Modeling Workgroup (MWG) Quarterly Review Minutes

April 2, 2024

Event webpage: Link

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

ACTION ITEMS

- **Gary Shenk will reach out to Chaopeng Shen, Kim Van Meter, and Shuyu Chang to coordinate on the Machine Learning work with the CBP watershed modeling team.**
  - **Status: Complete.**
- **Once the optimization webinars have been scheduled, the Modeling Workgroup (MWG) staffer will share the calendar invites for the webinars with the MWG mailing list.**
  - **Status: Waiting on the optimization team to scheduled the webinars.**
- **Kalyan Deb, Pouyan Nejadhashemi, and Gregorio Toscano-Pulido will reach out to Olivia Devereux and Lew Linker to have a conversation about relevant information for the presentation to Lancaster, PA on April 11, 2024.**
  - **Status: Complete – met with Olivia Devereux.**
  - **Follow up action for PA DEP/Lancaster County Conservation district – Gregorio Toscano-Pulido and the optimization team are preparing a formal data request, which will involve a follow up meeting.**
    - **Before this meeting, have a pre-meeting with Lew Linker to discuss when the draft materials are nearly ready.**
- **Alex Gunnerson will schedule a time to discuss the process for deciding land use classification, how to treat mixed open, and how to incorporate the high-resolution land use data into watershed modeling efforts and at a future modeling team meeting.**
  - **Status: Complete - met on April 9th and will have follow up meetings as needed.**
- **Richard Tian will send the data files on the treatment of tidal wetlands and oysters in Phase 6 to Zhengui Wang.**
  - **Status: Complete.**
- **The MWG Staffer will find a time for the modeling team to discuss Samuel Canfield's interest in using INLA for the RAND BMP climate sensitivity work.**
  - **Status: The staffer will wait until RAND is officially on contract before reaching out, as this may partially depend on the results of the literature review.**

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

Summary

Lew Linker began by summarizing the importance of adapting to the needs of the partnership, in this case the collapse of the Francis Scott Key bridge over the Patapsco in Baltimore. If there is a way the Modeling Workgroup can support this effort, they will.

Lew announced that Alex Gunnerson, current Modeling WG and STAR staffer, will be leaving the staffer position to start a new job as a Geographer with USGS. He will be working with the CBP GIS team at the CBPO.

10:05 Using Machine Learning Approaches for Phase 7 WSM – Kim Van Meter and Chaopeng Shen, PSU

The development of machine learning approaches to advance the calibration and application of the Phase 7 Watershed Model was discussed.

Summary

Kim began by introducing the team leading the effort and their expertise. Kim then discussed the challenges and opportunities of leveraging machine learning (ML) approaches. Kim outlined the three major project tasks on slide 4. Kim then explained each of the project tasks in more detail on slides 6 through 8.

Chaopeng explained why the team started with a continental scale model before moving to the Chesapeake Bay watershed. Chaopeng walked through a series of small multiple maps highlighting the Long short-term memory (LSTM) model performance metrics for suspended sediment. Chaopeng compared the performance of the conterminous US scale model with the local scale (Chesapeake Bay Watershed).

10:30 Discussion of Machine Learning Approaches for Phase 7 WSM

Summary

Dave said there is a lot of uncertainty around agricultural land use at the 1-meter scale, especially for low vegetation, in determining if an area is pasture or grassland. Dave asked how the machine learning approach will handle this uncertainty. Kim said this is true, but she expects there to be less uncertainty in the 1-meter data compared to the 10 or 30m data. This will be investigated as the project works through its three tasks. Kim said they will be investigating if using the monitoring data will help with understanding the predicative capacity of the machine learning model. Kim added there will be more explicit methods for representing and dealing with uncertainty. Dave said even at 1m land use, there are challenges with separating pasture from hay. Gary said the influence of land form and hydrography data on watershed model performance is even more of interest than land use to the modeling team. Chaopeng said the ML model must be supervised by monitoring points at different catchment sizes, which thankfully we have in relative abundance in the Chesapeake Bay watershed. Kim and Chaopeng are trying to advance a multi-scale modeling approach to satisfy the needs of this project, so there are some new elements that will be added, such as adding constraints to ensure smaller scale models are compatible with the macroscopic model. Shuyu commented that for large

geographic extent projects, there may be less of a difference, but we may see bigger improvements in smaller watersheds. Chaopeng caveated that at a finer scale uncertainty grows because there are fewer data points for supervision, but noted the team is developing a system for quantifying and representing uncertainty. The team will impose some constraints to reduce uncertainty.

Norm asked if there will be a sensitivity analysis incorporated into these tasks. Kim said yes, part of the interpreting the results will include looking at the sensitivity predictors. This is an extremely important part of model development. Chaopeng added that sometimes machine learning models do not have the sensitivity correct. Where the model does not perform well, we will perform secondary analyses. This may mean more time is required before achieving the correct sensitivity. Lew agreed the overall goal is improved model performance, which is quantifiable and will be key to this work.

Olivia asked if BMPs will be included in the machine learning methods for downscaling? This would make sense to Olivia because BMPs are located on the land, which should show up in the monitoring data. Kim replied that at the national scale, BMP data is not available. Given that we have better data in the Chesapeake, this could potentially be very useful. Olivia said the CBP is potentially moving towards a more spatially explicit product where users can place a BMP and define the drainage area to that location, but this will likely not be available for another two to three years. In the meantime, the CAST team could downscale and share BMP data with the ML team, but there is considerable uncertainty. Kim asked for greater clarification. Olivia said most urban BMPs are point specific, but agricultural BMPs are aggregated to county scale to protect farmer privacy. Kim and Olivia agreed to talk about this more offline as needed.

Gary said there will need to be more coordination between the modeling team at the CBP and this group. Please be on the lookout for emails setting this up. The watershed modeling team will likely have questions. Kim, Shuyu, and Chaopeng agreed.

10:40 Phase 7 Watershed Model (WSM) Overview – Gary Shenk, USGS-CBPO

Gary provided an updated timeline for completion of the Phase 7 Model in time for the 2026 partnership review.

Summary

Gary began by reviewing previously presented slides introducing the different Phase 7 development tracks of the WSM, how the components fit together, and which partners are involved. Major discussion points include scale and model evaluation and uncertainty. These conversations are taking place in a range of Water Quality Goal Implementation Team (WQGIT) workgroups, which are listed on slide 11.

To demonstrate how Phase 7 is different from Phase 6, Gary compared the methods for calculating average loads. Gary emphasized that consistency is more desirable than accuracy in a general sense because spatial and temporal trends are more important that the absolute value. There are two plans for Phase 7: what would be ideal/is somewhat experimental, and what the team knows will work.

Gary concluded with the overall structure of the model and its timeline for completion.

11:05 Discussion of the Phase 7 Model Overview

Summary

Chaopeng asked what the average size of the NHD 1:100K scale is. Gary said it is about 1 square mile on average.

Dave asked if CalCAST will be used inform to CAST outputs related to broad land use classes. Gary said yes, and we can use those other models for prior information to push us in a certain direction. The backstory is that when we presented this information to STAC, we got a lot of feedback to focus on uncertainty and do something like CalCAST.

Robert Sabo asked if the Phase 7 watershed model will attempt to capture intra-annual processes (e.g., crop uptake and ultimate yields throughout growing season) or if it will just be calibrated with annual time series. Gary replied annual CalCAST and CAST will use smoothed annual trends in yields. The Dynamic model will used estimated weather-dependent values. Joseph Delesantro will have more to say on this topic. Robert said he is trying to get a handle on how annual vs. intra-annual plays out with these loading factors.

