

A DEEP DIVE INTO MANGANESE DATA FROM UCMR 4



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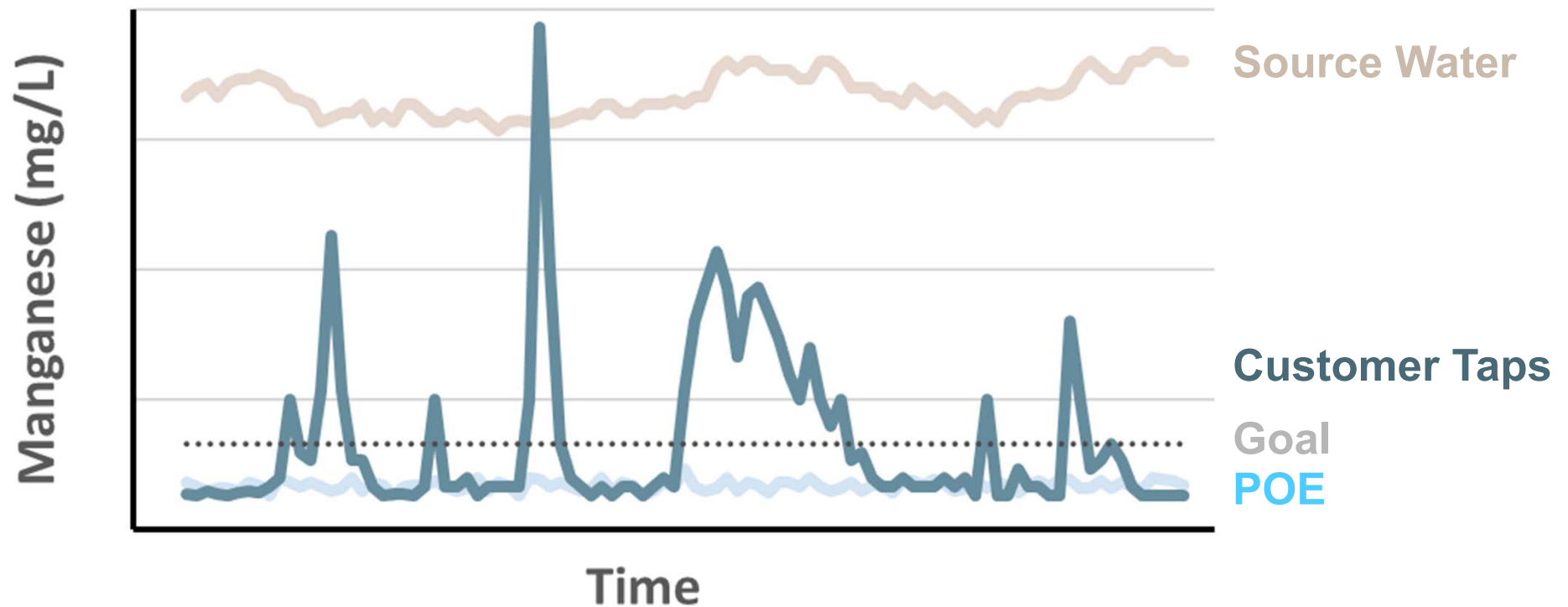
EVOLVING ISSUES REGARDING MANGANESE

- Research documenting adverse health effects at relevant concentrations
- Health Canada health-based guideline
- WHO proposed health-based guideline
- UCMRs 3/4 confirm widespread occurrence
- Greater appreciation of impacts of Mn on distribution systems and premise plumbing
 - Accumulation
 - Corrosion
 - Sorption of regulated metals
 - Risk of exposure to metals



Courtesy of AWWA Mn Sub-Committee 2021

ACCUMULATION & RELEASE IN DISTRIBUTION SYSTEMS



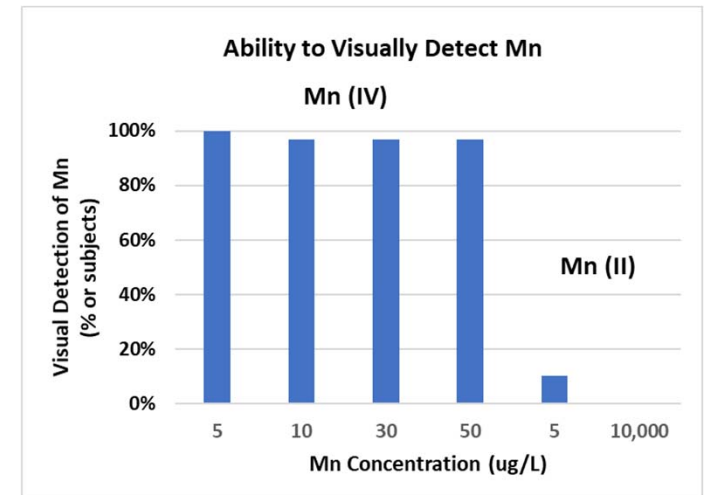
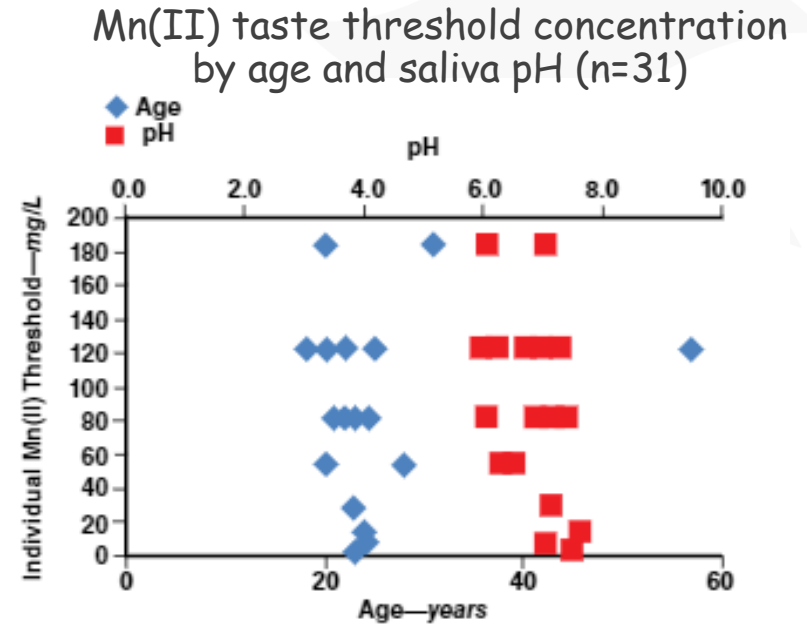
Source: Hill, AWWA Mn Subcommittee Presentation, January 14, 2021

