

Occurrence of Manganese in Drinking Water Systems in the USA and Pacific Northwest Patterns

Andy Eaton, PhD, BCES

Eaton Environmental Water Quality Consulting, LLC

South Pasadena, CA 91030

ade1014@gmail.com



American Water Works Association
Pacific Northwest Section

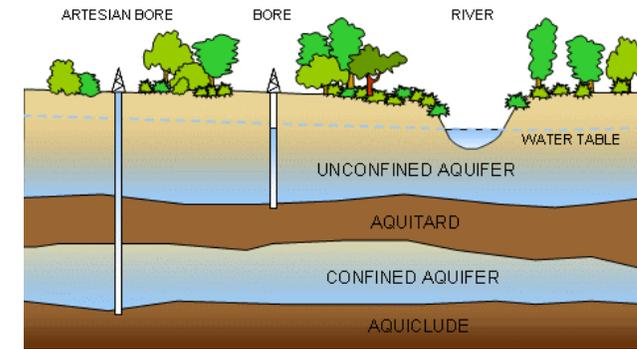
Items to be Covered

- UCMR 4 national occurrence – slicing and dicing from the National Contaminant Occurrence Database (NCOD)
- Pacific Northwest occurrence and potential issues – a subset from NCOD and closer look at what's uploaded.
- Conclusions



UCMR Sampling Requirements

- All Entry Point to the Distribution System Samples (no source)
- **GW** – 2 samples, 5 to 7 months apart
 - Assumption is that GW doesn't change rapidly
- **SW, MX, GU** – 4 samples, 3 months apart
 - Should capture some flow/seasonal variation/reservoir turnover



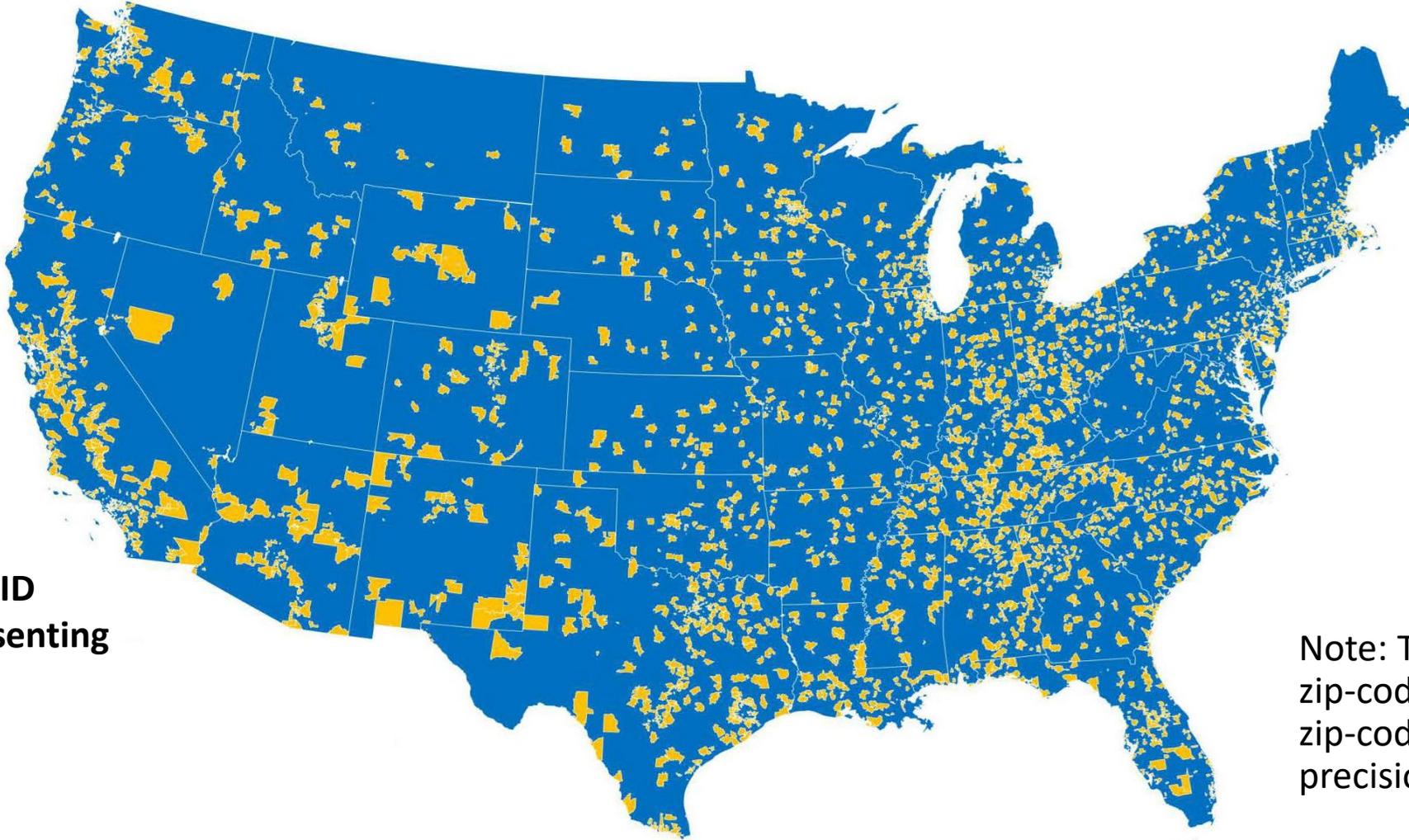
What Can We Learn About DW Occurrence From UCMR Mn Data?

