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Sediment Transport and Bathymetric History in Three Reservoirs, Lower Susquehanna River Basin, Pennsylvania and Maryland 1900-2015

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Problem

- The Chesapeake Bay was listed by EPA as an impaired water-body in 2010.
- Since early 1900's, three reservoirs in Lower Susquehanna River (LSR) Basin have been trapping and releasing sediments and nutrients
- To document reduced reservoir sediment storage capacity (SSC) extensive bathymetric and sediment coring studies conducted since 1990
- At SSC, sediment loads will likely increase to the upper Chesapeake Bay impacting the TMDL's, and the State's water-quality standards and load allocations.

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Objectives

- Provide historical context to transported sediment loads into and out of the Reservoirs
- Discuss major influences on sediment load transport
- Discuss the loss of reservoir SSC over time

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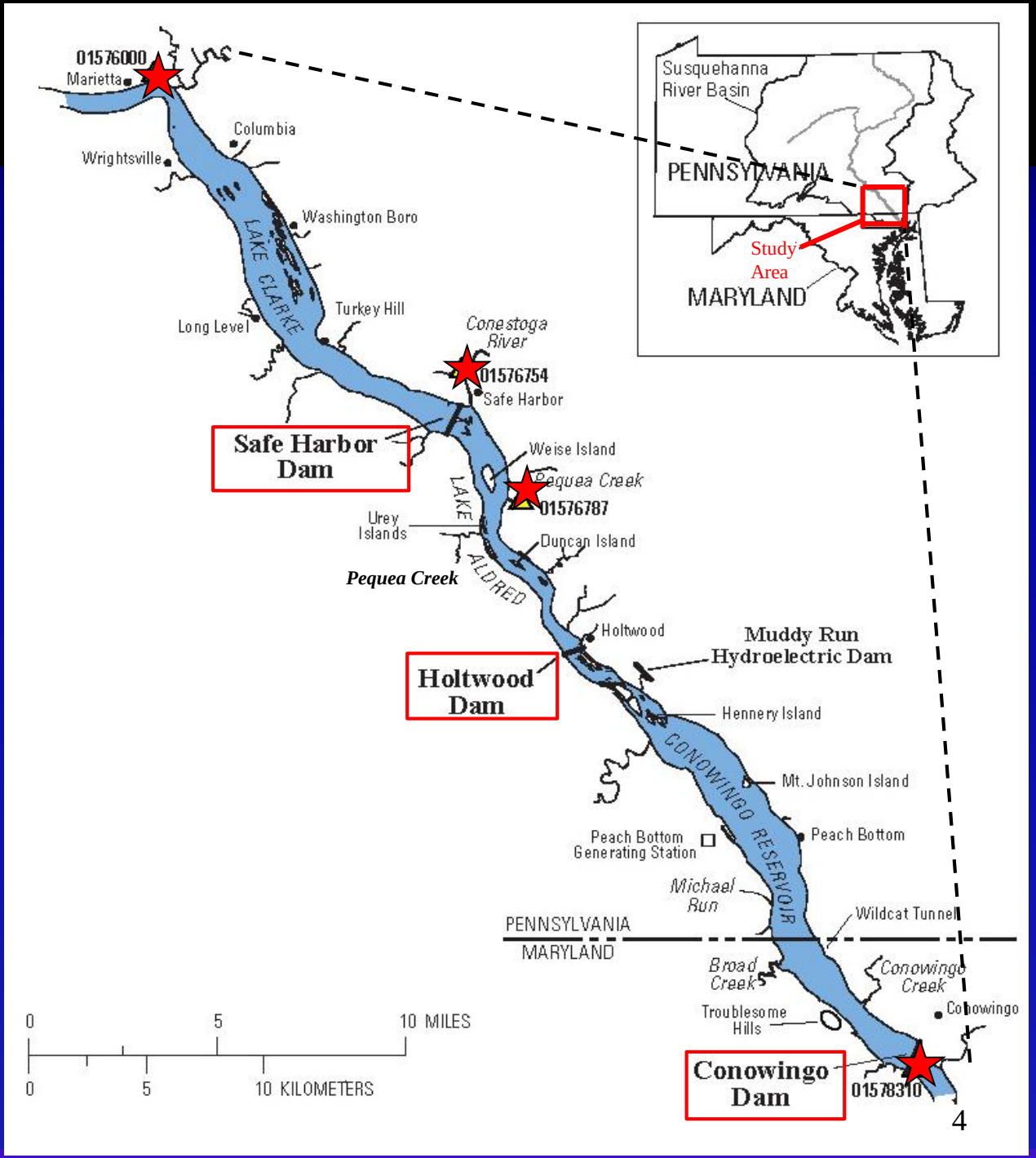
Susquehanna River Reservoirs



Lower Susquehanna River Reservoirs

Physical Characteristics

Dam/Reservoir Name	Dam Height (feet)	Original Design Capacity (ac ft)	Remaining Sediment Capacity (ac ft) (year)	Total Sediment Deposition (tons) (2010)
Safe Harbor / Lake Clarke	75	150,000	0 (1950)	92,400,000
Holtwood / Lake Aldred	55	60,000	0 (1920)	13,600,000
Conowingo / Conowingo	105	310,000	11,000	184,000,000
Total		**520,000**	**11,000**	**290,000,000**

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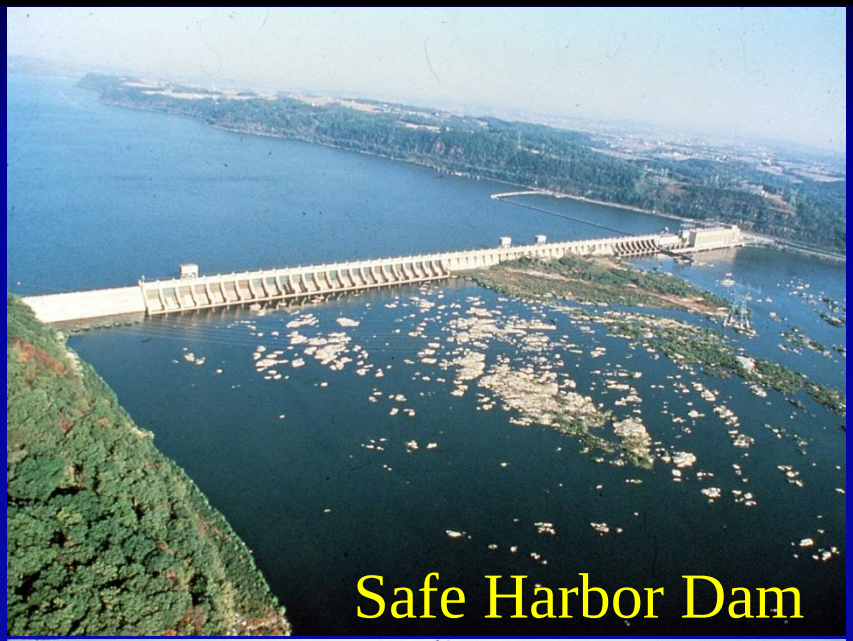
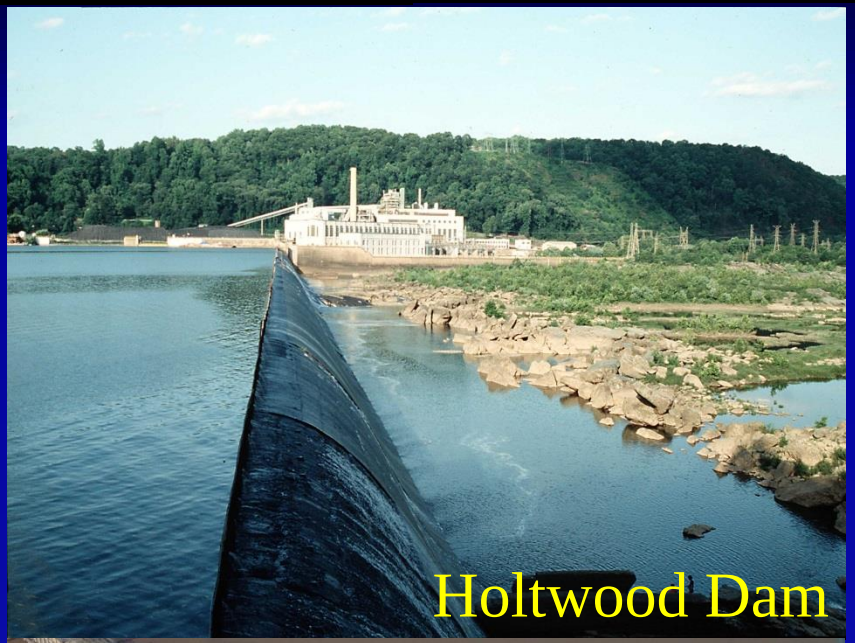
Lower Susquehanna Rivers Dams


