

Mapping Glacial Aquifers in Central MN as a Resource for Local Management

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DNR Ecological and Water Resources
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GEOLOGIC ATLAS OF BENTON COUNTY, MINNESOTA

COUNTY ATLAS SERIES C-23

PART A

(Published separately by the Minnesota Geological Survey)

PART B

Plate 6. Hydrogeology of the Surficial Sand Aquifer

Plate 7. Hydrogeologic Cross Sections

Plate 8. Hydrogeology of the Buried Aquifers and the Rice Area Aquifer System

Plate 9. Sensitivity of the Groundwater Systems to Pollution

Map Applications

1. Identify and Characterize

- Primary aquifer sources and extents
- Zones of aquifer sensitivity
- Potential areas of groundwater discharge

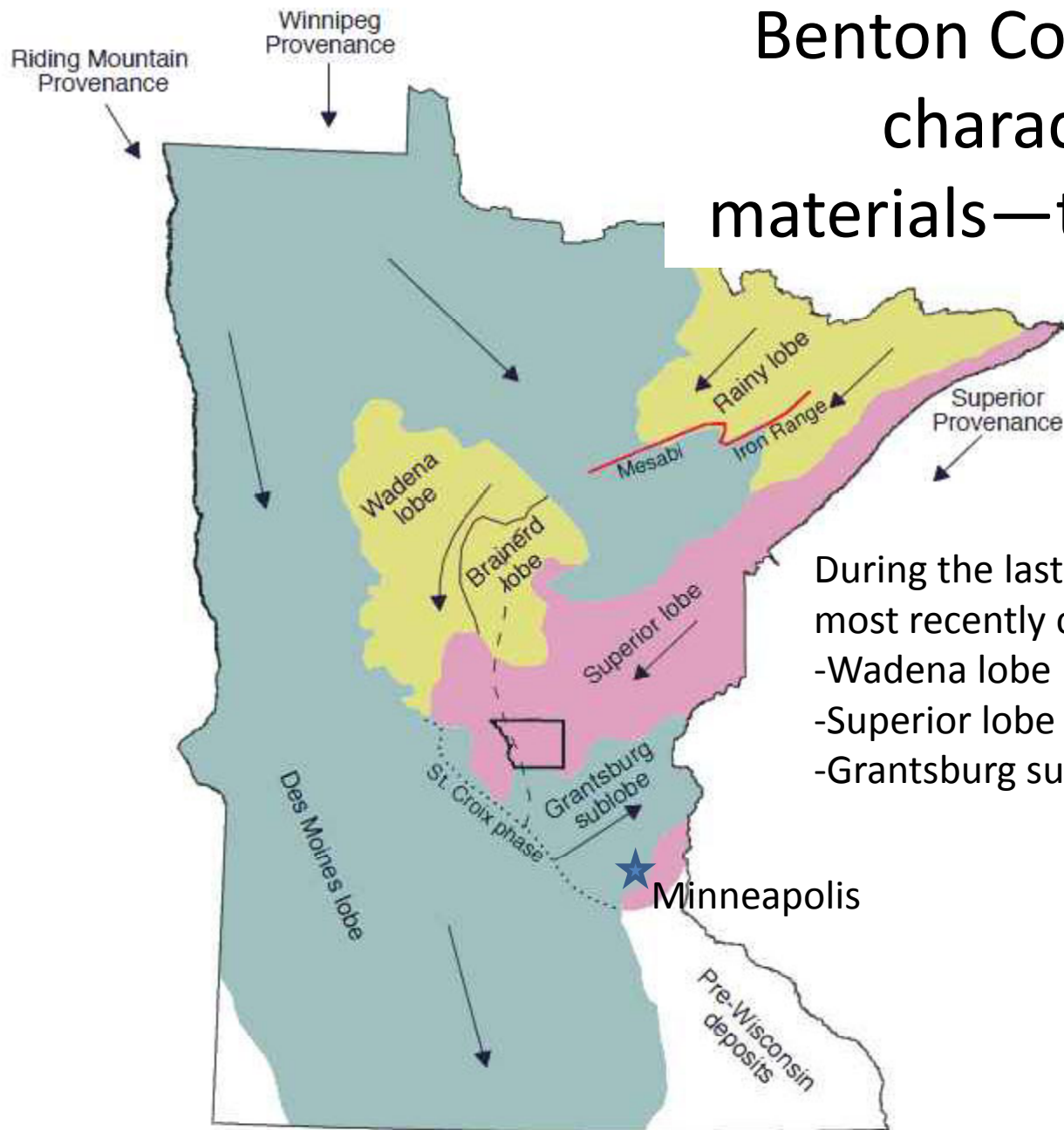
2. Manage

- Water appropriation permit evaluation
- Water supply assistance

3. Protect

- Feedlot/nutrient management
- Environmental review support

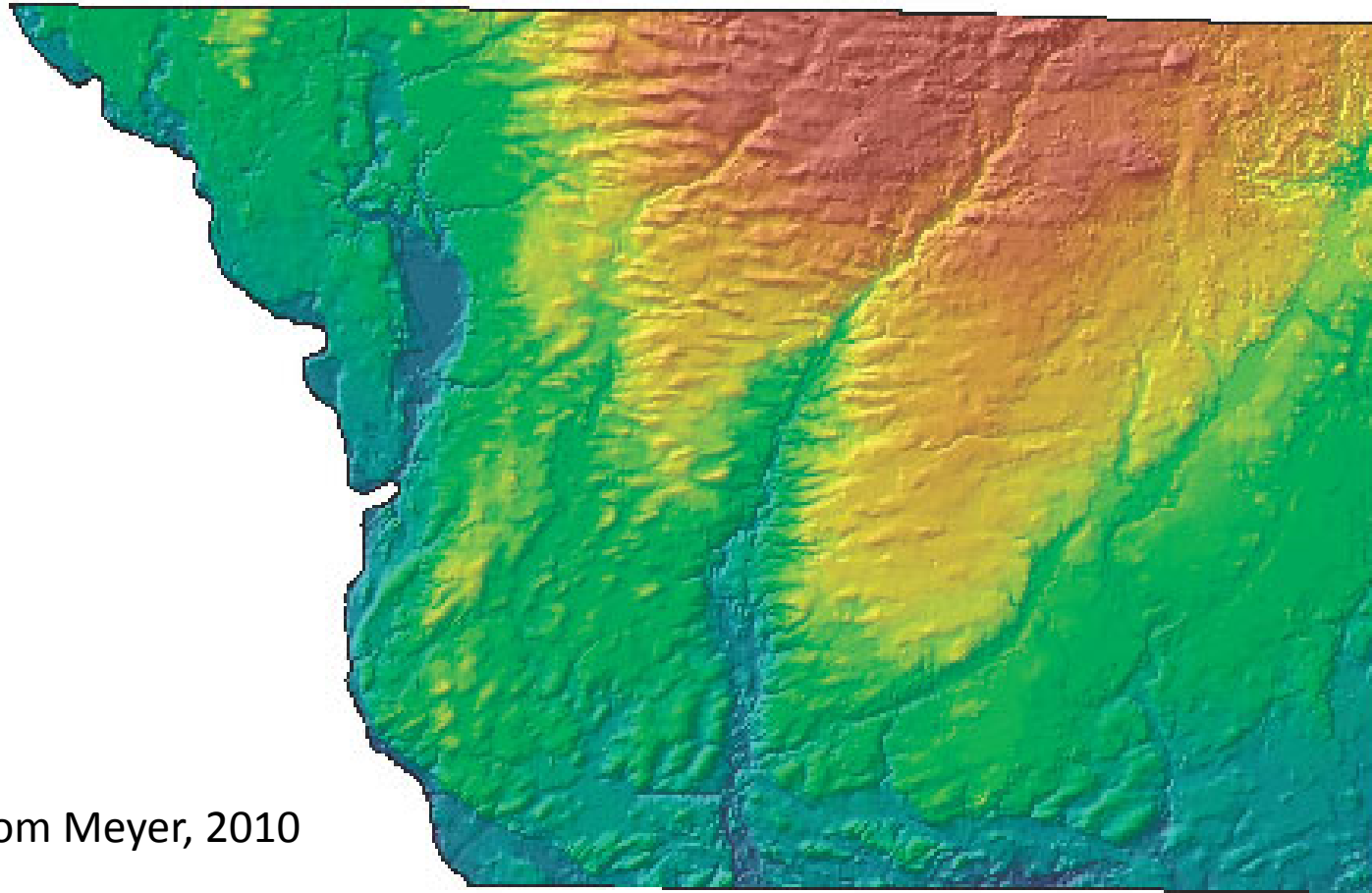
Benton County hydrology is characterized by glacial materials—till or sand/gravel



During the last glaciation the county was most recently covered with materials from:

- Wadena lobe
- Superior lobe
- Grantsburg sublobe (outwash)

Meyer, 2010



From Meyer, 2010

Figure 2. Physical relief of the land surface in Benton County. Elevation is shown by color: red (higher surface elevation) grading to blue (lower surface elevation). A false sun illumination at an elevation of 30° from the northwest (315°) provides contrast (gray shadowing) to accent details of landforms. The map was created using the U.S. Geological Survey's Digital Elevation Model with a 30-meter grid.

Part A-Simplified surficial geology

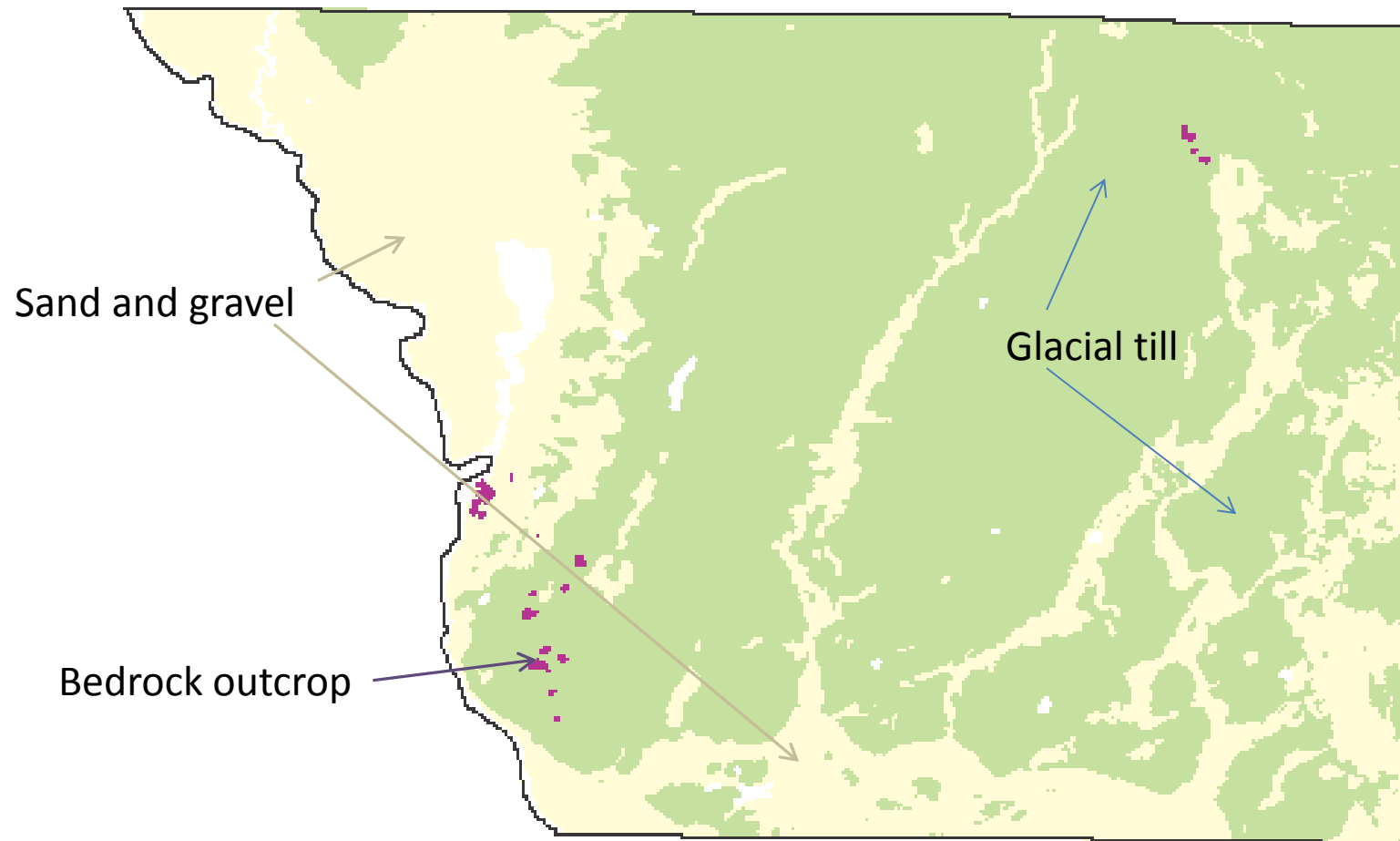


Figure 1. The map units from the 1:100,000 surficial geology map are combined into three simplified units in this figure: green is less permeable diamicton (glacial till) and bedded silt and clay, yellow is more permeable, bedded sand to gravel; and purple is bedrock. Water bodies are white.

