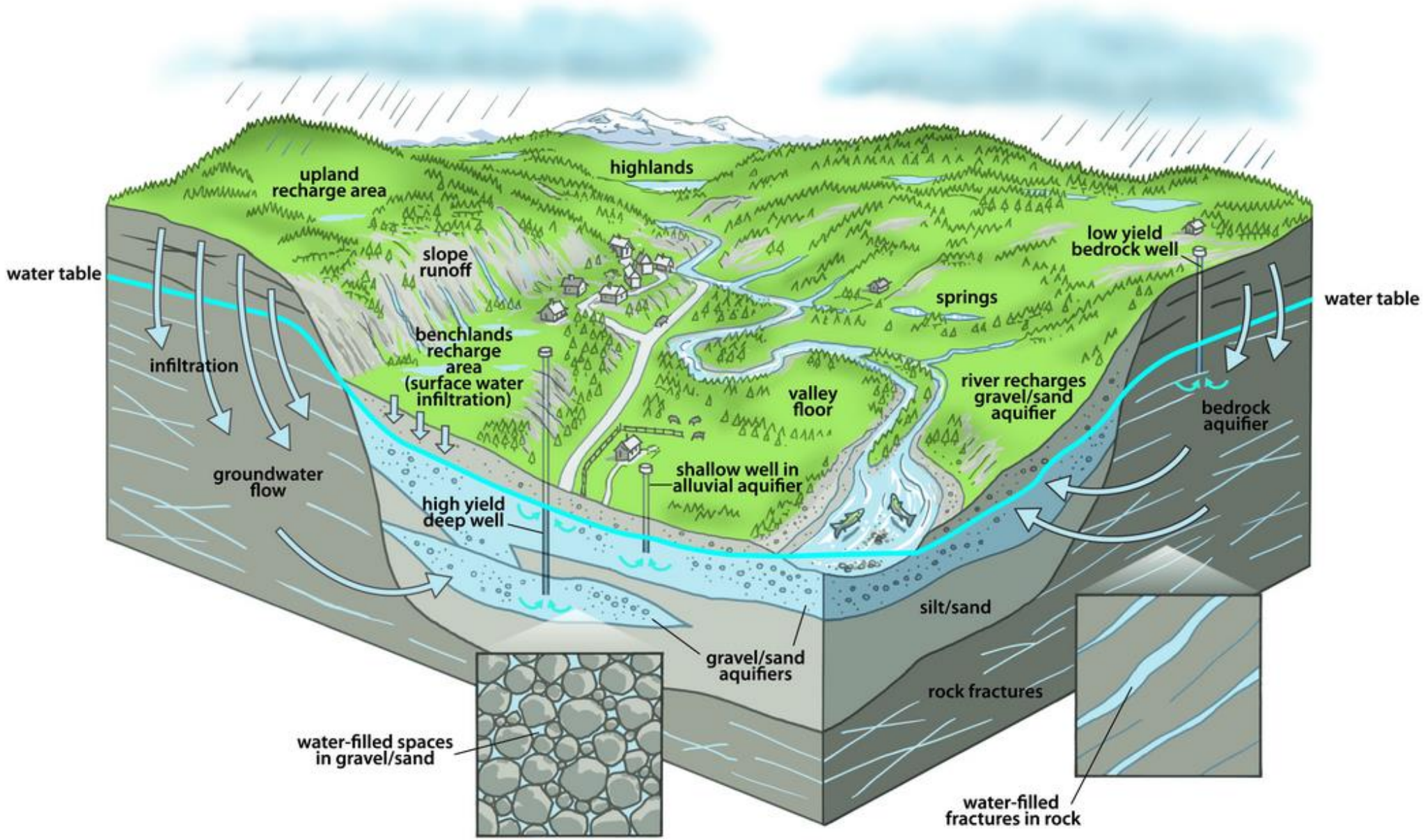
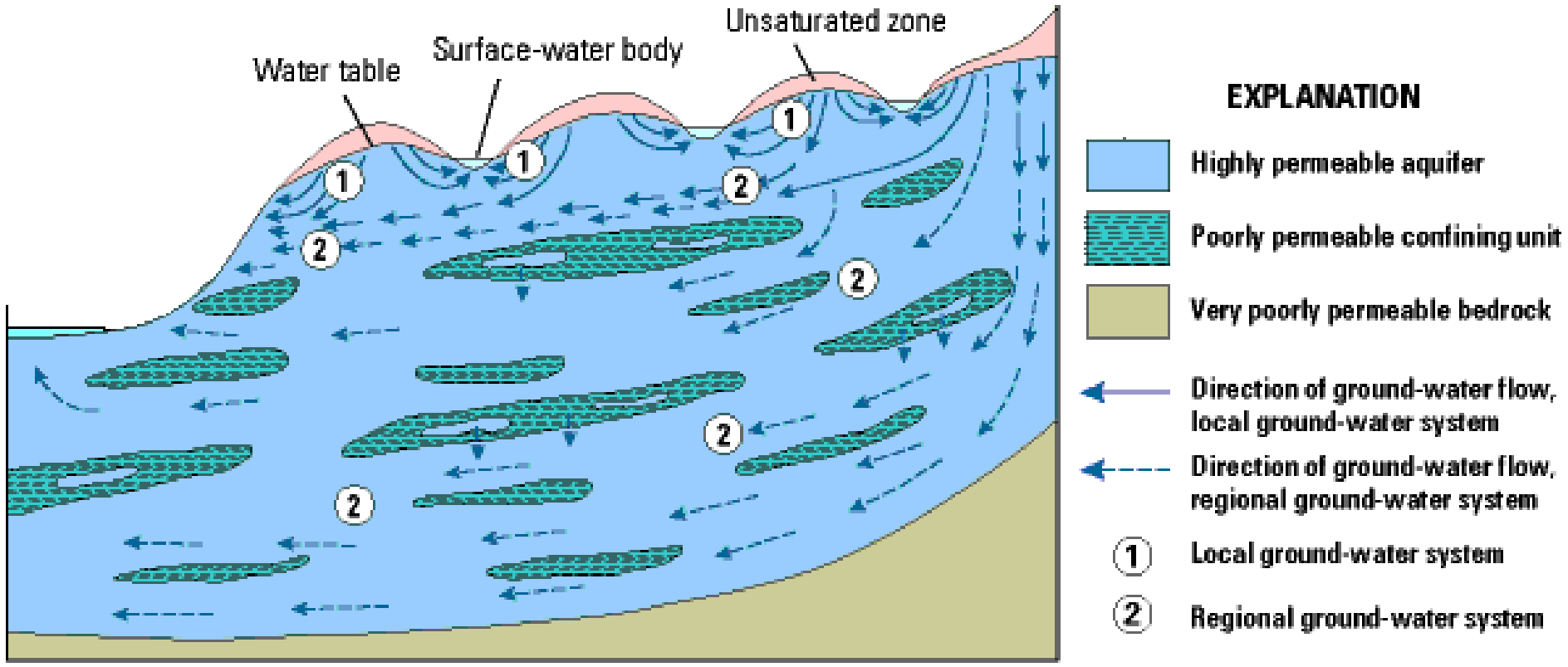
Groundwater 101+

Evan Christianson, PG

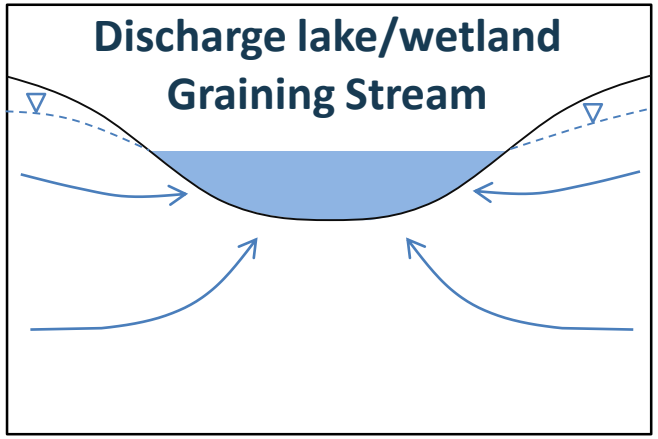

upland
recharge area
highlands
low yield
bedrock well
water table
slope
runoff
springs
water table
benchlands
recharge
area
(surface water
infiltration)
infiltration
valley
floor
river recharges
gravel/sand
aquifier
bedrock
aquifier
groundwater
flow
shallow well in
alluvial aquifier
high yield
deep well
silt/sand
gravel/sand
aquifiers
rock fractures
water-filled spaces
in gravel/sand
water-filled
fractures in rock

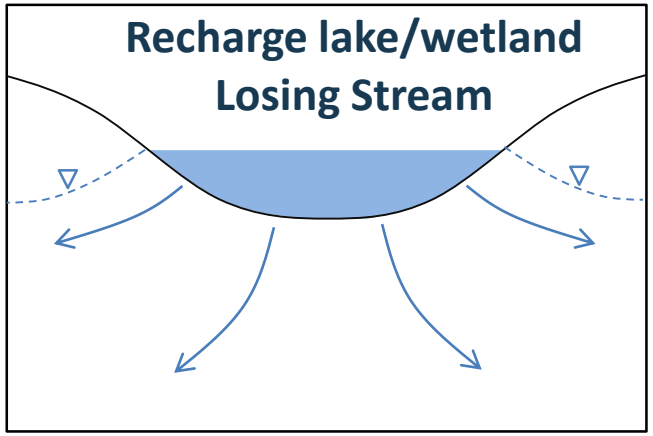
Local vs Regional Flow Systems

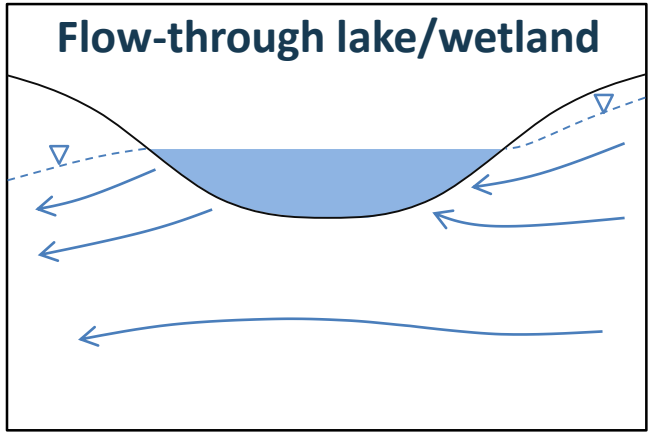


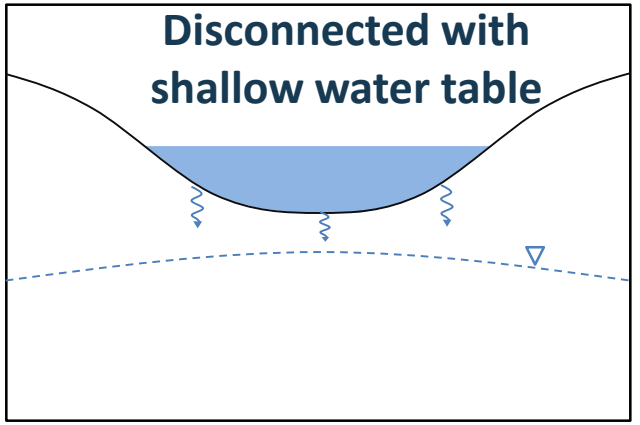
(Modified from Alley et al., 1999)

