Channel erosion and floodplain deposition processes in the Minnesota River Basin, USA

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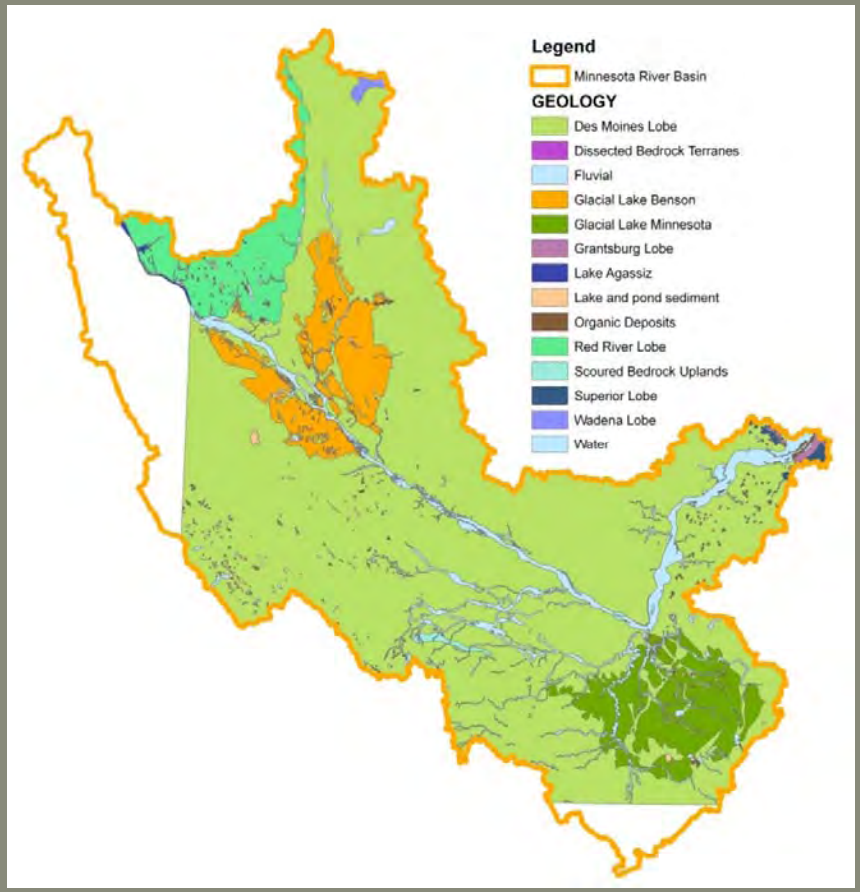
Research projects

- *Ravine, Bluff and Streambank (RBS) Erosion study of Minnesota River Basin* (Nieber and Mulla) MPCA (complete)
- *Streambank loading and floodplain sedimentation study* -MN Corn Growers (ongoing through 2011)
- *Differential response of MN watersheds to climate change* -USGS & MN Water Resources Center (complete)

Minnesota River largest sediment loader to upper Mississippi R.



