AqueoUS VETS®
Experienced. Proven. Reliable.

The Basic Principles of Water Treatment Media Pilot Trial Design and Evaluation

PFAS Removal Solutions: Current industry standards for removing PFAS with life cycle costs

+++ High ++ Medium + Low

Market Share: High → Low

	Description	PFAS Removal Effectiveness	Relative Cost		Other Considerations
Granular Activated Carbon (GAC)	**Due to its highly porous nature and large surface area, GAC absorbs contaminants at the interface between liquid and solids phases.**	Up to 99% effective depending on the chain length, GAC works best on longer-chain	++	GAC is cheaper unit cost but higher volumes are needed to remove the same amount of PFAS	Lower hydraulic loading rates When water has multiple different total organic carbons (TOC) GAC may remove TOC over the PFAS, decreasing effectiveness
Ion Exchange Resins (IX)	**Positively charged anion exchange resins attract PFAS and hold the contaminate from moving through the water. Can come in both gel (standard water treatment with higher capacity) or macroporous (best for elevated organic content) resin types**	Up to 99% effective for all chain lengths PFAS but also effective for long chain	+++	10-15% cheaper than GAC on a TOTEX basis but 50% cheaper than RO systems	IX is growing in market share compared to other technologies due to its lower cost IX has a lifespan of 6-18 months depending on PFAS concentration Most resins used are non-regenerable Does not need a large footprint for operations making it a better option for limited space
Specialty Media	Proprietary adsorptive medias that work like resins but have the relative cost of carbons	Effectiveness depending on chain Only suitable for low flow	++	Priced between IIX and GAC proprietary medias have benefit of both	New to emerging contaminants with long history in other remediation applications Performs similar to both resins and GAC Treats full spectrum of PFAS contaminants without being effected by co contaminates in the waste stream

Source: Amane analysis | Expert interviews | EPA | Dupont | Westech | AWWA

General Steps when preparing for pilot testing

Conduct Water Analysis

- Comprehensive water analysis to determine the specific PFAS contaminants present in the water

Feasibility Study

- Required design parameters for site and understanding technologies available, high-level costs

Select Media

- Based on the water analysis results, the appropriate filter media can be selected to effectively remove PFAS from the water

Conduct Pilot Testing

- Conduct media testing. In lab or in field

Determine Mechanical Design Parameters

- Bed depth, Media size, Backwash rates, Size of vessel

Long term Cost Analysis

- Routine maintenance and media economics including disposal and Building requirements

System Design Criteria: Empty Bed Contact Time (EBCT)

Empty Bed Contact Time is a measurement of media volume and water flow rate.

$$\cancel{EBCT = Weight\ (lbs)}$$

$$EBCT\ (min) = \frac{Carbon\ Volume\ (ft^3)}{Flow\ Rate\ (ft^3/min)}$$

$$Example: 7.5\ minutes\ EBCT\ at\ 1{,}000\ gpm$$

$$Carbon\ Volume\ (ft^3) = EBCT\ (min)\ x\ Flow\ Rate\ (ft^3/min) =$$

$$7.5 \text{min}\ x \frac{1{,}000}{7.48}\ ft^3/min = 1{,}003\ ft^3$$

Referring to any Media manufacturer's performance guarantee, it is always referenced in Bed Volumes which is also a measurement of the volume of media being supplied.

BVs x total CF x 7.48 gal/cf = total gallons treated

Piloting Programs Offer Small Scale Feasibility Study

Pilot testing is the most accurate preliminary media test but a much longer cycle.

- 4 Column and 8 Column Designs
- GAC, FLUORO-SORB®, and Ion Exchange Resin Media
- Pilots match hydraulic loading rate and EBCT in full scale with fluctuating water quality
  - HLR = Q / A
    - Where:
    - HLR is the hydraulic loading rate (typically expressed in gpm/ ft^2
    - Q is the flow rate of wastewater influent (typically expressed gpm)
    - A is the cross-sectional area of the treatment unit or basin (typically expressed in square feet, ft^2, or square meters, m^2).

Media	GAC	IX	FLUORO-SORB®
HLR	2-10 gpm/ ft^2	6-18 gpm/ ft^2	3-14 gpm/ ft^2

Per AWWA Guideline

Media Design Criteria Differences

Each media is designed to difference Empty Bed Contact Times (EBCT) and Hydraulic Loading Rates.

