Door County Well Monitoring Program - Fall 2021 Summary

UW OSHKOSH

ENVIRONMENTAL RESEARCH AND INNOVATION CENTER

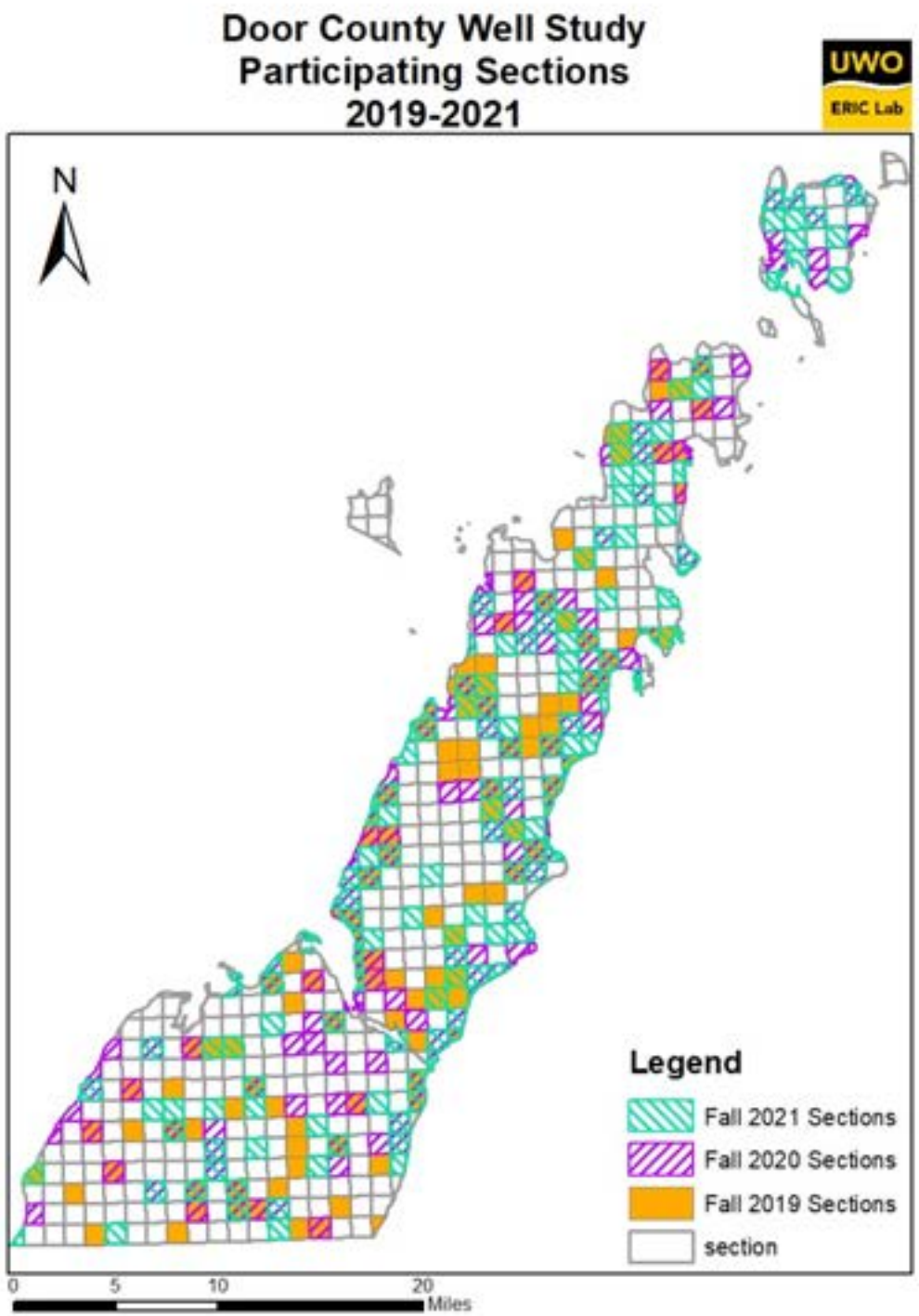
DECEMBER 1ST, 2021

Program Goals

- Provide continued education on water resources in Door County, WI
- Provide avenue for residents and guests to have the most accurate information on their drinking water quality
- Provide reliable information to guide county resources for the protection and maintenance of drinking water resources
- Be proactive with respect to drinking water resources, rather than reactive
- Create a groundwater water quality database for Door County
- Establish trends in groundwater data over time

Program Goals

- Target is at least one well per section (square mile) of Door County
- Spatially distributed data to look for trends and relationships
  - Soil type
  - Depth to bedrock
  - Water table depth
  - Land use



Karst Geology & Groundwater Susceptibility

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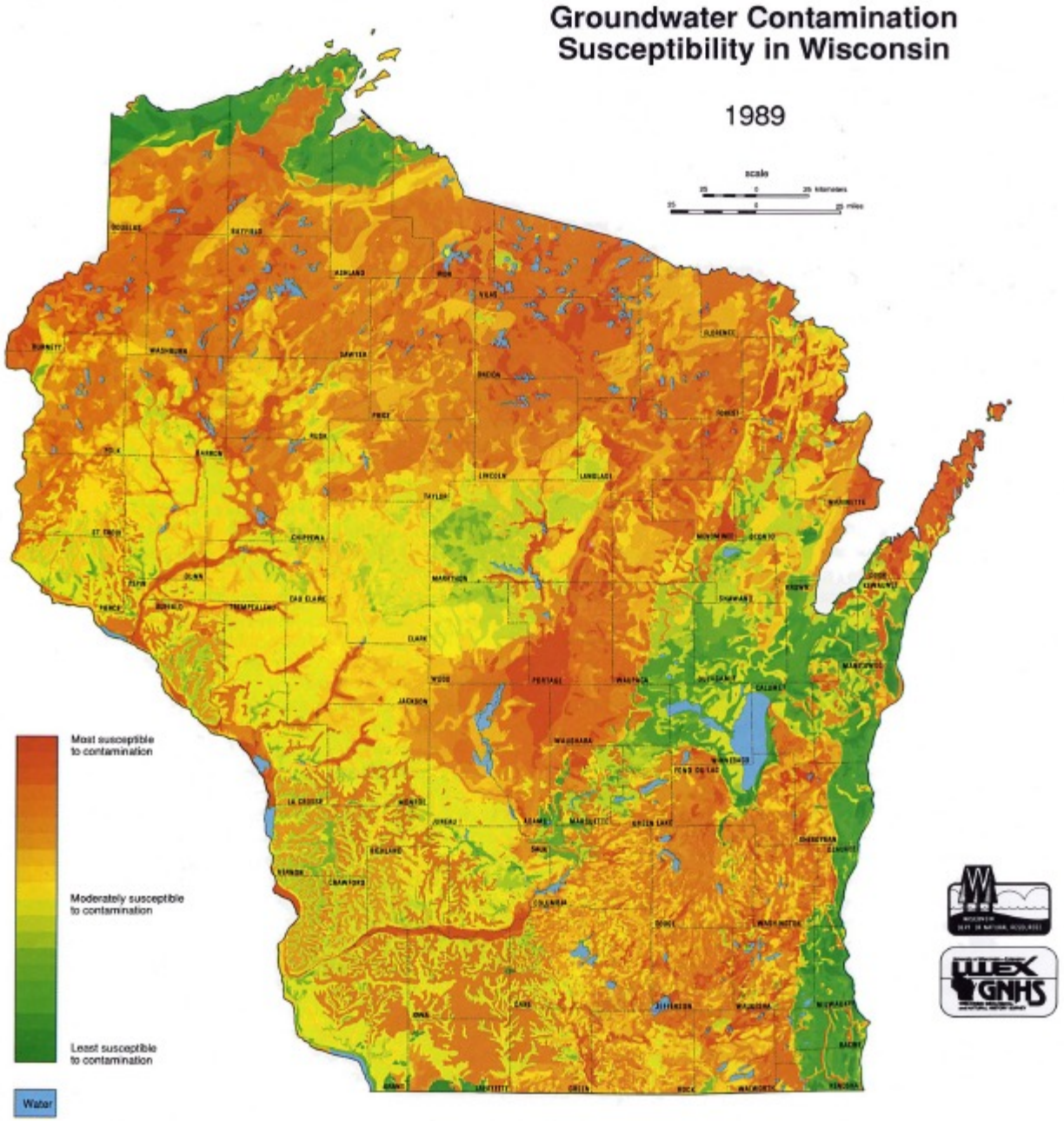
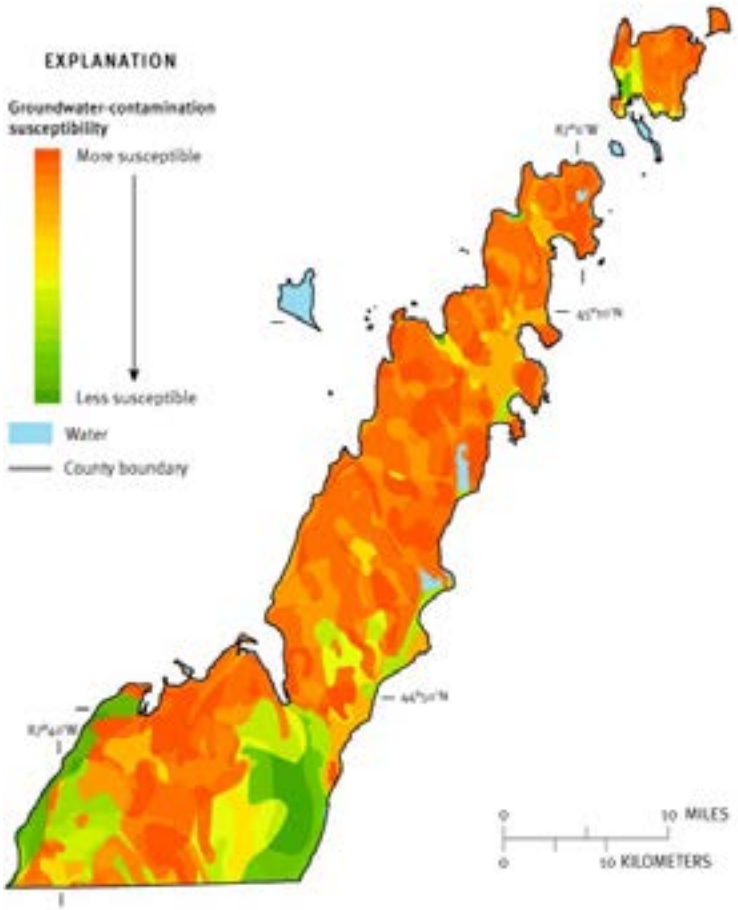
Susceptibility

- Based on factors such as:
  - Bedrock depth
  - Soil type
  - Depth to water table



Door County – Groundwater-Contamination Susceptibility Analysis



This groundwater-contamination susceptibility map is a composite of five resource characteristic maps, each of which was derived from generalized statewide information at small scales, and cannot be used for any site-specific purposes.

Map source: Schmidt, R.R., 1987, Groundwater contamination susceptibility map and evaluation: Wisconsin Department of Natural Resources, Wisconsin's Groundwater Management Plan Report 5, PUBL-WR-177-87, 27 p.

Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, http://wi.water.usgs.gov/gwcomp/