Sediment sources today

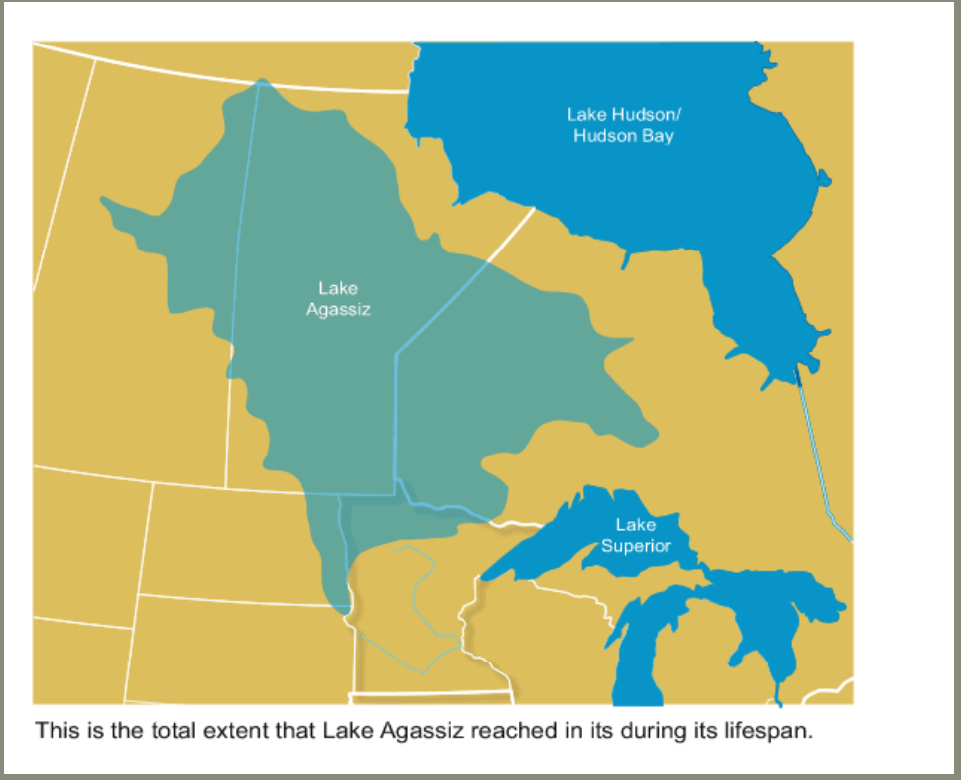
Channel erosion

Field erosion

Channels now largest source of sediment at MN river mouth (shown at left) 66 – 75%

Engstrom et al. 2009

Glacial River Warren carved wide valley 10,000 years b.p.



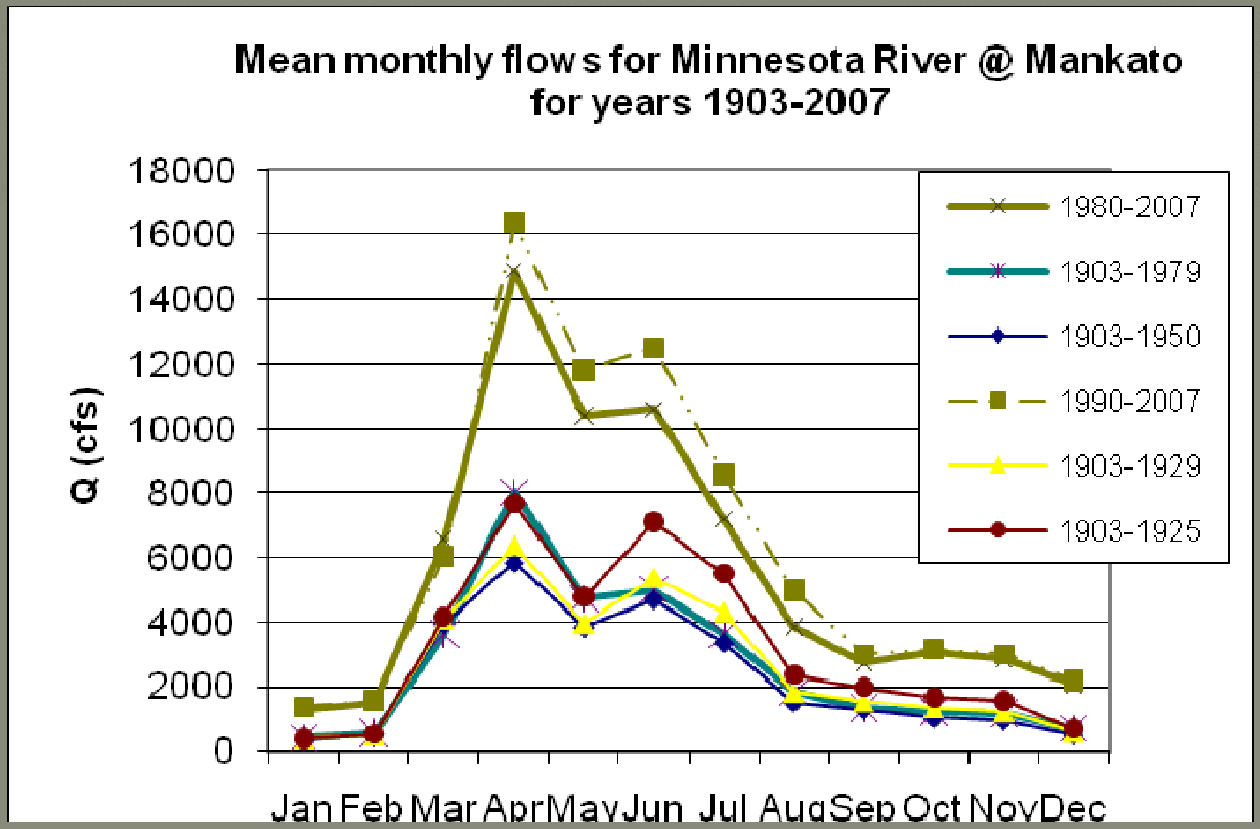
This is the total extent that Lake Agassiz reached in its during its lifespan.