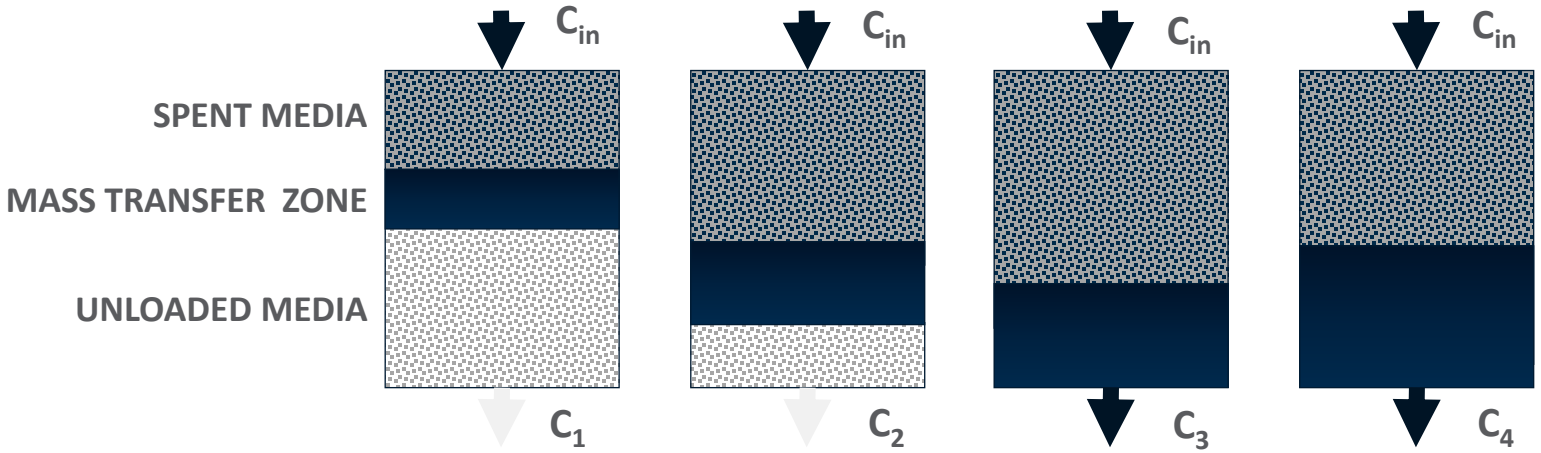
Media Type	GAC	Ion Exchange Resin	CETCO FLUORO-SORB®
EBCT (minimum)	10 minutes	2 minutes	2 minutes
Hydraulic Loading Rate	2 < X < 10 gpm/ft2	6 < X < 18 gpm/ft2	3 < X < 14 gpm/ft2 (Max. still unknown)
Start Up	Backwash	Pre-rinse *On or Off Site	Backwash
Prefiltration	Sometimes Bag / Cartridge Filters	Always Bag /Cartridge Filters	Sometimes/ Bag / Cartridge Filters

