Tidal Water Model for the Assessment of 2035 Climate Change Risk to the Chesapeake TMDL

Modeling Quarterly Review

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Chesapeake Bay Program
Science, Restoration, Partnership

Motivations: PSC Decisions of December 2020

- Jurisdictions are expected to include a narrative in the 2022-2023 Milestones that describes the current understanding of 2035 climate change conditions, to the effect that: “Preliminary estimates for the climate impact through 2035 indicate a doubling of the 2025 load effect. The effect of climate change on our ability to meet the Bay’s water quality standards is a significant and increasing concern.” .

- In 2025, the Partnership will consider results of updated methods, techniques, and studies and revisit existing estimated loads due to climate change to determine if any updates to those 2035 load estimates are needed.

Motivations: PSC Decisions of December 2020

However, the current model is insufficient for a 2035 climate change assessment because the current model was designed with an emphasis on bottom-water hypoxia. The current grid-structure and resolution are insufficient to examine water quality in open-water (other than the deep mainstem Bay) and estimate effects of 2035 climate change.

The next generation Bay Model capable of a 2035 climate change assessment must be fully operational by 2025 (all calibration completed and scenario-ready by December 2024).

Motivations: STAC Workshop

Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop

"It seems likely that collaboration and cooperation between the CBP and academic and government scientists will only deepen going forward to 2025. The CBP builds models and carries out analyses, not only for setting TMDLs, but also to enable collaboration with the Chesapeake Bay scientific community and support their research to deepen a technical understanding of how to restore Chesapeake Bay and its watershed. From this perspective, the CBP modeling tools are also a means to improve collaborative, broadly supported, coastal estuarine science and restoration."

Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop

The Chesapeake Bay Program should:

1. Implement a next-generation unstructured-grid modeling system … to meet the anticipated 2025 needs that will require specification of local tidal water TMDLs.
2. Use a single primary model that is supported by multiple models [and modeling teams]…
3. Continue to engage the scientific community for evaluating performance of the new models, and the stakeholders to ensure that the Bay's nutrient reduction plans and the local needs are adequately met.
4. Allocate more resources to support the implementation and application of the new primary estuarine model and the activities in 1-3. These resources should support additional staffing at CBPO to improve the estuarine models and support improved access to outputs from these models.

Motivations

Hood, Raleigh R. et al., 2021. The Chesapeake Bay Program Modelling System: Overview and Recommendations for Future Development *Ecological Modelling (in press)*

"A collaborative [multiple model team] approach is recommended for the next generation model of the Chesapeake Bay estuary. For efficacy and overall efficiency, modelling teams would be assigned to different tributaries but use the same estuarine model structure, state variables, and external forcings so that the tributaries could be easily aggregated into a whole Bay simulation as required for management and decision-making in the CBP Partnership. As in the case of the Chester River prototype, the individual modelling teams examining different Chesapeake Bay tidal tributaries would meet regularly to share findings and insights, improving the whole of the simulation throughout the Bay's tidal waters."

Motivations:

Chesapeake Community Research Symposium Session
Towards Next Generation Fine-Scale Models of the Chesapeake Watershed, Airshed, and Estuary
June 8, 2020.

Prototypes of linked watershed and estuary models called for in STAC's *Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop* demonstrated.

