CalCAST Sediment: Informing Phase 7 Cast TSS Modeling

9/15/2026

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Chesapeake Bay Program

Science, Restoration, Partnership

How it Works: CAST Sediment

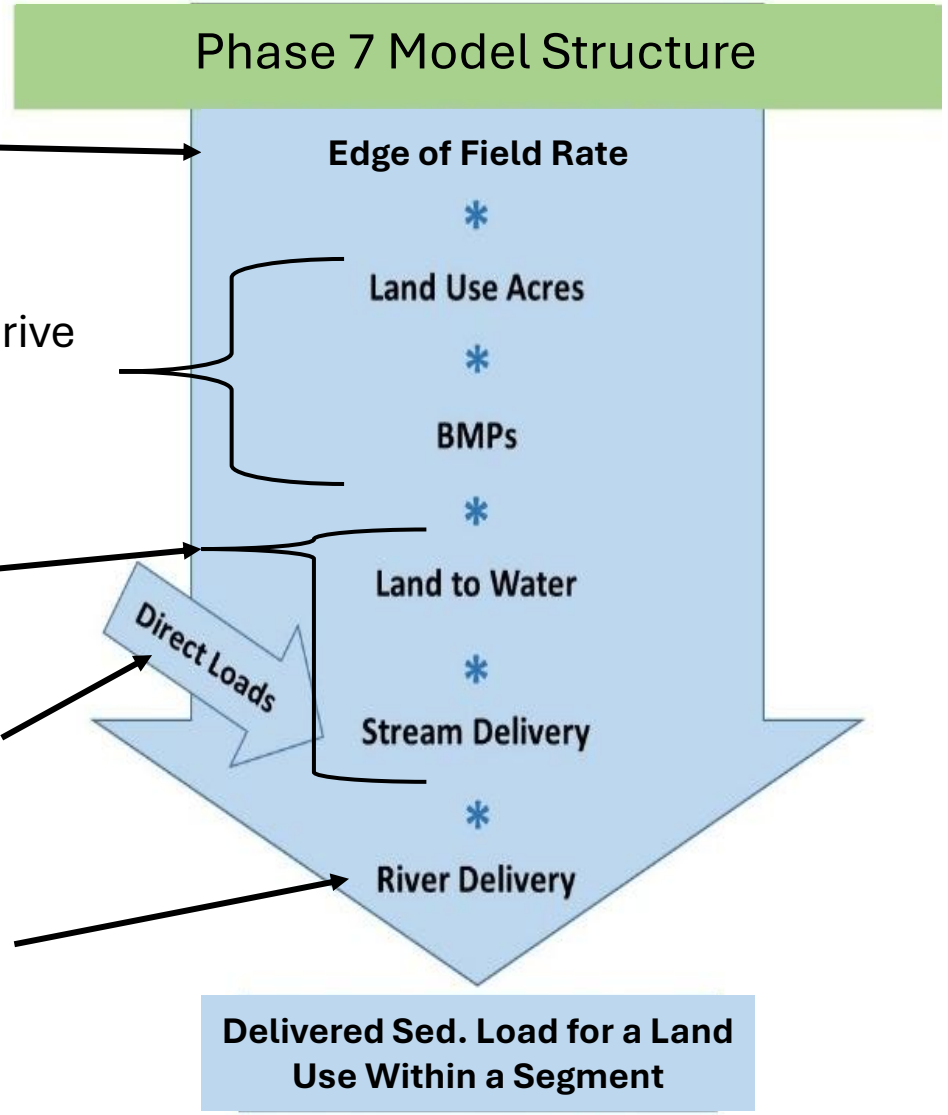
Calculated via RUSLE2 (hydro-period avg. via DWSM)

Multiply by the acres and BMP efficiencies to derive the Edge of Field load.

Apply transport and attenuation factors to estimate losses from edge of field to edge of stream and edge of river (CalCAST).

Direct loads include point sources or sources with separately defined transport.

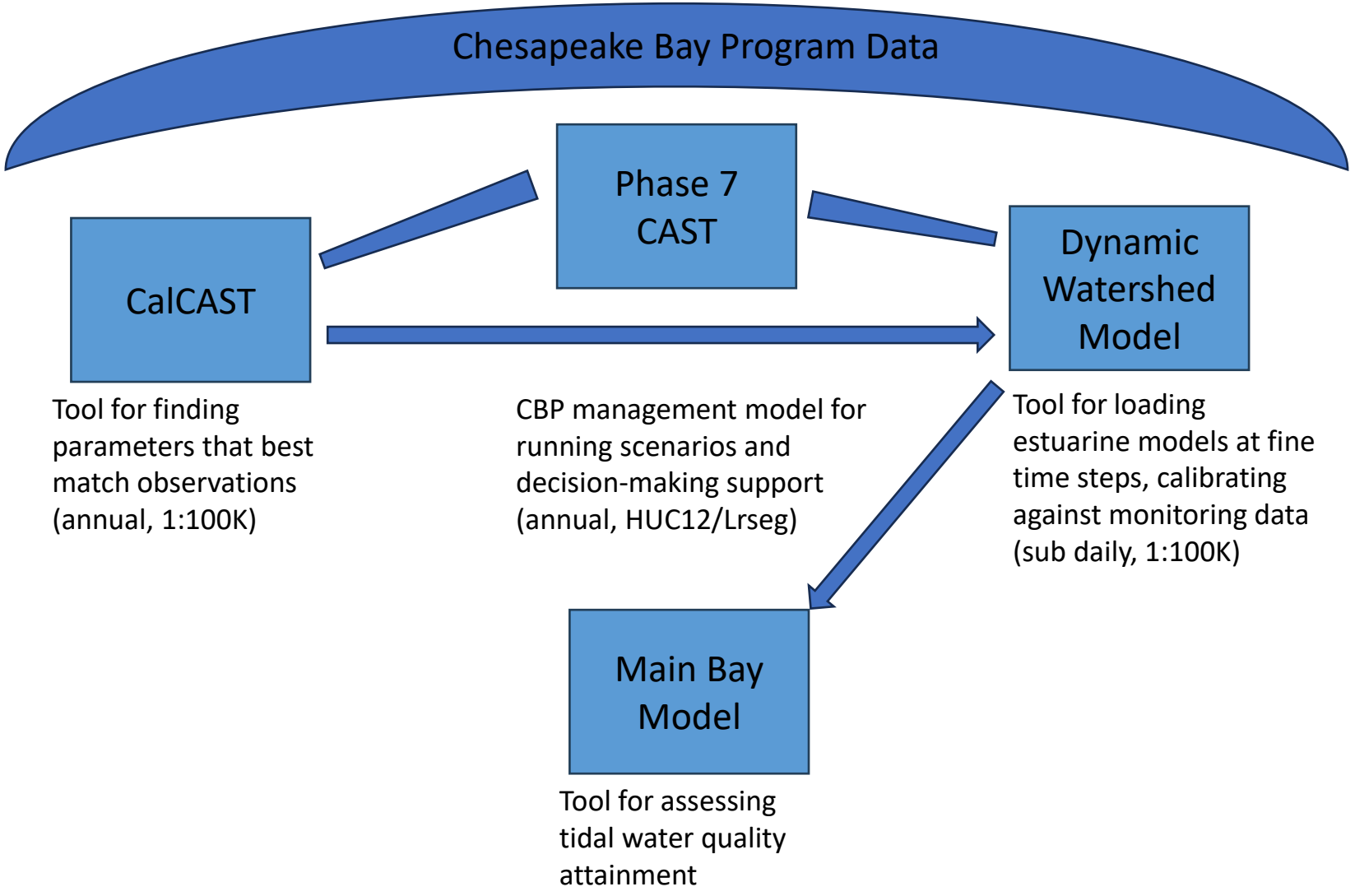
River Delivery Factors attenuate from rivers-to-Bay (DWSM)



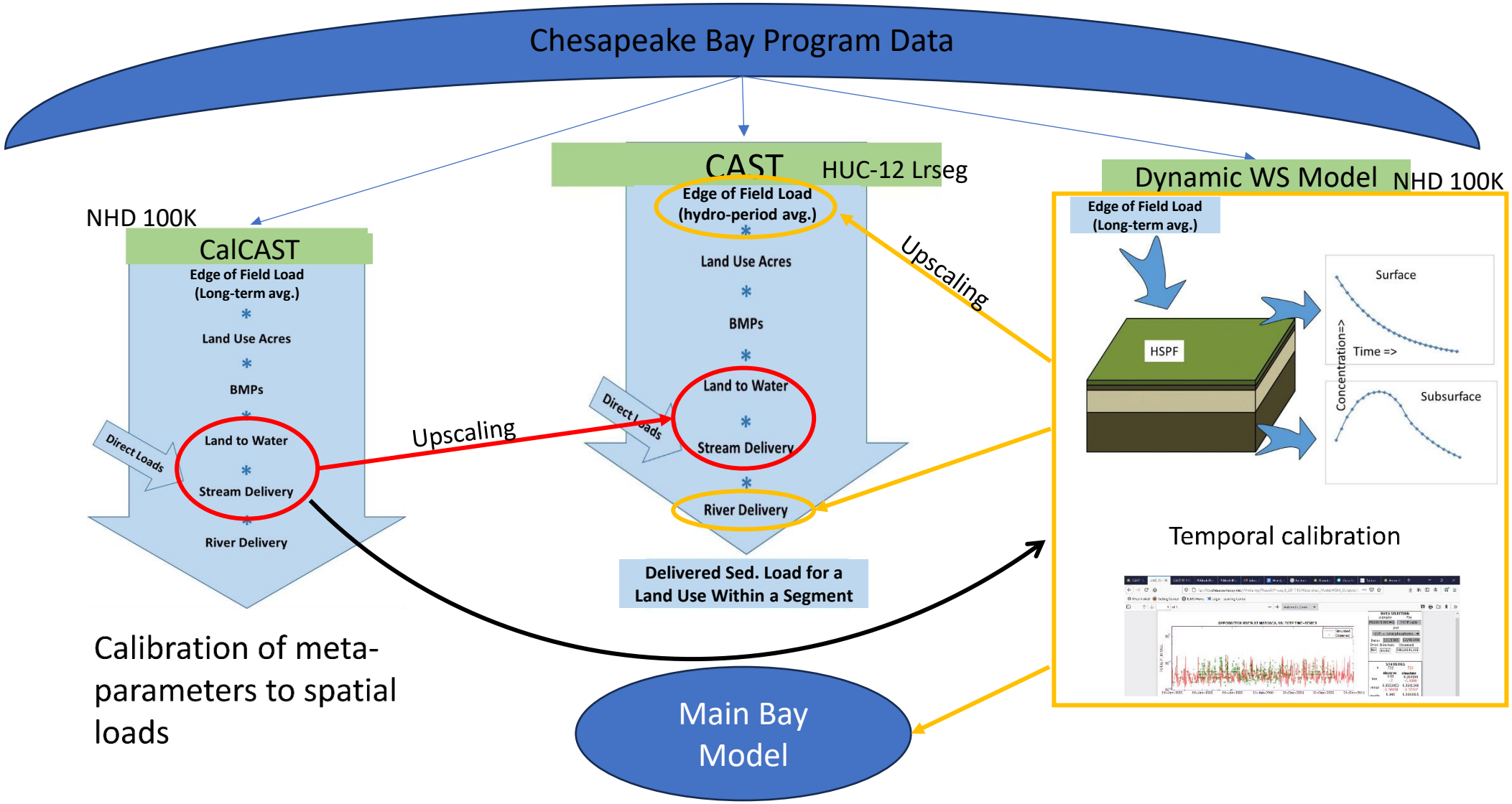
Phase 7 Suite of Models

Phase 7: A suite of models all using the same partnership approved and vetted data and reflecting the structure of CAST.

Phase 6: CAST was informed by various models with different data, timespans and structures.

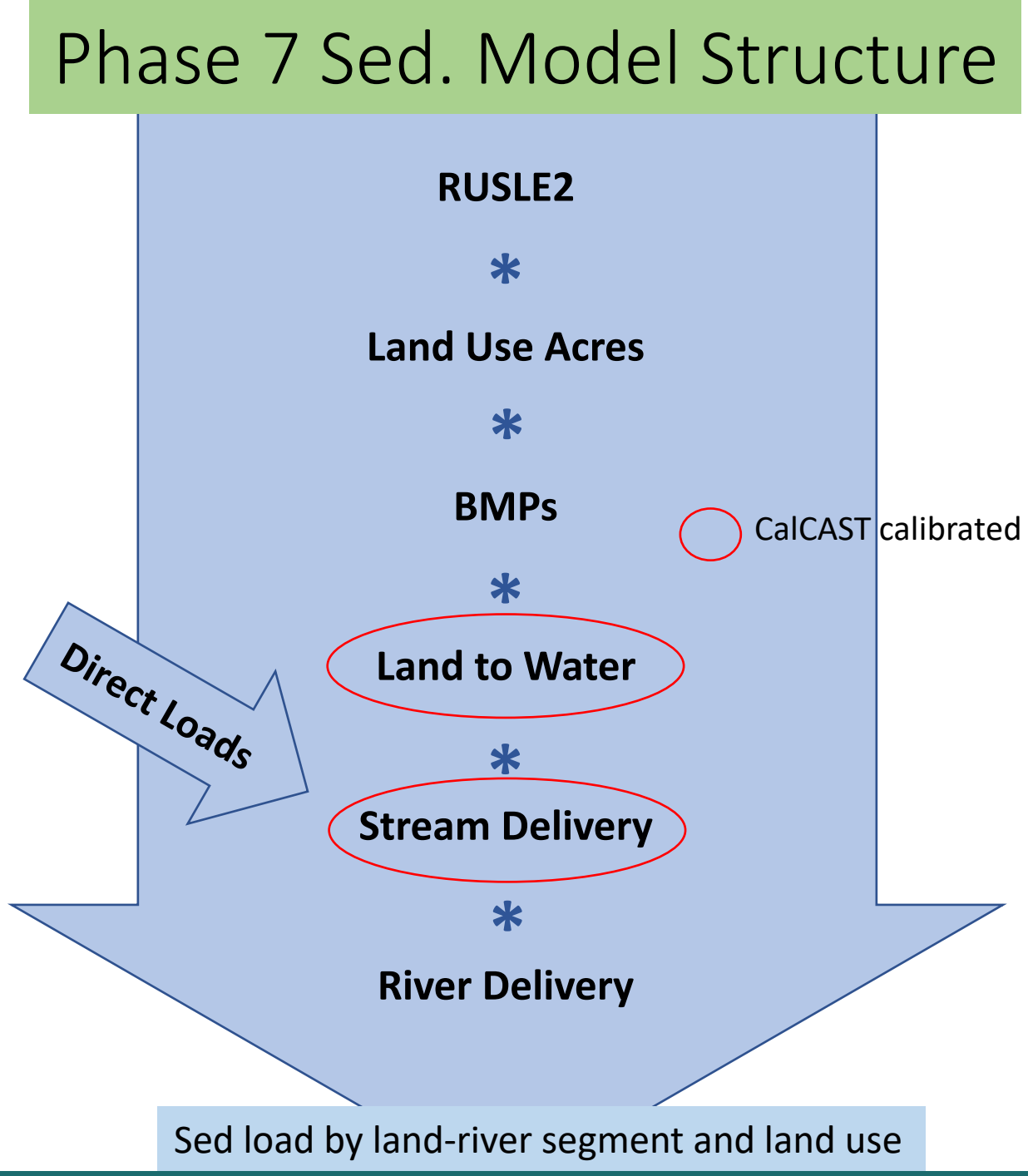


Suite of Models: Sediment



CalCAST: Sediment

- RUSLE2 recalculation (6 land cats)
  - Crosswalk to 16 CAST land classes
- P7 Land uses
- Land-to-water
  - Recalculate connectivity factors for all 16 LCs
  - Test influence of ponds, imperviousness, and geology as informed by reviews, workgroups, and literature
- Stream erosion and deposition updated from Noe et al.