11:15 Update on CalCAST Development – Isabella Bertani, UMCES-CBPO

Isabella described the progress made in work on improving the CalCAST model performance with the new calibration datasets (both average annual and annual) discussed at the January 2024 Quarterly.

Summary

Isabella began with a review of the current candidate set of CalCAST calibration stations and the variability in TN station drainage area. Isabella then walked through the model formulation and the best catchment predictors for average annual streamflow, stormflow, total nitrogen (TN), total phosphorus (TP), and sediment (slides 4-16). Isabella also discussed annual TN load and yield when normalizing for flow. Isabella concluded with a summary of next steps for CalCAST model development and refinement, specifically inputs, sensitivities, land to water/stream delivery, uncertainty in calibration loads, and lag formulation for annual models.

11:35 Discussion of CalCAST Development

Summary

Chaopeng Shen asked where the water withdrawals came from? What assumptions were made to locate the withdrawal? Isabella said the data were provided from jurisdictional representatives and compiled originally by Kyle Hinson, a former staffer. Lew added this data was reviewed by the Modeling Workgroup and applied to Phase 6. Isabella said some of the withdrawals were just at the county scale, so assumptions had to be made about where to locate those withdrawals. Robert Sabo said he believe USGS NWIS has standardize water use/withdrawal estimates across the CONUS: https://waterdata.usgs.gov/nwis/wu and https://www.usgs.gov/mission-areas/water-resources/science/water-use#science. Gary added that our withdrawal methodology for P6 is in section 8.3 of the documentation. Gopal will discuss withdrawals a bit in his

presentation https://cast-content.chesapeakebay.net/documents/8%20Direct%20Loads.pdf.

Steven Beiber asked if this only refers to surface water withdrawals or if it includes groundwater as well.

Dave said there are stream withdrawals and groundwater withdrawals for public water supply. Dave asked if both of these sources for that use case are considered in this analysis. Isabella said the team has discussed this topic and decided not to include groundwater withdrawals because it would be more difficult to incorporate as the location data is imprecise and how they influence conditions are unclear. We have data for most of the jurisdictions. Mark Bennet said given our geology, groundwater withdrawals are not going to have much of an impact on surface water. Dave asked if groundwater withdrawals would be important. Mark said for the most part, groundwater withdrawals will not make much of a difference for these models in the Chesapeake Bay watershed.

Lew asked which formulation will be used for Potential Evapotranspiration (PET) since it matters a lot. Isabella said multiple formulations (Penman–Monteith, Hamon, and others) were tested for climate change sensitivities and a final decision has not yet been made. CalCAST will have the ability to switch from one formulation to another in the model to see what provides the best performance. Lew asked if this is equation would be used for scenarios or just the model formulation. Isabella said all options are still on the table. Lew said he remembers from Isabella's previous presentation that Hamon performed well, but Hargraves-Samani also could be a good contender. Lew said Hamon is fraught with challenges and emphasized this decision will need to be examined hypercritically.

Dave said for watershed characteristics, percent carbonate showed up in everything except streamflow. Dave asked why that is. Isabella said percent carbonate is not a meaningful predictor for streamflow, but she is not sure why. Perhaps that is because the predictor percent anthracite coal mine land can behave similarly to and correlate with percent carbonate geology as they both are very fractured and transmissive environments. Perhaps other predictors cover the variability from percent carbonate and yield it redundant.

Lew asked if we need to think about seasonal CalCAST models for understanding climatic changes in delivery of loads in winter vs summertime. Winter-time loads to the Bay are preferred to summer time loads. Is this already handled in CalCAST? Isabella said having a seasonal model would give us different information than the annual model, which is what we currently have, but we need to think about prioritizing here. Only our time commitment to the annual model prevents us from developing a seasonal model. Lew said with the end goal in mind, he believes this is a critical issue. One example would be how to represent the change in PET on a seasonal basis. Isabella agreed to talk more about this. Gary said this consideration should be covered in Gopal's work, as it needs to be addressed in the Dynamic Watershed Model somehow.

Robert Sabo asked if in the total nitrogen predicted versus observed plots, when including ancillary predictor variables (four variables), R^2 increases by about 0.16. Isabella said R^2 increases from 0.68 to 0.84.

Robert asked where the ancillary datasets were acquired and what was the procedure for determining the appropriate variables. Isabella said it is an NHD Plus data release which has hundreds of variables (lithology, soil, anthracite mine land, stream catchment, etc.). In terms of model selection, we have not yet implemented a formal selection procedure, such as forward or backwards selection. We are just including predictors one at a time. The runtime of CalCAST at this point would make it prohibitive to run a full-scale comprehensive model selection procedure, but as we gain more information about what types of predictors make a difference, we may just consider a subset of our current pool of candidate predictors and then run a more formal model selection on that subset. Robert agreed this would be very difficult from a technical perspective said he would be happy to participate in some exploratory exercises with these ancillary variables.

Lew asked if water withdrawals were included as a point in the new database. Isabella said the county of the data and the cubic feet per second were included and split within LandRiver-segments based on land use (urban or agricultural) and whether it was public supply or irrigation. Isabella has downscaled the data to the NHD plus scale. Lew said there is a Phase 6 dataset the machine learning team may be interested in using. Isabella suggested that the machine learning team reach out to her if they are interested in utilizing these water withdrawals data.

11:45 Progress in Phase 7 WSM Development – Gopal Bhatt, Penn State-CBPO

The NHDplus 100K scale Phase 7 Dynamic Watershed Model (DWM) is using a nested model segmentation of streams and rivers with a hybrid structure for the simulation of water quality processes using Hydrological Simulation Program – Fortran (HSPF) and non-iterative routing models. Gopal surveyed the ongoing model development progress on the structure, implementation, and testing of a simplified water quality routing for small NHDplus streams for phosphorus and describe activities upcoming in the next quarter.

Summary

The purpose of the DWM is to provide inputs for the estuarine models, assist with watershed model calibration and scenario applications, and support research and collaboration activities. The DWM is comprised of a nested model segmentation of streams and river mainstems. Gopal began with a review of the DWM structure, how it connects to CalCAST, and prior model development progress.

Gopal then focused on recent progress in water quality (TN & TP) routing for small streams, specifically the 1) building blocks of water quality routing, 2) structure of water quality routing, 3) model testing and verification.

1. Gopal described the importance of developing model parameters that provide information on flow and seasonal variability for small 100K NHDplus streams. Tools such as WRTDS-K and Fluxmaster-K can be useful.
2. Gopal walked through the structure using HSPF and UNEC to identify emergent behaviors.
3. Gopal then described some prototype results for output and the beta parameters.

Gopal also presented some data on surface water withdrawals which were provided by VA DEQ, which included a very rough assessment of TN loads.

Gopal concluded with a summary of progress over the past quarter and next steps for the DWM in the coming quarters.

12:10 Discussion of Phase 7 WSM Development Progress

Summary

Lew said the seasonal concentration and hourly flow in the DWM helps identify the critical seasonal aspect of inputs to the tidal Bay and watershed. Gopal explained the DWM is complementing CalCAST with the seasonal aspect for both generating loads across different scenarios and loading the actual model.

