

Bull Run
TREATMENT
PROJECTS

*Our water: Safe and abundant
for generations to come*

PORTLAND WATER BUREAU

Bull Run Treatment Projects

**Headloss Characterization and
(Productivity) Performance of Three
Different Dual Media Filter
Configurations Comparison**

**Humberto Piedra-Ruiz, Sr. Engineering
Associate**

4/29/2022



PNWS-AWWA
Water 2022
Tacoma, WA • April 27-29

Presentation Outline

- Background
- Questions
 - Headloss Accumulation Rate
 - Headloss Along Filter Column
 - 5 gpm/sf vs 10 gpm/sf
 - Filter Aid effects on Headloss and UFRVs
- Lessons Learned



Background



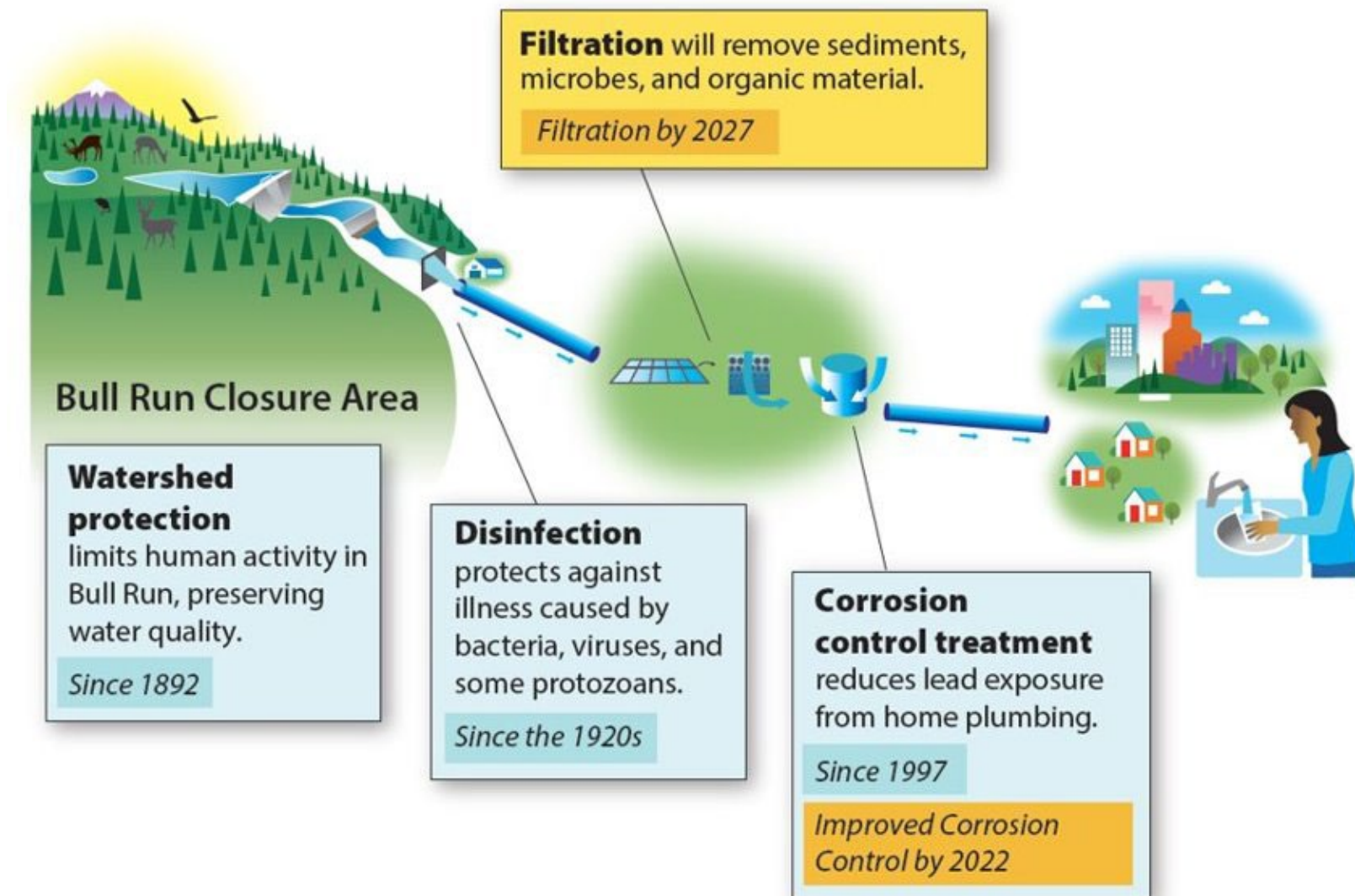
Thanks to thoughtful planning, Bull Run has been a source of **excellent water since 1895**



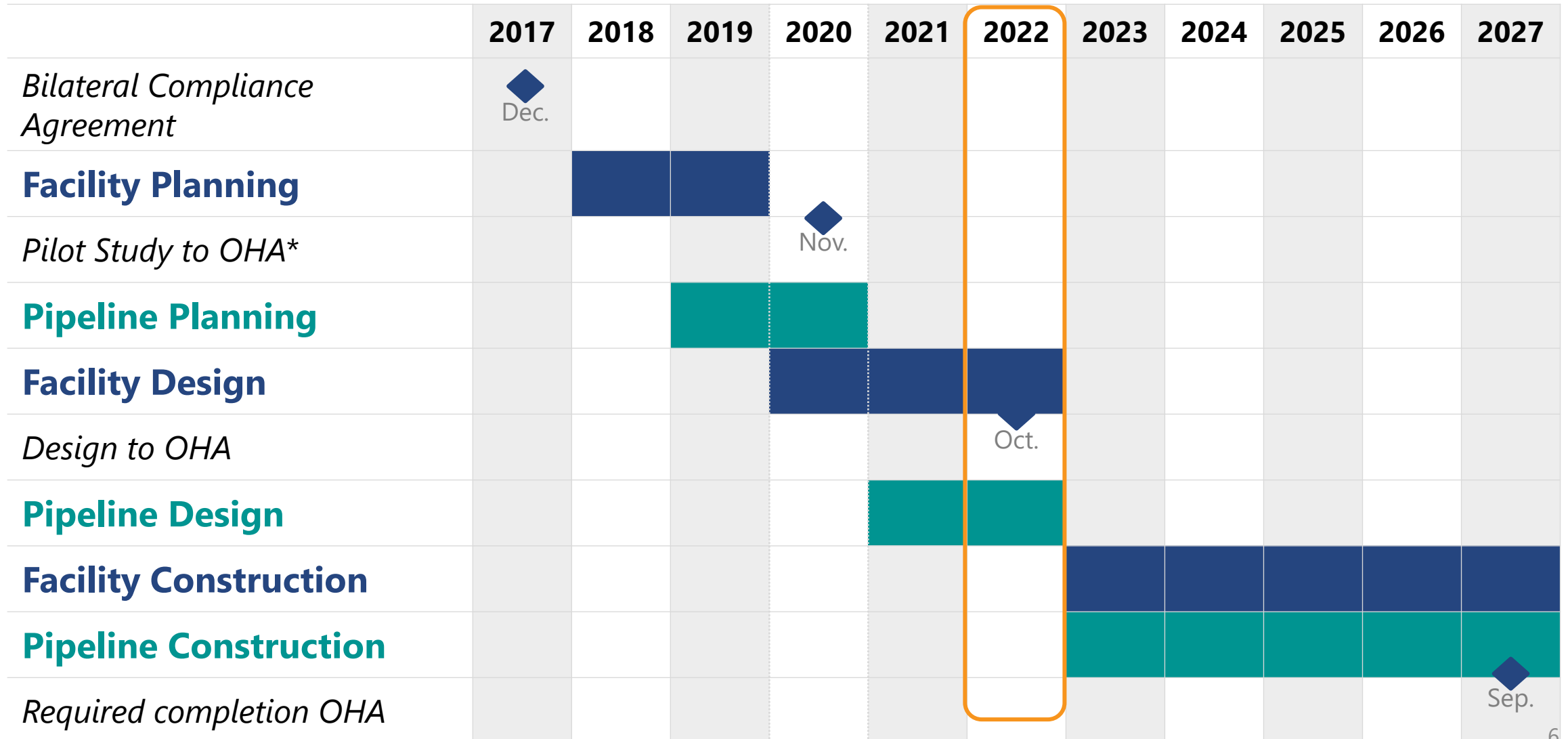
- Serves almost 1 million people
- Serves the City of Portland and wholesale customers
- Uses 100 million gallons of water on an average day



Improvements to our system are needed to meet national drinking water standards

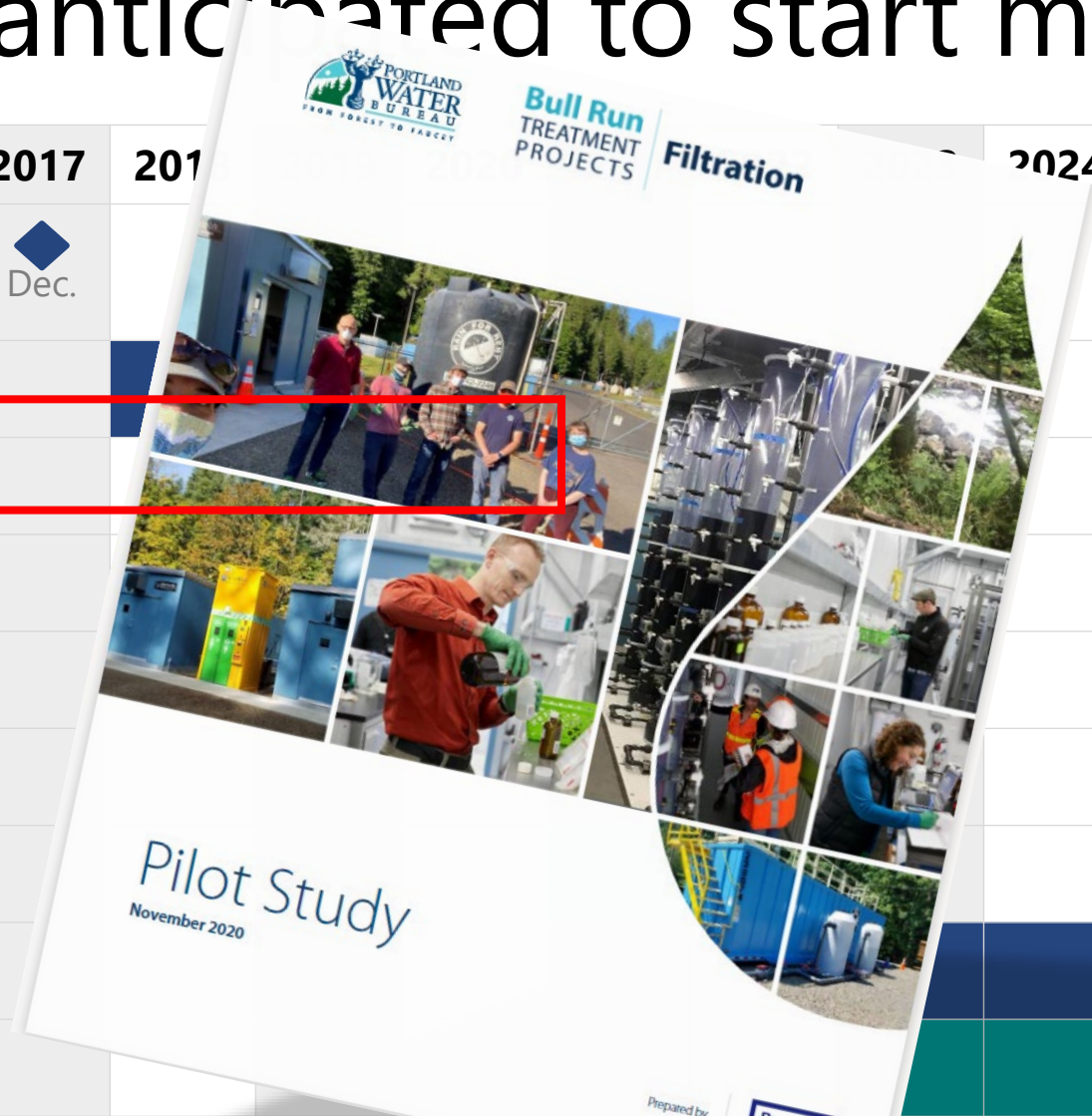


Construction anticipated to start mid-2023



Construction anticipated to start mid-2023

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bilateral Compliance Agreement	◆ Dec.										
Facility Planning											
<i>Pilot Study to OHA*</i>											
Pipeline Planning											
Facility Design											
<i>Design to OHA</i>											
Pipeline Design											
Facility Construction											
Pipeline Construction											

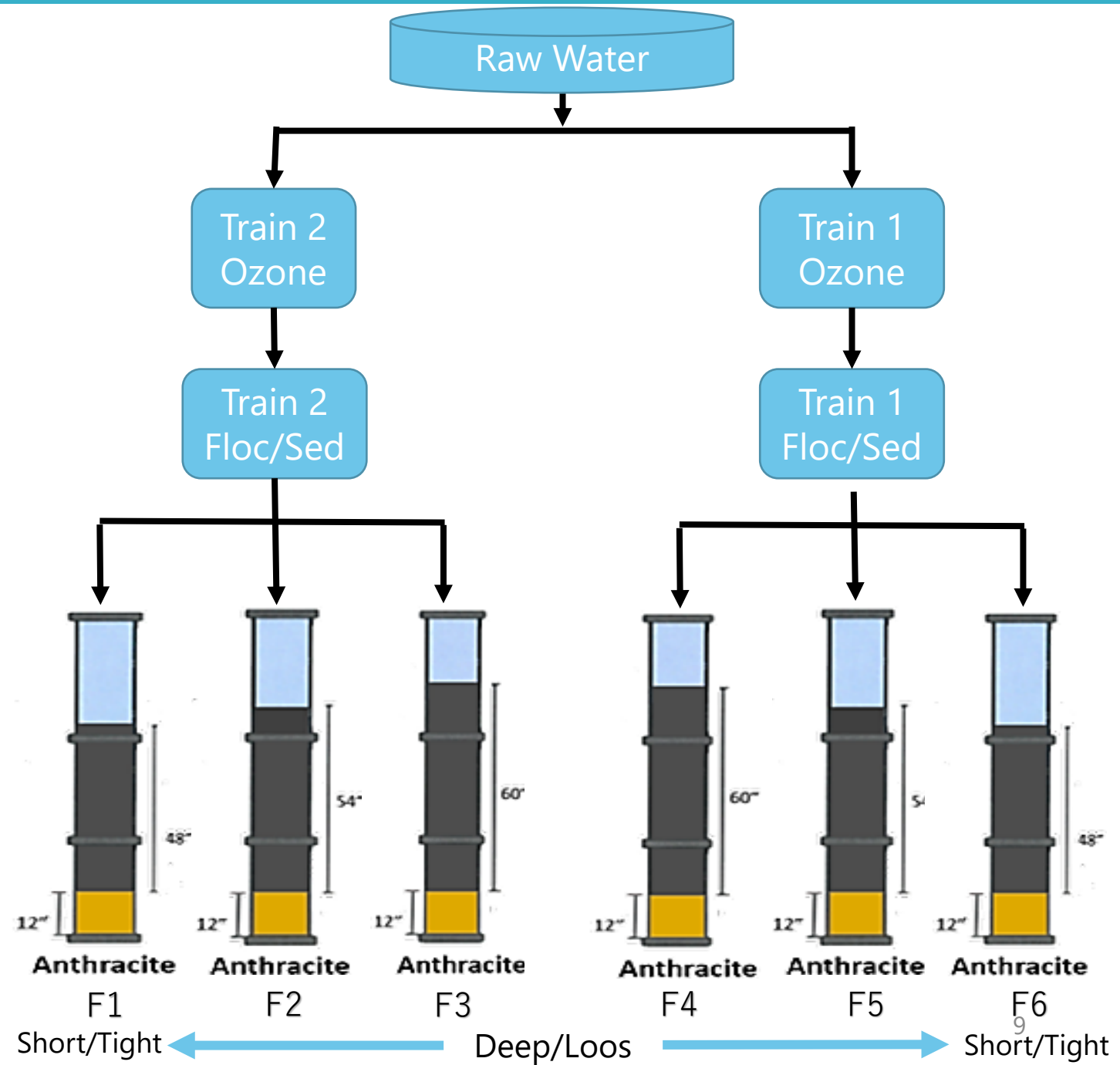


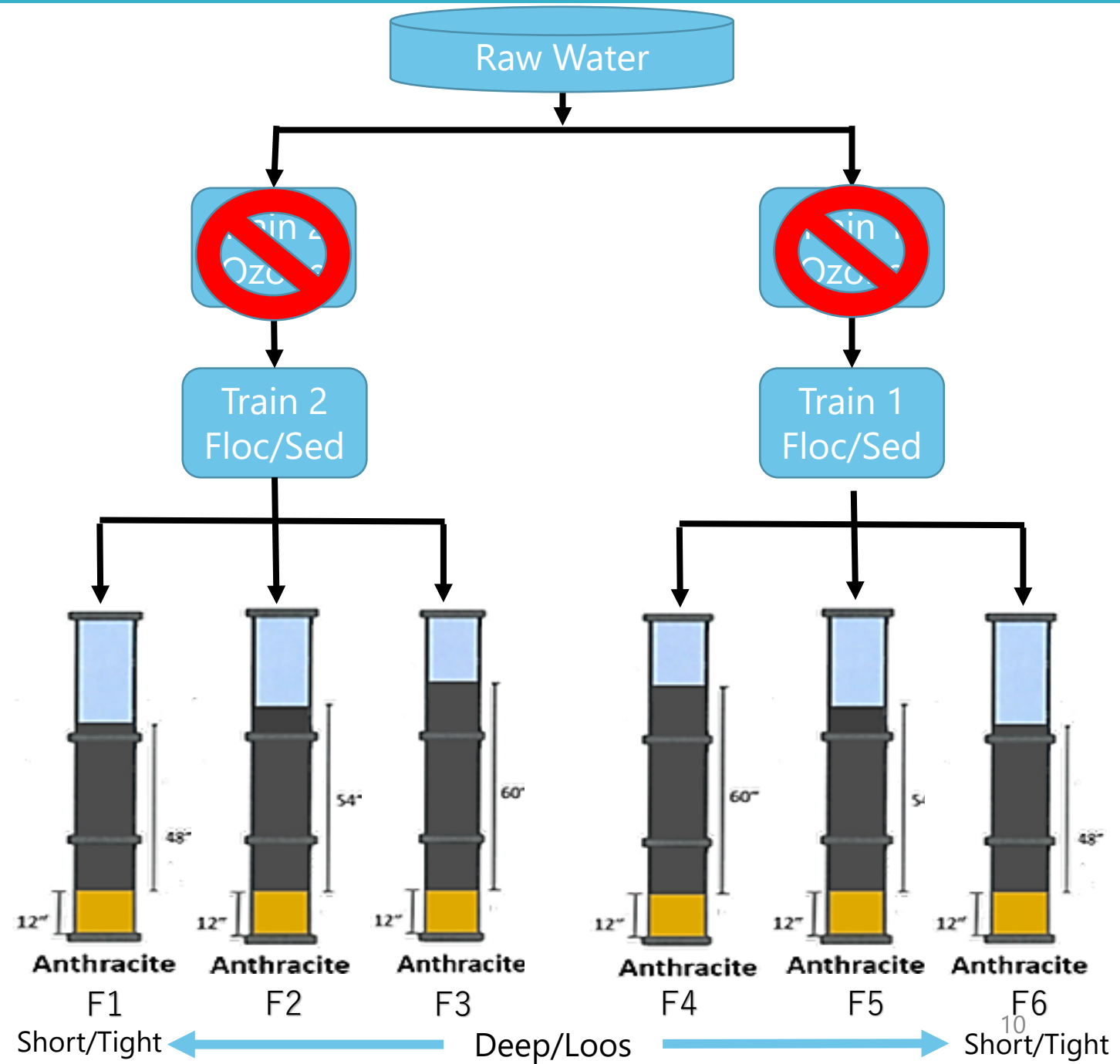
• **Pilot Study Report** available online

