Geomorphology of S River
Progress Report, Fall 2005

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Outline

- Hypotheses Being Tested
- Provisional Conclusions
- Progress Report
- Proposed work plan through 6/30/06
- Future efforts
- Summary

Hypotheses Being Evaluated

1. Bank erosion represents a significant source of Hg to the river channel.
2. Hg associated with silt and clay, after being introduced into the channel from bank erosion, will be stored for “significant” periods of time at “characteristic” locations within the wetted perimeter of the stream.
3. Annual rates of storage on floodplains are low enough to be neglected.

Provisional Conclusions

1. Although bank erosion rates on South River are low compared to many rivers of similar size and geomorphic setting, bank erosion is pervasive, and eroding bank sediments often have high Hg concentrations.
2. Preliminary estimates suggest that bank erosion is a significant source of fine-grained sediment to the stream, possibly accounting for around 5-10% of the annual suspended load.
3. Significant deposits of fine-grained sediment occur within the wetted perimeter along the channel margins. These “channel margin mud deposits” are nearly all associated with accumulations of “large woody debris”.
4. At least one fine-grained deposit has *very* high Hg concentrations, with values up to 600 ppm.

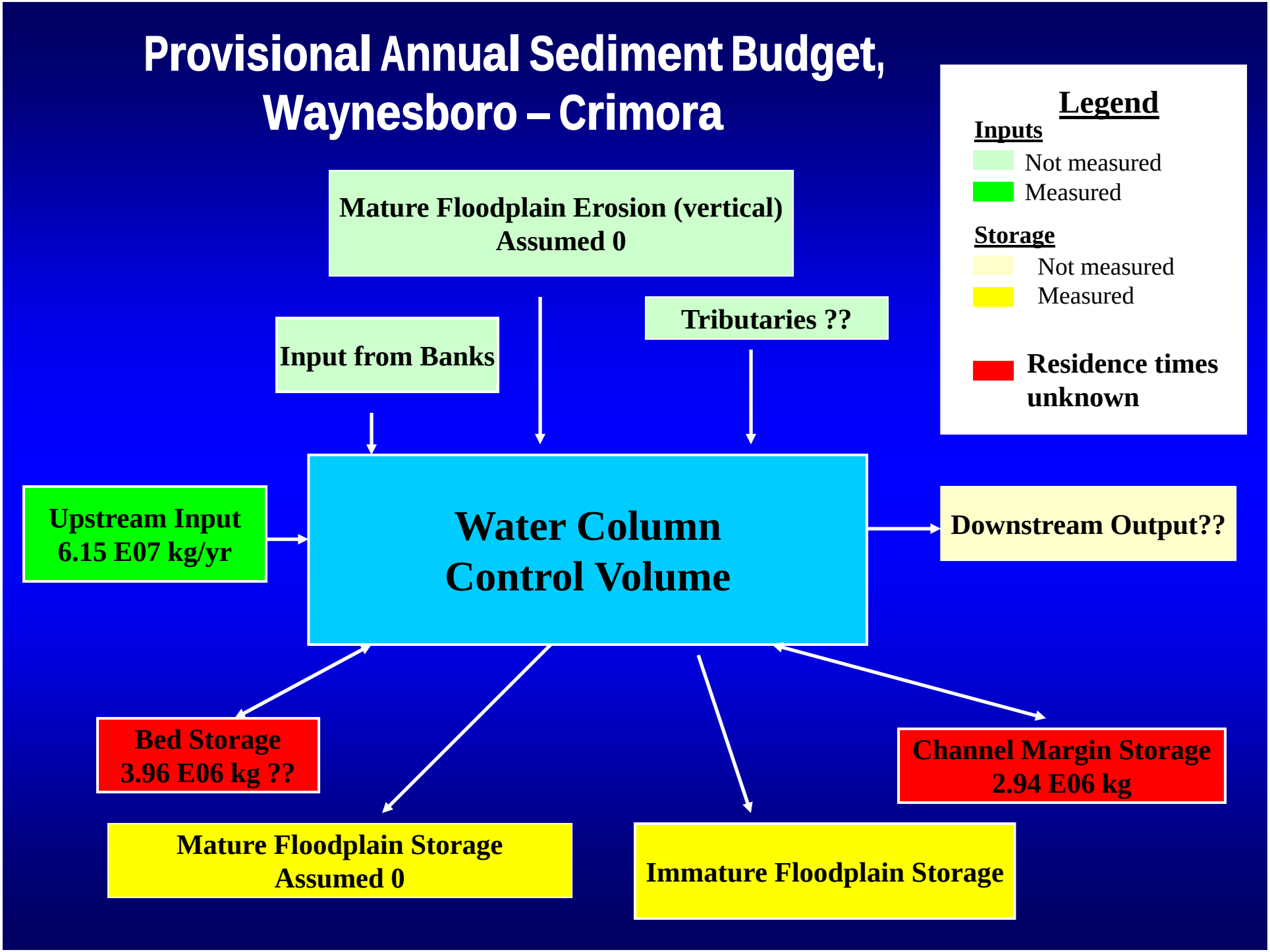
Progress Report – Our Primary Focus

- ***Annual sediment budget for silt and clay***
- Formulated for the plant site to Waynesboro to Crimora

Motivation for the Sediment Budget Approach

- Comprehensive: includes all sources and depositional sites along the stream and its alluvial valley.
- Includes a historical perspective
  - Sedimentation must be evaluated through time
- Interpretations involve understanding of *processes* of sediment supply, transport, erosion, and deposition
  - Understanding process necessary for forecasting and engineering design

Provisional Annual Sediment Budget, Waynesboro – Crimora

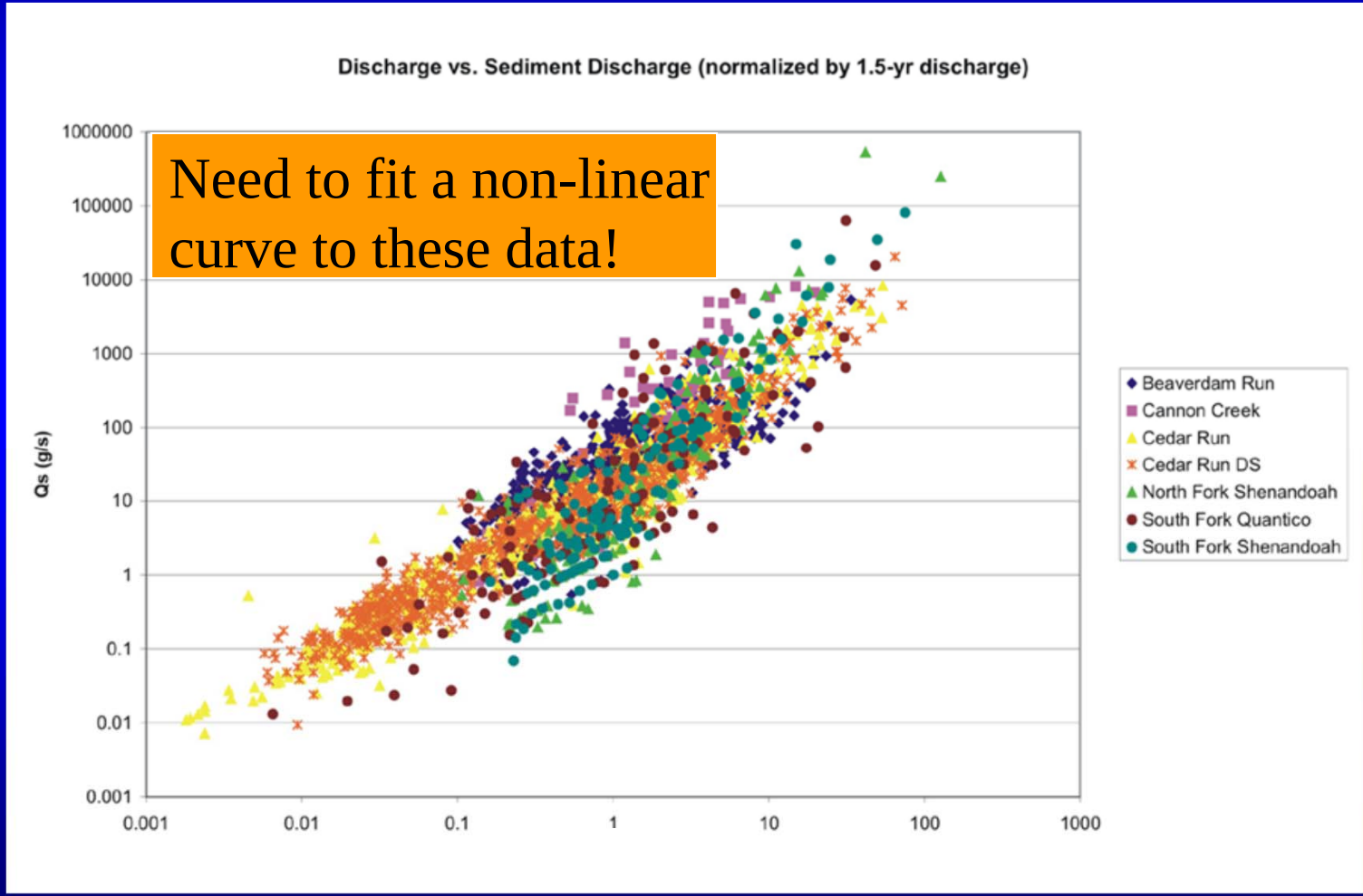


Discussion of Selected Budget Components & Supporting Analyses

- Measurements/computations in progress
  - Suspended sediment inputs
  - Bank erosion
  - Fine-grained channel margin deposits
- Supporting Analyses
  - Mapping eroding banks
  - Geomorphic mapping of the alluvial valley
- Plans to measure other components before June ‘06

Suspended Sediment Inputs (and Outputs) Determined From A Regional Sediment Rating Curve

Sediment Flux (g/s)



