



Taking your Data to the Next Level: ***Optimizing AdDesignS for More Accurate PFAS Performance Modeling***

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The information in this PowerPoint limited to attendees of the PNWS AWWA 2025 Conference

Agenda

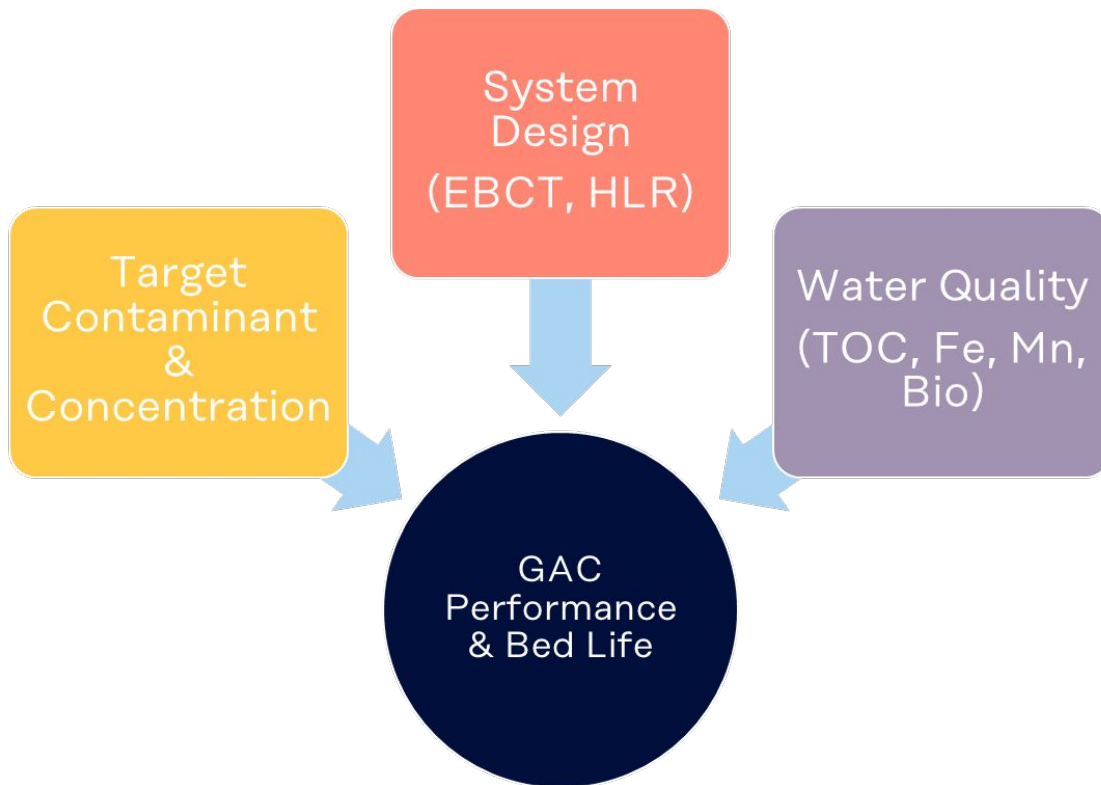
9:00 AM Water Treatment Track

- **Why do we test?**
- **What is AdDesignS?**
- **How do we know AdDesignS Works?**
- **Case Studies**

How and Why Do We Test?

Why Should I Test?

There are many factors that **impact GAC performance and bed life**



...difficult to quantify
performance and bed life without
testing

Feasibility

- Does GAC remove the target contaminant?

Bed Life Estimation

- How often will the GAC bed need to be exchanged?

Product Comparison

- Which GAC performance is best at this site?

There are a few test methods available to help answer these questions:

1. Isotherms
2. Rapid Small-Scale Column Test
3. Pilot Test

Each method has its **advantages and disadvantages**

What Can a Test Tell Me?

Test Method	Time to Completion	Relative Cost	Ability to Compare Medias	Predictability of Full-Scale
Isotherm	Quick Days to Weeks	Low	Poor	Limited
RSSCT	Moderate Weeks to Months	Variable	Fair	Better*
Pilot	Long Months to a Year	Variable	Good	Best**

*RSSCTs for PFAS have been shown to both **over and under** predict GAC performance

When pilot is designed to **mimic full-scale operation (e.g., match HLR) and run long enough to see long-term water quality impacts

Sometimes, real-world constraints limit the testing options a utility can pursue

In this case, mathematical models can improve the accuracy of the full-scale prediction

What is AdDesignS?

What is AdDesignS?

Originally developed by [Michigan Tech](#)

Currently preferred tool of the [EPA](#) for PFAS contaminated sites to estimate performance

Mathematical modeling software freely available through the [EPA](#)

Utilizes Freundlich isotherm values and surface diffusion coefficients to [estimate breakthrough](#)

Allows users to [input values](#) for the media, vessel, and contaminant of interest

The model utilizes [lots](#) of data...

The screenshot displays the AdDesignS software interface with several overlapping panels:

- Water Properties:** Includes input fields for Pressure (atm) and Temperature (15.0 C), and a Correlations button.
- Fixed Bed Properties:** Includes an Adsorbent Database section with fields for Bed Length, Bed Diameter, Bed Mass, Flowrate, EBCT, and Bed Density, each with a unit dropdown.
- Simulation Parameters for PSDM Only:** Includes fields for Total Run Time, First Point Displayed, Time Step, Number of Axial Elements, and Number of Collocation Points (Axial and Radial Directions).
- Kinetic Parameters for PFOA:** Includes sections for Film Diffusion, Surface Diffusion, and Pore Diffusion coefficients, along with a Gnielinski Correlation section.
- Component Properties:** A detailed panel for inputting contaminant data, including Name, Molecular Weight, Molar Volume @ NBP, Boiling Point, Initial Concentration, Liquid Density, Solubility, Vapor Pressure, Refractive Index, and CAS Number.
- Freundlich Isotherm Parameters:** Includes fields for Freundlich K and 1/n, and a Source of K and 1/n dropdown.

For more information: https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=540206&Lab=CESER



How do we know AdDesignS Works?

How Do We Know AdDesignS Works?

“Case Study Zero”

