Update on Multiple Tributary Model (MTM) Selection

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Modeling Workgroup Quarterly - October 5th 2022

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Outline

- Why we are Developing MTMs
- Details about MTMs
- Process and Exercises to recommend the Tributaries for MTM Development
- Results of the Process and Exercises
- Discussion by WQ GIT and GIT Representatives
- Current Options Proposed for Concurrence with the WQ GIT and GIT Representatives

Context - Why create MTMs?

Phase 7 Model Development is Underway

- Main Bay Model - covers all 92 tidal segments at a finer spatial resolution compared to Phase 6
- Multiple tributary models (MTMs) - Small number of tributary systems modeled at an even higher spatial resolution
  - Why MTMs?
    - Assisting and Improving Tidal Chesapeake TMDLs
    - Improved Assessment of Shallow Water Processes (Important Living Resource Component)
    - Improving CBP Science, Analysis, and Implementation for Chesapeake Climate Change Impacts
    - Adherence to STAC Guidance on Bay Modeling

See presentations given by Lew at the August WQ GIT and July Modeling WG for more details.

"Short-term and long-term efforts should continue the present trend of resolving finer spatial scales to make the estuarine models more directly applicable to assessing the performance of management actions at scales relevant to local communities and stakeholders.
...refining spatial scale and increasing parameters have costs in computational time, development effort, data requirements, and parameter uncertainty. Some regions of the Chesapeake Bay may not benefit from further increases in spatial and temporal resolution and so careful consideration should be given to determining exactly where higher resolution is needed."
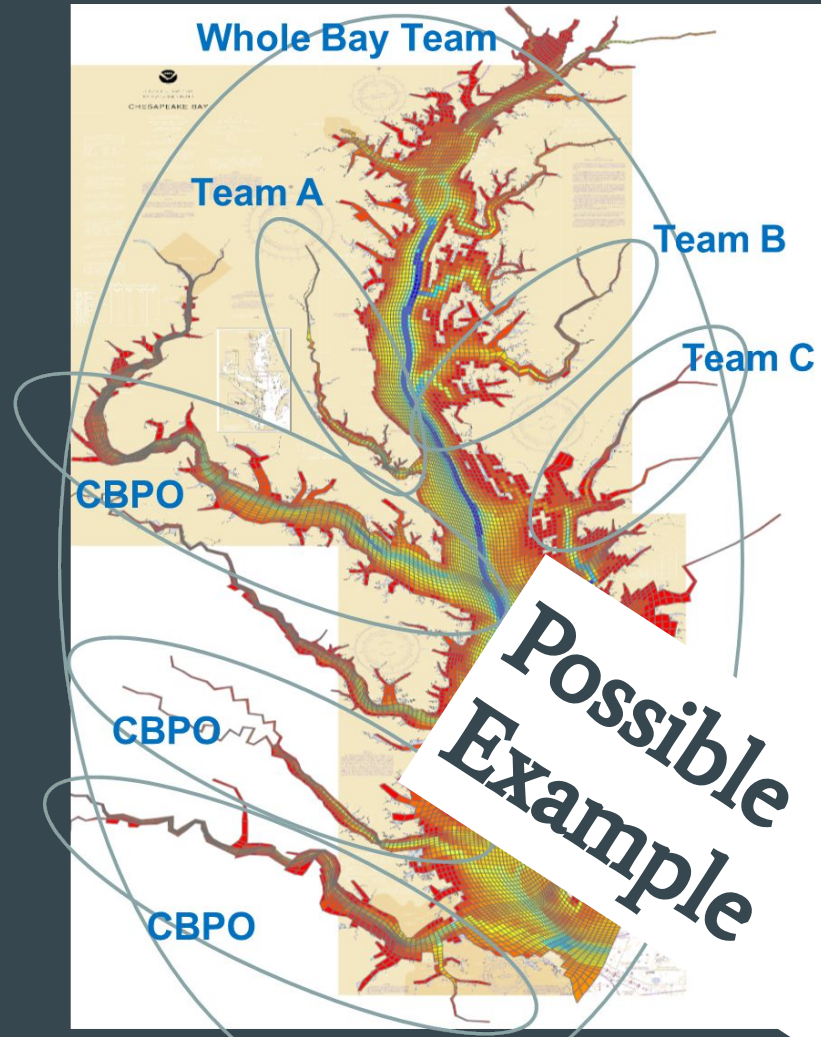--Hood et al., 2021

Context - Details about MTMs

Number of possible MTMs - 6

- 1 mostly completed through previous work and to be incorporated by CBPO team
  - York River
- 5 to be selected by the partnership (WQ GIT + other GIT representatives recommend, Management Board decides)
  - 2 for in-house modeling by CBPO
  - 3 for a forthcoming RFA

How to Choose which Tributaries to select for MTM Development?

