American Water Works Association
ConnecticutSection

7th Annual Water Quality & Treatment Symposium

Retrofitting a Surface Water Treatment Plant for PFAS Removal – Braintree, MA

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Presentation Outline

- **Town of Braintree & Great Pond WTP**

- **Existing Filtration System**

- **Filter Retrofit Design**

- **Construction**

- **Full Scale Demonstration Test**

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Braintree Water System Overview

- **Braintree, MA**
  - Population – 35,700
  - Number of Customers (11,770)
  - Average Demand – 3.4 MGD

- **Supply**
  - Great Pond Reservoir System
  - Upper Pond, Lower Pond, Richardi Reservoir
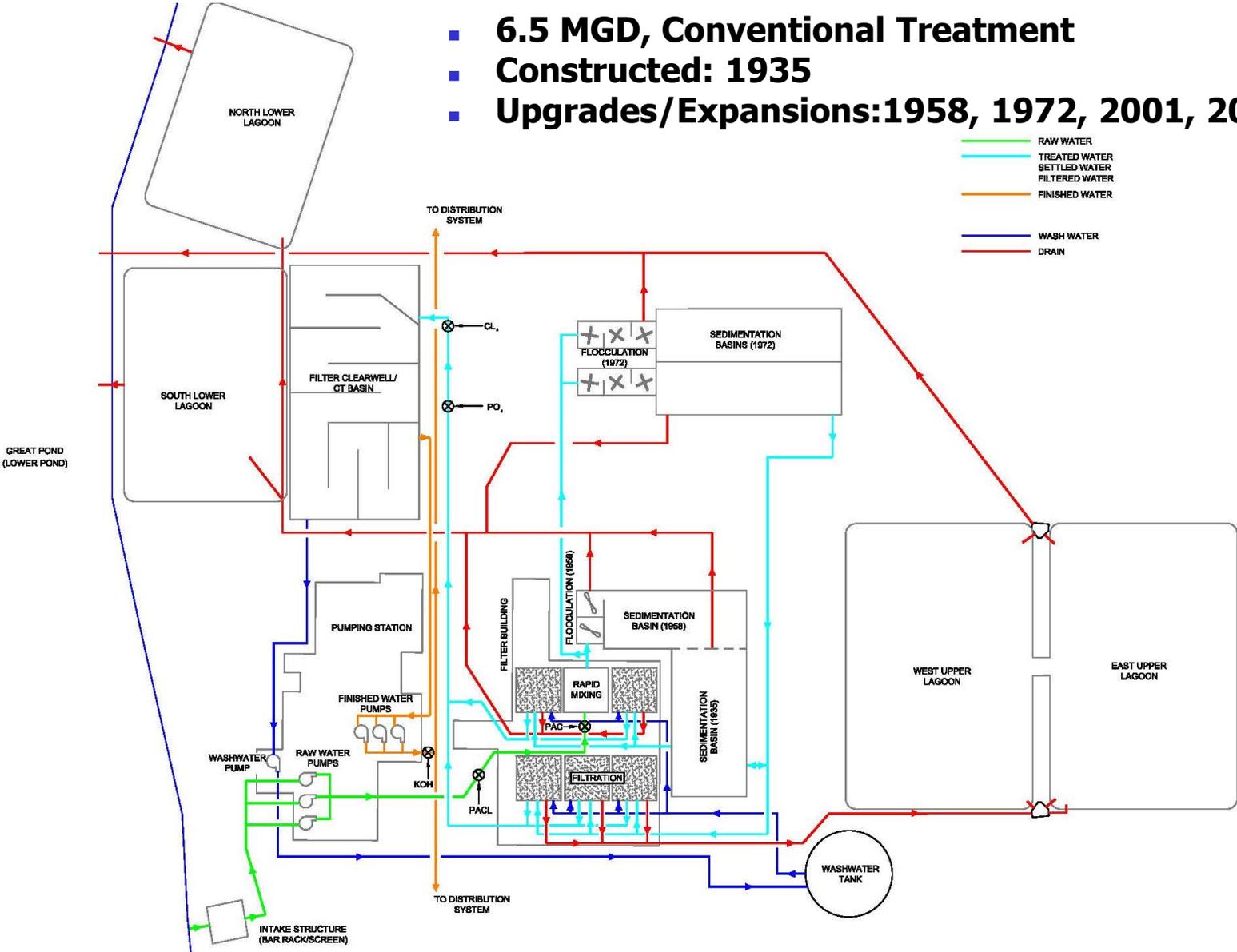 - Shared Water Supply System
  - Randolph and Holbrook

- **Great Pond WTP**
  - 6.5 MGD, Conventional Treatment
  - Constructed: 1935
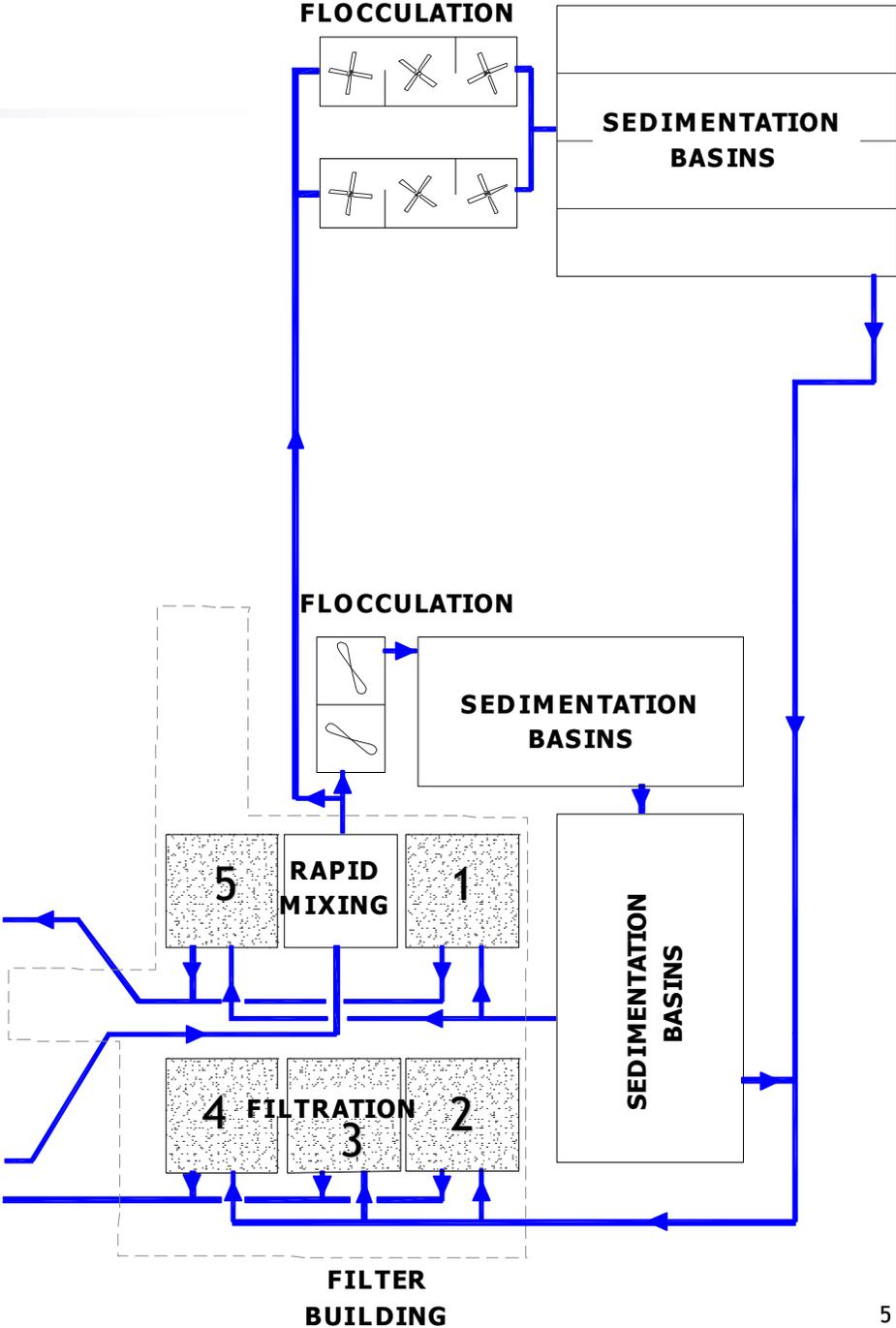 - Upgrades/Expansions:1958, 1972, 2001, 2010, 2012

