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TOOLS AND STRATEGIES FOR REDUCING CHANNEL EROSION IN MINNESOTA

Background and approach

- Channel loading major source of sediment in much of MN River basin and around Midwest
- Need approach to prioritize restoration and management sites with limited funds
- Science transfer: need usable tools for TMDLs

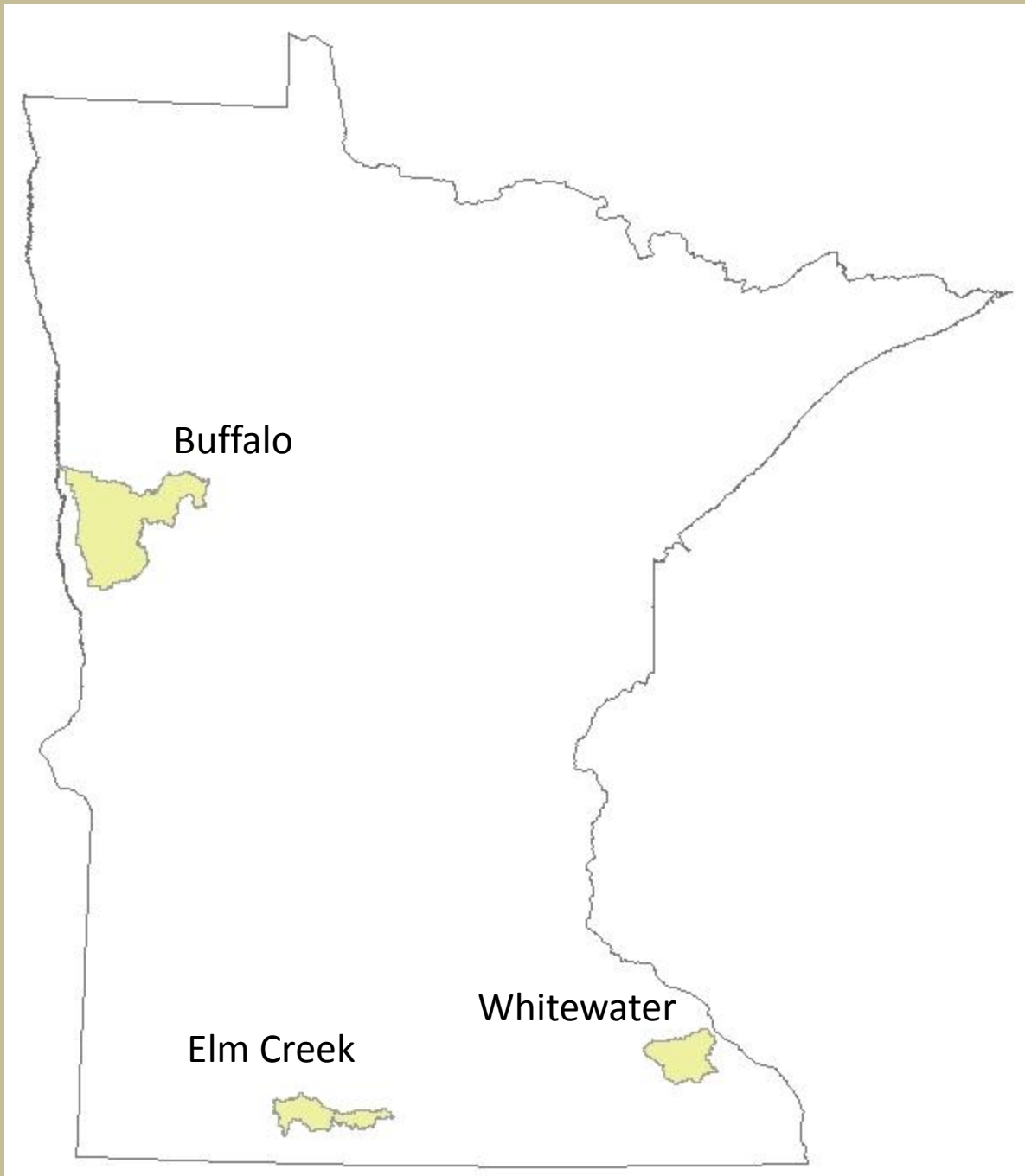
Two prioritization projects

MN Dept. of Agriculture

- Prioritization of restoration actions in sentinel watersheds
 - Development of tools for use in TMDLs
 - Research into hydrologic drivers of erosion to help target flow-reduction BMPs

