Groundwater & Well Water Education Program

Pierce County

Kevin Masarik
Center for Watershed Science and Education

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

Extension
UNIVERSITY OF WISCONSIN–MADISON

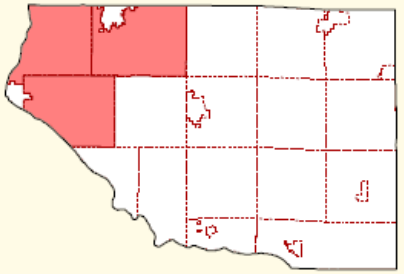
Through the University of Wisconsin-Extension, all Wisconsin people can access University resources and engage in lifelong learning, wherever they live and work.

Today's presentation

- Where well water comes from
- Understanding your well construction
- Common well water problems
- Where and why these problems occur
- Ways to improve water quality

Towns of Clifton, Oak Grove and River Falls

Pierce County, July 2019



RIVER FALLS

Kinnickinnic River Watershed

29

CLIFTON

35

RIVER FALLS

65

PRESCOTT

10

Trimbelle River and Isabelle Creek Watershed

OAK GROVE

35

- Watershed Boundary
- Streams
- Lakes/Reservoirs
- Wetlands
- State/US Highways
- Other Roads
- Town Boundaries
- Municipalities

Miles

0 1 2 3 4 5

0 1 2 3 4 5

Kilometers

N

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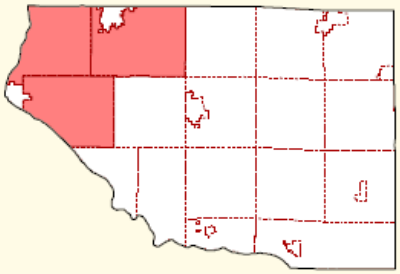

SAMPLE DISTRIBUTION

NUMBER OF SAMPLES per 1/4 1/4 SECTION

Miles
0 1 2 3 4 5
0 1 2 3 4 5
Kilometers
N

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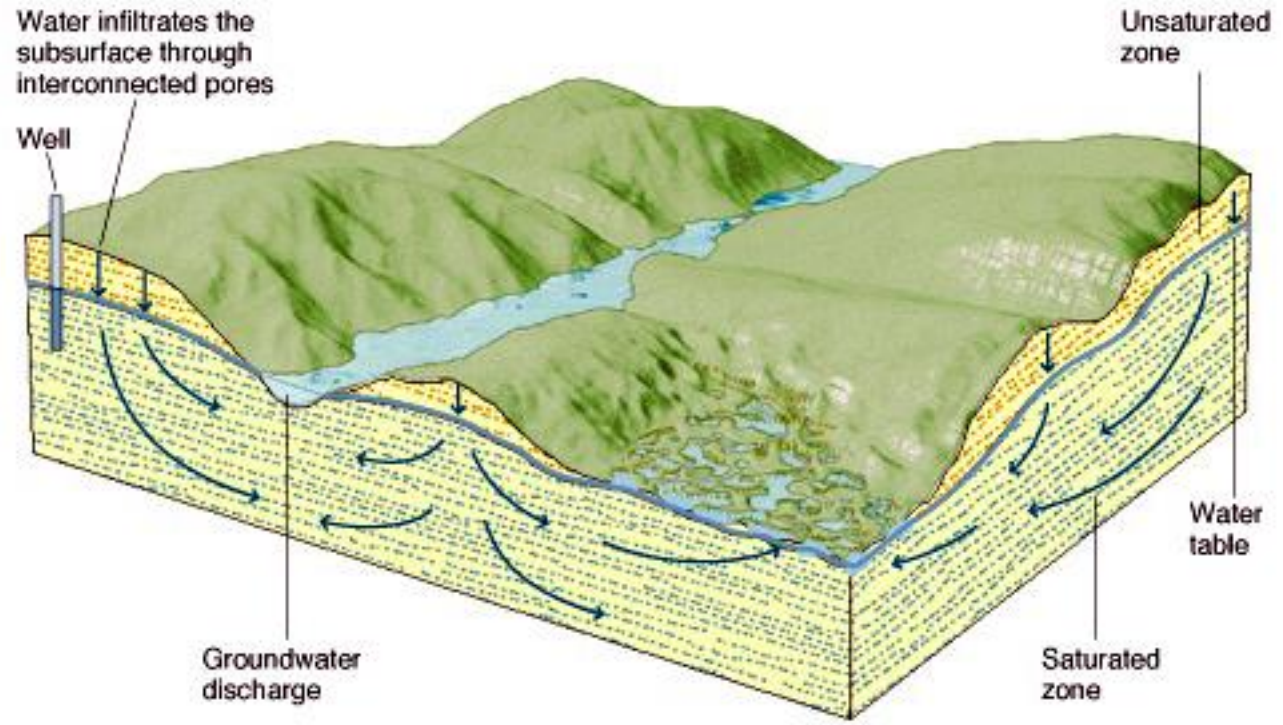
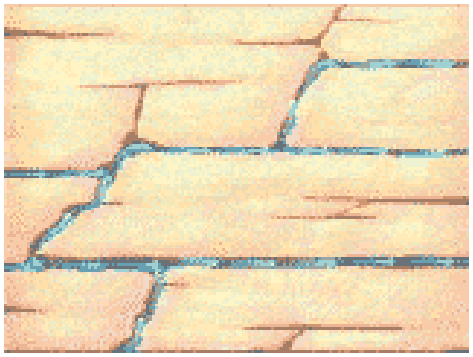
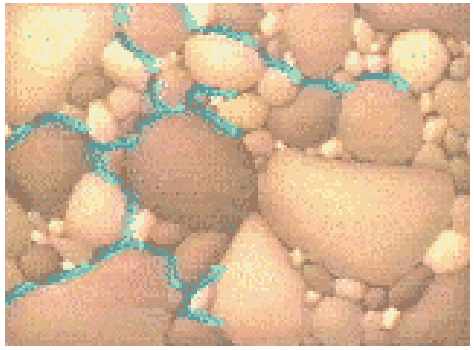
Groundwater Movement



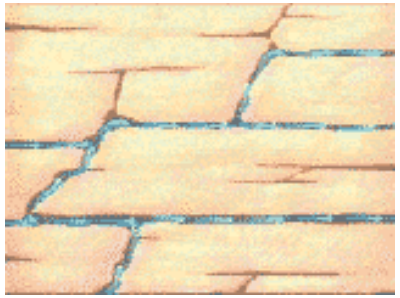




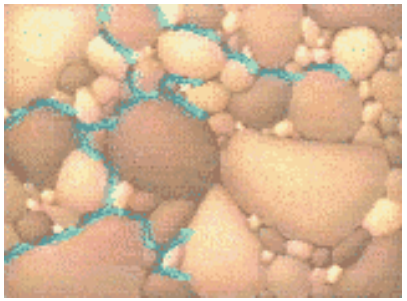
Aquifers: Our groundwater storage units

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

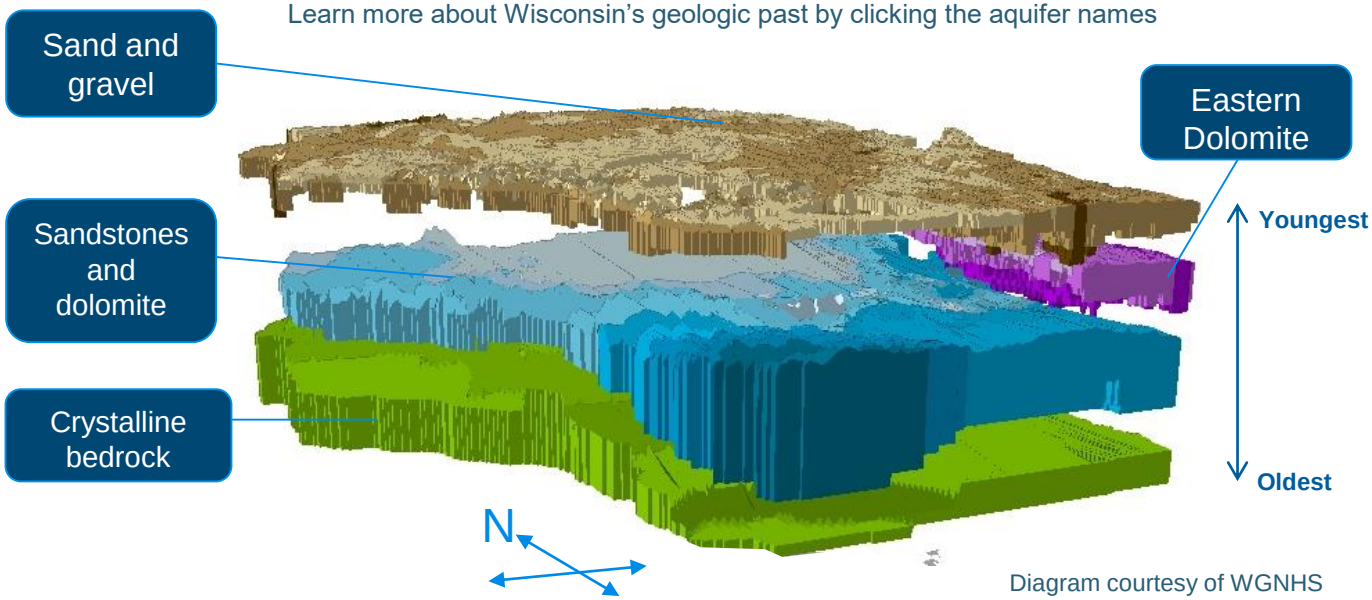


Diagram courtesy of WGNHS

Towns of Clifton, Oak Grove and River Falls

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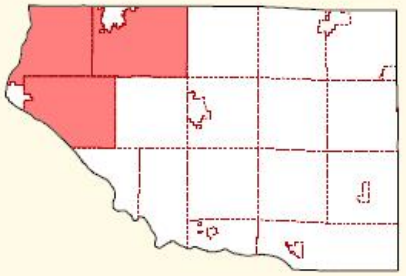

