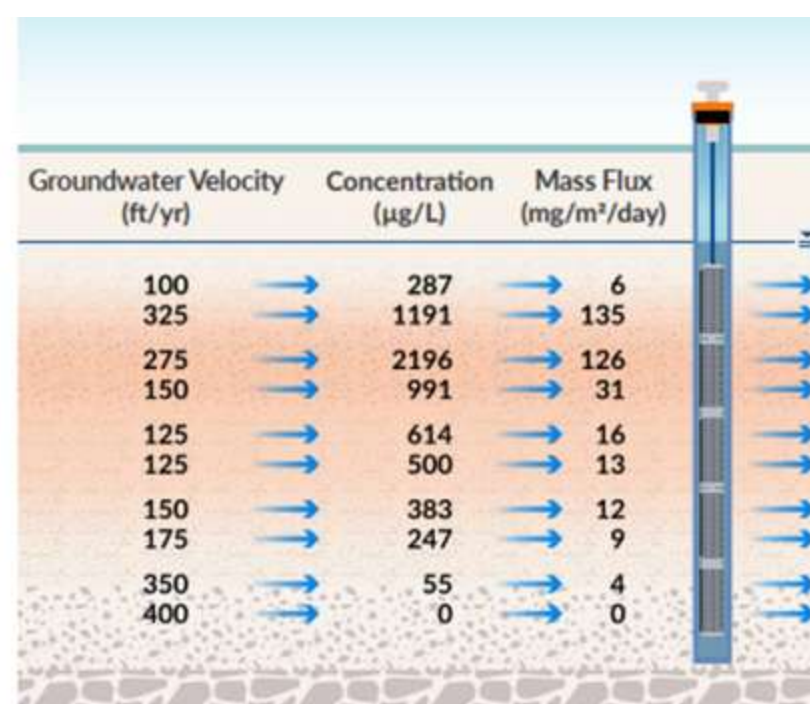
Bulk Average Methods (Pump/Slug Test)

- Do NOT delineate mass flux
- Not ideal for in-situ remediation designs
- Potential under- or over-treatment

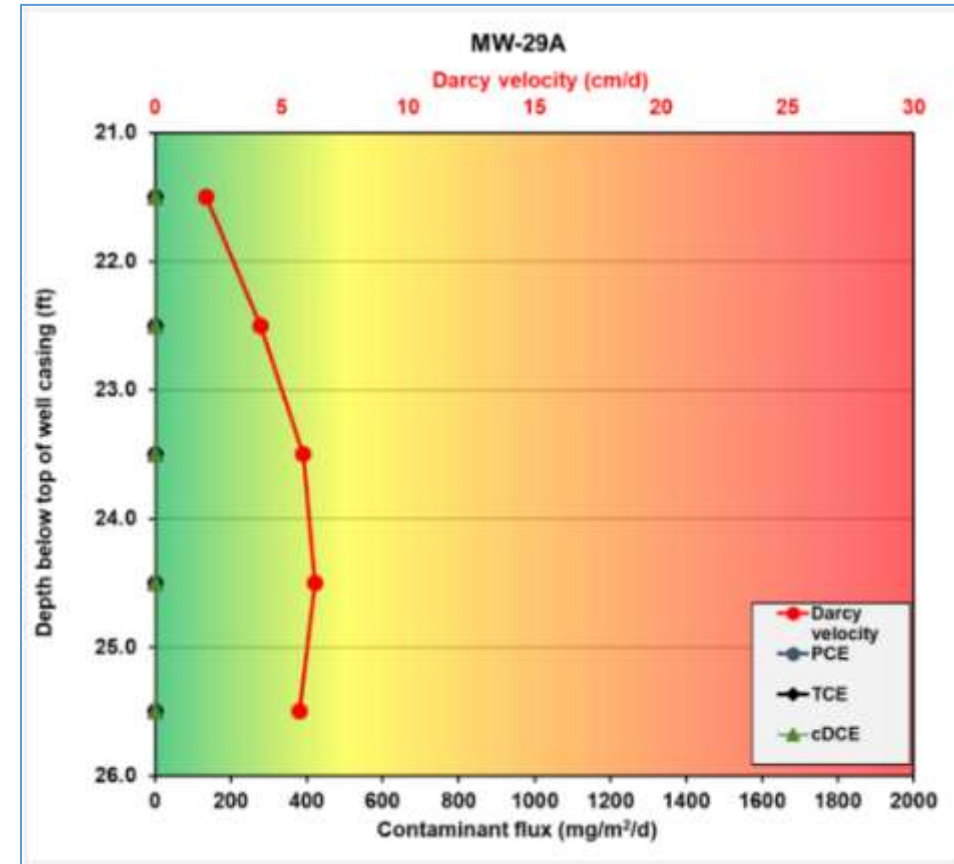
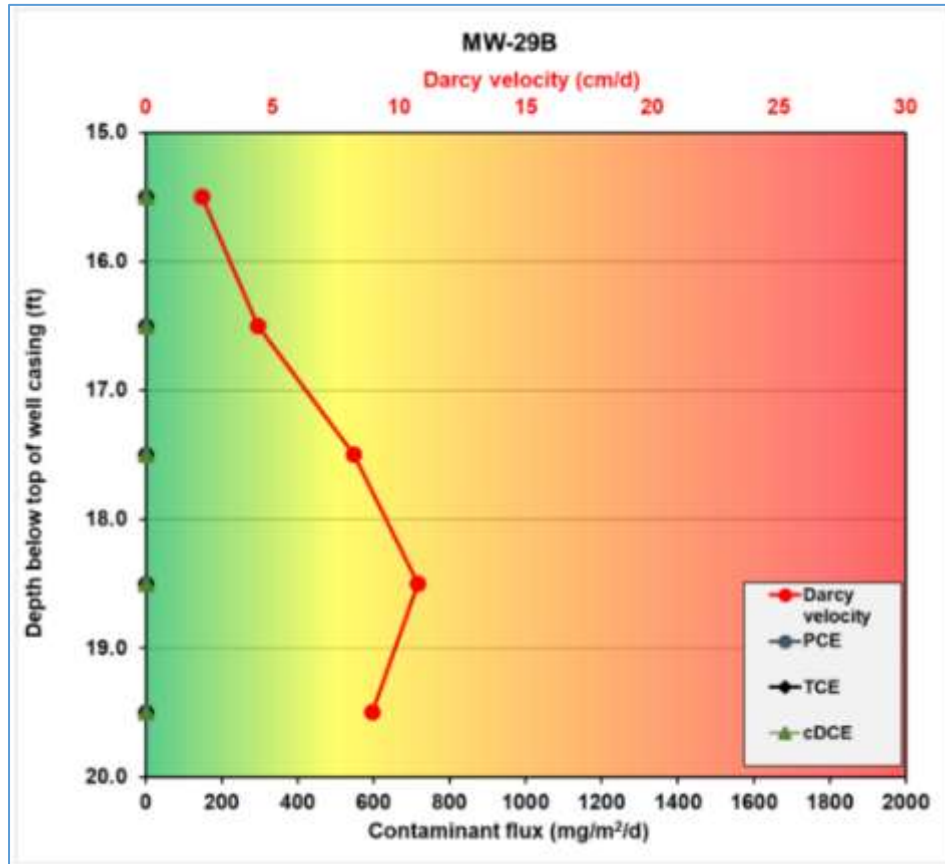


Flux Meters

- High resolution in treatment zone
- Identifies flux zones
- Optimize product placement
- Improved performance and lowered cost



