Watershed Model Calibration

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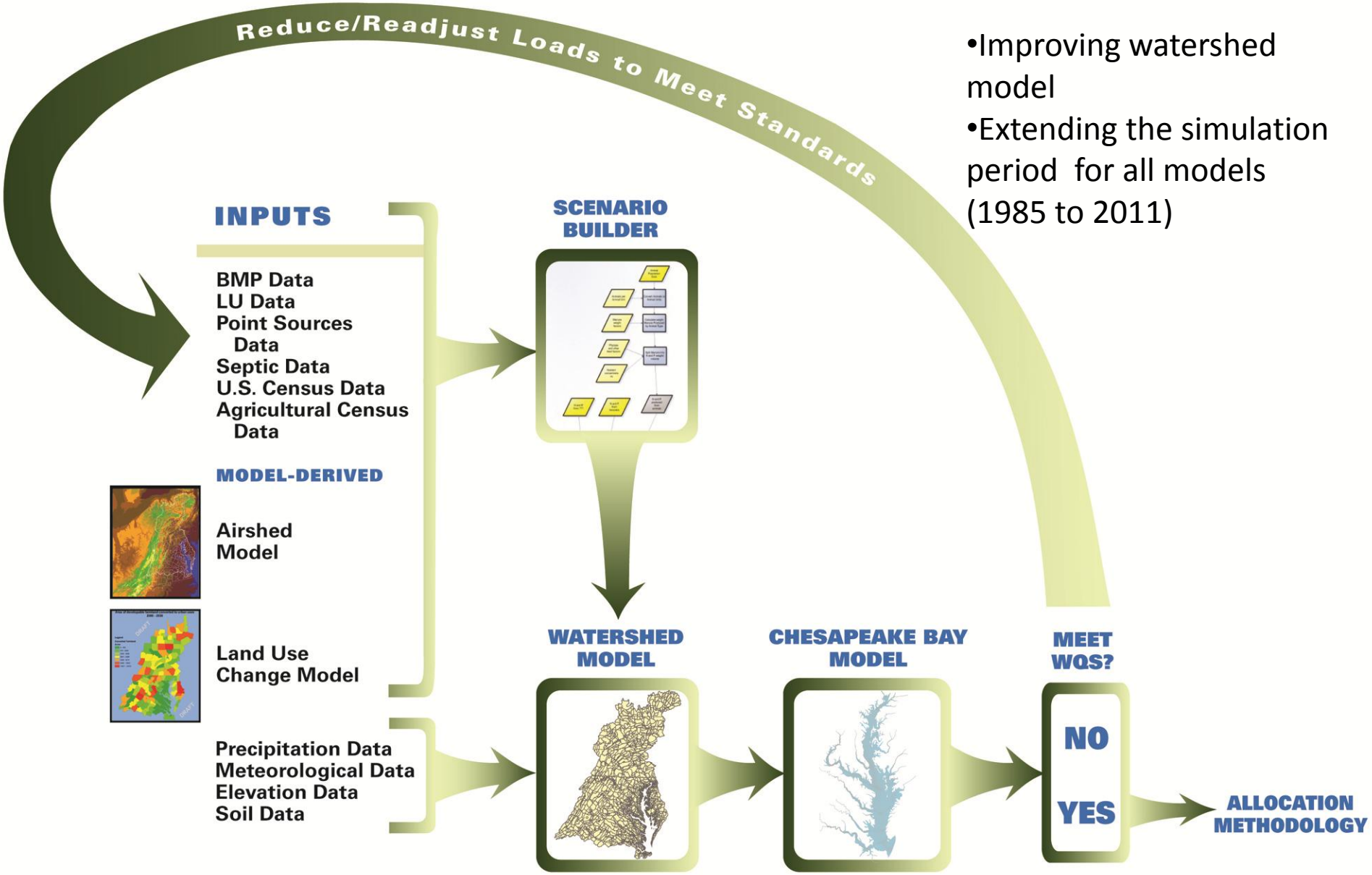
Gary Shenk, Gopal Bhatt CBPO
WQGIT 10/8/2014

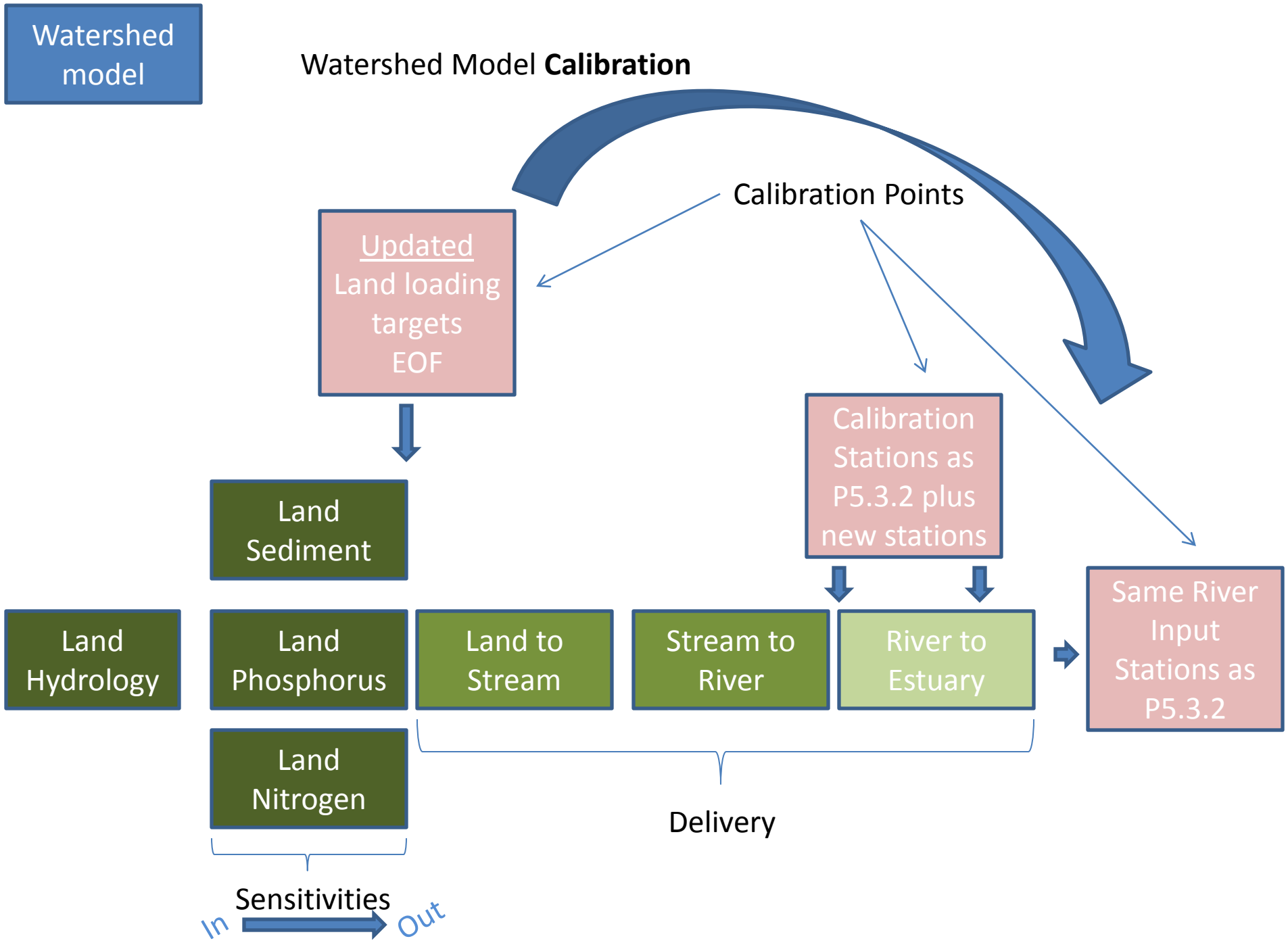
Chesapeake Bay Partnership Models



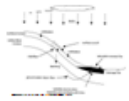
- Improving watershed model
- Extending the simulation period for all models (1985 to 2011)

Watershed Model Calibration

- Compares outputs of the model to observed data
- Ensures accuracy of the model and provides consistency with previously developed models
- Data applied in the calibration
  - Within modeling workgroup
    - Same flow stations
    - Same river water quality monitoring stations and data used throughout watershed
    - Same large river input loading stations used
    - Plus…extension of calibration data where available
  - Spanning multiple workgroups
    - Loading targets are under literature review


Watershed model
Watershed Model **Calibration**
Calibration Points
Updated
Land loading targets
EOF
Calibration Stations as P5.3.2 plus new stations
Land Sediment
Land Hydrology
Land Phosphorus
Land to Stream
Stream to River
River to Estuary
Same River Input Stations as P5.3.2
Land Nitrogen
Delivery
Sensitivities
In
Out

Scale in the Chesapeake Bay Program Watershed Model

Landscape	Phase 5		Phase 6		Sparrow	Other Data Sources
	Nutrients	Sediment	Nutrients	Sediment		
Field   		**AG and Forest:** Used RUSLE2 to estimate EOF sediment targets **Urban**: Used Langland and Cronin To estimate pervious vs impervious loading	*Can we estimate EOF loads directly based on available information?*	*Should we update the sediment EOF estimates?*	Sources (fertilizer, manure, atdep, urban area) multiplied by global coefficients	Literature Reviews from TetraTech Sources in Phase 5 documentation Sensitivity documentation CEAP APLE
Land to stream   	Field-level, hillslope, and small stream processes are all combined in the Edge-of-Stream nutrient estimates No EOF is simulated EOS estimates are a combination of regional factors and field-scale process simulation calibrated to average export rates Informed by inputs and calibration	Hillslope and small stream processes are combined in a sediment delivery ratio that is based on the average distance between each major land use type and a major river, adjusted for the coastal plain.	*Can we estimate watershed delivery based on landscape parameters?*		Land to Water factors such as soil parameters and slopes	ICPRB/USGS Sparrow Land Data team Connected Impervious Land Data team Urban Tree Canopy
Stream to River   			*Can we estimate small stream effects?*		Explicitly simulated to NHD+ level	ICPRB/USGS Sparrow Land Data team Urban Stream Corridor Land Data team Riparian Forest Land Data team Riverine Wetlands Center for Watershed Protection CBP Grant
River to Estuary   	Directly Simulated in HSPF for river averaging at least 100 cfs Calibrated to WQ data		Directly Simulate in HSPF for river averaging at least 100 cfs Calibrate to WQ data		Explicitly simulated	Calibrate to sparrow DFS or loads?

