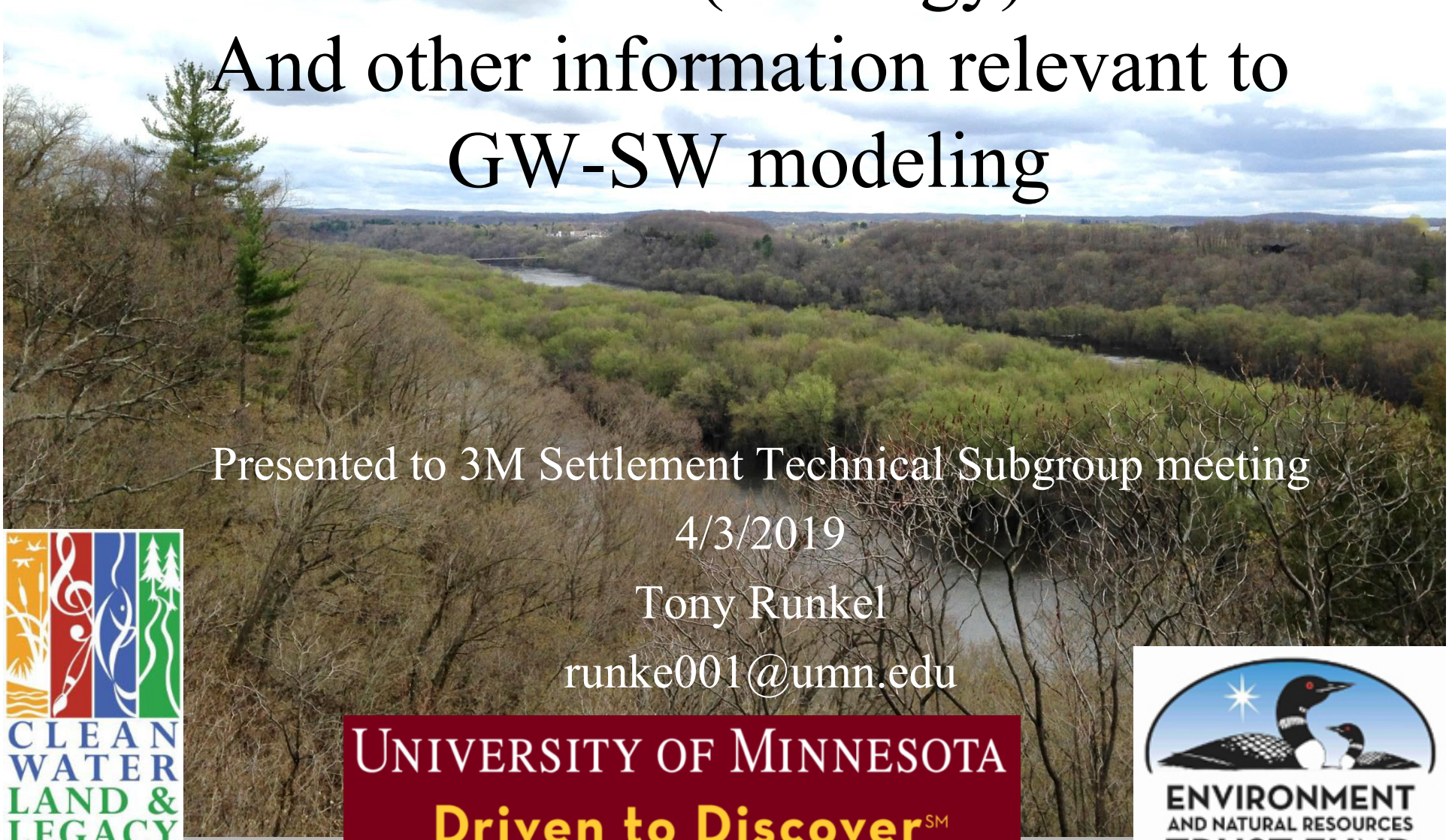
Washington County Geologic Atlas Part A (Geology) And other information relevant to GW-SW modeling



Presented to 3M Settlement Technical Subgroup meeting

4/3/2019

Tony Runkel

runke001@umn.edu

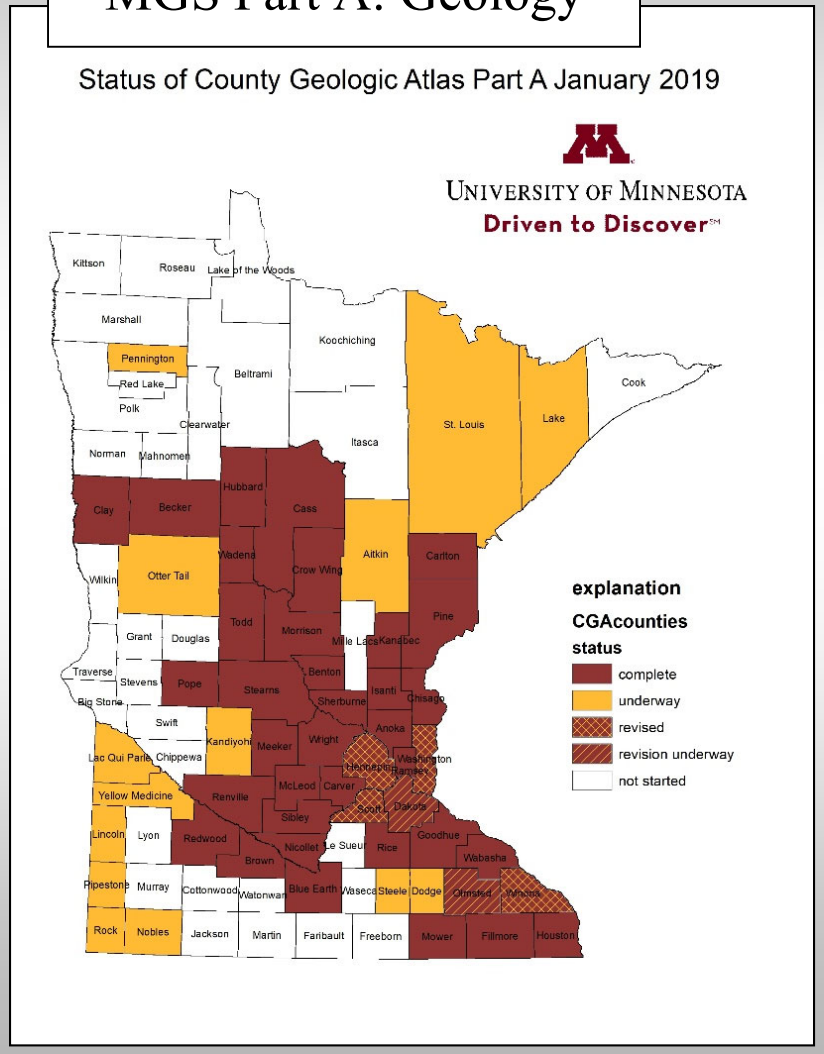
CLEAN WATER LAND & LEGACY AMENDMENT

UNIVERSITY OF MINNESOTA
Driven to Discover℠

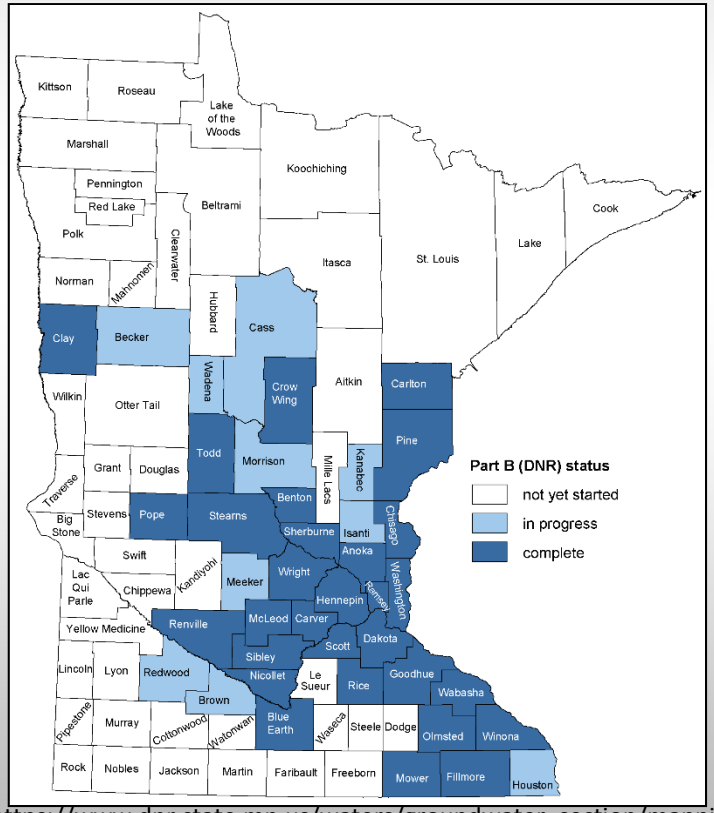
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