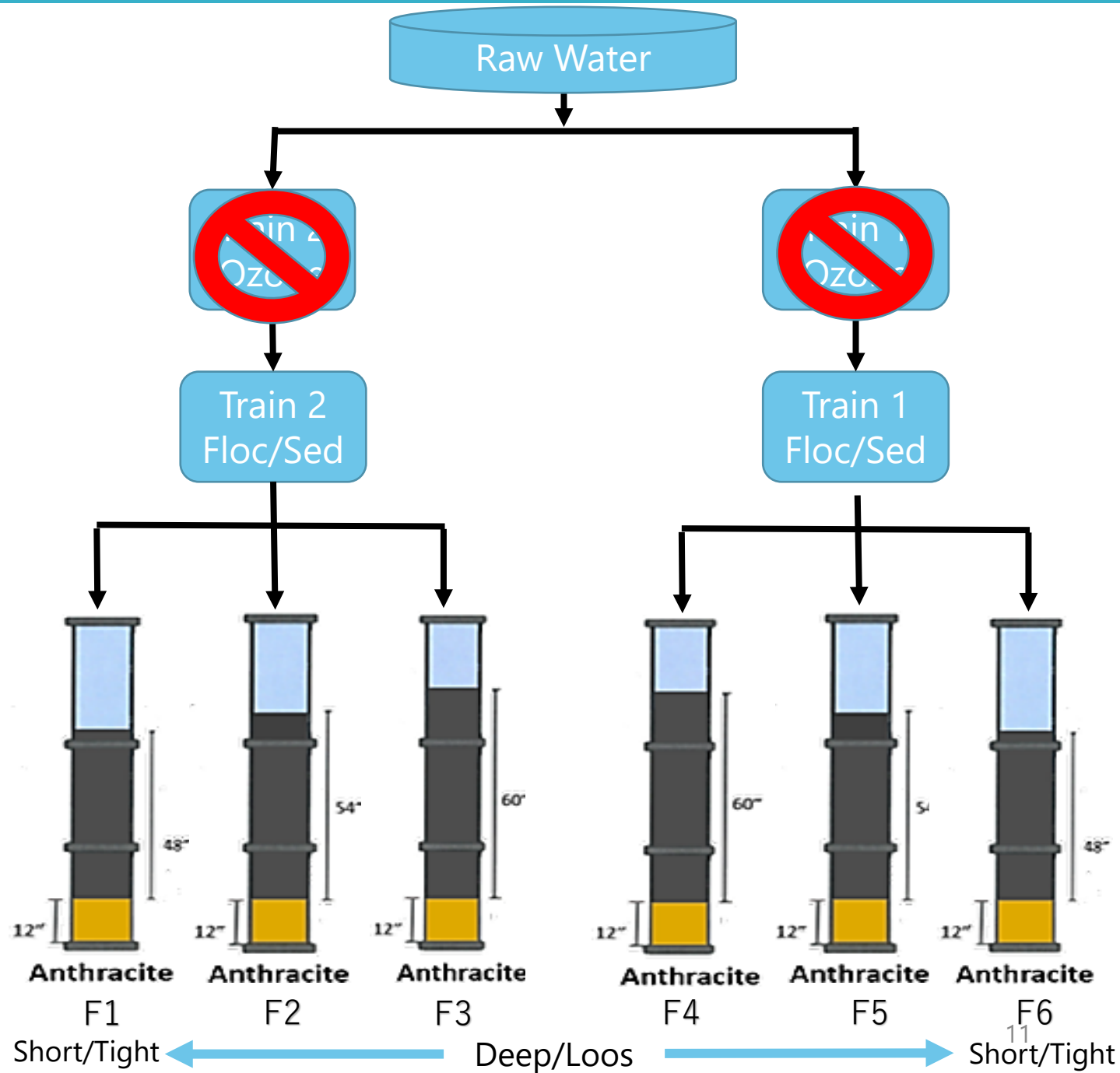
• <https://www.portland.gov/water/bullruntreatment/news/2021/4/30/science-helping-shape-future-bull-run-water>

Pilot Filter Configuration

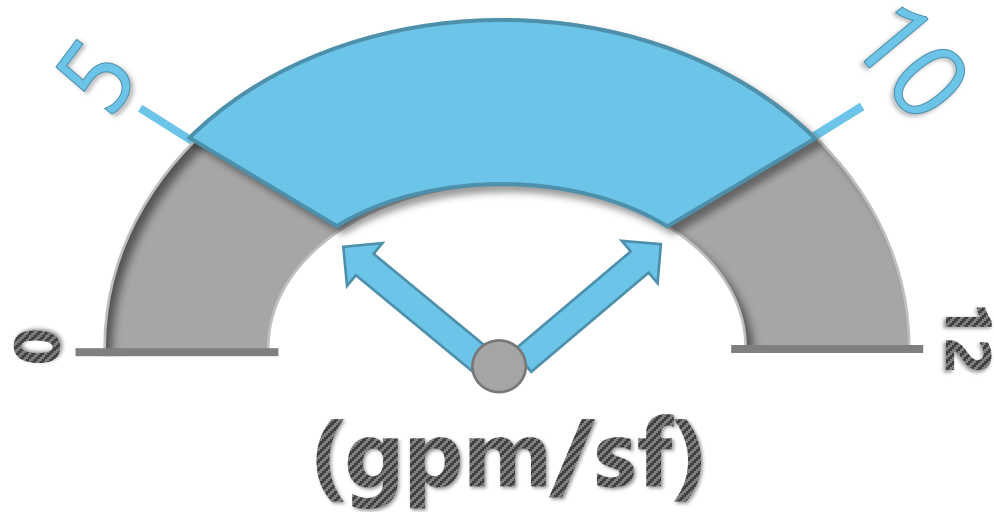
A photograph of a water treatment facility. In the center, there is a yellow vertical structure with a green door featuring safety symbols. On either side of this central unit are two light blue rectangular buildings with double doors. Each blue building has a small sign that reads "Intuitech Pilot Systems". The entire setup is on a gravel surface with a dense forest in the background. A large, bold, dark blue text overlay reads "Pilot Filter Configuration".



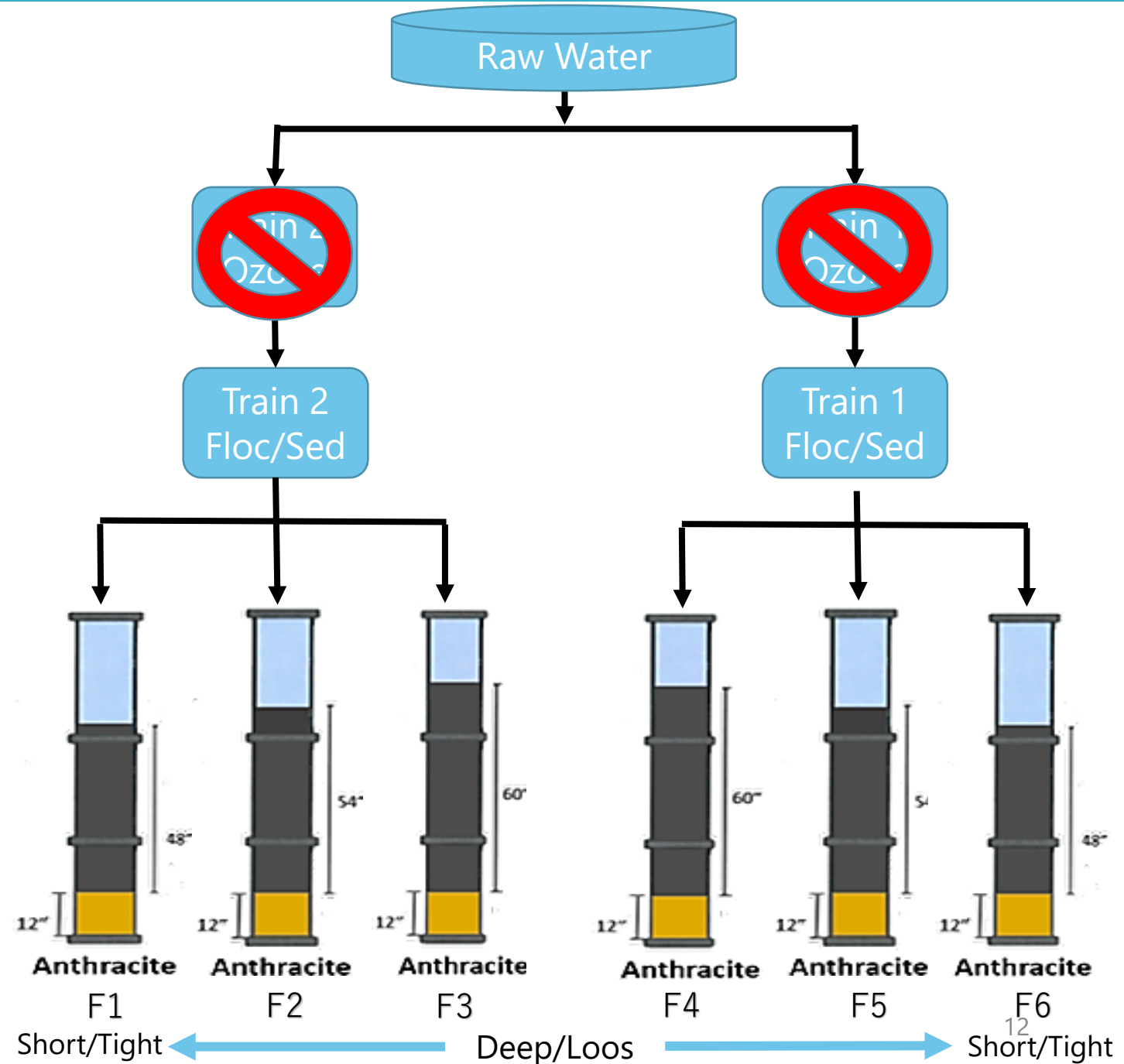




✓ Filtration Rates Tested




<u>Train 2</u>	<u>vs</u>	<u>Train 1</u>
Ferric		Alum
+		
C-359		



Questions





2. What does the Headloss Along Filter Column look like and how does it change during filter run?

3. What are the effects on filter headloss and Productivity when running filters at 5 gpm/sf vs 10 gpm/sf ?

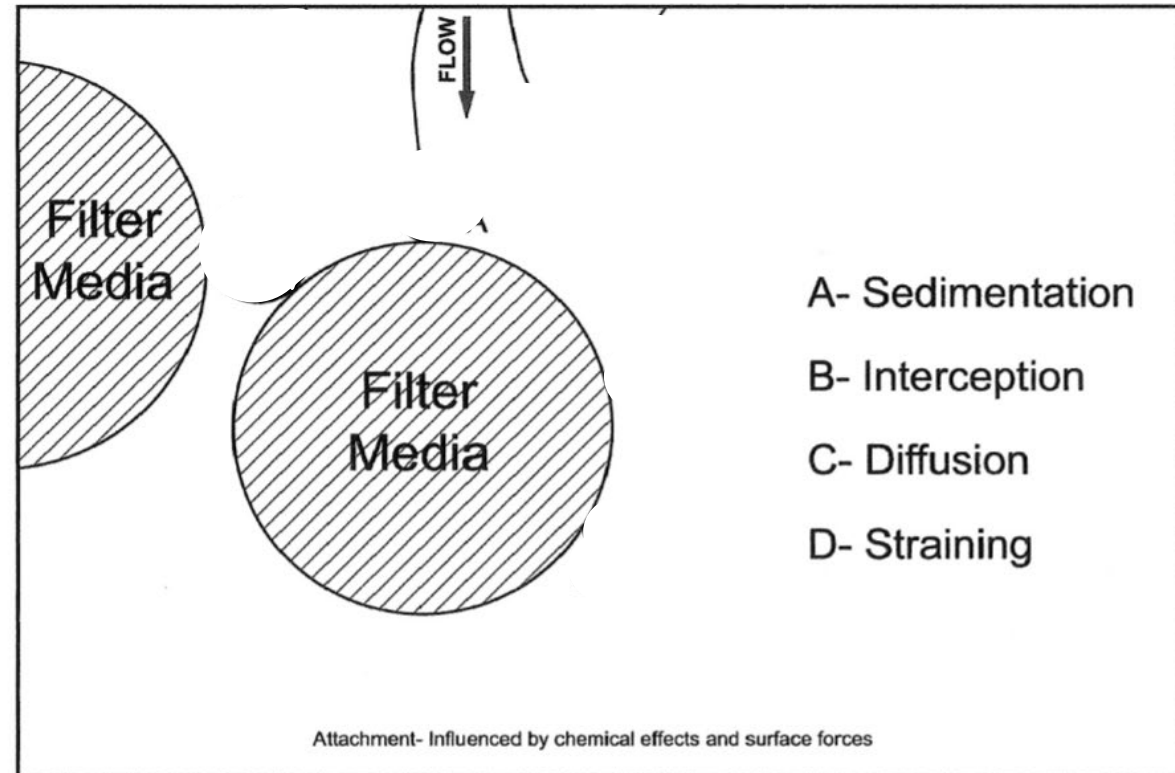
1. What is the Headloss Accumulation Rate and how is it affected?

4. What are the effects of using filter aid on filter headloss and UFRV performance?

1. What is the headloss accumulation rate?

The background image shows two blue portable toilets with white doors and a yellow and green emergency shelter in the center. The shelter has a green door with a white cross and a yellow door with a red cross. The text "ShieldSafe" is visible on the yellow door. The scene is set in a wooded area with green trees in the background. A chain-link fence is visible on the right side.

1. What is the Headloss accumulation rate?

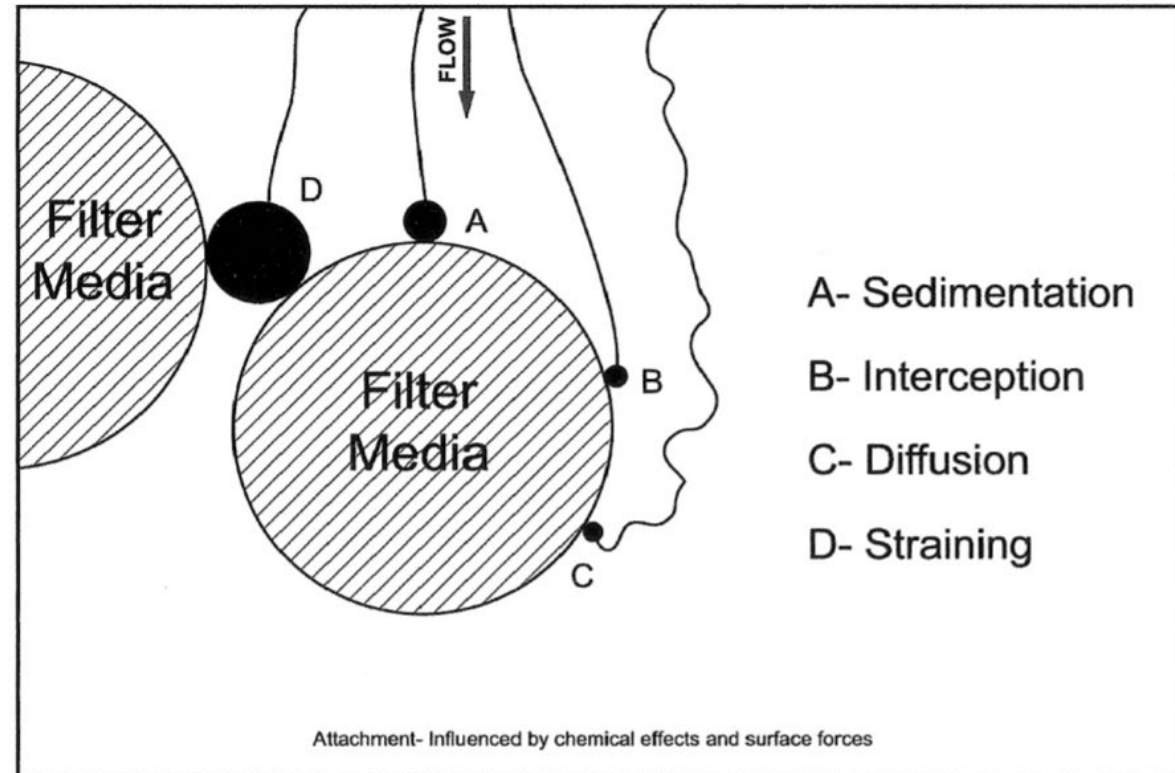


Courtesy of Kevin Castro.

From AWWA M37

1. What is the Headloss accumulation rate?

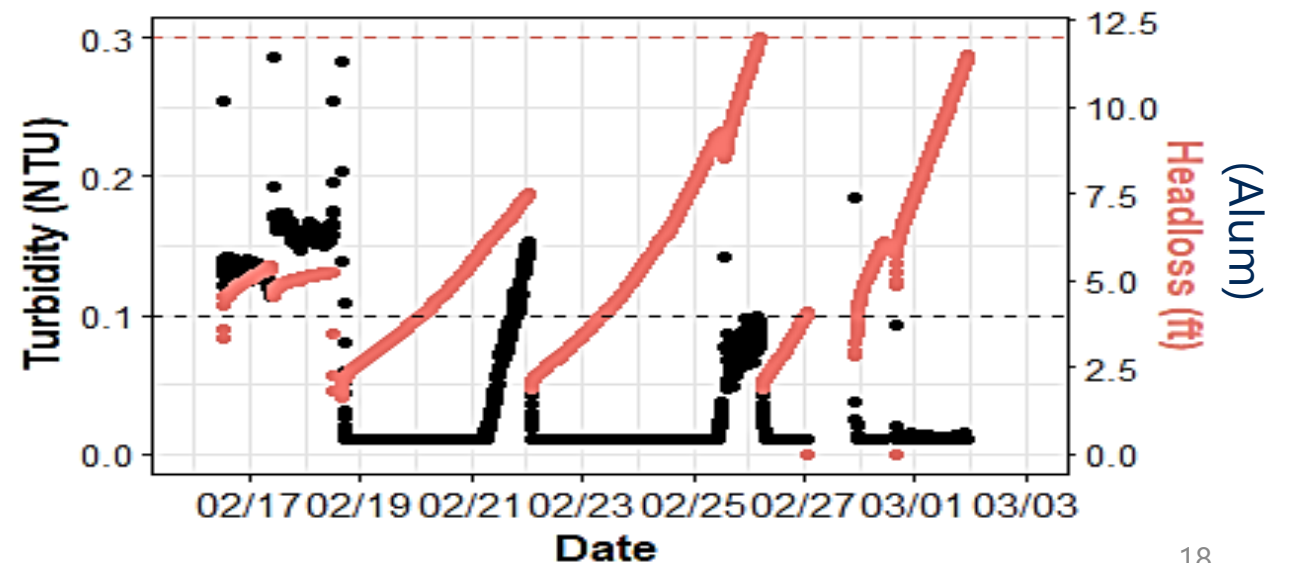
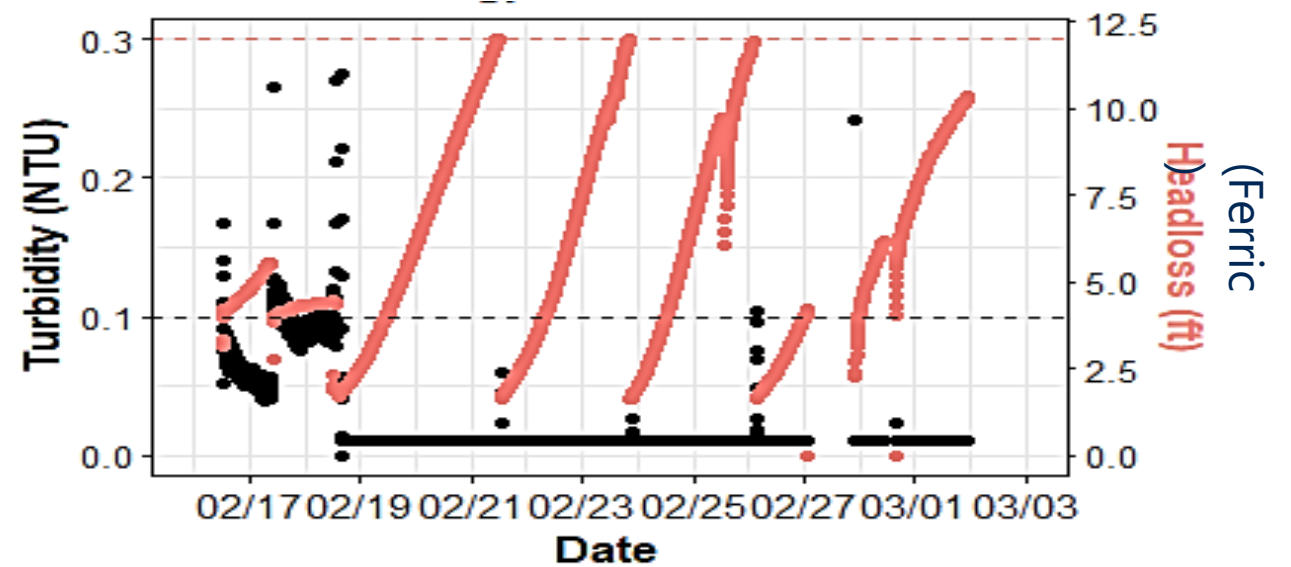
1. Inertia (Sedimentation)
2. Interception
3. Brownian Diffusion
4. Straining



