DNR datasets related to the County Geologic Atlas Program, Part B: Hydrogeology

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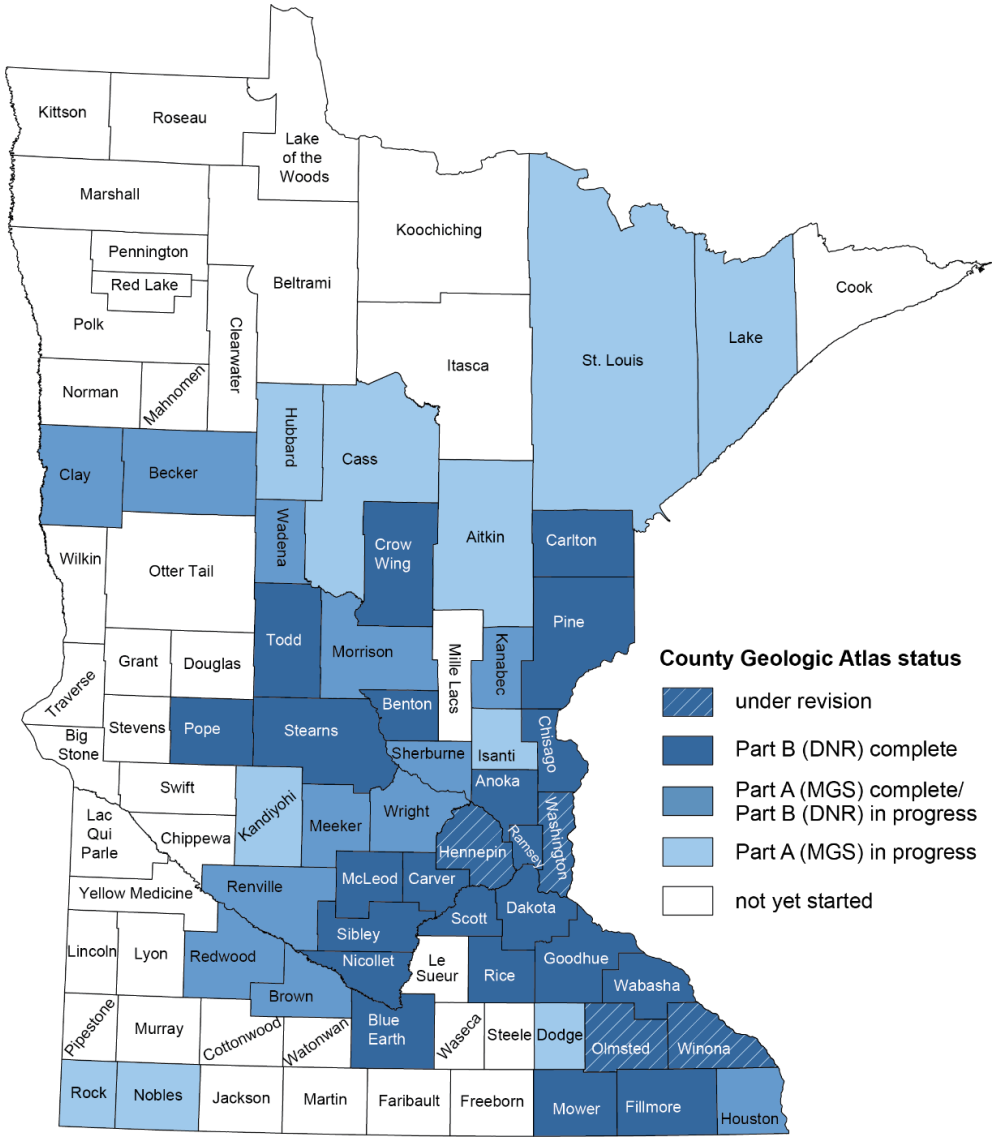
INTRODUCTION

- DNR County Geologic Atlas Part B started early 1990s
- CGA reports, methods, and procedures published online
- Large statewide datasets now available
- DNR Monitoring and Surveys Unit monitors groundwater levels, stream flow, lake levels and climate

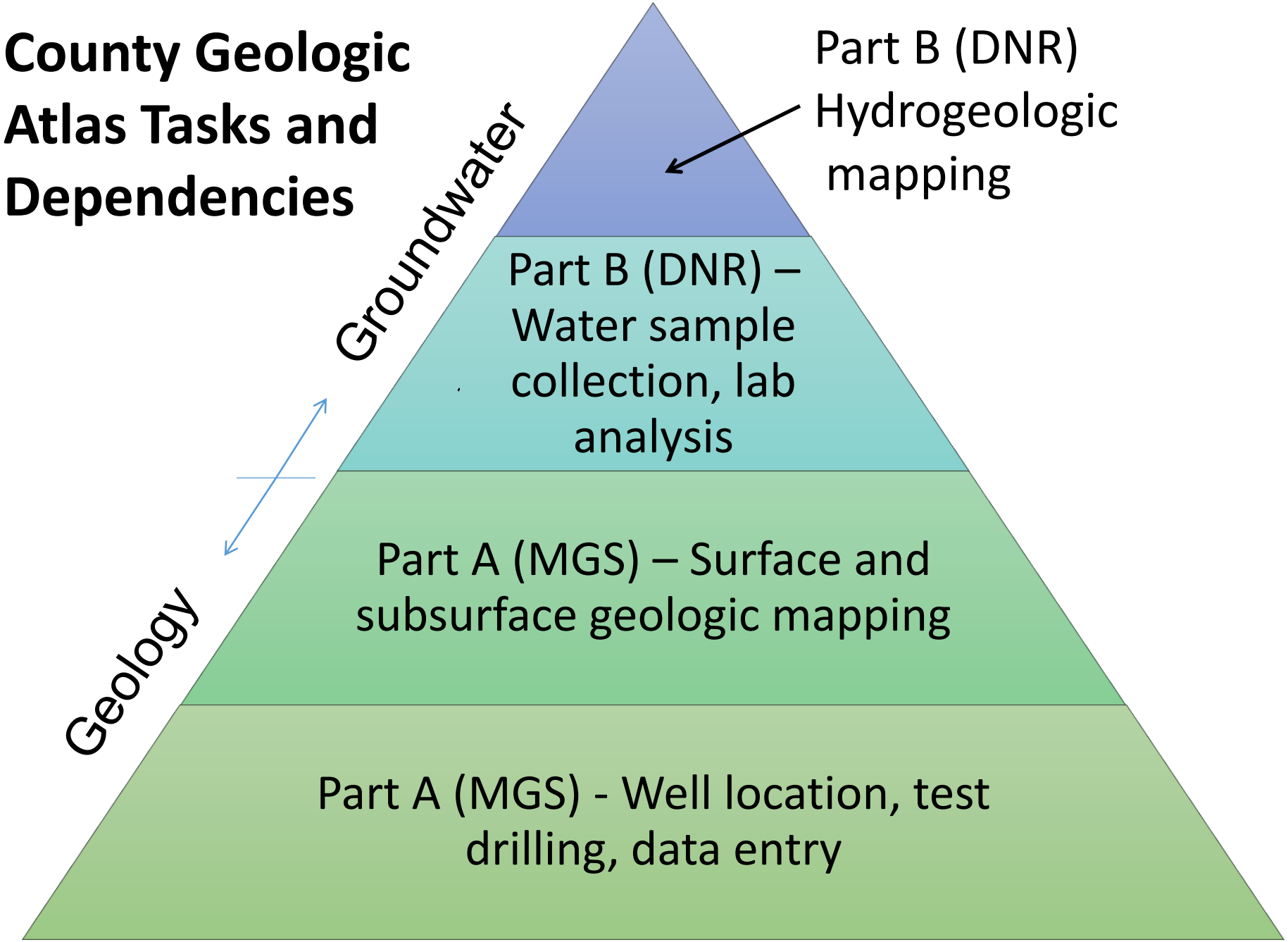
County Geologic Atlas Parts A and B

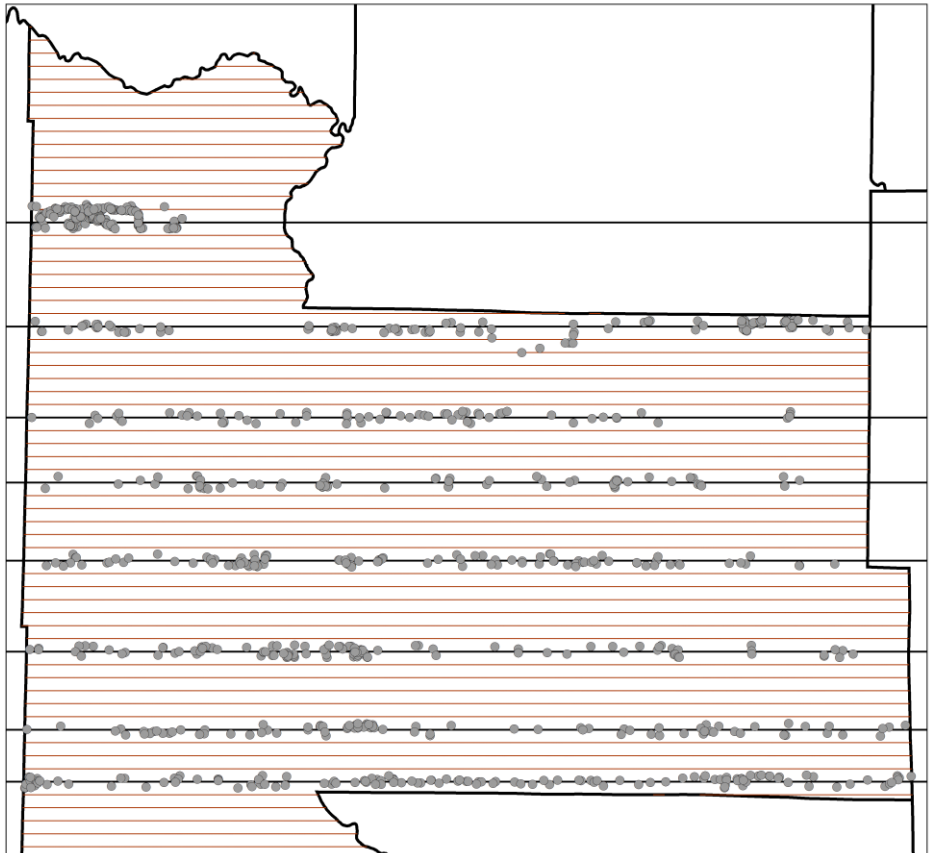


ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

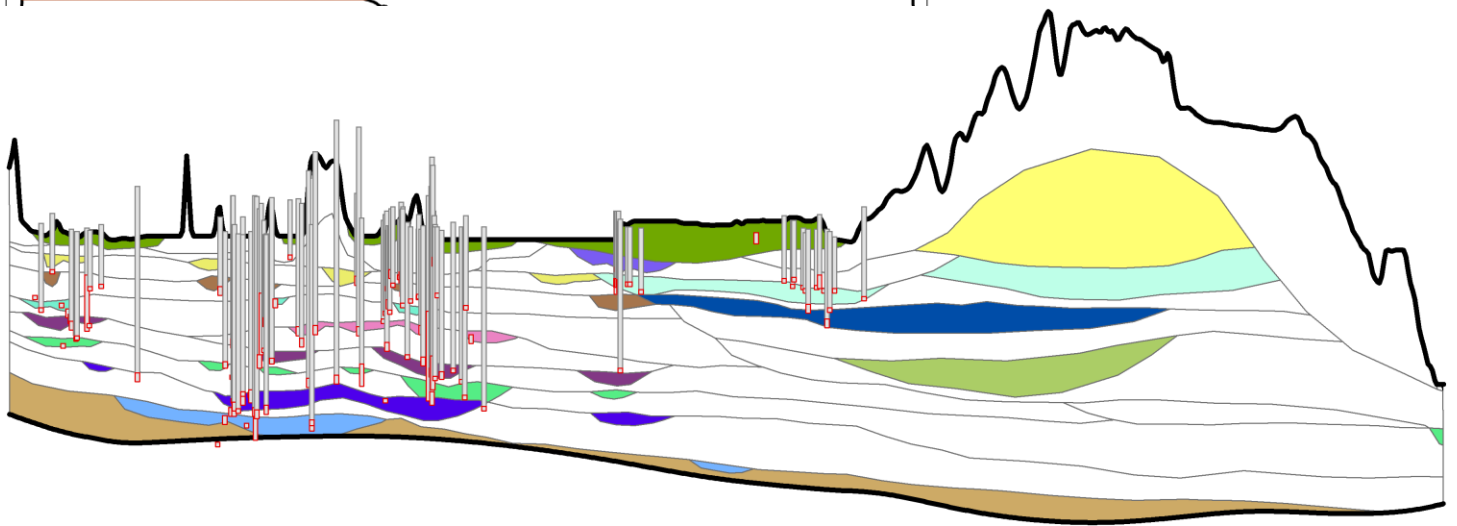
CLEAN WATER LAND & LEGACY AMENDMENT

County Geologic Atlas Tasks and Dependencies





Use all data to plan selection of wells for water sampling



Constructing Base Data

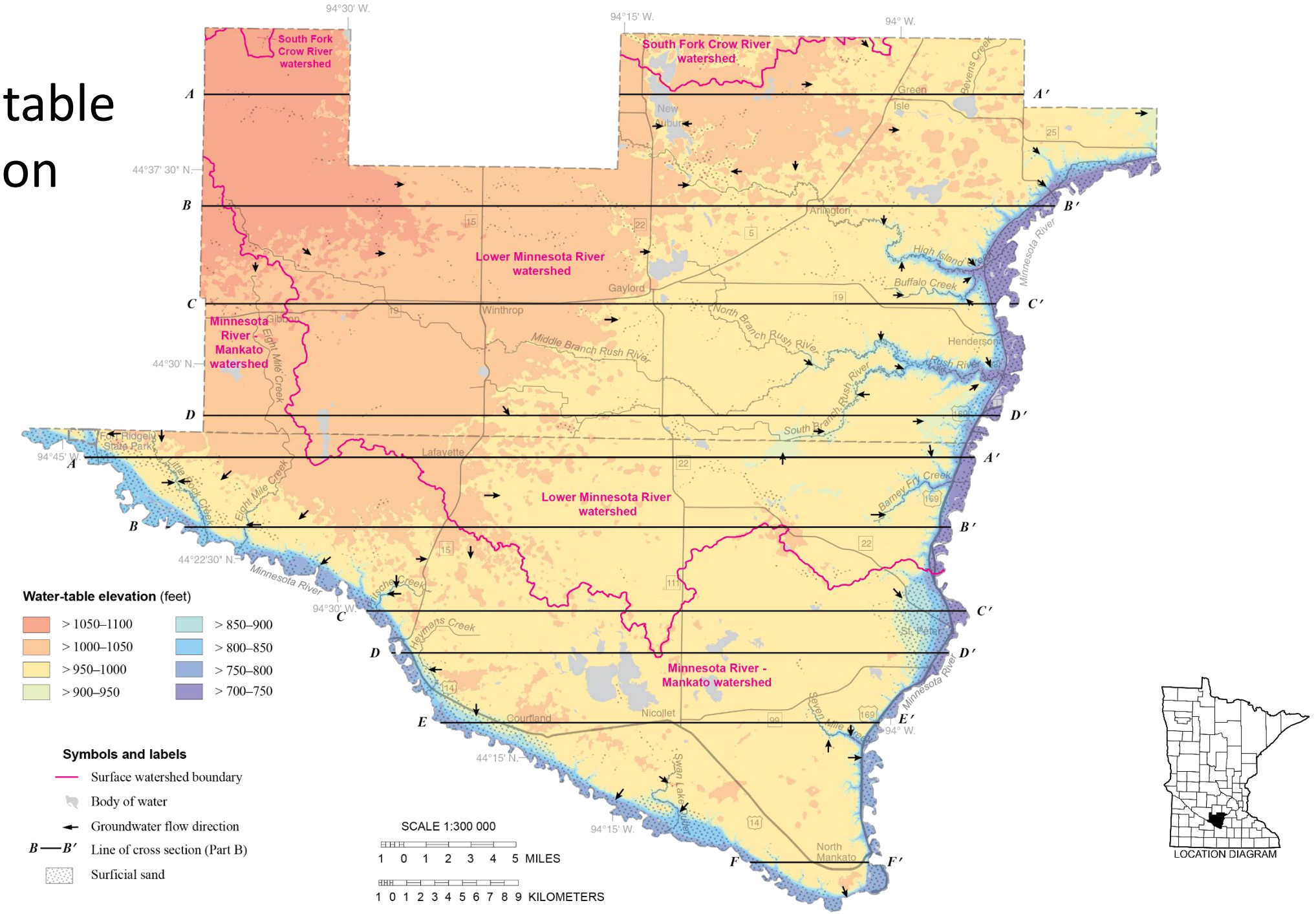
- Quaternary aquifer (AQUIFER_Q). Determine for all wells in county where feasible.
  - Solely based on geology, where well screen intersects aquifer. No aquifer test or other hydraulic data
  - Well feature class with AQUIFER_Q – included with Part B datasets.
  - AQUIFER_Q only valid inside one county.
    Not added to CWI.

Constructing Base Data

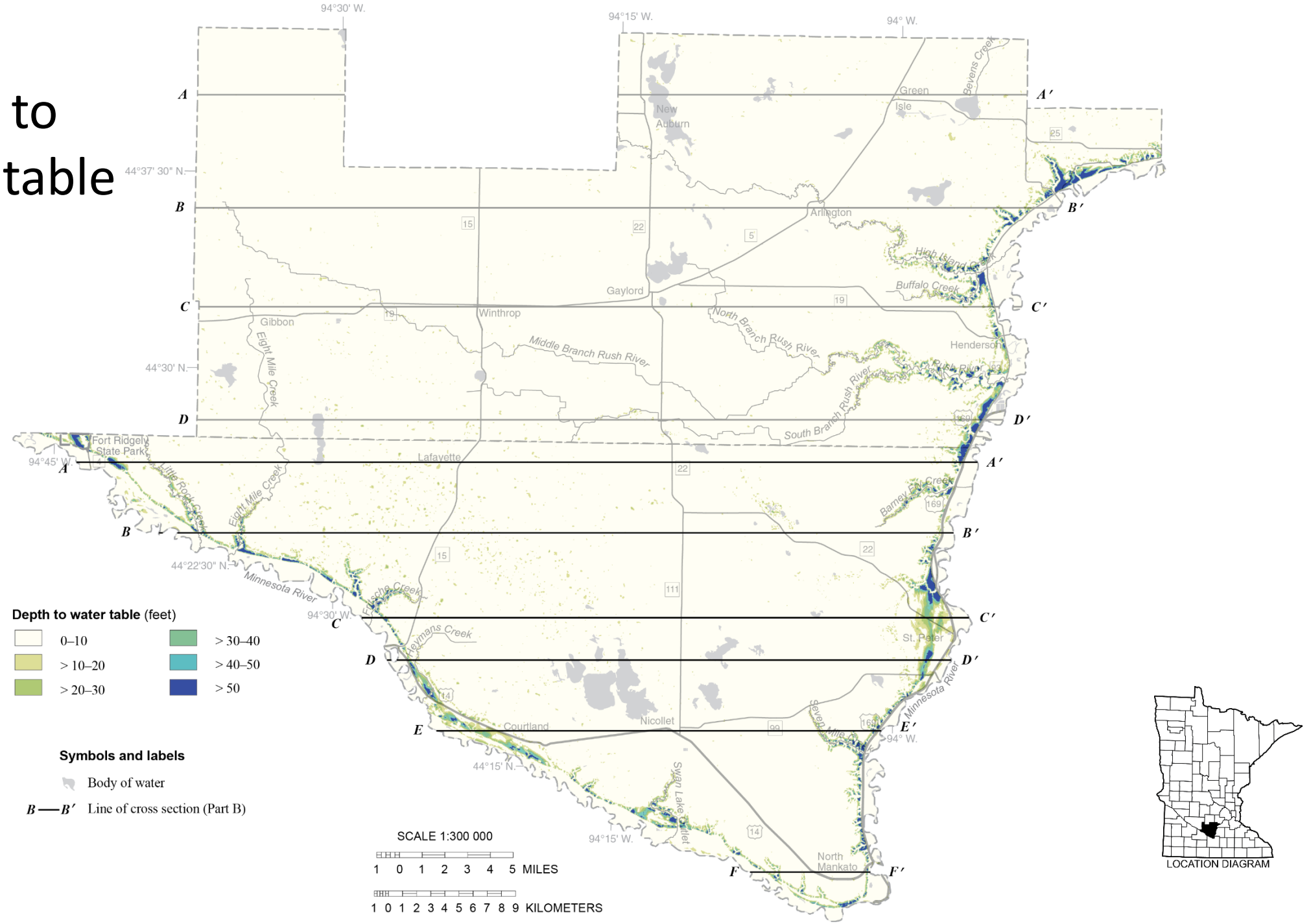
Data Sources - water-table elevation and depth to water table maps

- NRCS County Soil Survey – Depth to wet conditions in soils (not perched)
- Elevation of surface water bodies (rivers and lakes)
- Static water elevation in wells from County Well Index (CWI) and measured during sampling.