McKnight Foundation

- Developing a comprehensive approach for reducing channel erosion in the MN River Basin
 - GIS
 - Landowner meetings
 - Cost-benefit analysis
 - Development of cost-effective riparian corridor BMPs



Three regions

- Red River Basin
- Cornbelt- Des Moines Lobe till plain
- Driftless Area

Prioritization tools: a MN-specific bank erosion index



- Installation of long-term research in 3 ecoregions
 - Driftless region (Whitewater)
 - South Central MN (Elm Creek)
 - Red River Basin (Buffalo)

Comparison to USLE

BEHI parameters

Bank resistance vs. erosion forces

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001b, 2006b). Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream:		Location:	
Station:		Observers:	
Date:		Valley Type:	

Study Bank Height / Bankfull Height (C) (Fig. 3-7)				BEHI Score
Study Bank Height (ft.) (A)	Bankfull Height (ft.) (B)	(A) / (B) =	(C)	
Root Depth / Study Bank Height (E)				
Root Depth (ft.) (D)	Study Bank Height (ft.) (A)	(D) / (A) =	(E)	
Weighted Root Density (G)				
Root Density as % (F)	(F) × (E) =	(G)		
Bank Angle (H)				
Bank Angle as Degrees (H)				
Surface Protection (I)				
Surface Protection as % (I)				
Bank Material Adjustment:		Bank Material Adjustment		
Bedrock (Overall Very Low BEHI)		Boulders (Overall Low BEHI)		
Cobble (Subtract 10 points if uniform med. to large cobble)		Gravel or Composite Matrix (Add 5-10 points depending on percentage of bank material that is composed of sand)		
Sand (Add 10 points)		Silt/Clay (No adjustment)		
Stratification Adjustment		Stratification Adjustment		
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage				

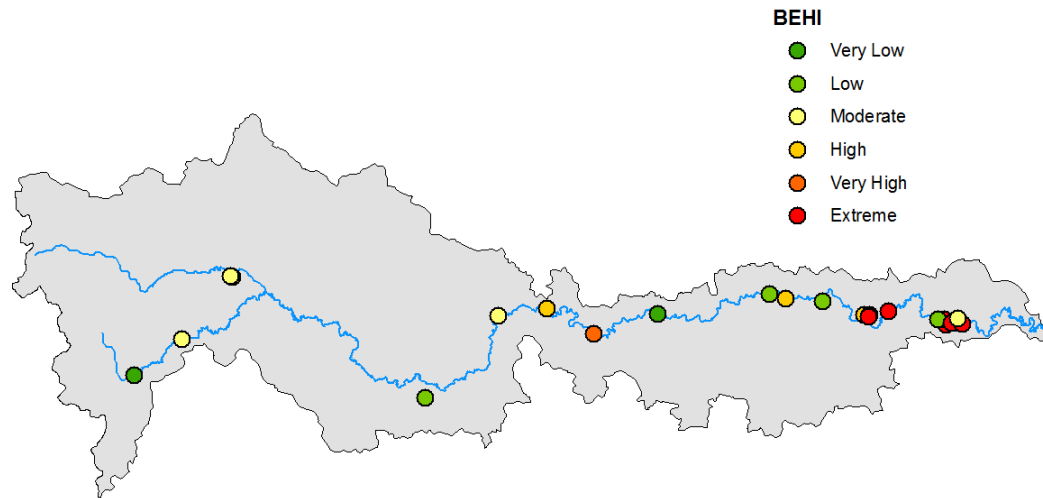
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50	

Bank Sketch

General findings

- Bank ht: bankfull ht
- Rooting depth/density
 - Grass
 - trees
- Soil properties
 - Alluvial (lower Whitewater, Elm)
 - Lake plain clay (Buffalo)
 - Glacial till (Buffalo, Elm)