Safe Harbor Dam


Holtwood Dam


Conowingo Dam


Flooding at Conowingo Dam

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Susquehanna Sediment Transport

- Where did all the sediment come from?
- Predominately from three source sectors
  - ❖ Logging and land clearing
  - ❖ Agriculture
  - ❖ Coal mining
- Each source sector sediment loads were greatest early part of 20th century

Susquehanna Sediment Transport

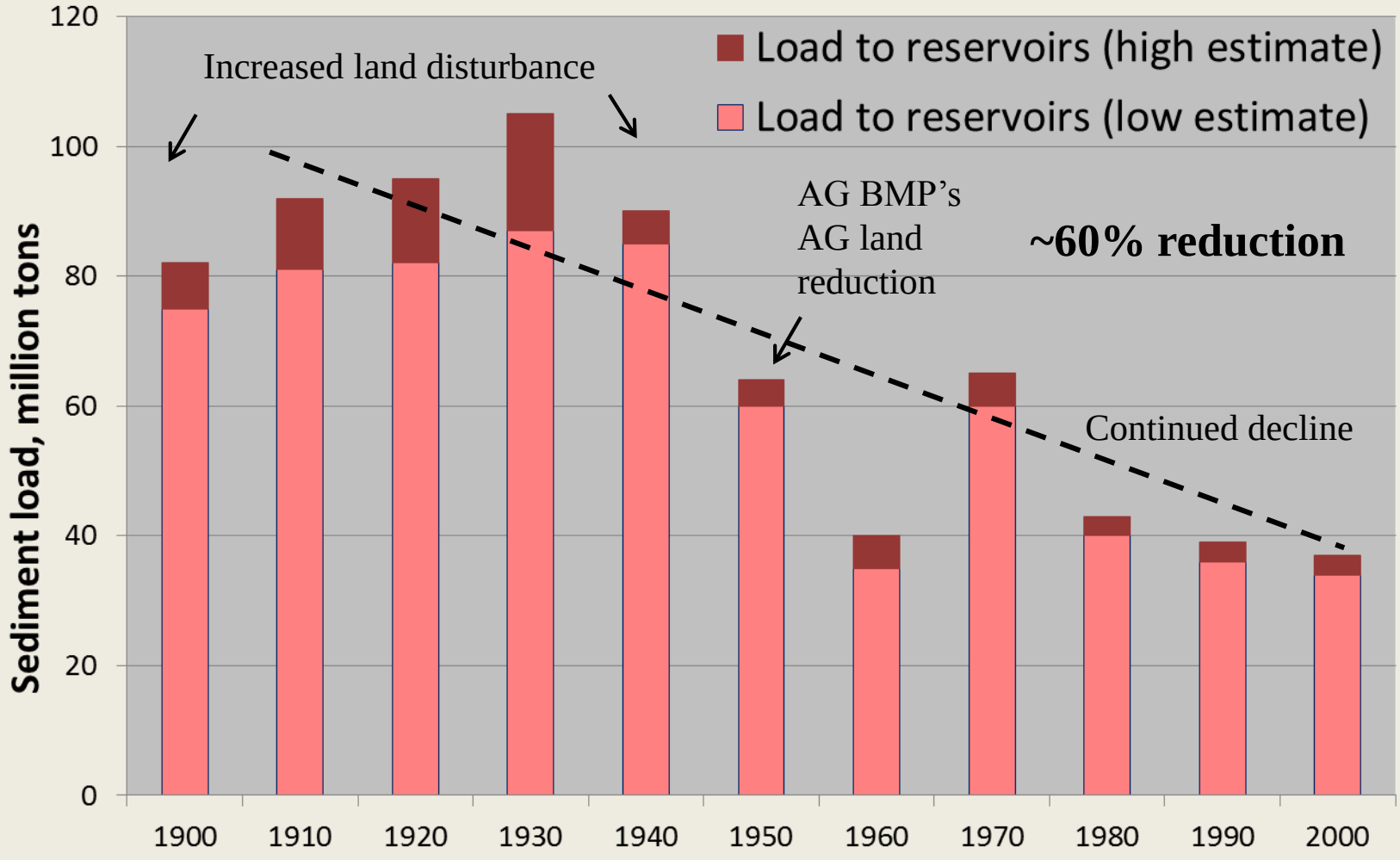
Decline in sediment loads from prominent landuse sources in SRB

Source	Early 1900's	Current
Logging/clearing	2-3 m/t/yr	½ m/t/yr
Agriculture	4-6 m/t/yr	2-3 m/t/yr
Coal production	3 m/t/yr	<0.5 m/t/yr

*based on literature reviews and current information

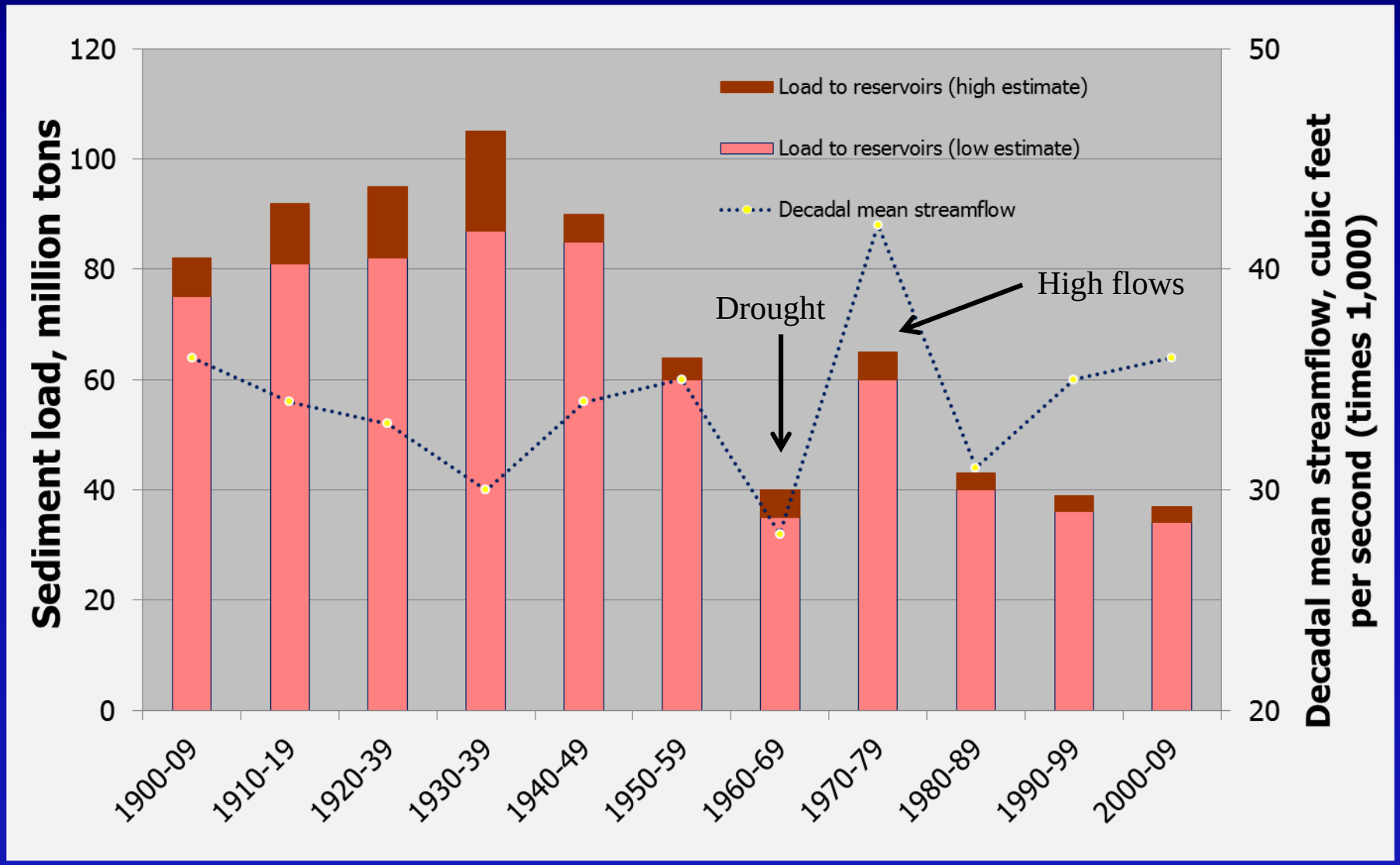
Estimated Sediment Loads to Reservoirs 1900-2009

