Preliminary James River Chlorophyll Criteria Attainment Results of VAMWA Scenarios run through the VIMS Eutrophication Model

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James River RAP Meeting

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Outline

- James River Chlorophyll Criteria and Assessment Methodology Refresher
- Description of VAMWA scenarios
- Presentation of preliminary VAMWA results
- Wrap-up

DEQ is proposing two sets of chlorophyll-a criteria for the tidal James River

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Designated Use	Chlorophyll-*a* µg/l	Chesapeake Bay Program Segment	Temporal Application
Open water	8	JMSTF2	March 1 - May 31 (spring)
	10	JMSTF1	
	13	JMSOH	
	7	JMSMH	
	8	JMSPH	
	21	JMSTF2	July 1 - September 30 (summer)
	24	JMSTF1	
	11	JMSOH	
	7	JMSMH	
	7	JMSPH	

Proposed seasonal mean criteria

DEQ is proposing two sets of chlorophyll-a criteria for the tidal James River

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Open water	8	JMSTF2	March 1 - May 31 (spring)
	10	JMSTF1	
	13	JMSOH	
	7	JMSMH	
	8	JMSPH	
	21	JMSTF2	July 1 - September 30 (summer)
	24	JMSTF1	
	11	JMSOH	
	7	JMSMH	
	7	JMSPH	

Proposed seasonal mean criteria

Applicable during the summer only

Chlorophyll-*a* µg/l	Chesapeake Bay Program Segment	Spatial Application	Duration
52	JMSTF2	River mile 95 to downstream boundary of JMSTF2	1-Month median
52	JMSTF1	Upstream boundary of JMSTF1 to river mile 67	1-Month median
34	JMSTF1	River mile 67 to downstream boundary of JMSTF1	1-Month median
--	JMSOH	Entire segment	--
59	JMSMH	Entire segment	1-Day median
20	JMSPH	Entire segment	1-Day median

Magnitude

PROPOSED SEASONAL MEAN CRITERIA

Designated Use	Chlorophyll-*a* µg/l	Chesapeake Bay Program Segment	Temporal Application
Open water	8	JMSTF2	March 1 - May 31 (spring)
	10	JMSTF1	
	13	JMSOH	
	7	JMSMH	
	8	JMSPH	
	21	JMSTF2	July 1 - September 30 (summer)
	24	JMSTF1	
	11	JMSOH	
	7	JMSMH	
	7	JMSPH	

Duration

Frequency: Two exceedences every six seasons

EXAMPLE

	Criterion = 10	Criterion = 24
YEAR	**SPRING MEAN (µg/l)**	**SUMMER MEAN (µg/l)**
Year 1	**12**	23
Year 2	10	20
Year 3	8	**28**
Year 4	8	10
Year 5	**11**	18
Year 6	10	**29**

ATTAINMENT

EXAMPLE

	Criterion = 10	Criterion = 24
YEAR	**SPRING MEAN (µg/l)**	**SUMMER MEAN (µg/l)**
Year 1	10	**26**
Year 2	10	20
Year 3	8	**28**
Year 4	8	10
Year 5	9	18
Year 6	10	**29**

NON-ATTAINMENT

PROPOSED SHORT-DURATION CRITERIA

Magnitude

Chlorophyll-*a* µg/l	Chesapeake Bay Program Segment	Spatial Application	Duration
52	JMSTF2	River mile 95 to downstream boundary of JMSTF2	1-Month median
52	JMSTF1	Upstream boundary of JMSTF1 to river mile 67	1-Month median
34	JMSTF1	River mile 67 to downstream boundary of JMSTF1	1-Month median
--	JMSOH	Entire segment	--
59	JMSMH	Entire segment	1-Day median
20	JMSPH	Entire segment	1-Day median

Duration

Frequency: 10% exceedence frequency over six summer seasons

EXAMPLE

Month- Year	1-Month Median (µg/)
July-1st year	56
August-1st year	20
September-1st year	19
July-2nd year	32
August-2nd year	17
September-2nd year	10
July-3rd year	29
August-3rd year	50
September-3rd year	39
July-4th year	22
August-4th year	21
September-4th year	12
July-5th year	30
August-5th year	25
September-5th year	16
July-6th year	46
August-6th year	35
September-6th year	10

Criterion = 52 µg/l

Exceedence frequency = 1/18 = 6%

ATTAINMENT

EXAMPLE

Month- Year	1-Month Median (µg/)
July-1st year	**56**
August-1st year	20
September-1st year	19
July-2nd year	32
August-2nd year	17
September-2nd year	10
July-3rd year	29
August-3rd year	50
September-3rd year	39
July-4th year	22
August-4th year	21
September-4th year	12
July-5th year	30
August-5th year	25
September-5th year	16
July-6th year	46
August-6th year	35
September-6th year	**55**

Criterion = 52 µg/l

Exceedence frequency = 2/18 = 11%

NON-ATTAINMENT

Date	1-Day Median (µg/)
7/1/2007	10
8/15/2007	9
8/19/2007	7
9/10/2007	3
7/4/2008	10
8/24/2008	**29**
9/24/2008	3
7/3/2009	9
8/14/2009	7
8/28/2009	13
9/5/2009	4
7/10/2010	2
7/17/2010	**30**
8/1/2010	7
9/15/2010	10
7/1/2011	5
8/15/2011	20
9/10/2011	4
7/4/2012	8
7/20/2012	2
8/24/2012	3
9/24/2012	2

Criterion = 20 µg/l

EXAMPLE

Exceedence frequency = 2/22= 9%

ATTAINMENT

Criterion = 20 µg/l

EXAMPLE

Date	1-Day Median (µg/)
7/1/2007	10
8/15/2007	9
8/19/2007	7
9/10/2007	3
7/4/2008	10
8/24/2008	**29**
9/24/2008	3
7/3/2009	9
8/14/2009	7
8/28/2009	13
9/5/2009	4
7/10/2010	2
7/17/2010	**30**
8/1/2010	7
9/15/2010	10
7/1/2011	5
8/15/2011	**21**
9/10/2011	4
7/4/2012	8
7/20/2012	2
8/24/2012	3
9/24/2012	2

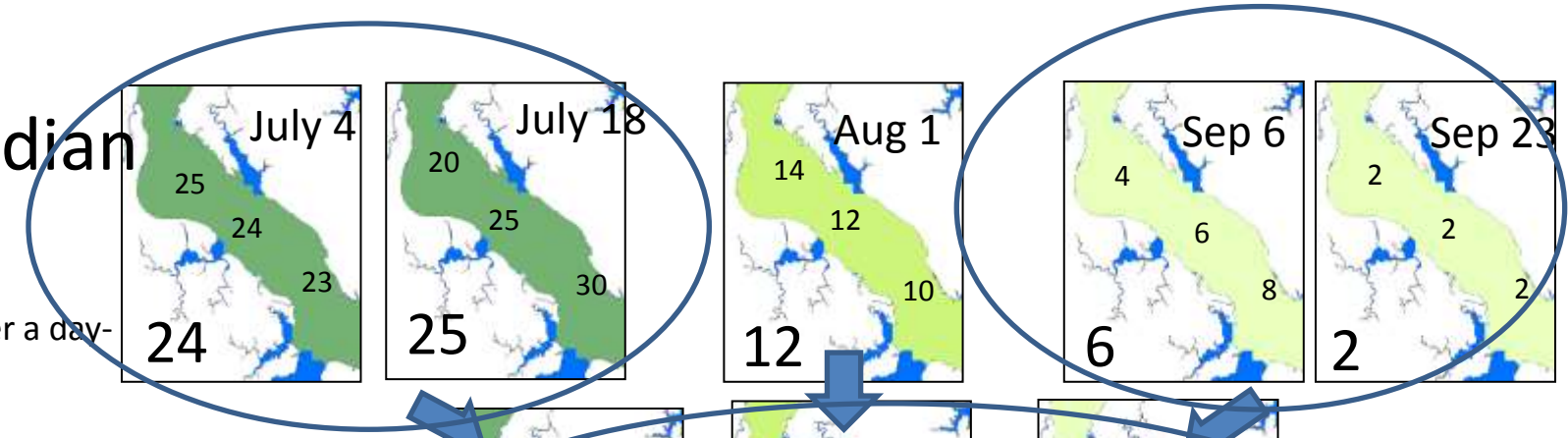
Exceedence frequency = 3/22 = 14%

NON-ATTAINMENT

Assessment methodology (i.e., how monitoring data are to be analyzed)

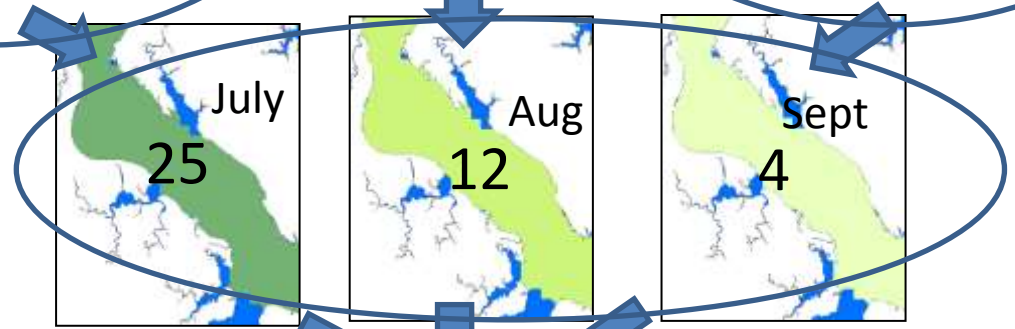
1-Day Median Criteria

(Samples pooled over a day-MEDIAN)



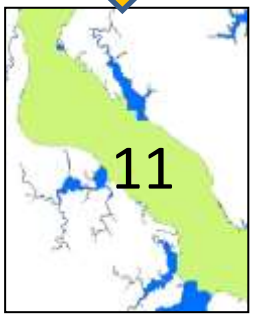
1-Month Median Criteria

(Daily values pooled over a month -MEDIAN)



Seasonal Mean Criteria

(Monthly values pooled over a season –GEOMETRIC MEAN)



Existing Criteria and Existing Assessment Methodology

Compared to proposed criteria…

Magnitude Most of the existing criteria are greater in magnitude.