Elevation:
(meters)

- 200 - 220
- 221 - 240
- 241 - 260
- 261 - 280
- 281 - 300
- 301 - 320
- 321 - 340
- 341 - 360
- 361 - 380

Miles
0 1 2 3 4 5

N

0 1 2 3 4 5
Kilometers

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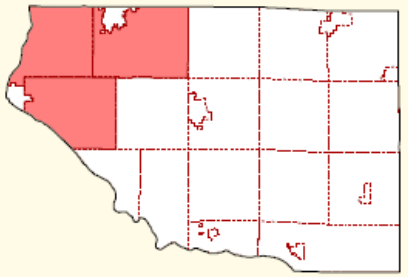

Depth to Bedrock:

- within 5 ft - more than 70% of area
- within 5 ft - 35 to 70% of area
- 5 to 50 ft
- 50 to 100 ft
- greater than 100 ft

Miles
0 1 2 3 4 5

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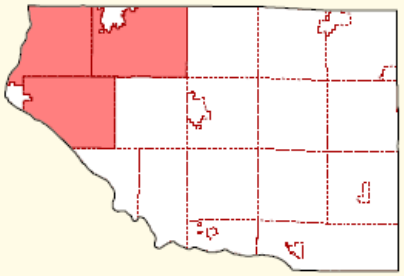

Bedrock Units:

- Galena-Platteville Dolomite
- St Peter Sandstone
- Prairie du Chien Dolomite
- Cambrian Sandstone

Miles
0 1 2 3 4 5

N

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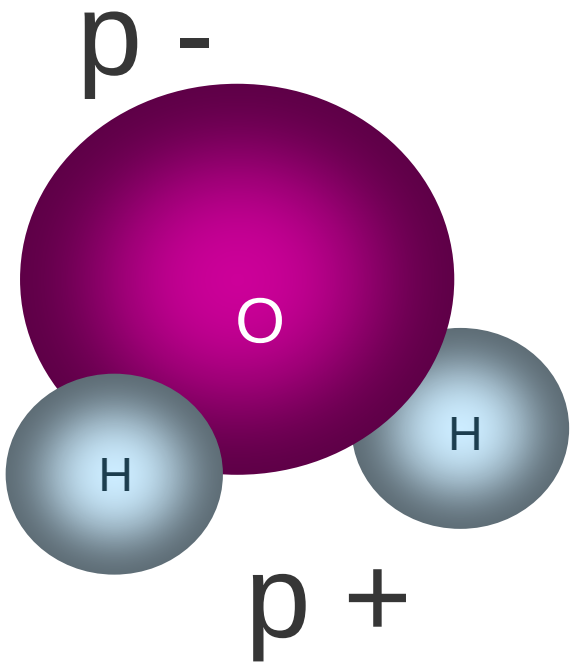
water basics

- "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



Interpreting Drinking Water Test Results

Tests important to health:

- Bacteria
- Sodium
- Nitrate
- Copper
- Lead
- Triazine
- Zinc
- Sulfate
- Arsenic

Tests for aesthetic (taste,color,odor) problems:

- Hardness
- Iron
- Manganese
- Chloride

Other important indicator tests:

- Saturation Index
- Alkalinity
- Conductivity
- Potassium

Red = human-influenced **Blue** = naturally found

Health Concern Categories

Acute Effects

- Usually seen within a short time after exposure to a particular contaminant or substance.

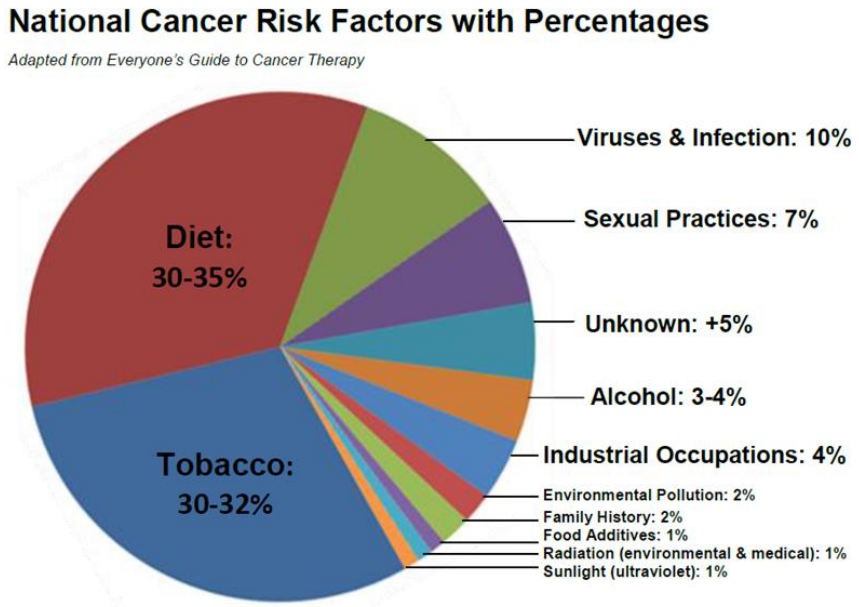
(ex. Bacteria or viral contamination which may cause intestinal disease)

Chronic Effects

- Result from exposure to a substance over a long period of time.
- Increase risk of developing health complications later in life.

(ex. Arsenic or pesticides can increase the risk of developing certain cancers)

Chronic related health concerns are generally about risk management



Being struck by lightning	**0.16 in 1,000 chance.**
0.010 mg/L of arsenic in drinking water.	**3 out of 1,000 people likely to develop cancer.**
2 pCi of indoor radon level.	**4 out of 1,000 people likely to develop lung cancer.[1]**
2 pCi of indoor radon combined with smoking.	**32 out of 1,000 people could develop lung cancer.[1]**

Drinking water quality is only one part of an individual's total risk.

[1]http://www.epa.gov/radon/healthrisks.html

Private vs. Public Water Supplies

Public Water Supplies

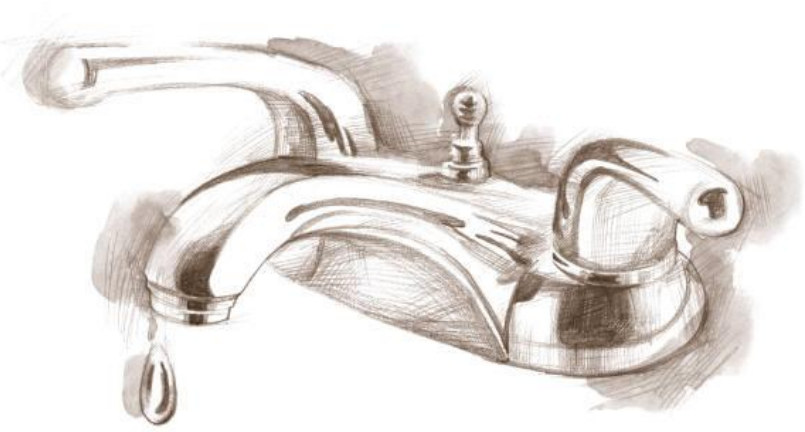
- Regularly tested and regulated by drinking water standards.

Private Wells

- Not required to be regularly tested.
- Not required to take corrective action
- Owners must take special precautions to ensure safe drinking water.

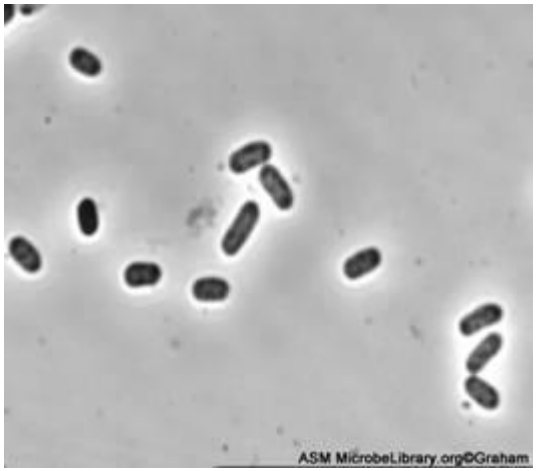
Why do people test their water?

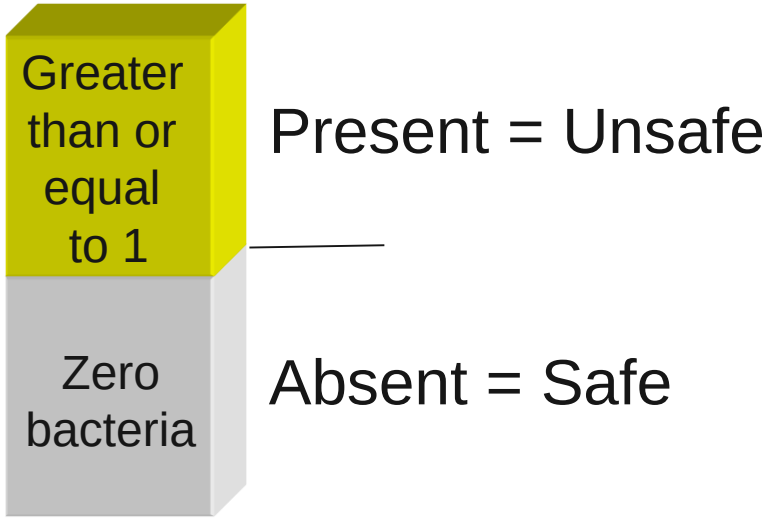
- Installed a new well
- Change in taste or odor
- Buying or selling their home
- Plumbing issues
- Want to know if it’s safe to drink.



