



# Navigating Rising Waters with Collaborative Resilience Strategies

Rachel Pichelmann, PE, CFM | MnDOT Hydraulic Resiliency Engineer

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# Presentation Outline





# Impacts of Flooding & MnDOT's Flood Resilience Challenge

Rachel Pichelmann, PE, CFM | MnDOT Hydraulic Resiliency Engineer

# MnDOT's Infrastructure



~2,660 bridges  
over waterways



~11,000+ miles of  
roadway



>70,000 culverts



~80,000 storm  
sewer pipes

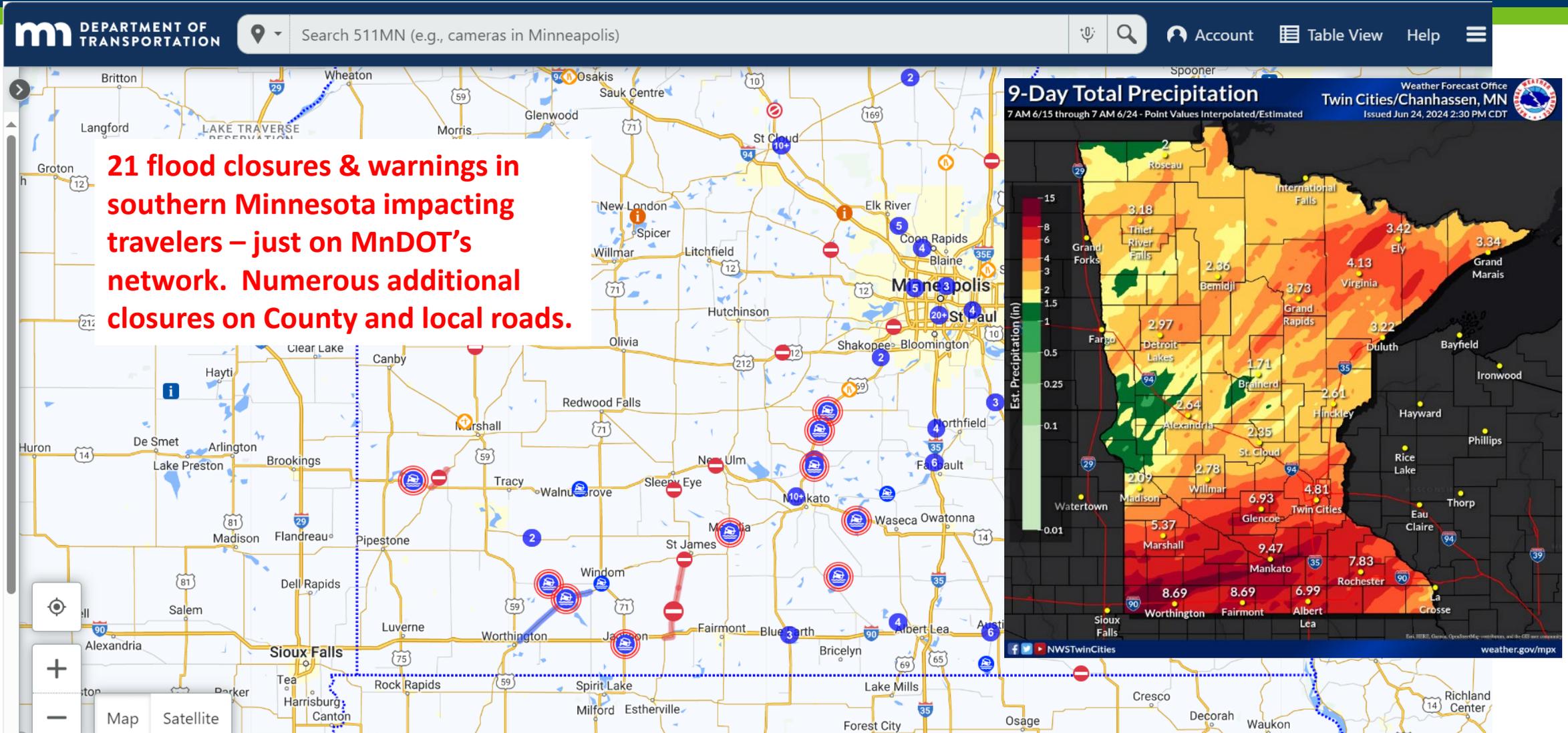


~1,700  
Stormwater BMPs



Many other  
assets!