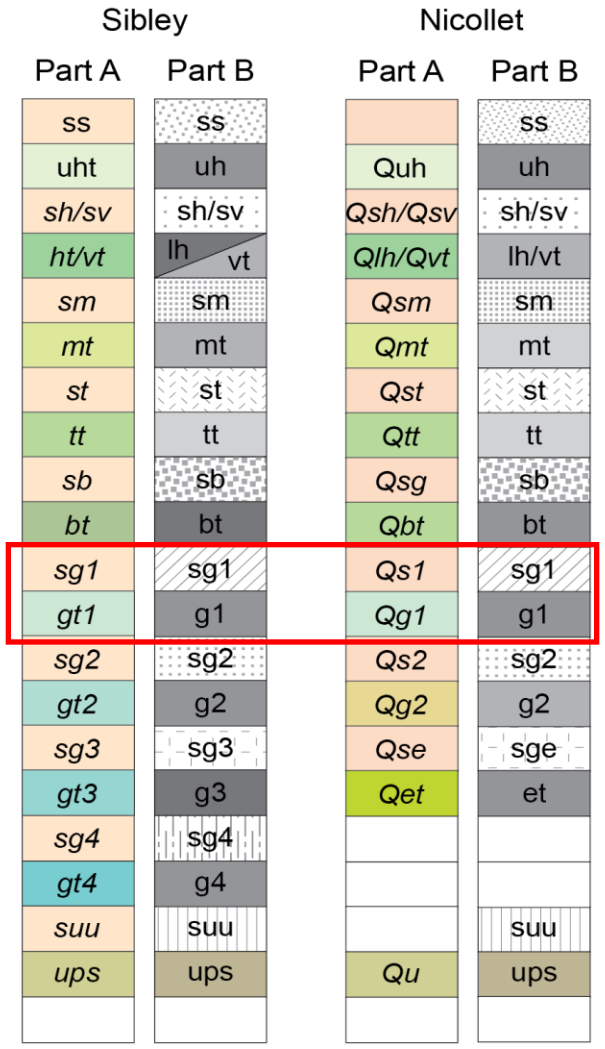
Water table elevation



Depth to water table



Aquifer sg1 Potentiometric Surface



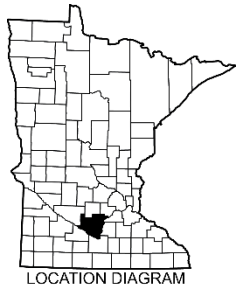
Percent sand in aquitard

>50% and ≤60%

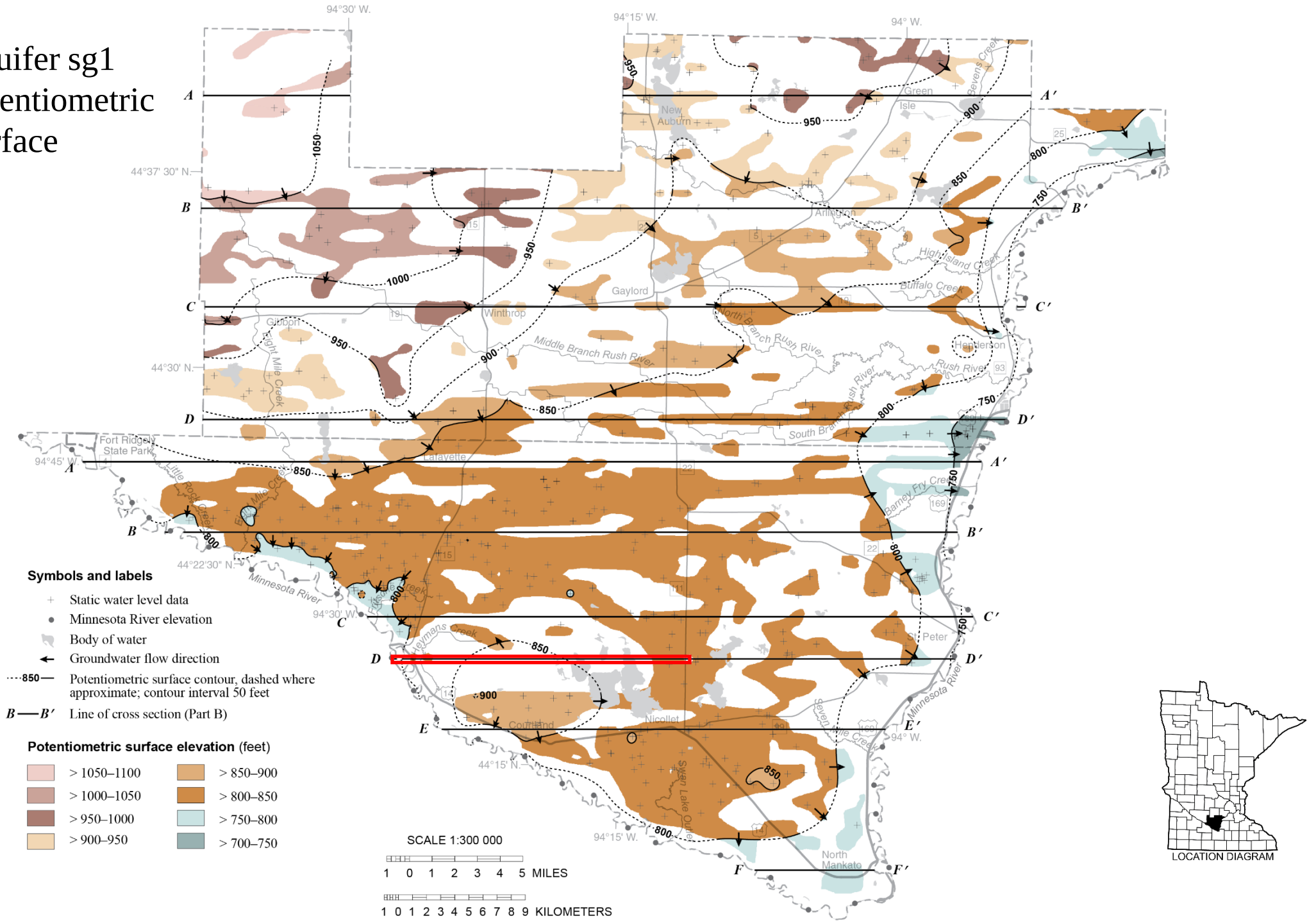
>40% and ≤50%

>30% and ≤40%

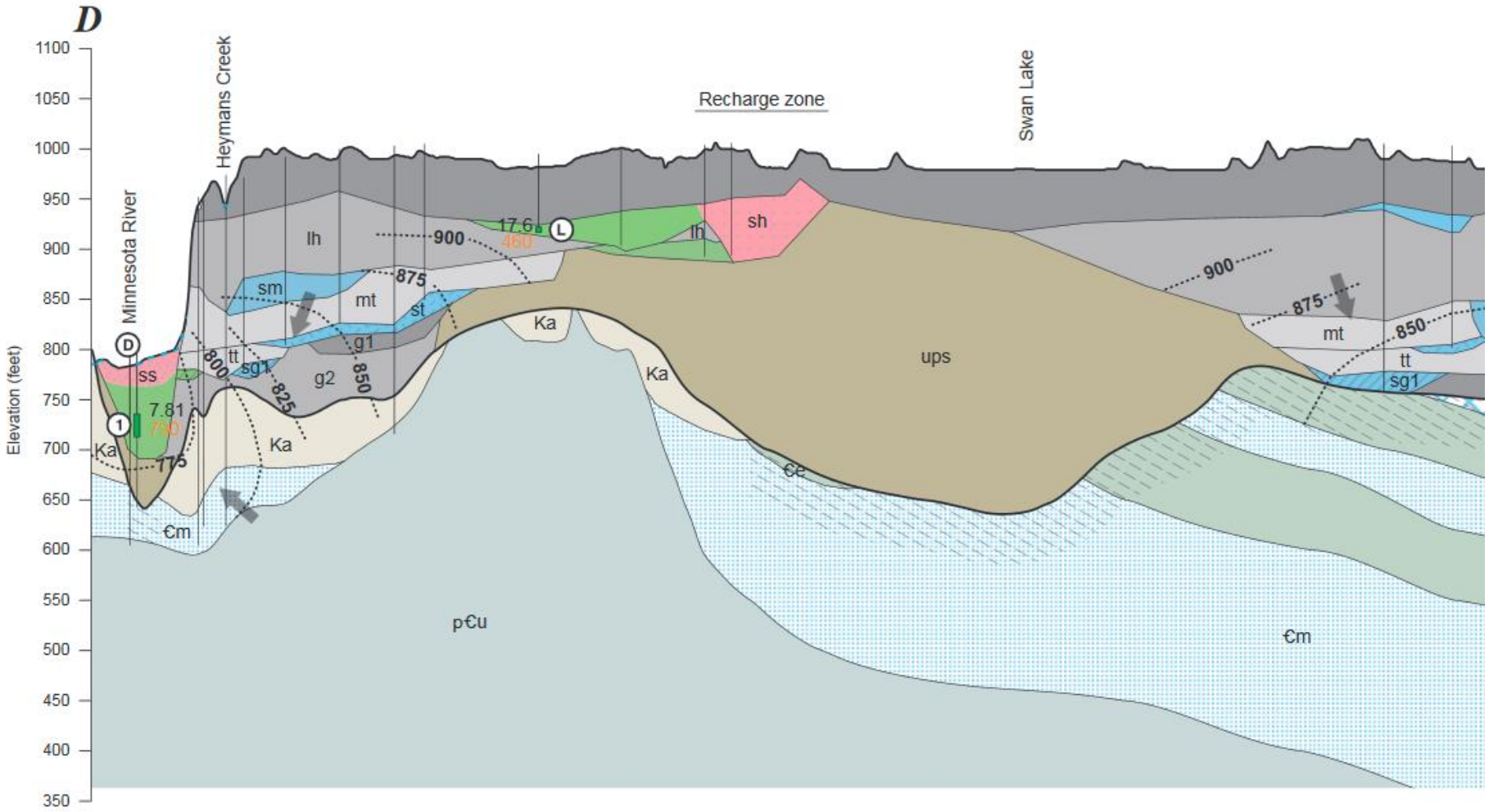
≤30%



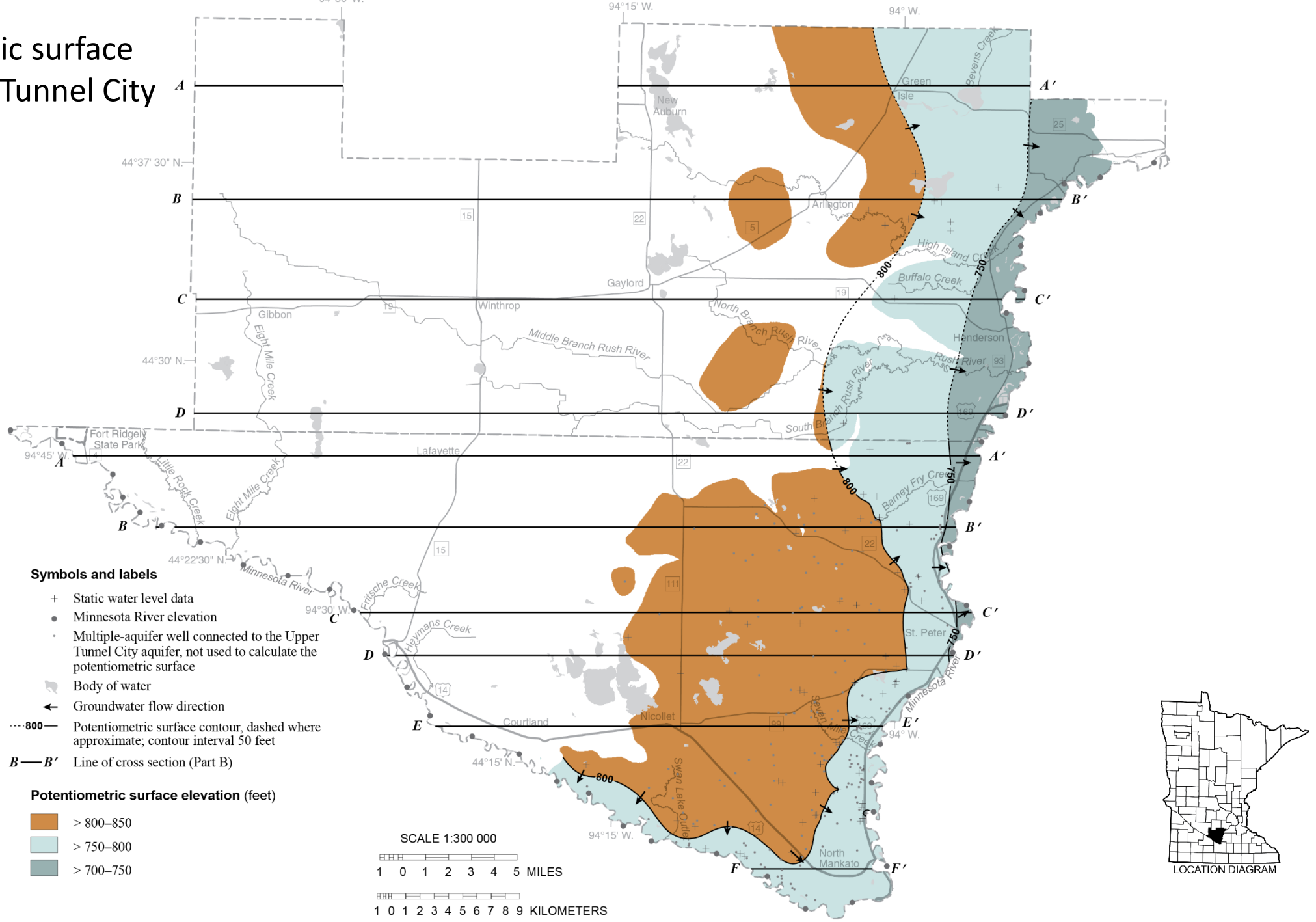
Aquifer sg1 Potentiometric Surface



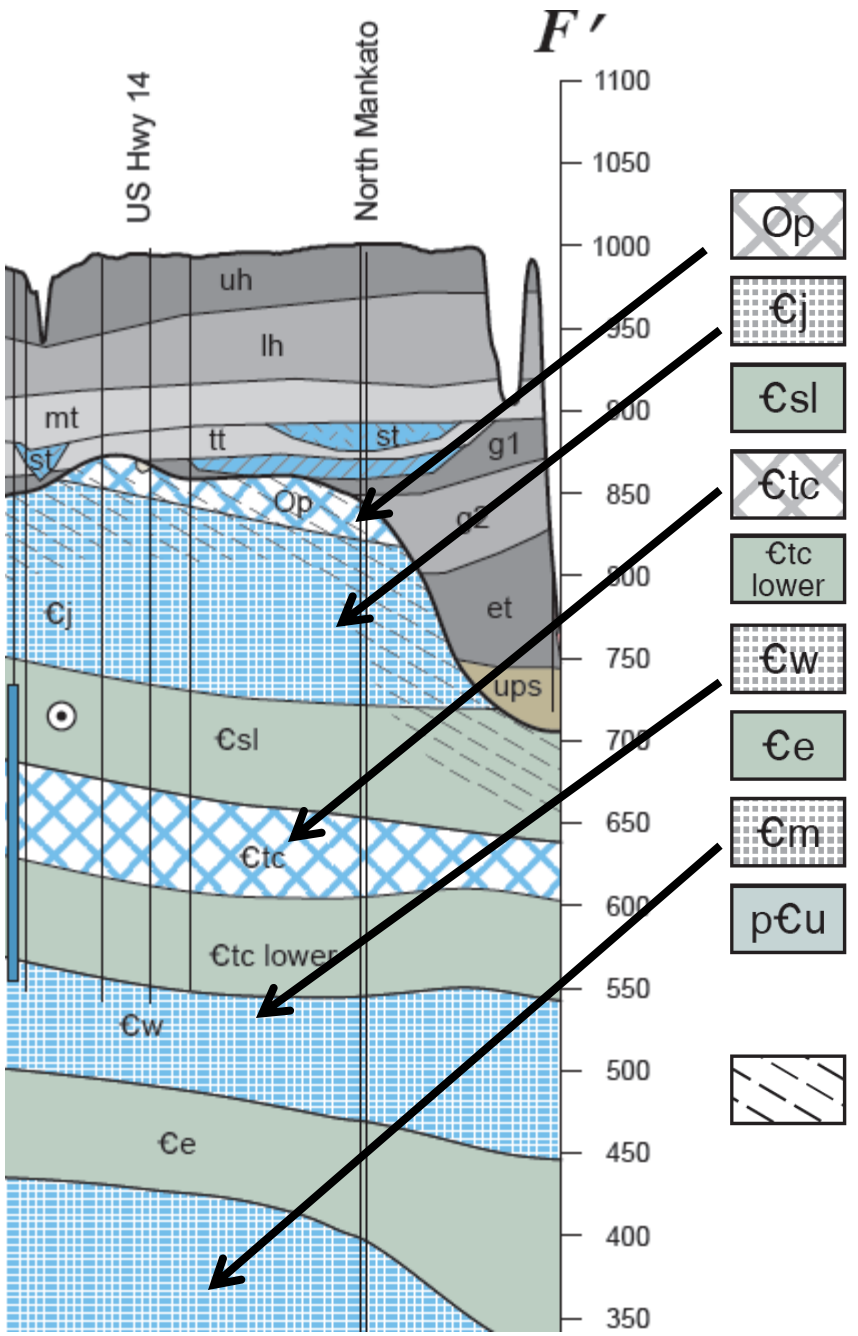
Aquifer sg1 Cross Section Flow



Potentiometric surface of the Upper Tunnel City aquifer



Bedrock hydrostratigraphy



Op — Prairie du Chien

Cj — Jordan

Csl — St. Lawrence Formation

Ctc — Upper Tunnel City

Ctc lower — Lower Tunnel City Group

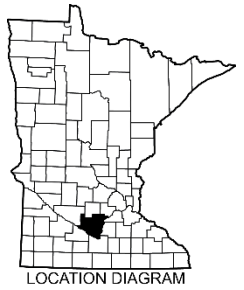
Cw — Wonewoc

Ce — Eau Claire Formation

Cm — Mt. Simon

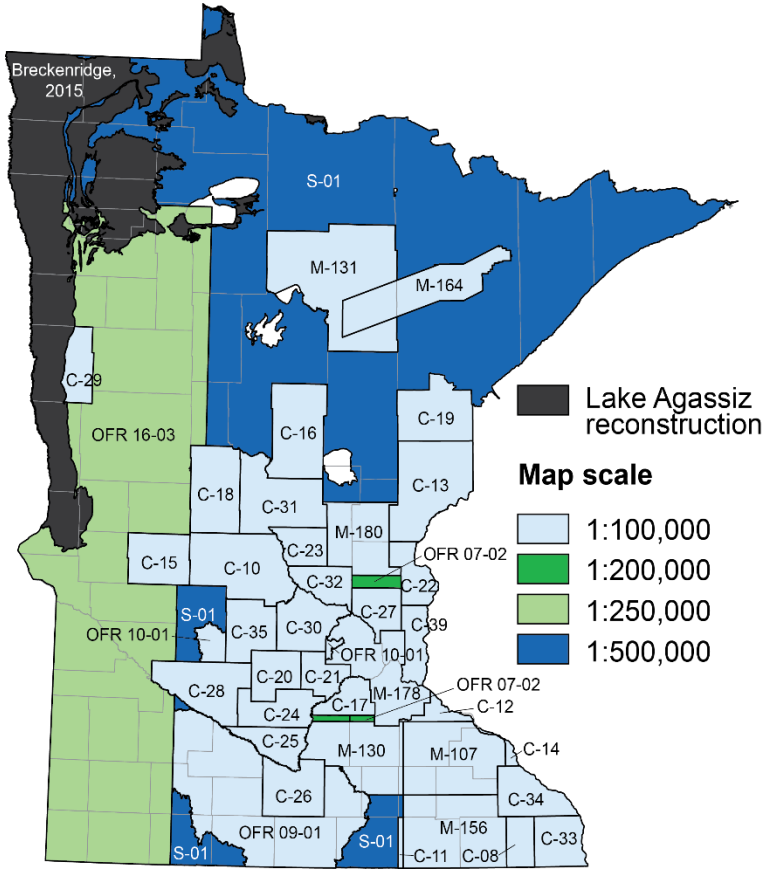
pCu — Precambrian crystalline bedrock

Enhanced-permeability zone



Pollution Sensitivity of Near-Surface Materials

Soil data used to create statewide coverage

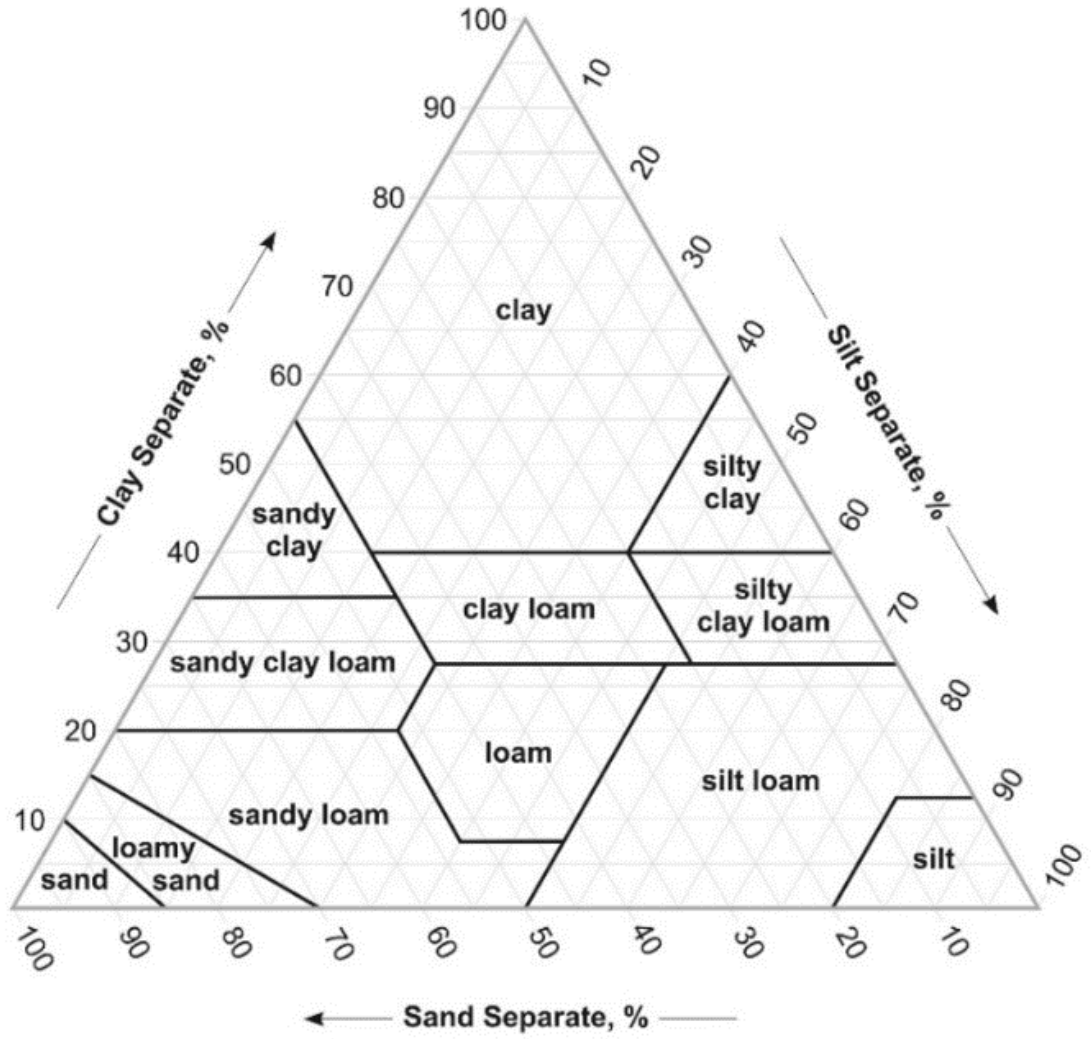


Surficial geology map coverage used to create statewide surficial geology map

Soil		Surficial Geology		Travel Time
36 inches ÷ transmission rate	+	84 inches ÷ transmission rate	=	To reach depth of 10 feet (120 inches)