County Geologic Atlas Program: 2 Parts

MGS Part A: Geology



DNR Part B: Hydrogeology



https://www.dnr.state.mn.us/waters/groundwater_section/mapping/status.html

Geologic Atlas of Washington County
Part A

- Plate 1: Data-Base Map
- Plate 2: Bedrock Geology
- Plate 3: Surficial Geology
- Plate 4: Quaternary Stratigraphy
- Plate 5: Sand Distribution Model
- Plate 6: Bedrock Topography and Depth to Bedrock

ALL PRODUCTS AVAILABLE AS PAPER MAPS/REPORTS AND AS DIGITAL FILES SUITABLE FOR GIS APPLICATIONS

Washington County Atlas, 2016

Data-Base Map

-Exposures of the rock

-Core samples

-Water well construction records (CWI) **(>14,000 located wells)**

-Scientific and engineering borings (QDI)

-Drill cuttings

-Borehole geophysical log

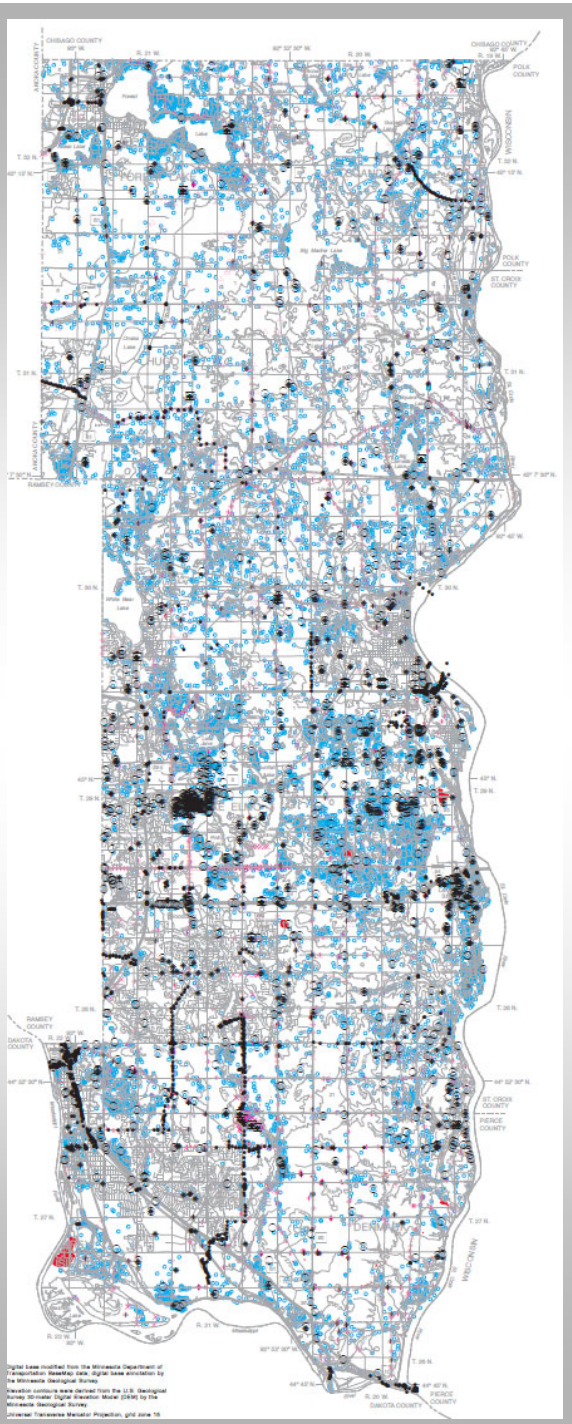
-Giddings probe holes

-Texture analysis

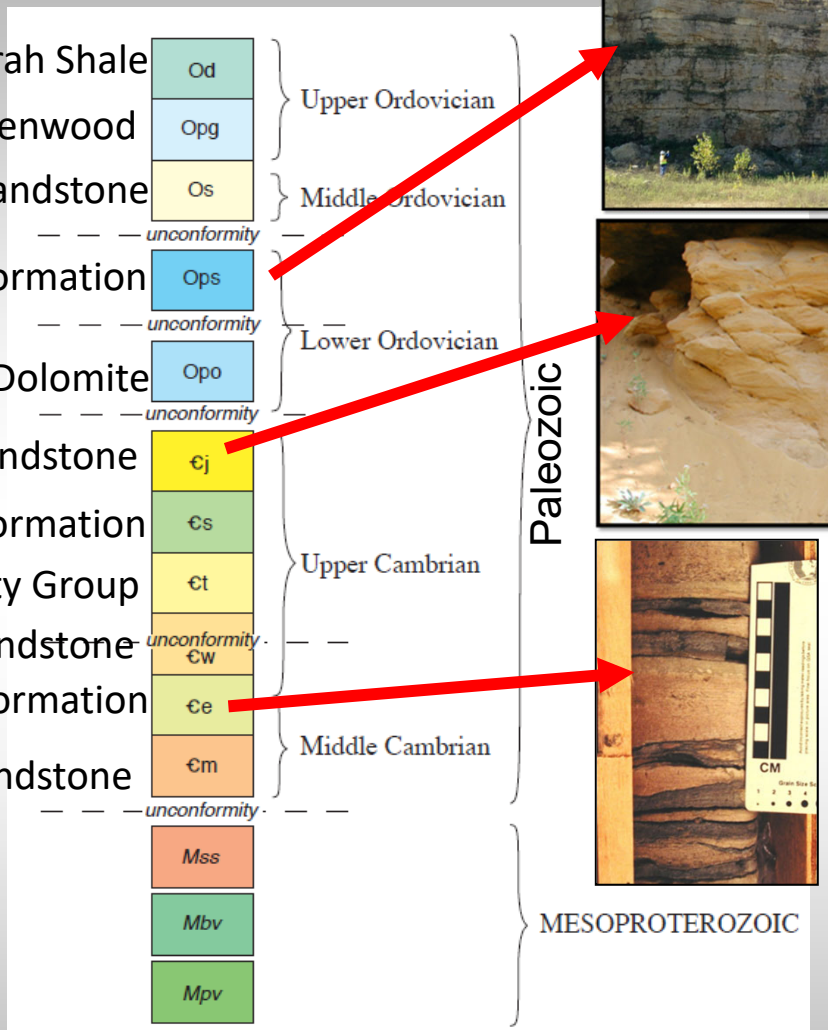
-Soil auger hole

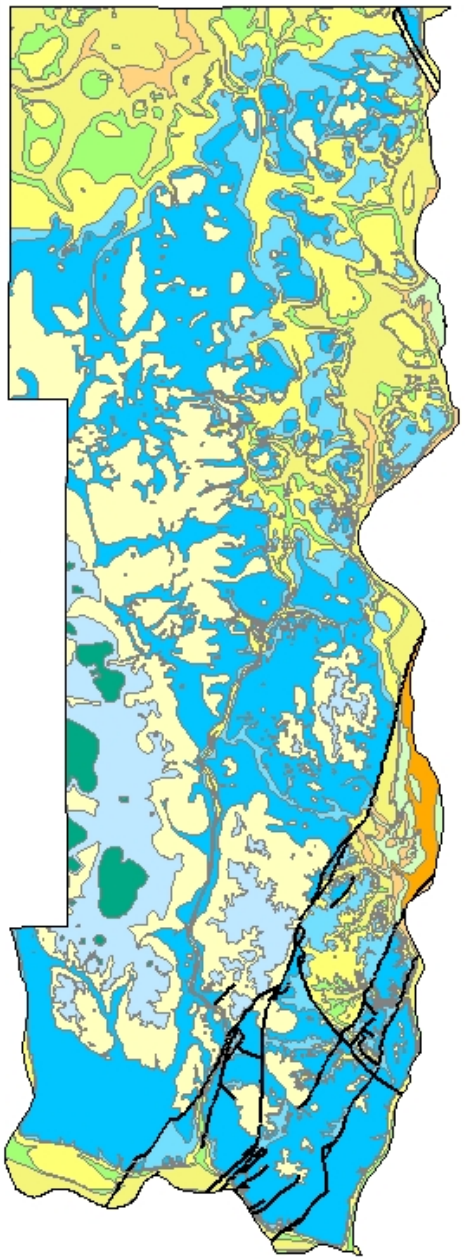
-Passive seismic sounding

-Seismic refraction sounding



Bedrock Geology

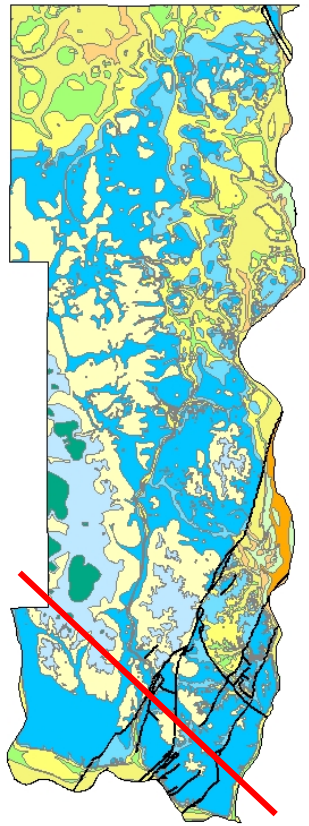


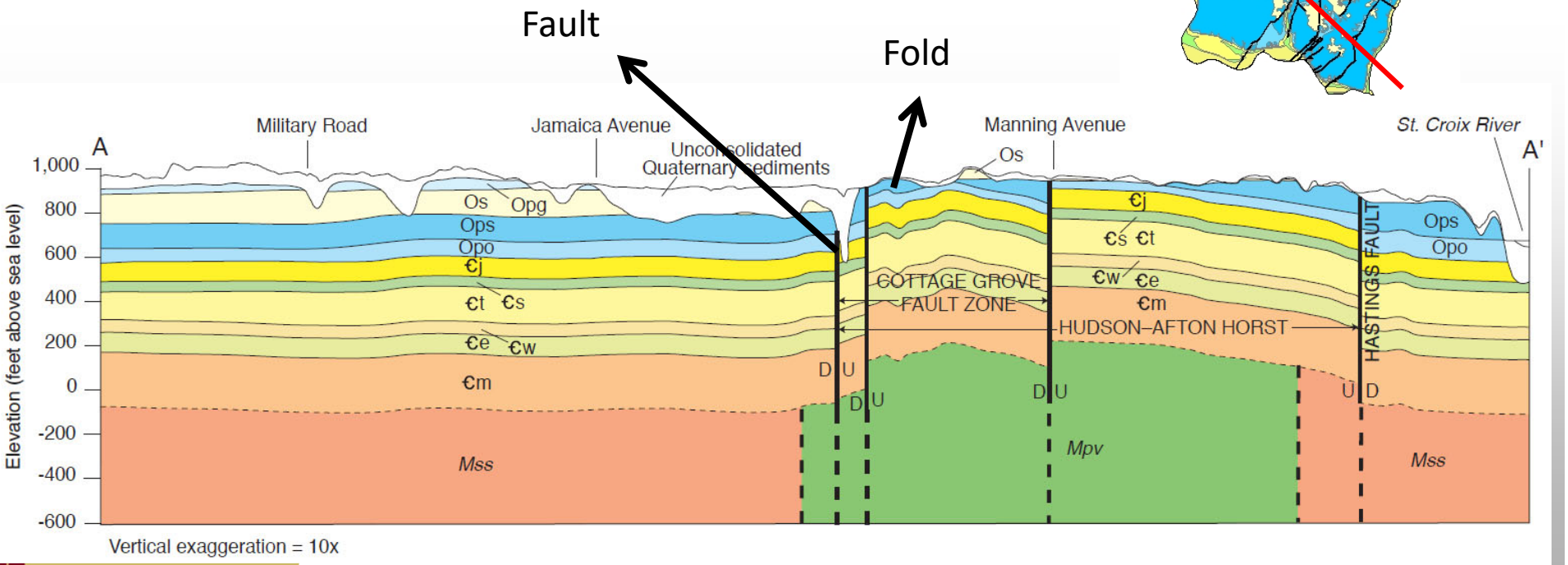


- Bedrock geologic maps depicts the type, structure, and distribution of all of the different bedrock units beneath the Quaternary sediment.

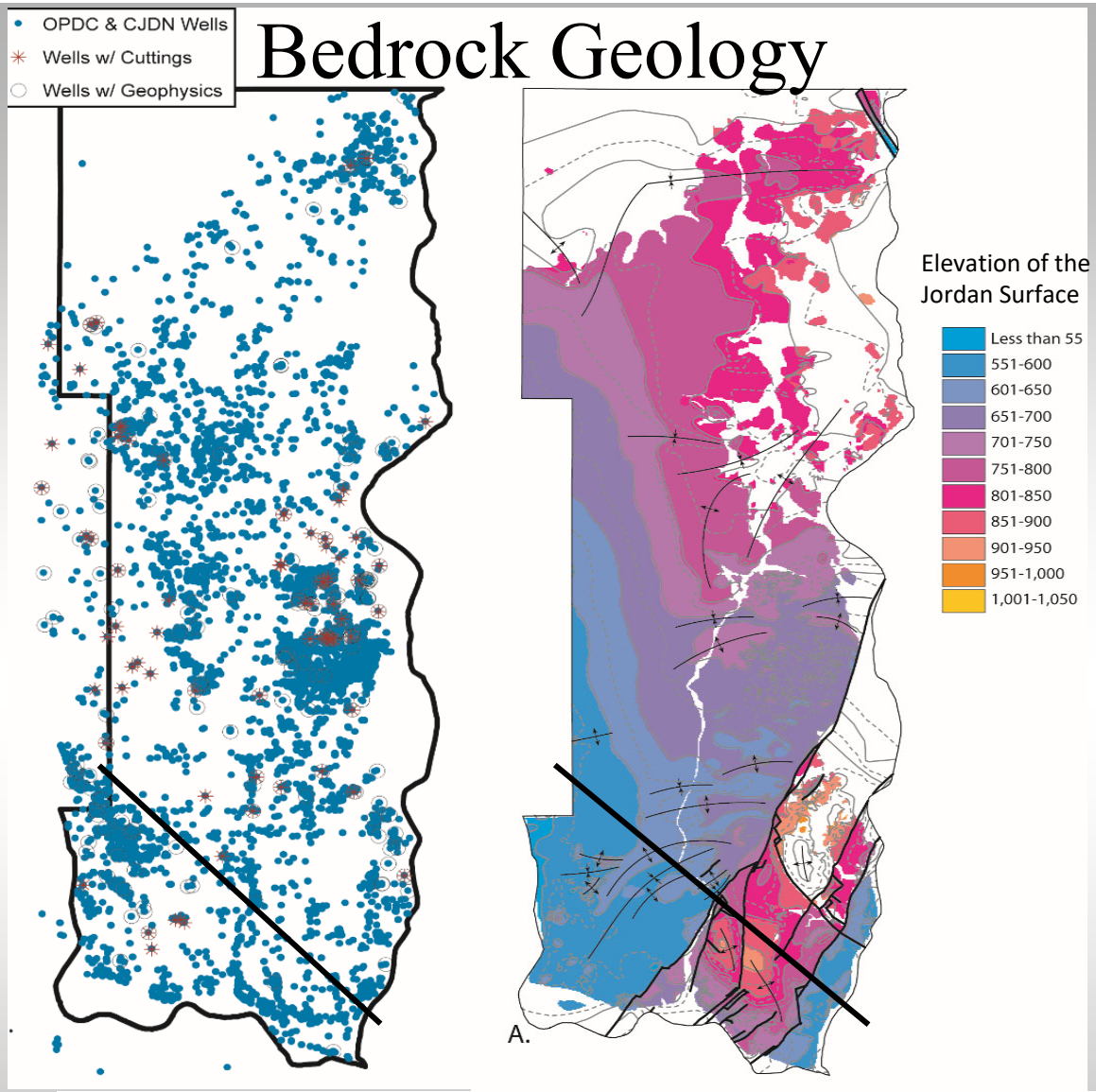
Bedrock Geology

Cross sections depict how the rock formations are stacked in a vertical sequence, their structure and thickness





