Groundwater and Well Water Education Program

Towns of Armenia and Port Edwards

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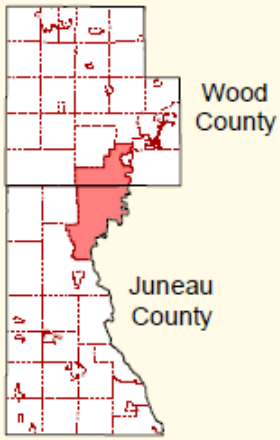
UW Extension
University of Wisconsin-Extension

Towns of Armenia & Port Edwards

Juneau & Wood Counties, May 2018

- 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



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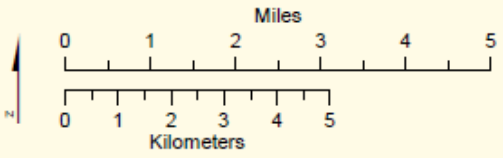
PORT EDWARDS
NEKOOSA
173
80
Cranberry Creek Watershed
Lower Yellow River Watershed
FINLEY
ARMENIA
Wisconsin Rapids Watershed
MONROE
Petenwell Lake
Fourteenmile Creek Watershed
80
NECEDAH

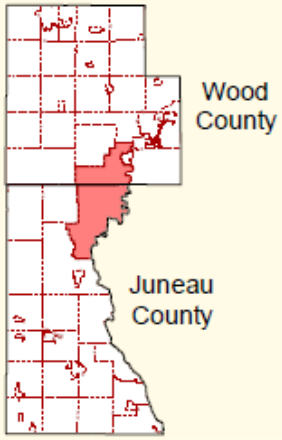
Towns of Armenia & Port Edwards

Juneau & Wood Counties, May 2018

SAMPLE DISTRIBUTION

NUMBER OF SAMPLES per 1/4 1/4 SECTION





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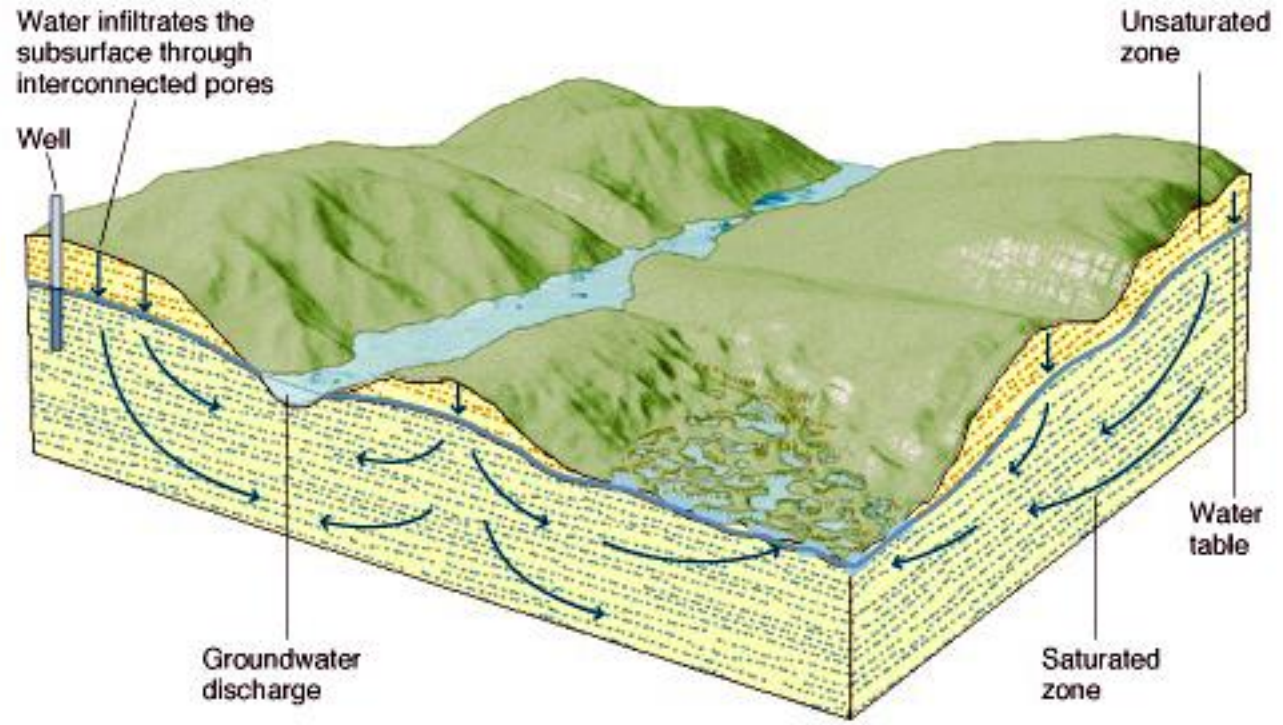
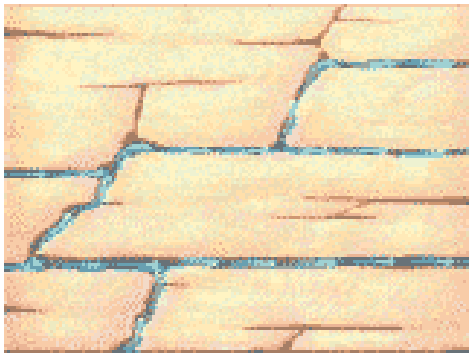
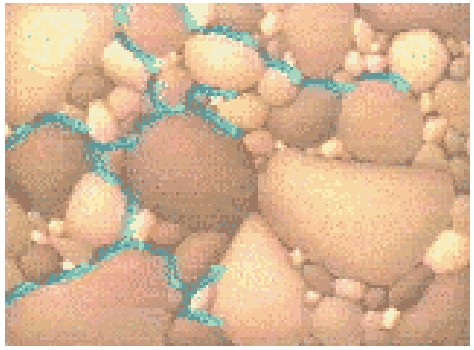
Today's presentation

- Groundwater Basics: Where does my water come from
- Well Construction
- What did we test for and why?
- General groundwater quality in the Towns of Armenia and Port Edwards
- Improving your water quality

