South River Geomorphology Update April 2009

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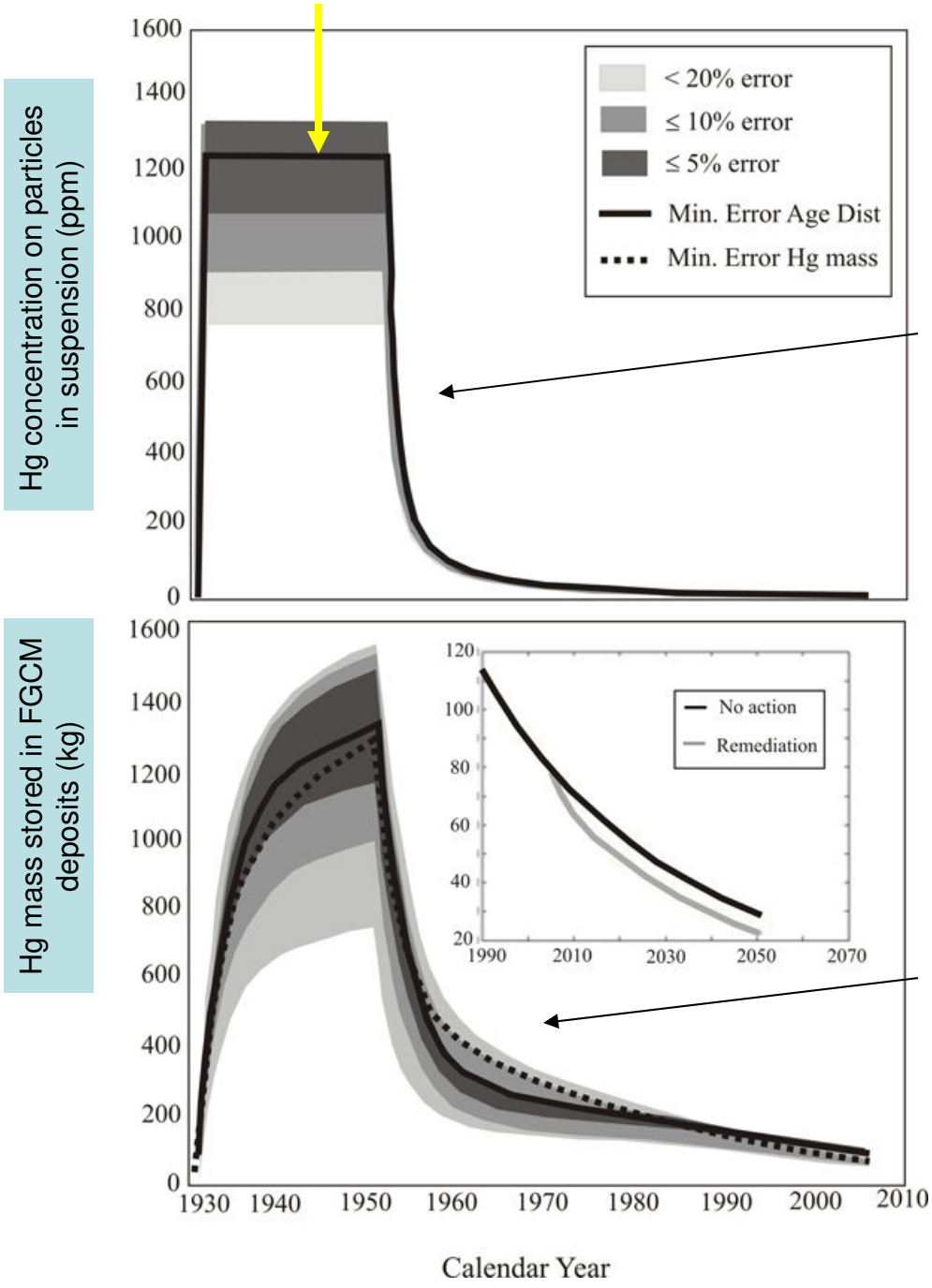
Topics

- Updated and Finalized Modeling of Hg Storage in Fine-Grained Channel Margin Deposits, 1930-2050
- Using Tree Morphology To Identify SLOW Bank Erosion – a pilot study
- Hydraulic Modeling of River Bank Erosion
- Residence Time of Silt and Clay in South River Gravel Stream Bed
- Baseline Studies – Pilot Bank Stabilization Site

Modeling Hg storage in FGCM deposits

- Goals:
  - reconstruct past Hg concentrations on suspended sediment in the South River from release period to the present
  - Assess temporal changes in Hg storage in FGCM deposits
  - Evaluate recovery times associated with certain remediation strategies
- Status:
  - Paper almost ready to submit (SCIENCE)
    - Skalak and Pizzuto…..

Note “hindcasted” Hg concentrations on particles in water column ~ 1200 ppm during “release period”



Hg on Particles in the water column of the South River – A model “hindcast”

Model Predictions of the Total Mass of Hg Stored in Fine-Grained Channel Margin Deposits

Tree Morphology As an Indicator of Bank Erosion

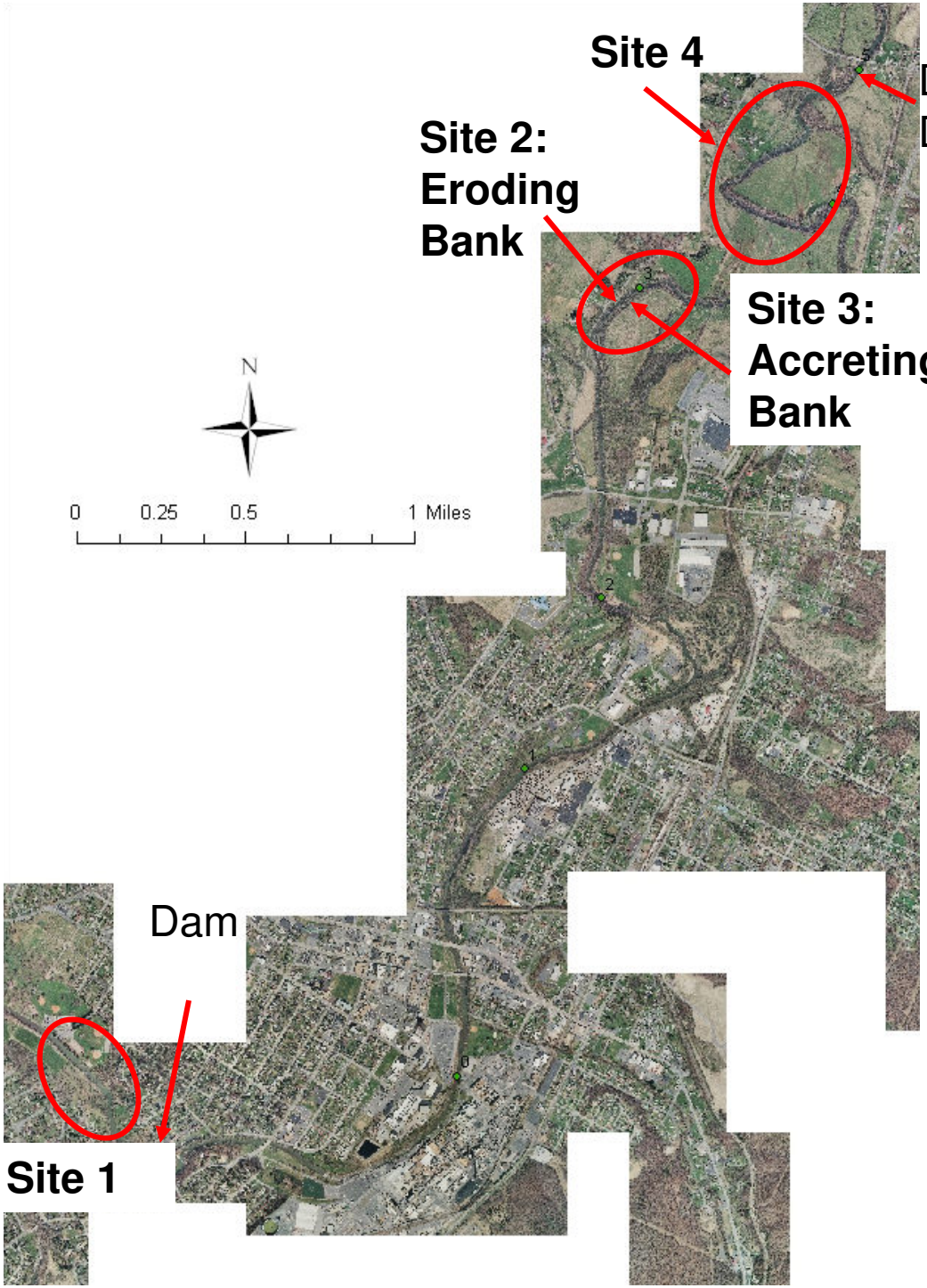
- An experiment….performed in January our Total Station died…