Mean Daily Water Discharge/ 1.5 Year Water Discharge

Storage in Fine-Grained Channel Margin Deposits

- Mud is stored in deposits along the margins of the channel in areas of low velocity caused by:
  - Channel expansions
  - Eddies
  - Reduced slope
  - Large woody debris

4 Settings of Mud Deposition

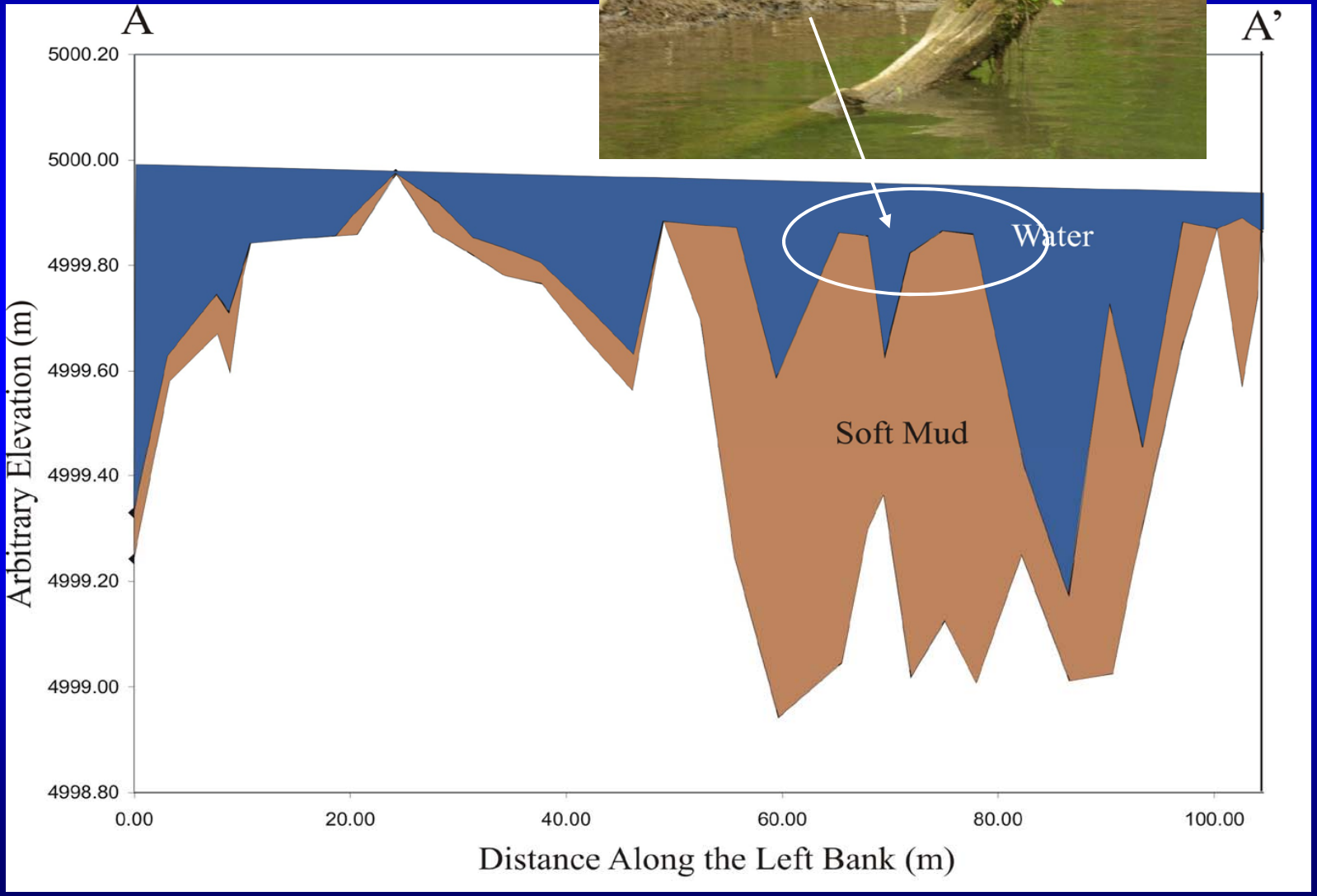
Riffles that accumulate LWD

Long Pools in Areas of Low Slope

Channel bifurcations

“Side Eddies” caused by trees

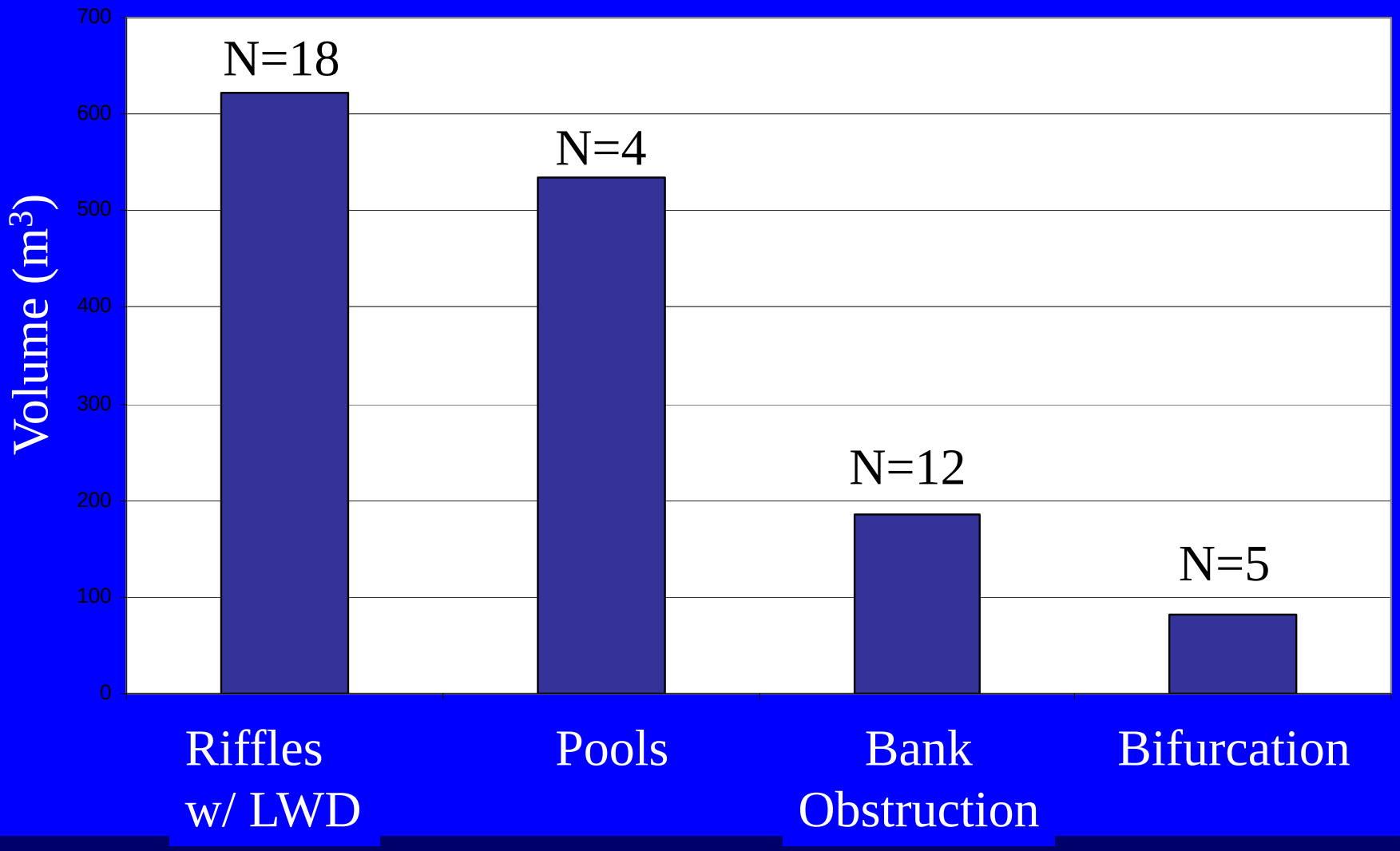
Some deposits are THICK!!



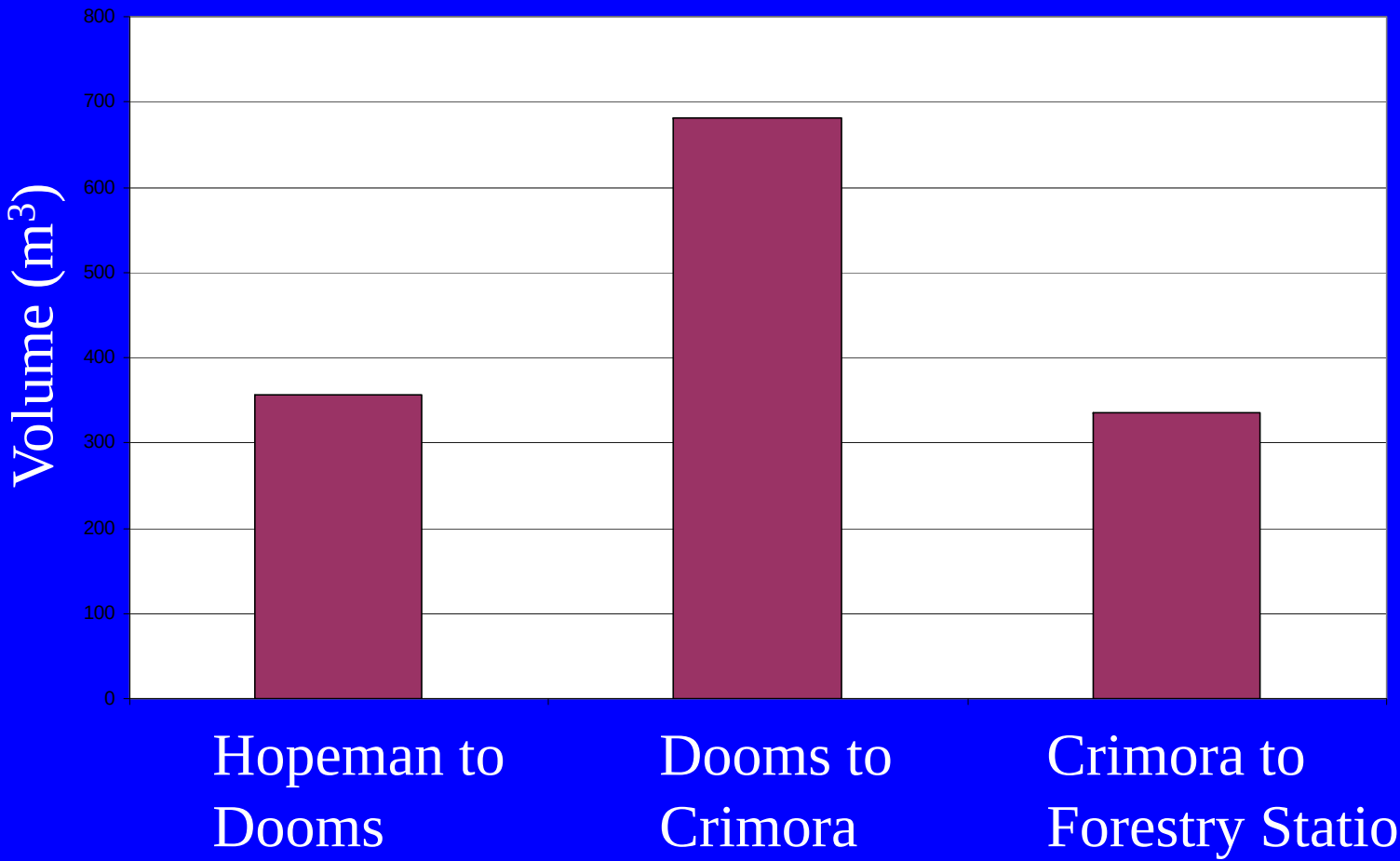
Mapping Fine-Grained Channel Margin Deposits

