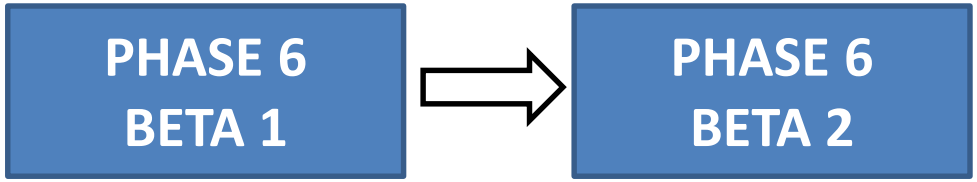
Phase 6 Watershed Model – Beta 2

Modeling Quarterly Review Meeting

Gopal Bhatt

Penn State University

Presentation outline



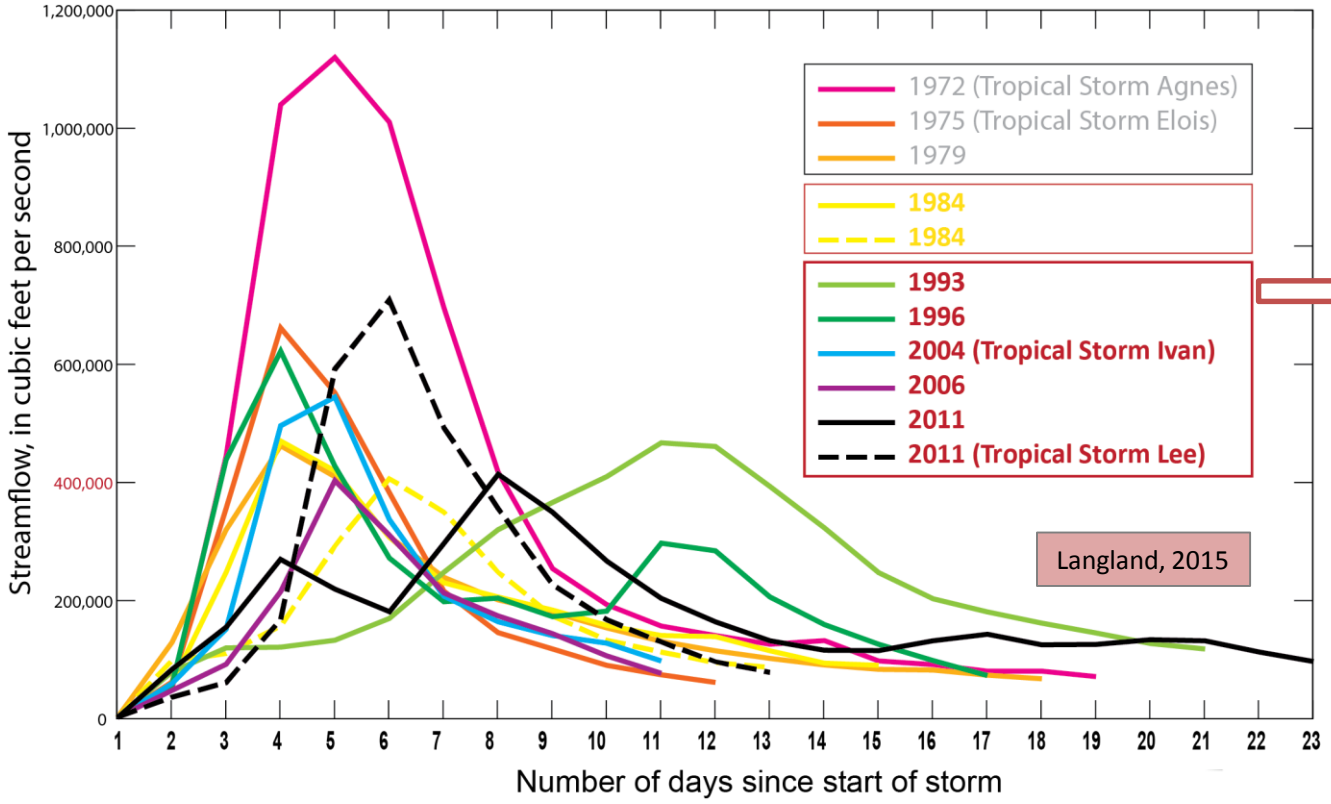
1. hydrology simulation – extreme flow events
2. RUSLE2 erosion rates and sediment delivery ratios
3. sediment loads from developed streams as a source
4. revised calibration target calculation
5. updated *land-to-water*, and *stream-to-river* factors
6. Mead Westvaco point source facility
7. *stream to river* factors for point source facilities
8. water quality monitoring data cleanup
9. representation of reservoirs on simulated rivers
10. rSAS model for groundwater nitrate transport

Review of Beta 2 calibration …

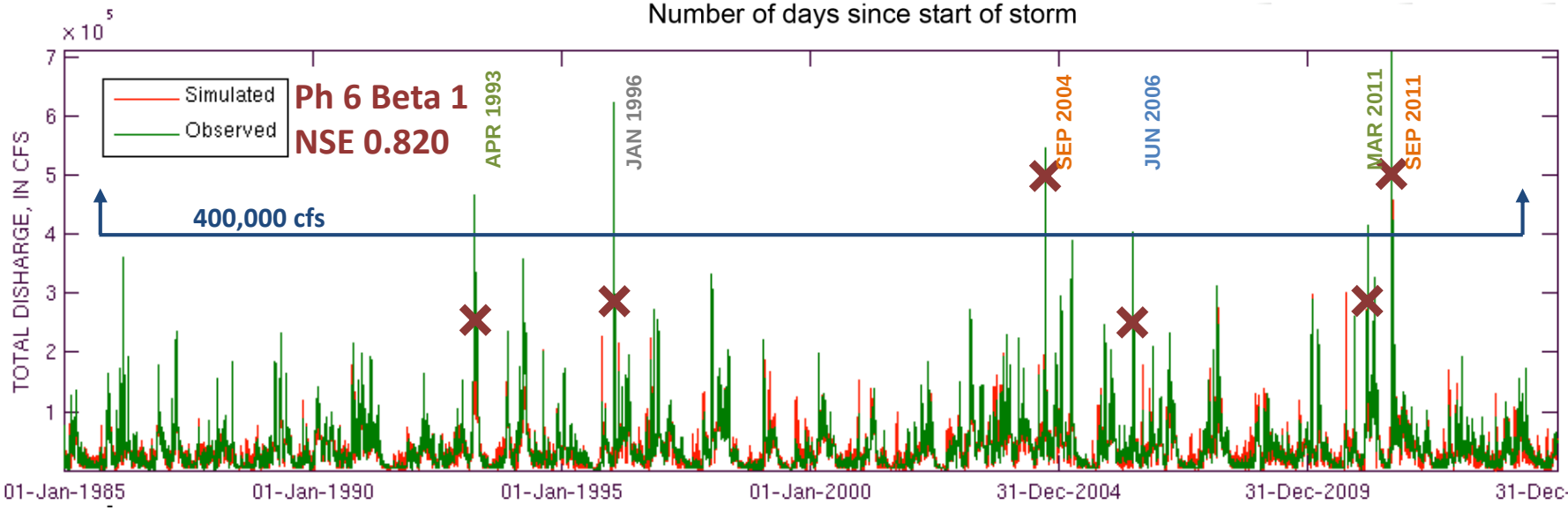
1. hydrology simulation – extreme flow events

- Calibration was updated to improve the simulation of extreme flow events.
- Existing diversion dataset was comprehensively reviewed, and updates were made to expand the dataset to year 2014 – Kyle Hinson
- Land use dataset – Jessica Rigelman
  - Tree canopy over scrub shrub were removed
  - Feeding operation acres were calculated using per animal instead of acres per farm type
  - Ag land use proportioned to LR-segments based on crop vs. pasture vs. ag percent instead of ag only.

Susquehanna River at Conowingo, MD



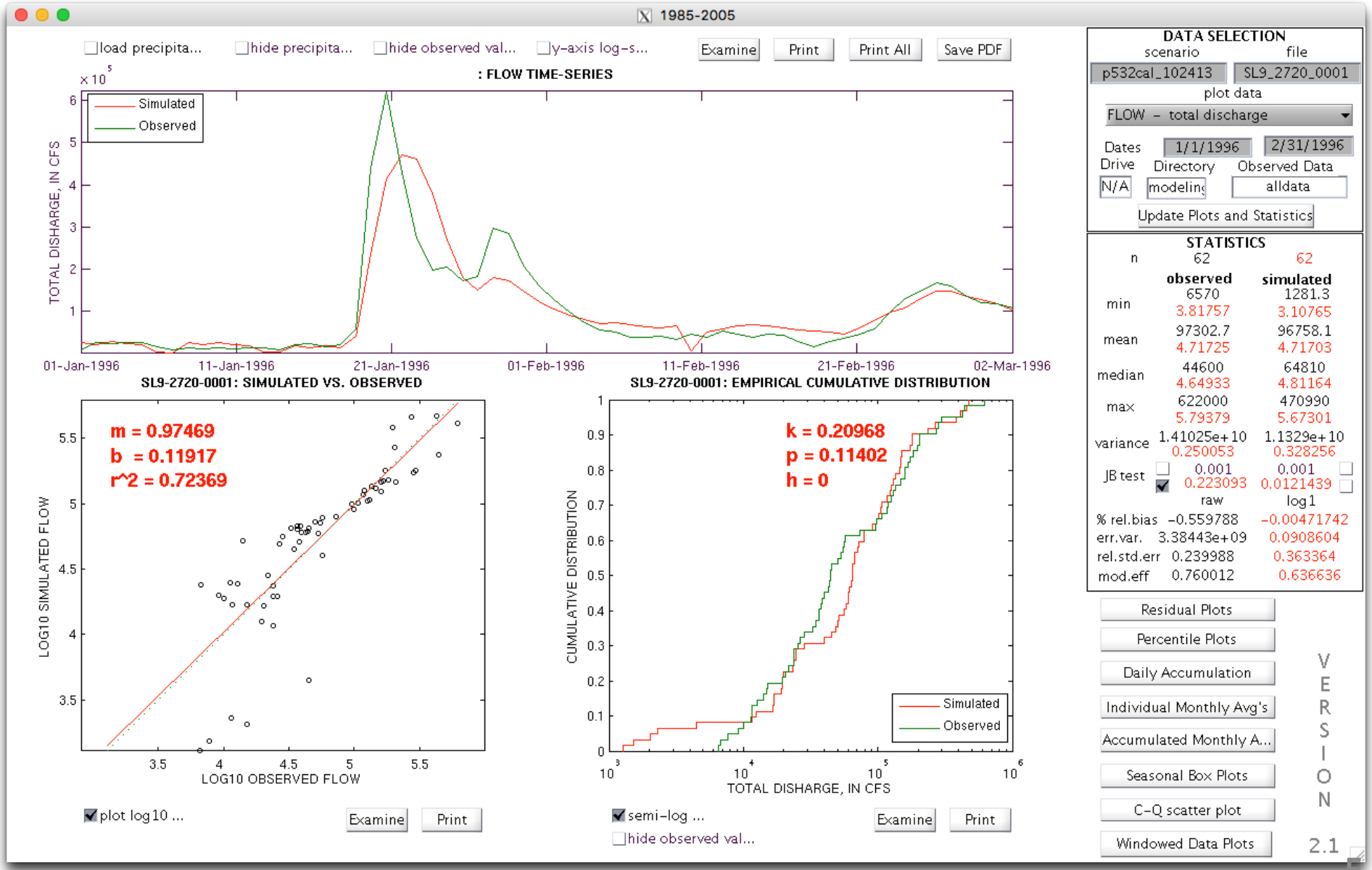
6 Extreme Events



SUSQUEHANNA AT CONOWINGO

PHASE 5

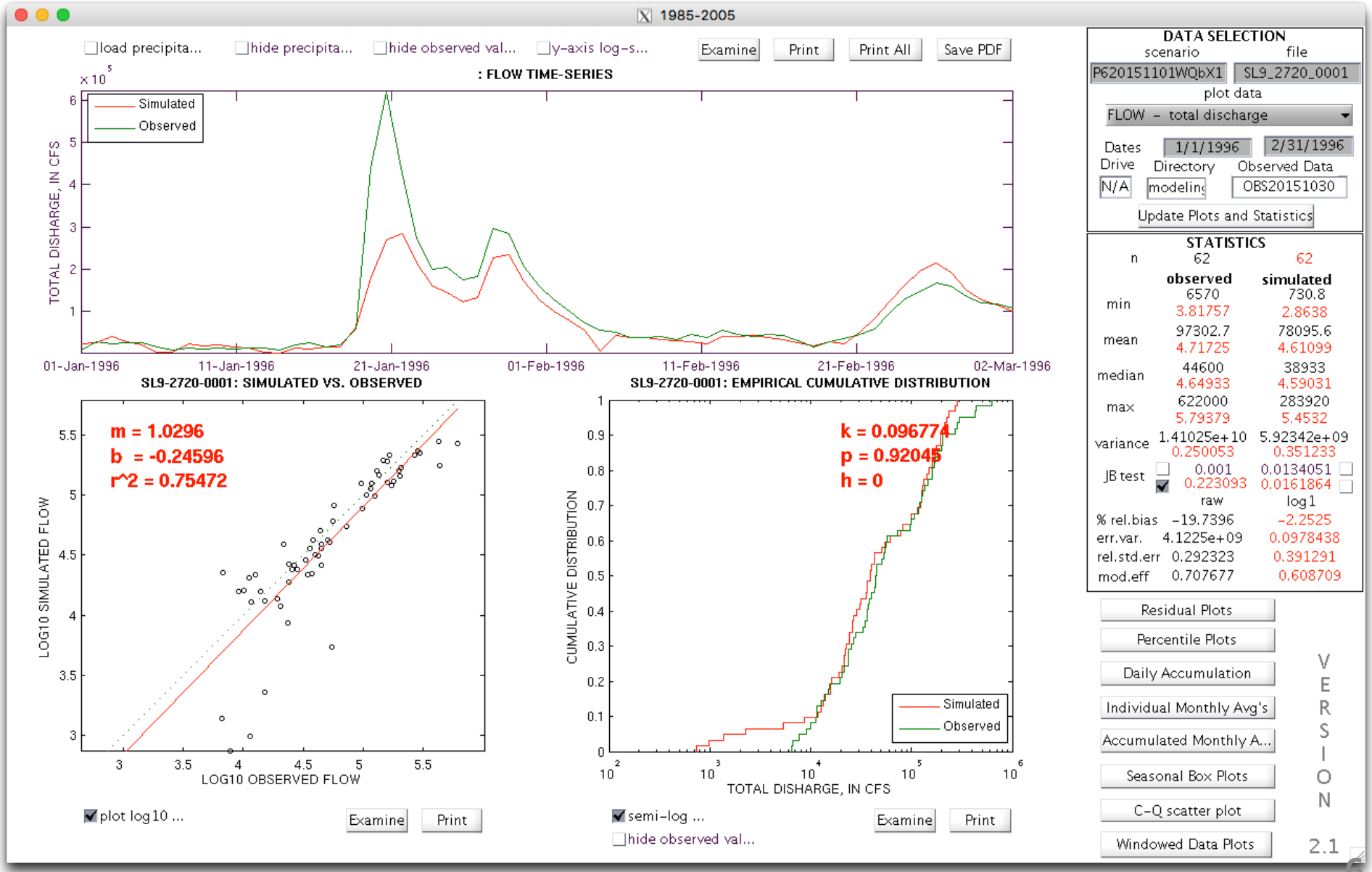
1996 BIG MELT



SUSQUEHANNA AT CONOWINGO

PHASE 6 BETA 1

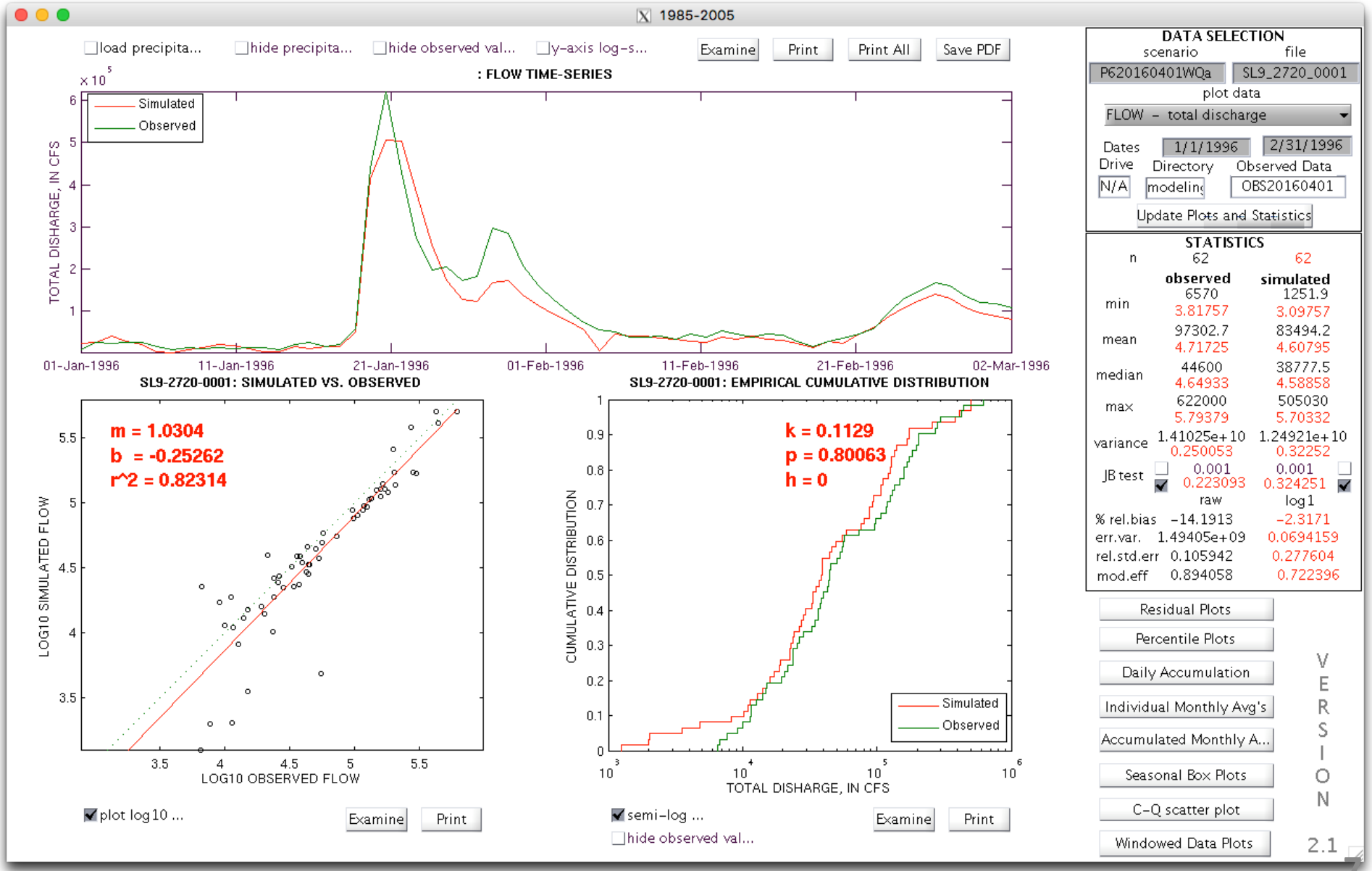
1996 BIG MELT

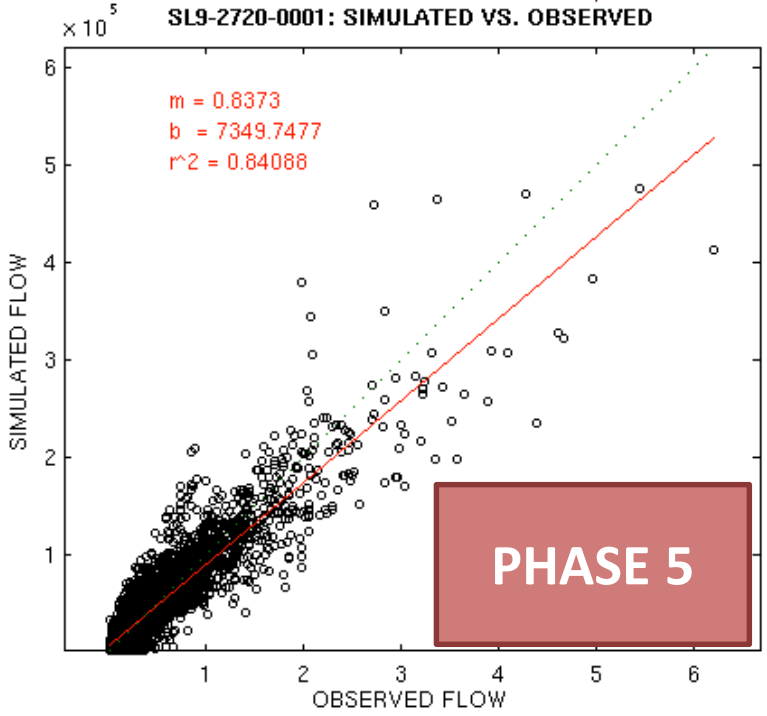


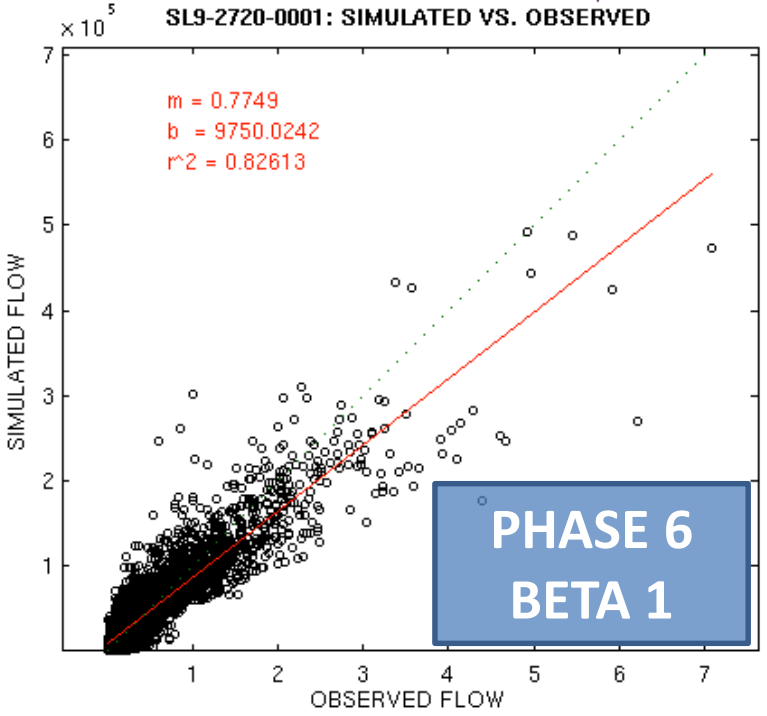
SUSQUEHANNA AT CONOWINGO

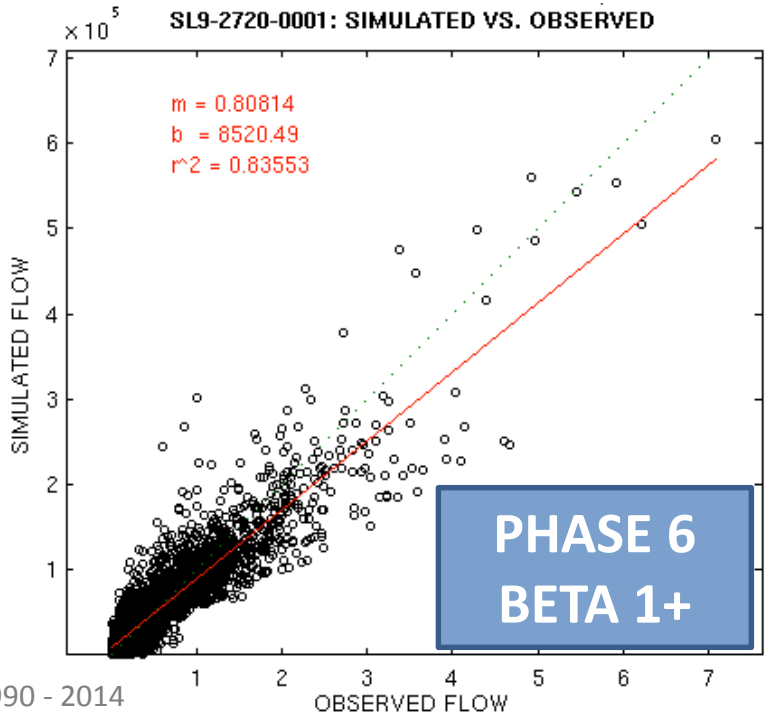
PHASE 6 BETA 2

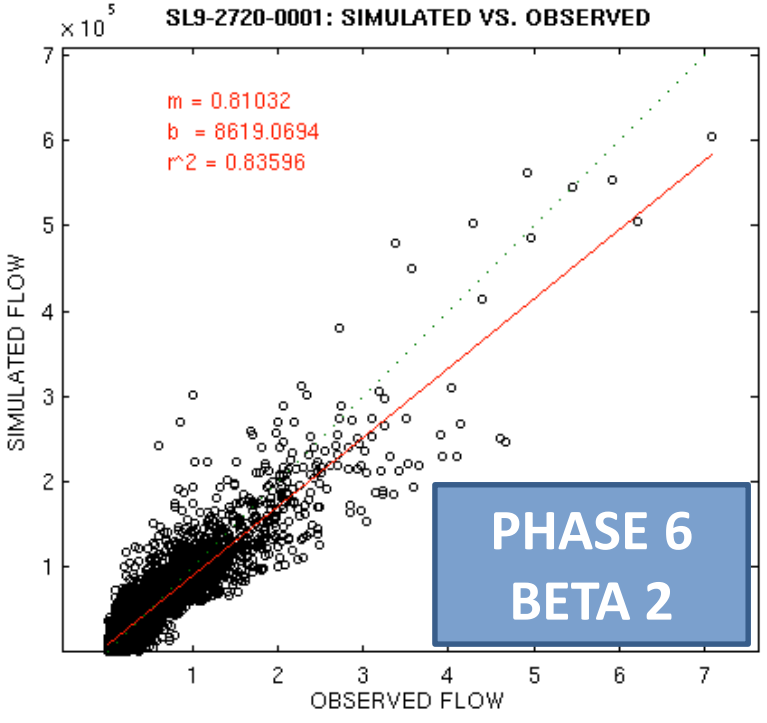
1996 BIG MELT





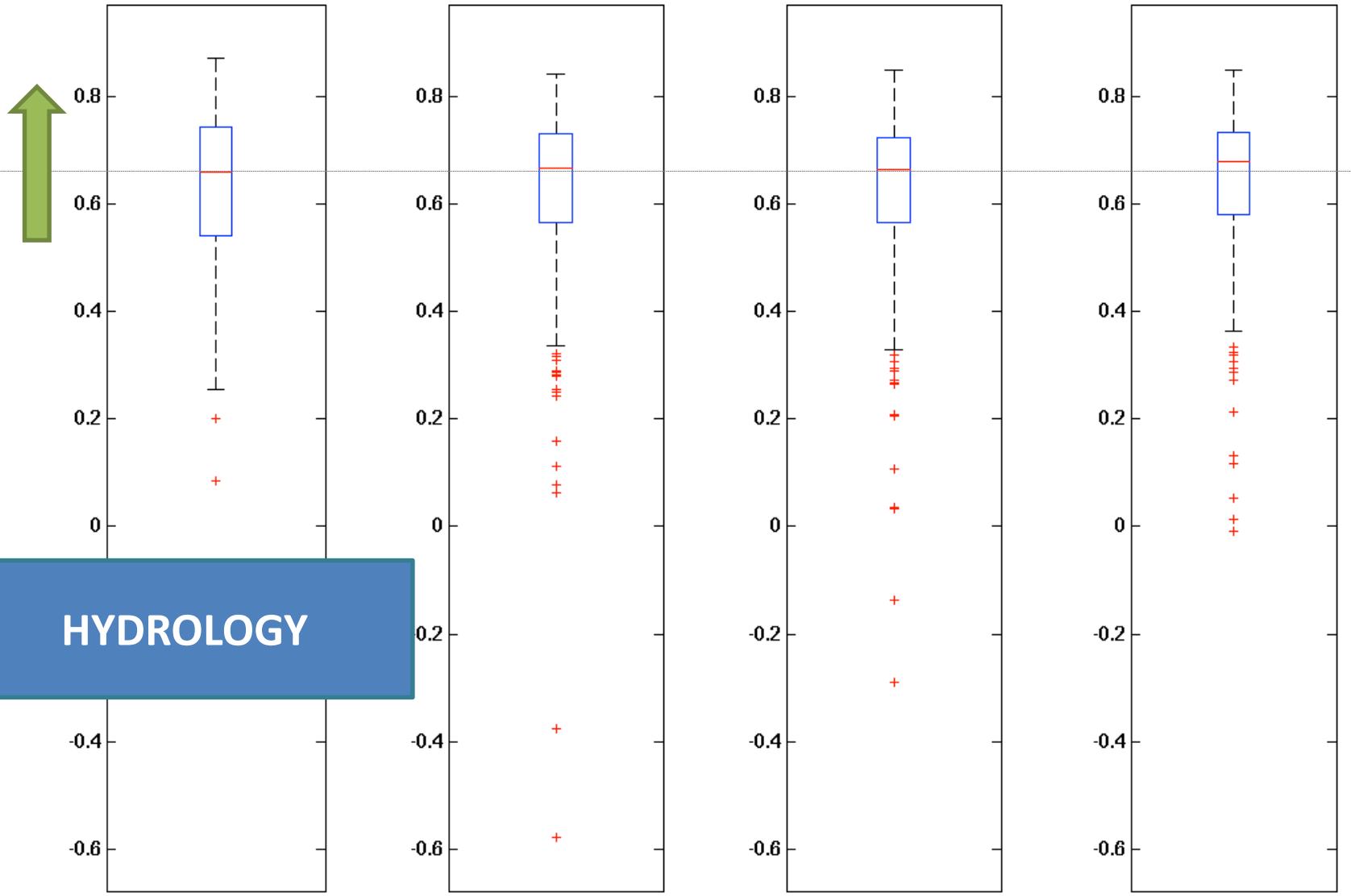






Years 1990 - 2014

Nash-Sutcliffe Efficiency at 191 Calibration Stations



HYDROLOGY

Phase 5

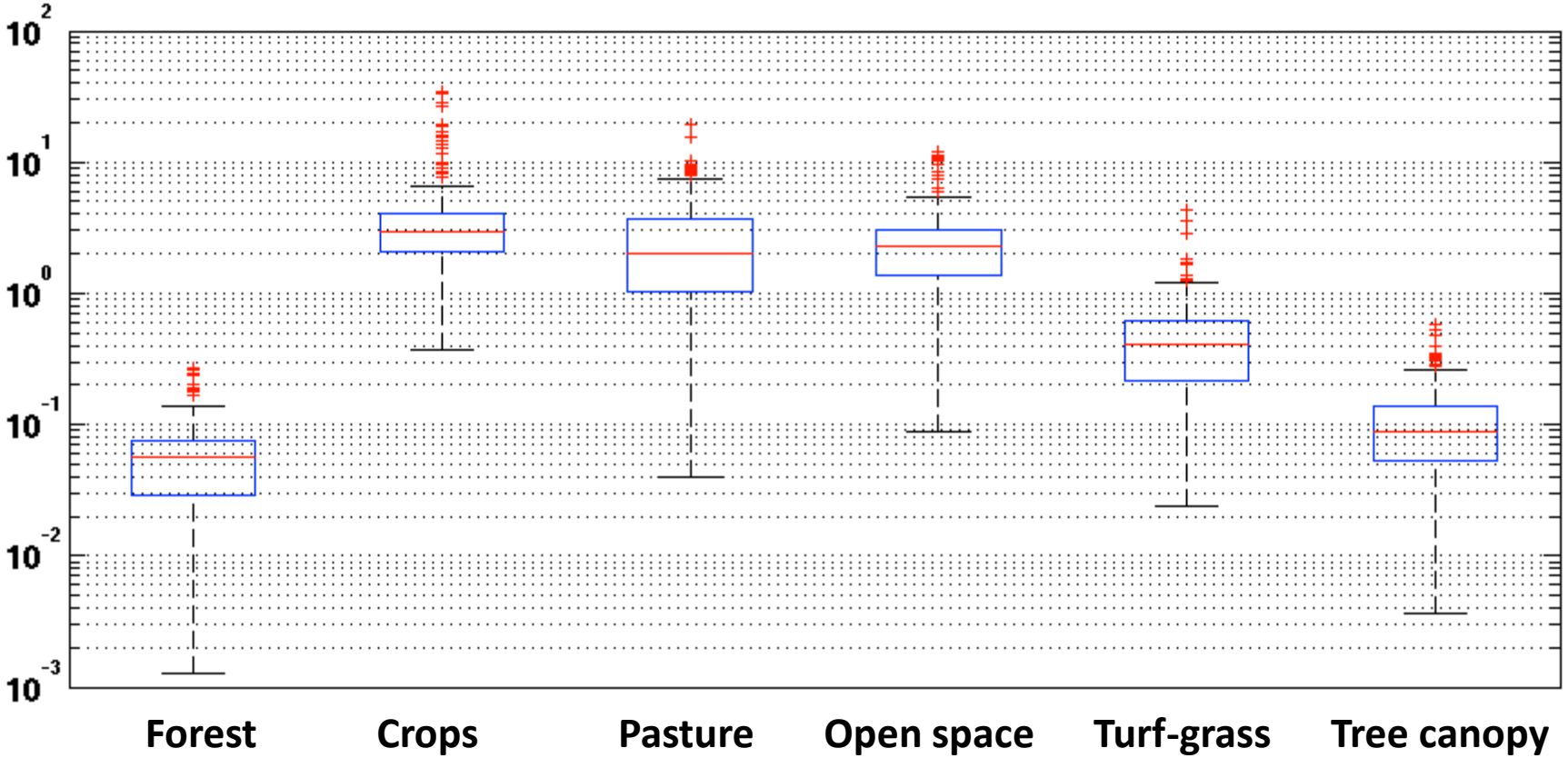
Phase 6 Beta 1

Phase 6 Beta 2 (extreme flows)

Phase 6 Beta 2

2. RUSLE2 erosion rates and sediment delivery ratios

- RUSLE2 erosion rates for 6 land-use categories (forest, crop, pasture, open space, turf-grass, and tree canopy) were calculated – David Saavedra and Peter Claggett



3. sediment loads from developed streams as a source

- Watershed model was updated to accept stream loads as a new input.
- Stream sediment loads were calculated as a function of (a) fraction impervious, and (b) fraction C&D (C, D, and C/D) hydrologic soil group.
- This will allow for a separate reporting and accouting of stream loads.