Tree and Bank Analysis

- Objective: Determine if trees on a bank can indicate if a bank is eroding or accumulating sediment.
- Motivation:
  - Erosion rates on the South River are often too low to measure using traditional methods
- Hypothesis:
  - Bank erosion may be even more pervasive along the South River than we have been able to document using traditional methods

Experimental Design

- Study “tree morphology” on 3 types of banks with known behavior:
  - Stable
  - Eroding
  - Accreting
- Study “tree morphology” on 1 type of bank whose behavior is unknown
  - But which is believed to be eroding
- See if trees on the “potentially” eroding bank are similar in some features to the “known” eroding bank

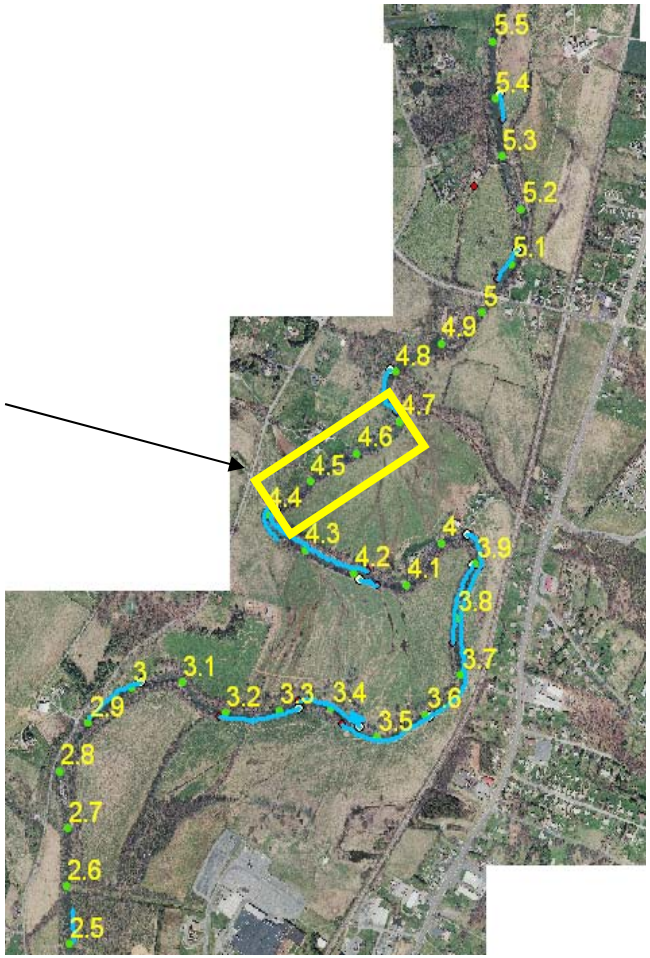


STUDY SITES and Experimental Design

Bank Conditions at 4 Study Sites:

1. STABLE (?)
   - Upstream of intact dam
2. ERODING
3. ACCRETING
4. POSSIBLY ERODING? (compare with 1-3 to tell)

The Potentially Eroding Site…



-Has not be identified by previous mapping as an "eroding bank"
-Is upstream of the recently breached Dooms Dam (removal of the dam should enhance the potential for erosion)

Tree and Bank Analysis

- Procedure:
  - 1. Randomly select 15 specimens per site
  - 2. Measure undercut
  - 3. Record location on bank
  - 4. Measure lean
  - 5. Measure diameter

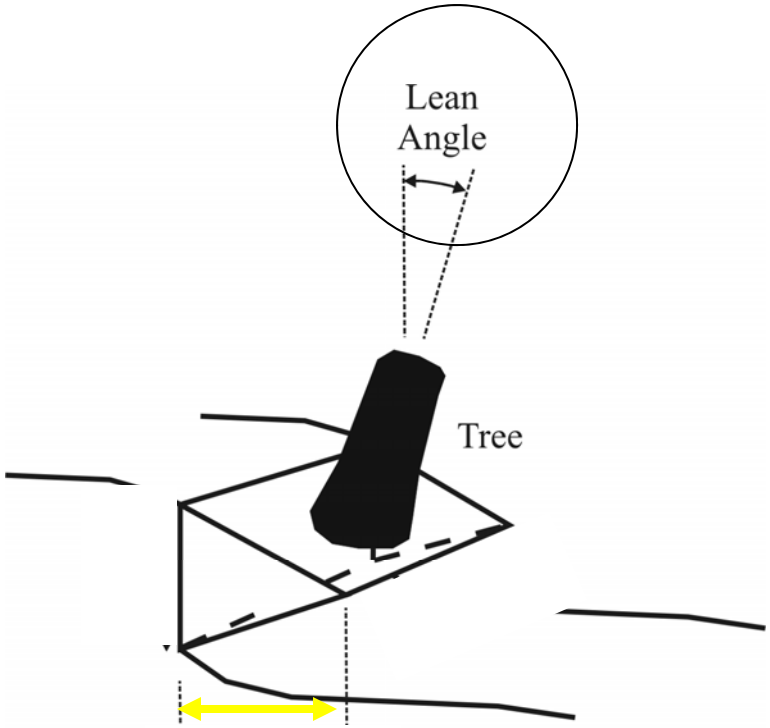
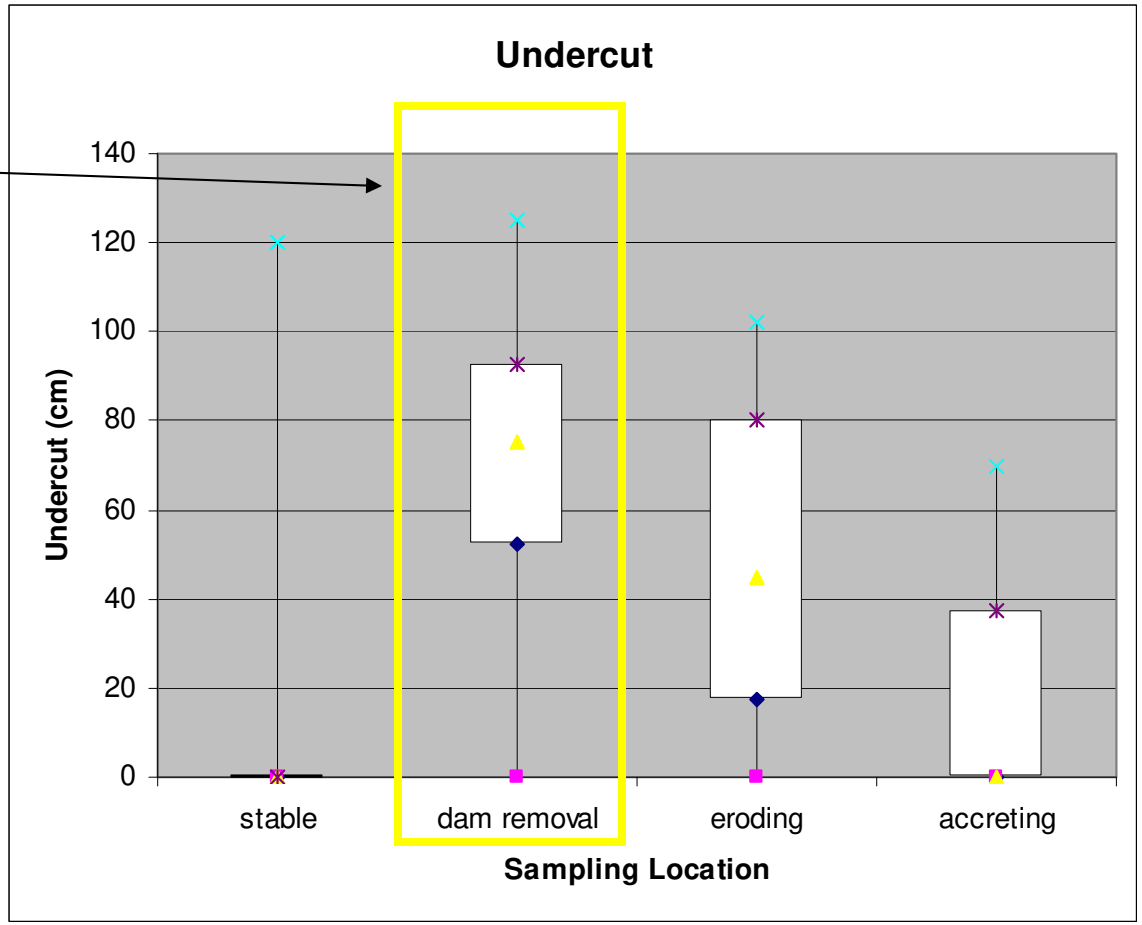