Map adapted from Richard W. Ojakangas and Charles L. Matsch's *Minnesota's Geology*. University of Minnesota Press, Minneapolis, 1982

Present –day Minnesota River is underfit to wide valley

Hydrologic alteration

- Increased streamflow in MN River
- Low flow to 90th percentile most changed

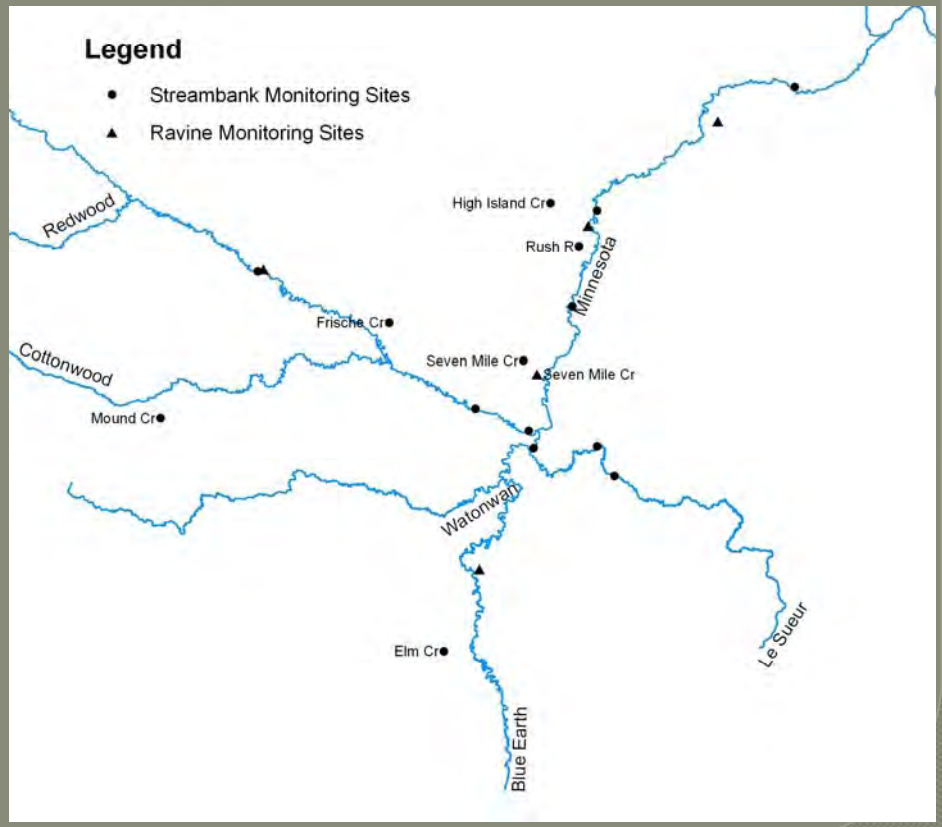


Lenhart C, Peterson H, and Nieber. J. 2011. Increased Streamflow in Agricultural Watersheds of the Midwest: Implications for Management. *Watershed Science Bulletin*, April 2011 issue.

