Using GIS Technology to Inform Watershed Modeling and Conservation Practice Implementation at the Local Level

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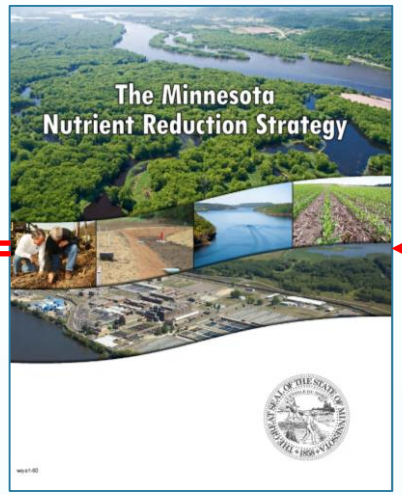
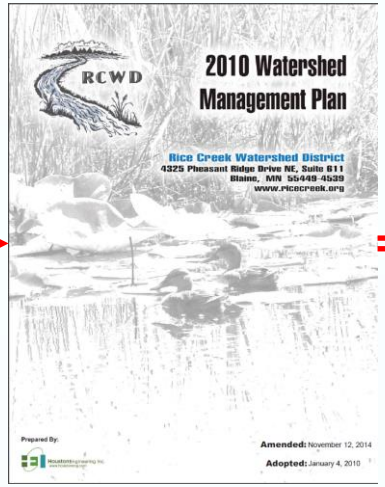
Using technology for watershed planning across spatial scales?



Watershed/Basins
Models
SWAT/HSPF

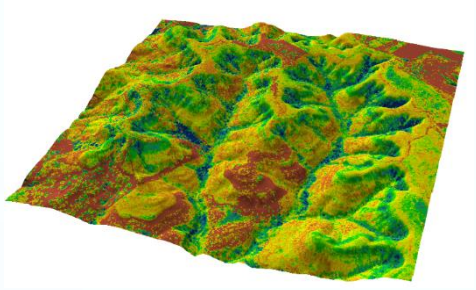


State

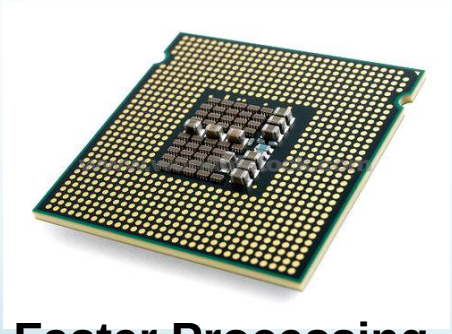
Watershed &
Regional

Field (Land Owner or SWCD)