Landuse Change



Estimated Sediment Loads to Reservoirs 1900-2009

Climatic Variability



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Conowingo Bathymetry 1929-2015

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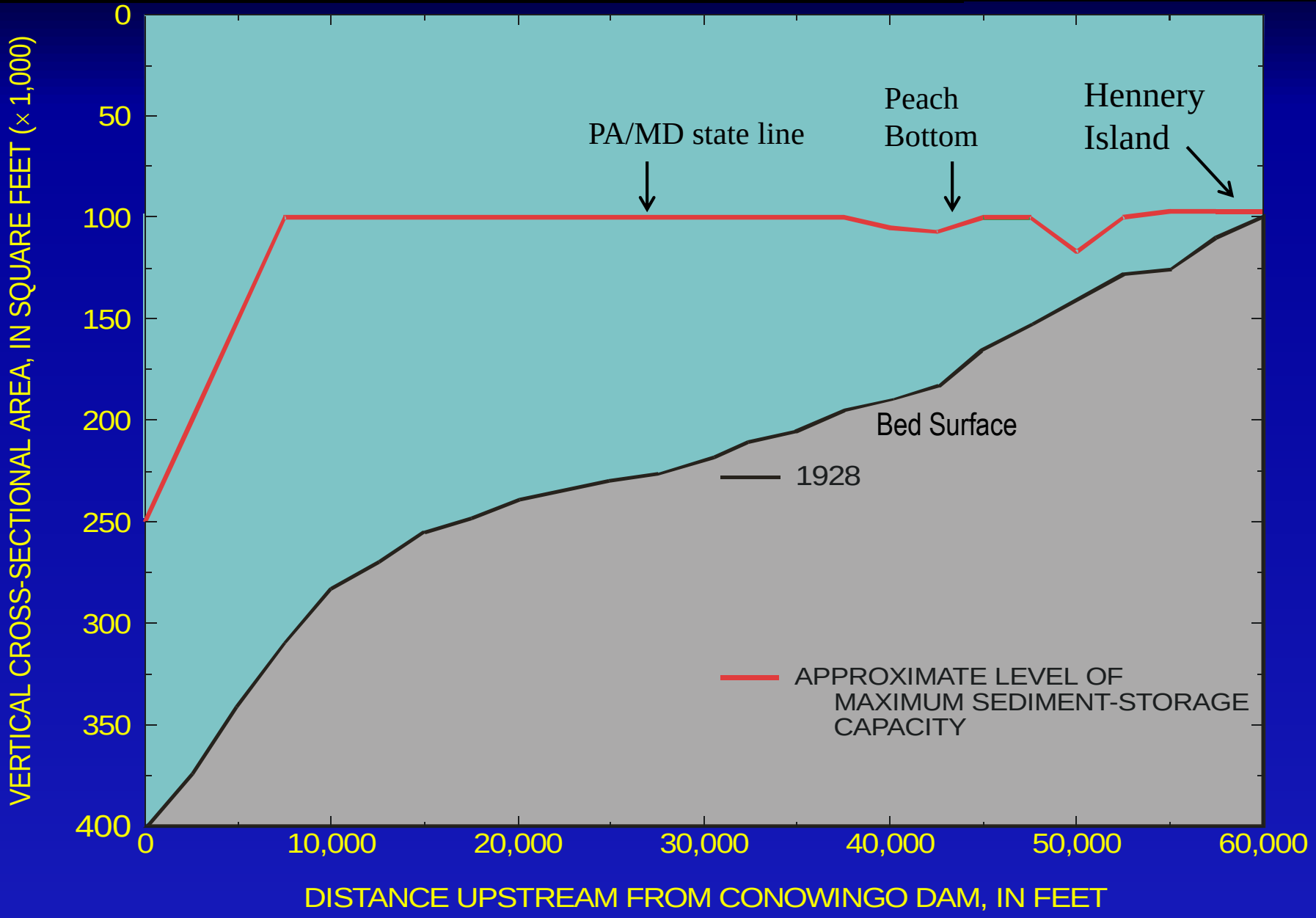
Conowingo Dam - Bathymetry Change



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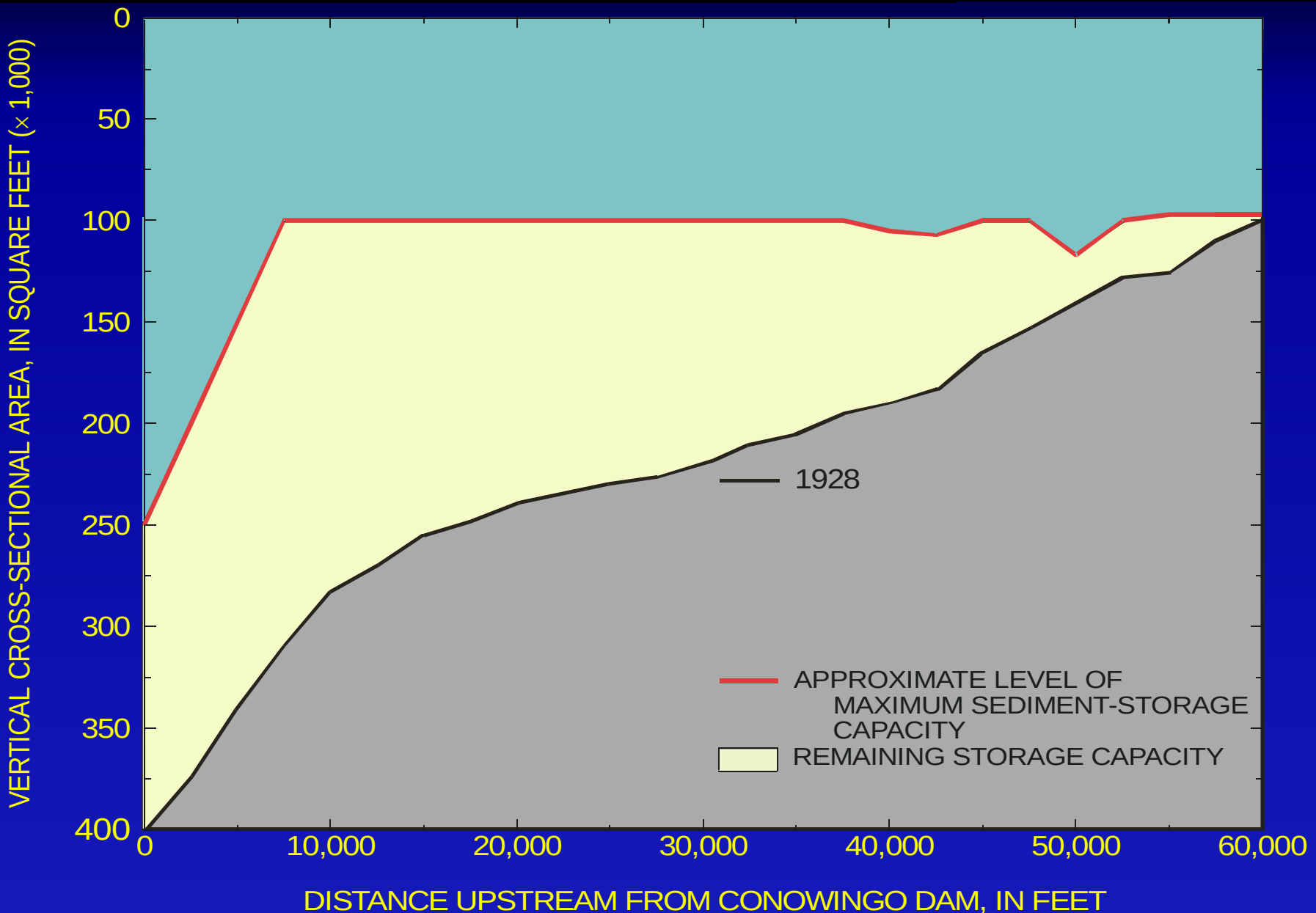
Conowingo Dam - Bathymetry Change