Understanding Groundwater Velocity



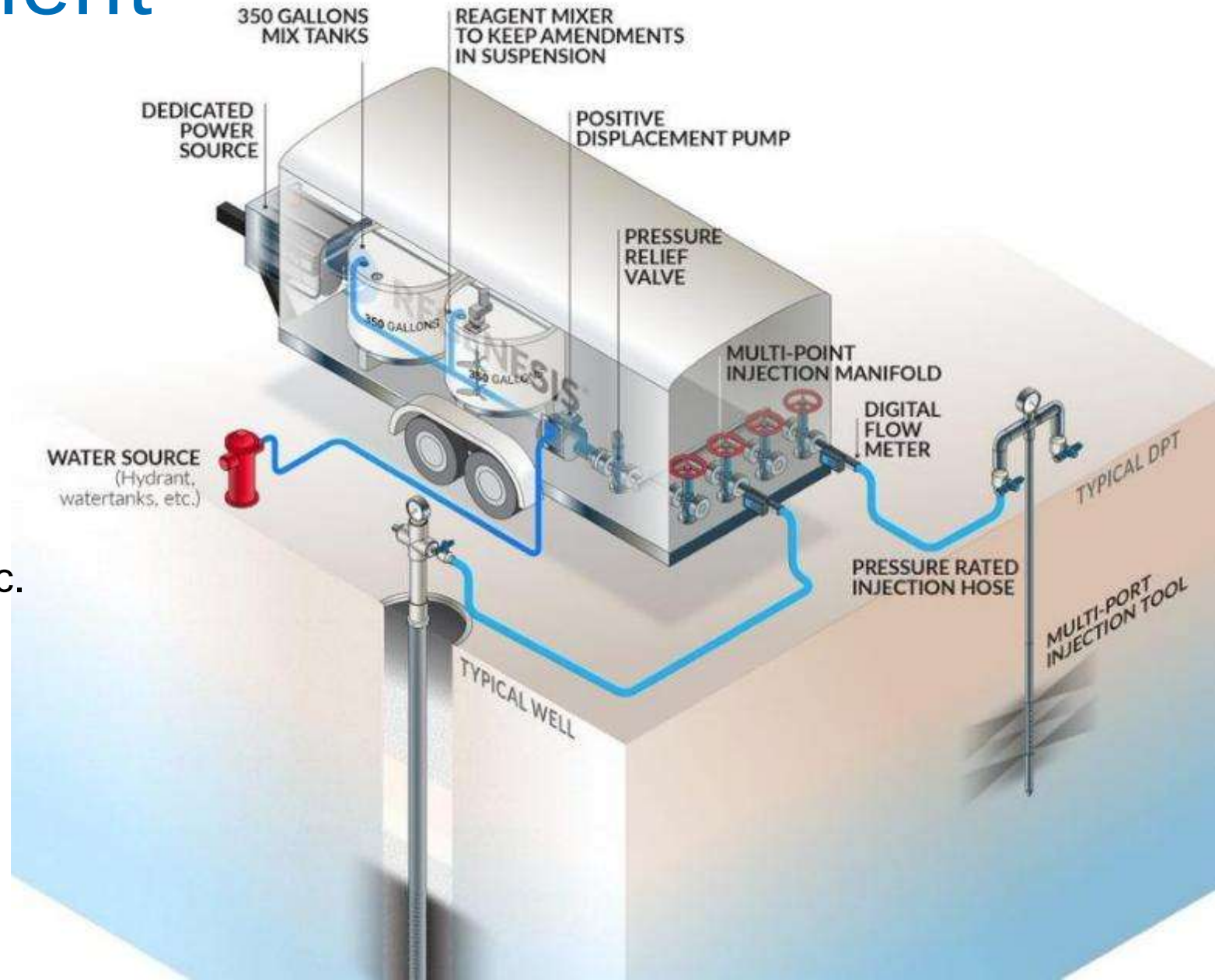
Pilot Test Layout

- 9 Direct-Push Injection Points
- Paired Wells UG & DG
- Bottom up DPT Injection using 3' retractable screens
- ~8500-gallons of CAC Solution
- Avg. injection pressure of 16 psi
- Avg. flow rate of 6.45 gpm

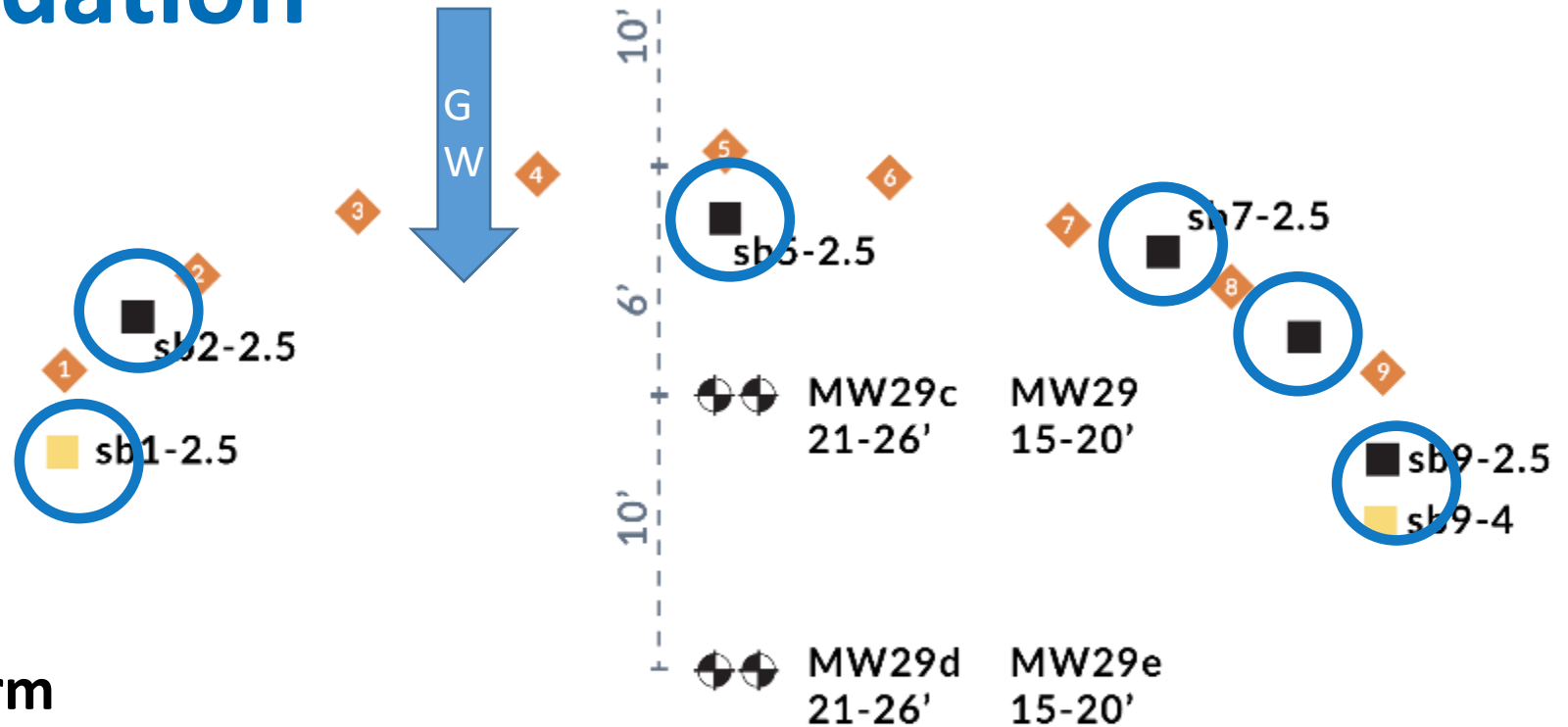


Injection Equipment

- **Purpose-built injection platforms to maximize efficiency on-site**
 - Positive displacement
 - Onboard power
 - Multi-point manifold
 - Mixing tanks
 - Transfer pumps and other misc. equipment
 - Flow and pressure sensors
 - Safety equipment