Scale in the Chesapeake Bay Program Watershed Model

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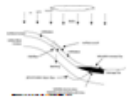
Land to stream   	Field-level, hillslope, and small stream processes are all combined in the Edge-of-Stream nutrient estimates No EOF is simulated EOS estimates are a combination of regional factors and field-scale process simulation calibrated to average export rates Informed by inputs and calibration	Hillslope and small stream processes are combined in a sediment delivery ratio that is based on the average distance between each major land use type and a major river, adjusted for the coastal plain.				
Stream to River    						
River to Estuary   	Directly Simulated in HSPF for river averaging at least 100 cfs Calibrated to WQ data					

- Phase 5 had calibrated regional Factors to account for differences in small watershed and small stream delivery
- Necessary to meet water quality measurements
- Presented difficulties in communication

Scale in the Chesapeake Bay Program Watershed Model

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	Nutrients	Sediment	Nutrients	Sediment		
Field   		**AG and Forest:** Used RUSLE2 to estimate EOF sediment targets **Urban**: Used Langland and Cronin To estimate pervious vs	*Can we estimate EOF loads directly based on available information?*	*Should we update the sediment EOF estimates?*	Sources (fertilizer, manure, atdep, urban area) multiplied by global coefficients	Literature Reviews from TetraTech Sources in Phase 5 documentation Sensitivity documentation CEAP APLE
Land to stream  					Land to Water factors such as soil parameters and slopes	ICPRB/USGS Sparrow Land Data team Connected Impervious Land Data team Urban Tree Canopy
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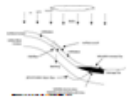
- If we can describe the function of hillslopes and small streams ….

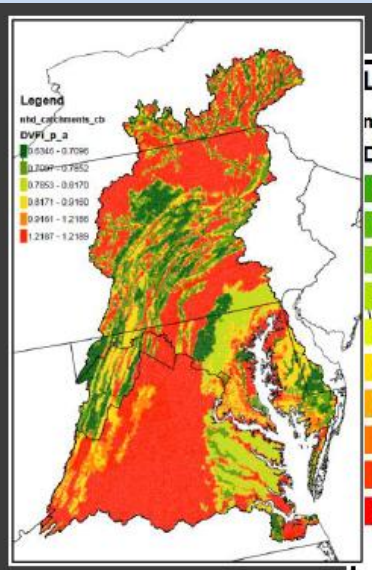
Scale in the Chesapeake Bay Program Watershed Model

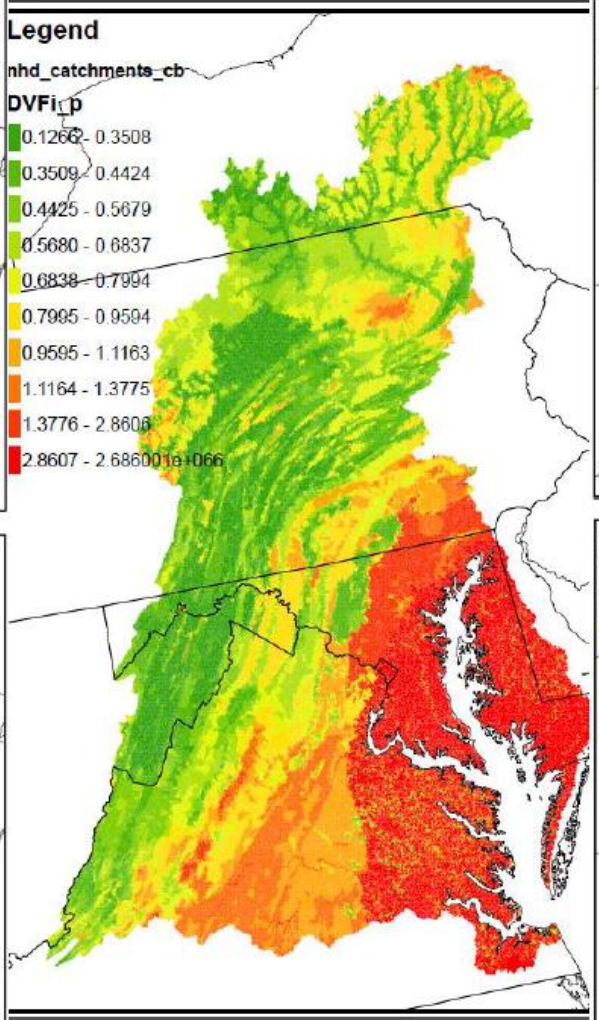
Landscape	Phase 5 Nutrients	Phase 5 Sediment	Phase 6 Nutrients	Phase 6 Sediment	Sparrow	Other Data Sources
Field   		**AG and Forest:** Used RUSLE2 to estimate EOF sediment targets **Urban**: Used Langland and Cronin To estimate pervious vs impervious loading	*Can we estimate EOF loads directly based on available information?*	*Should we update the sediment EOF estimates?*	Sources (fertilizer, manure, atdep, urban area) multiplied by global coefficients	Literature Reviews from TetraTech Sources in Phase 5 documentation Sensitivity documentation CEAP APLE
Land to stream   	Field-level, hillslope, and small stream processes are all combined in the Edge-of-Stream nutrient estimates No EOF is simulated EOS estimates are a combination of regional factors and field-scale process simulation calibrated to average export rates Informed by inputs and calibration	Hillslope and small stream processes are combined in a sediment delivery ratio that is based on the average distance between each major land use type and a major river, adjusted for the coastal plain.	*Can we estimate watershed delivery based on landscape parameters?*			
Stream to River    			*Can we estimate small stream effects?*			CBP Grant
River to Estuary   	Directly Simulated in HSPF for river averaging at least 100 cfs Calibrated to WQ data		Directly Simulate in HSPF for river averaging at least 100 cfs Calibrate to WQ data		Explicitly simulated	Calibrate to sparrow DFS or loads?

… we can put them into phase 6

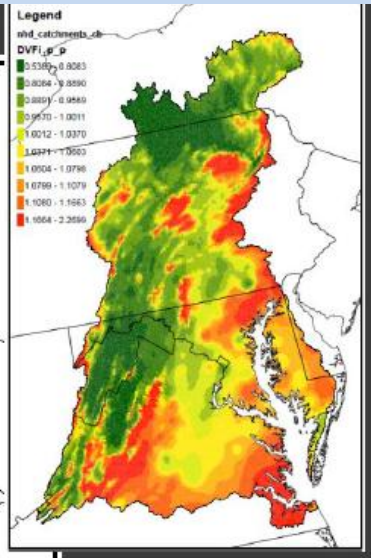
Sparrow estimates of phosphorus processes from land to water

Type A Soils (-)

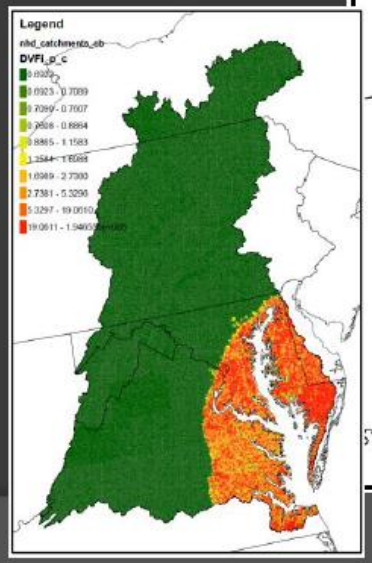




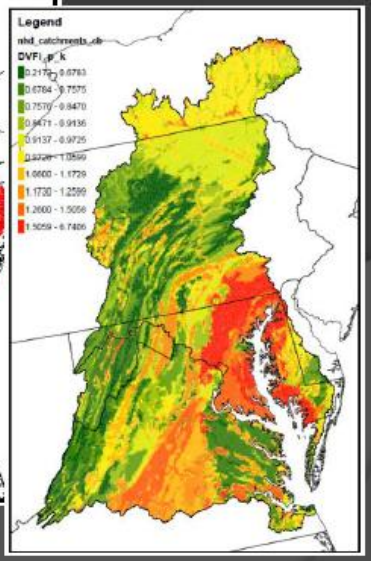
Precip (+)



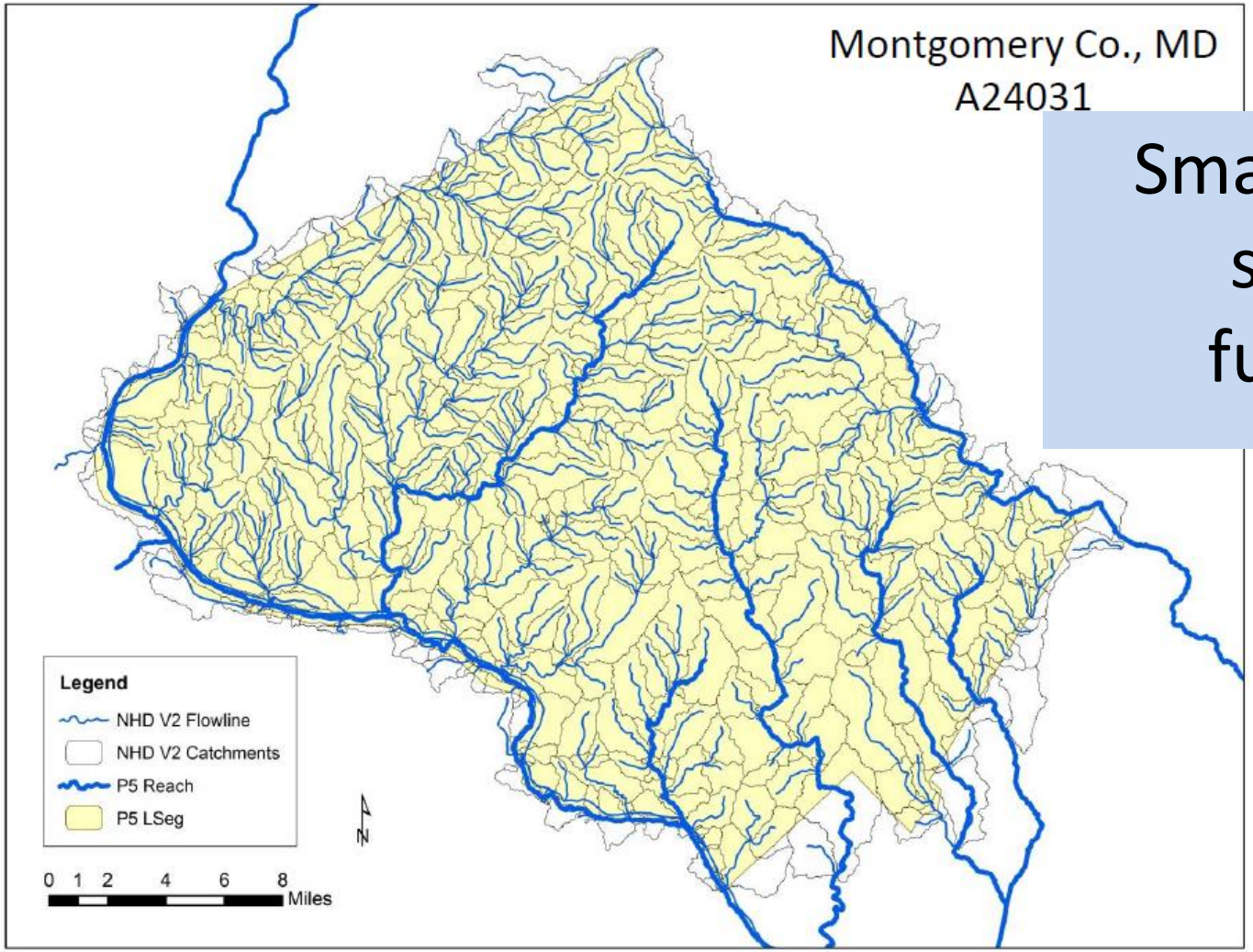
Coastal Plain (+)