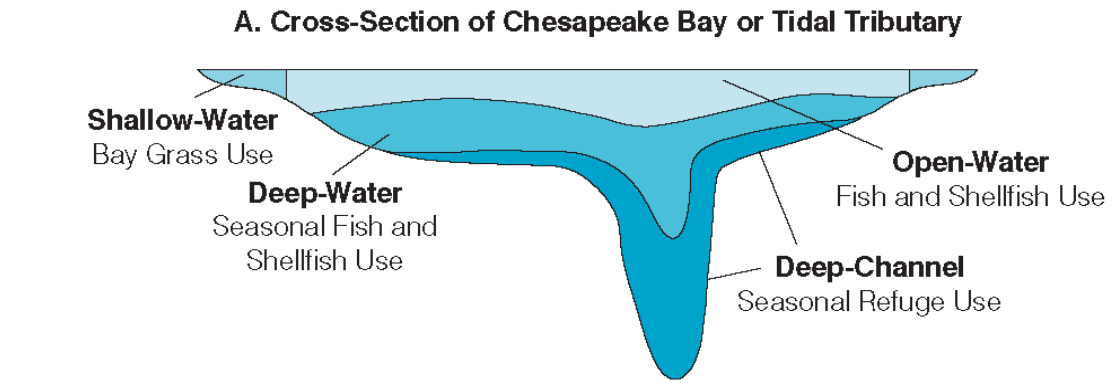
Motivations: Doing More at Least Cost

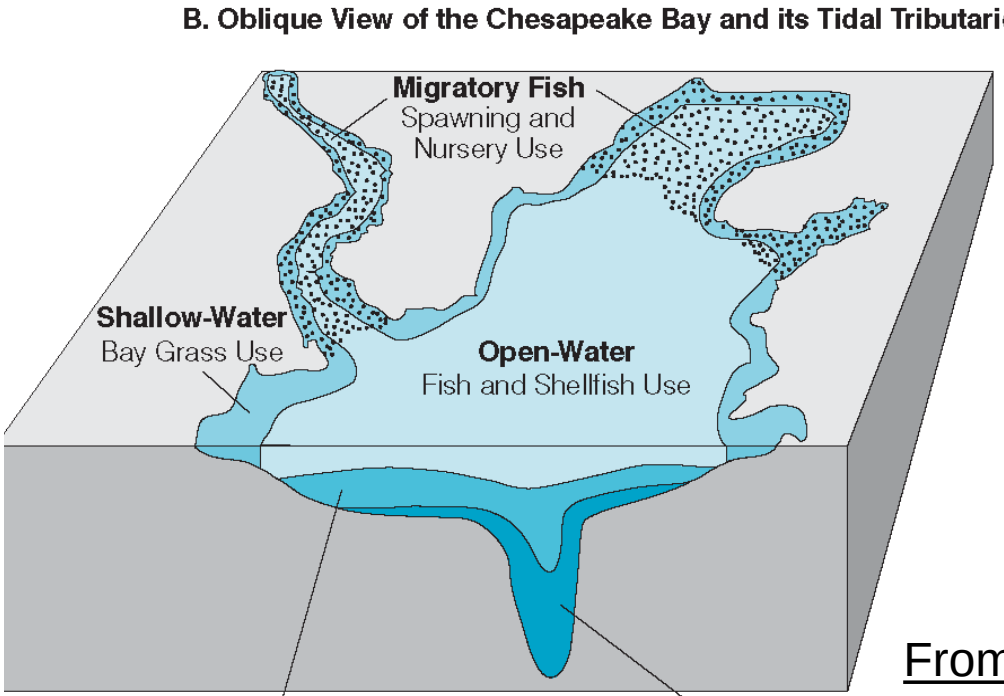
Using one model to cover all the current tidal Chesapeake TMDLs

- One model would bring all the tidal TMDLs up to the current state-of-science.
- Allow comparison of existing tidal tributary TMDLs with the next generation Bay Model – another tool in the kit.
- Allow the use of ancillary tools like optimization, atmo. dep. loads, updated BMPs and land use, and other features of the next generation CBP models in existing tidal water TMDLs.
- Fine scale models in the tidal tributary watersheds and tidal waters will allow for more efficient management options in the main stem Bay and tidal tributaries.

Tools We Have: A good TMDL is Based on Good Living Resource Based Water Quality Standards

A good TMDL starts with good water quality standards. Standards of Deep Water, Deep Channel, Open Water, and Shallow Water Dissolved Oxygen (DO) are key for protection of living resources. Chlorophyll and SAV/clarity standards are protect living resources in the James River and DC waters and in shallow waters, respectively.



