CITY OF MINNEAPOLIS

Adventures at Fridley Filter Plant: Converting from Anthracite to GAC. Lessons learned and much, much more!!

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Minneapolis
City of Lakes

mpls

Today's topics

- General overview of treatment process
- Rehab of the 1925 filter plant
- Operations results
  - New disinfection flexibility
  - Granular Activated Carbon filters (biologically active)
  - Strange biological activity
  - More strange biological activity
- Questions

Minneapolis Water

Source water
Mississippi River

Max capacity
140 MGD

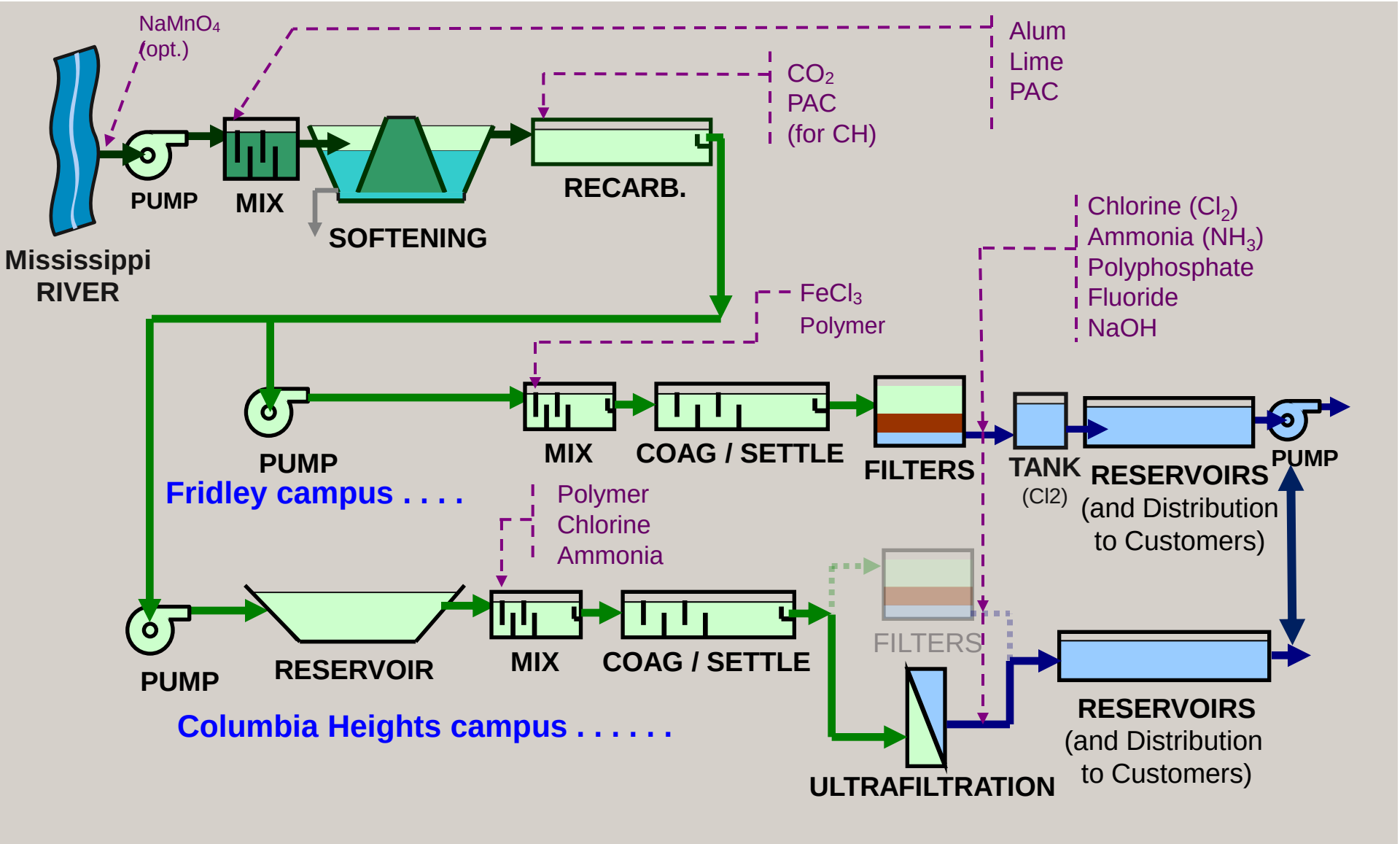
Average rate
55 MGD

Annual production
19.8 billion gallons

24/7 365 operation

Fridley Campus

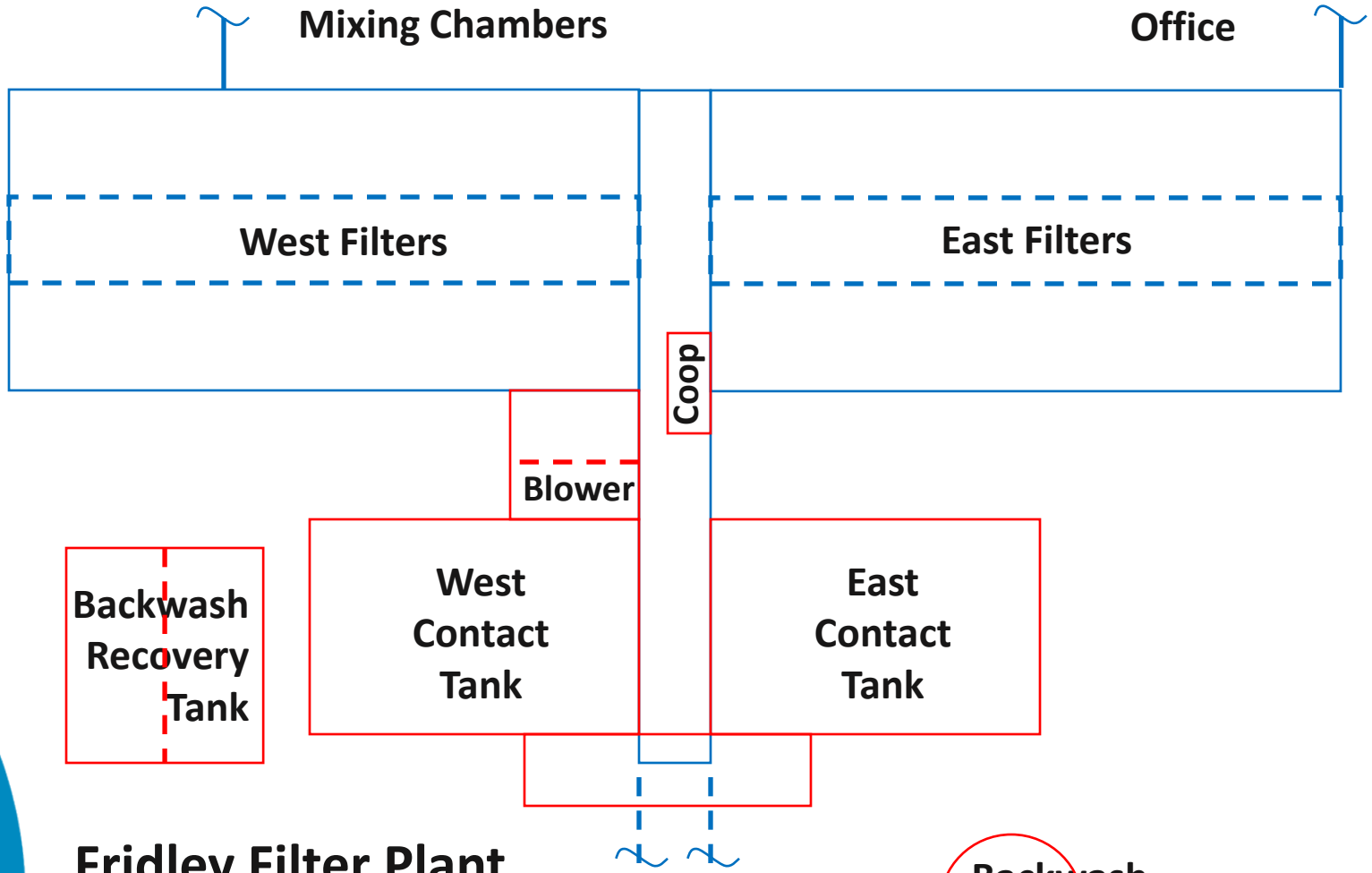
MWW Treatment System - 2025




Fridley Filter Plant
Constructed in 1920’s

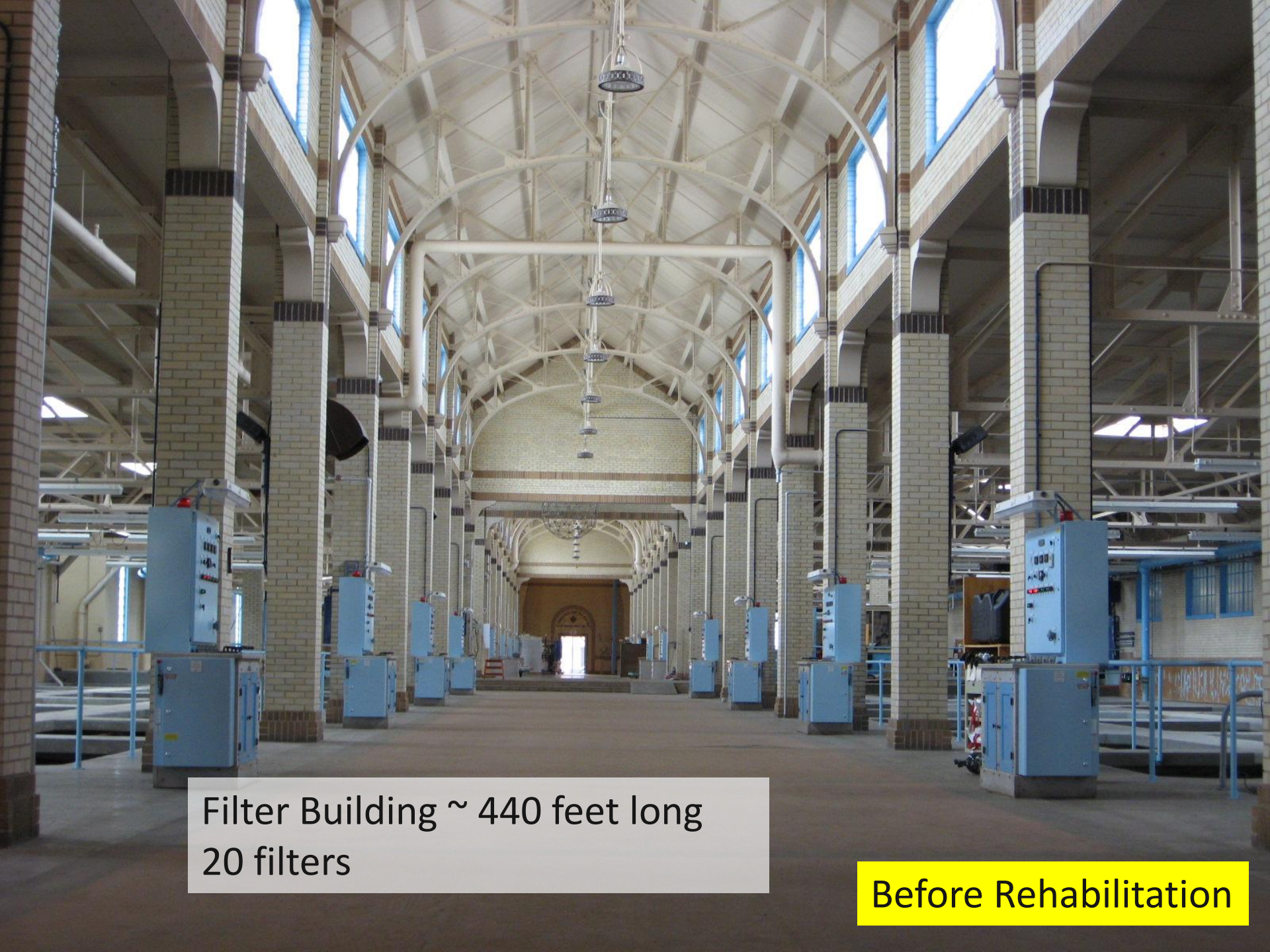