# MnDOT's 511 Map on 6/23/2024





Hwy 19 at Henderson, 2024



10/03/2010



Hwy 76

NWS La Crosse  
Money Creek,  
southern Winona County  
August 19, 2007

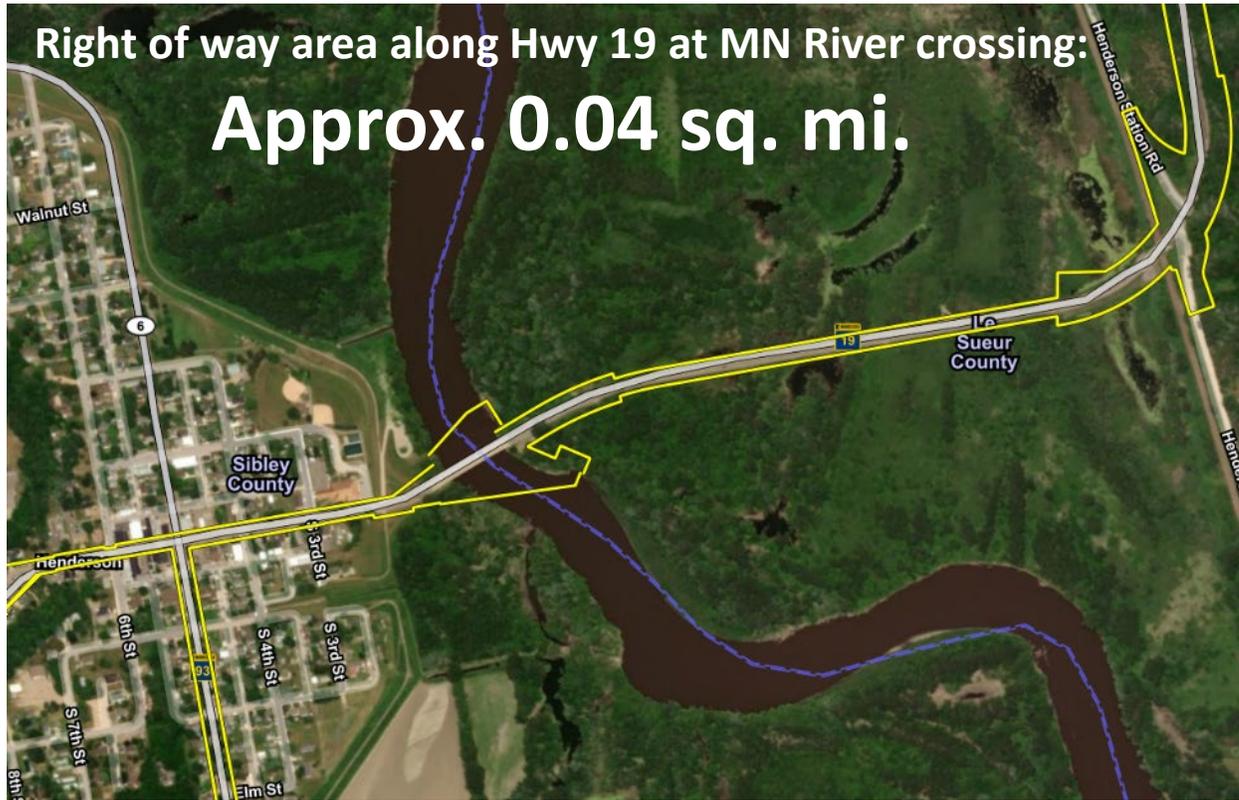


Brad Horn  
HWY 74 in White  
Water State Park, MN  
August 20, 2007

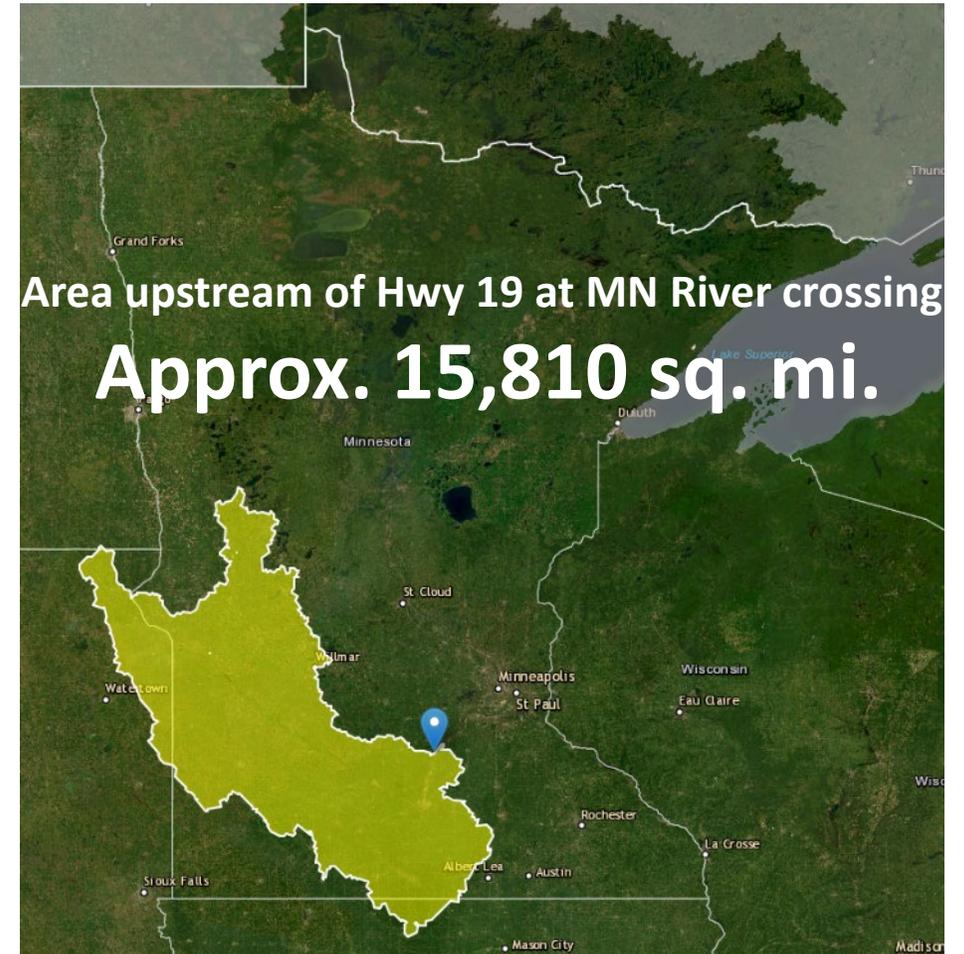


US Hwy 169 near Le Sueur, 2024

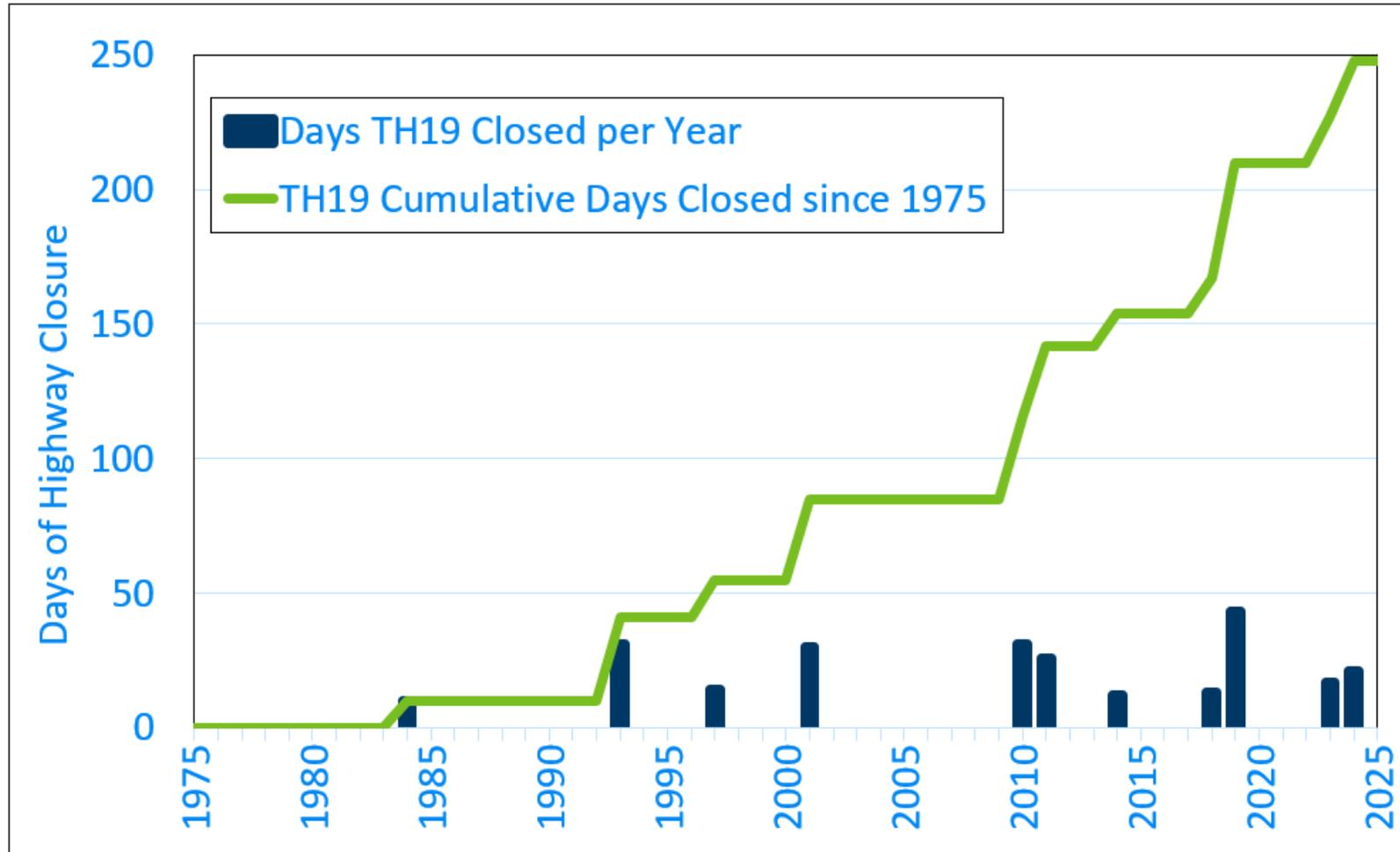
# State Right of Way vs. Watershed Area



**VS.**

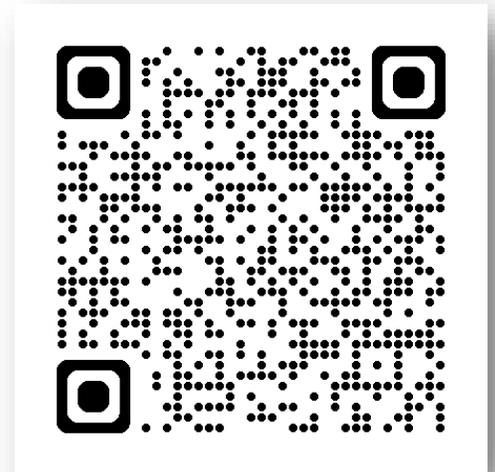
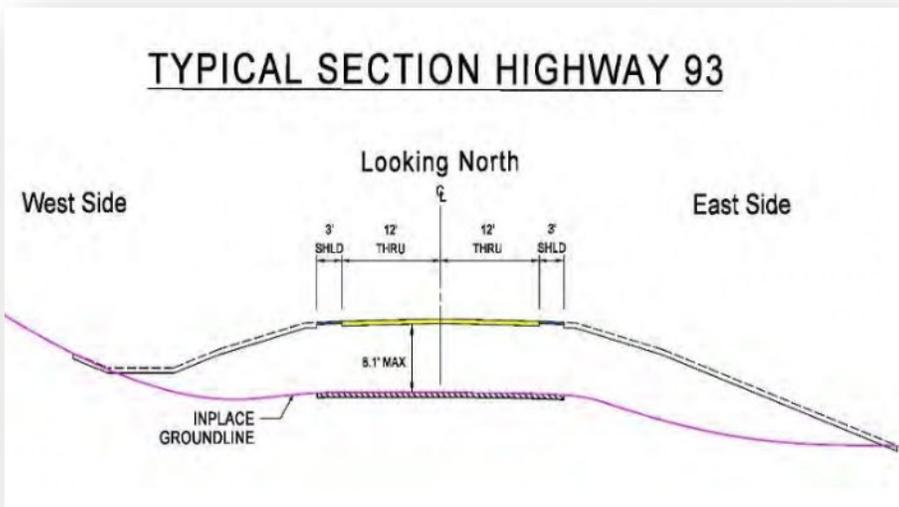
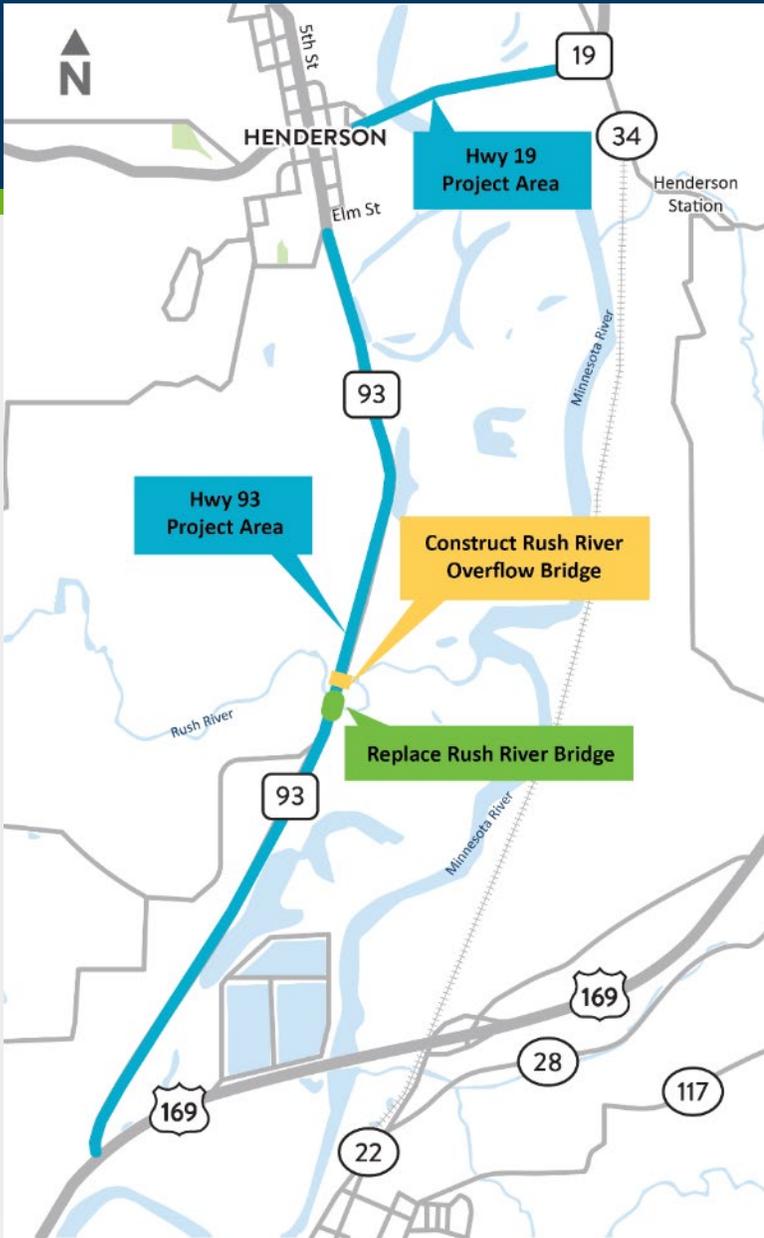


# Closures on Hwy 19 at Henderson due to Minnesota River Flooding



# Hwy 93 Flood Mitigation at Henderson

- Raise 3.6 miles of Hwy 93 up to eight feet
- Construct overflow bridge & replace main channel bridge at Rush River
- \$30.6 M construction cost
- Construction ongoing



TH93 Project Website

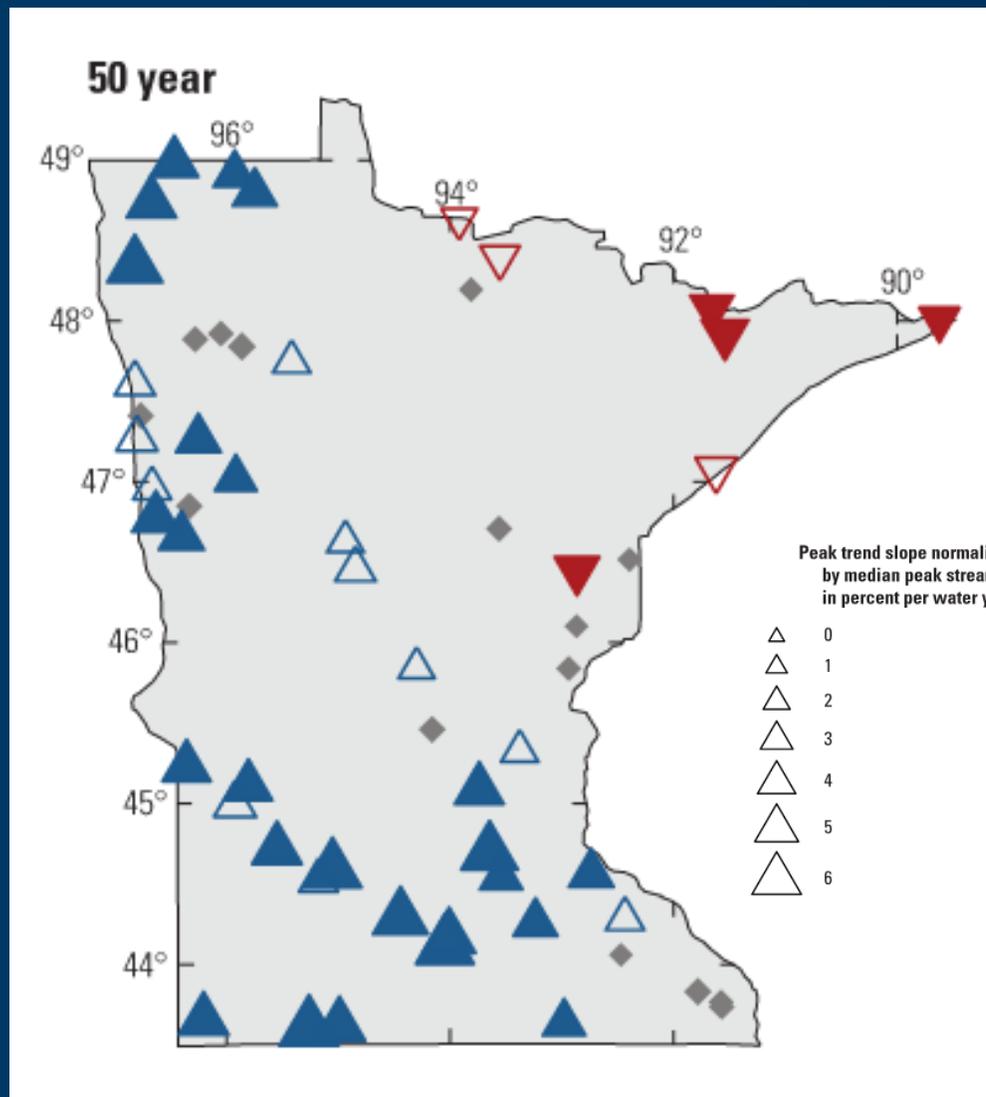
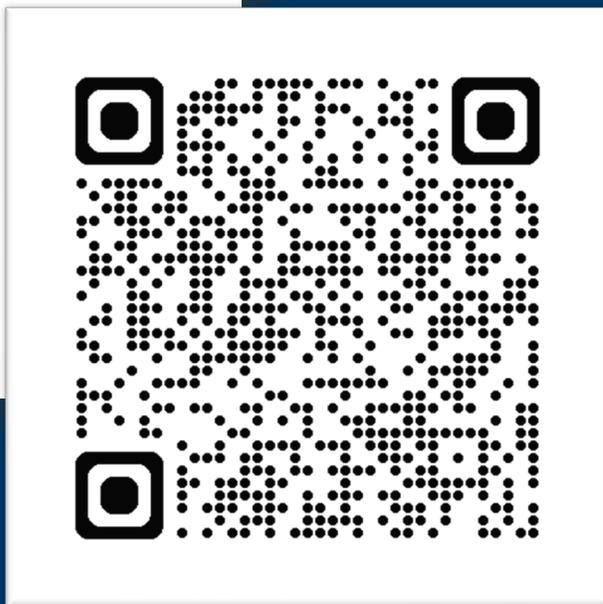
Prepared in cooperation with the Illinois Department of Transportation, Iowa Department of Transportation, Michigan Department of Transportation, Minnesota Department of Transportation, Missouri Department of Transportation, Montana Department of Natural Resources and Conservation, North Dakota Department of Water Resources, South Dakota Department of Transportation, and Wisconsin Department of Transportation