Dave asked if the CBP has the history of how much TN and TP has been removed from the system. Gopal said that for Virginia, we have the data for the entire calibration period. Dave said 1.25 million pounds per year of lower delivery seems like a lot, but looking at the full period, there does not seem to be much change. Dave asked over this whole time period, have the removed solids from WWTPs been directed to landfill. Gopal said 1.25 million pounds per year need to be put in context. If put in Phase 7, it would require equitable treatment across the board, including spatial apportionment in the shallow water regions. Lew agree it is worth checking into and mentioned Rob Burgholzer has been helpful in collaborating on this work, such as investigating the destination of rapid sand filtration treatment. Lew noted we use Phase 6 to assess tracking up to 2025. Lew stressed the need to get some equivalent data from all of the below fall line databases, such as Maryland.

Lew said everything is aimed towards improving the model performance. Immediately, the beta 2 parameter is giving us a reasonable result. Depending on the statistics, it is as good or better as Phase 6. Gopal said that we need to be careful to not lose work from Phase 6. All these results include the work from Phase 6, which is baked into the product. The quality of the results is in part due to those components. Gary said on slide 17, this is very similar in variability to what the simulated river received in Phase 6, so it is an unfair comparison. Gary found it reassuring that the scatterplot looks better. Gopal said that in discussions, we are in a good place. For the initial prototype, it is encouraging we are moving in the right direction. We still need to evaluate the different variability in explaining the parameters.

12:30 LUNCH

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

The presentation focused on results of the Optimization Approach in Lancaster, PA, and demonstrate the integration of web-user and decision-making interfaces across county, state, and watershed levels.

Summary

Kalyan began by outlining the timeline of the project. Kalyan used Lancaster County, PA as an example to evaluate the results of the optimization analysis. Kalyan walked through two scenarios that are based on the Phase III Watershed Implementation Plans (WIPs) for the county. This included a demonstration of alternative trade-off solutions using multi-objective optimizations, such as for cost or load reductions. Kalyan showcased multiple ways of visualizing these results, such as web maps, parallel coordinate plots, and horizontal bar plots.

Kalyan described that a series of optimization webinars will be scheduled to demonstrate how to use the tool going forward. Once scheduled, Alex Gunnerson will share the calendar invites for the webinar with the Modeling Workgroup.

Kalyan explained that this project has inspired much academic work. For example, there have been one journal publication, one conference publication, and five abstracts submitted to an upcoming conference on environmental modeling and software.

Gregorio shared a video which demonstrates the capacity of the web-interface for users to access these results and inform their WIP development. This allows for the usage of existing CAST scenarios and new scenarios.

Next steps for the optimization team include using artificial intelligence to enhance optimization, parallel computing platform for faster execution, and workshops with CBP users for feedback and improvement of our approaches.

1:30 Optimization Discussion

Summary

Olivia said that this is significant cost reduction given that the estimate for the 2019 progress, used as a baseline, is estimated at $2,712,262,352.99 for the entire Chesapeake Bay watershed. The amount for just Lancaster, PA is $95,859,654.04. Pouyan said the cost they got is from the most updated version of CAST. Pouyan obtained the cost from this website: https://cast.chesapeakebay.net/Documentation/CostProfiles. Olivia said they got this cost from the CAST. Kalyan said all this information comes from CAST, except for cost. Olivia said that that link has data for each state as well as an unweighted average for the entire Chesapeake Bay watershed. Costs are built into CAST and users can specify their own or use those default costs under the cost profile page, once logged in. The costs are incorporated into the BMP Submitted vs. Credited report. Those data are all stored in the CAST database too. Pouyan said we are currently utilizing the CoreCAST system, which unfortunately does not include a feature to manage or analyze cost profiles directly within its framework. Consequently, we must perform cost calculations externally to CoreCAST. This requirement led Pouyan to reference the website for the integration of cost considerations into our analysis. Olivia said yes, most of the BMP crediting and other logic is built into the CAST code, not stored queries or database tables. Gregorio said CoreCAST does not return the cost of BMPs, so we are using TblCostBmpAnimal and TblCostBmpLand from ScenarioBuilderV3MetaData to compute the cost. The MSU team is excluding all BMPs with cost 0 from our selection. Gregorio said furthermore, when we are working with counties from multiple states, we do not use CostProfile=4 (Watershed), but we check the state of each county and we compute the respective cost.

Lew said counties like Lancaster, PA have many commitments. Given the significant costs, they would like to prefer the least cost possible. Somewhere in the webinar, we should include things like the target for the county being provided as an example, which in this case is load. Kalyan agreed. Pouyan said he reviewed the documents for Lancaster, PA, and the load target was 25 million pounds reduced of TN by 2025. We saw some discrepancies between the County Action Plan (CAP) and what CAST is showing. Pouyan said we should have a side conversation between Olivia and Lew to discuss this before our presentation to the county on April 11th.

Dave asked when the team plans on having the webinars. Kalyan said it depends on who needs to be there and when would be best. The MSU team is in a position to talk about case studies using the software we have, so if there are some case studies you would like to discuss, let us know in advance so we can plan accordingly. We are thinking early Fall 2024. Dave said the team is most likely to receive feedback when the users begin experimenting with the tool. This will be most useful in 2027/2028 when we make the next set of WIPs. Kalyan said he welcomes feedback to help tailor the optimization tool.

1:40 Most Implemented Agricultural and Urban Stormwater BMPs – Olivia Devereux (Devereux Consulting) and Auston Smith (EPA-CBPO)

Olivia presented the methodology and data used to show the percent contribution of each BMP to the total Phase III WIP reductions. This creates a ranking of the most important BMPs to the states in their planning efforts. Auston presented on the context for this effort, the RAND Climate Resilient Stormwater Support project (see next agenda item).

Summary

Auston began by explaining the overall structure and purpose of the cooperative agreement, including the specific project related to BMPs. Olivia then walked through the methodology to identify the BMPs included in the most implemented list. Olivia also described the BMP isolation scenario example and provided caveats on how this data should be used.

Lew said the CBP will decide which BMPs RAND should consider in their research.

Dave said the goal of this analysis was to determine which subset of BMPs RAND should use to evaluate the difference under future climate change hydrology. Dave commented that some of these BMPs could likely be discarded quickly, like animal waste management systems because it is more of a loading rate than an efficiency. Olivia said the engineers who design animal waste management systems consider annual rainfall in their calculations. Mark said it will change the design but not necessarily efficiency. Olivia countered that if the design changes the efficiency will change. Dave said his overall point is that RAND should focus on the nuances of specific BMPs. Olivia suggested focusing on BMPs which will persist on the landscape. Olivia said anything that is a plan should be taken off the list for evaluation. The plans will adapt and make new recommendations. Lew said the modeling team will be working with the Urban Stormwater Workgroup and we will defer to them in terms of efficiencies we should use,

and will discuss this on Thursday, April 4th, 2024. A month would be quite good in terms of the list.

Norm Goulet asked could someone send him the percent of implementation in CAST23 for each of the urban BMPs for the joint meeting? Olivia said here is the link for the data that she presented. Olivia sent Norm the data directly. Data can also be downloaded from that site. https://public.tableau.com/views/WIPPriorityBMPs/TSS?:language=en-US&:sid=&:display_count=n&:origin=viz_share_link. Norm said he is looking for actual implementation. The WIP level of implementation does not completely reflect what has actually been going into the ground or undertaken (i.e. Urban nutrient management numbers or tree planting were unrealistic in the WIP). Olivia confirmed she has emailed that to Norm. Olivia also said see this link on CAST to see the BMP effectiveness, cost effectiveness, and most implemented. It uses 2020 progress and the WIP 3, but I will update in the next month as we release CAST-23.