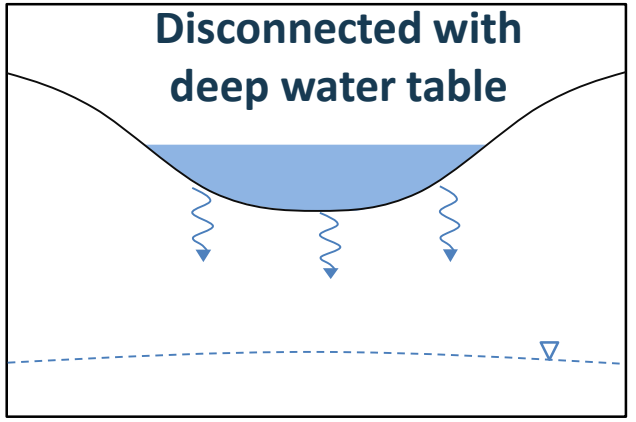
Groundwater – Surface Water Interaction

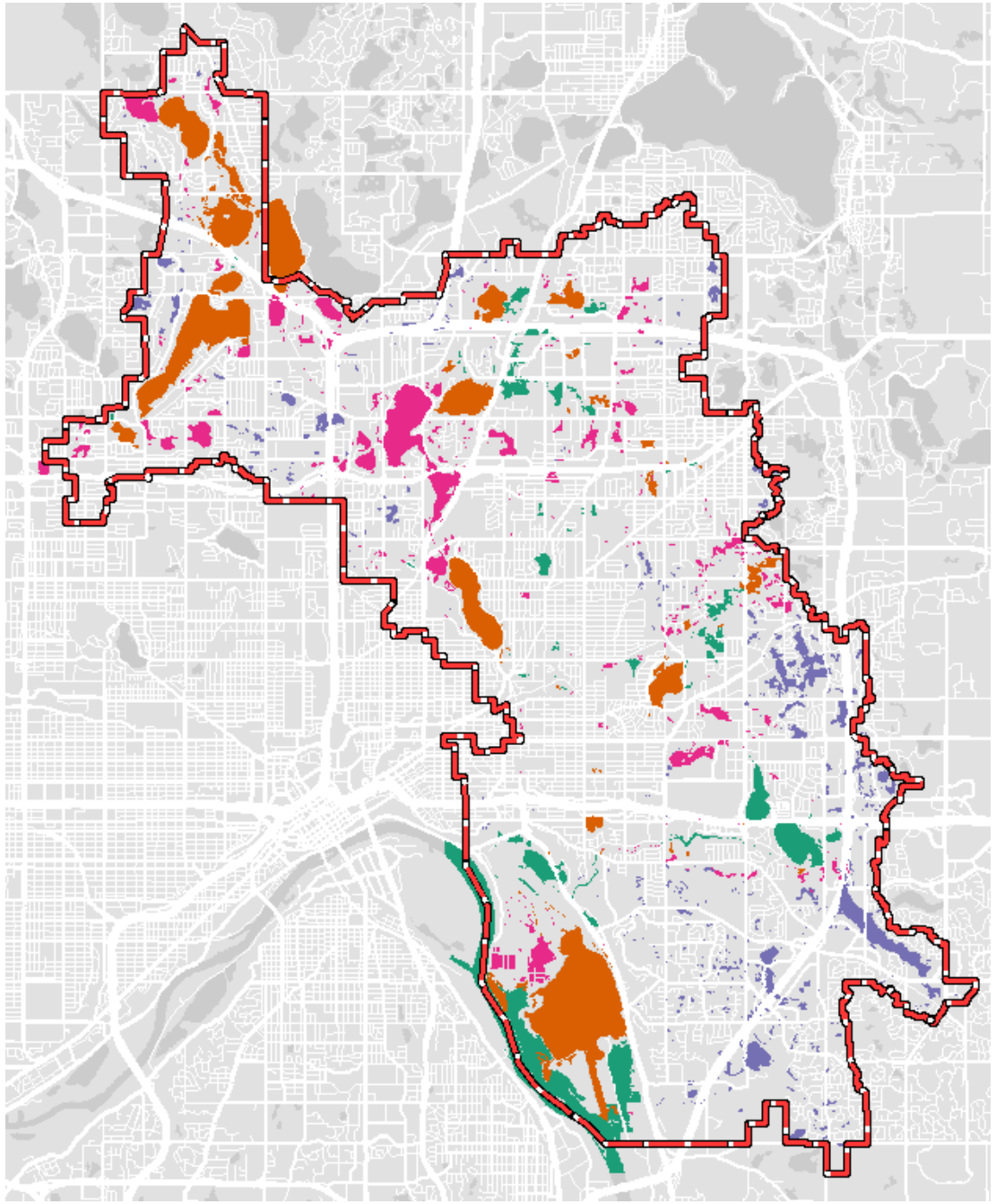






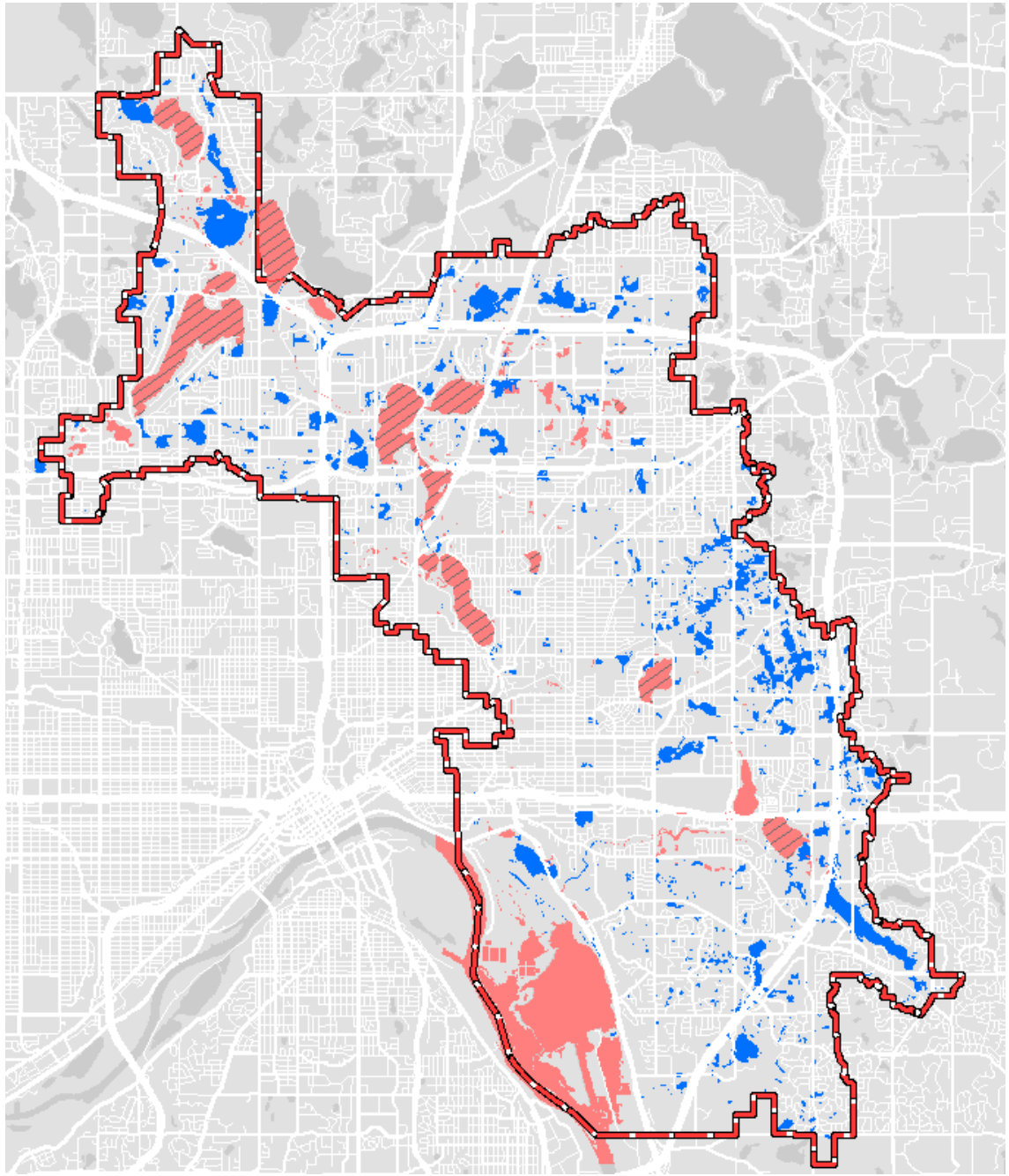






Connection with Regional Groundwater System

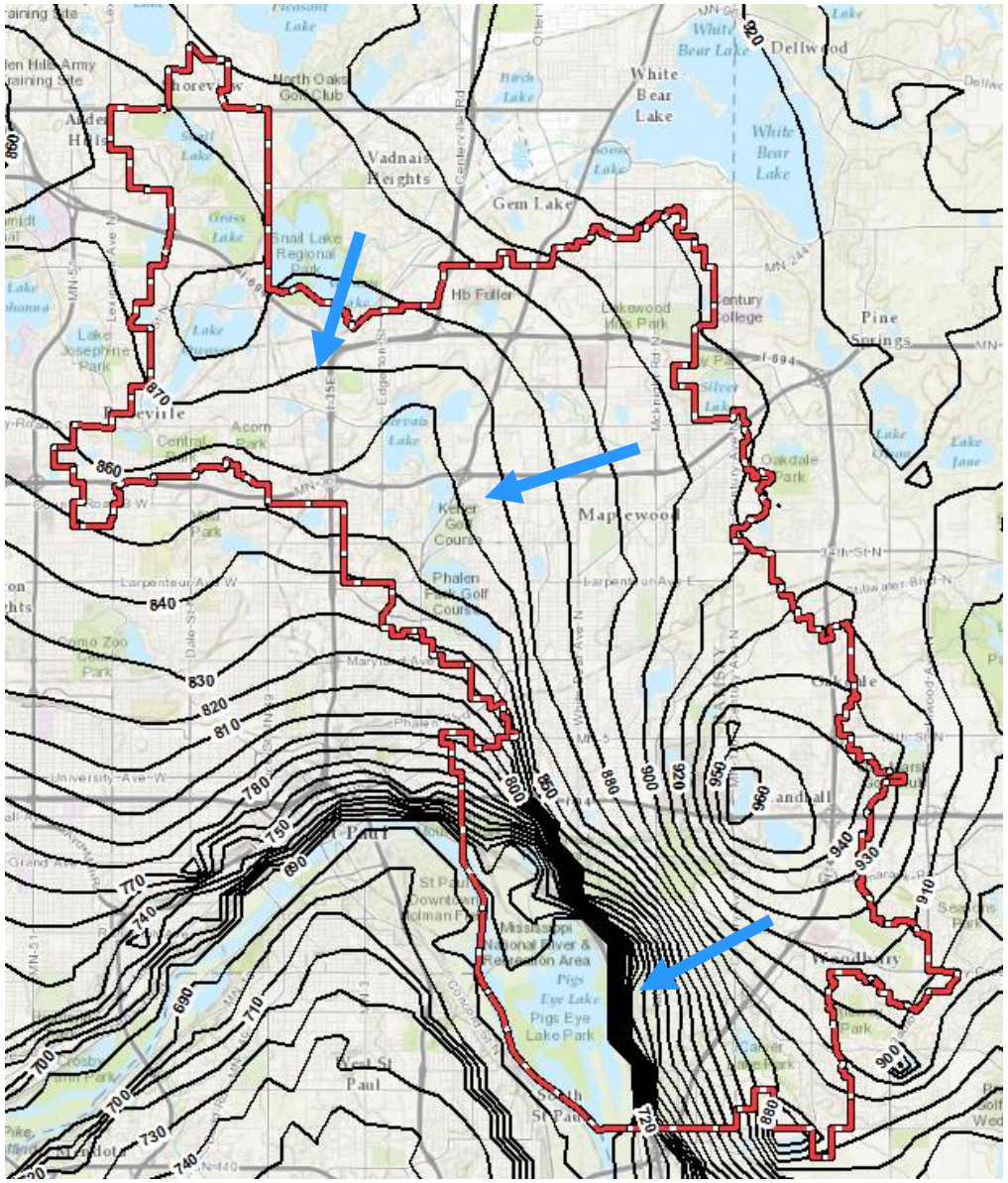
- Discharge Lake/Wetland, Gaining Stream
- Flow-Through Lake/Wetland/Stream
- Perched Lake/Wetland/Stream
- Recharge Lake/Wetland, Losing Stream

