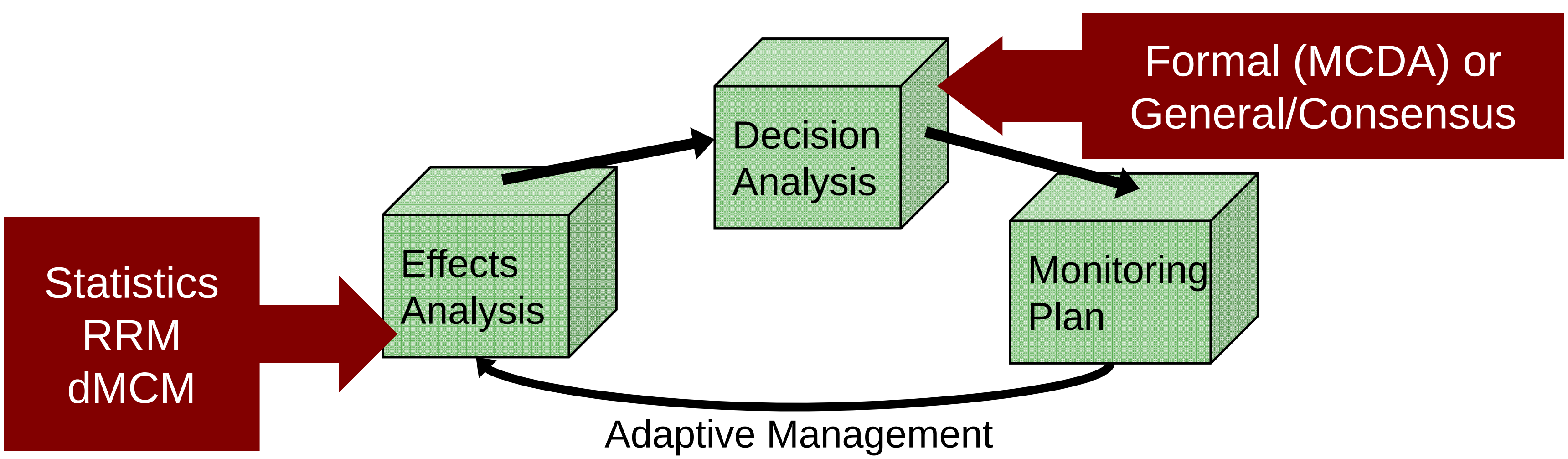
Objectives

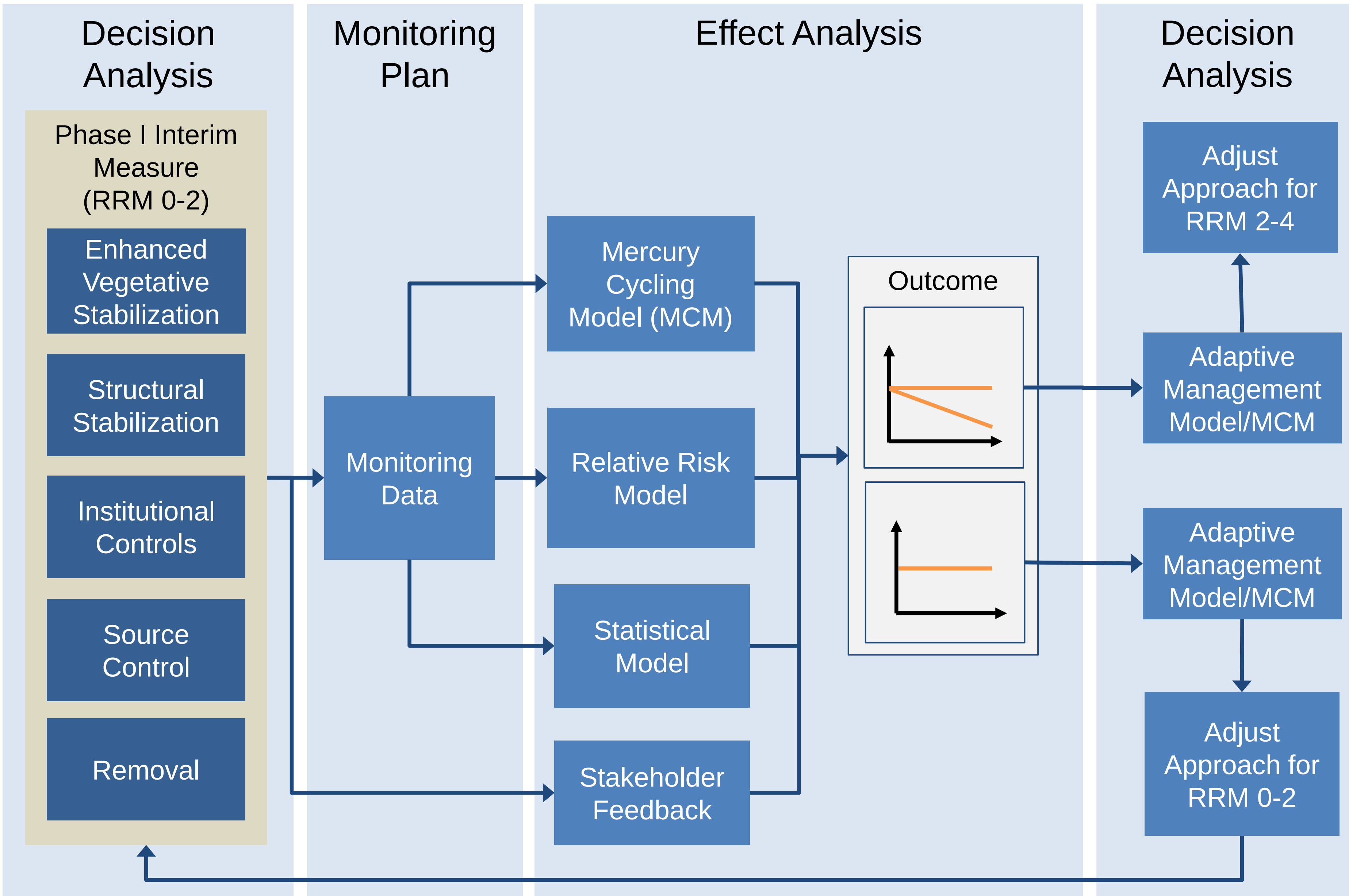
- Describe how the various models in use for AOC 4 can be integrated in the Enhanced Adaptive Management (EAM) Framework
- Identify data inputs for various models to identify missing/inadequate data
- Define goals, scope and construction of a simulated data set to test models

Model Integration: General Relationships

- **EAM Key Requirements:**
  - ***Decision analysis*** to prioritize management strategies given objectives and uncertainties in the future states
  - ***Effects analysis*** to define potential range of future states
  - ***Monitoring plan*** to collect data that informs management decisions about key conditions



Model Integration: Detailed Example



EAM Input Summary Matrix

EAM Input	Objective	Spatial Scale	Data Input	Data Output
Relative Risk Model	-Assess the relative threat posed by different risk sources, and their stressors, to selected endpoints in AOC 4.	Risk regions: RRM -3.4 to 1.6 RRM 1.6 to 7.2 RRM 7.2 to 15.1 RRM 15.1 to 24.1 RRM 24.1 to 32.2	-Avian[1] blood MeHg -Habitat -Air, water temperature -Fish[2] tissue THg -Water quality[3]	-Numeric score indicating relative importance of different risks to the endpoints in risk regions
Dynamic Mercury Cycling Model	-Predict and assess THg loading reductions due to bank stabilization -Interpret monitoring data -Address uncertainty	RRM 0 to 25	-THg and MeHg loading[4] -Water quality[5] -Sediment THg and MeHg, physical parameters[6], cores -Pore Water THg, MeHg, DOC -Food Web THg, MeHg	-Predictions of THg and MeHg concentrations in abiotic and biotic media over various spatial and temporal scales
Statistical Model	-Predict the effect of bank stabilization on mercury concentrations in other environmental compartments	RRM 0 to 2 (currently)	-Precipitation, discharge -THg and MeHg in surface water, sediment, biota -Bank erosion and THg loading -Geomorphology	-Surface water THg and MeHg -Sediment THg -Smallmouth bass THg