**Peak Streamflow Trends in Minnesota and Their Relation to Changes in Climate, Water Years 1921–2020**

Chapter E of  
**Peak Streamflow Trends and Their Relation to Changes in Climate in Illinois, Iowa, Michigan, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wisconsin**

Scientific Investigations Report 2023–5064–E

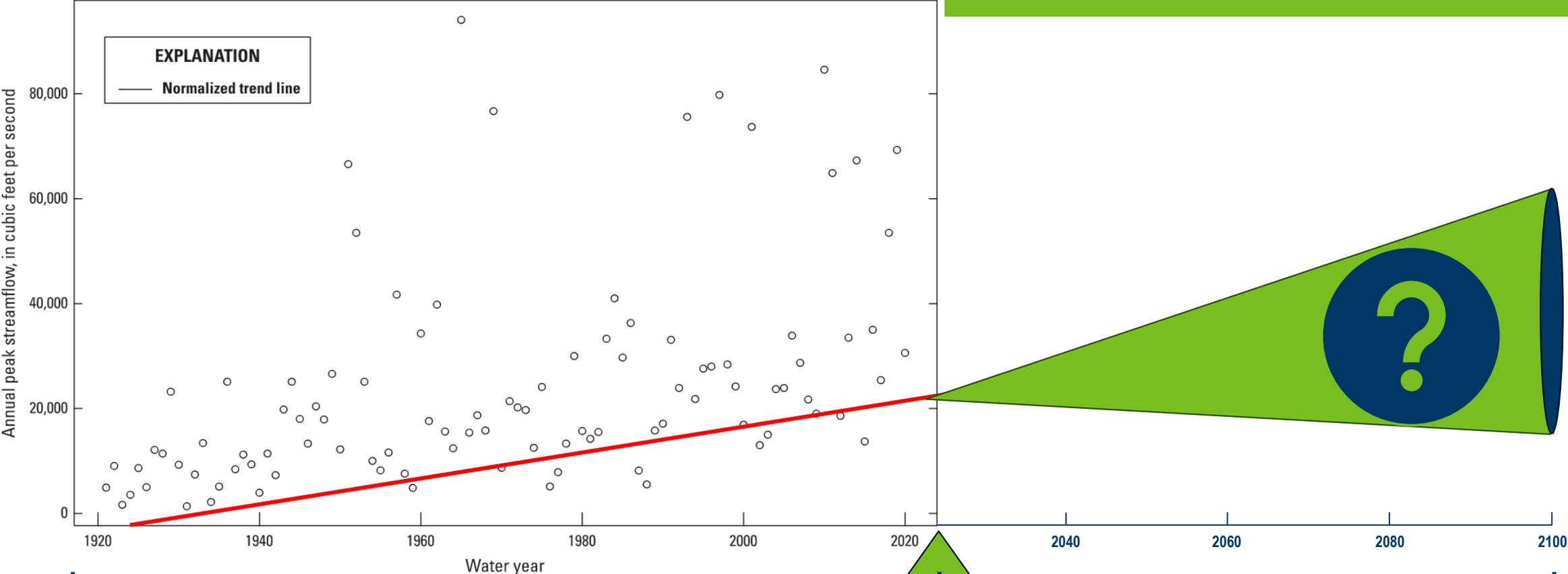
U.S. Department of the Interior  
U.S. Geological Survey



**Figure 11.** Maps showing likelihood and normalized magnitude of monotonic trends in median annual peak streamflow for streamgages in the 100-, 75-, 50-, and 30-year analysis periods in Minnesota.

# Design Data vs. Service Life Timeframes

A. Upward monotonic trend in annual peak streamflow for U.S. Geological Survey streamgage 05325000



Design Data

Asset Design & Construction

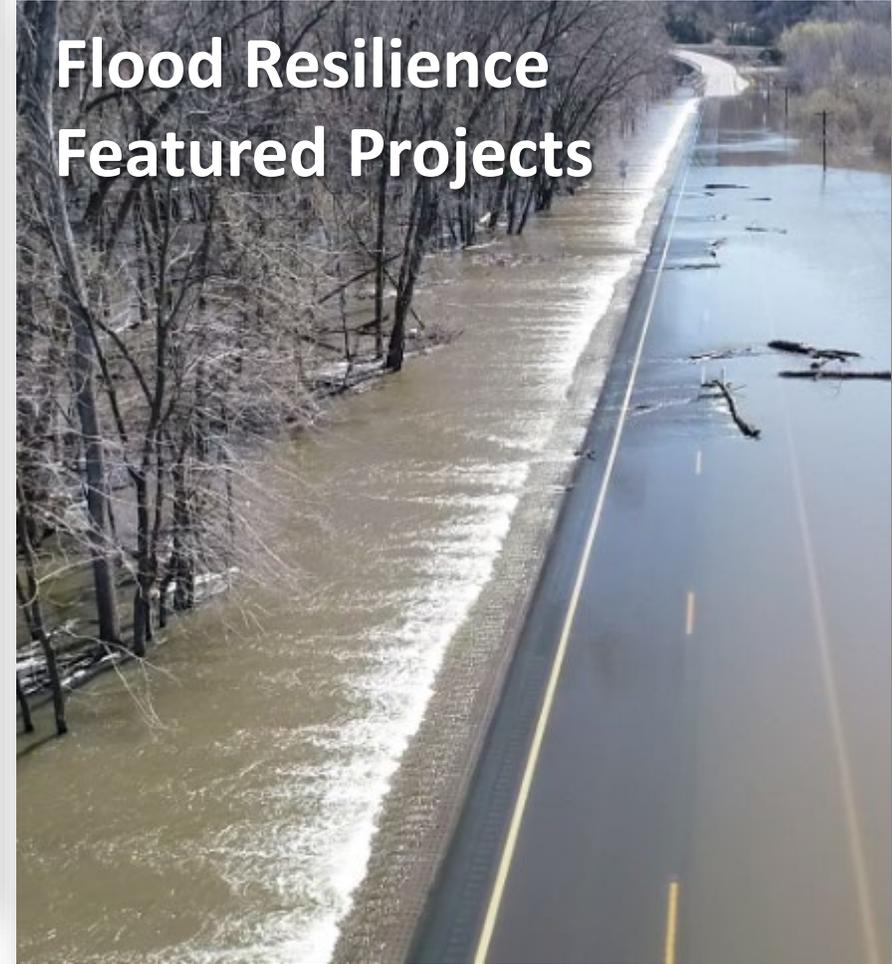
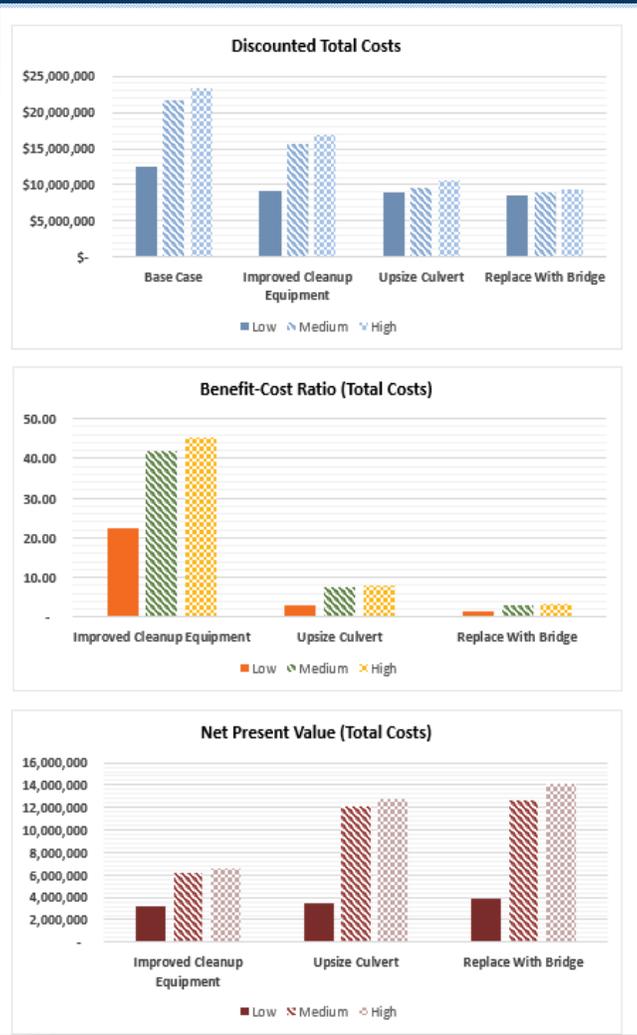
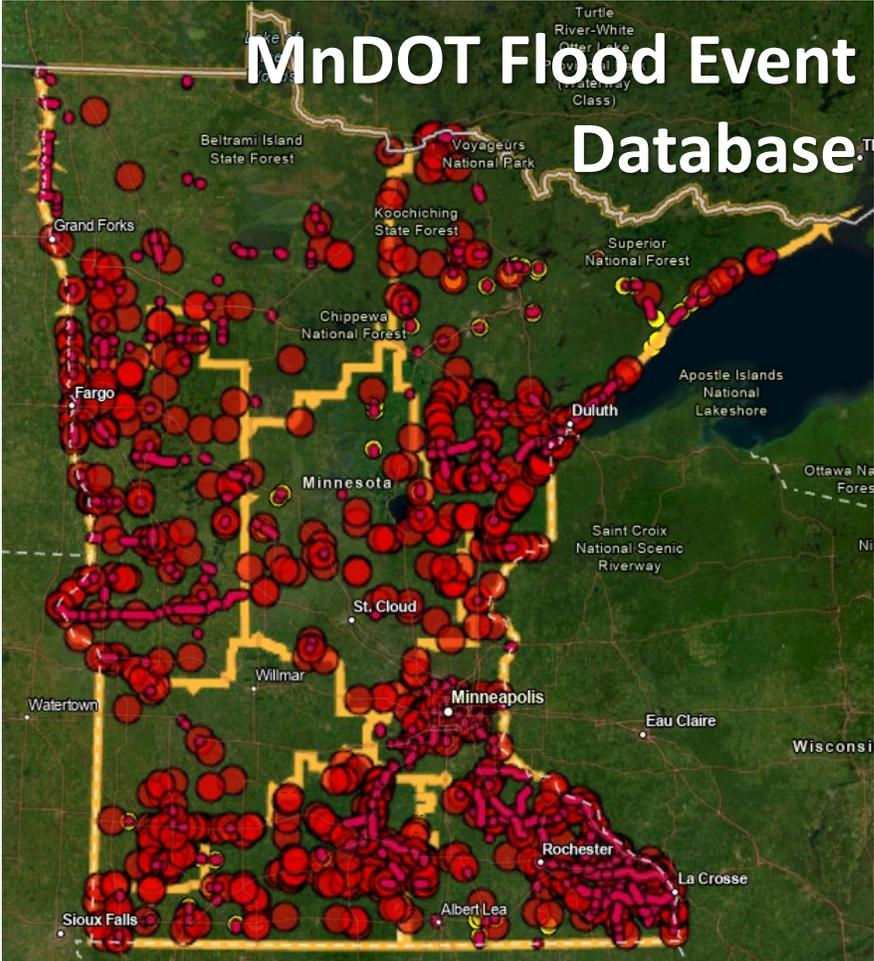
Service Life

