

# Regression Analysis of Total Suspended Solids Concentrations to Estimate Streambank, Upland Field, and Classic Gully Sediment Contributions to Minnesota River Tributaries



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# Acknowledgements

- Scott Matteson – High Island CWP, MNSU Water Resouce Center
- Paul Wymar – Chippewa River CWP
- Watonwan River CWP
- Maple River CWP
- Scott MacLean – Little Cottonwood River, Seven Mile Creek CWP's
- USGS
- Bill VanRyswyk - MDA

# Sediment source contributions: what are the percentages?



Chetomba Creek

Photos courtesy of Stephanie Klamm – Hawk Creek CWP

# Sediment Sources:



Streambanks  
and Bluffs



Construction Sites



Classic Gullies



Urban Stormwater



Agricultural Fields  
(includes sediment from  
open tile intakes)



# The Link Between Runoff Source and Sediment Source Contributions to Rivers



# The Link Between Runoff Type and Sediment Source Contributions to Rivers



Bottom of ravine 10/18/07



Top of ravine 10/18/07

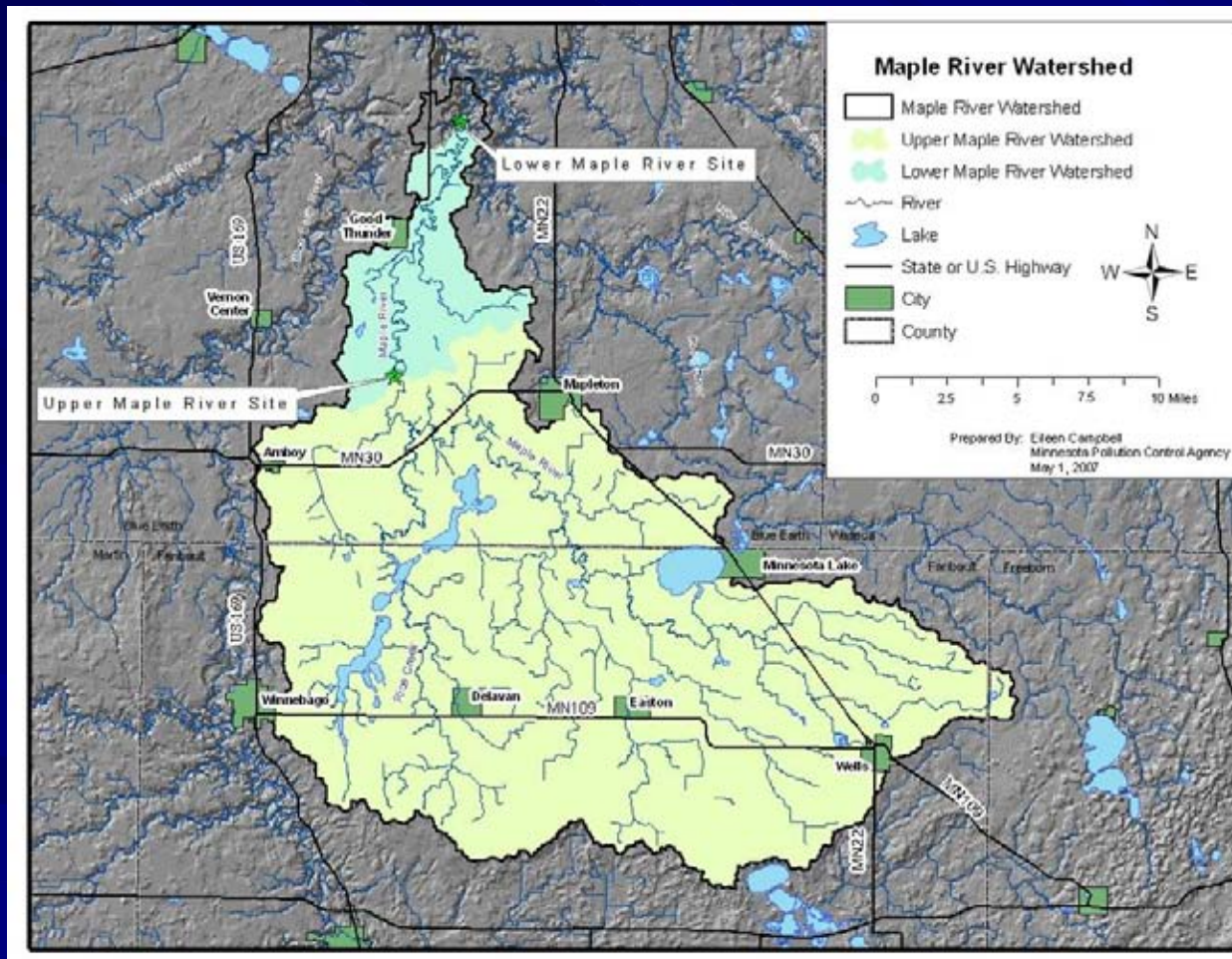
# The Link Between Runoff Type and Sediment Source Contributions to Rivers