1:50 **Stormwater Management in a Changing Climate Storm Water Management Models (SWMM) & AG BMPs – Michelle Miro and Krista Romita Grocholski, RAND**

The presentation was a quick overview of the project to apply existing, well-documented, open source, and public domain stormwater and/or watershed models under different future climate hydrologic conditions to determine relative change in pollutant removal efficiency in existing CBP-approved stormwater management BMPs under future climate conditions. Plans to work closely with the CBP were also discussed.

Summary

Krista gave a brief overview of the project and the team. Michelle then explained the general approach for activity four, which was discussed in detail with the CBP modeling team in late February.

In terms of engagement to date, the team presented the highlights of the project, the focus on relative efficiencies, and GCM selection at the January Quarterly shortly after learning they were given the award. At the modeling team meeting on February 20th, the approach was discussed in more detail and timeline. Additionally, modeling team members will present on CBP modeling to the RAND team once they have received the monies and are under contract.

Michelle confirmed with the next steps which will begin once the project has funding. This includes a literature review, engaging with the workgroup, and finalizing model selection.

2:05 **Combined Discussion of Top 20 Most Implemented Agricultural and Urban Stormwater BMPs and Stormwater Management in a Changing Climate SWM & AG BMPs**

Summary

Lew said there may be some unit area of Chesapeake Bay land use/land cover, and that unit area would be well characterized across different physiographic regions. This would consider relative difference in load export under differing hydrology scenarios wrought

by climate change. With SWMM, this works fine, but there is some discomfort with whether Soil & Water Assessment Tool (SWAT) is capable of handling these mechanistic challenges. HSPF has performed well at the small scale and is not only mechanistic, but we have this ready to go with all inputs for regions of the Chesapeake. We may want to consider this approach.

Gary said he would be interested to learn about what is found in the literature review because he has concerns about HSPF and SWAT, specifically how they consider runoff to be caused by infiltration excess which really doesn't happen in this area. Gary wants to know how different people have thought about this. Michelle agreed this is one of the team's priorities.

Norm said the Northern Virginia Regional Commission is going through a selection process now for the HSPF Occoquan Model, the two leading contenders are SWAT because of the calibration routines and a machine learning version.

2:15 Advances in Precision Agriculture Practices – Katie Walker, Chesapeake Conservancy

The presentation featured new developments for site-specific modeling that support BMP implementation planning. A proof of concept has been deployed in the FieldDoc platform to support nitrogen, phosphorus, and sediment reduction estimates.

Summary

Katie began with a review of the Objective 3, BMP Planning and Reporting: Scaling Precision Conservation in the Chesapeake Bay Watershed, project. Katie identified two challenges that this project is designed to address, and the three products which should help achieve the project goals. This includes connecting BMP planning, tracking, and reporting; understanding BMP impacts at the site scale; and BMP opportunity layers. Katie also shared a list of the partners involved in this project.

Katie provided an overview of FieldDoc and how it is used by partners. Katie also explained the relative confidence index pilot to understand BMP impacts at the site scale.

Barry Evans then walked through how on the fly models are powered, which in this case is the watershed API and fast zonal statistics API. Barry walked through how this approach would work for a Riparian Forest Buffer, and then how this would be tested at different sites. Barry listed the data resources and models that contribute to the BMP load reduction API.

Barry added that the project looked at urban BMPs as well. This included an investigation into the capacity to better identify opportunities for stormwater BMP implementation through hydro-conditioning of DEMs with available infrastructure data and existing BMPs in the city of Lancaster. The primary objective is to spatially define drainage areas for existing stormwater BMPs based on latitude/longitude, the site area, and high-resolution digital elevation model.

Barry said they have looked at a large suite of BMPs and categorized them into archetypes.

Katie concluded with next steps and discussion questions for the Modeling Workgroup to consider.

2:45 Discussion of Precision Agriculture Practices

Summary

Dave asked to return to slide 12 and said the team recommended buffer 2 for Total Suspended Solids (TSS) reasons, but in management we may be inclined to say that buffer 1 is ideal because it helps with nitrogen and phosphorus goals. Katie said it depends on the priorities of the implementer, whether they are shading, habitat, nutrients, or sediment. If you have less resources, you will likely have a higher confidence for less buffer if selecting number 2. Olivia added that this is different than CAST because it is a field specific tool and designed for helping people implementing grants. In many cases they are more concerned with sediment reductions than perhaps nutrients. Katie reiterated that it really comes down to the local implementation planning. Barry added that if one was to reverse the confidence values, buffer 1 may become more attractive because you are more likely to exceed the expectations.

Lew clarified that this presentation is for informational purposes and that the implementers are the real audience of this work. Katie said for the most part, this project is informational for the Modeling Workgroup and it should be shared with networks. One piece of feedback the team received is that project implementers want to see similar results and an understanding of how the two are connected. Another relevant point is Chesapeake Conservancy is working with Drexel to house a project with EPA-CBPO that may be helpful to the Modeling Workgroup in other efforts. Once this transition to EPA-CBPO is complete, Lew said the tools can be shared with the Modeling Workgroup mailing list so that awareness about this tool is broadened.

Olivia asked when the project will be wrapped up and when it will be stored here. Katie said it will be complete by July and will be moved over to the CIMS server. Katie is working with Megan Thynge at EPA to complete this move.

2:55 Phase 7 Land Use Progress – Peter Claggett, USGS-CBPO

Summary

Peter began by providing an overview of the CBP 1m land use data, including the current classes, potential new classes, and potential new National Hydrography Dataset (NHD) variables. Some of these new NHD variables include effective impervious surfaces, channel/ditch density, road density, and others. Additional Phase 7 Land Use/Land Cover (LULC) related activities include reconciling mapped classes (forest harvest, agriculture, stormwater ponds, and animal operations) with reported values, updating with new datasets (septic methodologies, tidal shoreline, Revised Universal Soil Loss Equation (RUSLE)), and attribution of segmentation.

3:05 Discussion of Phase 7 Land Use Progress

Summary

Lew said this work is exciting and is a great opportunity to demonstrate incremental improvement from previous years.

Dave asked who makes the decision to divide up the "Mixed Open" category. Peter said it is not his decision to make but was thinking maybe the Modeling Workgroup would be the best place to make that decision. The Land Use workgroup mainly oversees the classification of the data once the scheme is determined. Gary says it really is the WQGIT's decision as the modeling workgroup can look at broad trends in the data, but it really falls to the source workgroups and existing literature to decide loading differences. Dave said he is not sure there is much data available on this topic. Olivia said the Agricultural Modeling Team (AMT) is looking at a lot of this, including the scale. Gary said the AMT is the only one who has bought into this idea, but many of the other workgroups are curious. This remote sensing data has turned the metaphorical lights on, but just because we have the data does not mean we know how to use it properly.

Norm said the level of detail is great for some aspects, but he is concerned of outstripping our ability to accurately describe loading. Norm added that the mixed open is the perfect example of the good and the bad. While the individual land uses are relatively minor, it can have a difference in some segments, especially for heavy solarized segments in VA. There is not a whole lot of information in the literature about these loading rates for solar. Peter said there is precedence for adjusting the loading rates relative to something else. If we know that at least some portions of solar fields are heavily compacted (e.g., road rights of ways), we might be able to get a better result. Ultimately the WQGIT or source sector workgroups are going to need to make a decision. Peter added that in some portions of the watershed mixed open is 100% timber harvests, in other locations it is 100% solar, but in others it is a large mix including roadways. At 12 classes, the model would be agnostic to this variability.