# MnDOT's Commitment to Resilience

- Statewide plans with flooding identified as significant hazard, expected to increase with climate change:
  - State Hazard Mitigation Plan (2024)
  - Climate Action Framework (2022)
  - State Water Plan (2020)
  - MnDOT Statewide Multimodal Transportation Plan (2022)
  - MnDOT Resilience Improvement Plan (2024)
- Resilience: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

# Flood Resilience Resources

## MnDOT Flood Event Database



## Flood Resilience Featured Projects

## Flood Risk Assessment Tool

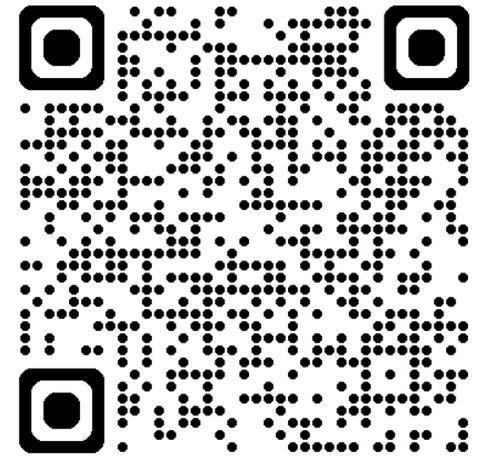
# Flood Resilience at Highway 101

- Recent flood closures in 1993, 1997, 2001, 2010 (2x), 2011, 2014
- 2011 study estimated daily cost of closure: **\$670,000/day** (2009 dollars)
- New crossing constructed 2014-2015 with cost of approx. \$20 million
  - Project included **flood risk reduction and environmental/habitat improvements**
- Estimated **72 days of avoided closures** since new crossing was constructed
  - Closures avoided in 2018 (~14 days), 2019 (~36 days), 2023 (~8 days) & 2024 (~14 days)



# Funding Flood Resilience

- \$50 million statewide flood mitigation program established after 2010 floods
  - 34 flood resilience projects constructed between 2011 & 2016
  - Project costs range from \$20,000 to \$20 million
- 2026 Leg Session Governor recommendation
  - \$4 million in Trunk Highway cash to establish MnDOT's Drainage Asset Management Program



MnDOT Flood Mitigation  
Project Website

# Flood Monitoring Improvements

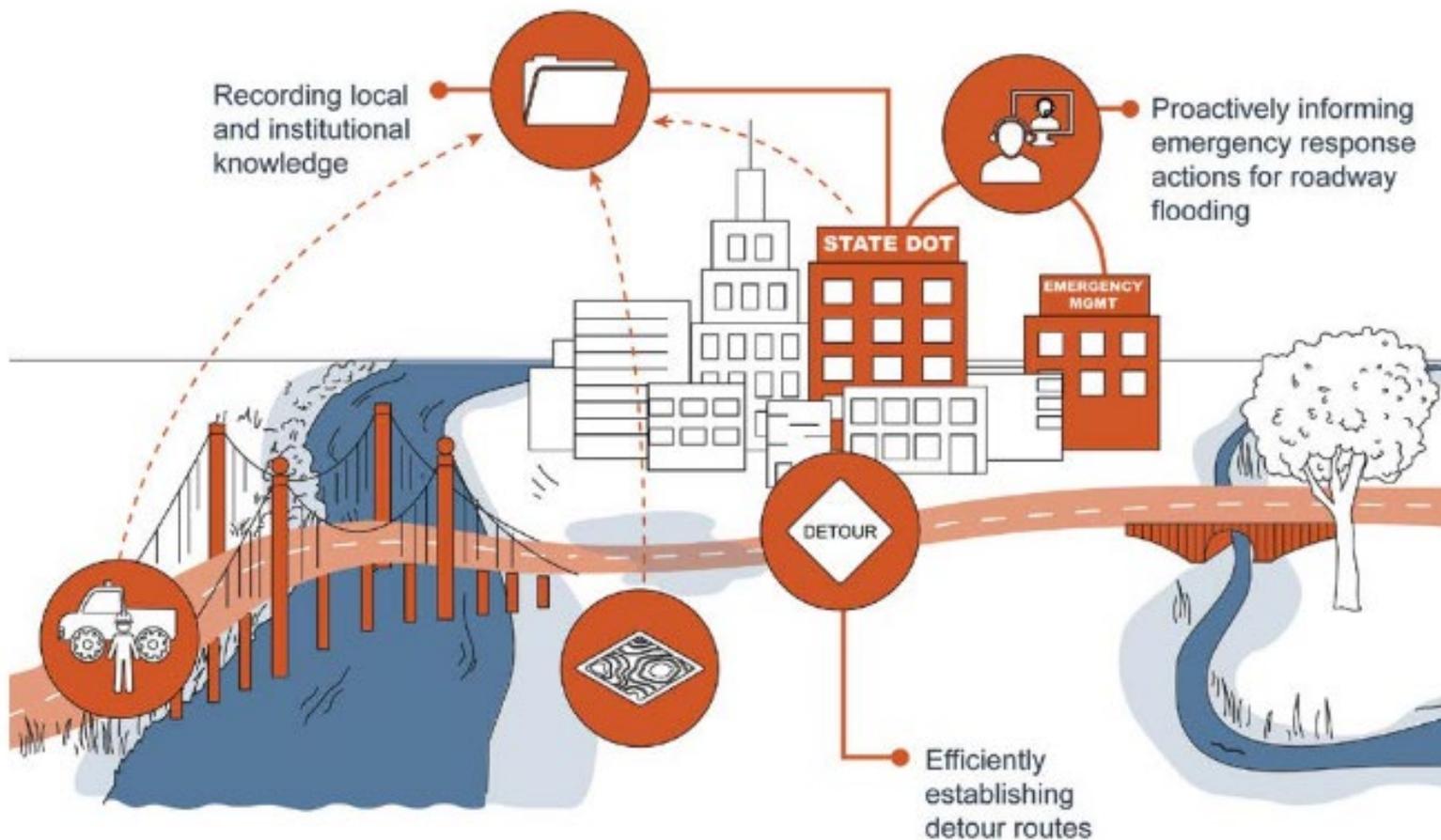
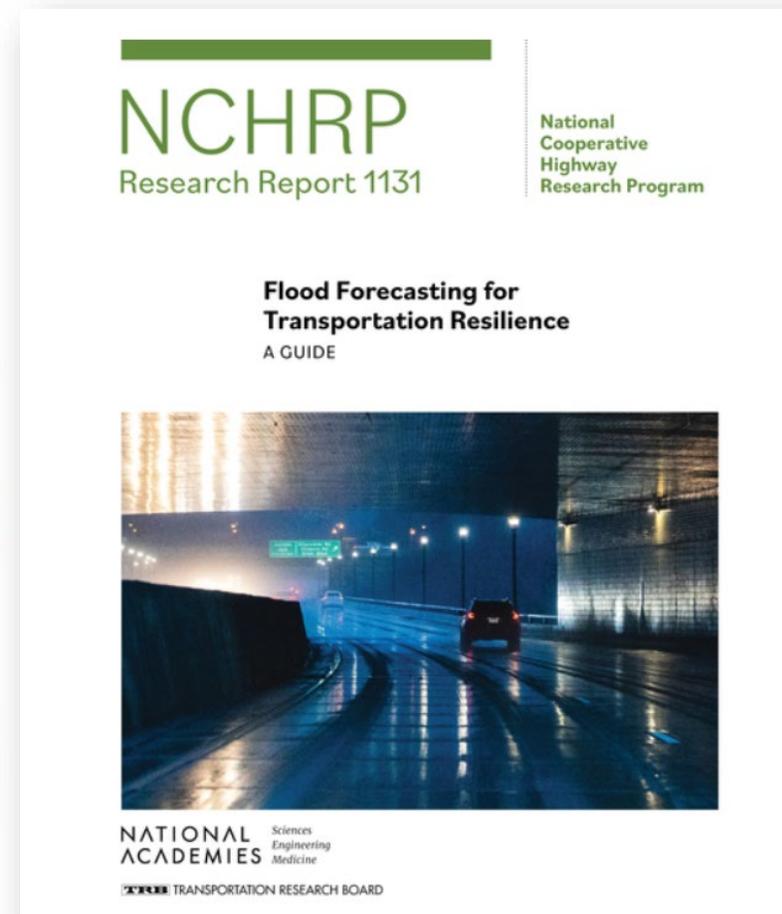


Figure 4-1. DOT capabilities that support mature operations that leverage flood forecasting.





# MN Silver Jackets: MN Flood Center Strategic Plan

## Participating Agencies

### Federal

- Federal Emergency Management Agency (FEMA)
- National Oceanic and Atmospheric Administration (NOAA)
- Natural Resource Conservation Service (NRCS)  
Minnesota | Natural Resources Conservation Service
- U.S. Army Corps of Engineers (USACE)
- U.S. Geological Survey (USGS)

### State

- Minnesota Board of Water and Soil Resources
- Minnesota Department of Commerce
- Minnesota Department of Labor and Industry
- Minnesota Department of Natural Resources (MN DNR)
- Minnesota Department of Transportation (MnDOT)
- Minnesota Homeland Security and Emergency Management (HSEM)

- Primary Objectives:
  - ✓ Develop a common mission (purpose & need statement)
  - ✓ Identify data and resources currently available within partner agencies
  - ✓ Identify additional data and resources needed to improve flood preparedness, monitoring, response, and recovery in MN
  - ✓ Develop strategic plan and identify potential funding sources
- Partners: USACE (lead), BWSR, DPS/HSEM, MDA, MnDNR, MnDOT, MNIT MnGeo, MPCA, MSU, NWS, UMN, USGS, NRCS, MDH, Met Council

## Why the name "Silver Jackets"?



During disaster response, agencies are often identified by the color jacket or shirt they wear. For example, FEMA has typically worn blue jackets or shirts and USACE has worn red. The name 'Silver Jackets' was coined to represent many agencies working together to tackle flooding issues.

- Flooding is a significant climate hazard in Minnesota.
  - Extreme rains and flood events are becoming more frequent.
  - Flooding impacts transportation infrastructure and the traveling public.
- MnDOT is committed to providing a **safe and resilient transportation system** today and into the future.
- Meaningful steps toward flood resilience include:
  - Engineering decision-making that considers increasing future flood risk.
  - Collaboration with other partners to implement flood risk reduction strategies at the watershed scale, pool resources, and share knowledge.
  - Infrastructure investments that are cost-effective long-term.



# Water Management Resources

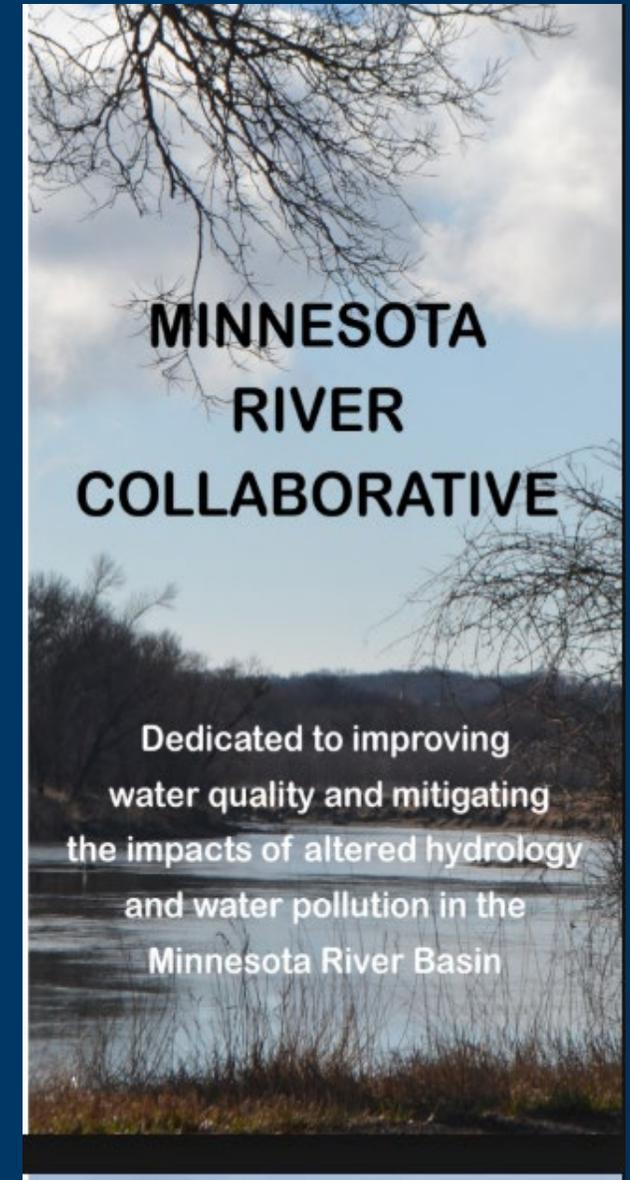
Suzanne Jiwani, PE | Minnesota River Collaborative