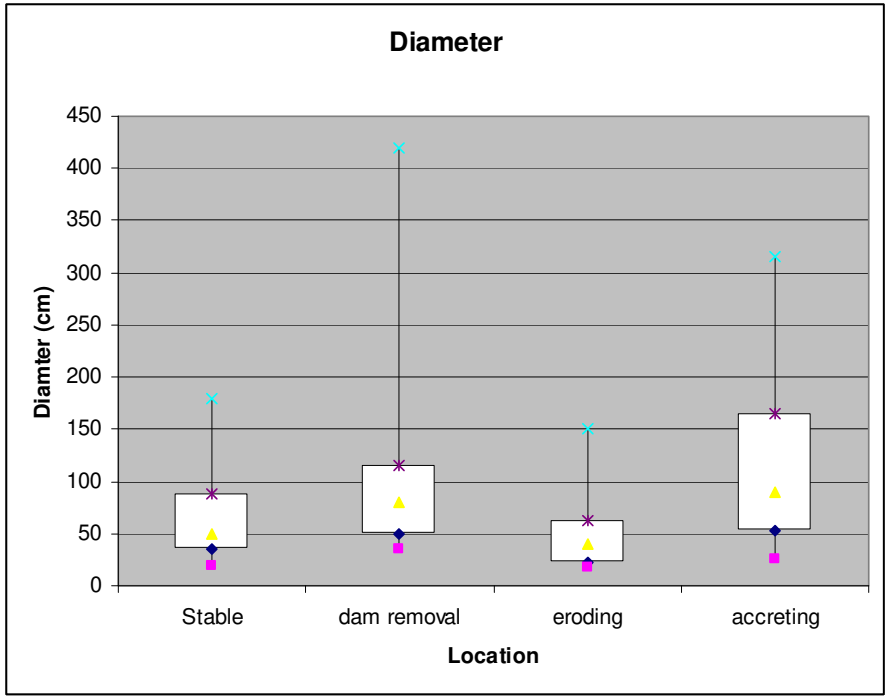
Figure 1.

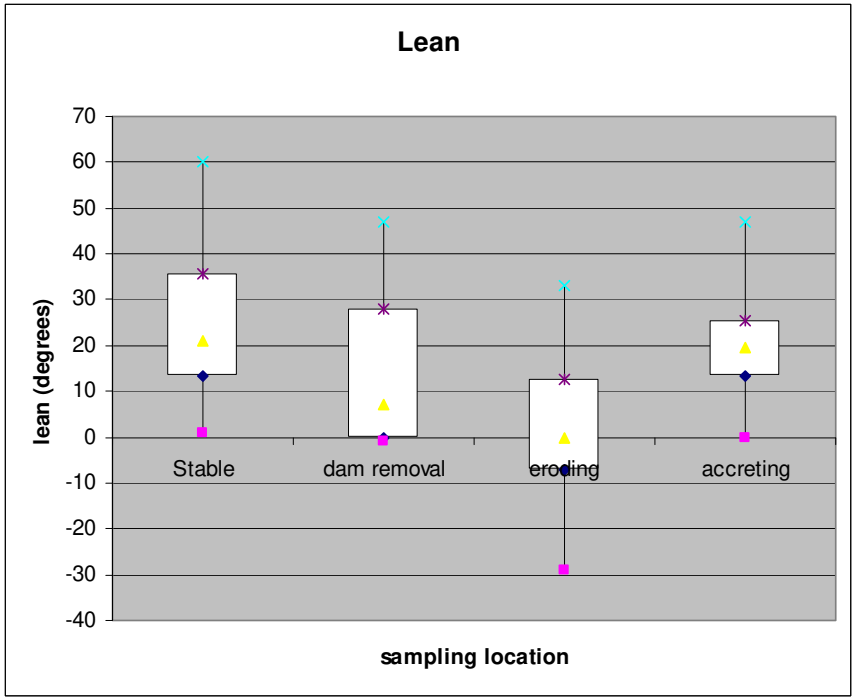
Results: Trees on eroding banks are significantly more “undercut” than trees on stable or accreting banks

The bank above Dooms Dam is likely eroding… There is also likely more bank erosion on South River than we have mapped….



Other results are interesting…





Conceptual Model: How Trees Respond to Bank Retreat

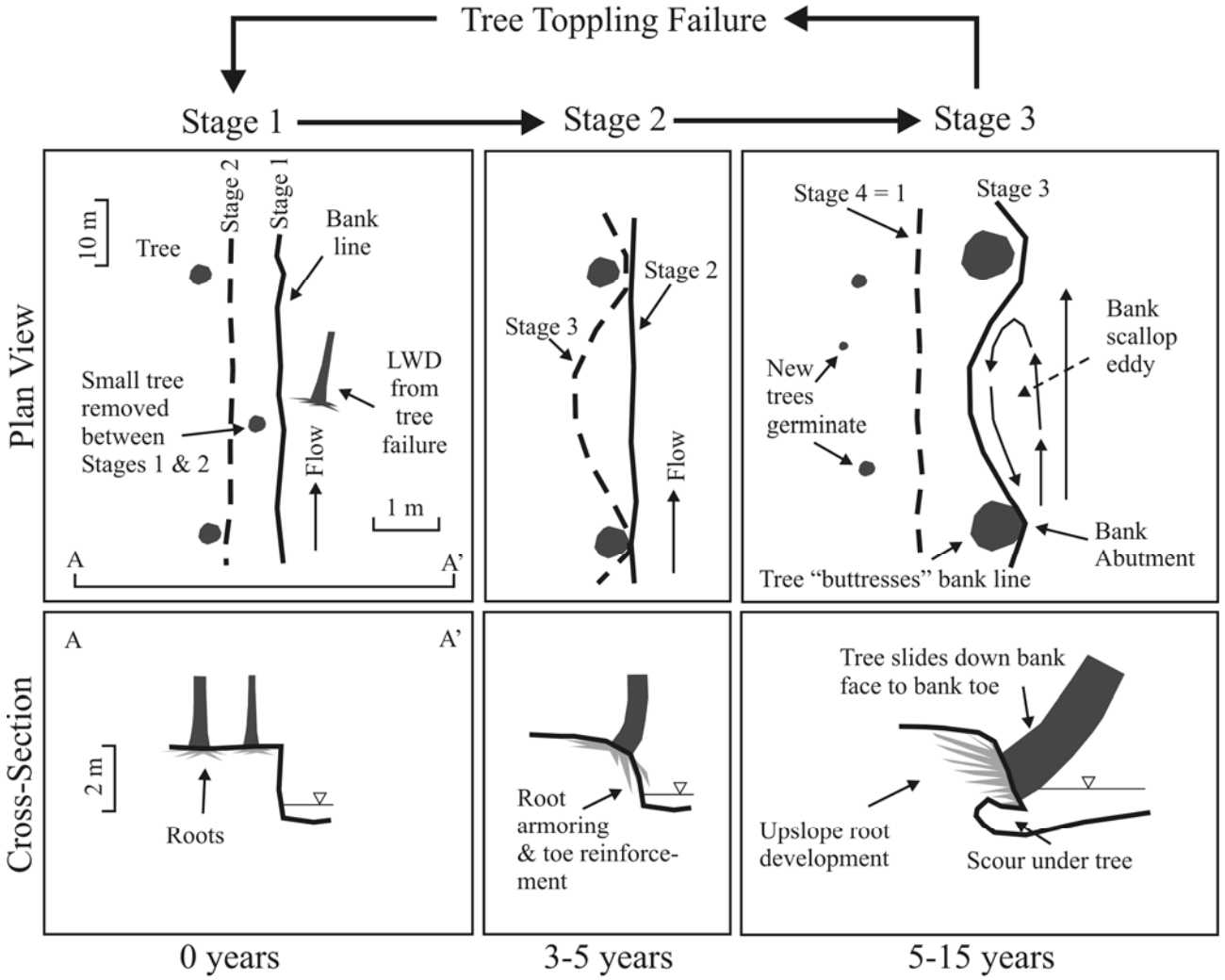


Figure 14.

