

Water Quality at the Millville Elementary School

Presented to the Town of Millville Board of Selectmen

August 14, 2023



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Topics

*What was
not an emergency
is now over*

- Introduction
- MES water quality + treatment
- Water quality history (Fe, Mn, color, DBPs)
- Moving forward – new operations and engineering team
- So what happened?

Water Compliance Solutions, LLC



Richard W. Gullick, PhD

University	Major	Degree	Year
Michigan State University	Environmental Science	B.S.	1980
University of North Carolina at Chapel Hill	Environmental Management and Protection	M.S.P.H.	1983
The University of Michigan	Environmental Engineering	PhD	1998

- Water industry executive, manager, scientist, operator
- Licensed drinking water treatment operator (MA, RI, VA, NJ)
- Experienced with large and small water systems
- Started assisting Millville in Fall 2019

Work History after PhD

Position	Organization	Location
Senior Water Quality Engineer	American Water	Voorhees, NJ
Director of Water Resources	Cornwell Engineering Group (EE&T)	Winslow, NJ
Water Superintendent/ Chief of Water Quality	Passaic Valley Water Commission	Totowa, NJ
Director of Operations	Rivanna Water & Sewer Authority	Charlottesville, VA
Water Compliance Specialist	RCAP Solutions, Inc.	Gardner, MA
Founder/Owner	Water Compliance Solutions, LLC	Leominster, MA

Rich's supervisors who were A.P Black Award Winners



Phil Singer, Fran DiGiano, (Rich Gullick), Walt Weber, Mark LeChevallier



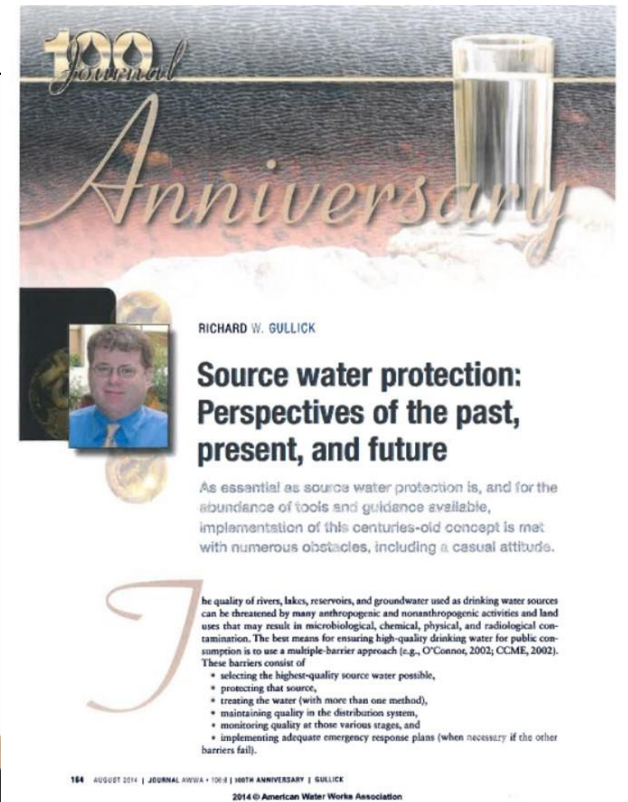
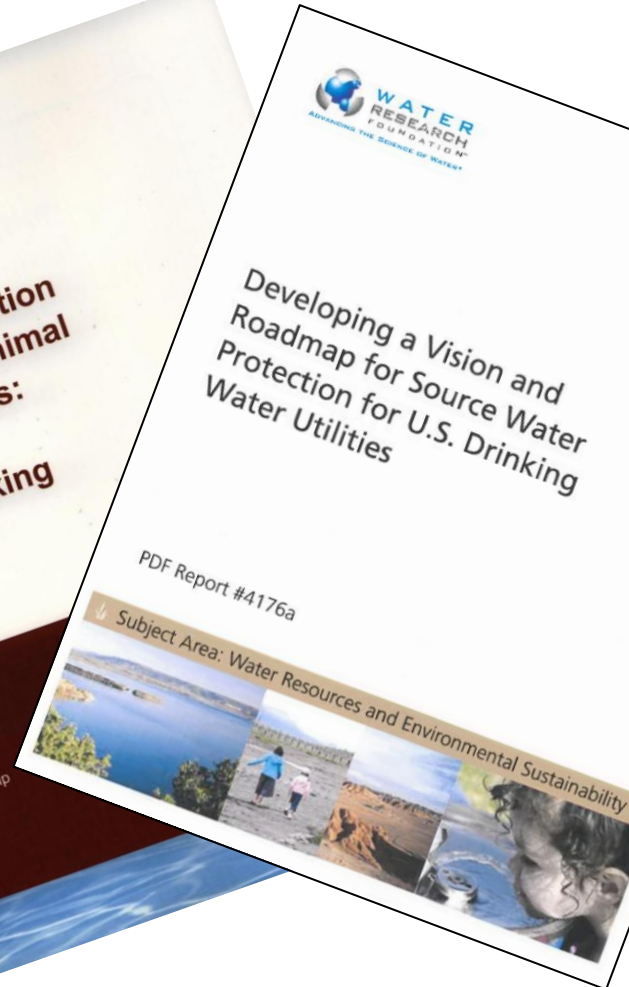
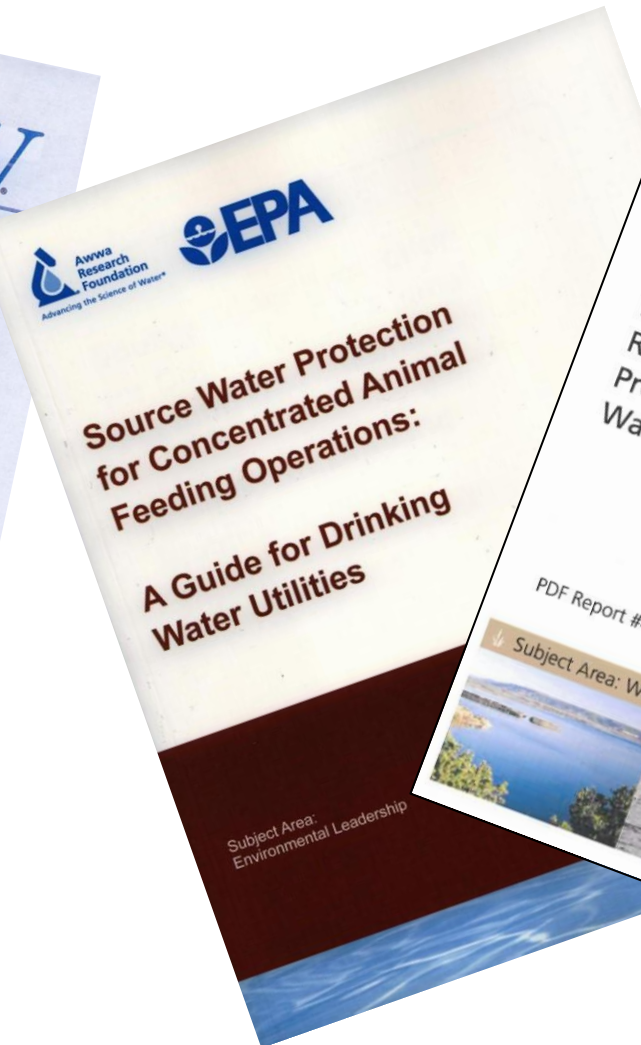
Dave Cornwell

Photo credit: Dr. Dave Reckhow (Nov. 1999 AWWA WQTC in Tampa, FL)

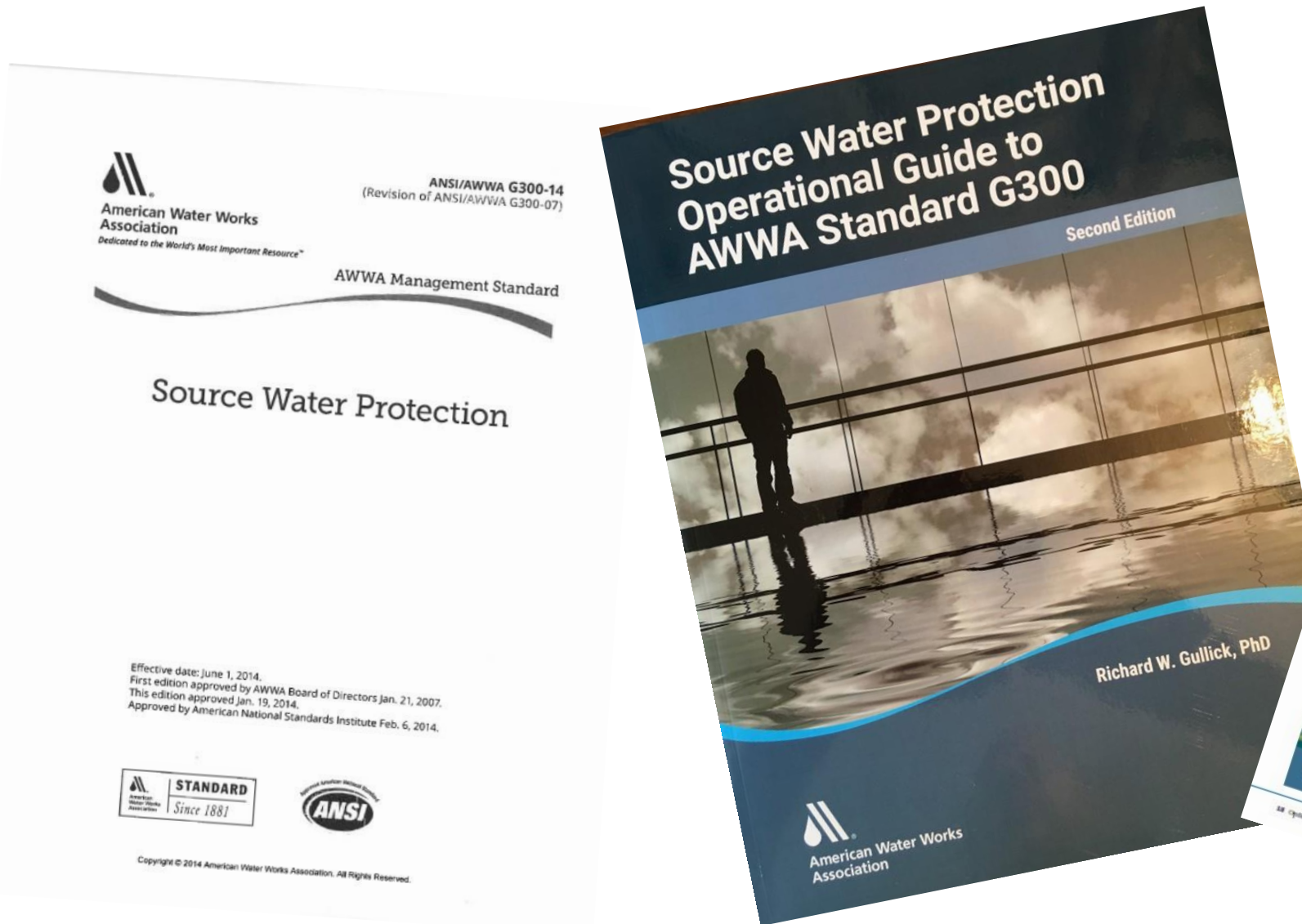
University of North Carolina at Chapel Hill

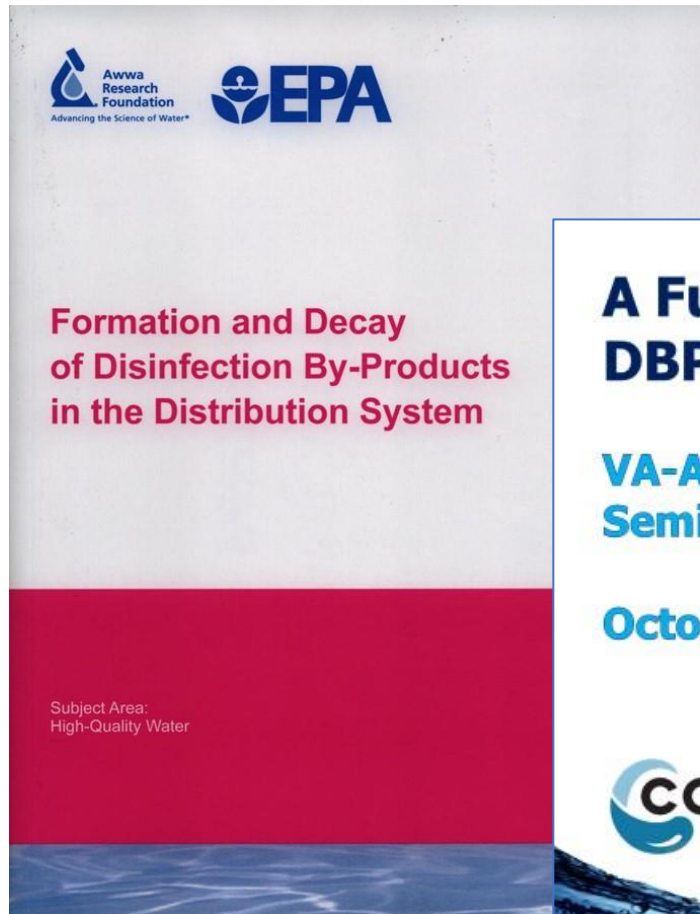


Source Water Protection



AWWA Source Water Protection Standard





Treatment and DBPs

A Fundamental Approach for DBP Control

VA-AWWA 2016 Fall Plant Operations Seminar

October 5, 2016

Richard Brown
David Tungate (RWSA)
Richard Gullick (RWSA)
David Cornwell

CORNWELL ENGINEERING GROUP

RIVANNA
WATER & SEWER AUTHORITY



PRELIMINARY ASSESSMENT OF ARSENIC TREATMENT NEEDS FOR AMERICAN WATER UTILITY SUBSIDIARIES

Integrated Membrane Systems for Treatment of River Water

Assessment and Treatment of Aesthetic Water Quality Issues Associated with Hard Water: St. Joseph, MO and other Midwest Waters

Athletes at MSU, UNC, and U-Mich while Rich attended

University	Athlete	NCAA + Pro Championships
MSU	❖ Earvin “Magic” Johnson ❖ Kirk Gibson	NCAA + 5 NBA 2 MLB World Series
UNC	❖ Michael Jordan ❖ James Worthy ❖ Lawrence Taylor	NCAA + 6 NBA NCAA + 3 NBA 2 NFL Superbowls
U-Mich	❖ The “Fab Five” (C. Weber, J. Rose, J. Howard, R. Jackson, J. King) ❖ Tom Brady	2 NCAA Runners-up NCAA (tie); 7 NFL Superbowls

Dr. Gullick attended the 3/26/79 NCAA men’s basketball championship game with MSU vs. Indiana State + Larry Bird

Data Processing

LONG-TERM DATA MANAGEMENT SYSTEM

Millville Elementary School (PWSID #2188004)