Bedrock Geology

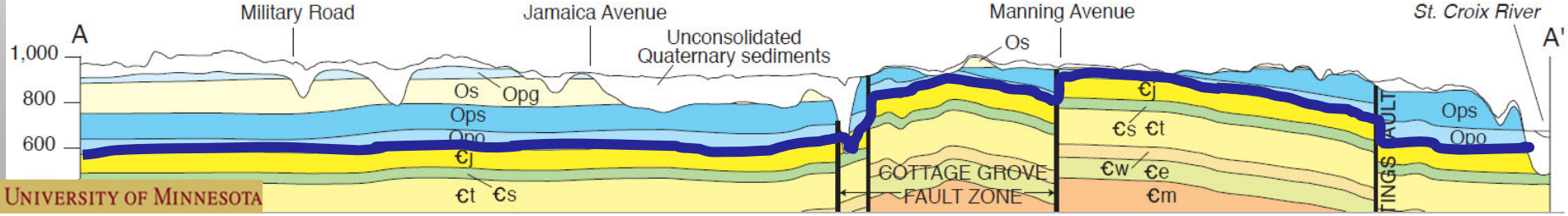


Washington County Structure Mapping of the top of the Jordan Sandstone

-Over 500 feet of relief on the Jordan surface

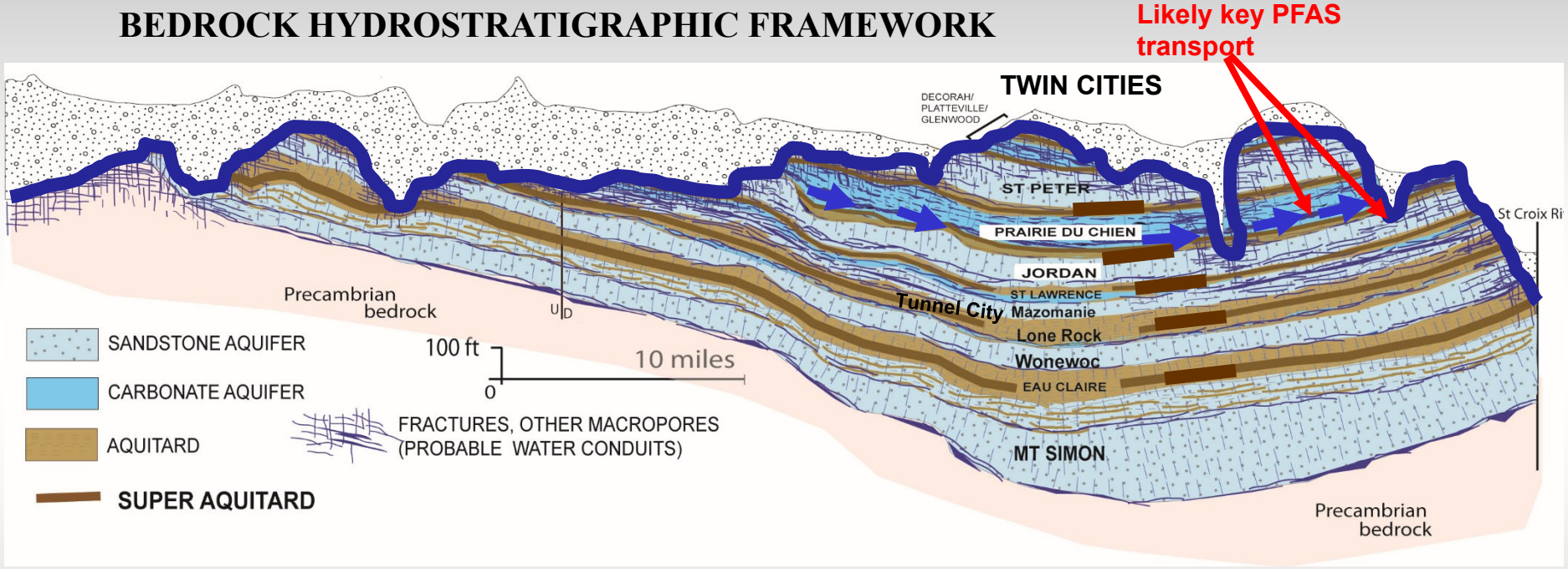
-Near vertical displacement on the order of 50-300 feet at faults

-Rasters of tops of all bedrock units are part of the atlas products (therefore the elevation and thickness of all units is gridded)



Related MGS research offers information on hydrogeologic properties (some of which is used for DNR Part B of atlas)

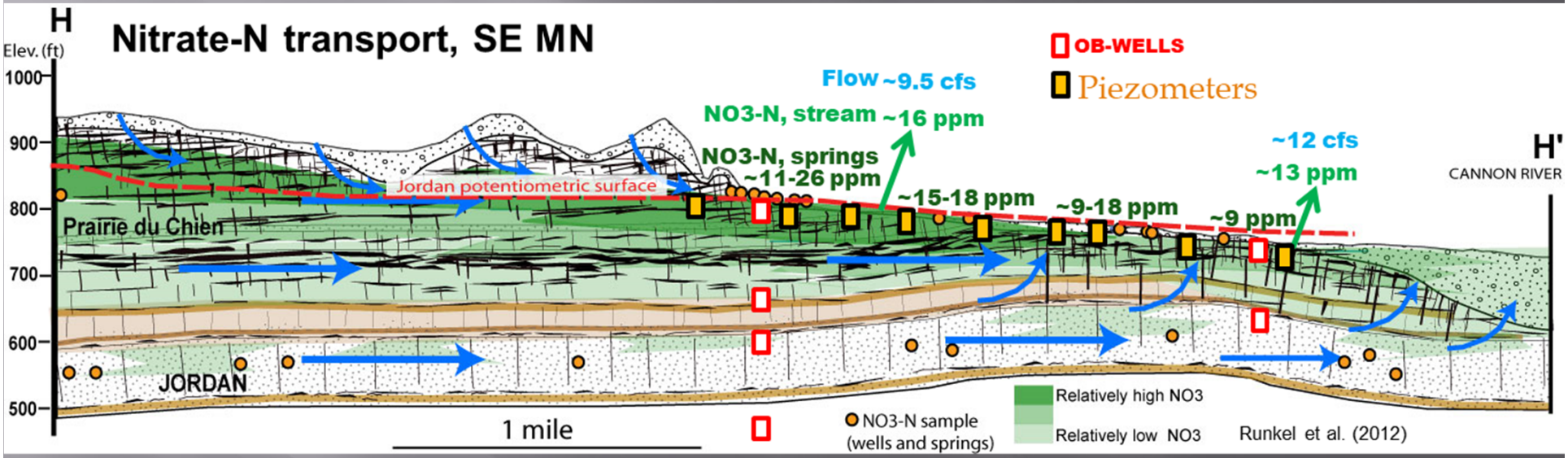
BEDROCK HYDROSTRATIGRAPHIC FRAMEWORK



Based on:
30+ years detailed mapping
Thousands of borehole geophysical logs
Hundreds of hydraulic tests at multiple scales
Fracture characterization (outcrop and boreholes)
Groundwater chemistry (esp residence time, e.g. MNDNR Part B atlases)
Dye tracing