Case Study Zero - Water Quality

Flowrate = 8 MGD

PFOA = 51 ng/L

TOC = 1.1 ppm

Other PFAS present less than MCLs

Testing Design

GAC media = F400

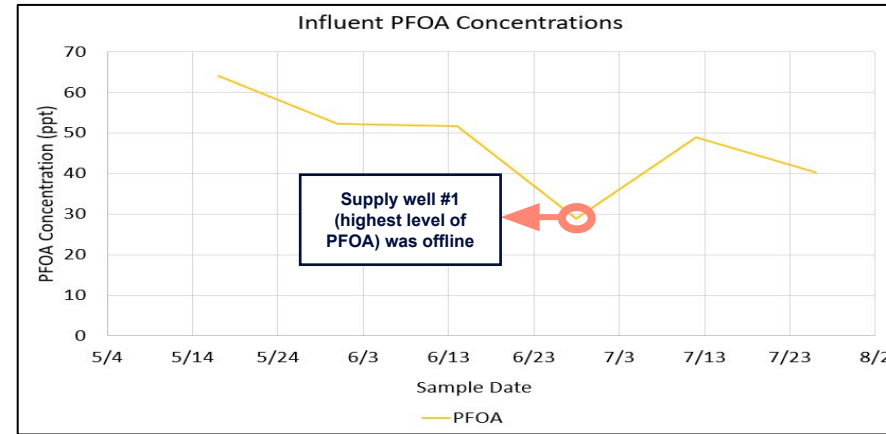
Operation = Continuous

Configuration = 4 columns in series

GAC full-scale vs. pilot-scale

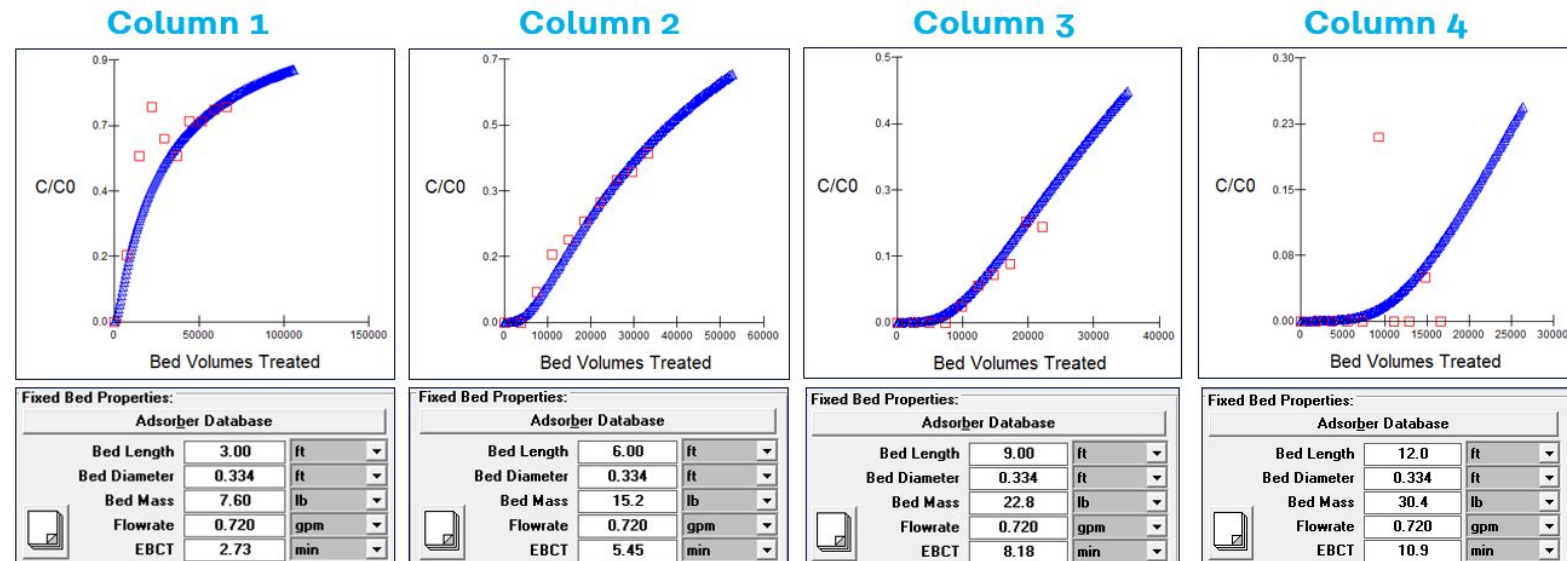
HLR = 8.2 gpm/sf vs. 8.3 gpm/sf

EBCT = 10.7 min vs. 10.8 min



△ Effluent Prediction	
□ Effluent Data	
Freundlich Isotherm Parameters	
Freundlich K	47.0
Freundlich 1/n	0.920
Source of K and 1/n User Entry	

Site Specific AdDesignS Modeling Results



An Expedited pilot test could have been run thanks to AdDesignS!

Potential Impact of an Expedited Pilot

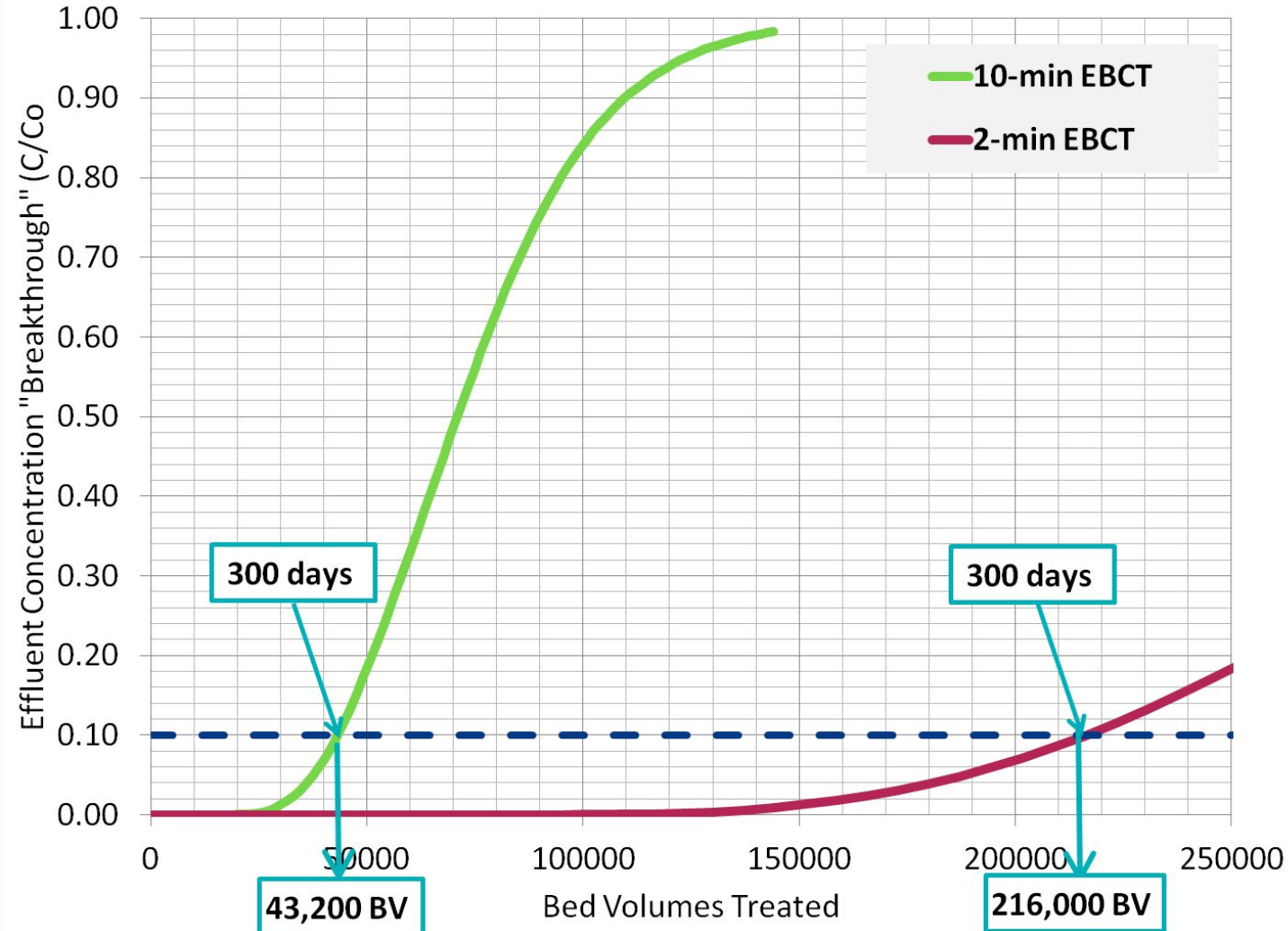
The short column was predictive of the other three column effluents

- Results from the short EBCT informs performance of the long EBCT
- This may allow for the test to be ran in ~1/4th of the time
- The sample budget is also reduced, eliminating the need for a large sample volume and cost

Impact	Short EBCT	Long EBCT
Sample Cost	20x(\$500/sample) \$10,000	50x(\$500/sample) \$25,000
Water Volume	200,000 gal	800,000 gal

Case Studies

Refresher: Deciphering a Conceptual Breakthrough Curve



Green: GAC System
Bed volume = 10,000 gal

Red: IX System
Bed Volume = 2,000 gal

1,000 gpm design flow
GAC and IX each treat the
same volume (432 MG)
in same time (300 days)

**Which is less expensive to
exchange?**

CASE STUDY 1 CONTEXT

Groundwater Supply | Great Lakes Region | 4 MGD System Flow

Background TOC = < 1.0 mg/L

KEY PFAS Compounds:

- PFOA = 58 ng/L or ppt
- PFHxA = 3 ng/L or ppt

Other Pilot Study Notes

- Unit shut on/off with the well
- Was on ~20% of the time
- Co-occurring TCE at 3.4 ppb

