

Evaluation of the James River Chlorophyll Assessment Methodology

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Fall 2015 SAG Meeting

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What is Assessment Methodology?

“For each WQS, the state, territory, or authorized tribe should describe how it assesses attainment with the standard. The description may be included in the approved WQS or in other implementing regulations or policies and procedures such as the state, territory, or authorized tribe’s continuous planning process or consolidated assessment and listing methodology. This includes defining the water quality indicators it measures and the procedures for analyzing and interpreting data in order to decide whether standards are met or water quality is impaired. This should include collection and analysis of multiple types of data providing information relevant to assessing attainment with approved WQS....”

USEPA—2002 “Consolidated Assessment and Listing Methodology—Toward a Compendium of Best Practices”

<http://water.epa.gov/type/watersheds/monitoring/calm.cfm>

WATER QUALITY STANDARDS (WQS)



Establishes acceptable pollutant concentrations

ASSESSMENT METHODOLOGY

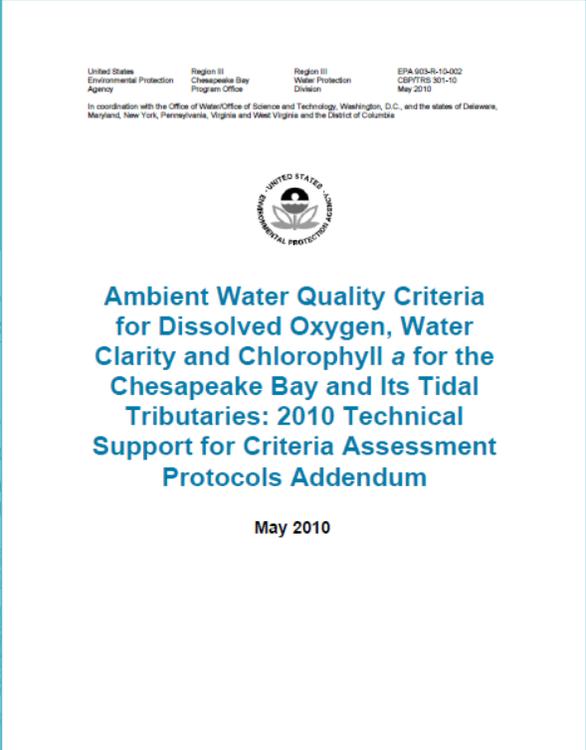
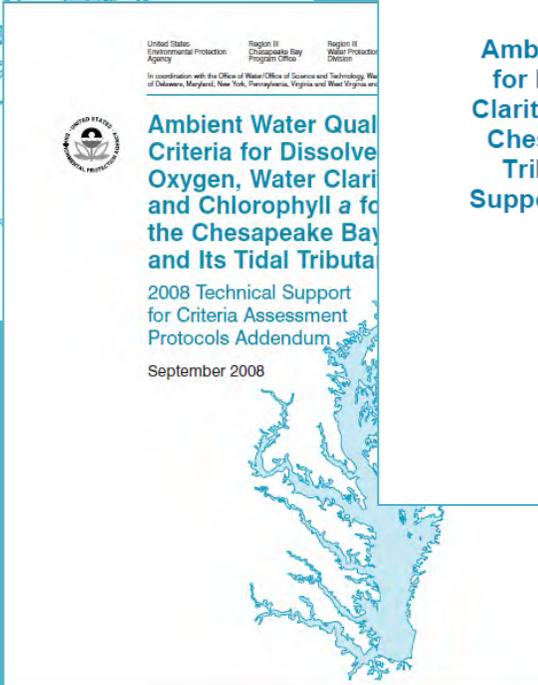
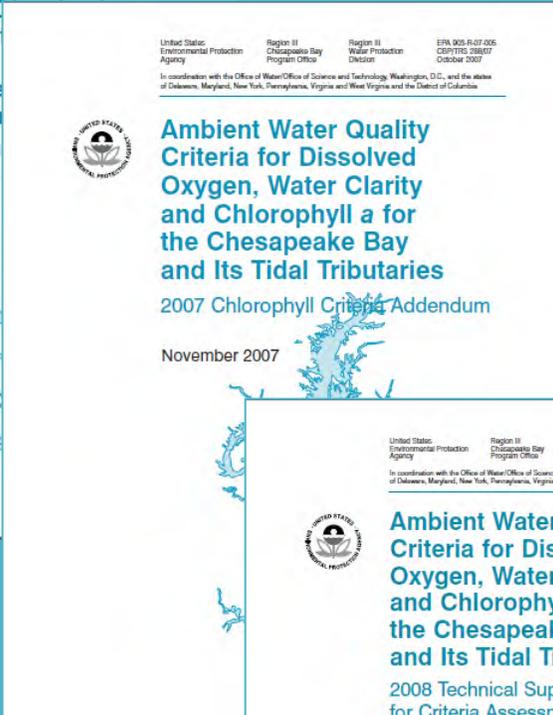
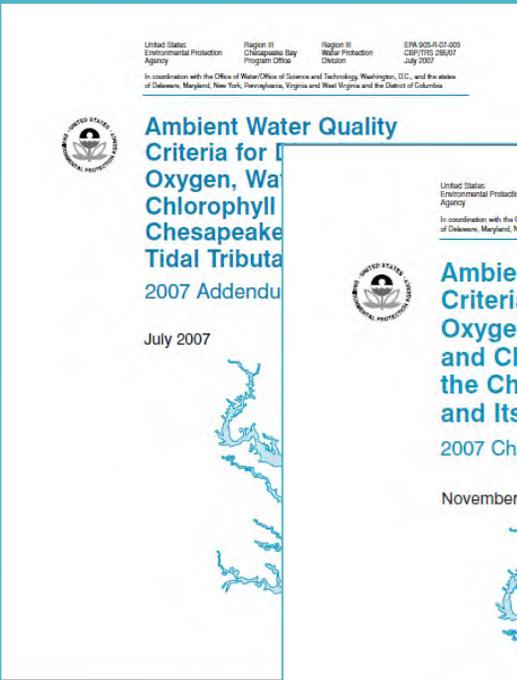
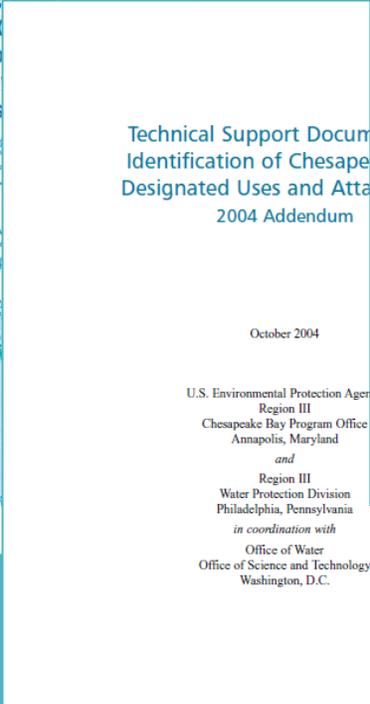
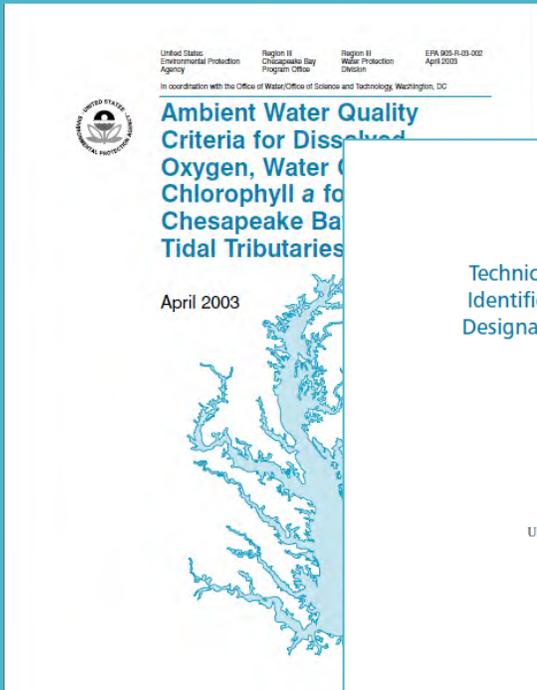