- Located 39 deposits in the study reach
- Surveyed 23 of these
  - an average mud deposit is about 20 m long, 4 m wide and 80 cm deep

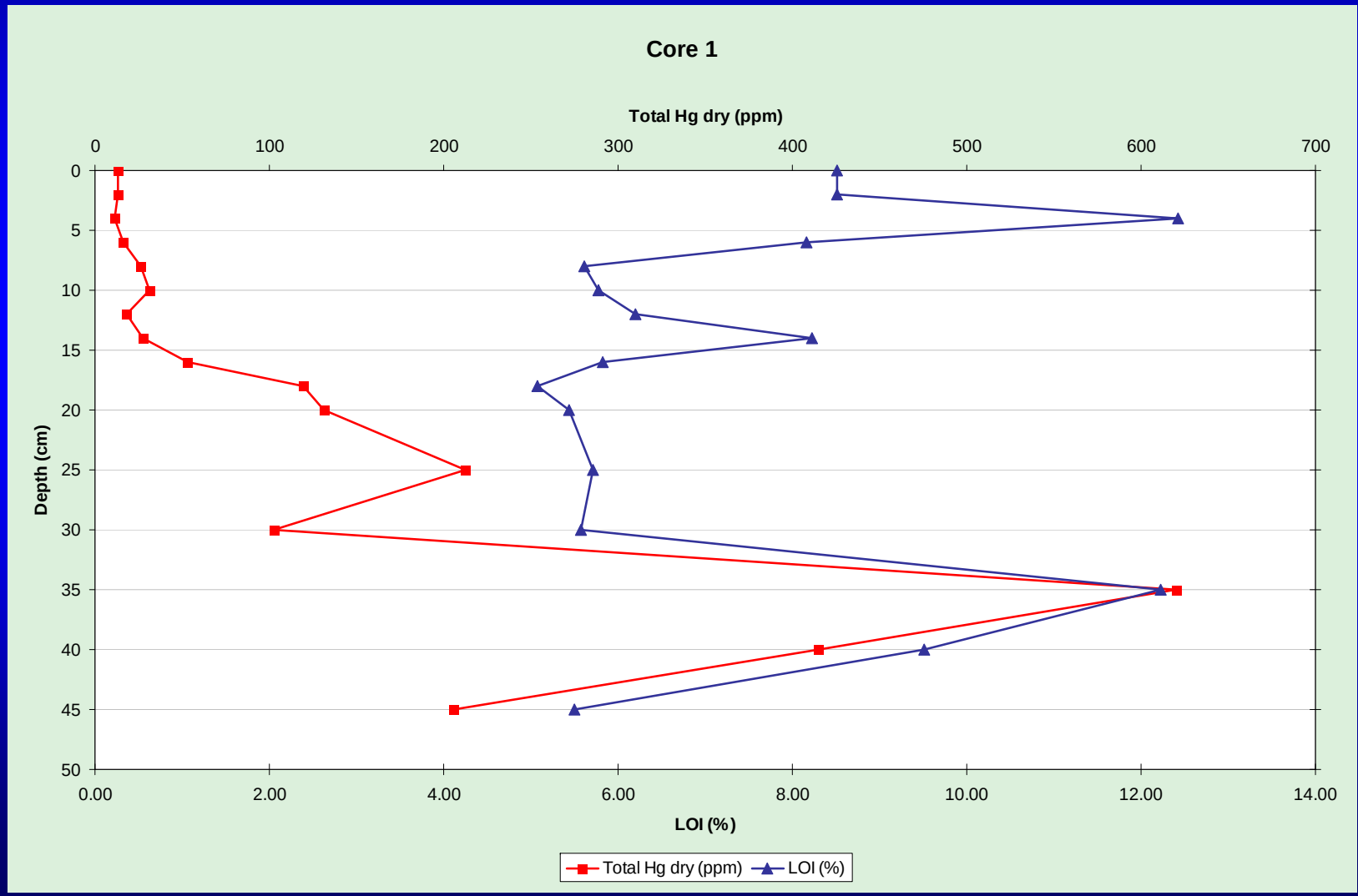
Volume in Each Category



Storage Volumes by River Reach



At least 1 Deposit has VERY High Hg Concentrations!



Bank Erosion

- Historical Mapping From Aerial Photographs
- Grain Size of Eroding Banks
- Hg Sampling of Eroding Banks

Summary of Aerial Photos Used

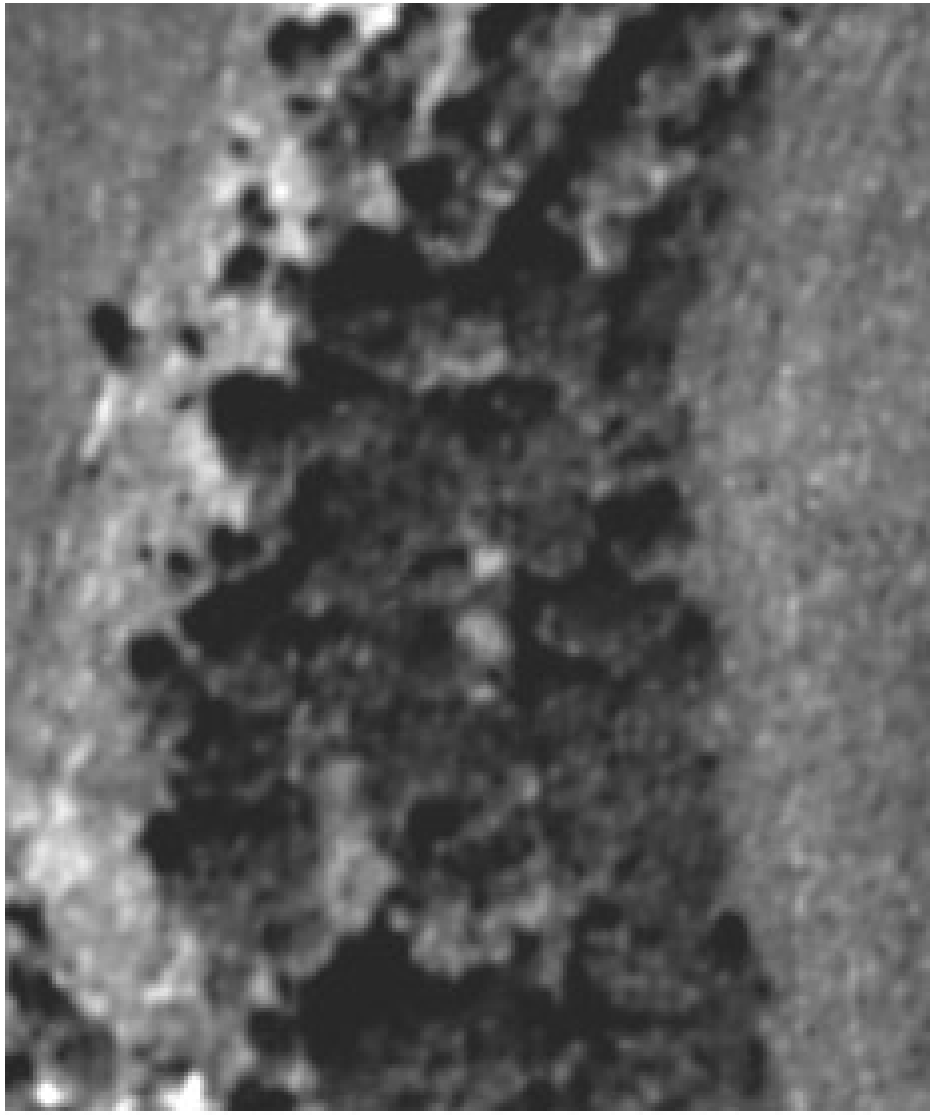
AERIAL PHOTO SUMMARY

YEAR	COLOR	PIXEL	PROJECTION	SCALE	DATE	SEASON	SECTIONS	*DISPLACEMENT
1937	Grey	0.35	UTM17	m				
1957	Grey	0.38	UTM17	m				2m
1959	Grey	0.84	UTM17	m				
1963	Grey	0.40	UTM17	m				
1968	Grey	0.41	UTM17	m				
1974	Grey	0.69	UTM17	m				2m
2005	RBG	0.15	State Pl	ft				

* Object located in photo 2005 used as reference

Some photos aren’t very useful….