- First comprehensive study of Mn in US 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 at a single entry point or PWS (variability over time and impact on compliance)
- Frequency of occurrence above different levels of interest
(20 ppb, 50 ppb, 80 ppb, 120 ppb, 300 ppb)



UCMR 4 Sampling was Extensive

~38,000 Data Points Representing ~5,000 Systems



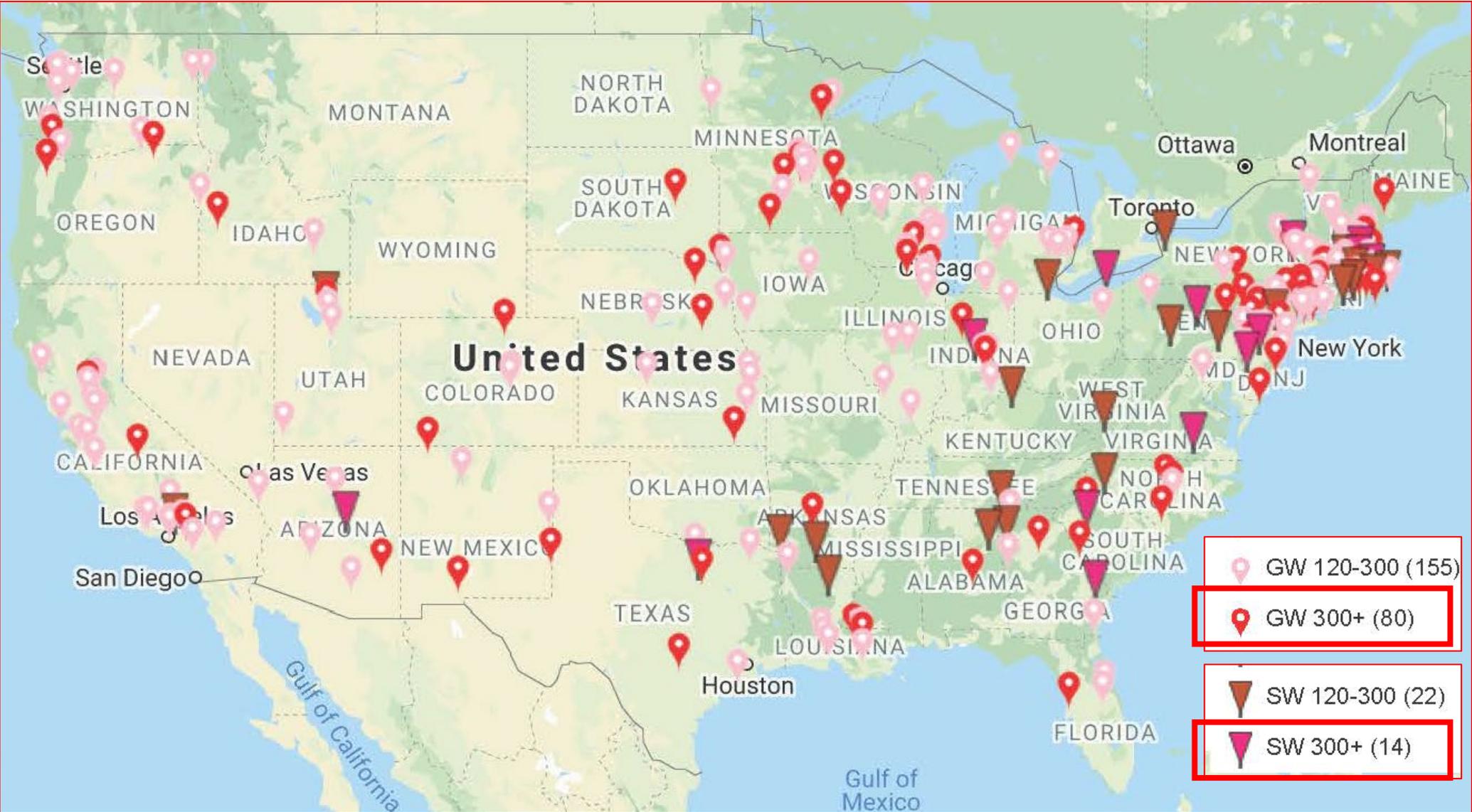
~1800 OR-WA-ID
samples representing
~235 systems