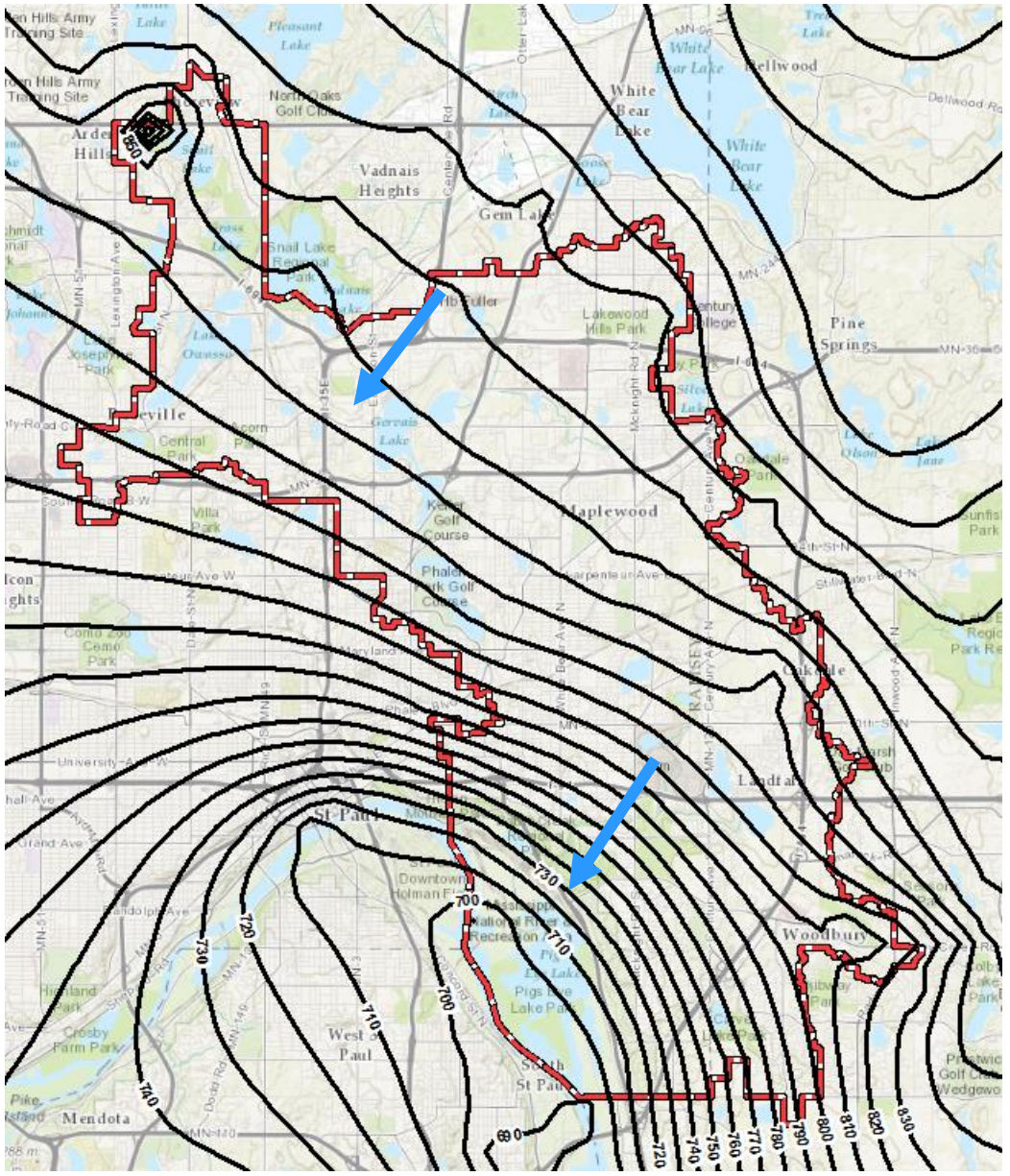


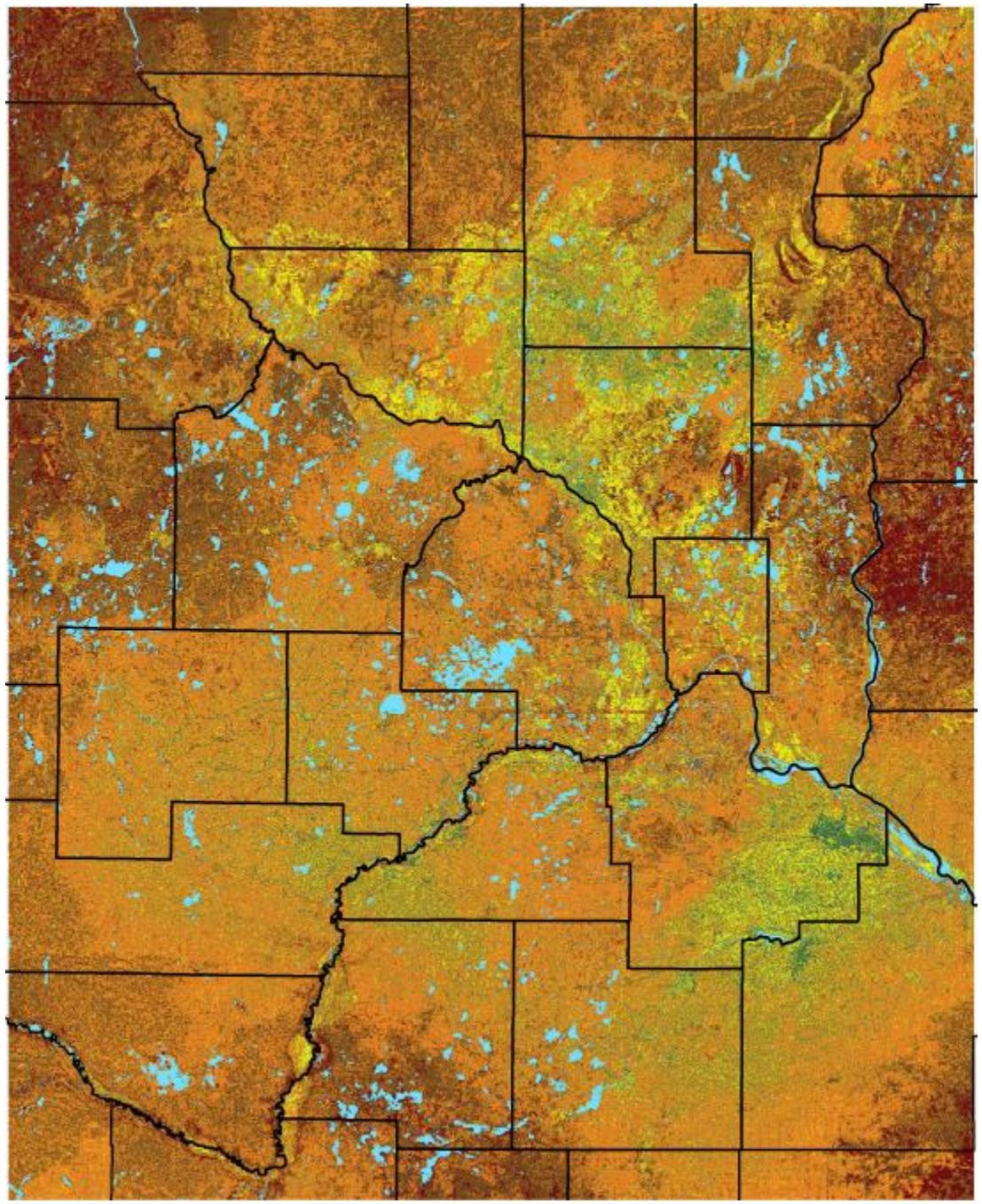
Vulnerability to changes in groundwater system

- Not Vulnerable
- Vulnerable
- Vulnerable with wide litoral zone

Groundwater Flow Directions



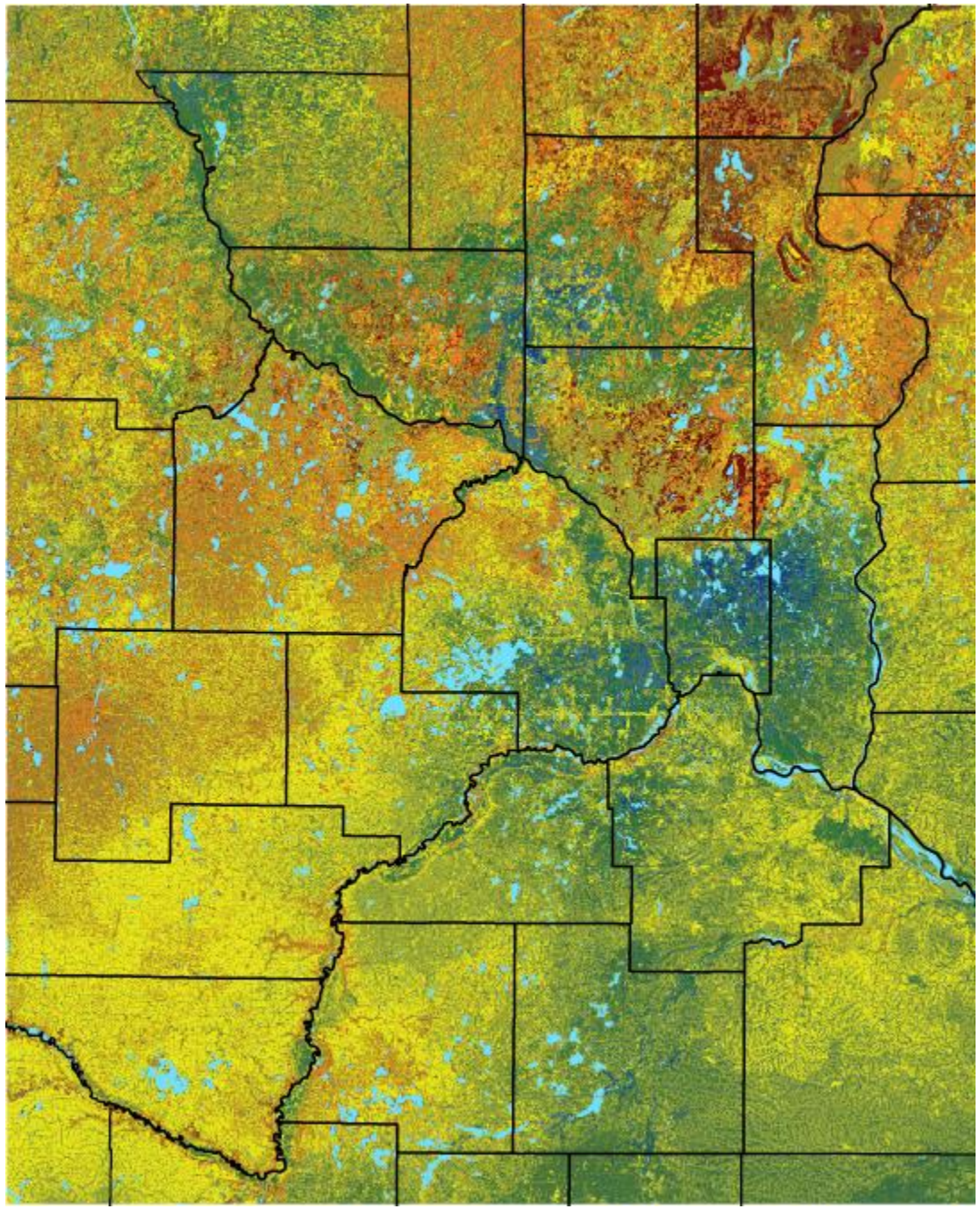




2012

Groundwater Recharge (in/yr)

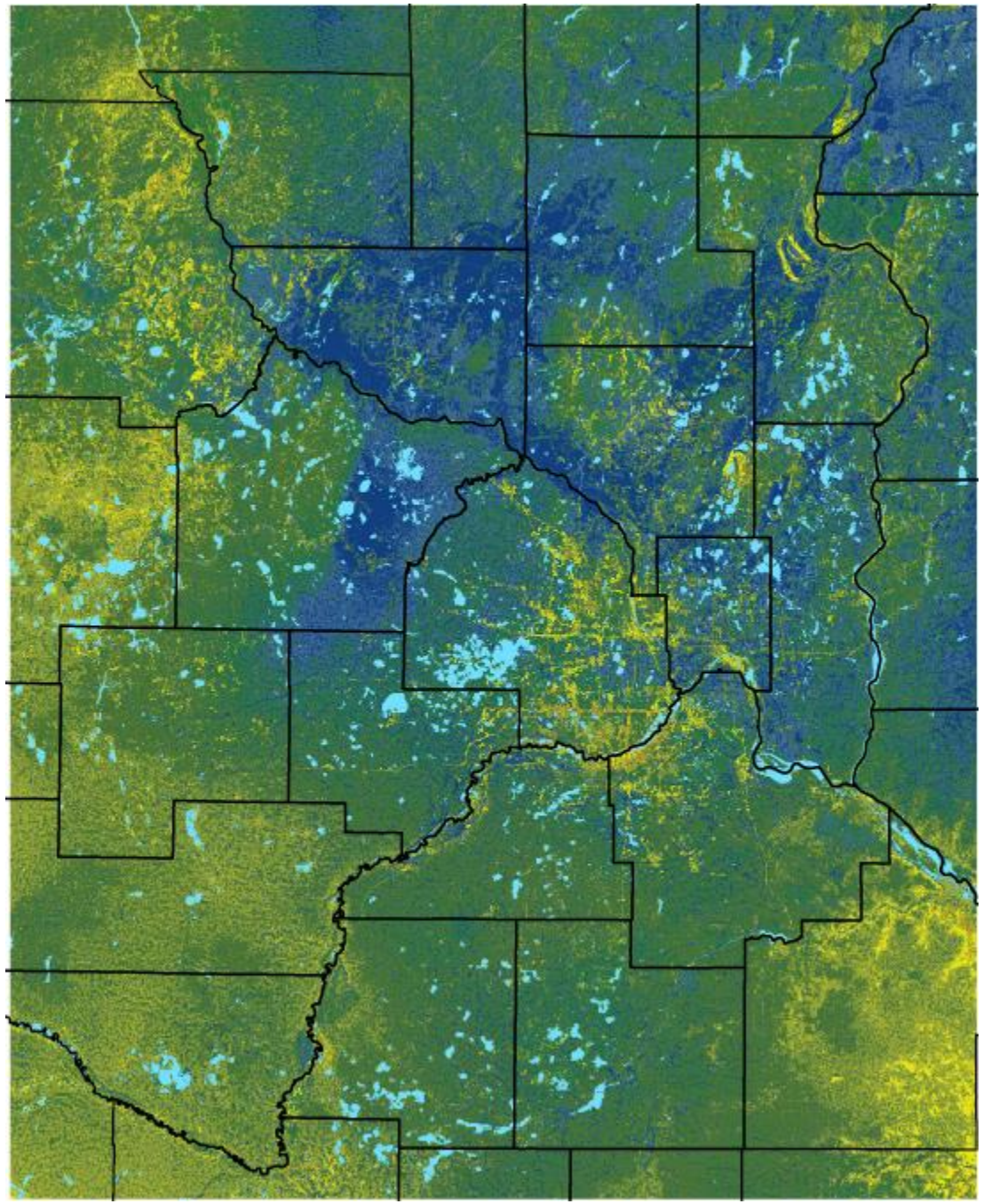
- 0.00 - 2.00
- 2.01 - 4.00
- 4.01 - 6.00
- 6.01 - 8.00
- 8.01 - 10.00
- 10.01 - 12.00
- 12.01 - 14.00
- 14.01 - 16.00
- 16.01 - 18.00
- > 18.01
- Water Body



2013

Groundwater Recharge (in/yr)

