Chippewa County Well Water Quality Inventory & Nitrate Source Occurrence

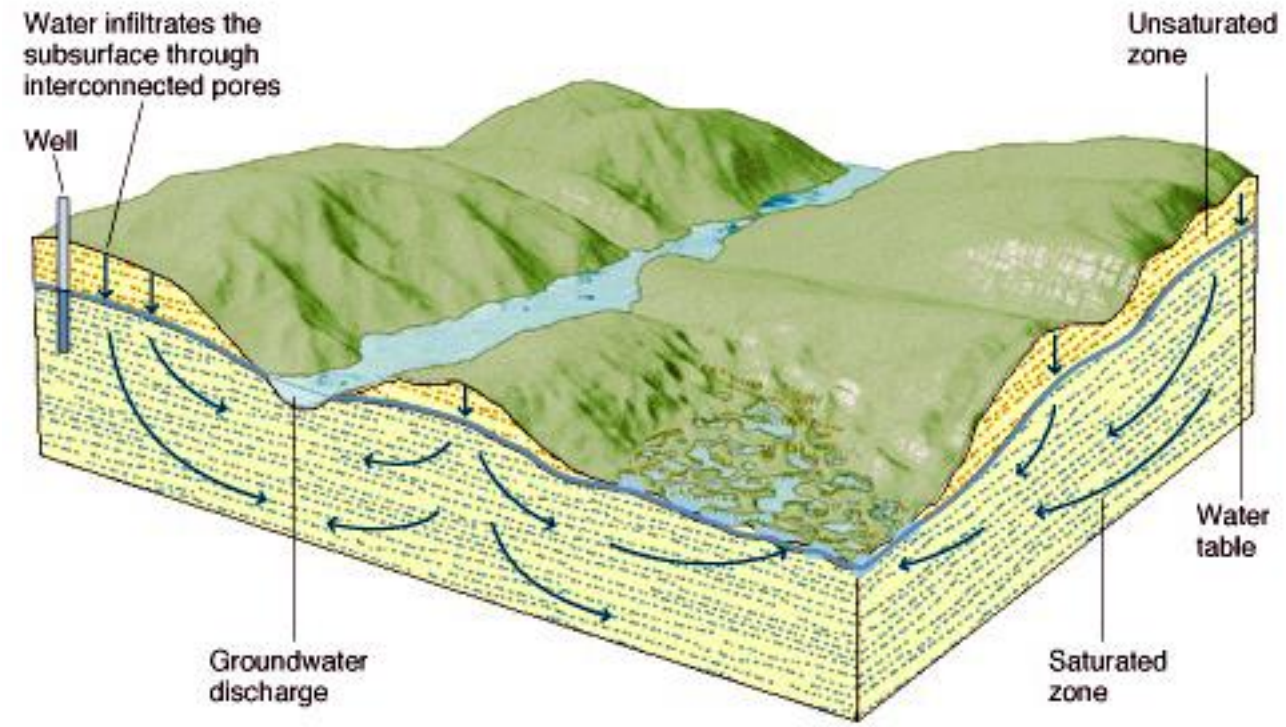
Chippewa County
"Stewardship for Sustainability"
Land Conservation and Forest Management

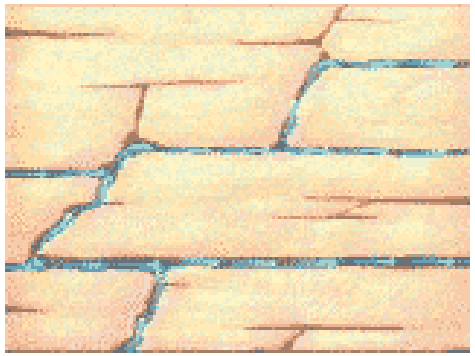
CHIPPEWA COUNTY
Public Health
Prevent. Promote. Protect.

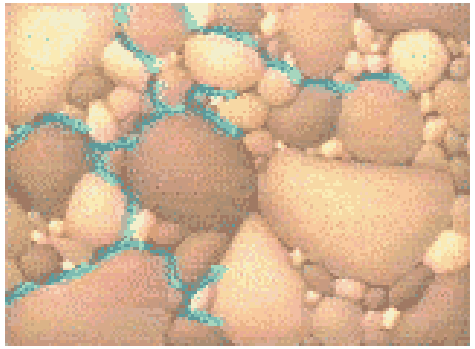
Center for Watershed Science and Education
College of Natural Resources
University of Wisconsin-Stevens Point

Extension
UNIVERSITY OF WISCONSIN-MADISON

Groundwater Movement



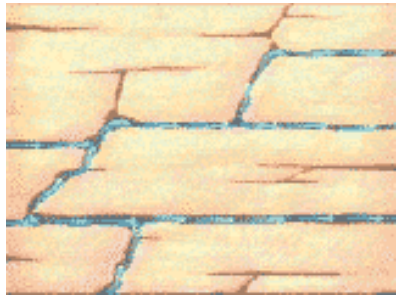




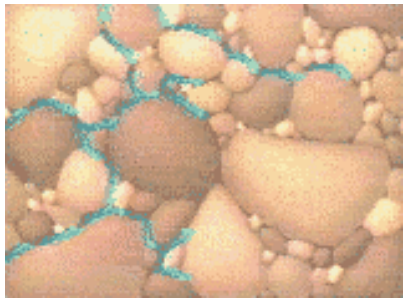
Aquifers: Our groundwater storage units

Aquifers are geologic formations that store and transmit groundwater.

The aquifer properties determine how quickly groundwater flows, how much water an aquifer can hold and how easily groundwater can become contaminated. Some aquifers may also contain naturally occurring elements that make water unsafe.



Water and contaminants can move quickly through cracks and fractures.



Water moving through tiny spaces in between sand particles or sandstone moves slower and allows for filtration of some contaminants.

Wisconsin's geology is like a layered cake. Underneath all of Wisconsin lies the Crystalline bedrock which does not hold much water. Think of this layer like the foundation of your house. All groundwater sits on top of this foundation. Groundwater is stored in the various **sandstone**, **dolomite** and **sand/gravel** aquifers above the **crystalline bedrock** layer. The layers are arranged in the order which they formed, oldest on the bottom and youngest on top.

Learn more about Wisconsin's geologic past by clicking the aquifer names

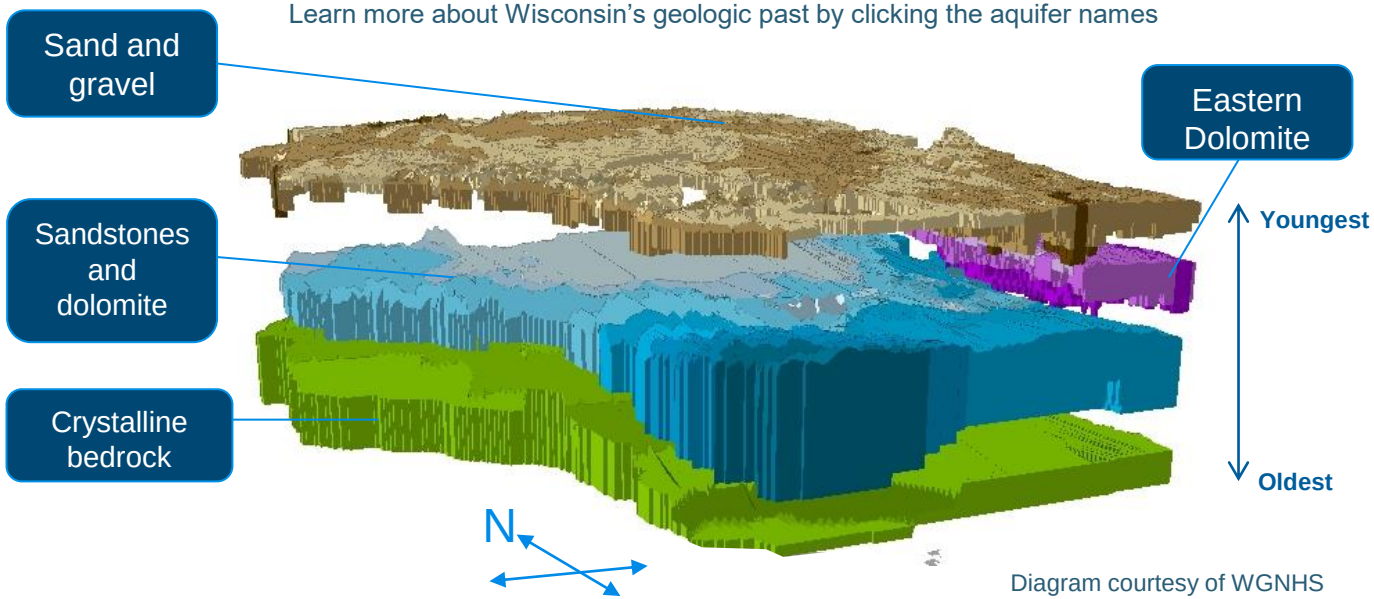
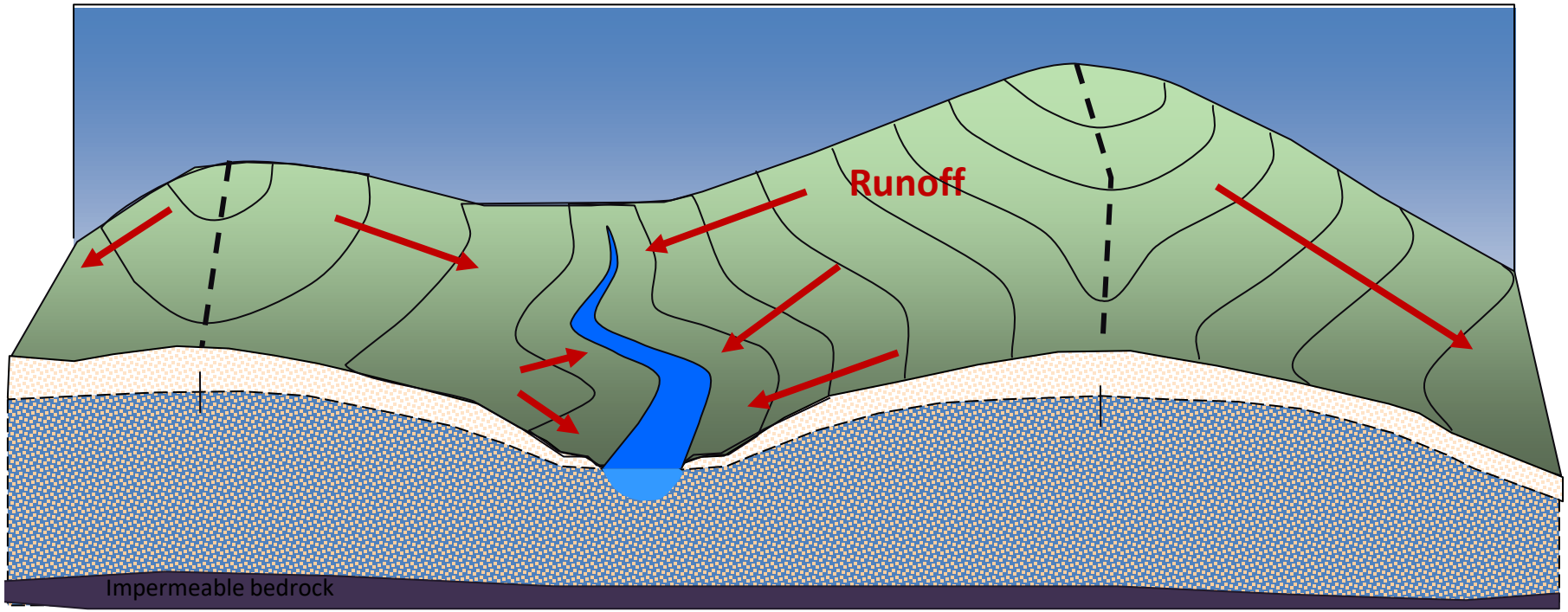
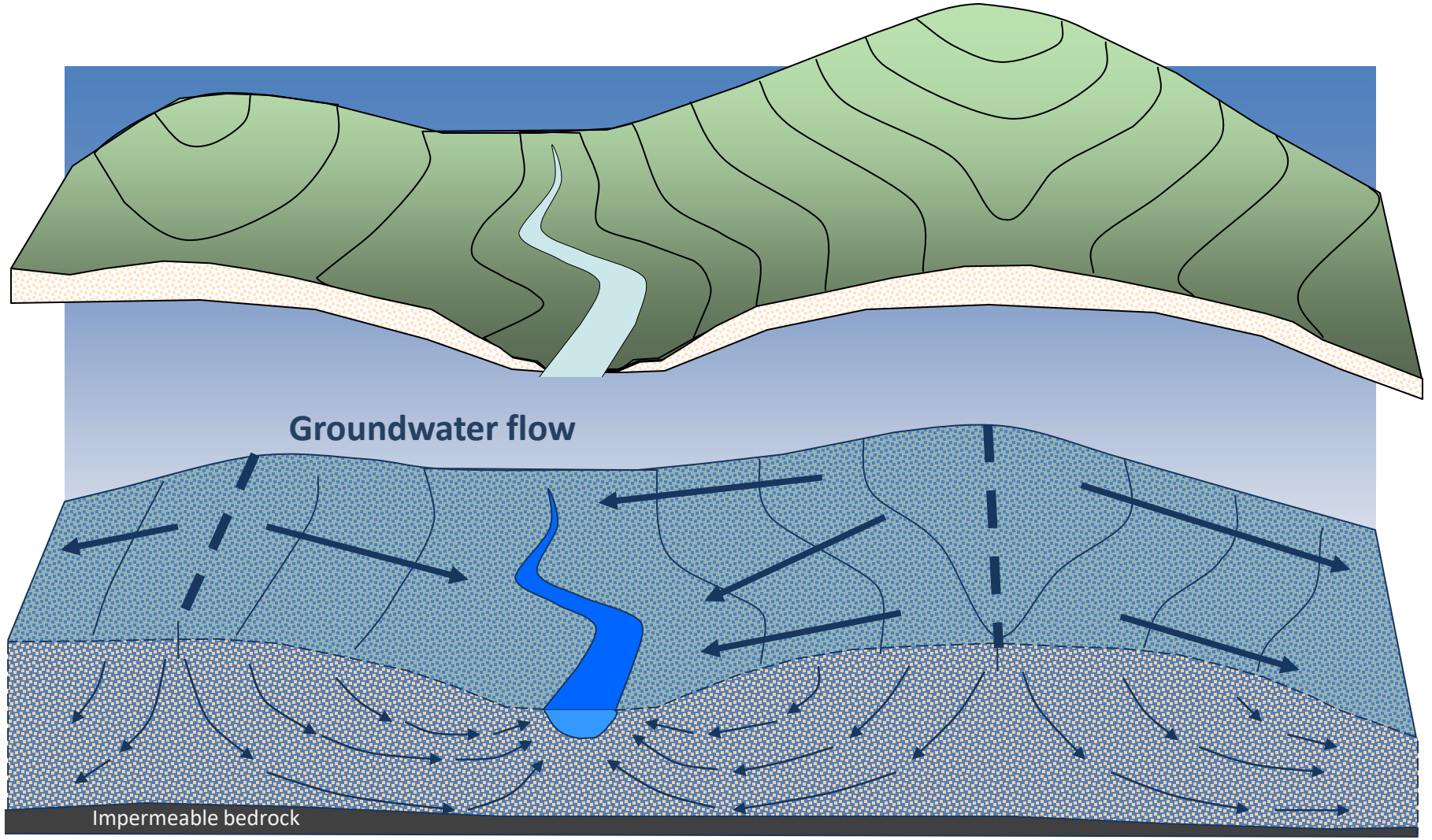


