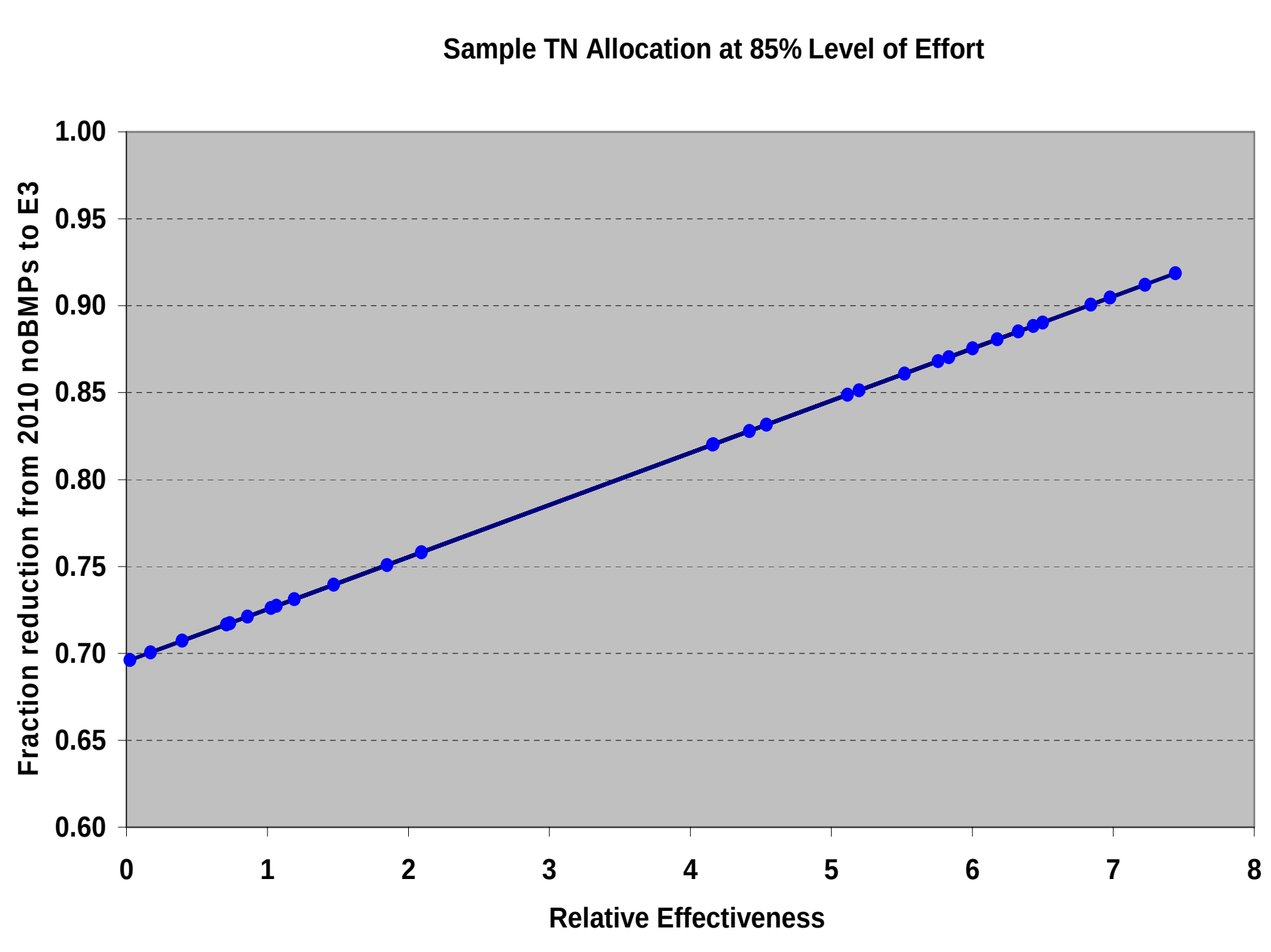
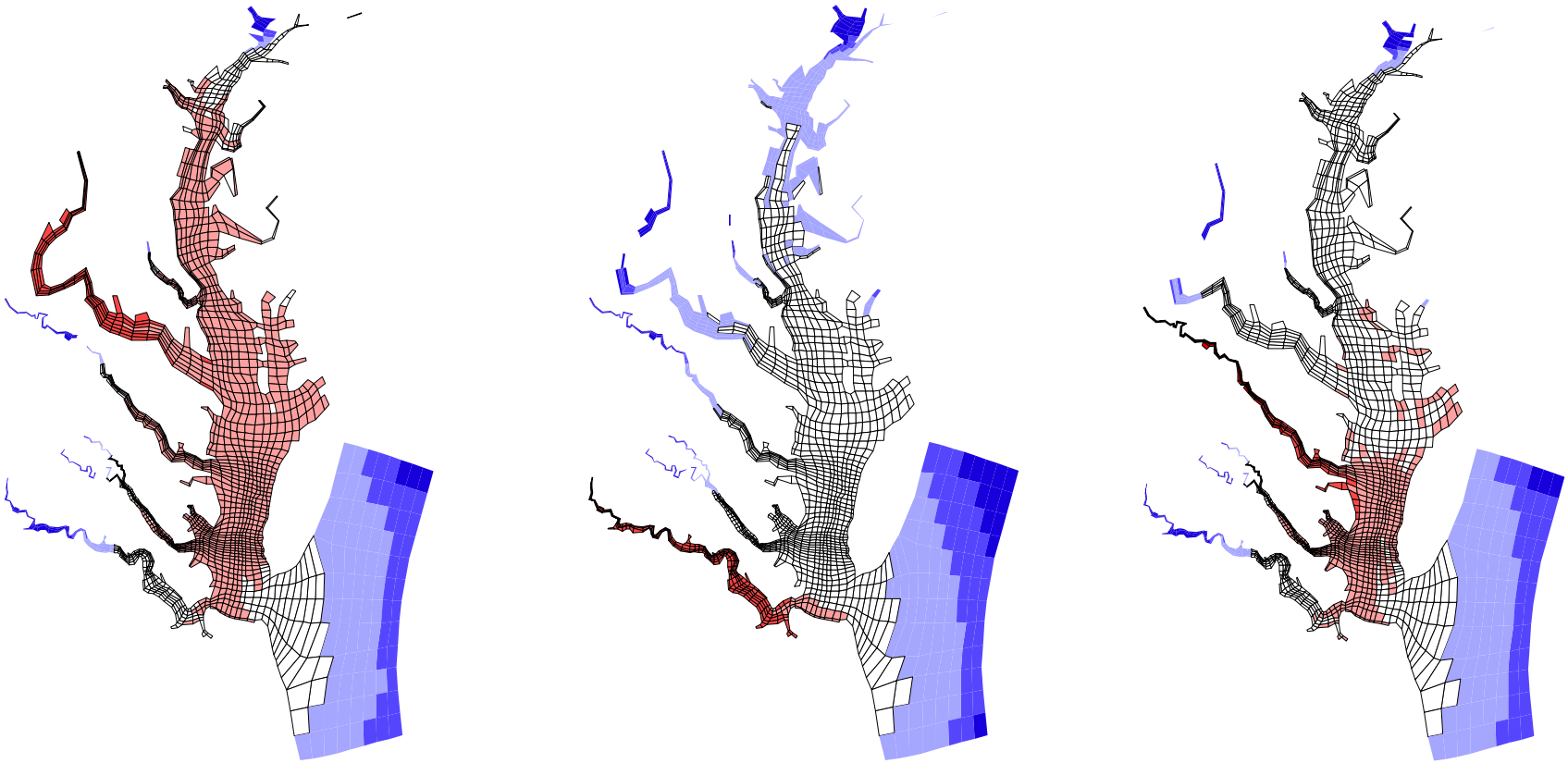

Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
1
2
3
4
5
6
7
8
Relative Effectiveness

Location on the Bay (Estuarine Transport)

- Understand which basins affect which areas of the bay and by how much

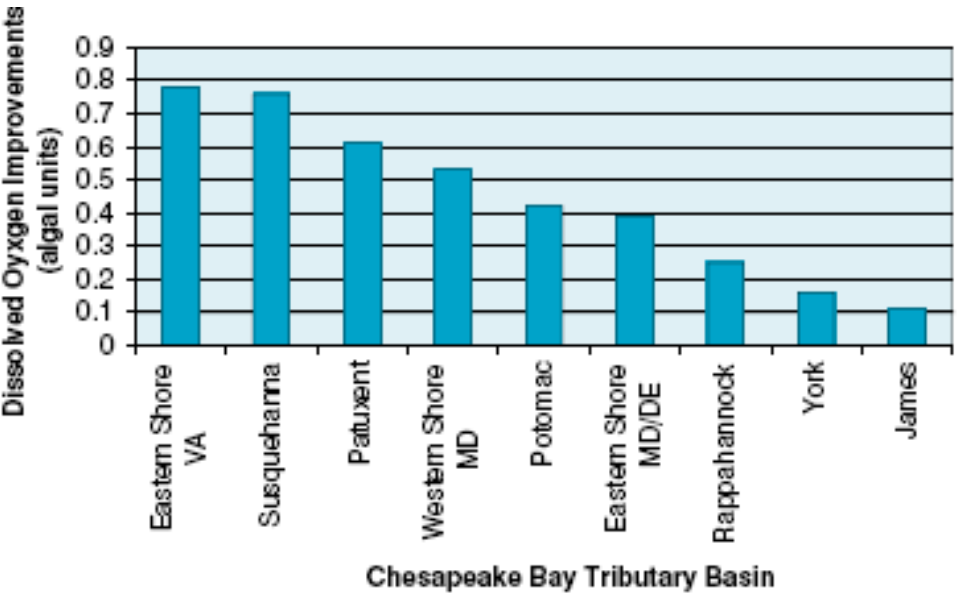


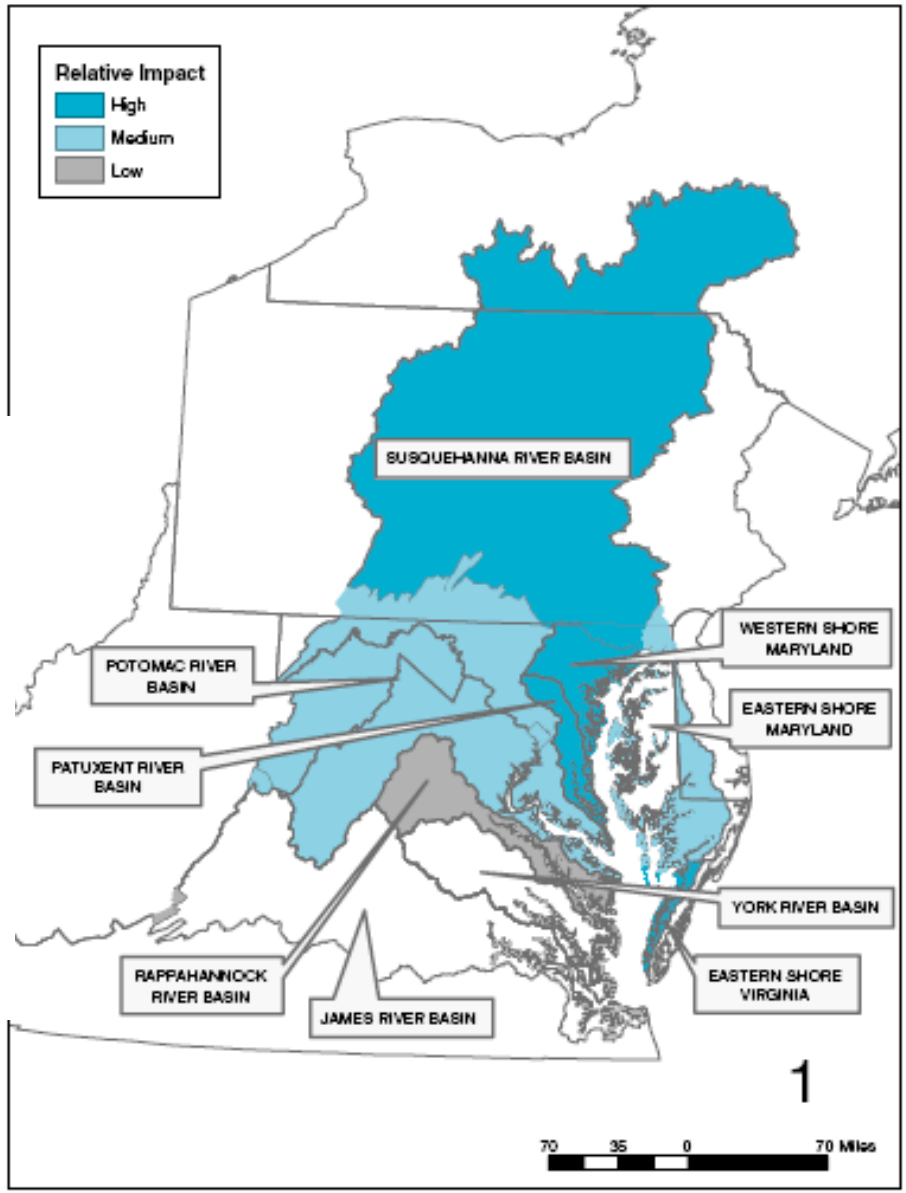
Procedure to Construct Each Run

- Set one basin at E3 loads and all other watersheds at P5.1 calibration levels
- Record the reduction in mean DO concentration and unallowable non-attainment (red areas of CFD) for each criterion and designated use area
- Repeat for each basin

Previous Geographic Run Scenarios

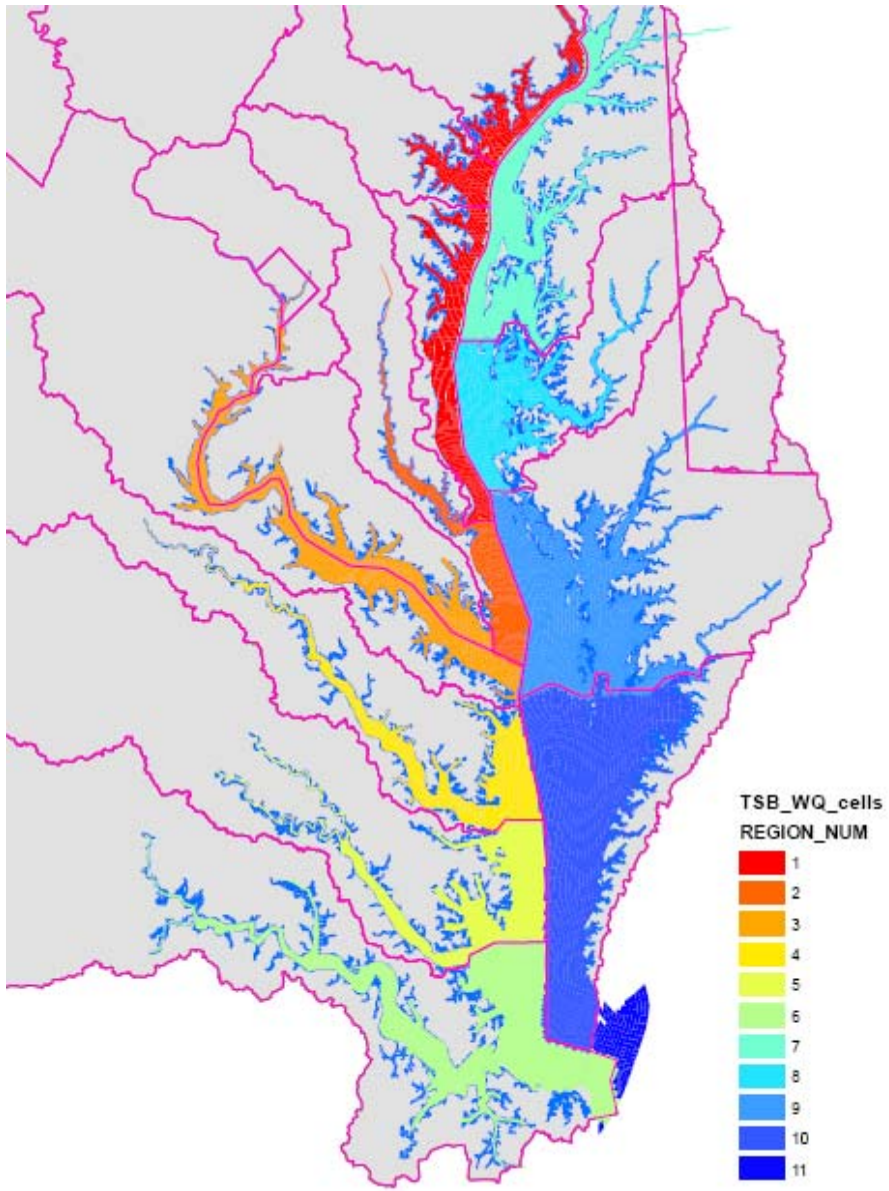
The geographic scenarios previously run in the 2003 allocation effort. The analysis was on 9 geographic regions.





Current Geographic Run Scenarios

- Extended to 21 scenarios:
  - Susquehanna
  - West Shore Chesapeake
  - **Patuxent**
  - Patuxent AFL
  - Patuxent BFL
  - **Potomac**
  - Potomac AFL
  - Potomac BFL
  - **Rappahannock**
  - Rappahannock AFL
  - Rappahannock BFL
  - **York**
  - York AFL
  - York BFL
  - **James**
  - James AFL
  - James BFL
  - Upper MD-DE Eastern Shore*
  - Middle MD-DE Eastern Shore*
  - Lower MD-DE Eastern Shore*
  - VA Eastern Shore



Relative Effectiveness of Reductions

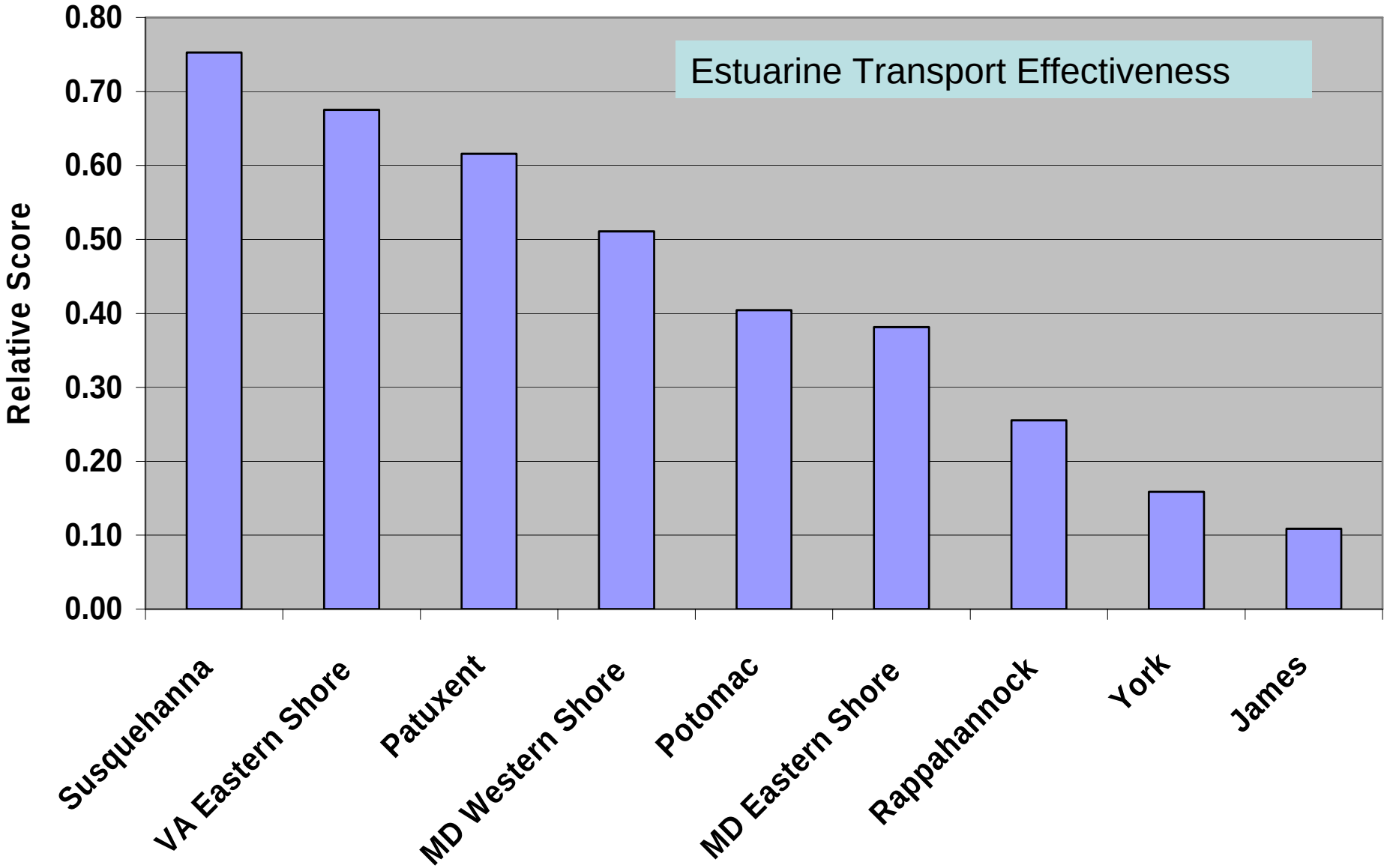
- Effectiveness of load reductions to the Bay by basin is normalized to be comparable
- Reduced TN &TP loads are aggregated into a Algal unit

  Algal unit = TN + 10*TP

- The effectiveness is calculated as:

  changes in mean DO concentration or unallowable non-attainment divided by algal unit in million lbs

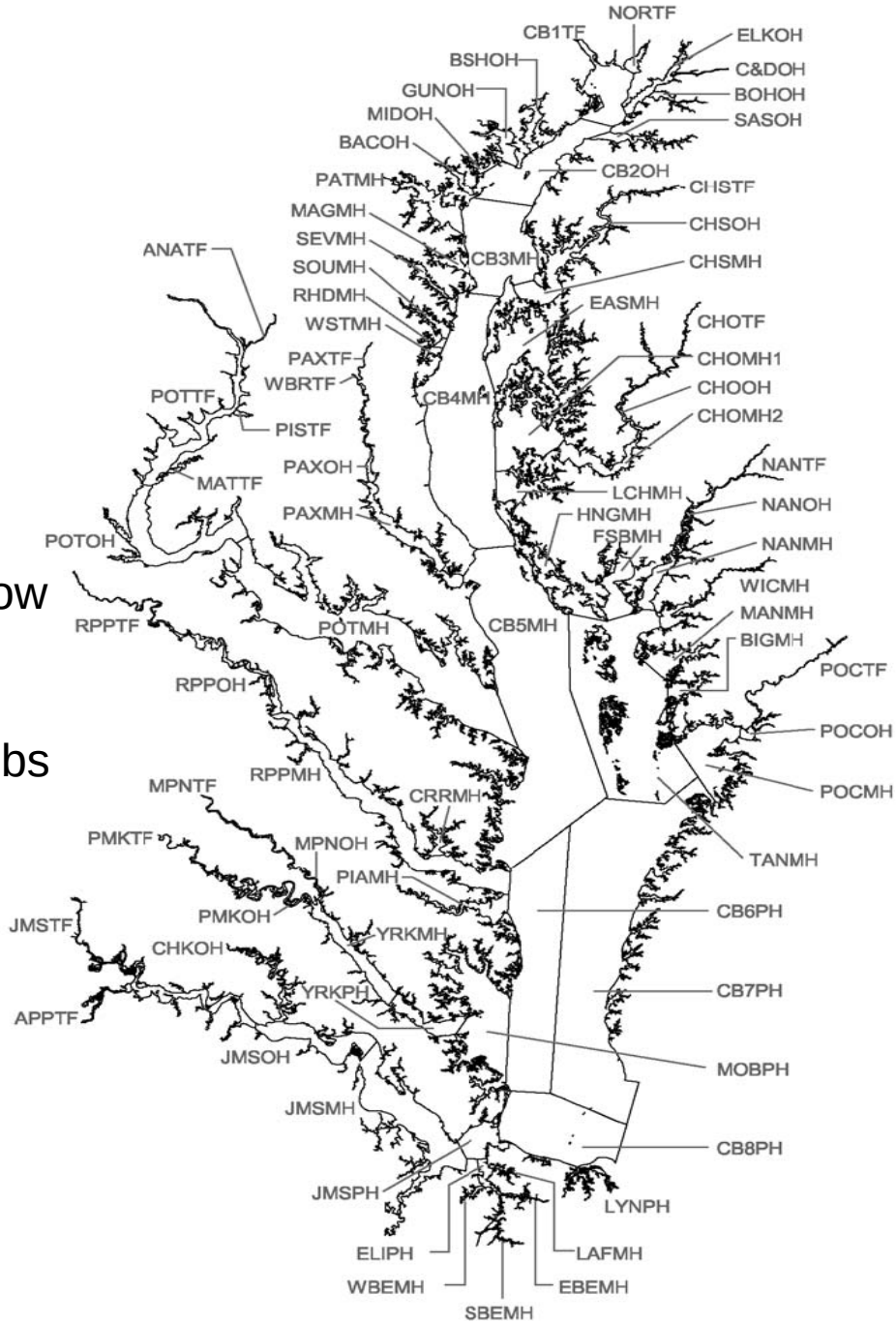
Relative Effectiveness of Reductions to the Estuary by Basin on Main Stem Deep Water (2002 models)