4. revised calibration target calculation

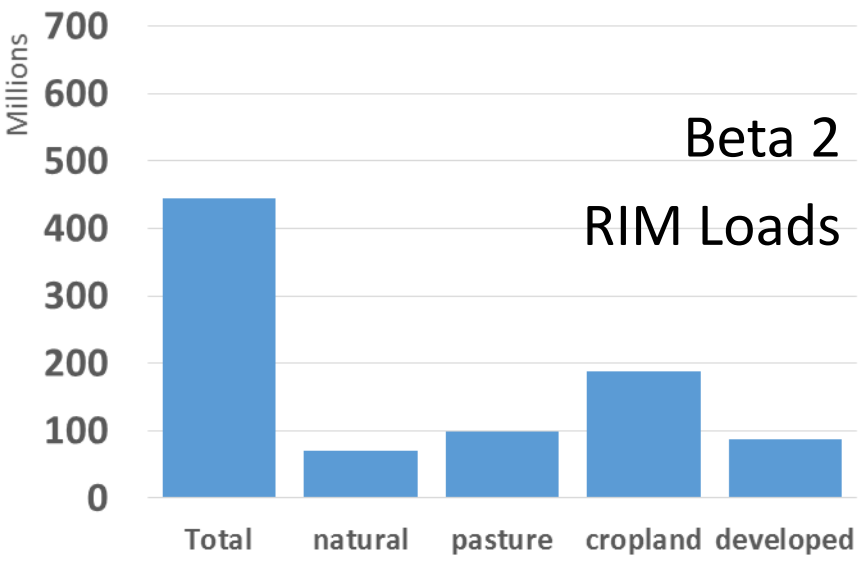
Olivia Devereux

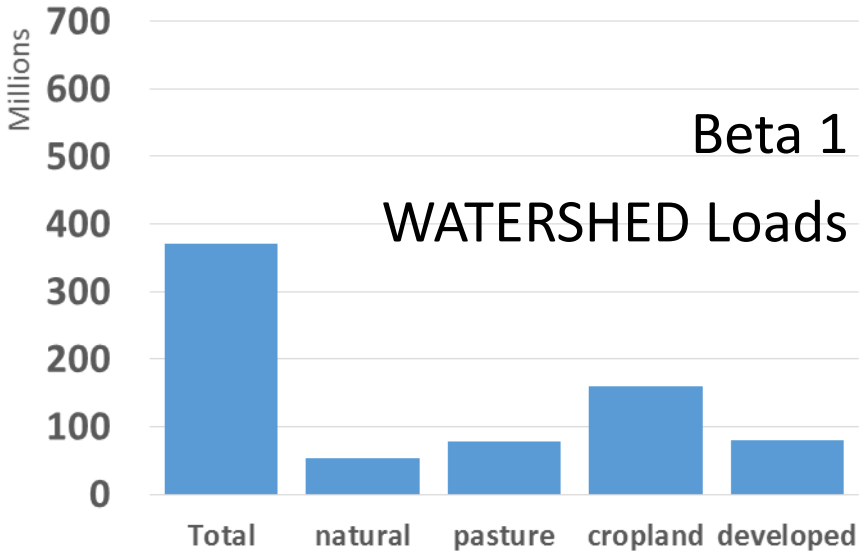
RIM Indicator loads were used in place of Watershed Indicator loads

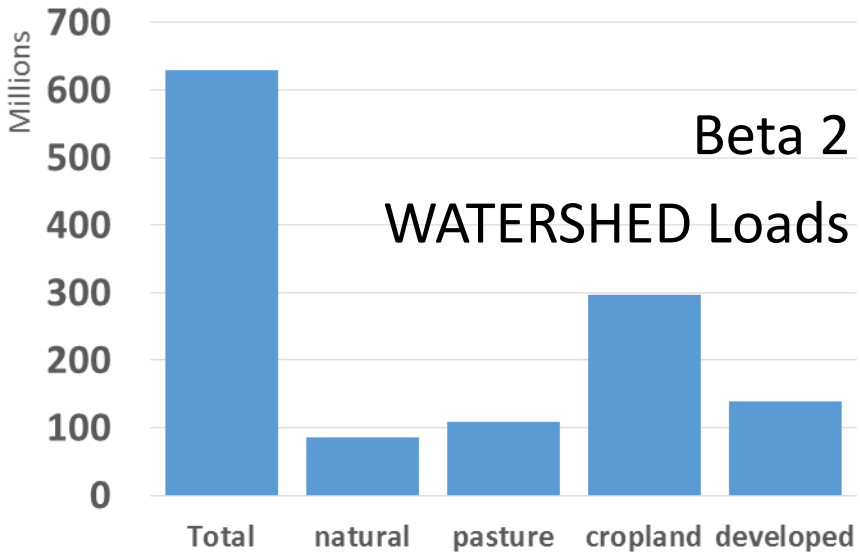
Beta 1: Watershed indicator load = 317 Mlb/yr

Beta 2: RIM indicator load = 213 Mlb/yr

Edge of Small Stream Nitrogen Loads (in pounds/year)







EOSS loads do <u>not</u> include feeding operations, point sources, and septic.

4. revised calibration target calculation

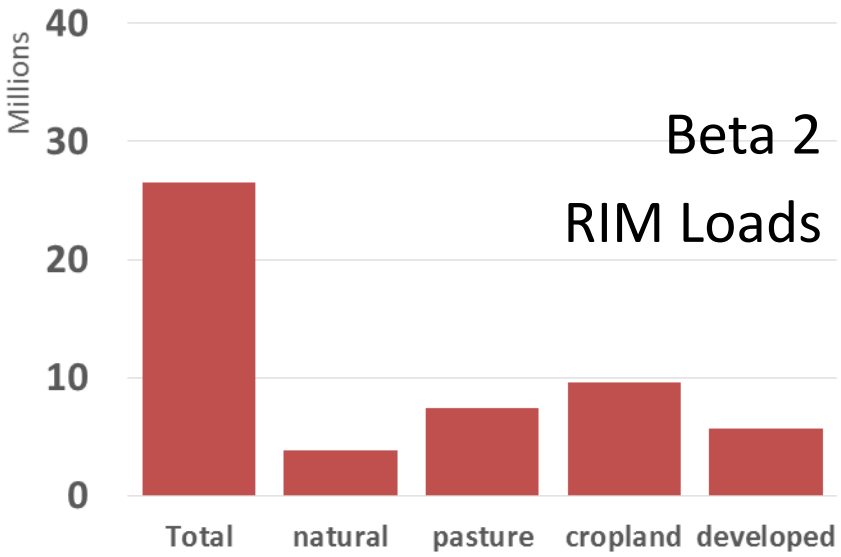
Olivia Devereux

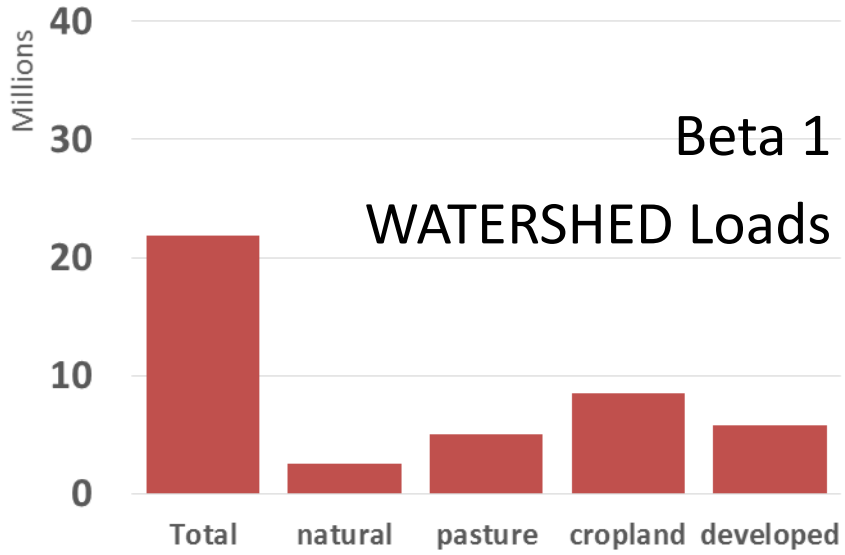
RIM Indicator loads were used in place of Watershed Indicator loads

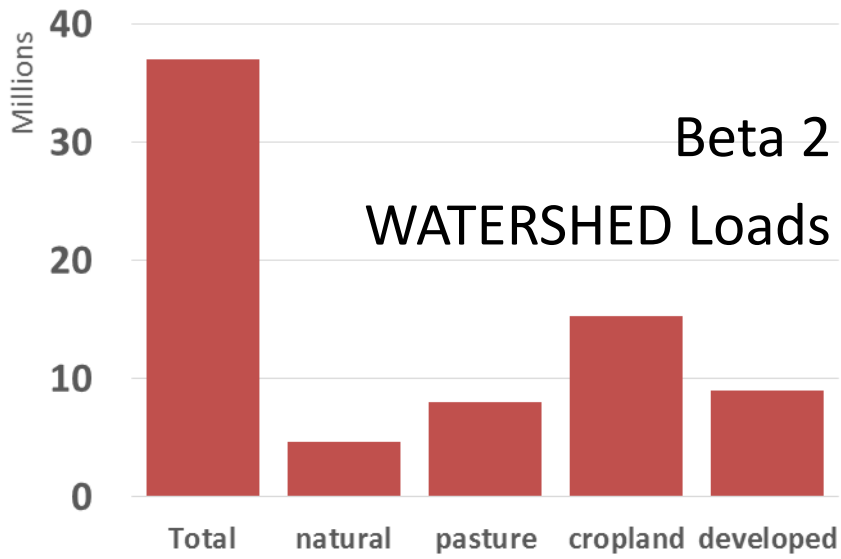
Beta 1: Watershed indicator load = 21.0 Mlb/yr

Beta 2: RIM indicator load = 14.5 Mlb/yr

Edge of Small Stream Phosphorus Loads (in pounds/year)





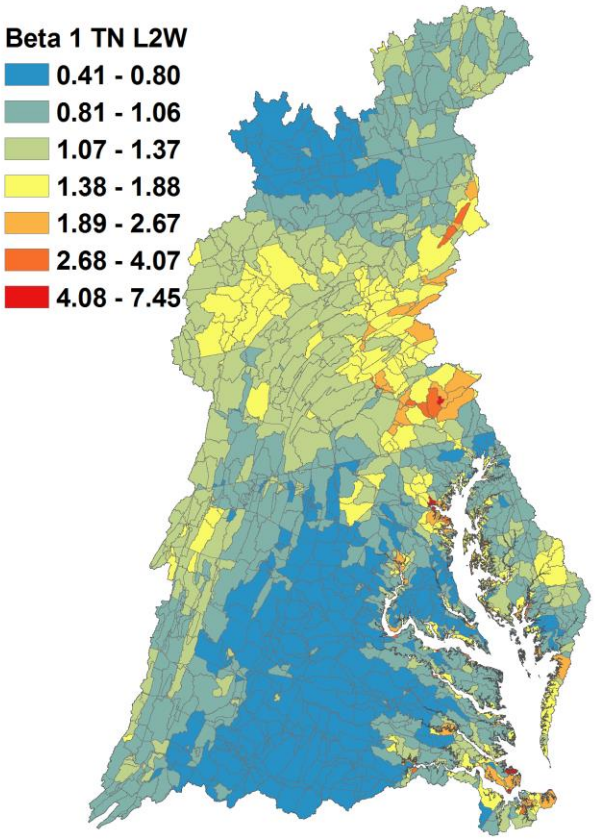


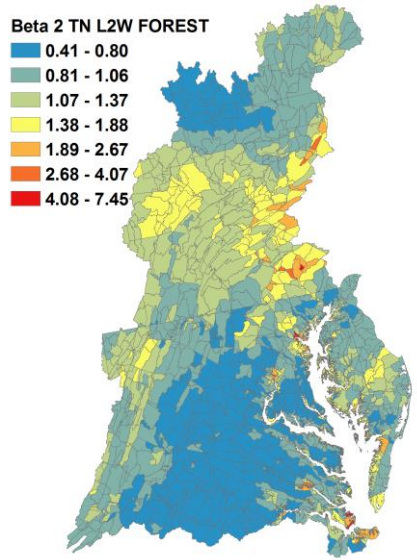
EOSS loads do not include feeding operations, point sources, and septic.

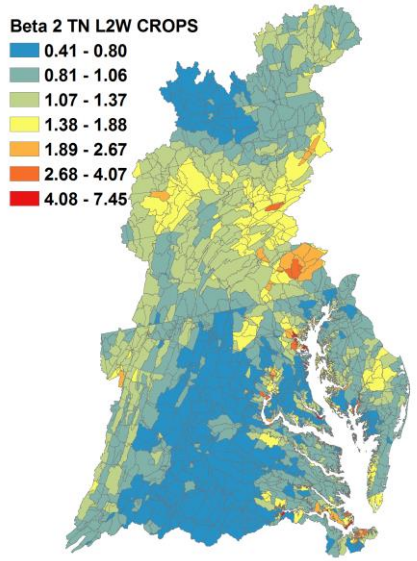
5. updated land-to-water, and stream-to-river factors

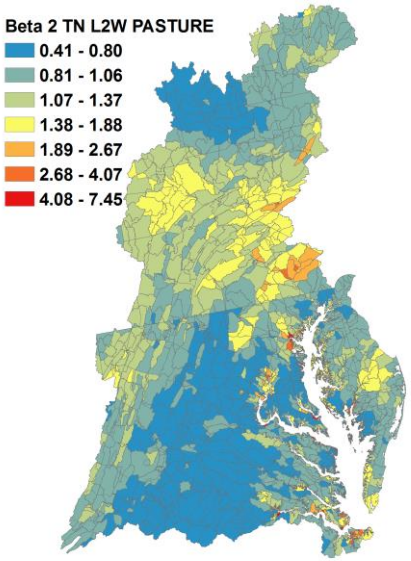
Ross Mandel

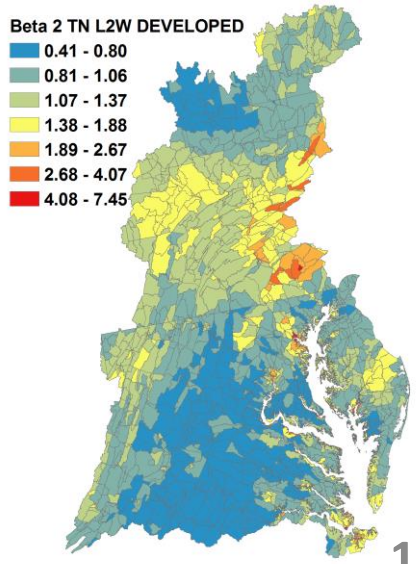
- Beta 1 had a single land-to-water factors. In Beta 2 they were calculated separately for major land uses.











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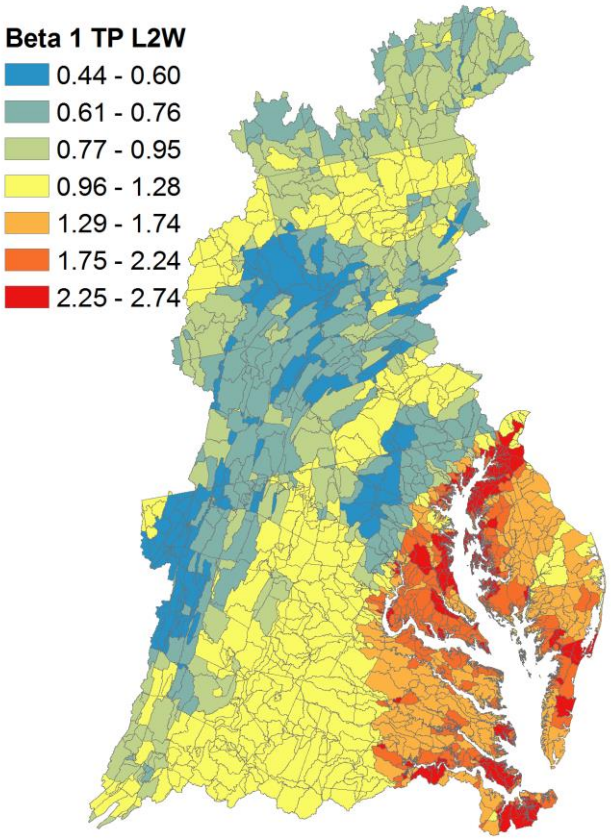

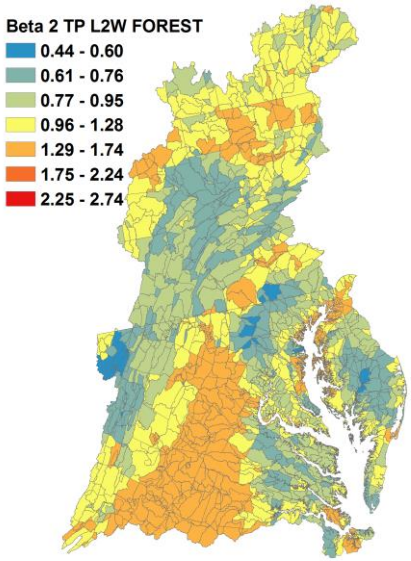

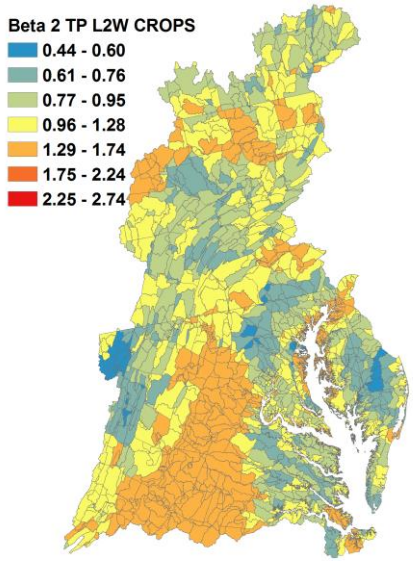

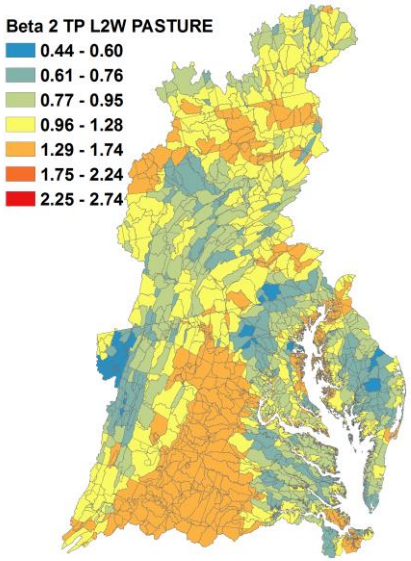

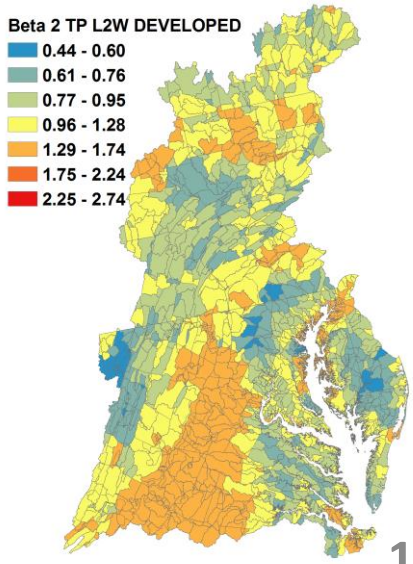

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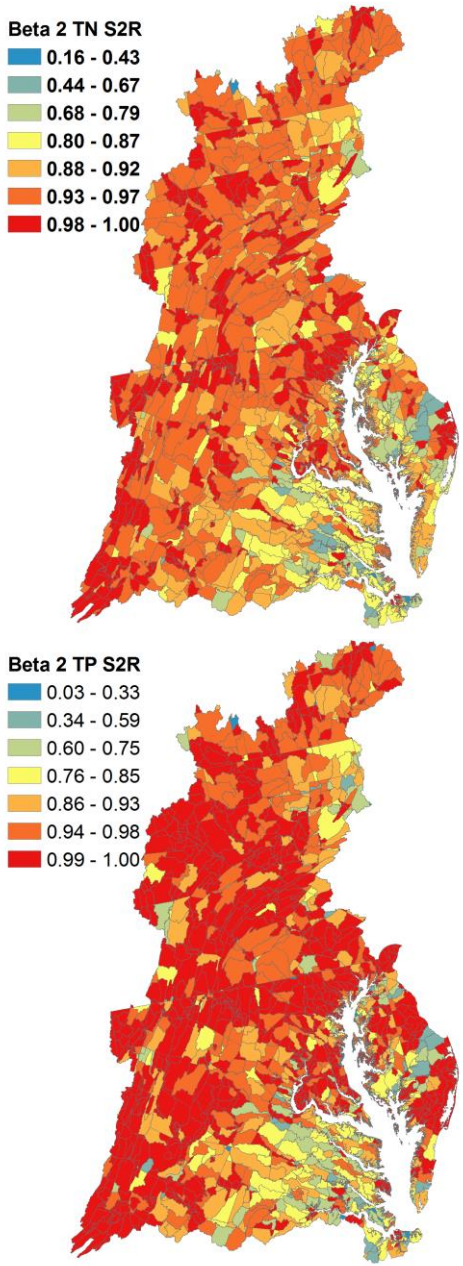
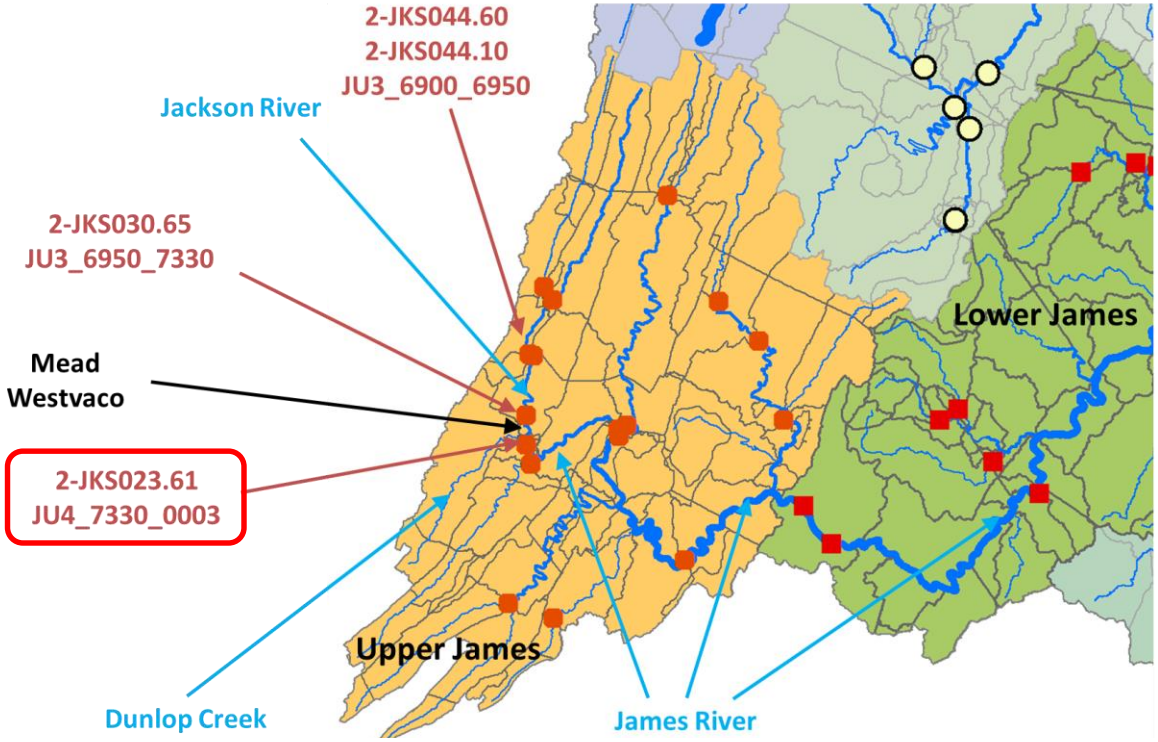
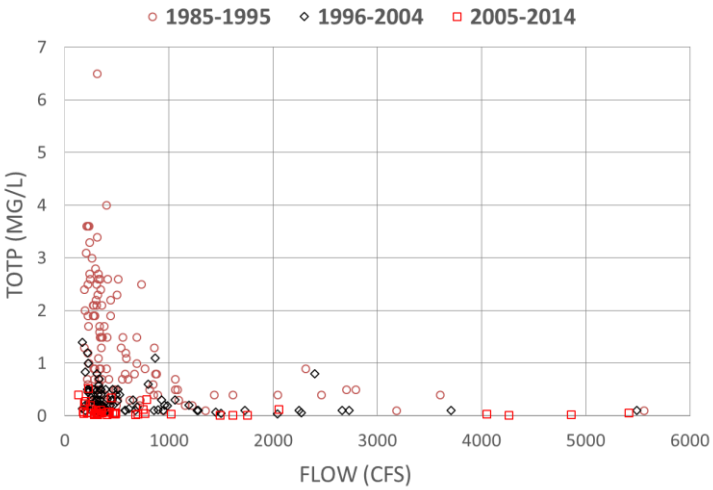
Ross Mandel

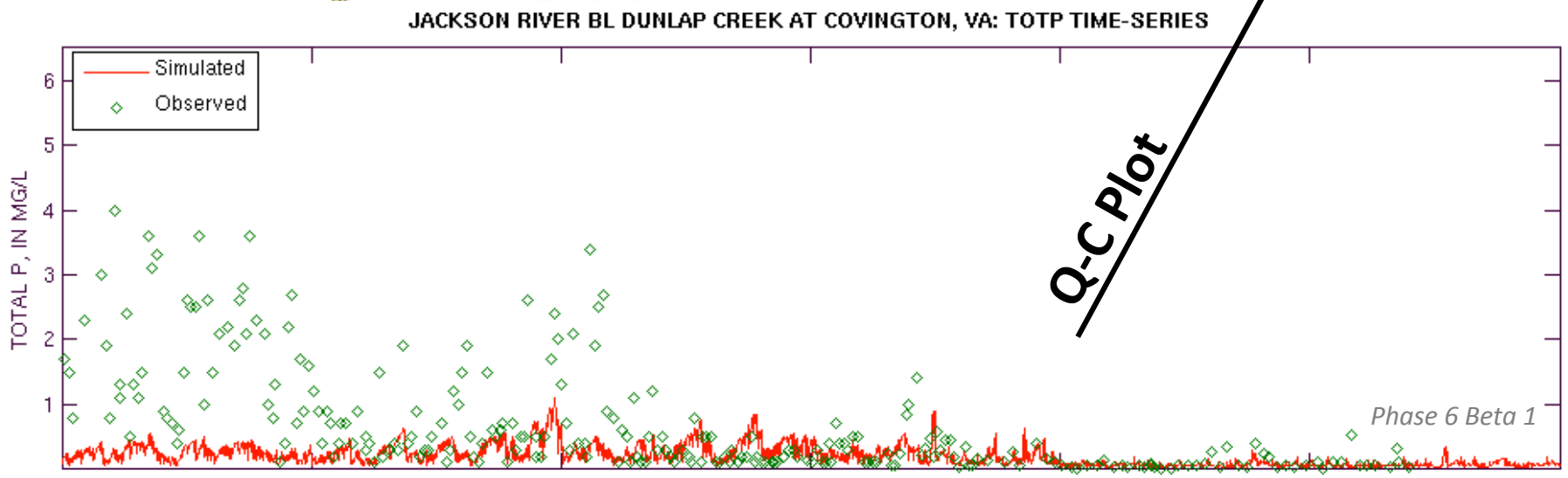


- Maryland and Hampton Roads added and removed impoundments
  - 29 MDE and 4 HRPDC Impoundments Added
  - 486 MDE and 4 HRPDC Impoundments Removed
- Improved identification of tidal/non-tidal boundary in NHD+ reaches
- Addition of “Headwater” P6 reservoirs (reservoirs on P6 reaches with no reaches upstream)