Pollution Sensitivity of Near-Surface Materials

Matrix texture from NRCS Soil Triangle



Pollution Sensitivity of Near-Surface Materials

Table 1. Transmission rates through unsaturated materials for Hydrologic Soil Groups and Surficial Geologic Textures

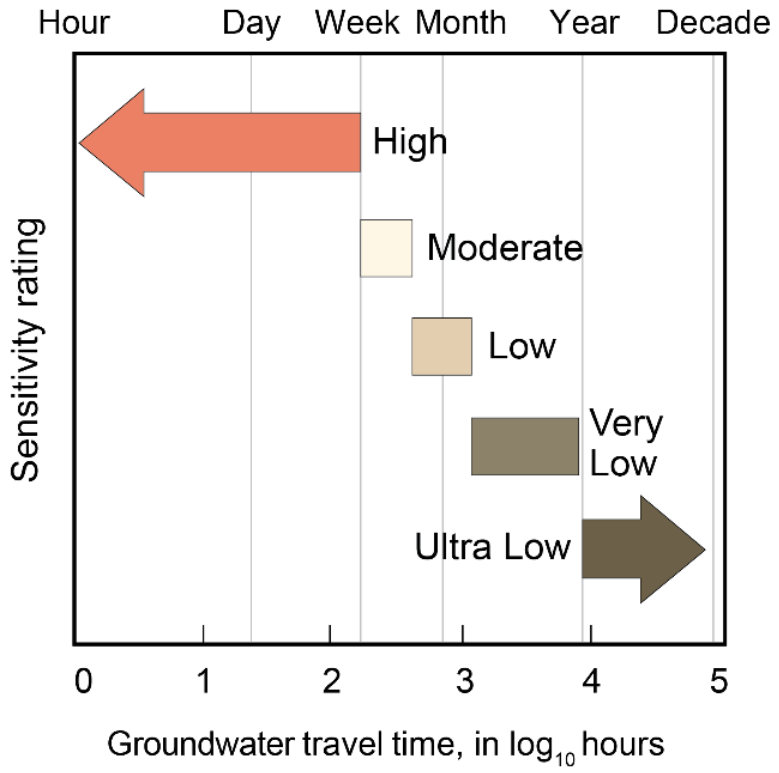
Hydrologic Soil Group (0'-3')				Surficial Geologic Texture (3'-10')	
Group	Saturated K_s [in/hr]	% K_s	"I" Unsaturated Transmission rate [in/hr]	Classification	"II" Unsaturated Transmission rate [in/hr]
A, A/D	2*	0.5	1	gravel, sandy gravel, silty gravel	1
	1.42*	0.5		sand, silty sand	0.71
B, B/D	1*	0.5	0.50	silt, loamy sand, units with eolian sand designation	0.50
	0.57*	0.5		sandy loam, peat***	0.28
--	0.482****	0.5	--	loess (Peoria)	0.218
C, C/D	0.3**	0.25	0.075	silt loam, loam	0.075
	0.14**	0.25		sandy clay loam	0.035
D	≤0.06*	0.25	0.015	clay, clay loam, silty clay loam, sandy clay, silty clay	0.015
--	0.000043*****	0.25	--	Glacial lake sediments of lakes Agassiz and Duluth	0.000011

Example Time of Travel Calculations

Example A - The cell location has attributes of both the Hydrologic Soil Group (HSG) and the surficial geologic texture. In this example, the cell's HSG is A and the surficial geologic texture is Loamy Sand.		**0-3 ft. below ground surface**	**3–10 ft. below ground surface**	**Total Time of Travel (hours)**	**Sensitivity Category**
	Transmission Determination	36"/ soil transmission rate (in/hr)	84"/ surficial geologic transmission rate (in/hr)		
	Calculation	36"/ 0.50"/hr	84"/ 0.5"/hr		
	Resulting Travel Time in Hours	72	168	240	Moderate, 170–430 hours
Example B - The cell location has no hydrologic soil group attributes (e.g.- gravel pit), only surficial geologic texture attributes (Loamy Sand) are used for the travel time calculation.			**0–10 ft.**		
	Transmission Determination		120"/ surficial geologic transmission rate (in/hr)		
	Calculation		120"/ 0.5"/hr		
	Resulting Travel Time in Hours		240	240	Moderate, 170–430 hours

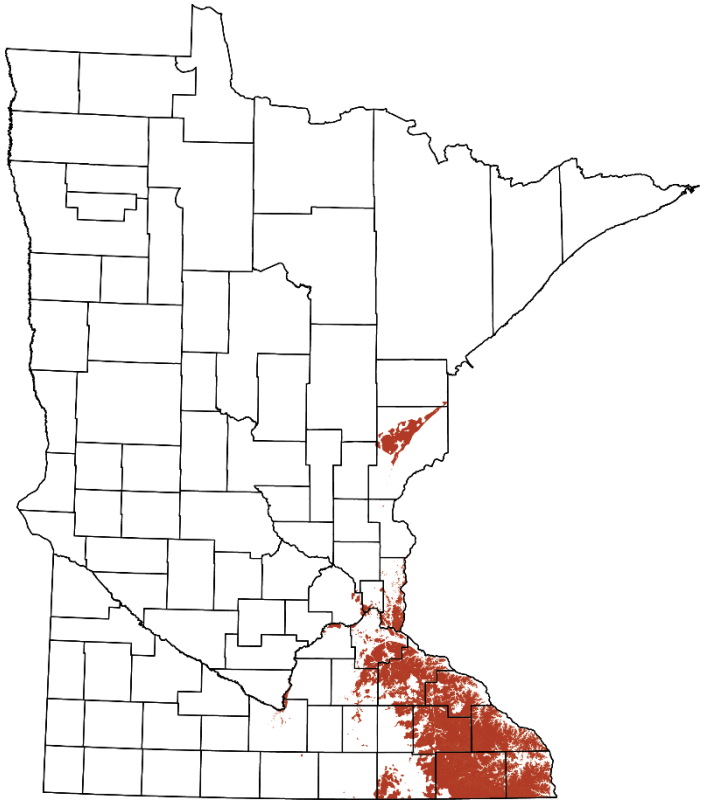
Sensitivity Rating

Near-Surface Pollution Sensitivity	Time of Travel	Description
High	≤ 170 hours	Hours to a week
Moderate	>170–430 hours	A week to weeks
Low	>430–1600 hours	Weeks to months
Very Low	>1600–8000 hours	Months to a year
Ultra Low	>8000 hours	More than a year
Special Conditions: karst, bedrock at or near surface, peatlands, disturbed lands	Not applicable	See descriptions in Special Conditions

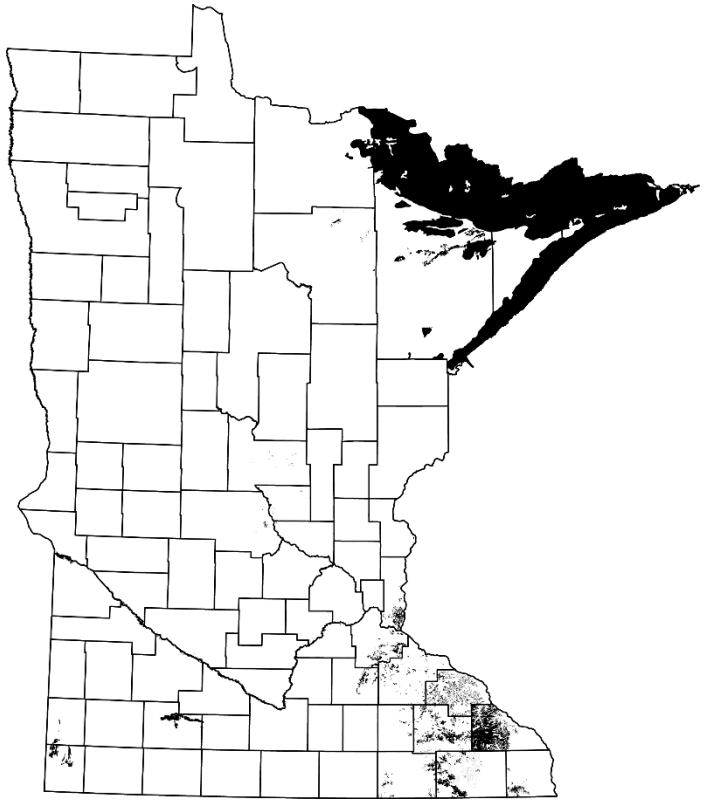


Special Conditions

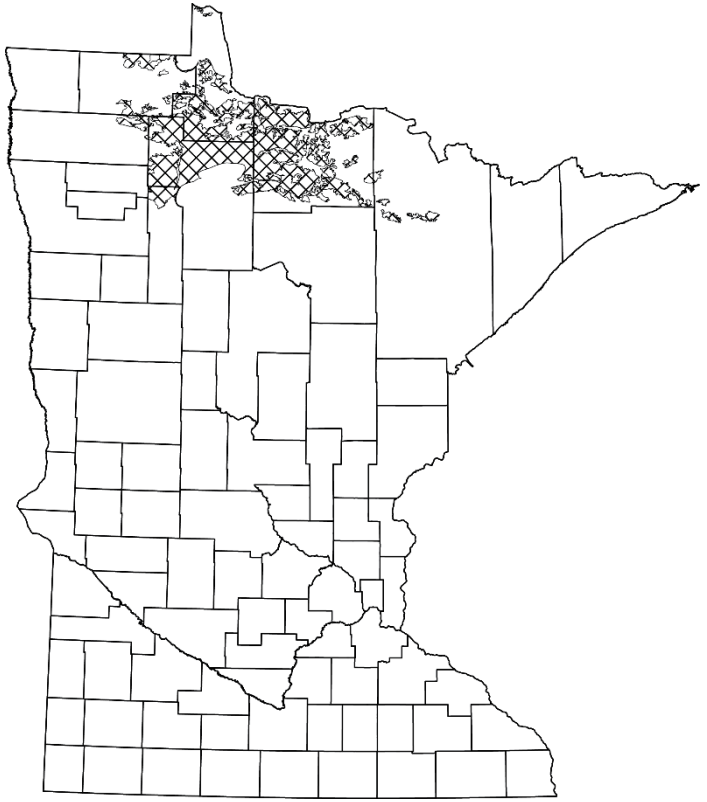
Regions prone to karst



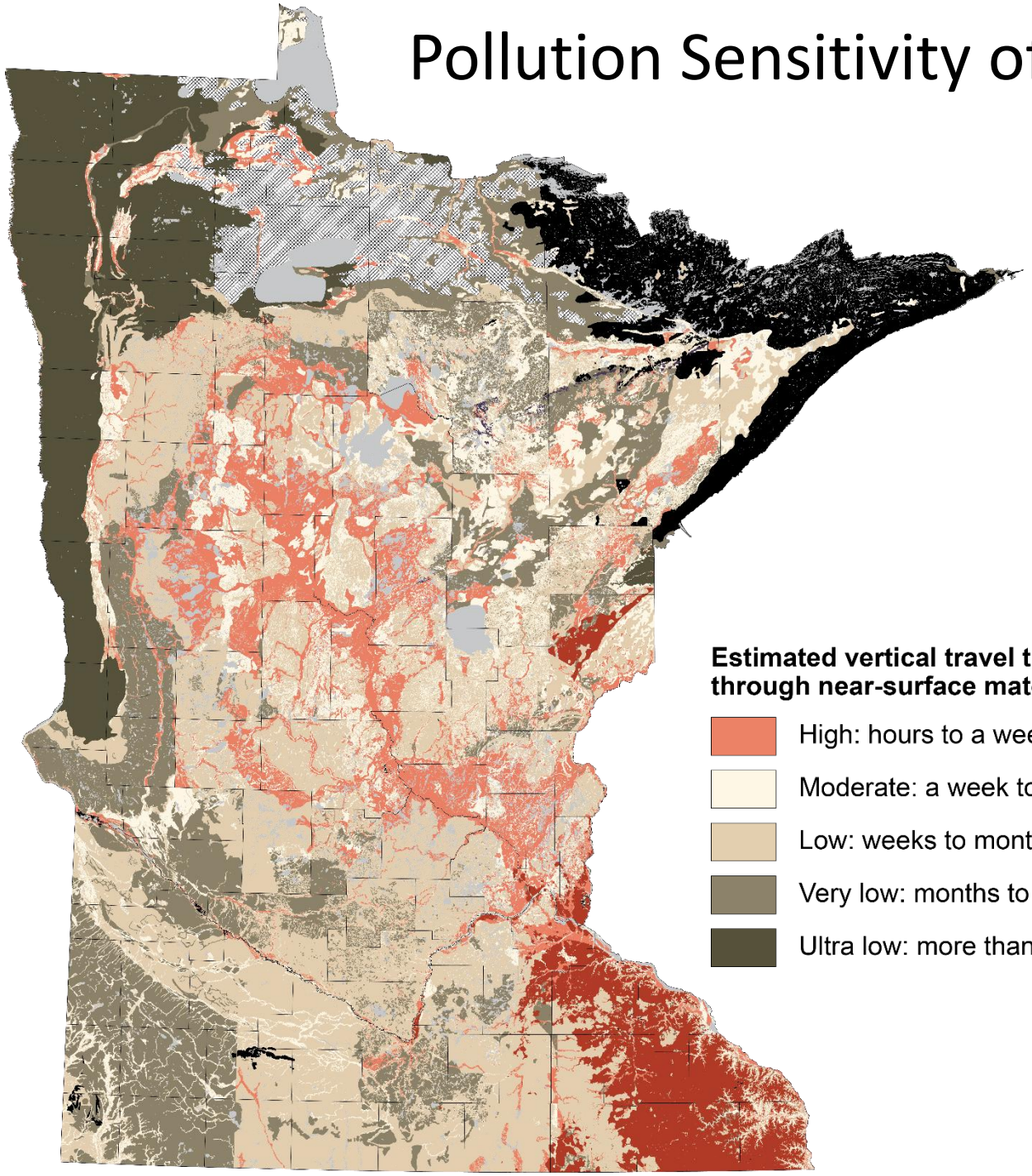
Bedrock at or near the surface



North-central peatlands



Pollution Sensitivity of Near-Surface Materials



Estimated vertical travel time through near-surface materials

- High: hours to a week
- Moderate: a week to weeks
- Low: weeks to months
- Very low: months to a year
- Ultra low: more than a year

- Water

Special Conditions

- Karst
- Bedrock at or near surface
- Disturbed lands
- Peatlands

300 dpi

Surficial Geologic Map Central Minnesota

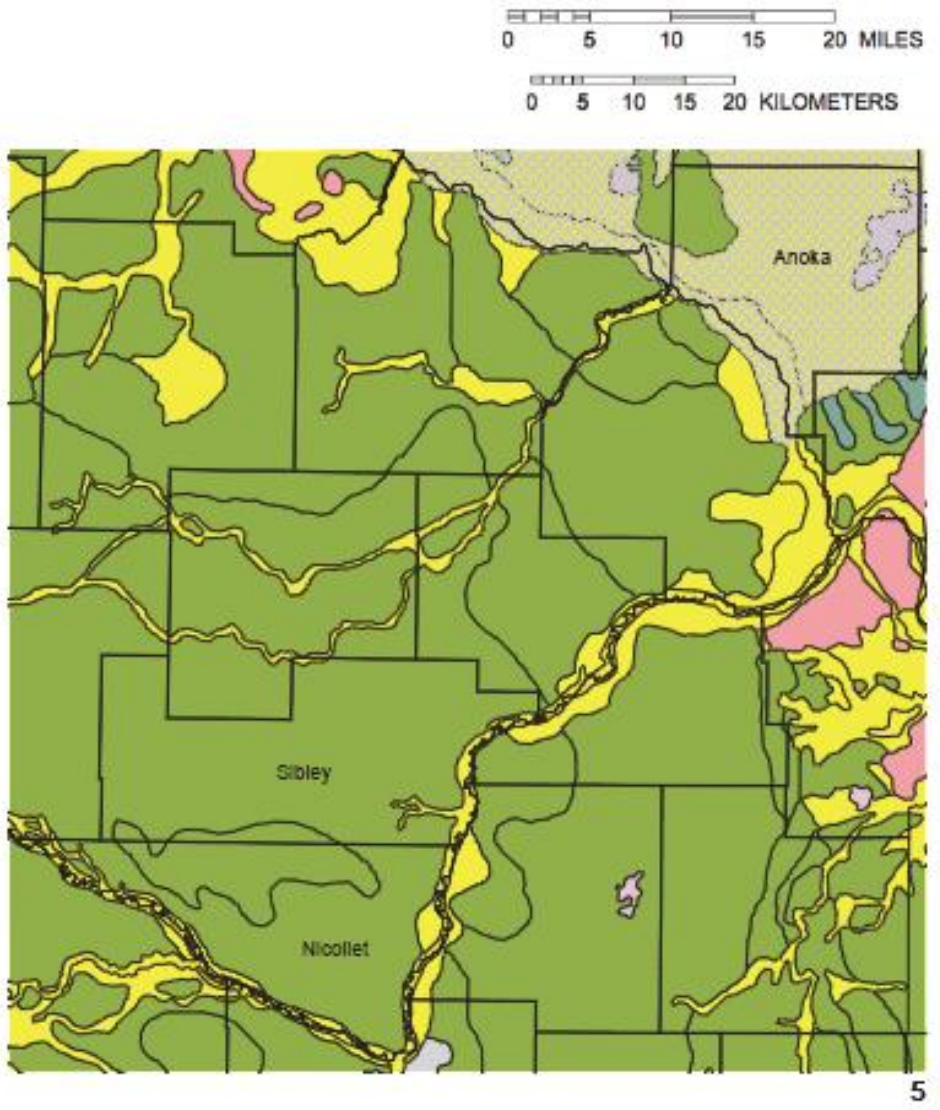
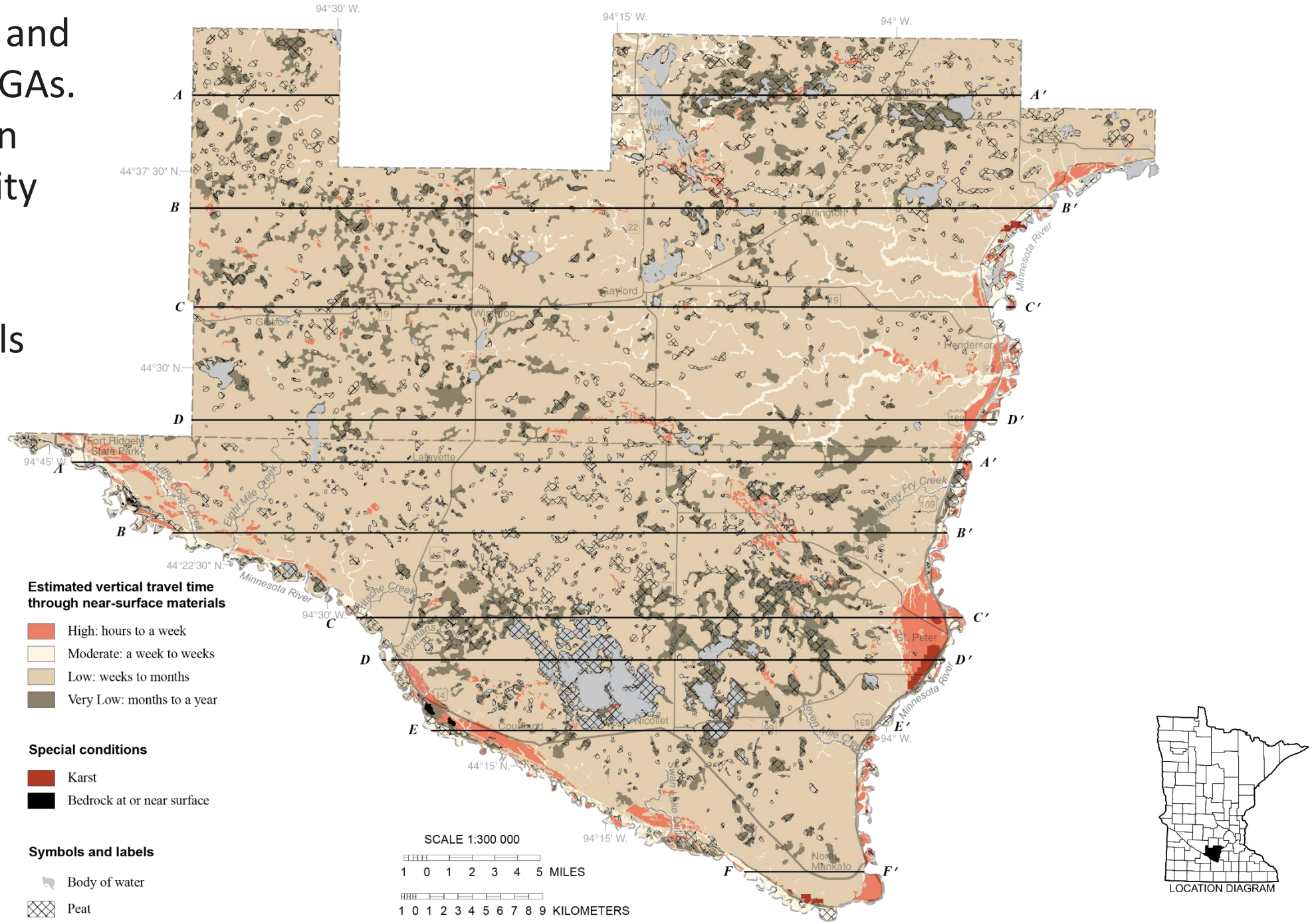