Monitors drainage improvement projects in Minnesota River Basin

Work with concerned citizens to employ strategies that employ water protection strategies

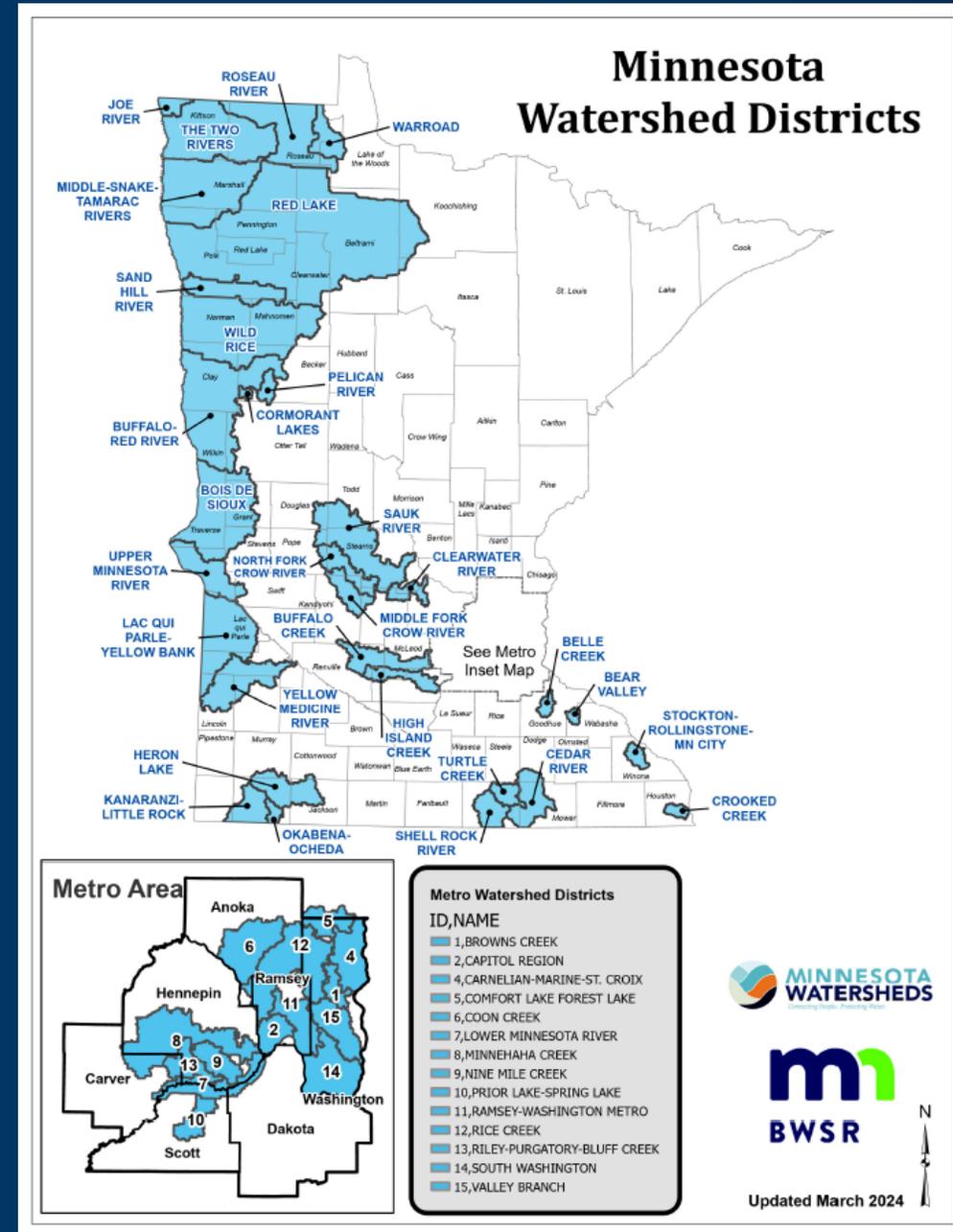
Intervene on projects not meeting Minnesota Drainage Code

Members include over 30 individuals with expertise in law, science, engineering, economics, agriculture, soils, hydrology, and grassroots organizing and support from 7 organizations



# Watershed District Actions

Watershed districts and watershed management organizations are a valuable resource Minnesota has to protect our water resources



# Ramsey Washington Watershed District Runoff Management



## Rule C: Stormwater Management Guidance

### What am I required to do for stormwater management?

Applicants are required to meet three major standards pertaining to stormwater management on their site.

1. Rate Control– Proposed runoff rates shall not exceed existing runoff rates for the 2, 10, and 100-year critical storm events using Atlas 14 rainfall depths and MSE3 rainfall distributions.
2. Volume Reduction– Stormwater runoff volume reduction shall be achieved onsite in the amount of 1.1 inches of rainfall off new **and** reconstructed impervious surfaces. To achieve the most effective treatment, stormwater Best Management Practices (BMPs) may retain a maximum of 2.5” of runoff over their tributary impervious surfaces.
3. Water Quality– Developments must incorporate BMPs that achieve 90% total suspended solids (TSS) removal from the disturbed area of the project on an annual basis. If applicants have sufficiently addressed the above Volume Reduction Requirement, then TSS removal requirements are generally considered met without additional documentation —however, additional water quality calculations and/or water quality modeling may be requested.

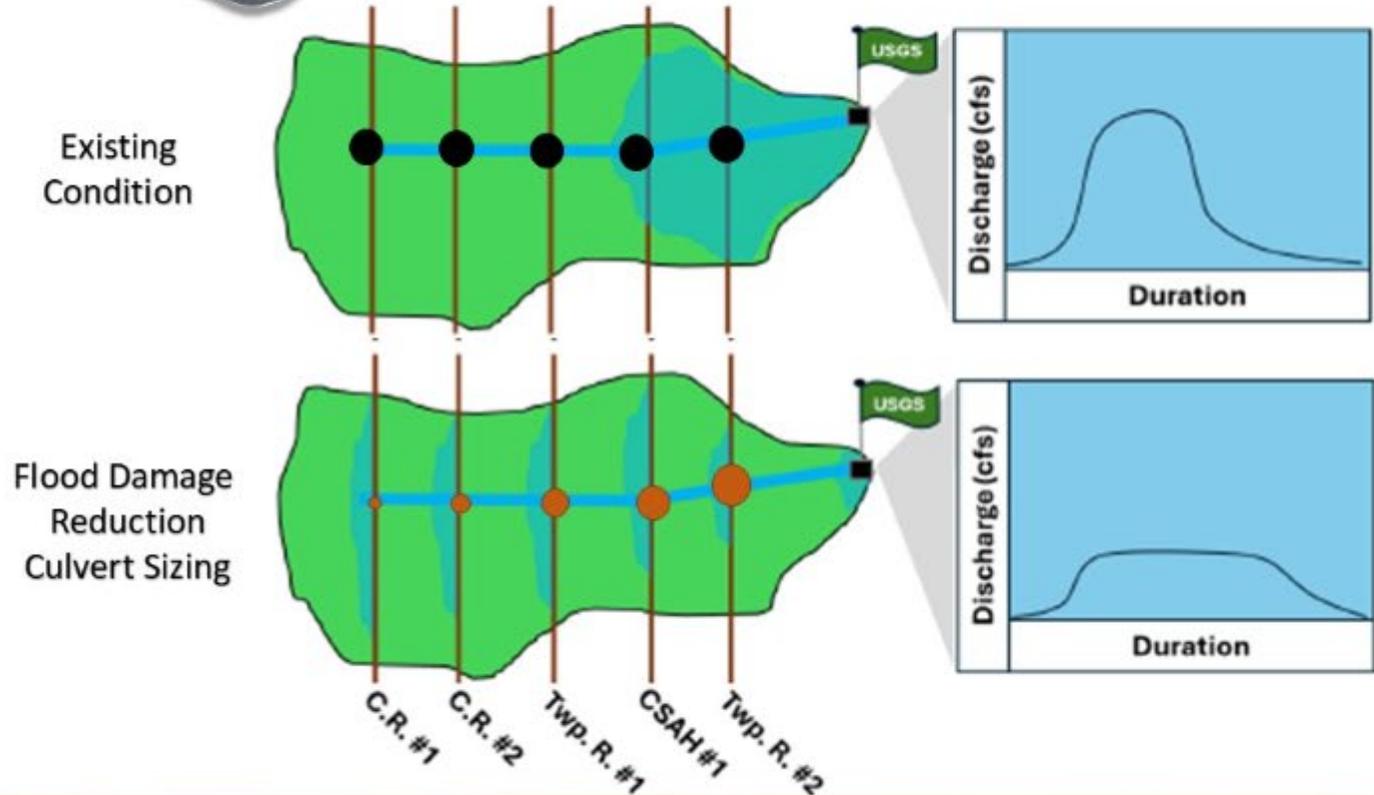
The following computer modeling programs will be accepted: HydroCAD, XP SWMMM, and TR-20. Other programs will be accepted as approved by the District.

# MANAGE WATER RESOURCES

## USING CULVERT SIZING TO CONTROL WATERFLOW



- Road culverts not sized for Flood Damage Reduction; roads downstream may be overtopped; flooding over open fields
- Road culverts increase in size, proportionate with the size of the culvert's drainage area to store water along the edges of fields and grassed drainage ditches



Welcome to Bois de Sioux Watershed District!

# Bois de Sioux Watershed District Tools for Drainage

## TILE - DID YOU KNOW?

Tile in rural settings (similar to gutters, curb and storm sewer systems in urban settings) is an important tool for management of excess water. The District uses a 1/4" co-efficient - learn more about what this means by watching this [short video](#). To learn more, check-out how tile is connected to:

- [click here for soil health benefits](#)

- [click here for the water table](#)

- [click here for erosion reduction](#)

- [click here for flood control](#)

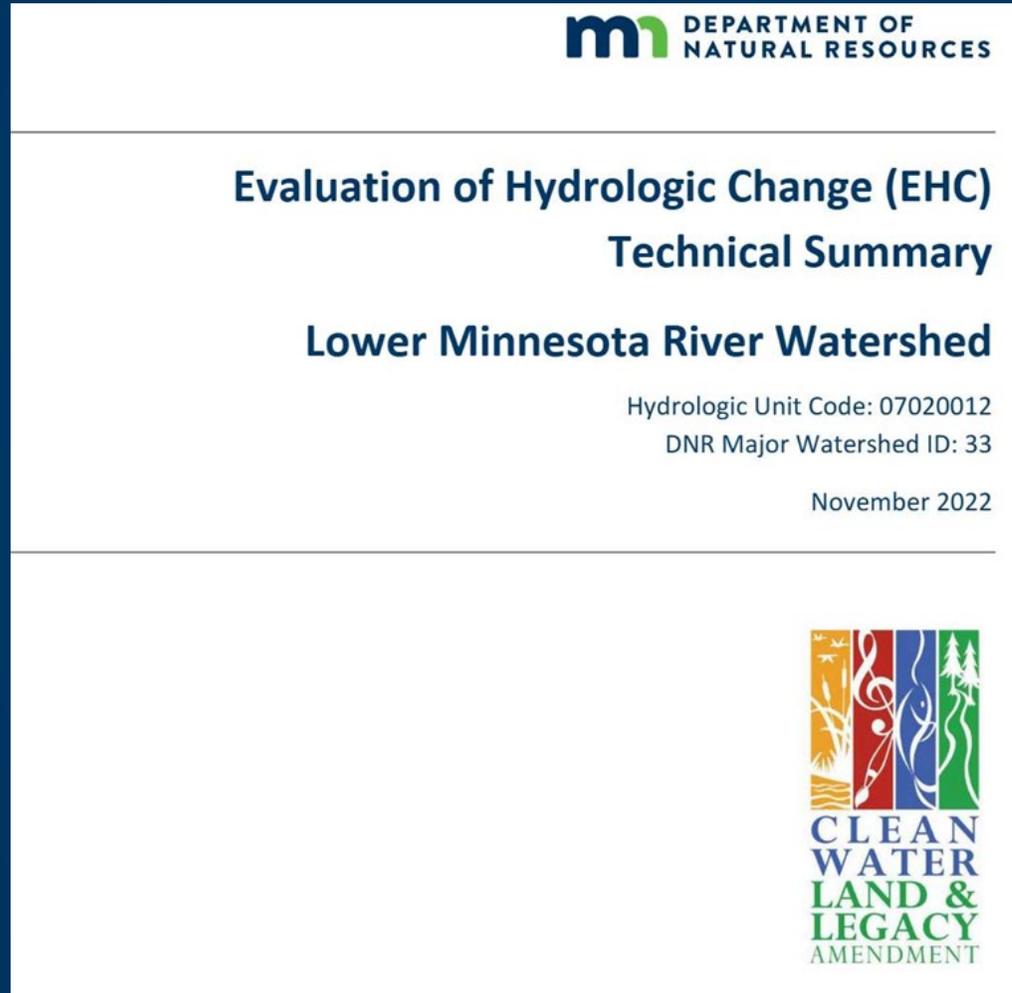
- [click here for water quality](#)

