

Predicting Responses in Physical and Biological Compartments to Reductions in Mercury Loading From River Banks

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INTRODUCTION

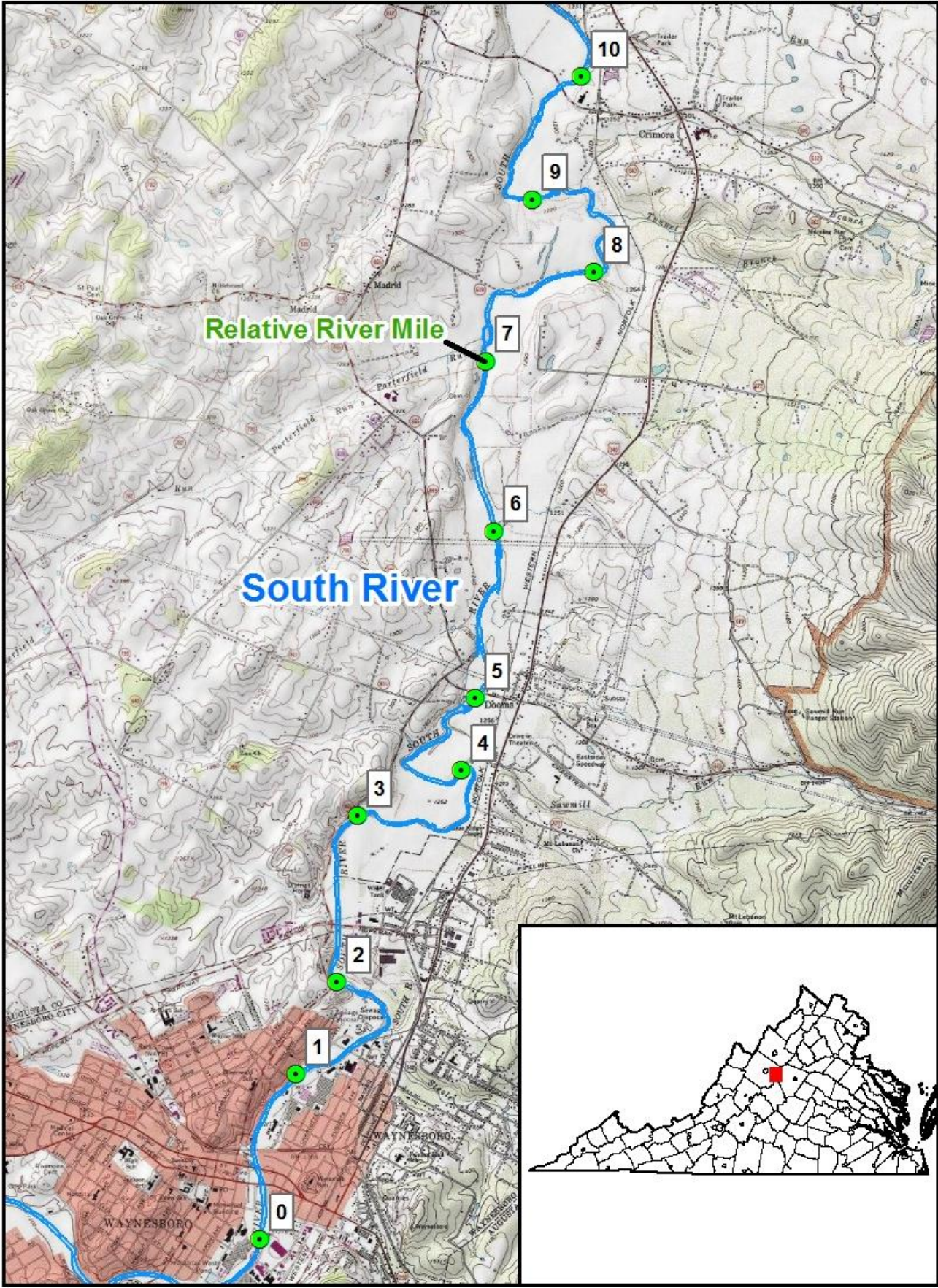
Historical mercury (Hg) releases occurred at a textile manufacturing facility on the South River, VA (Figure 1). These releases resulted in increased Hg concentrations in biotic and abiotic media, which have not declined over the past thirty years in some media (e.g., fish tissue), as originally expected. Introduction of legacy Hg impacted bank soils of the South River , and bank erosion is the most significant source of Hg loading to the system. Interim remedial measures targeted at reducing this source within the first few river miles were initiated in 2016.

