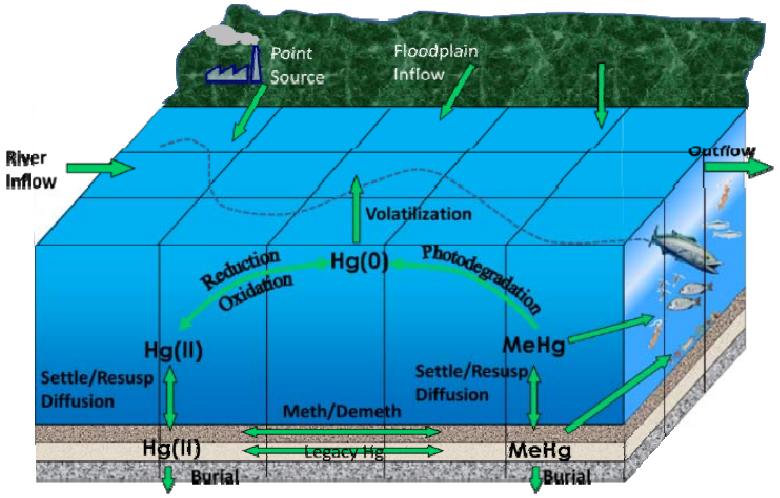
Mechanistic Mercury Modeling in the South River Project Update

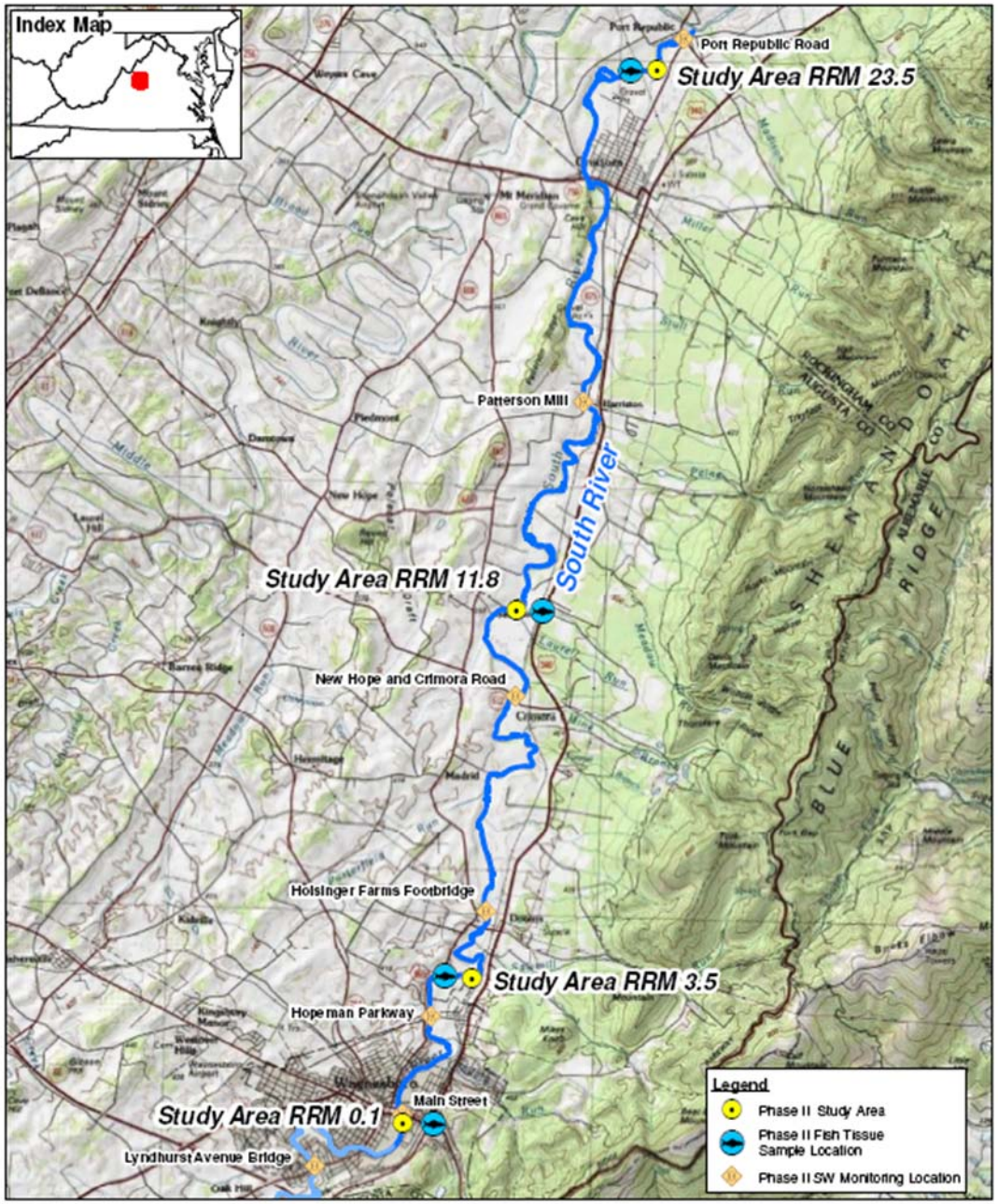


Reed Harris and David Hutchinson
RHE Ltd.

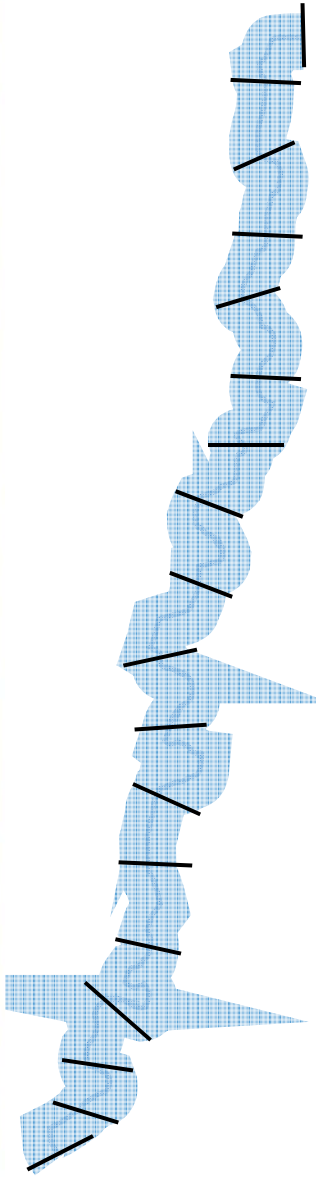
October 19, 2016

Topics

- Solids fluxes
- Model calibration update
- Some scenario results



Model Grid



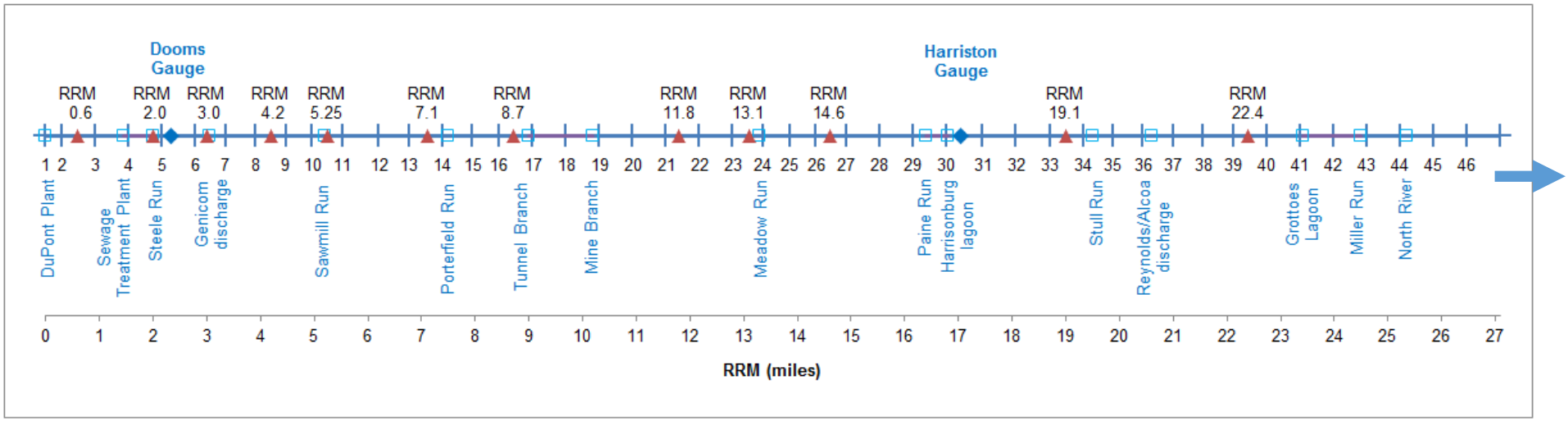
Represent river as a set of connected well-mixed cells

RM 0-27

Floodplain is a boundary, not modeled with D-MCM

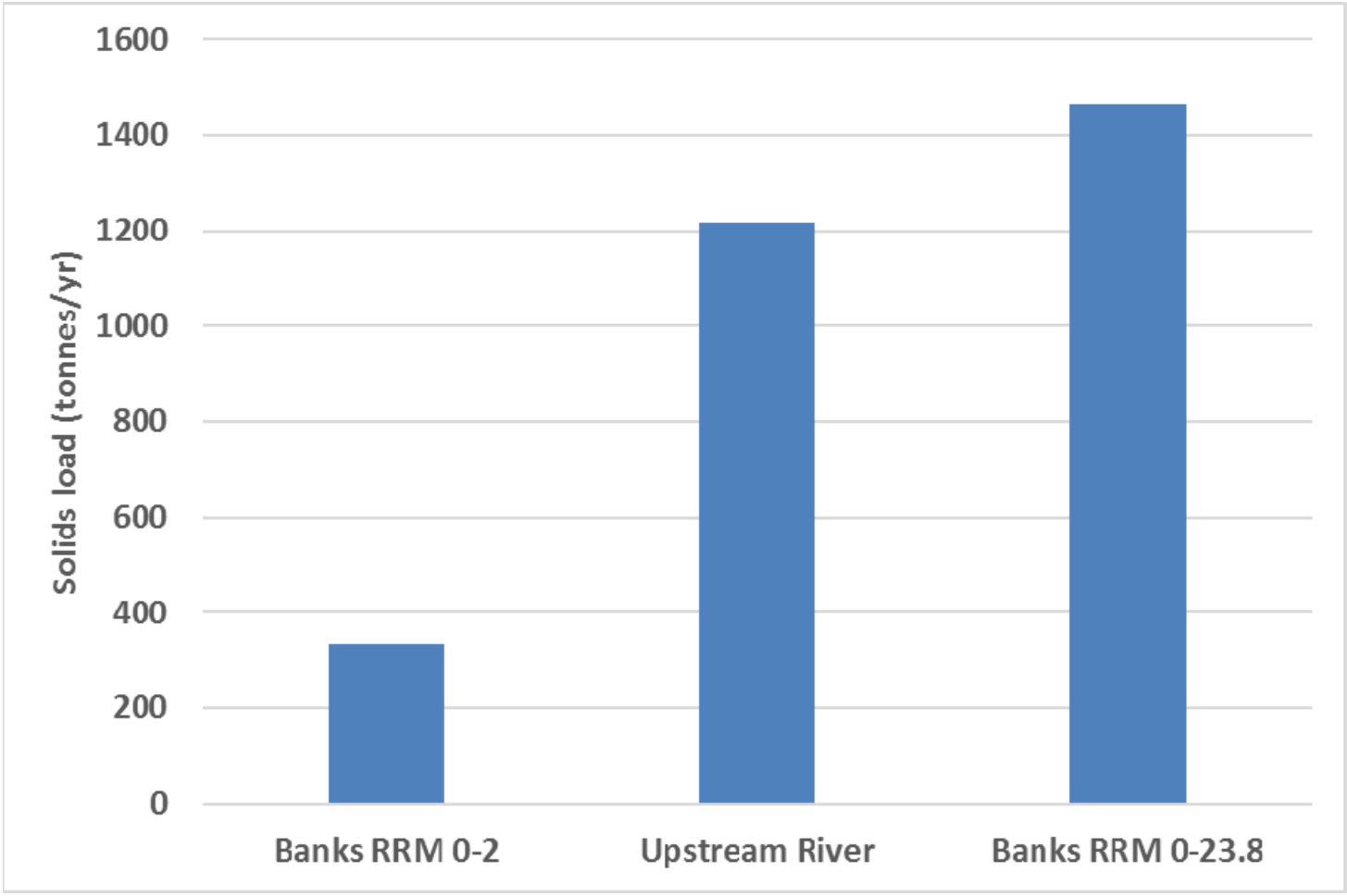
Model Grid

- 46 cells, each roughly 1 km long
- Simulation spans RRM 0 to ~RRM 27
- Water inputs increase flow along river



Solids loads to South River

Bank erosion used in model for RRM 0-2 is small compared to solids inputs from upstream, but comparable if we look at RRM 0-23.8