Quantifying channel erosion in the Minnesota River Basin

RBS study

- Bank erosion with monitoring
- Historic aerial photos
- Measured bank properties – particle size, cohesive & shear strength
- Modeling with CONCEPTS




Ravines
Bluffs (valley walls)
Stream banks
© 2010 Google
Image © 2010 DigitalGlobe
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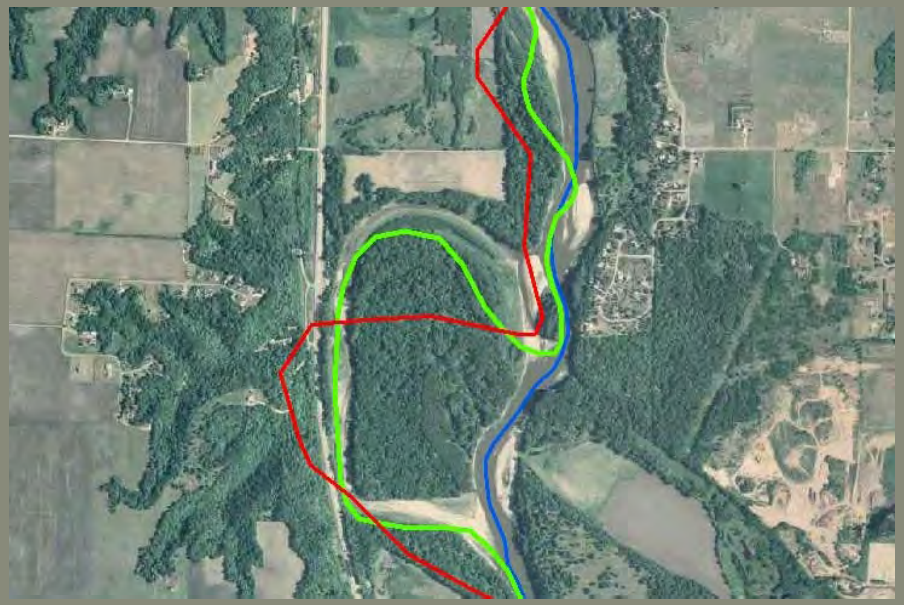
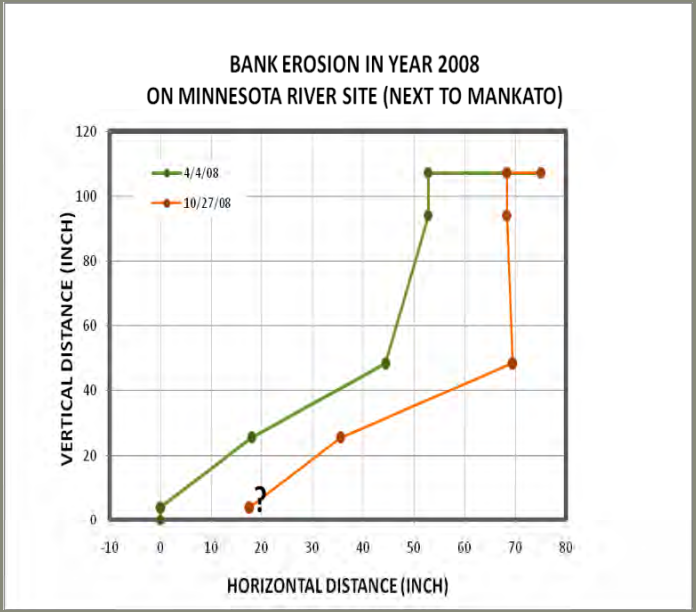
Channel change: slope and sinuosity



- changes to length/ and sinuosity since 1938
- Loss of 10-15% of length on MN River from channelization, cutoffs
- Impact on sediment transport modeled