From Meyer, 2010



Foley 2,600 people
Sauk Rapids 12,800 people
Rice 1,300 people

Map Applications

1. Identify and Characterize

- Primary aquifer sources and extents
- Zones of aquifer sensitivity
- Potential areas of groundwater discharge

2. Manage

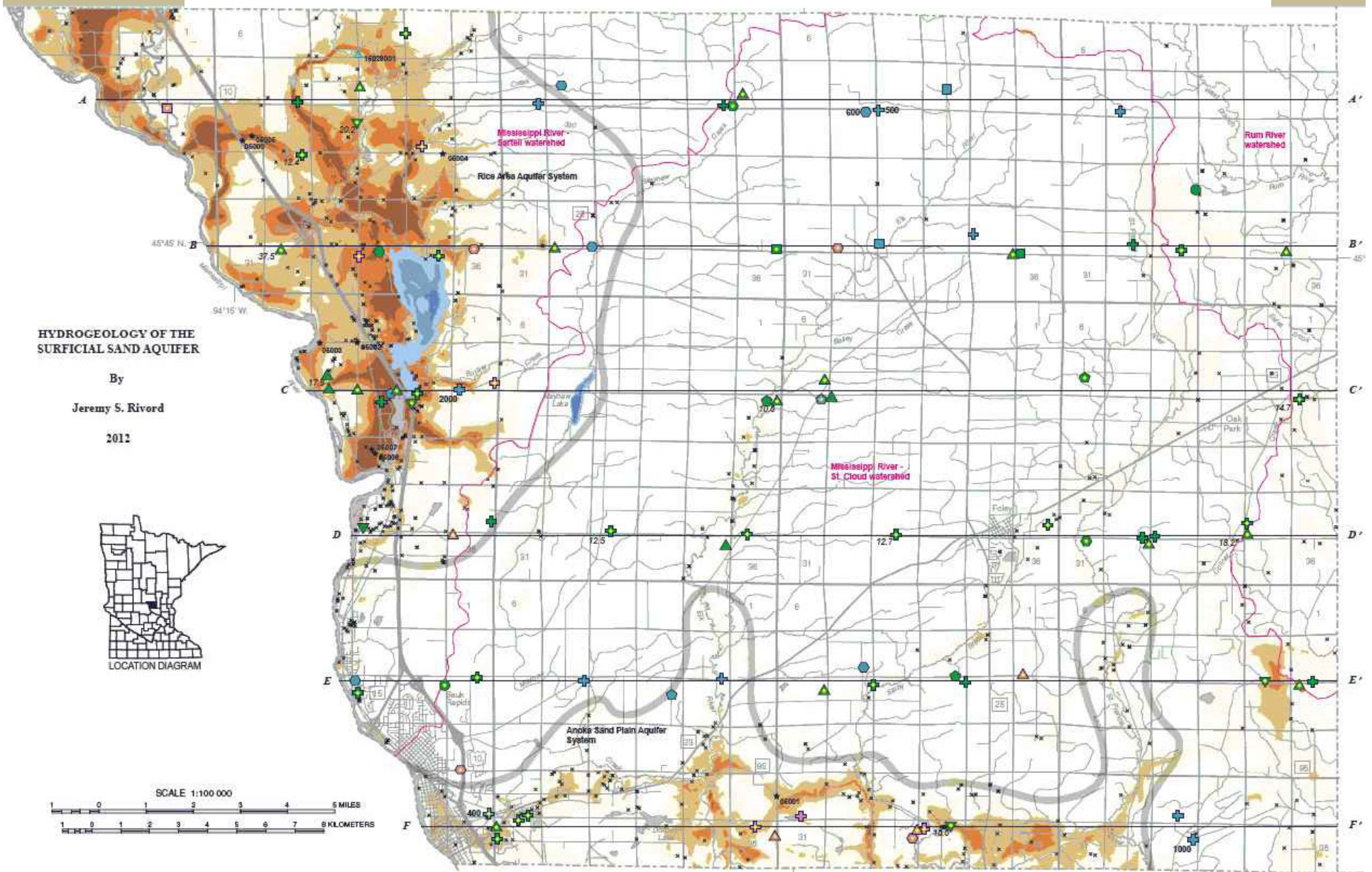
- Water appropriation permit evaluation
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3. Protect

- Feedlot/nutrient management
- Environmental review support

Characterize—Hydrogeology of the Surficial Sand Aquifer

Surficial sand aquifer extent, thickness and chemistry of sampled wells



Characterize—Surficial sand aquifer extent, thickness and chemistry of sampled wells

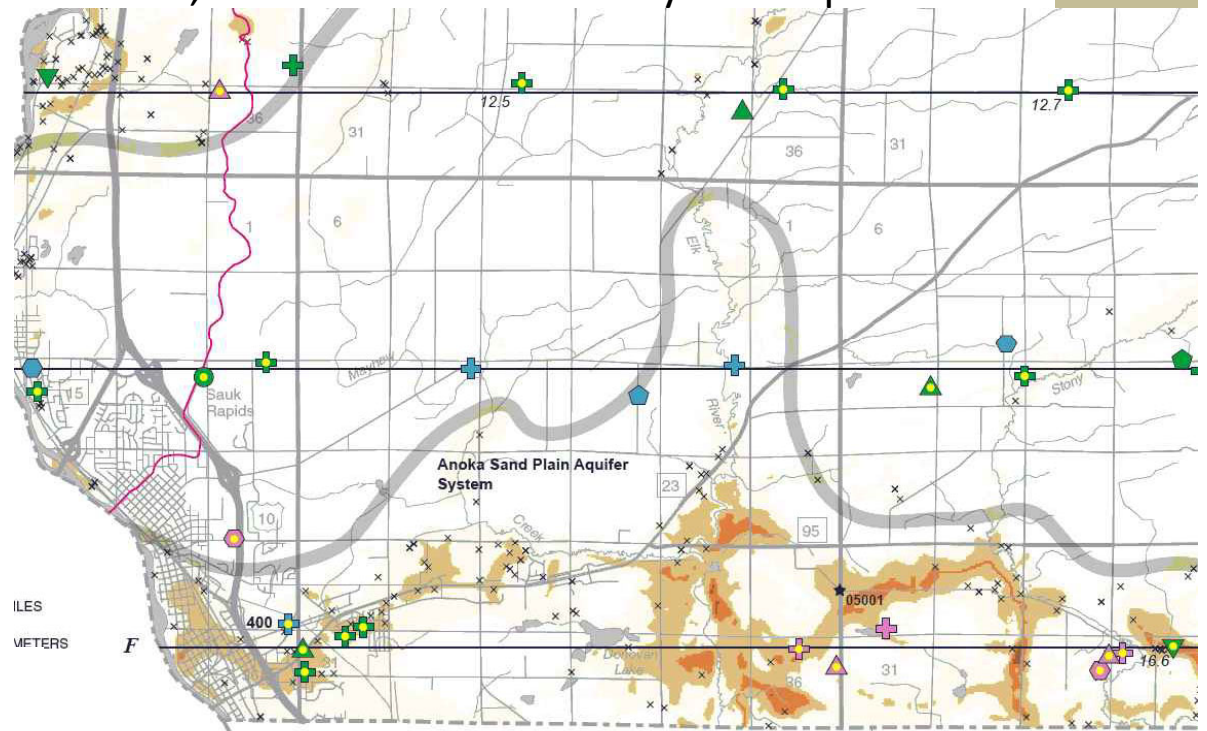
Map symbols and labels

- 16.6 If shown, nitrate as nitrogen concentration equals or exceeds 10 parts per million.
- If shown on well symbol, chloride to bromide ratio greater than 300.
- 2000 If shown, groundwater residence time in years, estimated by carbon-14 (¹⁴C) isotope analysis.
- ★ 05007 DNR observation well where labeled on hydrographs shown in Figure 2.
- △ 15029001 DNR/MPCA streamflow monitoring location.
- × Selected well log used to map extent of aquifer.
- Surface watershed boundary.
- Area County Aquifer System.
- F F' Line of cross section.

Sampled well and aquifer symbols

- ▼ Surficial sand aquifer.
- Buried sand and gravel aquifer units.*
- ▲ Supra-Emerald aquifer unit (se)
- ✚ Sub-Emerald aquifer unit (sb)
- Pre-Wisconsinan aquifer unit (sx)
- Pre-Wisconsinan aquifer unit (sw)
- Other wells.
- ◆ Unmapped buried aquifer
- Bedrock

* Buried sand and gravel aquifer units are listed on Plate 7 with their associated sand units from Plate 4, Part A.



Estimated surficial sand aquifer thickness (feet)

- Surficial sand not present or no data available.
- > 0 to 25
- > 25 to 50
- > 50 to 75
- > 75

Tritium age

Color indicates tritium age of water sampled in well.

- Recent—Water entered the ground since about 1953 (10 or more tritium units [TU]).
- Mixed—Water is a mixture of recent and vintage waters (greater than 1 TU to less than 10 TU).
- Vintage—Water entered the ground before 1953 (less than or equal to 1 TU).