GAC Full-Scale Design

Design HLR: 8.3 gpm/ft²

Design EBCT: Approx. 10 minutes

Average HLR: 5.3 gpm/ft²

Average EBCT: Approx. 15 minutes

Three M12-40 systems

Pilot Design

EBCT: Approx. 5 minutes

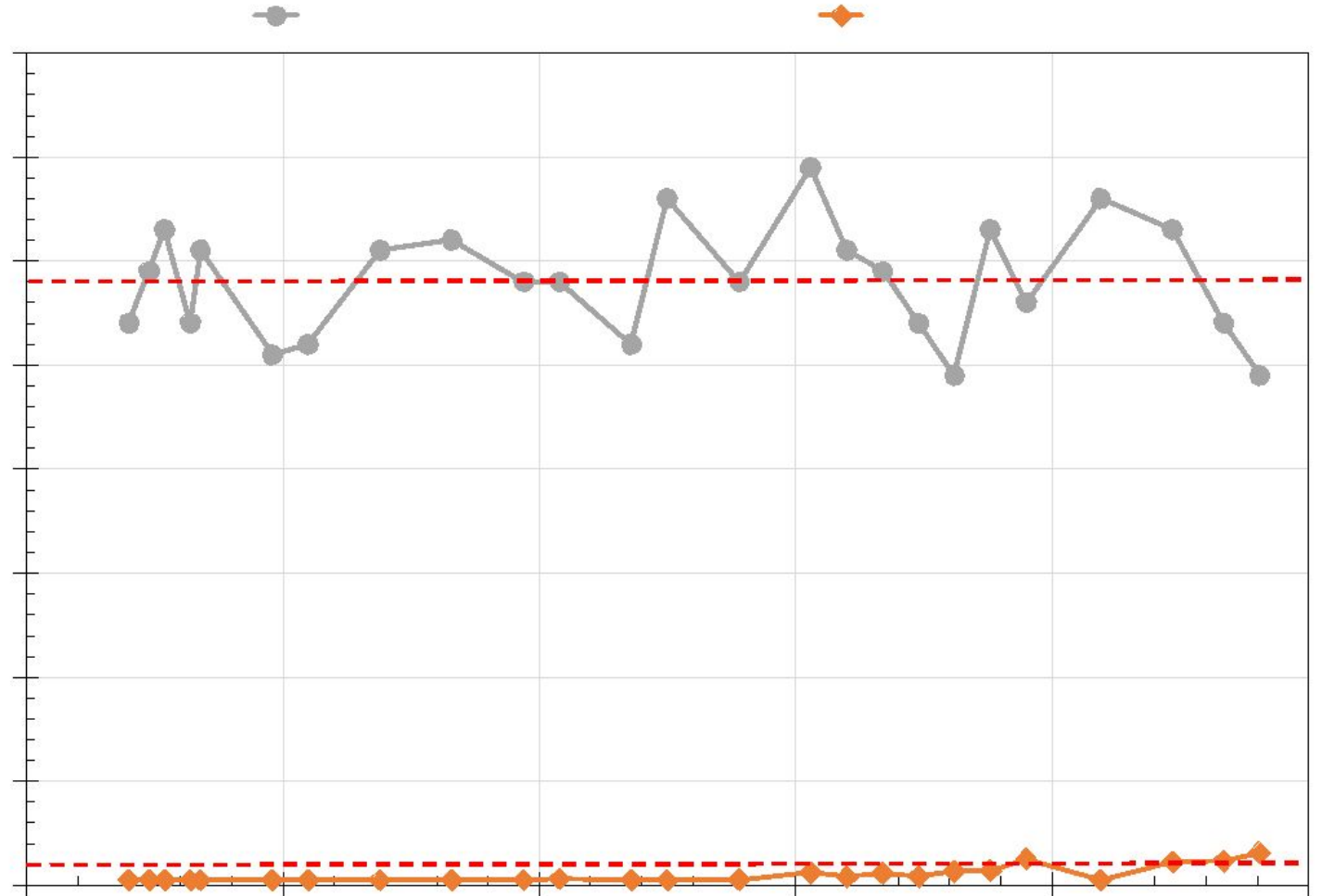
HLR: 5.3 gpm/ft²

A second column with a higher HLR

PFOA Pilot Results

The initial pilot results demonstrated >1 year of operation

At the end, the effluent was only 3.1 ppt (< 4.0 ppt goal) (remaining capacity!)

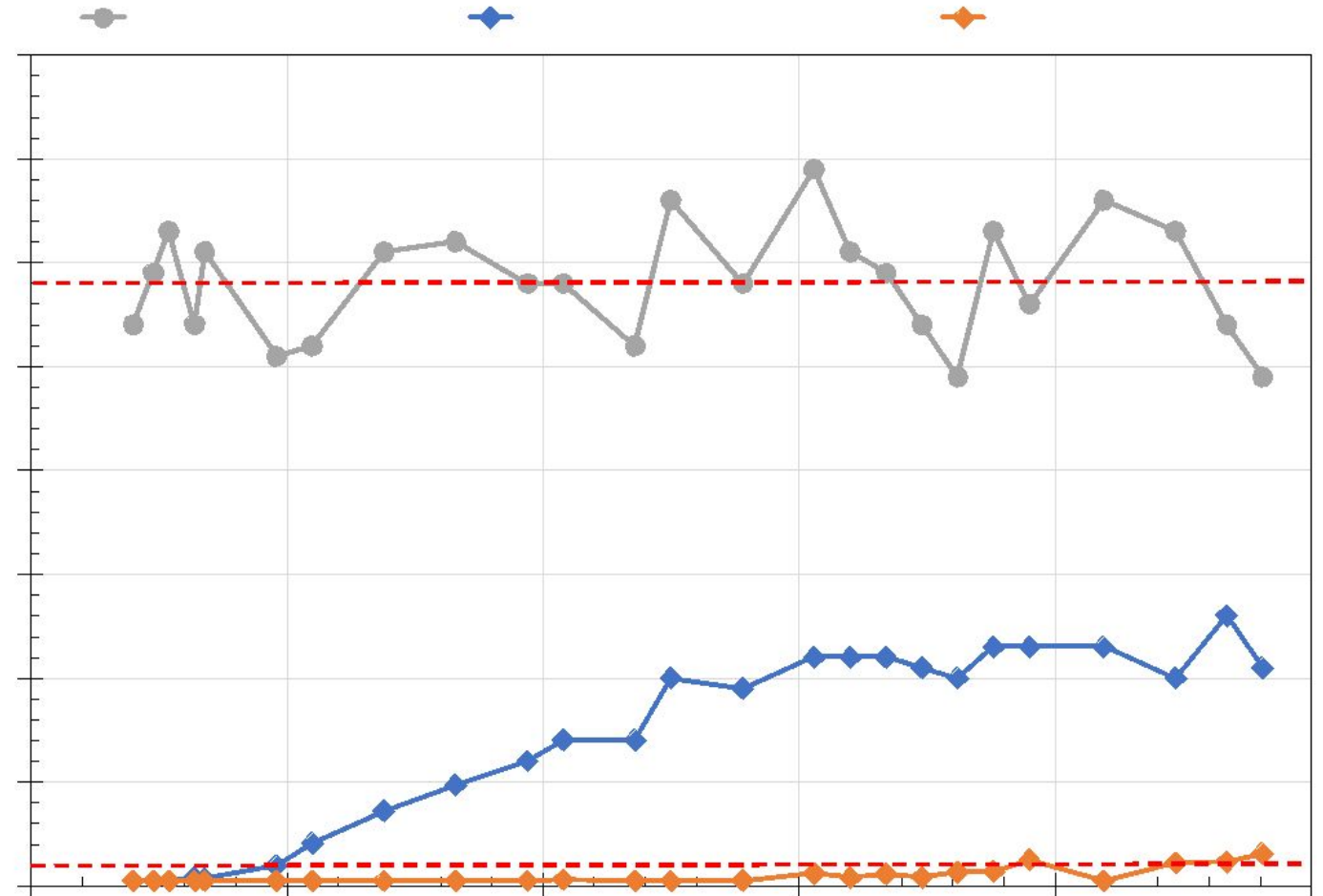


PFOA Pilot Results

Elevated HLR Column demonstrated MTZ containment and roughly 3 months or 14k BV throughput to 4 ppt PFOA