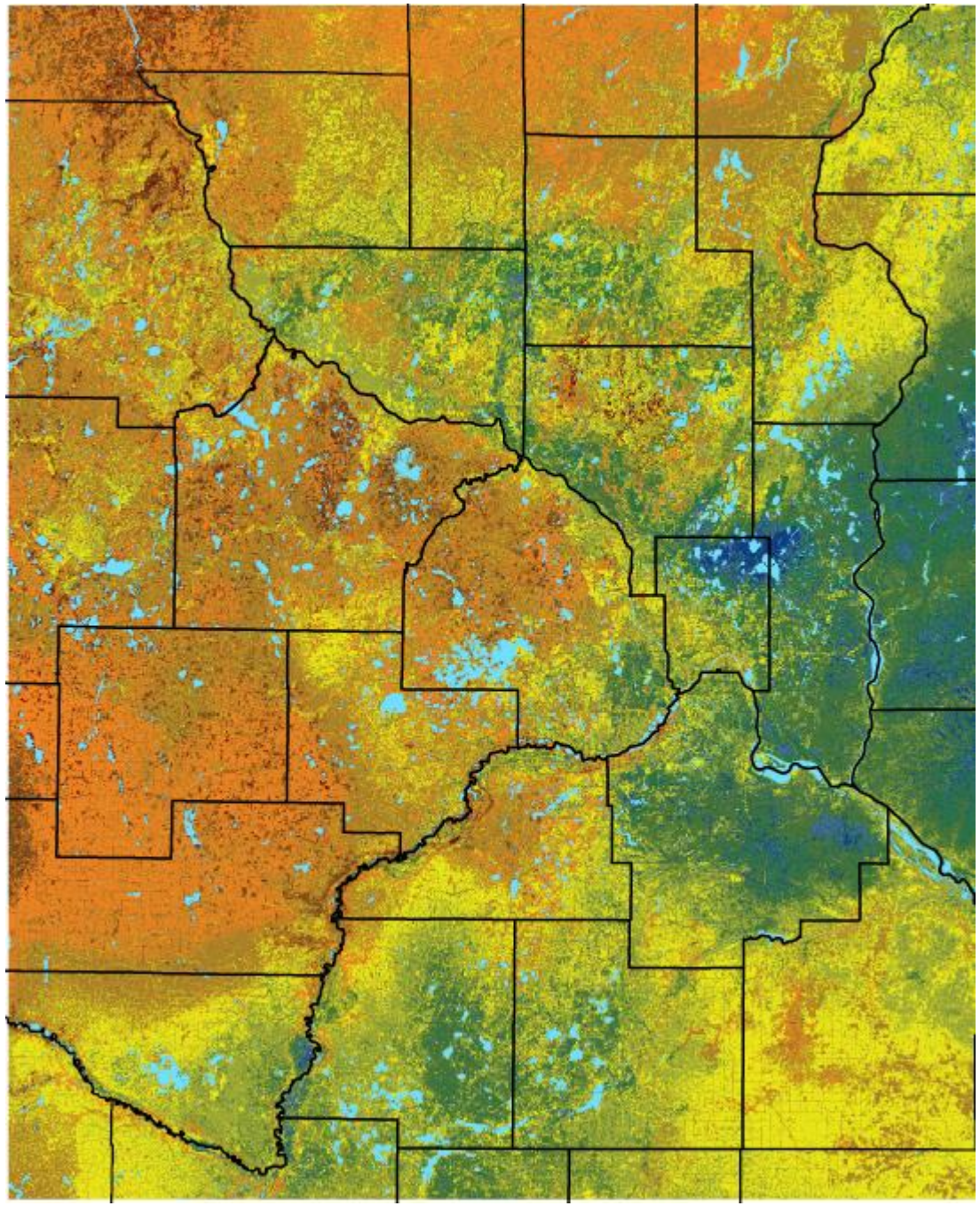
- 0.00 - 2.00
- 2.01 - 4.00
- 4.01 - 6.00
- 6.01 - 8.00
- 8.01 - 10.00
- 10.01 - 12.00
- 12.01 - 14.00
- 14.01 - 16.00
- 16.01 - 18.00
- > 18.01
- Water Body



2014

Groundwater Recharge (in/yr)

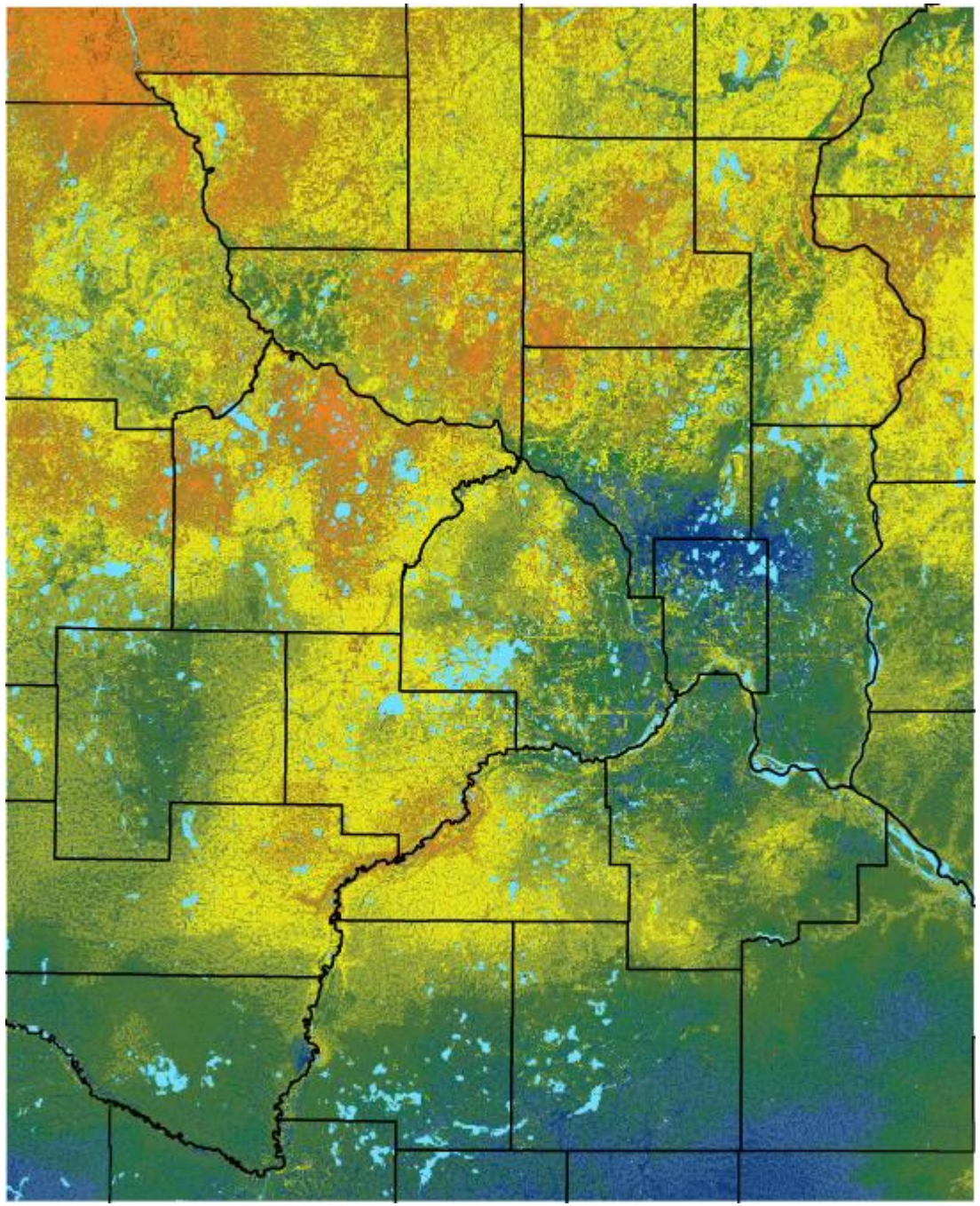
- 0.00 - 2.00
- 2.01 - 4.00
- 4.01 - 6.00
- 6.01 - 8.00
- 8.01 - 10.00
- 10.01 - 12.00
- 12.01 - 14.00
- 14.01 - 16.00
- 16.01 - 18.00
- > 18.01
- Water Body



2015

Groundwater Recharge (in/yr)

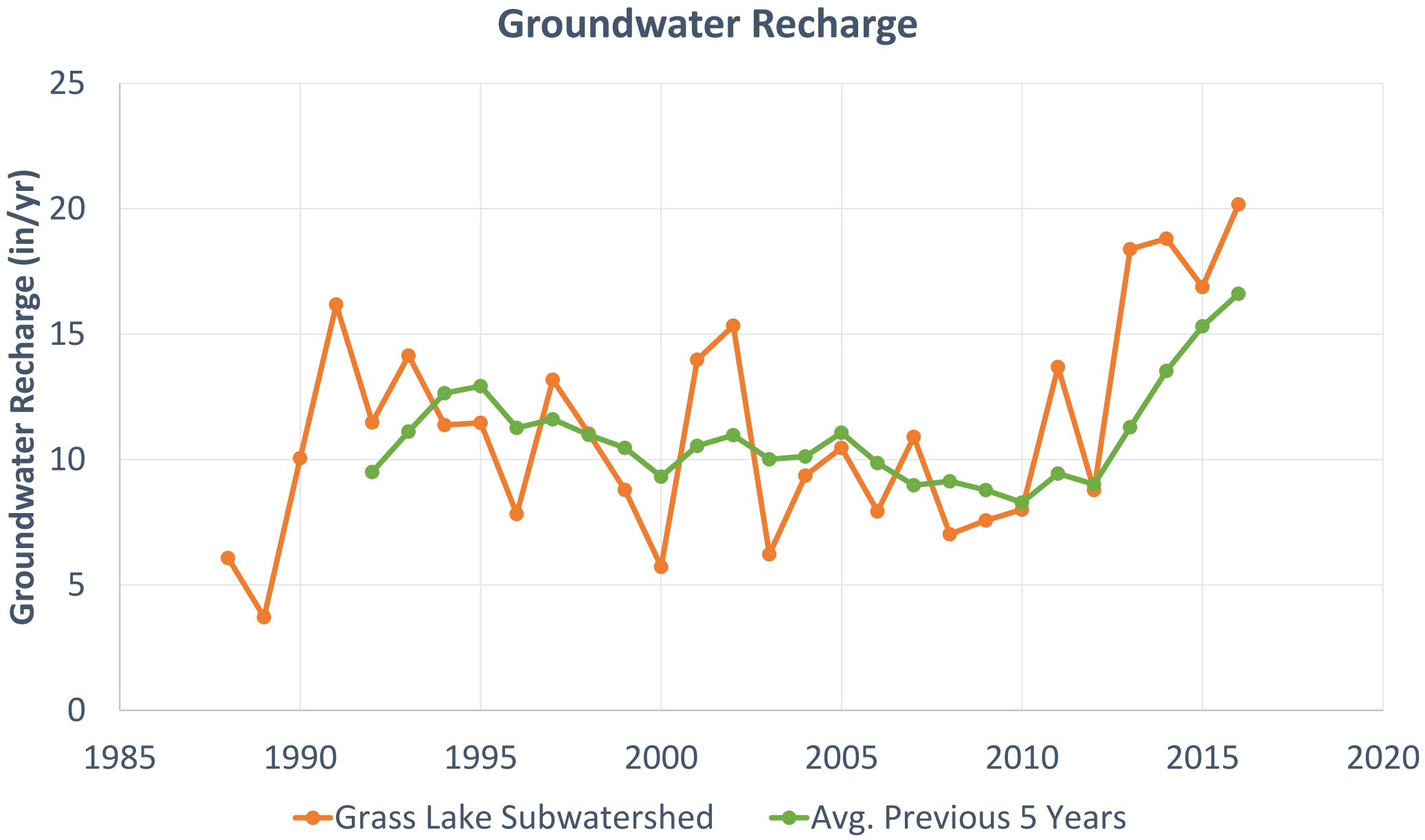
- 0.00 - 2.00
- 2.01 - 4.00
- 4.01 - 6.00
- 6.01 - 8.00
- 8.01 - 10.00
- 10.01 - 12.00
- 12.01 - 14.00
- 14.01 - 16.00
- 16.01 - 18.00
- > 18.01
- Water Body

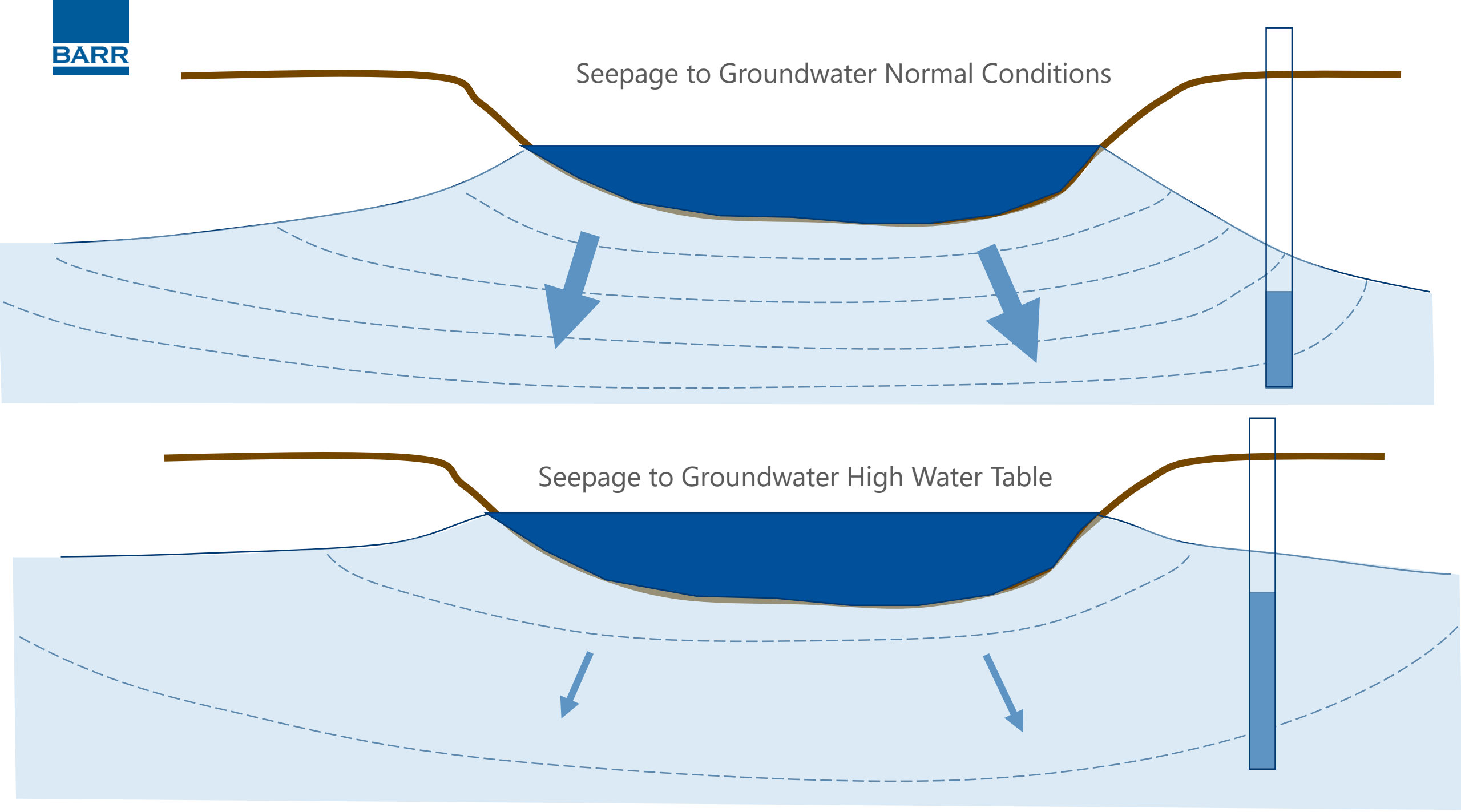


2016

Groundwater Recharge (in/yr)