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Great Pond Water Treatment Plant

- 6.5 MGD, Conventional Treatment
- Constructed: 1935
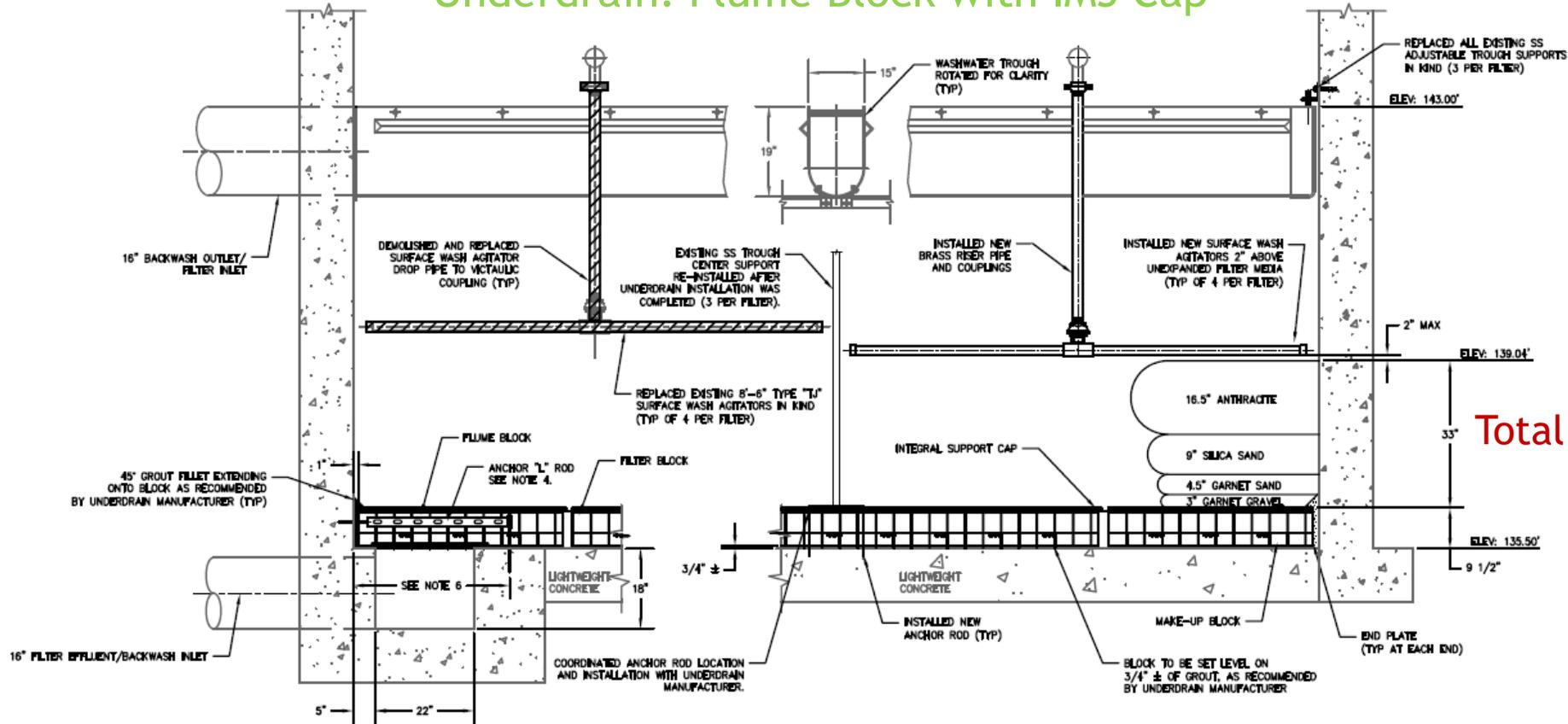- Upgrades/Expansions:1958, 1972, 2001, 2010, 2012
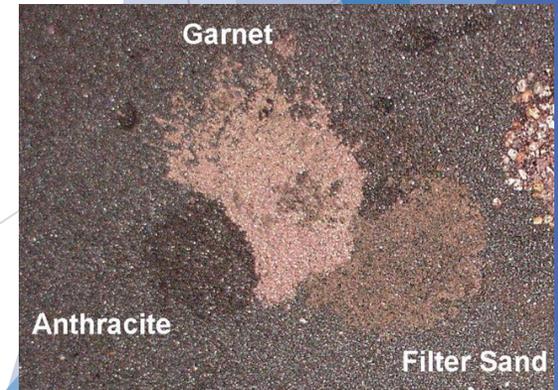
Filtration System

Existing Filtration System

Filter Size: 18' x 18' = 324 square feet
Underdrain: Flume Block with IMS Cap

Total Media Depth 33"

Media	Depth	Characteristics
Garnet Gravel	3"	3/16" x #14
Garnet Sand	4.5"	ES = 0.18-0.32 mm; UC = 2.2 or less
Silica Sand	9"	ES = 0.45-0.55 mm; UC = 1.6 or less
Anthracite	16.5"	ES = 1.00 mm; UC = 1.7 or less

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Filter Media Design

Empty Bed Contact Time (GAC Media Depth 42"):
Peak (6.5 MGD), 5 Filters: 9.4 Minutes
Peak (6.5 MGD), 4 Filters: 7.5 Minutes
Maximum Daily Flow (4.61 MGD, past 10 years), 4 filters: 10.6 minutes
Average (3.4 MGD), 5 Filters: 18 Minutes
Average (3.4 MGD), 4 Filters: 14.4 Minutes

Existing L/d ratio: 1,495
L/d - ratio of filter bed depth to effective media diameter
Typical L/d for dual media filters is between 1,000 and 2,000

Media	Depth	Characteristics
GAC (Calgon FS-300)	42"	ES = 0.8 - 1.0 mm; UC = 2.1 or less
Filter Sand	6"	ES = 0.45 – 0.55 mm; UC = 1.6 or less
L/d ratio: 1,490		

Calgon Filtrasorb 300 (FS-300)*
Apparent Density: 0.56 g/CC
Iodine Number: 900 mg/g