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

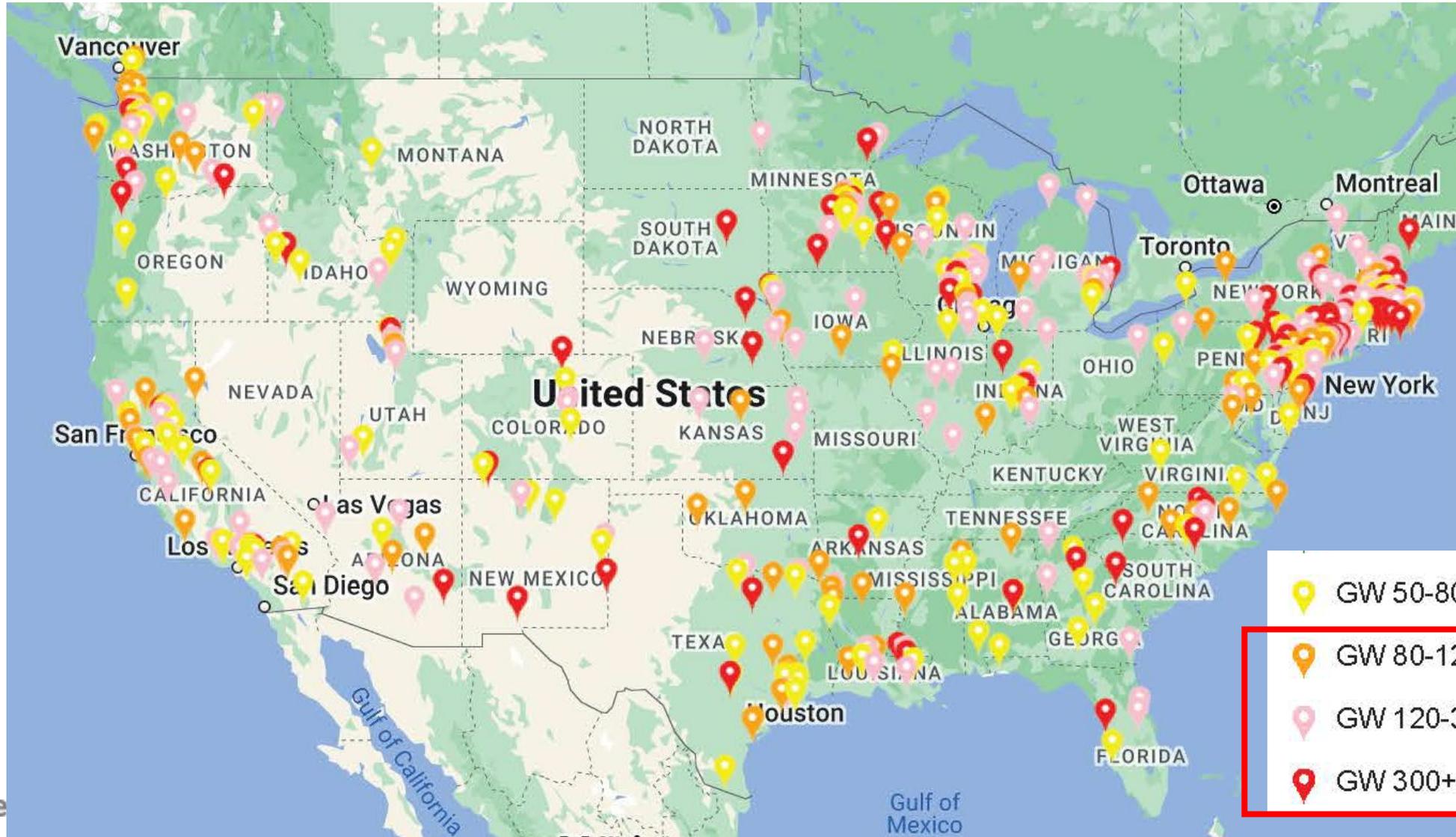


American Water Works Association
Pacific Northwest Section

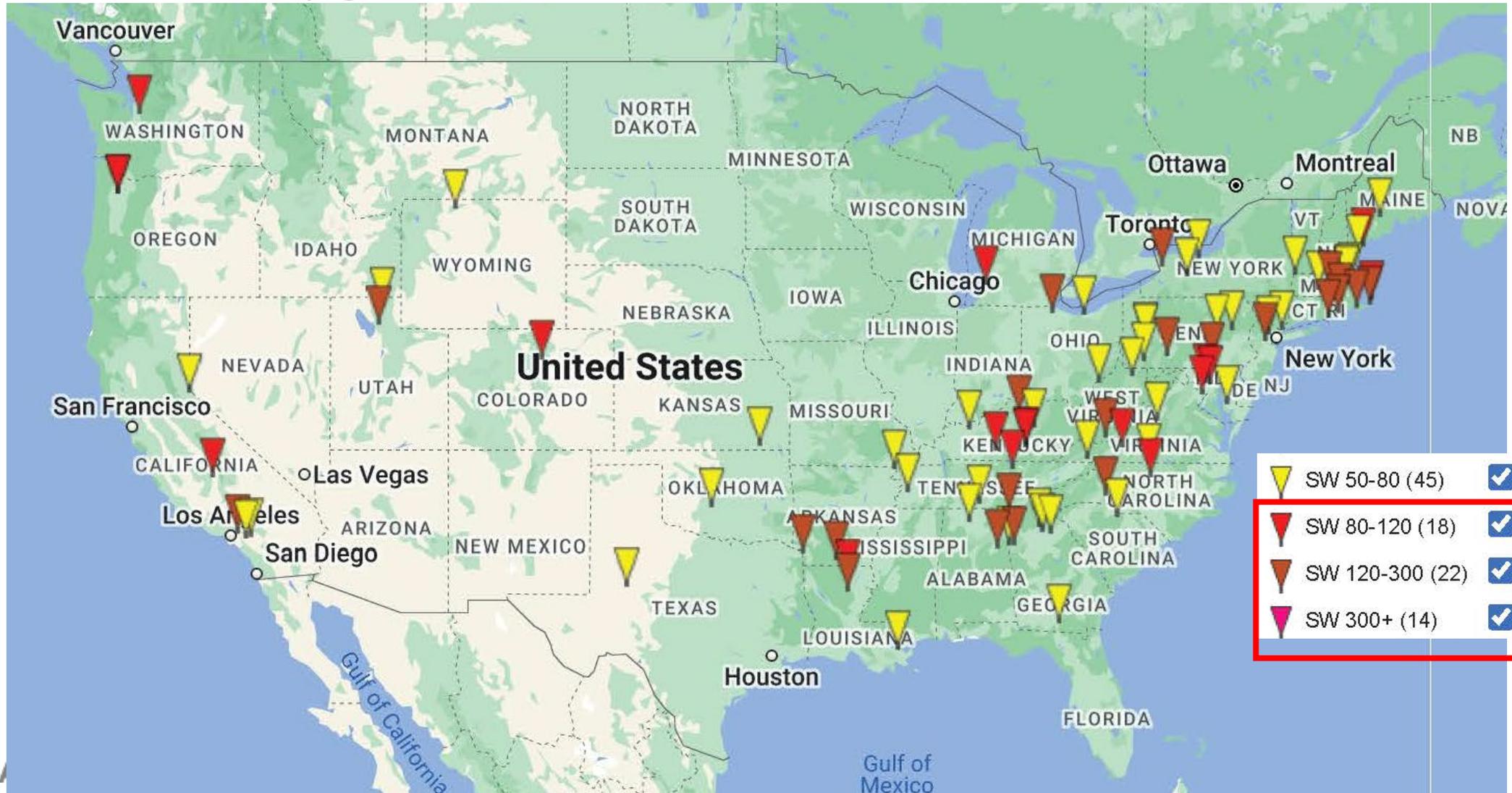
Maximum Mn by Source Water Type Where Mn > 120 µg/L (Health Canada Guideline) or Current EPA HRL of 300 µg/L