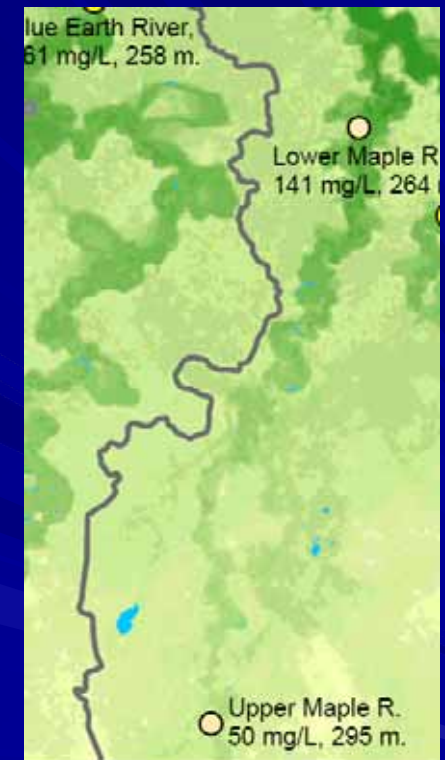
Maple River

Lower Monitoring Site

# TSS Streambank Erosion Regression Method Example: Maple River



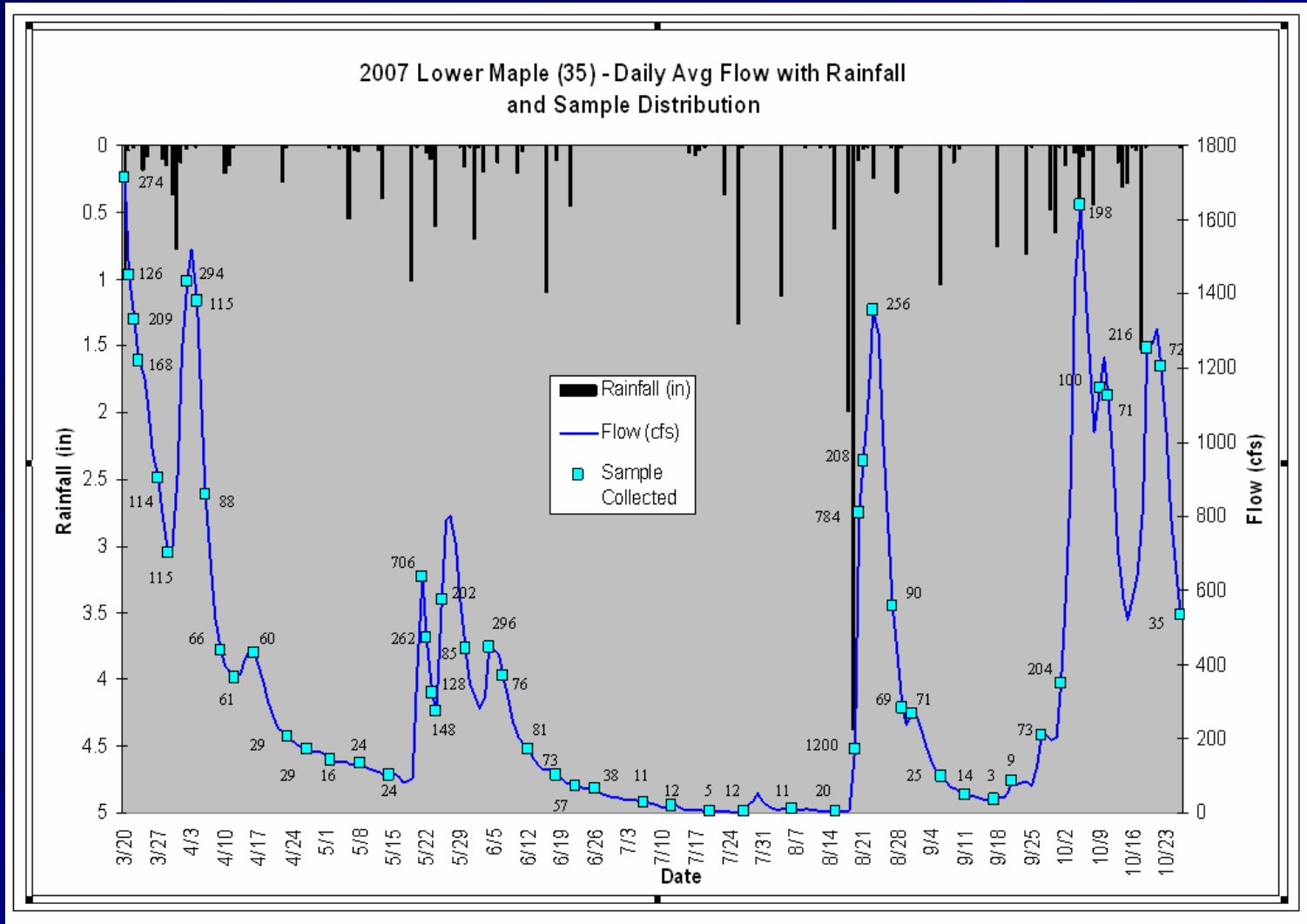
## Watershed slope



Map courtesy of Scott Matteson MNSU Water Resource Center

Map courtesy of Eileen Campbell - MPCA

# Sampling Frequency





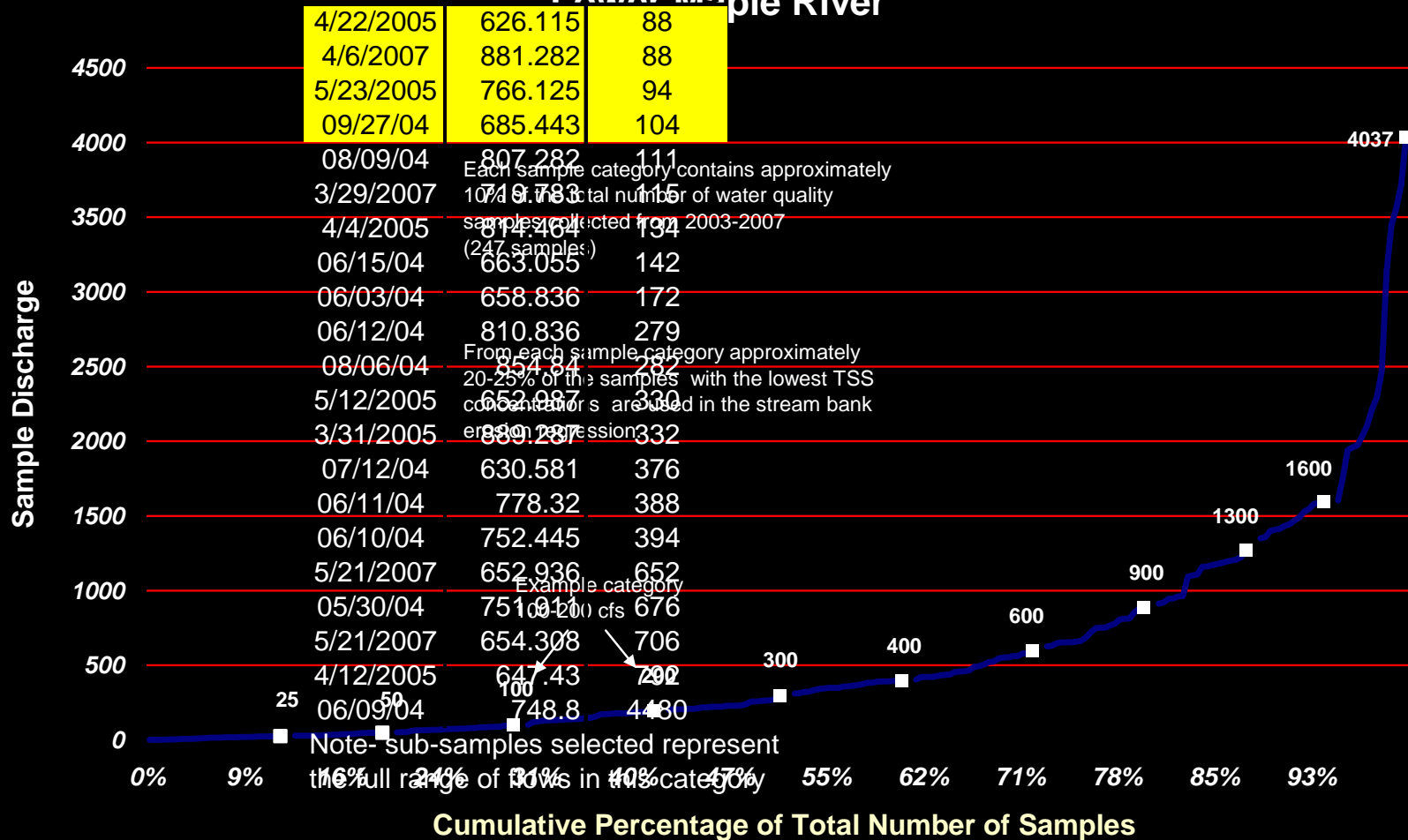
# Step 1: Select Samples For SBE Regression

Example: Samples used in the 600 to 900 cfs sample category:  
 21 samples in entire sample set, 4 used in the SBE regression (19%)

## Discharge Range of Sample Categories

600-900 cfs Flow TSS Maple River

4/22/2005	626.115	88
4/6/2007	881.282	88
5/23/2005	766.125	94
09/27/04	685.443	104