Elm Cr. BEHI prioritization



Erosion rates (ft/yr)

Very low: .02- .10

Low: .1-.2,

Mod: .25-.6,

High/v. high: .6-2.0,

extreme: 2-8

Loading (mass)=

2 to 1600 tons/yr

per segment;

mean ~ 100 t/yr

Lower Elm Creek
producing most of
sediment

Pros & cons of index

- Useful for prioritization and TMDL load estimates
- Builds on DNR, MPCA work in Whitewater & Buffalo watersheds
- Problems - net transport?
- Biota vs. turbidity TMDLs?

Measurement of net sediment rate

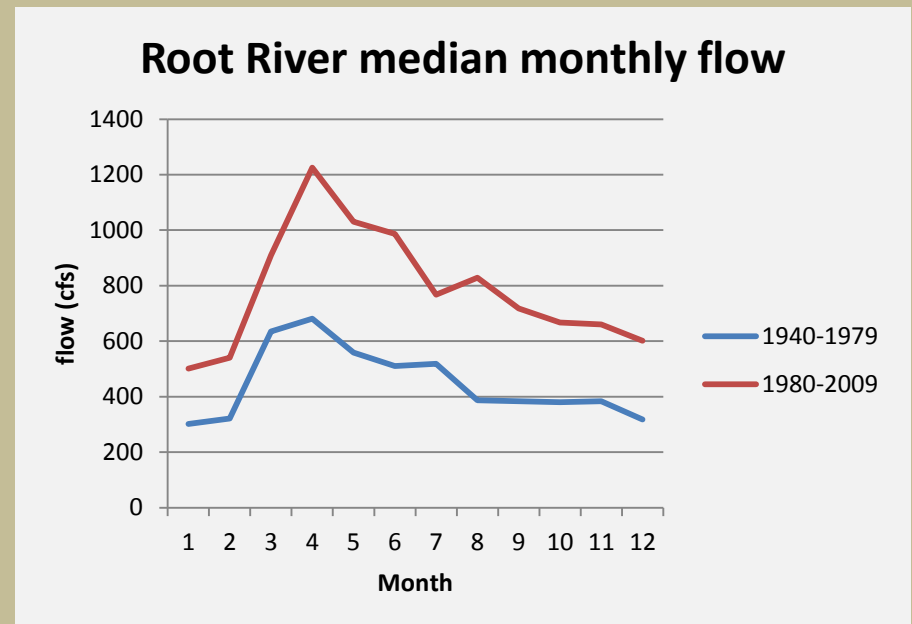
- Field measures of deposit volume with tree core dating in forest
- Scale up to whole river using model in GIS to get tons/year deposited



Hydrologic drivers of erosion: streamflow change statistics

- Hydrologic regime change: Indicators of Hydrologic Alteration (IHA)
- Streamflow-Precipitation (Q:P)
- Land cover & climate change
- Impacts on channel erosion and evolution?

Driftless area example



Hydrologic drivers of erosion: BSTEM modeling

- Mechanics of bank collapse – data on soil erodibility, other
- Input to BSTEM
- Calculates mass of sediment eroded

Input bank geometry and flow conditions

Work through all 4 sections then hit the "Run Bank Geometry Macro" button.

1) Select EITHER Option A or Option B for Bank Profile and enter the data in the relevant box-cells in the alternative option are ignored in the simulation and may be left blank if desired.

2) Enter bank material layer thicknesses (if bank is all one material it helps to divide it into several layers).

3) If bank is submerged then select the appropriate channel flow elevation to include confining pressure and calculate erosion amount; otherwise set to an elevation below the bank toe.

To ensure bank profile is correct you can view it by clicking the **View Bank Geometry** button.