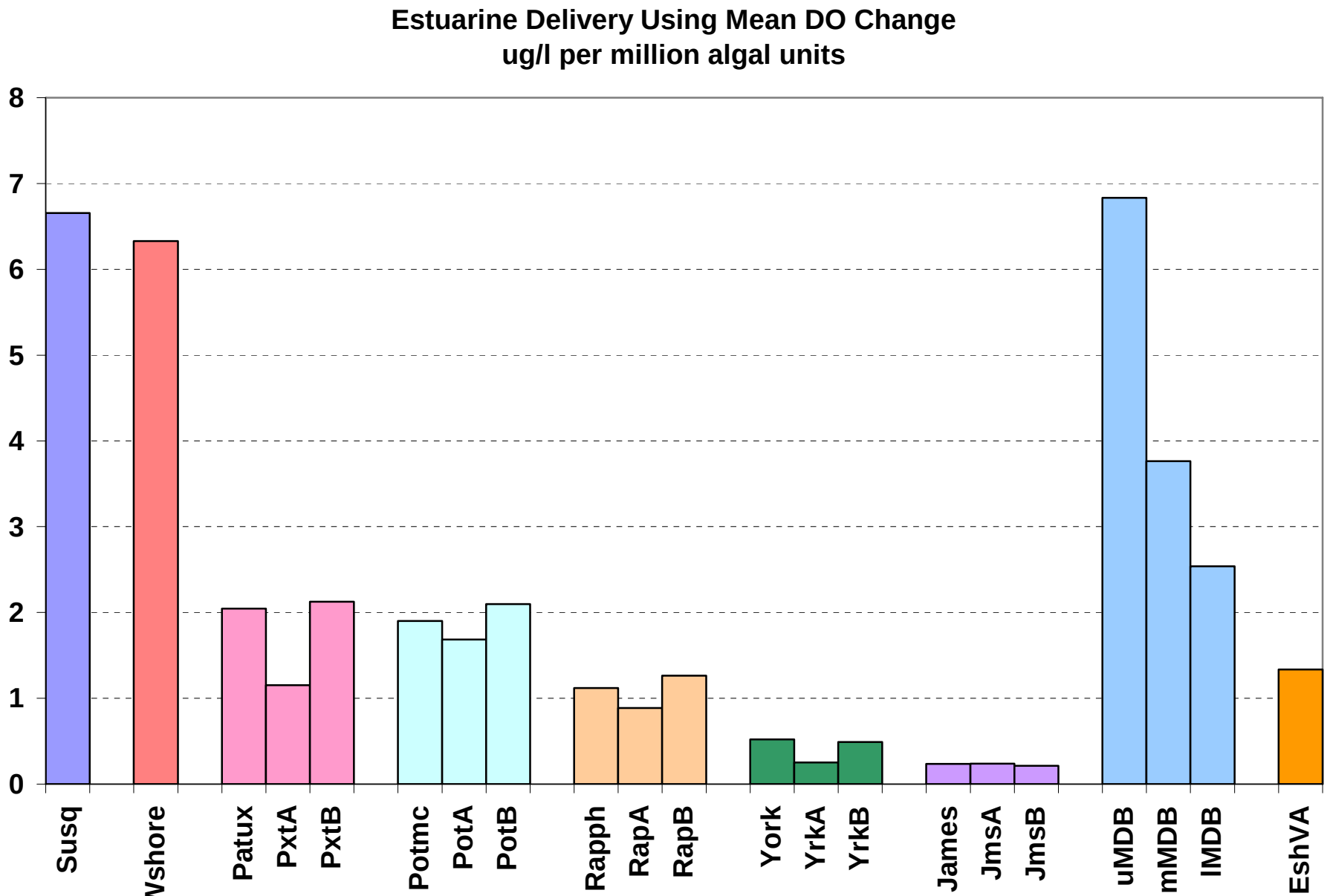


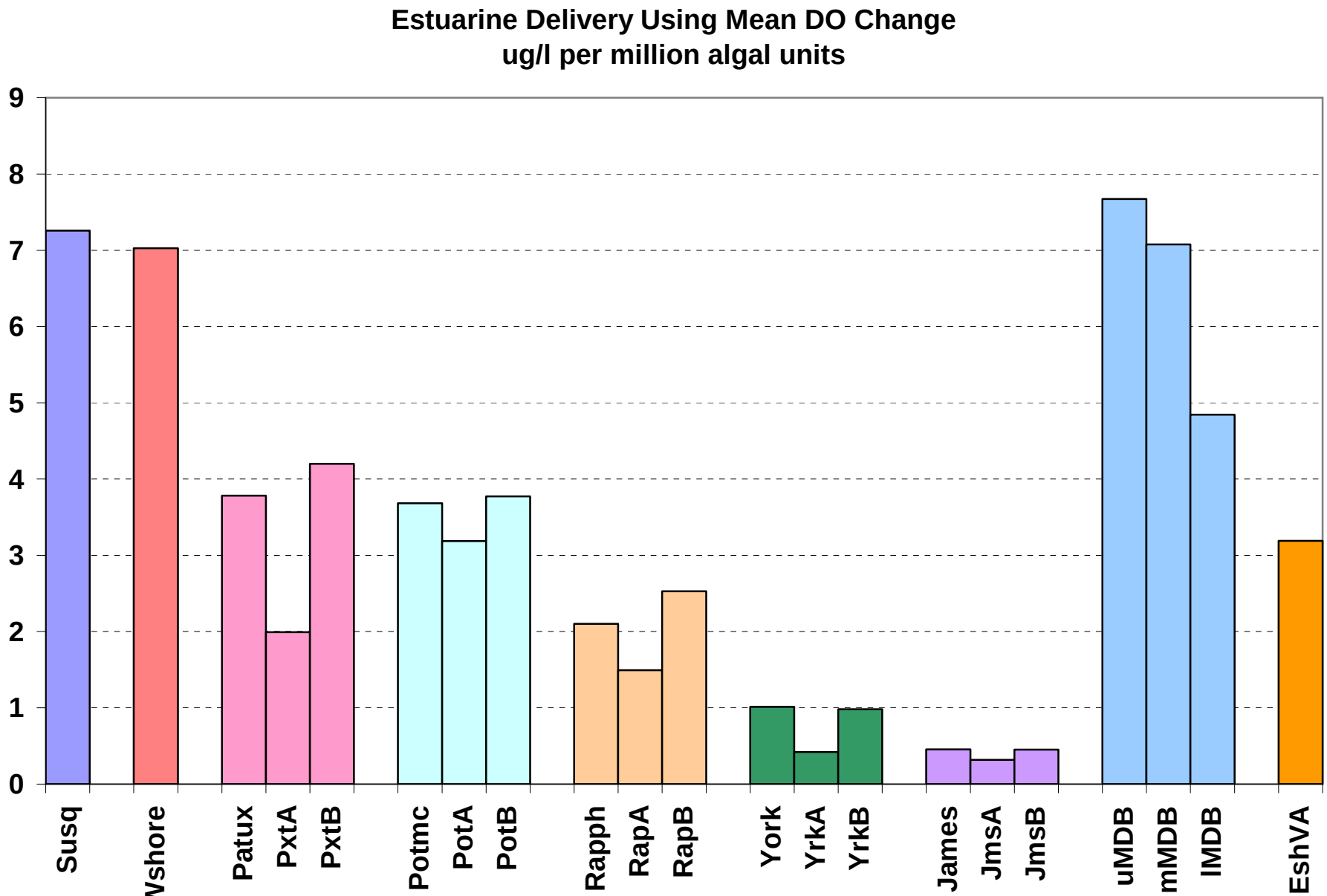
Chesapeake Bay Segments

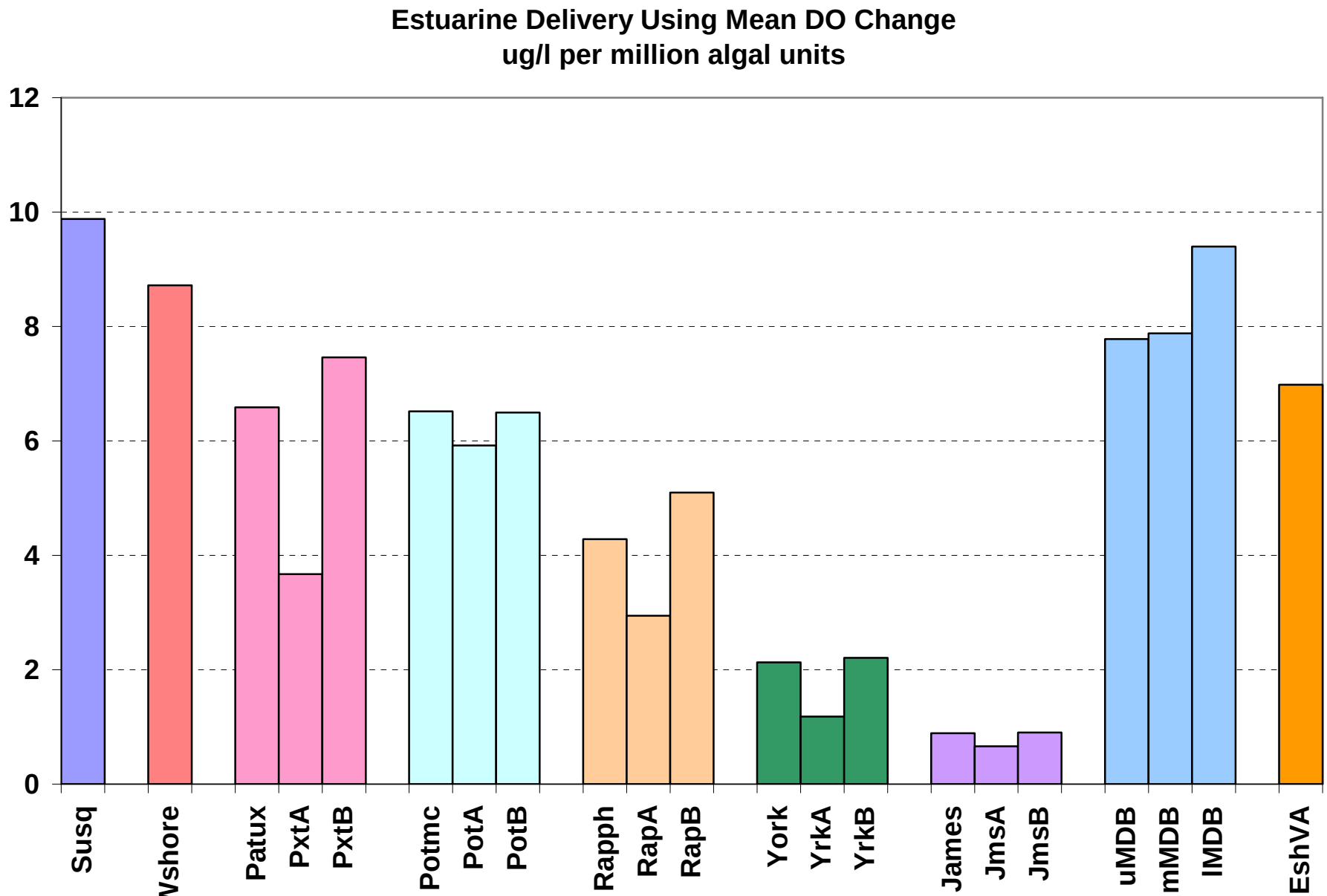
Quick run-through to get a feel for how These things work

Moving down the bay and into the tribs

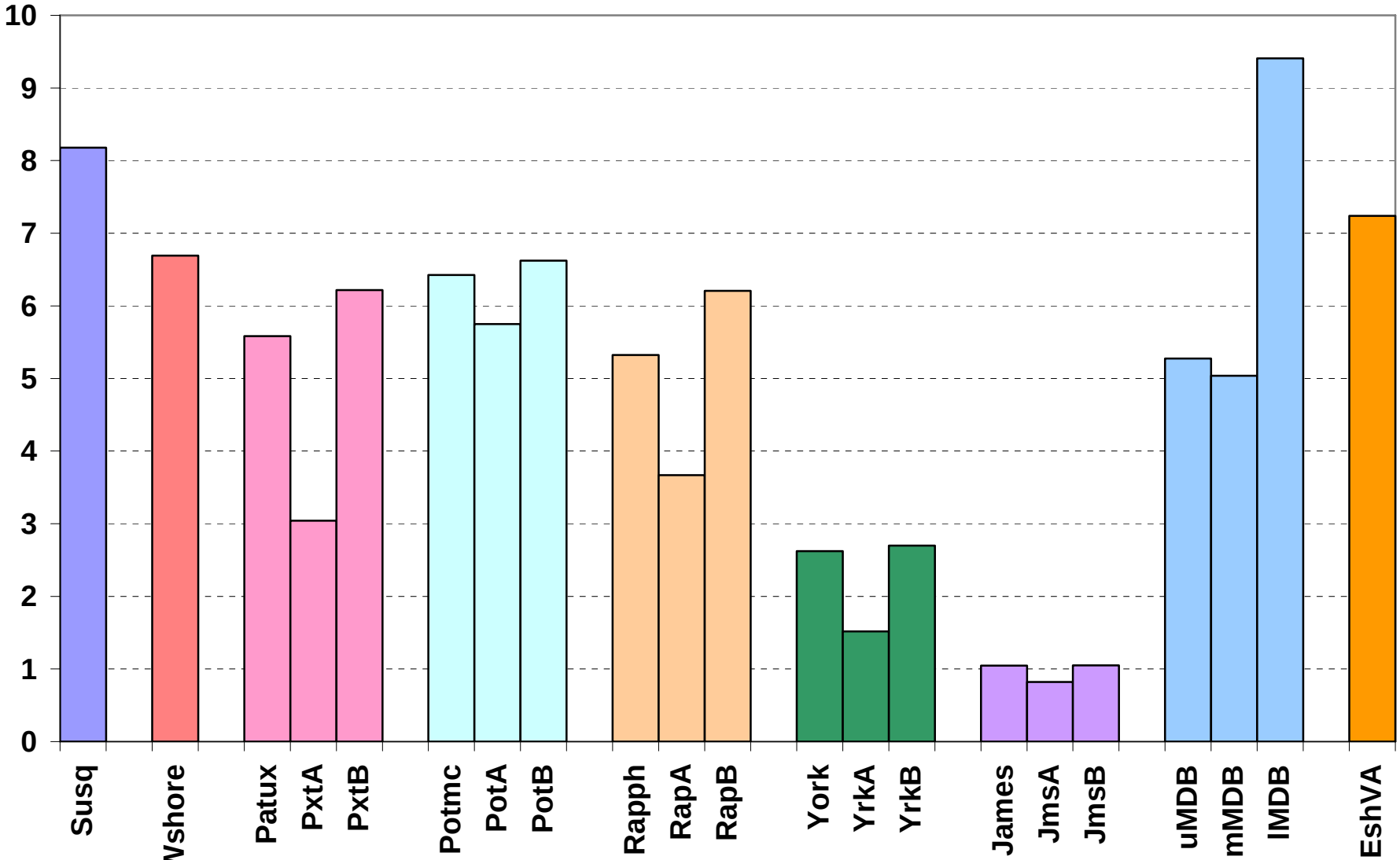


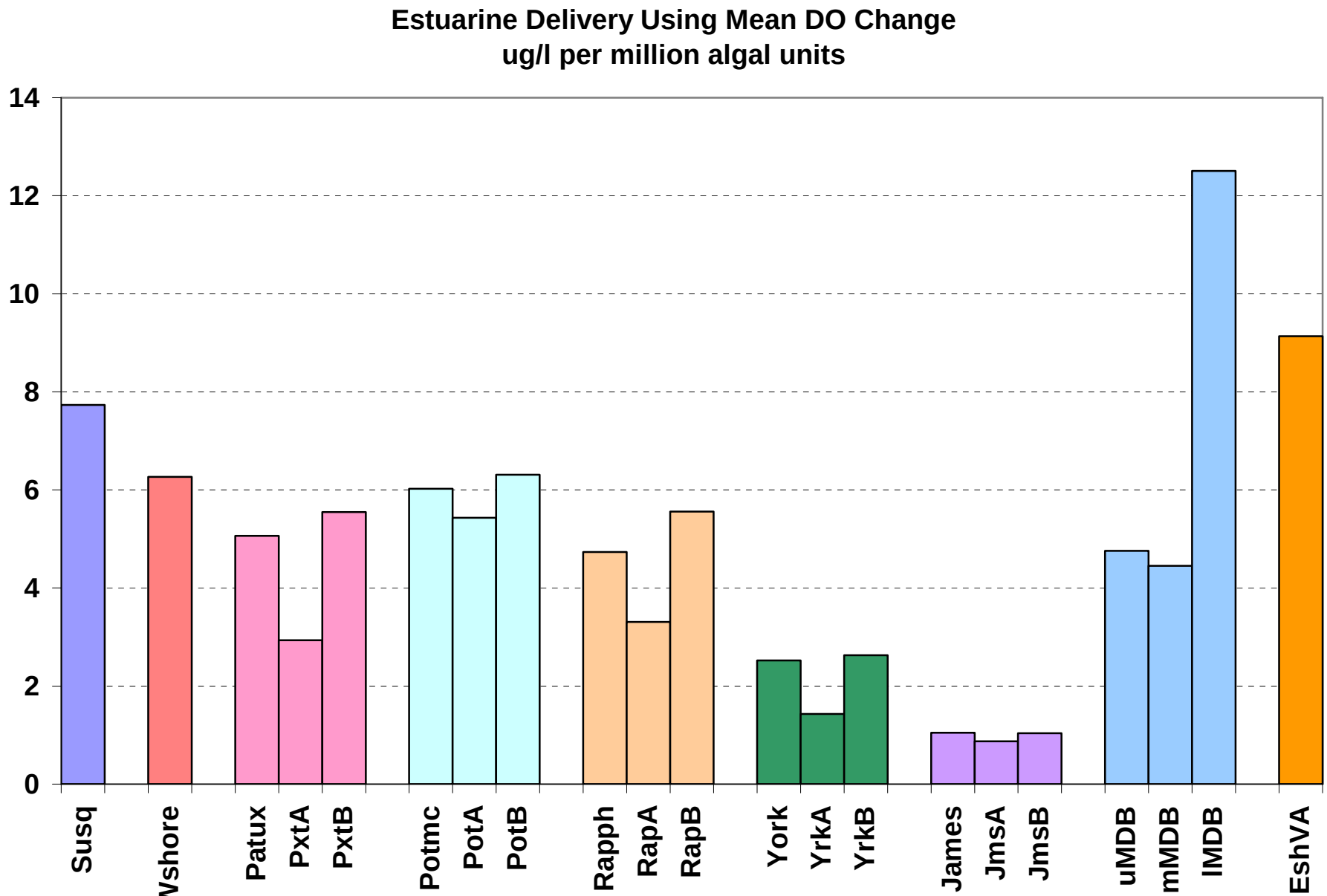

Estuarine Delivery Using Mean DO Change
ug/l per million algal units
8
7
6
5
4
3
2
1
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA

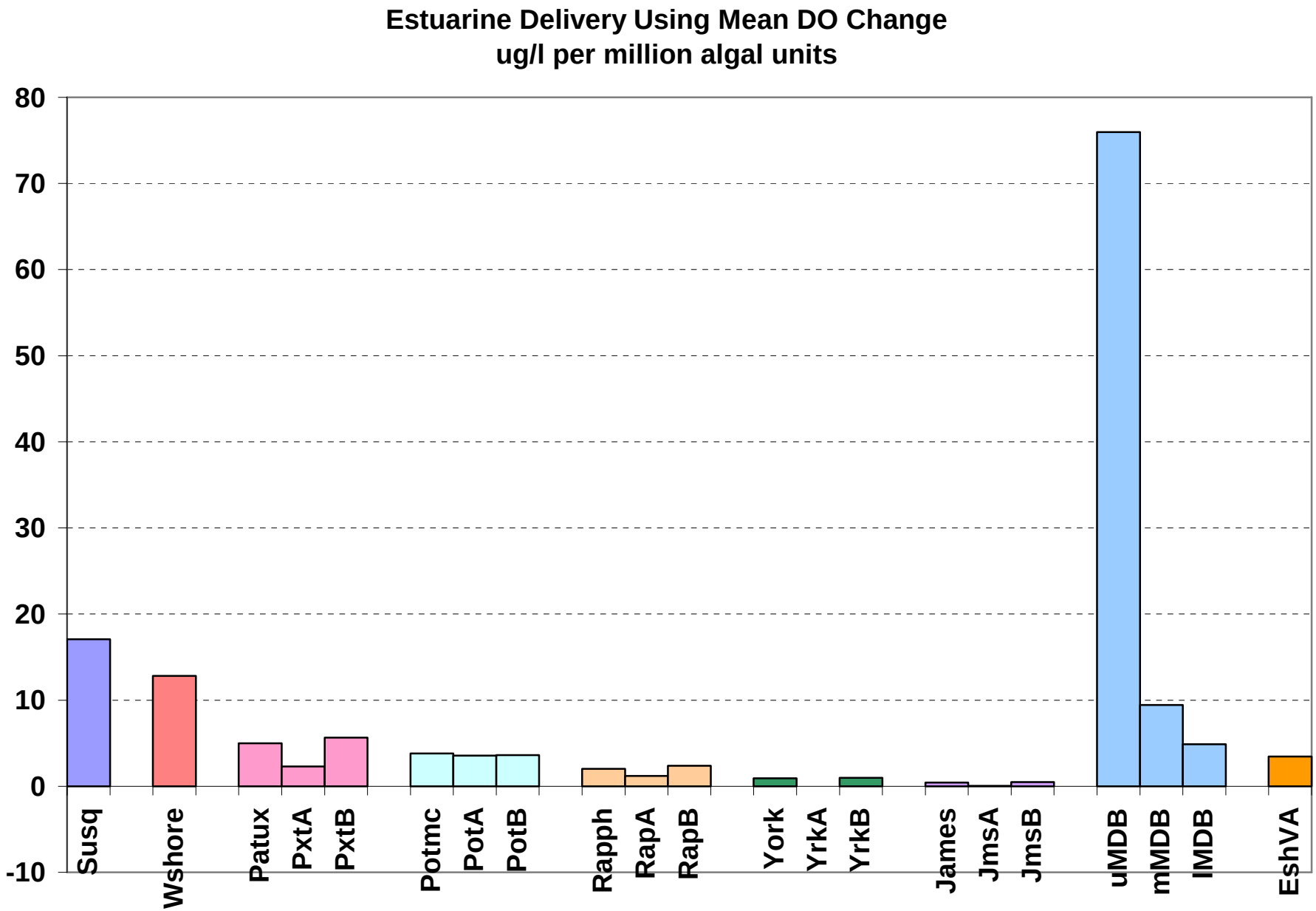

Estuarine Delivery Using Mean DO Change
ug/l per million algal units
9
8
7
6
5
4
3
2
1
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA


Estuarine Delivery Using Mean DO Change
ug/l per million algal units
12
10
8
6
4
2
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA

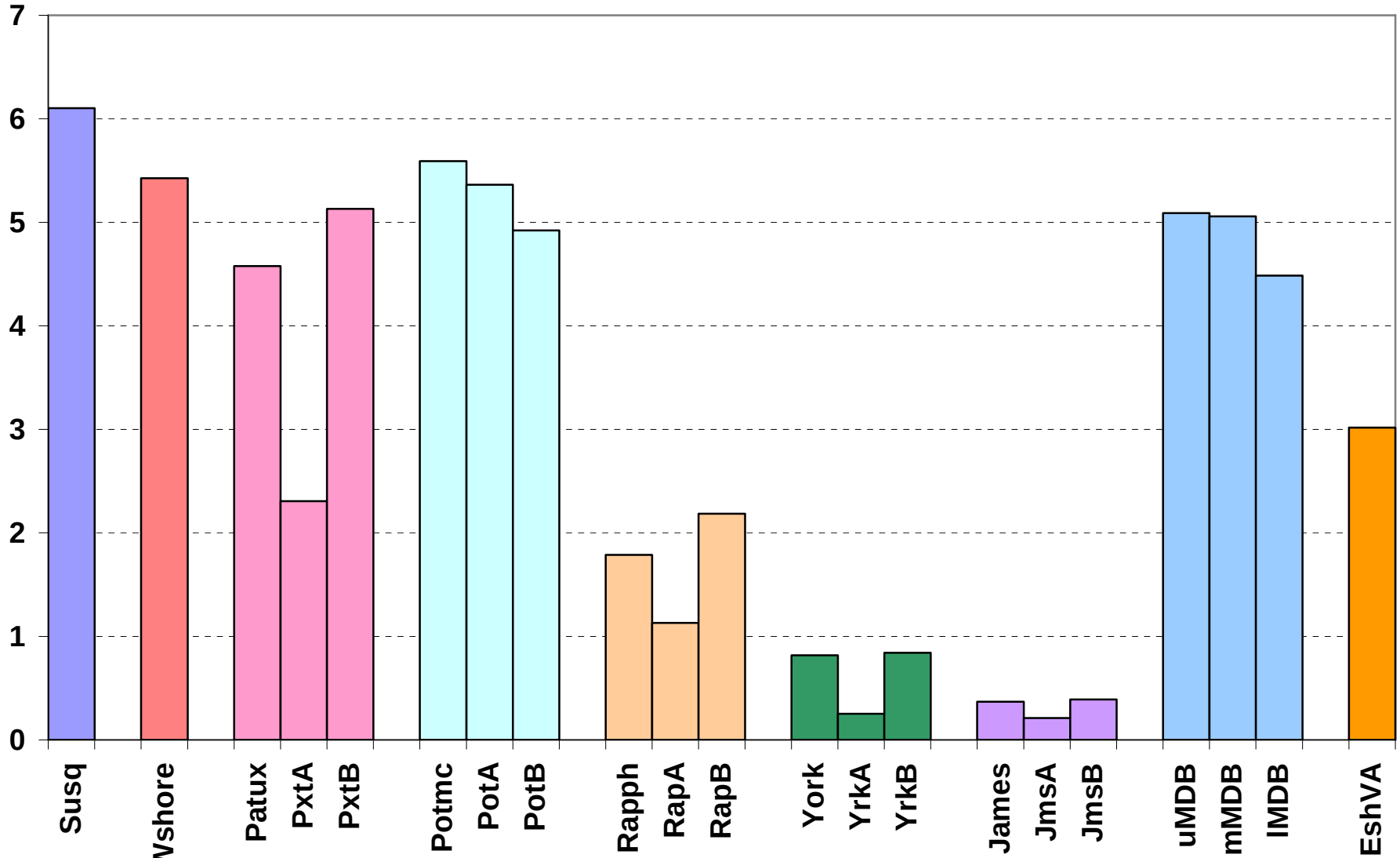
Estuarine Delivery Using Mean DO Change
ug/l per million algal units



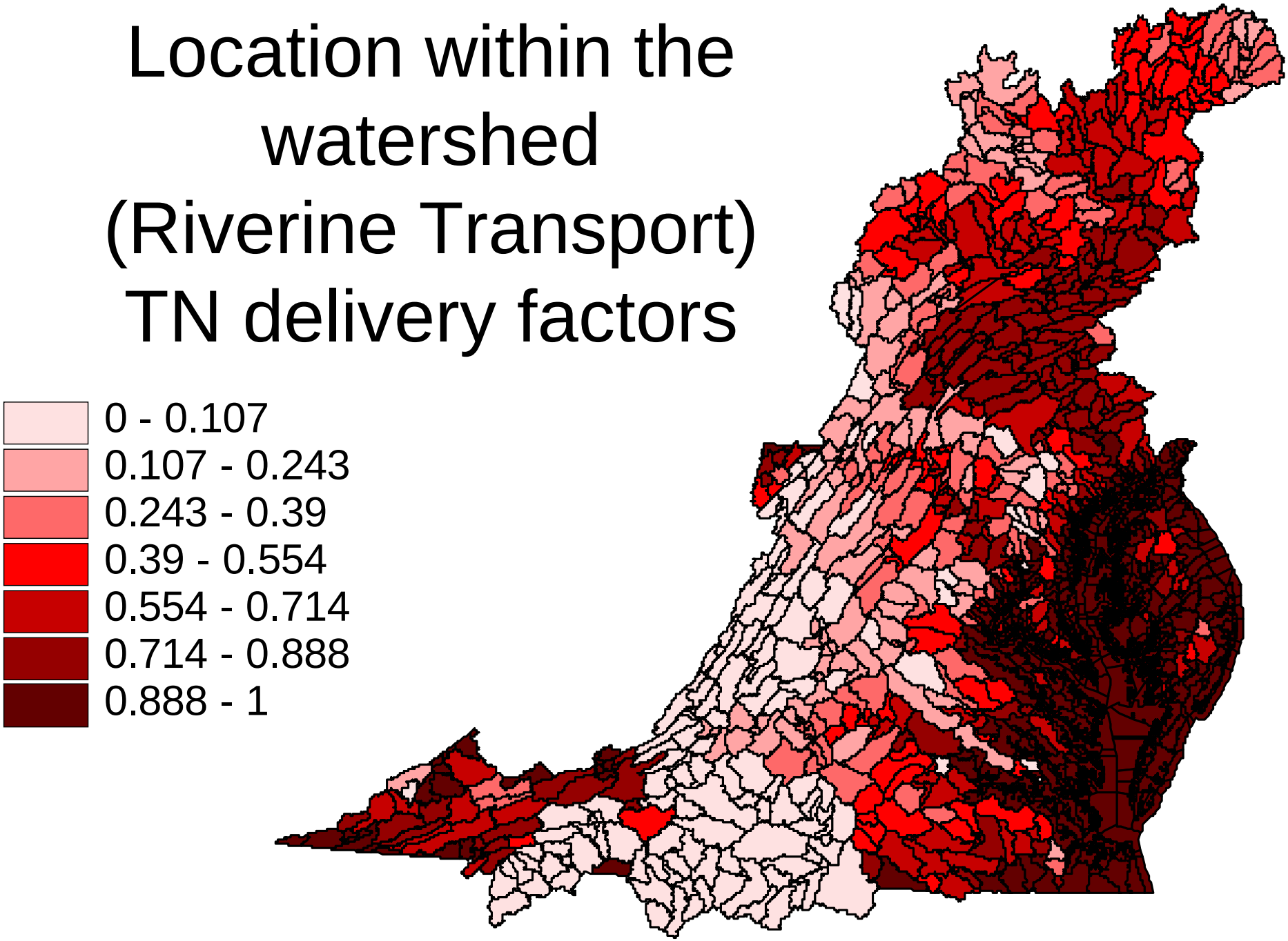

Estuarine Delivery Using Mean DO Change
ug/l per million algal units
14
12
10
8
6
4
2
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA