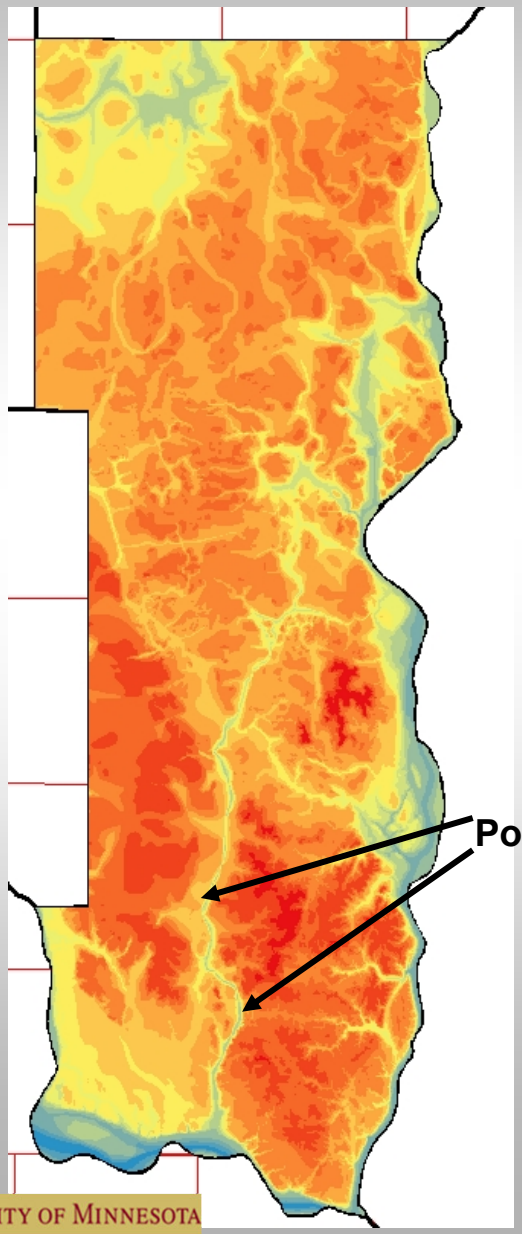
Some Key References relevant to SE MN:
Alexander et al 1996
Runkel et al 2003, 2006, 2013, 2014, 2018
Tipping et al 2006
Anderson et al 2011
Luhman et al 2011
Green et al 2012
Meyer et al 2016
Many other reports/pubs on county & smaller scale map and hydro projects, **including Washington Co**

Hydrostratigraphy integrated with regional water chemistry data for conceptual model of contaminant transport



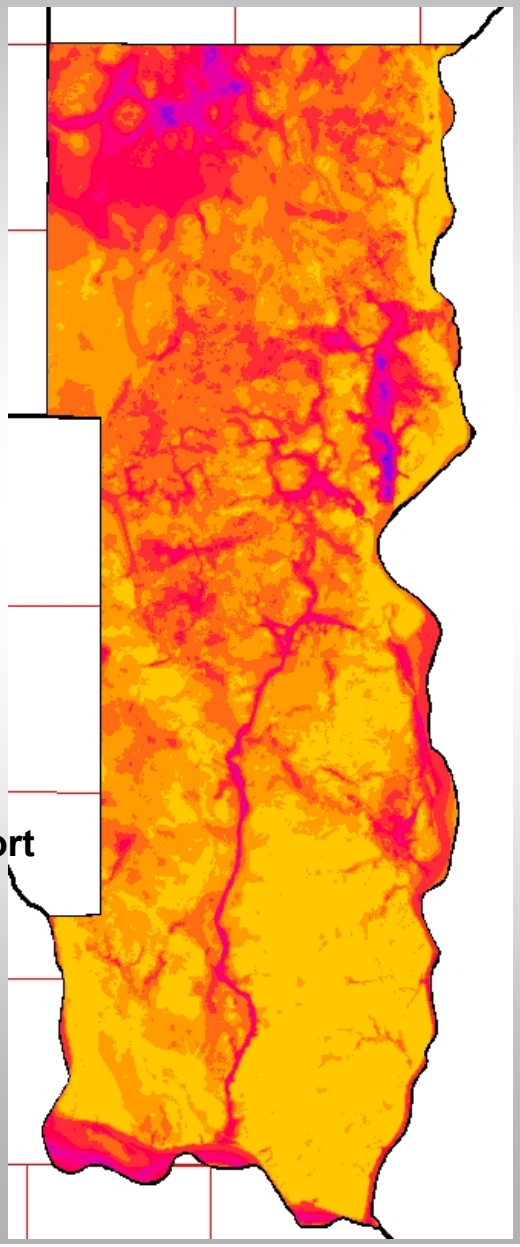
Bedrock Topography

- Elevation of the bedrock surface (350-1050 ft)

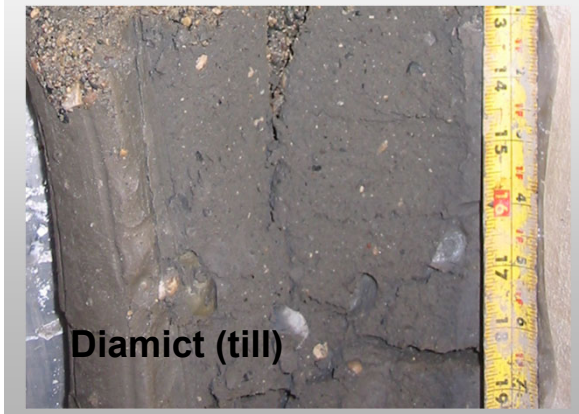


Depth to Bedrock

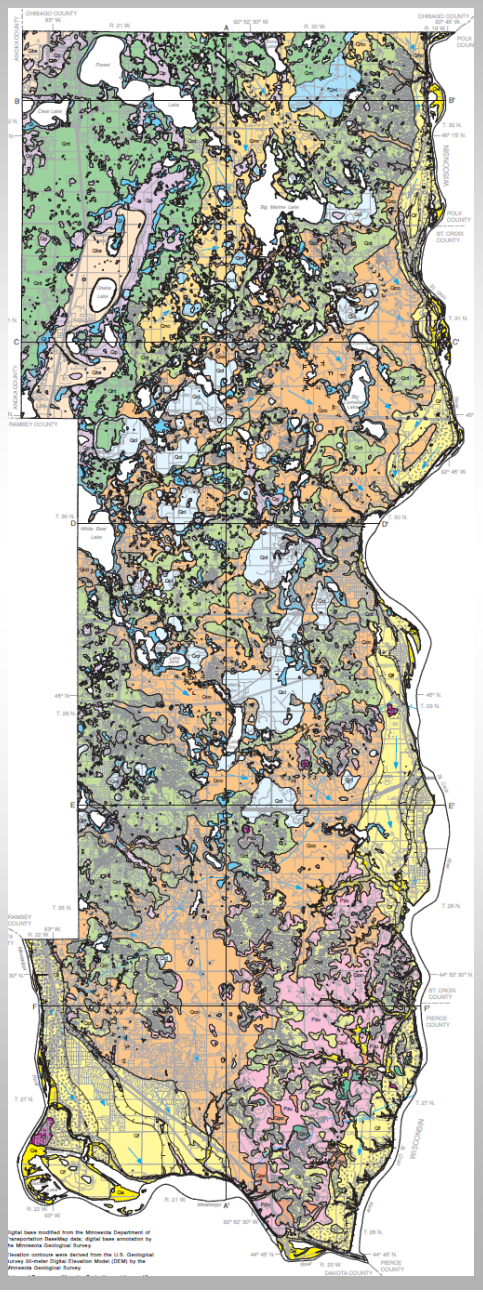
- Range from 0 to 450 feet thick.