The policies DEQ uses to implement the WQS

bb. The following site specific numerical chlorophyll a criteria apply March 1 through May 31 and July 1 through September 30 as seasonal means to the tidal James River (excludes tributaries) segments JMSTF2, JMSTF1, JMSOH, JMSMH, JMSPH and are implemented in accordance with subsection D of 9VAC25-260-185.

| Designated Use | Chlorophyll a μl | Chesapeake Bay Program Segment | Temporal Application |
|----------------|-----------------------------|--------------------------------|-----------------------|
| Open Water | 10 | JMSTF2 | March 1 - May 31 |
| | 15 | JMSTF1 | |
| | 15 | JMSOH | |
| | 12 | JMSMH | |
| | 12 | JMSPH | |
| | 15 | JMSTF2 | July 1 - September 30 |
| | 23 | JMSTF1 | |
| | 22 | JMSOH | |
| | 10 | JMSMH | |
| | 10 | JMSPH | |

3. Attainment of these criteria shall be assessed through comparison of the generated cumulative frequency distribution of the monitoring data to the applicable criteria reference curve for each designated use. If the monitoring data cumulative frequency curve is completely contained inside the reference curve, then the segment is in attainment of the designated use. The reference curves and procedures to be followed are published in the USEPA, Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, April 2003 and the 2004 (EPA 903-R-03-002 October 2004) and 2007 (CBP/TRS 285-07, EPA 903-R-07-003), 2007 (CBP/TRS 288/07, EPA 903-R-07-005), 2008 (CBP/TRS 290-08, EPA 903-R-08-001, and 2010 (CBP/TRS 301-10, EPA 903-R-10-002) addenda. An exception to this requirement is in measuring attainment of the SAV and water clarity acres, which are compared directly to the criteria.



http://www.chesapeakebay.net/content/publications/cbp_20138.pdf

http://www.chesapeakebay.net/content/publications/cbp_51366.pdf

http://www.chesapeakebay.net/channel_files/20963/2008_addendum_ambient_water_quality_criteria.pdf

The procedures used to implement the special Bay criteria, including JR chlorophyll, are published in a series of EPA technical documents.

Since the JR chlorophyll criteria were adopted in the WQS in 2005, the assessment procedure has not been altered.

Ten years of additional knowledge provide the opportunity to evaluate the methodology and revise, if need be.

On July 15, 2015, DEQ hosted a webinar for the SAP to walk everyone through the methodology.

Improving the James River Chlorophyll Assessment Procedure



Tish Robertson
Office of Monitoring and Assessment
VA DEQ
July 15, 2015

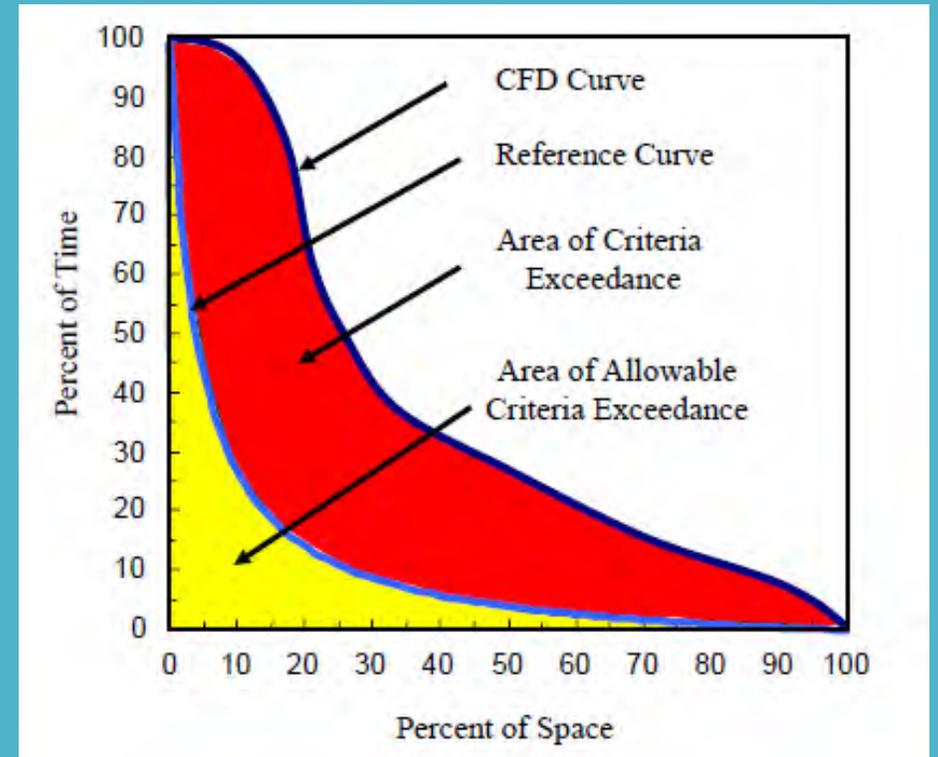
The known methodological weaknesses of the assessment framework were shared with the group, as well as a “straw man” proposal for addressing these weaknesses.