Edge of Field Sediment Loading Rate

(RUSLE2)

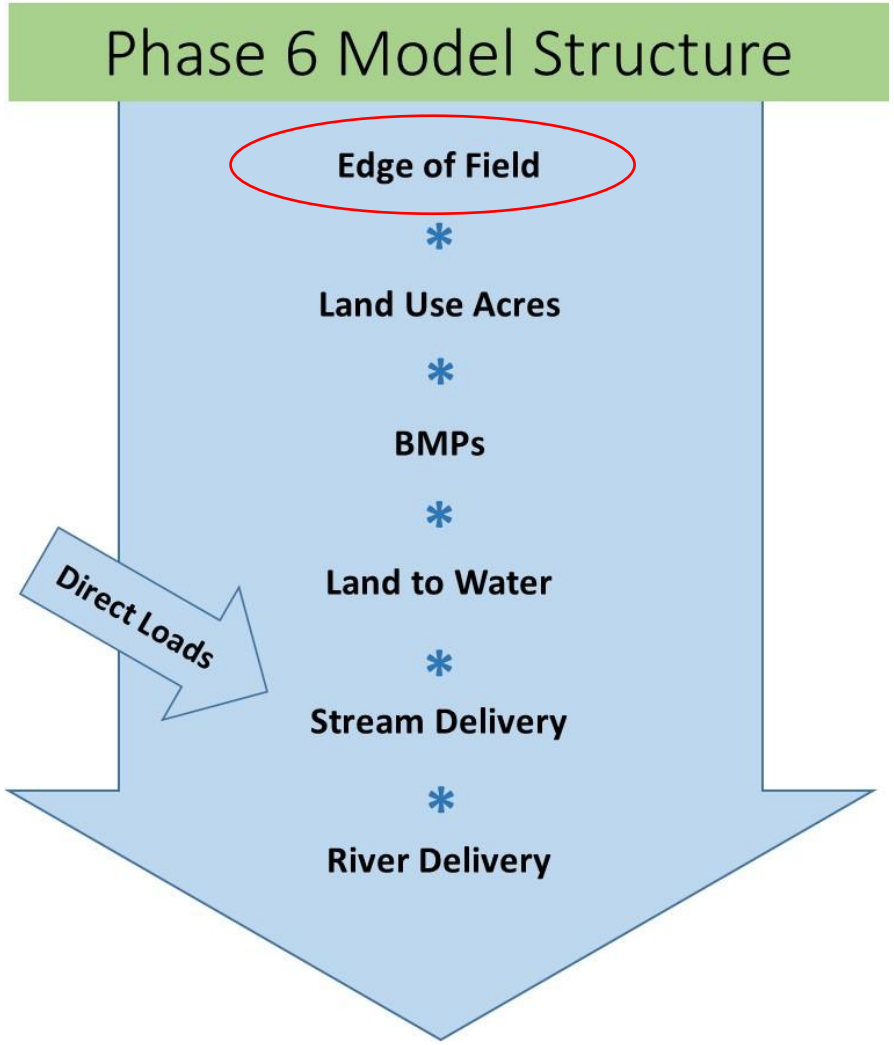
Consistent with Phase 6

RUSLE => R * K * LS * C * P

- R = Runoff
- K = Erodibility
- LS = slope length

} Evaluated at 10 meter resolution

- C = Cover
  - By land use and catchment
- P = Practice
  - = 1 since no action loads



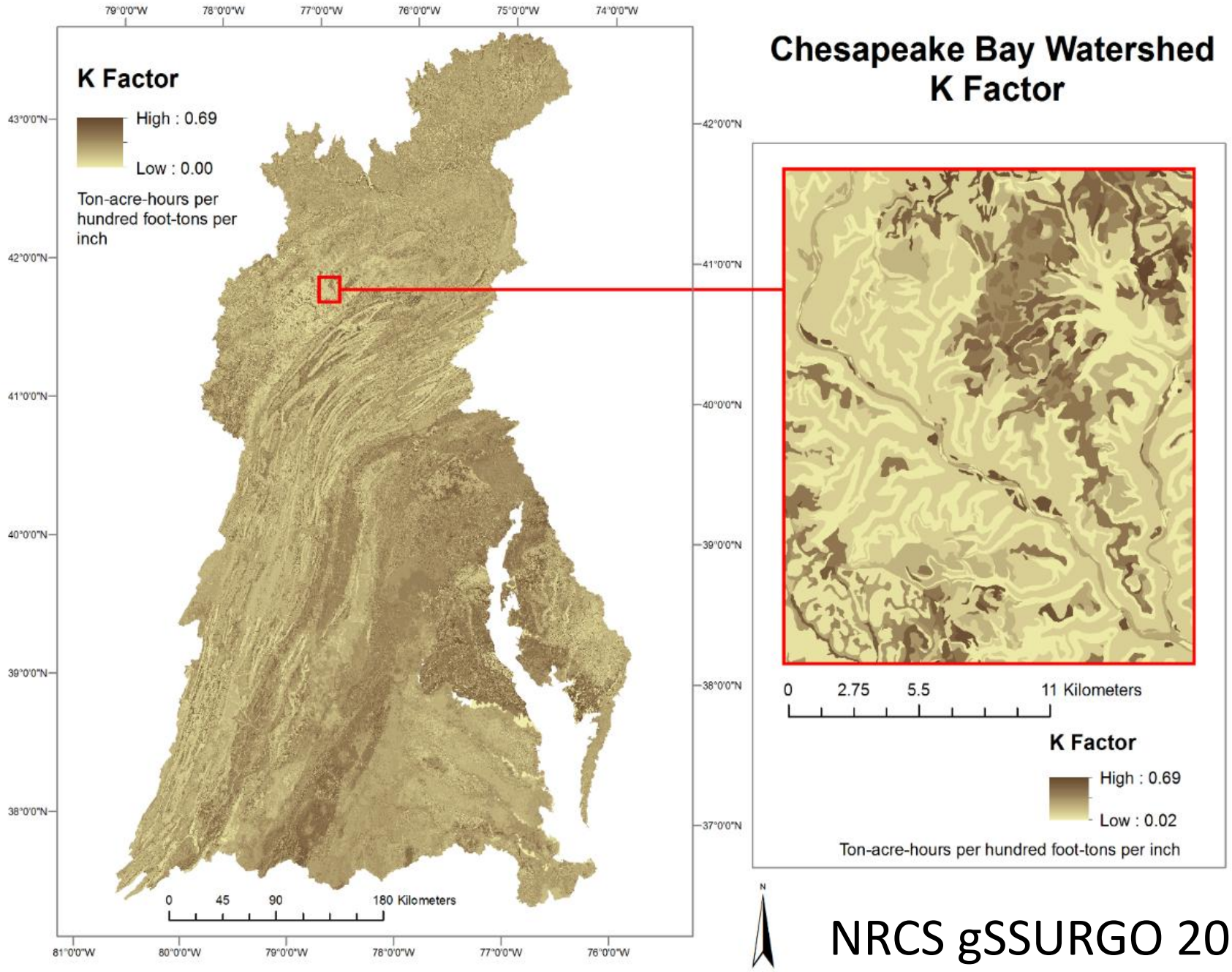
Consistent with Phase 6

1. The R, K, and LS factors are determined at a 10-meter scale. R factors are monthly while the K and LS factors are constant through time
2. The R, K, and LS factors are aggregated to major land use class and catchment-county model unit.
3. A monthly C factor is generated for each pervious land use and catchment-county model unit. The land uses in this step are the Phase 7 land uses.
4. Monthly sediment washoff is calculated as R * K * LS * C and then aggregated to a long-term average by land use and catchment-county model unit.
5. Impervious and non-mapped land use loading rates calculated relative to forest and turfgrass loading rates.

Handled via BMPs

EOF Load = R * K * LS * C * ~~P~~

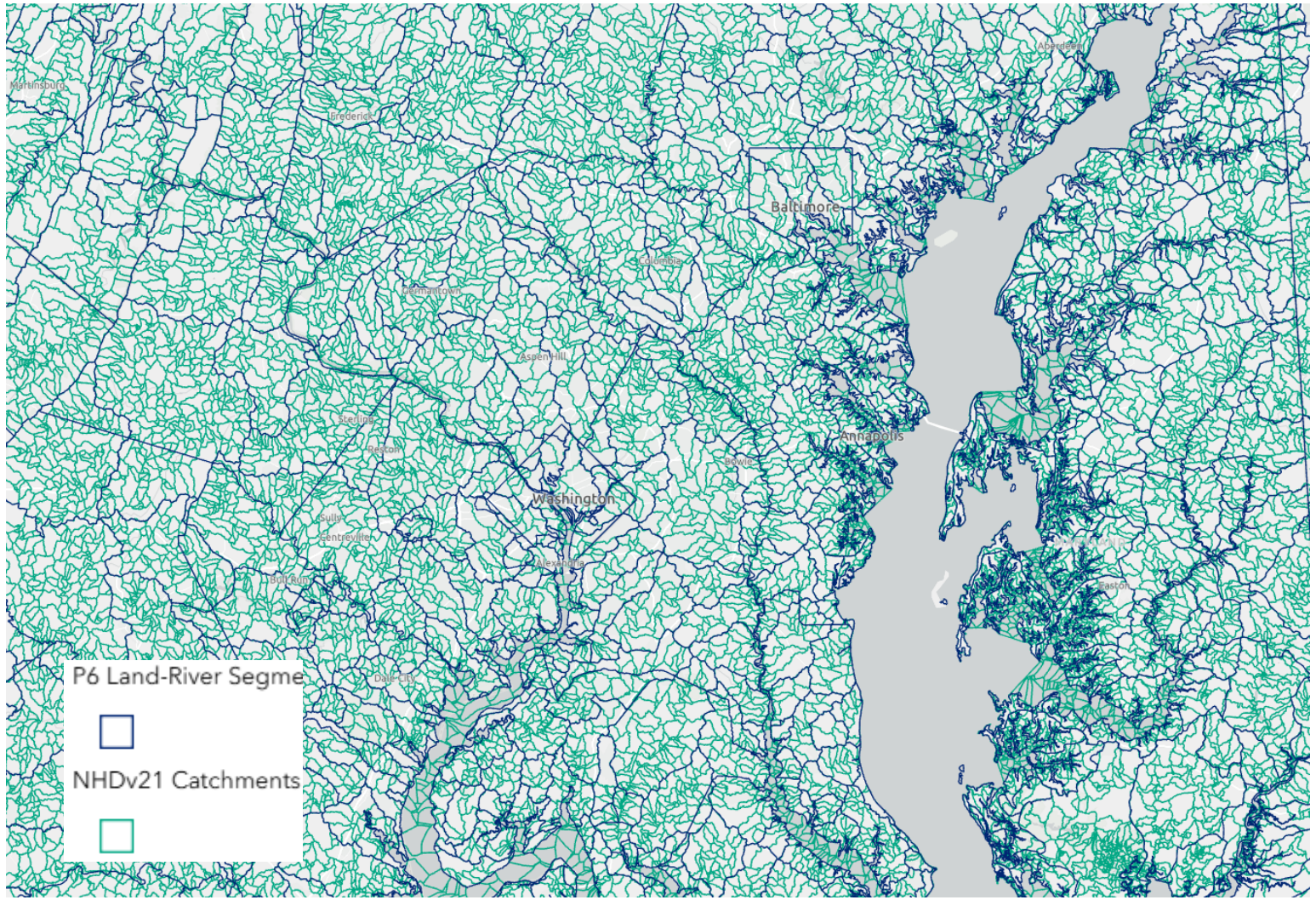
- **R** – Rainfall erosivity (energy of raindrops and overland flow)
- **K** – Soil erodibility (sensitivity of soil to erosion)
- **LS** – Topographic factor (slope length and steepness)
- **C** – crop cover and vegetation management
- **P** – Practice, BMP not used in EOF calculation.



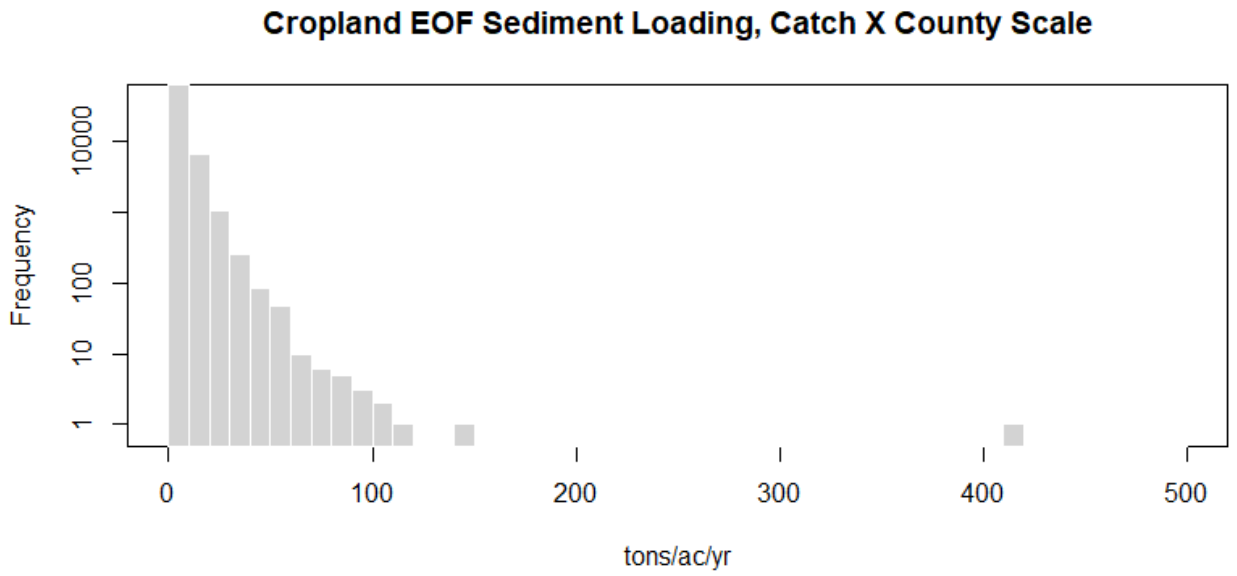
NRCS gSSURGO 2015

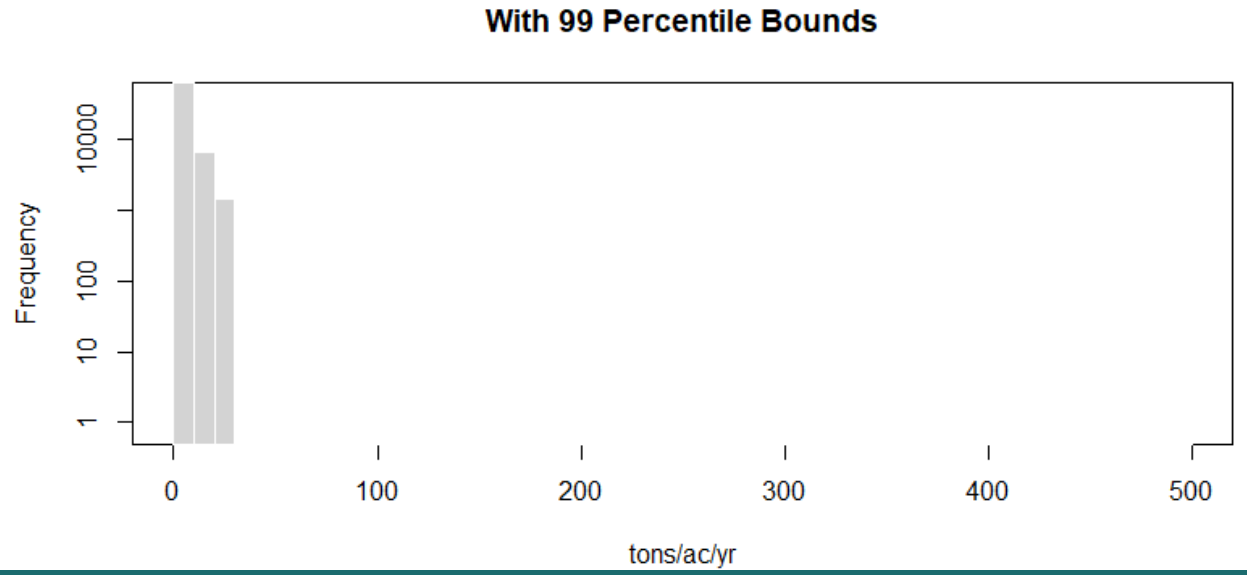
What's Different in Phase 7

- Spatial scale. P6 Lrseg to P7 catchment-county. Much finer spatial resolution.
- P7 Land classes and land uses.
  - New C-factors and translation factor from workgroups.
  - 6 categories in P6, 16 CAST classes in P7