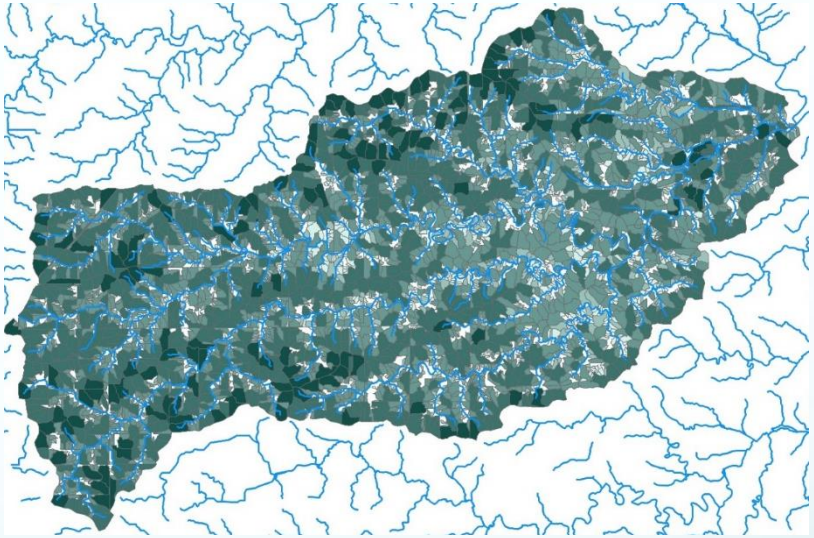
Water Resources Geoprocessing



High Resolution Datasets

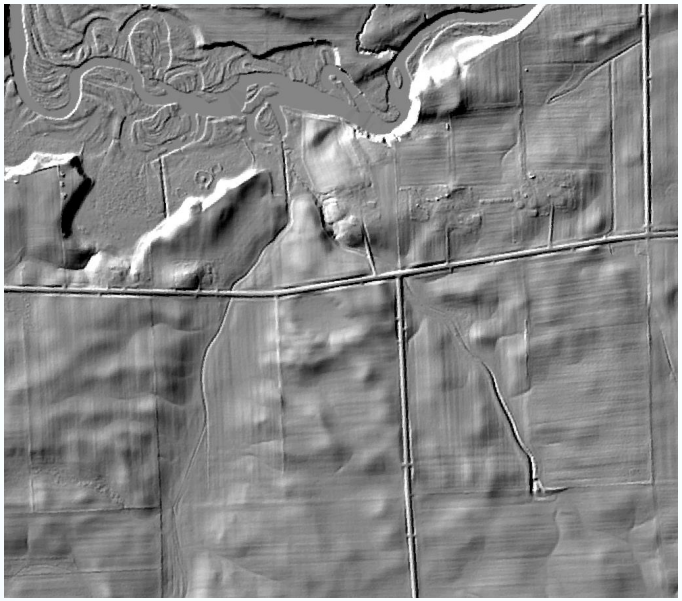


Faster Processing

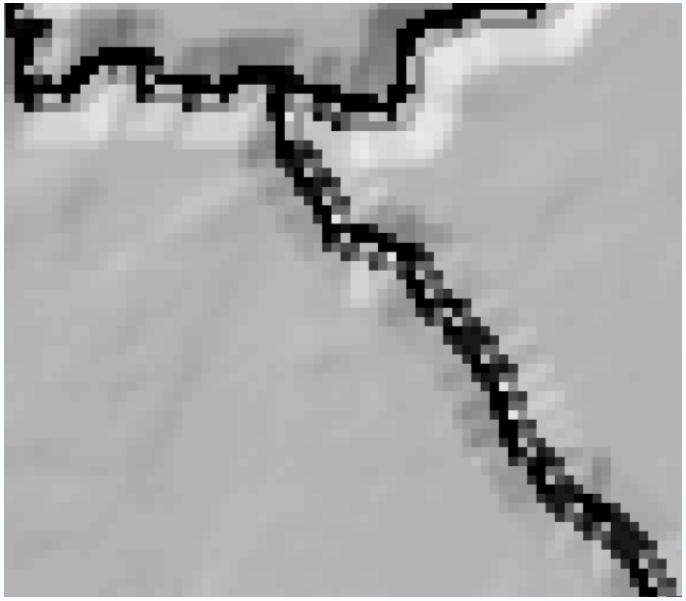


Base Datasets

LiDAR



NHD PLUS

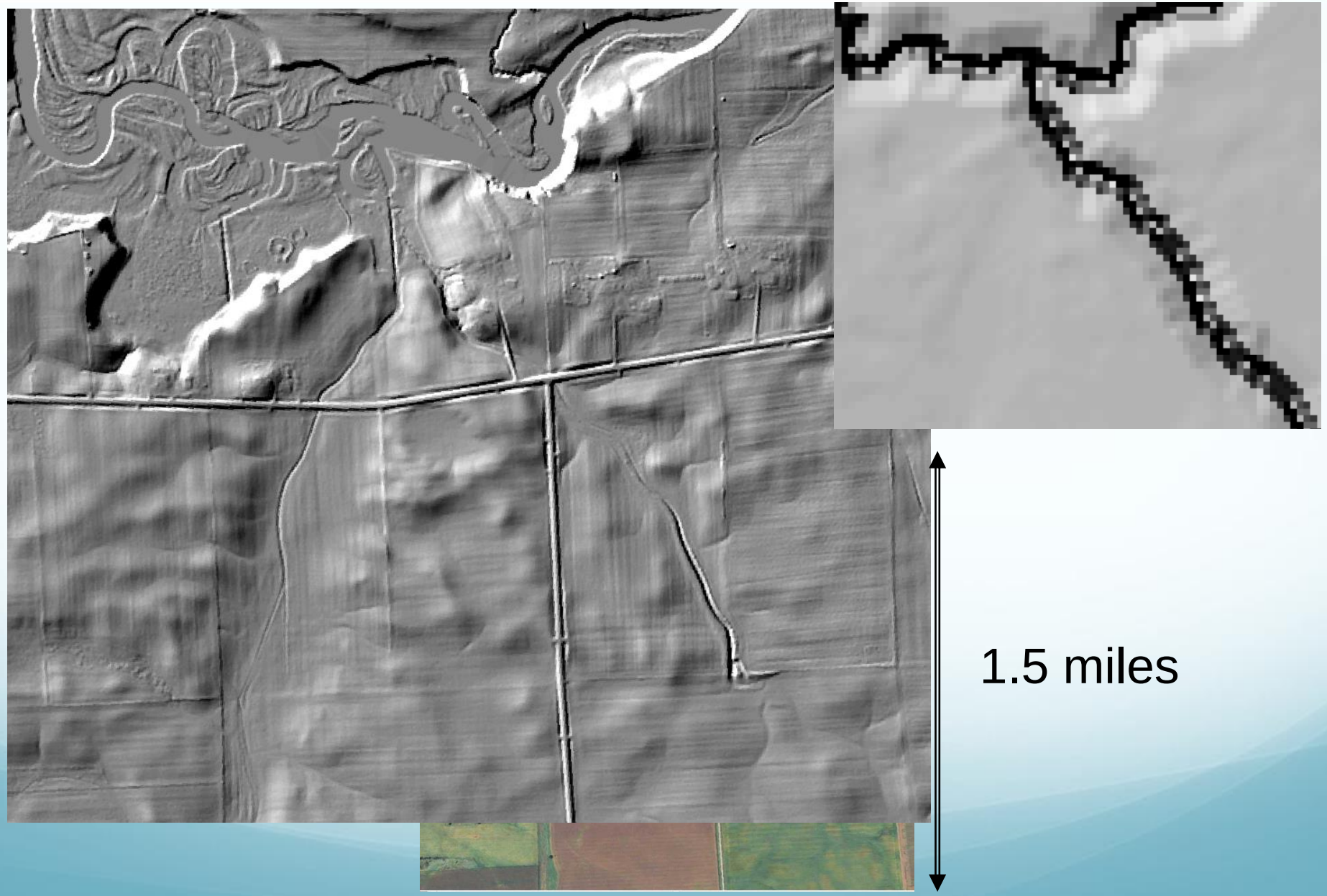


1.5 miles

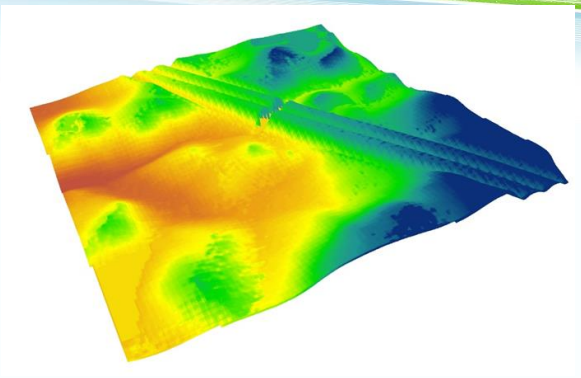
LiDAR

PTMA – Base Data

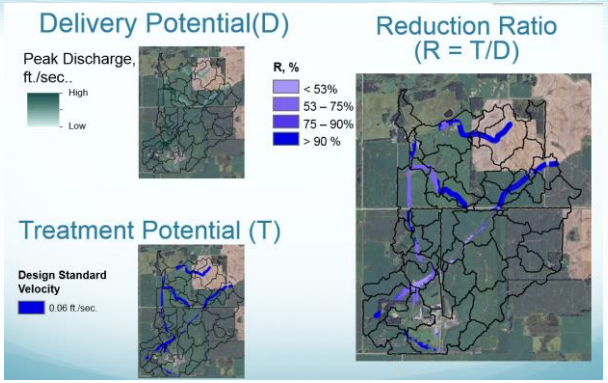
NHD PLUS



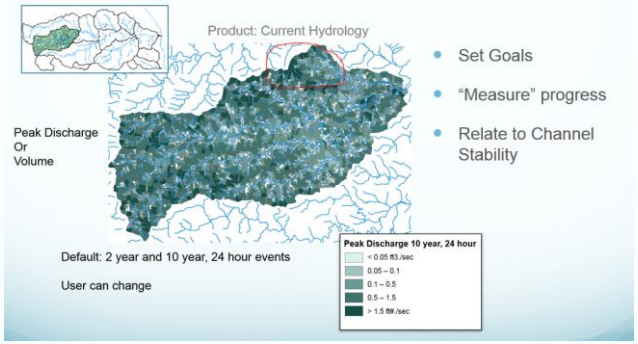
Some Example Data Products



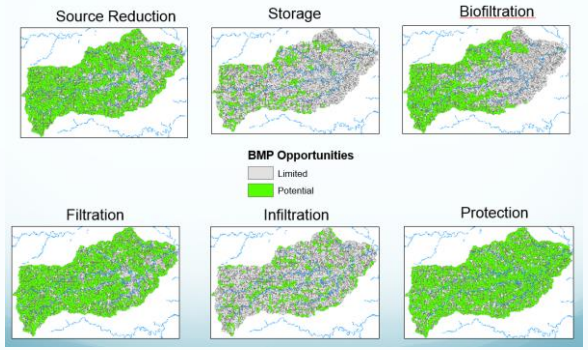
Hydro-Conditioned DEM



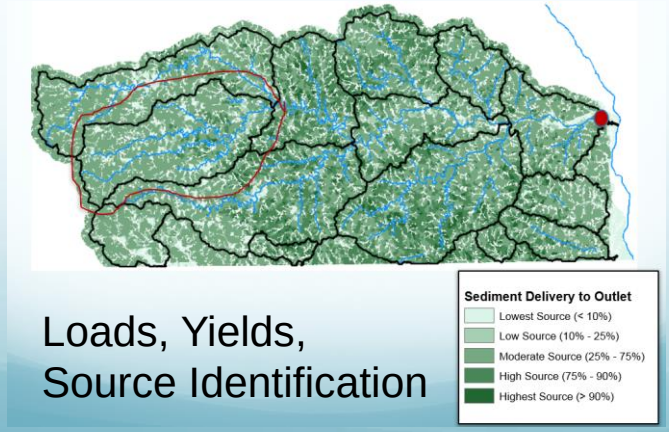
WQ Benefits



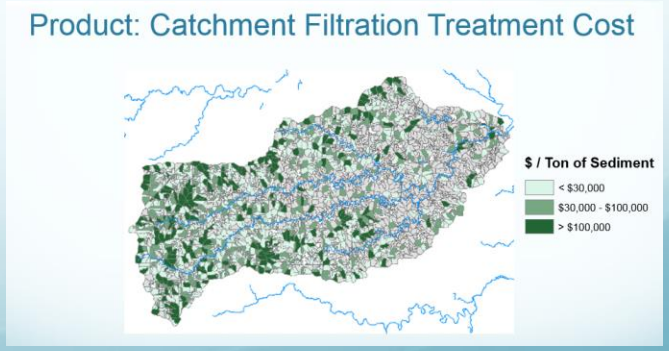
Hydrology



BMP Suitability

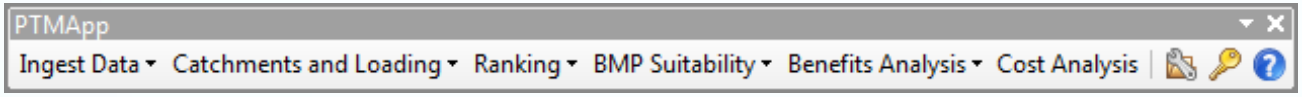


Loads, Yields, Source Identification



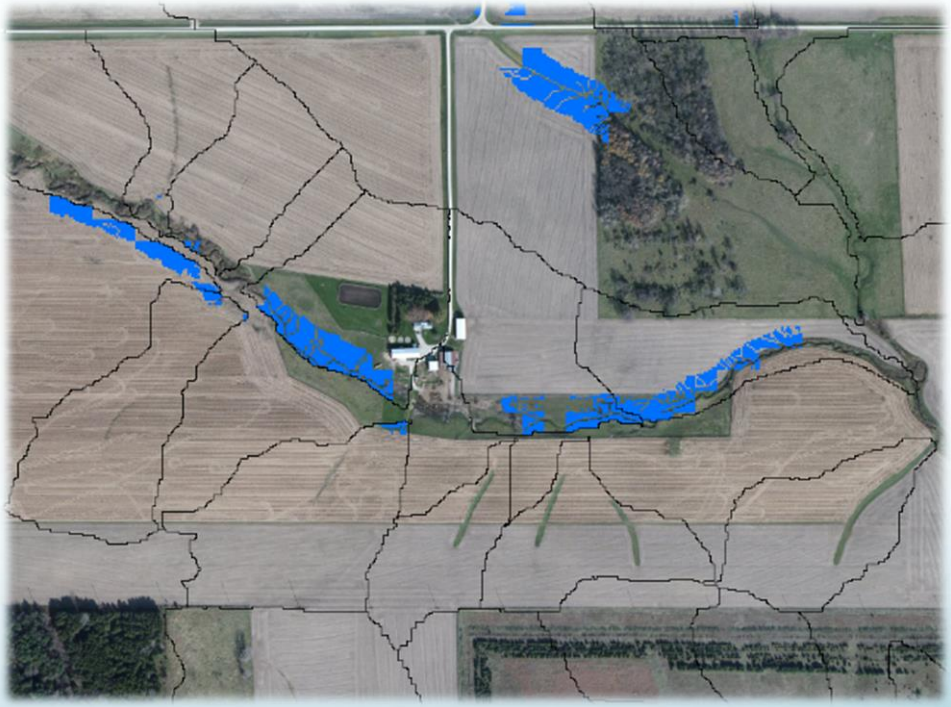
Treatment Cost Estimates

Prioritize, Target, Measure Application
PTMApp – What Is It?



ArcGIS toolbar application that allows users to:

- **Prioritize resources of concern**
- **Target specific locations for the implementation of BMPs and CPs**
- **Measure benefits to priority resources and cost analysis of implementation.**
- **Decision Support Tool for managers**



Field Prioritization

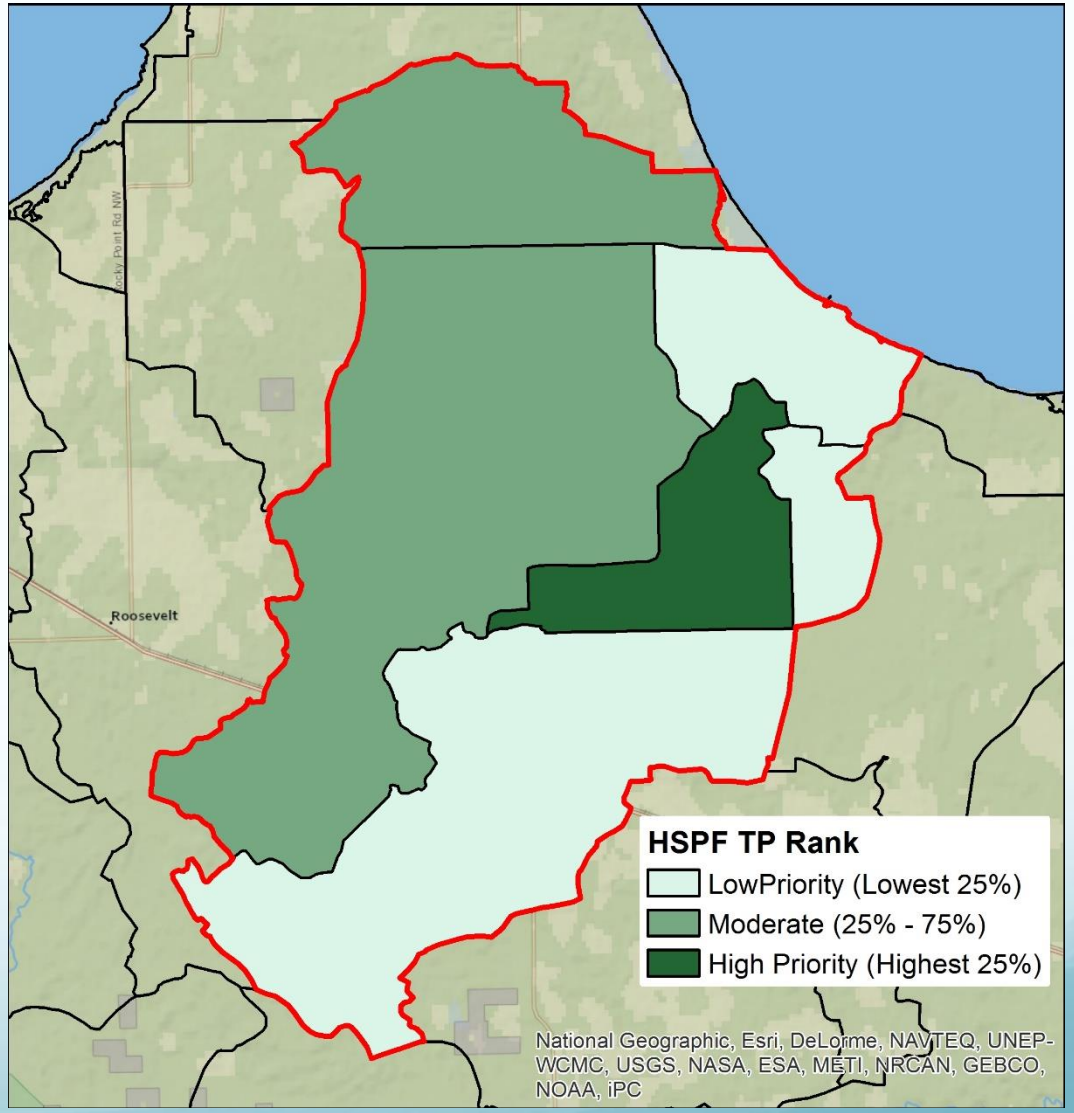
What areas supply the highest loading?