Given the many number of tributaries and embayments, how should the WQ GIT in conjunction with the partnership choose which tributaries to recommend to the Management Board for MTM Development?

- Our constraints:
  - Many tidal segments and a limited budget for the MTM teams
  - Many interests and many potential uses or applications across the partnership
  - A short timeline
- A structured approach (matrix) was suggested to help rank or order options at the July Modeling Workgroup Quarterly

What did we do?

Why did we do it?

A "decision matrix" was created to assess tributary options based on selected criteria of interest provided by the partnership at the September 7th MTM Discussion Meeting.

Weights were defined by and applied to criteria by a small group of partnership representatives to help delineate options in greater detail.

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The "decision matrix" label is misleading… The matrix is a <u>guide</u> and served as a <u>framework</u> for the discussion with the WQ GIT and other GIT representatives.

Our Method

- **<u>Step 1</u>**: Gather Input - Attendees of September 7th MTM Discussion provided a long list of potential criteria, as well as a list of tributaries, to consider
  - The meeting was requested by the WQ GIT on August 22nd
  - Participants included representatives from multiple GITs, in addition to WQ GIT and jurisdictional partners

Our Method

- <u>Step 1</u>: Gather Input - Attendees of September 7th MTM Discussion provided a long list of potential criteria, as well as a list of tributaries, to consider
- <u>**Step 2**</u>: Refine - Criteria were combined when similar and reasonable to make them scorable; very small embayments were removed from the list if they would have been an inefficient use of resources
  - Efforts were made to keep a relative balance in number of criteria for different categories (Water Quality, Living Resources, Cross-GIT, etc.)
  - Here is the list of <u>criteria</u> and <u>tributaries</u> considered.

Our Method

- <u>Step 1</u>: Gather Input - Attendees of September 7th MTM Discussion provided a long list of potential criteria, as well as a list of tributaries, to consider
- <u>Step 2</u>: Refine - Criteria were combined when similar and reasonable to make them scorable; very small embayments were removed from the list if they would have been an inefficient use of resources
- **<u>Step 3</u>**: Two Exercises - A small group representing the partnership ranked the criteria and contributed their knowledge as to which criteria applied to which tributary
  - Small group was inclusive of partnership - one from each tidal jurisdiction and each GIT
  - Criteria were ranked and given a weight using a pairwise approach
  - Weighted scores were calculated for tributaries based on small group scores in the "decision matrix"
  - A few scores were calculated by Alex and Jeremy in conjunction with experts for those datasets (Protected Lands, Impervious Surfaces, Shallow Water)

Caveats

We had a small but mighty - and generous - group of volunteers from across the partnership

This was very quickly completed and in only one stage due to the compressed timeline

However, the exercise's main purpose was to guide and frame the discussion at the September WQ GIT, not an attempt to publish a journal article or extensive report. Good > perfect.

THANK YOU to all our September 7 discussion and October 3 discussion participants

Extra big THANK YOU to those who responded to and helped with the exercises:

- Britt Slattery, Bruce Vogt, Cheyenne Owens, George Onyullo, Guido Yactayo, KC Filippino, Peter Tango, Renee Thompson, Tish Robertson

Results from the Two Exercises

Results of the pairwise comparison exercise

Totaled responses

Greatest weight (3) applied to upper tier criteria that had the most paired wins

Lowest weight (1 = no multiplier) applied to bottom

			Total	Rank
criteria 5	E	WQS attainment: challenge or success (WQ)	90	1
criteria 14	N	Tidal wetlands (LR)	84	2
criteria 7	G	Restoration and conservation priorities (LR)	82	3
criteria 9	I	Fish habitat (LR)	69	4
criteria 11	K	Underserved or EJ (Misc)	62	5
criteria 16	P	SAV (LR)	57	6
criteria 3	C	Contribution (WQ)	57	6
criteria 17	Q	Cross-GIT Restoration composite (All)	56	8
criteria 8	H	Monitoring data (All)	53	9
criteria 4	D	Weak spots (WQ)	52	10
criteria 1	A	Well-studied (WQ)	52	10
criteria 13	M	Shallow water (All)	50	12
criteria 10	J	Percent impervious (Misc)	48	13
criteria 2	B	Oysters sanctuaries and aquaculture (LR)	47	14
criteria 6	F	Focus area (All)	42	15
criteria 15	O	Protected Lands (Misc)	42	15
criteria 12	L	PCBs (WQ)	37	17