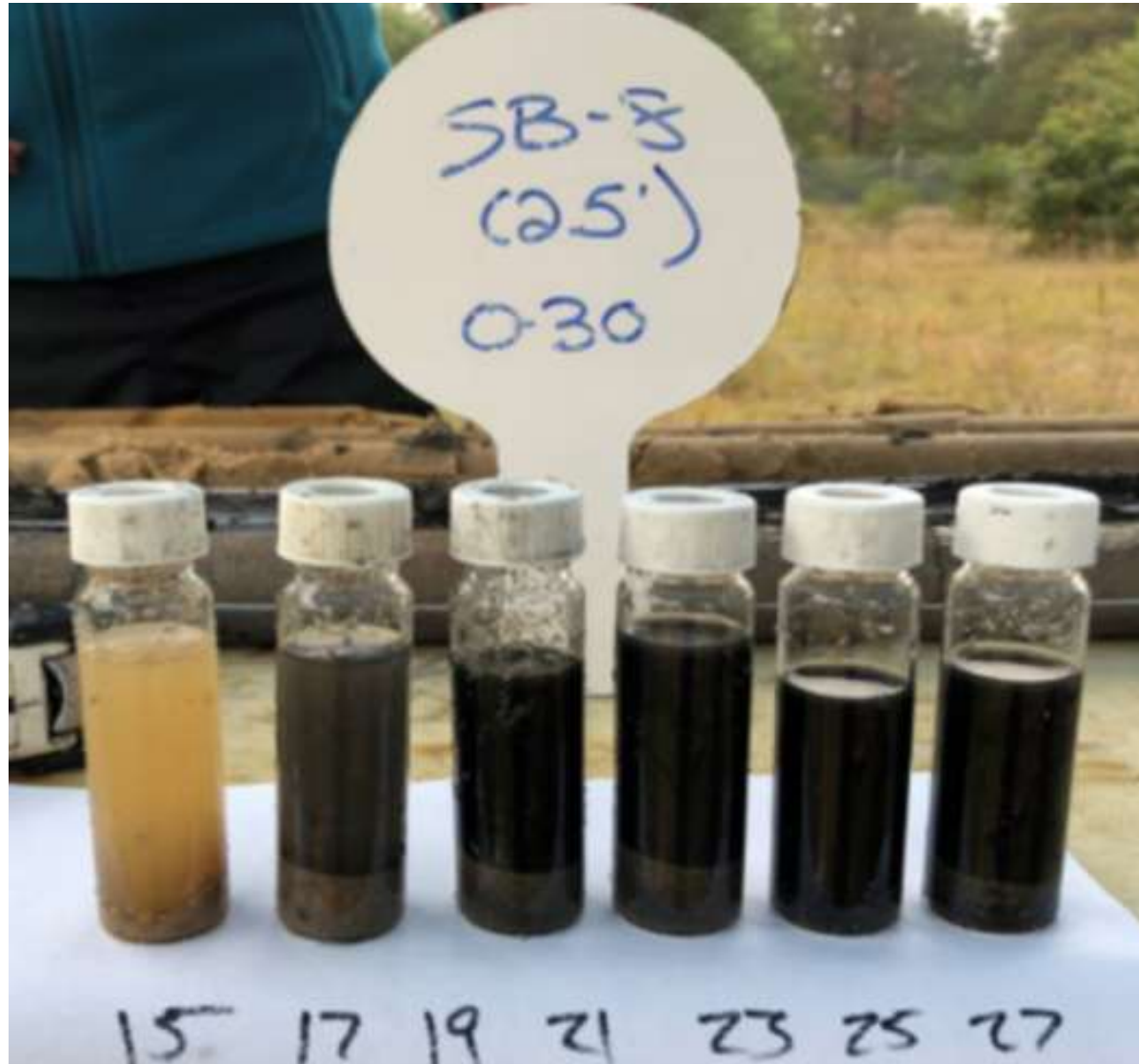


Placement Validation

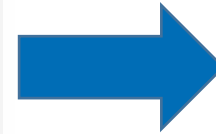
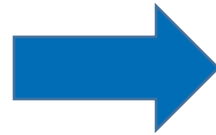


- Planned field steps to confirm and optimize CAC distribution
- Pre- and Post-Soil Cores
- Piezometers