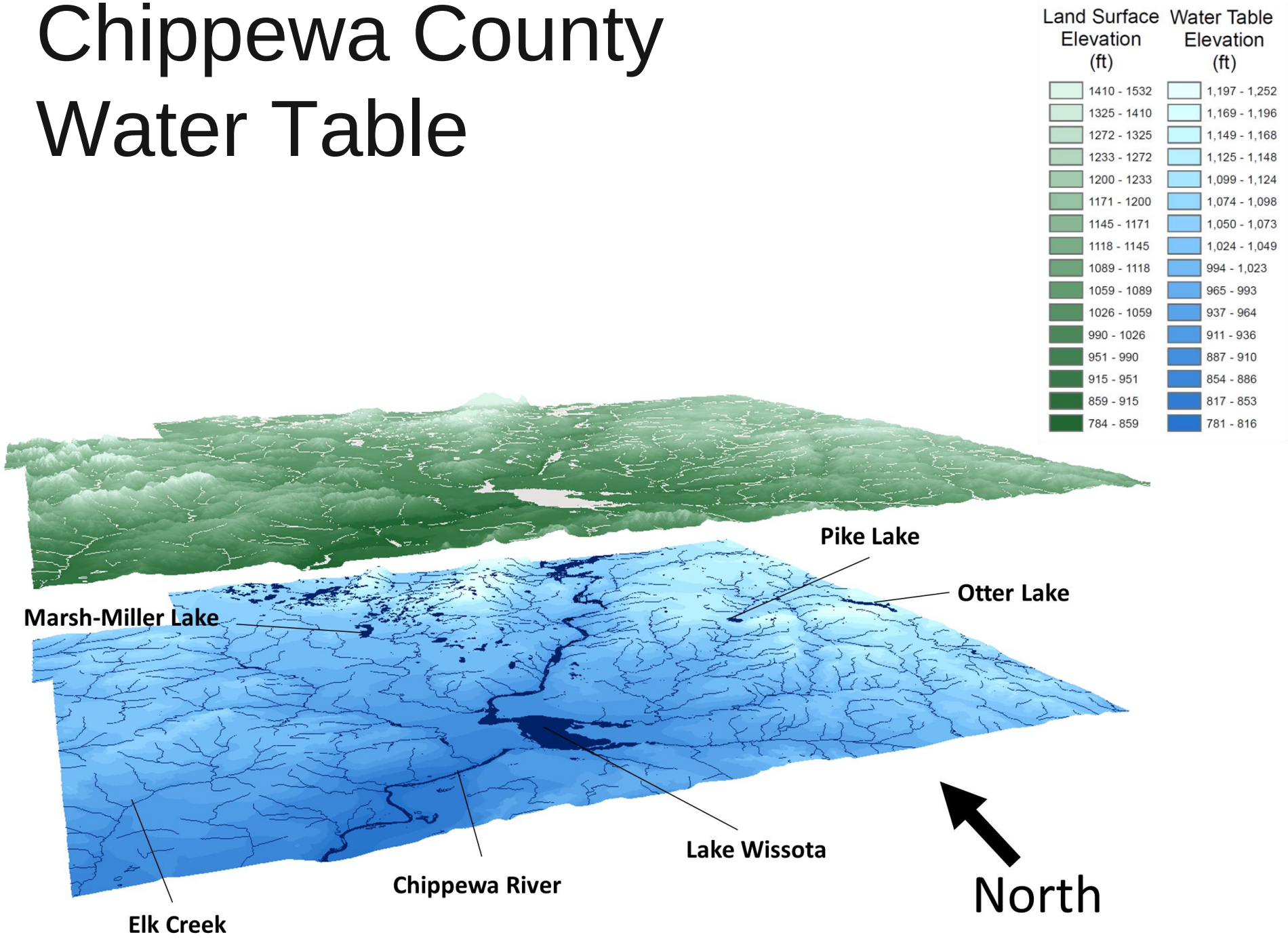
Diagram courtesy of WGNHS

Watershed – the land area where water originates for lakes, rivers or streams. Water flows from high elevation to low elevation.




Groundwater flow
Impermeable bedrock

Chippewa County Water Table



General Groundwater Flow Direction

0 0.125 0.25 0.5 Miles

N
W E
S

Legend

Well Water Table

The black arrows show generalized groundwater flow direction in the area near your well. Groundwater flows perpendicular to the groundwater elevation lines and moves from high areas (hills) to low areas (streams,rivers). In general, residential wells impacted by land use are usually the result of those activities occuring within a roughly 1/2 mile distance from a well.

Disclaimer: This map is for educational purposes only. Groundwater flow is a best guess based on currently available information.

Cartography by Sean Piette

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0 0.125 0.25 0.5 Miles

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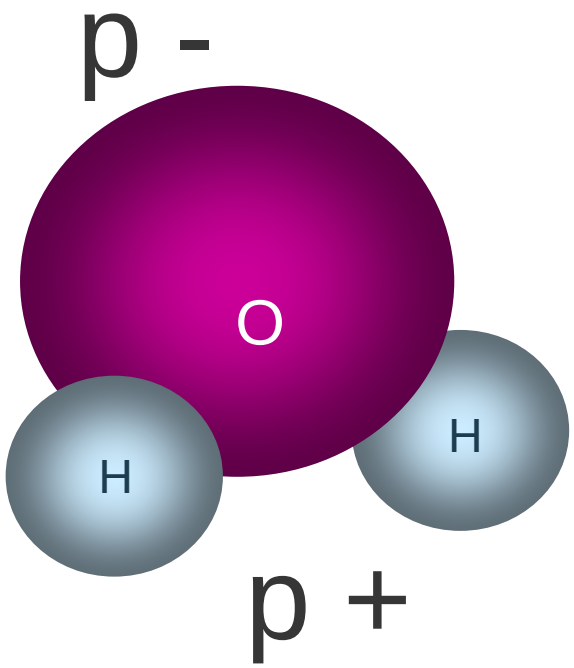
Cartography by Sean Piette

water basics

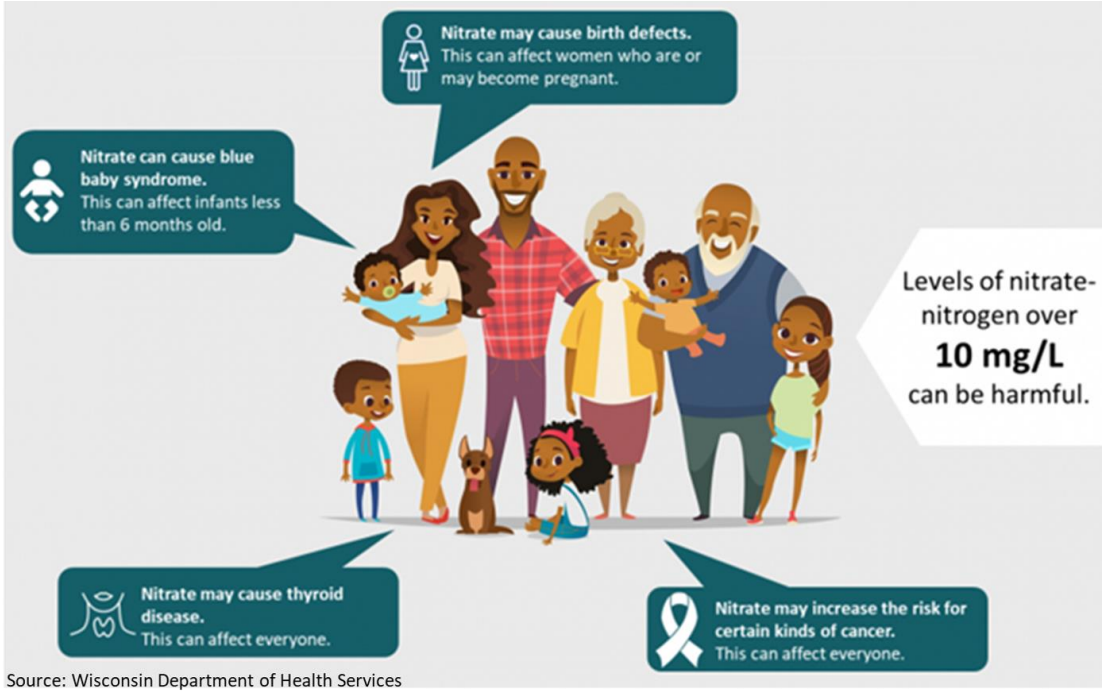
- "Universal Solvent"
- Naturally has "stuff" dissolved in it.
  - Impurities depend on rocks, minerals, land-use, plumbing, packaging, and other materials that water comes in contact with.
- Can also treat water to take "stuff" out



Nitrate-Nitrogen

Health Effects:

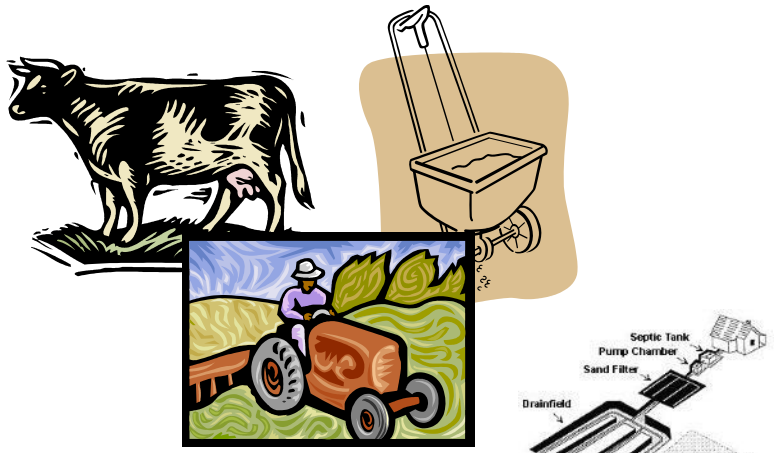
- Methemoglobinemia (blue baby disease)
- Possible links to birth defects and miscarriages (humans and livestock)
- Indicator of other contaminants



Source: Wisconsin Department of Health Services

Sources:

- Agricultural fertilizer
- Lawn fertilizer
- Septic systems
- Animal wastes



What to do if your nitrate levels are high?