MN AESTHETIC THRESHOLDS NOT VALIDATED BY SCIENCE

Sain et al. 2014 (J.AWWA)

- Cannot taste Mn at SMCL
- SMCL is misleading for visual effects
 - Visual detection Mn(IV) < SMCL
 - Visual detection of Mn(II) >> SMCL
- Assumption is consumers will not drink severely discolored water does not hold if Mn(II) present

Courtesy of AWWA Mn Sub-Committee 2021



CURRENT Mn REGULATORY ENVIRONMENT

Agency/Date	Type	Level (µg/L)
USEPA (SMCL prior to formation of EPA; HA 2004)	Maximum Contaminant Level (MCL)	None
	Secondary Maximum Contaminant Level (SMCL)	50
	Life-time Health Advisory (HA) Adult	300
	1- and 10-Day HA Adult	1,000
	10-Day HA Child	300
Health Canada (2019)	Maximum Acceptable Concentration (MAC)	120
	Aesthetic Objective Level	20
World Health Organization (2020)	Proposed Health Guideline	80
England/Wales (2007?)	Maximum Concentration (aesthetic/accumulation)	50

Mn Treatment Guidance Manual (WRF4373) recommendation - 15 to 20 µg/L

Courtesy of AWWA Mn Sub-Committee 2021

NEW HEALTH EFFECTS RESEARCH HAS OCCURRED SINCE THE EPA HEALTH ADVISORY

- EPA HA published 2004
- Key studies for Health Canada's and WHO assessments performed after 2004
 - Neurological effects in children: Bouchard et al. (2011), Khan et al. (2011), Roels et al. (2012), Oulhote et al. (2014)
 - Various rat studies: Kern et al. (2010, 2011) and Beaudin et al. (2013)
- Coetzee et al. (2016) identified more than 30 papers published between 2002 and 2016 involving neurological impacts of Mn on childhood development

WHAT CAN WE LEARN ABOUT OCCURRENCE FROM UCMR Mn DATA?

- First comprehensive study of Mn in finished drinking water
- Mn occurrence by system size (<10K vs > 10K)
- Mn occurrence for GW systems vs SW systems
- Geographic distribution of Mn occurrence (regional issue vs. national)
- Impact of multiple samples for a single entry point (variability over time)
- Frequency of occurrence above different levels of interest
(20 ppb, 50 ppb, 80 ppb, 120 ppb, 300 ppb)

BRIEF HISTORY OF UNREGULATED CONTAMINANT MONITORING RULES



- Every 5 years
- No more than 30 compounds per UCMR
- Traditionally mostly organics (emerging contaminants)
- Entry point sampling (not source); sometimes Distribution System
(so blending or changing sources can lead to variability)
- UCMR 3 had a lot of metals plus ClO₃/ClO₂
(and Mn and Ge were added for small systems)
- UCMR 4 included Mn and Ge for all systems