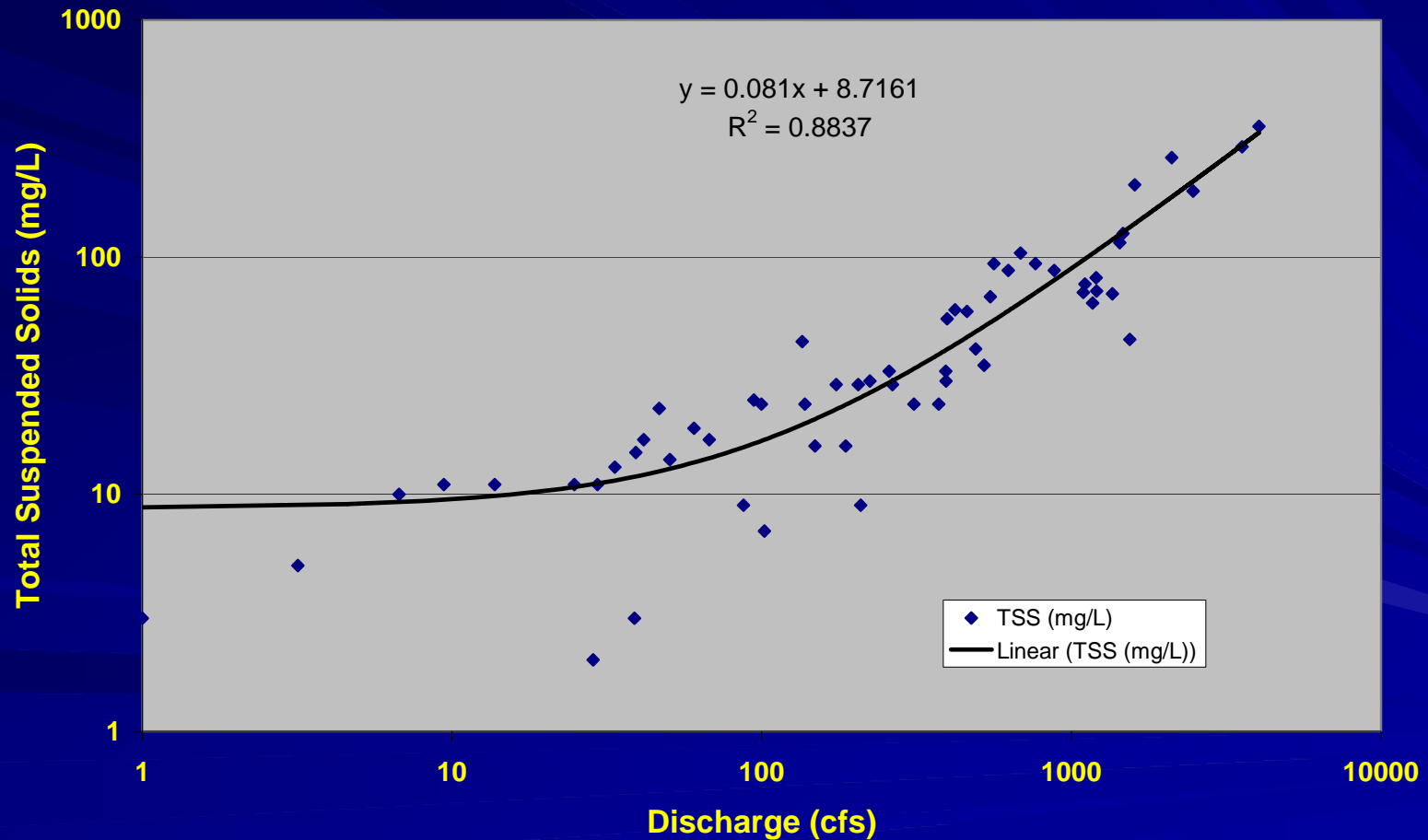


Note- sub-samples selected represent the full range of flows in the category

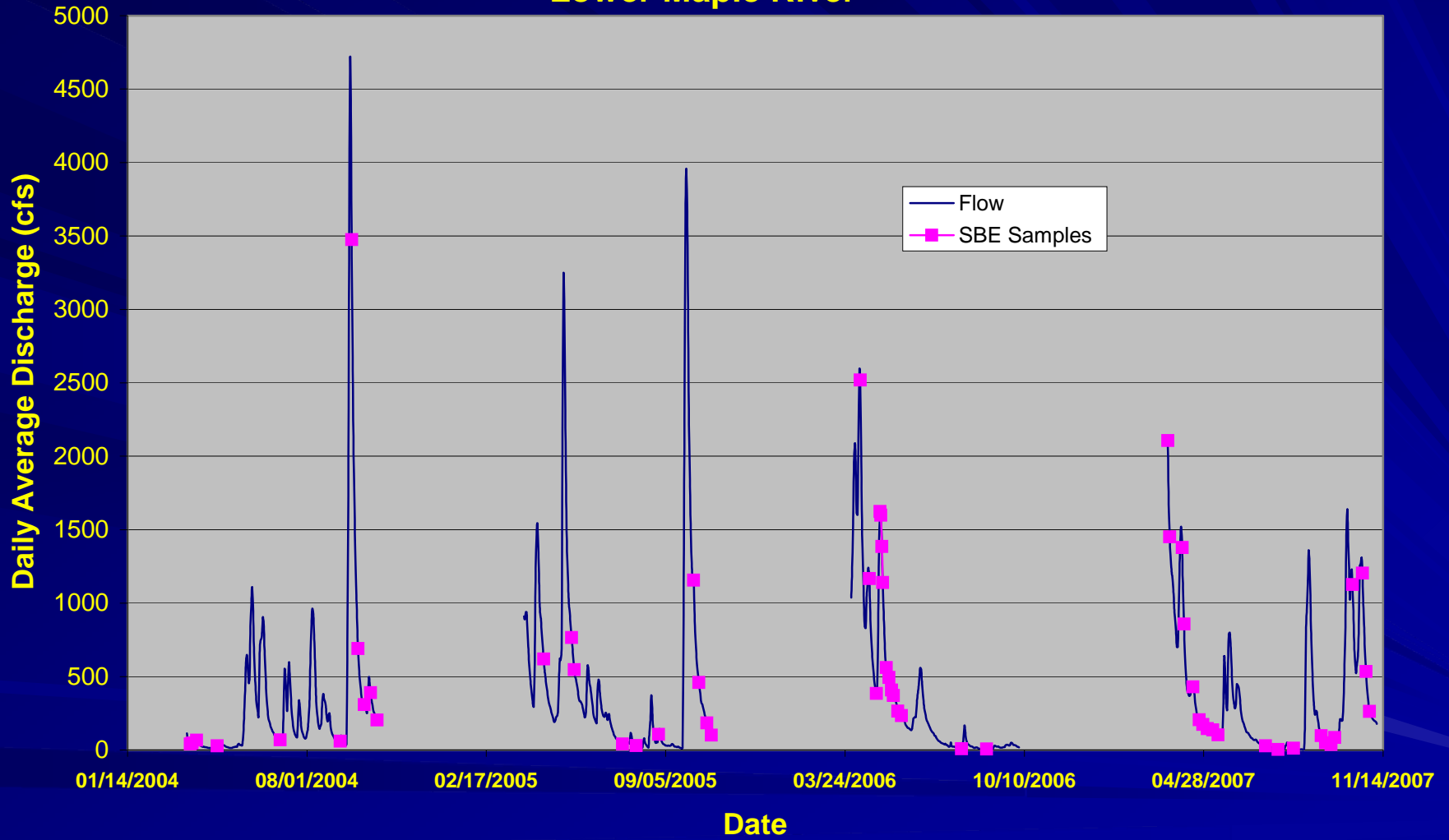
Cumulative Percentage of Total Number of Samples