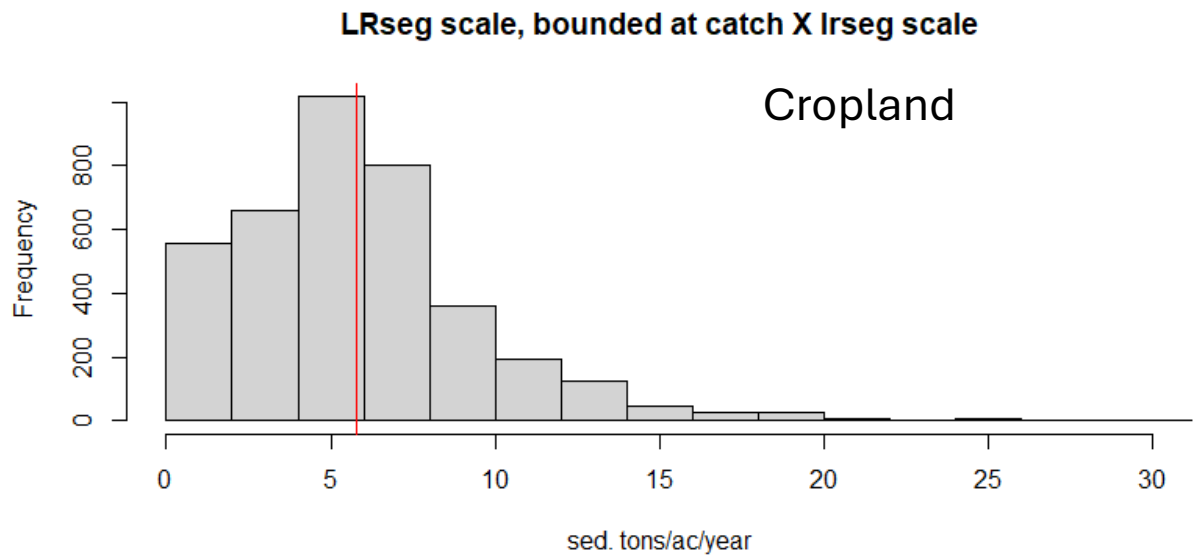


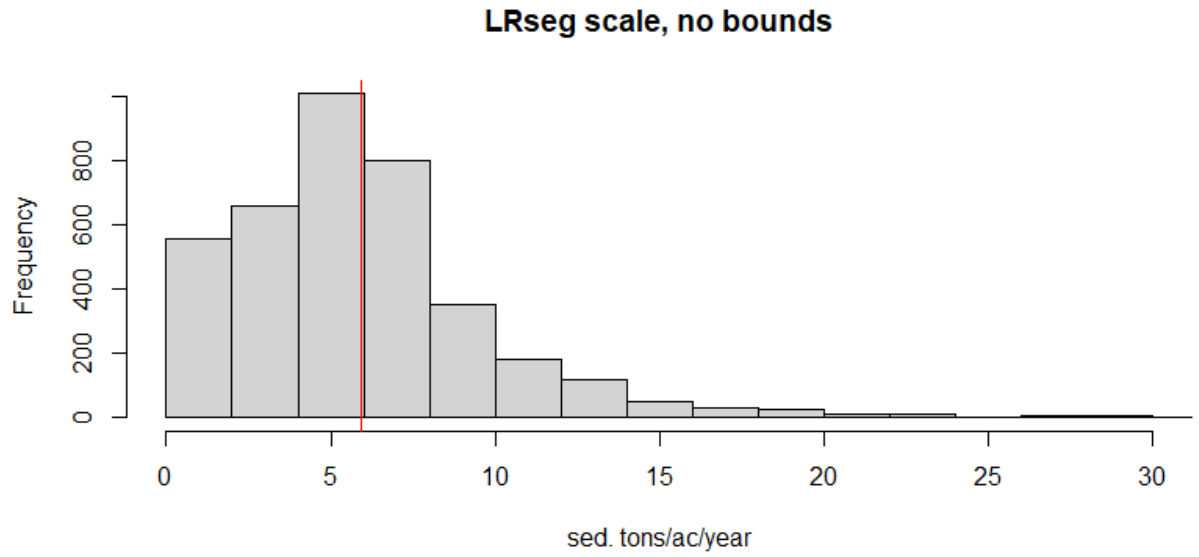
- RUSLE applied at the finer P7 catchment-county scale generates anomalous values, not present when summarized at the Lrseg scale.
- Applying a simple 1%-99% bounding removes anomalous values at the finer spatial scale…





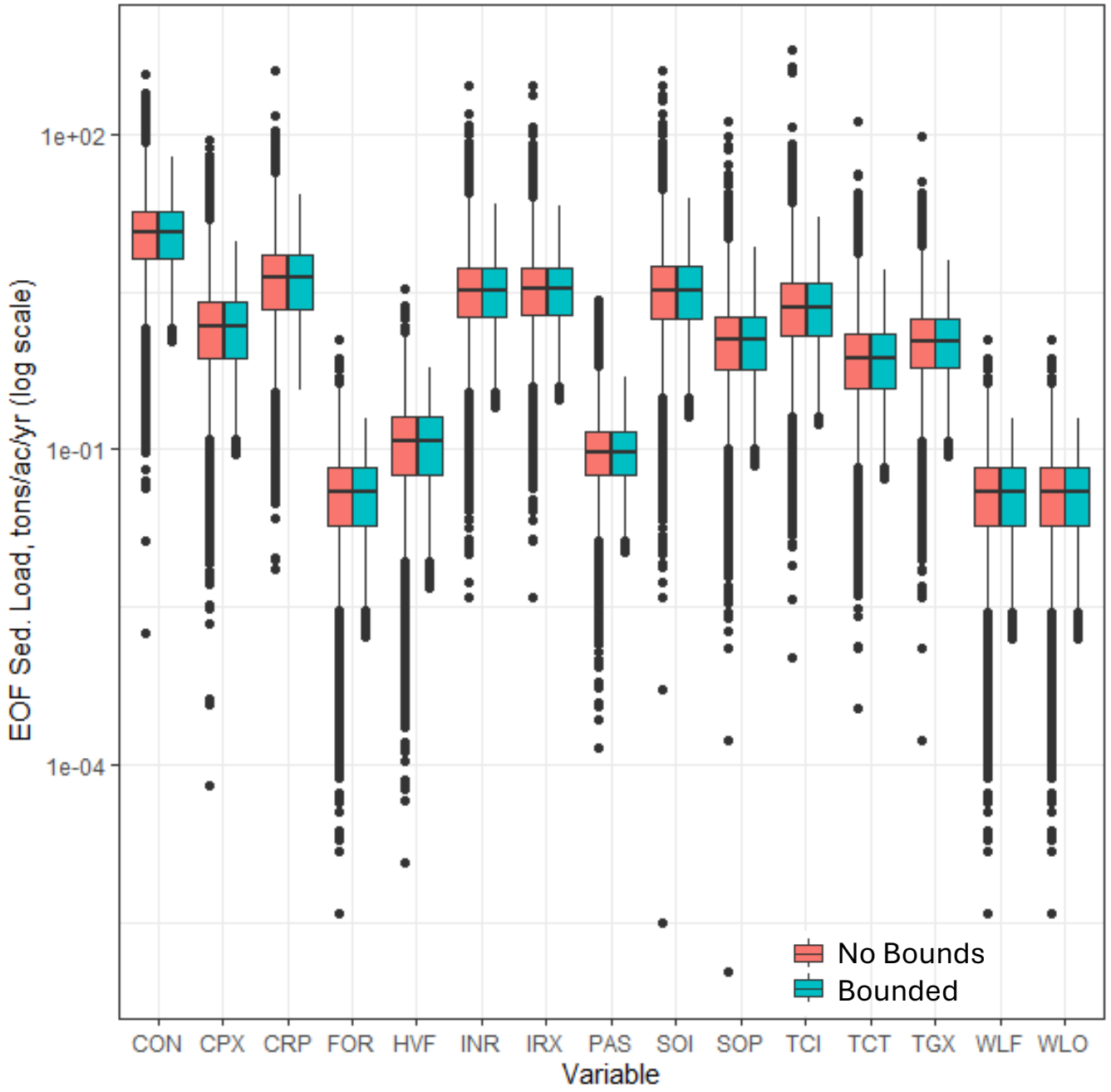
- RUSLE applied at the finer P7 catchment-county scale generates anomalous values, not present when summarized at the Lrseg scale.
- Applying a simple 1%-99% bounding removes anomalous values at the finer spatial scale…
- Without significantly altering the distribution or mean of EOF loading rates at larger scales.





Edge of Field Sediment (log scale)

CON – Construction
CPX – Construction Pervious
CRP – Cropland
FOR – Forested
HVF – Harvested Forest
INR – Impervious Non-road
IRX – Impervious Roads
SOI – Solar Impervious
SOP – Solar Pervious
TCI – Tree Canopy over Imp.
TCT – Tree Canopy over Turf
TG – Turf Grass
WLF – Wetland Floodplain
WLO – Wetland Other



Note: Summarized at the land class scale, but there is variation based on C-factor at the land-use scale.

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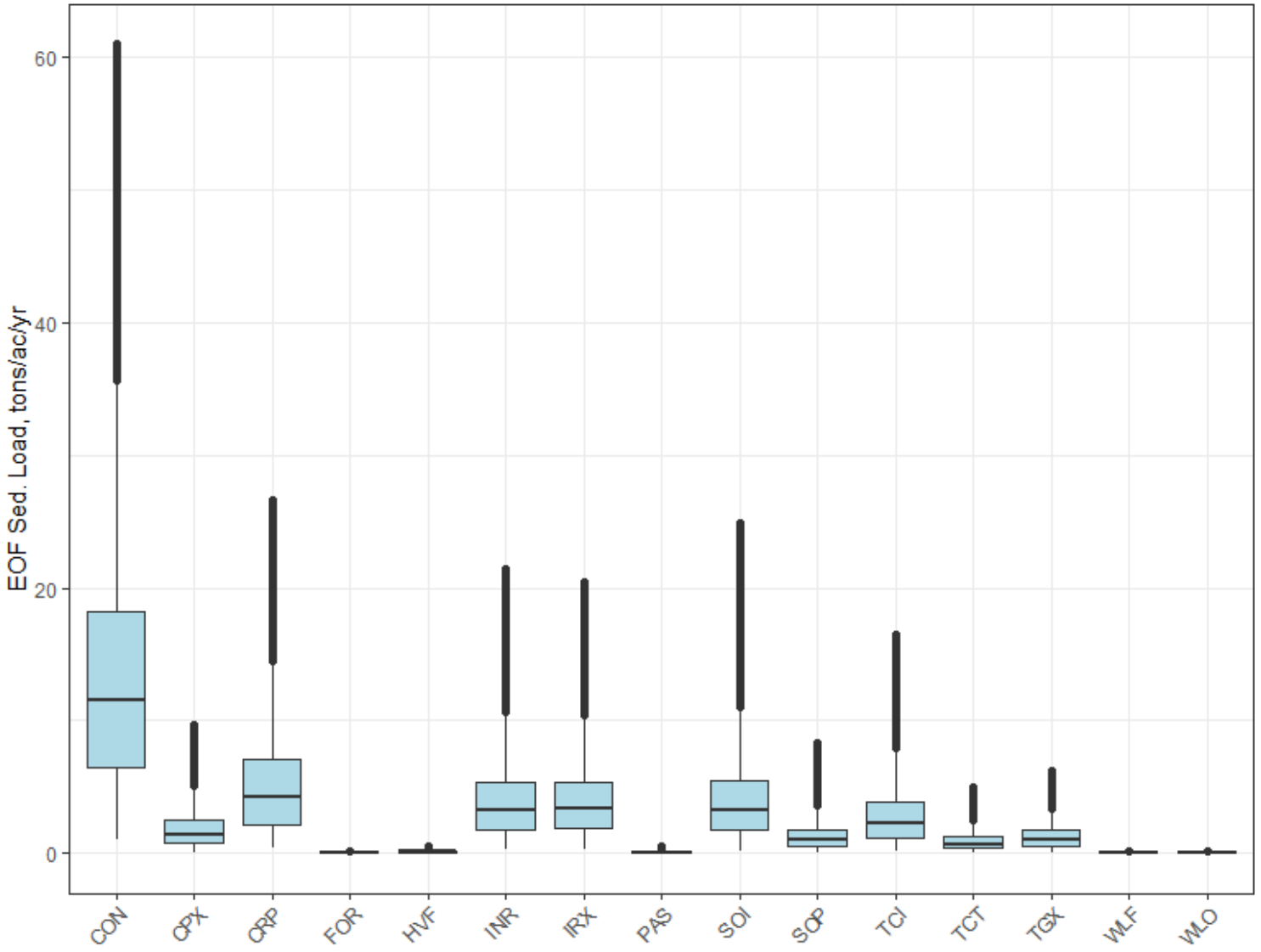

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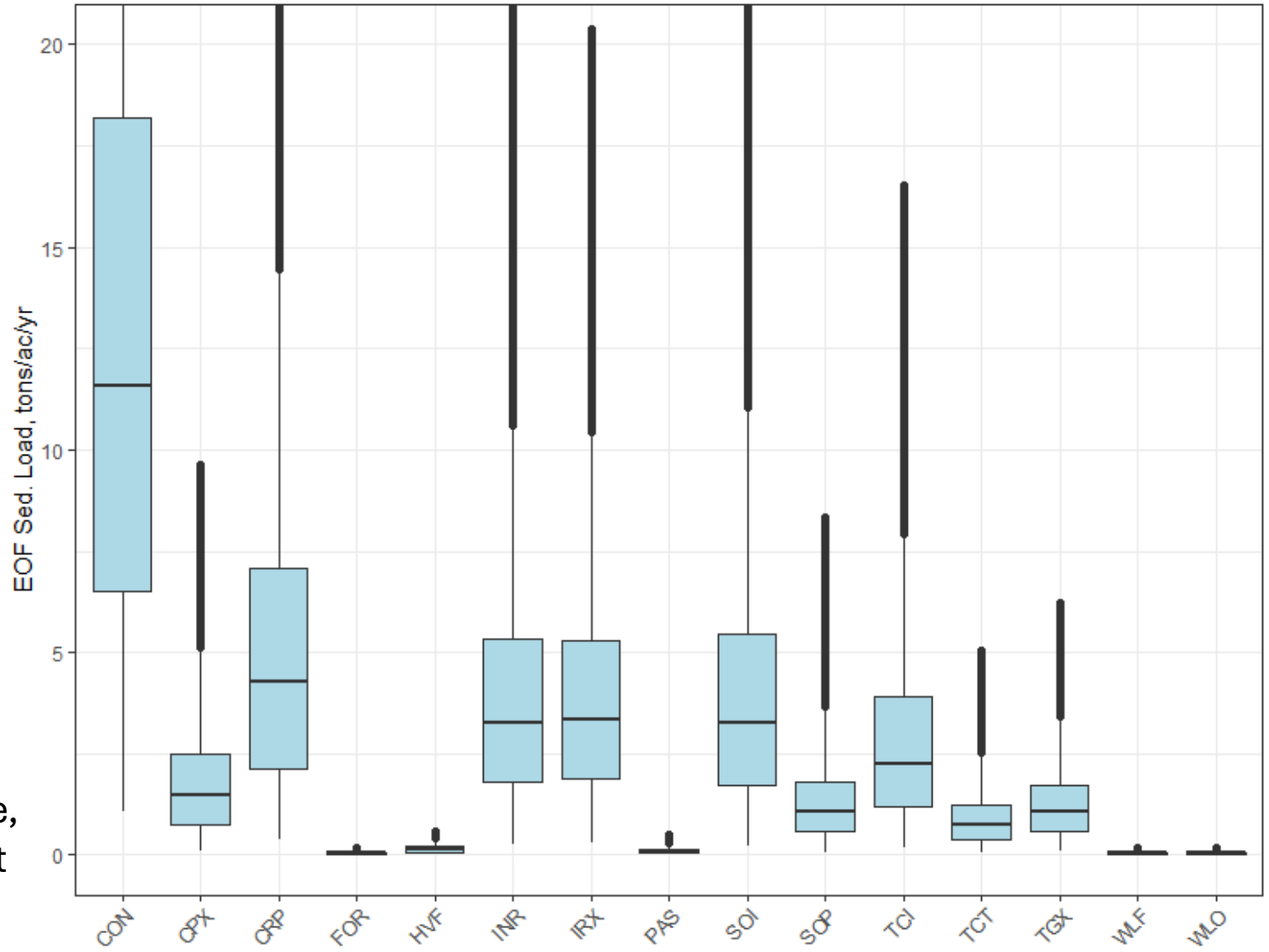