Project “at a glance”

- Reconstruct filters
  - Opportunity to abate asbestos and lead paint
- Add Granular Activated Carbon media
- Add air scour to clean filters
- Add filter to waste
- Remove and replace pipes in gallery
- Contact Tanks (disinfection flexibility)
- Backwash supply tank
- Backwash water recovery system



Fridley Filter Plant Rehabilitation

Backwash Supply Tank


Filter Building ~ 440 feet long
20 filters
Before Rehabilitation

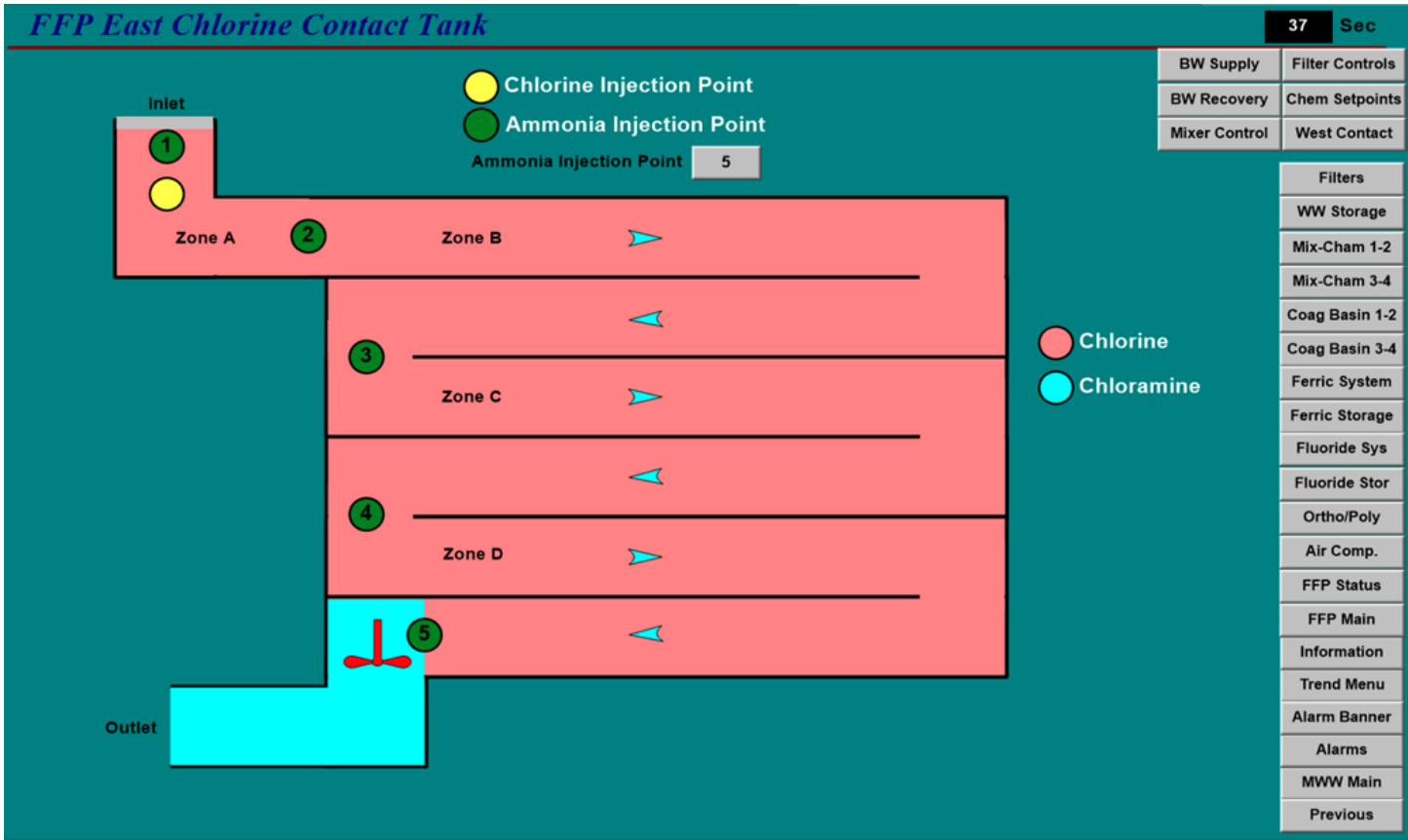

AIR SCOUR
AIR SCOUR
VAV
RELIEF VENT FOR

East GAC filters online in 2020

- West filters taken offline for construction
  - 2022
- New Backwash recipe
- New operational procedures for filters
- No prefiltration disinfection
  - Lost roughly 8 hours of chloramine contact time
- New contact tanks provide flexibility for varying free chlorine contact time from 30 seconds to 45 minutes