Courtesy of Kevin Castro.
From AWWA M37

1. What is the Headloss accumulation rate?

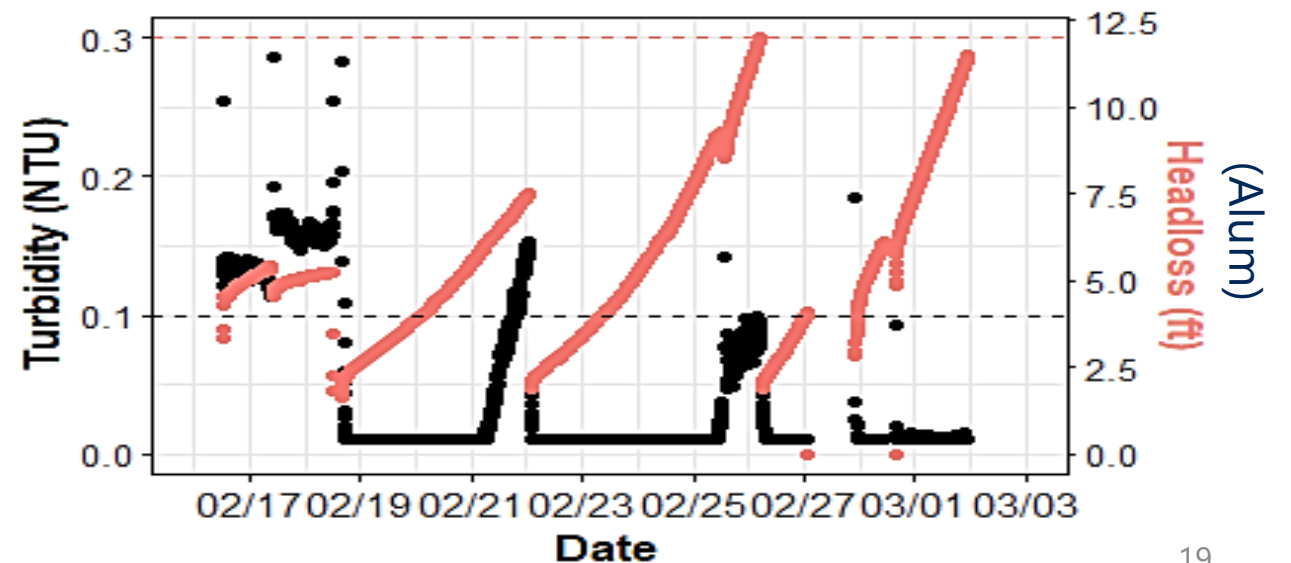
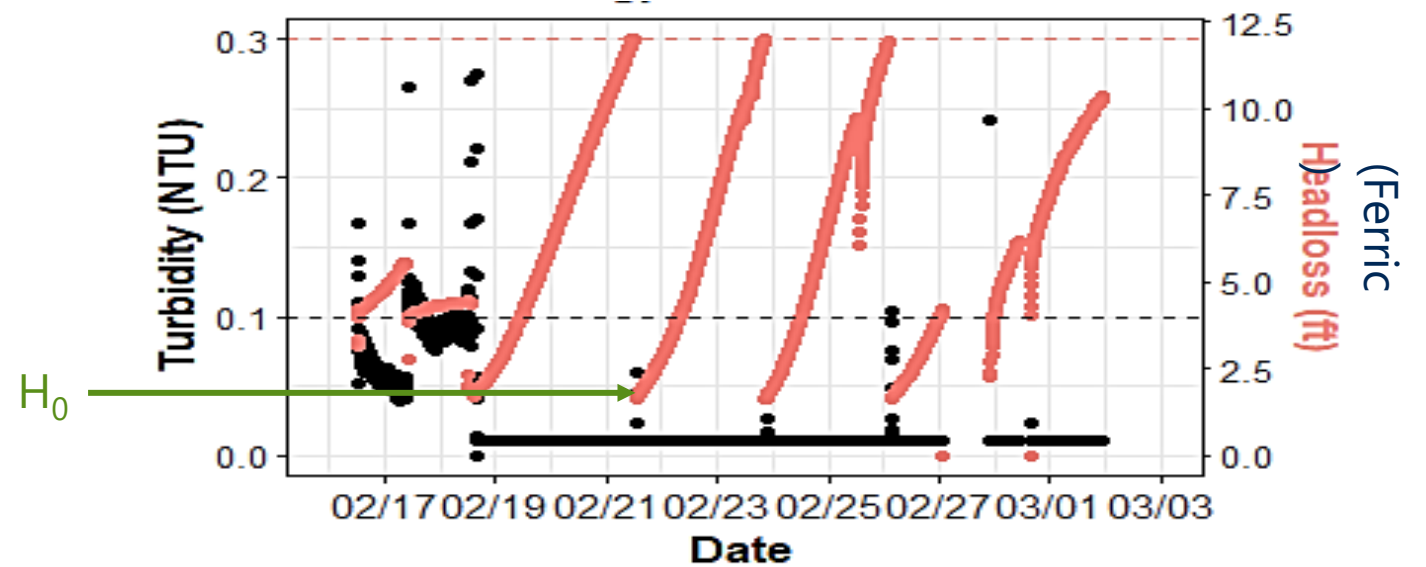
Headloss accumulation rate (ft/hr) = _____



1. What is the Headloss accumulation rate?

$$\text{Headloss accumulation rate (ft/hr)} = \frac{H_0}{\text{Time}}$$

H_0 = initial headloss (Clean Bed Headloss, CBHL)
(ft)

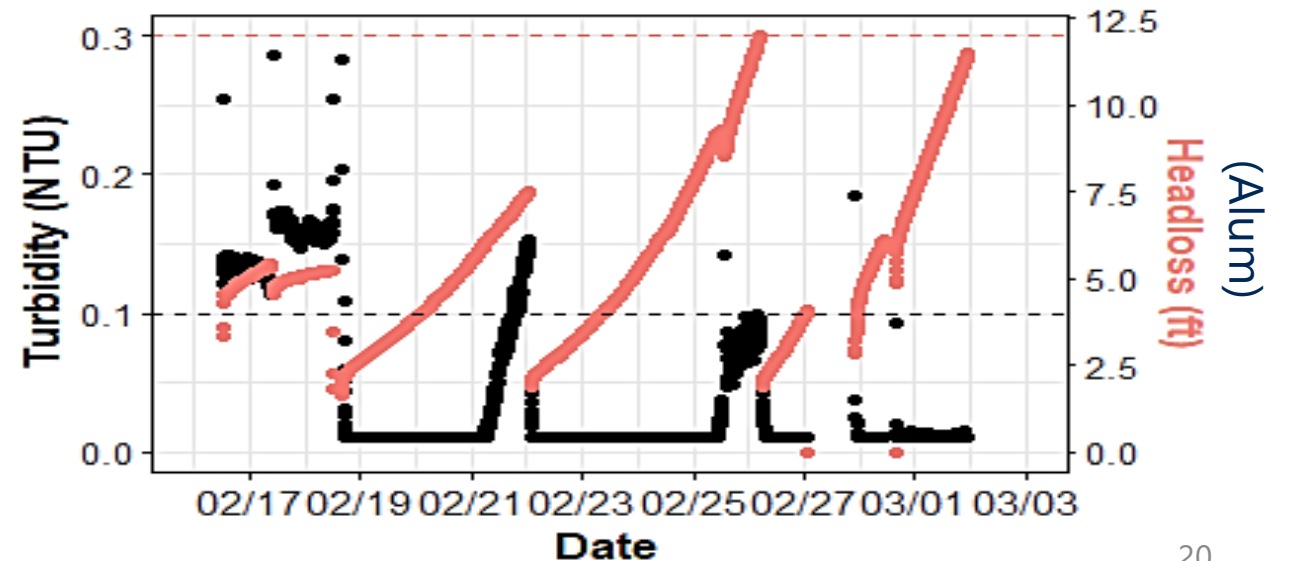
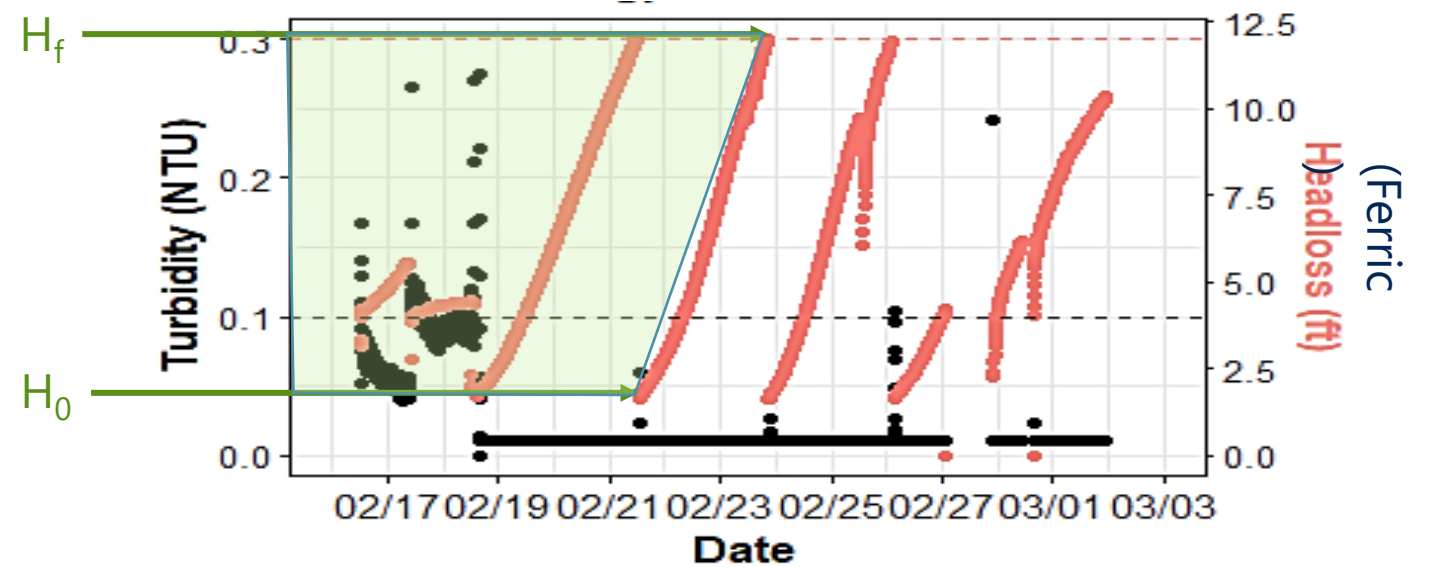


1. What is the Headloss accumulation rate?

$$\text{Headloss accumulation rate (ft/hr)} = \frac{H_f - H_0}{\text{Time}}$$

H_f = final headloss (Terminating Headloss) (ft)

H_0 = initial headloss (Clean Bed Headloss, CBHL) (ft)



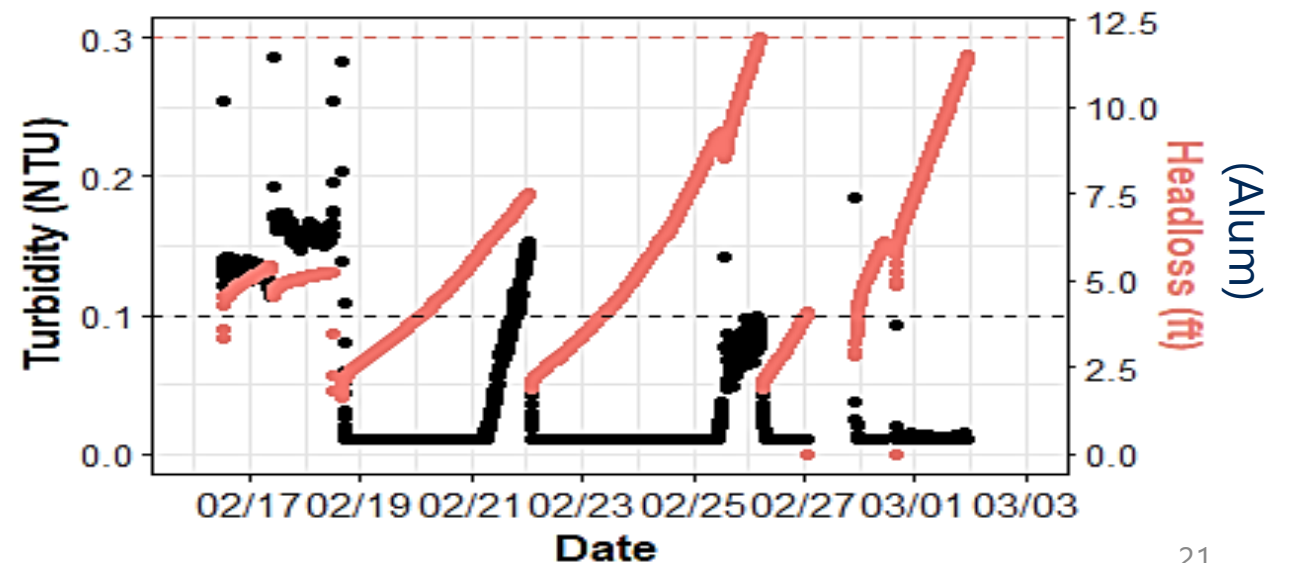
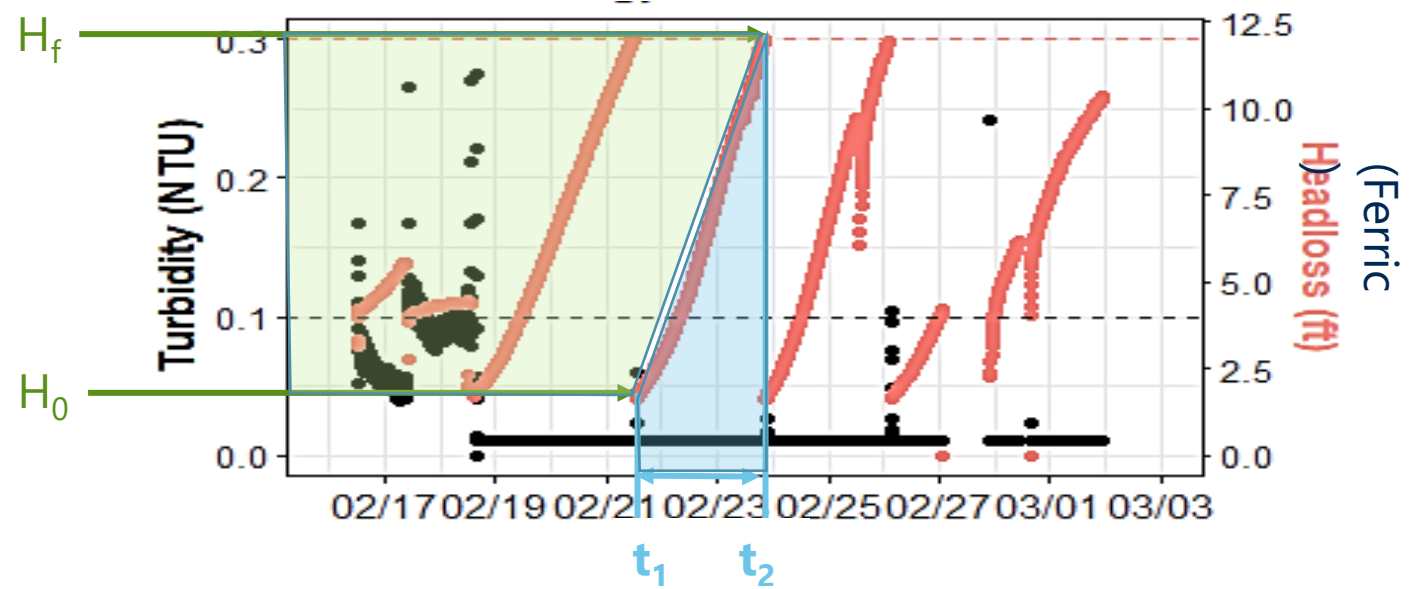
1. What is the Headloss accumulation rate?

$$\text{Headloss accumulation rate (ft/hr)} = \frac{H_f - H_0}{t_2 - t_1}$$

H_f = final headloss (ft)

H_0 = initial headloss (Clean Bed Headloss, CBHL) (ft)

$t_2 - t_1$ = filtration period (hr)



