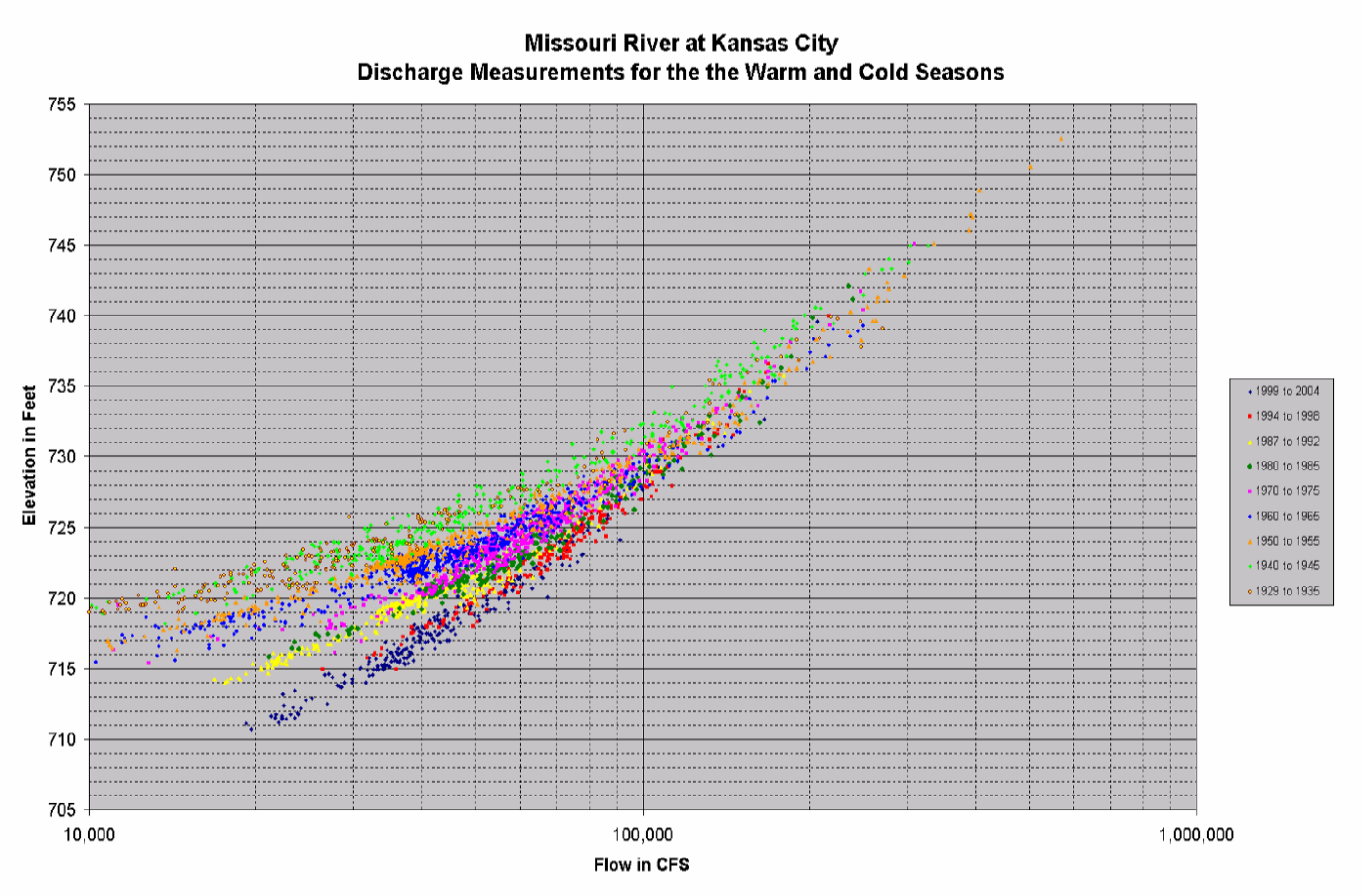
US Army Corps
of Engineers
Kansas City District