As part of the remedy selection process, a set of robust statistical models were developed to predict responses in physical and biological media associated with completion of the interim measures (i.e. bank stabilization). The models integrated site-specific data collected over more than a decade and built upon the detailed site conceptual model. Model parameters included total mercury (THg) and methylmercury (MeHg) concentrations in a number of physical media (e.g. sediment, soil, and surface water), biological media (e.g. fish tissue), as well as meteorological, adjacent land use, and stream discharge data. Different remedial scenarios (i.e. 50% and 100% reduction in Hg loading from eroding banks) were evaluated in order to inform remedial decision making. Model runs predicted significant THg reductions in surface water and sediments adjacent to and downstream of the proposed interim measures.

A short-term monitoring (STM) program comprised of multiple lines of evidence is being implemented that aims to document the predicted reduction in Hg concentrations in a range of biotic and abiotic endpoints. The STM program is intended to evaluate changes in Hg concentrations at specific bank segments following remediation over a relatively short time period (i.e. 2-10 years). Key learnings from a Pilot Bank Stabilization project were built into the STM program in order to maximize the ability to not only detect reductions in Hg loading attributable to the interim measures, but also to be able to differentiate those from changes that may be due to other factors.

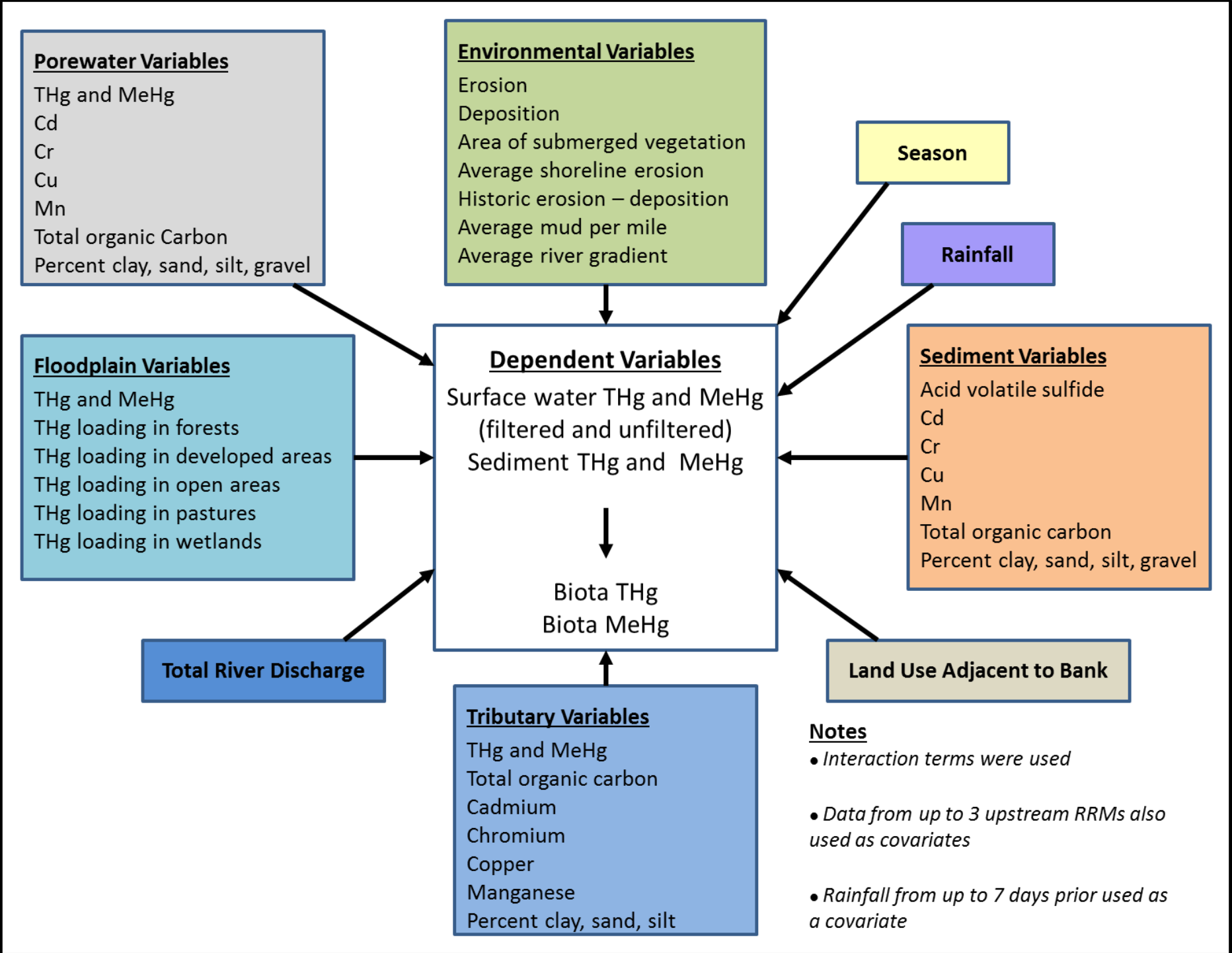
STUDY AREA

Figure 1: South River study region extending from relative river miles (RRM) 0 - 10



VARIABLES USED IN STEPWISE REGRESSION

Figure 2: Variables considered in a stepwise regression. Arrows point from potential independent (explanatory) variables to dependent variables (to be predicted).