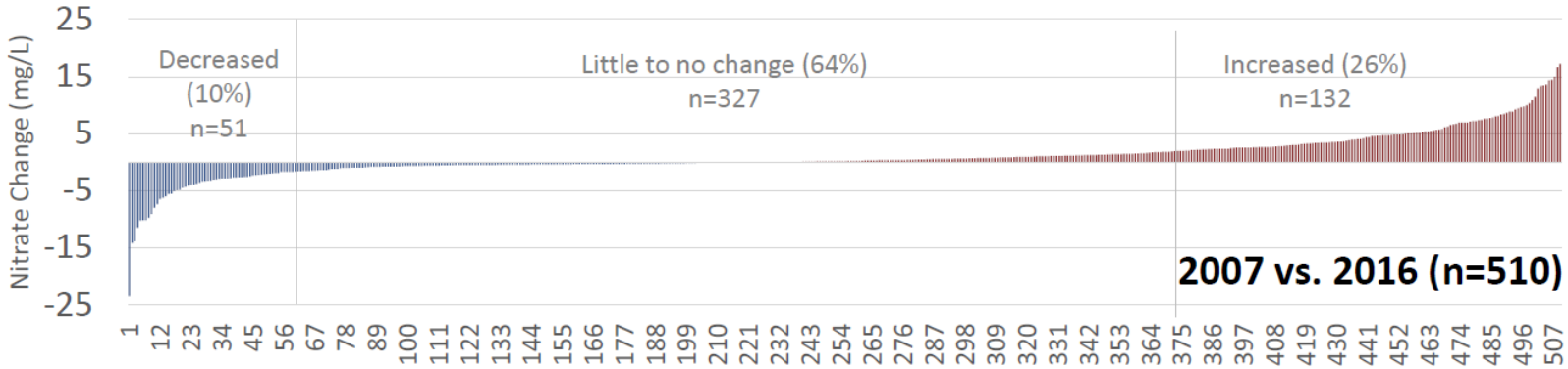
Solution:

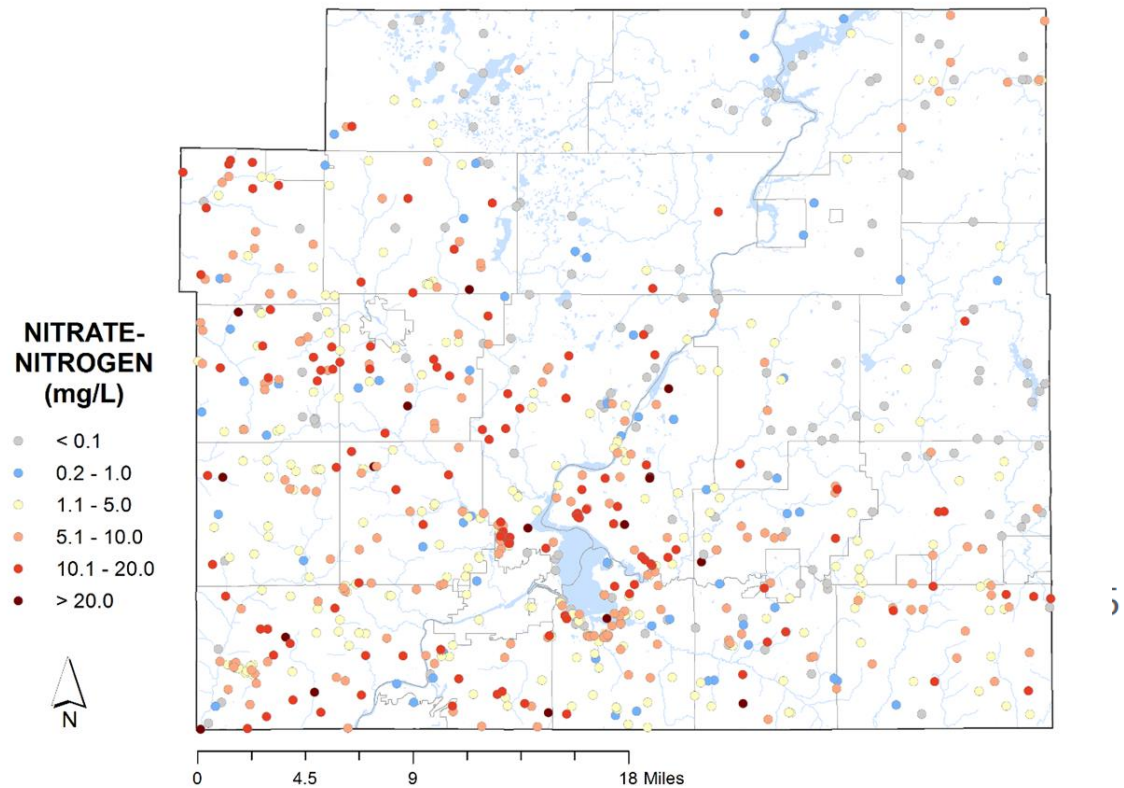
- **Eliminate contamination source or reduce nitrogen inputs**

Short term:

- **Change well depth or relocate well**
- **Carry or buy water**
- **Water treatment devices**
  - **Reverse osmosis**
  - **Distillation**
  - **Anion exchange**

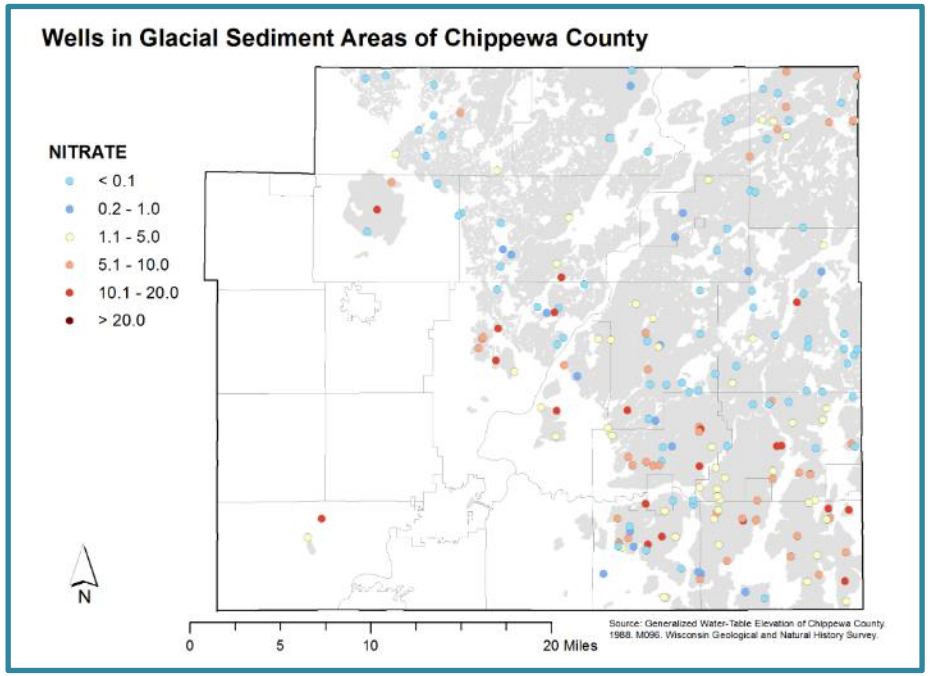
Comparing nitrate concentrations over time

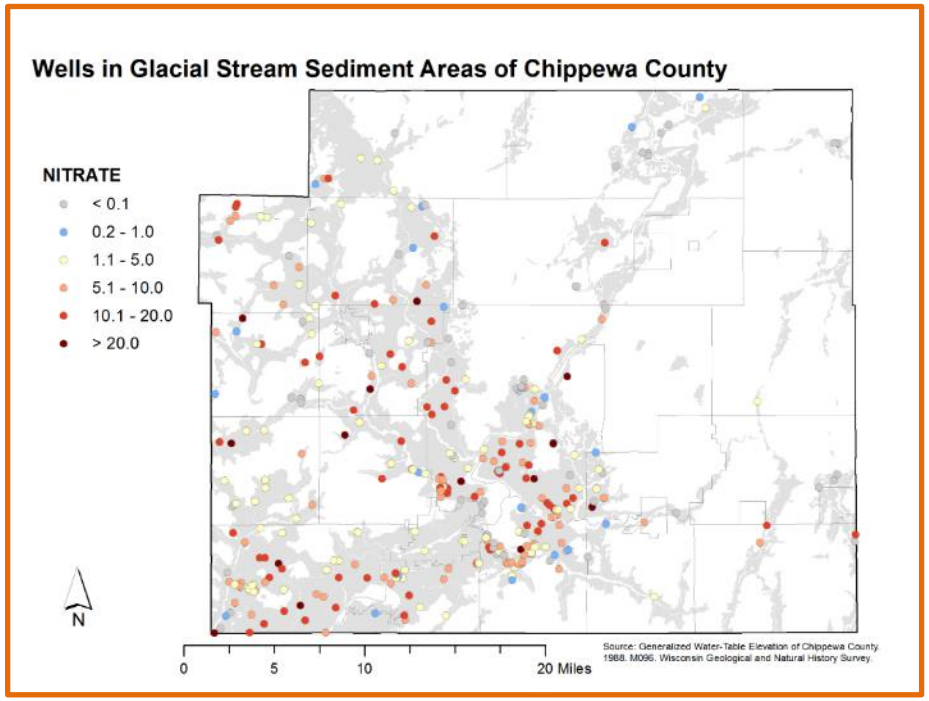


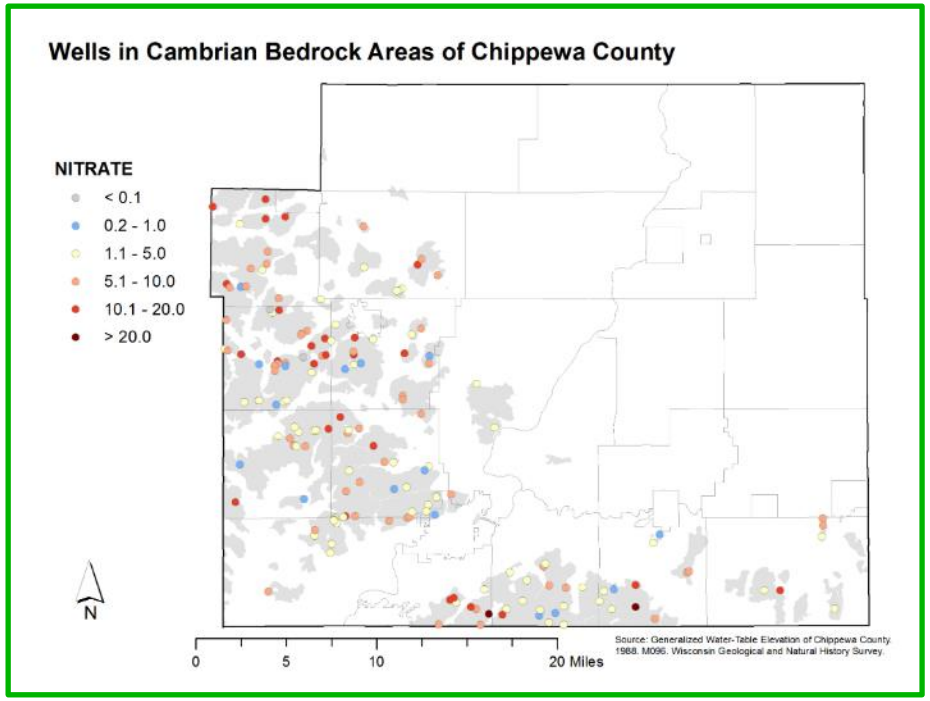


Year	Nitrate Average (mg N/L)	Greater than 10 mg/L
1985	4.2	11.3%
2007	4.7	12.3%
2016	5.5	18.3%

Aquifer Type		Nitrate-N	
	n	Mean	% > 10 mg/L
Meltwater Stream	360	6.4	24.2
Glacial Sediment	207	3.6	9.7
Cambrian	170	5.9	17.0







Chippewa Groundwater Quality Index

1985, 2007, 2016, 2019, 2020…..