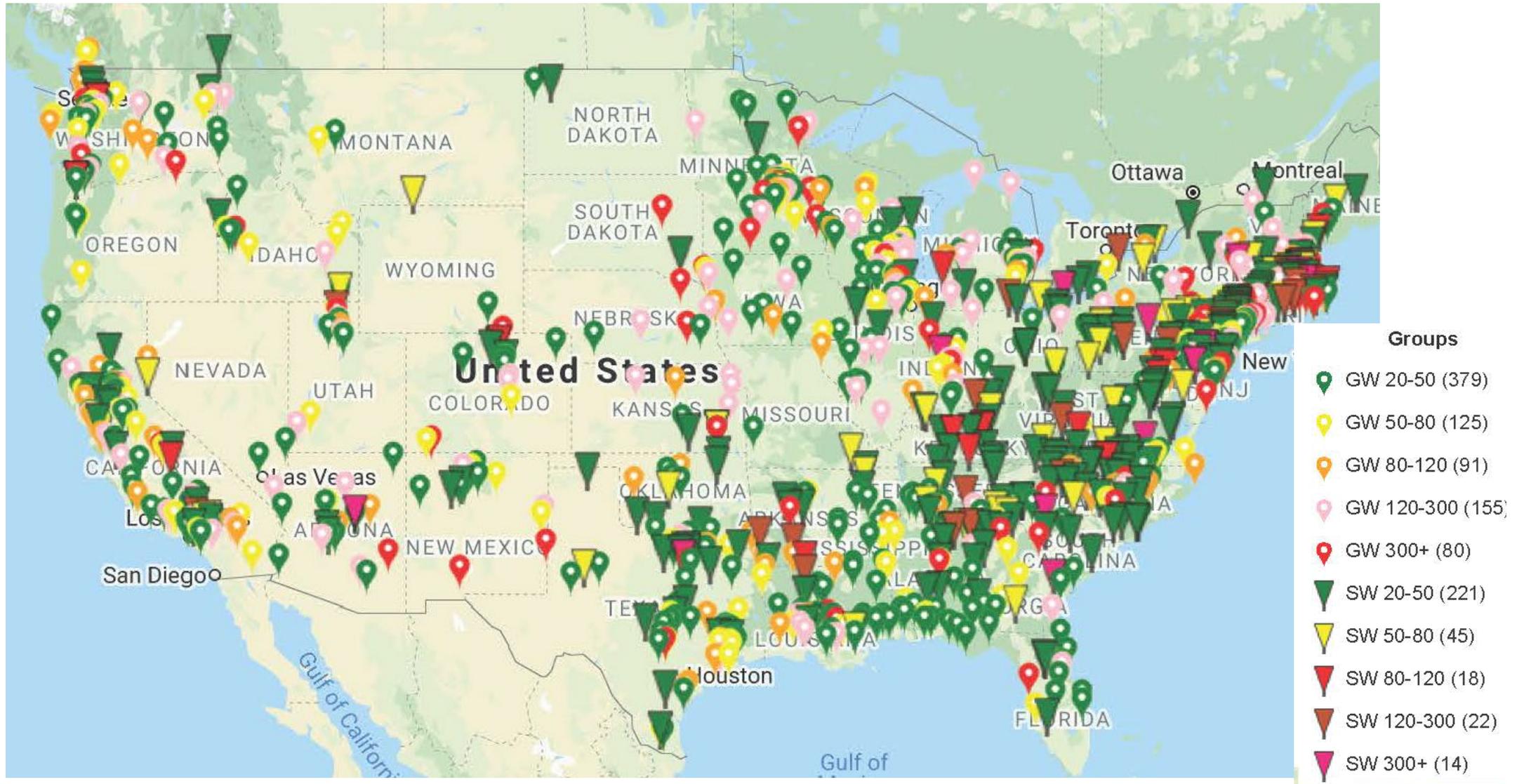
Maximum Mn for Groundwater Source Systems Where Mn > 50 $\mu\text{g}/\text{L}$ (Current SMCL) or 80 (WHO Guideline)