Characterize—Surficial sand aquifer extent, thickness and chemistry of sampled wells

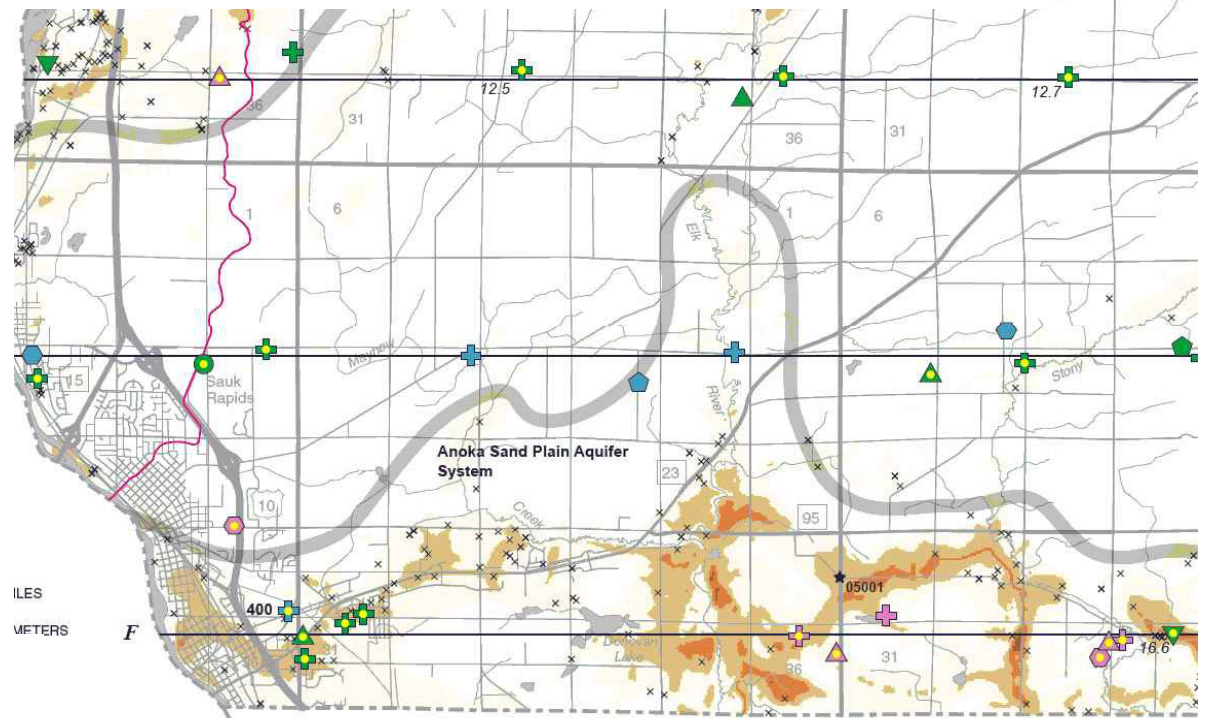
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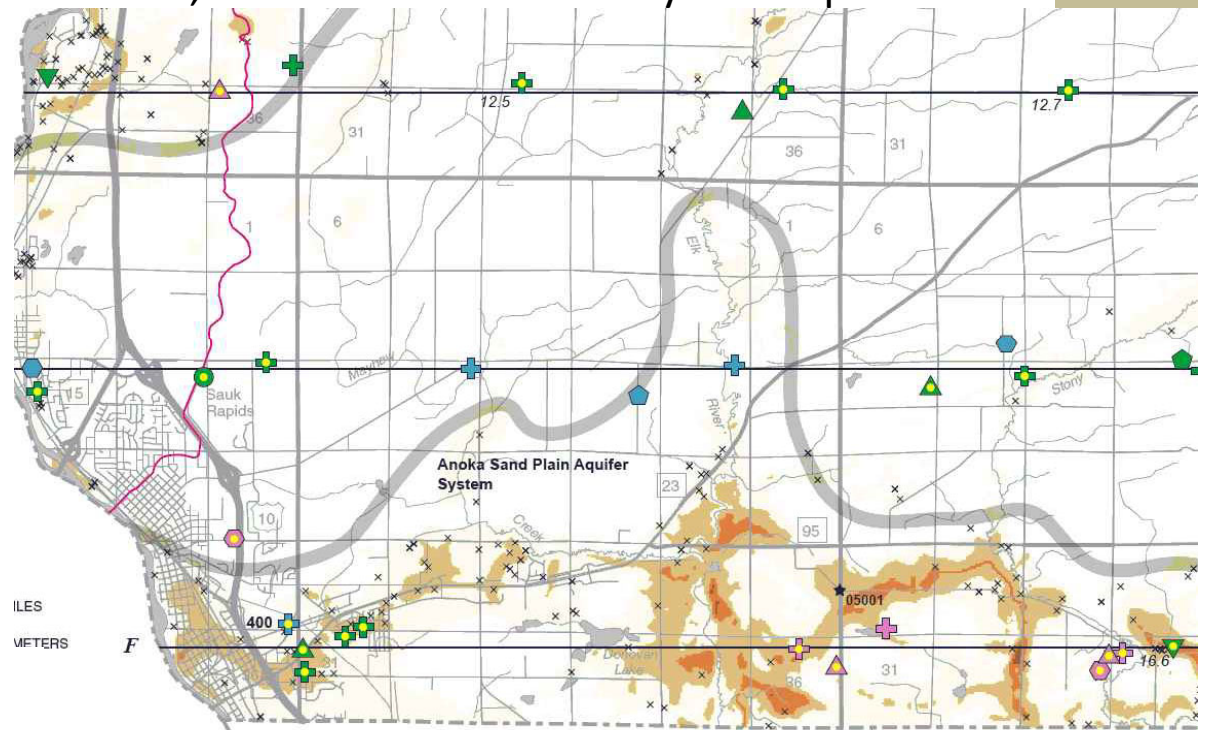
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- > 50 to 75
- > 75

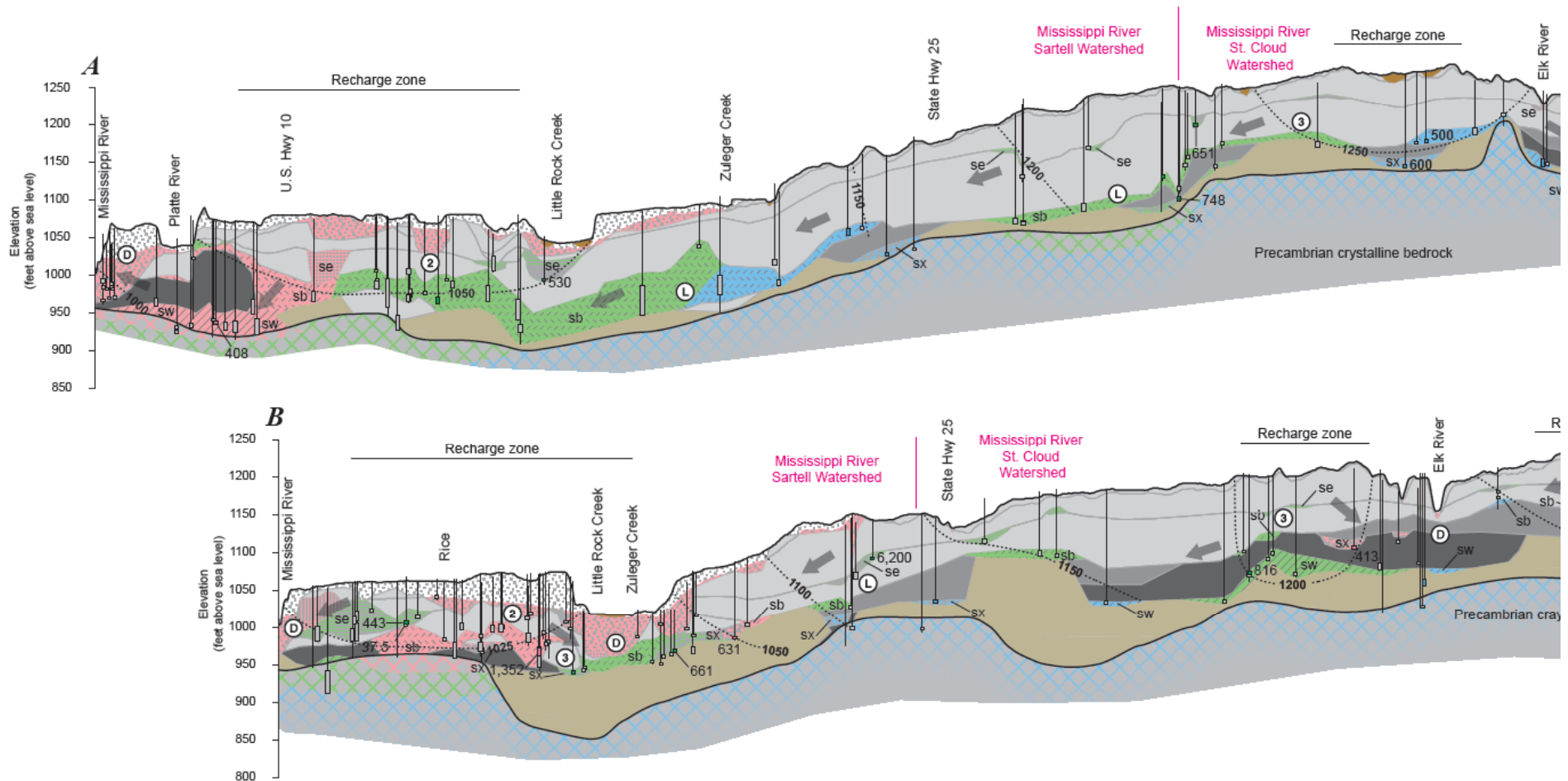
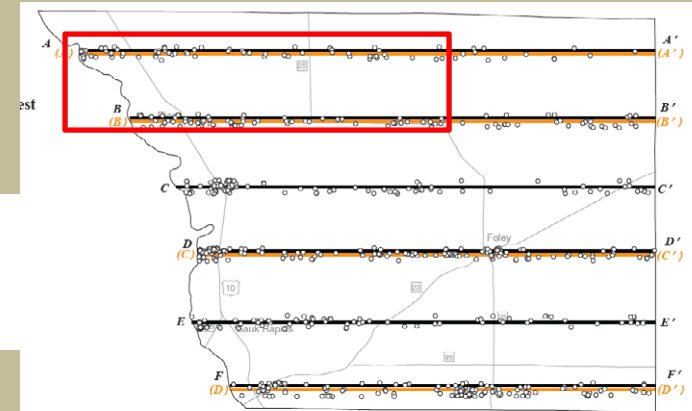
Tritium age

Color indicates tritium age of water sampled in well.

- Recent—Water entered the ground since about 1953 (10 or more tritium units [TU]).
- Mixed—Water is a mixture of recent and vintage waters (greater than 1 TU to less than 10 TU).
- Vintage—Water entered the ground before 1953 (less than or equal to 1 TU).

Characterize—Hydrogeologic Cross Sections

Western portions of cross sections A-A' and B-B'



Characterize—Hydrogeology of the Buried Aquifers

Elevation of the potentiometric surface and reported water use for 2010 in the sub-Emerald buried aquifer unit (sb)