Duration Seasonal means only

Frequency Much more stringent. Exceedence rates are calculated in space AND time, rather than just time over a 3-year period

Assessment methodology Monitoring data are spatially interpolated to a grid. A seasonal mean is calculated for each grid cell to enable the estimation of spatial exceedence for a segment.

Description of VAMWA Scenarios

VAMWA Scenario Descriptions*

Highest

Nutrient Loads

Lowest

- VAMWA B: 2017 Watershed General Permit Waste Load Allocations.
- VAMWA B+: Same TN loads as VAMWA B; tests sensitivity to TP reductions
- VAMWA B/D: Seasonal Hybrid. Annual TN and TP loads are same as VAMWA B. Summer loads are same as VAMWA D (above fall line and upper estuary) and VAMWA C (lower estuary).
- VAMWA C: Intermediate scenario.
- VAMWA D: Intermediate scenario.
- VAMWA E: Watershed Implementation Plan II Level of Effort, estimated to achieve existing James River chlorophyll criteria the CBP Watershed Model (Phase 5.3.2) and Time Variable Sediment Transport Water Quality Model.

* All scenarios include Virginia's Watershed Implementation Plan II level-of-effort for nonpoint source controls

Scenario	Upper Estuary Above Fall Line	Upper Estuary Below Fall Line	Lower Estuary (HRSD)
"B" TMDL Chl-a Stage 1B	Typical POTW=WQMP/WGP (TN=6, TP=0.41 mg/L) Industrial=WQMPR	Typical POTW= WQMP/WGP (TN=5, TP=0.41 mg/L) Industrial=WQMPR	HRSD TN=3.554 Mlb/yr HRSD TP=0.318 Mlb/yr (Typically TN=6.500, TP=0.582 mg/L) No Industrials Present
"B+" P Sensitivity Stage 1B+	All POTW & Industrial TN= Same as Stage 1B All POTW TP=0.2 mg/L (-50% from 1B) All Industrial TP=Same % Reduction	All POTW & Industrial TN= Same as Stage 1B All POTW TP=0.2 mg/L (-50% from 1B) All Industrial TP=Same % Reduction	HRSD TN=Same as Stage 1B HRSD TP=0.109 Mlb/yr (0.2 mg/l)
"B/D" Seasonal Hybrid	Scenario B as Annual Avg Scenario D as Summer Avg (May – Sept)	Scenario B as Annual Avg Scenario D as Summer Avg (May – Sept)	Scenario B as Annual Avg Scenario C as Summer Avg (May – Sept)
"C" Intermediate Scenario 1C	Typical POTW Reductions TN=5 mg/L (-17% from 1B) TP=0.3 mg/L (-25%) Indus=Same % Reduction	Typical POTW Reductions TN=4 mg/L (-20% from 1B) TP=0.3 mg/L (-25%) Indus=Same % Reduction	HRSD TN= 2.734 Mlb/yr HRSD TP= 0.164 Mlb/yr (TN=5 mg/L, TP=0.3 mg/L)
"D" Intermediate Scenario 1D	Typical POTW Reductions TN=4 mg/L (-33% from 1B) TP=0.2 mg/L (-50%) Indus=Same % Reduction	Typical POTW Reductions TN=4 mg/L (-20% from 1B) TP=0.2 mg/L (-50%) Indus=Same % Reduction	HRSD TN= 2.187 Mlb/yr HRSD TP= 0.109 Mlb/yr (TN=4 mg/L, TP=0.2 mg/L)
"E" TMDL Chl-a Stage 2	Base on Input Deck Used to Achieve Chl-a Attainment During 2010 TMDL Model	Base on Input Deck Used to Achieve Chl-a Attainment During 2010 TMDL Model	Base on Input Deck Used to Achieve Chl-a Attainment During 2010 TMDL Model

Estimated James River Basin Discharged PS Load

TN = 12,302,200 lbs/yr
TP = 893,800 lbs/yr

TN = 12,302,200 lbs/yr
TP = 403,700 lbs/yr

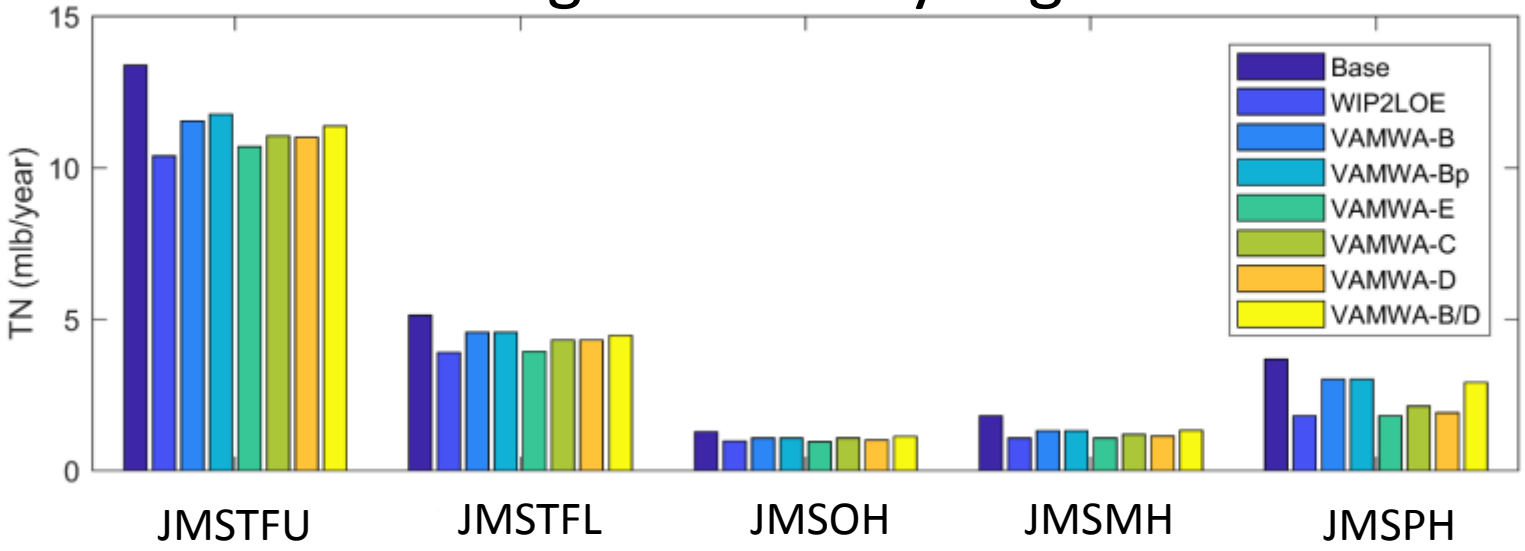
TN = 11,805,700 lbs/yr
TP = 626,200 lbs/yr

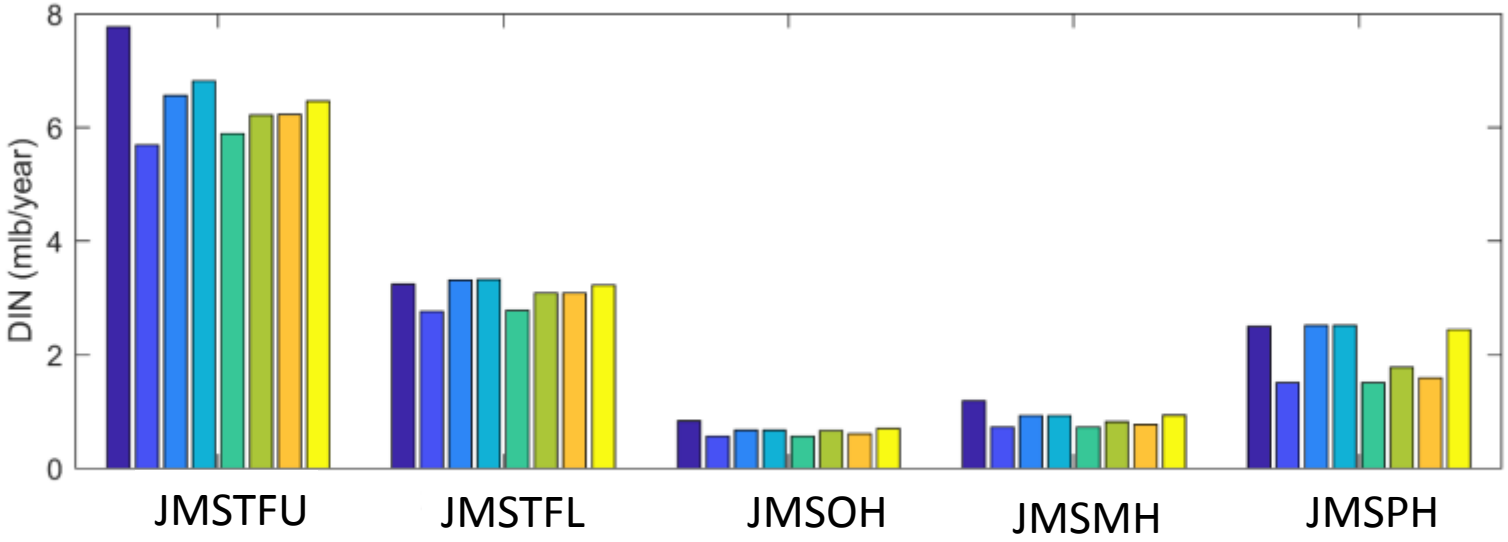
TN = 10,081,800 lbs/yr
TP = 580,500 lbs/yr