MODEL DEVELOPMENT

Figure 3: Model development process

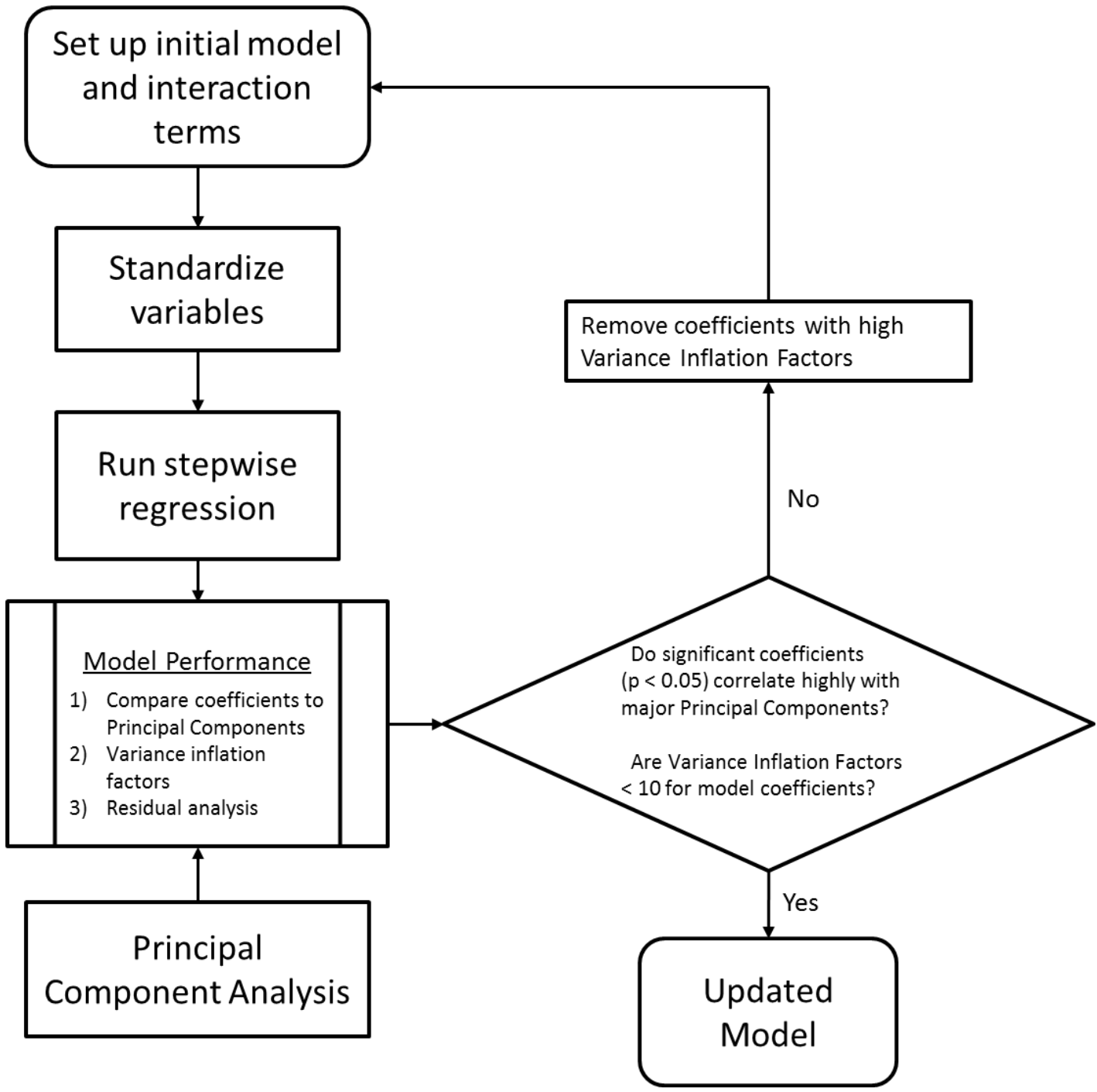


Table 1: A subset of important explanatory (independent) variables included in each statistical model

Surface Water THg	Surface Water MeHg	Sediment THg	Bass THg ¹	Bass MeHg ¹
Bank THg Load	Bank THg Load	Bank THg Load	Bank THg Load	Bank THg Load
Floodplain THg	Inflows (tributary, GW, ditches, etc.)	Floodplain THg	Fish length	Fish length
Submerged Aquatic Vegetation THg	Submerged Aquatic Vegetation THg	Submerged Aquatic Vegetation THg	Submerged Aquatic Vegetation THg	Submerged Aquatic Vegetation THg
Discharge rate ²	Discharge rate ²	Discharge rate ²	Discharge rate ²	Discharge rate ²
Porewater THg	Porewater THg	Porewater THg	Porewater THg	Porewater THg
Sediment THg	Rainfall	Surface Water THg	Sediment THg ³	Sediment THg ³
Land Use ⁴	Land Use ⁴	Rainfall	Surface Water MeHg ³	Surface Water MeHg ³
Other Environmental Variables ⁵	Other Environmental Variables ⁵	Other Environmental Variables ⁵	Diet (especially <i>Trichoptera</i> THg)	Diet
R ² : 0.54	R ² : 0.47	R ² : 0.64	R ² : 0.56	R ² : 0.62
Sample Size: 1688	Sample Size: 2184	Sample Size: 375	Sample Size: 903	Sample Size: 286

¹ Lag terms representing discharge and surface water data at upstream RRM are important for Bass THg and MeHg