Groundwater Movement



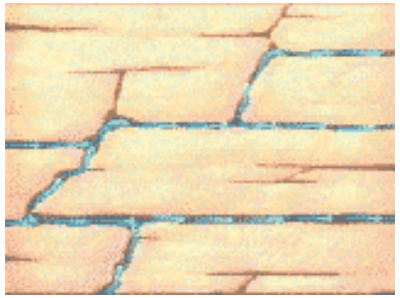




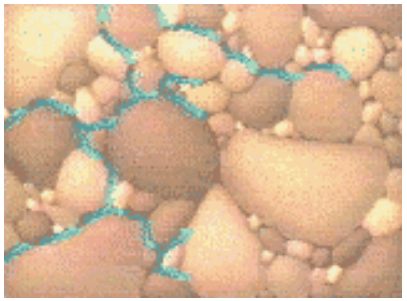
Aquifers: Our groundwater storage units

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

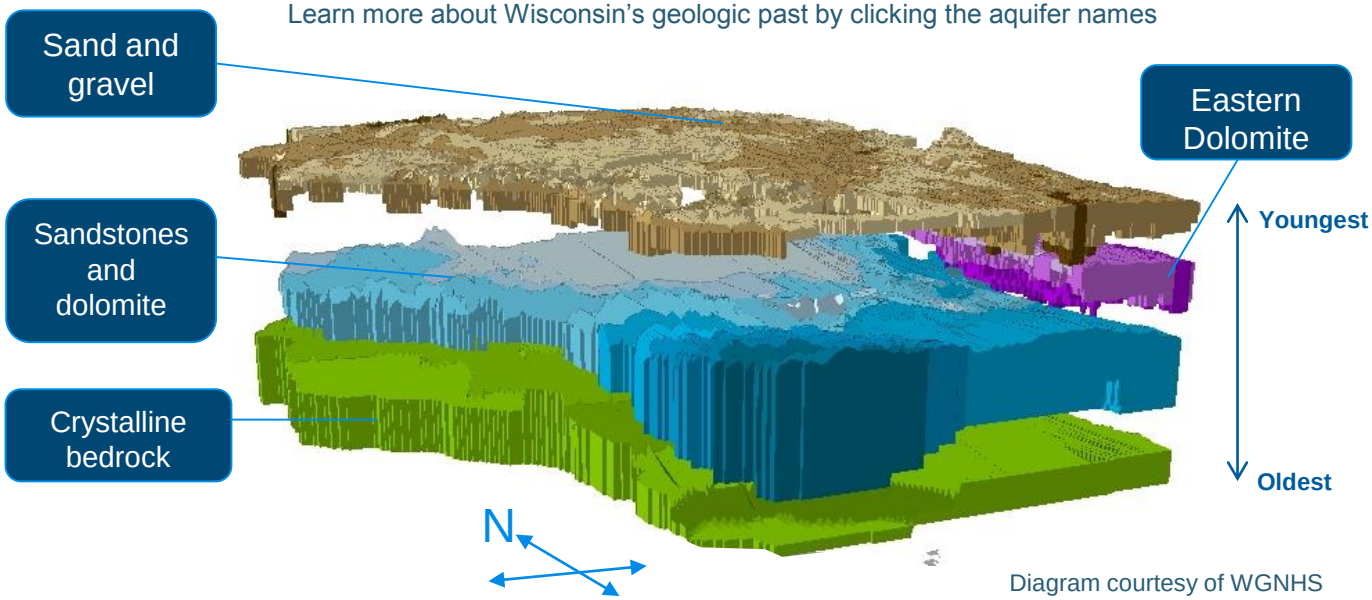
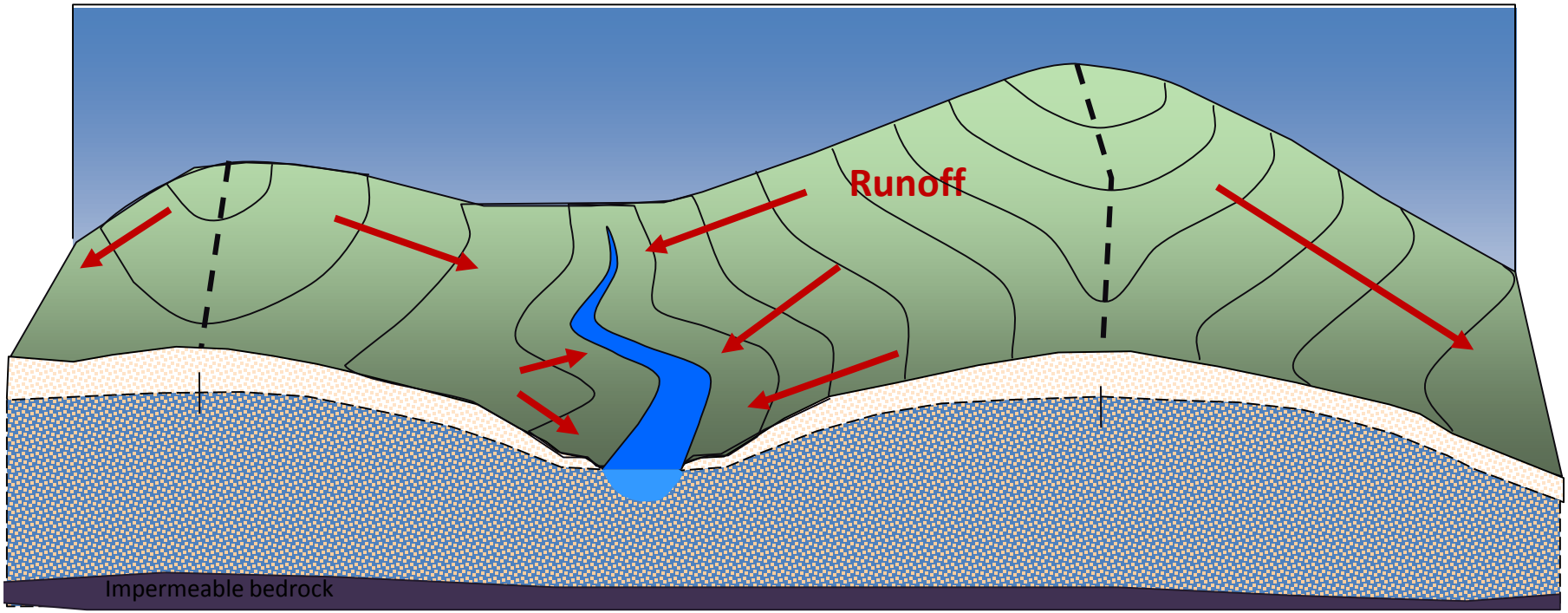
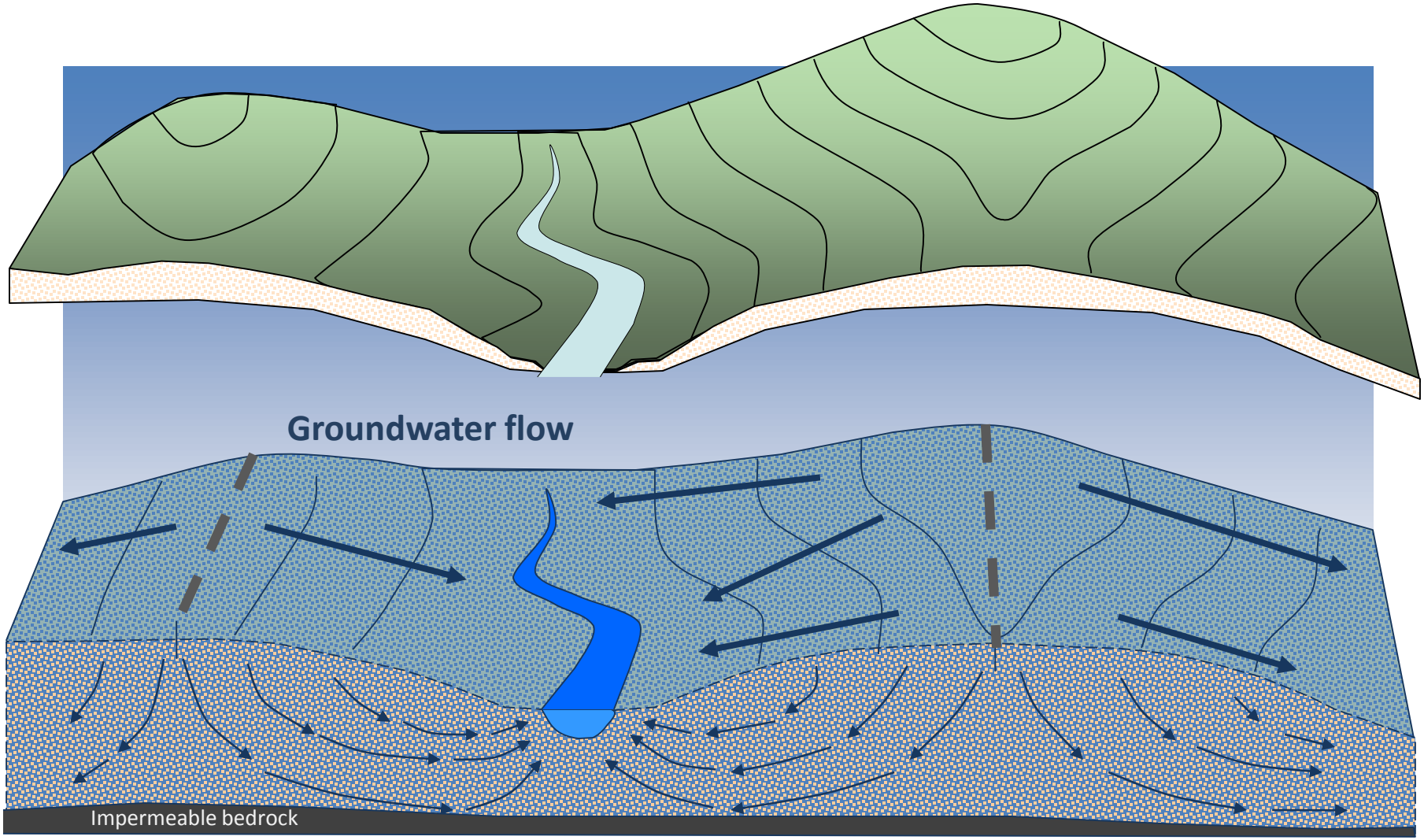


Diagram courtesy of WGNHS

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




Groundwater flow
Impermeable bedrock

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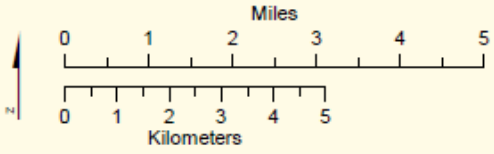

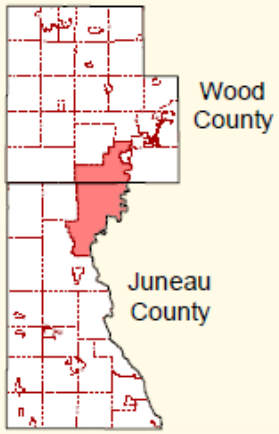

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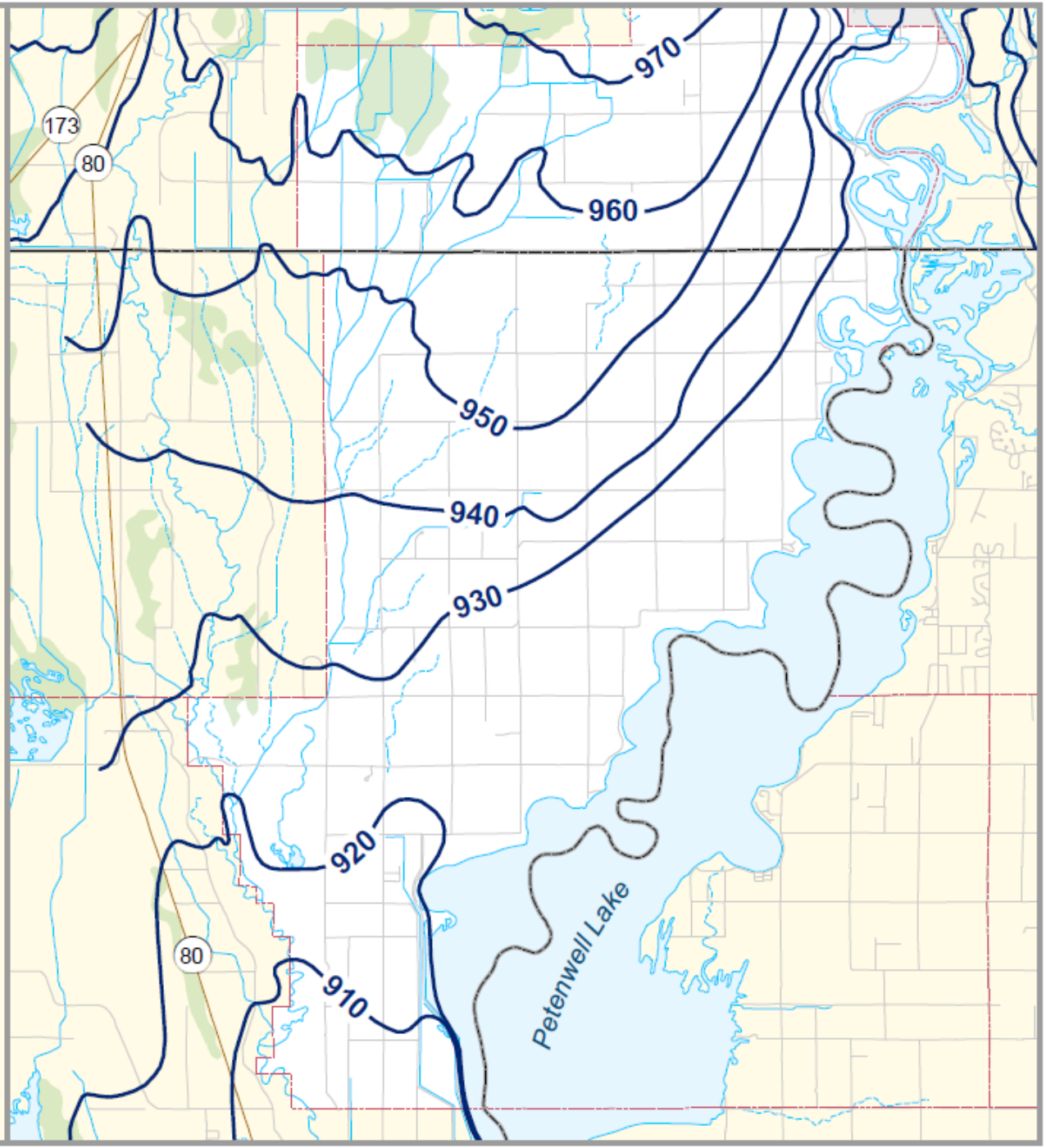

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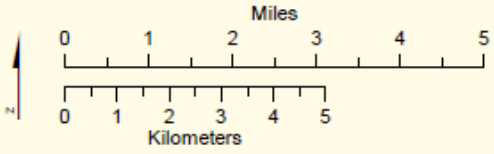