New operational flexibility

- Increase free chlorine contact time to increase CT
- Switch to ammonia pass 3-5
- Tanks built to address specific scenario



Water main break floods downtown Minneapolis

Brandt Williams MINNEAPOLIS January 3, 2013 7:46 PM

Listen *Water main break floods downtown Minneapolis*

Share

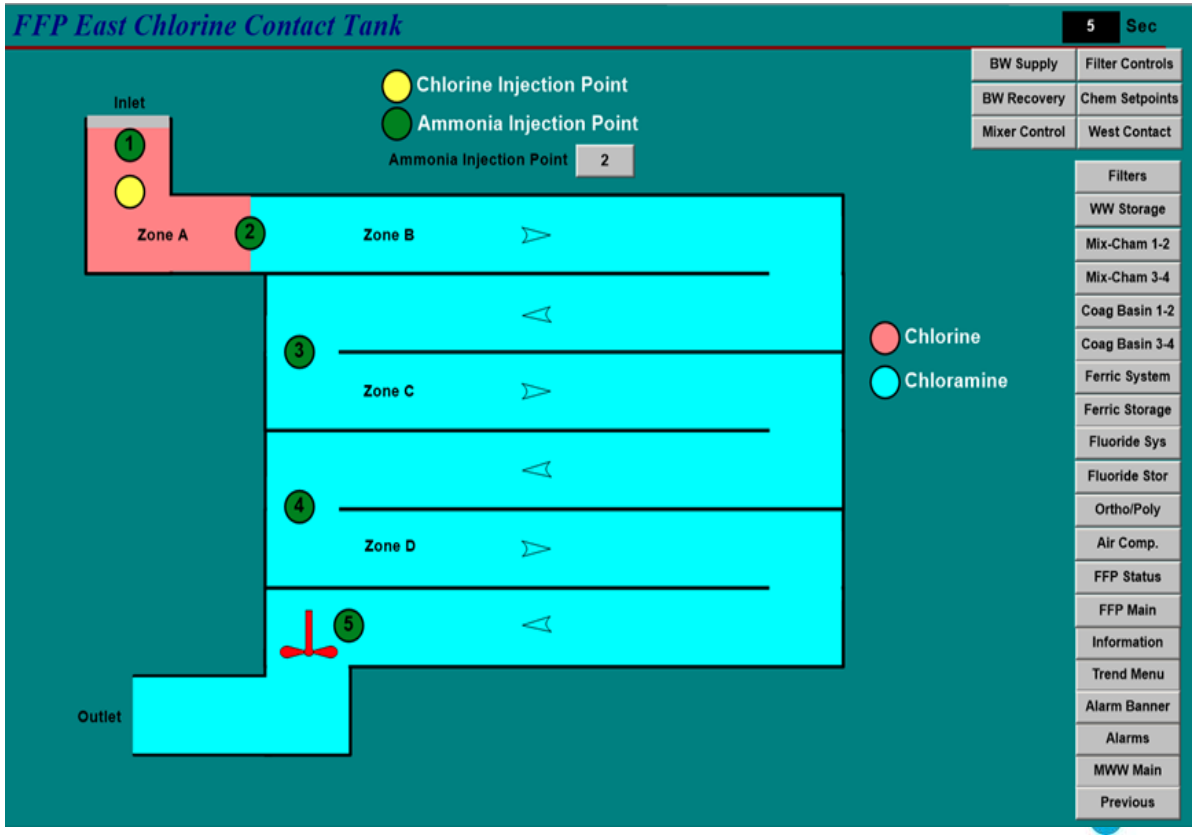
City officials say a private contractor working to build a

where city officials say the

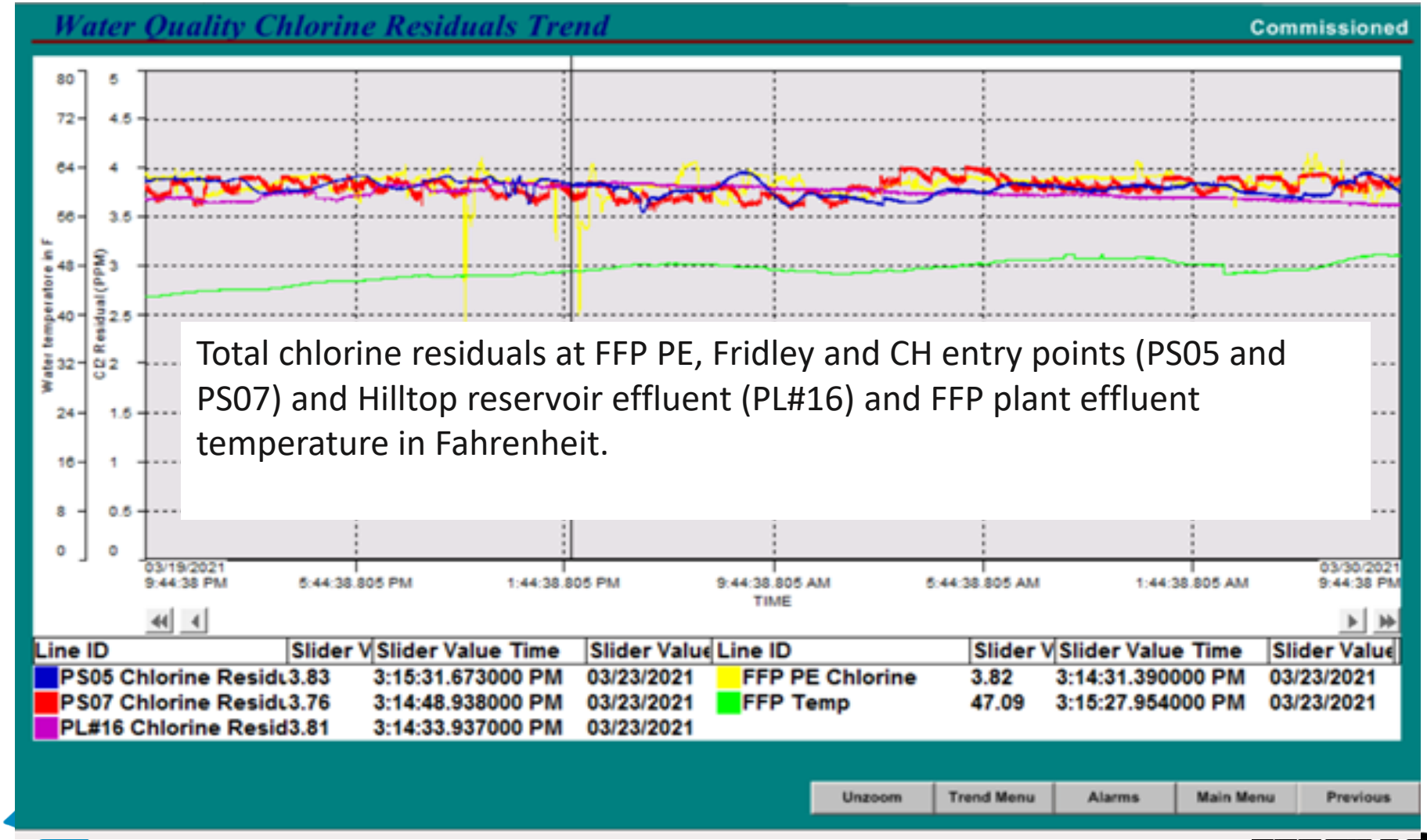
‘Normal’ summer/fall disinfection

- Water is warming up and the CT with it.
- We want to reduce free chlorine to minimize the formation of DBPs.

