Modeling Workgroup (MWG) Quarterly Review

June 20, 2023

Meeting Materials: [Link](#)

This meeting was recorded for internal use only to assure the accuracy of meeting notes.

ACTION ITEMS

- **Lew Linker will check with Peter Tango to see if shallow water monitoring programs or data available at lower latitudes, like Tampa Bay or Charleston. Lew will also look into other data sources.**
- **The optimization team will work with Tim Parris (tparis@chesapeakebay.net) and John Massey (jmassey@chesapeakebay.net) to improve computation time when running simulations with Core CAST.**
- **The Main Bay Model team will discuss the shoreline erosion work and its feasibility. If feasible, this proposal will be taken to the WQGIT and other respective groups.**

MEETING MINUTES

10:00   Announcements and Amendments to the Agenda – Mark Bennett, USGS and Dave Montali, Tetra Tech

Summary

Lew Linker shared updates on the many Requests for Assistance (RFA) the Chesapeake Bay Program (CBP) has released, which will assist with the work and mission of the Modeling WG.

- UMCES won the bioassays award.
- The watershed modeler RFA was successfully competed, and Gopal Bhatt was selected.
- VIMS won the Rappahannock Multiple Tributary Model (MTM) award.
- Applicants should be in for the remaining MTMs (Choptank and Patapsco) by July 3rd. A decision should be made promptly following application submissions.
- The stormwater best management practice (BMP) RFA should be available soon.
- Submerged Aquatic Vegetation (SAV) and Remote Sensing RFA should be available soon.

The Coastal and Estuarine Research Federation (CERF) meeting is coming up in November. Abstracts have been submitted and sessions are being formed by the leads. The CBP MWG will have a session at CERF.

10:05   [Phase 7 Watershed Model Overview](#) – Gary Shenk, USGS-CBPO

Gary provided an overall summary of progress.

Summary

Gary provided updates on Phase 7 Development tracks and timelines, setting the stage for more in detail presentations by Isabella and Gopal later in the meeting. Gary outlined the goals for the end of 2025 and raised the topic of the Phase 7 model being "as good or better" than Phase 6 and what that phrase means. This includes questions of actual purpose and balancing between higher R^2 values and being right for the right reasons. These discussions inform decisions regarding potential evapotranspiration (PET), which has implications for climate change assessment considerations. Gary compared the benefits and drawbacks of adjustments and calibration. Gary also provided some examples of how the work is applied.

10:20 Discussion of the Phase 7 Model Overview

Summary

Lew thanked Gary for bringing forth interesting information on evapotranspiration. Lew emphasized the need to focus discussion time on the approach for evapotranspiration given the magnitude of this factor's influence on loads, which is on the scale of millions of pounds. On slide 19, Lew said these figures seem to merit the discussion and investigation of evapotranspiration, with one feature being that cities tend to pop out. Lew noted that evapotranspiration is a model and is typically calibrated, so PET needs to be a calibration point in the model. Gary said they want to identify trends, like how cities pop out, and any others, especially those that may develop due to climate change.

Lew asked if the modeling team can use a seasonally weighted approach for PET in development, given PET expresses itself strongly in the summertime. If looking at a seasonal calibration point, this could be very informative.

Dave asked if the modeling team is using PET to accommodate an unknown in the water balance. Gary said we use PET to understand ET so we can improve our runoff calculations.

Bryant Thomas asked about the chart on the right on slide 19, specifically what is being represented. Gary replied this is total annual average PET, which can be thought of as demand that is not always fulfilled. The total runoff (including storm and groundwater) is calculated as precipitation in minus actual evapotranspiration. Actual evapotranspiration is modified from PET using different factors on the ground like seasonality and cities.

Jeremy Testa asked about the plant response of PET changes in the future, specifically the CO2 fertilization effect. Jeremy asked if this is an important part of the PET budget in the model. Gary said in Phase 6, stomatal resistance change due to increases in CO2 was present and will likely be included in Phase 7 as well. In terms of vegetation in general, a lot of these changes may be expressed as land use. Lew mentioned the team has been discussing this question of phenology with EPA's Office of Research and Development (ORD) regarding tree species, and other thoughts are welcome. Jeremy said this is a wicked problem to deal with and said a question to consider is understanding the type of uncertainty we are dealing with when it comes to constraints and whether it will make a difference for the model. Isabella said she has used the enhanced vegetation index (EVI)

as a predictor for PET, but found it was highly correlated with land use, so land use was employed in these examples to reduce collinearity. Isabella said CalCAST probably does not have enough calibration stations to tease out the statistically correlated factors. Lew said the EVI should have promise, and asked if other researchers see trends in EVI and other natural land uses over time. Lew asked if EVI could be explored this way in the watershed model. Isabella said this could be explored in the annual version of CalCAST.

Bill Keeling asked about getting credit for management actions in Phase 7, like Hay and Pasture, since things were removed in Phase 6. Bill said it seems like Phase 7 is too far down the pipeline for discussing how Virginia might get credit for these BMPs. Gary said this question is outside the scope of the Modeling WG. Dave said it seems like a task for the Agricultural Modeling Team (AMT). Tom said they are discussing this at the AMT now and will continue to discuss topics like this. Bill said he will bring this topic of Virginia getting credit to the AMT.

Guido Yactayo said the Penman-Monteith equation accounts for changes in CO2 levels and its effects on the simulation of potential evapotranspiration. Guido asked if the modeling team has considered using that equation. Gary replied yes, they have, but Penman-Monteith has many different variables, which comes with its own benefits and drawbacks. Gary said this approach is under consideration and updates will be provided at future quarterlies.

Regarding slide 19, Norm asked if the figure on the right is calibrated to 2055? Gary replied he believes that is the average over the calibration period of 1985-2014.

10:30   Update on CalCAST Development – Isabella Bertani, UMCES

Isabella provided an update on the progress made in the development of CalCAST, specifically focusing on testing watershed predictors of spatial variability in streamflow. She also discussed a proposed approach to develop a reproducible workflow to gather water quality data for watershed model calibration.

Summary

Isabella began with the motivations and advantages of developing a reproducible workflow to download water quality data from EPA's Water Quality Portal for watershed model calibration. Isabella presented an exploratory analysis (broken out into steps 1a-3) to illustrate how this approach might fare, and provided a few examples (slides 6-16). Isabella proposed next steps for standardizing this workflow.