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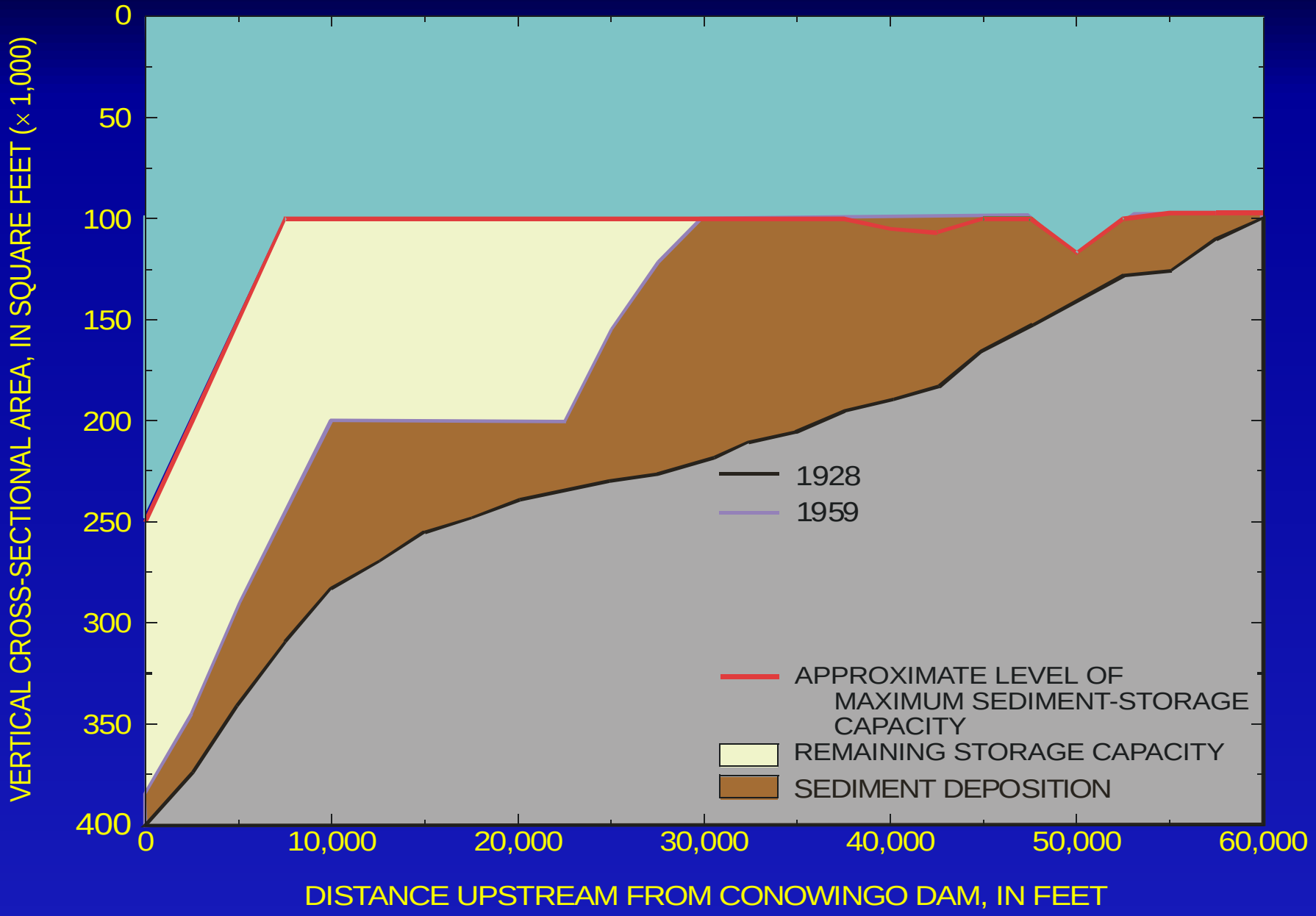
Conowingo Dam - Bathymetry Change



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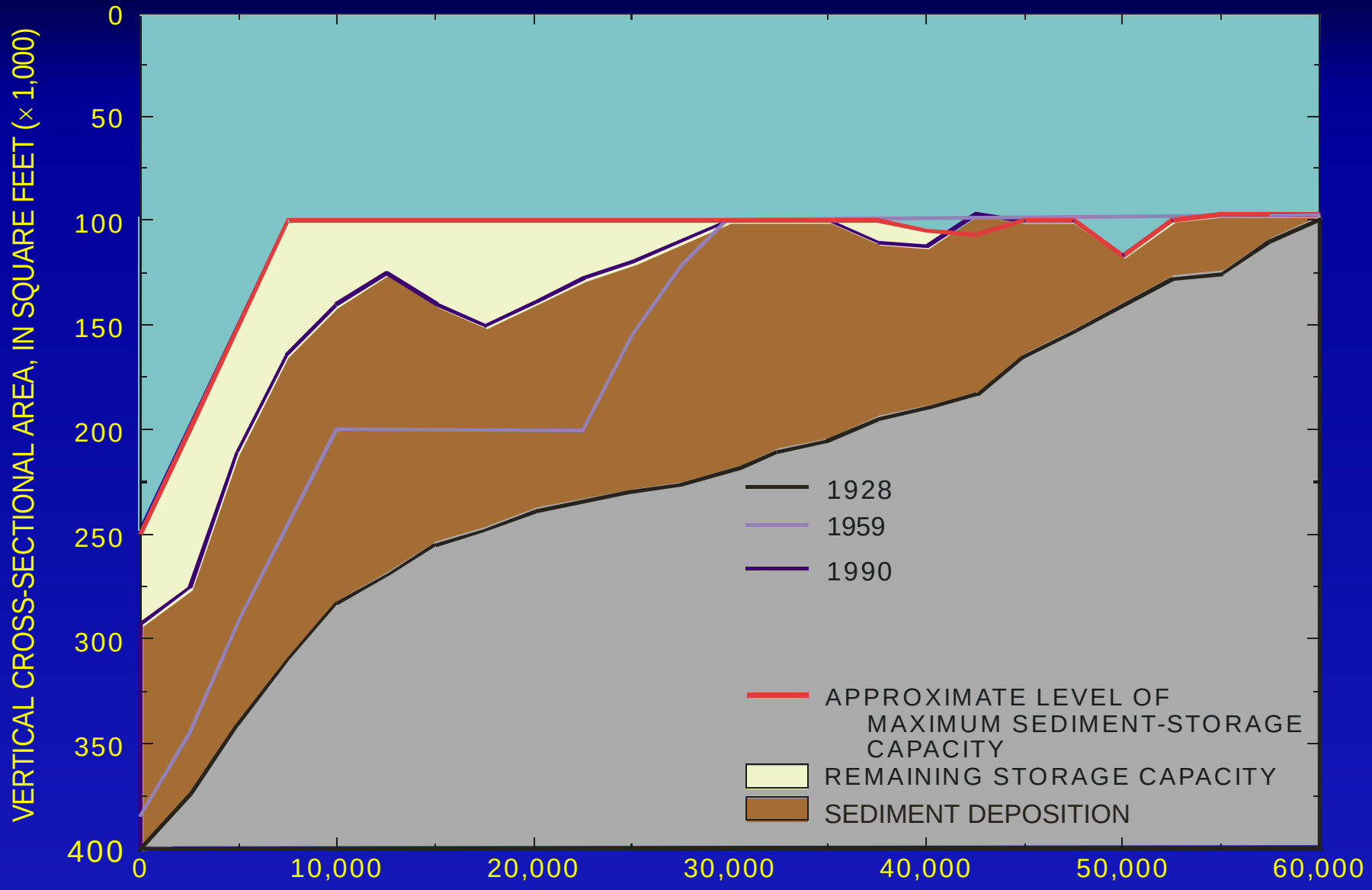
Conowingo Dam - Bathymetry Change