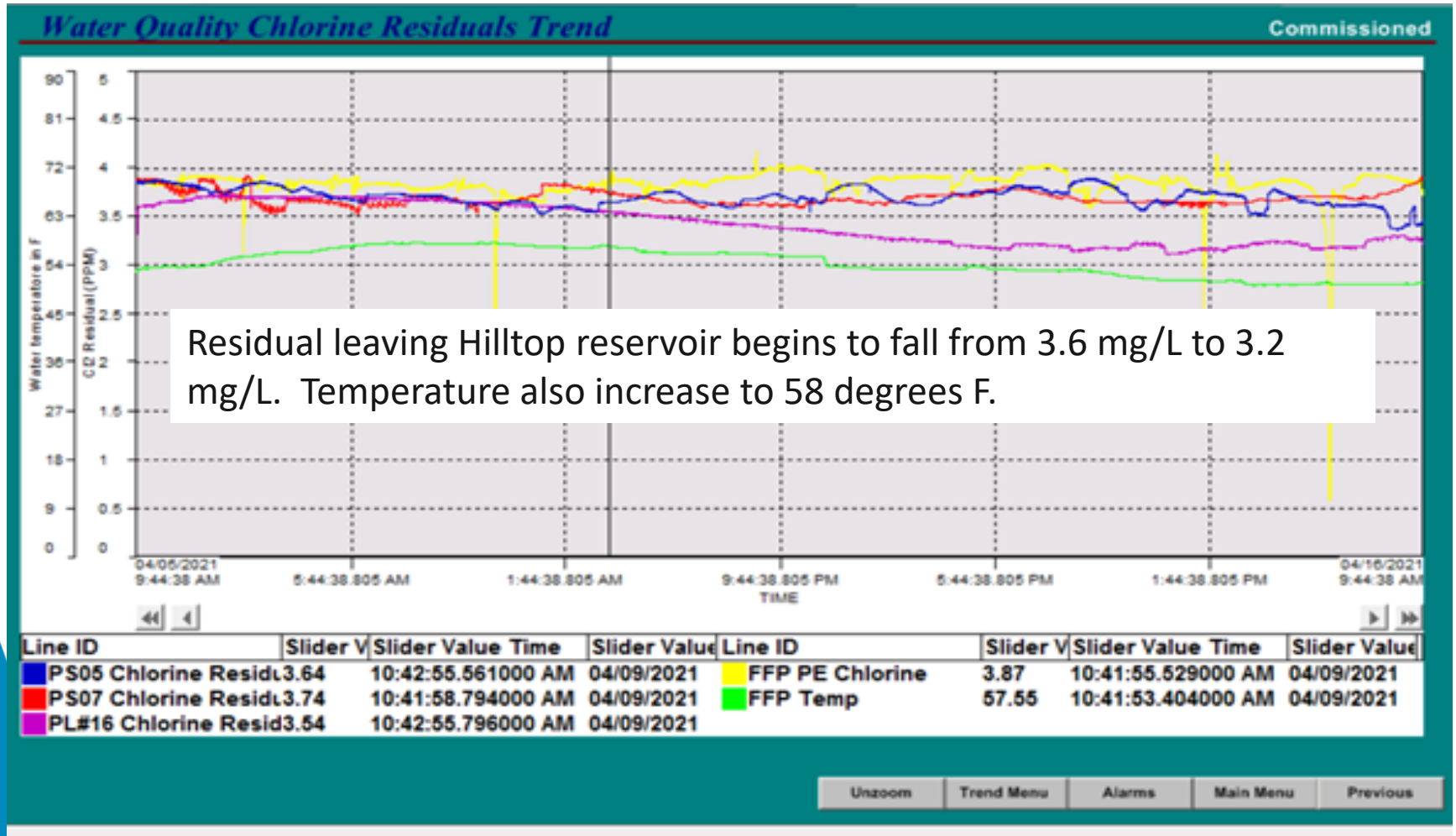
Year one, no issues with new filters!



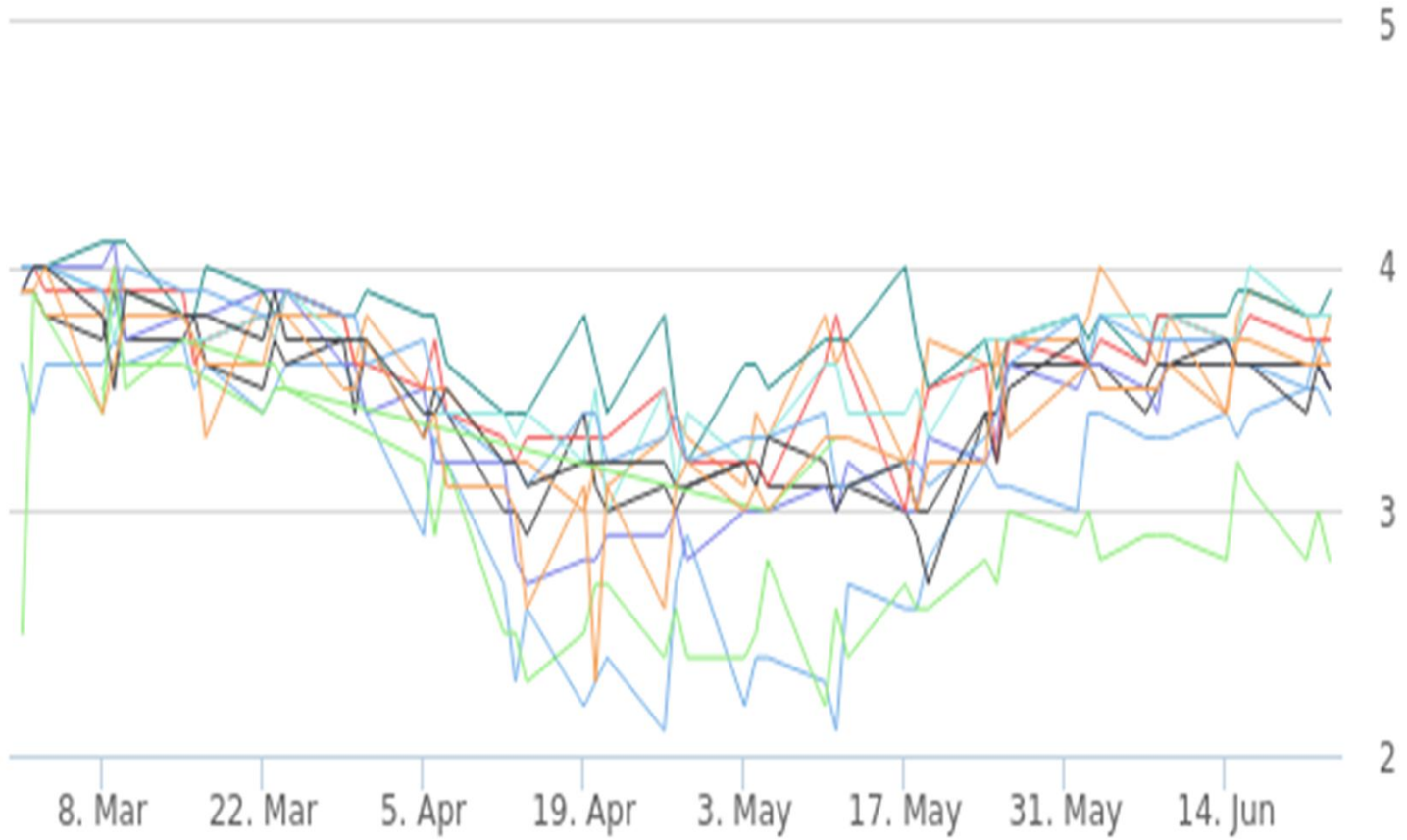
Spring of 2021 and all is well



Residual decay begins…



In early April, the residuals also begin to dip in the distribution system.



The investigation begins…

- Conducted SDS on EP water and determined decay isolated to FFP. CH water was fine.
- Residual would drop 0.5 mg/L in less than 24 hours and over 1.5 mg/L in 4 days but would stop at approximately 2.0 mg/L and remain stable.
- Analysis of water showed no nitrification or over/under feed of ammonia and chlorine. Ratio was just under 5.0.

	Analyte	PS5	PS7	PS8
4/26/2021	Chlorine	3.5	3.4	3.6
	pH	9	8.97	8.97
4/27/2021	Chlorine	3.05	3.2	3.5
	pH	8.89	8.88	8.84
4/28/2021	Chlorine	2.6	3	3.3
	pH	8.81	8.87	8.81
4/29/2021	Chlorine	2.25	2.9	3.3
	pH	8.78	8.86	8.79
4/30/2021	Chlorine	2	2.75	3.1
	pH	8.74	8.84	8.79

What was the cause?