TN = 9,383,600 lbs/yr
TP = 403,100 lbs/yr

TN = 8,683,500 lbs/yr
TP = 490,800 lbs/yr

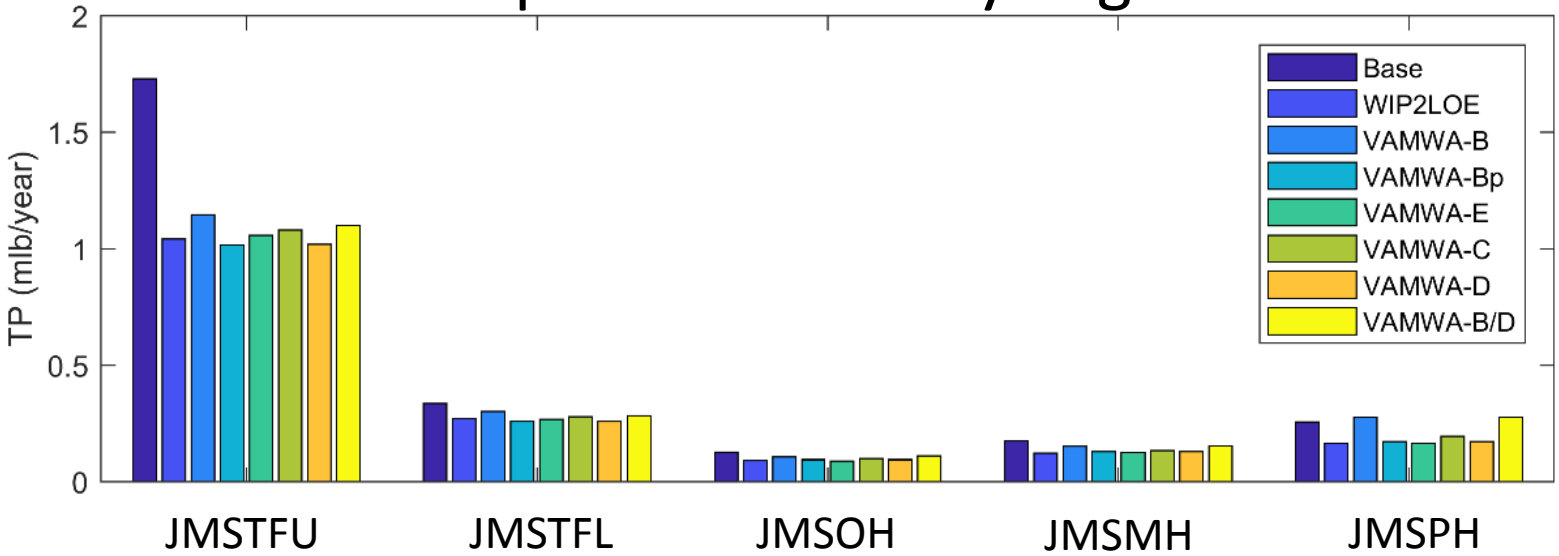
Nitrogen Loads by Segment

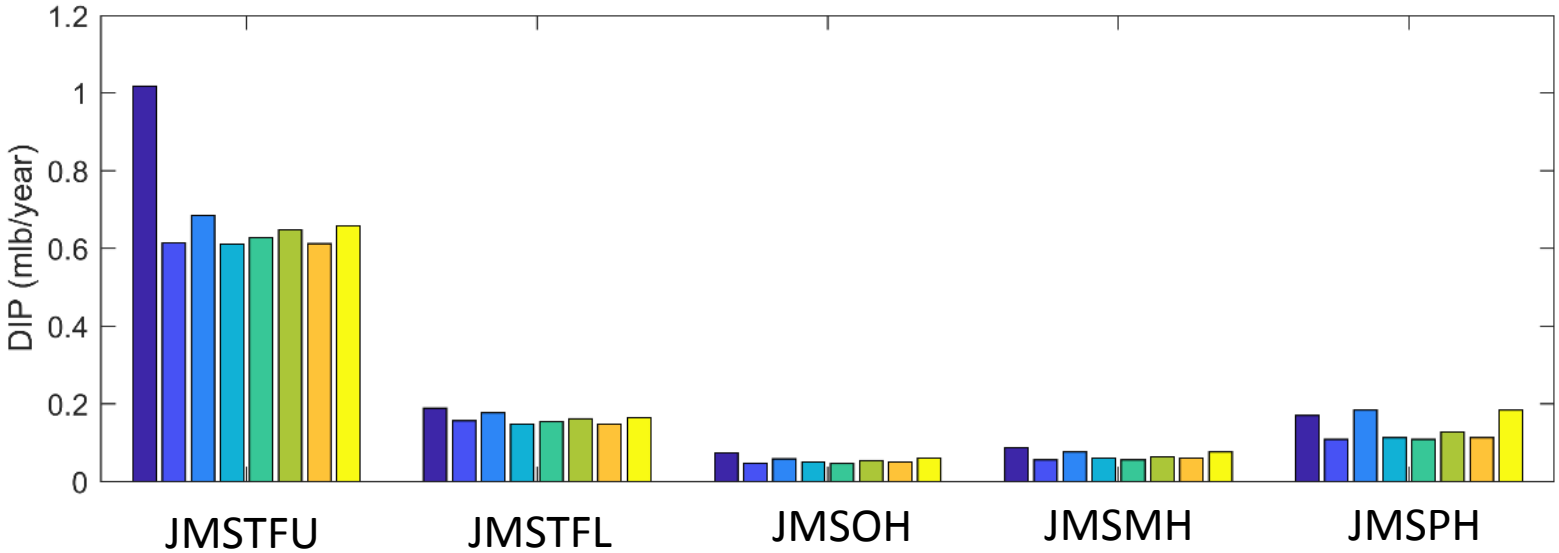




Fall line → Mouth

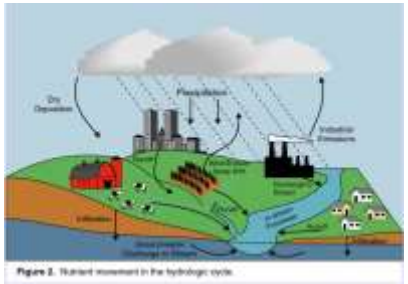
Phosphorus Loads by Segment





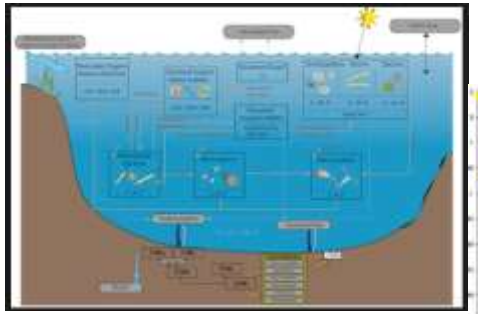
Fall line → Mouth

Phase 6 Bay Watershed Model

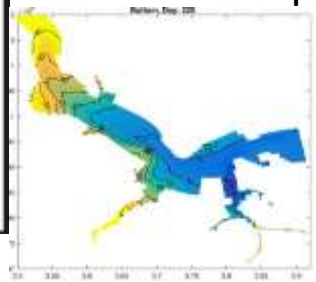


A specific loading condition is simulated via a watershed model using the average hydrology over some specified period. We call this a "scenario".