Modeling - HSPF

- MPCA utilizing statewide for TMDL/WRAP development
- 34 subwatersheds
- Typical subwatershed areas are HUC12 Scale (~10,000 acres)
- Basin-scale model
- Simulates watershed hydrology and water quality
- Simulates in-stream processes
- Time-series

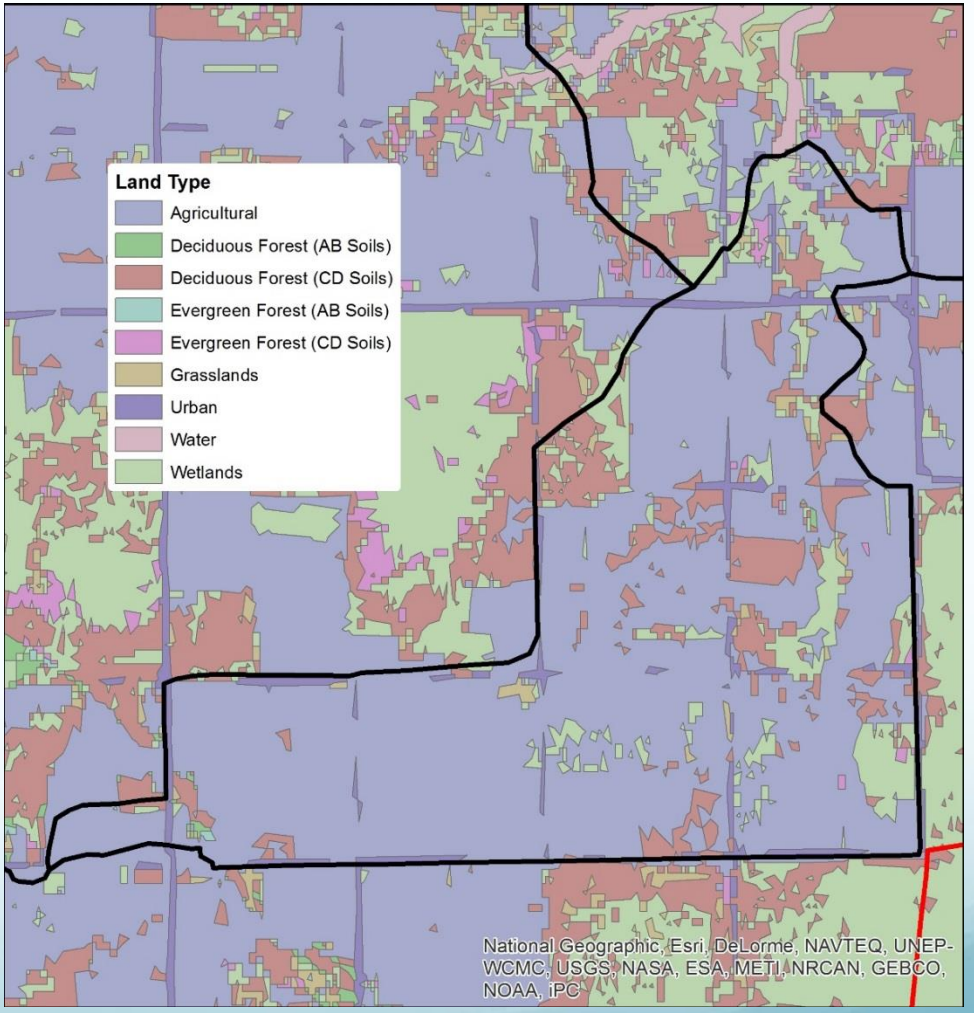
Targeting - HSPF

- Landscape yields by subwatershed can be ranked (average annual)
- Ranking based on sediment, total phosphorus, total nitrogen, etc.
- Simple quantile ranking (others can be used)

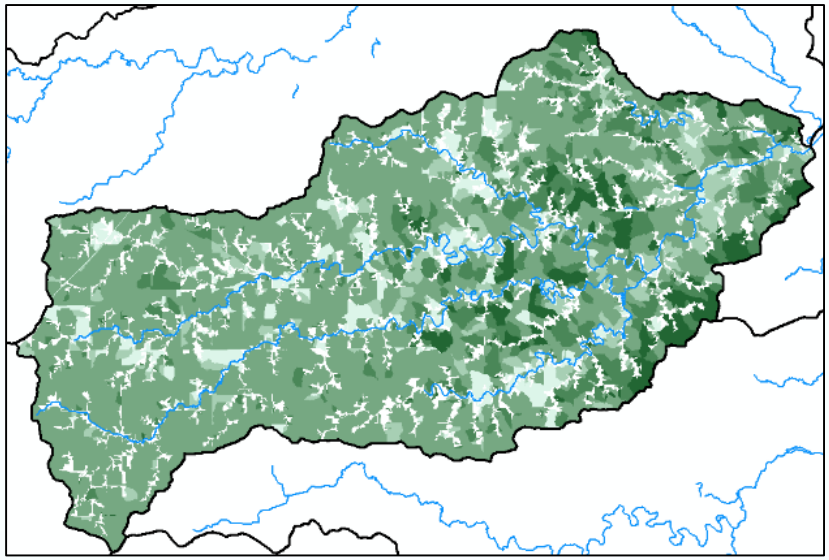


Targeting - HSPF

- Predominantly agricultural
- **Feedback:** Agricultural producers don't like targeting all agriculture the same
- How to better resolve and target problem areas within the agricultural land use.
- All HRUs of the same type act the same way



Enhanced Geospatial Water Quality Products

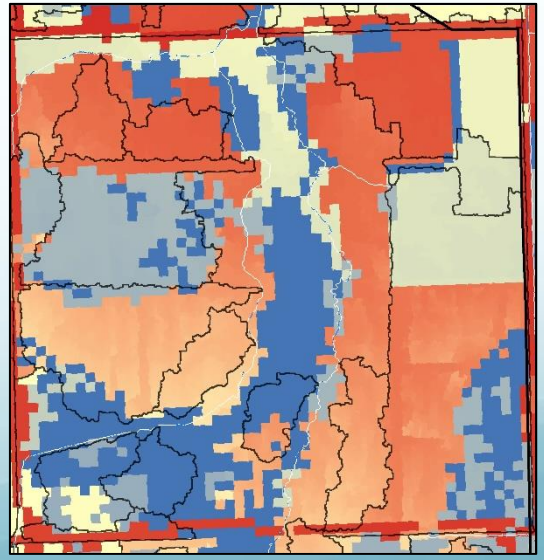


Components

- Hydrologically corrected DEM
- Land use
- Soils
- RUSLE
- Sediment delivery ratio
- Sediment transport

Where do PTMApp pick up from HSPF/SWAT?

- Higher resolution catchments (5 to 140 acres, Average ~40 acres)
- Smart rasters allow for yield and load relative to priority resource
- Add utility at a **local** scale



~ 1 sq. mi.

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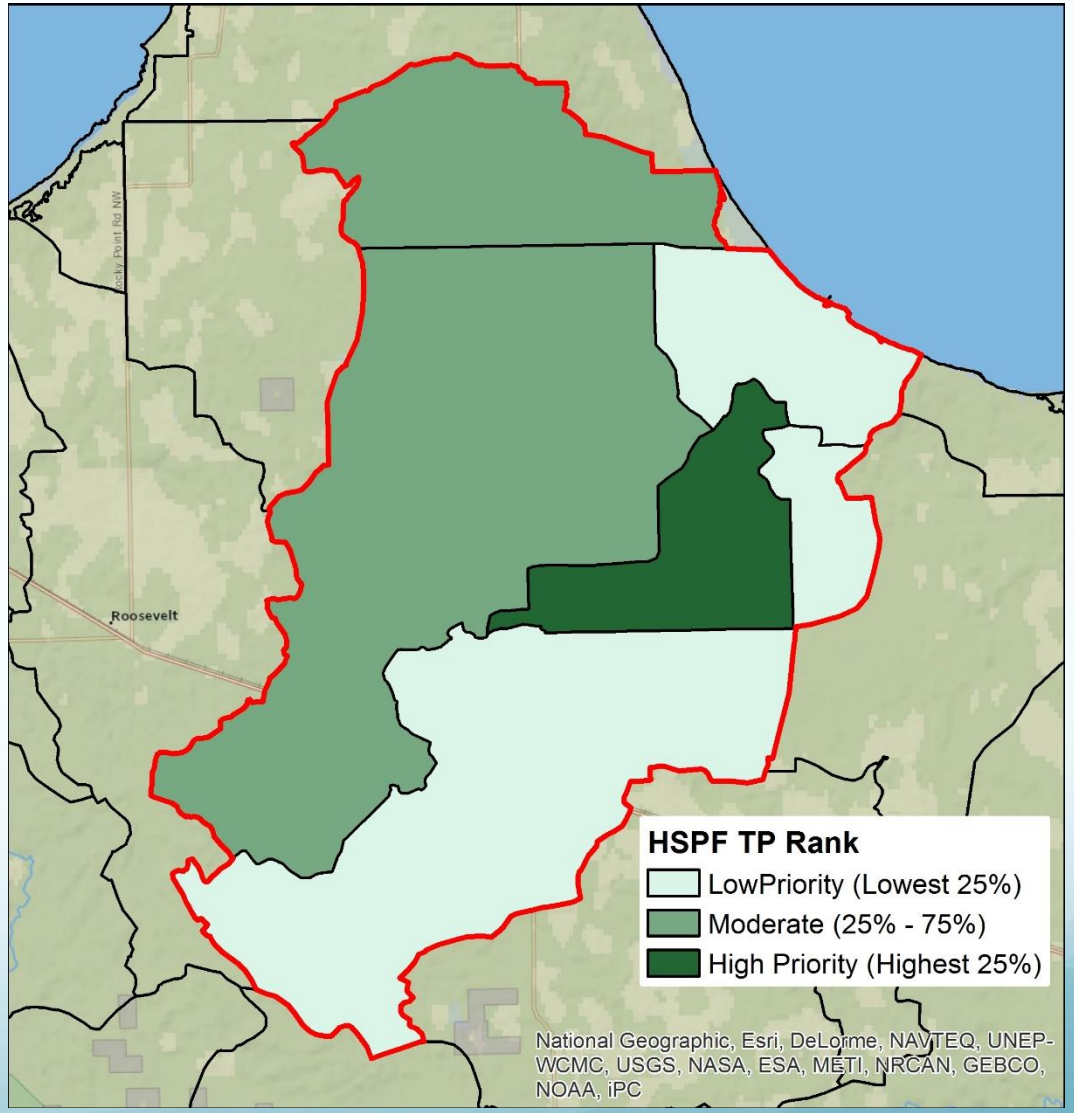
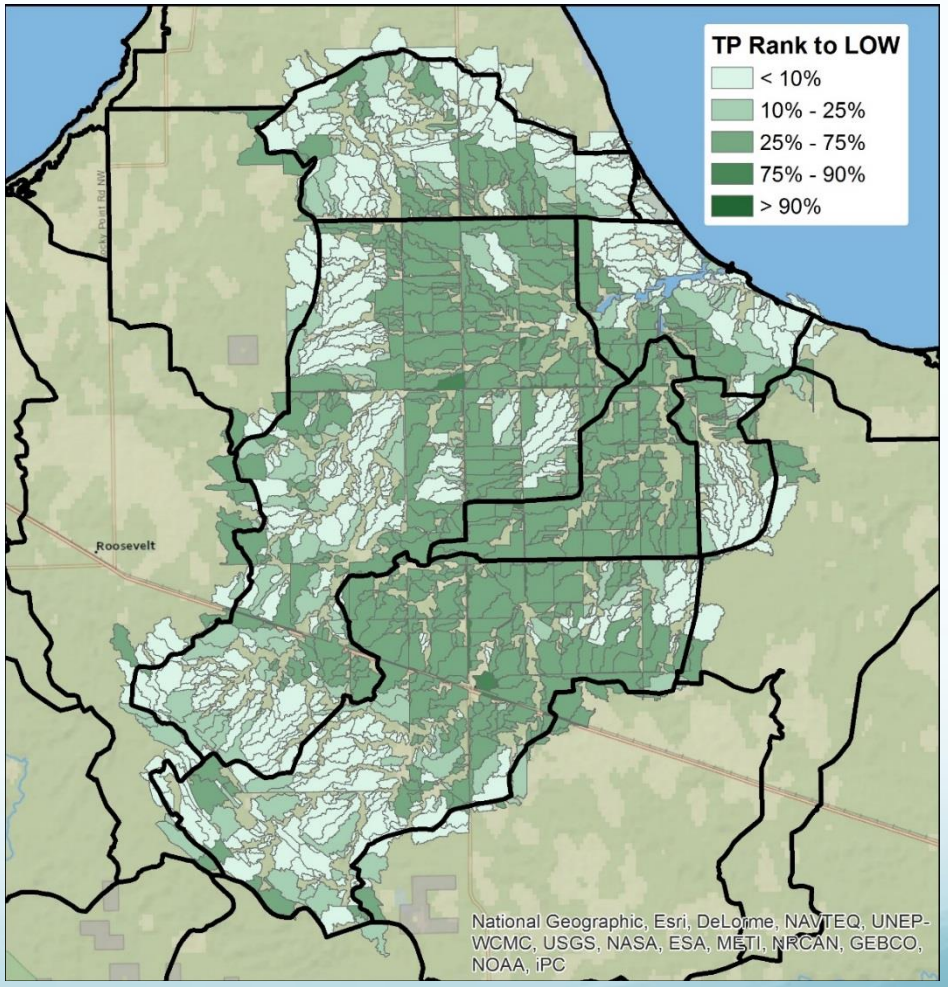