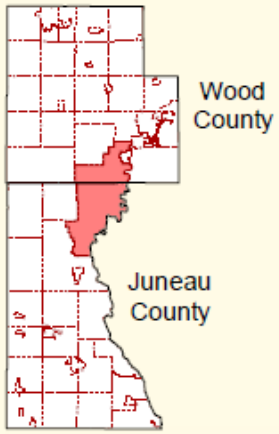

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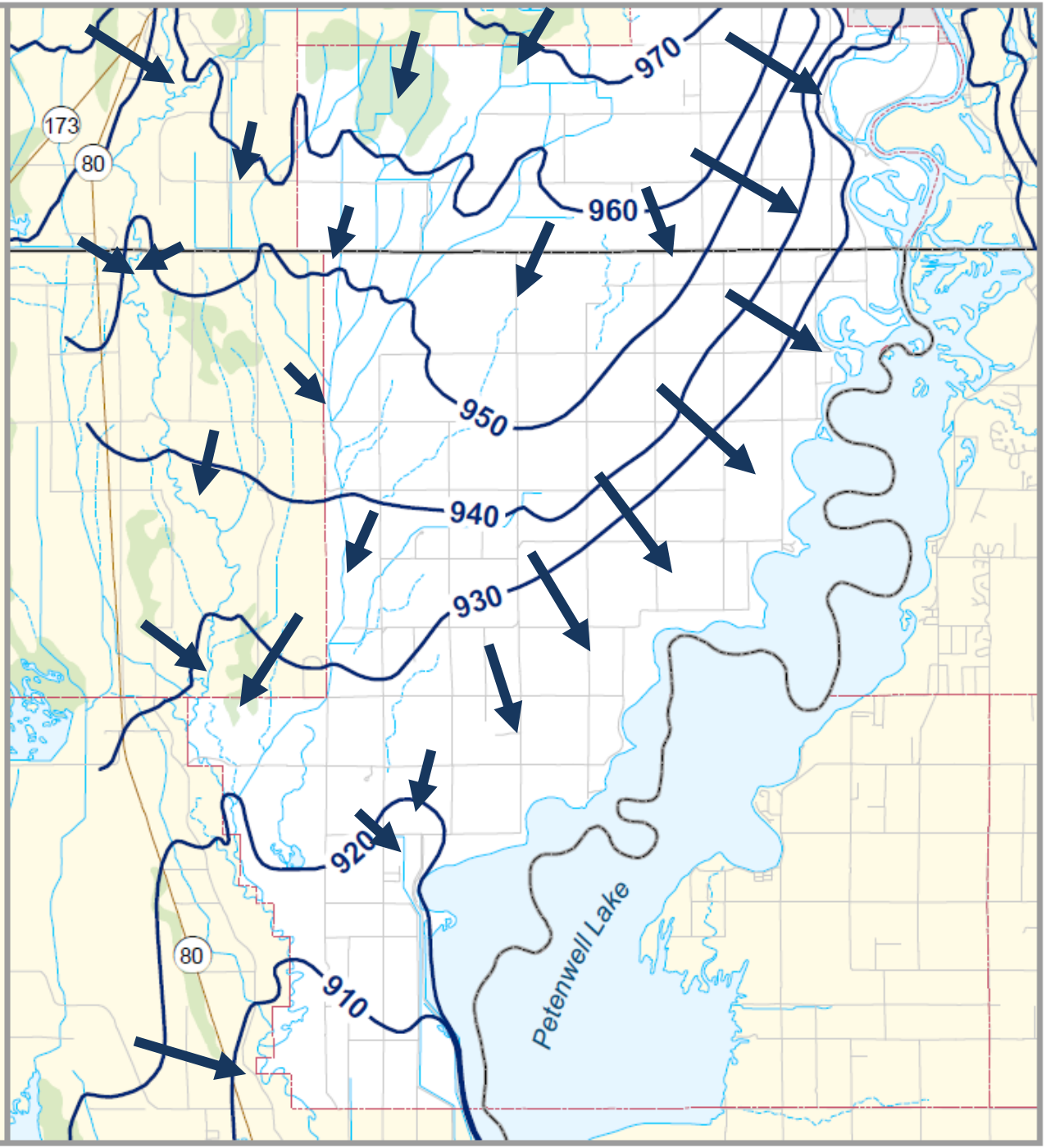

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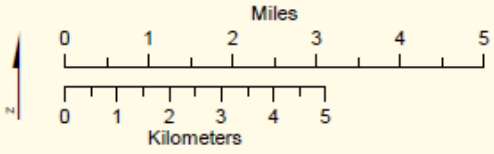

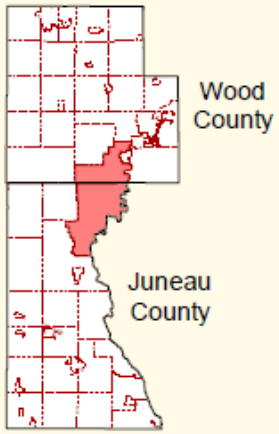

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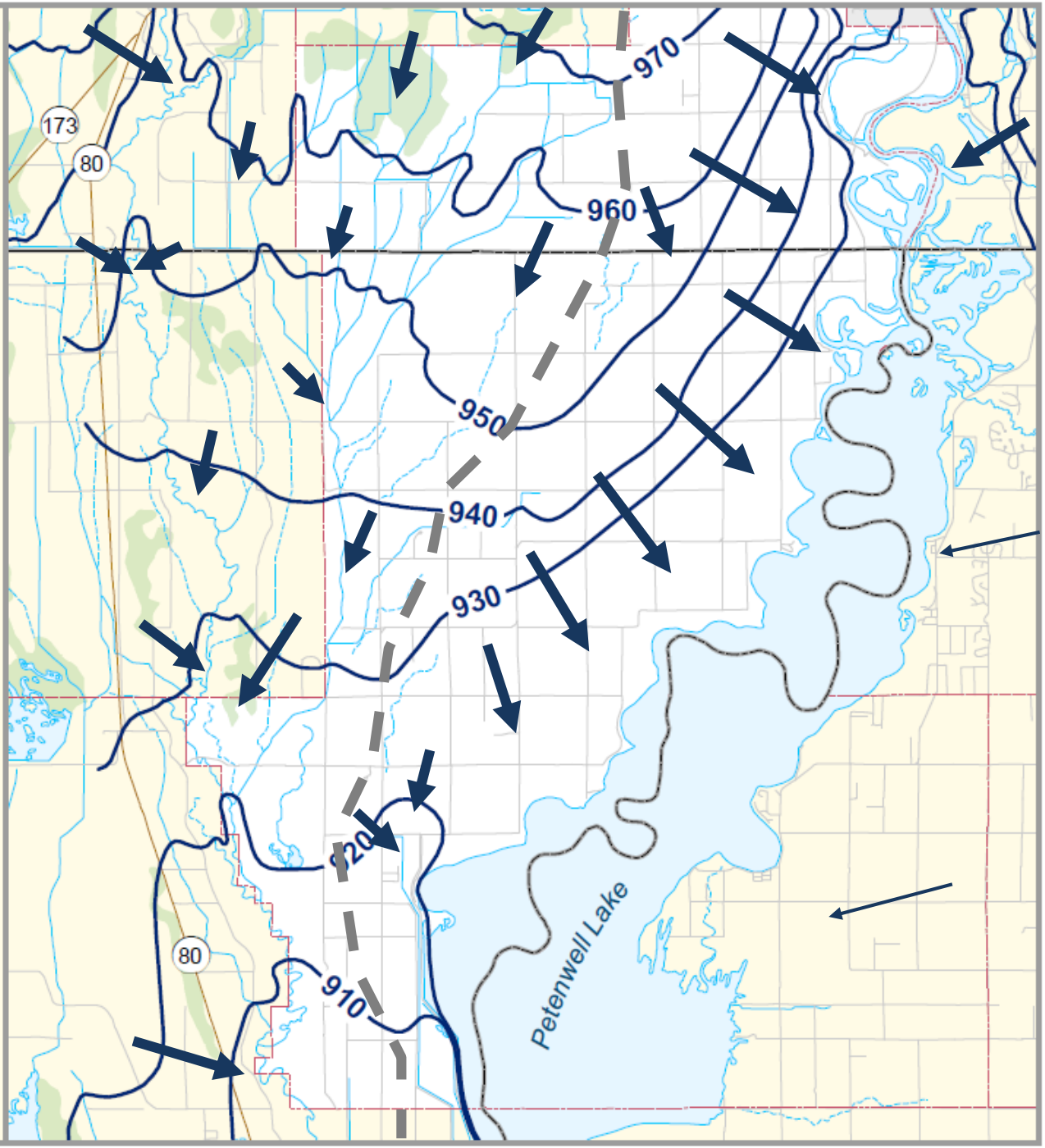
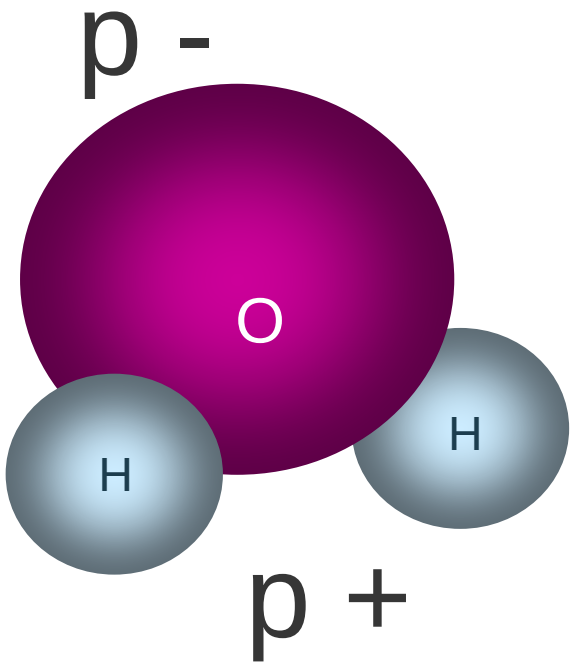


water basics

- "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.
- Treatment sometimes used to take impurities 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

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.

Towns of Armenia & Port Edwards

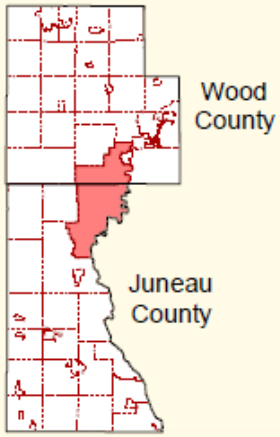
Juneau & Wood Counties, May 2018

DEPTH OF WELL (ft)