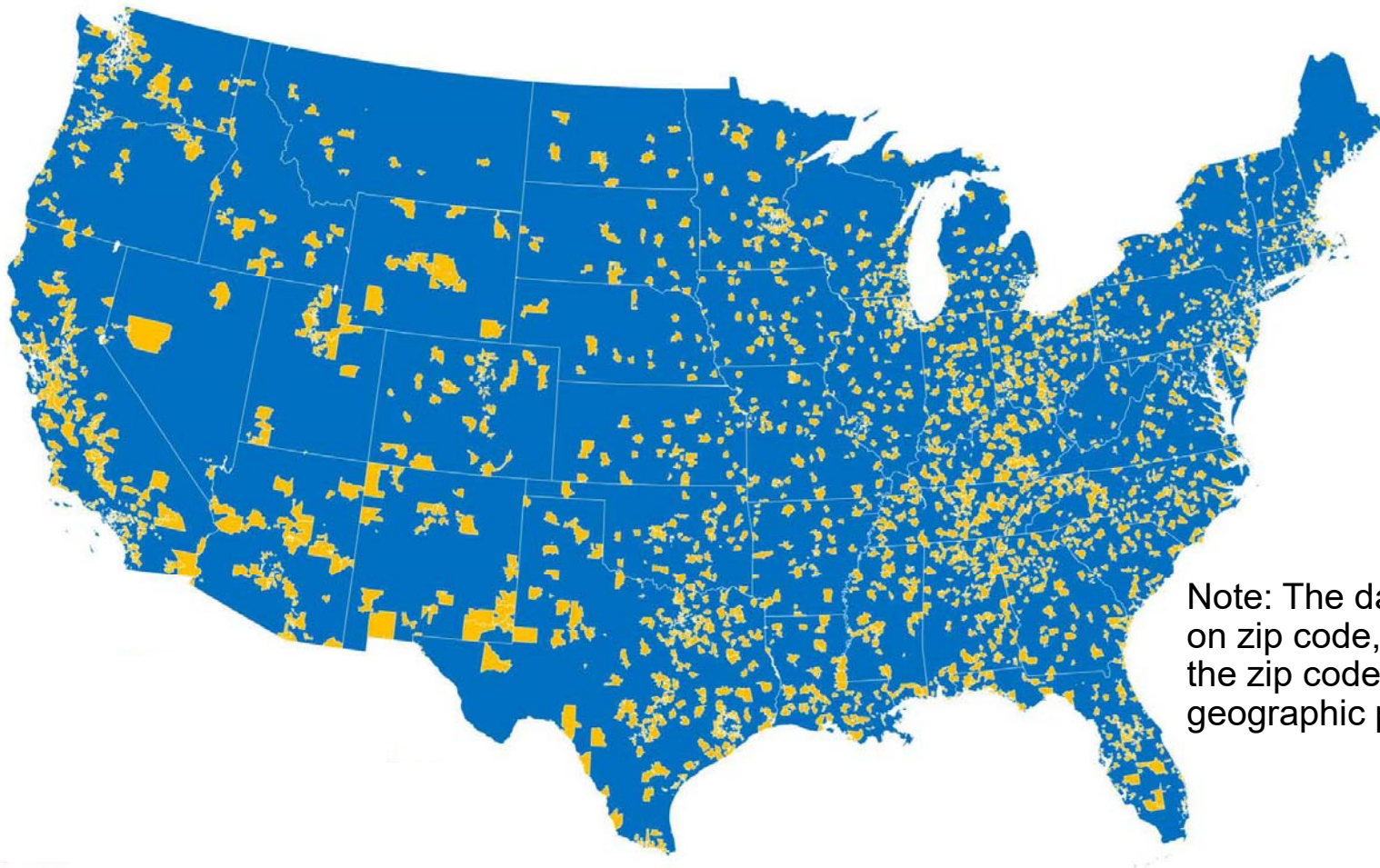
UCMR 4 OVERVIEW



2018-2020 monitoring

- ~2700 surface water systems (2465 Large, 258 Small)
- ~2800 ground water systems (2231 Large, 548 Small)
- ~37,000 samples overall when done, representing ~ 15,400 entry points

UCMR 4 SAMPLING WAS EXTENSIVE



Note: The data are based on zip code, so the larger the zip code, the less geographic precision

IS THIS THE ONLY SOURCE OF DW Mn DATA?

- There was a small (~1,000 samples) groundwater system survey (NIRS) by EPA in the early 80's.
- USGS has studied Mn extensively, but only in source waters.
- EPA/USGS did a detailed study of 25 treatment plants about 5 years ago that included Mn.
- There have been a few other very small studies (< 50 plants).
- UCMR 3 included Mn, but only for ~800 small systems.
- There are some states that require Mn monitoring, but it tends to be more targeted.

So no, it's not the only source, but it's the most comprehensive

PATTERNS DON'T CHANGE MUCH OVER TIME

- Nearly all UCMR4 data are now available in the National Contaminant Occurrence Database (NCOD).
- Overall patterns of occurrence are unlikely to change as final results are uploaded.

Date	~# of samples reported	% samples with Mn hits (>0.4 µg/L)	~# of PWS reported	% PWS with Mn hits (>0.4 µg/L)
01-19	4500	69%	1100	83%
05-19	9000	68%	1900	85%
10-19	18000	70%	3200	88%
01-20	22000	70%	3700	88%
01-21	36000	70%	5000	89%
04-21	37400	70%	5018	90%

This raises the question of whether we really need data from this many PWS to assess occurrence.

HOW DOES UCMR 4 COMPARE WITH UCMR 3 DATA?

- UCMR 3 included only a small set of samples.
(6000 UCMR 3 vs 37,000 UCMR 4)
- UCMR 3 included only small systems (<10K pop).
(~700 UCMR 3 vs ~5,500 UCMR 4)
- Reporting limits were different.
(1 µg/L in UCMR 3 and 0.4 µg/L in UCMR 4)

MANGANESE- a DEEP DIVE (BY ENTRY POINTS)

Statistic	UCMR3 SS All	UCMR4 SS All	UCMR4 All	UCMR3 SS GW	UCMR4 SS GW	UCMR4 GW all	UCMR3 SS SW	UCMR4 SS SW	UCMR4 SW All
Maximum	3550	2500	4000	3550	2500	4000	1400	550	2600
95 th percentile	68	50	43	97	71	63	28	24	19
90 th percentile	29	27	20	46	37	31	14	12	11
Median	1.7	1.7	1.2	2.2	2	1.2	1.4	1.4	1.0
MRL (ug/L)	1	0.4	0.4	1	0.4	0.4	1	0.4	0.4
~Total samples	5935	3000	36000	3564	1900	21000	2019	1100	13000

