USGS
science for a changing world

Loads, Trends, and Indicators for Selected Non-tidal Sites, Chesapeake Bay Watershed, 1985-2011

Nontidal Workgroup 9/19/12

Project staff –

Mike Langland –USGS, PA

Joel Blomquist – USGS, MD

Ken Hyer – USGS, VA

Doug Moyer – USGS, VA

Jeff Chanat - USGS, MD/VA

Nontidal Workgroup 9/8/10

Topics –

- Discussion of sites and site selection
- Presentation of streamflow and trend (loads, FAC) results
- Summary
- Indicators (discussion)

Discussion of sites and site selection

Loads and trends over multiple time periods

Time period	Length of Record	Type	Number of sites
1985-2011	27 yrs	Load/tend	31
2002-2011	10 yrs	Load/tend	1
2007-2011	5 yrs	Loads only	33 (65)
2002-2011	10 years	Secondary/loads	16 (81)

WHY?

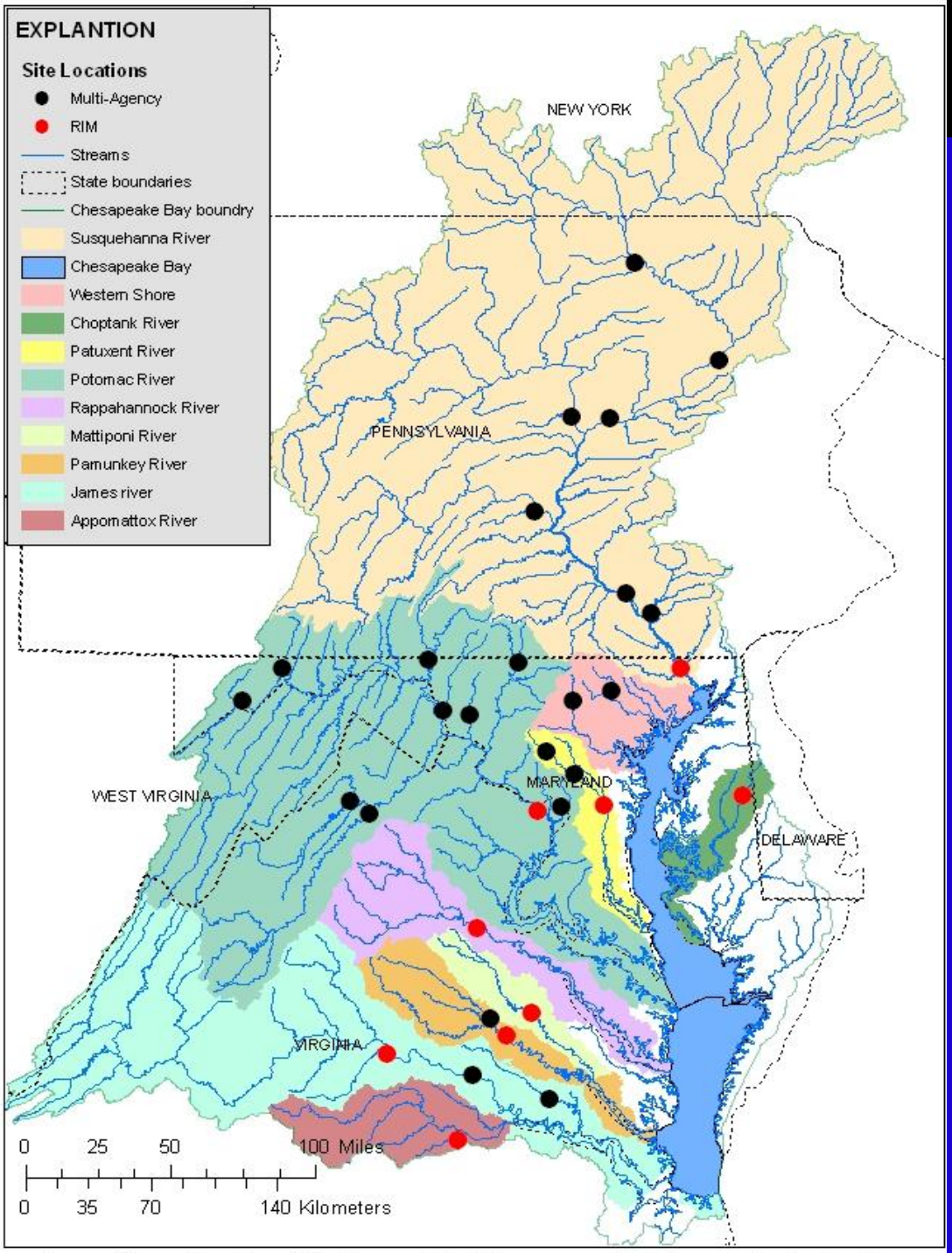
- Align with current NTN Monitoring site list (LT and10 yr trends, 5 yr load)
- Examine changes over shorter time frames (since 2000 agreement)
- Development of indicators and measures of change

USGS
science for a changing world

Currently (2011) USGS updating loads and trends at 31 long-term (1985) stations in Bay Watershed

9 River Input Stations

22 Upstream Stations



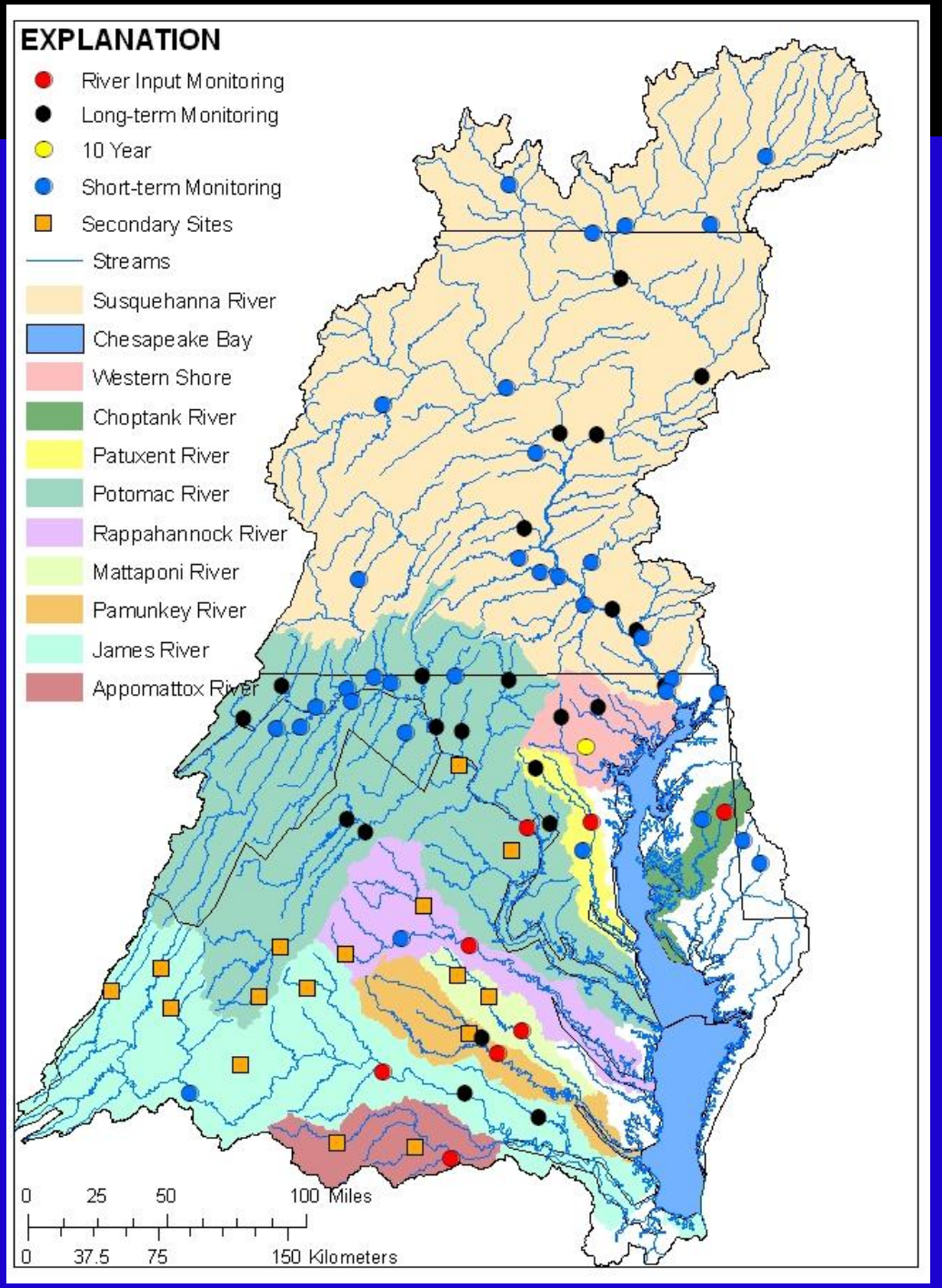
USGS
science for a changing world

Currently (2011) USGS updating loads and trends at 65 stations in Bay Watershed

1 site added with 10+ years (yellow)

