

Fluvial Geomorphology of the South River:

Implications for Mercury Cycling

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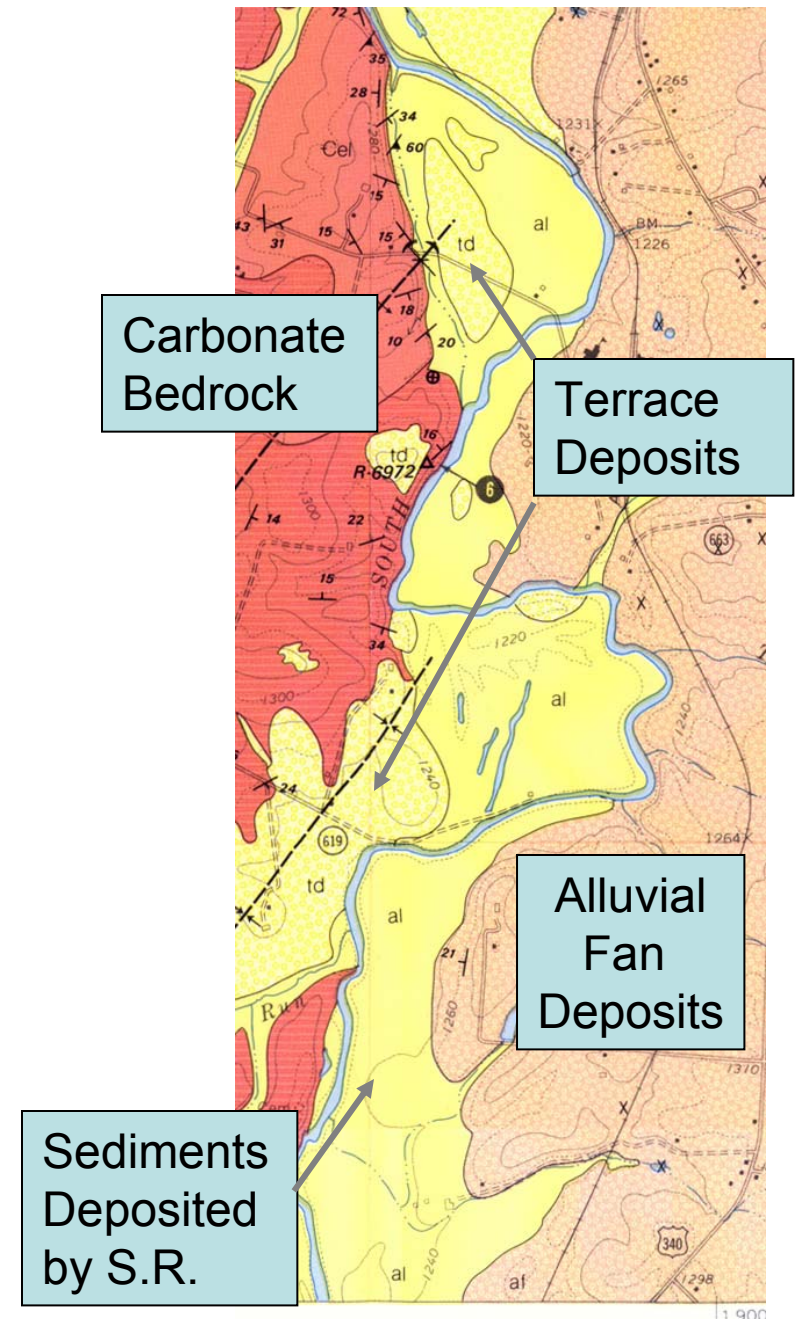
Outline

- Geomorphic characteristics of the South River
- South River's Sediment Budget
- Cycling of mercury by the South River: key processes
- South River's history of sediment and mercury cycling
- Conclusion

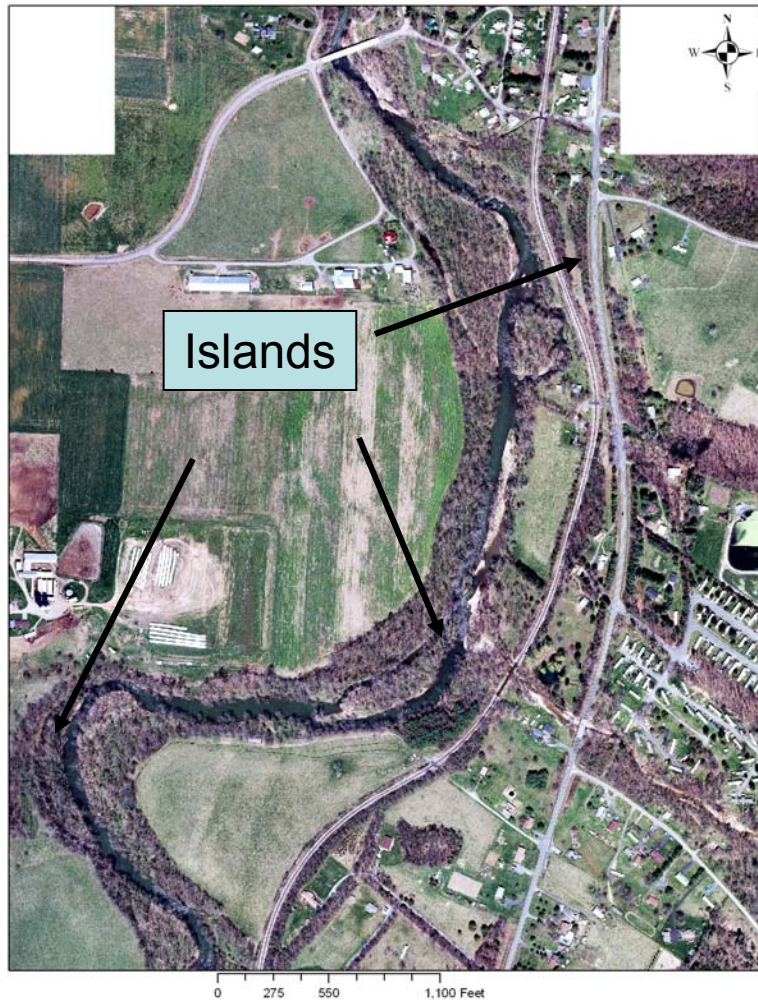
Geomorphology of the South River

Geologic Setting

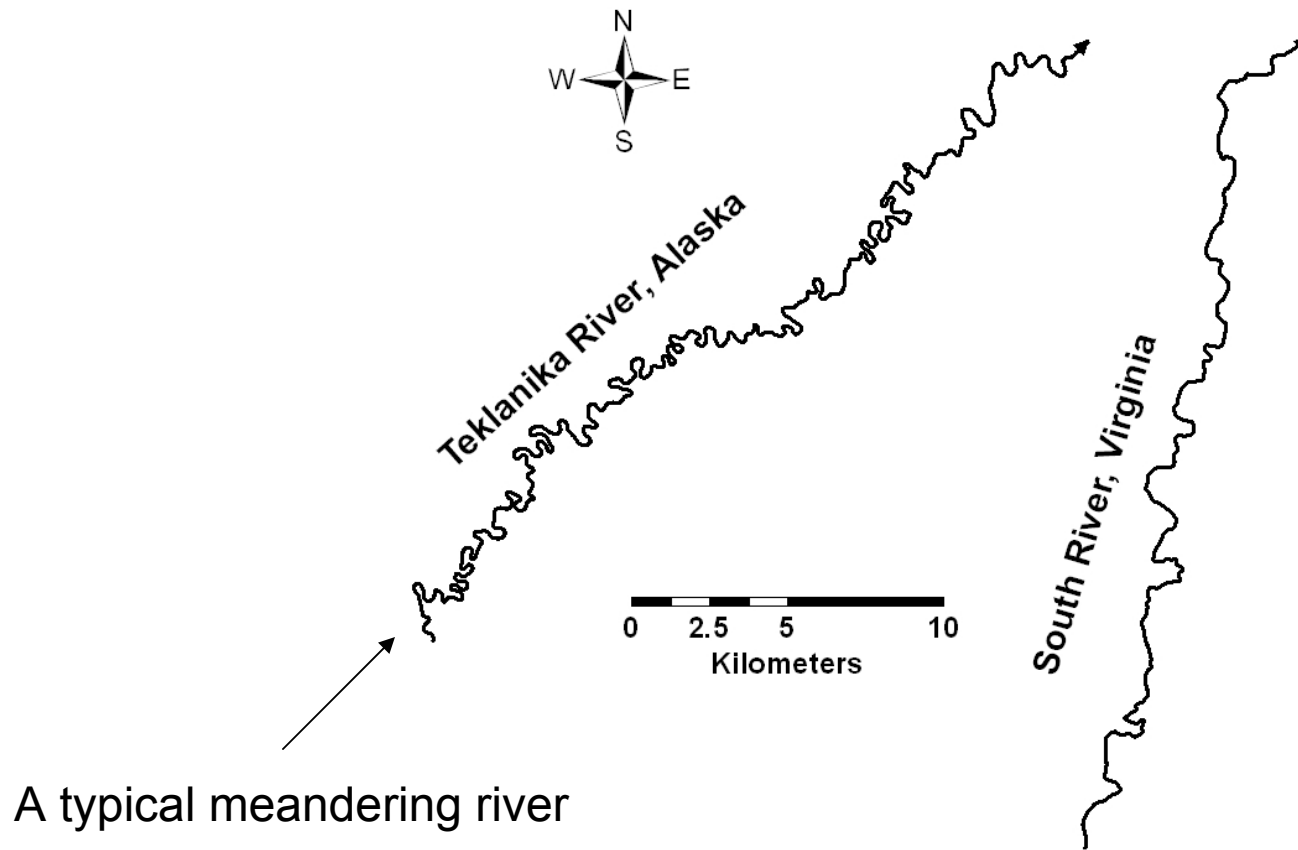
The South River flows through a narrow alluvial valley bordered by carbonate bedrock, terrace, and alluvial fan deposits