Degradation of the Kansas City Reach of the Missouri River

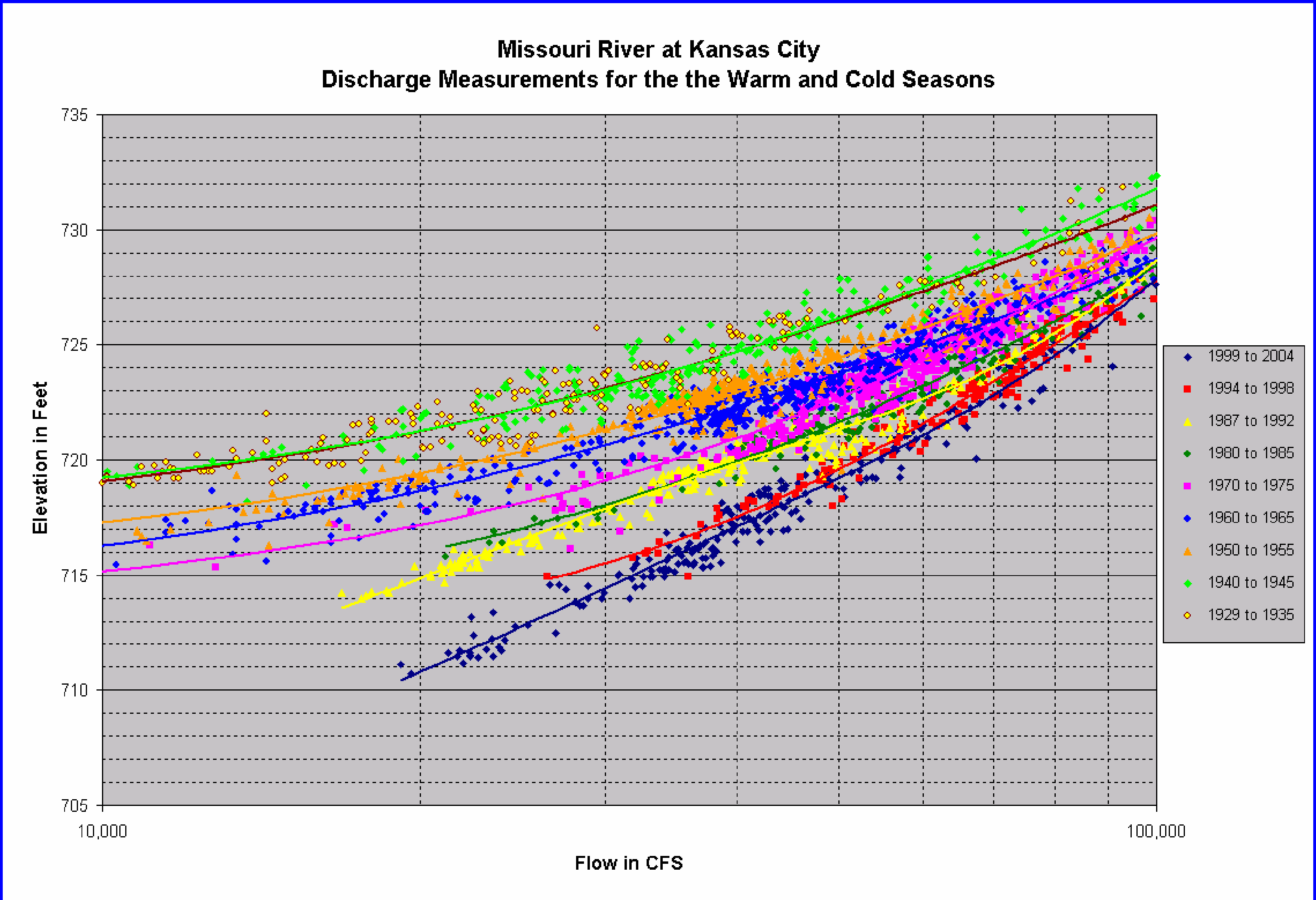
The Kansas City Reach

The Problem

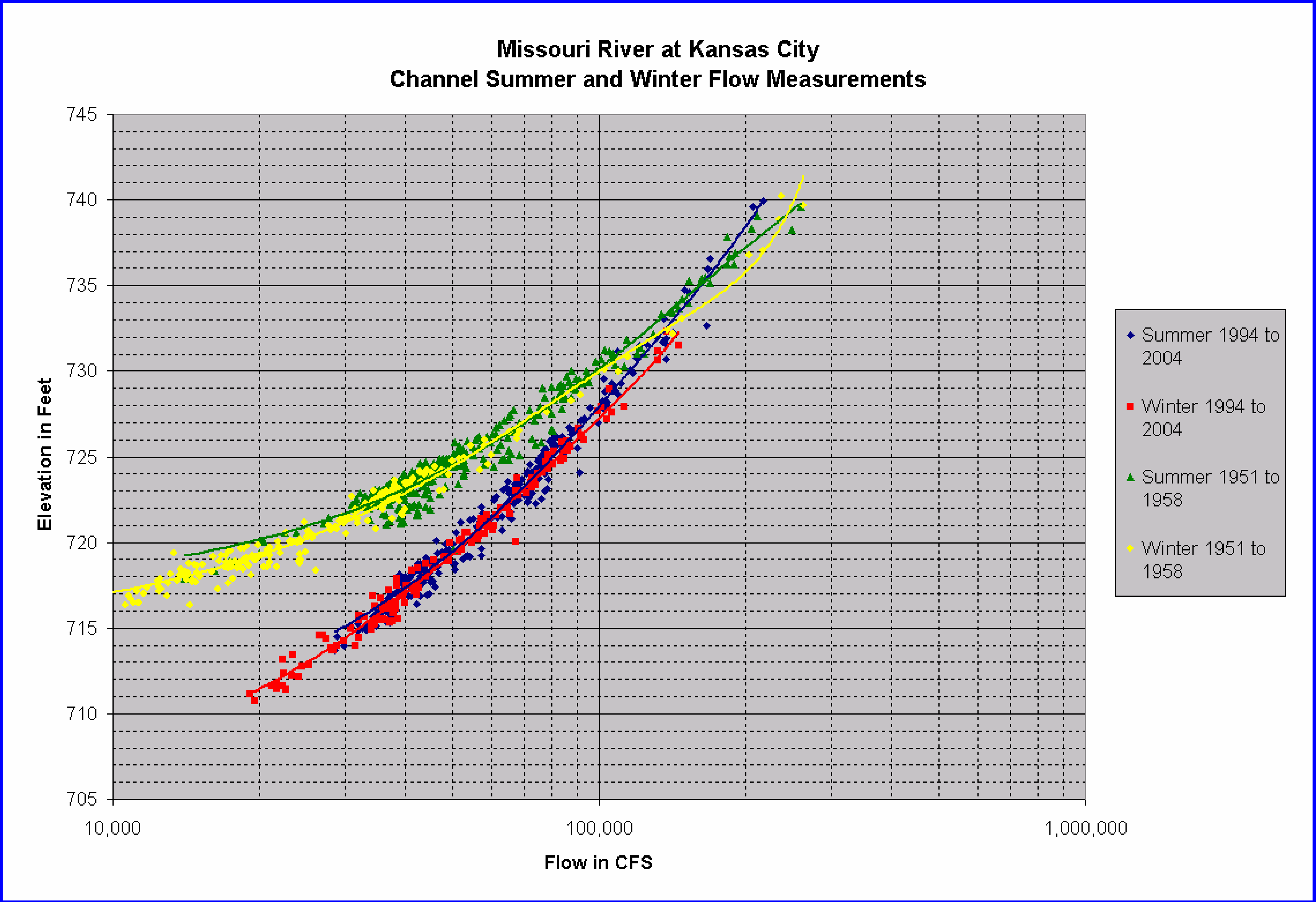


Missouri River at Kansas City
Discharge Measurements for the the Warm and Cold Seasons
Elevation in Feet
755
750
745
740
735
730
725
720
715
710
705
10,000
100,000
1,000,000
Flow in CFS
1999 to 2004
1994 to 1998
1987 to 1992
1980 to 1985
1970 to 1975
1960 to 1965
1950 to 1955
1940 to 1945
1929 to 1935

Best Fit Lines



Seasonal Changes



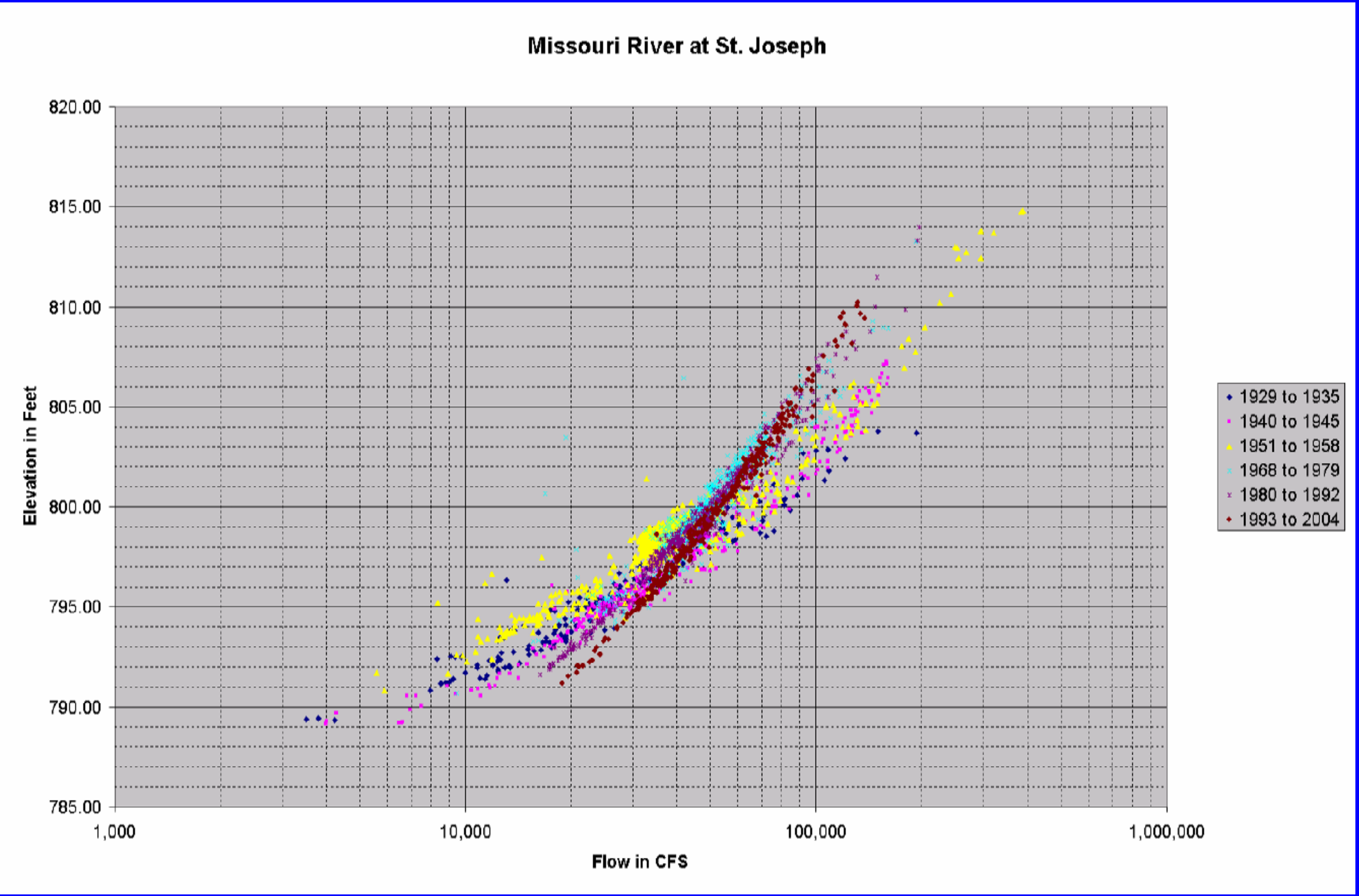
Why?

Hypothesis

1. Upstream reservoirs (hungry water).
2. River training structures (dikes and revetments).
3. Commercial sand mining (dredging).
4. Major Floods.
5. River cut-offs.