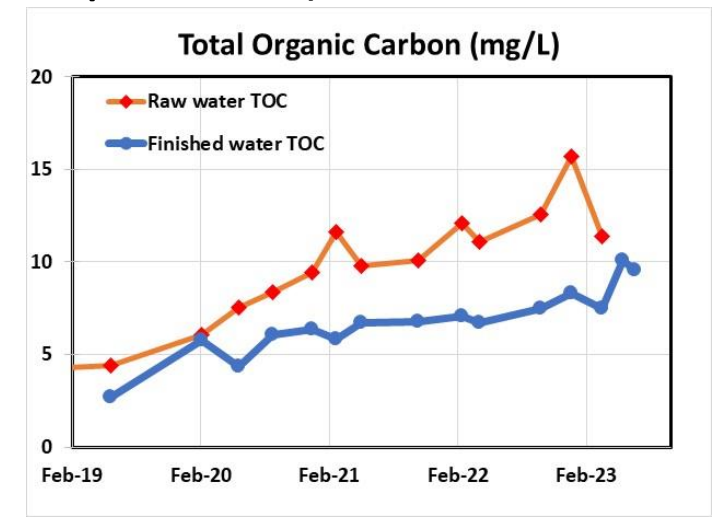
Table of Contents

#	SECTION
1	Events
2	Violations
3	Monitoring schedule
4	Fe + Mn
5	Fe + Mn sorted
6	Total Phosphate and Silica
7	Perchlorate, PFAS, and nitrate
8	Chlorine
9	TOC
10	LCR
11	LCR sorted
12	Bacteria
13	Disinfection byproducts (DBPs) - are in a separate Excel workbook

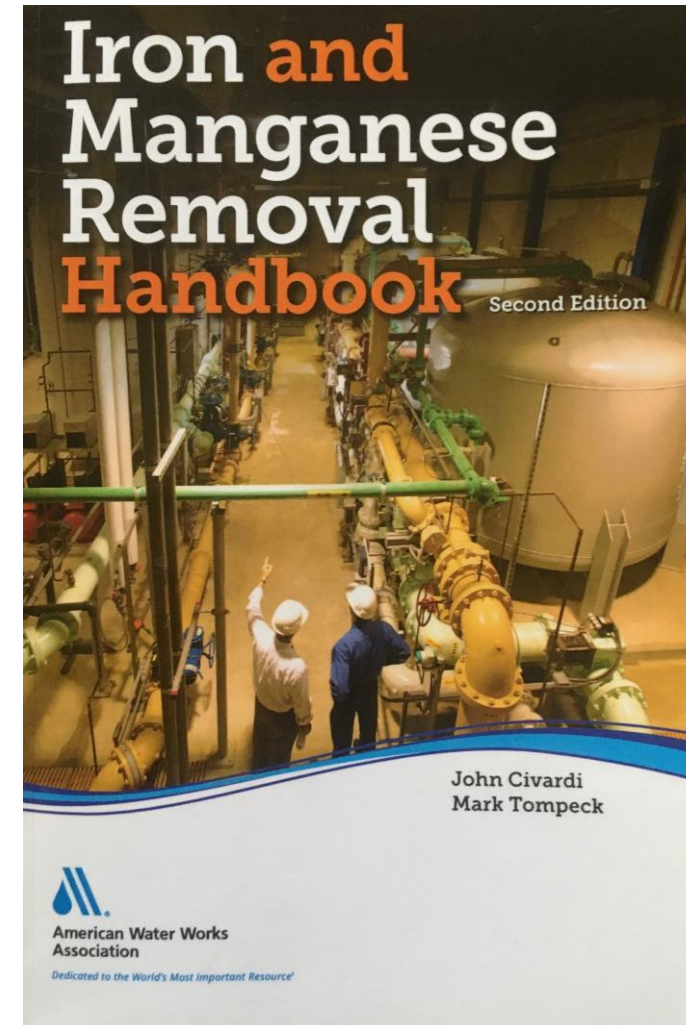
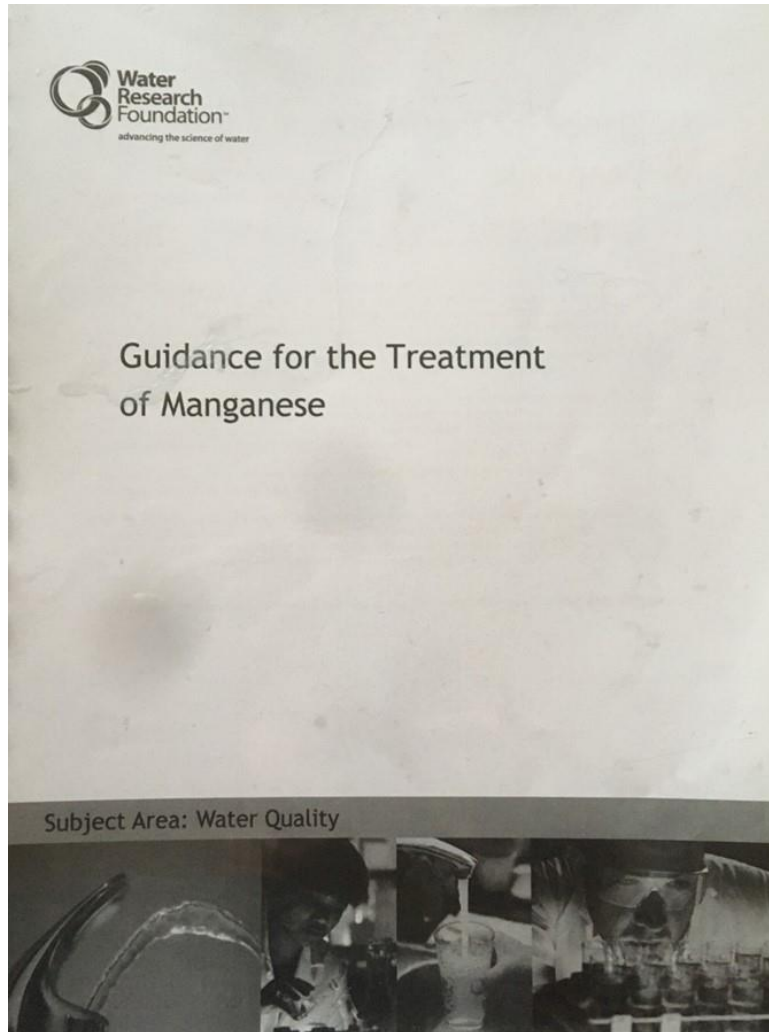
Raw Water Quality (Well Water)

- **Deep well (1001 ft)** – primary fracture at 142 ft, next largest is > 800 ft; pump set at ~450 feet
- No evidence of connection to surface water near the well
- Very good quality except high in iron (10 – 15 mg/L) and manganese (1.1 mg/L)
- Also corrosive water – not a health issue in itself but can dissolve lead and copper from plumbing
- There are no chlorinated DBPs (HAAs or THMs) in the raw water
- High total organic carbon (TOC) for a well water (not in itself a problem)

- ❖ Iron and manganese are removed by the greensand filtration system
- ❖ Corrosivity is treated by pH adjustment with soda ash and addition of phosphate and silica



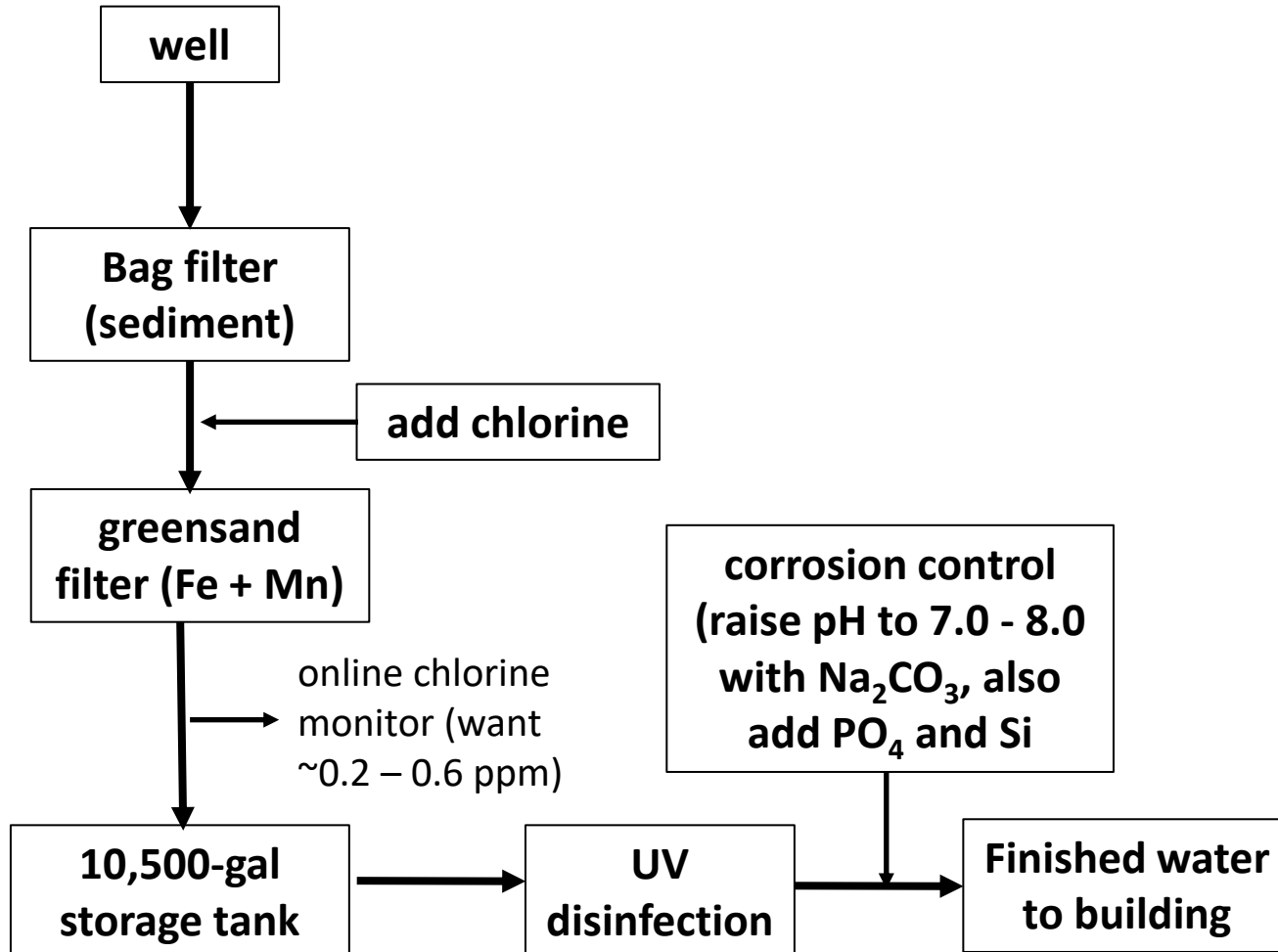
Metals Chemistry + Treatment



Metals Chemistry

- Iron (Fe) and manganese (Mn)
- Total = particulate + colloidal + dissolved
- Colloid is combination of metal + organic compound
- Particulate and colloidal forms cause color, dissolved does not
- Oxidants (permanganate, chlorine) oxidize dissolved form into particulate or colloidal
- Particulate will be removed by filters + settling
- Colloidal + dissolved forms will not be removed by filters or settling
- Colloidal is a potential problem (passing through filters and causing color), and would require an additional chemical addition

Millville Water Treatment System



- Chlorine oxidizes most dissolved Fe + some Mn which is then captured by 18" of greensand filter (GSF) media
- The chlorine creates a manganese dioxide coating on the GSF media that adsorbs the remaining dissolved Fe/Mn and allows it to be oxidized by chlorine over time (especially important for Mn)
- Chlorine in GSF effluent is monitored continuously. Normally desire a chlorine residual of 0.5 to 1.0 ppm, but lower levels are used at MES to minimize formation of DBPs
- Want $[\text{Mn}] \leq 0.015 \text{ ppm}$

August 11, 2023



***Raw well
water***

***Bag filter
effluent***

***GSF
influent***

***GSF
effluent***

***Finished
water***

***Distilled
water***

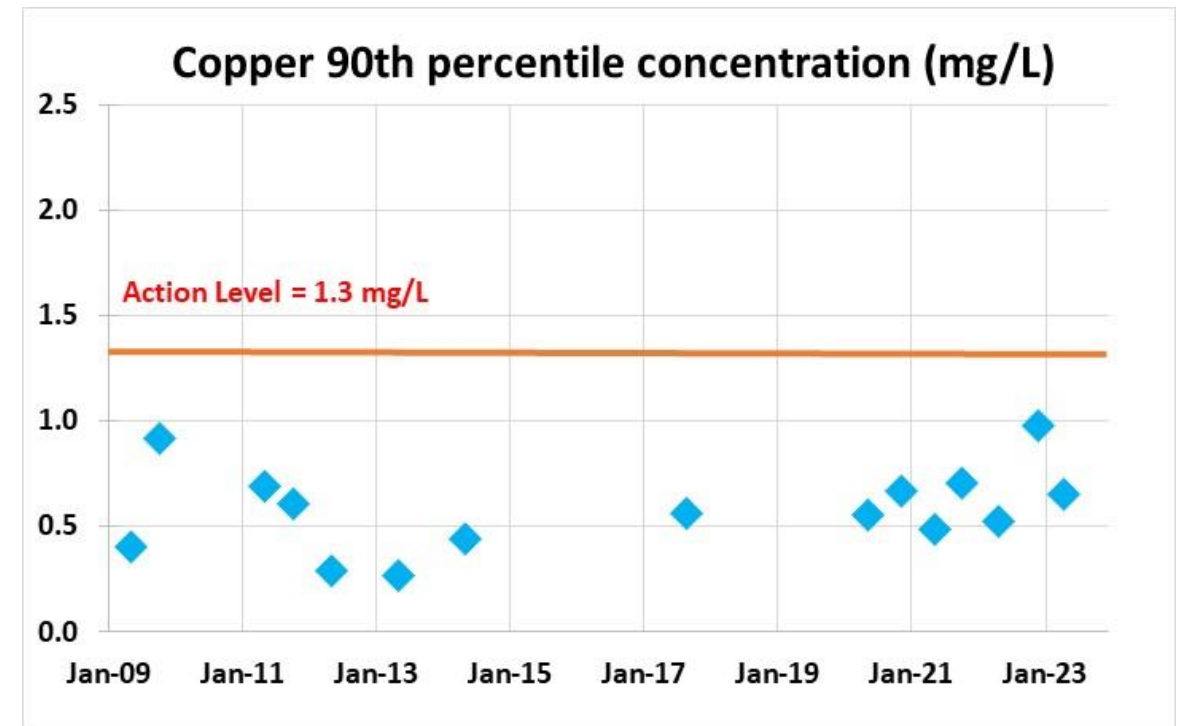
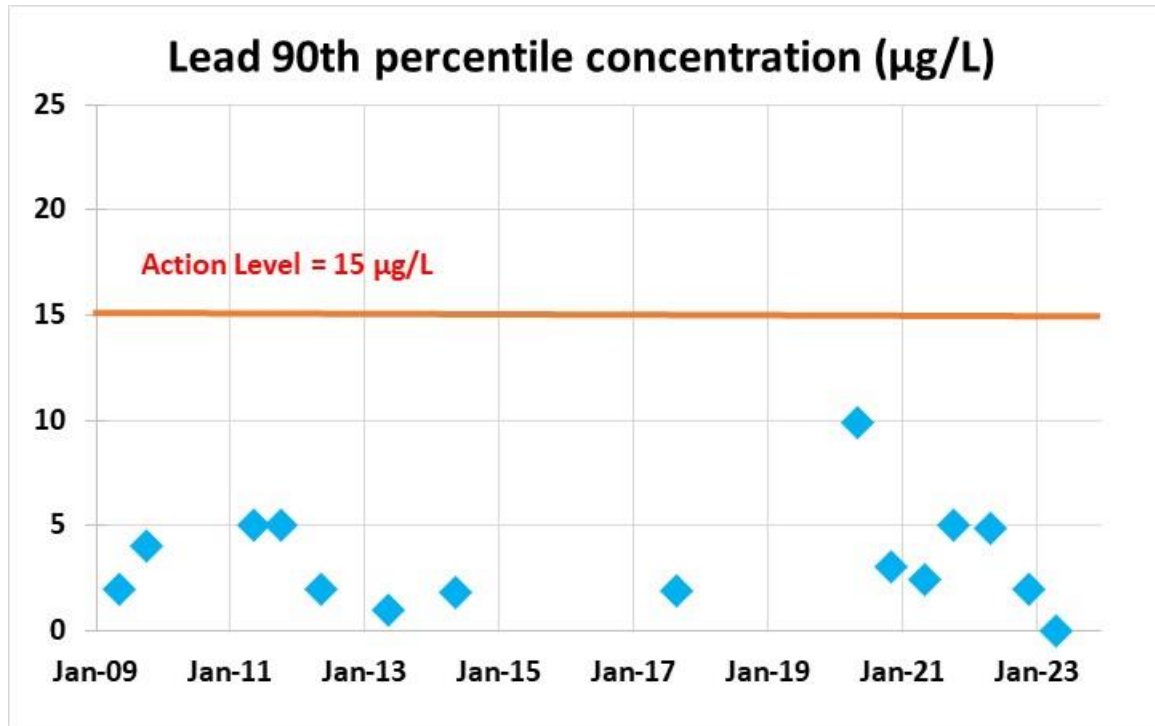
Treated water quality is typically good