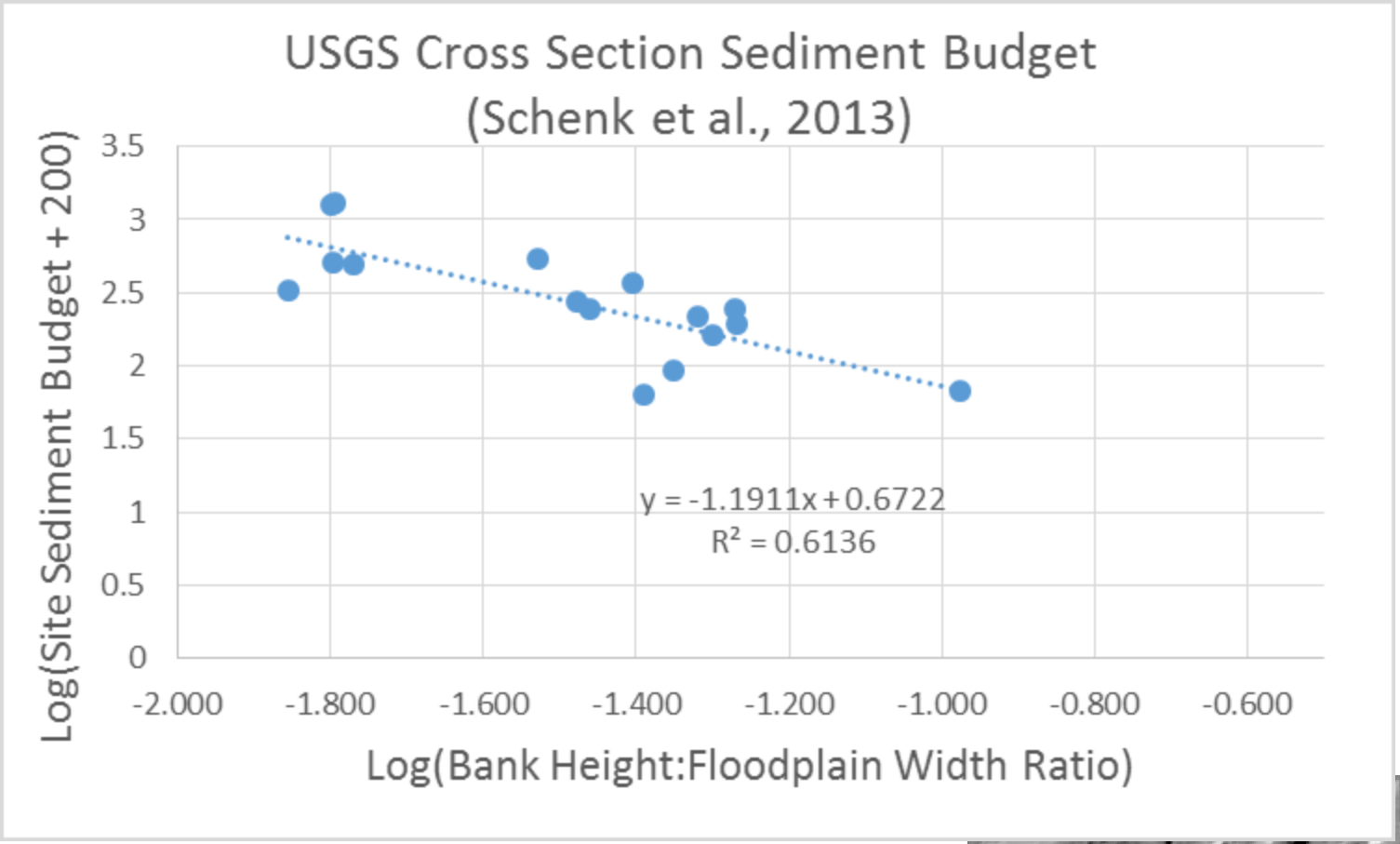
Soil K-factor (+)