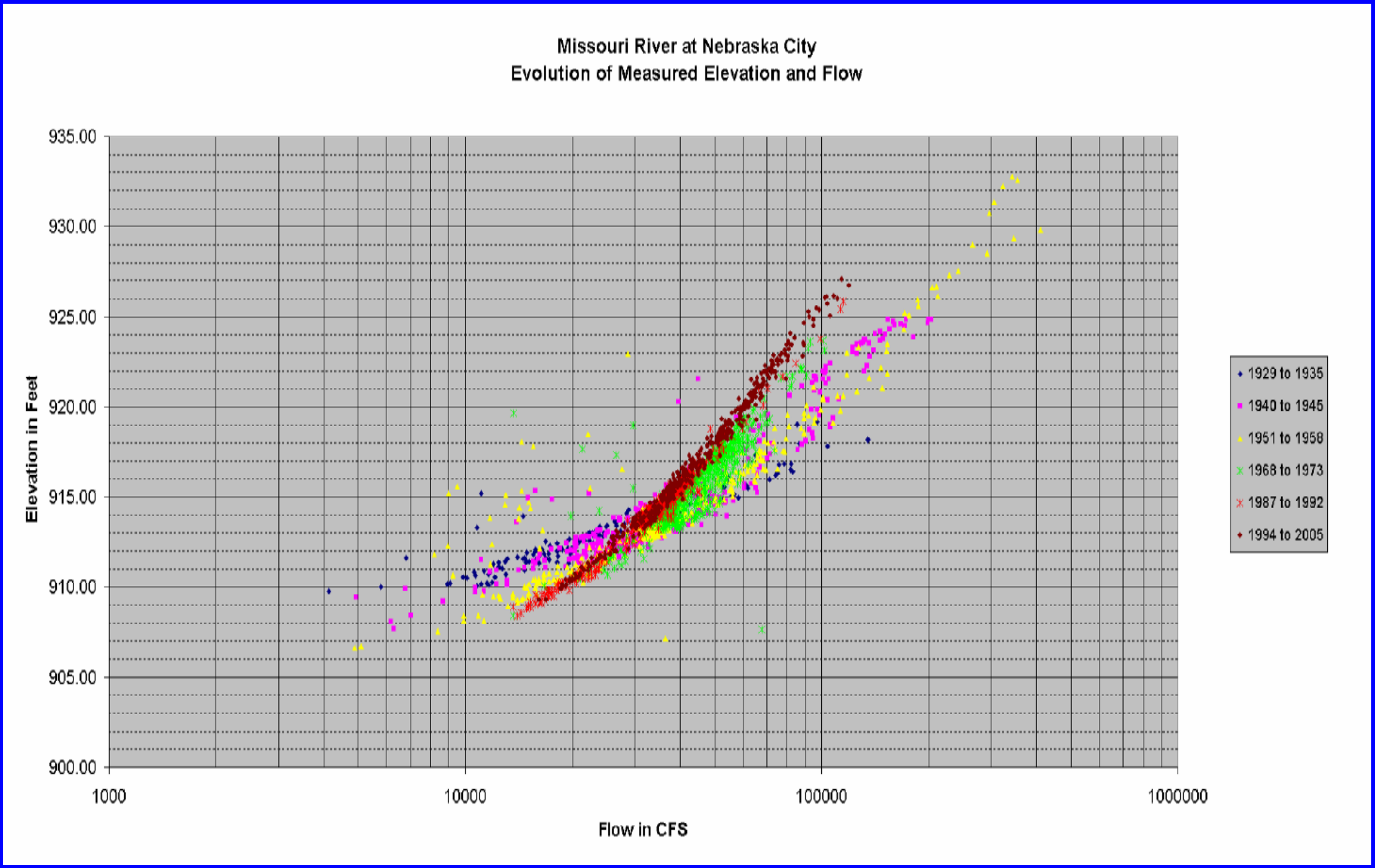
Upstream Reservoirs

St. Joseph

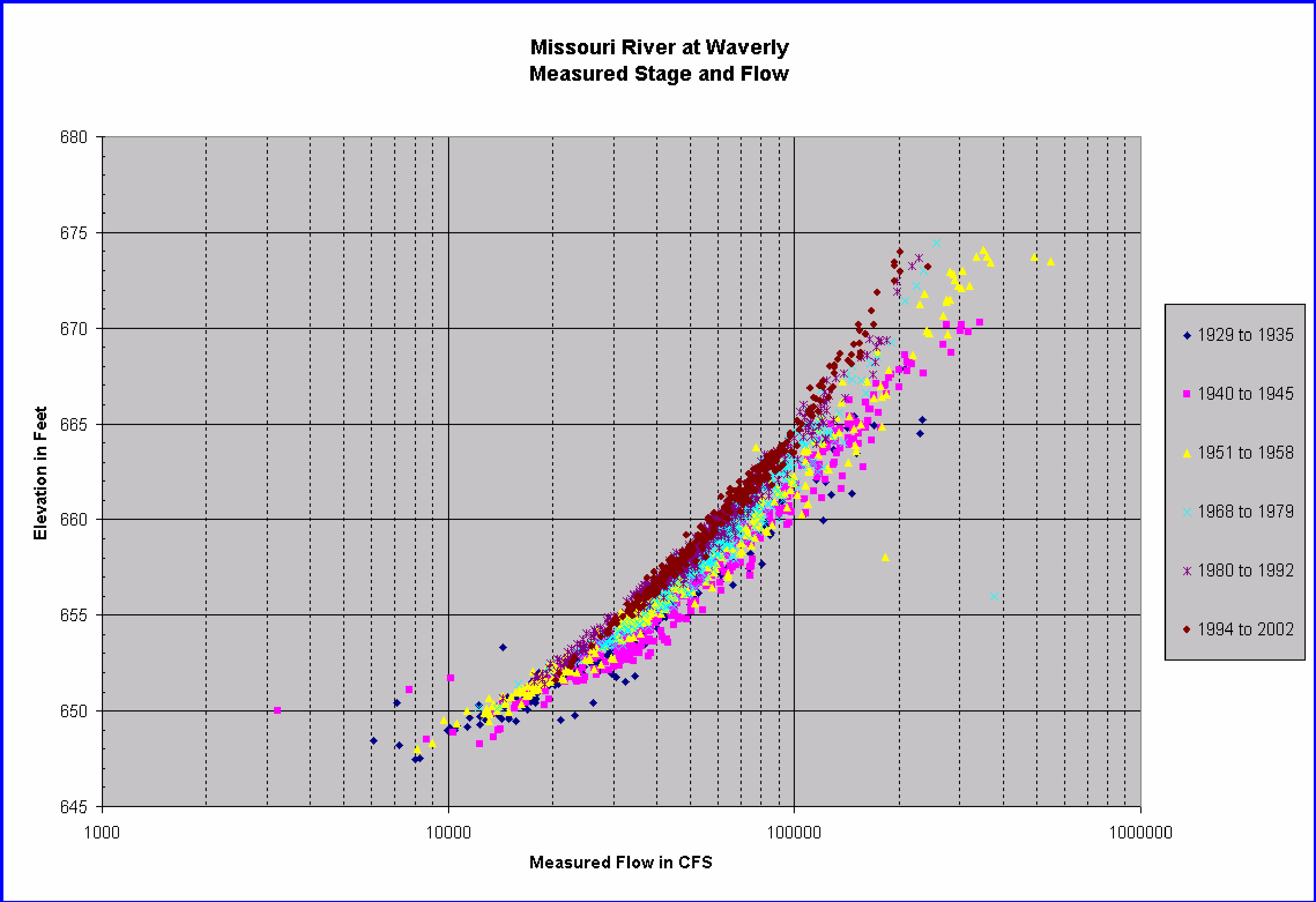


Missouri River at St. Joseph
Elevation in Feet
820.00
815.00
810.00
805.00
800.00
795.00
790.00
785.00
1,000
10,000
100,000
1,000,000
Flow in CFS
1929 to 1935
1940 to 1945
1951 to 1958
1968 to 1979
1980 to 1992
1993 to 2004

Nebraska City



Waverly



Missouri River at Waverly
Measured Stage and Flow
Elevation in Feet
680
675
670
665
660
655
650
645
1000
10000
100000
1000000
Measured Flow in CFS
1929 to 1935
1940 to 1945
1951 to 1958
1968 to 1979
1980 to 1992
1994 to 2002

Discounting the Impact of Upstream Reservoirs

- Mainstem reservoirs are 600 miles upstream.
- Kansas River only contributes 10% of Missouri River flow; therefore reservoirs inconsequential.
- Change in sediment supply is wash load – grain sizes not found in the bed.
- Bed load is only 5 to 15% of total load.
- Bed erosion has caused the problem at Kansas City.
- Similar erosion not seen at upstream and downstream gages

