The Role of Groundwater in Watershed Studies

MGWA Spring Conference

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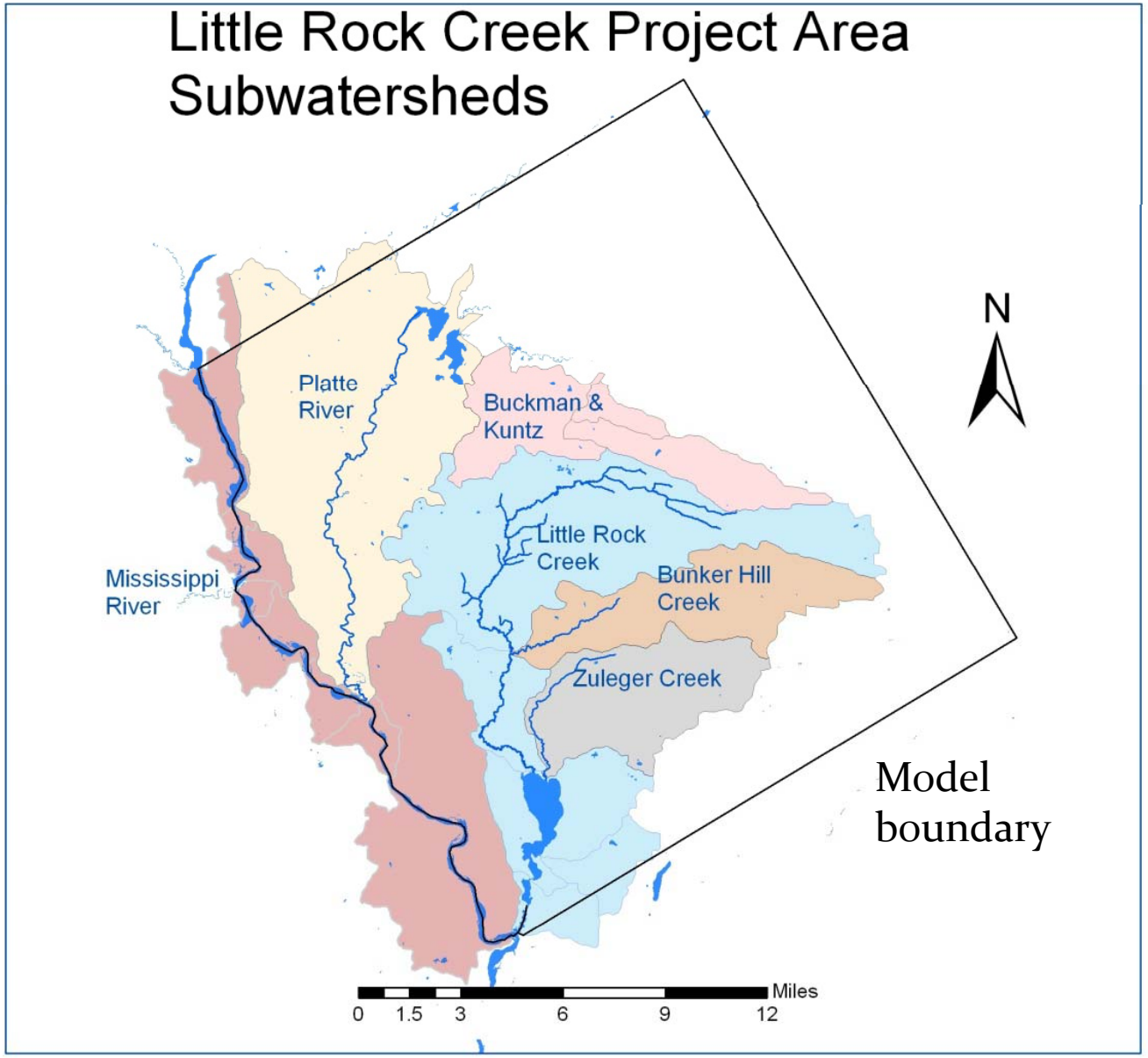
Today's Goals

1) Describe the first groundwater model constructed for MPCA TMDL studies;

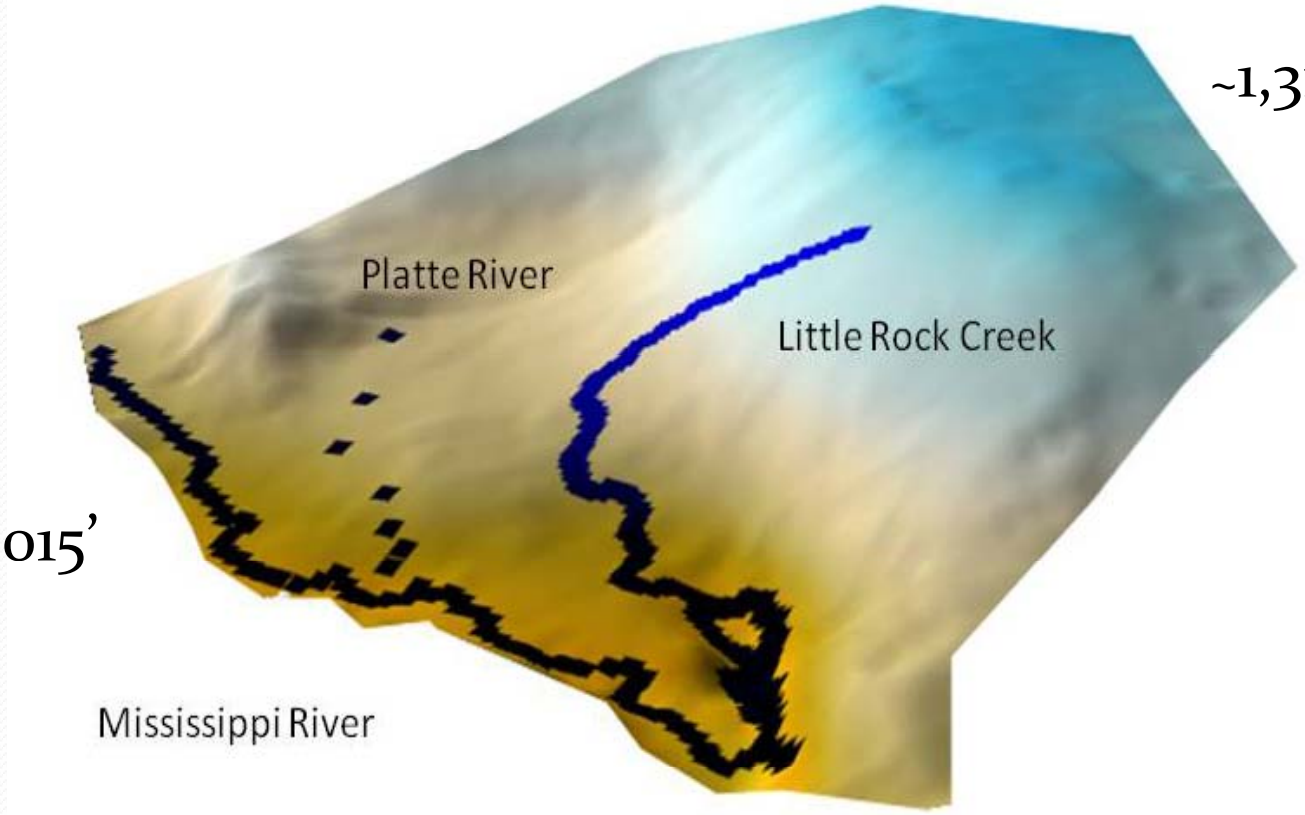
2) Demonstrate that trends observed at this local scale are operating state-wide;

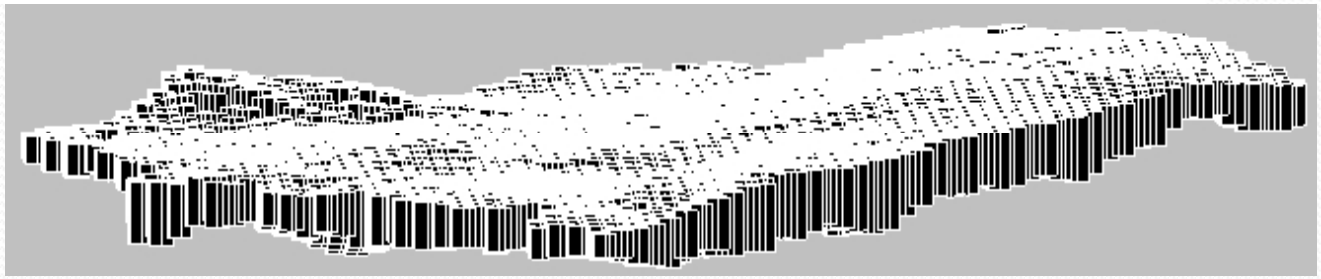
3) Suggest a connection between the hydrologic trends.