The South River – A single-thread, sinuous channel with islands



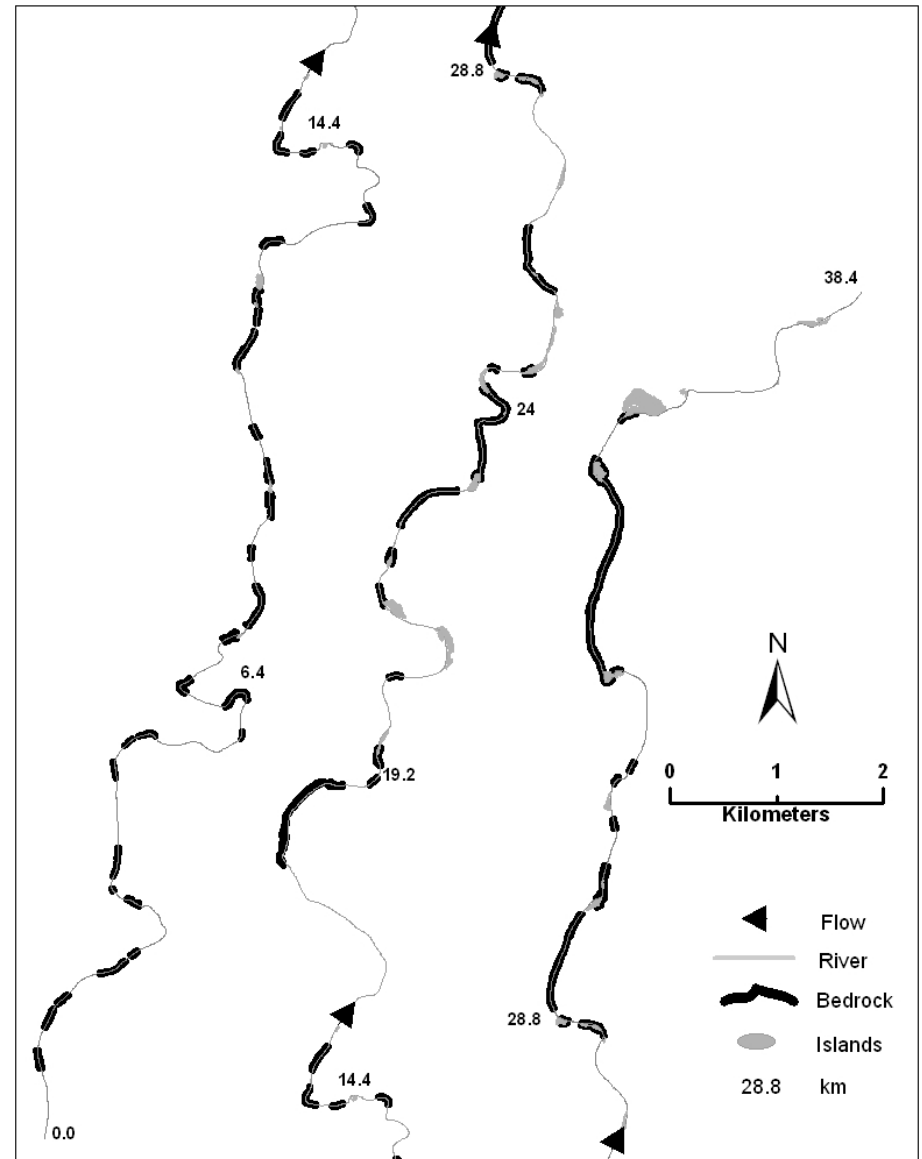
Bends of the South River Look Different From Typical MEANDERS



Nonmeandering (but sinuous)
Planform: Caused by frequent
exposures of bedrock (?)

- Bedrock is difficult for the river to erode
- Impedes the development of bends

Bedrock exposures in the Channel of the South River, Waynesboro – Port Republic

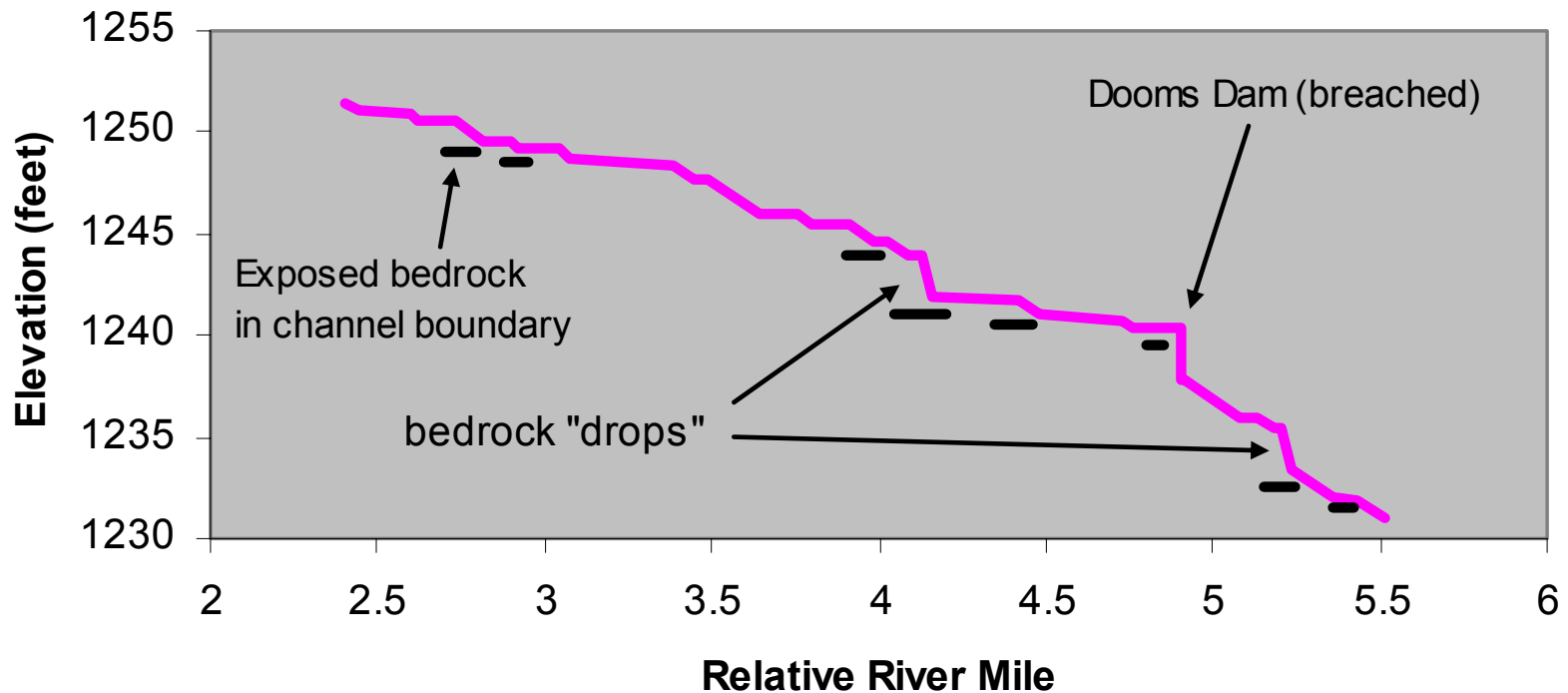


Bed Material of the South River

- Mostly gravel-sized
 - Cobbles predominate
- Other areas consist of:
 - Sand and gravel
 - Mud and sand
 - Bedrock