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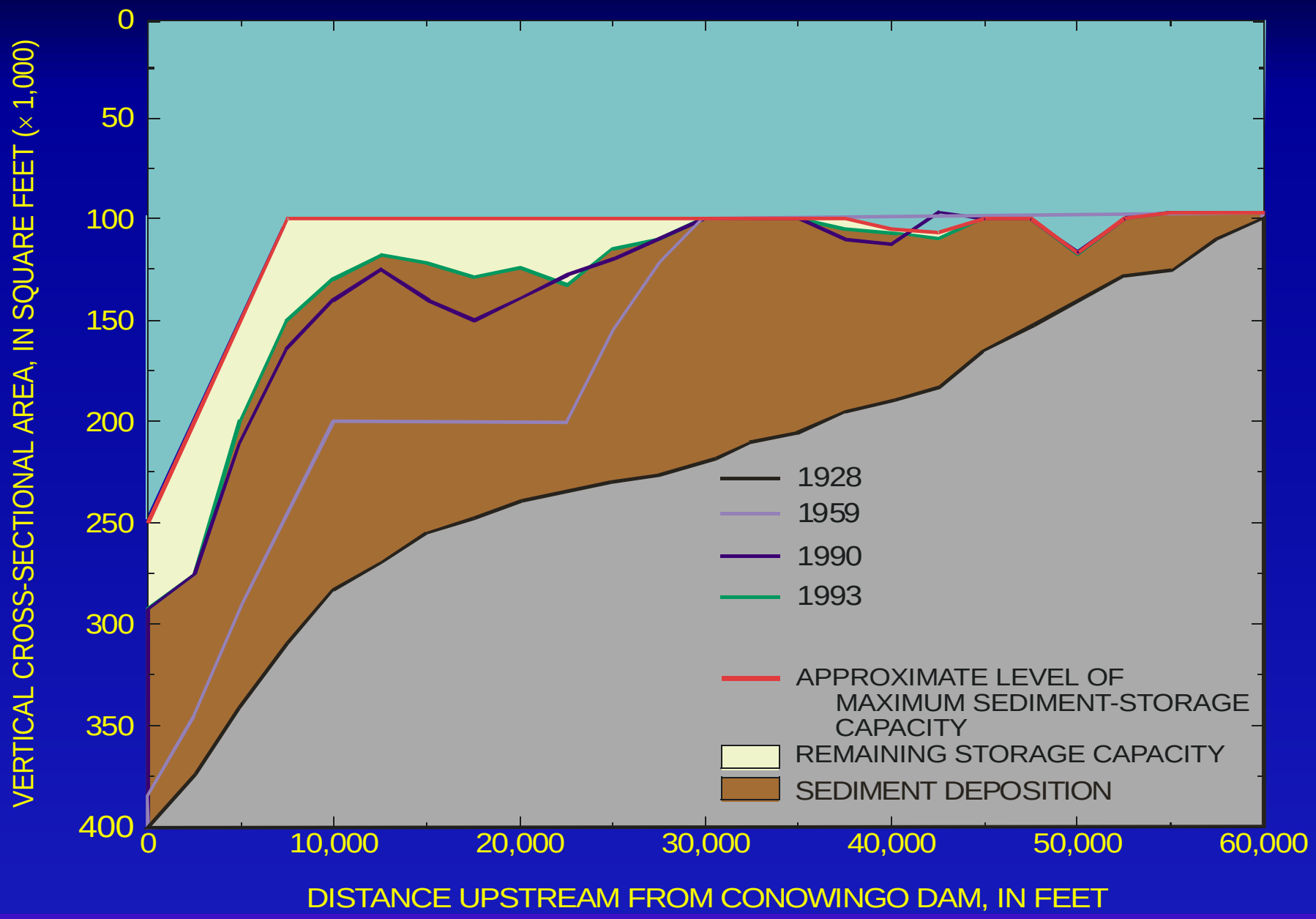
Conowingo Dam - Bathymetry Change