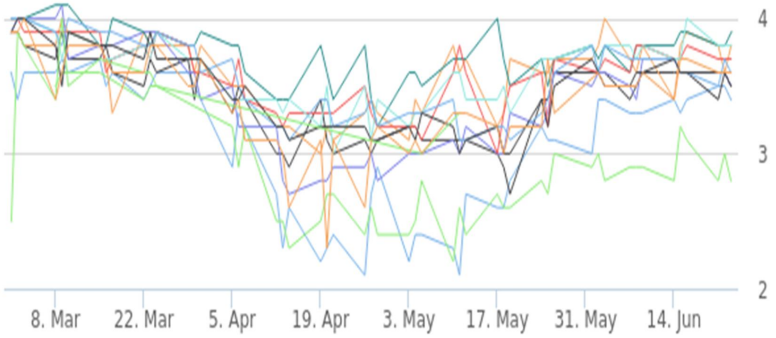
- River remained fairly constant
- Only variables were temp and GAC filters
- Filtering PE sample through a 0.2 micron filter and conducted a SDS - did not have the dramatic decay

Getting closer to solving the problem.

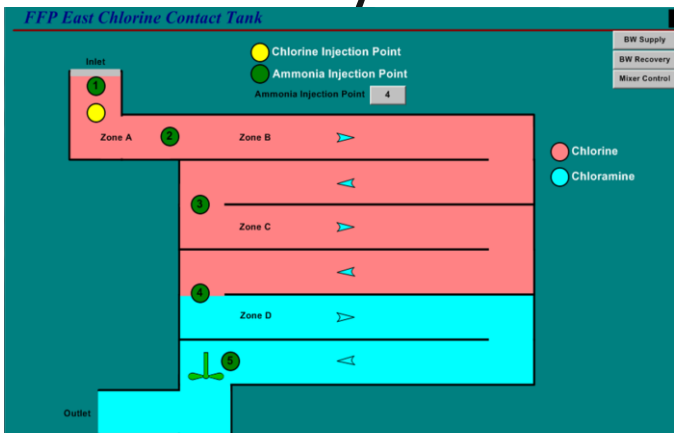

Plant conversion experience:
ozone BAC process installation
and disinfectant residual control

- Turned to Google and a utility in FL had the same issues when they switched from anthracite to GAC and fortunately they had several grad students investigate the cause.
- Solution was to increase free chlorine contact time to oxidize excess extracellular material sloughing off the microorganisms
- Interesting that this did not show up the previous summer and that the bioactivity was low based on DO readings and water temp

Problem solved

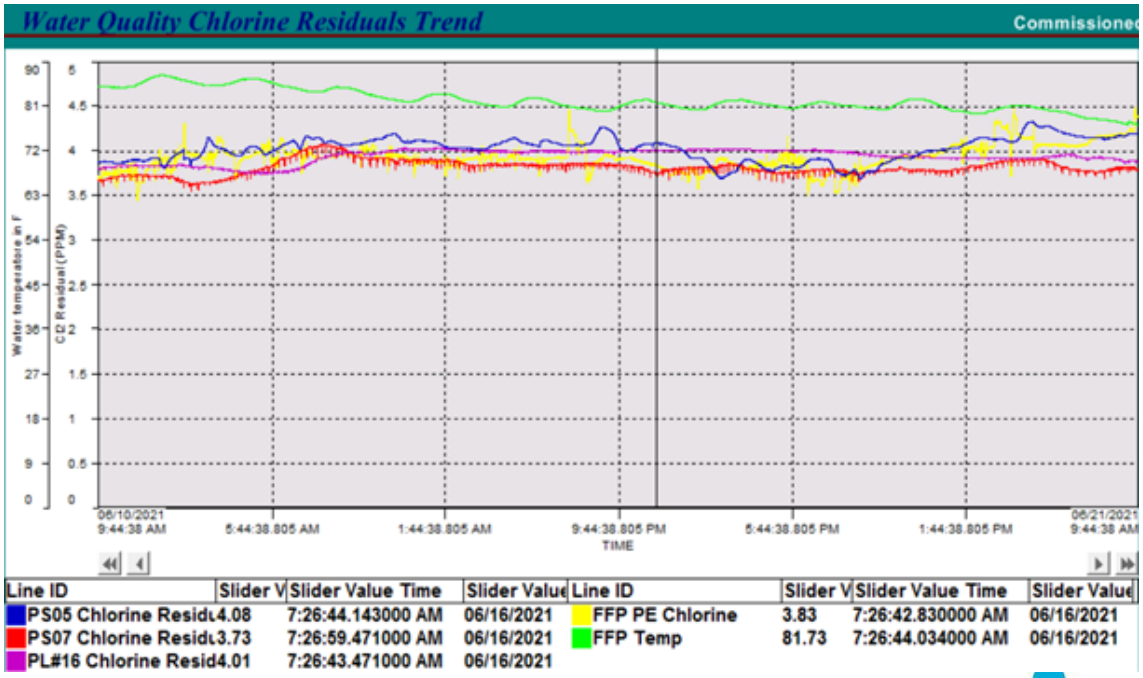


- On 5/12 we switched to pass 4 for 2hrs = 12 minutes of free contact time
- On 5/13 same test but pass 3 = 6.5 minutes then returned to pass 2
- Ran 7 day SDS on both
- Pass 3 showed minimal residual decay, compared to full scale paired sample which showed a decay of 1.5 mg/L over same period



Problem solved

- Switched to pass 3 on May 17th
- DBP (TTHMs) did increase but never went over 30 ug/L
- Residual stabilized in reservoirs and in the system
- On June 24 switched back to pass 2 and had no more decay issues.



Well not really...

- Fall of 2021 had the same problem of residual decay
- Switched to longer free chlorine contact time
- Continued well into summer. Switched to pass 3 on June 28, 2022
- In November of 2022 switched to pass 4 to address decay and pass 5 in December
- Thought the bugs weren't active in winter??

New wrinkle...AOB

- In early Feb 2022 we noticed an uptick in chlorine demand from the East filters which went on line in 2020.
- We typically see river ammonia (0.05-0.10 mg/L) when it freezes over - Dec. to Feb.
- Despite water temps in the low 30's, AOB were converting the river ammonia to nitrite
  - Not a big issues except it was interfering with the oxidation of the extracellular polymeric substances (EPS)

Winter biological activity?

- Very manageable problem (if you have free chlorine contact time)
- Slight increase in chlorine demand to oxidize nitrite
  - 5 to 1 chlorine to nitrite ratio, quick reaciton
- We do not see nitrification in the distribution system in cold water but apparently do see it in the GAC filters during cold water

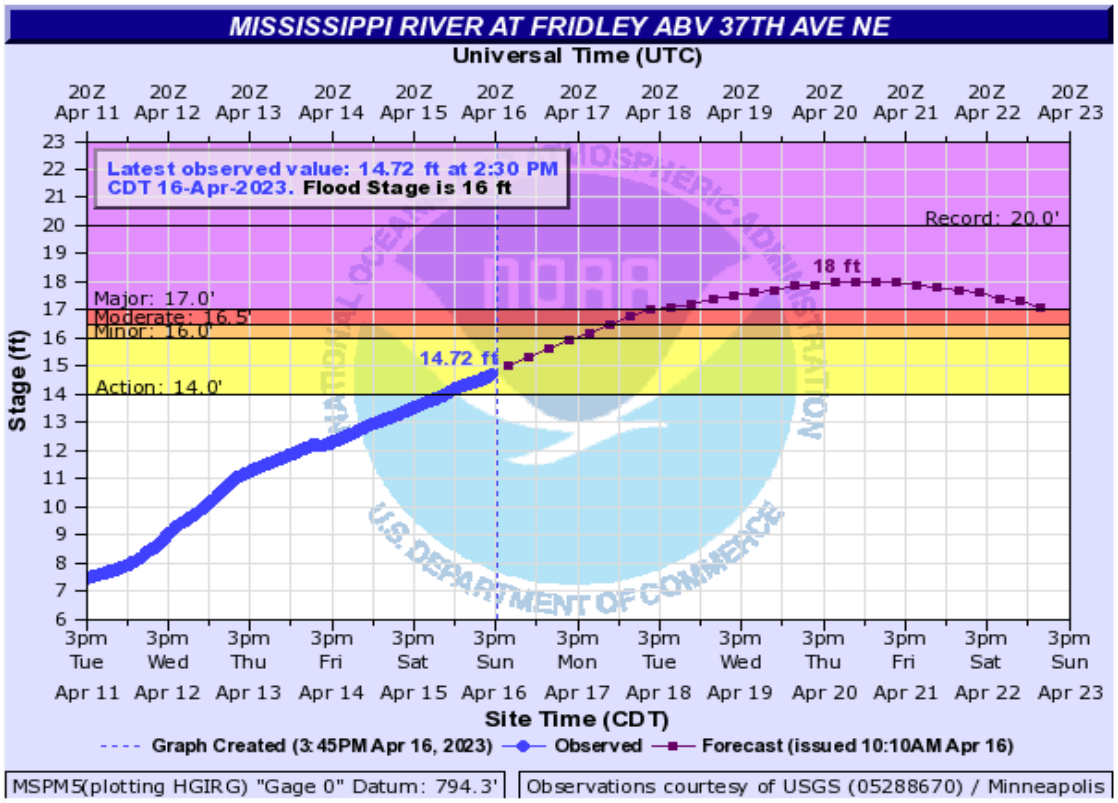
Time for some outside help

- U of MN enlisted to help identify what is going on.