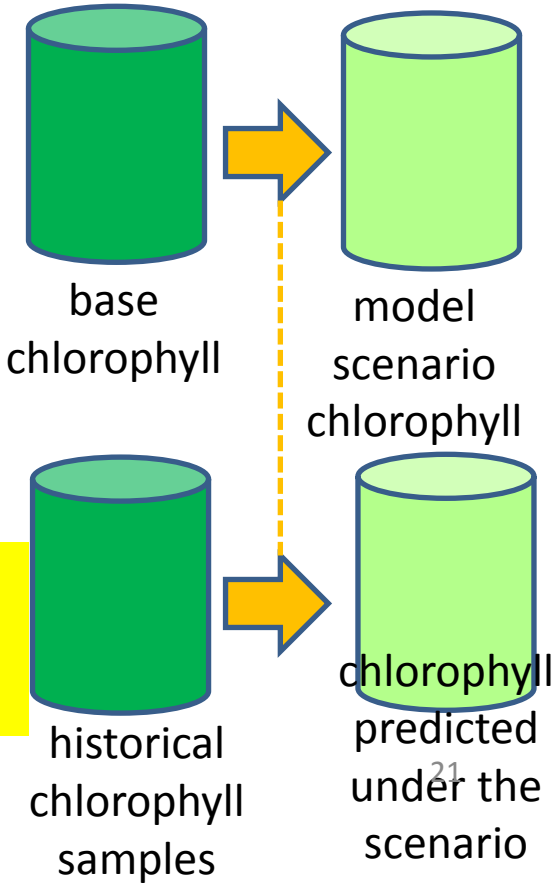
loads



VIMS water quality model



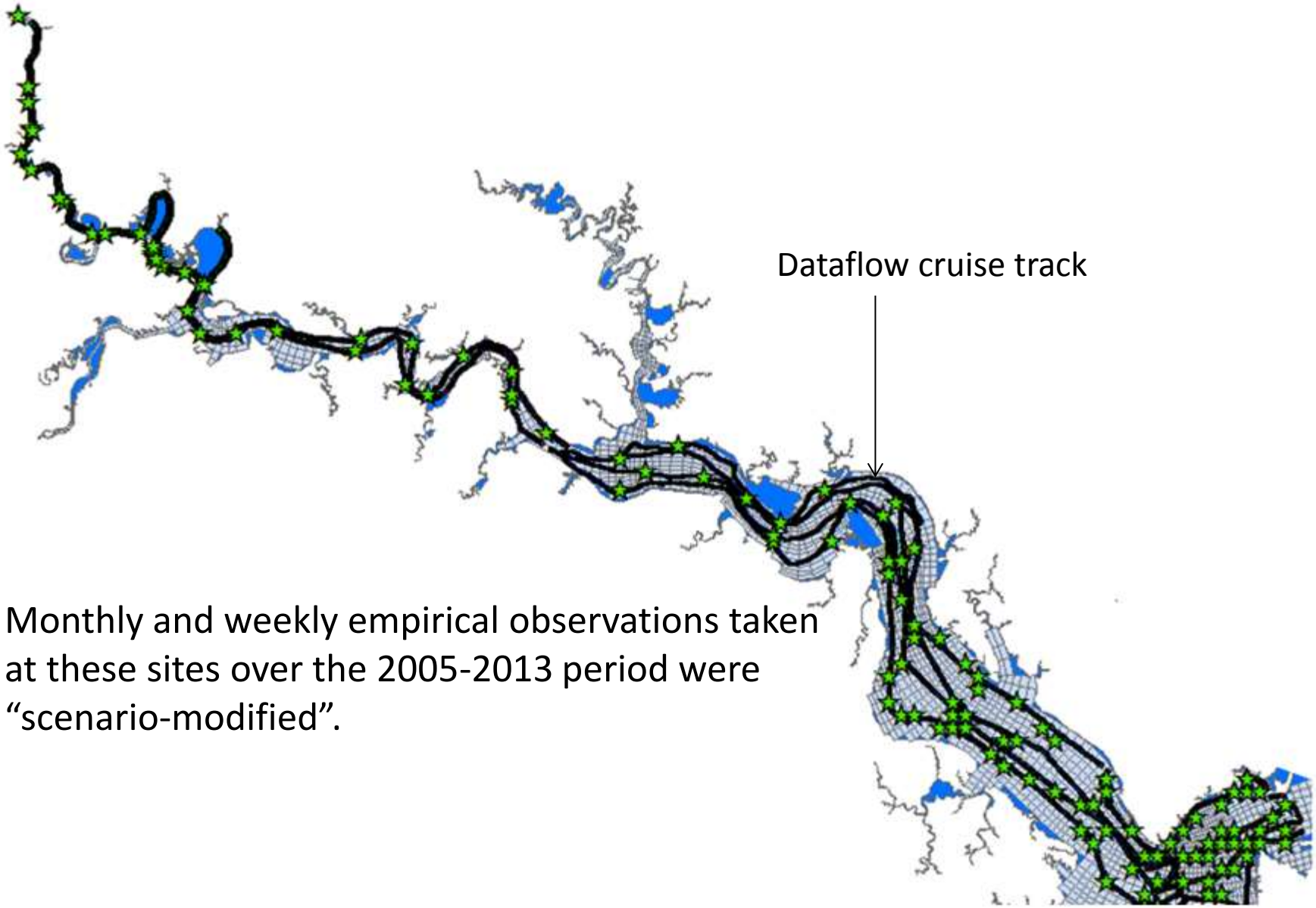
How does the modeled chlorophyll under the loading condition compare to the base chlorophyll?



The simulated change is then used to modify historical chlorophyll to "scenario" chlorophyll

We have chosen the 2005-2013 period for running load reduction scenarios.

- 2005-2013 base loadings and hydrology
- 2005-2013 empirical observations to be “scenario-modified”



Monthly and weekly empirical observations taken at these sites over the 2005-2013 period were “scenario-modified”.

Assessment Results

Summary of Criteria Assessment Results

Chesapeake Bay Program Scoping Scenarios

	Existing Criteria	Proposed Seasonal Mean Criteria	Proposed Short-Duration Criteria
Observed 2005-2013			
2013 Progress			
2017 Progress			
DO Attainment			
WIP2			
E3			

Nonattainment predicted under scenario

Full attainment predicted under scenario

Summary of Criteria Assessment Results

Chesapeake Bay Program Scoping Scenarios

	Existing Criteria	Proposed Seasonal Mean Criteria	Proposed Short-Duration Criteria
Observed 2005-2013			
2013 Progress			
2017 Progress			
DO Attainment			
WIP2			
E3			

VAMWA Point Source Scenarios

	Existing Criteria	Proposed Seasonal Mean Criteria	Proposed Short-Duration Criteria
VAMWA B			
VAMWA B+			
VAMWA B/D			
VAMWA C			
VAMWA D			
VAMWA E			

Nonattainment predicted under scenario

Full attainment predicted under scenario

Assessment Results for Existing Criteria under Selected Scenarios

Observed

SPRING	Baseline				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	1.4	21.8
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.0	0.0	10.1	0.0	0.0
2008-2010	0.0	0.0	10.1	0.0	2.4
2009-2011	0.0	0.0	10.1	0.0	2.4
2010-2012	0.0	8.0	0.0	0.0	2.4
2011-2013	0.0	8.0	0.0	2.8	0.0

SUMMER	Baseline				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	10.0	2.0	0.0	0.0	10.5
2006-2008	3.5	0.4	0.0	4.2	1.5
2007-2009	26.2	10.3	0.0	8.8	5.6
2008-2010	41.3	24.5	0.0	12.4	5.8
2009-2011	51.9	45.9	0.0	5.7	1.7
2010-2012	37.7	52.5	0.0	0.9	0.0
2011-2013	19.1	52.6	0.0	0.0	0.0

VAMWA C

SPRING	VAMWA C				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.7	21.8
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.0	0.0	0.0	0.0	0.0
2008-2010	0.0	0.0	0.0	0.0	0.0
2009-2011	0.0	0.0	0.0	0.0	0.0
2010-2012	0.0	0.0	0.0	0.0	0.0
2011-2013	0.0	0.0	0.0	0.0	0.0

SUMMER	VAMWA C				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.0	10.5
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.6	3.4	0.0	0.0	0.0
2008-2010	4.4	14.8	0.0	0.0	0.0
2009-2011	13.5	39.6	0.0	0.0	0.0
2010-2012	15.2	48.9	0.0	0.0	0.0
2011-2013	10.9	41.4	0.0	0.0	0.0

VAMWA E

SPRING	VAMWA E				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.8	21.8
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.0	0.0	0.0	0.0	0.0
2008-2010	0.0	0.0	0.0	0.0	0.0
2009-2011	0.0	0.0	0.0	0.0	0.0
2010-2012	0.0	0.0	0.0	0.0	0.0
2011-2013	0.0	0.0	0.0	0.0	0.0

SUMMER	VAMWA E				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.0	10.5
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.4	2.5	0.0	0.0	0.0
2008-2010	3.5	13.9	0.0	0.0	0.0
2009-2011	12.4	38.7	0.0	0.0	0.0
2010-2012	13.7	47.4	0.0	0.0	0.0
2011-2013	10.0	39.3	0.0	0.0	0.0

E3

SPRING	E3				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.7	21.8
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.0	0.0	0.0	0.0	0.0
2008-2010	0.0	0.0	0.0	0.0	0.0
2009-2011	0.0	0.0	0.0	0.0	0.0
2010-2012	0.0	0.0	0.0	0.0	0.0
2011-2013	0.0	0.0	0.0	0.0	0.0

SUMMER	E3				
period	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005-2007	0.0	0.0	0.0	0.0	10.5
2006-2008	0.0	0.0	0.0	0.0	0.0
2007-2009	0.0	1.2	0.0	0.0	0.0
2008-2010	0.0	4.7	0.0	0.0	0.0
2009-2011	1.2	17.4	0.0	0.0	0.0
2010-2012	1.2	14.8	0.0	0.0	0.0
2011-2013	0.4	10.7	0.0	0.0	0.0

Values are excessive space-time exceedence rates (%).

Red values indicate non-attainment.

Observed

Assessment Results for Proposed Criteria under Selected Scenarios

Seasonal Mean Criteria

SPRING	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	2	5	10	**8**	**11**
2006	7	8	10	6	5
2007	5	6	4	4	7
2008	4	4	7	6	5
2009	7	7	**23**	6	6
2010	4	4	7	5	**10**
2011	7	8	6	4	6
2012	**10**	**13**	2	5	4
2013	5	5	5	**8**	5
SUMMER	**Baseline**				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	14	14	10	**10**	**9**
2006	9	11	8	6	6
2007	8	12	3	5	7
2008	12	15	8	**9**	**8**
2009	**26**	22	7	6	**8**
2010	**30**	**25**	10	4	3
2011	20	**33**	7	4	4
2012	15	**29**	2	3	**8**
2013	20	22	5	4	6

Values are estimated seasonal chlorophyll means (µg/l).

Red values are exceedences of proposed criteria.