Isabella then presented preliminary results from testing watershed predictors of total flow in CalCAST. Isabella began with an overview of CalCAST, before walking through different preliminary PET methods and calculations. Isabella compared preliminary results with SPAtially Referenced Regression On Watershed (SPARROW), then concluded with proposed next steps for CalCAST.

10:50   Discussion of CalCAST development

Summary

For the reproducible data workflow conversation

Bryant Thomas said he is not too familiar with the water quality portal and what screening is done on data included in the system. For the organizations that are not jurisdictions or USGS, please be aware of the methods used and Quality Assurance/Quality Control (QA/QC). Virginia classifies data received from outside organizations based on QA/QC, methodology, etc. Not all data may be appropriate for use in model calibration. Just a cautionary note.

Lew said standardizing the data is a needed patch and the perfect should not be the enemy of the good. Lew said Isabella is pointing to where the team will ultimately be with documentation. Lew suggested preserving current data for calibration and use the portal for future data. Isabella agreed a combination of approaches will be needed.

Bryant asked if Isabella is looking at stations where only pollutant concentration data is used for calibration or are only stations with collocated flow and concentration data being considered. Isabella said the station data can be used in two ways. For CalCAST, loadings are calculated to as many stations as possible to verify the model, but the model is calibrated to concentrations. This results in 2 tiers of stations: one not for calibrating but still informing the model (like seasonality), and another tier for calculating the loads with, which requires at least 20 data points per year. Gopal added that right now the idea is to gather the data and then determine how we will use it and for what purposes. For example, the load information will be needed for CalCAST and concentration data alone for the Dynamic Watershed Model (DWM) calibration. How we calculate the load allocation will be tricky and determined later. In the past, load information was used in two ways: one to assess model performance at the calibration stations, and also for verification of the loading rates at a finer scale. Bryant said he is pleased to hear they are looking at the data and considering how it can be used.

Lew suggested Isabella develop a two-step prototype implementation for monitoring organizations to work at. Isabella said this is something she can aspire to, pending approval from Gopal and Gary. It might look like an R Shiny app or another list of sorts. Lew emphasized the need to share these new tools with collaborators and the public so others can benefit from this work and view the work. Isabella agreed with this, saying there is interest from UMCES. Lew agreed, saying there is interest from STAC as well.

Karl Berger said it is encouraging to see work on this already. Karl said for water quality managers, it is helpful for CBP folks to share feedback on the data and how it is being used. This type of two-way communication informs funders on how the data might be used. Isabella said she heard similar questions from monitoring groups at the STAC workshop, since they want to know the criteria for including data in the calibration. Isabella said the goal is to improve communication, so data collectors and program funders know the standards for making it into the portal.

Gary said everything said today is important, but reminded everyone that there are limited resources, given how time consuming this work can be. The goal is to do it once and maximize efficiency. Isabella emphasized gathering the data is not simple, a lot of QA/QC is needed. By standardizing this through a script, this work will hopefully not need to be repeated.

Bryant thanked Isabella for her work on this topic and asked her to reach out to him if she needed assistance from VA DEQ.

For the CalCAST conversation

There was no discussion.

11:00   [**Progress in Phase 7 WSM Development**](#) **– Gopal Bhatt, Penn State**

The National Hydrography Dataset (NHD) plus 100K scale Phase 7 Dynamic Watershed Model (DWM) prototype with simulations of hydrology, sediment, nutrients, water temperature, DO, and phytoplankton is now operational for the entire watershed. The DWM is using a nested model segmentation of streams and rivers with a hybrid structure for the simulation of water quality processes using HSPF and Simple Routing models. During this quarter, refinements have been made on the segmentation and computational elements of the model operations. Gopal surveyed progress and described activities upcoming in the next quarter.

Summary

Gopal began with an overview of the DWM, explaining the purpose and framework. Gopal then gave a summary of prior model development progress and identified issues and refinements of note. Gopal explained the updated model segmentation, which included reclassification of streams (non-tidal, terminal, tidal), mainstem vs. streams, and the sub-watershed boundary. Gopal noted changes in results from the model segmentation updates. Gopal concluded with a check in on model runtime and a summary of completed work and next steps.

11:30   **Discussion of Phase 7 WSM Development Progress**

Summary

Regarding [slide 11](#), Lew said now that we have a much delineation between tidal water, tidal wetlands, and land, the level of detail is quite fantastic. Because of the fine scale Lew said he expects there to be a significant aggregation effect (up to a 1 km setting, Phase 6 bay model grid cell), but asked for confirmation from Richard and Nicole. Gopal said he believes this is correct for the next step of linking the DWM to the estuarine model. Gopal said some conceptual exploration of the linkage has been explored so far, but this is the major next step. Gopal said finer scale modeling has pros and cons, and these are some examples of balancing the issue spatial scale.

Olivia Devereux asked do we know the WSM's sensitivity to the change in segmentation or flow routing? Do we know the estuarine model's sensitivity to tidal water designations? Gary replied that is a complicated question. The DWM sensitivity would not be known until it is built. This is more about getting a DWM structure that can match CAST/CalCAST results at an aggregated temporal scale. Previous discussion with MTM developers indicated that NHD scale was probably appropriate.

Lew said it was fascinating how the changes in delineation documented on slide 18 improve model calibration for Phase 7 development.

Regarding slide 14, Lew said the analogy that resistance in both circuits are equivalent is illustrative and asked how that factors into the aggregation effect being described. Gopal replied in a way we are accounting for the attenuation properly by calculating the equivalent effect of each reach. Lew said that clarifies his understanding and everything seems appropriate.

1:00 Development of Efficient Multi-Objective Optimization Procedures – Gregorio Toscano, Kalyan Deb, Pouyan Nejadhashemi, and Hoda Razavi, MSU

Gregorio presented progress since the April Quarterly in the development of efficient multi-objective (MO) optimization procedures including replicating the study with the rest of the BMPs.

<u>**Summary**</u>

Gregorio began the optimization update with a brief overview of the objective of the project and the project timeline. Gregorio then walked through the 8 experiments the team has performed so far, illustrating processes and results (slides 7-24). Gregorio concluded with major takeaways from the experiments and next steps for the optimization team.

