Sediment Simulation in Phase 6

Gary Shenk – USGS - Chesapeake Bay Program

1/17/17

Partnership Feedback on Modeling

- **Water Quality Goal Implementation Team**
  - Need more **transparent and easier** to understand decision-support tools to enable successful engagement of local partners

- **Scientific and Technical Advisory Committee**
  - Multiple Models
  - Phosphorus
  - Complex Reservoir Dynamics
  - Fine-scale processes

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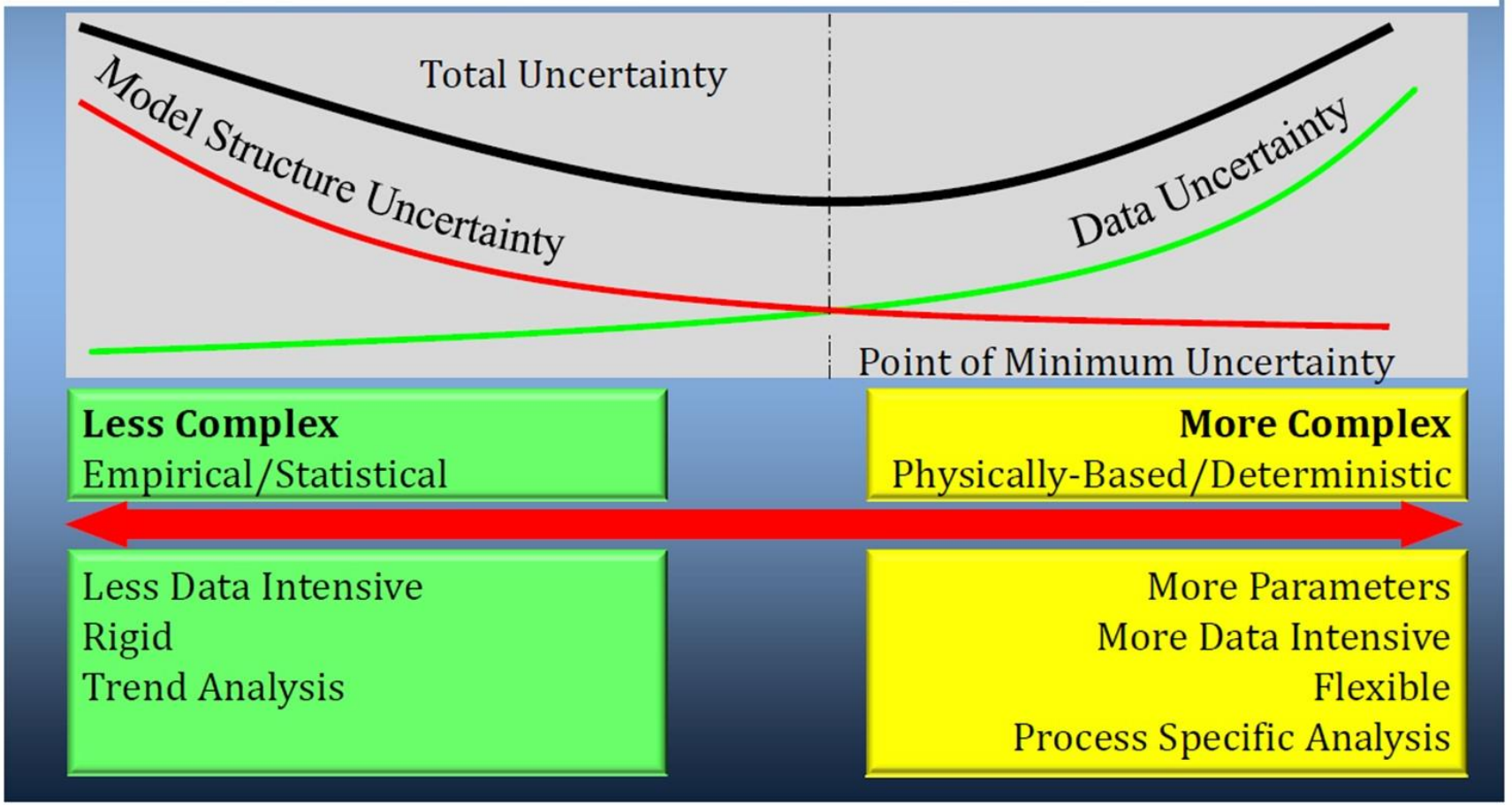
Keep it Simple!!

Include Everything!!!

Model Continuum



Slide from Mazdak Arabi





Steady State Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Stream Delivery

*

River Delivery

Direct Loads

Phase 6

Keep It Simple

Include Everything

Average Load + ΔInputs * Sensitivity

*

Land Use Acres

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BMPs

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Land to Water

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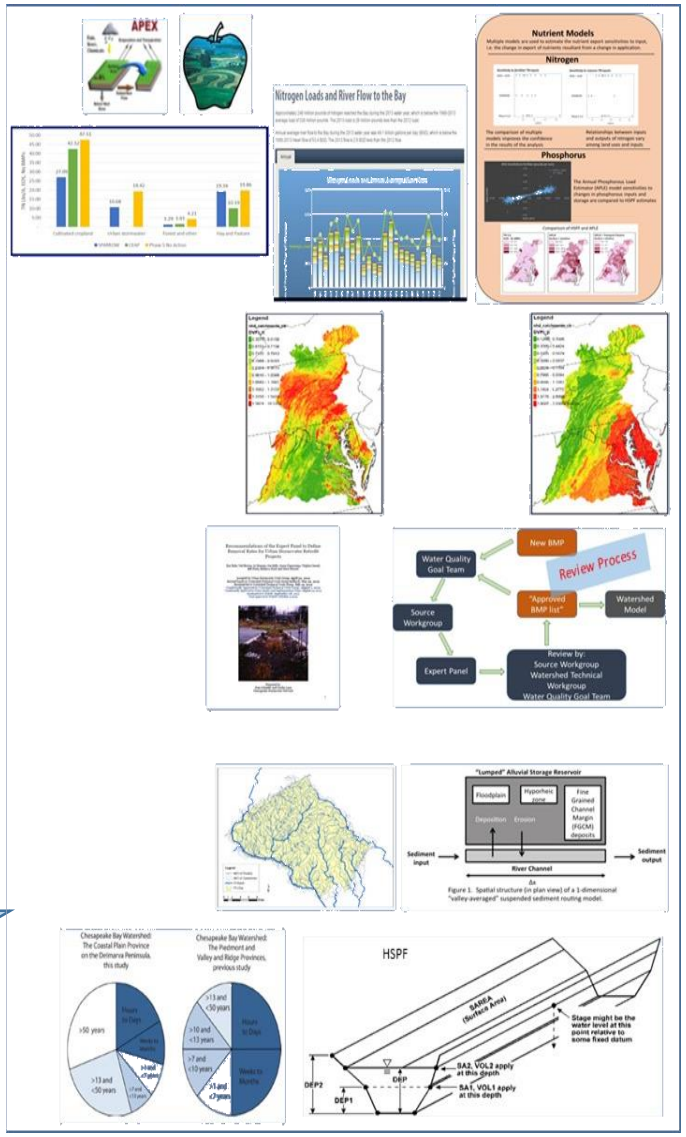
Stream Delivery