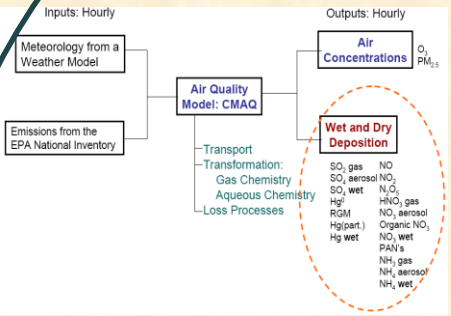


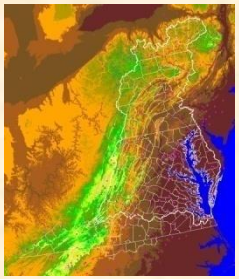
From Batiuk (2003)

Tools We Have to Make a Good Start: The Established Nutrient Allocation Decision Support System

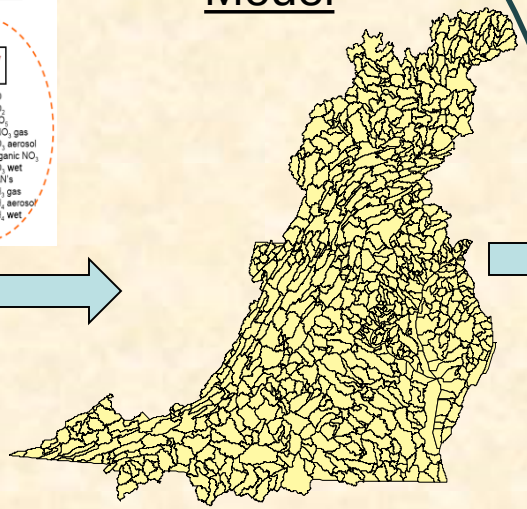
Used to Assess Target Loads

Airshed Model

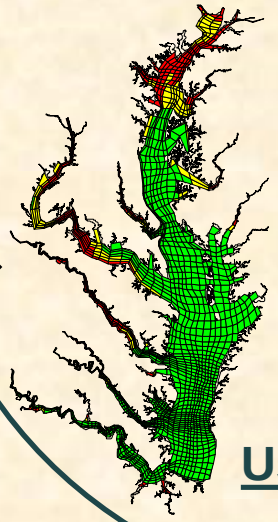




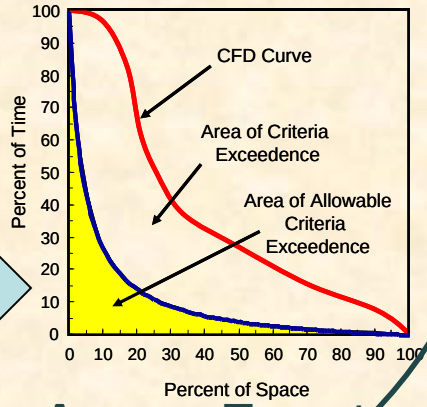
Watershed Model



Bay Model



Criteria Assessment Procedures



Used to Assess Target Load Achievement