- 0.00 - 2.00
- 2.01 - 4.00
- 4.01 - 6.00
- 6.01 - 8.00
- 8.01 - 10.00
- 10.01 - 12.00
- 12.01 - 14.00
- 14.01 - 16.00
- 16.01 - 18.00
- > 18.01
- Water Body

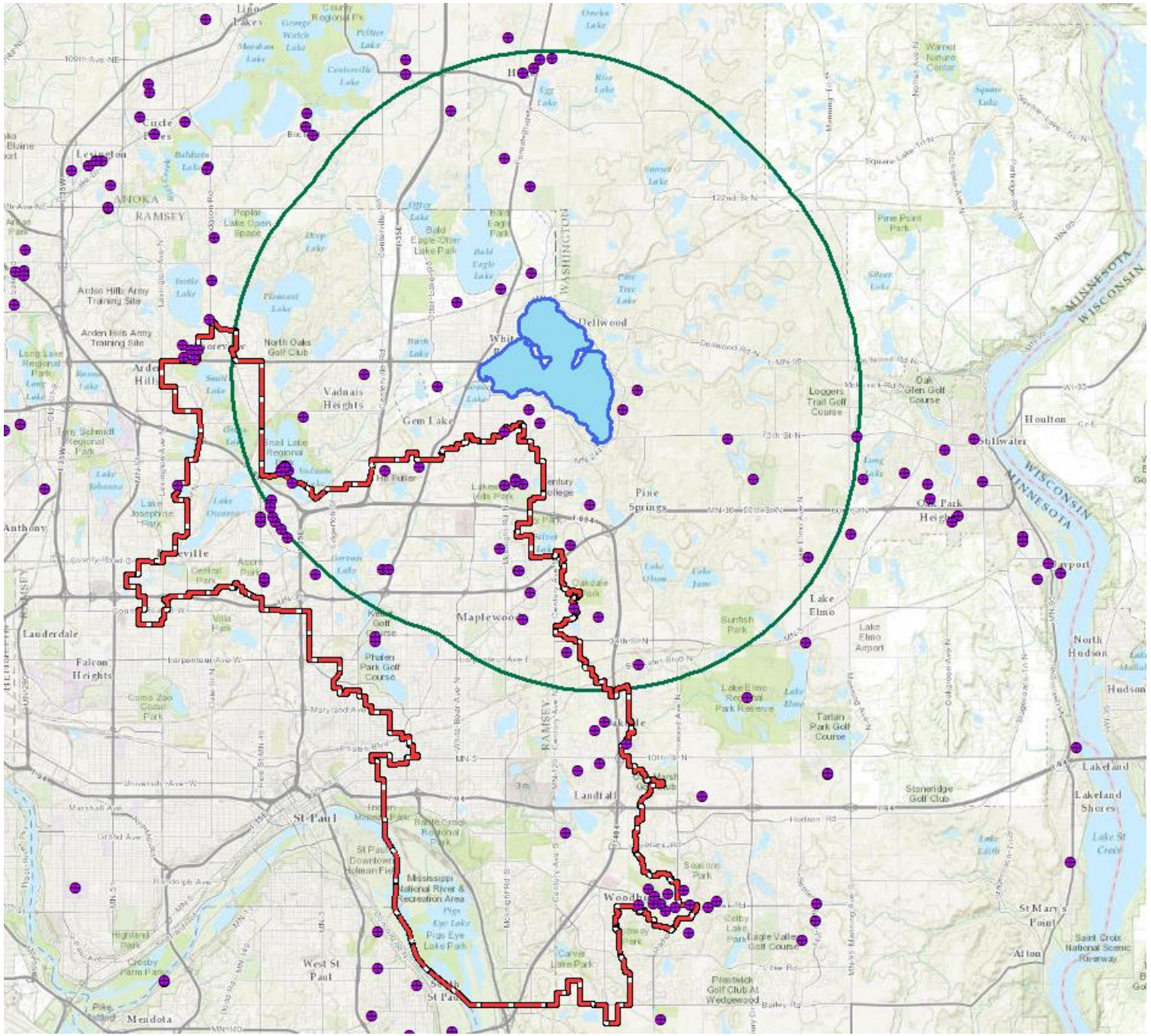

Groundwater Recharge
Groundwater Recharge (in/yr)
25
20
15
10
5
0
1985
1990
1995
2000
2005
2010
2015
2020
Grass Lake Subwatershed
Avg. Previous 5 Years

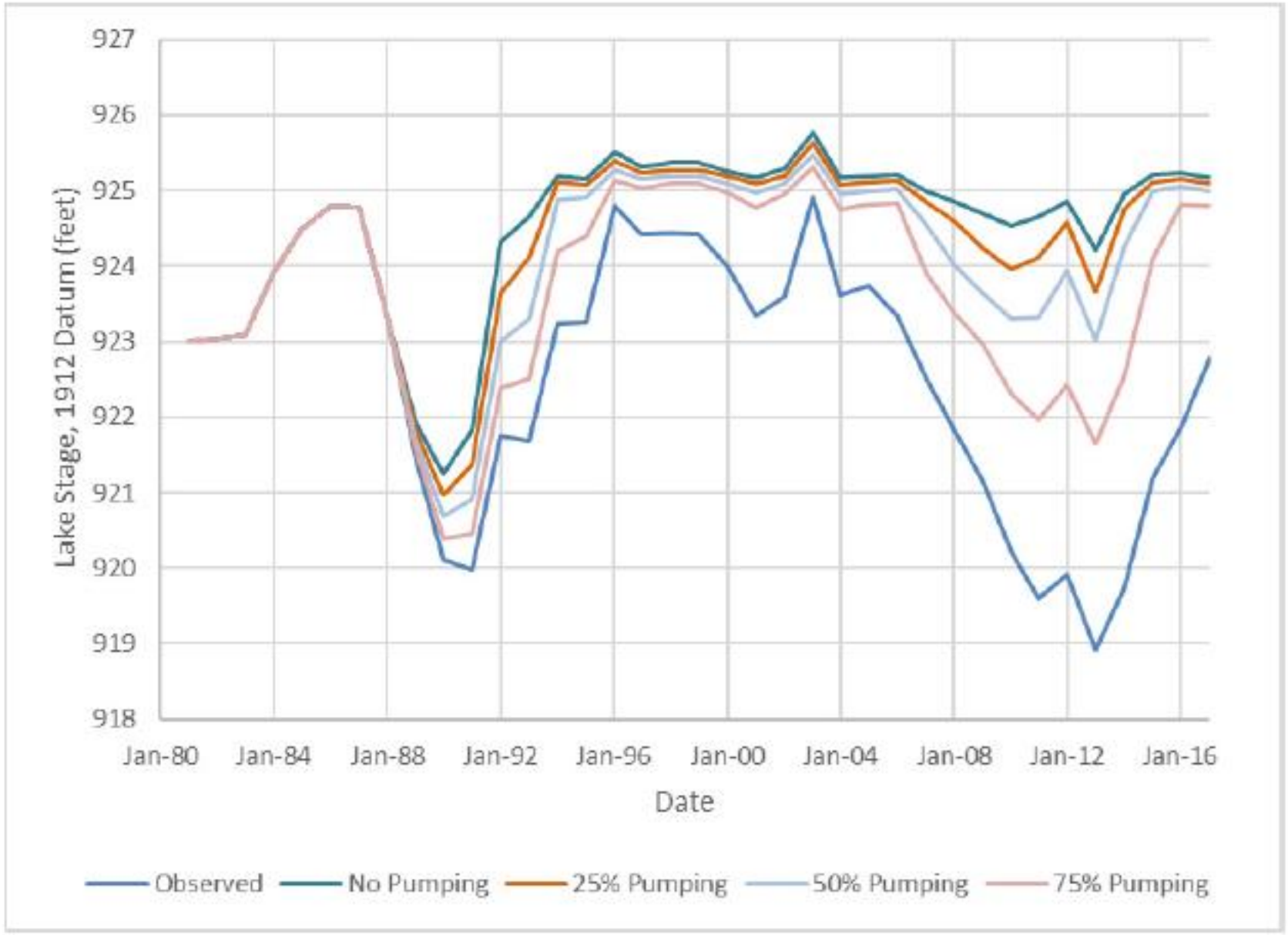

Seepage to Groundwater Normal Conditions
Seepage to Groundwater High Water Table

White Bear Lake Lawsuit

Order of the Court Summary (August 30, 2017)

- DNR is temporarily prohibited from issuing appropriation permits for new groundwater wells, or increasing appropriation amounts in existing groundwater
- Review all groundwater appropriation permits within 5-mile radius of White Bear Lake to ensure compliance with sustainability standard
  - If permits do not comply they will be down-sized
- Set a collective annual withdrawl limit
- Set a trigger elevation of 923.5 feet
  - Residential irrigation ban when White Bear Lake falls below 923.5 and continues until stage reaches 924 feet
- Requires per capita residential water use of 75 gallons per day. Total per capita use of 90 gallons per day.
- Contingency plan for conversion to surface water sources

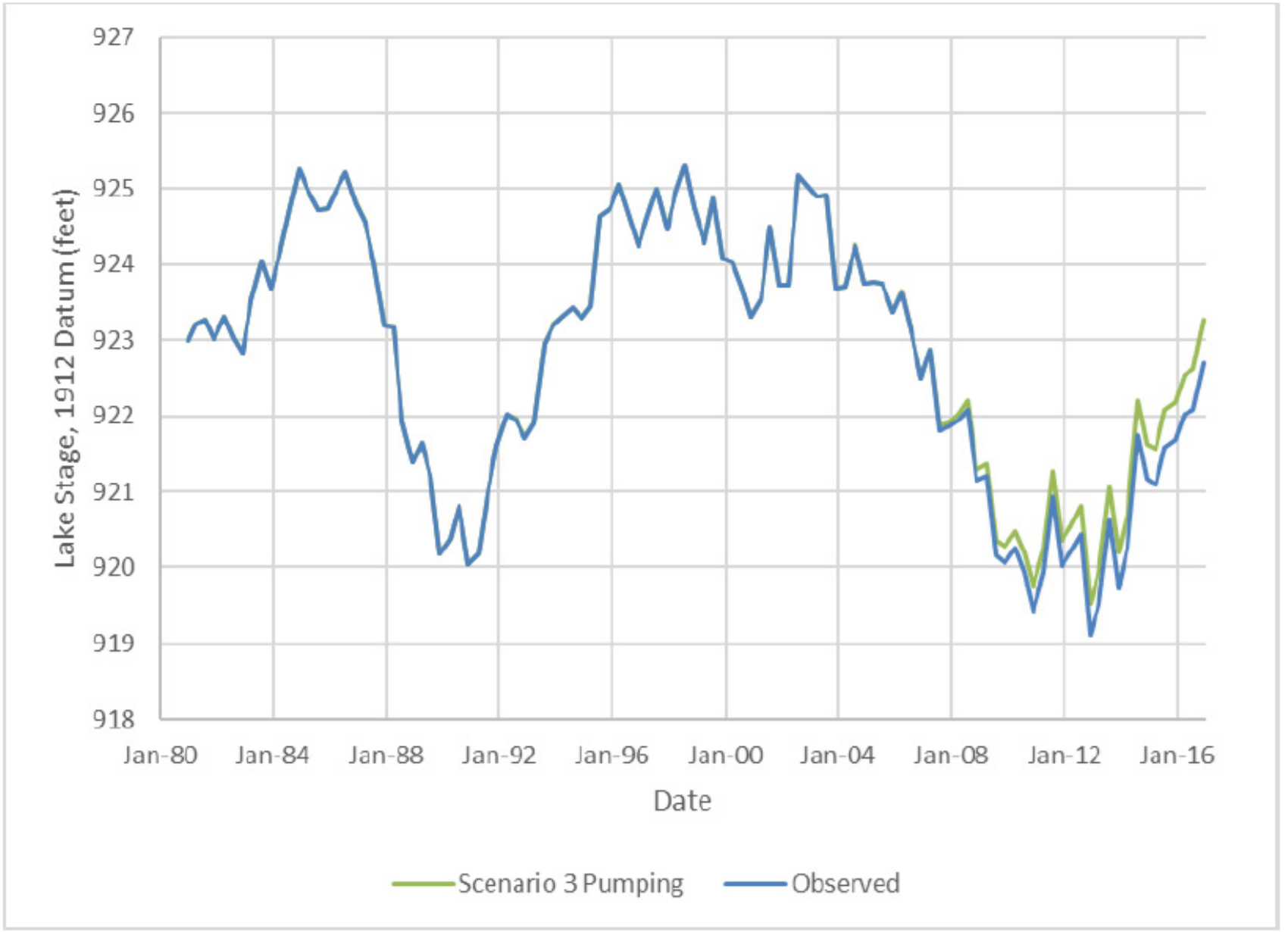

Municipal Supply Well
RWMWD Boundary
White Bear Lake 5 Mile Buffer
White Bear Lake