*

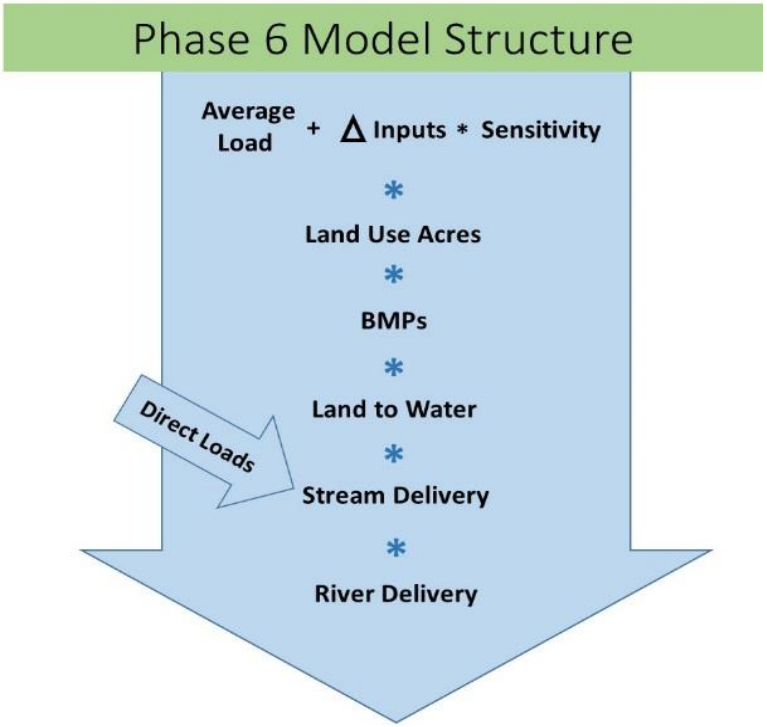
River Delivery

Direct Loads

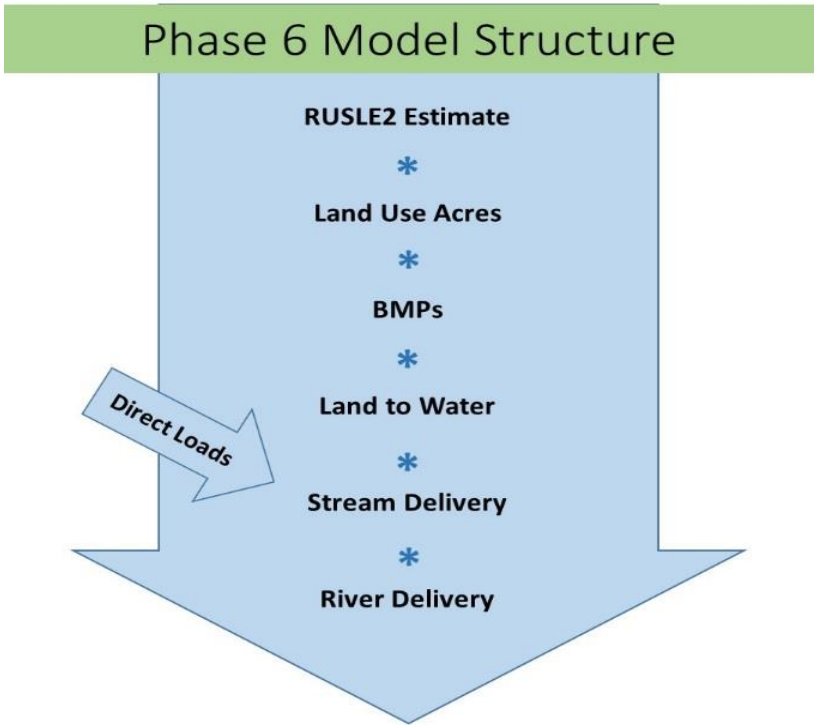


Sediment is similar to nutrients but no sensitivity

Nutrients



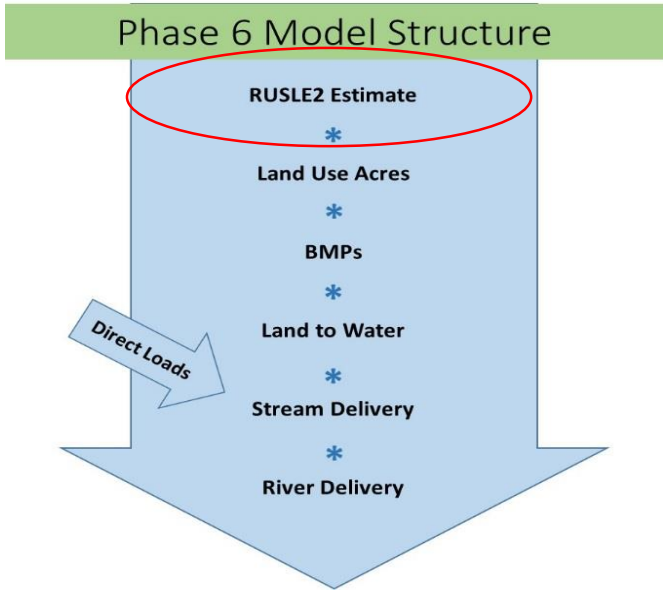
Sediment



Beta 2

RUSLE2 = Edge-of-Field Loads

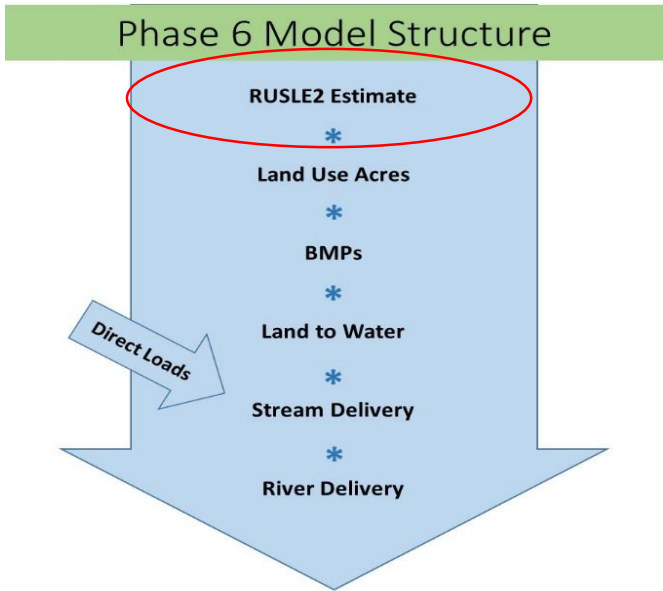
- Evaluated at the 10m Pixel Level
- Summarized to LRseg and land use
  - Forest
  - Open Space
  - Crop
  - Pasture
  - Turfgrass
  - Tree Canopy over Turfgrass



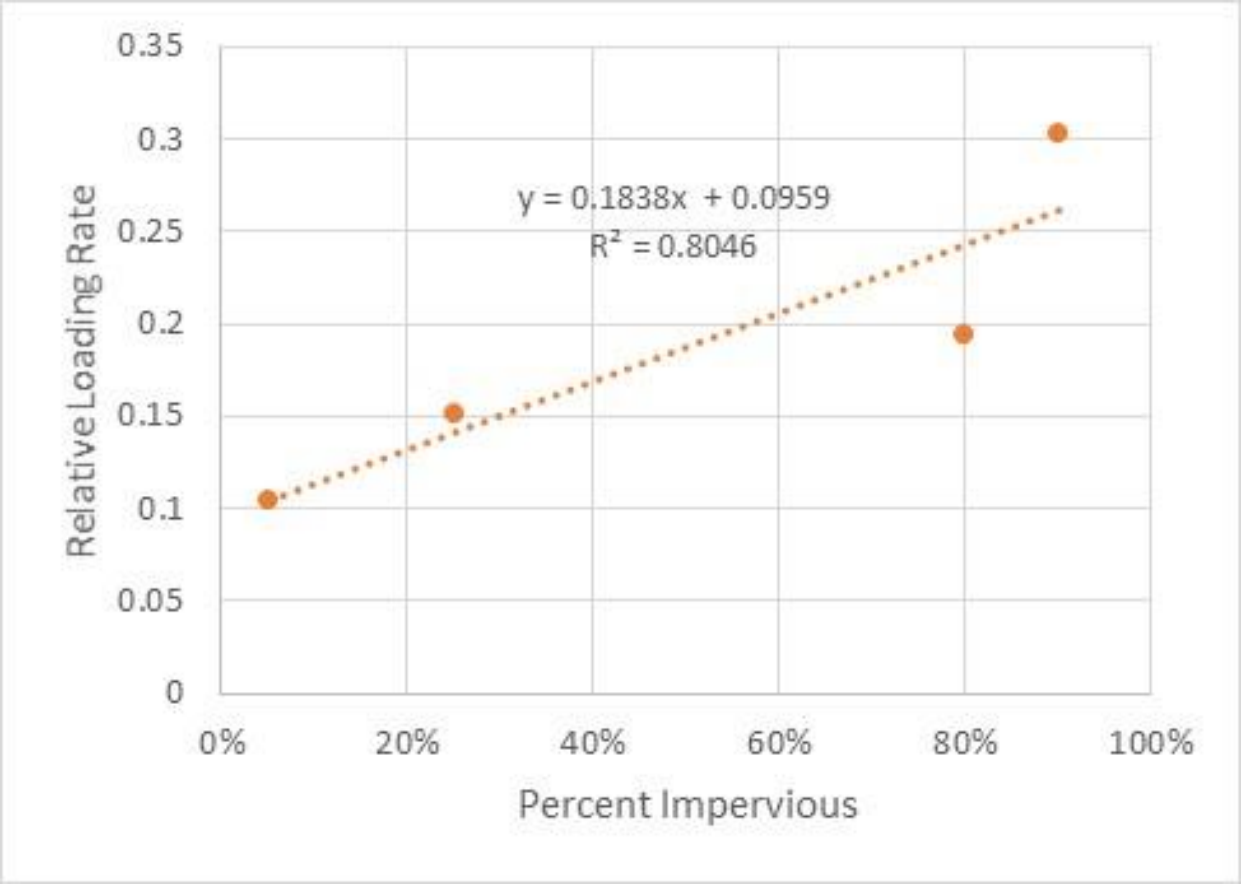
RUSLE2 => A = RKLSCP

Beta 2

- R = Runoff
  - = $1.24P^{1.36}$ P from PRISM
- K = Erodibility
  - from STATSGO and gSSURGO
- LS = slope length
  - = (Flow Accumulation x Cell Resolution / 22.1)$^{0.4}$ x (Sin(Slope x 0.01745) / 0.09)$^{1.4}$ x 1.4
- C = Cover
  - from Tetratech and AgWG
- P = Practice
  - = 1 since no action loads