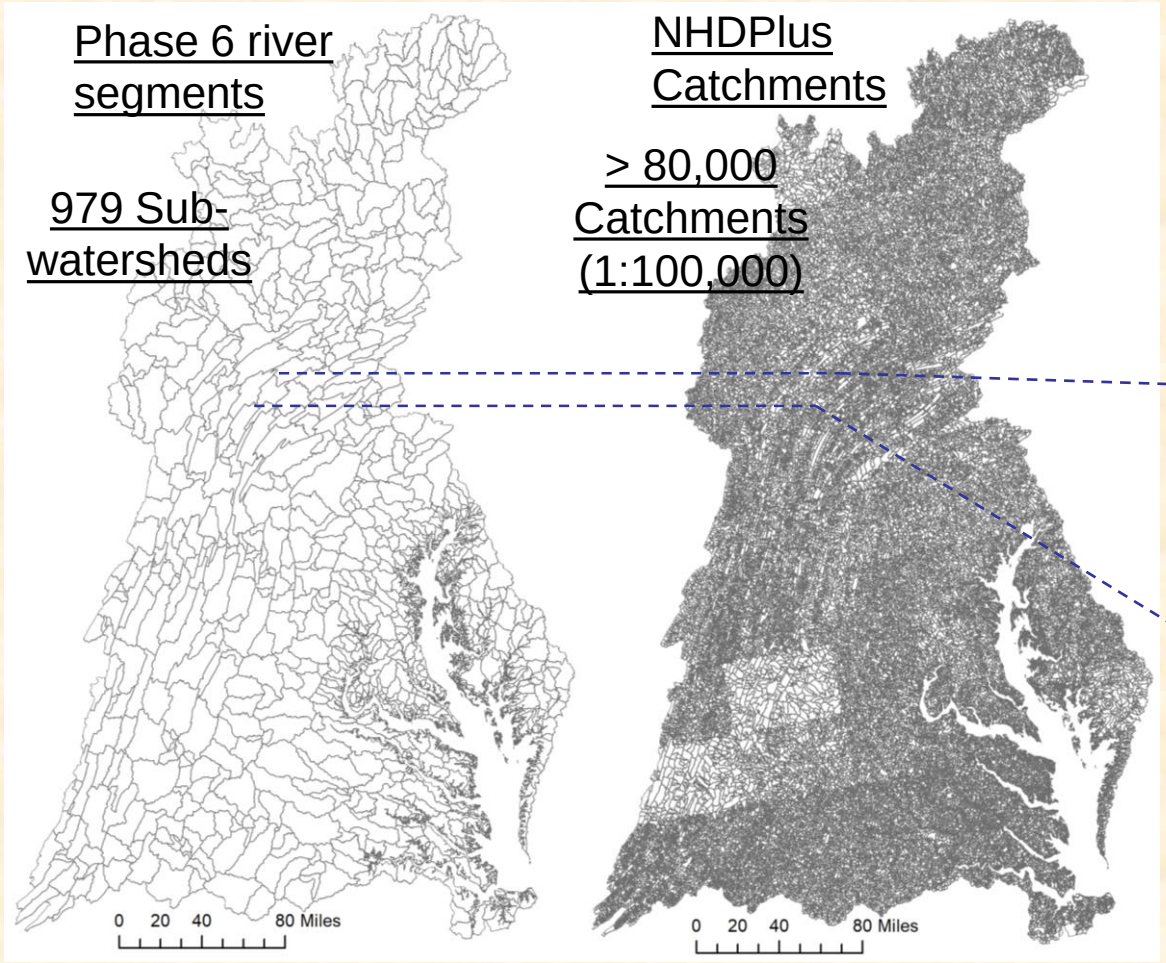
Land Use Model

2035 Climate Effects

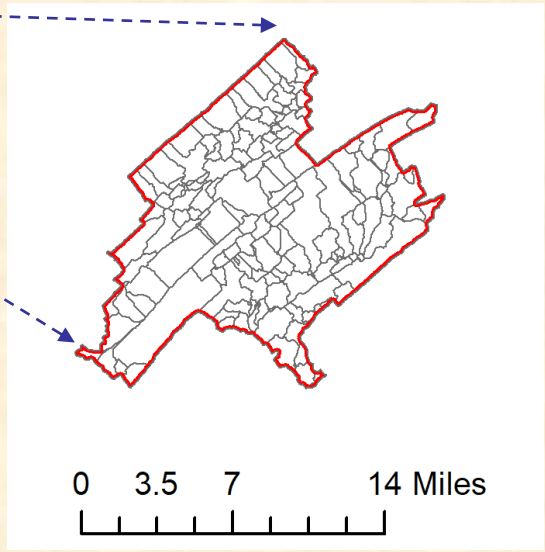
2035 Climate Change Target

Tools We Are Developing: Fine Scale Watershed and Airshed Models

Scale – Phase 6 vs. CRHM 2020



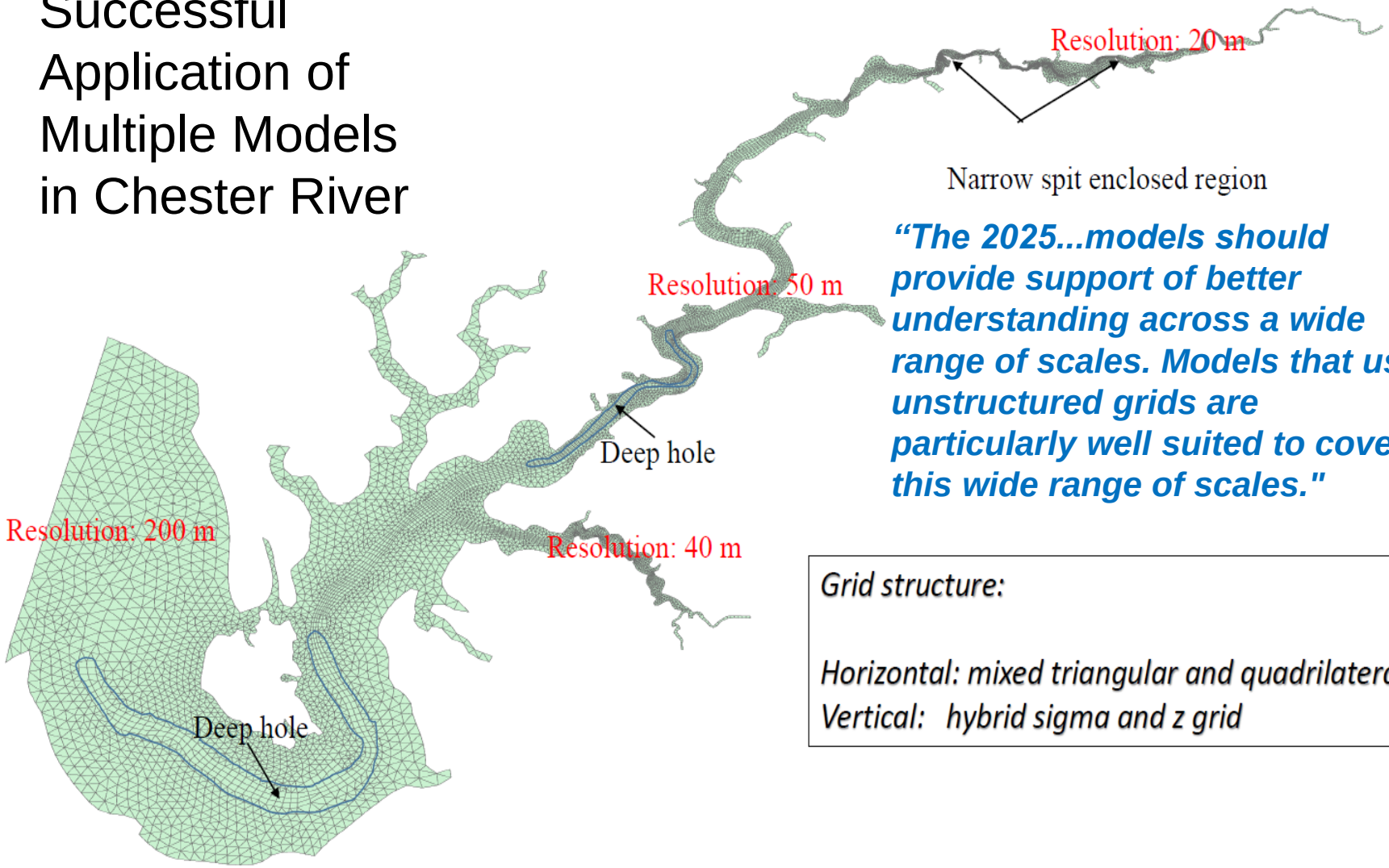
- Simulation at NHD catchments would be considerably finer scale than that of Phase 6 (approx. 80x)
- Ability to represent watershed characteristics at finer scale



"The CBP partnership should expand its efforts to make its models applicable to smaller "local" scales, appropriate to decision making for smaller-scale jurisdictions and watersheds."

Tools we are developing: Example of an Unstructured Grid and Multiple Model Teams in Chester River

Successful Application of Multiple Models in Chester River



"The 2025...models should provide support of better understanding across a wide range of scales. Models that use unstructured grids are particularly well suited to cover this wide range of scales."