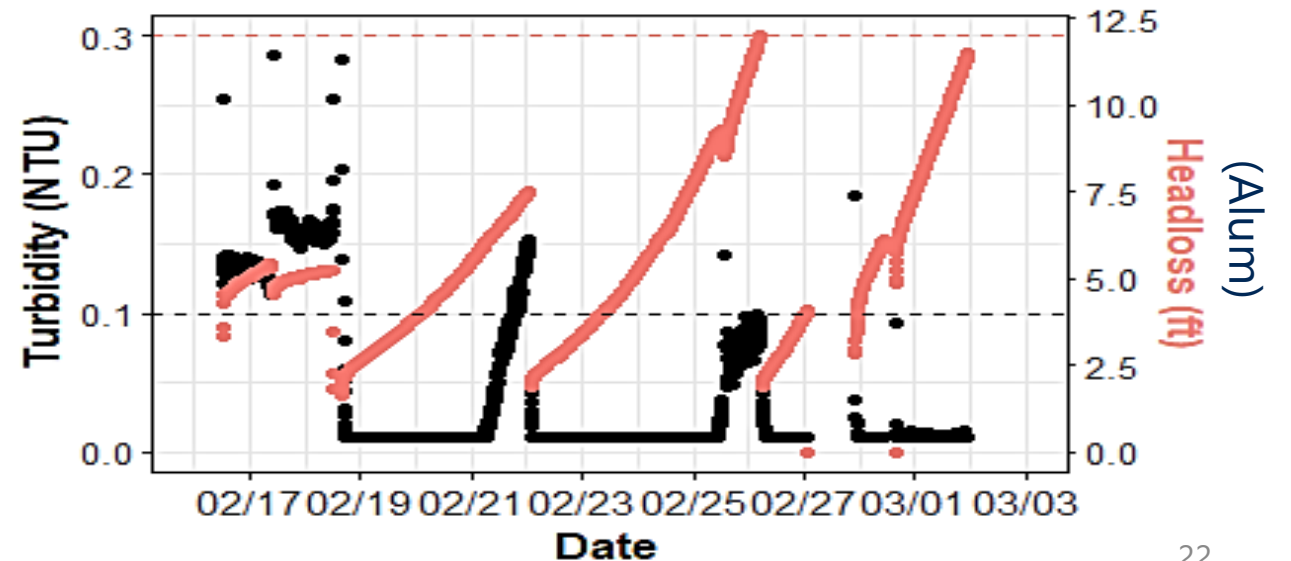
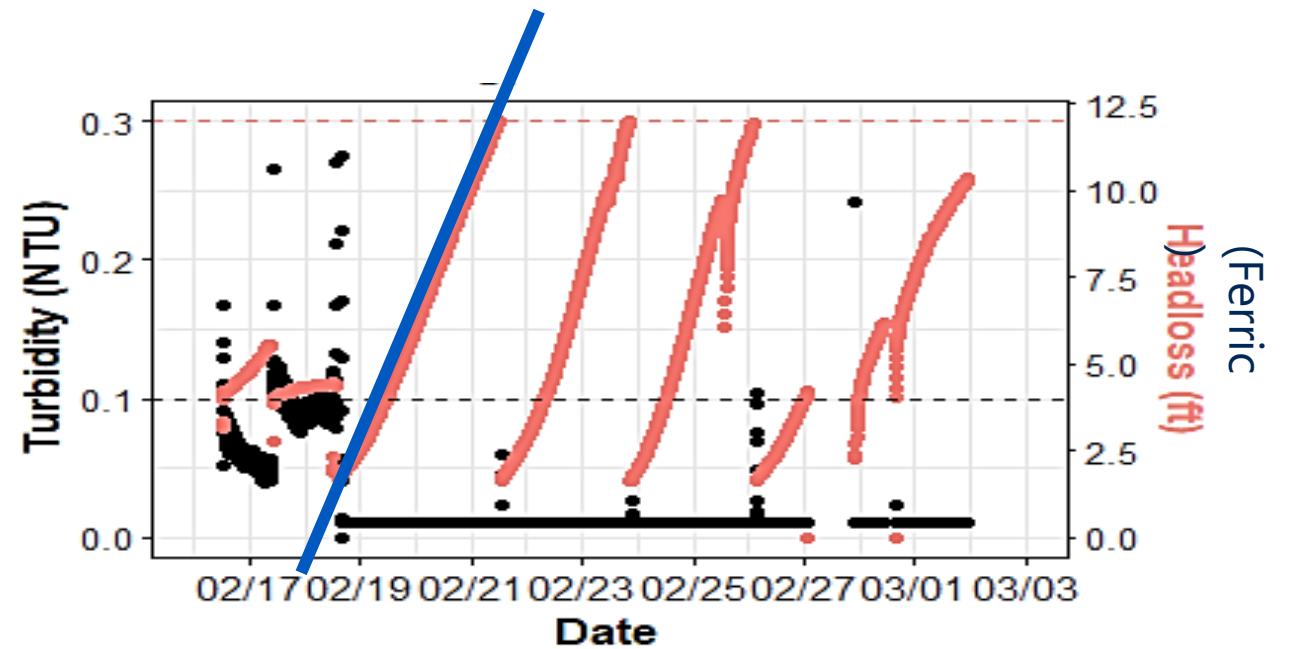
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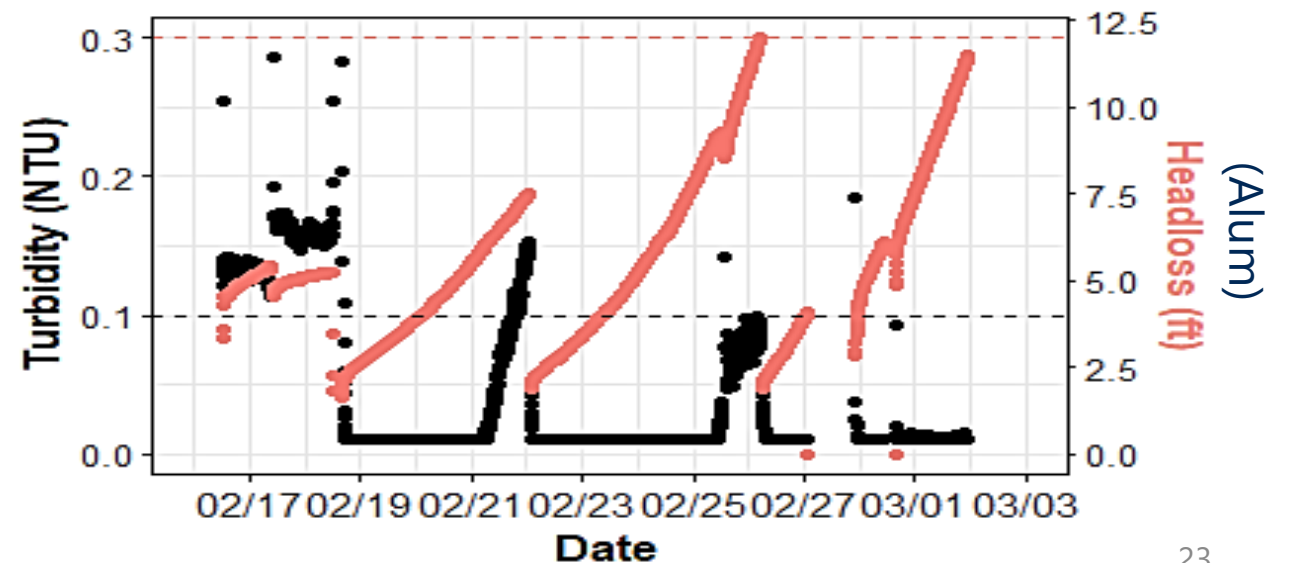
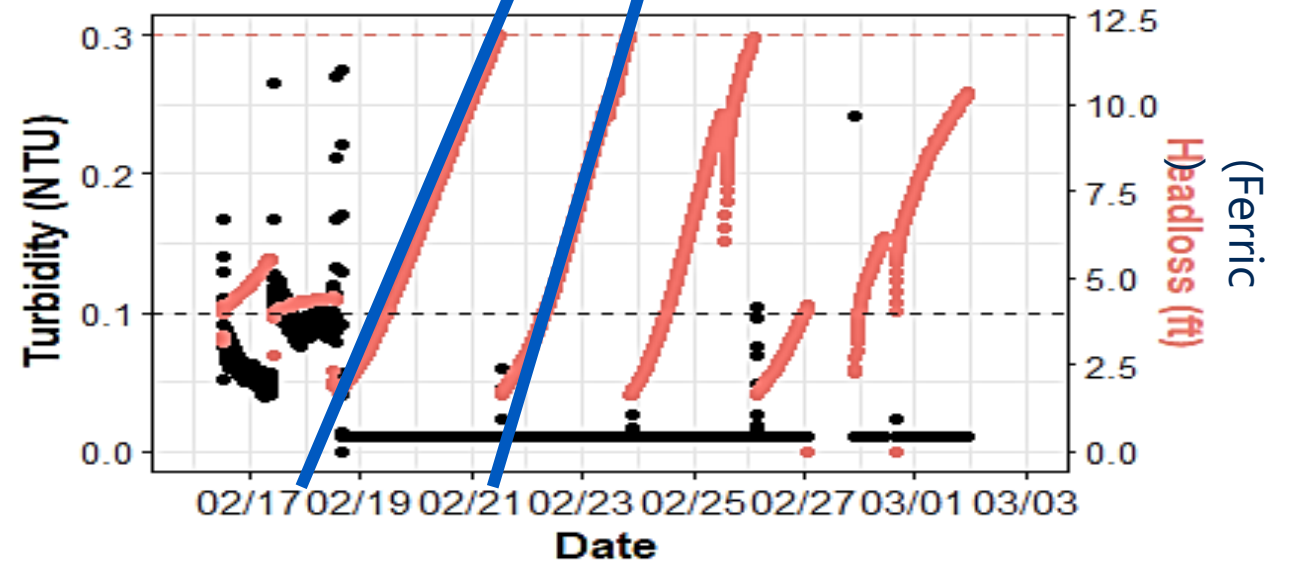
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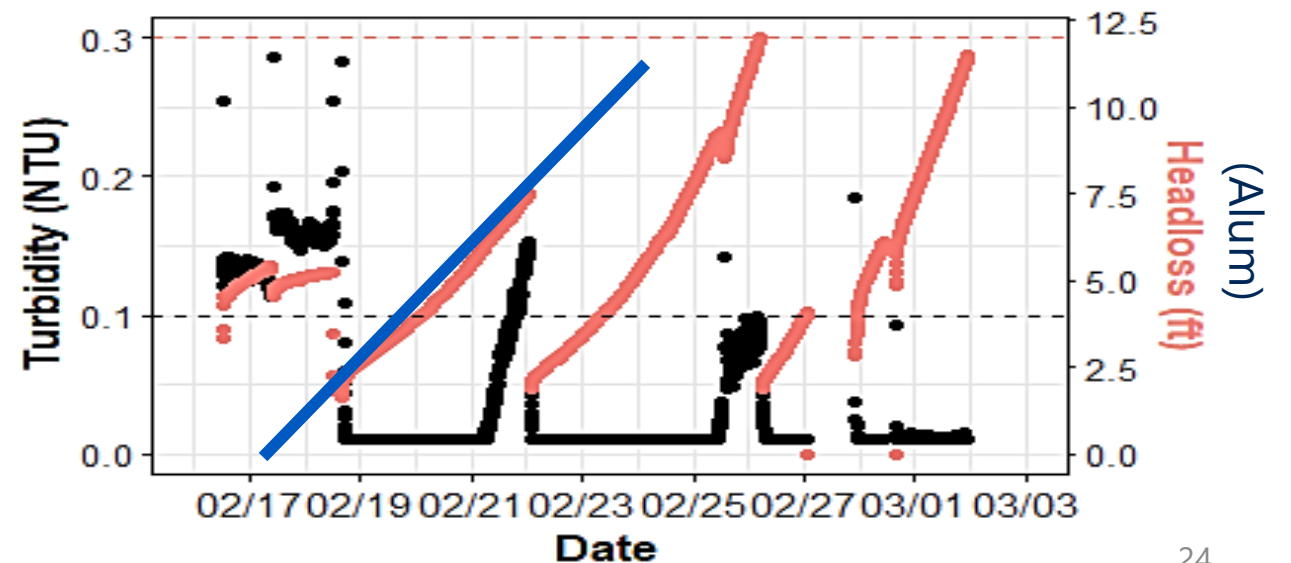
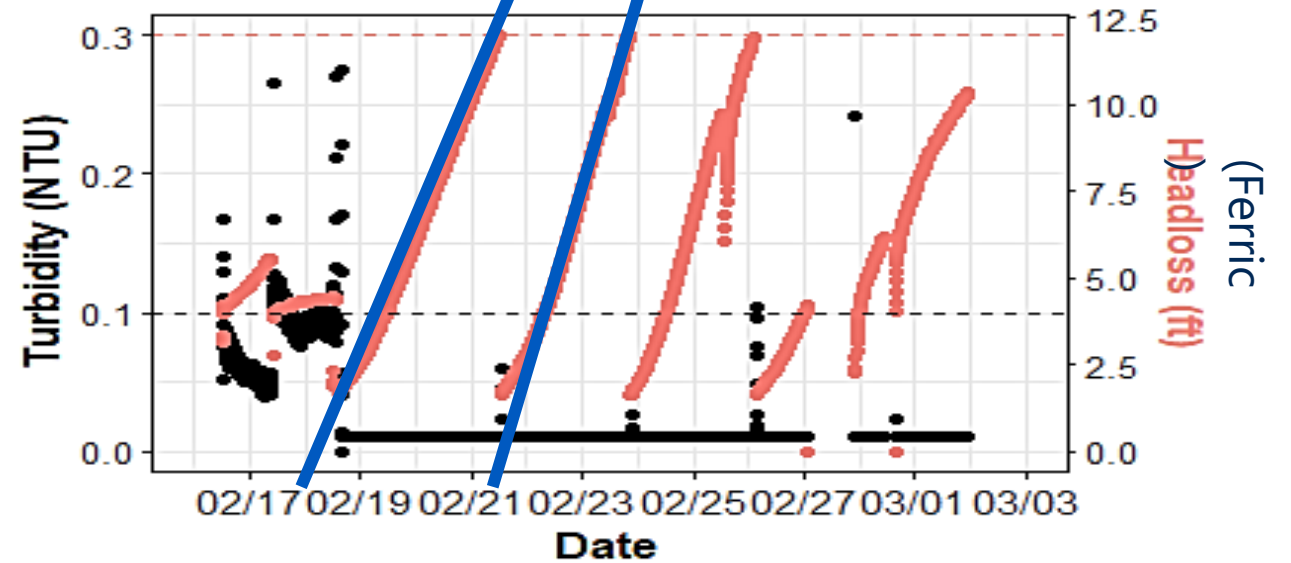
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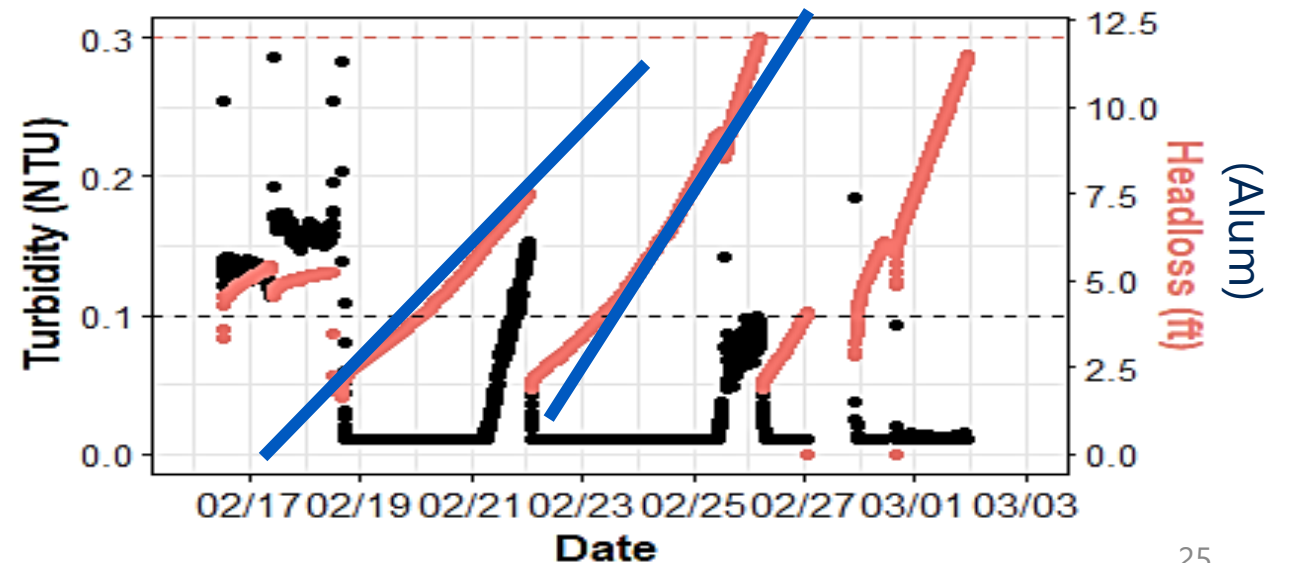
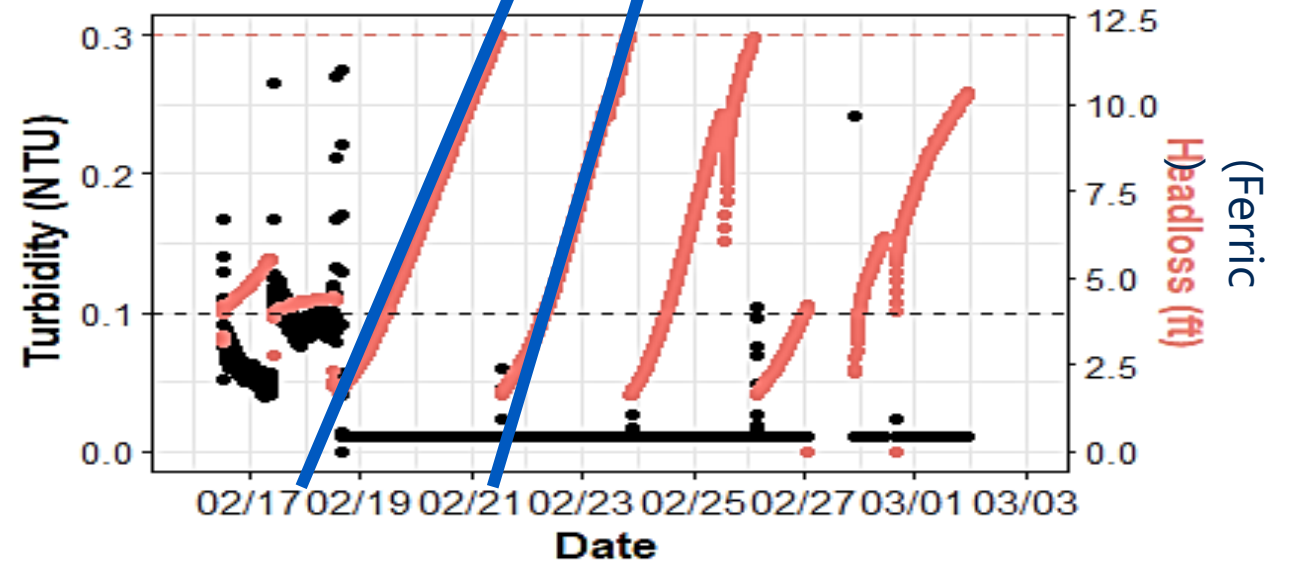
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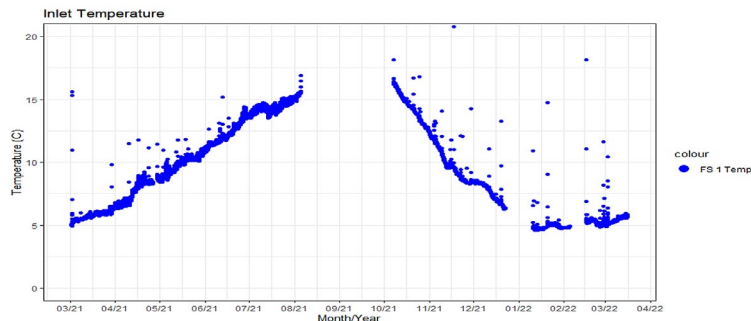
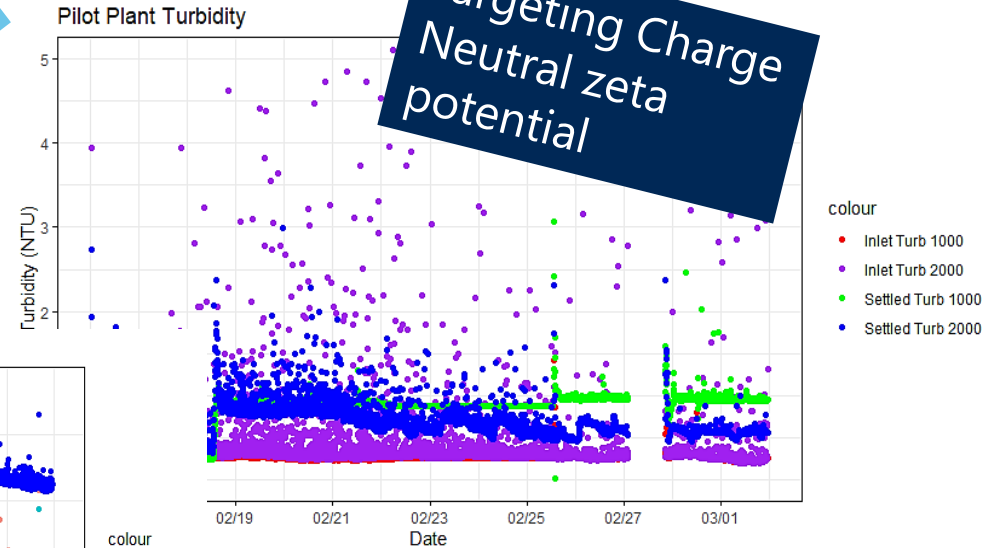
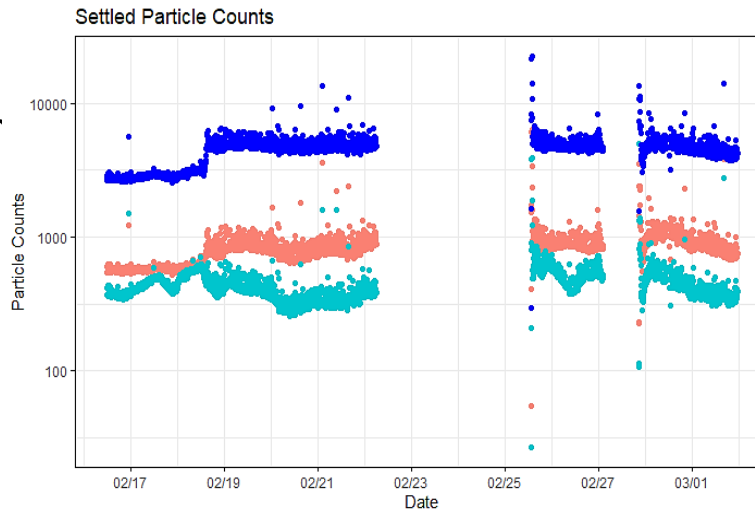


Headloss Accumulation Rate is affected by

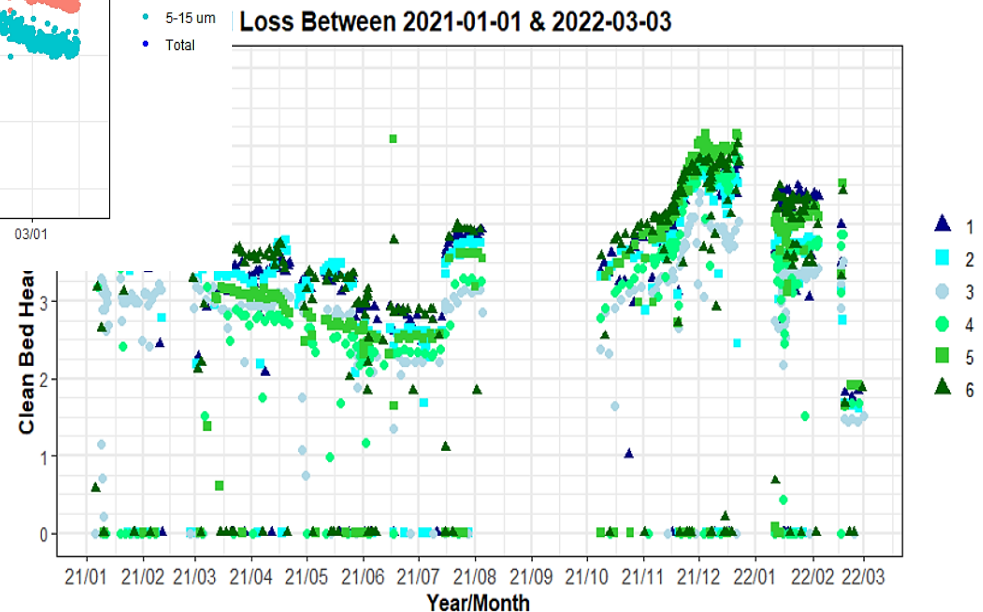
- Upstream water quality
 - Type of chemicals used
 - Number of particles
 - Size of particles
 - Zeta potential
- Filter flow rate
- Temperature
- Filter media configuration
- Type of filter aid
- Filter backwash quality
- Filter ripening

Alum vs
Ferric

Targeting Charge
Neutral zeta
potential



Non-
ionic
Filter Aid





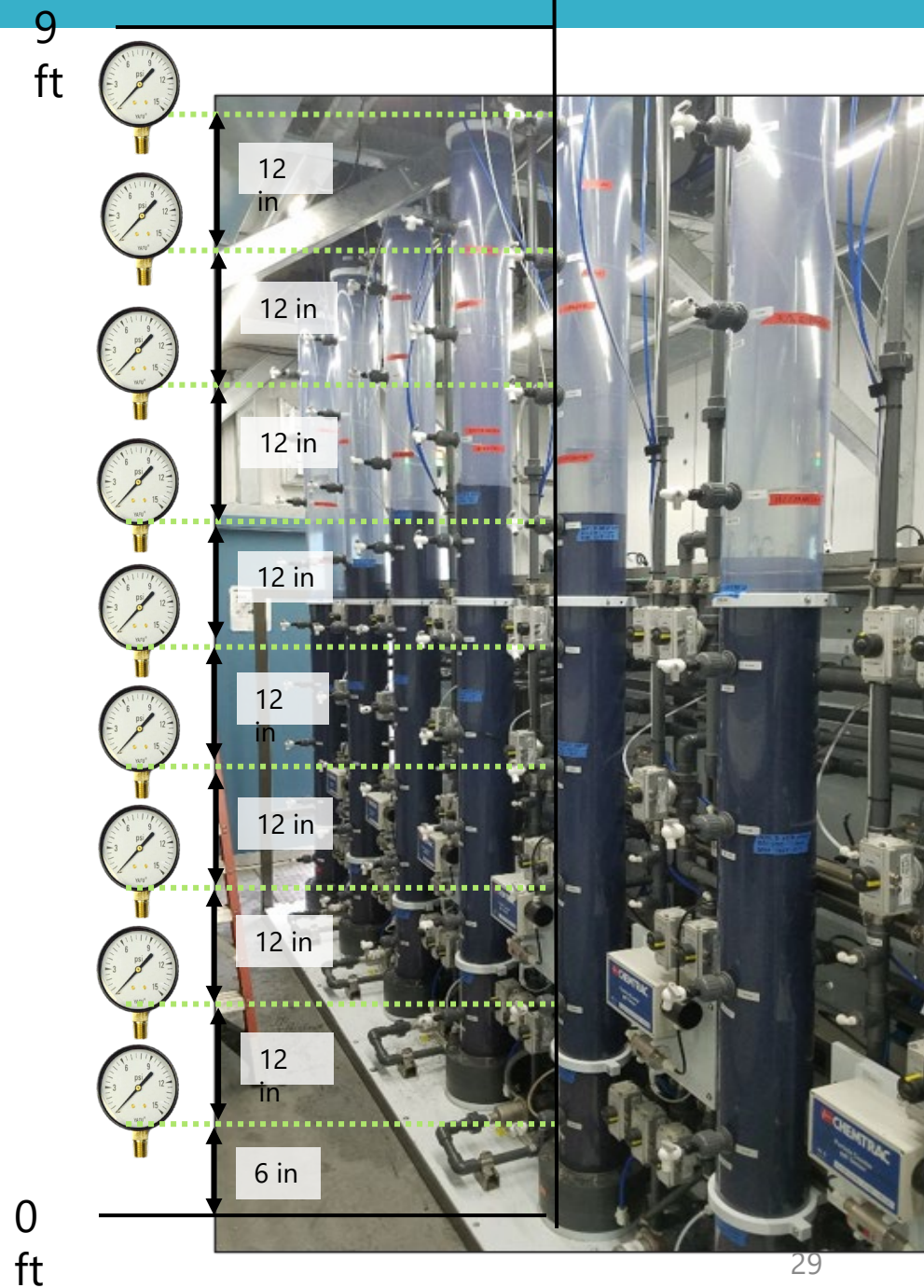
2. What does the headloss along filter column look like and how does it change during a filter run?