- **Good Water Quality:** Overall, the quality of the treated water at MES is quite good and currently meets all of the state and federal regulatory requirements with the sole exception of haloacetic acids (HAA5).
- Also had color issues from manganese occasionally in recent years

❖ The MES water meets all regulatory requirements for the following important water quality parameters:

- | | |
|---|---|
| ✓ Bacteria and other microorganisms | ✓ Per- and polyfluoroalkyl substances (PFAS) |
| ✓ Total trihalomethanes (TTHM) | ✓ Radiological substances |
| ✓ Lead and copper | ✓ Nitrate and nitrite |
| ✓ Synthetic organic chemicals (SOCs) | ✓ Pesticides (insecticides, herbicides, rodenticides) |
| ✓ Volatile organic chemicals (VOCs) | ✓ Algae and algal toxins |
| ✓ Heavy metals (mercury, cadmium, etc.) | ✓ Taste and odor |

Lead and Copper Results



SDWA regulatory violations

Regulation	Date	Description
Haloacetic acids (HAA5)	10/25/22	NON for part of 9 quarters of violations since 2016
Iron and Manganese	10/25/22	Treatment Technique violation due to high manganese
Monitoring and Reporting Violation	6/28/23	Notice of Noncompliance for failing to sample for perchlorate in 4th quarter 2022
Monitoring and Reporting Violation	8/26/21	Failure to properly test for and/or report iron and manganese results to MassDEP within required period (for 4th quarter 2020)
Lead and Copper Rule	7/11/23	Notice of Noncompliance for failing to provide notice of the lead and copper monitoring results in the 1st half of 2022 to the people served within the 30-day deadline (it was delivered 63 days after receiving the results)
Sanitary Survey (5 violations) July 30, 2020		1. Written alarm protocols not established for critical chemicals 2. Alarms and interlocks are tested periodically but are not noted in an alarm testing log book 3. The system does not automatically shut down when an alarm is triggered on a critical chemical 4. A critical chemical feed shut down does not require manual on-site reset 5. The treatment plant is visited only once per week, which is less frequently than the minimum allowed for a 2-T plant.

Too much chlorine, too little chlorine

- HAAs can be kept under the MCLs by not overdosing the chlorine used for greensand
- Chlorine spikes caused high HAAs over the MCL
- Response strategy was to lower the chlorine target level
- Instead, could have kept the necessary existing target and do an improved job of meeting it
- Operator blamed MassDEP pressure for the low chlorine target, but 2020 Sanitary Survey said to maintain no lower than 0.3 ppm (mg/L)
- Operator further let the chlorine levels get even lower than the target range, and below the levels necessary for proper greensand function
- The lack of chlorine caused the greensand to fail, and it would no longer remove all of the dissolved Fe/Mn

What is manganese?

- Manganese (Mn) is naturally present in the environment
- Essential nutrient for normal growth and health, and helps the body break down fats, carbohydrates, and proteins as a part of several enzymes
- Mn is naturally present in many foods, with the top sources in diets of U.S. adults being grain products, tea, and vegetables
- Various other foods contain Mn including coffee and many spices such as black pepper
- Drinking water also may contain small amounts of Mn
- Typical daily multivitamin has 1.0 to 4.5 mg of Mn
- **One of these dietary supplement pills contains as much Mn (50 mg) as 12 gallons of the raw well water at MES (1.1 mg/L)**



25
Mn
Manganese
54.938



Health needs of manganese

➤ ***This much Mn would not be consumed via MES' treated water***

Adequate Intakes (AIs) for Manganese (from National Institutes of Health)

Age	Male	Female	Pregnancy	Lactation
Birth to 6 mths*	0.003 mg	0.003 mg		
7–12 months	0.6 mg	0.6 mg		
1–3 years	1.2 mg	1.2 mg		
4–8 years	1.5 mg	1.5 mg		
9–13 years	1.9 mg	1.6 mg		
14–18 years	2.2 mg	1.6 mg	2.0 mg	2.6 mg
19–50 years	2.3 mg	1.8 mg	2.0 mg	2.6 mg
51+ years	2.3 mg	1.8 mg		

Source: <https://ods.od.nih.gov/factsheets/Manganese-HealthProfessional/#en5>

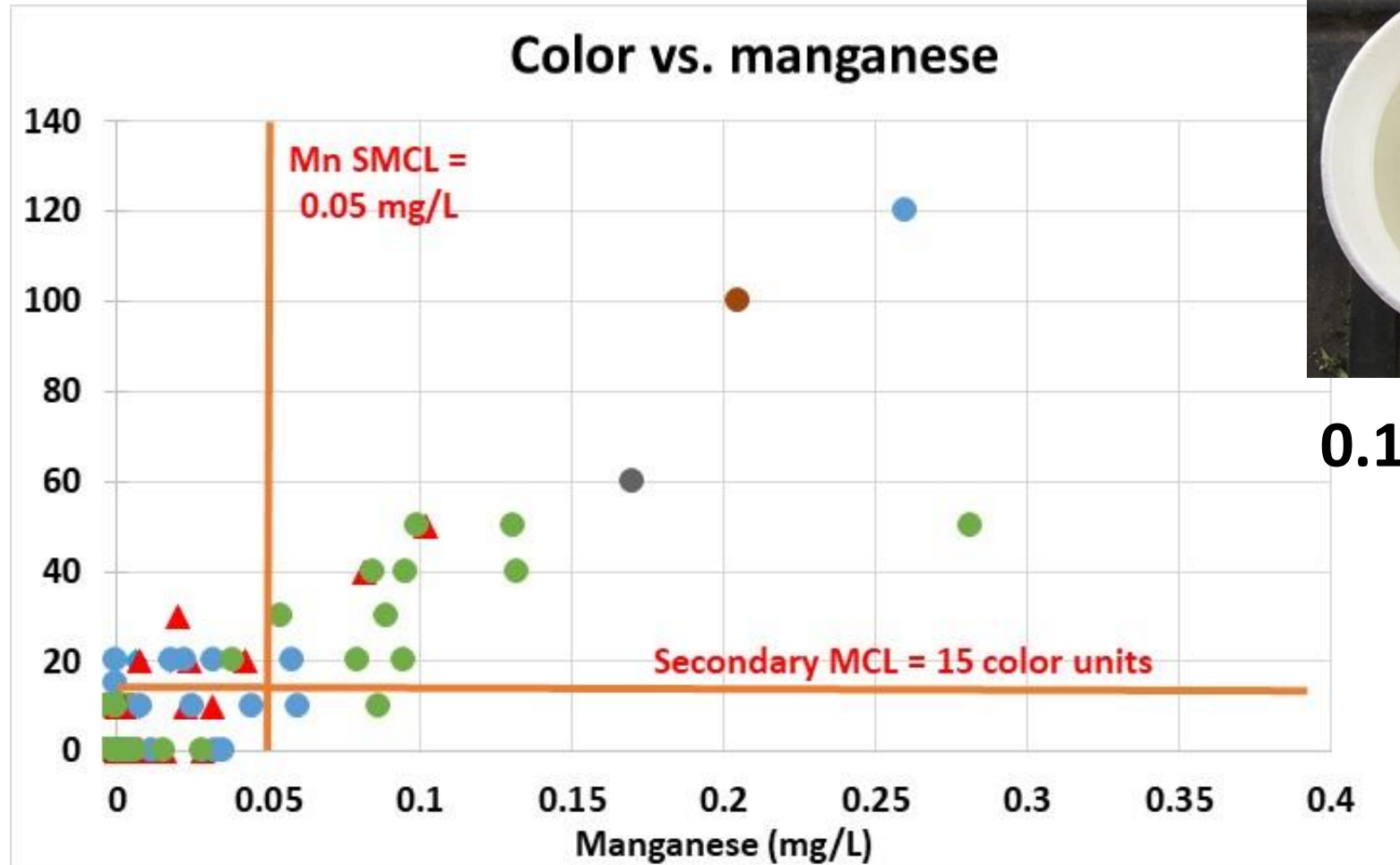
Impact of manganese?

- Can cause color when 0.02 – 0.05 mg/L Mn and it is oxidized into particulate form (not dissolved)
- Color ranges from light yellow to dark yellow to brown to grey to black with increasing concentration
- MES's treated water has no detectable Mn when the GSFs are working well
- Normally Mn at MES is below the health advisory levels (0.3 and 1.0 mg/L).
- Raw water Mn ~1.1 mg/L

- MassDEP: *"The general population water concentration exposure limits of 0.3 and 1 mg/L have been set based upon typical daily dietary manganese intake levels not known to be associated with adverse health effects. **This does not imply that intakes above these levels will necessarily cause health problems.**"*
- Compare HALs to dietary requirements...

Manganese concentration units:	µg/L	mg/L
Secondary MCL (aesthetic effects)	50	0.05
Realistic necessary target level	≤ 15	≤ 0.015
Lifetime health advisory level	< 300	< 0.3
Short-term health advisory level (possible neurological effects)	< 1,000	< 1.0

Correlating manganese to color (data + photo from other water systems)