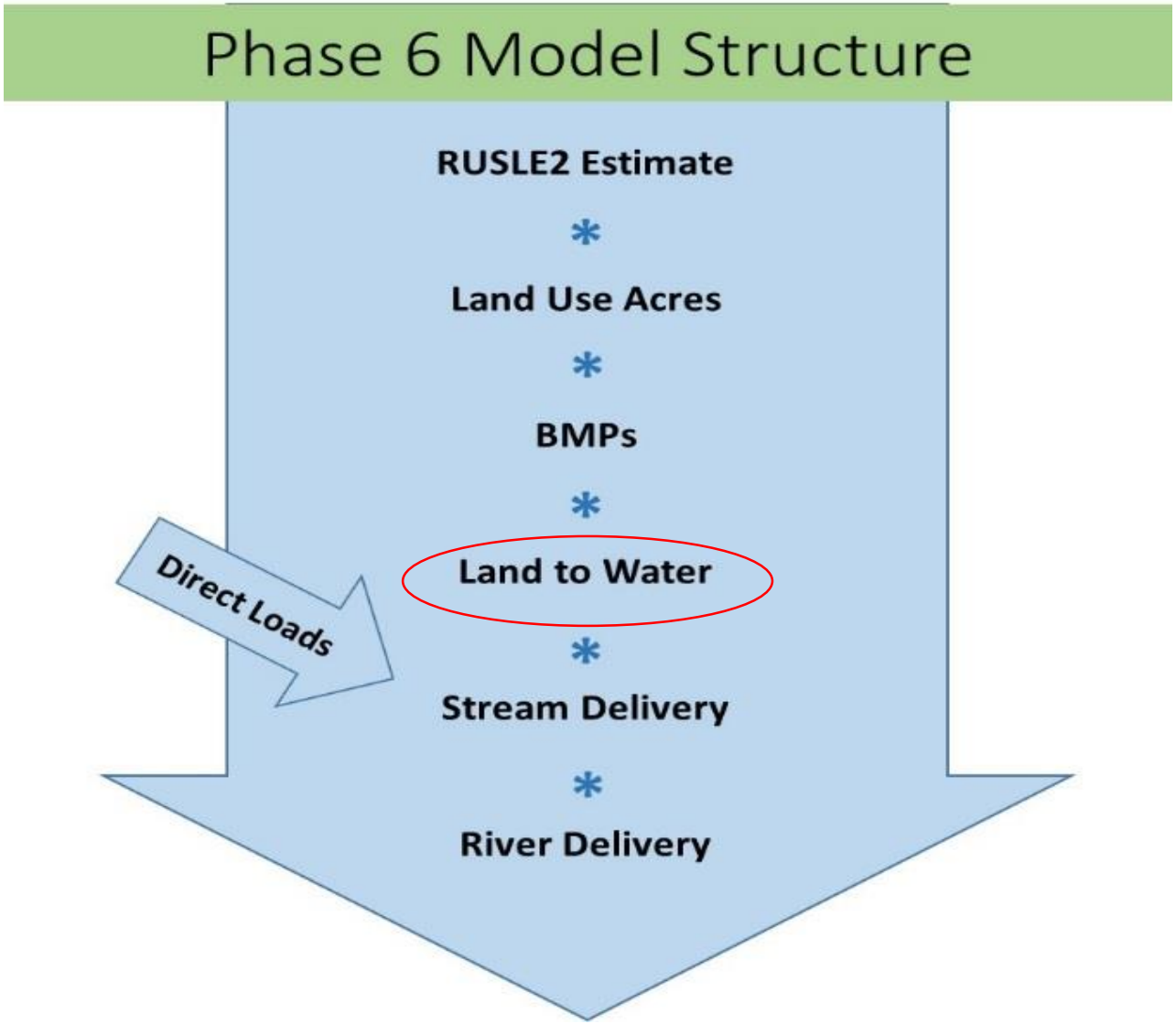
Land use factors



Factor
1.0
3.0
3.0
3.0
1.0

- Impervious is 3x the sediment load **according to *outfall* data** in the NSQD

Sediment Delivery Ratio



Interconnectivity Metric

Calculation related to Slope, Area, Flowpath Length, and Roughness

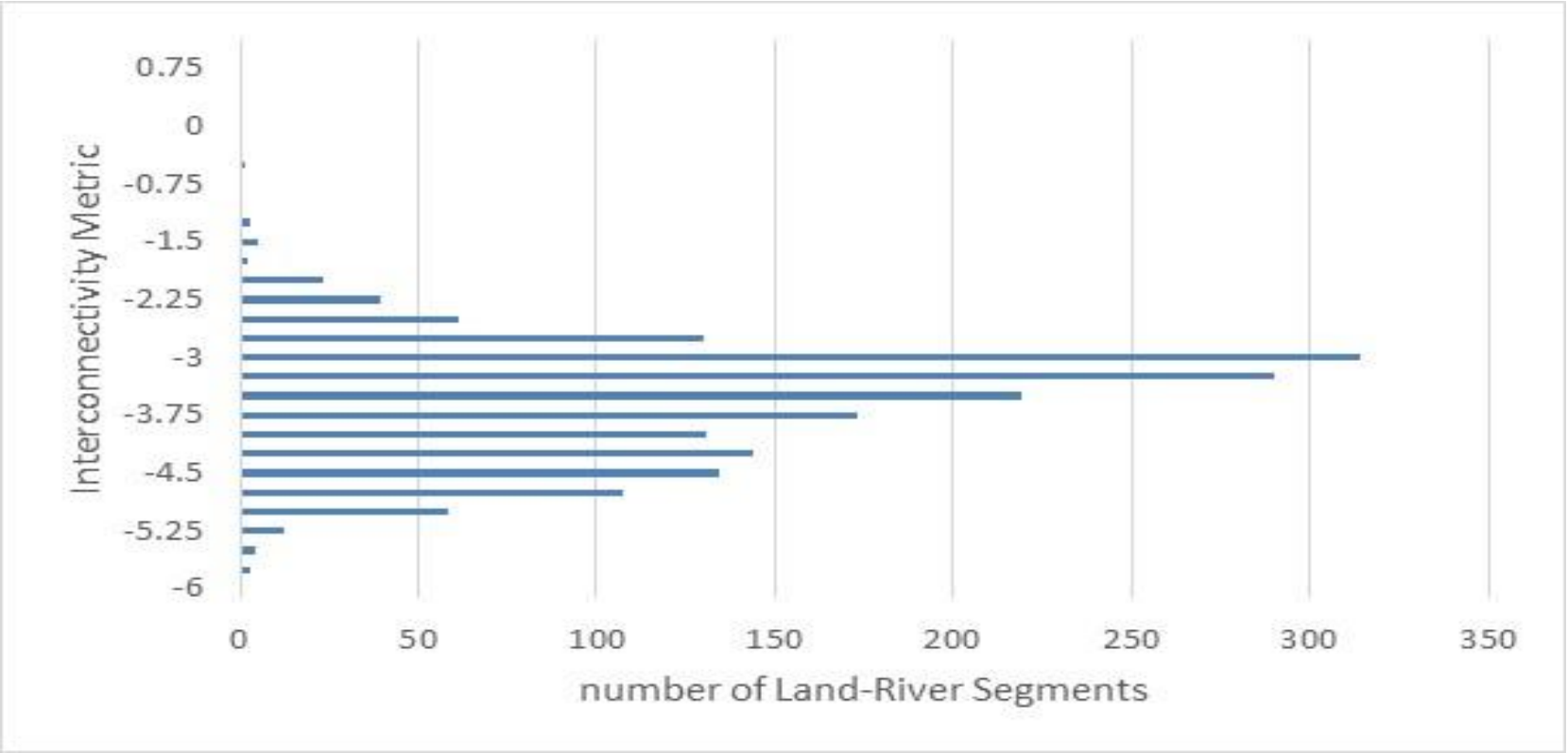
$$IC = log_{10}\left(\frac{D_{up}}{D_{dn}}\right)$$

D_{up} ~ roughness (-), Slope (+), Area (+)

D_{down} ~ roughness (-), Slope (-), distance (+)

Interconnectivity Metric

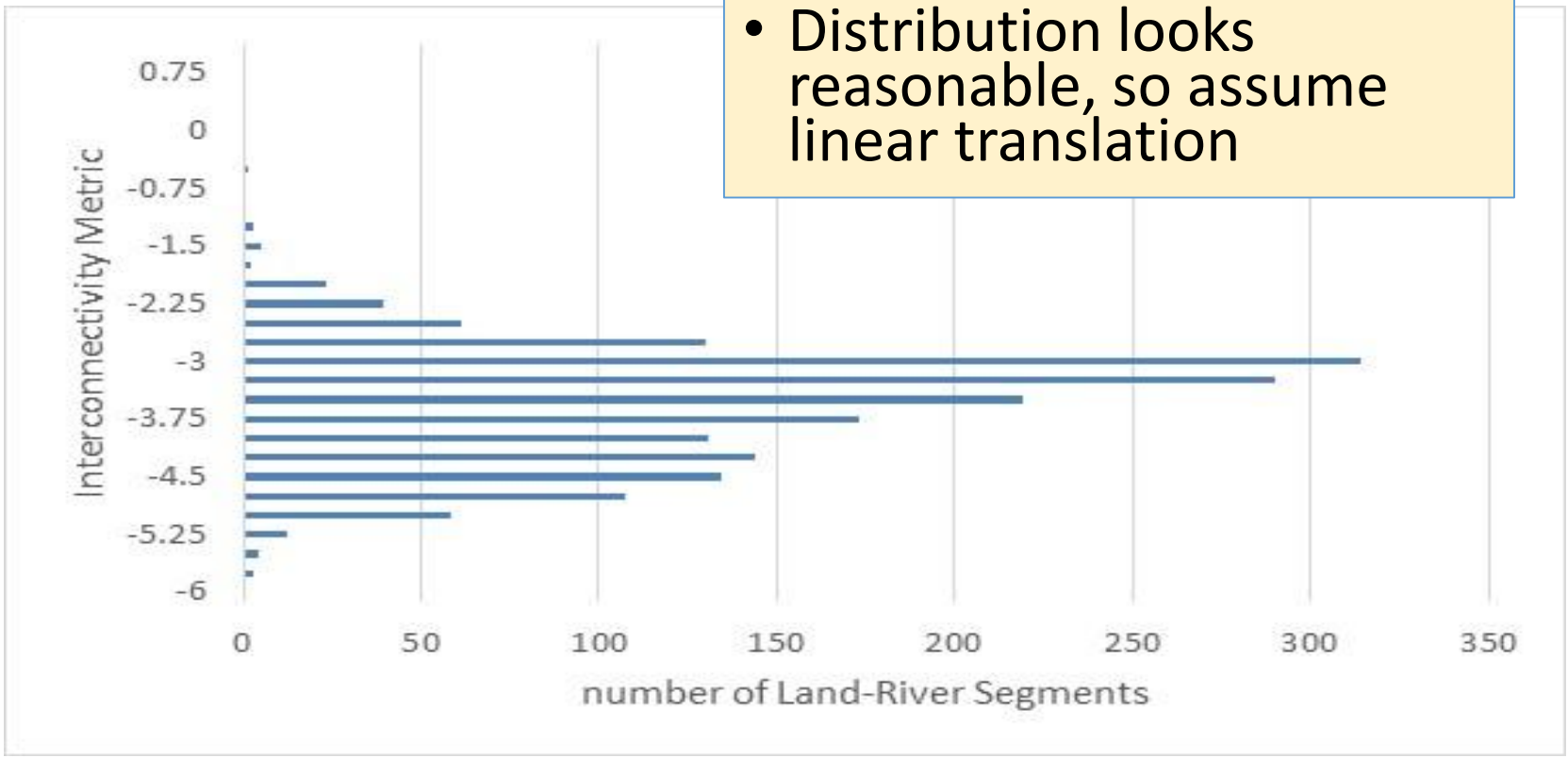
Calculation related to Slope, Area, Flowpath Length, and Roughness