The Longitudinal Water Surface Profile

Pools and Riffles, Bedrock Drops, and Breached Dams



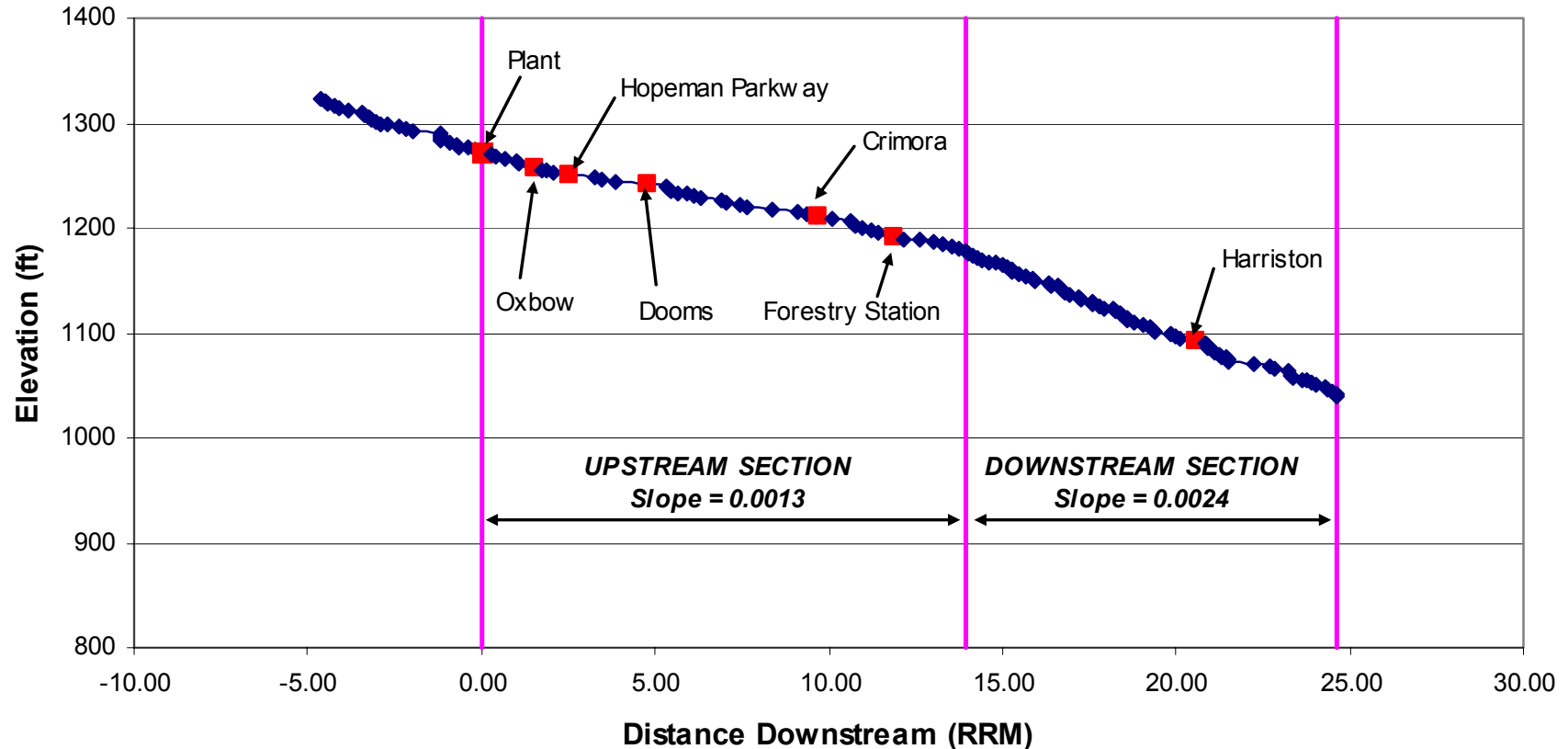
Geomorphic Classifications of South River

Type of Classification	Classification of S. River	Comments
Bed material	Gravel-bed	Implies that significant movement of the bed material occurs only a few times per year
Plan Form	Sinuuous	Not meandering, braided, or anastomosing; implies lateral stability
Type of load	Mixed load	Both bedload and suspended load transport are important
Source of sediment supply, extent of external control	Bedrock-Alluvial	Bedrock lowers potential rates of change during storm discharges
Size of sediment supply	Low	Suggests that sediment yield and sediment fluxes are relatively low

The Best Summary Classification For South River

- South River is:
 - a bedrock channel
 - with a gravel bed...
- NOT an alluvial channel....
- “A bedrock channel cannot substantially widen, lower, or shift its bed without eroding bedrock”
 - Turowski et al., 2007

Two Different Parts of the River



Upstream vs Downstream Reaches

- Upstream:
 - Wider floodplain
 - Finer-grained deposits
 - Lower slope
 - Fewer islands
- Upstream:
 - Greater retention of Hg associated with deposition fine-grained particles
 - Greater ongoing supply of Hg to the channel from bank erosion

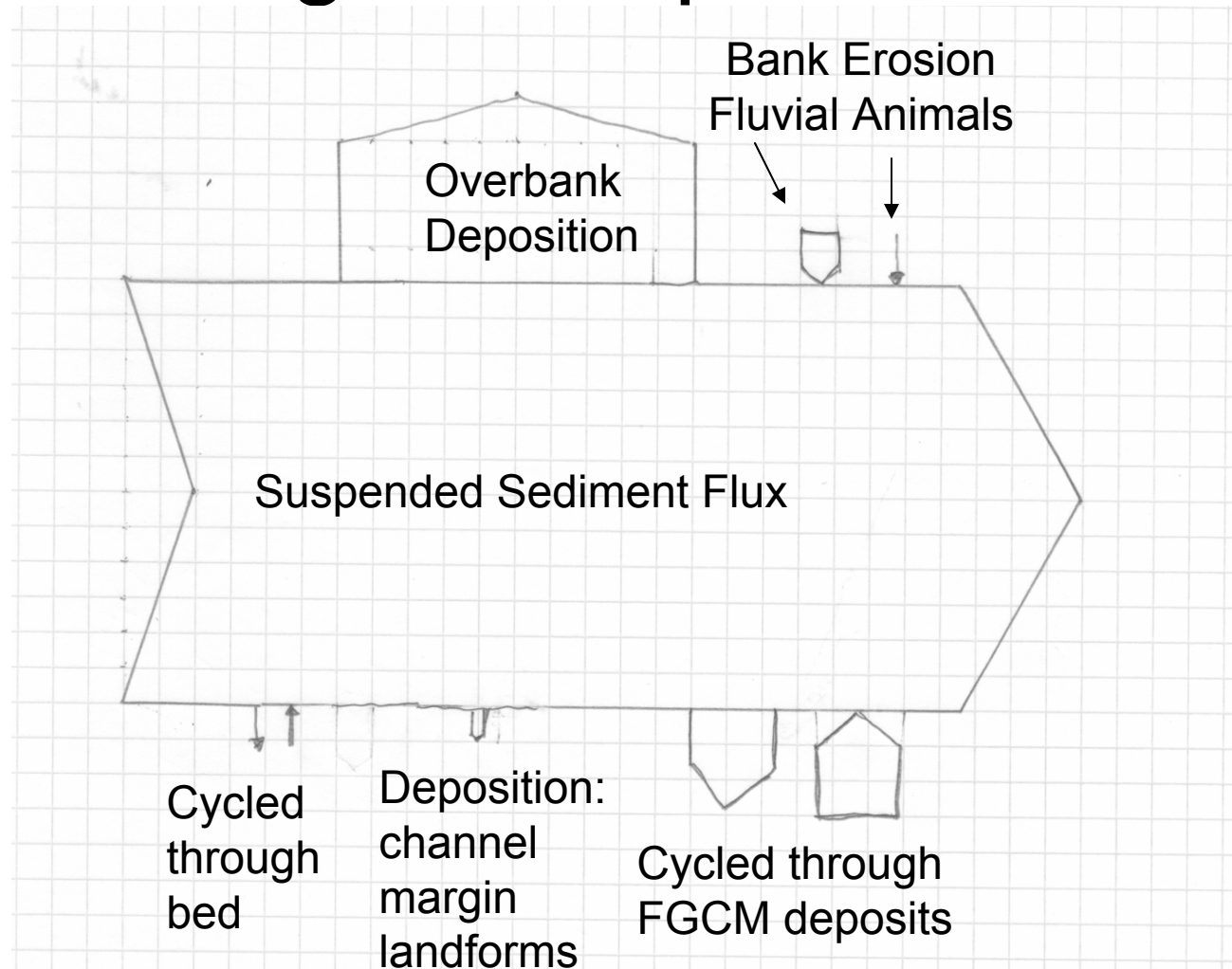
The Sediment Budget of the South River

- Important processes for sediment transport and storage
 - Mercury is carried along with the sediment