Study Area

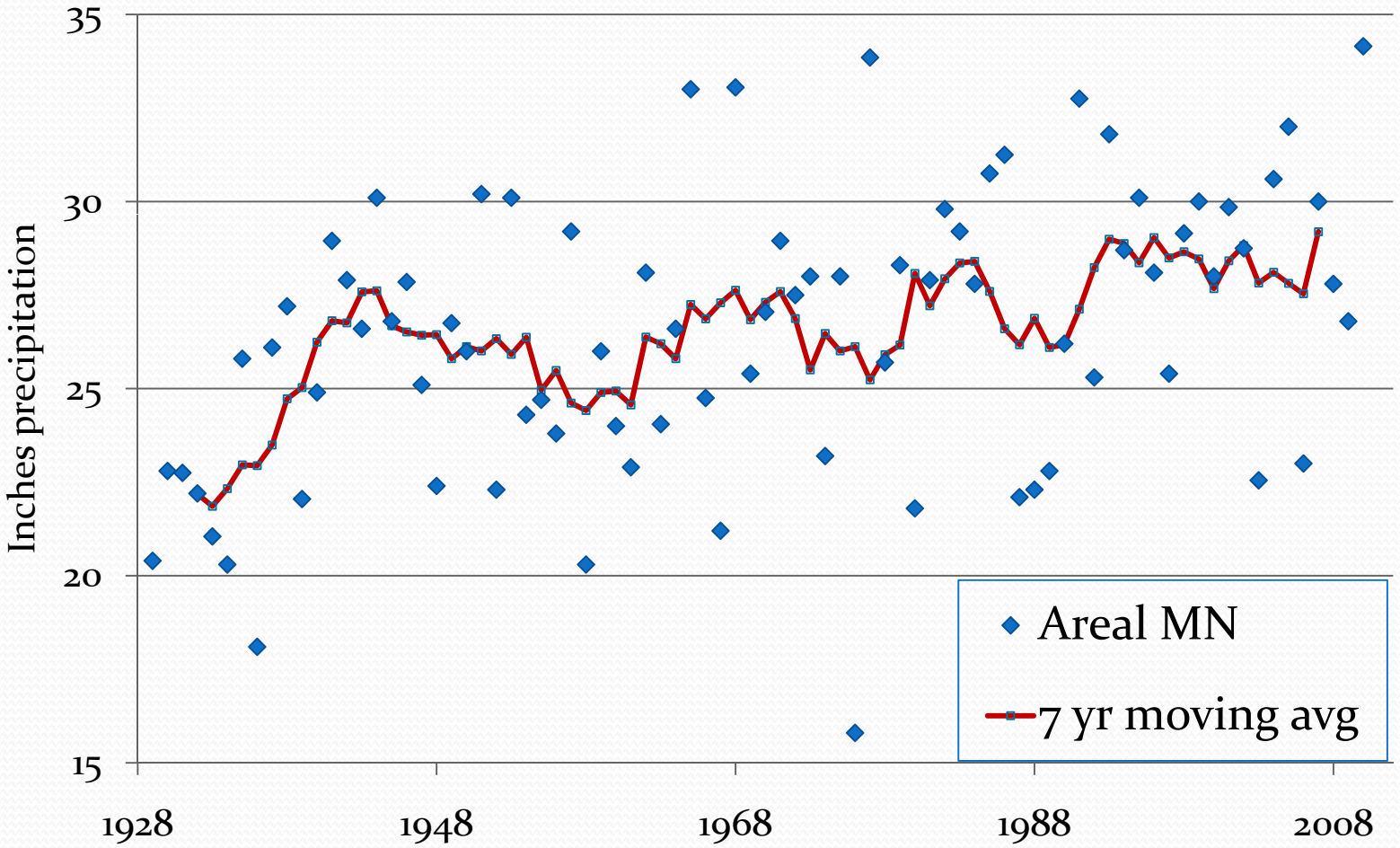

Little Rock Creek Project Area
Subwatersheds
Platte River
Buckman & Kuntz
Little Rock Creek
Bunker Hill Creek
Zuleger Creek
Mississippi River
N
Model boundary
Miles
0 1.5 3 6 9 12