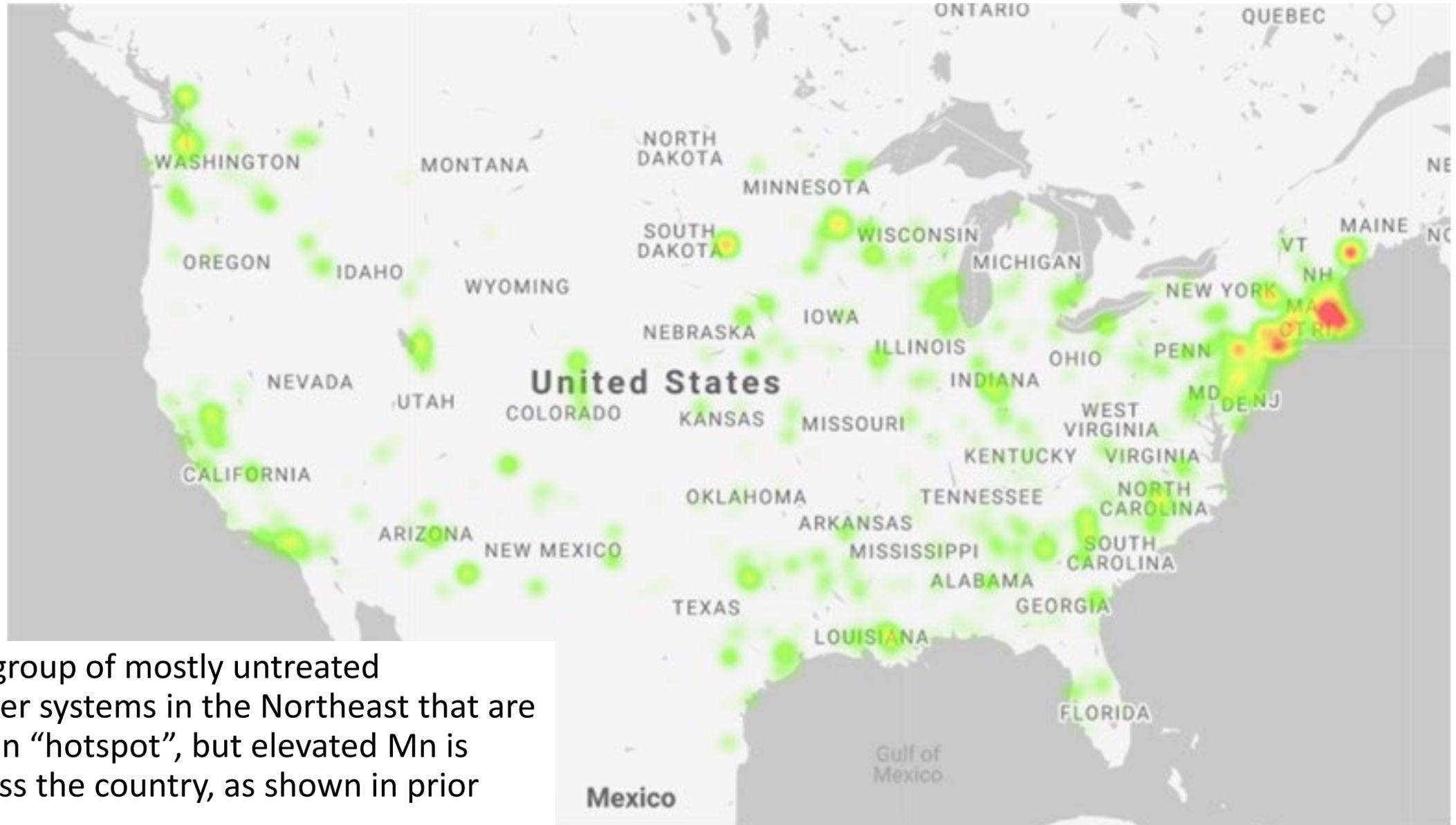
Maximum Mn for Surface Water Source Systems Where Mn > 50 µg/L (Current SMCL) or 80 (WHO Guideline)



Max Mn by Source Water Type Where Mn > 20 µg/L (Aesthetic Guideline Level)



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

% of UCMR 4 Systems Exceeding Various Potential Standards Based on Final UCMR 4 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	25.9%	32.3% (NIRS 27%)
50 µg/L	EPA SMCL	12.9%	17.8% (NIRS 16%)
80 µg/L	WHO Provisional GV	8.8%	12.8% (NIRS 12%)
120 µg/L	Health Canada's MAC	6.1%	9.0% (NIRS 7.3%)
300 µg/L	EPA HRL	2.1%	3.1% (NIRS 3.2%)

Note: EPA often uses 2% occurrence by PWS as a threshold for potential regulation.

The NIRS study was a 900 system GW only survey in the 1990s and results are very similar to UCMR GW!

If We Look At Source Type And System Size In Detail, 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	548	2240	248	258	2475
>20	27.0%	42.2%	26.6%	33.8%	16.5%	16.7%	14.8%
>50	16.0%	23.3%	12.8%	19.2%	4.8%	6.2%	5.3%
>80	11.6%	15.9%	9.5%	13.8%	4.0%	4.3%	2.8%
>120	7.3%	11.4%	6.8%	9.7%	2.0%	3.9%	1.7%
>300	3.2%	4.0%	2.7%	3.3%	0.4%	1.2%	0.6%

	All S- UCMR3	All S- UCMR4	All-L UCMR4
Count	672	799	4237
>20	33.8%	24.0%	26.3%
>50	17.3%	11.0%	13.3%
>80	12.1%	8.0%	9.0%
>120	8.3%	5.9%	6.1%
>300	2.8%	2.1%	2.1%

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

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%

This suggests that the UCMR program may not need to sample all **large** systems to assess national occurrence frequencies!