A	... 25	6 %
B	26-50	27 %
C	51-100	30 %
D	101-150	<1 %
E	151-200	0 %
F	201 ...	0 %

Mapped value is the average for the 1/4 1/4 section

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



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Well and Casing Depth

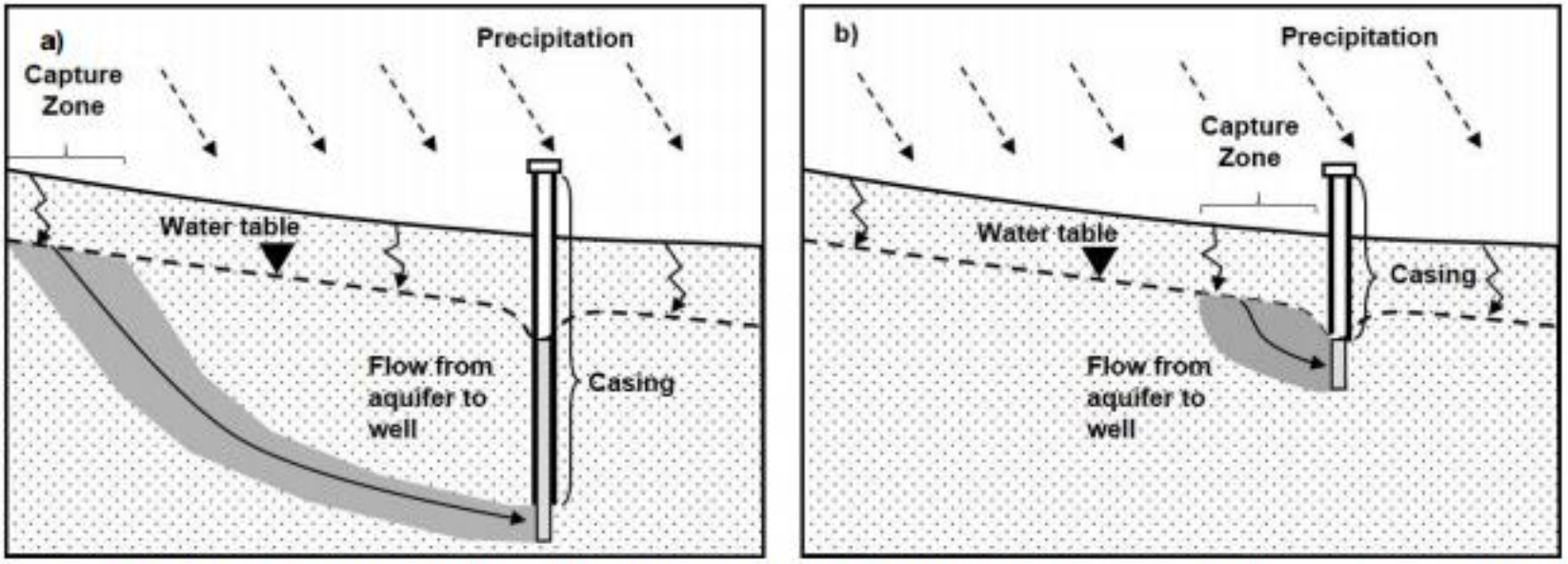
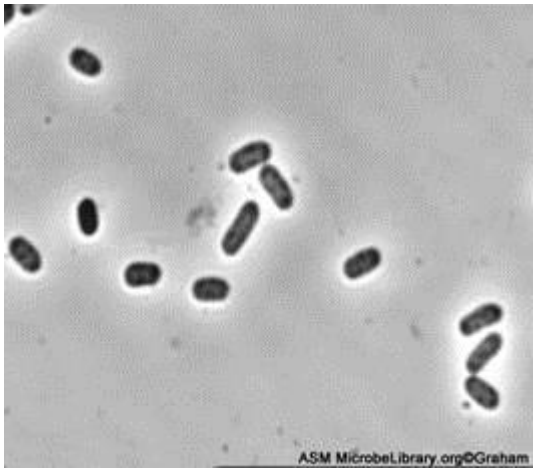


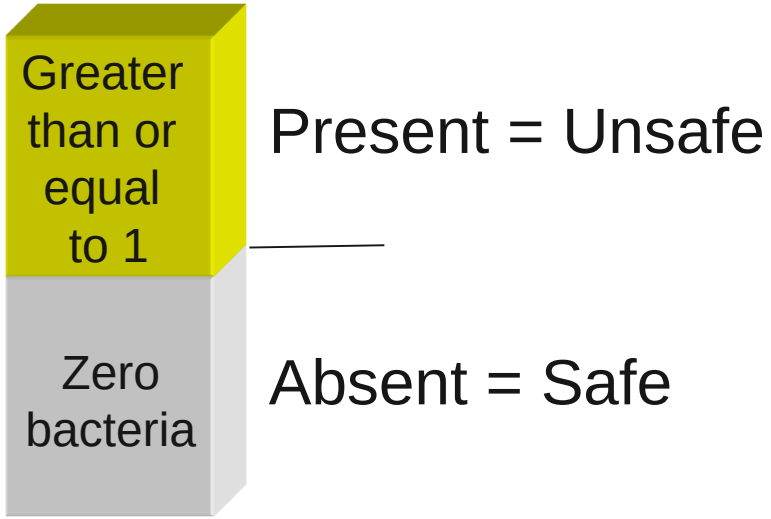
Figure 7. Diagrams illustrating how well and casing depth influence the capture zone of a well. Wells in which the casing extends below the water table will tend to have capture zones that are located further away from the well (a) than one in which the casing does not extend as far or may not extent past the water table (b).

- Typical well construction in area have wells screened between 15-30 feet below the water table
- Capture zone ~ ¼ to ½ mile upgradient of well

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

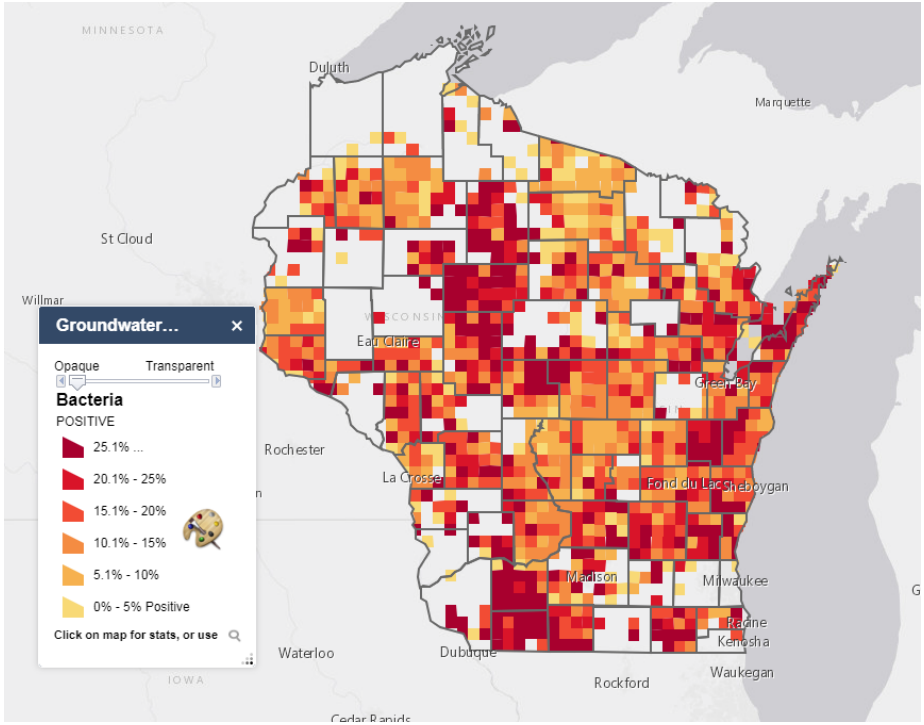
- Confirmation that bacteria originated from a human or animal fecal source.
- E. coli are often present with harmful bacteria, viruses and parasites that can cause serious gastrointestinal illnesses.
- Any detectable level of E.coli means your water is unsafe to drink.

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)

Coliform Bacteria in Wells

- Statewide, estimate that 15-25% of wells are likely to test positive for coliform bacteria
- 8% tested positive in Towns of Armenia and Port Edwards
  (8/104 samples)
- No E.coli positives



Well Construction

Photos courtesy of: Matt Zoschke

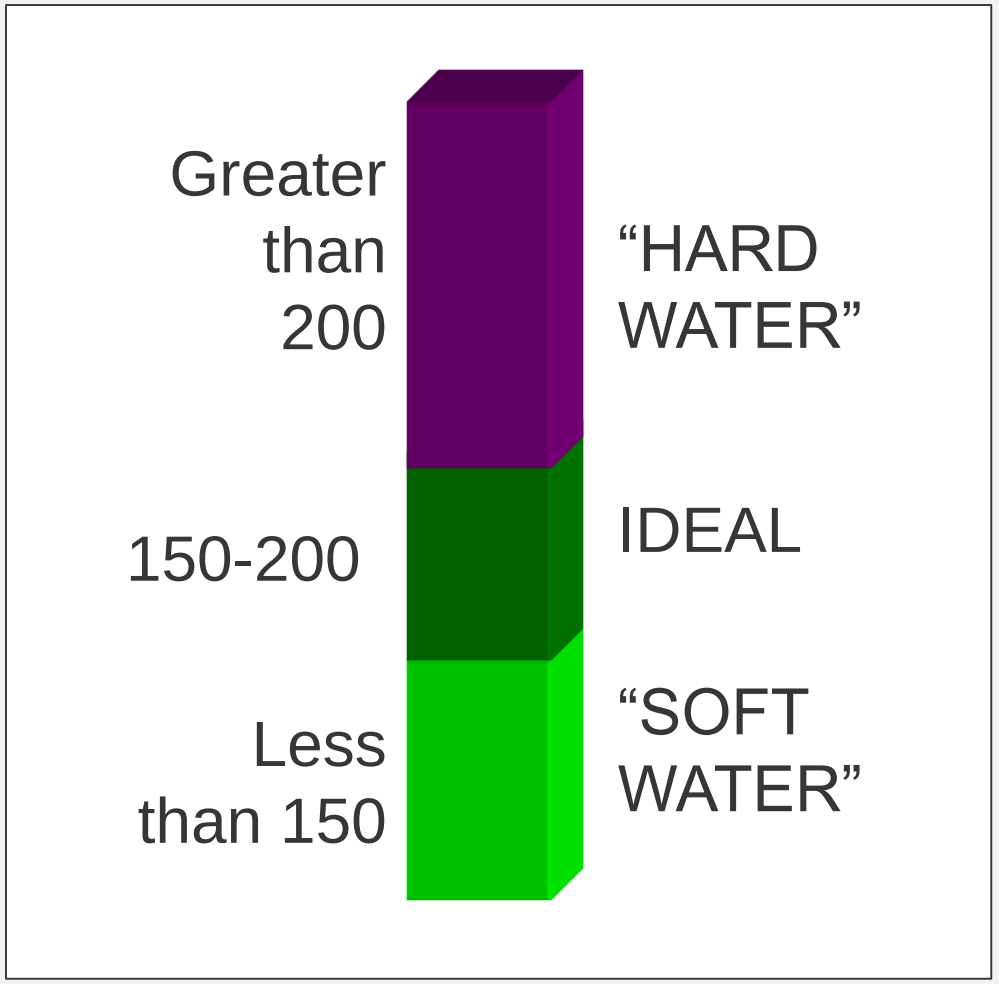
Rock and Soil Impacts on Water Quality

Tests for Aesthetic Problems

Hardness

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

- Problems with too much hardness: scaling, scum, use more detergent, decrease water heater efficiency



Towns of Armenia & Port Edwards

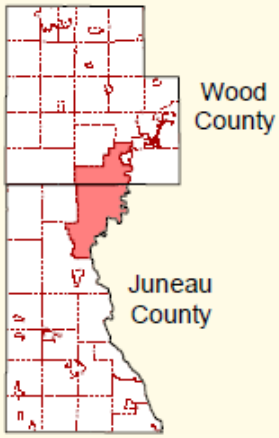
Juneau & Wood Counties, May 2018

TOTAL HARDNESS (ppm CaCO3)

A	... 50	25	26%
B	51 - 100	24	25%
C	101 - 200	31	32%
D	201 - 300	14	15%
E	301 - 400	2	2%
F	401 ...	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