² Discharge interaction terms important in all models

³ Surface Water and Sediment Hg are important in BassTHg and Bass MeHg Models

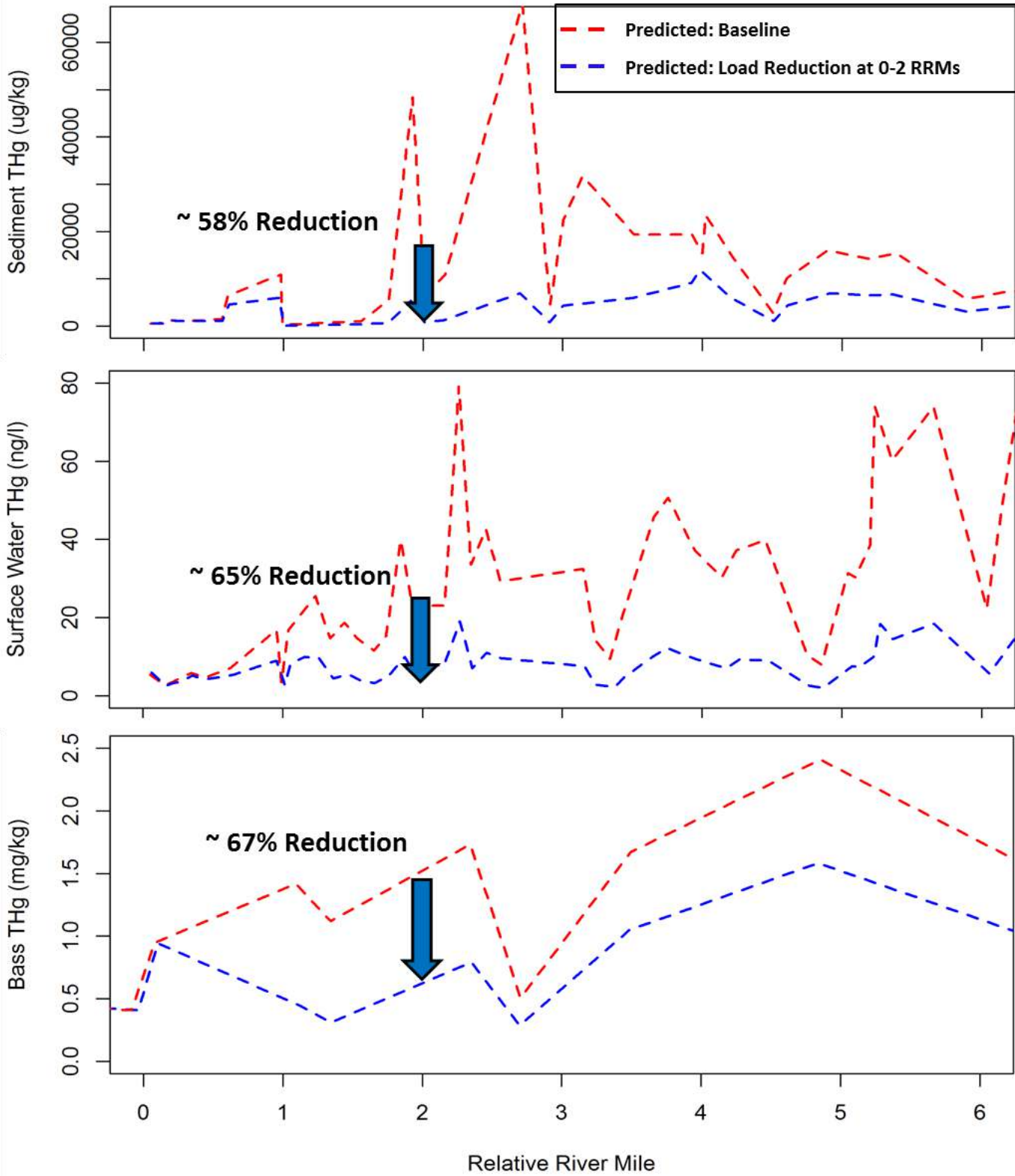
⁴ Forested land use is highly significant (<0.001) in Surface Water THg and MeHg

⁵ Include % shore erosion, deposition, and floodplain area adjacent to the RRM



PREDICTIONS

Figure 4: Statistical model projections for the baseline scenario and a potential remediation scenario



DISCUSSION

- Statistical models included complex interaction terms among some of the explanatory variables, which improve model performance compared to models without interaction terms.
- Models are robust (they explain ~47-64% of the variability in dependent variables) but do not consider mechanistic aspects.
- Models do not consider temporal aspects; as such they cannot predict the time-frame to achieve the predicted conditions.
- Bank loadings are a critical component in the models, including interactions with river discharge and precipitation; no other variable *consistently* has comparable impacts to reductions in THg and MeHg concentrations.
- A power analysis based on the predictions of the statistical model confirm that the number of samples being collected as a part of the SR monitoring program is sufficient to be able to detect significant decreases in Hg in all media type.
- Predictions using the statistical models support the evaluations for the South River Relative Risk Models (see Thakali et al, **Poster MP-114**) and the Enhanced Adaptive Management (see Grosso et al, **Poster RO-081**)