Headloss Along Filter Column

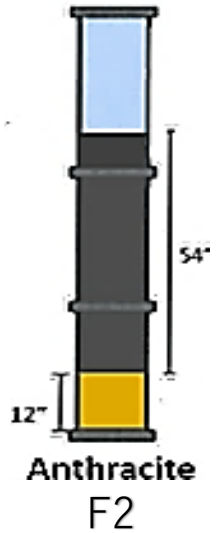


0
ft

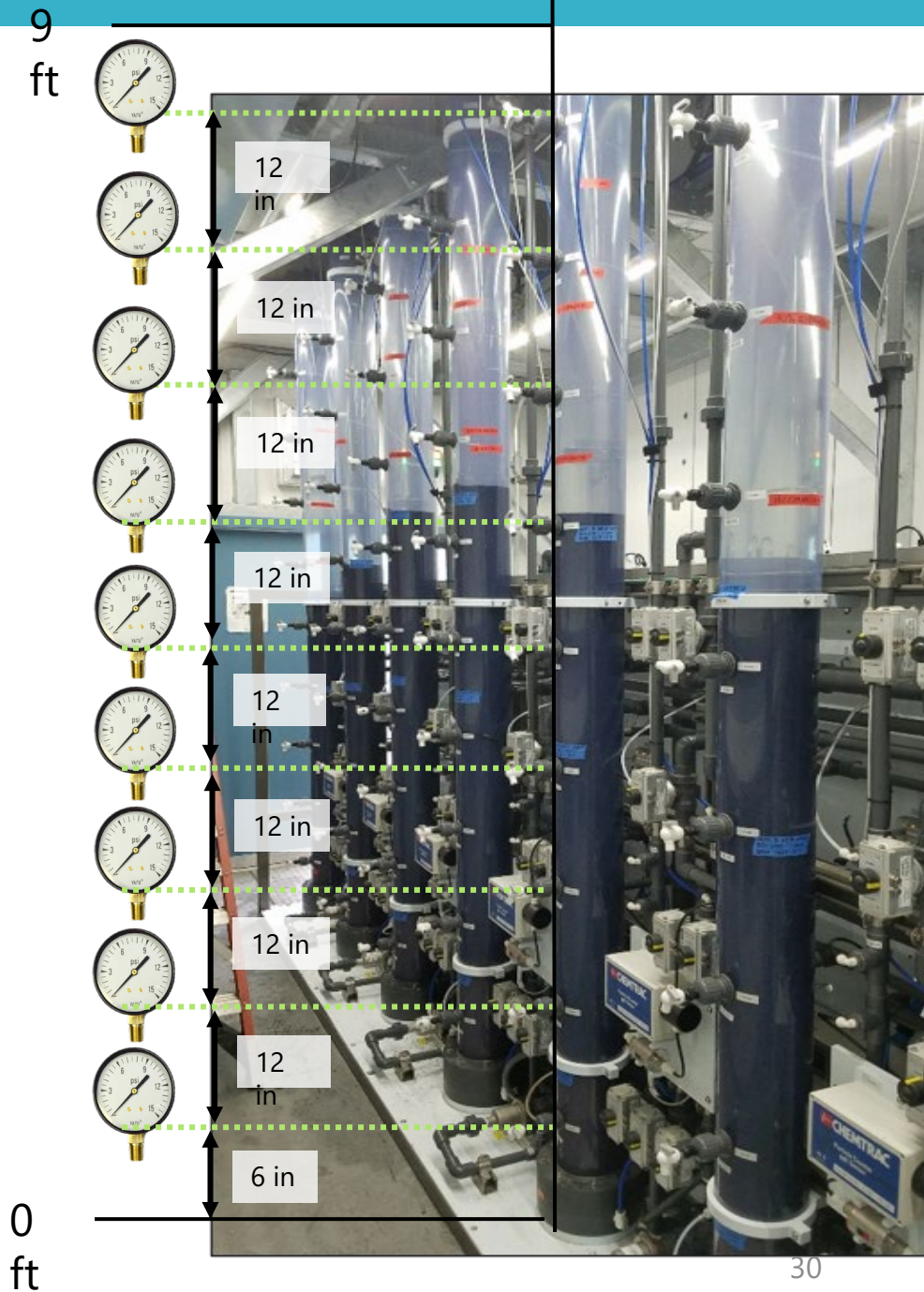
Headloss Along Filter Column



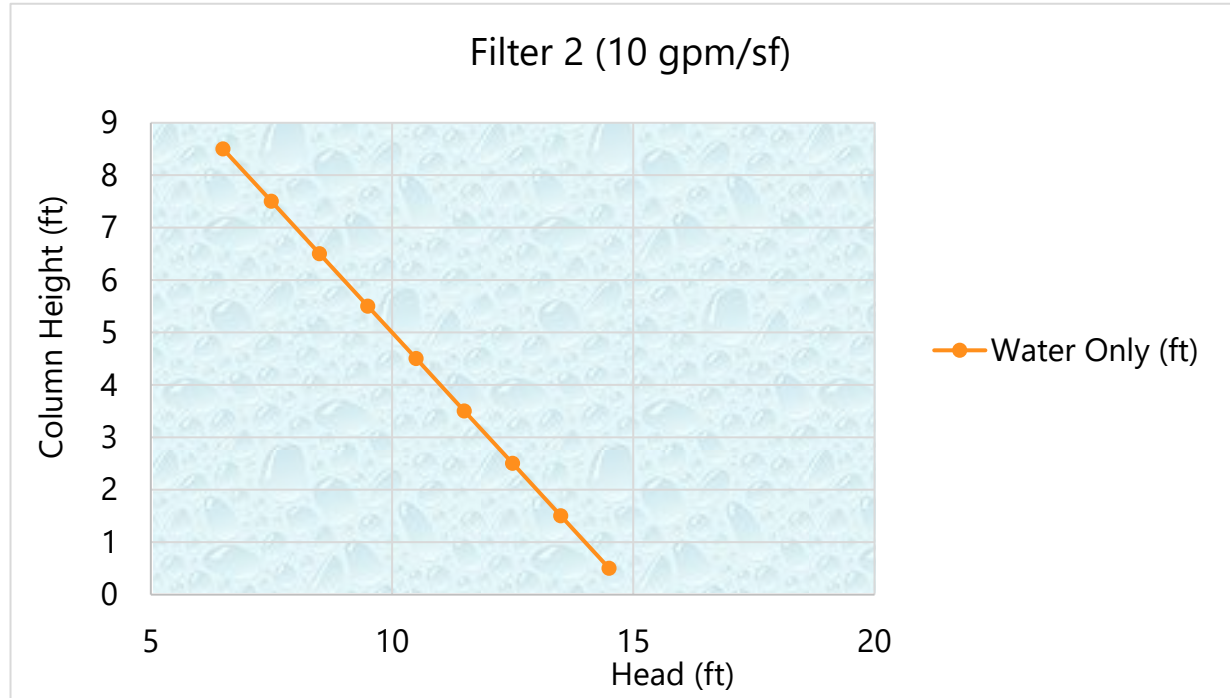
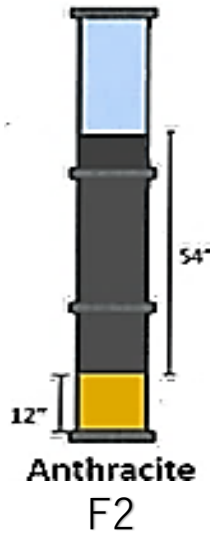
Headloss Along Filter Column



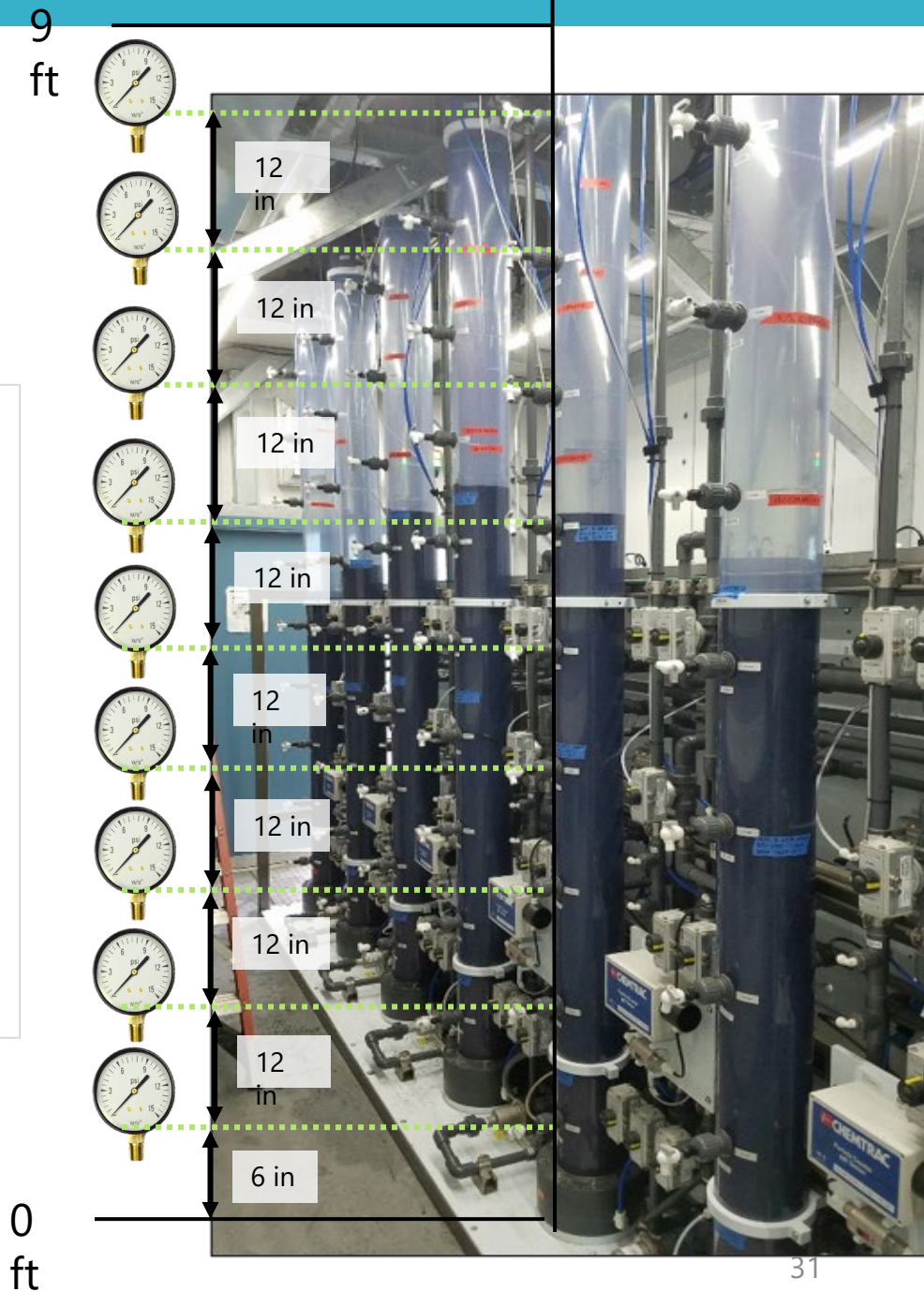
Depth = 66 "
 Anthracite = 54"
 Effect size (mm)= 1.05 – 1.15
 Silica sand = 12"
 Effect. size (mm)= 0.55 – 0.65
 L/d ratio = 1 650



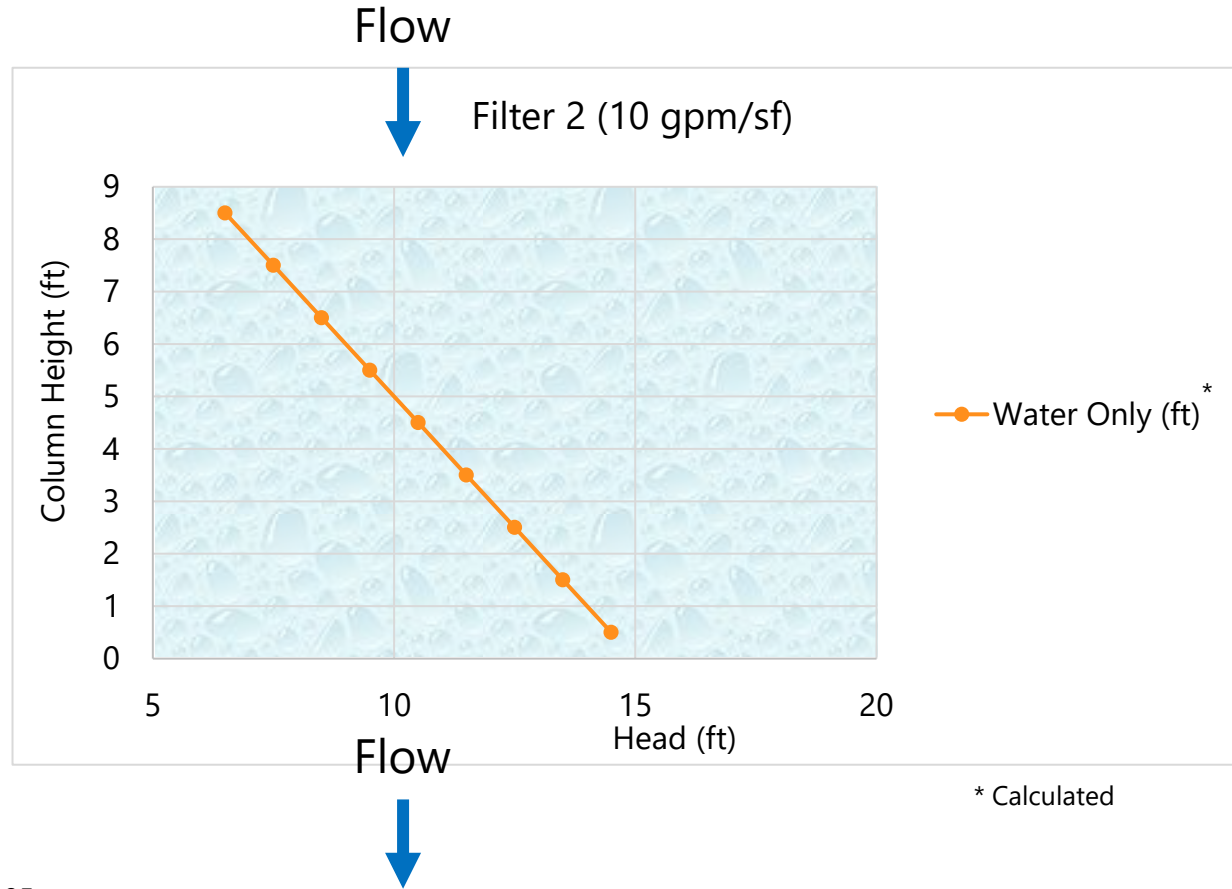
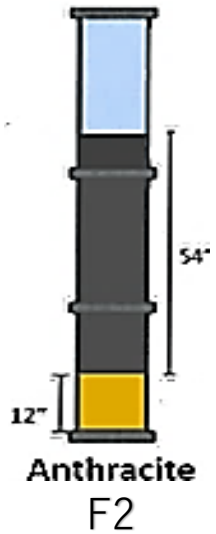
Headloss Along Filter Column



Depth = 66 "
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 L/d ratio = 1.650

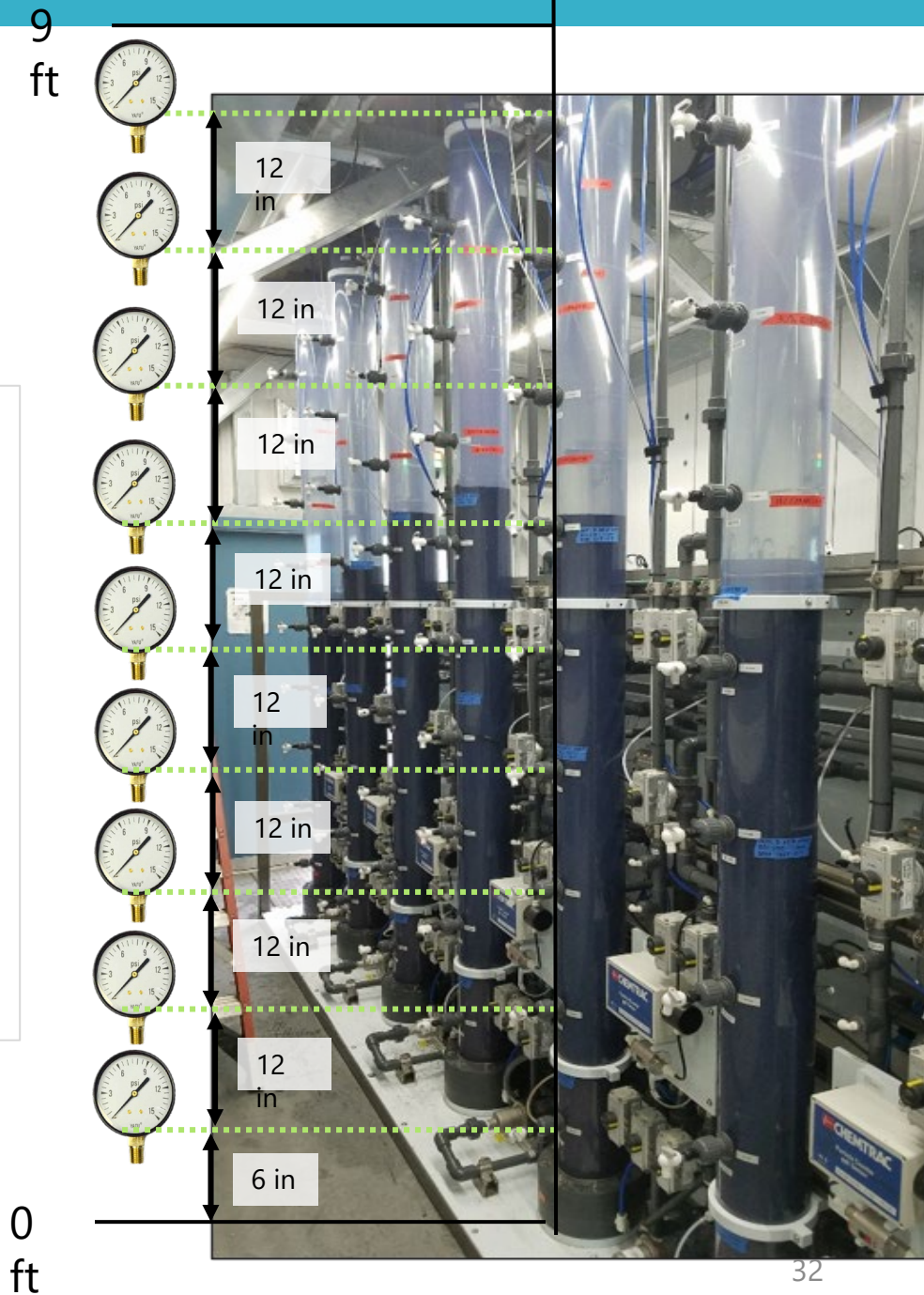


Headloss Along Filter Column

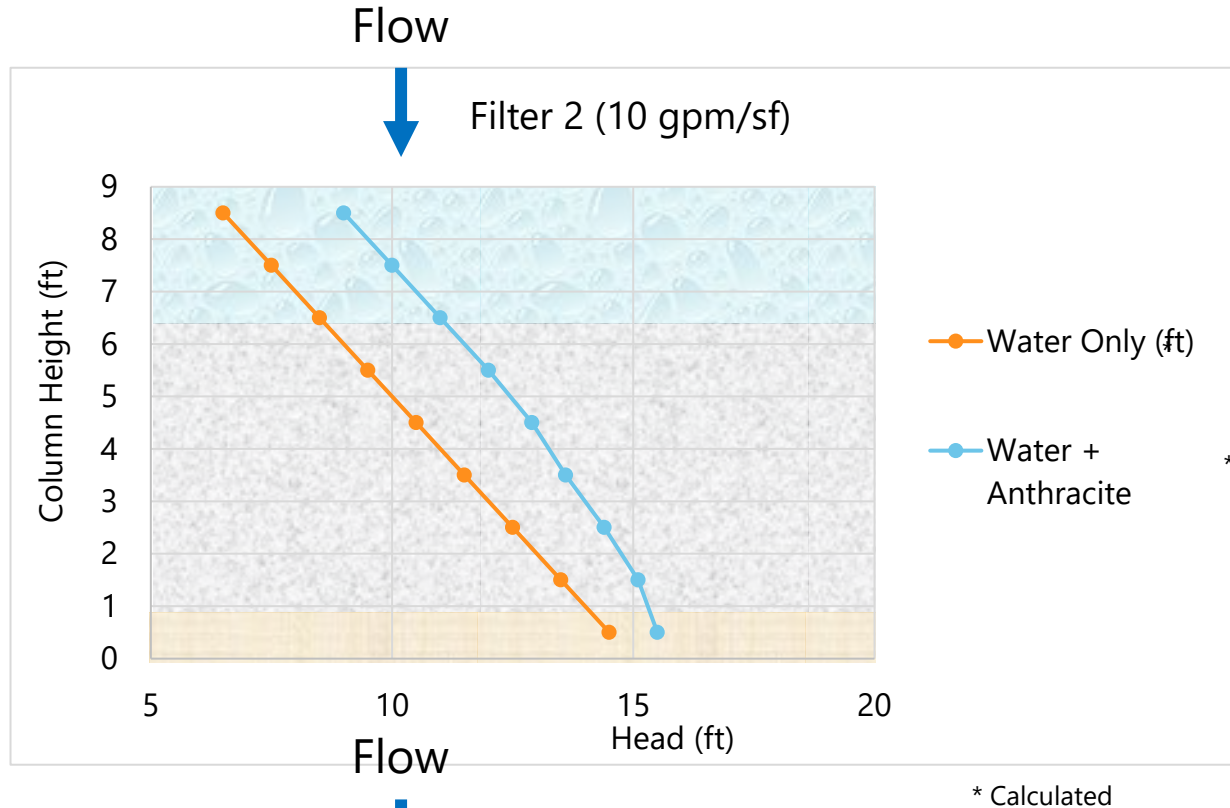
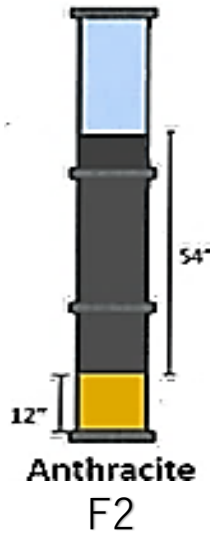