6. Mead Westvaco Industrial Point Source Facility



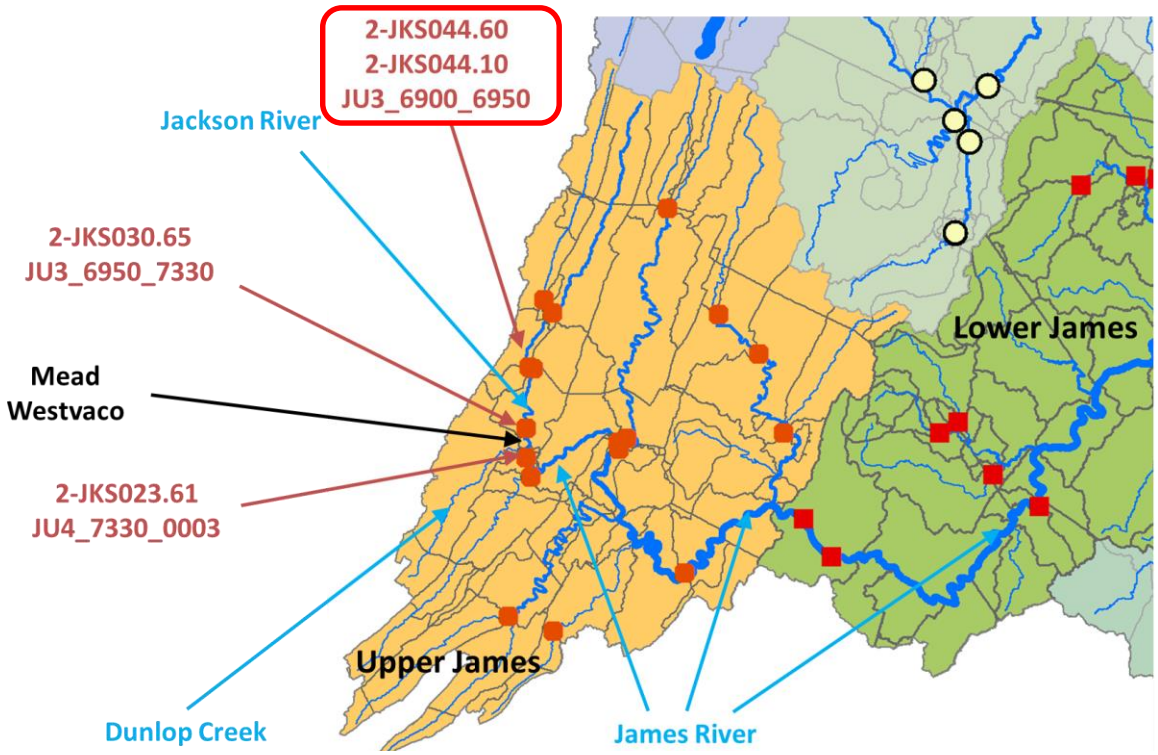


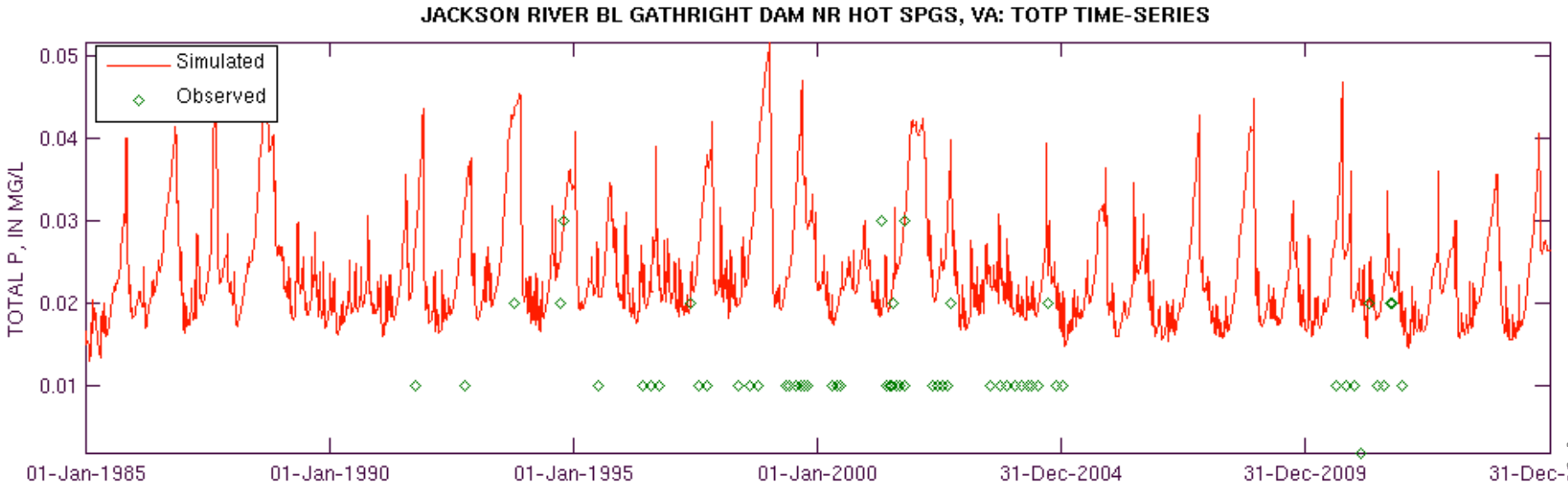


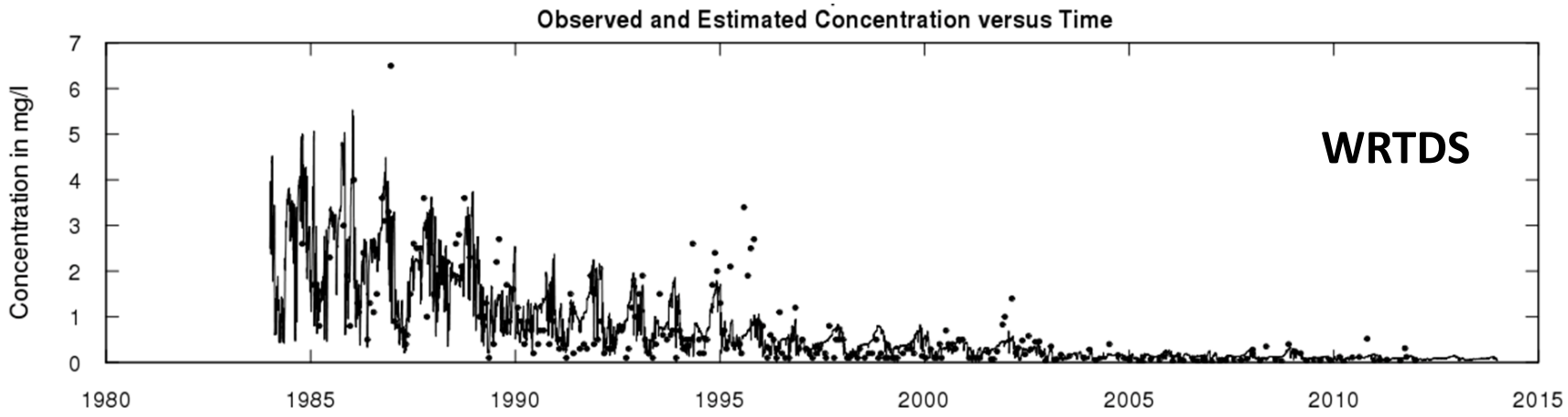
Q-C Plot

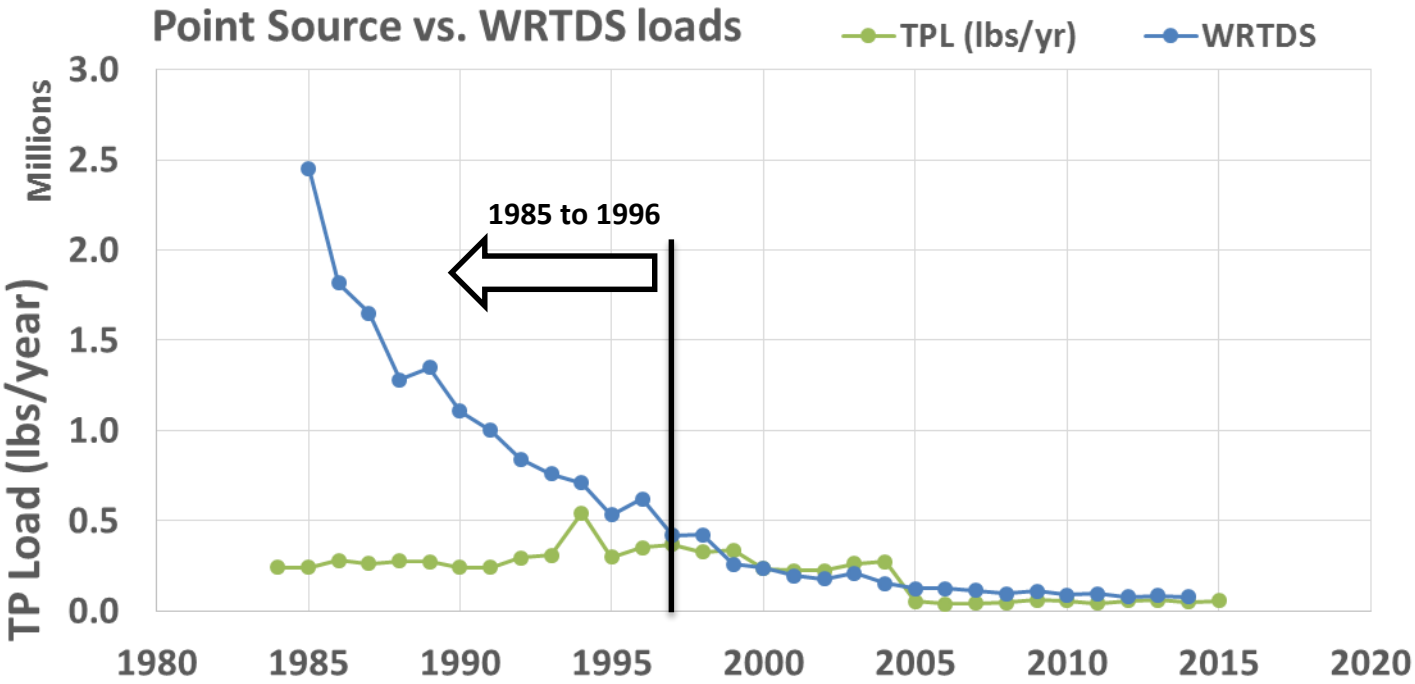
Phase 6 Beta 1

6. Mead Westvaco Industrial Point Source Facility





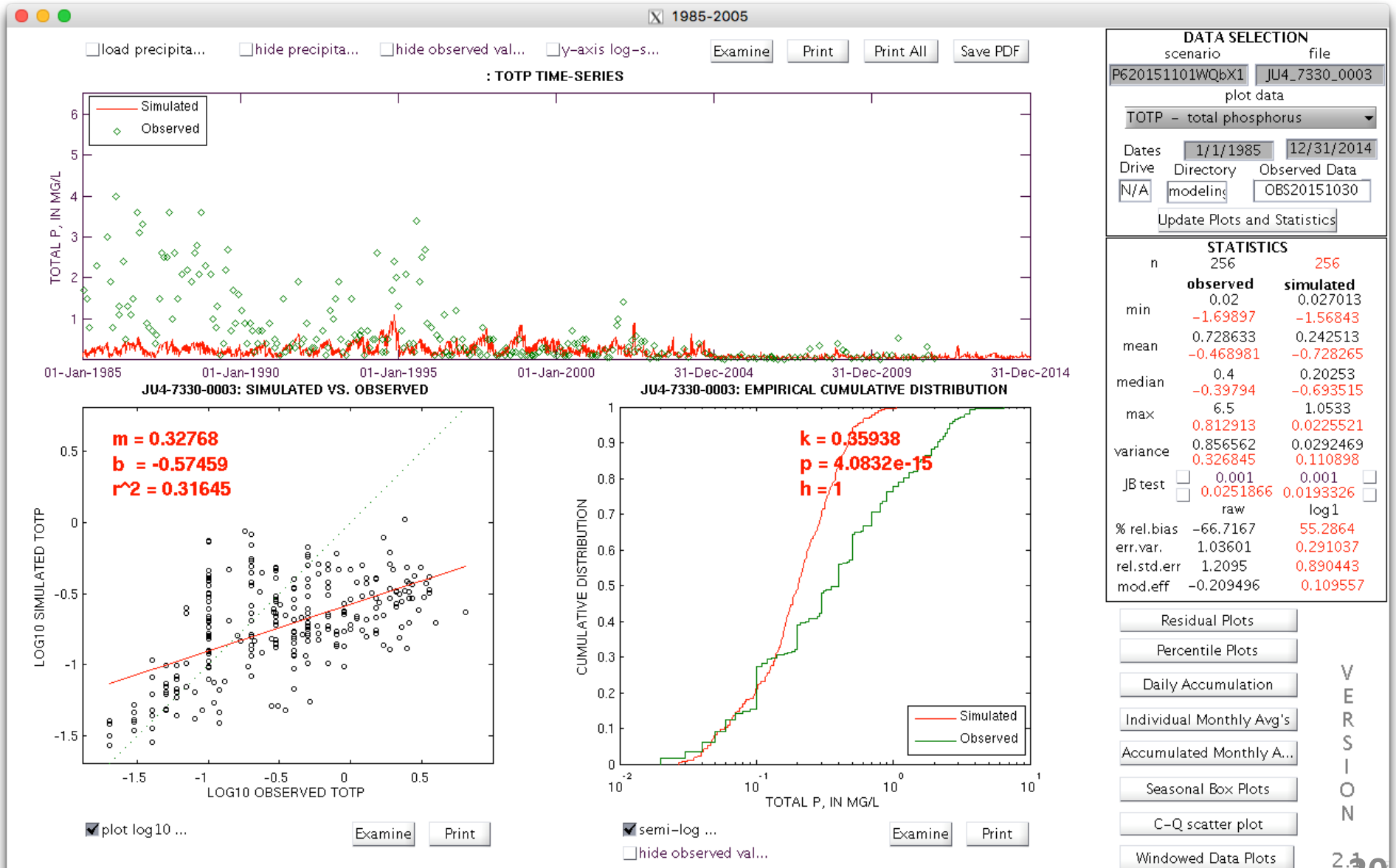

Observed and Estimated Concentration versus Time
Concentration in mg/l
7
6
5
4
3
2
1
0
1980
1985
1990
1995
2000
2005
2010
2015
WRTDS


Point Source vs. WRTDS loads
TPL (lbs/yr)
WRTDS
TP Load (lbs/year)
Millions
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1985 to 1996
1980
1985
1990
1995
2000
2005
2010
2015
2020

JACKSON RIVER BL DUNLAP CREEK AT COVINGTON, VA

PHASE 6 BETA 1

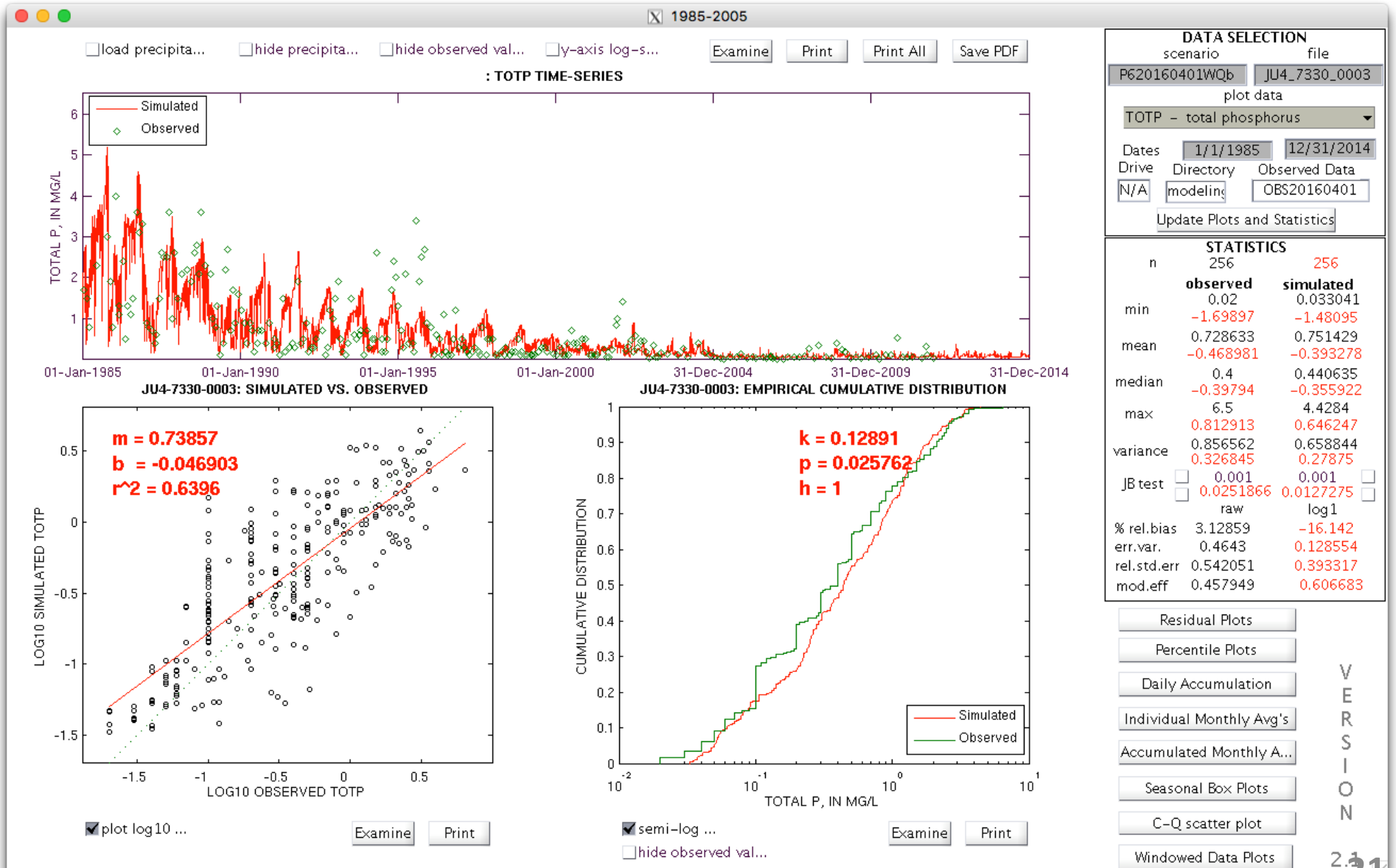
PHOSPHORUS



JACKSON RIVER BL DUNLAP CREEK AT COVINGTON, VA

PHASE 6 BETA 2

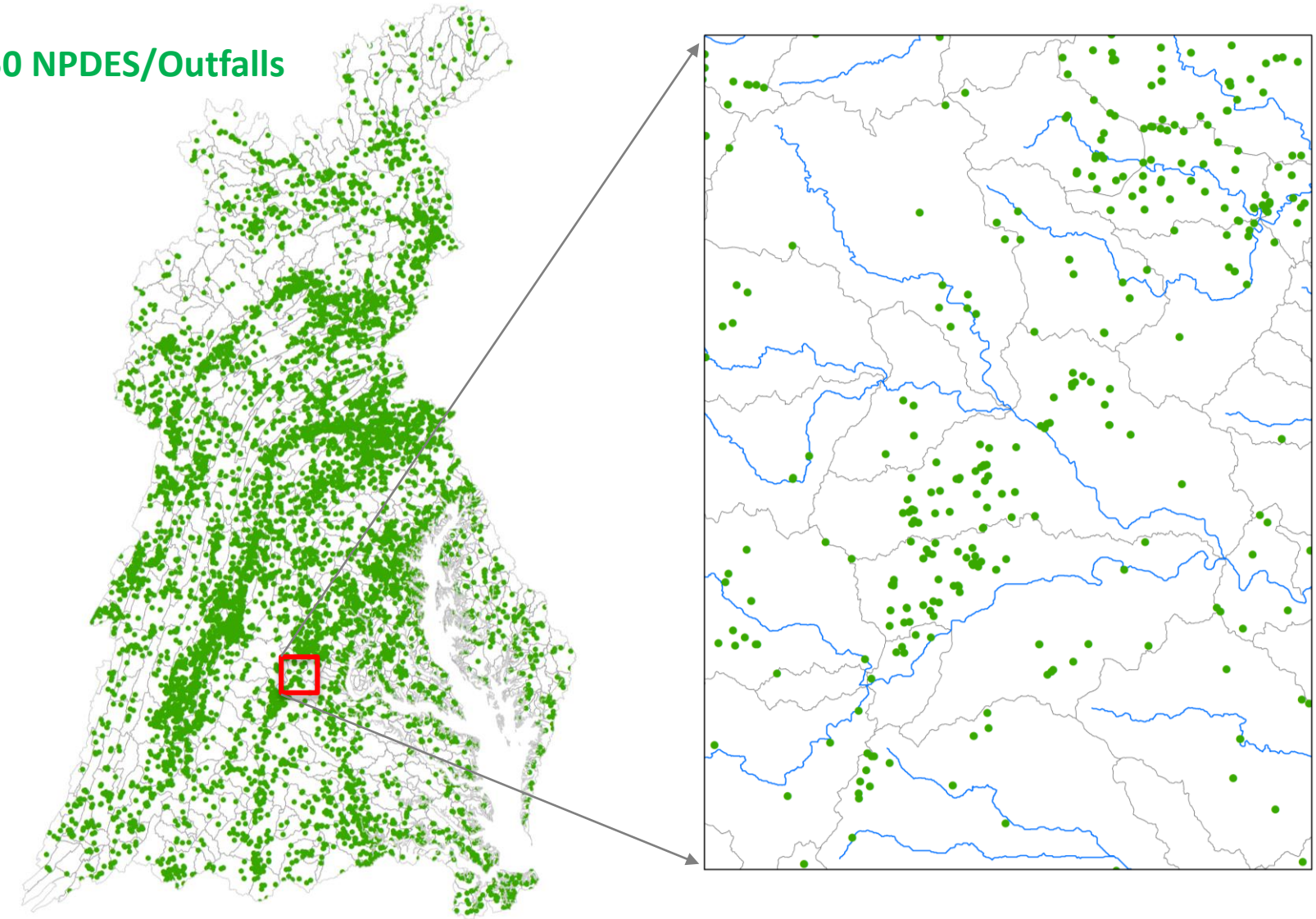
PHOSPHORUS



7. stream to river factors for point source facilities

Ning Zhou, Ross Mandel

~ 8150 NPDES/Outfalls



8. water quality monitoring data cleanup

Guido Yactayo

PHASE 5 RSEG	AGENCY	STATIONID	LAT2	LONG2	Comments
JU4_7000_7300	VADEQ	'2-POT000.12	37.75166700	-79.99695000	ERROR. use JU2_7360_7000
SL4_2140_2240	PADER	'WQN0211	40.19111111	-76.73111111	ERROR. use SL4_2240_2310
SW0_1520_1600	PADER	'WQN0423	41.07472222	-77.59222222	ERROR. use SW3_1600_1580
SW4_1430_1490	PADER	'WQN0418	41.26138889	-77.90277778	ERROR. use SW4_1490_1400
SW3_1091_1380	PADER	'WQN0419	41.32000000	-78.08083333	ERROR. use SW3_1380_1490
SU5_0610_0600	PADER	'WQN0332	41.94888889	-76.51750000	ERROR. use SU5_0600_0750
PL0_5010_5130	VADEQ	'1AAUA007.92	38.46340000	-77.38540000	ERROR. use PL1_5690_0001
JU3_6950_7330	VADEQ	2-JKS030.65			Located above point source

9. representation of reservoirs on simulated rivers

Ross Mandel

- 28 simulated reaches were identified as reservoirs.
- They are simulated as a reach, but the affect of the reservoir is superimposed using SPARROW factors.

Basins	Number of Reservoirs
Appomattox	1
James Upper	2
Potomac Lower	5
Potomac Middle	1
Potomac Shenandoah	3
Potomac Upper	4
Susquehanna Juniata	1
Susquehanna Lower	4
Susquehanna Upper	2
Susquehanna West Br	2
Western Shore Middle	2
Western Shore Upper	1

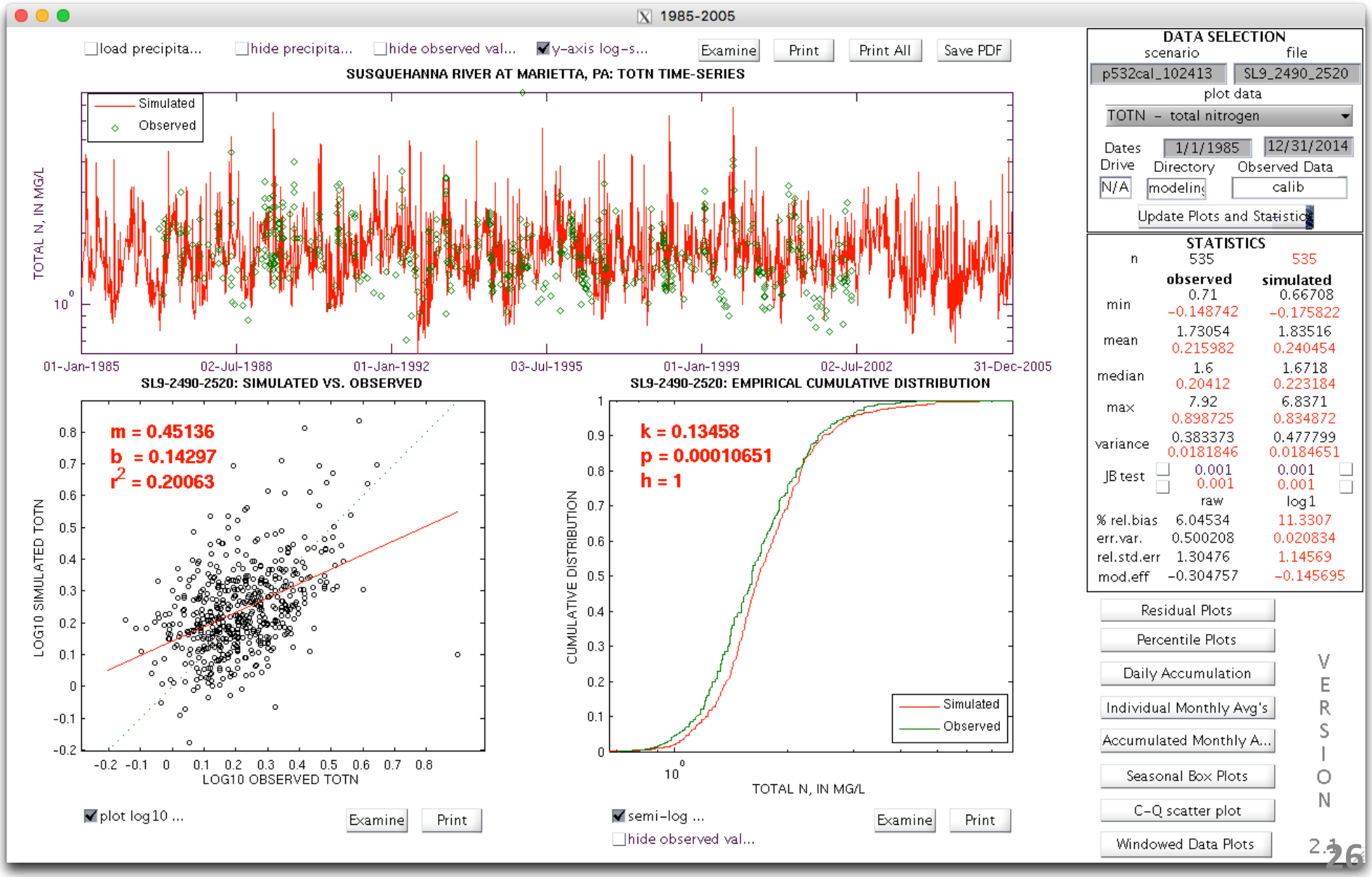
10. rSAS model for groundwater nitrate transport

- rSAS was run for the entire Chesapeake Bay.
- Run time in calibration mode is approx. 33 hours of wall time on CBPO computation cluster.
- Some discrepancies need to be reconciled in terms of simulated loads and the groundwater nitrate targets.