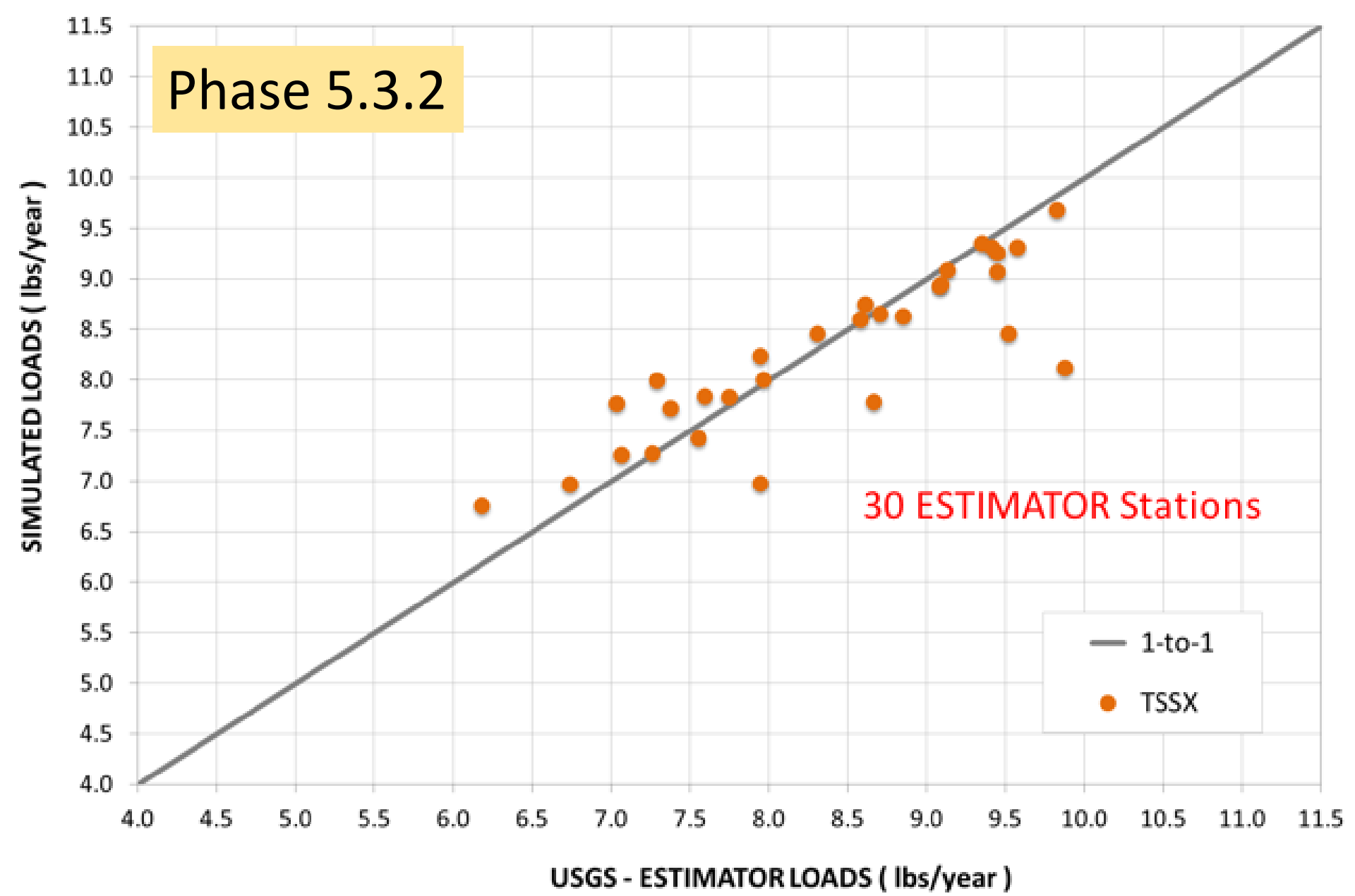


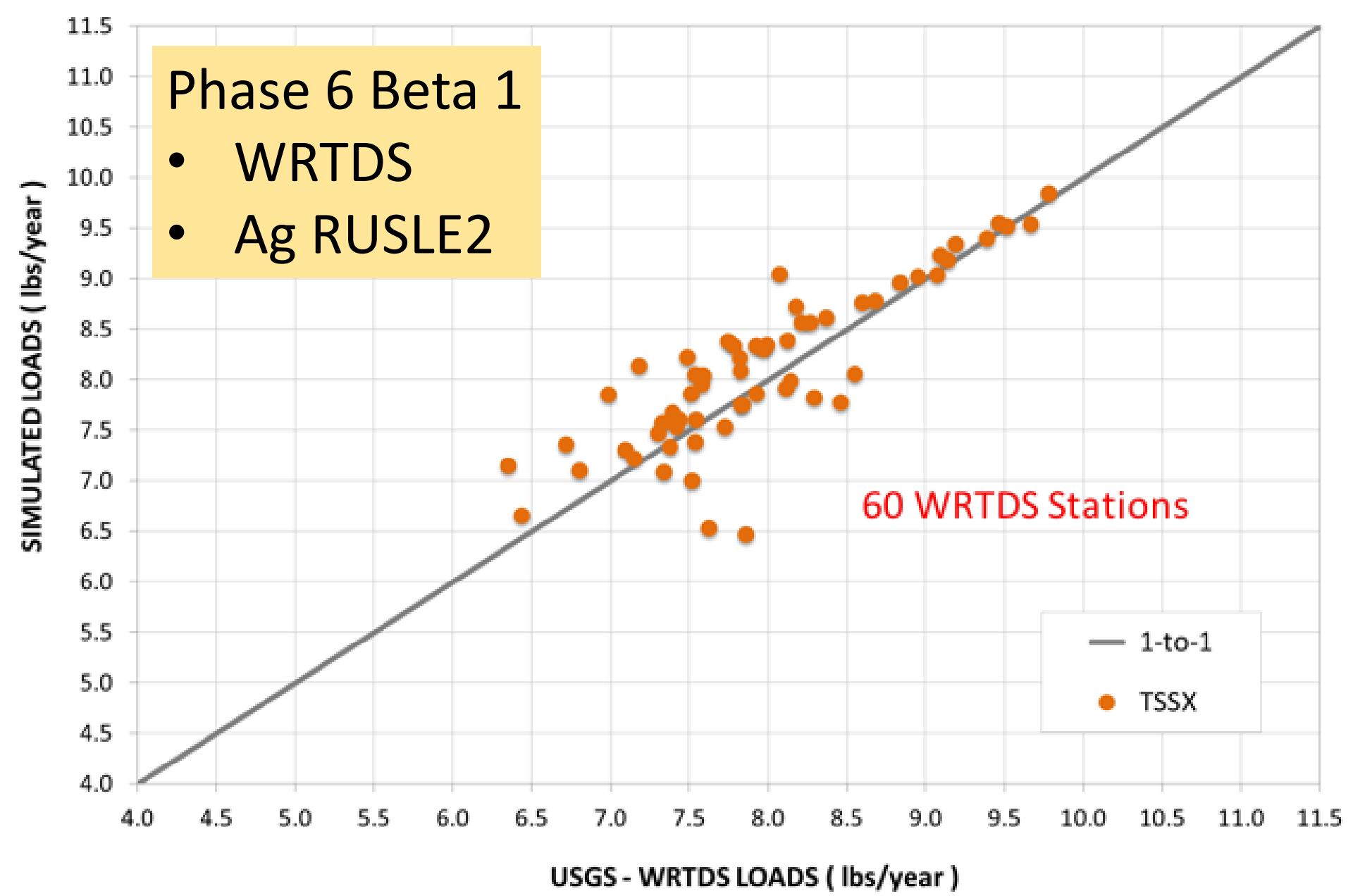
Peter Claggett and David Saavedra (UMBC)