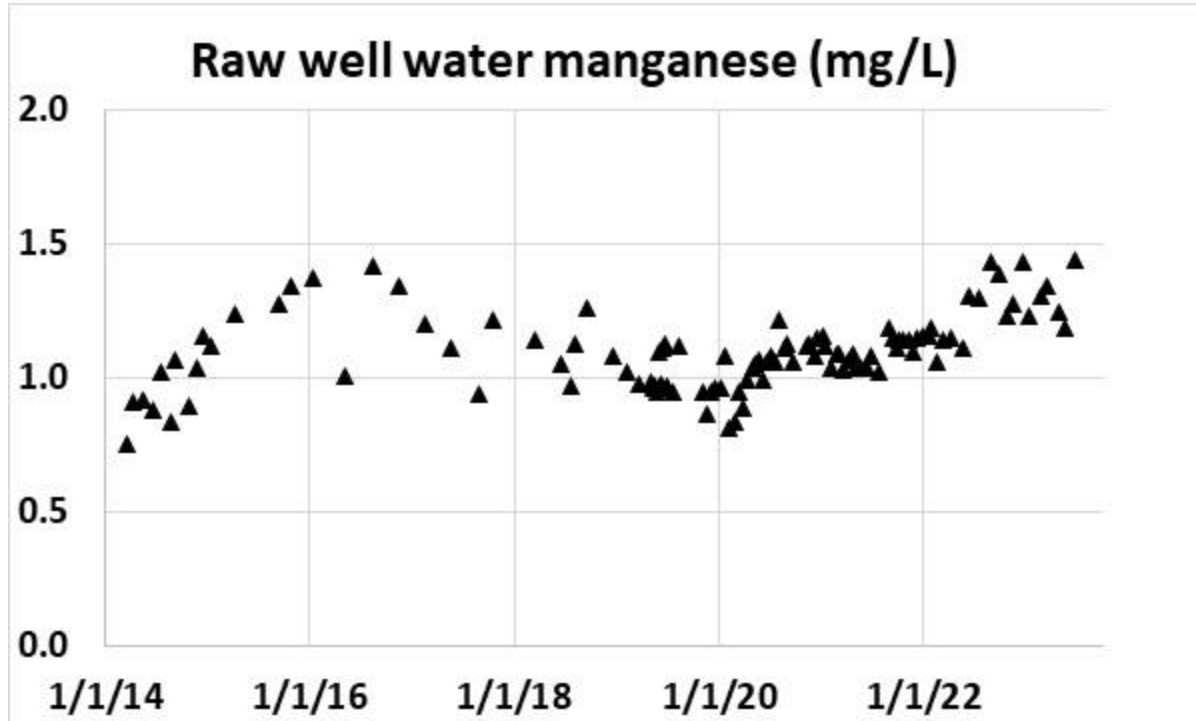


0.1 mg/L Mn

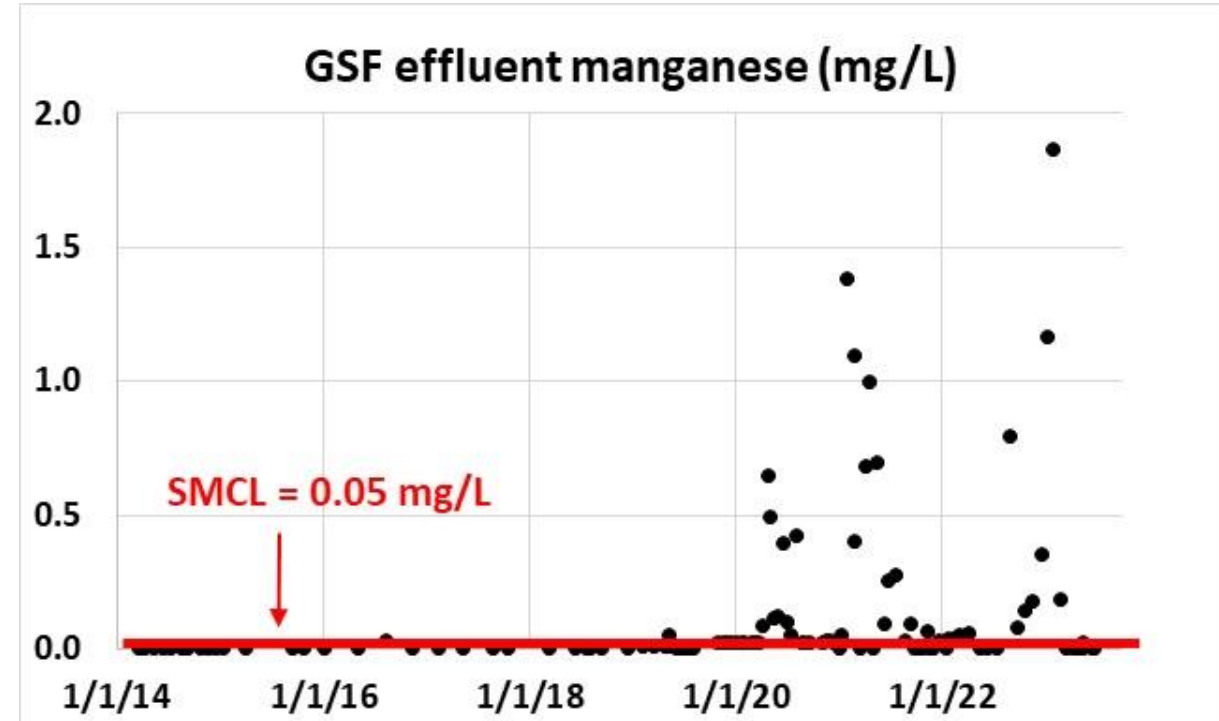
Distilled
water

Total Manganese

➤ From 2014 to early 2020 there were good results for Fe + Mn removal

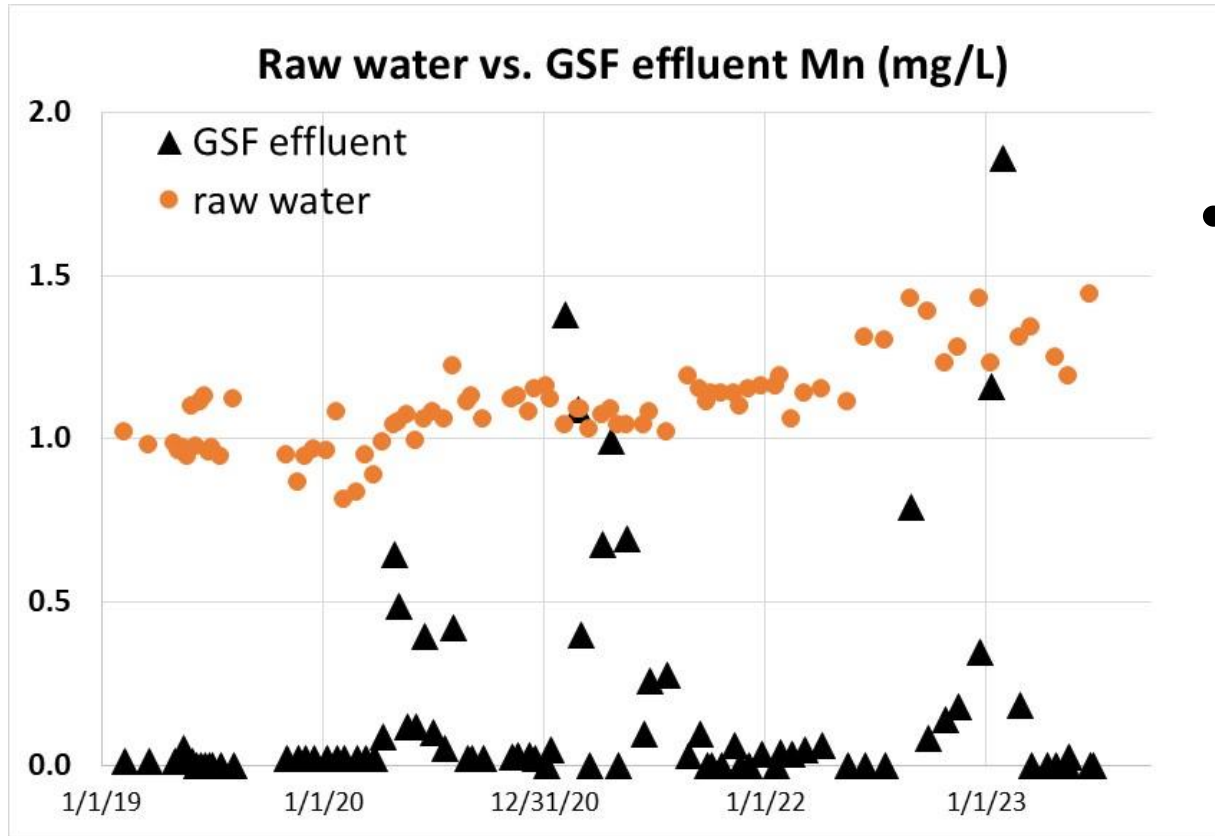


Raw water Mn averages ~ 1.1 mg/L



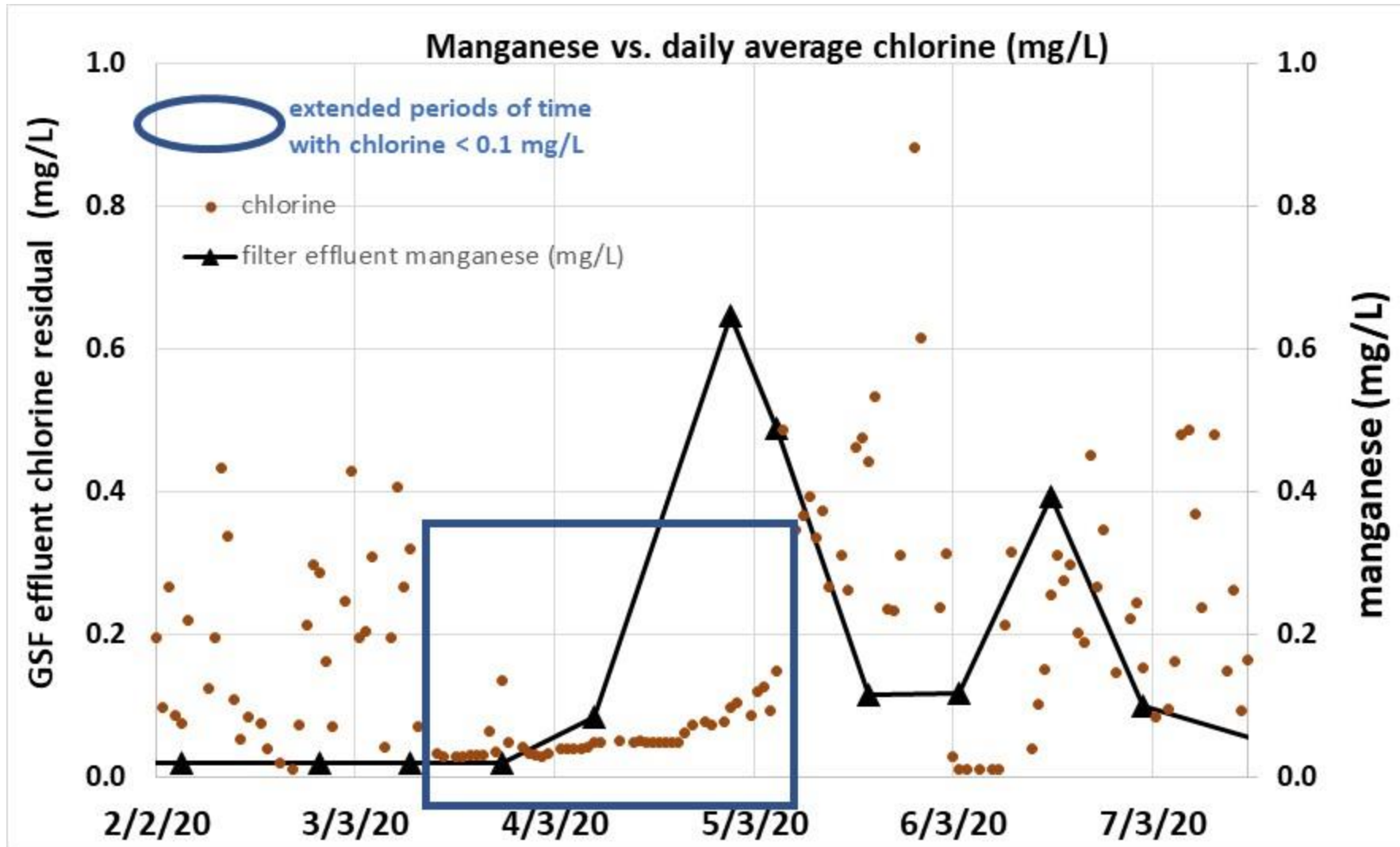
SMCL = 0.05 mg/L (ppm)
(actual target ≤ 0.015 mg/L)

Manganese



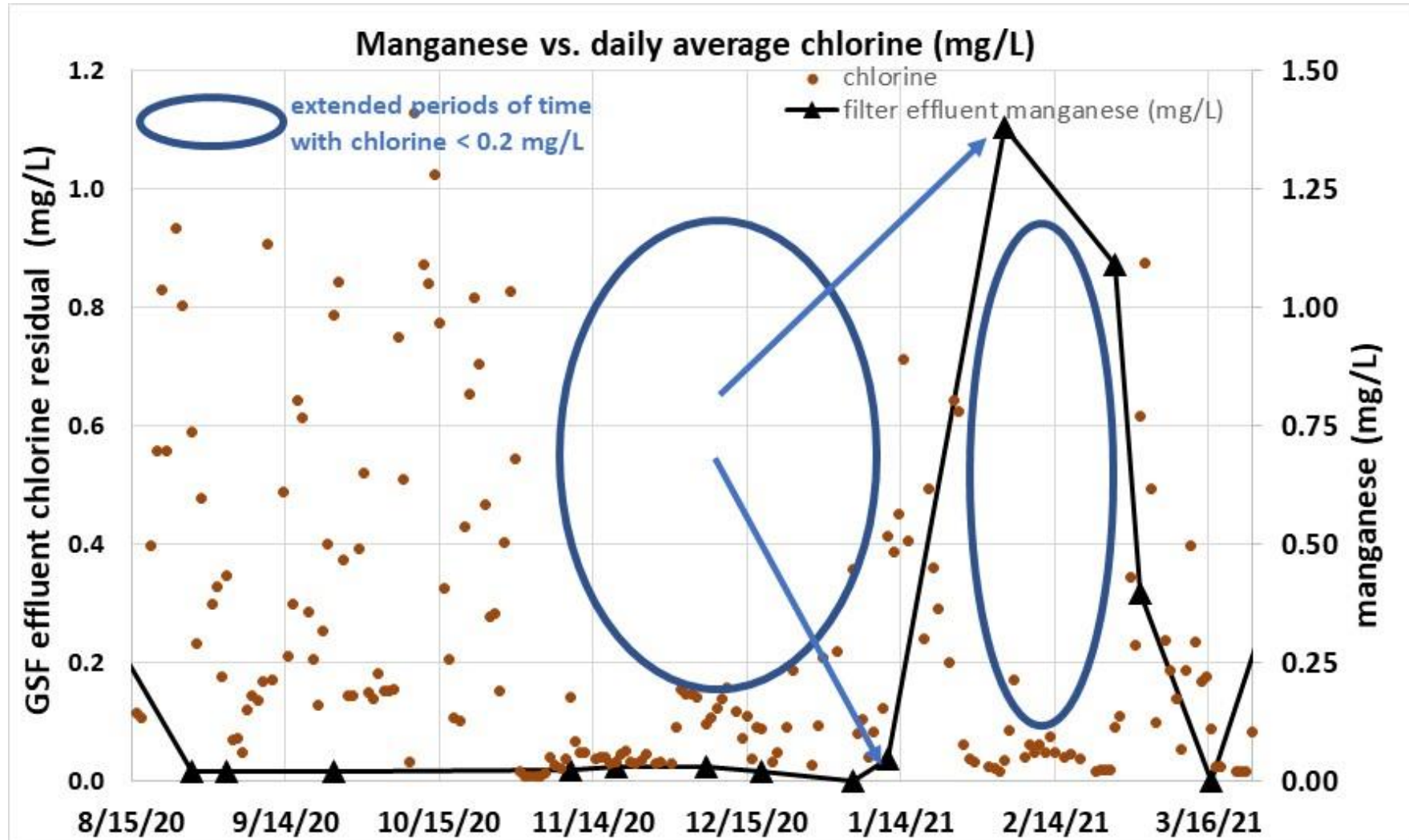
- Mn harder to remove than Fe
- From 2014 to early 2020 there were good results for Fe + Mn removal
- Then at least 4 occasions with high Mn in 2020 – 2022 **following consistently low chlorine:**
 - a. April 2020
 - b. Feb. 2021
 - c. Mar. – July 2021
 - d. Aug. 2022 – Feb. 2023

April 2020: Mn vs. chlorine

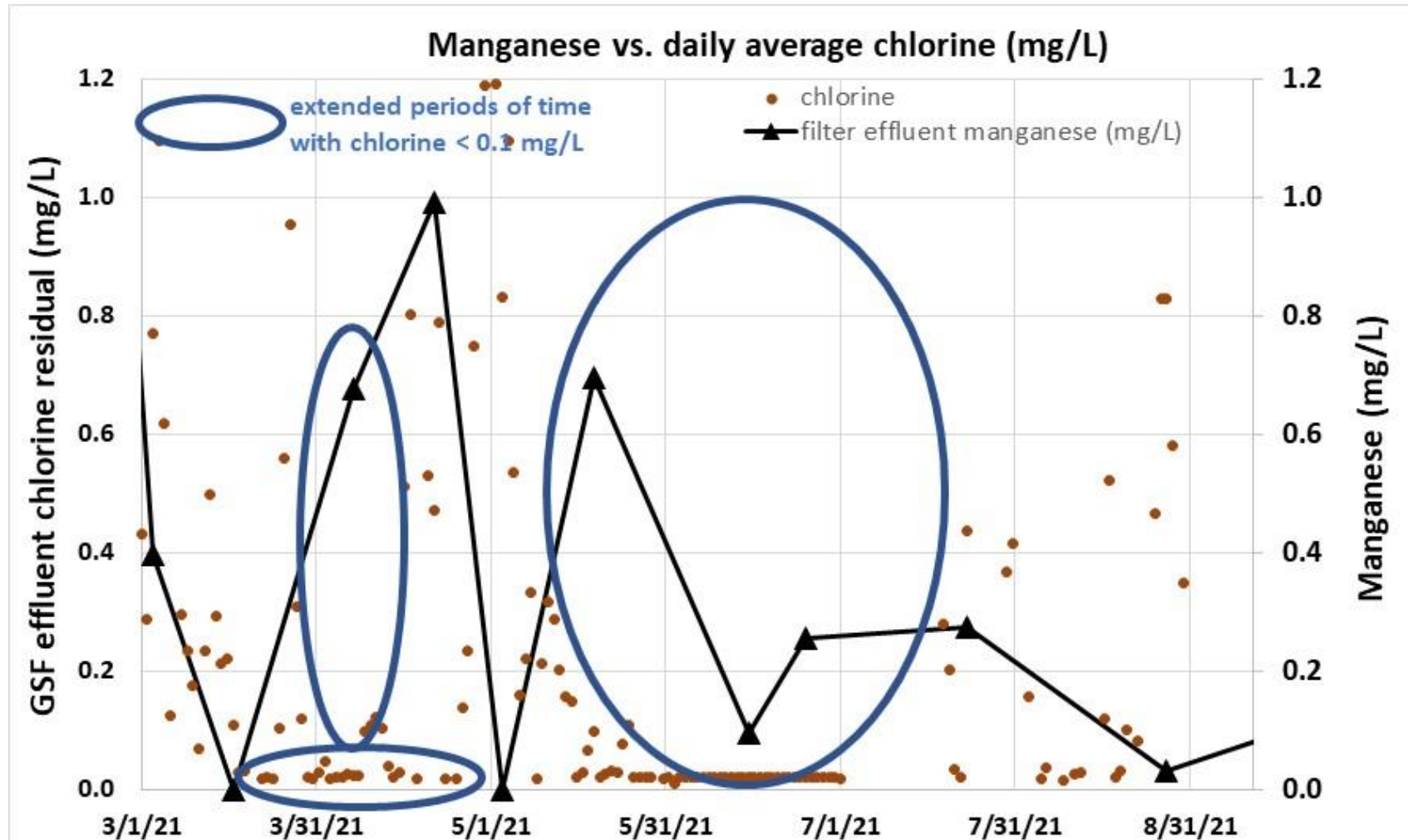


Per Operator – The low chlorine levels occurred after a large rapid increase in raw water iron, then iron steadied but chlorine remained low and wasn't increased