Close-up showing poor resolution …



Other photos are terrific!

ALLIED READY MIX AREA

Aerial Photo 2005

Meters
0 25 50 100

South River - Virginia
Waynesboro

Allied Ready Mix Plant

Oxbow Area

Meters
0 55 110 220

Aerial Photo 1974

South River - Virginia
Waynesboro

Control points provide
Check on accuracy!

Waste Water Treatment Plant

Compare superposition

Meters
0 15 30 60

Red Lines Network Used In
Correlation Between Aerial Photos.
Lines:
Joining Center Of Tanks
Parallel With Building
Diagonal

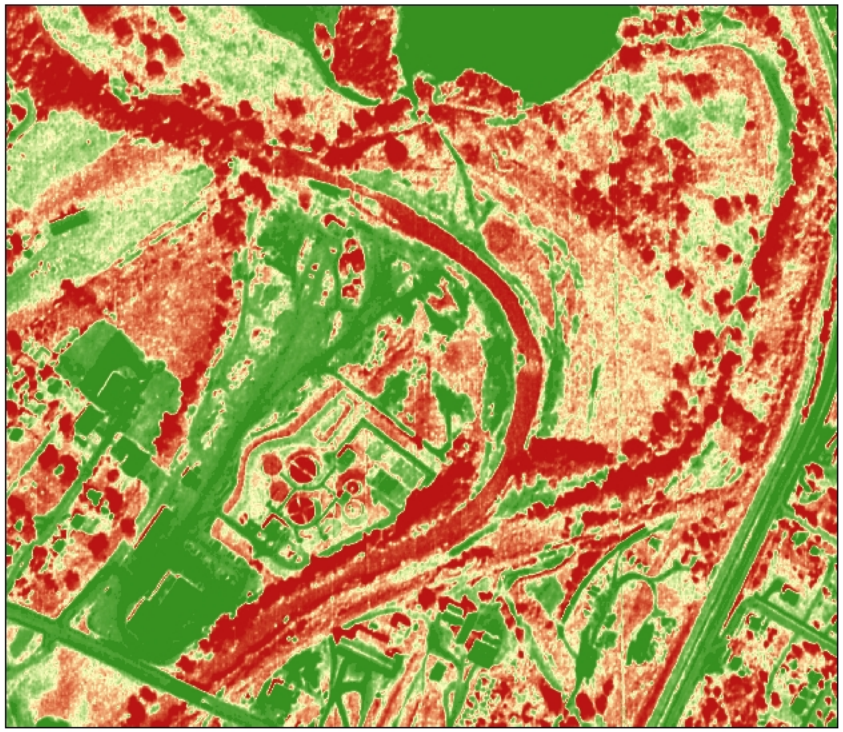
Aerial Photo 2005

South River - Virginia
Waynesboro

Changing color schemes improves contrast!