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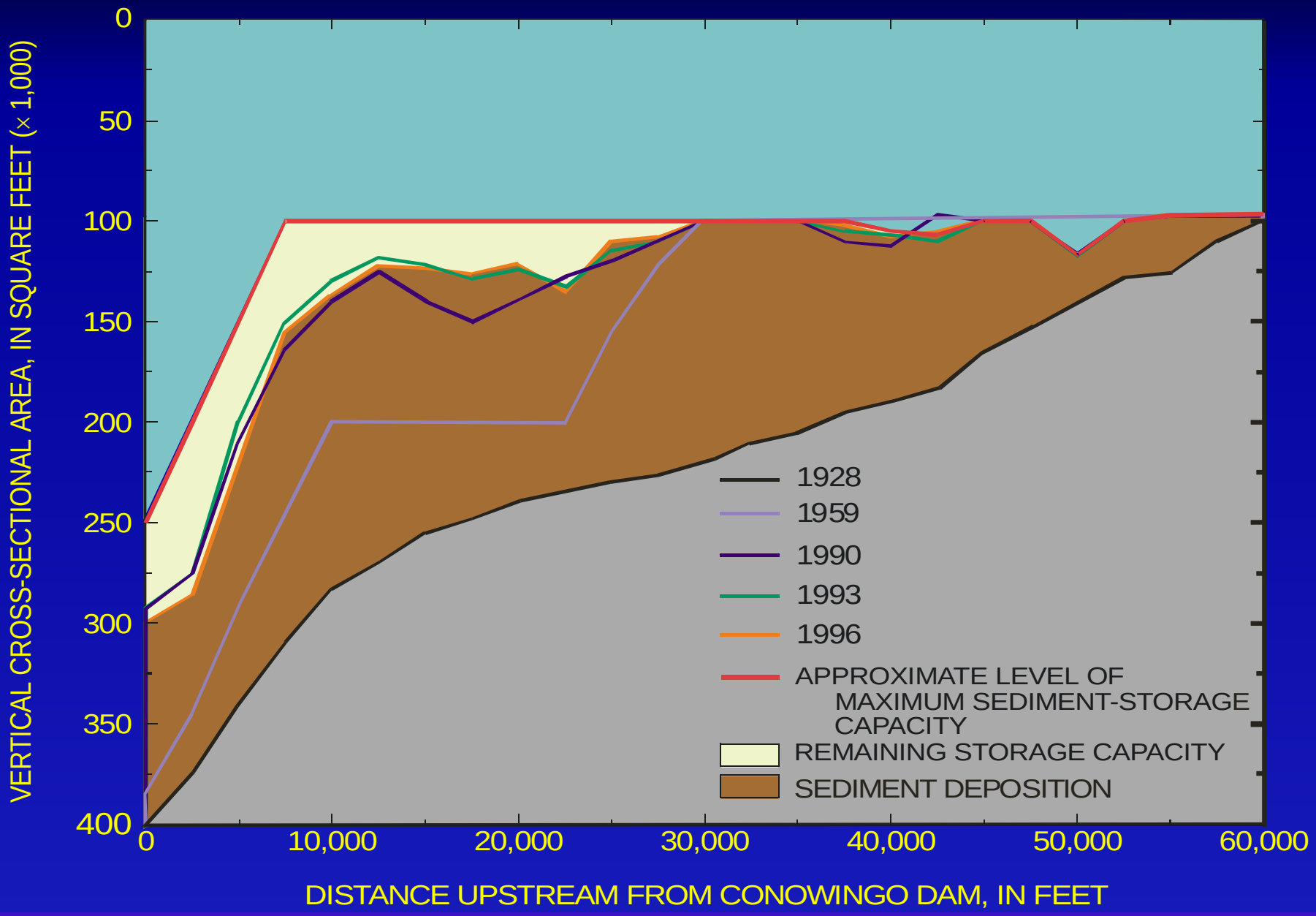
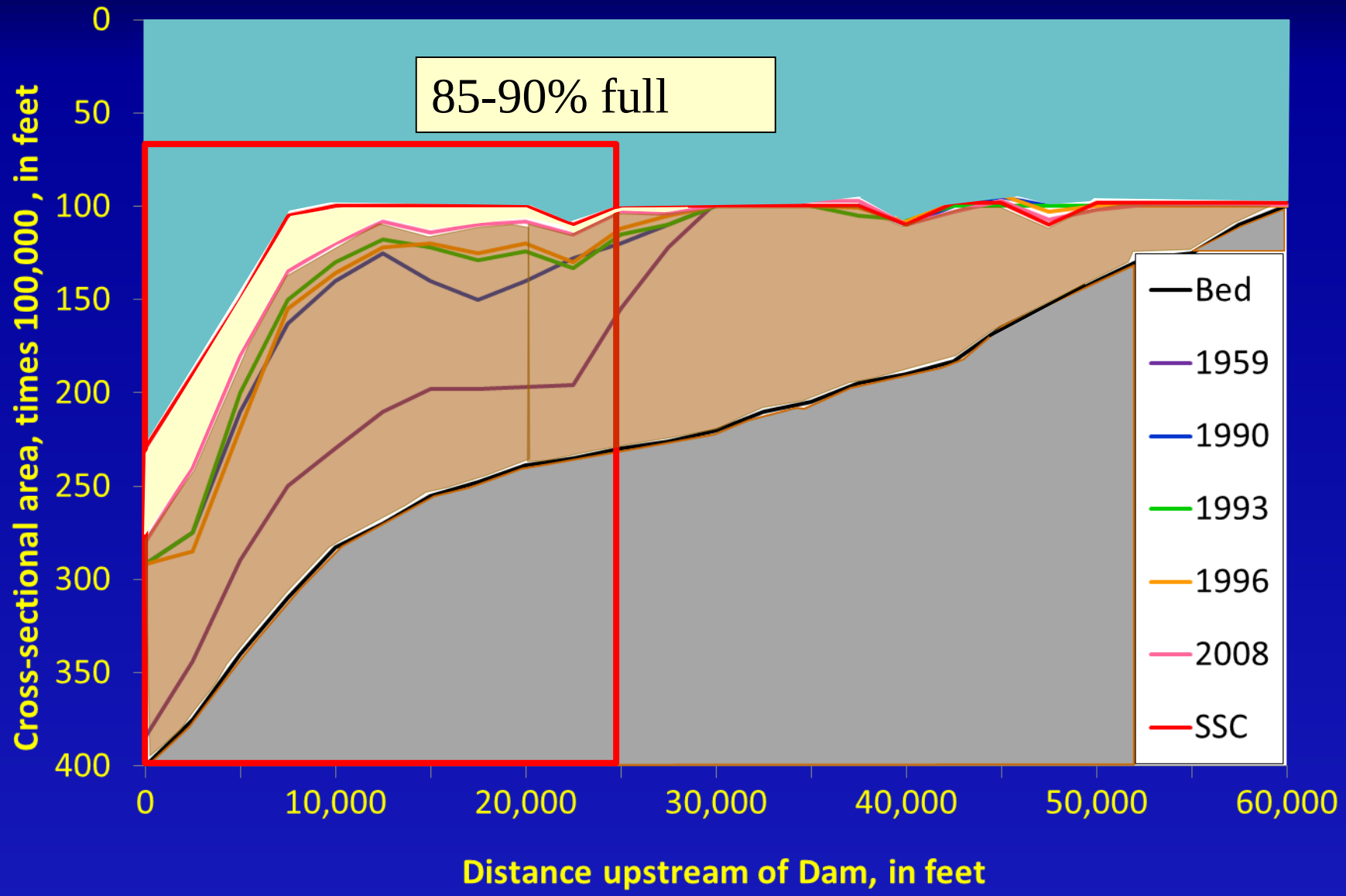
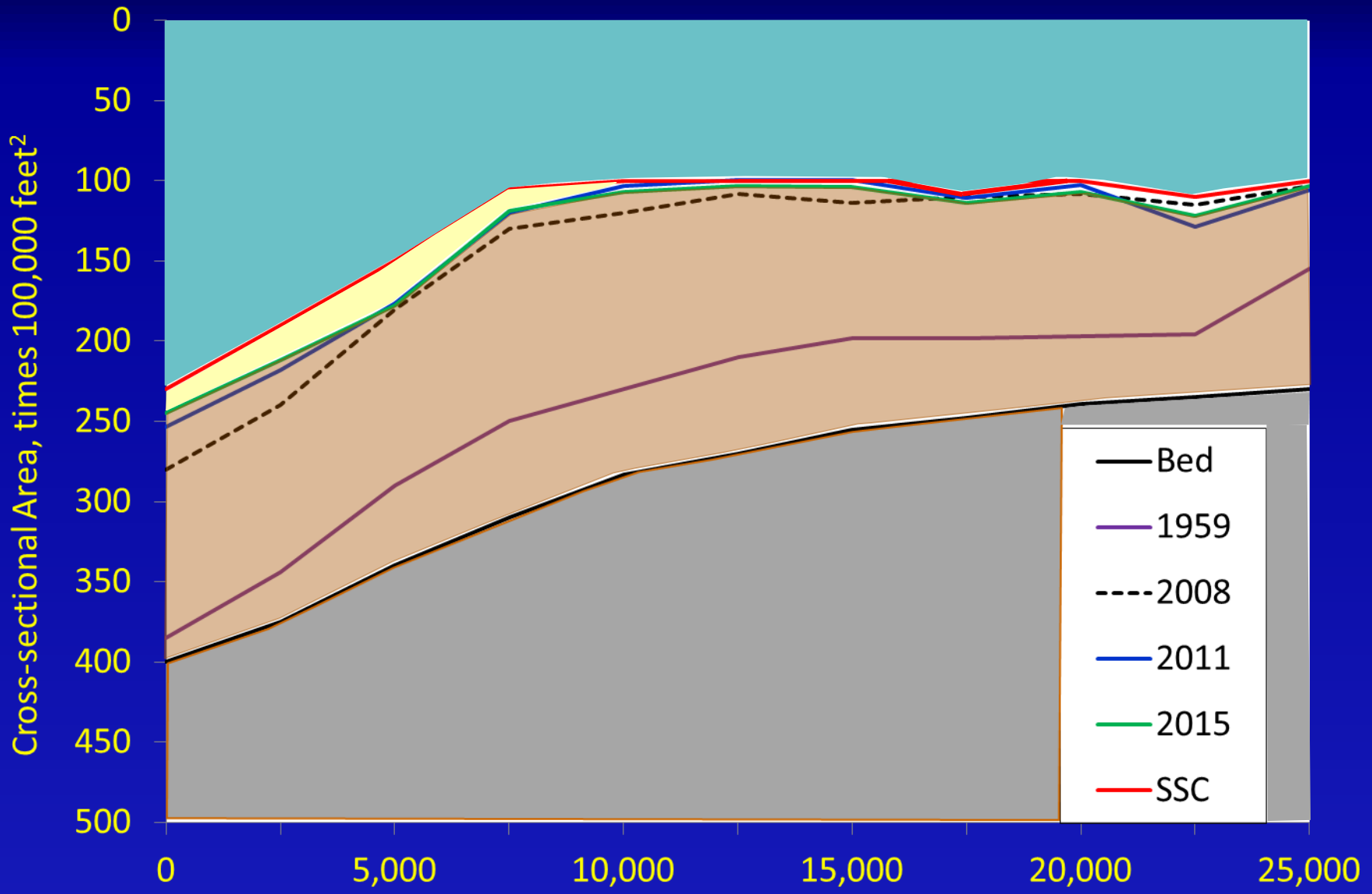
Conowingo Dam - Bathymetry Change