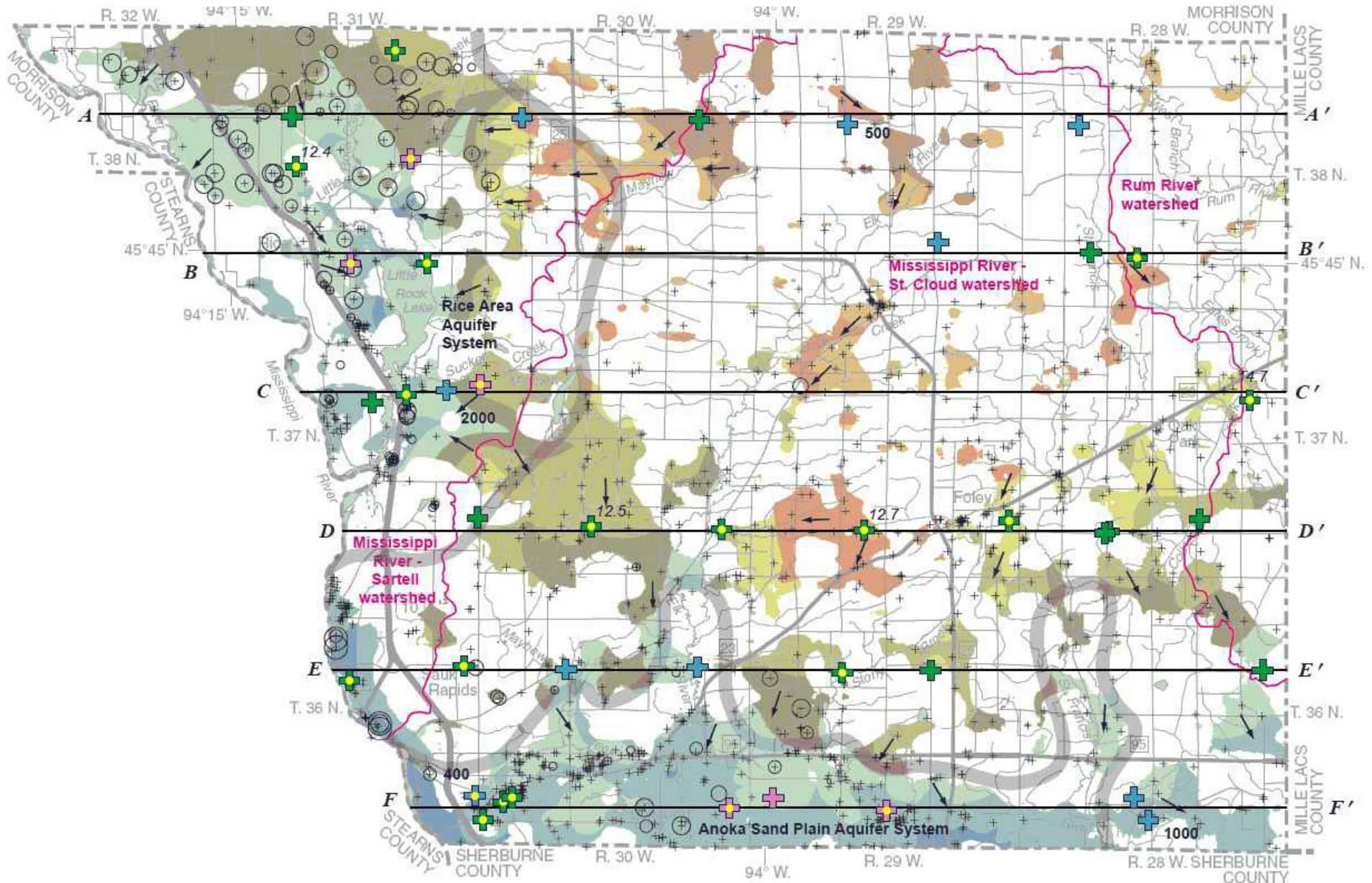


Plate 8—Hydrogeology of the Buried Aquifers

Legend for potentiometric surfaces

MAP EXPLANATION FOR FIGURES 1–3

Sampled well and aquifer symbols

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Other wells.

- ◆ Unmapped buried aquifer
- Bedrock

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Map symbols and labels

- + Static water level data.
- If shown on well symbol, chloride to bromide ratio greater than 300.
- ← General direction of groundwater flow.
- Surface watershed boundary.
- Area Aquifer System.
- F F' Line of cross section.
- Body of water.

Water use reported by DNR groundwater appropriation permit holders for 2010 (millions of gallons per year)

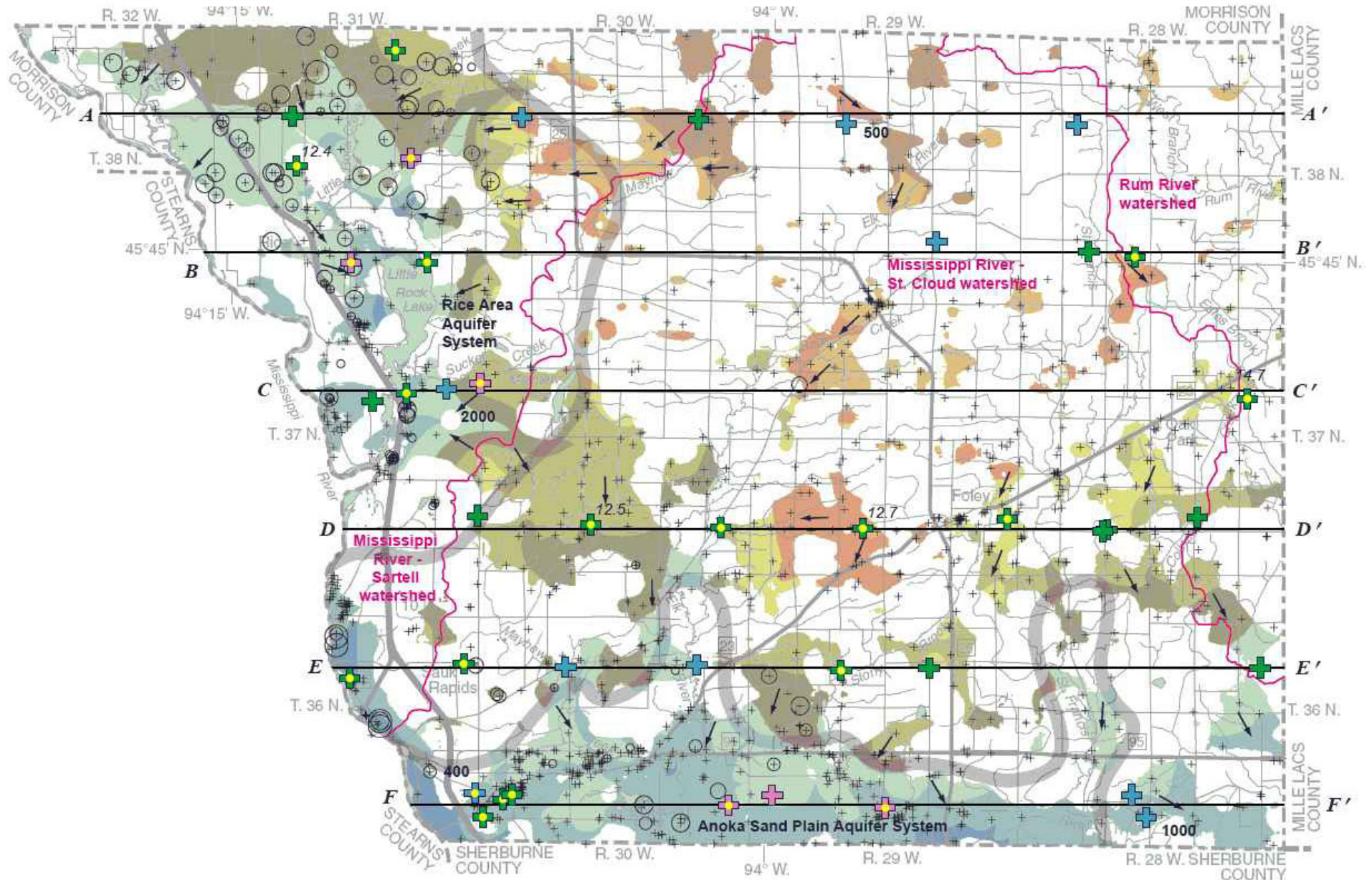
- 0–1
- >1–10
- >10–20
- >20–50
- >50

Potentiometric elevation of aquifer (feet above mean sea level)

- > 1,275 to 1,300
- > 1,250 to 1,275
- > 1,225 to 1,250
- > 1,200 to 1,225
- > 1,175 to 1,200
- > 1,150 to 1,175
- > 1,125 to 1,150
- > 1,100 to 1,125
- > 1,075 to 1,100
- > 1,050 to 1,075
- > 1,025 to 1,050
- > 1,000 to 1,025
- > 975 to 1,000

Characterize—Hydrogeology of the Buried Aquifers

Elevation of the potentiometric surface and reported water use for 2010 in the sub-Emerald buried aquifer unit (sb)



Map Applications

1. Identify and Characterize

- Primary aquifer sources and extents
- Zones of aquifer sensitivity
- Potential areas of groundwater discharge

2. Manage

- Water appropriation permit evaluation
- Water supply assistance

3. Protect

- Feedlot/nutrient management
- Environmental review support

Manage—Water Use

TABLE 1. Water use reported for 2010 by use category.

[Data from Minnesota Department of Natural Resources, State Water Use Data System; MGY, million gallons per year]

Use Category	Water Use (MGY)	Percent of Use
Major Crop Irrigation	3097.7	84.7
Municipal Waterworks	196.6	5.4
Commercial/Institutional Waterworks	221.4	6.1
Non-Crop Irrigation	75.9	2.1
Livestock Watering	65.6	1.8
Total	3657.2	100*

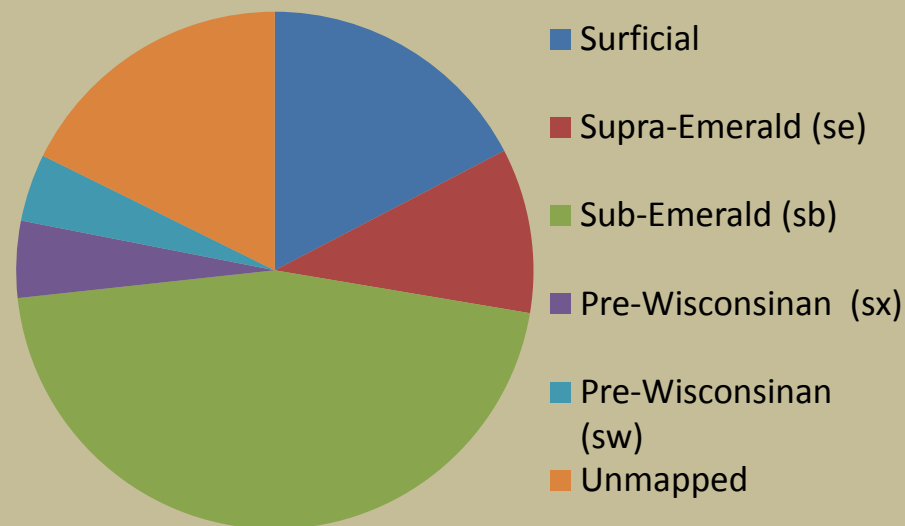
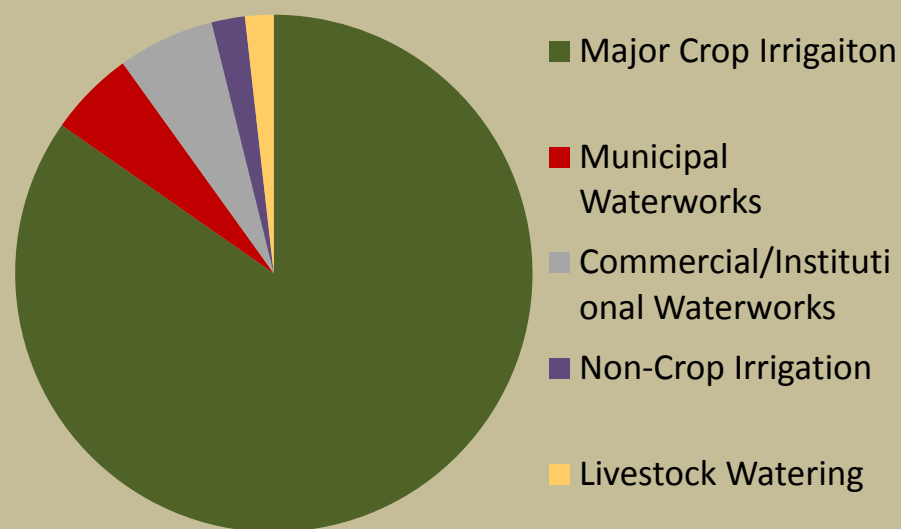
* Percentages do not add up to 100 due to rounding.

TABLE 2. Water use reported for 2010 by aquifer.