# Step 2: Create SBE Regression

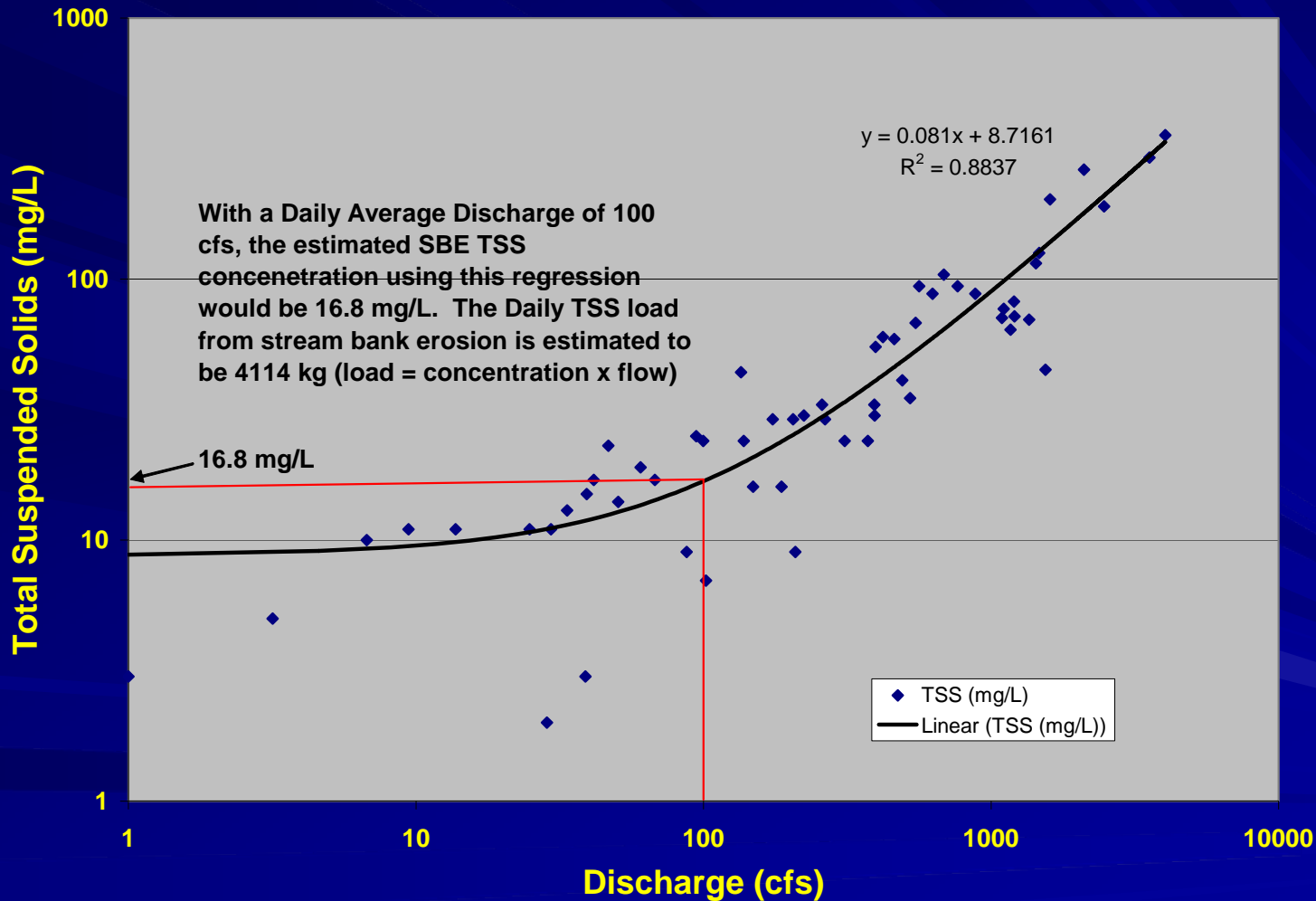
## Stream Bank Erosion Regression Lower Maple River 2003-2007



# Stream Bank Erosion Regression Samples and Daily Average Discharge Lower Maple River



# Step 2: Compute Daily Streambank Erosion (SBE) Loads



Daily Average Flow x SBE TSS Concentration = Daily SBE Load

# Step 3: Compute Seasonal Streambank Erosion Load (generally 4/1 through 9/30)

- Sum of Daily SBE loads = Seasonal SBE load

# Step 4: Compute the Streambank Erosion Proportion of Seasonal TSS Loads

<b>Lower Maple River Streambank Erosion Contribution</b>			
<b>Year</b>	<b>Seasonal TSS Load (tons)</b>	<b>Seasonal Stream Bank Erosion TSS Load (tons)</b>	<b>% of Seasonal TSS Load from Stream Bank Erosion</b>
2003	20511	4190	20%
2004	111604	25572	23%
2005	93808	33129	35%
2006	24610	18217	74%
2007	36902	16953	46%
<b>Numeric 5 year average SBE contribution</b>			<b>40%</b>

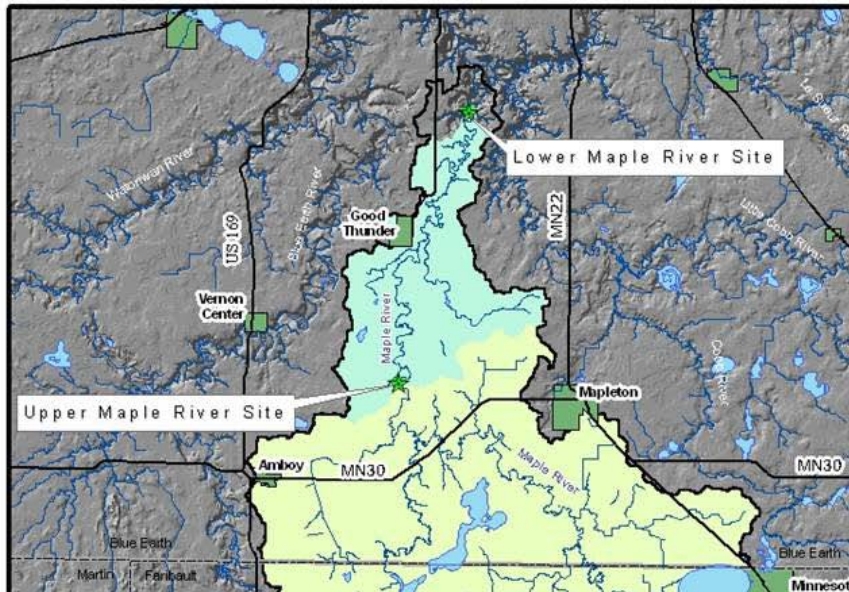
# Percentage of Seasonal TSS Loads from Streambank Erosion Using TSS Flow Weighted Mean Concentrations

<b>Lower Maple River Streambank Erosion Contributions</b>				
<b>Year</b>	<b>monitoring season dates</b>	<b>Lower Maple Seasonal TSS FWMC</b>	<b>Lower Maple Stream Bank Erosion TSS FWMC</b>	<b>% of TSS load from Streambank Erosion</b>
2003	4/24-10/1	264	54	20.4%
2004	3/21-10/18	561	129	23.0%
2005	4/1-10/26	353	126	35.7%
2006	3/31-10/4	140	103	73.2%
2007	3/20-10/26	171	79	45.9%
<b>Numeric 5 year average SBE contribution</b>				<b>40%</b>