Targeting – Enhanced Geospatial Water Quality Products

- Differences based on:
  - Surface loading,
  - Travel time, and
  - First-Order Decay
    - Field to Catchment
    - Catchment to Subwatershed
    - Subwatershed to Outlet
- Catchment Scale ~40 acres
- Incorporate Model outputs for surface loading for either Subwatersheds or HRUs



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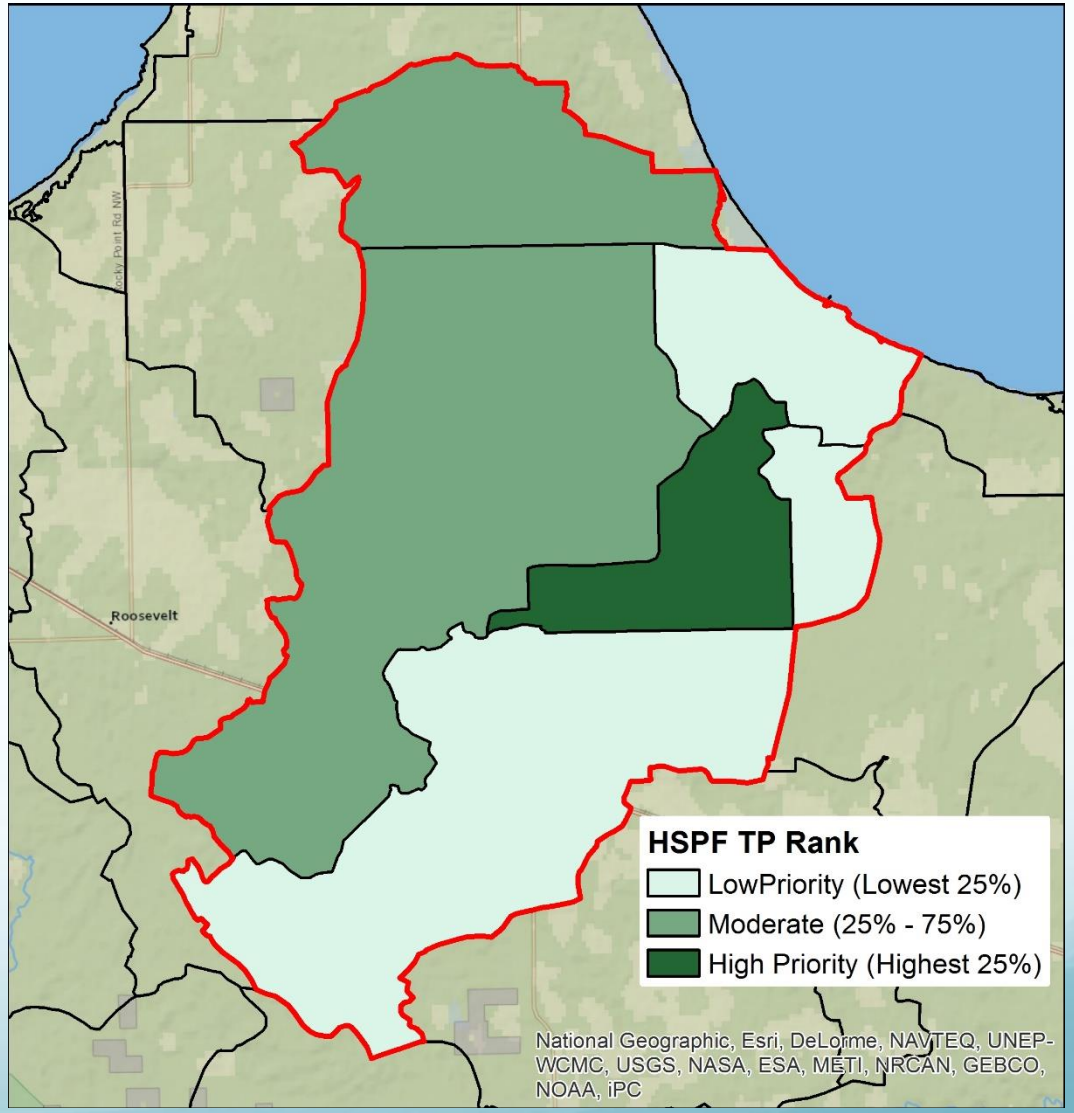
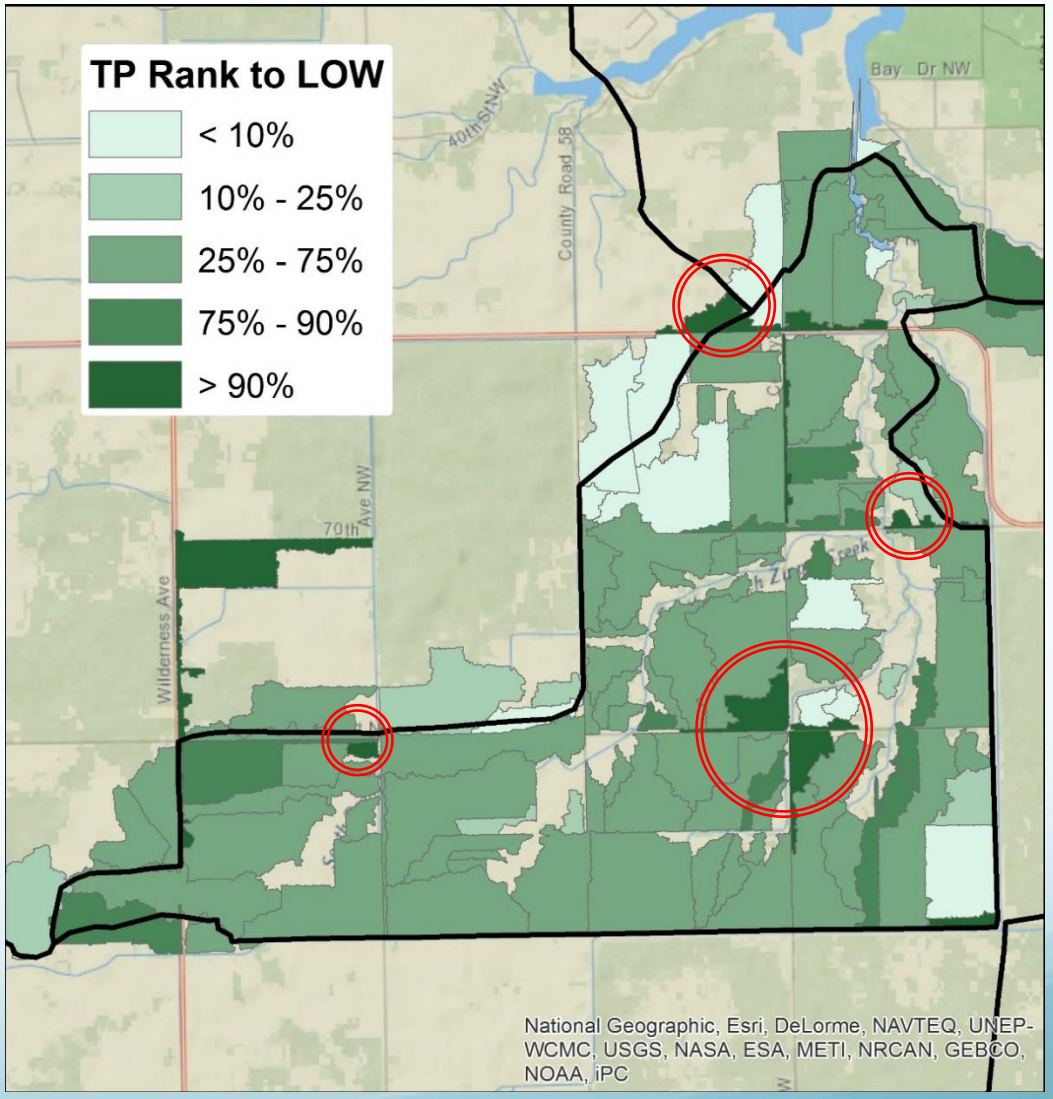


Targeting – Enhanced Geospatial Water Quality Products

- Target watershed
- Catchments loading values calculated **to Lake of the Woods**
- Ranked for TP loading to Lake of the Woods **over the target watershed**

Most likely within <u>target watershed</u> to contribute TP to Lake of the Wood



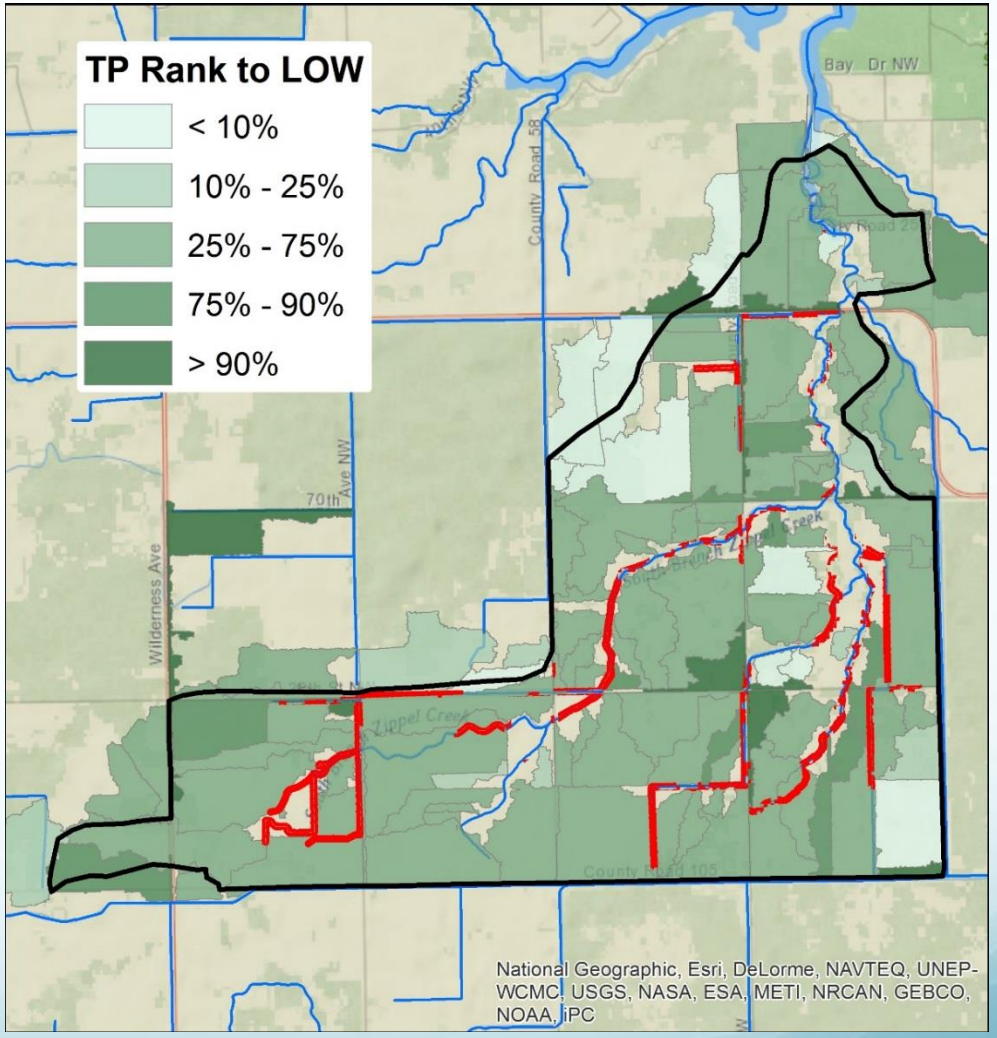
BMP Suitability

Where is there potential to place a BMP on the landscape

Field Scale BMP Suitability

Filter Strips

- Land Within 100 ft. of a flowline
- NLCD 2006 data classified as cultivated
- < 8.1 tons/year of sediment contributing
- Contributing Area < 124 acres