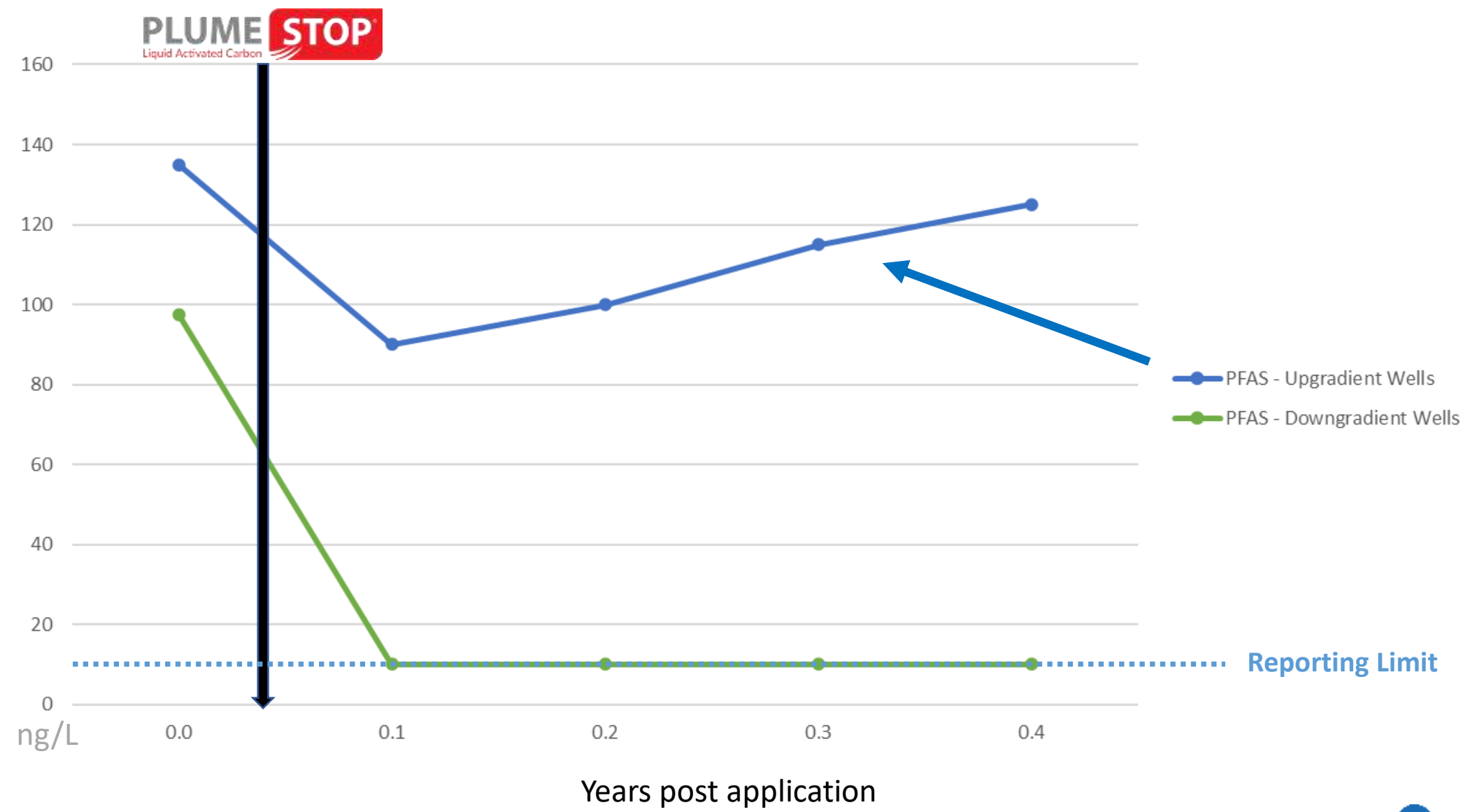
CAC-Distribution Confirmation



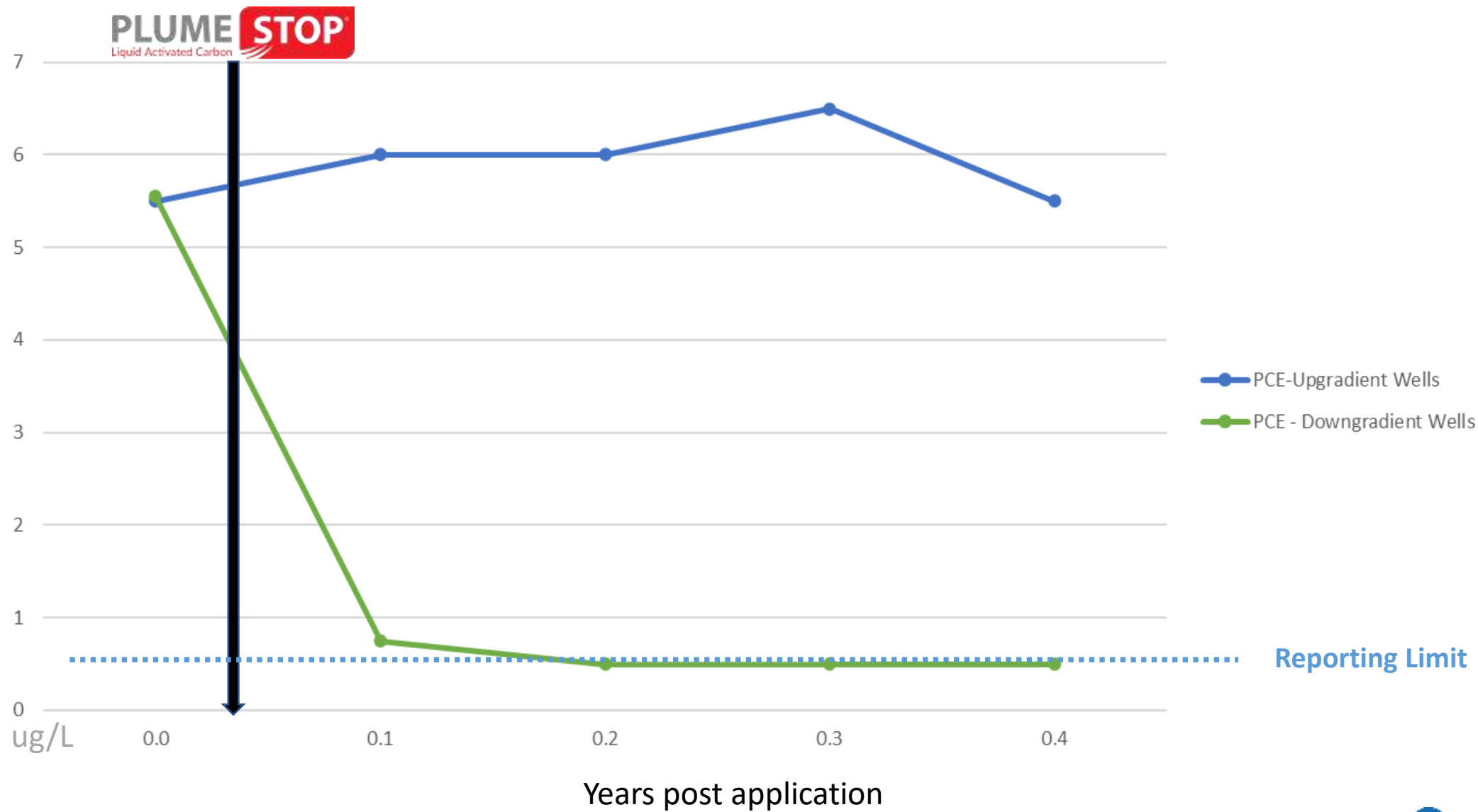
CAC-Distribution Confirmation



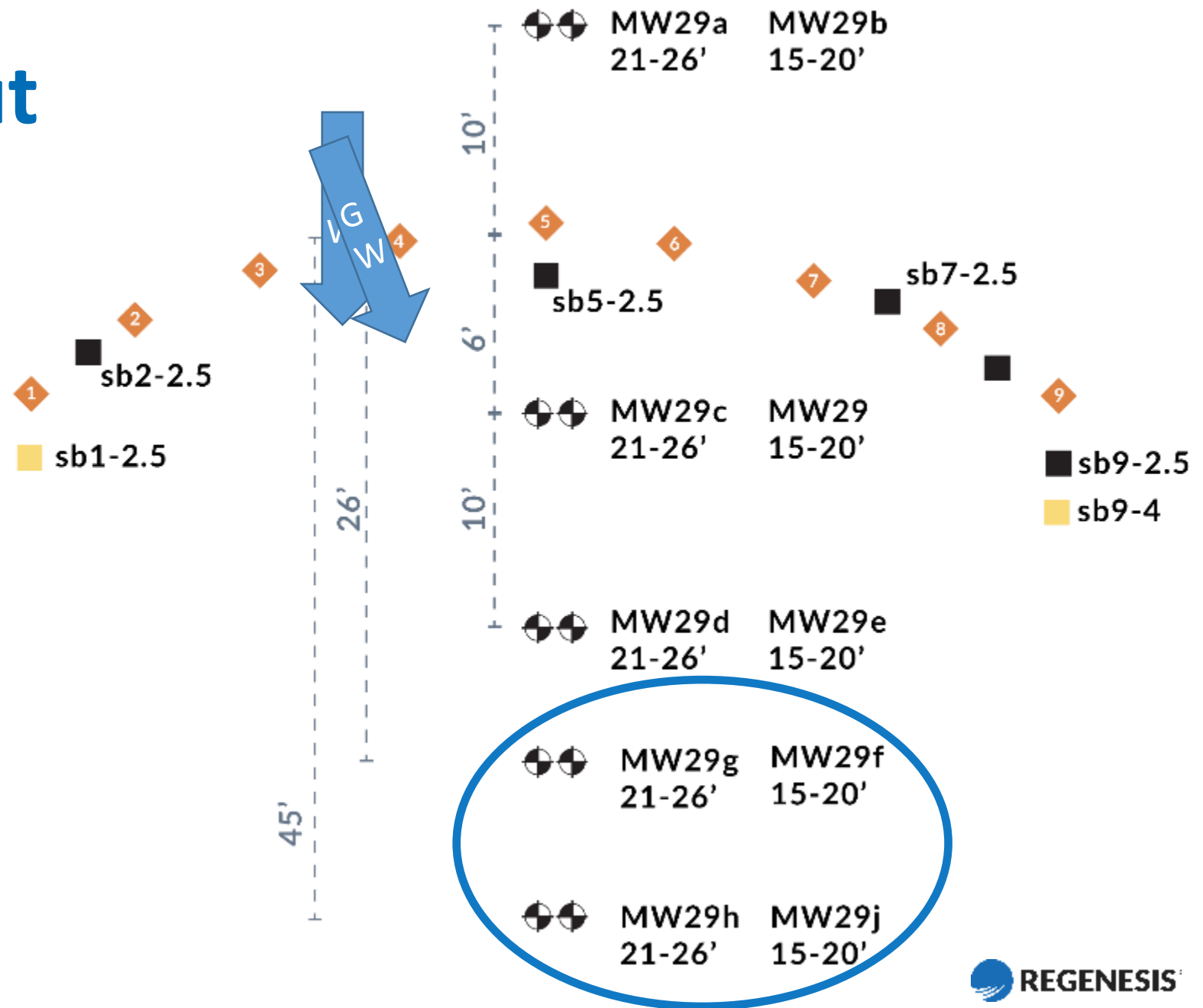
Average Total PFAS Concentrations in Upgradient and Downgradient Well Pairs