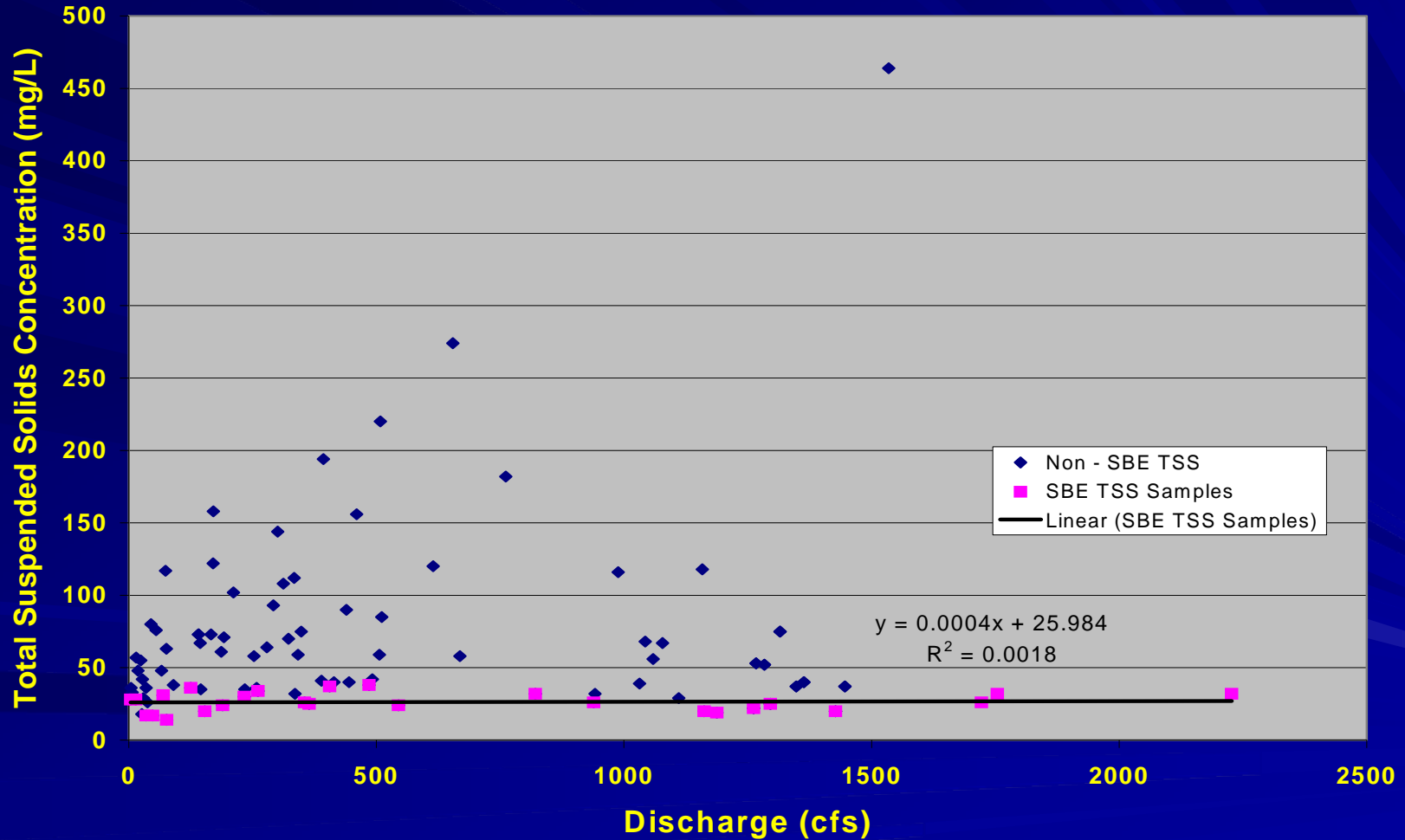
# Summary Table – Average Streambank Erosion Proportion of Seasonal TSS Loads by Watershed

<b>Watershed</b>	<b>Data Years</b>	<b>Average streambank erosion proportion of seasonal TSS load</b>
Watowan R.	7	41%
High Island Cr.	5	31%
Little Cottonwood R.	7	20%
Chippewa R.	8	38%
7 Mile Cr.	8	20%
Maple River	5	40%

# Computing Field and Classic gully TSS Load Proportions Upper Maple River Site

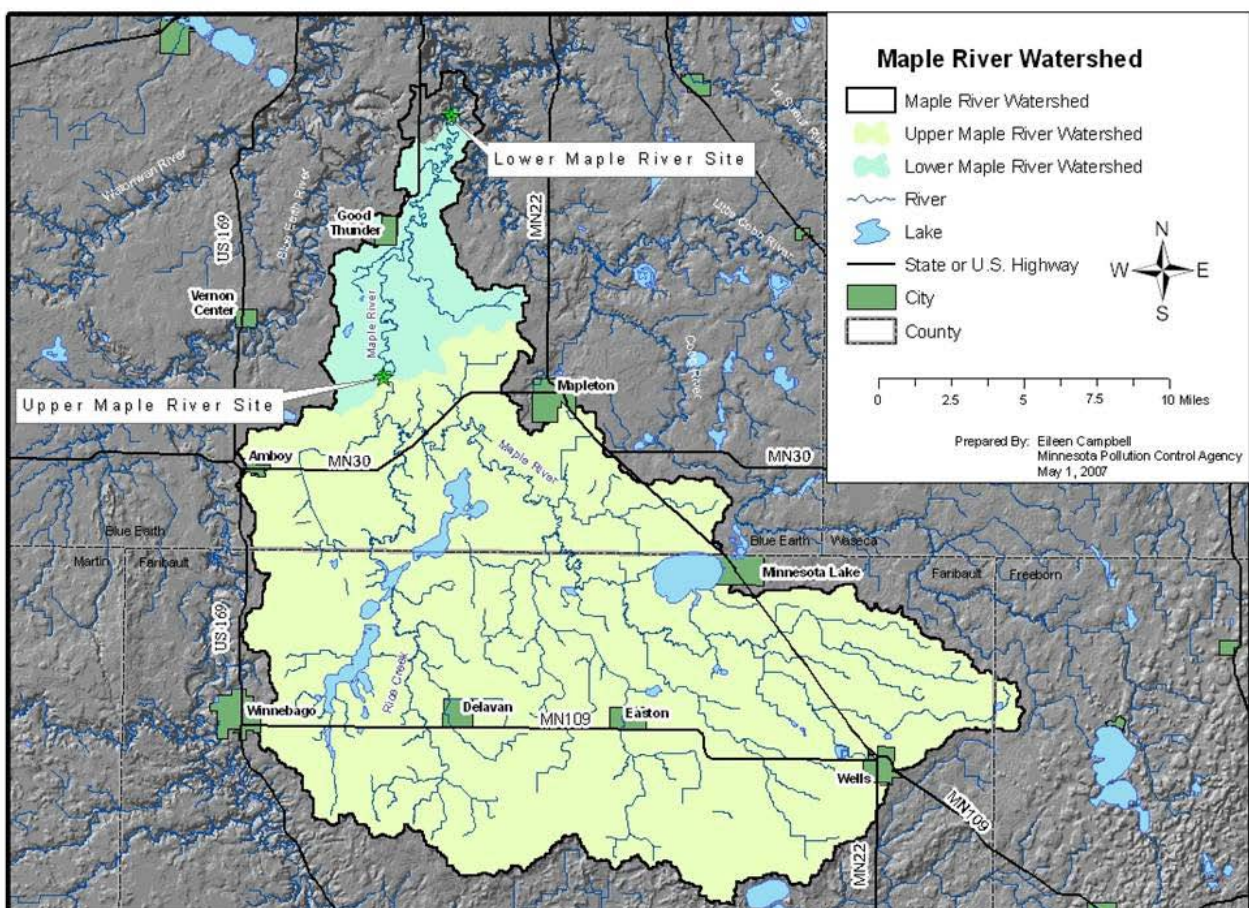


# Upper Maple River SBE Regression



# Streambank Erosion Proportion of Seasonal TSS Load by Year – Upper Maple River

<b>Upper Maple River - TSS Source Contributions</b>					
Year	Seasonal TSS FWMC.	Streambank Erosion TSS FWMC	Field Erosion TSS FWMC	% of Seasonal TSS Load from SBE	% of TSS Load from Field Erosion
2006	50.86	26.4	24.5	51.9%	48.1%
2007	61.57	26.3	35.2	43%	57.2%
Two Year numeric Average SBE contribution				47%	



### Upper Maple River - TSS Source Contributions

Year	Seasonal TSS FWMC.	Streambank Erosion TSS FWMC	Field Erosion TSS FWMC	% of Seasonal TSS Load from SBE	% of TSS Load from Field Erosion
2006	50.86	26.4	24.5	51.9%	48.1%
2007	61.57	26.3	35.2	43%	57.2%
Two Year numeric Average SBE contribution				47%	

# TSS Load Source Proportions for the Lower Maple River

**Lower Maple River Source Contributions**

Year	Lower Maple Seasonal TSS FWMC	Lower Maple SBE TSS FWMC	Field Erosion TSS FWMC (computed from Upper Maple site)	% of TSS load from SBE	% of TSS load from Field Erosion	% of TSS load from Classic Gulleys
2003	264.3	54.0		20.4%		
2004	561.1	128.8		23.0%		
2005	353	126.0		35.7%		
2006	140	102.5	24.5	73.2%	17.5%	9.3%
2007	171.25	78.7	35.2	45.9%	20.6%	33.5%