Topography: Surface Elevation

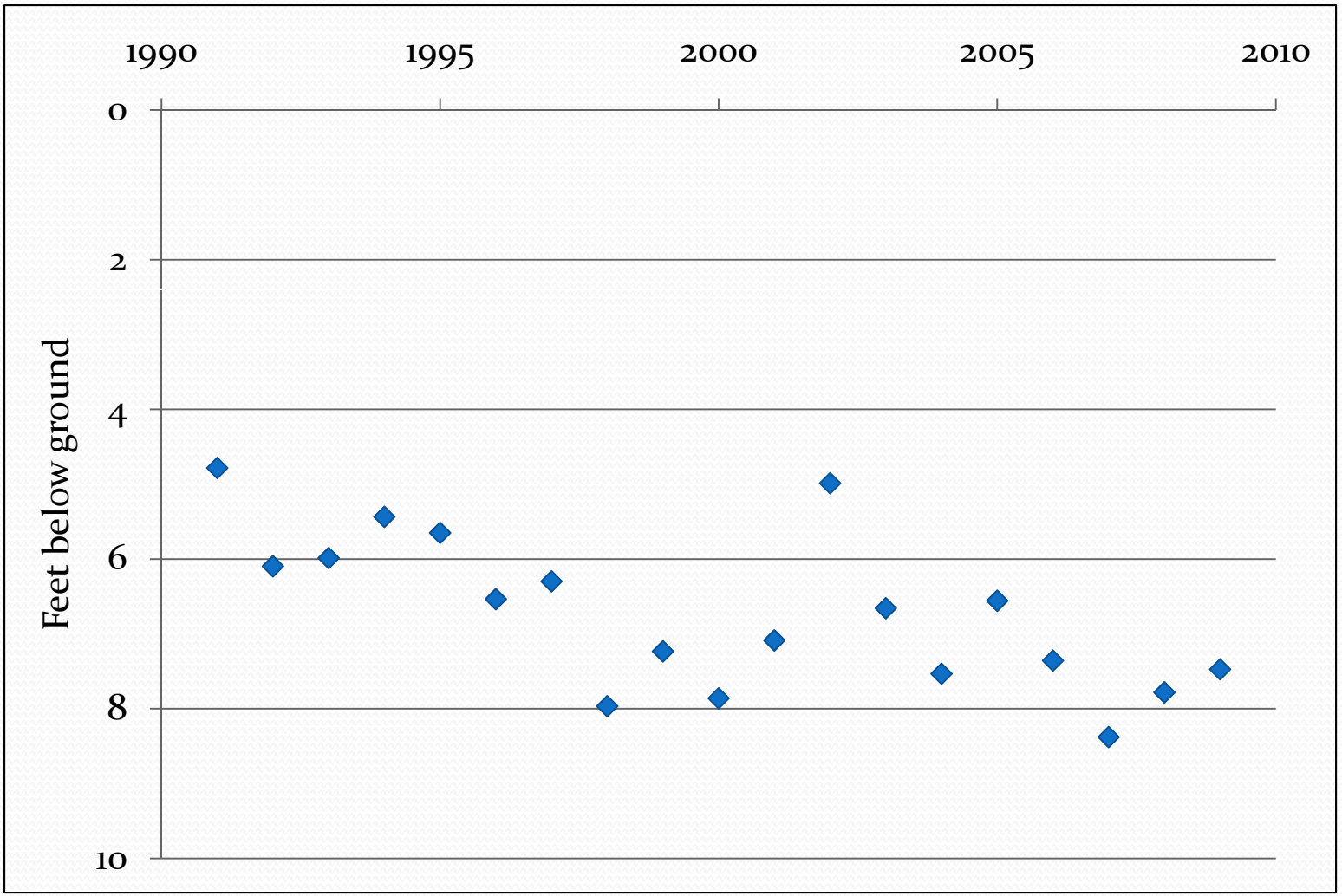




Precipitation in Minnesota
An Areal Average

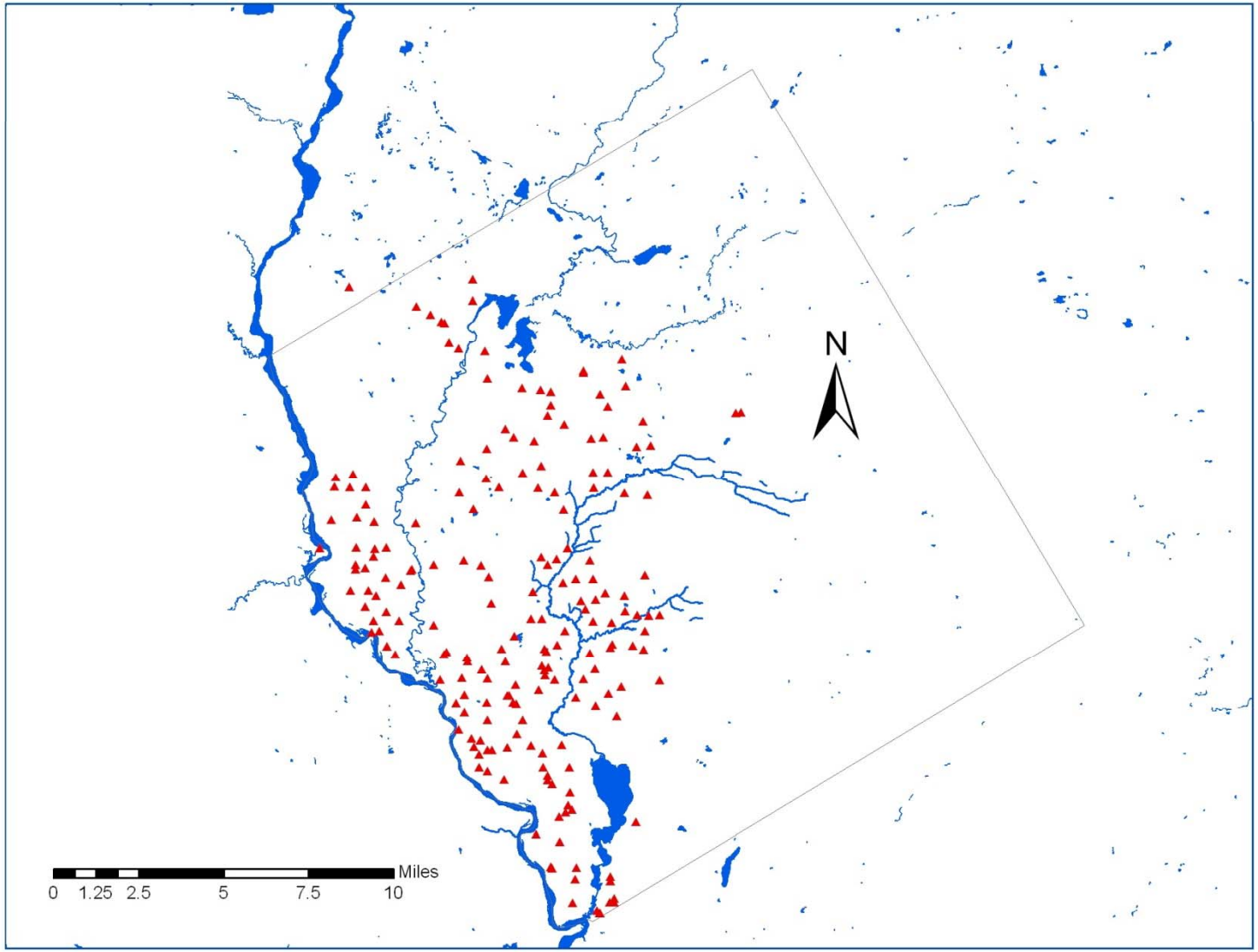


Groundwater Levels: Obwell 5004

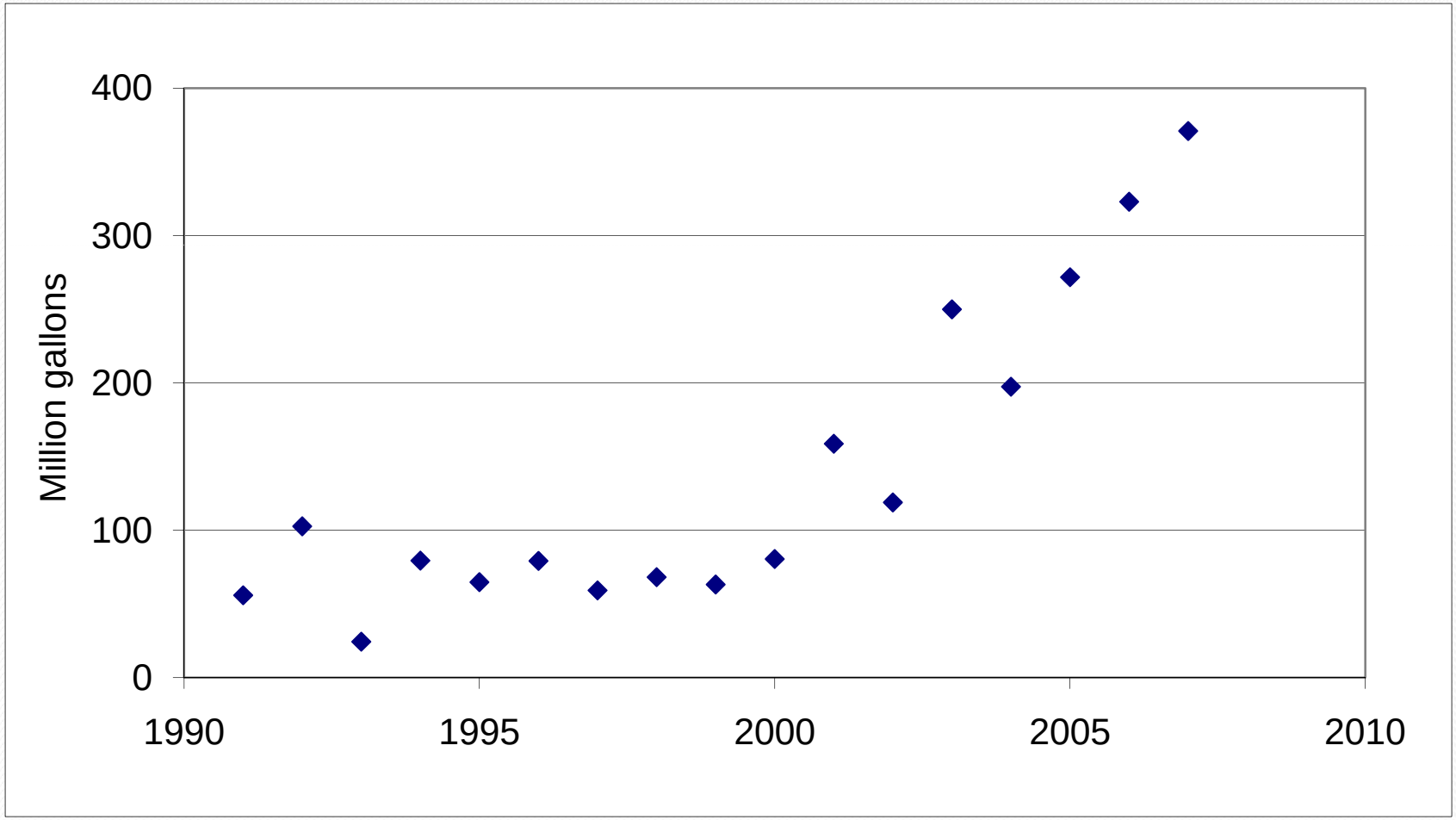


Statistically significant decline, p= 0.01

High Capacity Wells

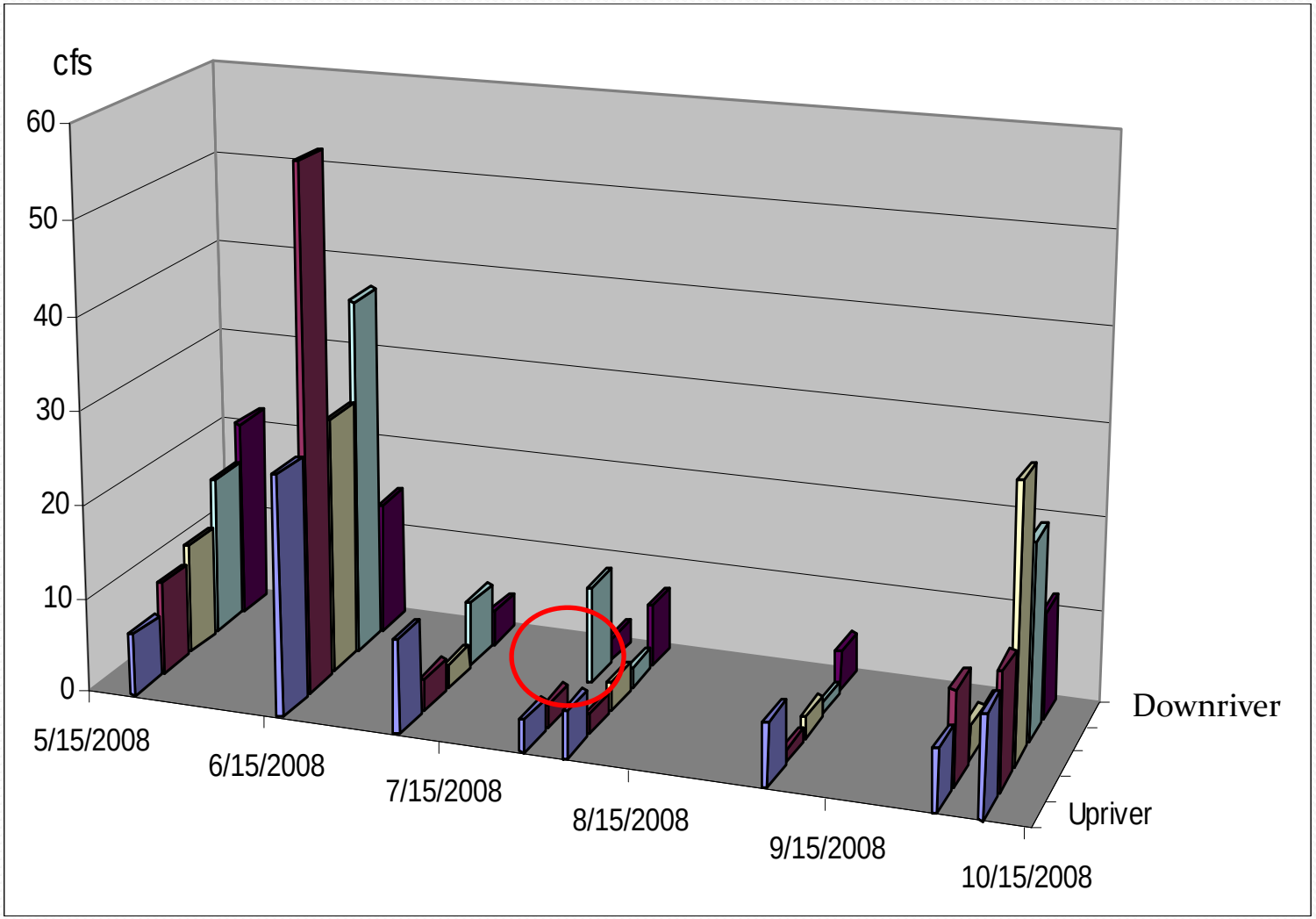


Groundwater Pumping in the Watershed



Statistically significant to p= 0.01

Creek Discharge with Time



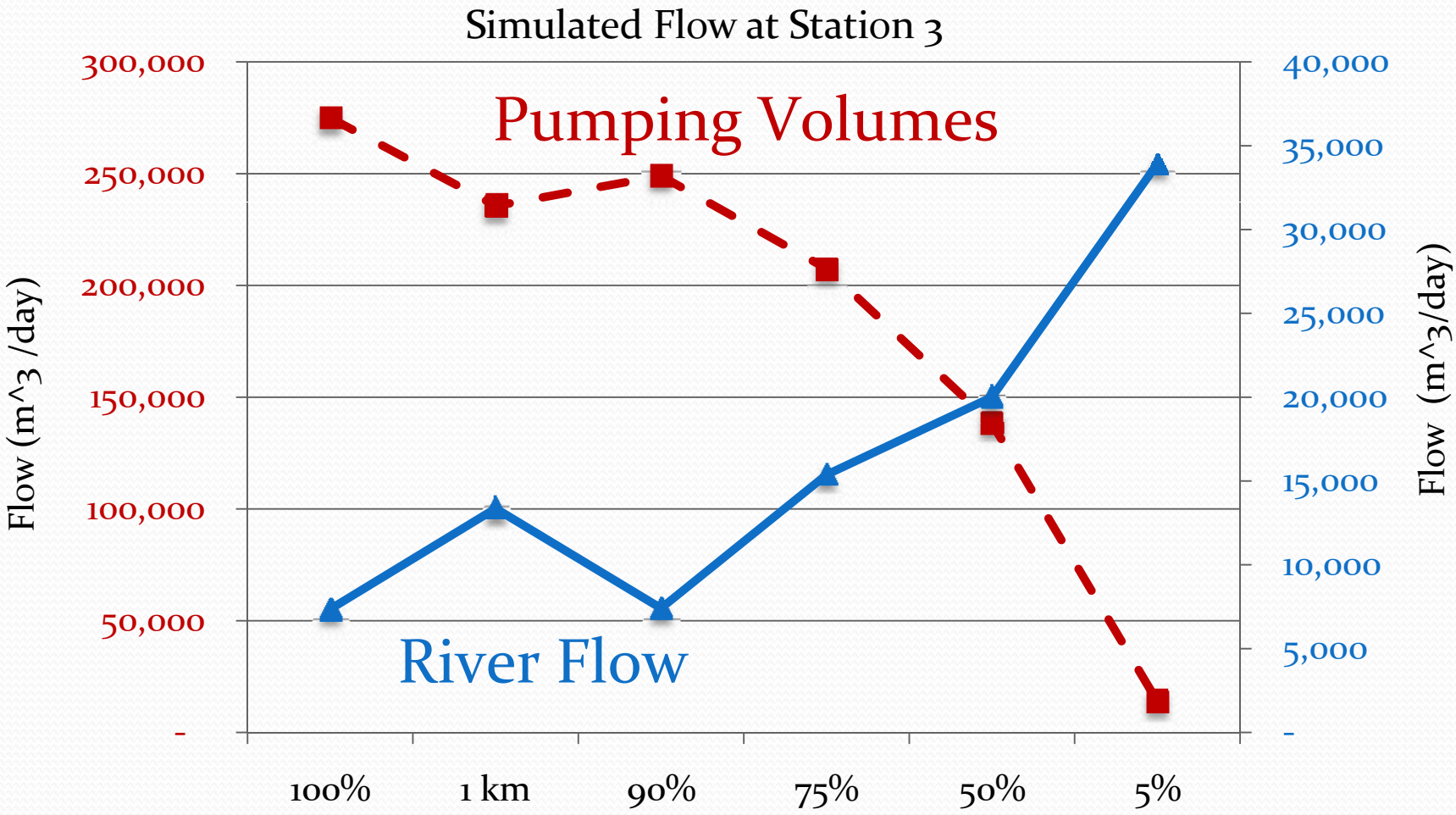
Model Specifics

- MODFLOW running within GMS v.7;
- Two Steady-state models built to represent pumping (Summer) and non-pumping seasons;
- Single layer system;
- Pilot points used for Recharge, single polygon for hydraulic conductivity;
- Calibrated to seven flow gaging stations on three streams;