Feedback was solicited and received.

What's the framework?

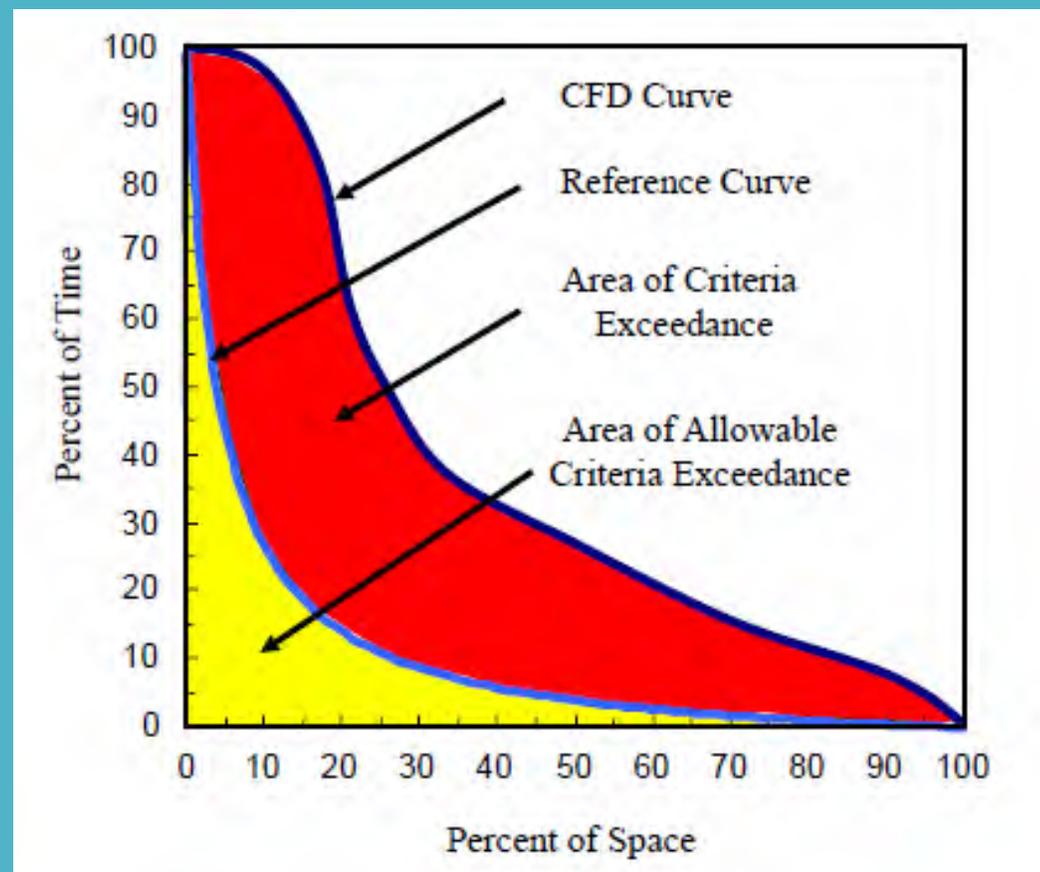
What's the framework?

The Cumulative Frequency Diagram carves out the “allowable” exceedance frequency in space and time.



[Tango, Peter J. and Richard A. Batiuk, 2013. Deriving Chesapeake Bay Water Quality Standards. Journal of the American Water Resources Association \(JAWRA\) 1-18.](#)

- The CFD was developed by the Bay Program for the purpose of dissolved oxygen assessments.
- DEQ adopted the CFD for JR chlorophyll only out of expediency.
- The CFD is as experimental as it is innovative.



How does it work?

Steps:

1. Spatial interpolation of monitoring data

| | | | | |
|-------|----|--|----|----|
| | 30 | | | 30 |
| 1-Jul | | | 50 | |
| | | | | |
| | 10 | | | 10 |
| | | | | |
| | 10 | | | 10 |
| 1-Aug | | | 30 | |
| | | | | |
| | 20 | | | 10 |
| | | | | |
| | 40 | | | 20 |
| 1-Sep | | | 20 | |
| | | | | |
| | 10 | | | 10 |

JR segment
sampled
once monthly
at five stations.

How does it work?

Steps:

1. Spatial interpolation of monitoring data

| | | | | | | | | |
|-------|----|--|----|----|----|----|----|----|
| 1-Jul | 30 | | | 30 | 30 | 40 | 50 | 30 |
| | | | 50 | | 40 | 40 | 50 | 20 |
| | | | | | 30 | 30 | 40 | 10 |
| | 10 | | | 10 | 20 | 30 | 30 | 10 |
| 1-Aug | 10 | | | 10 | 10 | 20 | 30 | 10 |
| | | | 30 | | 20 | 20 | 30 | 20 |
| | | | | | 10 | 30 | 20 | 10 |
| | 20 | | | 10 | 10 | 10 | 10 | 10 |
| 1-Sep | 40 | | | 20 | 40 | 30 | 20 | 20 |
| | | | 20 | | 30 | 20 | 20 | 10 |
| | | | | | 20 | 20 | 10 | 10 |
| | 10 | | | 10 | 10 | 10 | 10 | 10 |

Field observations are interpolated so that the entire segment is represented in the assessment.