[Data from Minnesota Department of Natural Resources, State Water Use Data System; MGY, million gallons per year]

Aquifer Unit	Water Use (MGY)	Percent of Use
Surficial sand aquifer	634.5	17.3
Supra-Emerald buried aquifer unit (se)	376.6	10.3
Sub-Emerald buried aquifer unit (sb)	1669.3	45.6
Pre-Wisconsinan buried aquifer unit (sx)	175.4	4.8
Pre-Wisconsinan buried aquifer unit (sw)	154.2	4.2
Unmapped buried sand aquifer in geologic unit Qu	647.2	17.7
Total	3657.2	100*

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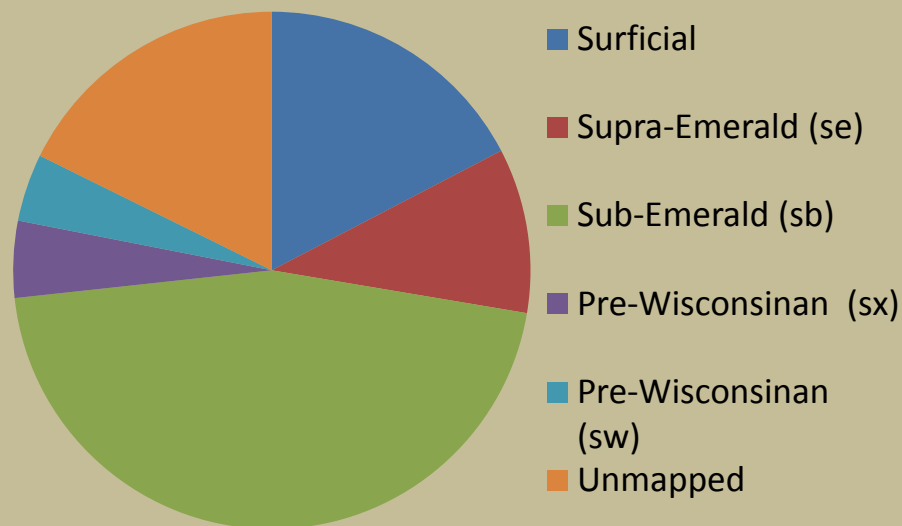
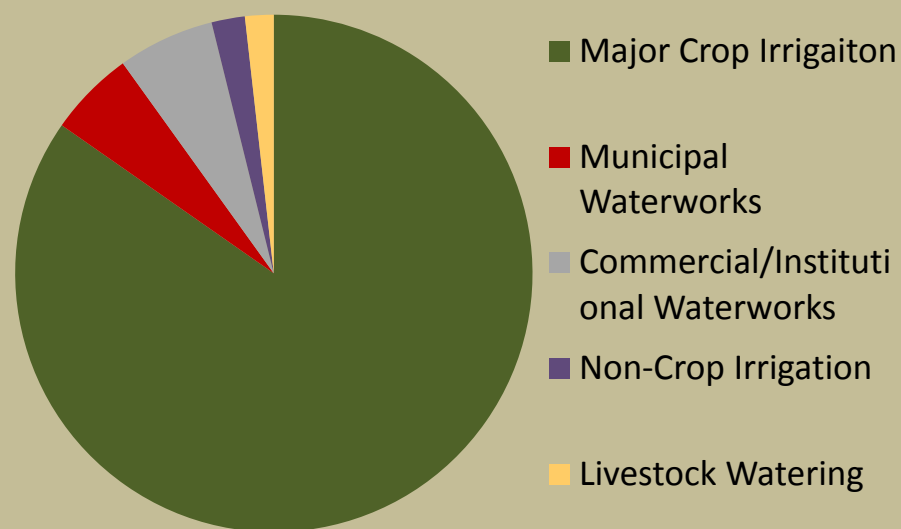
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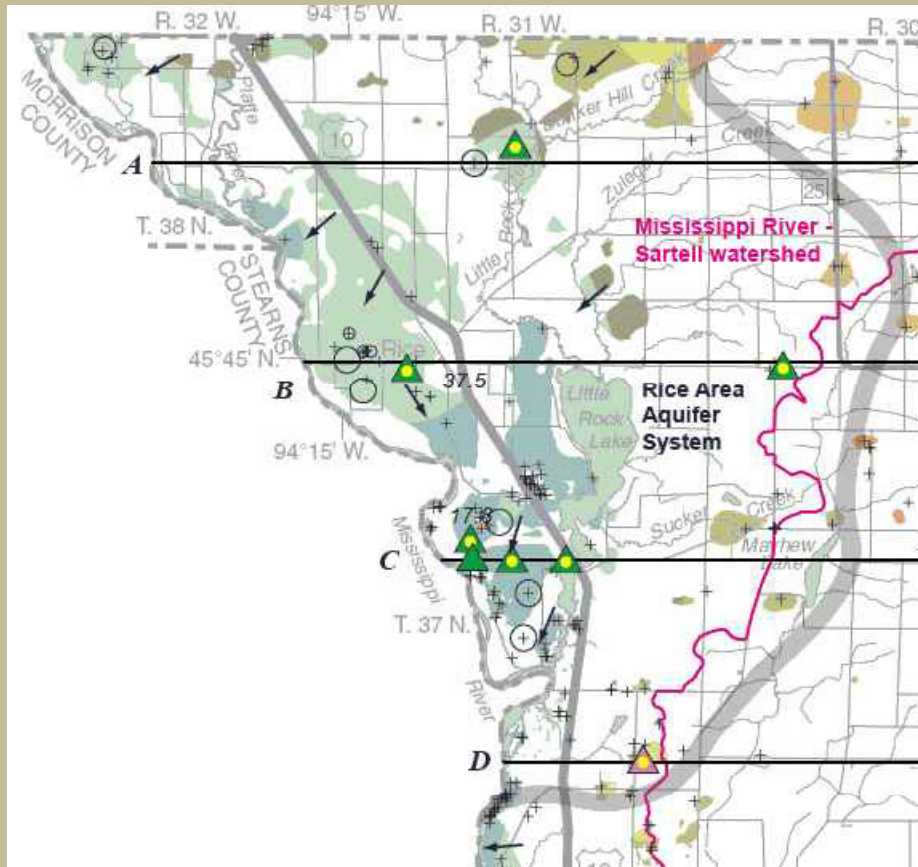
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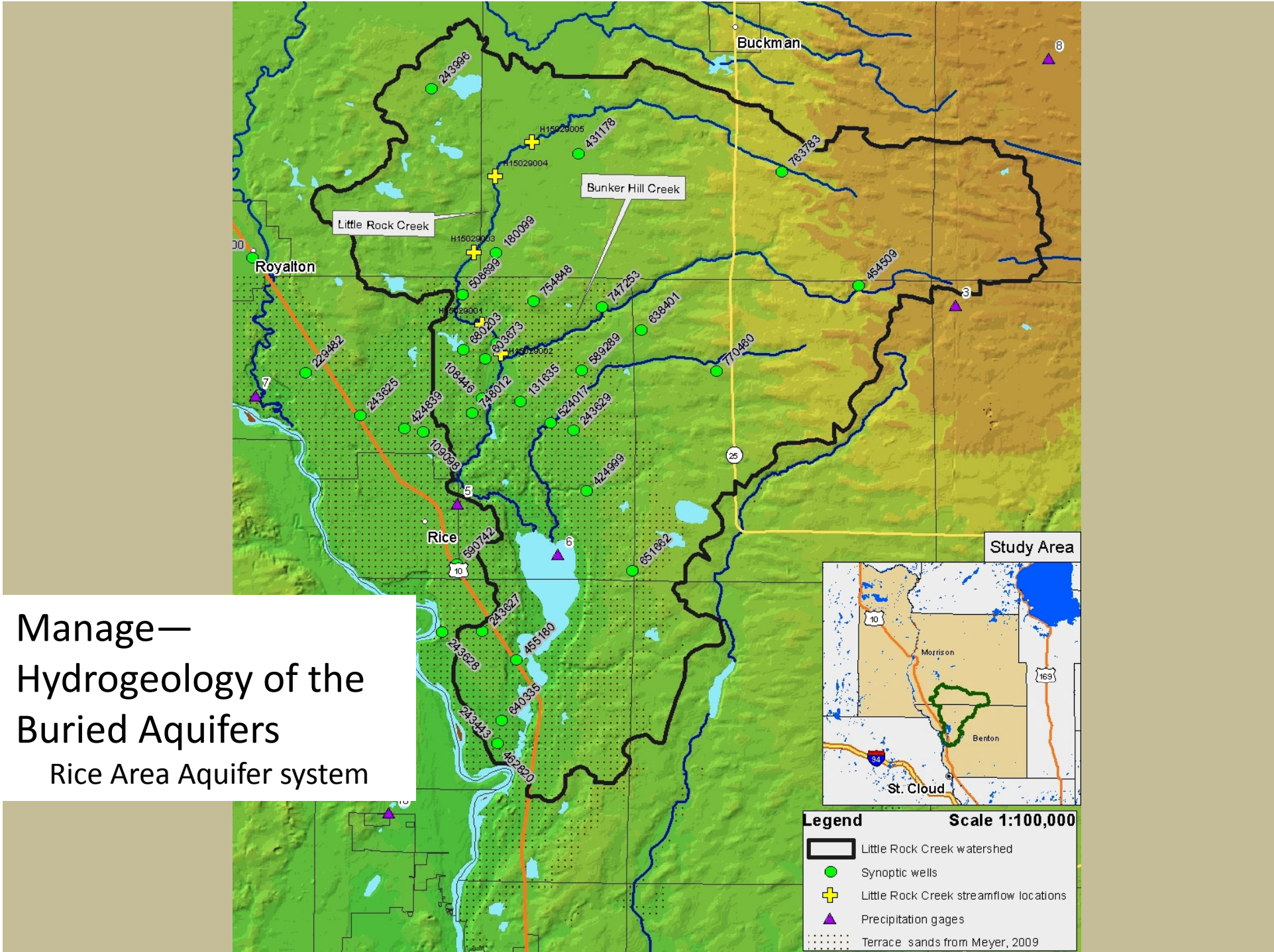
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Manage—Hydrogeology of the Buried Aquifers