Pizzuto et al., in review

Tree and Bank Analysis: Results

- There is a significant difference in “undercutting” between the intact dam and both the breached dam and the eroding site, indicating eroding conditions are likely above Dooms Dam
- This method identifies an eroding bank that had not been previously identified.
- Perhaps bank erosion along the South River is significantly more extensive than previously documented….

Hg Loading From Bank Erosion
Spatially Explicit Annualized Loading Rates

- Focus on reaches between bridge crossings
  - But much greater spatial resolution available
- Goal:
  - Identify areas of the river that produce enhanced Hg loading through bank erosion on annual timescales

Bank Erosion – Conceptual Model

- Bank erosion is driven by:
  - Near bank hydraulic forcing (velocity)
- Bank erosion rates vary with:
  - Bank material type
    - Bedrock
    - Alluvium
    - Terrace/alluvial fan
  - Many other factors we choose to ignore….

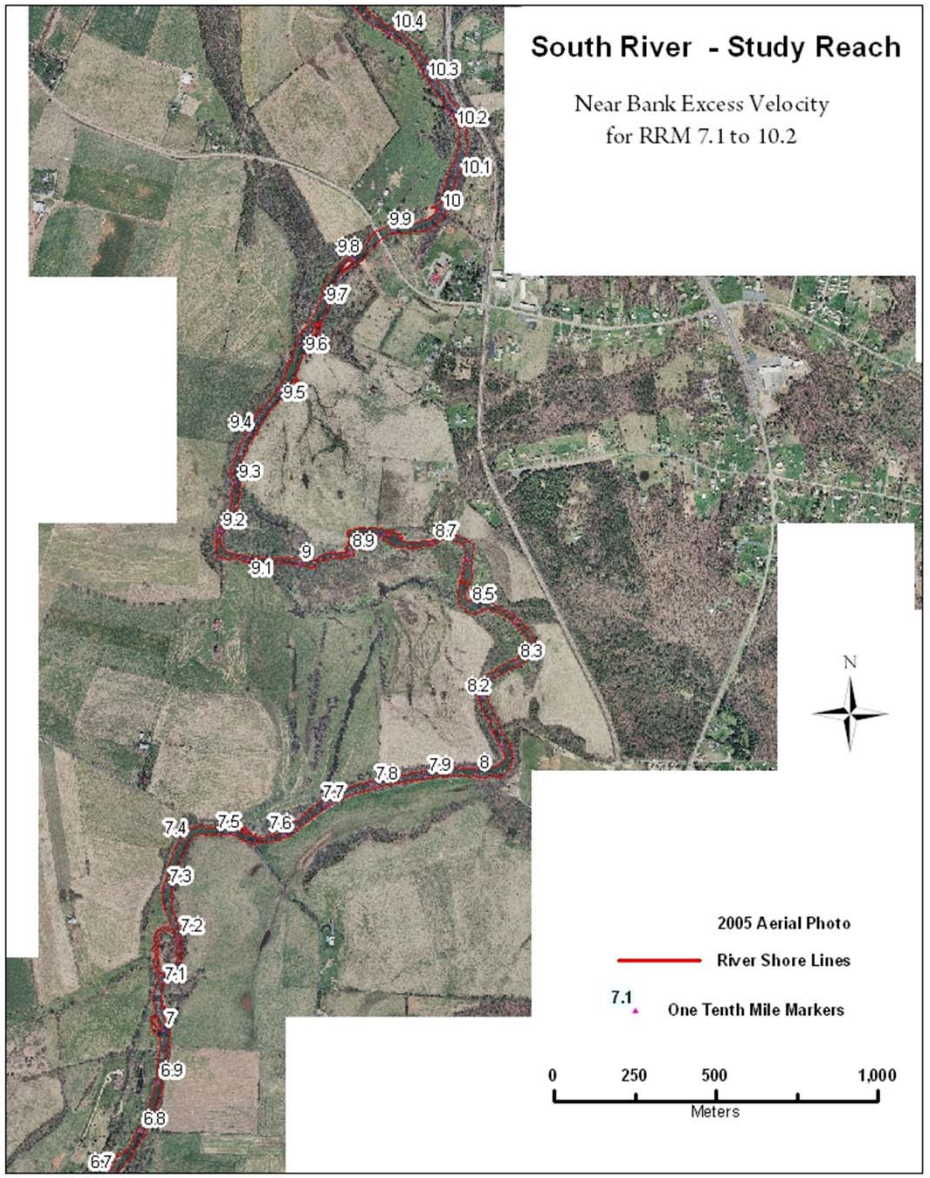
Bank Erosion – Modeling Approach

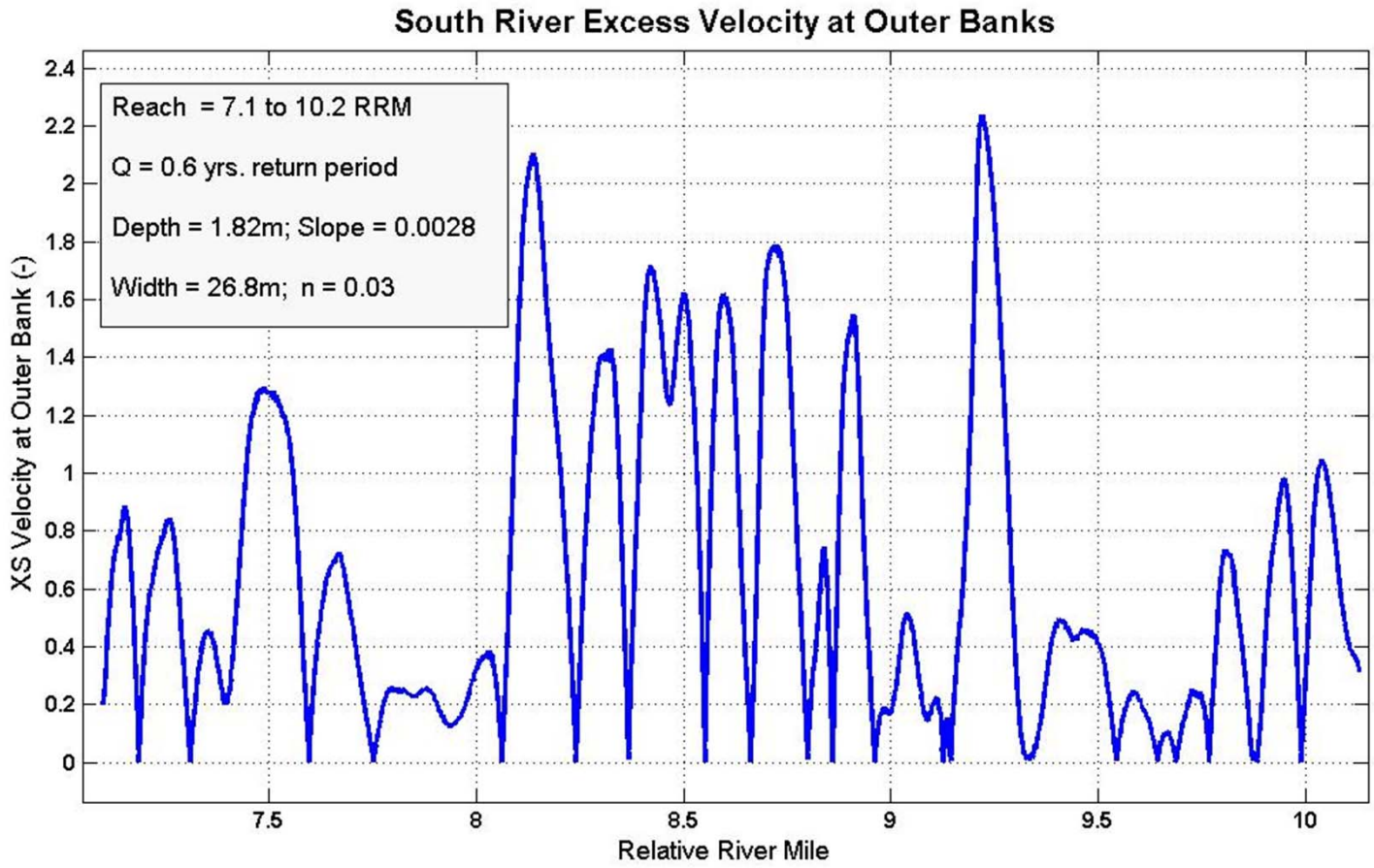
- Modeling approach
  - Compute near bank velocity
    - Predicts locations where erosion is expected
- Calibration with field data
  - Correlate observed erosion rate for different bank "types"
    - Aerial photo data
    - LiDAR data
- Use calibrated model for prediction along the entire river