Low-Rate column had initial breakthrough at roughly 1 year or 21k BV

- Last detection at 3.1 ppt PFOA at roughly 27k BV



AdDesignS Calibration and Modeling

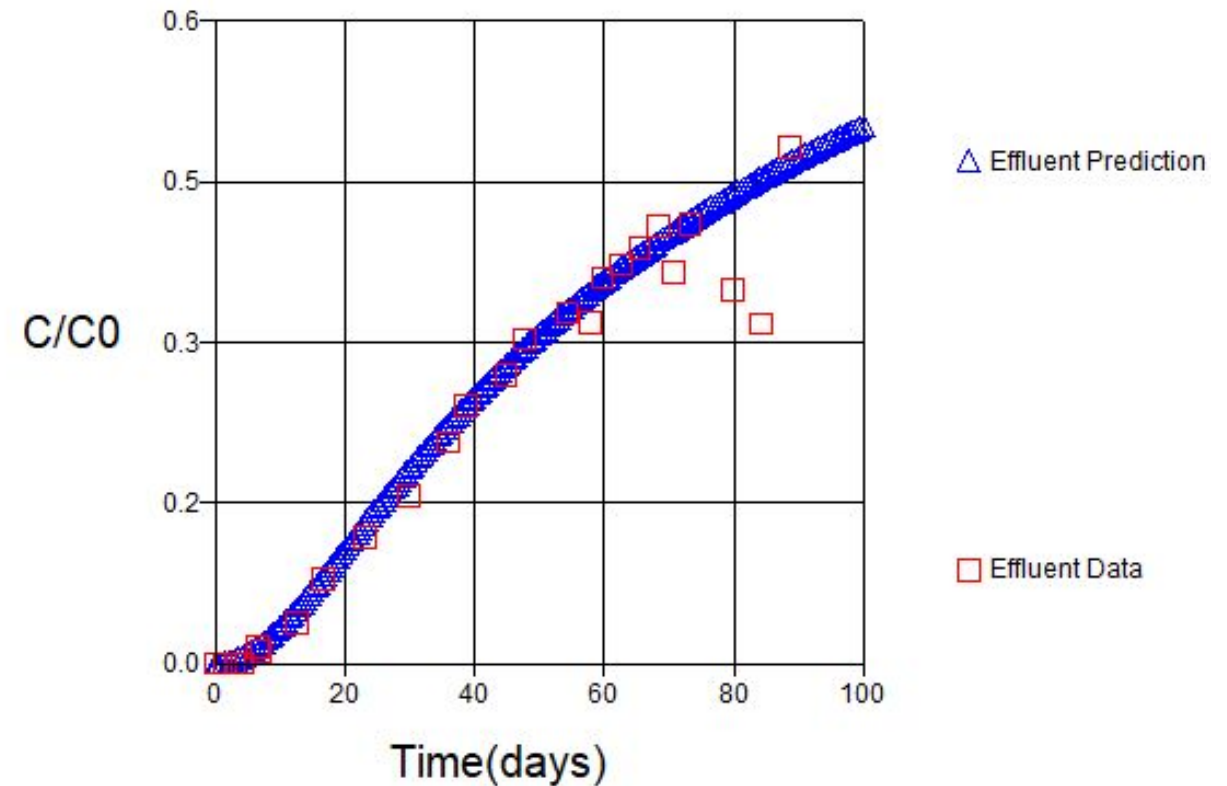
AdDesignS Software is provided by the US EPA as part of the ETDOT suite

Utilizes the pore-size-diffusion-model (PSDM)

Modeling may help with:

- Scaling pilot data to inform expected full-scale performance
- Evaluating multiple hydraulic designs

Model Calibration – PFOA High-Rate Column



STRONGLY RECOMMEND TRAINING OR KNOWLEDGE BEFORE ATTEMPTING!

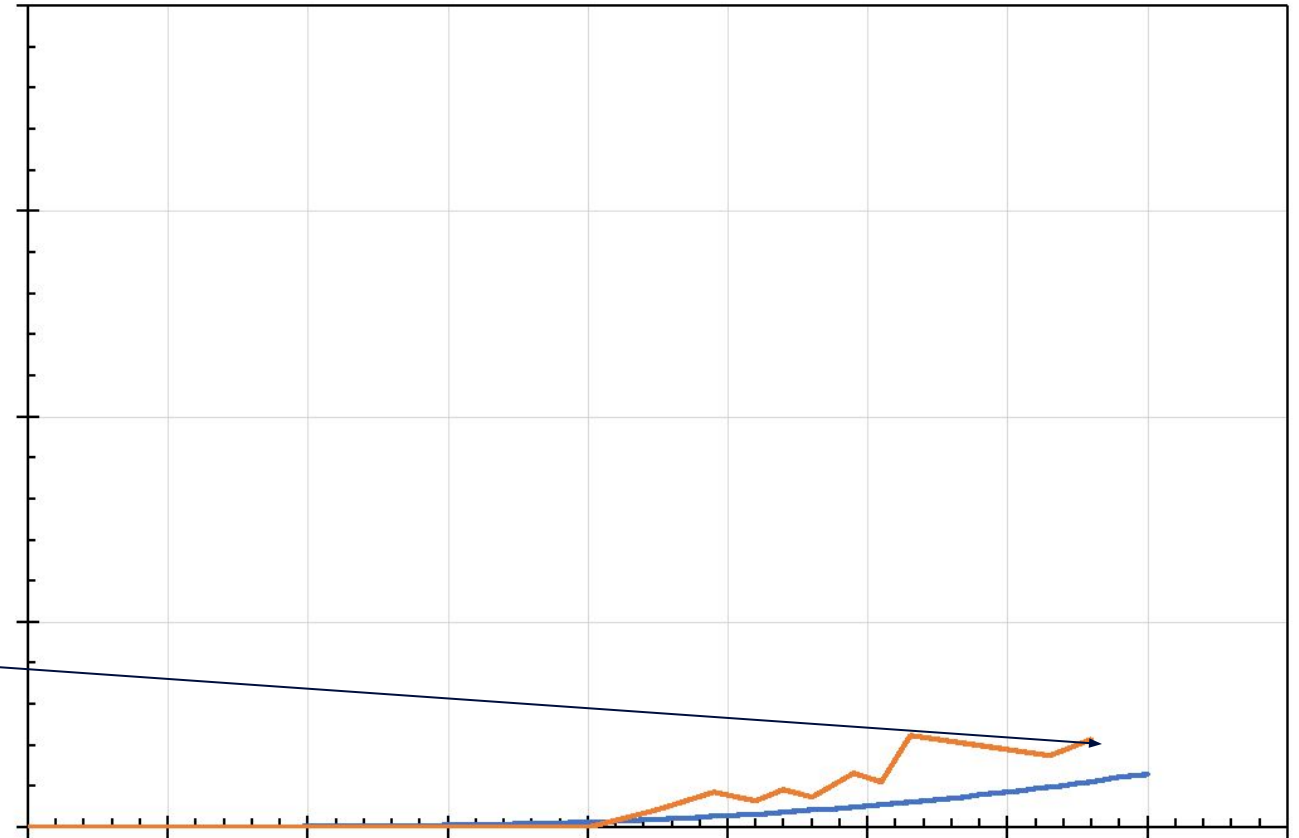
Predictability of AdDesignS

Pilot breakthrough was incomplete

- Effluent was 3.1 ppt

Based on the calibration, the model closely predicts the low HLR

□ Within 5% of the concentration!



Full-Scale Prediction

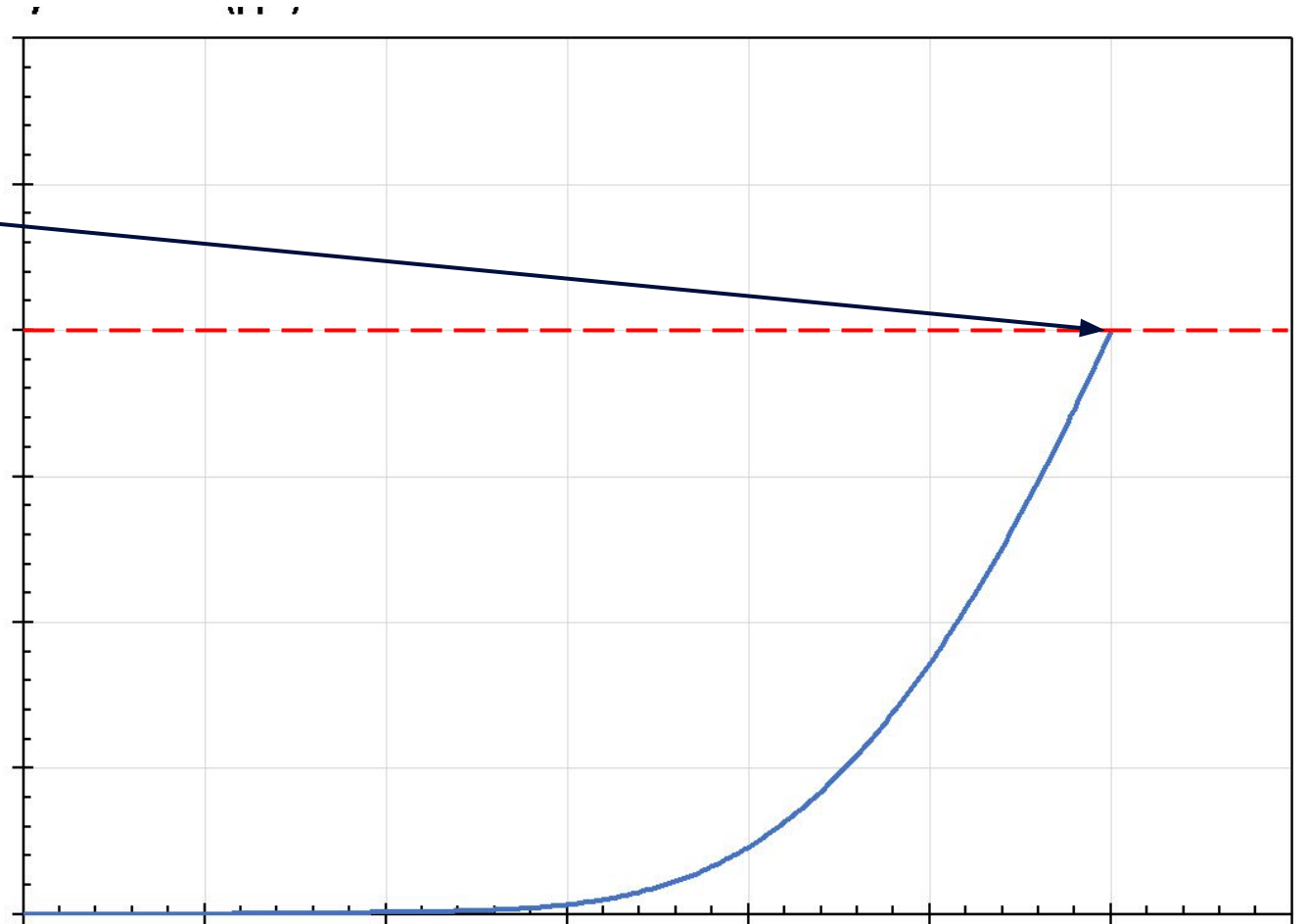
Full-Scale Run Time:

PFOA Dictates Exchange
~19 months
of continuous operation

This represents the effluent of the
lead vessel in a lead/lag

**Full-scale run-time is modeled by
using the **expected system design**
with the **pilot calibration results****

This demonstrates an initial
expectation of performance



Case Study Discussion

Testing HLR □ HLR Drives MTZ □ MTZ Drive Use Rate

HLR Drives Piloting Time

- High HLR: 14k BV to 4 ppt (MCL)
- Low HLR: 27k BV to 3.1 ppt; remaining capacity

Pilot Testing may be expedited, but there is a catch...

- Adequate data must be collected!
- AdDesignS must be used. □ This is not straight forward, and fatal mistakes can be made.
 - Need knowledge of GAC adsorption and experience.
 - Model slightly overpredicted performance in the low-rate column ~5%.
- Actual full-scale run time may be greater than what is typically predicted (continuous v intermittent operation).

Collaborative Pilot Testing is Key!

CASE STUDY 2 CONTEXT

Ground Water Supply | Rocky Mountain Region | 1 MGD System Flow

Background TOC = < 1.0 mg/L

KEY PFAS Compounds:

- PFOA = 6.7 ng/L or ppt
- PFOS = 18 ng/L or ppt
- PFHxS = 33 ng/L or ppt
- PFPeA = 20 ng/L or ppt

GAC Full-Scale Design

EBCT: ~8 minutes

HLR: 5.7 gpm/ft²

One M12 system

IX Full-Scale Design

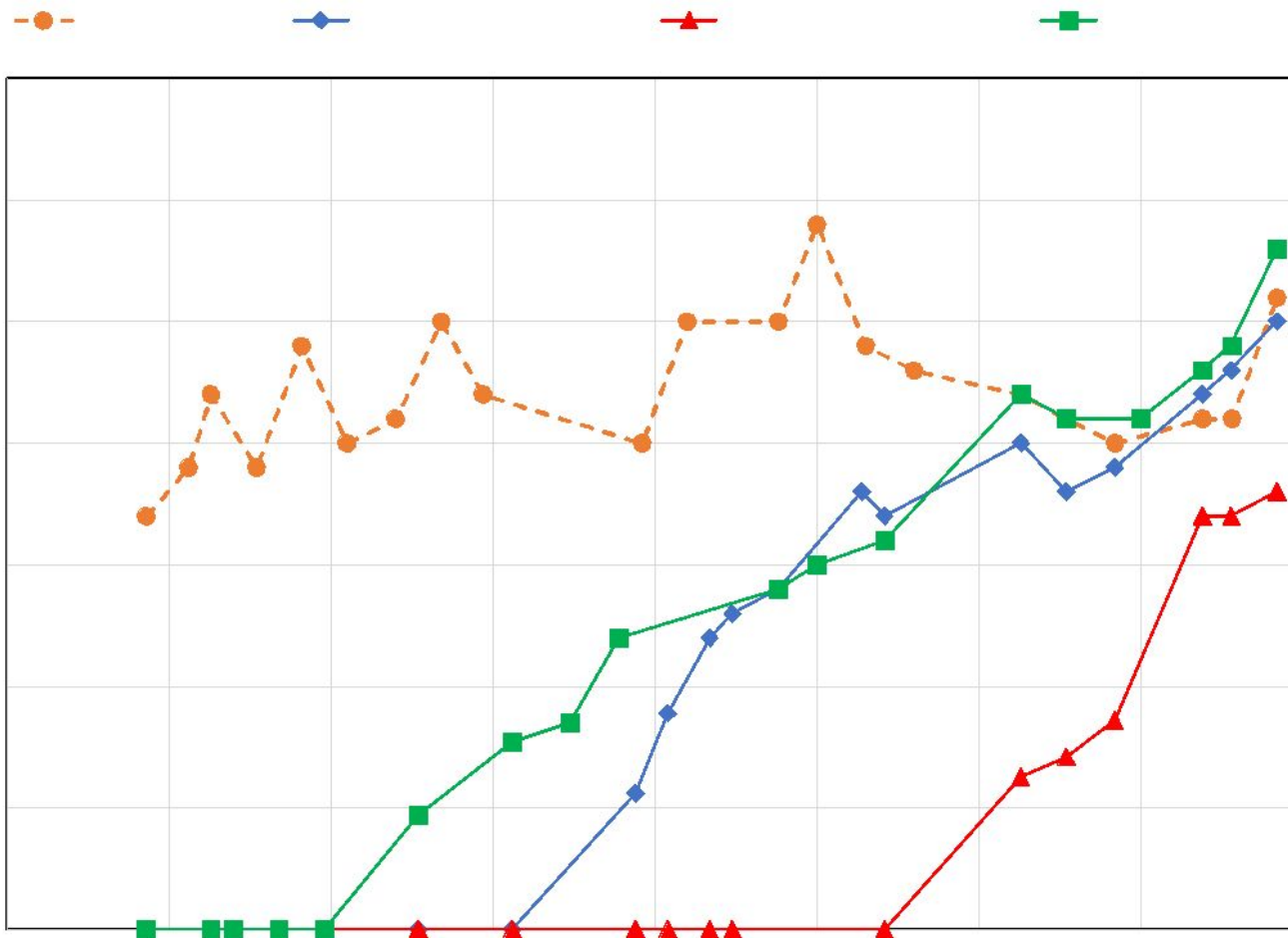
~~GAC Pilot Design~~
~~EBCT: ~2.8 minutes~~

~~EBCT: 8.8 minutes~~

~~HLR: 8.7 gpm/ft²~~

~~HLR: 5.7 gpm/ft²~~
~~One M10 system~~

Short Chain (PFPeA) Removal



Gel resin (green)

- shortest run time for PFPeA breakthrough

Macroporous resin (red)