*Successfully piloted in 2004 as filter media and compliance with SWTR/ESWTR
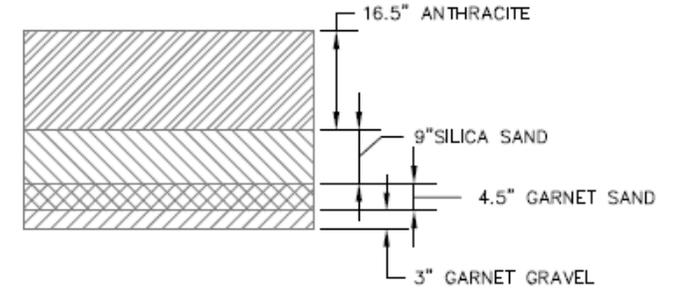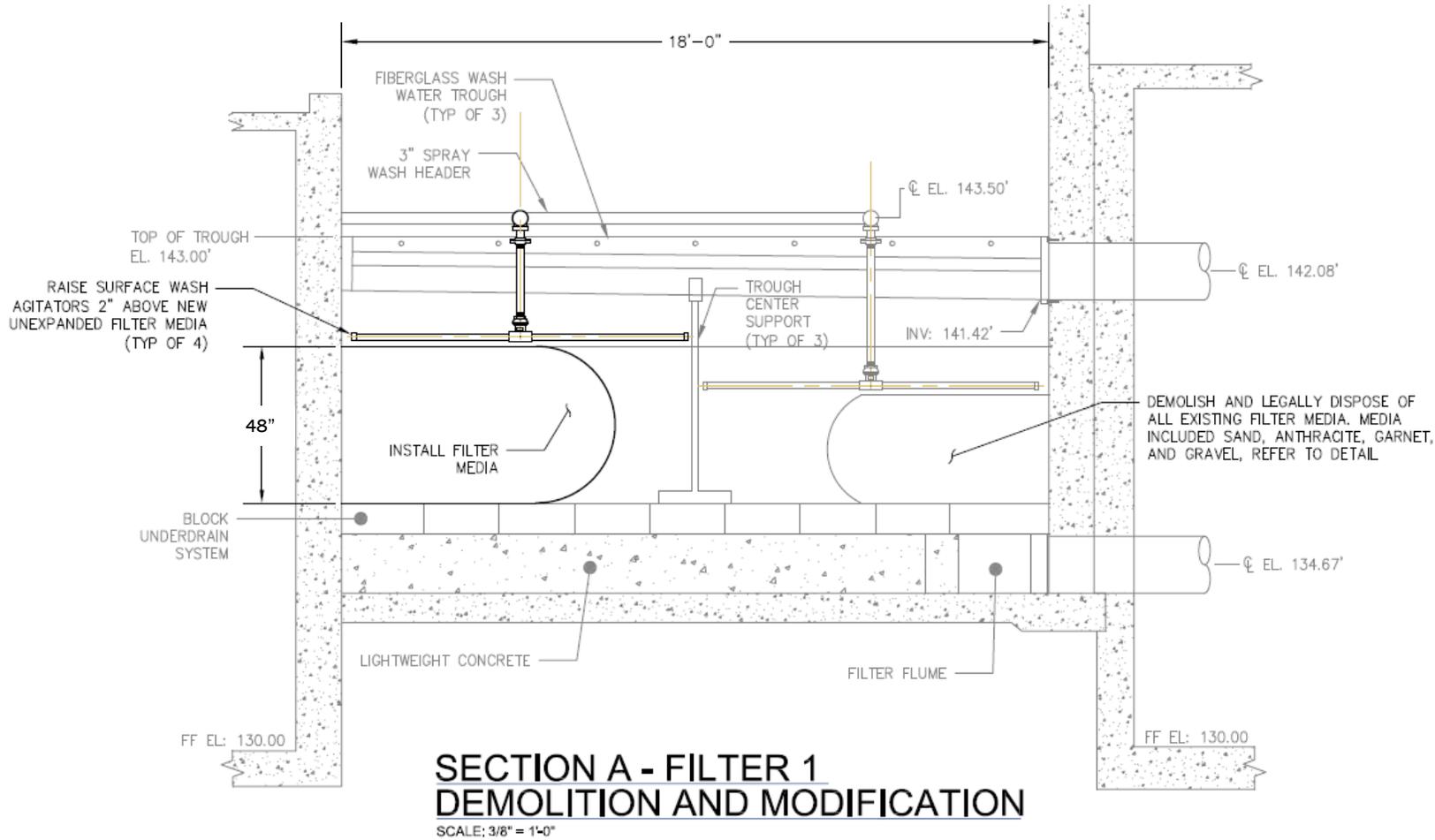
Filter Loading Rate
Peak (6.5 MGD), 5 Filters: 2.6 gpm/sf
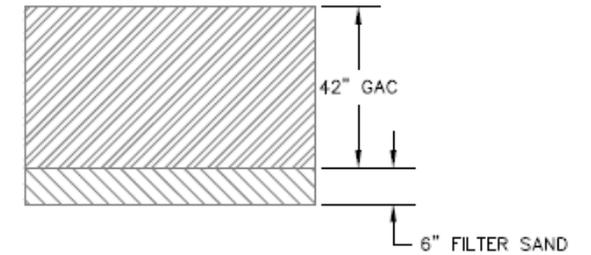Peak (6.5 MGD), 4 Filters: 3.2 gpm/sf

Average (3.4 MGD), 5 Filters: 1.5 gpm/sf
Average (3.4 MGD), 4 Filters: 1.8 gpm/sf

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Filter Design

FIBERGLASS WASH WATER TROUGH (TYP OF 3)

3" SPRAY WASH HEADER

℄ EL. 143.50'

TOP OF TROUGH EL. 143.00'

℄ EL. 142.08'

RAISE SURFACE WASH AGITATORS 2" ABOVE NEW UNEXPANDED FILTER MEDIA (TYP OF 4)

TROUGH CENTER SUPPORT (TYP OF 3)

INV: 141.42'

48"

INSTALL FILTER MEDIA

DEMOLISH AND LEGALLY DISPOSE OF ALL EXISTING FILTER MEDIA. MEDIA INCLUDED SAND, ANTHRACITE, GARNET, AND GRAVEL, REFER TO DETAIL

BLOCK UNDERDRAIN SYSTEM

℄ EL. 134.67'

LIGHTWEIGHT CONCRETE

FILTER FLUME

FF EL: 130.00

FF EL: 130.00

SECTION A - FILTER 1
DEMOLITION AND MODIFICATION
SCALE: 3/8" = 1'-0"