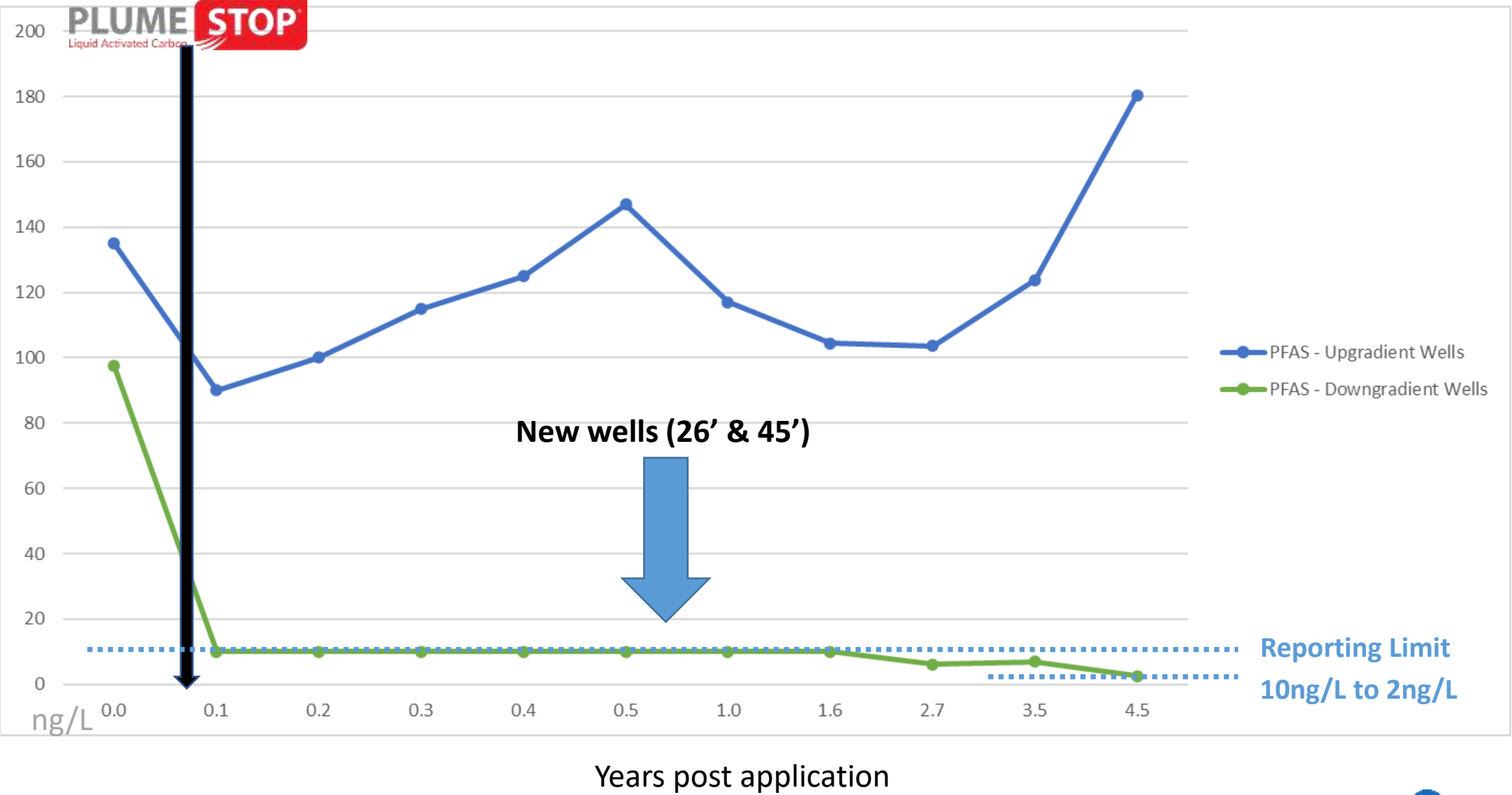
Average PCE Concentrations in Upgradient and Downgradient Well Pairs



