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Bank Erosion and Morphology of the Kaskaskia River

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Of Engineers
St. Louis District

APPLIED RIVER ENGINEERING CENTER

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Team Partners :

Fayette County
Soil and Water
Conservation District

Carlyle Lake
Ecosystem Partnership

USDA NRCS Natural Resources Conservation Service

One Corps Serving the Armed Forces and the Nation

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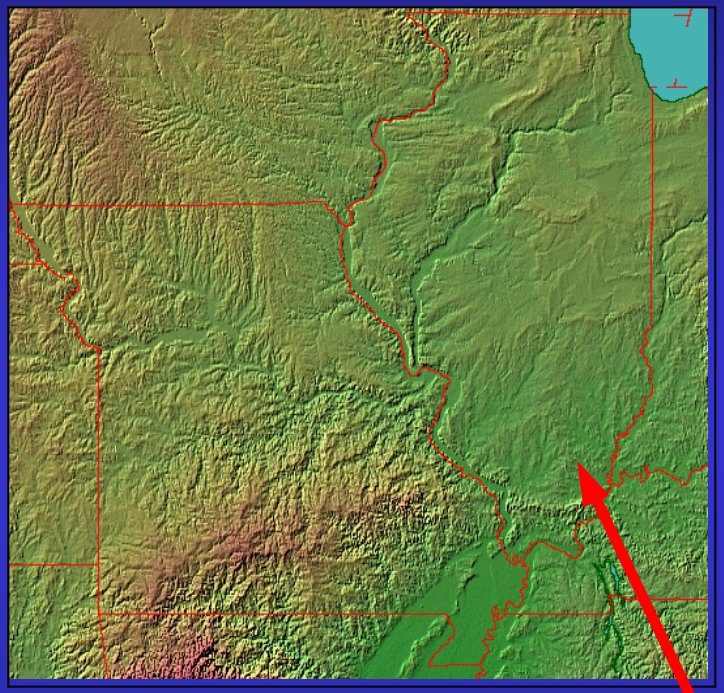
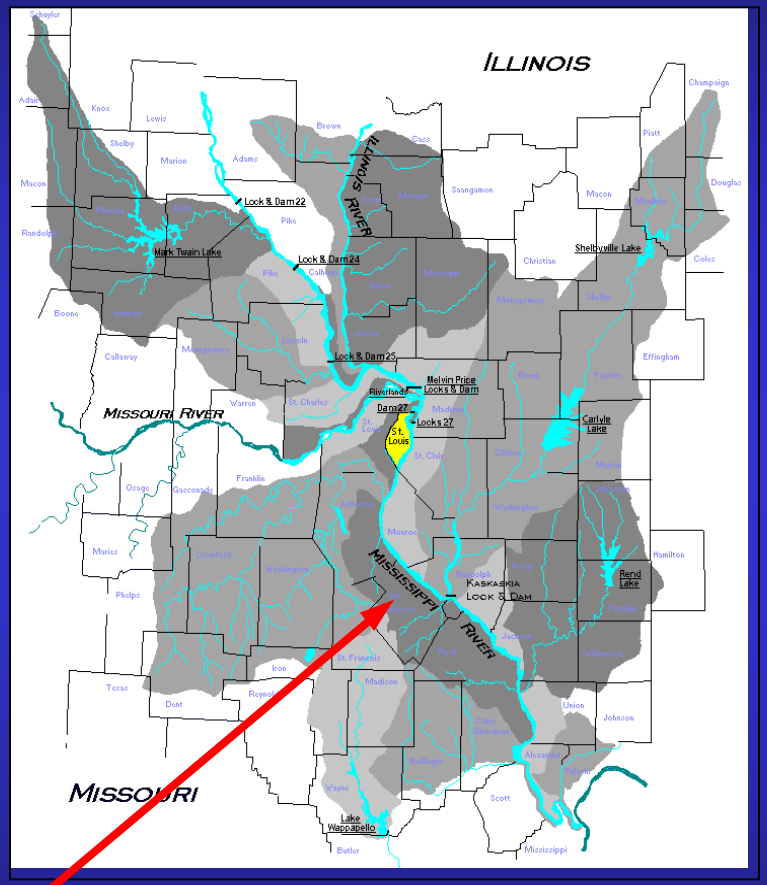
Vicinity





Study Reach

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Background Information

- The Kaskaskia is a typical alluvial channel with a length of over 300 miles, while the total fall is approximately 390 ft

- The watershed of the Kaskaskia River covers 5,790 mi^2, the second largest in the state of Illinois

- The length of the watershed is about 175 miles and has an average width of 33 miles, with a maximum width of 55 miles

- The natural flow regime has been altered by three major Corps of Engineer's projects. Two flood control reservoirs; the 26,000-acre Carlyle Lake Project (1967) and the 11,200-acre Lake Shelbyville (1970). The final project was the Kaskaskia River Navigation Project (1972)

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Study Divided into Two Sections

Middle Kaskaskia – Shelbyville Dam to Carlyle Lake

- **Consists of 98 River Miles**
- **Major Factors in the present river morphology were the major land use changes that occurred during the past 170 years**
- **Bank Erosion Study Completed in 2003**

Lower Kaskaskia – Carlyle Dam to the Confluence of the Mississippi

- **Consists of 95 River Miles**
- **Major Factor in the present river morphology was the straightening of 52 miles of river for navigation purposes**
- **Effect of the Kaskaskia River Navigation Project Completed in 1999**