Hydraulic Modeling Results

- Based on morphology of the channel centerline
- Discretized at 4 foot intervals
- Smoothed
- Velocity at outer bank depends on:
  - Average channel width, depth, slope, “roughness”
  - Some sediment transport parameters
  - Local channel curvature

Some Example Results For RRM 7.1- 10.2





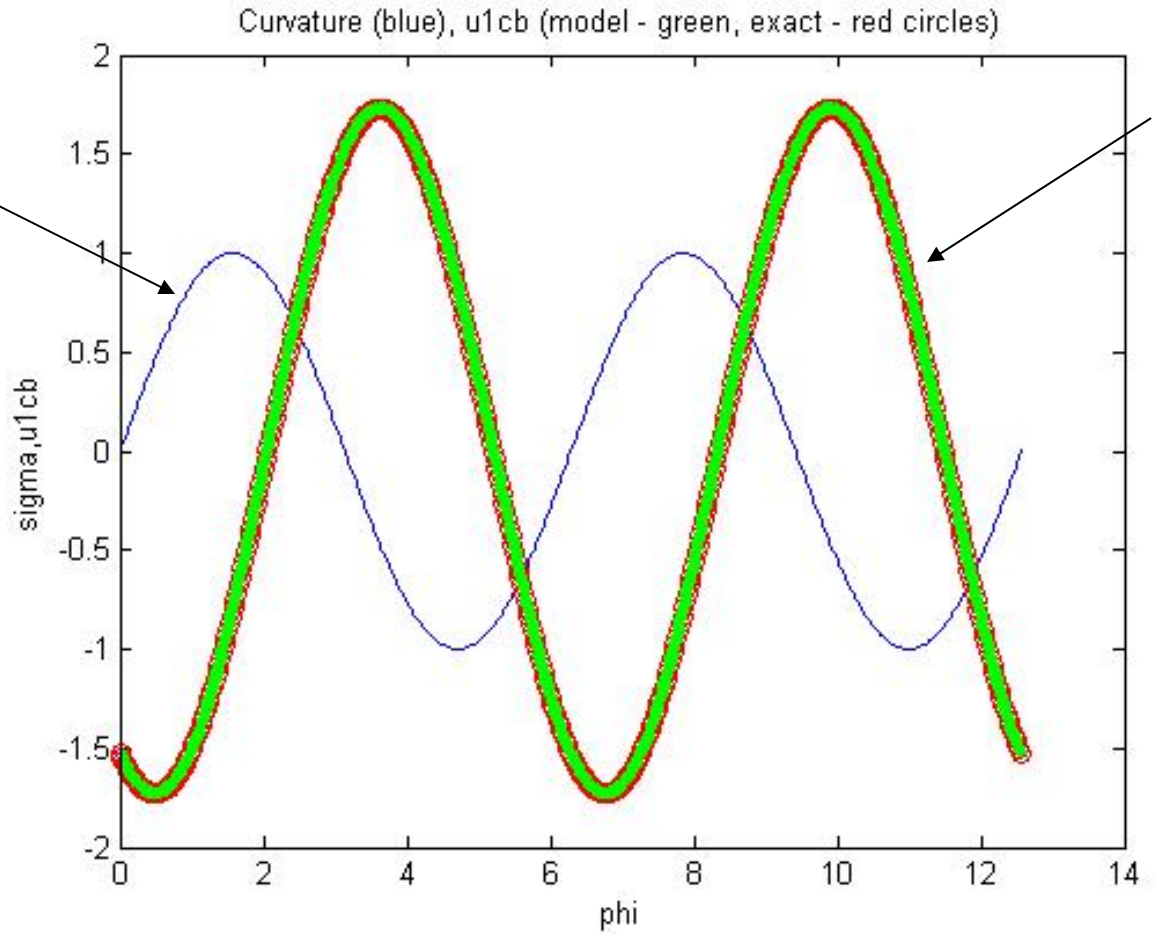
-"Excess Velocity" is a (dimensionless) measure of the difference between the average velocity of a reach and the local velocity near the outside bank (which is always higher than the reach average velocity)

-Theoretically, any excess velocity ~>0 should cause bank erosion

Effect of Curvature on “Excess Velocity”

- Maximum velocity occurs downstream of the apex of a bend due to the momentum of the flow

Effect of Curvature on "Excess Velocity" example from symmetrical sinusoidal channel