Coliform bacteria

- Generally do not cause illness, but indicate a pathway for potentially harmful microorganisms to enter your water supply.
  - Harmful bacteria and viruses can cause gastrointestinal disease, cholera, hepatitis
- Well Code: “Properly constructed well should be able to provide bacteria free water continuously without the need for treatment”
- Recommend using an alternative source of water until a test indicates your well is absent of coliform bacteria
- Sources:
  - Live in soils and on vegetation
  - Human and animal waste
  - Sampling error





If coliform bacteria was detected, we also checked for e.coli bacteria test

- Confirmation that bacteria originated from a human or animal fecal source.
- E. coli are often present with harmful bacteria, viruses and parasites that can cause serious gastrointestinal illnesses.
- Any detectable level of E.coli means your water is unsafe to drink.

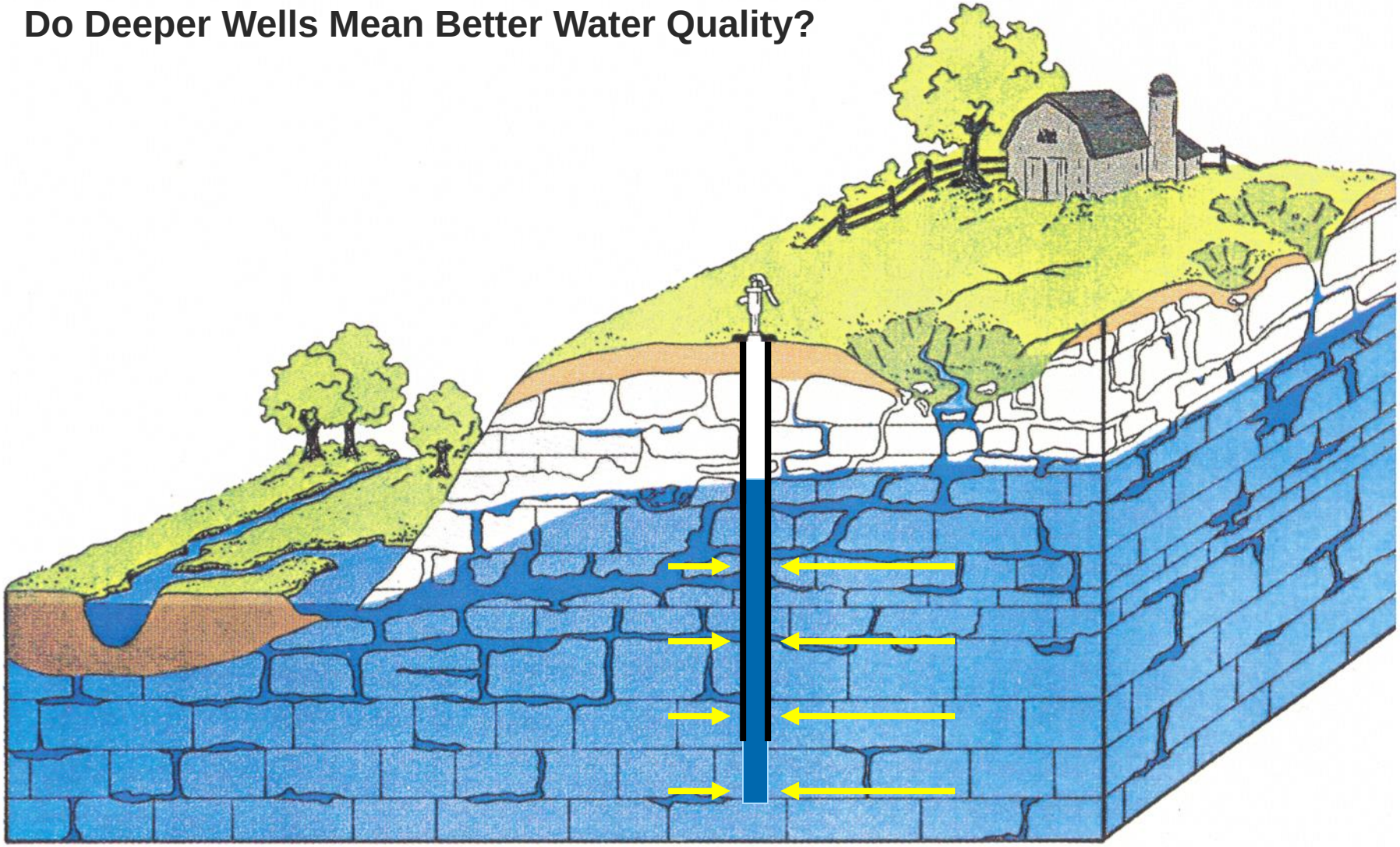
Contaminants	Sources	Symptoms
BACTERIA		
Escherichia coliform (E. coli) *Salmonella* *Campylobacter* *E. coli 0157* (Requires a special water test for detection. Causes similar, but more serious illness than other E.coli strains. Requires medical treatment.)	• Infected human and animal feces • Manure • Septic systems • Sewage	• Gastrointestinal illness • Low-grade fever • Begins 12 hrs - 7 days after exposure
Leptosporidia	• Urine of livestock, dogs and wildlife • Manure	• High fever, severe headache and red eyes • Gastrointestinal illness • Begins 2-28 days after exposure
MICROSCOPIC PARASITES		
Cryptosporidia *Giardia*	• Infected human and animal feces • Manure • Septic systems • Sewage	• Gastrointestinal illness • Begins 2-14 days after exposure
VIRUSES		
Norovirus	• Infected human feces and vomit • Septic systems • Sewage	• Gastrointestinal illness • Low-grade fever & headache • Begins 12-48 hrs after exposure
CHEMICALS		
Nitrate	• Fertilizers • Manure • Bio-solids • Septic systems	Methemoglobinemia or "Blue Baby Syndrome" – No documented cases in Door County, but elevated nitrate levels in well water may indicate risk of contamination by additional pathogens.
Atrazine (trade-name herbicide for control of broadleaf and grassy weeds)	Estimated to be most heavily used herbicide in the U.S. in 1987/89, with its most extensive use for corn and soybeans in the Midwest, including WI. In 1993, it became a restricted-use herbicide nationally. U.S. EPA set a max. contaminant level (MCL) at 3 parts per billion for safe drinking water.	Short-term exposure above the MCL may cause: congestion of heart, lungs and kidneys; low blood pressure; muscle spasms; weight loss; damage to adrenal glands. Long-term exposure above MCL may cause: weight loss, cardio-vascular damage, retinal and some muscle degeneration; cancer.

Information Sources: United States Department of Health and Human Services – Centers for Disease Control and Prevention (www.cdc.gov) and United States Environmental Protection Agency (www.epa.gov)

Well Construction

Photos courtesy of: Matt Zoschke

Do Deeper Wells Mean Better Water Quality?



What should I do if coliform bacteria was present?

1. **Use alternative source of water for drinking**
2. **Retest**
3. **Try to identify any sanitary defects**
   - Loose or non-existent well cap
   - Well construction faults
   - A nearby unused well or pit
   - Inadequate filtration by soil
4. **Disinfect the well**
5. **Retest to ensure well is bacteria free.**

- ***For reoccurring bacteria problems the best solution may be a new well or if new well is unlikely to remedy the problem because of geology, may seek approval for treatment.***

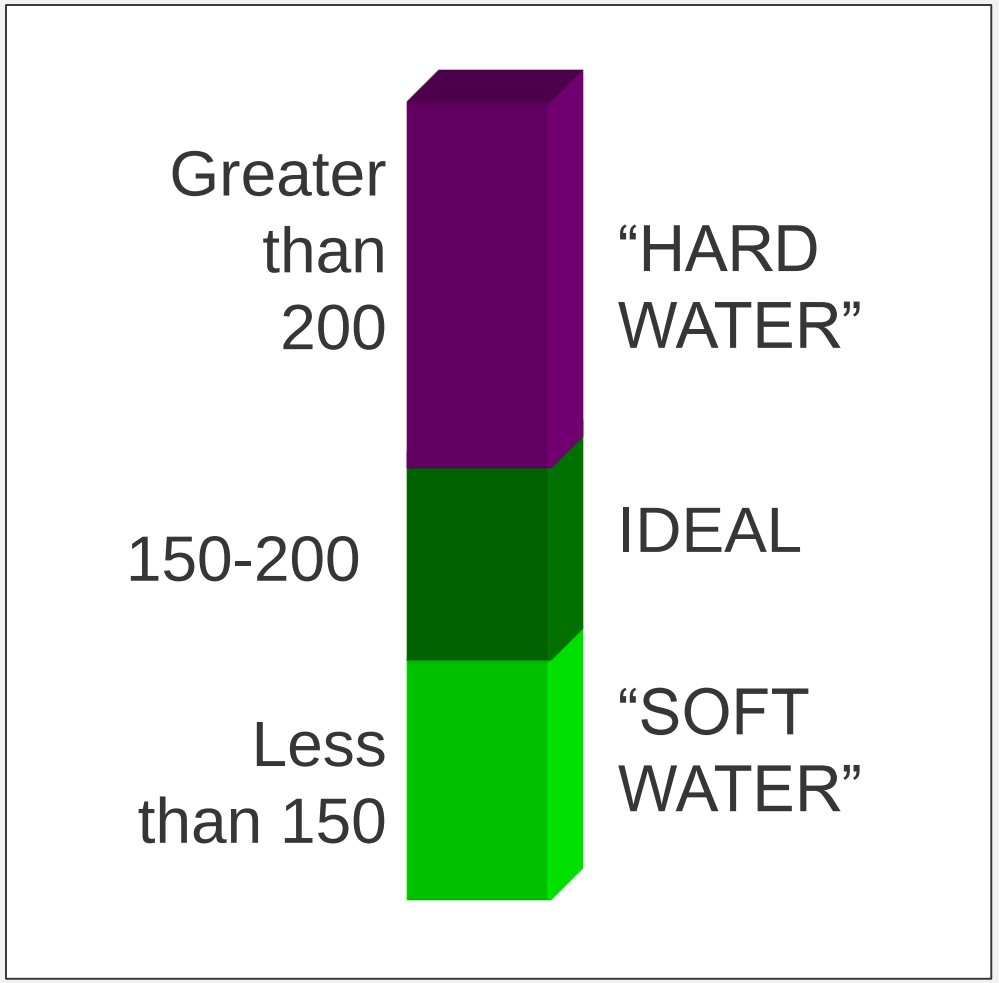
Rock and Soil Impacts on Water Quality

Tests for Aesthetic Problems

Hardness

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

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



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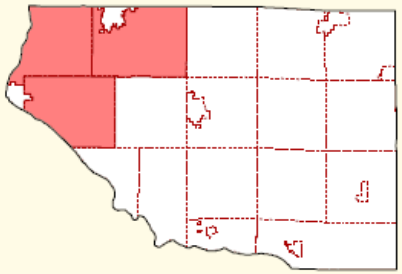