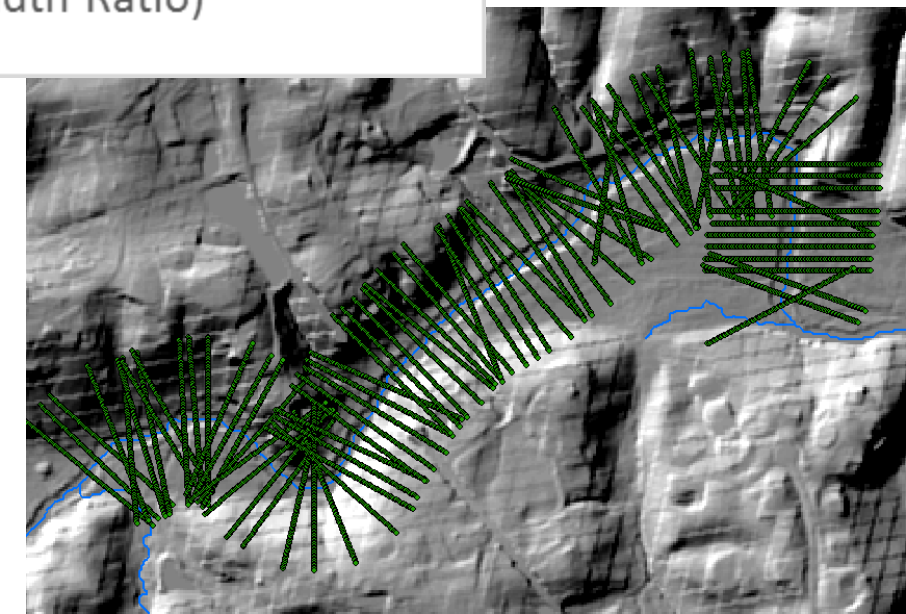
SPARROW Scale vs. P6 Scale



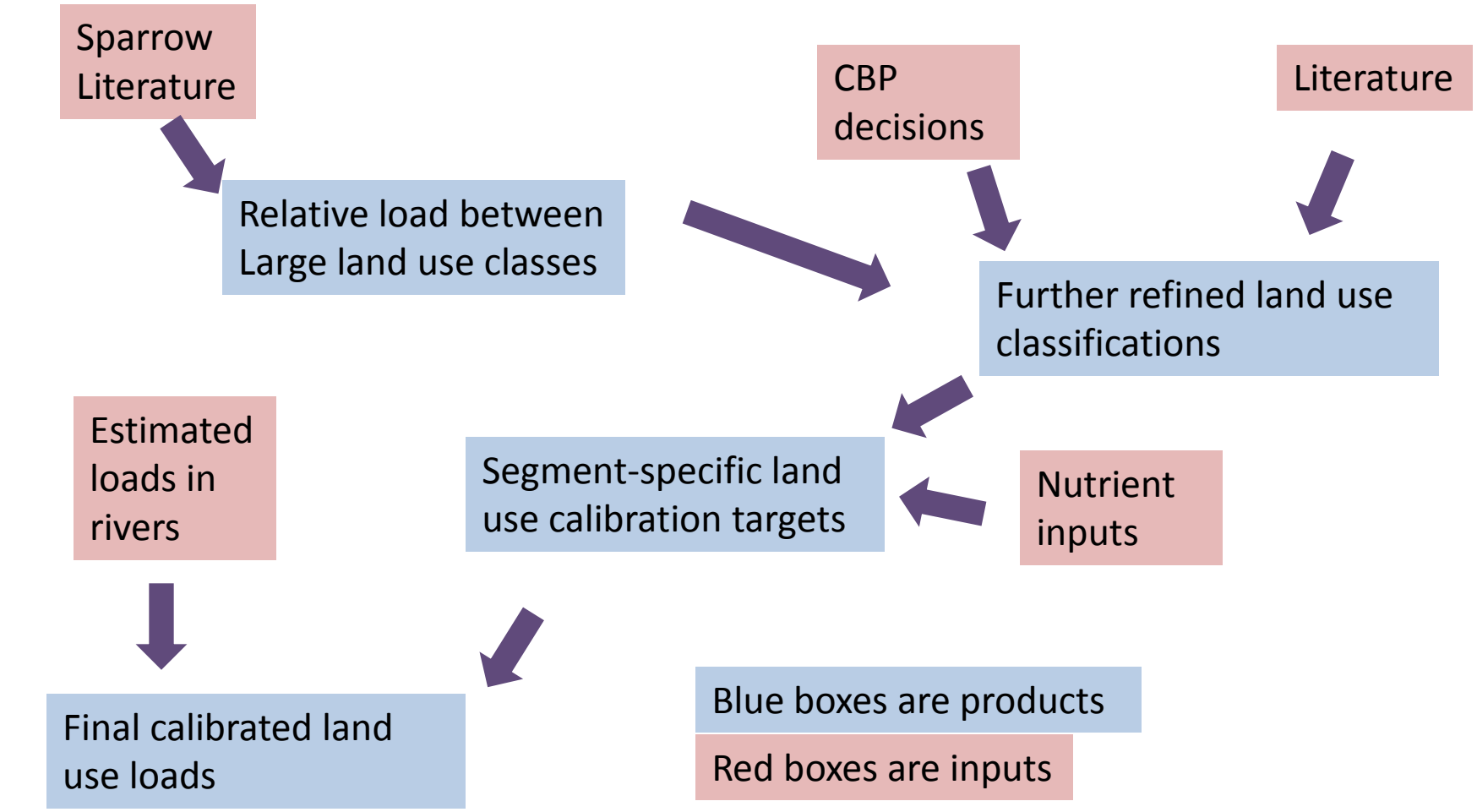
Small scale stream function



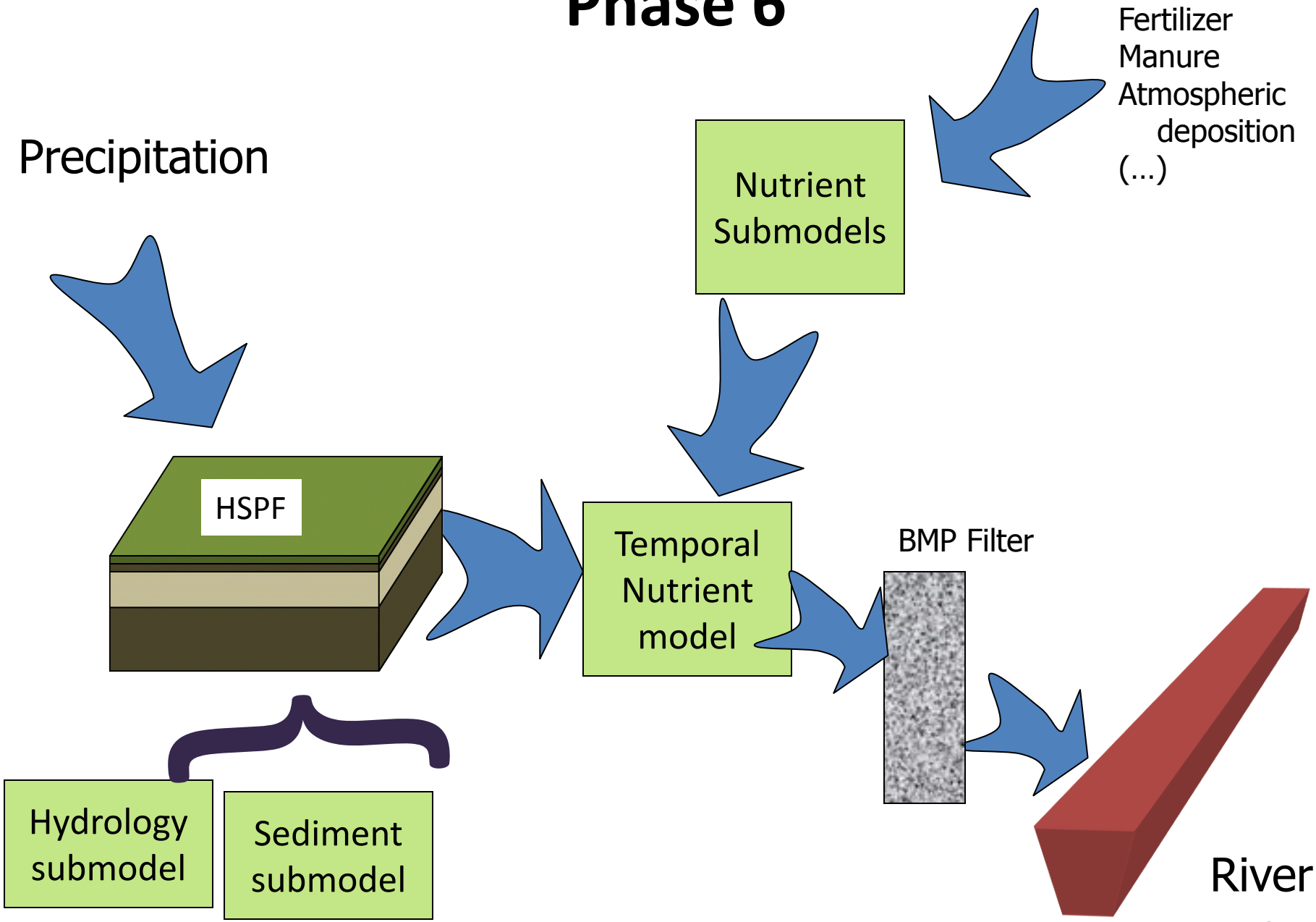
Small scale stream function



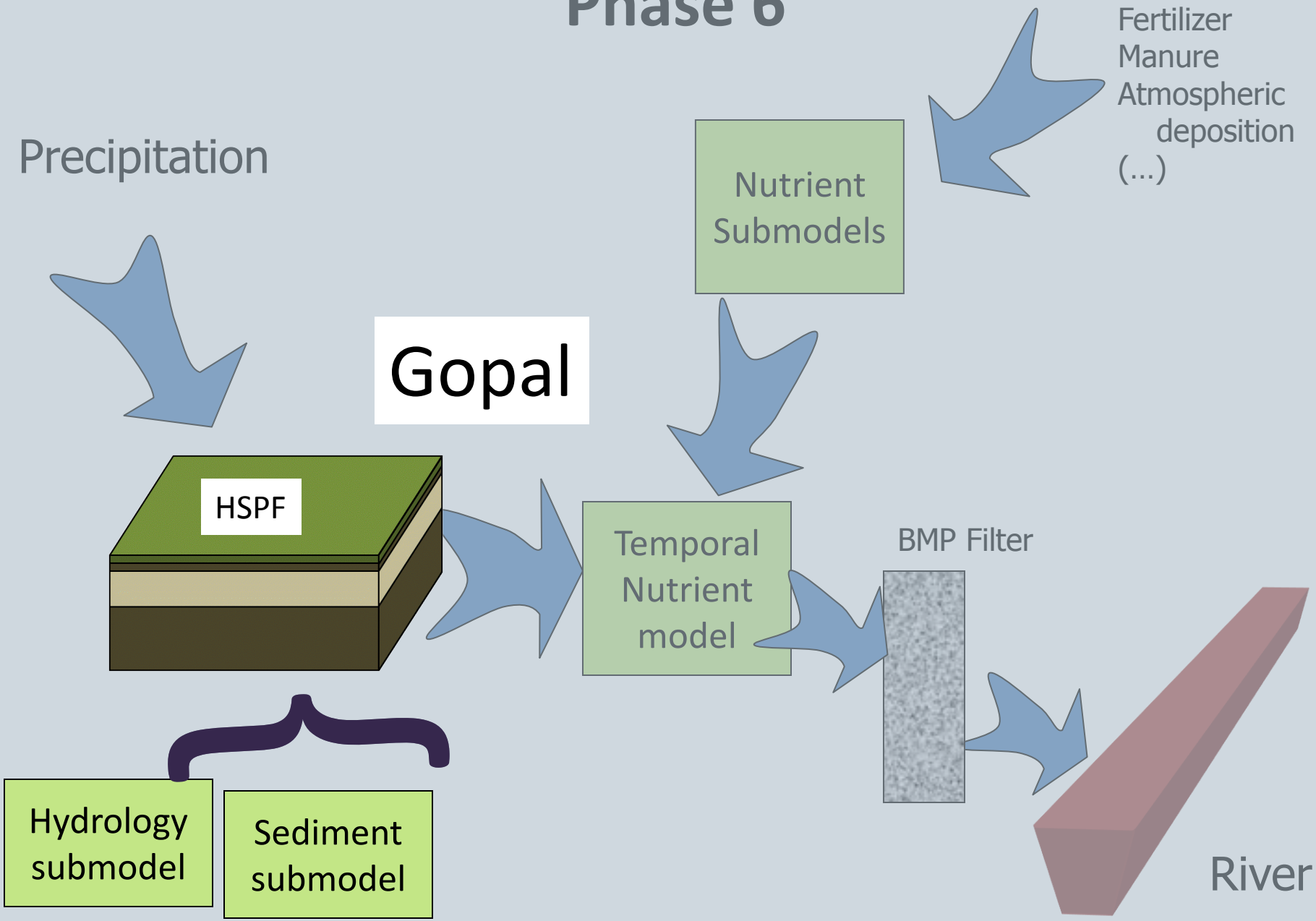
Land Use Load Decisions – Phase 6



Phase 6


Fertilizer
Manure
Atmospheric deposition
(…)
Nutrient Submodels
Precipitation
HSPF
Temporal Nutrient model
BMP Filter
Hydrology submodel
Sediment submodel
River