- [do you know how drain tile works?](#)

- [click for a suprising way to reduce erosion](#)

- Provide Educational Information on Drainage
- Track Drain Tile Installation
- Maintain Non-contributing Drainage Areas
- Encourages Controlled Subsurface Drainage Systems

# MnDNR Evaluation of Hydrologic Change Reports



- MnDNR developed EHC reports for 47 HUC8 watersheds
- Review stream and precipitation gage data
- Determine if there are statistically significant changes at the gage location

# EHC Summary Table

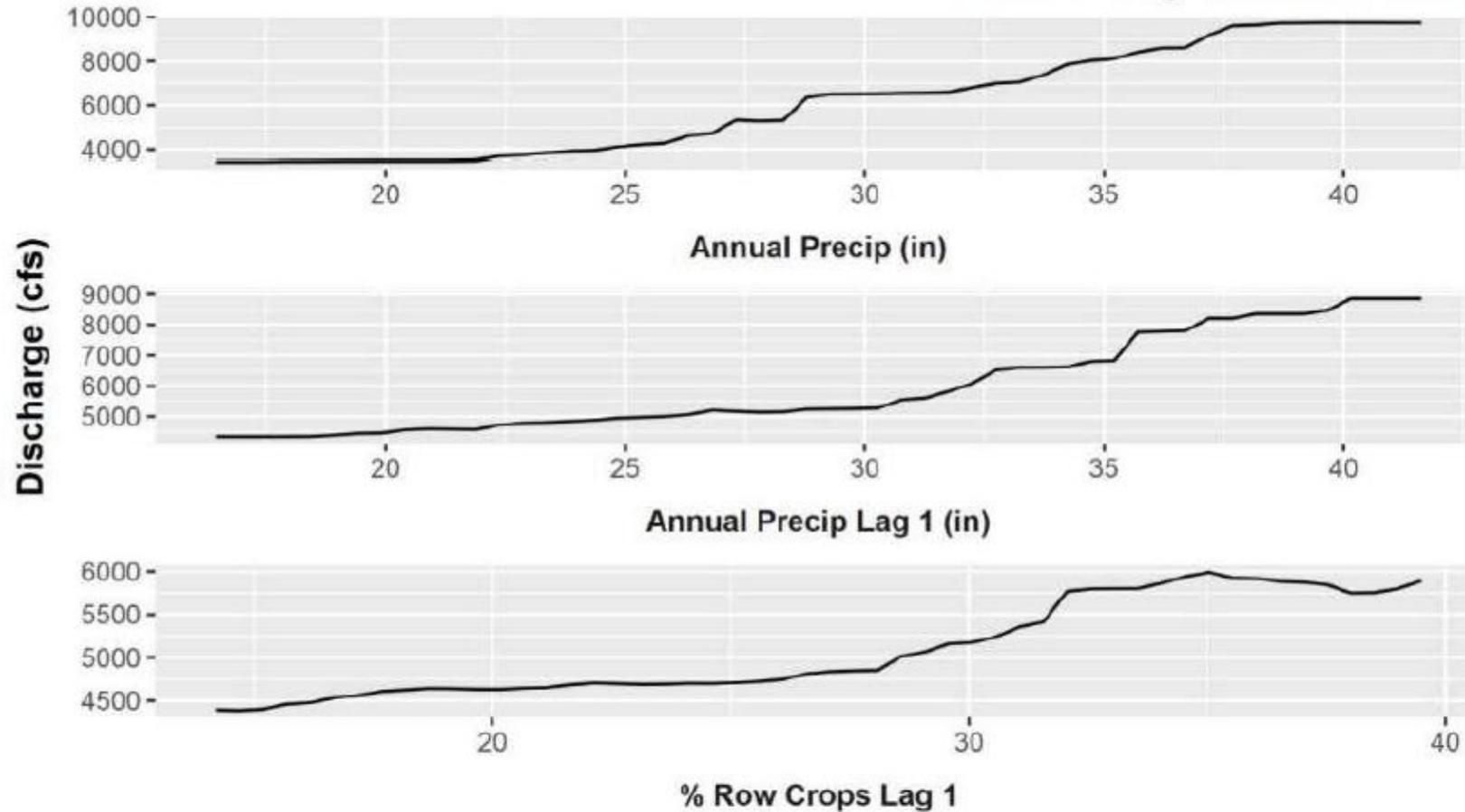
Hydrologic Group	Metric	Magnitude Change (%)	Magnitude Impact	RVA Change (%)	RVA Impact
Annual Values	Annual Precipitation	15	Moderate	-27	Major
	Annual Discharge	122	Extreme	-47	Major
	Annual Peak Discharge	80	Extreme	-33	Major
	Annual Runoff Ratios	97	Extreme	-47	Major
Low Flows	7-Day Minimum	141	Extreme	-45	Major
	August Median Base Flow	126	Extreme	-3	Neutral
	90% Flow Duration	190	Extreme	-100	Extreme
Moderate Flows	May Median Flow	185	Extreme	-66	Extreme
	50% Flow Duration	205	Extreme	n/a	n/a
	1.5 Year Return Interval Flows	123	Extreme	n/a	n/a
	Annual Baseflow	126	Extreme	-47	Major
High Flows	10% Flow Duration	110	Extreme	189	Extreme
	5 Year Return Interval Flows	74	Extreme	n/a	n/a
	10 Year Return Interval Flows	60	Extreme	n/a	n/a
	3-Day Maximum	96	Extreme	-31	Major
Flow Timing	Julian Day Max Flow	42	Major	3	Neutral
	Julian Day Min Flow	92	Extreme	-10	Moderate
Flashiness	High Pulse Count	50	Major	24	Major
	Low Pulse Count	-100	Extreme	-17	Moderate
	Number of Reversals	-10	Moderate	31	Major
	Rise Rate	118	Extreme	-24	Major

Impact Concern Legend						
>50	20 to 50	10 to 20	10 to -10	-10 to -20	-20 to -50	< -50
Extreme	Major	Moderate	Neutral	Moderate	Major	Extreme

Table 1. EHC summary table for the Minnesota River near Jordan (05330000) (1991 Change Point)

- Uses 21 key metrics
- Evaluates:
  - Magnitude of change
  - Range of Variability
  - Level of Watershed Impact