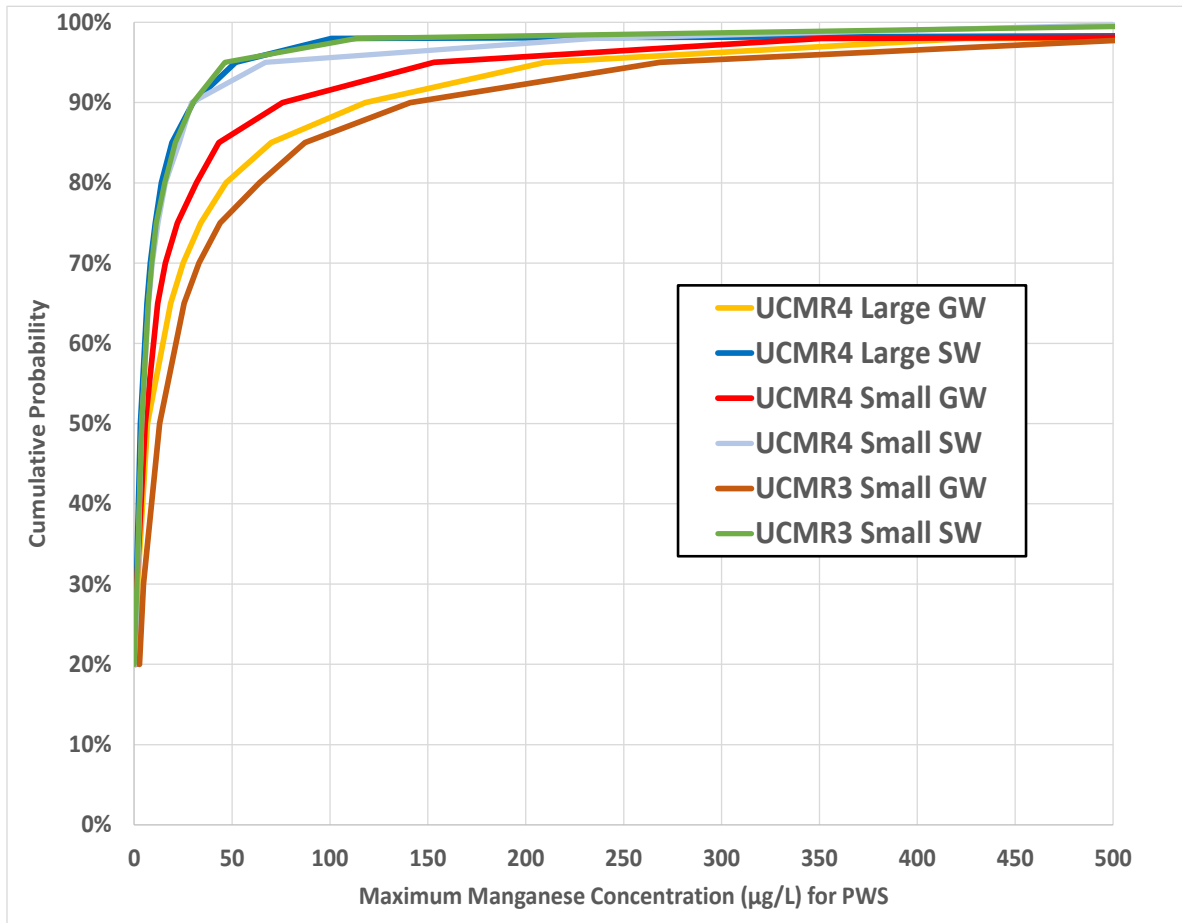
- The small systems (SS) tested in UCMR 3 had generally higher values than the UCMR 4 small systems or full set of UCMR 4 samples (UCMR 3 sites slightly more likely to exceed 50 µg/L).

UCMR 4 data from Jan 2021 NCOD

UCMR 3 DATA VS UCMR 4 SMALL SYSTEM DATA

- Sites with GW sources were higher than sites with SW sources (same in UCMR 3 and UCMR 4).
- Occasionally exceeded the SMCL (again the same).
- There were some VERY high concentrations measured(again same).
- Could vary significantly at the same sample point over time (again the same as UCMR 4).
- **BUT UCMR 3 entry points have much greater frequency of exceedances than UCMR 4 small systems (sample selection?).**