Phase 6


Fertilizer
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(…)
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Gopal
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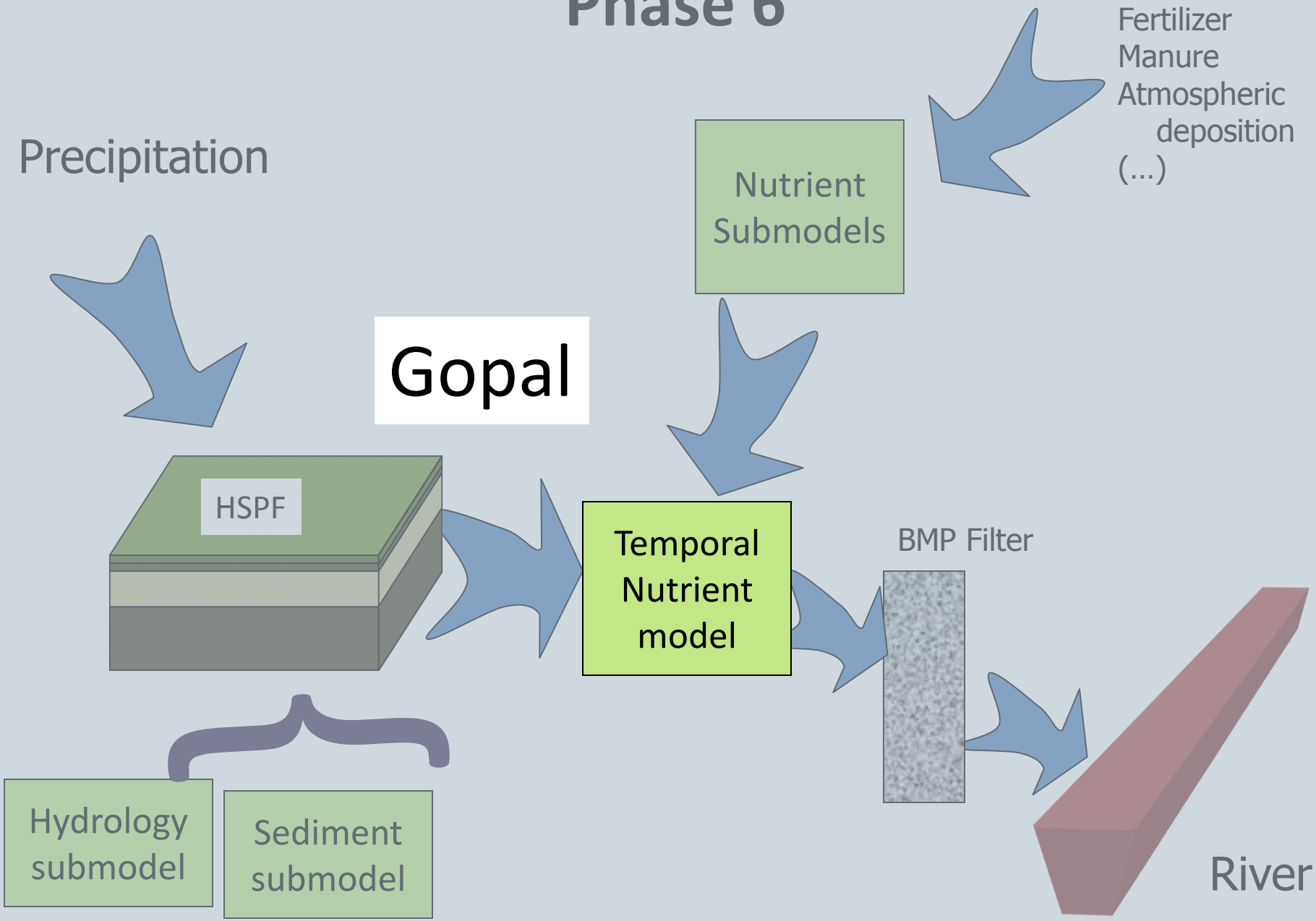
Phase 6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(…)
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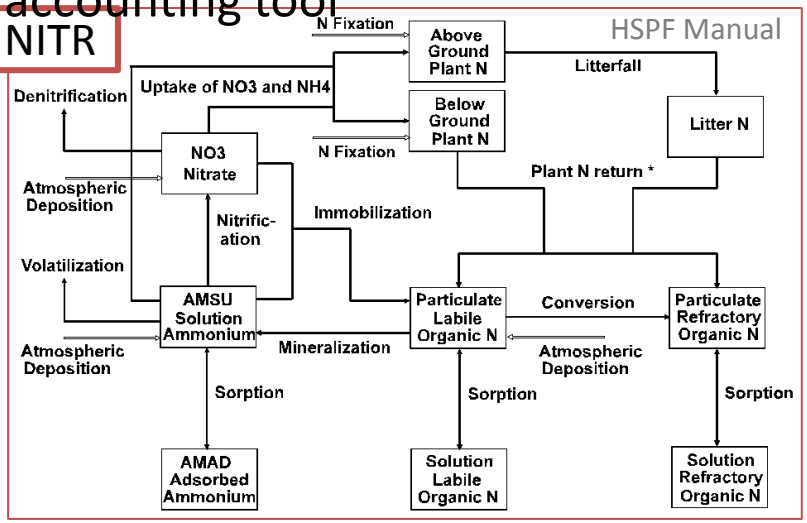
Temporal Nutrient model
BMP Filter
Hydrology submodel
Sediment submodel
River

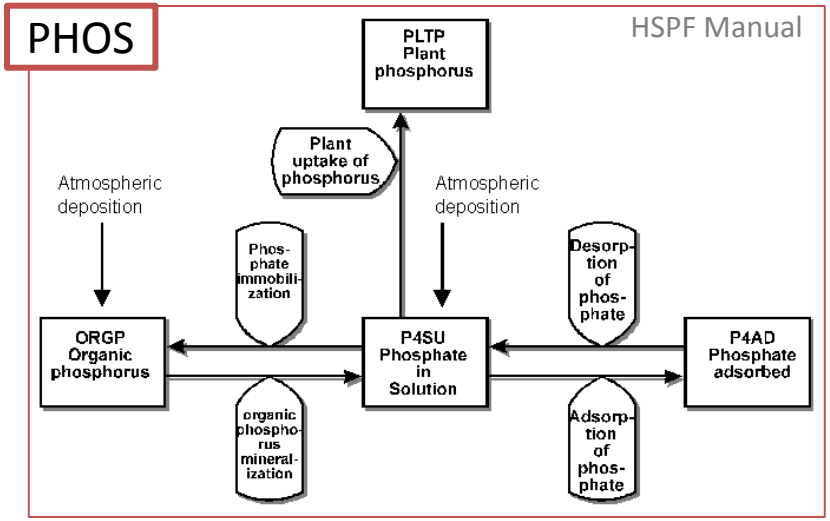
Revised Phase 6 Watershed Model Structure:

as a simple, transparent, and easy to understand accounting tool

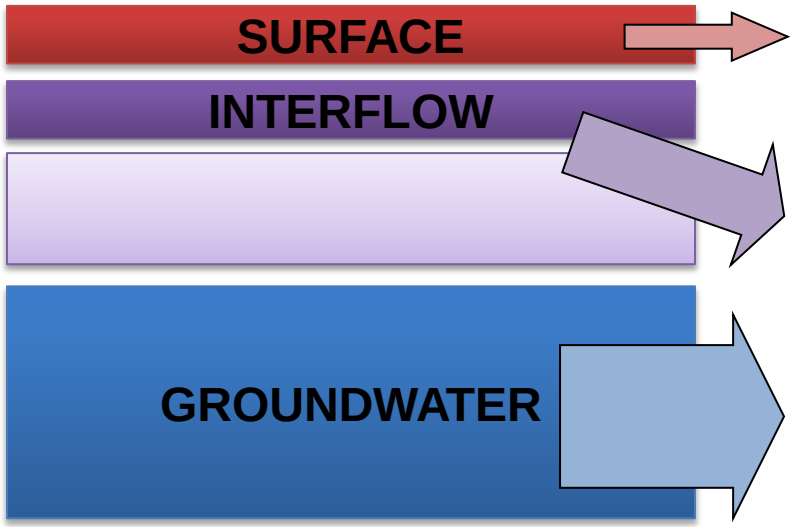
NITR



PHOS



PQUAL

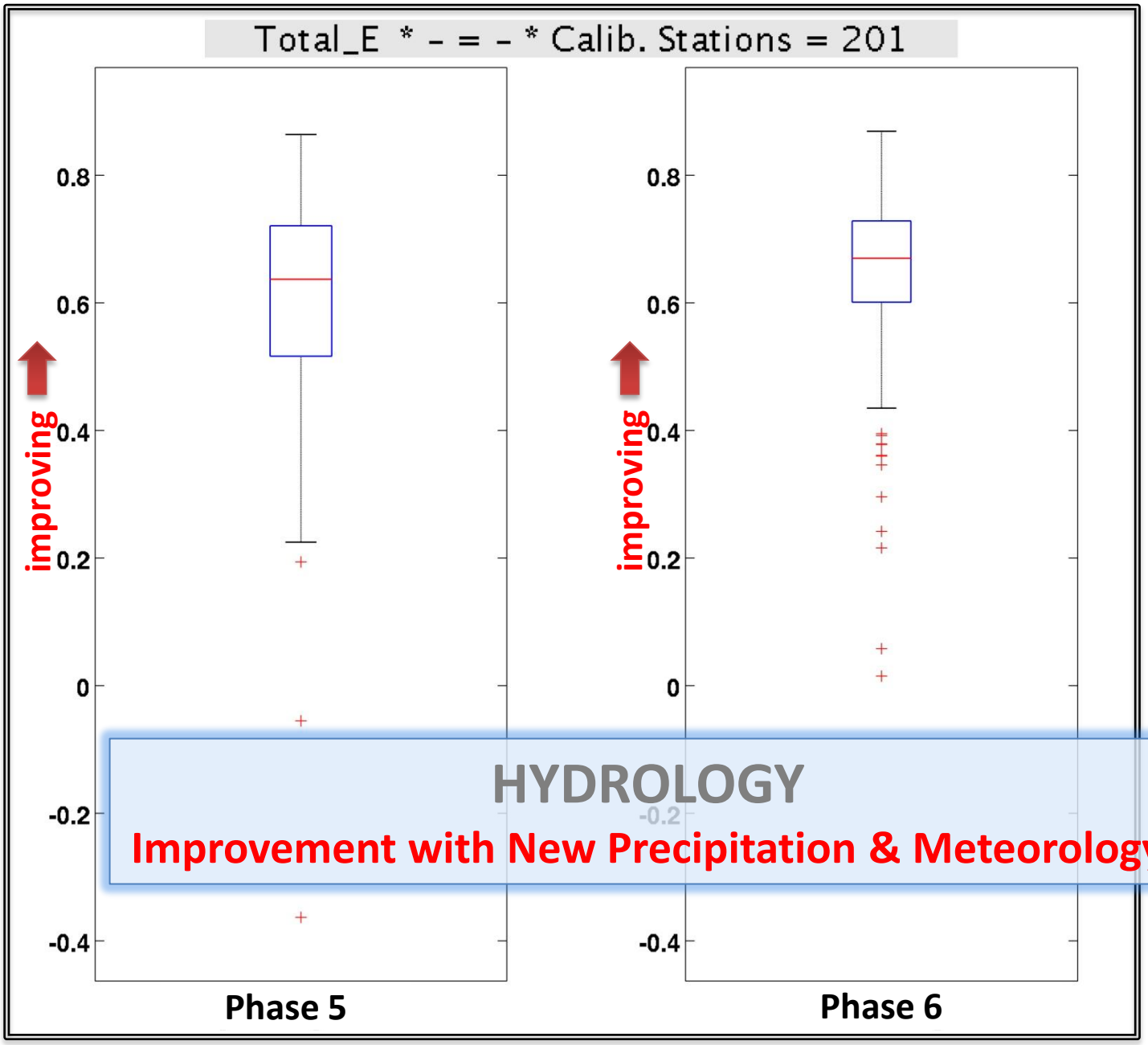


NH3 = Flow x Conc. + Sed x factor

NH3 = Flow x Conc.

NH3 = Flow x Conc.