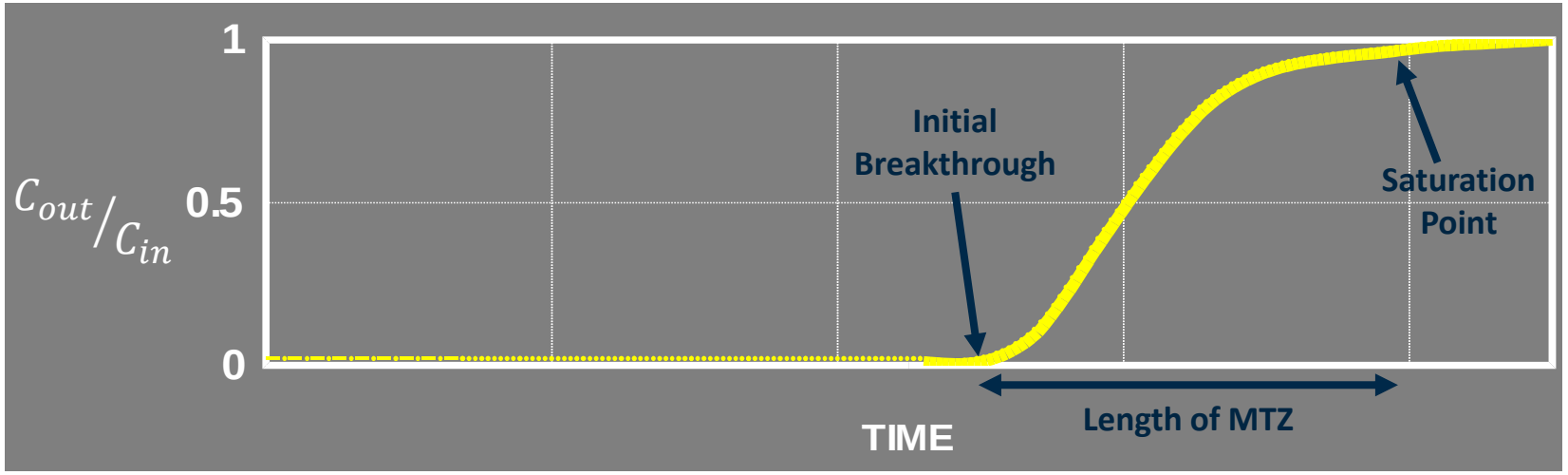
EXAMPLE: 2 MGD (1,400 gpm) Facility

Media Type	GAC	Ion Exchange Resin	CETCO FLUORO-SORB®
Number and Size of Lead-Lag System	2 – 12 ft. diameter	1 – 12 ft. diameter	1 – 12 ft. diameter
Side Shell Height	8 ft.	4 ft.	4 ft.
Volume per vessel	936 ft3	420 ft3 (min. bed depth)	420 ft3

How Do These Treatment Systems Work?

Media loading and design criteria is determined by the contact time with the water and the hydraulic loading.