SUSQUEHANNA AT MARIETTA

PHASE 5

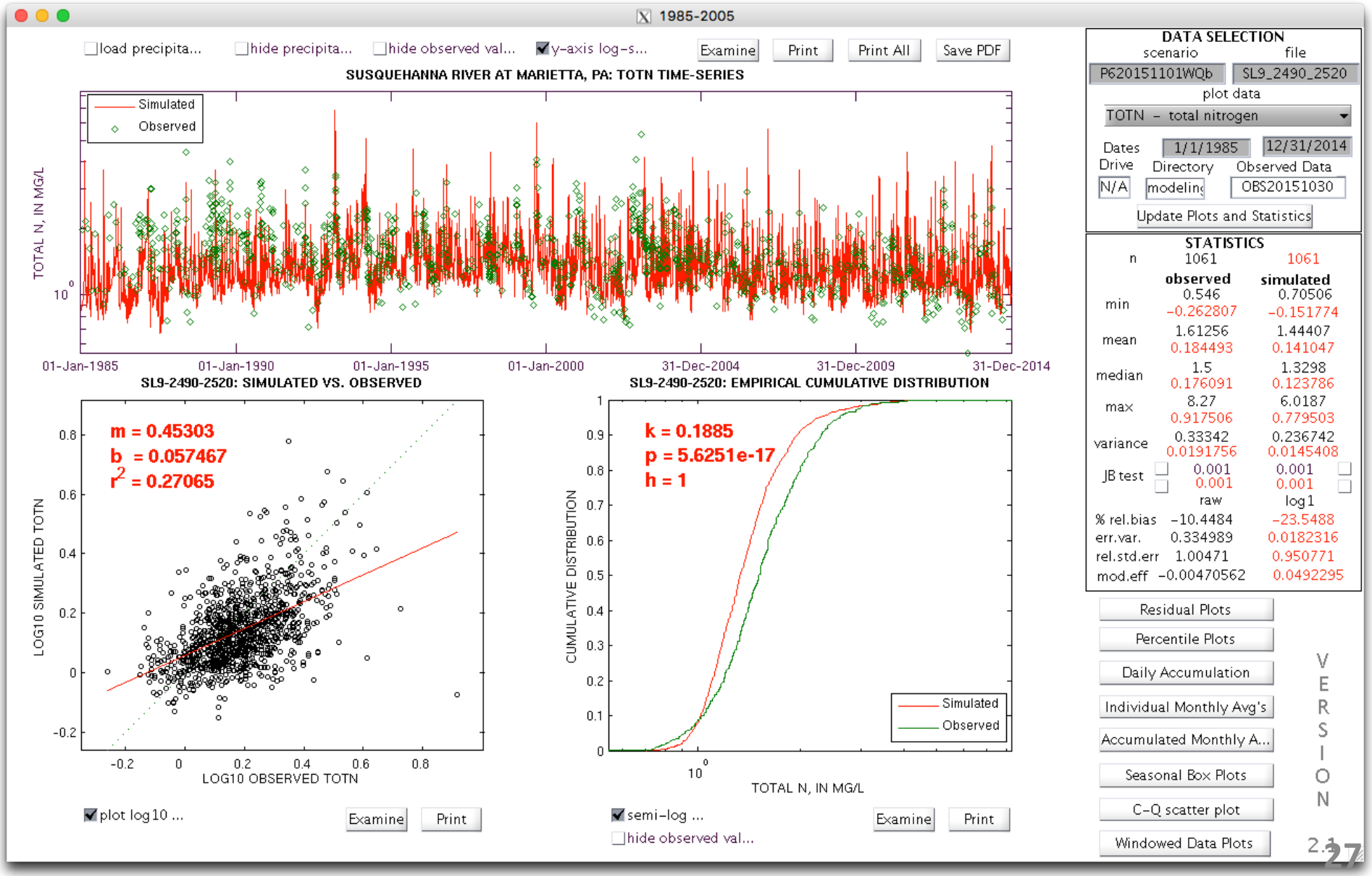
NITROGEN



SUSQUEHANNA AT MARIETTA

PHASE 6 BETA 1

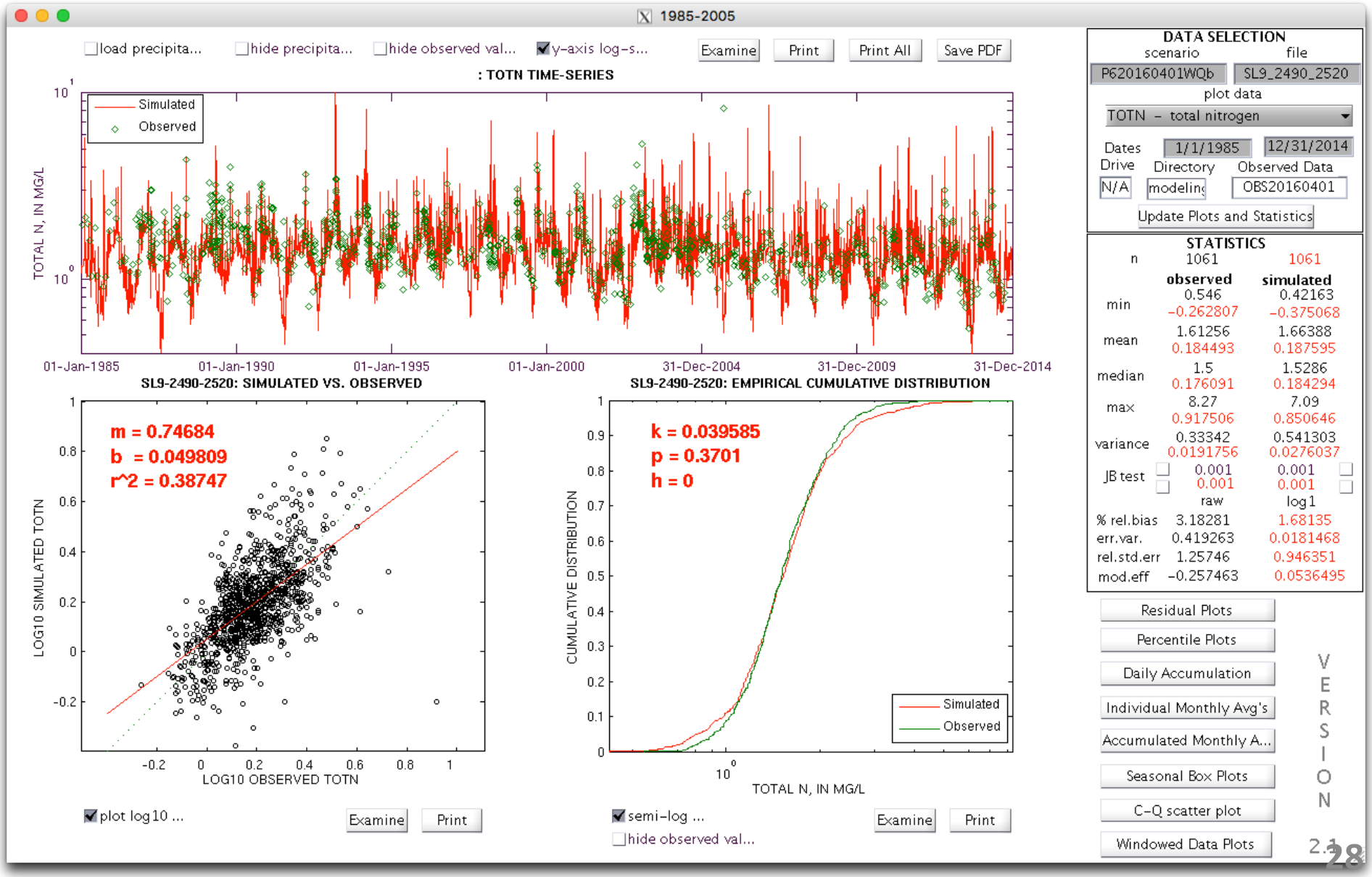
NITROGEN



SUSQUEHANNA AT MARIETTA

PHASE 6 BETA 2

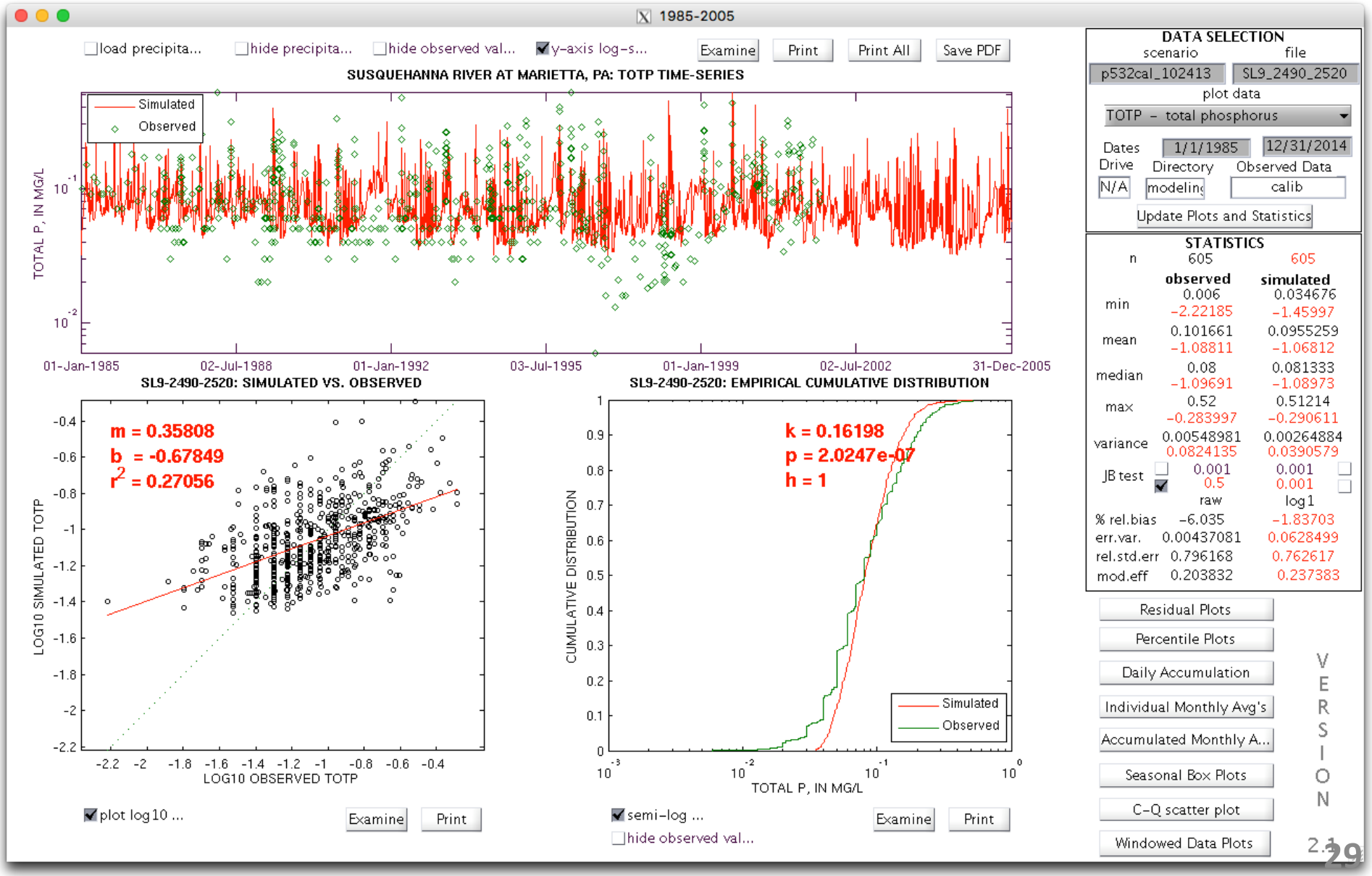
NITROGEN



SUSQUEHANNA AT MARIETTA

PHASE 5

PHOSPHORUS



SUSQUEHANNA AT MARIETTA

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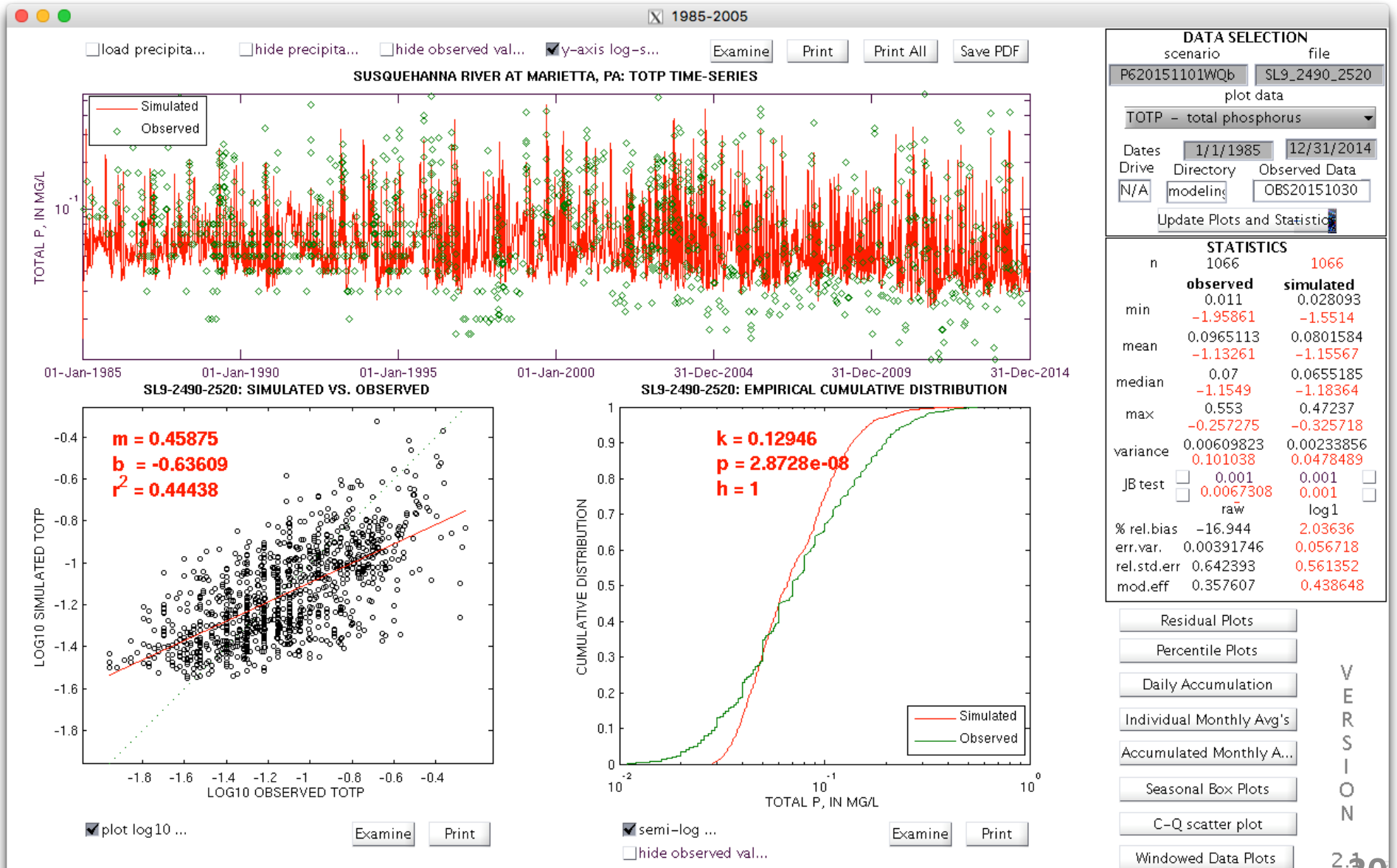
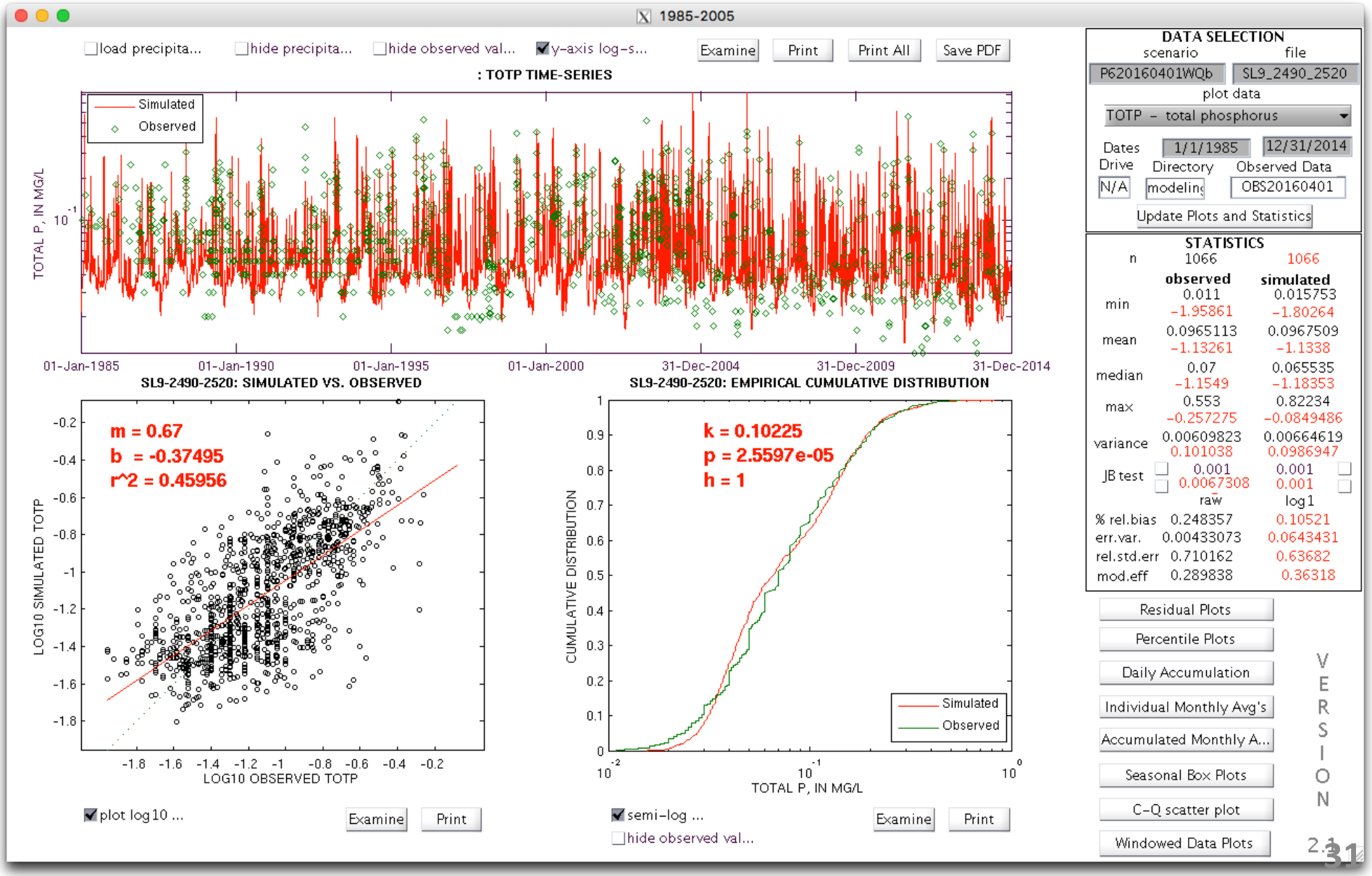