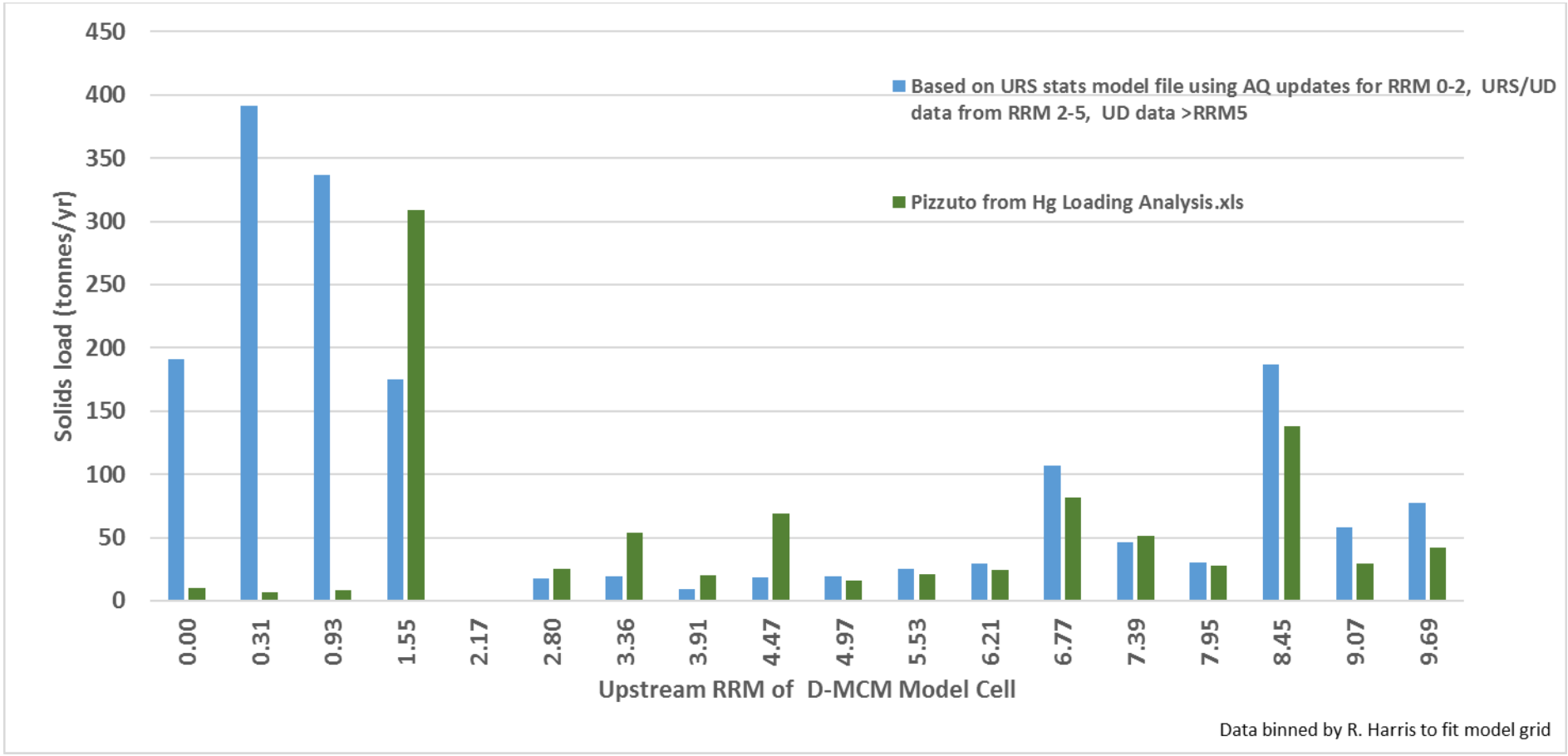


Bank loads from Pizzuto et al. (Hg loading analysis – rch, Bank Erosion Loading tab, col AH)

Upstream inputs are based on flow-TSS relationship. This estimate and the above graph are from “Sediiment Discharge RRM -2.8 to 0.3 rch.xlsx”

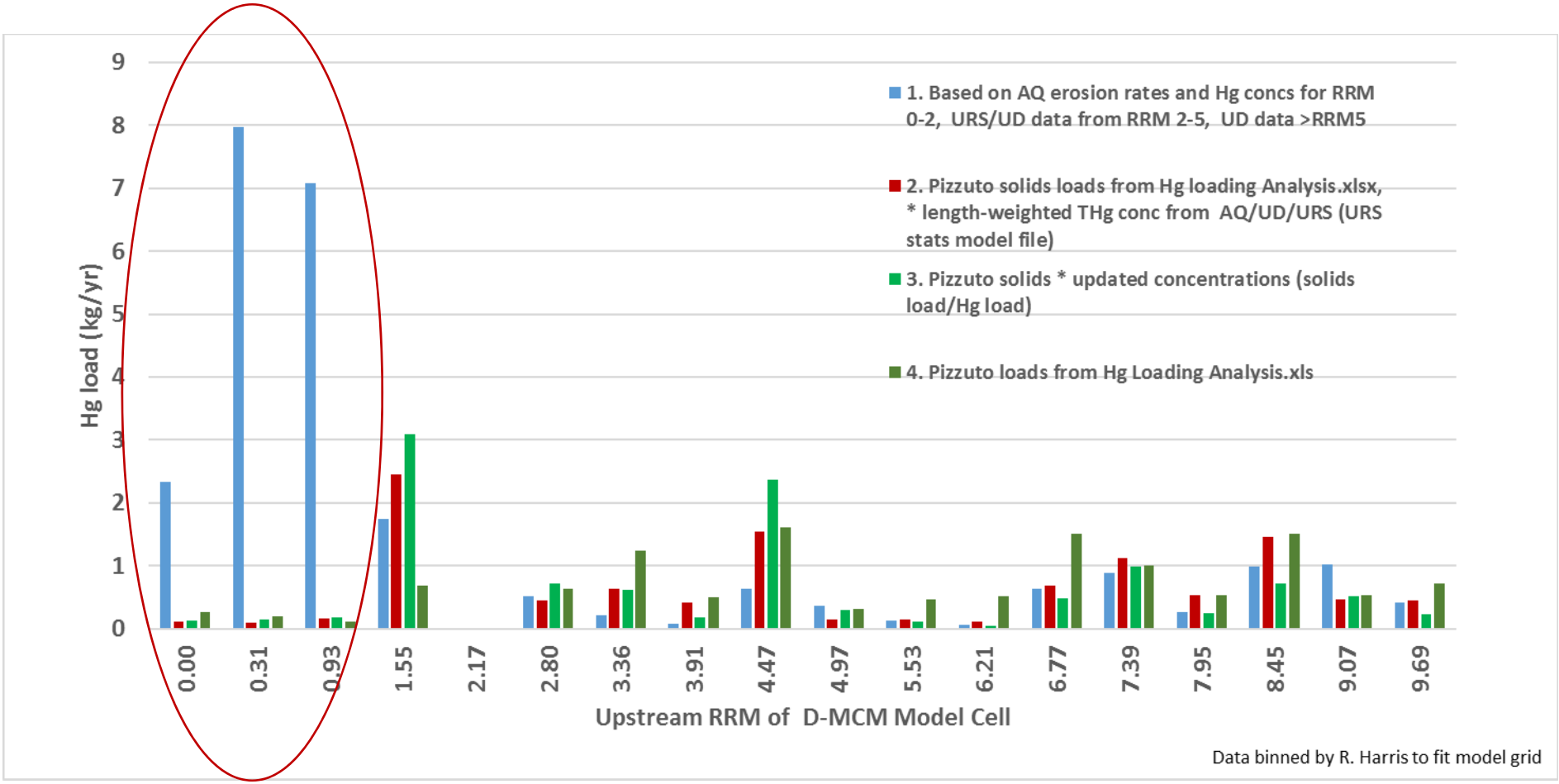
Based on Pizzuto numbers, most of the bank erosion in the first two miles is between RRM 1.55-2.17.

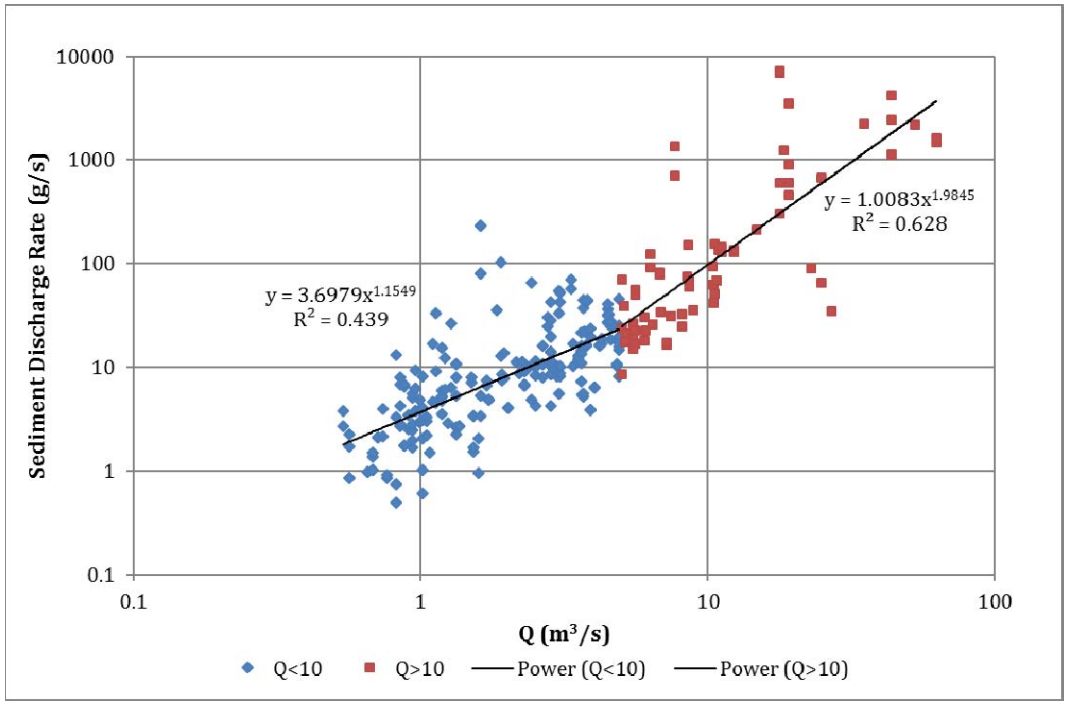
If we used the Anchor/QEA solids load estimates, the first two miles would load ~1100 tonnes/yr of solids, comparable with the estimated inputs from upstream (~1200 tonnes/yr)



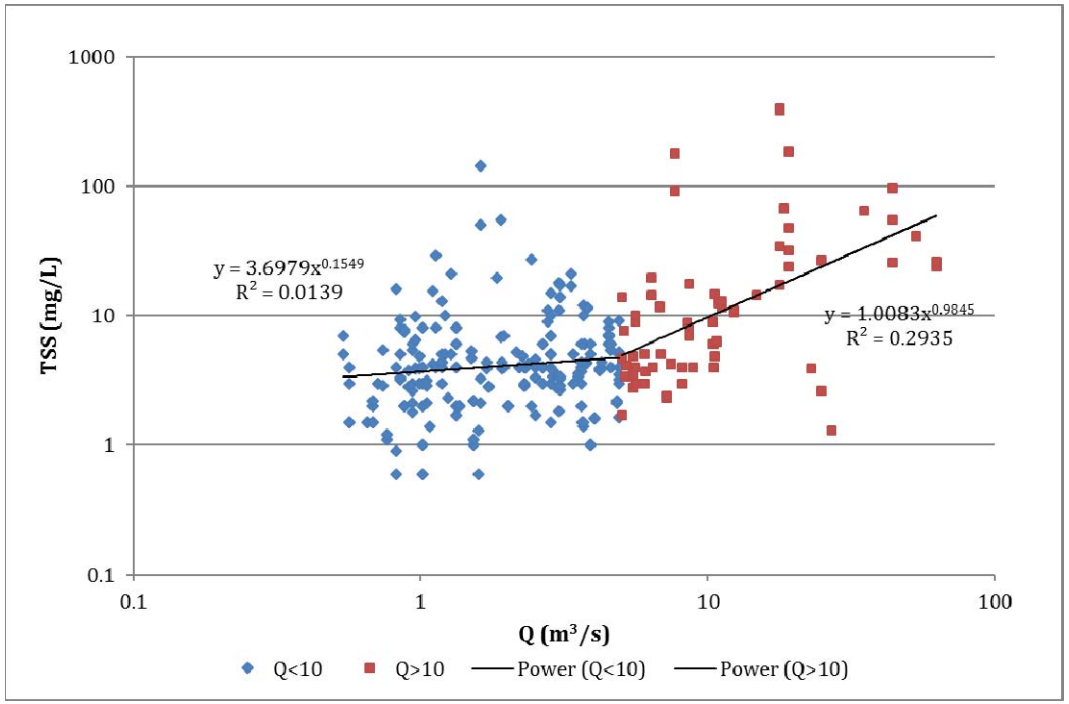
Estimated Hg bank erosion loads using different combinations of solids loads and Hg concentrations….

- Wide range for first few miles….





Solids load vs flow (upper panel), and TSS vs flow, (lower panel) for RRM minus 2.8 to 0 from 1999-2014 (n=312)



There is a lot of variability in TSS at a given flow.

RRM	Date	Q_RRM	Q cms	TSS_MGL
-2.7	2006-09-02	630	17.8396	17.26
-2.7	2006-09-02	630	17.8396	34.05
-2.7	2006-09-02	630	17.8396	384.1

Pizzuto estimates of solids fluxes at Waynesboro are much bigger than what was used in the model for 2006-2014 (~1200 tonnes/yr)..

Why?

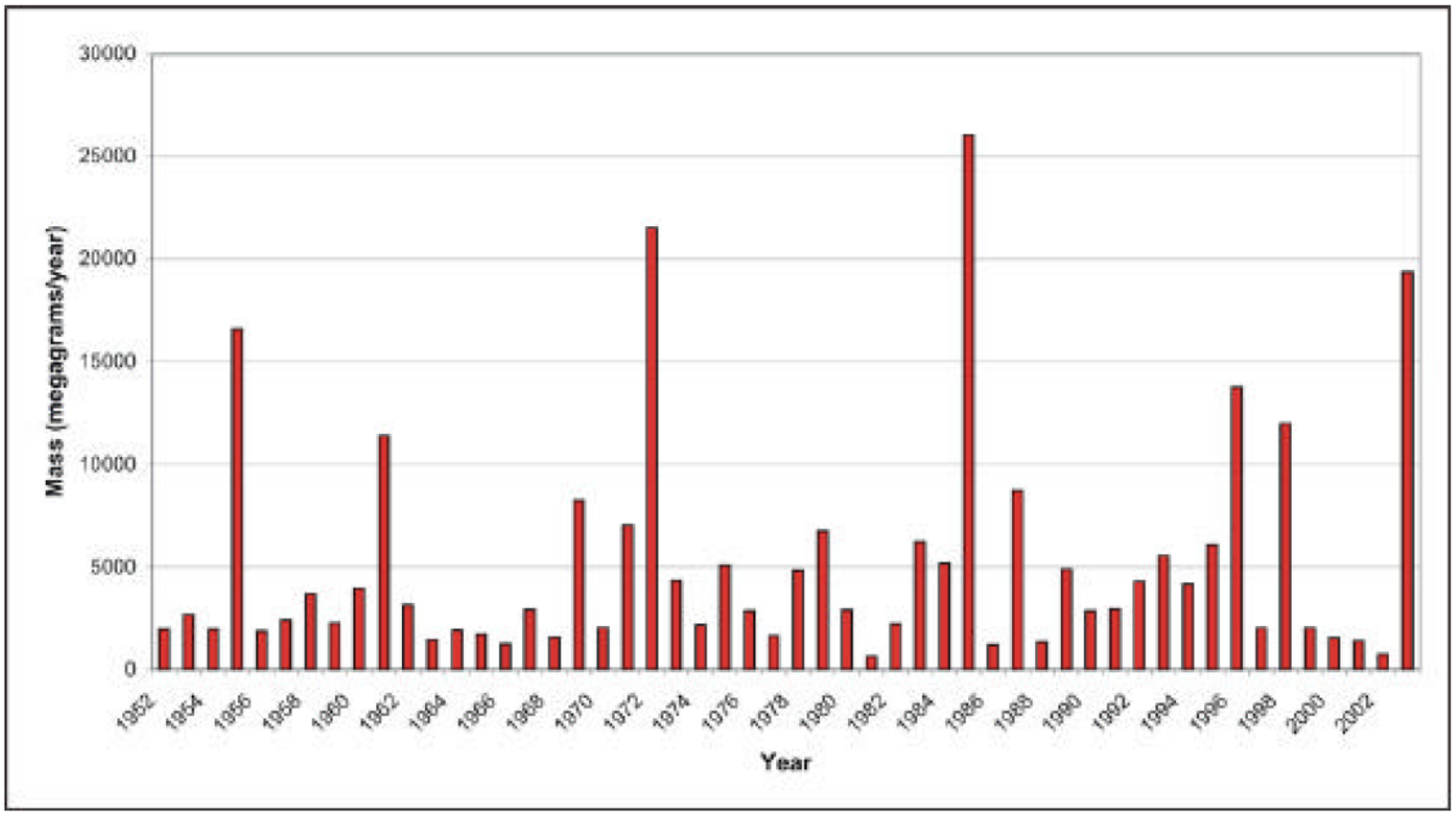


Figure 11.12. Total mass of suspended sediment for each year of discharge data on South River at Waynesboro