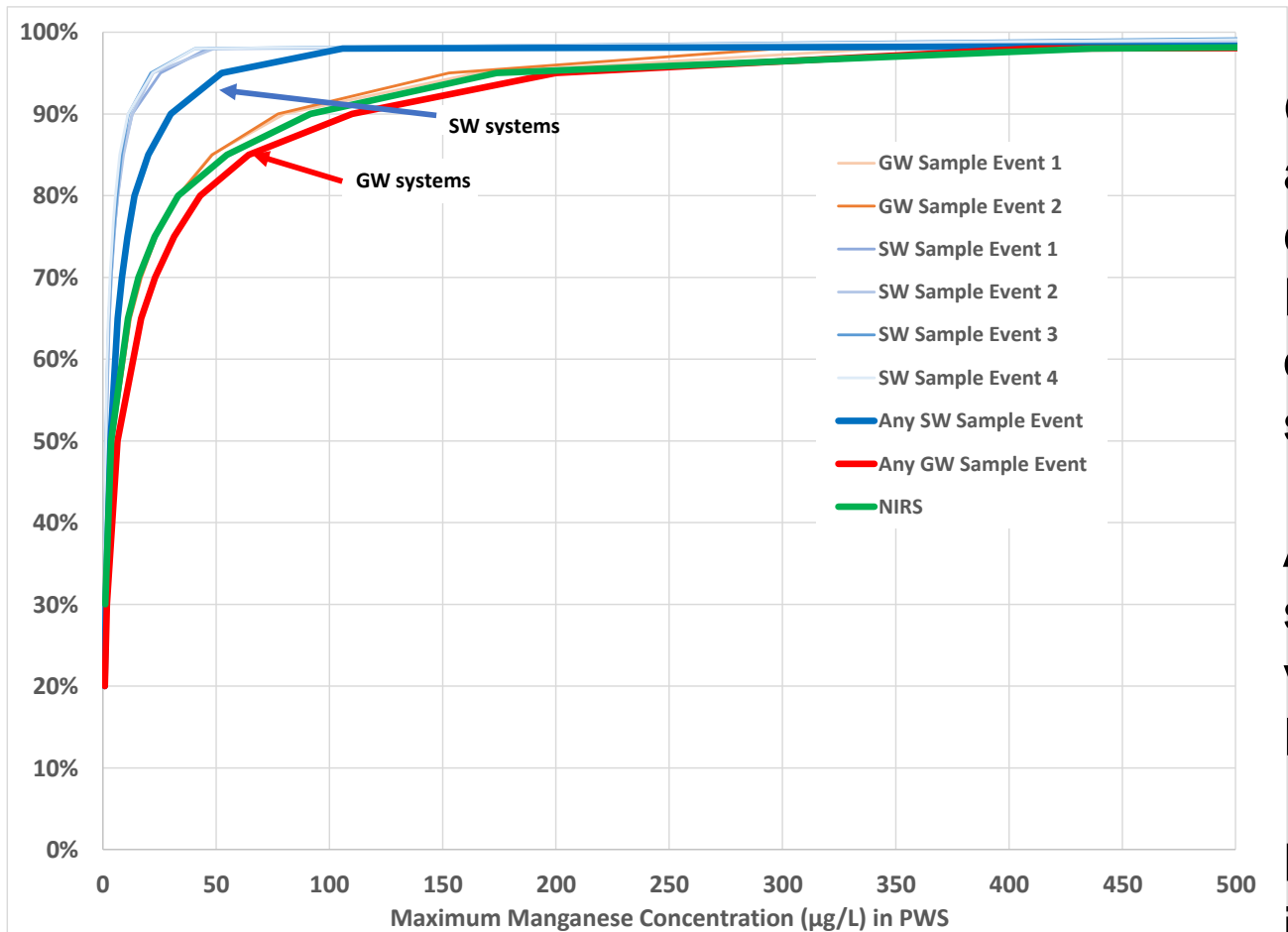
LARGE SYSTEMS VS SMALL SYSTEM ENTRY POINTS



UCMR 3 Small system groundwater pattern is inconsistent with UCMR 4 groundwater system patterns suggesting that 800 systems is not adequate to characterize occurrence in the ~50,000 small groundwater systems.

Note: X axis cut off to focus on levels of interest

SW vs GW ENTRY POINTS



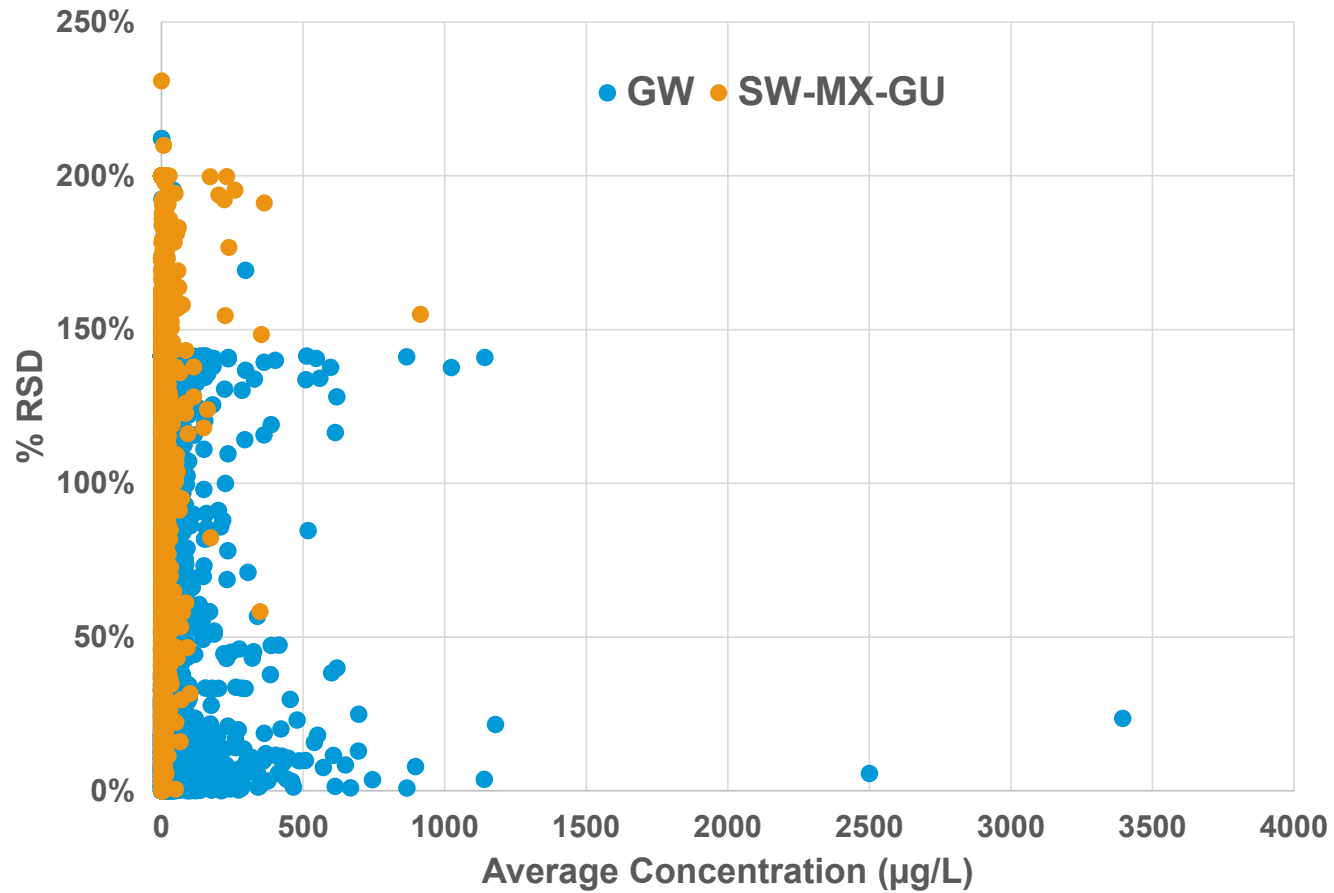
GW source entry points (EP) are more likely to have higher concentrations of Mn than SW EPs, but the overall frequency of detection (>0.4 µg/L) is similar.