1:20 Optimization Discussion

<u>**Summary**</u>

Dave Montali asked what Gregorio's major point was for the land conversion topic. Dave asked what is changing the base condition in this example (slide 11), since he felt it was pretty clear cut what is being done. Pouyan replied that for land conversion BMPs, the base condition keeps changing based on new loads and land uses for each scenario, which adds complexity to the optimization process.

Olivia Devereux said just like you need to do the land conversion before efficiency BMPs, you will find that you need to do the animal BMPs before the efficiency BMPs too. Those change the concentrations of nutrients to which the efficiency BMPs are applied. Pouyan thanked Olivia for the suggestion and said they will consider and show those results in the next round of updates. Pouyan said the animal loads will not change the load in the county, since they are internal, but manure transport will make a difference.

Lew asked if bi-level is needed for land conversion BMPs since the loads of many land uses are changed and that changes the efficiency of the BMPs. Pouyan said the land conversion and efficiency BMPs are being applied together, which requires the bi-level approach because the first approach looks at where to apply the land conversion BMP, and the second approach looks at where to apply efficiency BMPs with those land conversion BMPs applied. Lew concluded it is necessary for the bi-level approach to include the land conversion BMPs.

Gary asked does it matter if the land conversion and animal BMPs are split out into different categories, or can they just be considered non-efficiency BMPs within the Latin hypercube optimization? Pouyan replied there are different efficiency properties to land use/land conversion and animal BMPs, leading to different behavior in the scenario. Pouyan said this is why bi-level has been a priority. Pouyan explained how the land conversion BMPs do not show up on the pareto front until one arrives at more expensive BMP costs.

Olivia said animal BMPs can change the concentration of nutrients in manure, so they remove nutrients from the system altogether.

Lew said we might be seeing an emerging approach to optimization: bi-level for animal/animal waste and land conversion, and a single group for everything else. Pouyan said next time they will focus their presentation on results and less so on methods. Lew said this will attract more attention from decision makers.

Dave said for the riparian forest buffers on fenced pasture corridor, we already know that is the cheapest option for getting quick improvements towards meeting the Watershed Implementation Plans (WIPs). Dave said whether we call it land conversion or animal BMPs, maybe we should create a separate category for this one since it is interacting at three different levels. Pouyan agreed, and said we know not all of the BMPs will be possible in each setting, so the results will need to be checked by the experts. Right now, however, it takes a long time to run these results. Olivia asked why it takes so long to run the results, given that previously CAST was set up to run thousands of simulations at once. Gregorio said they are limited to five virtual machines, which has slowed down the process of completing scenarios. Olivia suggested working with Tim Parris and John Massey to improve computation time.

Bill Keeling said currently when a forest buffer is reported it is applied proportionally to all agricultural land uses, including pasture. However, you cannot have a grass or forest buffer on pasture without exclusion. Pouyan replied the optimization team cannot implement any scenario that CAST does not accept, so it should not be a problem. Bill replied his point is that the assumption used to distribute regular buffers is flawed because that distribution lowers the available acres for the exclusion buffers.

1:50 **[Case Study of Decarbonized Economy Benefits to Nitrogen Reduction in the Chesapeake](#) – Chris Nolte, Dan Loughlin, and Uma Shankar, EPA-ORD**

Chris discussed initial work in the application of scenarios developed by EPA's Center for Environmental Measurement and Modeling to estimate atmospheric nitrogen reductions due to decarbonizing the economy with respect to power generation, mobile sources, and other CO_2 emission sources. The scenarios would be run initially in Phase 6 watershed and Bay models to assess the degree of additional nitrogen reductions to the Chesapeake that would result from the national economic and policy actions of decarbonization. The scenarios would run for the years of 2035, 2045, 2055, and 2075 on Phase 6 and then later on the Phase 7 suite of models when they are completed.

Summary

Lew began with some context about the importance of monitoring trends in air quality, given how reductions in air emissions and deposition has been a source of load reductions in the Chesapeake Bay watershed and is promising for future reductions from the mobile sector.

Chris began with a review of the key models used to inform these scenarios: namely the Community Multiscale Air Quality (CMAQ) model and the Global Change Analysis Model (GCAM). Chris then walked through the applications of these model approaches, like scenario design and procedure. Chris walked through the results of the following scenarios:

- Reference: A baseline scenario that includes:
  - Limited GHG mitigation and no additional air pollutant control requirements
- StateTargets: A mitigation scenario that includes:
  - State GHG reduction goals, implemented as regional CO2 targets
  - New CA light-duty electrification targets adopted by Section 177 states
  - Medium- and Heavy-Duty Electrification MOU adopted by signatory states
- NetZeroZEV: A mitigation scenario that includes:
  - A national, economy-wide declining CO2 cap reaches Net-Zero by 2050
  - Transportation electrification targets in StateTargets adopted nationally

2:05   Discussion of Decarbonized Economy Benefits

<u>**Summary**</u>

Olivia asked if dry and wet included in M3DRY reference to slide 19? Olivia saw M3DRY and did not know what that means. Chris said yes dry and wet is included, plus reduced and oxidized nitrogen. M3DRY refers to a dry deposition scheme within CMAQ. Jesse Bash developed another dry deposition scheme called Surface Tiled Aerosol and Gaseous Exchange (STAGE), that is more appropriate for ecological uses and has a land use specific loading rate. STAGE was developed to address the needs in Hood et al. 2021: https://doi.org/10.1016/j.ecolmodel.2021.109635.

Lew asked about slide 18, and said the magnitude of the scale looks very large. Chris said everything on this slide is in percent change to better illustrate the differences between scenarios. Lew asked if this is demonstrating electric vehicles (EVs) hitting the roadways. Chris said EVs are part of the reductions, but another large factor is cleaner engines as the fleet is updated due to older regulations.

Lew asked about slide 11, specifically if the data are additive or changes to the reference case. Chris replied they are relative to the reference case.

On slide 12, Lew said it looks like the mid-Atlantic garners some larger benefits from the reductions in NOx reductions. Chris said he think that interpretation is correct, but that a lot of the variation comes from differing baselines between states with and without coal power plants still online.