Door County – Depth to Water Table

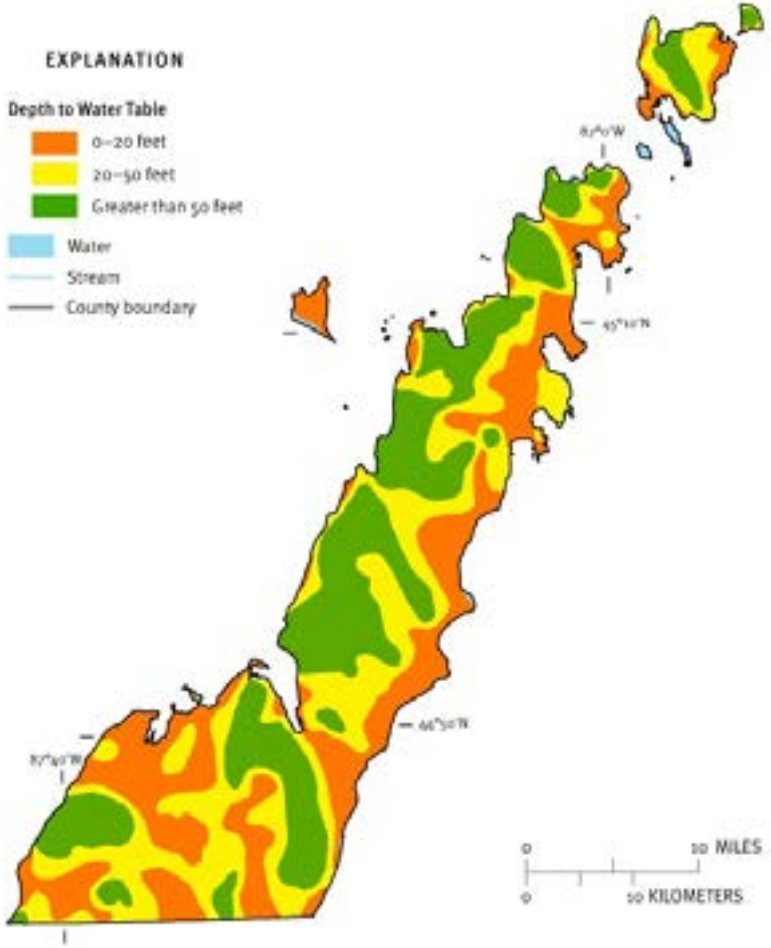


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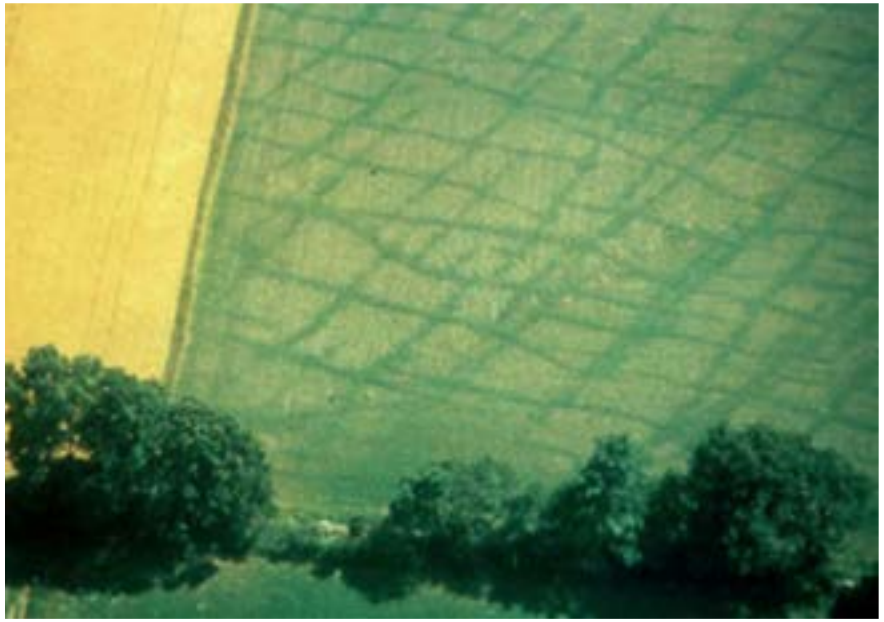
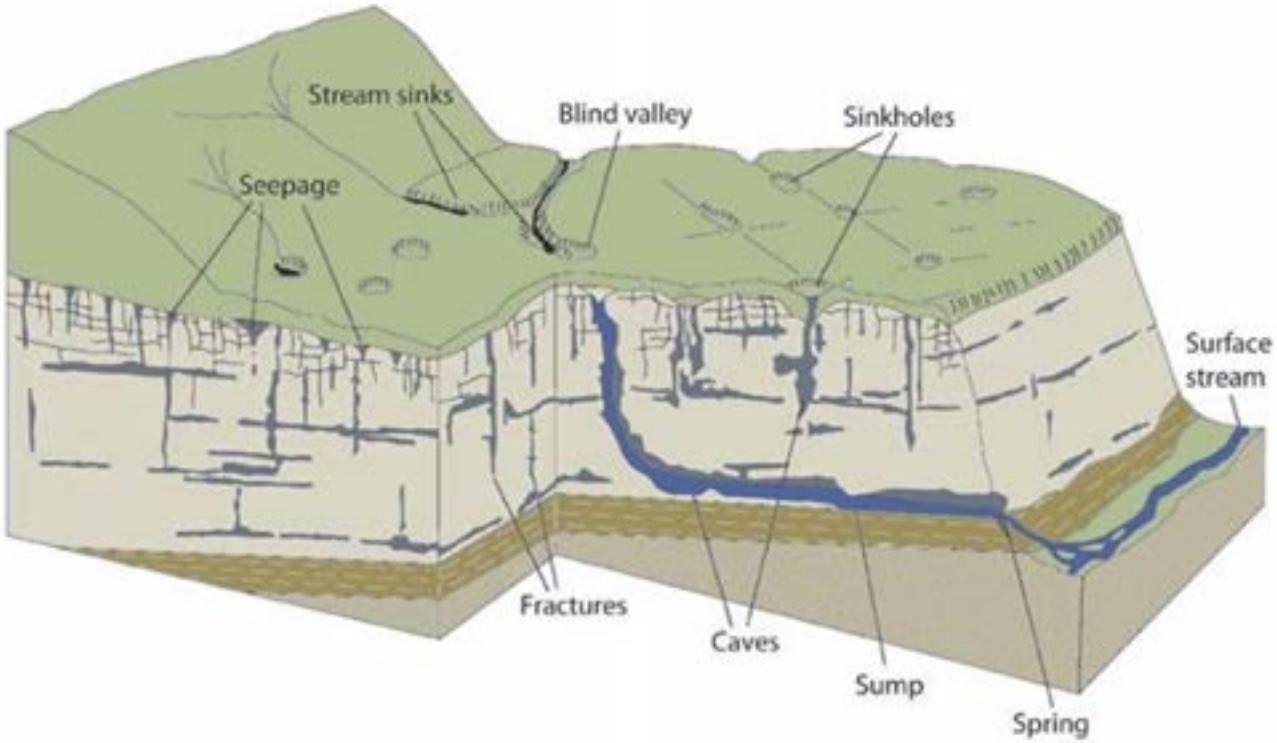
Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, http://wi.water.usgs.gov/gwcomp/

What is Karst Geology?

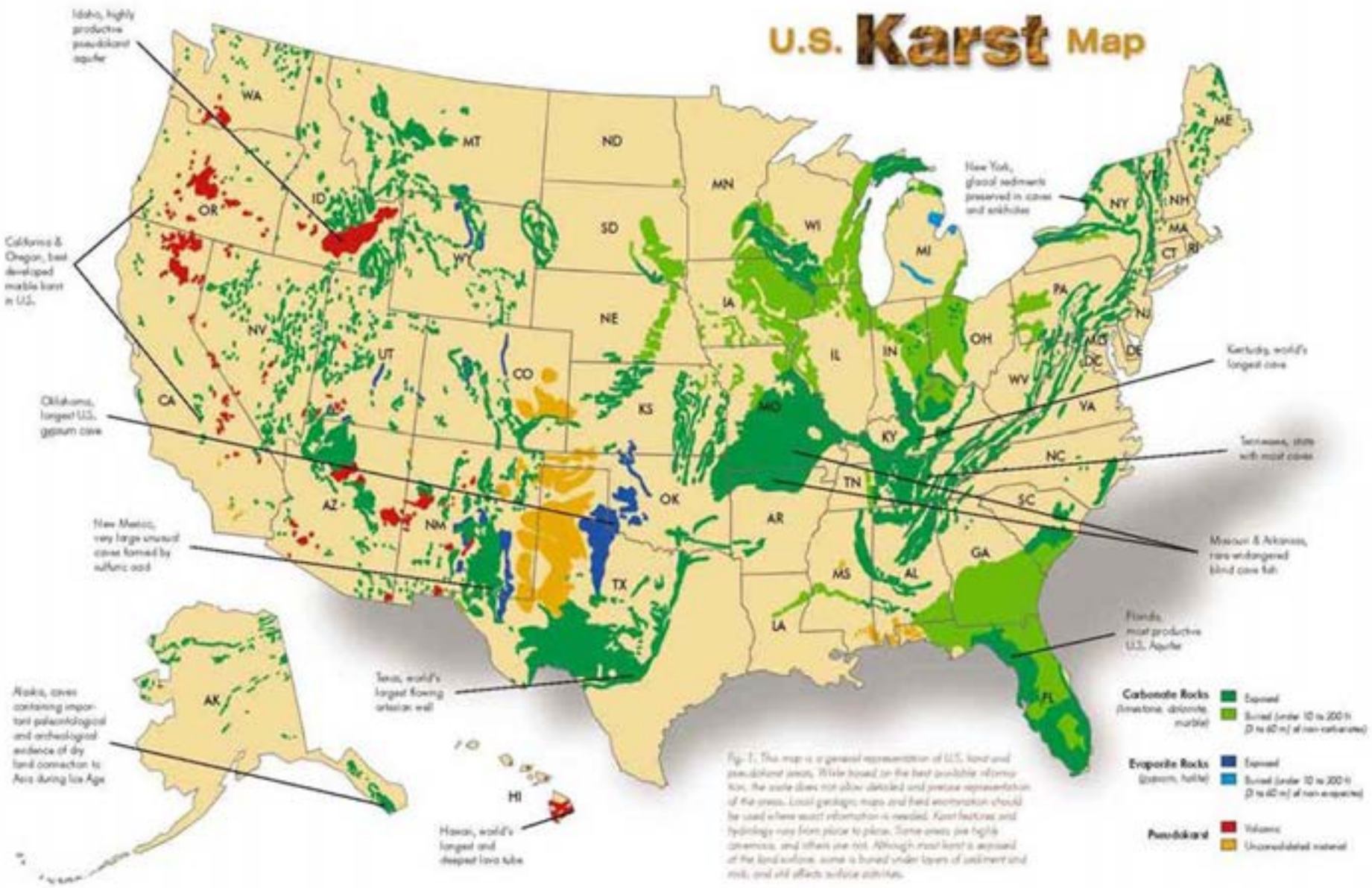
- A landscape created when water dissolves rocks
- Made of dolomite and limestone



Karst Geology Impact on Groundwater

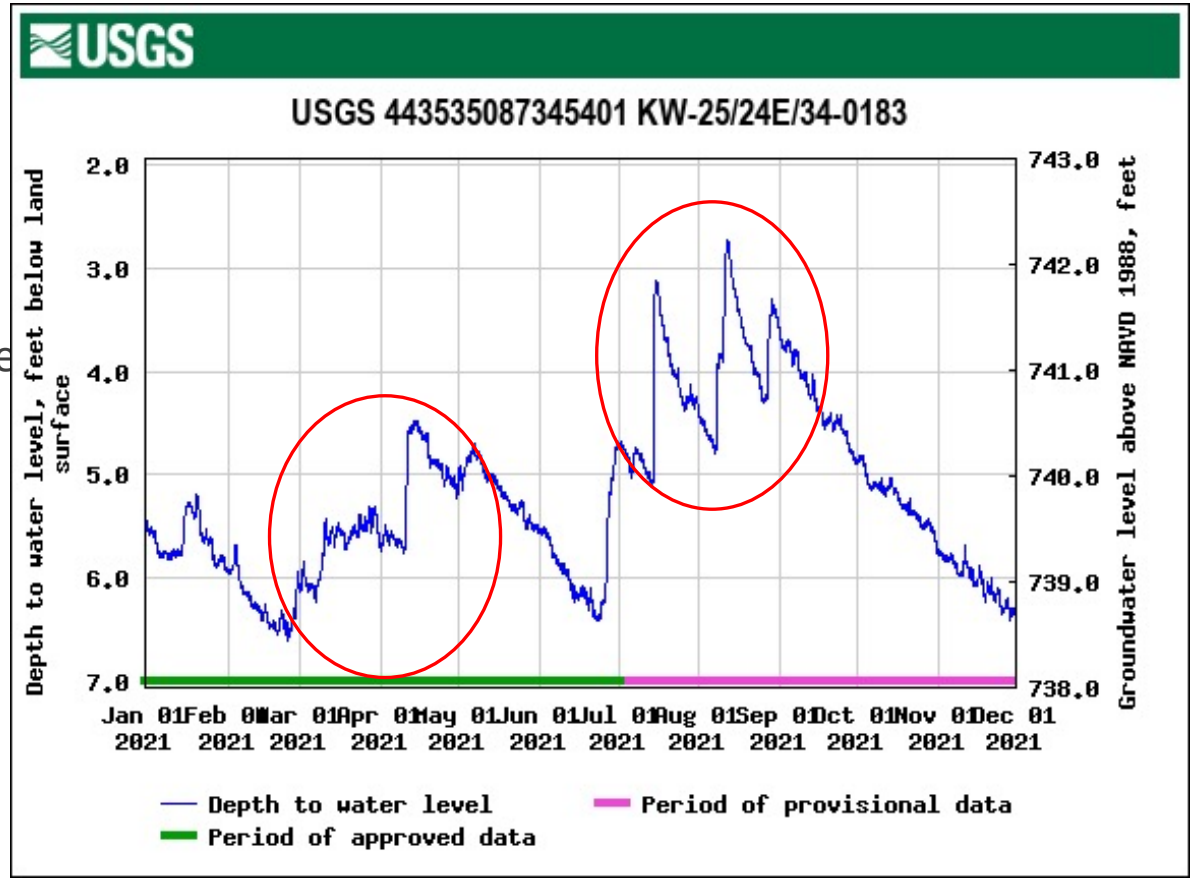


Karst Geology features as seen above create direct conduits to groundwater, where contaminants can easily make their way into our drinking water


U.S. Karst Map
Idaho, highly productive pseudokarst aquifer
California & Oregon, best developed mobile karst in U.S.
Oklahoma, largest U.S. gypsum cave
New Mexico, very large unusual caves formed by sulfuric acid
Alaska, caves containing important paleontological and archeological evidence of dry land connection to Asia during Ice Age
Texas, world's largest flowing artesian well
Hawaii, world's longest and deepest lava tube
New York, glacial sediments preserved in caves and sinkholes
Kentucky, world's longest cave
Tennessee, state with most caves
Missouri & Arkansas, rare endangered blind cave fish
Florida, most productive U.S. Aquifer
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
OH
PA
NY
VT
NH
ME
MA
CT
RI
NJ
DE
MD
DC
AK
HI
Carbonate Rocks (limestone, dolomite, marble)
Exposed
Buried (under 10 to 200 ft (3 to 60 m) of non-carbonates)
Evaporite Rocks (gypsum, halite)
Exposed
Buried (under 10 to 200 ft (3 to 60 m) of non-evaporites)
Pseudokarst
Volcanic
Unconsolidated material

