



South River Phase 1 Interim Measures: Refinement of Bank Management Areas

March 19, 2014

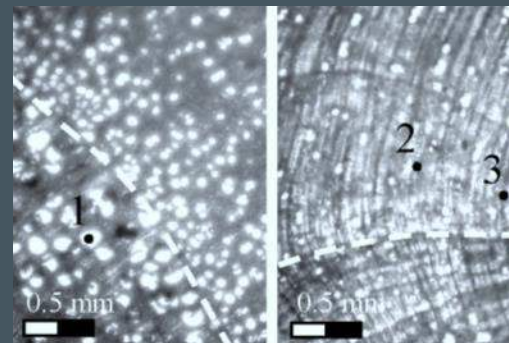
Agenda

- Bank erosion rates from exposed tree roots
- Hydrodynamic modeling
- Bank erosion rate regression relationships
- RRM 0-2 bank mercury loading rates
- Preliminary RRM 0-2 bank management areas (BMAs)

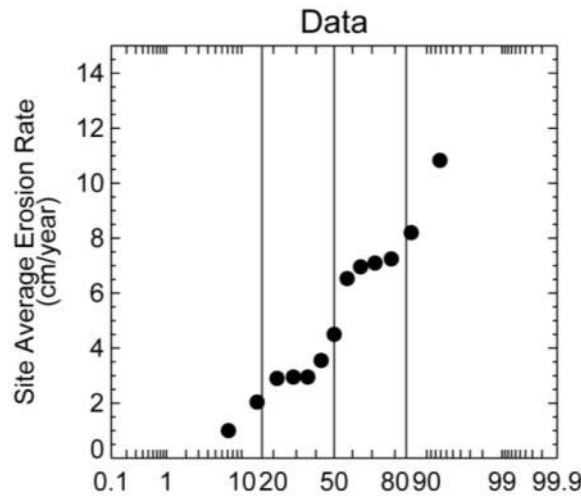


Bank Erosion Rates: Exposed Tree Roots

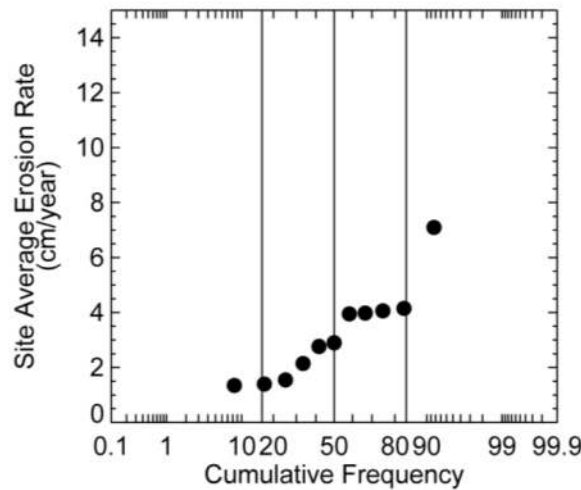
- 2013 Stephanie Stotts University of Delaware Doctor of Philosophy dissertation
- 24 riparian root stations sampled in RRM 2-10
 - Evaluated anatomical changes in riparian tree roots exposed by bank erosion
 - Accurate and precise estimates of contemporary bank erosion rates (years to decades)



Left Bank



Right Bank



Note: Left and right banks oriented looking downstream

Bank Erosion Rate Data: RRM 2-10

- Range of measured erosion rates
- Higher erosion rates (> 3 cm/ year) corroborated with independent photogrammetric techniques

Hydrodynamic Modeling Objectives

- Refine BMA identification
 - Estimate peak velocities and shear stresses during high flow events
 - Support regression analyses of measured bank erosion rates at RRM 2-10 exposed tree roots
 - Extrapolate erosion rates to RRM 0-2
- Support follow-on bank stabilization design

Hydrodynamic Model Framework

- Model developed using Environmental Fluid Dynamics Code (EFDC), a widely accepted hydrodynamic modeling system
 - Computational fluid dynamics
 - Approved and supported by USEPA
 - Frequently used to support sediment cleanup evaluations and designs in rivers, estuaries and coasts
- Simulates flow in up to three dimensions
 - Two-dimensional model used for South River

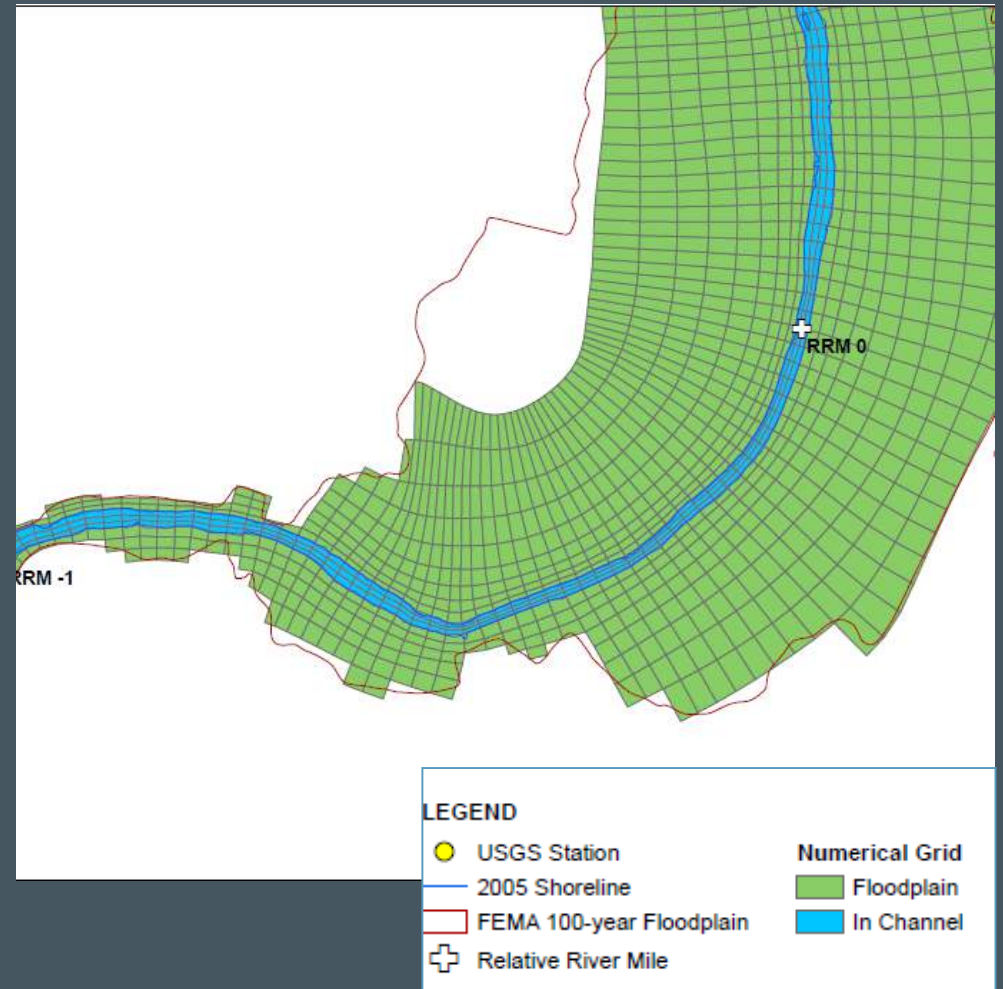
Hydrodynamic Model Domain

- Covers 18.5 miles of the South River
 - From Waynesboro (RRM -2)
 - To Harriston (RRM 16.5)
- Laterally extended to the FEMA 100-year flood contour