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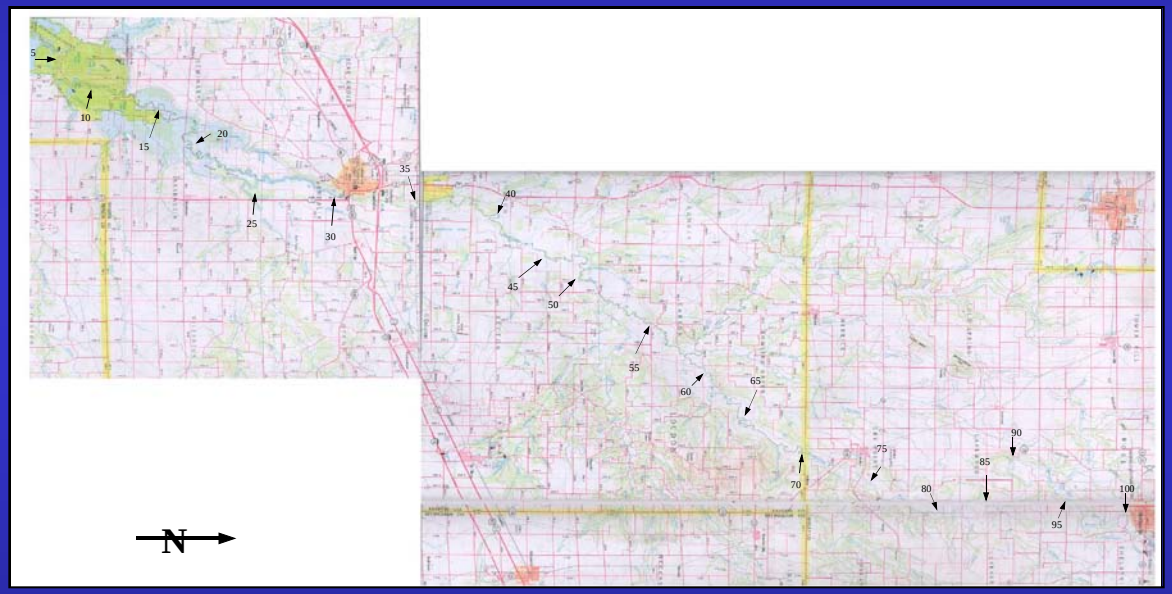
Middle Kaskaskia Section
Shelbyville Dam to Carlyle Lake

- Drainage area of 2140 mi^2
- Peak flow at Vandalia 19,300 cfs
- Researched several land use maps and aerial photos
- Analyzed over 100 river bends



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Analysis and Data Collection Methodology

- The first complete survey of the State of Illinois was conducted by the Government Land Office (GLO) between 1820 and 1830. Of the GLO, only miles 0-50 of the Kaskaskia River and its floodplain were available
- Aerial photos of the entire main channel and floodplain of the Kaskaskia River were gathered for the years 1938, 1966, and 1998. The aerial photos were scanned in and large mosaics were generated
- The GLO was used for qualitative comparison of the relative position of the river in 1820 versus 1998. It was also used for land use changes of the floodplain in 1820 versus 1938, 1966, and 1998
- The 1938, 1966, and 1998 aerial photos were used for qualitative comparison of relative position of the river attributes such as width, length, wetted edge, etc. and also for land use changes, feet of bare bank, etc.

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1820 GLO Survey

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1966 Mosaic

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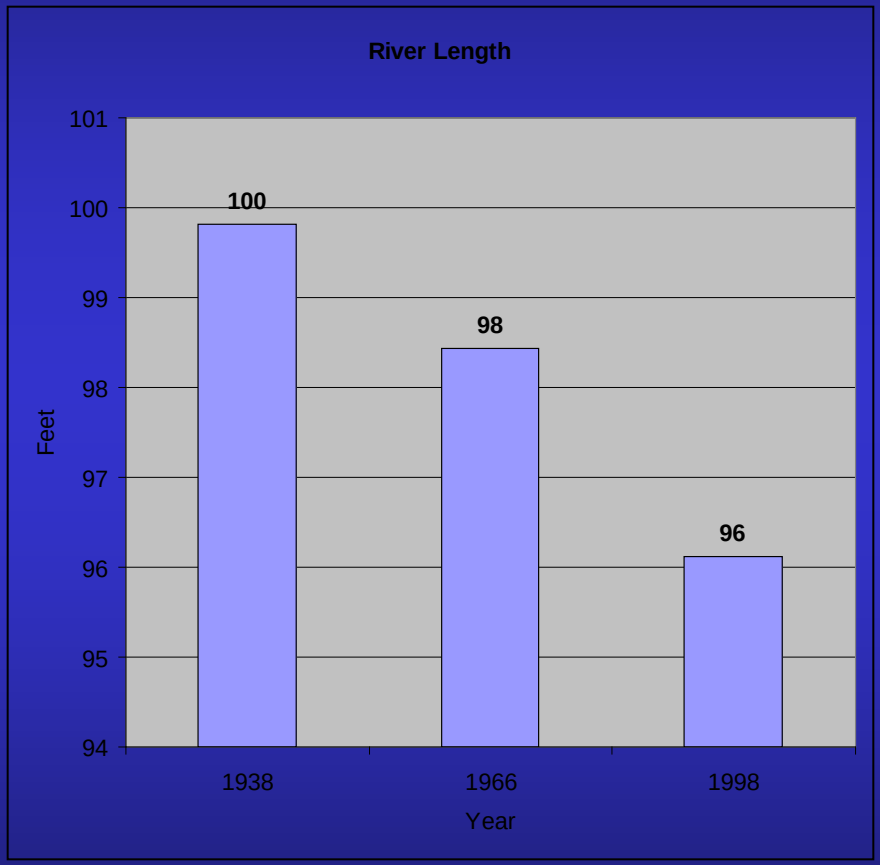
River Length and Sinuosity

- The river was measured as approximately 102 miles in 1938 and 98 miles in 1998, an overall loss of 4 miles
- The sinuosity of the entire study reach was computed as 1.8 in 1938 and 1.7 in 1998



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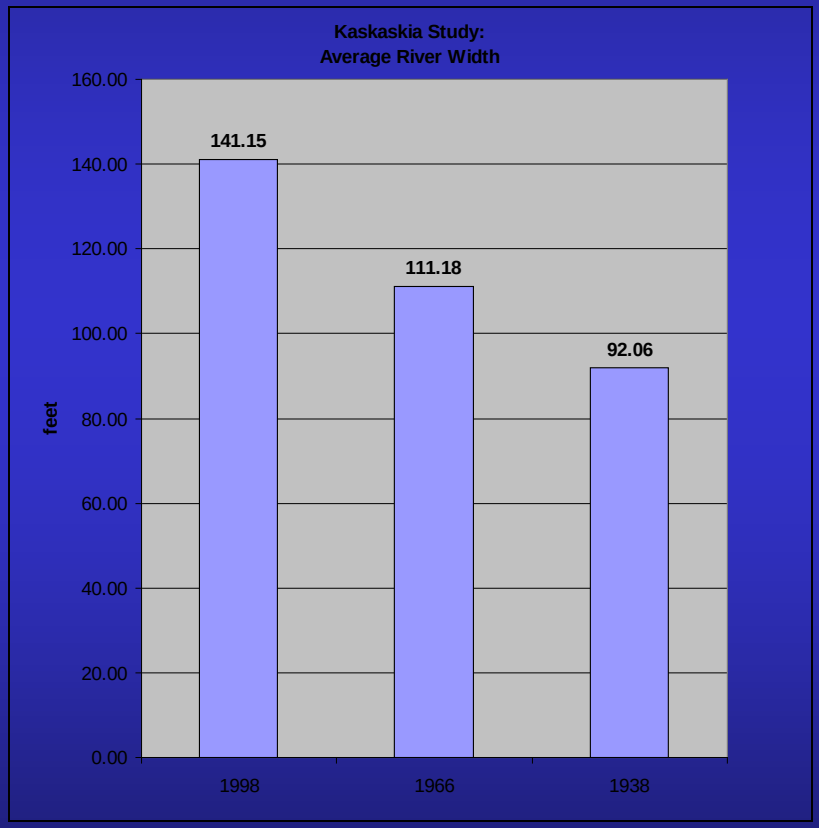
Average Channel Widths and Widening Rates