Summary of Important Processes

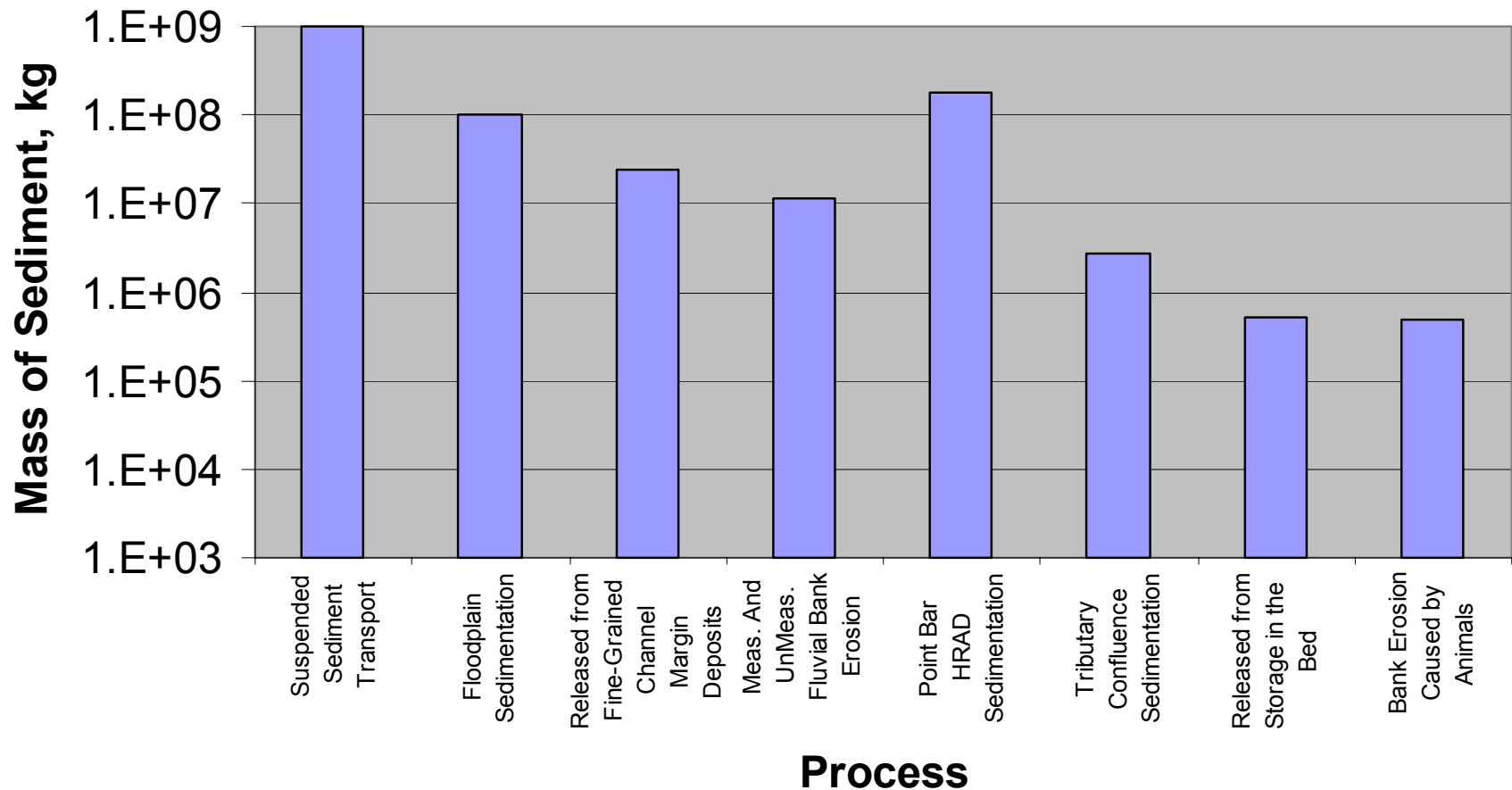
- Suspended sediment transport by the river
- Floodplain deposition
 - “Valley flat”
 - Near the channel margins
- Bank erosion
- Deposits within the channel itself
 - Behind large woody debris (“logs”)
 - “Fine-grained Channel Margin” (FGCM) deposits
 - On the bed
 - Fine-grained sediments stored within the pores of larger gravel-sized grains

Relative Magnitude of Sediment Budget Components



Some Quantitative Estimates...

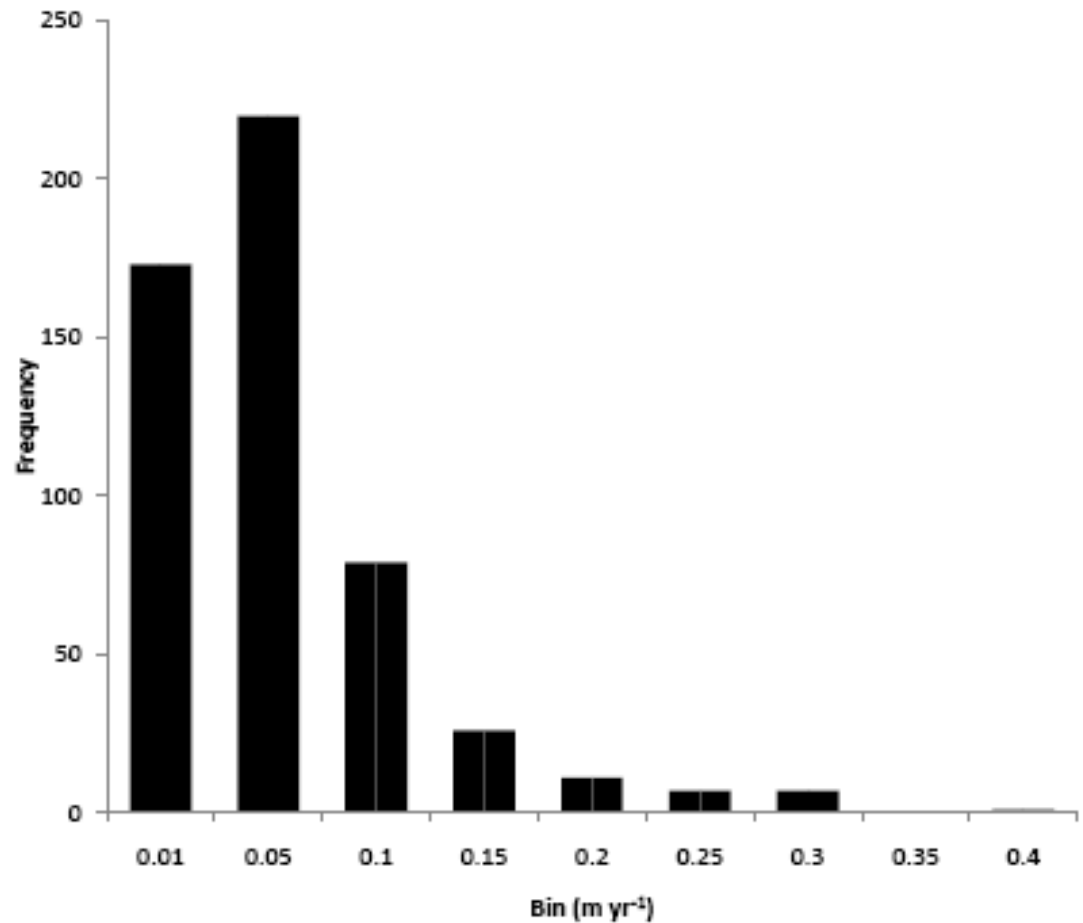
Relative Magnitude of Sedimentation Processes, South River, VA, 1930-2005 (RRM 2.5-5.43)



Specific Components of the Sediment Budget

- Bank erosion
- Fine-grained channel margin deposits
- Floodplain deposition near the channel margins
- The channel bed
 - Dating of sediment in storage
- Overview