<u>GOAL</u>: To learn how well water quality changes over time

How variable is well water quality from year to year?

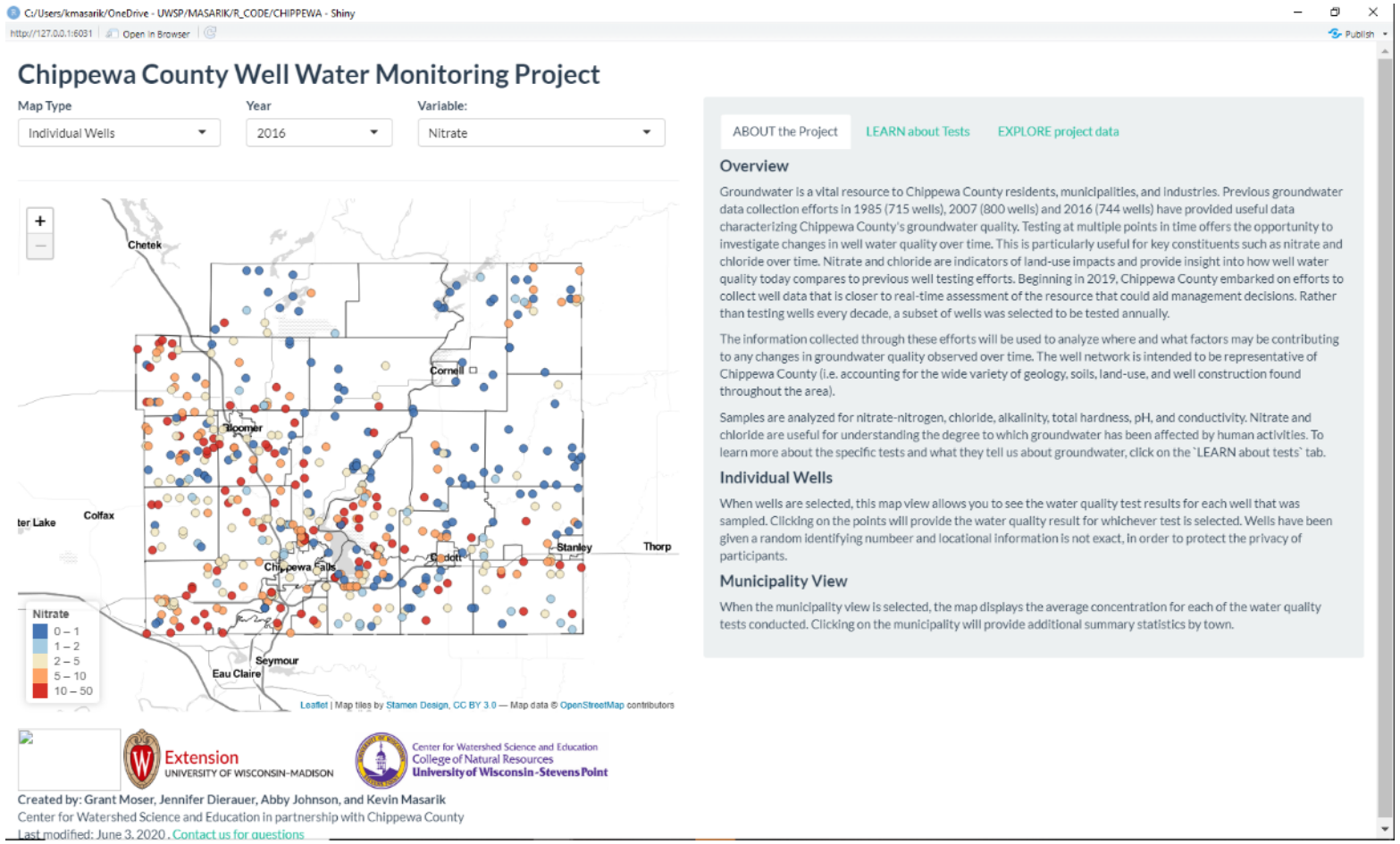
Is well water quality getting better, worse, or staying the same?

If changing, what can we learn about where and why

This project works best when:

- Wells are representative of diverse geology and land use
- The same wells are sampled every year

Chippewa County Well Water Quality Index



Beginning in 2019, annual well testing of up to 210 wells

- 70 wells each from each stratum (Cambrian, Meltwater Stream Sediment, Glacial)
- Wells will be selected to obtain representative land cover distribution
- Wells with known well construction

Nitrate / Chloride

- Useful for understanding land-use impacts on groundwater

Conductivity

- Overall water quality, combination of both land-use, rocks, and soils

Total Hardness / Alkalinity / pH

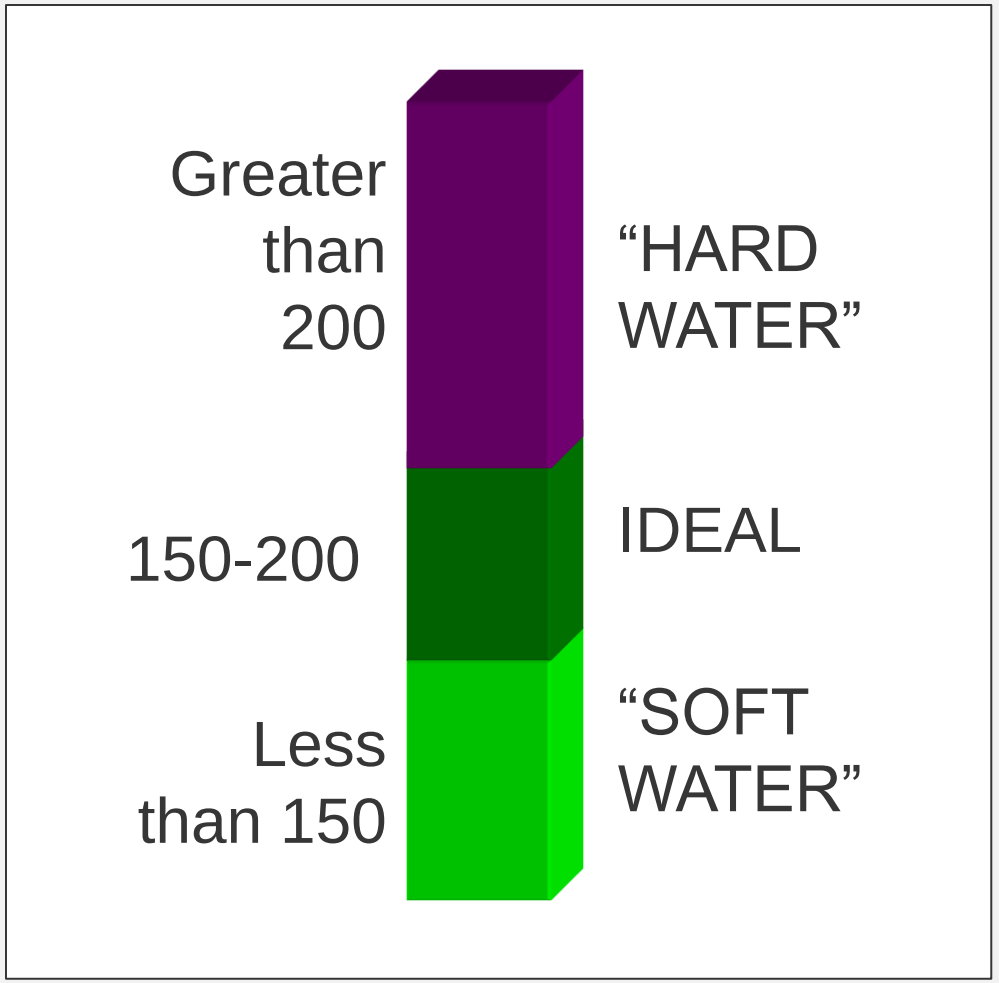
- Help us understand how rocks and soils impact groundwater

Tests for Aesthetic Problems

Hardness

- Natural (rocks and soils)
- Primarily calcium and magnesium

- Problems: scaling, scum, use more detergent, decrease water heater efficiency



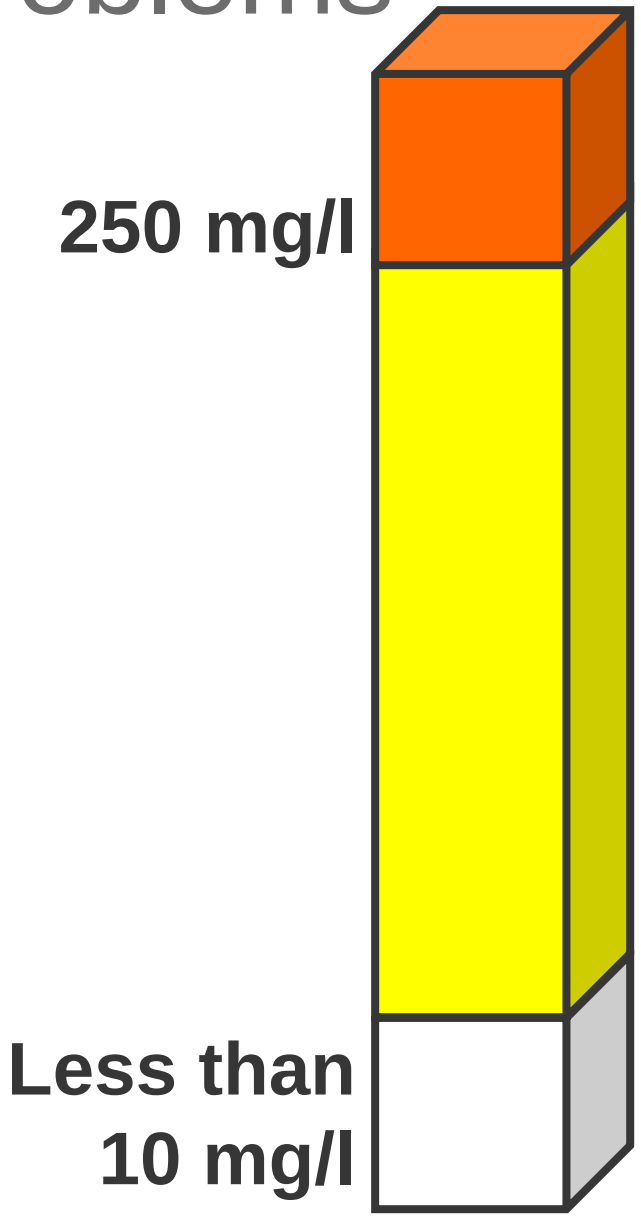
Tests for Overall Water Quality

- **Alkalinity** – ability to neutralize acid
- **Conductivity** –
  - Measure of total ions
  - can be used to indicate presence of contaminants (~ twice the hardness)
- **pH** – Indicates water's acidity and helps determine if water will corrode plumbing