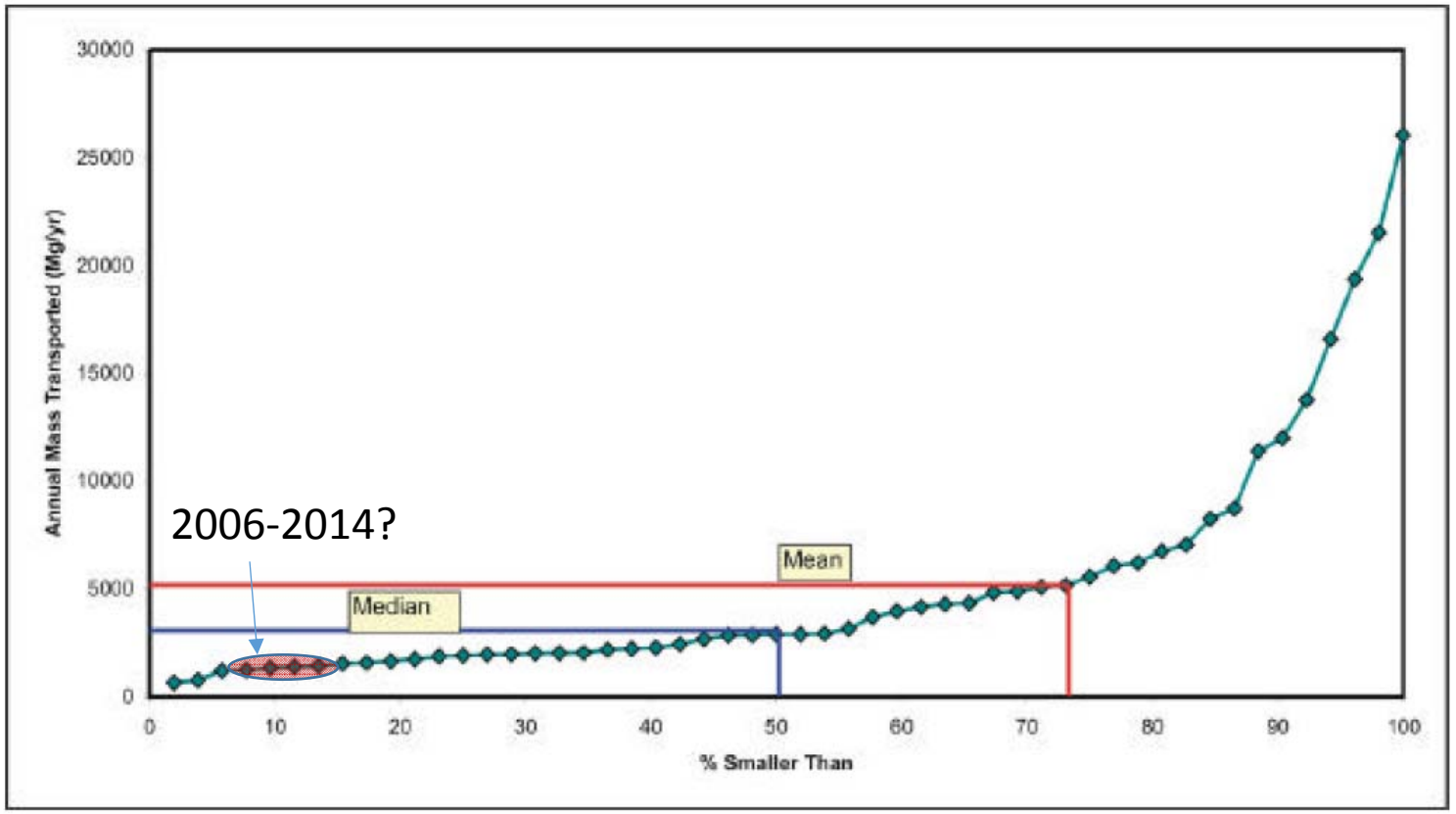
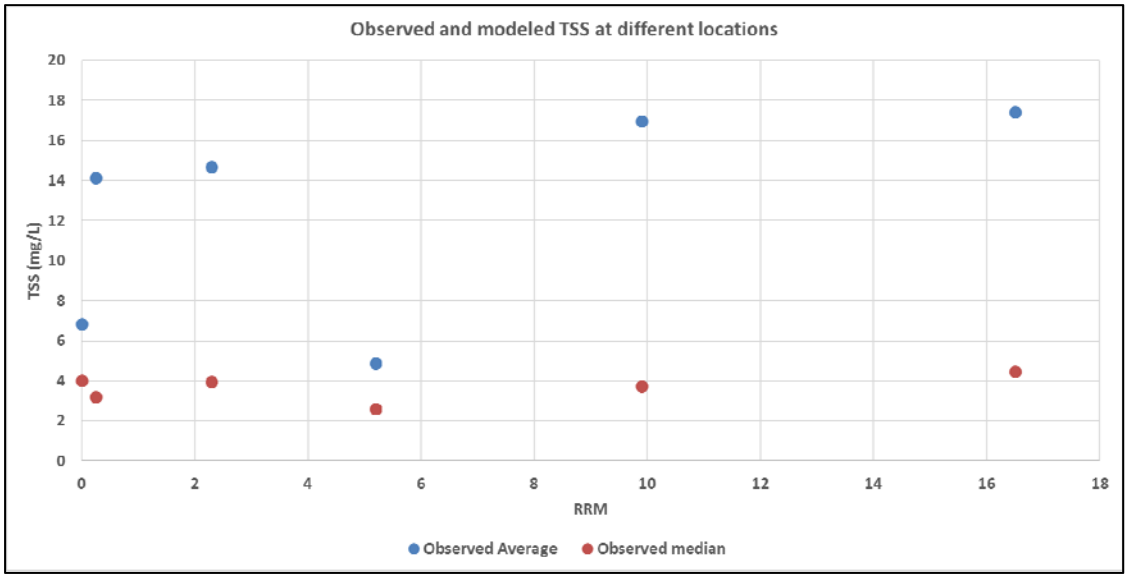
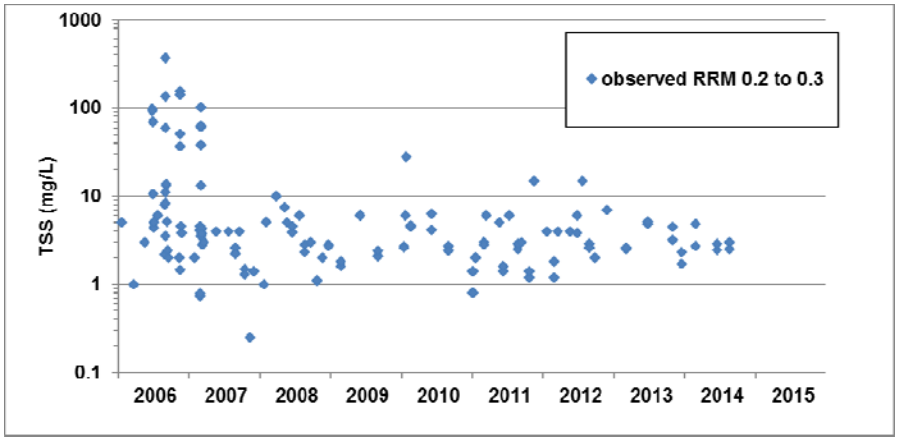


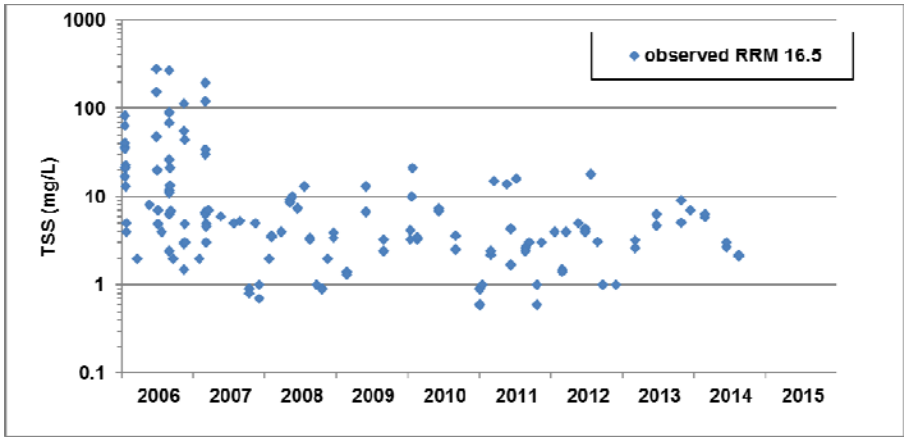
Figure 11.13. The exceedance probability (% of yearly sediment fluxes smaller than a given value) for a given annual mass of suspended sediment for the South River at Waynesboro. The mean value is indicated by the red line; it has a value of 5150 Mg/yr and is transported by the 73rd percentile of yearly sediment fluxes sorted by size. The median value is indicated by the blue line; it has a value of 2900 Mg/yr and is transported by the 50th percentile of yearly sediment fluxes sorted by size.

Does TSS increase from RRM 0-25?

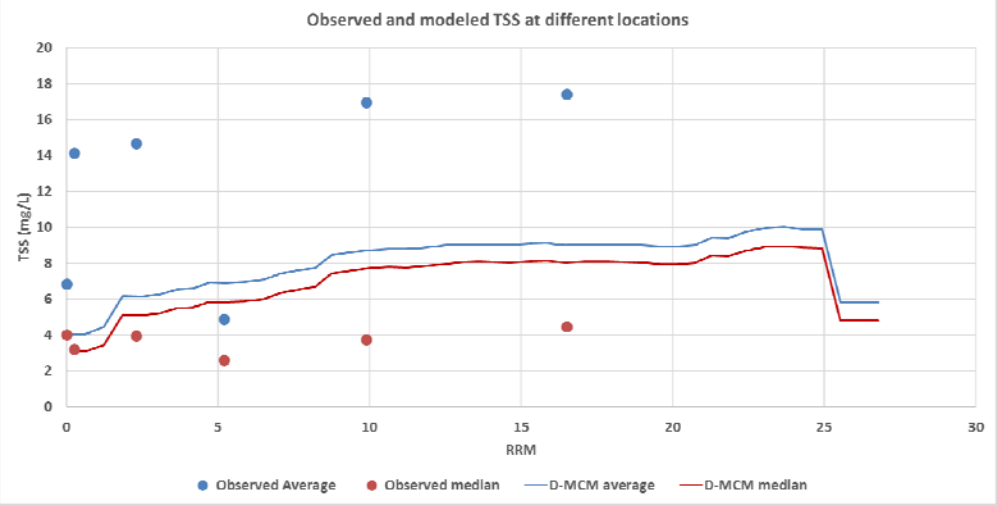


TSS seems similar at RRM 0.2 and RRM 16.5…..



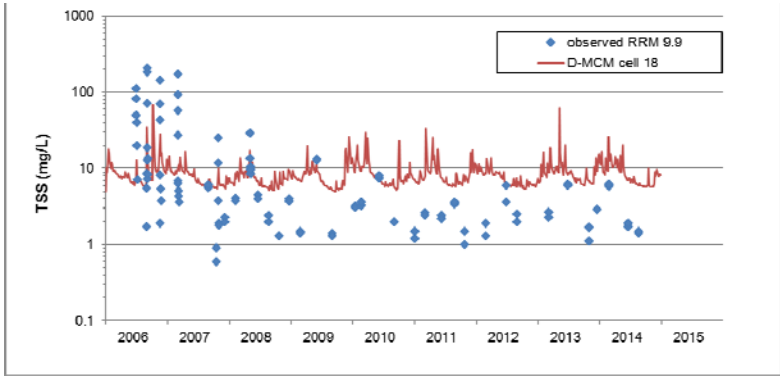


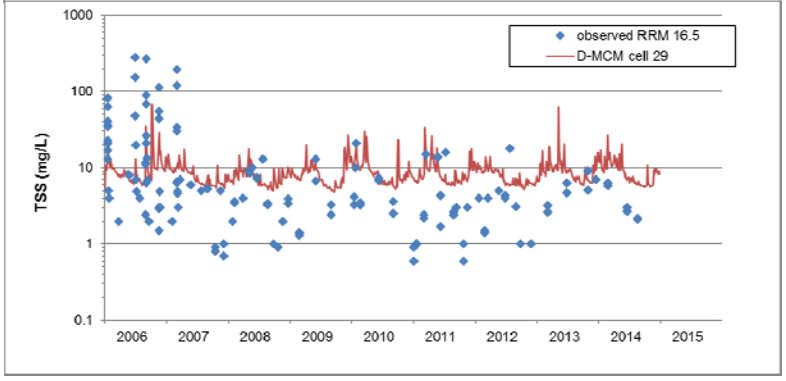
If we assume no sediment accumulation along the river….



TSS increases along the river in the simulation due to inputs from banks.