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates

Monitoring Event Interpolations

| | | | |
|----|----|----|----|
| 30 | 40 | 50 | 30 |
| 40 | 40 | 50 | 20 |
| 30 | 30 | 40 | 10 |
| 20 | 30 | 30 | 10 |

| | | | |
|----|----|----|----|
| 10 | 20 | 30 | 10 |
| 20 | 20 | 30 | 20 |
| 10 | 30 | 20 | 10 |
| 10 | 10 | 10 | 10 |

| | | | |
|----|----|----|----|
| 40 | 30 | 20 | 20 |
| 30 | 20 | 20 | 10 |
| 20 | 20 | 10 | 10 |
| 10 | 10 | 10 | 10 |

Seasonal Geometric Mean

| | | | |
|----|----|----|----|
| 23 | 29 | 31 | 18 |
| 29 | 25 | 31 | 16 |
| 18 | 26 | 20 | 10 |
| 13 | 14 | 14 | 10 |

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates

Monitoring Event Interpolations

| | | | |
|----|----|----|----|
| 30 | 40 | 50 | 30 |
| 40 | 40 | 50 | 20 |
| 30 | 30 | 40 | 10 |
| 20 | 30 | 30 | 10 |

| | | | |
|----|----|----|----|
| 10 | 20 | 30 | 10 |
| 20 | 20 | 30 | 20 |
| 10 | 30 | 20 | 10 |
| 10 | 10 | 10 | 10 |

| | | | |
|----|----|----|----|
| 40 | 30 | 20 | 20 |
| 30 | 20 | 20 | 10 |
| 20 | 20 | 10 | 10 |
| 10 | 10 | 10 | 10 |

Seasonal Geometric Mean

| | | | |
|----|----|----|----|
| 23 | 29 | 31 | 18 |
| 29 | 25 | 31 | 16 |
| 18 | 26 | 20 | 10 |
| 13 | 14 | 14 | 10 |

| | | | |
|---|---|---|---|
| X | X | X | X |
| X | X | X | X |
| X | X | X | ✓ |
| ✓ | ✓ | ✓ | ✓ |

Assessment Layer

Exceedance rate = # of exceedances divided by total # of estimates

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates
3. Build the CFD

| | Spatial Exceedance Rate |
|--------------|-------------------------|
| Spring Year1 | 25% |
| Spring Year2 | 33% |
| Spring Year3 | 10% |

Three years of spatial exceedance rates

| | Ranked Spatial Exceedance Rate |
|--------------|--------------------------------|
| Spring Year2 | 33% |
| Spring Year1 | 25% |
| Spring Year3 | 10% |

Rank them from worse to best

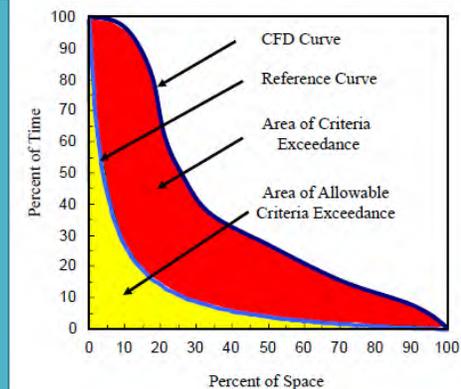
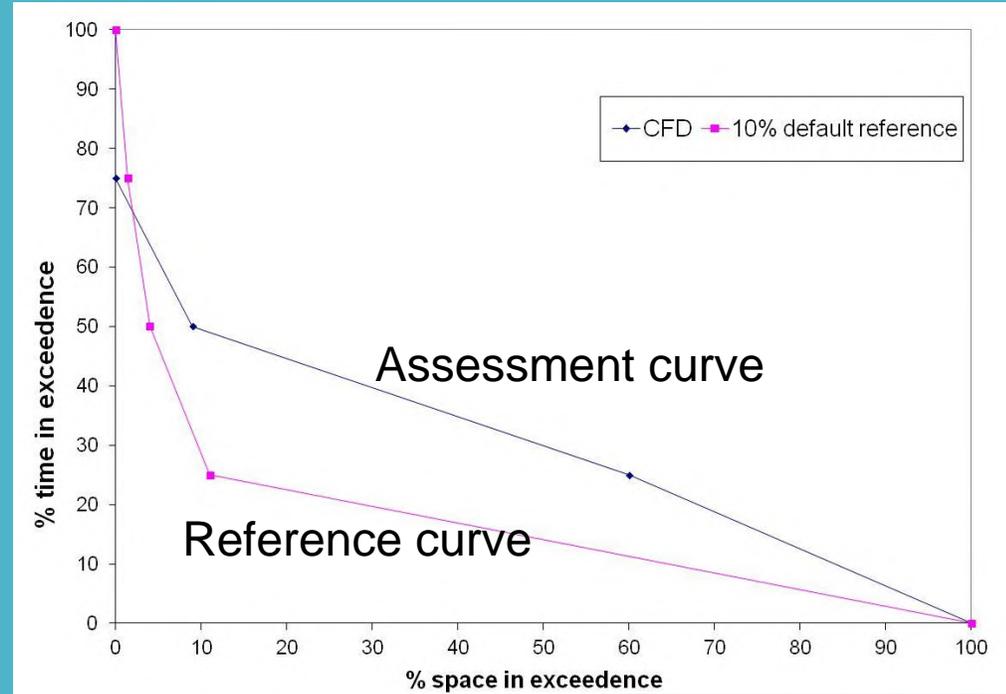
| Season-Year | Ranked Spatial Exceedance Rate | Temporal Exceedance Rate |
|--------------|--------------------------------|--------------------------|
| | 100% | 0% |
| Spring Year2 | 33% | 25% |
| Spring Year1 | 25% | 50% |
| Spring Year3 | 10% | 75% |
| | 0% | 100% |