Lew suggested taking this conversation to a future modeling team meeting for expanded discussion. We must choose carefully what to prioritize. Alex Gunnerson will schedule a time to discuss the process for deciding land use classification, how to treat mixed open, and how to incorporate the high-resolution land use data into watershed modeling efforts and at a future modeling team meeting. This meeting took place later in April 2024.

Dave said there is a WQGIT funding proposal for next year and asked for more explanation. Peter said Katie Brownson put in a proposal about timber harvests. Peter said we have previously mapped them, but they are double counted in Phase 6 because they are lumped into mixed open. Regardless of what we decide to do, some actions will need to be taken to reduce double counting (animal operations, timber harvest, etc.). Peter said that proposal is to explore the loading rate.

3:30 ADJOURN

Participants: Alex Gunnerson, Alex Soroka, Ali Shokoufandeh, Andy Fitch, Arianna Johns, Auston Smith, Barry Evans, Bill Keeling, Breck Sullivan, Carl Friedrichs, Carlington Wallace, Cassandra Davis, Chaopeng Shen, Clifton Bell, Clint Gill, Dave Montali, Doug Bell, Elizabeth Hoffman, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano Pulido, Guido Yactayo,

Hoda Razavi, Isabella Bertani, Jesse Bash, Jeff Sweeney, Jian Shen, Jim George, Jonathan Leiman, Joseph Delesantro, Joseph Zhang, Karl Blankenship, Katie Walker, Kalyanmoy Deb, Kevin Mclean, Kimberly Dagen, Kim Van Meter, Krista Romita Grocholski, Lew Linker, Mark Bennett, Michelle Miro, Mukhtar Ibrahim, Neil Ganju, Nicole Cai, Normand Goulet, Olivia Devereux, Peter Claggett, Pouyan Nejadhashemi, Qian Zhang, Rebecca Murphy, Richard Tian, Robert Sabo, Ruth Cassilly, Sam Merrill, Samuel Canfield, Shuyu Chang, Sophia Grossweiler, Steven Bieber, Tom Butler, Tyler Trostle, Zhengui Wang.

Modeling Workgroup Quarterly Review

April 3, 2024

Event webpage: Link

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

10:05 Update on Main Bay Model (MBM) Progress – Zhengui Wang and Joseph Zhang, VIMS

Progress on the MBM water quality simulation was presented. First, the team successfully tested a method in redistributing the total nutrient loading over time to fix the large anomalous nutrient concentrations related to watershed loading. Second, the team also improved the simulation of nutrients and chlorophyll-a, and the latest results will be presented. Lastly, the team gave a short statistical summary of the latest MBM model skill.

Summary

Zhengui began by describing the anomalous loading issue and how it was addressed by redistributing nutrient loading over time through three steps. Zhengui then described improvement in the MBM simulation of nutrients and chlorophyll-a. Next, Zhengui described a summary of the latest MBM skills scores that compared Phase 7 preliminary results with Phase 6 results. Zhengui concluded with next steps for the MBM development.

10:35 Discussion of the Main Bay Model (MBM) Progress

Summary

Lew said slide 5 of this presentation demonstrates two things:

- People are paying attention to the input loads.
- This originates as a watershed loading problem and a number of fixes have been applied at both ends.
    - Gopal added we are concurrently working on this problem and by applying fixes from both ends, we will be able to tackle the challenge. There are two ways to tackle this problem:
        - The F table with HSPF showed that anomalies arise when flows reach very low values. Some strategies have been developed to keep that from happening.
        - Another issue was no flow associated with septic loads. One solution was determining how much flow should be associated with those loads.
            - Lew added that when you get away from cities in the coastal plain, there are many septic systems and this becomes clear when we move to a finer scale. These problems can be better resolved which help with overall mass-balance considerations.

In regard to slide 7, Lew said that flow is low in August and can lead to concentrations approaching infinity if the load is constant. This requires adjustments to the flow consideration for these dry time periods. Lew said we should consider how we operationally use these fixes in the Main Bay Model and see if they make any differences in the scenarios by comparing with a non-corrected scenario. Zhengui agreed.

Lew said it is reassuring to see the results in slide 8 and asked how Zhengui adjusted the phosphate simulations. Zhengui said there is a partition coefficient to control sediment phosphate release. Lew said that Walt Boynton and Jeremy Testa have indicated through observations that we will likely see improvement in bottom ammonia release as we reduce nutrients. Lew indicated it would be nice if we could capture these observations in the scenarios as well.

Carl said it is difficult for him to decipher the time scale on slide 8 and noted that if a station goes anoxic as soon as it turns over in the fall, the phosphate precipitates and drops out of the water column. We see this over and over, but the Bay scientific community does not seem to make comments on it. In Phase 6, we got rid of the excess phosphorus by precipitating it out when the Bay turns over. I think what you did as an alternative seems fine, but you may want to look at the Phase 6 model and data. You may want to plot phosphate and Dissolved Oxygen (DO) and consider adding this to the model. Joseph said this question of settling is being considered. Lew said the team could use a DO signal due to climate change's potential phenology shifts in the Bay. Carl said DO should be the signal.

Regarding slide 10, Lew asked if the plots are showing one Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) segment or a collection of stations compared to SCHISM. Zhengui said they use the exact points which are determined using interpolation. Lew said that those points on the chart are approximations since they move around, but one should consider the uncertainties in the exact location. Joseph said that SCHISM uses the exact location for linear regression, but they are working to incorporate the uncertainty.

Lew asked if on slide 13, the team can revisit and investigate the diatom settling rate. Carl Cerco said Lew is looking at the spring bloom and this is something that has frustrated him for 30 years. Carl believes the diatoms may be regulating their buoyancy, so that by putting themselves in the bottom layer they get moved upstream. Carl said there may be algal seeds or spores which rise from the bottom. Carl said he would not be surprised if this is not perfect. Marjy said she is also frustrated by this question, but said in Jesse Turner's erosion paper, Jesse developed a ballasting parameterization so that the more inorganic sediment you have in the water column, the faster they adhere together sink faster. In wet years when there is more sediment, you get a faster sinking rate. It did not solve the problem, but it was informative. Marjy said it leads to more algal growth on the surface and was helpful for modeling hypoxia. Jian Shen said he noticed when doing bottom age of the water column, it is very sensitive to resuspension. When we reduce the last layer in net settling, resuspension must also be included. Aggregation of settling must also be completed. Surface water movement down the water column is slow because of the pycnocline, and it is less than five days in general. Jian said we need to test this

mechanism. Lew said it looks like there is improvement in simulations of DO in CB4.3C, which is great because this is important.

Lew asked what order the MBM team is approaching submerged aquatic vegetation (SAV), wetlands, oysters, and shoreline erosion. Lew said it is critical the CBPO supports this work as it is needed for a shallow water assessment. Joseph said their first priority is SAV because that is part of the TMDL, then they will focus on tidal shoreline erosion. The team will use Carl Cerco's approach for the oysters and tidal wetlands incorporation. The MBM team will see how much time we have available for other components after that. Lew suggested discussing this at a future MBM monthly meeting or a weekly modeling team meeting. Jian said the VIMS data is pretty good coverage for SAV beds, which will be used to initialize SAV coverage. Simulations will be used to suppress growth and kill off SAV, which can be compared with the survey data, but this can be very difficult if TSS or temperature are off. Jian thinks Carl's approach for wetlands will be appropriate for the initial review regarding nutrient, DO, and carbon components. Joseph asked if the information from Phase 6 has also been provided to the MBM team. Zhengui said he has the reports and code, but needs the data files from Richard. Richard agreed to send the observation data for wetlands and oysters to Zhengui and Joseph.