Approximately 5% of GW source EPs exceeded 80 µg/L vs less than 2% of SW source EP samples.

Multiple sample events increases the likelihood of higher values

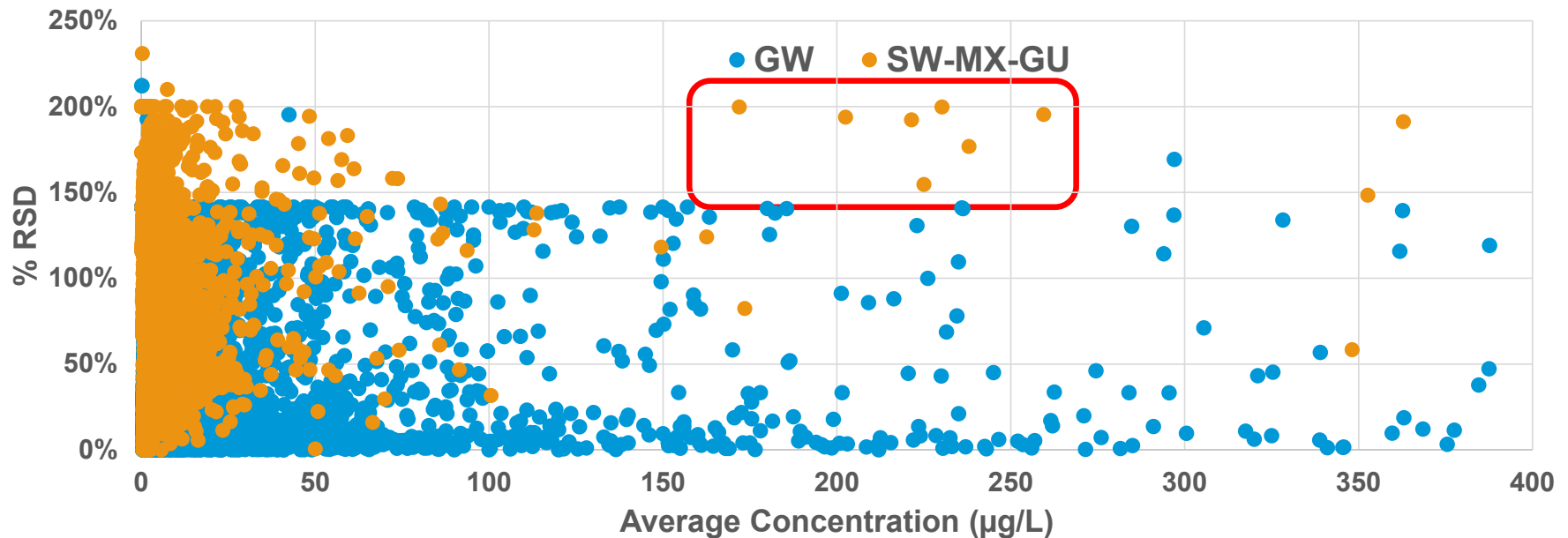
Note: X axis cut off to focus on levels of interest

RELATIVELY HIGH VARIABILITY OVER TIME INCREASES THE # OF SYSTEMS EXCEEDING A LIMIT



OTHER OBSERVATIONS on UCMR 4 DATA

- Some surface water systems have high concentrations and high %RSD. The UCMR 4 database does not allow us to easily distinguish between source variability over time versus possible impact of treatment changes.



BUT ENTRY POINTS DOESN'T REALLY TELL US WHAT WE NEED TO KNOW

- Compliance is normally based on PWS as a whole.
- The median or average or even frequency distributions are not good measures for a contaminant with high %RSD.
- Looking at the maximum manganese for a PWS during the course of UCMR 4 is a better indicator of the issues that may impact manganese regulatory actions (and is a more conservative approach).
- Individual entry point data is still relevant to understanding possible causes for PWS manganese levels.

% OF UCMR 4 SYSTEMS EXCEEDING VARIOUS POTENTIAL STANDARDS (AS OF APRIL 2021 DATA)

		% of PWS with <u>Maximum</u> Mn exceeding value	
Standard	Source of Standard	All Systems	GW Systems
20 µg/L	Health Canada's Aesthetic Objective	25.7%	32.2% (NIRS 27%)
50 µg/L	EPA SMCL	10.2%	17.8% (NIRS 16%)
80 µg/L	WHO Proposed	8.7%	12.7% (NIRS 11.6%)
120 µg/L	Health Canada's MAC	6.0%	9.0% (NIRS 7.3%)
300 µg/L	EPA HRL	2.1%	3.1% (NIRS 3.2%)

Note that EPA often uses 2% of PWS as a threshold for potential regulation.

TRENDS DON'T CHANGE SUBSTANTIALLY AS THE NUMBER OF SYSTEMS WITH RESULTS INCREASES

Threshold	% of Large Systems Exceeding		
Last Sample Date	Dec 2018	Dec 2019	2021
Samples	10,204	25,906	34,151
Number of systems	1763	3693	4220
> 120 µg/L	5.1%	5.4%	6.1%
> 20 µg/L	23.1%	24.7%	26.1%

BUT MULTIPLE SAMPLE EVENTS DOES INCREASE THE FREQUENCY OF EXCEEDANCES

Threshold	% of Systems Exceeding							
Source	GW			SW				
Event	SE1	SE2	Any SE	SE1	SE2	SE3	SE4	Any SE
Systems	2735	2666	2777	2667	2646	2647	2566	2721
> 120 µg/L	6.9%	6.7%	9.0%	0.8%	0.6%	0.3%	0.4%	1.8%
> 20 µg/L	27.2%	27.5%	32.2%	6.3%	5.9%	5.1%	5.3%	14.8%

A GW system may change wells over time and SW systems could see lake turnover or changes in treatment over time.