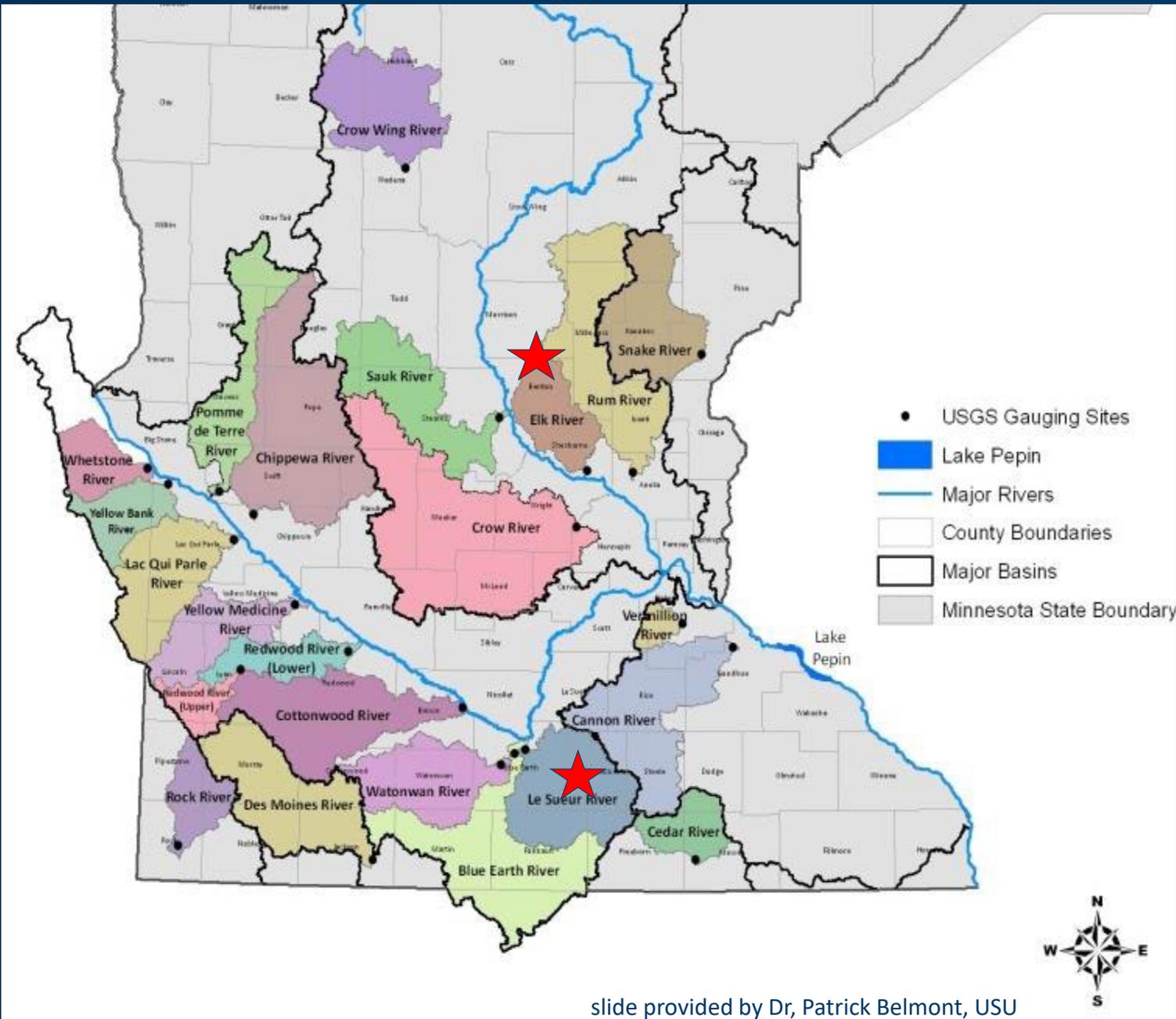
## Partial Dependence Plots



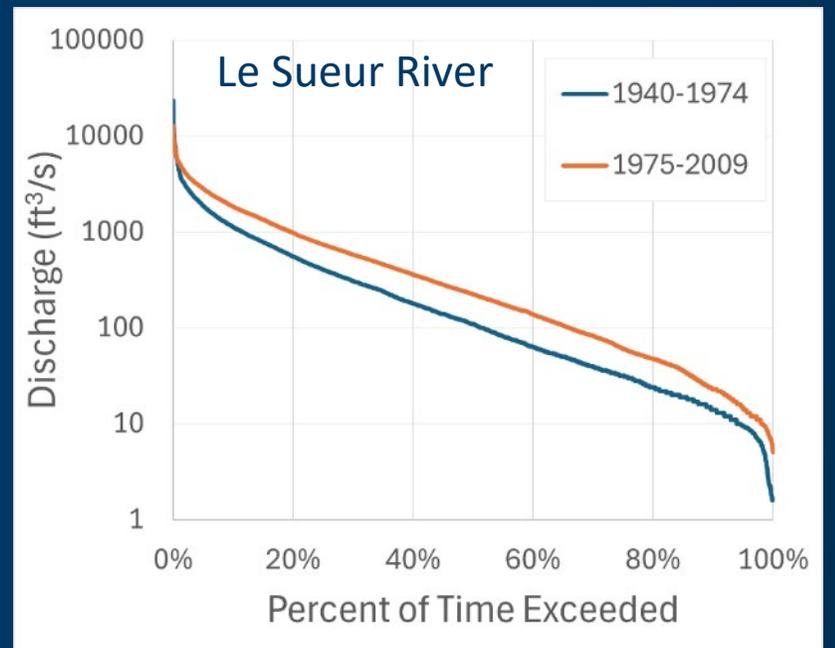
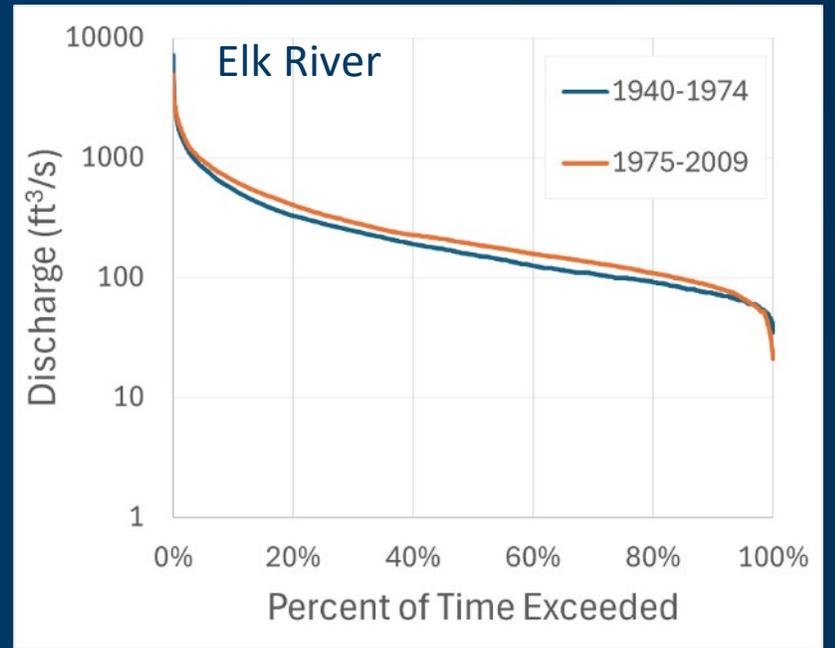
The partial dependence plots describe the marginal effect between the variable and response while accounting for the average effect of other predictors

(Friedman 2001)

**Figure 36. Random Forest Regression variable importance and partial dependence plots for the Minnesota River near Jordan (05330000)**

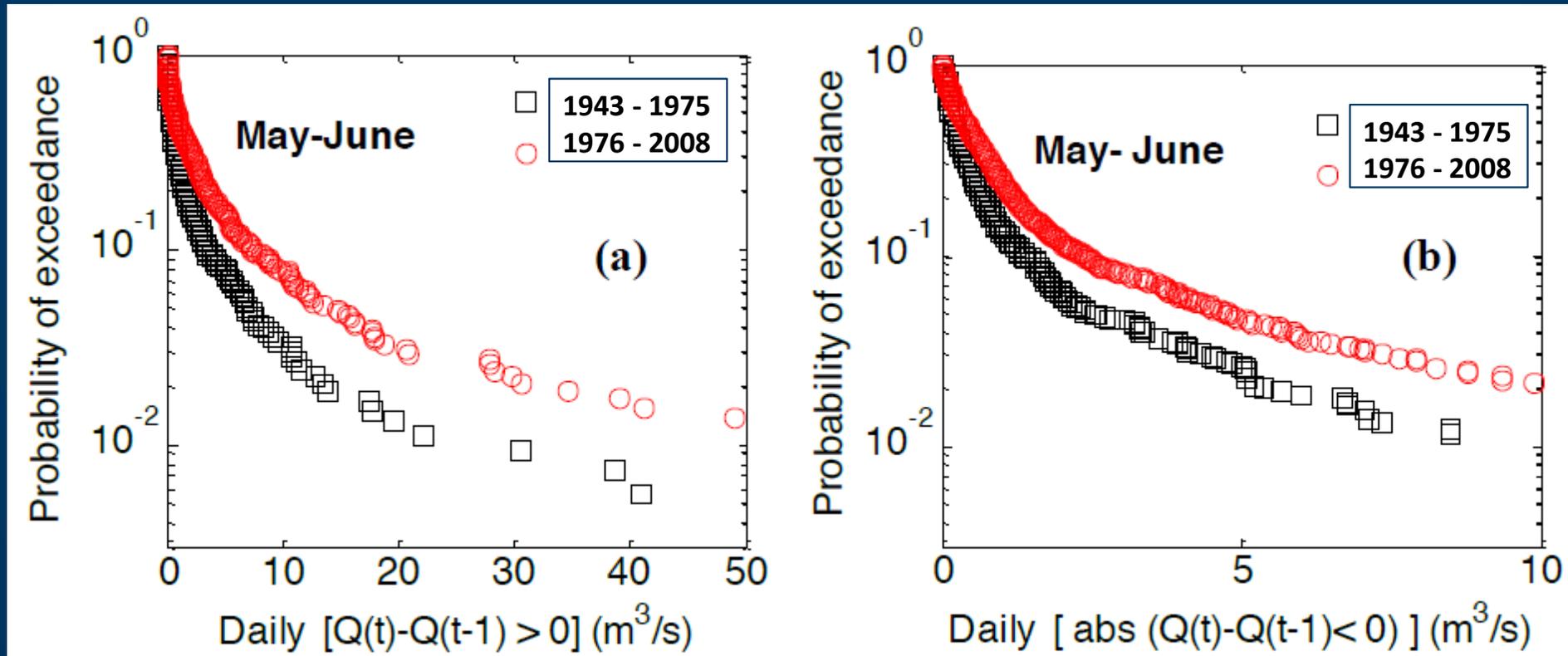


slide provided by Dr, Patrick Belmont, USU



# Increased Flashiness of Redwood River Basin Flow

Redwood River Basin flow data





# Drainage Law and BWSR's Storage Program

Rita Weaver, P.E. | BWSR Chief Engineer

# Let's look for solution-based programs

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## Twentieth century agricultural drainage creates more erosive rivers

Shawn P. Schottler,<sup>1\*</sup> Jason Ulrich,<sup>2</sup> Patrick Belmont,<sup>3</sup> Richard Moore,<sup>4</sup> J. Wesley Lauer,<sup>5</sup>  
Daniel R. Engstrom<sup>1</sup> and James E. Almendinger<sup>1</sup>

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<sup>2</sup> *Department of Biosystems and Bioproducts Engineering, University of Minnesota, St Paul, MN 55108, USA*

<sup>3</sup> *Department of Watershed Science, Utah State University, Logan, Utah 84332, USA*

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## Increased precipitation as the main driver of increased streamflow in tile-drained watersheds of the upper midwestern U.S.

[S. Gupta](#), [Nathaniel W. Baeumler](#), [Andrew C. Kessler](#), [Melinda K. Brown](#), [W. M. Schuh](#), [Kari A. Wolf](#) [less](#) • Published 2018 •

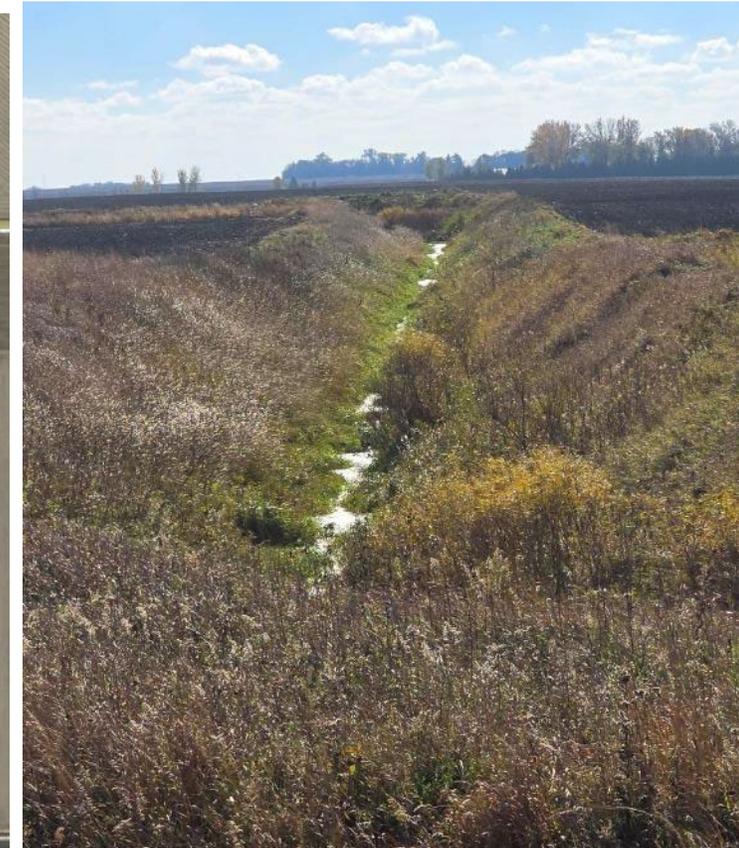
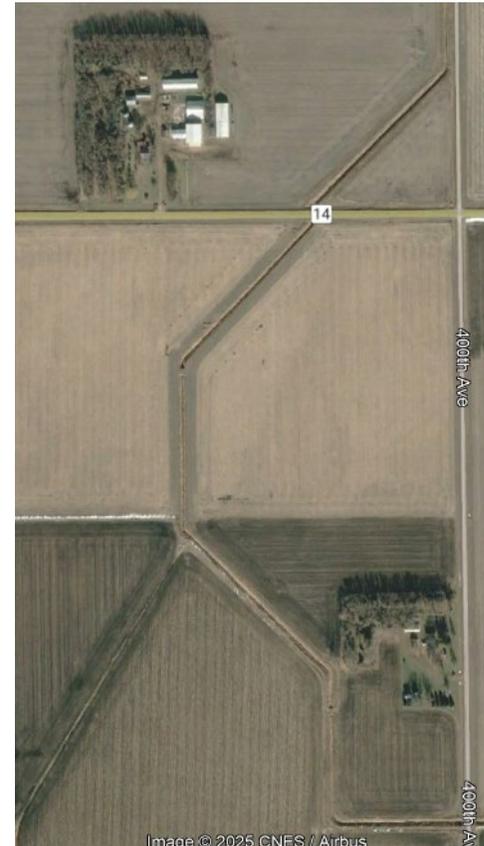
Environmental Science • Transactions of the ASABE

# Private vs. Public Drainage

Private Drainage, owned by typically one farmer and consists of a series of underground pipe (pattern tile).



Public Drainage, owned by many farmers and often large ditches and or underground pipe systems.