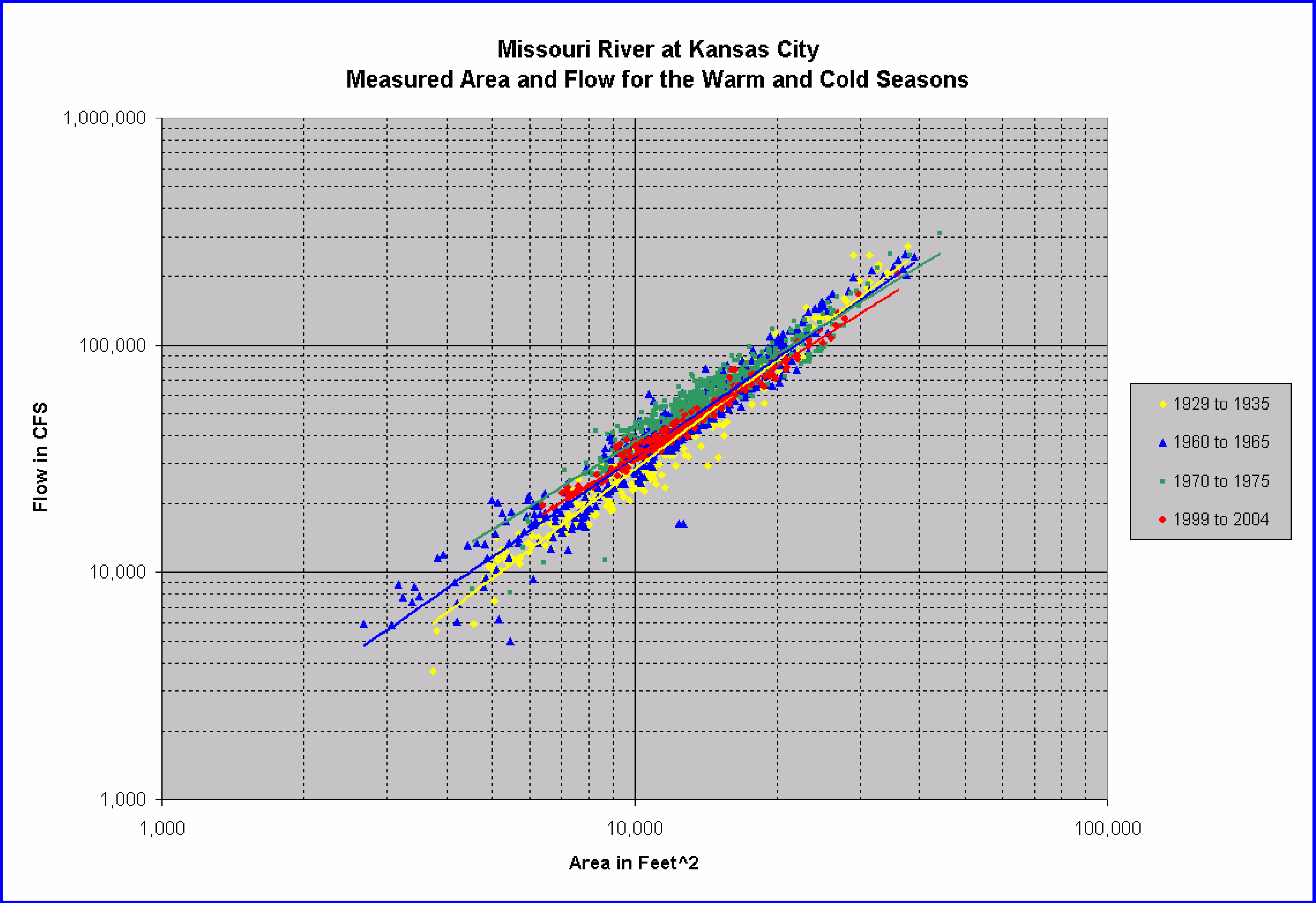
River Training Structures

Sediment Transport

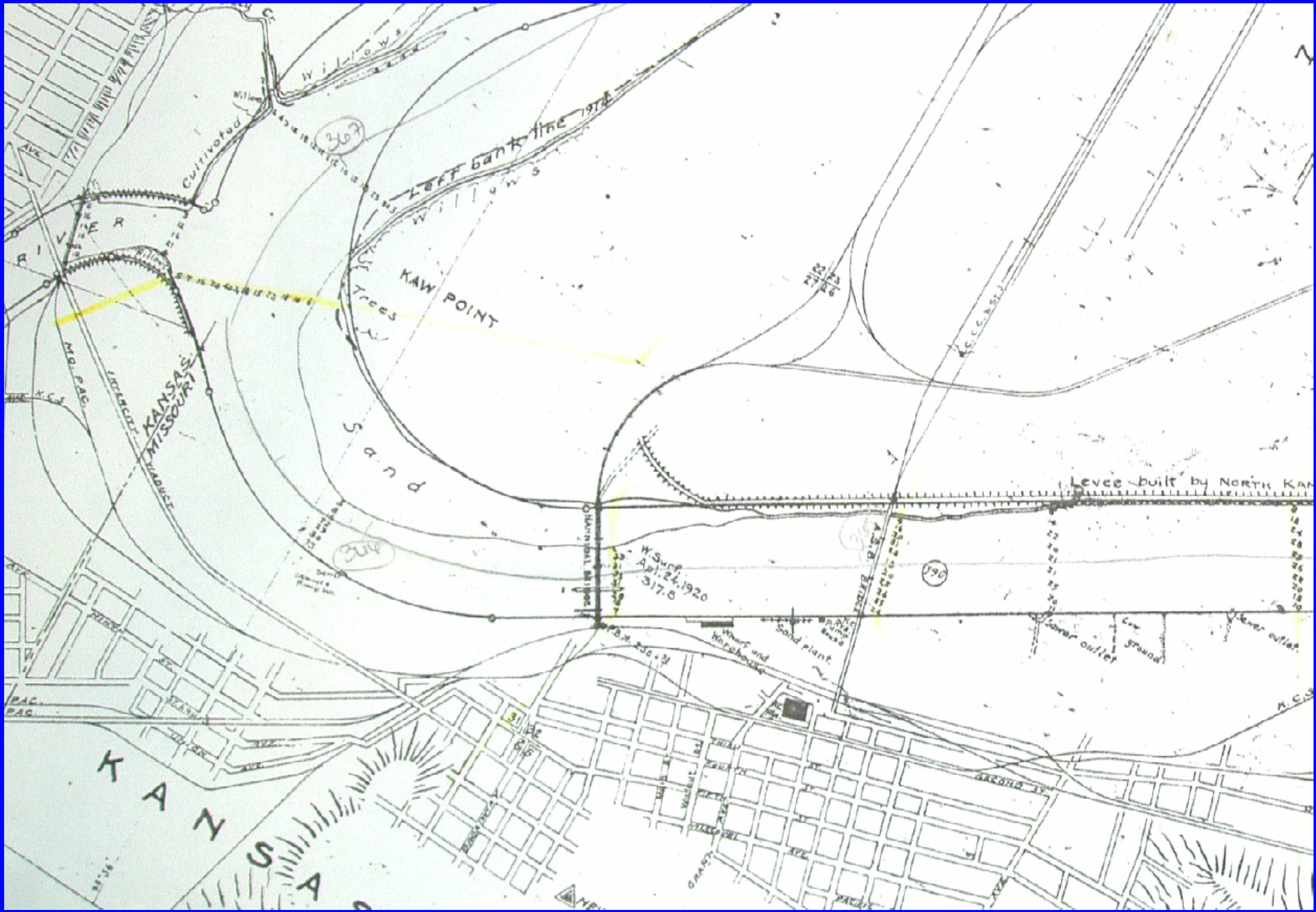
- Function of velocity, depth, roughness, grain size distribution, kinematic viscosity, fall velocity, etc.
- Velocity is a predominant parameter.
- From Yang's excess stream power and from excess shear stress:

$$\text{Transport potential} = f(V^5)$$

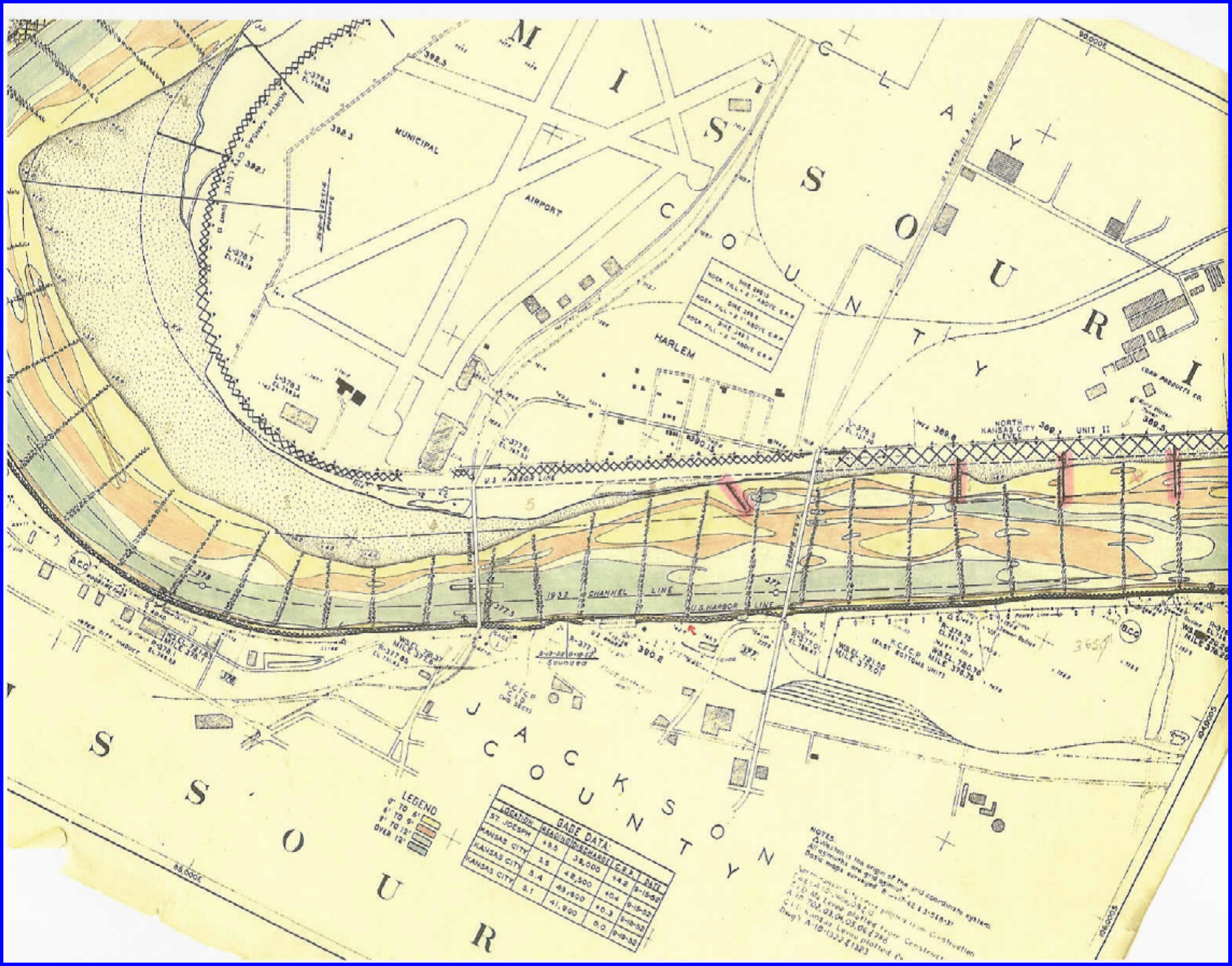
Area-Discharge as an Indicator of Velocity