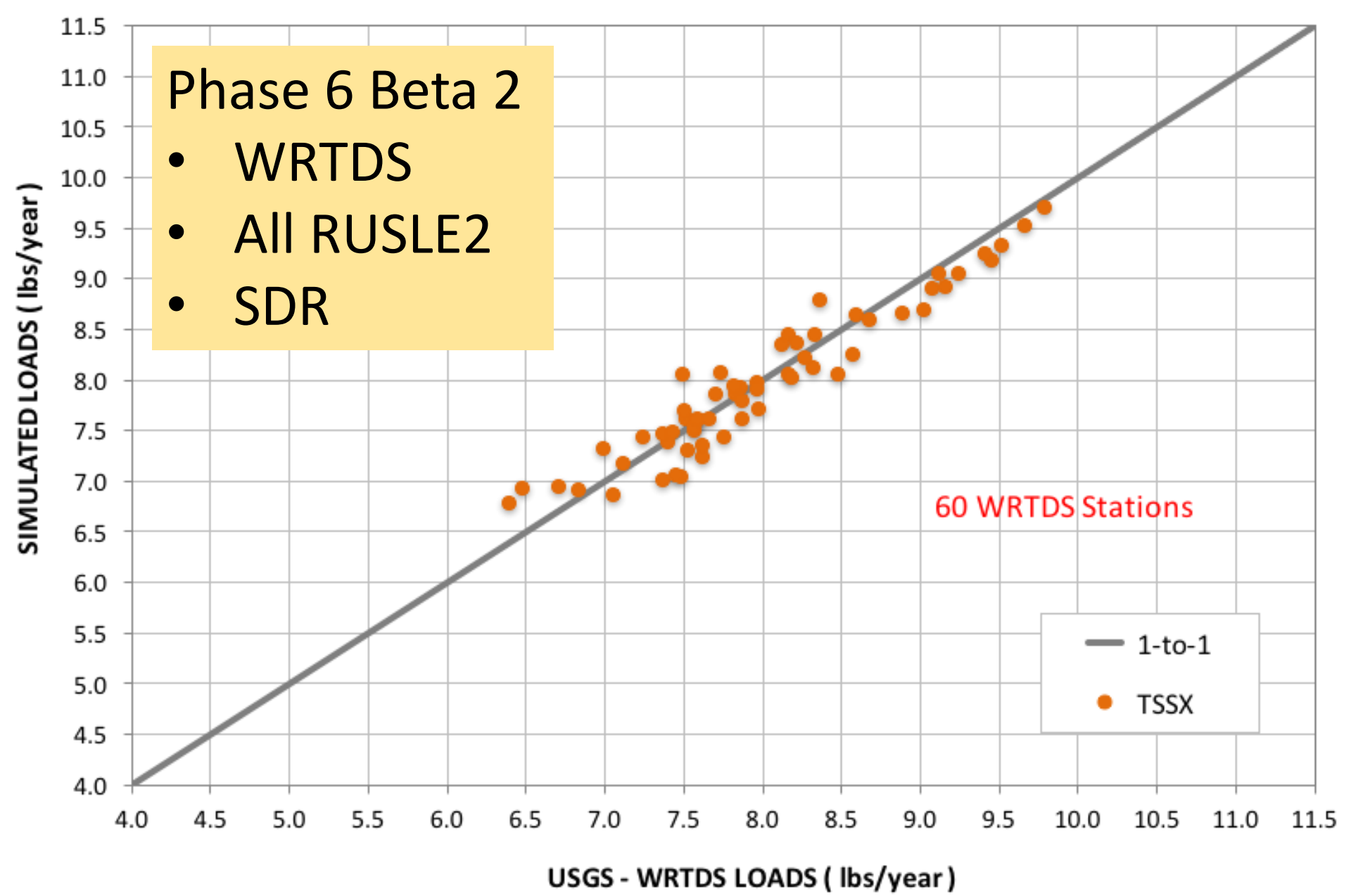
Sediment Delivery Ratio

- Need to convert to scale of 0 to 1 with an average of 0.25
- Distribution looks reasonable, so assume linear translation

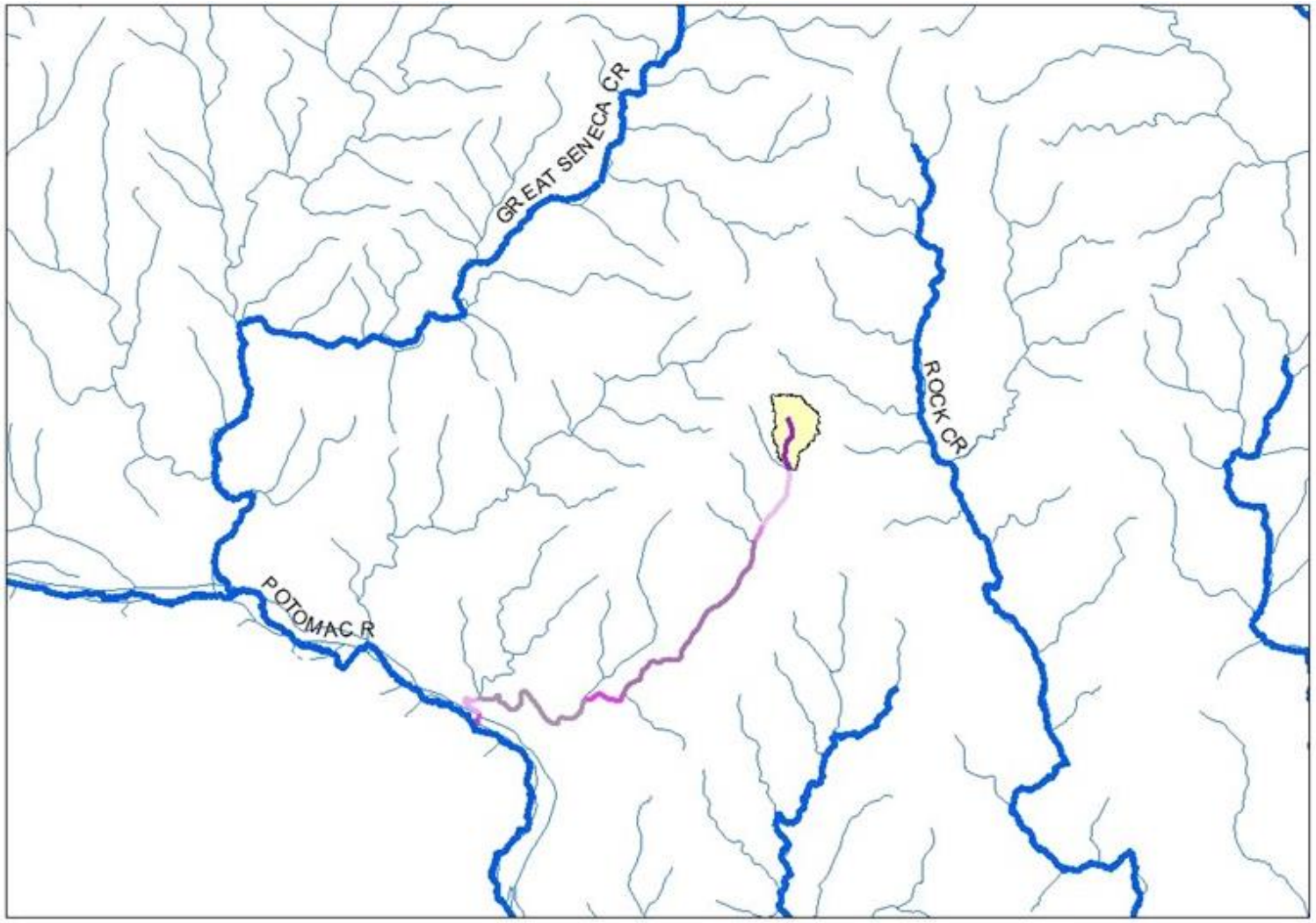



Phase 5.3.2
SIMULATED LOADS (lbs/year)
USGS - ESTIMATOR LOADS (lbs/year)
30 ESTIMATOR Stations
1-to-1
TSSX
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5