Option A - Draw a detailed bank profile using the boxes below

☐ Option A

Point	Station (m)	Elevation (m)	Top of toe?
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
L			
M			
N			
O			
P			
Q			
R			
S			
T			
U			
V			
W			

Shear emergence elev

Shear surface angle

Option B - Enter a bank height and angle, the model will generate a bank profile

☒ Option B

5.0 a) Input bank height (m)

85.0 b) Input bank angle (°)

1.0 c) Input bank toe length (m)

25.0 d) Input bank toe angle (°)

Input shear surface angle

Bank layer thickness (m)

Elevation of layer base (m)

Layer	Thickness (m)
Layer 1	5.00
Layer 2	5.00
Layer 3	5.00
Layer 4	5.00
Layer 5	5.00

Parallel layers, starting from point B

Channel parameters

Input reach length (m)

Input reach slope (m/m)

Input concentration (kg/kg)

Input elevation of flow (m)

Input duration of flow (hrs)

Definition of points used in bank profile

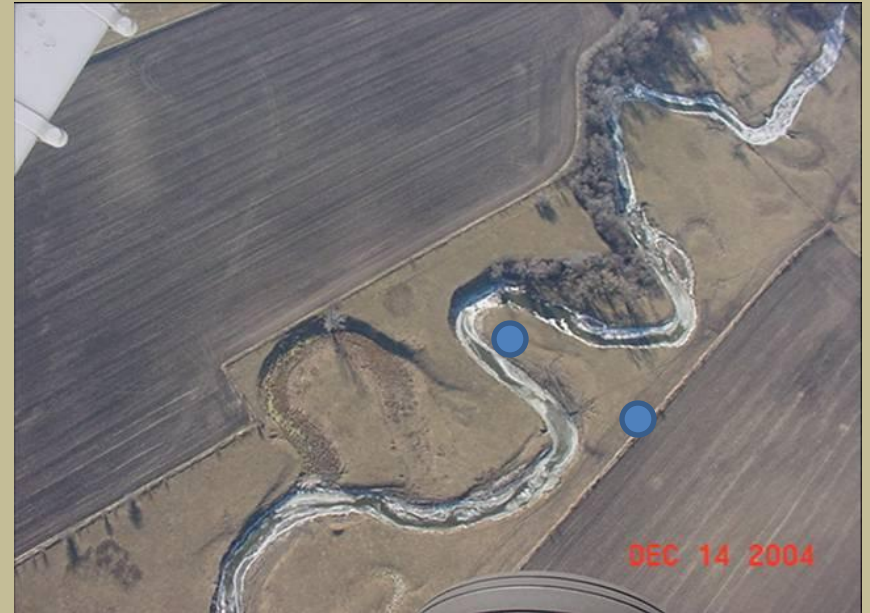
A - bank top: place beyond start of shear surface
 B - bank edge
 C-P - breaks of slope on bank (if no breaks of slope place as intermediary points)
 Q - top of bank toe
 R-U - breaks of slope on bank toe (if no breaks of slope then insert as intermediary points)
 V - base of bank toe
 W - end point (typically mid point of channel)

Notes:
 Bank profile may overhang.
 If the bank profile is fully populated, the shear surface emergence point should be anywhere between points B and Q.
 The shear surface emergence point must not be on a horizontal section - the elevation of this point must be unique or an error message will display.

View Bank Geometry

Field studies of bank erosion mechanisms

- Benchmarked sites for resurvey-to calibrate BEHI and BSTEM
- Well transect to document water level
- Bank collapse monitored with time-lapse cameras; resurvey
- Water sources: specific conductivity & isotopes



Comparison of priorities

Elm Creek (south central)

SEDIMENT Sources

- streambanks, fields

PRIORITIES

- Sediment loading to MN River, wetlands & waterfowl

SOLUTIONS:

- Wetland storage
- Targeted bluff and channels

Whitewater (Driftless Area)

SEDIMENT Sources

- Fields, banks

PRIORITIES

- Trout fishing

SOLUTIONS:

- Reduce field erosion; hydrologic storage; streambanks?