Estuarine Delivery Using Mean DO Change
ug/l per million algal units
80
70
60
50
40
30
20
10
0
-10
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA

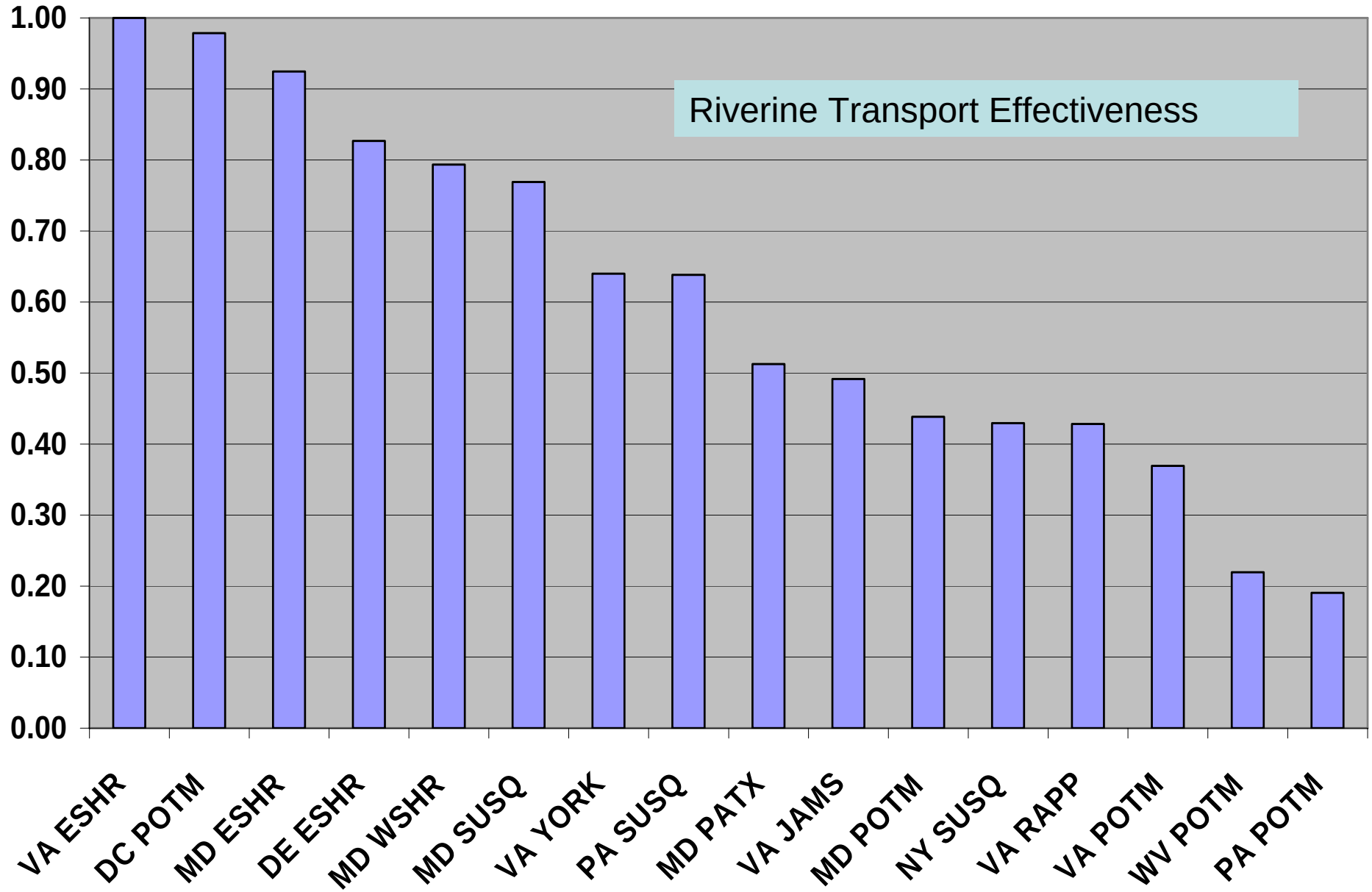
Estuarine Delivery Using Mean DO Change
ug/l per million algal units

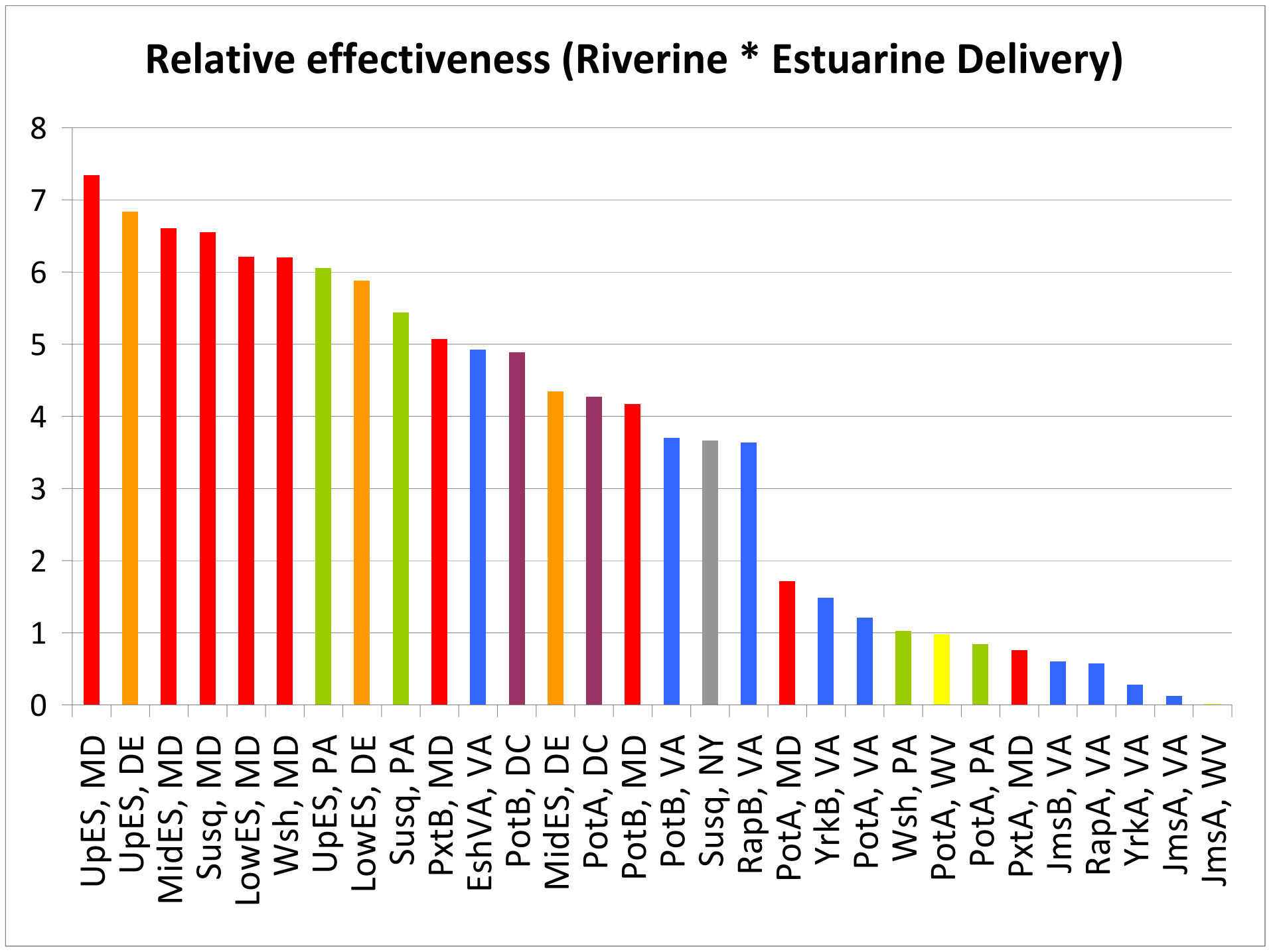


Location within the watershed (Riverine Transport) TN delivery factors



TN Delivery Factors for the Calibration p5.1




Relative effectiveness (Riverine * Estuarine Delivery)
8
7
6
5
4
3
2
1
0
UpES, MD
UpES, DE
MidES, MD
Susq, MD
LowES, MD
Wsh, MD
UpES, PA
LowES, DE
Susq, PA
PxtB, MD
EshVA, VA
PotB, DC
MidES, DE
PotA, DC
PotB, MD
PotB, VA
Susq, NY
RapB, VA
PotA, MD
YrkB, VA
PotA, VA
Wsh, PA
PotA, WV
PotA, PA
PxtA, MD
JmsB, VA
RapA, VA
YrkA, VA
JmsA, VA
JmsA, WV

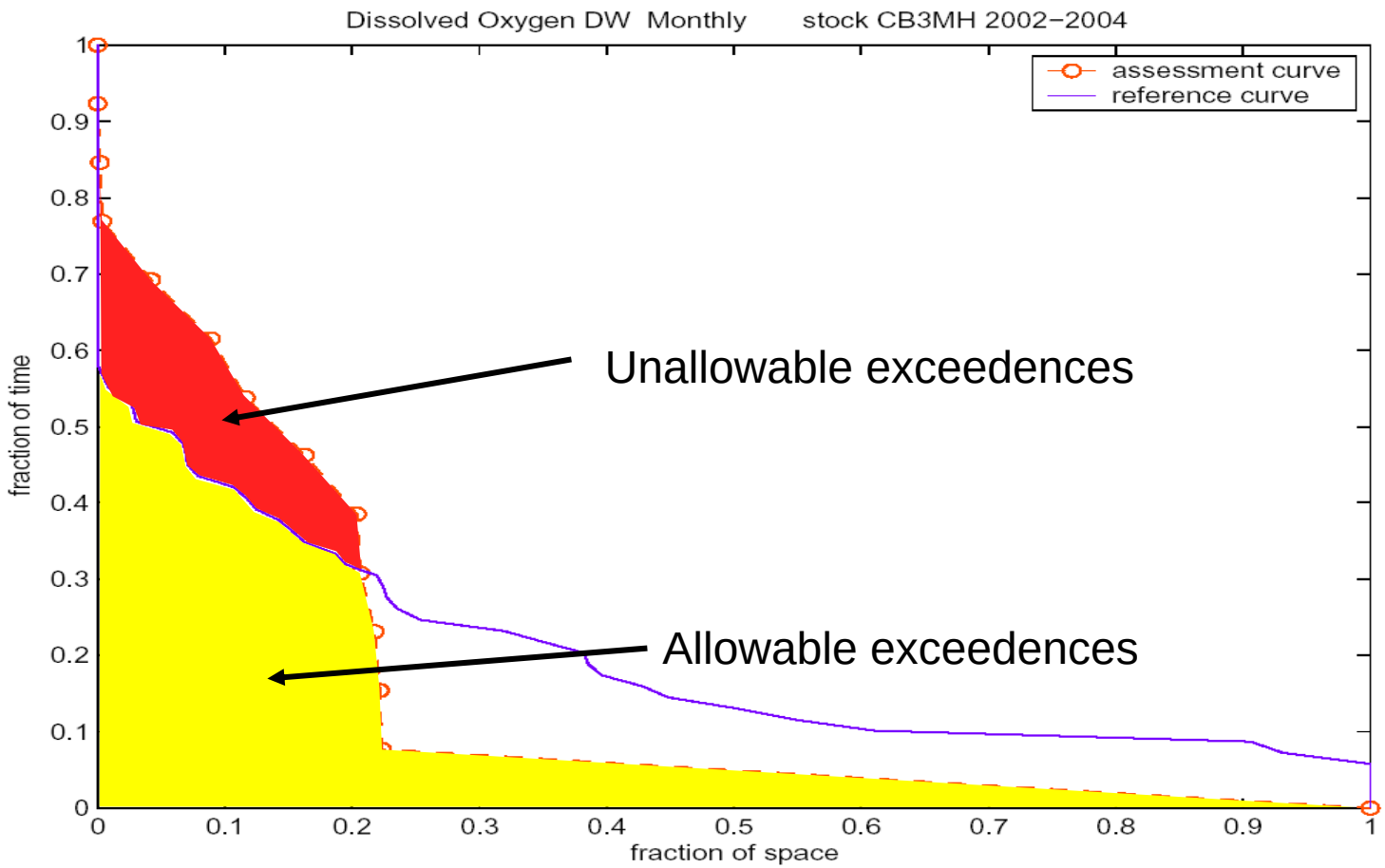
Some Decisions to Make

- Metric
  - Mean DO
  - Red Area of CFD
- Split Allocations by AFL/BFL
  - VA Potomac now has:
    - VA Potomac BFL
    - VA Potomac AFL
  - PA Potomac and MD BFL Potomac have different estuarine effectiveness

More Decisions

- Where to judge Estuarine effectiveness
  - CB4 DW
  - Deep Channel?
  - More Segments?
- How to translate riverine and estuarine effectiveness to an allocation

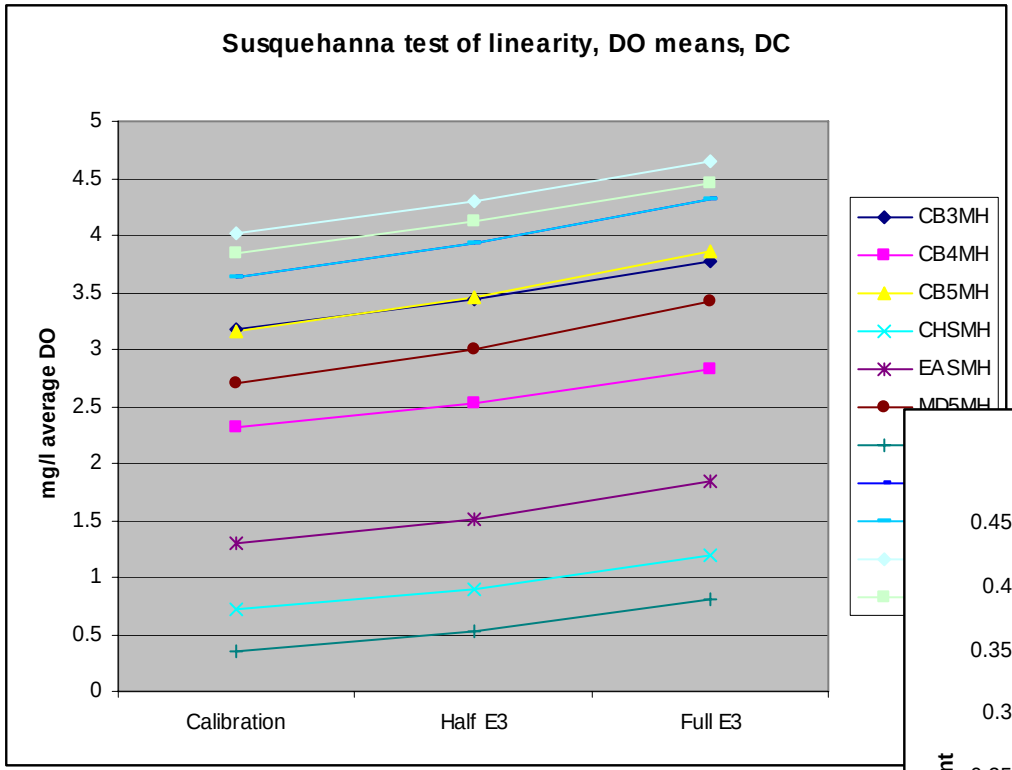
Metric, mean DO or red area?



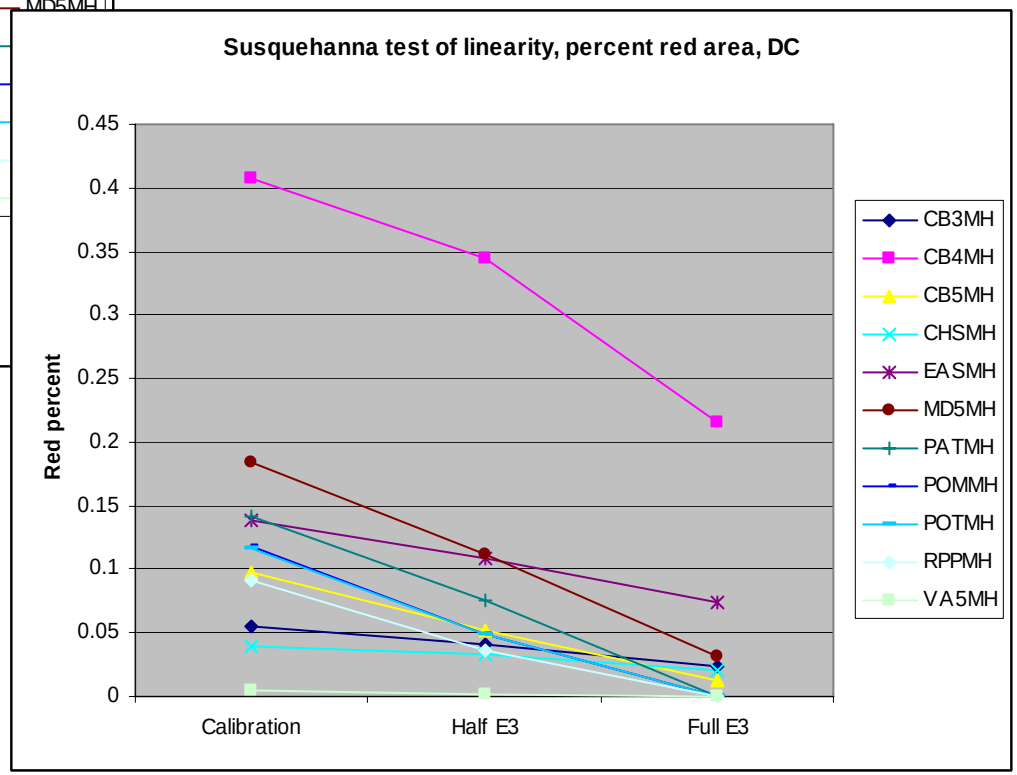
What makes a good metric?

- Relevance
  - Percent Red Area is exactly what we are trying to reduce
  - Mean DO is the underlying parameter
- Broad applicability
  - DO mean does not work well for open water
  - Percent Red Area does not work for areas with zero violation in the base or geographic run
- Linearity
  - Does it naturally favor large or small reductions

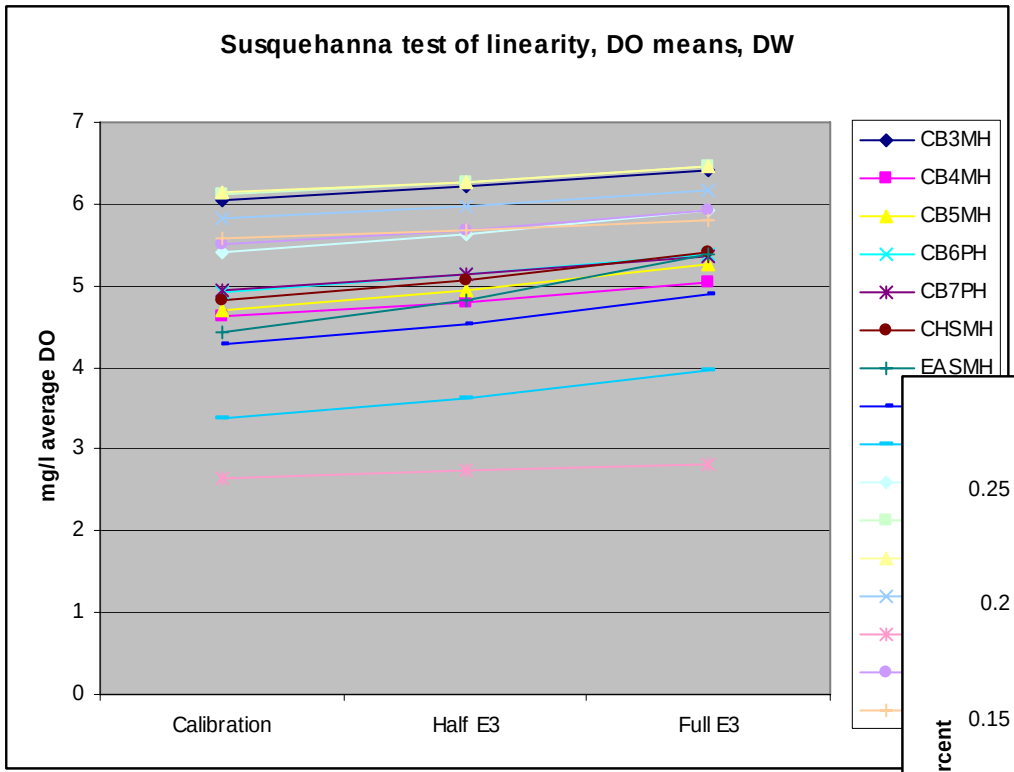
Linearity Deep Channel



- Both are mostly linear

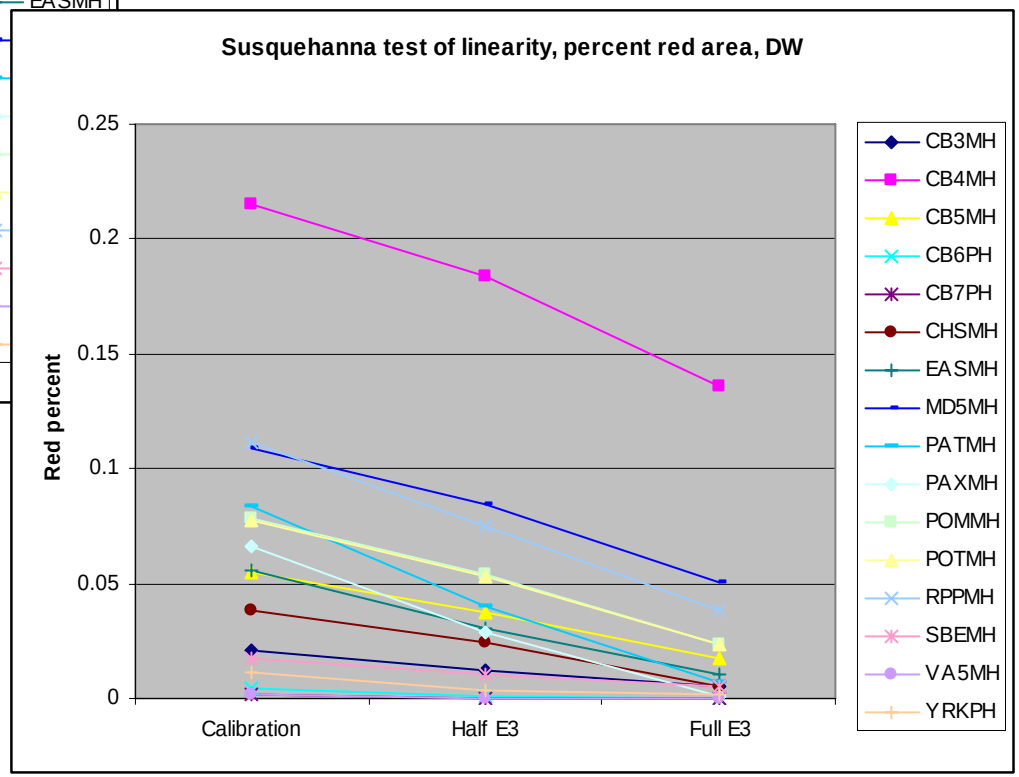


Linearity Deep Water

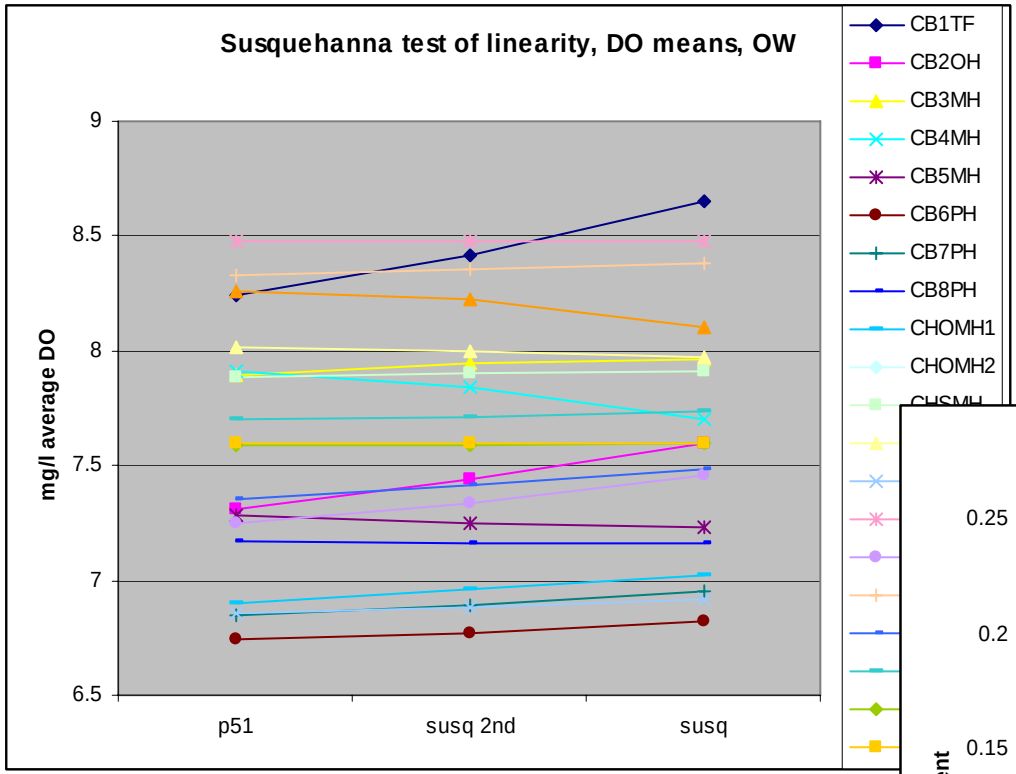


- Both are mostly linear

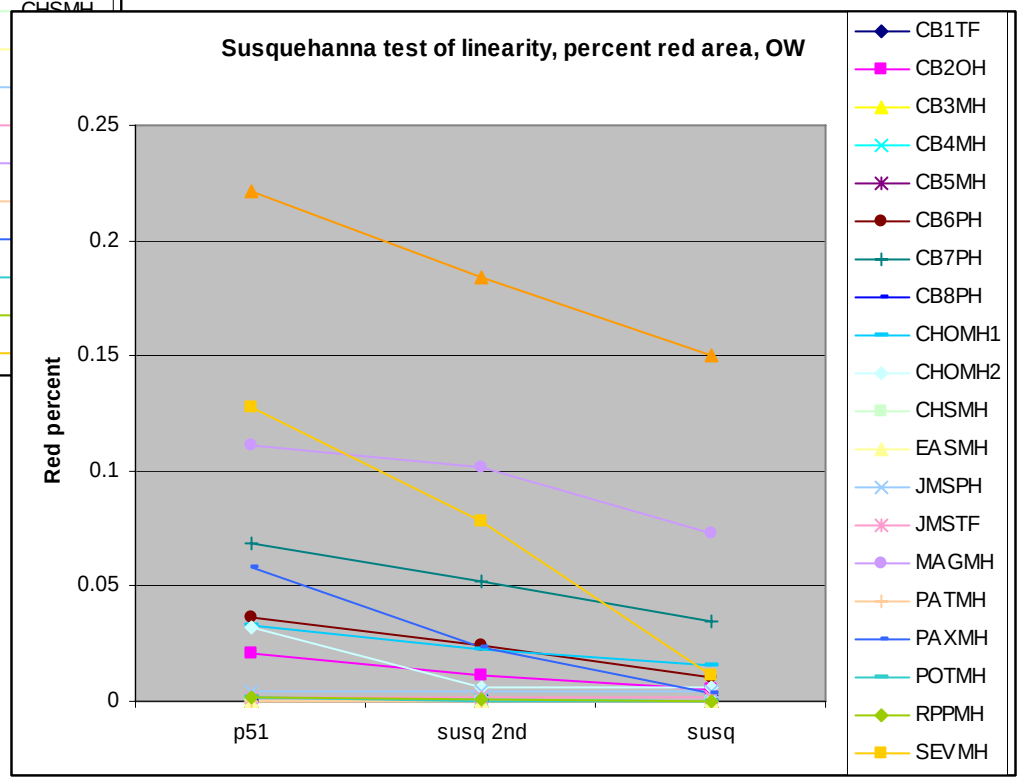
- Mean DO is more linear
- Percent bottoms out