Allied Ready Mix Plant

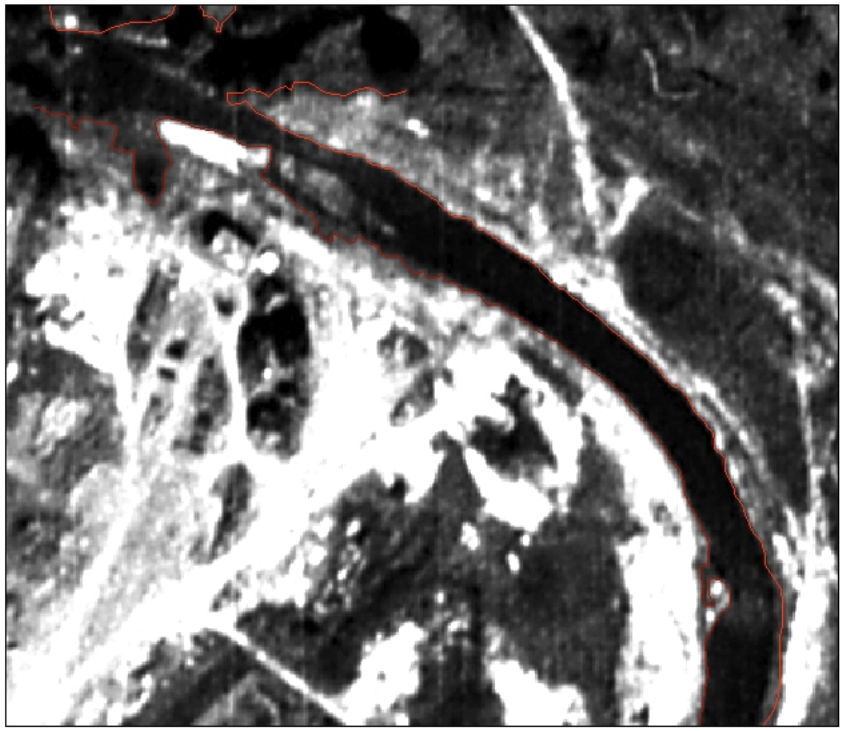
Oxbow Area



Meters
0 55 110 220

Aerial Photo 1974
Rastar-
Stretched color ramp

South River - Virginia
Waynesboro



Kilometers

0 0.025 0.05 0.1

1974oxb_rb

r1974_106131.tif

Value

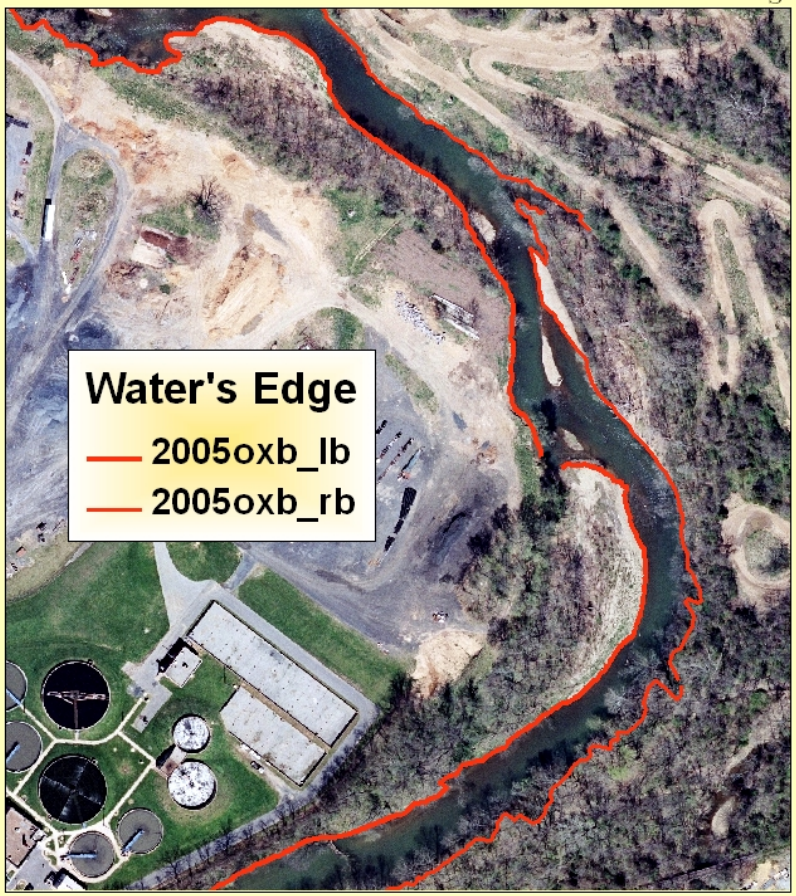
High : 255

Low : 40

1974oxb_lb

ALLIED READY MIX AREA

Relative River Bank Position



Left & Right Bank (Water's Edge)
2005

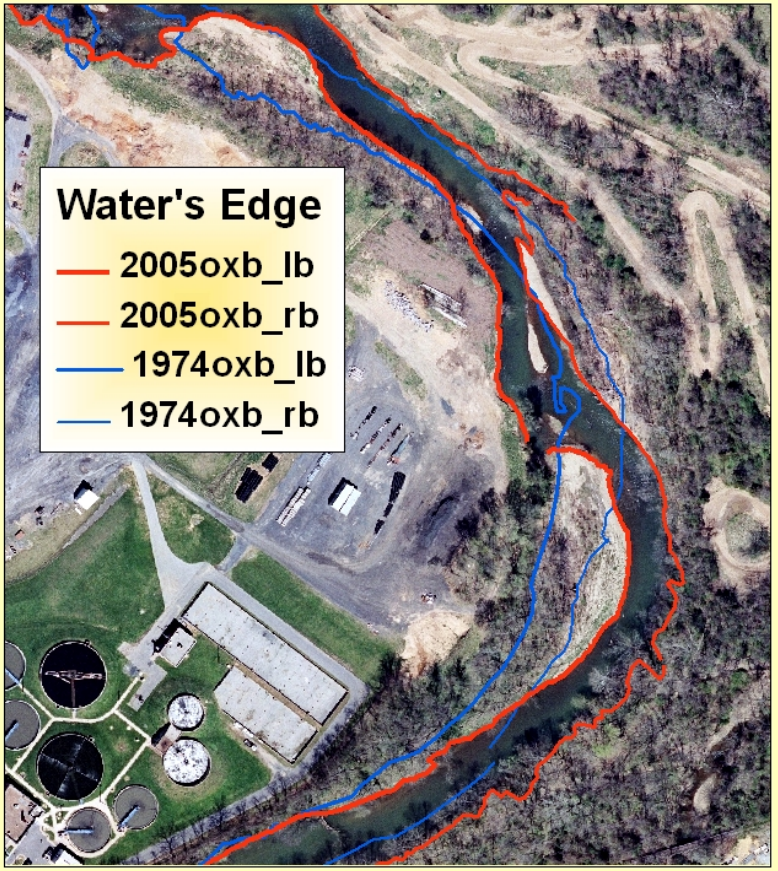
Meters
0 50 100

Southriver - Virginia
Waynesboro

DATE: OCT. 2005

ALLIED READY MIX AREA

Movement of River Over Time



Meters
0 50 100

Left & Right Bank (Water's Edge)
2005 & 1974

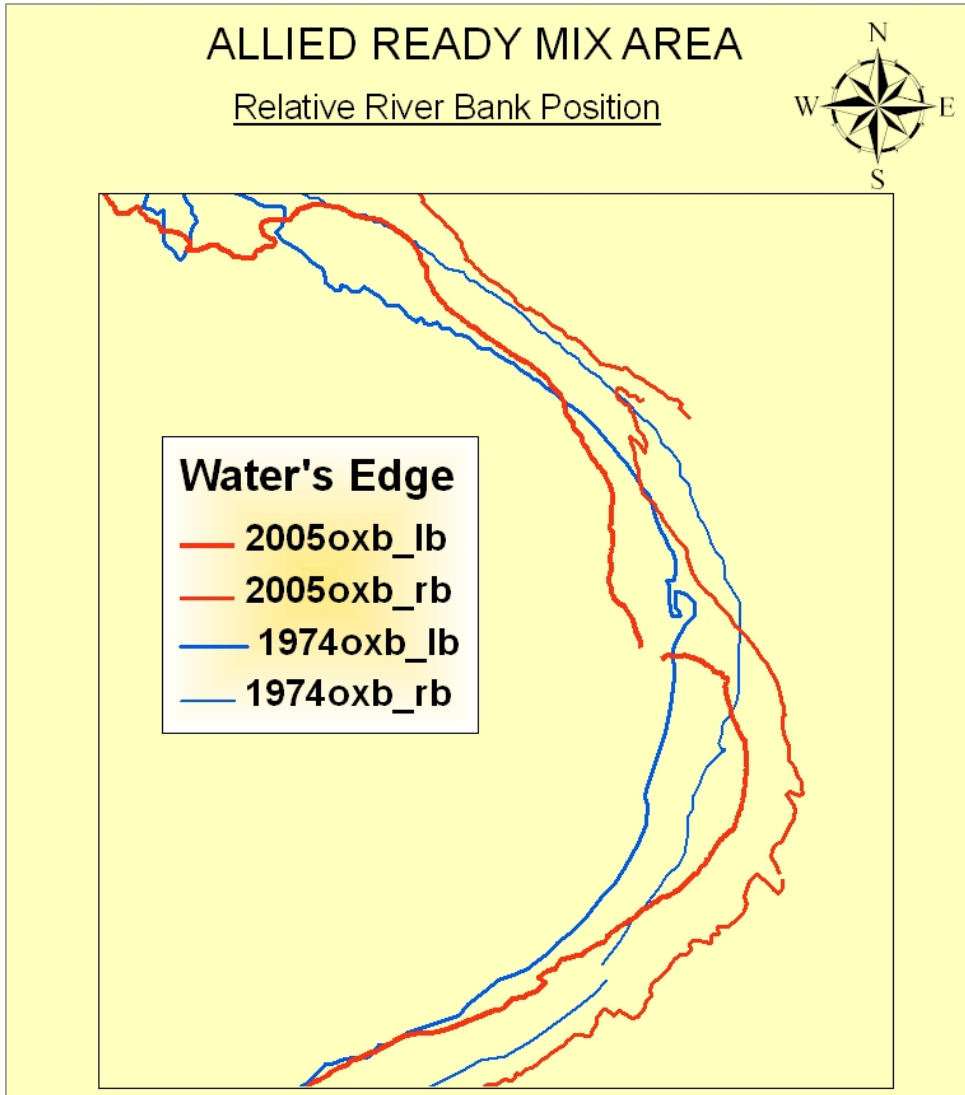
Aerial Photo 2005

Southriver - Virginia
Waynesboro

DATE: OCT. 2005

ALLIED READY MIX AREA

Relative River Bank Position



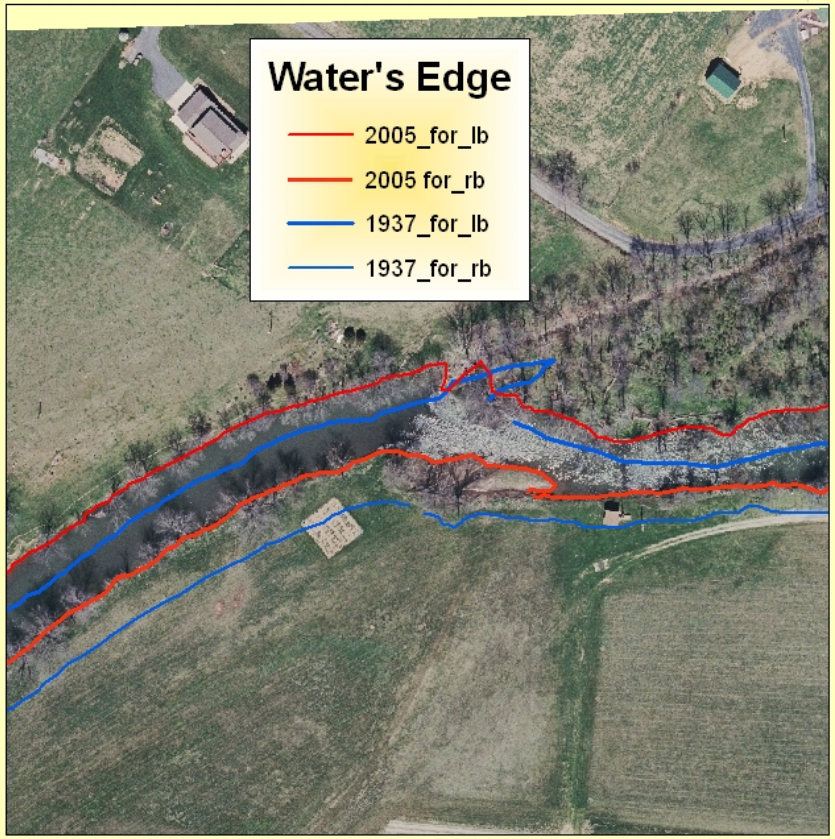
Left & Right Bank (Water's Edge)
2005 & 1974