- Calibrated to nine observation wells.

Model Results

The Little Rock model found that the high capacity groundwater withdrawals were reducing flow in the creek. In consequence, altered flow of groundwater was labeled as a primary cause of stream impairment.

Model Scenarios: What Happens If Pumping is Reduced?



Algae Blooms in August 2007

Photo by Amy Robak, Benton SWCD

Study Parameters

- Time Period

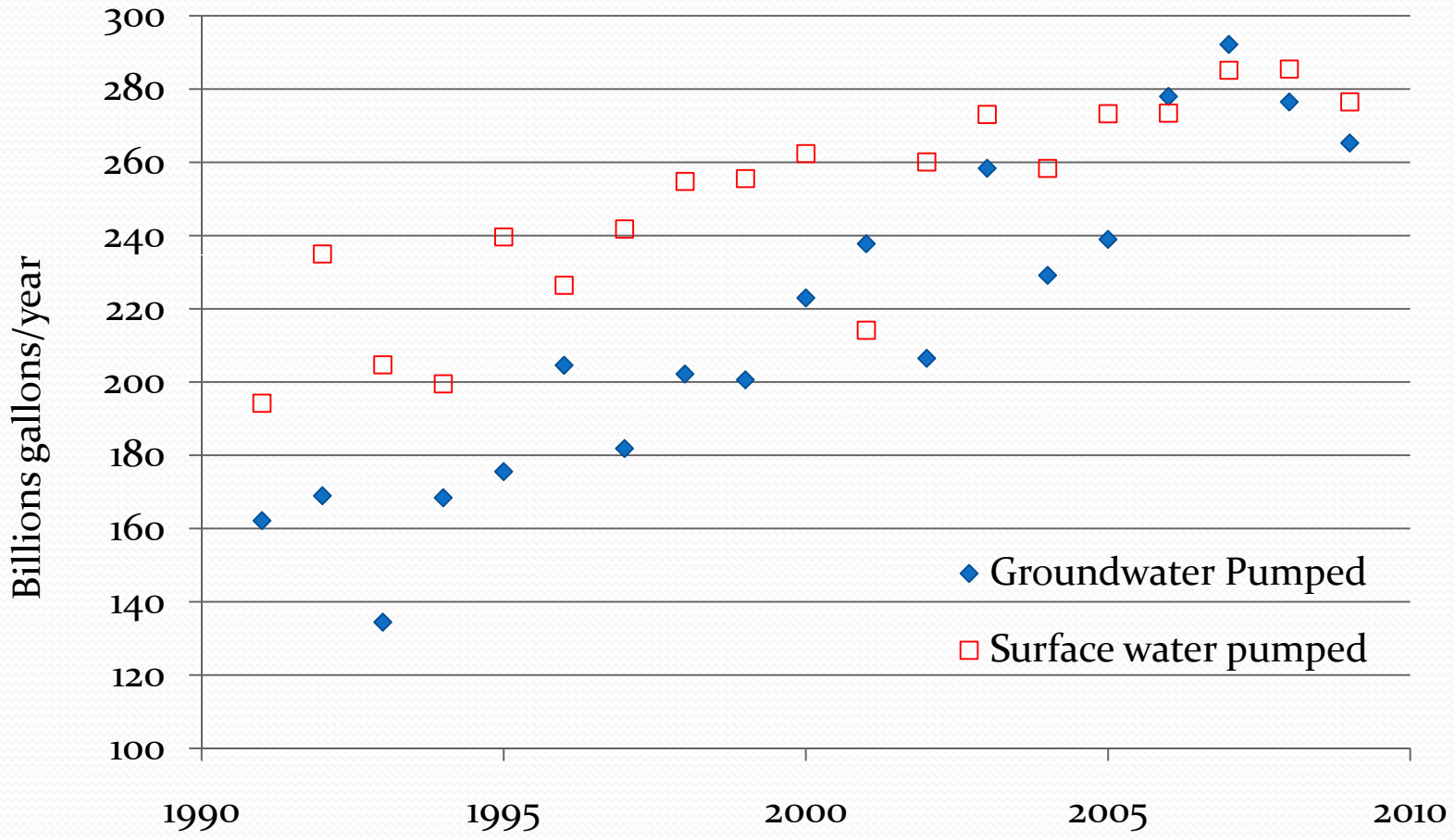
  1991 – 2009

- Datasets
  1. Water Appropriations: DNR SWUDs
  2. Observation Wells: DNR Obwell Network
  3. Stream flow: USGS & DNR/MPCA Coop. Gaging
  4. Precipitation: Western Regional Climate Center

- Statistical tests

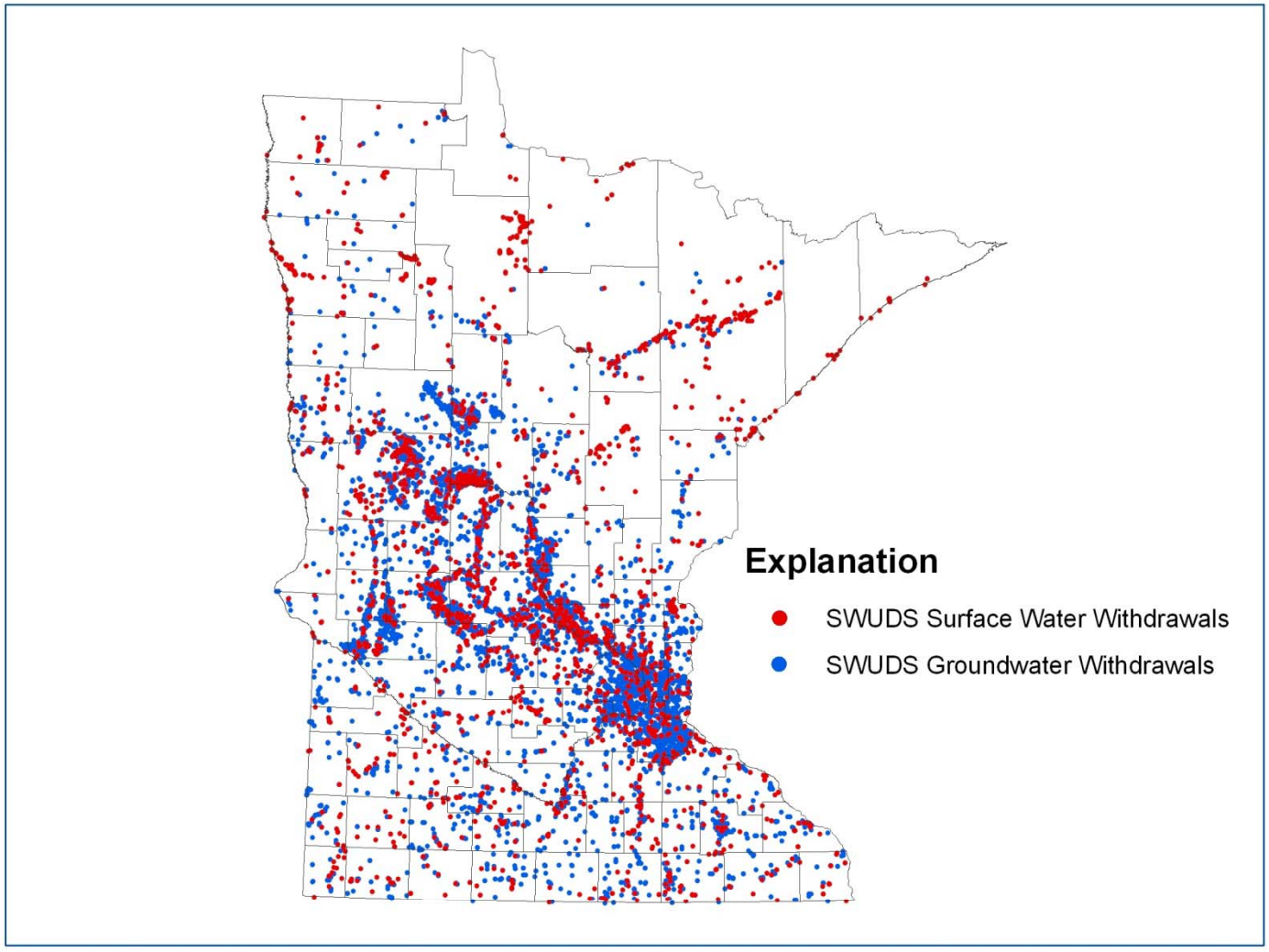
  Mann-Kendall nonparametric & Sen's Method