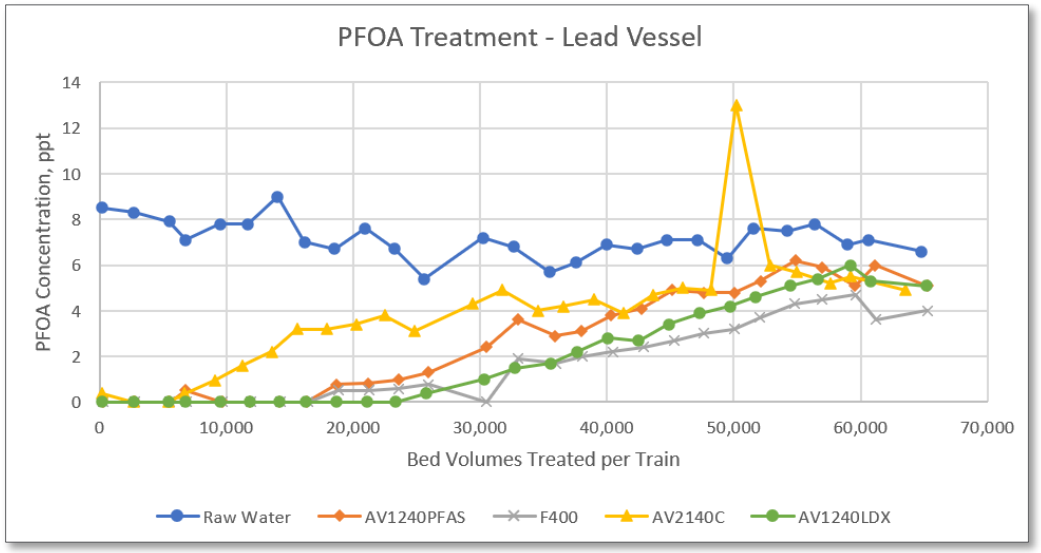


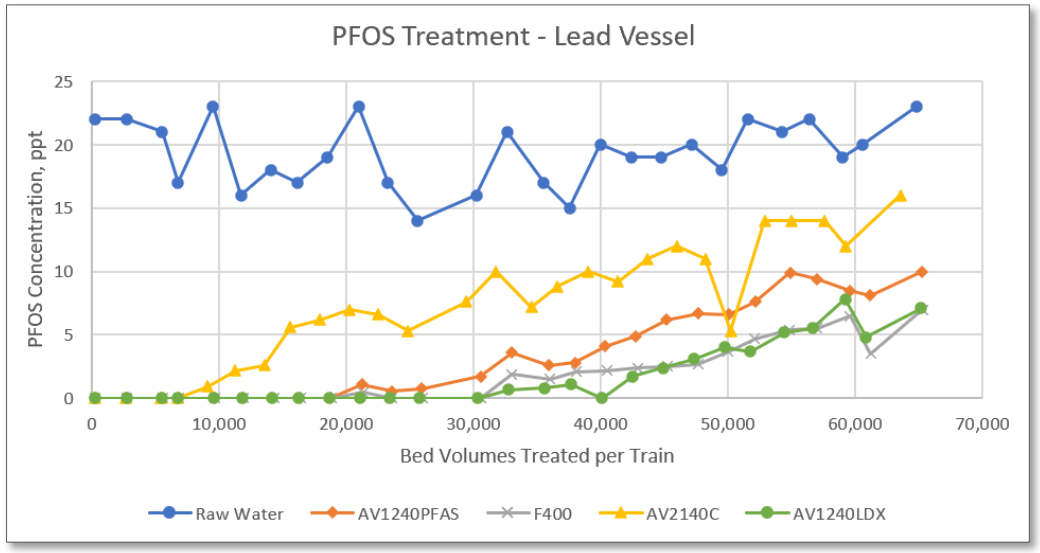
GAC Pilot Study Ventura County, CA

They were only testing GAC because they needed to remove both 123-TCP and PFAS Compounds.

Design Criteria	
EBCT	5 minutes*
Hydraulic Loading	8.2 gpm/ft2
Influent Water Quality	
PFOA	7.2 ppt
PFOS	18.9 ppt
TOC	0.29 ppm Avg.

*The pilot was run with lead-lag configuration. EBCT per column. Lag Columns did not breakthrough.



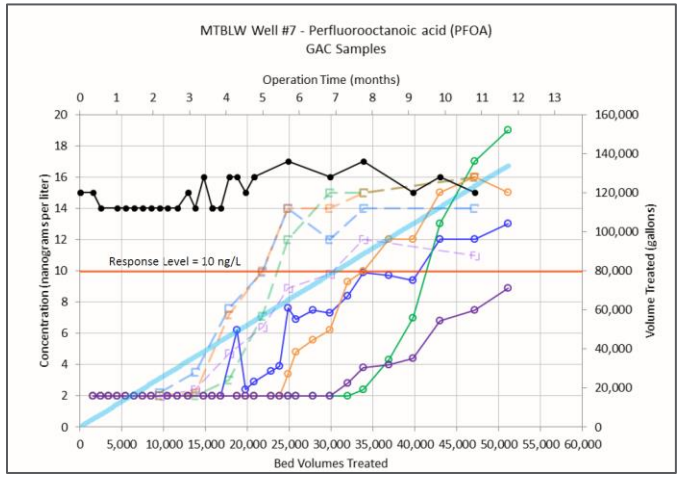


Trussell TECHNOLOGIES INC

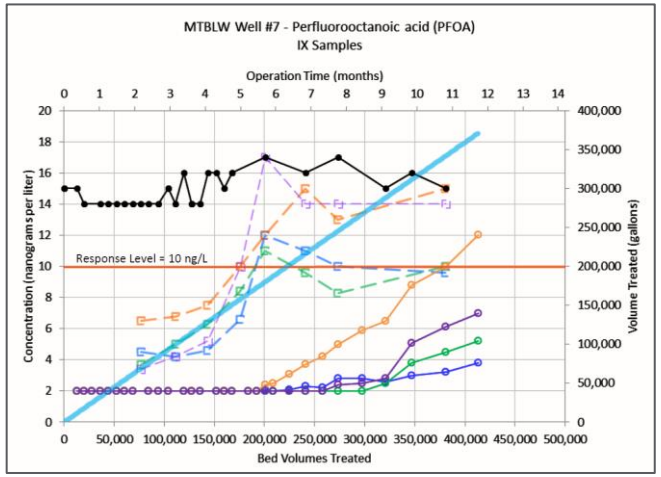
Pilot Data – Los Angeles County, CA #1– IX Resin and GAC

This was a comparison between GAC and IX Resin for both PFOA and PFOS.

