Modeling Workgroup (MWG) Quarterly Review

April 4, 2023

Event webpage: Link

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

ACTIONS & DECISIONS

- **Dave Montali will reach out to Jeremy Hanson to let the Water Quality Goal Implementation Team (WQGIT) know there is interest in the reconstitution of the Wastewater Treatment Workgroup (WWTWG) to consider the following topics:**
  - **Sanitary Sewer Overflows (SSOs)**
  - **Combined Sewer Overflows (CSOs)**
  - **Exfiltration**
  - **Boat discharges**
- **Alex Gunnerson will schedule the following topics for follow up conversation at the weekly modeling *ad hoc* meetings.**
  - **Grid boundary conditions, such as the Choptank and Patapsco.**
  - **Purpose of the Multiple Tributary Models (MTMs).**
  - **Submerged Aquatic Vegetation (SAV) model next steps and continued conversation.**
  - **Reproducing lag times identified by the Comprehensive Evaluation of System Response (CESR) team.**
- **Dave Montali will meet with Gregorio Toscano to ask questions about the optimization work and progress.**
- **The Modeling Team will undertake the charge the CESR team has laid out regarding the need to successfully reproduce lag times using the Phase 7 suite of models. Updates will be provided at future Modeling Workgroup (MWG) quarterlies.**
- **Gopal Bhatt will follow up with Bryant Thomas about his question on re-segmentation, which was not answered in the meeting due to time constraints.**
  - **The question: "Regarding re-segmentation, Bryant asked if the watershed boundaries are delineated by the computer using elevation, NHD layers, and any supplementary layers. Bryant asked what the quality assurance process is for checking/confirming the delineated boundaries, assuming one cannot check every NHD level watershed."**
- **Marc Hensel will respond to Nicole Cai's email and her questions about the SAV work.**

Meeting Minutes

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

Summary

Lew announced the Watershed Modeler RFA is now open. The following competitive grant funding opportunity has been published on Grants.gov titled as EPA-R3-CBP-23-07: https://www.grants.gov/web/grants/view-opportunity.html?oppId=347277. The closing date is May 18th.

Lew reminded attendees the Chesapeake Bay Program (CBP) Modeling Team has a session at the Coastal and Estuarine Research Federation (CERF) conference in November. The deadline to submit an abstract is May 10.

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

Gary provided a general overall summary of progress.

Summary

Gary began with the same set of overview slides that he presented on in January, which included the review of relationships between the Chesapeake Assessment Scenario Tool (CAST), CalCAST, and the Dynamic Watershed Model (DWM); the timeline for model development; and the development goals for each year. Gary provided some comments on new or revised direct load sources in the model, such as boat discharges, tidal shoreline erosion, potentially boat wakes, tidal flooding, Combined Sewer Overflows (CSOs), and grey infrastructure.

10:30 Discussion of the Phase 7 Model Overview

Summary

Norm said the Watershed Technical Workgroup (WTWG) is not on the list on slide 11, and the boat discharges question needs to go to the WTWG first before going to the WQGIT. Lew commented he believes the WQGIT was not interested in considering boat discharges in the Phase 6 model but bringing it into Phase 7 makes sense since it will receive credit in Anne Arundel County and in other tidal embayments. Lew said we will be sure to honor our commitments and talk to all appropriate workgroups in turn.

Olivia Devereux asked how CSOs are being defined, specifically if that is Combined Sewer Systems (CSS), CSO+SSO, or something else. Olivia said as long as you are talking about direct loads, drinking water plants should be included. Gary said thanks for the reminder on drinking water. I had it in the documentation but neglected to put it in the presentation.

Dave said he reached out to the former chair of the Wastewater Treatment Workgroup (WWTWG) and learned they are inactive. He suggested they find a new chair and become more active to help address this question, which he believes is understood by the WQGIT. Bryant asked if the question for discussion is how SSOs should be represented in the model and if they should be associated with CSOs. Bryant said in Virginia, they do not have widespread CSO communities and SSOs tend to be episodic and short lived. Bryant understands looking to understand SSOs for loading and calibration purposes but is not sure where they fit into the Total

Maximum Daily Load (TMDL) scenarios. Lew replied that makes sense since SSOs are episodic and usually rectified fairly quickly. As discussed at the January Quarterly, SSOs are not part of the TMDL as this was a policy decision of the CBP, but CSOs are included. Lew said he can see looking for SSO upsets based on the monitoring data, but that remains firmly in the realm of policy decision makers.

Dave said he believes the question relevant to the SSO discussion is: "Should we try to represent SSOs for calibration?" Dave said we decided the discussion needs to start with the WWTWG, looking at notable repetitions in SSOs in select locations. This would be a tricky question since SSOs are illegal in the first place and there would be information acquisition difficulties. So, we concluded the WWTWG needs to figure this out since it is a policy decision. Norm said unfortunately the WWTWG is inactive, so we may need to consider which group can address this topic. Norm said we should be differentiating between a load source and not so much the crediting aspect. Norm said they are episodic, but SSOs are not an inconsequential load so the policy may need to be revisited. Gary said one approach might be if an SSO was not part of waste load allocation or load allocation, it can still be a part of the model calibration with no loads are permitted. Lew said this is an interesting thought to put it in the calibration but not in the allocation. Bryant said Virginia has done something similar with local TMDLs. Norm added there is also USGS info on septic systems that show higher loads. Bryant Thomas said he thinks there will be a lack of detail on SSOs rendering more uncertainty than usefulness, but he decided to direct his comments to the WWTWG.