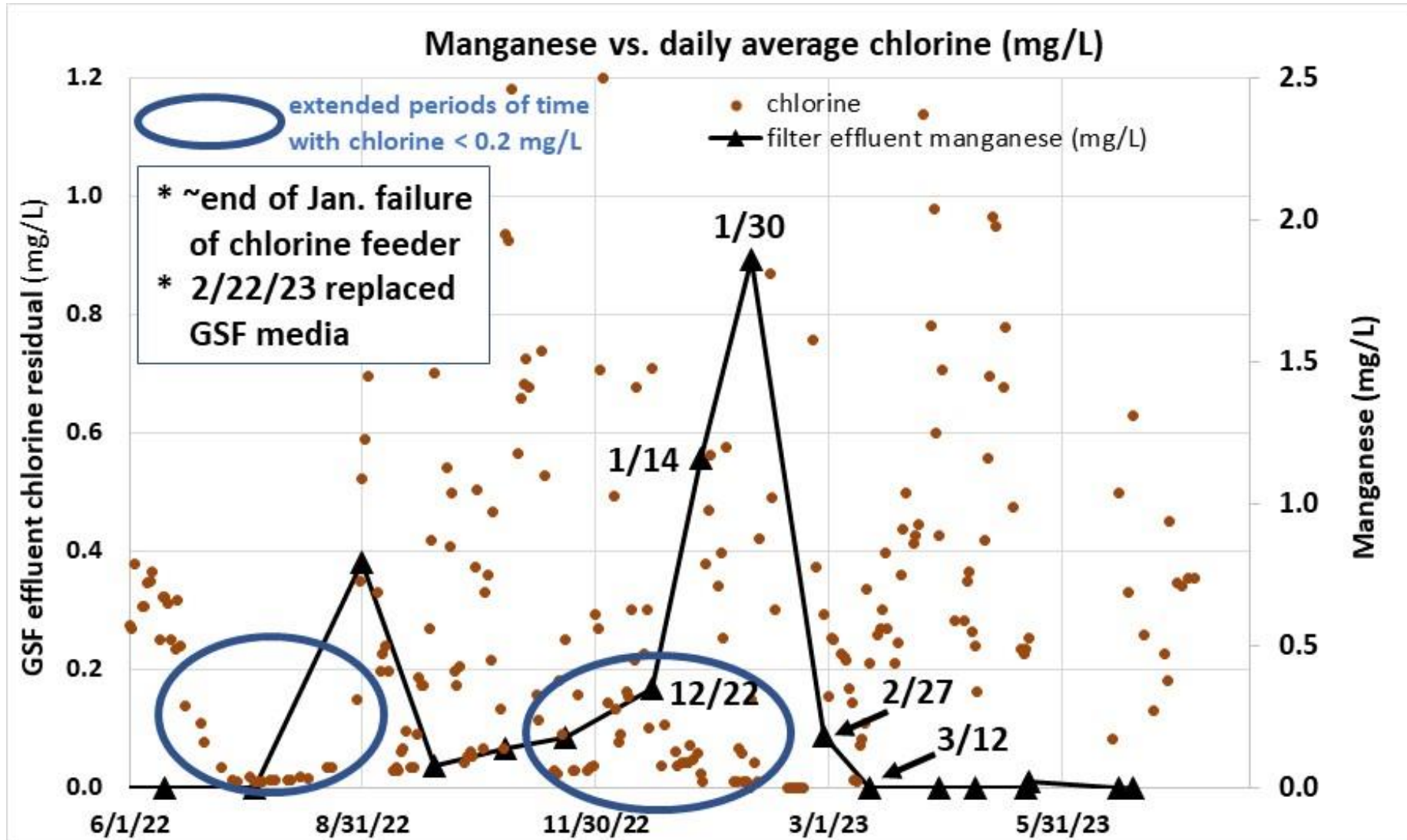
Feb. 2021: Mn vs. chlorine



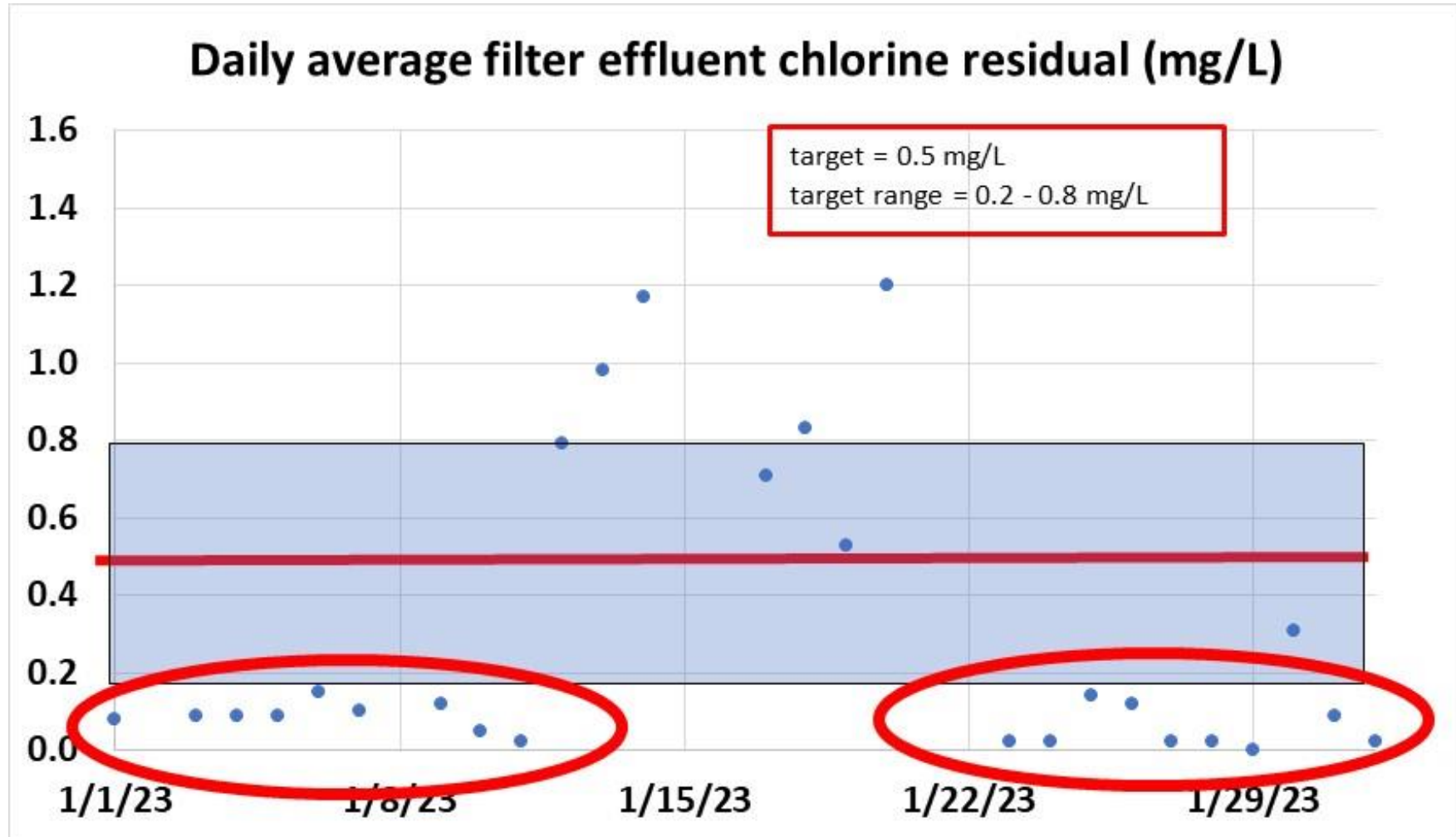
Mar-July 2021: Mn vs. chlorine



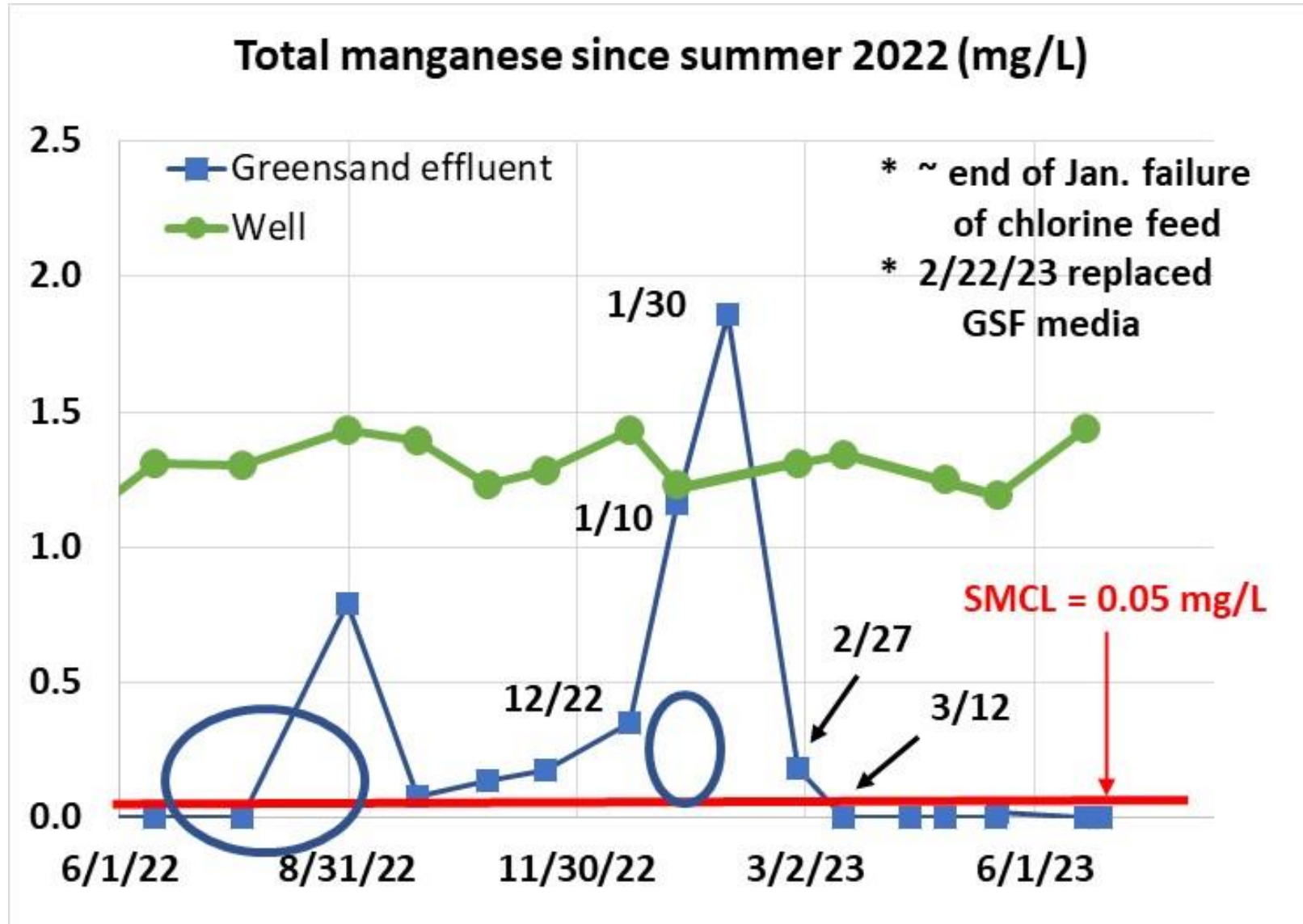
2022 - 2023: Mn vs. chlorine



Low chlorine in January 2023



2022 – 2023 Manganese



February 8, 2023



Photos: Scott Hebert, BMRSD – the water “is coming out brown again, this time worse than back in September in my opinion”

3/8/23 (after 2/22 filter media replacement)



(GS In = GSF influent with chlorine)

- The clear filtered water shows the previous color in late February was not from colloids. If colloids had been present in February they would have been present in March, but aren't.

A Healthy Perspective on Manganese

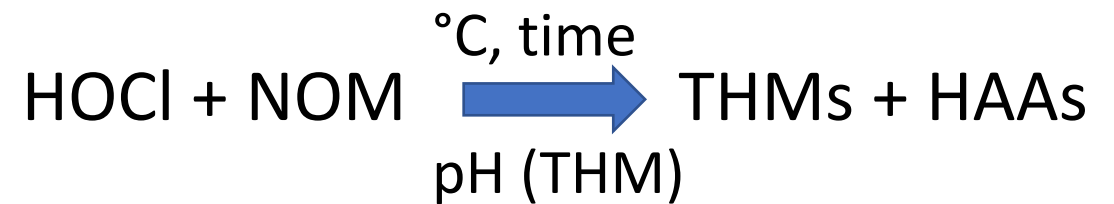
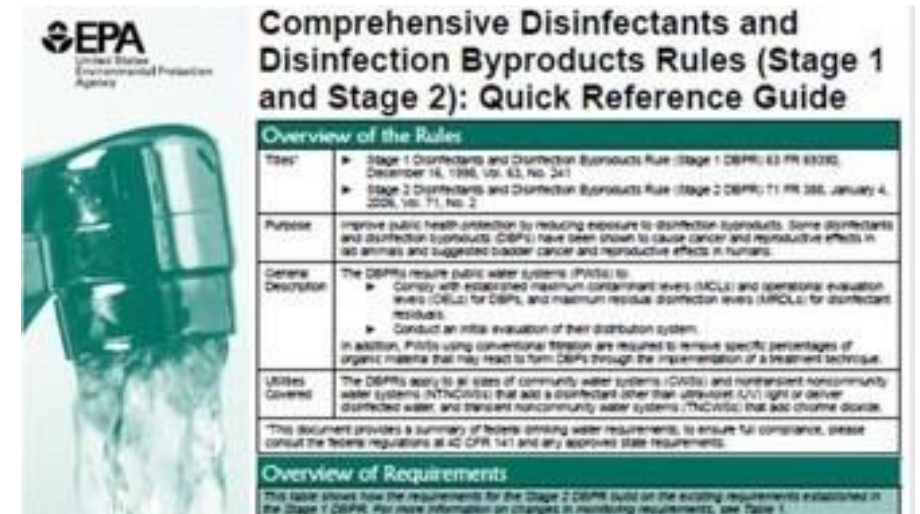
Even at the highest level of manganese observed in the GSF effluent (1.86 mg/L on 1/30/23), it would take over seven (7) gallons of that water to be equivalent to one manganese dietary supplement pill (50 mg)

One quart of that water would provide the needed daily intake of Mn for a child

... and Mn is normally not detected!