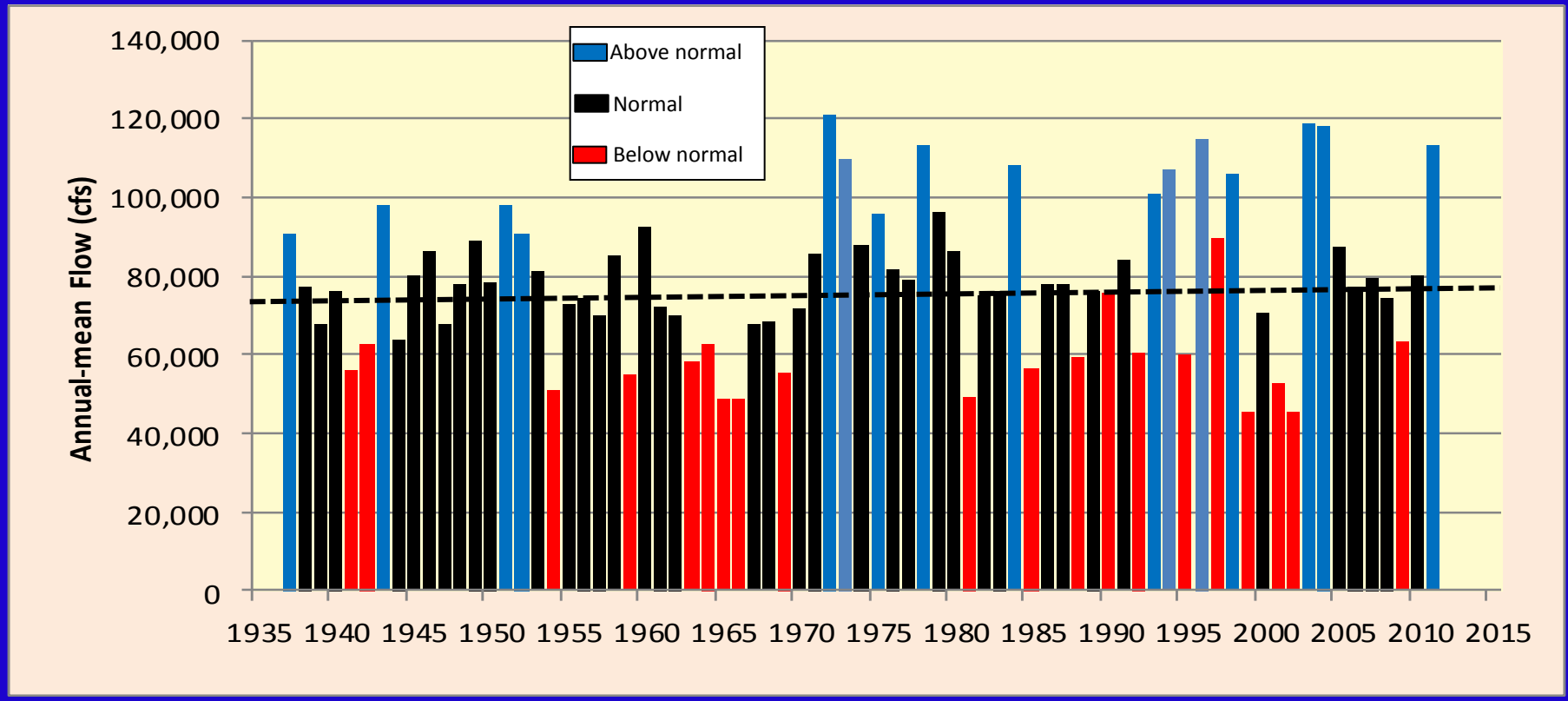
33 sites with 6-9 years (blue)

16 Secondary sites (brown)



Streamflow – Total Flow to the Bay

- For WY2011 113,000 cfs (above normal year) (+30% vs 2010)
- 30% above long-term mean (78,300 cfs)
- Fifth highest since 1937

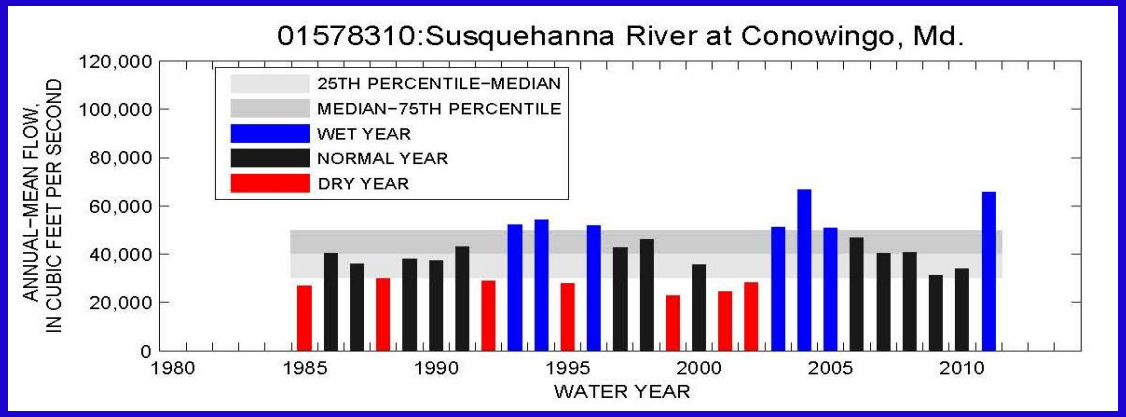


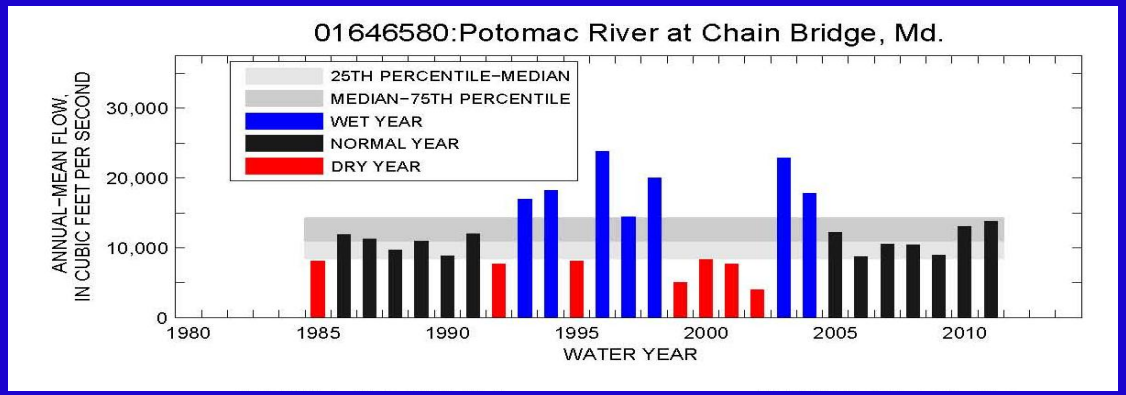
Streamflow – Site Results

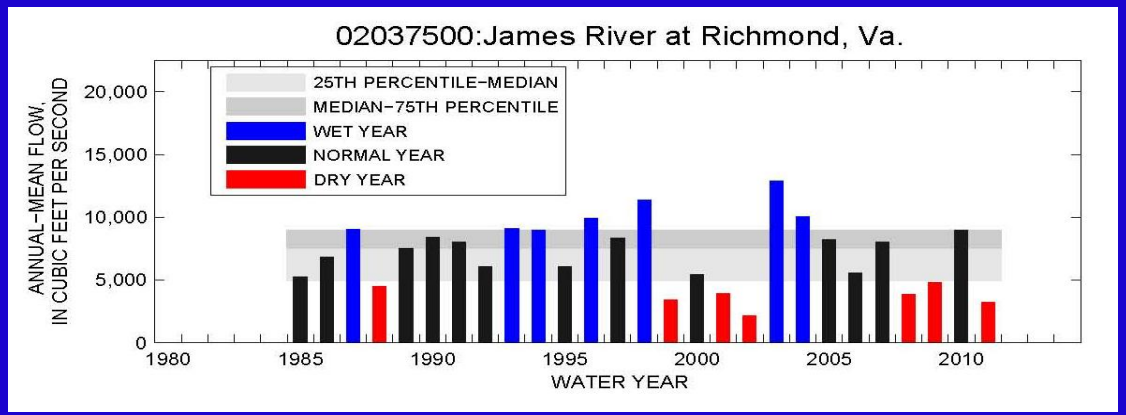
Produce Annual and Seasonal Streamflows for all 31 Sites

For 2011 – 2 significant trends in streamflow for the 31 sites (Susquehanna)

17 of the 31 sites had increase in flow vs. 2010







USGS
science for a changing world

ESTIMATOR MODEL

$$\ln(c) = \hat{\beta}_0 + \hat{\beta}_1 \ln(q/q_c) + \hat{\beta}_2 \left[\ln(q/q_c)\right]^2 + \hat{\beta}_3 (t - t_c) + \hat{\beta}_4 (t - t_c)^2 + \hat{\beta}_5 \sin(2\pi t) + \hat{\beta}_6 \cos(2\pi t) + \varepsilon$$

where:

c is measured concentration, in milligrams per liter;

q is measured daily-mean streamflow, in cubic feet per second;

t is time, in decimal years;

q_c t_c are centering variables (orthogonal) for streamflow and time;