Bryant Thomas asked for more information about certainty/uncertainty analysis to be conducted for the updated models. Gary replied uncertainty estimates of the parameters and predictions are inherently part of CalCAST. When we talk about this model as being as good or better than the Phase 6 suite of models, that is a different question than the confidence intervals that come out of CalCAST. This is a nuanced conversation when considering anthropogenic loads. It is very difficult to do, but the Modeling WG is much better equipped to do this now through modeling and monitoring. Bryant replied it is good to hear plans are in place to address this as best as possible as the confidence in estimates will be helpful. Building up from model calibrations and points where the MWG can evaluate model predictions spatially will help us direct future efforts to in characterizing model performance. This can direct future monitoring efforts to improve model performance. Gary replied having the estimates will help us focus during model development, but whether the estimates are used for management is now for the MWG to decide.

In response to the grey infrastructure slide (slide 15), Lew asked how would we know the grey infrastructure loads given many of cities are in the tidal portions of the watershed. Lew said the questions of interest might be: does this load exist, is it meaningful enough to include it, how will we quantify the loads? Lew expressed his interest in this conversation. Gary said right now the team is asking questions and exploring these topics.

Dave asked what the timeline is for investigating these new or revised loads for the topics Gary raised today. Gary said an answer will be needed by the end of 2025 at the latest, but the partnership will need time to discuss this. Dave asked about a timeline for implementing relevant to the Modeling WG. A detailed timeline is not yes established, but Gary was hoping to get some answers from the partnership by the end of 2023. These topics are being raised now there is appropriate time for discussion. Bryant asked if this timeline includes the grey infrastructure sanitary, exfiltration, and collection questions. Gary said ideally yes, but it depends on

information availability. Bryant asked if the WWTWG would address these questions. Gary said he believes yes, in addition to the involvement of the Urban Stormwater WG and the WQGIT. Bryant said the recent Scientific and Technical Advisory Committee (STAC) workshop was informative and led him to believe the type of systems (agent, gravity, pressure, etc.) will be a critical factor. Another important consideration is collection systems since they fall under National Pollutant Discharge Elimination System (NPDES) even though they are not a traditional point source. Gary said especially since the STAC workshop will produce recommendations along these lines, it needs to be considered. These topics may not be included in the model, but there will at least need to be a note about it. Dave asked when the workshop report will be available. Gary said the report is in progress and will be done by the end of the year. KC Filippino said she and Karl Berger are currently working on it.

Dave asked if he should formally tee up this conversation, explaining the need to rejuvenate the WWTWG to the WQGIT. Lew and Gary agreed it would be a good idea to bring it up to Jeremy Hanson.

Lew said the MWG is dependent on the partnership to address key factors, such as crop uptake and the implication of longer growing seasons, in the context of the climate change assessment. Tom Butler said the Agricultural Modeling Team (AMT) will be involved in this and will take this up in time.

Dave asked what part of the partnership will address the tidal flooding/measure the muck. Gary said since it is a load source the WQGIT will need to weigh in, but the MWG will need to decide if there is enough information to include it in the model besides just a note about it. Dave concluded the MWG will need to look into it further before asking the WQGIT to contribute. Dave asked where the muck load comes from. Gary said during tidal flooding (king tide or storm surge), the floodwaters pick up a significant amount of nitrogen, specifically nitrate and ammonia from the land. The program measures the concentrations in the river and the water on the landscape with conservative assumptions, which yielded results meeting as much as the load allocation.

10:45 CalCAST Updates – Isabella Bertani, UMCES

Isabella illustrated results of testing how different meteorological datasets and different potential evapotranspiration (PET) formulations impact CalCAST model performance. Isabella provided an update on an effort to downscale water withdrawals to the National Hydrography Dataset (NHD) catchment scale. CalCAST is a relatively parsimonious Bayesian modeling tool that is being developed to test predictors and spatially calibrate parameters that will ultimately inform prediction of flow and loads at monitoring stations throughout the watershed.

Summary

Isabella began with the same slides introducing CalCAST from the previous quarterly review. The bulk of Isabella's presentation focused on testing different meteorological datasets in CalCAST, testing different PET formulations in CalCAST, and downscaling MD water withdrawals to NHD catchments. The results presented are preliminary and no formal conclusions are being drawn at this time.

Isabella walked through the different datasets and formulations, comparing the Phase 6 data and formulations (Hamon method) with alternative datasets and formulations. Isabella highlighted preliminary results, by looking at residuals and spatial distribution. No decisions are being made based on these results, they are for explorational purpose at this point.

Isabella provided an update on the methods used to downscale water withdrawals in Maryland.

Isabella concluded with some next steps, which include:

- Continue exploring PET formulations (including considerations for climate change applications).
- Use CalCAST to test predictors that can help explain spatial variability in flow and load observations and develop parameters for CAST/DM.
- Continue updating/improving P6 datasets (e.g., CSO, withdrawals, point sources).

11:05 Discussion of CalCAST development

Summary

Dave asked about the Maryland withdrawals and if Maryland Department of the Environment can help out. Isabella said the information was lost and MDE cannot dedicate the resources to help with this effort.

Lew asked about slide 9 and the comparisons between Parameter-elevation Regressions on Independent Slopes Model (PRISM) and North American Land Data Assimilation System (NLDAS), specifically any downsides of using PRISM instead of NLDAS at the NHD scale. Isabella said she has not thought about this extensively, but we need to consider this question in terms of the Dynamic Watershed Model (DWM). Isabella said she can devise ways to retain NLDAS in the DWM if we think it fits best at the daily scale but have PRISM match CalCAST at an annual scale. One of the downsides of using PRISM across the board is it is very computationally intensive in the DWM, but to get around the issue we can use PRISM for CalCAST and downscale NLDAS. Gopal said there are no real downsides to what Isabella proposed. From the start it was clear that running the DWM at a natively NHD scale with the time series information would be very computationally intensive and would likely exceed the 24-hour threshold with little added benefit. Gary agreed. Gopal asked a clarifying question: so, Lew is suggesting a hybrid approach – PRISM for CalCAST and NLDAS for DWM, which Gopal said NLDAS need to remain in use for DWM. Isabella added PRISM is available at a daily scale and NLDAS is available at an hourly time scale. Lew asked how the hybrid approach would get transferred. Gary said CalCAST is giving overall water balance information that will be temporally disaggregated by the DWM using NLDAS as a time series, but it needs the PRISM informed predictions of CalCAST at a land segment scale. NHD catchments would be too computationally intensive.