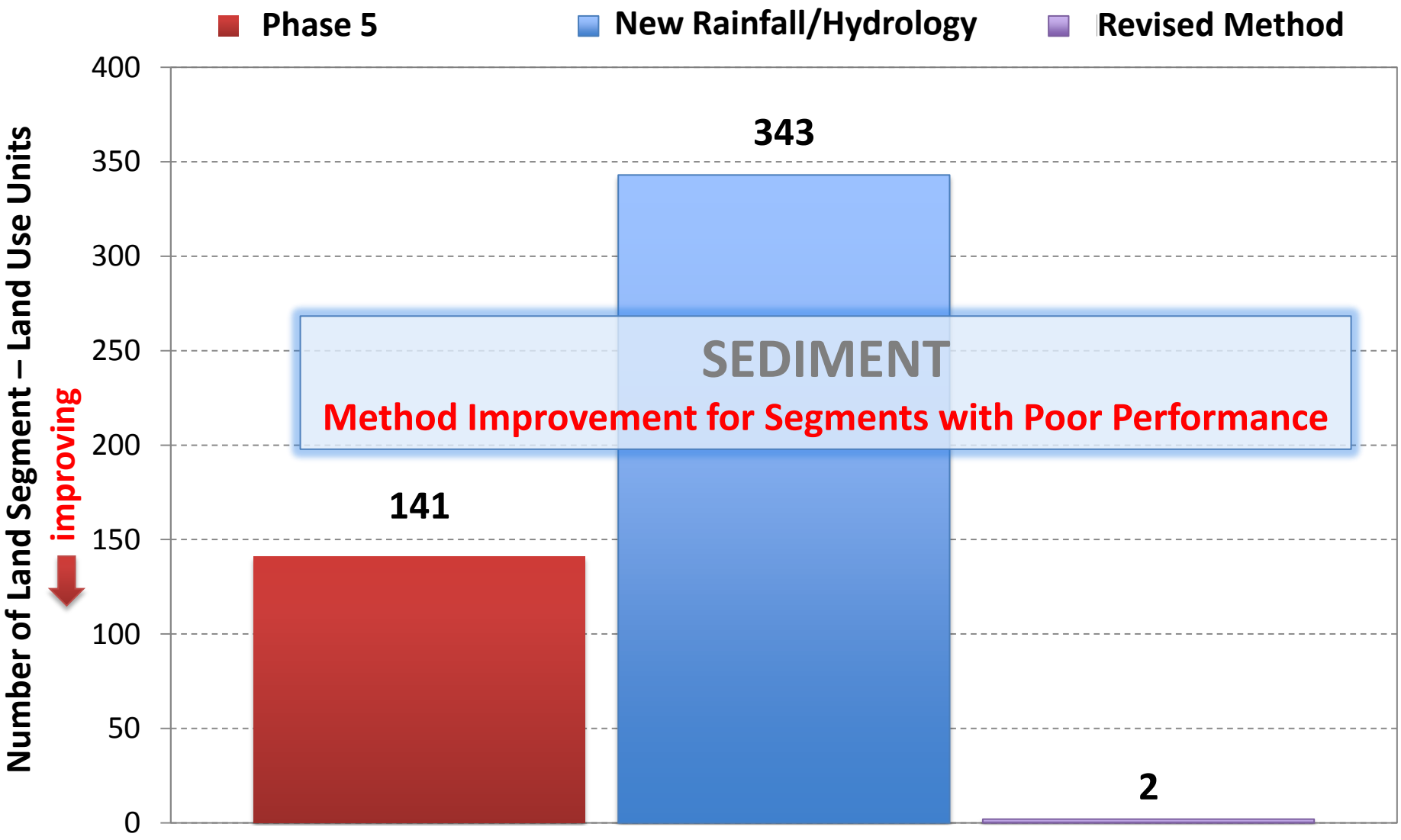
Adapted from Shenk, 2009



HYDROLOGY

Improvement with New Precipitation & Meteorology

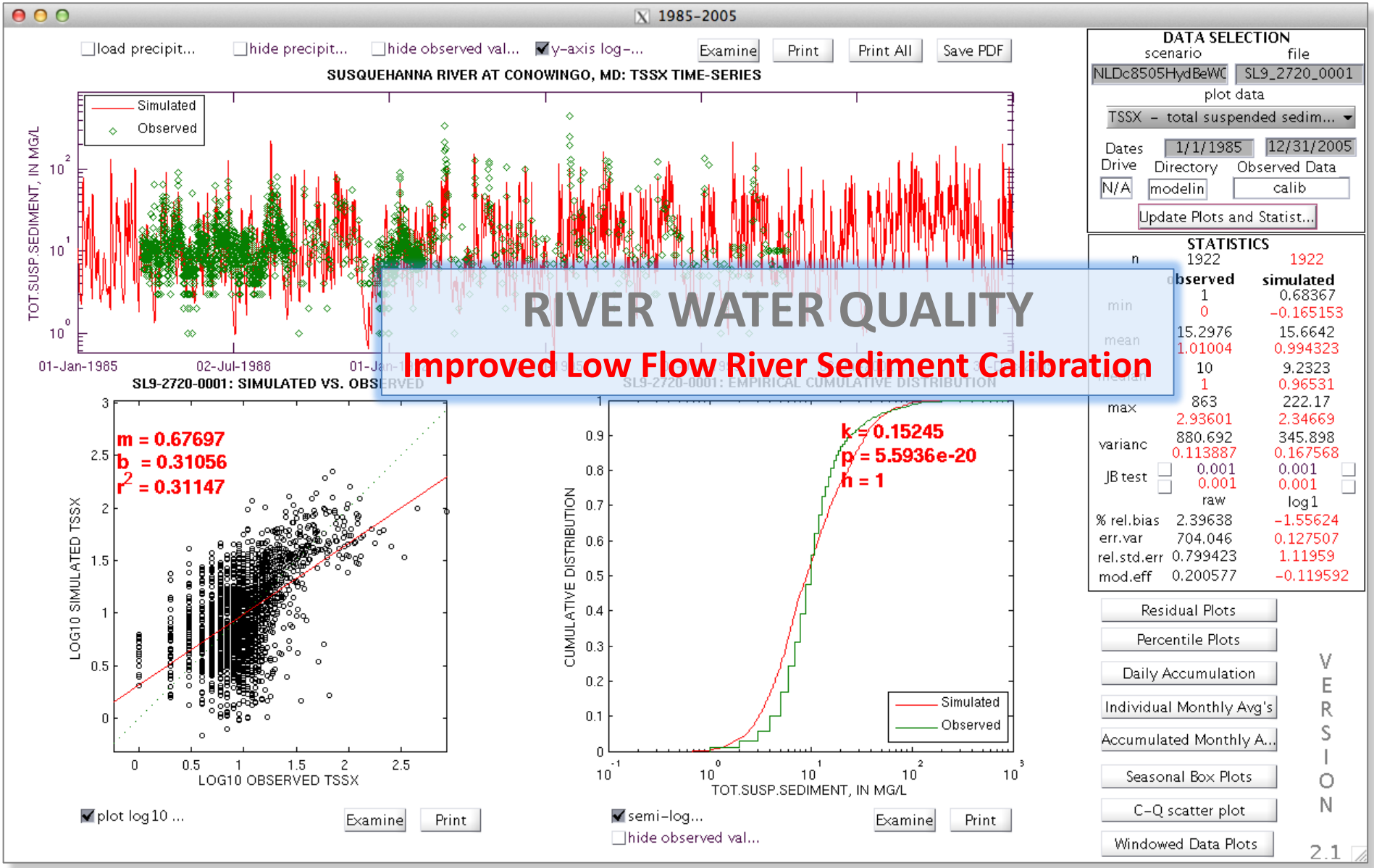
Improvement in Matching the a-priori *Targets**



* Total Number of Land Segments (367) x Number of **Pervious** Land Uses (25) = 9175