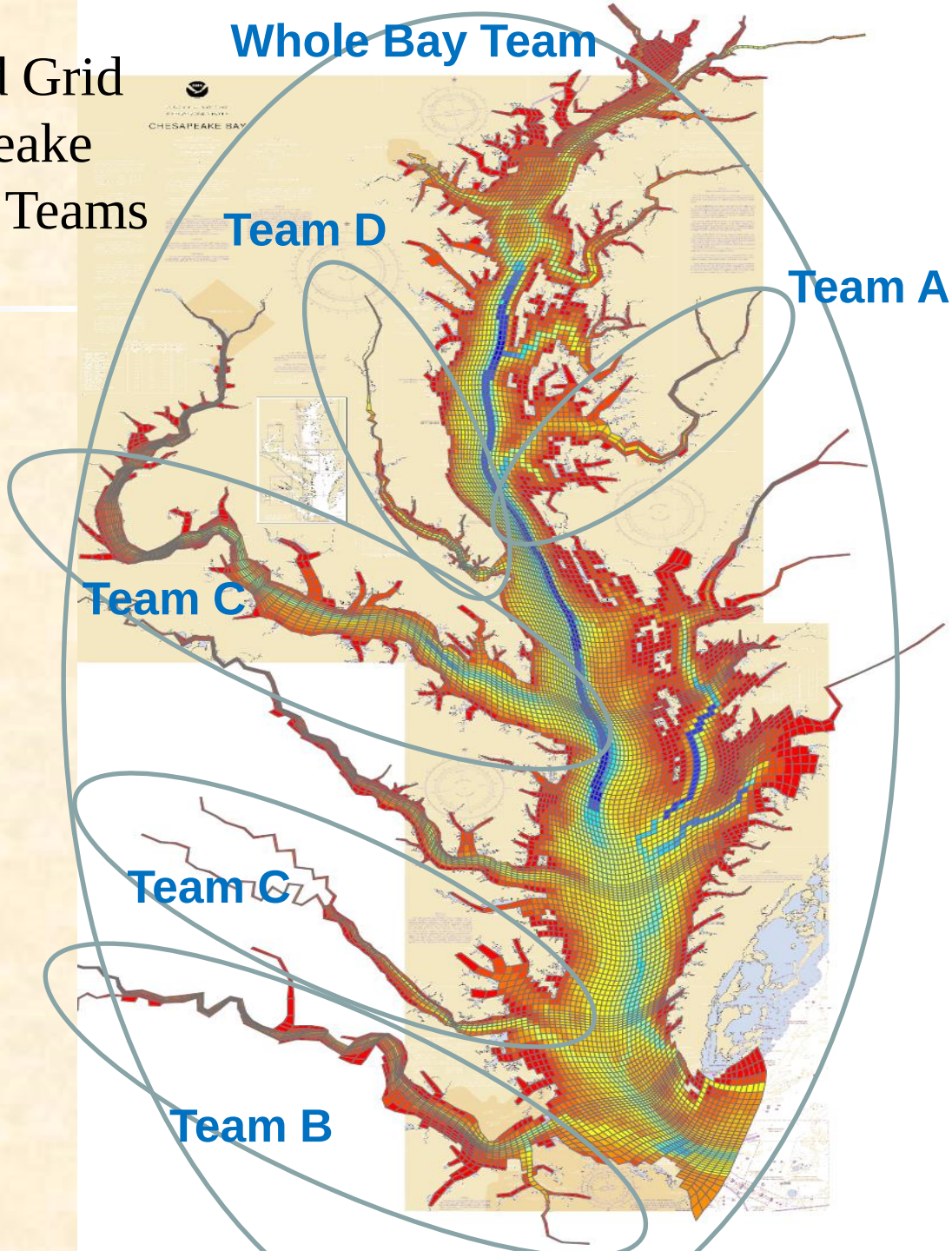
Grid structure:

Horizontal: mixed triangular and quadrilateral
Vertical: hybrid sigma and z grid

Source: Chester River Hydrodynamic and Water Quality Modeling using SCHISM/HEM3D. Wang, Zhang, et al. *STAC Shallow Water Modeling Workshop* April 20, 2016