Lew asked if there are any objections to using PRISM for CalCAST, given the hybrid approach described above. There were no objections. The MWG agreed CalCAST will use the daily PRISM data.

Samuel Canfield asked Isabella if she has tried experimenting with PET formulations for NLDAS as much as PRISM. Isabella said most of the experimentation has been done for PRISM because the largest improvement in model performance has been detected for PRISM, although

she will continue with PET experimentation with NLDAS. Samuel said the McGuinness-Bordne formulation may or may not be an improvement. Isabella said it is worth trying.

Lew asked about evapotranspiration regarding climate change on slide 17. Lew commented the ridgeline is very clear and under Hamon it is a lot cooler compared to Penman-Monteith. Penman looks to be a lot more accurate when considering factors like wind, which are unaccounted for in Hamon. Lew said we need to transition away from Hamon. Isabella said she has been reviewing these different methodologies and said there are many options, which are optimized for different reasons. Lew said STAC indicated Penman-Monteith is closest to first principles and is the preferred option.

Lew said this is an important topic to consider in the context of climate change.

11:20 Development of Efficient Multi-Objective Optimization Procedures – Development of Efficient Multi-Objective Optimization Procedures – Gregorio Toscano, Kalyan Deb, Pouyan Nejadhashemi, and Hoda Razavi, MSU

Progress in developing efficient multi-objective (MO) optimization procedures, including generative MO optimization using the current hybrid optimization procedure and population-based evolutionary algorithms was presented.

Summary

Gregorio began with an update on the current status of the project and its timeline. This was followed by an overview of algorithm development and the progress in Phases 1 and 2 of the project. Gregorio then identified projected project development for Phase 2 and the expected benefits of optimization from Phase 3. Gregorio explained the potential implications and benefits of the innovization approach and experiment.

Gregorio presented the methodologies for Best Management Practice (BMP) selection ranking based on land use. Three strategies were used for re-optimization:

1. Strategy 1: Rank the top BMPs based on the implementation acreages.
2. Strategy 2: Rank the top BMPs based on the percentage of maximum allowable acreage.
3. Strategy 3: Rank the top BMPs based on the amount of nitrogen reduction per dollar spent.

Gregorio showed how these methods apply to Berkeley County, WV and then identified four conditions for re-optimization. Comparing methods across counties, Gregorio identified the performance measures which are a ratio of the hypervolume and said the best results came from re-optimization-based innovization.

Gregorio concluded with the following points:

- The team has developed multi-objective methods that accept users' preferences and find several solutions in a single run.
- Such a tool will help reduce the time to evaluate and analyze optimization algorithms.
- Innovization can support a more efficient search.
- The results are promising.

Next steps for the optimization team include:

- Replicating the study with the rest of the BMPs.
- Incorporating results in the design of future approaches.

11:45 Optimization Discussion

Summary

Lew asked if the team would produce an hour-long webinar to explain the status of project progress and future work. It would be distributed to the CBP community more broadly and key audiences would include the WQGIT and STAC. Kalyan said this is a good idea and the optimization team was planning on doing something similar to this. Kalyan added a lot can be learned from the innovization approaches, including what to do, with exceptions for certain counties. Kalyan said the search can be more effective and extended to the watershed level, which is the plan for next steps. Kalyan said all these topics can be discussed in the webinar and welcomes guidance on what to include. Lew said it would be good to have a date for the webinar established by the STAC July Quarterly so it can be publicized there. Lew said STAC will want to delve into the data technically, but for the webinar the focus should be less technical and more focused on the benefits of optimization for end users.

Lew commented the figure on slide 17 is excellent. Kalyan said innovization represents innovation through optimization.

Gary asked about the hypervolume figure on slide 30 and what it represents. Kalyan said it represents the tradeoffs between F1 and F2. The goal is to get the value as close to one as possible without running too many variables. Gary asked why all the values are not being calculated as one. Kalyan replied when you see .80, it means 80% of the original is being represented. Gregorio said if you had endless time, all values would be one, but because of computational constraints, the team creates a false pareto front which is just for comparison purposes of all the approaches together. Sometimes a small number of variables is effective.

Dave said he would like to have a multi-hour call with Gregorio in the future to ask him questions and better understand this work. By having this conversation, Dave said he can help facilitate the optimization advisory team.

Pouyan said that using a series of pareto fronts with different optimal locations based on cost and target parameters, one can create a single pareto front of optimal points.

Robert Sabo said some drivers of nitrogen and phosphorus loads are independent of BMPs, like fertilizer applications. Robert asked if these optimization scenarios can consider alternatives to BMPs/explore hypothetical scenarios. Three examples to consider are:

1. A poultry plant closes north of Richmond.
2. Less development than expected occurs in Fredericksburg.
3. Gas prices go down and fertilizer application increases.

Robert asked if the larger scale drivers of water quality can be considered at a county scale with different hypotheticals. Pouyan replied optimization is bound to Chesapeake Assessment Scenario Tool (CAST), so those limitations constrain the hypotheticals we can consider. Robert said he supposes you can modify your inputs, then you can re-run optimization under those different scenarios.