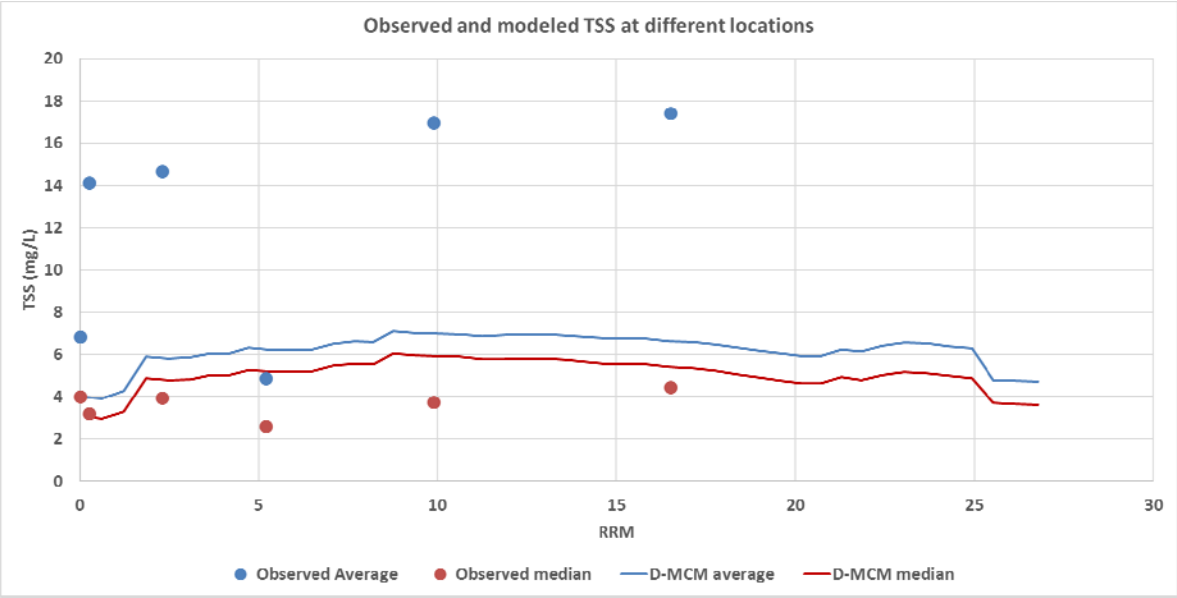
(Tributaries assumed to have same TSS as South River at upstream end of model domain)



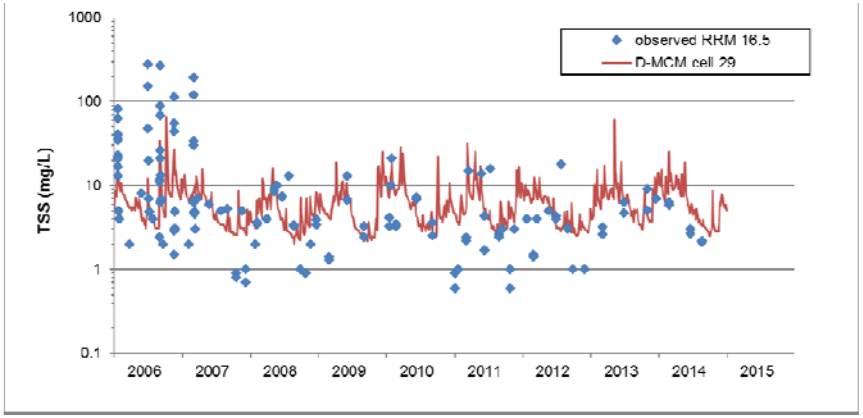


Modeled TSS is too high at downstream sites.

We reduced solids resuspension to get TSS to be more stable along the river



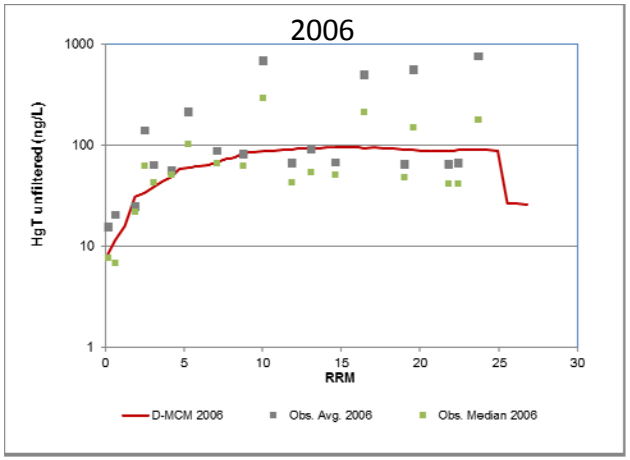
Solids resuspension reduced to about 30% of settling.

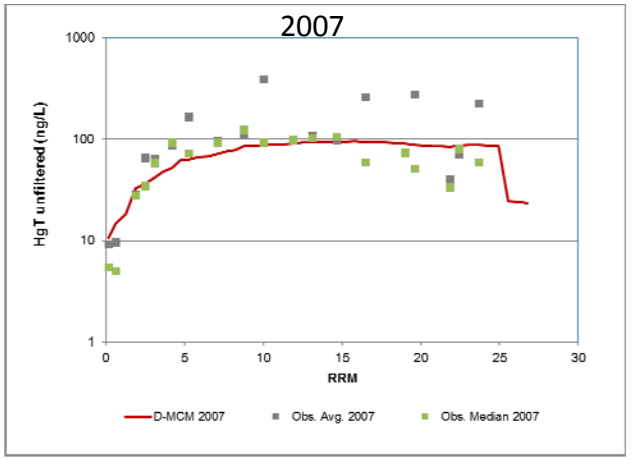


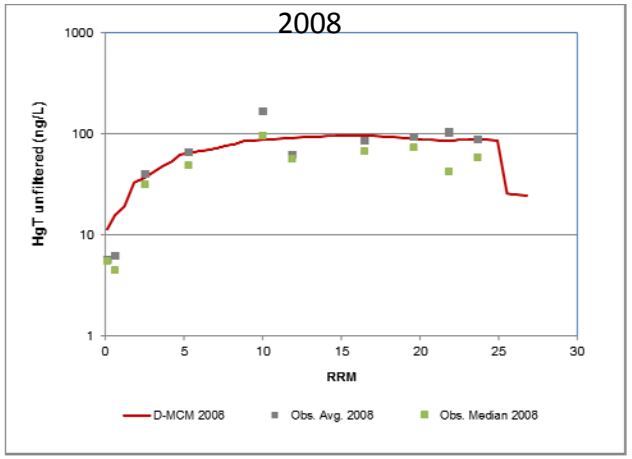
Downstream TSS predictions improved

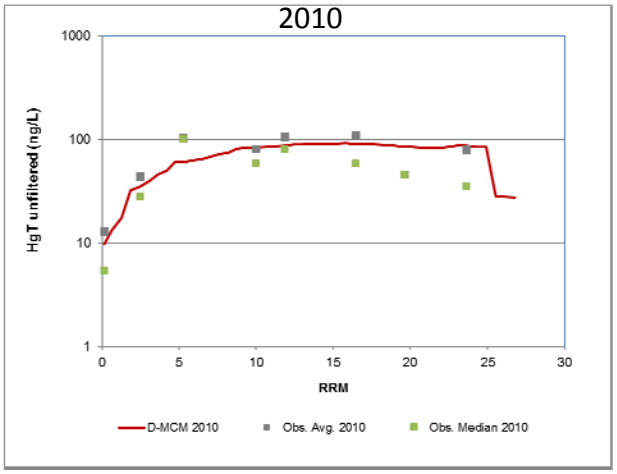
Current Calibration Results

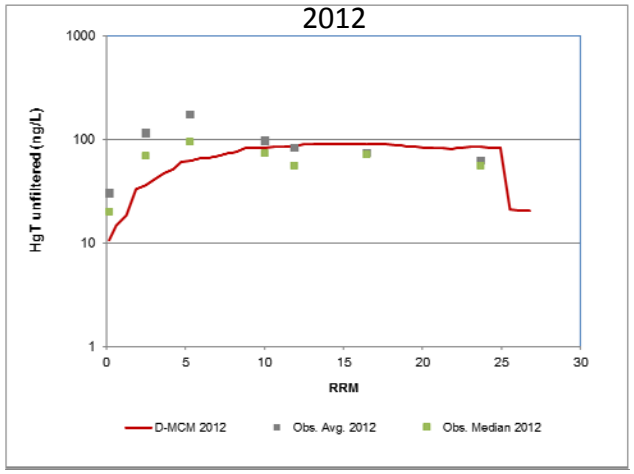
Model Calibration – Bulk Total Mercury in water (ng/L unfiltered)

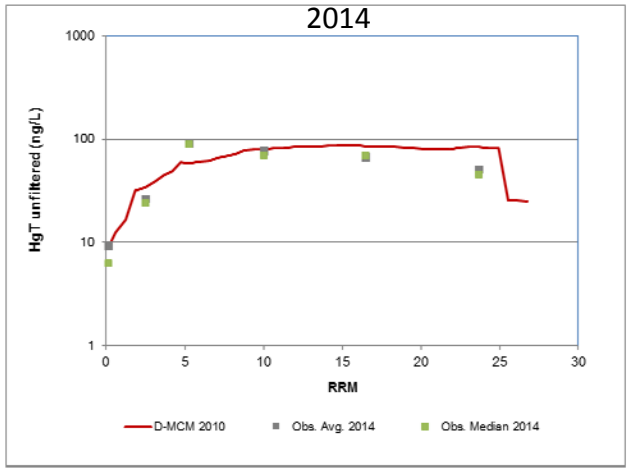




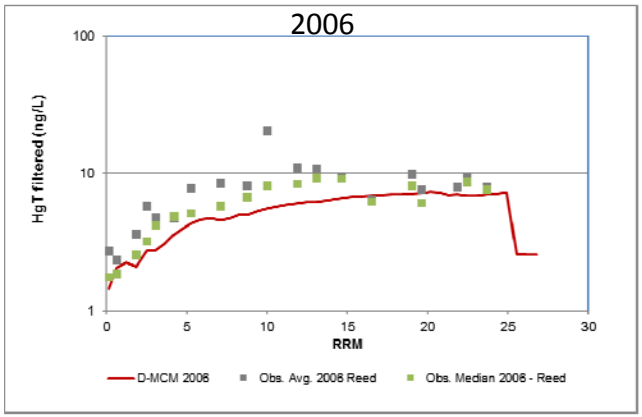


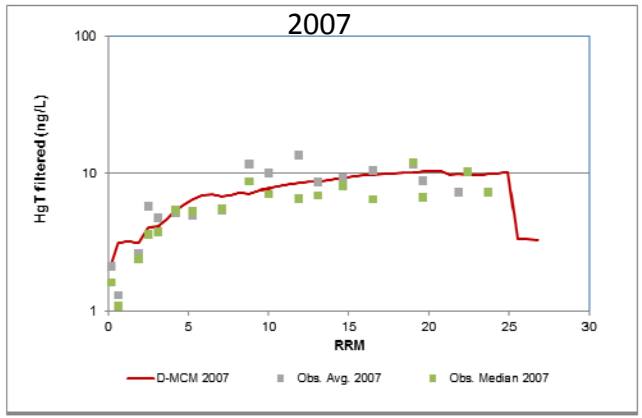


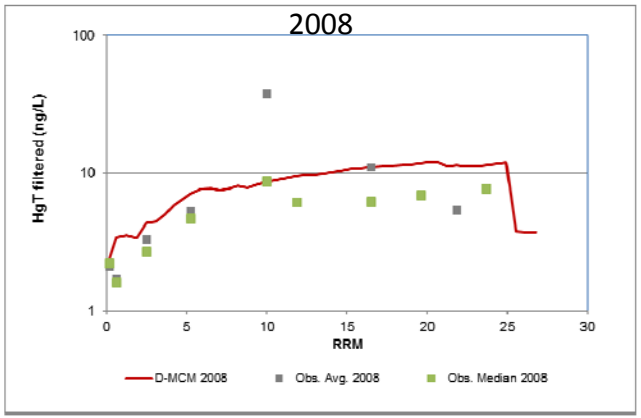


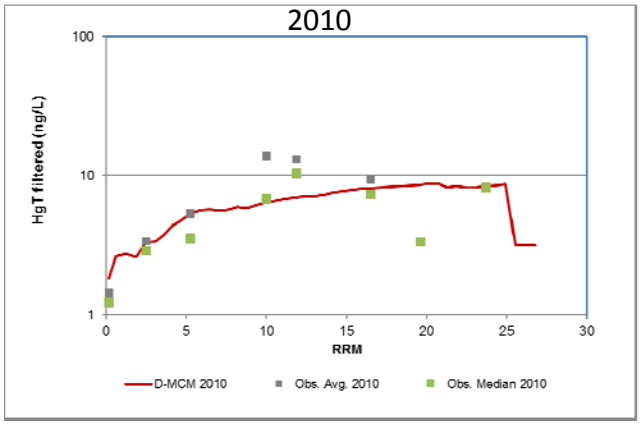


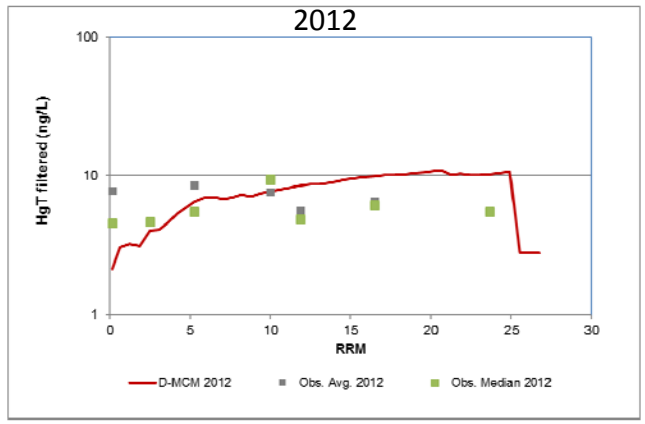
Model Calibration – Filtered Total Mercury in water (ng/L)