TOTAL HARDNESS (ppm CaCO3)

A	... 50	20	8 %
B	51 - 100	1	<1 %
C	101 - 200	0	0 %
D	201 - 300	90	36 %
E	301 - 400	127	51 %
F	401 ...	11	4 %

Mapped value is the average for the 1/4 1/4 section
Treated samples not mapped

Miles
0 1 2 3 4 5
0 1 2 3 4 5
Kilometers
N

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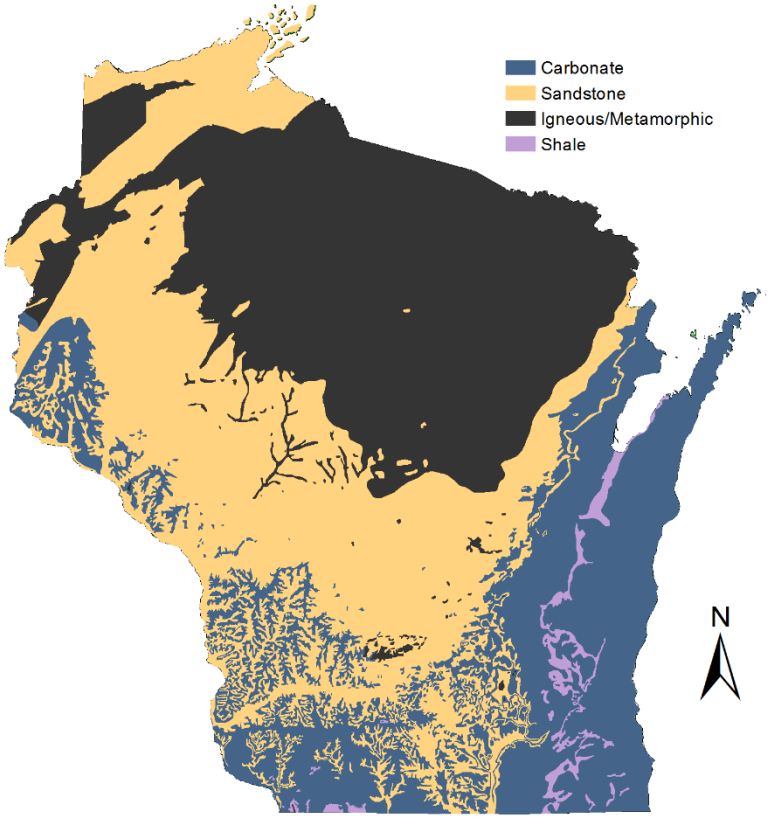
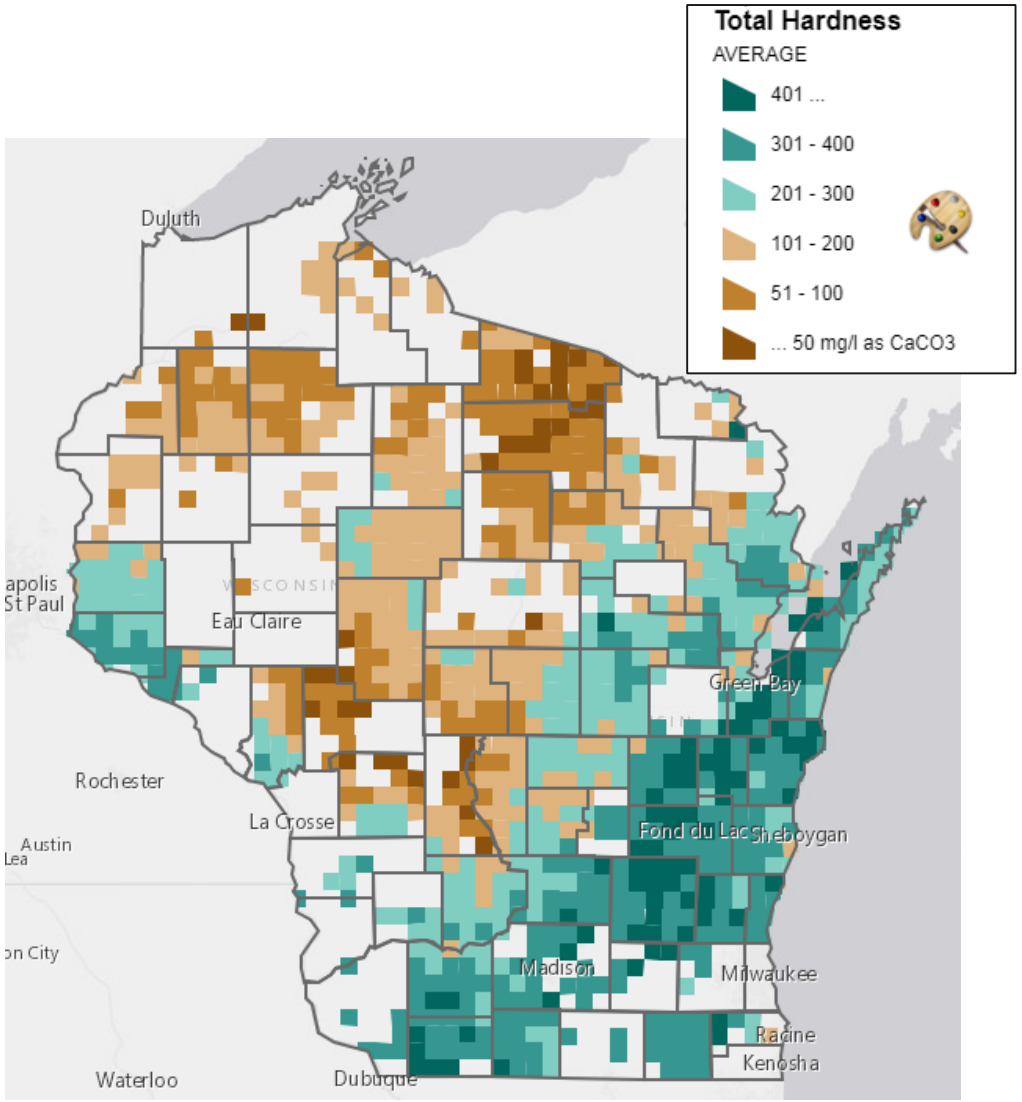
Hardness of Wisconsin's groundwater