Red boxes indicate 6-year periods of non-attainment.

Short-duration criteria

SUMMER	Baseline				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%)

Assessment Results for Proposed Criteria under Selected Scenarios

Observed

Seasonal Mean Criteria

SPRING	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	2	5	10	**8**	**11**
2006	7	8	10	6	5
2007	5	6	4	4	7
2008	4	4	7	6	5
2009	7	7	**23**	6	6
2010	4	4	7	5	**10**
2011	7	8	6	4	6
2012	**10**	**13**	2	5	4
2013	5	5	5	**8**	5

SUMMER	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	14	14	10	**10**	**9**
2006	9	11	8	6	6
2007	8	12	3	5	7
2008	12	15	8	**9**	**8**
2009	**26**	22	7	6	**8**
2010	**30**	**25**	10	4	3
2011	20	**33**	7	4	4
2012	15	**29**	2	3	**8**
2013	20	22	5	4	6

Short-duration criteria

SUMMER	Baseline				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

VAMWA B

Seasonal Mean Criteria

SPRING	VAMWA B				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	1	3	7	6	**9**
2006	4	5	8	4	3
2007	2	4	3	4	5
2008	2	3	5	5	5
2009	4	5	**21**	5	5
2010	4	3	5	4	8
2011	5	6	4	3	6
2012	**9**	11	2	5	3
2013	4	5	4	6	5

SUMMER	VAMWA B				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	8	12	8	**8**	7
2006	4	7	6	5	5
2007	5	15	3	4	5
2008	6	13	7	7	7
2009	18	19	6	5	7
2010	**22**	21	8	3	3
2011	17	**31**	5	4	4
2012	13	**28**	2	3	7
2013	16	19	3	4	5

Values are estimated seasonal chlorophyll means (µg/l).

Red values are exceedences of proposed criteria.

Red boxes indicate 6-year periods of non-attainment.

Short-duration criteria

SUMMER	VAMWA B				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	4%
2006-2011	0%	6%	0%	0%	4%
2007-2012	0%	6%	0%	0%	5%
2008-2013	0%	6%	0%	0%	5%

Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%) →

Assessment Results for Proposed Criteria under Selected Scenarios

Observed

Seasonal Mean Criteria

SPRING	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	2	5	10	**8**	**11**
2006	7	8	10	6	5
2007	5	6	4	4	7
2008	4	4	7	6	5
2009	7	7	**23**	6	6
2010	4	4	7	5	**10**
2011	7	8	6	4	6
2012	**10**	**13**	2	5	4
2013	5	5	5	**8**	5

SUMMER	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	14	14	10	**10**	**9**
2006	9	11	8	6	6
2007	8	12	3	5	7
2008	12	15	8	**9**	**8**
2009	**26**	22	7	6	**8**
2010	**30**	**25**	10	4	3
2011	20	**33**	7	4	4
2012	15	**29**	2	3	**8**
2013	20	22	5	4	6

Short-duration criteria

SUMMER	Baseline				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%) →

VAMWA B+

Seasonal Mean Criteria

SPRING	VAMWA B+				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	1	3	6	6	**9**
2006	3	4	8	5	3
2007	2	3	2	4	5
2008	1	2	4	6	6
2009	3	3	**18**	5	5
2010	2	3	5	4	8
2011	4	5	4	2	7
2012	7	9	2	5	3
2013	3	4	3	6	6

SUMMER	VAMWA B+				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	7	11	8	**8**	7
2006	4	6	6	5	5
2007	4	14	3	4	5
2008	5	13	7	7	7
2009	16	16	7	5	7
2010	19	18	9	3	3
2011	15	**27**	4	4	4
2012	11	24	2	3	7
2013	14	16	2	4	5

Values are estimated seasonal chlorophyll means (µg/l).

Red values are exceedences of proposed criteria.

Red boxes indicate 6-year periods of non-attainment.

Short-duration criteria

SUMMER	VAMWA B+				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	4%
2006-2011	0%	0%	0%	0%	4%
2007-2012	0%	0%	0%	0%	5%
2008-2013	0%	0%	0%	0%	5%

Assessment Results for Proposed Criteria under Selected Scenarios

Observed

Seasonal Mean Criteria

SPRING	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	2	5	10	**8**	**11**
2006	7	8	10	6	5
2007	5	6	4	4	7
2008	4	4	7	6	5
2009	7	7	**23**	6	6
2010	4	4	7	5	**10**
2011	7	8	6	4	6
2012	**10**	**13**	2	5	4
2013	5	5	5	**8**	5
SUMMER	Baseline				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	14	14	10	**10**	**9**
2006	9	11	8	6	6
2007	8	12	3	5	7
2008	12	15	8	**9**	**8**
2009	**26**	22	7	6	**8**
2010	**30**	**25**	10	4	3
2011	20	**33**	7	4	4
2012	15	**29**	2	3	**8**
2013	20	22	5	4	6

Short-duration criteria

SUMMER	Baseline				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

VAMWA B/D

Seasonal Mean Criteria

SPRING	VAMWA B/D				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	1	4	7	6	**9**
2006	3	6	9	4	3
2007	2	4	3	4	5
2008	1	3	4	6	5
2009	4	5	**20**	5	5
2010	3	3	5	4	8
2011	5	6	4	3	6
2012	8	10	2	5	3
2013	4	5	4	7	5
SUMMER	VAMWA B/D				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	7	11	8	7	7
2006	4	6	5	5	5
2007	4	14	3	3	5
2008	5	12	7	6	6
2009	16	17	6	4	6
2010	19	19	8	3	2
2011	15	**27**	5	3	4
2012	11	**25**	2	3	6
2013	14	17	3	4	4

Values are estimated seasonal chlorophyll means (µg/l).

Red values are exceedences of proposed criteria.

Red boxes indicate 6-year periods of non-attainment.

Short-duration criteria

SUMMER	VAMWA B/D				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	4%
2006-2011	0%	6%	0%	0%	4%
2007-2012	0%	6%	0%	0%	5%
2008-2013	0%	6%	0%	0%	5%

Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%) →

VAMWA B/D

TN = 11,805,700lbs/yr
TP = 626,200 lbs/yr

Seasonal Mean Criteria

SPRING	VAMWA B/D				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	1	4	7	6	**9**
2006	3	6	9	4	3
2007	2	4	3	4	5
2008	1	3	4	6	5
2009	4	5	**20**	5	5
2010	3	3	5	4	8
2011	5	6	4	3	6
2012	8	10	2	5	3
2013	4	5	4	7	5
SUMMER	VAMWA B/D				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	7	11	8	7	7
2006	4	6	5	5	5
2007	4	14	3	3	5
2008	5	12	7	6	6
2009	16	17	6	4	6
2010	19	19	8	3	2
2011	15	**27**	5	3	4
2012	11	**25**	2	3	6
2013	14	17	3	4	4

Values are estimated seasonal chlorophyll means (µg/l).

Red values are exceedences of proposed criteria.

VAMWA C

TN = 10,081,800 lbs/yr
TP = 580,500 lbs/yr

Seasonal Mean Criteria

SPRING	VAMWA C				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	1	3	7	6	8
2006	3	5	8	4	2
2007	2	4	2	3	5
2008	2	3	5	5	5
2009	4	4	**22**	5	5
2010	3	3	5	4	8
2011	4	6	4	3	5
2012	8	10	2	4	3
2013	4	5	4	6	4
SUMMER	VAMWA C				
Year	JMSTFU	JMSTFL	JMSOH	JMSMH	JMSPH
2005	8	9	7	7	7
2006	4	6	6	5	5
2007	6	8	3	3	5
2008	6	13	6	6	6
2009	17	18	6	4	6
2010	21	20	8	3	2
2011	16	**28**	5	3	4
2012	12	**26**	1	3	7
2013	15	18	3	4	4