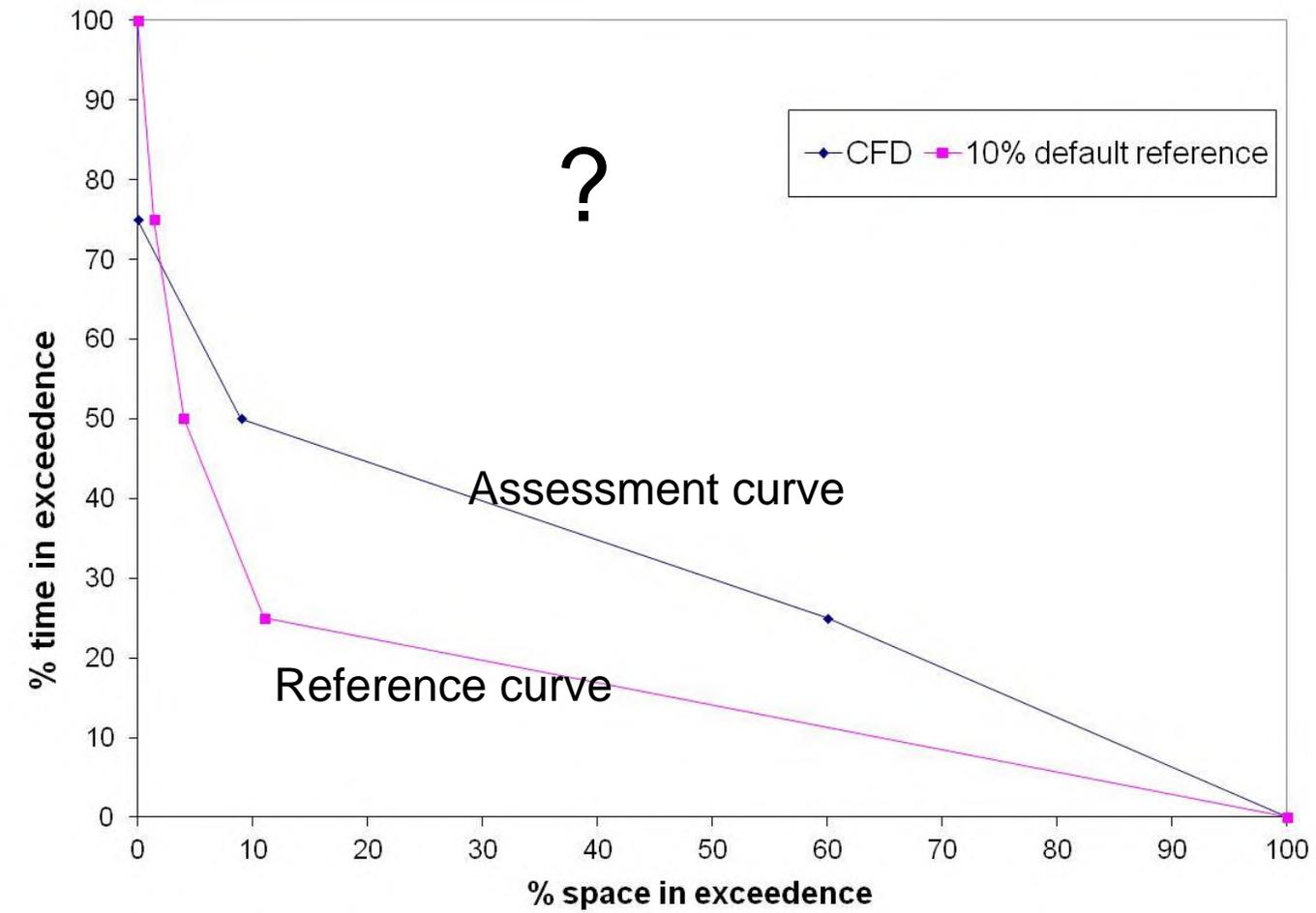
Assign each exceedance with a cumulative probability using the Weibull equation

How does it work?

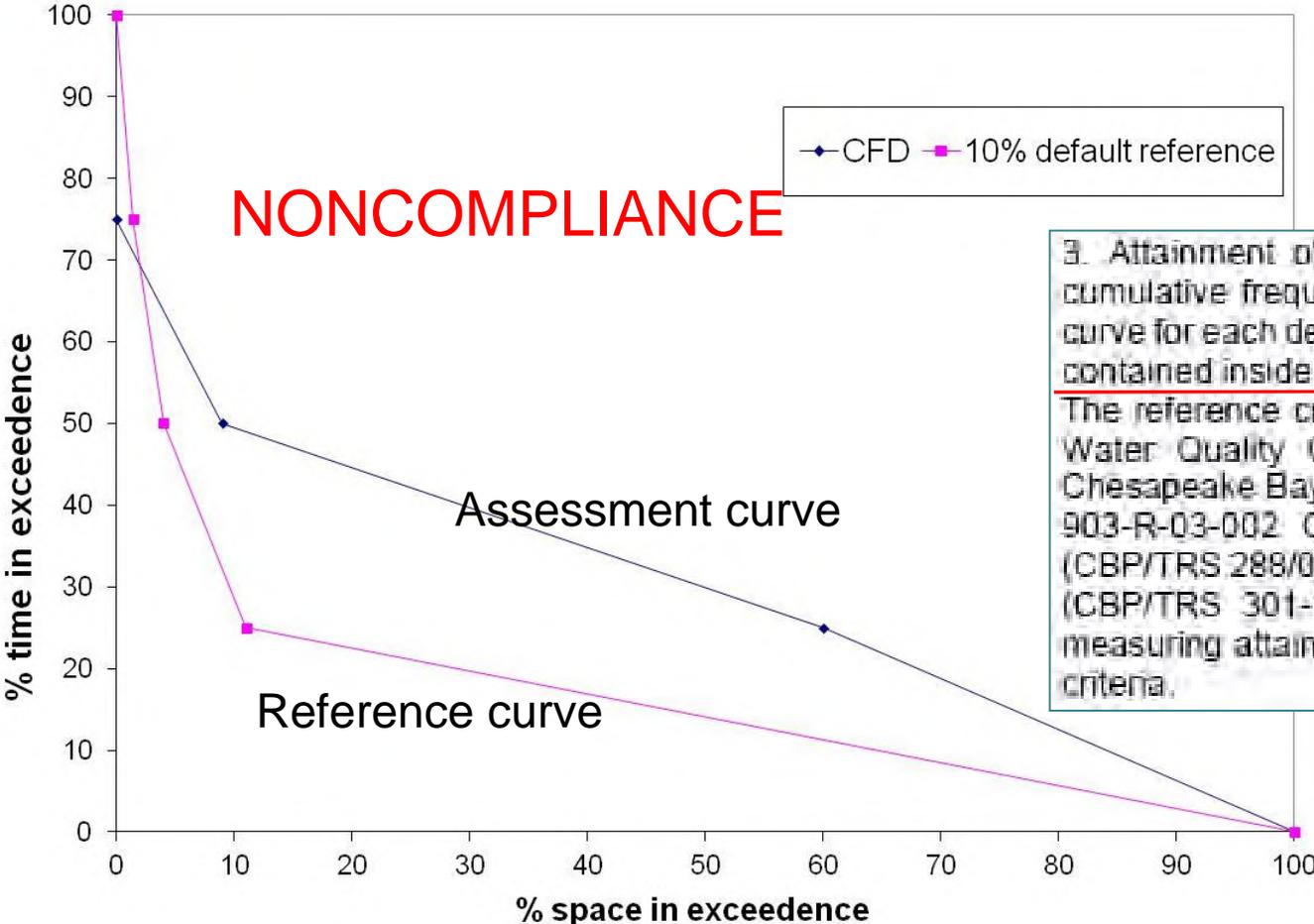
Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates
3. Build the CFD