Tests for Aesthetic Problems

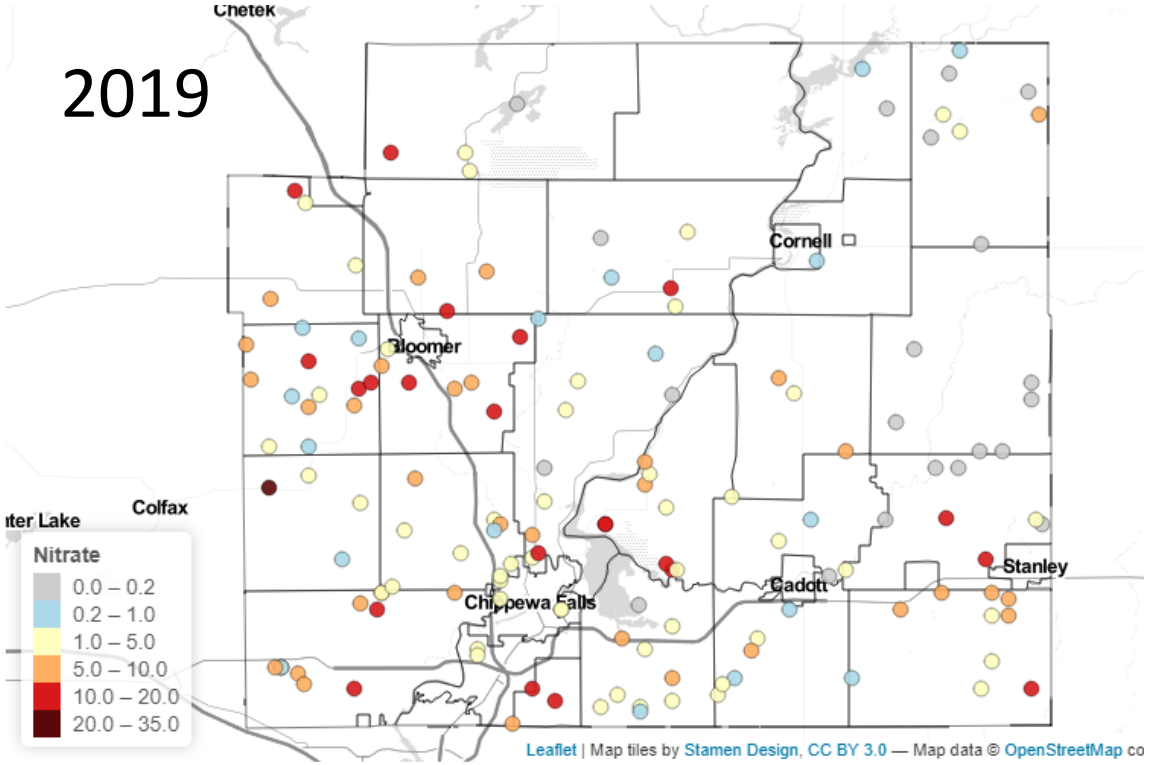
Chloride

- Greater than 250 mg/l
  - No direct effects on health
  - Salty taste
  - Exceeds recommended level
- Greater than 10 mg/l may indicate human impact
- Less than 10 mg/l considered “natural” in much of WI
- **Sources:** Fertilizers, Septic Systems and Road Salt



Nitrate in Chippewa County Wells

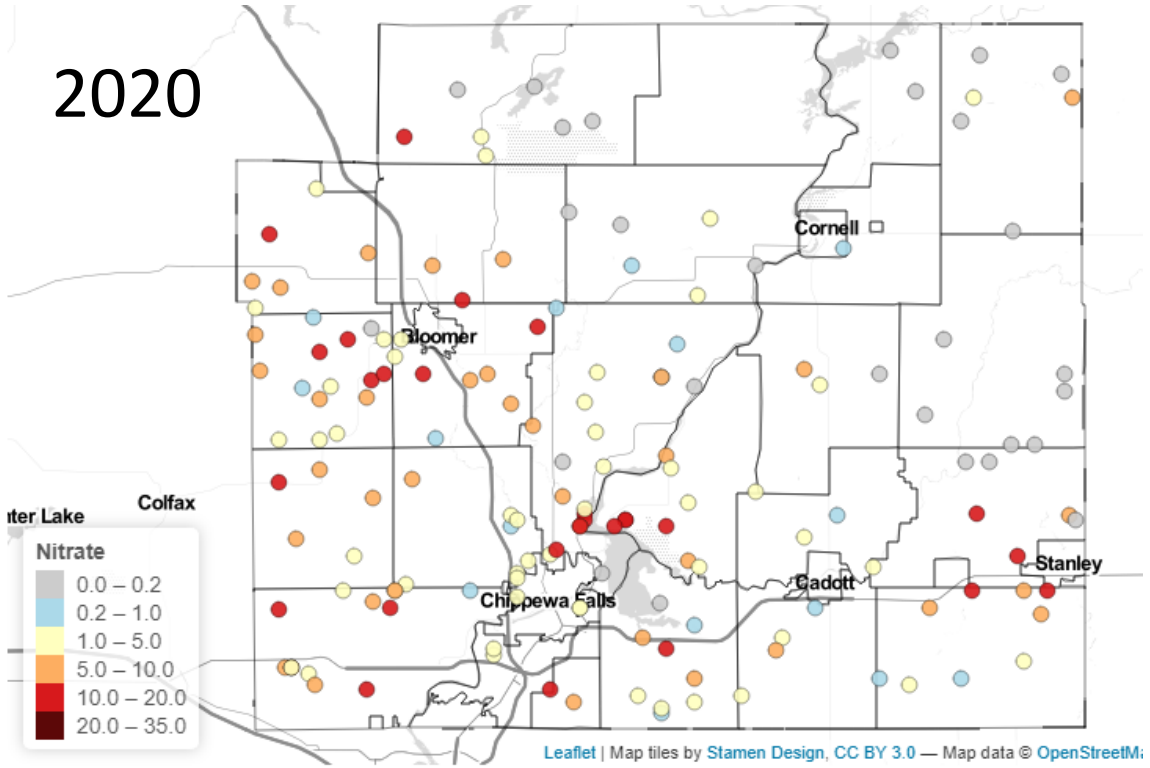
2019



Nitrate (mg/L as N)		
None Detected	0	0 %
... 2.0	53	34 %
2.1 - 5.0	42	27 %
5.1 - 10.0	35	23 %
10.1 - 20.0	24	15 %
20.1 ...	1	<1 %

Avg: 4.8 for 155 Samples

2020

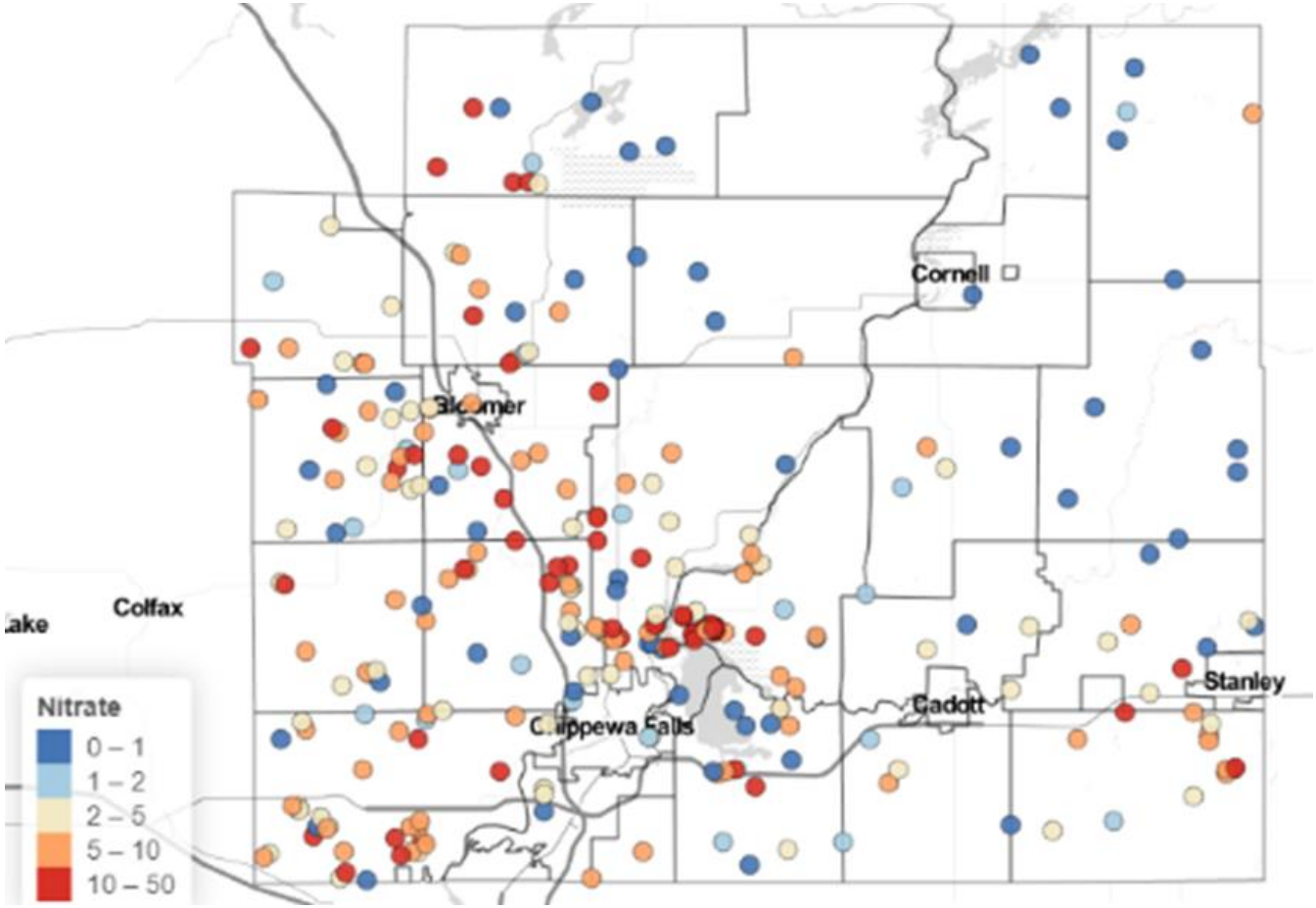


Nitrate (mg/L as N)		
None Detected	26	16 %
... 2.0	37	23 %
2.1 - 5.0	32	20 %
5.1 - 10.0	39	24 %
10.1 - 20.0	28	17 %
20.1 ...	0	0 %

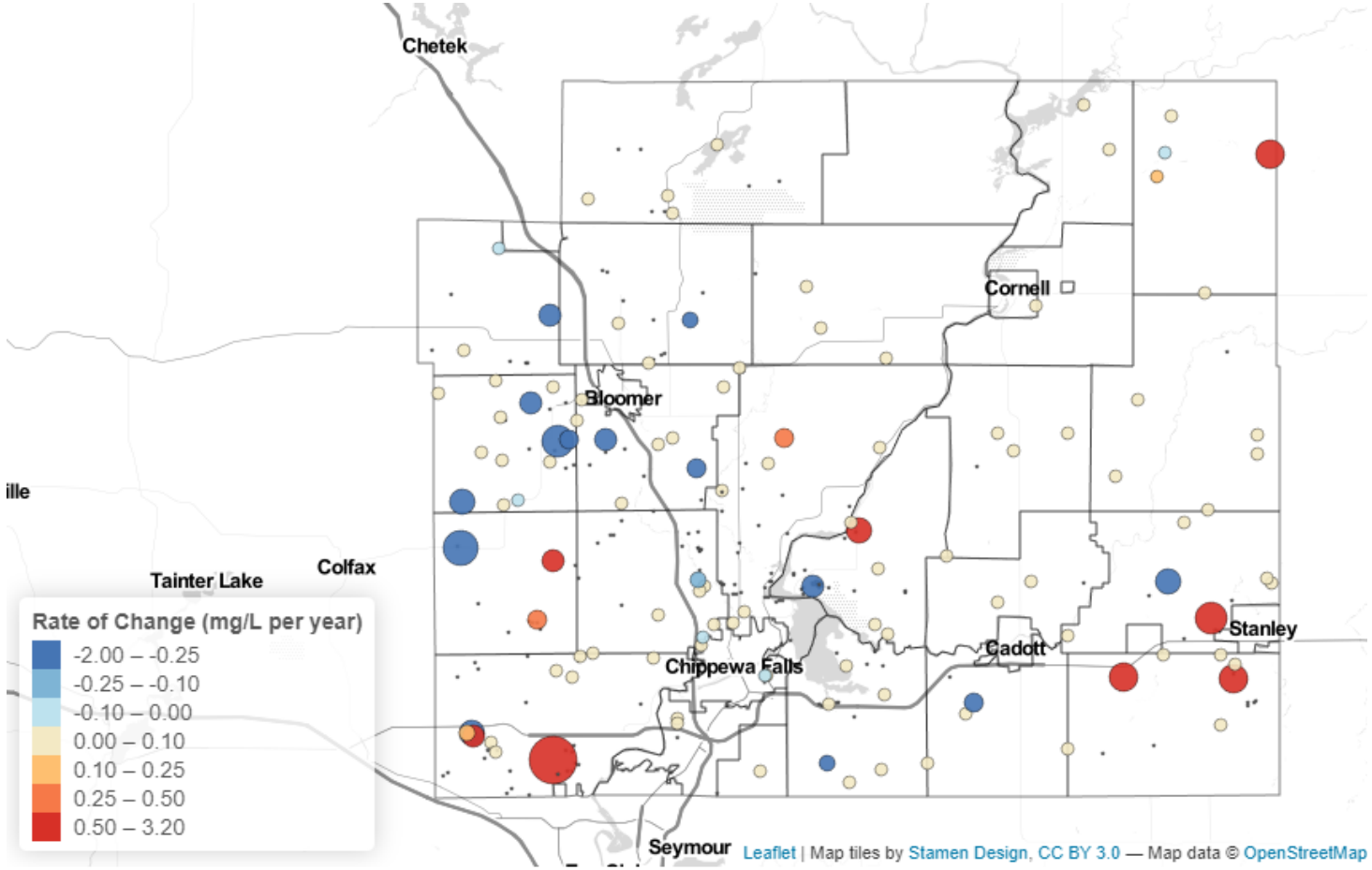
Avg: 4.9 for 162 Samples

Chippewa County 2022 – Nitrate-Nitrogen

Nitrate-Nitrogen (mg/L)	Number of Samples	Percent
Less than 0.1	29	10%
0.1 – 2.0	52	18%
2.1 – 5.0	65	22%
5.1 – 10.0	78	27%
10.1 – 20.0	64	22%
Greater than 20.0	2	<1%