Issues: Time lag for WQ response

CAST Report:

Assessing The Health of Streams in Agricultural Landscapes: How Land Management Change Impacts Water Quality . 2012. (Special Publication:
Project Manager - Rick Cruse, Iowa
Water Center)

- MN River basin may take decades for noticeable gains
- Smaller basins may respond more quickly --

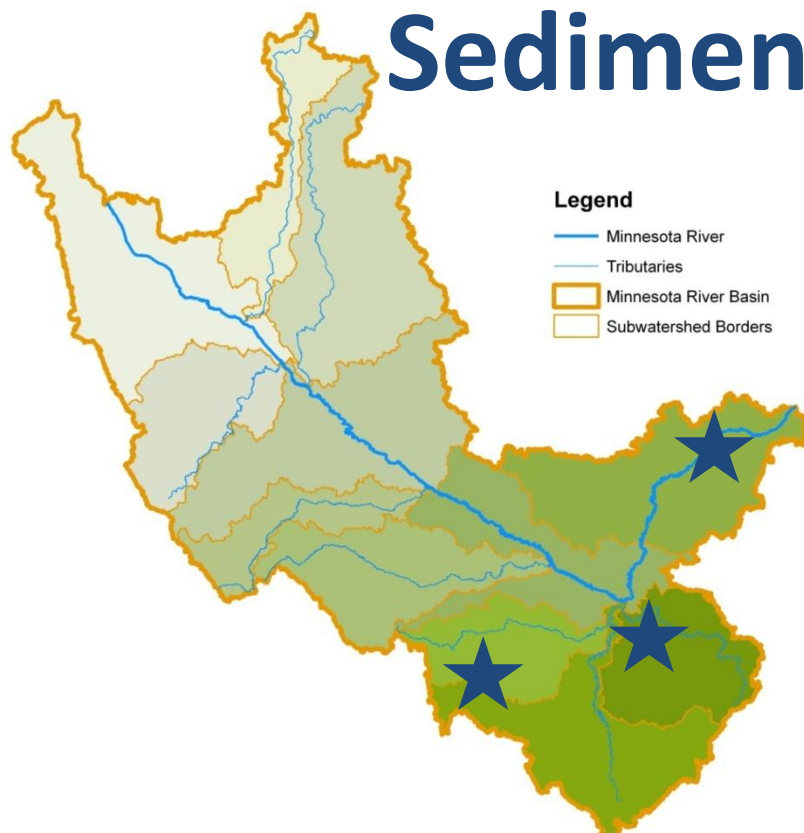


McKnight Study on MN River Basin

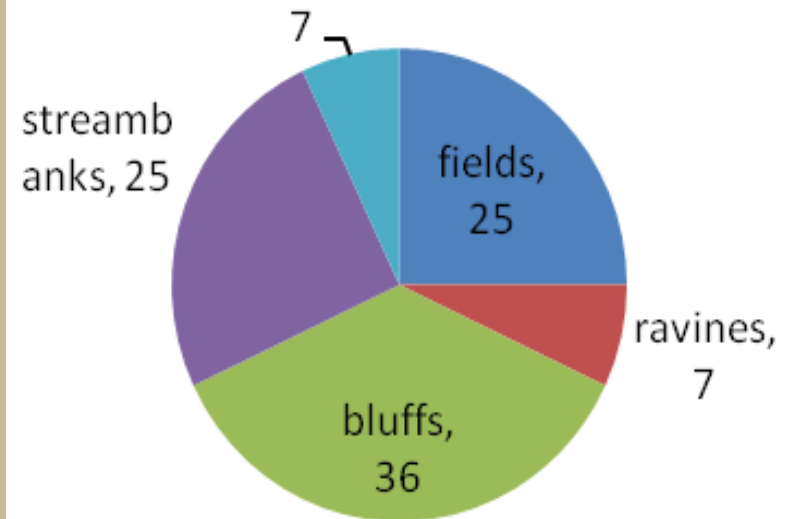
- Collection of existing data
- Cost benefit data
- Case studies
- Development of cost-effective riparian BMPs