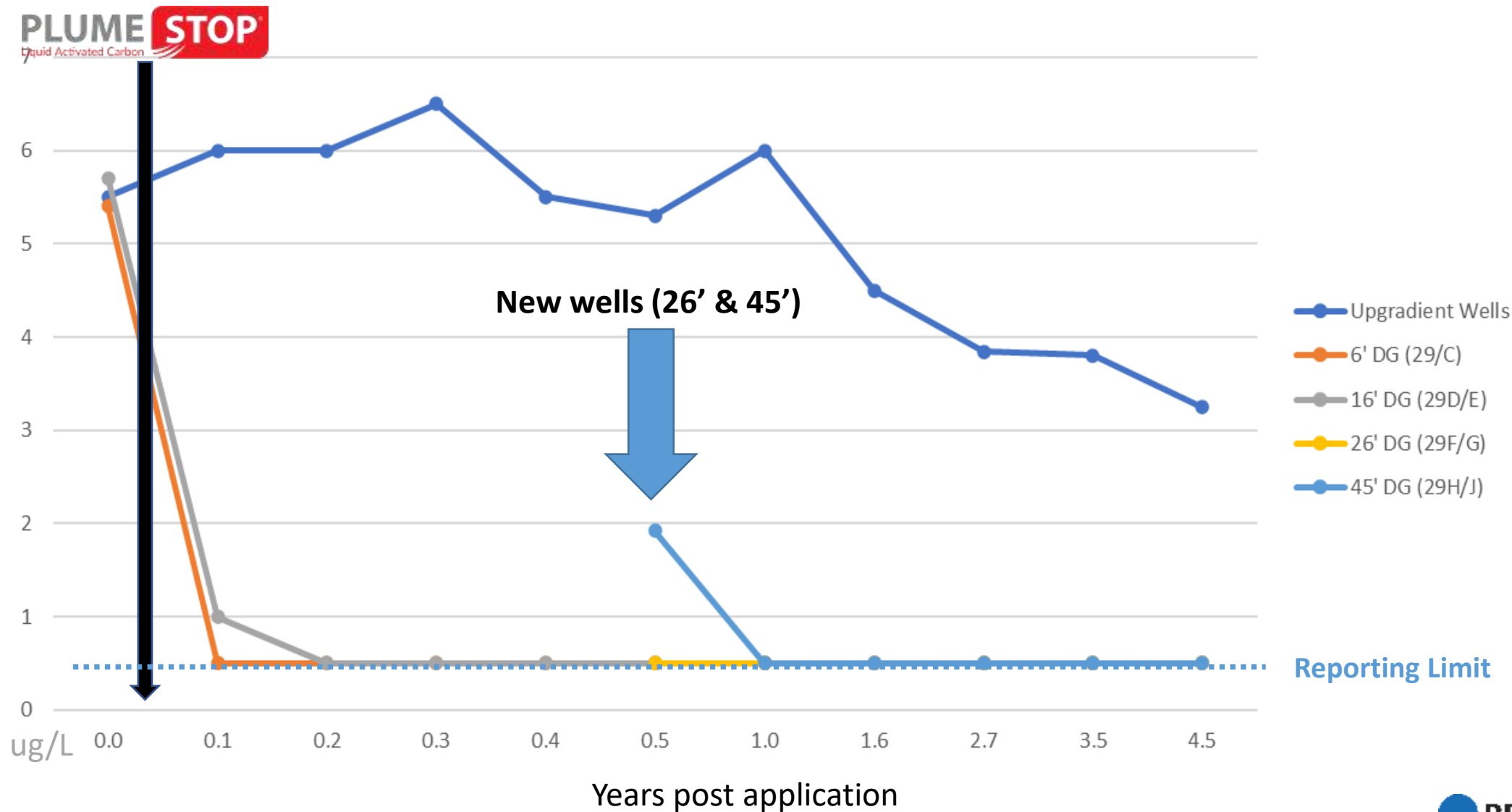
Pilot Test Layout



Average PFAS Concentrations in Upgradient and Downgradient Well Pairs

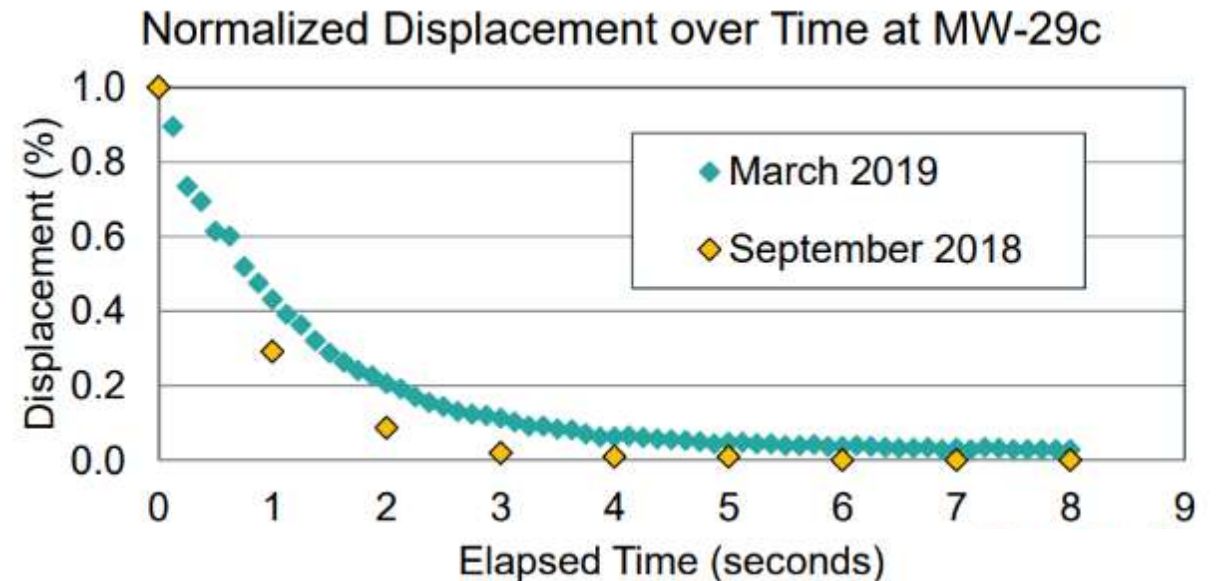


Average PCE Concentrations in Upgradient and Downgradient Wells Pairs



Did the CAC Application change the Characteristics of the Site?

**Pre-/Post-Injection Slug Test
Results Relatively Unchanged**



Source Treatment - Grayling, MI



Founded in 1913

147,000 Acres

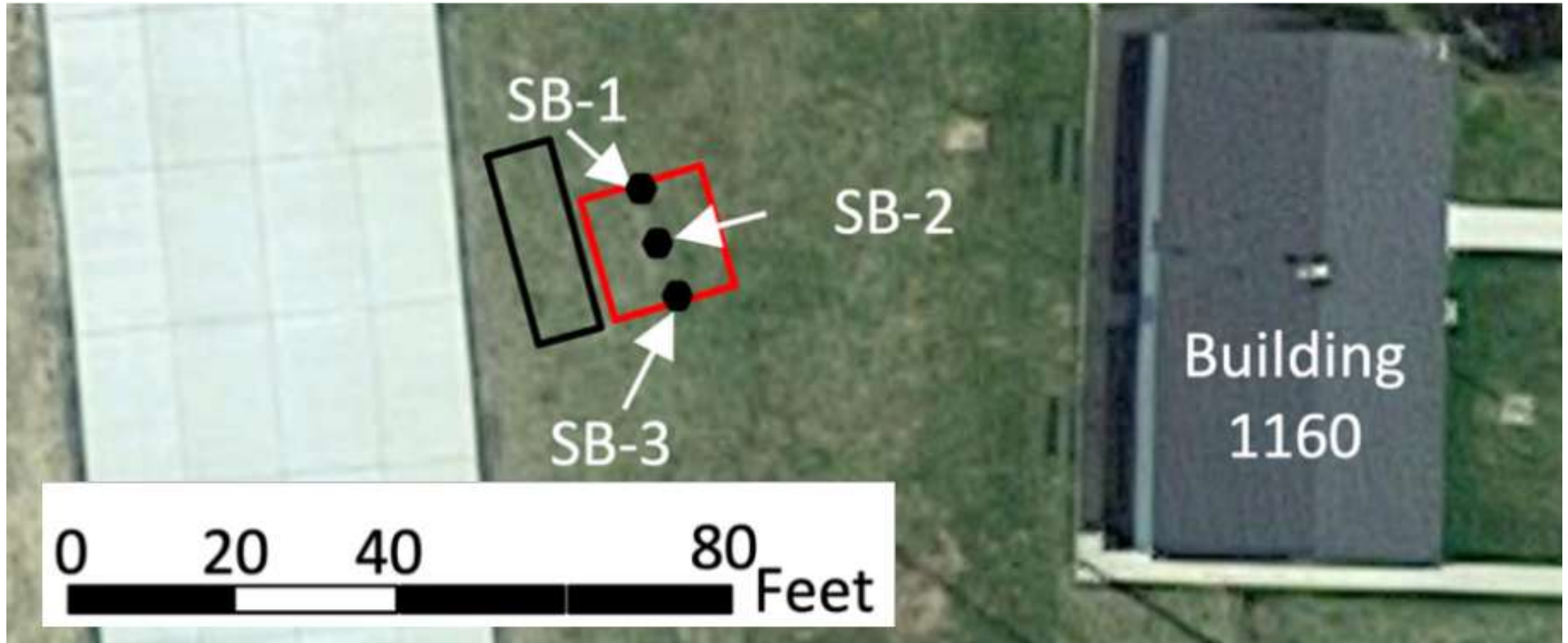
Largest National Guard Training
Center In the Country