- The average channel width was approximately 92 ft in 1938, 111 ft in 1966, and 141 ft in 1998
- This resulted in an overall channel width increase of over 54% from 1938 to 1998
- The channel widened, on average of 0.8 ft/yr between 1938 and 1998
- Widening rate immediately downstream of Shelbyville Dam is the same as the average widening rate



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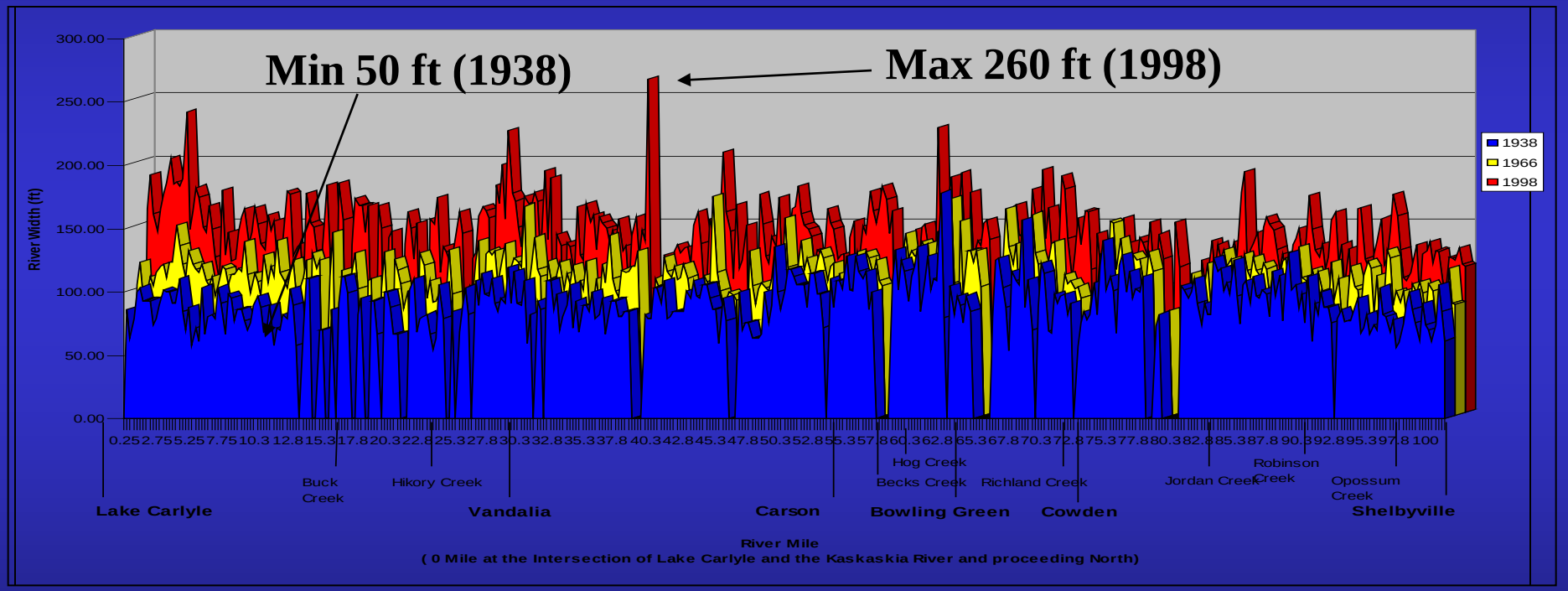
Channel Widths

(1938, 1966, and 1998)



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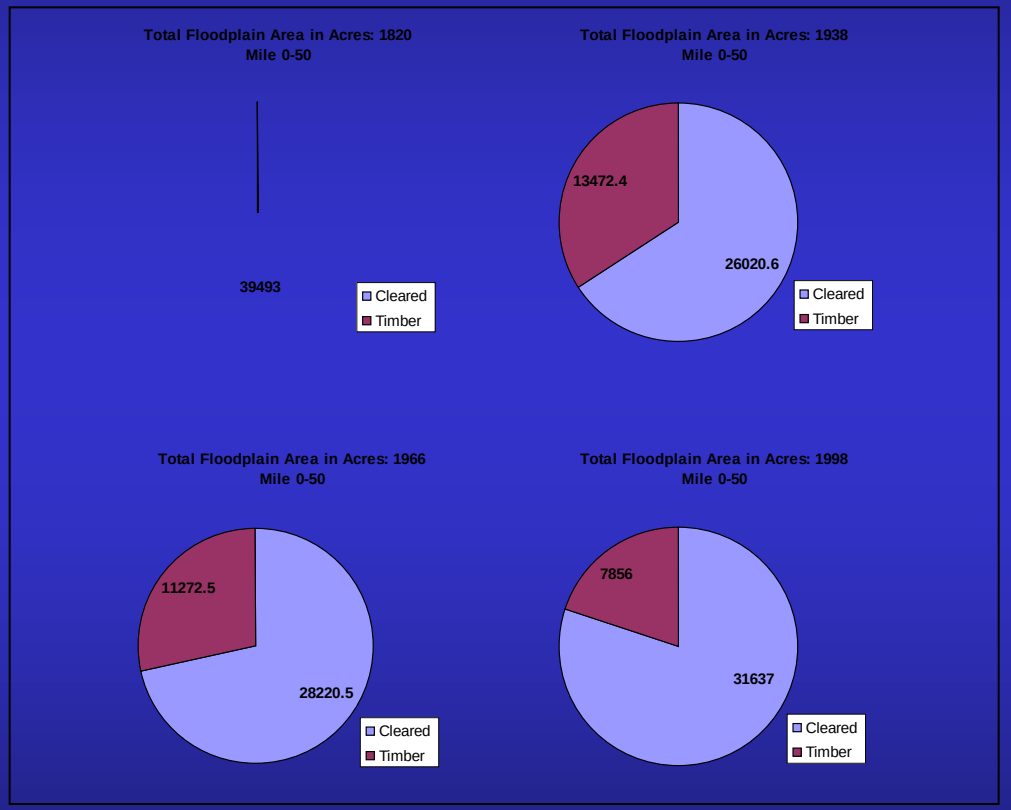
Land Use Change
(River Miles 0-50)