Short-duration criteria exceedence rates

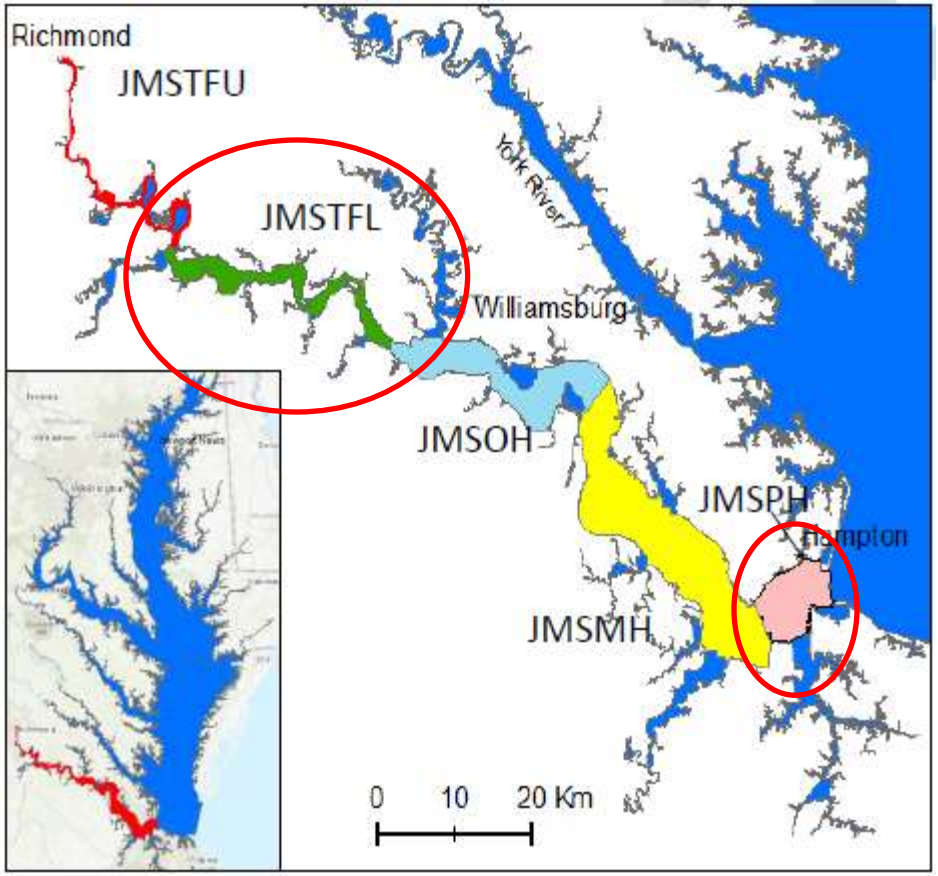
VAMWA B/D

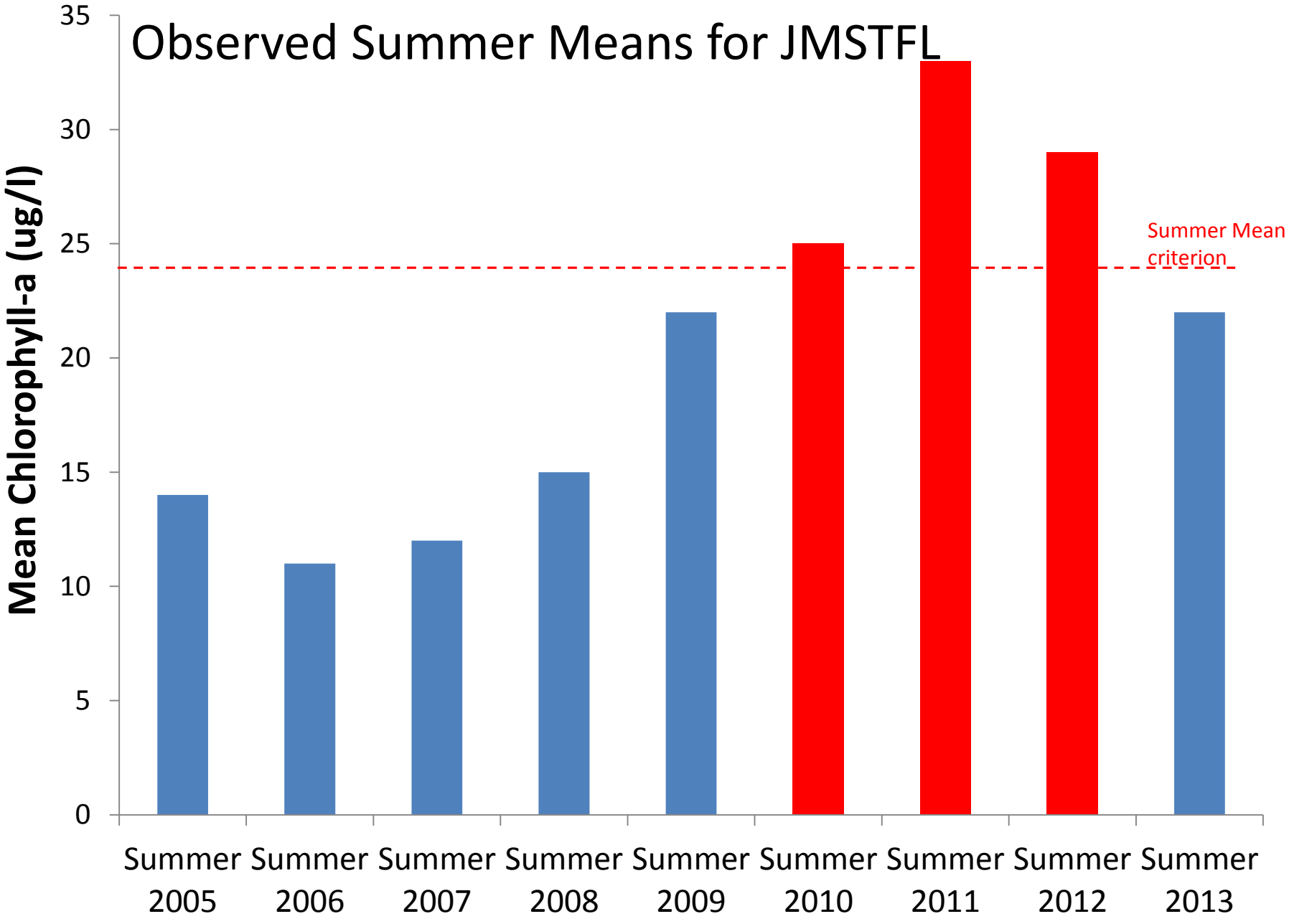
SUMMER	VAMWA B/D				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	4%
2006-2011	0%	6%	0%	0%	4%
2007-2012	0%	6%	0%	0%	5%
2008-2013	0%	6%	0%	0%	5%

VAMWA C

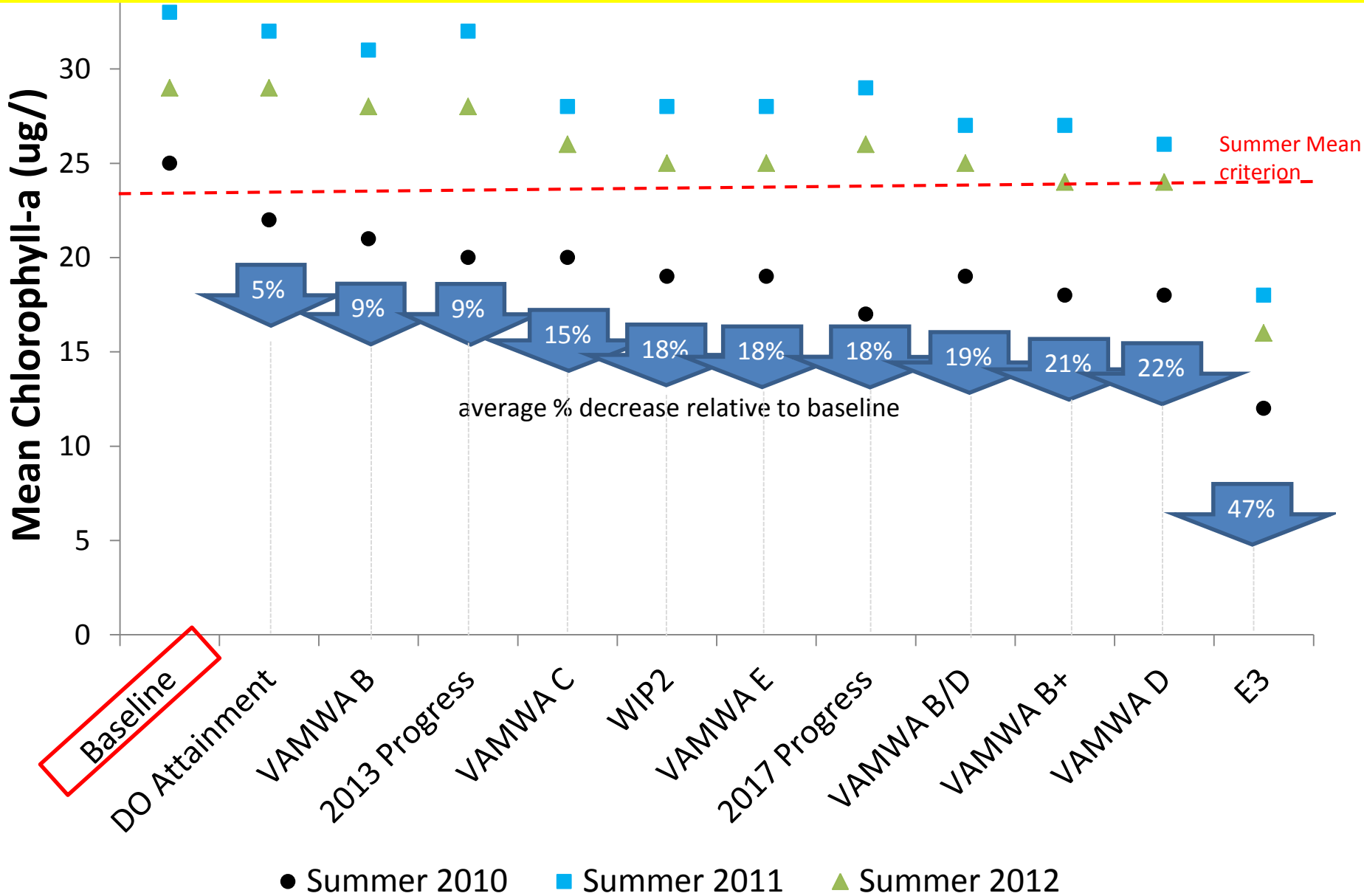
SUMMER	VAMWA C				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	4%
2006-2011	0%	6%	0%	0%	4%
2007-2012	0%	6%	0%	0%	5%
2008-2013	0%	6%	0%	0%	5%

Let's focus on the problem children. (JMSTFL-summer and JMSPH-summer)




Observed Summer Means for JMSTFL
Mean Chlorophyll-a (ug/l)
35
30
25
20
15
10
5
0
Summer Mean criterion
Summer 2005
Summer 2006
Summer 2007
Summer 2008
Summer 2009
Summer 2010
Summer 2011
Summer 2012
Summer 2013