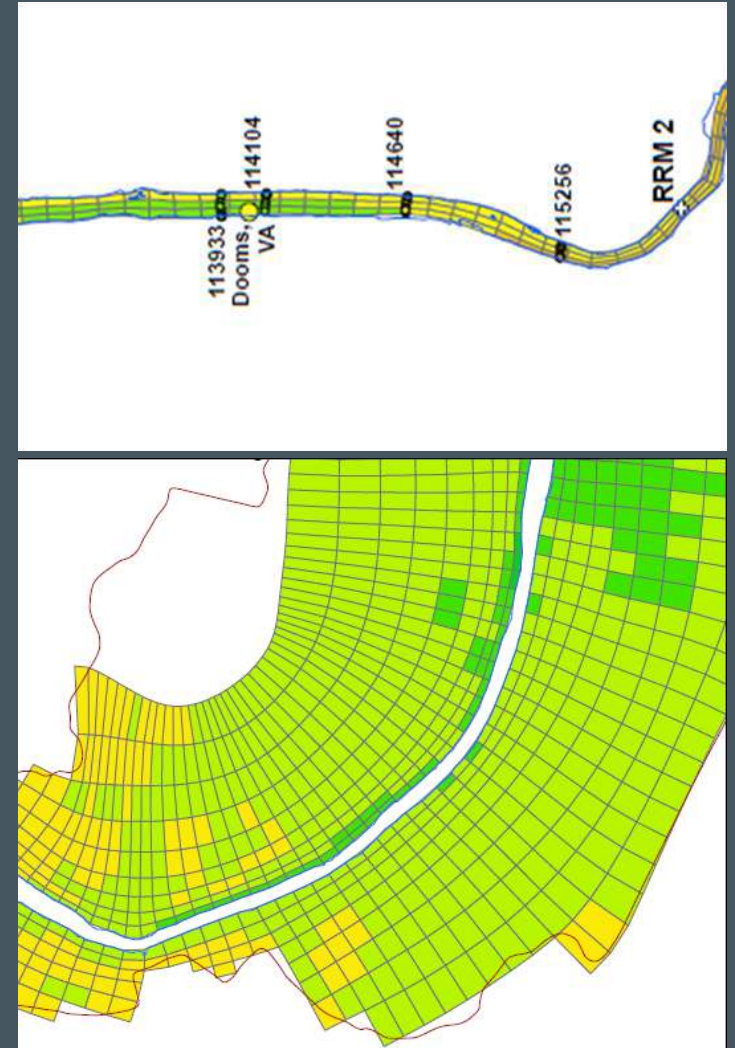
Hydrodynamic Model Grid

- Defined channel boundary with 2005 shoreline
- In-channel grid
 - 3-cells across
 - Average length: 100 ft
 - Average width: 30 ft
- 13,300 cells total
 - Includes floodplain and channel

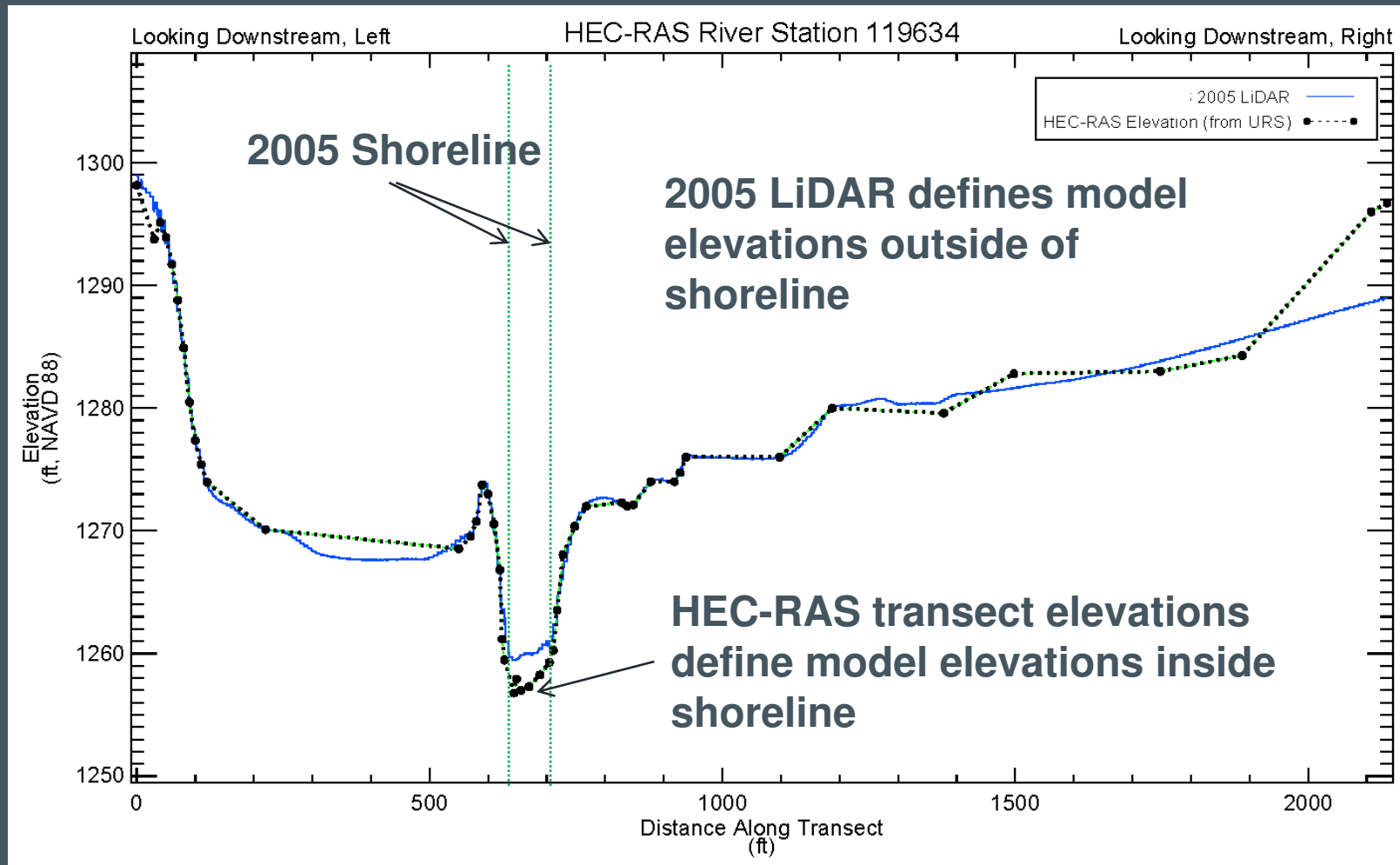


Model Bathymetry and Topography

- Bank and floodplain elevations defined with extensive 2005 LiDAR data
- Channel bed elevations defined with HEC-RAS cross-sections
 - Interpolated bed elevations between cross-sections
 - Cross-checked interpolation with published channel elevation profiles