- The total floodplain area between miles 0 and 50 was approximately 39,500 acres
- In 1820, 99.9 % of the floodplain was forested
- By 1998, 80% of the floodplain was cleared



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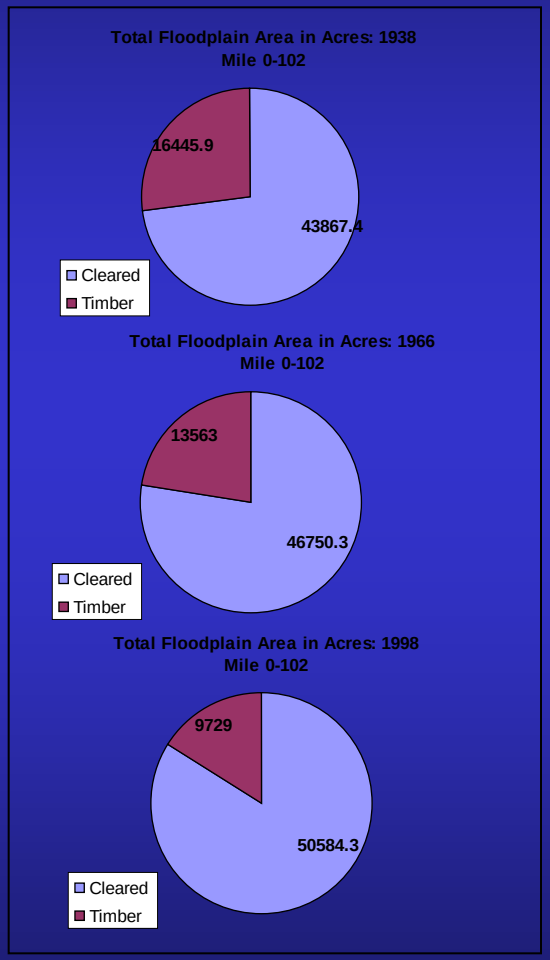
Land Use Change

(Total Floodplain)

- The total floodplain area between miles 0 and 102 was measured as approximately 60,300 acres
- It was estimated that by 1966, 73% of the total floodplain was cleared and by 1998 over 84% was cleared



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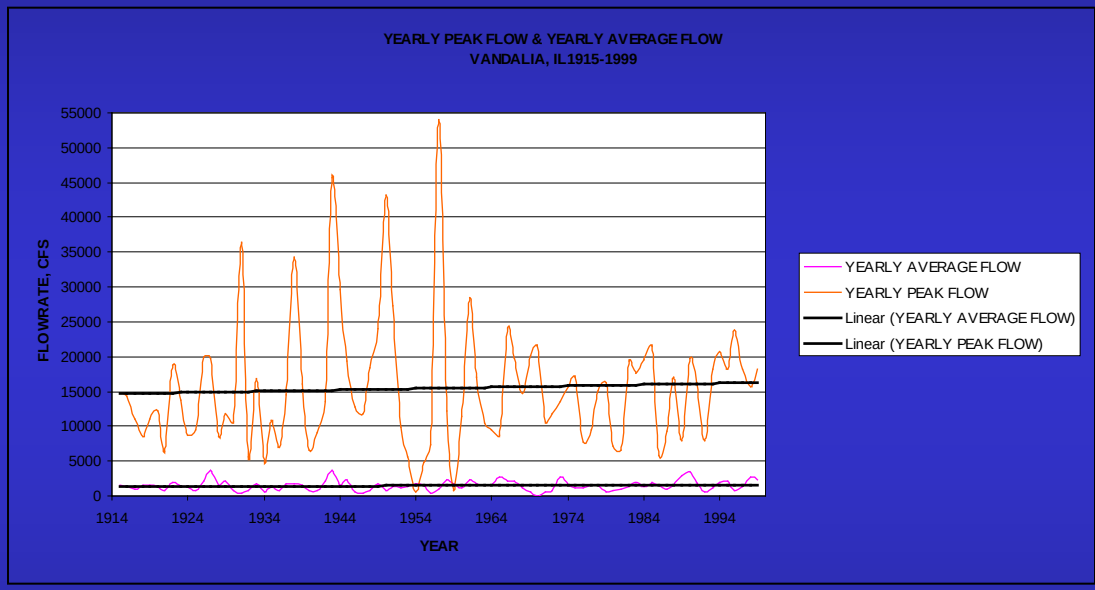
Historical Flow Trends

- Historical flow trends were examined at the Vandalia and Shelbyville gages
- Average annual flow rate increased 17% between the period 1972 to 1999 (1,841cfs) compared to the period 1842-1969 (1,532cfs)



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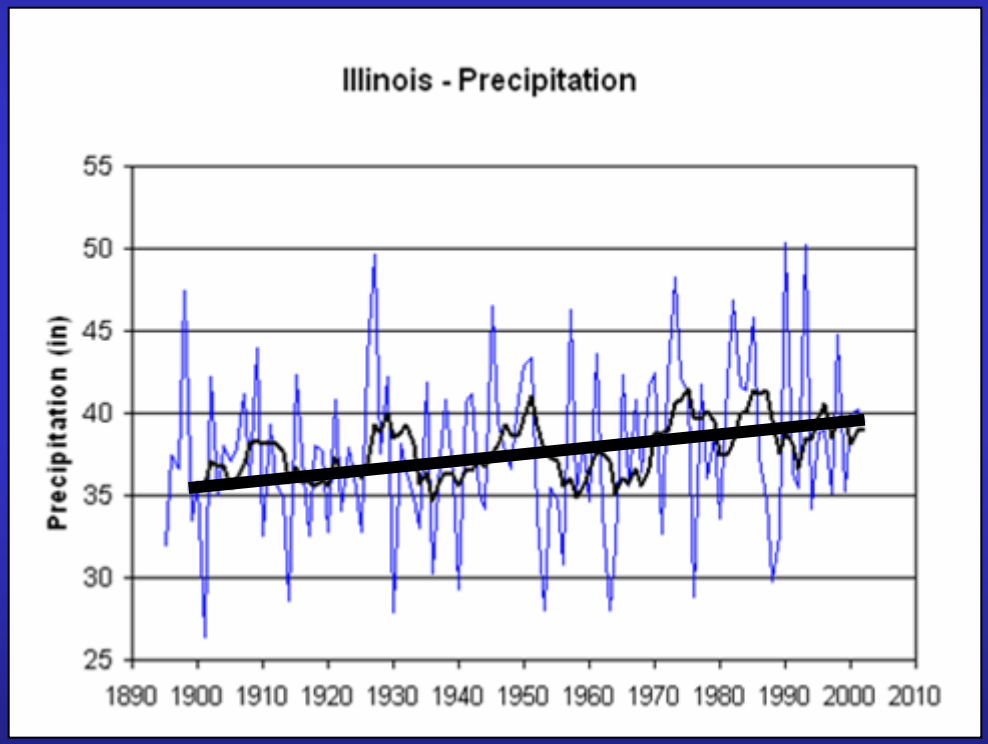
Historical Precipitation Trends