Southriver - Virginia
Waynesboro

DATE: OCT. 2005

FORESTRY STATION

River Bank Positions



Left & Right Water's Edge
2005 & 1937

Aerial Photo 2005

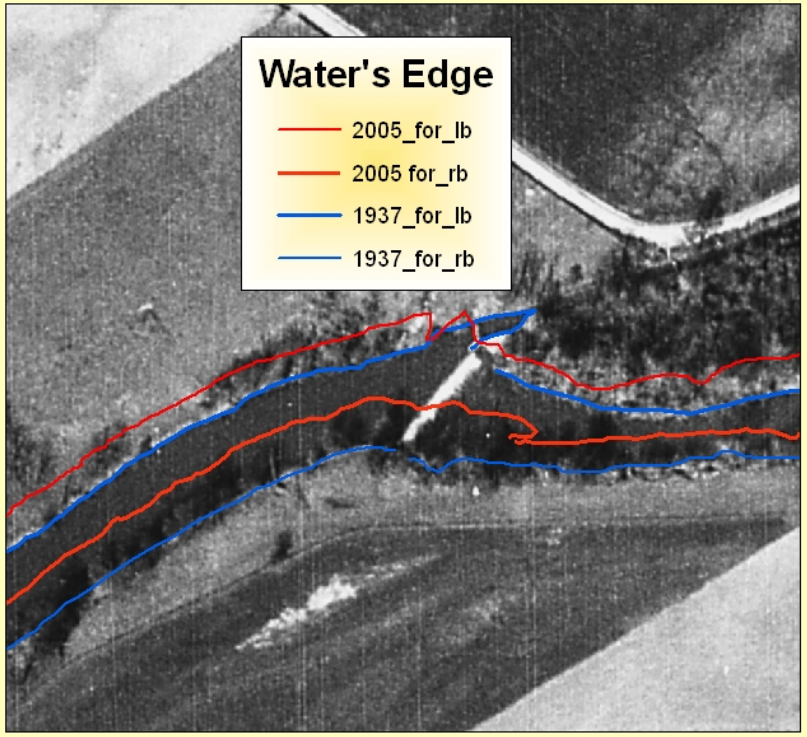
0 25 50 100 Meters

Southriver - Virginia
Waynesboro

Date: Oct. 2005

FORESTRY STATION

River Bank Positions



Left & Right Water's Edge
2005 & 1937

Aerial Photo 1937

0 25 50 100 Meters

Southriver - Virginia
Waynesboro

Date: Oct. 2005

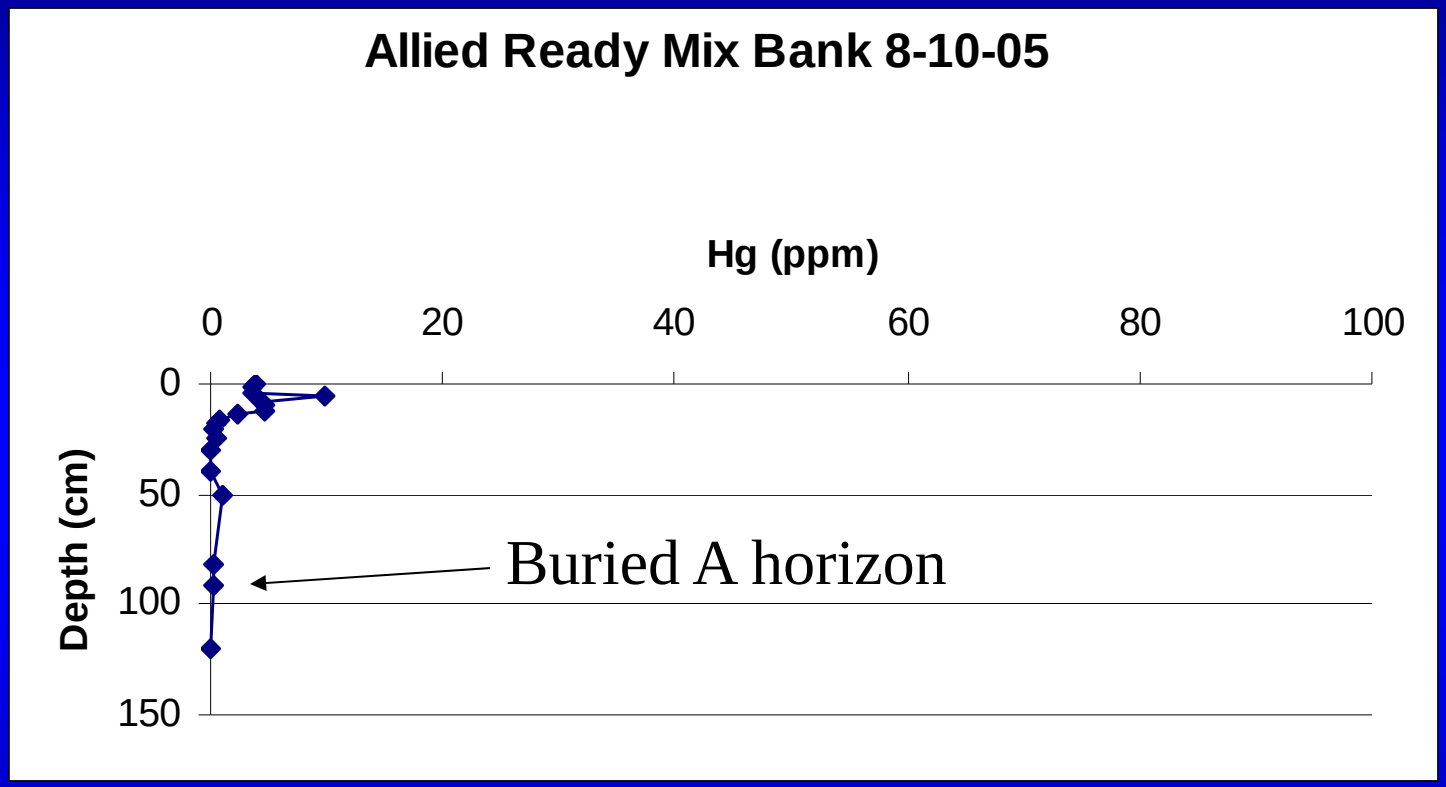
Summary of Aerial Photo Analysis

- This process will be repeated for selected reaches from Waynesboro – Port Republic
- We are still assessing the utility of this analysis to provide good quantitative measurements of long term bank erosion

Sampling Eroding Banks

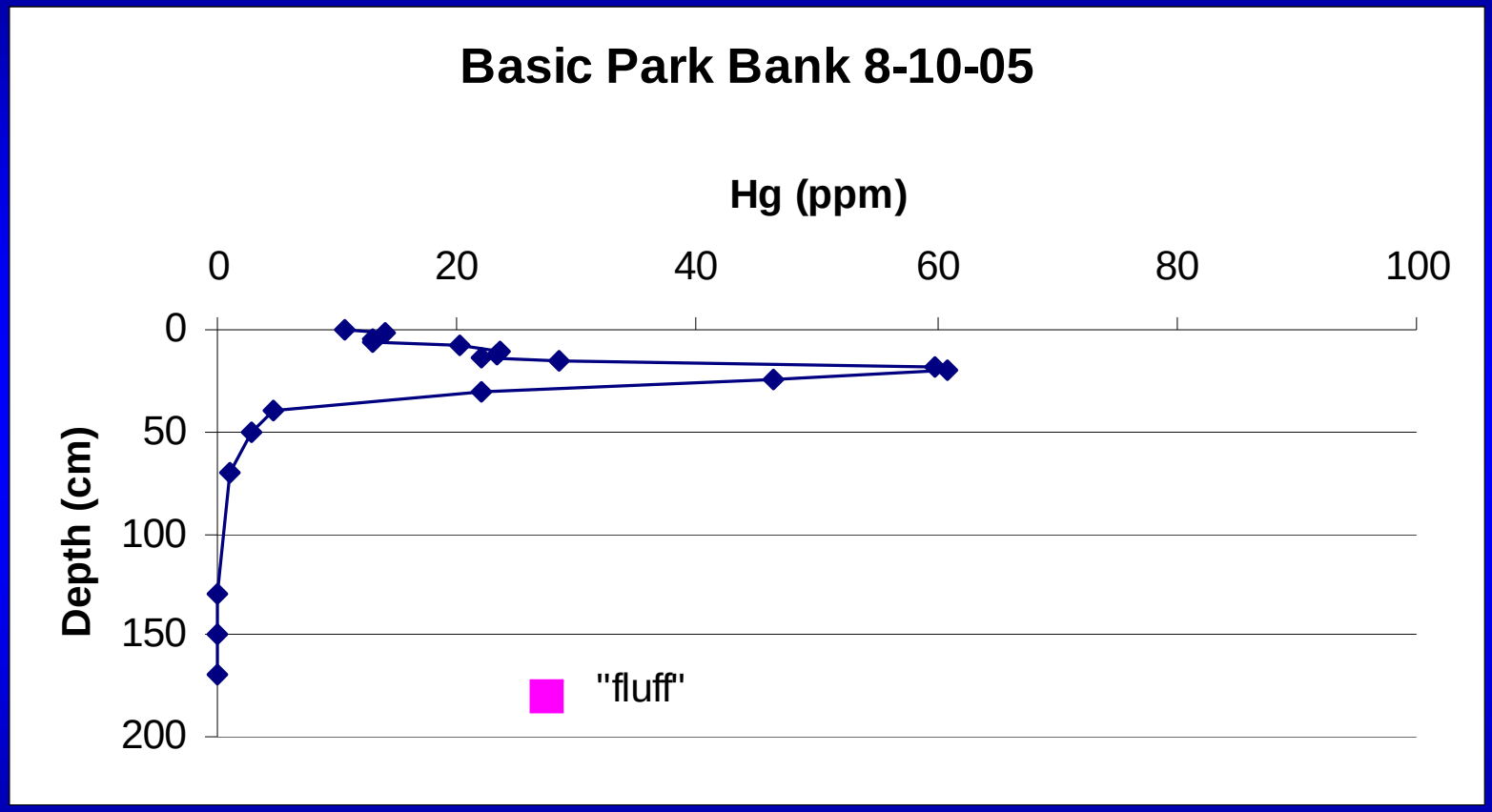
- Convert gross volumes of erosion to:
  - Mass of silt and clay supplied
  - Mass of Hg supplied
- 5 “accessible” sites sampled:
  - Allied Ready Mix
  - Basic Park
  - Forestry Station
  - Grand Caverns
  - Hopeman Pkwy (Ralph and Dick – no grain size data)

Allied Ready Mix



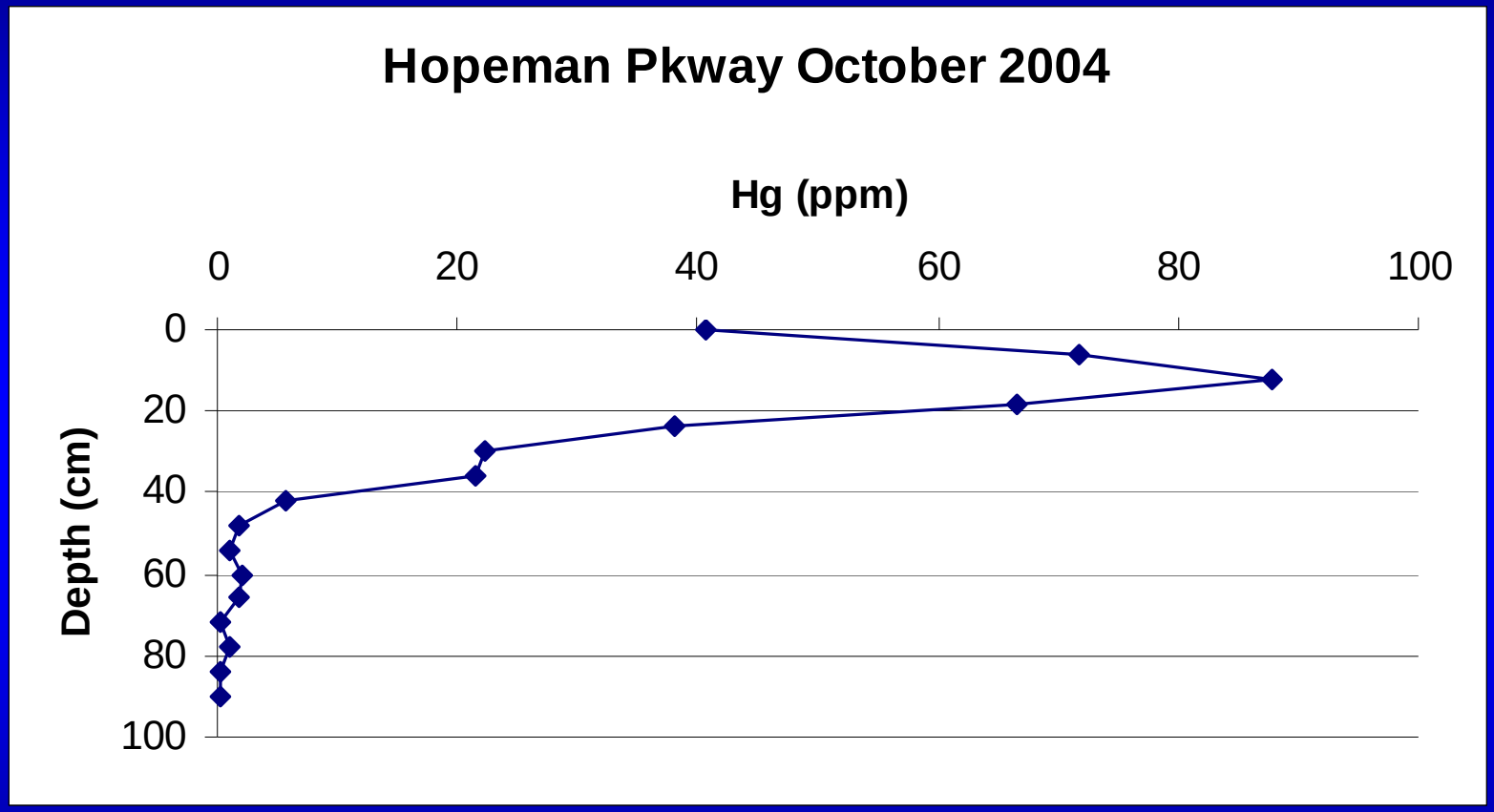
- Sandy sediment
- Mostly deposited far from channel ?
- Buried A horizon 81-92 cm