Prototype Phase 6 – TSSX : : 1985 – 2005

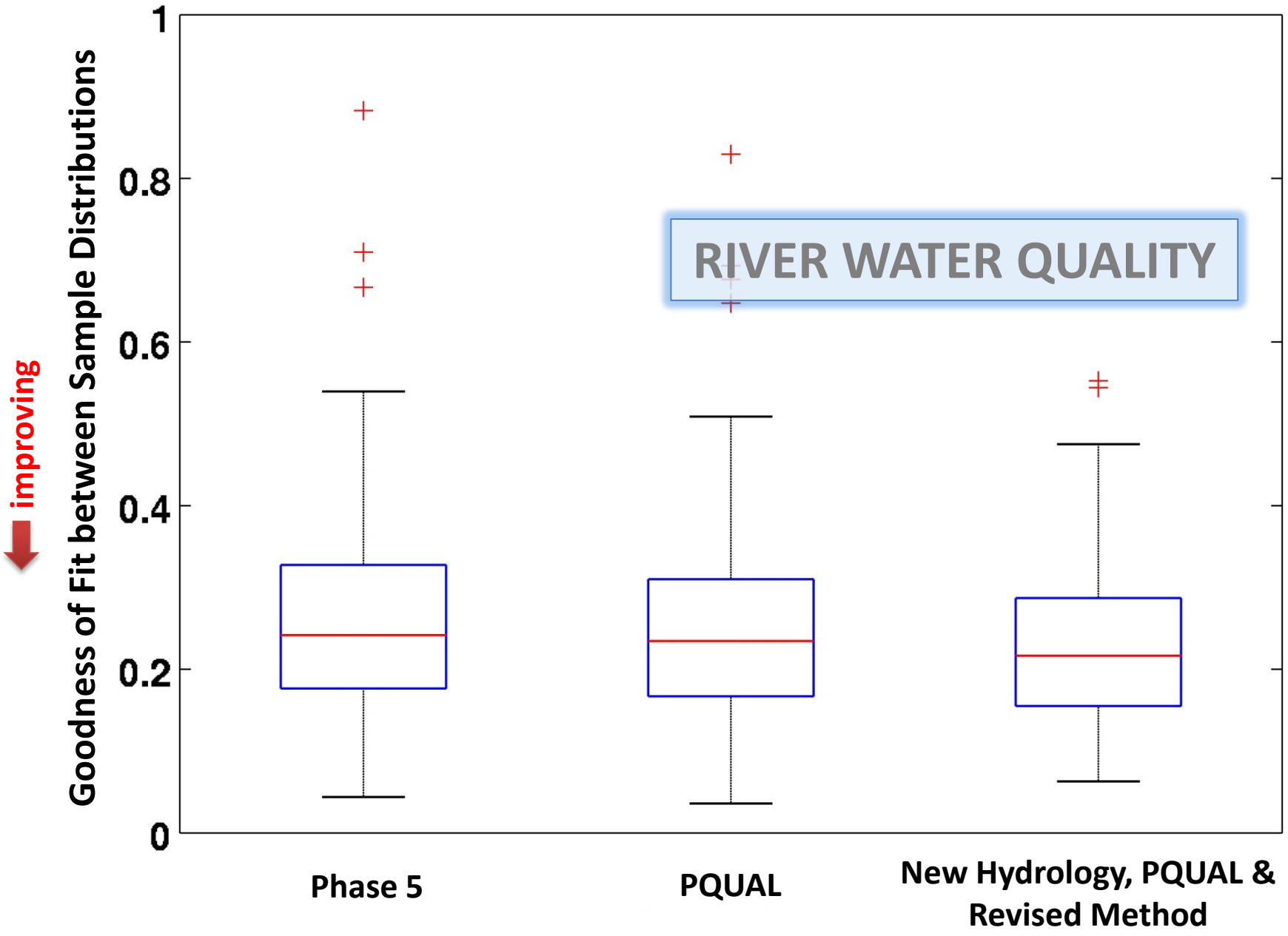
Susquehanna River near Conowingo, MD



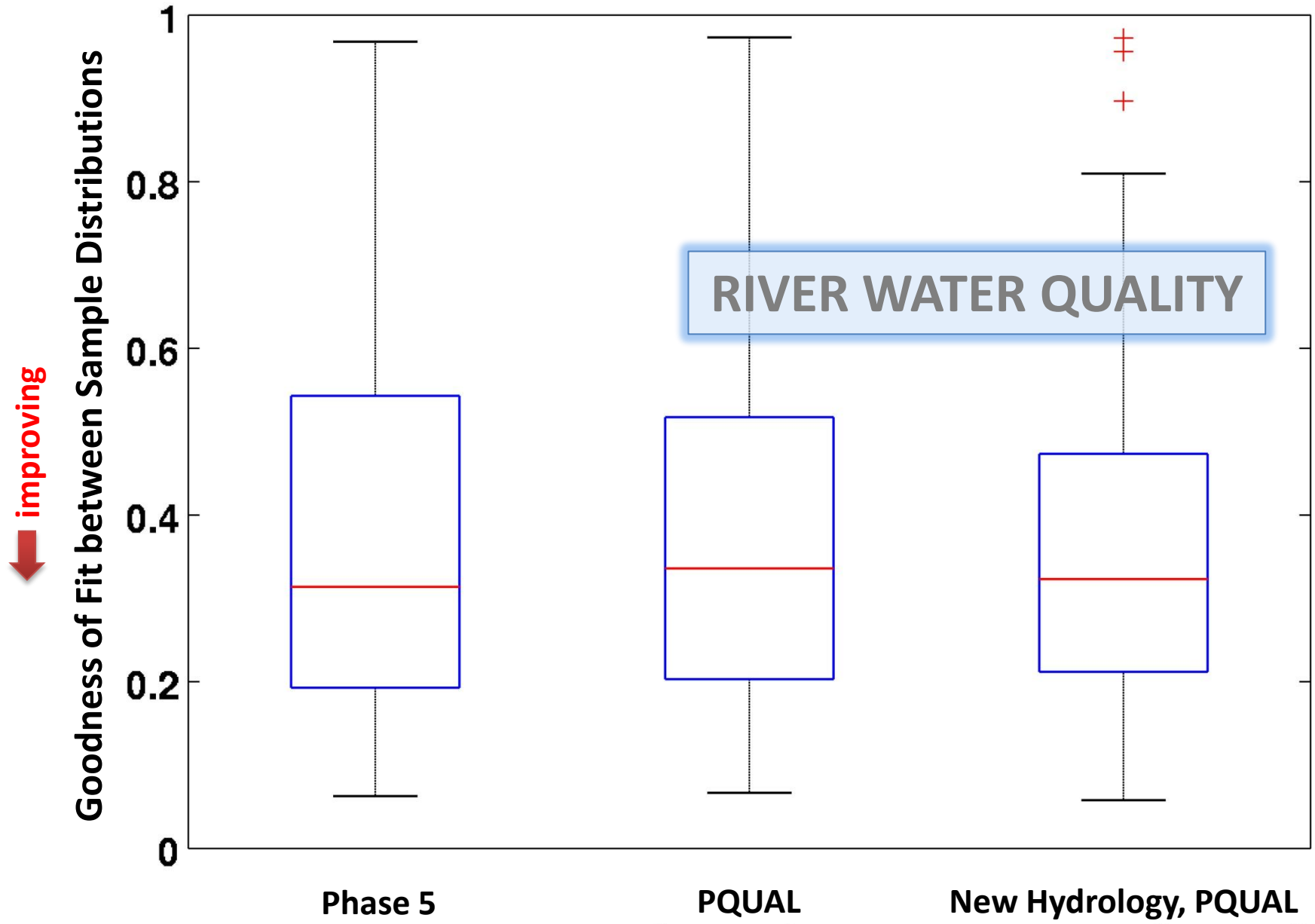
RIVER WATER QUALITY

Improved Low Flow River Sediment Calibration

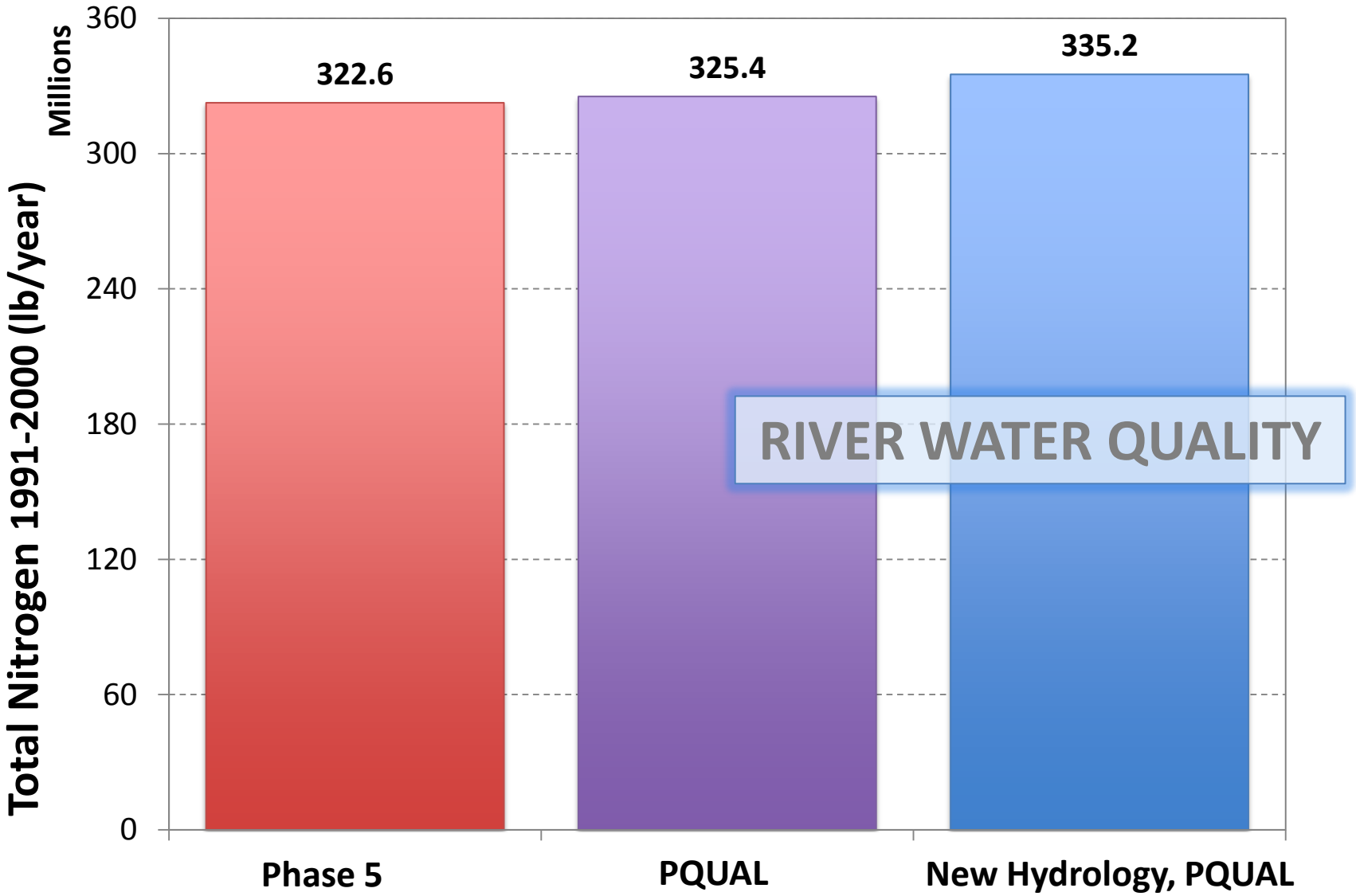
Total Suspended Sediment (TSSX) at 193 Monitoring Stations