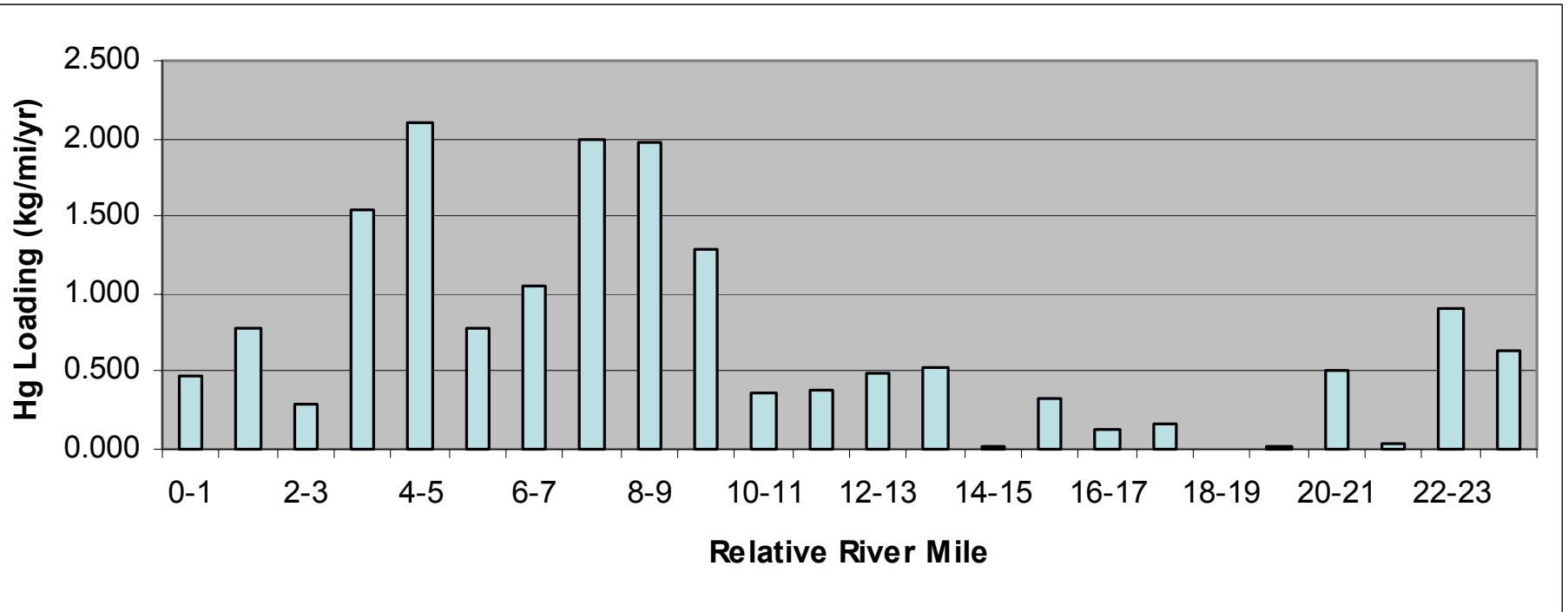
Bank Erosion Rates



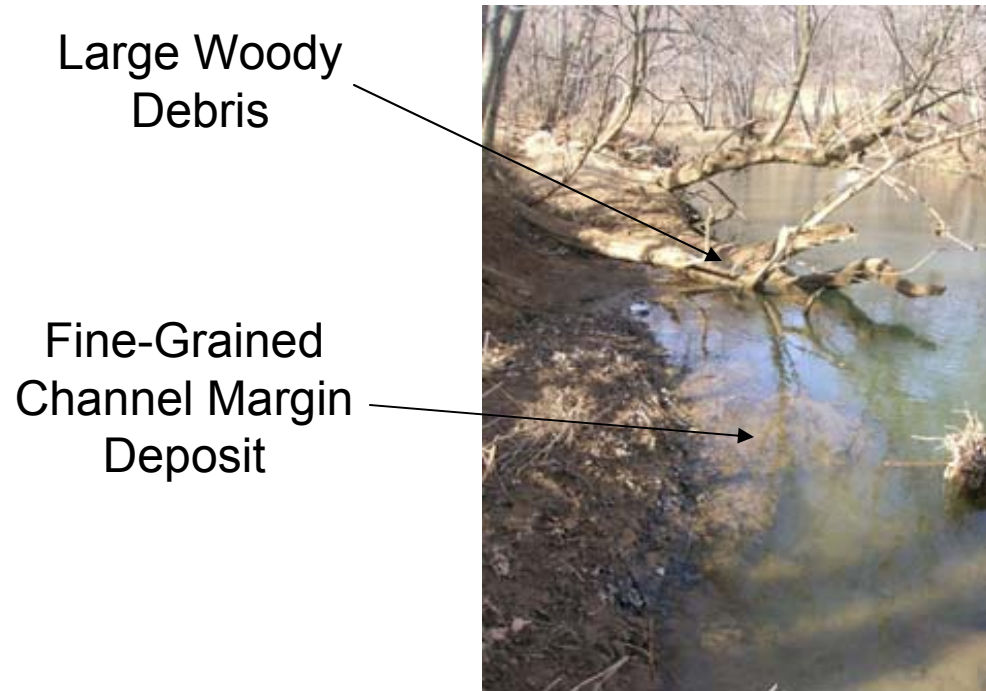
Modal rate is 0.05 m/yr (2 INCHES OF BANK RETREAT PER YEAR!!)

Mercury Loading From Bank Erosion:

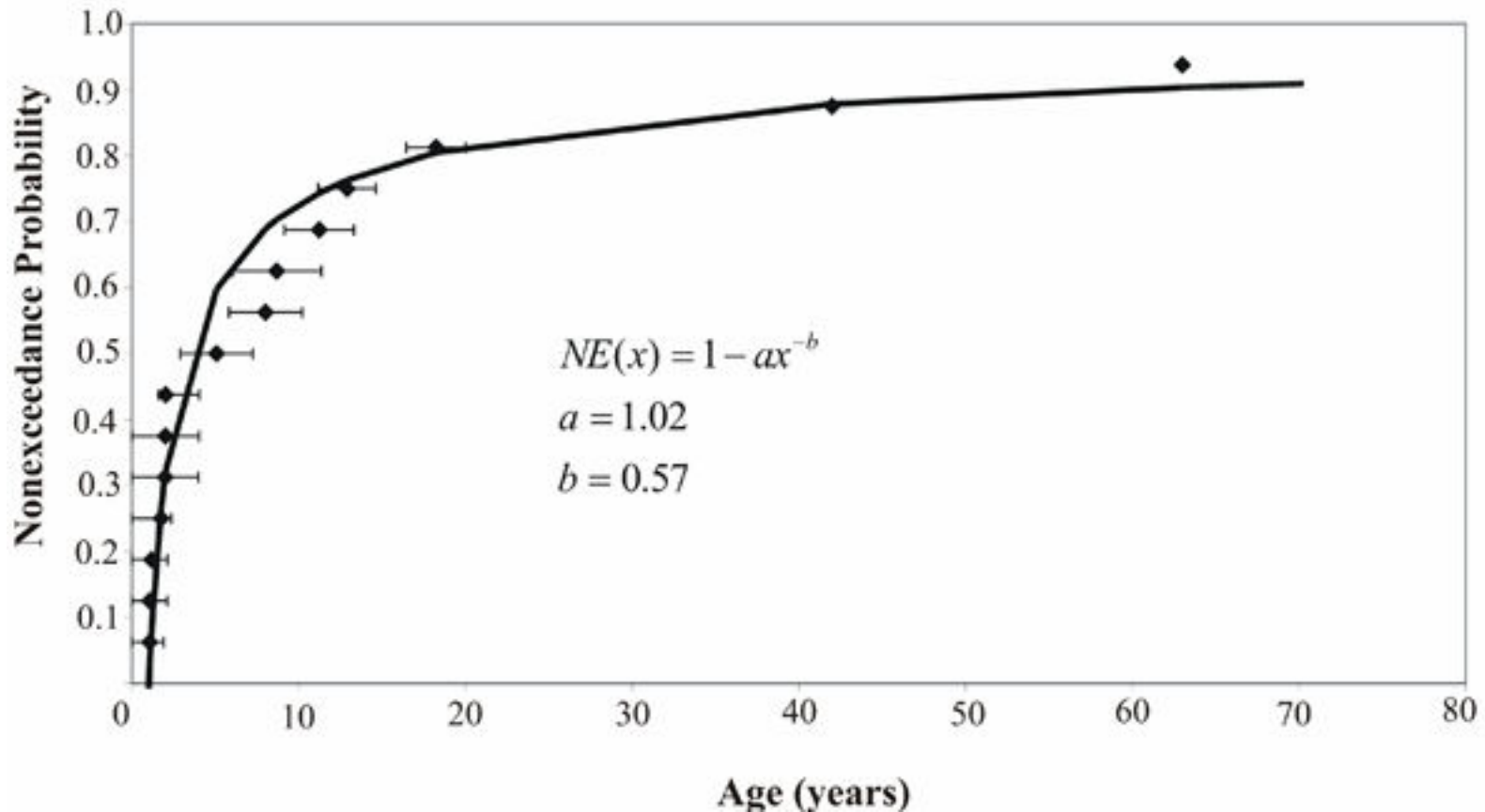
Highest in the Upstream ½ of the Study Area