x3

x2

Unweighted and weighted results summarized by 20 tributary options, with ranks

(9 larger tributaries shaded green in left-hand column)

	Unweighted total	Weighted score	unweighted rank	weighted rank	Change from weights	Tier / rough grade
Potomac	13.408	29.325	1	1	0	A+
Choptank	12.917	28.833	2	2	0	A+
Rappahannock	11.692	26.450	3	3	0	A
York	11.612	25.819	4	4	0	A
Patuxent	11.583	24.750	5	5	0	A- or B+
Chester	11.050	24.317	6	6	0	A- or B+
Patapsco	10.250	22.458	8	7	1	B
Back	10.167	22.333	9	8	1	B
Manokin	10.117	20.933	10	9	1	C
James	9.626	20.712	12	10	2	C
Pocomoke	9.258	20.608	14	11	3	C
Lynnhaven	10.350	20.592	7	12	-5	C
Wicomico	9.283	20.517	13	13	0	C
Nanticoke	9.833	20.333	11	14	-3	C
Sassafras	8.625	18.542	15	15	0	D
Northeast	8.200	18.017	19	16	3	D
Big Annemessex	8.542	17.292	17	17	0	D
South	8.600	16.967	16	18	-2	D
Severn	8.308	16.592	18	19	-1	D
Magothy	7.500	14.167	20	20	0	D

What this tells us

Highlights:

- Potomac is the clear #1
- Choptank is solid #2 and is the next obvious choice
- The order of the top 6 is unchanged by the weights, but there may be other criteria or principles to consider with the results
- Weighted scores give us a sense of a grade distribution
  - Several options are extremely closely matched (everything marked as a C is within 20-21 weighted points) and are largely interchangeable
  - Several options appeared worth removing from the discussion (marked "D")

Unweighted and weighted results summarized by 14 tributary options, with ranks

(9 larger tributaries shaded green in left-hand column)

	Unweighted total	Weighted score	unweighted rank	weighted rank	Change from weights	Tier / rough grade
Potomac	13.408	**29.325**	**1**	**1**	0	A+
Choptank	12.917	**28.833**	**2**	**2**	0	A+
Rappahannock	11.692	**26.450**	**3**	**3**	0	A
York	11.612	**25.819**	**4**	**4**	0	A
Patuxent	11.583	**24.750**	**5**	**5**	0	A- or B+
Chester	11.050	**24.317**	**6**	**6**	0	A- or B+
Patapsco	10.250	**22.458**	8	7	1	B
Back	10.167	**22.333**	9	8	1	B
Manokin	10.117	**20.933**	10	9	1	C
James	9.626	**20.712**	12	10	2	C
Pocomoke	9.258	**20.608**	14	11	3	C
Lynnhaven	10.350	**20.592**	7	12	-5	C
Wicomico	9.283	**20.517**	13	13	0	C
Nanticoke	9.833	**20.333**	11	14	-3	C

WQ GIT Response to the Exercise Results

- After presenting the results to the WQ GIT, a second discussion was requested to further consider jurisdictional modeling needs and discuss which options should be presented to the Management Board
  - This discussion was held on <u>October 3rd</u>
- Two sets of options were proposed discussed at this meeting, and they are being sent today to the WQ GIT and other GIT representatives in the process for concurrence

Options to present to the Management Board*

- Option A: Original top six tributaries recommended as the result of the exercises GIT representatives took part in
  - Potomac
  - Choptank
  - Rappahannock
  - York
  - Patuxent
  - Chester

  *Waiting on concurrence from the WQ GIT and GIT representative participating in the process