* Calculated

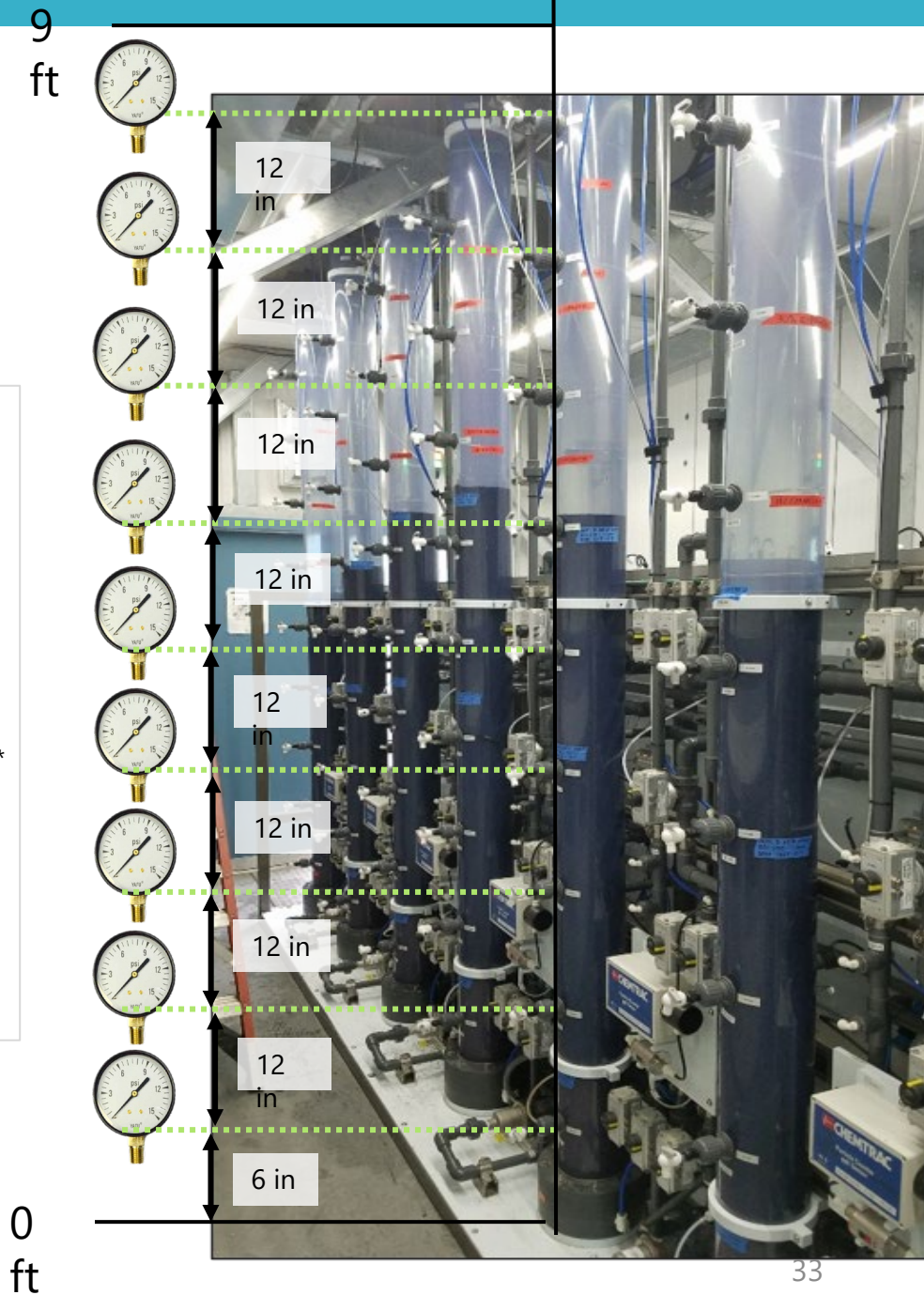
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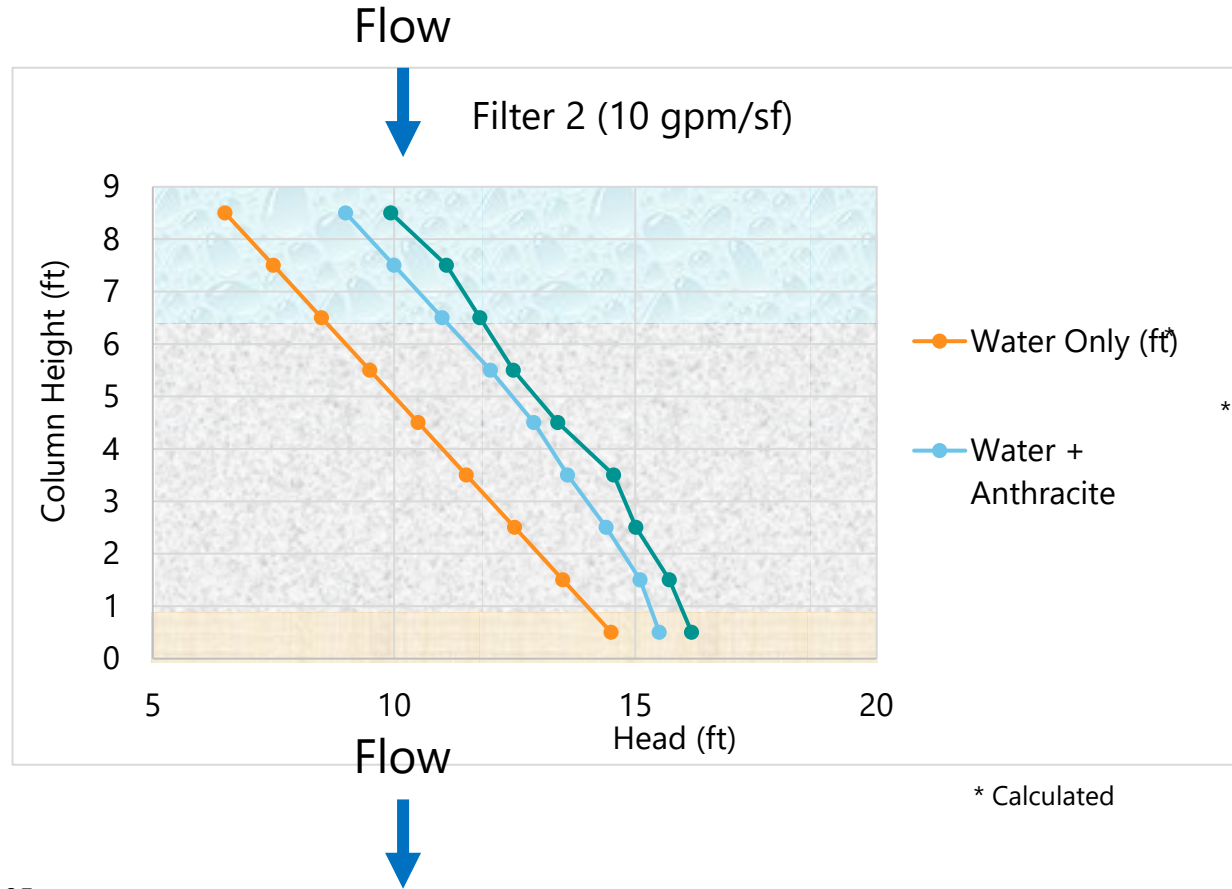
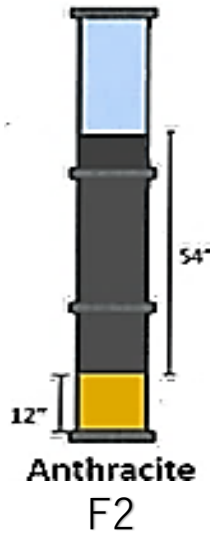
Headloss Along Filter Column



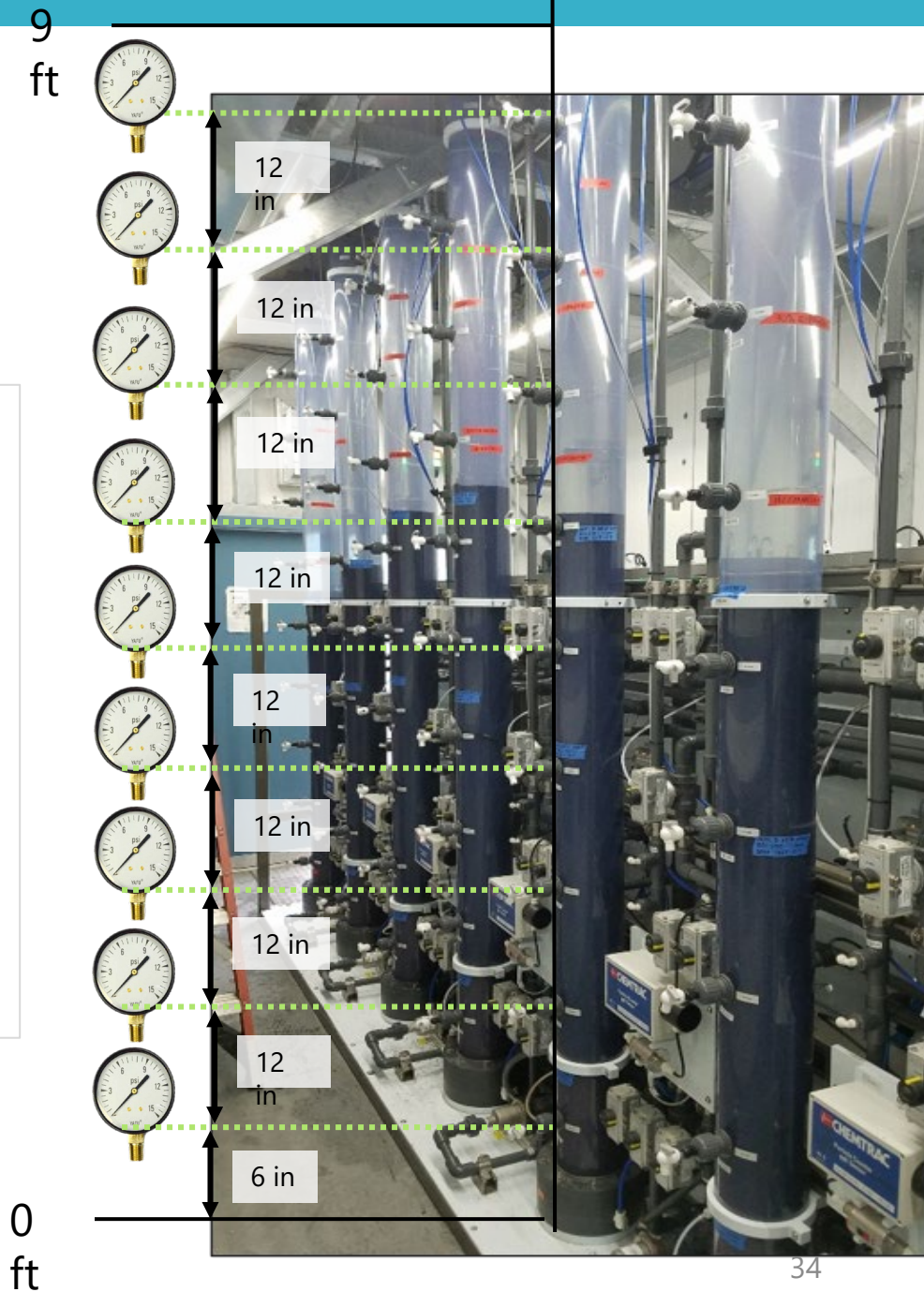
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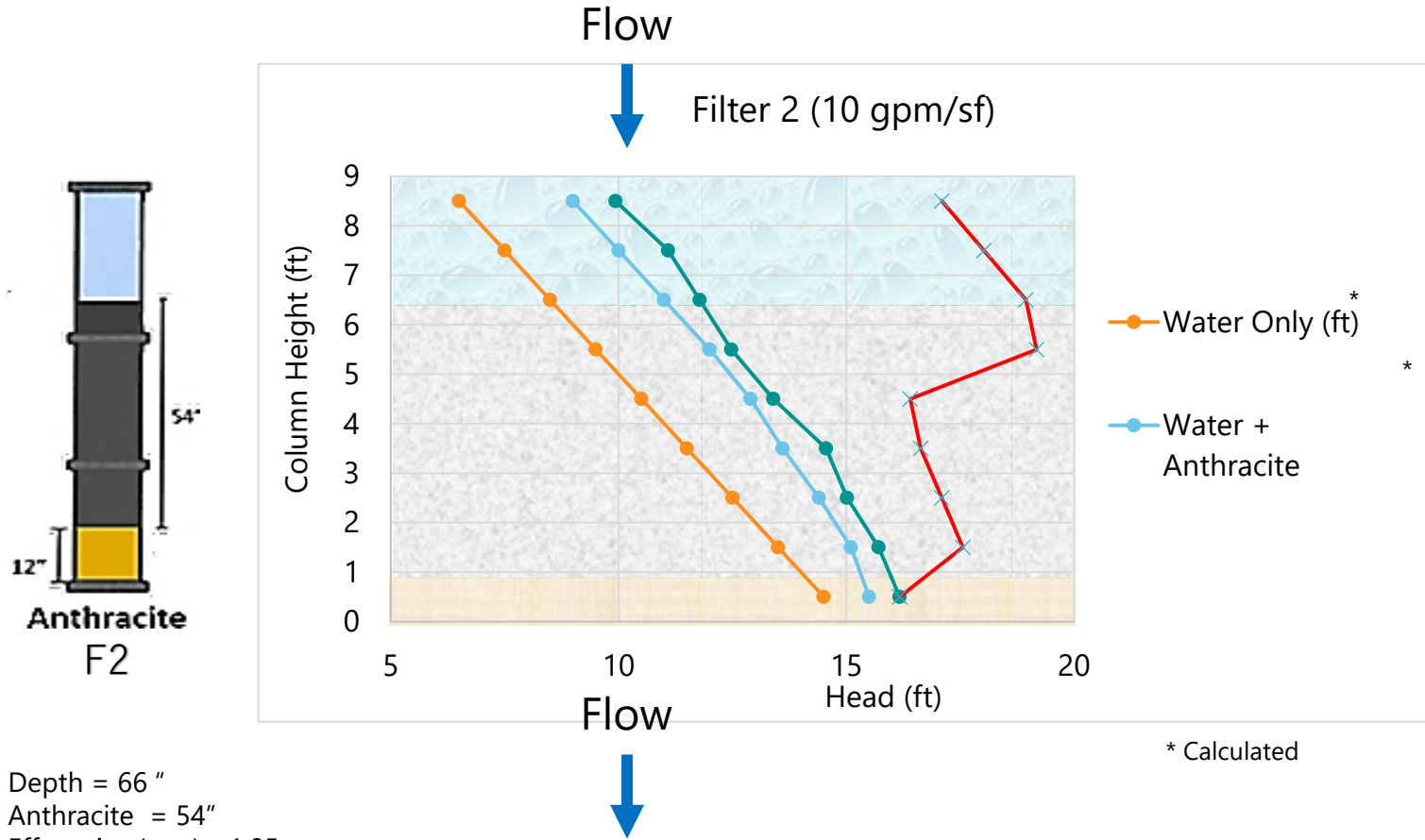
Headloss Along Filter Column