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Sediment Transport

What's New

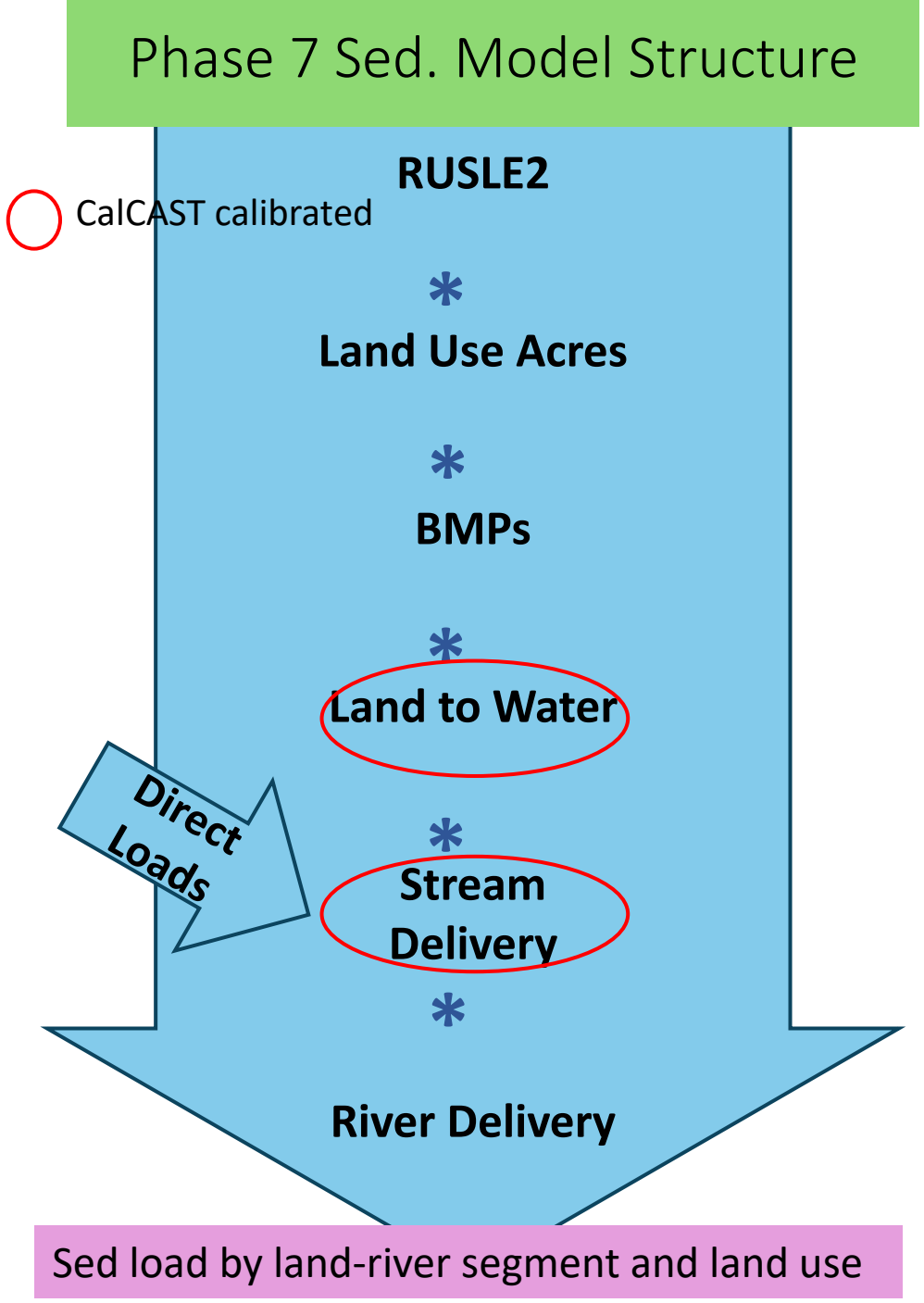
More land use differentiation
- P6 used 6 RUSLE land uses categories
- P7 uses the 16 land classes with separate index of connectivity factors

Higher spatial resolution
- From LRSEG to NHD

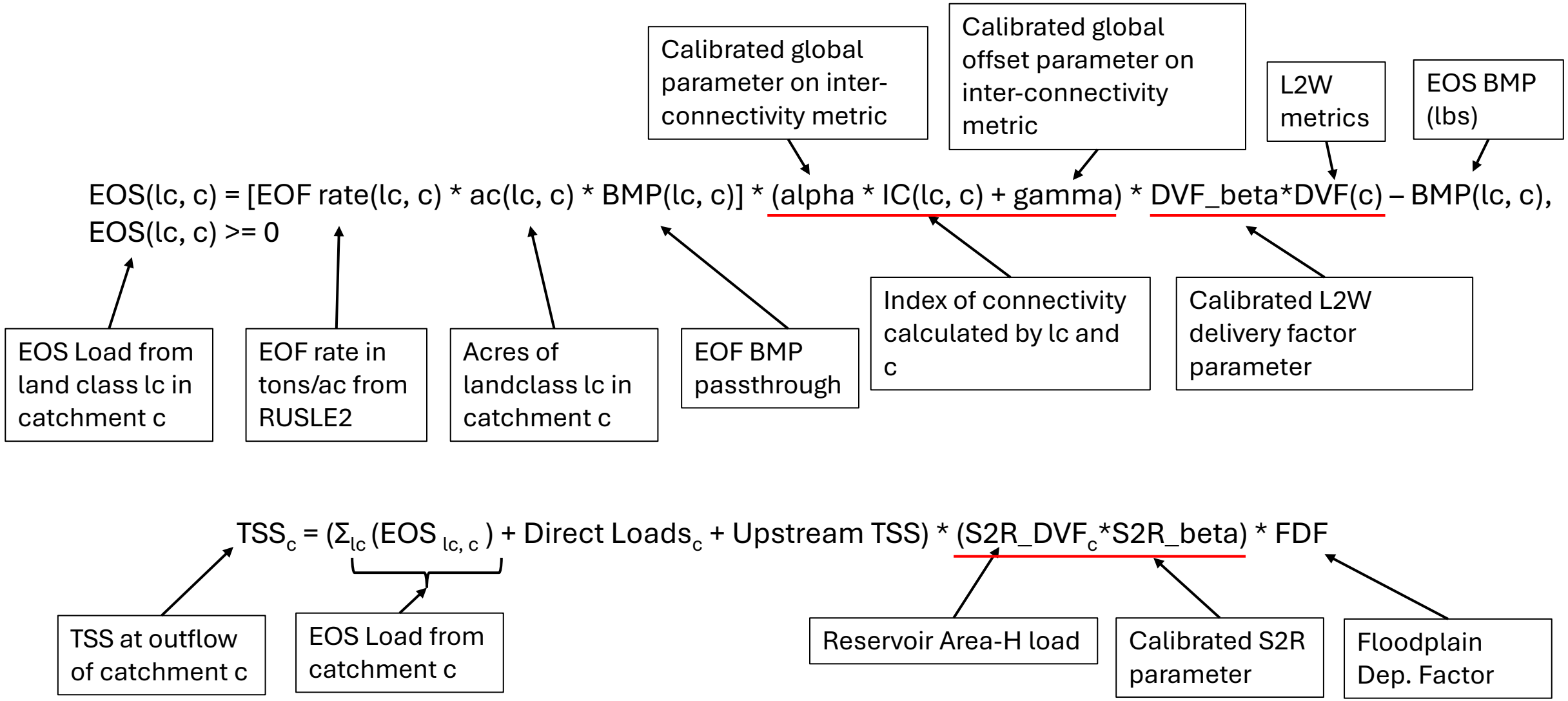
More calibration stations representing greater diversity of watershed composition and structure
- 60 stations -> 152

Robust statistical calibration of parameters
- CalCAST
- Testing new Land-to-water predictors

New stream bed and bank erosion and floodplain deposition estimation
- Retain P6 assumptions, but informed by latest USGS surveys (Noe et al., in prep)



Sediment Model



Sediment Model

Calibrated global parameter on inter-connectivity metric

Calibrated global offset parameter on inter-connectivity metric

L2W metrics

EOS BMP (lbs)

$$EOS(lc, c) = [EOF\ rate(lc, c) * ac(lc, c) * BMP(lc, c)] * (alpha * IC(lc, c) + gamma) * DVF\_beta*DVF(c) - BMP(lc, c),\ EOS(lc, c) >= 0$$

EOS Load from land class lc in catchment c

EOF rate in tons/ac from RUSLE2

Acres of landclass lc in catchment c

EOF BMP passthrough

Index of connectivity calculated by lc and c

Calibrated L2W delivery factor parameter

$$TSS_c = (\Sigma_{lc}(EOS_{lc, c}) + Direct\ Loads_c + Upstream\ TSS) * (S2R\_DVF_c*S2R\_beta) * FDF$$