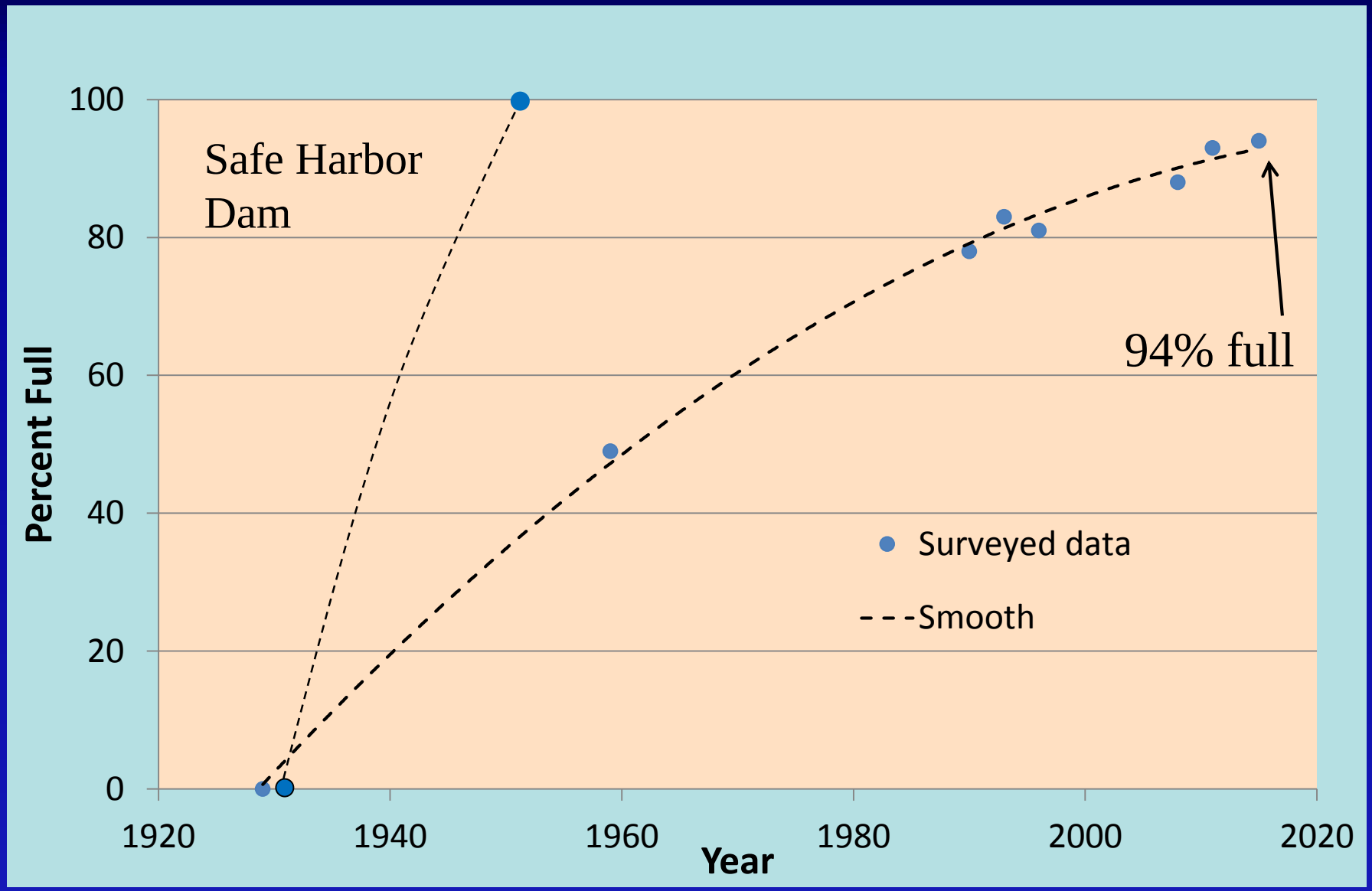
Conowingo Dam - Bathymetry Change



Conowingo Dam – Bathymetry Change



Conowingo Dam – loss of sediment storage capacity (SSC)



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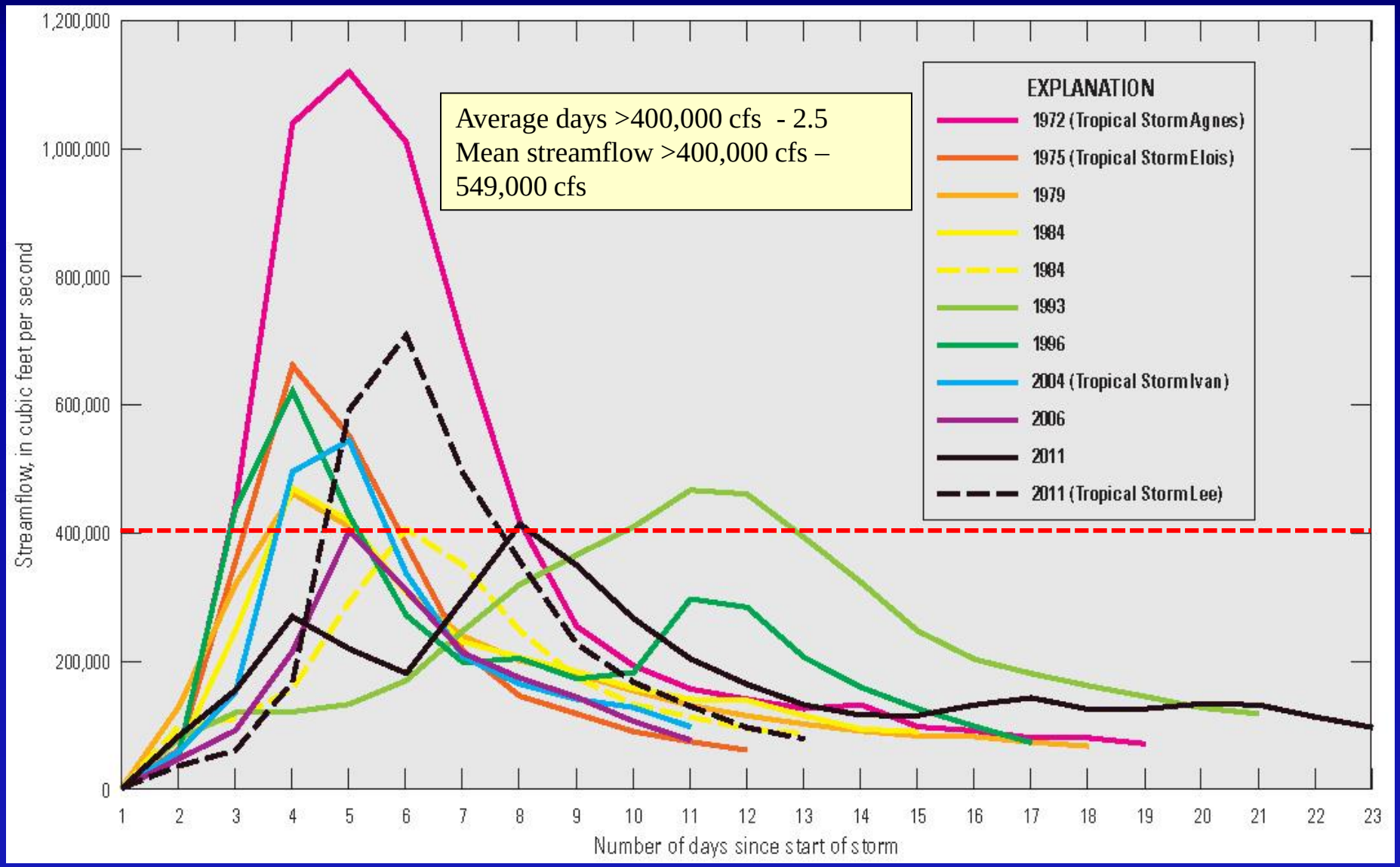
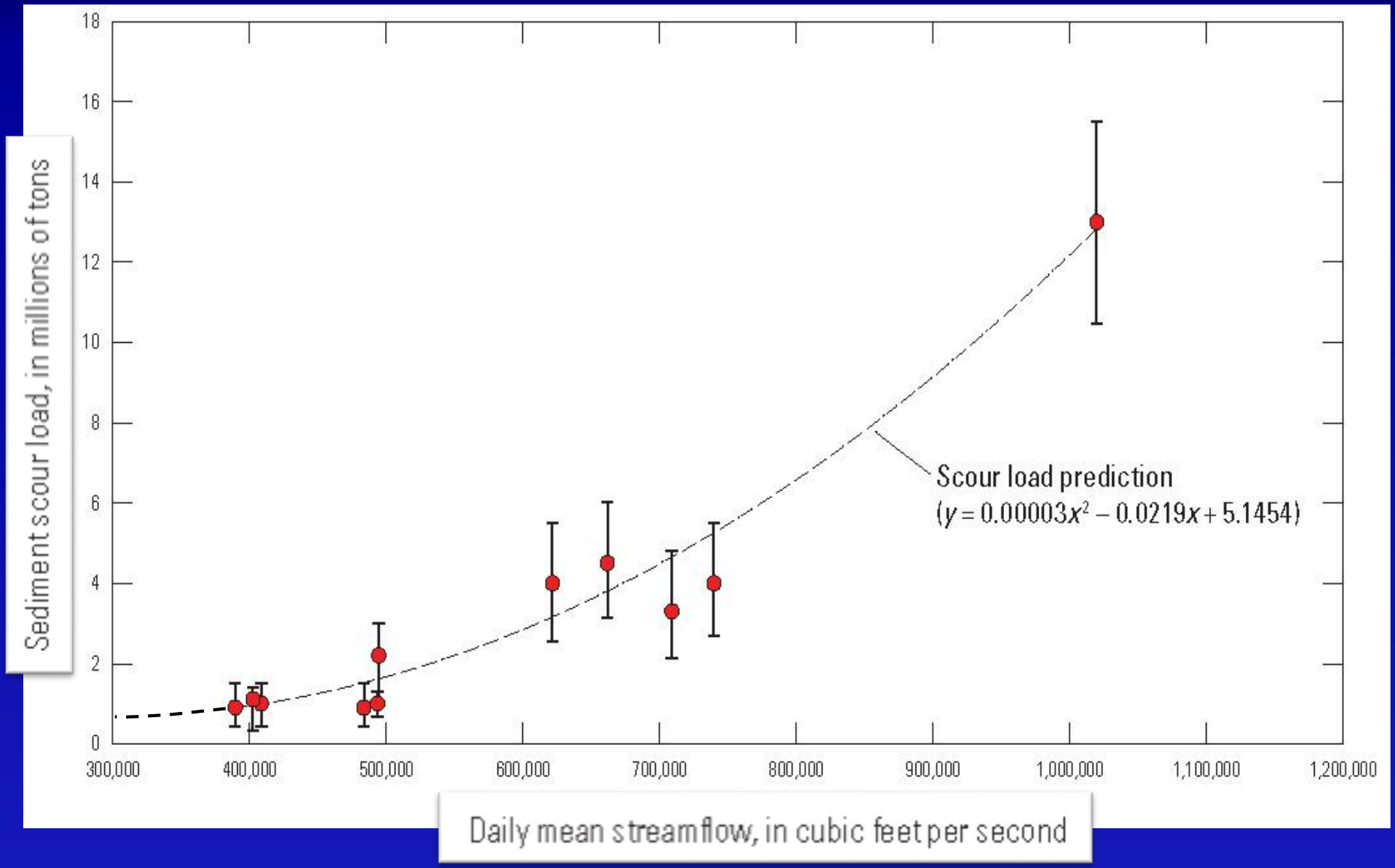
Reservoir System Scour Predictions