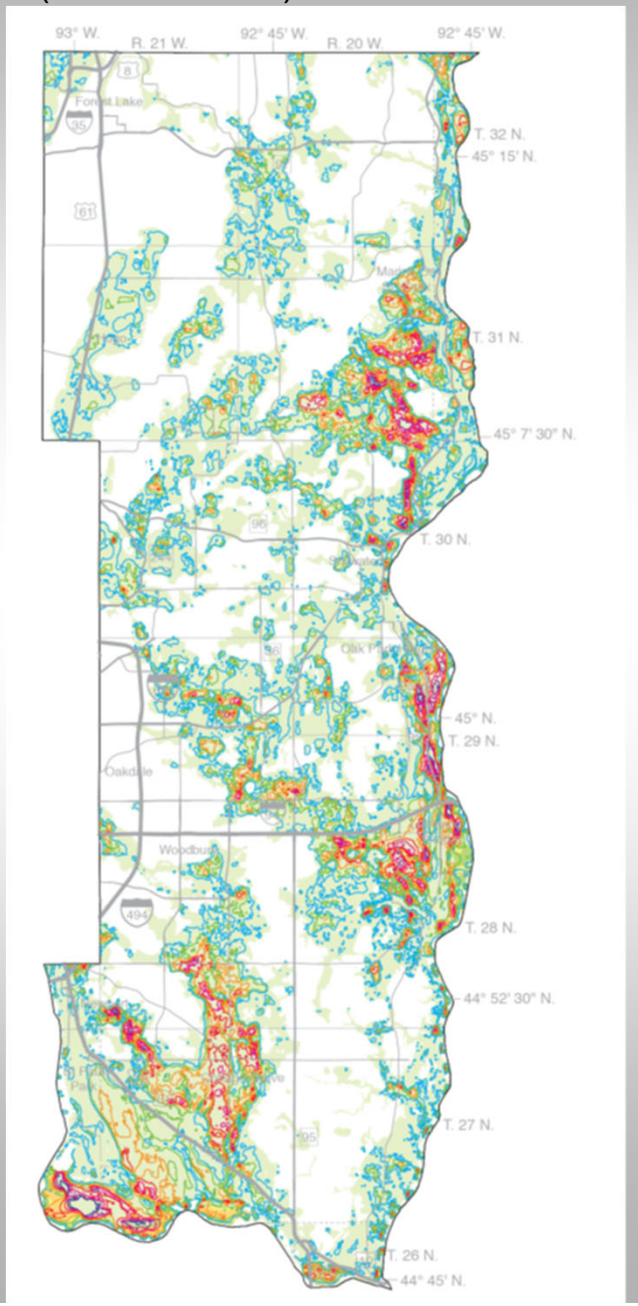
Quaternary Unconsolidated sediment



Surficial Geologic map

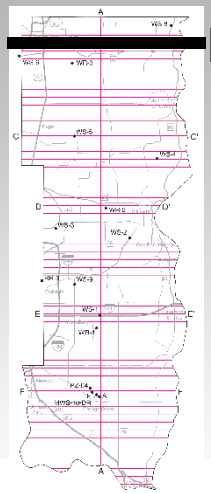


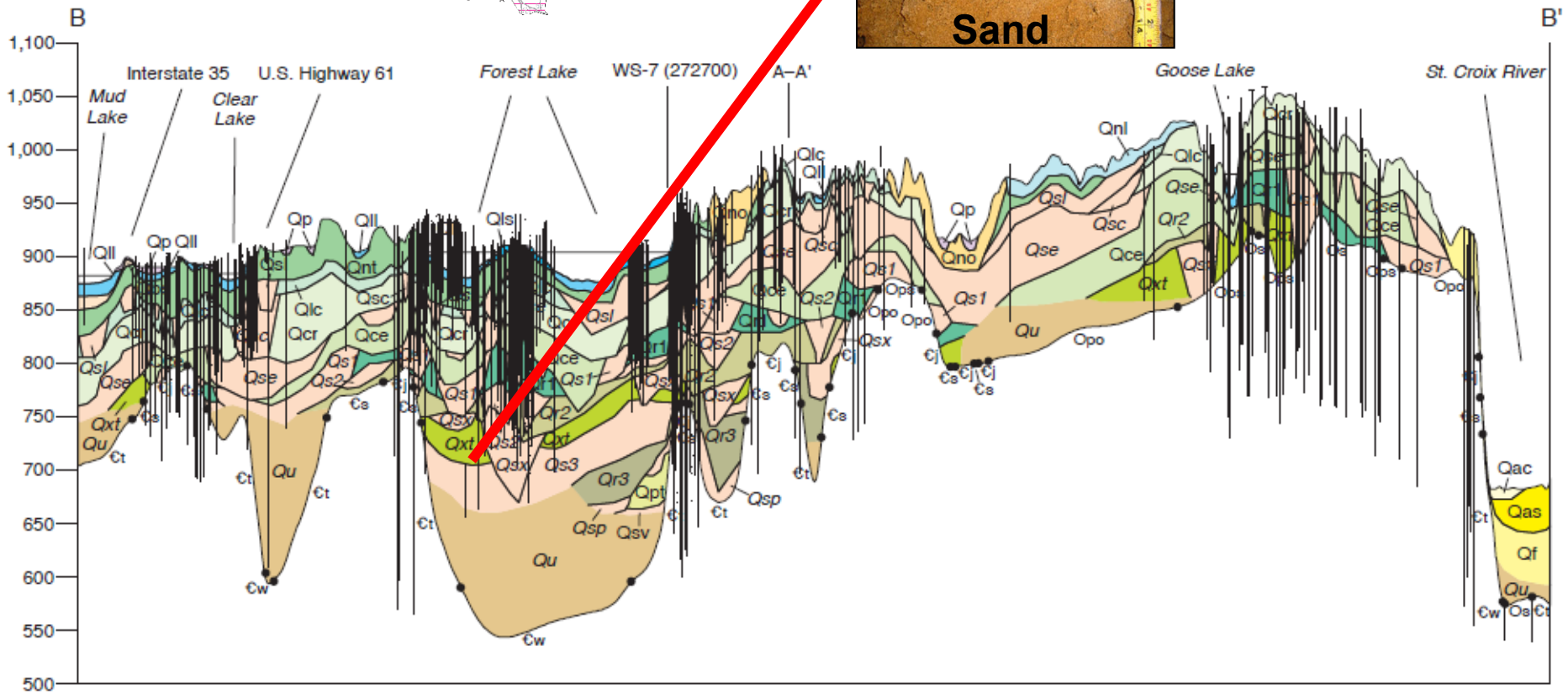
Surficial Sand and Gravel only (with thickness)