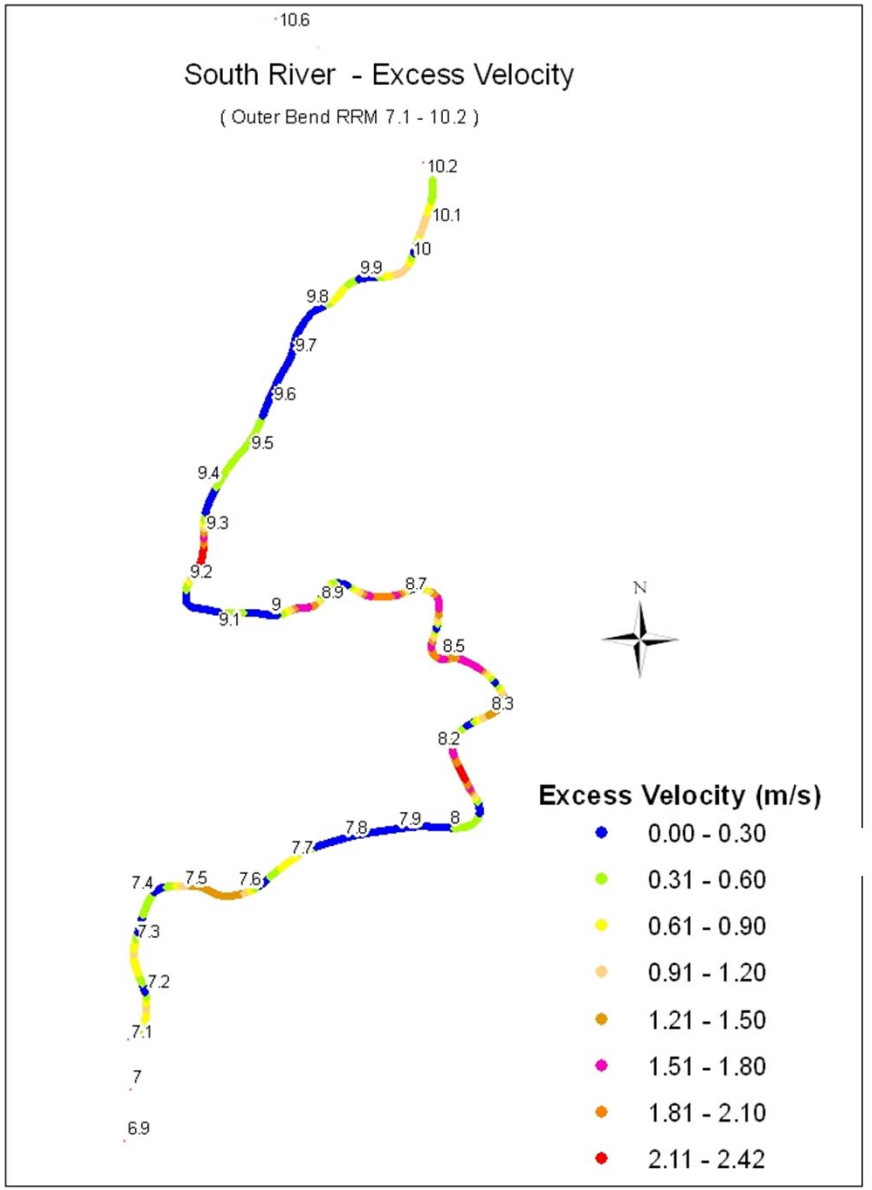


Channel curvature

"Excess" velocity at left bank

Downvalley direction

“Excess” velocity for RRM 7.1-10.2



Bank Erosion Rate

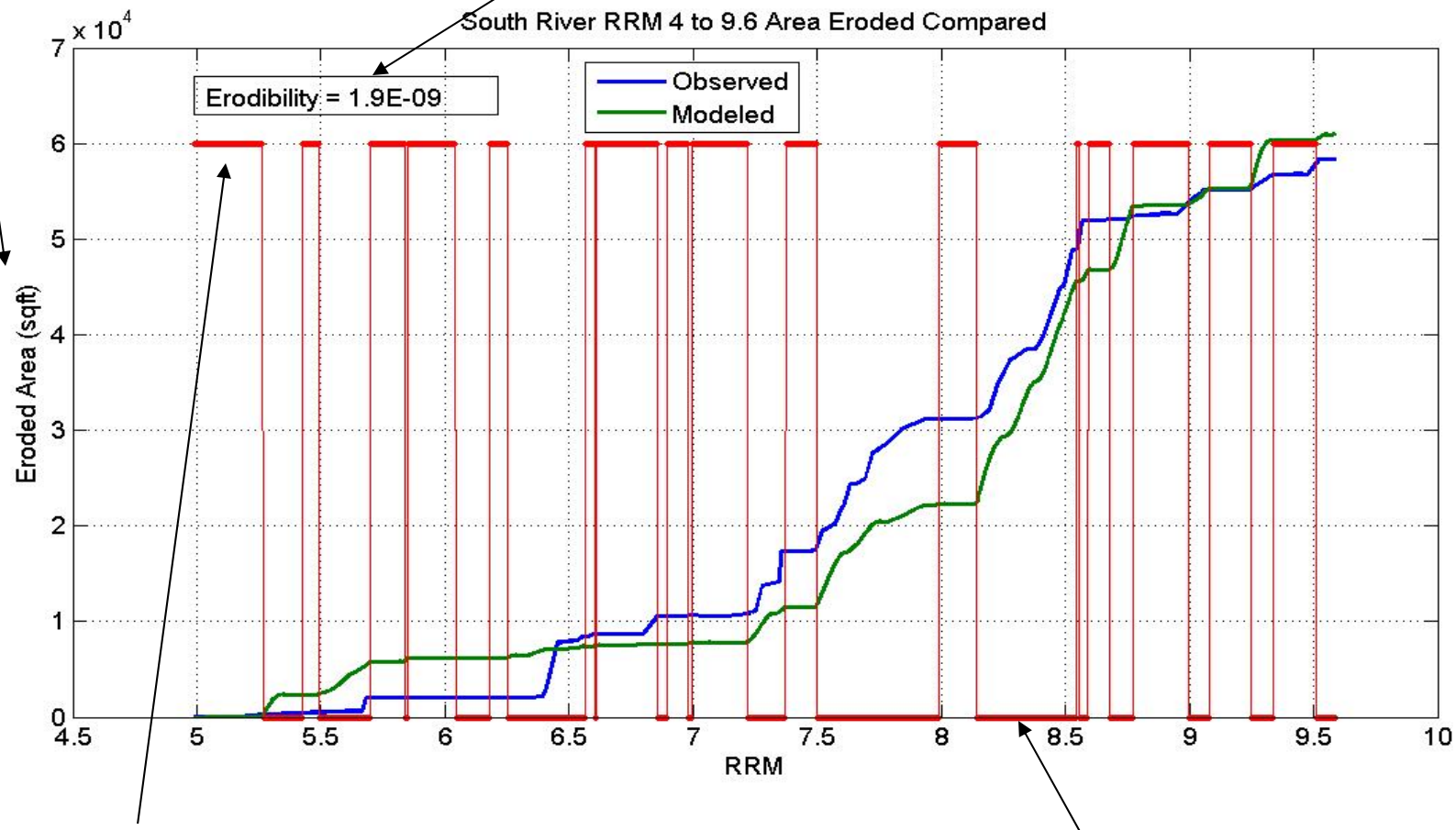
- Proportional to “excess” velocity….
- Proportionality constant
  - Varies with material
  - Determined by calibration with observed long-term erosion rates from aerial photos.

Results

- Some examples for selected reaches defined by bridge crossings

Cumulative area removed by bank erosion, ‘37-’05

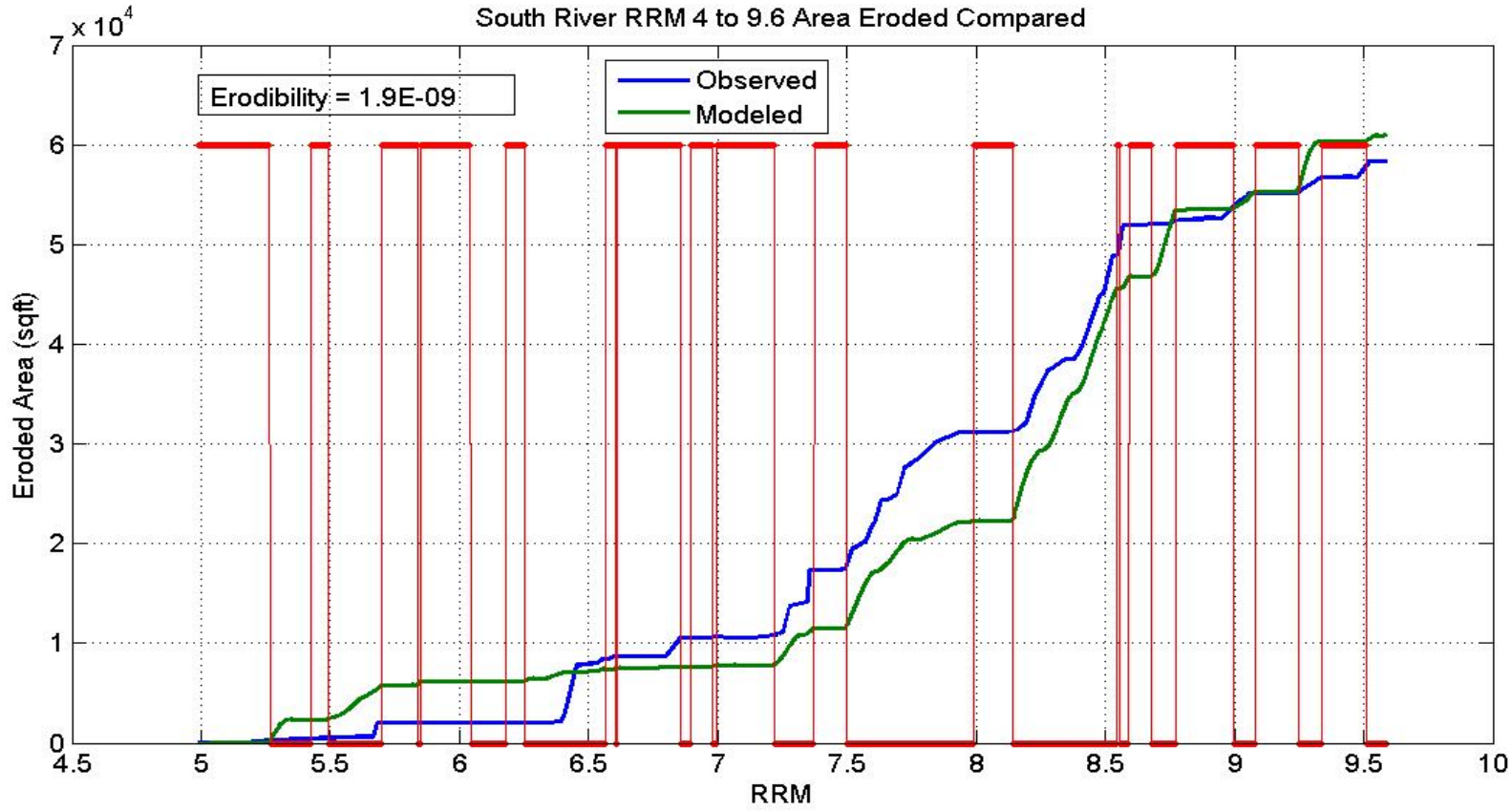
Constant erodibility coefficient represents rate of erosion by “constant” steady bankfull discharge