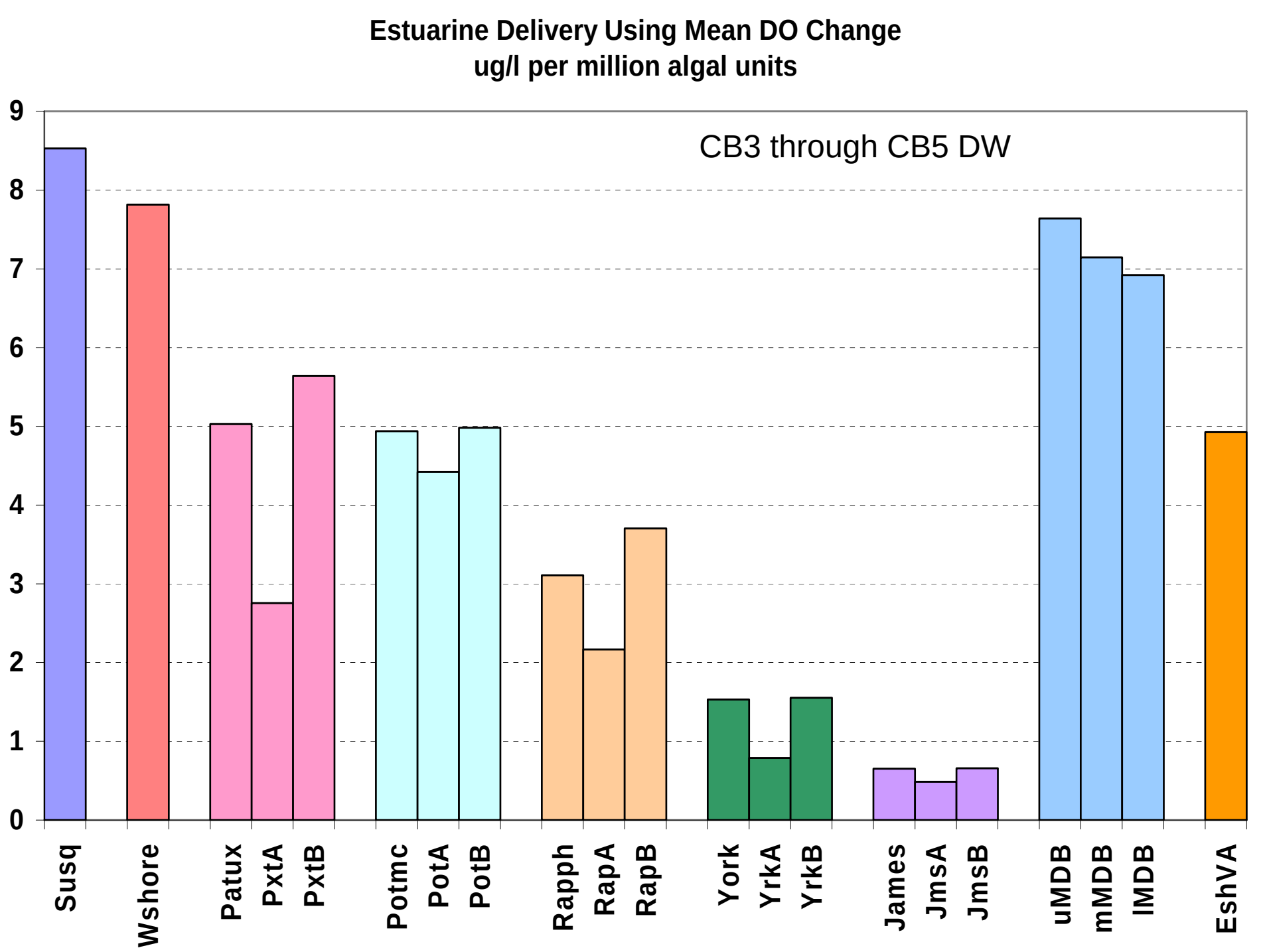
Linearity Open Water



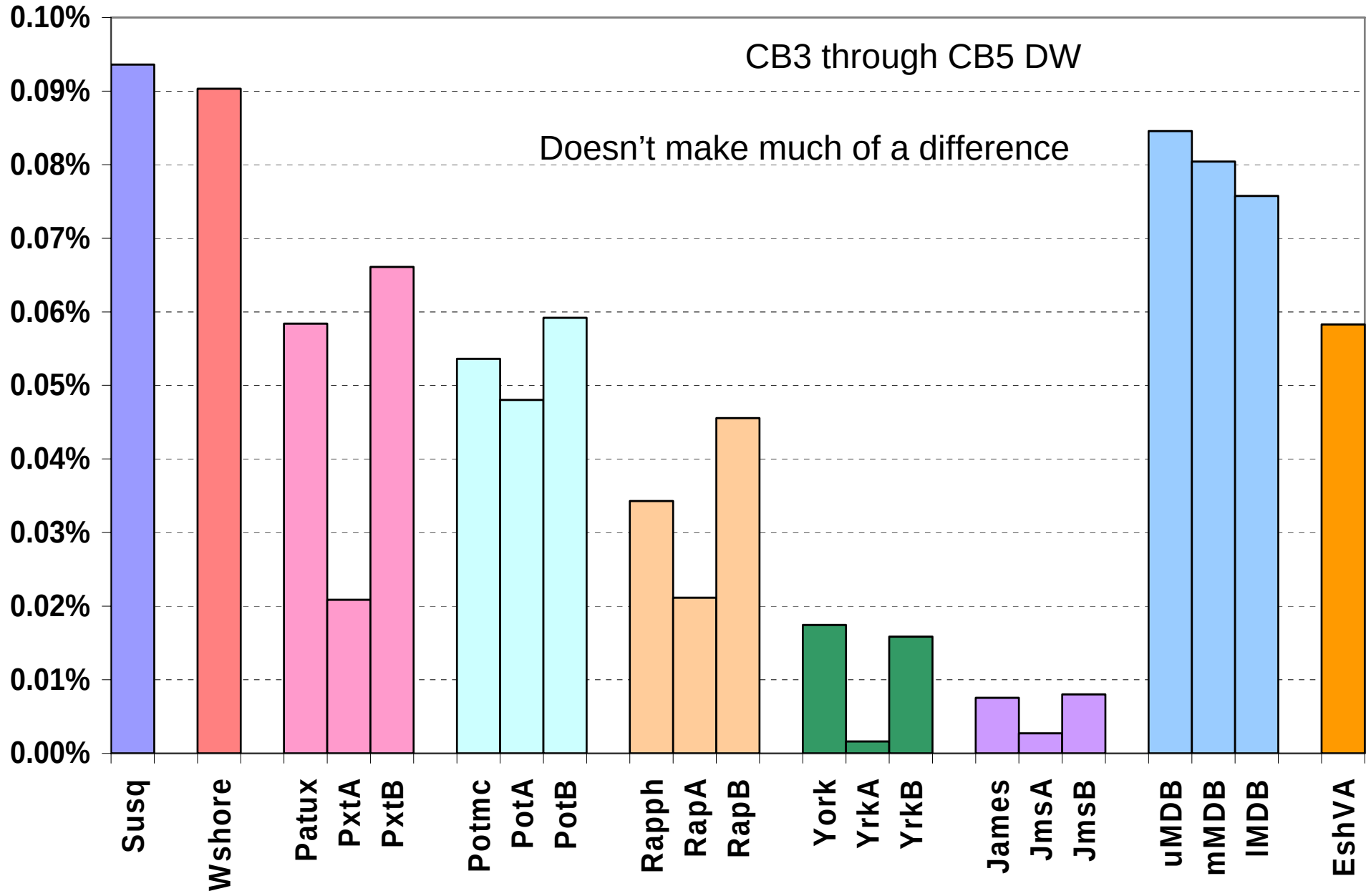
- Both are somewhat linear



- Not all areas increase in average DO


Estuarine Delivery Using Mean DO Change
ug/l per million algal units
CB3 through CB5 DW
9
8
7
6
5
4
3
2
1
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA

Estuarine Delivery Using Percent Violation Change
Percent Red Area Decrease per million algal units



Which Metric to use

- Mean DO is relevant, linear, and applicable to all DW and DC, but not all Open Water
- Percent violation is relevant, a little less linear, and applicable to some DW, DC, and OW areas
- Recommendation:
  - Mean DO is easily understood and more broadly applicable
  - Do not apply to Open Water as the metric is not as good and OW issues are mostly local or not limiting

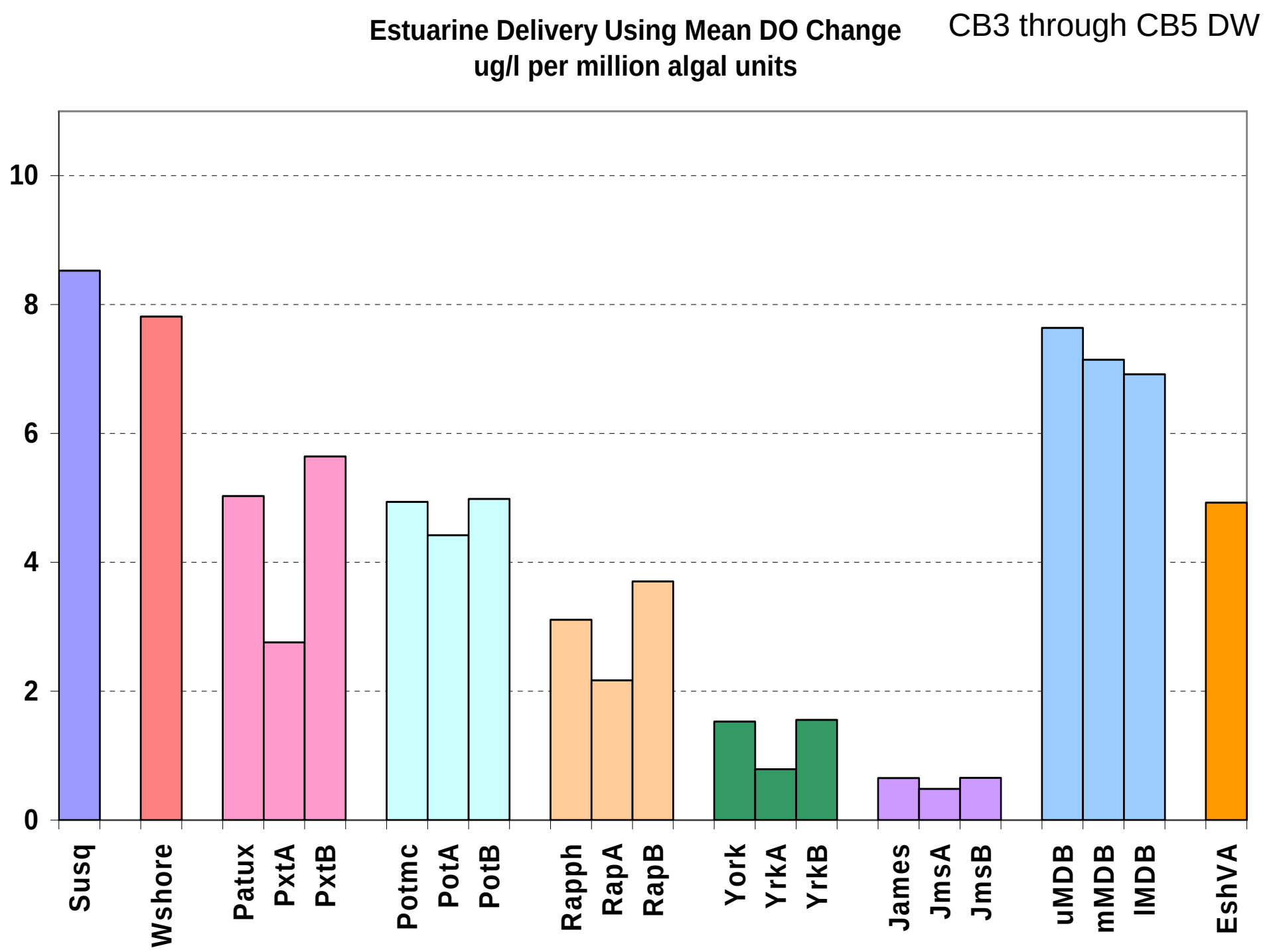
Split Basins

- Geographic isolation runs found a significant different between the loads that entered at the fall line and those that entered below.
- Recommendation to split allocation **calculation** by above and below fall line.
  - Does not mean that allocations will be split

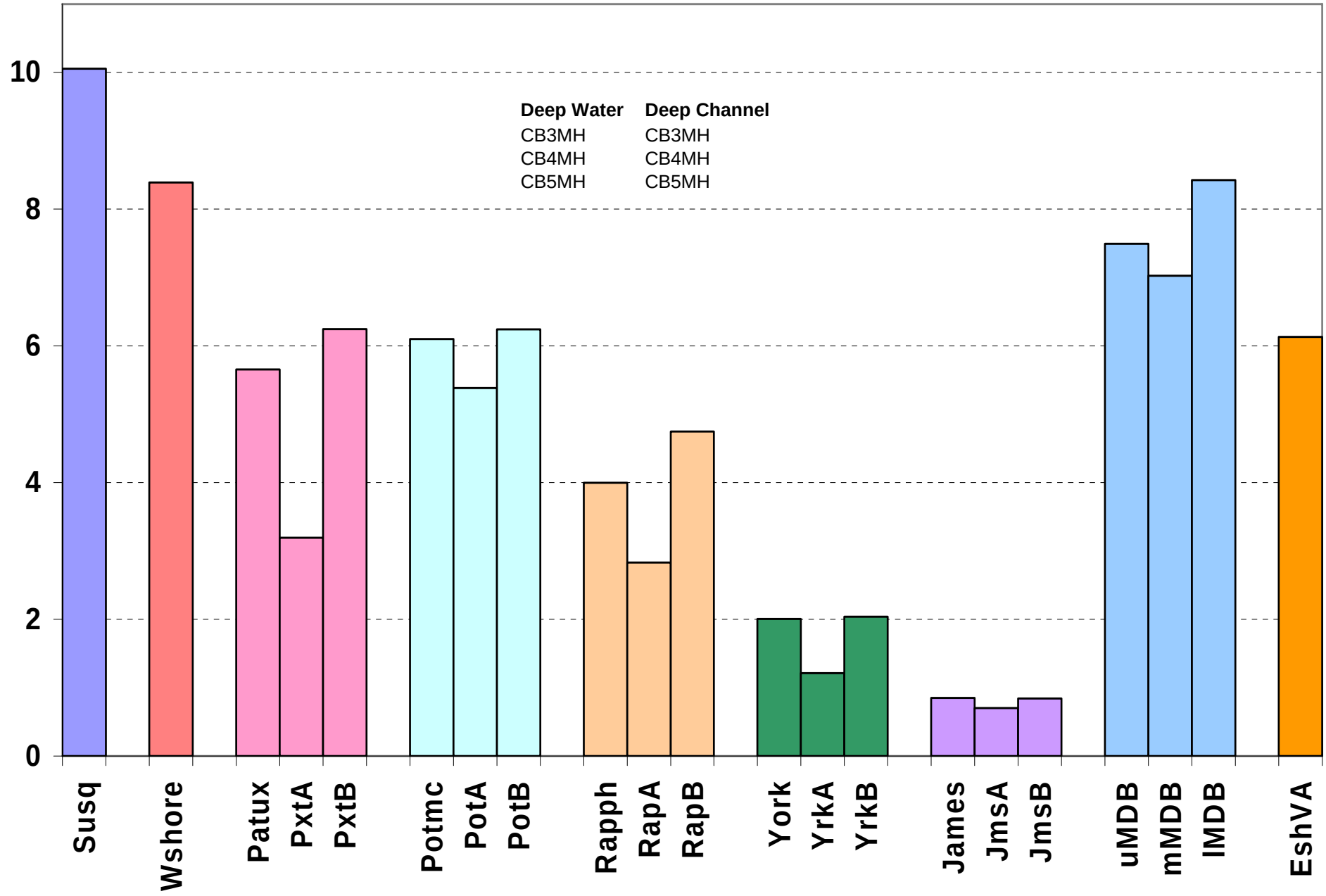
Geography

- CB3 – CB5 DW
  - Main part of the Bay DW (as in 2003)
- CB3 – CB5 DW and DC
  - Includes broader group
- CB3 – CB5 DW and DC + POTMH DW
  - Potomac attains at a low loading rate
- Add in more local segments
  - All segments not attaining at trib strategy

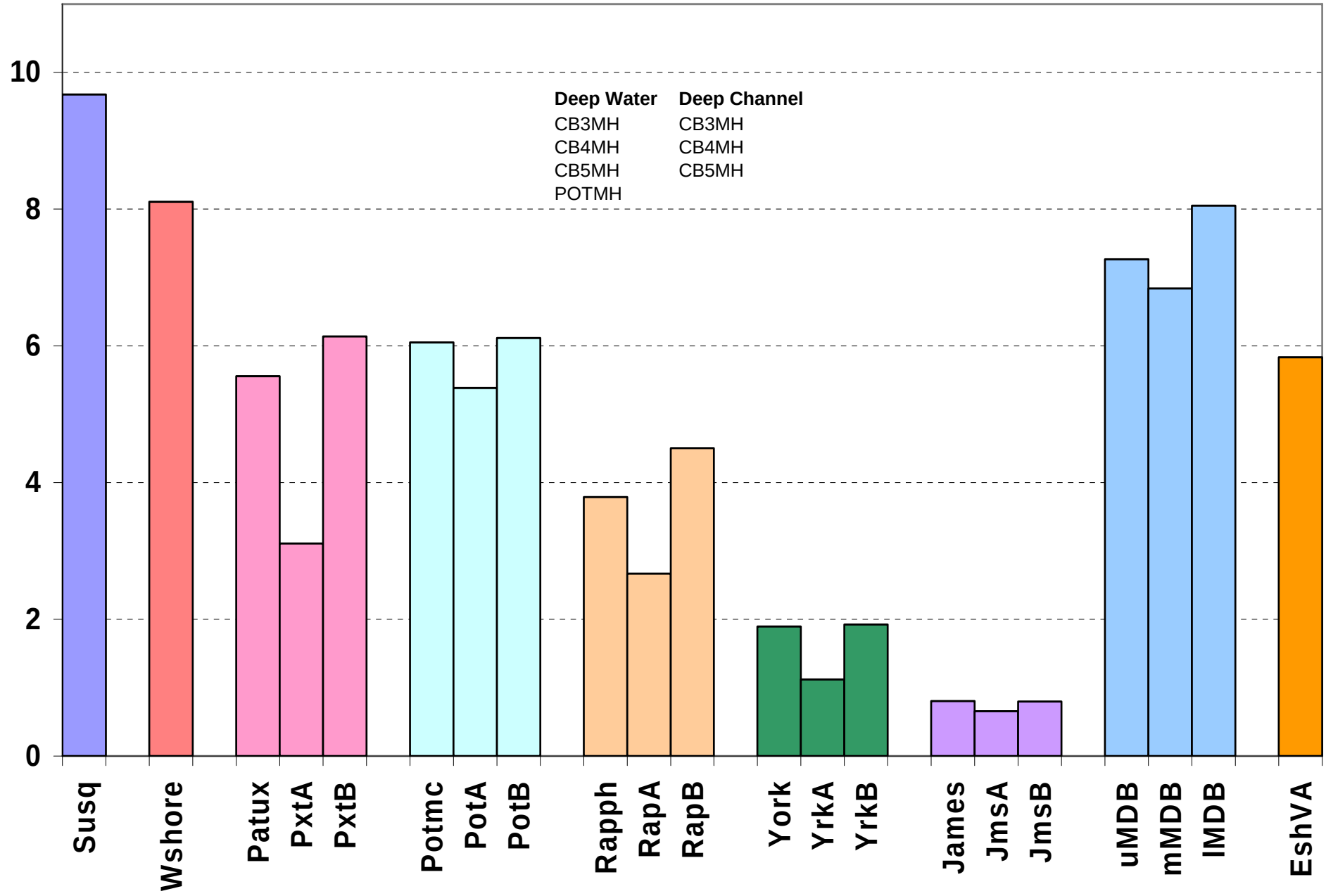
CB3 through CB5 DW

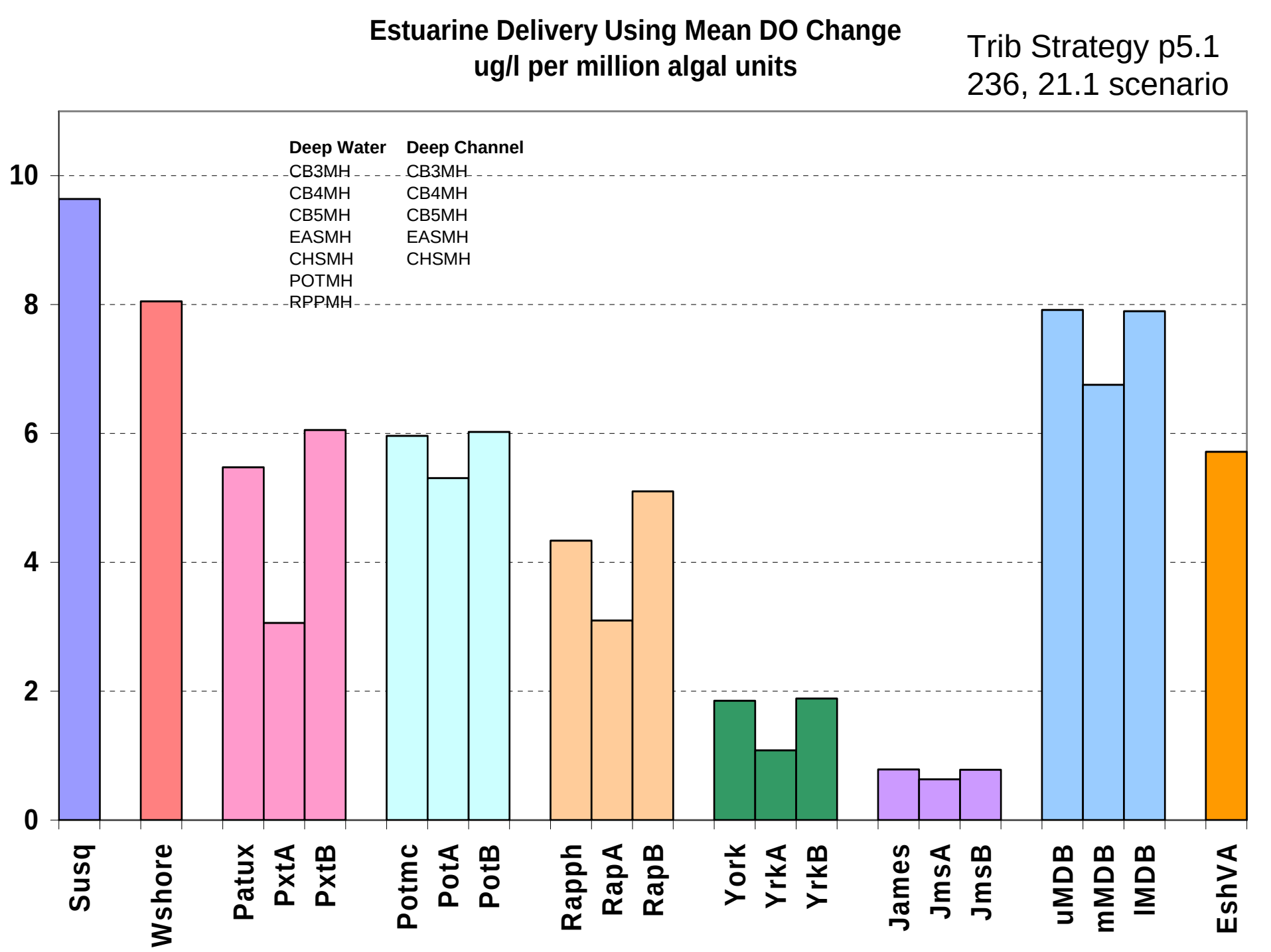


Estuarine Delivery Using Mean DO Change
ug/l per million algal units



Estuarine Delivery Using Mean DO Change
ug/l per million algal units




Estuarine Delivery Using Mean DO Change
ug/l per million algal units
Trib Strategy p5.1
236, 21.1 scenario
Deep Water
CB3MH
CB4MH
CB5MH
EASMH
CHSMH
POTMH
RPPMH
Deep Channel
CB3MH
CB4MH
CB5MH
EASMH
CHSMH
10
8
6
4
2
0
Susq
Wshore
Patux
PxtA
PxtB
Potmc
PotA
PotB
Rapph
RapA
RapB
York
YrkA
YrkB
James
JmsA
JmsB
uMDB
mMDB
lMDB
EshVA