Erosion monitoring

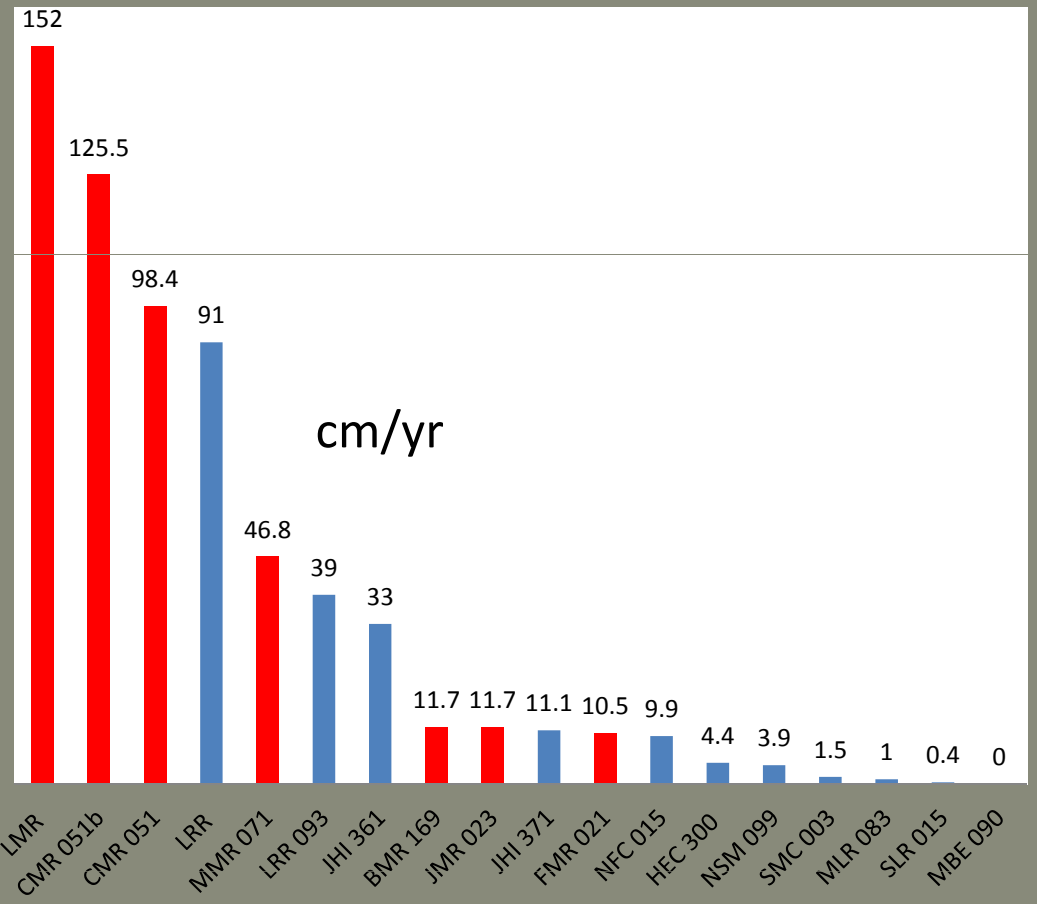


MN River– alluvial;
Low strength

Tributaries– highly variable but similar; glacial till more resistant

Bank erosion rates

- Main stem MN River highest
- Steep drop zone to MN Valley highest tribs
- sediment delivery ratio ?
- 60% fine sediment