Disinfection Byproducts (DBPs) (byproduct of treatment process)

- Haloacetic acids (HAAs) and trihalomethanes (THMs) are chlorinated organic compounds
- Formed by reaction between chlorine and natural organic matter (NOM)
- NOM is usually measured as total organic carbon (TOC)
- At MES the 'DBPs' come from chlorine used for oxidation of metals and not for disinfection, so technically the DBPs are '*oxidation byproducts*' and not '*disinfection byproducts*' (but are still regulated as DBPs)



Regulated Disinfection Byproducts

REGULATIONS

- Monitor monthly at one location and quarterly at the second location
- Compliance with the Maximum Contaminant Level (MCL) is based on 4-quarter locational running annual averages (LRAA)
- HAA5 MCL = 60 µg/L (ppb)
- TTHM MCL = 80 µg/L

HEALTH EFFECTS

- No known acute health effects
- Potential chronic health effects from long-term exposure:
 - HAAs - increased risk of cancer
 - THMs - Liver, kidney or central nervous system problems; increased risk of cancer
- Levels below the regulated Maximum Contaminant Levels (MCLs) are considered to be protective of public health

MassDEP on HAA5 health effects

- On MCL exceedances: *“This is not an immediate risk. If it had been, you would have been notified right away”.*
- *“Although this is not an emergency (emphasis by MassDEP), you have a right to know what happened, what you should do, and what we are doing to correct this situation.”*
- *“Some people who drink water containing haloacetic acids in excess of the MCL over many years may have an increased risk of getting cancer.”*
- The MCL is based on exposure of 2 liters (2.1 quarts) per day for 70 yrs
- *“Pregnant women and women of childbearing age may be at increased risk and should seek advice from their health care providers if they have any concerns.”*

MassDEP on HAA5 health effects

- ***“Consumption of water with HAA5 levels somewhat above the MCL for limited durations, for example, while corrective actions are being taken to lower the levels, is not likely to significantly increase risks of adverse health effects for most people.”***

- *“Overall the water is safe to drink. The MCL is development (sic) for those that have been exposed to elevated haloacetic acids over many years...*
- *Those in the sensitive population (pregnant women and women of childbearing age) may be at increased risk and should seek advice from their health care provider if they have any concerns.”*

source: 8/2/19 e-mail from MassDEP Central Region Drinking Water Chief Robert Bostwick to MES

MassDEP Fact Sheet on HAA5 Exposure

- ***“What are the health risks associated with using water containing HAA5? HAA5 are possibly carcinogenic to humans based on evidence of carcinogenicity in laboratory animals and limited evidence in people.***
- *Other effects have been reported in experimental animals exposed to high levels of HAA5 and other disinfection byproducts. These include effects on the liver, kidneys, and reproductive system and on development.*
- *The significance of these effects is uncertain as some studies of people have reported similar effects while others have not. Scientists are working to address these differences.”*

Source: <https://www.mass.gov/doc/factsheet-haloacetic-acids-and-total-trihalomethane-in-drinking-water-information-for-consumers/download>

MassDEP Fact Sheet on HAA5 Exposure

- *“However, pregnant women and women of childbearing age may be at increased risk and should seek advice from their health care providers if they have any concerns.*
- ***What about breastfeeding infants?*** *Breast milk can also be a source of HAA5 exposure for infants. However, those infants will benefit from any exposure reductions experienced by the mother, and they also gain a substantial health benefit from breastfeeding. The Centers for Disease Control and Prevention recommend that nursing mothers continue to breastfeed their babies because of the numerous protective health benefits despite the potential presence of environmental contaminants.”*

Source: <https://www.mass.gov/doc/factsheet-haloacetic-acids-and-total-trihalomethane-in-drinking-water-information-for-consumers/download>

HAA5 considerations

➤ **LRAA was not often above the MCL, and barely at that:**

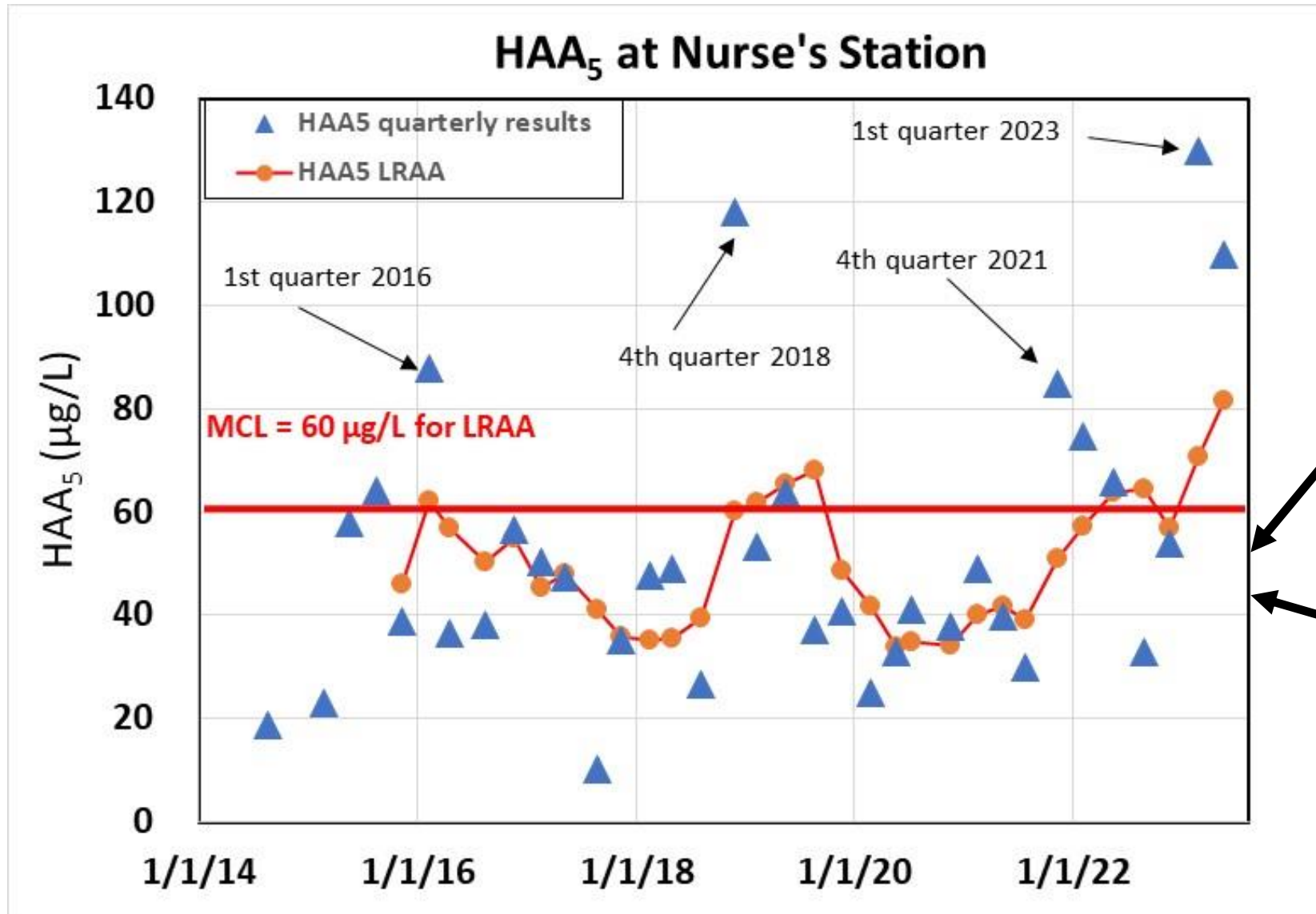
- Most of the time Millville's HAA5 LRAA results were well below the MCL level of 60 ppb
- When HAA5 violations did occur, the LRAA exceeded the MCL by just a few parts per billion
- HAA5 LRAA was within 62 to 71 ppb for 8 of the 9 quarters with violations, with the most recent quarter at 82 ppb
- The DBP regulations are rather conservative, and safety factors are built into the MCLs

HAA5 considerations

➤ **LRAA calculation method can overemphasize single-sample results:**

- Each result is used for four consecutive quarters in the LRAA calculations
- One high sample result can cause a full year of violations (one each quarter), even if that one high result only lasted for a few days or weeks
- A total of only 4 individual HAA5 samples caused the 9 MCL quarterly violations and resulting Public Notices at MES
- Three of those four individual high HAA5 results were known to be caused by short-term operational overdosing of chlorine that occurred for only one day, 4-6 days, and 20 days
- The other MCL exceedance was at 62 ppb for one quarter, and was also likely a short-term chlorine overfeed

Haloacetic acids (HAA₅)



Average of the LRAAs is 51 µg/L (85% of the MCL)

Avg. of the LRAAs would be ~43 µg/L if the results for those 4 quarters were typical values (72% of the MCL)

Nine quarters of HAA5 violations (from four HAA5 'events')

HAA5 MCL violations (limit allowed is 60 ppb):			
Event #	Sample location	Quarter	LRAA (ppb)
1	Nurse's Station	1st quarter	62
2	308 Teacher's Lounge	4th quarter	63
	Nurse's Station + Teacher's Lounge	1st quarter	62, 66
	Nurse's Station + Teacher's Lounge	2nd quarter	65, 65
	Nurse's Station + Teacher's Lounge	3rd quarter	68, 67
3	Nurse's Station	2nd quarter	64
	Nurse's Station	3rd quarter	65
4	Nurse's Station + Teacher's Lounge	1st quarter	71, 71
	Nurse's Station + Teacher's Lounge	2nd quarter	82, 66

HAA5 event #1 (one quarter of violation)

- This HAA5 MCL exceedance was the result of a single sample taken on 2/10/16 with a result of 88 ppb.
- The HAA5 result from the previous sample on 11/10/15 was only 39 ppb and subsequently on 4/15/16 was only 37 ppb (see Figure 2).
- The result of 88 ppb caused the LRAA to increase to 62 ppb at the Nurse's Station for that one quarter, just over the MCL of 60 ppb.
- At the Teachers Lounge the MCL was met that quarter with an LRAA of 60 ppb.

HAA5 event #2 (four quarters of violations)

- Chlorine was overdosed for ~20 days from 11/15/18 to 12/4/18
- Operator claimed the iron level in the well water went up and they then increased the chlorine to compensate for the additional oxidant demand.
- Then the iron level went down and the operator did not adjust the chlorine dose in response
- The HAA5 result for 11/29/18 at the Nurse's Station was 118 ppb, while the preceding 10 quarters of HAA5 results averaged only 40 ppb with a range of 10 to 57 ppb.
- The high chlorine level was soon discovered and reduced (and HAA5 would decrease)
- Importantly, that one short-term period of high chlorine resulted in a single high HAA5 result (118 ppb) that basically by itself caused four quarters of HAA5 violations.
- And that was even despite the much lower HAA5 results that occurred for the rest of that year.
- Had the HAA5 result for 11/29/18 been 87 ppb or lower (instead of 118 ppb) then there would have been no MCL exceedances or violations at that time (assuming the other quarters' results were the same)

HAA5 event #2 (four quarters of violations)

MES Disinfection Byproduct Monitoring Results							
DBP Sample	Sample Date	3-Day	1-Day	Nurses Station		Room #308	
Period		Precursor CI Residual	Precursor CI Residual	HAA5	TTHM	HAA5	TTHM
Q2 - 2018	5/4/2018	0.76	1.04	49	61	49	60
Q3 – 2018	8/7/2018	0.13	0.13	27	-----	27	-----
Q3 - 2018	8/23/2018	0.34	0.32	-----	24	-----	25
Q4 – 2018	11/29/2018	1.61	1.44	118	90	129	91
Q1 - 2019	2/7/2019	0.22	0.27	53	48	59	47
Q2 - 2019	5/1/2019	0.13	0.13	-----	25	-----	21
Q2 – 2019	5/3/2019	0.67	0.65	72	40	20	41
Q2 – 2019	5/4/2019	0.53	0.35	49	-----	8.5	-----
Q2 – 2019	5/7/2019	0.32	0.4	-----	40	-----	41
Q2 – 2019	5/16/2019	0.16	0.19	30	27	31	27

HAA5 event #3 (two quarters of violations)

- In November 2021 the average daily chlorine level for the greensand effluent jumped from an average of 0.23 mg/L up to 1.33 mg/L for a single day on 11/6/21
- Sampling for HAA5 two days later had a very high result of 132 ppb
- So even though the chlorine level was reduced the day after completing the HAA5 sampling, that one day of a high chlorine level just before HAA5 sampling appears to have caused the high HAA5 result of 132 ppb and two quarters of violations.