Groundwater Recharge

- Study design requires samples to be collected in a narrow window of time (within ~30 hours) – **but why?**
  - Reduce any variables in groundwater quality
    - Weather conditions
    - Groundwater conditions – dry period or recharge period
    - Greater effects with karst geology



Testing Parameters

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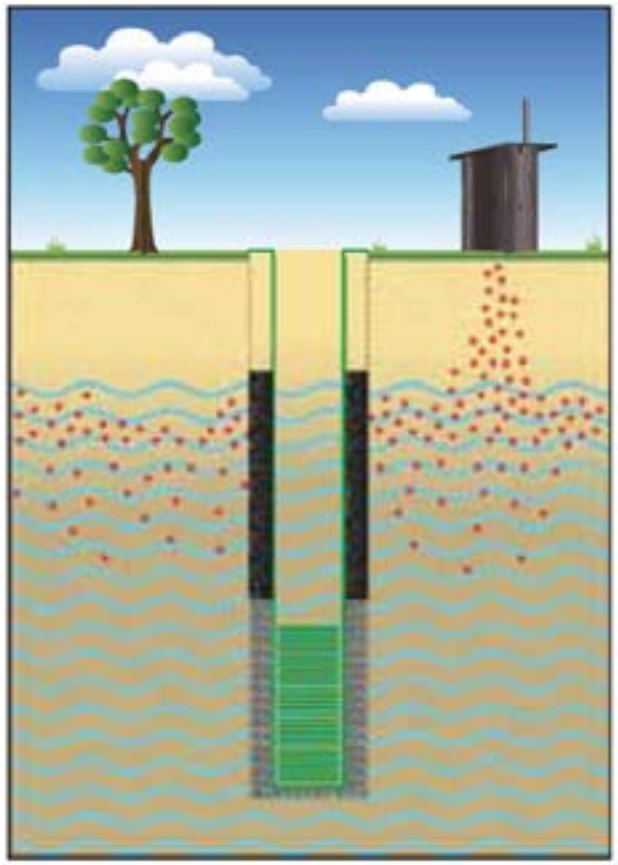
Bacteria

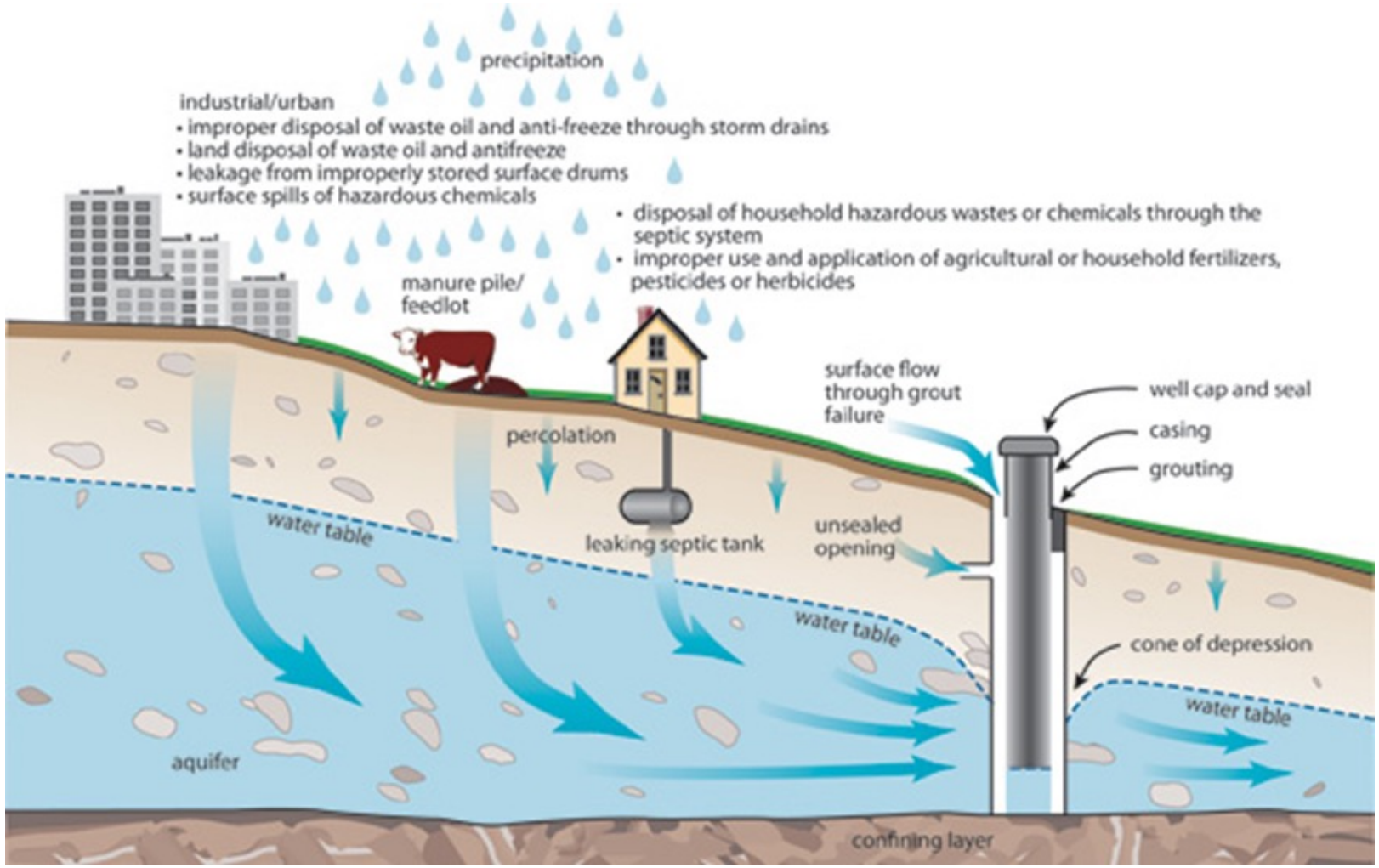
- Feces contain millions of microorganisms/gram
- Pathogens (disease-causers) usually found in low numbers
- Pathogens are usually more difficult to identify in the lab than indicator organisms
- Pathogens can be bacteria (E.coli), viruses (Norovirus), or protozoans (Cryptosporidium)
- We look for fecal indicator organisms that “indicate” that a recent contamination has occurred (and that pathogens also are likely present)

Sources of Bacteria

- Sources
  - Improperly constructed well
  - Older or damaged well
  - Distribution system issue (cracked pipe, dead end, etc)
  - Outside source of bacteria (agriculture, animal waste, human waste)

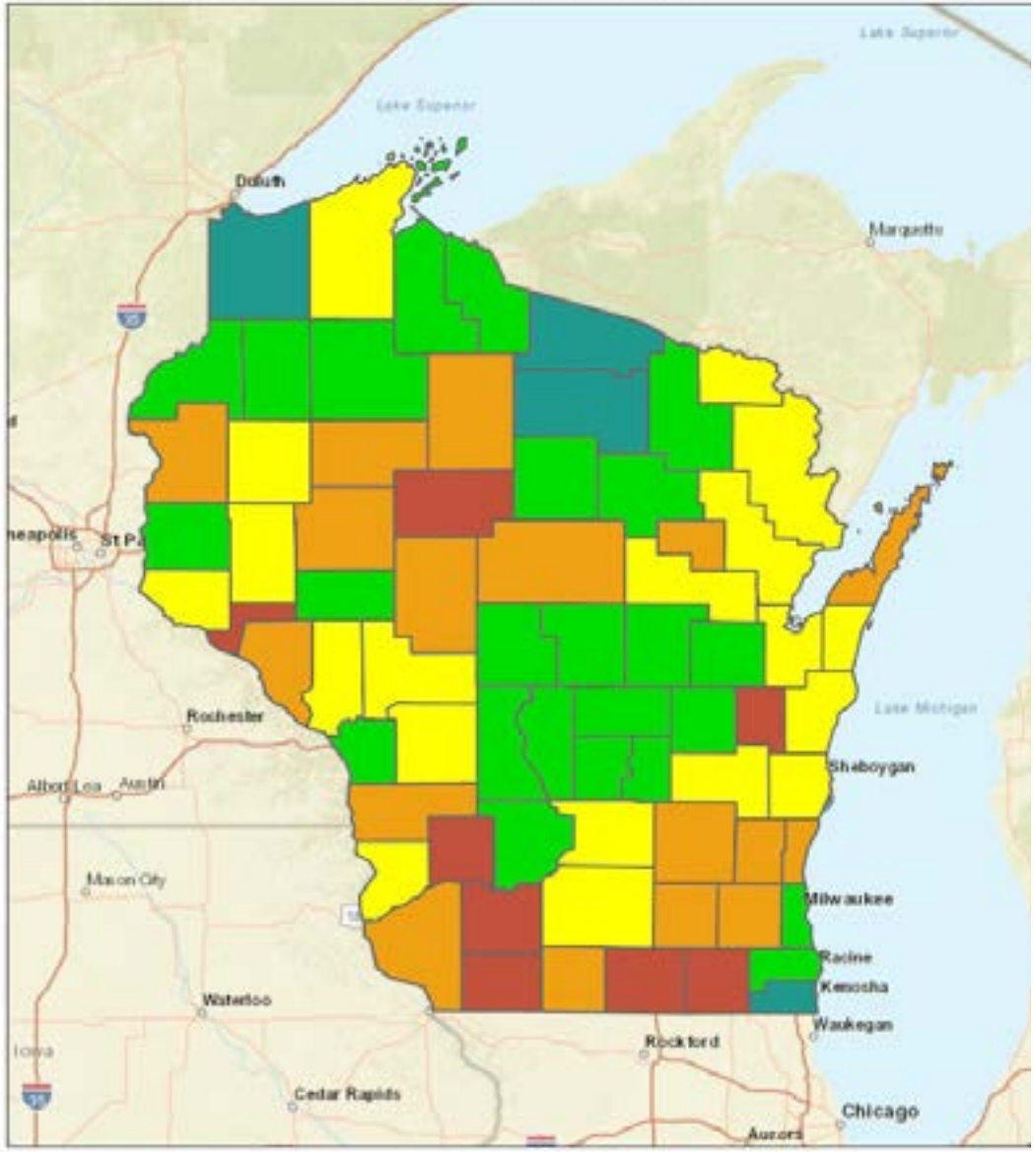


Sanitary Well



Sources of Bacteria

% Positive Bacteria



November 26, 2019

1:4,622,324

0 25 50 100 mi

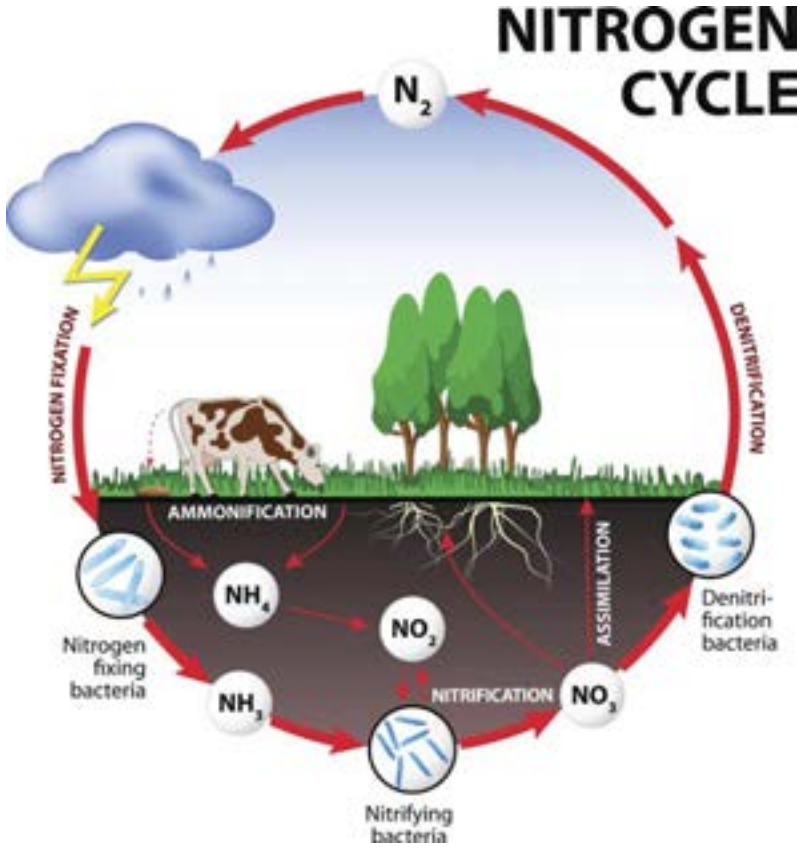
0 40 80 160 km

Bacteria - Percent - Positive by County

- 5.1% - 10%
- 10.1% - 15%
- 15.1% - 20%
- 20.1% - 25%
- 25.1% ...