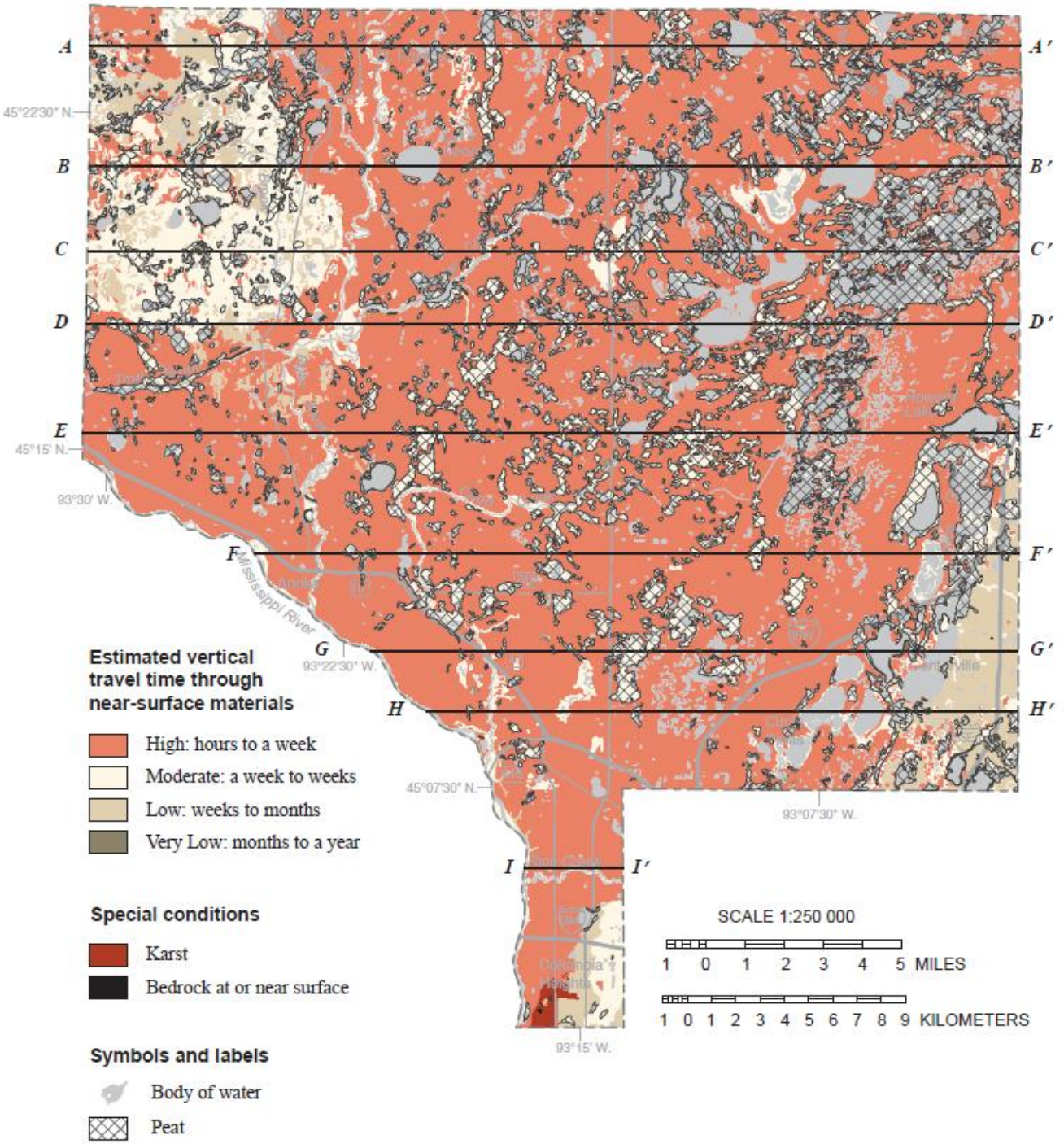
Figure 1: Map of the surficial geologic units in Anoka, Nicollet, and Sibley counties

MGWA Newsletter March 2017

Nicollet and Sibley CGAs. Pollution sensitivity of near-surface materials

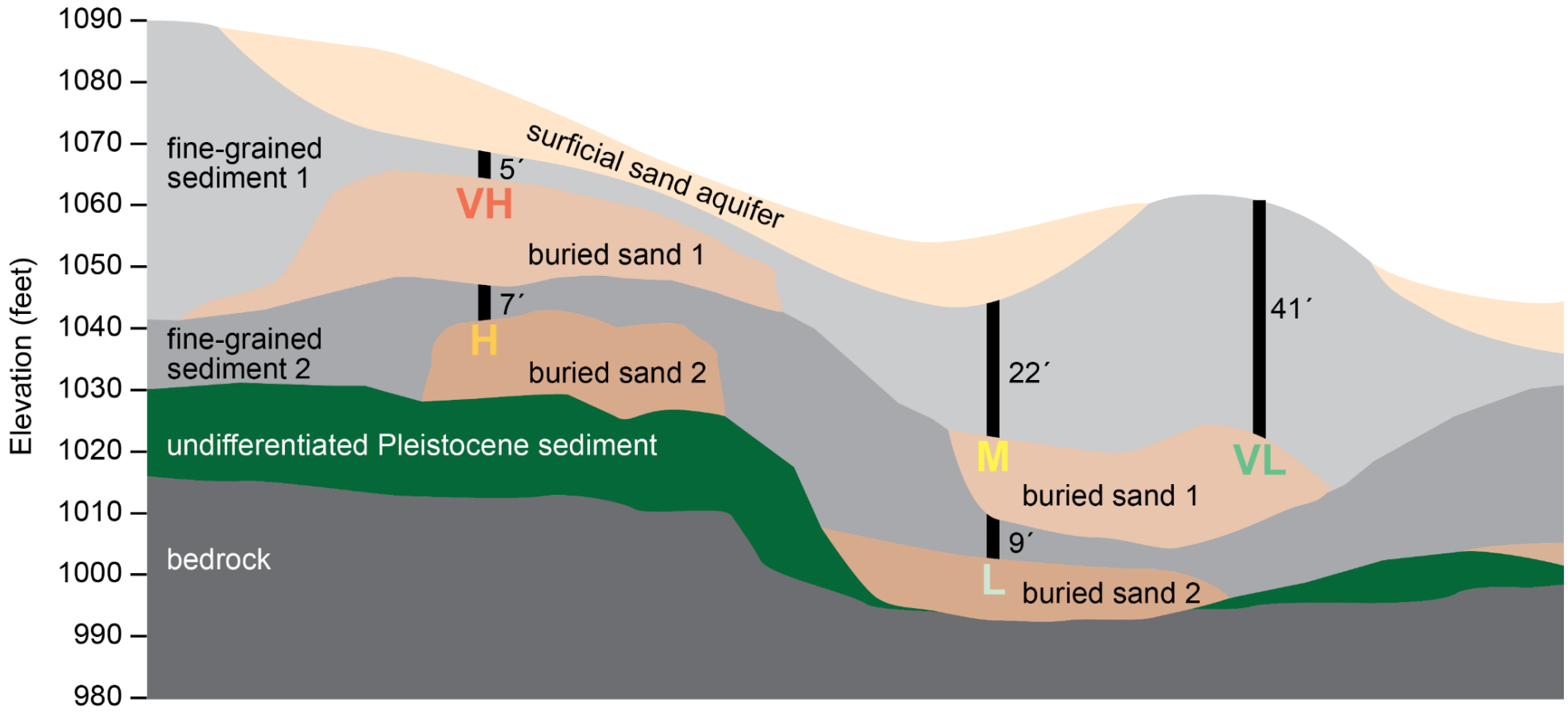


Anoka CGA Pollution sensitivity of near-surface materials



Pollution Sensitivity of Buried Aquifers and Bedrock Surface based on Cumulative Fine-grained Sediment (CFGS) Thickness

- Map the geology. Create rasters of geologic surfaces (MGS Part A)
  - surface elevation
  - Quaternary units
  - bedrock surface
- Calculate cumulative fine-grained sediment thickness above aquifer



Cumulative thickness of fine-grained sediment overlying the aquifer (in feet)				
≤ 10	>10 to 20	>20 to 30	>30 to 40	>40
VH	H	M	L	VL

FGS1 Thickness

3	12	0	5
20	15	6	13
25	0	5	13
10	30	17	2

+

FGS2 Thickness

0	11	23	0
18	10	3	5
20	5	0	5
35	30	8	0

=

Buried Sand 2 Cumulative Fine-grained Sediment Thickness Raster

3	23	23	5
38	25	9	18
45	5	5	18
45	60	25	2

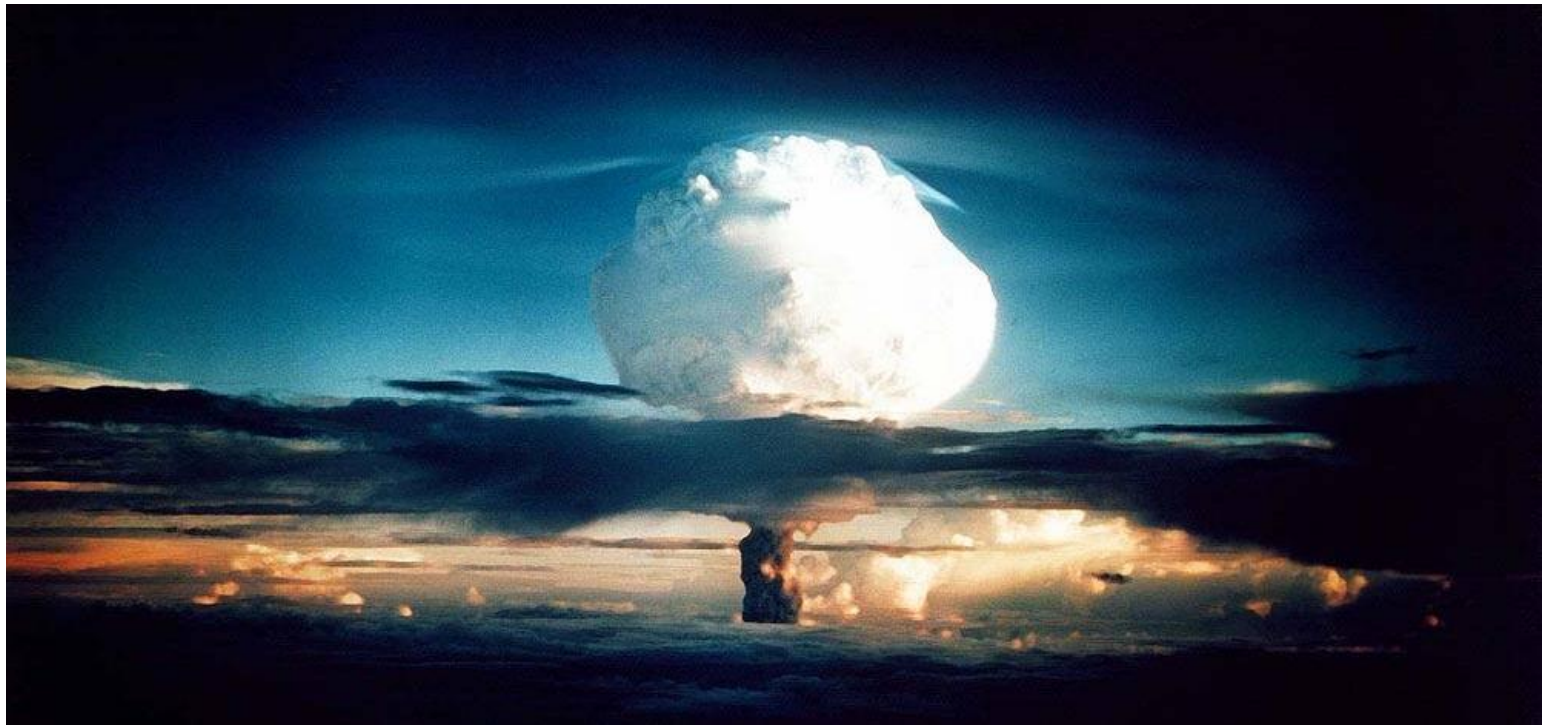
Assessing Sensitivity using Groundwater Residence Time from Tritium

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

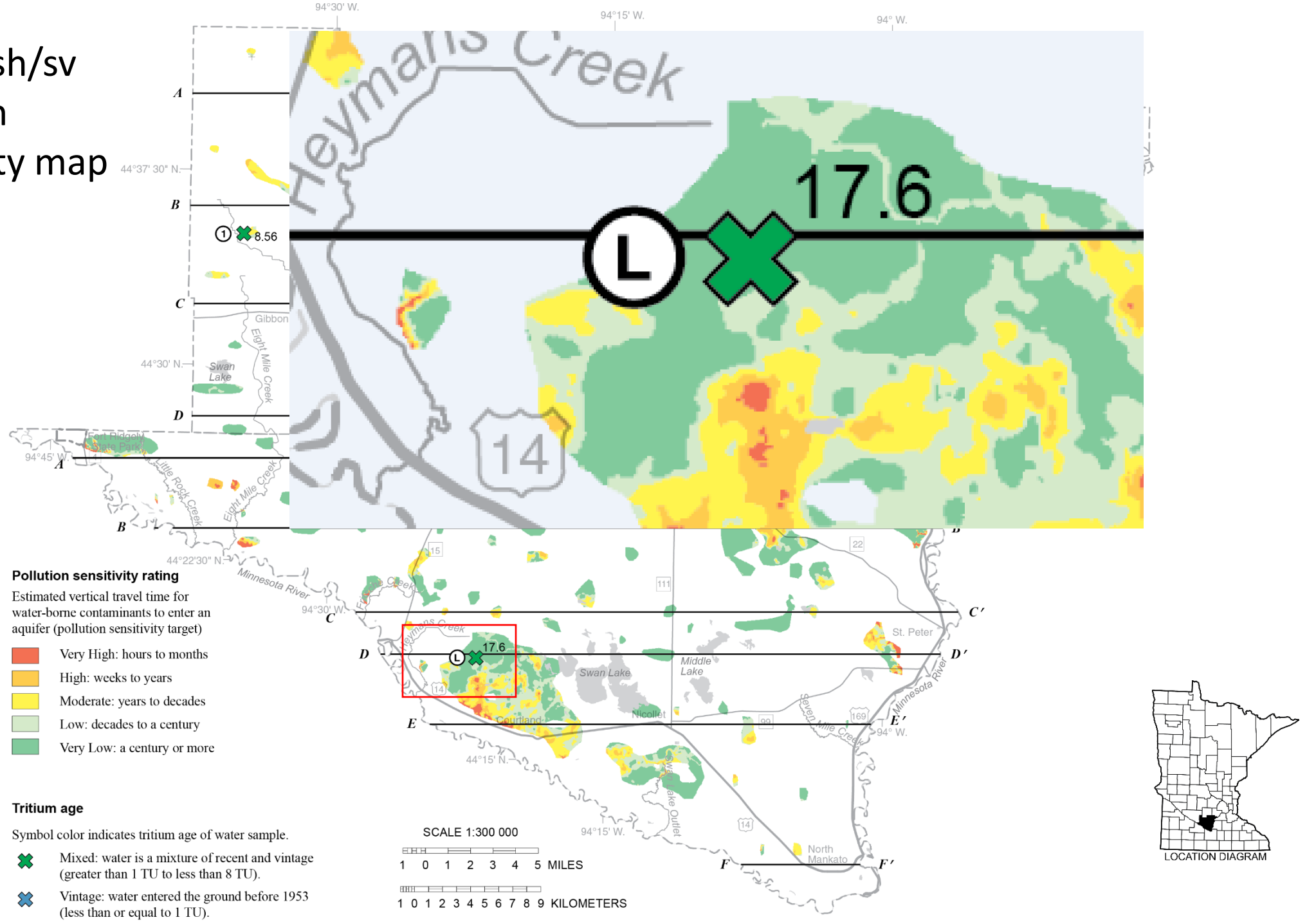
Mixed: water is a mixture of recent and vintage waters
(greater than 1 TU to less than 8 TU).

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

Well not sampled for tritium.



Aquifer sh/sv pollution sensitivity map



Pollution sensitivity rating

Estimated vertical travel time for water-borne contaminants to enter an aquifer (pollution sensitivity target)

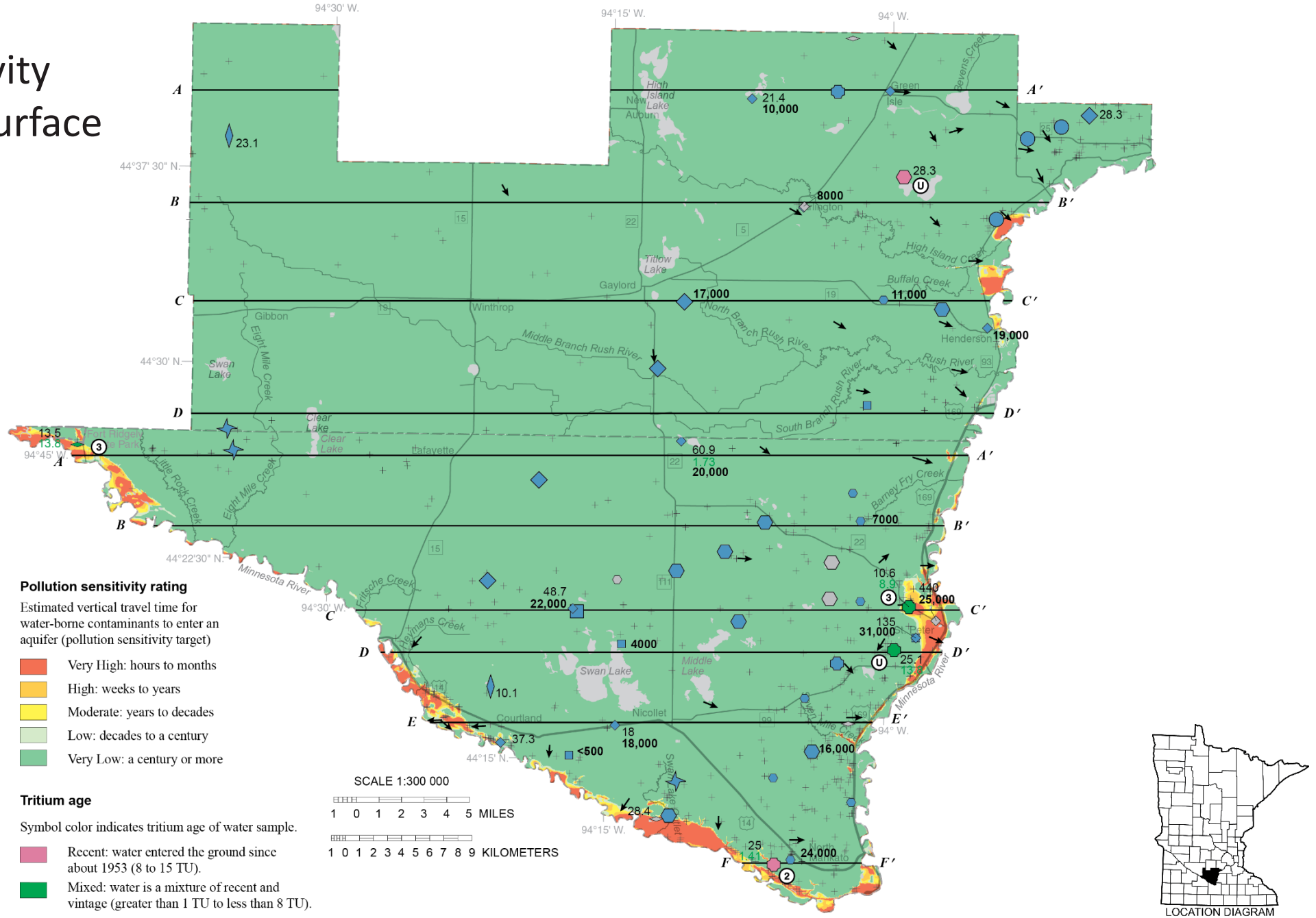
- Very High: hours to months
- High: weeks to years
- Moderate: years to decades
- Low: decades to a century
- Very Low: a century or more

Tritium age

Symbol color indicates tritium age of water sample.

- Mixed: water is a mixture of recent and vintage (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).

Pollution sensitivity of the bedrock surface



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- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Not sampled for tritium.