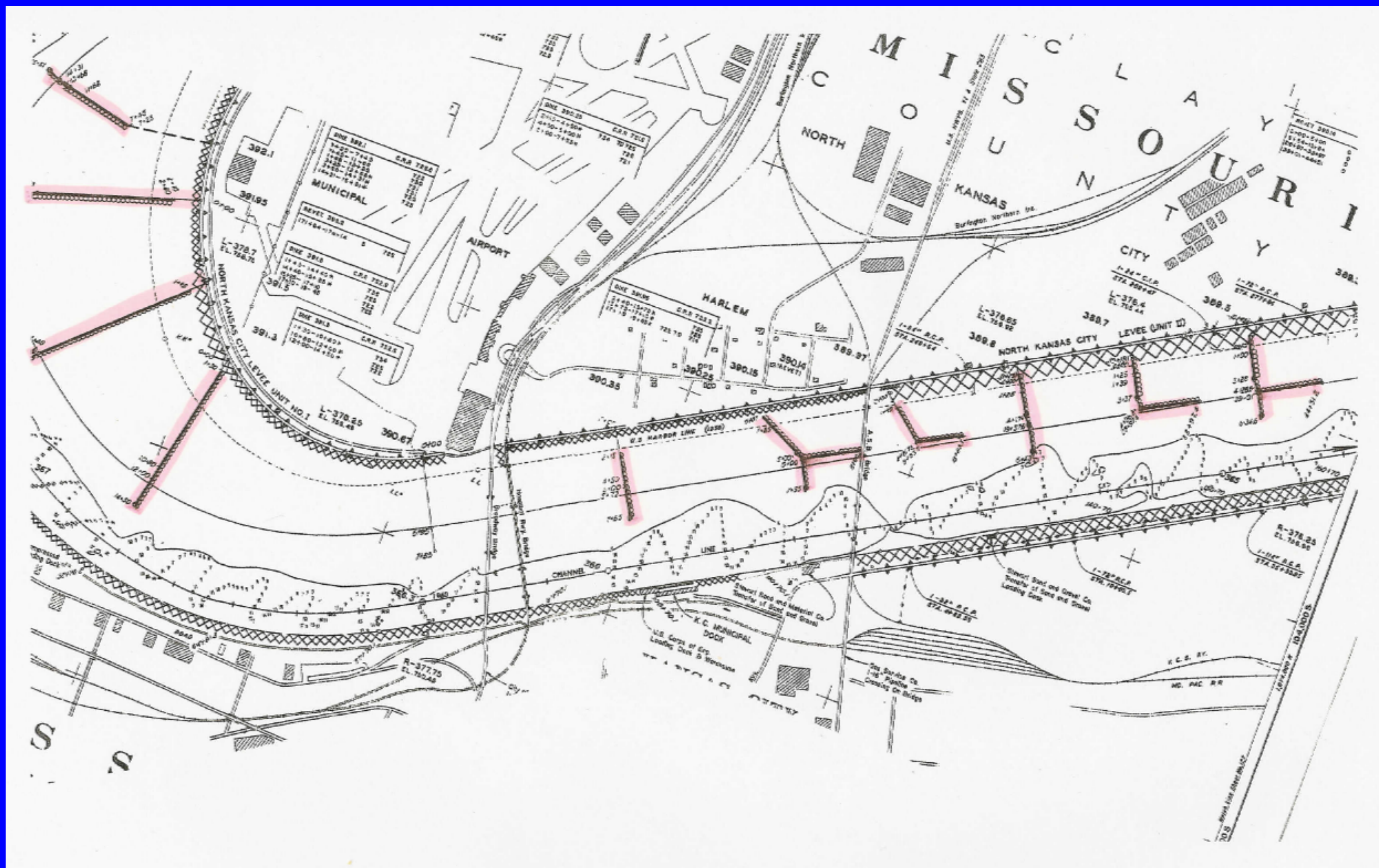
1920 Dikes and Revetments



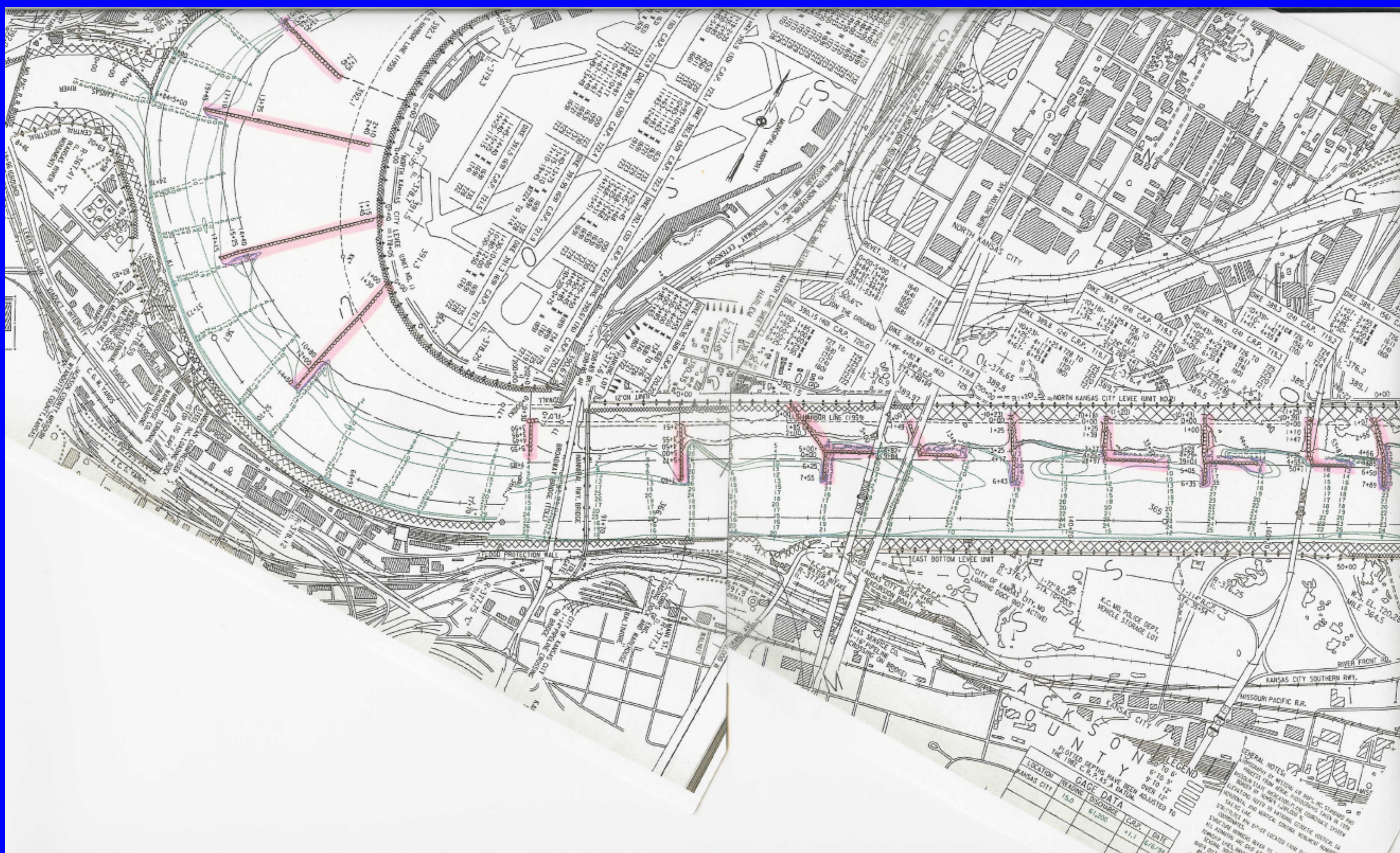
1952 Dikes and Revetments



1973 Dikes and Revetments



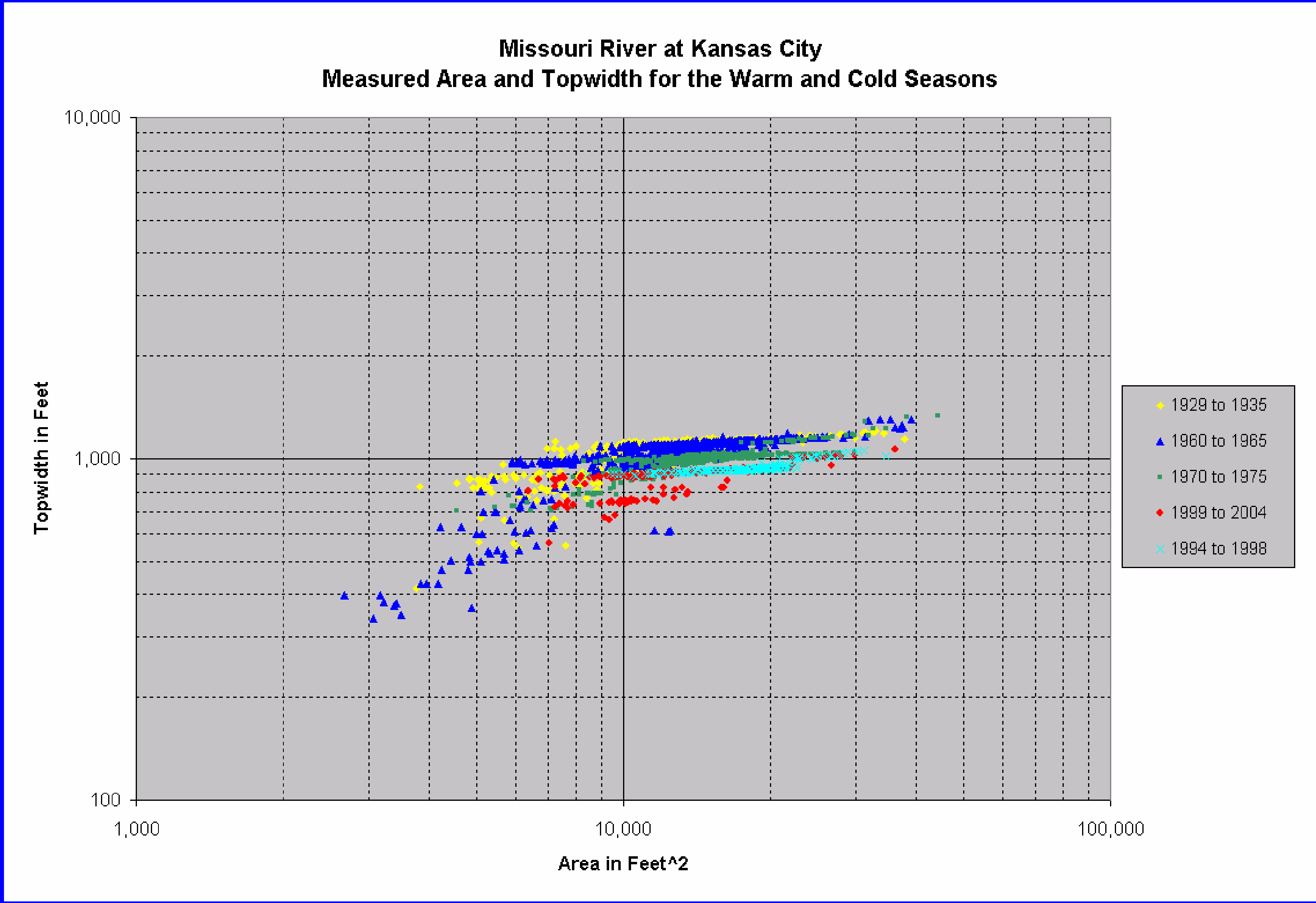
1994 Dikes and Revetments



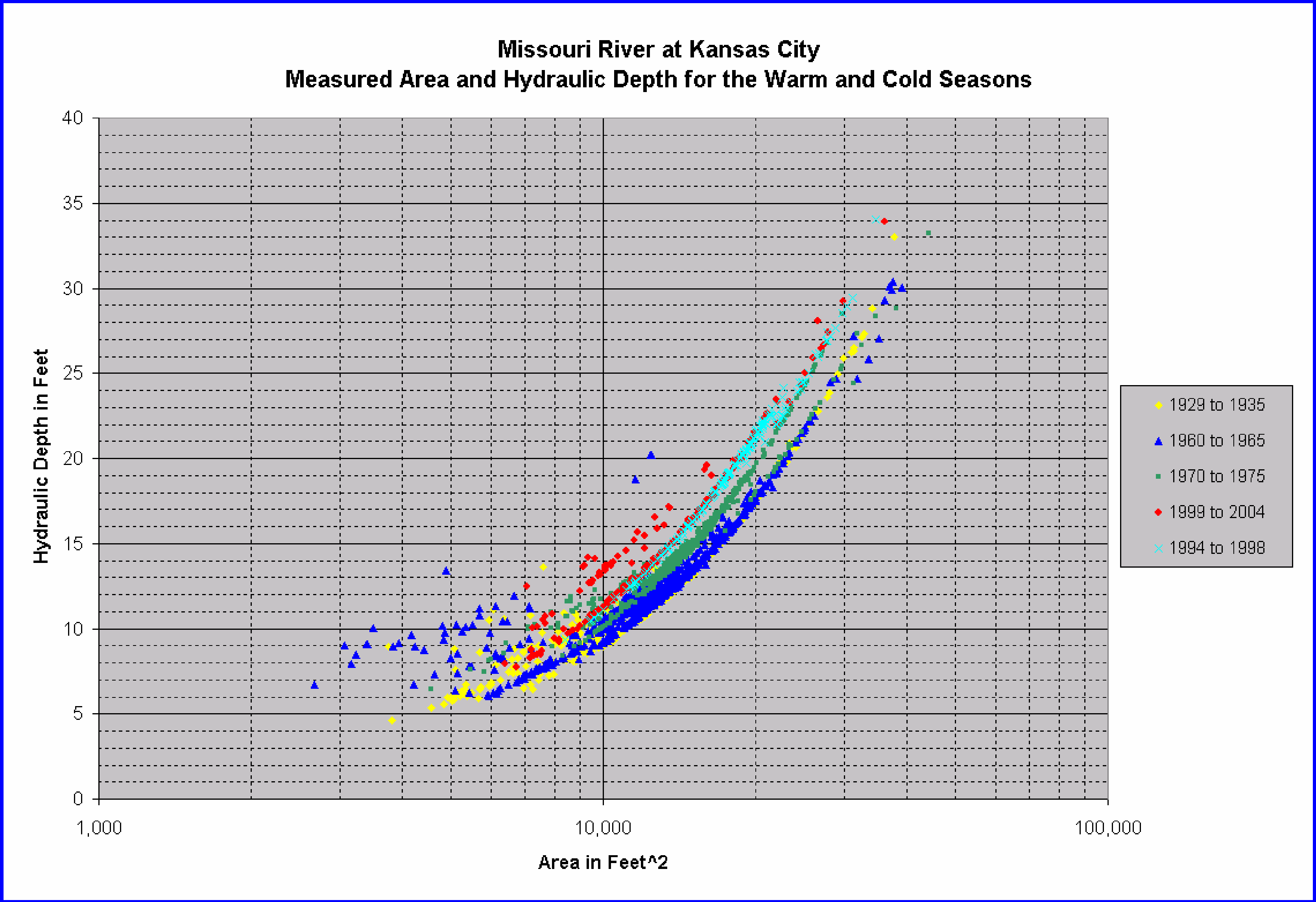
Effect of Dikes

Effect of Dikes (2)