Fine-Grained Channel Margin Deposits

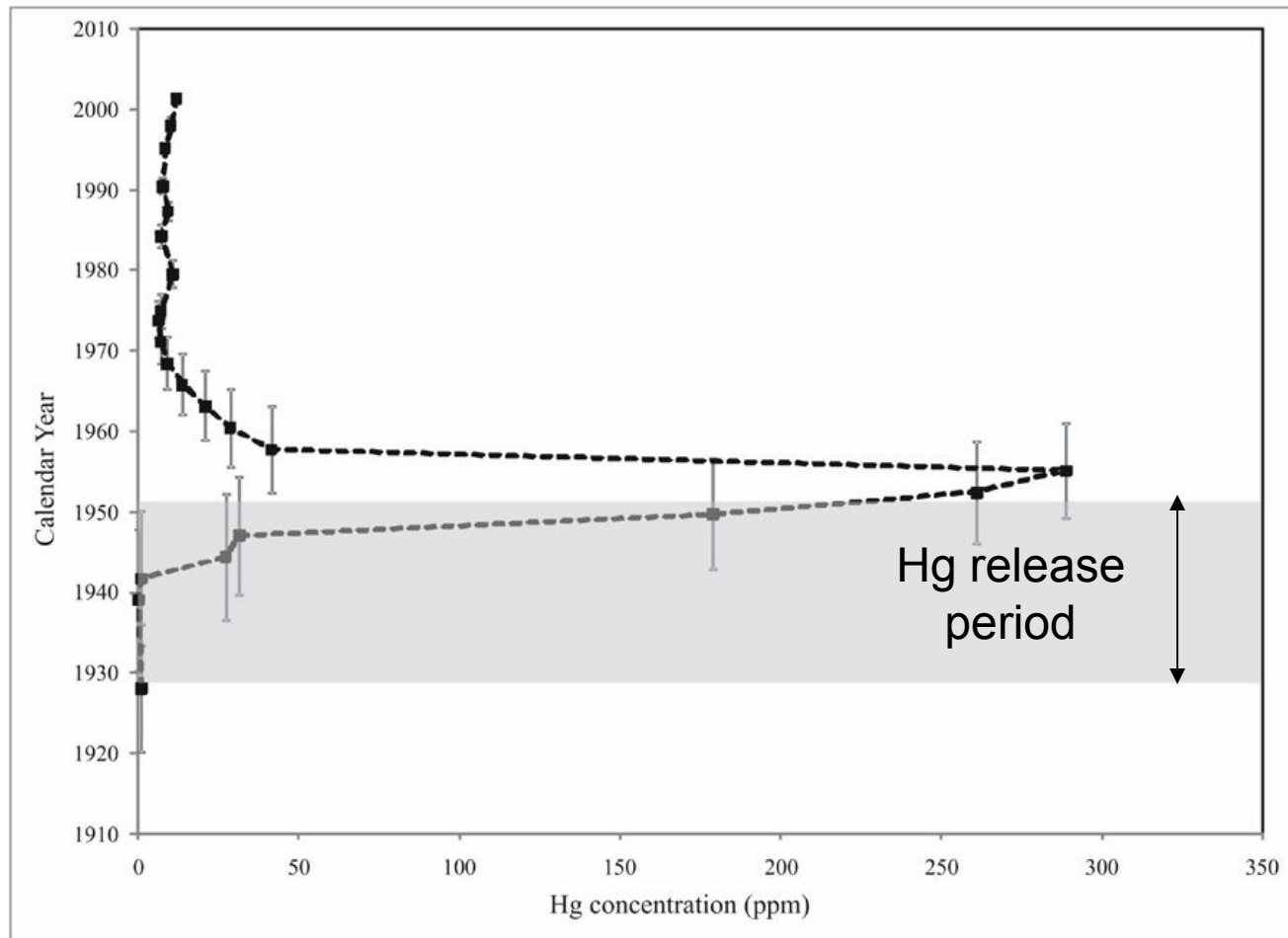


Distribution of Sediment Ages in FGCM Deposits



The residence time of sediment in these deposits is ~ 2 years, but ~10% of the deposits are > 50 years old !

FGCM Deposits Provide A Record of Past Hg Concentrations On Sediment in the South River