Simulated Effect of Pumping

Regional Reductions in Pumping

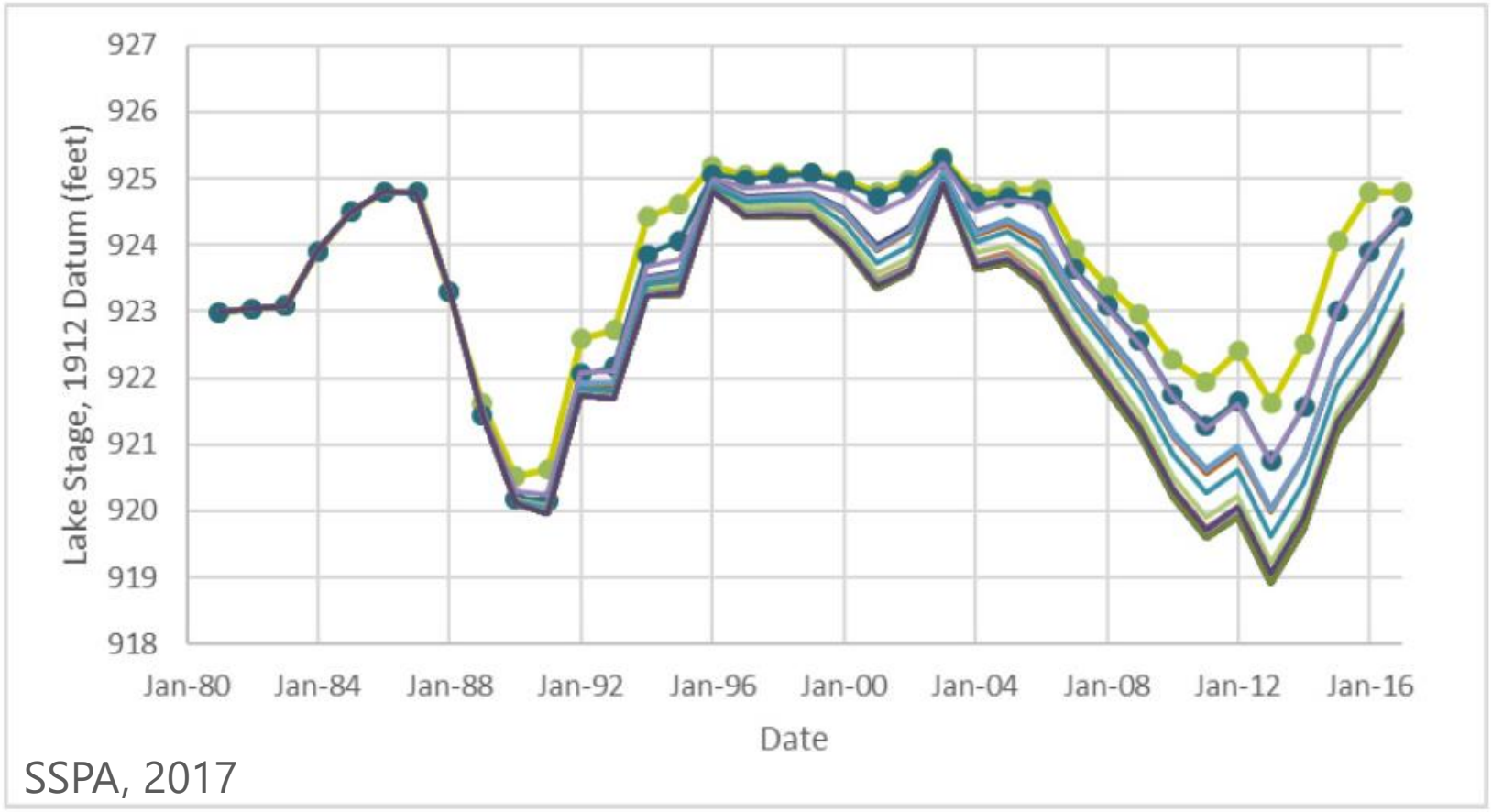
SSPA, 2017



Simulated Effect of Pumping

Limits on Irrigation

SSPA, 2017

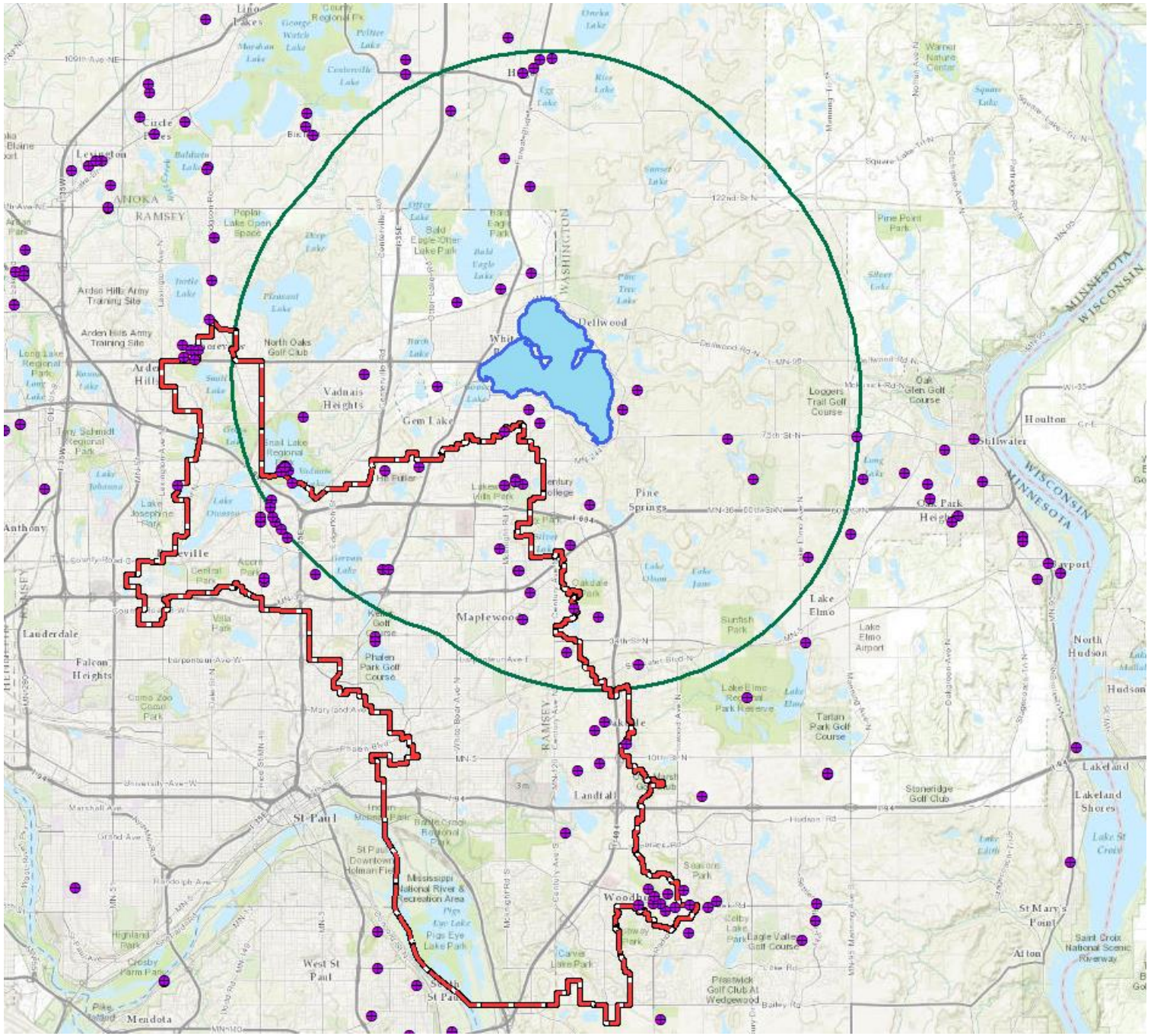


SSPA, 2017

Simulated Effect of Pumping

Individual Permits

Observed
1956-0368
1961-1031
1967-0032
1969-0163
1969-0174
1975-6218
1975-6379
1977-6104
1977-6176
1977-6229
1978-6197
1980-6153
1980-6214
1984-6120
1984-6121
1985-6123
1985-6168
1985-6200
1985-6321
1986-6165
1986-6211
1986-6316
1987-6149
1987-6205
1987-6206
1987-6207
1989-6009
1989-6037
1990-6325
1992-6031
1992-6065
1992-6137
1995-6039
1995-6119
2002-6073
2003-3036
2004-3020
2005-3012
2006-0618
2008-0754
2010-0390
2010-0445
2016-0244
2016-0437
1975-6207


Municipal Supply Well
RWMWD Boundary
White Bear Lake 5 Mile Buffer
White Bear Lake

White Bear Lake Lawsuit

Potential Impacts for the District

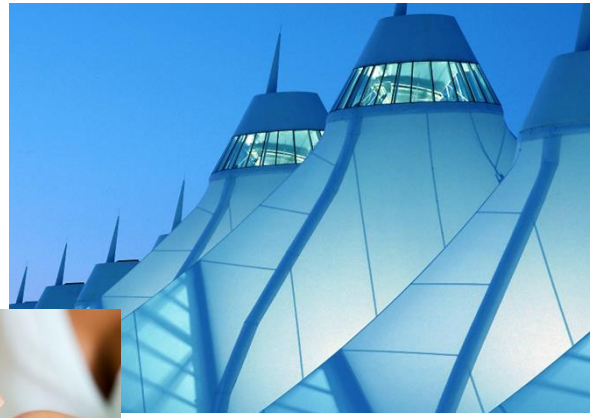
- Potential problems on construction projects if dewatering is necessary
- Conversion to surface water would likely involve St. Paul Regional Water.
  - Could have an effect on neighboring water bodies in the District
- Residential watering ban for district residents
- Precedent for future lawsuits, or similar measures to protect other water bodies

per- and polyfluoroalkyl substances (PFAS)

- PFAS are a class of synthetic compounds containing thousands of chemicals formed from carbon chains with fluorine attached to these chains
  - PFAS are surfactants (soap like) that repel oil and water, reduce wear or surface friction
- production began in 1940s and continues today
  - increased applications in 1960s and 1970s
  - some have been phased out and replaced

per- and polyfluoroalkyl substances (PFAS)

- primary users: glass cloth, non-stick cookware, coated papers, clothing/waterproofing (Scotchguard ™)
- secondary users: plating, fire fighting foams, plastic, construction, automotive, manufacturing, cosmetics, varnishes, sealers, many more…..