# Caveats and Criticisms

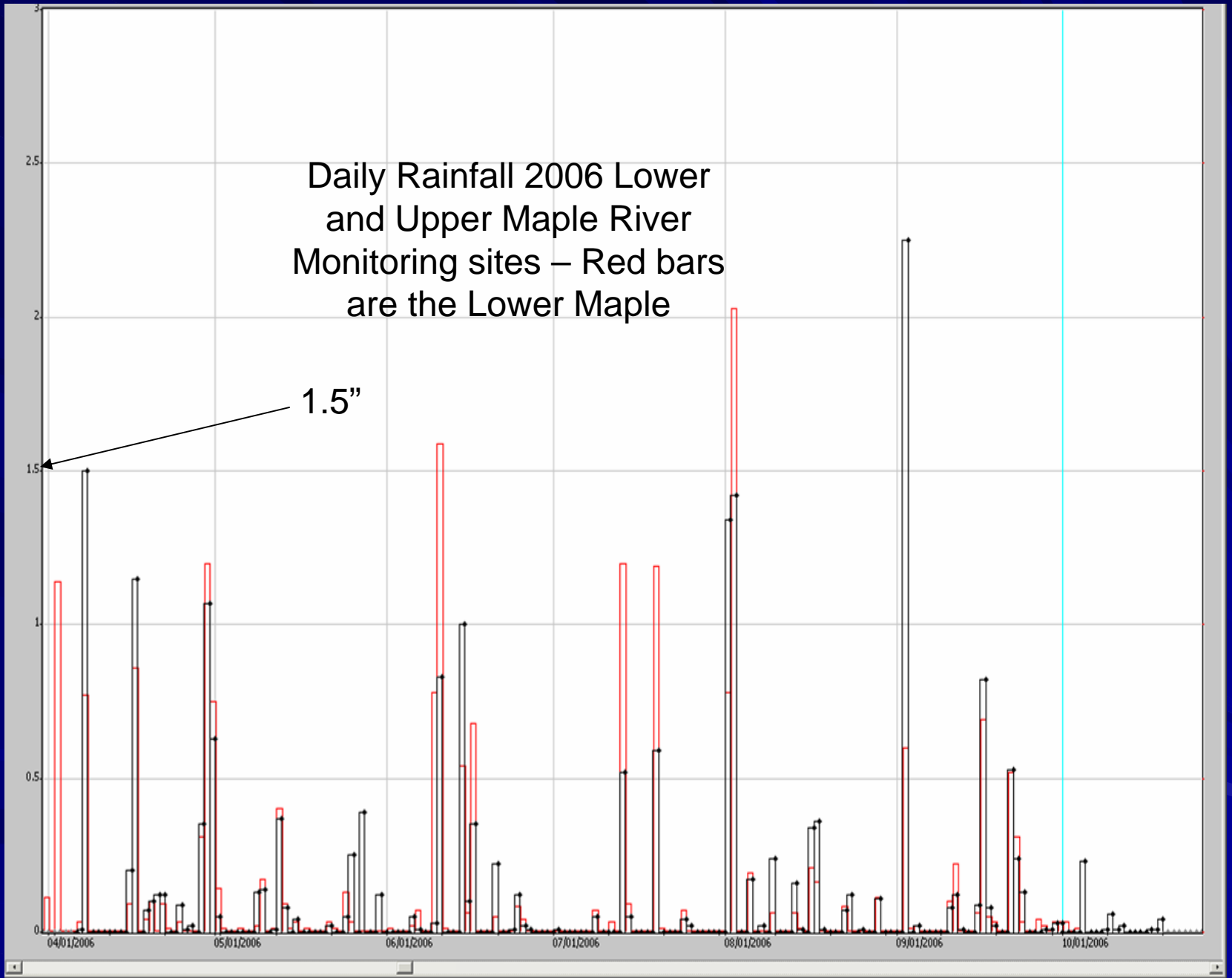
- Streambank Erosion from ice
- Rainfall on streambanks is not included
- Ephemeral gully erosion from tile outlets is included in the SBE calculation
- Too many samples: over-predicting SBE contributions
- More SBE occurs when flows are rising

# Conclusions

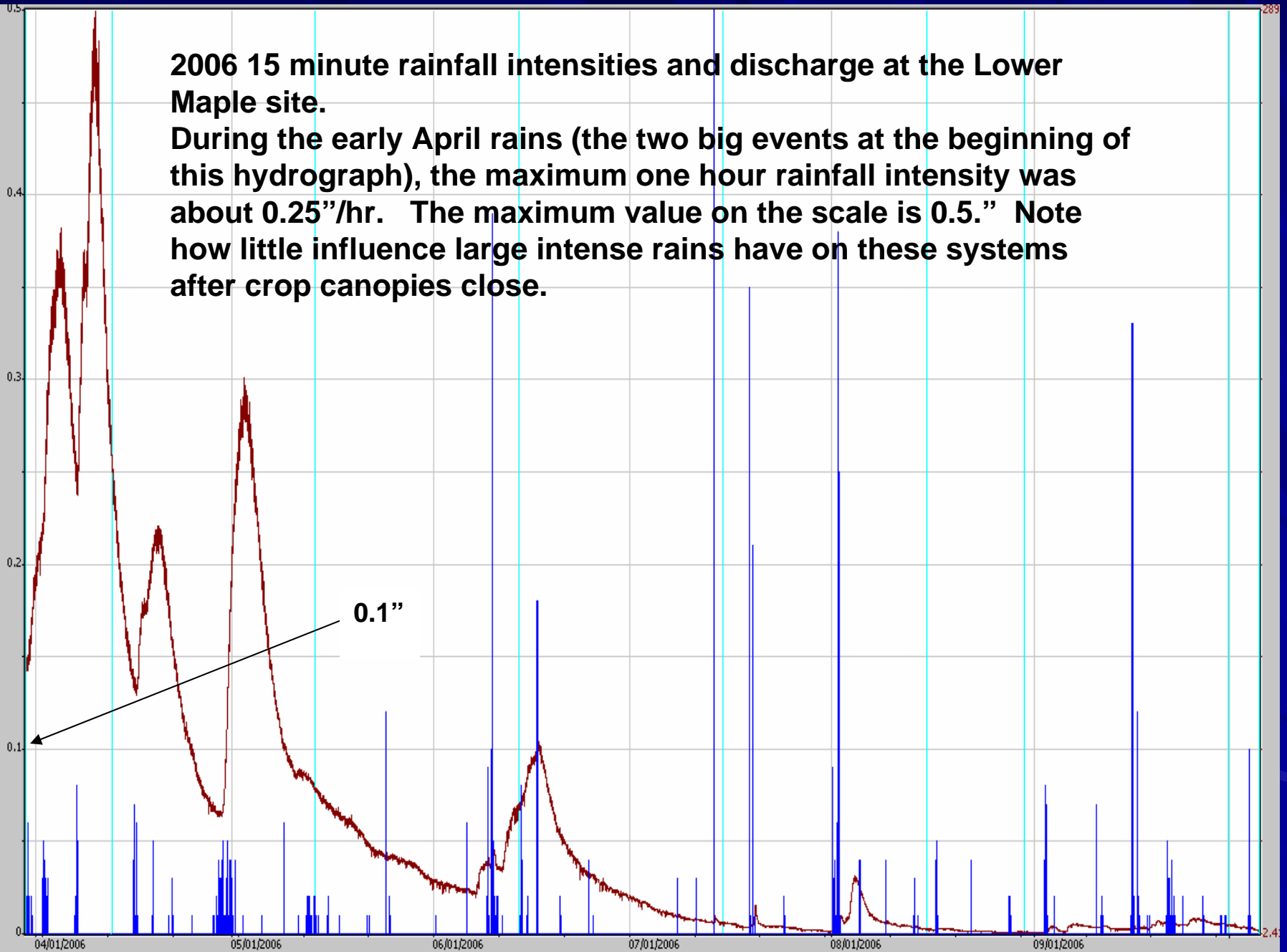
- For the analyzed watersheds, on average no more than 40% of TSS load can be from SBE
- SBE proportions are variable from year to year: climate, timing of events affect TSS source contributions
- When field and gully erosion are the dominant sediment sources, streams are the dirtiest
- In some watersheds all major sediment source contributions can be determined with this method.