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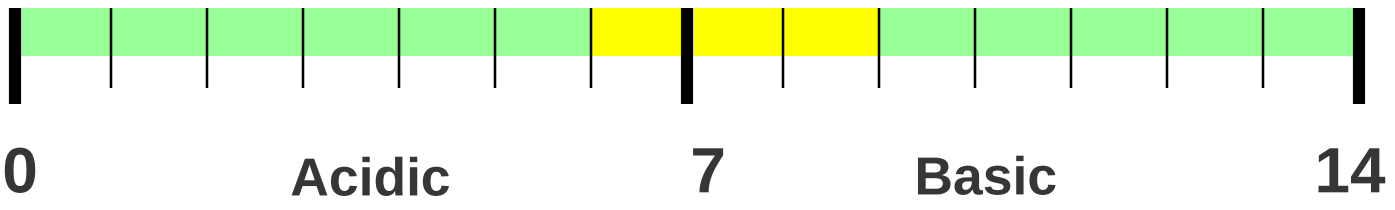
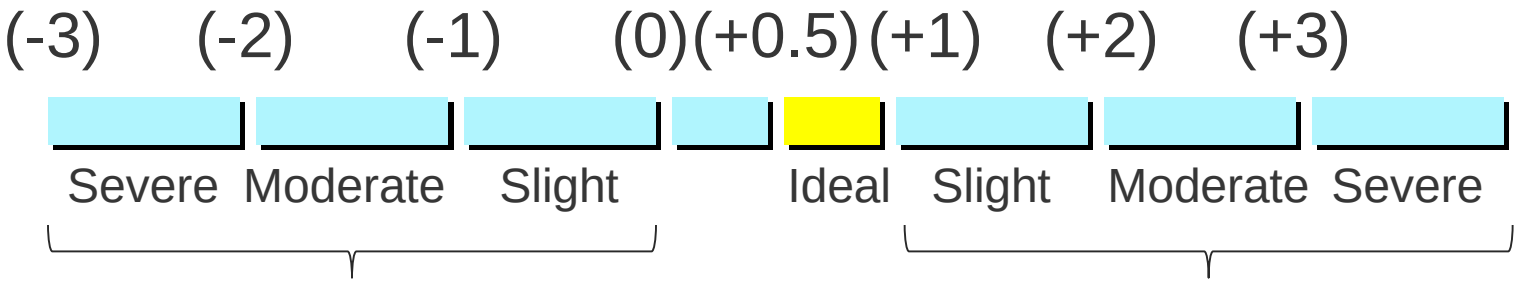
Tests for Overall Water Quality

- **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 Overall Water Quality

Saturation Index



Corrosion occurs

More likely to result in elevated copper and lead levels if found in plumbing

Scaling occurs

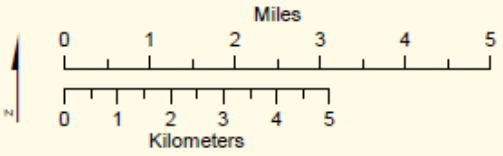
Towns of Armenia & Port Edwards

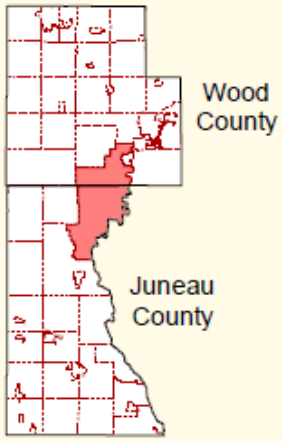
Juneau & Wood Counties, May 2018

SI (Saturation Index)

A	... -3.0	21	22 %
B	-2.9 - -2.0	10	10 %
C	-1.9 - -1.0	11	11 %
D	-0.9 - 0.0	51	53 %
E	0.1 - 1.0	3	3 %
F	1.1 ...	0	0 %

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





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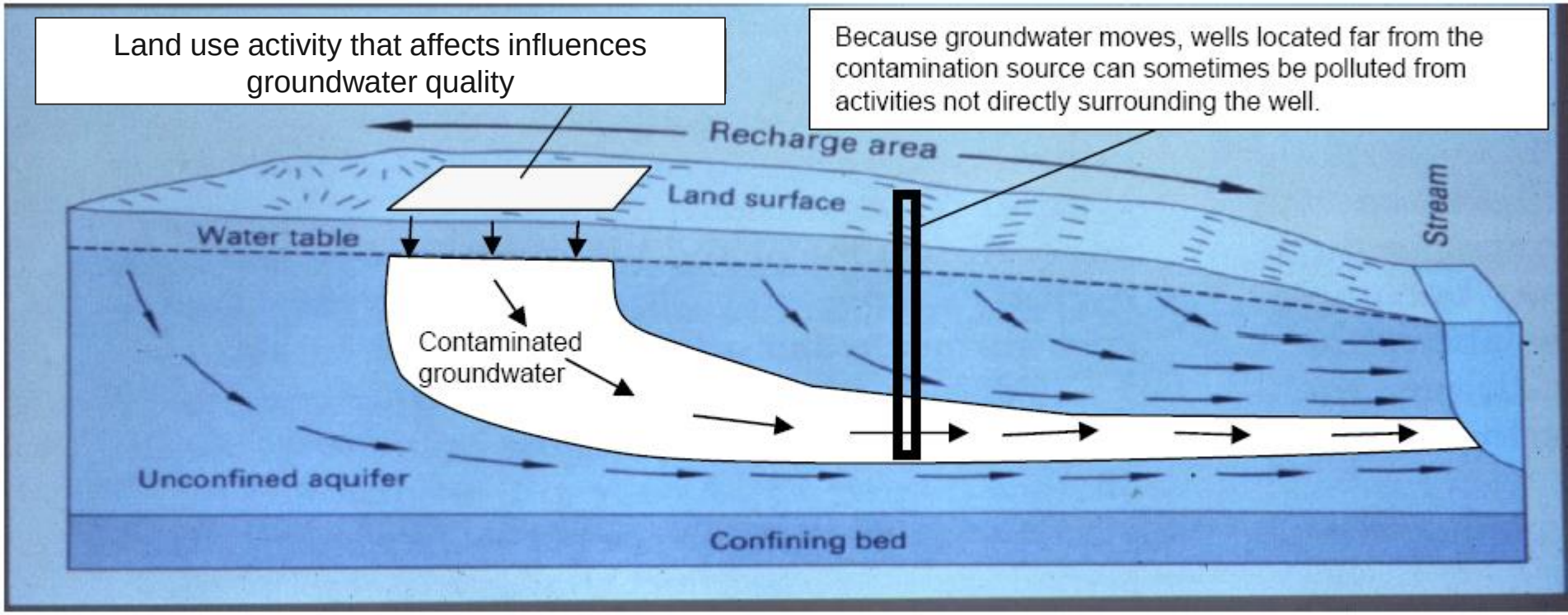
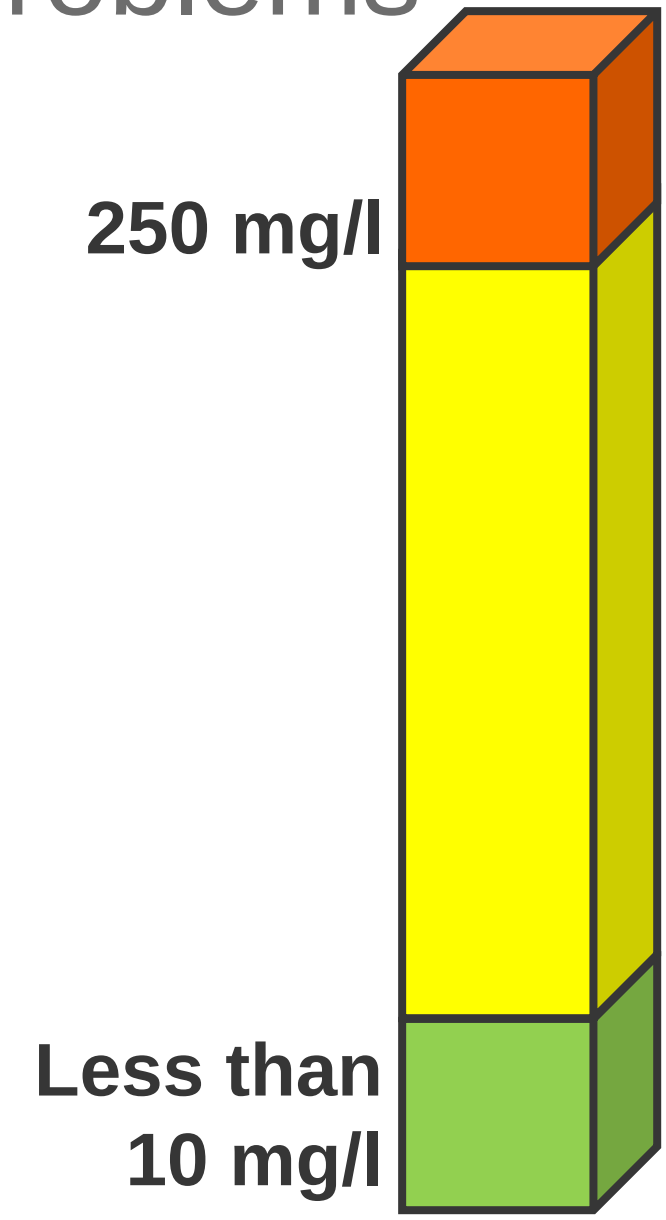
OIL
OIL
OIL
Soil


Land use activity that affects influences groundwater quality
Because groundwater moves, wells located far from the contamination source can sometimes be polluted from activities not directly surrounding the well.
Recharge area
Land surface
Water table
Stream
Contaminated groundwater
Unconfined aquifer
Confining bed

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 indicates likely land-use impacts
- Less than 10 mg/l considered “natural” in much of WI
- **Sources:** Fertilizers (potash), Septic Systems and Road Salt



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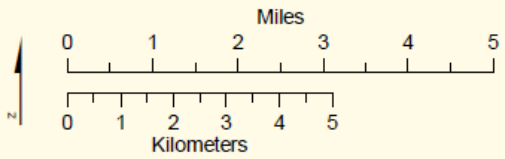
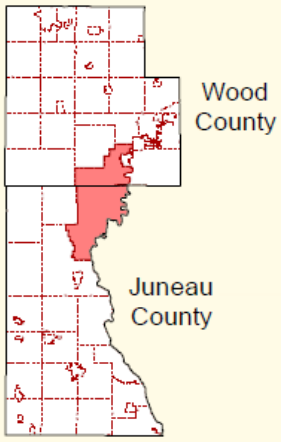
CHLORIDE (ppm)

A	None Detected	0	0 %
B	... 10	52	50 %
C	11 - 50	48	46 %
D	51 - 100	3	3 %
E	101 - 200	1	<1 %
F	201 ...	0	0 %

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





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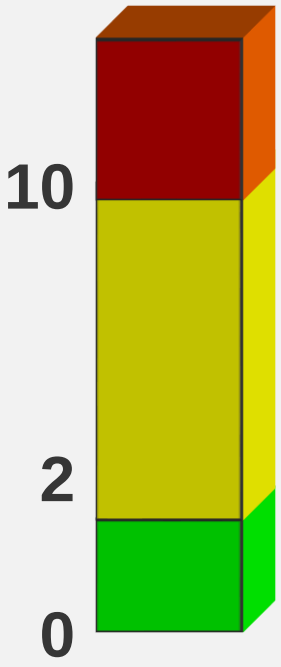
Nitrate-Nitrogen

- **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"

UNSAFE - for infants and pregnant women or women who may become pregnant; everyone should avoid long term consumption.