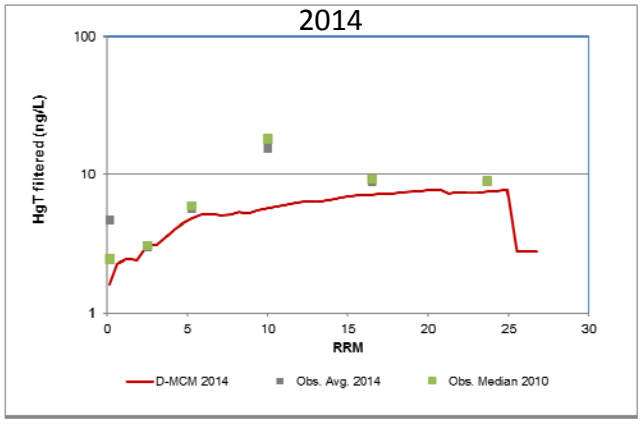




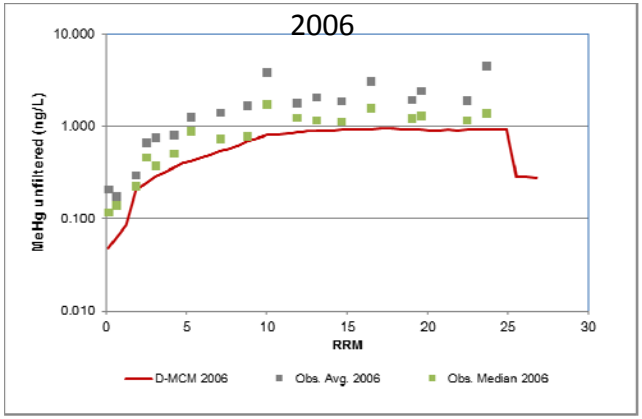


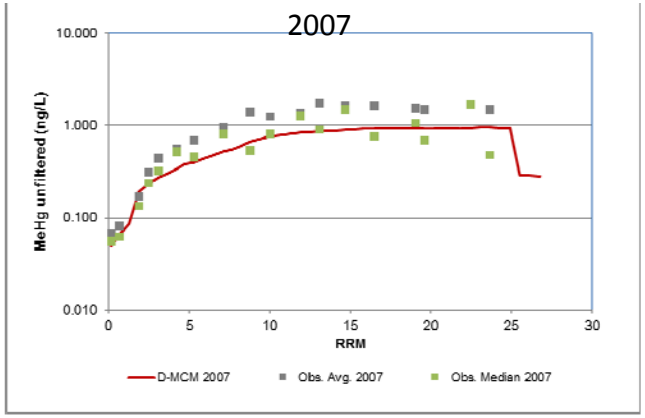


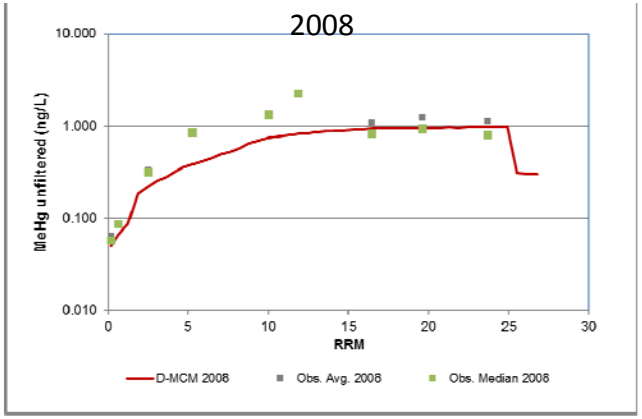


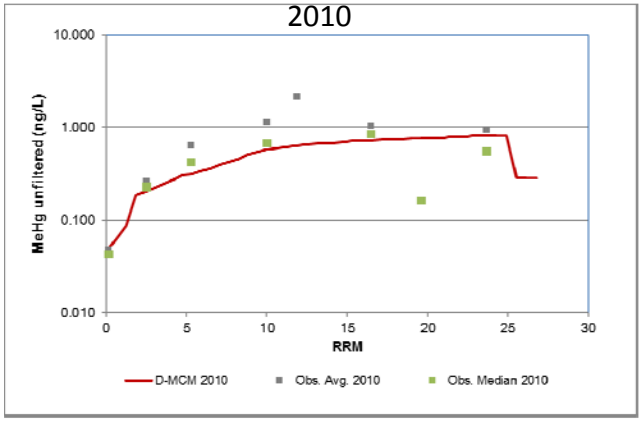


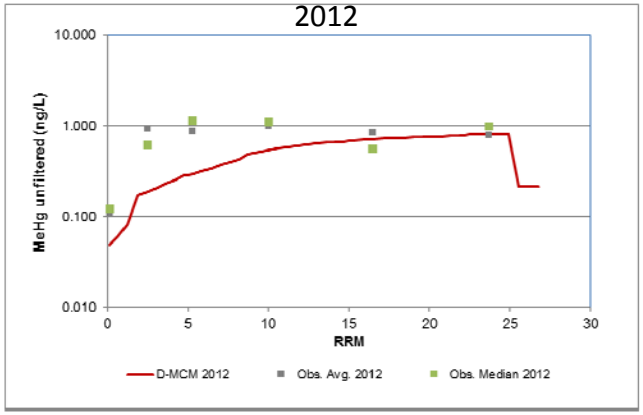
Model Calibration – Bulk Methylmercury in Water (ng/L unfiltered)

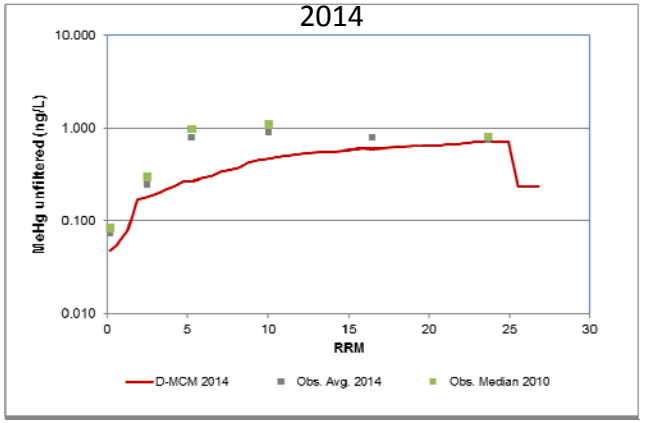




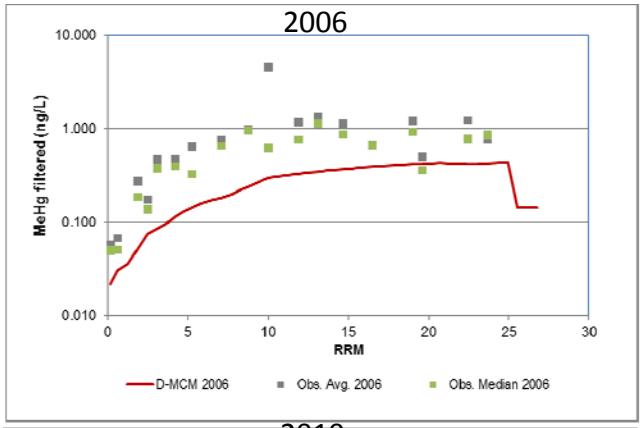


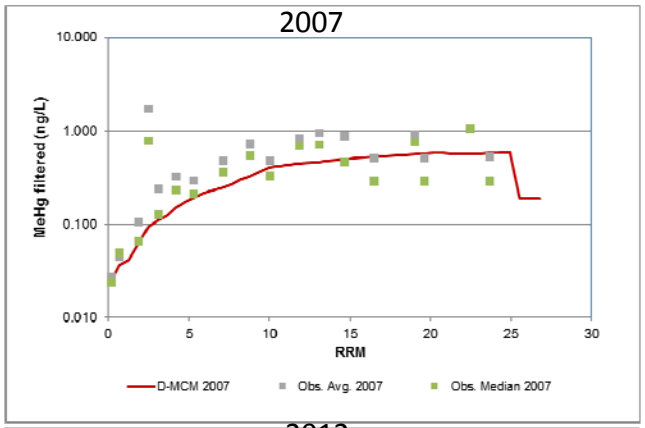


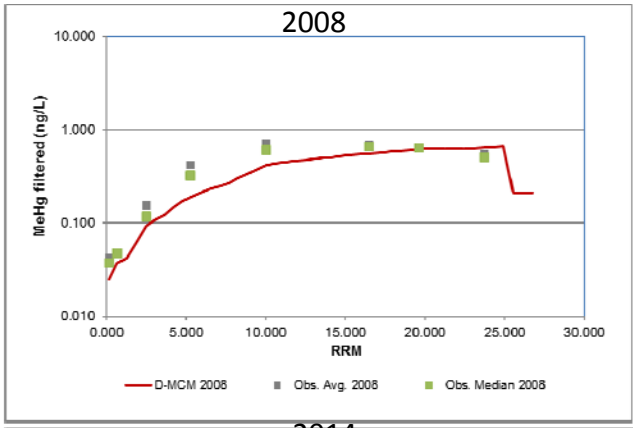


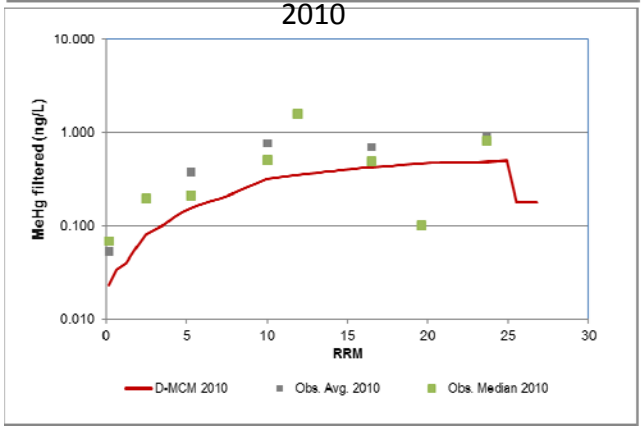


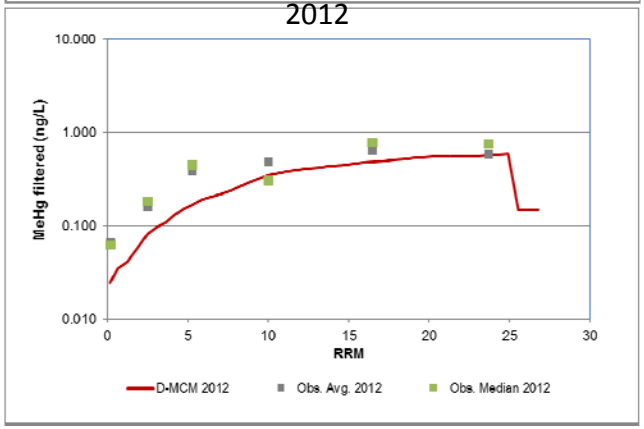
Model Calibration – Filtered Methylmercury in water (ng/L)