$\hat{\beta}_i$ are coefficients estimated by ordinary least squares (non-censored observations, for censored observations implements AMLE procedure)

sin and cos are seasonal components

ε residual error

Regression Diagnostics

STATION: 01576754 30-May-2007 13:32:45

CONESTOGA RIVER AT CONESTOGA, PA

PCODE: 00600, TN, mg/L
WATER YEAR MODEL

Model S: 0.25299

Conc model R^2: 0.12341
Load model R^2: 0.94016

Ser. corr. residuals: 0.57636
#Flag 1, SC > 0.3
#Flag 2, SC > 0.5

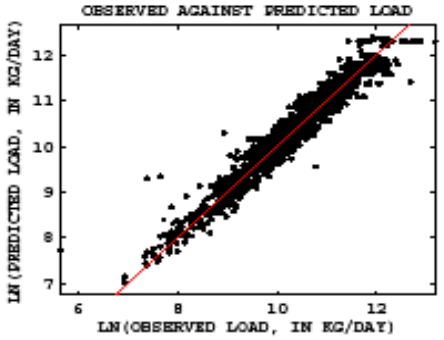
PPCC: 0.9727
#Flag 1, PPCC < 0.975

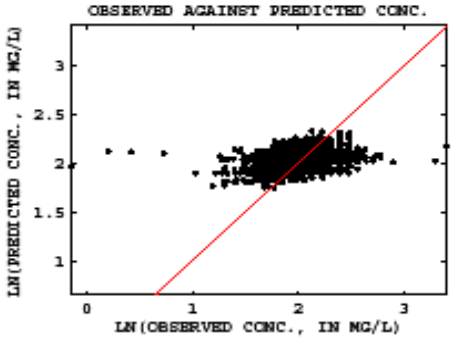
* $\ln(load_e) - \ln(load_o)$

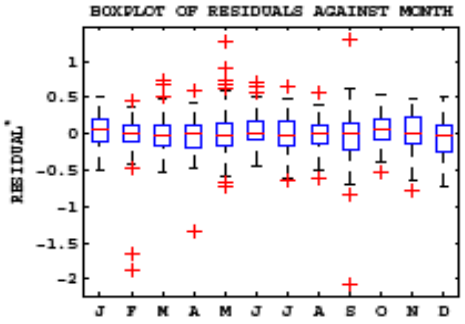
Model terms:

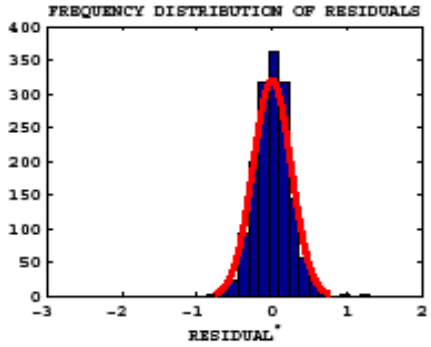
CONSTANT
LOG-FLOW
LOG-FLOW SQUARED
DEC_TIME
DEC_TIME SQUARED
SIN(2*PI*T)
COS(2*PI*T)