"NATURAL"

Sources: Agricultural fertilizer, lawn fertilizer, septic systems, animal wastes or other bio-solid applications

*Indicator of other potential contaminants

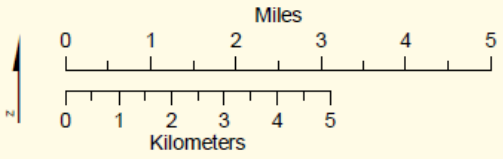
Towns of Armenia & Port Edwards

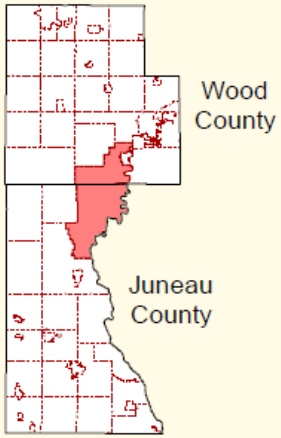
Juneau & Wood Counties, May 2018

NITRATE-NITRITE (ppm N)

A	None Detected	14	13 %
B	... 2.0	31	30 %
C	2.1 - 5.0	6	6 %
D	5.1 - 10.0	9	9 %
E	10.1 - 20.0	19	18 %
F	20.1 ...	25	24 %

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





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College of Natural Resources
University of Wisconsin-Stevens Point

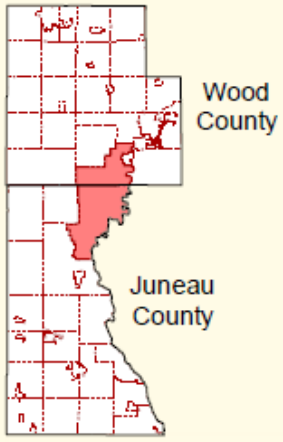
Towns of Armenia & Port Edwards

Juneau & Wood Counties, May 2018

Soil Drainage Class

- Excessively Drained
- Somewhat Excessively Drained
- Well Drained
- Moderately Well Drained
- Somewhat Poorly Drained
- Poorly Drained
- Very Poorly Drained

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



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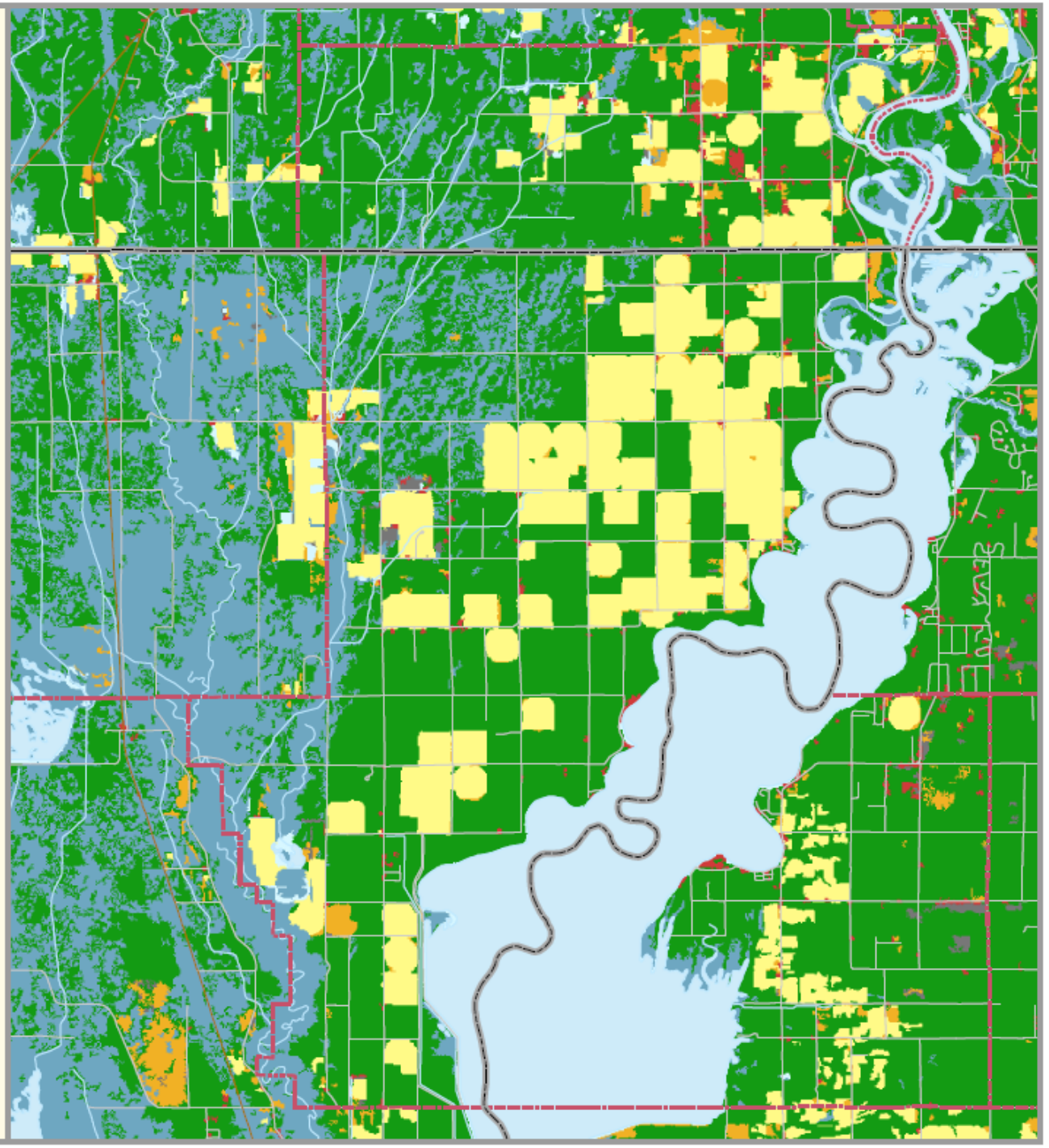
Juneau & Wood Counties, May 2018

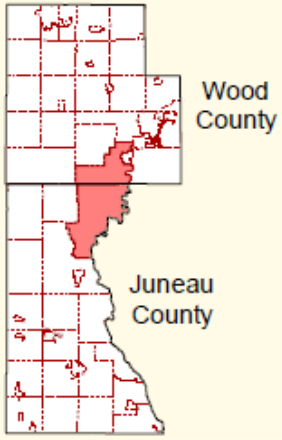


Land Use:

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

Miles
0 1 2 3 4 5

Kilometers
0 1 2 3 4 5



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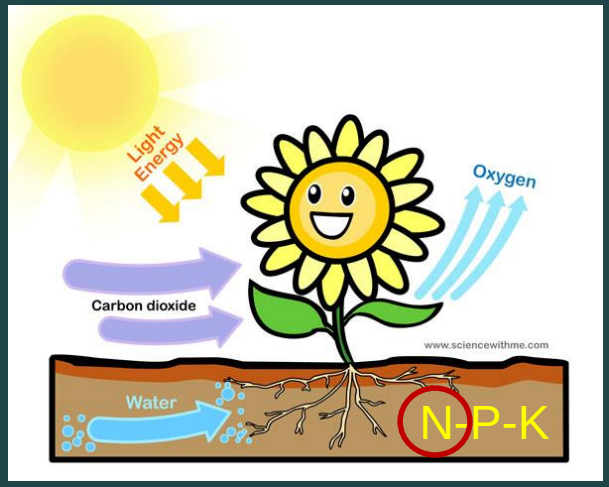
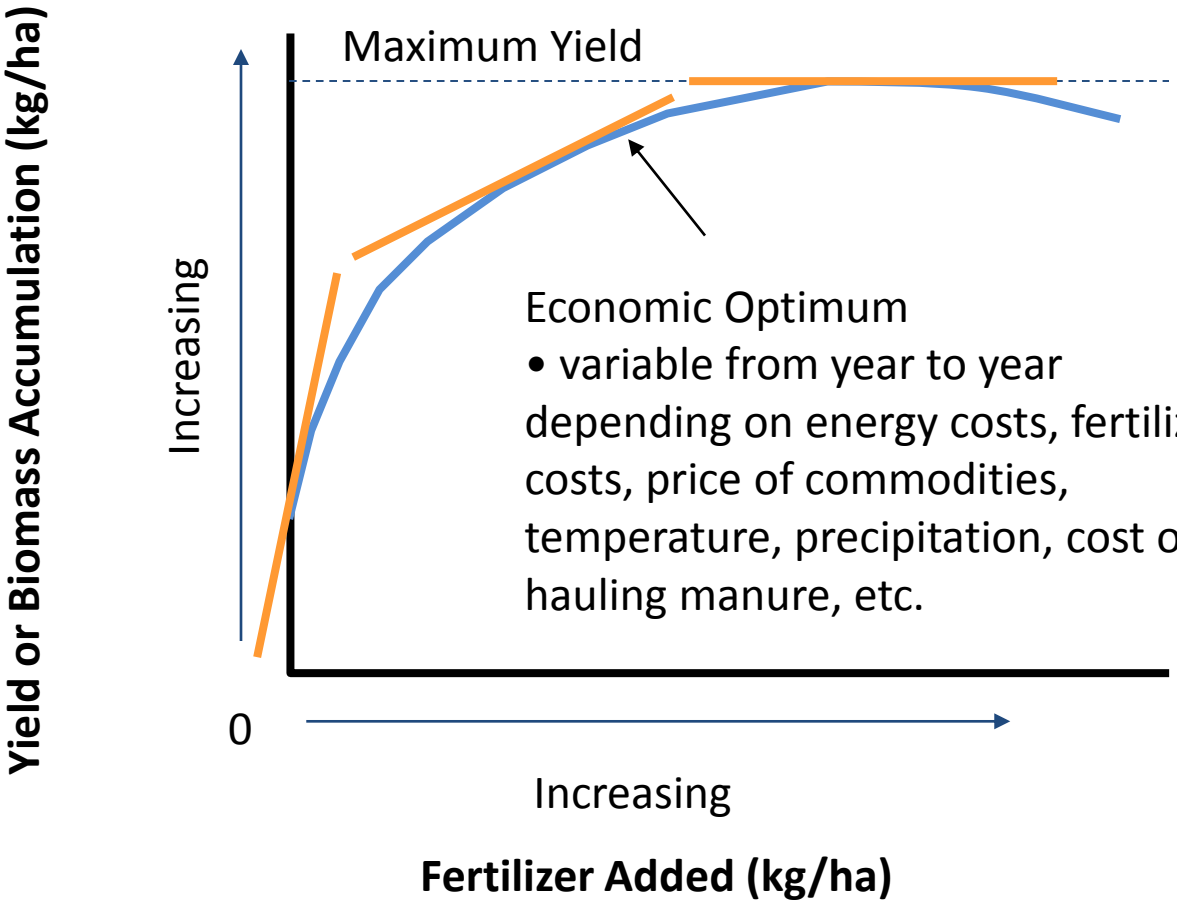
Less