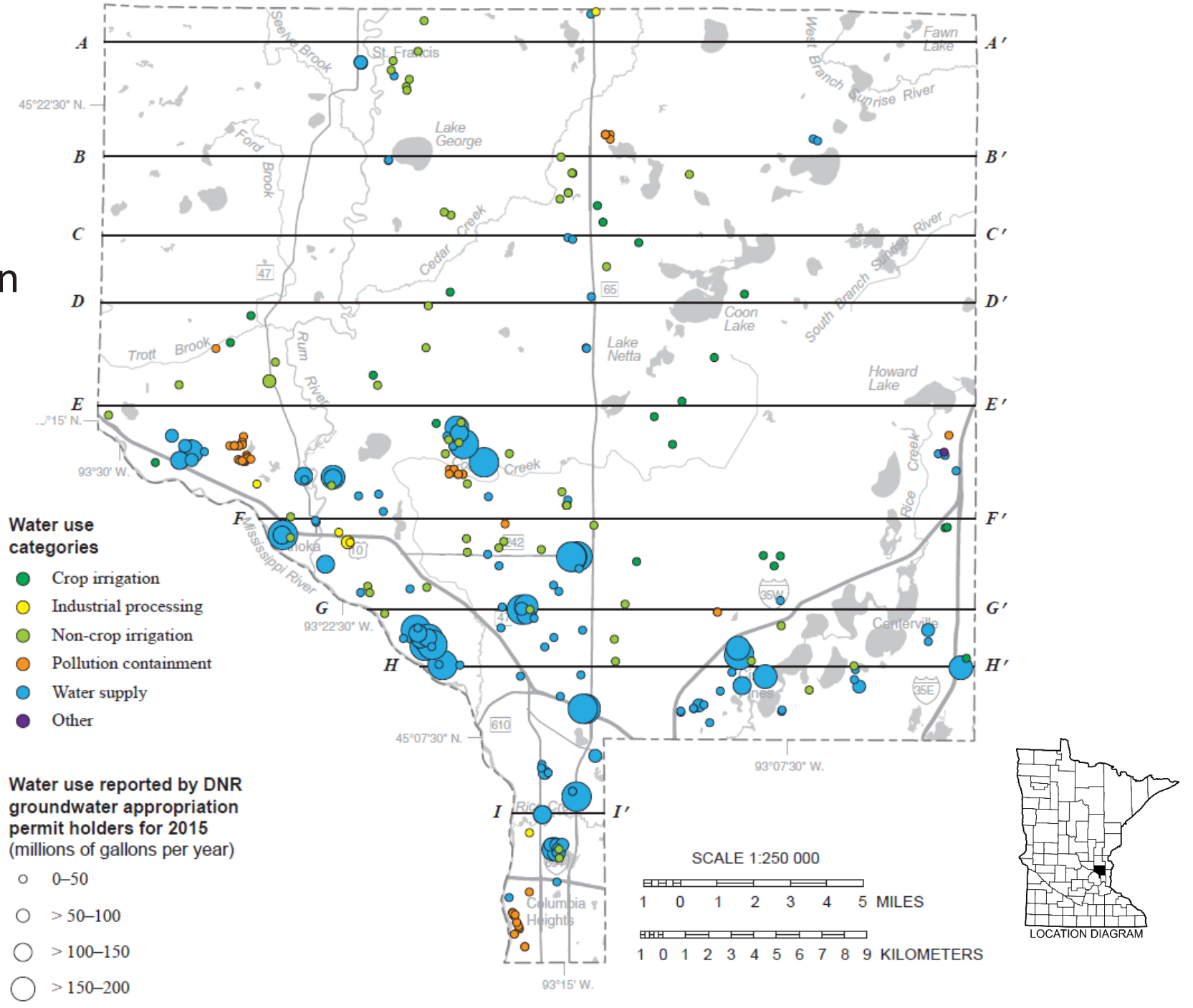
SCALE 1:300 000

1 0 1 2 3 4 5 MILES

1 0 1 2 3 4 5 6 7 8 9 KILOMETERS

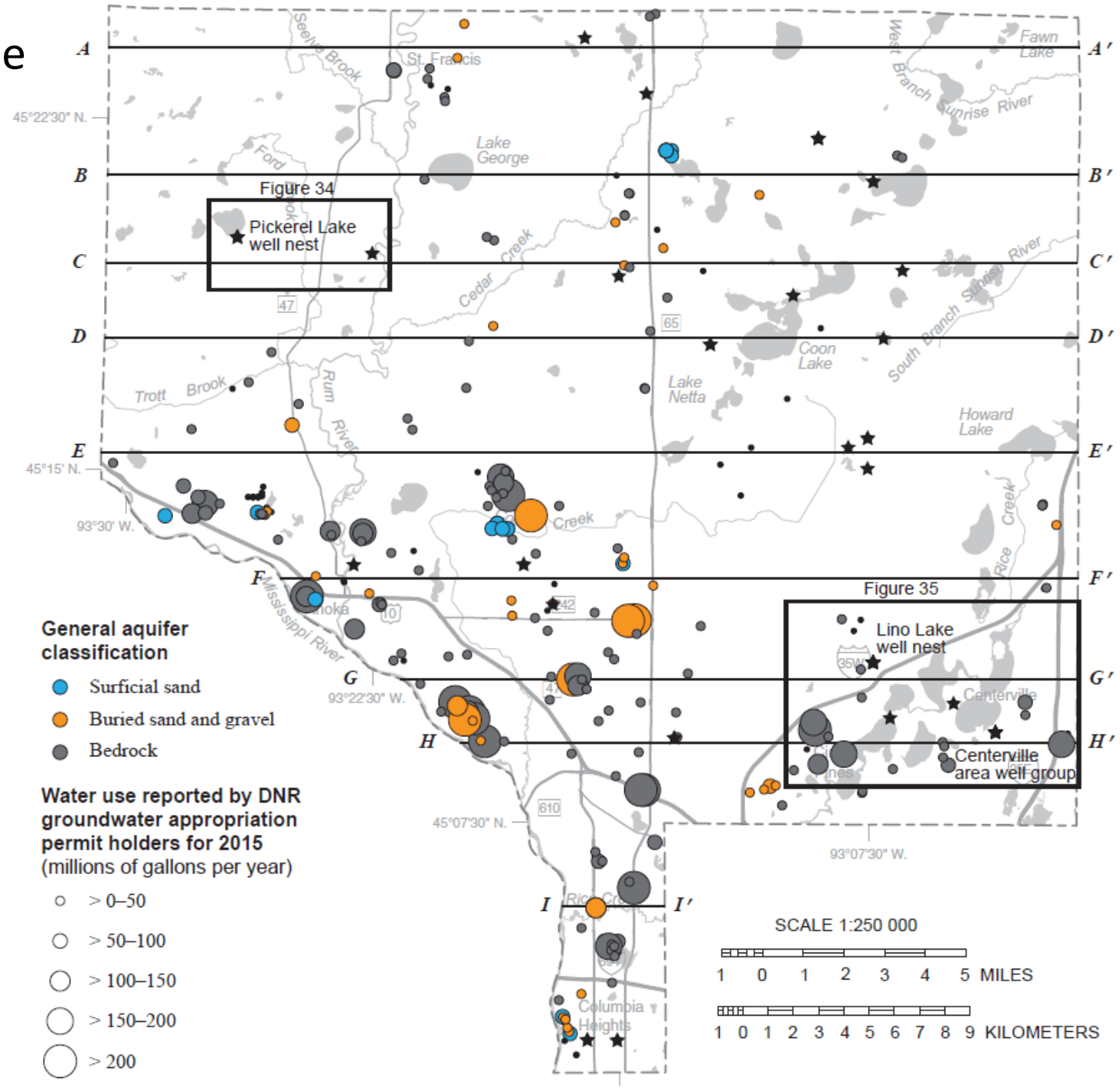
Groundwater use

Locations of DNR groundwater appropriation permit holders by water use



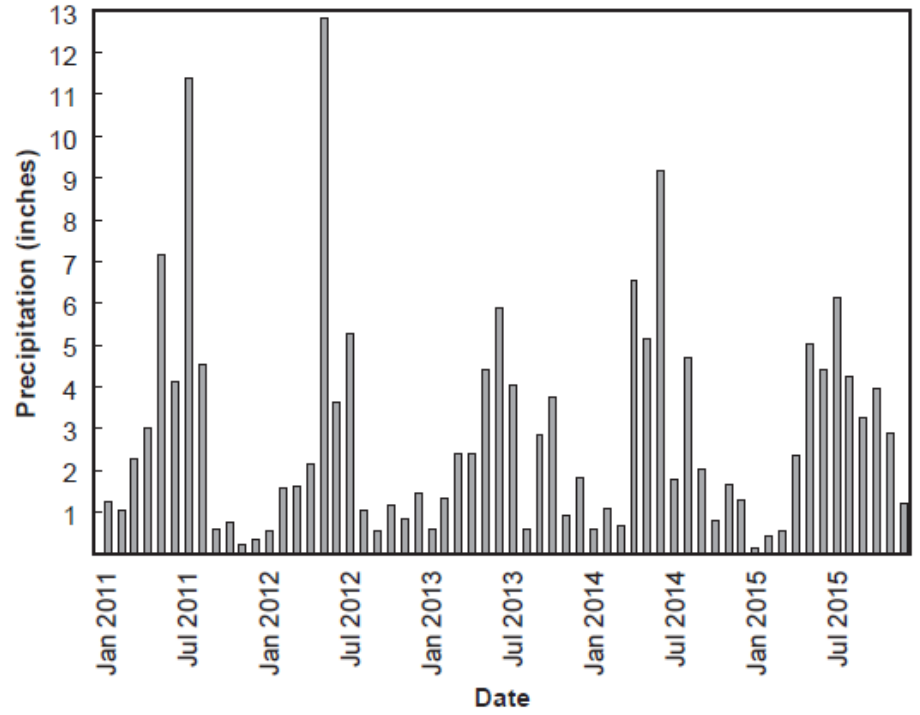
Groundwater use

Locations of DNR Groundwater appropriation permit holders by general aquifer classification

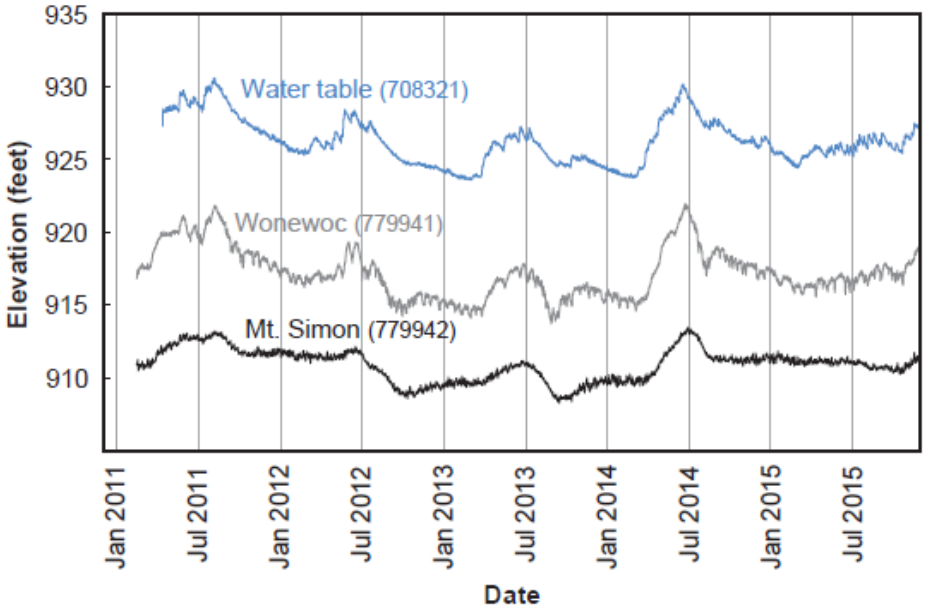


Pickerel Lake area

Monthly precipitation

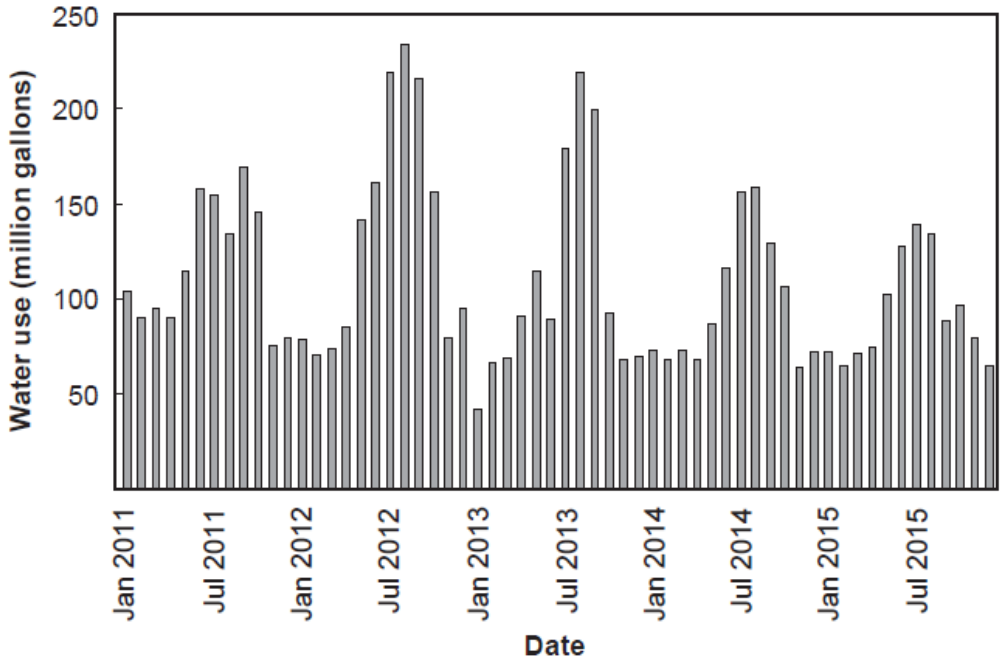


Hydrograph of the water table, Wonewoc, and Mt. Simon aquifers showing seasonal fluctuation in a low groundwater use area.

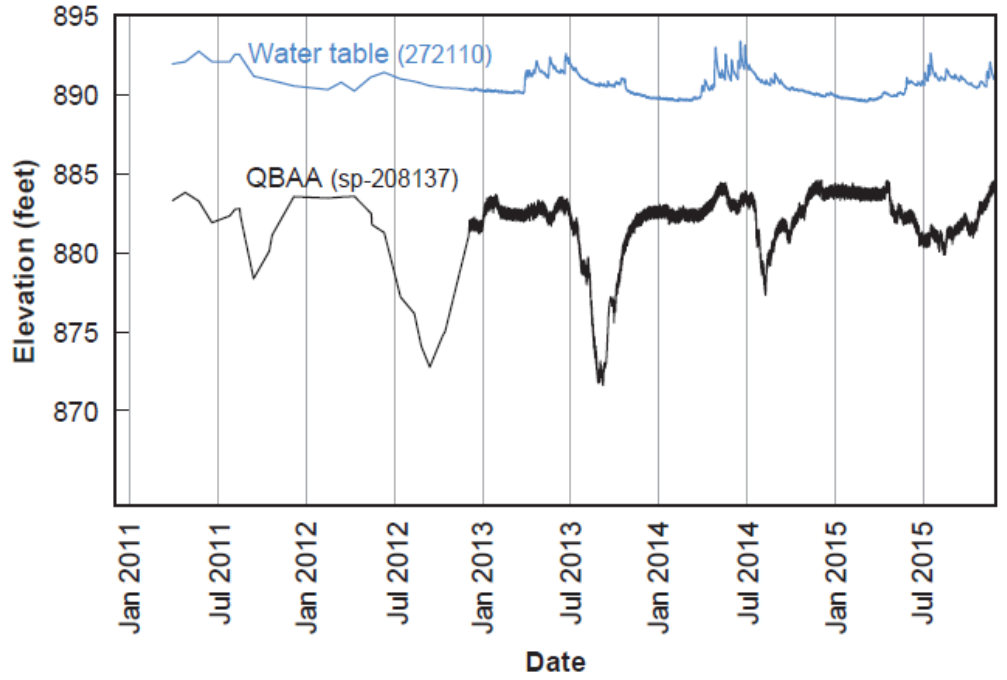


Lino Lakes area

Monthly groundwater use from 20 wells in Lino Lake and Centerville area.



Hydrograph of the water table and sp (QBAA – buried sand and gravel) aquifers from the Centerville area.



Anoka County

Specific capacity and transmissivity of selected wells

Specific capacity data adapted from the County Well Index; gpm/ft, gallons per minute per foot; transmissivity data are from MDH and USGS tests compiled by the DNR; gpd/ft, gallons per day per foot, -- means no data, * means no tests available.

Aquifer (CWI Code)	Specific Capacity (gpm/ft)					Transmissivity (gpd/ft)		
	Casing Diameter (inches)	Mean	Min	Max	Number of Tests	Casing Diameter (inches)	Mean	Number of Tests
Unconsolidated units								
Surficial sand and gravel (QWTA)	12	25	--	--	1	*	--	--
Buried sand and gravel (QBAA)	12–30	31.4	4	83.3	13	12–20	226,000	2
Bedrock units								
Prairie du Chien–Jordan (OPCJ)	12–18	44	9	168	7	14	112,000	1
Jordan–St. Lawrence (CJSL)	24	33	--	--	1	*	--	--
Jordan–Mt. Simon (CJMS)	24	11	11	11	2	*	--	--
Wonewoc (CWOC)	18	15	--	--	1	*	--	--
Wonewoc–Mt. Simon (CWMS)	16–18	25	24	27	4	24	14,000	1
Tunnel City (CTCG)	14	35	--	--	1	14	10,000	1
Tunnel City–Wonewoc (CTCW)	12–24	31	8	138	17	18–24	35,000	3
Tunnel City–Eau Claire (CTCE)	12–18	22	8	44	4	16	22,000	1
Tunnel City–Mt. Simon (CTCM)	12–20	18	8	28	13	*	--	--
Eau Claire–Mt. Simon (CEMS)	12	17	--	--	1	*	--	--
Mt. Simon (CMTS)	12–24	21	13	31	11	14–18	22,000	6
Mt. Simon–Hinkley (CMSH)	18	19	--	--	1	*	--	--
Multiple (MTPL)	18	11	--	--	1	*	--	--

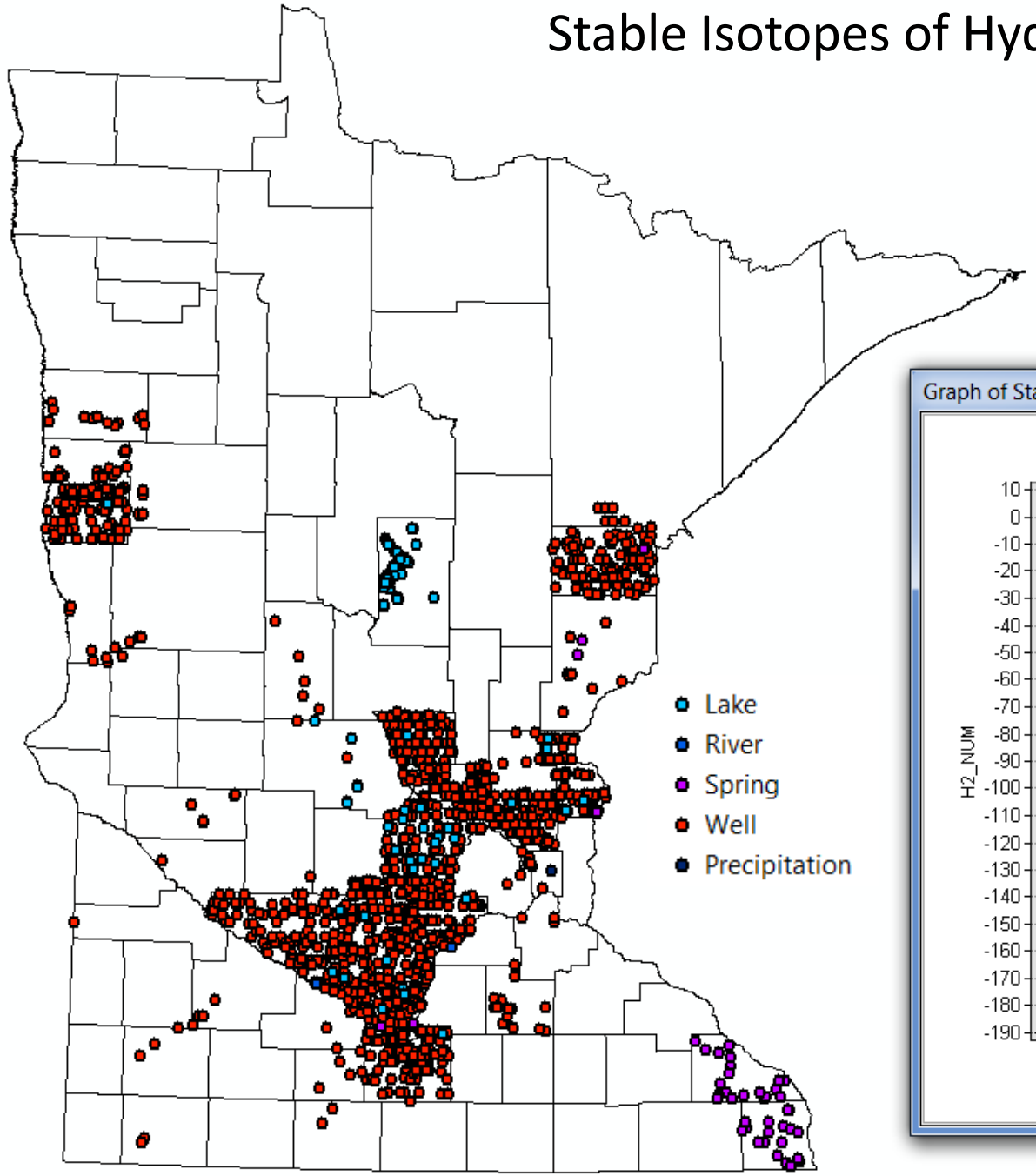
Specific Capacity from CWI well development data