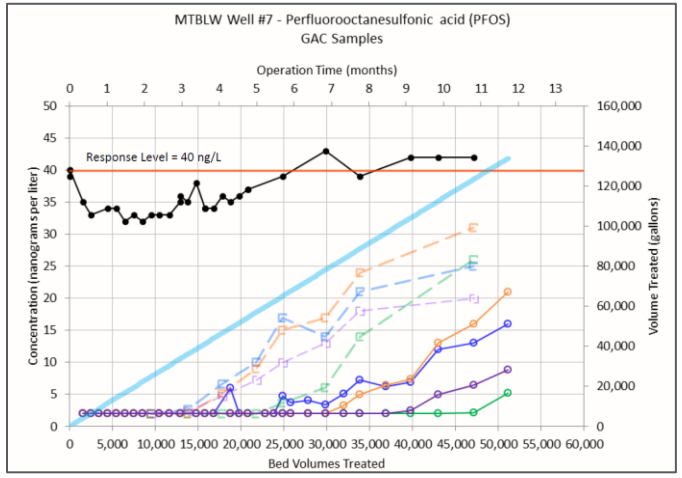
GAC: PFOA Removal



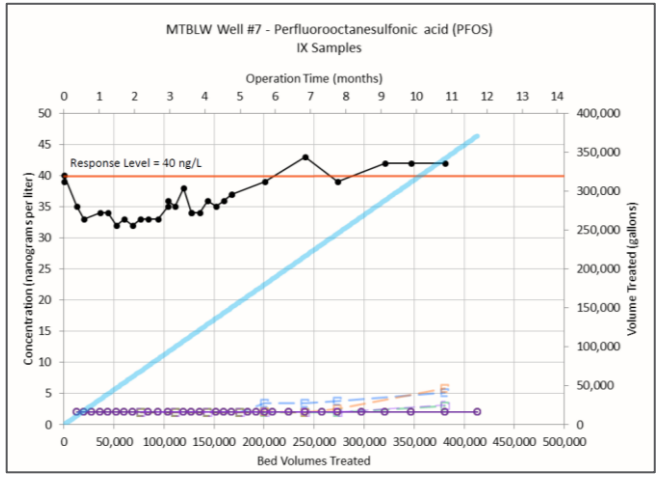
Ion Exchange Resin : PFOA Removal



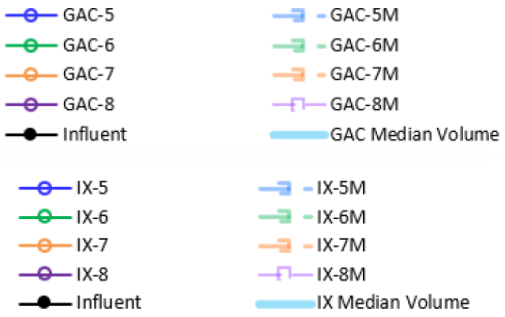
GAC: PFOS Removal



Ion Exchange Resin: PFOS Removal



GAC Design Criteria	
EBCT	10 minutes
Hydraulic Loading	8.2 gpm/ft2
Ion Exchange Resin Design Criteria	
EBCT	1.2 minutes
Hydraulic Loading	16 gpm/ft2
Influent Water Quality	
PFOA	11-17 ppt
PFOS	29-37 ppt
TOC	0.68 ppm Avg.