Consumptive Withdrawals by Source



Increasing Trends that are statistically significant to p= 0.001

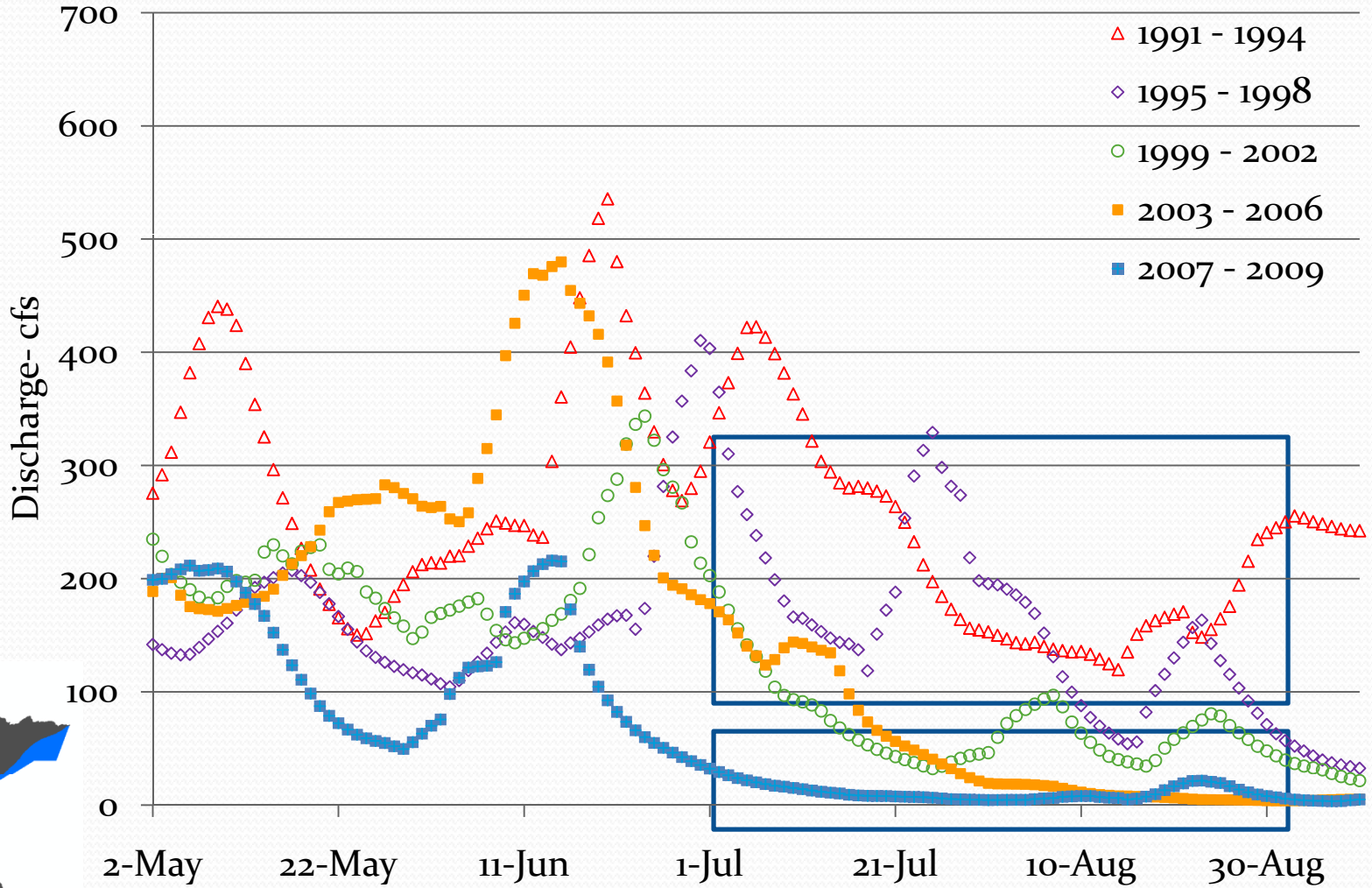
Locations of Permitted Withdrawals

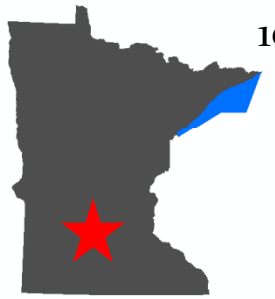


http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

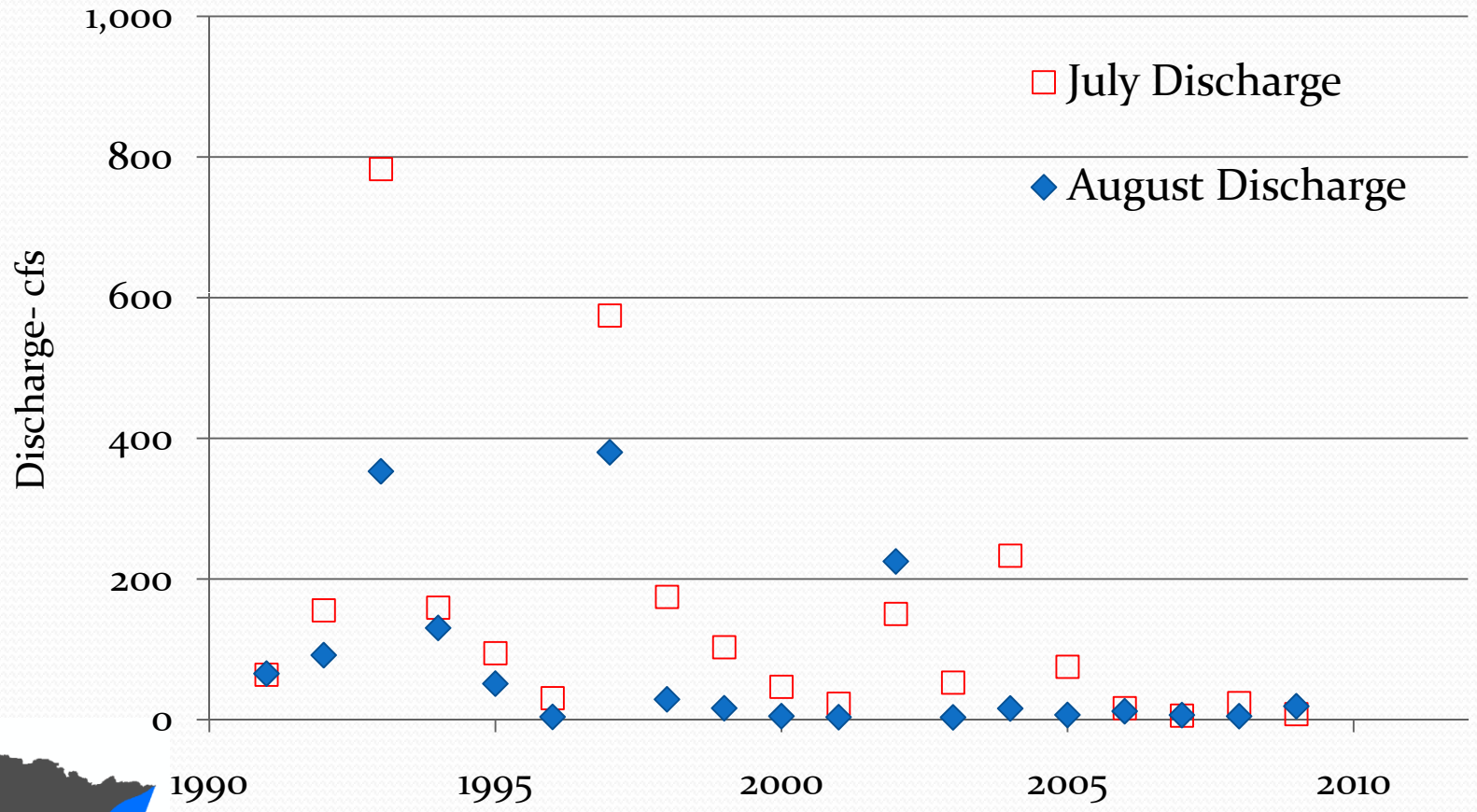
What is a Gaging Station?