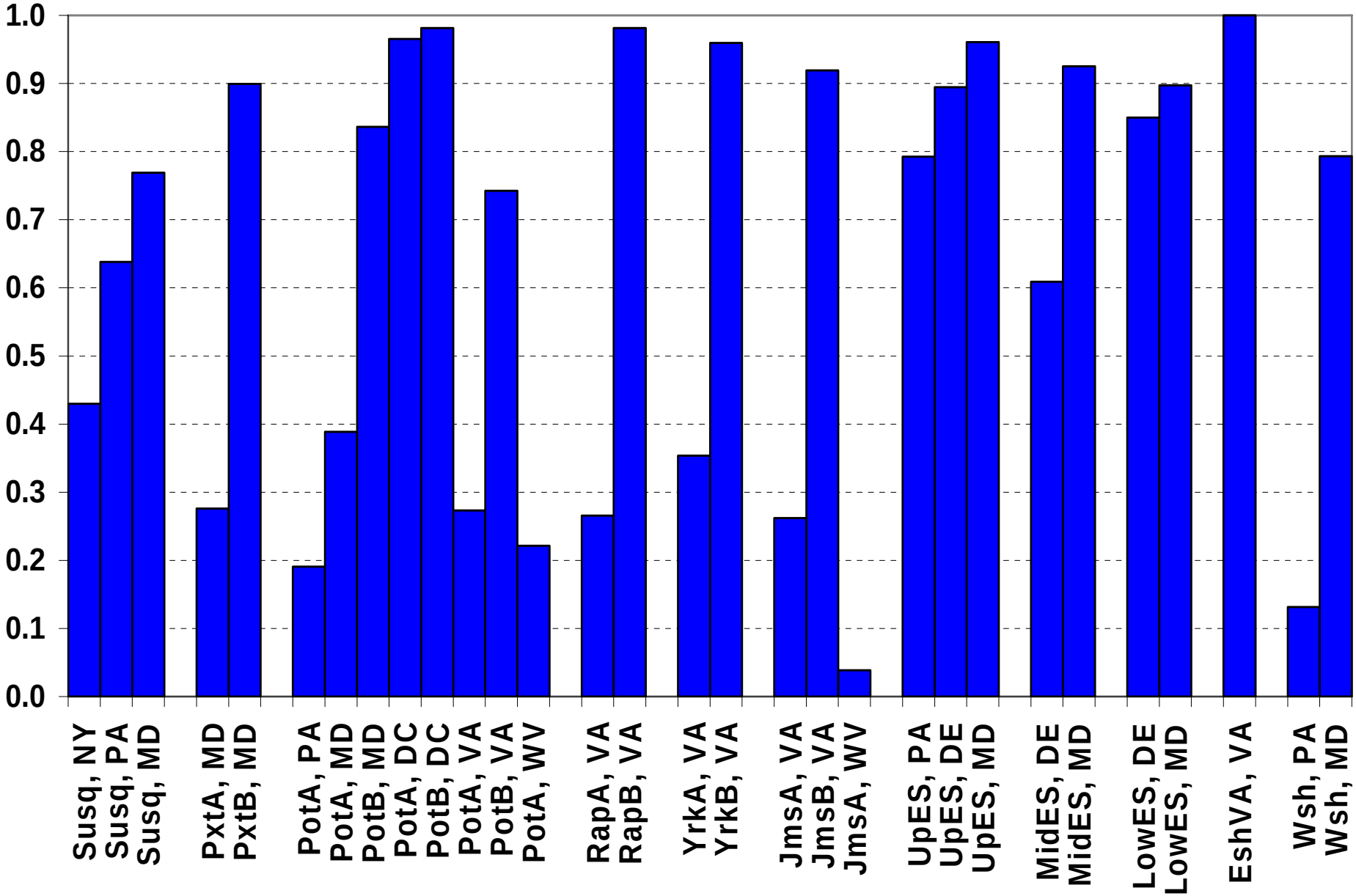
Geography

- Recommendation
  - Use CB3MH, CB4MH, and CB5MH, for DW and DC, plus POTMH for DW
  - Most impaired segments
  - Centrally located
  - Large group of segments (7)
  - Final allocation decisions are not particularly sensitive to this choice

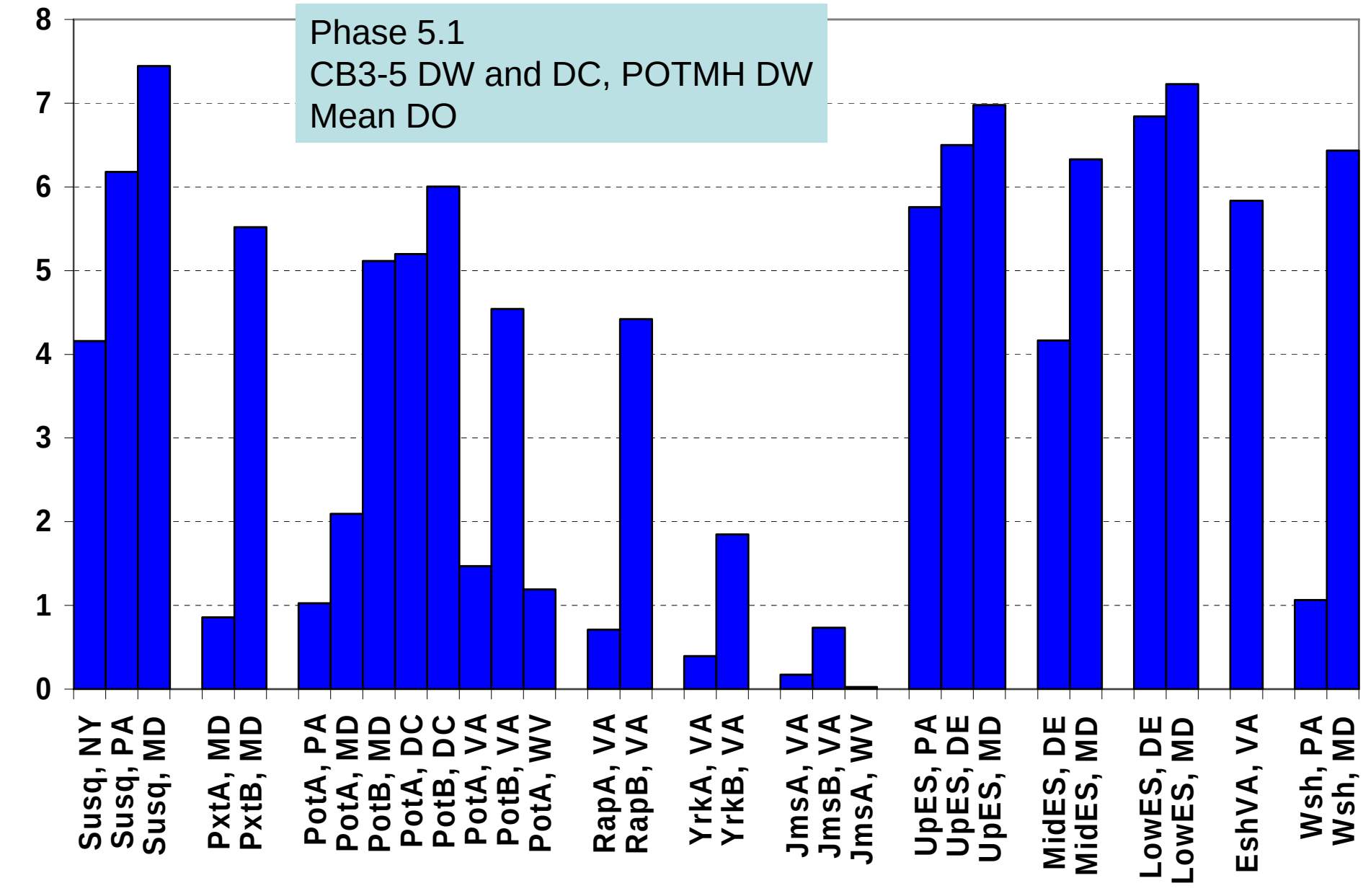
Example

- CB3-5 DW and DC plus POTMH DW
- Mean DO
- AFL/BFL
- Made up slope

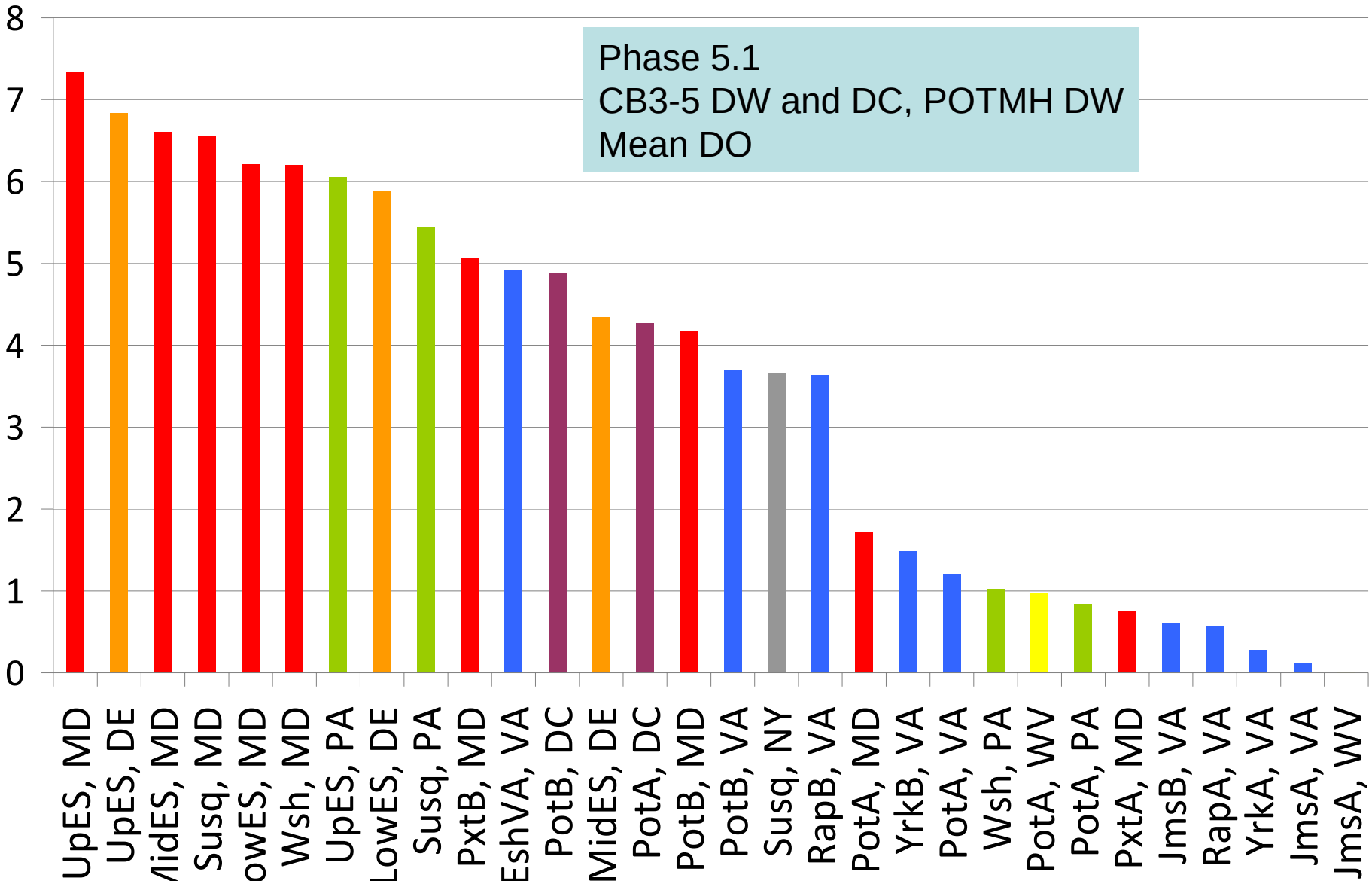
TN Delivery Factors, Phase 5.1

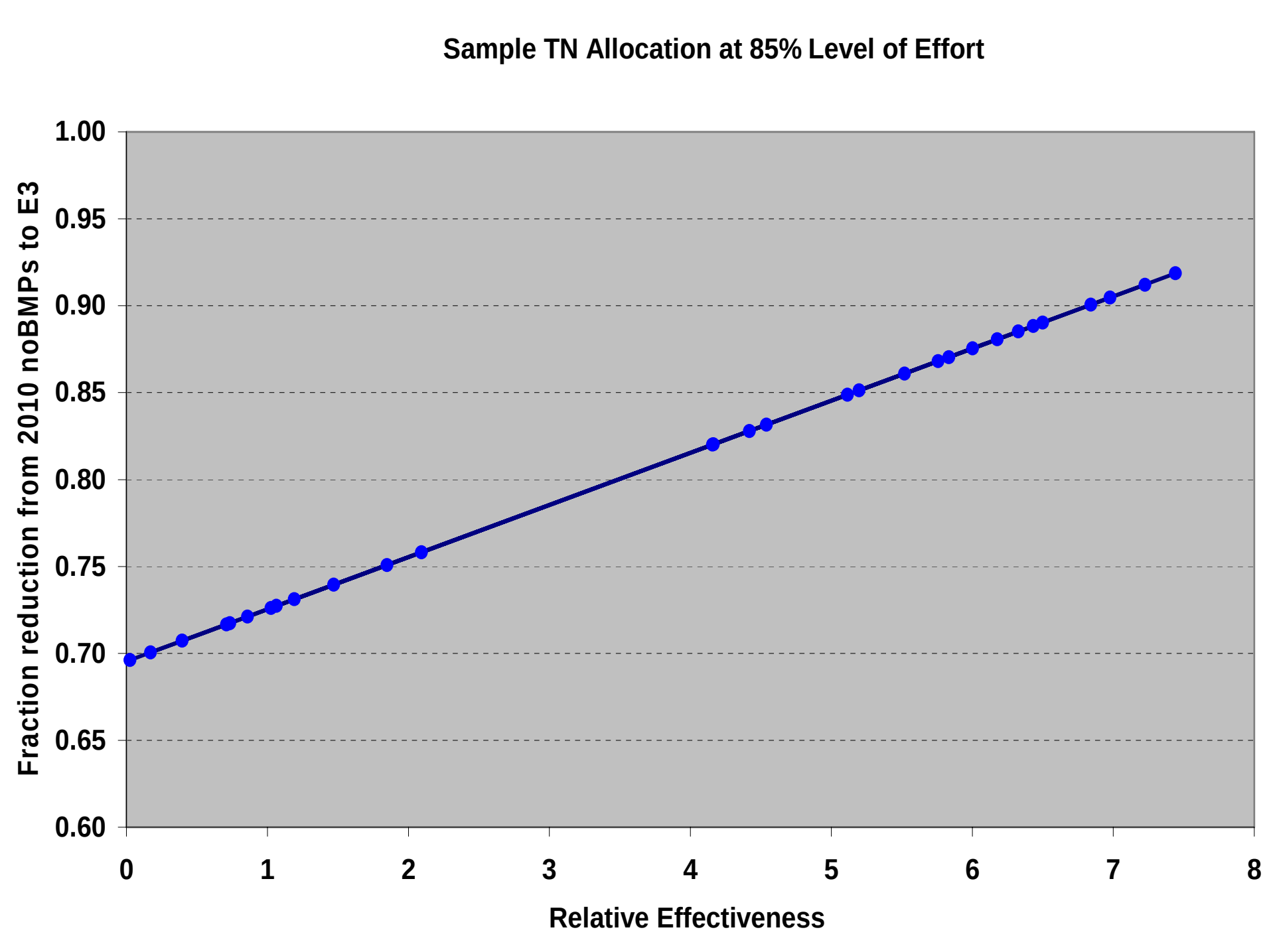


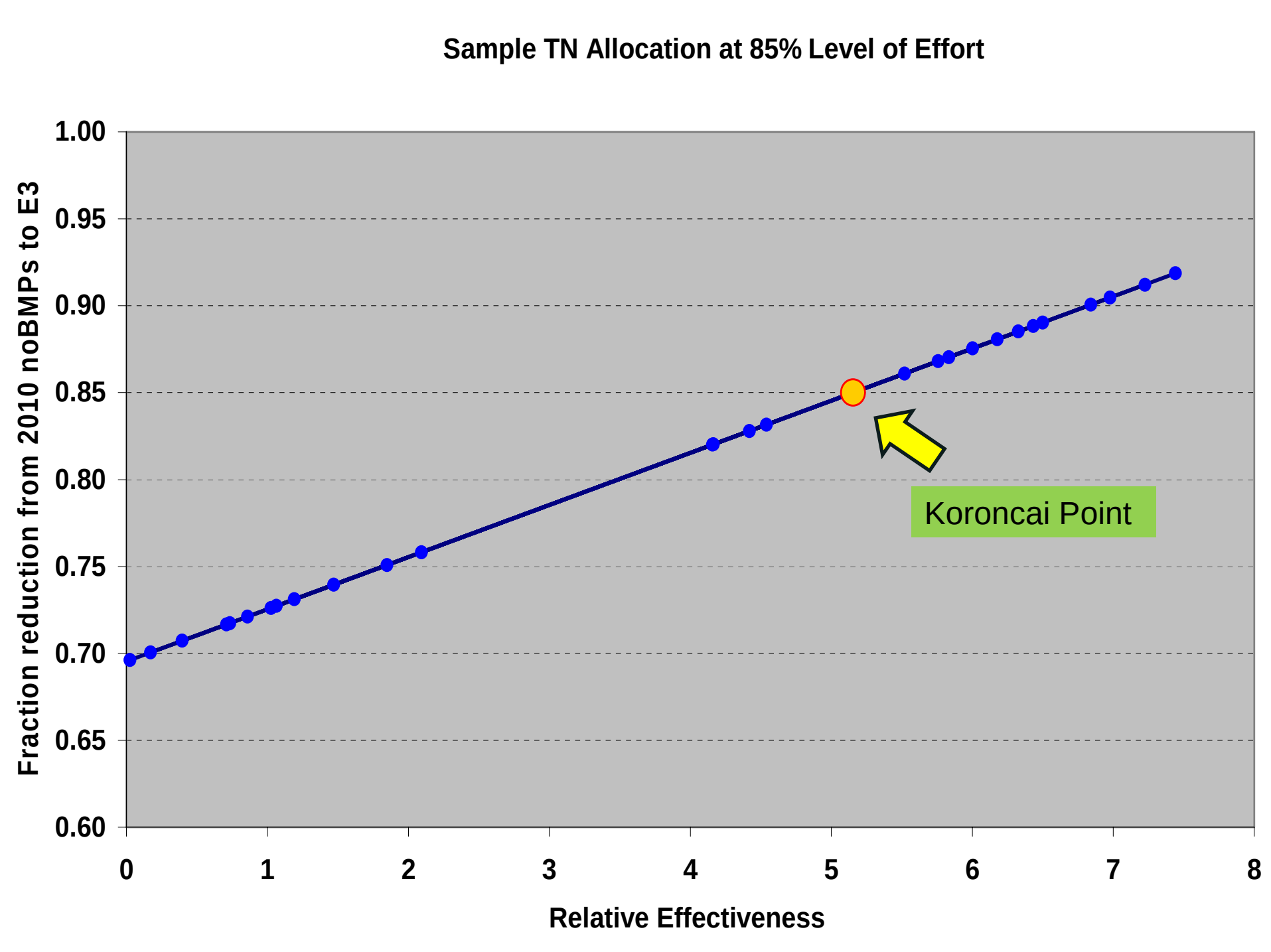
TN Relative Effectiveness



Relative effectiveness (Riverine * Estuarine Delivery)




Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
1
2
3
4
5
6
7
8
Relative Effectiveness


Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
1
2
3
4
5
6
7
8
Relative Effectiveness
Koroncai Point

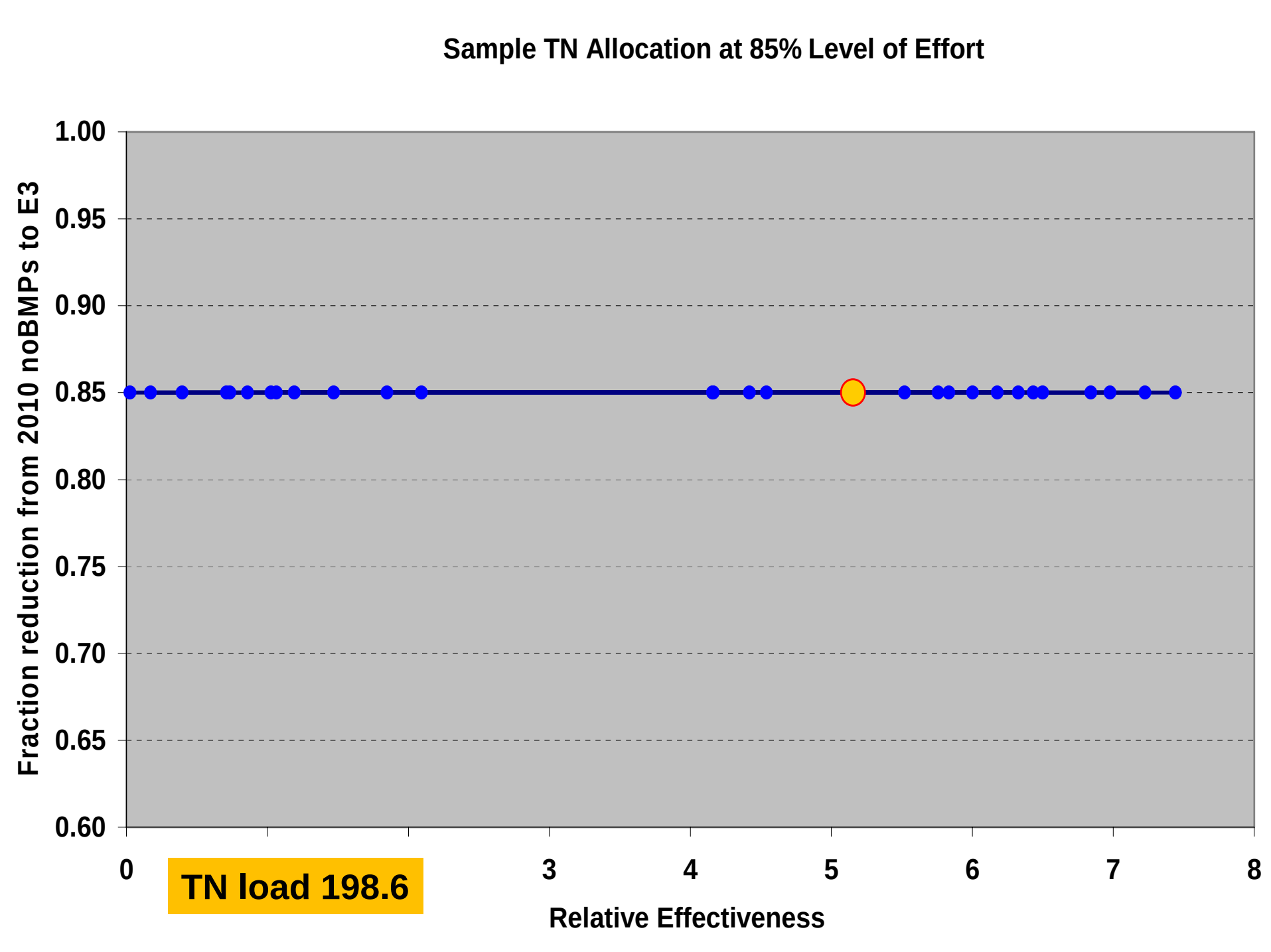
Pivot Point

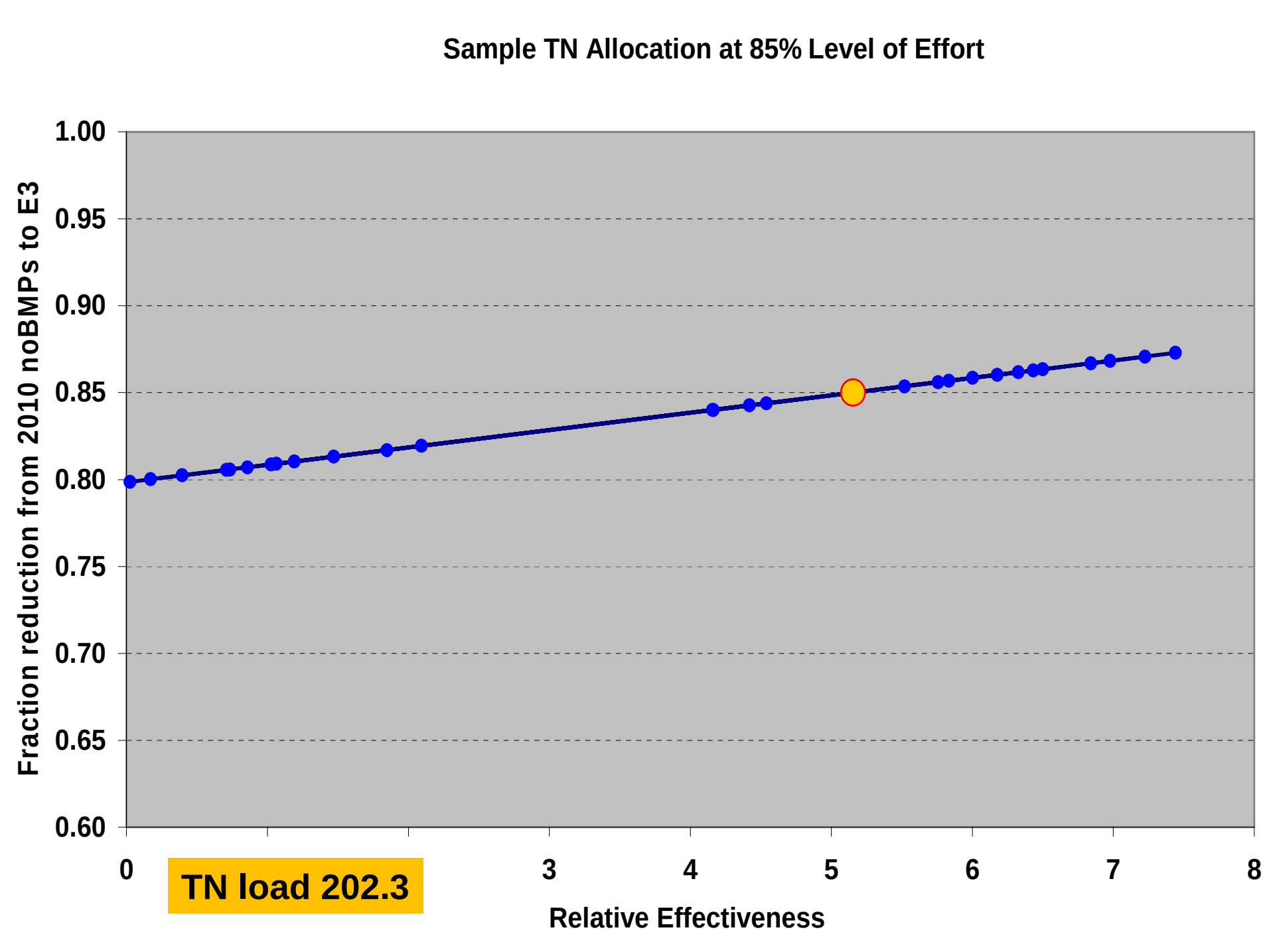
- Pivoting the line about the Koroncai point results in equivalent water quality, but changes the relative effort for higher and lower relative score basins