Minnesota River Main stem Tributaries

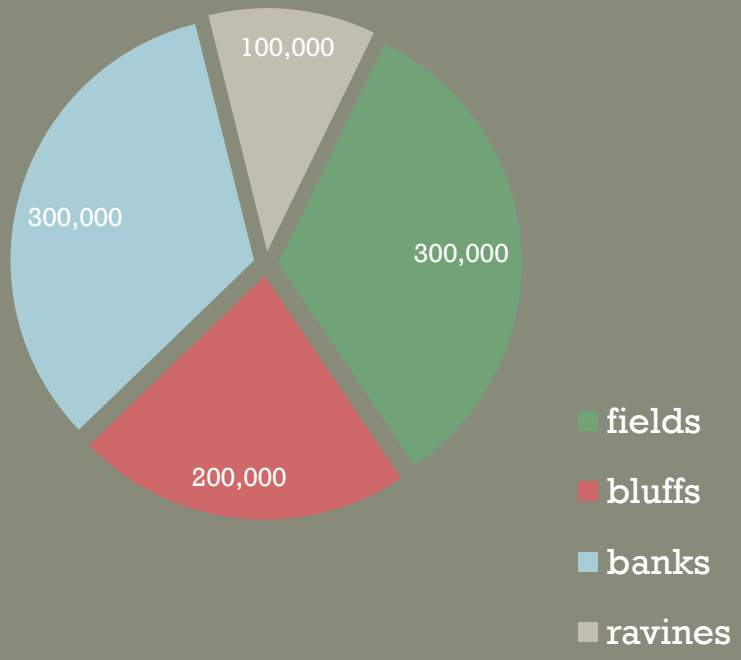
Channel widening

- Minnesota River and Elm Creek width increased by 50-75%

- Increased lateral erosion (up to 10 ft/yr on Minnesota River)
- 0-5 ft/yr on tribs

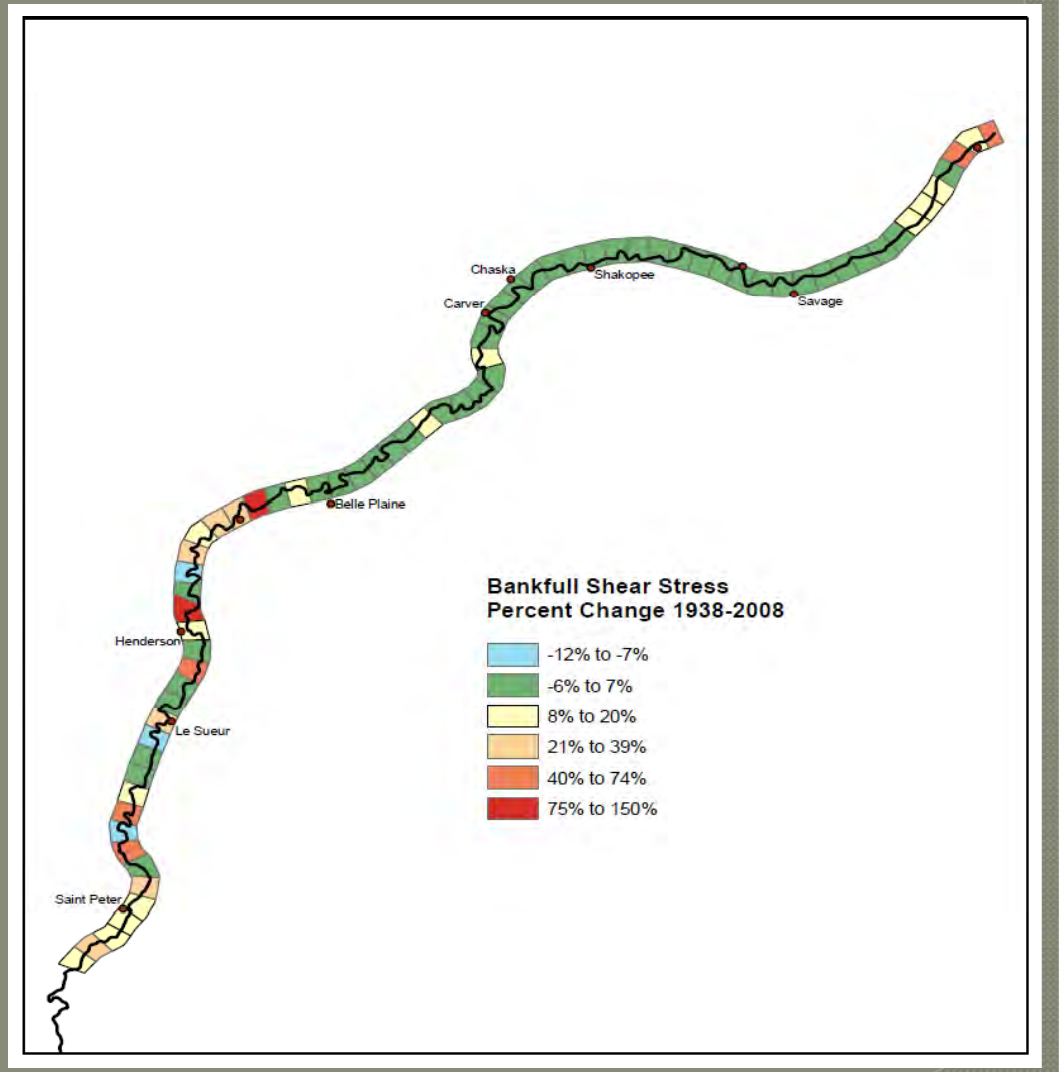
Sediment loading (gross)