- The WQGIT and other GIT representatives recommend the following tributaries for development:
  - For In house Development by the CBPO Modeling Team:
    - Potomac
    - James
    - York
  - For inclusion in an RFA:
    - Choptank
    - Patapsco
    - Rappahannock
  - Request for funding for one or two additional tributary teams, of which the following three options were suggested (Note - $250,000 covers one tributary team to develop the model, engage with stakeholders, and apply the model over the course of five years. Approximately $50,000 per year, per team)
    - Patuxent
    - Chester
    - Pocomoke

Next Steps

- After concurrence on the options for MTM development, the options will be provided to the Management Board for a decision.
  - Target date for presenting to the Management Board: October 13th
- Once a decision has been made, the RFA will indicate which three tributaries are to modeled by the MTM teams and the in-house estuarine modelers can better direct their work on the two tributaries for in house development
  - The MTM teams will develop the model, engage with stakeholders, present updates to the Modeling Workgroup, and apply the model over the course of five years
  - A potential timeline might look like:
    - Q1 2023: Begin work
    - 2025: Fully Operational MTMs
    - 2026: CBP Review of MTMs
    - 2027: CBP Application of MTMs

Questions?

Bonus slides: details and methods

How did we determine the weight for criteria?

17 criteria is a lot, how do we determine our priorities and what matters more than something else?

We used a method called "pairwise comparison"

"…which of the two criteria do you feel is more critical for evaluating which tidal tributaries are selected for higher resolution estuarine modeling?"

Each pair only judged once. For 17 criteria this equals 136 pairs. Variations of this method involve scoring the difference, which we did not do for simplicity.

Option	A	B	C	D	E
A		A or B?	A or C?	A or D?	A or E?
B			B or C?	B or D?	B or E?
C				C or D?	C or E?
D					D or E?

How did we determine the values for Impervious Coverage?

A. Percentage of a tributary's total segment shed area that is classified as impervious, using the new high resolution LU/LC data for the years 2017/2018, as defined by the Chesapeake Healthy Watersheds Assessment.

a. High - 1
   i. Back - 40.5%
   ii. Lynnhaven - 36.53%
   iii. Severn   - 22.67%
   iv. Magothy - 21.73%
   v. Patapsco - 21.6%
b. Medium-High - 0.75
   i. South - 14.45%
   ii. Patuxent - 11.83%

c. Medium - 0.5
   i. Wicomico - 7.71%
   ii. Northeast - 7.6%
   iii. Potomac - 5.99%
d. Medium-Low - 0.25
   i. James - 4.77%
   ii. York - 3.78%
   iii. Nanticoke - 3.64%
   iv. Choptank - 3.53%
   v. Rappahannock - 3.2%
   vi. Chester - 2.89%
   vii. Manokin - 2.69%
   viii. Sassafras - 2.61%
   ix. Pocomoke - 2.45%
   x. Big Annemessex - 2.12%

How did we determine the values for Protected Lands?

A. Percentage of a tributary's total segment shed area that is protected. Used the 2018 protected lands raster to calculate values in ArcGIS Pro

- a. High - 1
    - i. Manokin - 40.442579%
    - ii. Big Annemessex - 31.189944%
    - iii. Patuxent - 30.328349%
    - iv. Pocomoke - 29.773576%
    - v. Chester - 29.1743%
- b. Medium-High - 0.75
    - i. Nanticoke - 27.736501%
    - ii. Choptank - 25.288197%
    - iii. James - 23.246228%
    - iv. Potomac - 23.087291%
   - v. Sassafras - 22.697645%

- c. Medium Low - 0.5
    - i. Patapsco - 21.667196%
    - ii. Rappahannock - 21.247337%
    - iii. Wicomico - 20.563572%
    - iv. Lynnhaven - 17.60295%
    - v. Severn   - 12.096648%
- d. Low - 0.25
    - i. Northeast - 11.253867%
    - ii. York - 9.932504%
    - iii. Back - 8.46069%
    - iv. South - 8.192314%
    - v. Magothy - 6.45614%

How did we determine the values for Shallow water?

To capture segments with relatively greater expected influence from management actions, we are interested in segments with lower total volumes (x axis, in km^3) and higher relative % shallow volume (as %). The green shaded area signifies the demarcation of interest based on grouping (segments with <0.1 km^3 volume and >10% shallow water volume). Segments that meet only one of these criteria fall into the yellow shaded areas.