Basic Park 8-10-05



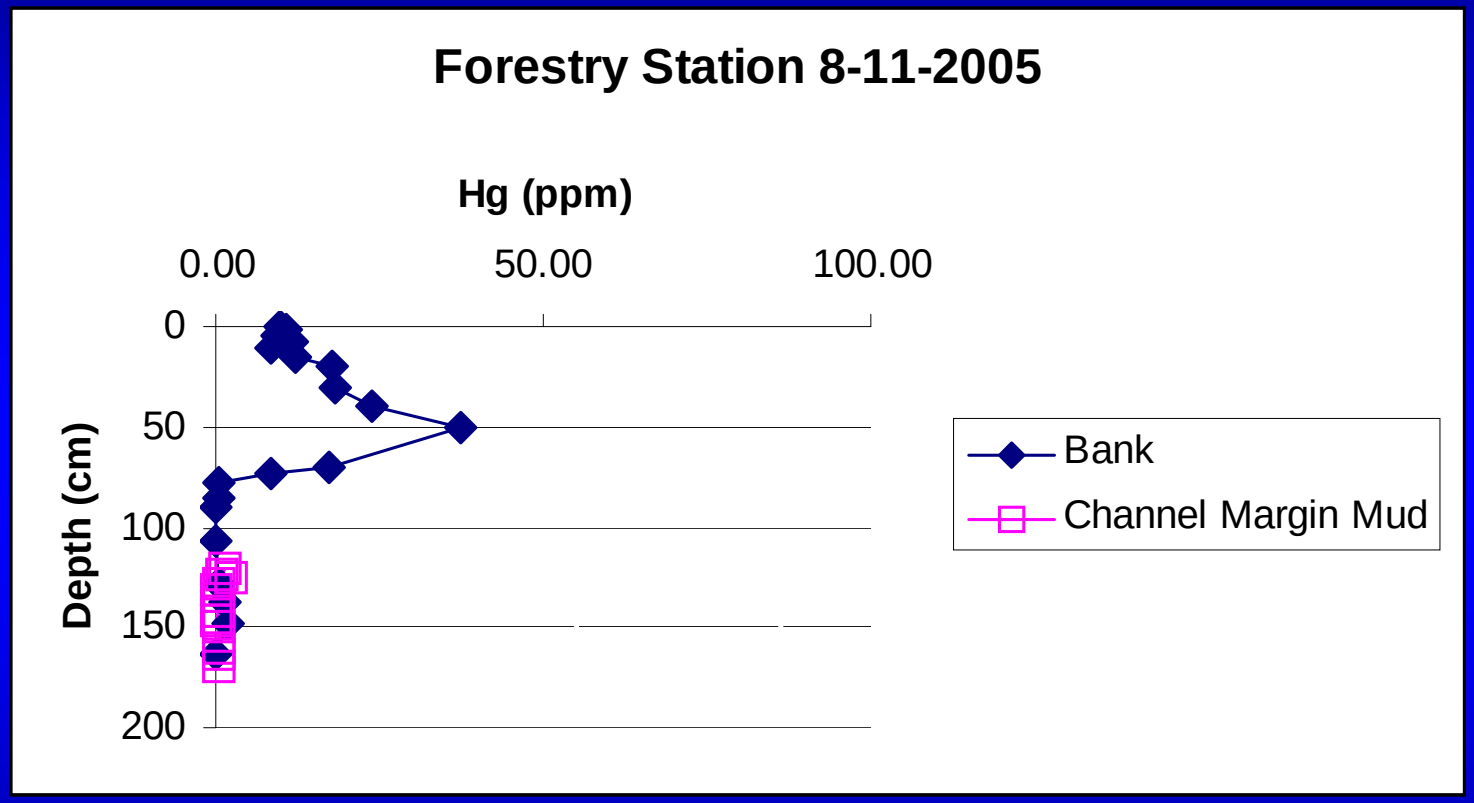
- Silty sediment
- Deposited adjacent to channel
- “Fluff” is part of a channel margin mud deposit at base of bank

Hopeman Parkway Bank October 2004



- Silty sediment
- Deposited adjacent to channel

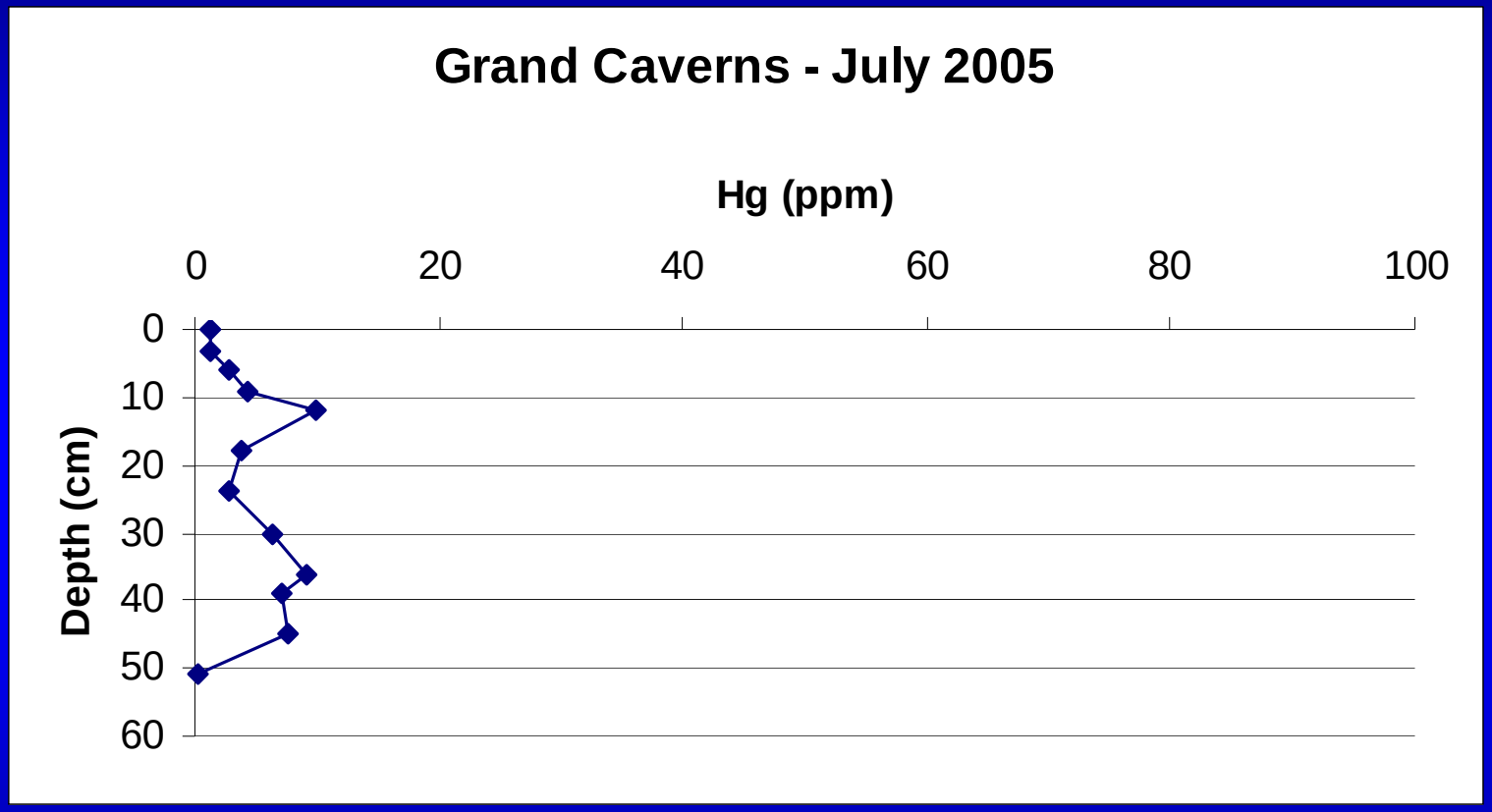
Forestry Station Eroding Bank 8-11-05



- Silty sediment
- Deposited adjacent to channel
- “Mill pond deposits” 128-144 cm
- “Channel margin mud” from adjacent bank (very low Hg not typical of most S. River transported muds)??