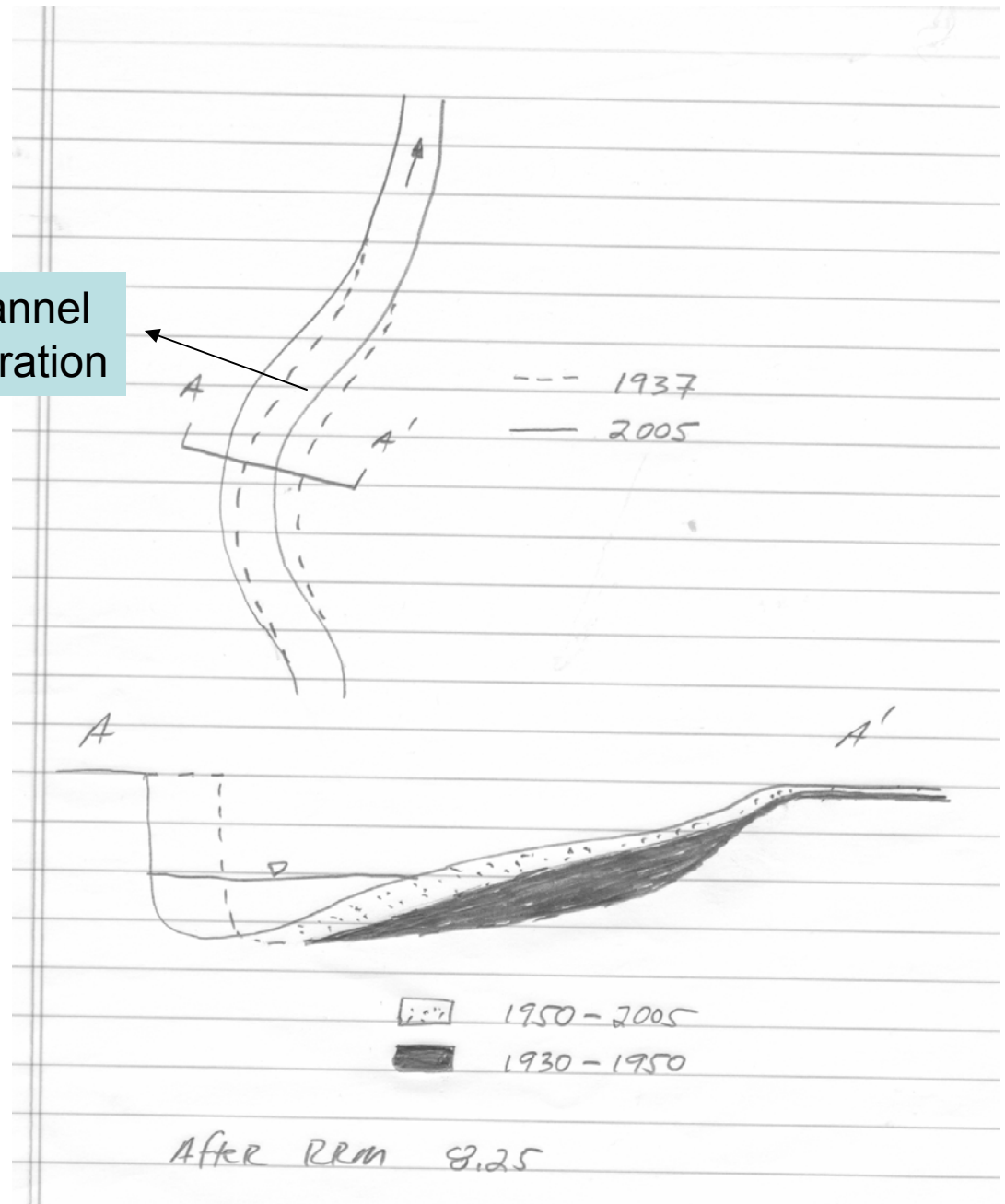


Channel Margin Floodplain Deposits

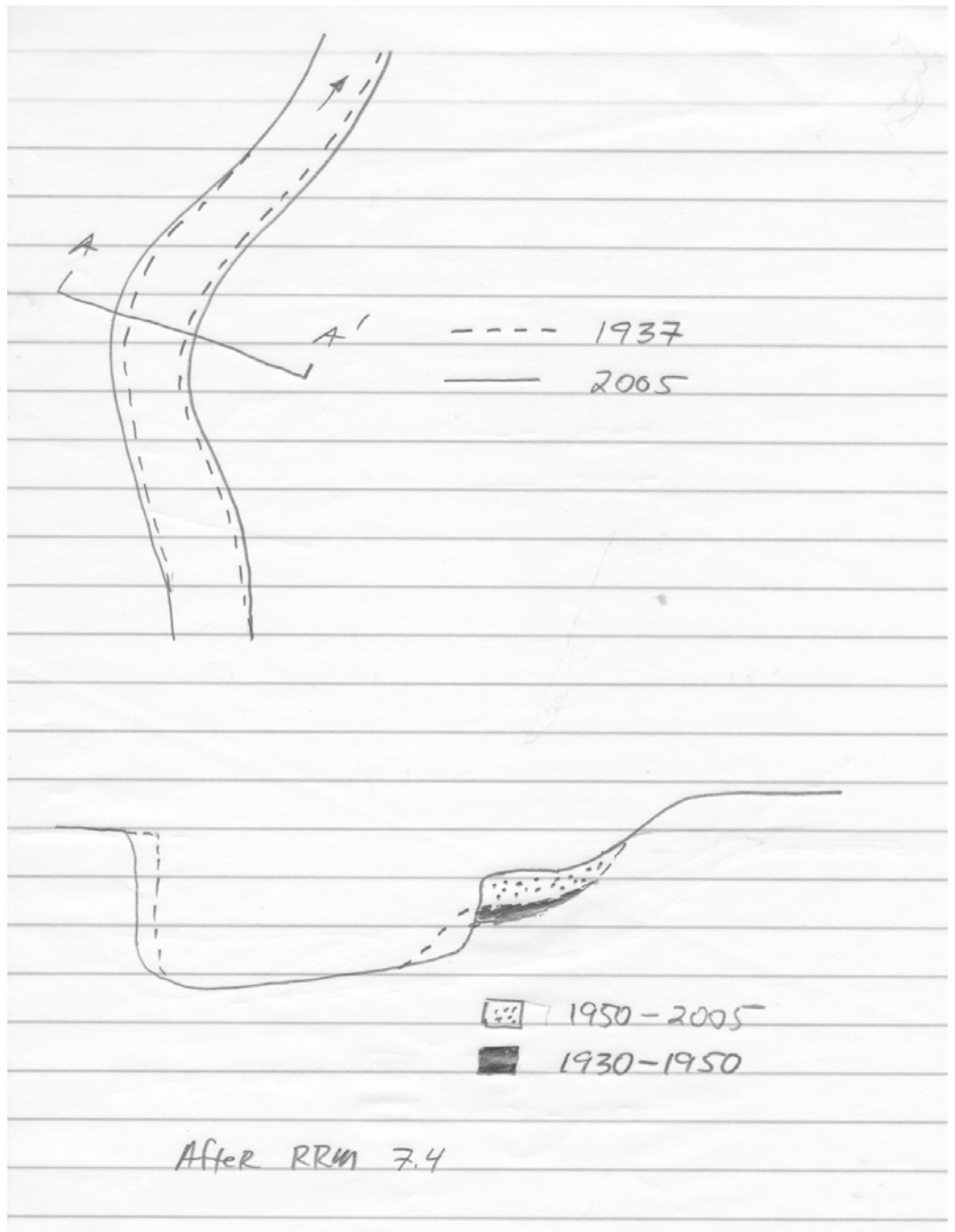
- Deposits initially identified by shoreline mapping from aerial photographs
 - 1937-2005
- Hypothesis:
 - Deposits dating from the period of mercury release could have very high Hg concentrations
- Denoted as HRADs:
 - Hg Release Age Deposits

Point Bar HRAD

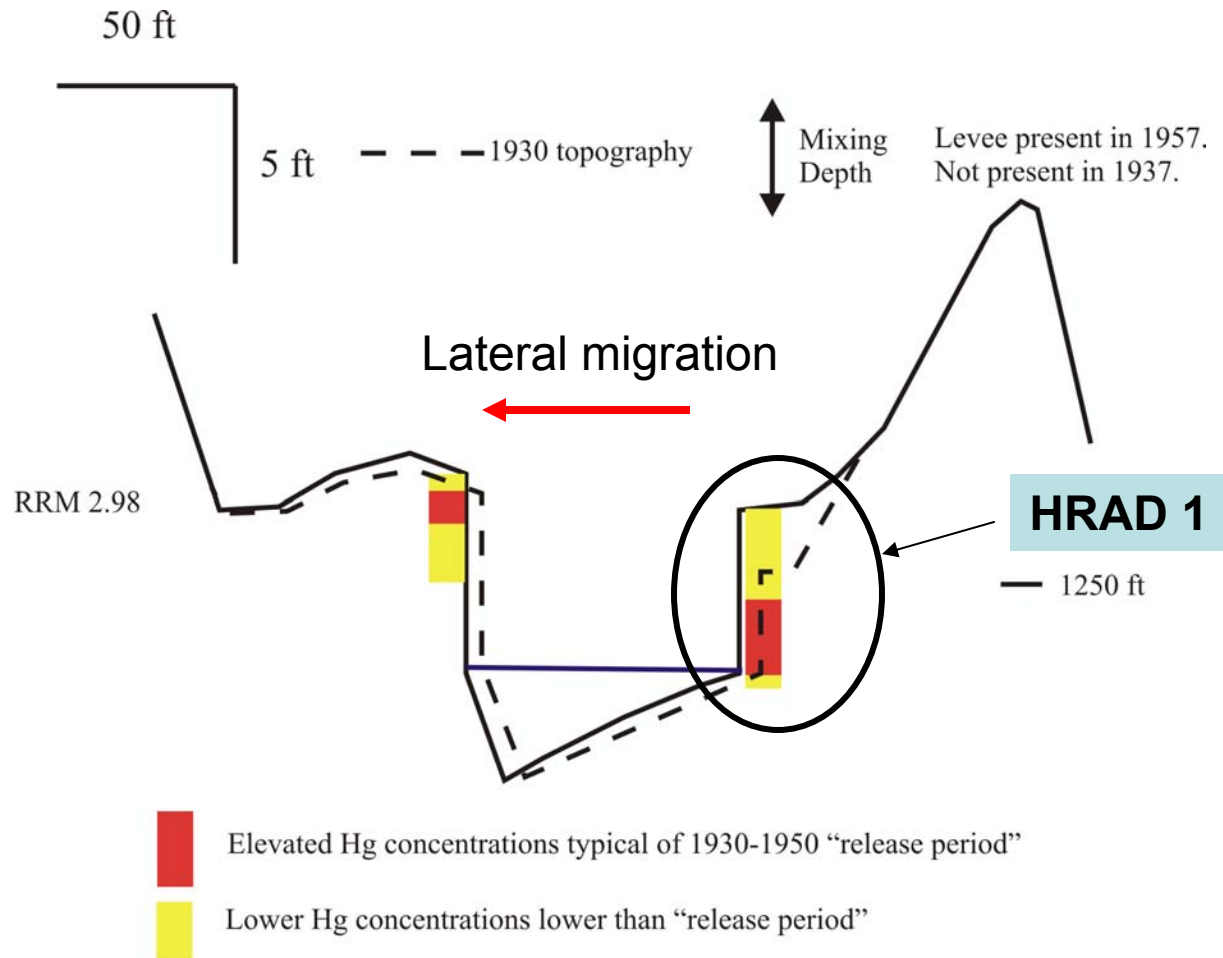
Channel
migration



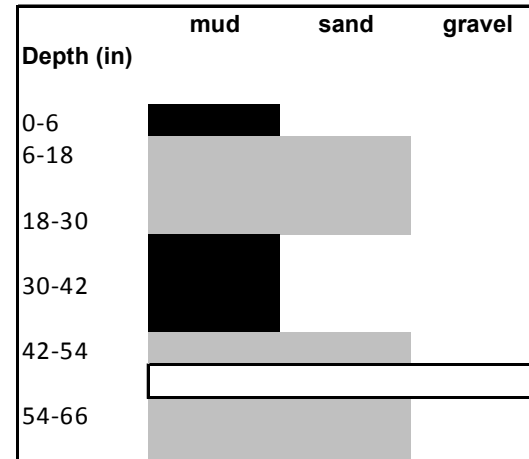
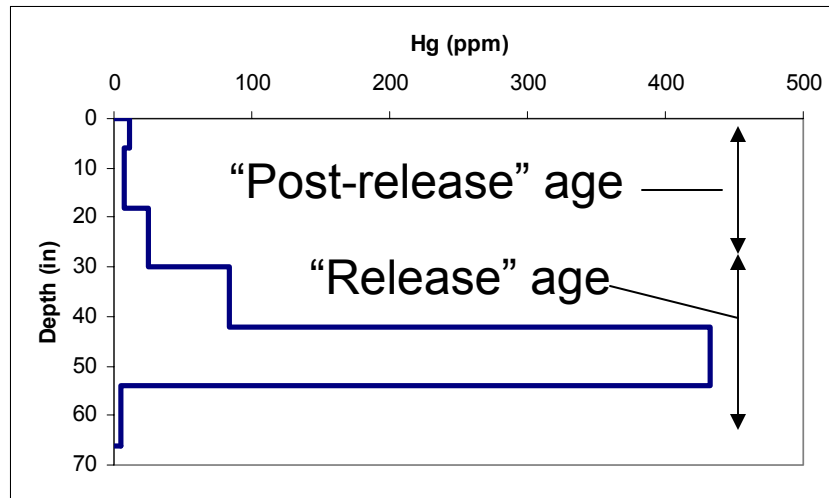
“Bench” HRAD