Home To Grayling Army Airfield

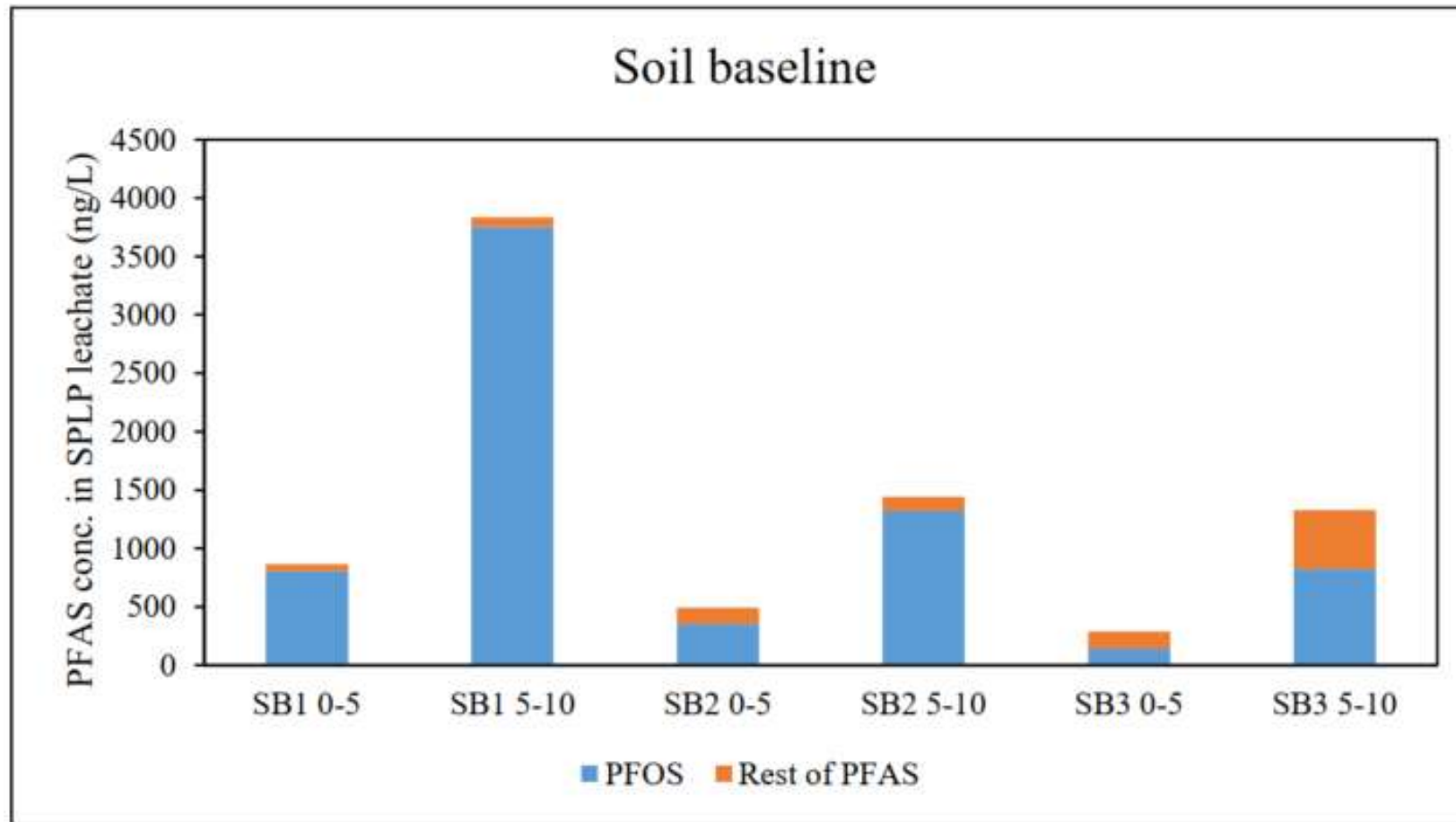
923 Acres

History of contaminant releases:
TPH, VOCs, and PFAS

Source Treatment-Grayling, MI



Baseline Data-Soil Leachability (SPLP)



Baseline Data-TOP Assay

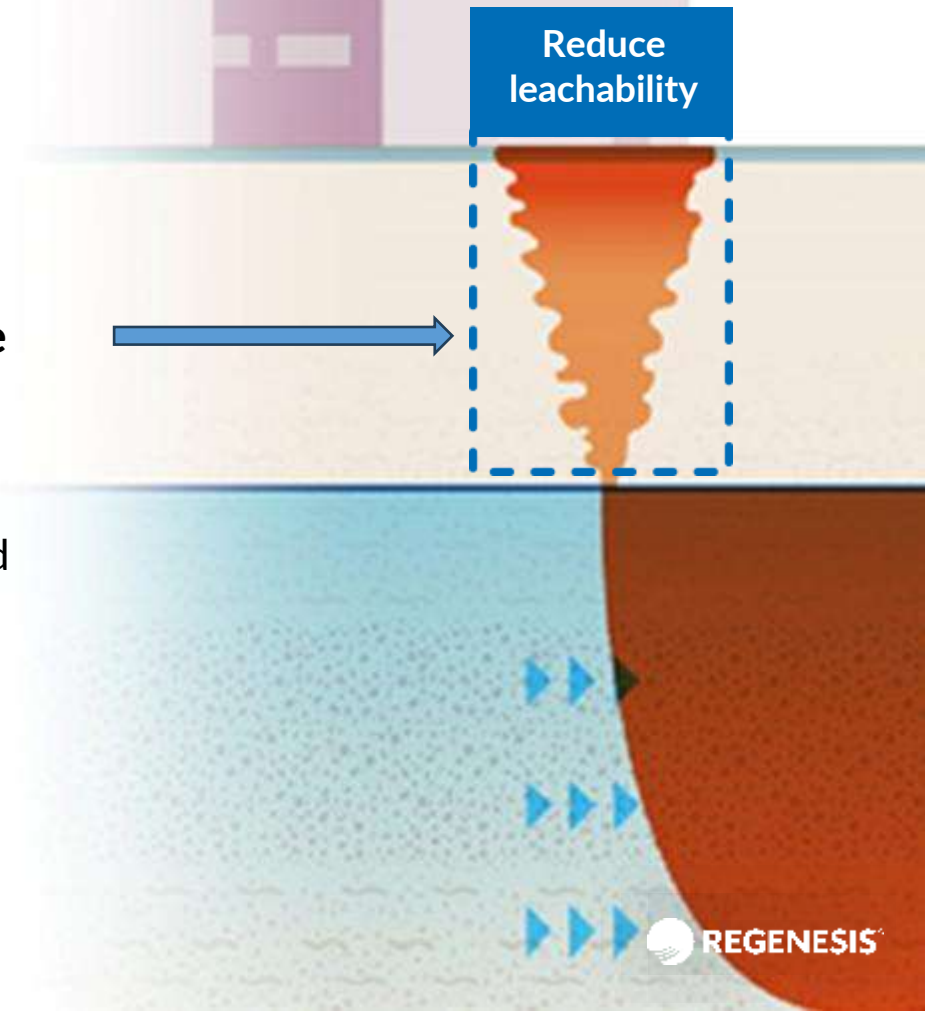
	SB 1 0-5 ft bgs		SB 1 5-10 ft bgs	
Sample type	Soil		Soil	
TOP assay	Pre-oxidation	Post-oxidation	Pre-oxidation	Post-oxidation
PFBA	ND	32.6	ND	22.8
PFPeA	ND	43.2	ND	43.7
PFHxA	13.7	193	ND	442
PFHpA	ND	17.6	ND	10.9
PFOA	14.7	58.4	ND	35.5
PFNA	31.3	28.6	35.9	27.6
PFDA	10.6	ND	ND	ND
PFHxS	97.1	118	109	111
PFHpS	ND	ND	10.4	ND
PFOS	1,990	1,770	7,460	5,020
6:2 FTS	55.2	ND	ND	ND
Sum (ng/L)	2,212.6	2,261.4	7,615.3	5,713.5

Vadose Soils – Microaggregate Solid

Goal: Stabilize PFAS through adsorption and reduce leaching to groundwater



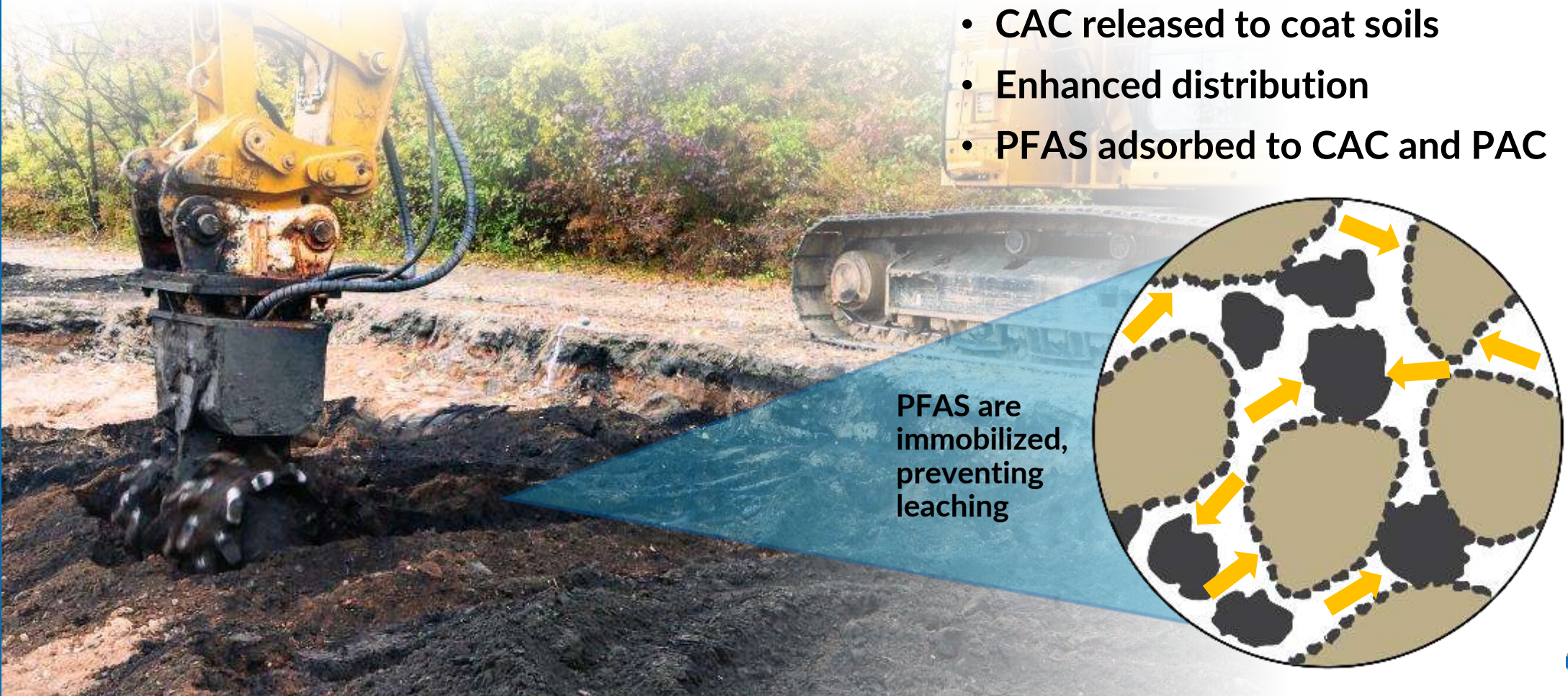
- **Engineered composite microaggregate:**
 - Colloidal Activated Carbon (1-2 μ m)
 - Powdered Activated Carbon (20 μ m)