Lew said this was a great introduction to the EPA ORD team, since the CBP would like to be identified as a co-benefit for this work. Lew asked if Chris and the team could have

preliminary results ready by October to present. Chris said they would need to talk more about what is needed in the model runs, but that timeline sounds like it should work.

Gary commented that he went to the STAC workshop on solar panels, and they referenced this work, which led us to a conversation about competing demand between agricultural land and solar power.

Gary asked what takes five hours in the GCAM calculation. Chris said the GCAM USA has a large system of equations with many geographies and constraints, which need to be solved over many iterations. The iterative process and many constraints of GCAM USA, such as renewable energy portfolios and market clearing prices, lead to a longer run time. This means a series of equations has to be solved each time the model is run.

2:30   [Review of the 2020 to 2023 Summer Hypoxia Forecasts](#) – Isabella Bertani, UMCES

Isabella reviewed the 2020 to 2023 Summer Hypoxia Forecasts since she and a team of VIMS, UMCES, DNR, and University of Michigan PIs had refined the methodology. Attempted refinements to the method for the 2023 forecast and the 2023 forecast results were discussed.

Summary

Isabella said the information in this presentation is a preview of what will be shared in the upcoming [Hypoxia forecast press release](#) later this week, or early next week. Isabella then provided some reminders about the model, before diving into the 2023 forecast. Isabella outlined some of the potential revisions to the model that were considered, and noted why they were rejected and what each experiment revealed. Isabella then detailed a few other ideas the team is considering for future experimentation with the model.

2:45   Discussion of the summer hypoxia forecasts.

Summary

Sushanth Gupta asked why the figure in green on [slide 13](#) had a bimodal distribution, instead of unimodal like the rest of the figures. Isabella said she believes this is the case because not enough simulations were run, so the model did not converge on these variables. However, more runs would not be expected to change the overall uncertainty in this parameter. Isabella said this issue should be resolved in the next round of updates.

Lew said this work demonstrates the importance of incrementalism in improving models.

2:50   [Progress of the Agricultural Modeling Team](#) – Tom Butler, EPA-CBPO

Tom described progress of the Ag Modeling Team (AMT) in its role in determining the agricultural data inputs for the Phase 7 Watershed Model.

Summary

Tom began with a reminder of the AMT's scope and purpose. Tom then outlined recent progress, which included finalizing a workplan, working in the sandbox version of

CAST, and informal work on crop yield data. Future work includes continued sandbox testing with crop yields, land use categories, manure production & storage, legume fixation, and crop uptake vs removal.

3:00 Discussion of Agricultural Modeling Work Group

<u>**Summary**</u>

Lew commented many of the upcoming topics of the AMT are major topics of discussion. Tom said everyone is welcome to attend the AMT meetings to participate in these discussions.

Bill Keeling said he will follow up with Tom after the meeting via email to express some concerns he has for the AMT. Tom indicated he will read the email and follow up with Bill.

3:00 ADJOURN

Participants: Alex Gunnerson, Anna Kasko, Arianna Johns, Beck Fishell, Bill Keeling, Bryant Thomas, Carlington Wallace, Chris Nolte, Dave Montali, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano, Guido Yactayo, Hassan Mirsajadi, Hoda Razavi, Isabella Bertani, Jeremy Testa, Jesse Bash, Jian Shen, Jim George, Jonathan Leiman, Joseph Zhang, Karinna Nunez, Karl Berger, KC Filippino, Kevin McLean, Kimberly Dagen, Kristin Saunders, Larry Sanford, Leonard Schugam, Lew Linker, Marjy Friedrichs, Mark Bennett, Martha Shimkin, Mukhtar Ibrahim, Nicole Cai, Norm Goulet, Olivia Devereux, Pouyan Nejadhashemi, Richard Tian, Robert Burgholzer, Sam Merrill, Samuel Canfield, Sophia Grossweiler, Sushanth Gupta, Tish Robertson, Tom Butler, Xia Xie, Zhenghua Jin.

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9:00   **Announcements and Amendments to the Agenda – Dave Montali, Tetra Tech and Mark Bennett, USGS**

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- The stormwater best management practice (BMP) RFA should be available soon.
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The CERF meeting is coming up in November. Abstracts have been submitted and sessions are being formed by the leads. The CBP MWG will have a session at CERF.

9:05   **[Comprehensive Assessment of the Impacts of Large Reductions in Point Source Nutrient Loading to the Patapsco River Estuary](#) – Jeremy Testa and Walter Boynton, UMCES**

This analysis examined changes in municipal and industrial nutrient loading rates to the Patapsco River estuary over the past 35 years and the associated changes in nutrient concentrations, chlorophyll-a, and dissolved oxygen. A nutrient budget was developed for the estuary over three periods within the 35-year times series to investigate how internal recycling influenced the estuary. Substantial declines in industrial nutrient loading were associated with long-term declines in nutrients and surface water chlorophyll but increasing bottom-water chlorophyll (potentially delivered from the mainstem Bay) combined with warming possibly contributed to relative stability in dissolved oxygen.

Summary

Jeremy began with an explanation of the motivating questions and three major approaches for this analysis. Jeremy then used monitoring data for total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) to illustrate the historical and

current state of Patapsco loads by wastewater source sector (industrial or municipal). Jeremy walked through the nitrogen and phosphorus budgets for the Patapsco to explain how the export of nutrients to the Bay has declined and sediment recycling is critical to understanding water quality criteria. The presentation concluded with the following take home points:

- There is a signal of decreasing TN and TP concentrations in the estuary consistent with wastewater treatment plant (WWTP) load declines. WWTP was previously dominated by industrial load sources.
- TN and TP further declined with an upgrade to Patapsco WWTPs.
- Exchange with the mainstem Bay is important:
  - Evidence for chlorophyll-a import from mainstem
  - Reduced TN loads to Patapsco led to reduced Patapsco loads to Bay
  - TP exchanges with Bay may now be comparable to external loads
- Sediment-water recycling of TN has declined as load declined, but TP fluxes from sediments remain a central part of the budget.