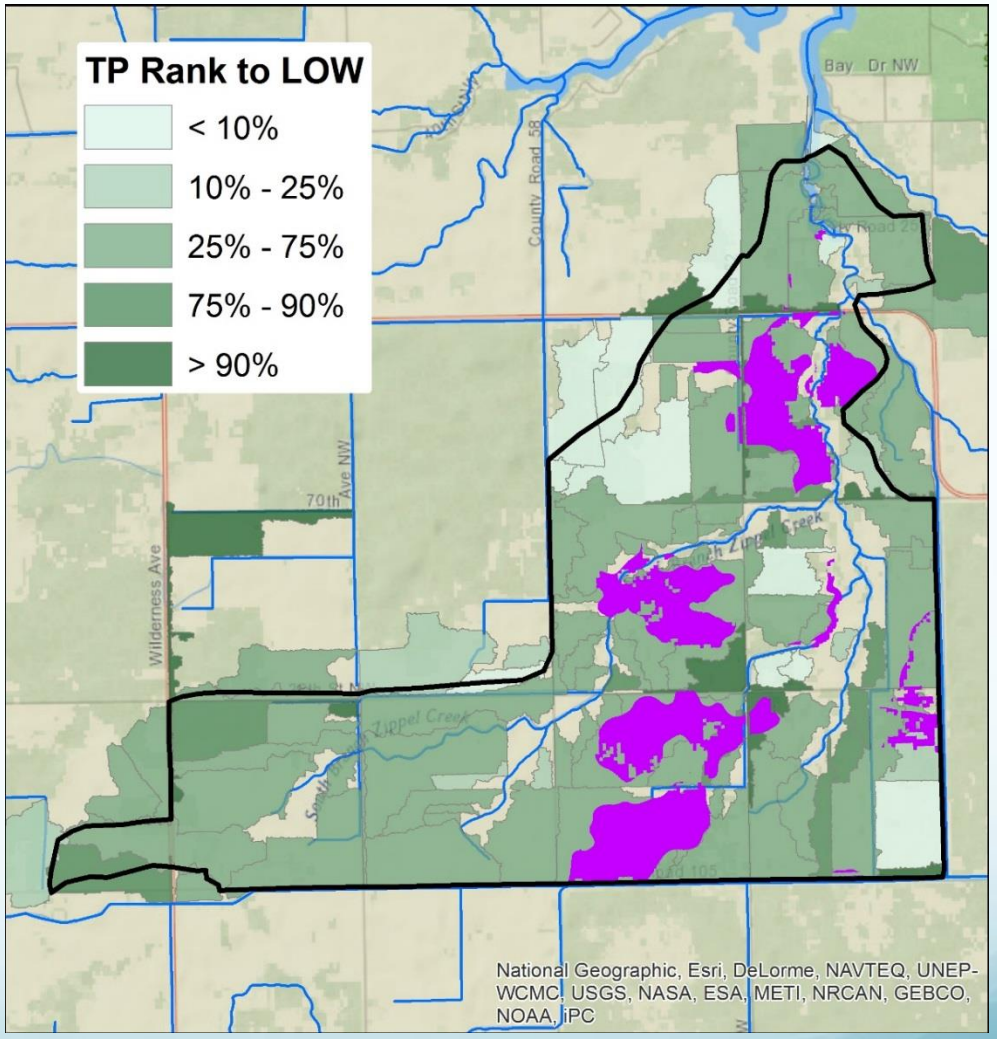
Criteria based on NRCS Design Standards

Treatment Group	BMP Type	Criteria	Code
Storage	Sediment Basin/WASCOB	• High sediment yield: accumulated sediment delivered to flow line; percentile rank > 90; • Contributing drainage area < 40 acres; • National Land Cover Dataset (NLCD) (2006) land cover is cultivated lands; • ≥ 0.25 acres of the catchment has opportunities for Sediment Basin/WASCOBs.	350/638
	Controlled Drainage	• Slope ≤ 1%; • NLCD 2011 data classified as cultivated; • ≥ 80% of catchment has opportunities for controlled drainage.	554
Filtration	Grassed Waterways	• Channelized flow path; • NLCD 2011 data classified as cultivated; • Slope ≥ 3% and ≤ 12%; • Flow Length ≤ 750 ft • Drainage area ≤ 7 acres; • ≥ 0.5 acres of catchment has opportunities for grassed waterways.	412
	Filter Strip	• Land Within 100 ft. of flowline; • NLCD 2011 data classified as cultivated; • < 8.1 tons/year of sediment; • Contributing Area < 124 acres.	393
	Saturated Buffers	• Within 100 ft of waterway; • SSURGO minimum depth to water table ≤ 2ft; • NLCD 2011 data classified as cultivated.	NA
Biofiltration	De-nitrifying Bioreactors	• Slope ≤ 1%; • NLCD 2011 data classified as cultivated; • ≥ 50% of catchment has opportunities for controlled drainage.	554
Infiltration	2-stage Ditch	• NLCD 2011 data classified as cultivated; • Drainage ditch based on MN DNR 24K streams; • Bank heights ≤ 10 ft.	NA
Protection			
Source Load Reduction	Cover Crops	• ≥ 20% of catchment is NLCD 2011 cultivated lands.	340
	Perennials	• Low crop productivity: SSURGO Crop Productivity Index ≤ 61; • NLCD 2011 data classified as cultivated; • ≥ 5 acres of catchment has opportunities for perennials.	327
User Defined			

Field Scale BMP Suitability

Perennials

- Low crop productivity: SSURGO Crop Productivity Index ≤ 61
- NLCD 2006 data classified as cultivated
- ≥ 5 acres of catchment has opportunities for perennials



Field Scale BMP Suitability

Filter Strips

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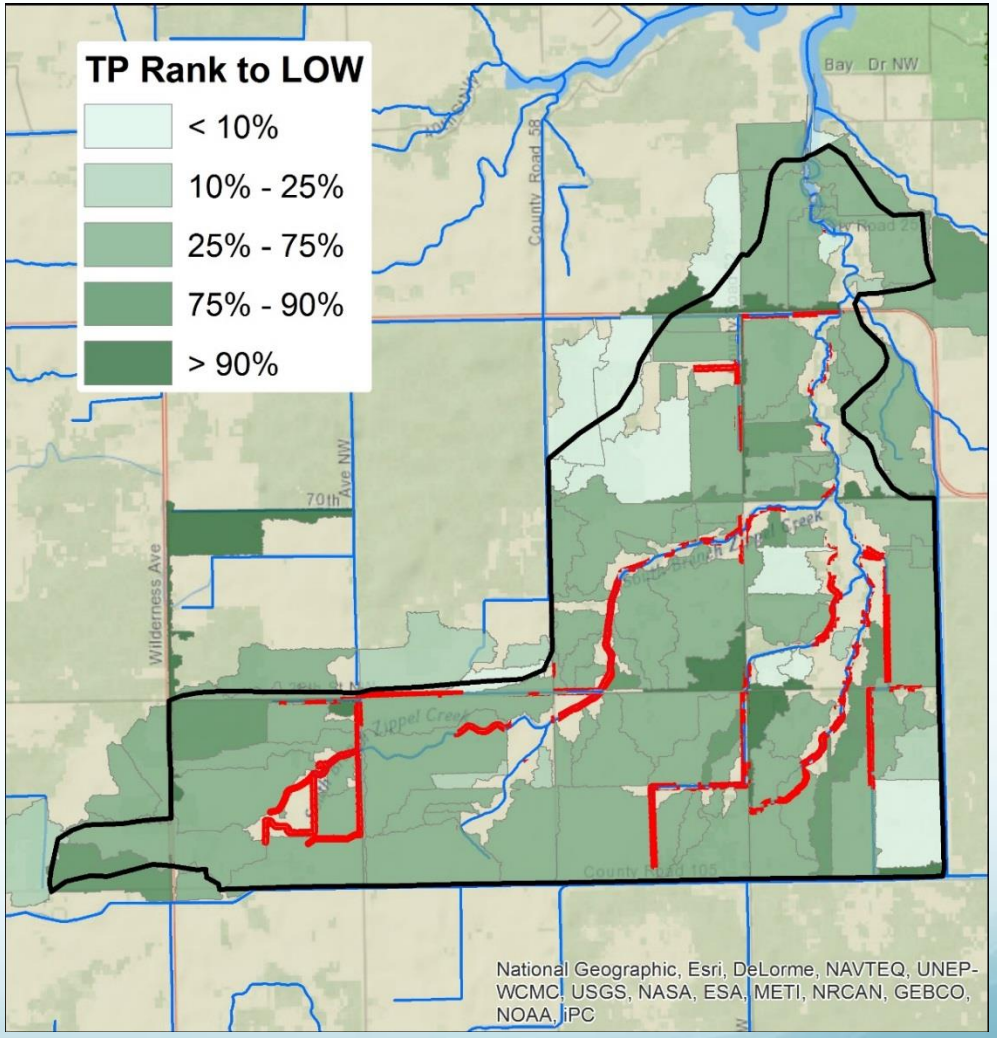
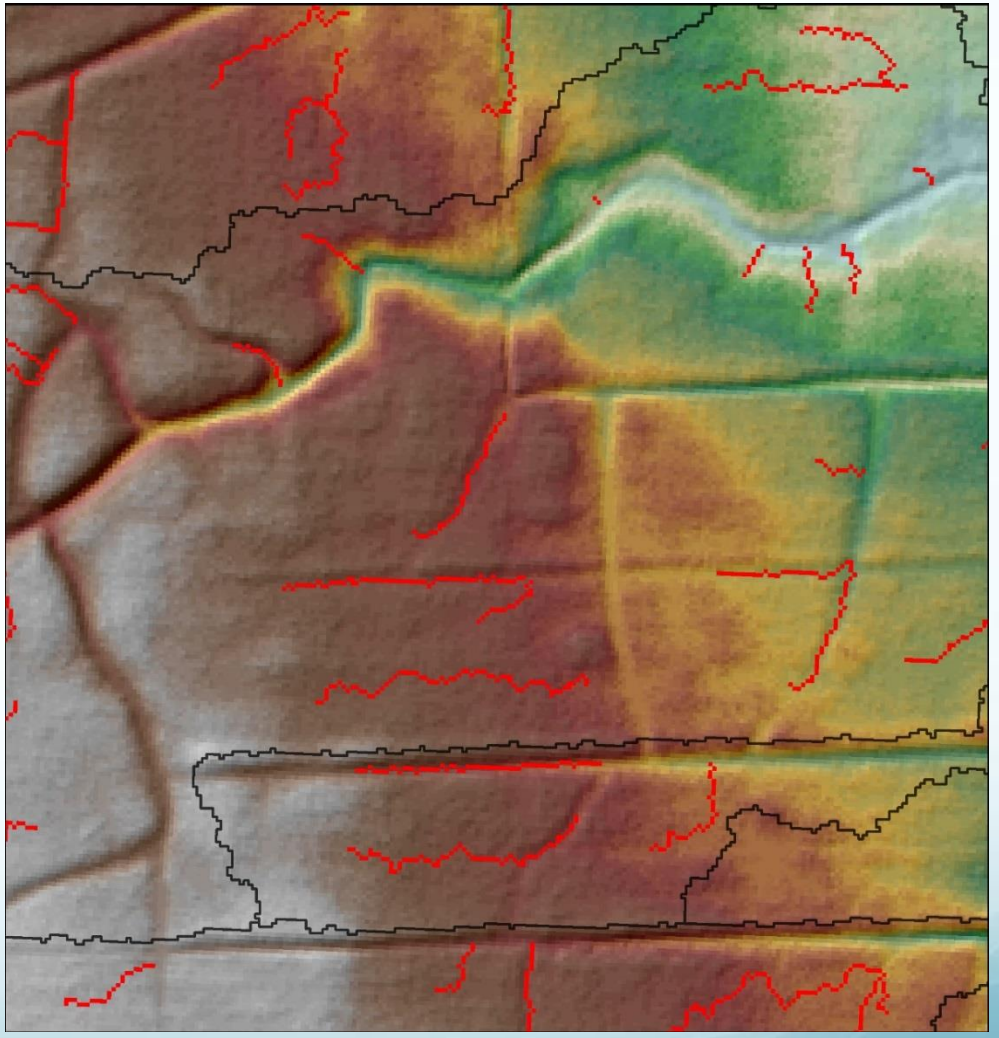
- Contributing Area < 124 acres