16.5" ANTHRACITE

9" SILICA SAND

4.5" GARNET SAND

3" GARNET GRAVEL

EXISTING FILTER MEDIA
SCALE: NTS

42" GAC

6" FILTER SAND

PROPOSED FILTER MEDIA
SCALE: NTS

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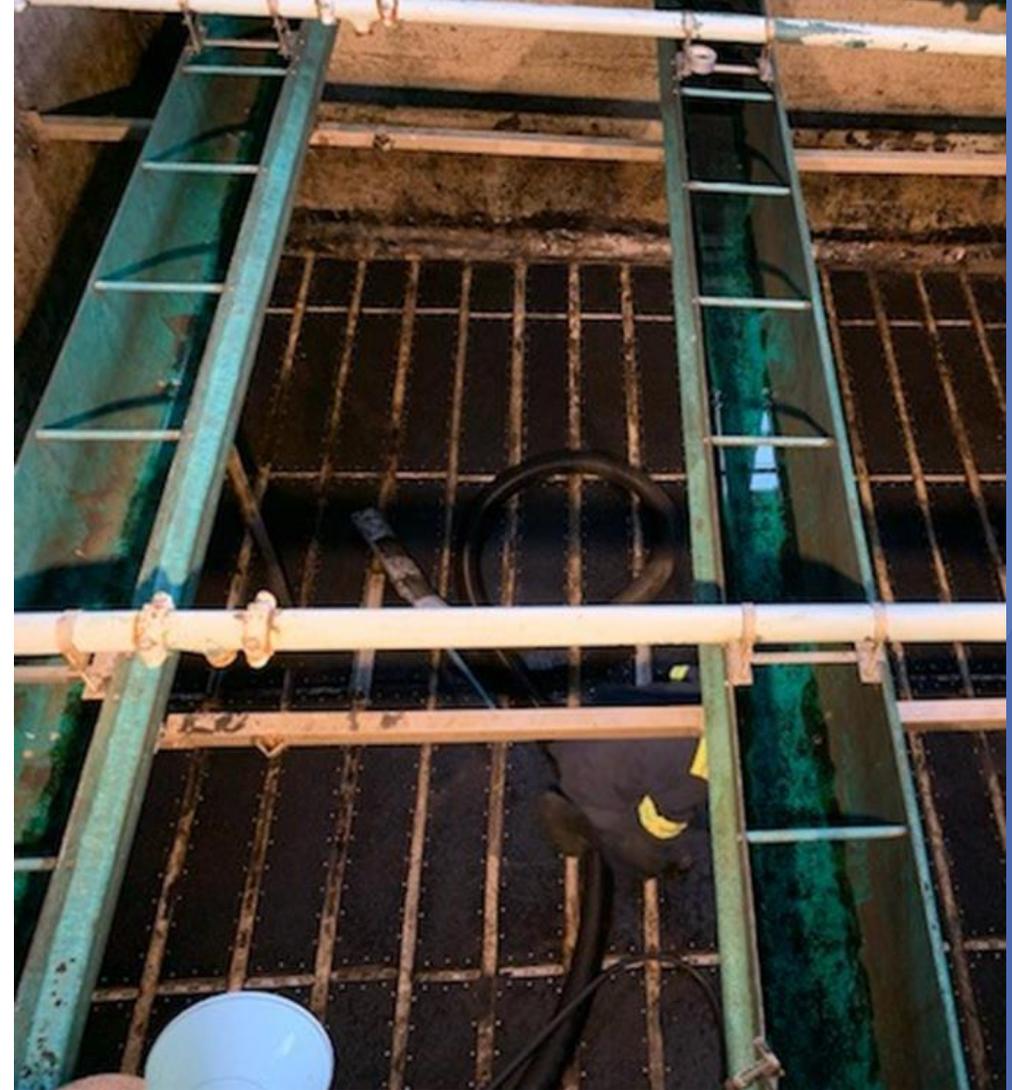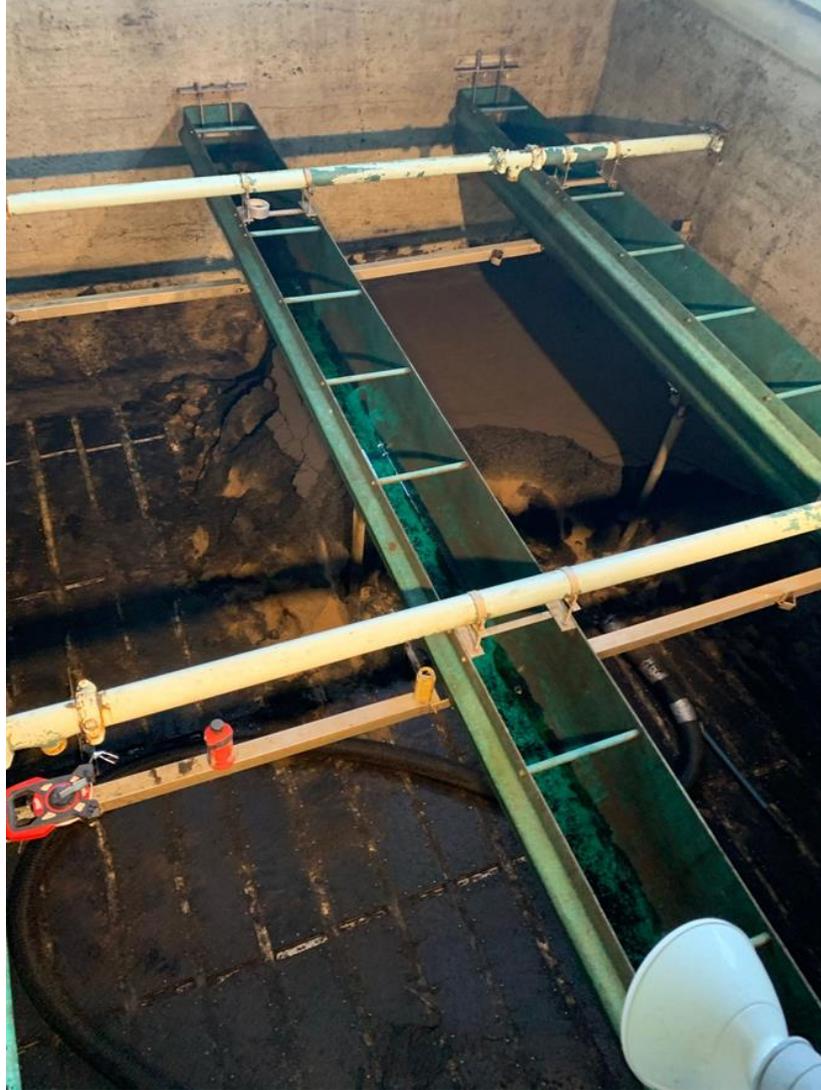DRINKING WATER PROFESSIONALS

Project Implementation

1. Submit Design and Permitting to MA-DEP
   - Retrofit 1 filter with new media (sand/GAC)
   - Complete 30-Day full scale demonstration test
   - If the results are good, replace media in remaining 4 filters

2. Bid project with phased implementation
   - Phase 1 – replace media in test filter (Filter #1)
   - Wait up to 90 days for demonstration test and MA-DEP approval
   - Re-mobilize and replace media in remaining 4 filters

3. Bid Results
   - 2 bids received
   - $299,000 for all 5 filters, $1.32/cf for GAC

4. Demonstration Test: November 19, 2020 to December 19, 2020

5. Remaining 4 Filters: February 1, 2021 to February 24, 2021

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Media Replacement – Removal

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Media Replacement – Removal

Media Replacement – Inspect Underdrain

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Media Replacement – Install Sand

Media Replacement – Backwash Sand

Media Replacement – Reinstall Sweepers

Media Replacement – Install GAC

Media Replacement – Backwash Fines

Full Scale Demonstration Study

- 1 Filter (Filter #1)
- Replace Media and Operate for 30 days
- Review Operations and Water Quality

Table 3
Operation Monitoring Parameters

Parameter	Test Equipment
WTP flow, gpm	On-line Instrumentation
Filter Headloss, feet	Manually Recorded
Filter Runtime	Manually Recorded
Filter Backwash Duration	Manually Recorded

Table 2
Water Quality Sampling Frequency – Test Filter

Parameter	Sampling Interval
Turbidity	Filter #1 and CFE: continuous monitoring and grab samples every 2 hours
pH	Filter #1 and CFE: grab samples every 4 hours
Alkalinity	Filter #1 and CFE: daily grab sample (every 24 hours)
PFAS	Raw, Filter #1, and Finished Water: weekly (Test Days: 7, 14, 21, and 28)
UV-254	Settled Water, Filter #1, and CFE: daily grab sample (every 24 hours)
TOC	Settled Water, Filter #1, and CFE: weekly (Test Days: 7, 14, 21, and 28)

Test Conditions:
November 19, 2020 to December 19, 2020

Average
Flow: 462 gpm
Filter Loading Rate: 1.4 gpm/sf
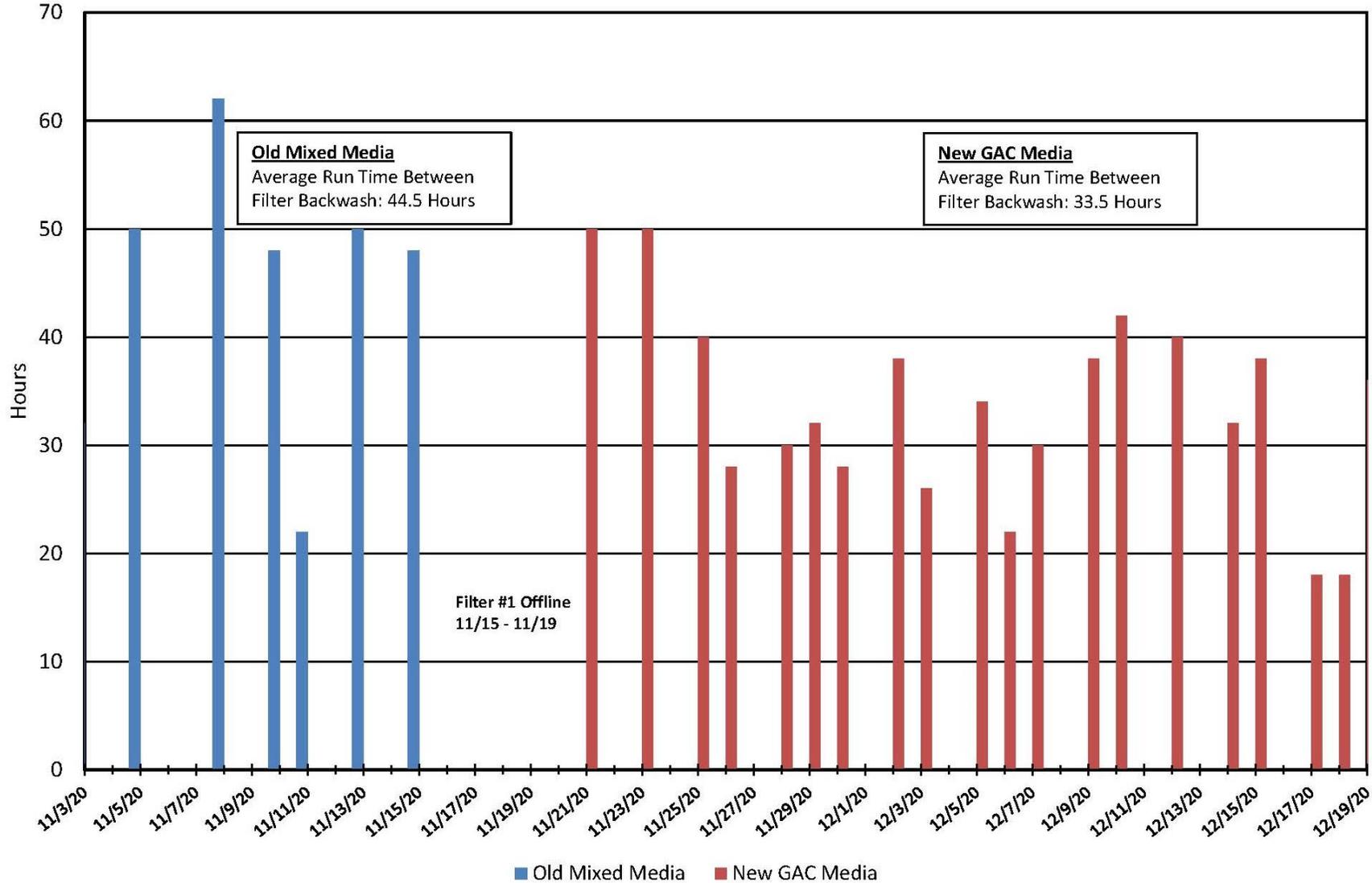EBCT: 18.4 minutes