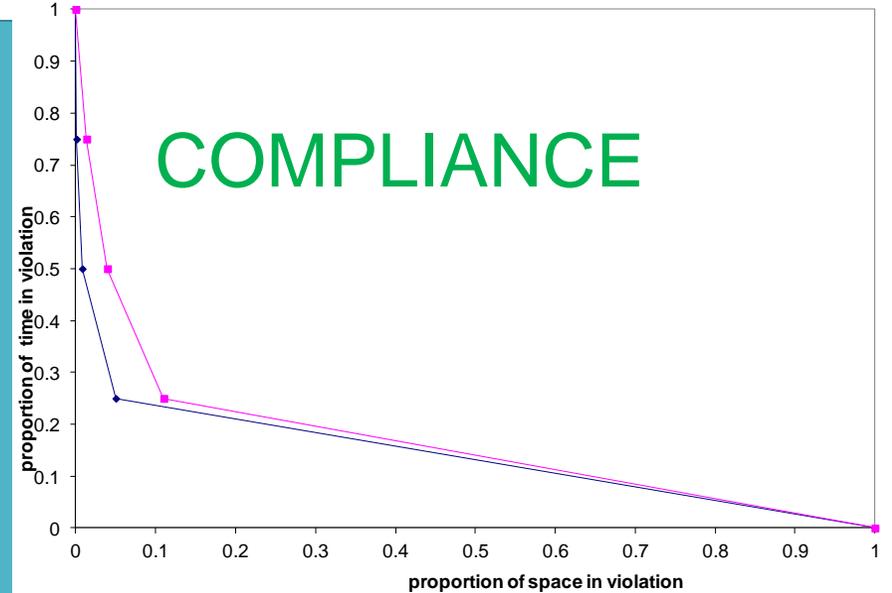




9 VAC 25-260 Virginia Water Quality Standards



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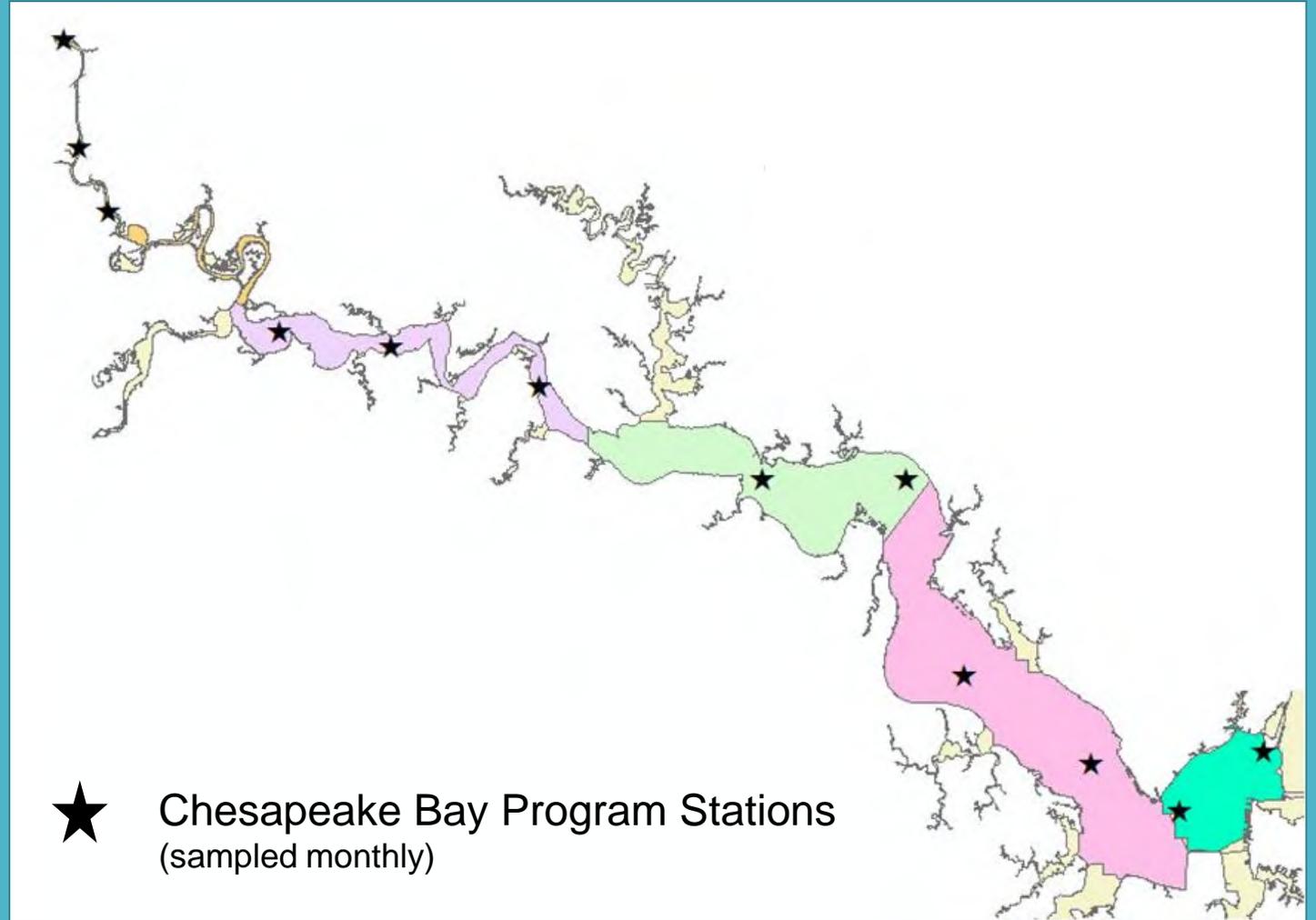
Weaknesses of the CFD Framework Identified by DEQ

The datasets generated from monthly fixed station visits are not sufficient to produce accurate estimations of exceedance as defined by the current methodology.