Forestry Station
"Mill Pond
Deposits"

Grand Caverns “Near-Bank Samples July 2005



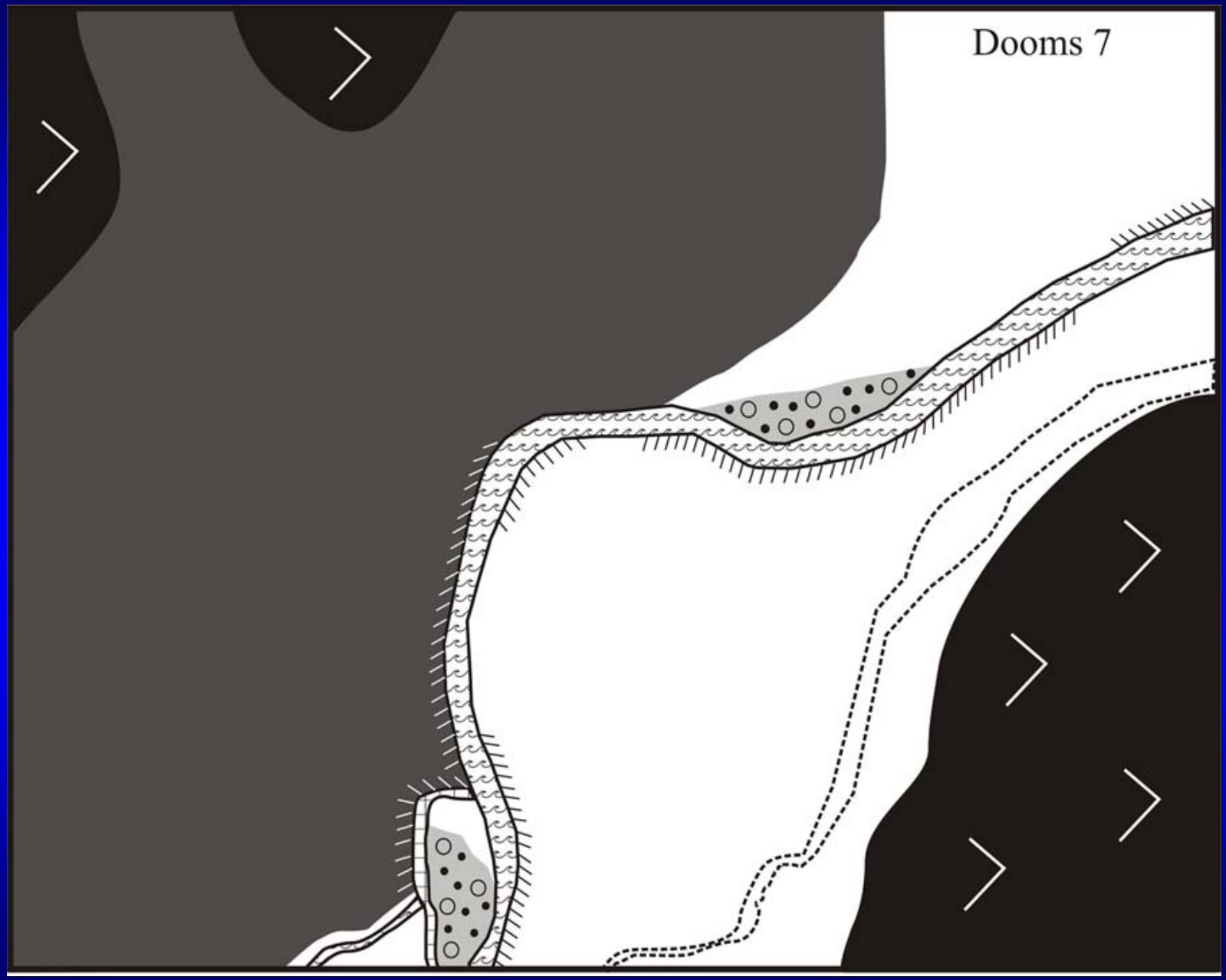
- Sandy sediment
- Deposited tens of meters from the channel

Geomorphic Mapping To Support the Sediment Budget

- Completed from Waynesboro-Crimora
- Reconnaissance observations from Crimora to Port Republic

What is Mapped??

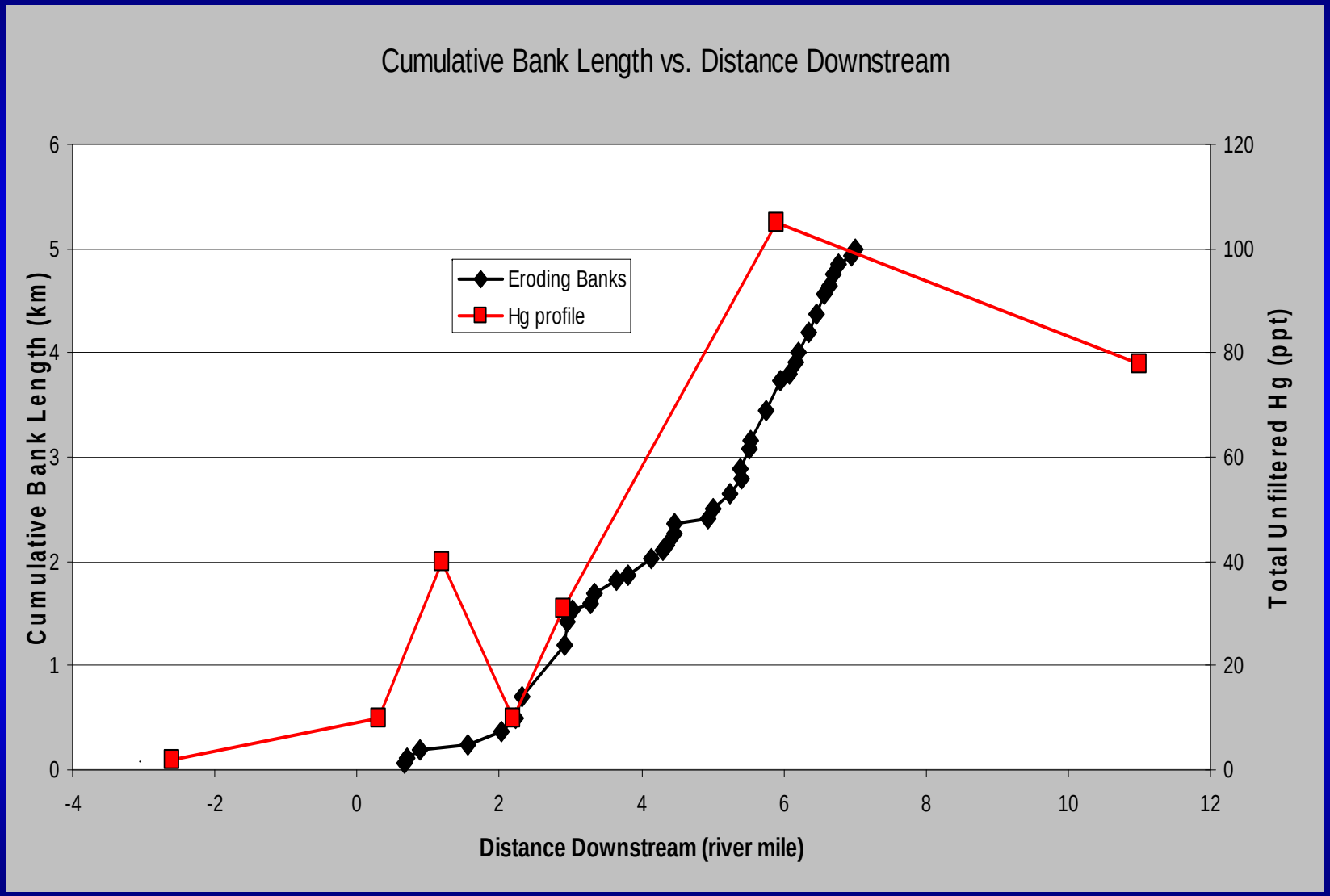
- Bedrock units that border the valley
- Terraces and alluvial fan deposits
- “Mature” and “immature” floodplain deposits
- Eroding banks
- “Floodplain channels”
- Mud deposits in the channel perimeter


Dooms 7

Significance of mapping

- Analysis of geomorphic maps may provide interesting insights into Hg transport and accumulation in the river channel.

- Possible association between Hg sources from banks and observed Total Hg in the water column in the upstream study area.


Cumulative Bank Length vs. Distance Downstream
Eroding Banks
Hg profile
Cumulative Bank Length (km)
Total Unfiltered Hg (ppt)
Distance Downstream (river mile)
0
1
2
3
4
5
6
0
20
40
60
80
100
120
-4
-2
0
2
4
6
8
10
12

Workplan, Nov. 05-June 06

1. Improve estimates of sediment input and output using sediment rating curve.
2. Measure “immature” and “mature” floodplain storage at 1 location each.
3. Estimate silt and clay stored in pores of bed material.
4. Determine annual bank erosion rates from aerial photographs
5. Use radionuclides to determine residence times of fine-grained channel margin deposits.

Workplan, Nov. 05-June 06, cont'd

7. Explore implications of sediment budget for "particulate-associated" Hg.
8. Test hypothesis that reach from Crimora-Port Republic stores less sediment than upstream.
   - Map fine-grained deposits in 10 500 m reaches in downstream reach.

Proposed Radionuclide Study of Fine-grained Channel Margin Deposits (FGCMD)

- Standard methods require “steady deposition” or measurement of complete profile
- FGCMD subject to periodic erosion, most too young to have complete Pb210 Inventory
- Approach: determine initial concentration from suspended sediment, atmospheric deposition independently of cores
- Correct all cores for grain size, organic content
- Analyze cores with really good recovery

Proposed Radionuclide Study

- Measure Cs137, Pb210, Hg, grain size, organic content (LOI) in fine-grained channel margin deposits
- Sample terrace where erosion and deposition = 0 to determine net atmospheric inventory
- Sample suspended sediment so initial activity is known over a range of discharges
- Age of each slice of core can be determined

Proposed Studies Beyond June ’05

To provide quantitative understanding of sediment budget components, leading to “predictive” capability

1. What processes and variables control the rates and patterns of bank erosion from Waynesboro to Port Republic?
   - *Understand, quantify and predict bank erosion under a variety of conditions.*
   - *Local measurements using erosion pins, tripod mounted lidar??*
     - *Start these studies soon..?*
2. What processes and variables control rates of deposition and erosion of fine-grained channel margin deposits?

Provisional Conclusions

1. Although bank erosion rates on South River are low compared to many rivers of similar size and geomorphic setting, bank erosion is pervasive, and eroding bank sediments often have high Hg concentrations.
2. Preliminary estimates suggest that bank erosion is a significant source of fine-grained sediment to the stream, possibly accounting for around 5-10% of the annual suspended load.
3. Significant deposits of fine-grained sediment occur within the wetted perimeter along the channel margins. These “channel margin mud deposits” are nearly all associated with accumulations of “large woody debris”.
4. At least one fine-grained deposit has *very* high Hg concentrations, with values up to 600 ppm.