Maximum
Flow: 674 gpm
Filter Loading Rate: 2.1 gpm/sf
EBCT: 12.6 minutes

Table 4
Water Quality Goals, Demonstration Test Filter

Water Quality Parameter	Goal
PFAS6	Less than 10.0 ppt
Turbidity	Less than 0.3 NTU

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Full Scale Demonstration Study – Filter Run Time

Old Mixed Media
Average Run Time Between
Filter Backwash: 44.5 Hours

New GAC Media
Average Run Time Between
Filter Backwash: 33.5 Hours

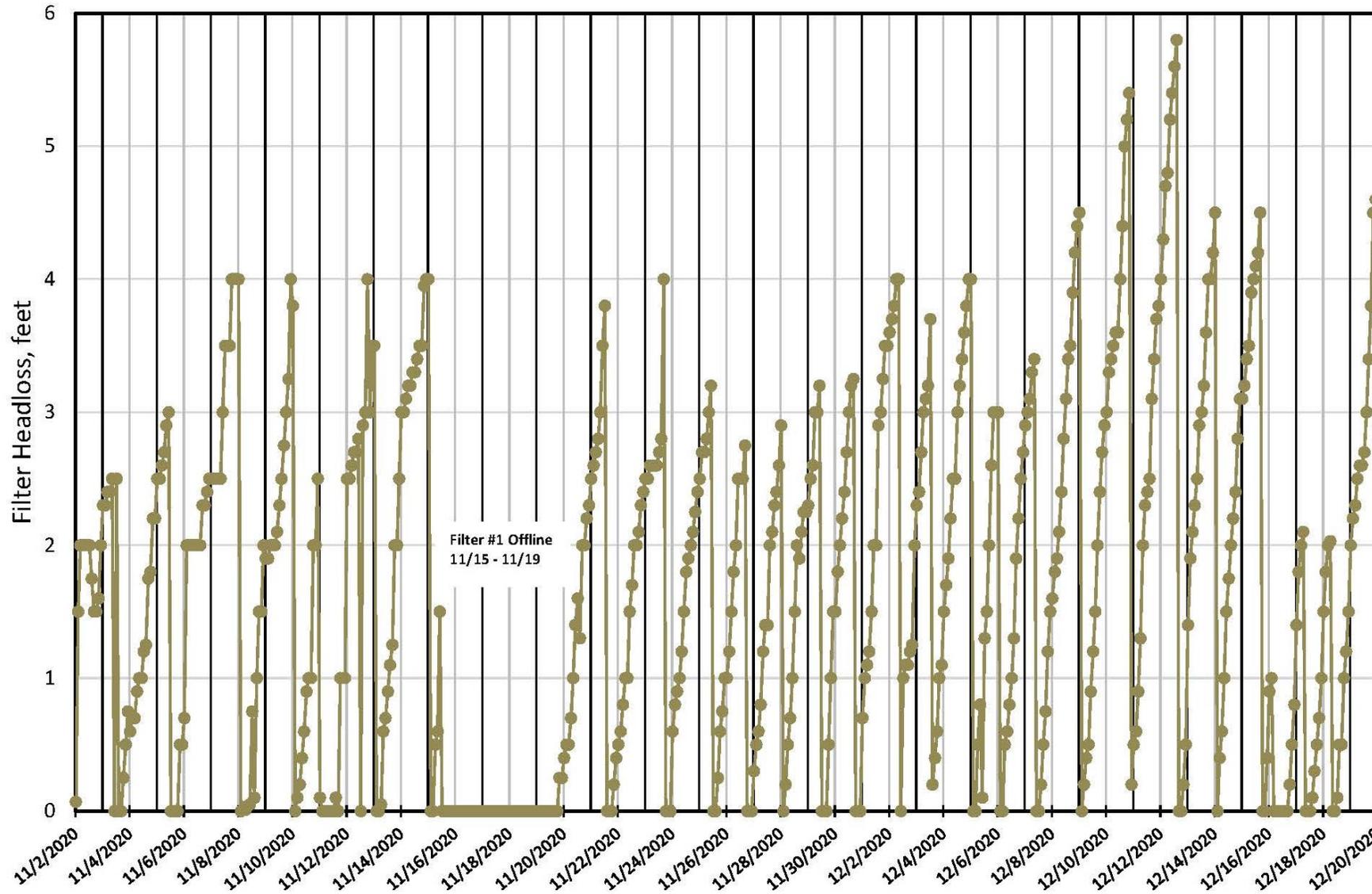Filter #1 Offline
11/15 - 11/19

Legend: ■ Old Mixed Media ■ New GAC Media

Before Test
Filter Run Time: 22-62 hours

During Test
Filter Run Time: 18-50 hours

Filter run time decreased ~11 hrs

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Full Scale Demonstration Study – Headloss

Before Test
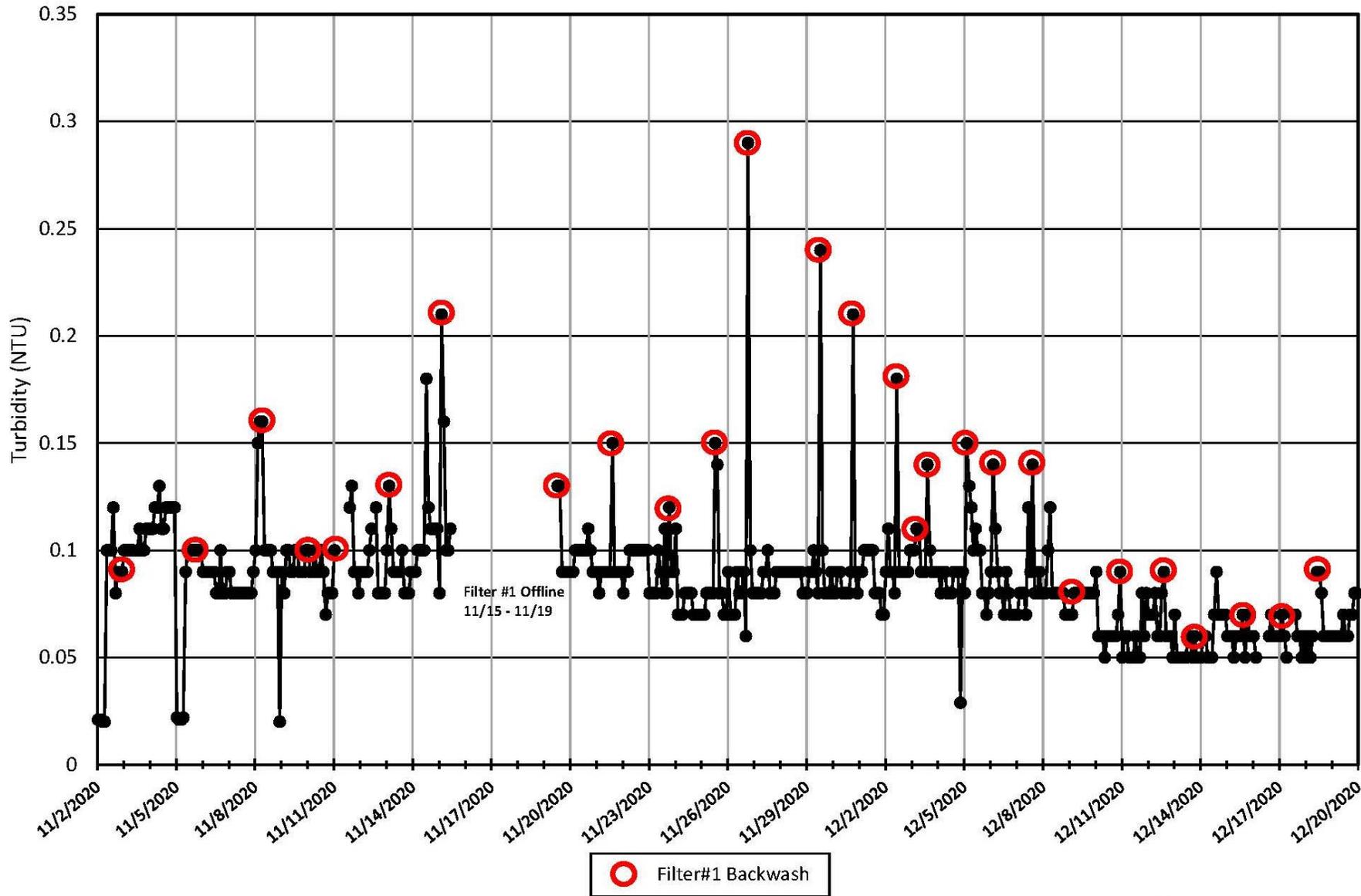Average Headloss: 3.3 ft
Maximum Headloss: 4.0 ft