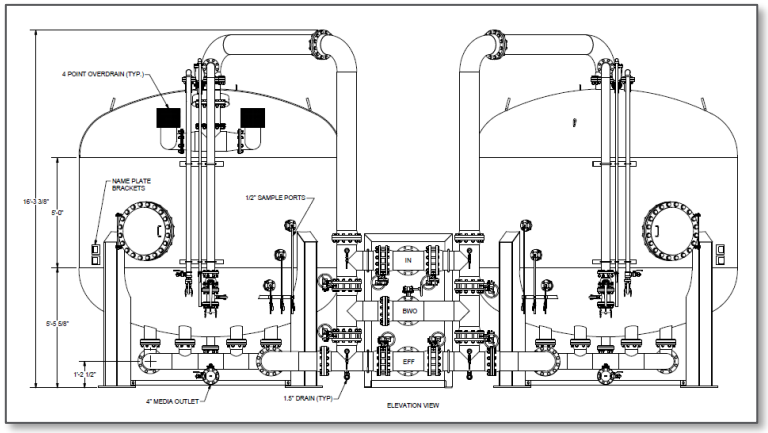
Conclusion: IX Resin 10X longer

Treatment Options: CETCO FLUORO-SORB®

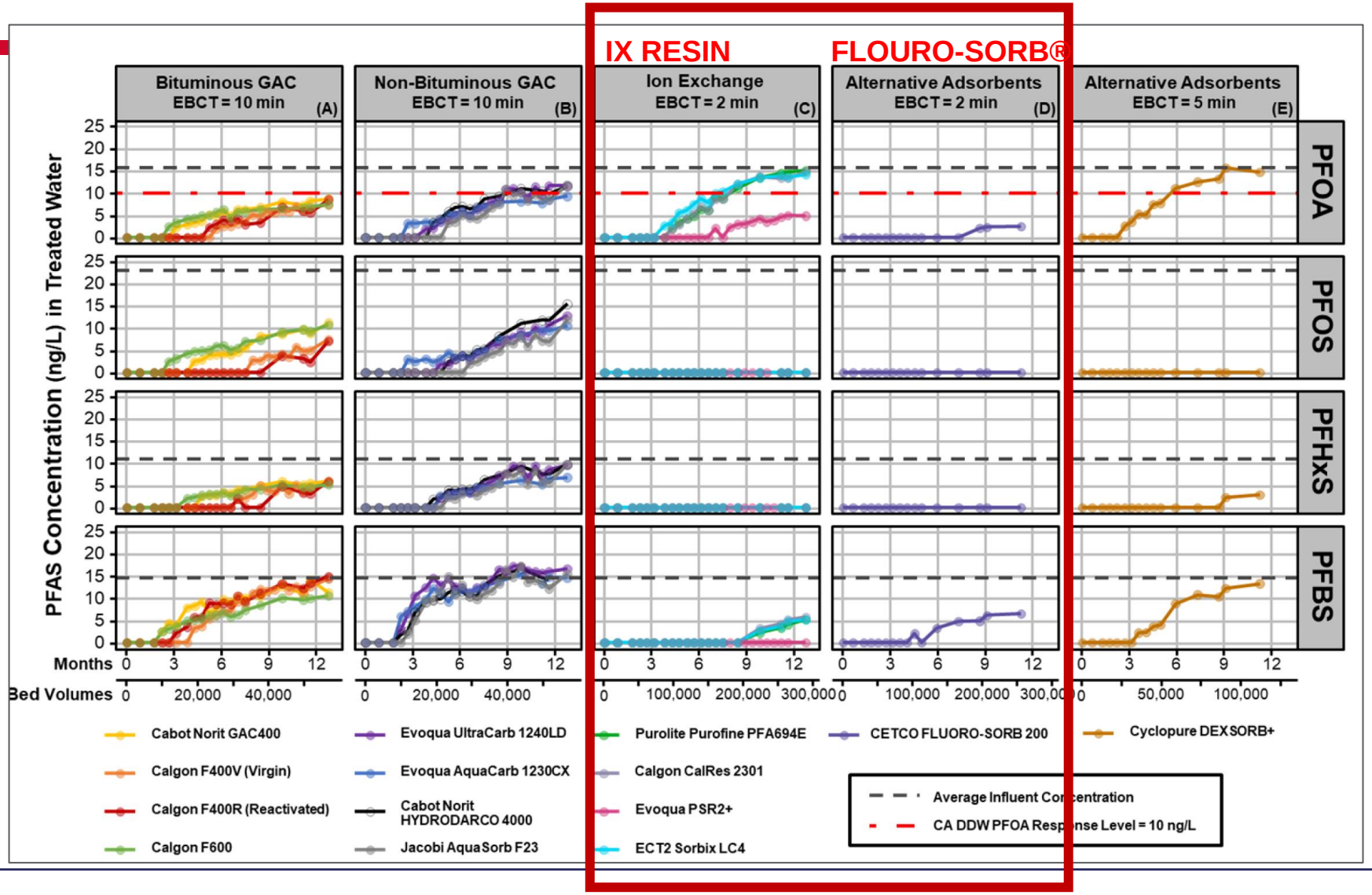
A new media showing to perform as well as ion exchange resin.

Municipal applications: FLUORO-SORB® 200

- Adsorbent that is proprietary
- >2 min empty bed contact time
  - Example: SJW is using 2.5 minutes
- Hydraulic Loading Rate < 14 gpm/ft^2
  - 12 ft. dia. vessel max. flow rate → 1,600 gpm
  - Testing for max capability
- Overall System Height < 15 ft. (LowPro™)
- Apparent Density 49.9 lb/ft^3
- Requires Backwashing
- Works well with long and short-chain PFAS compounds
- Currently no other compounds that significantly affect or shorten the bed life



Orange County Water District PFAS Pilot Study



Questions?

Visit our website for more information

www.aqueousvets.com

PFAS Treatment Options: IX Single Pass Resin

IX – Ion Exchange

- >1.6 min empty bed contact time, typically 2-3 minutes per vessel
- Hydraulic Loading Rate 6 > X < 18 gpm/ft^2
  - 12 ft. dia. vessel max. flow rate → 2,000 gpm
- 25-28 psi DP with 535 cu. ft resin per vessel
- Overall System Height 16’-4”
- 4-point inlet distributor
- PFAS or Perchlorate Selective Resin
  - Competing anion concentrations (SO_4, NO_3, HCO_3, Cl, TOC) allow us to predict resin bed life
  - Background anions affect resin bed life