9:30   Discussion of Assessing Impacts of Large Reductions in Point Source Nutrient Loading to the Patapsco River Estuary

<u>Summary</u>

Lew said the nutrient budget diagrams are helpful visualizations for illustrating sediment response and how the shipping channels serve as a pump for phosphorus, as are showing the proportions of surface and bottom phosphorus. Lew noted the Patapsco MTM team should track the point source changes demonstrated in this presentation, specifically the upset in the Back River WWTPs. Jeremy replied that typically when these loads change from WWTPs, we expect to see surface changes with very little lag. Given the known failures at Patapsco WWTPs, it is somewhat confusing that the loads have not increased. This might be indicative of an uncertainty in which part of the process occurs or this issue might be better illuminated with more recent data for 2022. Dave replied that from what he has seen anecdotally, loading has increased as WWTP upgrades are under construction and a short period of time is required for the fine tuning of load treatments. Dave added that even with proper performance, authorized loading may be increasing if the flow from upgraded WWTPs is higher. Lew replied the plant being referenced was a bit of an outlier because they had a lot of loads from industry, which were so toxic that they had to triage for a while, and it does seem like they had some construction for a while. Lew said he appreciates this history of degradation and recovery in understanding loads over time.

Walter said it will be fascinating to see what is measured in regard to these fluxes in 2023. When similar work was completed in the 1990s, the values were very high, so it would be interesting to see how much they have changed. In the Back River, the deposited nitrogen was being denitrified, demonstrating the magnitude of recycling. This reinforced his bias that getting a little oxygen in the deep water will really change the biogeochemistry.

Dave asked if Jeremy and Walter accounted for Sanitary Sewer Overflows (SSOs) in this work. Jeremy said SSOs were not explicitly included. Lew said that since the team included inputs from the watershed model, the Baltimore SSOs would have been accounted for. Jeremy said yes, the team used those inputs, but he is unsure of the extent of SSOs in influencing loads. Lew said SSOs in Baltimore are relatively clean compared to Washington, D.C., so SSOs should not be a big factor in the load. Dave asked this question because he was wondering if heavy precipitation influenced by climate change may be playing a role in offsetting WWTP improvements due to SSOs. Lew said that is likely not the case due to infrastructure improvements in Baltimore.

Regarding the discrepancies on slide 10, Larry Sanford said putting this in the context of the physical system seems to indicate the surface water is not very affected by the main Bay. Jeremy said that seems to be correct. Larry said this is almost two separate systems that are connected: shallow waters and the deep channel. They are only connected through mixing in the inner harbor. Larry replied this implies a longer residence time in the surface waters and that the Patapsco is influencing itself more than the Bay is influencing it. For chlorophyll, Jeremy said the algal concentrations in the Patapsco has historically been high. Jeremy said the big flows seem to push the algae out of the Patapsco, demonstrating a flushing effect, and the channel at the bottom serves as a pipe back into the system.

Jian said it is interesting to see this response from sediment. Jian asked how quickly the nutrient accumulation in the sediment responds to the point source reductions. Jeremy said the conventional view has been that sediments will accumulate nutrients and hold on to them for a long period of time. For the Back River, there was enough information to piece a time series together. Within a year, this data for TN seemed to indicate you might see a nitrogen response to point source reductions. In places in the Baltic where they have done this, it seems to take about 5-10 years to see a difference for TP. For logistical reasons, they will be unable to do the deep channel, but they will be able to test this in the shallow waters. Jian replied he has done Baltimore Harbor before and there is a different residence time between surface and the bottom (20-40 days), but even at the surface residence times can last up to six days. Jian said he can share his paper on this topic with Larry and Jeremy.

9:40   **Update on Main Bay Model (MBM) Progress** – Jian Shen, VIMS

Jian Shen presented progress in the MBM development.

Summary

Jian began with a summary of progress from the previous quarter, grouping the updates into three main categories: the hydrodynamic model, water quality model, and toolbox. Jian then highlighted some focal studies from during this period, such as testing a decoupled modeling approach using a horizontal dye simulation. Jian concluded with updates scheduled for the next phase, which include model calibration and source contribution.

10:10 Discussion of the Main Bay Model (MBM) Progress

Summary

Lew said this work for the MBM is just right because it is documenting detailed and careful development of the model. The MBM is right on time according to the Phase 7 Development calendar.

Lew asked about slide 26, specifically if the MBM team means to calibrate the model without the generalized wetlands approach. Jian replied this wetland implementation is used in the ICM, and it is likely that each of the MTMs will require a separate approach for wetlands. Lew said the calibration will be focused on the mainstem, so the wetlands would have a minimal effect at this point before they move to the tributaries since this is a stepwise approach. Jian added that after the mainstem is calibrated, the tributaries might will be calibrated. However, some might not be fully accurate because the model cannot account for localized changes, but the calibration should be sufficient for the overall purpose thanks to flexibility with model parameterization.

Lew said in the watershed model, Gopal carefully walked through the process of invoking how and why changes are implemented. Lew recommended preserving results from before the change and after the change in the documentation. Jian said that is a good idea, and he is working with Joseph to follow this process.

Lew said some stepwise discipline will need to be imposed on parameterization across the MTMs and MBM. While there may be some flexibility allowed for regional differences, the parameterization needs to be standardized to avoid introducing model artifacts, like growth rates or settling rates, since the MTMs and MBM will be needed for management purposes. Any proposed changes in parameterization should be brought to the monthly MBM meeting. Jian agreed and said his preference is for simpler models and minimal parameterization when possible. Lew said that is a solid calibration philosophy.

On slide 27, Lew said the take home point is the entire coastal system is connected and we should try to quantify those connections. Lew gave the example of how major point source reductions in Long Island Sound have a very small but measurable impact on boundary conditions for the Bay. Lew suggested adding a point for the figure on the left about VA, MD, and DE coastal inland bays to identify the shared benefits of the nutrient reductions. Lew said the question will be: "For the infinitesimal amount of TN being exchanged at the boundary condition, how much will that matter to the MBM?" Jian replied this effort is quite difficult and despite Nicole volunteering to help with this, it will take some time. Lew said this work falls into the "would be nice to have category," not the deadline driven mandatory category.