Dave asked if in creating these conditions, rather than cost per pound of nitrogen which was one of the early constraints, total nutrients could be measured. Kalyan said the top few BMPs were selected based a few major pieces of criteria, such as cost per pound nitrogen reduction. Once these BMPs are selected, the optimization can be run with just those select few BMPs. Pouyan replied the final optimization (innovization) is enabled through machine learning. Kalyan said as a user, you can test different hypotheses with the machine innovization derived BMPs. This might take 10-20 minutes to run, but it is comparable. Dave replied there are probably ways to manipulate the optimization by restricting available BMPs without requiring a different baseline. Robert said he is glad to hear for planning purposes, including climate change, there is flexibility for different baseline scenarios. Pouyan said there is flexibility for changing the baseline scenarios in CAST as well.

12:30 LUNCH

1:15 The *COMPREHENSIVE EVALUATION OF SYSTEM RESPONSE (CESR)* of the Chesapeake Report and Its Recommendations for CBP Modeling – Denice Wardrop, CRC, and Kurt Stephenson, Virginia Tech

The upcoming release of the CESR Report was described. Its objectives are to 1) identify gaps and uncertainties in system responses that impact efforts designed to attain water quality standards; 2) identify recent scientific developments that can shed light on the gaps and uncertainties in system responses; 3) recommend research strategies that improve understanding of system responses; and 4) recommend strategies for integrating scientific and technical analysis with active adaptive management in order to aid decision-making under uncertainty.

Summary

Denice began with a review of the CESR Report, explaining that the CESR report is focused on why the CBP is not seeing the changes it expected from load reductions. This presentation on the CESR report focused on load reductions, water conditions, and living resources.

For load reductions, the major finding was existing nonpoint source water quality programs are insufficient to achieve the nonpoint source reductions required by the TMDL. The implications of this finding are new nonpoint source programs and approaches are needed to improve Nonpoint source (NPS) program effectiveness. Additional funding alone will likely be insufficient.

For water conditions, the major finding was nutrient load reductions have not produced the expected level of improvement in water quality, and a response gap may be particularly pronounced in the Bay's deep channel. The modest reductions in nutrient loads achieved Bay wide, which are substantial in some locales, have initiated a recovery. Water quality response to nutrient reductions is less than expected. In the deeper waters of the Bay, progress towards attainment has been slow. There are tipping points in the Bay ecosystem that can slow recovery in early stages but potentially accelerate recovery down the road. Some Bay conditions are changing, permanently altered, and irreversible. The implications of this finding are additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in

some regions of the bay under existing technologies. This reality may necessitate assessing the costs and tradeoffs of attaining numerical water quality criteria in specific situations and locations and adapting numeric goals if desired.

For living resources, the major finding was it might not be possible to meet all TMDL and WQ goals, but this may not be necessary to meet and support living resource goals. Water quality improvements in shallow water may have more of a benefit to living resources than elsewhere. Water quality alone does not guarantee improvements in Living Resources - there are other factors. The implications of this finding are the legal requirements of the Clean Water Act (the water quality goal) divert attention away from considering multiple means of improving living resources (support of aquatic life as the designated use) as articulated in the Chesapeake Bay Watershed Agreement. Opportunities exist to adjust water quality goals to prioritize management actions that improve living resource response.

1:50 Discussion of *COMPREHENSIVE EVALUATION OF SYSTEM RESPONSE (CESR)* and Its Recommendations for CBP Modeling

Summary

Dave asked if there are any synthesis or recommendations from CESR about what the MWG should be doing differently. Denice said two points for consideration come to mind. One is the attention to shallow waters, which she recognizes the MWG is moving in that direction but is incredibly important for modeling and monitoring of tipping points and linkages between habitats, like the flow of benefits from shallow waters down to deep waters. The second point is the intense focus for modeling of water quality has sucked oxygen out of modeling for living resources, so the CESR report highlights possibilities for moving forward. Kurt said in the watershed, there is a need to encourage partners to have a finer scale notion of where to make investments with their limited resources. Kurt added increased modeling capacity to deal with uncertainties and identifying where uncertainties are present would be helpful. Dave said he does not disagree with any part of those two points but is unsure if this fits the role of the MWG. Dave said he thought he heard we should be spending fewer resources on water quality modeling and more resources on living resources. Denice emphasized those are not the only points of consideration for the MWG and added CESR used the best information they had to answer the question “What did we expect would happen, what happened, and was there a response gap?” The determination of whether there was a significant response gap or not, and whether the response gap differed between habitats is an important question. These questions were answered with the available data and are heavily caveated. Denice said an ask of the MWG could be that the MWG recreate the response gaps identified in CESR. Lew said he thinks CESR is great and that is a good suggestion.

Lew emphasized there are real response gaps with the Watershed Implementation Plans (WIPs), especially with Conowingo and Climate Change. The question “How do we define success in the deep channel?” includes a 1% uncertainty gap, does not count all non-attainment (10% time and space forgiveness), and considers variances for the assessment. Lew said how we define things is contributing in part to the response gap. Lew said we are simply not going to achieve attainment all the time in the deep channel given the ambitiousness of water quality standards. Whether it is the Clean Water Act (CWA) or TMDL, we must always pursue the water quality standards.

Carl Cerco said this presentation gives him great pause. When the model is run in various load reduction scenarios, the model is given 10 years before it is assessed, since that is the approximate time needed for sediment to begin reaching a steady state. Since restoration has been occurring since the 1980s, one would expect to see some response. Carl thinks there is a lot of investigation to be done and the modeling team needs to respond to this.

Gary agreed the MWG should try to replicate the blue dots on slide 19, but said his main concern is that in the modeled results (orange dots) it represents changes in concentration with essentially the same flow all the time and the biggest variance within the blue dots is the difference between wet and dry years. Essentially the orange dots represent a change in concentration and the blue dots represent a change in flow. Gary said in his presentation on the next day about the TMDL indicator, it asks similar questions and shows there is a lag in Phosphorus in the model but not so much in Nitrogen. Gary said one way to evaluate the Phase 7 suite of models is if the model can recreate those blue dots on slide 19. Lew said this is a good idea and suggested, with caveats, undertaking this charge.