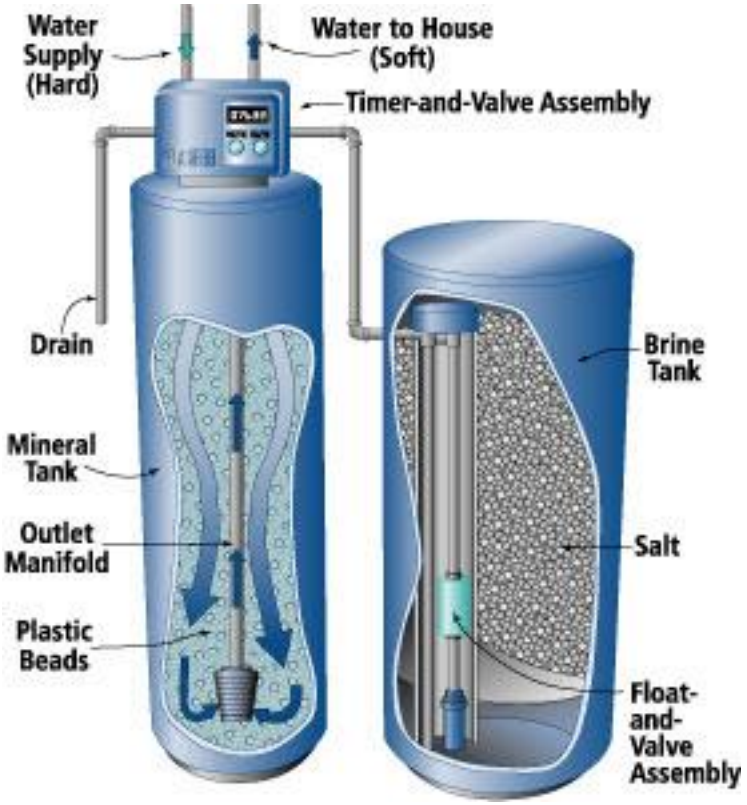


Source: WI Well Water Viewer

Water Softening

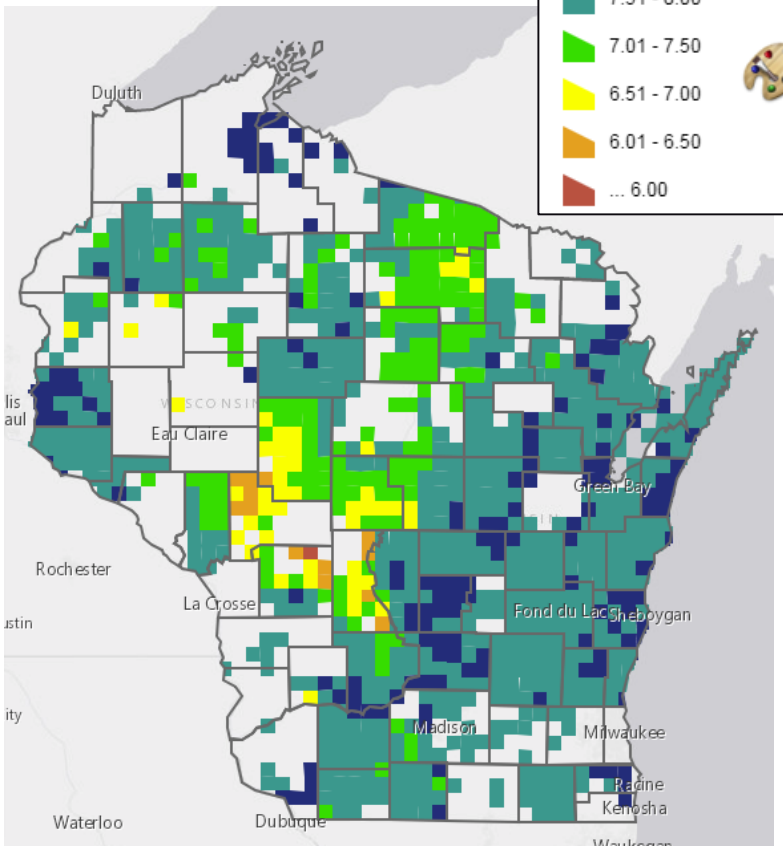
Water softeners remove calcium and magnesium which cause scaling and exchange it for sodium (or potassium).

- **Negative: Increases sodium content of water.**
- **Suggestions:**
  - **Bypass your drinking water faucet.**
  - **Do not soften water for outdoor faucets.**
  - **If you are concerned about sodium levels – use potassium chloride softener salt.**



pH of Wisconsin's groundwater

- Measure of acidity
- Levels less than 7.0 are:
  - More likely to cause corrosion
  - More likely to result in elevated levels of lead/copper if found in plumbing system
- Treatment: Acid-neutralizer



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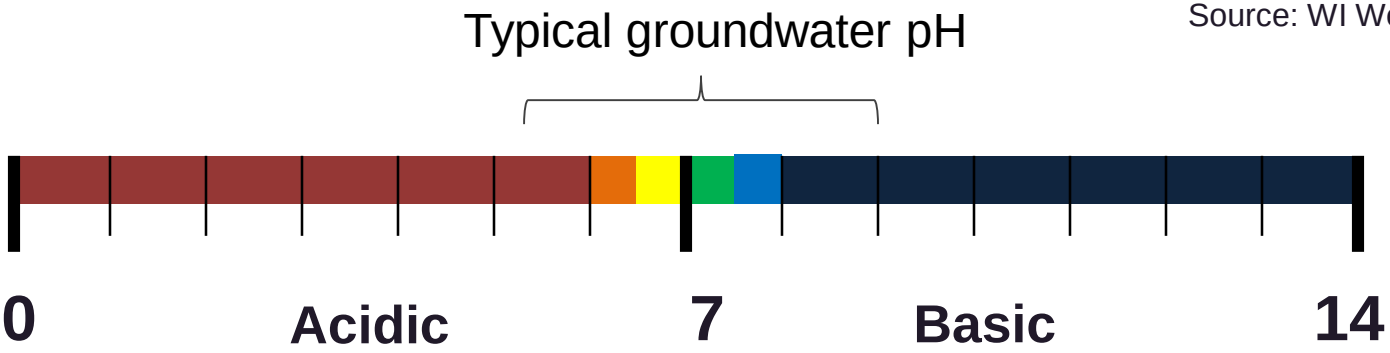
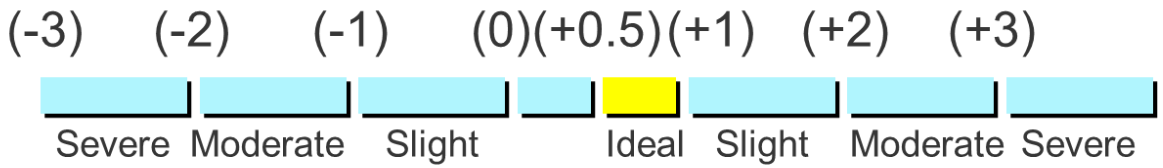


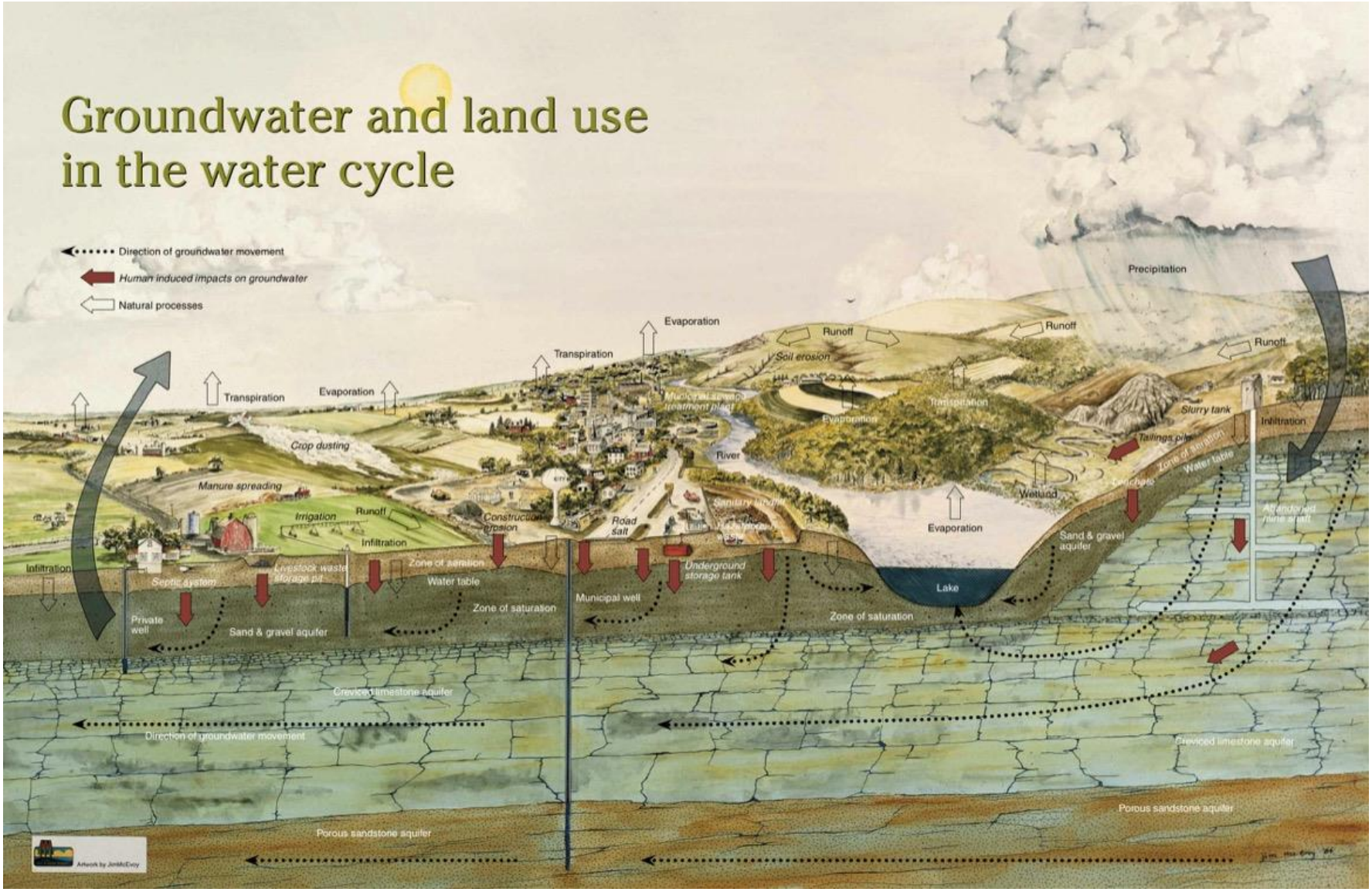
Overall Water Quality Tests

- **Alkalinity** – ability to neutralize acid
- **Conductivity -** Measure of total ions, usually about twice the hardness
- **Saturation Index** – measures whether water corrodes or forms scale

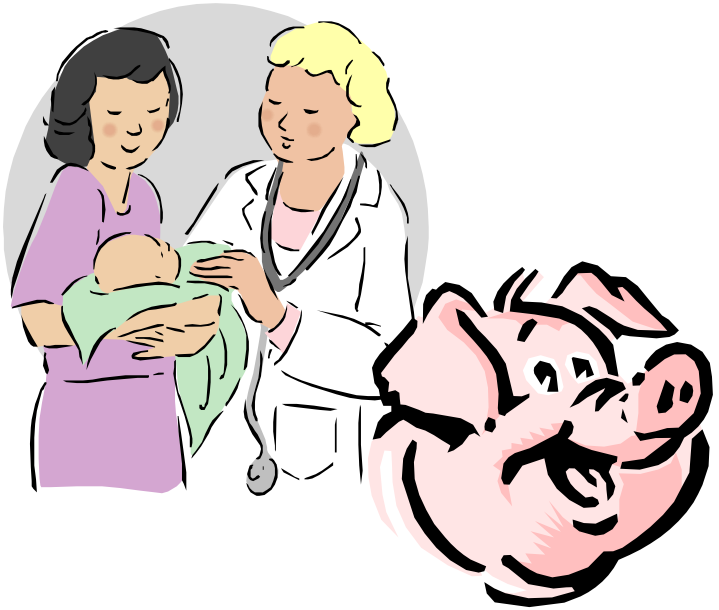


Corrosion occurs

Scaling occurs


Groundwater and land use in the water cycle
Direction of groundwater movement
Human induced impacts on groundwater
Natural processes
Precipitation
Evaporation
Transpiration
Runoff
Soil erosion
Crop dusting
Manure spreading
Irrigation
Infiltration
Construction erosion
Road salt
Septic system
Livestock waste storage pit
Zone of aeration
Water table
Zone of saturation
Private well
Sand & gravel aquifer
Municipal well
Underground storage tank
River
Wetland
Lake
Sand & gravel aquifer
Sludge
Tailings pile
Slurry tank
Concrete
Abandoned mine shaft
Fractured limestone aquifer
Direction of groundwater movement
Porous sandstone aquifer
Artwork by JonMcEvoy