Example Elevation Cross Section



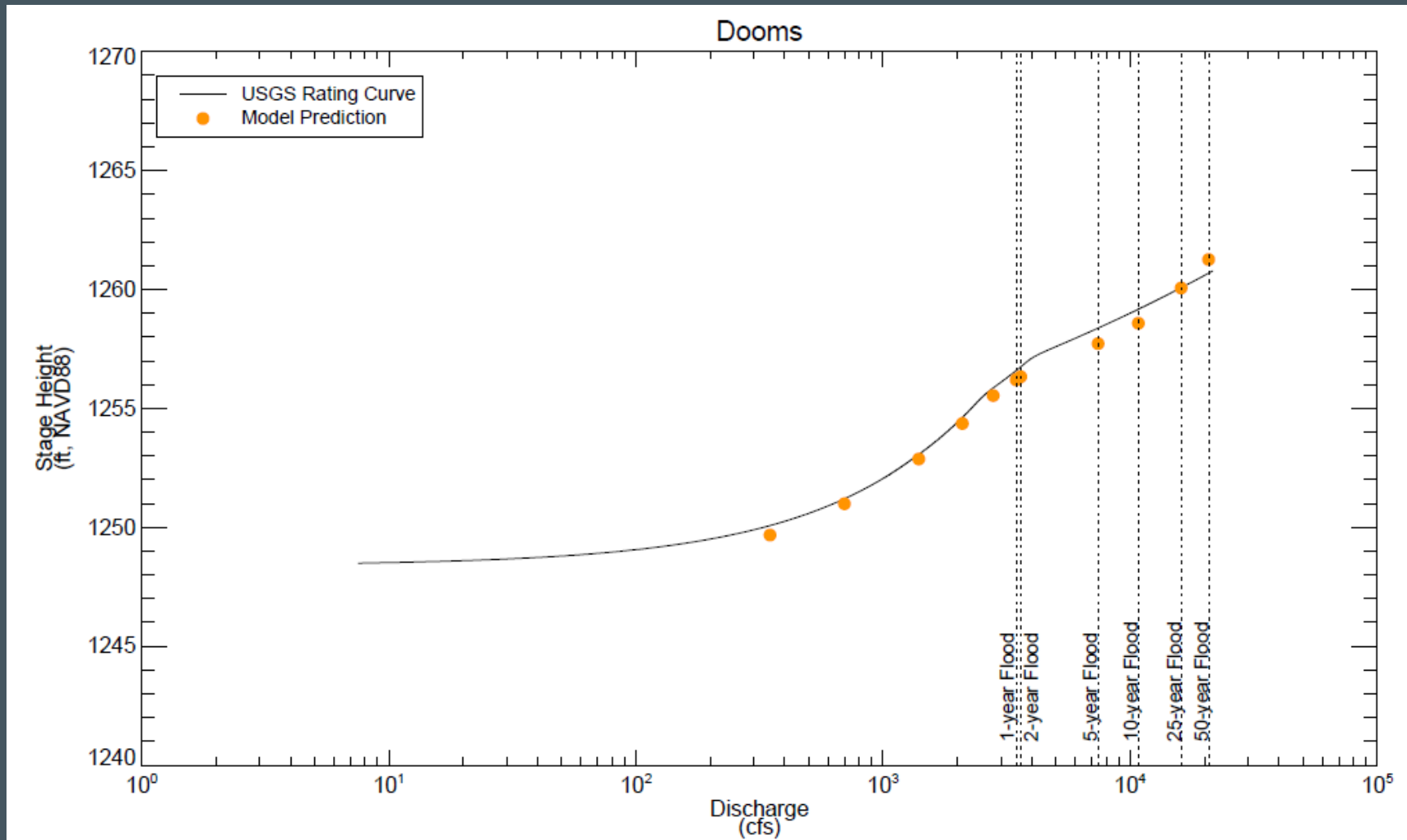
Model Flow and Stage Inputs

- Upstream flow inputs from the USGS gage at Waynesboro
- Tributary in-flows
 - Grouped into 7 major tributaries
 - Estimated inflow rates using drainage area proportions
- Downstream water surface elevations from USGS rating curve for the Harriston gage

Model Calibration & Validation

- Model calibrated to USGS stage height rating curves for the Doods and Waynesboro gages
 - Calibration based on a series of steady state flow simulations for medium and high-flow events
 - Adjustable parameter: effective bed roughness in the channel and floodplain
- Model validated by simulating the Nov. 2013–Feb. 2014 hydrograph
 - Compared modeled and actual water surface elevations at the Waynesboro and Doods gages during validation period