Total Nitrogen (TOTN) at 149 Monitoring Stations

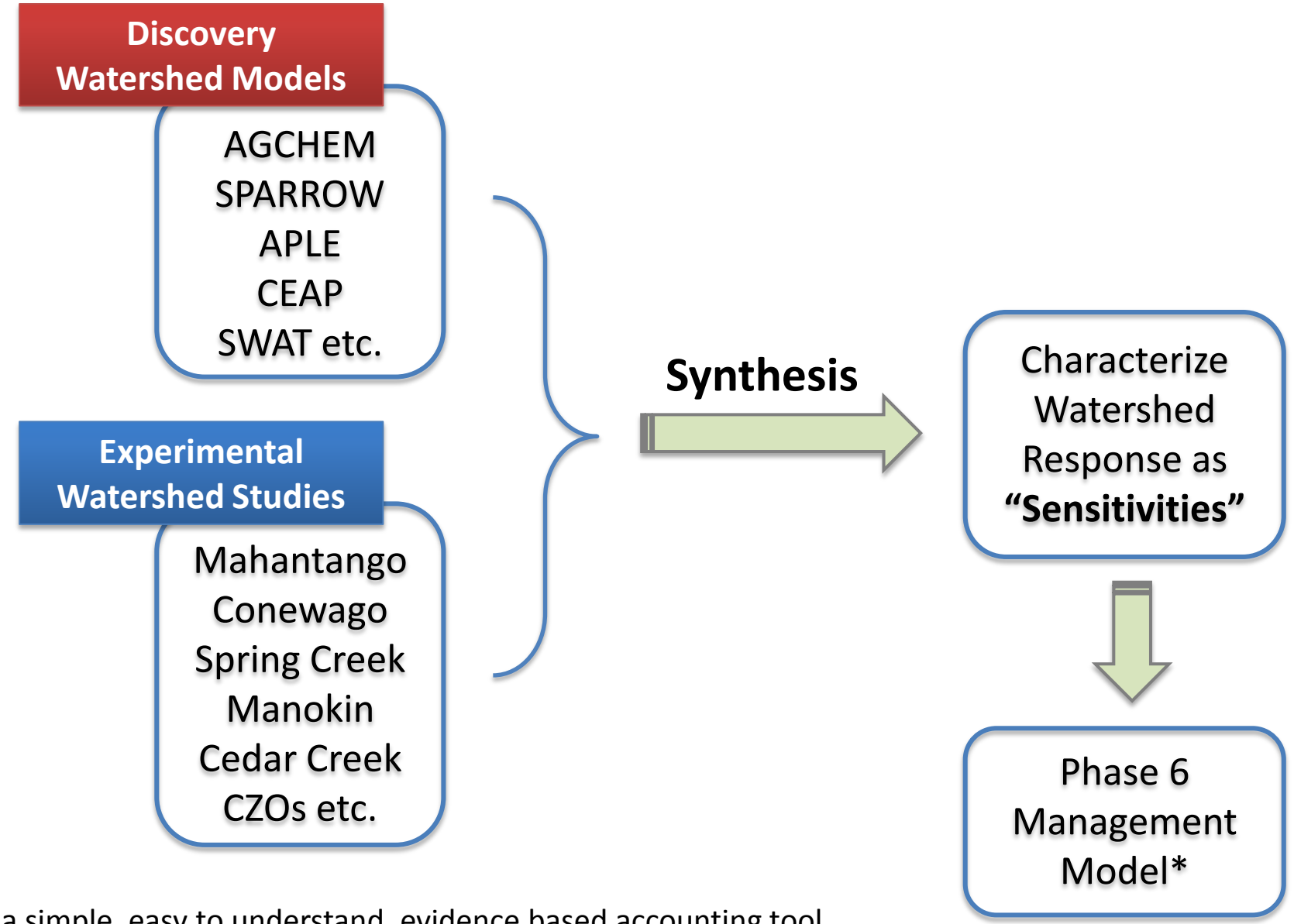


Total Nitrogen Delivered to the Bay



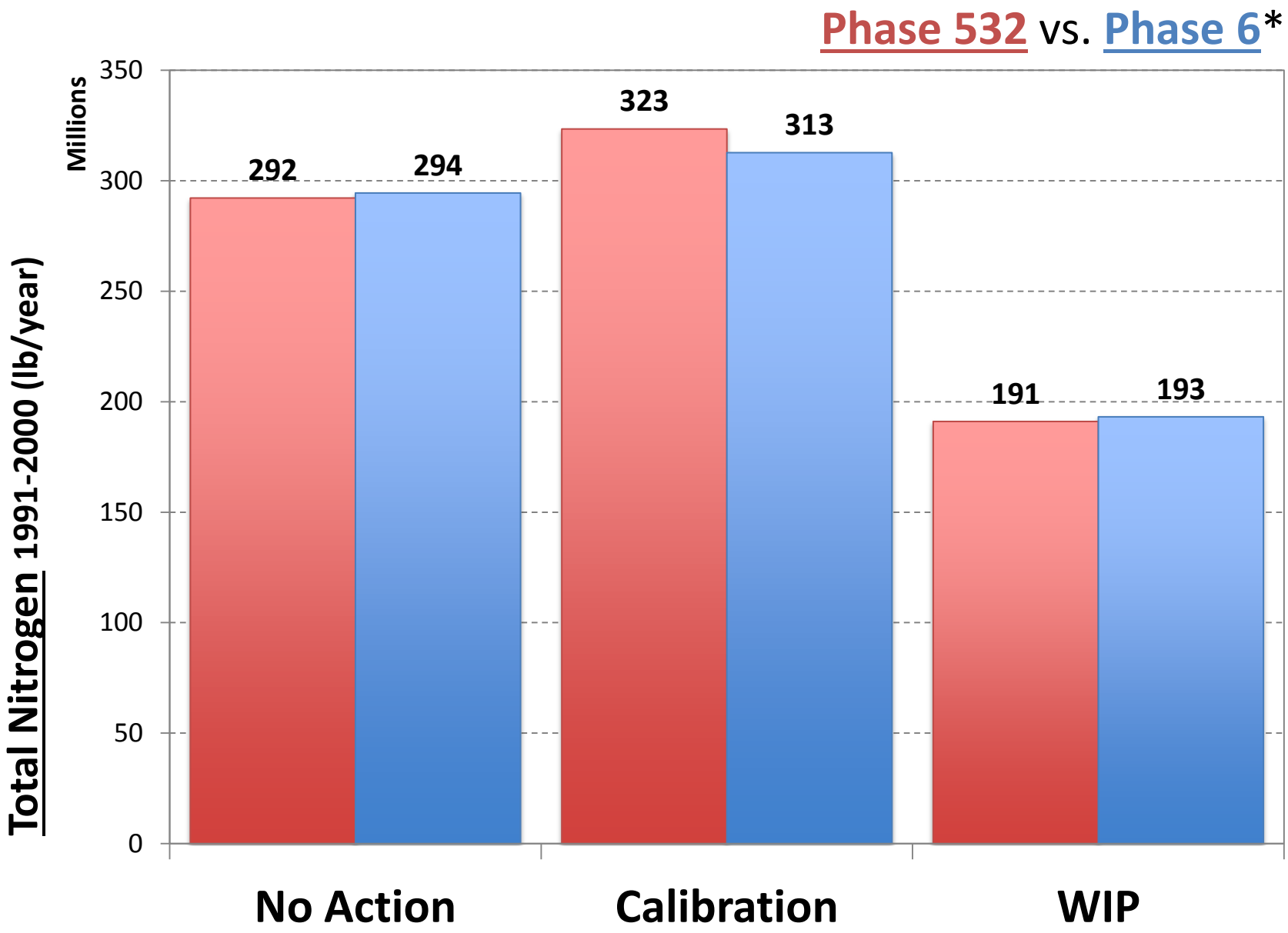
Watershed Model Nutrient Export Sensitivity

for accounting of management scenarios



* a simple, easy to understand, evidence based accounting tool.

Provisionally Operational Phase 6 Watershed Model



* using draft nutrient export sensitivities

Progress Summary

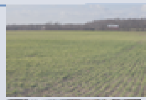
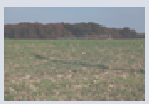
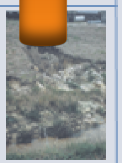
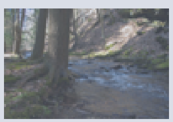
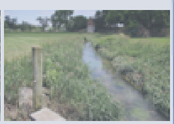
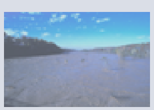
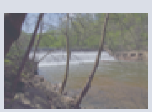
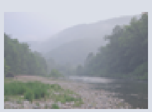
- All models have been extended to the year 2011
- Hydrology calibration complete and improved
- Provisional Phase 6 watershed model
  - Running with PQUAL concept - sensitivities
  - Transport factors in development
- Immediate next steps
  - Continued refinement of sensitivities
  - Development of land-stream/stream-river transport factors
  - Integrating extended airshed model with watershed model and estuarine model
  - Further evaluation of linked models in the extended time period

Calibration Timeline

- **October 2014 –** Rough Draft of major changes to nutrient processing in Scenario Builder will need to be complete. Continued sensitivity refinement
- **February 2015 -** draft targets for draft land Uses
- **March 2015 –** All major partnership decisions are made on changes to scenario builder processing and data. Scenario builder final modifications begin.
- **April 2015 -** final targets approved by Modeling Workgroup for draft land uses
- **Early October 2015 –** All inputs are final and delivered to the WSM by the scenario builder team for the final calibration run. Final targets are based on this information.
- **December 2015 -** Phase 6 draft model is complete.
- **December 2015 – December 2016 -** Evaluation followed by fine tuning during the next year. Key scenarios available
- **September 2016 –** Final comments on the draft Phase 6 model
- **December 2016 -** All models are final. The partnership decision-making process begins to discuss how these new models will be used in the WIP3 process

Scale in the Chesapeake Bay Program Watershed Model

Thank You

Landscape	***Phase 5***		***Phase 6***		***Sparrow***	***Other Data Sources***
	Nutrients	***Sediment***	***Nutrients***	***Sediment***		
Field   		**AG and Forest:** Used RUSLE2 to estimate EOF sediment targets **Urban:** Used Langland and Cronin To estimate pervious vs impervious loading	*Can we estimate EOF loads directly based on available information?*	*Should we update the sediment EOF estimates?*	Sources (fertilizer, manure, atdep, urban area) multiplied by global coefficients	Literature Reviews from TetraTech Sources in Phase 5 documentation Sensitivity documentation CEAP APLE
Land to stream   	Fiel… l, hillslope, and … stream pro… are all com… in the Edge-of-S… esti… No E… simulate… EOS … ates are com… ion of reg… fact… d field-sc… process simulation calibrated to average export rates Informed by inputs and calibration	Hillslope and small stre… are c… ent delivery ratio … based on the … e di… ch r… and use … and a… river … ed fo…	*Can we e… te watersh… ivery … ased o… scape … ramet…*		La… ater factors su… oil parameters … pes	ICPRB/USGS Sparrow Land Dat… m Connected Impervi… and Data … Urban Tree Canopy
Stream to River    			*Can we estimate small stream effects?*		Explicitly simulated to NHD+ level	ICPRB/USGS Sparrow Land Data team Urban Stream Corridor Land Data team Riparian Forest Land Data team Riverine Wetlands Center for Watershed Protection CBP Grant
River to Estuary   	Directly Simulated in HSPF for river averaging at least 100 cfs Calibrated to WQ data		Directly Simulate in HSPF for river averaging at least 100 cfs Calibrate to WQ data		Explicitly simulated	Calibrate to sparrow DFS or loads?