SUSQUEHANNA AT MARIETTA

PHASE 6 BETA 2

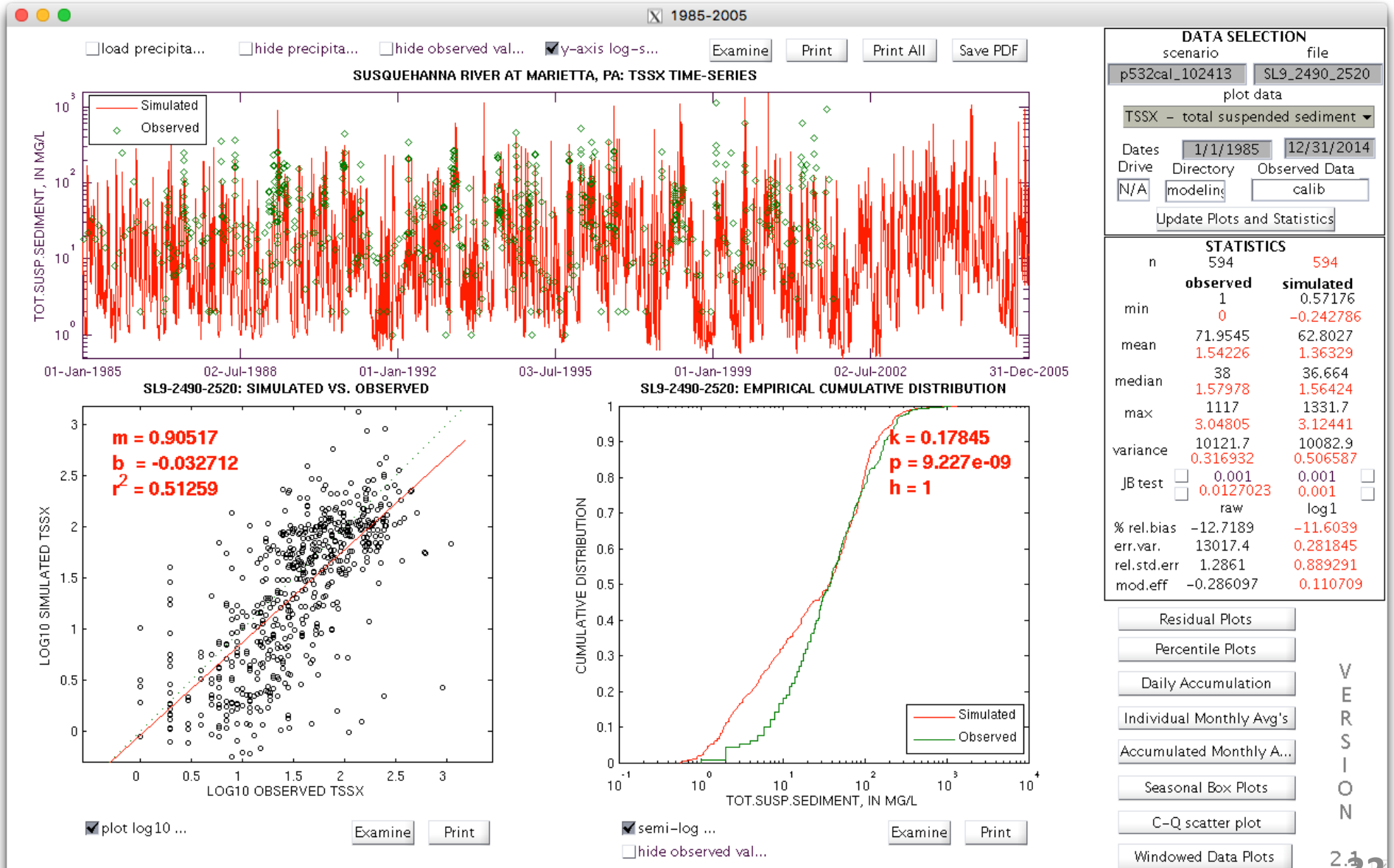
PHOSPHORUS



SUSQUEHANNA AT MARIETTA

PHASE 5

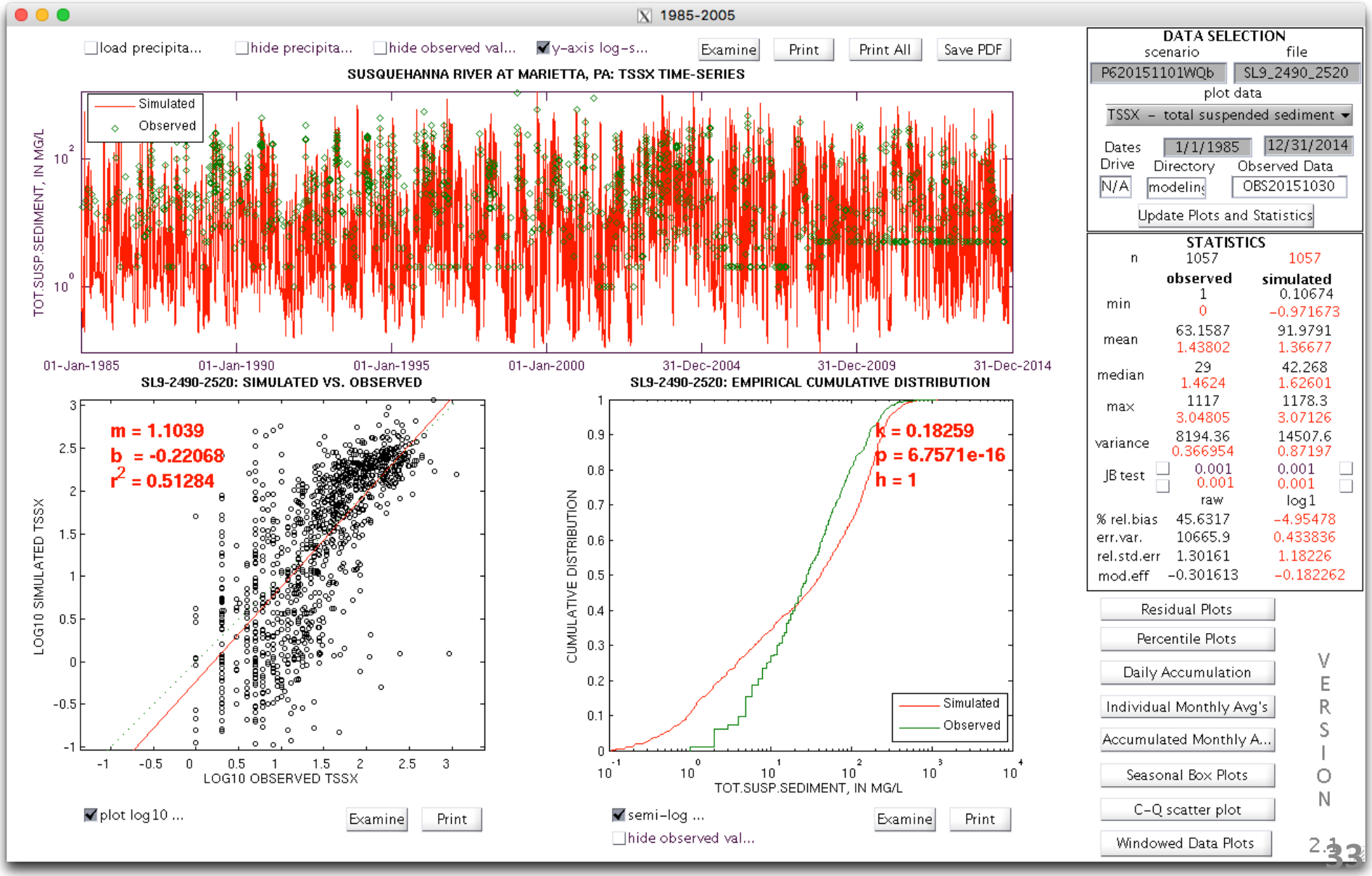
SEDIMENT



SUSQUEHANNA AT MARIETTA

PHASE 6 BETA 1

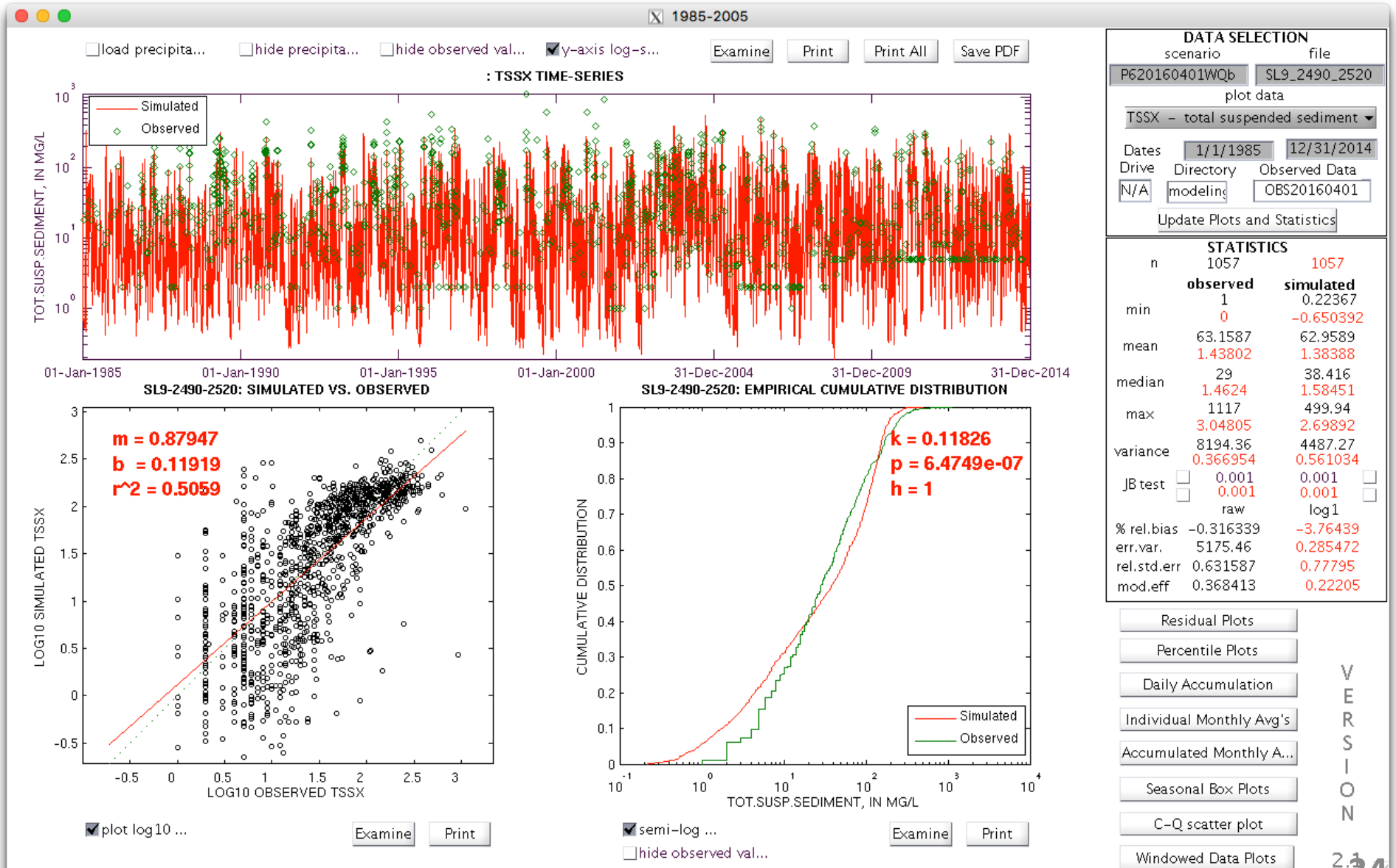
SEDIMENT



SUSQUEHANNA AT MARIETTA

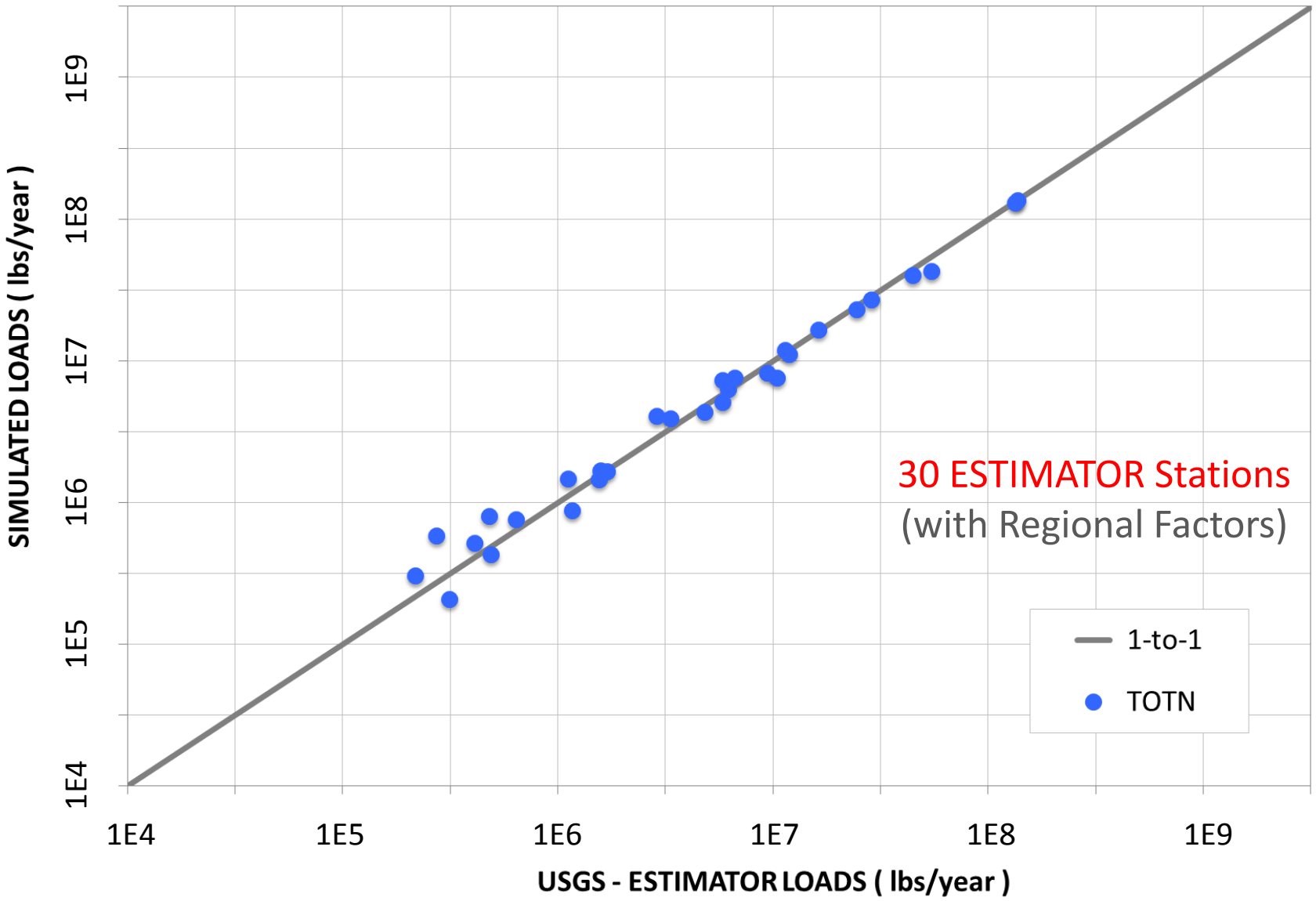
PHASE 6 BETA 2

SEDIMENT



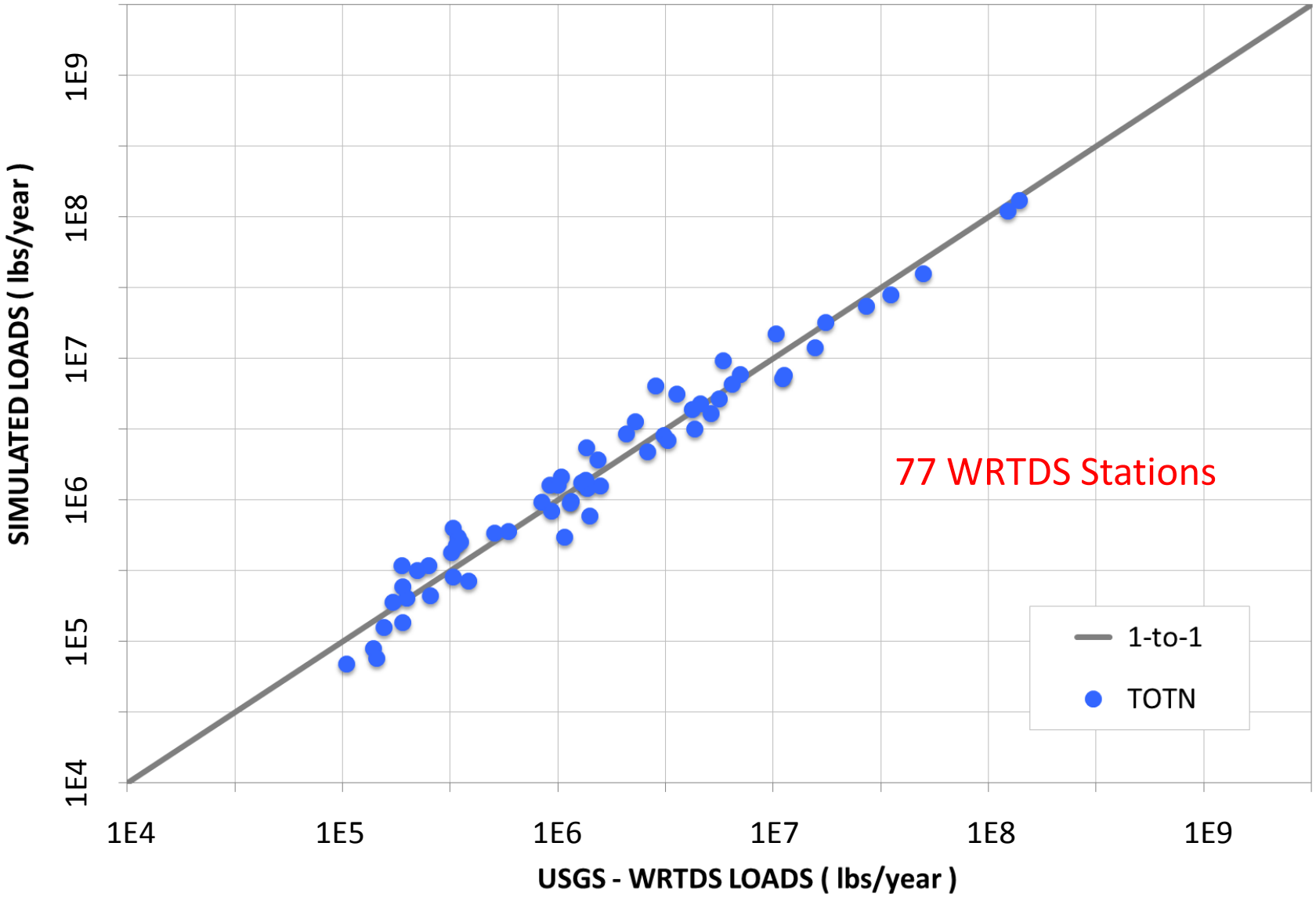
PHASE 5

NITROGEN



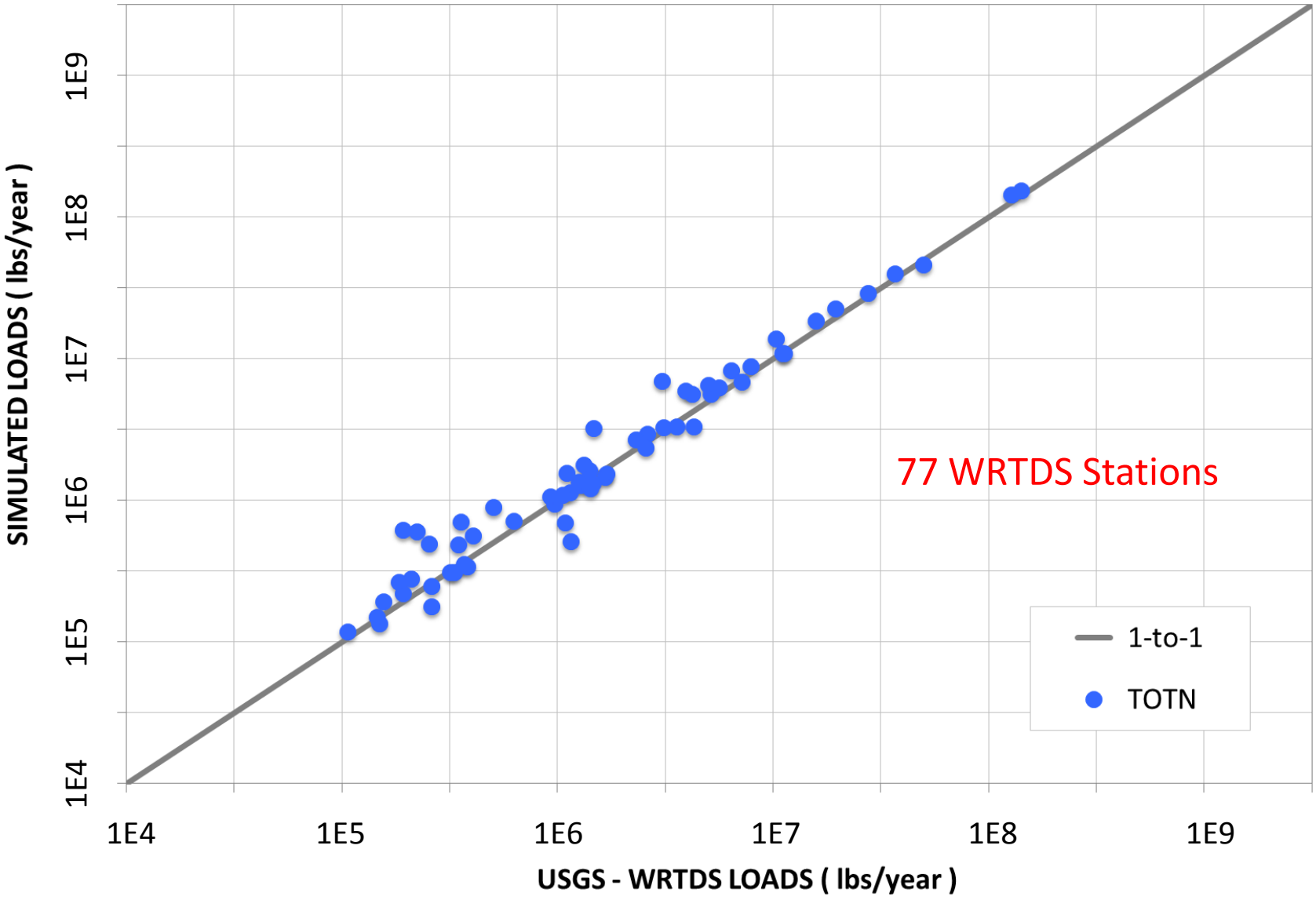
PHASE 6
BETA 1

NITROGEN



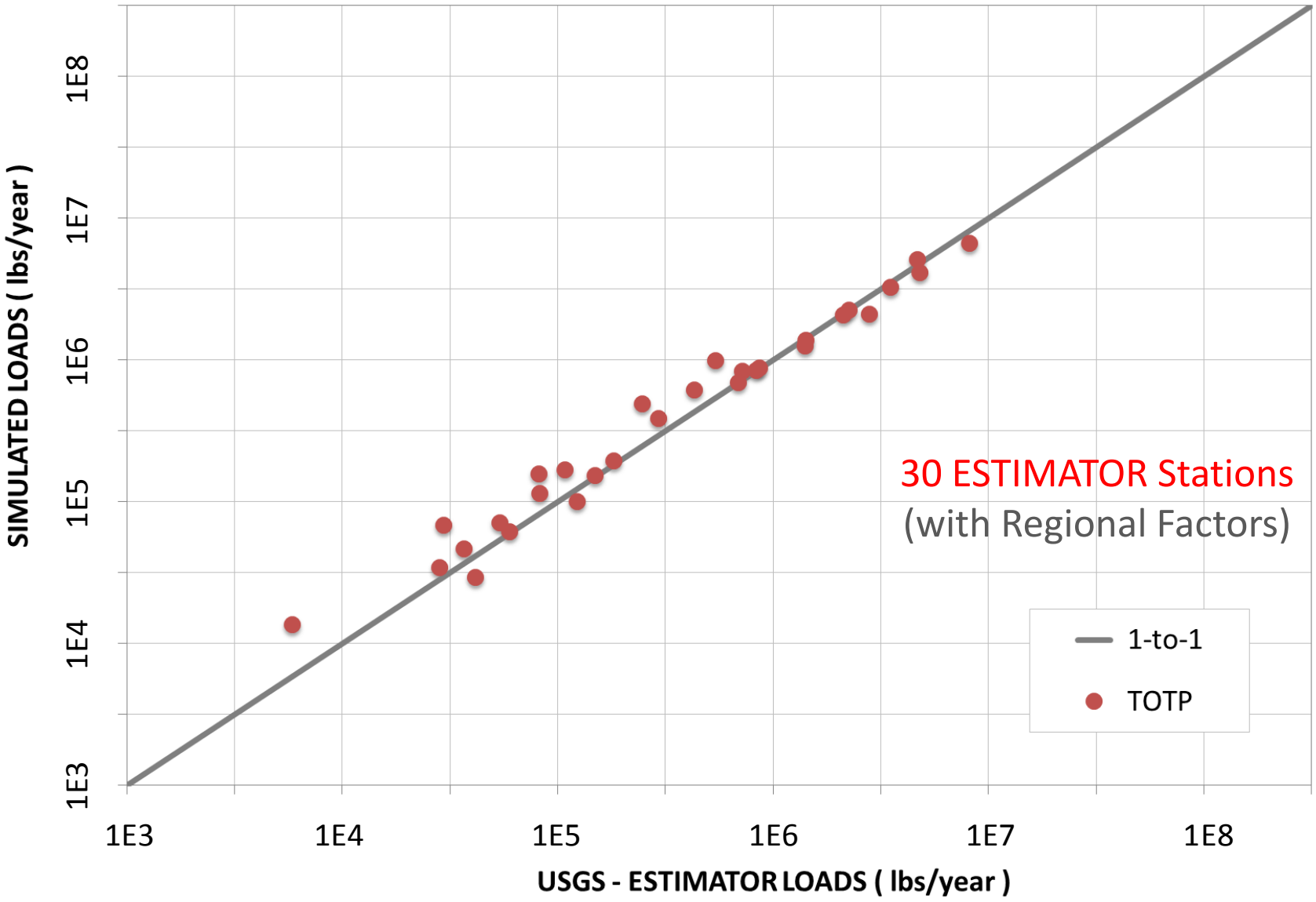
PHASE 6
BETA 2x

NITROGEN



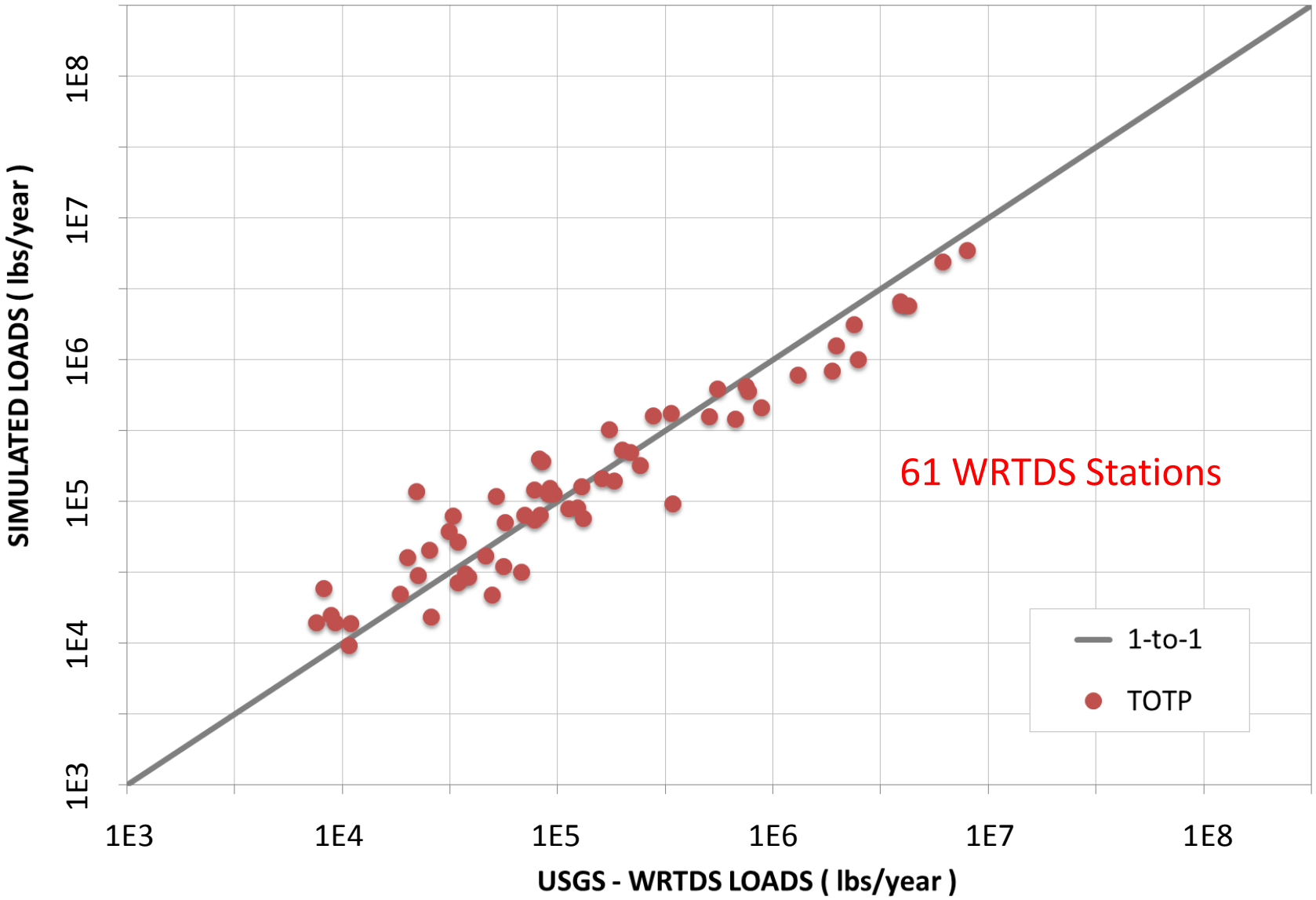
PHASE 5

PHOSPHORUS



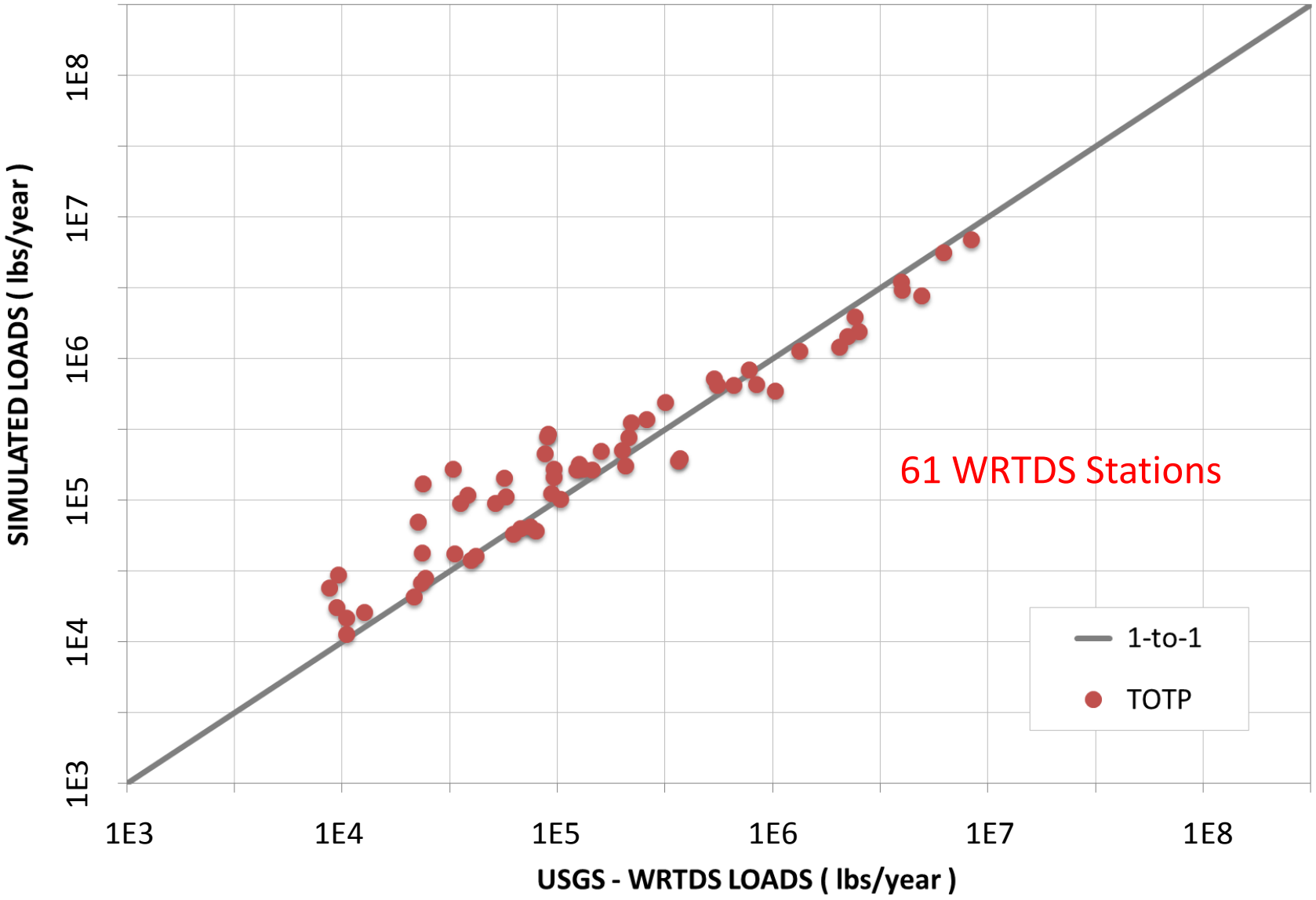
PHASE 6
BETA 1

PHOSPHORUS



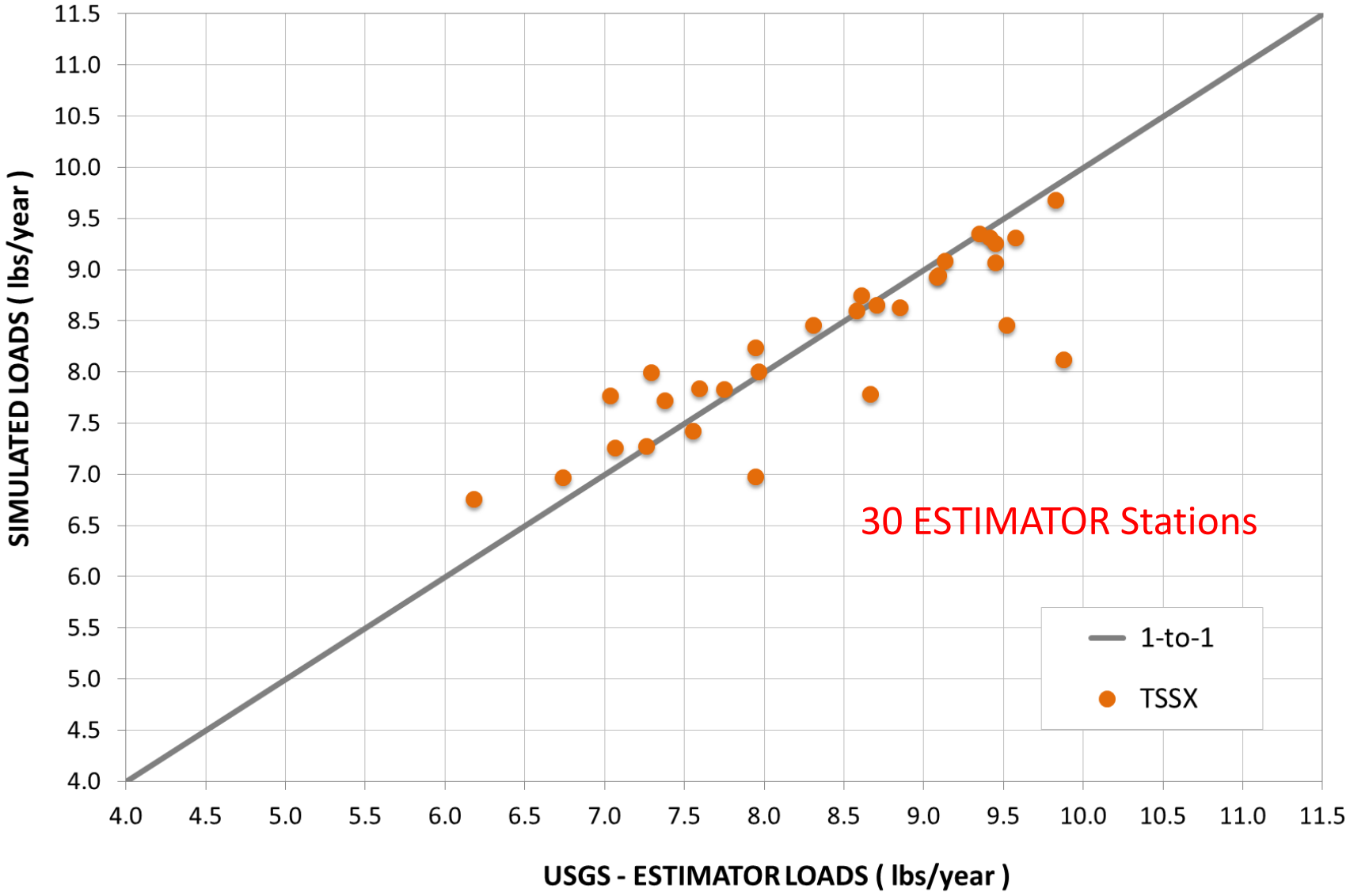
PHASE 6
BETA 2x

PHOSPHORUS



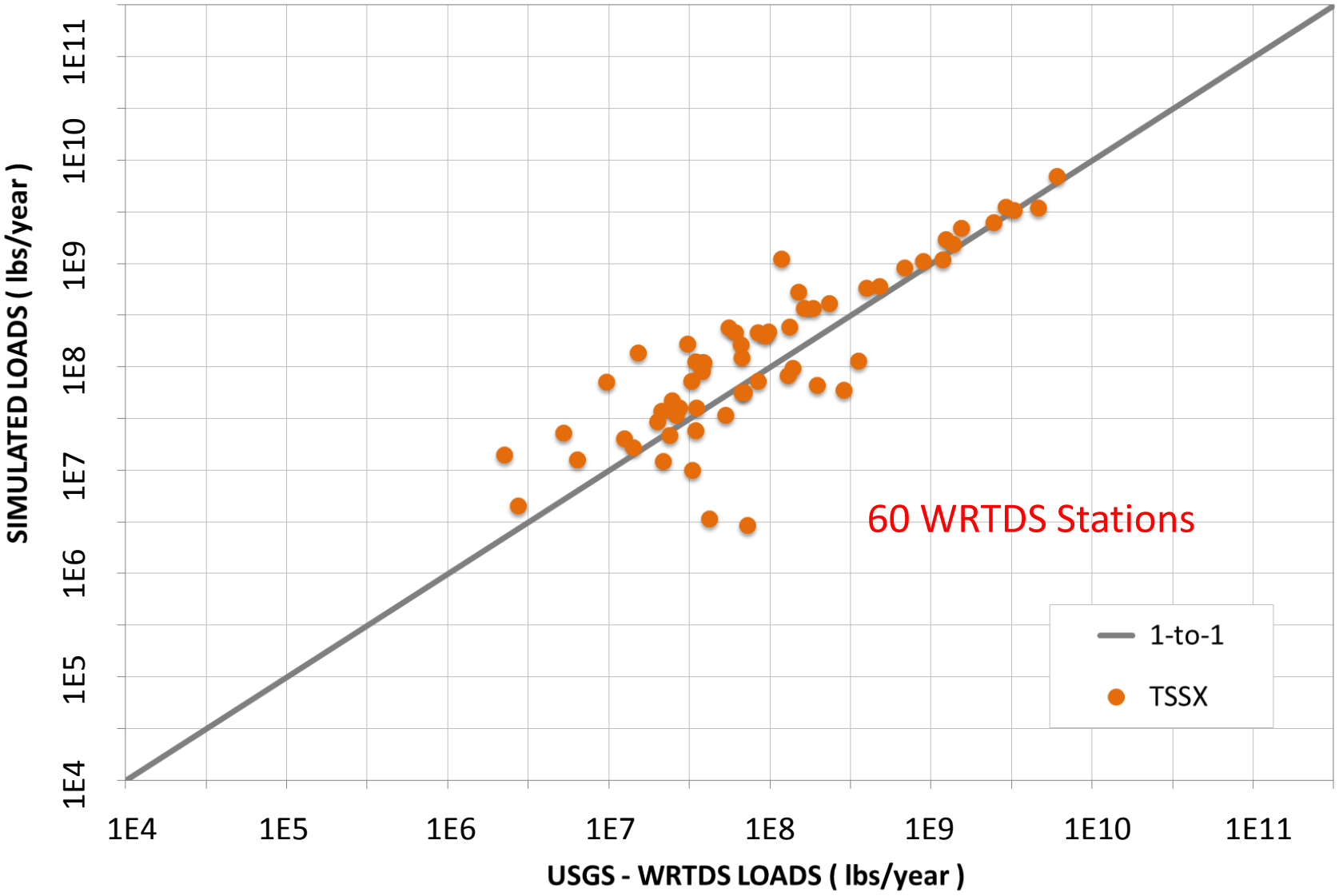
PHASE 5

SEDIMENT



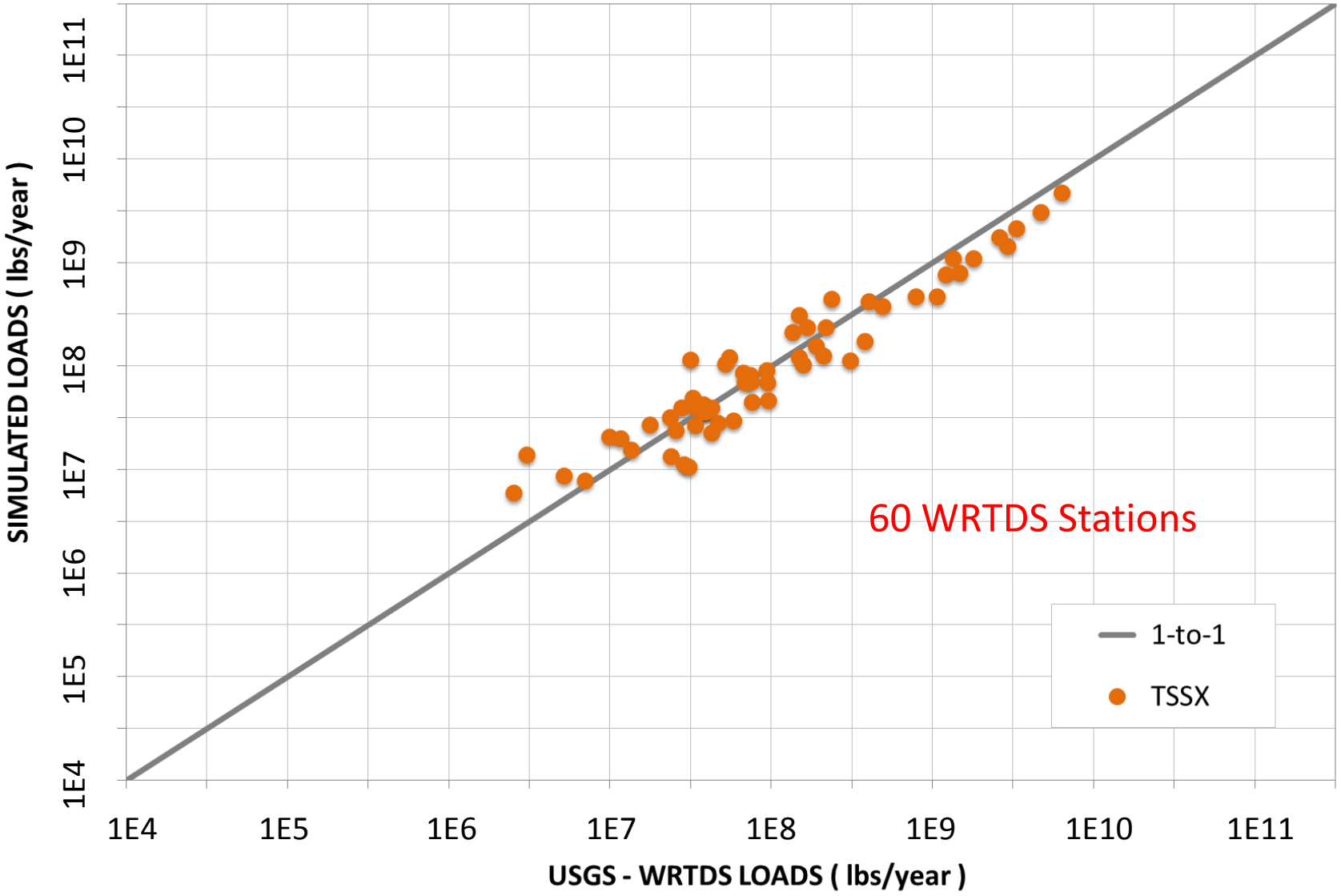
PHASE 6
BETA 1

SEDIMENT



PHASE 6
BETA 2x

SEDIMENT



Further refinements, e.g.,

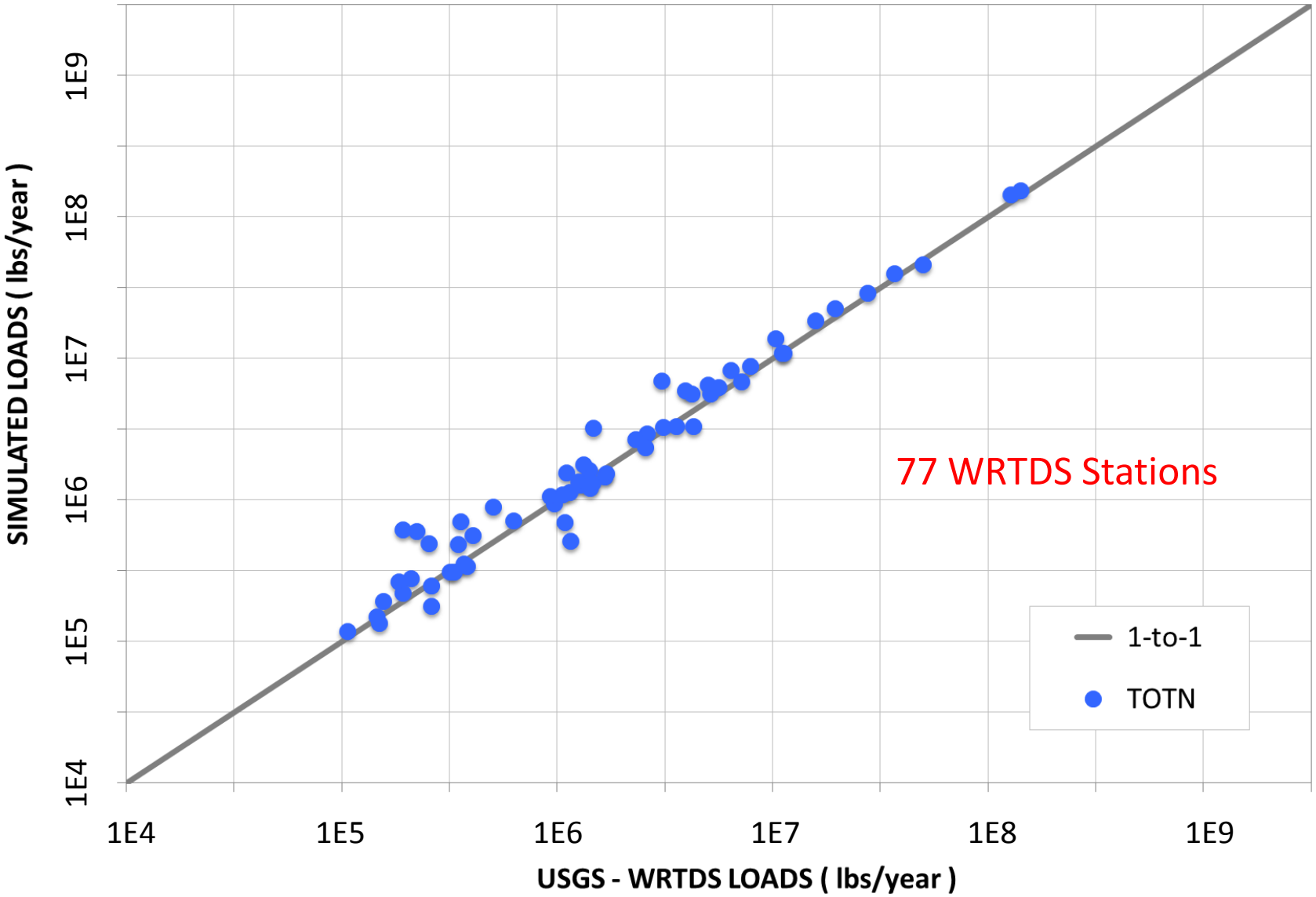
- A *potential* double counting between how the Soil Mehlich 3 sensitivity and SPARROW delivery variance factors (DVFs) for % coastal plains was identified.
- Observation data for 5 additional monitoring sites, where USGS provided WRTDS loads, were added.
- Calibration objective function for sediment was changed.