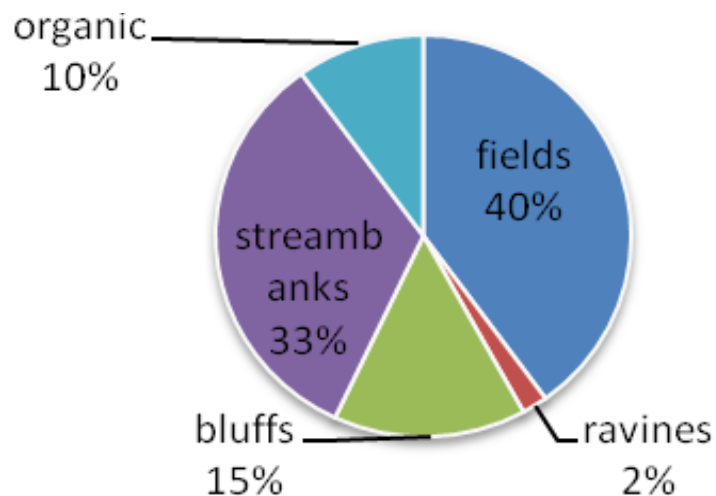
Sediment sources



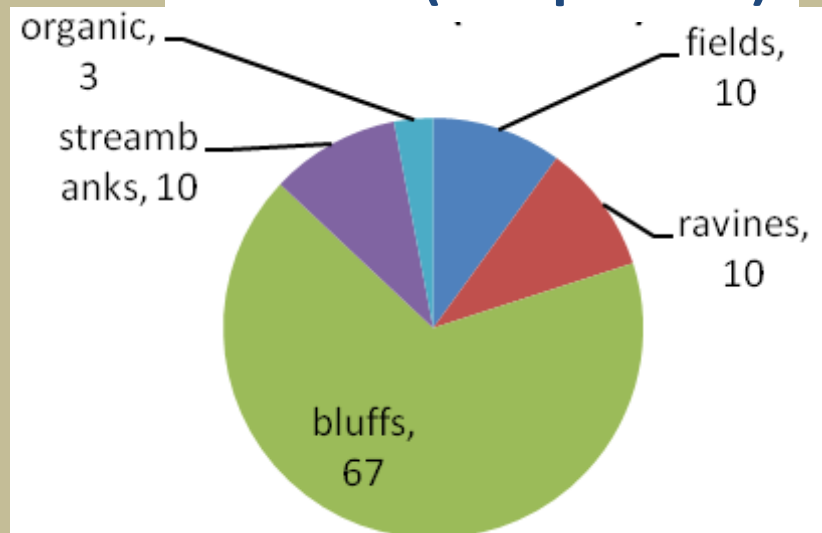
Minnesota main channel



Elm Creek (headwaters)



LeSueur (steep bluffs)



BMPs targeting

By geomorphic region

- Western till plains / prairie potholes
- Bluff country
- Lower MN river

Cost/benefits

- Cost of ravines, bluffs, streambanks
- landowner preferences
- Fit with ag systems
- Total ecological services