- Annual precipitation at Urbana, Illinois between 1900 and 2001
- Tend line indicates that the average annual rain fall is increasing



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Current State of the Middle Kaskaskia River

- **Bank erosion was prevalent throughout the study reach**
- **Most bend channels were actively eroding, containing vertical banks, large sand bars, downed trees and channel blockages**

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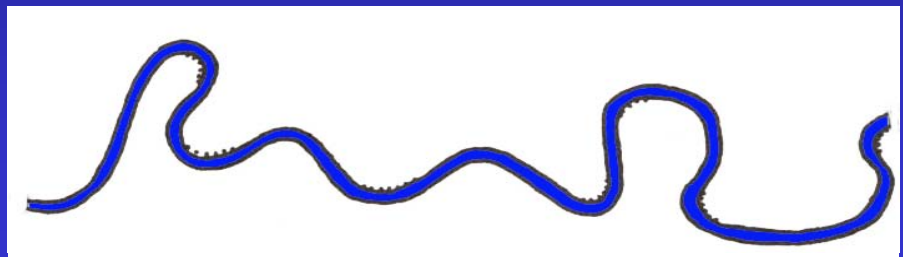
Current State of the Middle Kaskaskia River

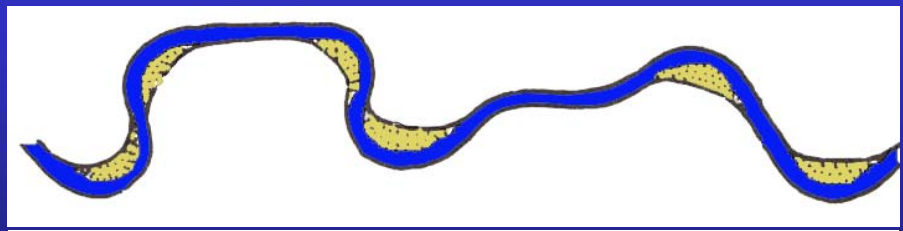
- **Due to the increased widening, decrease in sinuosity and reduction of the channels ability to transport sediment the channel is transforming**

1938



Sinuous Canaliform

1998



Sinuous Braided Canaliform

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Effects on Tributaries

- **Most of the tributaries have been channelized in the basin**
- **Headcutting has occurred along most of these channels, with widespread deposition of fine material**
- **The middle reaches of the tributaries have experienced moderate to sustainable bank erosion**

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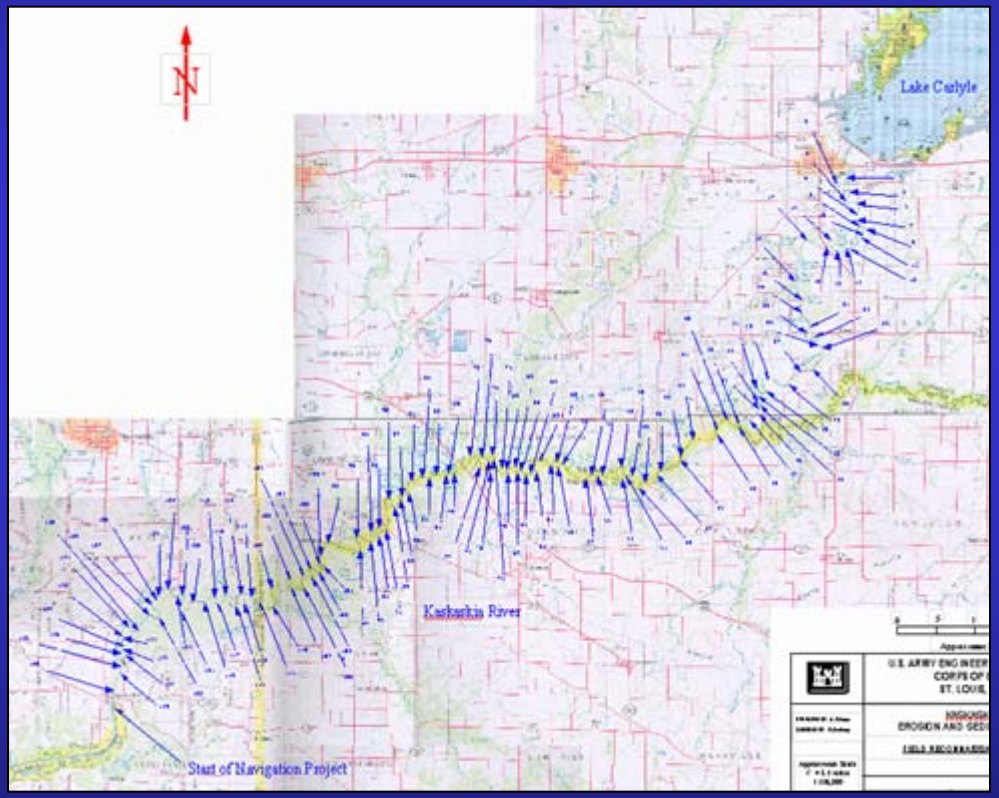
Lower Kaskaskia Section

Carlyle Dam to Confluence of Mississippi

- Divided into three river regimes
- Drainage area of over 3,800 mi^2
- Peak flow at Kasky Lock 50,300 cfs
- Analyzed over 130 bends



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The Kaskaskia River Navigation Project

- **The Kaskaskia River Project is part of the national transportation system. It is integrated with a part of the 26,000 mile inland waterway system. It is also integrated with the North American railway system and highway system, giving it intermodal connectivity.**
- **The Kaskaskia River Project was completed in 1976 at a Federal cost of $140 Million. The State of Illinois was the local sponsor for the project contributing $24 Million in funding for land acquisition and spoil site development.**
- **Since opening in 1976 the Kaskaskia River Project has originated or terminated more than 53 million tons of cargo valued in excess of $2.6 Billion.**