HOW ELSE CAN WE DISSECT THE DATA TO DETERMINE WHETHER NATIONAL REGULATION MAY BE APPROPRIATE?



- Clearly overall occurrence frequencies suggests its worth re-considering the health and aesthetic thresholds.
- We know it's not solely a groundwater system issue.
- Is it more of a small system issue?
- Is it local, regional, or national in scope?
- Do local treatment practices impact occurrence frequencies?

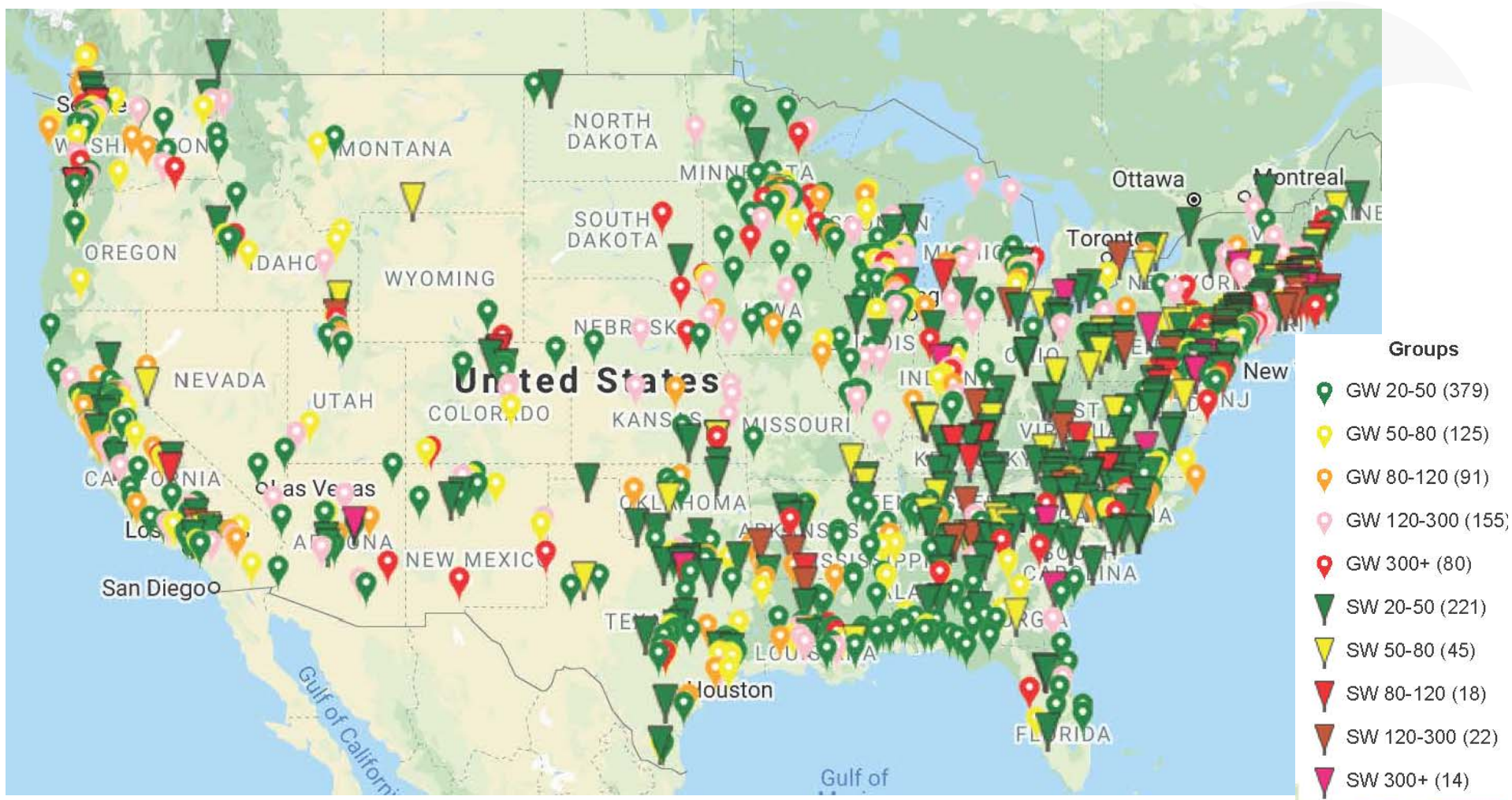
IF WE LOOK AT SOURCE TYPE AND SYSTEM SIZE WE LEARN MORE

	S-GW NIRS	S-GW- UCMR3	S-GW- UCMR4	L-GW UCMR4	S-SW UCMR3	S-SW UCMR4	L-SW UCMR4
Count	992	447	547	2230	248	257	2464
>20	27%	42.2%	26.5%	33.6%	16.5%	16.3%	14.6%
>50	16%	23.3%	12.6%	19.0%	4.8%	5.8%	5.2%
>80	11.6%	15.9%	9.0%	13.6%	4.0%	3.9%	2.7%
>120	7.3%	11.4%	6.4%	9.6%	2.0%	3.5%	1.6%
>300	3.2%	4.0%	2.6%	3.2%	0.4%	0.8%	0.6%

	All-S UCMR3	All-S UCMR4	All-L UCMR4
Count	672	798	4220
>20	33.8%	23.9%	26.1%
>50	17.3%	10.9%	13.2%
>80	12.1%	7.6%	8.9%
>120	8.3%	5.6%	6.1%
>300	2.8%	2.0%	2.1%

- GW systems are more likely to have high Mn than surface water systems.
- Although UCMR 3 data show frequent high occurrence in small systems, UCMR 4 suggests occurrence is similar in small and large systems.
- More than 25% of systems have maximum levels above the recommended Health Canada aesthetic standard of 20 µg/L.