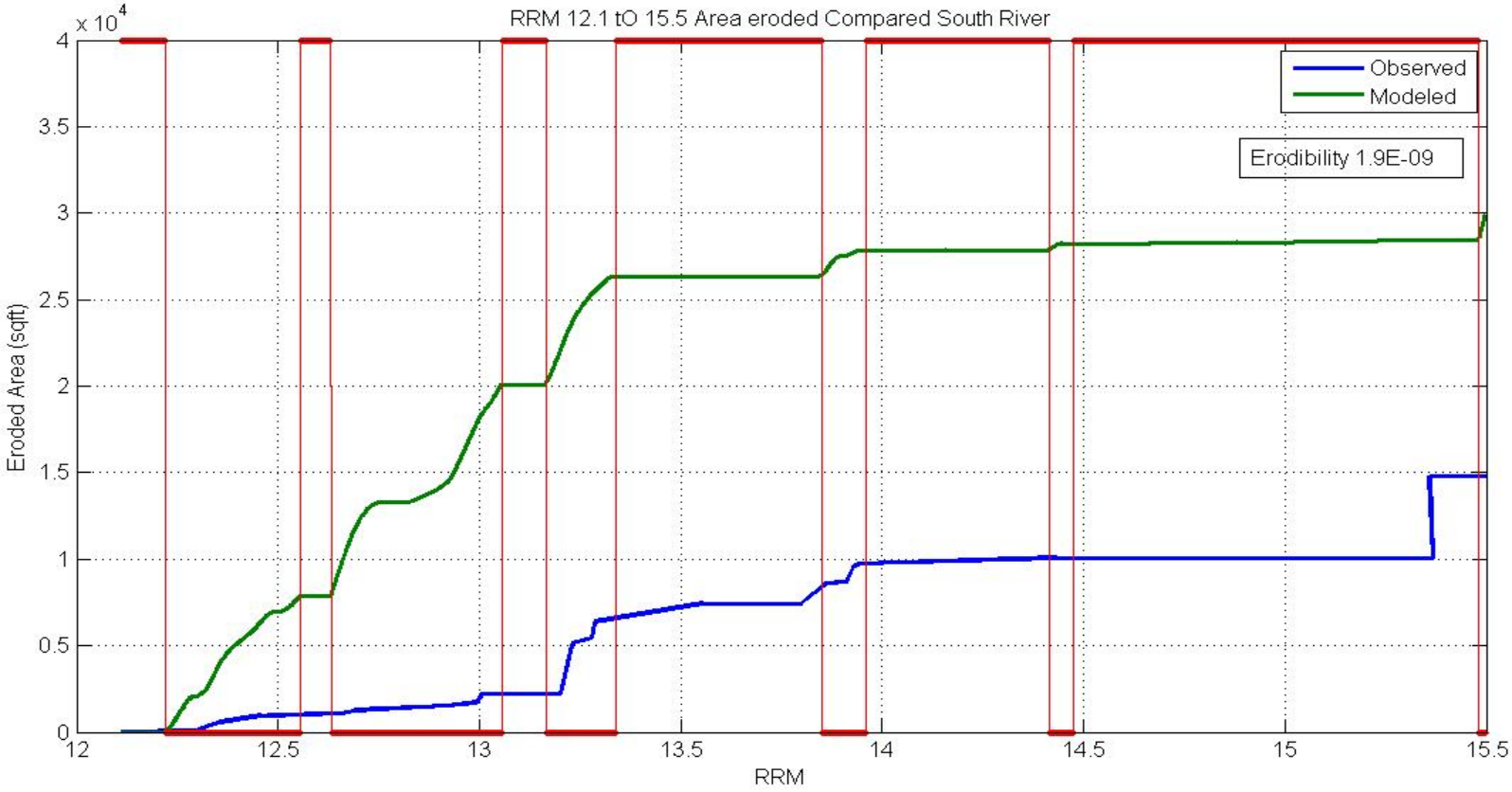
“High” red lines indicate where bedrock is exposed and hence erosion is assumed to be 0

Areas where bedrock is NOT exposed

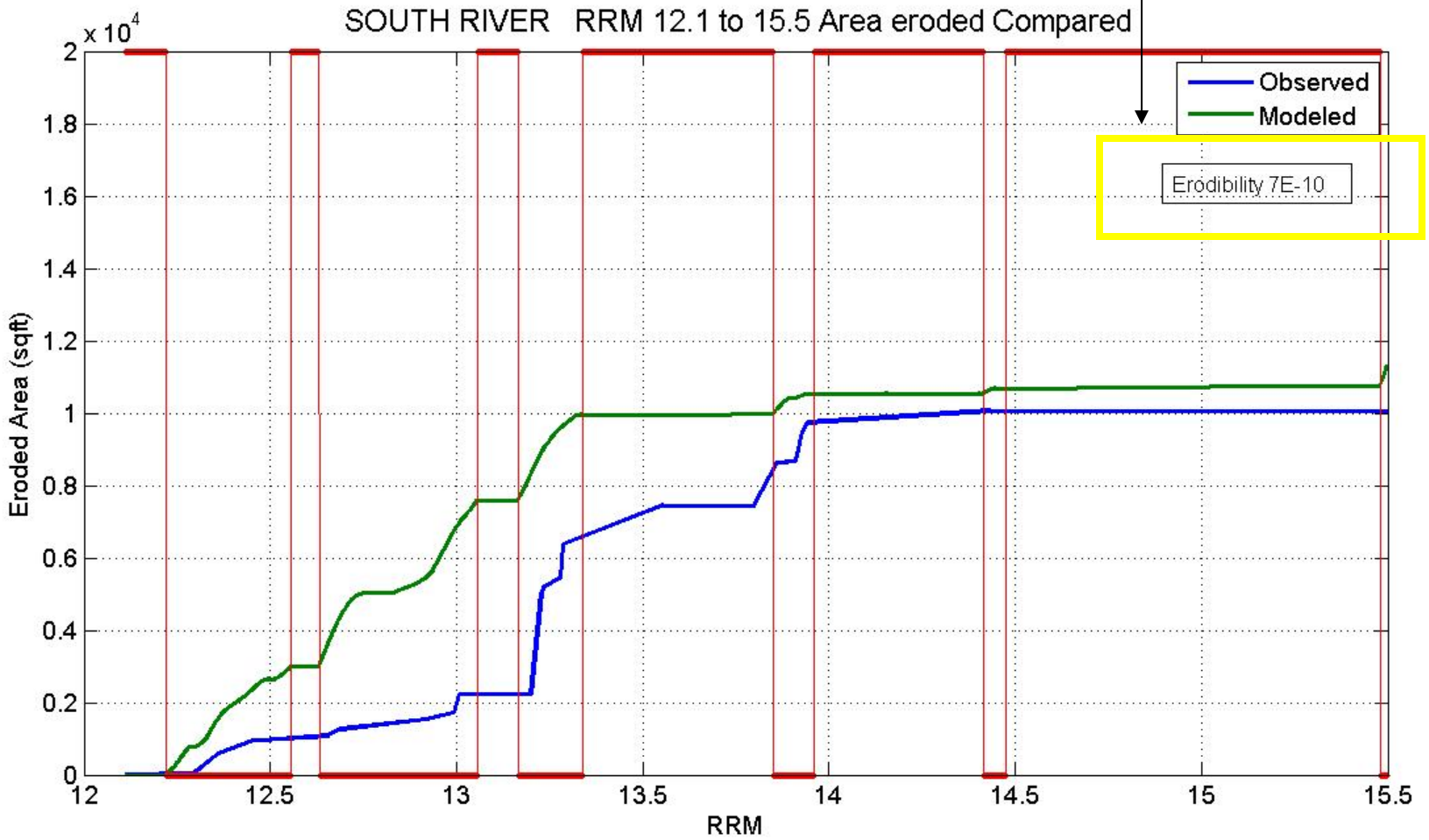
Comments – The model predictions fit observations GREAT in this reach!