For slides 8-10, Gary asked if the main point was that the de-coupled mode was good enough or not good enough. Jian replied if one is looking for the related difference, they did not calculate the statistic, but one could estimate it would not be too high. Jian said these are still two different models, so there will always be some differences in calibration. One example might be residence time and growth rate. Ultimately, these differences will need to be reviewed by others to determine which range of values is tolerable. Lew said this is all a time step issue and illustrates a serious trade off resulting from computation limitations. We want to reduce run times as much as we can without

changing management decisions. Gary asked if we could do two test runs, maybe one doing E3 through both systems and the entire process to see how large the management differences are. Jian said when they were calibrating the water quality model, they would compare the coupled and decoupled models, plus the response. Jian said they are still testing the transport component.

Carl said the MBM team has good ideas for testing, and this is a work in progress, but what was presented is not good enough yet for representing the dissolved oxygen (DO). The team needs to better represent stratification and/or improve boundary conditions. Jian fully agreed, and said they are working on addressing this. This comment will be rediscussed at the next quarterly.

Lew asked what time step is being used now. Jian replied we are currently at an hourly time step with SCHISM ICM. Carl asked for more detail. Jian said this is saving hydrodynamics for hourly intervals and testing recycling at finer frequency because the grid is much finer. Joseph replied that Carl's points are well taken, and this is still very much a work in progress.

10:20 **Refinement of the Temperature Dependence of Algal Growth Rates in the MBM and MTMs** – **Carl Cerco, Attain**

Carl described his examination of the shallow water monitoring data of continuous temperature and chlorophyll observations and other data sources for the purpose of refining the algal growth response to temperature in the MBMs and MTMs. The Modeling Workgroup will use this method, along with an updated a literature search and discussion from an upcoming STAC workshop on assessing climate change in the CBP.

Summary

Carl began with a review of the purpose of this exercise and initial indications for how to treat algal growth rates. Carl displayed data from five different sites across five different tributaries to illustrate what the data are showing. Carl then presented some potential conclusions, but emphasized the substantial caveats and provided some examples with data. Carl provided some next steps and the longer-term outlook for addressing this issue.

10:40 **Discussion of the Refinement of the Temperature Dependence of Algal Growth Rates**

Summary

Gary said for the continuous data presented, there were very infrequent outliers, so if we took every degree of temperature and created boxplots, it would be interesting to see if the median and 75 percentile continued to increase. This could help us investigate outliers in the continuous monitoring data. Isabella said she is helping Carl investigate this trend, and she can create the boxplots as needed and share them with the group. Gary said Isabella does not necessarily need to create box plots, but instead tease out that data as might be best. Carl said now is the time to check this out.

Tish Robertson said in reference to the chlorophyll criteria in the James, it would be interesting to see if at temperatures above 32 Celsius, concentrations drop below the level of concern. It is one thing to see a decline from a peak of 200 ug/l at high temps. It is another thing to see a decline below, say, 15 ug/l. Lew agreed with Tish's point that we need to look at ecologically relevant levels. Lew said he will check with Peter Tango to see if there are shallow water monitoring programs with data available at lower latitudes, like Tampa Bay or Charleston, to test chlorophyll at these higher temperatures. Dave said he liked Lew's idea of searching for additional data, but who will do that. Lew said he will undertake that action. Tish said VA DEQ has a slew of discrete data which she can compile and share with whomever wants it.

Lew said we have two independent methods of looking at chlorophyll in the shallow water monitoring program: continuous (fluorescence) and once a month grab samples (wet lab chemistry testing). We want to be able to convince ourselves that no matter how you measure this, we are sure of the changes we are seeing.

Clifton Bell said when looking at climate change impacts, it seems this might even flip chlorophyll attainment in some areas due to the single day temperature maximum.

Clifton said what Carl presents seem to be consistent with the literature. Additionally, there is resolution from the discussion of the quarterly in April regarding adaptation. We can still have adaptation in the curve, but days with extreme temperatures leading to times when the algal growth rate does not increase. Carl said one can probably find useful information in the document from Clifton. Lew said that will be excellent ancillary data for sharing with STAC.

Jian said in the James once the maximum reaches 30 C, the chlorophyll concentrations become very high. Jian noticed when exploring modeling results for the James, concentrations began dropping around 32 C, even when extending the curve for calibration purposes. Jian said the curve starts to drop off at higher temperatures due to nutrient limitation, so perhaps nutrient limitation at higher temperatures is where we should invest our analysis time. Gary said Jian's comment was really interesting. If high temperatures occur during periods of nutrient limitation, I also wonder if the 15 C spike happened during a high nutrient loading event.

Dave asked what, if anything needs to be decided today. Dave thinks the MWG is authorizing further investigation, a report out in October on that recommendation, and sharing that recommendation with STAC for their workshop in 2024. Lew said that sounds correct. The goal is to allow the broader scientific community to weigh in on this work. Lew said thanks to efforts from the MWG, we should at least be ready to share something with STAC for review in 2024. Lew said the question of a low temperature algal group remains. Dave said he sees nothing being decided today on that question. Lew said we cannot push the question of a low temperature algal group too far down the line since that will impact some portion of model development.

Carl said he thinks we need to look at interactions between temperature and nutrients, which is something he plans to do going forward.

10:50 [**Estimating Tidal Shoreline Recession and Bank Height**](#) – **Julie Herman, VIMS**

Julie described potential approaches to estimate tidal shoreline recession along with bank height that can be used to generate TSS, TN, and TP loads from the tidal shoreline, especially by using remote sensing data and AI. The initial stages of the study were described with a fuller description of the work coming in the October Quarterly.

Summary

Julie noted this work is still very much a work in progress and this will be a taste of more updates that will be shared at future quarterlies. Julie began by explaining some key terms, like bank height, erosion, and reach length. Next, Julie compared the older methodologies for shoreline inventories with the newer remote sensing methodologies, like drone imagery, LiDAR, and satellite imagery. Julie concluded with the next steps the team will be taking, including the usage of higher resolution imagery and machine learning applications.

11:00 Discussion of Estimating Tidal Shoreline Recession and Bank Height

Summary

Lew said this is great work and should be very informative to the MWG's mission, especially with the finer scale afforded by SCHISM.