Field Scale BMP Suitability

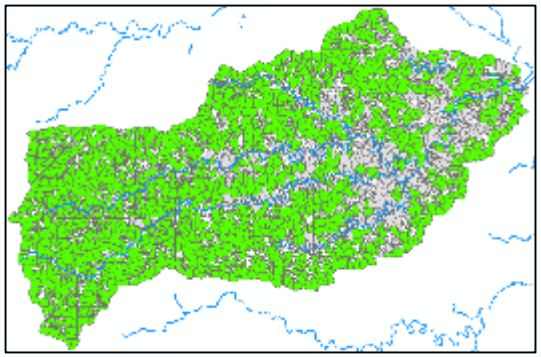
Sediment Basins (WASCOBS)

- High sediment yield: accumulated sediment delivered to flow line; percentile rank > 90
- Contributing drainage area < 40 acres;
- National Land Cover Dataset (NLCD) (2006) land cover is cultivated lands
- ≥ 0.25 acres of the catchment has opportunities for Sediment Basin/WASCOBs

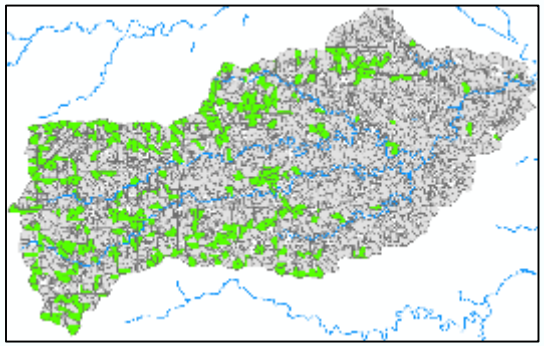


Product: Catchment Practice Suitability Maps

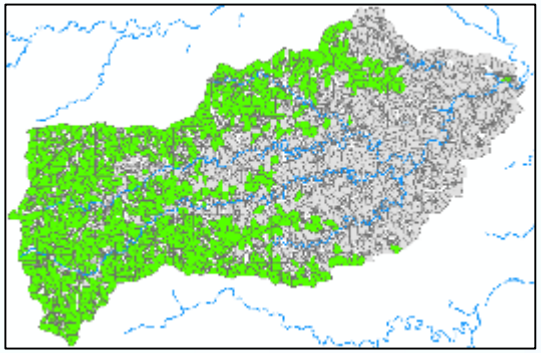
Source Reduction



Storage



Biofiltration

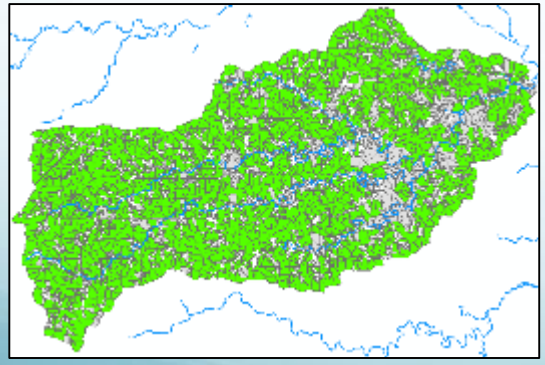


BMP Opportunities

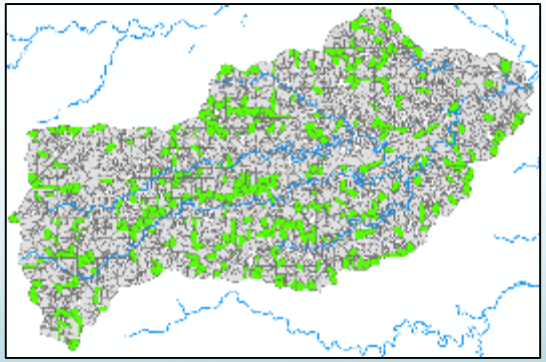
Limited

Potential

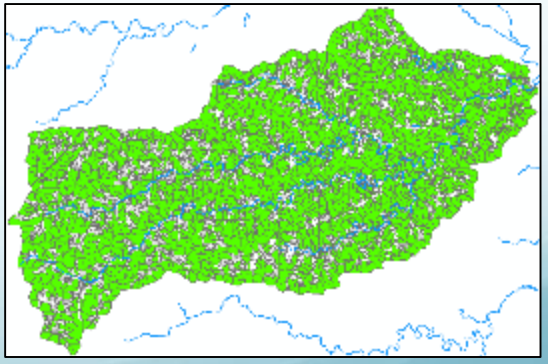
Filtration



Infiltration



Protection



Practice types are placed into “Treatment Groups” for Estimating Reductions in Loads.

BMP Suitability

	Storage	Filtration	Bio-Filtration	Infiltration	Protection	Source Reduction	User Defined
Treatment Process	Sedimentation	Sedimentation	Sedimentation & biological	Volume abstraction	Reduction in Mass Leaving Landscape?	Reduction of Mass Potential	User selects method (from those to left) or enters percentage
Form of Treated	Particulate	Particulate	Particulate	Dissolved	Total (Dissolved & Particulate)	Total (Dissolved & Particulate)	Total (Dissolved & Particulate)
Reduction Ratio	**Treatment Volume / Runoff Volume Delivered**	**Velocity Design Standard / Velocity During Peak Discharge**	**Velocity Design Standard / Velocity During Peak Discharge**	**BMP Abstraction Volume / Volume Delivered**	**Modified RUSLE Parameters**	**Actual reduction in mass**	**User selects method (from those to left) or enters percentage**

Delivery Potential(D)

Peak Discharge, ft./sec..

High

Low

Reduction Ratio (R = T/D)

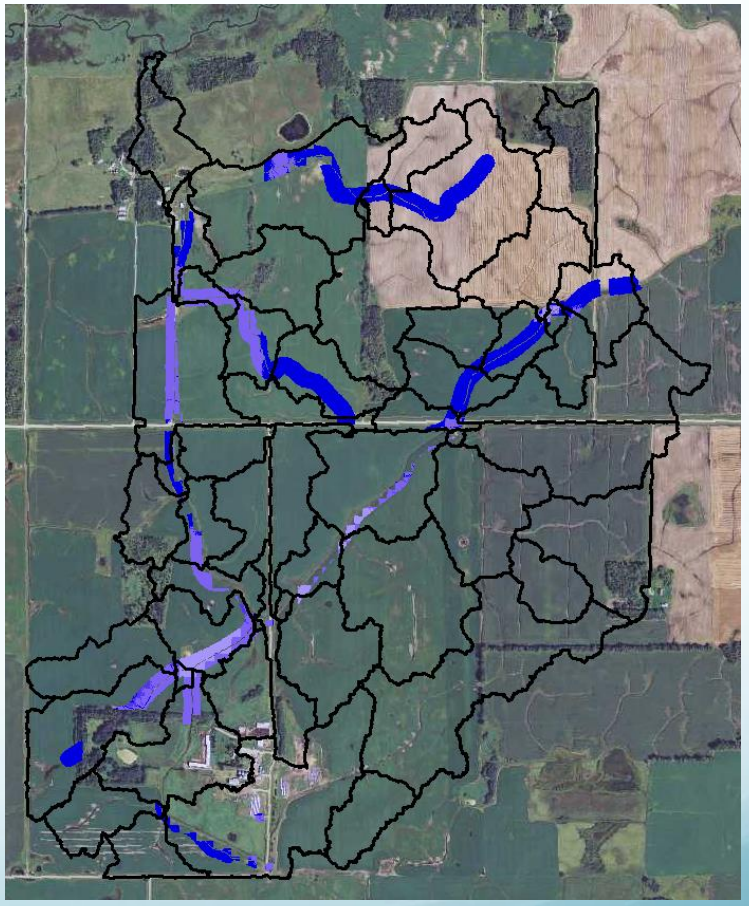
R, %

< 53%

53 – 75%

75 – 90%

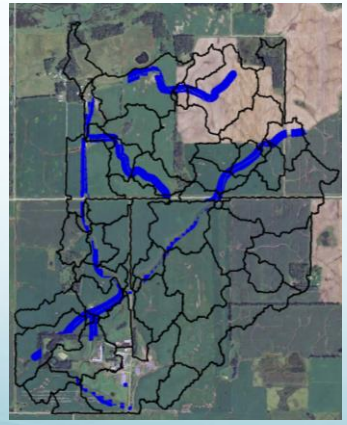
> 90 %



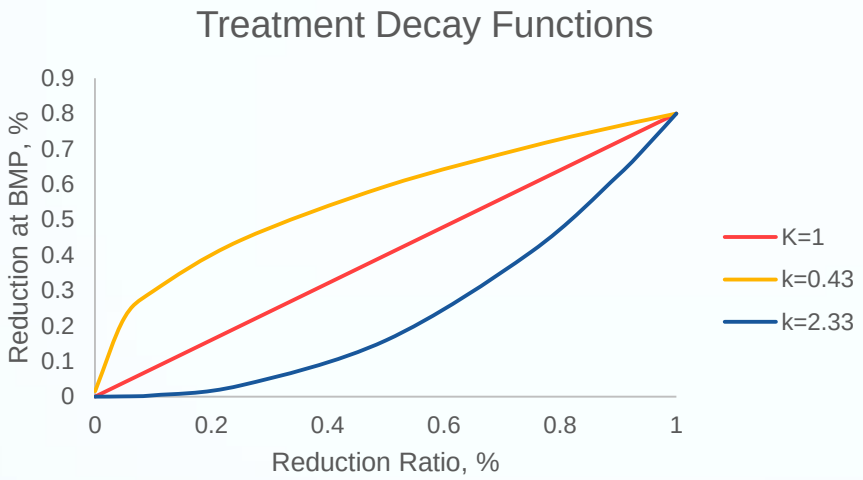
Treatment Potential (T)

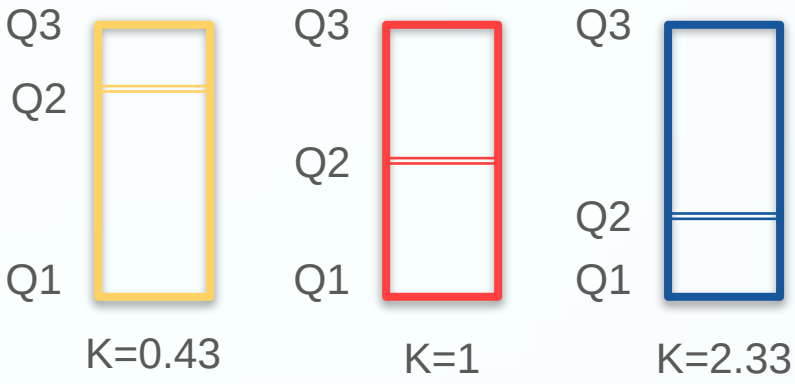
Design Standard Velocity

0.05 ft./sec.