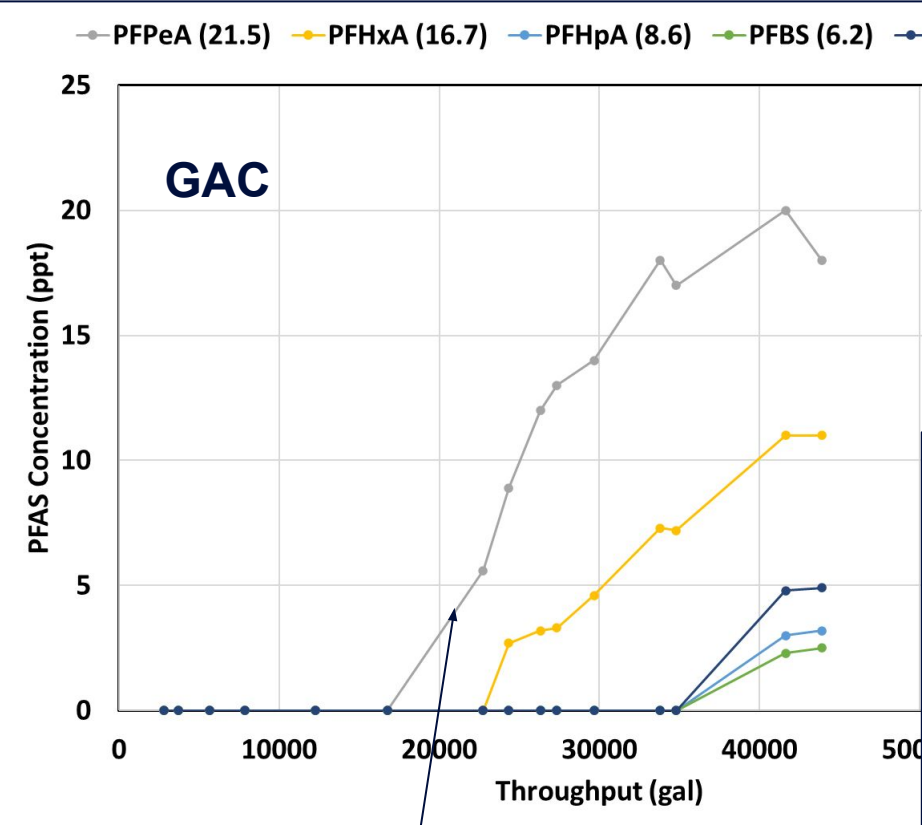
- longest run time

Ultimate breakthrough capacity to complete breakthrough

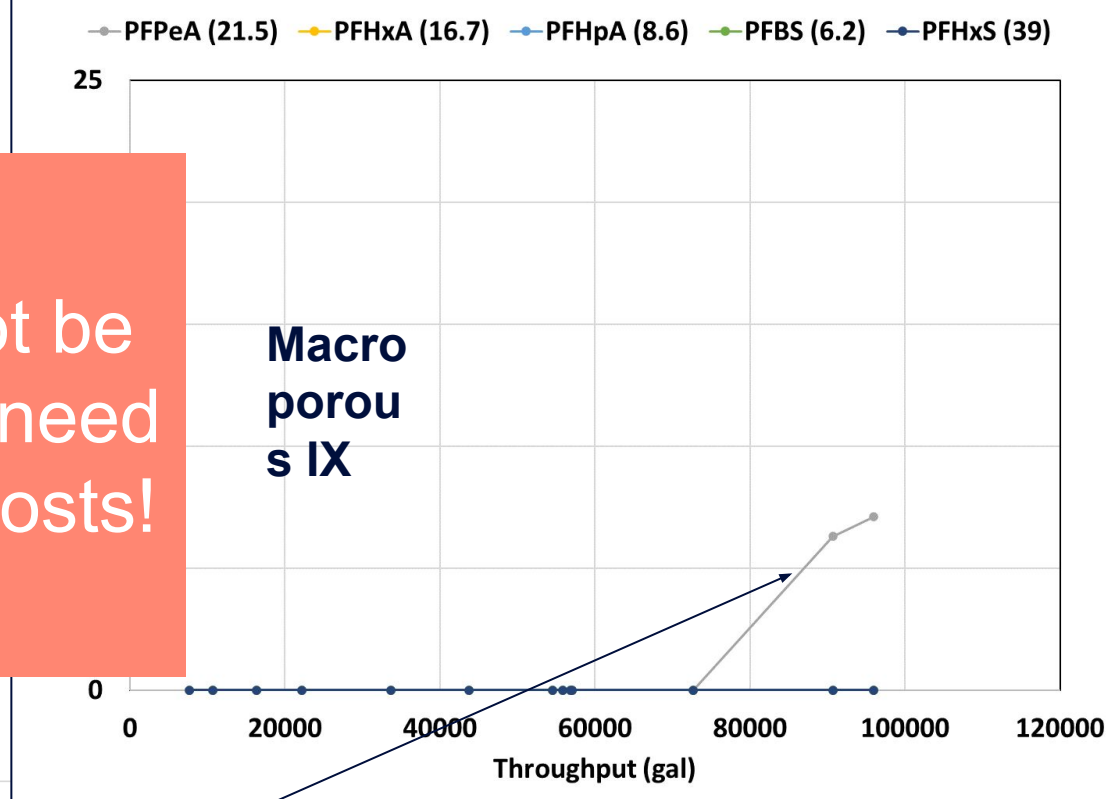
- similar times for all medias

What do the economics look like for this mode of operation?