Model Calibration at Dooms

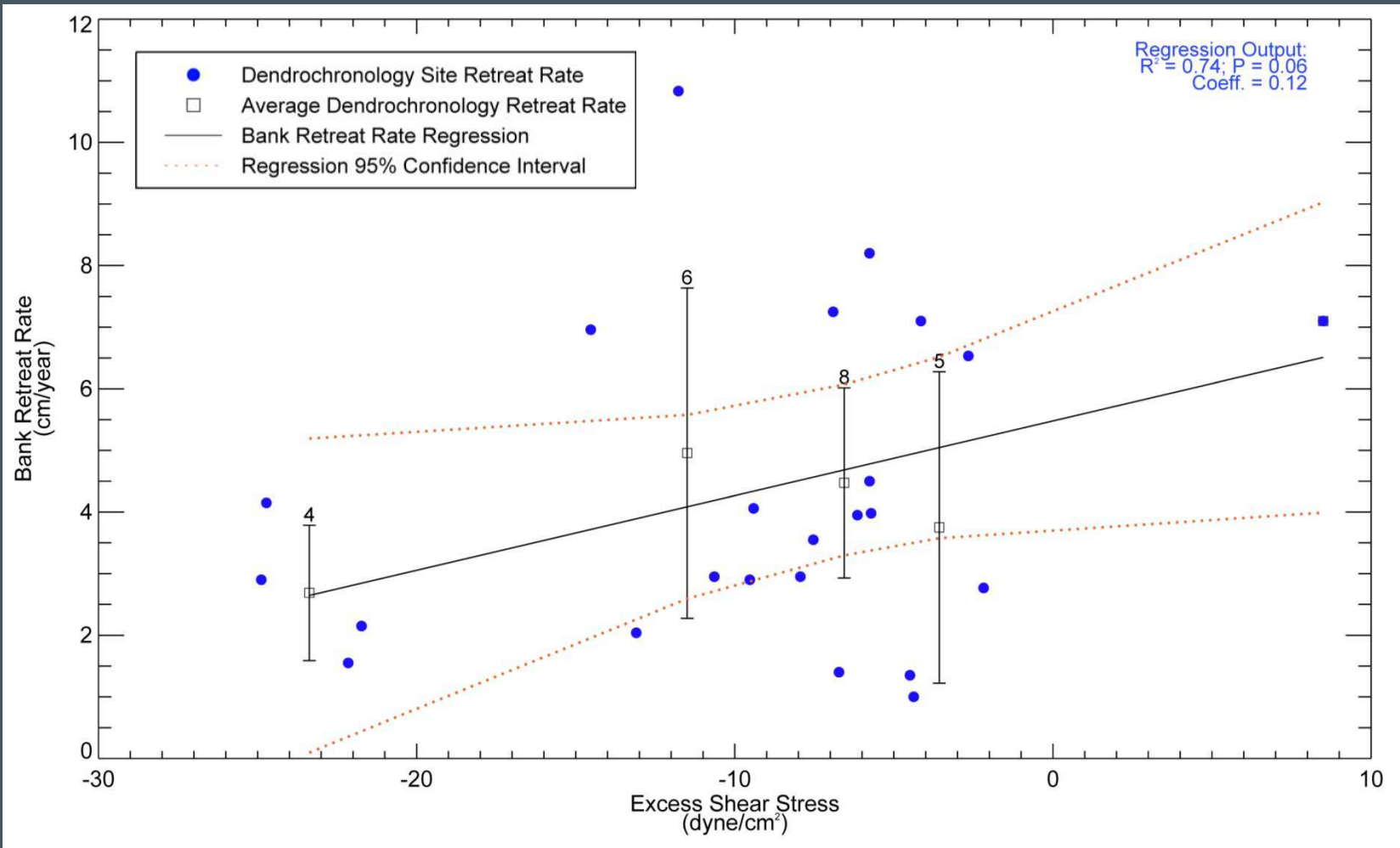


Bank Erosion Rate Regressions

- Regression parameters:
 - Bank full velocity (~2-yr flow)
 - Excess bank shear stress
 - Bank shear stress minus cross channel average
 - Bank height and angle
- Bank erosion sediment loads correlated with excess bank shear stress and bank height
- Ongoing refinements
 - Univ. Delaware LiDAR surveys (addl. erosion rates)
 - Supplemental root density / root depth surveys

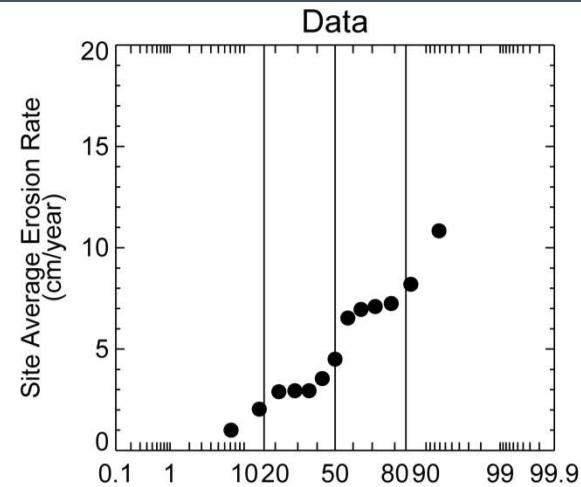
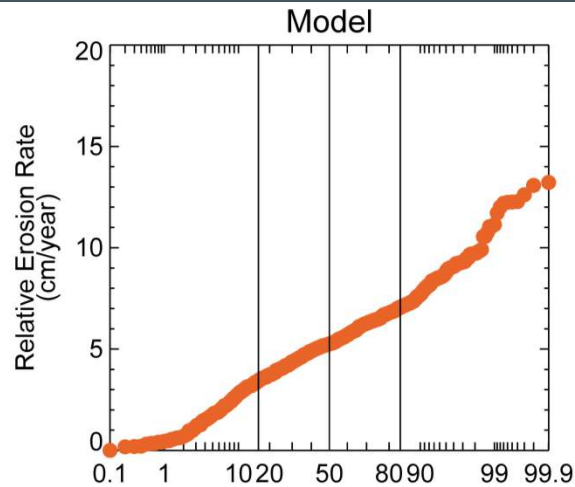


Excess Shear Stress vs. Bank Erosion Rate Regression Relationship

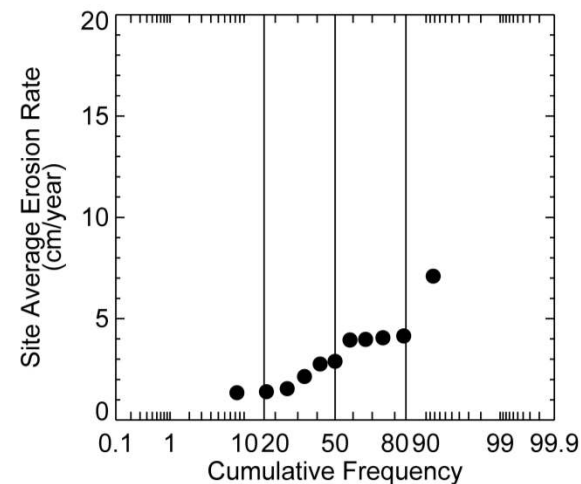
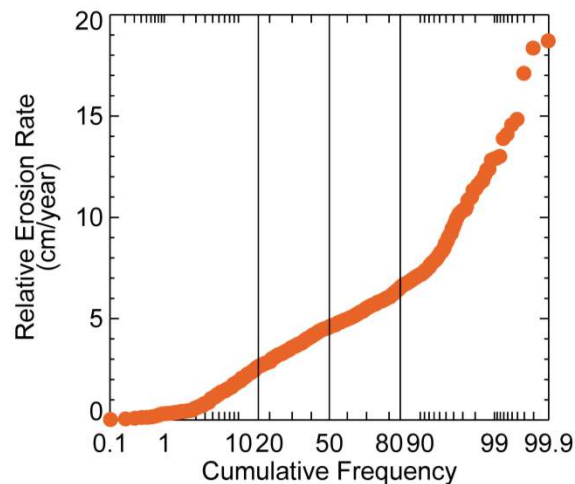