Segments: approx. % shallow & total volume
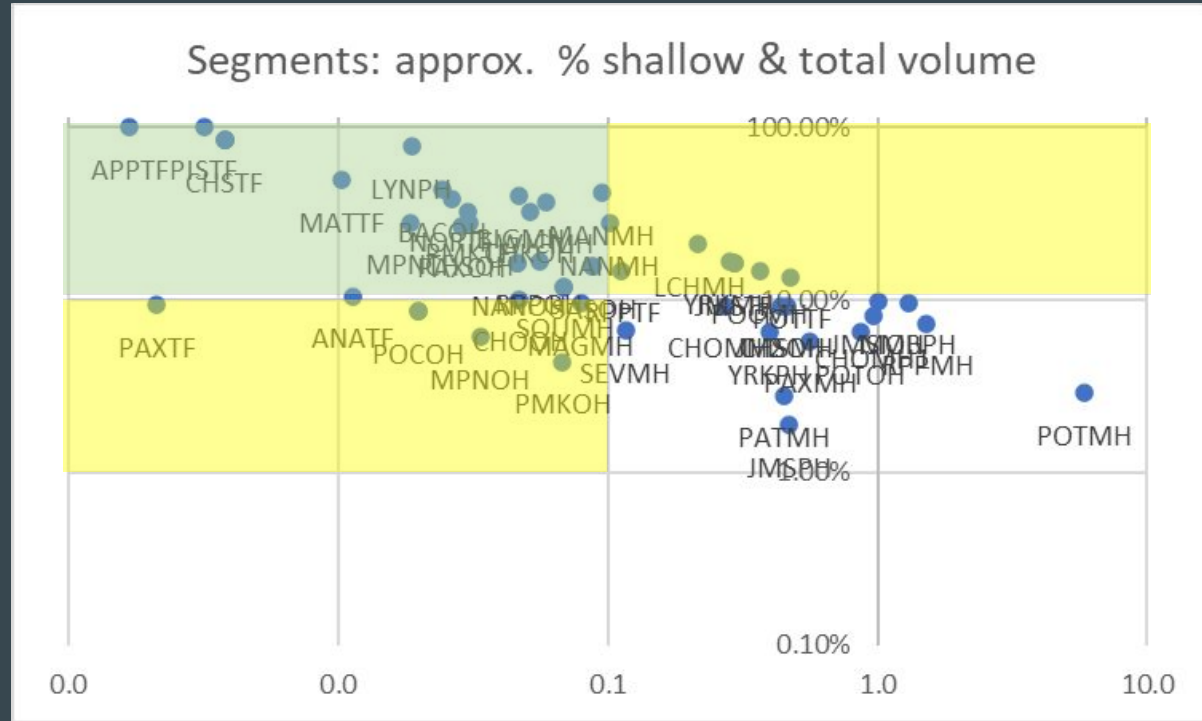
How did we determine the values for Shallow water? (continued)

Out of 55 segments for this exercise, coded based on previous slide (G if both met, Y if only 1 met, R if none met); totaled 20 options based on segments and scored as follows:

- For options with only 1 segment, the shading in the left-hand column matches the shading of that segment.
- For tributaries with multiple segments, shading follows this procedure:
- Green if the number of green segments is greater than or equal to the number of yellow and red segments (e.g., Potomac)
- Yellow if evenly distributed between green, yellow and red (e.g., Rappahannock, Patuxent, Nanticoke)
- Yellow if yellow segments are > either green or red (e.g., Pocomoke)
- Orange if (number of red segments) > (green plus yellow segments) but there are still 1 or more green segments
- Scoring is based on this shading, with green =1.0, yellow =0.5, orange=0.25 and red=0
- 10 Green, 6 Yellow, 2 Orange and 2 Red

	G	Y	R
Back	1	0	0
Big Annemessex	1	0	0
Chester	2	0	1
Choptank	1	1	3
James	2	1	8
Lynnhaven	1	0	0
Magothy	0	1	0
Manokin	1	0	0
Nanticoke	1	1	1
Northeast	1	0	0
Patapsco	0	0	1
Patuxent	1	1	1
Pocomoke	0	2	1
Potomac	3	1	2
Rappahannock	1	1	1
Sassafras	1	0	0
Severn	0	0	1
South	1	0	0
Wicomico	1	0	0
York	2	3	2
Totals	21	12	22