Kurt asked what Gary's four caveats are. Gary said the biggest one is the flow issue, but he can follow up and discuss with Carl later.

Larry Sanford said obviously the CBP cannot change direction now, but one idea is the Phase suite of 7 models can be capable of addressing shallow waters and habitat for living resources. Dave said he thinks those plans are already in place with the multiple tributary models. Larry said that is true, but there is more to add like considering the dynamic conditions of shallow water sediments and feedbacks between water quality and flow. Larry emphasized this point for post 2025 work. Lew said the Phase 7 suite of models should allow for looking at the attainment of every segment because of the improvements in spatial scale. Dave said he believes the intention to improve shallow water modeling is there and the current process in place will support these efforts. Denice said shallow waters should also be a testbed for understanding many different uncertainties, including how the system responds to increases in temperature under climate change, tipping points and non-linear interactions, and how habitat links to living resources. Denice said the improved ability for modeling and monitoring the shallows is critical for determining how the system responds.

Jim Uphoff said from a living resource perspective, he emphasized making this connection between living resources and water quality habitat can be very difficult. One example is from Mattawoman Creek where SAV rebounded and water quality improved, but then the fish monitoring program indicated fish populations there were nearly wiped out (ammonia poisoning was suspected but not proven). Agricultural watersheds tend to be idiosyncratic and mesohaline waters seem to be better. In an urban watershed, when there is hypoxia you lose habitat at the bottom of the water column, but in agricultural watersheds that is not necessarily the case. As a fisheries manager, Jim is less concerned about the dead zone and is more concerned about where spawning is happening, responses from zooplankton, and how the forage species are responding. Isabella said she is glad Jim mentioned zooplankton.

Lew said a charge has been laid the feet of the MWG to estimate the loads and lag times. The team will meet and respond at future MWG quarterlies.

2:20 Progress in Phase 7 WSM Development – Gopal Bhatt, Penn State

Gopal surveyed progress and described activities upcoming in the next Quarter.

Summary

Gopal began with a review of previous slides that provide context on the dynamic watershed model (DWM). Gopal provided an update on the timeline of development and the structure of the DWM. Gopal then outlined five next steps for the Phase 7 DWM updates and explained how each of those steps would be addressed:

1. Model re-segmentation
    a. Mainstem vs. NHD streams - an issue concerned with the aggregation effect.
    b. Sub-watershed boundary of river segments vs. NHD catchments - an issue concerned with boundary delineation.
2. Model runtime
3. Monitoring data (dynamically extend and expand)
4. Simple routing method for small streams
5. Flow and water quality calibration

2:50 Discussion of Phase 7 WSM Development Progress

Summary

Bryant Thomas asked for clarification on the NHD-scale and what level hydrologic unit code (HUC) does the NHD scale entail. Gary said he is not sure about the HUC level, but the NHD scale is about one square mile.

Bryant Thomas asked how the hydrology calibration is performed at the NHD level of detail. Bryant asked are there many streamflow gauges on the 1st/2nd order streams across various land uses for calibration purposes. Gopal said all of the gauge stations are being used and there are a number of stations monitoring the first and second order streams, but there are not as many as would be ideal. The monitoring stations are being used for both CalCAST and the DWM. The calibration is informed by *a priori* information, such as empirically based relationships with land uses, but they are being improved by CalCAST outputs which is looking at the variability of land use yields. Bryant said he thought there would be more gauges than 253 stations across the watershed that at least give the hydrology. Gopal said while that number is higher for hydrology (approximately 500 stations), there are quality constraints (length of time series, correct methods) so this lowers the number of usable stations for loads (approximately 120 stations).

Regarding re-segmentation, Bryant asked if the watershed boundaries are delineated by the computer using elevation, NHD layers, and any supplementary layers. Bryant asked what the quality assurance process is for checking/confirming the delineated boundaries, assuming one cannot check every NHD level watershed. Bryant and Gopal agreed to discuss this question offline given the time constraints.

KC Filippino asked if there is a plan to incorporate the new hyper-res hydrography data being developed by the Chesapeake Conservancy. Gary replied the watershed modeling team is not sure exactly what to do with the hyper-res data since this type of data has not existed before, so the team does not know exactly what it means. Gary said the team has a few strategies that they will try.

3:00 Progress of the Agricultural Modeling Team (AMT) – Tom Butler, EPA-CBPO

Tom described the progress of the AMT in its role in determining the agricultural data inputs for the Phase 7 Watershed Model. He provided background for how this group will function in collaboration with the MWG.

Summary

Tom emphasized that the AMT is hyper-focused on the inputs into the model. The AMT has been meeting and is currently working on decisional items. Tom outlined next steps for the AMT on slide 11.

3:10 Discussion of Agricultural Modeling Team

Summary

Robert Sabo seconded the importance of the crop uptake removal agenda item. When looking at the Bay model documentation, there are many uptake estimates and many core crops have parallel removal values, but Robert suggested removing the two-thirds rule of crop uptake for the Chesapeake Bay nutrient inventory. Removing this rule can give the MWG more certainty in mass balances when communicating with stakeholders.

Robert suggested better constraining the pasture removal values. Robert is working with researchers at University of Maryland Center for Environmental Sciences (UMCES) to improve the methodology for a more constrained estimate of how much nitrogen and phosphorus is being removed from pastures. So instead of the 907 lbs. per acre of pastureland removal as the nutrient uptake coefficient, the estimate is dependent on cattle population in a county. Tom said the AMT welcomes Robert's feedback on these items and hopes Robert can attend as needed. Robert said the estimate is achievable and would be a valuable contribution because it is not currently being incorporated into the mass balance equation due to uncertainty associated with the values.