Bank Erosion Regression Model vs. Data

Left Bank

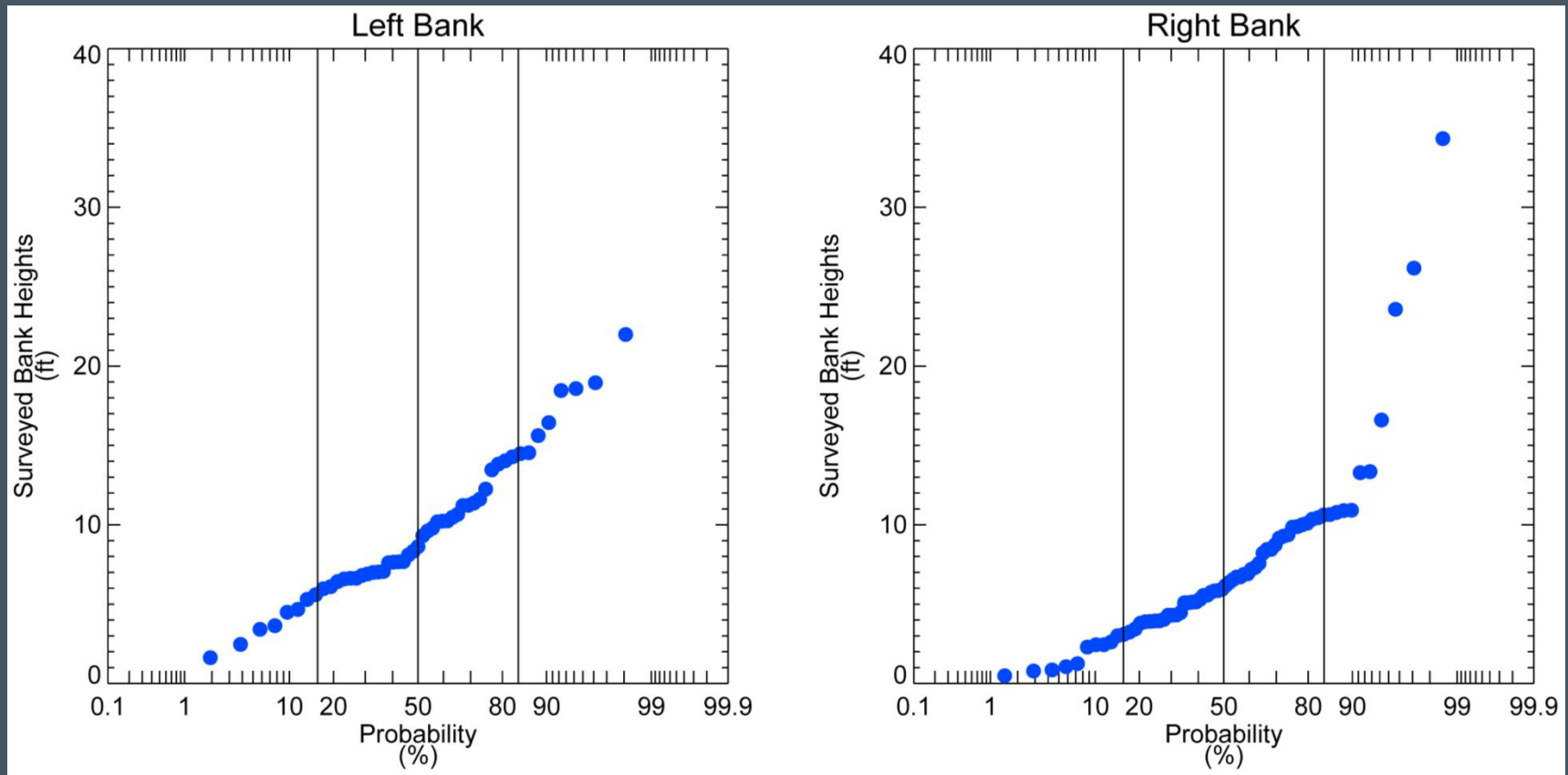


Right Bank



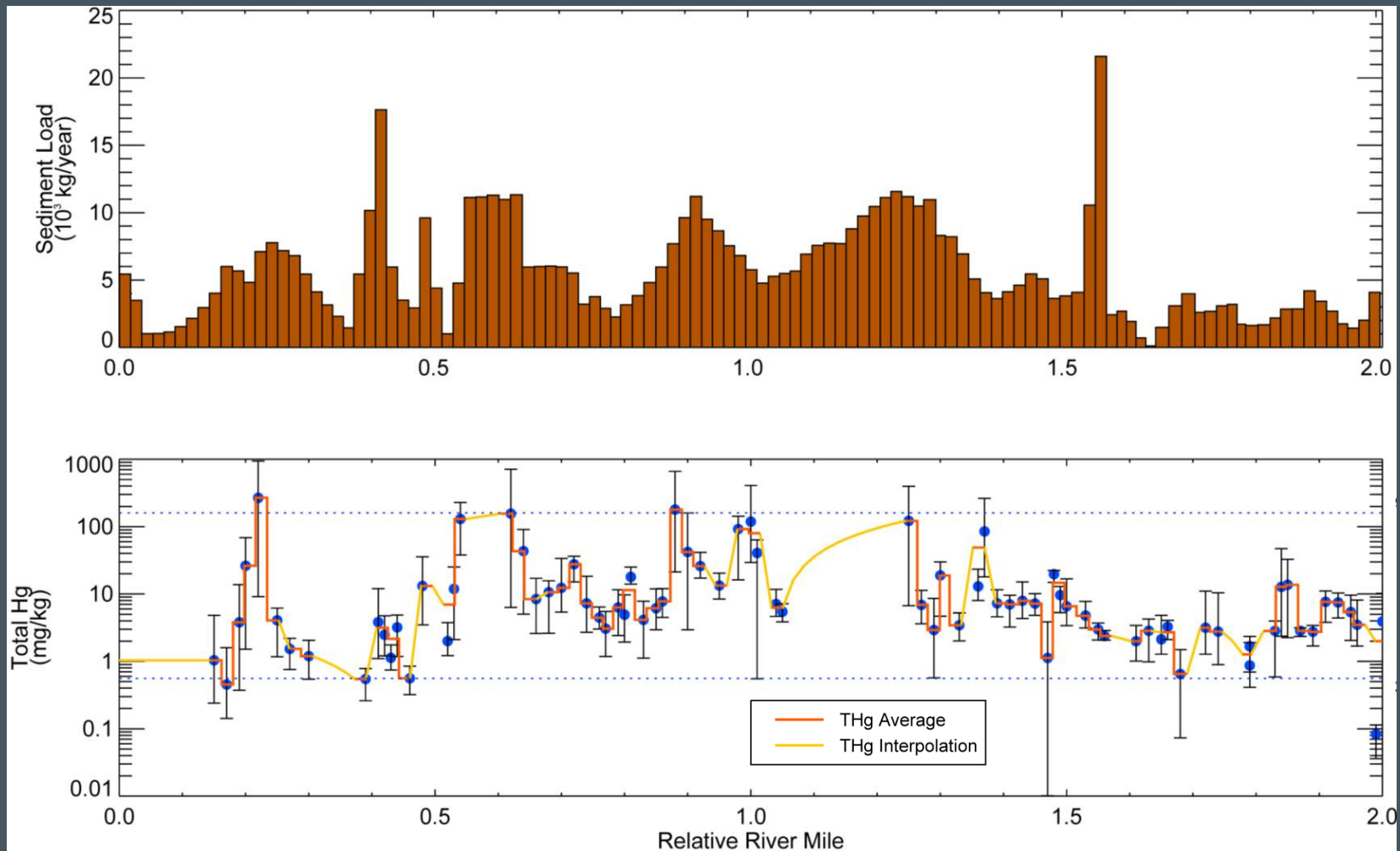
Note: Left and right banks oriented looking downstream