Jian said there was an oyster study in the Lynnhaven to determine how much carbon and nitrogen is removed. Jian said the study was not conclusive in quantifying nutrient and carbon removal but did note it needed to be diurnal for denitrification to take place.

Richard asked if these simulations are from the new grid, that include the Mattawoman. Joseph said yes. Richard asked if the new grid is available for him to use. Joseph said yes and Zhengui will reach out to Richard with the link to access the new grid.

Samuel Canfield asked if these components (SAV, Wetland, Oyster) are represented within the MBM, then how will that overlap with the Multiple Tributary Models (MTMs). Samuel said there should be overlap between the MBM and the MTMs at the shallow depths where these living resources are. Lew said yes, this is correct that there will be overlap.

10:45 Phase 7 Update of Model Criteria Assessment – Richard Tian, UMCES-CBPO

Richard provided progress on a water quality assessment of the entire tidal Bay.

Summary

Richard began by describing progress on method development for Phase 7 model criteria assessment. This included a review of the relevant designated uses, segmentation, and tidal stations included in the criteria assessment. Richard then walked through the steps and results of a water quality standards criterion assessment analysis based on an early test case. Richard also described a WIP scenario showing reductions in nutrient loads by the same percent across the watershed. Richard finished with the caveat that it is too early to draw any conclusions from the model.

11:05 Discussion of Whole Bay Criteria Assessment

Summary

Lew said this is a great demonstration of a prototype project and shows we are producing reasonable results. Once we get the new results for SCHISM, the results will likely improve even more.

Dave said we will discuss this topic in more detail and will have more time for discussion at future quarterlies.

11:15 East Coast Tracer Model – Nicole Cai, ORISE-CBPO

Progress on a regional cross-scale model of US East Coast estuaries and sounds was described. The purpose of this study is to investigate the connections among different water bodies, which will provide useful information and insights such as a quantified approach to assess the influence of coastal ocean atmospheric deposition to nitrogen loads at the Chesapeake Bay boundary.

Summary

Nicole began by explaining the motivations for conducting this study, which include understanding and predicting the physical, biogeochemical, and ecological interactions/responses between wetlands, estuaries, and the ocean. Relevant research questions are described on slides 4 and 5.

Nicole described improvements in the grid, considerations of scale, and freshwater loading from different estuaries along the east coast. Nicole demonstrated the improvement in freshwater loading performance metrics, as described by comparative tracer studies for Plum Island. Nicole walked through tracer study results for larger estuaries, such as Long Island Sound, Hudson River, Delaware Bay, and Chesapeake Bay. Nicole also described assessments of tide and salinity simulations.

Nicole concluded with next steps for this project, which include enhanced resolution for model grids at marshes, including locations like Plum Island, Milford Neck, and Sweet Hall.

11:30 Discussion of East Coast Tracer Model

Summary

Lew commented this tracer is something new we the team would not have been able to do this with Phase 6. This is a long-sought goal to calculate the atmospheric deposition that falls into the coastal waters of the of the ocean because of the large exchanges of water with the entrance to the Bay. One of the biggest sources of loads to the Bay is phosphorus and nitrogen, imported through the water in and by using atmospheric deposition to the coastal waters with the Community Multiscale Air Quality (CMAQ). This tracer study will allow the team to estimate the reduction of atmospheric deposition entering the Bay through coastal water exchange and can inform other estuary restoration efforts in locations like Long Island Sound.

Lew commented that on slide 15, if the team were to ask where to put atmospheric deposition, it would be in the blue band nearby Chesapeake Bay and Delaware Bay on day 365. This would allow for a reactive tracer surface nitrate and could connect to the atmospheric deposition for the coastal ocean. While concentrations will be infinitesimally

low, the exchange of water at the mouth is going to be many orders of magnitude larger. Quantifying this effect is key.

Joseph said this is great work, and for the few stations that have issues, talk to the SCHISM team as we have fixed the mesh issue now that we have better DEMs for those stations. Nicole replied tuning is required in the published results and will talk to Fei Da on the SCHISM team about this.

Larry said the variation in water level around coast, resembling a pulse, may be a result of climate change. Larry asked if Nicole has considered this in her work. Nicole said she was not aware of this phenomenon and will look into it further. When considering sea level rise, there are a few different ways of taking care of it. Nicole said in this case modeling scenario, we are considering sea level rise as one action. Larry said for sea level rise scenarios the variation is remarkable and not steady, as demonstrated in the Ocean City inlet. Nicole said expanding warming water might be part of it. Joseph Zhang added that there is periodicity in the signal.

Jian Shen said he has seen some literature about oscillation in the Bay that is connected to the coastal shelf. Larry said he has seen a correlation with the slowdown of the Atlantic meridional overturning circulation, likely due to climate change and the pulse.

11:40 Decarbonization Sensitivity Scenarios on GLIMPSE-GCAM-CMAQ – Chris Nolte, Dan Loughlin, and Jesse Bash, EPA-ORD

Initial work on decarbonization sensitivity scenarios on the atmospheric chemistry models of GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator (GLIMPSE), Global Change Analysis Model (GCAM), and CMAQ were described. Once estimated nitrogen deposition loads under estimated conditions of reduced carbon emission from stationary, mobile, and area sources are available from CMAQ the Phase 6 Watershed and Estuary Models will be run to understand the influence of reduced atmospheric nitrogen loads on water quality.

Summary

Chris began by reviewing the modeling framework used to calculate the atmospheric deposition estimates under different decarbonization scenarios. This included an overview of the GCAM, the variation used in these analyses, and the GLIMPSE. GLIMPSE is an EPA decision support system that allows for consideration of policy and non-policy levers.

Chris then described the application of these models to multiple scenarios: reference, state targets, and netzero EV (slide 8). Chris previewed the national CO2 and NOx projections from GCAM under the three scenarios, including the spatial distribution of NOx reductions (slides 9-12). Chris next walked through the connection from GCAM to the CMAQ model to understand implications for atmospheric deposition. This included a presentation of results and discussion of potential implications. Chris also discussed the results for emissions by state.

Chris concluded with ongoing work for this project, which includes new scenarios, such as Inflation Reduction Act (IRA), Net-Zero, and Alternative Net-Zero.

12:00 Discussion of Decarbonization Sensitivity Scenarios

Summary

Lew asked about slide 11, confirming if there is fleet turnover in the reference case (IRA included) and that these NOx reductions are estimated for 2032. Chris said this is correct except that these are older runs and they do not have the IRA runs yet. Chris said the basic point is that strong decreases in NOx are expected from reductions in transportation. Lew said that is an important point and these state targets are informative. These results can be run through our current model infrastructure now, just using the reference case and we will see a positive story. Chris said one needs to model the impacts of the reference case and the current status to tell the whole story of the relative contributions of each policy.