Quaternary Unconsolidated sediment

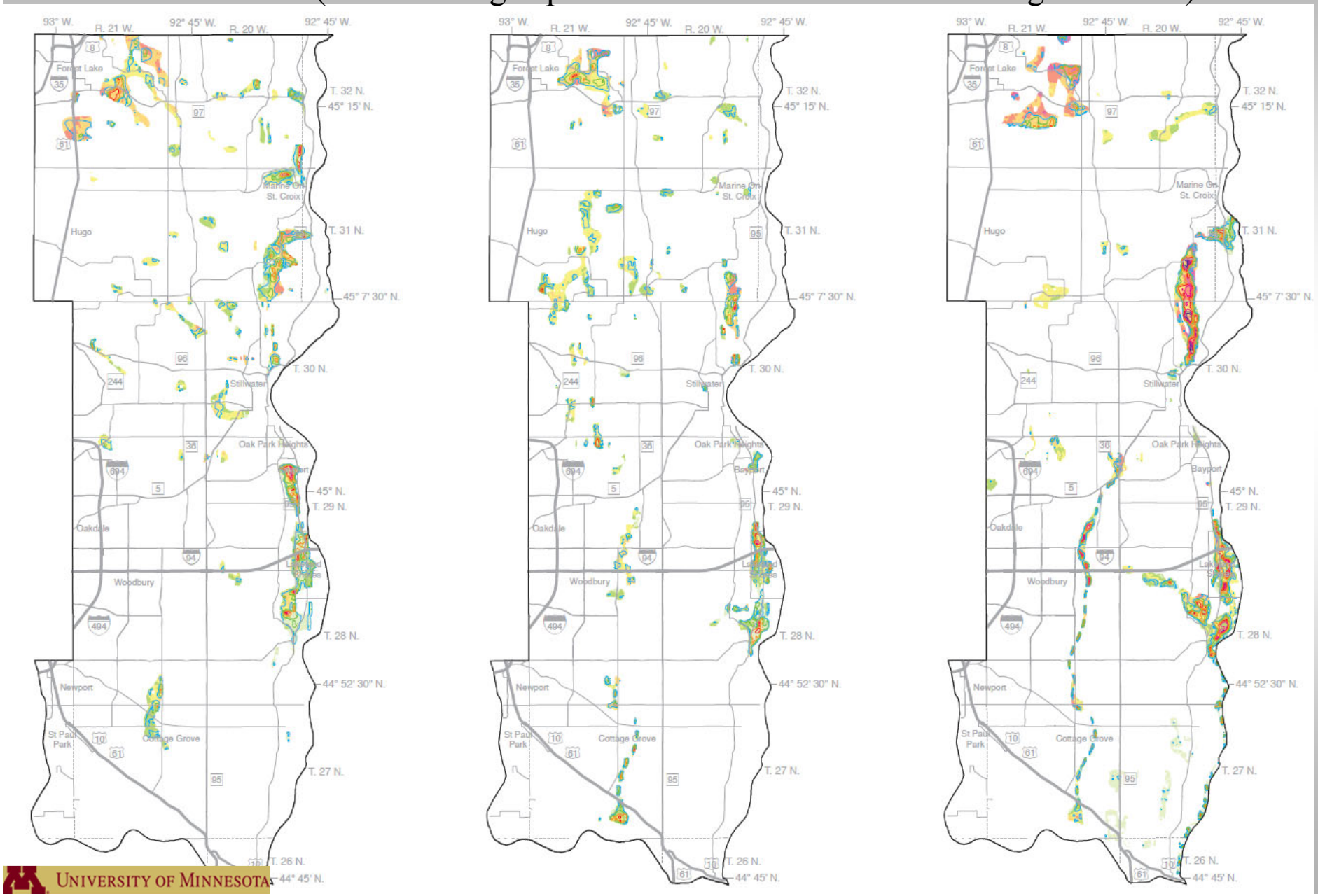
Cross-sections





Quaternary Unconsolidated sediment

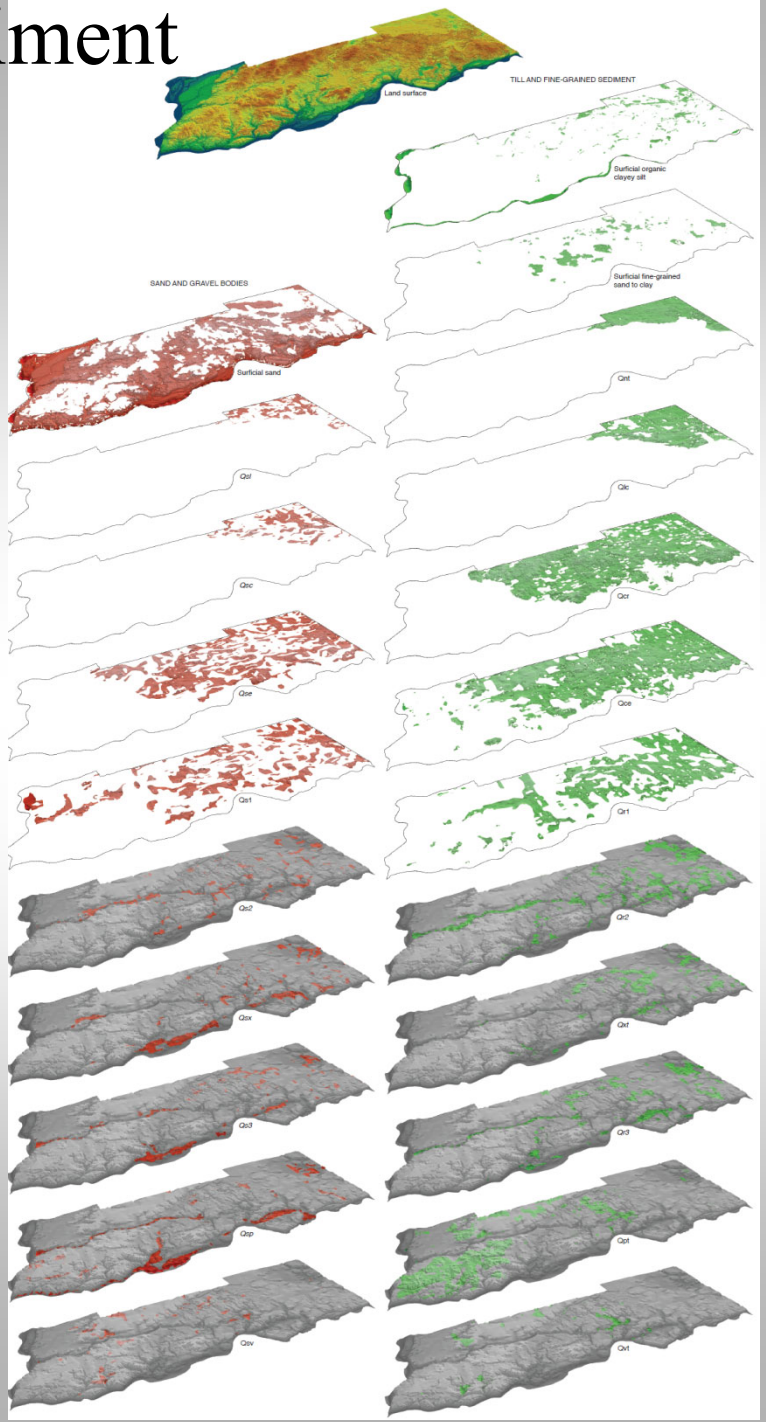
Sand Models (here showing depth and thickness of three sand and gravel units)



Quaternary Unconsolidated sediment

Sand Models

Stacked surfaces from land surface to bedrock surface
Major sand bodies on left
Intervening till and other fine grained sed on right
Gray shading is bedrock surface



Quaternary Unconsolidated sediment

Groundwater modeling

- "Containers" geometrically more complex than bedrock
- Matrix more complex
- Fractures poorly understood
- K values scarce and for fine units uncertain
- A number of methods have been applied for modeling

Appendix A. Table 2. Summary of horizontal and vertical hydraulic conductivity values method, this study.

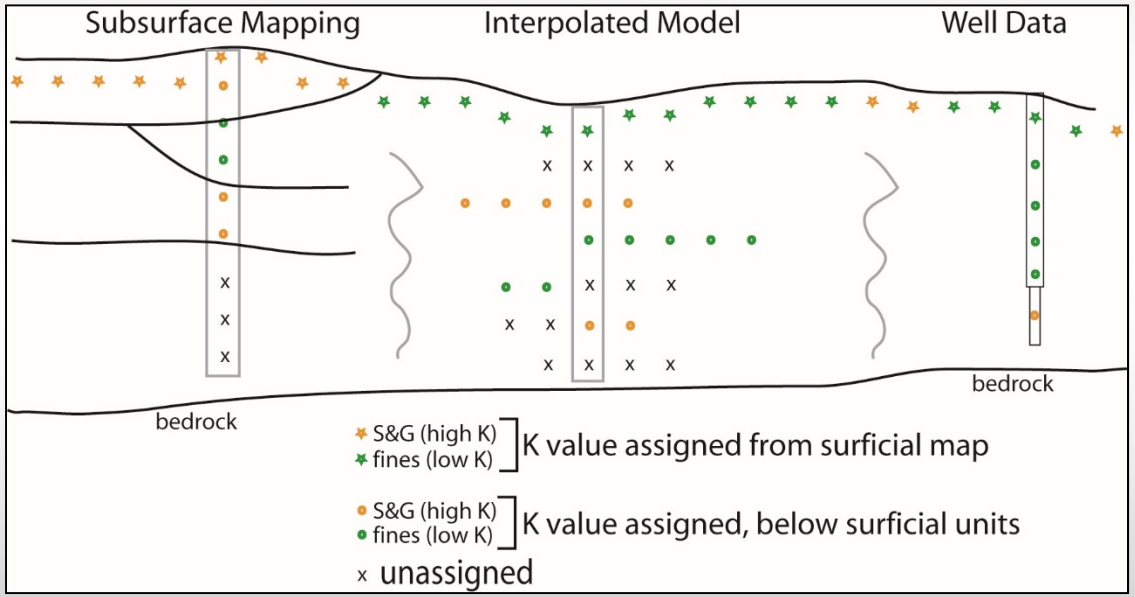
Hydraulic Conductivity - horizontal (ft/day)