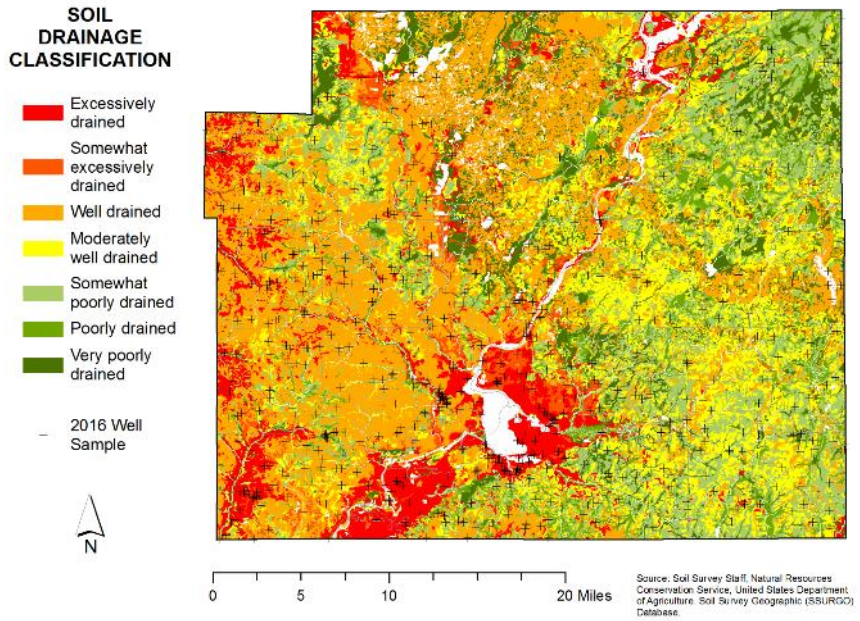


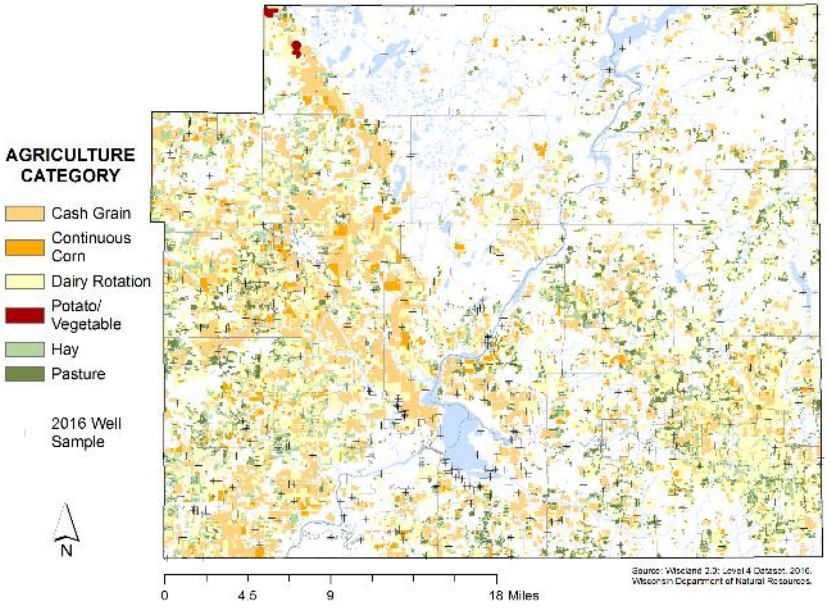
Preliminary Data - Chippewa County Trends

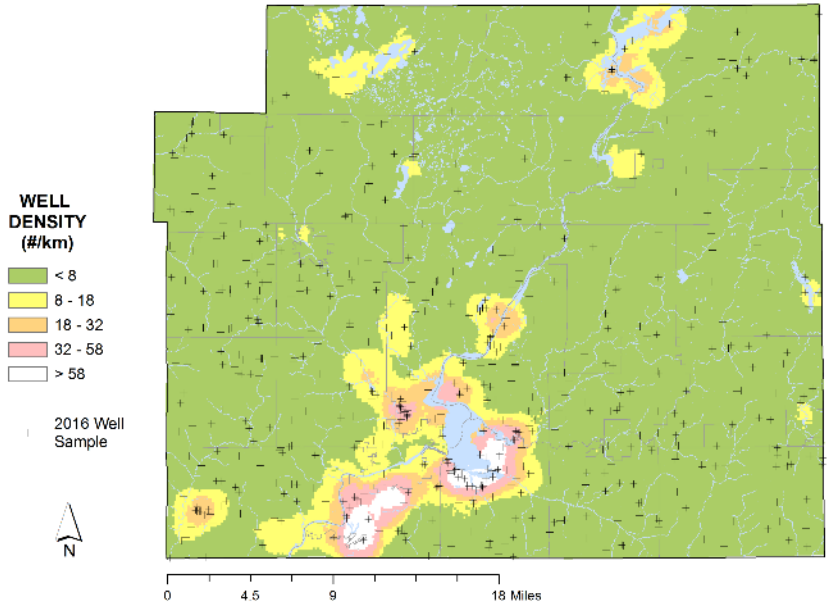


- Nitrate Trends
  - 26 wells decreasing (21%)
  - 15 wells increasing (12%)
  - 83 wells no trend (67%)

Modeling Nitrate Risk



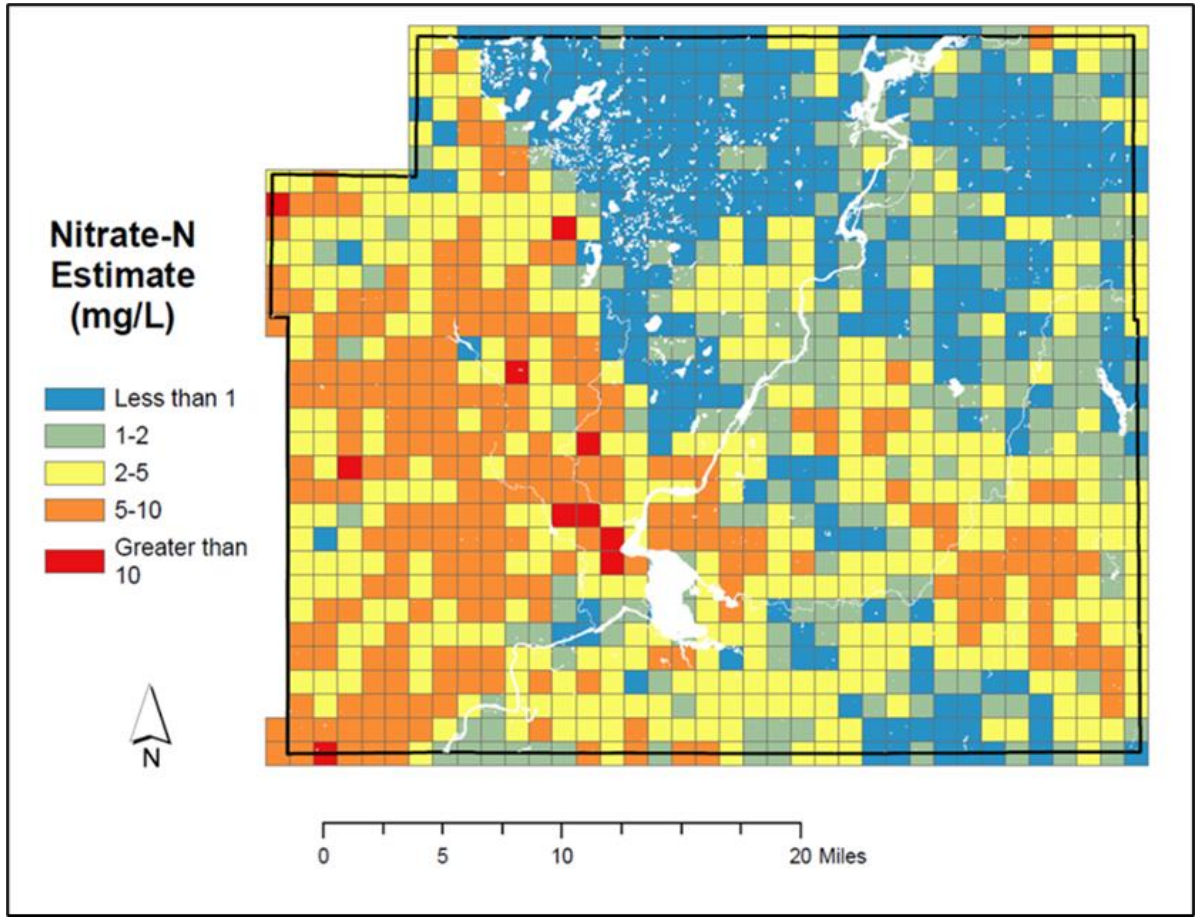





```
Original Fit 5
#------------------------------------------------------------------------

Call:
lm(formula = NITRATE_SQRT ~ CORN_CASH + DAIRY + HAY + RLTIVE_DNS +
    Weighted.Average.Rank, data = chippewa_combined)

Residuals:
    Min      1Q  Median      3Q     Max
-2.6939 -0.7798 -0.0012  0.7205  3.9679

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.21229    0.21826   0.973   0.3310
CORN_CASH           2.71980    0.27606   9.852  < 2e-16 ***
DAIRY               1.64863    0.28357   5.814 9.09e-09 ***
HAY                 2.43170    0.49096   4.953 9.07e-07 ***
RLTIVE_DNS          1.39460    0.32025   4.355 1.52e-05 ***
Weighted.Average.Rank  0.11734    0.05018   2.338   0.0196 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.12 on 738 degrees of freedom
Multiple R-squared:  0.2161,    Adjusted R-squared:  0.2108
F-statistic: 40.68 on 5 and 738 DF,  p-value: < 2.2e-16
```

Well Selection for Nitrate Source Occurrence

- County Trend Monitoring
  - Well owners that have submitted samples annually since 2019
  - 152 wells
- Nitrate Source Investigation
  - Additional wells selected from grid cells with a nitrate-N estimate greater than 5 mg/L
  - 141 wells