Lew asked for planning purposes, when can the CBP receive these inputs for total nitrogen, nitrate, ammonia, etc. for the reference, state target, and net-zero EV scenarios. Chris said the relative changes in total nitrogen deposition are available now, but the next simulations for 2035 will be completed by Jesse Bash in advance of the June Chesapeake Community Research Symposium. Lew said the CBP would probably benefit more from the most complete analysis, including the IRA and reference case. Lew believes the CBP can wait until that is complete later this year. Chris said it always takes a while to run these linked models due to the possibility for propagation error, so the sooner a heads up about a deadline the better. Lew said it is helpful to look out to 2050, 2075, and 2100, but yes 2035 is most relevant. Lew looks forward to hearing the presentation at Chesapeake Community Research Symposium in June.

12:10 LUNCH

12:40 Model Segment Viewer (MSV) Demonstration – Andy Fitch, USGS-CBPO

Andy described the extension of the MSV to the various Phase 6 and Phase 7 model grids of the Chesapeake watershed and tidal Bay. The MSV is a useful and easy to use web-based tool for model analysis and communication and is now widely available. One can access the MSV tool here.

Summary

Andy did a live demonstration of the Model Segmentation Viewer (MSV) and described the wide range of layers available. Andy noted that these datasets will eventually be available for download from this tool.

12:55 Discussion of MSV

Summary

Lew asked Andy to zoom in on the Baltimore Harbor, specifically the Francis Scott Key bridge, and turn on the layer for the Upper Bay grid. Lew said we may be asked to characterize the dispersal of material from the shipping channels resulting from the clean up efforts. When comparing between Phase 6 and Phase 7, it becomes apparent that the

new version of the grid has much higher resolution. Lew said this tool will likely be widely used and said this example is one demonstration of its utility.

Jian said this is a very smooth tool and asked if users can add their own data. Andy said if someone wants a layer added, they should send Andy an email (afitch@chesapeakebay.net) and he will add it to the tool.

1:05 Initial Progress With the Patapsco-Back Multiple Tributary Model (MTM) – Harry Wang, VIMS and Jeremy Testa, UMCES

The Patapsco-Back MTM Team, one of the three MTMs supported by a five-year grant, described progress on the MTM.

Summary

Harry described the high-resolution modeling grid in Patapsco/Back River, showcasing how the resolution varies based on areas of interest. Harry noted the location of the where the ship is entangled with the collapsed Francis Scott Key (FSK) Bridge in the harbor, highlighting the fine spatial resolution of the channel.

Harry then walked through the preliminary SCHISM hydrodynamic model calibration and validation results for parameters like water levels, velocities, temperatures, and salinities.

One application of this work is the Bear Creek proposed effluent outfall evaluation. Harry walked through some preliminary scenario results for spatial and temporal variability in this example.

Harry concluded with a summary of steps completed over the past quarter (slide 17).

1:25 Discussion of Patapsco-Back MTM

Summary

Lew said this is excellent work and is great to hear the models are seeking to be applied to help address the FSK bridge collapse. Lew noted that it could be informative to use these models to understand particulate dispersal from sediments in the Patapsco. Lew explained that the MBM will be the decision model for the TMDL, but the MTM will be used to answer unique and key local questions as demonstrated in this presentation. Dave asked what the timeline is for coordinating MBM nutrient calibration with the MTMs. Harry said the original plan is to get into the water quality model in June, which will be coordinated with the MBM, and is when Jeremy Testa will then lead the effort. If Harry is asked to support the Patapsco effort, that may take a few months to understand the sediment impacts. Lew said we may want to work on water quality at the same time as hydrodynamics, so that everything wraps up in December 2025 and is useful for TMDL work.

Larry Sanford asked about the boundary conditions for the FSK bridge simulations. Harry said they first needed to check if there was enough information available for forcing conditions locally or if they needed to use the MBM boundary condition and then expand to the Patapsco mouth.

Joseph Zhang said he is meeting with NOAA and Coast Guard managers to use real time simulations to help them plan for the FSK bridge clean-up effort. Joseph said he has incorporated and is testing the high-resolution grid Harry provided to see how much that informs these simulations. Lew asked if this work will include real time precipitation data or a long term average. Joseph replied we are using the following datasets: NOAA forcing functions, ocean models, atmospheric models, and USGS forcing. Joseph said the workflow has already been worked out. Lew said to let him know if the CBP can provide any help. Joseph said we can discuss ICM, tracers, and particle tracing with EPA to understand what their priorities are.

Larry said this is really great to hear, especially because this year has been so wet, that floatables from the wreck have washed up in other areas and there is a lot of local interest in this work.

1:35 Progress on the Rappahannock MTM – Qubin Qin, East Carolina University and Jian Shen, Zhengui Wang, Pierre St-Laurent, VIMS

Progress on the Rappahannock MTM was reviewed by the Rappahannock MTM Team.

Summary

Qubin provided a review of the goal and tasks of the Rappahannock MTM project, before describing the model grid and the 2011 scenario. Qubin walked through the initial ten-year hydrodynamic model run for the hydrology calibration period of 1991-2000. Qubin concluded with a discussion of model grid coverage for SAV and wetlands.

1:50 Discussion of Rappahannock MTM Progress

Summary

Lew said around the Tappahannock, there are fairly extensive protected wetlands. Lew said the generalized approach to be used in the MBM would be appropriate, but it ultimately comes down to VA DEQ making a decision. Qubin thanked Lew for the suggestion.

Dave asked if there is a better MTM to use for wetland estimation or if another team will look into wetlands in the Rappahannock. Lew said we will have multiple models at work in the Rappahannock: MTMs, the MBM, and others. Hopefully the MTM will show incremental or significant improvements over the MBM. The steps of priority are as follows:

1. Water quality
2. Compare with MBM
3. Support local decision making and interests

Richard commented he is seeming a similar phenomenon in the Chester river for salinity. Lew said this might be because salinity is variable depending on the season. Richard asked if we also need to do criteria assessment with the MTMs. Lew said his perspective is not yet, we should let the MBM do the heavy lifting and see how it performs relative to the MTMs for criteria assessment in the TMDL. Lew suggested the MTMs could be appended to the MBM.

Neil Ganju said that the Rappahannock is only behind the James and York when it comes to marsh area percentage.

2:00 Progress on the Choptank MTM – Jian Zhao, William Nardin, Elizabeth North, Larry Sanford, Jeremy Testa, UMCES and Jiabi Du, Texas A&M

Initial work on the Choptank MTM was described by the Choptank MTM team.

Summary

Jian Zhao began by explaining the Choptank model setup, such as the model grid and bathymetry. Jian also walked through considerations of how to couple with the MBM. Jian presented preliminary results for the hydrodynamic simulation, describing temperature and salinity validation.

Jian showcased differences between the Choptank MTM, the MBM, and Richard's initial simulation of the Choptank. Jian detailed a few discrepancies that should be resolved, like underestimated stratification and salt intrusion and surface elevation, and potential solutions for these challenges.

2:20 Discussion of Choptank MTM Progress

Summary

Dave asked if there is an established forum for one MTM team to talk to another. Lew said Joseph has organized the MTM teams and MBM team well and they meet on a monthly schedule to discuss these topics.

Lew said he is glad they are working with Richard because Richard led the path for the grid development. Lew added that there are many monitoring stations out there that can be useful. Lew said that we are governed by tight rules in this collaboration to ensure we can support decision makers, which are:

1. You may not alter any boundary conditions, whether they are from the Main Bay or the watershed. These inputs must be clean and correct.
2. In order to be considered for local TMDL work, it must be completed by December 2025 and then there is a year or review.

Richard said this is promising progress across the MTMs. Richard thanked Jian for including the earlier results so that the earlier versions of the model can capture saltwater intrusion. The only major difference between the previous grid and the new version is that Richard extended his to overlap wetlands and areas projected to be covered by sea level rise.