- Water samples for monitoring of microbiological water quality indicators (HPC, coliforms, total bacteria, DNA sequencing, ATP) analysis of ammonia, nitrite, nitrate, total organic carbon (TOC), DOC, and UV absorbance at 254 nm (UV_{254}). Additional water samples will be placed in clean glass bottles for analysis of ammonia, nitrite, and nitrate.
- Real-time quantitative polymerase chain reaction (qPCR) will be used to detect and quantify at least four genes of interest as described previously (Dionisi et al., 2002; Harms et al. 2003; Meinhardt et al. 2015; LaPara et al., 2011). The 16S rRNA gene for *Bacteria* will be used to quantify total bacterial biomass. Three genes target organisms associated with nitrification: the ammonia monooxygenase gene for ammonia-oxidizing *Bacteria* (*amoA*-AOB), the ammonia monooxygenase gene for ammonia-oxidizing *Archaea* (*amoA*-AOA), and *Nitrospira* capable of complete ammonia oxidation (comammox).
- EPS will be extracted from the BAC media and characterized with regard to proteins, polysaccharides, and humic acids. The filter media samples after ATP measurement, DNA extraction, and EPS extraction will be measured and used to normalize the ATP, qPCR, and EPS results for comparison with other biofiltration studies.

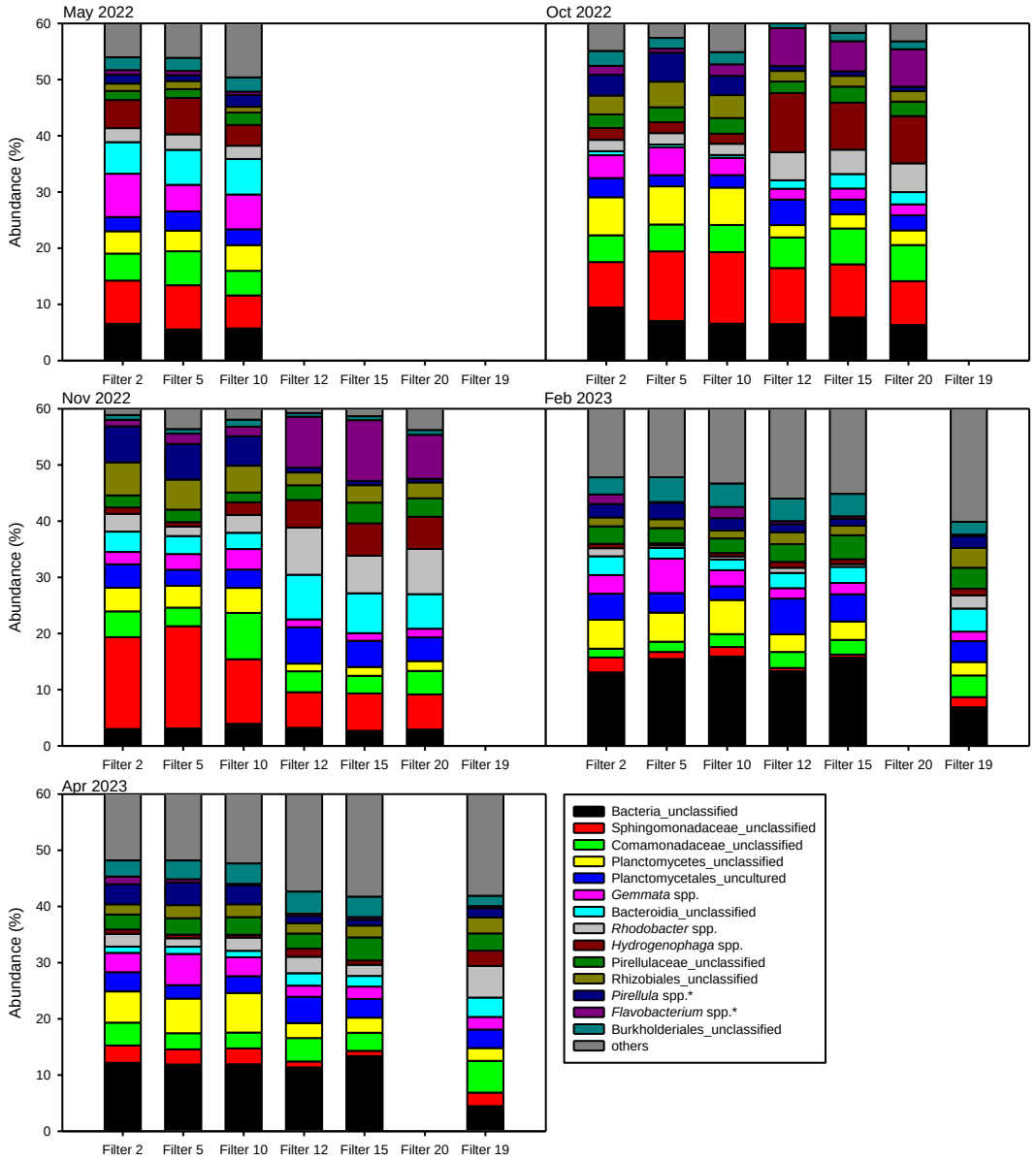
U of M

- Sampling began in May 2022
- Capture fall, winter and spring conditions
- Last round of sampling was during runoff in April 2023