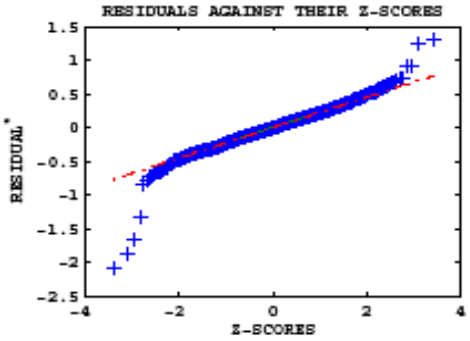
N = 1566
NCENS = 0

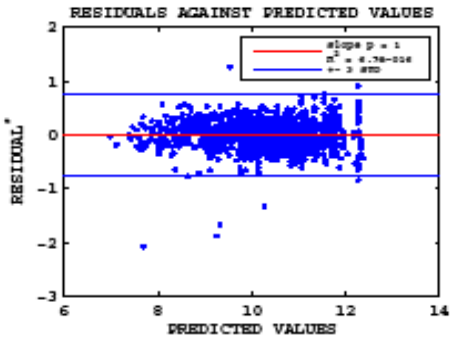


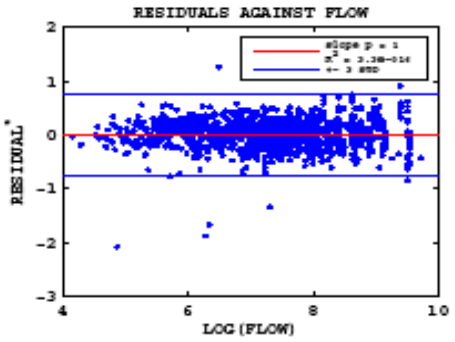


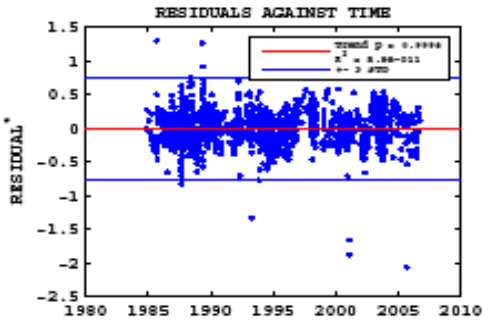




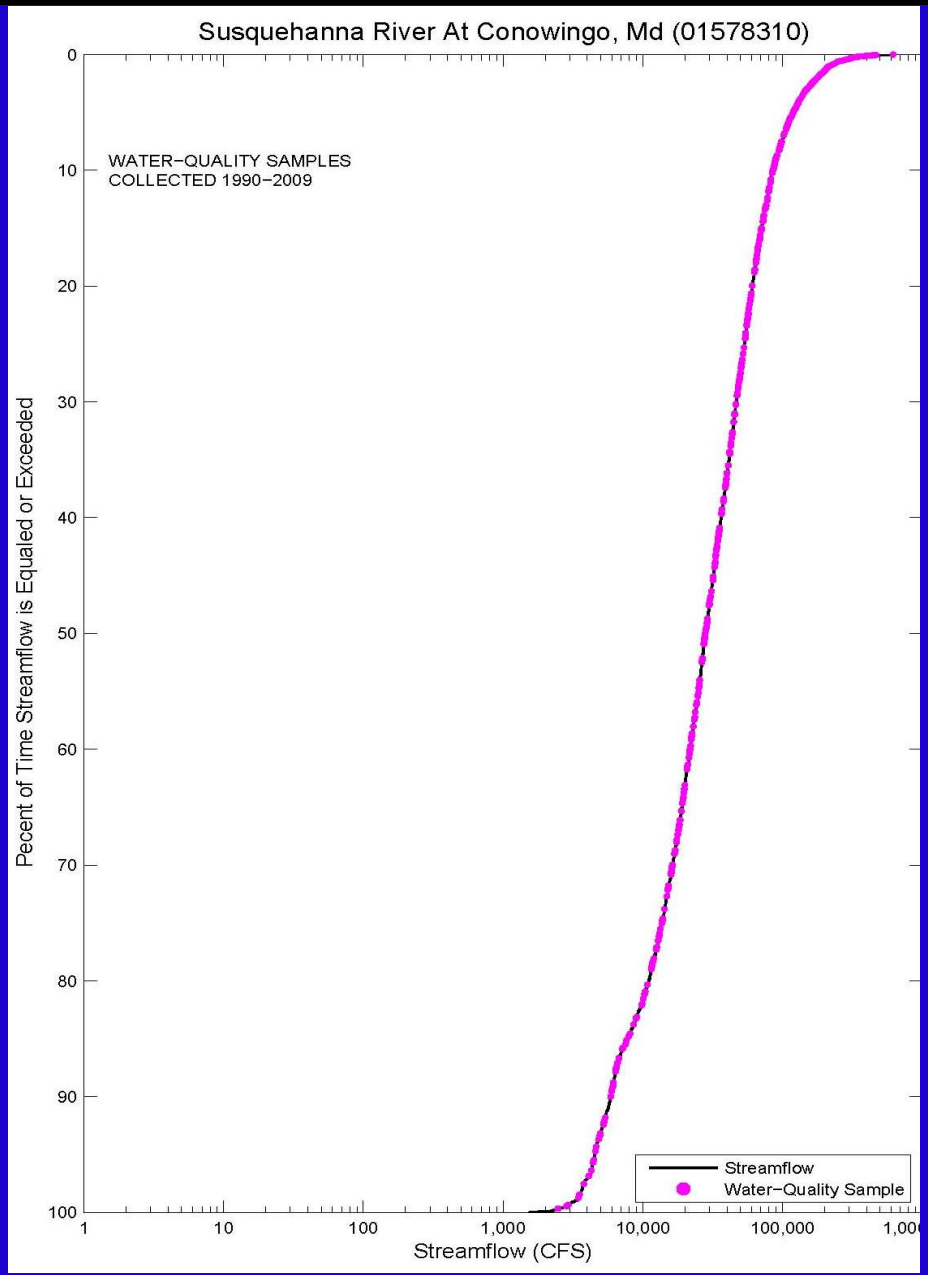


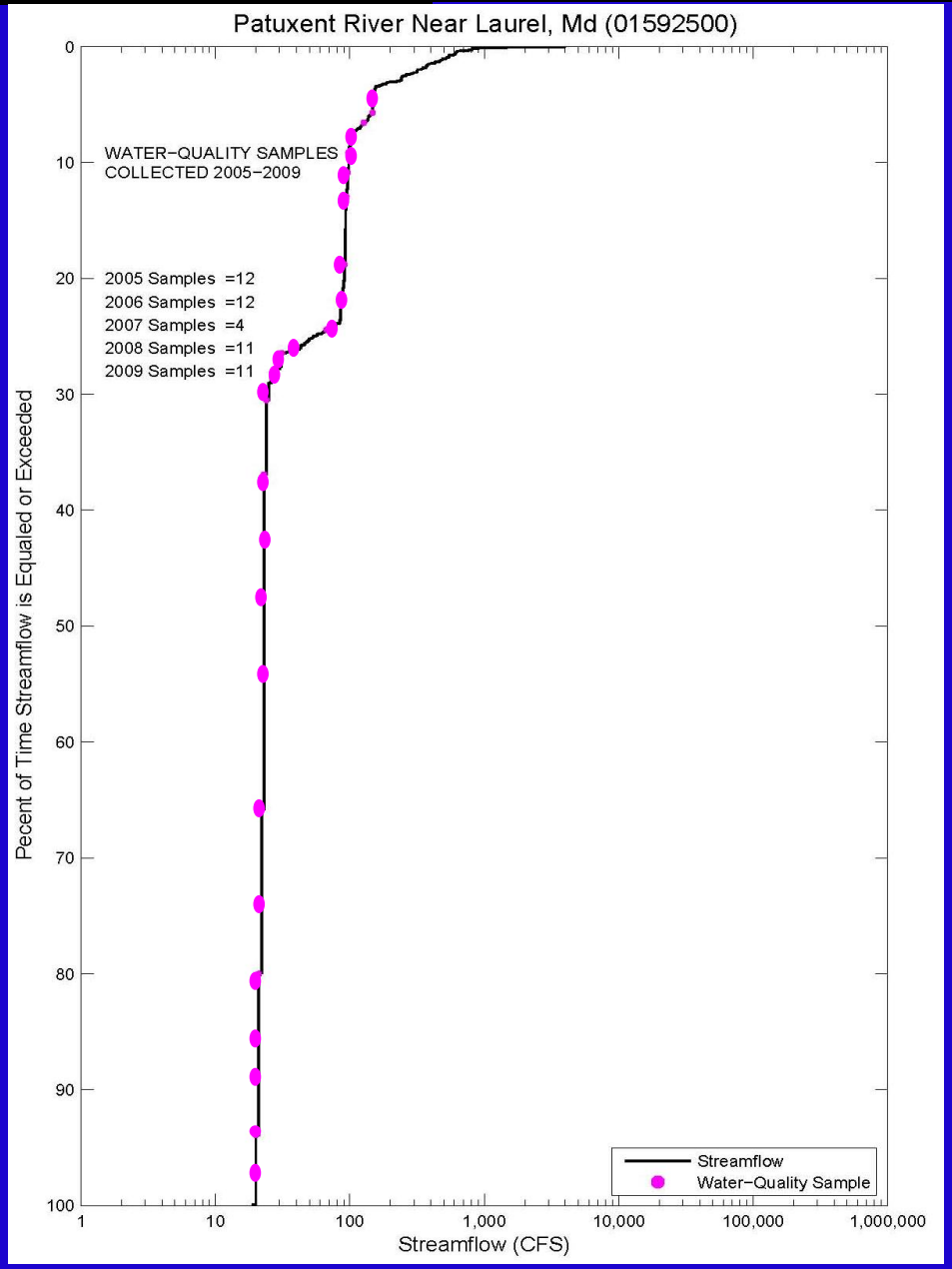






Additional Diagnostics





Combined RIM TN Load and A-M Streamflow

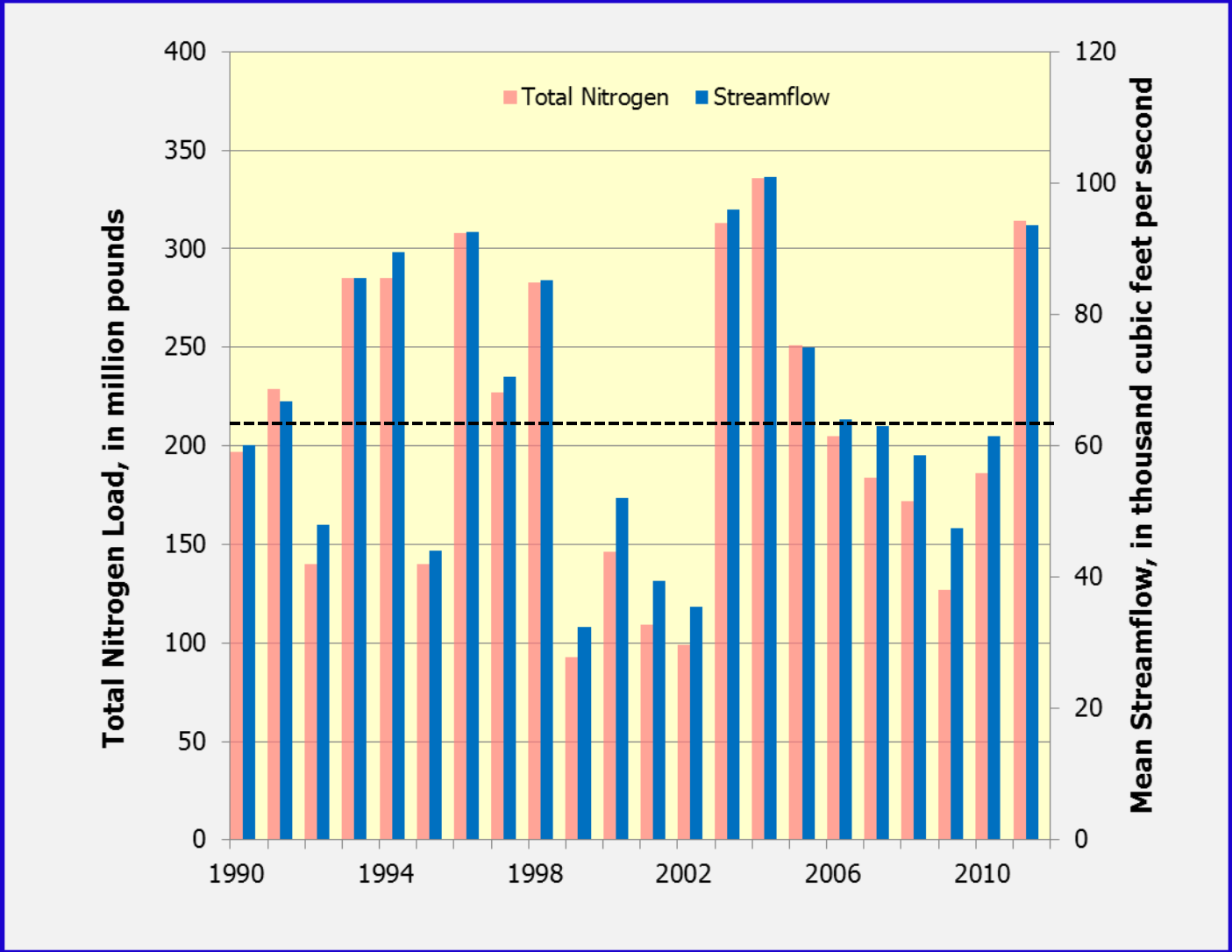
WY2011

314 Mlbs

LT Avg 211 Mlbs

+69% vs 2010

77% of TN load from Susquehanna River



Combined RIM TP Load and A-M Streamflow

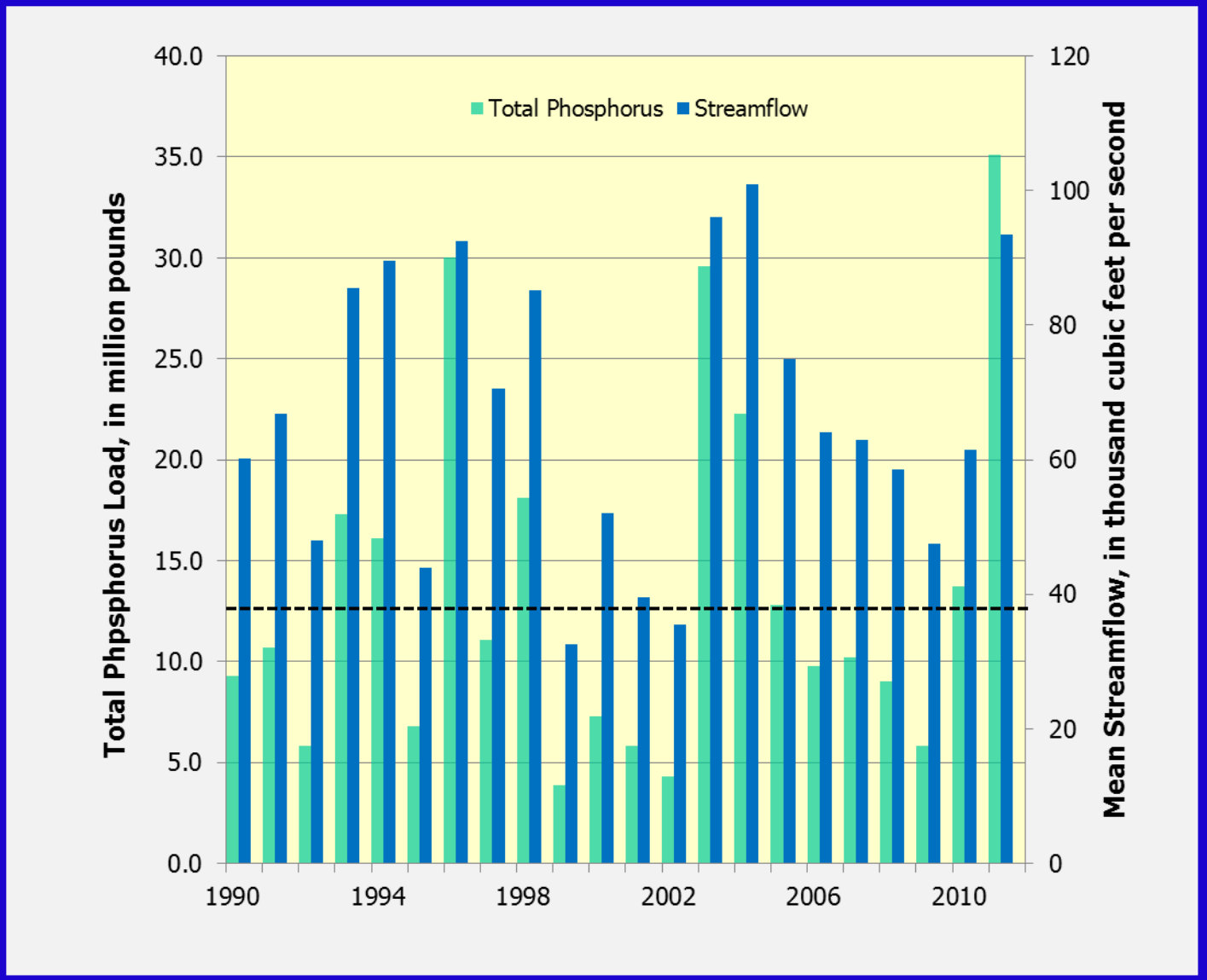
WY2011

35.1 Mlbs (highest load)

LT Avg 13.3 Mlbs