Notes:

EAM: Enhanced Adaptive Management
RRM: Relative River Mile
MeHg: Methylmercury
THg: Total mercury
DOC: Dissolved organic carbon
[1]Kingfisher, Carolina Wren
[2]Smallmouth Bass, White Sucker
[3]Water Quality, Fishing/Swimming/Boating River Use
[4]Includes surface water loading and bank loading
[5]THg, MeHg, DOC, temperature, pH, total suspended solids
[6]Grain Size, organic carbon, bulk density/porosity

Relative Risk Model Inputs

- Many redundancies
- Endpoints can be simplified:
  - Mercury in adult fish
  - Water quality:
    - Temperature/DO
    - Discharge
    - Bacteria

RRM Endpoint	Parameters of Importance	Number of Regions	Monitoring Parameters Required	LTM	DEQ	USGS	Other
Belted Kingfisher	Mercury	5	Blood samples				
	Fish Length	5					
	Potential Habitat	2	Land use type	✓			
	Territory	3	Nests per length of river section				
Carolina Wren	Mercury	4	Blood samples	✓			
	Nest Predation	5					
	Potential Habitat	2	Land use type	✓			
	Winter Air Temperature	4					✓
Smallmouth Bass	River Temperature	5				✓[1]	
	Mercury	5	Fish fillet mercury concentrations	✓	✓		
White Sucker	River Temperature	5				✓[1]	
	Stream Cover	5	Submerged aquatic vegetation cover	✓			
	Mercury	4	Fish fillet mercury concentrations		✓		
	Organic Contaminants	1					
Water Quality Standards	Dissolved Oxygen	5	Summer dissolved O2	✓			
	Bacteria	4	Bacteria indicators		✓		
	River Temperature	3	Winter temperature			✓[1]	
	River Discharge	3	Summer & winter discharge			✓[1]	
Fishing River Use	Dissolved Oxygen	5	Summer dissolved O2	✓			
	Methyl Mercury	4	Fish fillet MeHg concentrations	✓			
	River Temperature	5	Summer & winter temperature			✓[1]	
Swimming River Use	Bacteria	4	Bacteria indicators	✓			
	River Temperature	5	Summer & winter temperature			✓[1]	
	River Discharge	1	Summer discharge			✓	
Boating River Use	River Temperature	5	Summer & winter temperature			✓[1]	
	Bacteria	4	Bacteria indicators		✓		
	River Discharge	1	Winter discharge			✓	

Data are of sufficient spatial and temporal resolution
Data lack spatial or temporal adequacy
Data will not be collected

[1]Data are predicted for the South River based on USGS gage in Smith Creek near New Market.