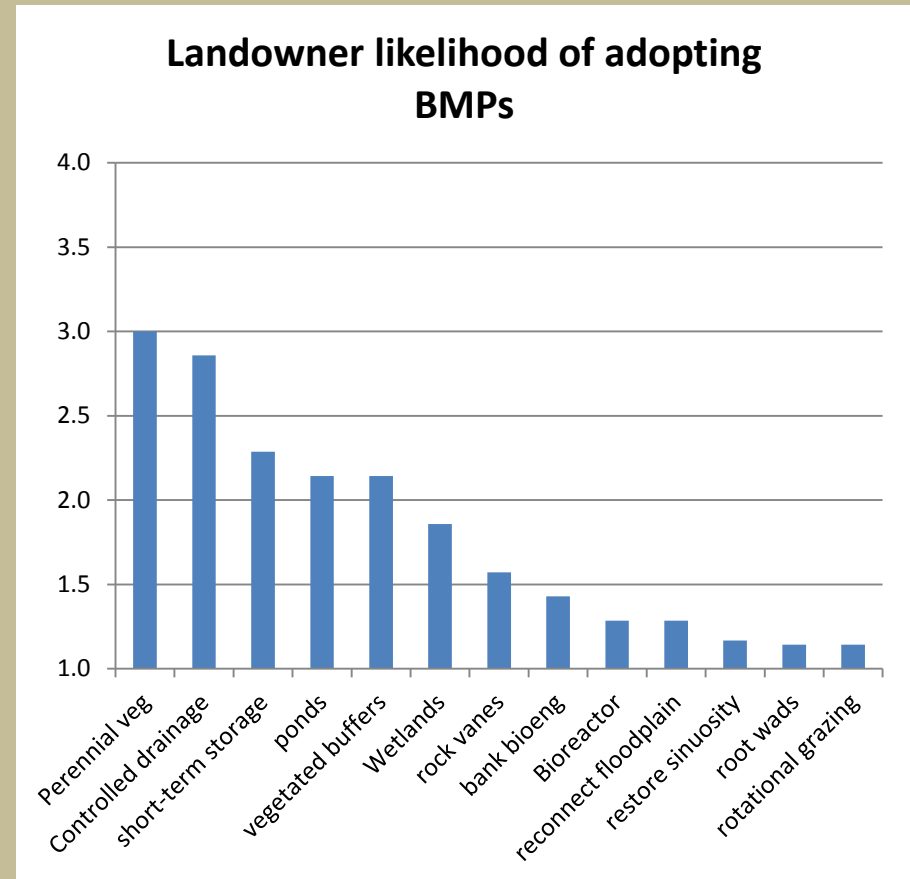
Cost of channel stabilization

- 57 projects, avg. \$100 per linear foot (range \$20-\$750)
- Hidden costs mobilization, consulting
- Preliminary findings
 - Rural/urban difference
 - Rock vs. wood
 - Haves (Twin Cities, trout streams, Red River flooding) vs. have nots – western MN River basin
 - Need cost-effective riparian zone BMPs

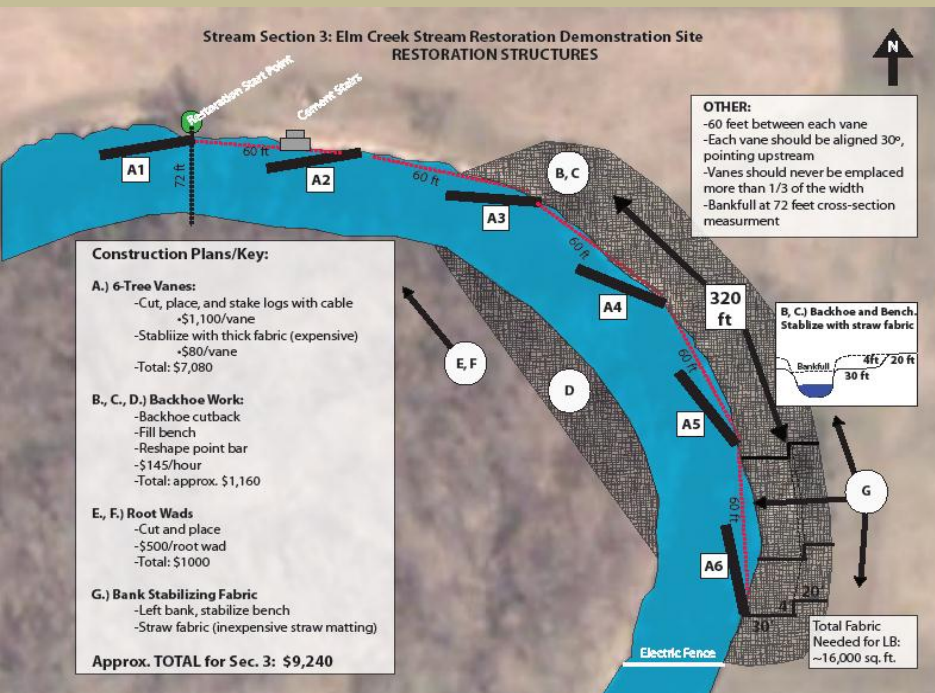
(data collected by L. Lahti)

Landowner meeting @ Elm Cr

- Survey from 12/14
- Familiar practices favored
- Stream restoration – unfamiliar
- Technology and training gap exists
- **Opportunity is in riparian corridor, less in fields**