we will examine differences on next 6 slides…

PHASE 6 BETA 2x ⇨ **PHASE 6 BETA 2**

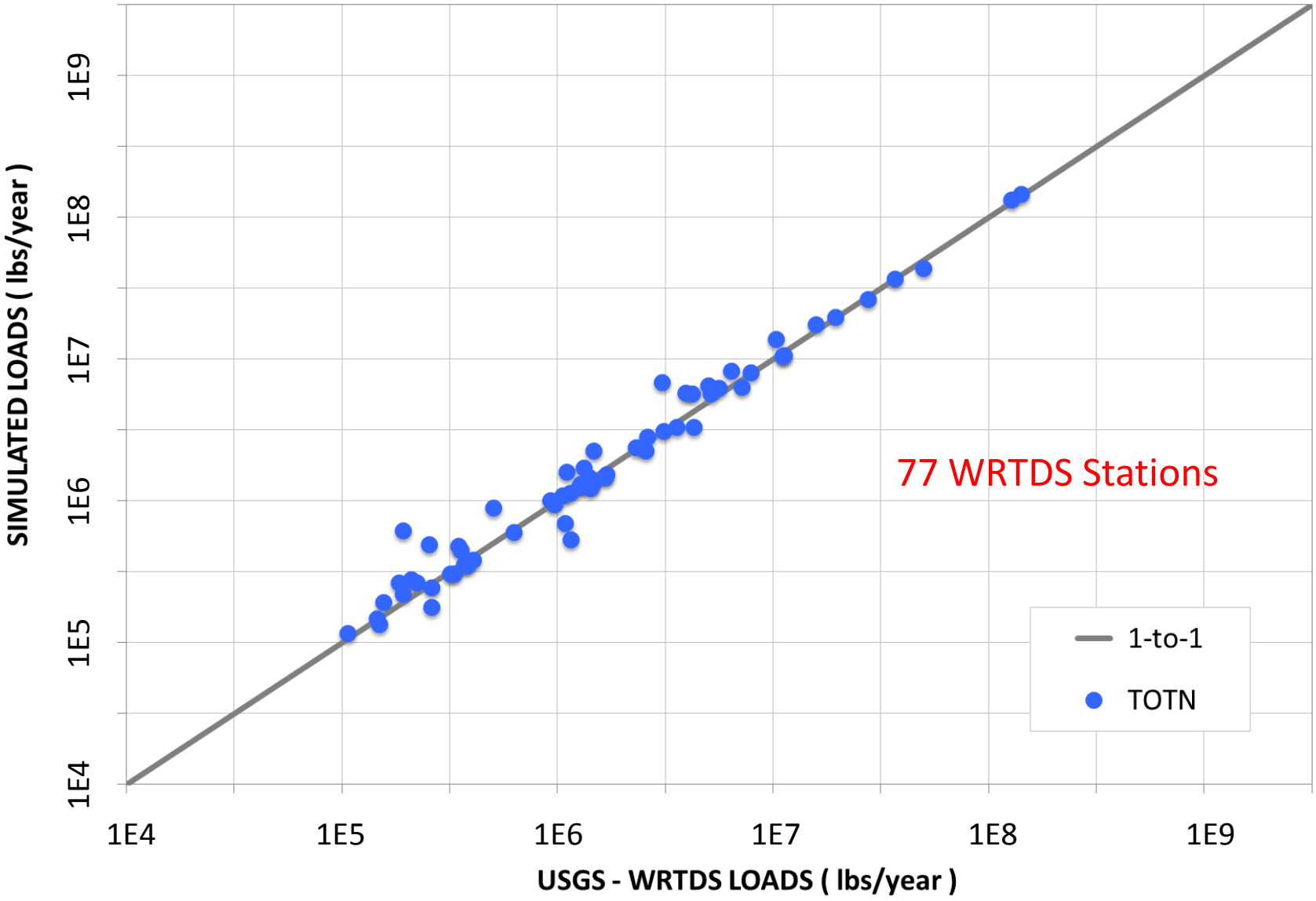
PHASE 6
BETA 2x

NITROGEN



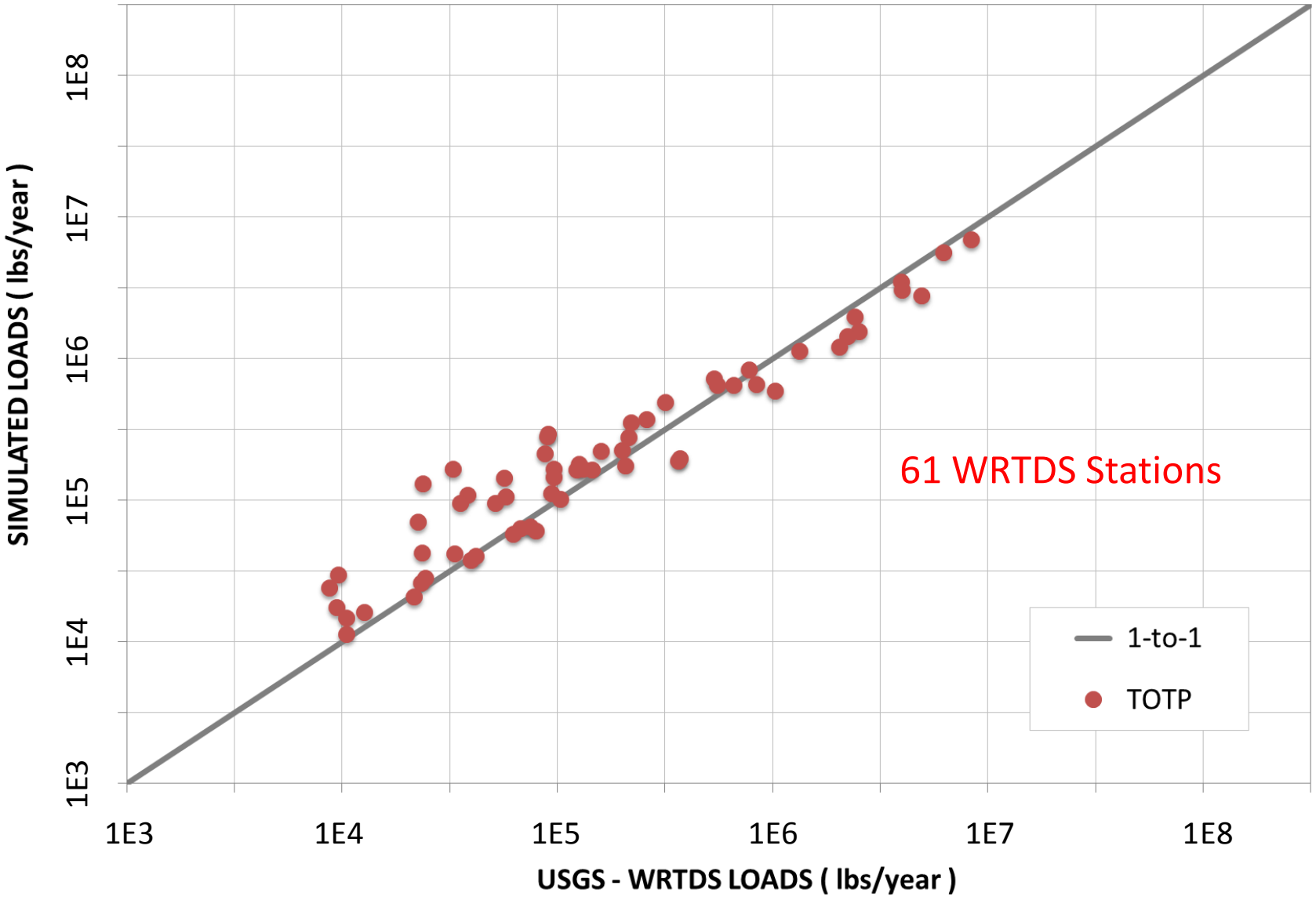
PHASE 6
BETA 2

NITROGEN



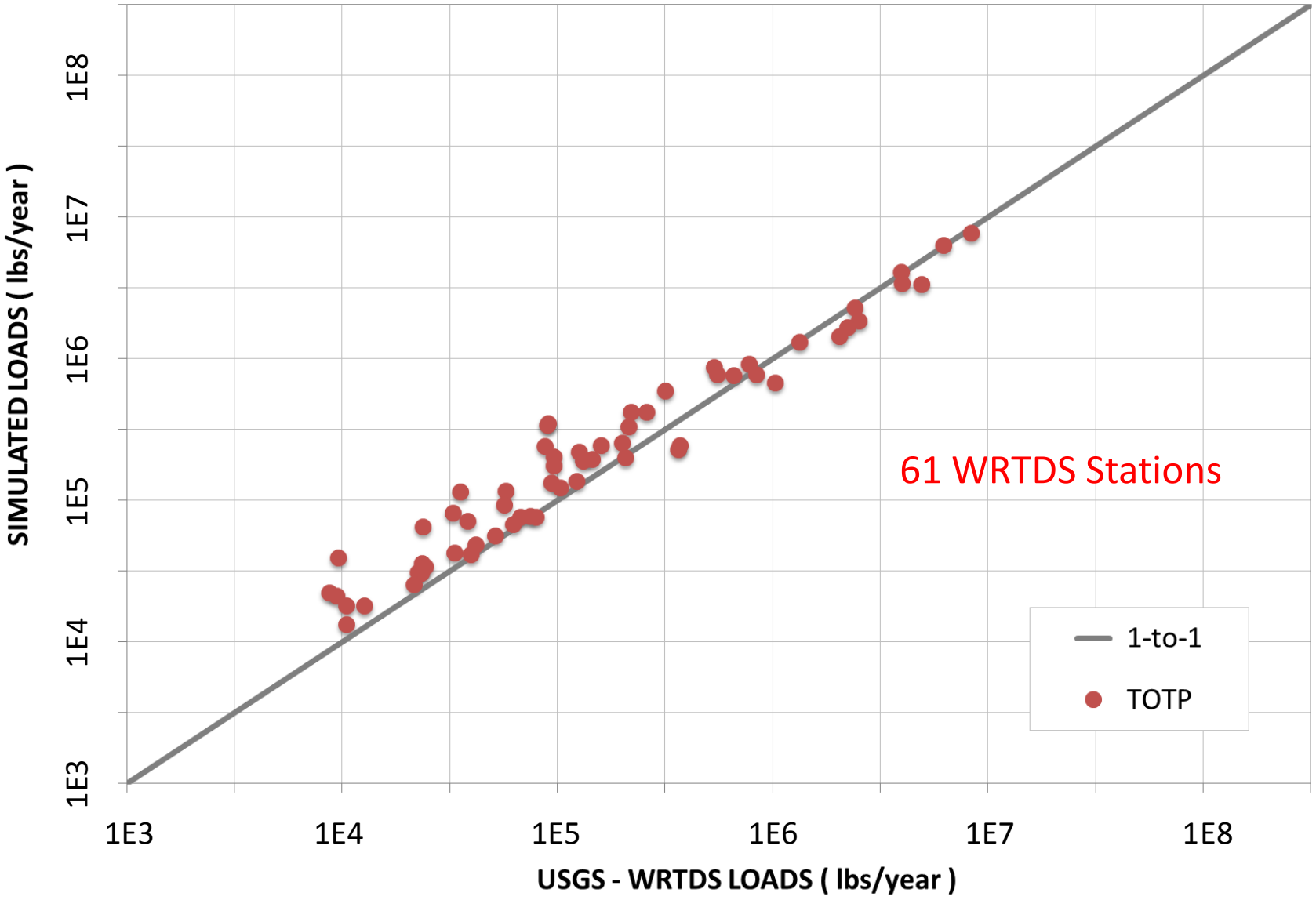
PHASE 6
BETA 2x

PHOSPHORUS



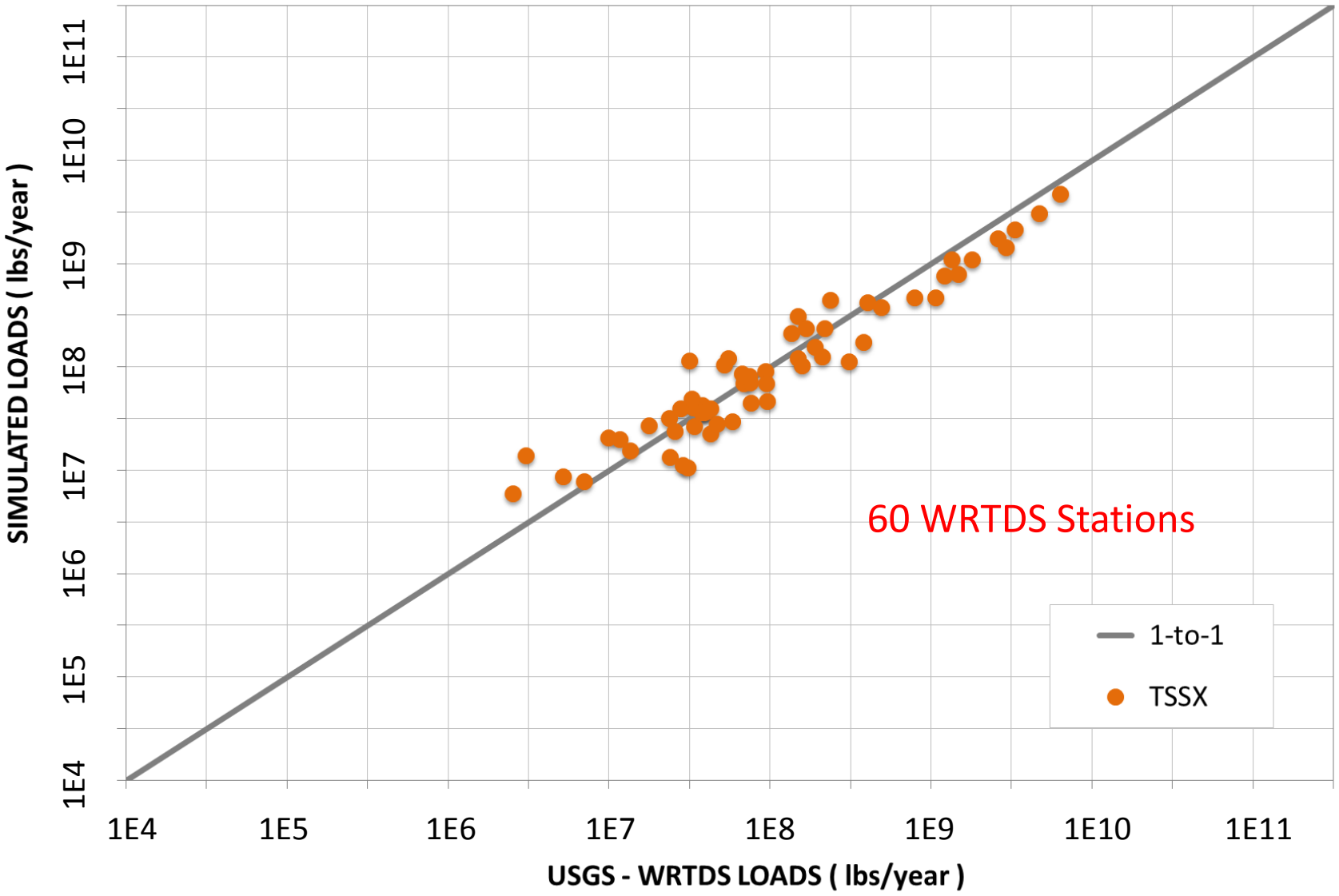
PHASE 6
BETA 2

PHOSPHORUS



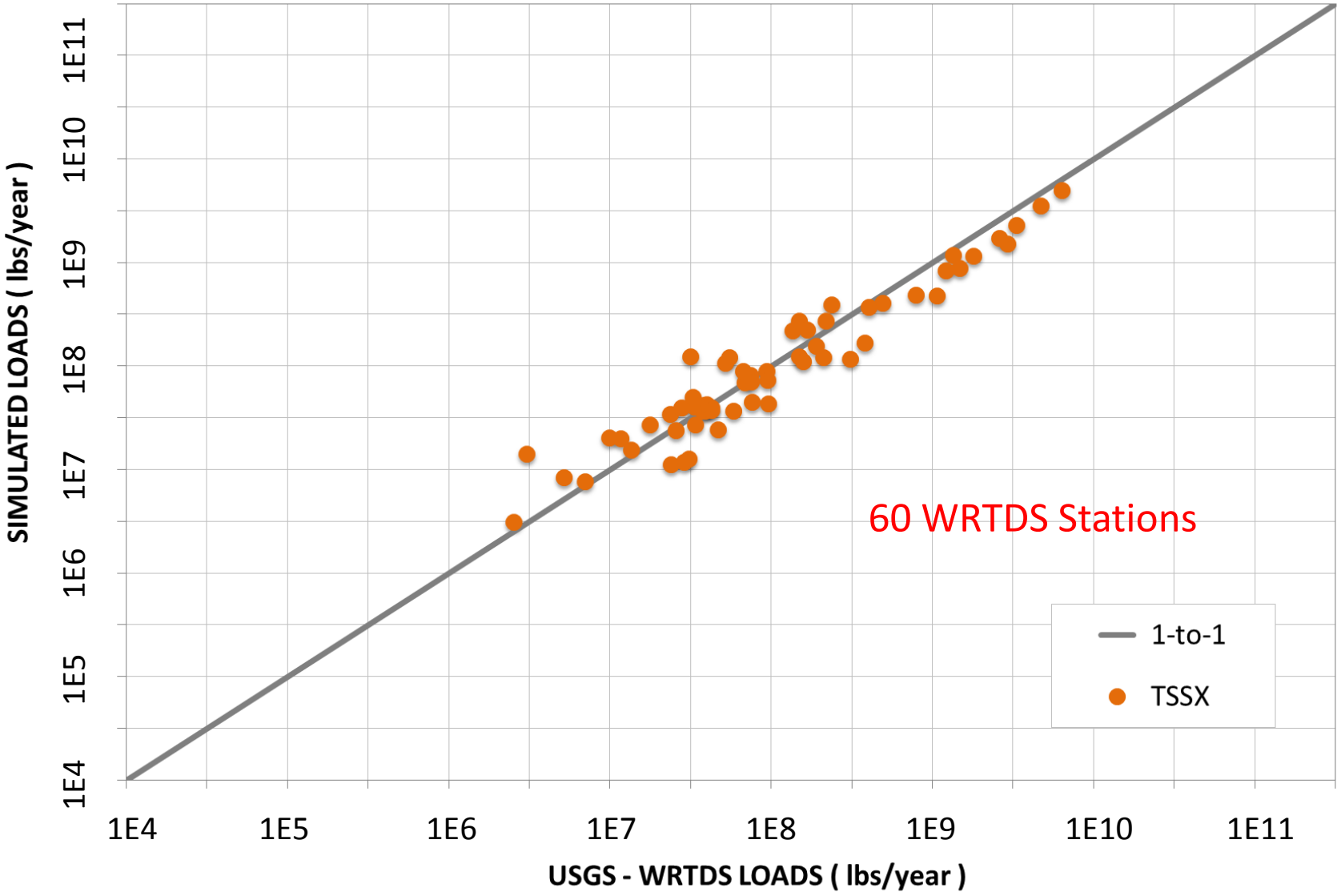
PHASE 6
BETA 2x

SEDIMENT



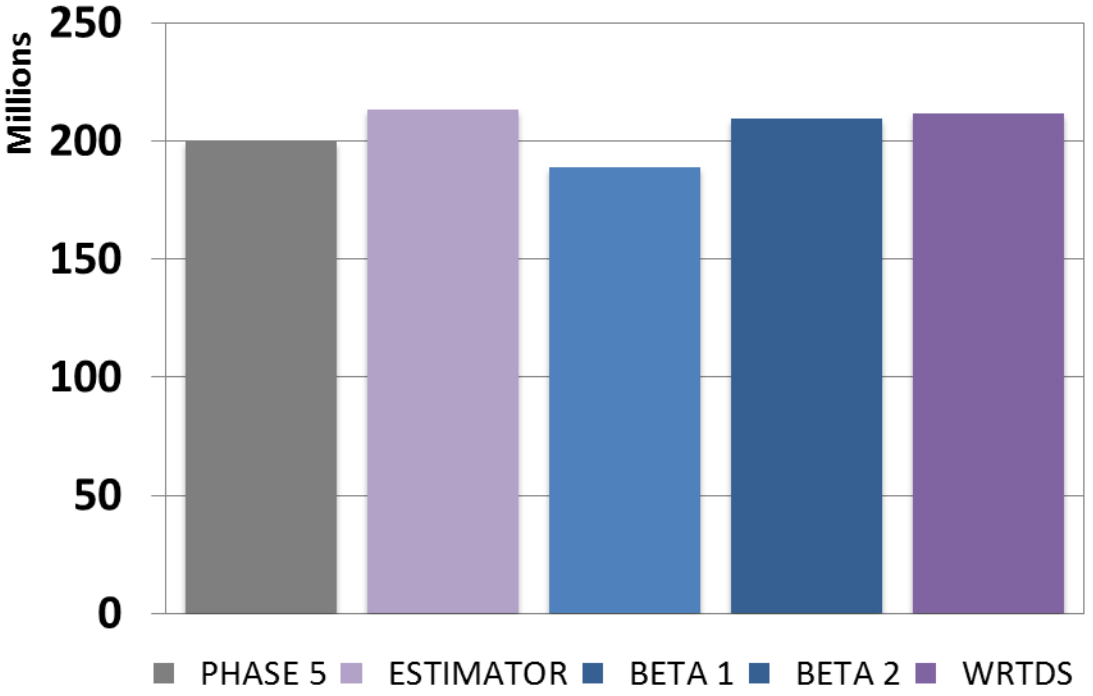
PHASE 6
BETA 2

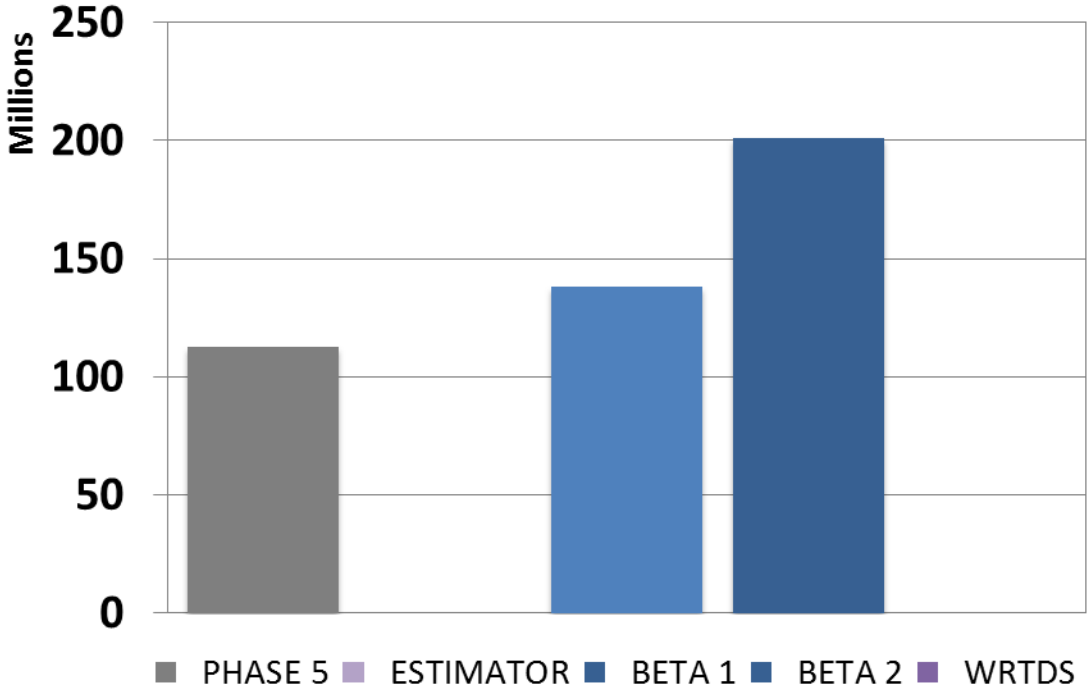
SEDIMENT



Nitrogen Loads

RIM (Fall-line) Loads

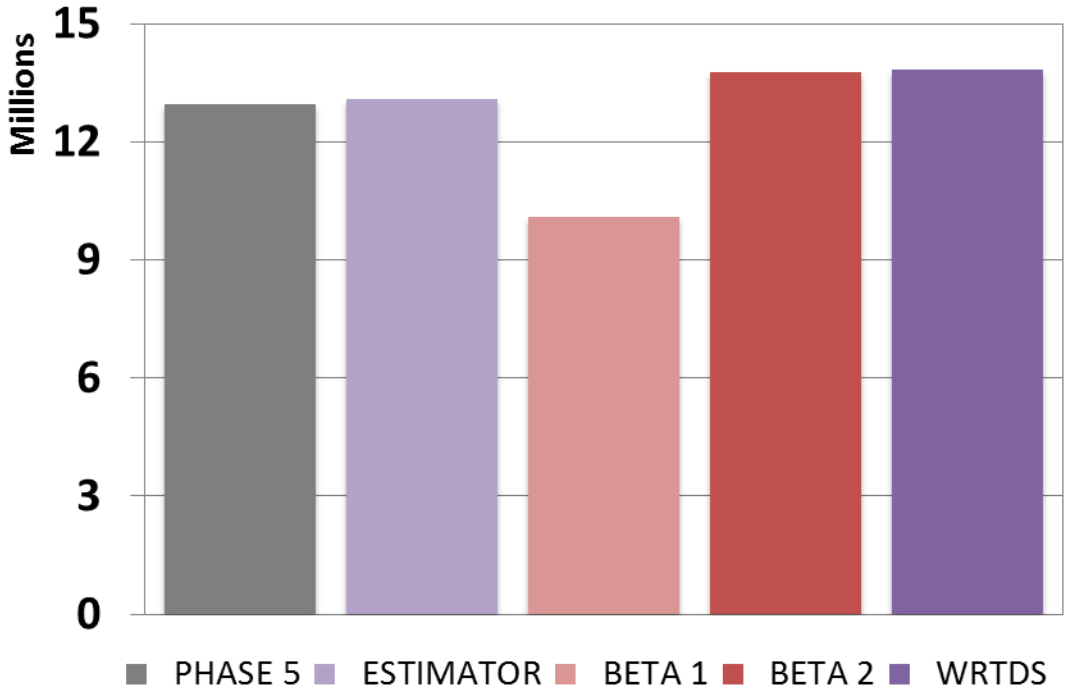


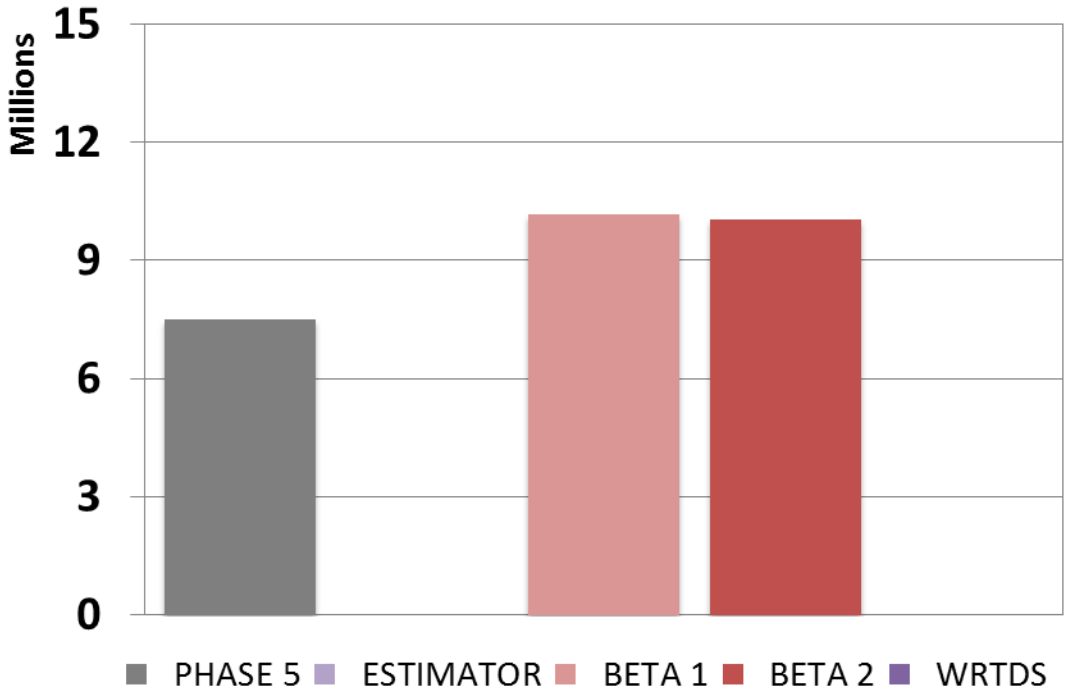


Below Fall-line Loads

Phosphorus Loads

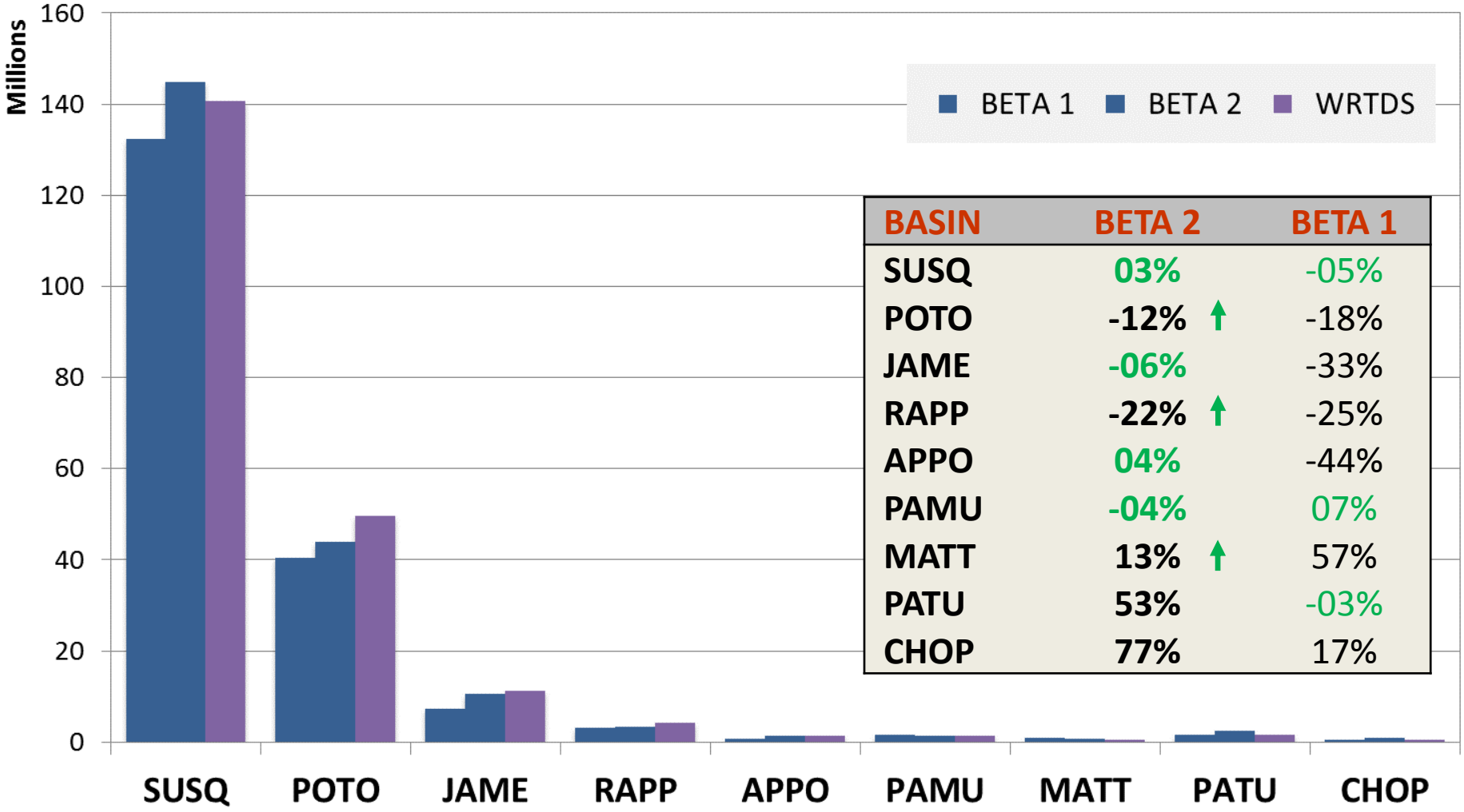
RIM (Fall-line) Loads





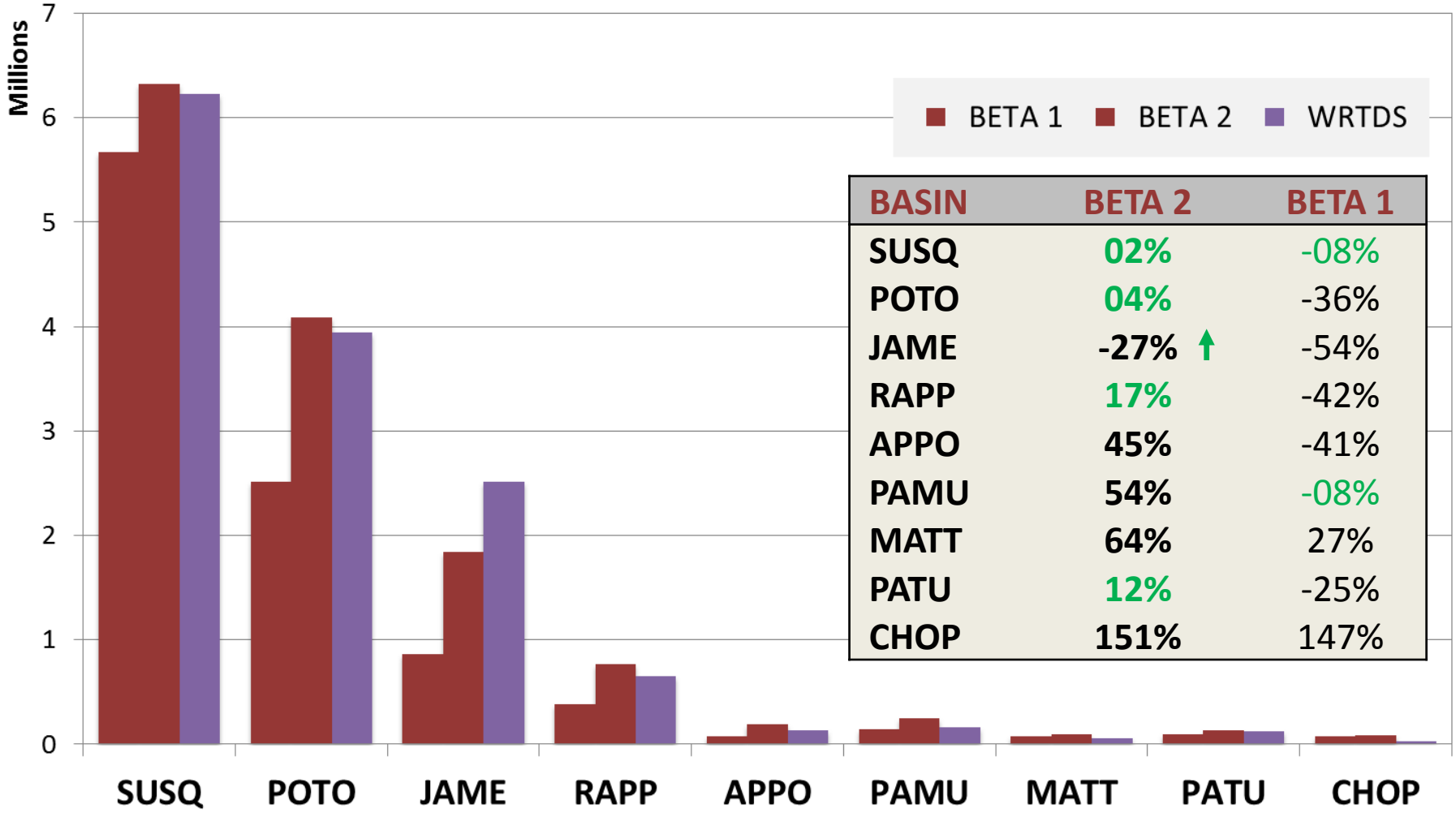
Below Fall-line Loads

Total **Nitrogen** at RIM Stations

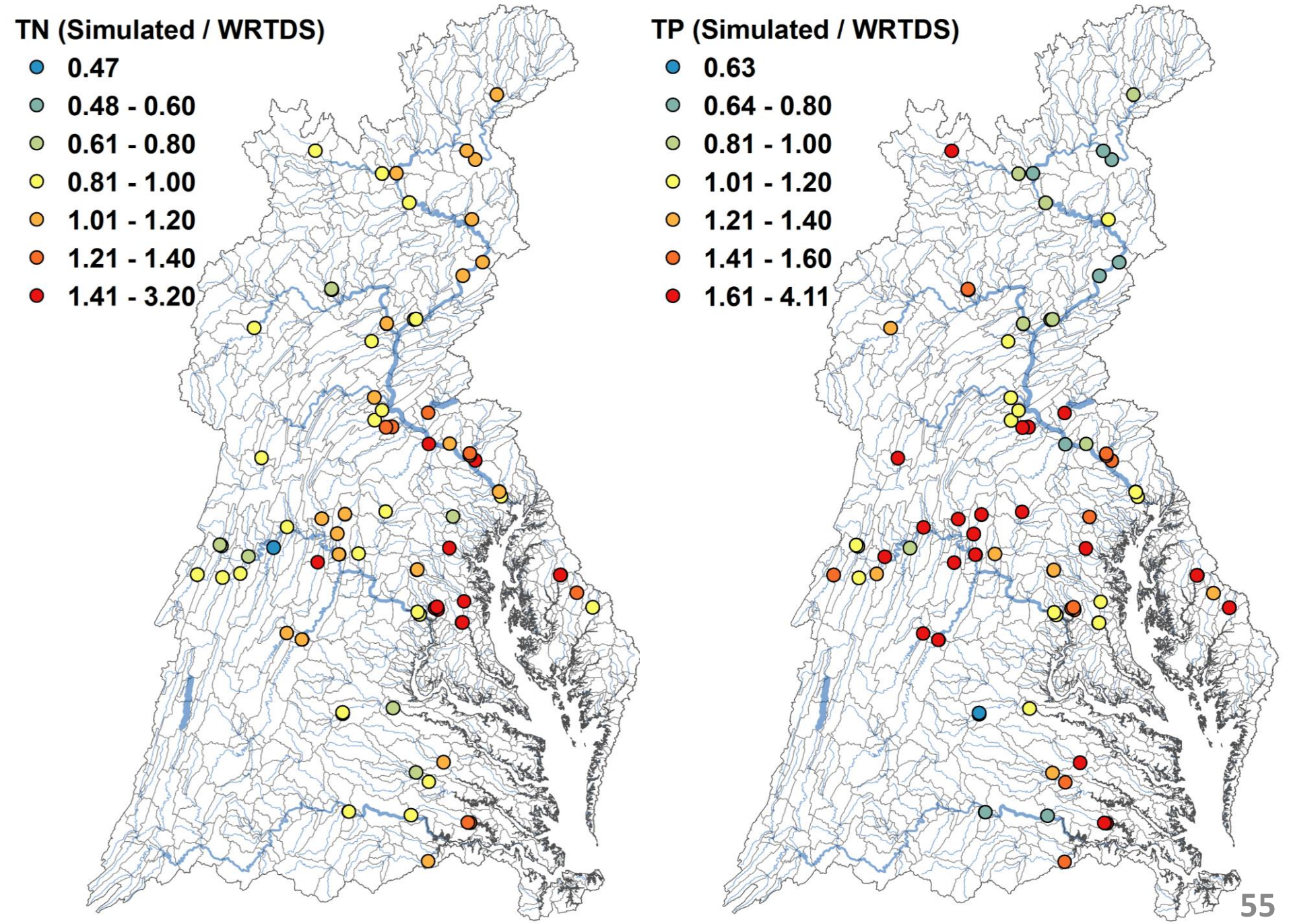


BASIN	BETA 2	BETA 1
SUSQ	03%	-05%
POTO	-12% ↑	-18%
JAME	-06%	-33%
RAPP	-22% ↑	-25%
APPO	04%	-44%
PAMU	-04%	07%
MATT	13% ↑	57%
PATU	53%	-03%
CHOP	77%	17%