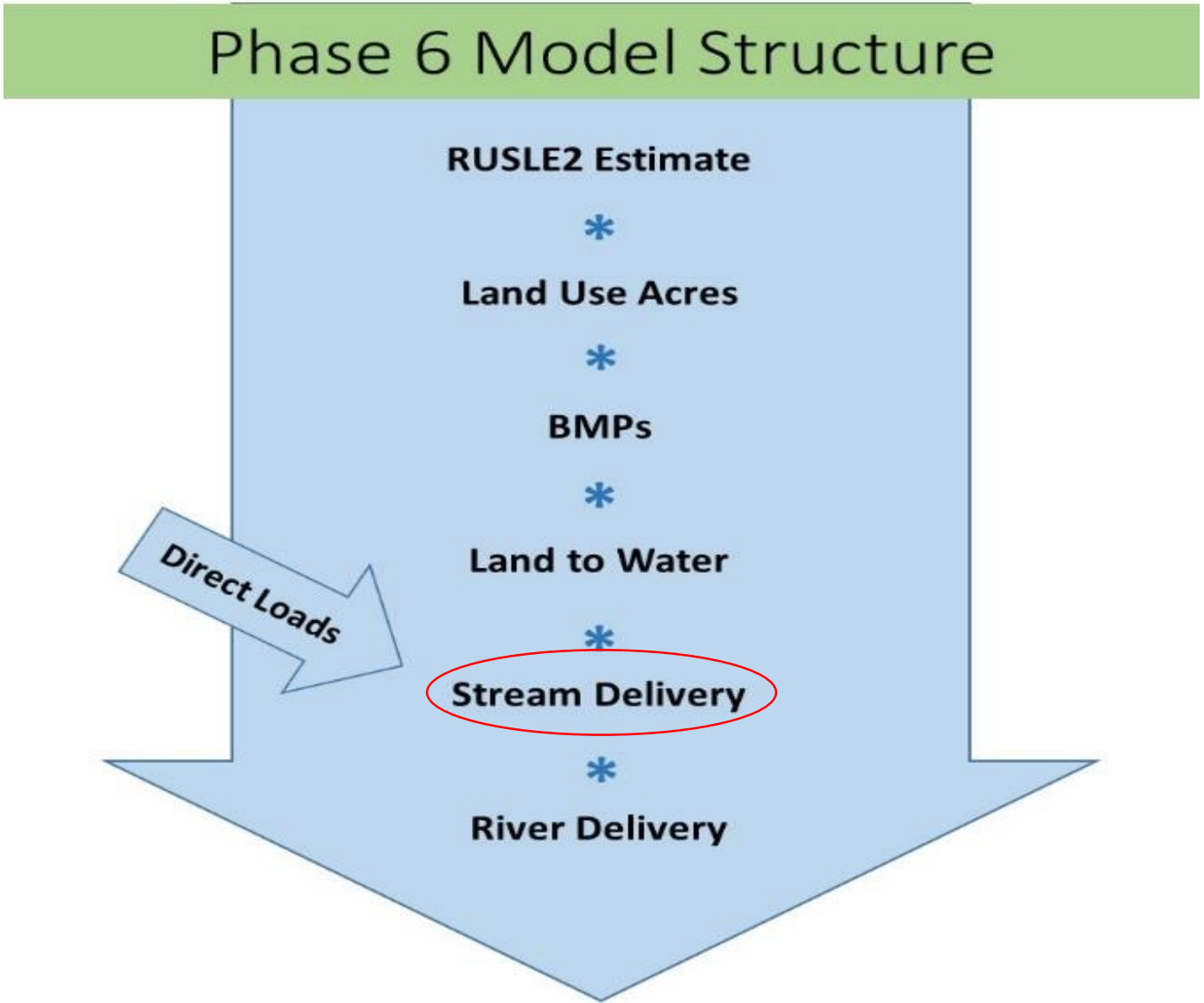

Phase 6 Beta 1
• WRTDS
• Ag RUSLE2
60 WRTDS Stations
1-to-1
TSSX
SIMULATED LOADS (lbs/year)
USGS - WRTDS LOADS (lbs/year)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5


Phase 6 Beta 2
• WRTDS
• All RUSLE2
• SDR
60 WRTDS Stations
1-to-1
TSSX
SIMULATED LOADS (lbs/year)
USGS - WRTDS LOADS (lbs/year)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5

Stream Delivery vs River Delivery



Stream Delivery



Methods of Stream Delivery

Method	Sparrow	Floodplain Regression	Stream Source Ratio
Nitrogen	Implemented in Beta 1,2,3	To be implemented in Beta 4	N/A
Phosphorus	Implemented in Beta 1,2,3	To be implemented in Beta 4	N/A
Sediment	Testing for final	To be implemented in Beta 4	Implemented in Beta 2 and 3 for Developed

Questions to be Answered during calibration

Use Sparrow, Floodplain Regression, or Average for N and P?

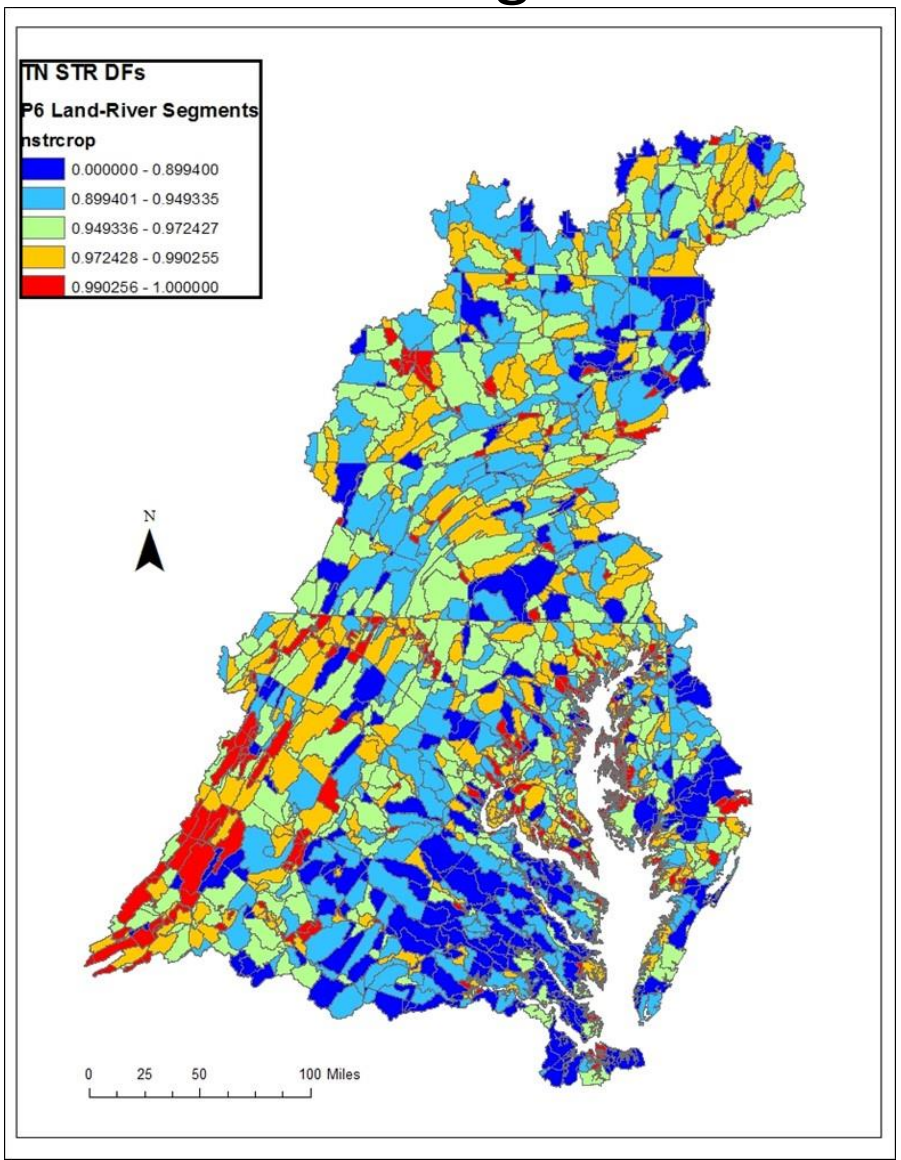
Use Sparrow, Floodplain Regression, SSR, or Average for Sediment?

Reach Attributes Used in SPARROW Models

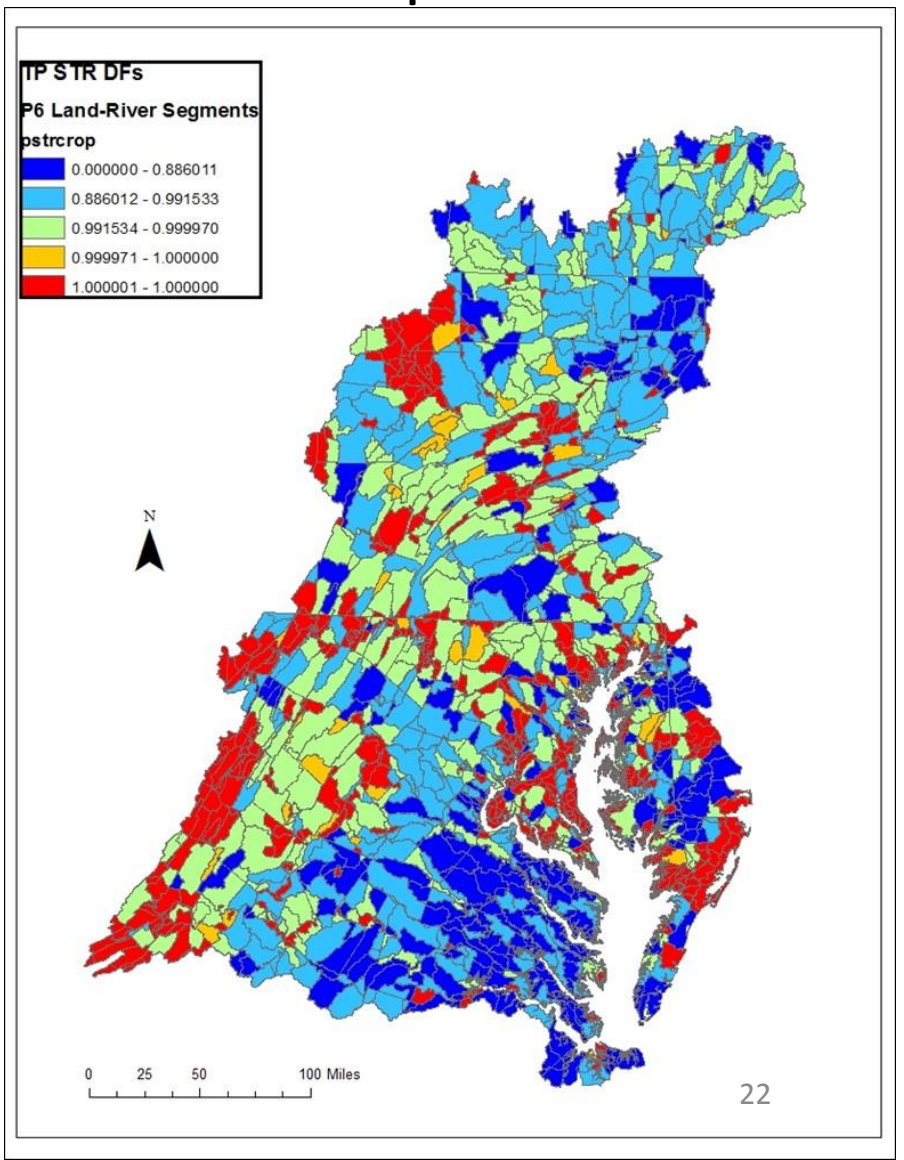
Explanatory Variable	Nitrogen	Phosphorus
Stream-to-River Factors (Aquatic Decay)	Impoundments: Hydraulic loading rate Rivers and streams: Average annual temperature Travel time	Impoundments: Hydraulic loading rate Rivers and streams: No losses represented