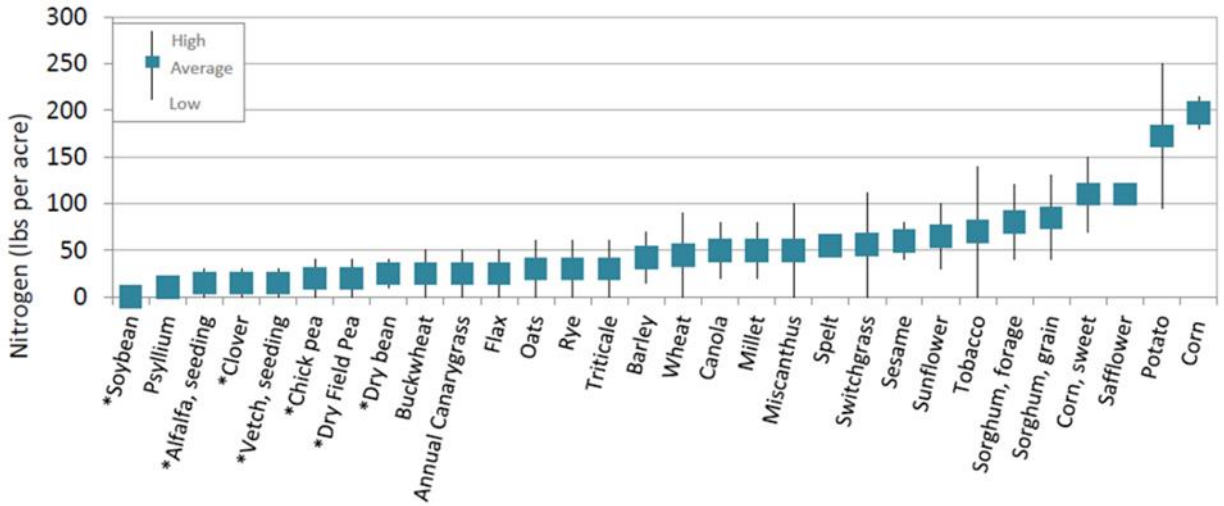


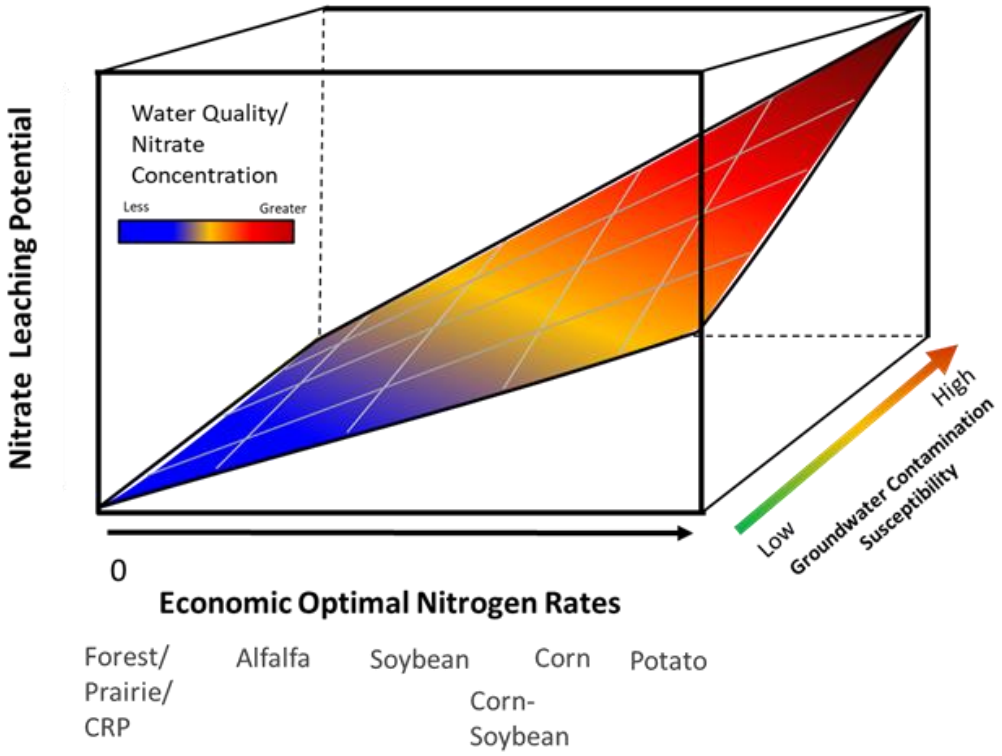
Annual Sampling (CTM) versus Nitrate Areas (NSI)

		Nitrate-Nitrogen			
	Samples	Mean Concentration	Greater than 2 mg/L	Greater than 5 mg/L	Greater than 10 mg/L
	n	mg/L	----------%----------		
CTM	151	4.7(4.4)	62	40	12
NSI	142	7.6(5.5)	82	59	34

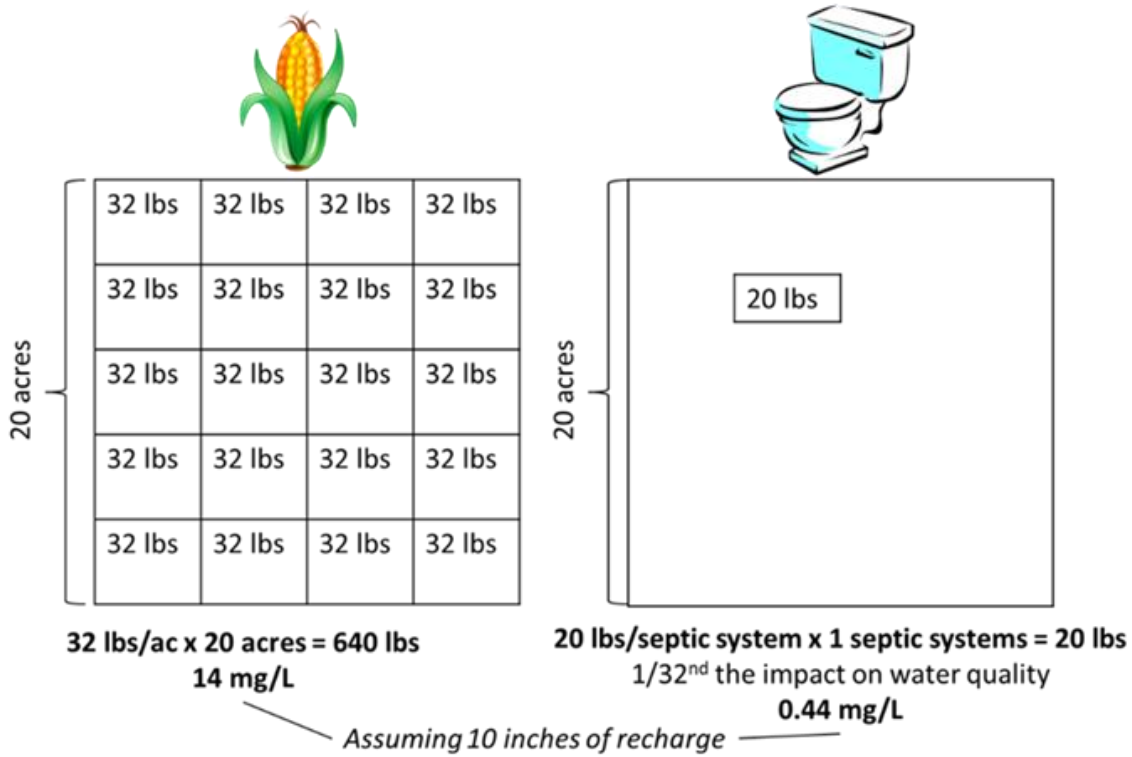
Overall, gridded predictive model did a better job of identifying areas of elevated nitrate than random sampling would have.

Nitrate losses from agricultural systems





Nitrate leaching losses from septic systems



Nitrate Source Tracers

Parameter	Samples	Limit of Detection	Samples with detections		Health value*	Min	Median	Mean	Max
	n	ug/L	n	%	ug/L or parts per billion				
Alachlor OA[1]	24	0.08	0	0		NA	NA	NA	NA
Alachlor ESA[1]	24	0.08	10	42		0.13	0.49	0.53	1.28
Metolachlor OA[1]	24	0.08	2	8		0.12	0.17	0.17	0.22
Metolachlor ESA[1]	24	0.08	21	88		0.12	0.61	0.95	6.01
	n	ng/L	n	%	ng/L or parts per trillion				
Acesulfame[2]	24	5	10	42		5.6	10.8	1,500	13,100
Sucralose[2]	24	25	11	46		27	43	1934	16,100
Caffeine[2]	24	12	3	13		12	12.3	14	18.7
Paraxanthine[2]	24	5	0	0		NA	NA	NA	NA
Carbamazepine[2]	24	2	1	4		7.6	7.6	7.6	7.6
Sulfamethoxazole[2]	24	5	2	8		64	117.5	117.5	171
Acetamiprid[3]	24	1.7	0	0		NA	NA	NA	NA
Clothianidin[3]	24	1.5	4	17	1,000,000	2.5	18.1	18.2	34.1
Dinotefuran[3]	24	0.7	0	0		NA	NA	NA	NA
Imidacloprid[3]	24	2.4	1	4	200	18.7	18.7	18.7	18.7
Thiamethoxam[3]	24	1.5	1	4	1,200,000	47.9	47.9	47.9	47.9

[1]Common pesticides

[2]Pharmaceuticals and personal care products (PPCPs)

[3]Neonicotinoid compounds

*If this column is absent it means that there is no recommended health value available due to low risk or lack of health/toxicity research on those compounds.

		Nitrate-Nitrogen	Chloride
	n	mg/L	
Agricultural Tracers	21	9.8(5.1)	20.4(13.8)
PPCPs	17	8.8(5.4)	35.8(60.1)
Only Agricultural Tracers	6	10.0(5.2)	19.2(14.9)
Only PPCP	3	4.7(5.2)	105(137)

Take aways:

- Agriculture has greater influence on nitrate concentrations
- Developed areas have greater influence on chloride concentrations

PFAS

What are PFAS?

- PFAS are a group of chemicals made by humans. Since the 1950s, PFAS have been used in many consumer products and industrial processes. They have properties that resist heat, grease, and water.

Where are PFAS found?

- While PFOA and PFOS have been phased out from their use in commercial products, they are still found in the environment from historical uses and in some firefighting foams. In addition, products are often made with other PFAS as replacements for PFOA and PFOS. These PFAS can be found in everyday products, such as:
  - Cleaning products.
  - Water-resistant fabrics, such as rain jackets, umbrellas and tents.
  - Grease-resistant paper.
  - Nonstick cookware.
  - Personal care products, like shampoo, dental floss, nail polish, and eye makeup.
  - Stain-resistant coatings used on carpets, upholstery, and other fabrics.

- Most studies have analyzed only a small number of chemicals. Research suggests that high levels of some PFAS may:
  - Increase cholesterol levels.
  - Decrease how well the body responds to vaccines.
  - Increase the risk of thyroid disease.
  - Decrease fertility in women.
  - Increase the risk of serious conditions like high blood pressure or pre-eclampsia during pregnancy.
  - Lower infant birth weights (the decrease in weight is small and may not affect health).