Evolution of Topwidth



Evolution of Hydraulic Depth

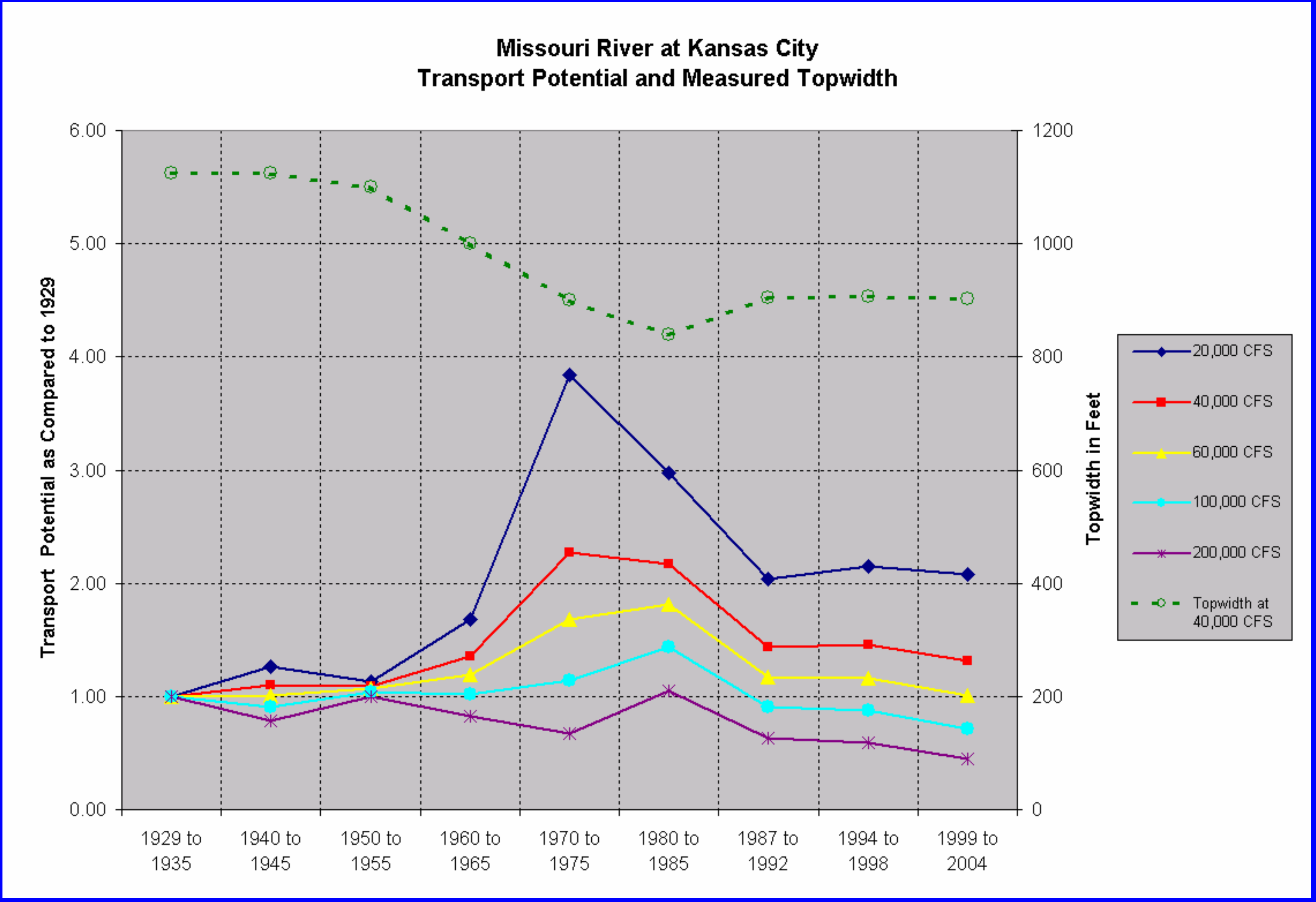


Transport Potential

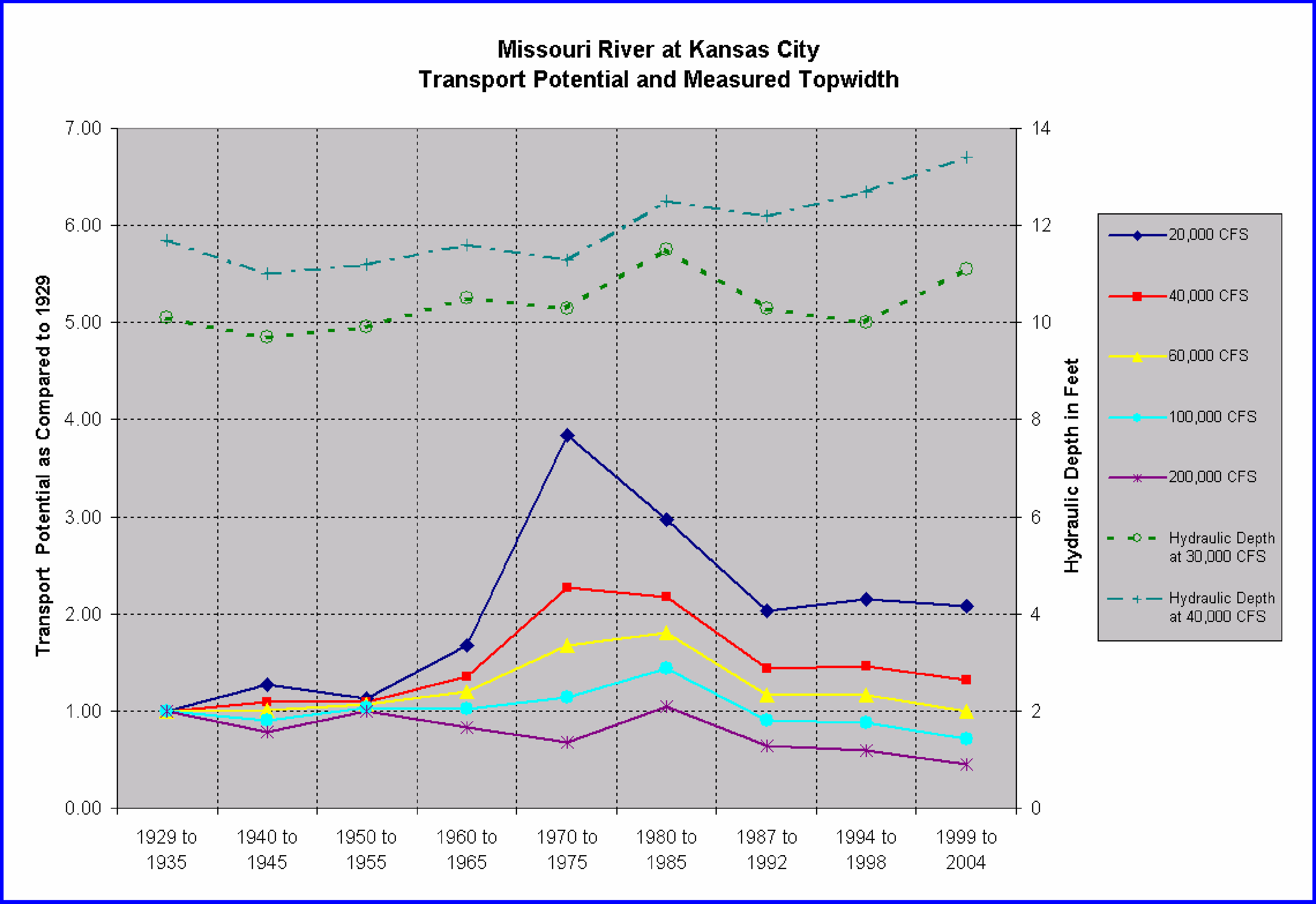
- Assume that the 1929 to 1945 period is a stable, base-line condition.
- Transport potential can be expressed as a ratio comparing the current period to the 1929 base line:

$$\text{Transport Ratio} = \frac{V_{\text{Period}}^{5}}{V_{1929}^{5}}$$

Transport Potential and Topwidth



Transport Potential and Hydraulic Depth



Minimization of Energy Expenditure

1. Rivers adjust their geometry to minimize energy expenditure.

2. In a natural setting, increased velocity would have stimulated:

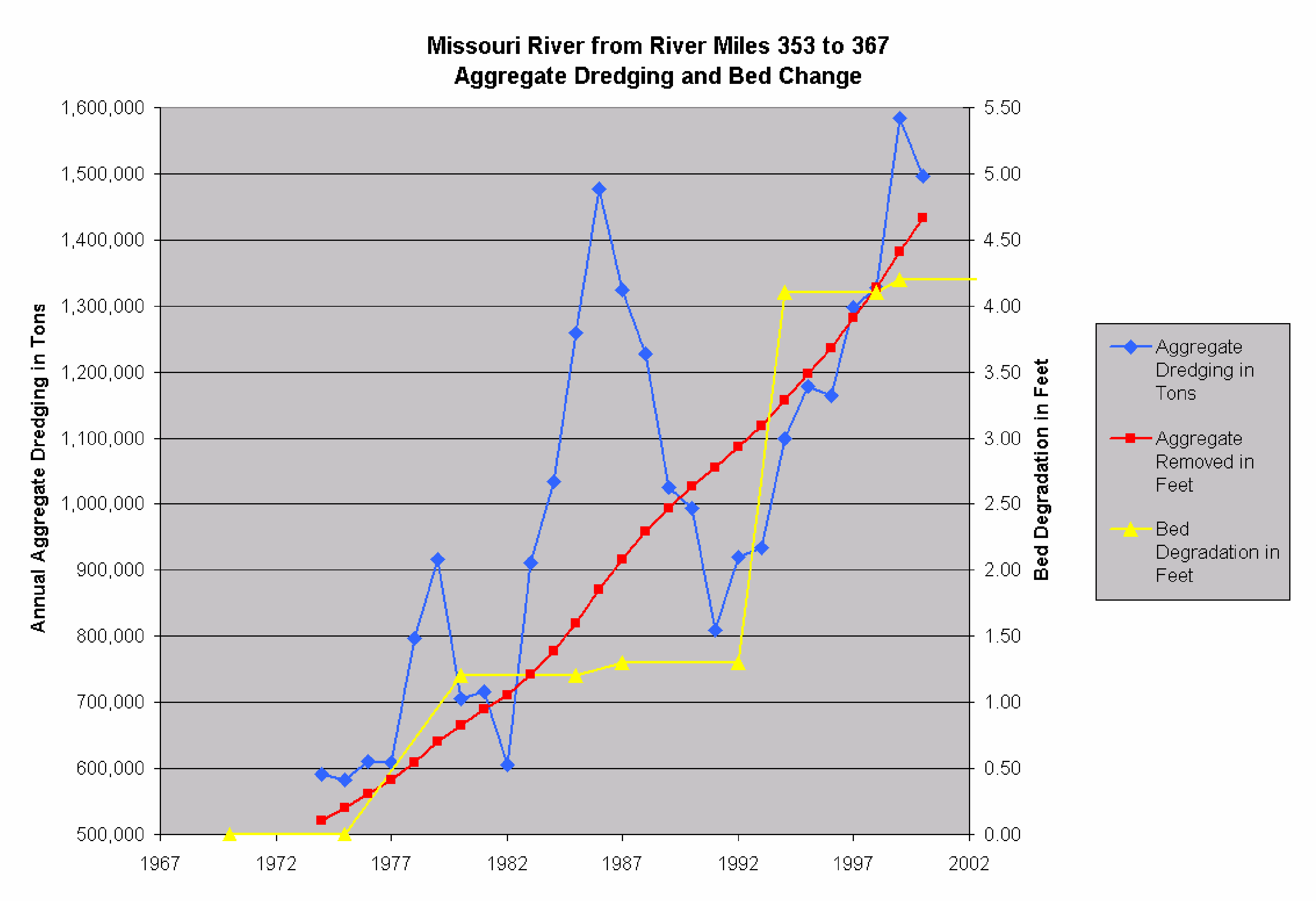
- Degradation.
- Bank caving.
- Meandering.

Minimization of Energy Expenditure (Cont.)

3. But the river is locked in place by dikes and revetments; therefore the bed can only erode to restore equilibrium.

Commercial Sand Dredging

Time History – RM 353 to 367



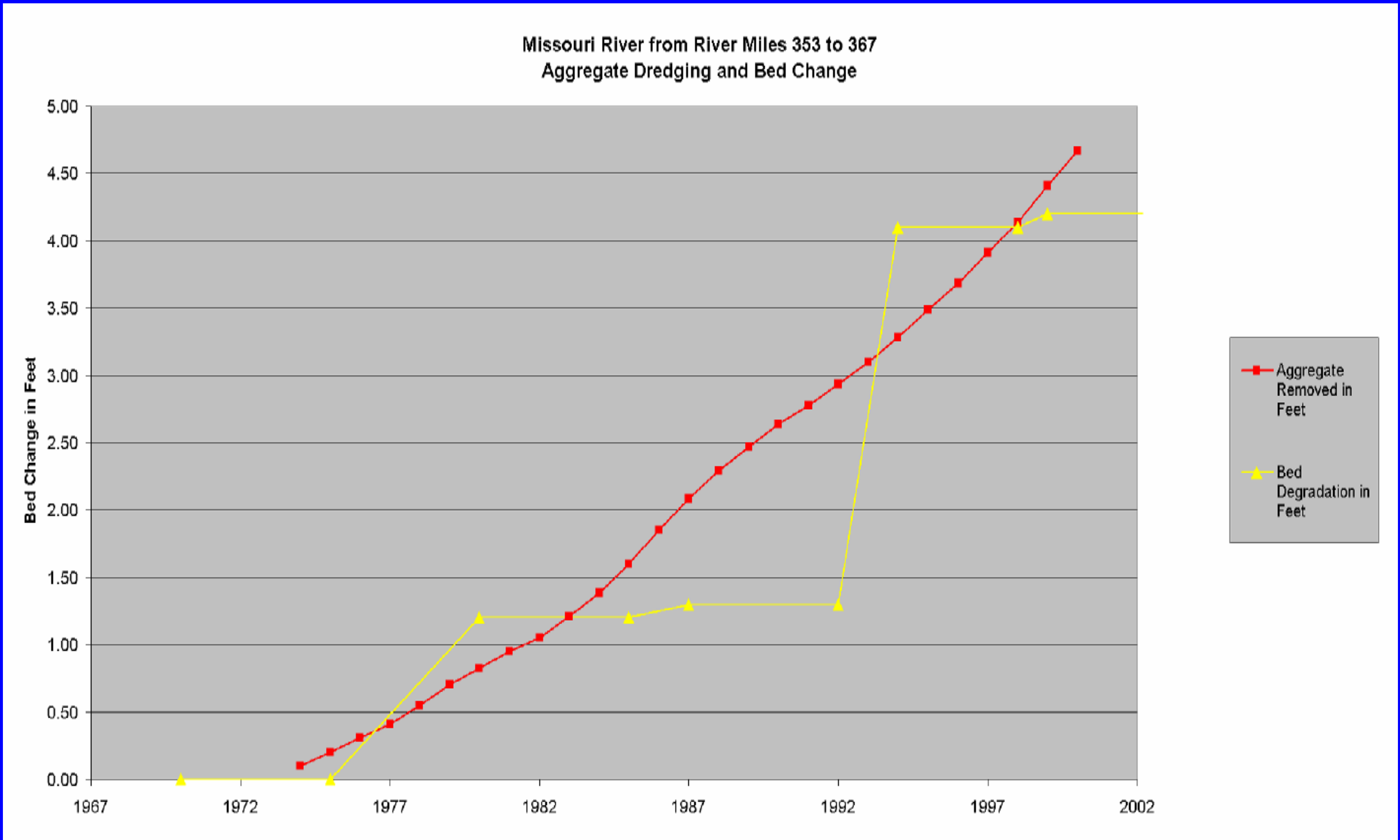
Two Ways of Analyzing Dredging

1. Since the volume of material removed is similar to the the change in the bed elevation, this implies that commercial dredging is responsible for the change.

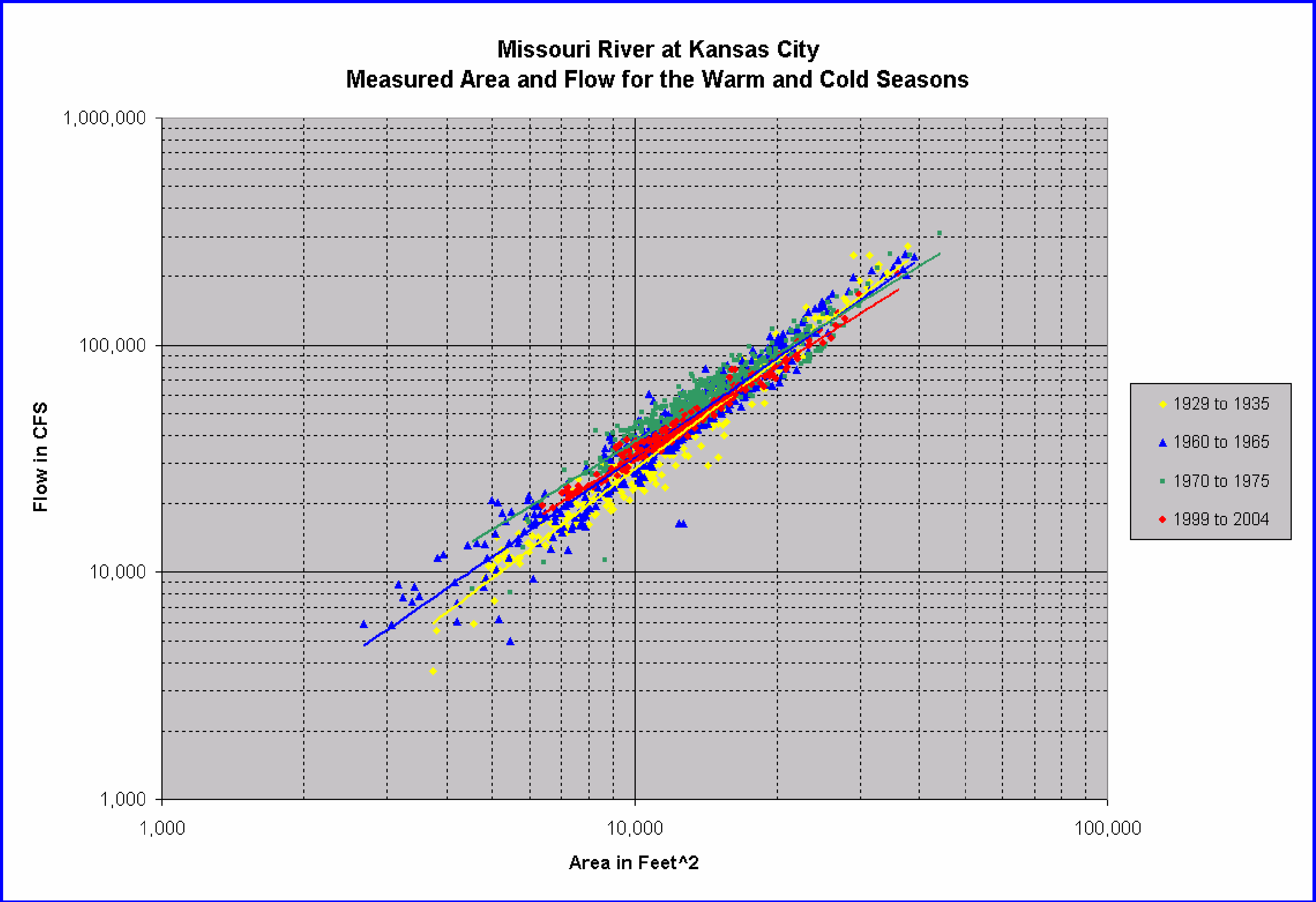
But –

- The time sequence does not agree.
- Unstable river.