10yr 24hr Storm





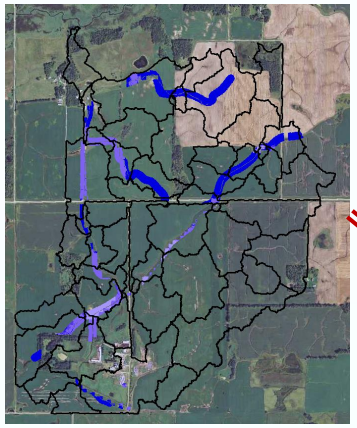
$R = a * r^K$

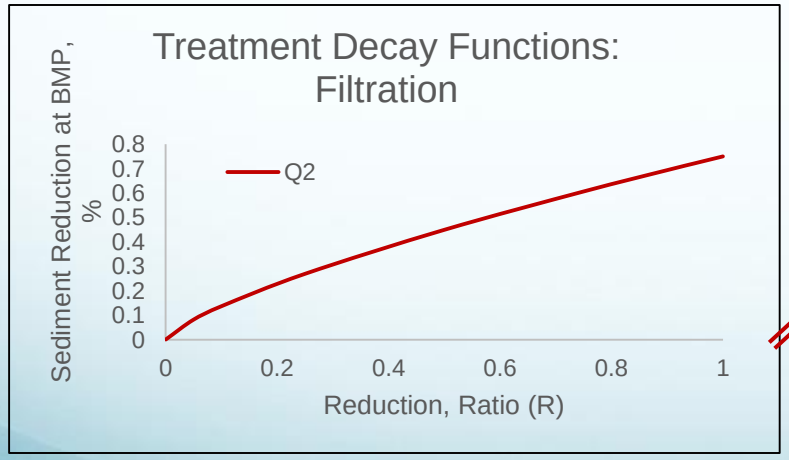
- R = reduction at BMP, %
- a = maximum observed % reduction
- r = reduction ratio, % (runoff delivered / treatment capacity)
- K = weighted function of interquartile range =(Q3-Q2)/(Q2-Q1)

Reduction Ratio

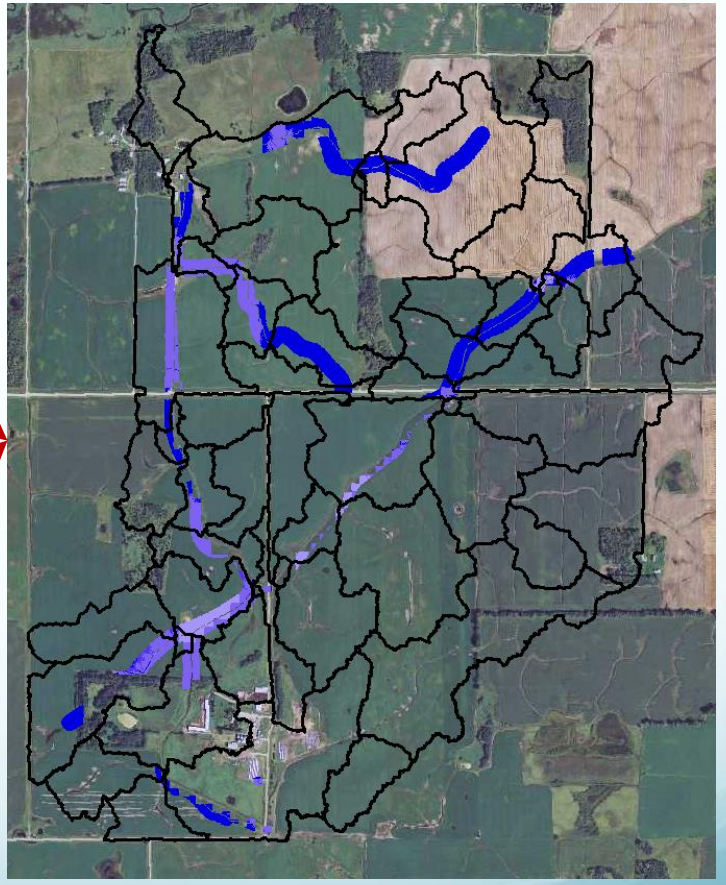
R, %

- < 53%
- 53 – 75%
- 75 – 90%
- > 90 %





% Sediment Reduction

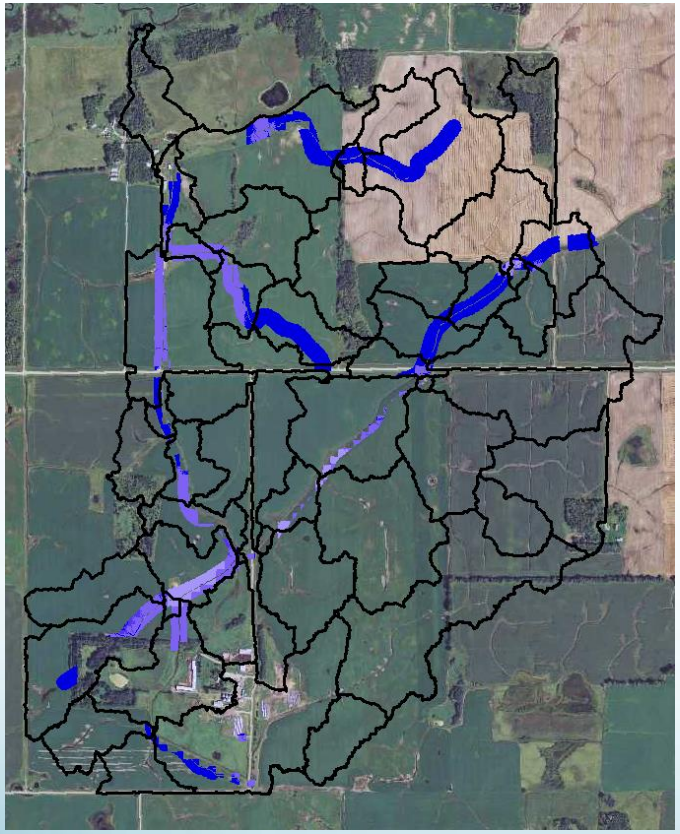


Sediment Reduction, %

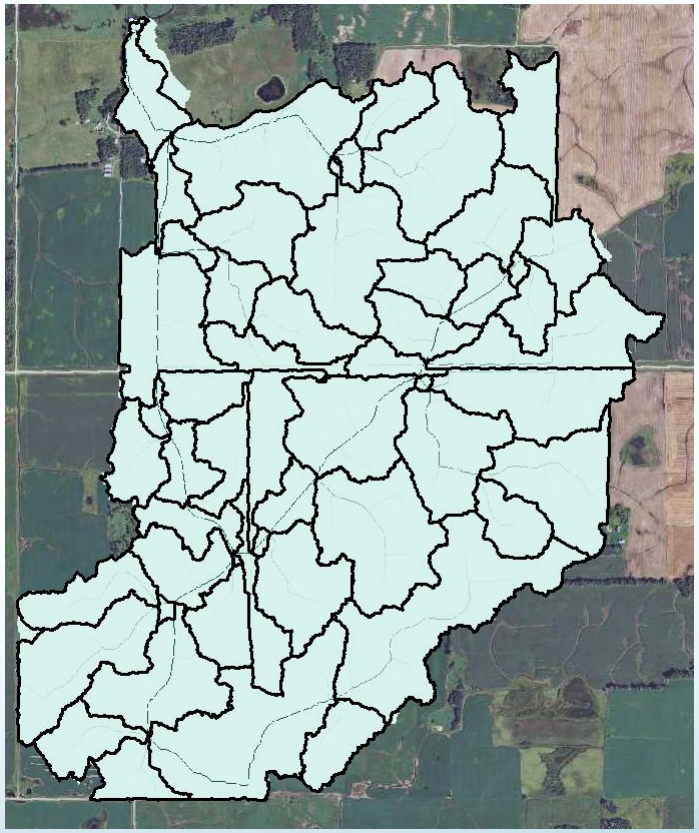
- <46%
- 47% - 60%
- 61% - 70%
- > 70%

Benefits Analysis

% Sediment Reduction

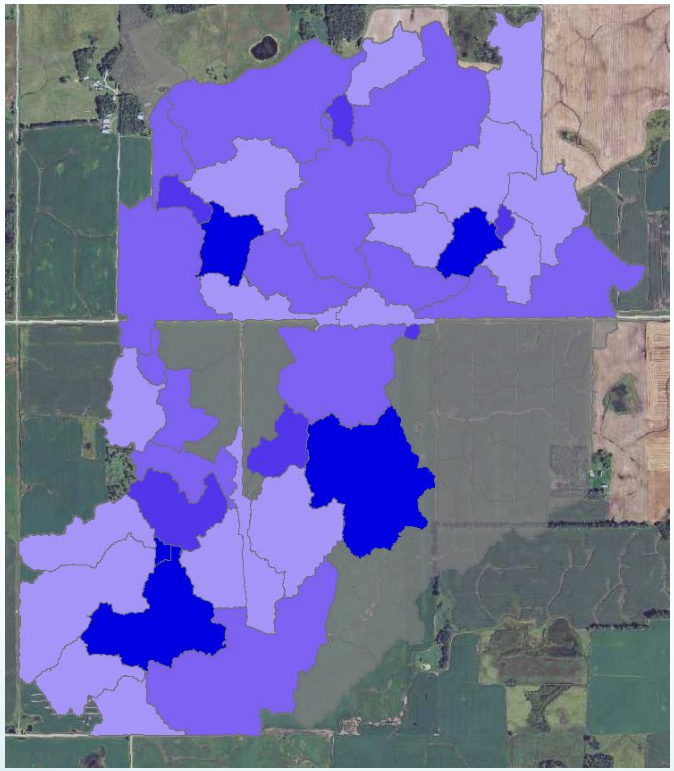


Sediment Delivered



Measured @ the Resource of Concern

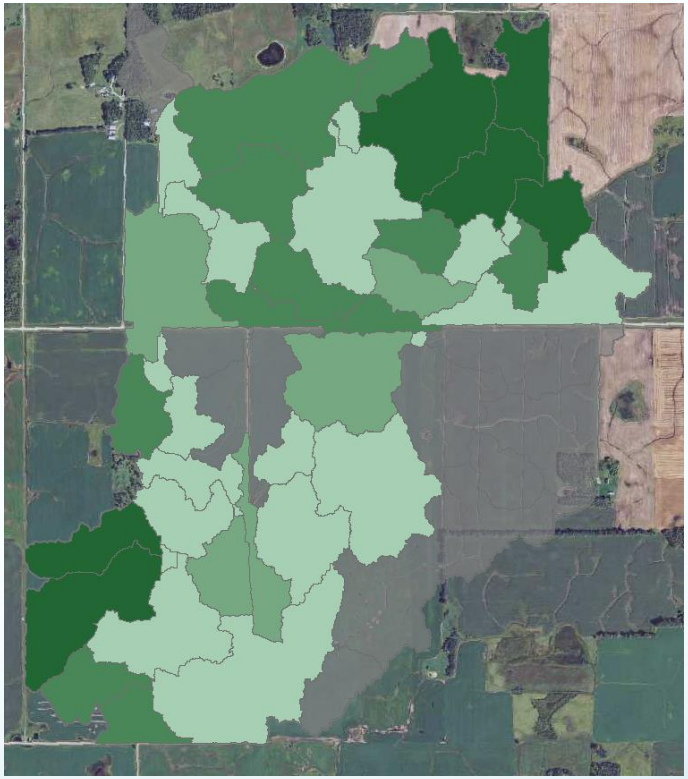
Cost-Effectiveness



$/ton Reduced

- < $4,000
- $4,000 - $13,000
- $13,000 - $30,000
- > $30,000

Total Potential Reduction



Reduction @ Resource, tons/year

- < 0.27
- 0.28 - 0.57
- 0.58 - 0.97
- > 0.98

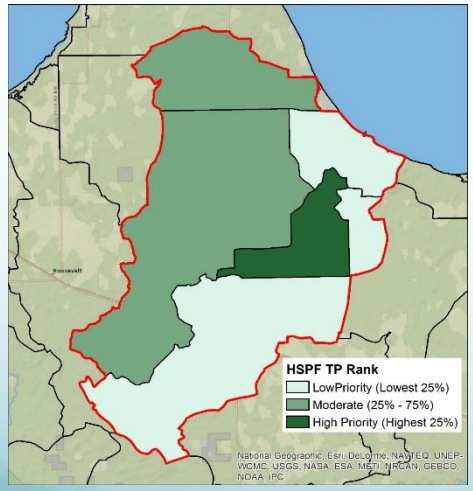
BMP Scenarios

How can this information be used to make better scenarios?