Chlorophyll predicted under each scenario for the three worst summers in JMSTFL



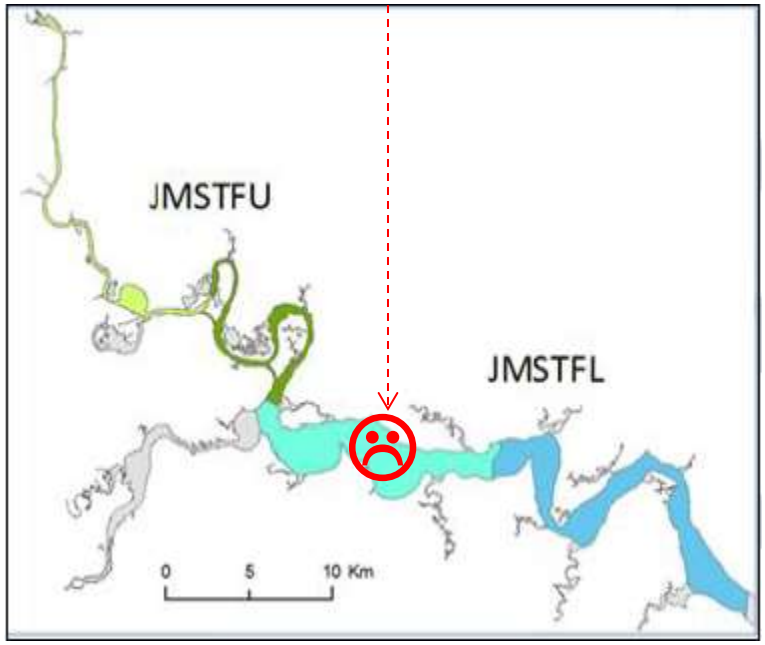
Non-attainment

Observed

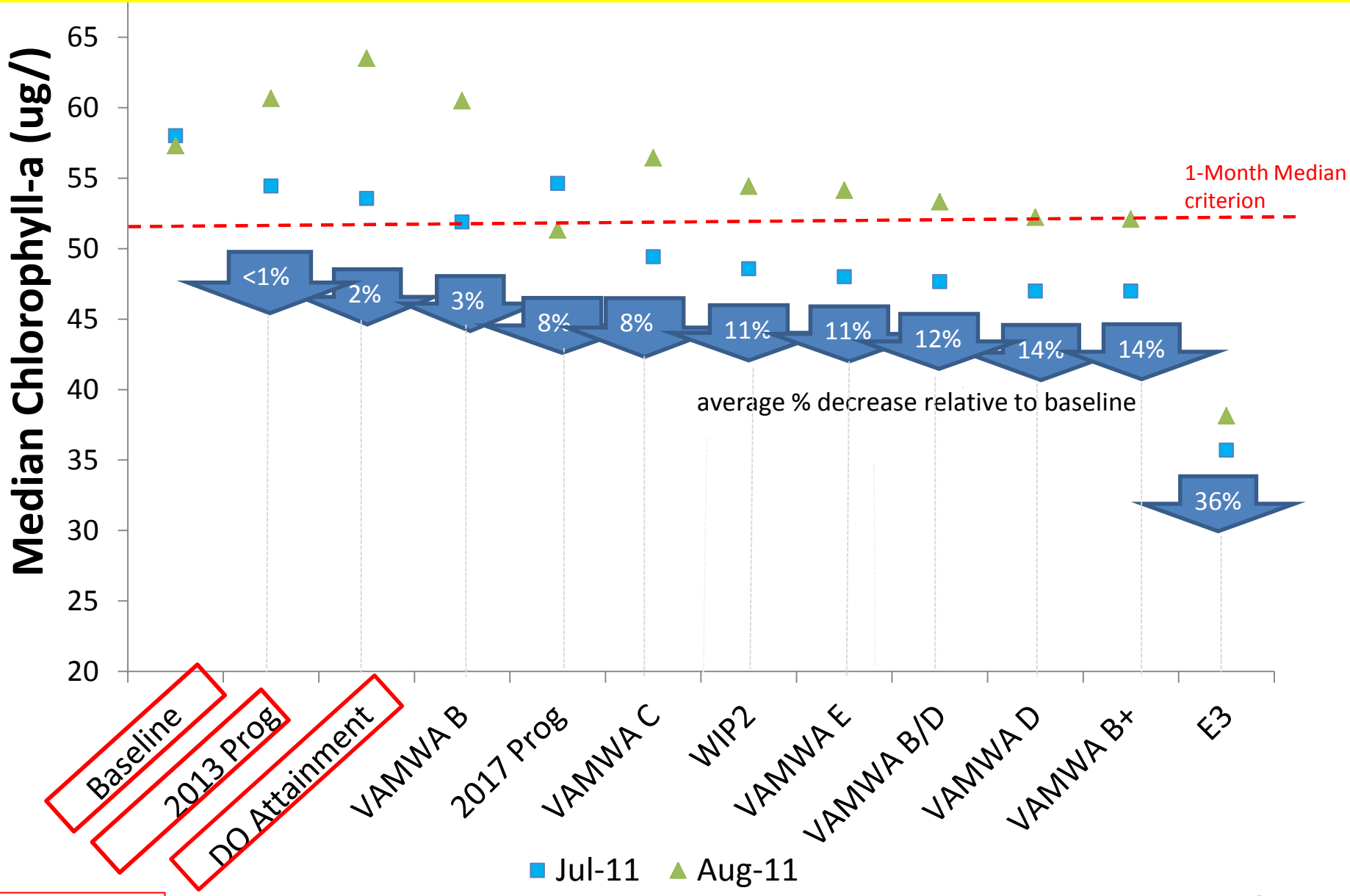
Short-duration criteria

SUMMER	Baseline				
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

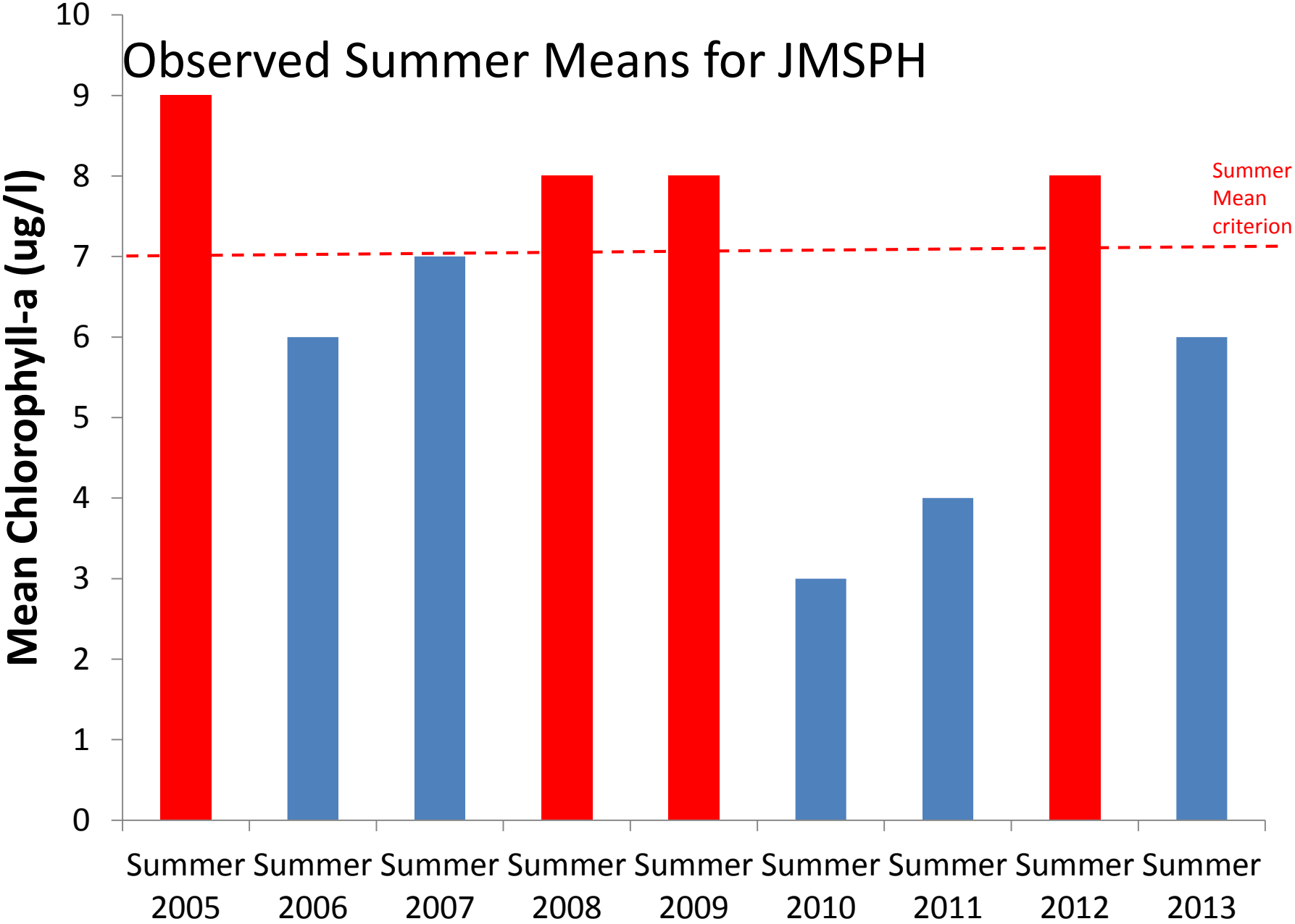
Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%)