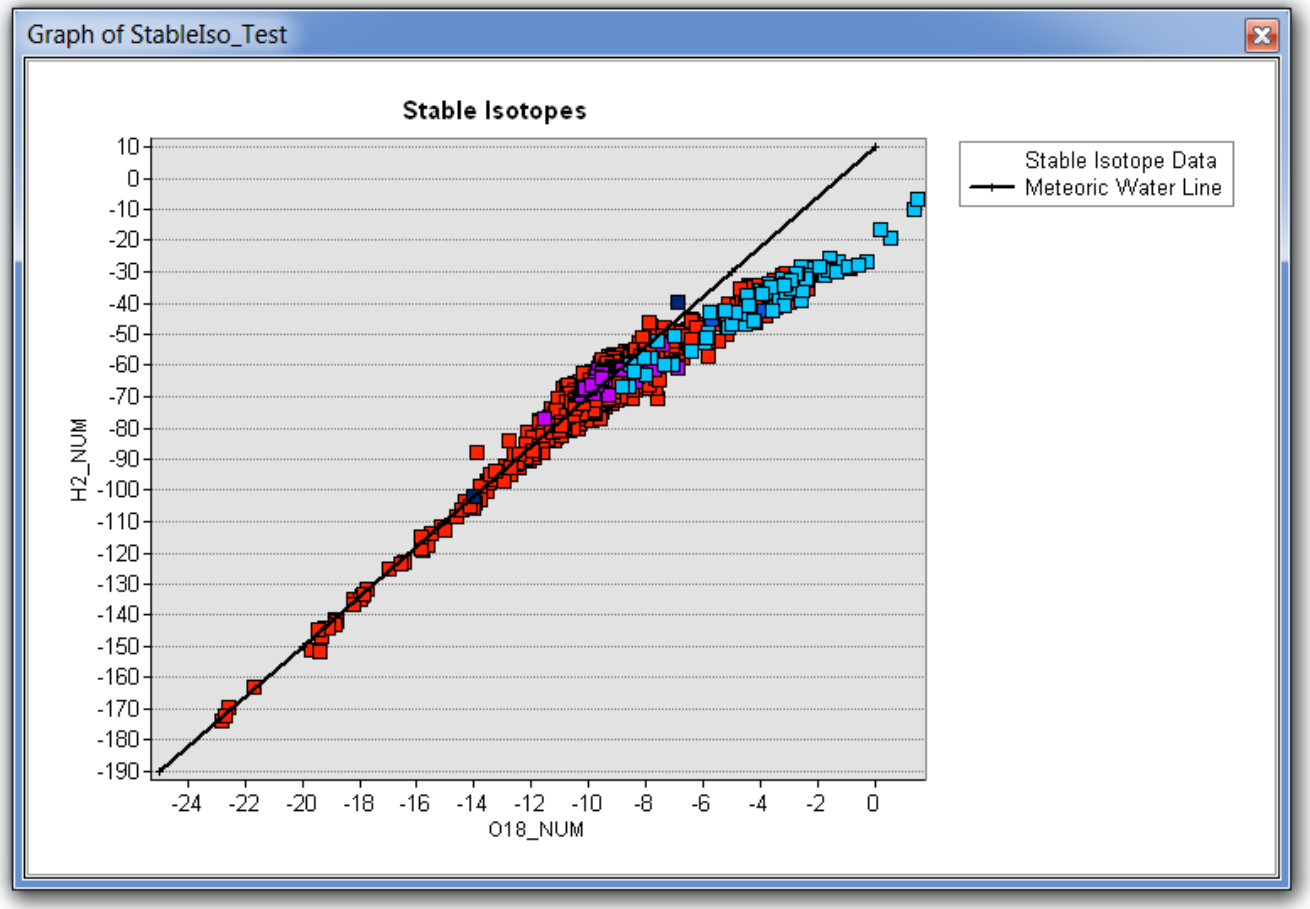
Transmissivity from Aquifer Test Compilation

Chemical Hydrogeology

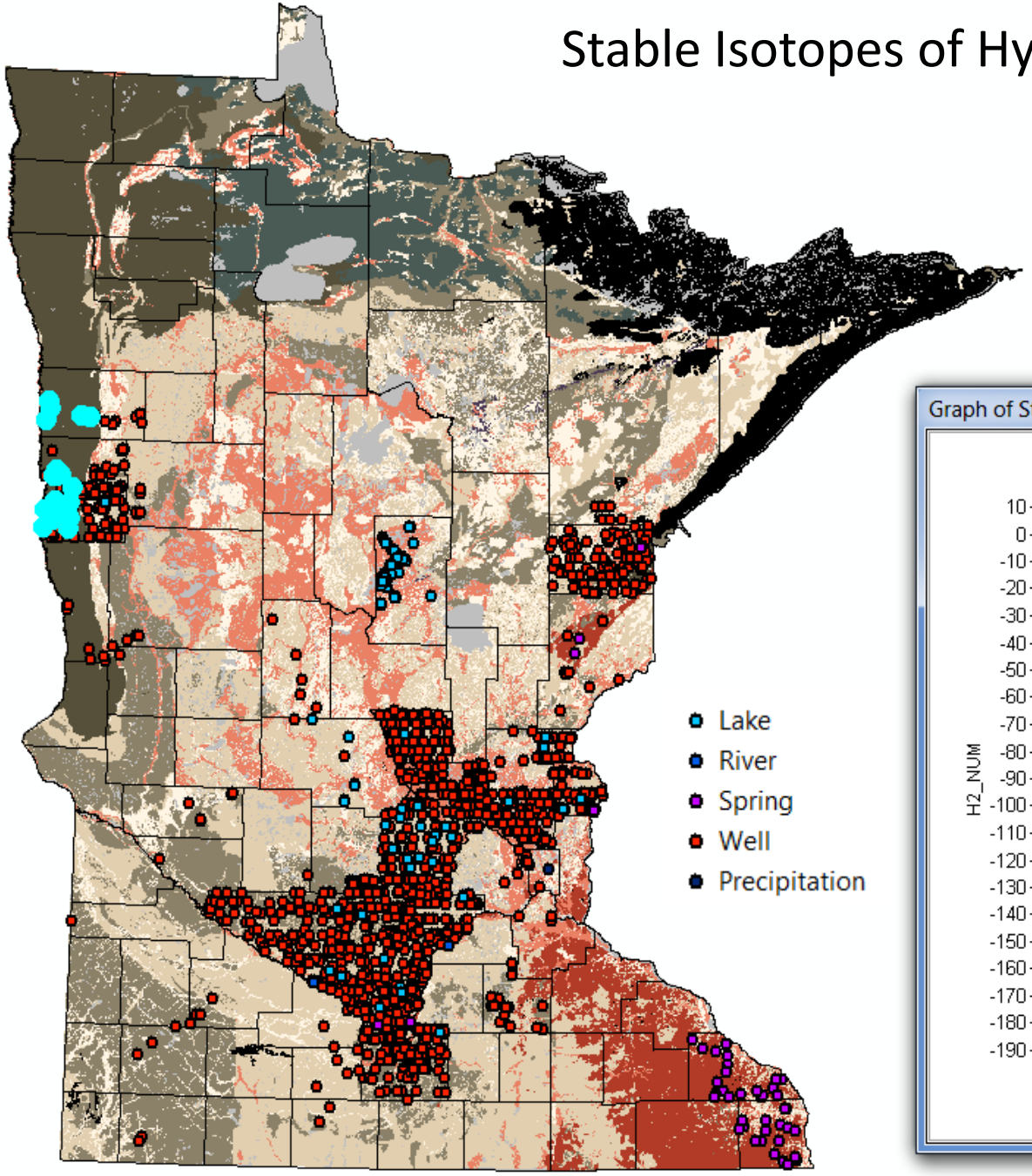
- Groundwater recharge sources
  - Stable Isotopes of oxygen and hydrogen
- Groundwater residence time indicators
  - Tritium
  - Carbon-14
- Inorganic chemistry of groundwater
  - Chemical evolution of groundwater

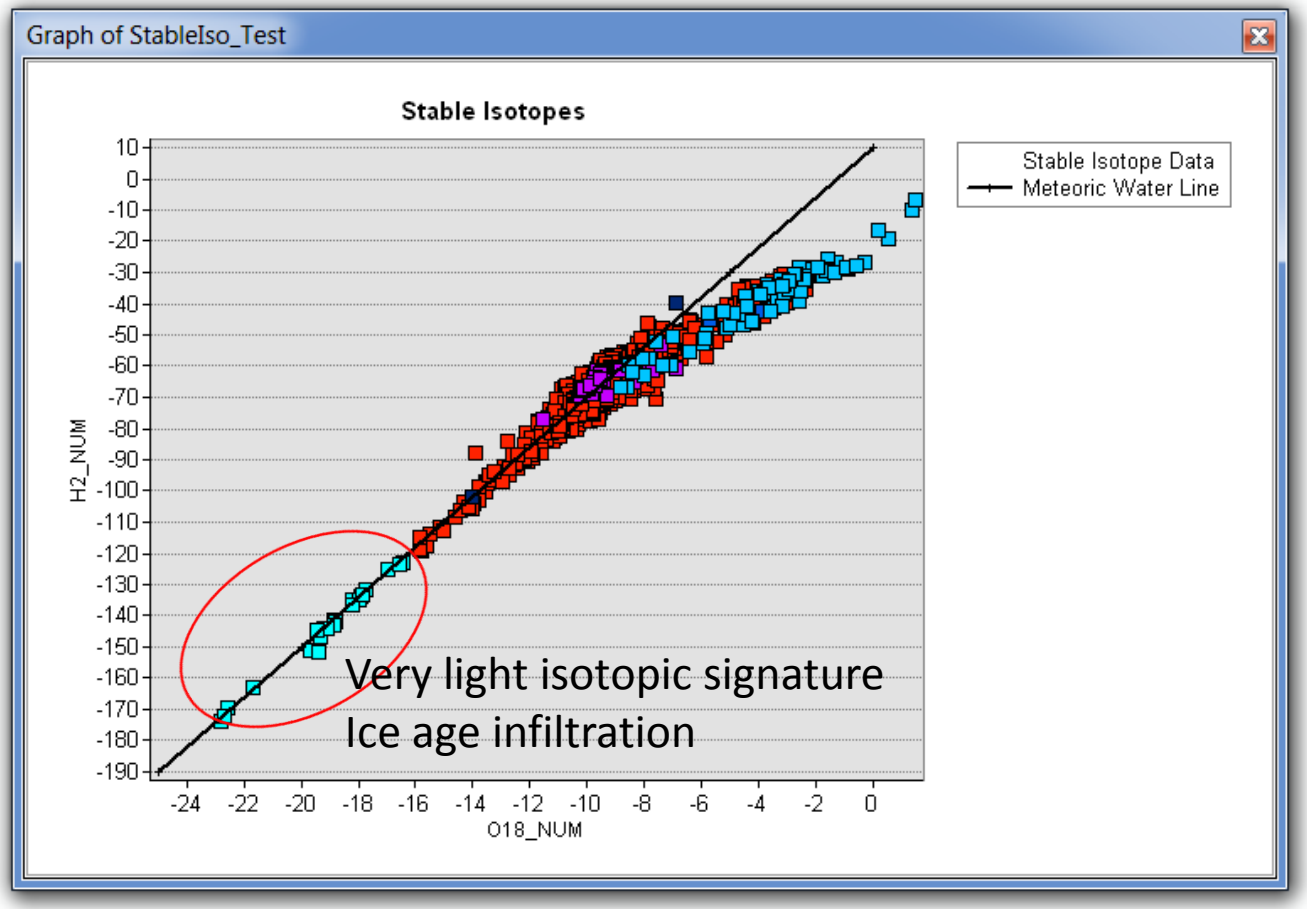
Stable Isotopes of Hydrogen and Oxygen



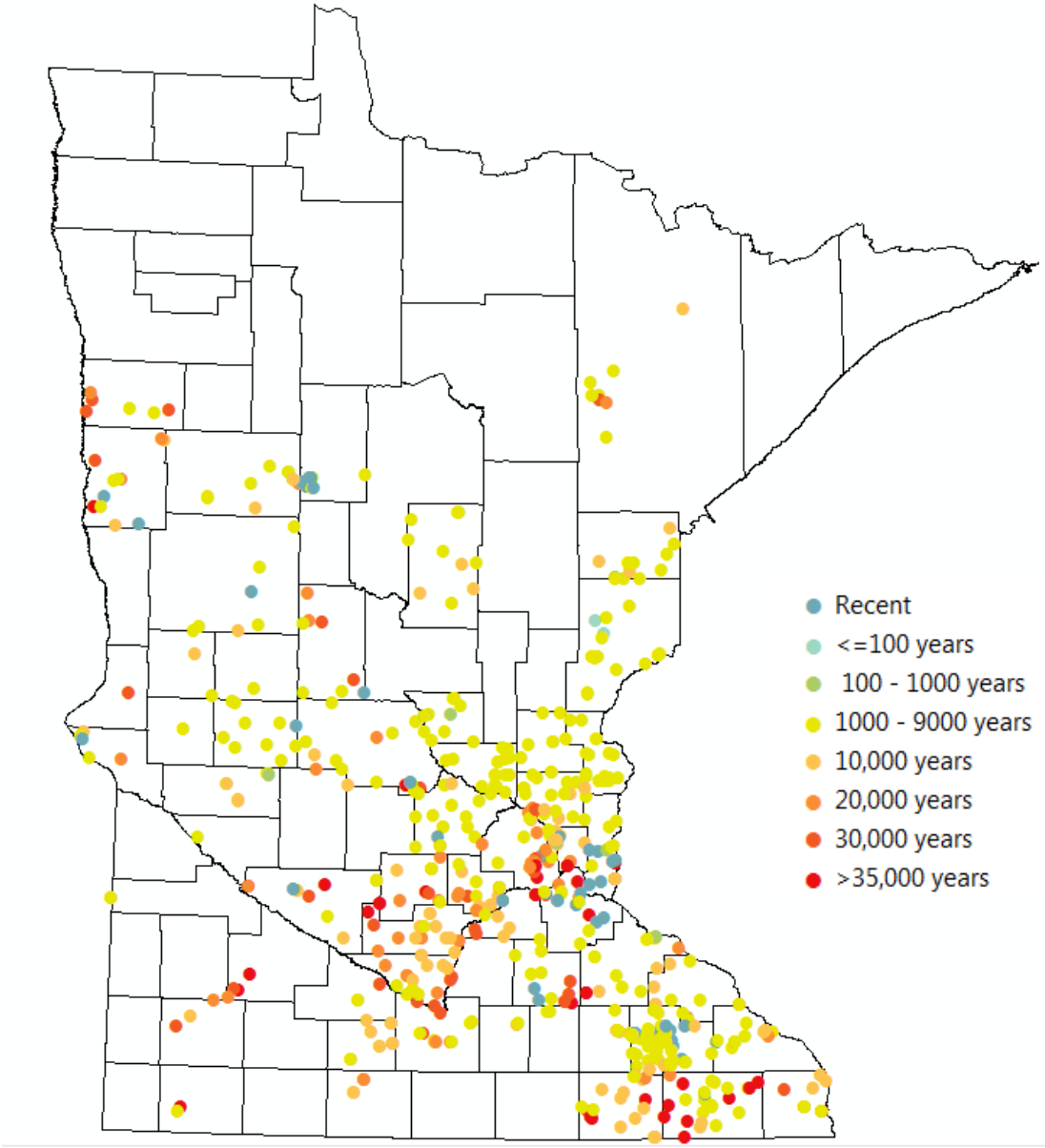


Stable Isotopes of Hydrogen and Oxygen

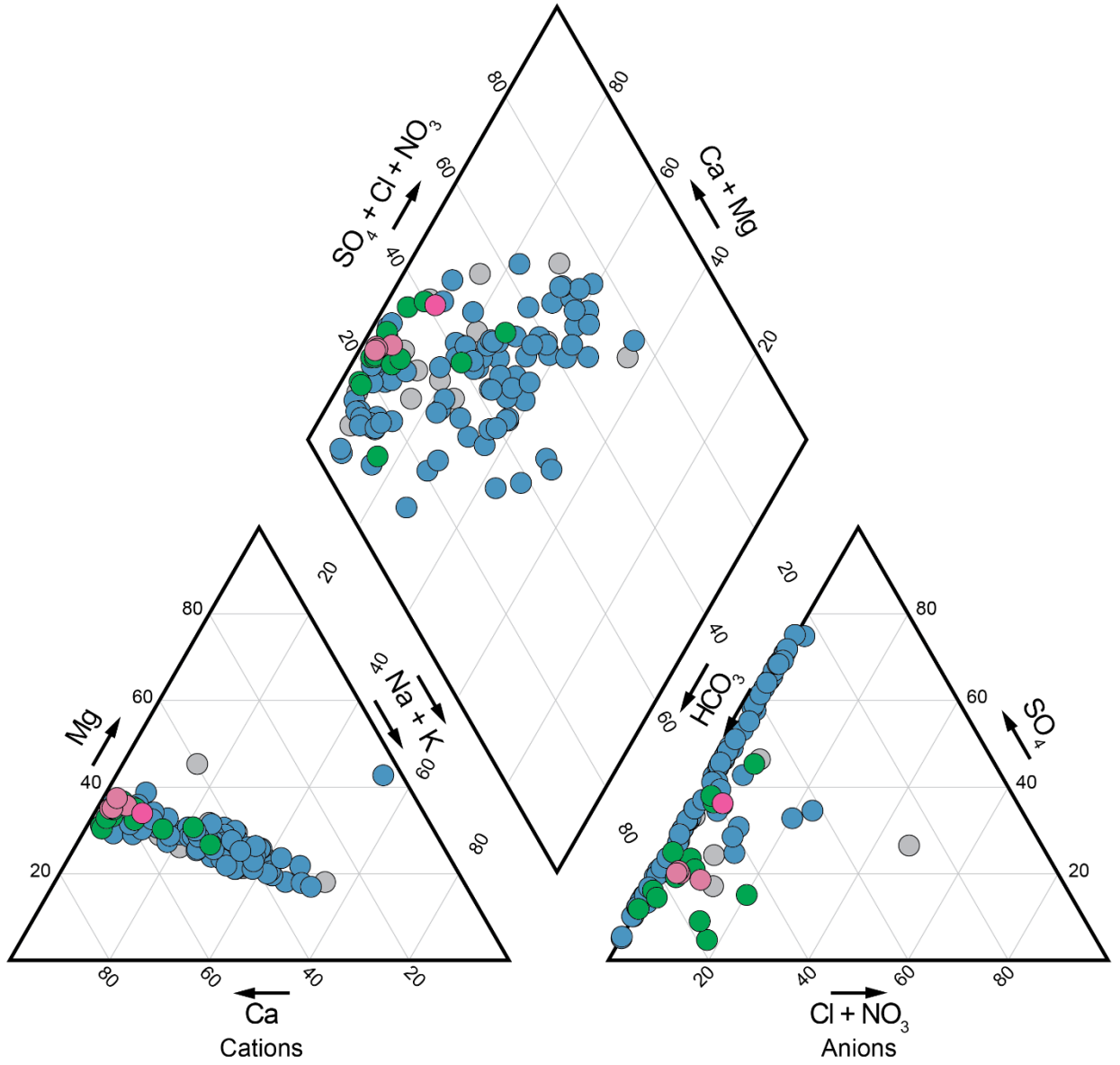




Carbon 14 Residence Time



Piper Plot of General Chemistry



Tritium age

Symbol color indicates tritium age of water sample.

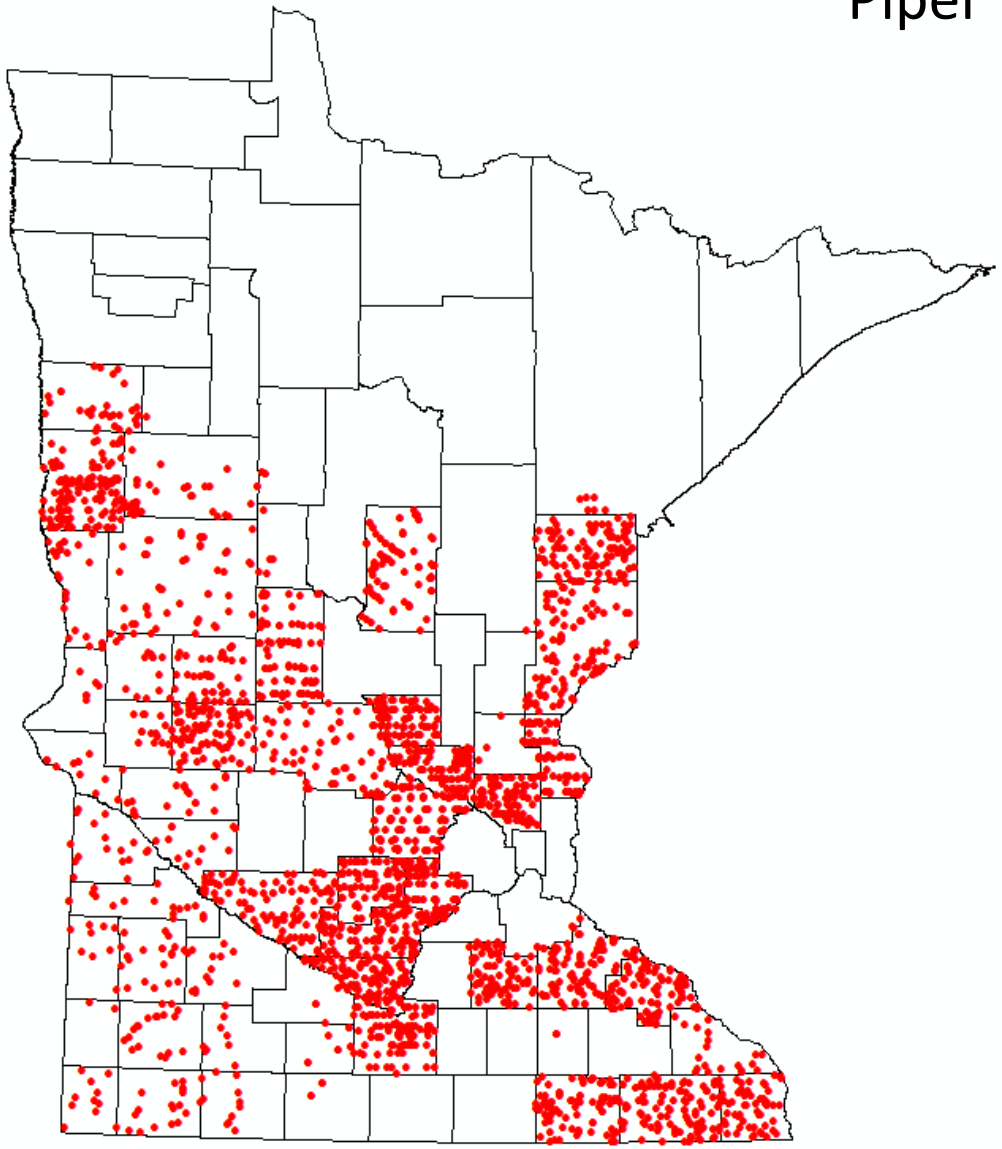
- Cold War era
- Recent
- Mixed
- Vintage
- Not sampled for tritium