Rice Area Aquifer system

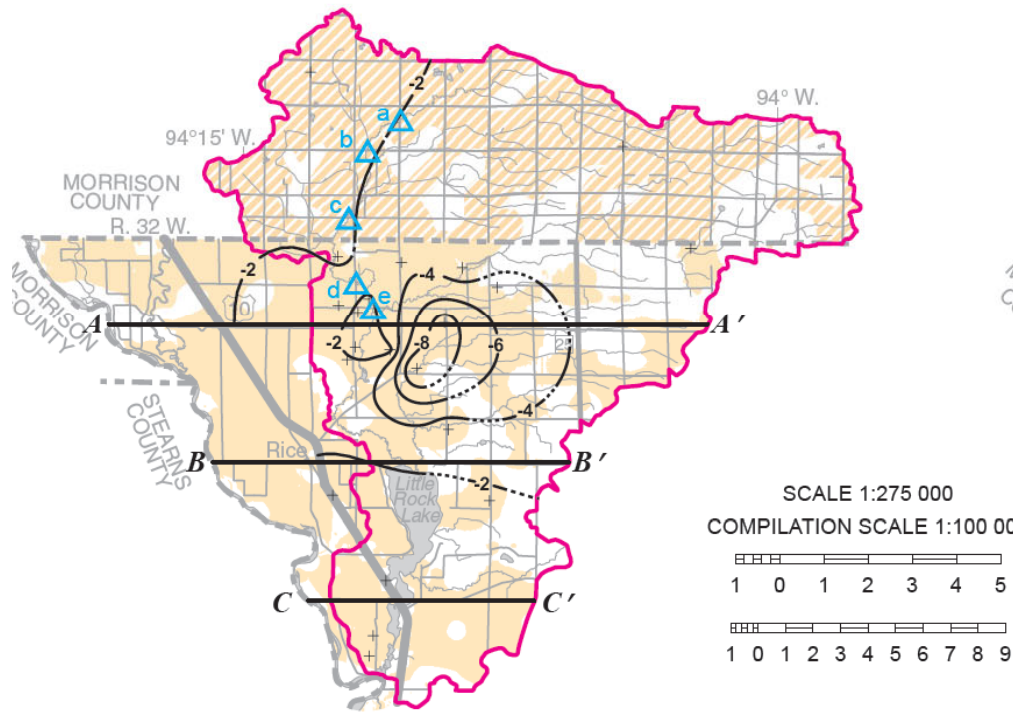




Manage—
Hydrogeology of the
Buried Aquifers
Rice Area Aquifer system

Plate 8—Hydrogeology of the Buried Aquifers

Synoptic water level study



April 2010 to July 2010 change in water levels

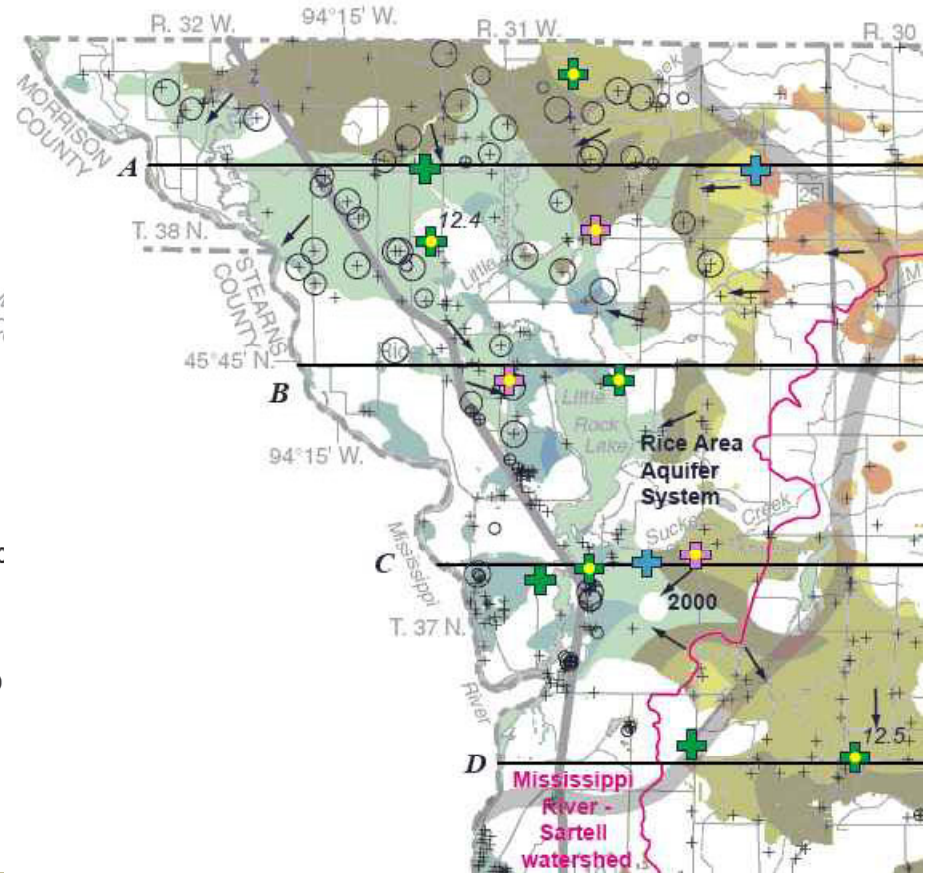
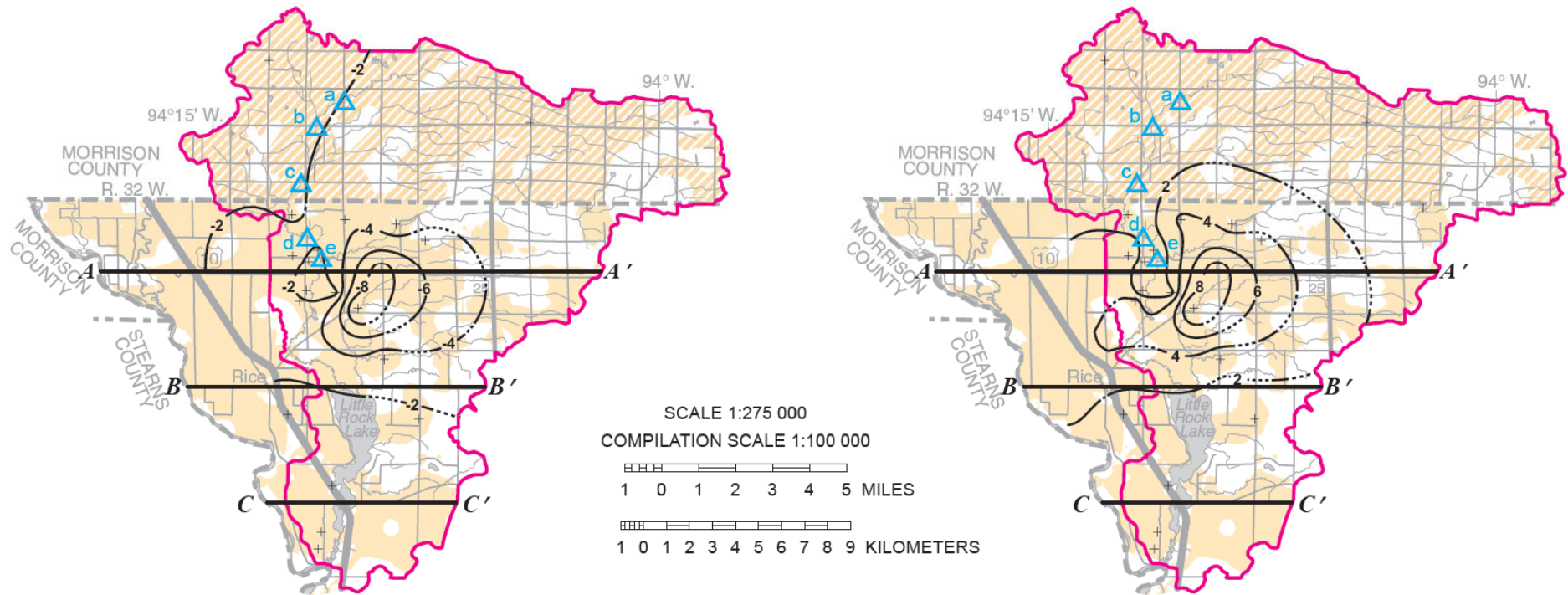


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Synoptic water level study

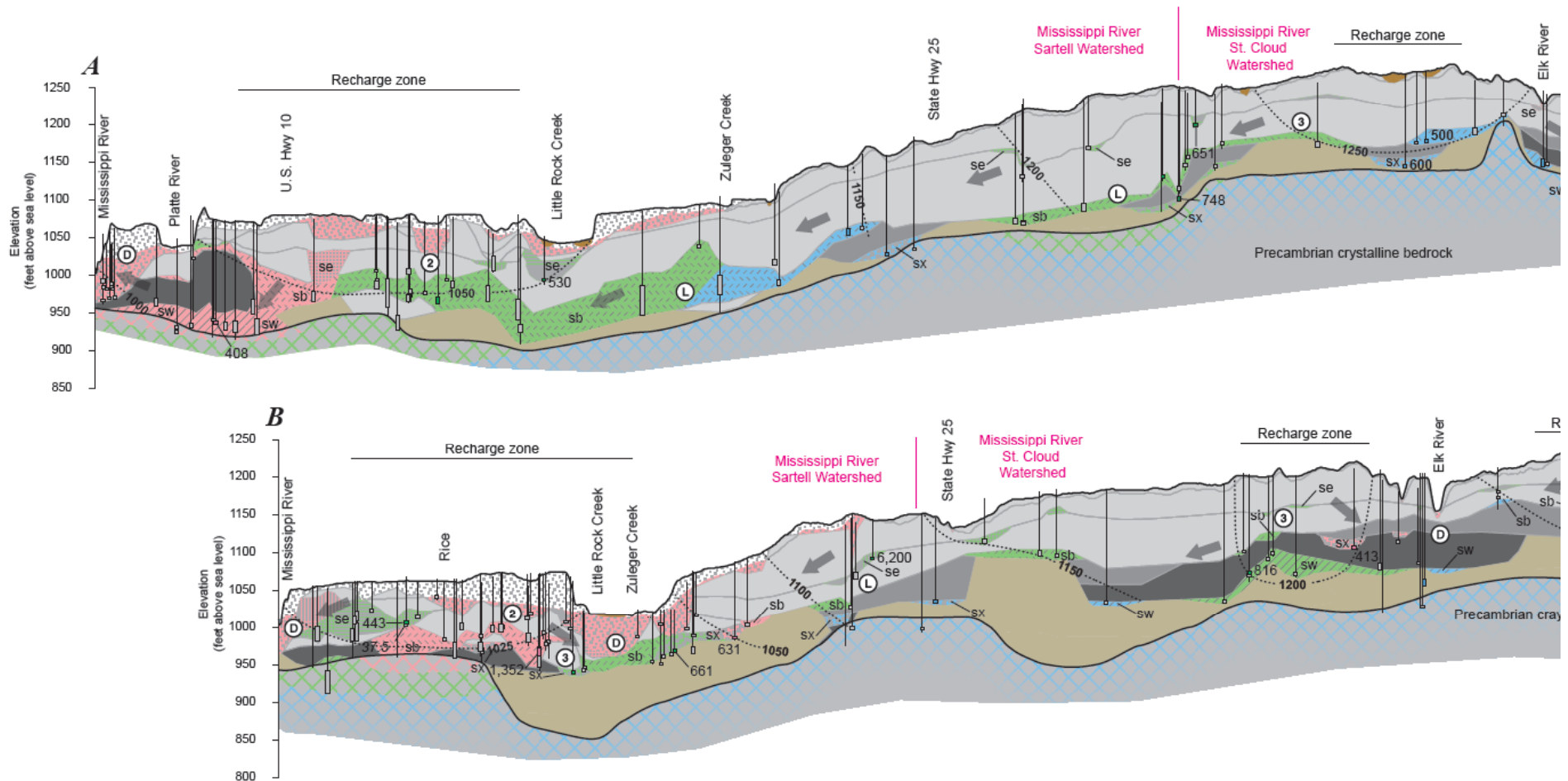
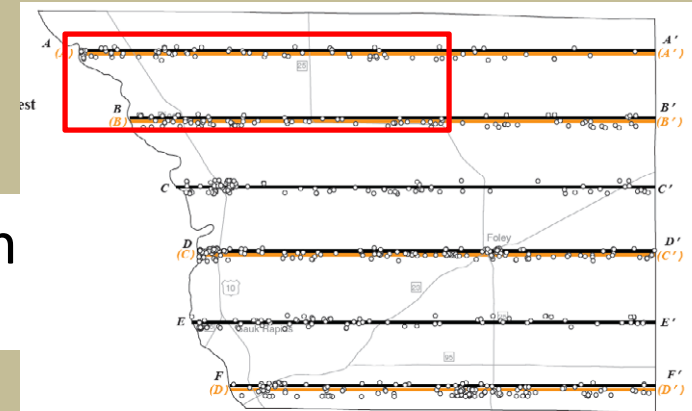


April 2010 to July 2010 change in water levels

July 2010 to September 2010 change in water levels

Characterize—Hydrogeologic Cross Section

Western portions of cross sections AA' and BB'