Time Sequence does not Agree



River Moving Toward Stability



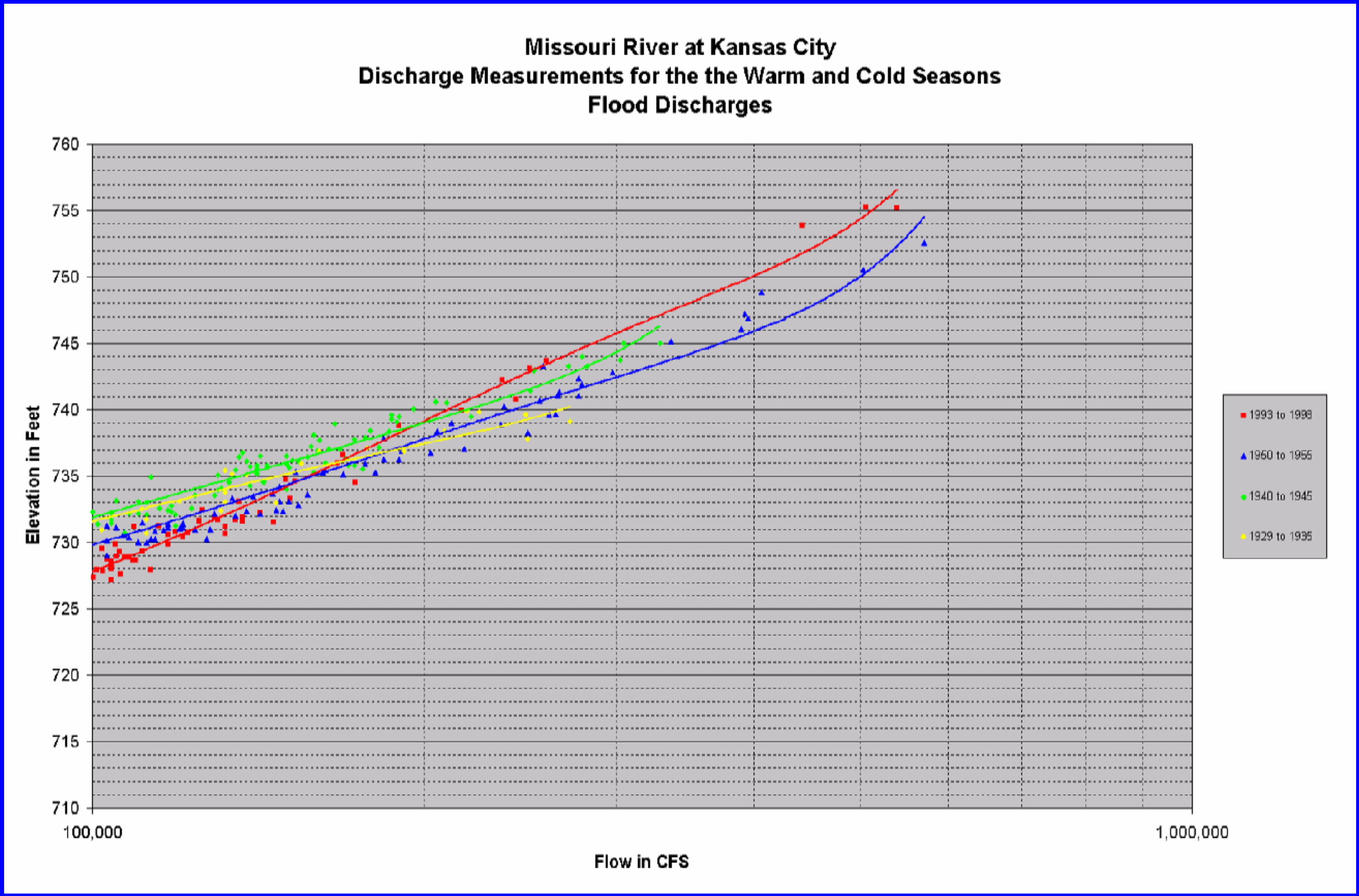
Second Way of Analyzing Dredging

2. Dredging is speeding the river's return to the 1929 area/velocity condition.

This implies: Once the river returns to the 1929 condition, continued dredging may degrade the river below the 1929 base condition.

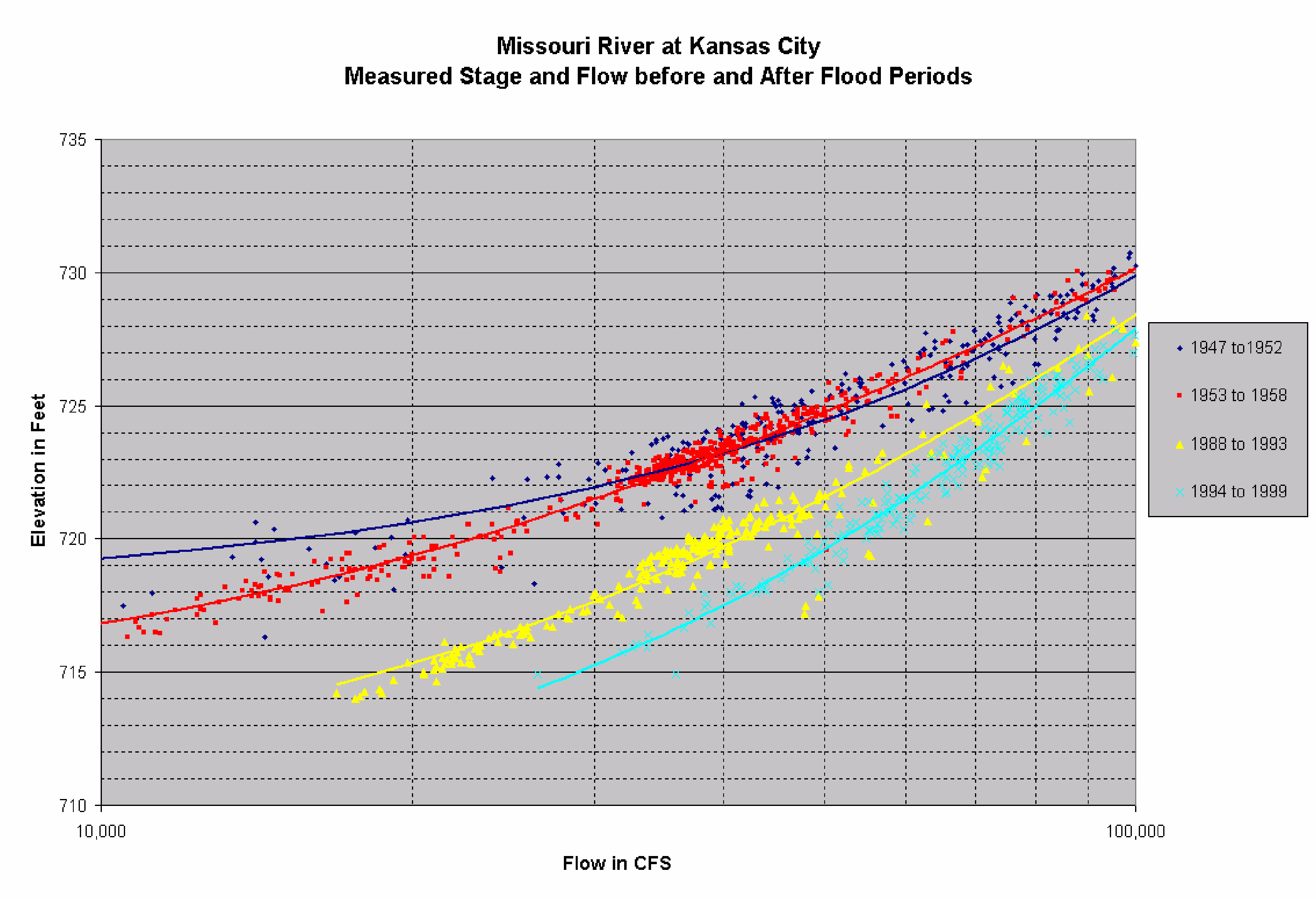
Major Floods

1951, 1952, and 1993 Floods



Increased Roughness

Flood Erosion



Conclusions

1. In channel velocity has been elevated by the presence of dikes.
2. 1.2 feet of further erosion is required to return to 1929 base-line condition.
3. Commercial dredging is accelerating the return to the base-line condition.
4. After the 1929 base-line condition is achieved, further dredging may adversely effect the river.
5. Major floods may result in erosion even below the 1929 base-line.

Further Work

1. Complete a report documenting this past year’s work, including flow and stage duration, grain size analysis, and other Missouri River gages.
2. Major floods.
3. Time history of cross-section morphology.
4. Modeling:
   – Major floods.
   – Dredging.
   – Structural alternatives.