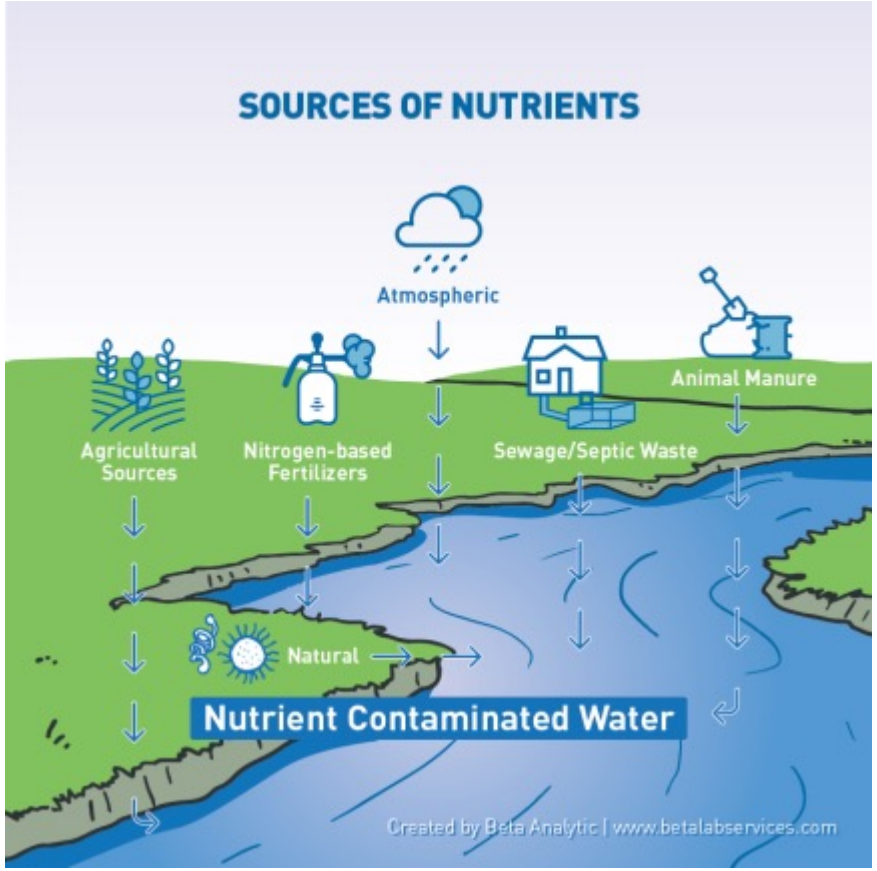
Nitrate

- Formed when nitrogen combines with oxygen in water
- Soluble – commonly found in runoff

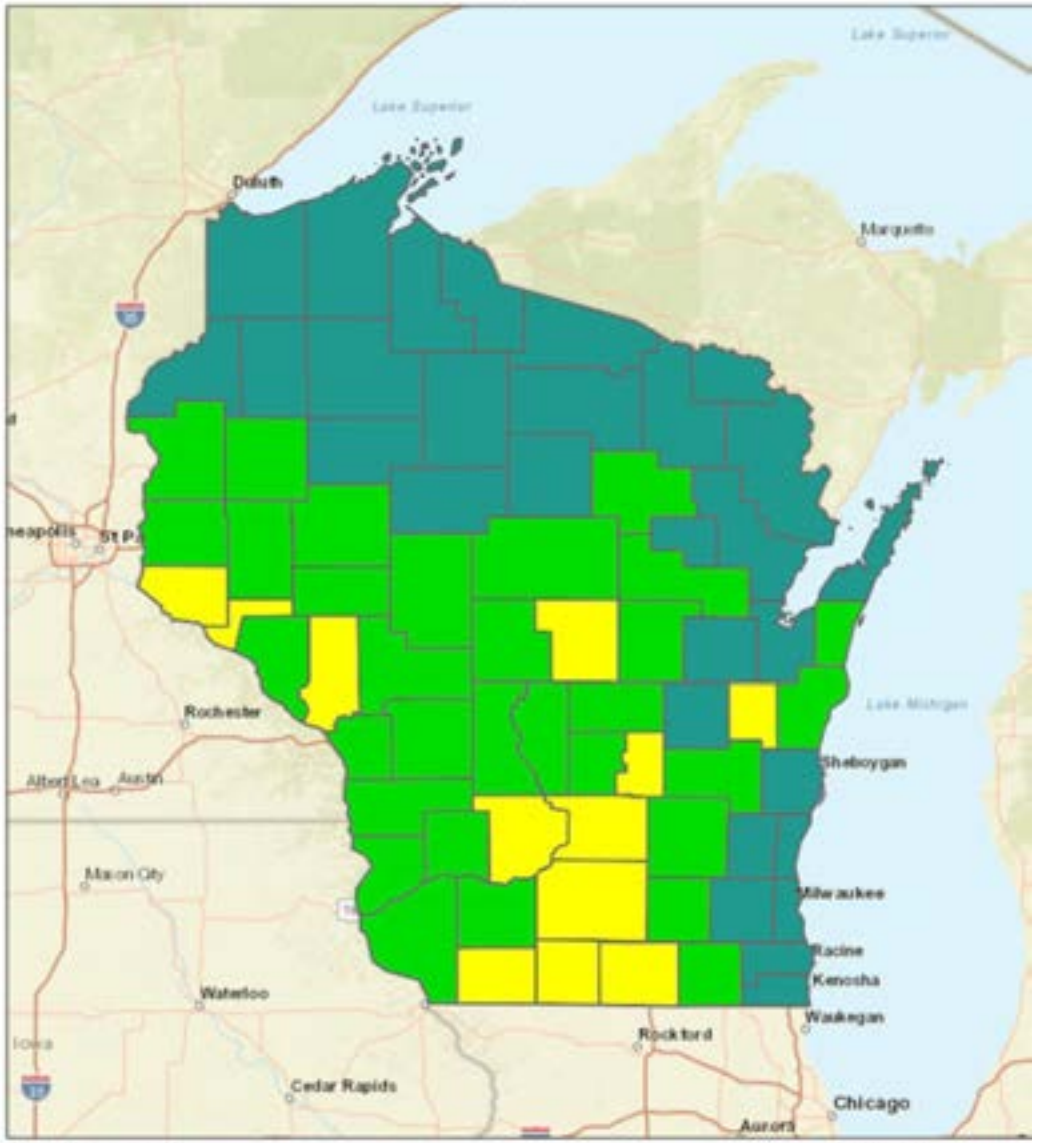


Nitrate

- Sources
  - Agriculture (manure and/or fertilizer)
  - Sewage/Septic
  - Animal waste
  - Atmospheric (trace amounts)
  - Lawn care (fertilizer)
  - Very low naturally occurring nitrate



Average Nitrate



November 26, 2019

1:4,622,324

0 25 50 100 mi

0 40 80 160 km

Nitrate - mg/l N - Average by County

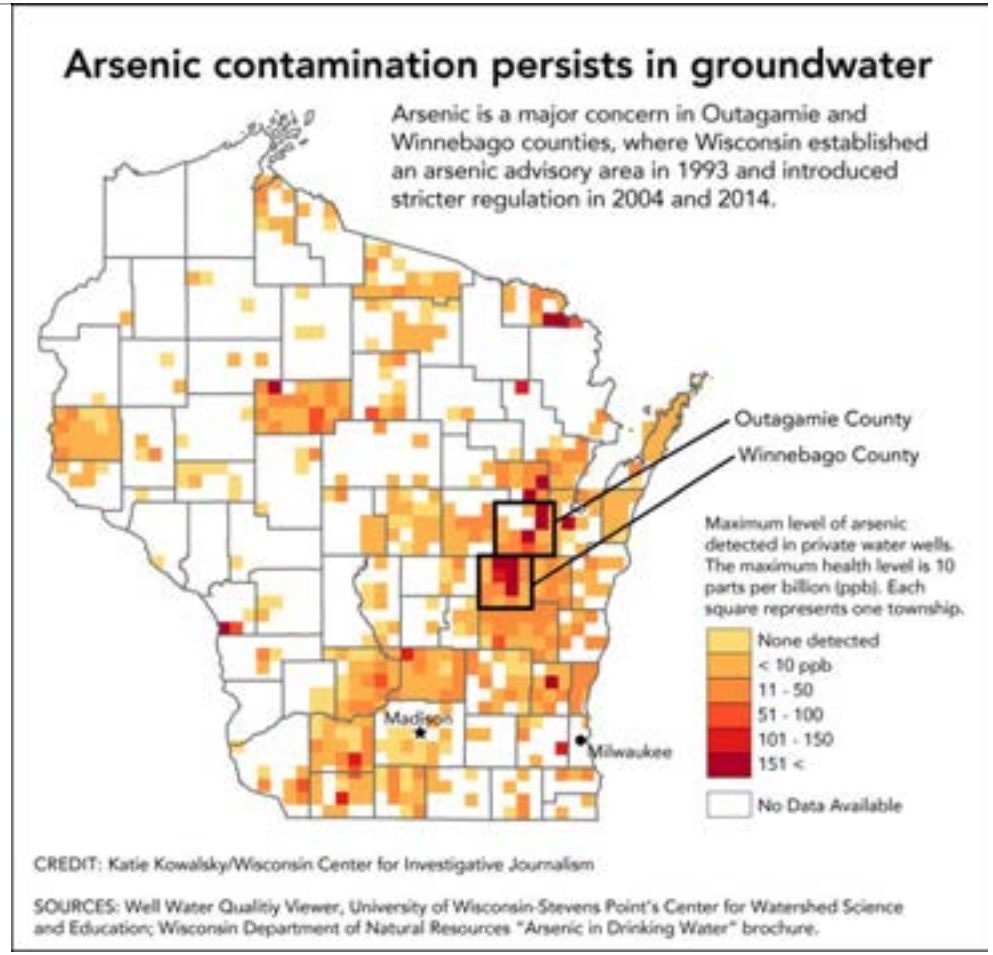
... 2.0 mg/l as N

2.1 - 5.0

5.1 - 10.0

Arsenic

- Sources
  - Most naturally occurring in bedrock
  - Lead arsenate pesticides were used in orchards from 1890s-1960s (binds to soil, does not usually migrate into groundwater)



Interpreting Results

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How much is one part per ...

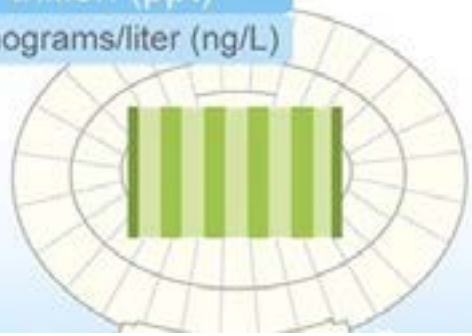
million (ppm)
milligrams/liter (mg/L)

= three drops added to a 42-gallon barrel

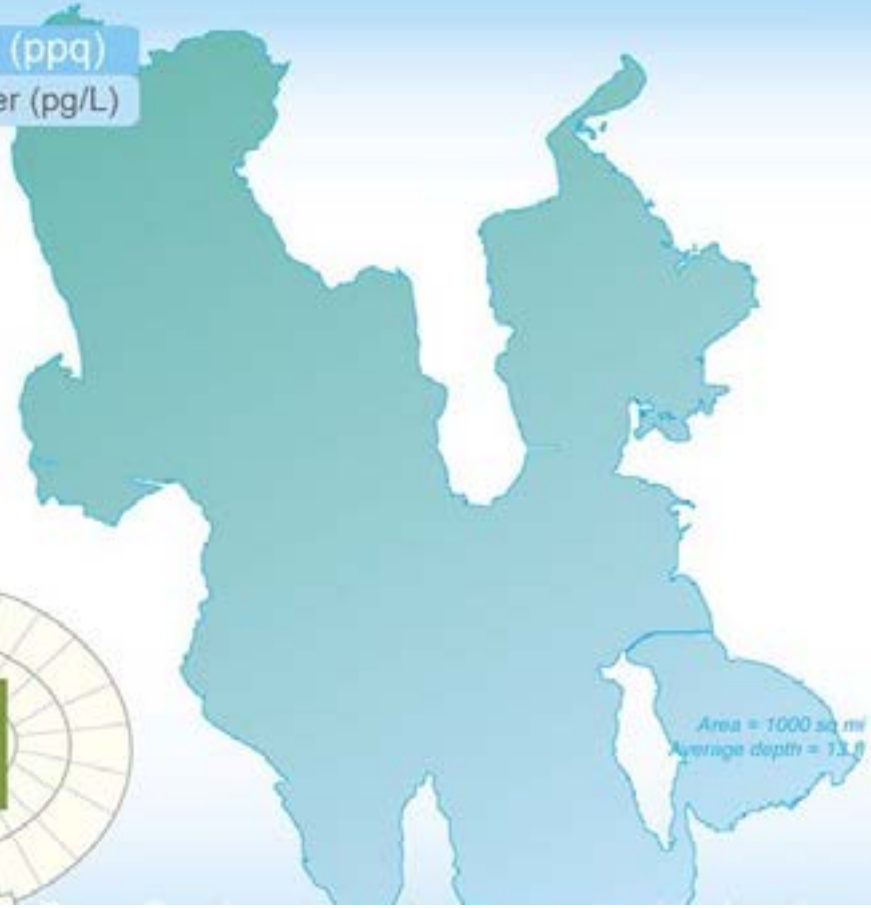
billion (ppb)
micrograms/liter (µg/L)

length = 35 feet, diameter = 8 feet

trillion (ppt)
nanograms/liter (ng/L)



quadrillion (ppq)
picograms/liter (pg/L)



What’s considered unsafe?