More

Nitrogen Fertilizer Added (lb/acre)

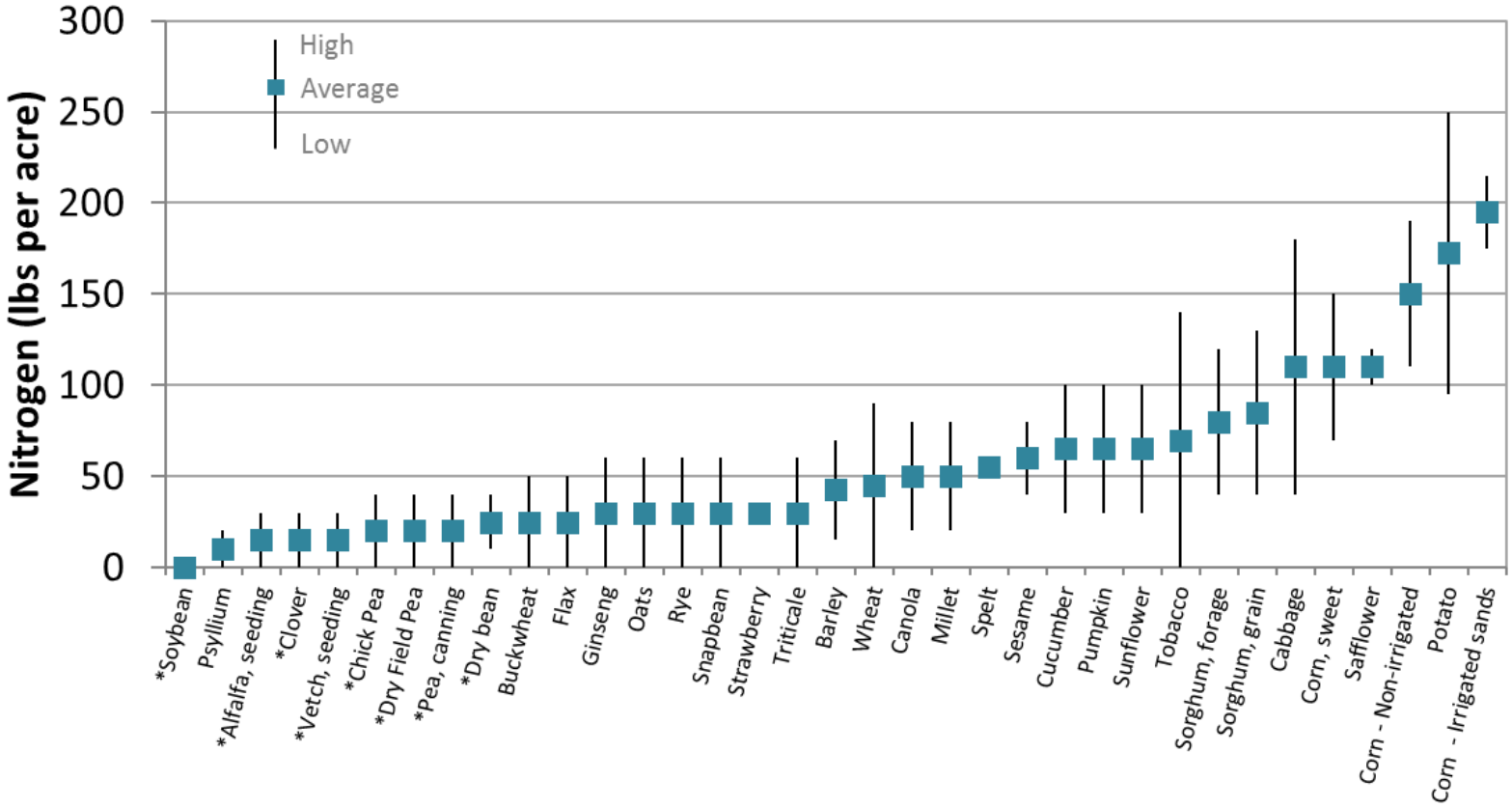


Yield response to nitrogen



$$\text{Slope} = \frac{\text{Added Yield}}{\text{Fertilizer Unit}}$$

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)

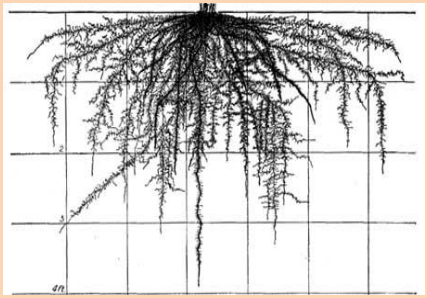
**16 -37X greater nitrate loss below continual corn cropping systems compared to perennial systems*

Comparing Corn to Perennial Ecosystems

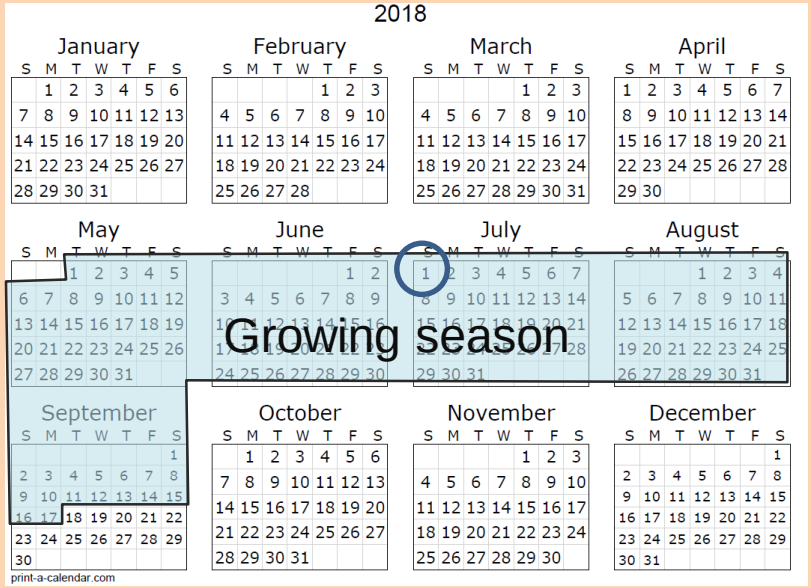
Nitrogen fertilizer use efficiency for Midwestern corn systems

37%

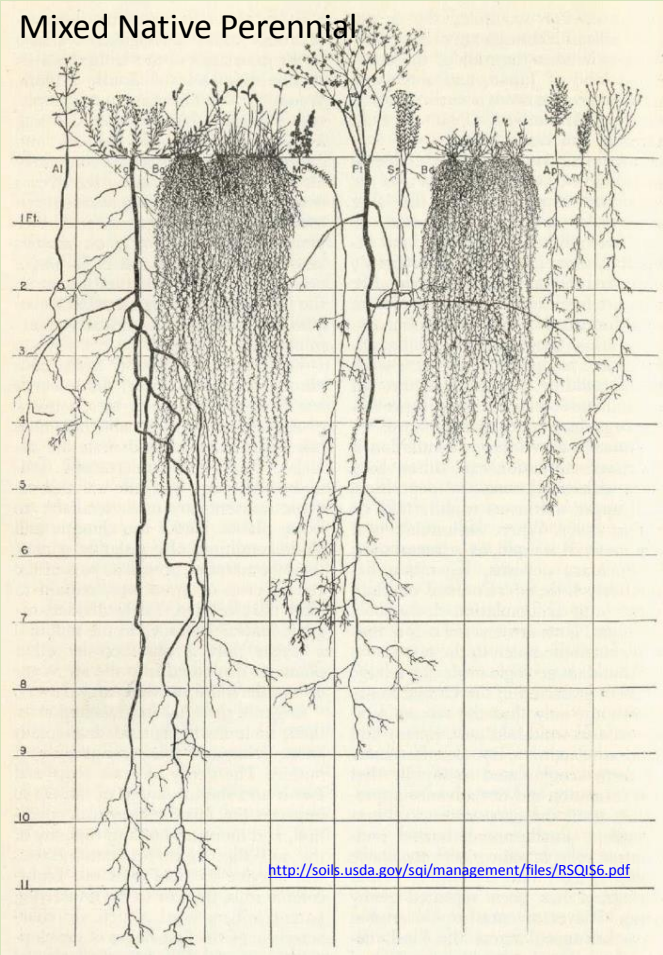
(Cassman et. al. 2002)