Wide Range of Bank Heights

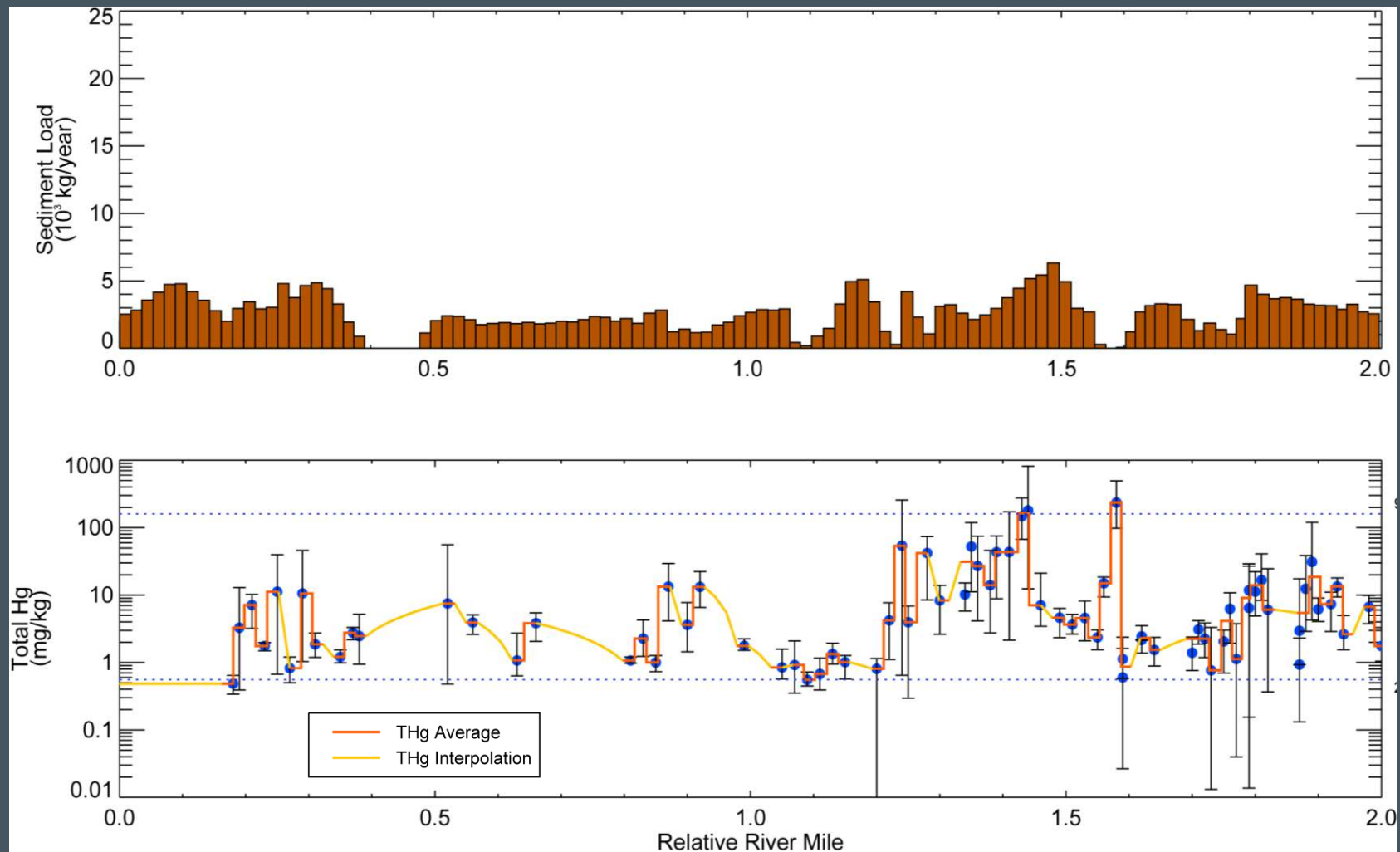


Note: Left and right banks oriented looking downstream

Left Bank Sediment Loading and Total Hg



Right Bank Sediment Loading and Total Hg



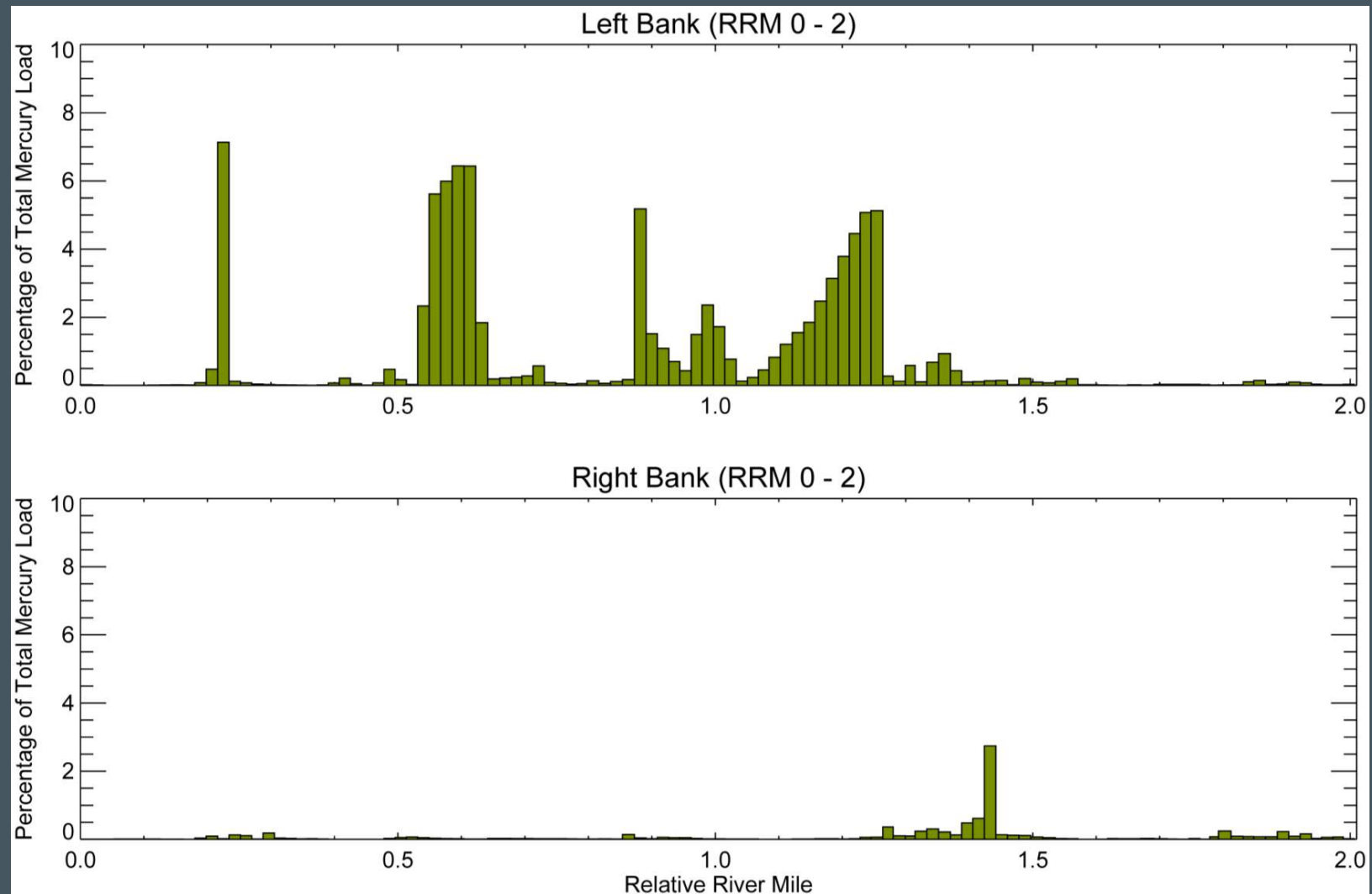
Calculated RRM 0-2 Bank Mercury Loading

- Key parameters for loading estimates:
 - Excess shear stress (modeled)
 - Bank height (measured)
 - Mercury concentration (measured and interpolated)
- Ongoing refinements
 - High resolution LiDAR surveys
 - Additional contemporary erosion rates
 - Supplemental root density / root depth surveys
 - Supplemental bank mercury concentration sampling