Parameter	Maximum Contaminant Level (MCL)	"Unsafe" Levels*
Total Coliform	0 MPN/100 mL	> 0 MPN/100 mL
E. coli	0 MPN/100 mL	> 0 MPN/100 mL
Nitrate	10 mg/L	> 10 mg/L
Arsenic	10 µg/L	> 10 µg/L
* "Unsafe" Levels refers to samples that exceed the MCL		

Interpreting Results

BACTERIA

- Tested for presence of Coliform and *E. coli* bacteria
- A negative or “0” result: there is no bacteria present in the sample and it is safe to drink
- A positive or any number: bacteria is present in the sample, and it is unsafe to drink

NITRATE

- “ND”: nitrate was not detected in the sample; water is safe to drink
- Between 0-9.9 mg/L: nitrate was detected in the “safe” range
- Over 10 mg/L: nitrate was detected over the “safe” range, water is unsafe to drink

Interpreting Results

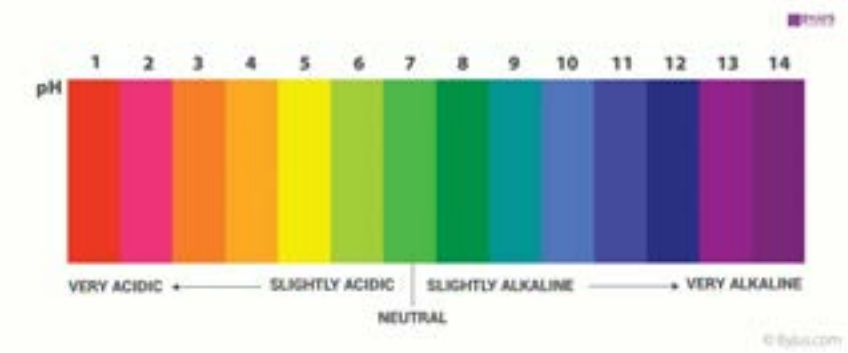
ARSENIC

- ND: arsenic was not detected in the sample
- Between 0-10 µg/L: arsenic was detected in the “safe” range
- Over 10 µg/L: arsenic was detected over the “safe” range

Interpreting Results

CUMULATIVE

pH: measure of the acid-base balance. Carbon dioxide concentration & increase in temperature can decrease pH of water.



Iron: a metal element that makes up 5% of the earth's crust. Iron is not considered hazardous to health. Recommended level is less than 0.3 mg/L

Hardness: water's ability to react with soap and produce a lather. Caused by ions such as calcium and magnesium. Not considered hazardous to health. Hard water can cause lime buildup/scaling on plumbing fixtures.

Water Hardness Scale		
Grains/Gal	mg/L & ppm	Classification
Less than 1	Less than 17.1	Soft
1 – 3.5	17.1 - 60	Slightly Hard
3.5 - 7	60 - 120	Moderately Hard
7 - 10	120 - 180	Hard
Over 10	Over 180	Very Hard

Alkalinity: water's ability to neutralize acids. Can be affected by natural deposits in the earth and industrial practices. It is not considered to be hazardous to health. Recommended level is between 75-200 mg/L

2021 Results

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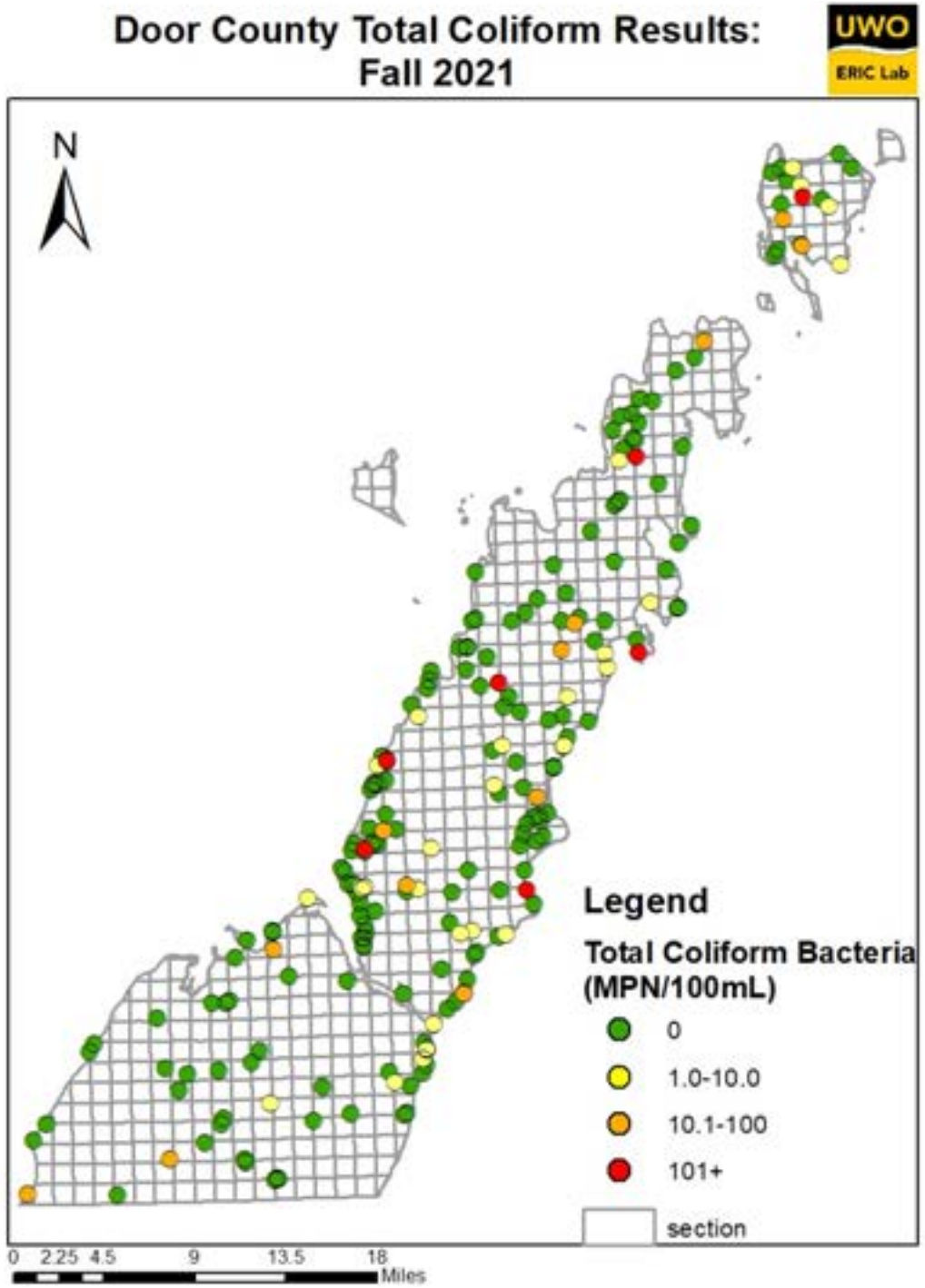
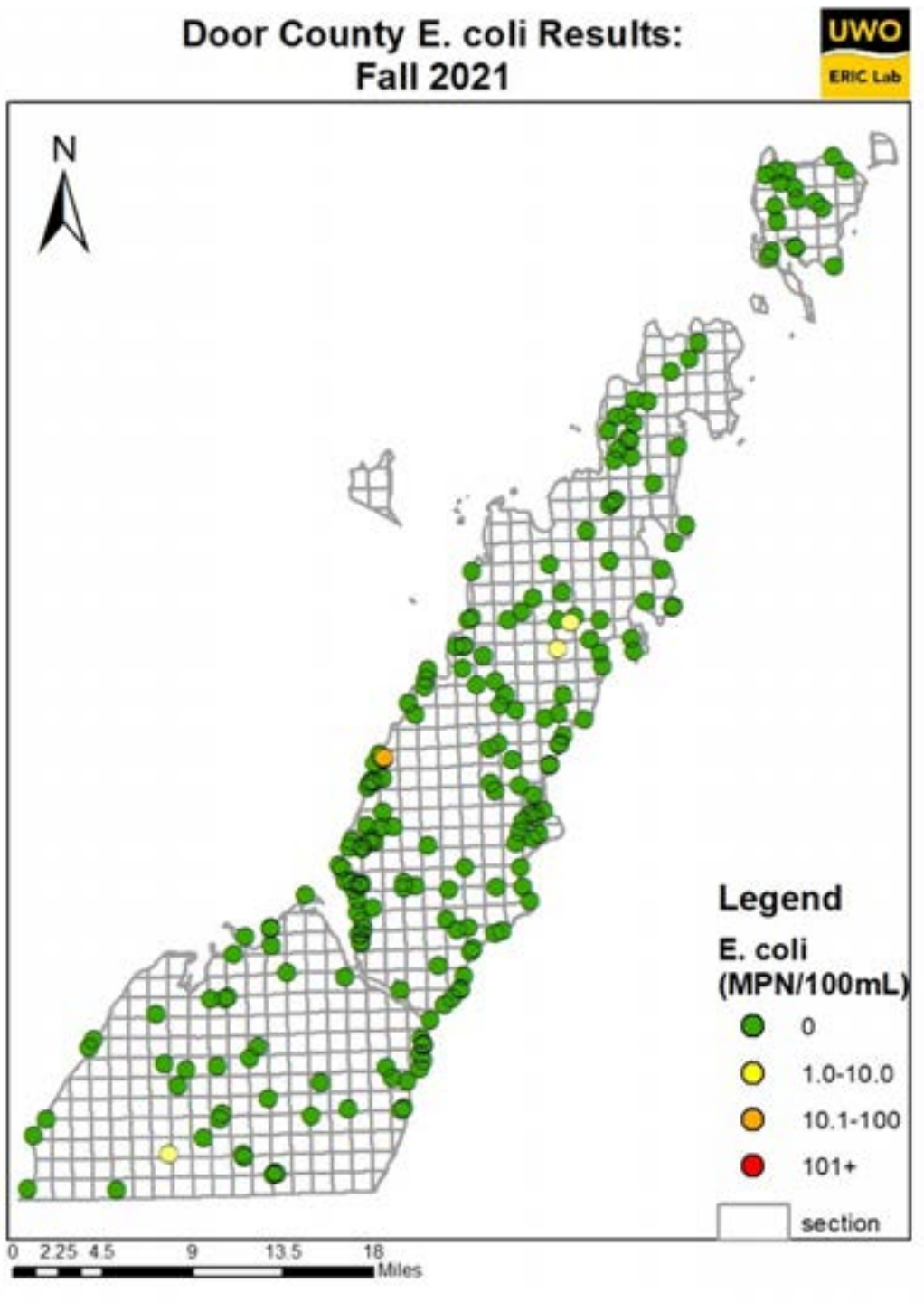
Coliform Bacteria

Coliform Result (MPN/100 mL)	# Samples	% Samples
0	166	76
1-10	30	14
10-100	14	6
100+	7	3
n=217		