- Streambank load from lower MN River (Mankato-St. Paul)
  - 350,000 t/year via BANCS model
  - 500,000---1,000,000 tons/year using modified BANCS model
  - Based on aerial photo change, 250,000-500,00 tons per year
- MN River annual suspended load is 100,000s tons to 1.5 million tons/year



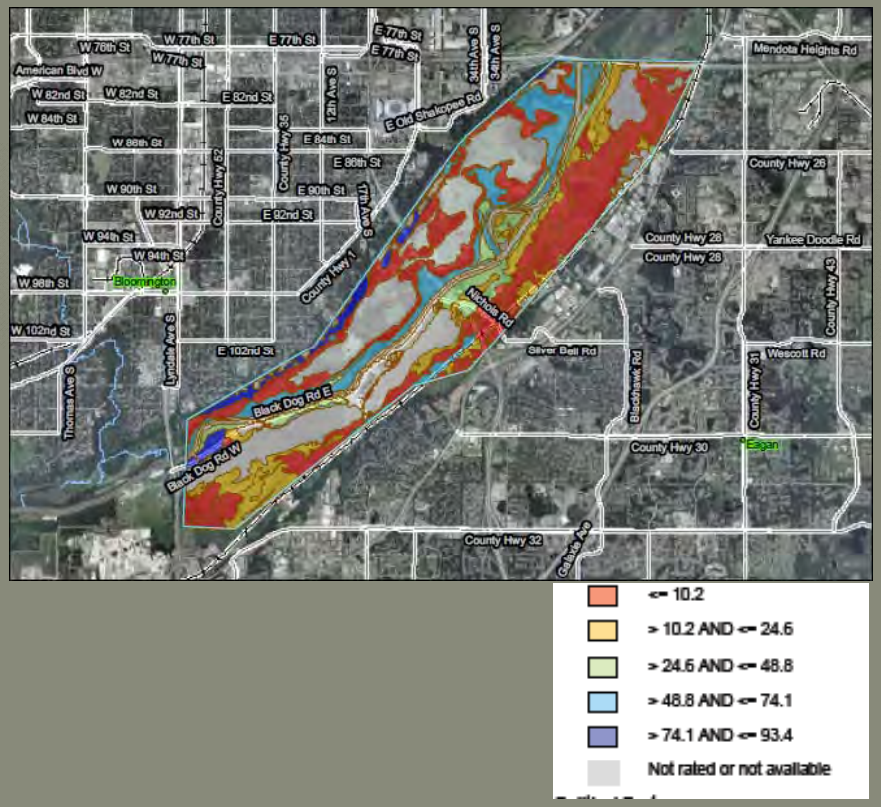
Net changes to sediment transport capacity

- Changes since 1938
  - - sinuosity
  - + slope
  - - floodplain connectivity
- Net change is increase in bankfull shear stress (red – orange colors)