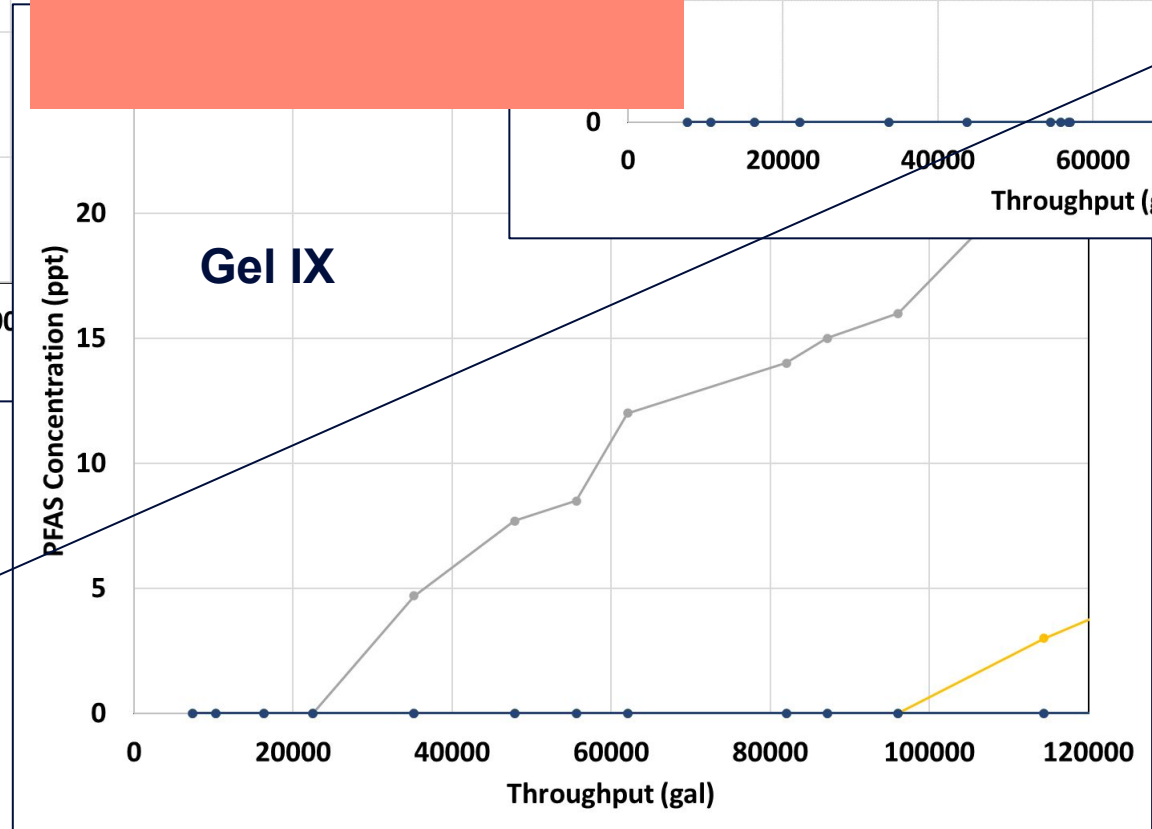
Pilot Results



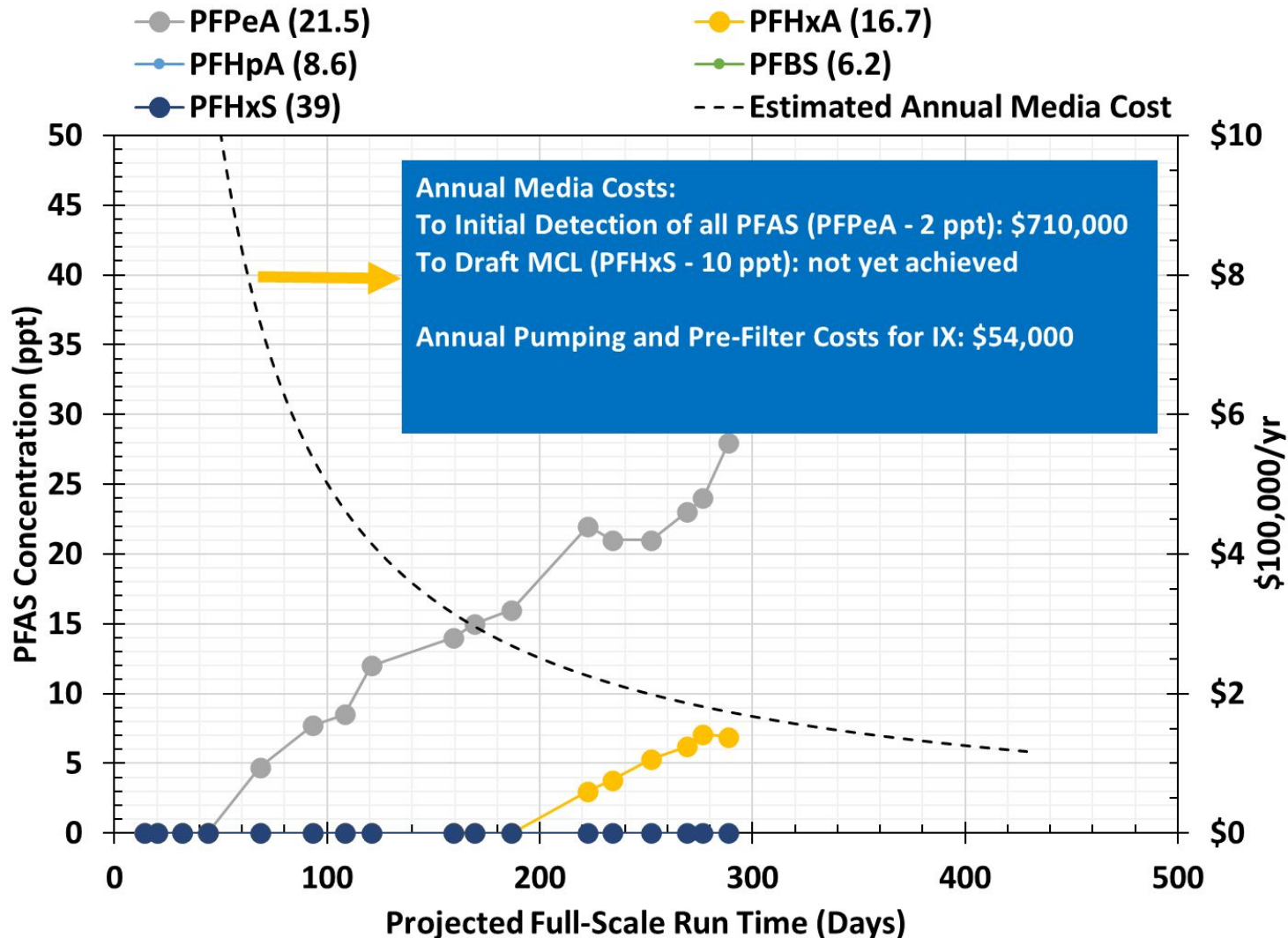
Volume is not be enough...we need to know the costs!



IX treats more than 4x the volume of GAC



Including Operating Costs – Gel Resin (Pumping Not Shown)



Unit Media Cost: \$412/ft³

Unit Media Disposal Cost: \$145/ft³

Annual Media Cost

- Assumes replacement on the day shown
- Includes Disposal – Incineration

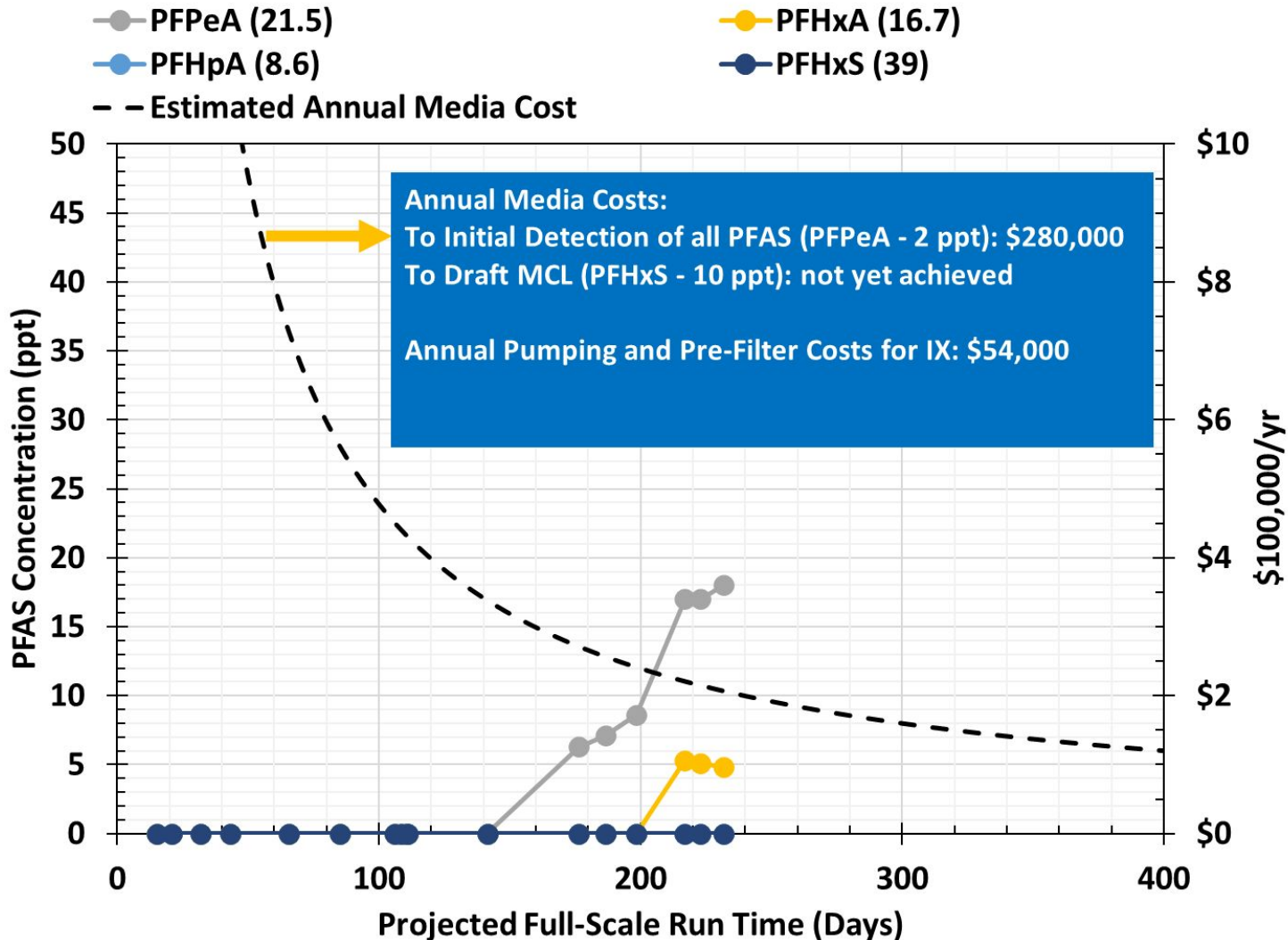
Operation based on PFPeA

- Resultant Cost: \$710k/yr

Pre-Filter cost:

- 2-week replacement interval (\$40k/yr MAX) – Disposal not included

Including Operating Cost – Macroporous Resin (Pumping Not Shown)