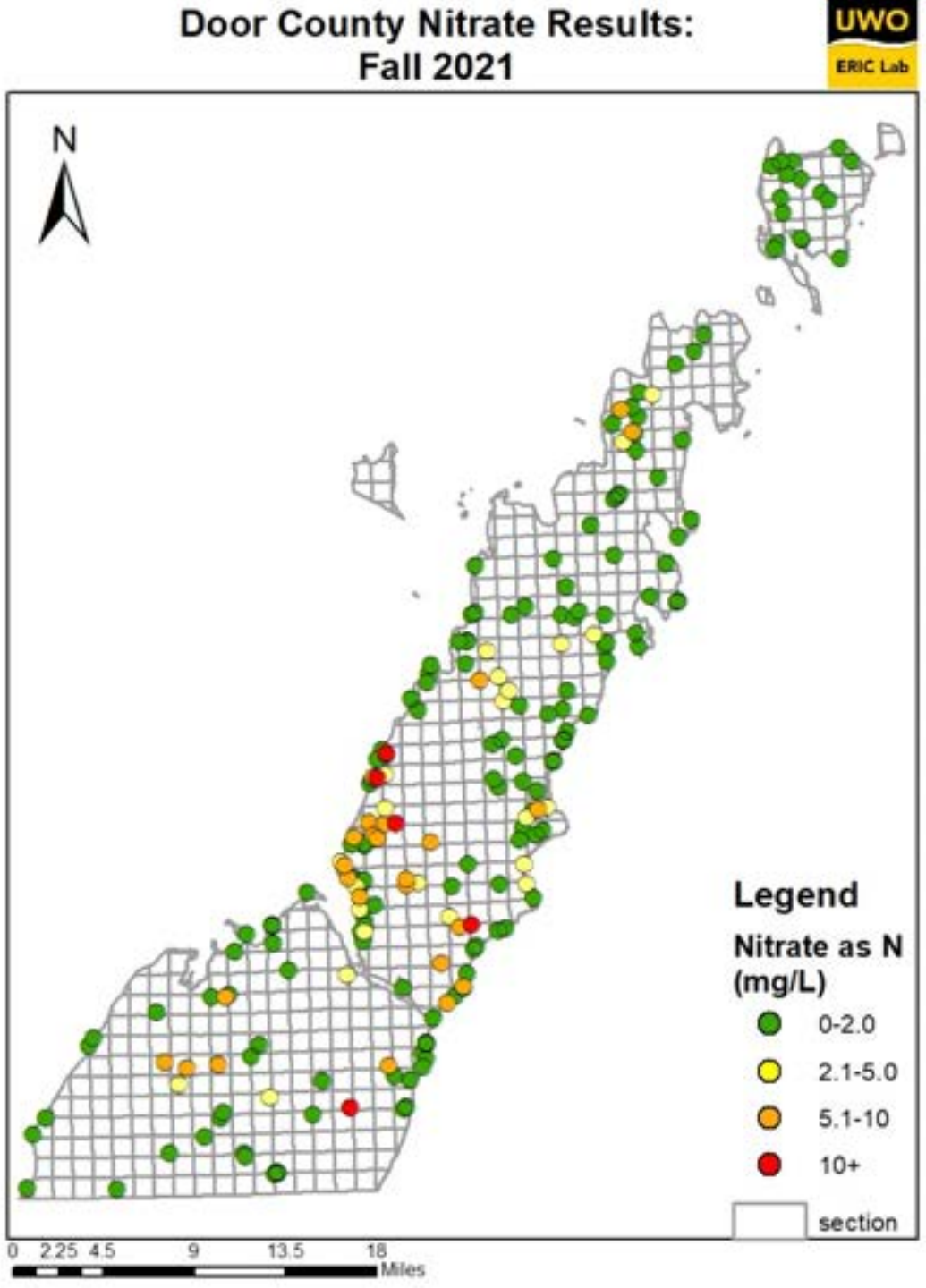
E. Coli Bacteria

***E coli* Result (MPN/100 mL)**	**# Samples**	**% Samples**
0	213	98
1-10	3	1
10-100	1	<1
100+	0	0
n=217		



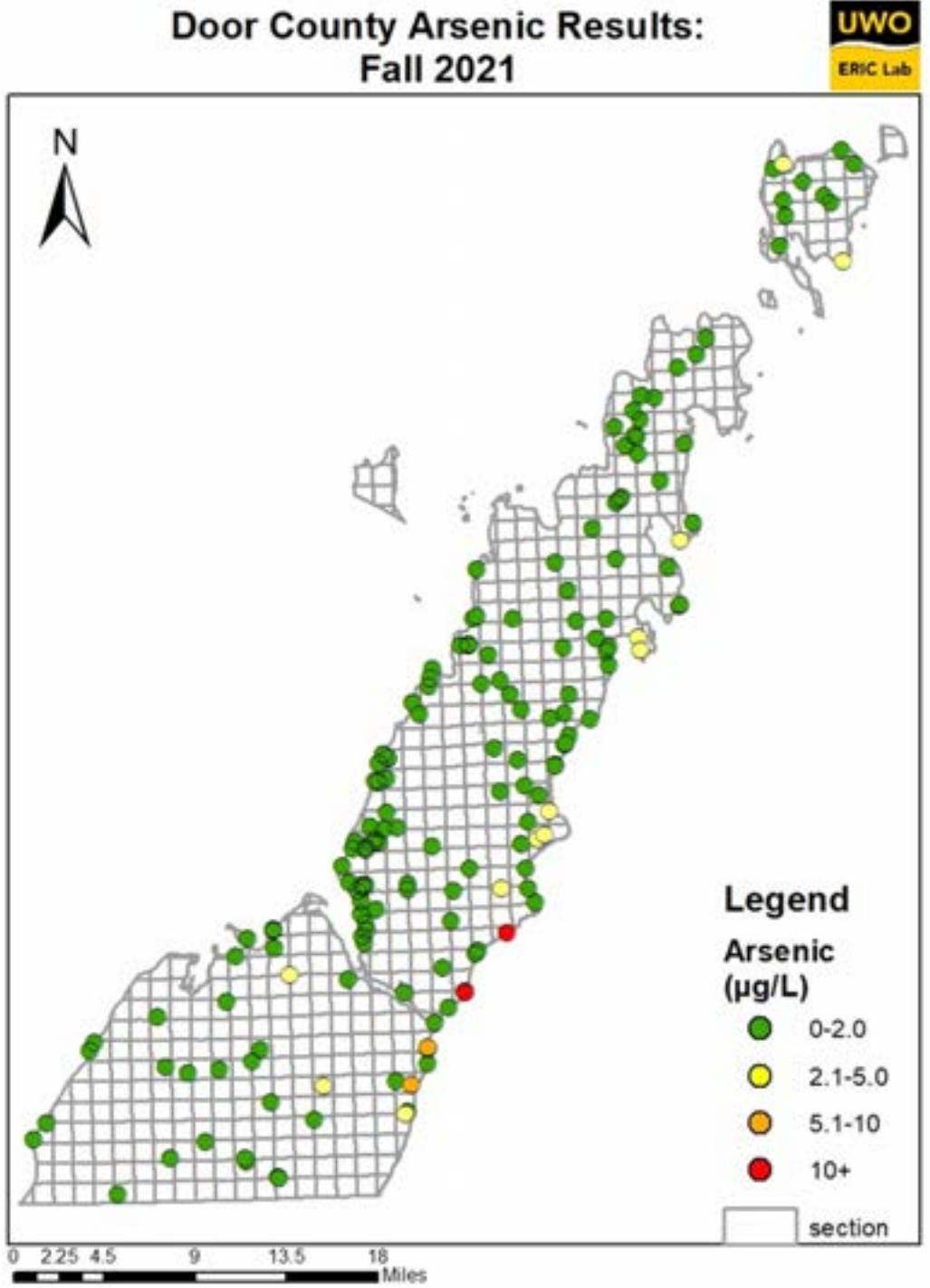
Nitrate

Nitrate Result (mg/L)	# Samples	% Samples
Less than 2	157	75
2-5	23	11
5-10	25	12
10+	5	2
n=210		



Arsenic

Arsenic Result (µg/L)	# Samples	% Samples
Less than 2	149	89
2-5	15	9
5-10	2	1
10+	2	1
n=168		



Previous Data

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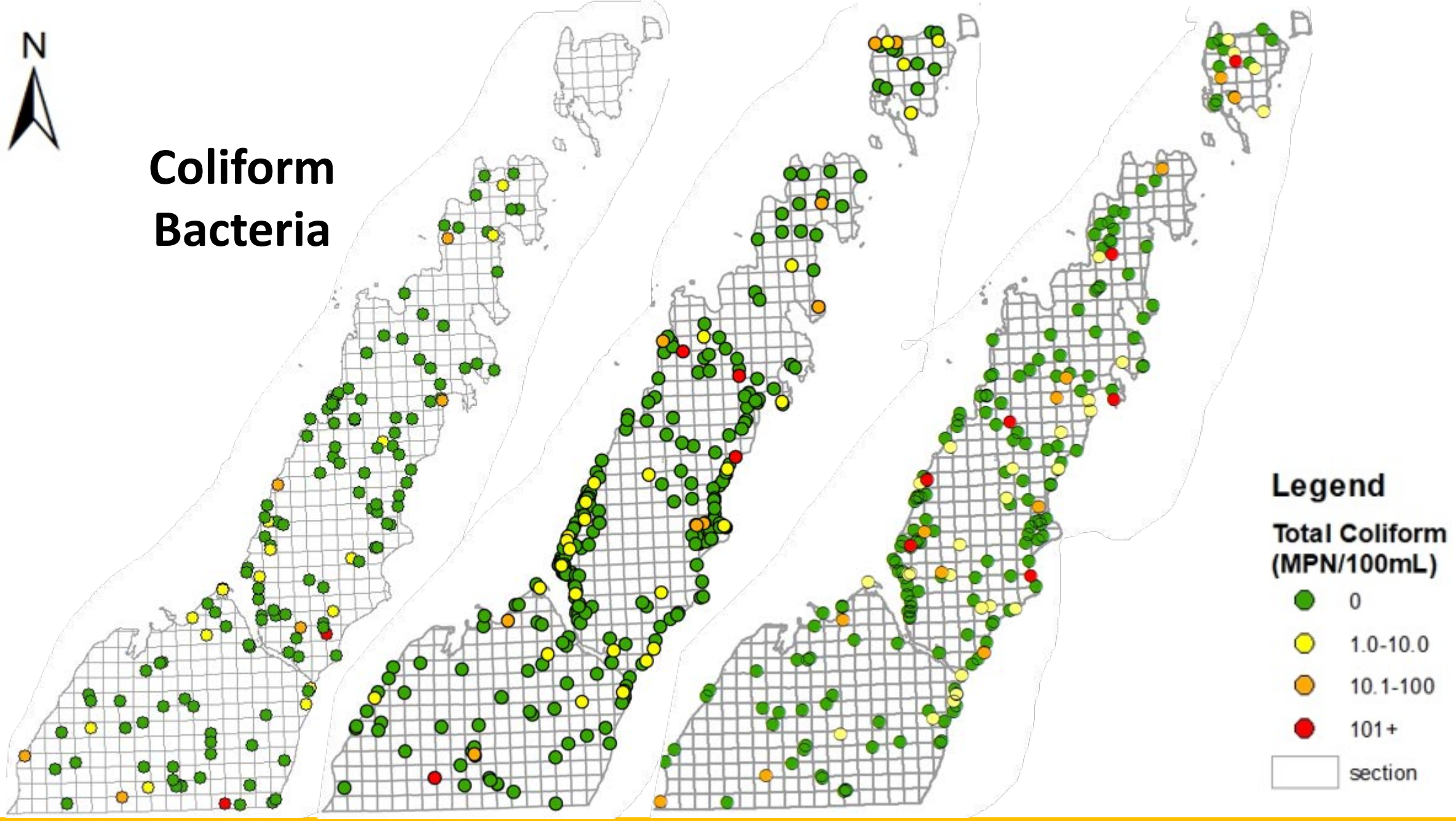
Coliform Bacteria