Mean Daily Discharge, Conowingo Dam, for Selected Storm Hydrographs



Reservoir System – Predicted Scour



Total scoured sediment for 19 storm events

Date	Daily-mean discharge (ft3/s)	Sediment scour storm load event (million tons)
May 1936	740,000	**3.5**
January 1940	493,000	**1.3**
January 1943	486,000	**1.2**
May 1946	528,000	**0.9**
November 1950	495,000	**1.8**
April 1960	451,000	**1.5**
February 1961	466,000	**1.6**
March 1964	571,000	**2.9**
February 1970	434,000	**1.3**
June 1972	**1,020,000**	**13.5**
September 1975	662,000	**4.4**
March 1979	462,000	**1.6**
February 1984	470,000	**1.7**
March 1986	406,000	**0.8**
April 1993	409,000	**1.1**
January 1996	622,000	**4.0**
September 2004	495,000	**2.1**
June 2006	403,000	**0.5**
March 2011	403,000	**0.5**
September 2011	709,000	**4.2**
Total estimated scour		**~50**

9 Storms

11 Storms

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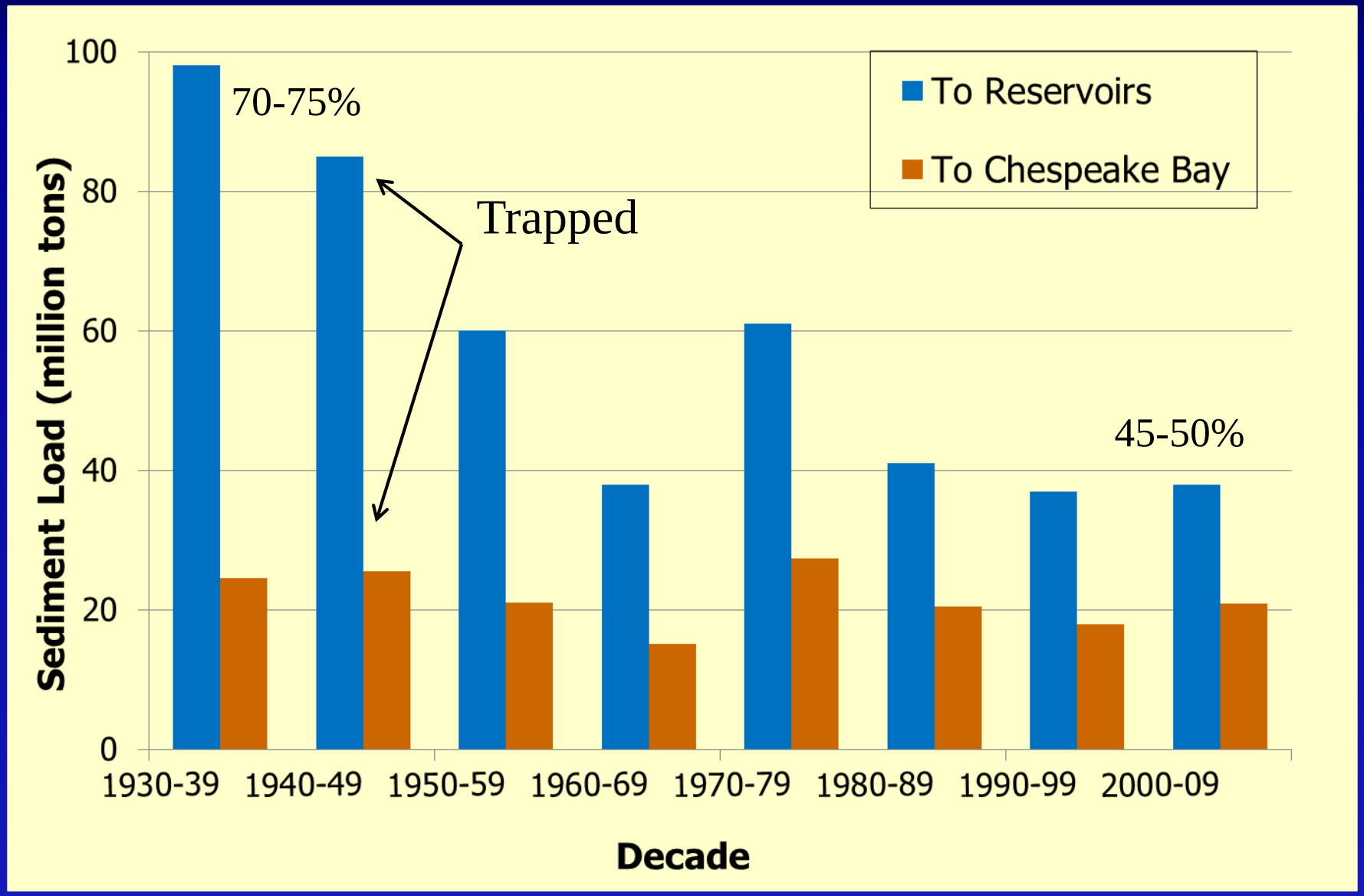
Predicted Sediment Loads from Reservoir Scour System

Mean Daily Streamflow (cubic feet per second, flow record 1968-2012)	Recurrence Interval (years)	Predicted total sediment load range to the Bay (million tons)	Predicted sediment scour range (million tons)	Percent scour to total load range to the Bay (%)
1,000,000	70	27.1 - 31.1	10.5 - 15.5	39 - 50
900,000	40	21.8 - 26.2	6.5 - 11	30 - 42
800,000	25	17.2 - 20.2	4.5 -7.5	26 - 37
700,000	17	13.1 - 15.6	3.5 - 6	27 - 37
600,000	10	7.9 - 10.1	2 – 4	24 - 39
500,000	5.7	4.9 - 6.9	1 - 3	20 - 42
400,000	4.8	2.4 - 3.4	0.5- 1.5	21 - 34
300,000	1.9	0.5 – 1.5	0 – 0.3	0 - 20

(~30%)

Predicted Decadal Sediment "Budget"



Final Thoughts

- Since construction of Conowingo Dam in 1929-2012
  - 470 M tons sediment transported into reservoir system
  - 290 M tons sediment trapped (long-term trapping ~60%)
  - 180 M tons sediment to the Chesapeake Bay
  - 50 M tons scour from regression estimates
- Sediment loads in the Susquehanna River dominated by historic landuse change and climatic variability
- LSUS River Reservoir system sediment capacity has been steadily declining and is in a state of "dynamic equilibrium"
- Averaging over a range of flows, approximately 30% of sediment transported to Chesapeake Bay likely from the reservoirs; 70% likely from the watershed