+170% vs 2010

75% of TN load from Susquehanna River (usually 45%)



Combined RIM SED Load and A-M Streamflow

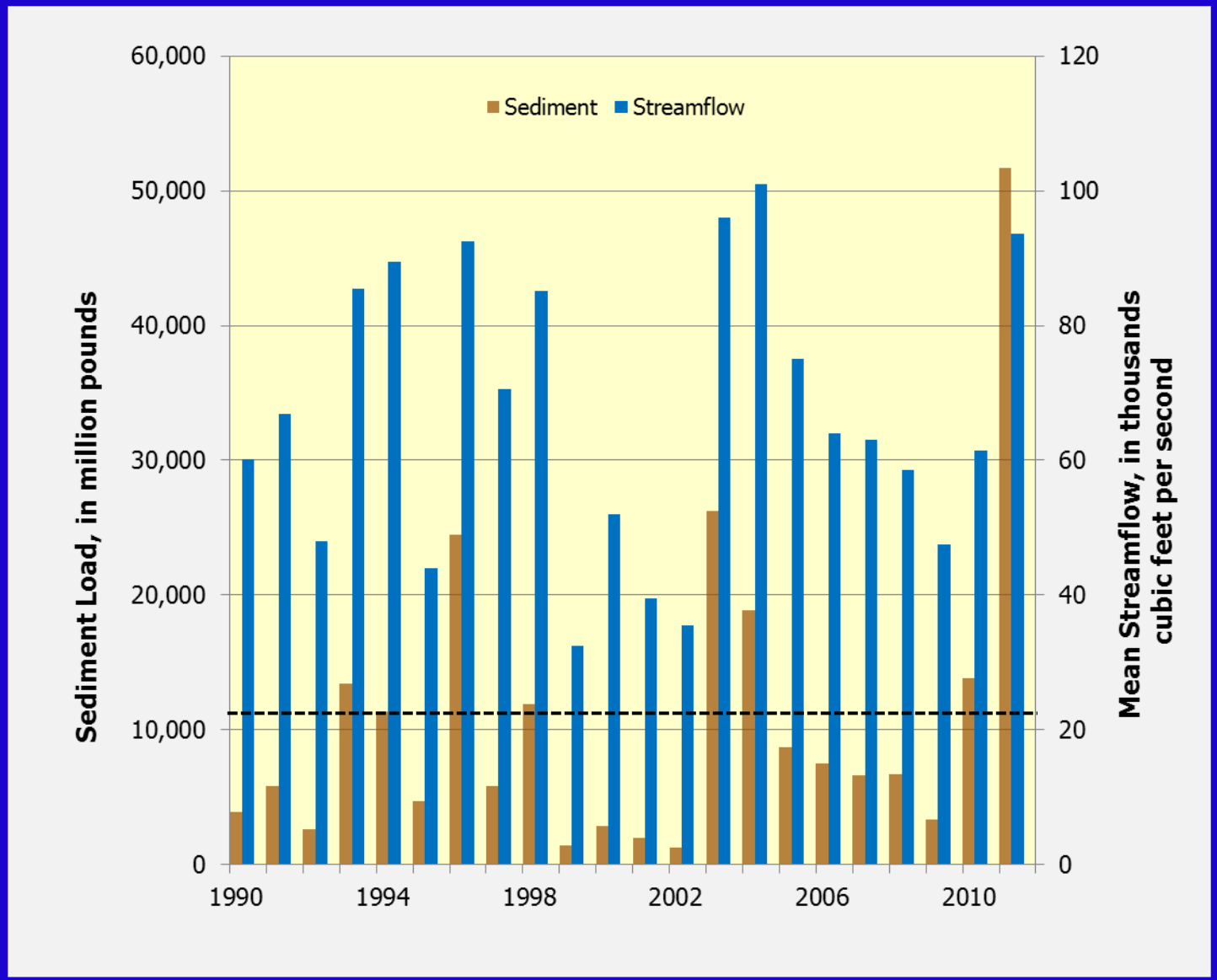
WY2011

51.7 B-lbs (highest load)

LT Avg 10.6 B-lbs

+230% vs 2010

75% of TN load from Susquehanna River (usually 40%)



USGS science for a changing world

FAC - TRENDS

Flow-adjusted concentration

- Useful for examining effects of management actions
- Helps to adjust for the "effects" of hydrology and season
- Flow adjustment from ESTIMATOR model
- Uses the slope coefficient (b), time (t), and time (t2) for non-linearity trend
- Many significant FAC trends