Impact of one single outlier chlorine result		
Date	avg. Cl2 (mg/L)	
10/25/21	0.11	
10/26/21	0.30	
10/27/21	0.29	
10/28/21	0.24	
10/29/21	0.39	
10/30/21	NA	
10/31/21	0.20	
11/1/21	NA	
11/2/21	0.14	
11/3/21	0.27	
11/4/21	0.03	
11/5/21	0.38	avg. Oct. 25 - Nov. 5 = 0.23 mg/L
11/6/21	1.33	then this one high outlier
11/7/21	NA	
11/8/21	0.59	sampled for HAA5 = 132 ppb
11/9/21	0.39	avg. thru Nov. 9 -18 = 0.27 mg/L
11/10/21	0.35	
11/11/21	NA	
11/12/21	0.26	
11/13/21	0.19	
11/14/21	0.23	
11/15/21	0.21	
11/16/21	0.20	
11/17/21	0.35	
11/18/21	0.29	

HAA5 event #4 (≥ 2 quarters of violations)

- In February 2023, sampling for HAA5 was conducted a few days after the operator replaced the greensand filter media and while operator was using very high chlorine concentrations
- They didn't adequately flush out the chlorine used to activate the new filter media prior to DBP sampling
- The corresponding HAA5 sample result was 250 ppb, which so far has contributed to two quarterly violations, with two more most likely yet to come due to the use of that result for four quarters of calculating the LRAA

Impact of poor sample timing		
Date	avg. Cl ₂ (mg/L)	Notes
2/19/23	replaced greensand	
2/21/23	4.44	
2/22/23	2.57	
2/23/23	1.58	
2/24/23	0.78	avg. 2.3 mg/L (Feb 21-14)
2/25/23	NA	
2/26/23	NA	
2/27/23	0.61	sampled for HAA5 = 250 ppb compared to 23 ppb on 1/10/23
2/28/23	NA	
3/1/23	0.32	avg. March 1 - 15 = 0.31 mg/L
3/2/23	0.53	
3/3/23	0.52	
3/4/23	NA	
3/5/23	NA	
3/6/23	0.47	
3/7/23	0.46	
3/8/23	0.45	
3/9/23	0.35	
3/10/23	0.30	
3/11/23	0.03	
3/12/23	0.02	
3/13/23	0.15	
3/14/23	0.17	
3/15/23	0.23	

Personal options regarding HAAs

- MassDEP suggests that if someone is concerned they may use bottled water or a home treatment system.
- Brita pitchers with activated carbon filters work well for removing HAAs and THMs
- Per MassDEP, *“An effective way to reduce exposures is to also use bottled water for preparing formula, beverages, or food that retains water (e.g., hot cereals, rice, or pasta). This approach also lessens the exposure for bottle-fed infants.*

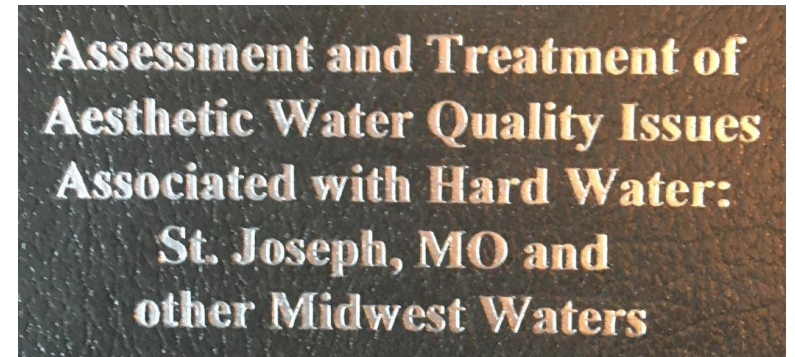
Bottled water?

- ✓ MassDEP has directed Millville to provide bottled water to the consumers since the MCL for HAA5 was exceeded
- ✓ Millville officials have stated they accept that order
- ❖ Part of Springfield's 7/7/23 Public Notice for a HAA5 violation:
"The HAA5 water quality violation is not a public health emergency. Customers may continue to use and consume the water as normal. The health risks of disinfection byproducts are associated with consumption at elevated levels for many years (i.e. decades or a lifetime)."

What about the pasta?

- THMs are volatile and would transfer to air upon boiling
- HAAs are ionic, not volatile, and tend to stay dissolved
- Laboratory experiments were conducted to determine potential excess exposures to HAAs from cooking a variety of foods in water (Raymer + Michael, 2010)
- Two of the nine HAAs measured were gone within 10 min. in boiling water (could be quicker, but no data < 10 min.)
- **Pasta (spaghetti) absorbed 2% to 11% of the other seven HAAs** measured during cooking in the HAA-spiked water

Source: Raymer, J. H., & Michael, L. C. (2010). *Uptake of water disinfection by-products into food*. RTI Press. RTI Press Methods Report No. MR-0016-1008
<https://doi.org/10.3768/rtipress.2010.mr.0016.1008>



➤ ***There's water quality research for spaghetti?***

Dr. Gullick once conducted research on the formation of solid precipitates in water used for boiling spaghetti

Pasta Math

- Assume 2 lbs. spaghetti is cooked in 3 gal. of water (11.4 L)
- That's enough for 16 meals (adult portion of 2 oz. dry pasta)
- Assume water contains 60 $\mu\text{g/L}$ (ppb) of HAA5
- Initial mass of HAA5 = 3 gal x 60 $\mu\text{g/L}$ = 681 μg = 0.681 mg
- HAAs at MES are mostly trichloroacetic acid (6% absorption) and dichloroacetic acid (11% absorption)
- Mass absorbed into pasta = 681 μg x 10% = 68.1 μg
- 68.1 μg / 16 people = 4.3 μg per person
- That's equivalent to drinking 14 liters (3.7 gallons or 15 quarts) of the water containing 60 ppb HAA5
- Alternatively, the 4.3 μg of HAA5 per portion of spaghetti is equivalent to < 1/3 of a cup of the water
- It would take eating 28 adult portions of spaghetti to consume equivalent HAA5 to that found in 2 liters of water with 60 $\mu\text{g/L}$ of HAA5... every day for 70 years?
- **It seems one just couldn't eat enough pasta for the HAAs to have an effect**

Is handwashing okay?

- **Manganese** (MassDEP Fact Sheet): “Can I bathe, shower or wash my hands with the water? Can I bathe my infant in this water? - Yes. Manganese is poorly absorbed through the skin.”
- **HAAs** are also not appreciably skin permeable
- **HAAs** (MassDEP Fact Sheet): “*Drinking water is the main source of exposure to HAA5, followed by ingestion of it in foods and/or ice prepared with the water. It is possible that small amounts of HAA5 could be absorbed through the skin during handwashing and showering.*”
- *Significant inhalation exposures of HAA5 chemicals during handwashing or showering does not occur as these chemicals do not readily vaporize into the air.*”
- **YES – handwashing is totally okay.**
- **And the skin exposure route sounds even less threatening for HAAs than the spaghetti route**

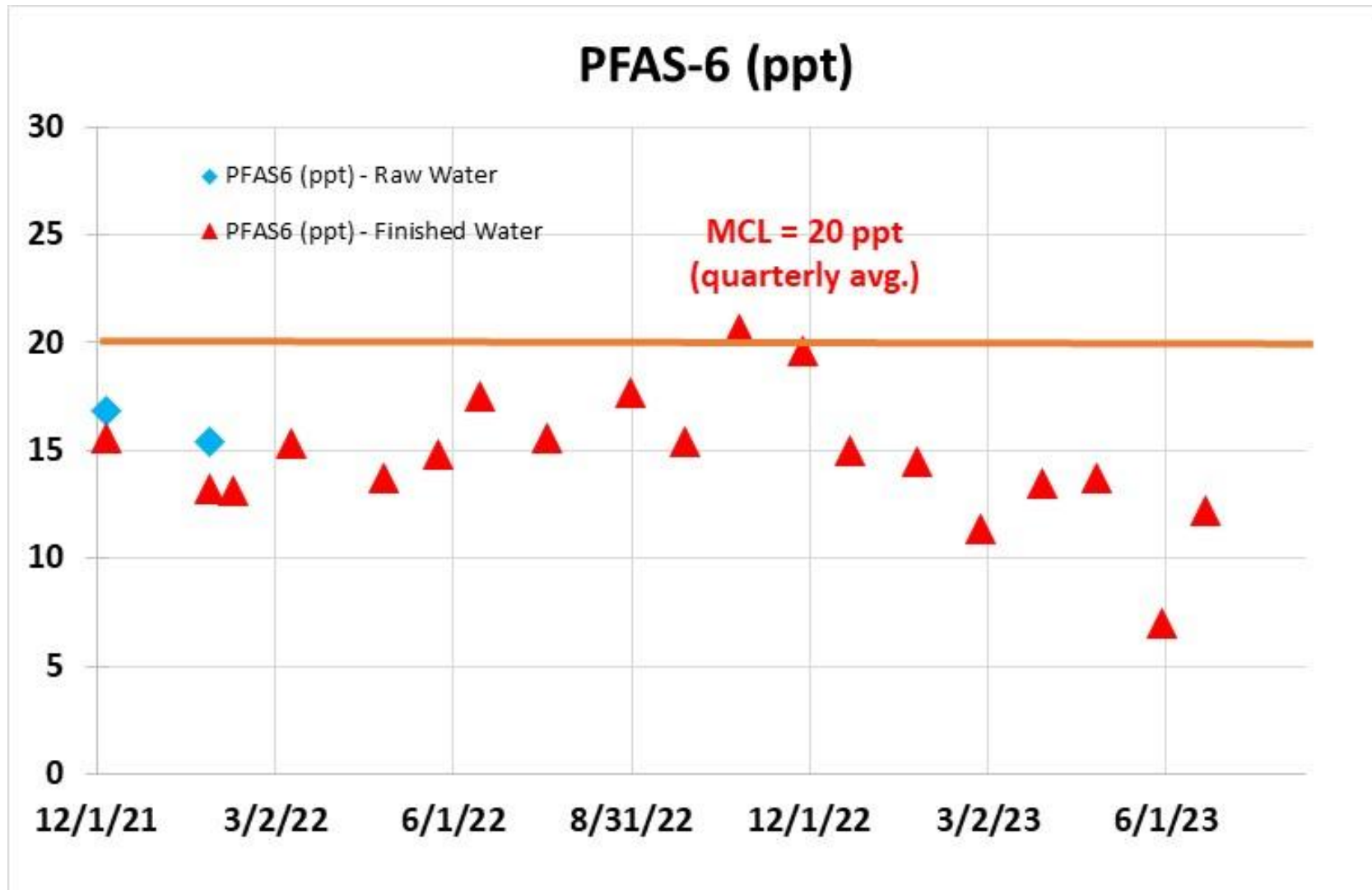
What about swimming?

- Swimming pools are chlorinated and may contain high concentrations of HAAs
- Per NIH: *For U.S. swimming pools disinfected with chlorine, dichloroacetic acid concentrations have been reported to range from 52 µg/L to 6,800 µg/L, and trichloroacetic acid concentrations from 76 µg/L to 1,900 µg/L*
- HAAs have been detected in swimmer's urine within 30 minutes of exposure to pool water

Top issues for MES

- 1. HAA5 violations**
- 2. Past failures for iron and manganese removal**
- 3. Poor public perception –**
 - DBP Public Notices are not as appropriately descriptive as they could be
 - Bubblers shut down; no one allowed to drink the water
 - Fearmongering from NWSI and BMRSD leadership
- 4. Changing EPA regulations:** Will likely need treatment for PFAS

Per- and polyfluoroalkyl substances (PFAS)



Moving forward...

*What was
not an emergency
is now over*

Solution for both HAAs and Fe/Mn:

- Improve operational oversight of GSF chlorine levels
- Include computer control to limit chlorine residual
- Switching from chlorine to permanganate (for HAAs) should not be necessary, but is a backup strategy

Additional options for HAAs:

- Install point-of-use GAC filters (kitchen, bubblers)
- Use GAC pitchers (Brita type)

Potential new PFAS regulation:

- Engineering study for (a) treatment alternatives and (b) possible interconnection with neighboring water system

The MES Water Quality Team

Affiliation	Location	Responsibility	Personnel
Water Compliance Solutions, LLC	Leominster, MA	Primary Operator; data management and reporting; primary responsibility for GSF effluent chlorine levels	Dr. Rich Gullick (4T)
Maintenance Service & Engineering, Inc. (contract pending)	Jefferson, MA	Secondary Operator	David Papale (1T, 1D)
MP Water Systems Management	Fall River, MA	Additional operator	Michael Poitras (4T, 4D)
McClure Engineering, Inc. (contract pending)	Charlton, MA	System design	Chris McClure, P.E.
The B.I.S. Group (contract pending)	West Hartford, CT	Instrumentation and meter verification and calibration	Robert Facey

*So, given the
actual water quality...*

- ❖ *How did the situation come about for the school to be closed for attendance by students in Fall 2023?*
- ❖ *Especially given they had been using bottled water for drinking for years?*

Posturing and grandstanding

- Fearmongering: *intentionally trying to make people afraid of something when this is not necessary or reasonable*
- In my opinion, there has been (and continues to be) a fair amount of posturing and grandstanding conducted by some of the BMRSD leadership, especially at their public meetings
- The misinformation has led to unnecessary worry, uncertainty and doubt.
- *Everyone cares about the children and water quality, so please don't imply otherwise.*

*“Leaky-gate:
RWSA employee resigns
in protest”*

Cville Weekly, 7/2/18 (Charlottesville, VA)

[see cillesensiblewaterplan.org]

Timeline for Greensand

- April 2022: with greensand failure, NWSI regenerated media with HOCl
- June 2022: visit to 'beaver pond'
- Summer 2022: chlorine levels were consistently low, averaging only 0.04 ppm (should be ~0.5 ppm). WCS commented, but Operator ignored saying it didn't matter due to low flow.
- Fall 2022: Fe/Mn breakthrough and colored water all autumn
- 10/25/22: MassDEP issues treatment technique violation for Fe/Mn

- 11/14/22: discussion w/DeFalco (BMRSD)
- 11/28/22: Zoom discussion w/MassDEP
- 12/5/22 Zoom meeting: NWSI confirmed recommended switch to permanganate (for DBPs) and replace greensand (for Fe/Mn); Millville and WCS agreed; NWSI was tasked with the required WS34 application + implementing changes
- Jan. 2023: Fe/Mn levels skyrocket
- Feb. 9 – 21, 2023: MES used trucked water

In Spring 2023...

- Millville had a plan proposed by NWSI and approved by MassDEP to replace chlorine with permanganate to solve the DBP problem
- Then a theory was put forth by NWSI of:
Busy beavers --> standing water --> higher TOC --> colloids --> unavoidable color in the school's water
- Higher TOC levels do cause higher DBPs, but that is not caused by the standing water

Timeline for Greensand

- 2/22/23: new GSF media put in
- 2/23-28/23: discussion of colloids causing color in treated water (or not...)

Citing from the Water Research Foundation's *Guidance for the Treatment of Manganese* (Brandhuber et al., 2013):

“Particulate Mn is typically operationally defined as Mn retained by a 0.45 to 1 micron filter. Mn that passes through the particulate filter but is retained by a 10,000 to 30,000 apparent molecular weight cutoff (MWCO) ultrafiltration membrane is operationally defined as colloidal Mn. Dissolved Mn is defined as the Mn passing through the ultrafiltration membrane.”

Citing from [Tobiason et al. \(2016\)](#):

“Distinguishing between particulate and dissolved forms of Mn is necessary... Traditional operational definitions of the dissolved fraction are often based on use of laboratory membrane filters with pore sizes of 0.2 to 1 micron. However, it is useful, and sometimes necessary, to also separate the traditional so-called dissolved fraction into colloidal and dissolved fractions by the use of an ultrafiltration membrane of a specified molecular weight cutoff, e.g., a 30,000 or 10,000 Dalton ultrafilter.”