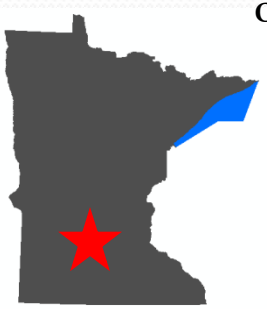
Grouped Hydrographs
High Island Creek near Henderson





High Island Creek- Summer flow



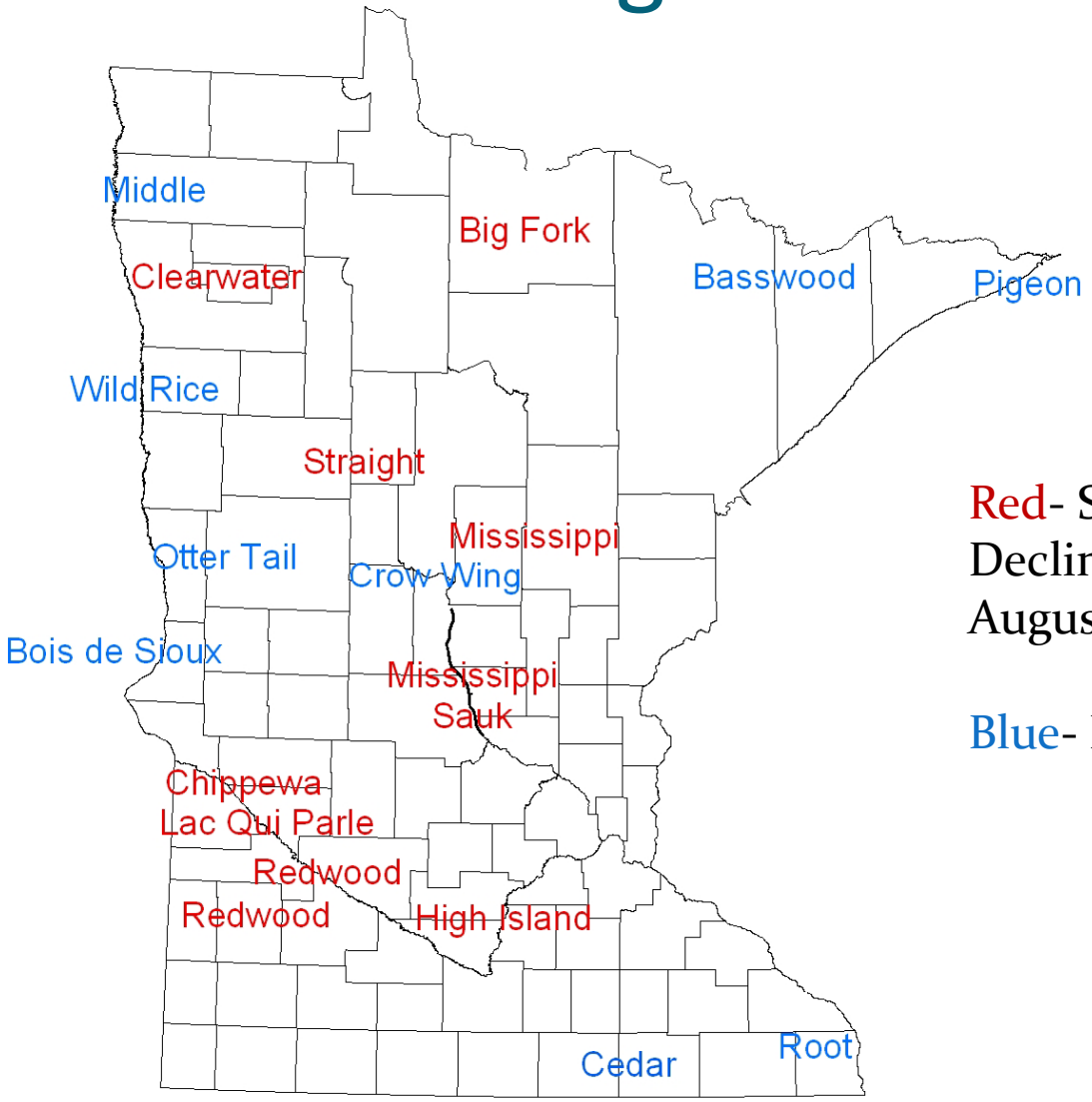


Statistically Significant Discharge Trends

July p= 0.05

August p= 0.05

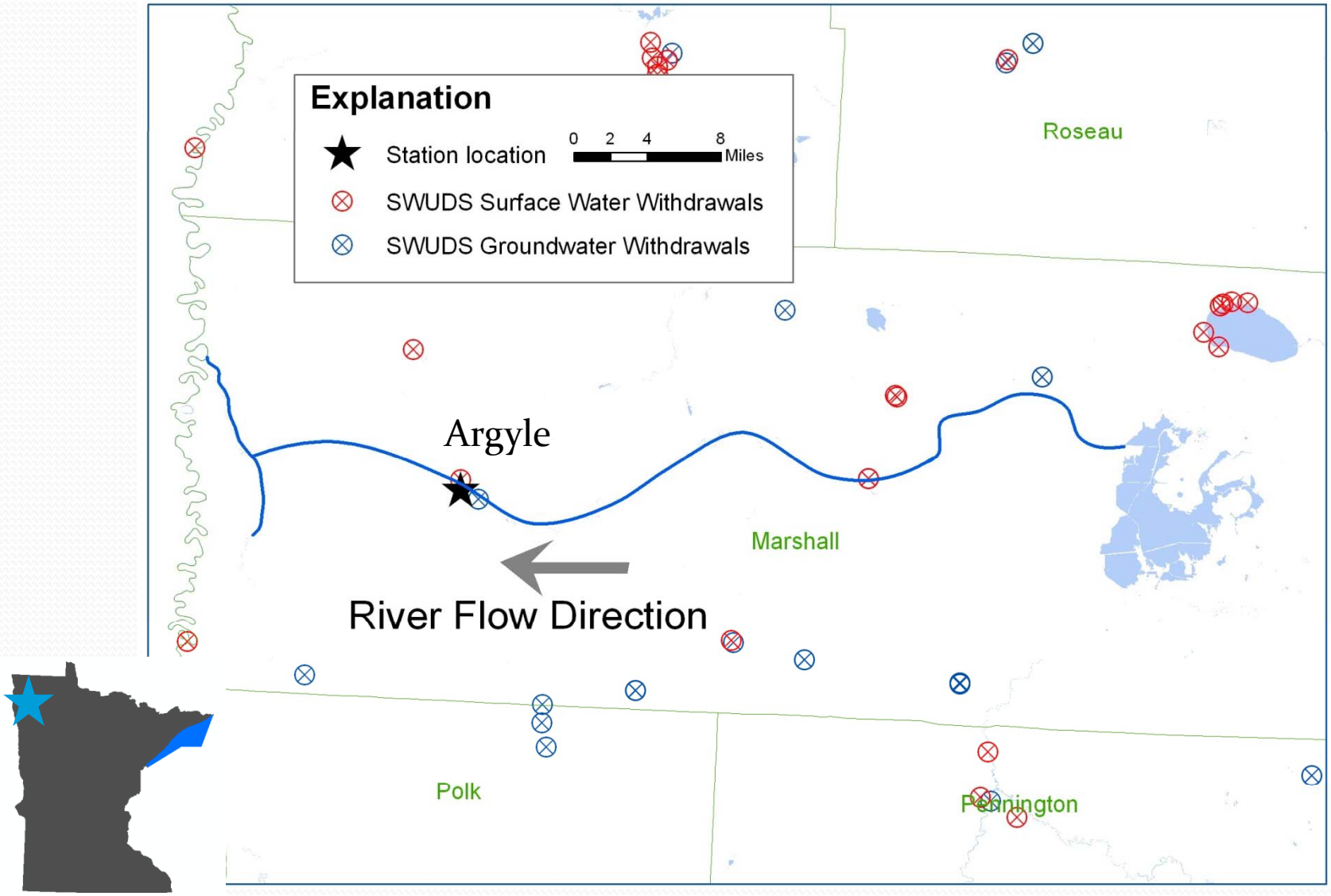
Distribution of Significant Trends



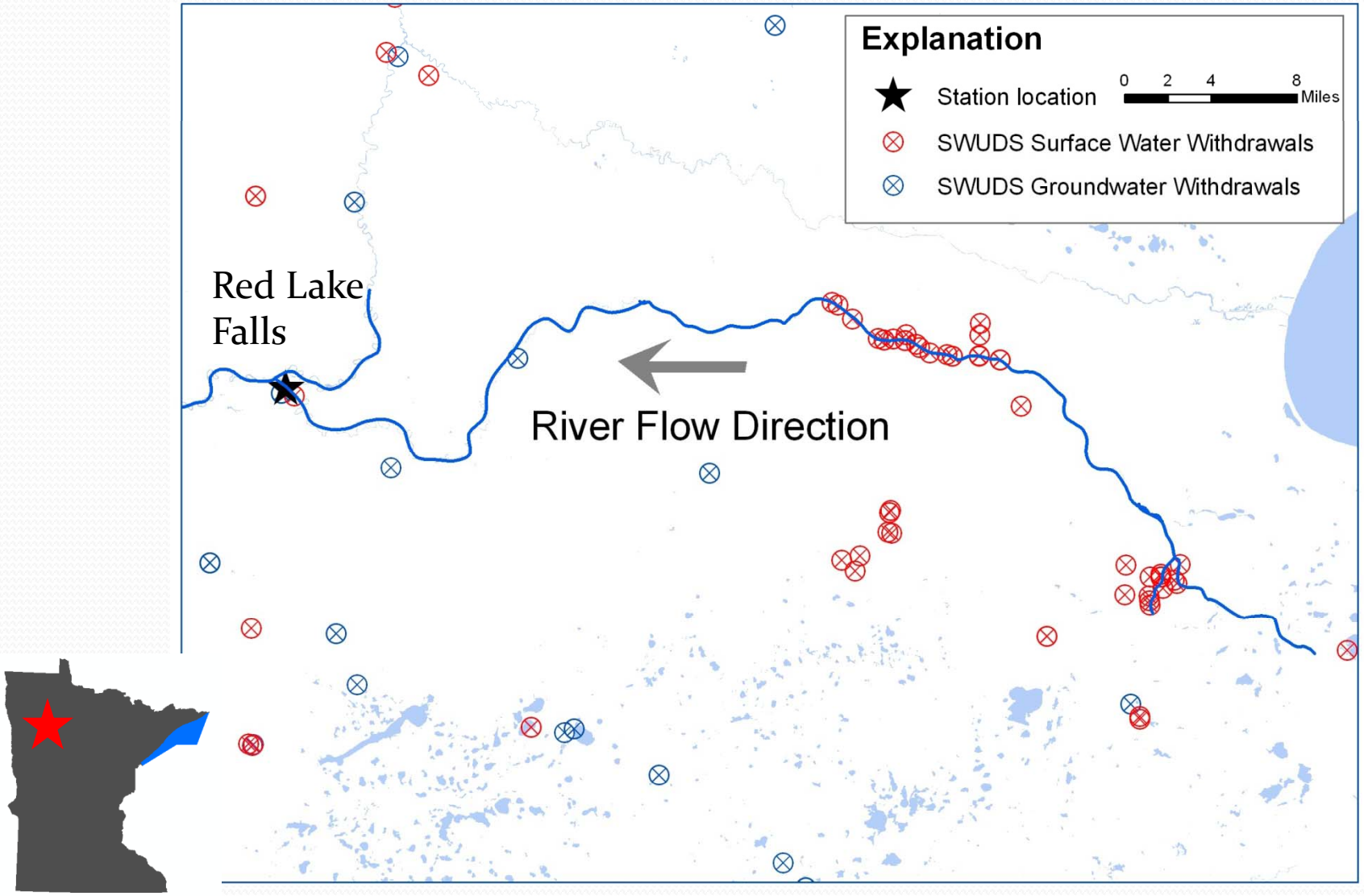
Red- Statistically Significant Decline in July and August Flows, p<=0.05.