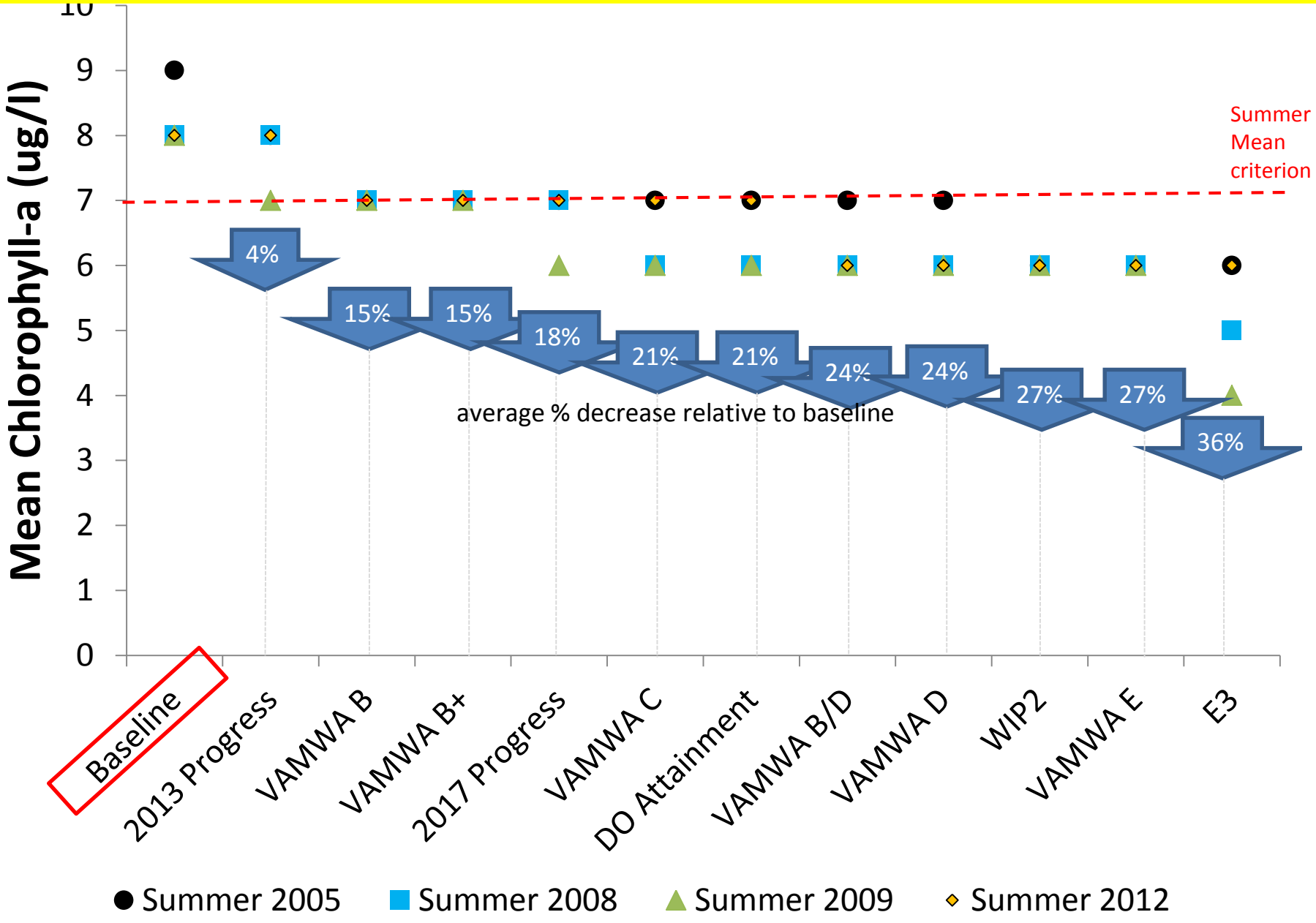
Chlorophyll predicted under each scenario for the two worst summer months for upper JMSTFL



Non-attainment


Observed Summer Means for JMSPH
Mean Chlorophyll-a (ug/l)
10
9
8
7
6
5
4
3
2
1
0
Summer Mean criterion
Summer 2005
Summer 2006
Summer 2007
Summer 2008
Summer 2009
Summer 2010
Summer 2011
Summer 2012
Summer 2013

Chlorophyll predicted under each scenario for the four worst summers for JMSPH



Non-attainment

Observed

Short-duration criteria

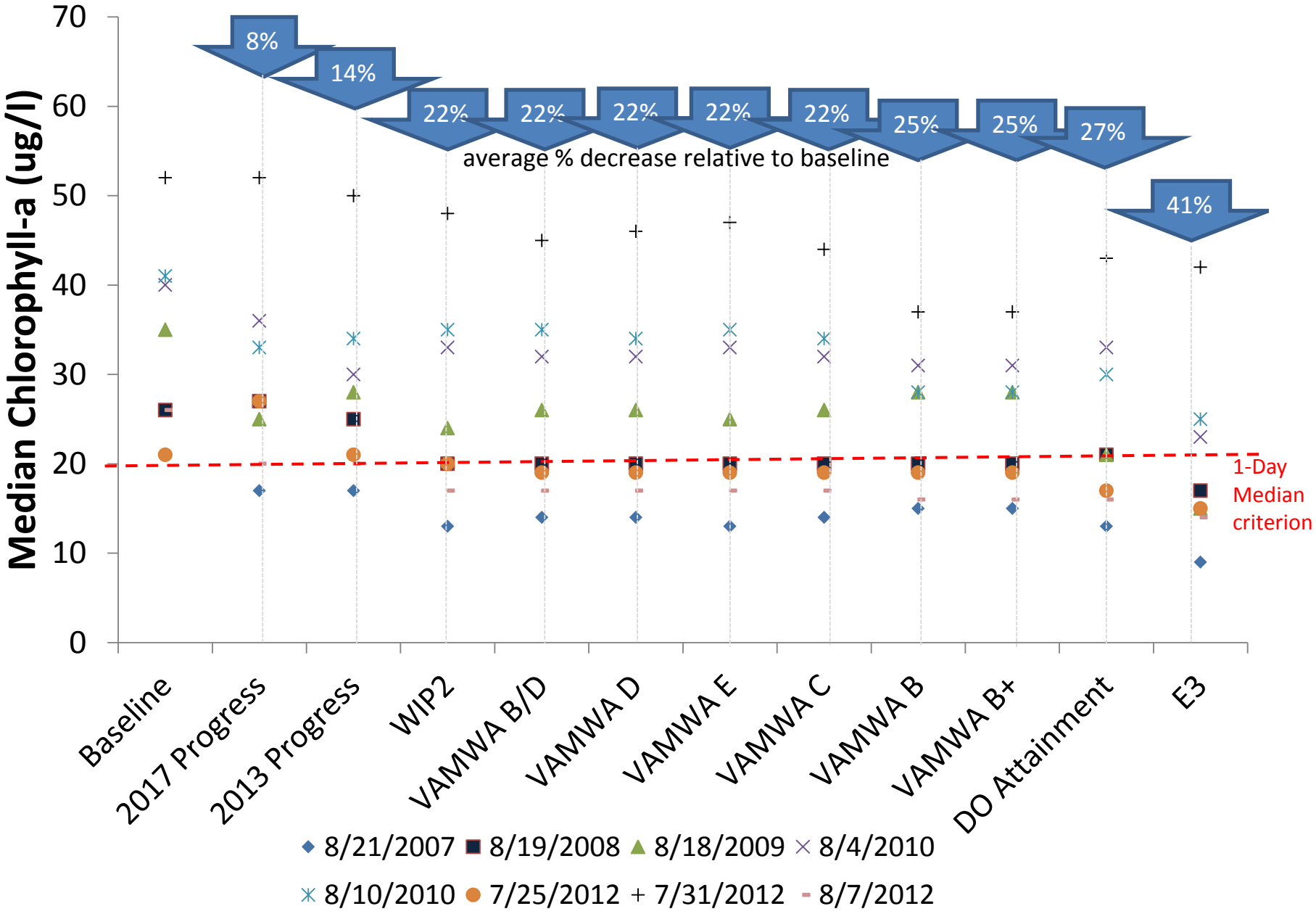
SUMMER		Baseline			
Period	lower JMSTFU	upper JMSTFL	lower JMSTFL	JMSMH	JMSPH
2005-2010	0%	0%	0%	0%	6%
2006-2011	0%	**12%**	0%	0%	6%
2007-2012	0%	**12%**	0%	0%	10%
2008-2013	0%	**12%**	0%	0%	9%

Exceedence rates of short-duration criteria. Red values indicate excessive exceedence rates (> 10%)

Close to non-attainment!

Exceedence rate =
8 exceedences / 79 summer days

Chlorophyll predicted under each scenario for the eight worst summer days for JMSPH



Wrap-up

- The VIMS model does not predict attainment of the existing criteria under any scenario.

- The VIMS model predicts that the proposed criteria are attainable under all VAMWA scenarios.

- The chlorophyll reductions under the VAMWA B and B+ are quite different in the tidal fresh, indicating the sensitivity to TP reductions in this part of the estuary.

- The reductions under the VAMWA B/D and D are similar, despite the different loadings.

- With the exception of VAMWA B, the VAMWA scenarios and the the CBPO's WIP2 scenario produce similar results.

Credit: George Tolton

Questions?

Credit: George Tolton

Credit: Tony Silvia