Nitrate-Nitrogen



Health Effects:

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

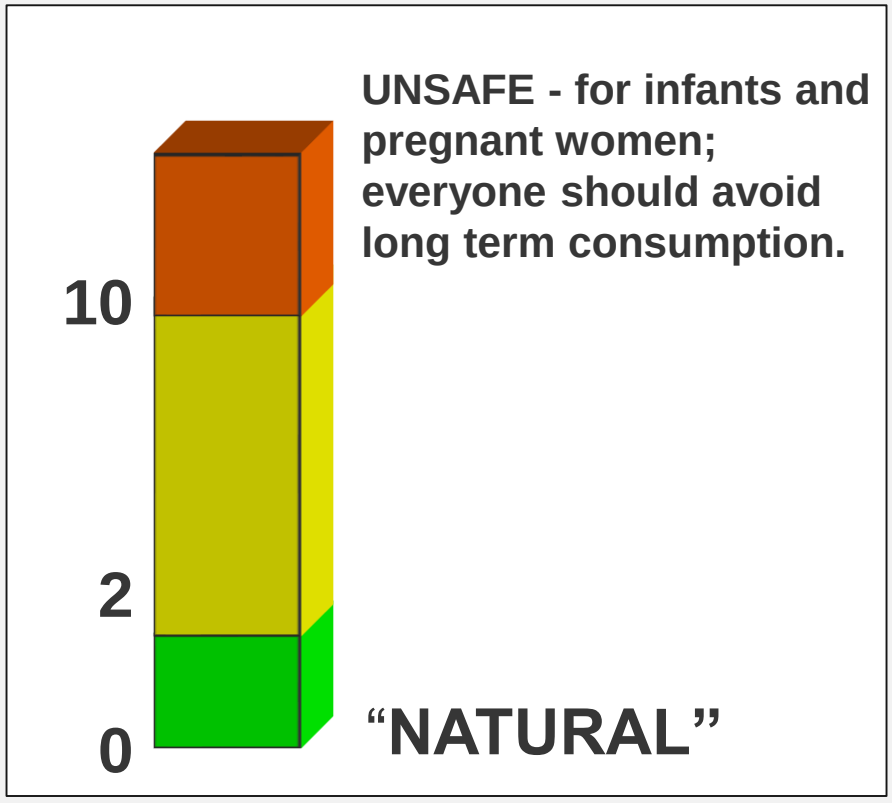
Sources:

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

Test Important to Health

Nitrate Nitrogen

- **Greater than 10 mg/L**
  Exceeds State and Federal Limits for Drinking Water
- **Between 2 and 10 mg/L**
  Some Human Impact
- **Less than 2.0 mg/L**
  "Transitional"
- **Less than 0.2 mg/L**
  "Natural"



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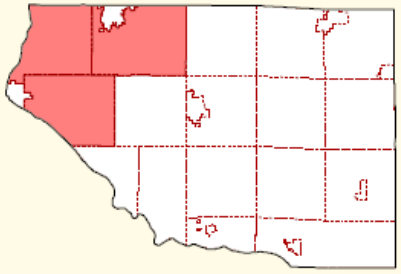

NITRATE-NITRITE (ppm N)

A	None Detected	21	8 %
B	... 2.0	42	17 %
C	2.1 - 5.0	62	25 %
D	5.1 - 10.0	80	32 %
E	10.1 - 20.0	41	16 %
F	20.1 ...	3	1 %

Mapped value is the average for the 1/4 1/4 section
Treated samples not mapped

Miles
0 1 2 3 4 5
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Kilometers
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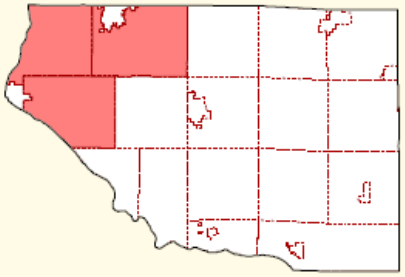

Land Use:

- Urban
- Agriculture
- Forest
- Shrub-Grass
- Wetland
- Water
- Barren

Miles
0 1 2 3 4 5

N

0 1 2 3 4 5
Kilometers

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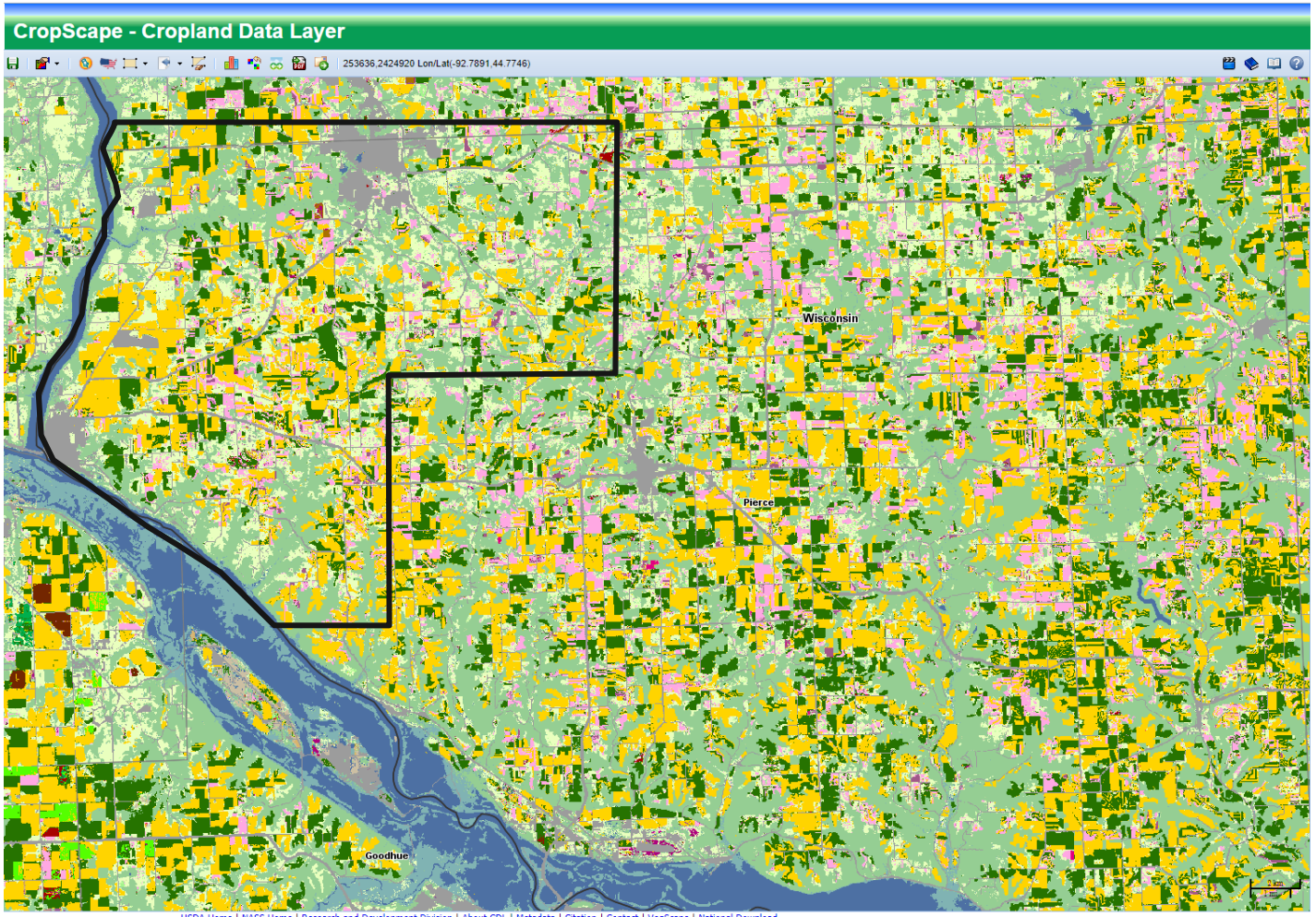
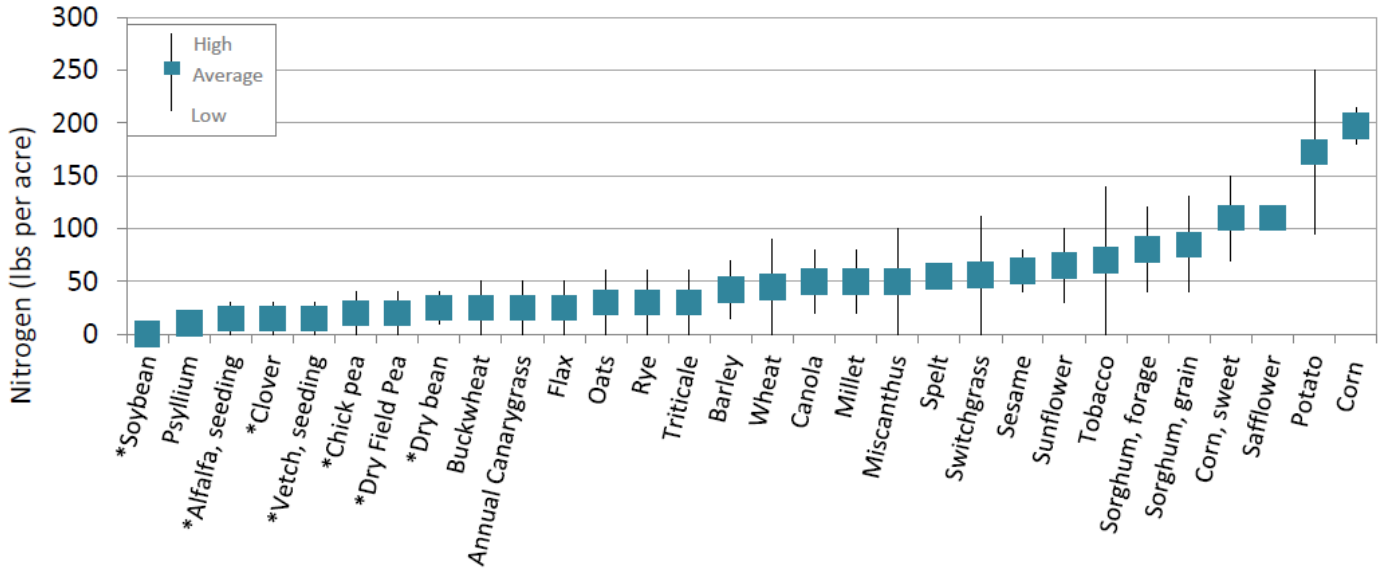
Cropland Data Layer:

- Corn
- Cotton
- Rice
- Sorghum
- Soybeans
- Sunflower
- Peanuts
- Tobacco
- Sweet Corn
- Pop or Orn Corn
- Mint
- Barley
- Durum Wheat
- Spring Wheat
- Winter Wheat
- Other Small Grains
- Dbl Crop WinWht/Soyb
- Rye
- Oats
- Millet
- Speltz
- Canola
- Flaxseed
- Safflower
- Rape Seed
- Mustard
- Alfalfa



Nitrogen fertilizer recommendations for common crops



* Legumes have symbiotic relationship with N fixing bacteria

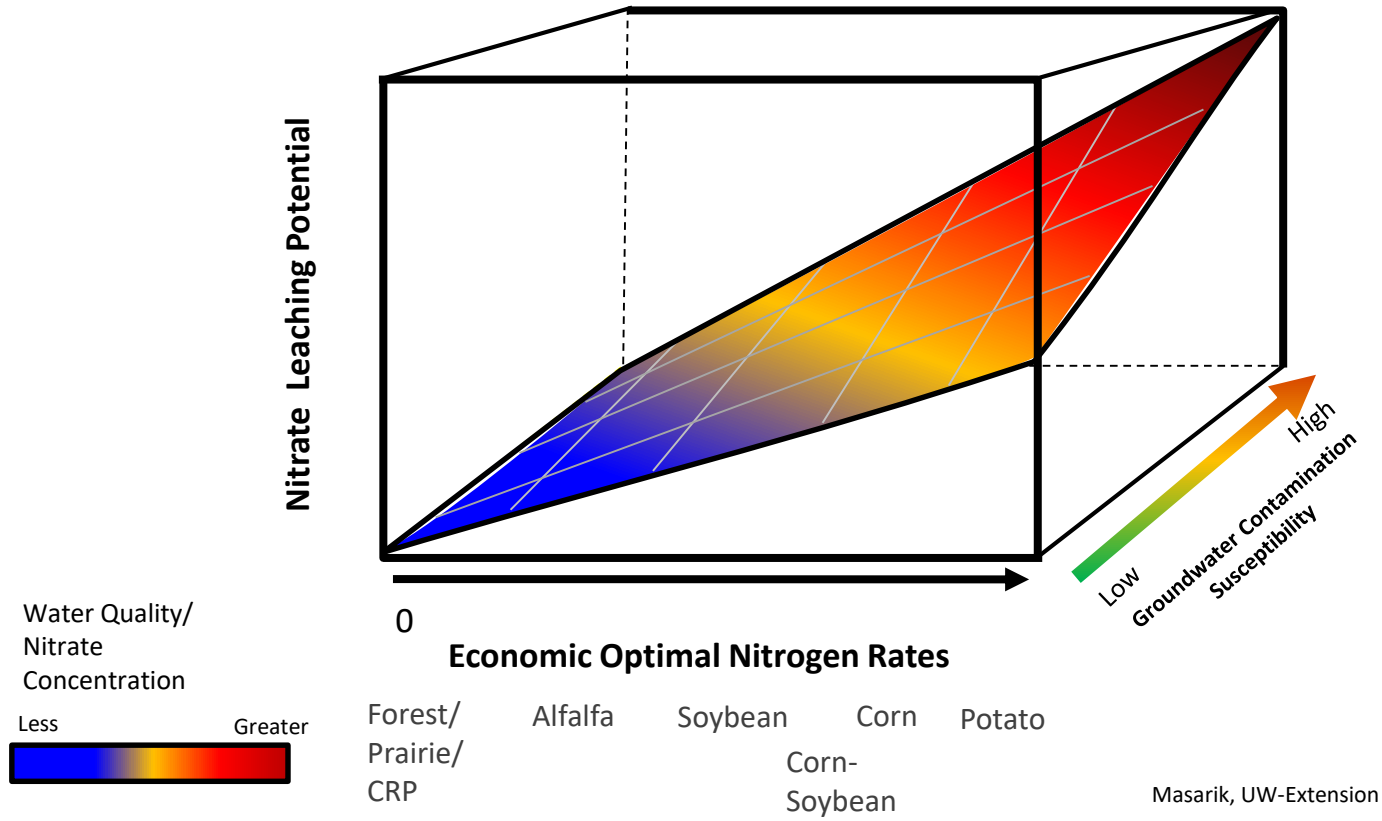
Alternative Field Crops Manual, 1989. University of Minnesota and University of Wisconsin -Madison
Nutrient application guidelines for field, vegetable and fruit crops in Wisconsin. A2809. 2012. University of Wisconsin-Madison
Miscanthus and switchgrass recommendations: Anderson et al., 2013; McIsaac et al., 2010; Vogel et al., 2002; Arundale et al, 2014

Effect of cropping systems on nitrate leaching loss in the Midwest

	Cropping systems	N Inputs	Nitrate-N Leaching	Water Drainage	Data Source
		kg N ha^{-1} yr^{-1}	kg N ha^{-1} yr^{-1}	mm yr^{-1}	
Annual	Corn-Corn	138	55	193	Randall et al., 1997 (1)
		180	37	399	Masarik et al., 2014 (2)
		151-221	17-32	63-187	Thomas et al., 2014 (3)
		202	63	590	Weed and Kanwar, 1996 (4)
		202	43	280	Randall and Iragavarapu, 1995 (5)
	Corn-Soybean	136-0	51	226	Randall et al., 1997 (1)
		168-0	34-46	ND	McIsaac et al., 2010 (6)
		168-0	34	470	Weed and Kanwar, 1996 (4)
		171-0	10-35	ND	Cambardella et al., 2015 (7)
Mixed	C-S-O/A-A	171-0-57-0	8-18	ND	Cambardella et al., 2015 (7)
Perennial	Alfalfa	0	2	104	Randall et al., 1997 (1)
	CRP	0	1	160	Randall et al., 1997 (1)
	Switchgrass	0	<1-4	ND	McIsaac et al., 2010 (6)
		112	2-11	52-156	Thomas et al., 2014 (3)
	Miscanthus	0	2-7	ND	McIsaac et al., 2010 (6)
		112	<1-1	52-147	Thomas et al., 2014 (3)
	Prairie	0	<1	122	Masarik, et al., 2014 (2)
	Pasture	0	1-10	ND	Cambardella et al., 2015 (7)

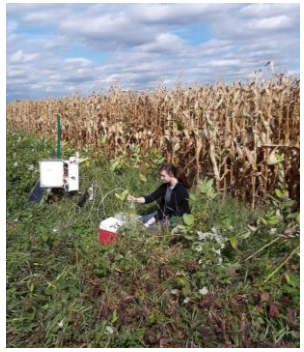
**16 -37X greater nitrate loss below continual corn cropping systems compared to perennial systems*

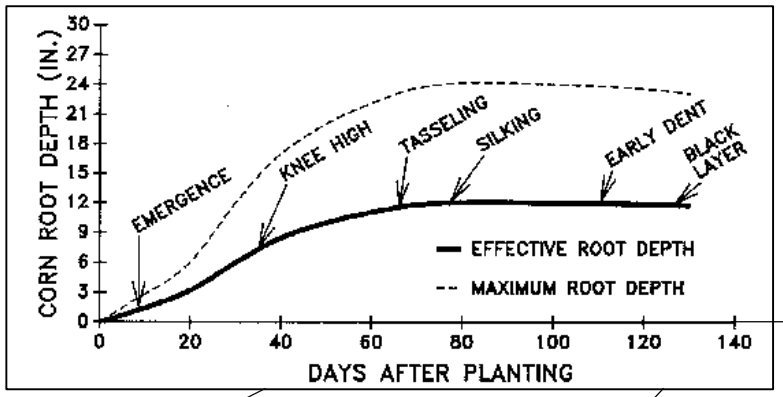
Nitrate Leaching Potential



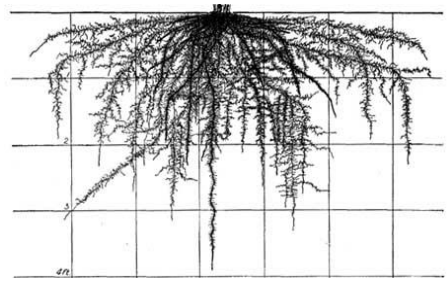
Masarik, UW-Extension



365



Graph of root depth: http://www.bae.ncsu.edu/programs/extension/evans/ag452-1.html

Picture of corn roots: http://www.soilandhealth.org/01aglibrary/010137veg.roots/010137ch2.html

Long-term nitrogen reduction strategies for agricultural areas

Good

Better

Best

Practice	Details	% Nitrate-N Reduction (StDev)	Reduction potential	Uncertainty
Timing	Fall to Spring Pre-plant	6 (25)	Low	High
	Spring pre-plant/sidedress 40-60 split compared to fall applied	5 (28)	Low	High
	Sidedress – Soil test based compared to pre-plant	7 (37)	Low	High
Nitrification Inhibitor	Nitrapyrin – Fall – Compared to applied w/out nitrapyrin	9 (19)	Low	Medium
Cover Crops	Rye	31 (29)	Medium	Medium
	Oat	28 (2)	Medium	Medium
Perennial	Biofuel Crops (ex. switchgrass, miscanthus)	72 (23)	High	Medium
	Conservation Reserve Program	85 (9)	High	Low
Extended Rotations	At least 2 years of alfalfa or other perennial crops in a 4 or 5 year rotation	42 (12)	Med-High	Low

Iowa Nutrient Reduction Strategy, 2014

What can I do to reduce my nitrate levels?