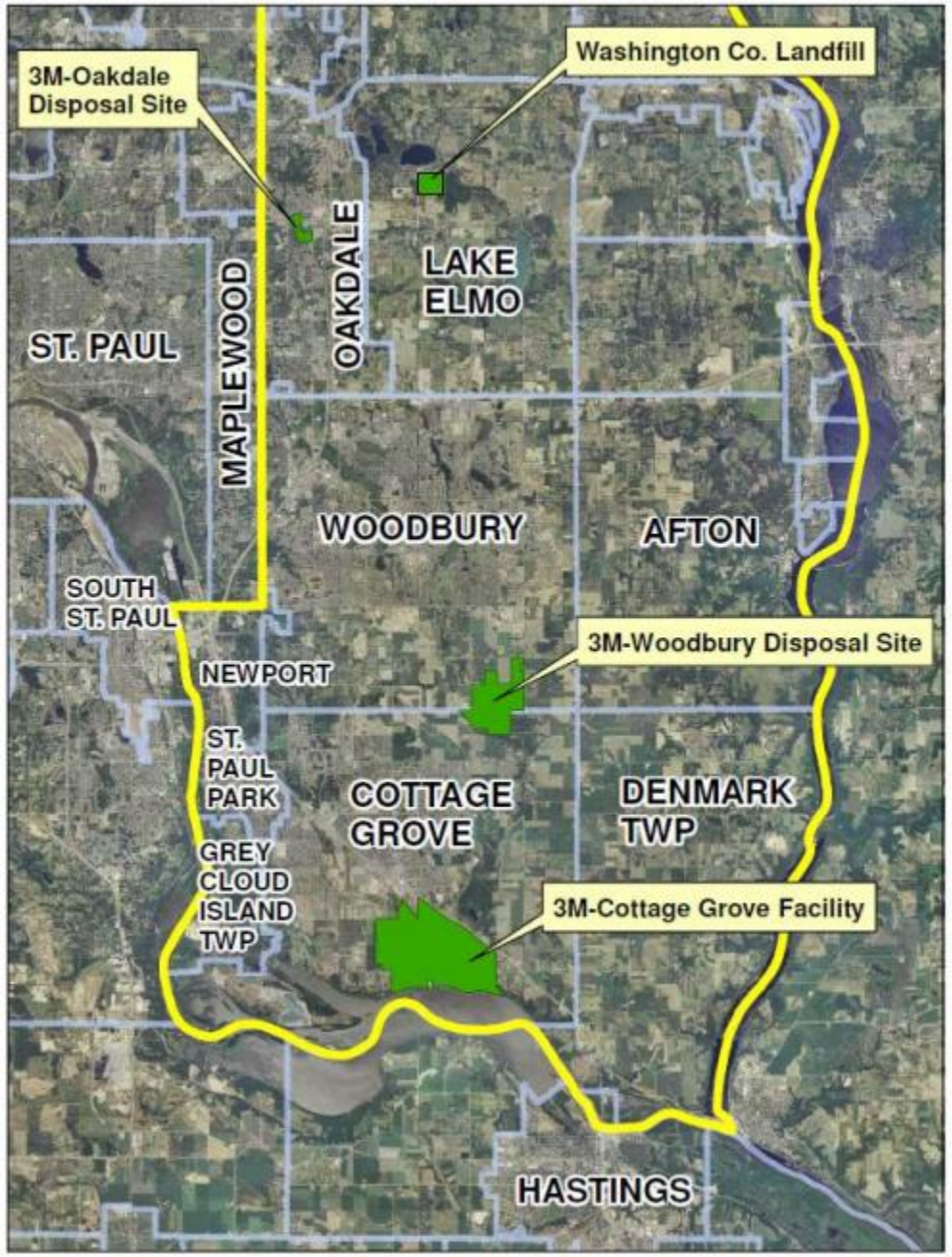


fate and transport

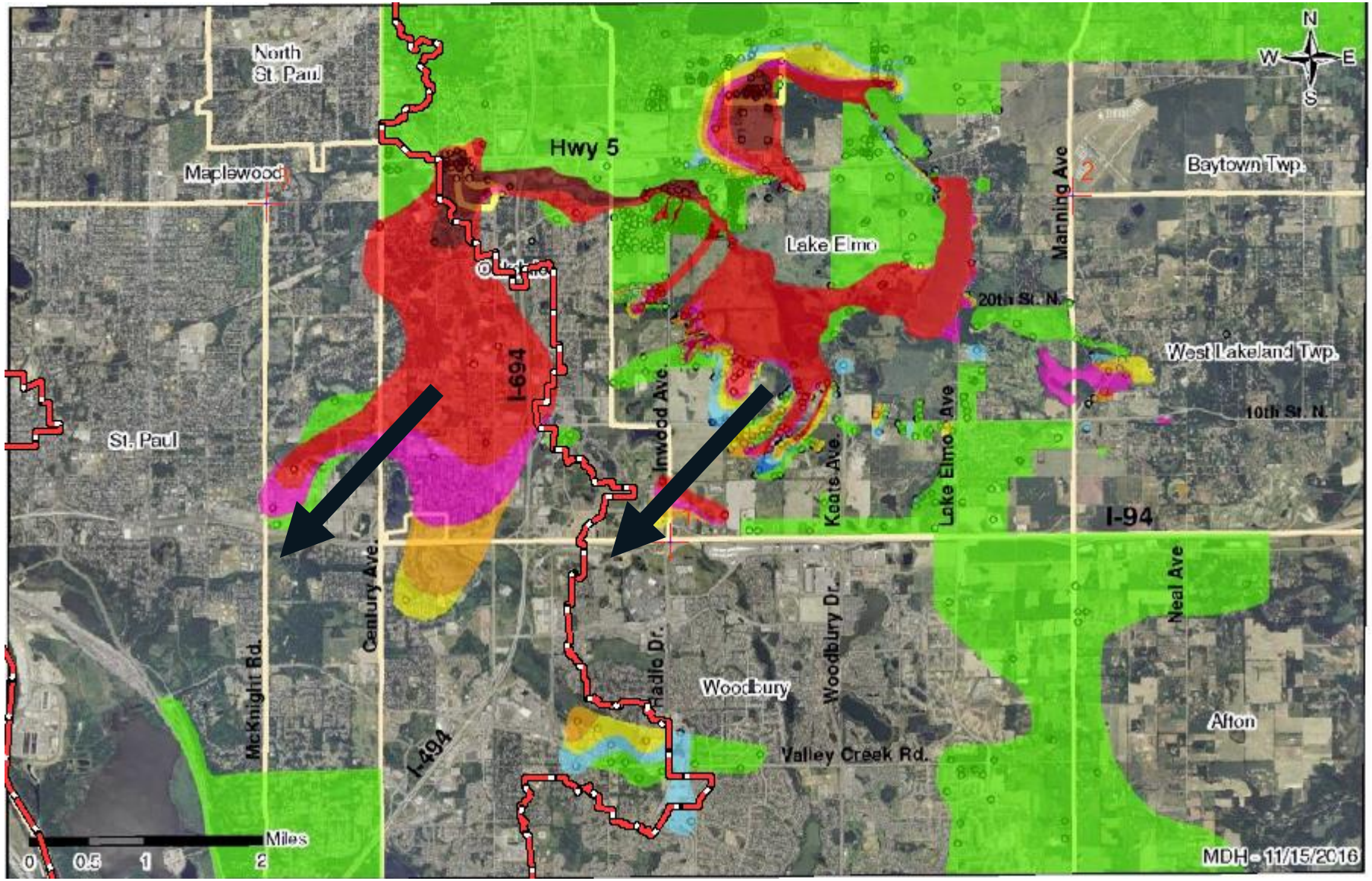
- PFAS were designed to resist degradation; generally do not degrade in the environment
- PFOA and PFOS not volatile
- Half-life of PFOA in humans is ~4 years, half-life of PFOS is about ~5 years[1]
- Bioaccumulates in fish and other aquatic animals
- Largely behave as tracers in groundwater, though transport may be retarded by:
  - Sorption to organic carbon (most significant)
  - Ionic attraction to calcium and magnesium

[1]Olsen, G.W., Burris, J.M., Ehresman, D.J., Froehlich, J.W., Seacat, A.M., Butenhoff, J.L., and Zobel, L.R., 2007. Half-Life of Serum Elimination of Perfluorooctanesulfonate,Perfluorohexanesulfonate, and Perfluorooctanoate in Retired Fluorochemical Production Workers. Environ Health Perspect. 2007 Sep; 115(9): 1298–1305.
Published online 2007 Jun 12. doi: 10.1289/ehp.10009

Location of 3M PFC Sites in Washington Co., Minnesota



Yingling, 2016



PFOA in Washington County Groundwater - All Aquifers - North

- PFOA >10x EPA HA
- PFOA >EPA HA and <10xEPA HA
- PFOA 75-100% EPA HA
- PFOA 50-75% EPA HA
- PFOA 25-50% EPA HA
- PFOA 10-25% EPA HA
- PFOA <10% EPA HA
- PFOA not detected
- Well with PFC data

Yingling, 2016

3M settled with MN for $850,000,000 in case brought related to damages to drinking water and natural resources

RWMWD?

Subgroup 2: Groundwater Protection, Sustainability, Conservation and Recharge

This Subgroup will analyze options and deliver recommendations to the Working Group for long-term solutions for groundwater protection, recharge, conservation, sustainability, and for groundwater studies and modeling needs in the East Metropolitan Area.

Structure

The group will be composed of technical experts from DNR, MPCA, MDH, 3M, Metropolitan Council, Washington County, Washington Conservation District, South Washington Watershed District, and the Valley Branch Watershed District. One technical representative each from the cities of Afton, Cottage Grove, Lake Elmo, Maplewood, Newport, Oakdale, St. Paul Park, Woodbury, and the townships of Denmark, Grey Cloud Island and West Lakeland will also be a part of this group.

- The Subgroup will meet monthly. While all members will be invited to each meeting, actual participation at a given meeting may be driven by the agenda set by the Operating Group for that meeting. It is understood that those who are interested in specific projects and approaches will be most likely to attend a particular meeting.
- The meetings will be open to the public, and time will be reserved at the end of each meeting for public questions or comments.

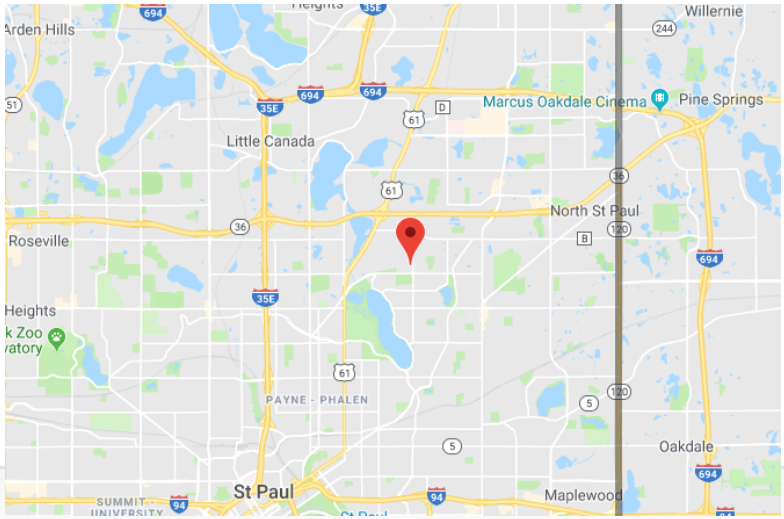
Project selection approach

Potential projects include water conservation and efficiency, open space acquisition, and groundwater recharge.

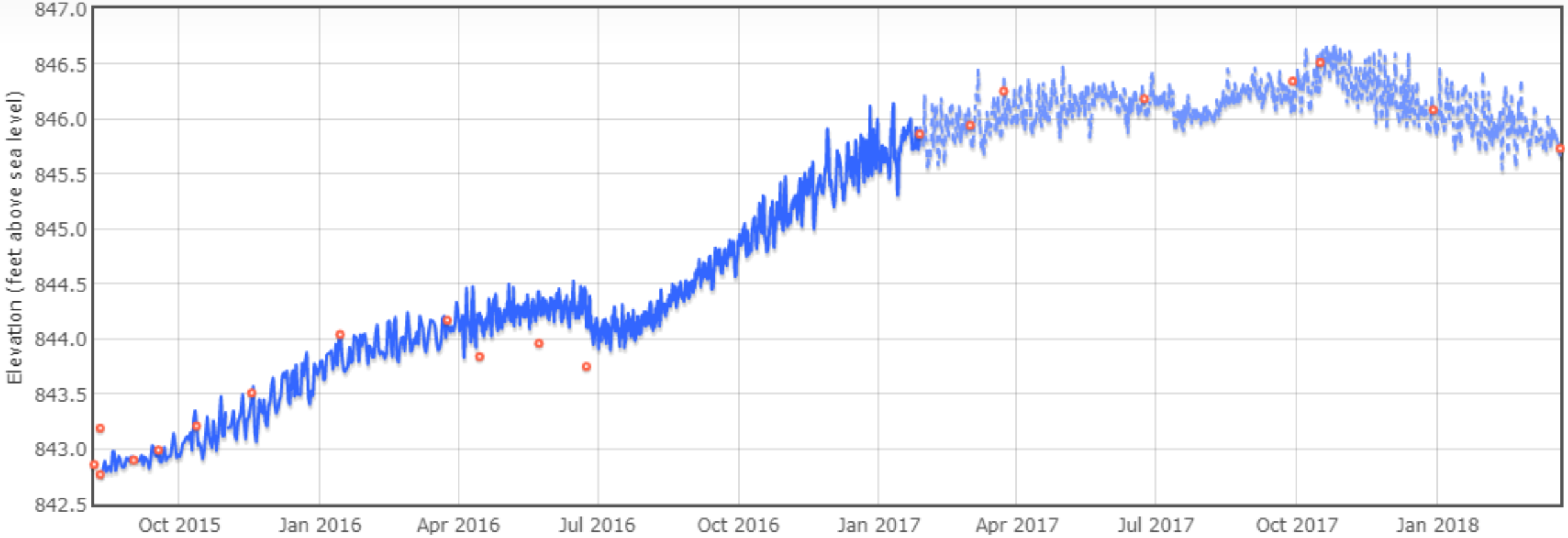
- The project options could be a mix of grants, where the grantee would develop the projects, and group-developed projects similar to Subgroup 1. Municipalities, counties and local non-governmental organizations (NGOs) will provide needs and feedback on emerging recommendations. Involvement by particular entities will vary and evolve over time.
- Under Operating and Subgroups' direction, technical subgroups will likely evolve to address specific project approaches, and the technical subgroups will work with individual communities depending on project proposals.
- Consultants will assist and support the group as needed on issues including natural resource damage restoration, facilitation, and contamination remediation.

DRAFT

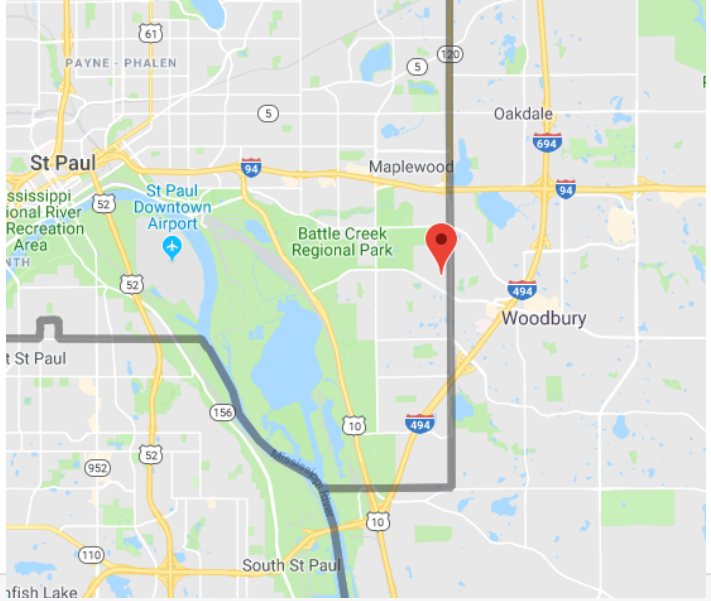
Link to Draft Settlement Working Group Proposal