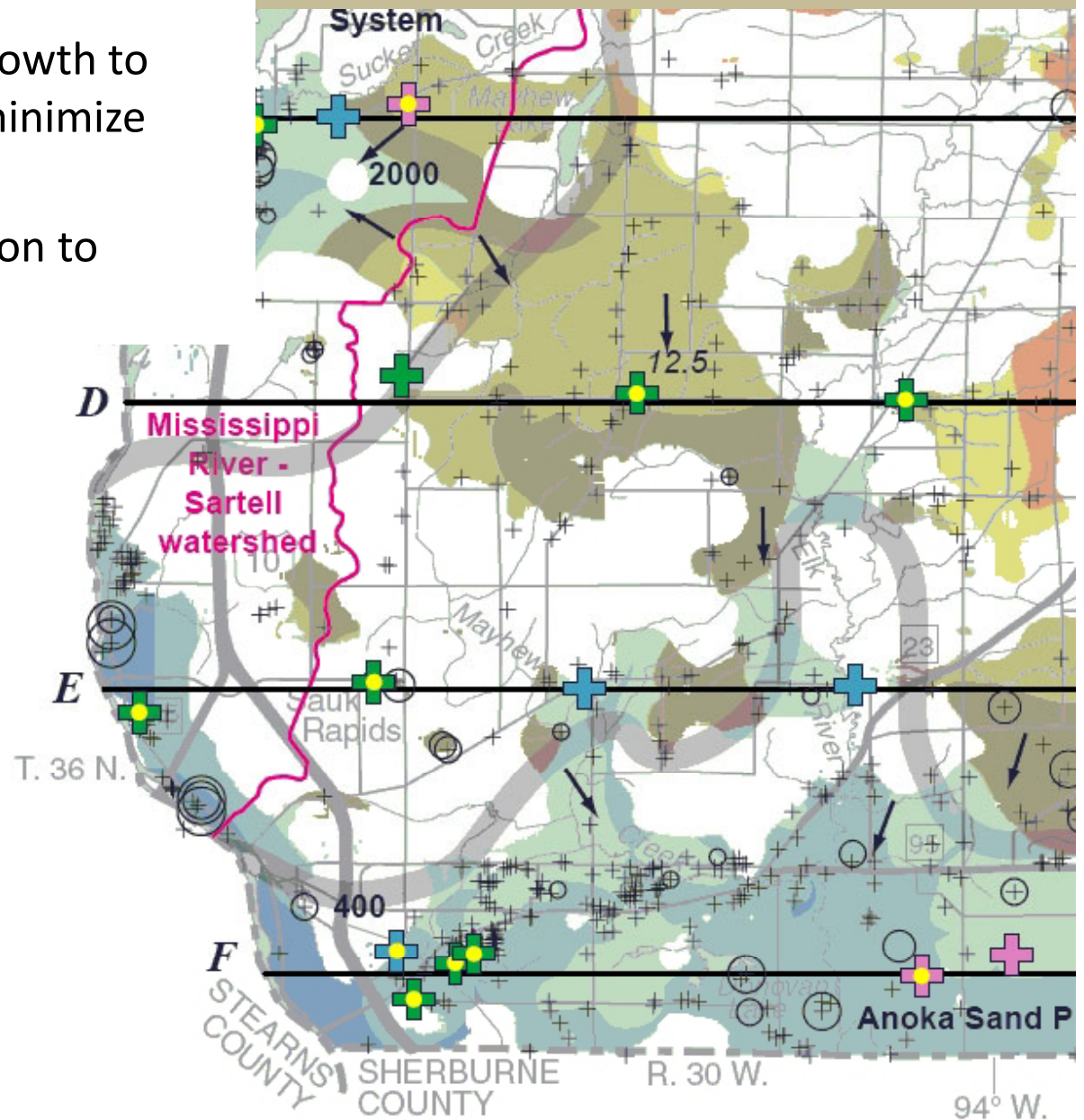


Map Applications

Development

- Pro-actively plan for future growth to protect water resources and minimize land use conflicts
- Provide information/education to appropriate audiences

1. Locates available groundwater
2. Identifies heavily utilized aquifers



Map Applications

1. Identify and Characterize

- Primary aquifer sources and extents
- Zones of aquifer sensitivity
- Potential areas of groundwater discharge

2. Manage

- Water appropriation permit evaluation
- Water supply assistance

3. Protect

- Feedlot/nutrient management
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Protect—Sensitivity of the Groundwater Systems to Pollution

Surface materials

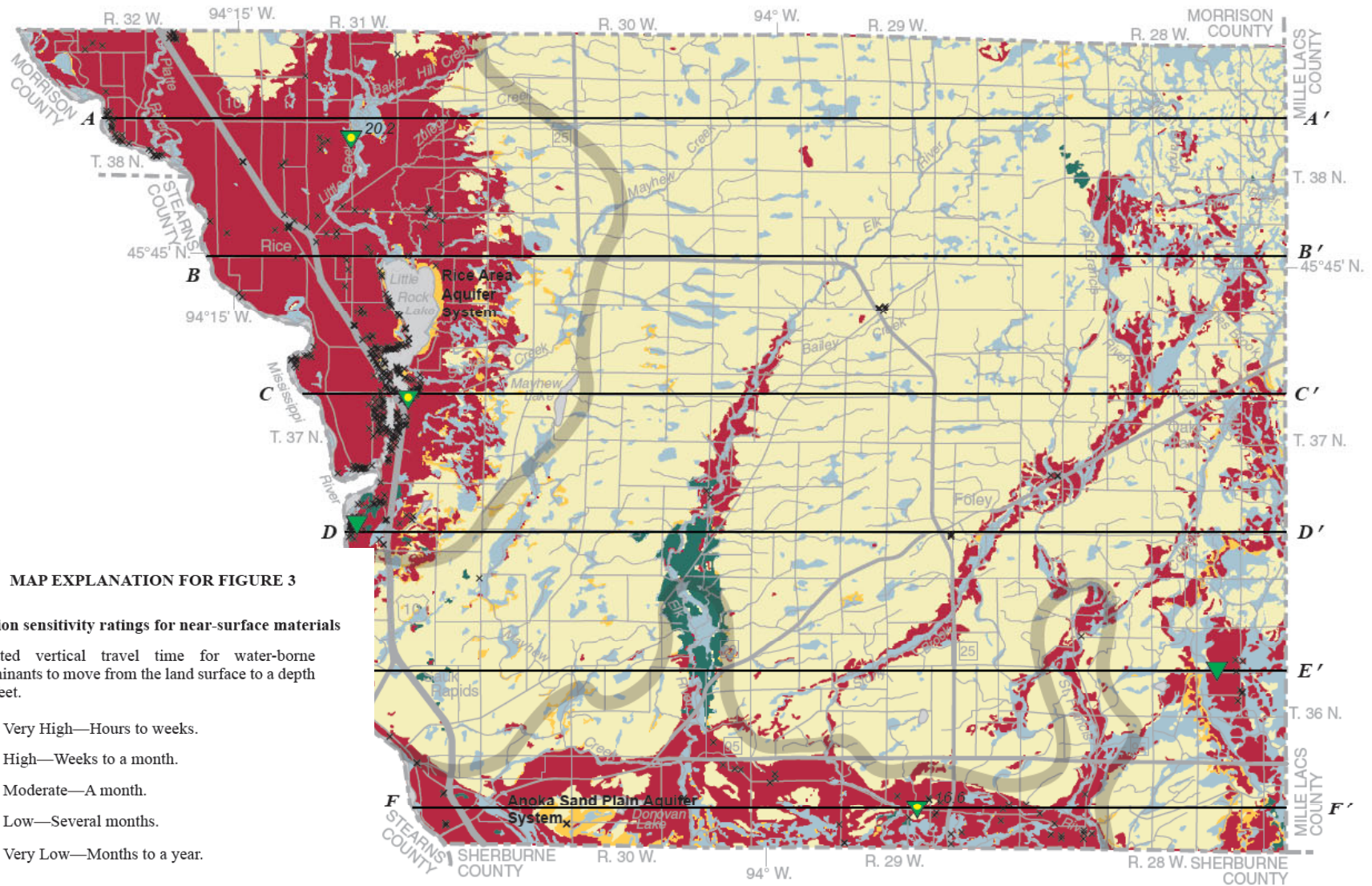
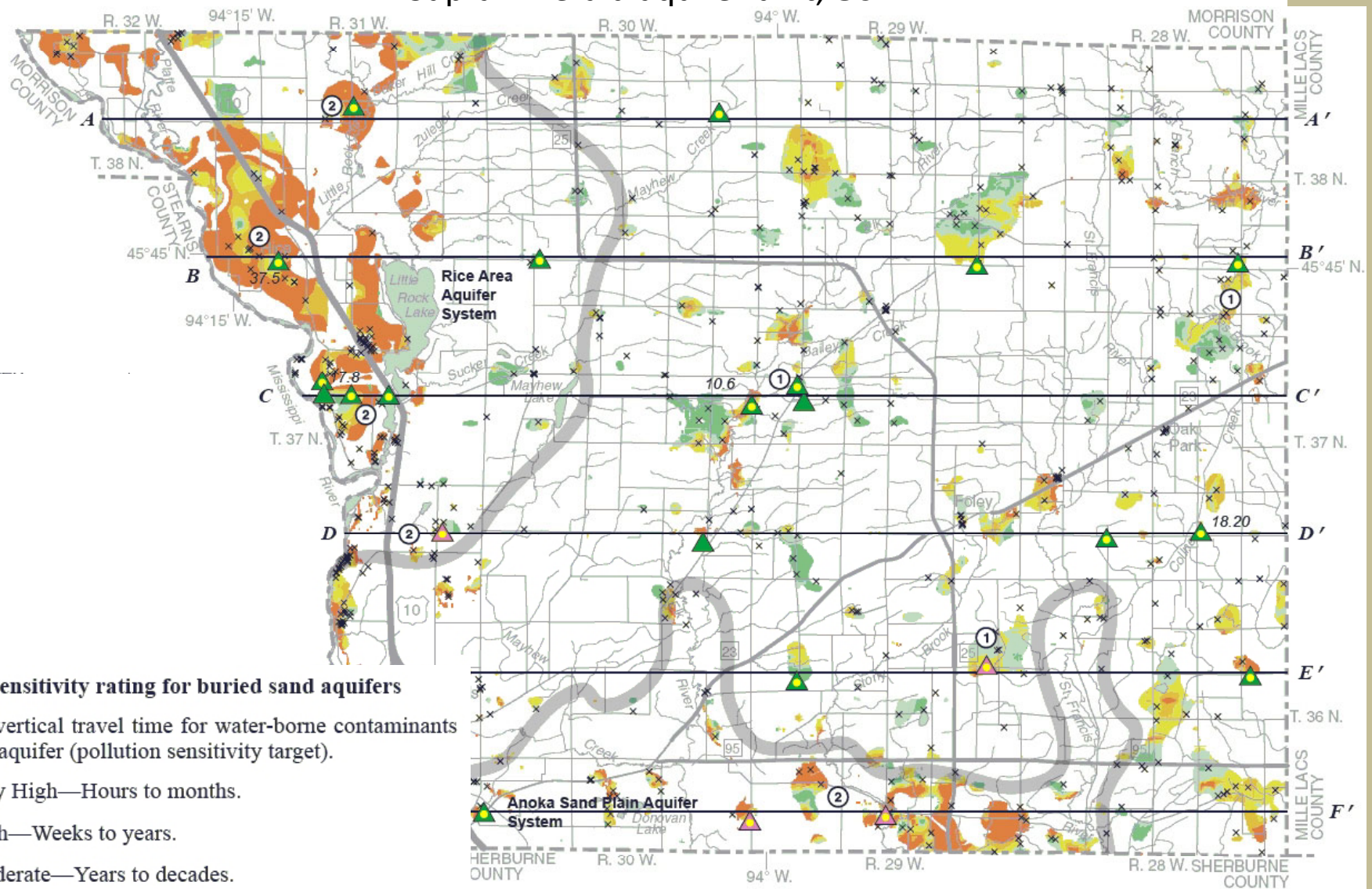


FIGURE 3. Pollution sensitivity of the near-surface materials.