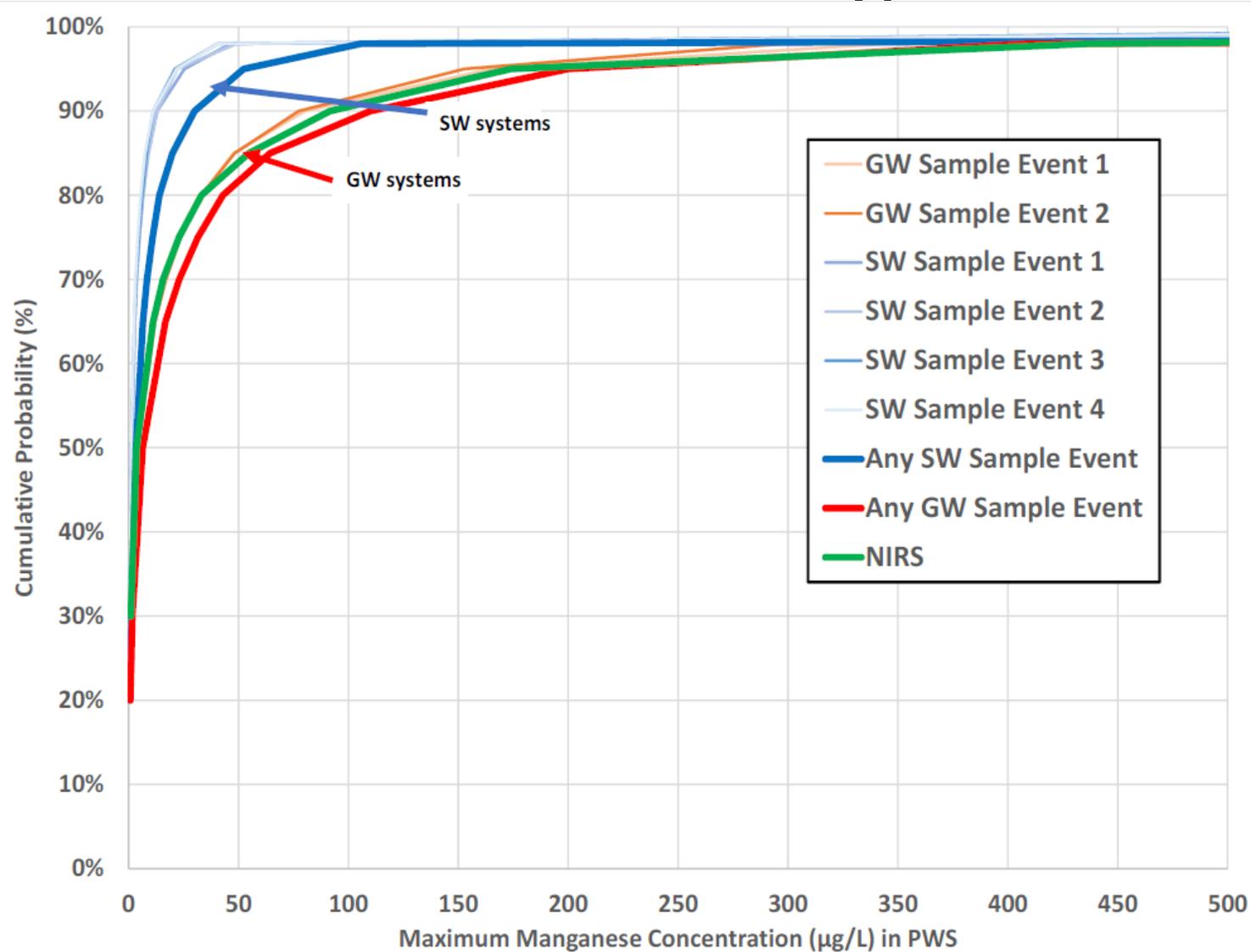
However, Multiple Sample Events Increases The Frequency Of Exceedances

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%

GW systems may change wells over time

SW systems could see lake turnover or changes in treatment over time

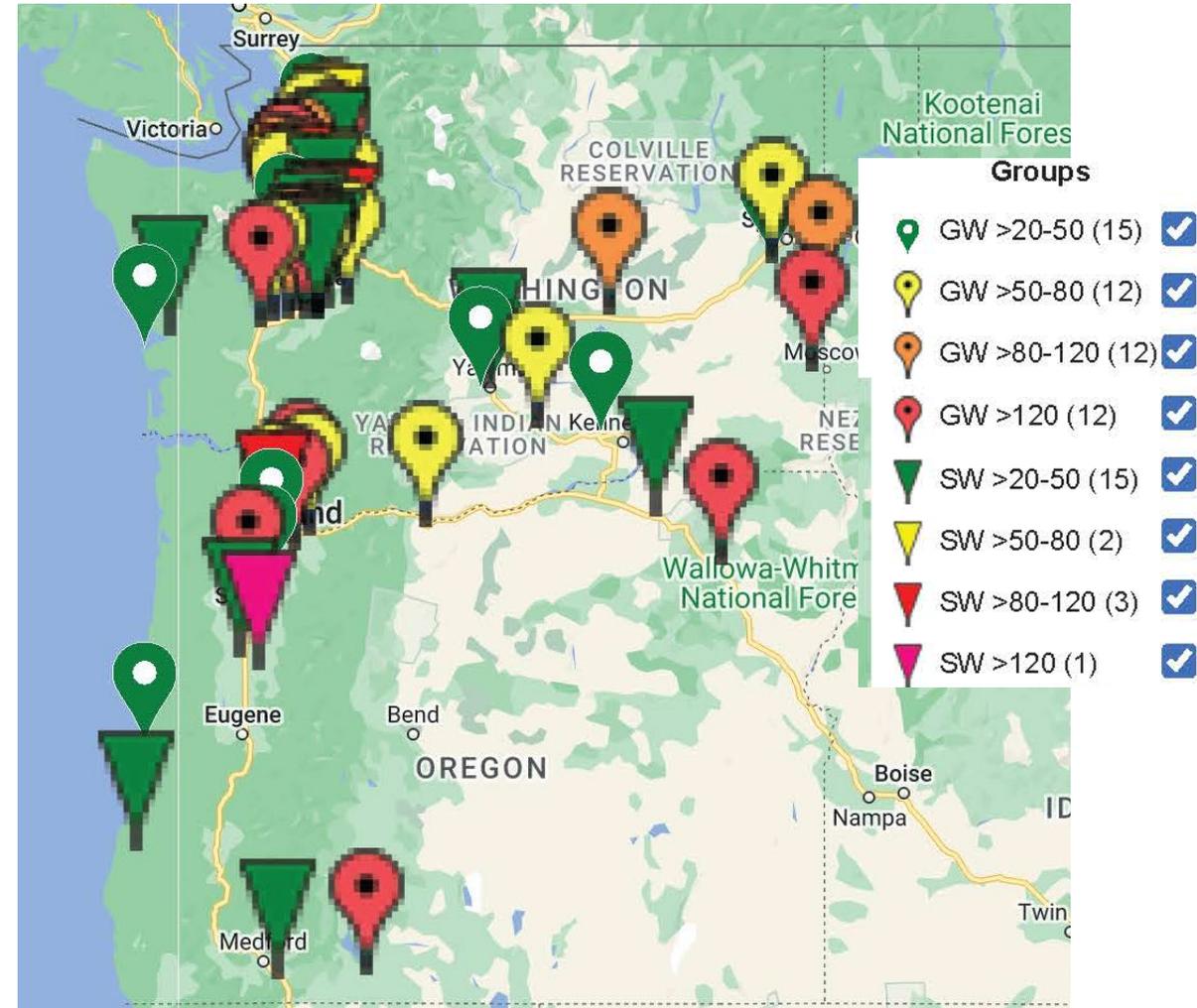
Probability Plots for National Mn Occurrence by Source Type and Sample Event