USGS science for a changing world

FAC - TN

For 1985-2011

21 of 31 sites (~68%) down, 3 sites up

4 of 9 RIM sites down

All 8 sites in SUS down

9 of 11 in Potomac down

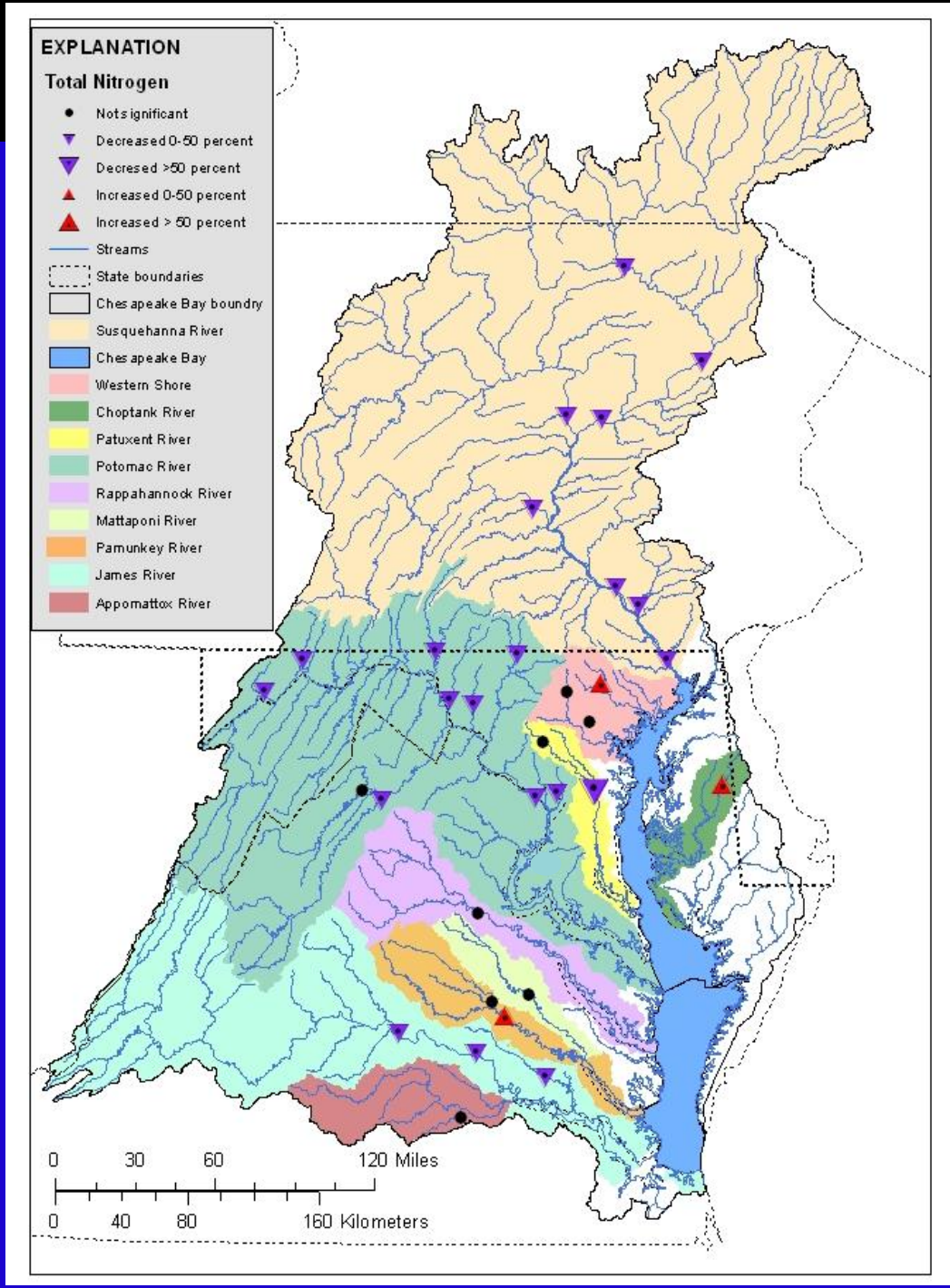
4 of 8 sites NS in VA

2010 - 21 DN, 2UP

2009 - 22 DN, 2 UP

2008 - 22 DN, 2 UP

2007 - 22 DN, 2 UP



USGS science for a changing world

FAC - TP

For 1985-2011

22 of 31 sites (~70%) down, 4 sites up

3 of 9 RIM sites downward, 3 upward

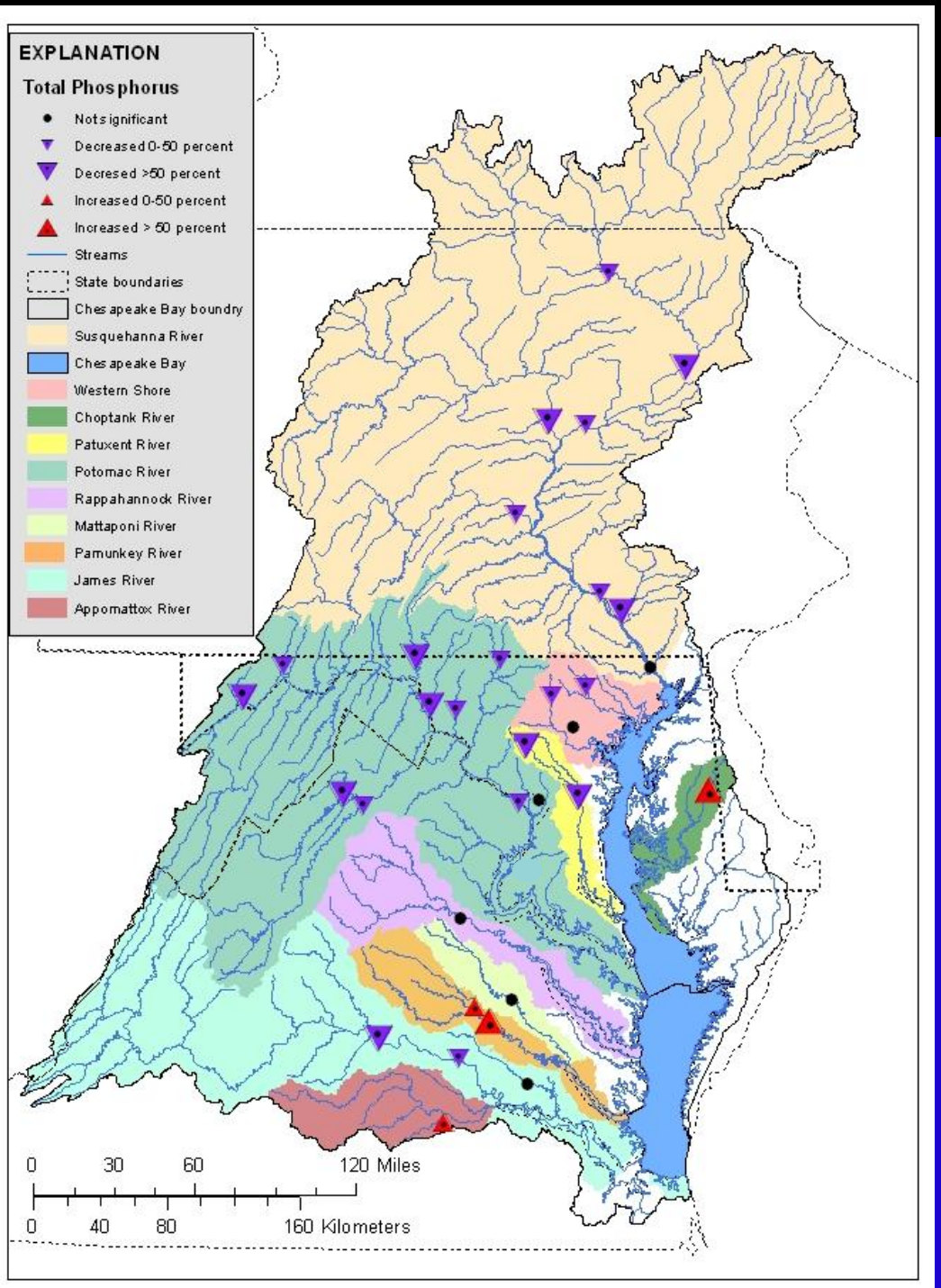
10 down sites exceed 50% reduction

2010 - 21 DN, 4 UP

2009 - 21 DN, 4 UP

2008 - 22 DN, 3 UP

2007 – 22 DN, 3 UP



USGS science for a changing world

FAC - SED

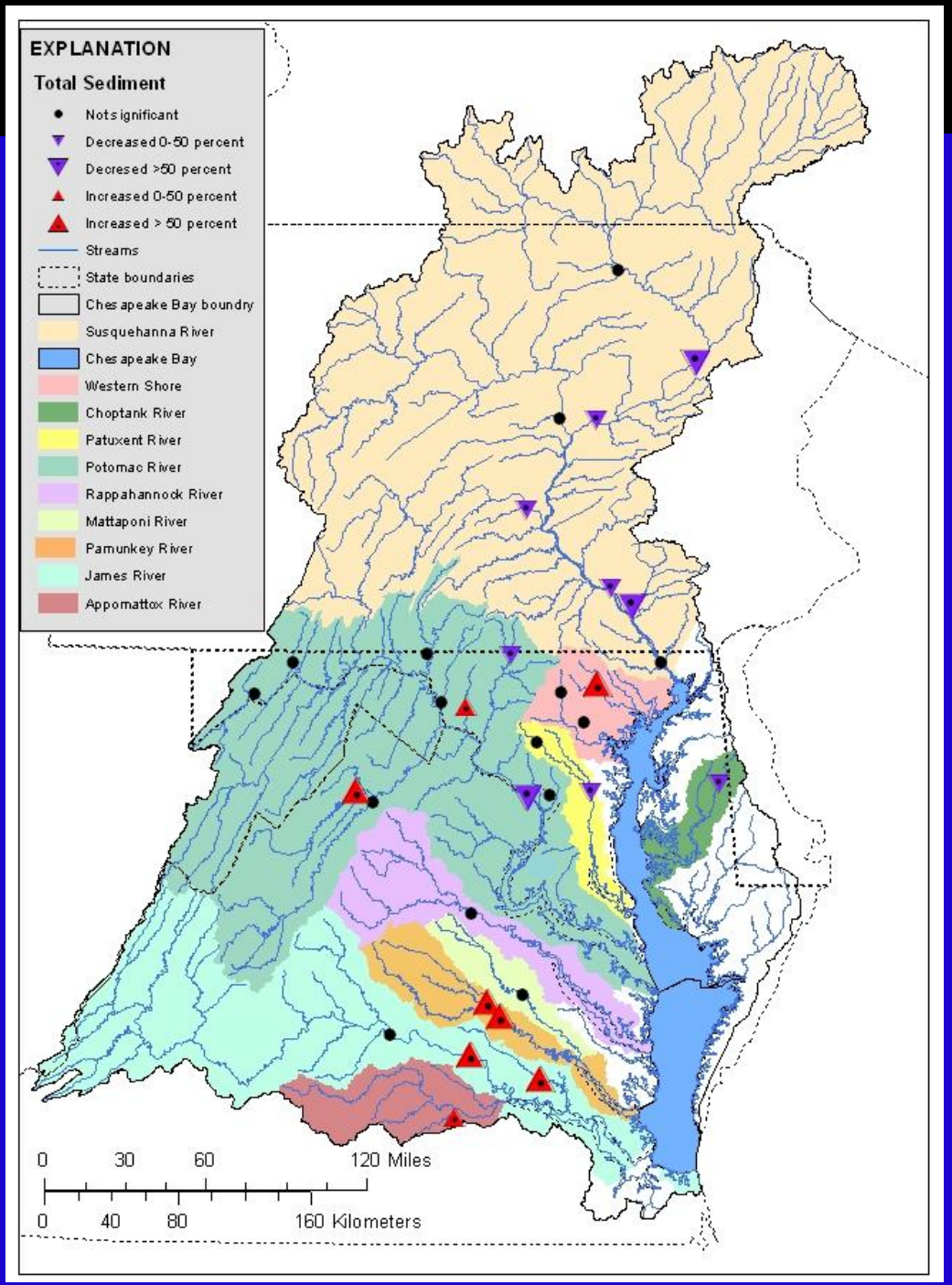
For 1985-2011

9 sites down, 8 sites up
6 > 50% up

14 of 31 sites ns (45%)