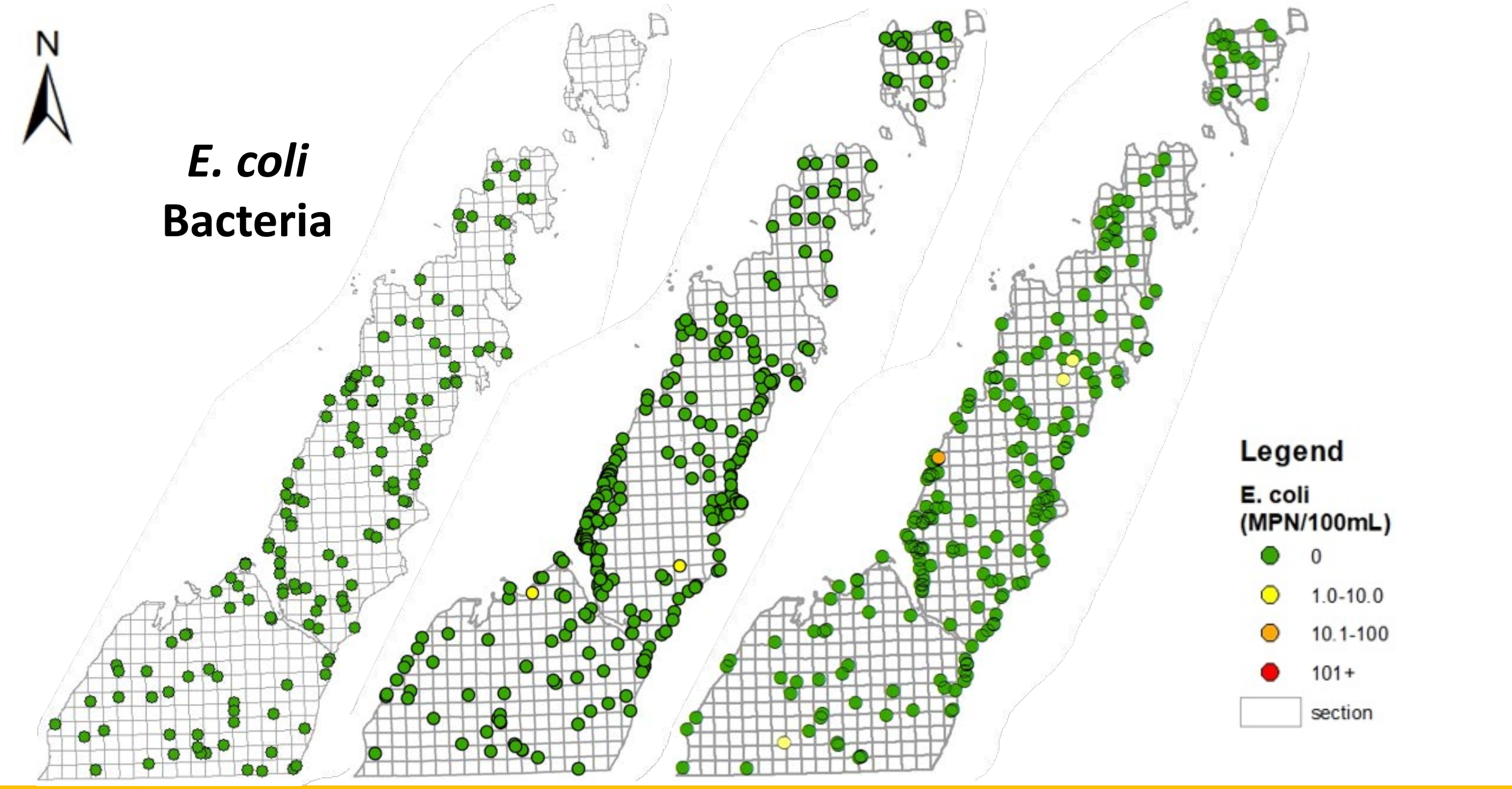


2019 2020 2021

Coliform Bacteria

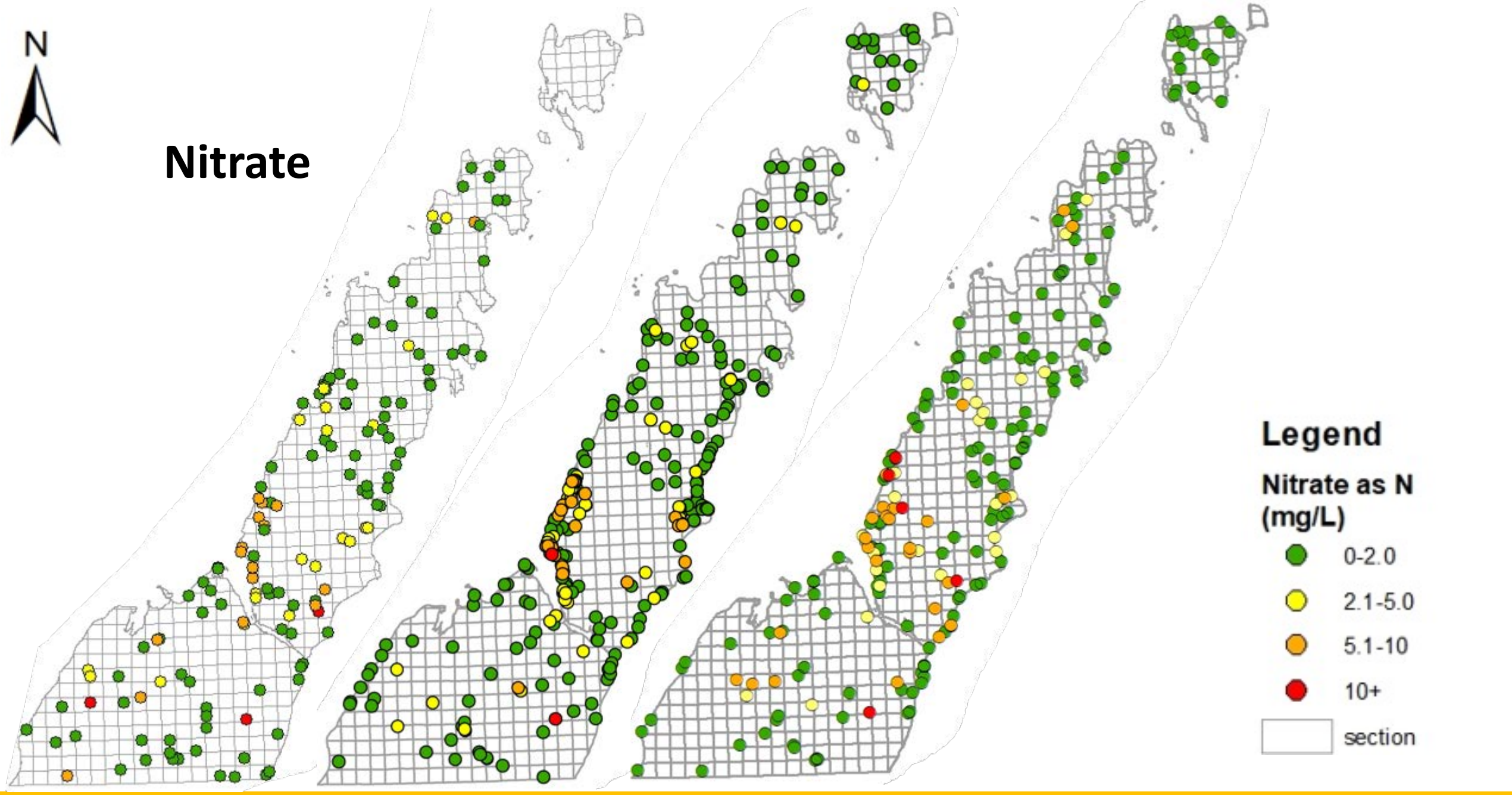
2019			2020			2021		
Coliform Result (MPN/100 mL)	# Samples	% Samples	Coliform Result (MPN/100 mL)	# Samples	% Samples	Coliform Result (MPN/100 mL)	# Samples	% Samples
0	125	84	0	254	86	0	166	76
1-10	15	10	1-10	28	9	1-10	30	14
10-100	6	4	10-100	9	3	10-100	14	6
100+	2	1	100+	4	1	100+	7	3
n=148			n=295			n=217		

Potential sampling errors? (Sample faucets must be properly disinfected)


N
E. coli
Bacteria
Legend
E. coli
(MPN/100mL)
0
1.0-10.0
10.1-100
101+
section
2019
2020
2021

E. coli Bacteria

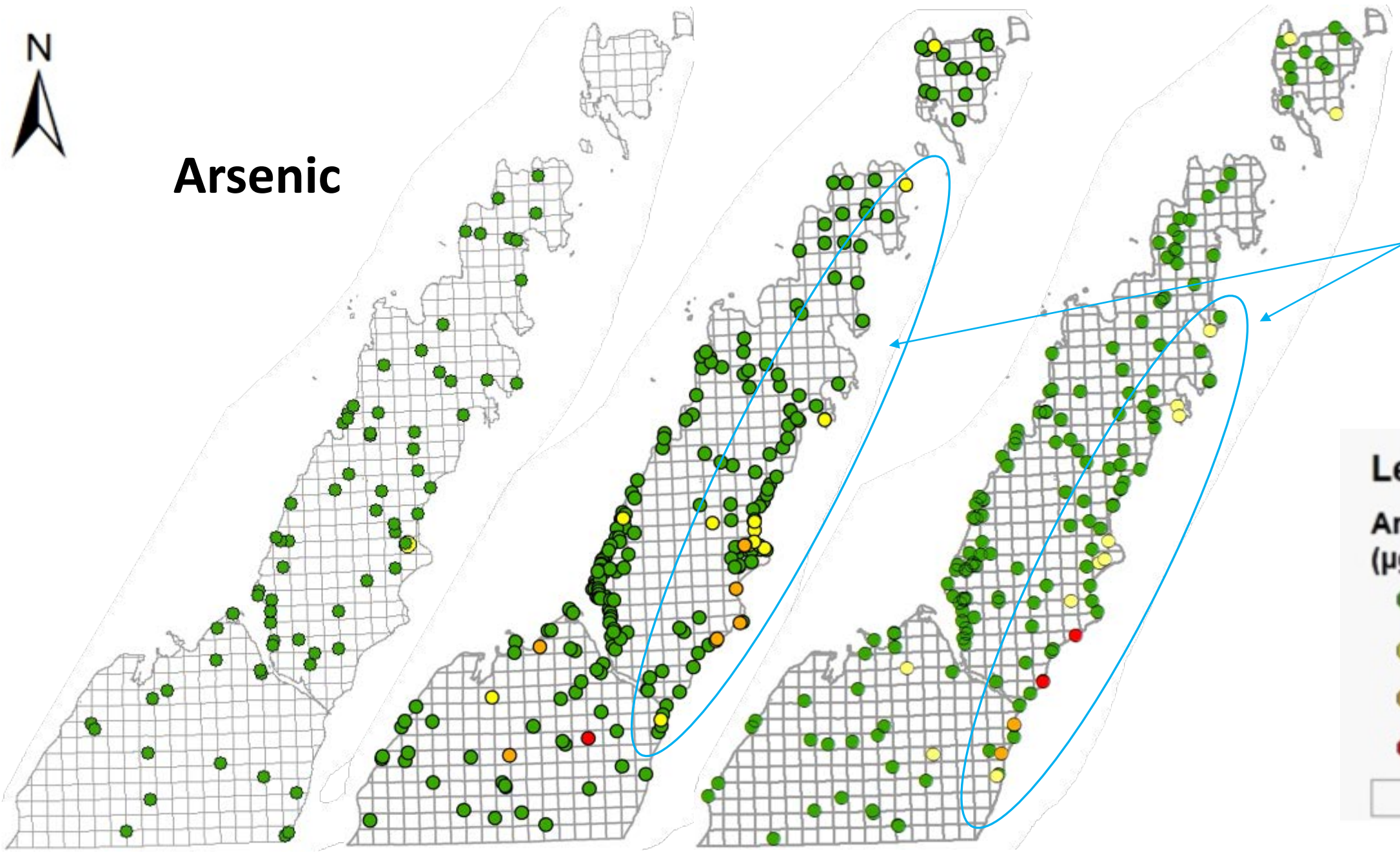
2019			2020			2021		
E coli **Result (MPN/100 mL)**	**# Samples**	**% Samples**	***E coli*** **Result (MPN/100 mL)**	**# Samples**	**% Samples**	***E coli*** **Result (MPN/100 mL)**	**# Samples**	**% Samples**
0	148	100	0	293	99	0	213	98
1-10	0	0	1-10	2	1	1-10	3	1
10-100	0	0	10-100	0	0	10-100	1	<1
100+	0	0	100+	0	0	100+	0	0
n=148			n=295			n=217		


N
Nitrate
Legend
Nitrate as N (mg/L)
0-2.0
2.1-5.0
5.1-10
10+
section
2019
2020
2021

Nitrate

2019			2020			2021		
Nitrate Result (mg/L)	**# Samples**	**% Samples**	**Nitrate Result (mg/L)**	**# Samples**	**% Samples**	**Nitrate Result (mg/L)**	**# Samples**	**% Samples**
Less than 2	104	71	Less than 2	206	72	Less than 2	157	75
2-5	23	16	2-5	46	16	2-5	23	11
5-10	16	11	5-10	34	12	5-10	25	12
10+	3	2	10+	2	1	10+	5	2
n=146			n=288			n=210		

Arsenic



Results show high concentrations along the shoreline, further research necessary to determine why

2019 2020 2021

Arsenic

2019			2020			2021		
Arsenic Result (µg/L)	**# Samples**	**% Samples**	**Arsenic Result (µg/L)**	**# Samples**	**% Samples**	**Arsenic Result (µg/L)**	**# Samples**	**% Samples**
Less than 2	70	99	Less than 2	214	90	Less than 2	149	89
2-5	1	1	2-5	15	6	2-5	15	9
5-10	0	0	5-10	7	3	5-10	2	1
10+	0	0	10+	1	<1	10+	2	1
n=71			n=237			n=168		

County-Wide Sampling Efforts

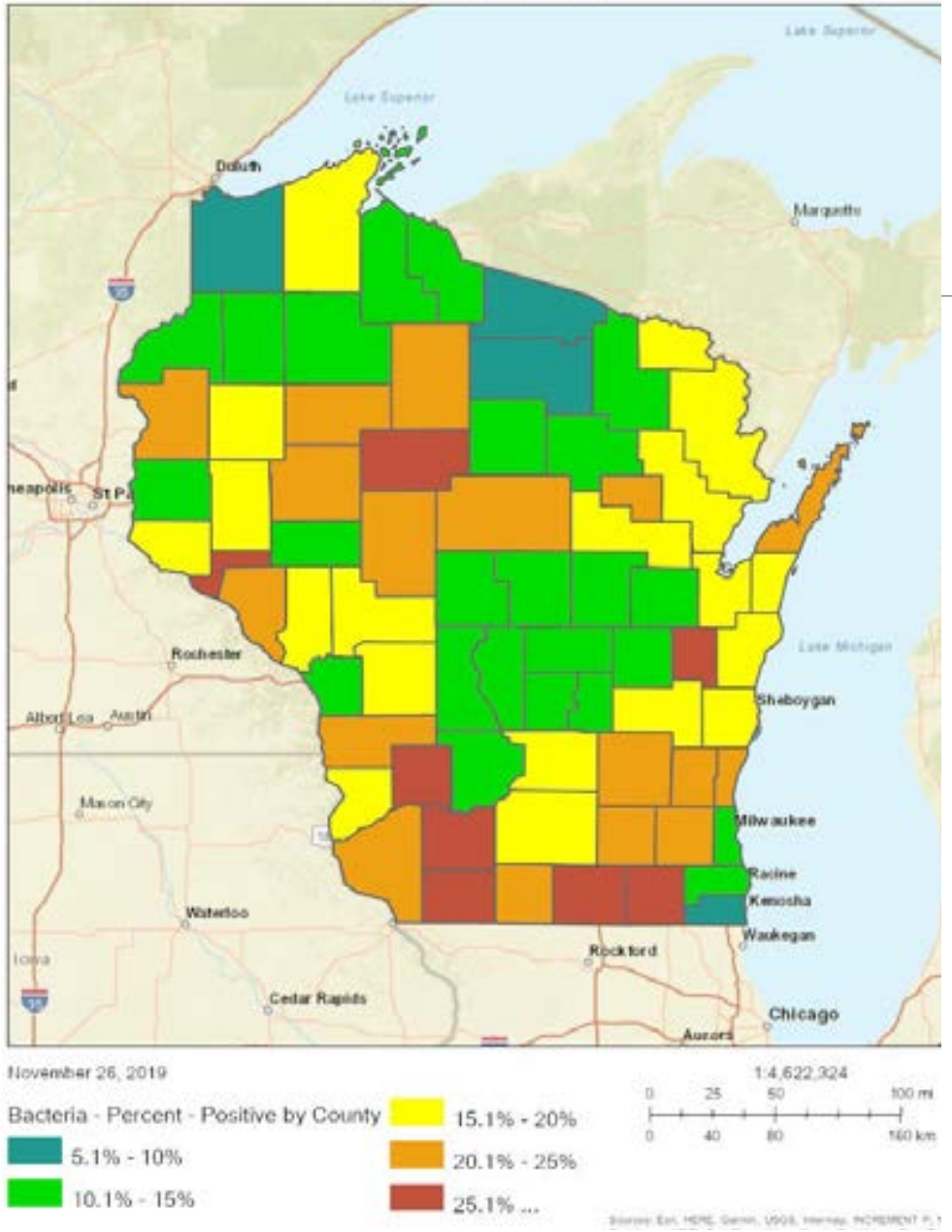
Percentage Exceeding Safe Water Quality Standards