TSS at outflow of catchment c

EOS Load from catchment c

Reservoir Area-H load

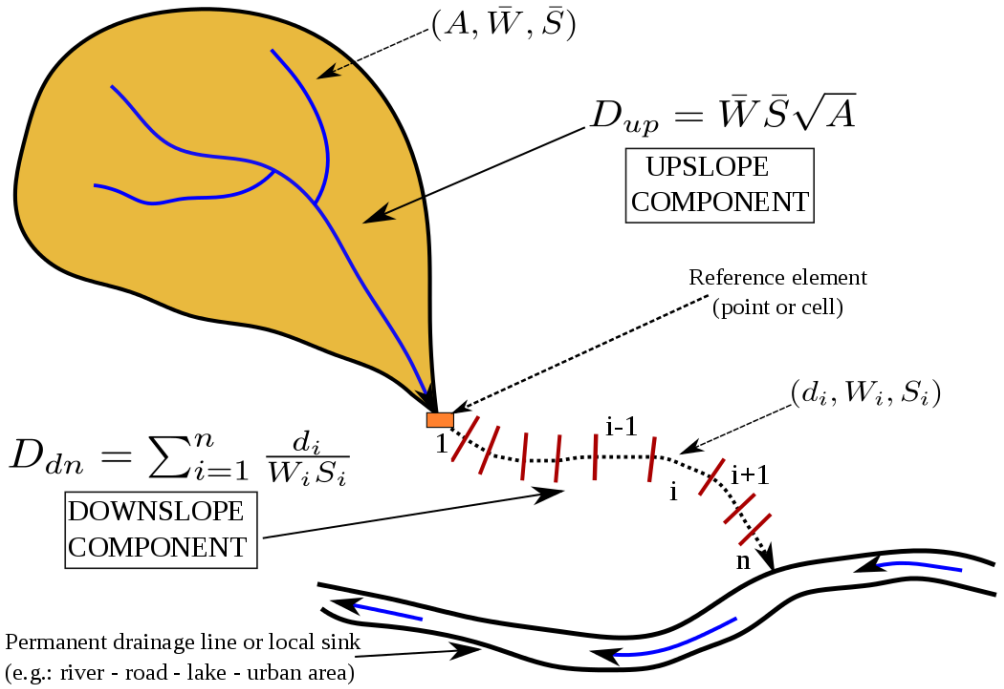
Calibrated S2R parameter

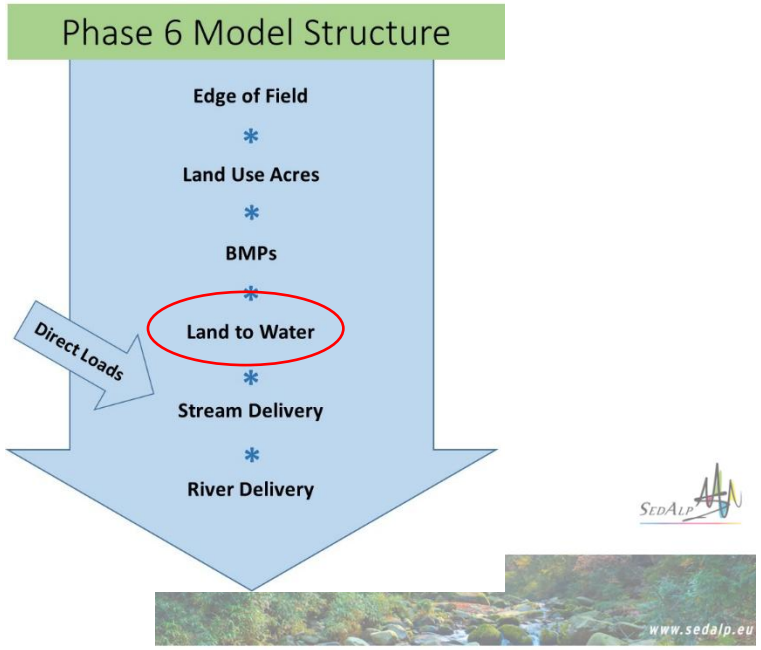
Floodplain Dep. Factor

Sediment Delivery to Small Streams

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

IC = Index of Connectivity





Guidelines on the Sediment Connectivity
ArcGis 10.1 and 10.2 Toolbox

Release: 1.1

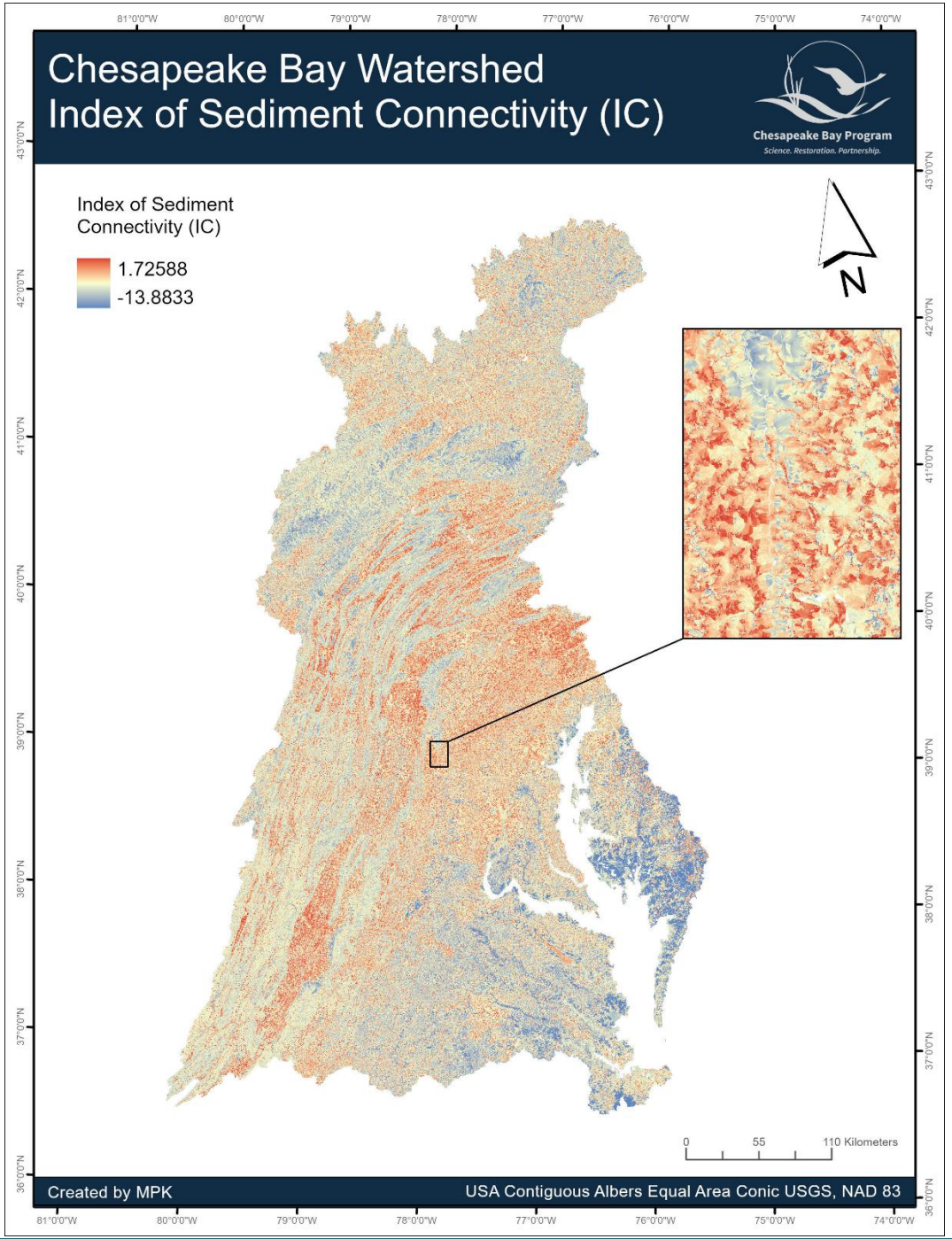
Marco Cavalli, Stefano Crema, Lorenzo Marchi
CNR-IRPI Padova (PP4)

June 2014

Sediment Delivery to Small Streams

For Phase 7:

- Use of an impedance factor that is more applicable to the Chesapeake Bay Watershed.
  - A LULC-weighted impedance factor was used to calculate IC to account for differences among land-cover within the Chesapeake Bay watershed (Cavalli et al. 2008).
  - As opposed to the terrain-derived weighting factor used in Phase 6 (Cavalli et al. 2013).
    - The terrain-weighted approach applied in Phase 6 was developed in environments where surface roughness is a primary control on connectivity.
  - The LULC-weighted approach uses C-factor to represent the relative influence of land cover on sediment flux.
  - More applicable to the watershed's agricultural, forested, developed, and wetland landscapes.
- Updated DEM

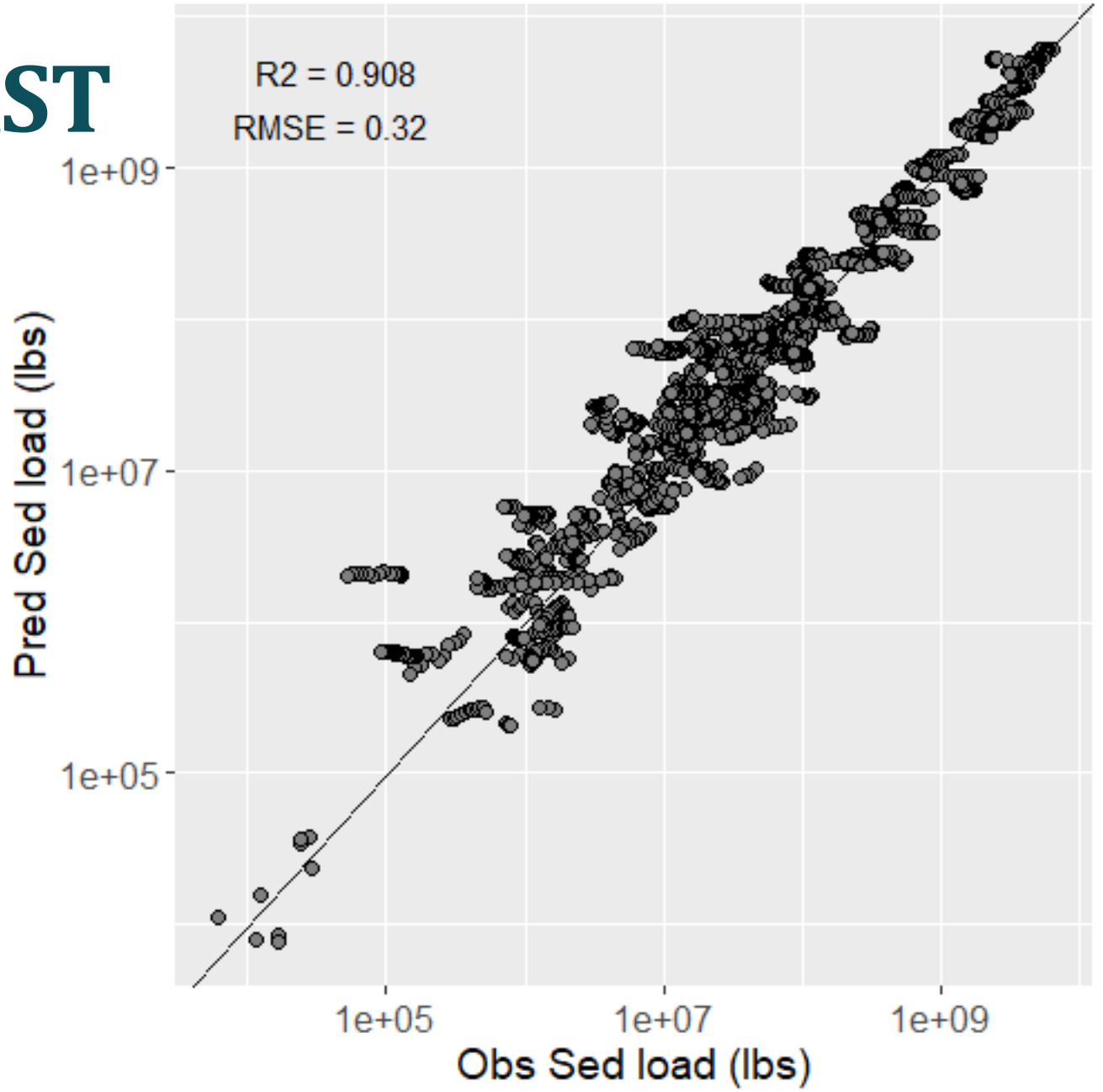


Comparing CalCAST results

- When comparing CalCAST results, these do not include the hand calibration and DWSM model calibration of River to Bay factors, and as such are NOT final results.
- Instead, this is a comparison of CalCAST results with P6 inputs and structure, to CalCAST results with P7 inputs and structure, both without the additional DWSM model calibration.

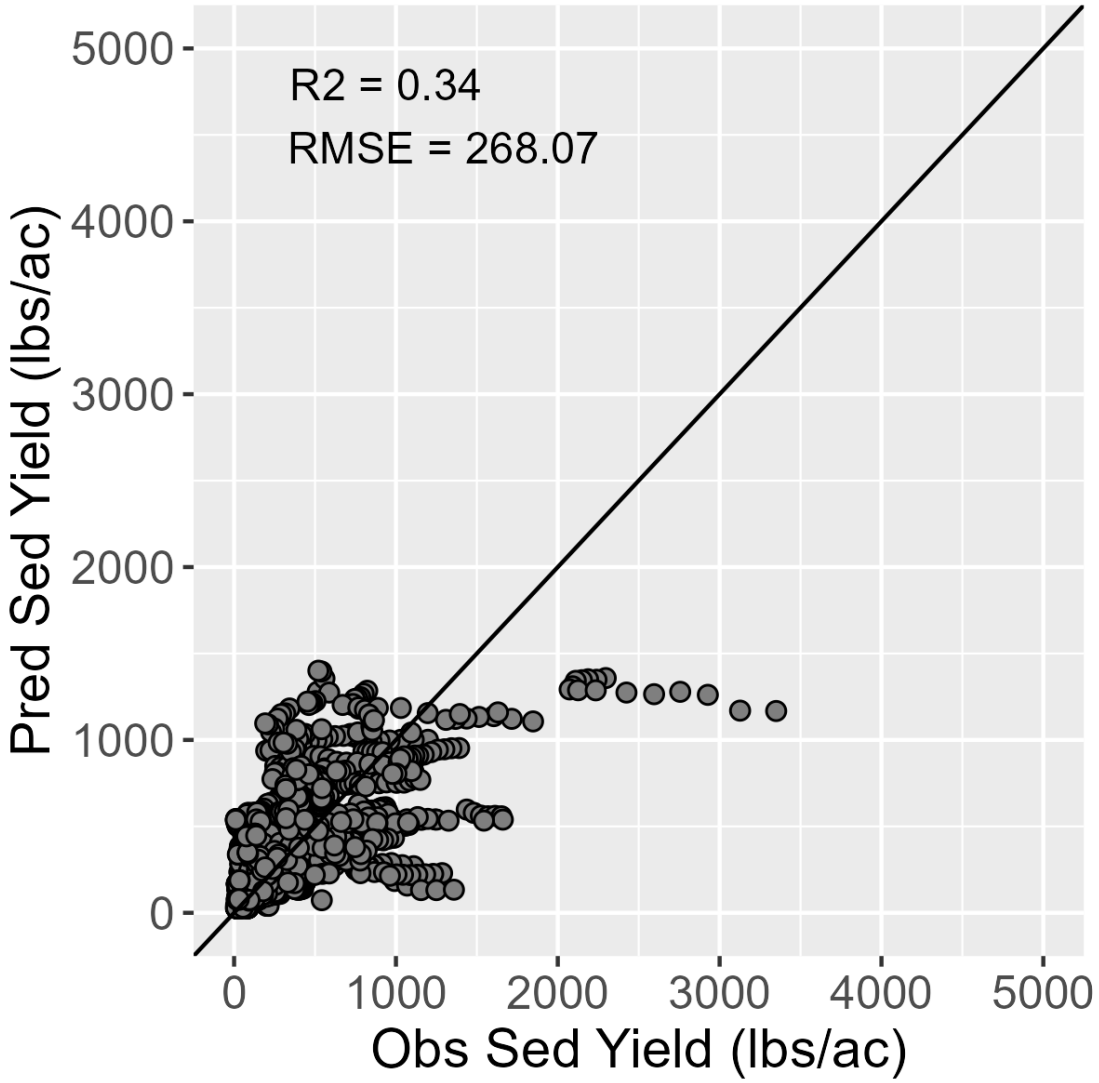
P7 Sediment CalCAST

Land-to-Water Factor	Coef. sign
Sed. Index of Connectivity	+
Impervious Non-Roads	-
Valley & Ridge Carbonate	-
Baseflow Index	-
Stream-to-River Factor	
Reservoir Area-head	-