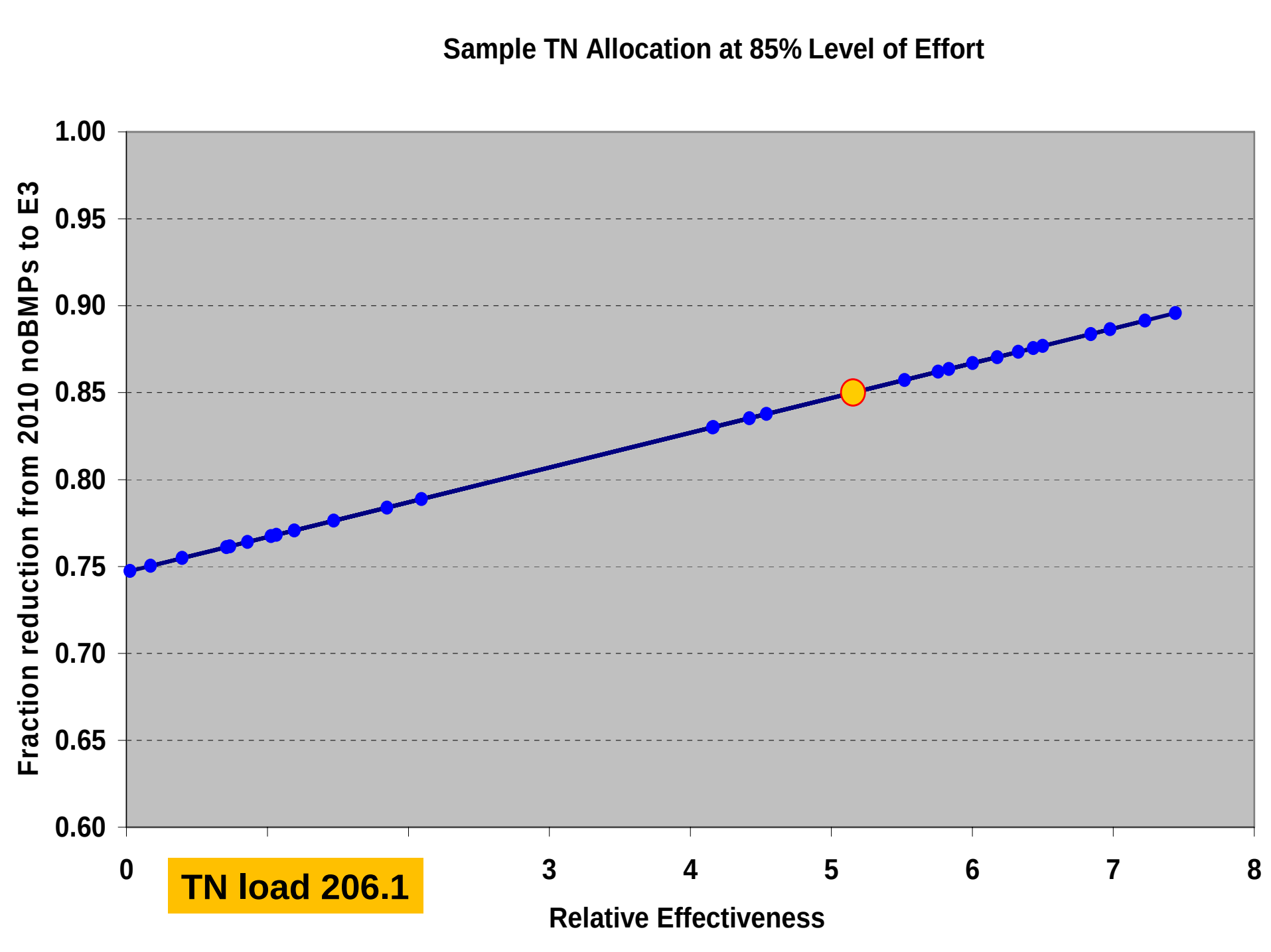
$$\sum\left(DeliveredLoad\right)\times\left(EstuarineDelivery\right)=C$$

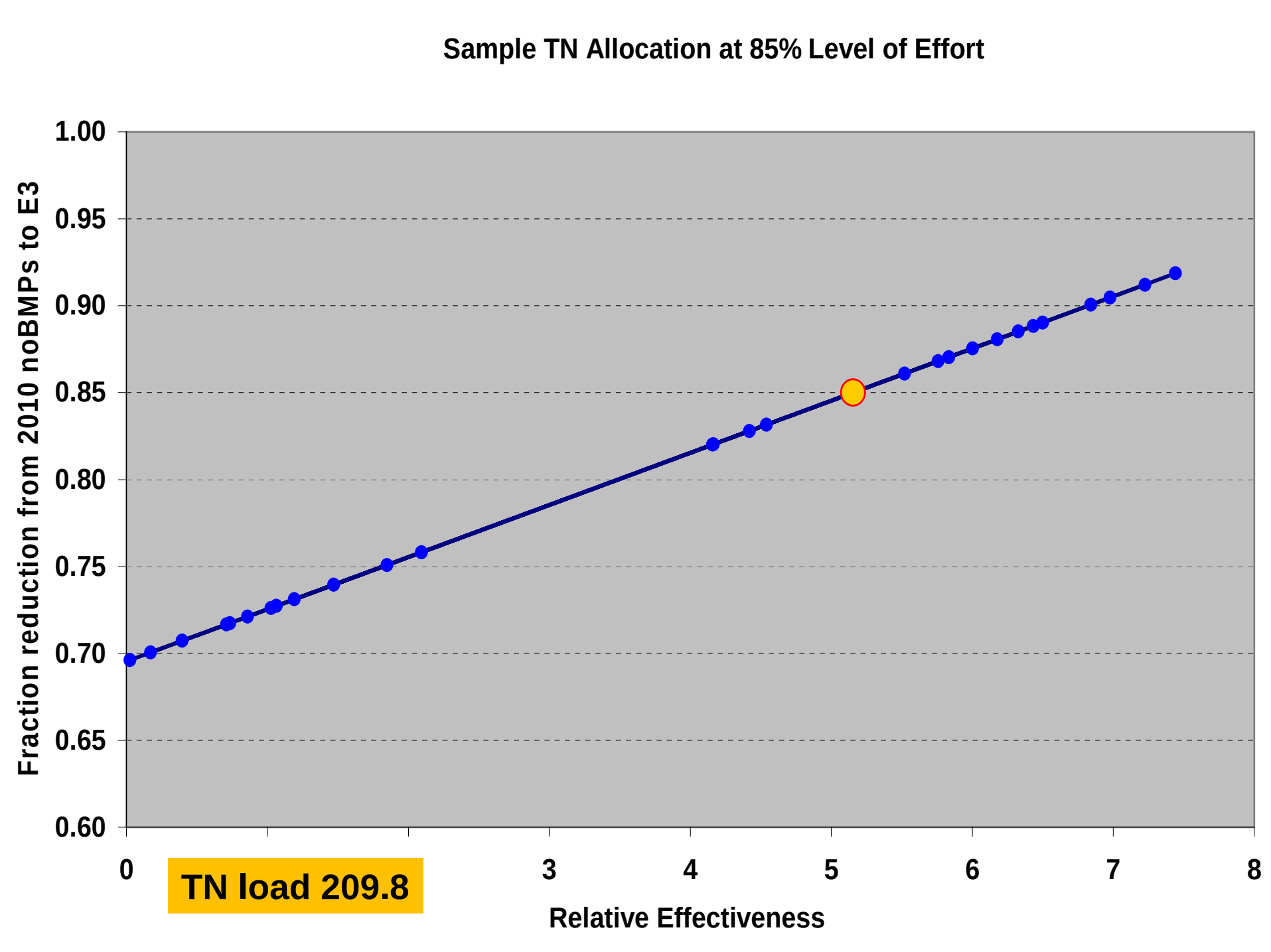
- Delivered Algal Units * Oxygen per AU = Oxygen

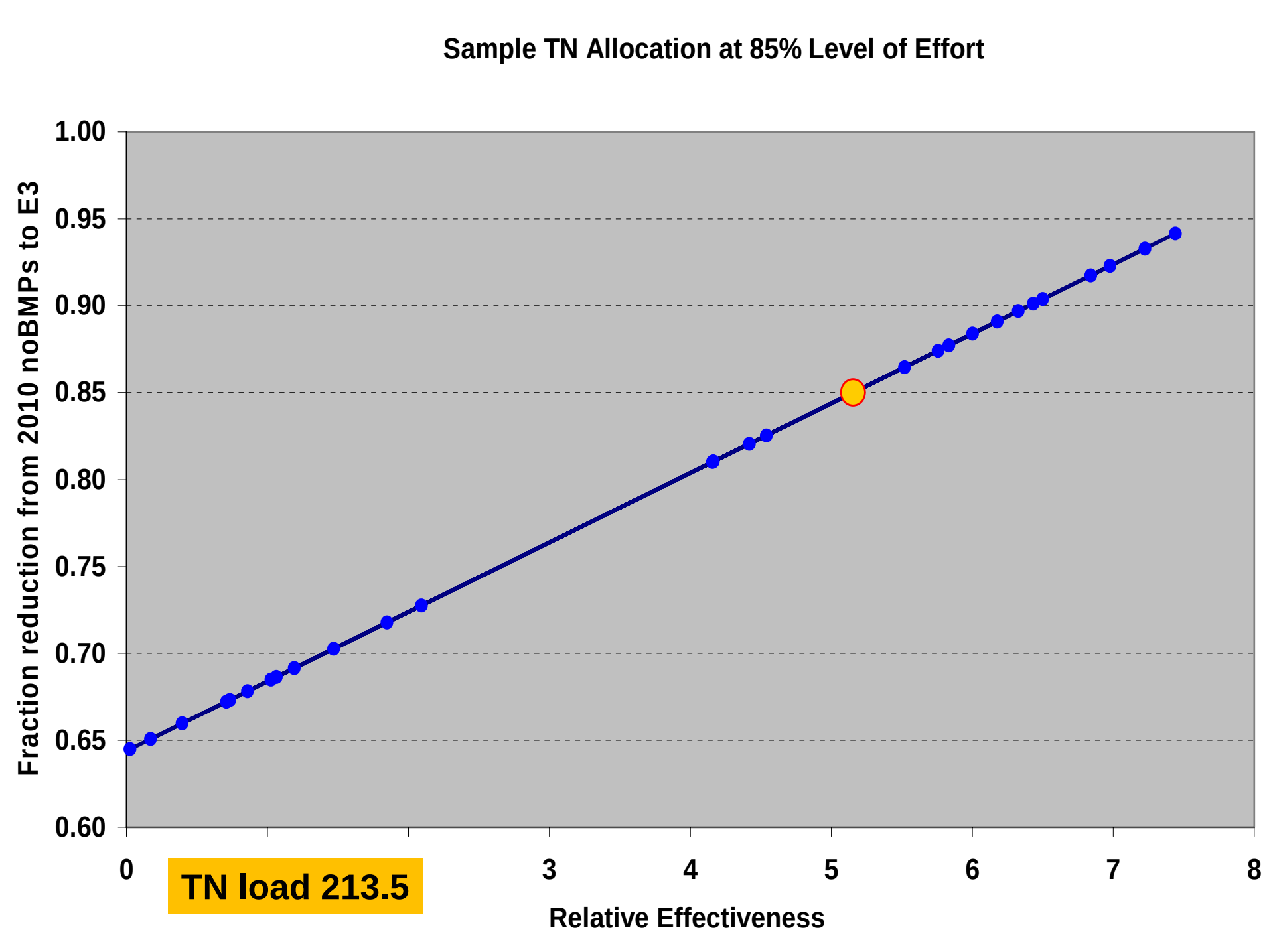
$$\sum\left(E3_i+\left(NoBMP_i-E3_i\right)\left(1-mX_i-b\right)\right)EstuarineDelivery_i=C$$

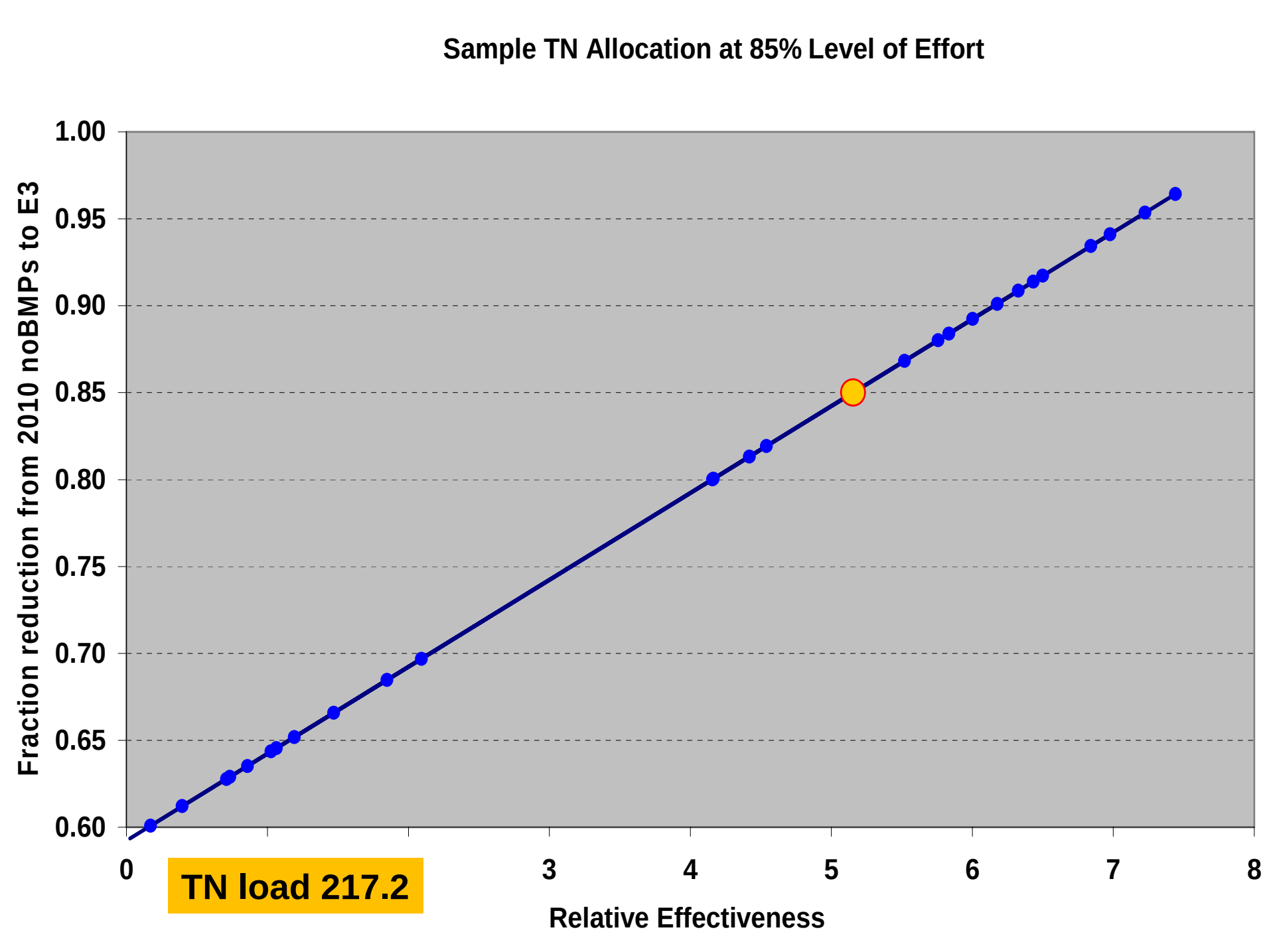

Sample TN Allocation at 85% Level of Effort
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Fraction reduction from 2010 noBMPs to E3
0
3
4
5
6
7
8
Relative Effectiveness
TN load 198.6


Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
3
4
5
6
7
8
TN load 202.3
Relative Effectiveness


Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
3
4
5
6
7
8
TN load 206.1
Relative Effectiveness


Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
3
4
5
6
7
8
TN load 209.8
Relative Effectiveness


Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
3
4
5
6
7
8
TN load 213.5
Relative Effectiveness

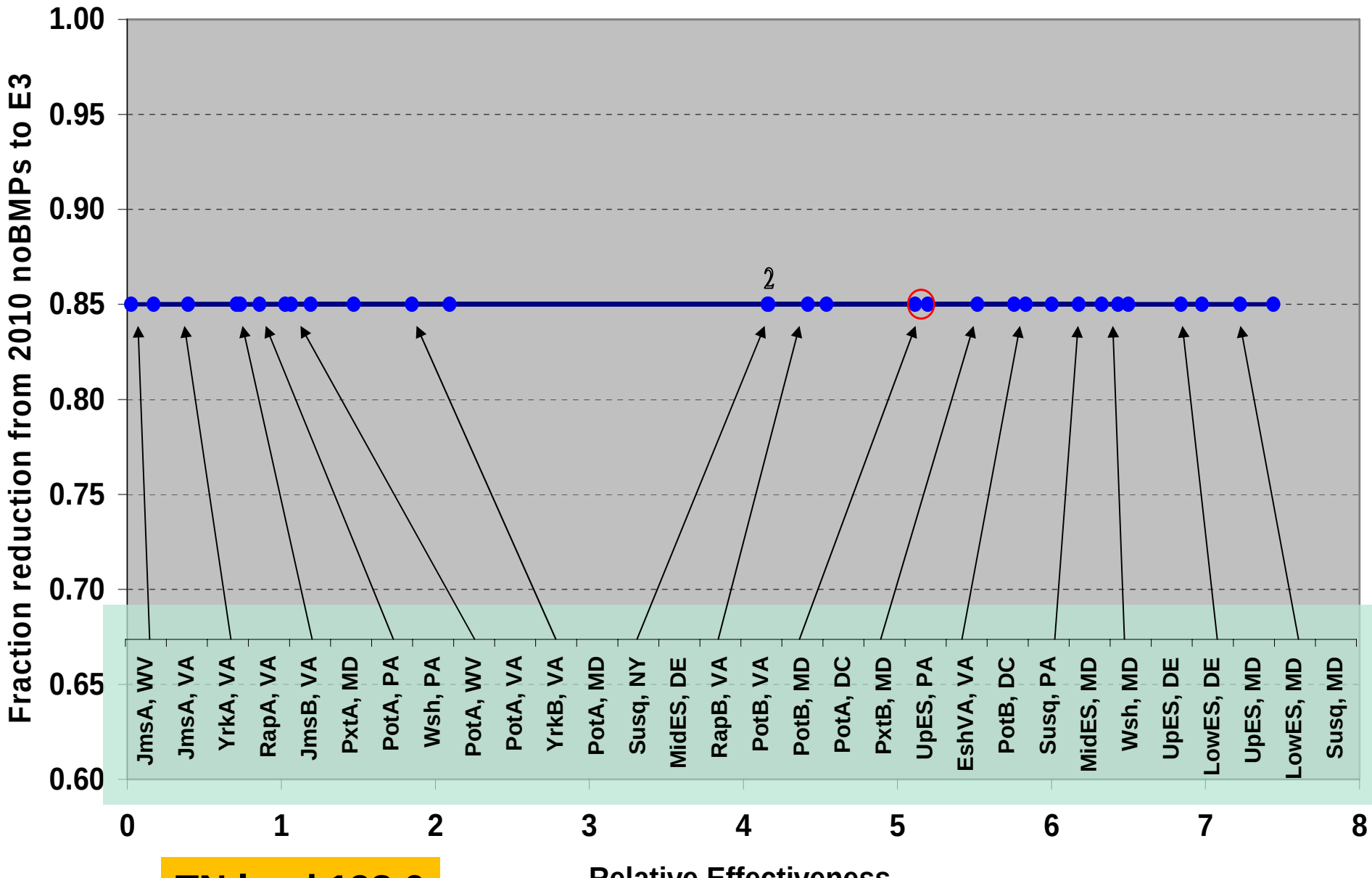

Sample TN Allocation at 85% Level of Effort
Fraction reduction from 2010 noBMPs to E3
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0
3
4
5
6
7
8
TN load 217.2
Relative Effectiveness

A Few Allocation Scenario

- 85% Level of Effort
  - Flat
  - Nothing Higher than 90% LOE
  - Nothing Higher than 95% LOE
- 90% Level of Effort
  - Flat
  - Nothing Higher than 93% LOE
  - Nothing Higher than 96% LOE
- TP

"Flat"

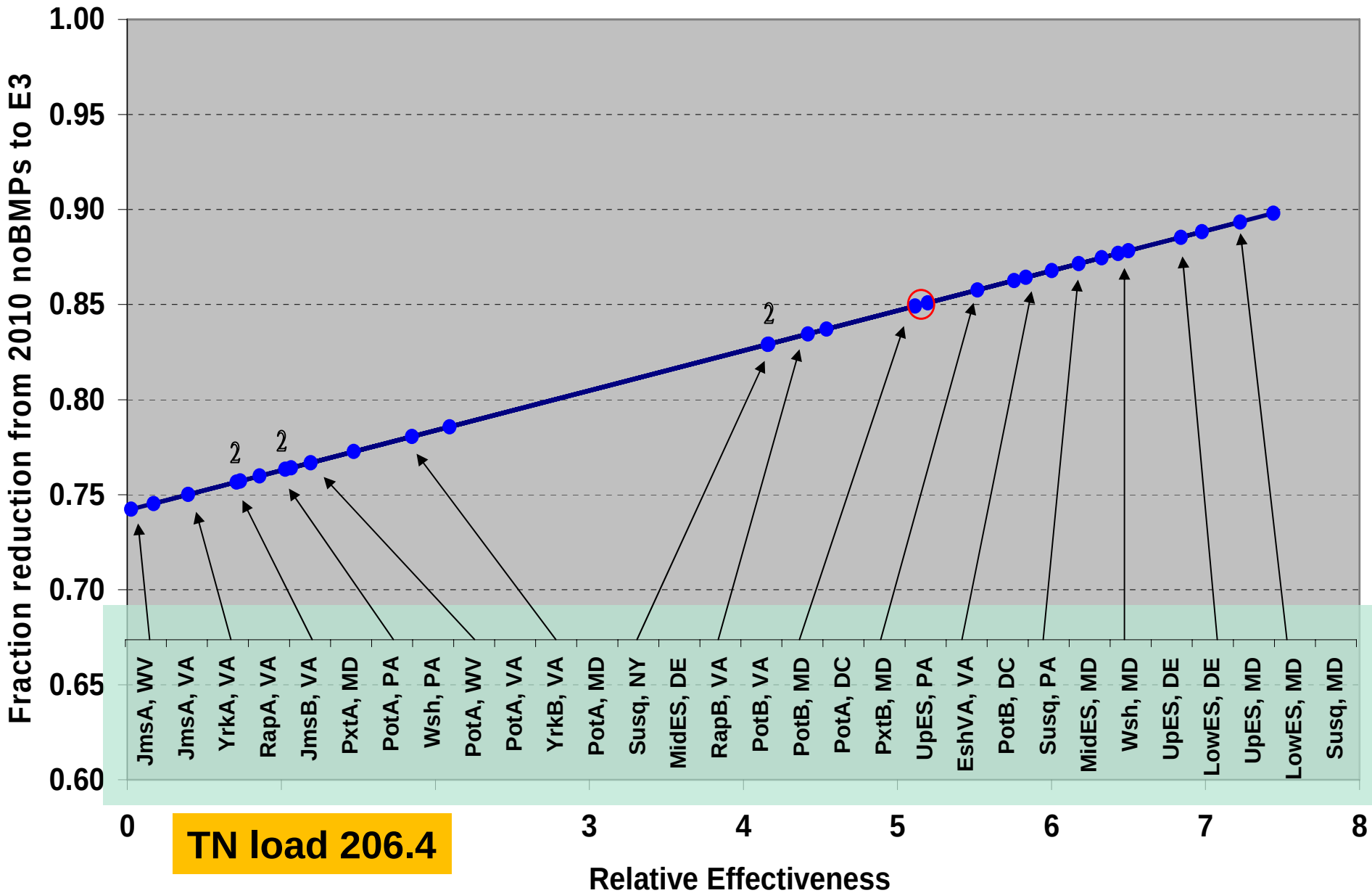
Sample TN Allocation at 85% Level of Effort



TN load 198.6

Nothing Over 90%

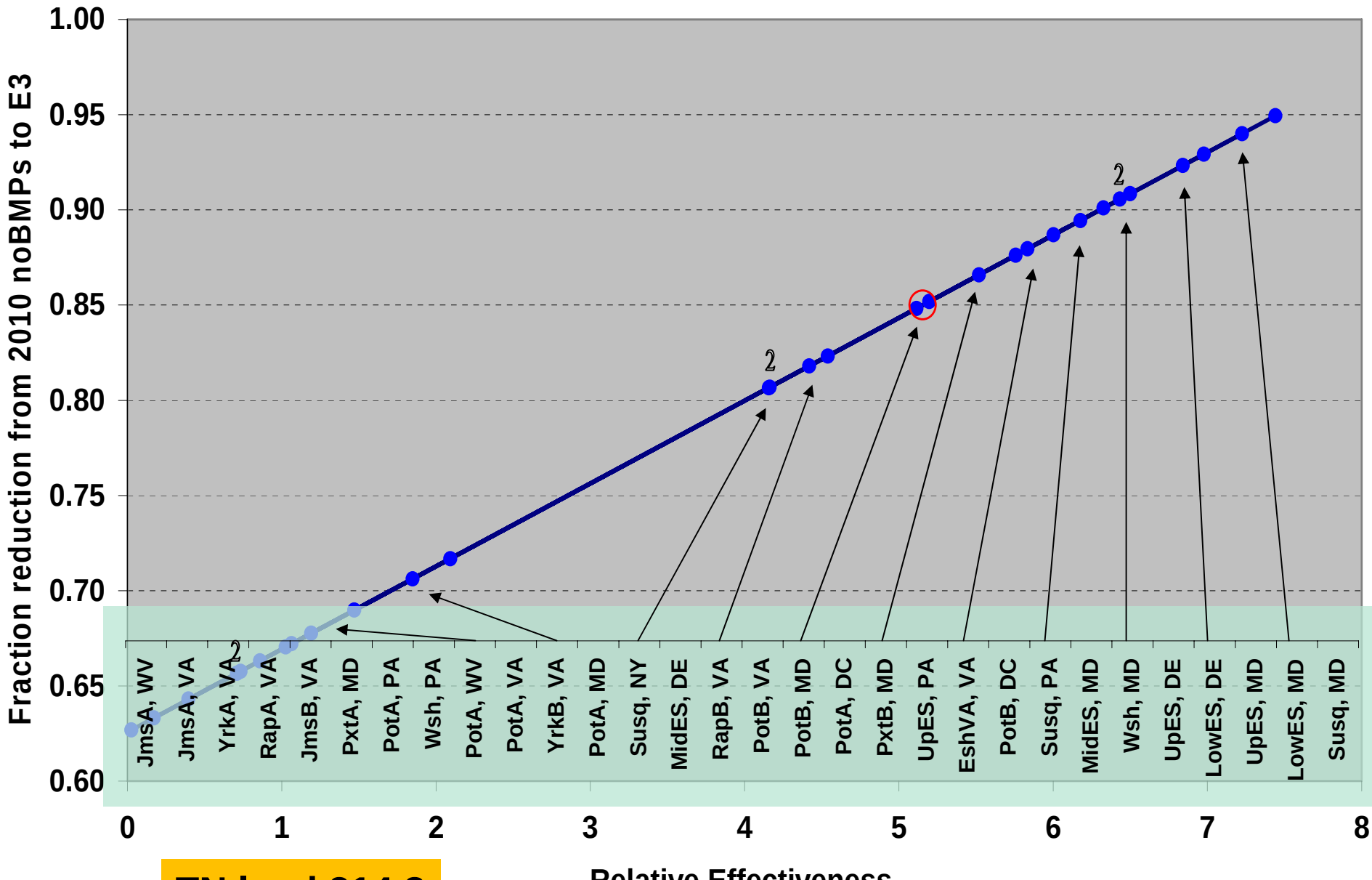
Sample TN Allocation at 85% Level of Effort