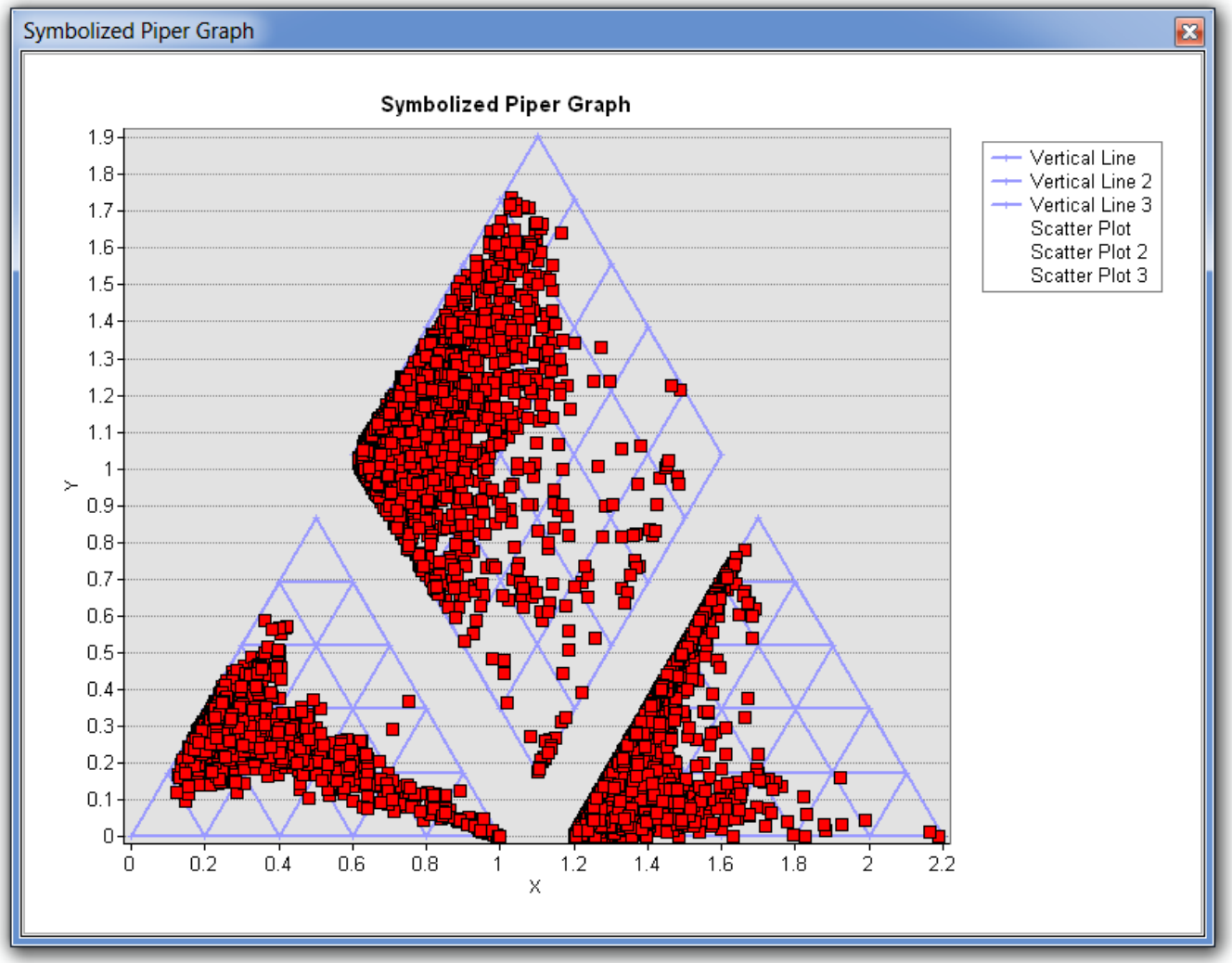
Chemicals

- Bicarbonate (HCO_3)
- Calcium (Ca)
- Chloride (Cl)
- Magnesium (Mg)
- Nitrate (NO_3)
- Potassium (K)
- Sodium (Na)
- Sulfate (SO_4)

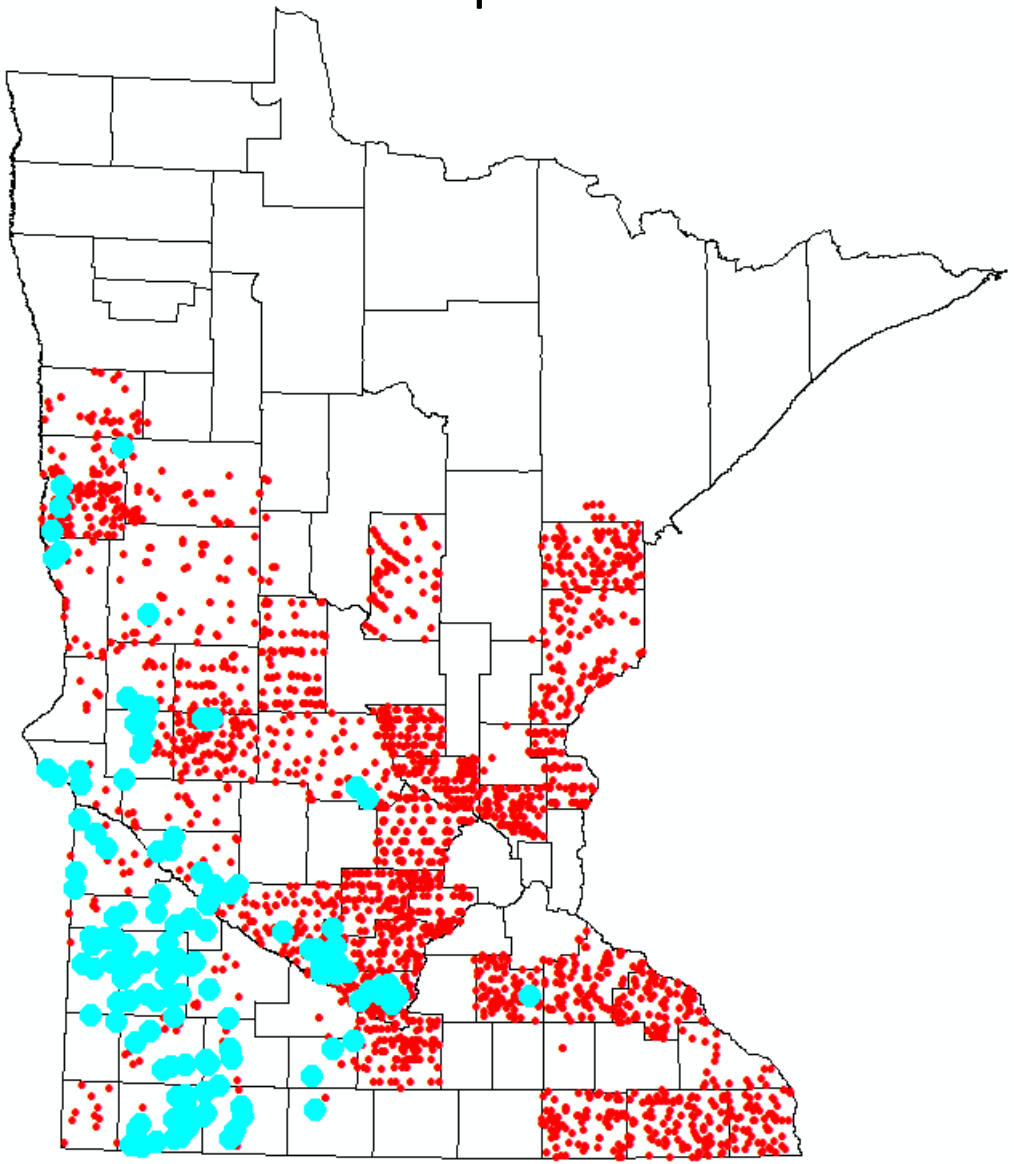
Nicollet CGA

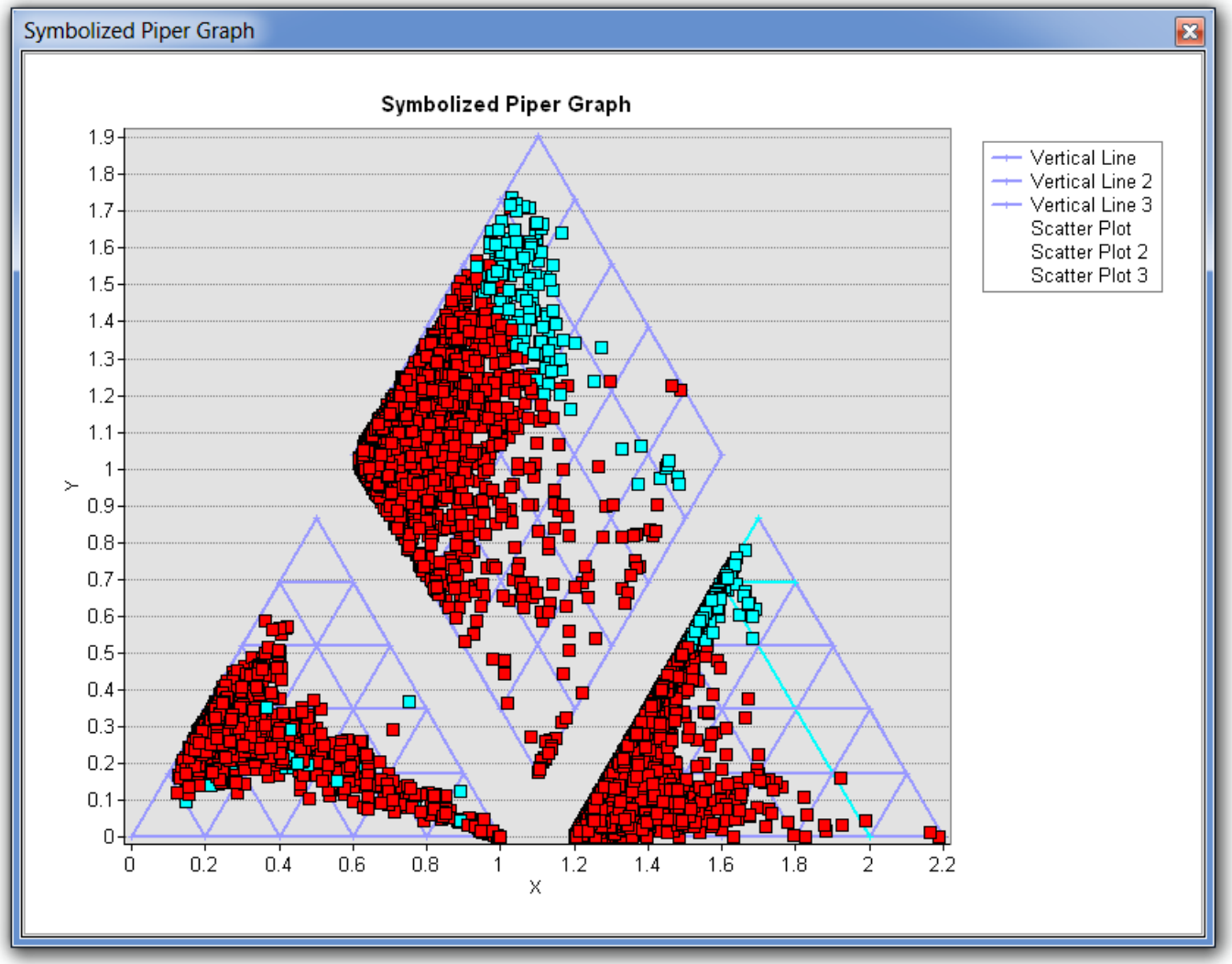
Piper Plot of General Chemistry



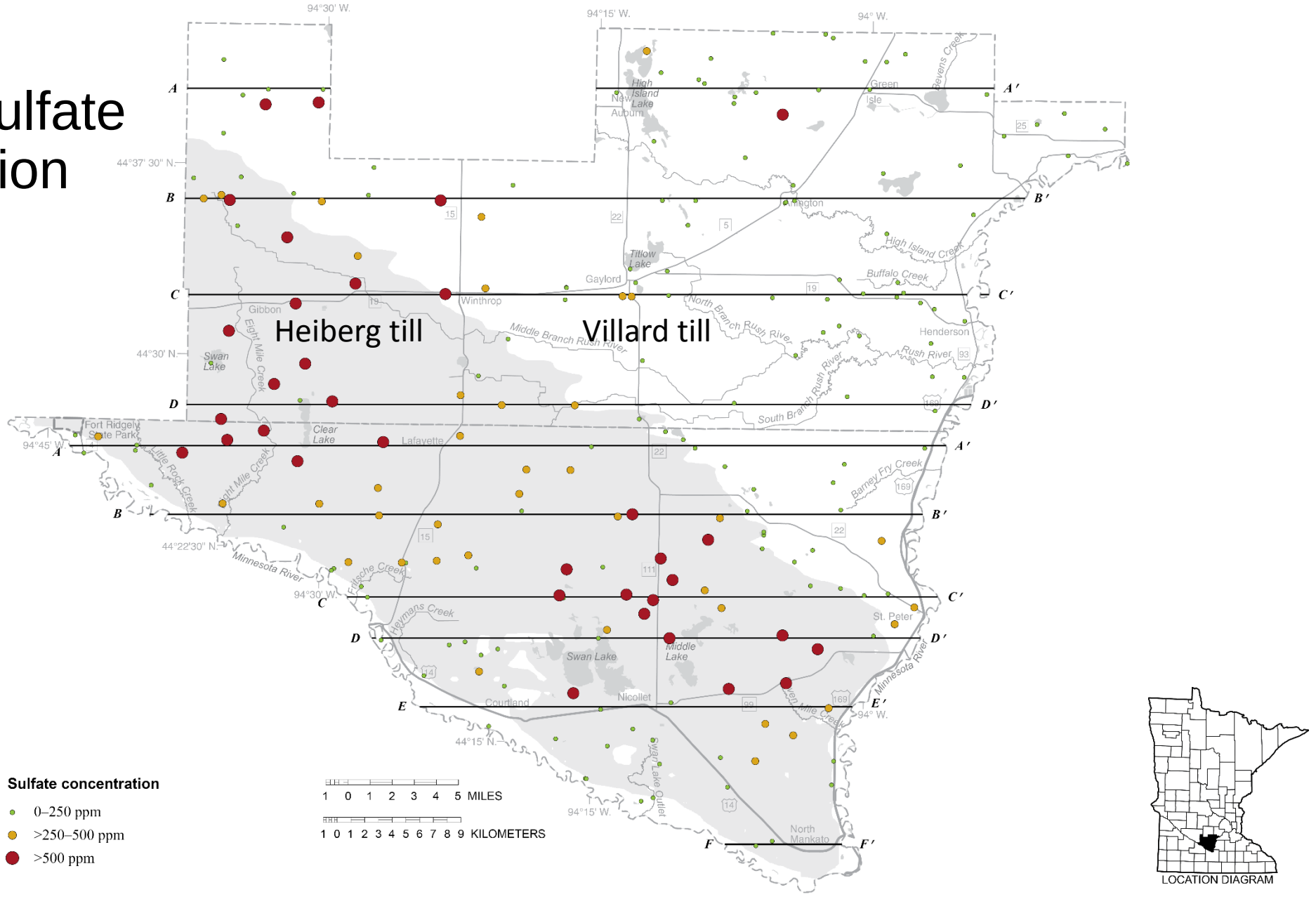


Piper Plot of General Chemistry – Sulfate Rich Groundwater

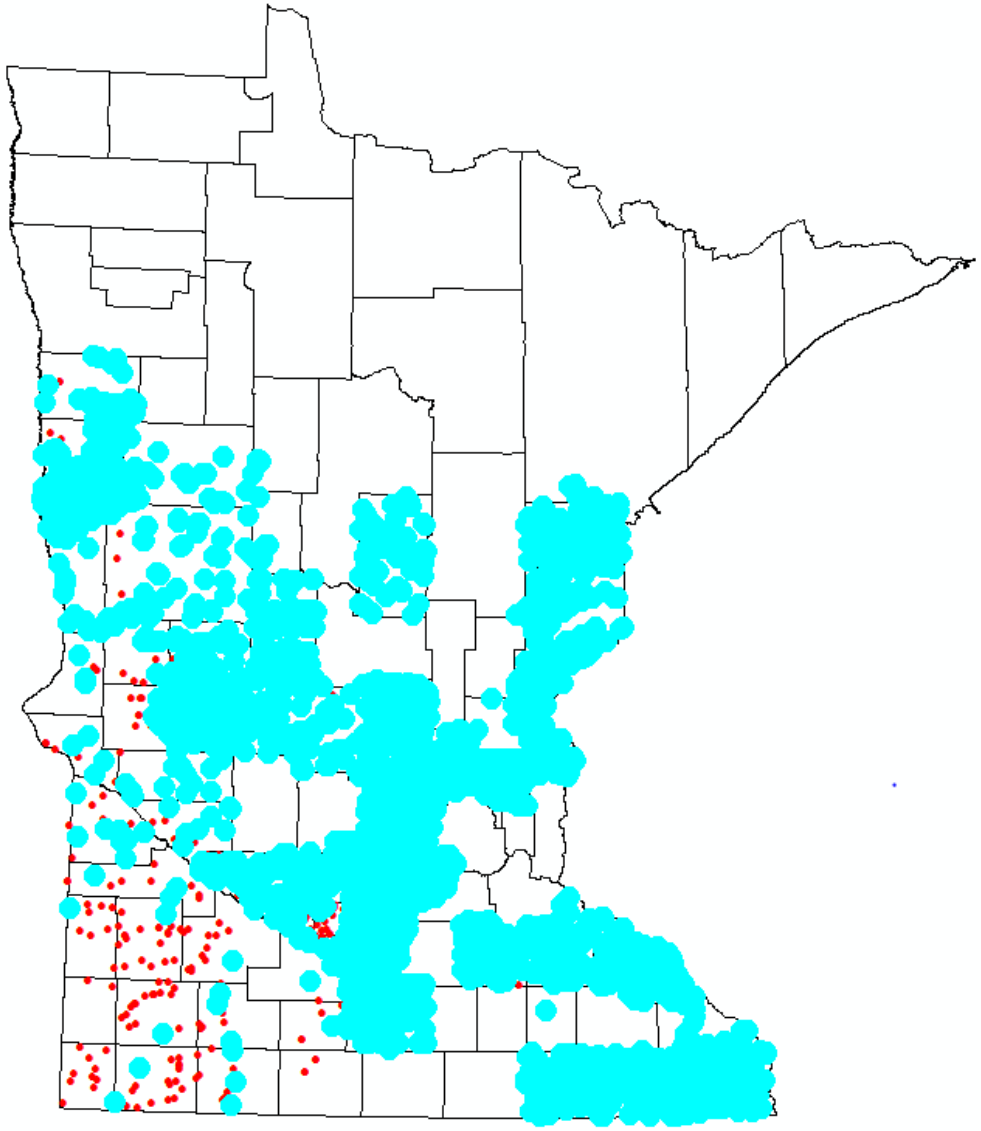


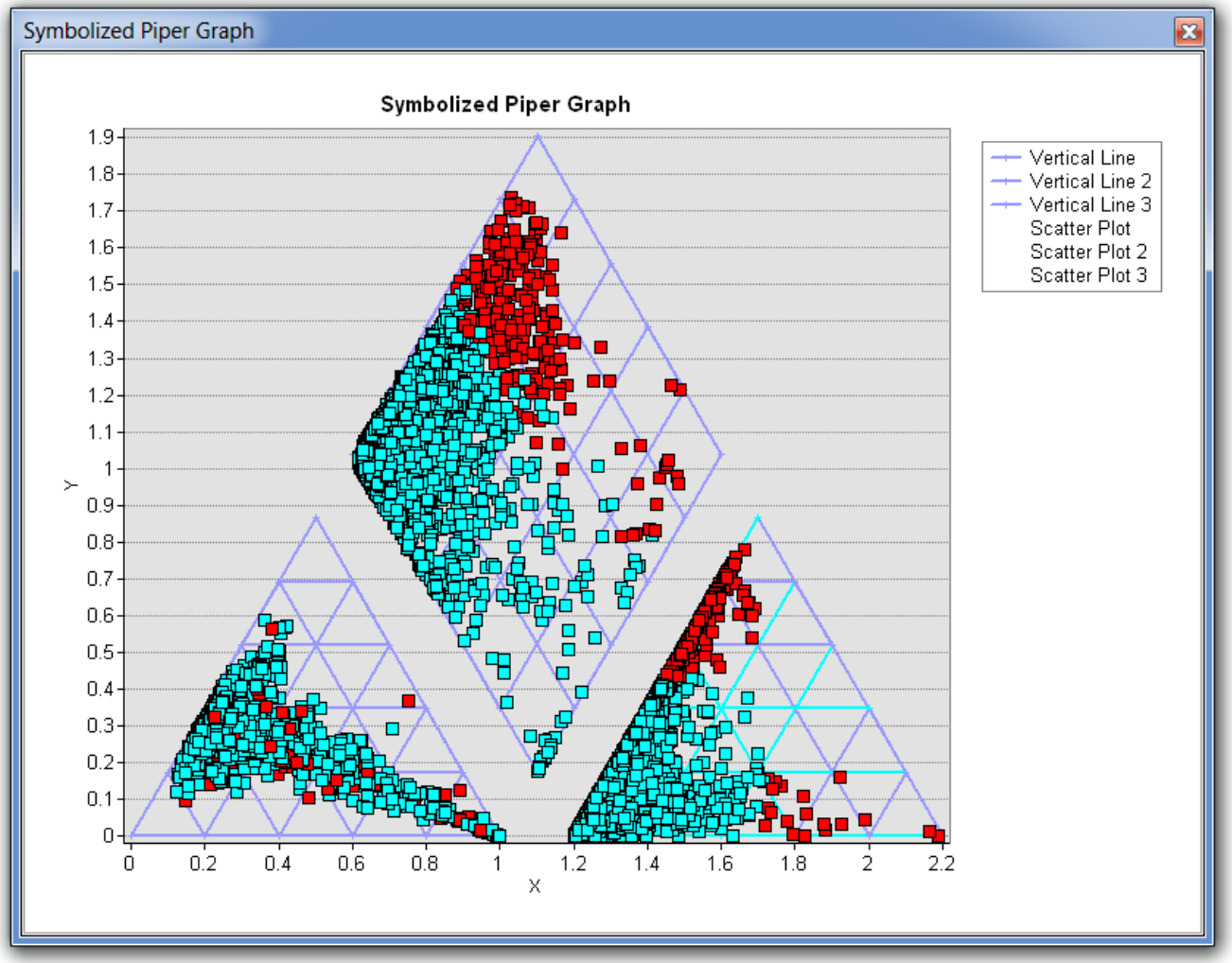


Elevated Sulfate Concentration



Piper Plot of General Chemistry – Calcium-Magnesium-Bicarbonate Groundwater





www.mndnr.gov/groundwatermapping

County Geologic Atlas Program

Program

Maps and Studies

Resources

Contacts

Maps and Studies

Products include maps and interpretive reports of geology, groundwater, pollution sensitivity, and special studies. Many provide separate GIS files and water chemistry information.