3:10 ADJOURN

Participants: Alex Gunnerson, Anna Kasko, Arianna Johns, Bill Keeling, Bryant Thomas, Carl Cerco, Carl Friedrichs, Carlington Wallace, Cassandra Davis, Cathy Wazniak, Dave Montali, Denice Wardrop, Doug Austin, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano-Pulido, Hoda Razavi, Isabella Bertani, Jamileh Soueidan, Jeff Sweeney, Jesse Bash, Jian Shen, Jim Uphoff, John Clune, Jonathan Leiman, Joseph Zhang, Kalyanmoy Deb, Karl Berger, Katie Walker, KC Filippino, Kevin McLean, Kimberly Dagen, Kurt Stephenson, Larry Sanford, Lee McDonnell, Lew Linker, Lisa Beatty, Mark Bennett, Mark Hoffman, Mukhtar Ibrahim, Nicole Cai, Norm Goulet, Olivia Devereux, Pouyan Nejadhashemi, Rebecca Murphy, Richard Tian, Robert Sabo, Sam Merrill, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Tish Robertson, Tom Butler, Tom Ihde, William Moore, Zhenghua Jin.

Modeling Workgroup Quarterly Review

April 5, 2023

Event webpage: Link

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

==========

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

Summary

Lew announced the Watershed Modeler RFA is now open. The following competitive grant funding opportunity has been published on Grants.gov titled as EPA-R3-CBP-23-07: https://www.grants.gov/web/grants/view-opportunity.html?oppId=347277. The closing date is May 18th.

Lew reminded attendees the CBP Modeling Team has a session at the Coastal and Estuarine Research Federation (CERF) conference in November. The deadline to submit an abstract is May 10.

9:10 Forecasting the Relative Roles of Climate Change and Habitat Management on Chesapeake SAV – Marc Hensel and Christopher Patrick, VIMS

To predict how climate change and human activities will affect future SAV habitat, 40 years of aerial survey, ground observation and water quality data are used in a structural equation modelling approach to describe how different seasonal variables have controlled annual cover in each SAV community across the Bay to date. Then the projected effects of climate change (i.e., temperature rise, precipitation, and nutrient and sediment loads) and human activities (i.e., nutrient input management) are used to estimate climate change influence on Chesapeake's SAV communities.

Summary

Marc began with the major question this work seeks to address: "How will climate change and human activities affect the major communities of seagrass and submerged aquatic vegetation (SAV) in the Chesapeake Bay?" To address the overall question, Marc posed and answered three sub questions throughout the presentation.

1. How have past environmental conditions affected seagrass and SAV communities?
    a. Climate (temperature, precipitation) and human activities (nutrients) have reshaped species dominance in CB.
2. How will environmental conditions shift with climate change & with human activities?
    a. Temperature rise and precipitation variation are inevitable. Nutrient reductions may dictate future Bay conditions.
3. How will shifting conditions and shifting species affect SAV meadow coverage into the future?
    a. Widgeon grass and freshwater dominance elevates the importance of future, further nutrient reductions for a vegetated Chesapeake Bay.

Marc concluded with the following take home messages:

1. Temperature increases will widen the shift in dominant species, and management must adjust accordingly.
2. Nutrient reductions in the tidal fresh/oligohaline & Ruppia zones are essential, especially because the new dominants respond best to nutrient management.
3. Local/regional action offsets and prevents the effects of global climate change.

Next steps for this work include:

1. We have segment goals and Bay wide goals, but now we need community goals.
2. We must start quantifying species shifts, food web shifts, and changes in fisheries.
3. What would other regions need to do predictions like this, as more conditions and species change?

Marc recommended exploring this application further.

9:40 Discussion of Forecasting the Relative Roles of Climate Change and Habitat Management on Chesapeake SAV

Summary

Lew said this report has great explanatory power and is very timely. In reference to the results on slide 13, Lew said the MWG has three tasks for the end of Phase 7 model development:

1. Characterizing hypoxia under climate change and nutrient reduction scenarios.
2. Characterizing chlorophyll *a* under climate change and nutrient reduction scenarios.
3. Characterizing SAV under climate change and nutrient reduction scenarios.
    a. Consistently, measuring SAV response to the light field (through total suspended sediment (TSS), phytoplankton, and epiphytes) has done a terrible job and always has done a terrible job. This makes the SAV report even more important because it shows other factors like salinity and temperature are critical, not just the light field.

Lew asked if the MWG would accept including the work Marc presented into the MBM and MTMs to help understand SAV beds, given the complimentary data it provides. If so, a few questions would need to be answered:

1. Does this approach make sense?
    a. Marc said this is a good idea and would be a strong partnership since this work focused on the past and the MWG has a future focus. Marc caveated model adjustments can be made, like incorporating Total Suspended Solids (TSS) where needed.
    b. Lew replied it looks like TSS is influencing chlorophyll and total phosphorus (TP) and temperature are influencing epiphytes. It appears that TP has an epiphyte phenomenon for the tidal fresh and mixed mesohaline, but not so much for *Zostera* or *Ruppia*. Marc said that is how the team is interpreting it as well.
    c. Marc explained the influence of last year's temperature in the tidal fresh is believed to be representing impacts on seeds.
2. Is Marc able to help with this?
3. Does this model meet public domain and open-source requirements?

Lew asked Joseph, Jian, Nicole, and Richard what obstacles might exist for incorporating this work. Marc said he will respond to Nicole's message so they can collaborate on this further. Jian Shen said it makes sense to put MBM SAV outputs into the SAV model Marc presented to test out results. Jian asked if there is a way to simplify this model, since the difficulty is seeing how the SAV bed is changing. Jian said salinity output from the MBM can be used to initialize the SAV area. Marc replied he does not allow beds to fully crash to zero for model operation reasons, but that it is possible to calculate predictions of a full crash per segment. Marc added the most important predictor for next year's SAV is this year's SAV, in year-by-year models. Lew said the MBM model could specify beds in the calibration period, so perhaps 2000 would be a good starting point. Lew said it might also be a multiple step process.