During Test
Average Headloss: 3.7 ft
Maximum Headloss: 5.8 ft

Same Filter Backwash Sequence
   20 minutes
   Surface Wash
   Low Wash
   High Wash

Filter #1 Offline
11/15 - 11/19

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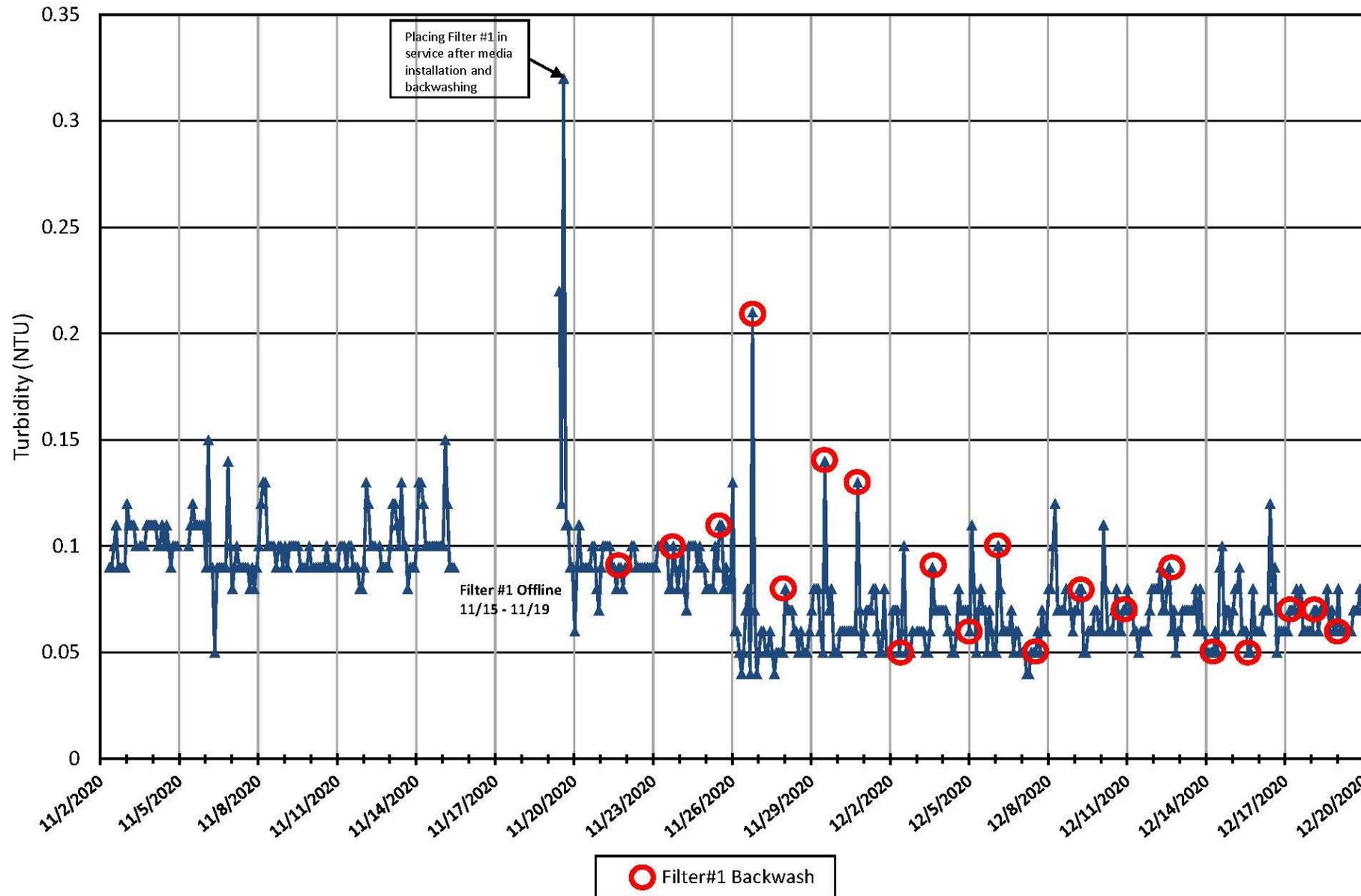DRINKING WATER PROFESSIONALS

Full Scale Demonstration Study – Turbidity

Peak Turbidity after backwashing decreased from 0.29 NTU to < 0.1 NTU after 3 weeks of operation.

Average Effluent Turbidity
Before Test: 0.09 NTU
After 3 Weeks: 0.06 NTU

Filter #1 Offline
11/15 - 11/19

○ Filter#1 Backwash

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Full Scale Demonstration Study – CFE Turbidity

Peak CFE Turbidity after backwashing Filter #1 not dramatically different after media replacement.