Total **Phosphorus** at RIM Stations



BASIN	BETA 2	BETA 1
SUSQ	02%	-08%
POTO	04%	-36%
JAME	-27% ↑	-54%
RAPP	17%	-42%
APPO	45%	-41%
PAMU	54%	-08%
MATT	64%	27%
PATU	12%	-25%
CHOP	151%	147%

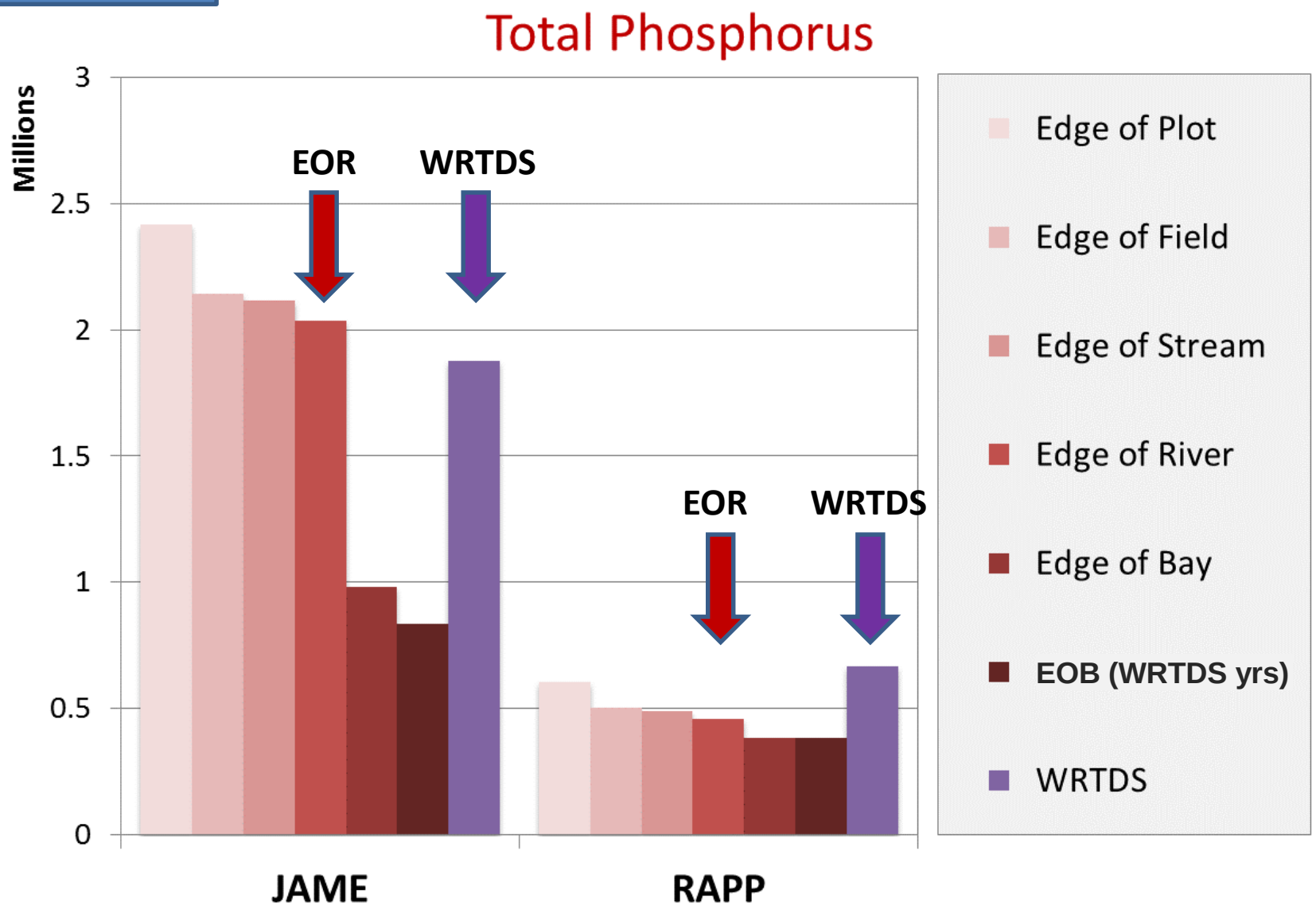

TN (Simulated / WRTDS)
0.47
0.48 - 0.60
0.61 - 0.80
0.81 - 1.00
1.01 - 1.20
1.21 - 1.40
1.41 - 3.20
TP (Simulated / WRTDS)
0.63
0.64 - 0.80
0.81 - 1.00
1.01 - 1.20
1.21 - 1.40
1.41 - 1.60
1.61 - 4.11

Phase-6 (process) simulation scales

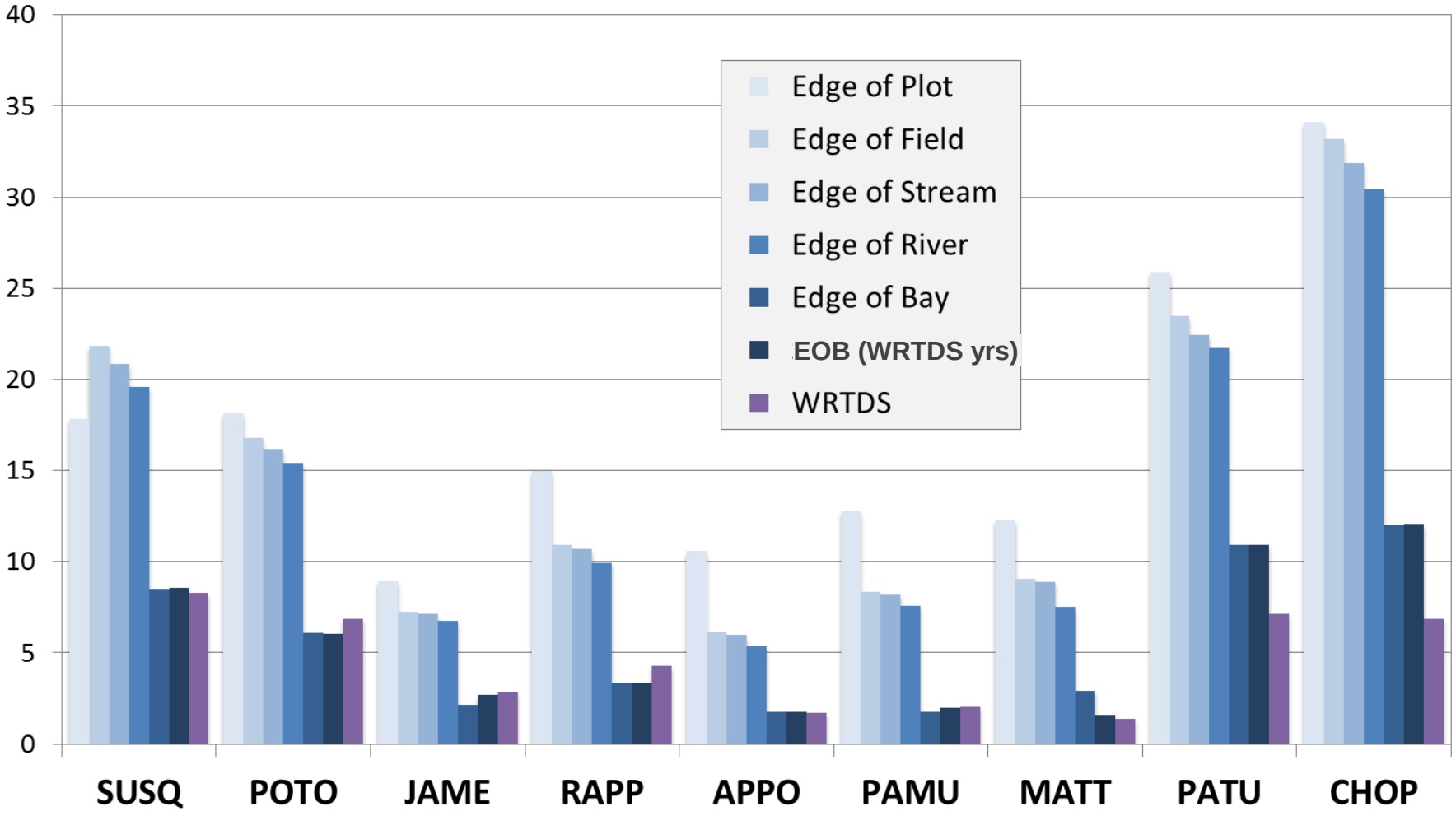
- **Edge of Plot** – loads from targets (e*ffect of source loads*)
- **Edge of Field** – loads after land-to-water variances
- **Edge of Stream** – loads after Septic, PS, & BMPs
- **Edge of River** – loads after stream-to-river factors
- **Delivered to Bay** – loads transported to the Bay

PHASE 6
BETA 1

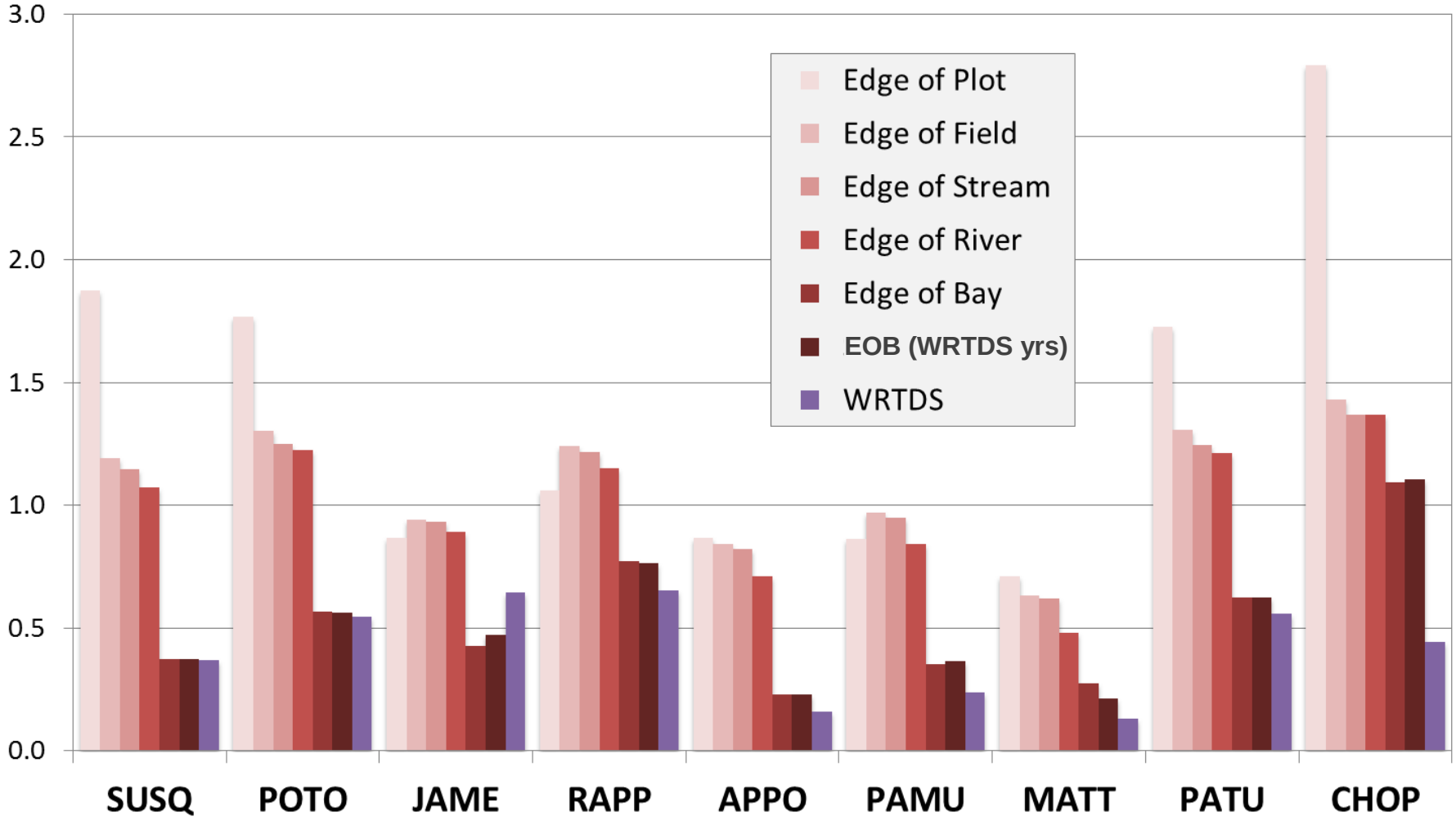
As presented in January Quarterly



Nitrogen budgets at P6 simulation scales (in pounds/acre/year)



Phosphorus budgets at P6 simulation scales (in pounds/acre/year)



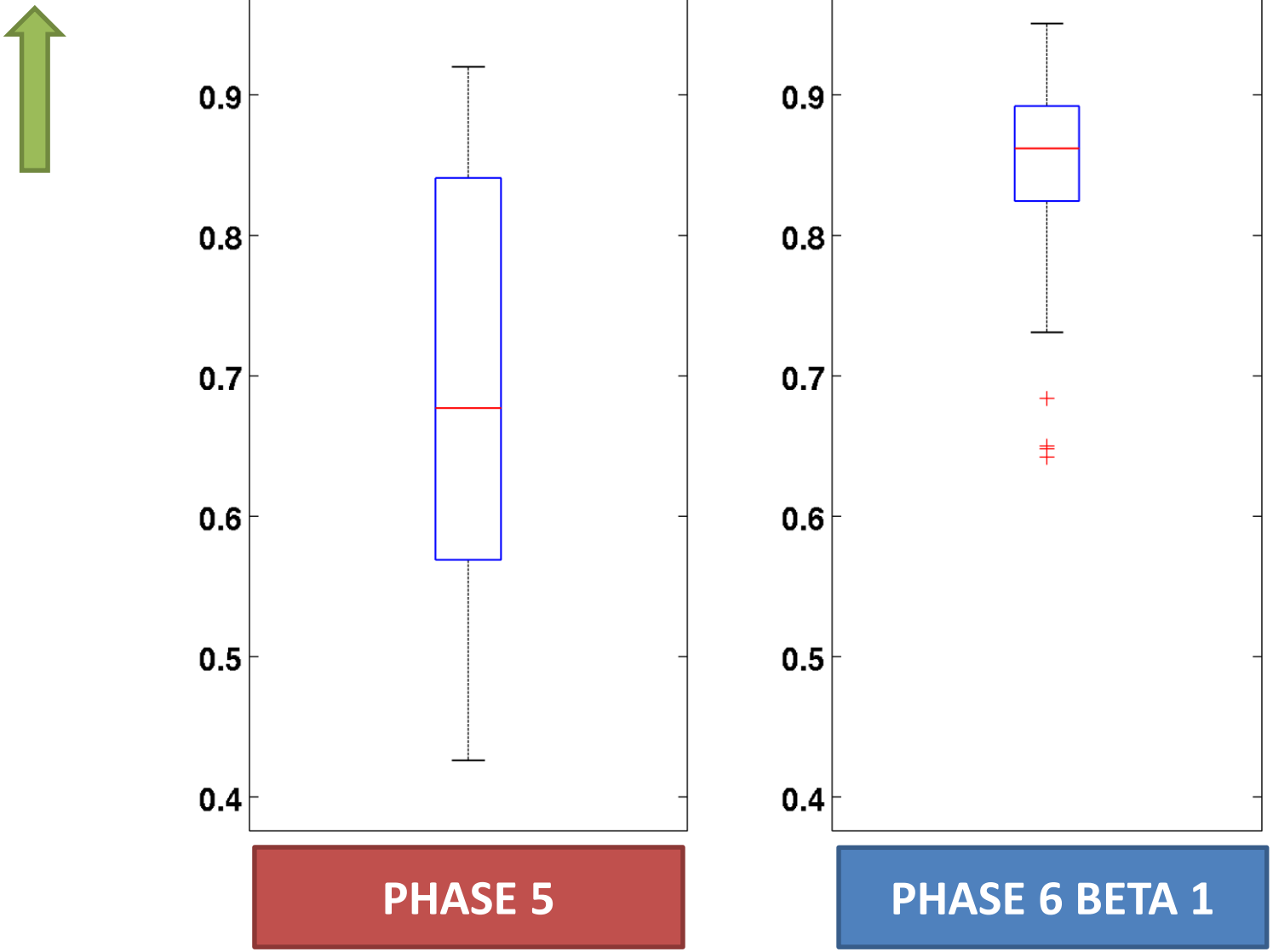
Next Step …

- Model documentation.