Unit Media Cost: \$385/ft³

Unit Media Disposal Cost: \$145/ft³

Annual Media Cost

- Assumes replacement on the day shown
- Includes Disposal – Incineration

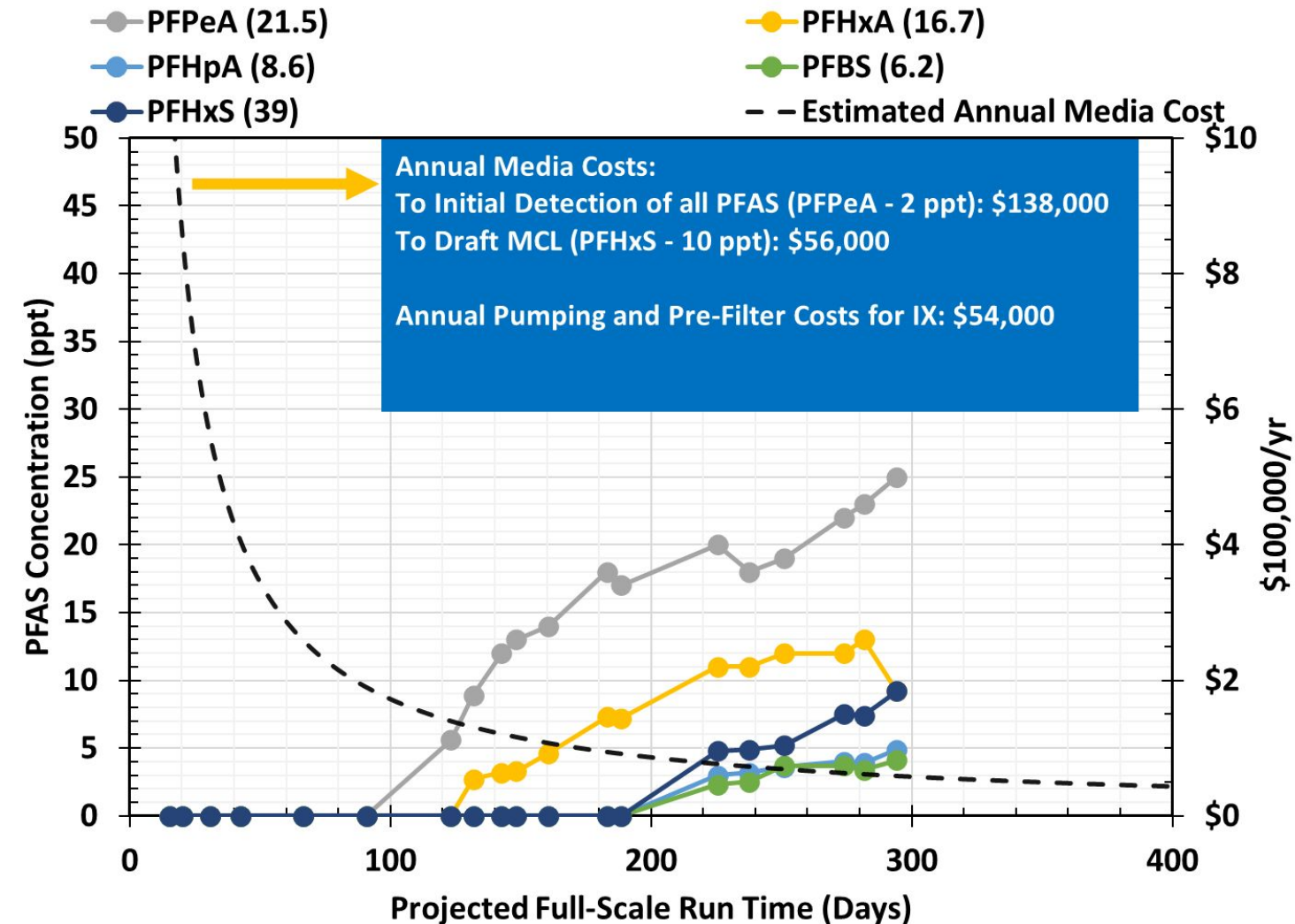
Operation based on PFPeA

- Resultant Cost: \$280k/yr

Pre-Filter cost:

- 2-week replacement interval (\$40k/yr MAX) – Disposal not included

Including Operating Cost – Reagglomerated Bituminous GAC (Pumping Not Shown)



Unit Media Cost: \$2.35/lb
Disposal is included

Annual Media Cost

- Assumes replacement on the day shown
- Includes Disposal – Reactivation

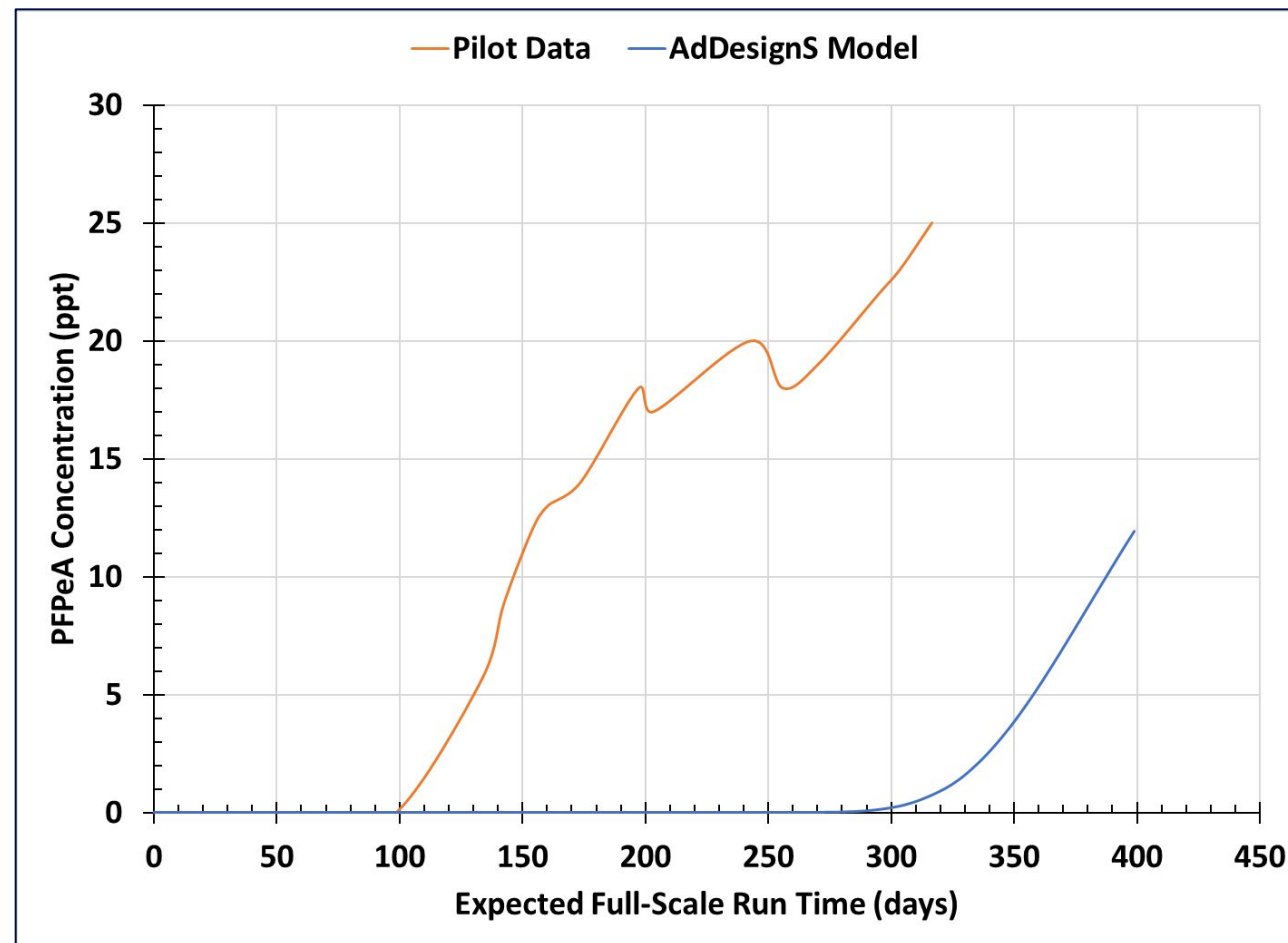
Operation based on PFPeA

- Resultant Cost: \$138k/yr

GAC Pumping \$3.6k/yr

Going a Step Further...Modeling a Full-Scale System

- Pilot breakthrough data calibrates AdDesignS
- Accounts for average system flow not design flow
- Demonstrates an increased performance – 300 days compared to 120 days
- This means the actual system economics will be even better!



Case Study Discussion

IX cost >> GAC cost

Prefilter and pumping costs are \$54k/yr (for IX)

No prefilter and lower pumping cost with GAC (\$3.6k/yr)

IX disposal is a significant cost adder

GAC was the chosen treatment for this utility

With Modeling:

GAC run time may be ~3x longer at full-scale than pilot

What Did I Learn Today?

- ☒ AdDesignS can be a useful tool to save money and expedite pilot testing, but prior knowledge of adsorption and the software are vital to success.
- ☒ Pilot Testing can be expedited to limit sample analysis cost and burden on the system.
- ☒ Collaborate with experts to leverage AdDesignS.
- ☒ GAC is generally less expensive than IX for media replacement to manage PFAS
- ☒ IX disposal and ancillary pre-filtration results in a significant cost increase.
- ☒

GAC and IX are proven technologies for PFAS removal!

Thank you.