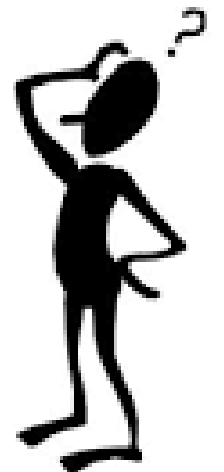
Timeline for Greensand

- then basically silence from NWSI in March...
- 4/10/23 NWSI to MassDEP – primary concerns were impact of TOC on iron oxidation and the intermittent operation of the WTP
- 4/17/23 draft WS34 provided by NWSI (mentions concern about TOC and colloids, but no mention of bacteria, *Giardia*, *Cryptosporidium*, or disinfection)
- 4/26/23: WCS' review of WS-34
- 4/26/23: Ferrari initial response (TOC and colloids; mentions possibility of bacteria from pond getting into well)

Dr. DeFalco e-mail 4/17/23

DeFalco to Ferrari/NWSI and others (about beavers/TOC/WCS LLC as obstacles):

- *“I appreciate, very much, your thorough overview and pointed/direct commentary/communication.*
- *I have not heard anything from anyone else on this so I appreciate both the information and respect to the school district and children of MES.*
- *It sounds as though things are in a difficult spot with non-certified non-experts trying to move this work in a particular direction that is less than ideal.”*



4/27/23 BMRSD School Committee meeting*

- Ferrari and DeFalco both indicated that they didn't want to move forward with permanganate since beavers threaten the well water quality via the upper elevation fractures and the chlorine used for disinfection would be discontinued
- *This was a new concept not previously expressed to Millville or WCS, LLC before 4/26/23*

* Robert Ferrari and Sean Murphy of NWSI presented. Video available at:
<https://www.youtube.com/watch?v=CCRDwks86Qo&list=PLZFzagk00pfdRNZSJzQQwo3MIBZHfCxHP>

Mr. Ferrari on 'beaver pond' (4/27/23)

- *"MES gets increasing TOC from rainfall. It's a very fragile, friable bedrock..."*
- *"I believe the well is now groundwater under the direct influence of surface water (GWUDI)..."*
- *"The beaver pond is scaring the hell out of me."*
- *"Beavers release giardia and cryptosporidium..."*
- *"We'd be taking away chlorine so possible problems with giardia and cryptosporidium..."*
- *"It's mind-boggling the DEP directive is being ignored."*
- *"I'm amazed DEP hasn't come in here and hit you with a cease and desist and consent order. I don't know how it hasn't happened."*
- *"I am being put in a position that is untenable. A disaster waiting to happen."*
- Threatened to resign if beavers are not removed
- **No mention of colloids?**

Ferrari's and DeFalco's theory

(4/27/23 meeting through 7/10/23 report)

➤ **NWSI refused to complete WS-34 application based effectively on belief that:**

1. The beavers and standing water affect the microbiological water quality in the well,
2. Chlorine is currently used for disinfection, and
3. Removing chlorine would require installing other treatment processes to compensate for the loss of disinfection

➤ **The delay was unfortunate and unnecessary:**

1. MassDEP made it clear 5/15/23 that they do **NOT** consider there to be a connection from the surface water to well water, and the beavers were not a concern either.
2. Chlorine is not used for disinfection at MES. Instead UV light is used for disinfection.
3. Per MassDEP, removal of the chlorine would **NOT** require any additional action or treatment related to disinfection

- **DeFalco:** *"The issue with the switchover (to permanganate) is that it involves removing the chlorine that actually kills the bacteria."*
- **Ferrari response:** *"That's correct. So must get rid of the beavers."*
- **Ferrari:** *"Right now our principal protection is the chlorine system."*

2020 MassDEP Sanitary Survey (Ferrari on beaver pond in 2020)

- Deficiency #3 required Millville to either remove the beavers or conduct MPA testing by 10/30/20, and document to MassDEP.
- Ferrari: *“Please note MPA testing (2013) determined a **low risk of surface influence upon groundwater.**”*
- Ferrari: *“NWSI previously conducted MPA sampling on May 27 and October 8, 2020 with the test results indicating **a numerical score of “0” and a LOW MA Risk Rating.**”*
- That means the MassDEP requirement was met and there was little to no concern about surface water contaminating the well.

Ferrari on beaver pond in 2019

NWSI – Addendum to Stage 2 Operational Evaluation Report, 10/2/19

- “NWSI conducted an evaluation of the precipitation (and inherent groundwater recharge) to determine any potential correlation.”
- “An initial evaluation of precipitation and well water iron concentration did not identify any direct correlation.
- “The manganese content in the raw well water appears generally unaffected by precipitation or seasonal impacts.”
- “The available microparticulate analysis does not identify any potential for direct surface water influence upon the well...”
- This indicates **there is no direct surface water influence or connectivity with the bedrock fractures, which is consistent with expectations, since the 1st significant water-bearing fracture in the well is approximately 142 ft. BGS.**”

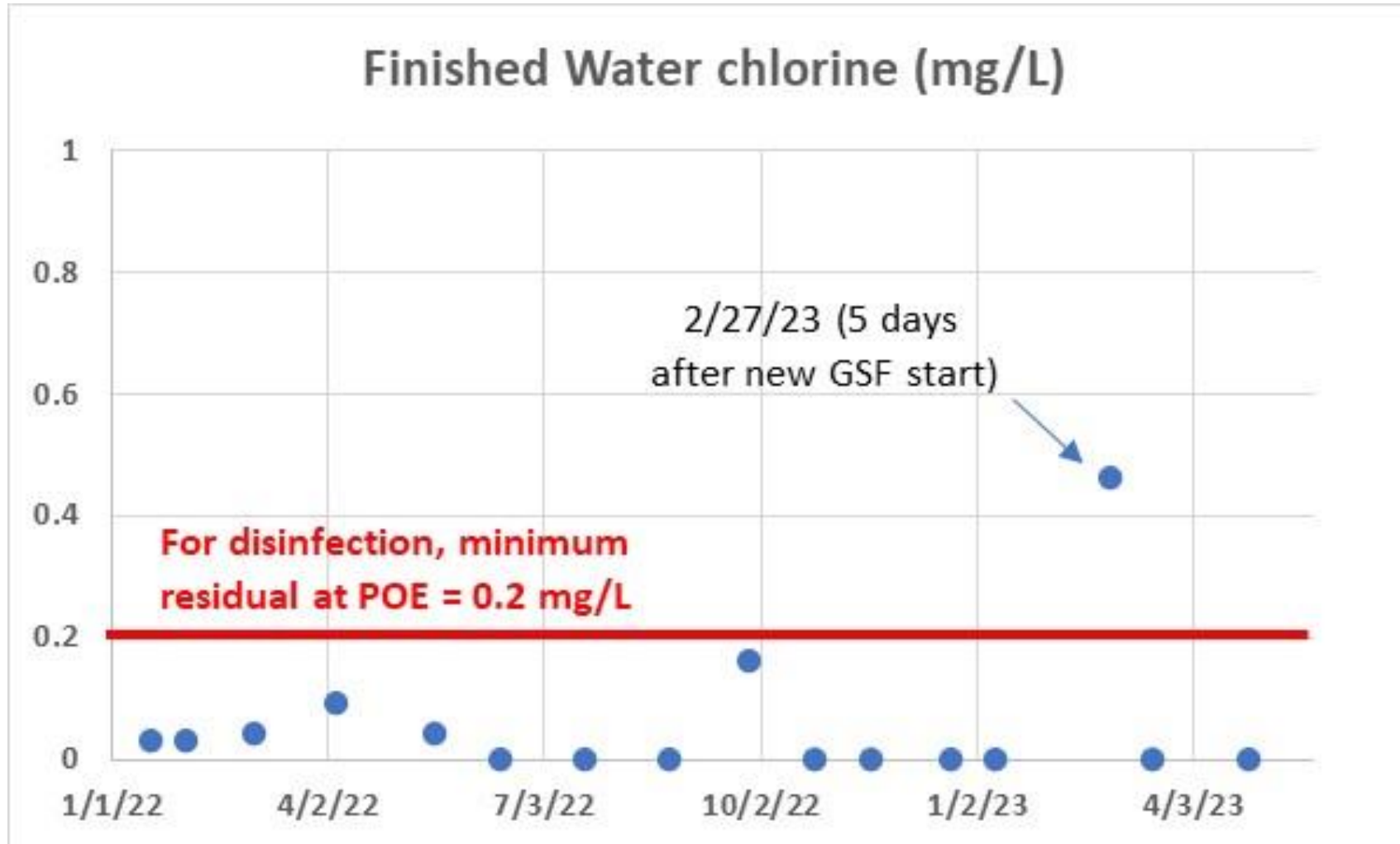
Another question...

*So assume the beavers were removed...
yet then the water stays... or beavers
return... how would the water supply
ever be considered safe?*

Chlorine disinfection?

- **Chlorine is not used for disinfection at MES**
- It is used as an oxidant for Fe/Mn removal by greensand filtration
- It has no measurable impact on *Cryptosporidium*, and no credit is possible for that from chlorine
- It reacts with iron within 10 to 15 seconds
- Very little contact time in the GSFs for chlorine to disinfect
- There is no determination or reporting of primary disinfection performance for MES (e.g., 'CT') or point of entry chlorine residuals
- Many point of entry and building chlorine residuals are 0.0 ppm
- NWSI allowed the chlorine residual to be ~0 ppm for repeated extended periods, including for over two consecutive months.

Chlorine not used for disinfection at MES



5/10/23 Zoom presentation for Millville

- After the misinformation publicized at the 4/27/23 School Committee meeting, Millville tasked WCS, LLC to prepare a summary of the water quality and provide facts regarding the incorrect information that had been put forth
- The Superintendent and Chair of the School Committee were invited to attend... **they declined...**
- **Why?** One said for open meeting law concerns...?

5/15/23 Joint BMRSD/Town meeting

- Mary Jude Pigsley (Regional Director of MassDEP's Central Region) said the standing water and beavers were not of concern to MassDEP, and she really didn't want to talk about the beavers.
- She said the well is over 1,000 feet deep, and that based on testing results MassDEP does not agree with Ferrari that the well *"is very susceptible to infiltration from the surface"*.
- Ms. Pigsley also asserted the high TOC is an old problem – in disagreement with Mr. Ferrari's theory that the recent TOC data are indicative of surface water infiltrating into the well
- Ms. Pigsley also accused Mr. Ferrari of fearmongering

5/15/23 Joint BMRSD/Town meeting

- Jennifer Gill (Millville Board of Selectmen) then instructed Mr. Ferrari that Millville wanted to move forward with the permanganate option
- Ms. Gill also noted that a representative of the greensand manufacturer had confirmed that the permanganate would work for Fe + Mn removal despite the relatively high TOC
- Millville leadership now thought the beaver question was settled and NWSI would make progress on the WS34 application for using permanganate...

Progress since 5/15/23 meeting?

- Silence from NWSI to Millville from 5/15/23 meeting until 7/10/23 report
- Several e-mails sent from Caruso + Gullick to Ferrari that went unanswered (5/23, 5/31, + 6/9)
- We directly asked for his position and progress but were ignored
- Apparently NWSI and BMRSD leadership remained fixated on the beavers

NWSI's 7/10/23 report

- 7/10/23 NWSI provides Millville with an unsolicited 234-page report
- Does not complete WS-34 application for permanganate
- Report has 186 uses of the word “beaver”

Ferrari demands the Town do one or more of six alternate actions or he would no longer work on the permanganate solution:

1. drain the standing water
2. use an alternate well
3. implement additional disinfection
4. add a UV disinfection unit
5. add granular activated carbon filtration for removal of organic compounds
6. connect to another water system

It was moving fast...

- 7/12/23: Town asks Ferrari about 3 of the 6 alternate conditions from 7/10/23 report; and tasks WCS, LLC with search for a new operator + engineer
- 7/14/23: Ferrari responded with a new demand about the beavers and also that Rich Gullick could no longer be involved; otherwise he would immediately resign
- 7/18/23: Town repeated their inquiry, and questioned Ferrari's change in position since 7/10/23
- 7/18/23: Ferrari says he would accept a new disinfection process plus TOC removal via GAC
- 7/24/23: Town Board agrees to consider GAC option since that could help PFAS (but not disinfection...)
- 7/25/23: Ferrari upset again...
- 7/25/23: BMRSD School Committee Chair bothered the beavers had not being addressed (misinformation)...
- 7/26/23: NWSI resigns as engineer + operator effective 7/28/23
- 7/27/23: BMRSD makes decision to move school
- 7/28/23: Millville had two T-4 Certified Operators onsite working before NWSI came for their last visit

NWSI's resignation

- 7/26/23: NWSI resigns as engineer/operator effective two days later
- 7/28/23: NWSI's last day at MES – picked up supplies and took data transmission equipment
- With only 2 days notice given for the resignation, Millville was stranded with no training time
- MassDEP requires 10 days notice for resigning operators, but did not enforce that policy

School Committee on 7/27/23

- This meeting was full of misinformation about the water supply and grandstanding by the speakers (too much to counter here...)
- Primary discussion by Daniel Keefe, Jason DeFalco, and Erin Vinacco
- Overblown indignation
- *“My focus is on the clean, safe drinking water for the school kids”*
- Even with bottled water agreed to be paid by the Town, the School Committee voted unanimously to transfer the students out of MES for the school year.
- This was stated to be a temporary move, with intention to return the students the following year if the water issues are resolved
- Video available at <https://www.youtube.com/watch?v=SShwAlYuZXk>

BMRSD's apparent reasons for transferring the students to another building

- They wanted to see progress on the WS-34 application for the switch to permanganate
- There are beavers causing standing water near the wellhead
- The water was brown (back in February...)
- Didn't feel it was safe to cook with the water
- Overall cost disputes with the Town of Millville and who pays for the bottled water
- Previous operator resigned as of 7/28/23

Dr. DeFalco per 8/11/23

Blackstone Valley Tribune

- *“Nothing is different from the spring, and we cannot continue to allow students and staff in the building with the current water issues. We are moving the PK-2 grade students to the JFK/AFM complex for the upcoming school year, and moving our administrative offices into Millville Elementary School.”*
- *The students and staff “must have access to clean and healthy drinking and cooking water.”*
- *“There is a great deal the town needs to do to ensure we can move our students and staff back into the school for school year 24-25.”*
- *“The BMRSD will always put the health and safety of our students and staff above all else—no matter the cost.”*

Costs of BMRSD's decision

- Lots of time and effort by a lot of people
- \$35,000 one way for the movers
- Stress for the schoolchildren
- Stress for the staff

My opinion...

- I do not believe it is appropriate to scare a generation of children away from drinking public tap water supplies in America, nor to impart this needless kind of worry and alarm to their parents
- The level of potential health risk from this water does not warrant such extreme action
- The water is not radioactive, does not have high levels of lead or arsenic, and does not have any microbial pathogens
- Instead the water occasionally has had short periods of trace levels of a treatment process byproduct that could take decades of exposure to potentially have an adverse impact
- The water is not nearly as poor quality or unhealthy as has been portrayed by school officials and Millville's former engineer/operator
- MassDEP assures us the HAA5 MCL exceedances *are NOT an emergency*, and claims "*Overall the water is safe to drink*".
- And yet the students were moved??

One of the few things I agree with Dr. DeFalco on...

“It sounds as though things are in a difficult spot with non-certified non-experts trying to move this work in a particular direction that is less than ideal.” (DeFalco 4/17/23)

***We just disagree on who the
“non-certified non-expert”
is who sabotaged this important process***

Moving forward...

- ☐ New operations team
- ☐ New procedures for operator inspections, data evaluation, and maintaining proper chlorine doses
- ☐ New engineer
- ☐ New computer control system (SCADA)

***What was
not an emergency
is now over***

Questions?



***Happy days
ahead!***

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