Daily Rainfall 2006 Lower  
and Upper Maple River  
Monitoring sites – Red bars  
are the Lower Maple

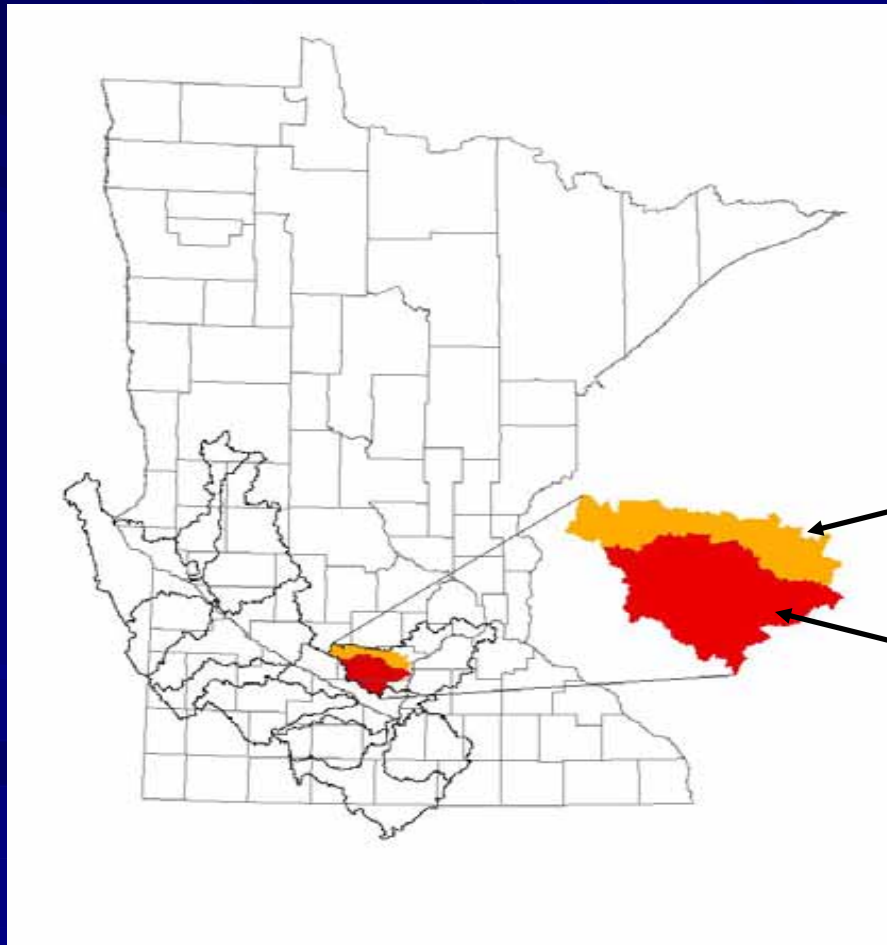
1.5"



**2006 15 minute rainfall intensities and discharge at the Lower Maple site.**  
**During the early April rains (the two big events at the beginning of this hydrograph), the maximum one hour rainfall intensity was about 0.25"/hr. The maximum value on the scale is 0.5." Note how little influence large intense rains have on these systems after crop canopies close.**



# Streambank/Bluff Erosion Estimates for High Island Creek Watershed



**High Island Creek  
Watershed**

**Rush River  
Watershed**

# Percentage of Land with Slopes Greater than 12% by Watershed

Watowan River Watershed and High Island Creek Watershed  
Steeply Sloped Lands (>12%)

Watowan River Watershed Outlet Area



Watershed Acreage = 544,545  
Percentage of Watershed >12% Slope = 0.4%

High Island Creek Watershed Outlet Area



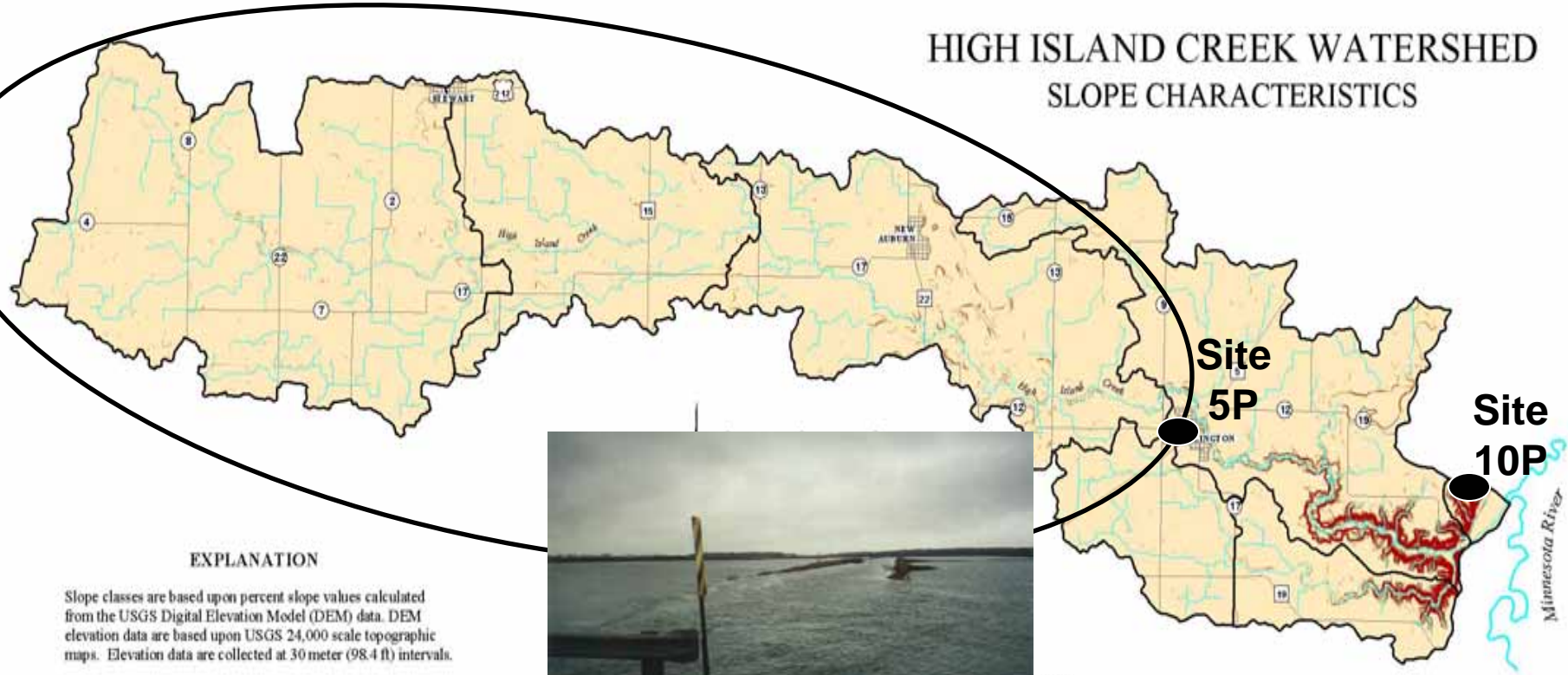
Watershed Acreage = 152,149  
Percentage of Watershed >12% Slope = 1.2%

- ▲ Monitoring Site
- >12% Sloped Land
- City
- ~ Stream

3 0 3 6 9 Miles

Map Prepared by: Scott Matteson  
Water Resources Center  
Minnesota State University, Mankato  
S0C006

# HIGH ISLAND CREEK WATERSHED SLOPE CHARACTERISTICS



## EXPLANATION

Slope classes are based upon percent slope values calculated from the USGS Digital Elevation Model (DEM) data. DEM elevation data are based upon USGS 24,000 scale topographic maps. Elevation data are collected at 30 meter (98.4 ft) intervals.