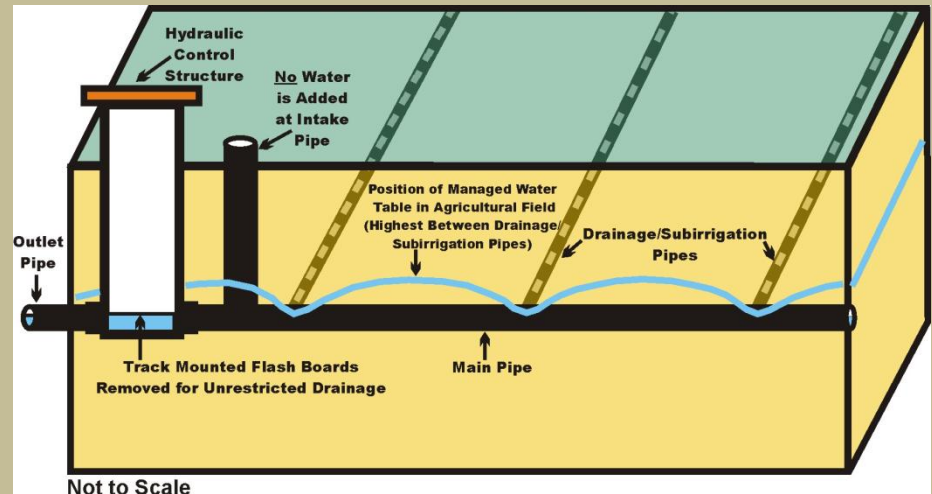


Use of low-cost, local materials



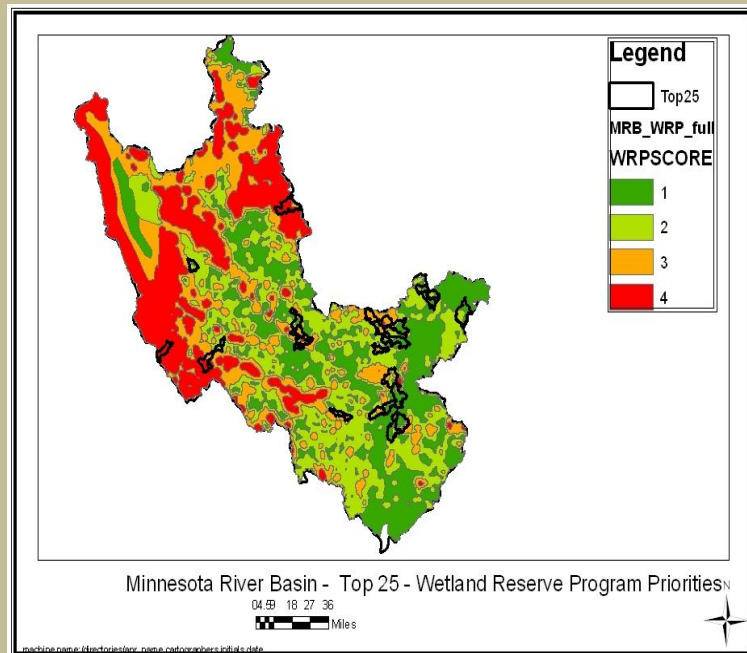
Tile flow interception

- Controlled drainage
- Saturated buffers
- Treatment wetlands



Watershed practices : water storage in restored wetlands

- Hydrologic storage
- Flood peak reduction
- Excellent N removal
- Some P removal



MN River strategy

- Short term – focus on riparian corridor where implementation is possible
- Focus on smaller watersheds where WQ improvements can be seen (esp. sentinel watersheds)
- MN Basin hydrologic change will require economic & policy shift to reduce flow
 - Change Farm Bill
 - Economic incentives

Future work

- MDA study to 2014
 - Develop strategies for different geomorphic regions in MN River basin by 2013
- Other
 - Channel evolution research
 - Riparian vegetation management guidelines update?

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Data, Meeting Assistance: Linse Lahti, Linda Meschke, Mary Presnail

Role of veg in bank erosion

Bluff – 25 ft



Stream bank 7 ft

Riparian veg BMP update is needed