- GW systems in general have much higher levels of Mn than SW systems.
- There is no real difference between distributions for individual sample events, but the more samples you take, the greater the likelihood of finding higher values.

Comparing OR-WA Data to National Data: PNWS GW Systems Have Potential Mn Issues

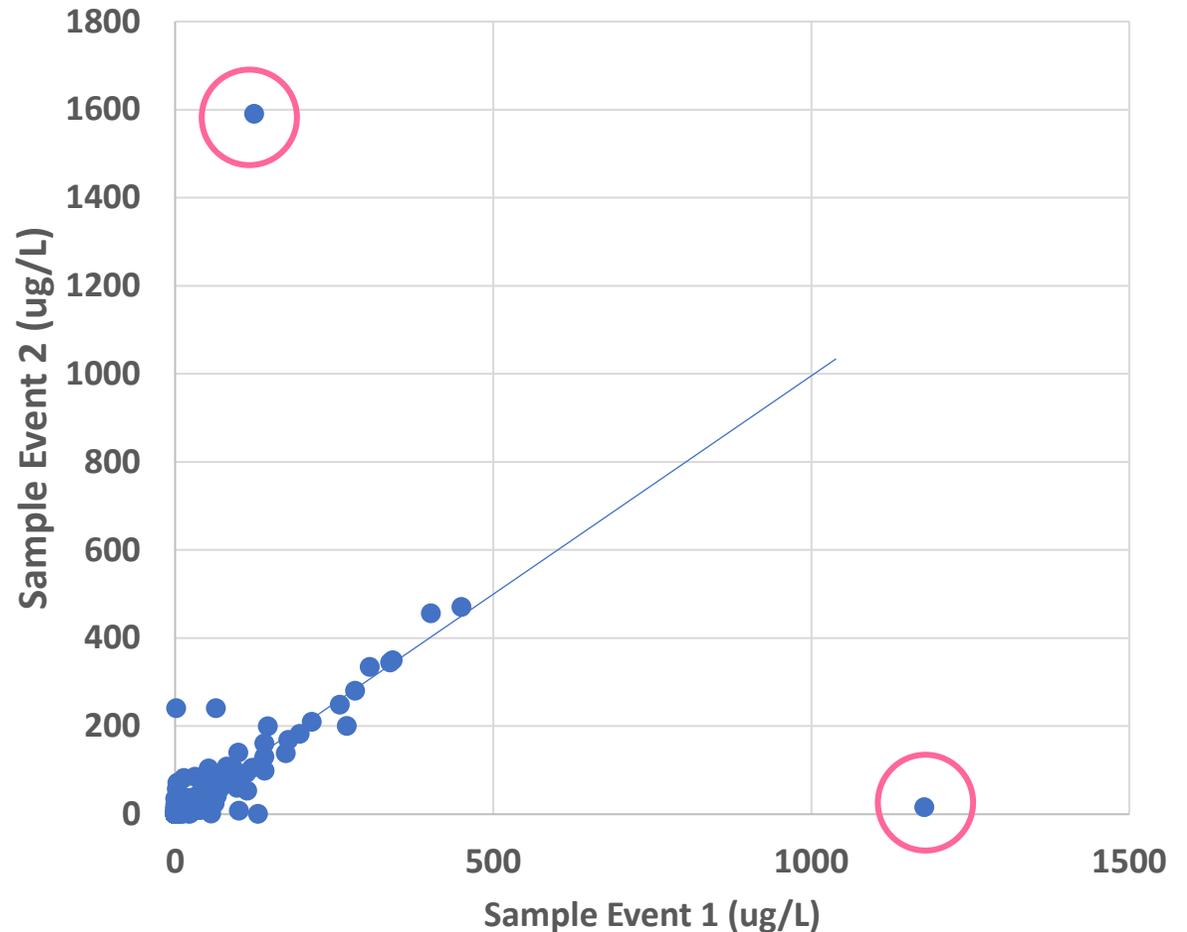
% of Systems Exceeding Specified Level				
Criteria	US GW	OR-WA GW	US SW	OR-WA SW
% >20	32%	43%	15%	20%
% > 50	18%	30%	5%	6%
% >80	13%	20%	3%	4%
% > 120	9%	10%	2%	1%



Only OR-WA systems are shown but Idaho has issues also.