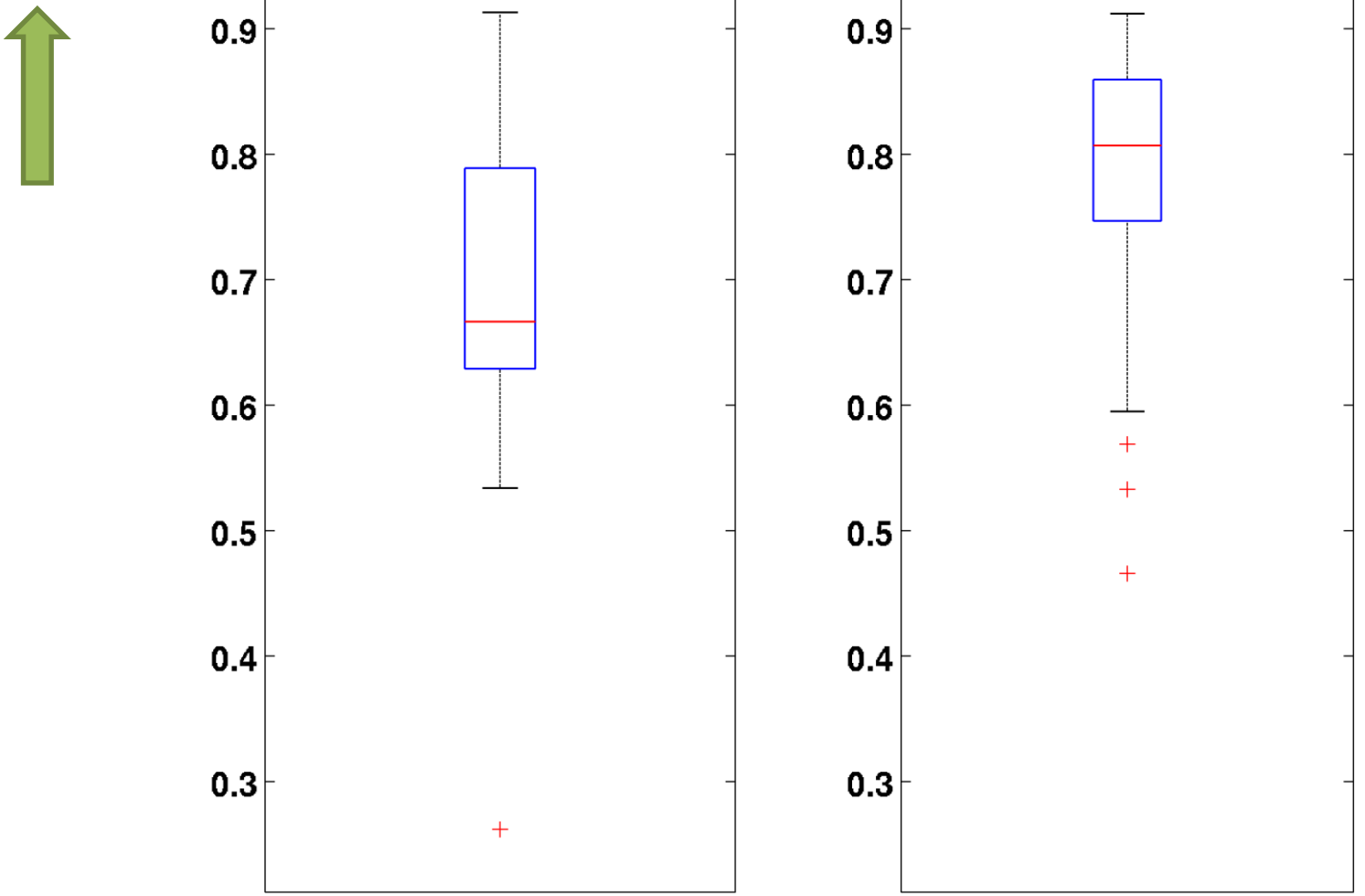
- Investigate overall nutrient mass balance, and riverine calibration.

- Stream to river delivery factors should be applied to septic and riparian pasture deposition loads.
- Based on the water withdrawal, nutrients should be removed from land-river segments discharging directly to the Bay.
- Bank and floodplain sediment and nutrient loads – Claggett and Noe.

Correlation – Total Nitrogen

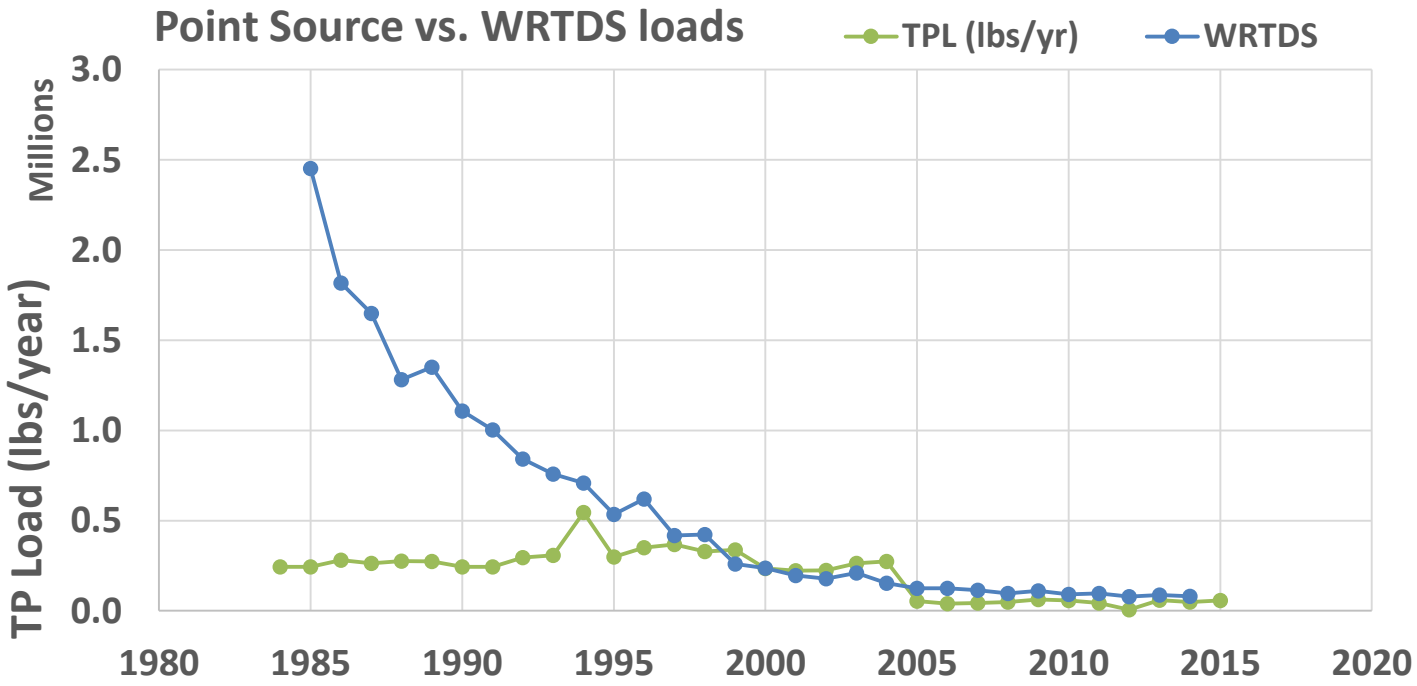


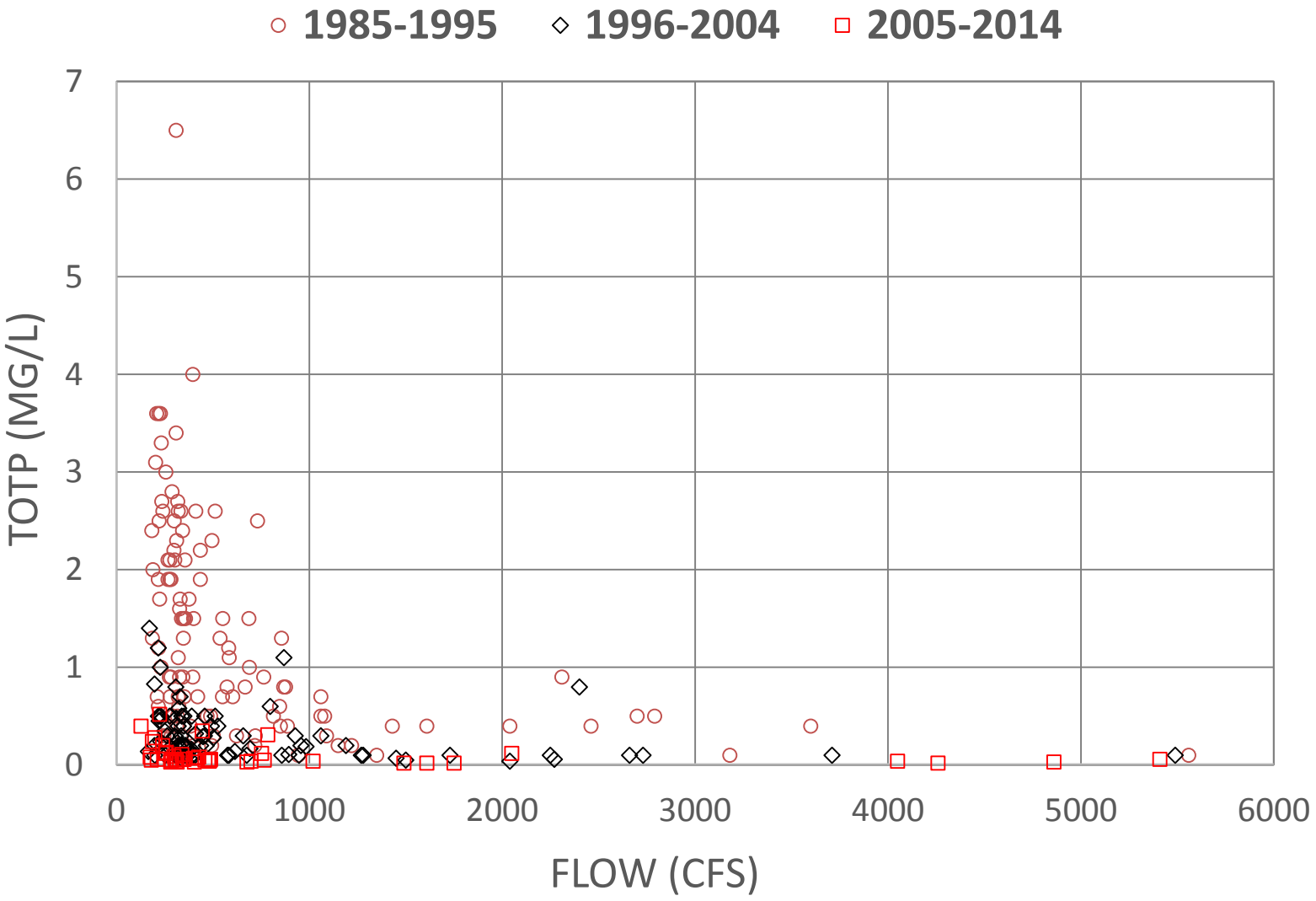
Correlation – Total Phosphorus



6. Phase 6 ***Beta 2***

- Updated and refined atmospheric deposition data
- Diversions, and revised SB dataset
- Revised sediment targets, and sediment delivery ratios
  - Crop and Pasture were included in Beta 1
  - Data for Forest, Open space, Tree canopy (over herbaceous and over scrub-shrub), and Turf grass are now available.
- Bank and floodplain sediment and nutrient loads – Claggett and Noe
- Revised estimates of lag-times and rSAS
- Improvements to lower Susquehanna reservoirs (including Conowingo)
- Simulation of phosphate export (dissolved vs. sorbed)

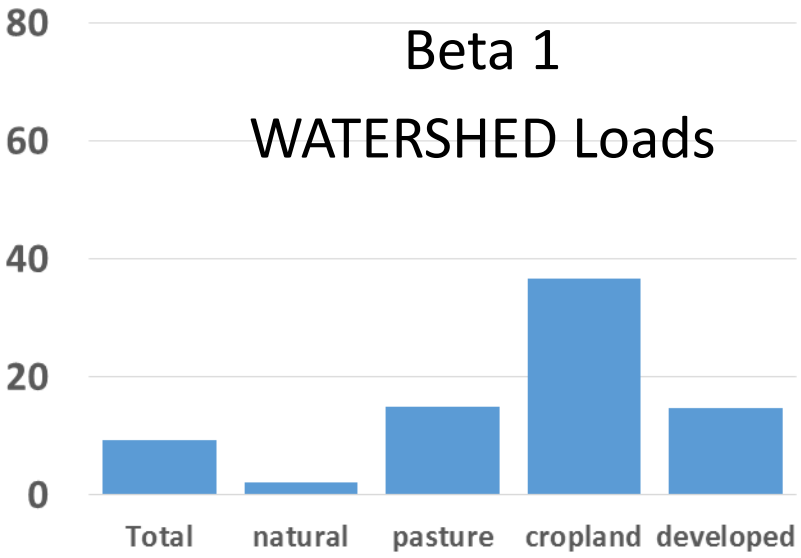

Point Source vs. WRTDS loads
TPL (lbs/yr)
WRTDS
TP Load (lbs/year)
Millions
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
2010
2015
2020

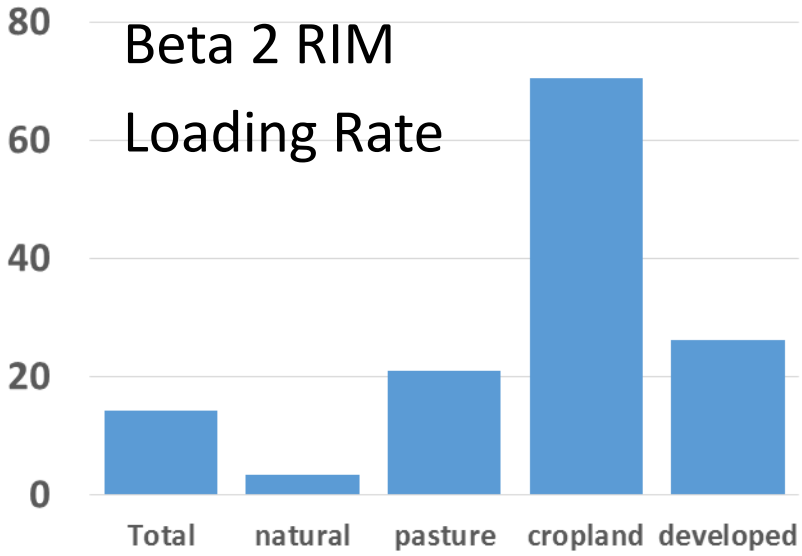

1985-1995
1996-2004
2005-2014
TOTP (MG/L)
0
1
2
3
4
5
6
7
0
1000
2000
3000
4000
5000
6000
FLOW (CFS)

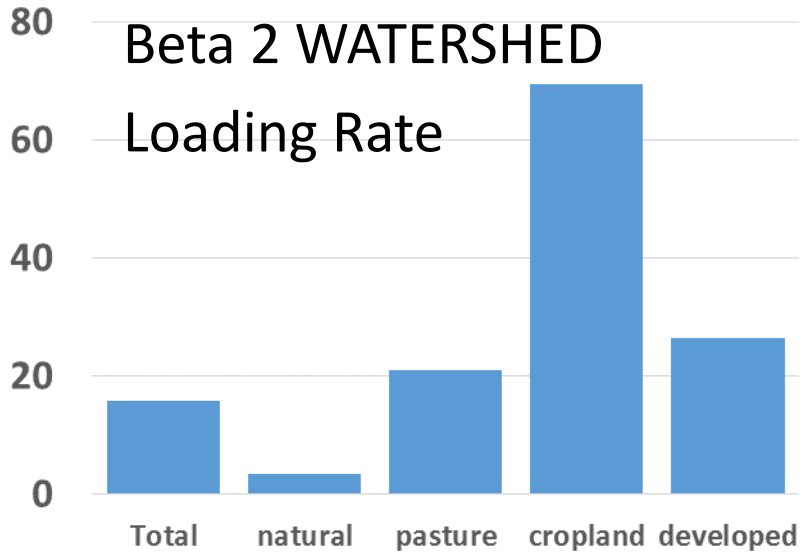
4. revised calibration target calculation

Olivia Devereux

Edge of Small Stream Nitrogen Loading Rate (in lb/ac/year)



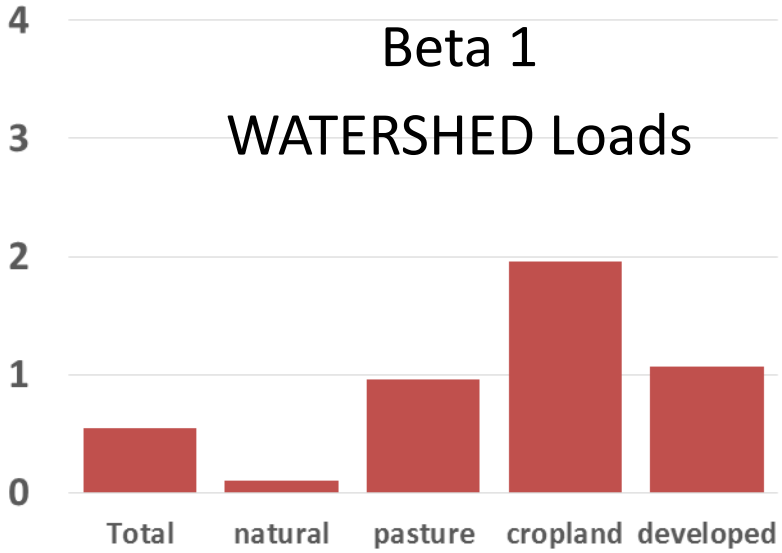


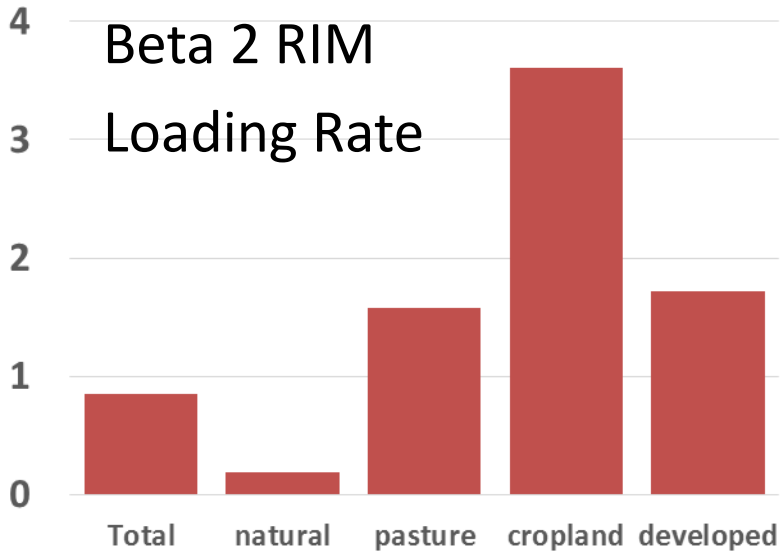


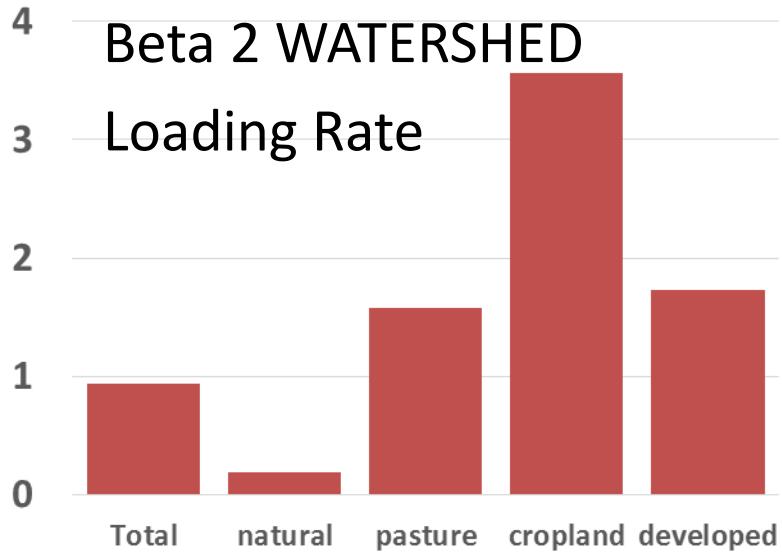
4. revised calibration target calculation

Olivia Devereux

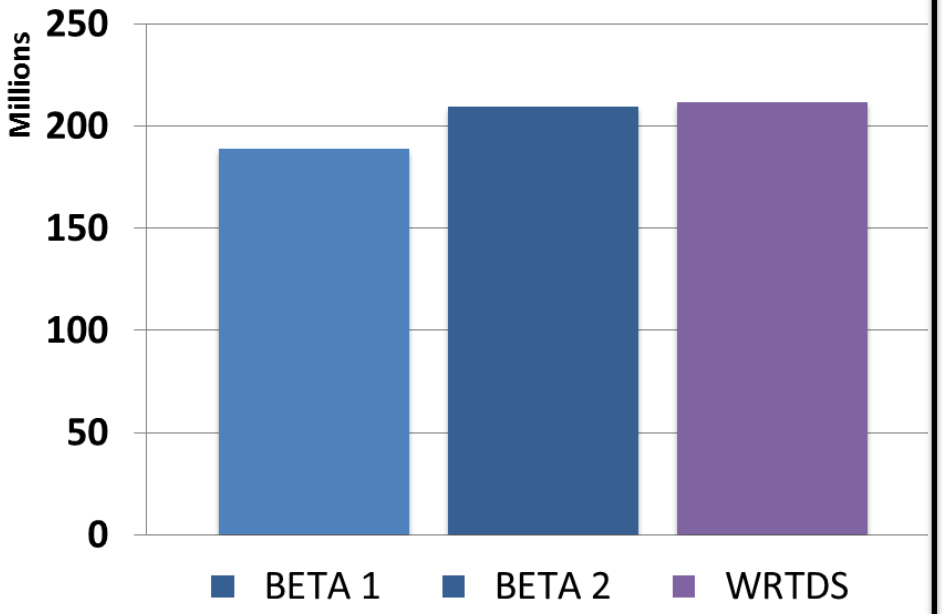
Edge of Small Stream Phosphorus Loading Rate (in lb/ac/year)

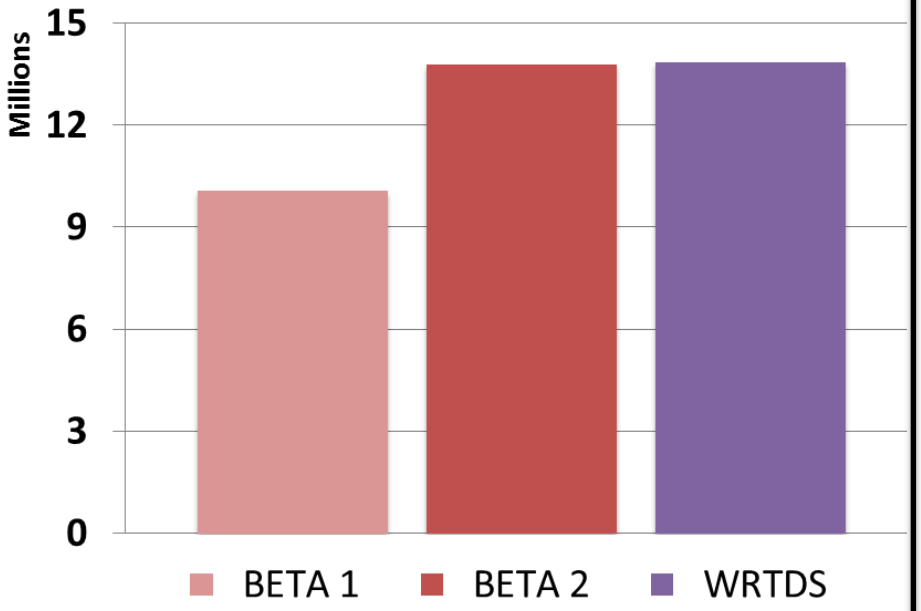




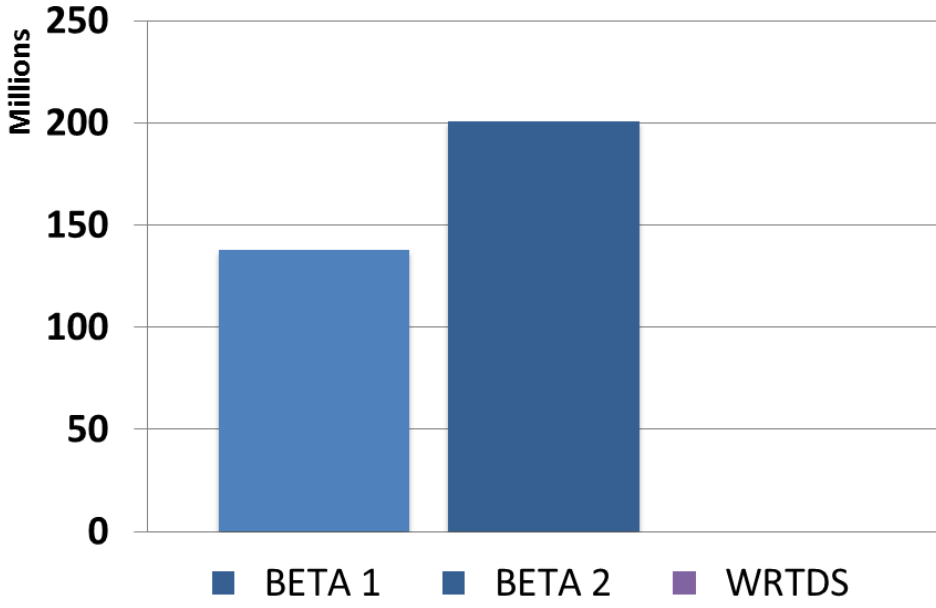


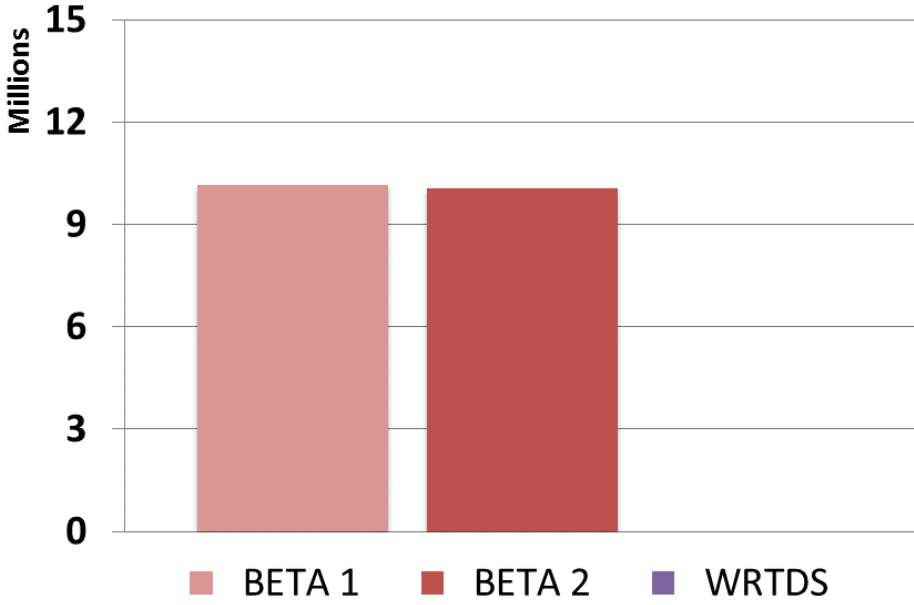
RIM (Fall-line) Loads

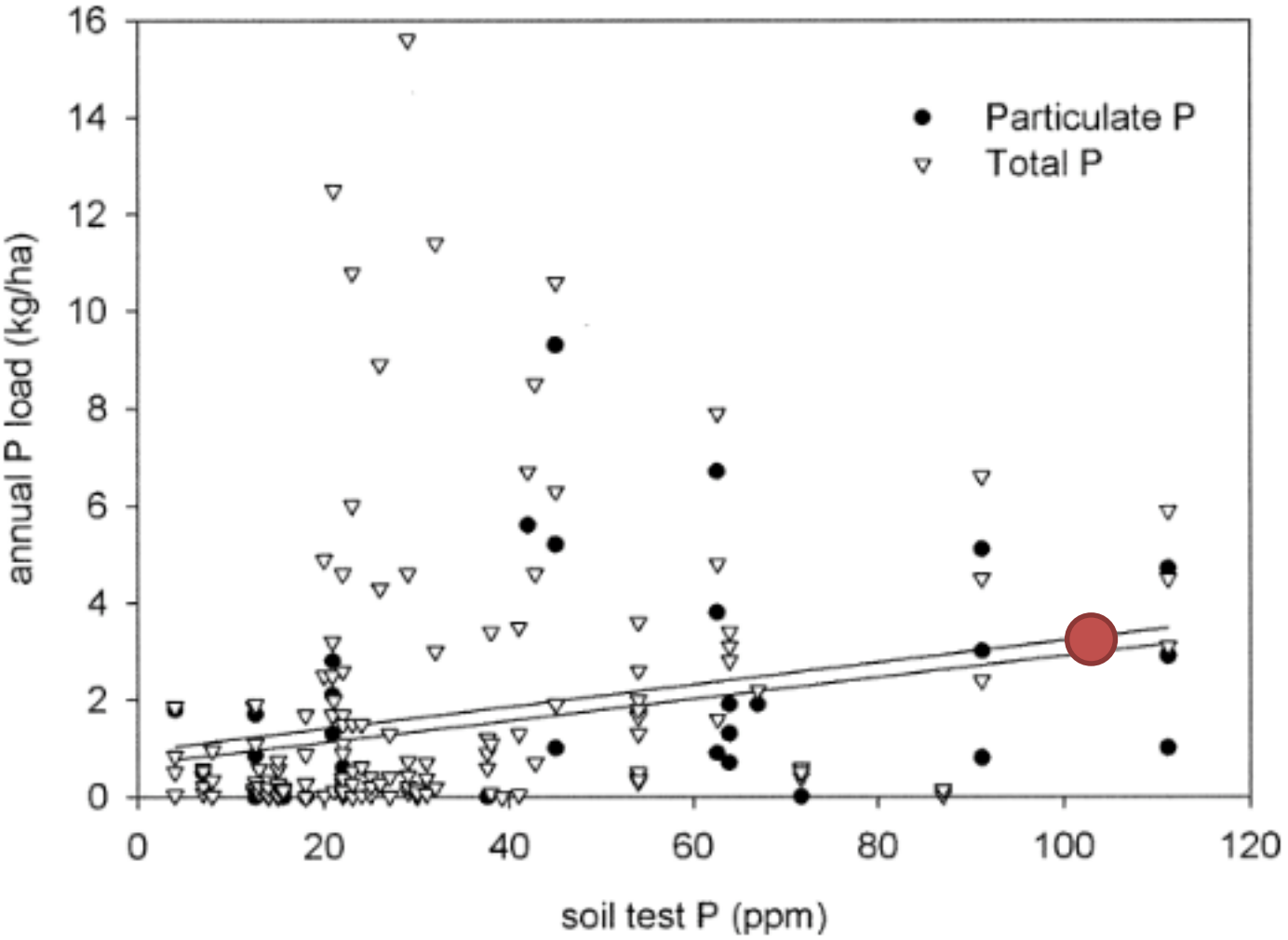




Below Fall-line Loads







Watershed average Soil M3 = 107

Figure 7 from Harmel et al. (2006)