Steve Bieber asked for a brief explanation of how Marc's model(s) take into account the amount of suitable habitat over time. One example might be changing salinity regimes due to precipitation changes or increases/decreases in shallow water area due to sea level rise, etc. Marc said this is not currently available due to data limitations.

Norm Goulet asked what the shift in species means for living resources. There was no response to this question due to time constraints.

Lew asked if the model could start from a different point other than 2020. Marc said yes but the model would require the data for those different years if starting earlier.

Nicole Cai asked how the model considers the SAV disease-temperature relationship, especially on the rising temperature scenario. Marc said it is not explicitly considered and there is no built-in threshold/tipping point, but implicitly it is included in die offs.

Gary asked what the gray lines represent on slide 13. Marc said they represent a correlation effect built into the model, meaning the factors do not drive each other, but are correlated and this relationship is represented, giving the Structural Equation Modelling (SEM) more explanatory power. Gary asked about the spatial scale and the variable this data represents. Marc replied the spatial scale is the water quality station level converted to the segment level. Observed past data is used as inputs, and monthly data is grouped into seasons as means and medians.

Richard Tian said he gave Marc the scenario outputs.

Gary said if the MWG finds the SAV model too difficult to integrate into the model, it can be used in postprocessing. Gary said he expects most living resource models to be used in post-processing but that should work. It would be better to have them integrated into the model to account for feedback mechanisms. Joseph said both pre-processing and post processing should work, which could incorporate that feedback mechanism.

Richard said it seems like you ran hundreds or thousands of simulations for each scenario and asked what was changed between runs. Marc said for one future, he adds the scalar to one random year from the past, meaning each separate simulation applies future conditions to a previous year. Richard asked about the spatial resolution of the runs. Marc said the runs are down station by station, but SAV communities are then overlayed on top of that station level data. The SAV model is not able to do actual species distribution change over time right now, because of lacking data availability. Abundance change over time within zones is present in the model, but more data on relative abundance change over time is needed.

Richard asked what time steps are used for future predictions. Marc said they are yearly time steps due to the limitations of the data. Richard asked how the model used the daily data he provided. Marc said that was summarized over each season.

Nicole said she was not sure if the distribution of SAV would be able to be included in preprocessing and instead it would just be included in post-processing. Lew said for the four communities in different yearly scenarios, we would need to know where we have the four communities in each segment. This would result in adding to each community and then do a water quality run to see the feedback impacts of SAV. Nicole and Marc said that sounds right because it would play into the initial condition.

Lew said to be clear, this is an exploratory item. At some point it will be brought forward for a decision to the MWG in a few quarters.

Joseph Zhang said he needs to see the code and model in more detail to determine what is feasible, such as the complexity and computational constraints of the SAV model.

Dave said it looks like Marc will be engaged with the MWG for the long term. Lew suggested setting up some *Ad Hoc* meetings in May so the team can dive into details of possible use as part of Phase 7 Suite of Models. Marc agreed.

10:00 Update on Main Bay Model (MBM) Progress – Joseph Zhang, VIMS

Joseph presented first results with the almost completed MBM code and discuss some key questions and plans for 1) mesh expansion to cover eastern shore and refinement in some key tributaries; 2) the SAV simulation approach in the MBM and related revision of the MBM mesh; and 3) recalibration workflow for the two-step ('offline') mode. Recalibrated hydrodynamic results on the revised new mesh were presented.

Summary

Joseph began with a reminder that this is a python-based workflow, and the model will be run in decoupled mode to allow for a two-step process. This is necessary to achieve the computation efficiency needs of the CBP.

Joseph began with an overview of improvements of the MBM mesh including the eastern shore, Lynnhaven, Potomac, and other areas. The new size of the MBM mesh is approximately at the limit of computational resources available.

Joseph then outlined results for hydrodynamic recalibrations from 2004-2009 and wave and sediment models.

In summary, the team has:

- Revised the MBM mesh for eastern shore, Potomac River, some SAV beds and some access channels.
- Recalibrated SCHISM for hydrodynamics, sediment, and wave dynamics throughout the Bay. A python-based workflow made the recalibration process easy.
- Error statistics for elevation, temperature, salinity, wave heights and sediment concentrations are generally satisfactory for both Bay channel stations and most of

tributary stations. Model results can be potentially used to examine episodic events (large river flows, hurricanes, etc.

Joseph concluded with an outline of future work for the MBM team which includes:

- Finalizing the mesh and recalibrate:
    - Andy and Karinna's final boundary (we already used a preliminary version from Karinna)
    - Rappahannock Shoal Channel
- The mesh size currently stands at 69K nodes (104K cells), which is probably at the limit of what can be handled with the HPC resources available.
- Performance tuning:
    - Proposed solution: divide the 10-yr simulation into two runs.
    - Each run covers 6 years, with 1 year overlap.
    - Each run is 'hot started' from a well warmed-up simulation.
    - Preliminary results showed promise for this approach.

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

Summary

Lew said he thinks the dataset Andy has been working on is complete. Gary said Andy made a few modifications and the documentation is nearly done.

Lew asked if we need another mesh for sea level rise or do simply acknowledge it as a model limitation. Joseph said this is a question for the whole MWG. Joseph said Karinna Nunez has data on bank height and shoreline erosion, including sand, silt, and clay. Lew said Karinna's team is updating the whole shoreline inventory.

Lew said it is great to see the added spatial detail in the Lynnhaven and the Virginia, Maryland, and Delaware coastal bays. Lew said greater interaction with these geographies post 2025 would be good for the CBP. Mark Nardi at USGS has been notified and will work with those communities to let them know about the desire to work together on these topics.