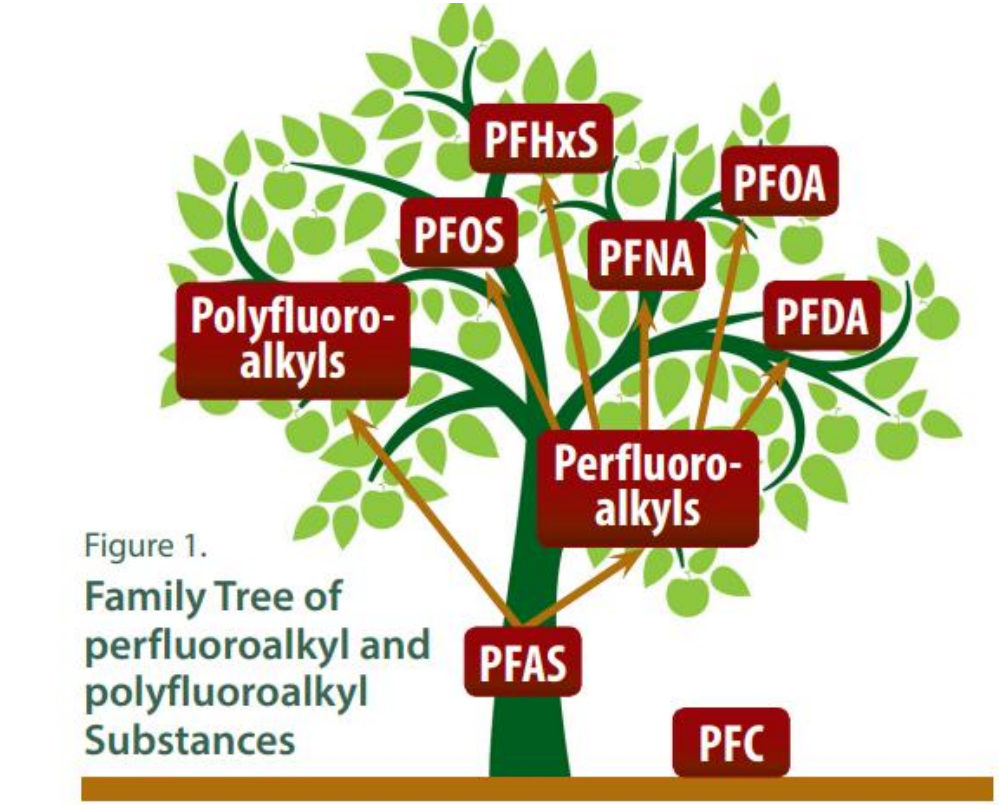


Figure 1.
Family Tree of perfluoroalkyl and polyfluoroalkyl Substances

Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations

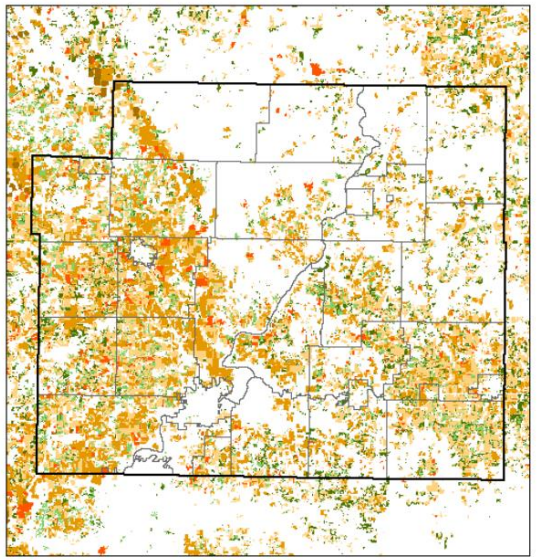
ATSDR

Perfluoroalkyl and Polyfluoroalkyl Substances

Parameter	Samples	Limit of Detection	Samples with detections		Health value*	Min	Median	Mean	Max
	n	ng/L	n	%	ng/L	ng/L or parts per trillion			
PFOA	**24**	**0.107**	**3**	**13**	**20**	**2.94**	**3.19**	**8.78**	**20.20**
PFOS	24	0.141	2	8	20	0.17	0.61	0.61	1.04
FOSA	24	0.153	0	0		NA	NA	NA	NA
N-EtFOSA	24	0.686	0	0		NA	NA	NA	NA
N-EtFOSE	24	0.21	0	0		NA	NA	NA	NA
N-EtFOSAA	24	0.21	0	0		NA	NA	NA	NA
Total of 6 above					20				
PFNA	24	0.146	1	4	30	0.19	0.19	0.19	0.19
PFHxS	24	0.14	3	13	40	0.19	1.22	3.21	8.23
HFPO-DA	24	0.19	0	0	300	NA	NA	NA	NA
PFDA	24	0.161	1	4	300	0.149	0.149	0.149	0.149
PFDoA	24	0.268	0	0	500	NA	NA	NA	NA
DONA	24	0.127	0	0	3,000	NA	NA	NA	NA
PFUnA	24	0.219	0	0	3,000	NA	NA	NA	NA
PFBA	24	0.342	4	17	10,000	1.23	6.35	15.31	47.30
PFTeDA	24	0.173	0	0	10,000	NA	NA	NA	NA
PFHxA	24	0.202	3	13	150,000	0.67	0.91	1.05	1.57
PFBS	24	0.228	3	13	450,000	0.26	2.05	4.77	12.00
PFPeA	24	0.148	3	13		0.26	0.80	0.76	1.22
PFHpA	24	0.148	2	8		0.36	3.42	3.42	6.49
PFPrS	24	0.255	1	4		0.46	0.46	0.46	0.46
PFPeS	24	0.134	2	8		0.39	1.41	1.41	2.43
FHpPA	24	0.435	1	4		1.11	1.11	1.11	1.11
PFBSA	24	0.427	1	4		1.23	1.23	1.23	1.23

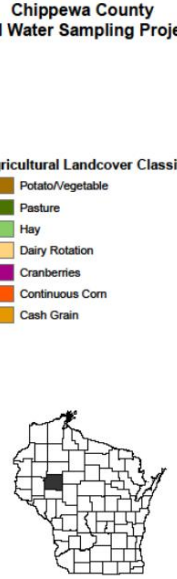
The one sample that detected PFAS above the health standard only contained PPCPs, no agricultural tracers

Landcover + Soil Drainage = Nitrate-N



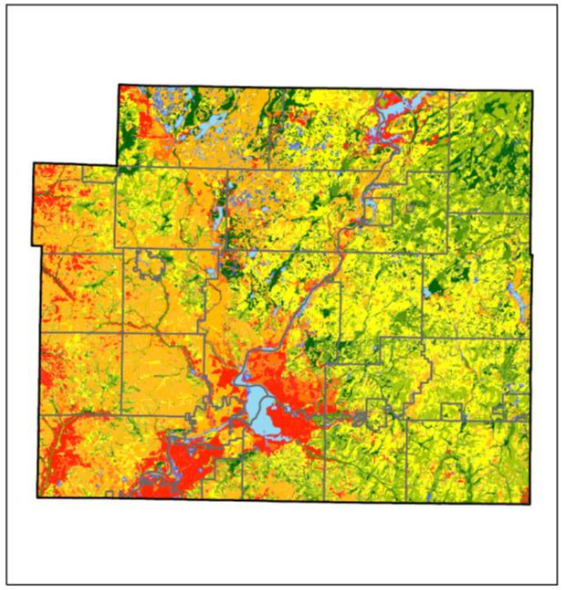
Chippewa County
Well Water Sampling Project

Agricultural Landcover Classification
- Potato/Vegetable
- Pasture
- Hay
- Dairy Rotation
- Cranberries
- Continuous Corn
- Cash Grain



Source: Wisland 2.0

Created: Elizabeth Belmont. February 28, 2022

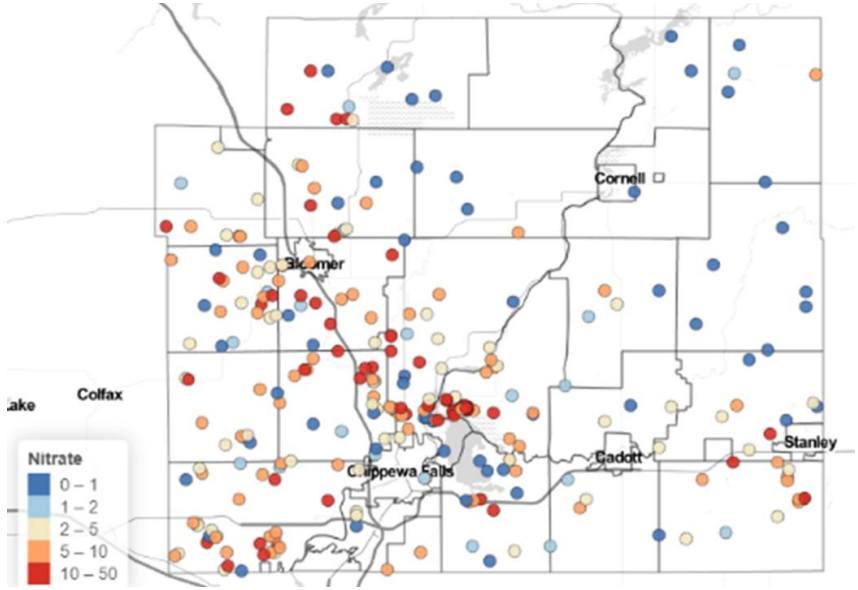


Chippewa County
Well Water Sampling Project

Drainage Classification
- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Water

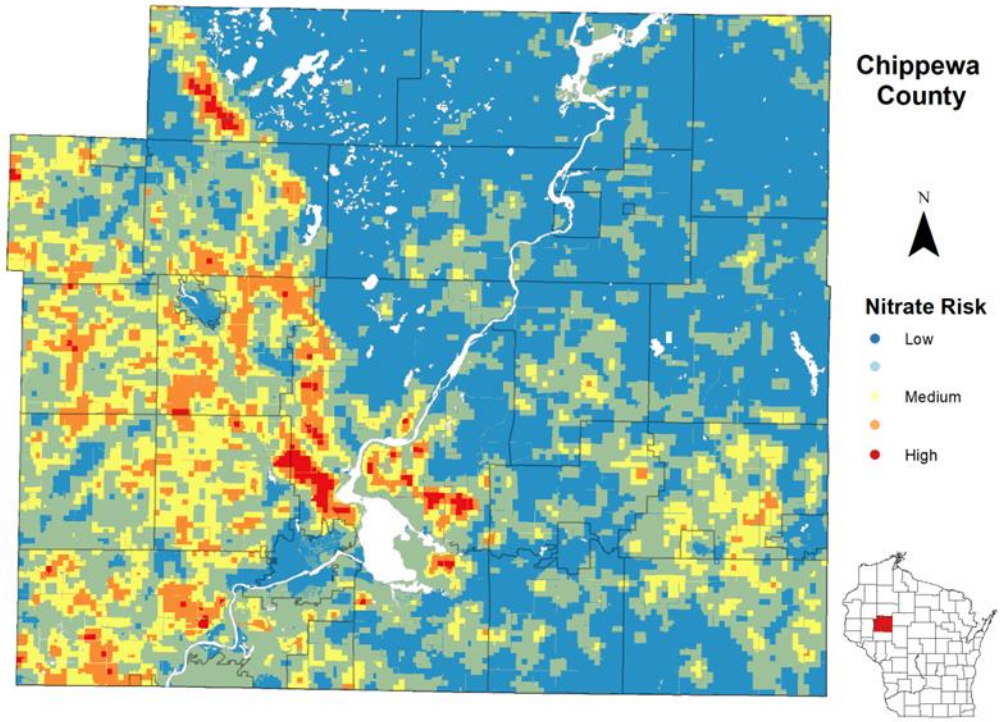
Source: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database

Created: Elizabeth Belmont. February 28, 2022

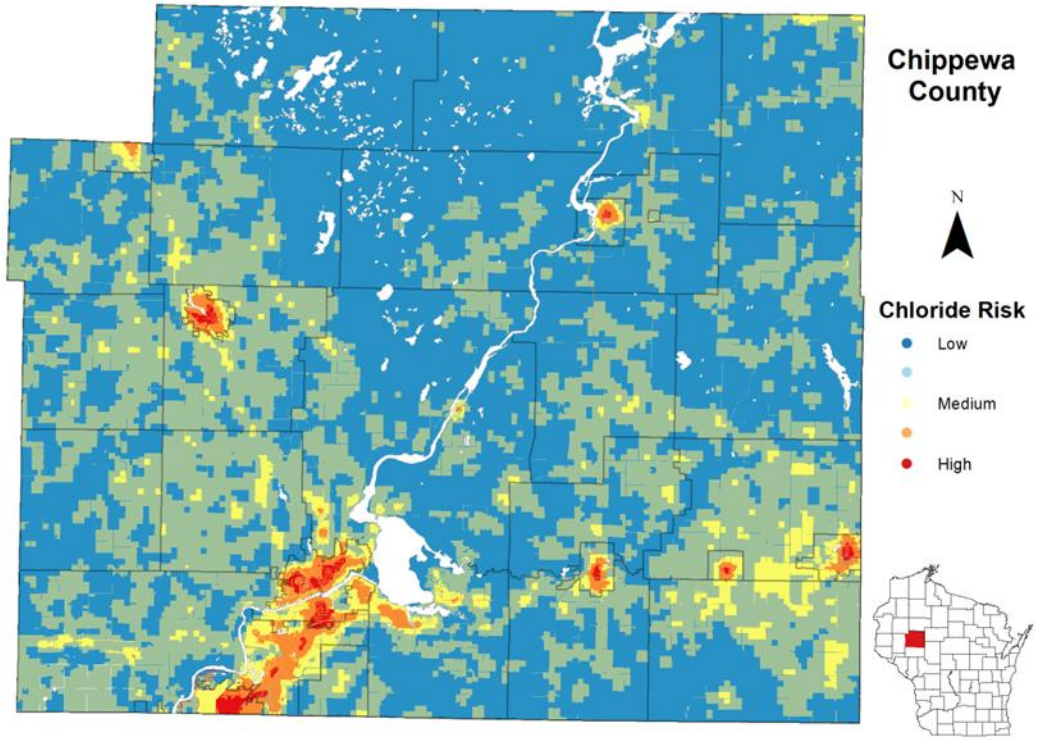


2022

Nitrate Risk Model



Chloride Risk Models



What's next for the project?

- Test kits for 2023 will be sent sometime in October

- **Coming in Year 5:**
  - Add new functionality to dashboard:
    - Land use, well construction, trends, etc.
  - Continue to analyze for trends in nitrate/chloride data
  - Investigate factors that might be contributing to trends
  - Utilize data to target outreach and management

Operating your private water utility:

- ***Periodically inspect and maintain*** the area around your well
- ***Test your water regularly*** to evaluate common water quality concerns
- ***If necessary, take corrective actions****

*Know when to call a licensed well driller or pump installer

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