Long-term Solution:

- **Reduce nitrogen inputs**

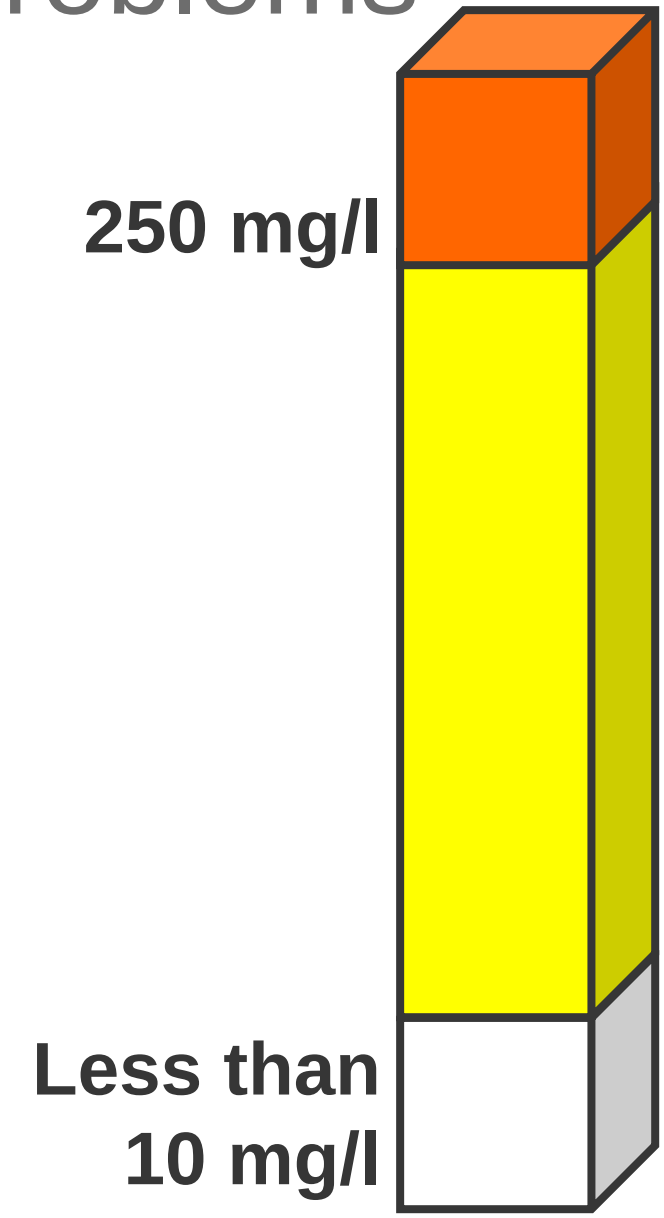
Short term:

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

Tests for Aesthetic Problems

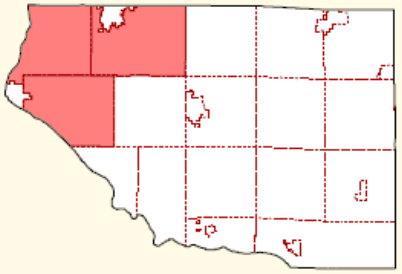
Chloride

- 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



Towns of Clifton, Oak Grove and River Falls

Pierce County, July 2019



CHLORIDE (ppm)

A	None Detected	0	0 %
B	... 10	71	29 %
C	11 - 50	161	65 %
D	51 - 100	15	6 %
E	101 - 200	2	<1 %
F	201 ...	0	0 %

Mapped value is the average for the 1/4 1/4 section
Treated samples not mapped

Miles
0 1 2 3 4 5
0 1 2 3 4 5
Kilometers
N

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

Pesticides in Wisconsin's groundwater

Pesticides include: insecticides, herbicides, fungicides and other substances used to control pests

- Health standards usually only account for parent compound
- Little research into health effects from the combination of chemicals and/or metabolites

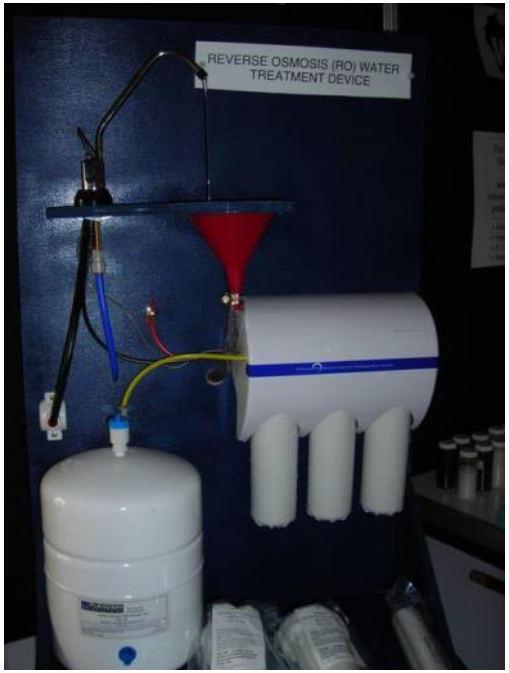
Dept. of Agriculture, Trade, and Consumer Protection Study (2017)*

- 41.7% of wells sampled contained detectable levels of at least one pesticide – very seldom found at levels above health standards
- Most frequently detected pesticides in Wisconsin:
  - Alachlor and its chemical breakdown products
  - Metolachlor and its chemical breakdown products
  - Atrazine and its chemical breakdown products
  - Metribuzin
  - Cyanazine and its chemical breakdown products.

*Agricultural chemicals in Wisconsin's groundwater-2017 DATCP

understanding water treatment

- **Advantages:**
  - + Reduce level of contaminants and other impurities
  - + Improve taste, color and odor
- **Disadvantages:**
  - – Require routine maintenance.
  - – Can require large amounts of energy.
  - – Testing is often the only way to know it is functioning properly for most health related contaminants.
- **Cautions:**
  - Treatment methods often selective for certain contaminants
  - Multiple treatment units may be necessary
  - Treatment may also remove beneficial elements from water in the process.



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

Recommendations for testing private wells

1. Bacteria

Every well should be tested once a year, and when you notice a change in taste, color, or smell.

2. Nitrate

Every well should be tested once a year, and before the well will be used by a woman who is or may become pregnant.

3. Arsenic

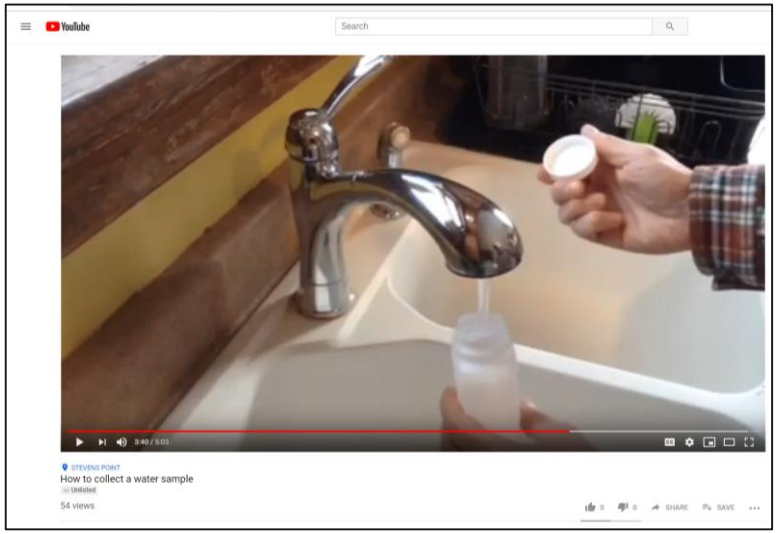
Every well should be tested once. If arsenic was present in previous tests, you should test once a year.

You may consider additional testing to look for:

- Naturally occurring contaminants in the rock and soil that may enter your well.
- Human caused contaminants from land-use, your plumbing materials, or other sources of pollution near your well.

Procedure for testing wells

- Locate a certified laboratory that performs the tests you are interested in:
  - WI DNR maintains a list of labs that test private wells https://dnr.wi.gov/topic/Wells/privateWellTest.html
  - Water and Environmental Analysis Laboratory (UWSP/Extension)



- Contact the laboratory to obtain sample bottles and instructions for the tests you are interested in
  - Many will mail sample kits directly to you
  - Some will allow you to return samples via mail or other delivery services

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- **Pierce County**
- **Pierce County Land and Water Conservation Department**
- **Pierce County Health Department**

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