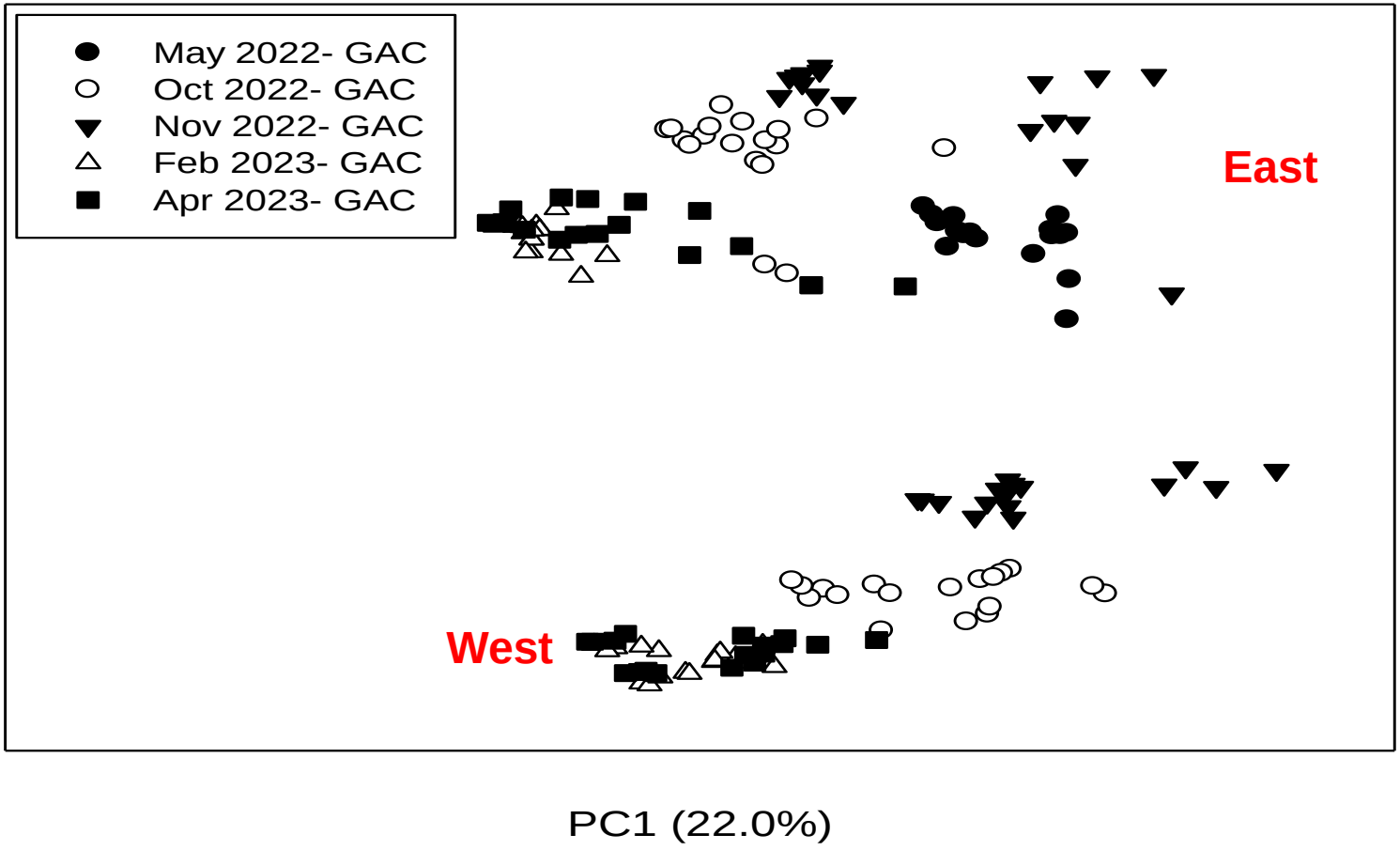


Community Composition on Filter Media

Sampled May, Oct, Nov of 2022, Feb and April of 2023



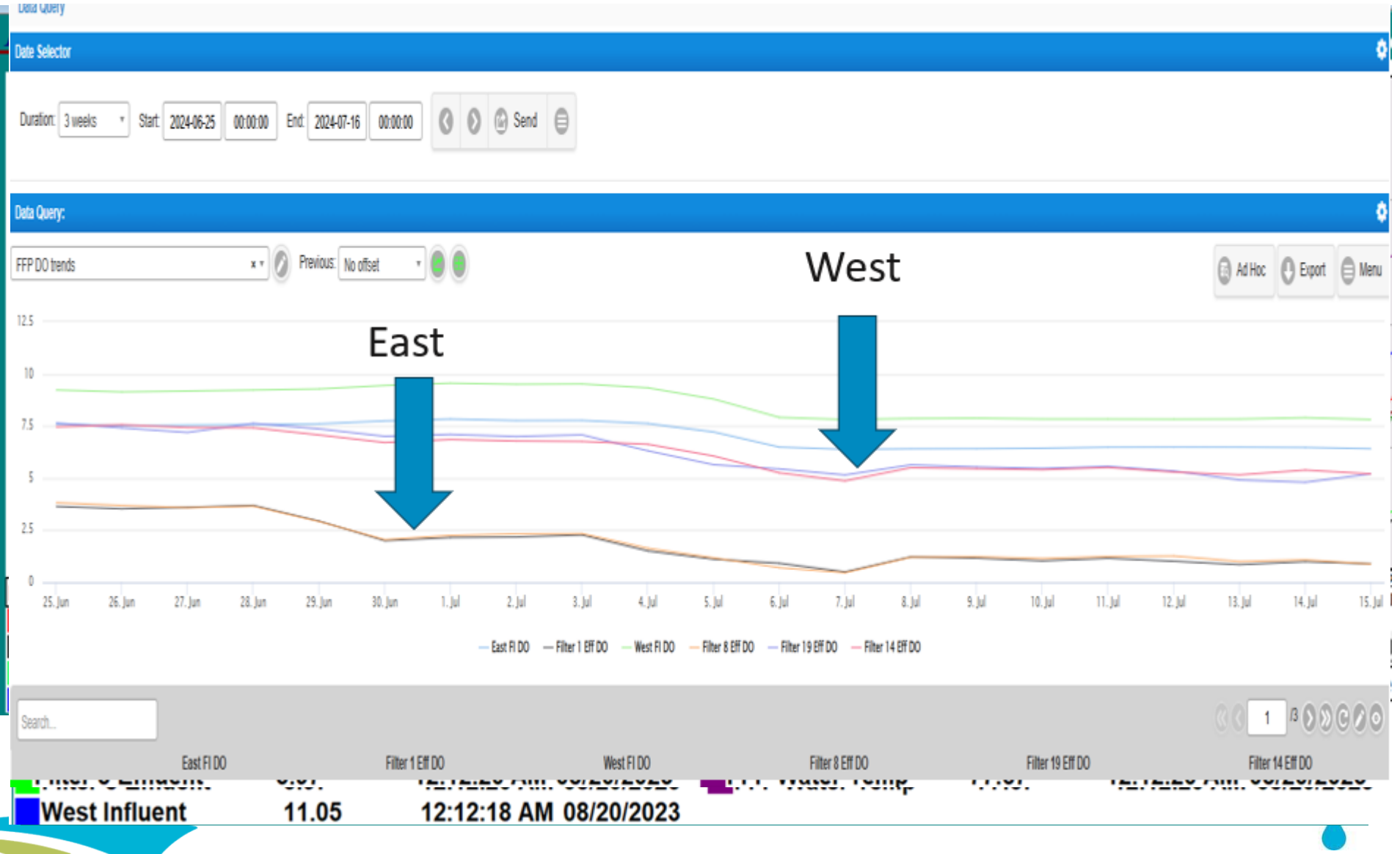
Microbial communities over time May 2022 to April 2023



U of M found biological community differences between E and W filters

- Research says GAC filters become active in weeks to months
- But when do they reach a steady state (bug hotel filled up)?
- Looks like 2 years for our East filters.
- How do we know?

2020-2024 July-August DO trend



East bugs vs. West bugs

- Helps explain why we saw a greater chlorine demand (and faster residual decay) on the East filters than the West
- In 2024 able to keep West effluent on pass 4 vs pass 5 for East - 6 minutes less of contact time to achieve same result
- But then something else happened – unexpected massive residual decay in the **summer** in our wholesale customer's distribution system

Residuals in our system seemed fine…

July to September weekly trend of TCR sites

Wholesale customers notice a drop

- Received calls from Golden Valley staff about lower than normal residuals in their system
- Called Bloomington and they were noticing it as well