Stream-to-River Delivery Factors

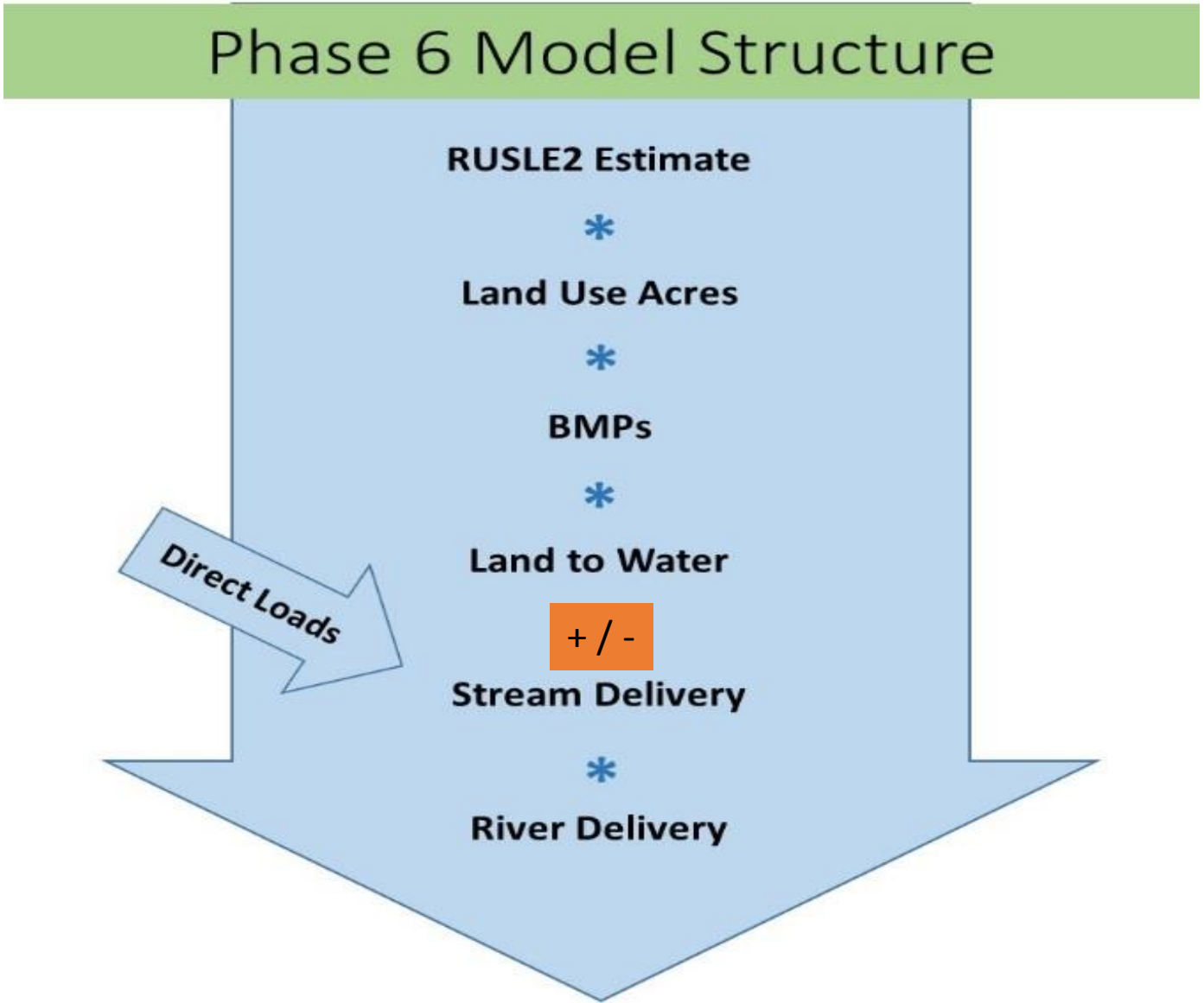
- Nitrogen



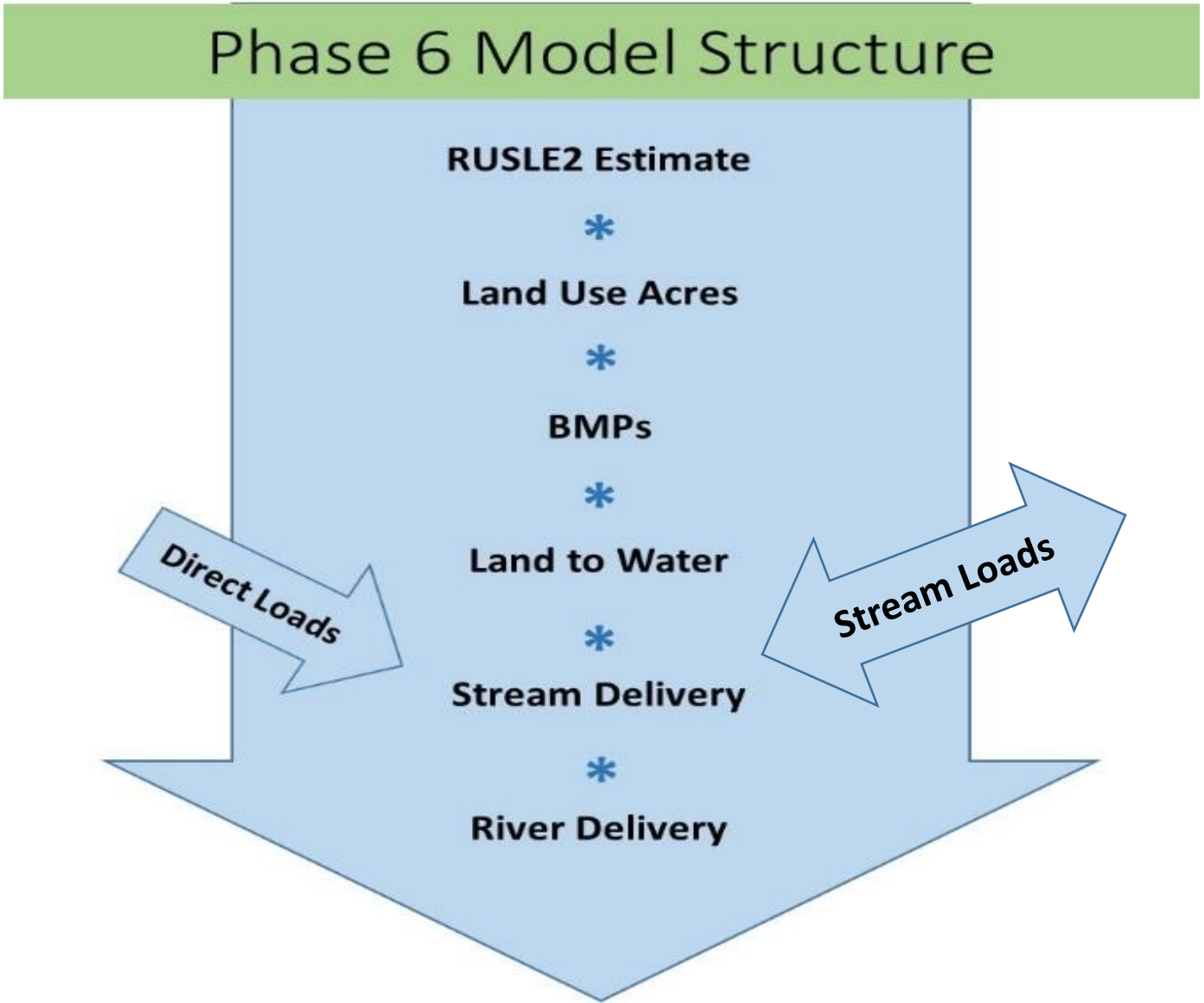
- Phosphorus



Stream Delivery – other models



Stream Delivery – other models



Streams as a source / sink

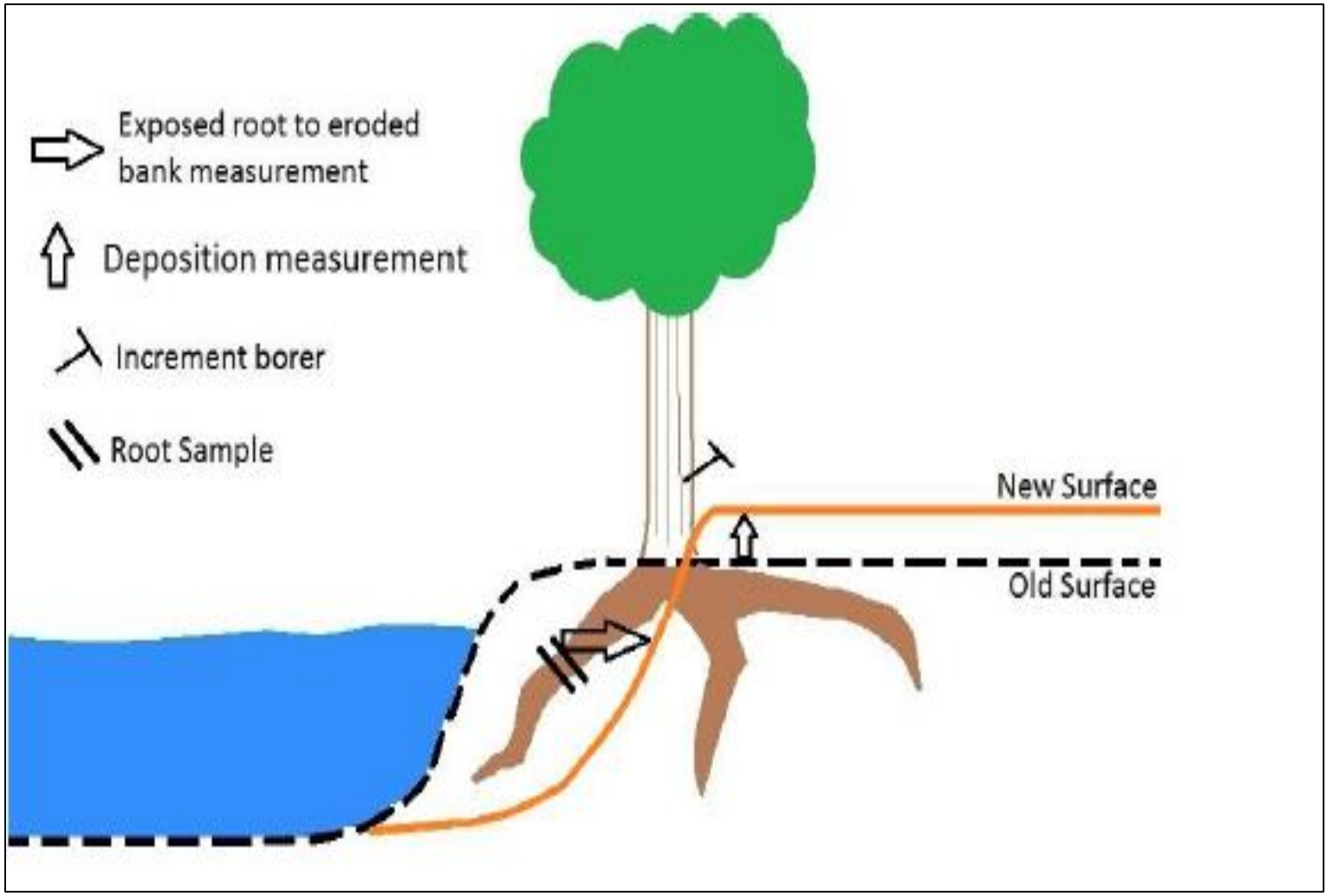
Land Uses

- Grain with manure
- MS4 roads
- Permitted feeding space
- Non-regulated turf grass
- …

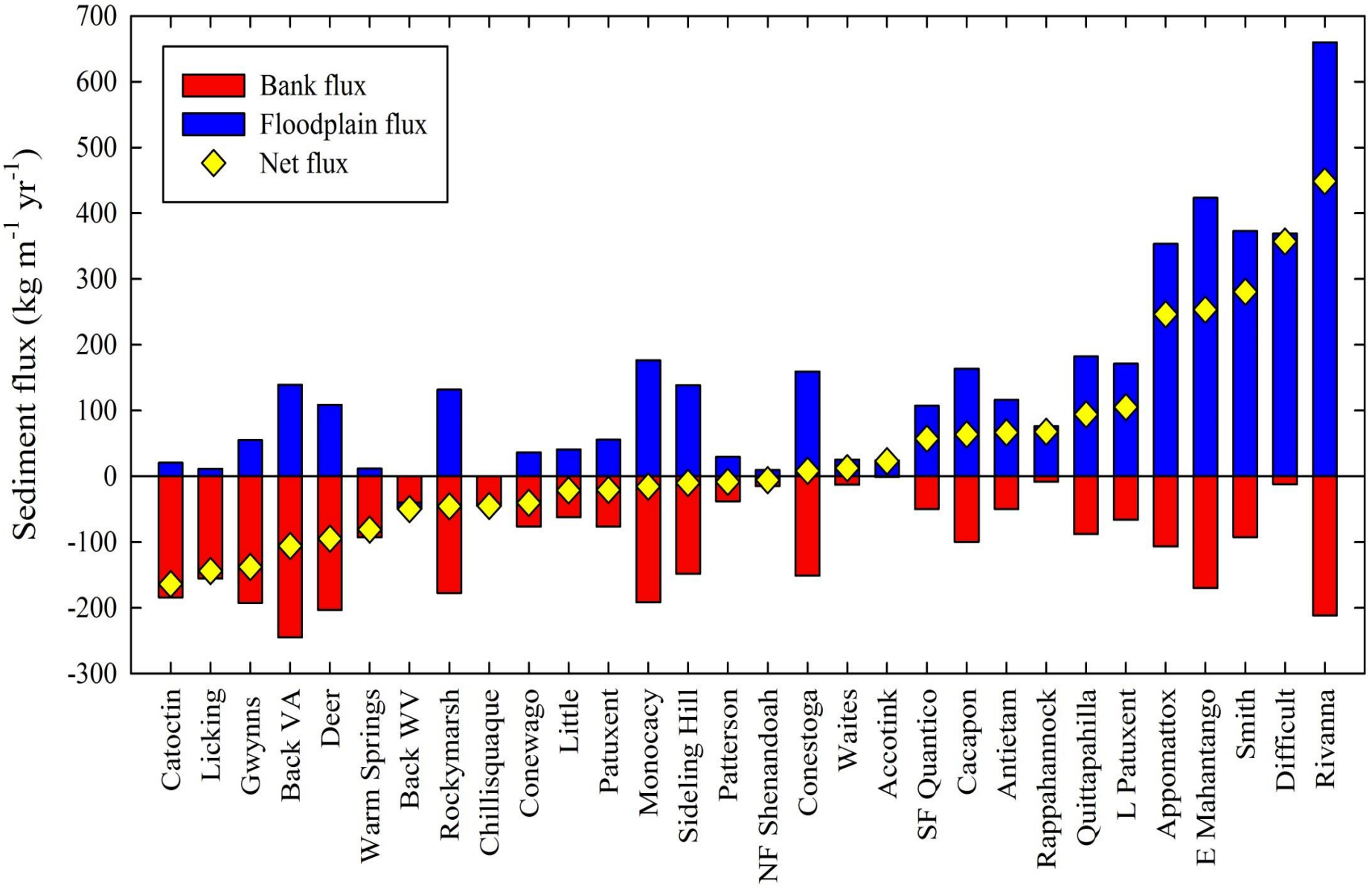
Sources

- WWTP
- Septic
- Atmospheric to water
- Bed and Bank (+)
- Floodplains (-)
- …

Floodplain Regression – Greg Noe



USGS Chesapeake Floodplain Network



USGS Chesapeake Floodplain Network

Floodplain Sediment Flux

$P<0.001$, $R^2=0.83$

Step	Beta	R^2 change	P
Constant			0.00
1. Channel depth	1.36	0.36	0.00
2. Channel width x depth	-0.70	0.11	0.00
3. 1974 land use in production	-0.31	0.06	0.01
4. Reach sinuousity	0.29	0.06	0.02
5. Physiographic Province	1.04	0.05	0.00
6. Rainfall and Runoff R-factor (USLE)	0.75	0.05	0.00
7. Subsurface flow contact time index	-0.41	0.04	0.01
8. Channel width / floodplain width	-0.28	0.04	0.03
9. Median elevation	-0.26	0.03	0.07

Bank Sediment Flux

$P<0.001$, $R^2=0.69$

Step	Beta	R^2 change	P
Constant			0.09
1. Floodplain width	-1.24	0.35	0.00
2. Dimensionless median elevation - relief ratio	0.21	0.14	0.13
3. Channel width / floodplain width	-0.52	0.07	0.01
4. P application rate	-0.47	0.05	0.01
5. Erodability K-factor (USLE)	0.38	0.08	0.02

OLD DATA

Developed - Stream Source Ratio

- Center for Watershed Protection

$$SSR = 1 - \frac{Upland\ Load}{Total\ Watershed\ Load}$$

- Compared
  - upland load (EMC * modeled flow)
  - Watershed load (Q-C curve applied to model flow)

- Regressed SSR against watershed characteristics

SSR = 1.4085*Impev + 0.5341*CDsoils - 0.2828

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Stream Restoration BMP