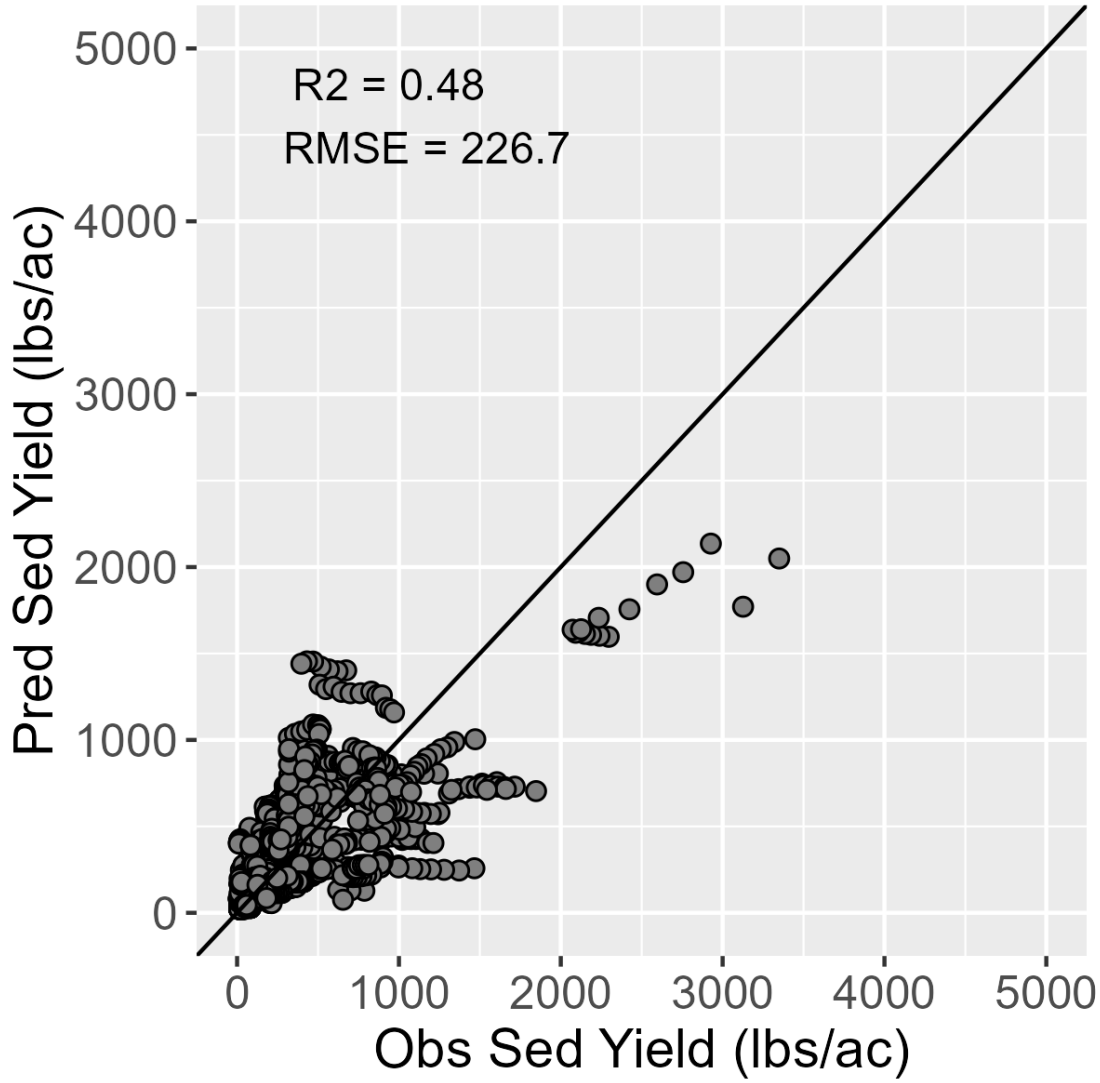


Performance: Yield

P6 inputs

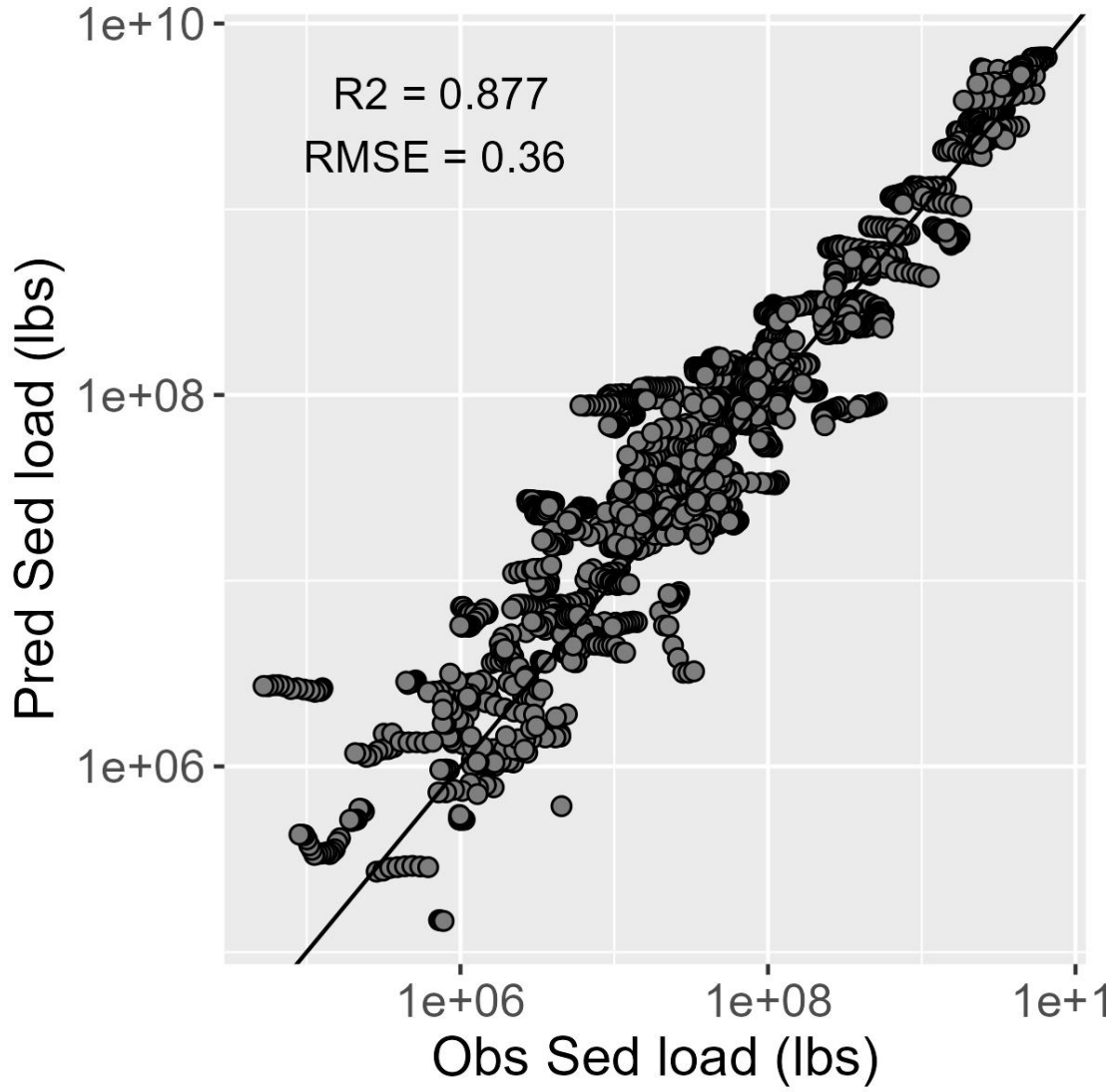


P7 inputs

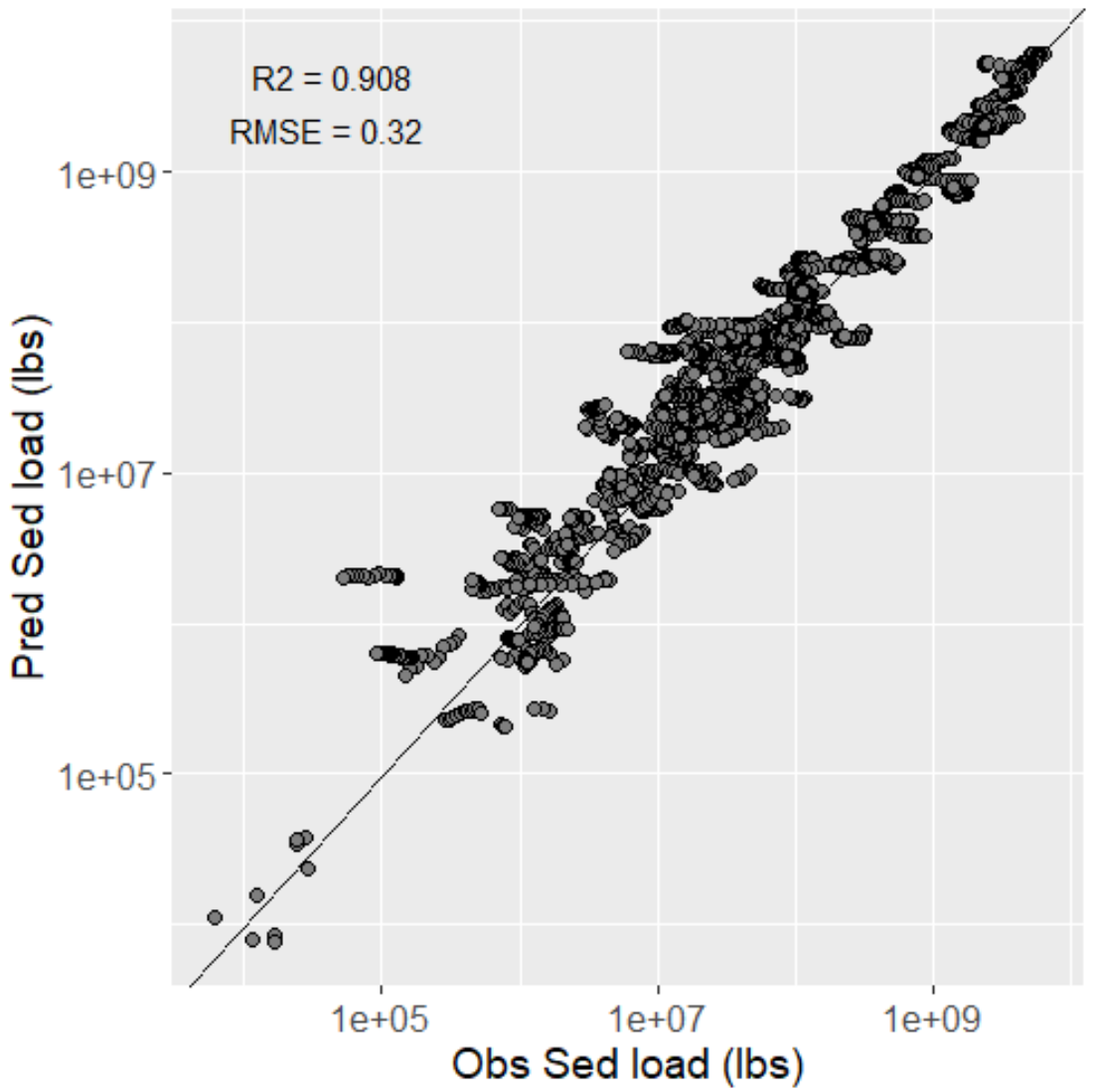


Performance: Log Load

P6 inputs

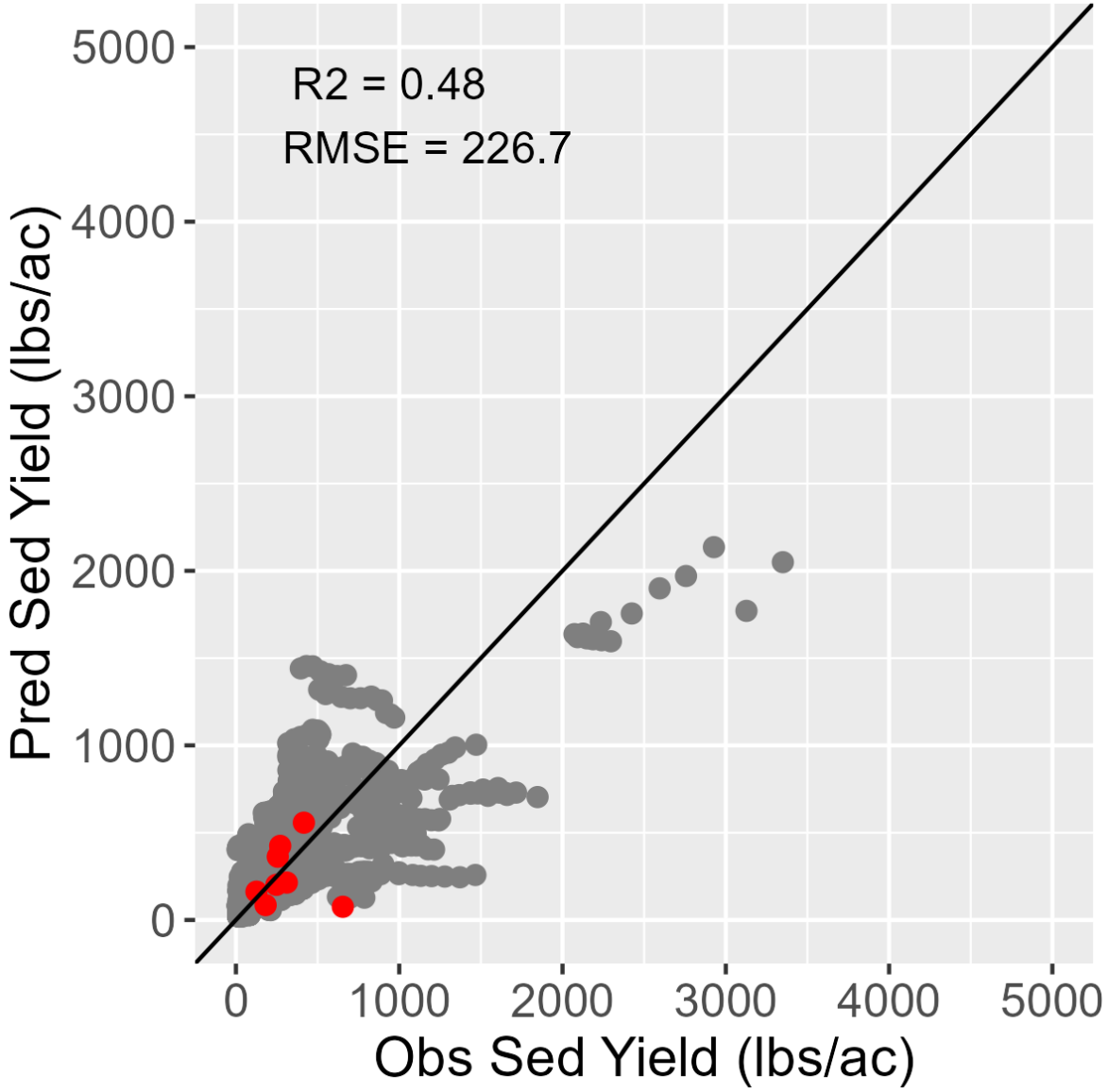


P7 inputs

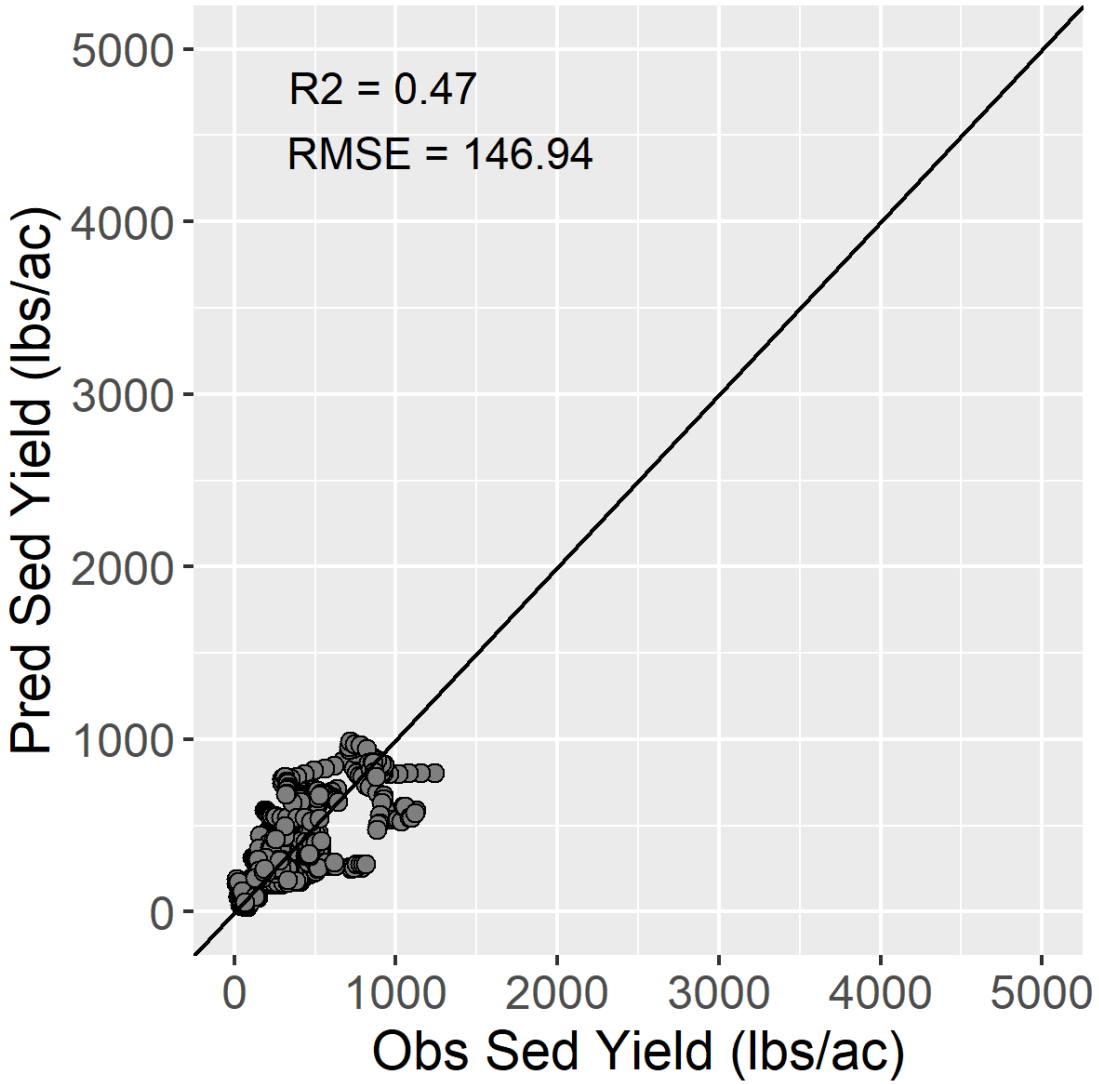


Performance is consistent across scales

Small urbanized catchments in SE Virginia (Hampton Roads) are shown in red.