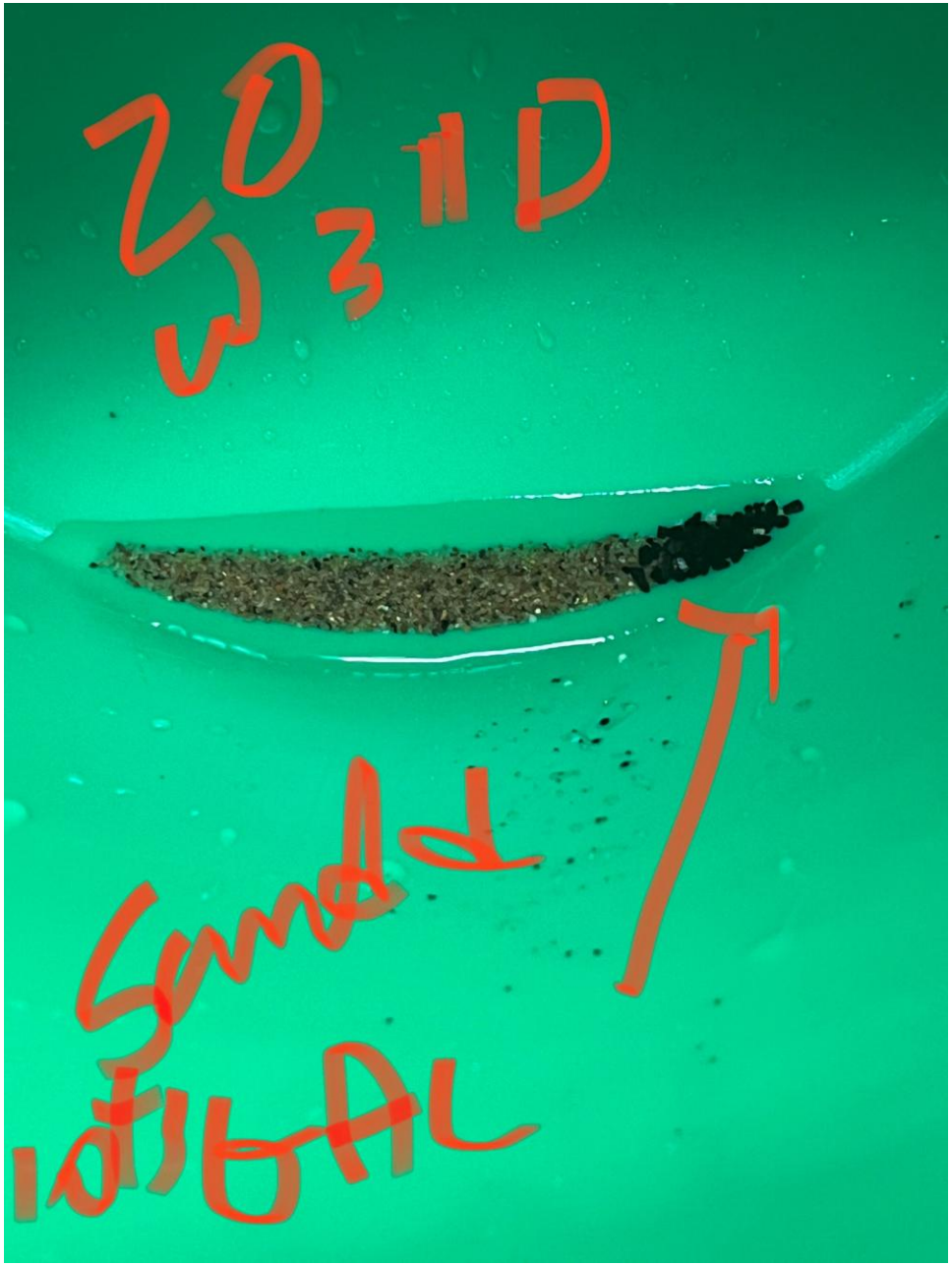
Another mystery

- We were stressing FFP to try to force underdrain failures
- Noticed filter media in effluent piping during startup of West filters in 2022
- Only seeing it when filtration rate was 2.5 gpm/sqft or higher
  - Normal rate is 0.8 gpm/sqft
- Fall of 2023 stressed 6 filters and in July of 2024 stressed the rest. Finished in late Sept

How do you stress a filter?

- Would run 3 filters on each side at a minimum rate of 3.0 gpm/sqft for 3 complete BW cycles
- Check the 3” drain valves and media traps for sand and GAC.
- Document and move to the next filters
- Rates did not allow for testing more filters

3-inch drain


20
3 11 D
Sand

Media trap

Back to the decay…

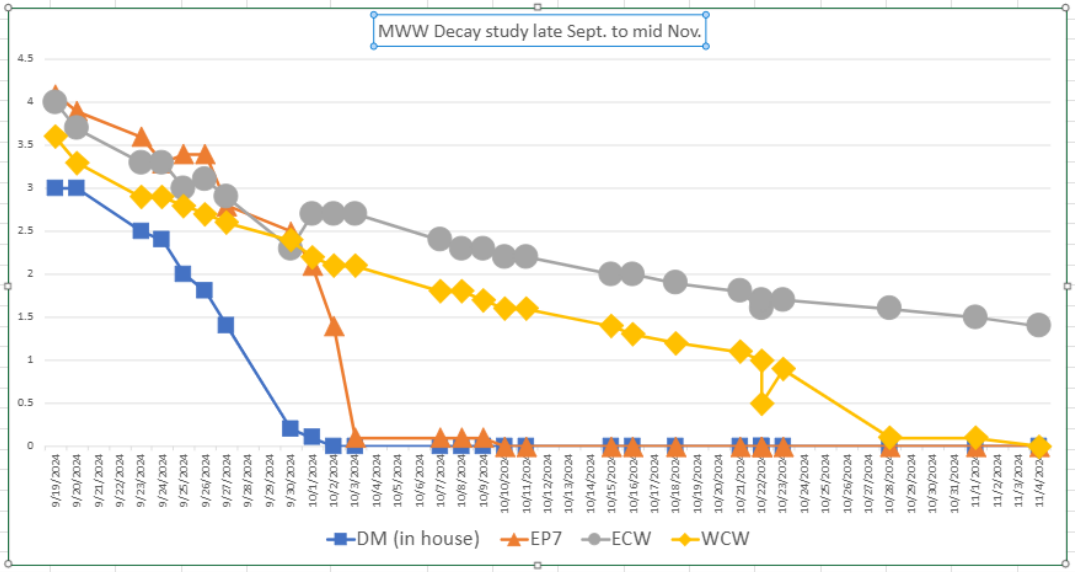
- Theory was that the increased rate through the filter was causing more extracellular material to shed from the filter thus increasing the demand on the chloramine residual.
- Chloramines being what they are took a long time (over a week) to oxidize or breakdown the materials which is why we didn't see it in our system
- Increased PE total chlorine residual at FFP to compensate for residual crash

More SDSs from EP and PEs

- Looked at water from the Fridley campus and the Columbia Heights campus since we blend the two
- Decay from Fridley campus started to decrease but still continued from CH campus
  - Water age is significantly higher from CH campus due to more onsite storage
- Adjust SDS to hold samples longer from Fridley campus to account for this

Lots of testing with mixed results

Sample	Lab Test Date	Cl2 (mg/L)	pH	Date Colleted
DM (in house)	9/19/2024	3		9/18/2024
EP7	9/19/2024	4.1		9/18/2024
ECW	9/19/2024	4		9/18/2024
WCW	9/19/2024	3.6		9/18/2024
DM (in house)	9/20/2024	3		9/18/2024
EP7	9/20/2024	3.9		9/18/2024
ECW	9/20/2024	3.7		9/18/2024
WCW	9/20/2024	3.3		9/18/2024
DM (in house)	9/23/2024	2.5		9/18/2024
EP7	9/23/2024	3.6		9/18/2024
ECW	9/23/2024	3.3		9/18/2024
WCW	9/23/2024	2.9		9/18/2024
DM (in house)	9/24/2024	2.4		9/18/2024
EP7	9/24/2024	3.6		9/18/2024
ECW	9/24/2024	3.3		9/18/2024
WCW	9/24/2024	2.9		9/18/2024
DM (in house)	9/25/2024	2		9/18/2024
EP7	9/25/2024	3.3		9/18/2024
ECW	9/25/2024	3		9/18/2024
WCW	9/25/2024	2.8		9/18/2024
DM (in house)	9/26/2024	1.8		9/18/2024
EP7	9/26/2024	3.4		9/18/2024
ECW	9/26/2024	3.1		9/18/2024
WCW	9/26/2024	2.7		9/18/2024
DM (in house)	9/27/2024	1.4		9/18/2024
EP7	9/27/2024	3.4		9/18/2024
ECW	9/27/2024	2.9		9/18/2024



Samples collected 9-5-2024 | Samples Collected 9-6-2024 | Samples Collected 9-13-2024 | Samples collected 9-18-2024 | Samples Collected 9-24-24 | Samples Collected 10-2-24 | Samples Collected 10-8-2024

SDS studies galore

- 11 SDS studies
- Both EPs, all PEs, reservoir effluents
- Eventually stretched out tests for 2 months and longer
- East filter residual held on longer that the West filters
  - Strange because the East had more bioactivity
- Things returned to baseline in late fall in 2024

Answers?

- Still looking for them!
- Will start running SDS in June to see what we see but do not plan on stressing the filters (maybe) to duplicate last year's issues
  - We will filter samples this time!
- Participating in WRF 5254: Evaluation and Demonstration of Biotechnological Tools and Methods for Improving Biofiltration Operation and Optimization
- Also looking at Advanced Oxidation Process with the U of M in 2025
  - Will ozone allow for extended chlorine contact time in warm water? Pretty sure yes

Take home points

- Filters produce awesome water 0.02-0.04 NTU
- Biological problems are manageable
- Free chlorine contact time is critical for our water if we want to maintain a good distribution residual
- GAC filters are not plug and play, at least not for our source water
- Monitoring in the distribution system is key
- Unexpected issues will arise, be ready for them!!

Questions?

mpls