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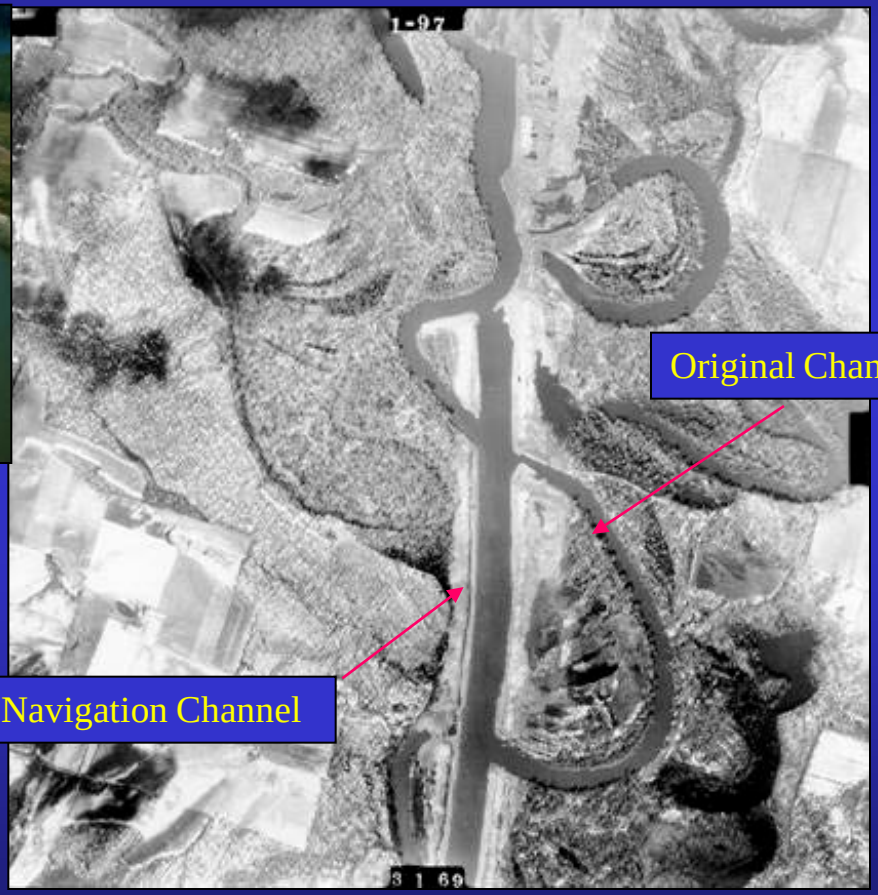
A River Transformed



- **The final excavation of the navigation channel was completed in 1972**
- **The lock and dam was completed in 1974**

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Morphological Effects of the Navigation Project

- Channelization of 36 miles, forming a 9 ft deep and 300 ft wide navigation channel (1972), overall reduction of 16 miles of channel length
- Channel straightening induced a destructive headcut near Fayetteville and moved upstream causing loss of private property and damage to the bottomland forest and aquatic habitat.
- The slope increased on average of 80% from 0.25 ft/mile to 0.45 ft/mile and width increased on average of 80% from 125 ft to 225 ft
- From 1972 to 1982 an estimated 2,500,000 yd^3 deposited within 6 miles of the upper navigation reach between Fayetteville and New Athens
- In 1982 a grade control structure was built in Fayetteville at the upstream end of the navigation channel to eliminate the headcutting but the structure was unable to arrest the headcuts that had already moved upstream of the project reach.

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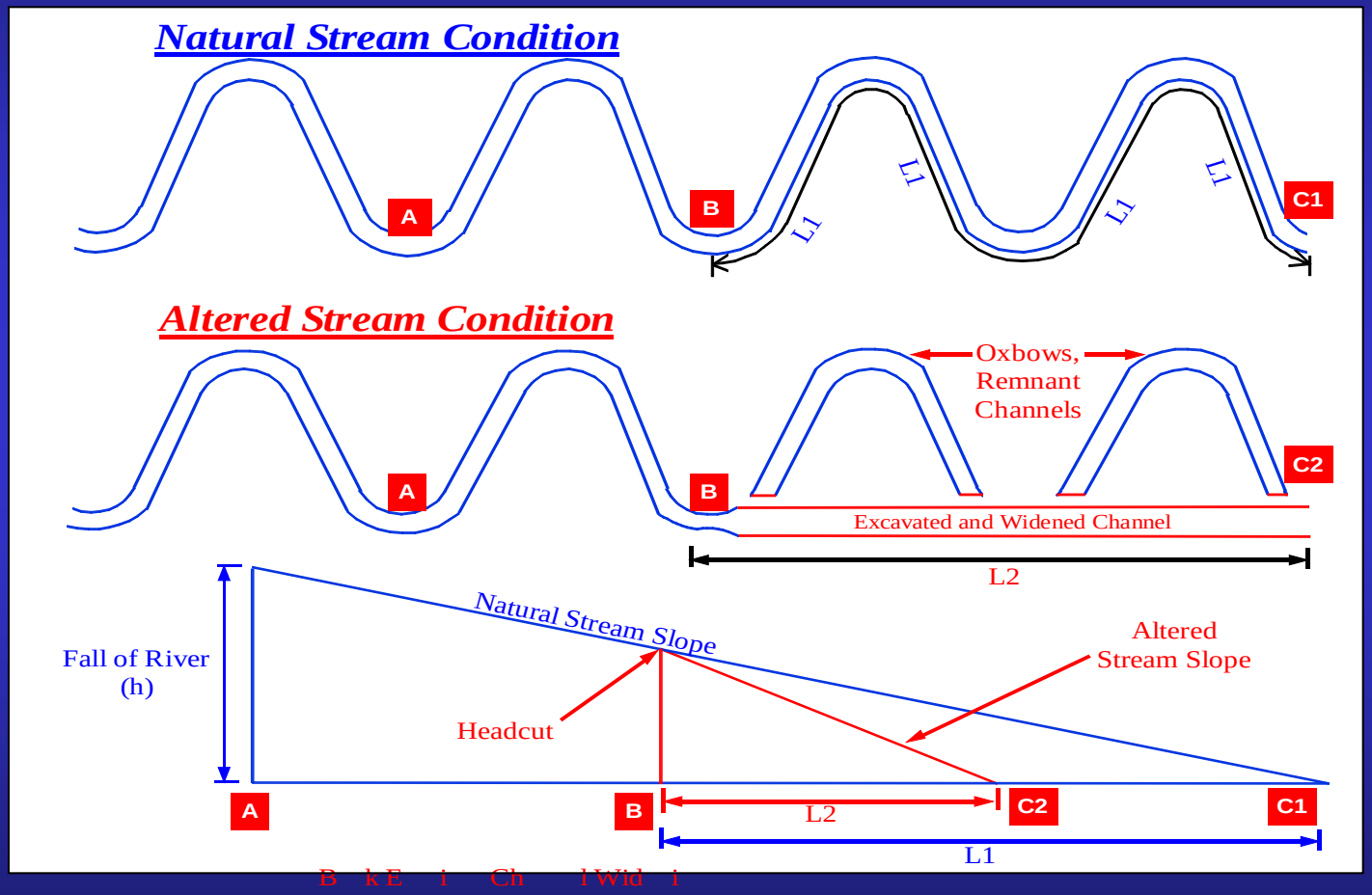
Common Effects of Channel Straightening