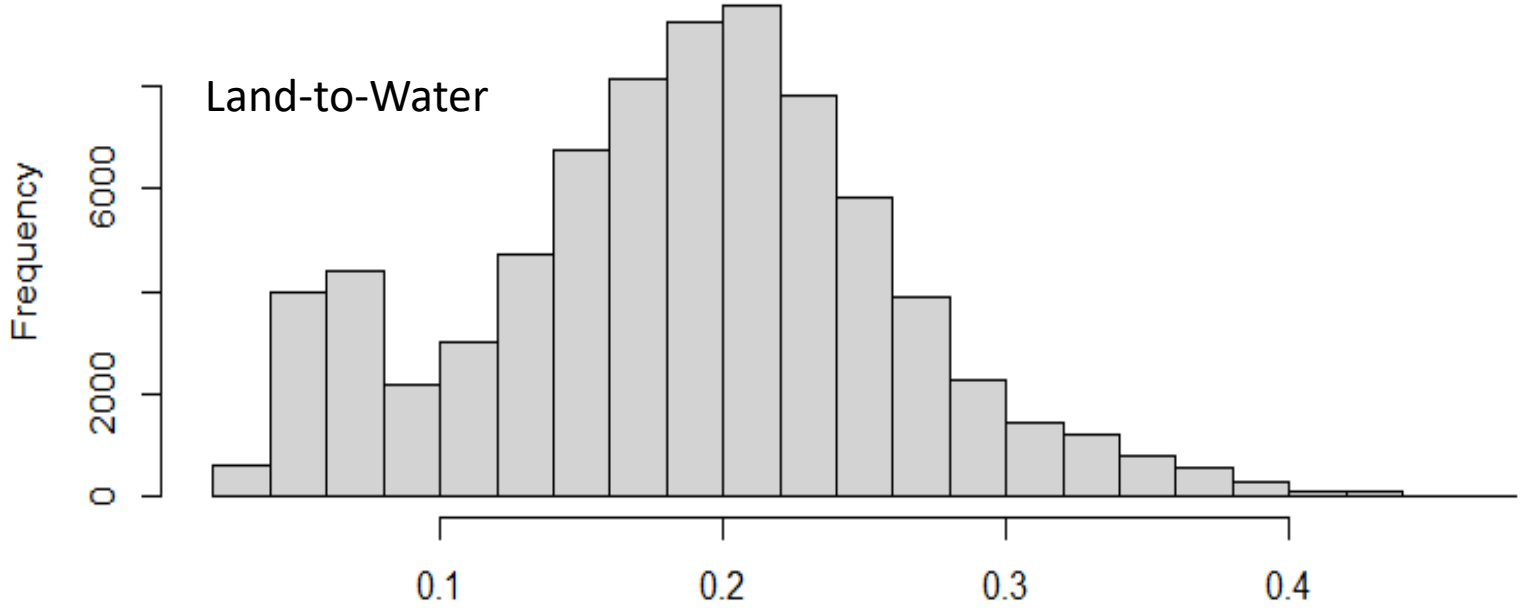
Yield Performance, P7 CalCAST with P6 monitoring

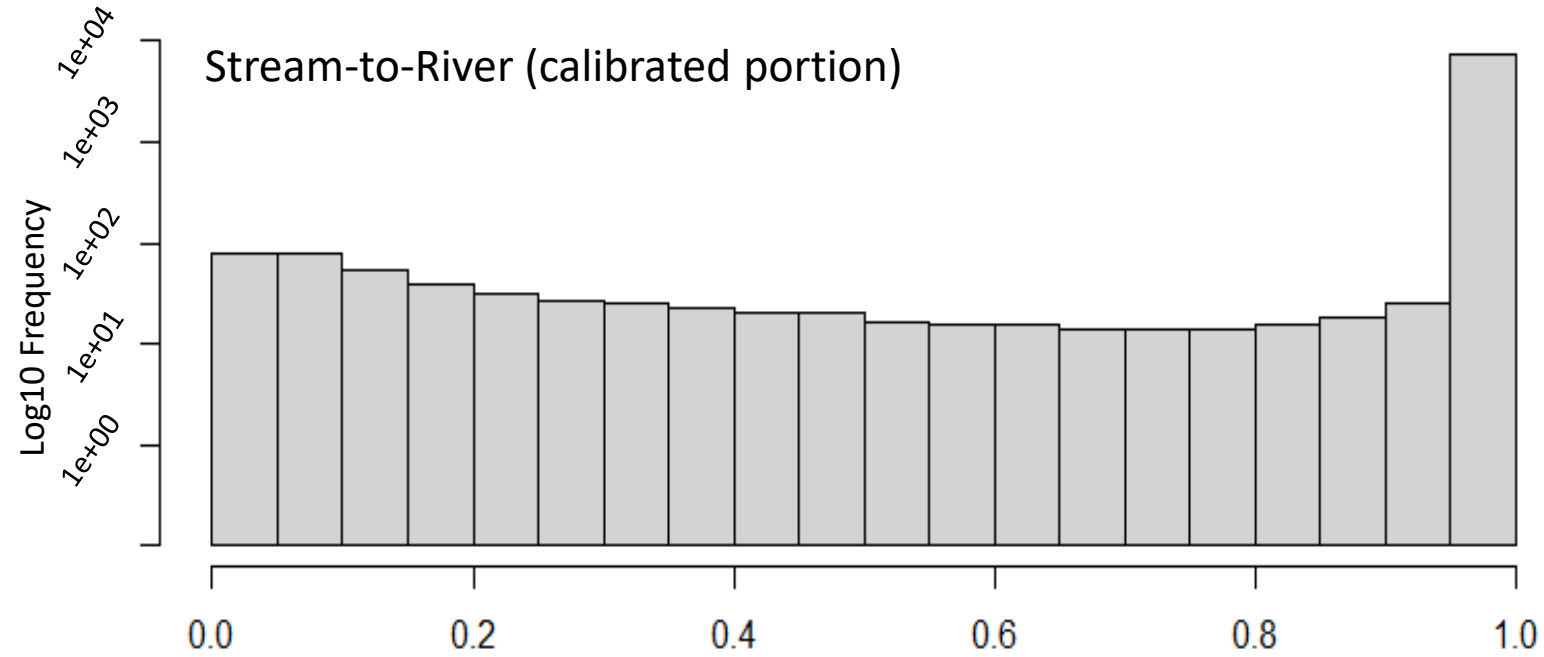


Parameters

EOS=EOF*L2W

EOR=EOS*S2R





Floodplain Delivery Factor

The total Stream-to-River factor is the combination of the calibrated factor and the Floodplain Delivery Factor (FDF).

- Implemented in CAST
- Average is ~0.84 (not official)
- Methods for FDF are retained from P6, but the underlying dataset has been updated…

Section 9.3:
The average streambank and floodplain sediment and nutrient flux rates are implemented in Phase 6 by transforming the floodplain depositional fluxes into delivery factors.
FDF = (US – FD) / (US),
Where US is the upstream load,
FD is the floodplain deposition load which is equal to the steam bed/bank erosion rate, assuming deposition and erosion are equal.

Stream Bed and Bank Erosion P6

- P6 stream bank erosion extrapolated values from the mean of 42 Chesapeake Floodplain Network (CFN) (Noe et al. 2015) sites which skewed towards large rivers.

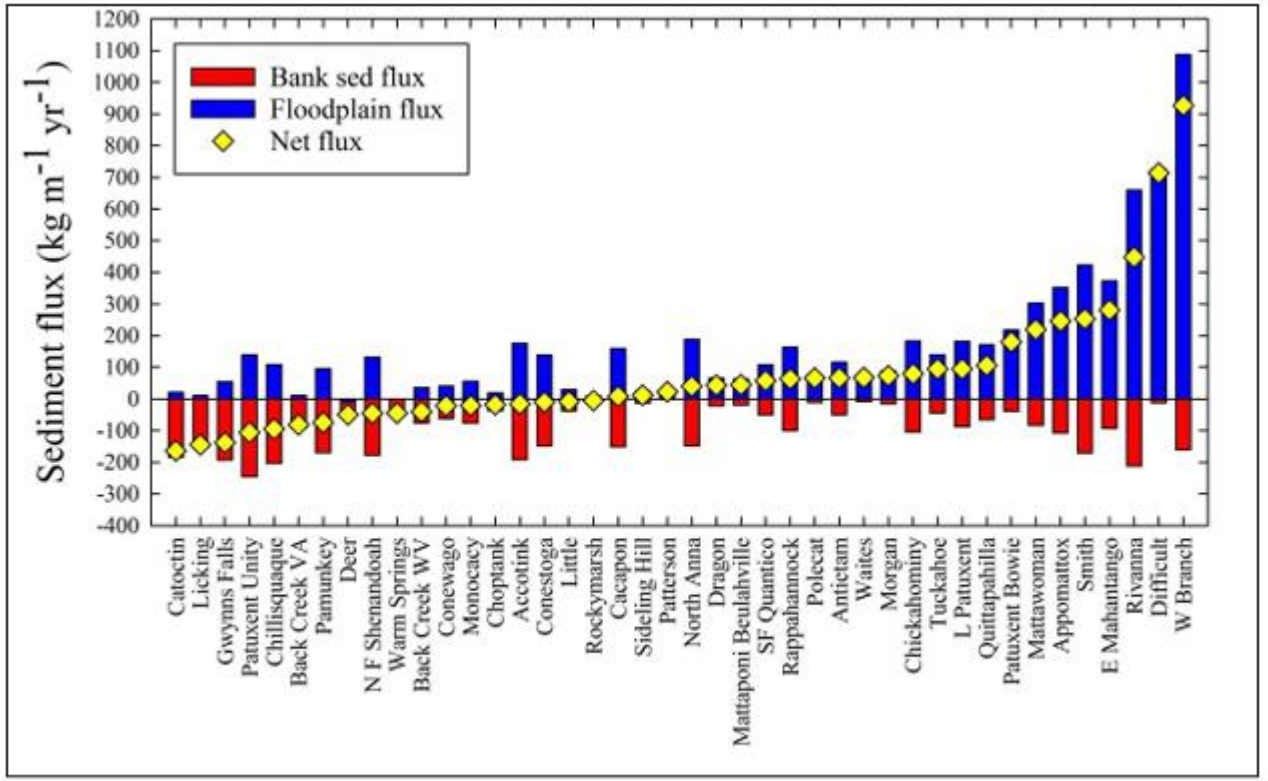
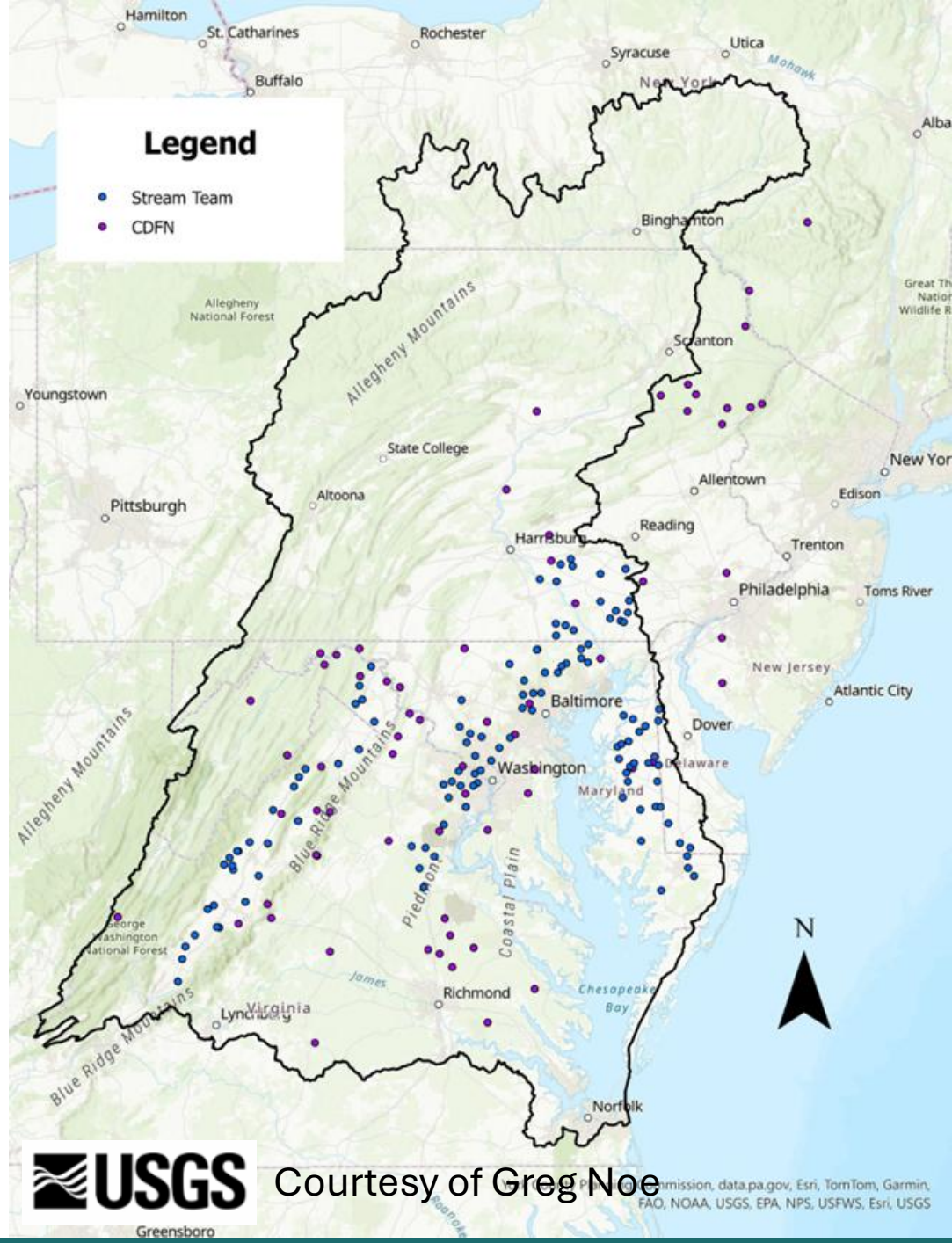


Figure 9-3: Sediment Streambank and floodplain fluxes at Chesapeake Bay Floodplain Network sites (Noe et al. 2016)

Stream Bed and Bank Erosion P7

- For P7, USGS measured long-term sediment fluxes using dendrogeomorphology in120 streams around the U.S. Mid-Atlantic, and then statistically modeled and extrapolated these across the Chesapeake Bay Watershed.
- Watershed wide average defines loading rate.



USGS
science for a changing world

Courtesy of Greg Noe

1. Chesapeake & Delaware Floodplain Network (CDFN)

a. PAPER:

i. Noe, G., K. Hopkins, P. Claggett, E. Schenk, M. Metes, L. Ahmed, T. Doody, and C. Hupp. 2022. Erosional and depositional streams: Measuring and modeling geomorphic change and watershed material budgets. *Environmental Research Letters* 17: 064015, doi.org/10.1088/1748-9326/ac6e47

b. DATA RELEASE:

i. Noe, G.B., Hopkins, K.G., Metes, M.J., Ahmed, L., Claggett, P.R., Doody, T.R., Schenk, E.R., and Hupp, C.R., 2020, Predictions of floodplain and streambank geomorphic change and flux, streambed characteristics, and catchment inputs and exports of sediment and nutrients for stream reaches in the Chesapeake Bay and Delaware River watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P93OUWYZ.

2. USGS-VaTech Stream Team (ST)

a. PAPER:

i. Mohs et al. in prep.

b. DATA RELEASES:

i. Mohs, T.G., Cashman, M.J., Noe, G.B., and Staub, L.E., 2023, Shenandoah Valley Stream Health and Habitat Assessments in West Virginia and Virginia (2021): U.S. Geological Survey data release, https://doi.org/10.5066/P97UX2LO.

ii. Mohs, T.G., Cashman, M.J., and Noe, G.B., 2024, Delmarva Peninsula Stream Health and Habitat Assessments in Maryland and Delaware (2022): U.S. Geological Survey data release, https://doi.org/10.5066/P97UX2LO

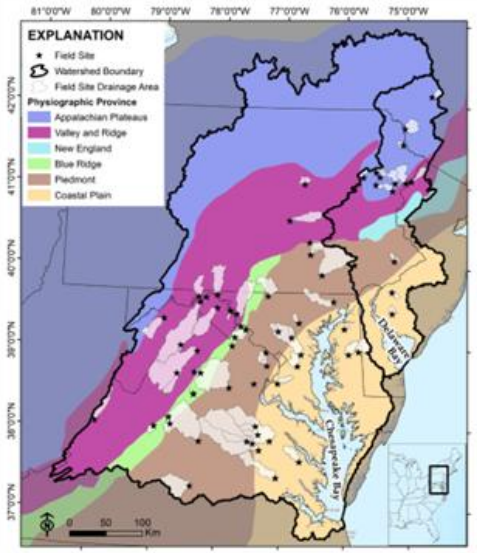
iii. Mohs, T.G., Huber, M.E., Cashman, M.J., and Noe, G.B., 2025, Stream health and habitat assessments for mixed agricultural streams in Pennsylvania and Maryland (2023): U.S. Geological Survey data release, https://doi.org/10.5066/P13MHXBQ.

iv. Mohs et al. in prep.