Average CFE Turbidity
Before Test: 0.10 NTU
After 3 Weeks: 0.07 NTU

Full Scale Demonstration Study – UV-254
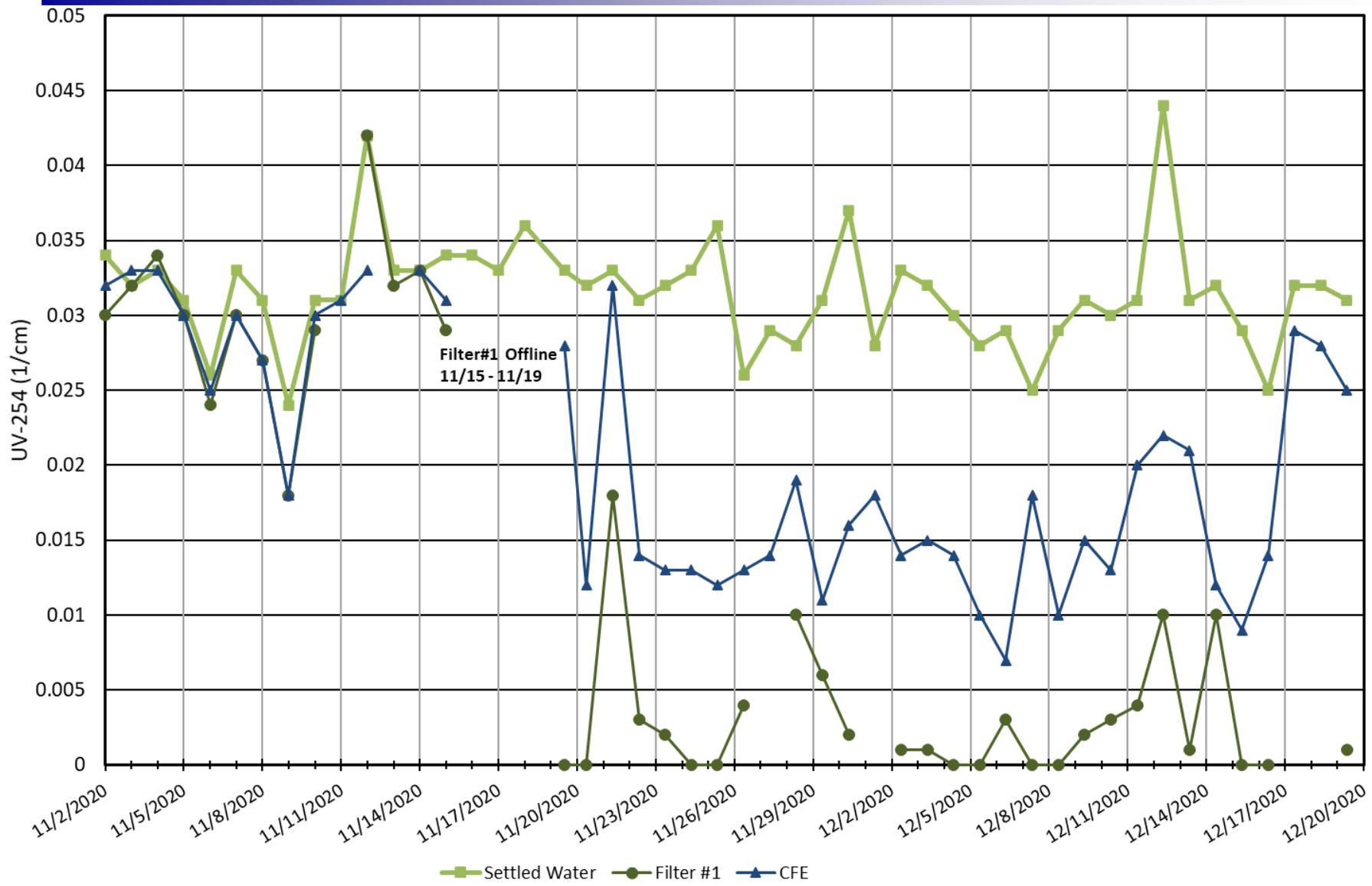
Steady Clarifier Effluent UV-254
Average: 0.031 1/cm
Range: 0.024 – 0.044 1/cm

UV-254 Before Test
Filter #1: 0.030 1/cm
CFE: 0.030

UV-254 During Test
Filter #1: 0.003 1/cm
CFE: 0.016 1/cm

44% reduction in CFE UV-254

Filter#1 Offline
11/15 - 11/19

Legend: Settled Water — Filter #1 — CFE

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Full Scale Demonstration Study – TOC

Table 6
TOC Sampling Results (mg/L)

	Raw Water	Settled Water	Filter #1	CFE	Total % Removal
Pre-Test Conditions					
11/9/2020	4.4	2.8	2.5	3	32%
Demonstration Test					
11/19/2020	3.8	1.8	<1.0	1.1	71%
11/25/2020	3.8	2.2	<1.0	1.2	68%
12/3/2020	4.5	3	<1.0	1.2	73%
12/9/2020	4.4	2.7	<1.0	1	77%
12/16/2020	4.5	2.6	<1.0	1.3	71%
Average*	**4.2**	**2.46**	**<1.0**	**1.16**	**72%**

*Average during the Demonstration Test

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Full Scale Demonstration Study - pH
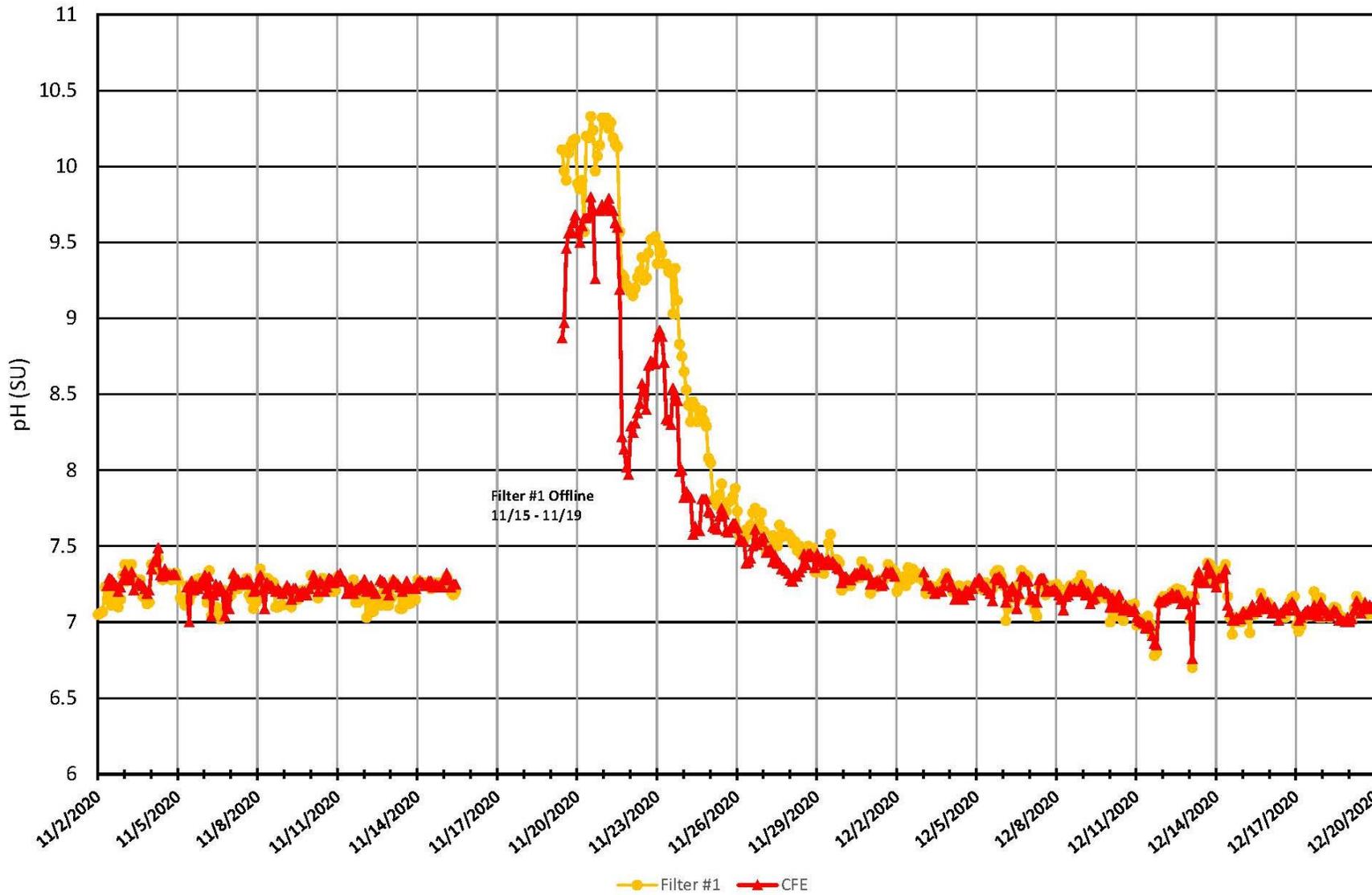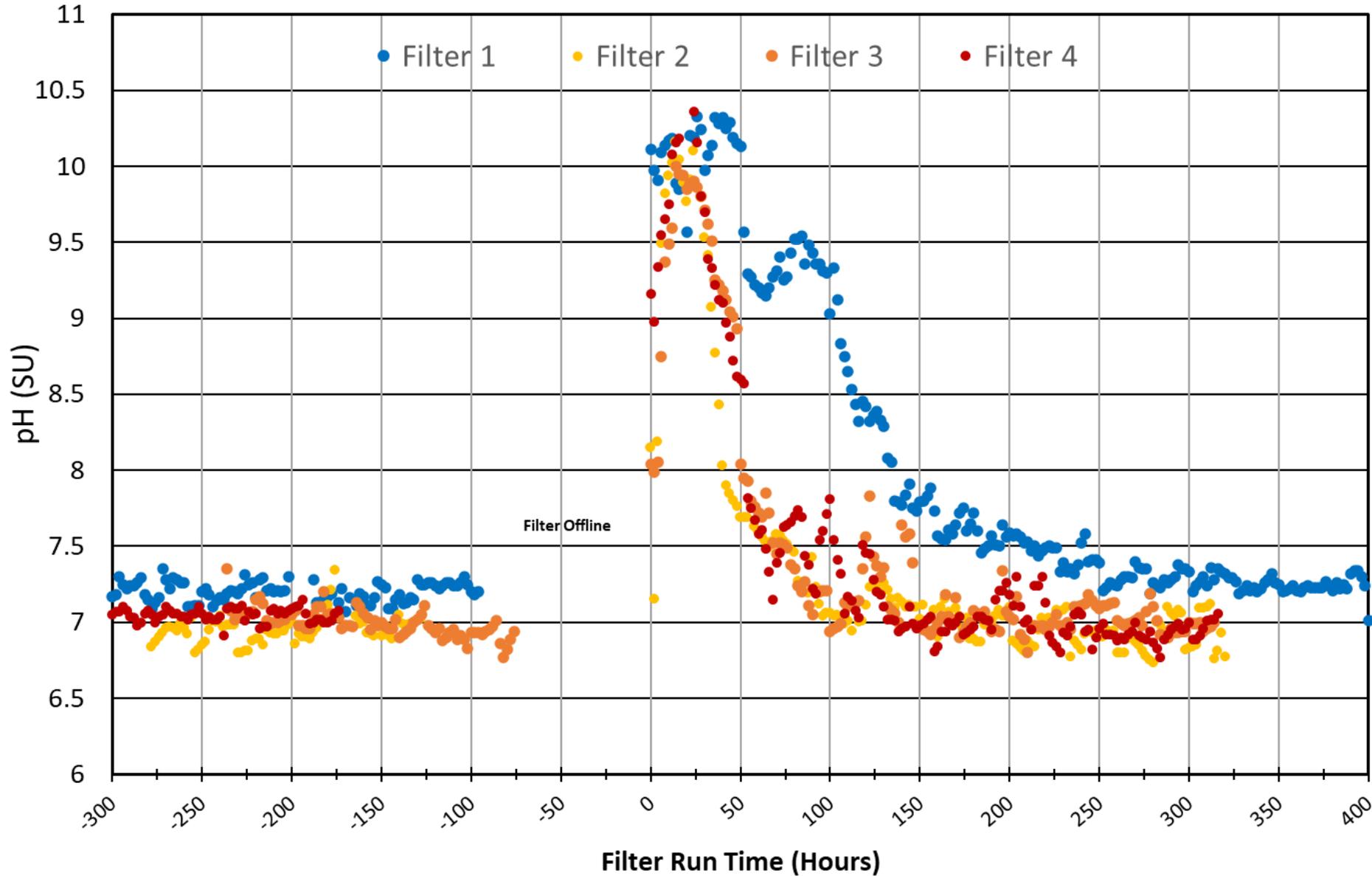