method/hydro_class		n	mean	min	max	geomean
Grain size	description					
1	loam to clay loam	1155	2.37E-01	2.83E-05	5.45E+00	9.64E-02
2	loam to sandy loam	325	1.26E+00	2.78E-03	1.42E+01	5.70E-01
3	loam, silt rich; silt and clay	79	3.45E-01	8.57E-03	3.35E+00	1.39E-01
4	loam to sandy clay loam	37	1.35E+00	8.85E-02	3.42E+00	1.02E+00
5	sand and gravel	168	5.47E+01	2.83E-02	3.09E+02	1.92E+01
6	fine sand	32	4.81E+00	5.84E-05	3.69E+01	1.61E-01
7	sandy silt	38	5.65E-01	1.42E-04	1.13E+01	2.42E-02
Lab Permeameter						
5	sand and gravel	3	2.34E+00	4.30E-01	4.50E+00	1.60E+00
Aquifer test						
5	sand and gravel	118	1.17E+02	4.82E-01	4.15E+02	6.53E+01
Slug test						
1	loam to clay loam	17	3.87E-01	5.67E-04	3.83E+00	2.80E-02
2	loam to sandy loam	34	2.27E+00	2.83E-03	4.30E+01	2.00E-01
3	loam, silt rich; silt and clay	7	1.43E-02	7.65E-05	9.35E-02	7.74E-04
5	sand and gravel	215	3.98E+01	5.00E-03	5.40E+02	8.07E+00
6	fine sand	14	3.91E+00	1.42E-03	2.61E+01	5.11E-01
7	sandy silt	18	2.49E+01	1.40E-01	1.50E+02	5.54E+00
Specific Capacity - excluding CWI						
5	sand and gravel	17	40.7294	1.5	152	2.66E+01

Hydraulic Conductivity - vertical (ft/day)

method		n	mean	min	max	geomean
Lab Permeameter - constant head						
1	loam to clay loam	17	1.68E-01	6.24E-05	2.83E+00	7.26E-04
5	sand and gravel	51	7.79E+00	4.82E-05	1.11E+02	1.69E+00
6	fine sand	2	1.70E+00	1.50E+00	1.90E+00	1.69E+00
7	sandy silt	9	8.55E-01	8.50E-04	5.67E+00	8.88E-02
Lab Permeameter - falling head						
1	loam to clay loam	37	7.14E-02	2.83E-06	1.98E+00	2.19E-04
2	loam to sandy loam	14	2.45E-01	1.98E-05	3.40E+00	9.81E-04
3	loam, silt rich; silt and clay	4	1.94E-04	6.80E-05	3.97E-04	1.55E-04
5	sand and gravel	4	4.27E-01	6.80E-03	1.13E+00	1.22E-01
6	fine sand	1	2.35E-01	2.35E-01	2.35E-01	2.35E-01
7	sandy silt	31	1.07E-01	9.35E-06	1.64E+00	1.73E-03
Aquifer test		3				
5	sand and gravel	3	6.76E+01	7.00E-01	1.01E+02	1.93E+01

Tipping et al., 2010

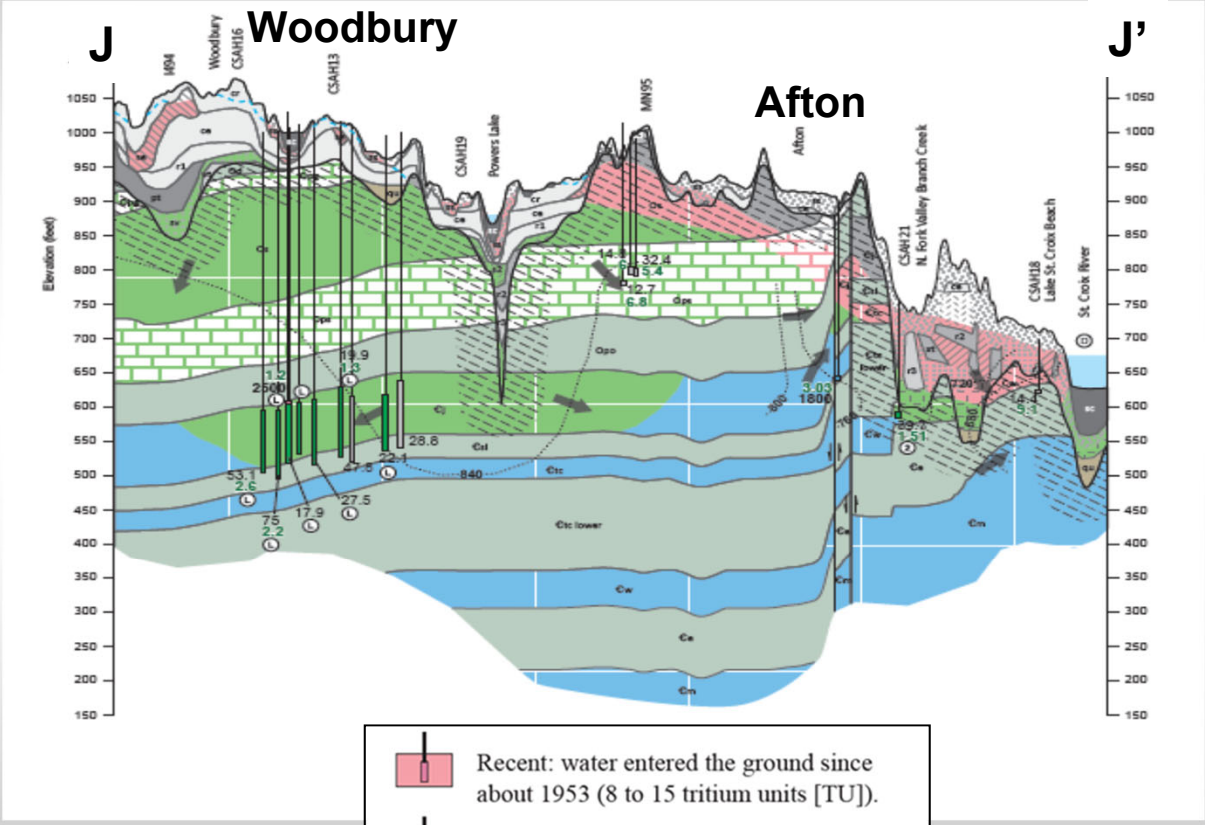


Tipping, 2011

DNR Part B: Hydrogeology

- Illustrates groundwater hydrogeologic setting, aquifer distribution, pollution sensitivity, groundwater recharge, and subsurface flow of the aquifers within the county.

Example Hydrogeologic cross section



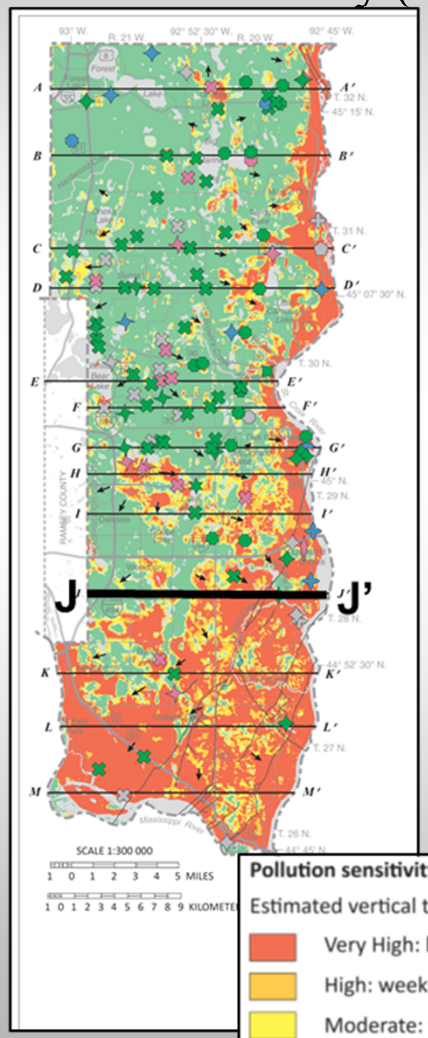
Recent: water entered the ground since about 1953 (8 to 15 tritium units [TU]).

Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).

Vintage: water entered the ground before 1953 (less than or equal to 1 TU).

Well not sampled for tritium.

Pollution Sensitivity (Bedrock)



Pollution sensitivity rating

Estimated vertical travel time.

- Very High: hours to months
- High: weeks to years
- Moderate: years to decades
- Low: decades to a century
- Very Low: a century or more