3 of 9 RIM sites downward, 2 upward

2010 - 10 DN, 7 UP
2009 - 12 DN, 4 UP
2008 - 15 DN, 2 UP
2007 - 15 DN, 2 UP



FAC – 10 year trends

Comparison of trends (POR to 10-yr)

	1985-2011	2002-2011	Change
TN	19 DN 3 UP	12 DN 1 UP	7 less improving sites
TP	22 DN 4 UP	11 DN 4 UP	11 less improving sites
SED	9 DN 8 UP	2 DN 11 UP	6 less improving sites

- Number of significant trends is less in the latter time period
- 6 of the 15 up trends in 1985-2011 became either down or not significant in 2002-2011

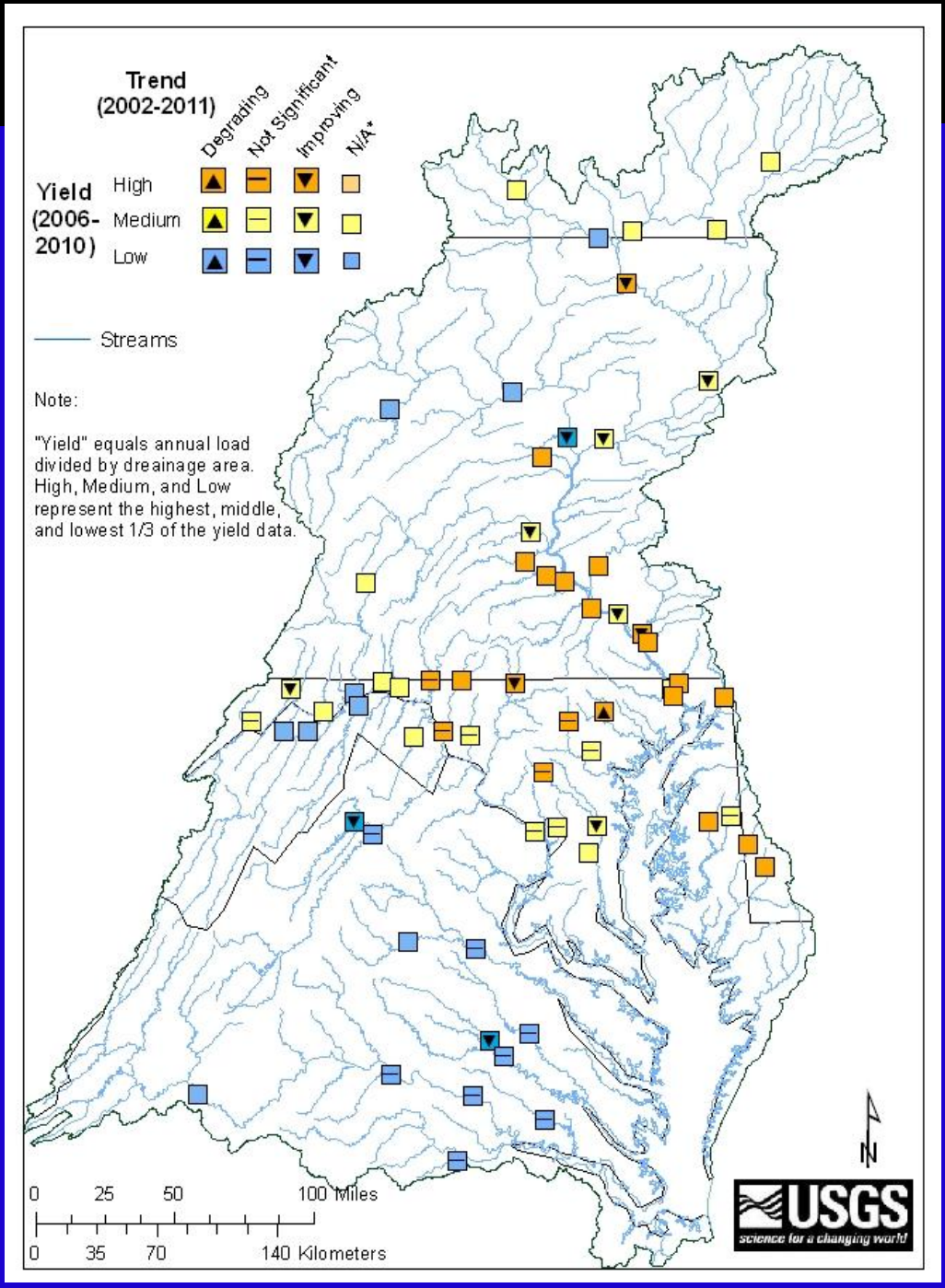
USGS
science for a changing world

TN Indicator

10 yr trend (31 sites)
5-yr TN Yields
(tons/mi^2) at 65 sites

12 of 31 sites indicate improving trends

Spatially, higher yield distribution in middle of Bay watershed, lower yields in lower Bay watershed