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

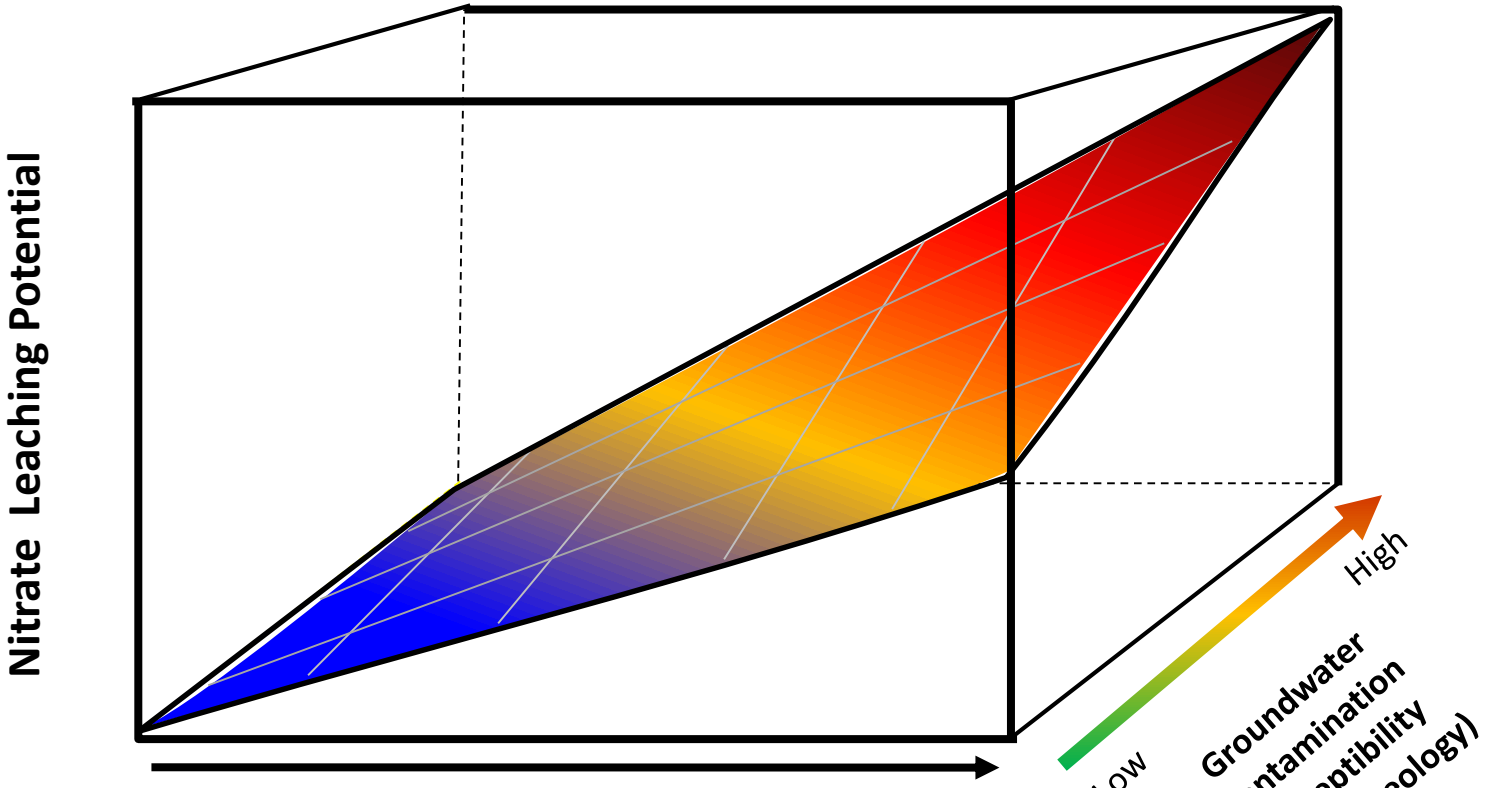


Mixed Native Perennial



http://soils.usda.gov/sqi/management/files/RSQIS6.pdf

Nitrate Leaching Potential



Masarik, UW-Extension

Nitrate in Wisconsin's groundwater

Nitrate (mg/L as N)		
None Detected	28114	33 %
... 2.0	20245	24 %
2.1 - 5.0	14816	18 %
5.1 - 10.0	12122	14 %
10.1 - 20.0	6900	8 %
20.1 ...	1878	2 %

Center for Watershed Science and Education, 2018

WisconsinWatch.org
Produced by the Wisconsin Center for Investigative Journalism

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We Recommend Failure at the Faucet Broken Whistle Flawed Forensics Cruel and Unusual? Precious Lives: Gun violence and kids

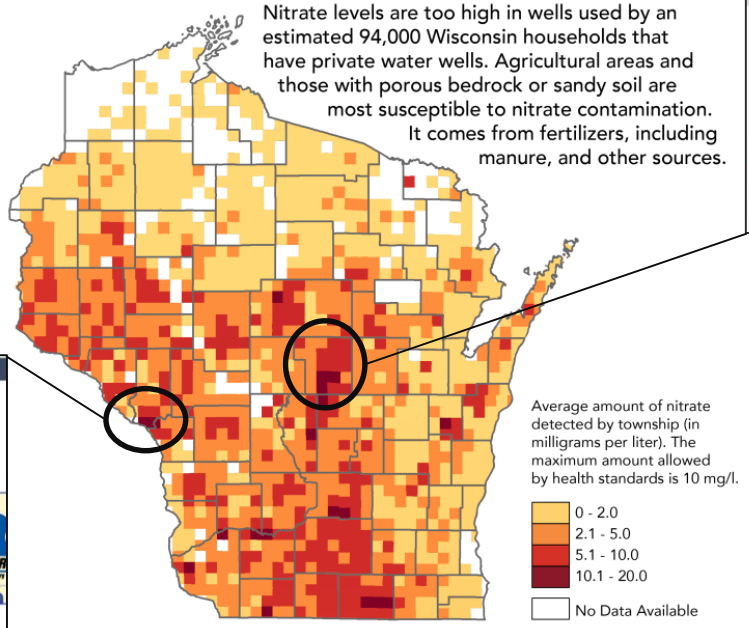
FAILURE AT THE FAUCET

Nitrate in water widespread, current rules no match for it

While nitrate contamination increases, experts say state's main approach unlikely to protect drinking water

By Kate Golden November 15, 2015

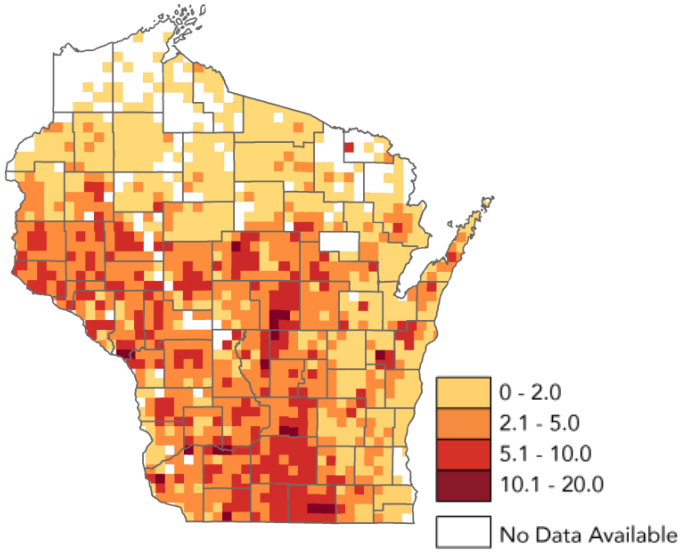
Nitrate in drinking water around Wisconsin



CREDIT: Katie Kowalsky/Wisconsin Center for Investigative Journalism

SOURCE: Well Water Quality Viewer, University of Wisconsin-Stevens Point's Center for Watershed Science and Education. Private Drinking Water Quality in Rural Wisconsin, Journal of Environmental Health, 2013.

Coarse textured surficial deposits



Map created using: Groundwater Contamination Susceptibility Model (GCSM); Surficial Deposits ("sdppw95c")

The GCSM was developed by the DNR, the US Geological Survey (USGS), the Wisconsin Geological & Natural History Survey (WGNHS), and the University of Wisconsin – Madison in the mid-1980s.

Shallow carbonate rock aquifer - Silurian

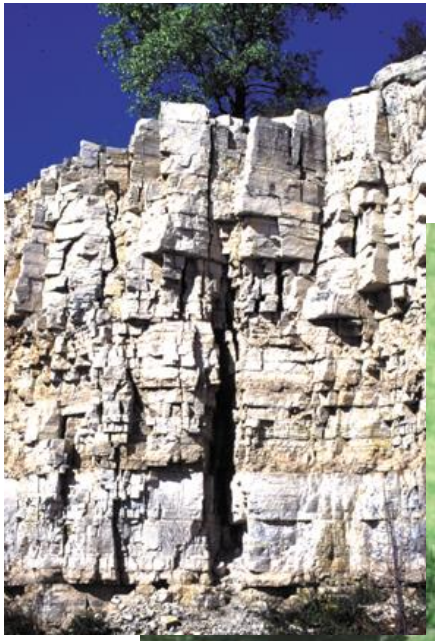
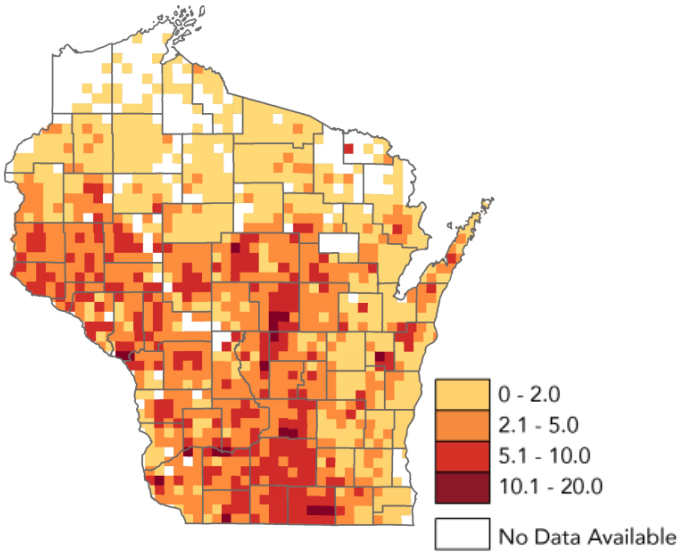


Photo credits: Ken Bradbury, WGNHS



What can be done to reduce nitrate levels?

Long term look at working to reduce nitrate loss to groundwater at the source:

- Have to implement the right tools
- Could take years to notice a response in wells

Short term look at providing safe water:

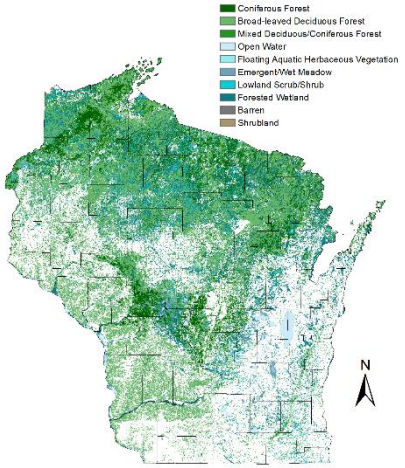
Private Wells (Lewandowski et. al. 2008)

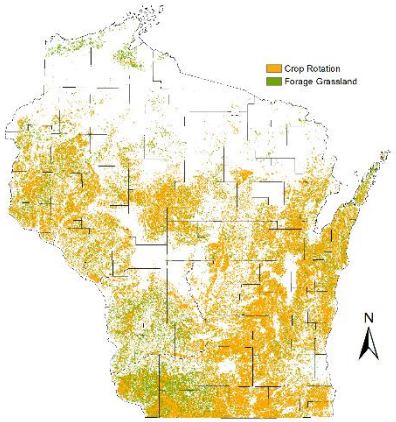
- New well (not guaranteed, deeper adds to expense) - $7,200
- Bottled water - $190/person/year
- Water treatment devices $800 + 100/yr
  - Reverse osmosis (also removes most pesticides)
  - Distillation (removes some pesticides)
  - Anion exchange (nitrate only, wouldn't have any effect on pesticides)

Additional testing recommendations:

- If nitrate levels above 10 mg/L:
  - DO NOT give water to infants, women who are or may become pregnant
  - All persons should avoid long-term consumption of water greater than 10 mg/L
  - If relying on treatment:
    - Test treated water periodically to ensure its providing safe water
- If nitrate levels less than 10 mg/L:
  - Test annually to ensure levels remain below 10 mg/L
  - If greater than 5 mg/L may consider testing quarterly for a year to understand variability

Land-use





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Soils/Geology

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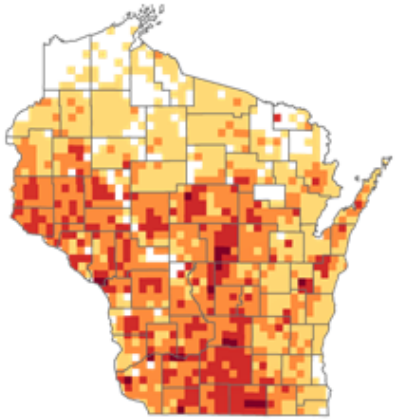

Nitrate Groundwater Quality

Slides from tonight's presentation posted online at:

https://www.uwsp.edu/cnr-ap/watershed/Pages/staff_masarik.aspx

University Place lecture discussing nitrate in Wisconsin's groundwater:

https://www.wiscontext.org/agricultural-practices-can-affect-levels-nitrate-groundwater

Kevin Masarik, email: kmasarik@uwsp.edu