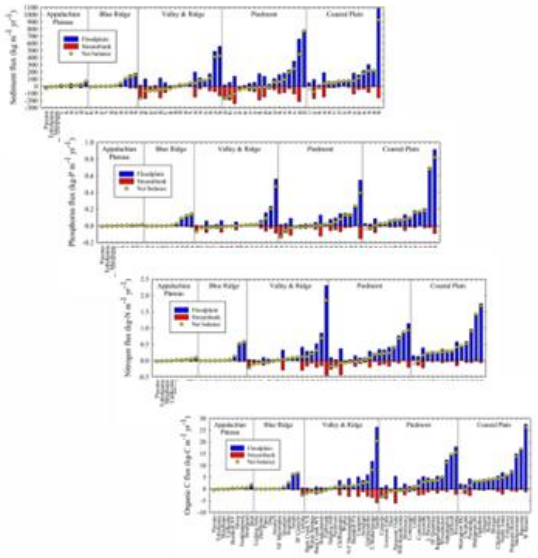
Courtesy of Greg Noe

USGS Chesapeake and Delaware Floodplain Network: approach

Measure



Analyze



Model
(Random Forest)

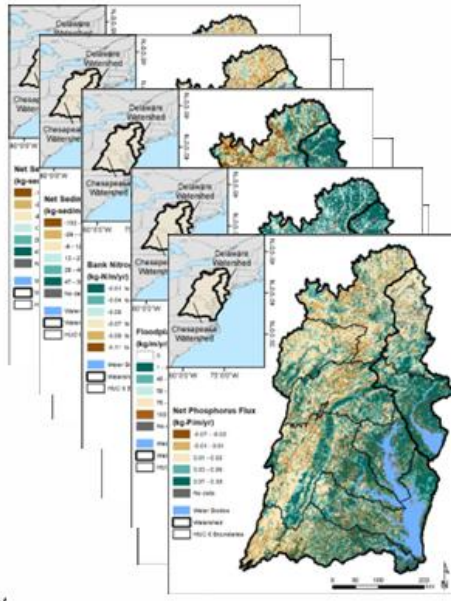
GIS reach-scale geomorphometry ("shape")
Floodplain width, bank height, channel width, …

Random Forests regressions

GIS upstream watershed attributes
Land use, hydrology, soils, topography

GIS upstream watershed attributes
FUTURE Land use, hydrology, soils, topography

Predict
(99,664 NHDPlusV2 reaches)



Predictions:

Floodplain sediment flux	Streambank sediment flux	Streambed d50
Floodplain fine sediment flux	Streambank fine sediment flux	Streambed fine sediment cover
Floodplain sediment-N flux	Streambank sediment-N flux	Streambed fine+sand cover
Floodplain sediment-P flux	Streambank sediment-P flux	
Floodplain sediment-C flux	Streambank sediment-C flux	
Floodplain change m^2	Streambank lateral erosion rate	
	Streambank change m^2	

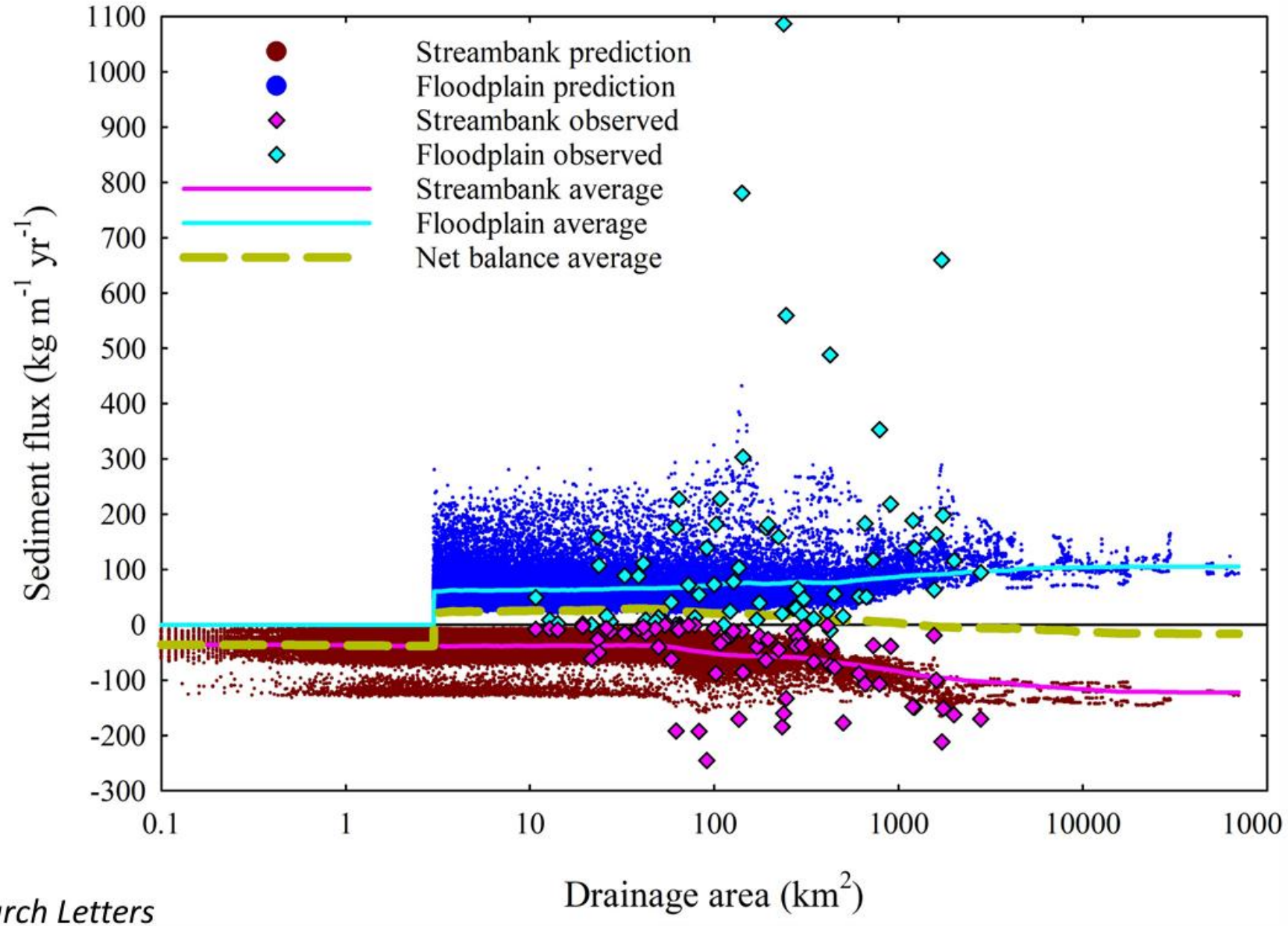
Annual rates

USGS

Predictions for each of the 74,133 nontidal NHD streams in the mid-Atlantic

Courtesy of Greg Noe

Censored out:
tidal, impounded, or
artificial flowpaths



Noe et al. 2020b,
U.S. Geological Survey data release,
https://doi.org/10.5066/P93OUWYZ.

USGS

Noe et al. 2022, *Environmental Research Letters*

Stream Bed and Bank Erosion

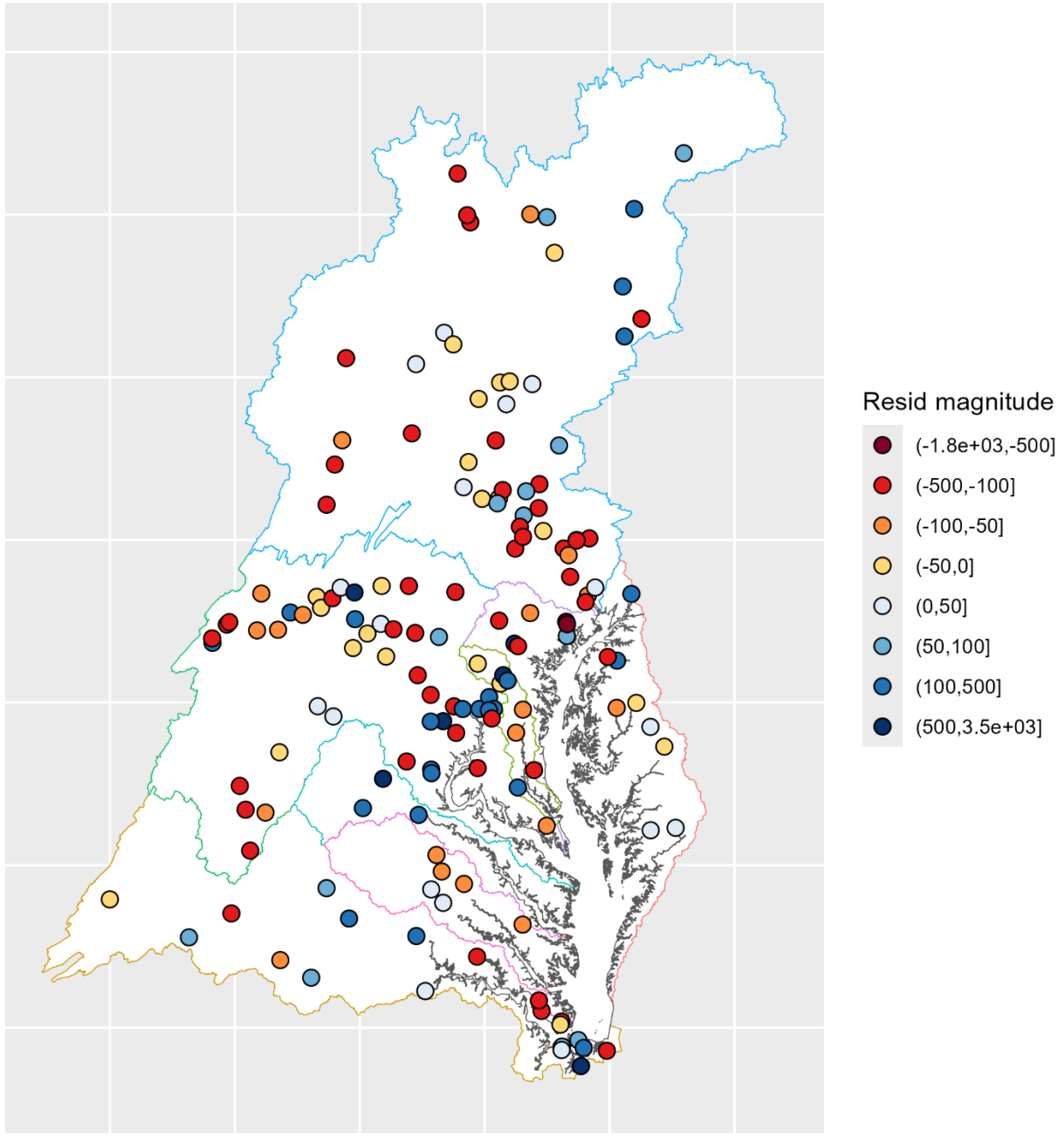
P6: 54 lbs/ft/year

- Applied to 1:100K streams
- 10.46 Mil lbs/year watershed wide

P7: 14.42 lbs/ft/year

- Calculated and applied based on 1:24K streams
- 4.45 Mil lbs/year watershed wide

Questions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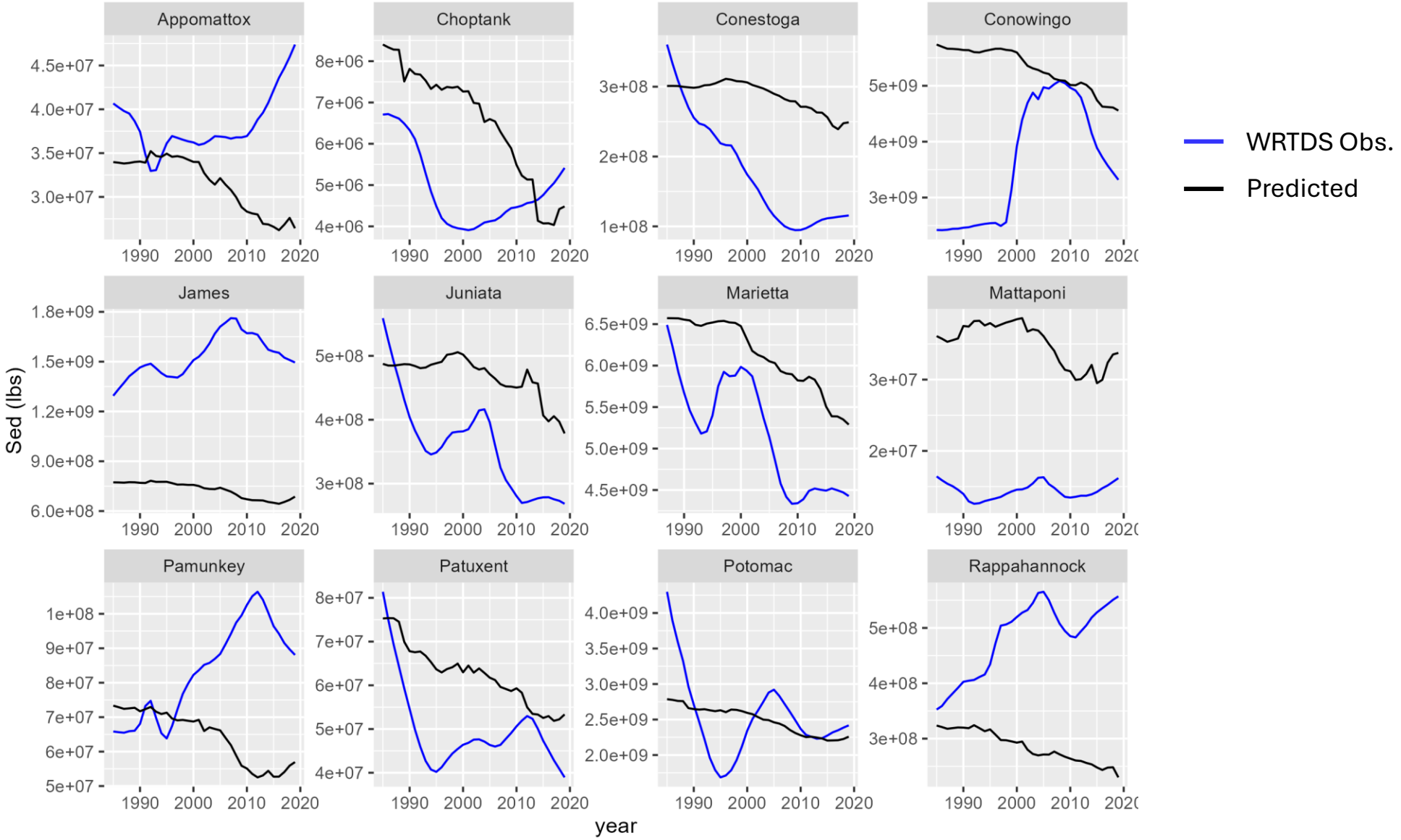
RIM Stations: P6 inputs



RIM Stations: P7 Draft