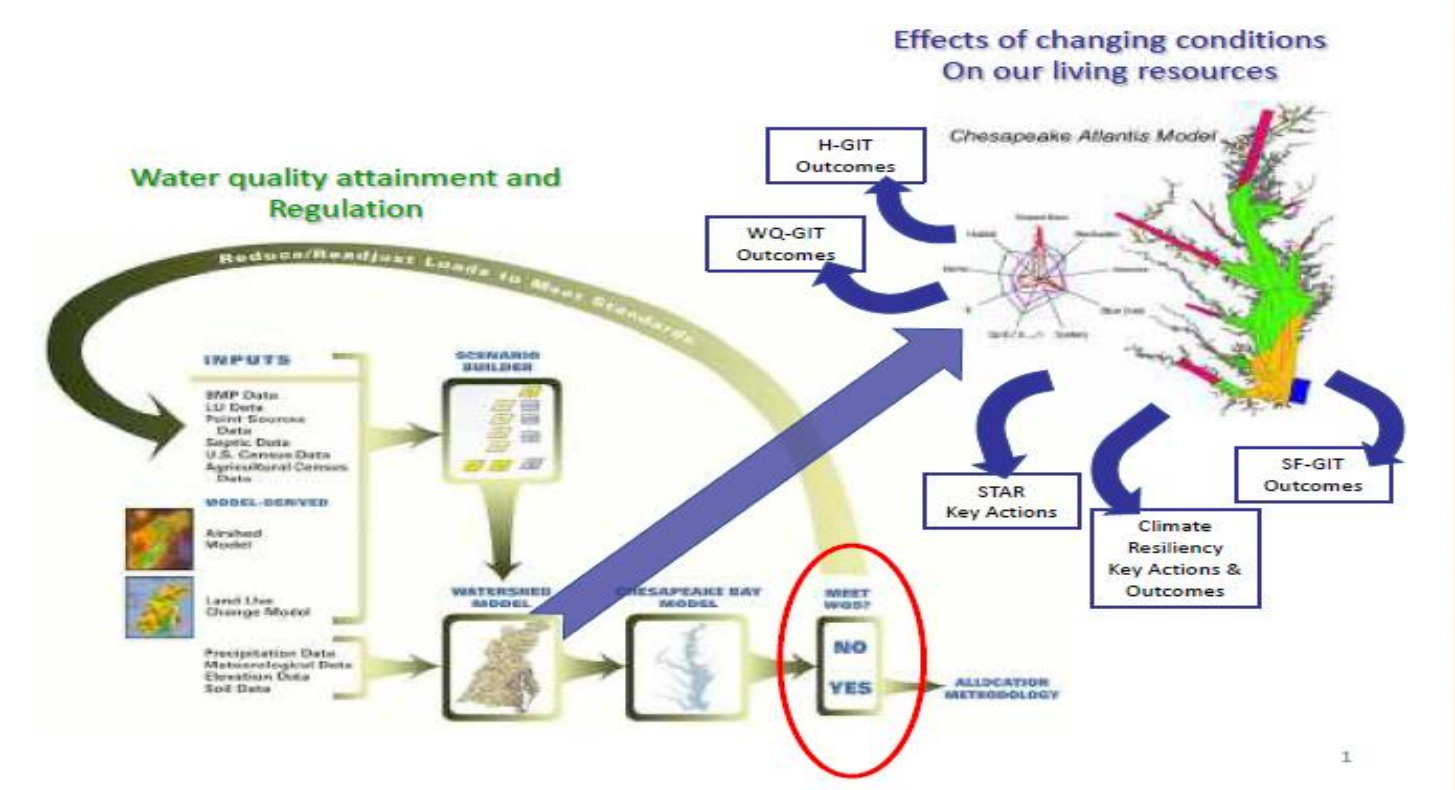
How an Unstructured Grid Model in the Chesapeake with Multiple Model Teams Could Work

- Similar to CMAQ multiple models approach.
- Main Bay Model of all tidal waters used for integration of tributary model findings and for management scenarios.
- Multiple model teams working in tributaries and sharing collaboratively information with all model teams on a regular basis.



Features of the 2035 Assessment of Climate Change Risk to CB Living Resource Based WQ Standards

- Effective simulation of 2035 climate change.
- Inclusion of cobenefits: ecological, social, and other benefits into management considerations.



Features of the 2035 Assessment of Climate Change Risk to CB Living Resource Based WQ Standards

- Added confidence of a multiple model approach.
- Optimization, better fine-scale BMP assessment, and other approaches for better environmental protection at least cost.
- Consistency and economies of scale among Chesapeake TMDL and other TMDLs in tidal waters and in the watershed.