Lew asked when the next shoreline inventory will be complete, since the MWG has a deadline of 12/31/2025. Julie said VIMS completed their second generation of tidal inventories in 2022. The first-generation inventory took 20 years, the second generation took 10 years, and the next generation is likely to take less time given the new methods, but Karinna can better answer that question. All of the most recent inventories are available online. Lew said in Phase 6, the model development calibration ended in 2017, so they did not get a chance to use the second generation. Lew said they will organize the usage of the second generation and keep an eye out for the third generation of data. Julie said to reach out to Karinna Nunez (karinna@vims.edu) with any questions.

Julie said the whole concept of bank height is not as straightforward as many may think. The MWG will need to make a decision around shoreline erosion that may be separate from the land-water interface, since often times bank height is set back from the actual beach. So high water may or may not reach all the way back to the bank, and for some erosion may only happen during storms. Chris Spaur said difference in bank height location is a philosophical challenge for shoreline management as well. Lew said Jeff Halka wrote a few sediment reports defining the fast land and intertidal areas, which are used in the model to generalize and keep the bank erosion simple. Lew said the team will use the second-generation inventory to aggregate up. Julie said the bank height displayed is grouped, but it is present in the inventory.

Richard commented that last year Karinna sent him the shoreline inventory files, but he is uncertain if they were the second-generation. Richard looked at bank height for Dorchester County and found three grouped categories: less than 5 meters, 5-30 meters, and greater than 5 meters. Lew said the modeling team will consider over the next few

years how to update shoreline erosion inputs with the next generation of shoreline inventories. Lew said this will be a resource issue in terms of the team's time.

Lew asked if the shoreline recession rate, bulk density, and bank height could be connected with the protected shoreline file. Lew suggested talking offline with Julie, Richard, Karinna, and other MTM members about the next generation shoreline assessment. Gary said in Phase 6 the team moved shoreline erosion into CAST as well, so we need to make sure there is complete consistency between the two models. Julie said the shoreline inventory does include shoreline erosion structures, like riprap, breakwaters, and bulkheads. Even things like docs and piers are part of a combined package in that shoreline inventory. Richard says there is a lot of information, so there needs to be time spent investigating how to integrate it into the model.

11:10 **Shoreline Erosion Testbeds of Corsica and Choptank Rivers** – **Richard Tian, UMCES**

Richard discussed progress in assessing the efficacy of a dynamic input of shoreline sediment and associated nutrients using fine scale models of the Corsica and Choptank Rivers. To do a dynamic input of shoreline loads the CBP would need 1) wave power (f wave speed, wave energy, and depth), 2) shoreline height, 3) protected shoreline, 4) bulk density, 5) sand, silt, clay classes, 6) eroded shoreline TN & TP species.

Summary

Richard began with context for the purpose and scope of this project in the Corsica and Choptank. For the Corsica, Richard discussed the grid used and compared observed wave height and power with simulated wave height and power. Richard also discussed the spatial distribution of shoreline erosion. For the Choptank, Richard focused more so on the grid and the new shoreline layer provided by Andy Fitch. The Choptank efforts are still a work in progress. Richard concluded that a dynamic simulation redistributes shoreline erosion in time and space based on wave power.

11:30 **Discussion of Shoreline Erosion Testbeds**

Summary

Lew said Richard has brought this very far. Lew asked about slide 12, specifically the approach for calculating wave power in comparing with CH3D. Lew asked if the same type of loads from ICM (which were averaged either seasonally or annually) are included in CH3D. Richard said he believes the full daily dataset is run in ICM. Carl said his recollection is that the long-term average erosion rate was provided to the watershed team, and they ratioed the long-term average rates to give the estuarine model daily rates based on flow. The sediment loads in ICM vary on a daily basis, based on runoff and how it varies on a daily basis, not on wave energy. If one adds up the shoreline erosion rates, they will reach the same long term average Jeff Halka calculated. Lew said a major step forward would be to use wave power as a separate input to more appropriately sequence shoreline erosion inputs. Richard said yes, a wave driven simulation could be done

hourly, but that would need to be a scientific decision given the large data files and fast changing nature of waves. Lew said yes, it would make sense to go up to an hour given the current set up with the MBM, assuming this is computationally feasible. Richard said it may be more doable for the MTMs, but it may be resource challenging to apply this to the entire Bay, so it is up to the MWG (especially the MBM team) to decide how much is feasible. Once one can run the wave model, the shoreline erosion does not require a lot of time since it does not require extensive calibration. It is straightforward compared to using variable bank height as presented in the shoreline inventory presentation previously, as that would require more work.

If Richard thinks it is ready, Lew suggested the MWG be asked "Do they approve updating the Phase 6 inputs from flow based only to a separation for watershed loads as described by Gopal on June 20th and shoreline erosion loads as calibrated by Richard in this presentation?" If so, that would frame Phase 7 inputs. Gary said there is nothing magical about the Phase 6 information. Gary's understanding is that we can update the inputs or think of the overall numbers we get from Julie's analysis and calibrate the model. We just need to make sure CAST and the estuarine models reflect the same loads. The team needs to understand what is being received from VIMS and the capabilities of SCHISM before a decision can be made. Dave agreed with talking about this more into the October Quarterly before making a decision.

Carl said the reason shoreline erosion loads wound up in the watershed model, was because the managers wanted to get credit for the respective BMPs implemented. If we follow what Richard is proposing, we will need to incorporate BMPs. We tried to do something like this once before and ended up stopping the effort because of management preferences. Carl said he does not think the decision is up to the MWG. Richard said perhaps if we use the simulated shoreline erosion rates, we can just modify the loading numbers which is then modified by BMPs as was done in Phase 6. Gary said the MWG can decide what base loading rates are for any load source, but BMP effectiveness is the purview of the Water Quality Goal Implementation Team (WQGIT). As long as this balance is respected, then this should be okay. Gary indicated the remaining question for him is whether to make an external assessment of loads by segment or a broad scale assessment of loads then divided by the model so CAST does not need to decide. That would allow them to be in the estuarine model and CAST. Lew said one step that needs to be taken is speaking with the MBM team to see if wave power can be handled by Phase 7 SCHISM for generating the shore erosion dataset. Lew emphasized the importance of shoreline erosion for TP loads – it is the same relative amount as all the loading from the watershed, although it is mostly inert and uncontrollable, so it does not show up in the WIPs. Step 1 is taking it to the MBM team, and step 2 is taking it to the WQGIT and other respective groups. Lew said shoreline height from the second-generation VIMS shoreline inventory needs to be included in the assessment.