HRAD 1 - Slow Lateral Migration, 1930-2005



HRAD 1

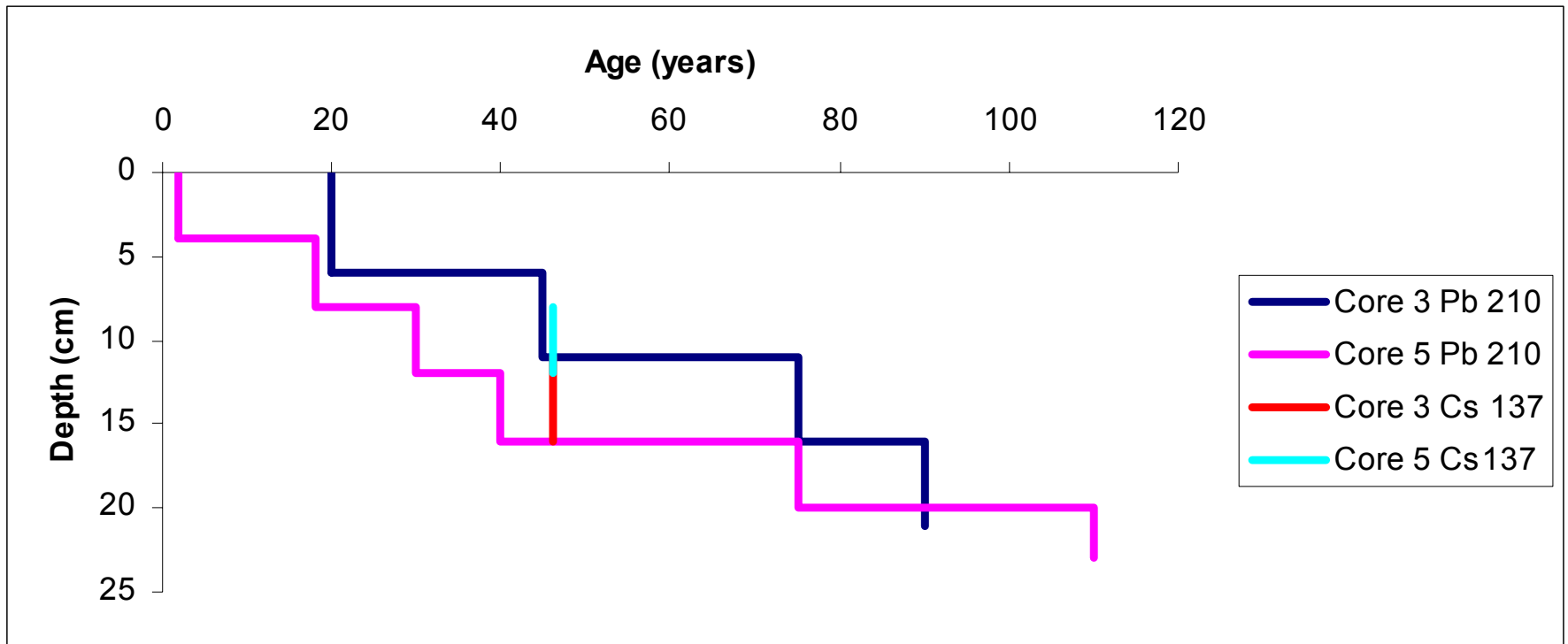


The Channel Bed

- Large areal extent
- A potential “reservoir” of Hg-contaminated fine-grained particles
 - Stored in between larger gravel grains
- Always in contact with the water column
 - Potential pathway for Hg to move up the food web



Pilot Dating Study



Hg-contaminated particles can be stored in the bed for many decades!!

Fine-Grained Sediment Budget - Summary

- Transport Process
 - Sediment carried in suspension by the river
- “Cycling” processes – storage and reworking
 - 1000 yr timescale
 - Floodplain deposition
 - Bank erosion
 - 1-100 year timescale
 - Fine-grained channel margin deposits
 - River bed

Sediment Budget of the South River – A Historical Perspective

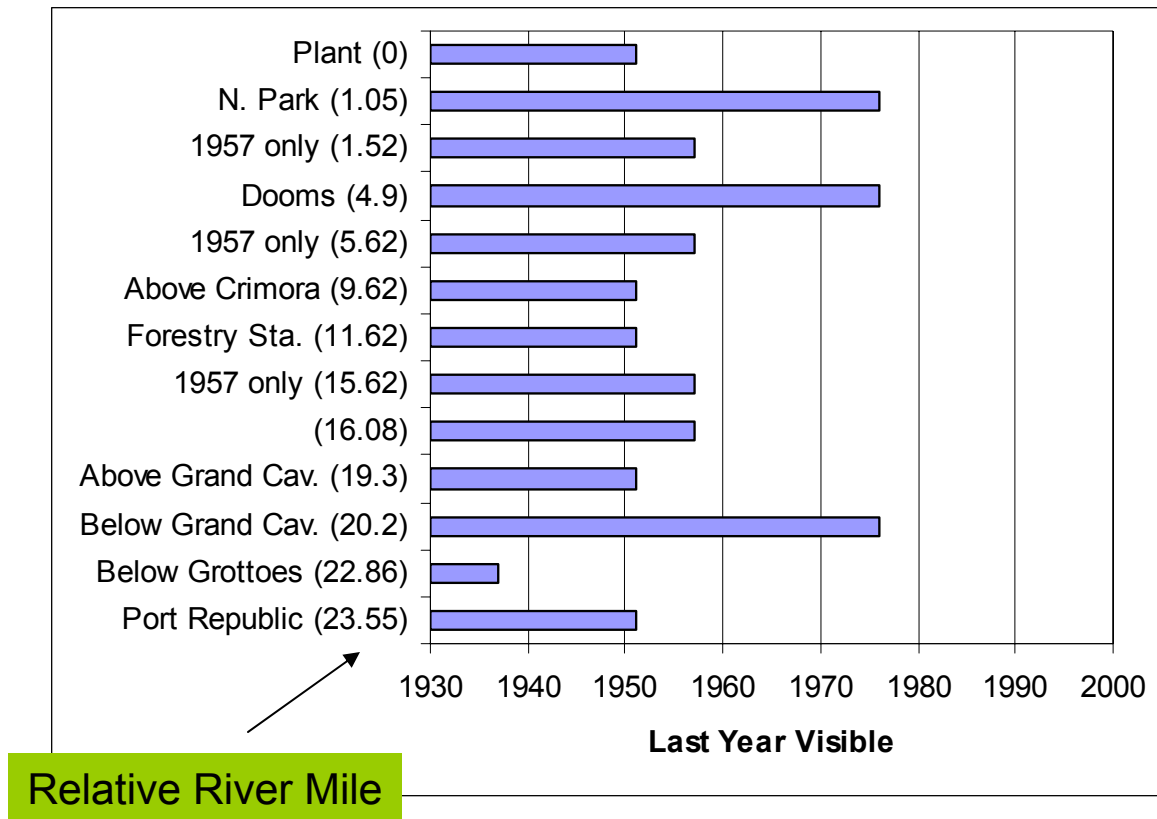
- Based on many studies of stream valleys of the eastern U.S.

Colonial Settlement – early 20th century

- High sediment loads due to land clearing and poor agricultural practices
- Widespread construction of mill dams
- Resulting in:
 - Accelerated deposition of sediment on flood plains
- Implication:
 - Enhanced storage of Hg released at the end of this period on floodplains

Historic Mill Dams and Impoundments

In 1937 ~ 1 Impoundment every 2 mi



Geology

All mill dams are gone or breached today!

Mid-20th century-Present

- Widespread breaching of mill dams
- Decline of agriculture
- Regional reforestation
- Urban development
- Resulting in:
 - Floodplain reworking through bank erosion
- Implication
 - Mercury stored in floodplains during early-mid 20th Century continues to be released to the channel of the South River
- BUT:
 - Erosional processes are VERY SLOW
 - Mercury in floodplain storage will persist for millenia

Conclusions

- Mercury was originally released to the South River from 1930-1950
 - Mercury was stored in sedimentary deposits on the floodplain and channel downstream of Waynesboro
 - Most storage occurred in the upstream half of the study area
- Sediment transport processes are slow along the South River
 - Significant deposits of sediment and mercury from the original release period remain today on the floodplain and in the stream channel itself
- Mercury reenters the water column today from:
 - Bank erosion
 - Reworking of:
 - The channel bed
 - Fine-grained channel margin deposits
 - *These processes appear to be most significant in the upstream half of the river*
- Many thousands of years will pass before mercury in storage will be removed by through natural transport by the South River