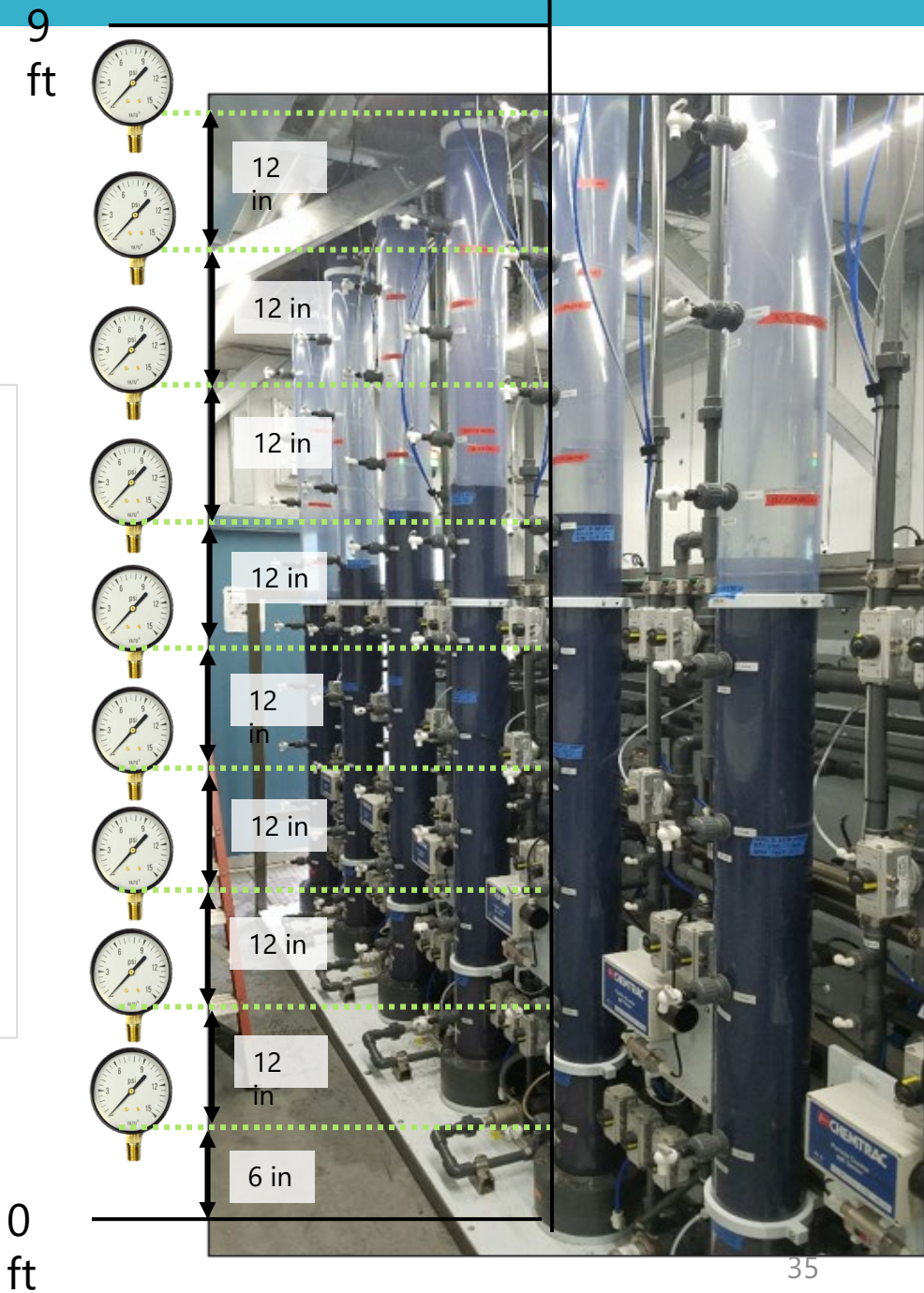
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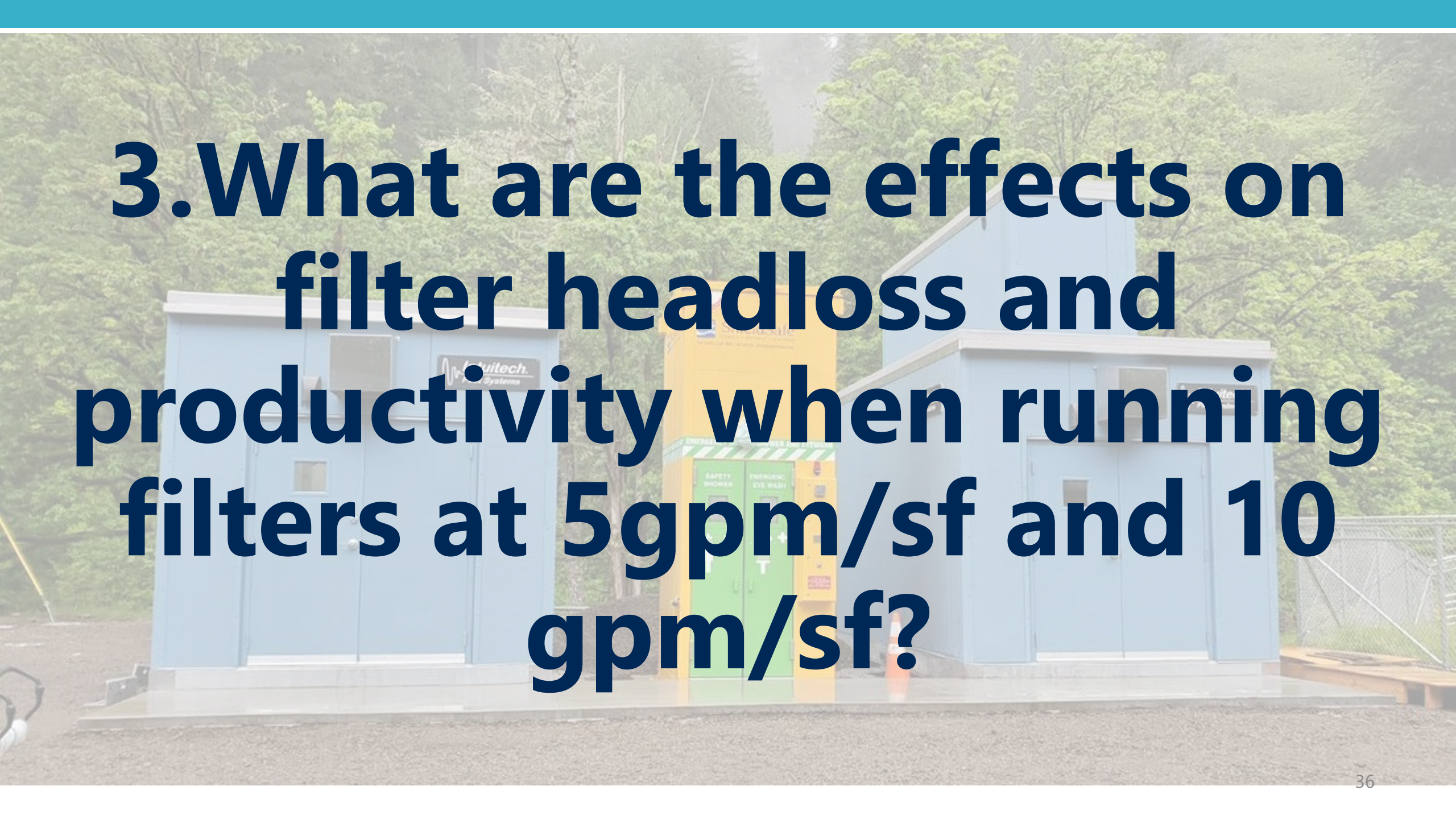


Headloss Along Filter Column



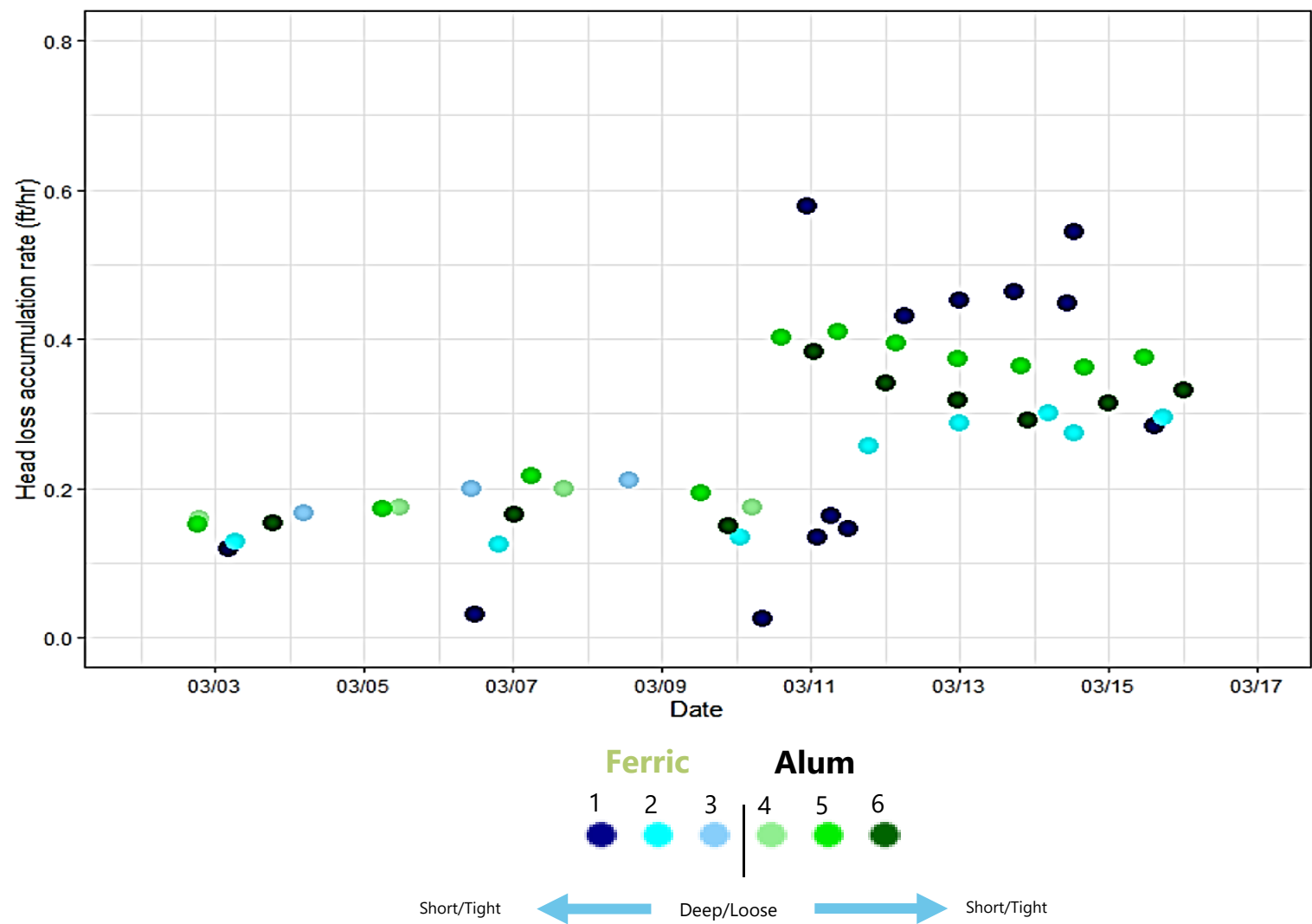
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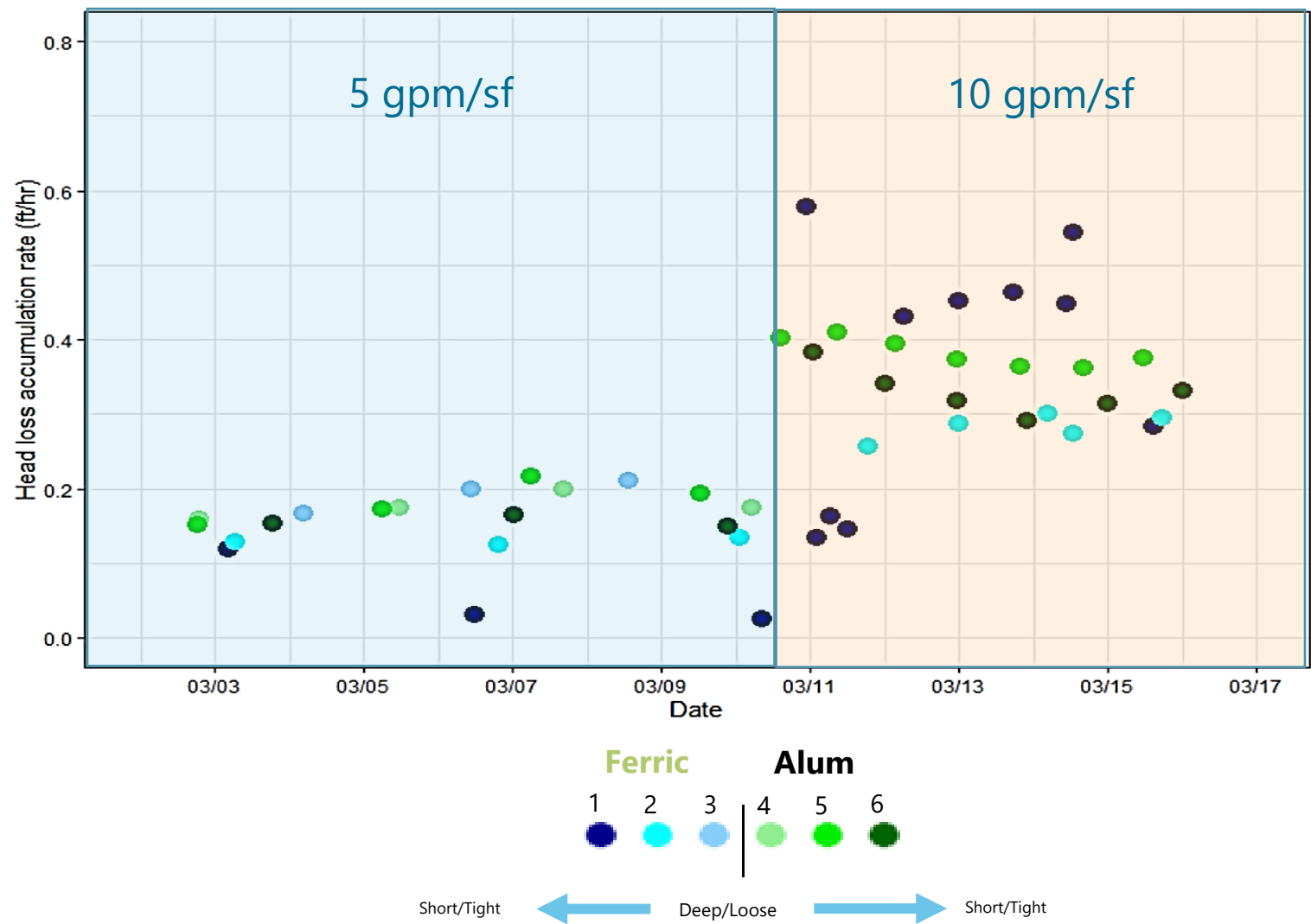
The background image shows an outdoor industrial setting, likely a wastewater treatment plant. In the foreground, there are two large, light blue rectangular filter housings. Between them is a yellow safety cabinet with green doors, labeled 'SAFETY SHOWER' and 'EMERGENCY EYE WASH'. The background is filled with lush green trees. The text is overlaid in a large, bold, dark blue font.

3. What are the effects on filter headloss and productivity when running filters at 5gpm/sf and 10 gpm/sf?

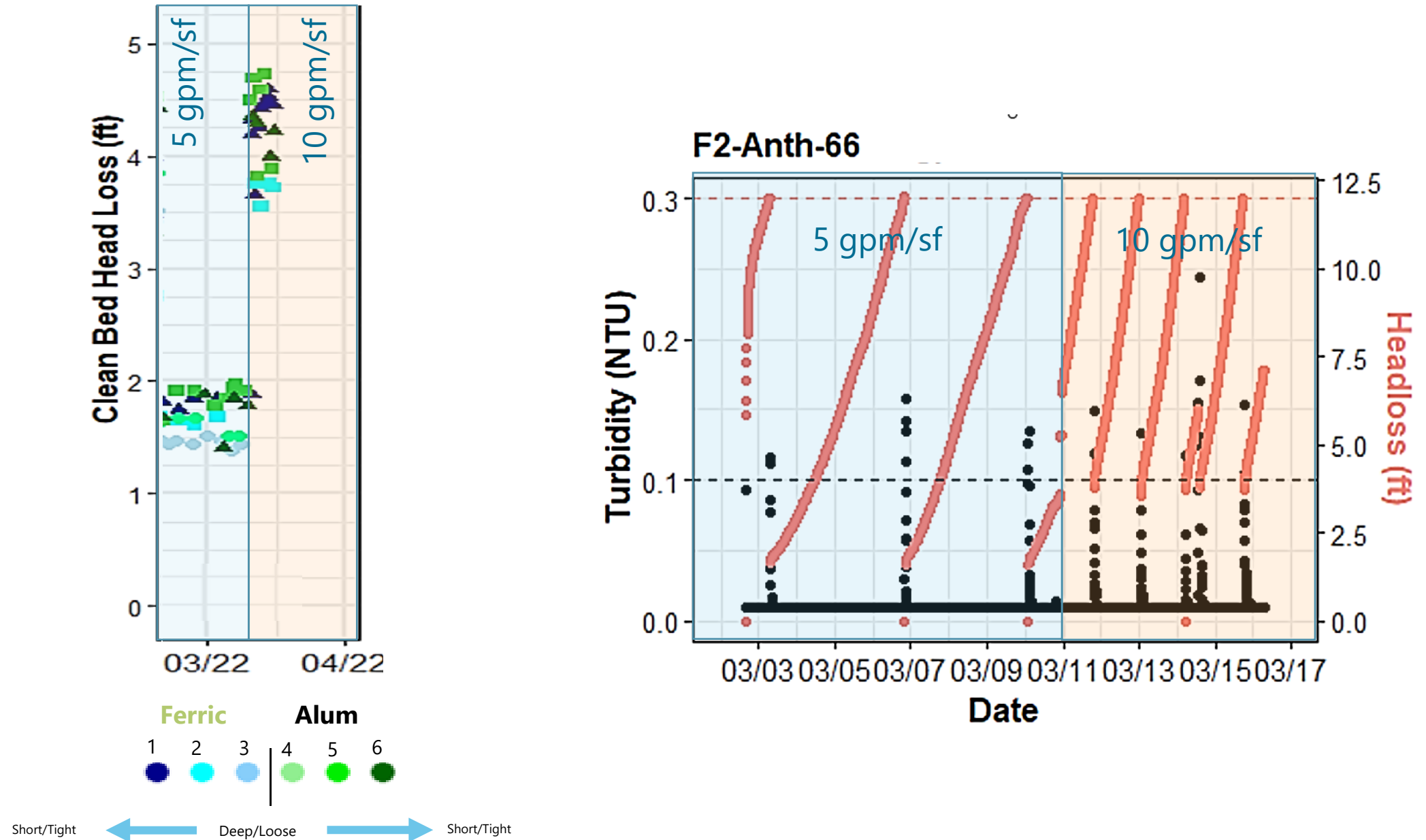
5 gpm/sf vs 10gpm/sf – Headloss Accumulation Rate



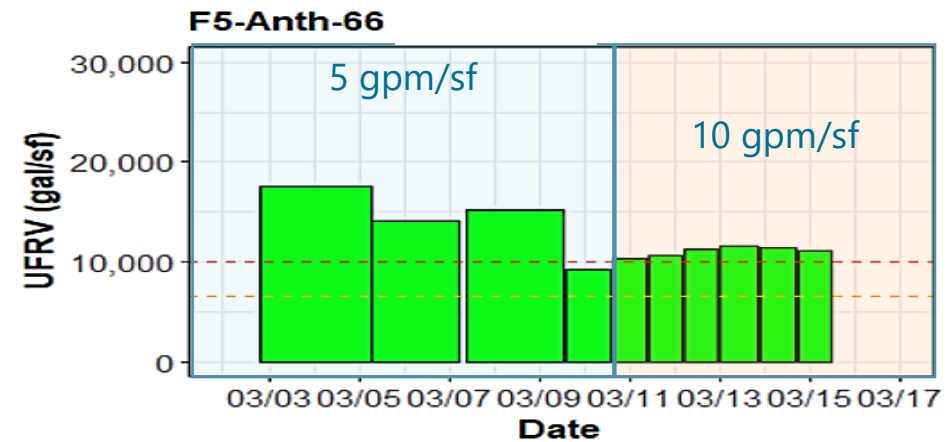
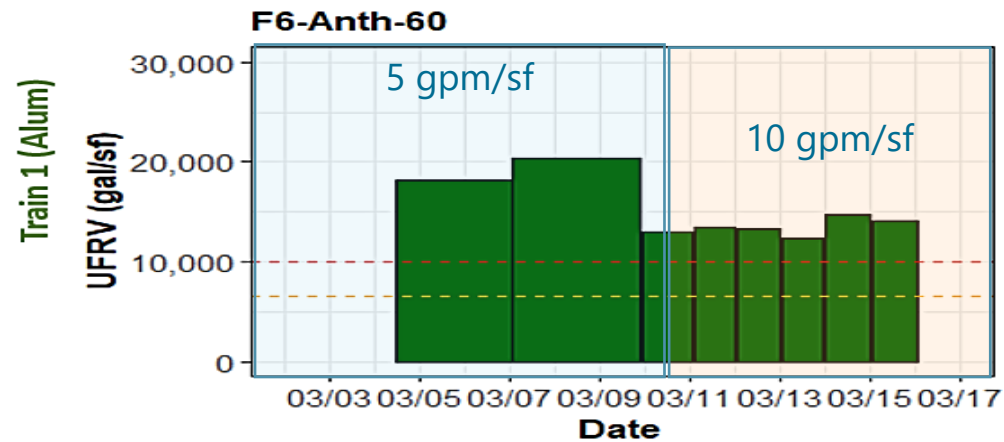
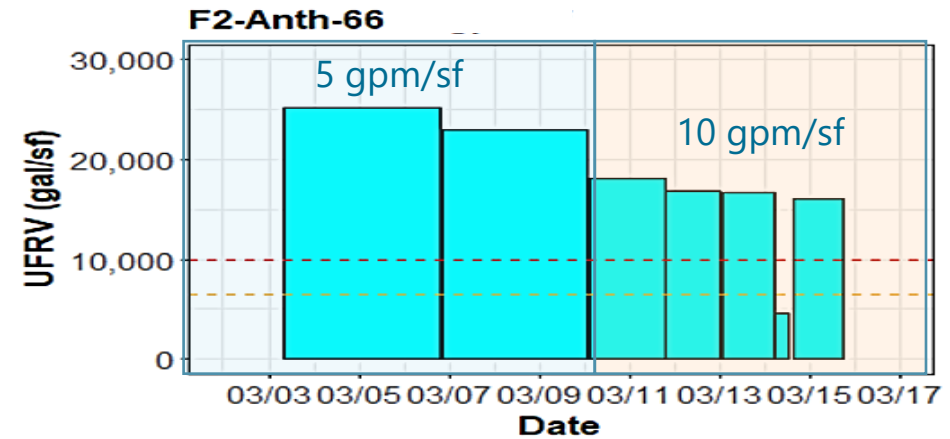
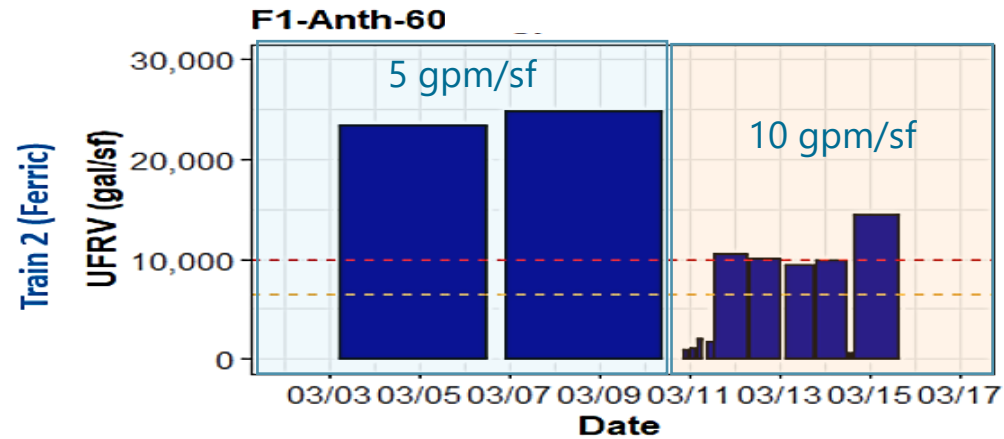
5 gpm/sf vs 10gpm/sf – Headloss Accumulation Rate



5 gpm/sf vs 10gpm/sf – CBHL (Clean Bed Headloss)