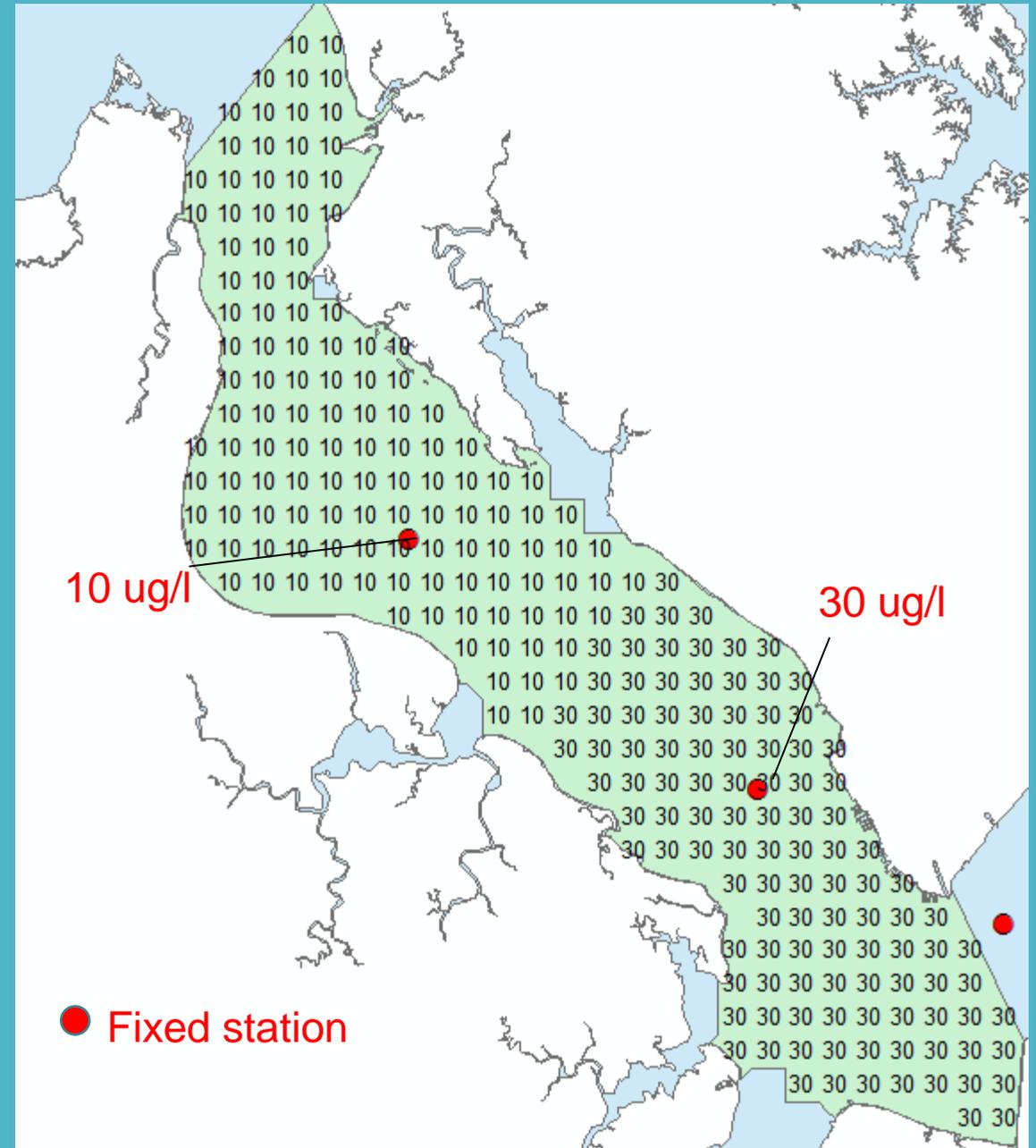
The CFD requires us to make an assumption about chlorophyll spatial and temporal variability under reference conditions. It is questionable that the rubric we are currently using is a good one.

Weakness #1: The datasets generated from monthly fixed station visits are not sufficient to produce accurate estimations of exceedance as defined by the current methodology.

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This is what an interpolation of a fixed station dataset looks like.



DEQ contracted with independent statistician Elgin Perry to perform a validation of the CFD when fixed station datasets are used to determine compliance.

His analysis was presented in the webinar, and his report was made available for SAP review.

The take-away:

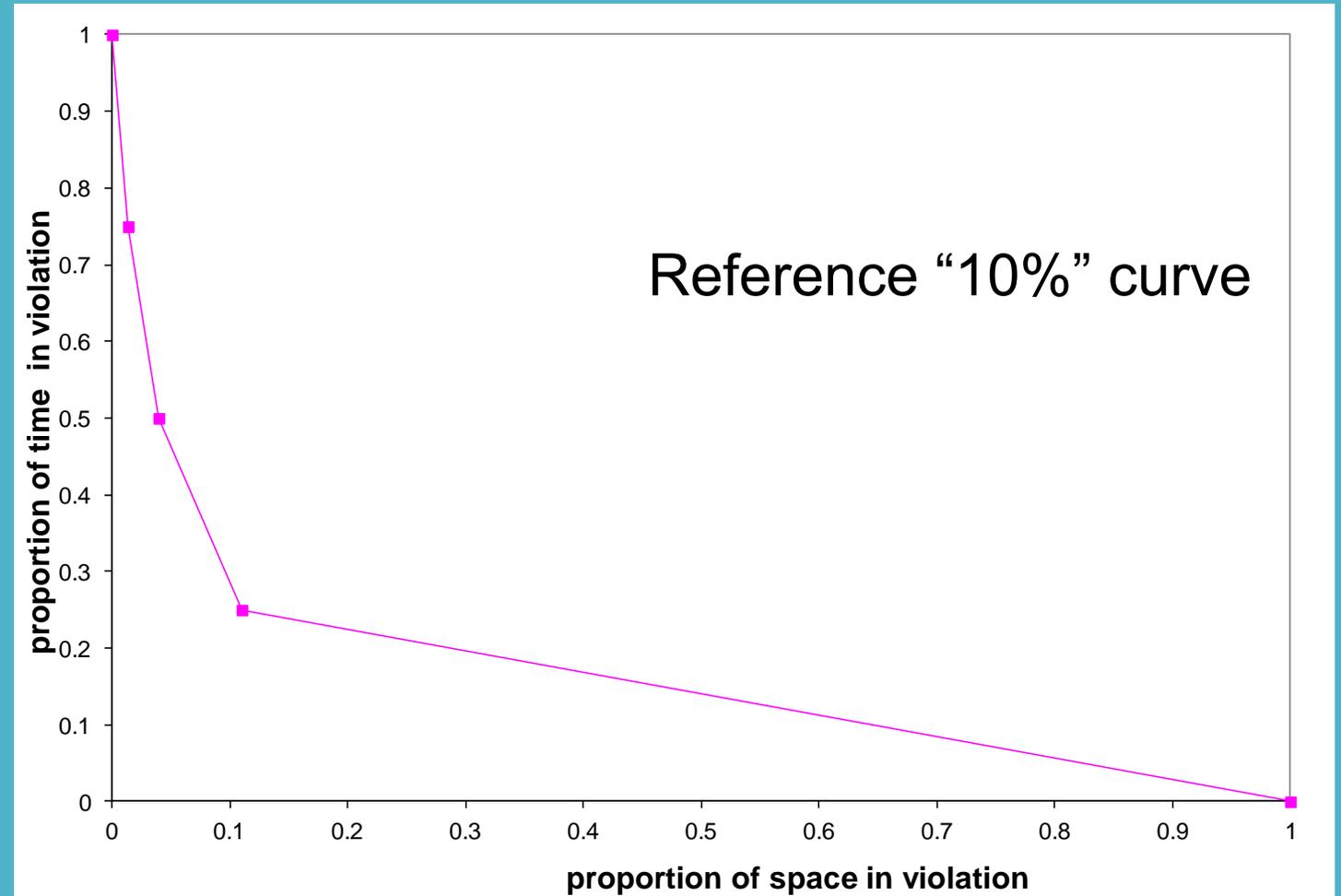
*“When the true condition of the estuary is either passing or failing, the sample CFD [based on fixed station data] has a high probability of reaching the wrong conclusion. **The odds of making the right decision are very little better than if the decision were reached by flipping a coin.**”*