RRM 12.75-15.5 – The same erodibility coefficient gives poor results……

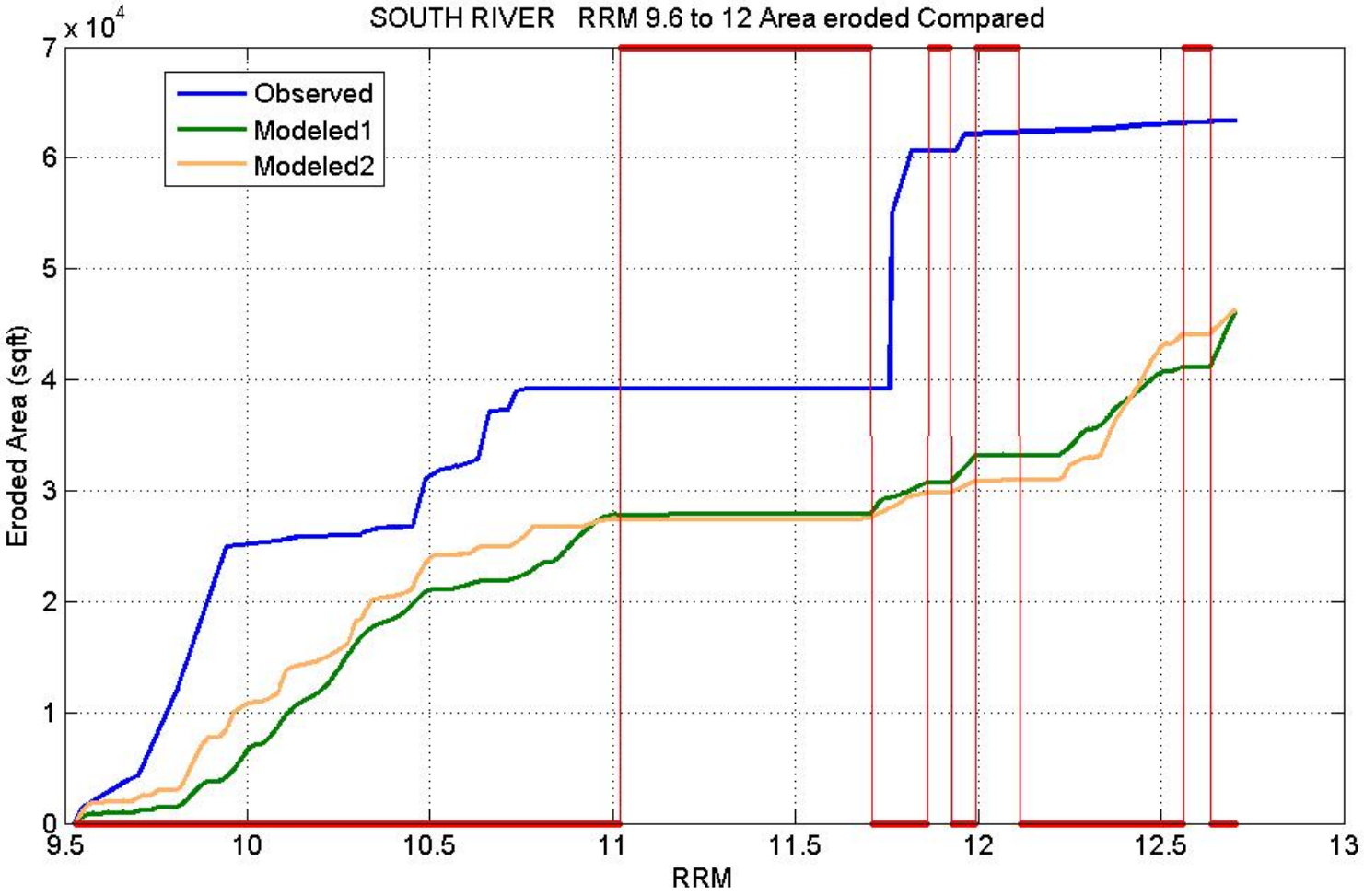


Try a lower erodibility….



Or, use a different erodibilility values values for alluvium, and terraces and alluvial fans….

Model #1 Composite Erodibility 1.9E-09
Model #2 Alluvium Erodibility 3.8E-09
& Terrace/ Fan 8.0E-10



Future developments…

- Finalize model calibration
- Combine with bank mercury database to estimate detailed spatial patterns of mercury loading
- Account for ~ annual variations in discharge…
  - Lidar data document large changes in observed rates depending on occurrence of high flows in a year

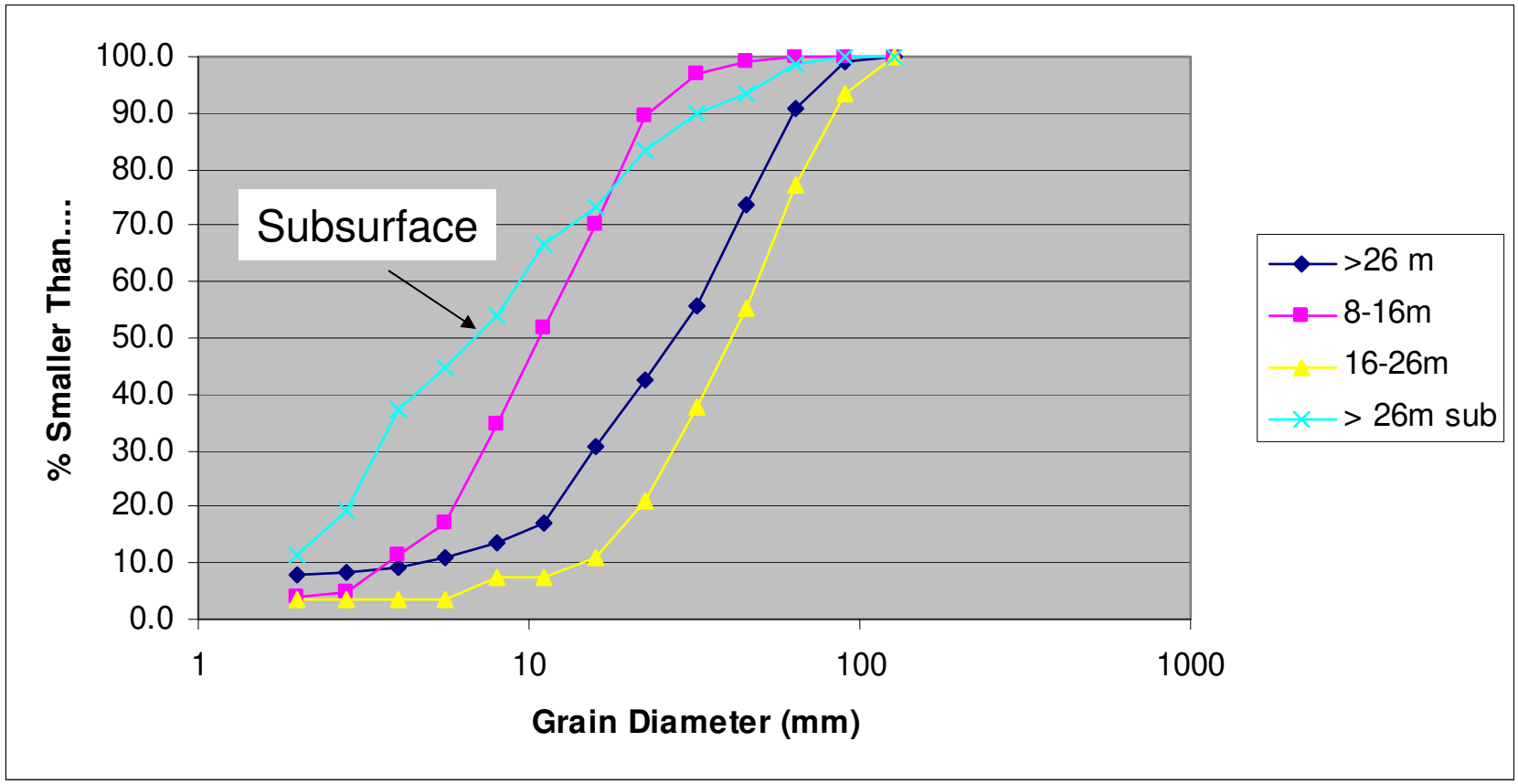
Residence Times of Silt/Clay in Gravel River Beds – RRM 3

- Coring
- Dating silt/clay using radioisotopes
- Frequency of reworking through scour and fill
  - Scour monitoring
  - Model computations
    - Mostly uncalibrated

Scour chains monitor extent of scour…..

Bed Material Size Distribution *along the scour chain transect*

Surface and Subsurface Grain Size Distributions



The subsurface sediment is much finer that the surface sediment!!

Pre-Project Monitoring – Bank Stabilization Pilot Study Site

- Surveyed channel morphology and sediment type through the reach
- Monitor ongoing bank erosion
  - Lidar
  - Bank erosion pins
- Decadal erosion rates from dendrochronology

Questions??