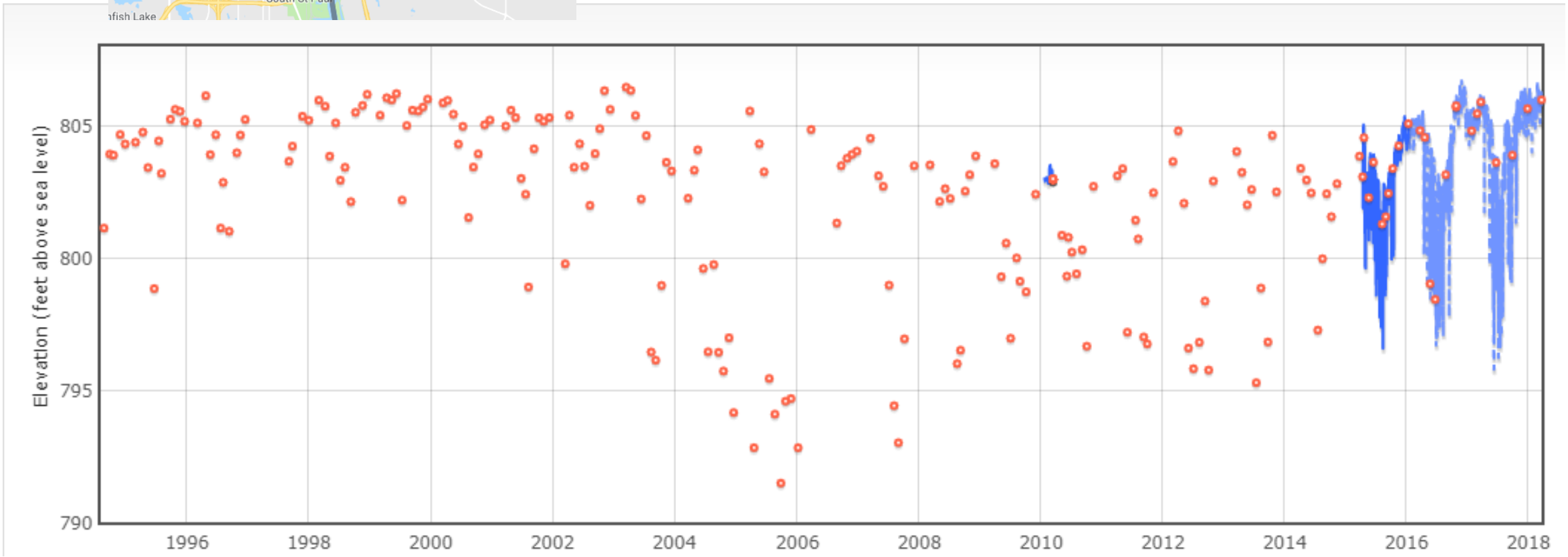
Quaternary Aquifer, Maplewood, Gateway Trail



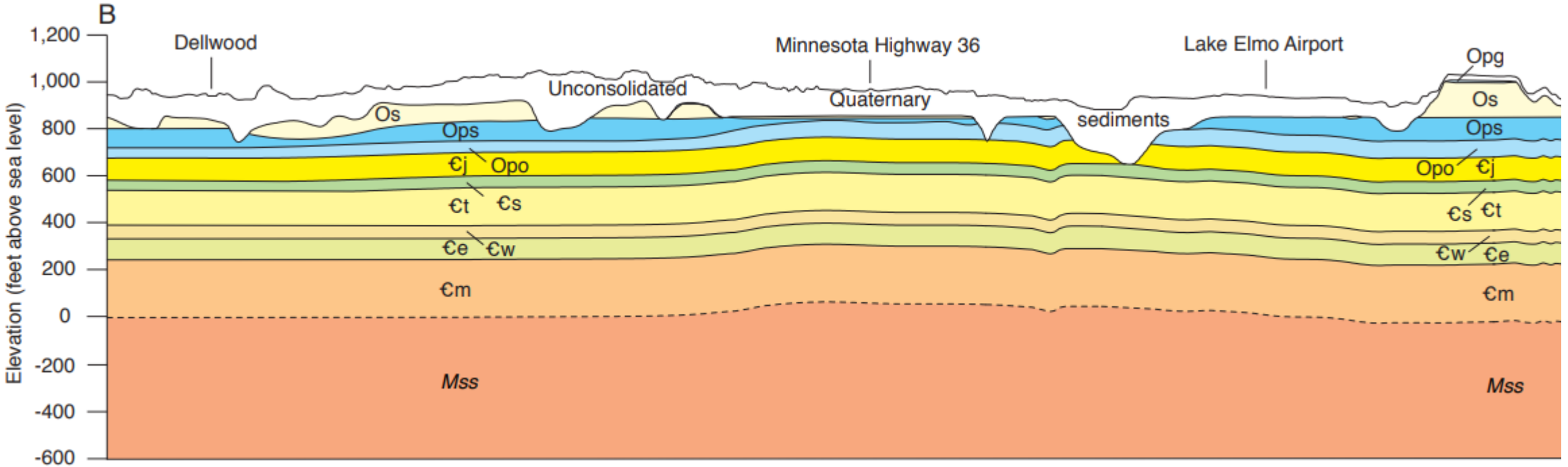
BARR



Jordan Aquifer, Maplewood, Ramsey County Workhouse

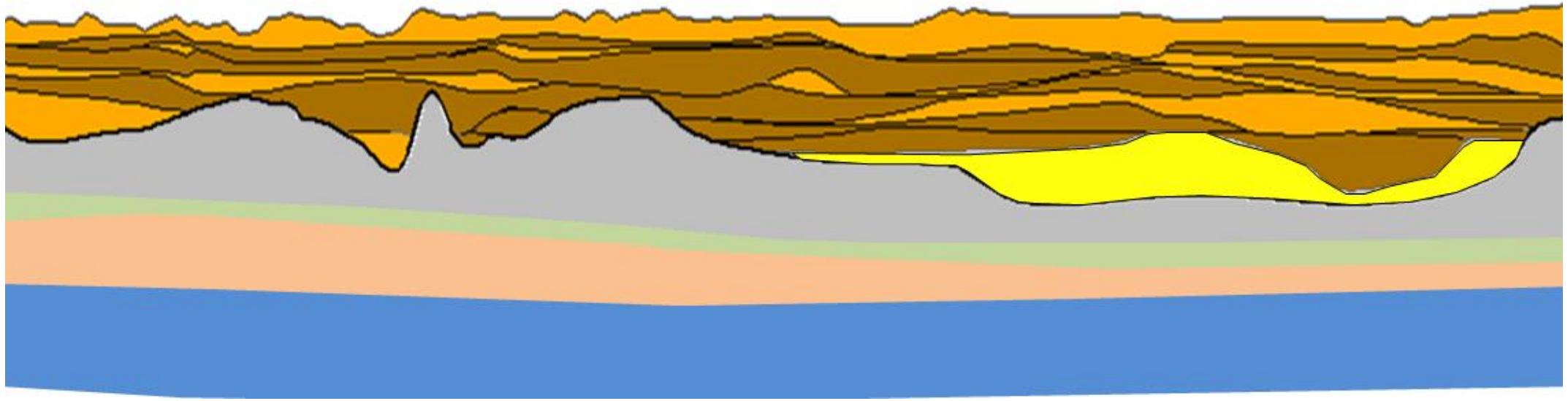


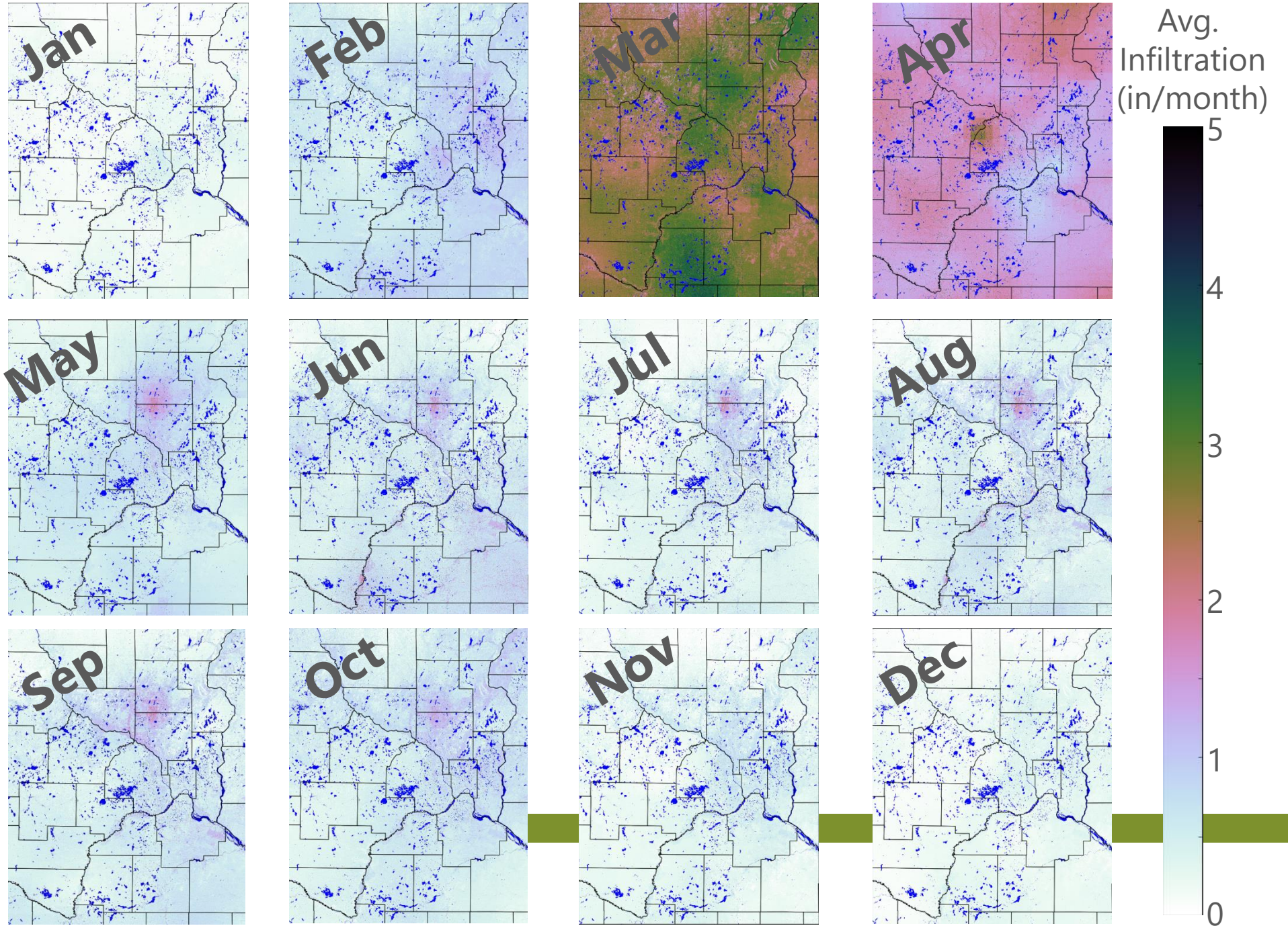
Geologic Cross Section



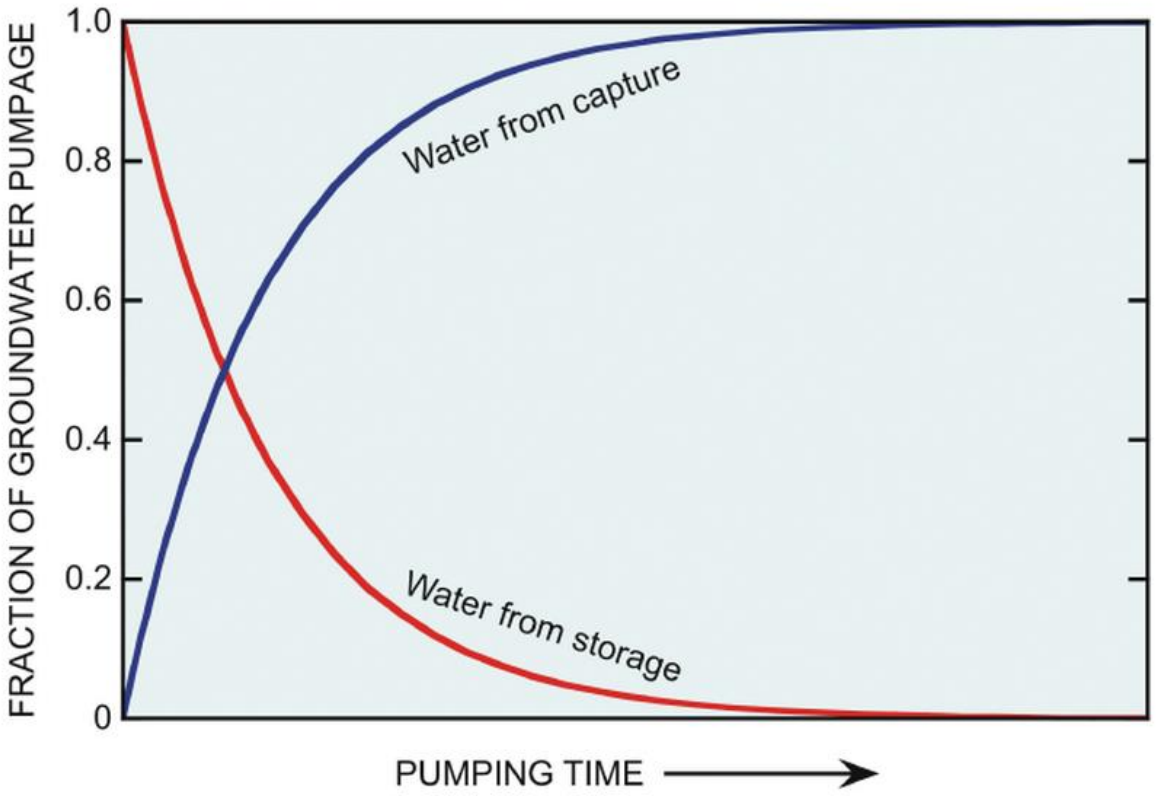
Washington County Geologic Atlas, MGS, 2016

Quaternary (Glacial) Hydrogeology




Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Avg. Infiltration (in/month)
5
4
3
2
1
0

Source of Water to New Well Changes Over Time



(days to decades to centuries)

capture = increased recharge and/or decrease in groundwater discharge

time scale depends on characteristics of aquifer and distance of well from water body

Groundwater
Volume 52, Issue S1, pages 100-111, 28 MAY 2014 DOI: 10.1111/gwat.12204
http://onlinelibrary.wiley.com/doi/10.1111/gwat.12204/full#gwat12204-fig-0001