Normal Filter Effluent pH: 7.2 - 7.5

Filter #1 pH after GAC: 10 - 10.3
CFE pH after GAC: > 9.5 - 9.8

Normal pH levels after ~ 10 days

Carbon Dioxide Treatment of GAC Media

Filter Effluent pH after CO_2 Treatment

pH Stabilization of Media

Without CO_2 Treatment: ~ 10 days

With CO_2 Treatment: ~ 3 days

Full Scale Demonstration Study –PFAS

Table 5
PFAS6 Sampling Results (ppt)

Sample Date	Raw Water	Filter #1 Effluent	Finished Water	Total % Removal
Pre-Test Conditions				
11/9/2020	19	21	20	**NA**
Demonstration Test				
11/19/2020	22	0	19	**14%**
11/24/2020	24	3	18	**25%**
12/2/2020	22	0	16	**27%**
12/8/2020	20	0	15	**25%**
12/15/2020	23	0	15	**35%**
Average*	**22.2**	**0.6**	**16.6**	**25%**

*Average during the Demonstration Test, 4 filters on-line including Filter #1

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Full Scale Demonstration Study – PFAS
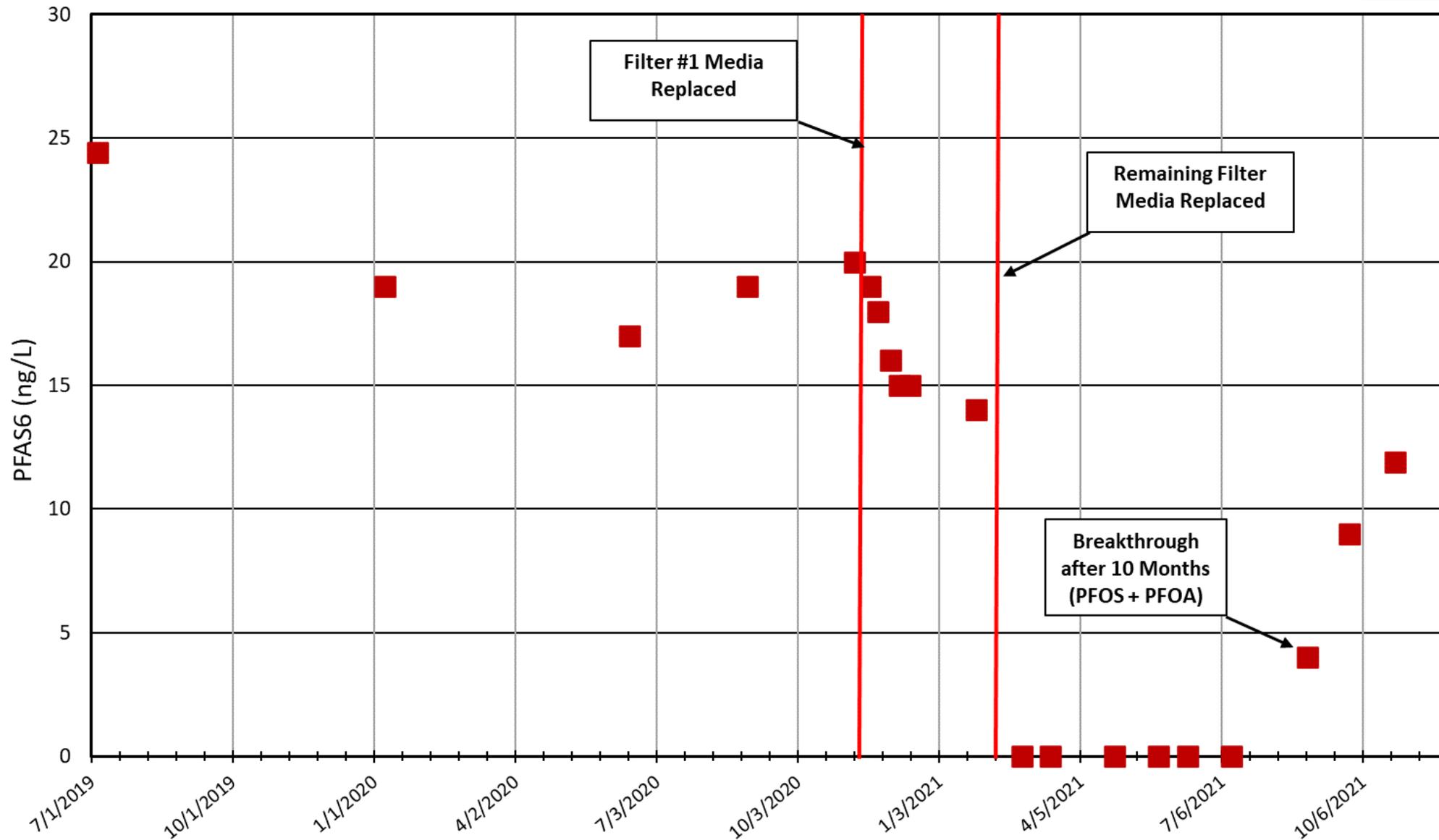
Questions?

Contact Information

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