Water Quality Standard	2021 Door County Results	2020 Door County Results	2019 Door County Results	Previous Door County Results* (Average)	Wisconsin**
Total Coliform (> 0 MPN/100 ml)	24%	14%	16%	18%	17%
E. coli (> 0 MPN/100 ml)	2%	1%	0%	6%	5%
Nitrate (> 10 mg/L)	2%	1%	2%	2%	8%
Arsenic (> 10 µg/L)	1%	<1%	0%	3%	5%

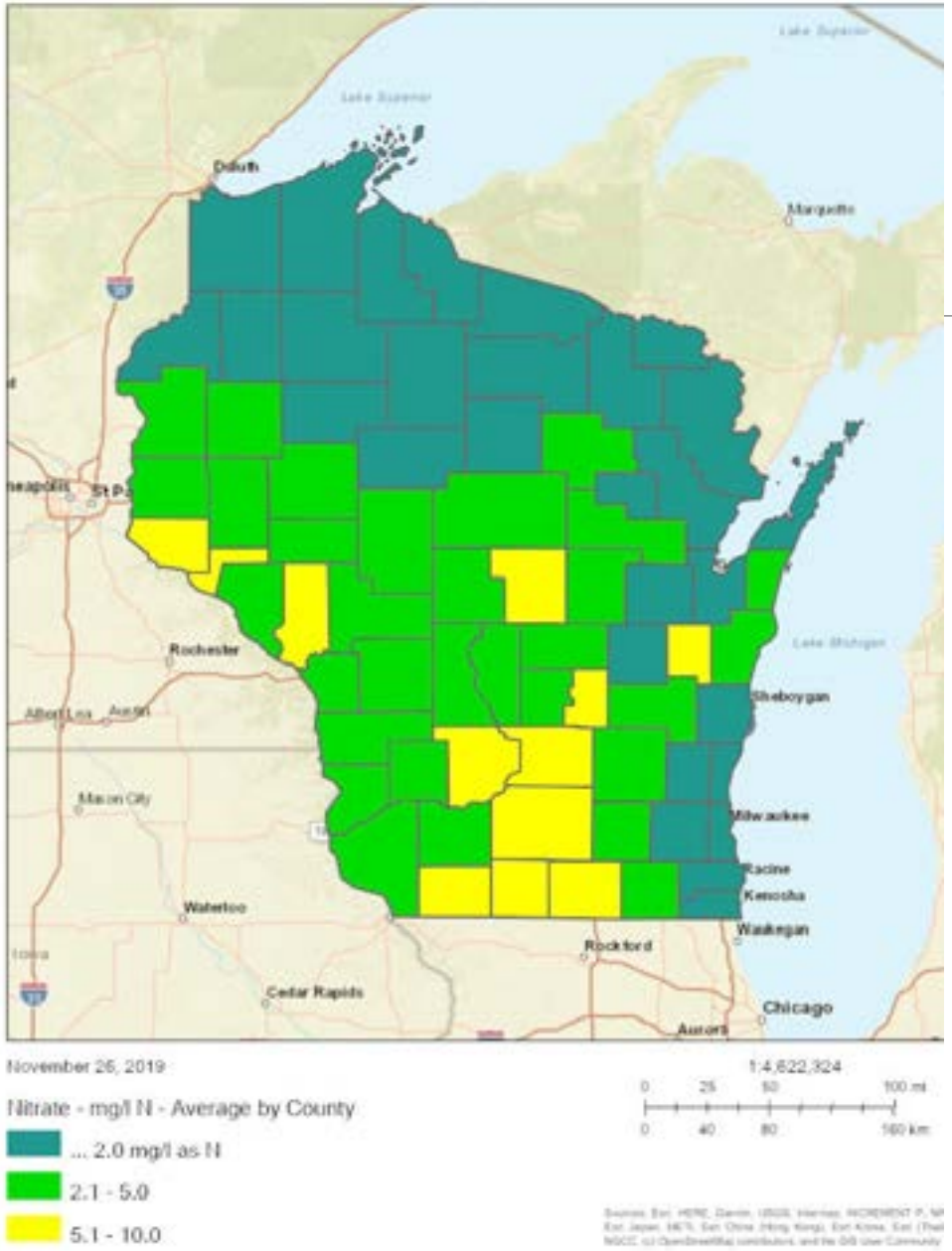
*Data derived from UWSP Well Viewer, UWO 2015 (480 samples) & 2016 (392 samples) community program, 2011-2015 UWEx Private Well Program (582 samples)

**Data derived from the Wisconsin Groundwater Coordinating Council Report & UWSP Well Viewer

% Positive Bacteria



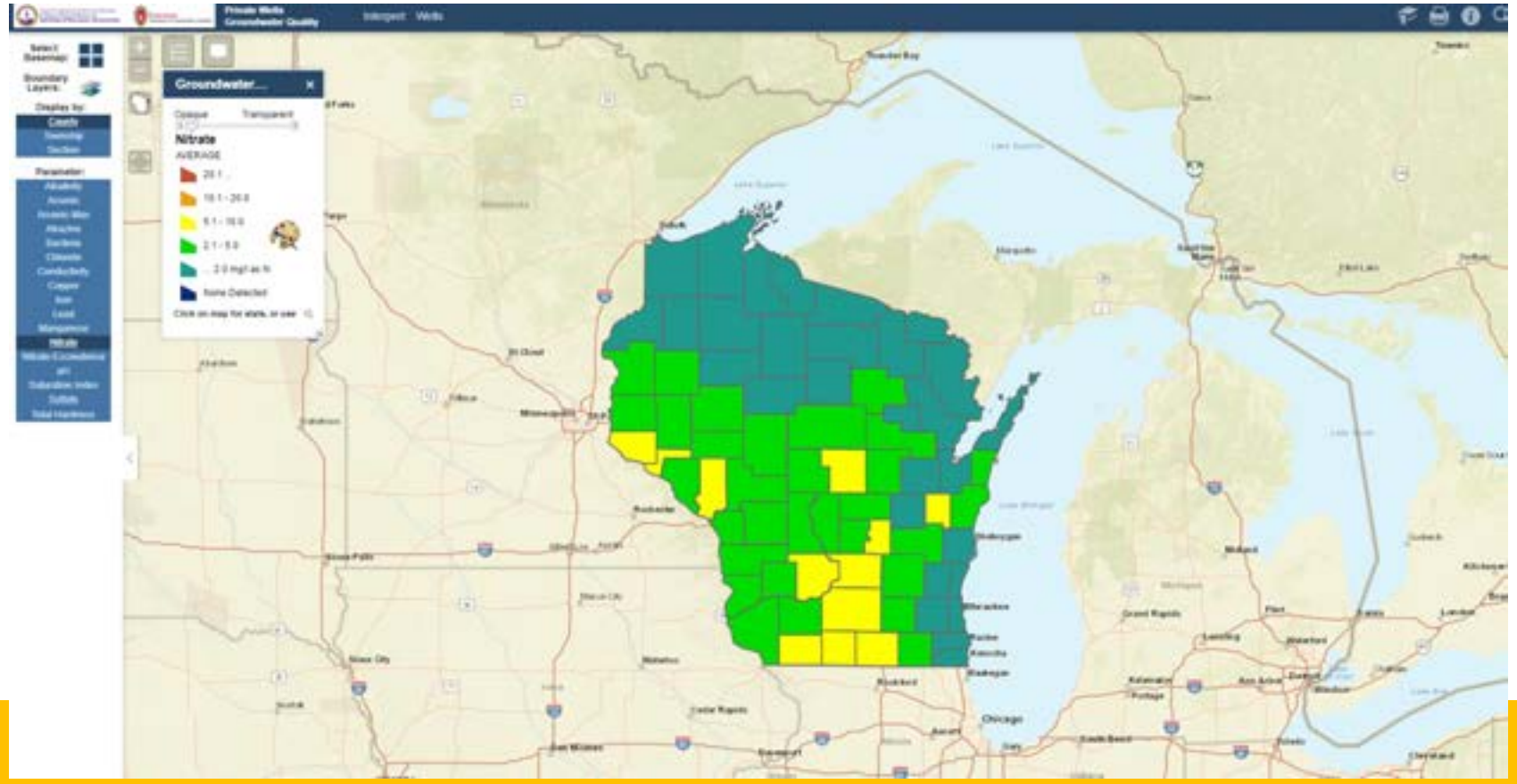
Average Nitrate



Statewide Private Well Data

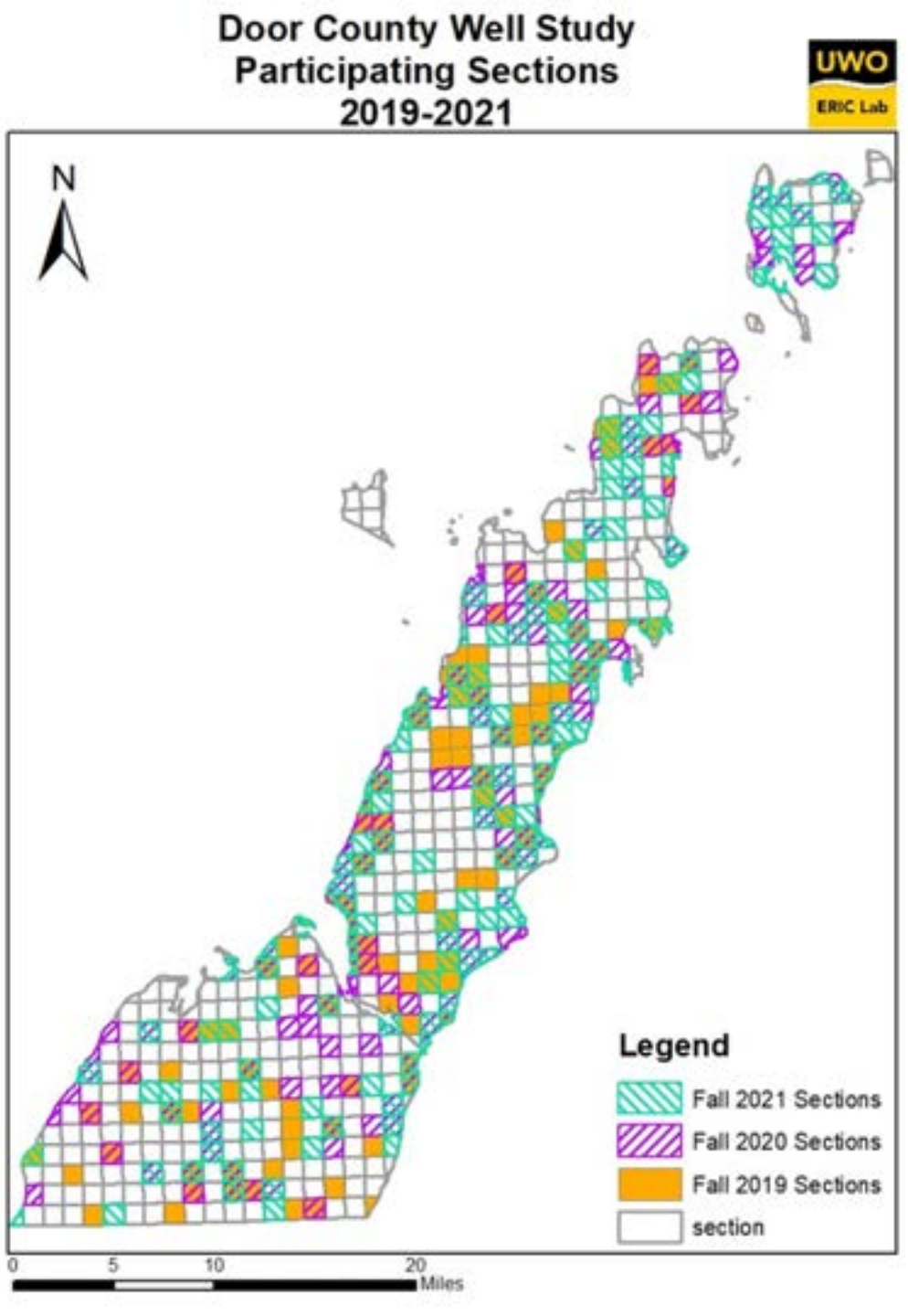
Where is the data going?

- Long-term goal is to upload all data onto UWSP Well Water Data Viewer https://www.uwsp.edu/cnr-ap/watershed/Pages/WellWaterViewer.aspx



Further Research & Plans

- Looking to do a targeted sampling in spring, summer, and/or fall (seasonal)
- Recruiting same volunteers from previous years plus additional wells in other sections across county
- Continuation as a long-term study (ongoing annual program)



Take Home Messages

- Karst geology makes Door County groundwater highly vulnerable to contamination and causes high variability in water quality results
- Sample your well at least annually for bacteria and nitrate, or more often if changes or problems observed (recommended)
- Do not hesitate to use your resources if you have questions or concerns about Door County groundwater quality
  - Wisconsin DNR
  - Door County Soil & Water Conservation Department
  - Door County Public Health

Special Thanks

- Thank you to Door County Soil & Water Department and Door County Public Health for your support throughout the last 3 years of sampling
- Thank you to Door County Medical Center for donating towards postage costs

QUESTIONS? CONTACT US AT ERIC@UWOSH.EDU OR (920) 424-3148

PRESENTATION & RECORDING AVAILABLE ONLINE AT UWOSH.EDU/ERIC

Thank you – we can't do this without you!

Tell us how we did so we can continue to improve upon the program – a survey will be sent via email in the coming weeks.