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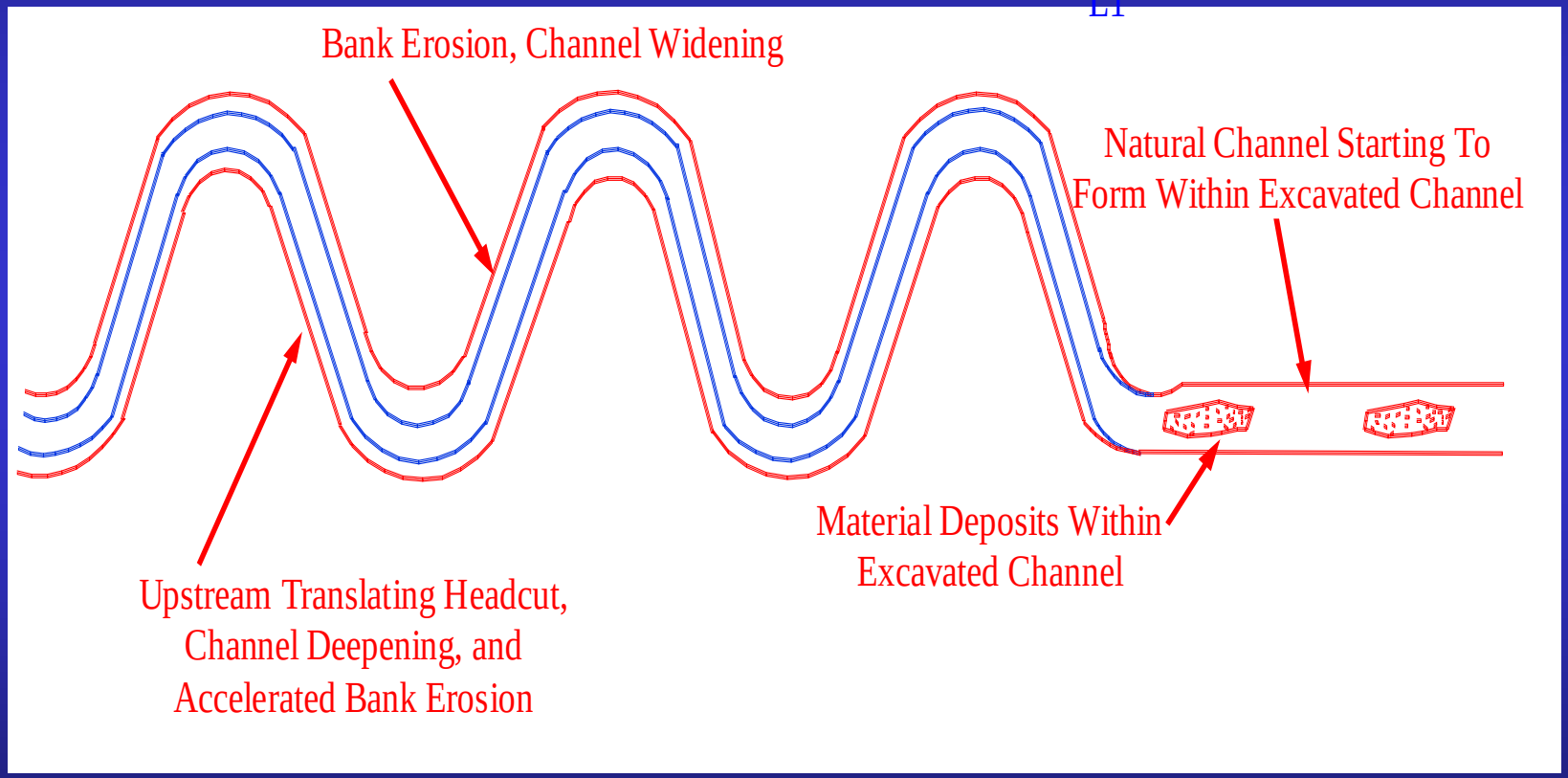
Results of Headcutting