County Geologic Atlas (CGA)

County by county geologic and groundwater information.

Part A: Geologic studies include surficial deposits and bedrock.

Part B: Groundwater studies include flow systems, aquifers, groundwater chemistry, and sensitivity to pollution.

Early atlases were not split into two parts.

Minnesota Hydrogeology Atlas (MHA)

Extends maps, reports, and data originally published in the CGA program to new statewide coverage.

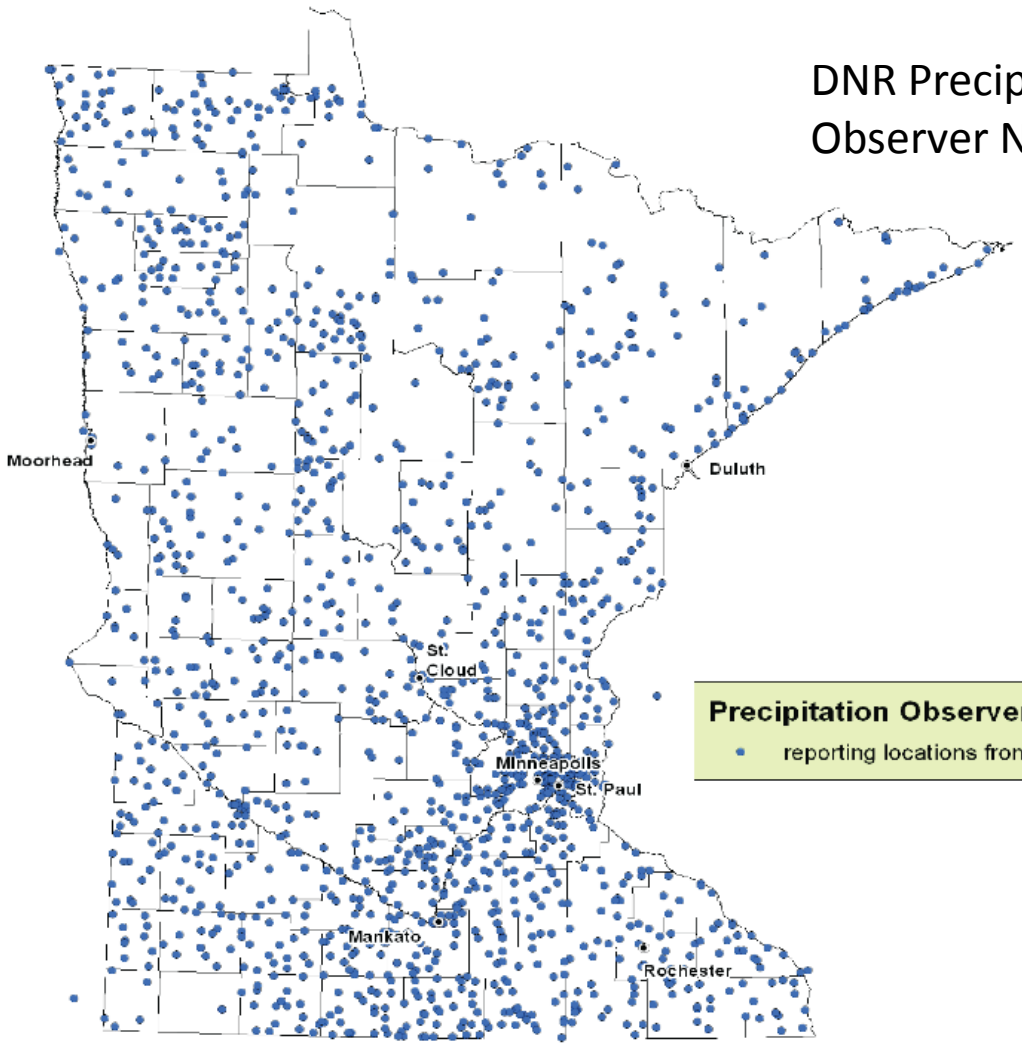
Regional Hydrogeologic Assessment (RHA)

Larger areas (typically 4-9 counties) covered in less detail than a County

Minnesota Department of Natural Resources
Water Monitoring and Surveys Unit

- Climatology
- Stream Flow
- Lake Levels
- Groundwater Levels

DNR Precipitation Observer Network

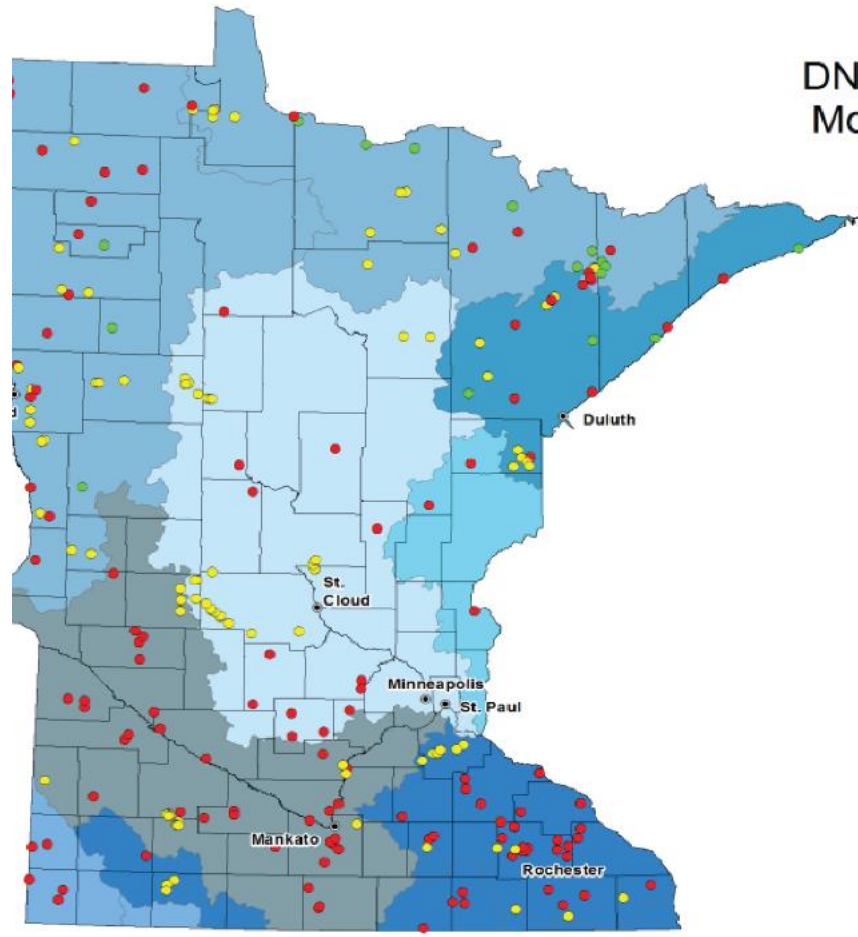


Precipitation Observer Network

- reporting locations from July 2011

DNR Surface Water Monitoring Network

October 2013



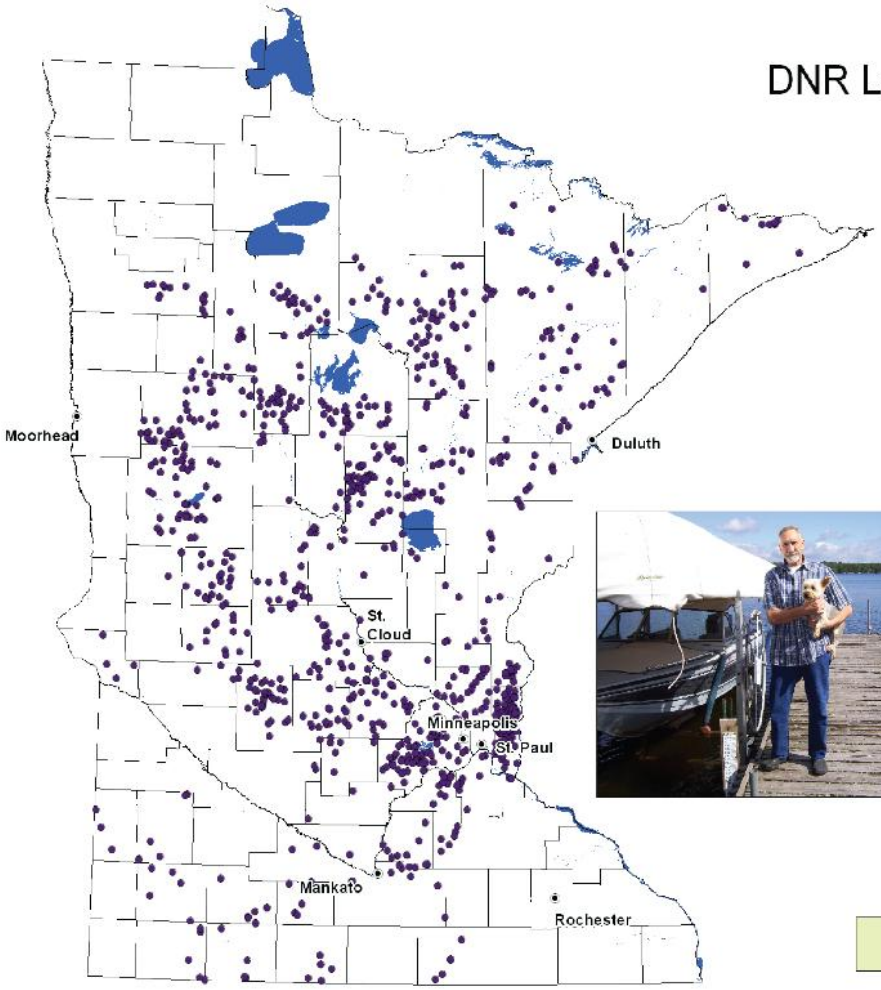
DNR work locations

- Telemetry, live-feed data (125)
- Non-telemetered data (109)
- Telemetry additions for 2014 (17)

Basin

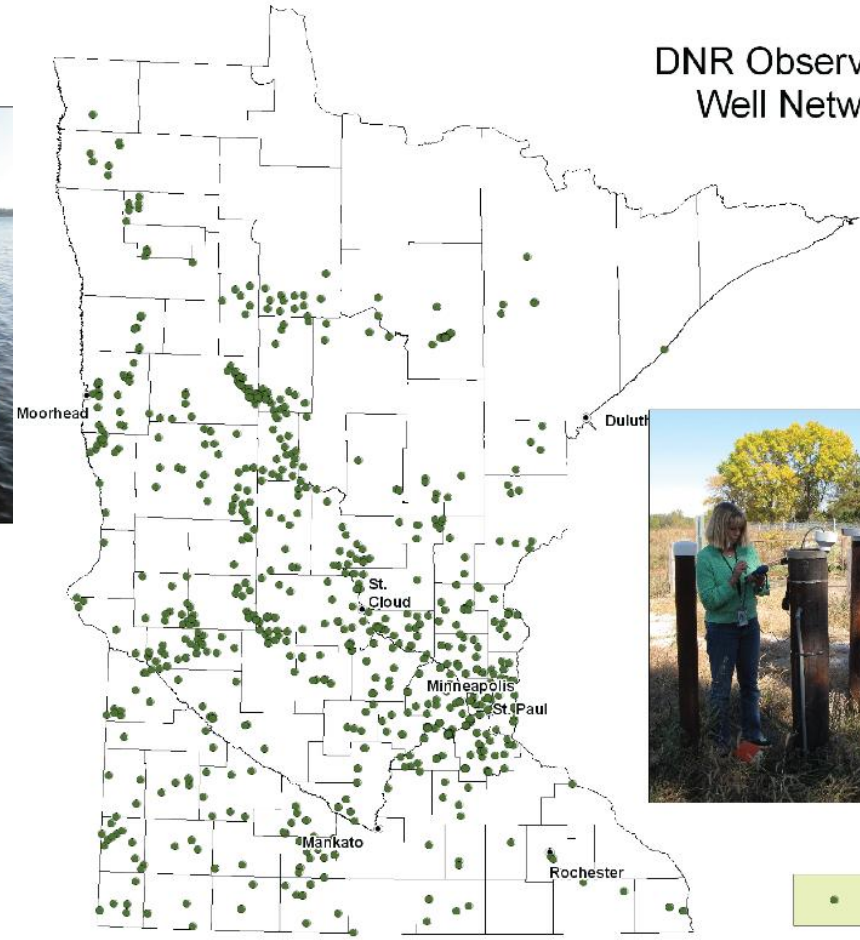
- Rainy/Red River Basin
- Lake Superior/Great Lakes Basin
- Mississippi Headwaters
- St. Croix River Basin
- Minnesota River Basin
- Sioux/Missouri River Basin
- Lower Mississippi River Basin

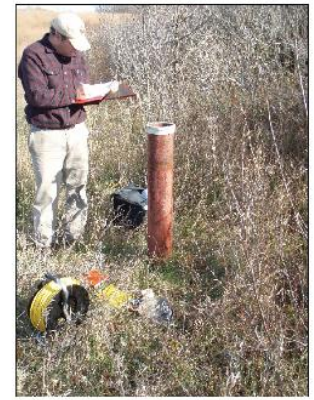
DNR Lake Gage Network



DNR Lake Gages

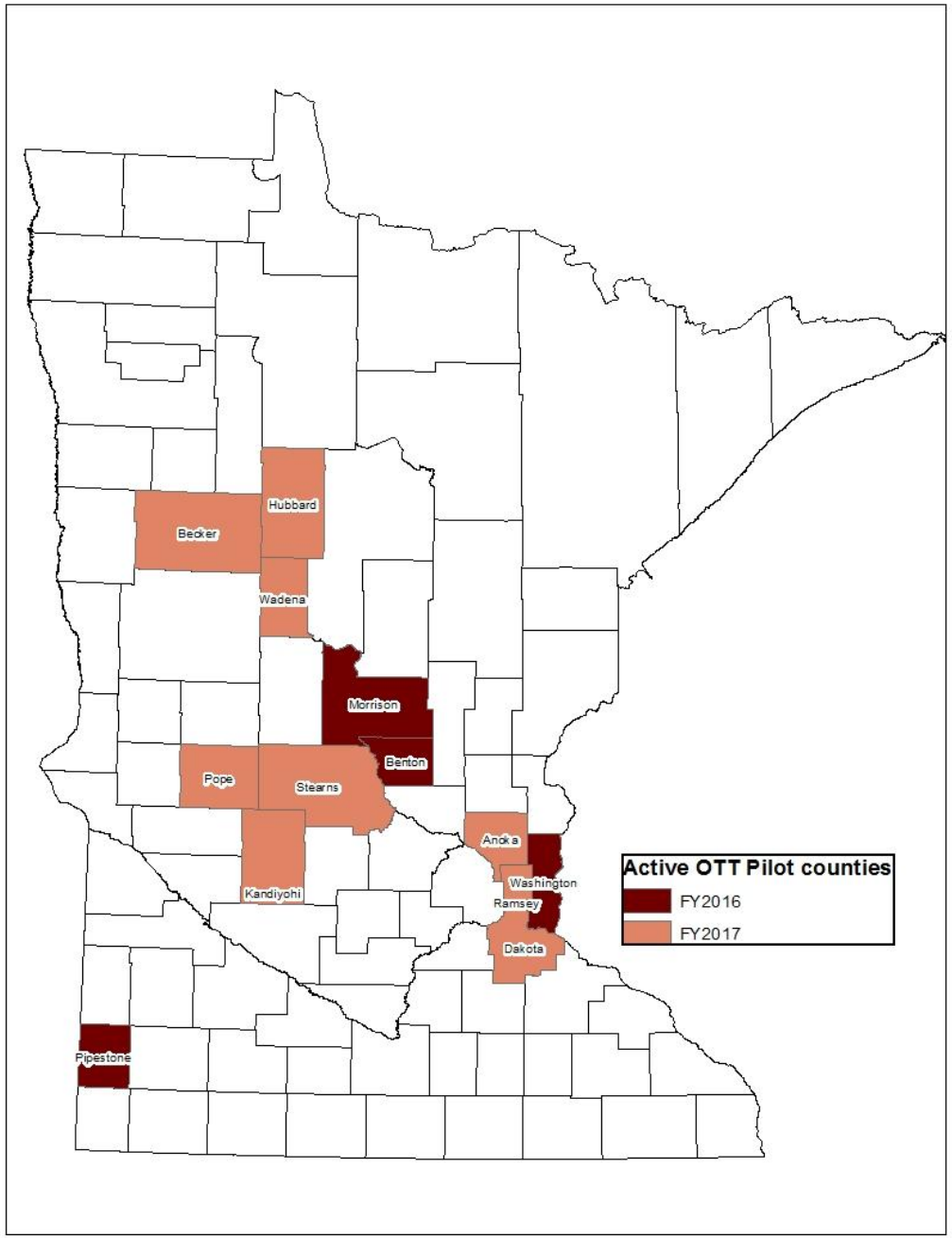
DNR Observation Well Network



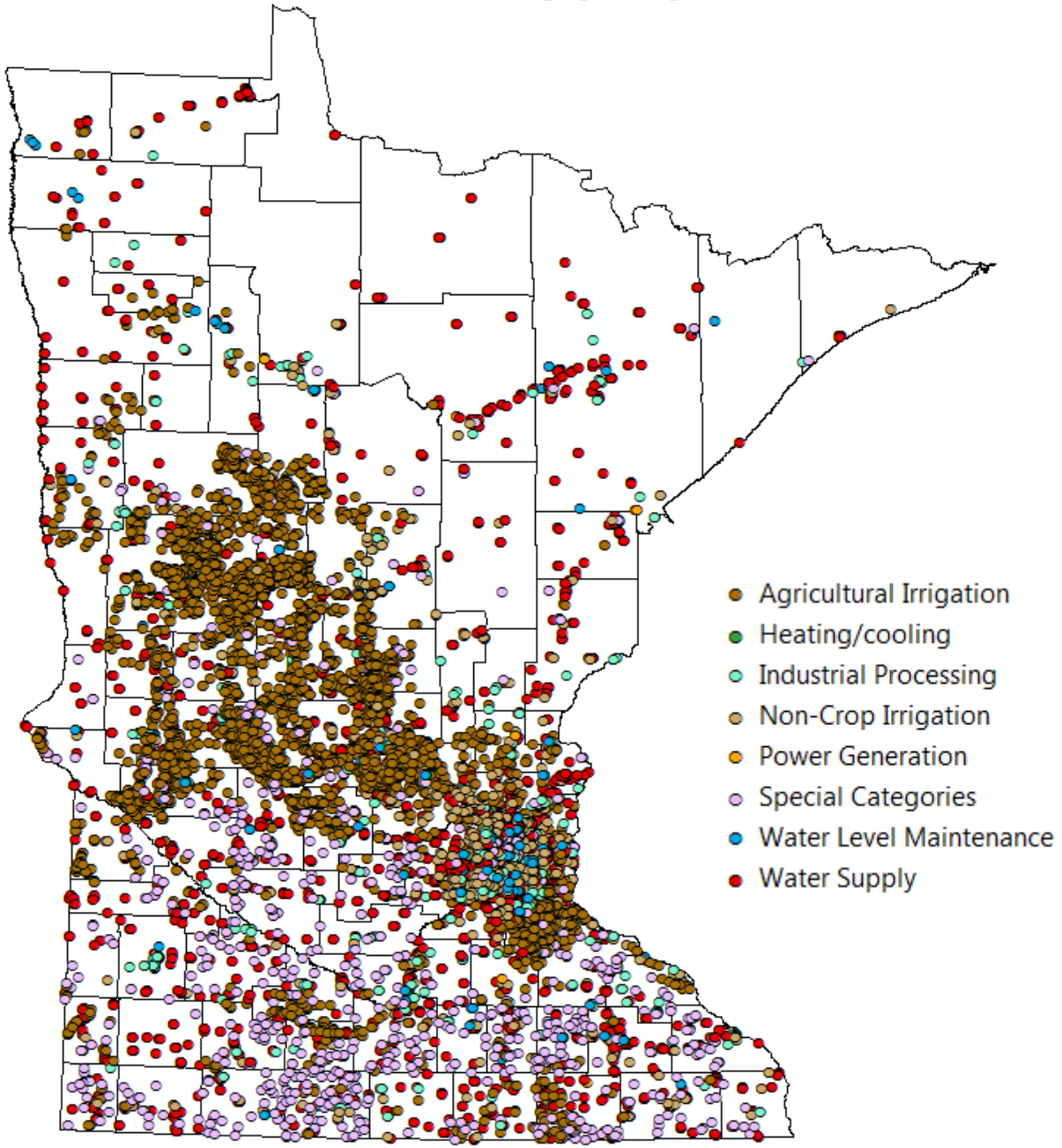


DNR Observation wells

Continuous Monitoring Pilot Counties



MPARS – Groundwater Appropriation Permit Locations



Conclusions

- County Geologic Atlas data analysis and reports created using documented methods and procedures
- Reports, data, and procedures published online
- Large statewide datasets compiled from individual county studies
- Atlas reports cover much of Minnesota. Statewide studies using chemistry and hydrology data from atlases possible
- Monitoring Unit moving to continuous recording for both surface water and groundwater sites.
- DNR MPARS database houses statewide permitted water use data

DNR Water Data on the Web

- County Geologic Atlas Maps and Data
  - http://www.mndnr.gov/groundwatermapping
- Cooperative Groundwater Monitoring (CGM)
  - http://www.dnr.state.mn.us/waters/cgm/index.html
- DNR/MPCA Cooperative Stream Gaging
  - http://www.dnr.state.mn.us/waters/csg/index.html
- DNR Lake Monitoring
  - http://www.dnr.state.mn.us/waters/surfacewater_section/lake_hydro/index.html
- DNR Precipitation Network
  - http://www.dnr.state.mn.us/climate/index.html
- MPARS (Water Use Data)
  - mndnr.gov search “water use” or
  - http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html
- Aquifer Properties Database
  - In development