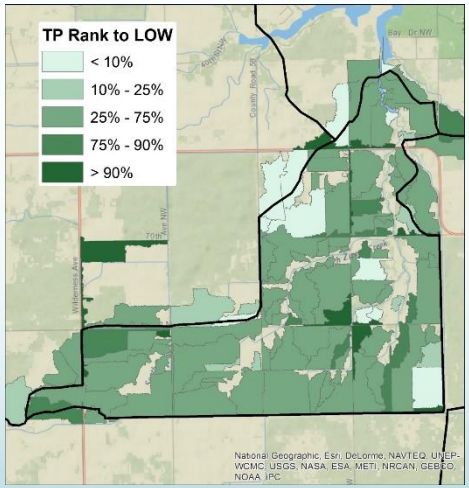
Build Better BMP Scenarios

1. Utilize HSPF subwatershed ranking, EWQP, and BMP suitability to develop 3 BMP scenarios
2. Insert the scenarios into the HSPF model
3. Run the modified HSPF model to evaluate the scenario results

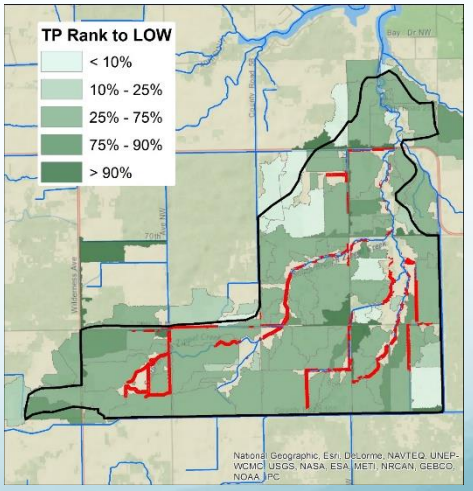
Watershed Model



Enhanced Geospatial Water Quality Products



BMP Suitability

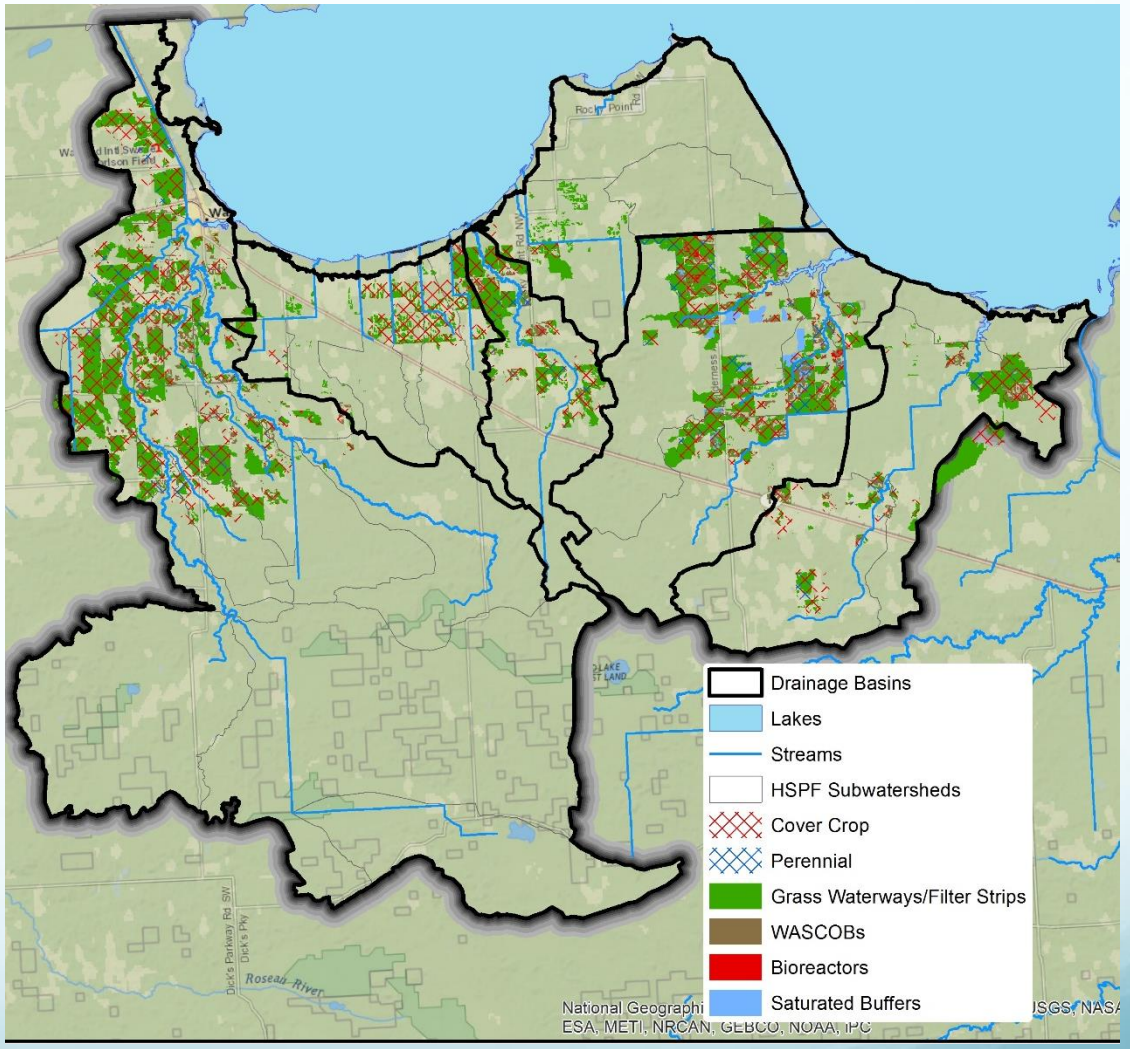


Modeling – BMP Scenarios in HSPF

3 Scenarios

1. Maximum BMP scenario (upper boundary condition)
2. Top 25% sources to LOW
3. Top 10% sources to LOW

- Broken down by major watersheds
- BMP priority based on local input



Modeling – BMP Scenarios in HSPF

Range of Top 10-25% Scenarios for Total Phosphorus

Major Tributary	Base Load	10%-25% Range Load Reduction	
	Load (lbs/year)	Load (lbs/year)	Percent (%)
Delivered to Lake of the Woods			
Direct Drainage	8,876	115 – 542	1.3 – 6.1
Warroad River	17,777	804 – 1,058	4.5 – 5.9
Willow Creek	1,944	146 – 183	7. – 9.4
Zippel Bay	5,269	778 – 868	14.8 – 16.5
Bostic Bay	3,149	105 – 158	3.3 – 5.0
Total Area	52,026	1,993 – 2,858	3.8 – 5.5

Limitations

- Processing Times
- LULC data (scale still 10m)
- Not Calibrated (DSS, relative values useful)
- Does not include existing practices
- Species of TN and TP
- Near channel sediment or in-stream sources
- BMP affects on hydrology

More Information

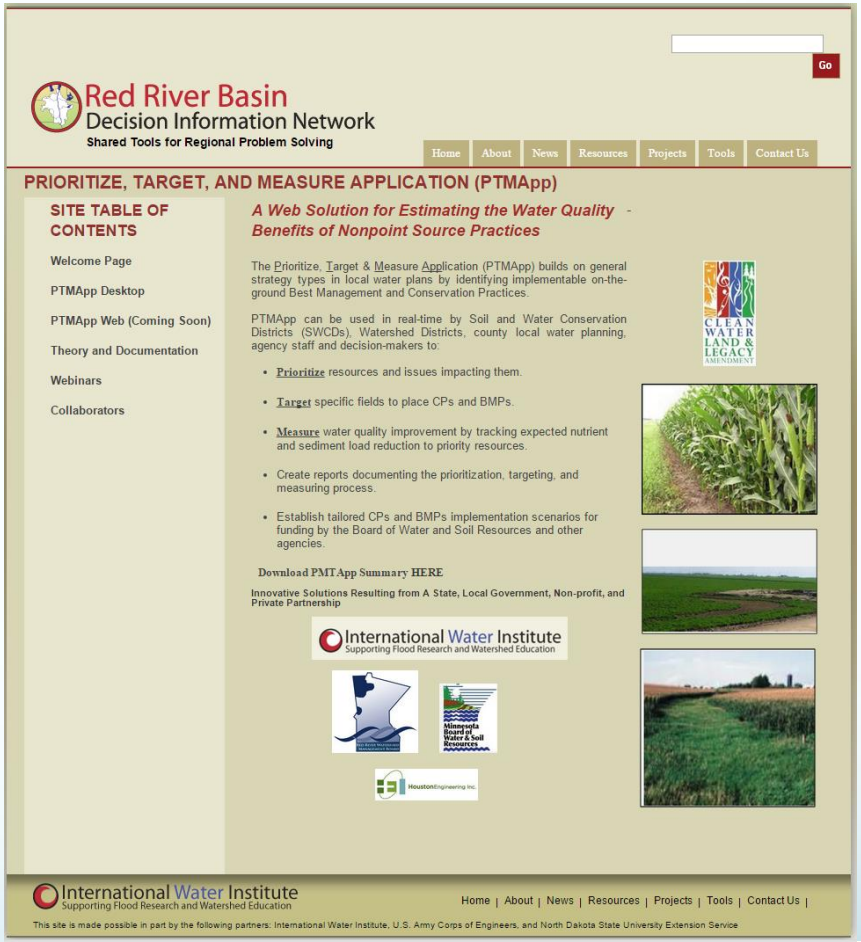
International Water Institute
Flood research and watershed education for the Red River Basin

http://www.iwinst.org/

Red River Basin
Decision Information Network
Shared Tools for Regional Problem Solving

http://www.rrbdin.org/

- Technical Memoranda
- Webinar Series
- PTMApp Desktop Download
- Web Version Coming Soon



Prioritize, Target Measure Application (PTMApp) Developers

- IWI is the Project Lead
- BWSR providing oversight and guidance
- HEI is sub consultant to IWI
- Funded with Clean Water, Land, & Legacy Funds

International Water Institute
Supporting Flood Research and Watershed Education

HoustonEngineering Inc.

Minnesota Board of Water & Soil Resources

CLEAN WATER LAND & LEGACY AMENDMENT

Several years of development incorporated into PTApp

HoustonEngineering Inc.

Photo Credit: J. Stephen Conn