-Elgin Perry

From “Notes on James River Chlorophyll Simulator and CFD Validation”

Weakness #2: The protocol requires us to make an assumption about chlorophyll spatial and temporal variability under reference conditions. It is questionable that the rubric we are currently using is a good one.

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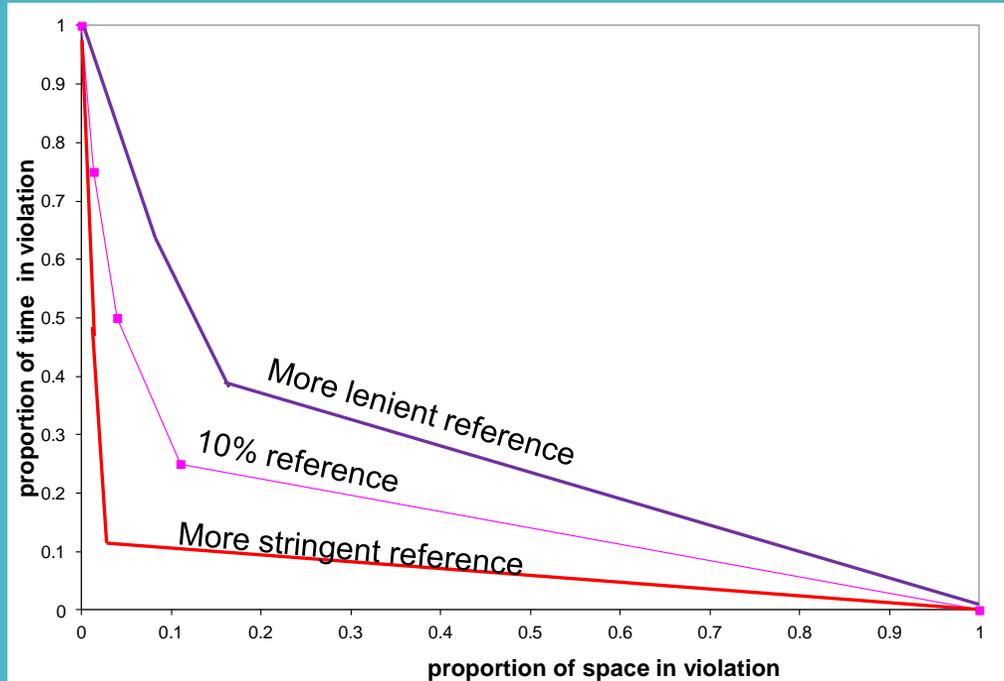
Is this distribution truly reflective of reference conditions, or is it an arbitrary line?

DEQ contracted with Claire Buchanan (ICPRB) to generate “bioreference” curves based on instantaneous exceedances of the JR criteria when nutrients are low and light availability is high (reference conditions).

Her analysis was presented in the webinar, and her report was made available for SAP review:

http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityStandards/James%20River%20Chl%20A%20Study/SAP_Reports/JamesR_BioIRefCurve_FINAL_09-08-2014.pdf

The take-away:



| JR criterion | stringency of bioreference relative to 10% curve |
|--------------|--|
| spring TF2 | slightly more lenient |
| spring TF1 | more stringent |
| spring OH | much more lenient |
| spring MH | much more lenient |
| spring PH | more stringent |
| summer TF2 | slightly more lenient |
| summer TF1 | slightly more lenient |
| summer OH | similar |
| summer MH | much more lenient |
| summer PH | much more stringent |

Claire's results suggest that the 10% curve is overly stringent in most cases, assuming that the JR criteria are adequate representations of reference.

Since the July webinar, an alternative assessment framework has been drafted and presented in front of the SAP. DEQ has asked the panel to evaluate the protectiveness of this proposed approach in addition to the current one.

| Assessment Element | Current Method | Alternative Method |
|--|--|--|
| Compatible data types | discrete (fixed station "grabs"), Dataflow | discrete, Dataflow, continuous |
| Data processing | All observations in a segment are interpolated by monitoring event. | All observations in a segment are averaged by monitoring event. Only Dataflow are interpolated. |
| Calculation of exceedance | Spatial exceedance rate determined from each seasonal interpolation. | The averages derived from each monitoring event are averaged geometrically over a season to represent a segment's seasonal chlorophyll expression. |
| Attainment determination | Distribution of exceedances relative to reference curve | Segment seasonal mean is compared to criterion. |
| Length of assessment period | Three years | Six years |
| Allowable frequency of exceedance | 10% space-time | 2 exceedances out of 6 (per criterion) |

The alternative method has the following advantages over the current method:

- more literal interpretation of the WQS
- easier to implement and explain
- more consistent with DEQ and EPA approaches/guidance
- fewer assumptions
- produces more confident results, free from bias
- compatible with multiple types of data

Next Steps

- Apply alternative method to model output.
- STAC review

Questions?