Joseph Zhang asked if Richard used the wind-wave model inside SCHISM for the simulation. Richard said yes. Richard said for CH3D the shoreline erosion is based on distributed, digital observations. Joseph asked for significant wave height if it is observed or simulated. Richard said it is simulated by CH3D based on wind affect in the empirical wave model. Joseph said he does not think the open boundary condition matters much for

the smaller Corsica, but for the larger Choptank it is much more important. Richard agreed and said for the boundary, he is using inputs from CH3D. Joseph said the influence of boundary condition should be considered. Richard agreed and said it is a major challenge.

Julie said the shoreline erosion rates on [slide 11](#) are beautiful because she has seen the same results for rivers in Virginia by Scott Hardaway. Higher erosion rates are seen on the southern shores and lower erosion rates in the northern shores, with the lowest rates in the protected tributaries. Additionally, VIMS did work on the effect of boat wakes on shoreline erosion and found it to be quite significant, especially for large vessels and in smaller tributaries, jet skis.

Larry Sanford says he agrees with the overall sense that this work is moving in an interesting and potentially productive direction, but it is not yet ready. Larry agreed with next steps to discuss this with the MBM team and bring in other colleagues like William Nardin at UMCES who is doing related detailed modeling work.

11:40 [**Progress on the Multiple Tributary Model (MTM) Effort and Introducing the Rappahannock MTM Team**](#) **– Lew Linker EPA-CBPO**

An update on the selection of three MTMs supported by an EPA RFA that will support the teams over five years was presented. The CBPO will also support two in-house MTM teams.

Summary

Lew began with the context that the motivation primary for the MTMs is improving CBP Science, Analysis, and Implementation for Chesapeake Climate Change Impacts, specifically the 2035 climate assessment. While there are additional motivations, this is the major component. Lew then walked through the schedule for MTM and MBM interim development, final development, and both review and application. Lew suggested there may be a need to extend the cooperative agreement for the MBM and MTMs into 2028 for extended review.

11:50 Discussion of MTM Progress

Summary

Raleigh Hood asked if the CBP has a strategy for sharing the model code with the broader scientific community. Lew said Joseph Zhang has been considering this point throughout MBM development. Lew also said Jian Shen has been leading the development of tools to facilitate interaction. Raleigh said this is good to hear, because he foresees lots of interest from the scientific community, especially regarding the MTMs. Lew said he is hopeful the MTMs will spur future investigations.

1:00   Rappahannock MTM – Qubin Qin and Nicole Cai, VIMS

Initial work on the Rappahannock MTM was described. Nicole described initiation of the MTM in the tidal Rappahannock. Qubin described assessing 2035 Climate Change Risks to the TMDL in the Rappahannock River using SCHISM.

Summary

Qubin's presentation

Qubin summarized some of the literature on water quality, numerical models, and previous modeling studies by the VIMS team in the Rappahannock. Qubin articulated the goal of this effort as "to develop and calibrate a high-resolution hydrodynamic-water quality model for the Rappahannock River, which will enable us to investigate and assess the water quality of the river. Specifically, we aim to use the model to forecast the potential risks to TMDL due to climate change by the year 2035." Qubin then walked through the 8 steps that comprise this goal (slide 11), before concluding with an overview of the two-phase timeline.

Nicole's presentation

Nicole spent the first half of her presentation discussing the horizontal and vertical grid for the Rappahannock. Nicole also outlined loadings from the Phase 6 watershed model. Nicole concluded with an evaluation of preliminary results for the Rappahannock, specifically tidal range and salinity.

1:15   Discussion of Rappahannock MTM

Summary

Discussion on Qubin's presentation

Lew said he was glad Qubin included water withdrawals in the model. Lew said climate change is probably a profound influence on flow on water withdrawals in Phase 7.

Dave asked what format the coordination between the MTMs will take. Lew said Joseph has graciously extended the MBM monthly meeting to coordinate MTMs. MTMs will continue to report out quarterly.

Dave asked what standardization efforts may be in place for MTM grids. Nicole said she has developed a standardized approach for grid creation and discussed this topic with the MBM team.

Gopal said as referenced in task 3, coordination will be required for linking with the watershed model. Gopal asked if discussions have started about how to decide the calibration period. Lew said he hopes the calibration period is in the RFA, but he envisions three tiers of calibration: tier 1 is respecting the 1991-2000 period of average hydrology, tier 2 is 2020-present, and tier 3 is 1985-1990. However, this tiered approach is not strictly necessary, although it would be beneficial.

Discussion on Nicole's presentation

Regarding [slide 6](#), Lew said from a manager's perspective, there is likely interest in what generates the hypoxia in the deepest parts of the Rappahannock, such as whether the source is from the mainstem bay or the local watershed and the consequences of these findings. Lew suggested spending time considering these questions. Nicole said this is a good research question and she will keep this in mind while working on the Rappahannock MTM. Dave asked if Lew is suggesting a hypoxia vertical profiler in the Rappahannock. Lew said it would be useful. Richard said there seem to be plans to put a vertical profiler in the Rappahannock. Marjy said she is not sure the Rappahannock has been officially selected for receiving a hypoxia vertical profiler, but she has suggested it as a great location and the top priority for the next hypoxia vertical profiler, if/when that becomes feasible.

1:55   ADJOURN

Participants : Alexander Gunnerson, Arianna Johns VA DEQ, Beck Fishell, Bill Keeling, Bryant Thomas, Carl Cerco, Carl Friedrichs, Carlington Wallace, Chris Spaur, Clifton Bell, Dave Montali, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano, Guido Yactayo, Isabella Bertani, Jamileh Soueidan, Jeremy Testa, Jesse Bash, Jian Shen, Joseph Zhang, Julie Herman, KC Filippino, Karl Berger, Karl Blankenship, Kevin McLean, Kimberly Dagen, Larry Sanford, Leonard Schugam, Lew Linker, Mallory Howdyshell, Marjy Friedrichs, Mukhtar Ibrahim, Nicole Cai, Qubin Qin, Raleigh Hood, Rebecca Murphy, Richard Tian, Sam Merrill, Samuel Canfield, Sushanth Gupta, Tish Robertson, Tyler Trostle, Zhenghua Jin.