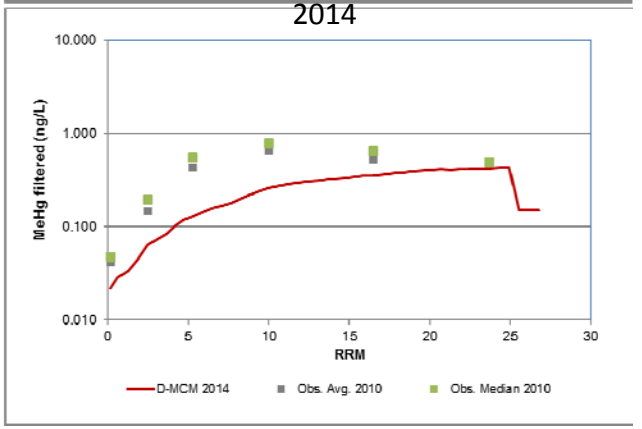




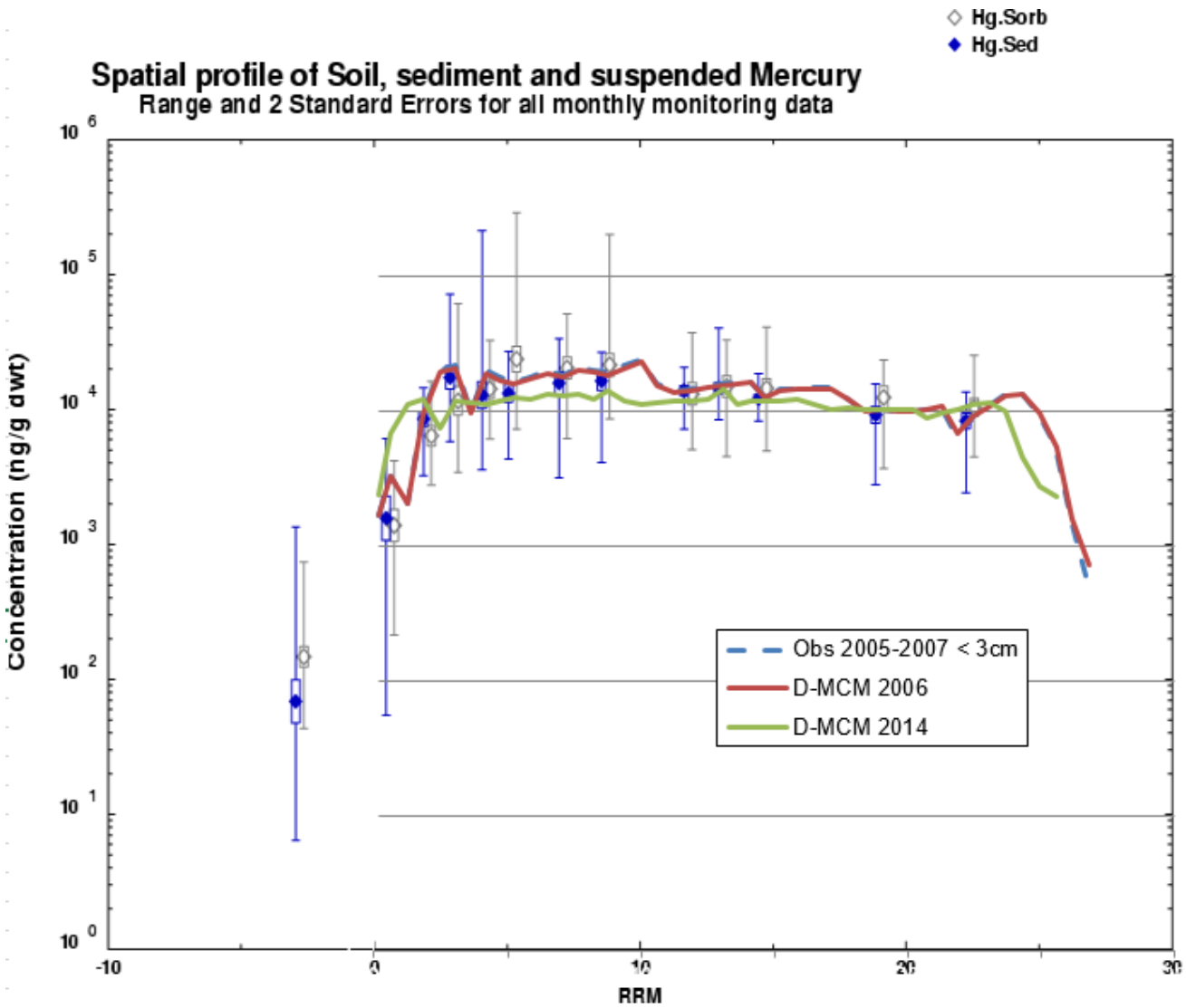






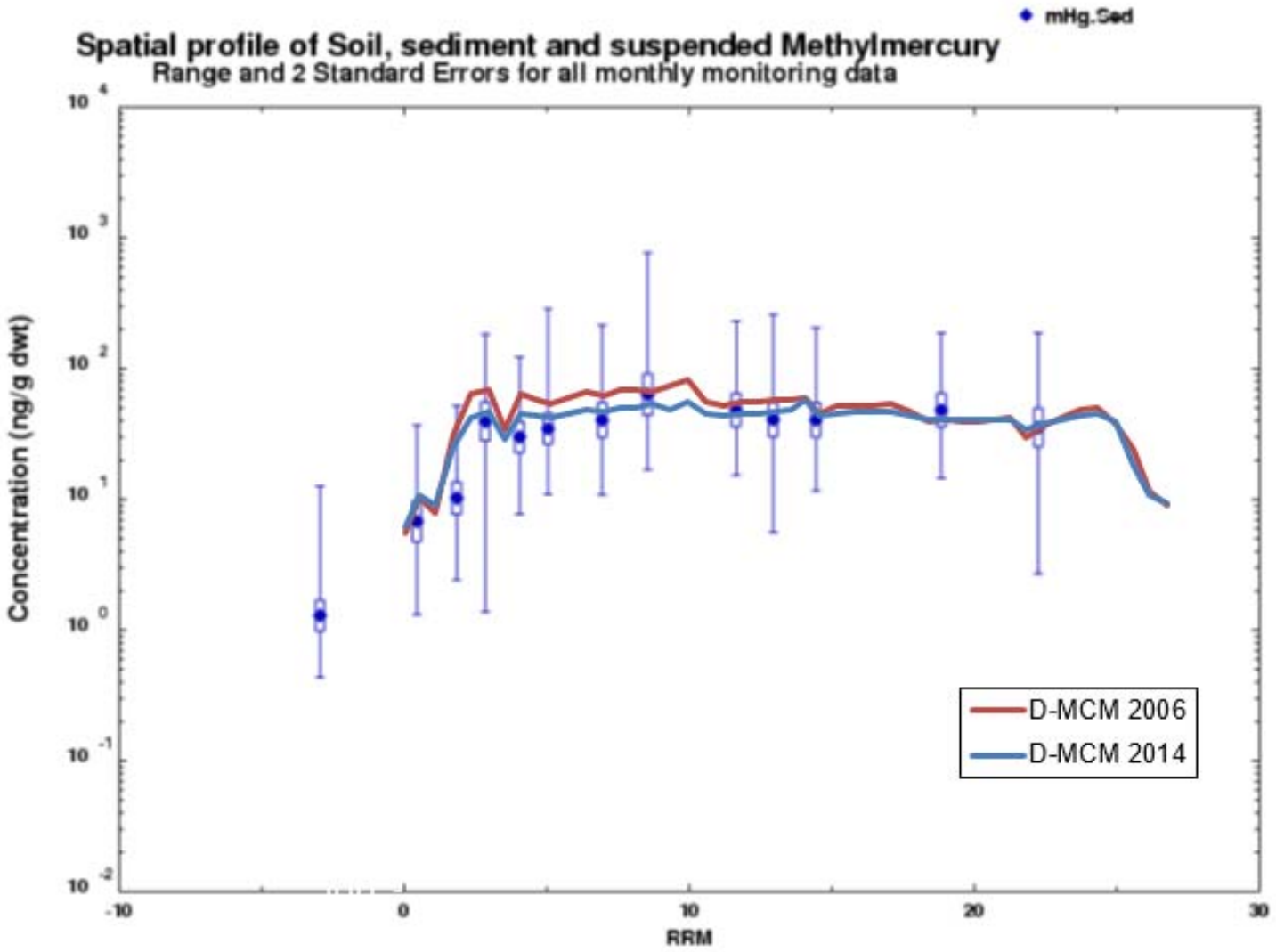


Observed and predicted THg in surface sediments in 2006 and 2014



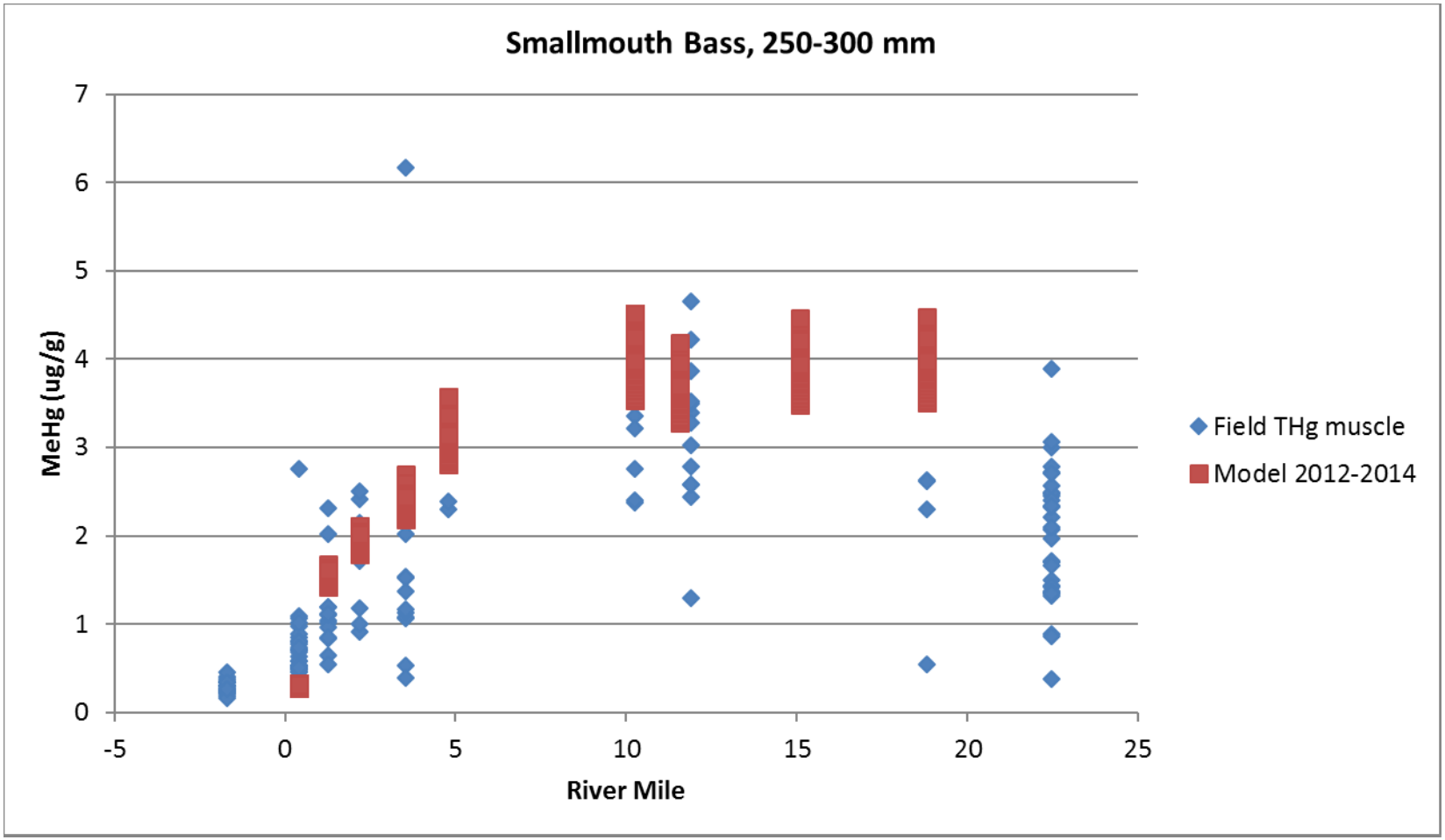
Data from HydroQual (2008)

Observed and predicted MeHg concentrations in sediments in 2006 and 2014



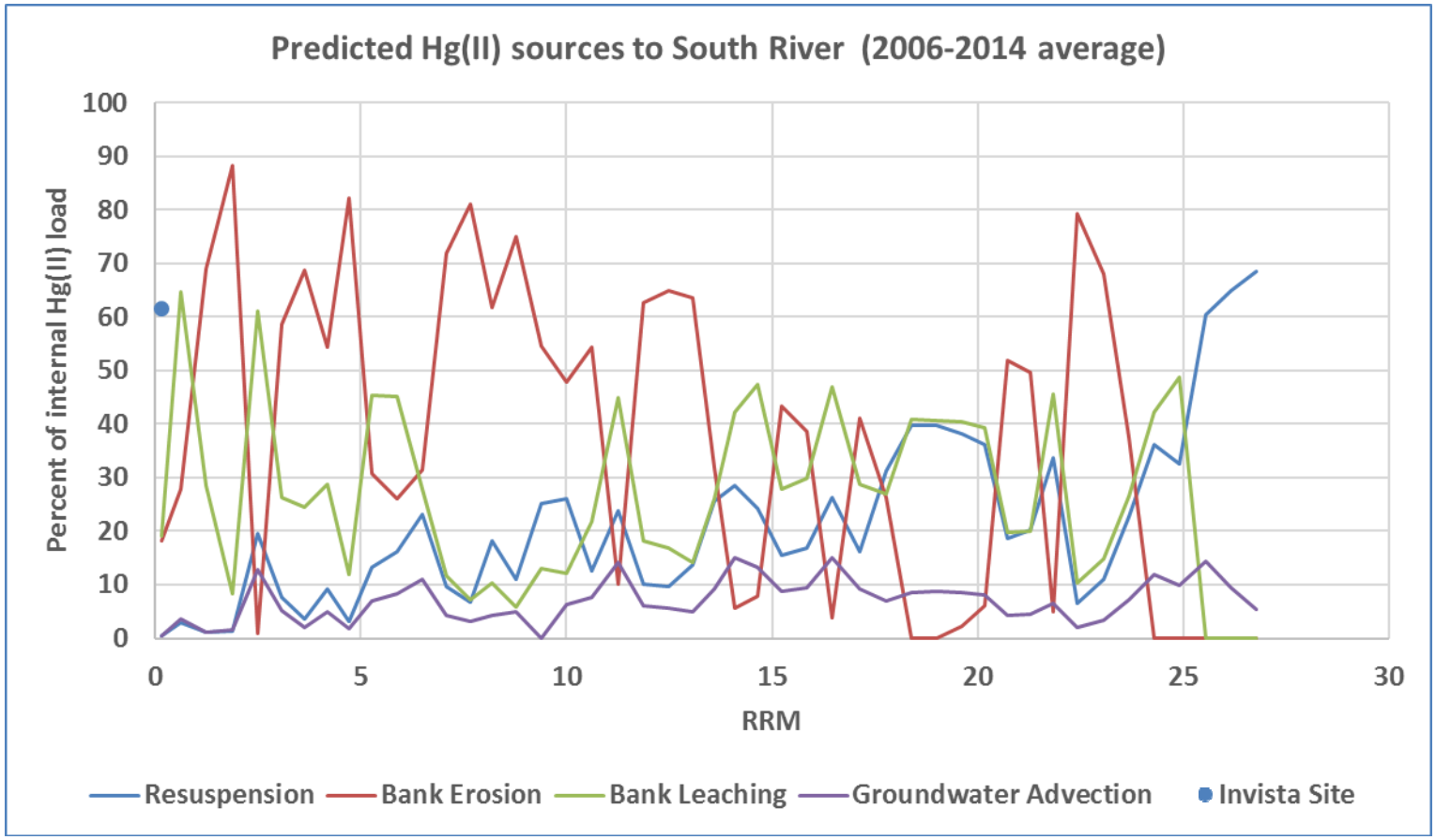
Data from HydroQual (2008)

Observed and predicted MeHg concentrations in Biota



Data from AECOM - URS

Sources of THg and MeHg



Bank erosion is primary source at most locations from RRM 0-10
Resuspension and bank leaching more important downstream?
Invista Site is significant source for Cell 1?

Model results for water column Hg are sensitive to gross and net rates of particle fluxes….

Net sedimentation

Can achieve same net sedimentation with different combinations of settling and resuspension.

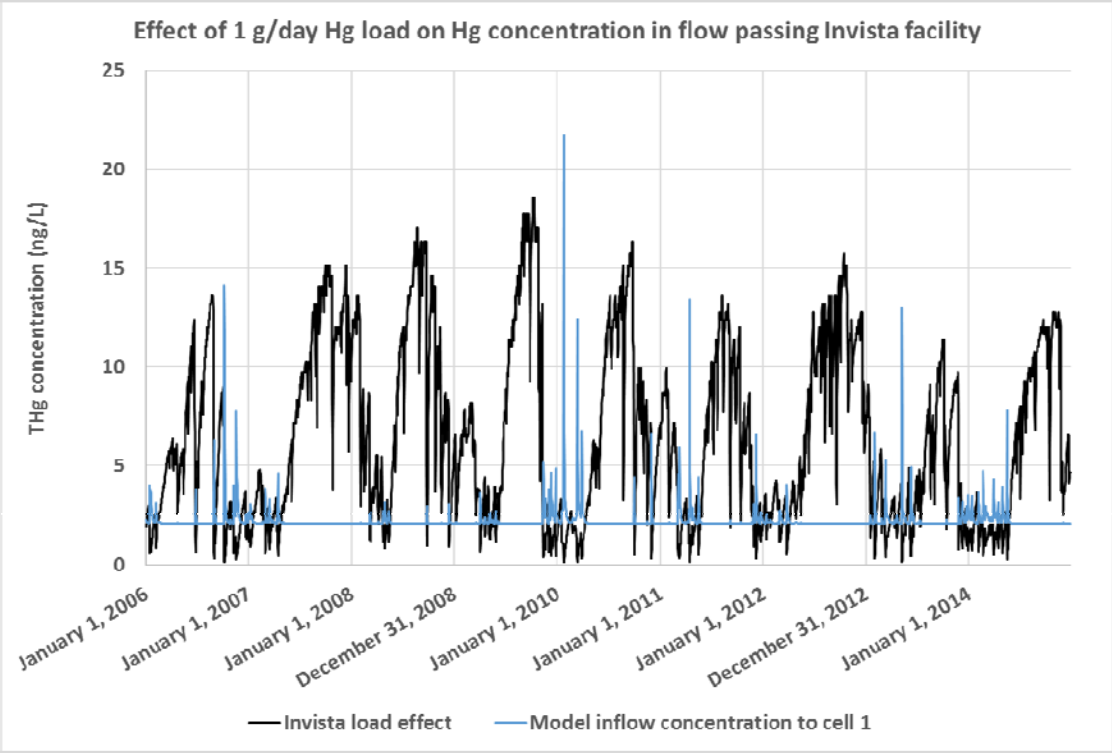
Faster resuspension and settling tend to make water column TSS Hg concentrations more like sediment concentrations.