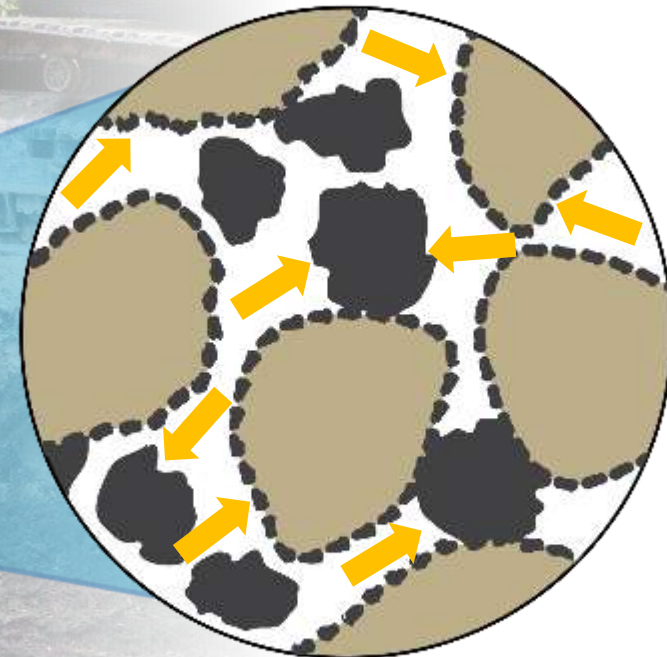
Leachability Reduction

Components:

- Disperses with soil moisture or added water
- CAC released to coat soils
- Enhanced distribution
- PFAS adsorbed to CAC and PAC



PFAS are immobilized, preventing leaching



High Wettability



SourceStop

PAC Mixture

- Less wettable products (i.e., less hydrophilic) such as PAC mixtures require more mixing for soil contact.
- SSS high “Wettability” (i.e., more hydrophilic) requires less mixing for better dispersion into soils.

Source Treatment-Grayling, MI

Application Details:

Location	Michigan
Treatment Area	225 square feet
Treatment Depth	0 to 10 ft bgs
Soil Volume Treated	84 cubic yards
Max. Total PFAS in Leachate	3,835 ng/L
Surficial Geology	Sand, topsoil cover
Implementation Date	September 2022



Source Treatment-Grayling, MI

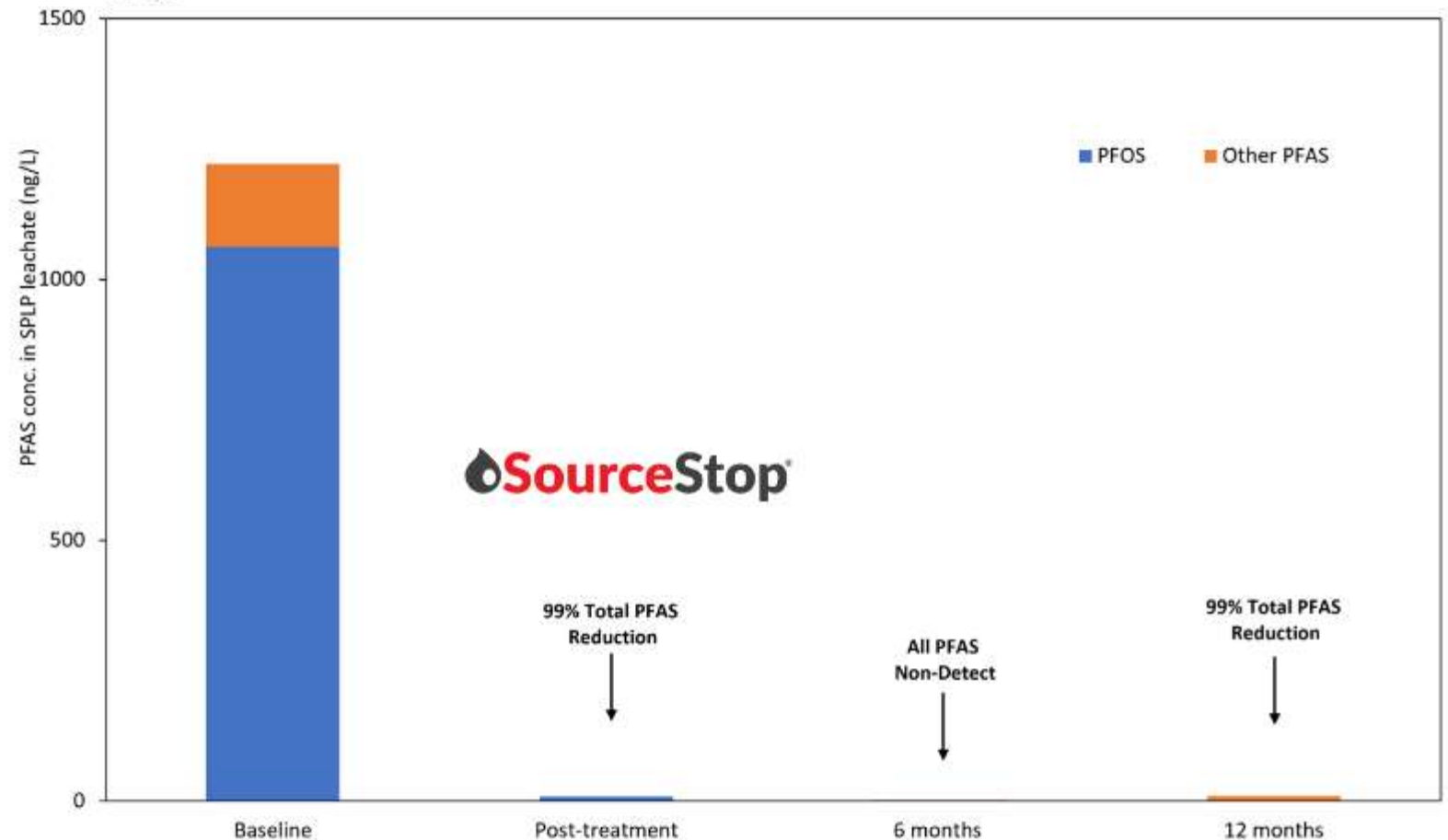


Source Treatment-Grayling, MI

Avg. PFOS/PFAS in Soil Leachate

Average PFOS and rest of PFAS concentrations in soil leachate at baseline and post-treatment at Site 1.

● PFOS
● Rest of PFAS



Summary

- **Shift to Retention-Based Remediation**
- **Role of Colloidal Activated Carbon**
- **Proven to achieve and maintain EPA MCLs**
- **No PFAS waste generated**
- **No lingering exposure risk**



Questions?



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REGENESIS

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