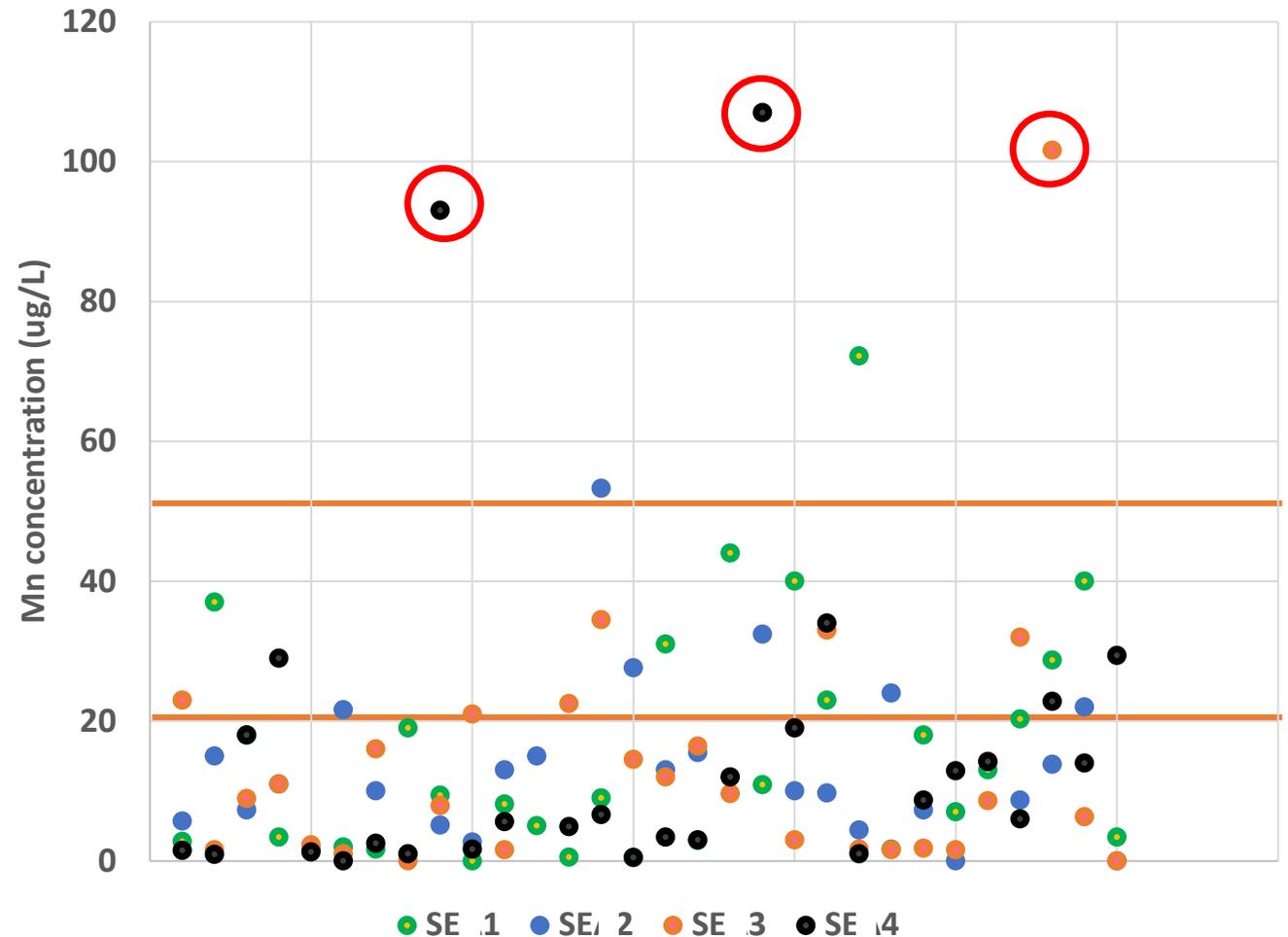
A Few Systems Appear to Have Significant Variability Over Time Even in Groundwater, But...

- Plot shows variation in results between sample events for groundwater systems in Oregon and Washington.
- In general results between sample events are very close, but once in a while there appear to be major differences- **most likely a data entry error**. The devil is always in the details!



PNW Surface Water Systems Show Substantial Variability Over Time

- Although there are <30 SW systems which have maximum values exceeding $10 \mu\text{g/L}$, variation in those may be substantial, and one system (not shown due to scale) even exceeds the Canadian guideline.
- Many sample points may exceed the $20 \mu\text{g/L}$ aesthetic guideline at different sample periods.



Conclusions

- Elevated Mn is not only a national issue, but also an issue for Oregon and Washington systems, particularly if we focus on the aesthetic guideline level of 20 $\mu\text{g}/\text{L}$.
- The number of small (<10K) systems sampled in the UCMR program does not adequately characterize Mn occurrence in small systems.
- Results from fewer systems overall appear to be adequate to assess occurrence on a nationwide basis for large systems.
- There can be significant variability over time. On a national basis, a single sample event is insufficient to determine potential exceedances at a given PWS. If you want to control Mn entering the distribution system, you should sample frequently.