Blue- No significant trend

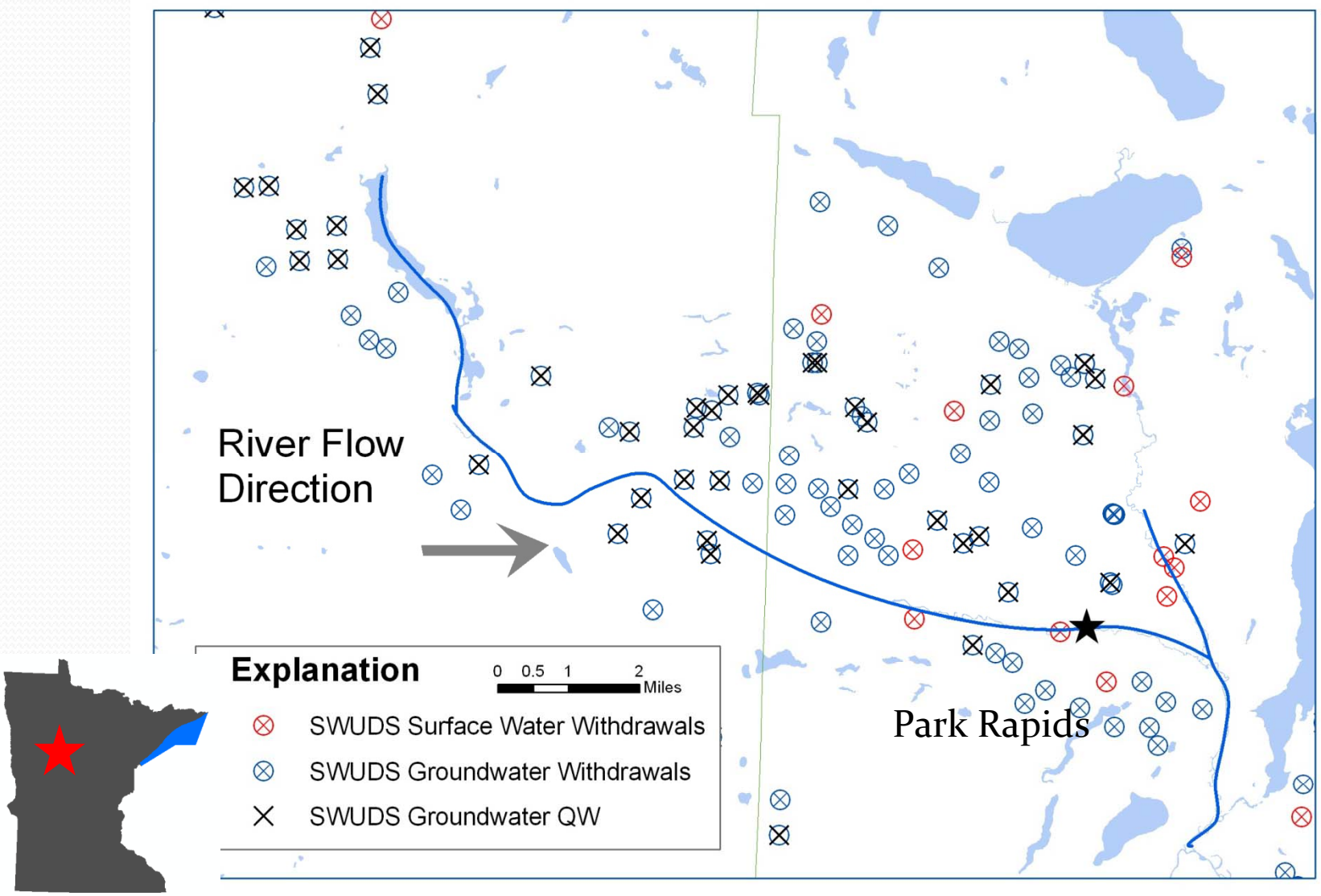
Middle River- **No Trend**



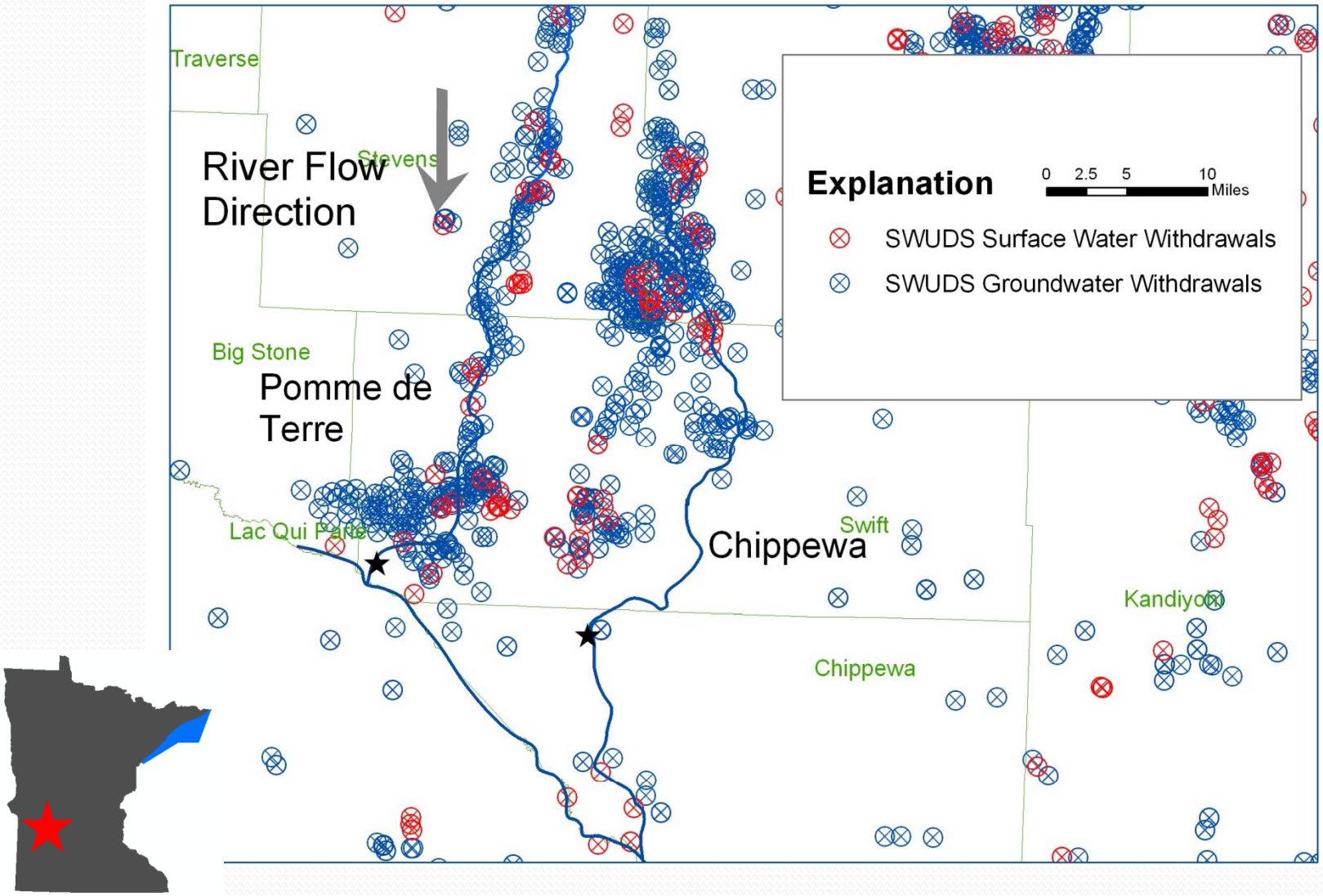
Clearwater River- **Decreasing Trend**



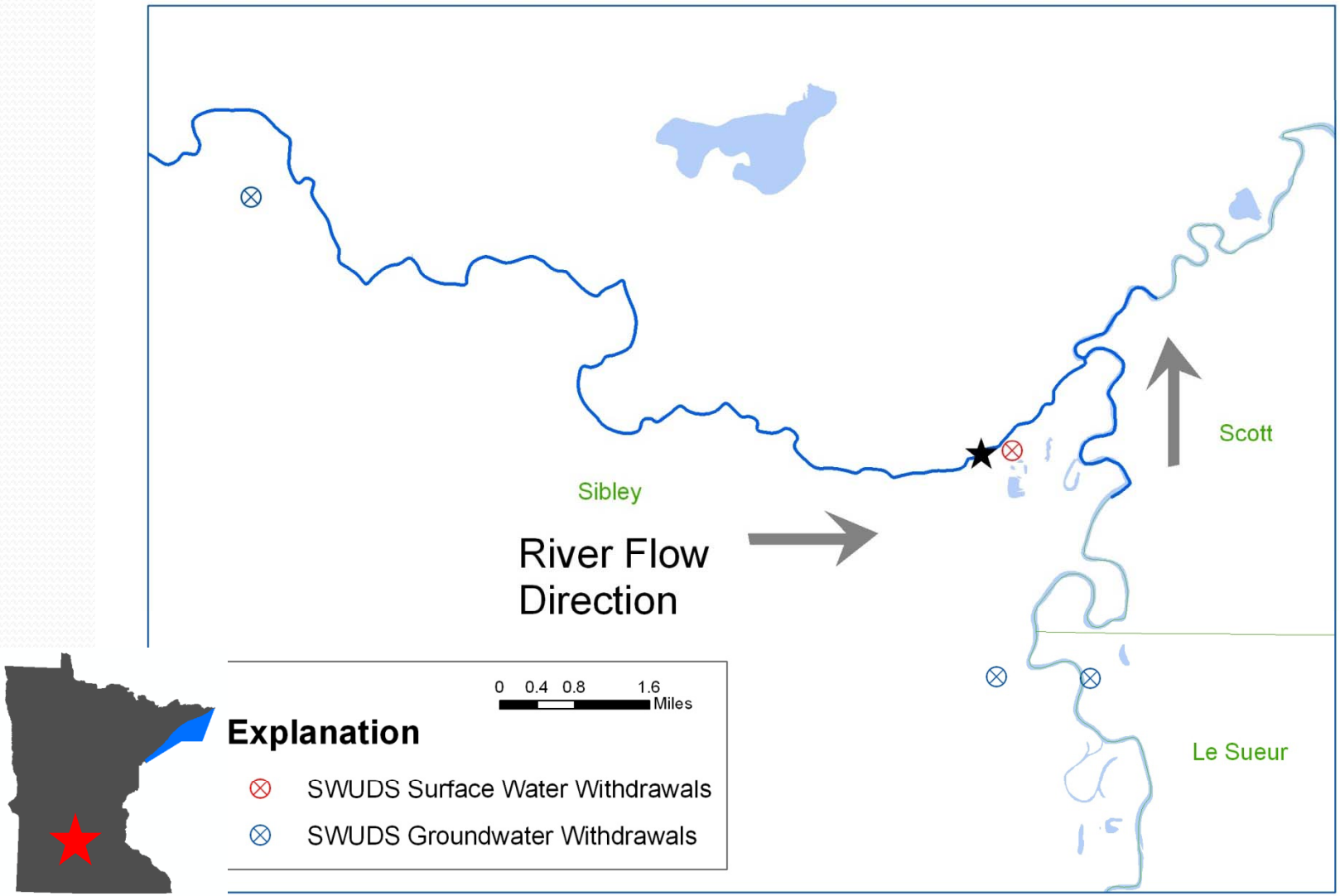
Straight River- **Decreasing Trend**



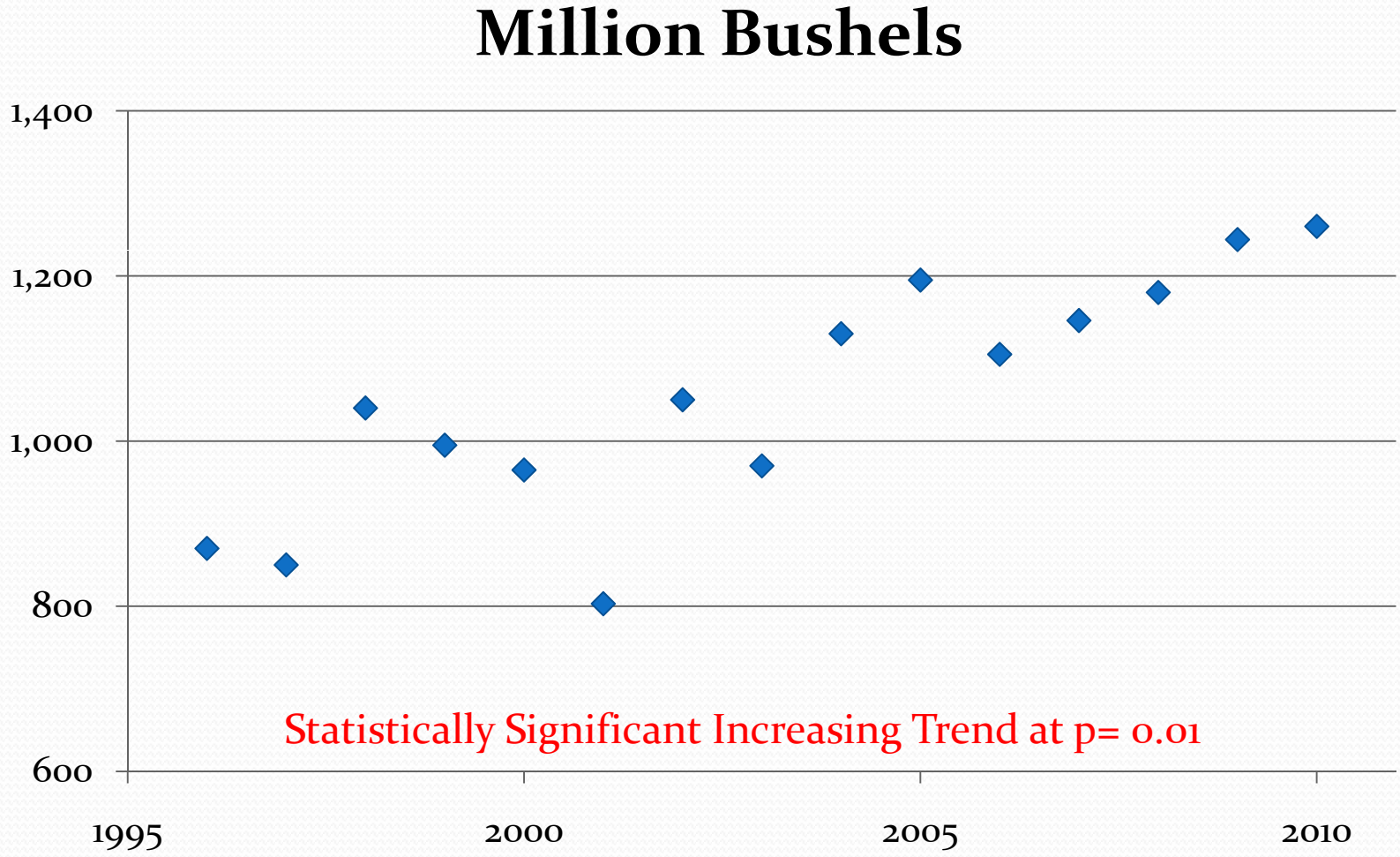
Chippewa River- **Decreasing Trend**



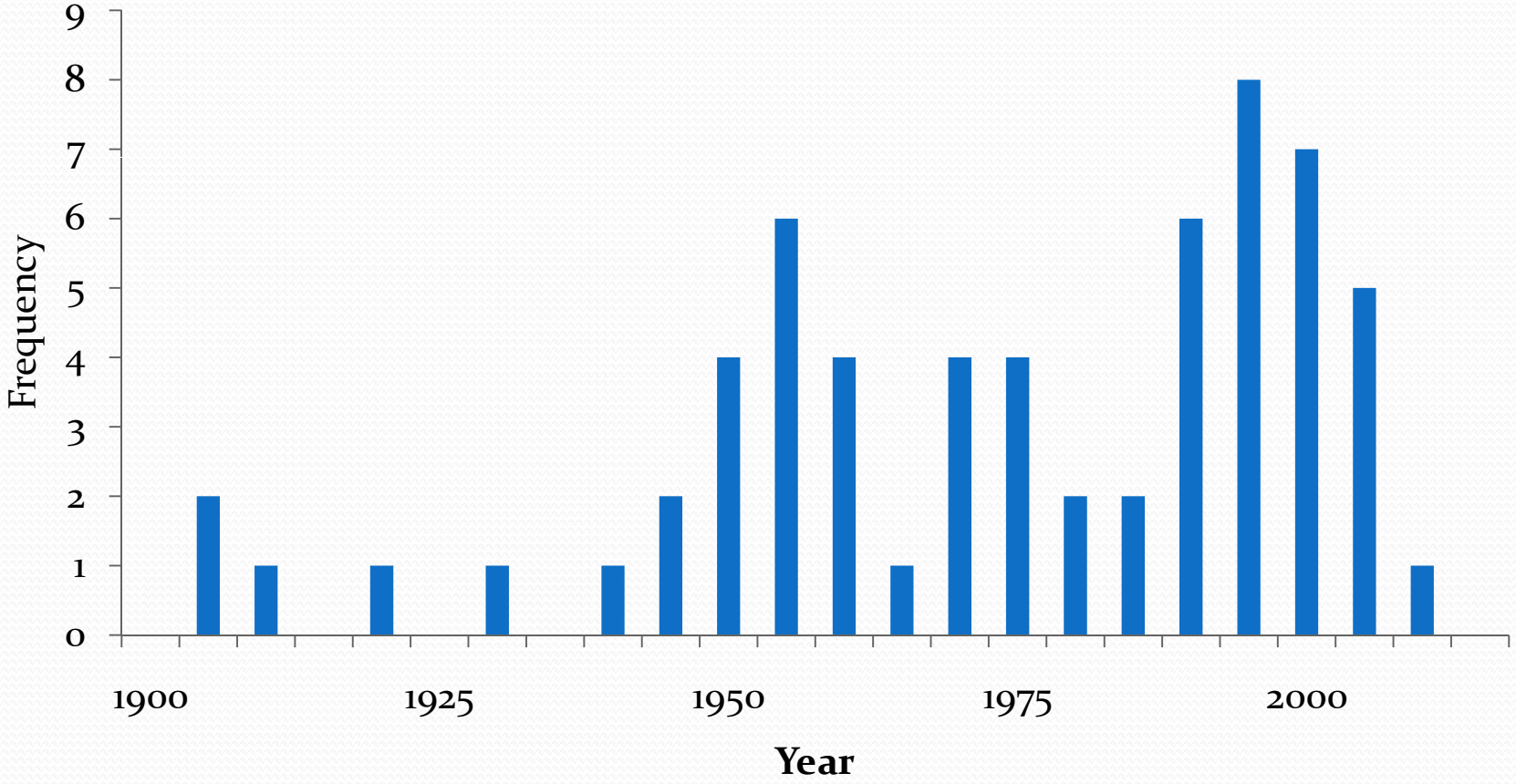
High Island Creek- Decreasing Trend



Corn Production Trends



Histogram of Dew Point Record Highs in July & August



Statistically Significant Increasing Trend

Conclusions

- The Little Rock groundwater model found probable cause and effect between increasing pumping and decreasing summer flows.
- This relationship is supported at a state-wide scale by a weight of evidence comparison of stream flow and water withdrawal trends.
- The MPCA now has a method for prioritizing watersheds for further groundwater investigation.

End