Lew commented there are some orthogonal channel grids, which seem key for getting the salinity correct. Jian added that they may need to increase the horizontal grid resolution for the channels. Lew said shipping channels are important and said it might be worth cross referencing the bathymetry with the NOAA shipping channels maps to help with salinity estimations.

Dave said where Nicole and Richard create the boundary condition, it looks like an arc, but with Qubin it looks more like a rectangular pier out into the Bay. Jian said Jiabi did

the boundary condition for the Choptank by interpolating to the MBM grid. Larry said the sill with no boundary for the Rappahannock is very much real in the bathymetry. We did a study many years ago that showed upwelling and additional energy was very important for getting saltwater above the sill. Larry said he suspects Jian is right that up the river geomorphology is constricting saltwater intrusion. Lew added that the Rappahannock sill goes out into the Bay, while the Choptank is flatter and more of a broad arc, so it depends on each tributary and a lot of discussion has gone into making these decisions. Richard said up to know, he does not know if anyone has done a sensitivity test to understand if this makes a meaningful difference. Harry Wang said if you are interested in the saltwater intrusion result, you may want to include the entire Bay channel across the eastern shore, as this was demonstrated in Larry's work. What will happen is that the water level is tilting towards the west, so the pycnocline will upwell, which will be very powerful for moving the saltwater into the Choptank. Harry suggested doing a sensitivity test with the high resolution grid, but is not sure if it is worth the effort as it would likely require a fair amount of time. Jian Shen asked if there is a velocity boundary. Jian Zhao said yes. Lew asked if there would be any stability challenges with a boundary condition if the MBM is well calibrated. Joseph said related to the comments by Dave, Larry, and Harry, in SCHISM one can draw a boundary anywhere because the model is stable, but that does not mean it will produce a sensible physical result. Joseph highly recommended that Jian Zhao think about potentially pushing out the boundary condition to the western shore. From the surface salinity simulation, it does not appear to be unstable. Joseph said if you impose everything, including velocity, you should be able to improve get consistent results. Once it is refined, we are dependent on you for informing us as we expect the results to be improved. Jian Zhao said the boundary condition was discussed with Jiabi Du. Joseph said Harry and Larry's suggestions seem sensible and he would be happy to advise Jian Zhao on the sensitivity calibration. Jian Shen said if you include the MBM with no change and move the boundary up to CB3.3 and down to CB4.3, that would be easier to control. Lew said he is a little concerned about the upper Bay boundary condition as it may have overlapping edges. Lew suggested ensuring consistency with the Patapsco MTM. Joseph said it might be simpler to have one open boundary at the mouth of the Bay. Jian Zhao said this is an initial discussion and we can return to this later at the MBM monthly meeting.

Larry said he was under the impression that the MBM will be used for the TMDL evaluation in all tributaries. Lew said that is correct and but it is possible that we could append the MTMs to the MBM in a final run or assessment. This is related to Richard's earlier question, which must first be proceeded by an understanding of the quality of MTM results. Larry said Joseph's approach may be valuable as well because it could show which features are meaningful for assessments in the MBM, leading to small tweaks.

Jian Shen said unless you are looking for a local TMDL, the MBM might be able to comprise special features from the MTM. Zhengui did a sensitivity study that showed the deep channel is receiving most of the saltwater. In that case, we set the model for one way exchange of the boundary condition. You can come up with different values for the MTMs because it allows for two-way exchange. For the James River, the Bay model also covers it. For the TMDL, there may be some challenges with discrepancies here.

2:30 **Progress in Estimating Nutrient Applications and Projecting Future Demand – Joseph Delesantro, ORISE-CBPO**

Advances in estimating nutrient applications and estimating future nutrient demand was reviewed.

Summary

Joseph showed plots that illustrate how cropland area is changing along with crop yields. Joseph explained the importance of crop yields and how they are tied to nutrient application. Joseph then outlined the planned path for investigating these trends and data (slide 6), which included steps for crop and weather data collection to create an annual estimation of yields. Joseph discussed statistical modeling methods for estimating annual yields and trend analyses, before describing the relative effect of various climate parameters on crop yields. Joseph concluded with next steps for this analysis (slide 14).

If you would like to learn more about this work in detail, you are welcome to join Agricultural Modeling Team (AMT).

2:45 **Discussion of Crop Yield Calculations for Estimating Nutrient Application and Projecting Future Demand**

Summary

Lew said we will move forward with whatever the AMT recommends. Lew suggested reminding the AMT that the modeling team will do climate change scenarios for 2035, 2055, and beyond as they will be part of their decision tradeoffs.

Dave said he believed yields would increase with climate change because of longer growing seasons, but asked if Joseph is saying we will have flat or negative yield in the long term. Joseph said he does not feel speculating on that at this point would be appropriate. Dave asked if some crops will likely perform better under climate change? Joseph said yes, but generally most major crops will likely see more negative effects. For example, corn, wheat, and barely will not do so well, but cotton and sorghum might improve. Joseph added that many of the other stressors are heat stressors and drought, which create a net negative effect on climate change. This is demonstrated in the literature. Dave said if the weather every year is driving nutrient application, it might be a while before the procedures farmers follow change in response to falling yields. Gary said the net effect of growing exactly the same crops everywhere is likely zero, but we are likely to see changes in what is planted where.

Lew asked if the table on slide 12 is from the literature or a synthesis paper. Joseph said this set of weather and climate parameters is a modification of what he has been doing to estimate the annual yields, which are taken from the literature and then included in the AMT models to inform yield estimates. Lew asked if the CO2 fertilization effect is represented in this table. Joseph said no, but this is something we may want to look at while analyzing this data, in addition to other datasets, and will likely be not as spatially distributed relative to other datasets. Lew said it would be interesting to hear what the AMT thinks on this topic.

2:55 Progress of the Agricultural Modeling Team – Tom Butler, EPA-CBPO

Tom described progress of the Ag Modeling Team 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 focus, its recent activities in crop yields, land uses, and manure acres. Tom said a lot of discussion has been focused on how manure relates to land use. Some discussion topics include:

- Is it realistic to split certain classes into acres with manure and acres without manure?
- If so, how can we improve the relationship that defines the acres of each category?

3:05 Discussion of Agricultural Modeling Team Progress

Summary

There were no questions or comments.

3:30 ADJOURN

Participants: Alex Gunnerson, Andy Fitch, Arianna Johns, Ashley Hullinger, Bill Keeling, Breck Sullivan, Carl Friedrichs, Carlington Wallace, Cassandra Davis, Cathy Wazniak, Carl Cerco, Chris Nolte, Clifton Bell, Clint Gill, Dave Montali, Gary Shenk, George Onyullo, Gopal Bhatt, Guido Yactayo, Harry Wang, Isabella Bertani, Jian Shen, Jian Zhao, Jesse Bash, John Clune, Jonathan Leiman, Joseph Delesantro, Karl Blankenship, Larry Sanford, Lew Linker, Marjy Friedrichs, Mark Bennett, Mukhtar Ibrahim, Neil Ganju, Nicole Cai, Normand Goulet, Pierre St-Laurent, Qubin Qin, Raleigh Hood, Rebecca Murphy, Richard Tian, Robert Burgholzer, Sam Merrill, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Steven Bieber, Thomas Cronin, Tish Robertson, Tom Butler, Tyler Trostle, Uma Shankar, Zhaoying Wei, Zhengui Wang