5 gpm/sf vs 10gpm/sf – UFRV Performance

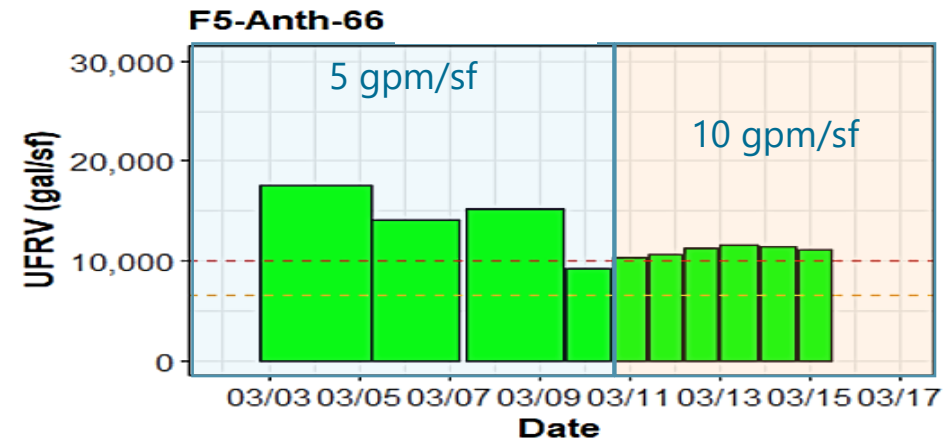
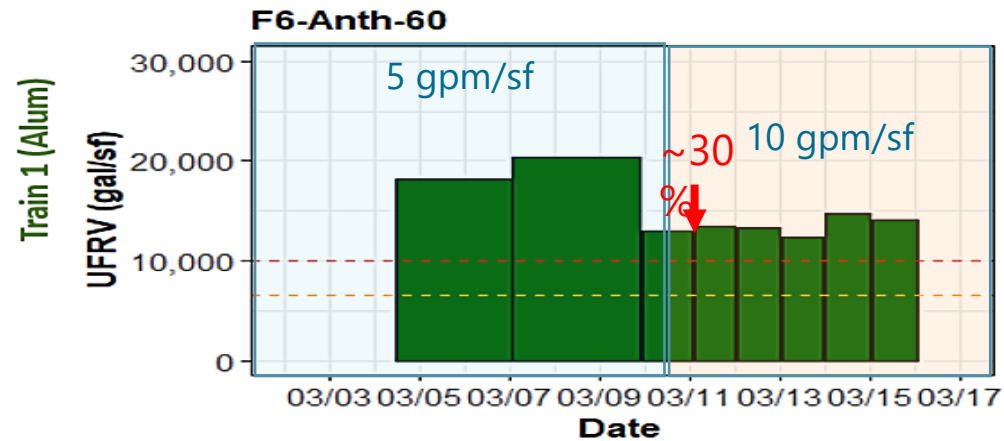
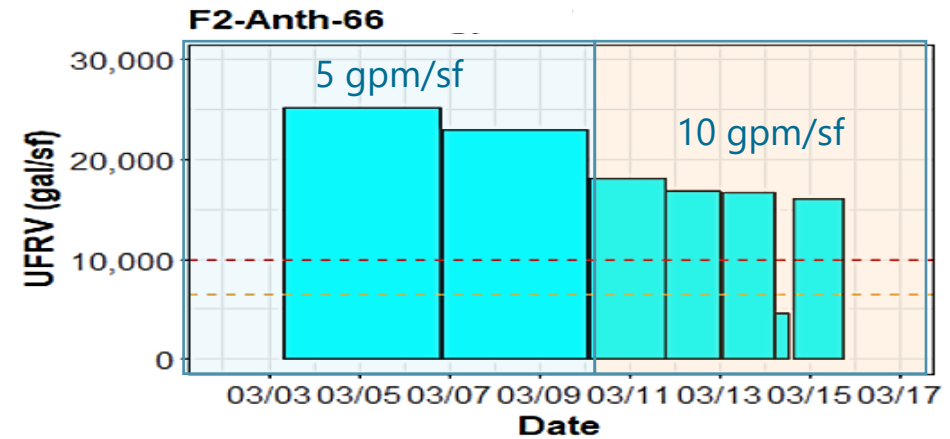
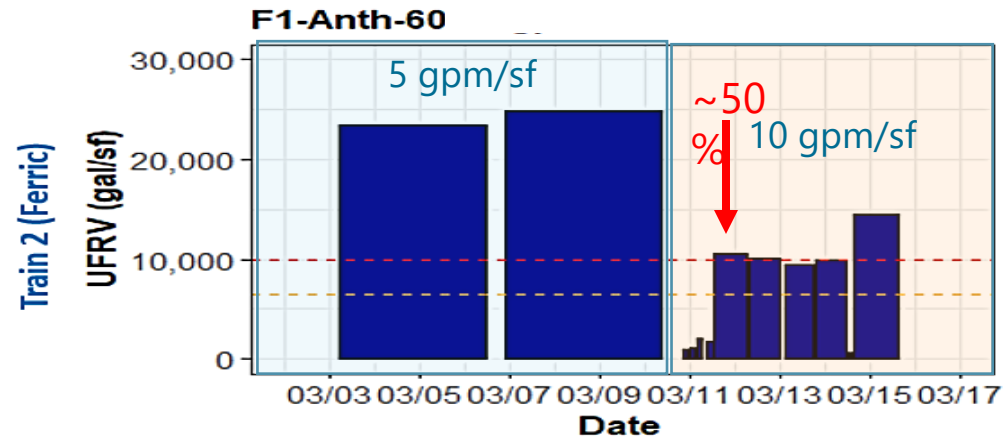


Short/Tight



Deep/Loose

5 gpm/sf vs 10gpm/sf – UFRV Performance



Short/Tight



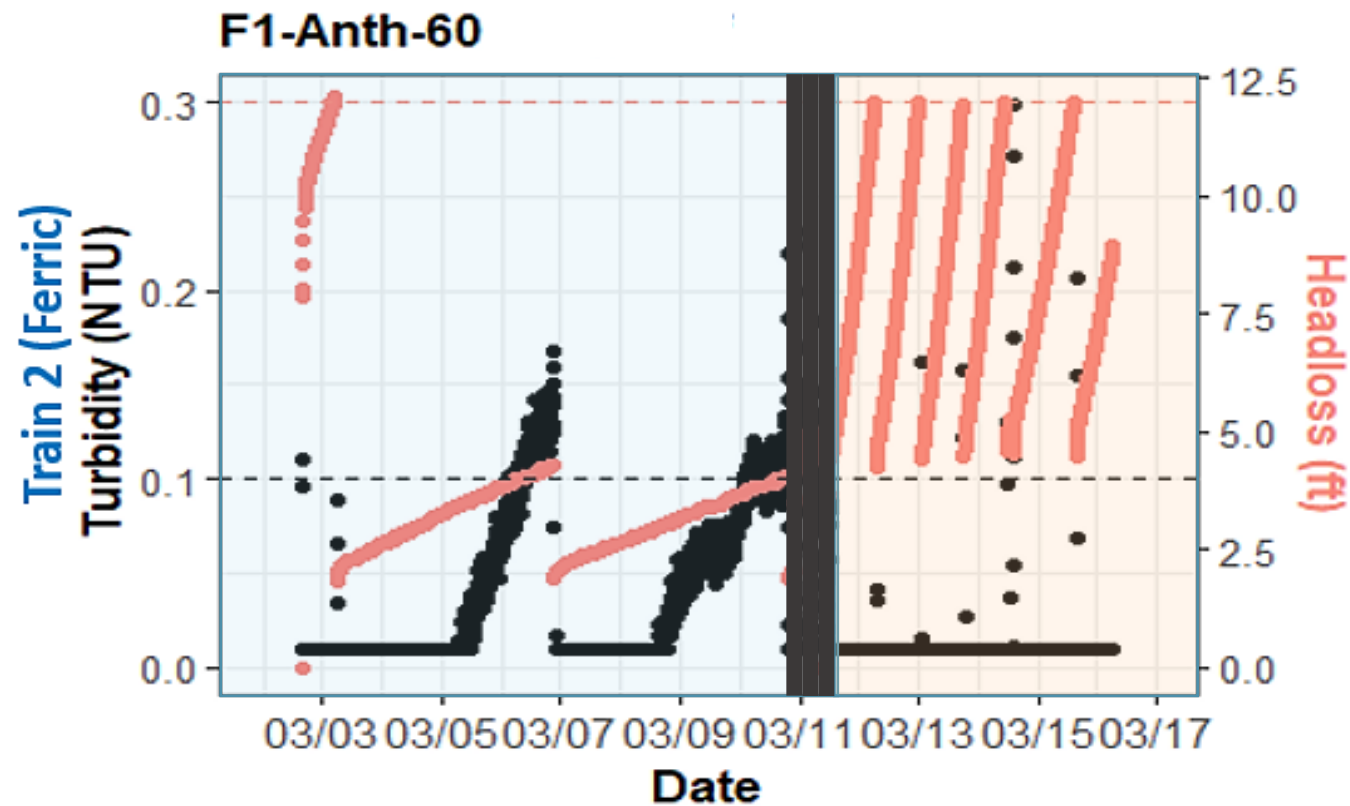
Deep/Loose

4. What are the effects of using filter aid on filter headloss and UFRV performance?

No Filter aid – Headloss Accumulation

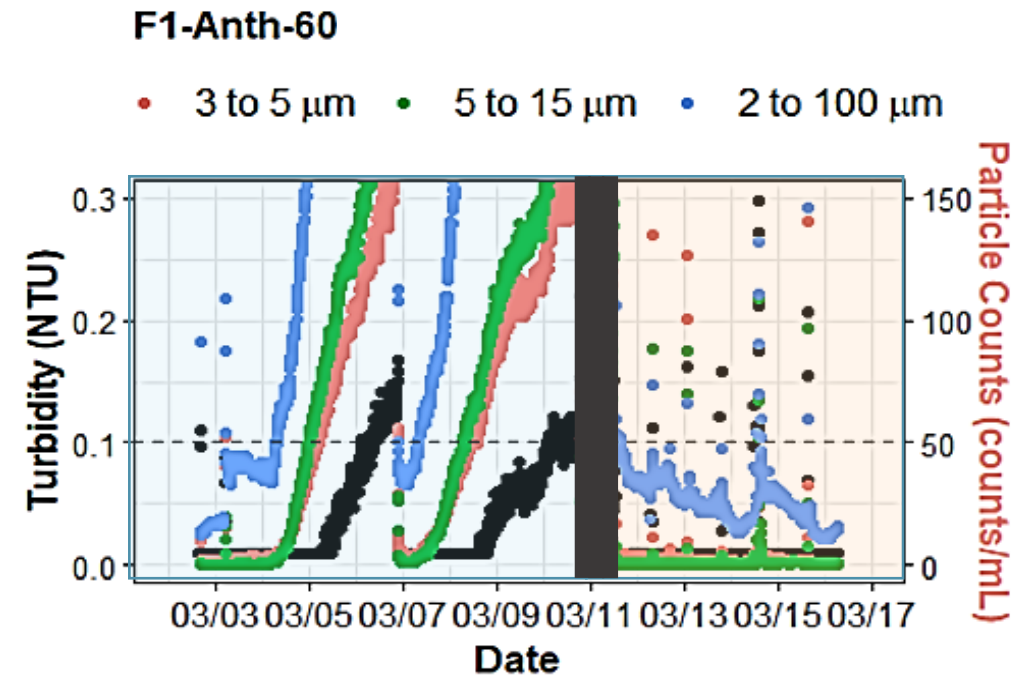
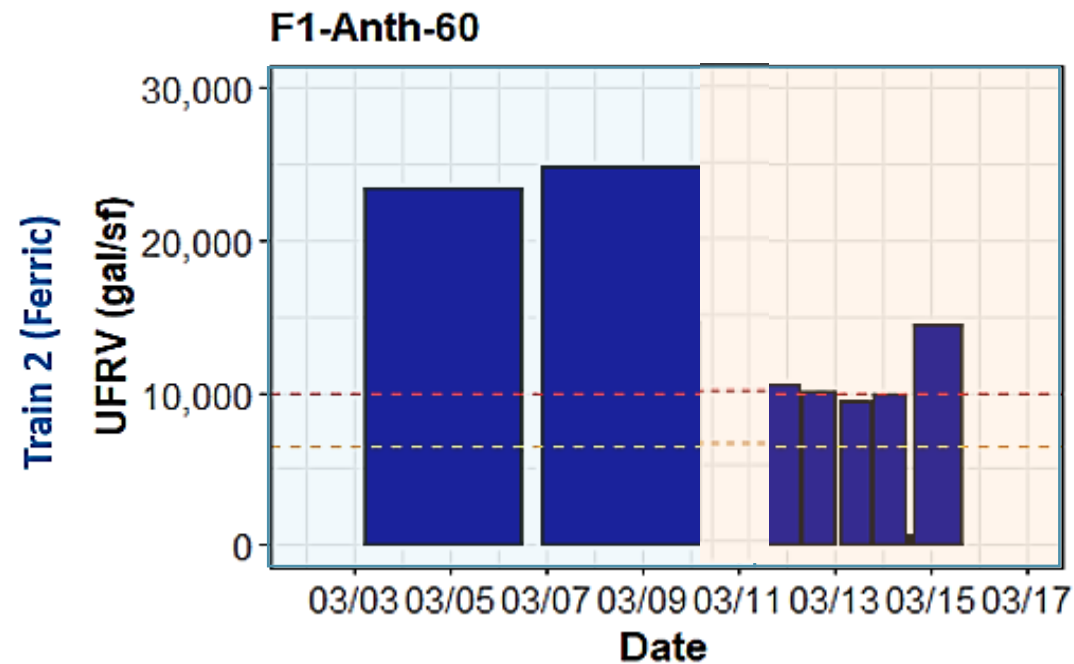
Rate

Without Filter Aid	With Filter Aid
5 gpm/sf	10 gpm/sf



No Filter aid – UFRV and Particle Control

Without Filter Aid	With Filter Aid
5 apm/sf	10 apm/sf



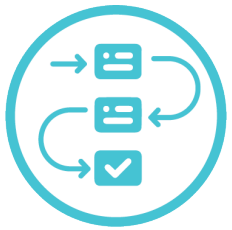
Lessons Learned



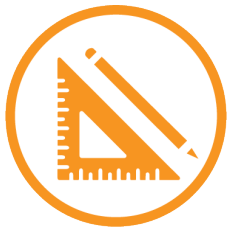
Summary & Lessons Learned

- ✓ 1. Headloss accumulation rate = measure of how much the pressure head is increasing across the filter column, with respect to time. And it is dependent on many factors, including:
 - ✓ Types of chemicals being used and the resulting zeta potential, filter flow rate, Temperature, Filter media configuration, type/dose of filter aid, filter backwash quality, Filter ripening.
- ✓ 2. Pressure head along the filter varies and can be a measure of how well the filter is performing.
- ✓ 3. The high 10 gpm/sf filtration rate has lower productivity than 5 gpm/sf.
 - ✓ Up to ~50% reduction in UFRVs in tighter media
 - ✓ Higher CBHL and shorter filter run times
- ✓ 4. Filter aid is needed to improved filter performance
 - ✓ Filter aid is required to control particles
 - ✓ Higher filter aid doses = higher headloss accumulation rate = lower Filter Run times = Lower UFRVs

On track to deliver filtered Bull Run water to customers beginning September 2027



**Planning
Completed
2018-2020**



**Design
Underway
2020-2022**



**Construction
Expected
2023-2027**



The Bull Run Treatment Projects will help keep our water **safe and abundant** for generations to come



**For our
health**



**For our
economy**



**For our
future**

Bull Run Filtration Pilot Team

Portland Water Bureau				Program Consultants		Design Consultant
Operations Treatment			Engineering	Resource Protection		
Water Quality <u>Yone Akagi</u> <u>Mac Gifford</u> <u>Anna Vosa</u> <u>Tom Krause</u> <u>Melanie Roy</u> Nadia Gillett	<u>Kimberly Gupta</u>	Water Quality Laboratory	Filtration Program		Brown and Caldwell <u>Lynn Stephens</u> <u>Damon Roth</u> Mia Vijanderan Bill Persich Joanie Stultz	Stantec/Carollo Patrick Carlson
	<u>Mojtaba Azadiaghdam</u> Kevin Cenicerros Steve Mauter Rick Norris James Carter Simon Kalpin Tim Anderson Gam Thiramoke John White	Sandy River Station	<u>Lyda Hakes</u> <u>Humberto Piedra-Ruiz</u>		Technical Advisory Committee Issam Najm Mark LeChevallier	
					Intuitech Brock Emerson Bryant Law Andrew Buchanan	

Questions?

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Bull Run
TREATMENT
PROJECTS

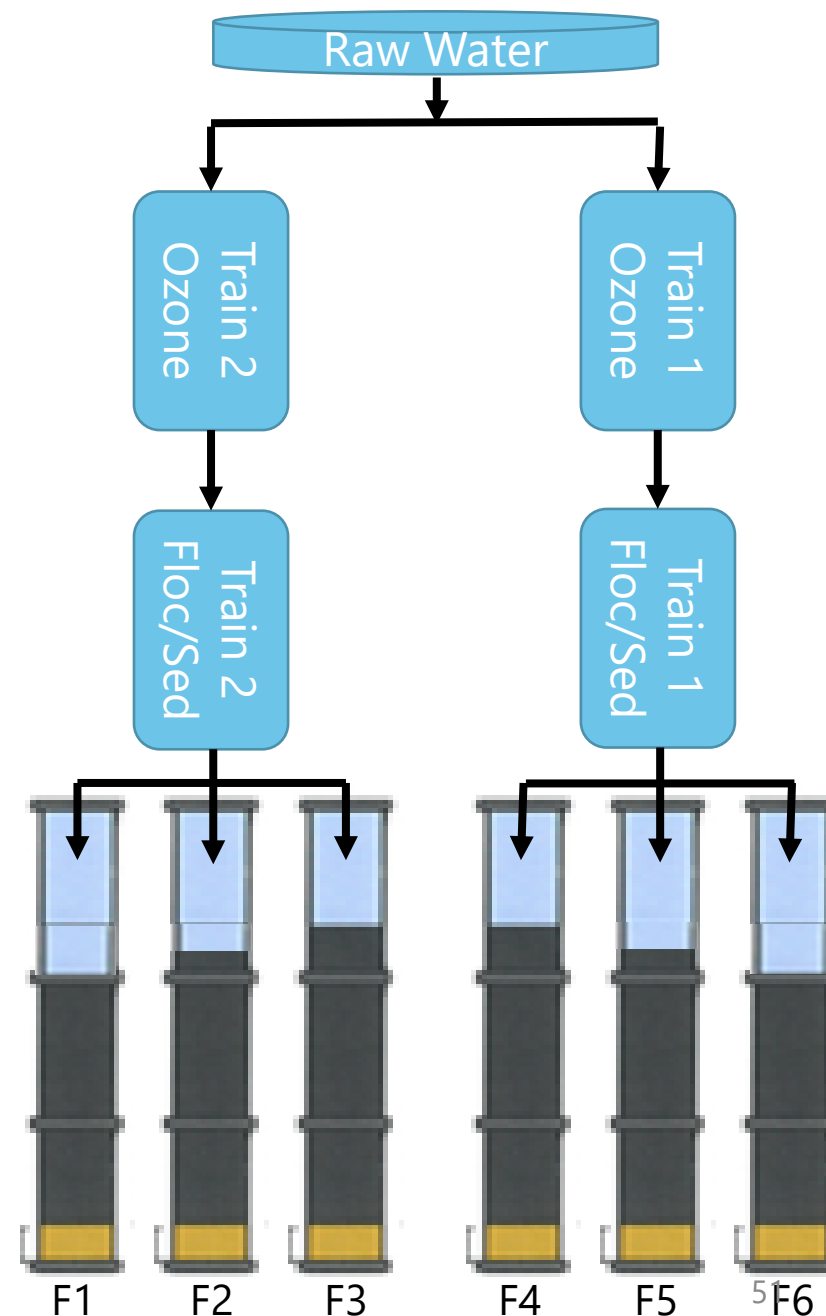
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for generations to come*

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Thank you!

✓ Filter configuration

Dual media filter configurations	Anth-60	Anth-66	Anth-72
Filter location	Filters 1, 6	Filters 2, 5	Filters 3, 4
Top layer filter media design			
Media type	Anthracite	Anthracite	Anthracite
Depth (in.)	48	54	60
Effective size (mm)	1.05–1.15	1.15–1.25	1.25–1.35
Bottom layer filter media design			
Media type	Silica Sand	Silica Sand	Silica Sand
Depth (in.)	12	12	12
Effective size (mm)	0.50–0.60	0.55–0.65	0.60–0.70
Total filter media design			
L/d ratio	1,660	1,650	1,640
Total depth (in.)	60	66	72



Ergun Equation for pressure drop along the length of the packed bed

$$h_L = K_v \frac{(1 - \varepsilon)^2}{\varepsilon^3} \frac{\mu L v}{p_w g d^2} + K_i \frac{1 - \varepsilon}{\varepsilon^3} \frac{L v^2}{g d}$$

Variable	Description
K_v	Headloss coefficient for viscous forces
K_i	Headloss coefficient for inertial forces
ε	porosity
μ	dynamic viscosity of water
p_w	density of water
g	acceleration due to gravity
L	length of column
v	filtration rate
d	media diameter, effective size