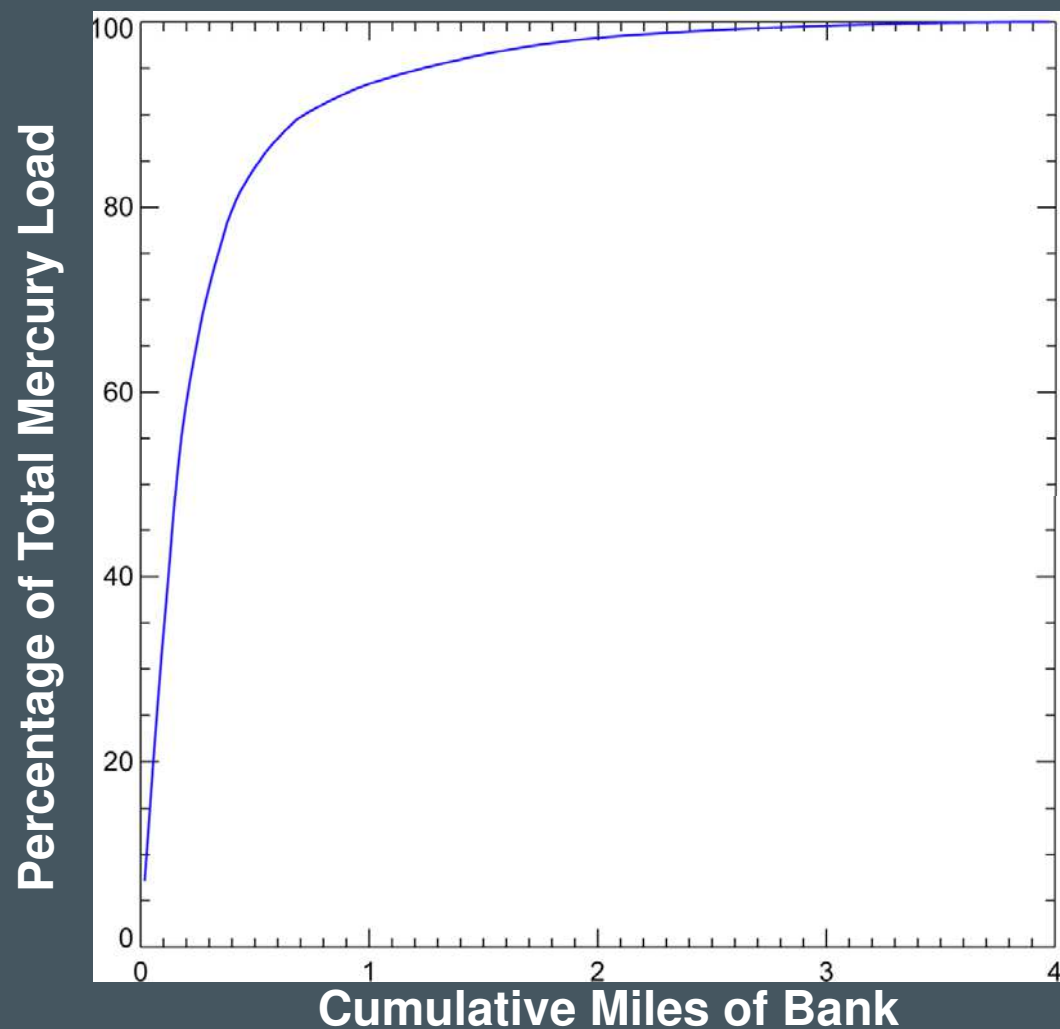
High Resolution LiDAR Surveys



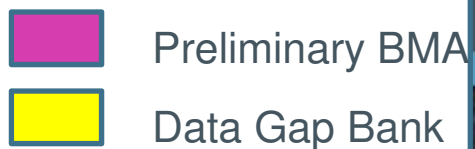
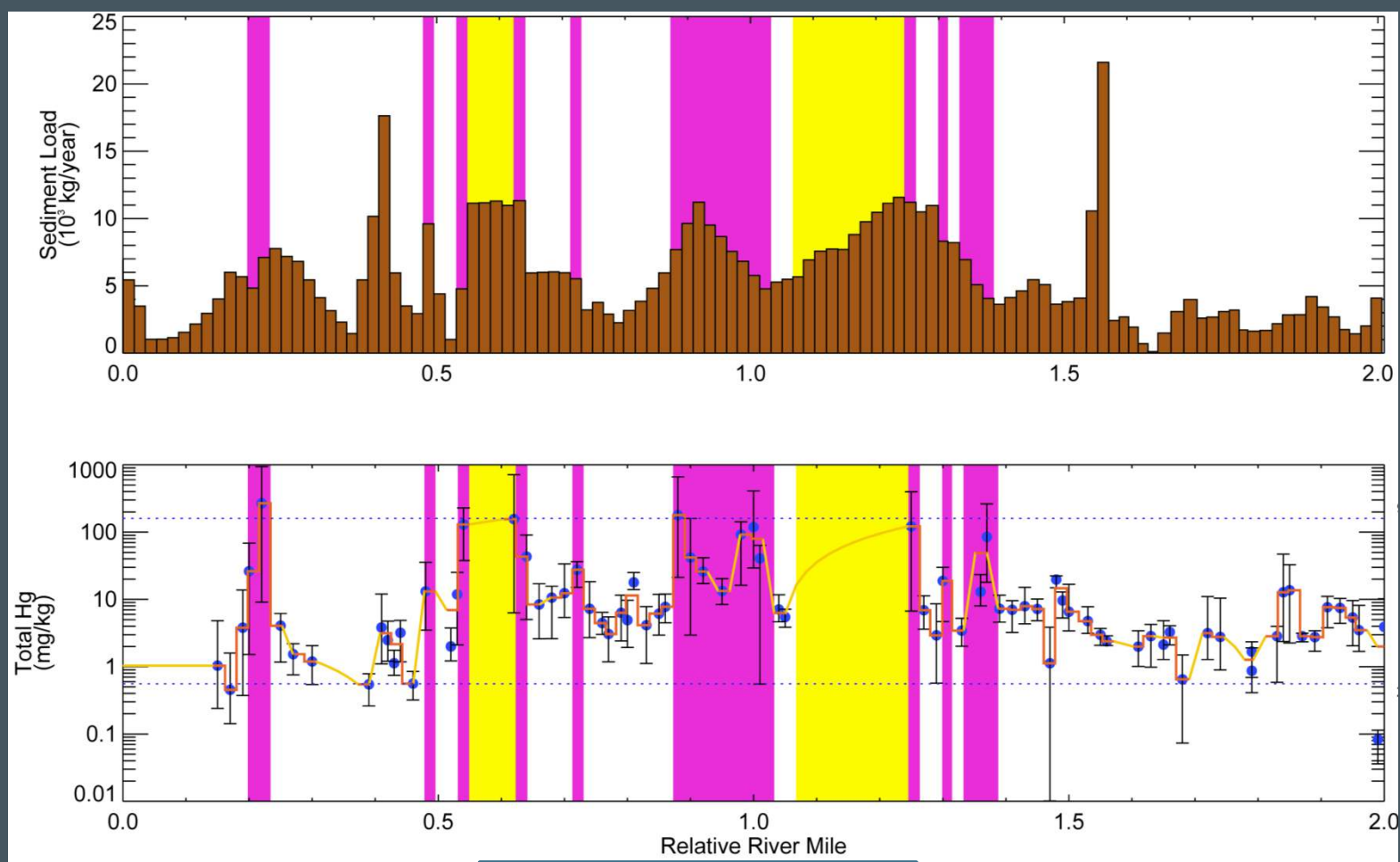
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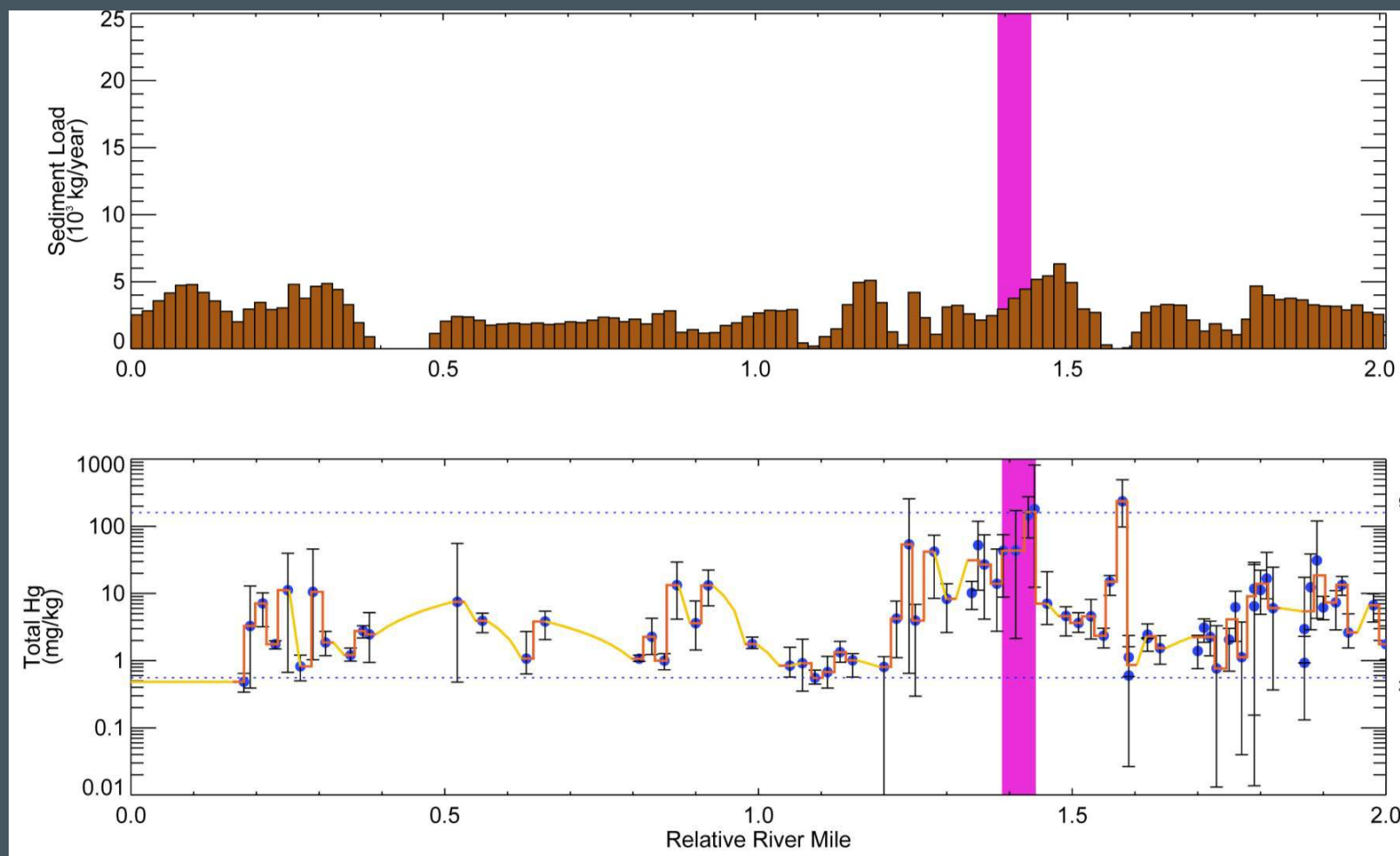
Preliminary Analysis of Cumulative Bank Mercury Loading: RRM 0-2



RRM 0-2 Left Bank Preliminary BMAs and Data Gap Banks



RRM 0-2 Right Bank Preliminary BMA



Preliminary BMA

Schedule / Path Forward

- March/ April –data gap sampling to refine BMAs
 - Supplemental bank Hg, LiDAR and other surveys
- June –draft Interim Measures Work Plan
- Summer/ fall –Interim measures design and permitting
 - Potentially continuing into mid-2015