TN load 206.4

Nothing Over 95%

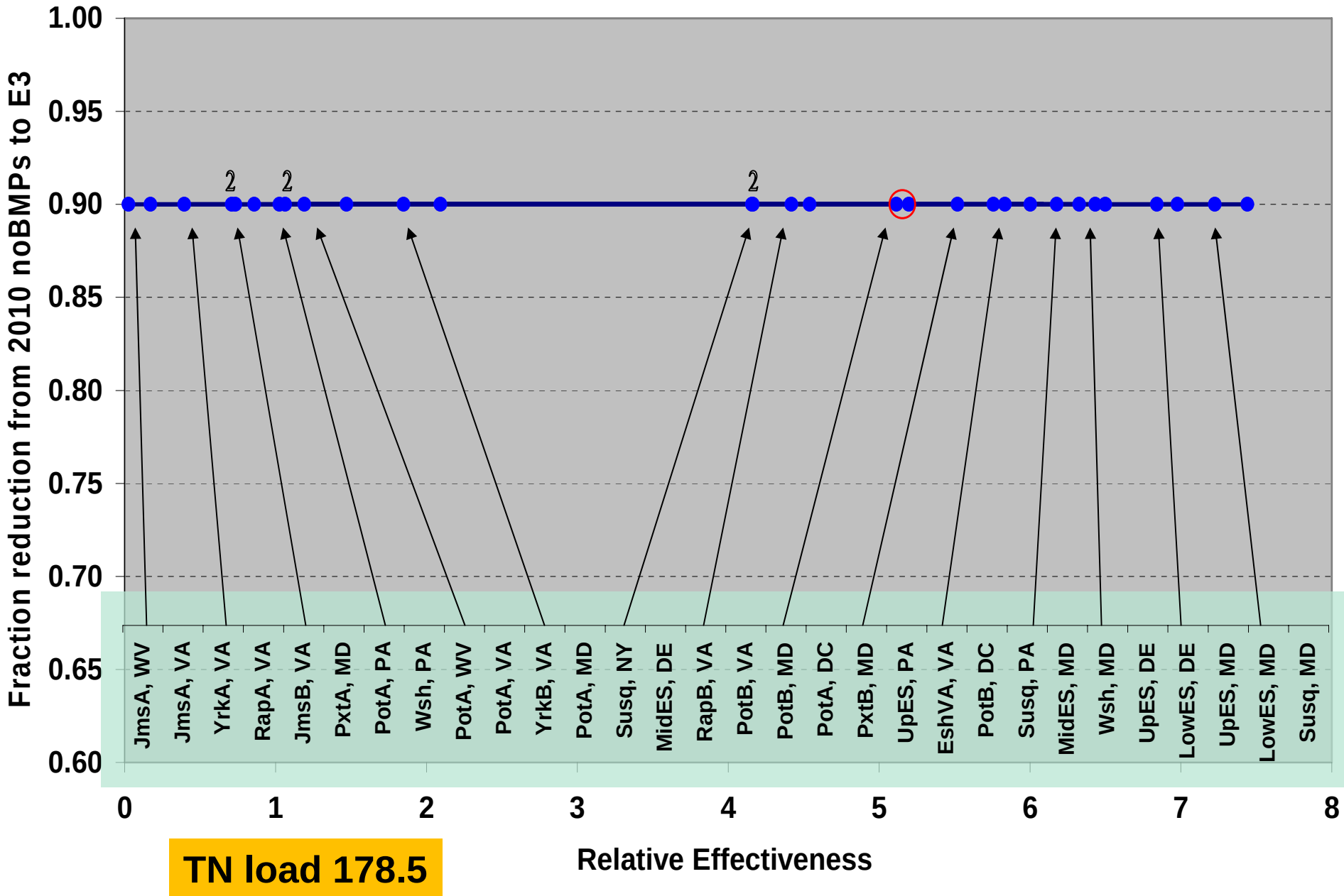
Sample TN Allocation at 85% Level of Effort



TN load 214.8

"Flat"

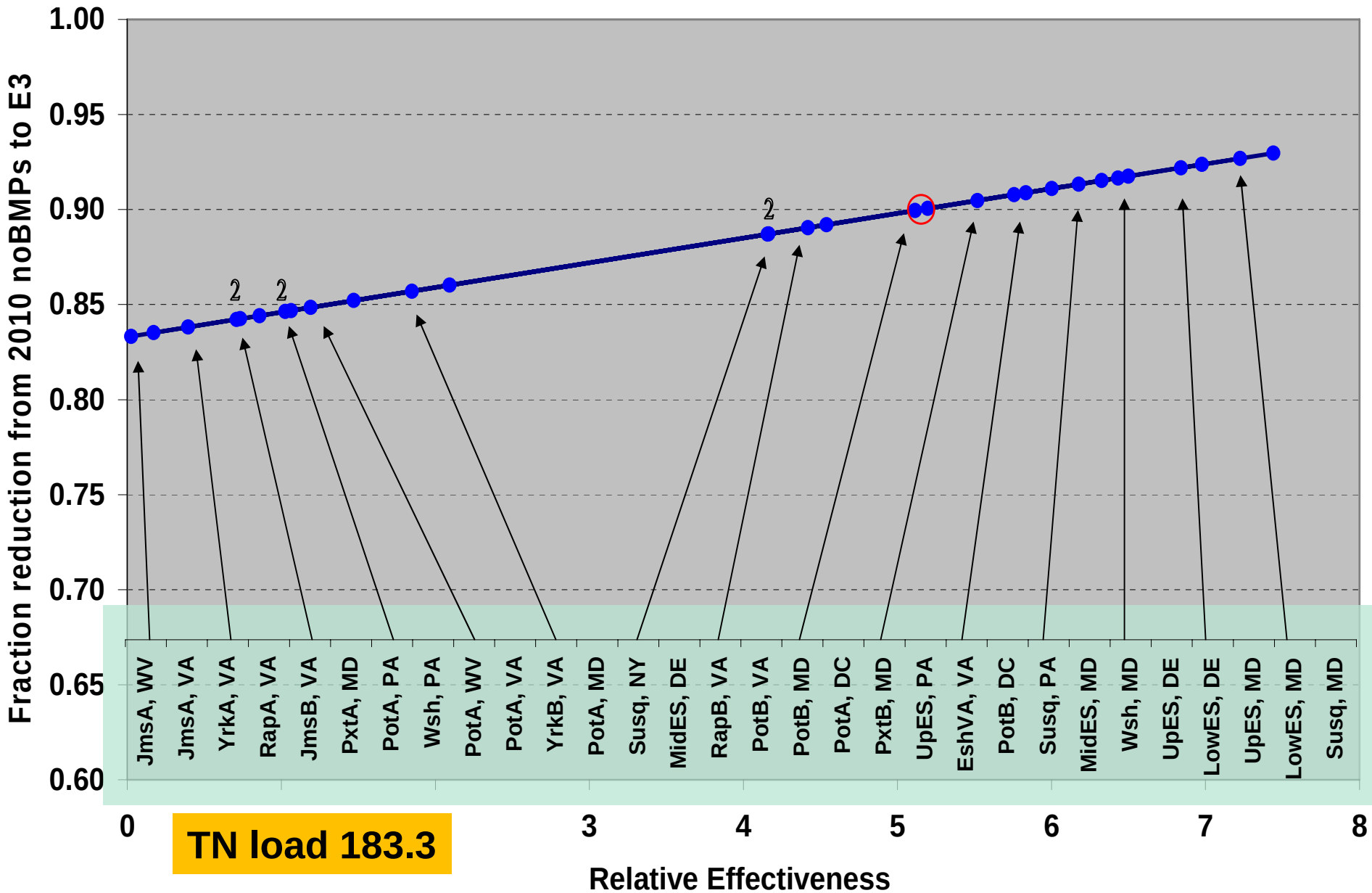
Sample TN Allocation at 90% Level of Effort



TN load 178.5

Nothing Over 93%

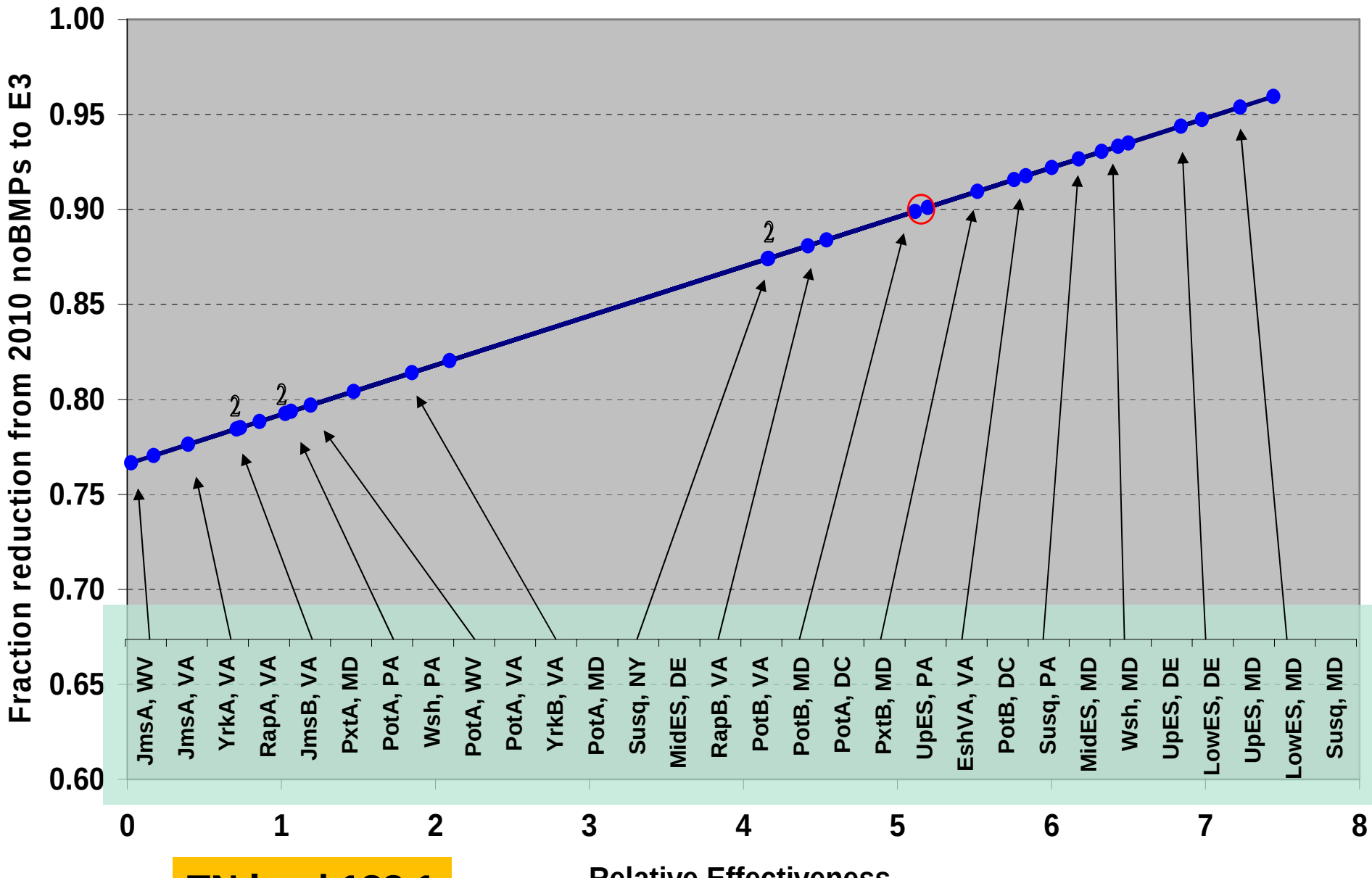
Sample TN Allocation at 90% Level of Effort



TN load 183.3

Nothing Over 96%

Sample TN Allocation at 90% Level of Effort



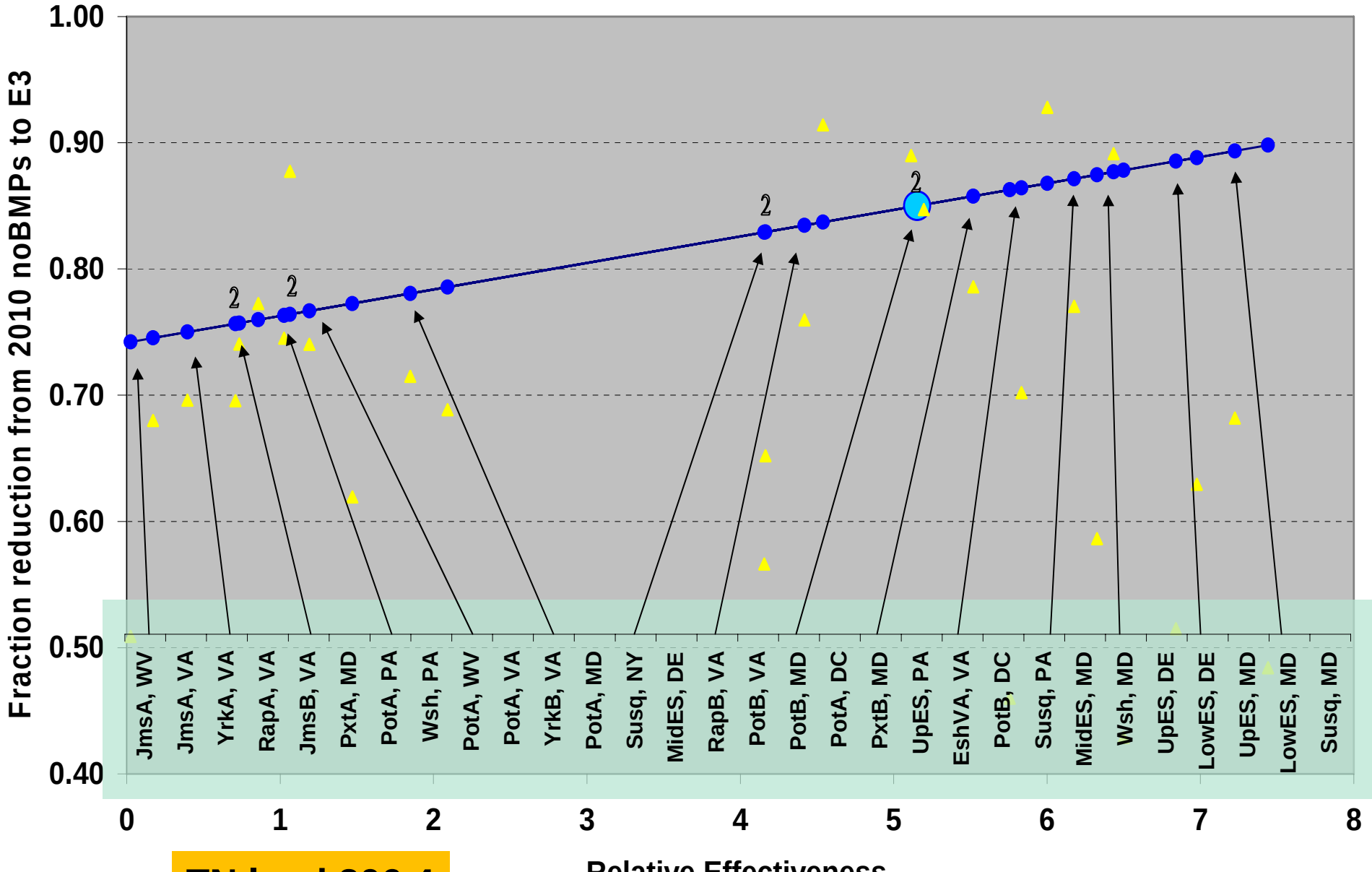
TN load 188.1

Allocations in relation to Scenarios

- Compared to current Trib Strategies
  - Problems with the phase5.1 trib strategy runs. Real loads are probably a little lower
- Compared to full voluntary or full regulatory

Nothing Over 90%

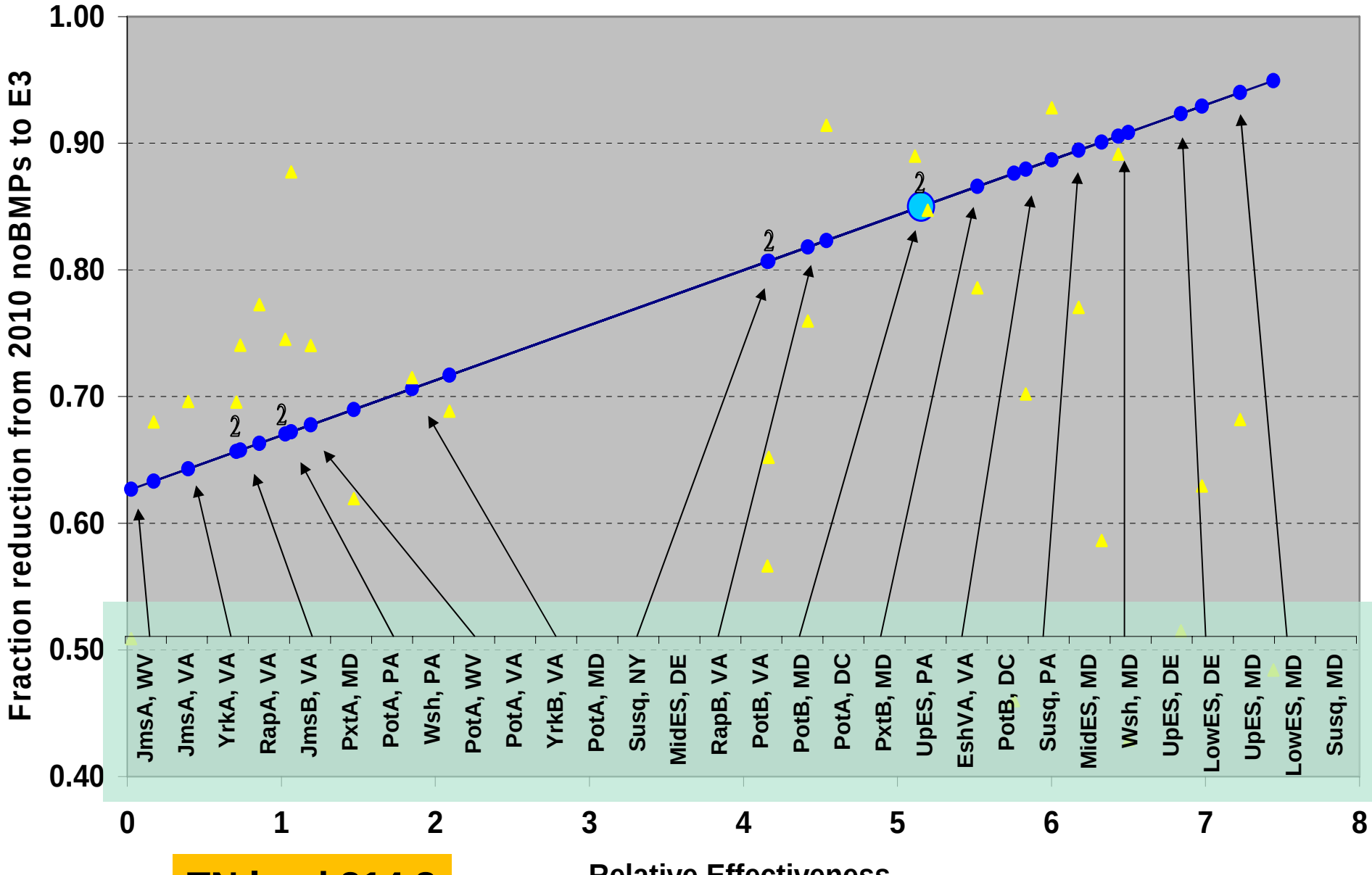
Sample Allocation at 85% Level of Effort



TN load 206.4

Nothing Over 95%

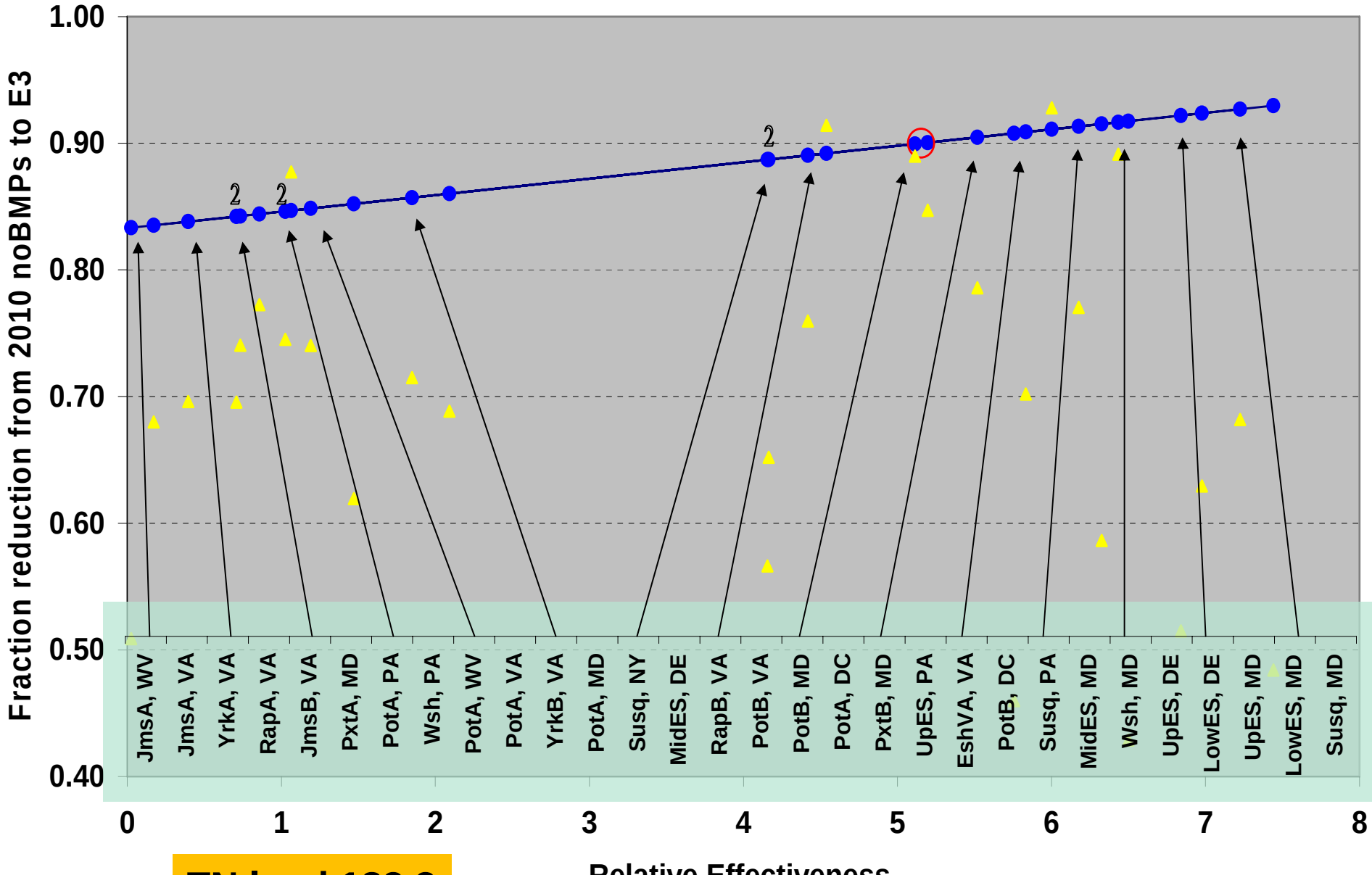
Sample Allocation at 85% Level of Effort



TN load 214.8

Nothing Over 93%

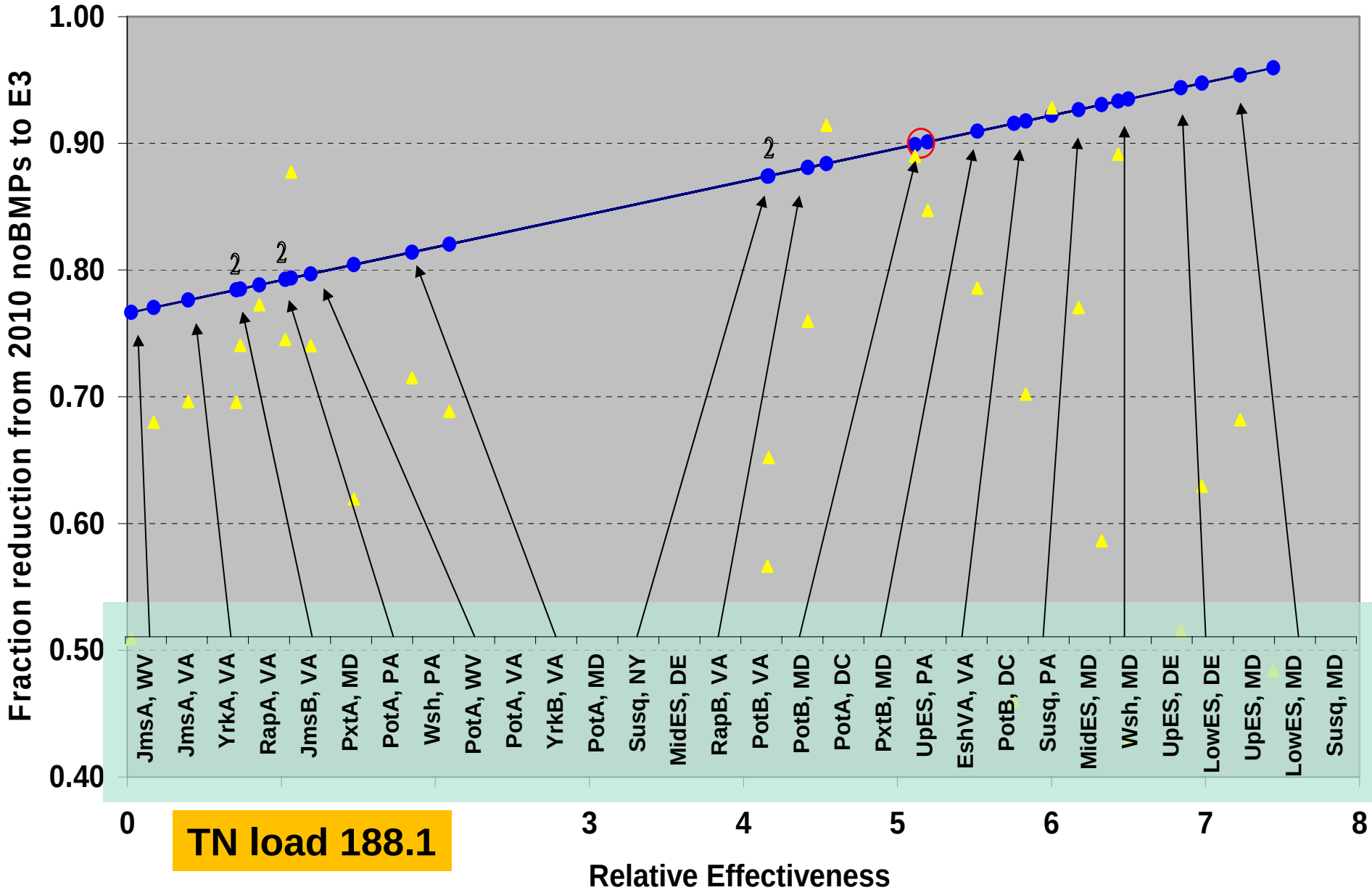
Sample Allocation at 90% Level of Effort