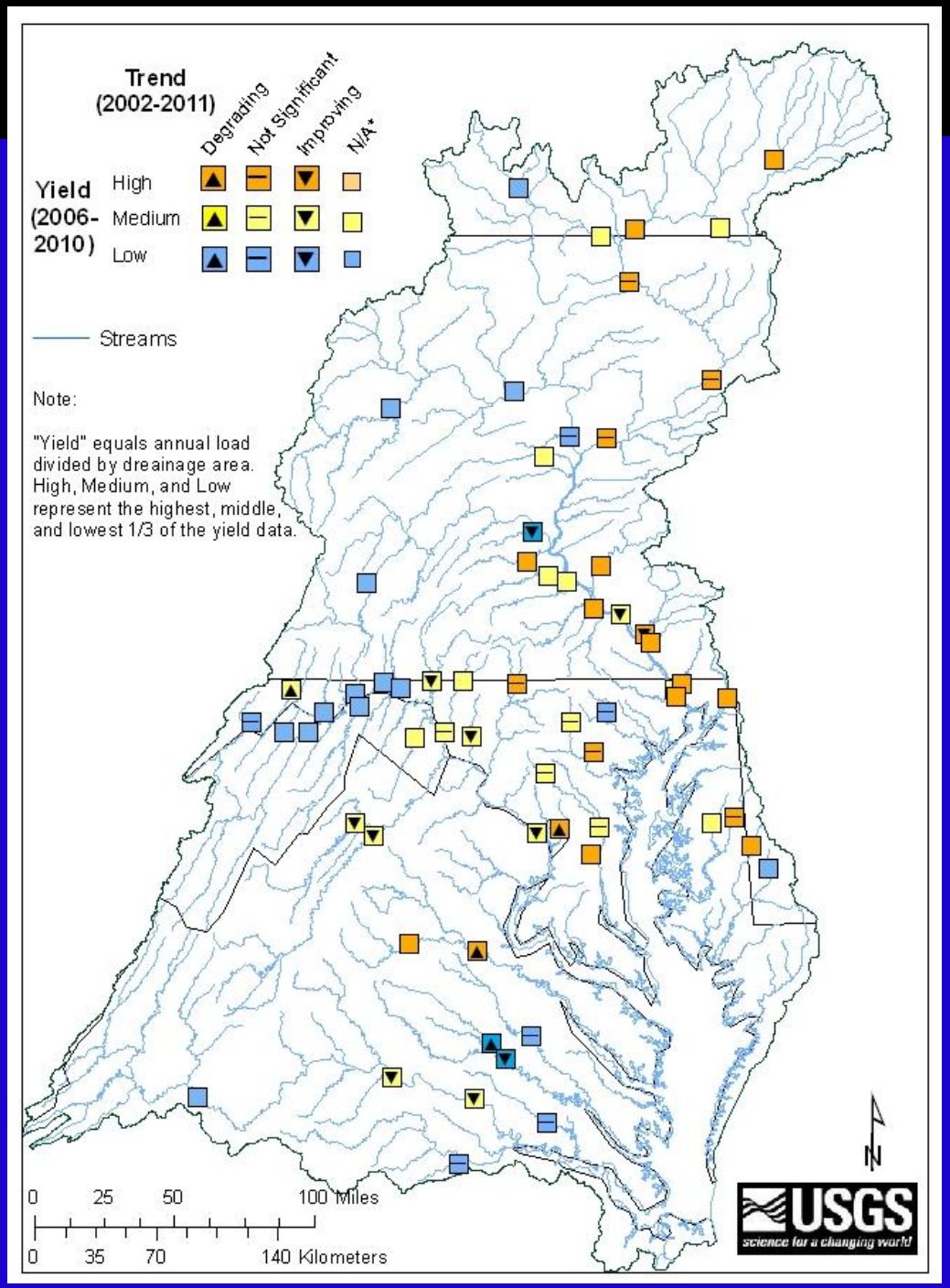
USGS
science for a changing world

TP Indicator

10 yr trend (33 sites)
5-yr TN Yields
(tons/mi^2) at 65 sites

12 of 31 sites indicate improving trends

No geographic yield distribution, except for western Potomac basin



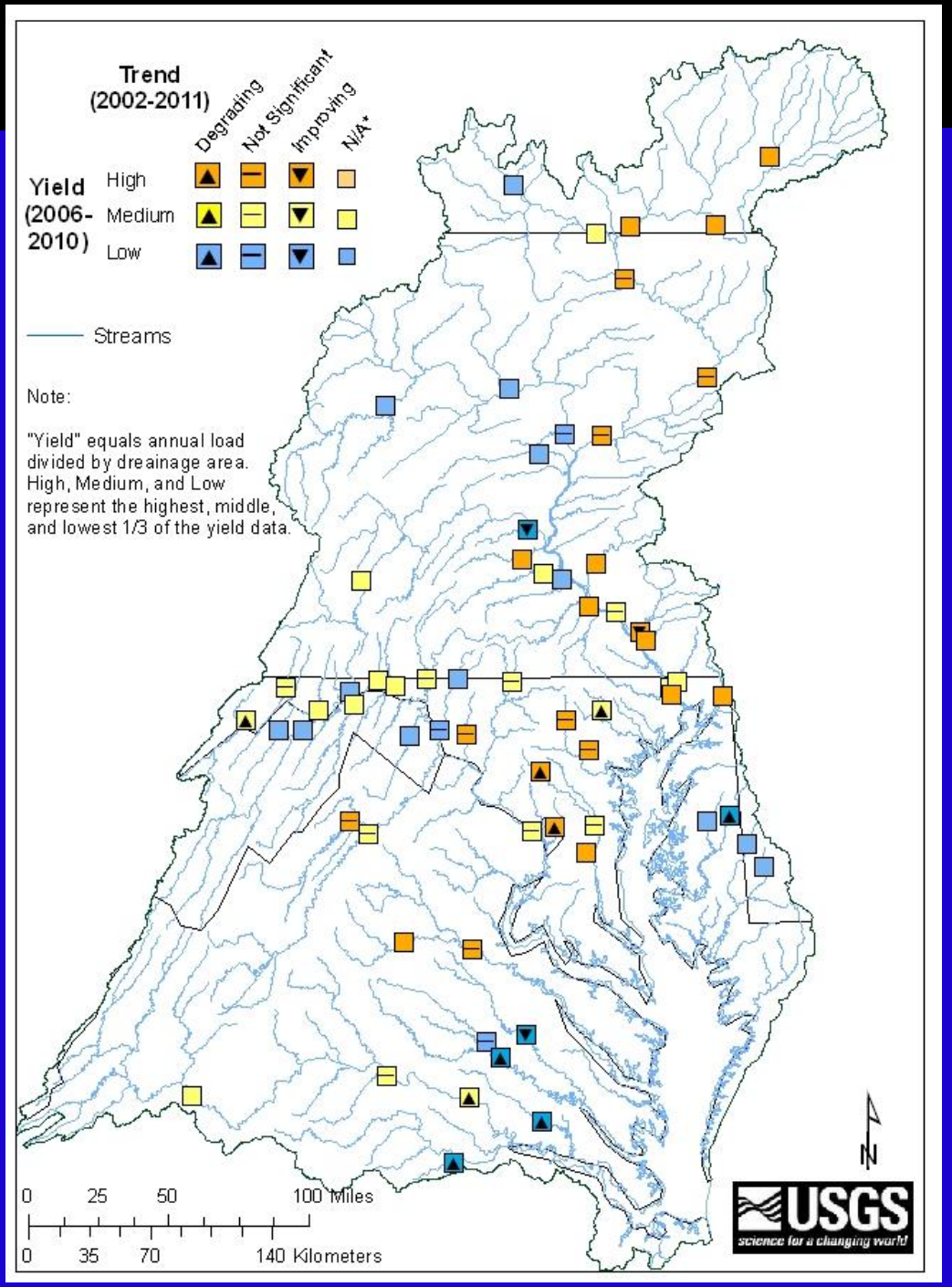
USGS
science for a changing world

SED Indicator

10 yr trend (33 sites)
5-yr TN Yields
(tons/mi^2) at 65 sites

3 of 31 sites indicate improving trends, 9 degrading trends

No geographic yield distribution is indicated



Indicator Summary

		10-year flow-adjusted trend (2002-2011)			
Total Nitrogen 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	1	4	3	14
	medium	0	7	6	10
	low	0	8	3	9
Total Phosphorus 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	2	6	1	12
	medium	1	5	8	8
	low	1	6	2	13
Sediment 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	2	8	1	11
	medium	4	8	0	9
	low	4	3	2	13

Table can be used to identify "best and worst" conditions

33 sites "no trends", 12 sites 2013, 20 sites 2014

USGS science for a changing world

Summary

- 1 site dropped, 2 added, total from 64 to 65 sites
- Flow to the Bay was 30% above LT mean in 2011
- 2 Susquehanna River sites with significant trends in streamflow
- FAC trends - the majority of the 31 sites were downward for TN (21) and TP (22), less (9) for SED
- Less improving trends as time period is shortened
- More “best than worst” scenarios for TN while TP and SED are equal

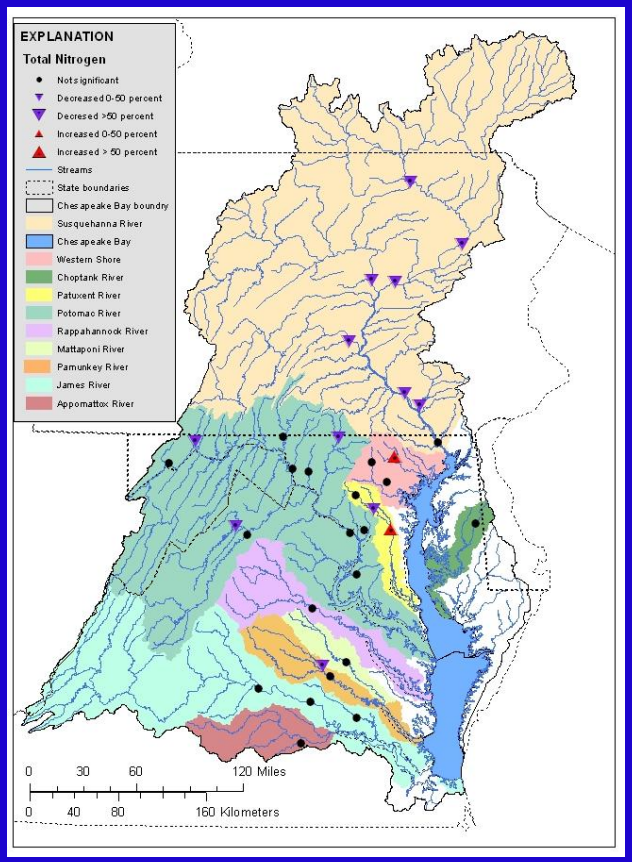
USGS
science for a changing world

Thank You

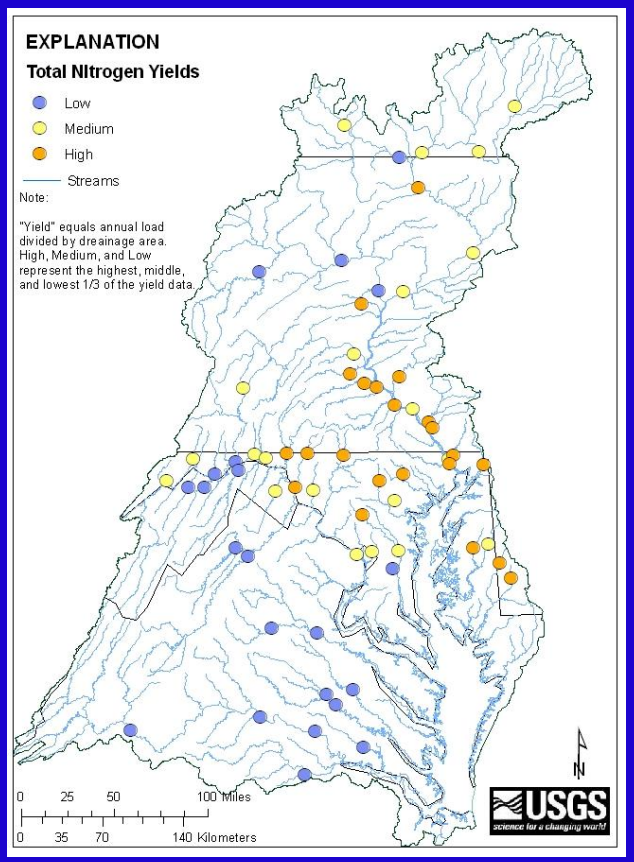
Questions?

Example figs of 10-trend, yields, and combined

10-year trend



5 year yields



Combo trend/yields