ACRES	PERCENT	SLOPE CLASS
146,485	96%	<= 3%
3,593	2%	> 3% and <= 6%
1,586	1%	> 6% and <= 12%
1,558	1%	> 12%

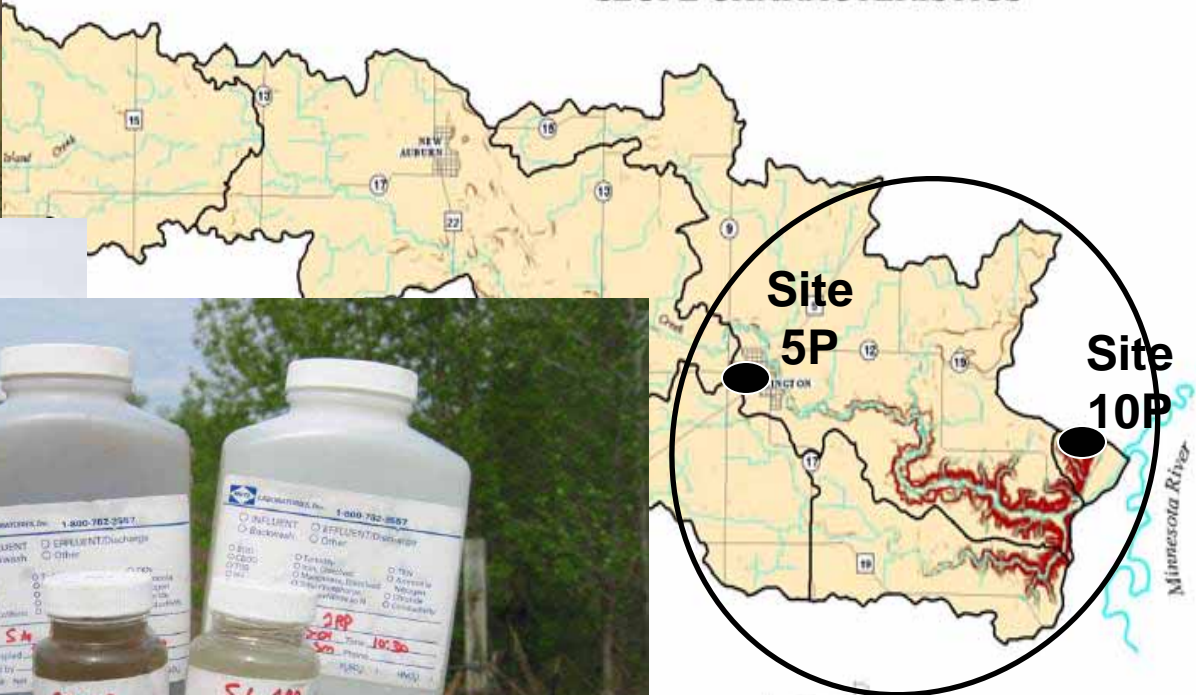


INDEX MAP  
PRIMARY SAMPLESHEDS



LOCATION MAP

# HIGH ISLAND CREEK WATERSHED SLOPE CHARACTERISTICS



Site  
5P  
10P

ACRES	PERCENT
146,485	96%
3,593	2%
1,586	1%
1,558	1%



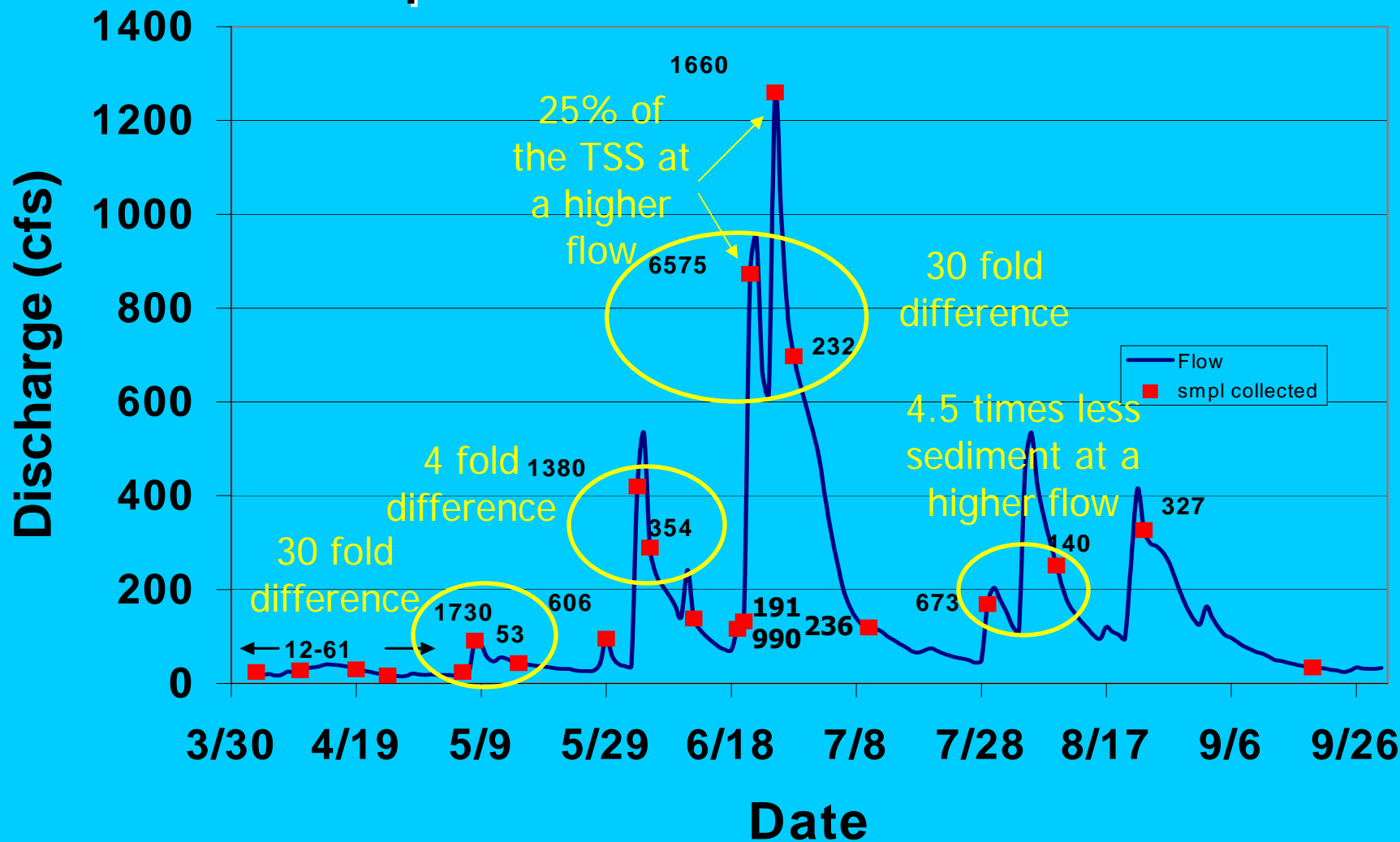
INDEX MAP  
PRIMARY SAMPLESHEDS

The High Island Creek Watershed  
Control Agency (MPCA) Clear



LOCATION MAP

# 2002 High Island Creek Daily Average Discharge and Total Suspended Solids Concentrations



# 2001 High Island Creek Total Suspended Solids Load