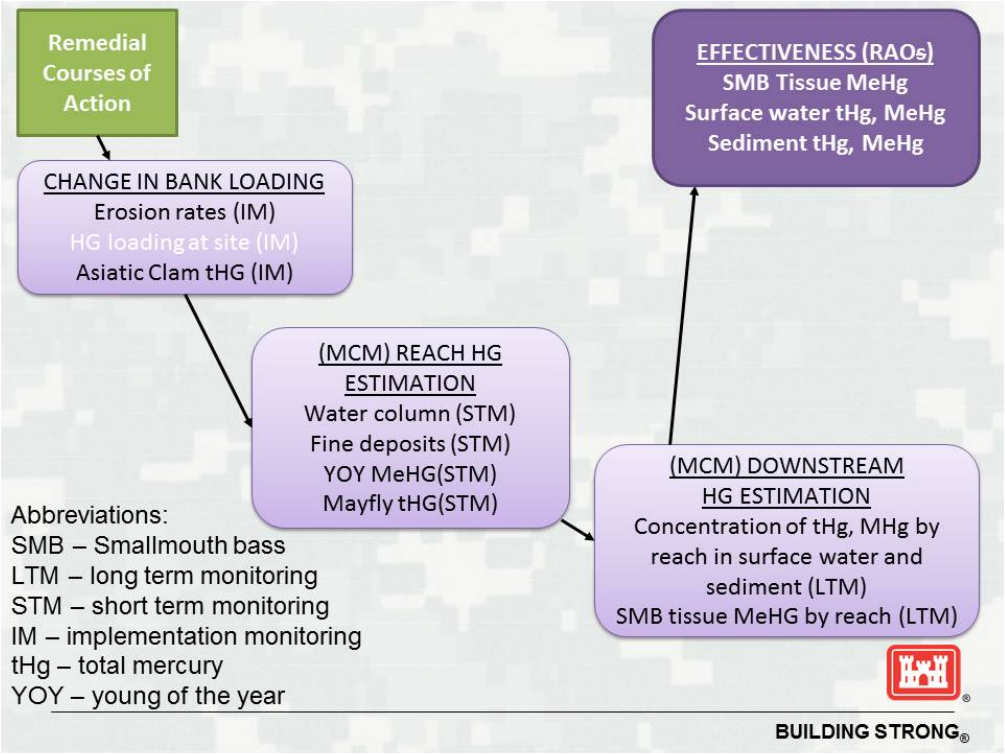
Data Inputs: Mercury Cycling Model

- Time-dependent mechanistic model
- Predicts the cycling and bioaccumulation of MeHg, Hg(II), and Hg(0)
- Critical component of adaptive management model

Discharge	✓
Loading Rates	
Bank loading rates	✓
Outfall loading	✓
Water quality	
THg, MeHg	✓
DOC	✓
T	✓
pH	✓
TSS	✓
Sediment	
THg, MeHg	✓
Grain Size	✓
Organic carbon/LOI	✓
Bulk density/porosity	✓
Cores	✓
Pore Water	
DOC	✓
THg, MeHg	✓
Food Web	✓

Data Inputs: Enhanced Adaptive Management Model

- Model inputs:
  - Bank loading
  - Bass tissue
  - Surface water THg and MeHg
  - Sediment THg and MeHg
  - Benthic community condition
- Requires mass balance model (e.g., MCM)



Data Inputs: Statistical Model

- Stepwise regression on large number of factors:
  - Surface water, sediment, and floodplain mercury are basic elements of all models
  - River is dynamic system, with surface water, sediment, floodplain, discharge, rainfall, pore water, etc. interacting
- Pros and cons:
  - \+ No theoretical mechanistic model is force fit to the data
  - \+ Statistical modeling attempts to evaluate all data for relevance
  - – There may be no framework by which to explain the associations

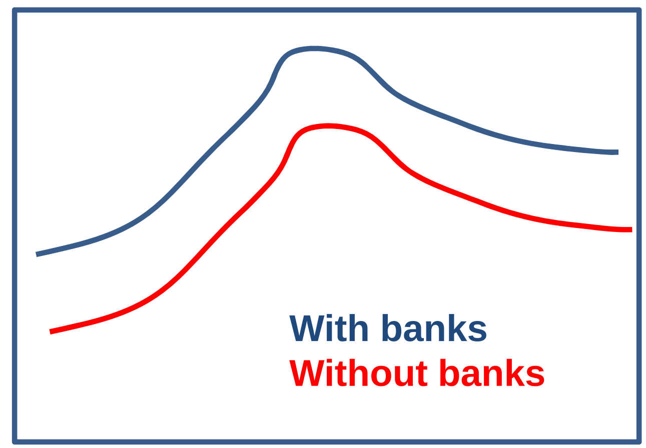
Simulated Data Set: Goals and Approach

- Goals:
  - Provide data to test EAM/MCM and RRM
  - Simulate potential post-remediation conditions in the South River
  - Identify missing, inadequate, or redundant data
  - Test statistical power of monitoring plan elements

- Approach:
  - Use statistical model to predict reductions for different remedial alternatives
  - Test response to various % reductions in bank THg loading in river reaches

Simulated Data Set Results

- Predict effect of bank THg loading reductions on:
  - YOY bass
  - Surface water mercury
    - IHg, MeHg
    - Total, filtered, particulate
  - Interstitial sediment THg and MeHg
- Time to achieve effect(s) unknown
- Future runs may include clams, mayflies, spiders or other data



Relative River Mile