Floodplain deposition

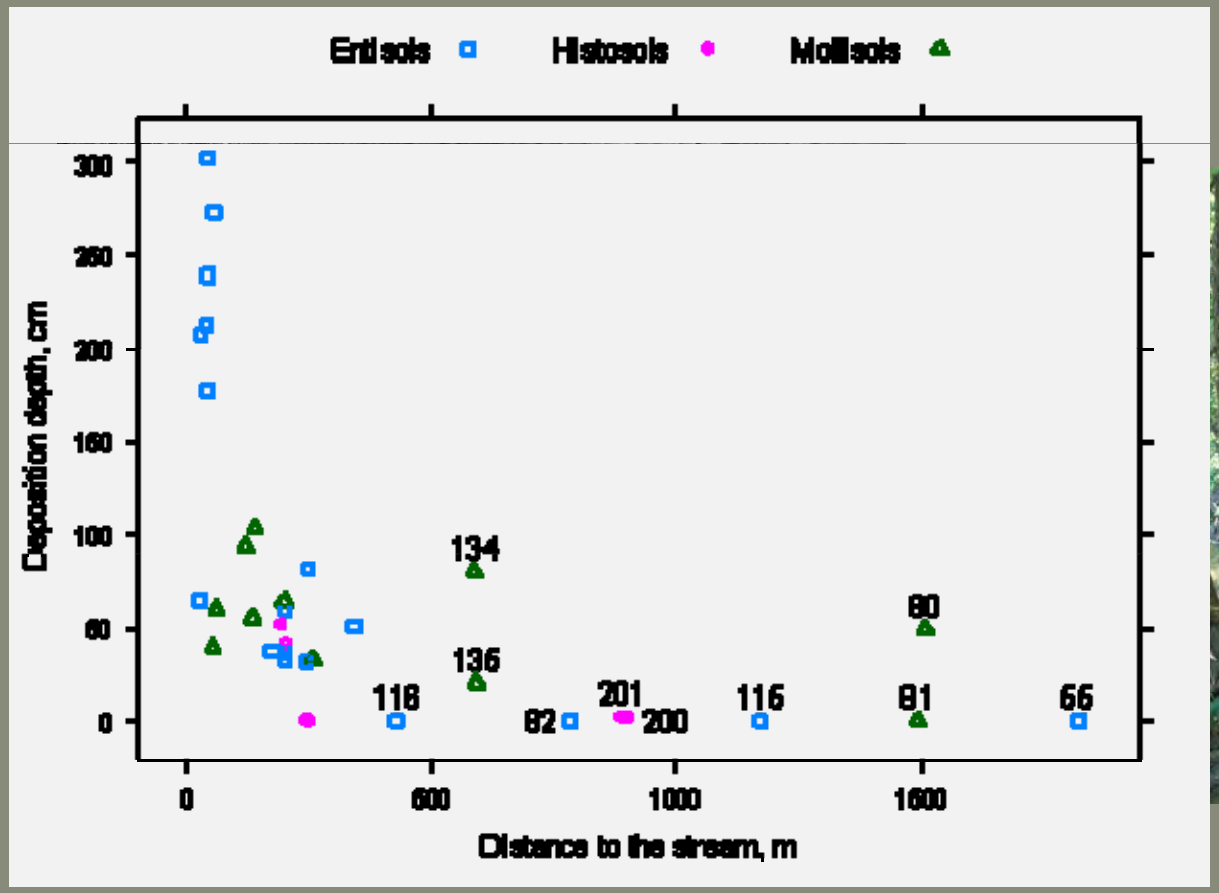
- MN valley a large sink for sediment
- 0.3-0.5 m mean post-European deposit depth on lower MN river
- Rate decreases away from channel boundary



Post-European deposition of sediment.

SEDIMENT NOT EVENLY DEPOSITED

LEVEE DEPOSITS HAVE HIGHEST RATES



Summary

- Hydrologic change
  - More flow, esp. mean flow to small flood
- Geomorphic alteration
  - Channelization
  - Widening response
  - Alterations cause less connected floodplain
- Channels now largest source of sediment in
- Streambanks are a major sed source
- Management options challenging; object of ongoing research - McKnight and MN Dept. of Agriculture grants

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- Water Resources Center, USGS

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