MAX Mn BY SOURCE WATER TYPE WHERE Mn > 20 µg/L



MAXIMUM Mn FOR GROUNDWATER SOURCE SYSTEMS WHERE Mn > 50 µg/L



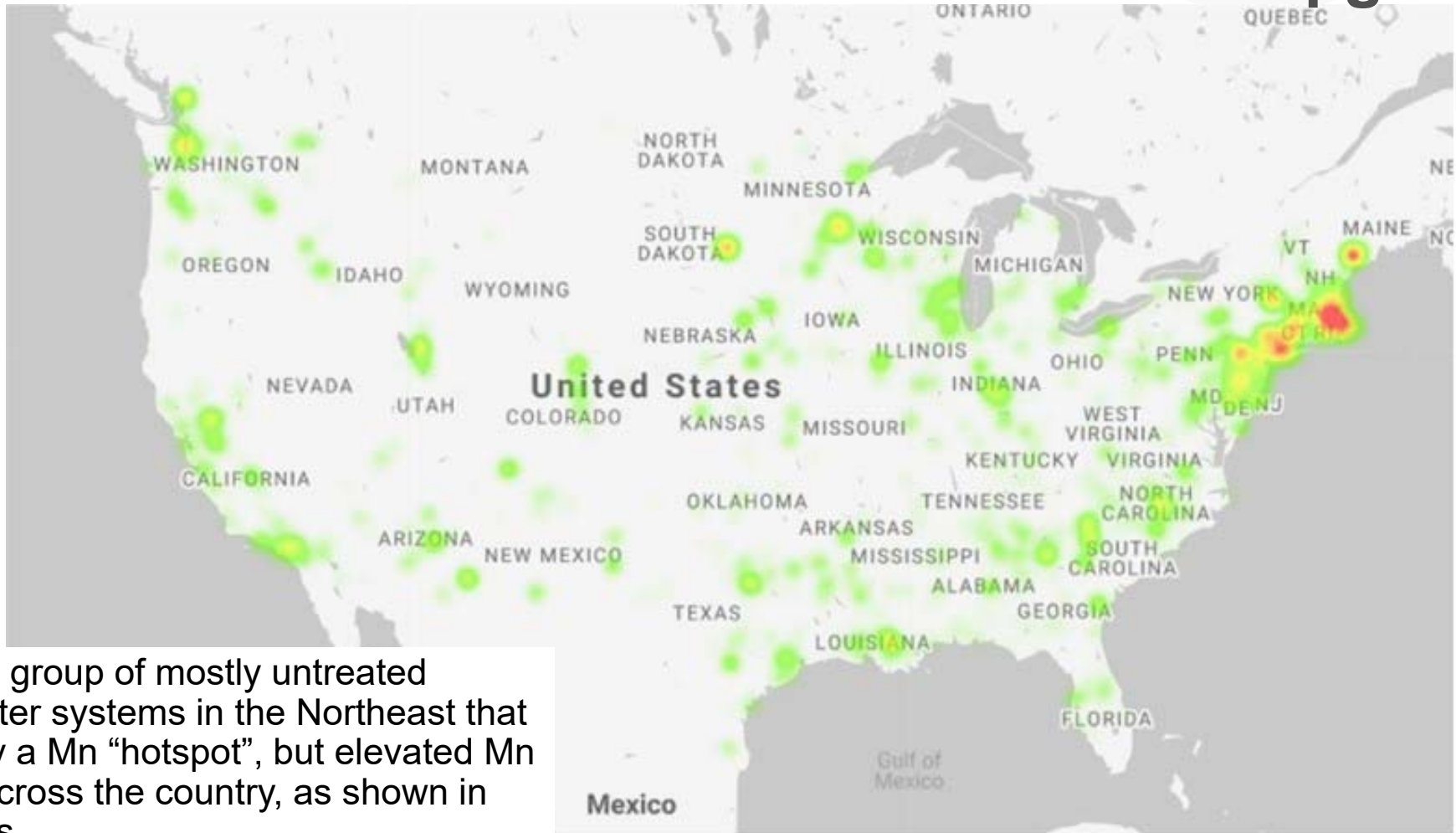
MAXIMUM Mn FOR SURFACE WATER SOURCE SYSTEMS WHERE Mn > 50 µg/L



MAXIMUM Mn BY SOURCE WATER TYPE WHERE Mn > 120 $\mu\text{g/L}$



HEAT MAP OF MAXIMUM Mn FOR PWSID > 20 µg/L



There is a group of mostly untreated groundwater systems in the Northeast that are clearly a Mn “hotspot”, but elevated Mn is found across the country, as shown in prior slides

CONCLUSIONS

- Significant UCMR 4 occurrence of manganese nationwide in GW and SW systems at levels above the SMCL and new international standards suggest a major impact on utilities if EPA re-examines regulatory levels.
- Entry point sampling likely represents a lower bound for exposure, due to the potential for release in the distribution system.
- It impacts both small and large utilities and 800 systems is clearly not enough to assess small system occurrence.
- There can be significant EP variability over time. A single sample is insufficient to determine potential exceedances at a given PWS.
- Results from fewer systems overall appear to be adequate to assess impacts on a nationwide basis.

QUESTIONS?

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