System recovery is potentially faster if wheels spin faster… (and the ongoing Hg loading stops)

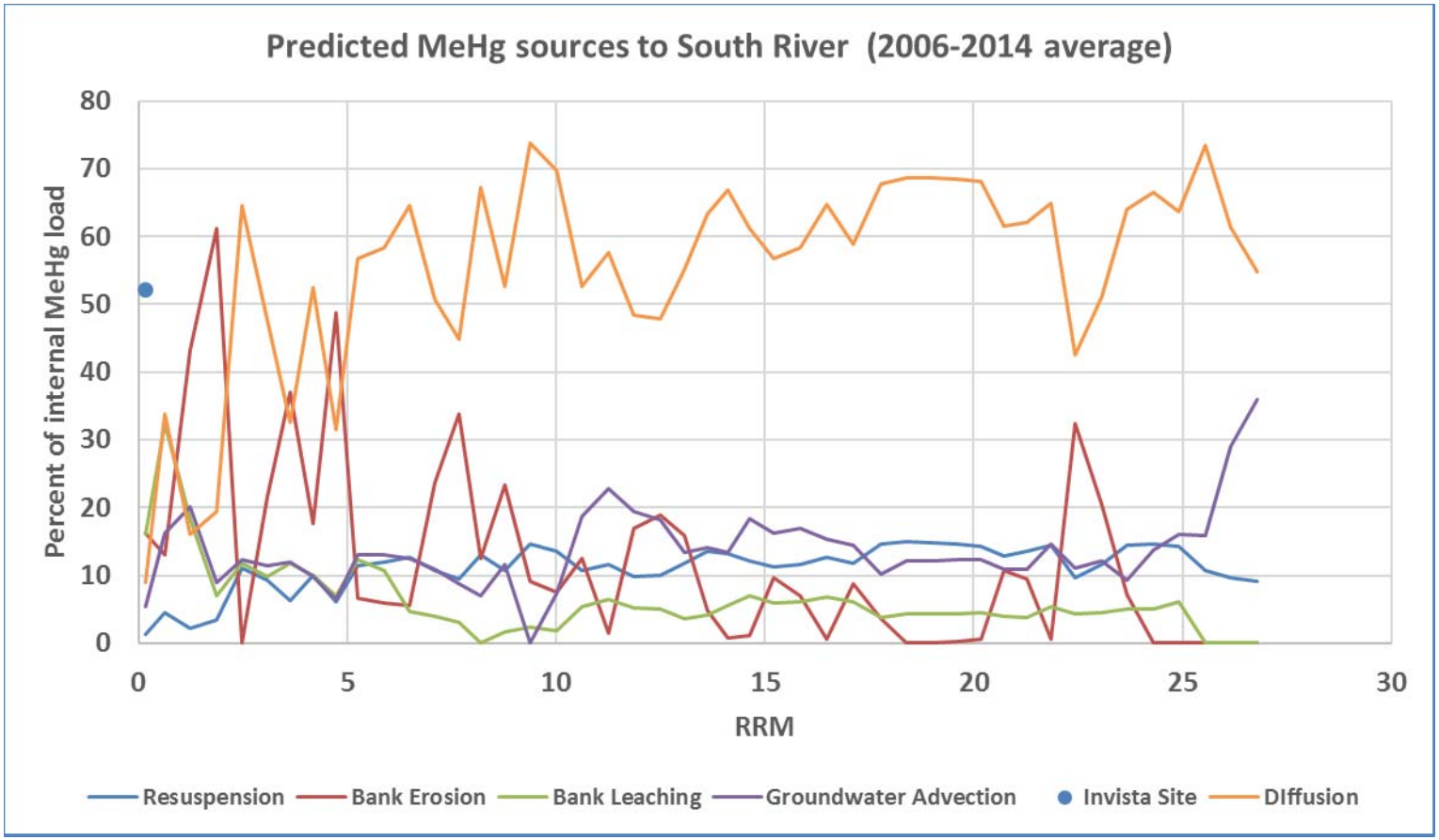
Importance of resuspension as an Hg source to water depends on this issue as well

How important is the mercury load from the Invista site?

- Estimate of 1 g Hg/day load from site



1 g Hg/day would increase Hg from ~1 to 18 ng/L as flow passes site, depending on flowrate.

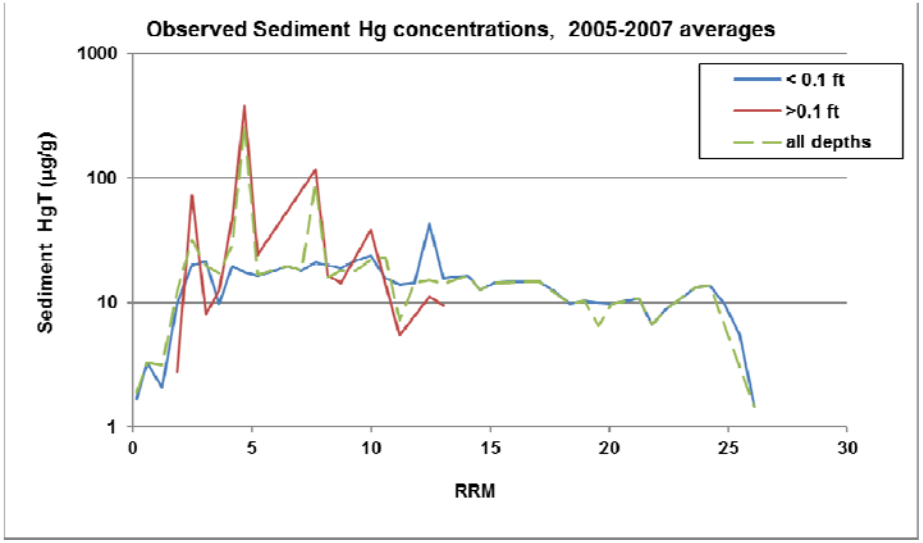


MeHg concentrations assumed to be 0.1% of THg for Invista site load, bank erosion, and bank leaching.

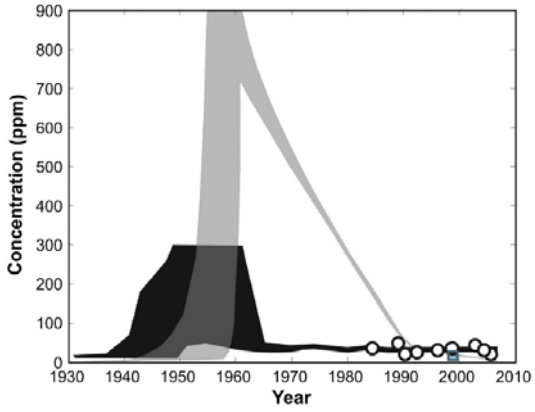
Is that reasonable?

Rate of Recovery

Sediment mercury concentrations have declined with time….



Hg concentrations are higher in deeper, older samples for RRM 0-10.

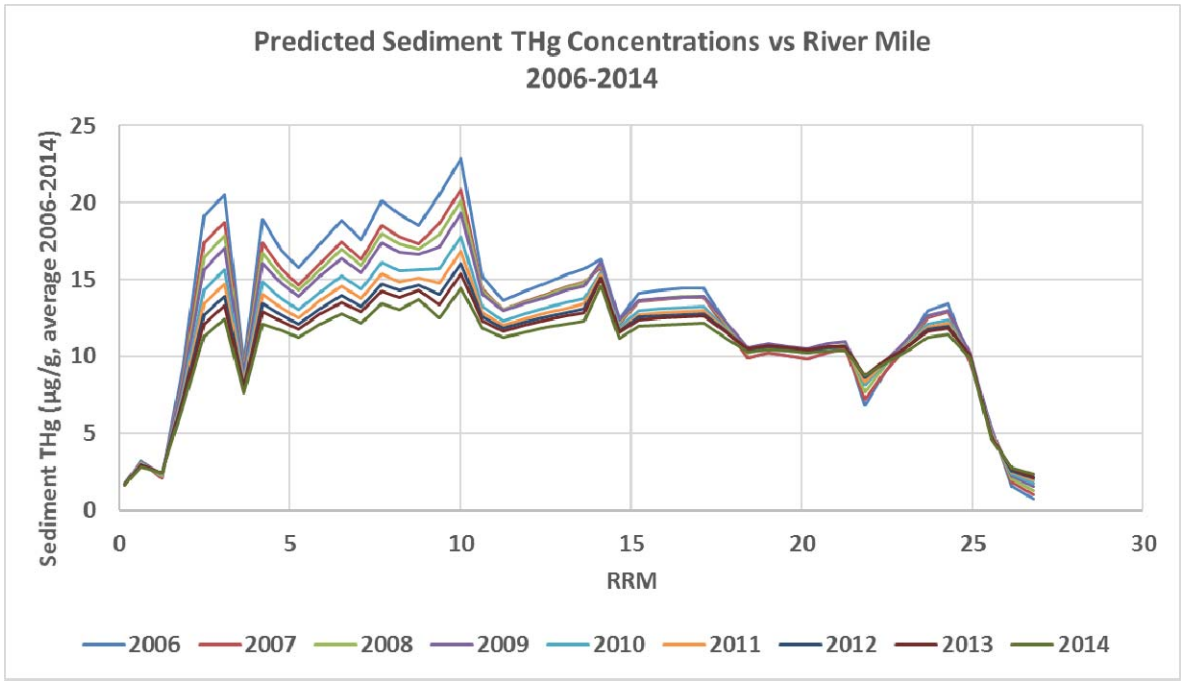


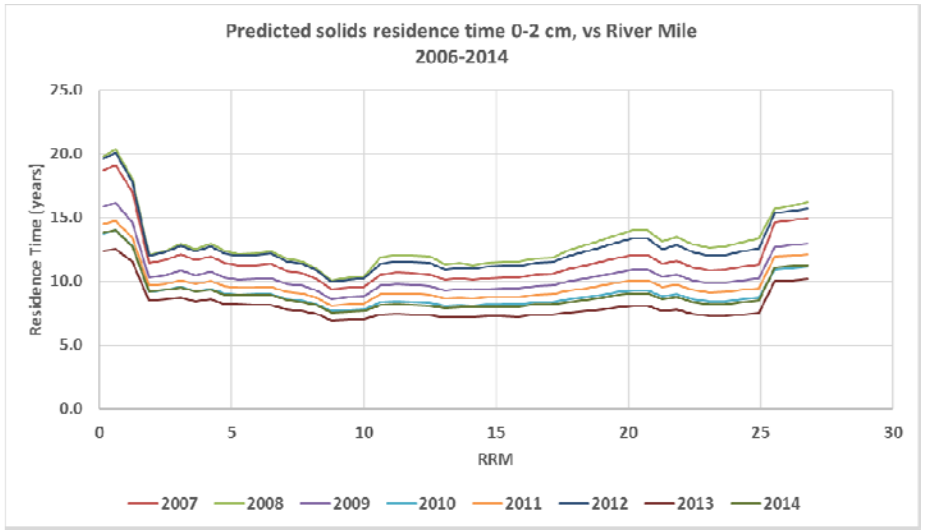
Reconstructing suspended sediment mercury contamination of a steep, gravel-bed river using reservoir theory

Katherine J. Skalak and James Pizzuto

Figure 10. Mercury concentration on suspended particles transported by the South River from 1930 to 2007. The gray region represents model reconstructions based on the age and Hg concentration distributions observed in FGCM deposits in 2007. The black region defines the history documented by the Dooms Dam core (range is defined by the 99% confidence intervals associated with radiometric dating; Skalak and Pizzuto, 2010). Circles are samples from FGCM deposits dated by bomb radiocarbon (data from Skalak and Pizzuto, 2010).

Upstream areas predicted to have declining THg in sediments from 2006-2014, particularly for RRM <10

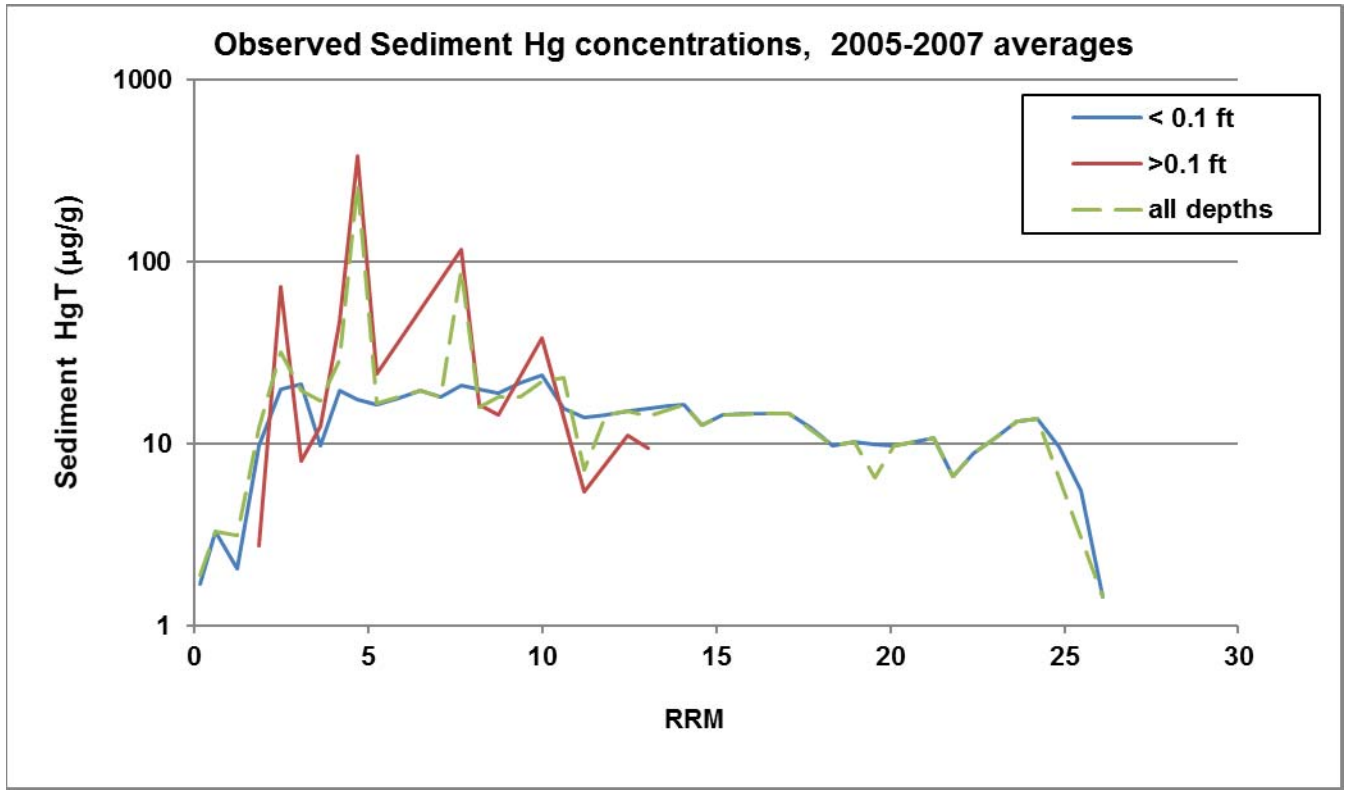




Particle residence time in surface sediments

Sediment Hg concentrations have declined over time from RRM ~2-10.