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Modeling a Headcut

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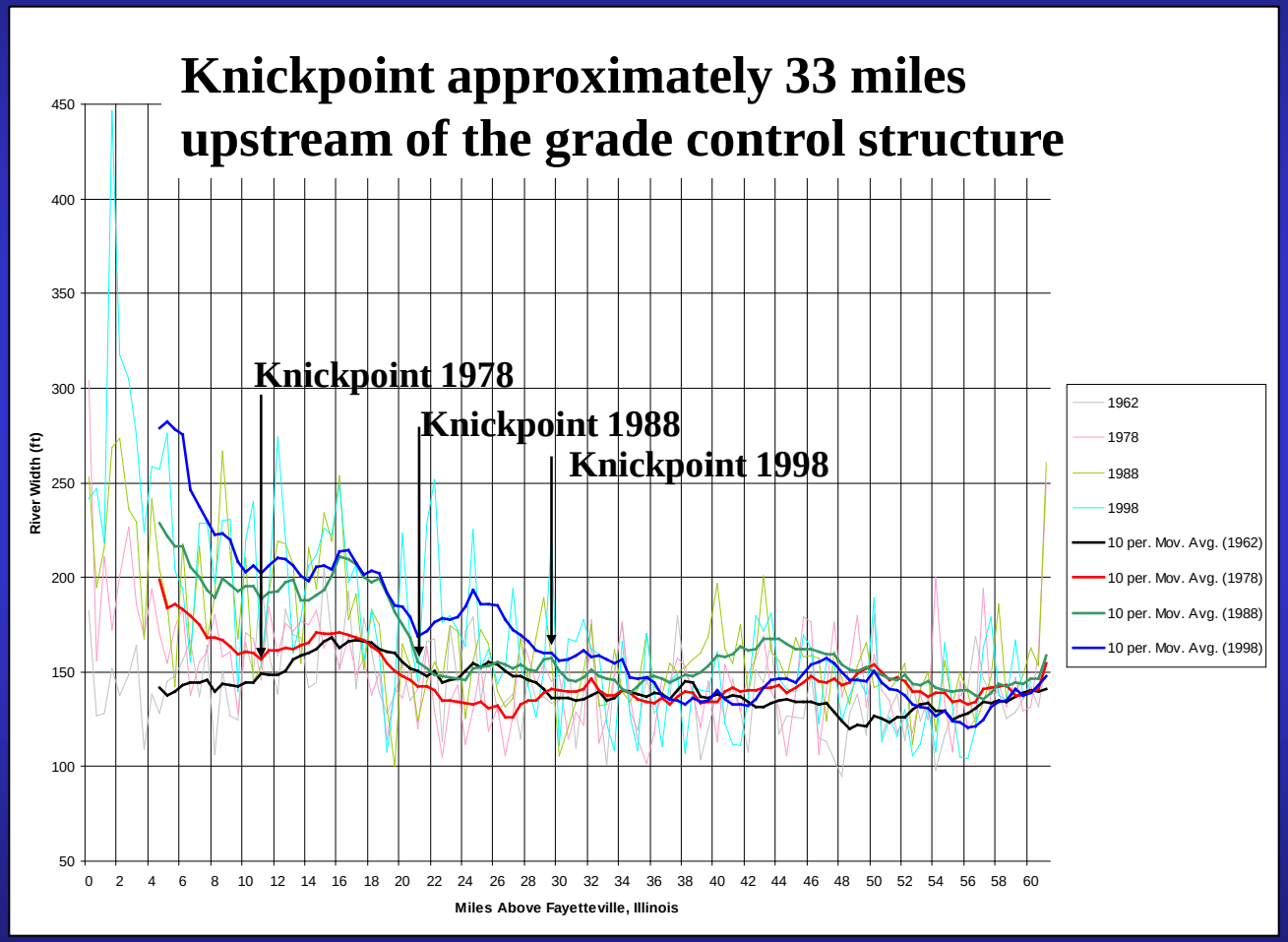
Knickpoint Location



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Effects on Tributaries

- **Headcuts are not isolated to the main channel, they adversely effect the entire system**

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Current Sate of River
Three Distinct River Regimes

Regime One

- Lake Carlyle to 7 miles downstream of Highway 160 (14 Miles Upstream of Fayetteville)
- Low to Moderate Traditional Bank Erosion

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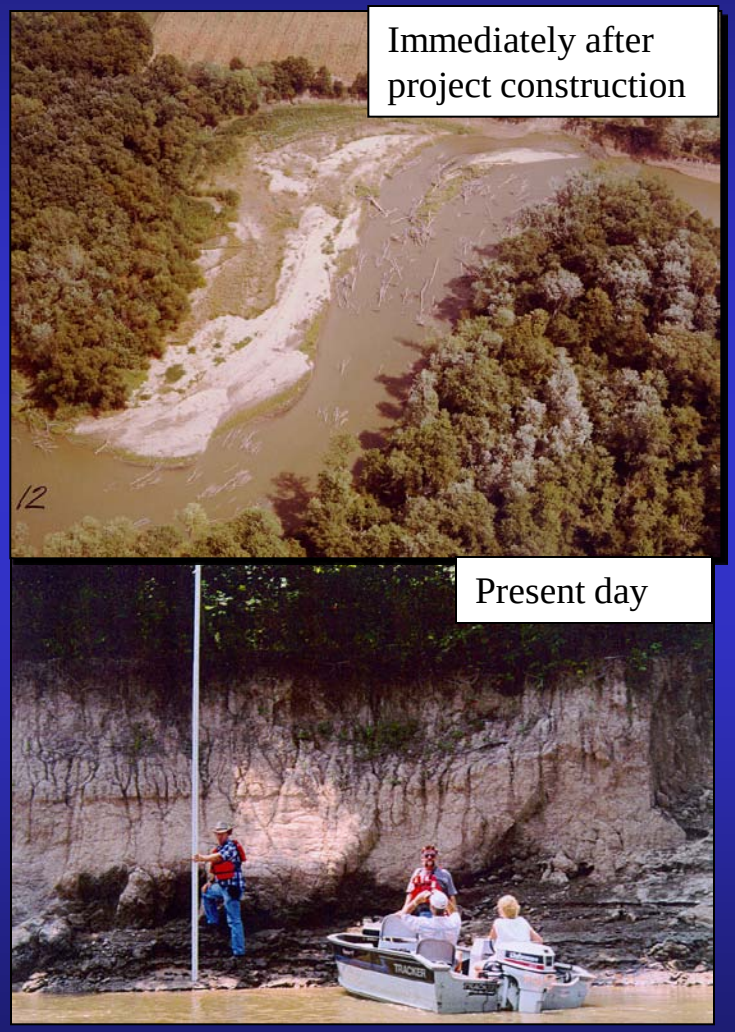
Current Sate of River
Three Distinct River Regimes

Regime Two

- 7 miles downstream of Highway 160 (14 Miles Upstream of Fayetteville) to approximately 2 miles below High Banks
- High Erosion, Channel Widening, Channel Downcutting, Loss of Bottomland Trees



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Current Sate of River

Three Distinct River Regimes

Regime Three

- 2 Miles Below High Banks to Fayetteville
- Dominant Sand Bar Formations, Development of Willows (Natural Healing)

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General River Morphology

- **Pattern – 1.44 to 2.10 sinuosity**
- **Dimension – 1962, 1978, 1988 and 1998 aerials were analyzed and the widening rate ranged from 0.14ft/yr to 5ft/yr**
- **Profile – Degradation is occurring on the lower part of the study reach due to the headcut. The knickpoint is located approximately 33 miles above Fayetteville, upstream of this point there is no major degradation of the channel.**
- **The Carlyle Dam has no apparent effect on the stability of the channel. Bends were measured immediately downstream of the dam and no significant increase in bank erosion was evident. (Lane's Equation – discharge and load are on opposite sides of scale so they cancel each other out)**

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Questions ?