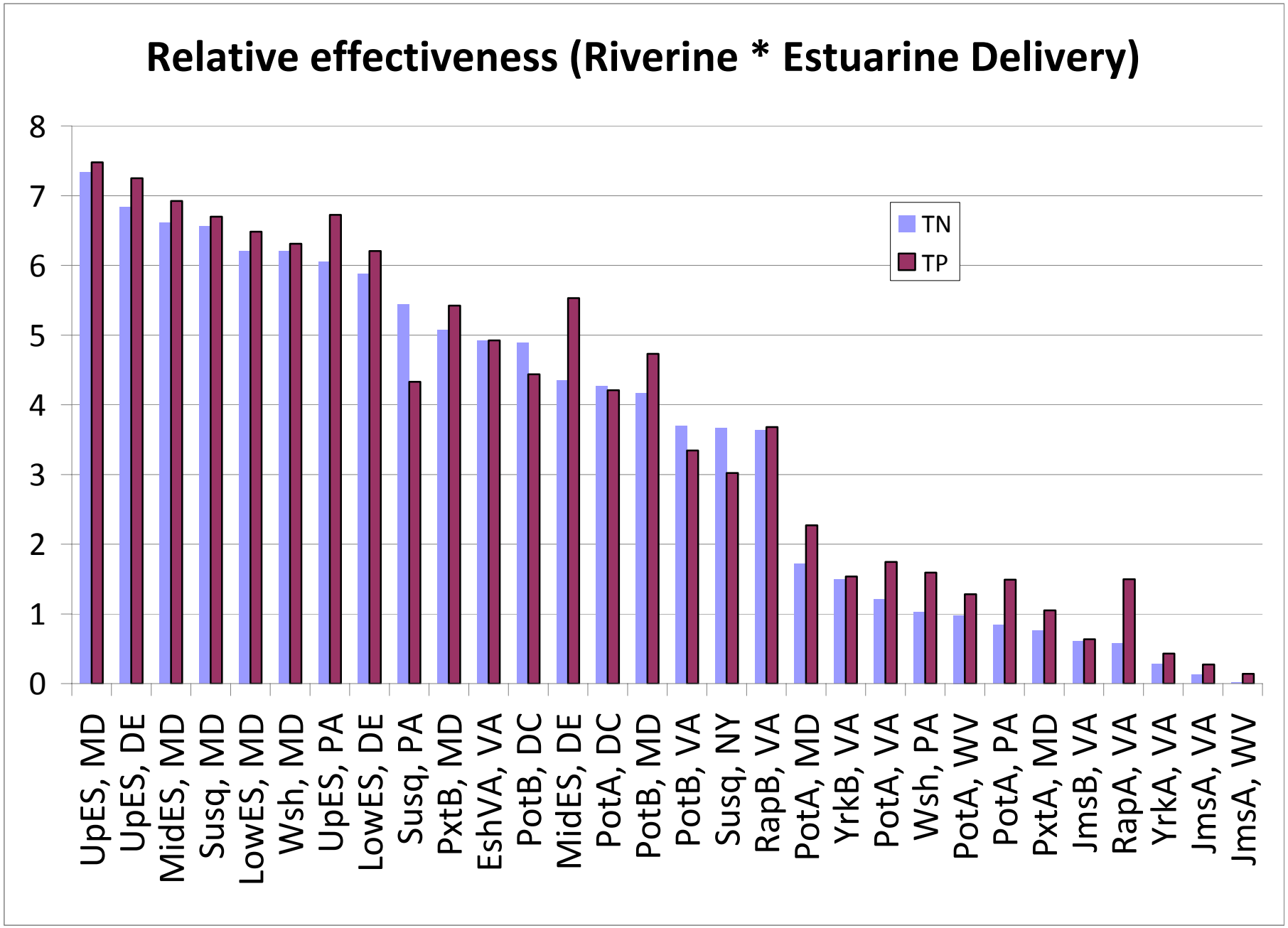
TN load 183.3

Nothing Over 96%

Sample Allocation at 90% Level of Effort



TN load 188.1

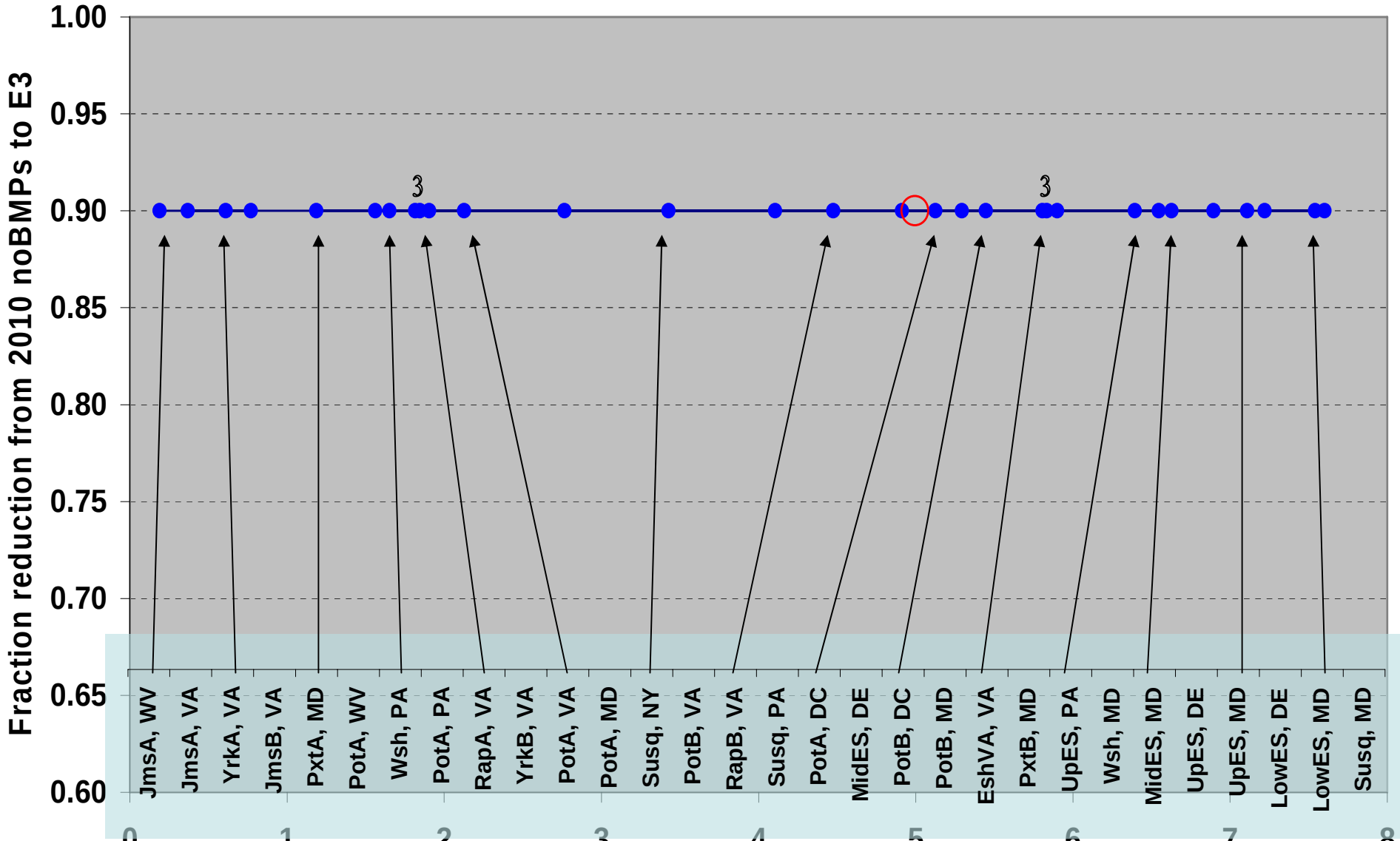

Relative effectiveness (Riverine * Estuarine Delivery)
8
7
6
5
4
3
2
1
0
TN
TP
UpES, MD
UpES, DE
MidES, MD
Susq, MD
LowES, MD
Wsh, MD
UpES, PA
LowES, DE
Susq, PA
PxtB, MD
EshVA, VA
PotB, DC
MidES, DE
PotA, DC
PotB, MD
PotB, VA
Susq, NY
RapB, VA
PotA, MD
YrkB, VA
PotA, VA
Wsh, PA
PotA, WV
PotA, PA
PxtA, MD
JmsB, VA
RapA, VA
YrkA, VA
JmsA, VA
JmsA, WV

Quick Look at TP

- 90% Level of Effort
  - Flat
  - Nothing Higher than 93% LOE
  - Nothing Higher than 96% LOE
- Comparison with TS

FLAT

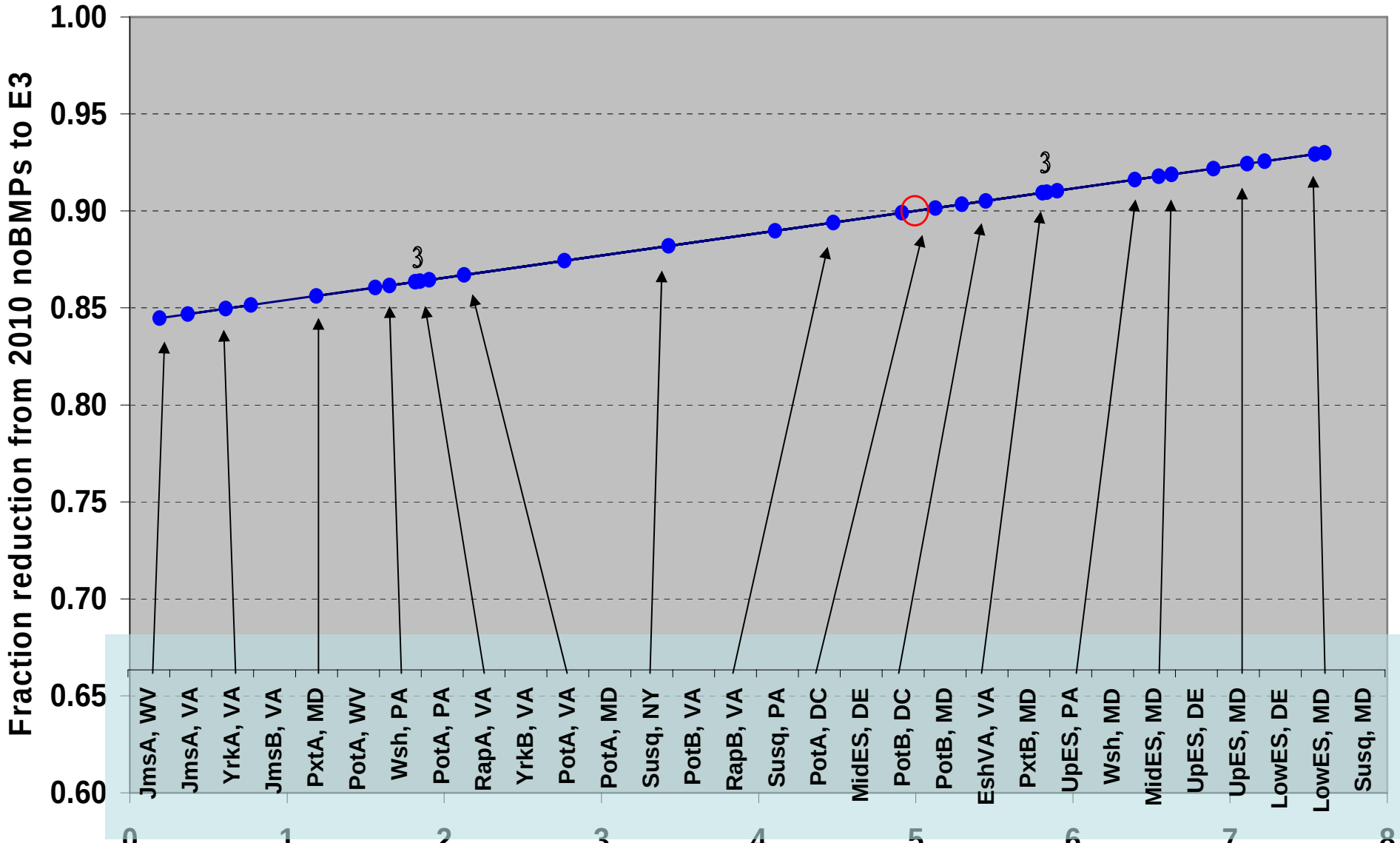
Sample Allocation at 90% Level of Effort



TP load 17.11

Nothing Over 93%

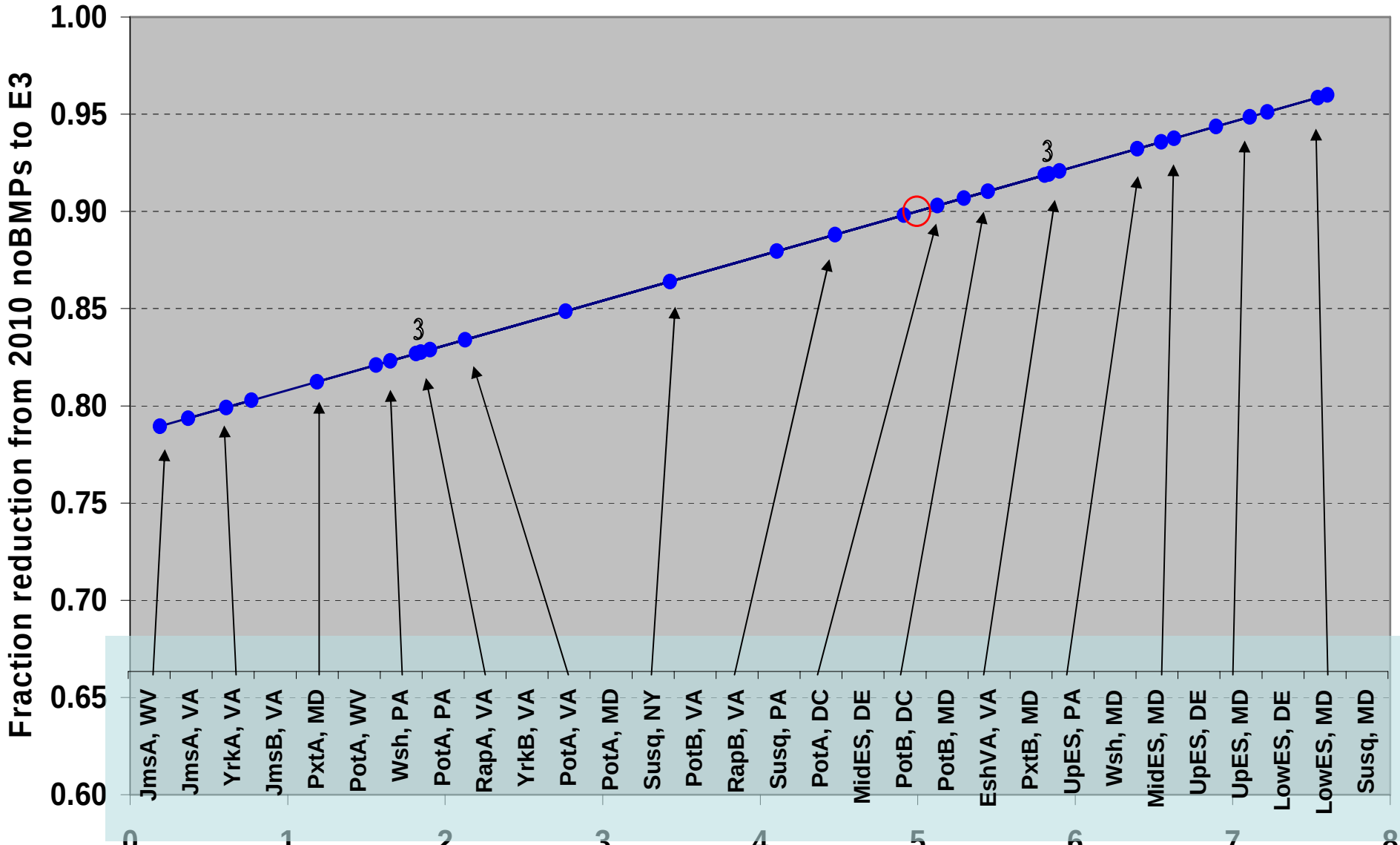
Sample Allocation at 90% Level of Effort



TP load 17.73

Nothing Over 96%

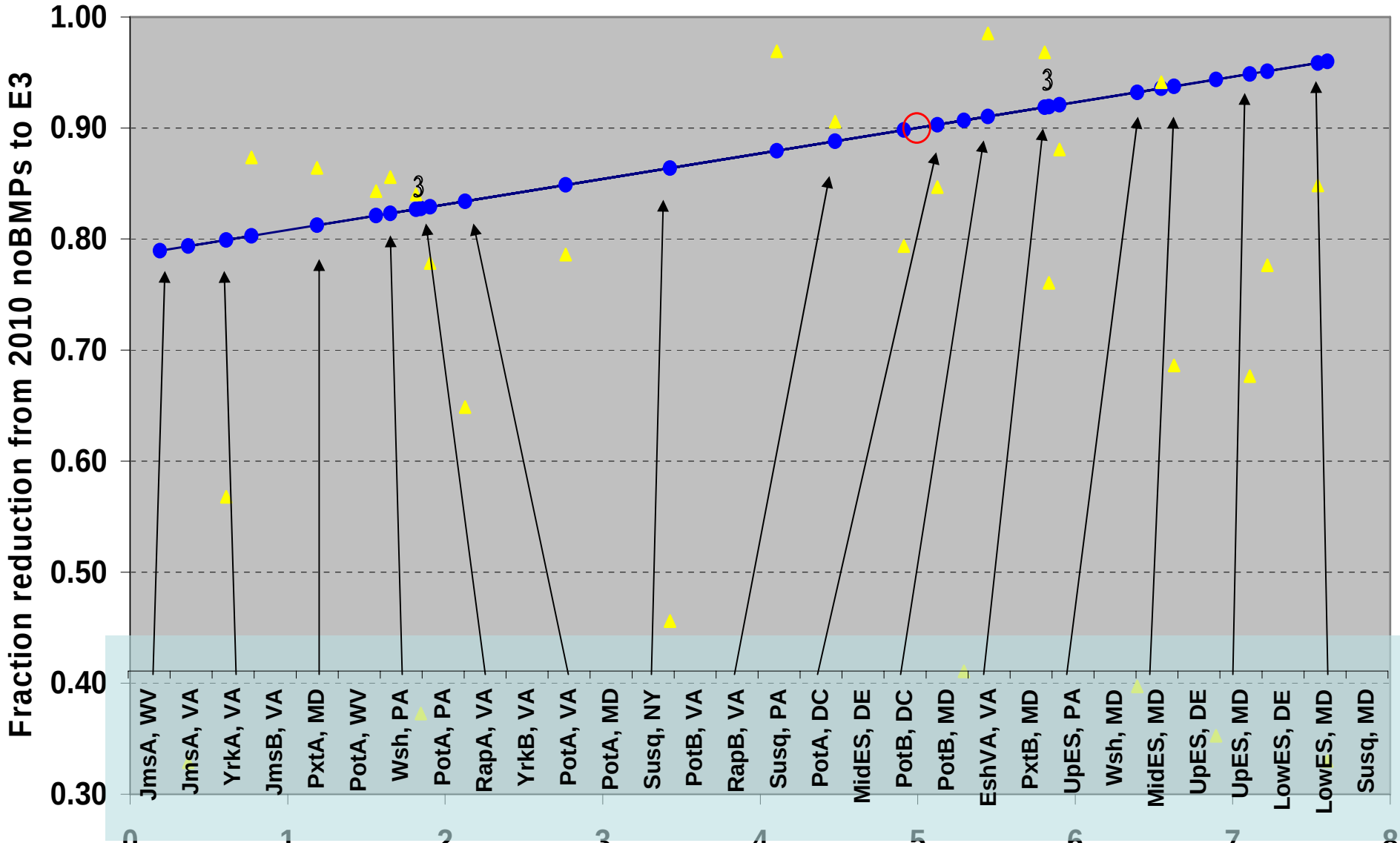
Sample Allocation at 90% Level of Effort



TP load 18.35

Nothing Over 96%

Sample Allocation at 90% Level of Effort



TP load 18.35

Once we have the final Phase 5.2 and WQST Models we'll be able to do more sophisticated load-response matrices that will allow us to look at N, P, and S tradeoffs to support the Implementation Plans.

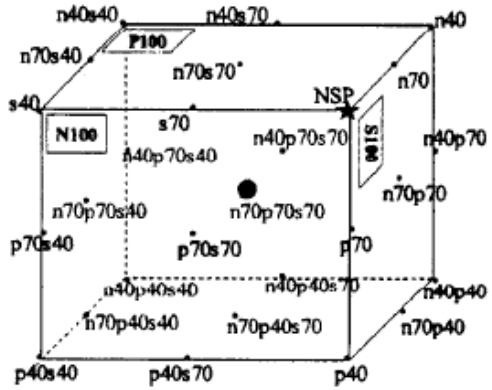


Fig. 7. Twenty-seven scenarios of different nitrogen, phosphorus, and sediment loads needed for volume analysis

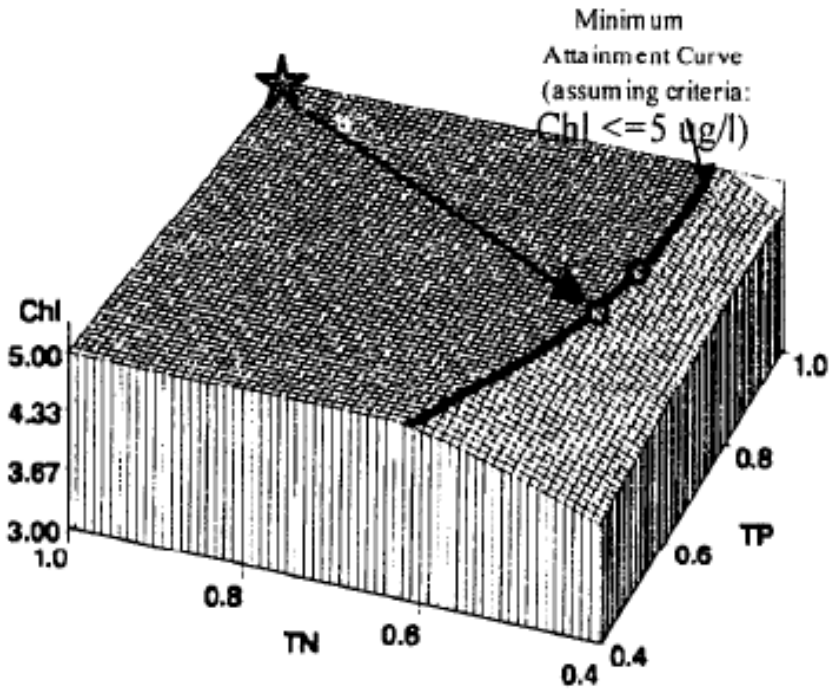


Fig. 6. Surface analysis of chlorophyll concentrations showing tradeoff curve for nitrogen and phosphorus loads which achieve estimated concentrations of 5 ug/l or less

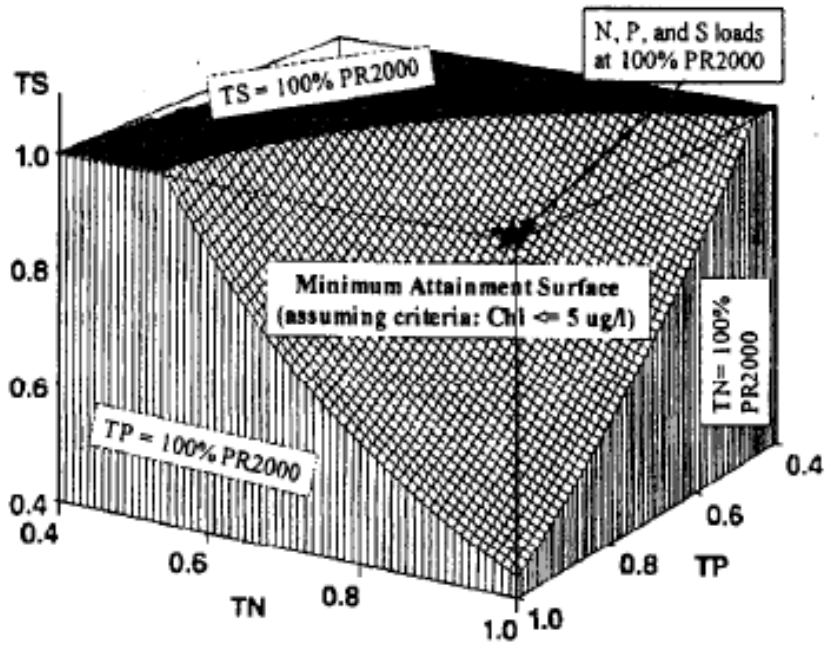


Fig. 8. Minimum attainment surface of Chl=5 ug/l at CB5–open water versus nitrogen, phosphorus, and sediment loads to Bay

Nitrogen Trial Allocations

TN				85% overall max 95% Allocation	85% overall max 90% Allocation	90% overall max 93% Allocation	90% overall max 96% Allocation
StateBasin	2010 No Action	Trib Strategy	E3				
DC Potm	15.48	2.81	1.58	3.25	3.47	2.85	2.72
DE Esh	8.63	5.79	3.16	3.65	3.82	3.61	3.51
MD Esh	33.17	18.42	10.19	11.85	12.78	11.95	11.42
MD Patux	9.77	3.88	2.22	3.86	3.60	3.13	3.28
MD Potm	57.38	22.64	12.35	22.67	20.82	17.92	18.98
MD Susq	2.22	1.50	0.74	0.81	0.89	0.84	0.80
MD Wsh	46.14	10.90	6.61	10.34	11.47	9.90	9.25
NY Susq	18.12	11.38	6.21	8.52	8.25	7.56	7.71
PA Potm	14.50	5.40	2.29	6.31	5.18	4.16	4.82
PA Susq	160.49	75.61	50.15	61.81	64.34	59.72	58.26
VA Esh	3.11	1.48	0.78	1.06	1.10	0.99	0.97
VA James	68.54	30.84	16.73	34.73	29.44	24.97	28.03
VA Potm	57.63	22.99	12.05	23.29	21.01	17.92	19.24
VA Rap	16.11	8.14	5.25	7.92	7.38	6.65	6.96
VA York	14.13	7.23	4.40	7.43	6.62	5.84	6.31
WV Potm	15.00	6.57	3.61	7.28	6.26	5.33	5.92
Total	540.44	235.57	138.31	214.79	206.43	183.35	188.18

Phosphorus Trial Allocations

TP				85% overall max 95%	85% overall max 90%	90% overall max 93%	90% overall max 96%
StateBasin	2010 No Action	Trib Strategy	E3	Allocation	Allocation	Allocation	Allocation
DC Potm	3.574	0.198	0.064	0.538	0.564	0.399	0.383
DE Esh	0.797	0.412	0.271	0.307	0.328	0.310	0.298
MD Esh	3.947	1.650	0.923	1.123	1.250	1.149	1.072
MD Patux	1.595	0.327	0.143	0.423	0.392	0.307	0.326
MD Potm	6.794	1.357	0.834	1.756	1.742	1.438	1.447
MD Susq	0.088	0.069	0.031	0.034	0.037	0.035	0.033
MD Wsh	6.762	0.748	0.373	0.954	1.143	0.898	0.783
NY Susq	1.247	0.881	0.445	0.613	0.589	0.540	0.554
PA Potm	0.897	0.489	0.411	0.543	0.513	0.478	0.495
PA Susq	8.268	3.128	1.771	2.764	2.755	2.426	2.432
VA Esh	0.486	0.218	0.134	0.176	0.181	0.166	0.162
VA James	14.976	6.634	3.619	7.190	6.256	5.320	5.885
VA Potm	8.503	2.128	1.172	2.691	2.481	2.032	2.159
VA Rap	2.091	1.265	0.857	1.121	1.082	1.005	1.028
VA York	1.557	0.689	0.403	0.719	0.648	0.562	0.605
WV Potm	1.111	0.731	0.592	0.738	0.704	0.664	0.685
Total	62.691	20.926	12.044	21.689	20.665	17.728	18.348