Protect—Sensitivity of the Groundwater Systems to Pollution

Supra Emerald aquifer unit, **se**



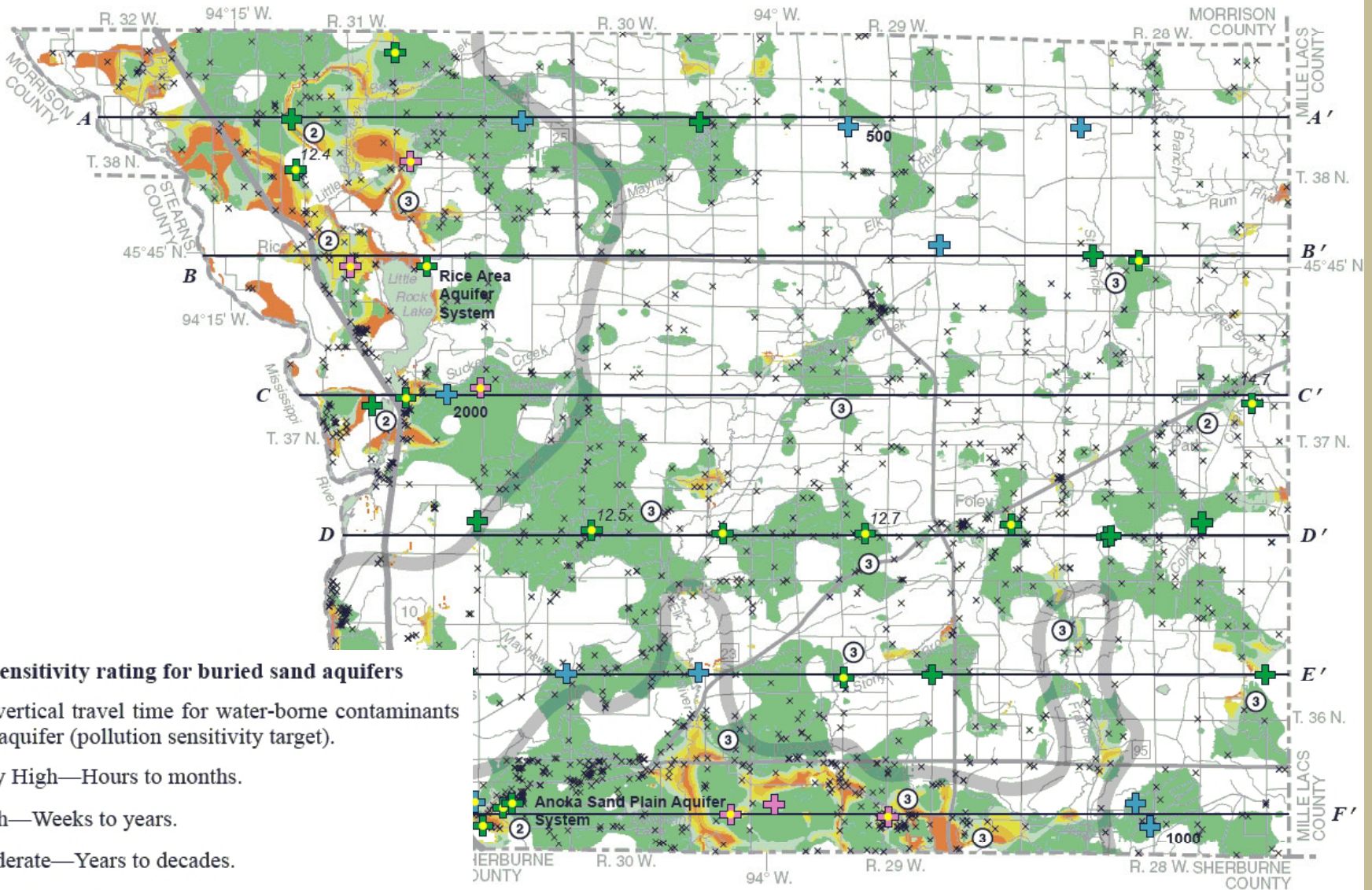
Pollution sensitivity rating for buried sand aquifers

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

- VH** Very High—Hours to months.
- H** High—Weeks to years.
- M** Moderate—Years to decades.
- L** Low—Decades to a century.
- VL** Very Low—A century or more.

Protect—Sensitivity of the Groundwater Systems to Pollution

Sub-Emerald aquifer unit, **sb**



Pollution sensitivity rating for buried sand aquifers

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

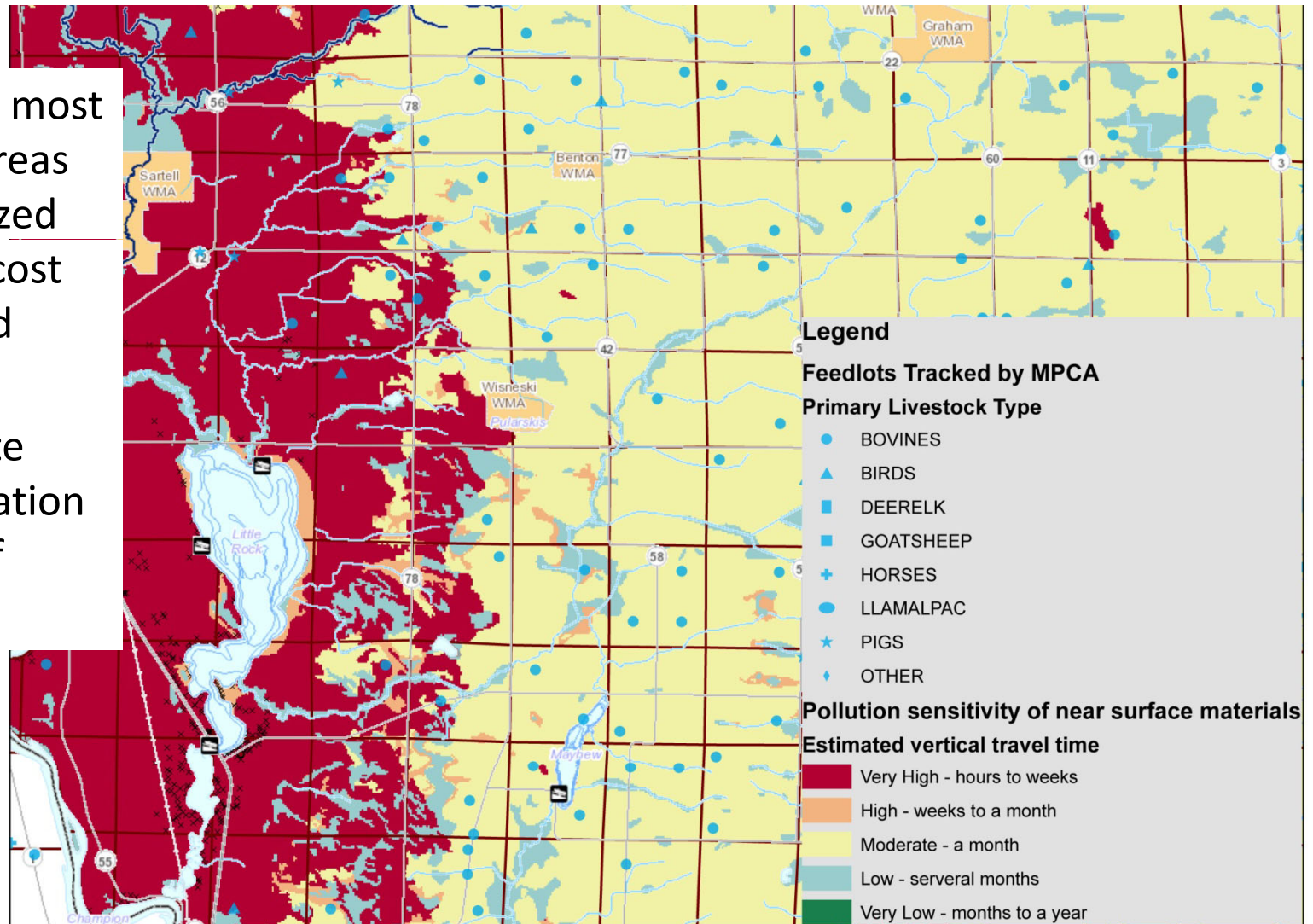
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Map Applications

Feedlot/nutrient management

- Reduce/minimize negative impacts of manure and fertilizer on surface water and groundwater

1. Feedlots in most sensitive areas are prioritized for BMPs, cost sharing and education
2. Concentrate communication on areas of concern

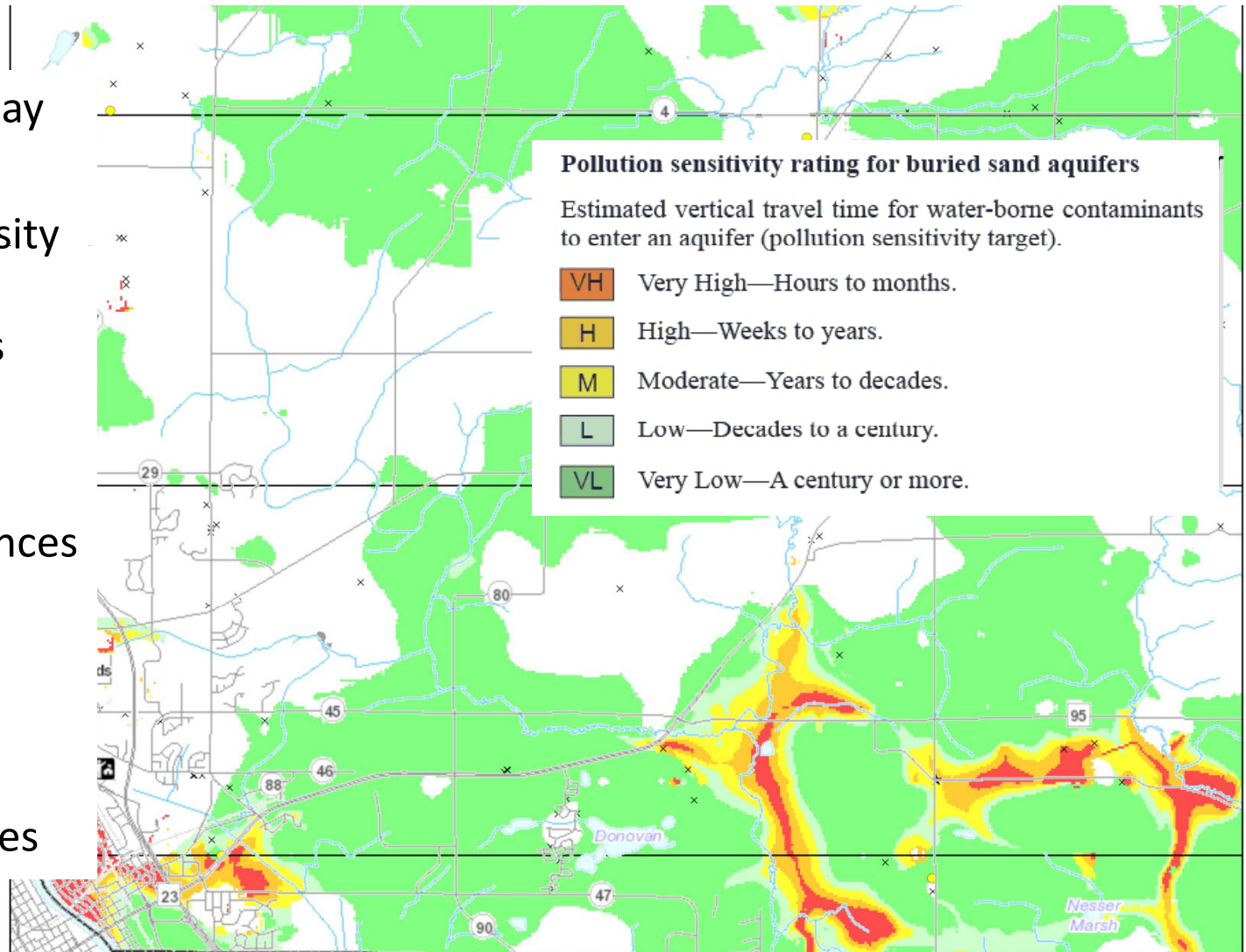


Map Applications

Protect

- Encourage LGUs to adopt development related ordinances and policies with water-based outcomes

1. Resource overlay districts
 - maximum density standards for septic systems
 - Stormwater management
 - Landfill ordinances to be in least sensitive areas
 - Municipal wellhead protection zones



Map Applications

Development

- Provide information and education to appropriate audiences
-
1. Include a series in the county newsletter/newspaper
 2. Library workshops incorporating the digital use
 3. Provide GIS data on GeoMoose

Thank you!

- Participating well owners for chemistry sampling and synoptic cooperation
- Benton SWCD for field support and cooperation
- Numerous technical reviewers for the atlas