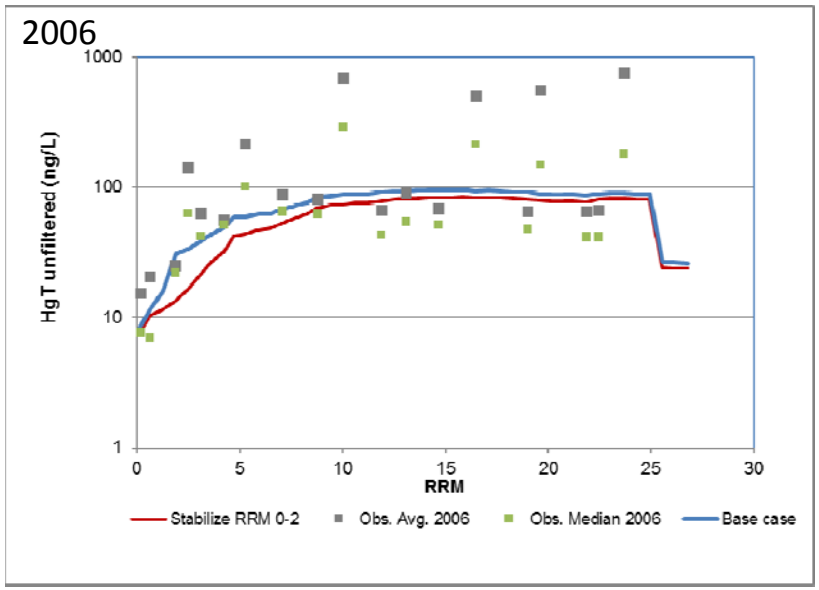
How much of the contamination is moving downstream, vs being buried?

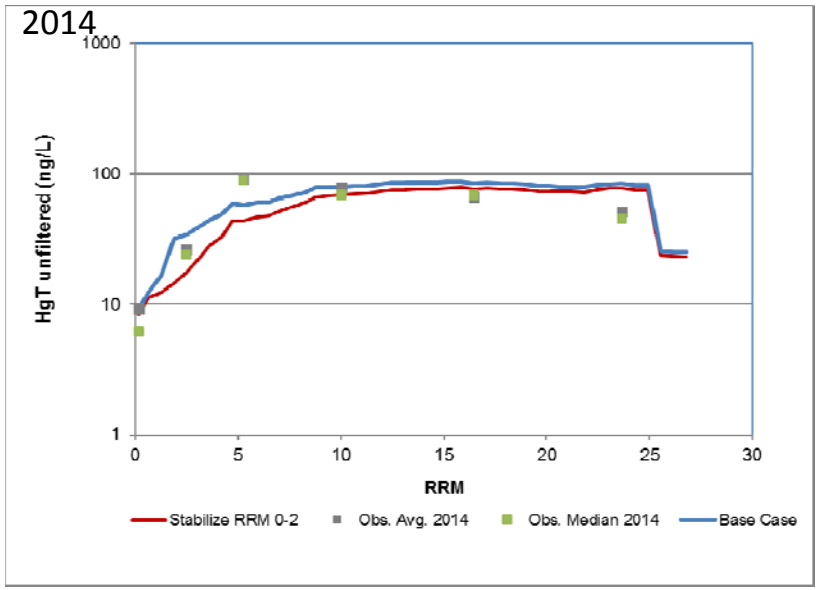


Bank Stabilization Scenarios

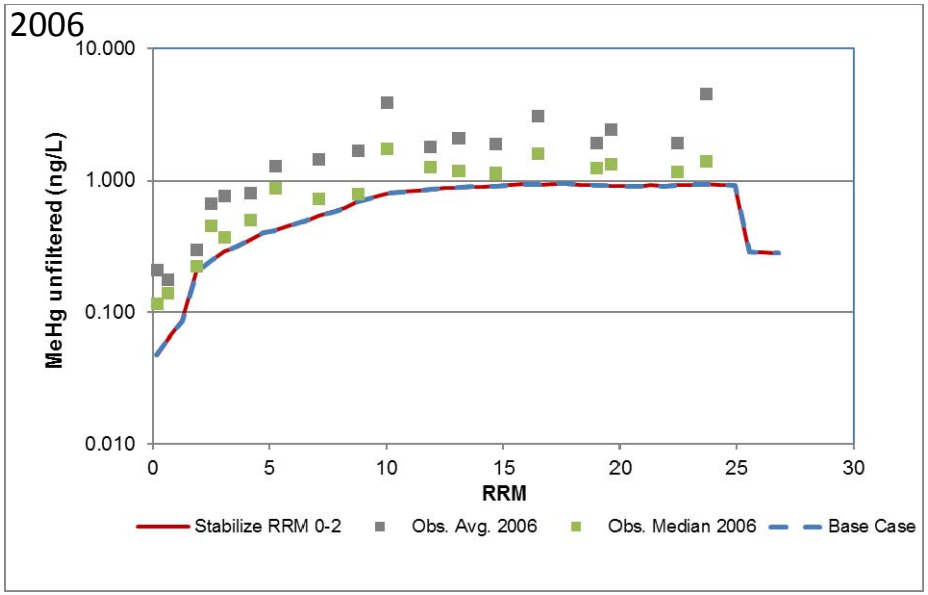
Simulated effect of stabilizing banks from RRM 0-2

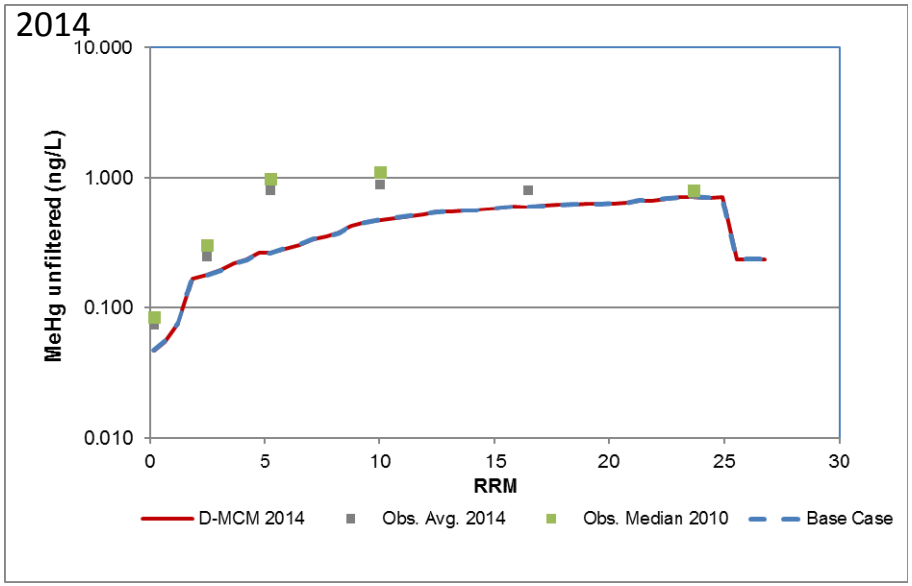
THg in water



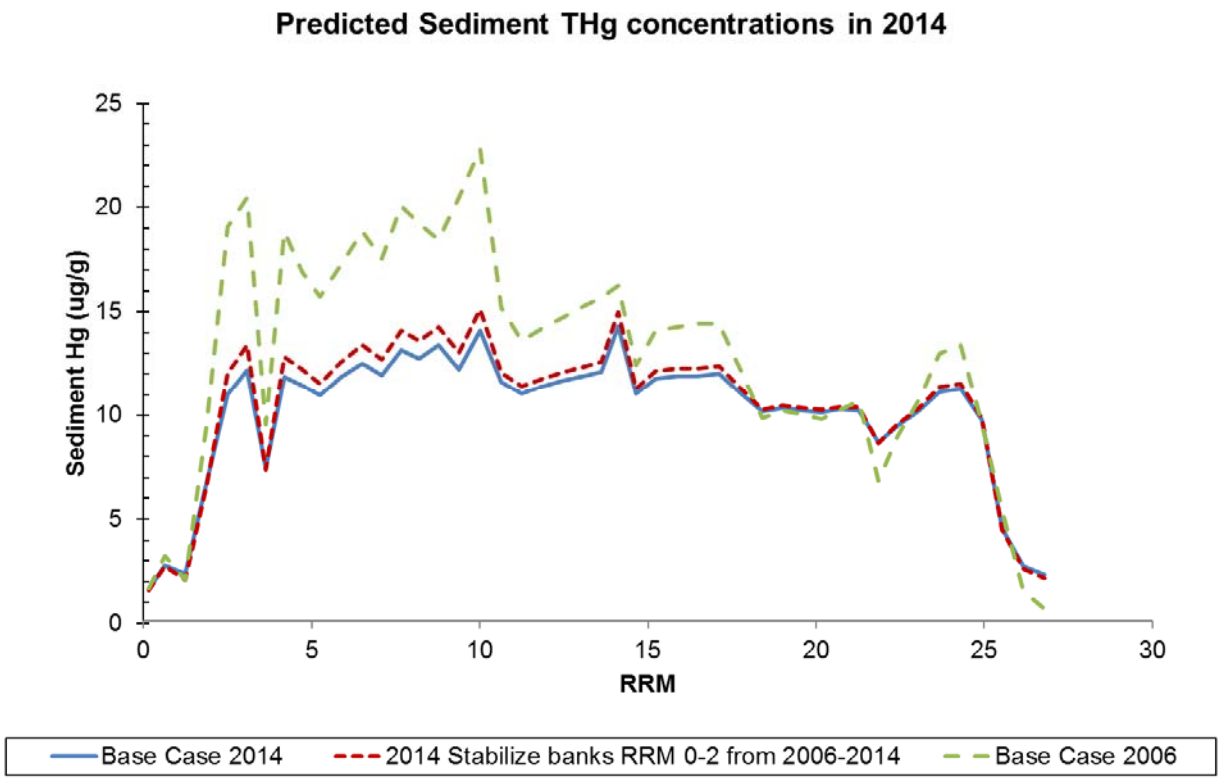


MeHg in water





Simulated effect of stabilizing banks from RRM 0-2



Predicted increase in 0-2 cm sediment THg and MeHg???

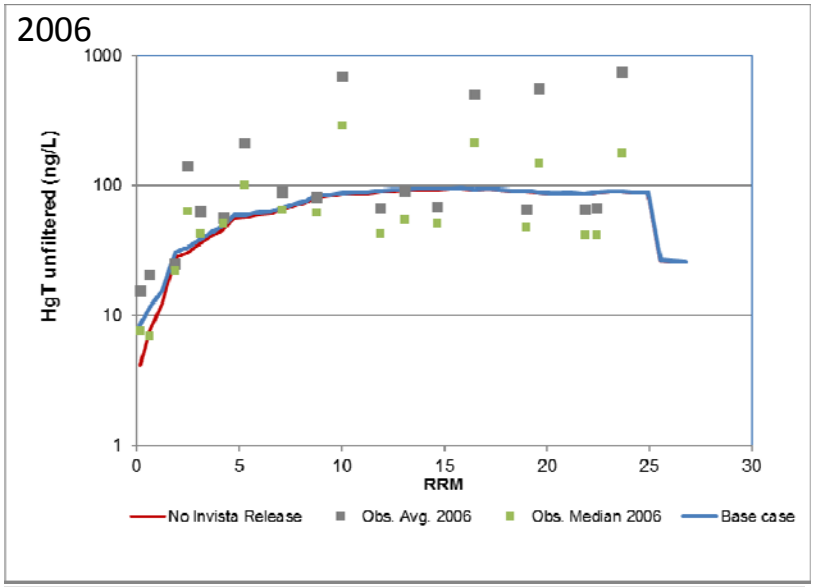
- Debugging why this happens…
- Probably strongly related to assumptions about sedimentation….

less settling -> slower particle turnover -> slower recovery

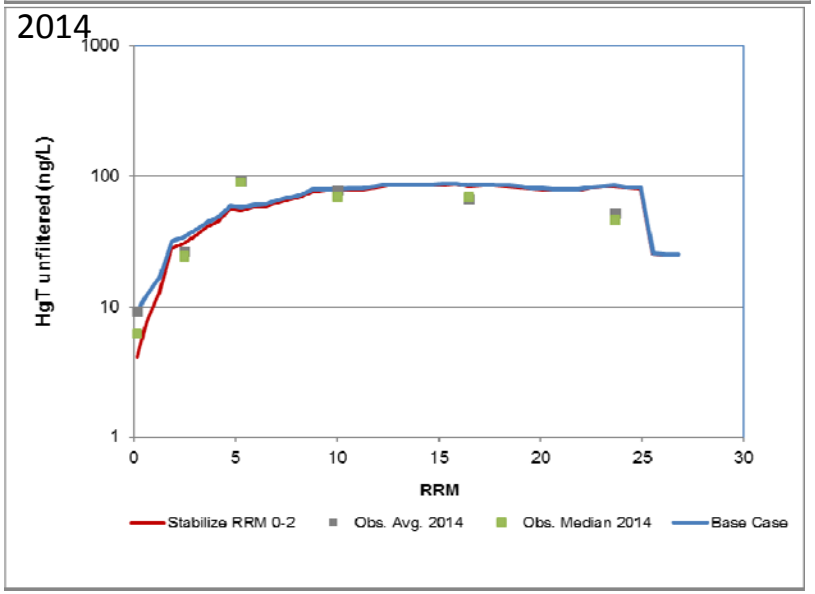
Simulated Effect of Eliminating Hg load from Invista Site

THg in water

2006



2014



Small effect on THg in water near facility site.

No meaningful effect on MeHg

Summary

- Model calibration close to complete..
- Results generally consistent with conceptual model
- Bank erosion is primary source of inorganic Hg to RRM 0-10.
- Model is low for MeHg in water. Is the solution to load more MeHg from sediments? Greater %MeHg in banks?
- Particle dynamics very important. Assumptions affect natural rate of recovery, downstream movement of contamination, and effects of bank stabilization.
- Exploring scenario result for stabilizing RRM 0-2…..