# The Rule of Reasonable Use

Benefit outweighs harm

May cast them upon the land of another

Acting in good faith

A landowner may drain his land

Avoid unnecessary injury

Reasonably improving drainage

# Public Drainage Law - Statute

1858 Public Statutes of the State of MN, Chapter 128. Lands allows for drainage

## CHAPTER LXXIII.

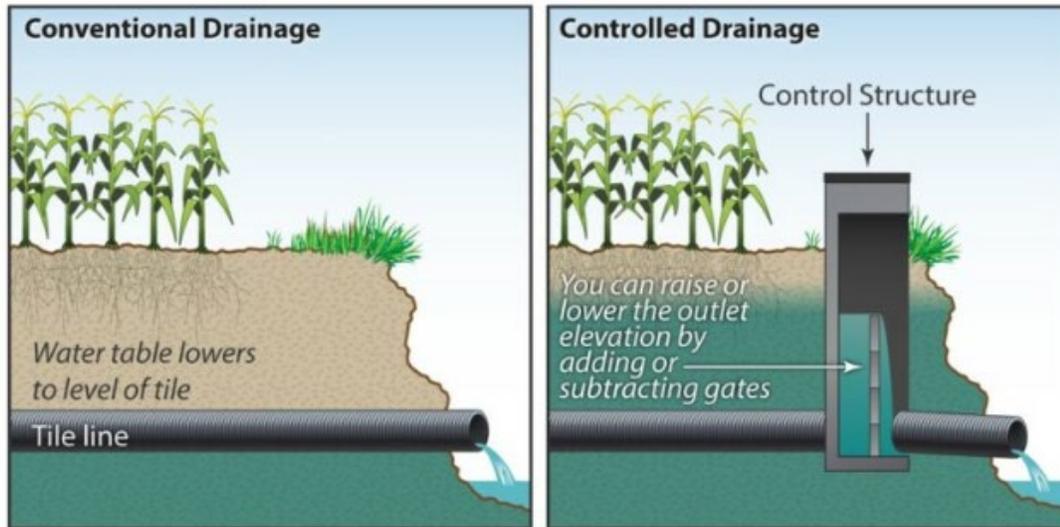
### *An Act to regulate and encourage the Drainage of Lands.*

SECTION 1. That any number of persons may associate themselves together for the purpose of draining lands and

SEC 5. The owner or owners of any lands through which said conduits shall pass, and who shall have paid their assessments thereon, shall, in all future time have the right and privilege to make lateral drains through any portion of their lands so assessed, and to lead and conduct the same into

# Conservation Drainage and Storage are Key

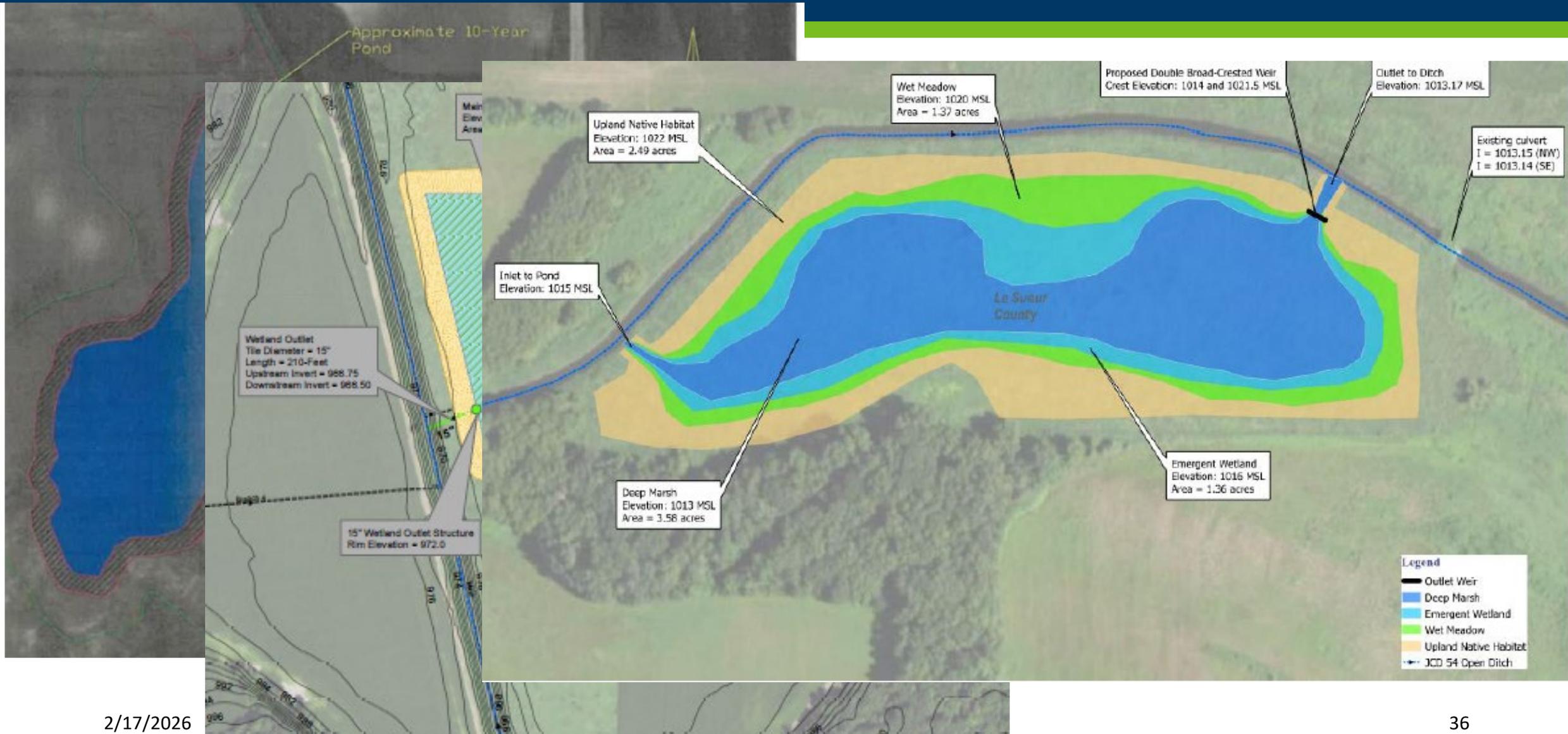
Since the State has allowed, and even encouraged drainage, we must find ways to incentivize producers to implement conservation drainage strategies



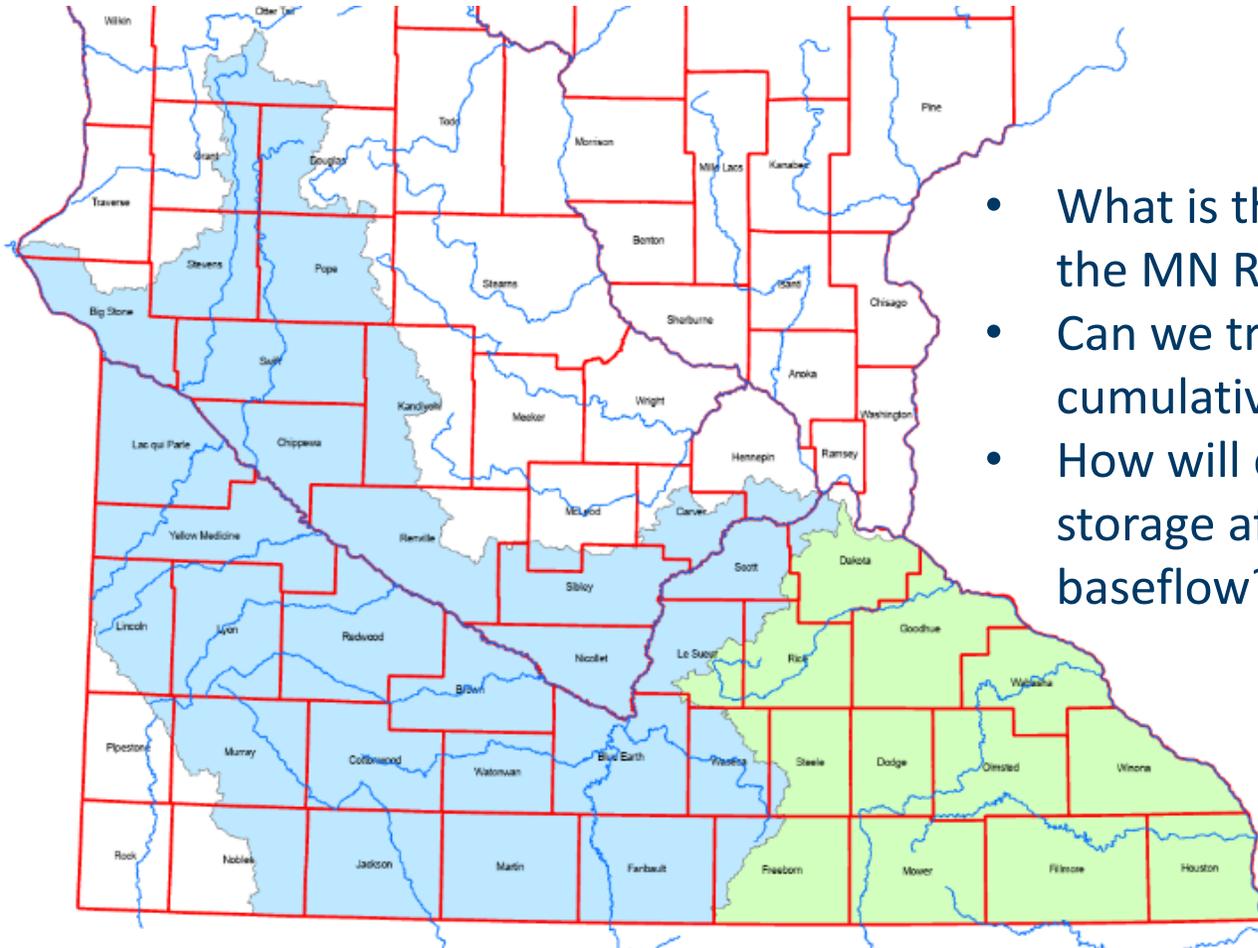
NRCS/SWCS photo by Lynn Betts

Both programs still require farmers to entirely pay for their drainage systems (no state funding is used except to pay for the additional practices implemented)

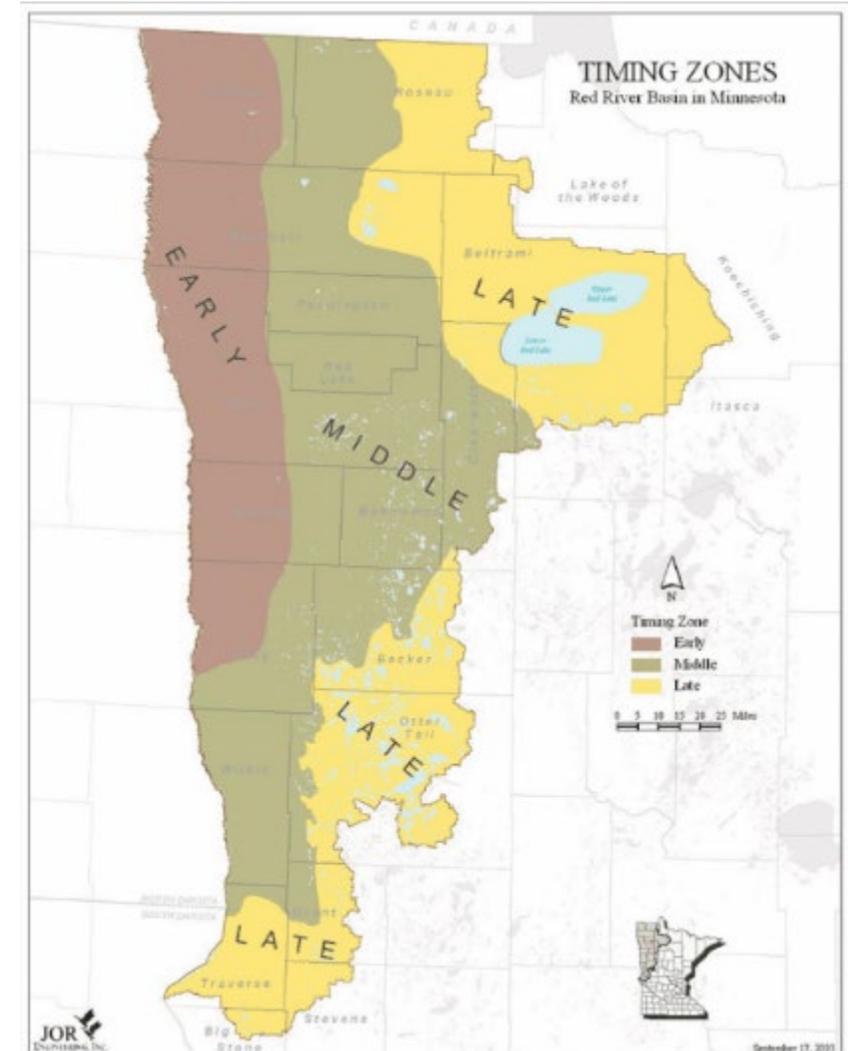
# The storage program helps the environment AND farmers



# Potential Side Effects?



- What is the effect on the MN River?
- Can we track the cumulative effect?
- How will our installed storage affect the baseflow?



# Key Takeaways

- Flooding can have significant impacts on the state's transportation network, and on the traveling public.
- Flood frequency and magnitude are increasing.
- Watershed districts have the plans and tools to implement effective flood risk reduction techniques.
- State agencies have had funding and support to help reduce flood risk.
- More funding is needed to advance the flood risk reduction work.