Lew asked if SAV biomass is available. Joseph said yes, thanks to Nicole's work.

For use in communication, Lew asked if Joseph has a sense of the exchange of water between Delaware Bay, Long Island Sound, and Pamlico Sound and if this topic has been explored. Joseph said this is on the to do list and can be explored. Lew said it might be worthwhile since there are shared resources and benefits to be described, like reductions in atmospheric deposition. Lew said it would be a useful statement to say, "As we improve the Chesapeake, we are improving conditions for our neighbors, even if the magnitude is small." Joseph said his concerns are this would not fit in the MBM. Lew said he was thinking the exchange of water would be considered in a different, larger domain model. Joseph said they will consider that work.

Lew asked what the MBM and MTMs are using for wind fields. Joseph said this is very important for waves, and they are using 12+ weather stations. Isabella said PRISM does not have wind, and Gopal added NLDAS does include wind. Lew said this could be important for the MTMs given wind channeling. Lew suggested forming a small technical team to utilize NLDAS wind data to augment the 12 stations.

Lew said it seems like we are doing the best we can with the computational resources we have. Perhaps a split approach will help, where the first run can cover three-year critical period 1993-1995 for nutrient loads. Gary said almost all of the runs only use data through 1995. We want the ability to do the ten-year run, but it is not looked at very often, so maybe it would make sense to not split it up and then for the longer run just let it take longer time. Lew said we should reserve ability to do the ten-year run. Gary agreed. Richard said a ten year spin up is necessary for sediment to settle, and this would have to be re-done for each scenario. Joseph said we may be able to get a hot start, if the pre-equilibrium starting place is well placed. Gary said it makes sense to test, but since we are getting two different answers for each scenario (continuous vs split management run). This is great for science, but for management we need one way to run the model and clear decision rules.

Richard asked why the sediment in the Corsica has a higher concentration in winter than in the summer. Joseph said this is because it is wintertime, and the wind is stronger. Lew said generally there would be higher flows off the watershed that time of year.

Richard asked if the multi-year runs are doing together or separately. Joseph they are done together.

Carl Cerco asked if this model is considered calibrated or are other efforts needed to finalize the tide and salinity. Joseph said a lot of effort already has been put into calibrating salinity, temperature, and other variables. Joseph said one should expect the salinity error to increase as you go into the upper Bay, so the MBM team feels the results are quite reasonable already. Carl said on slide 10, the observations match the modeled results quite well in the lower Bay, but diverge in the upper Bay. Joseph said the patterns demonstrated are due to atmospheric forcing from wind and is already considered well within acceptable error. One way to reduce the error is to improve wind data in the upper Bay.

Rebecca Murphy said the Digital Elevation Model (DEM) comment Joseph made on slide 21 is resonating with her as she works on the 4-Dimensional Interpolator. Rebecca asked what Joseph is doing with the DEMs. Joseph said the DEM failures are causing much of the error in the model, especially salinity. Joseph said they switched from Coastal National Elevation Dataset (CoNED) to NOAA's latest Digital Coast DEM, which has been an improvement. However, it is still not great given much of the channel survey data is recycled from a hundred years ago. Additionally, NOAA just finished collecting higher resolution bathymetry in the tributaries last summer, which should be very helpful for the MTMs, but it is not available for the mainstem due to the busyness of shipping channels. Lew said the fidelity of the model and observations looks great on slide 21, so Lew suggested making local corrections in the MBM or MTMs based on the monitoring data, with some smoothing done around them. Richard said he had the same observation in the Choptank. Rebecca said that is tempting, but she would be concerned as it might create more deep water not meeting attainment, and it would be more debatable than simply using the best available bathymetry from NOAA. Rebecca said this can be discussed further. Lew said he does not see the salinity question as being major, since the pycnoclines are already looking great.

Lew asked about the results of station CB3.3C on slide 15, and asked for the reason for this error. Joseph said no systematic bias was detected; this one station was experiencing error due to flow.

11:10 Refinement of the Temperature Dependence of Algal Growth Rates in the MBM and MTMs – Clifton Bell, Brown and Caldwell

Clifton described motivations for refining the algal growth response to temperature in the MBMs and MTMs. Possible approaches to achieve this is through 1) examination of the shallow water monitoring continuous temperature and chlorophyll measurements; 2) updating the literature search; and 3) convening a STAC workshop/session in the first or second quarter of 2024.

Summary

Clifton began with the context of this discussion, which started with the 2018 STAC recommendation and his understanding of how the MWG is responding to the recommendation.

Looking at the sharp divergence in algae rates under climate change in the James River chlorophyll model, questions were raised about perfect biochemical adaptation. This led to the team producing a literature review on the optimum temperatures for algal growth adaptation on different species in varying geographies.

Clifton concluded with two potential paths approaches and a path forward. The first approach is to find one set of rates that reproduces calibration, simulates thermal adaption, and simulates beyond-optimum conditions. The second potential path is to start with calibrated rates and adjust them for climate scenarios based on amount of projected warming.

11:30 Discussion of the Refinement of the Temperature Dependence of Algal Growth Rates in the MBM and MTMs

Summary

Raleigh Hood said this presentation assumes the same species will be predominate in the future. Raleigh suggested that if community composition of the phytoplankton changes over time with tropical species migrating into Chesapeake Bay, the assumption this presentation is based on will be false. Raleigh brought up the Eppley curve, which describes global phytoplankton species and growth rates as a function of temperature. Raleigh said from an academic perspective, the thousands of species of phytoplankton have different thermal optimums that continue to increase and a species with a higher optimum will replace another one. Clifton responded that the literature review indicated the tropical species mentioned show the same curve pattern at higher optimum temperatures. Clifton said very few species can maintain an optimum growth rate up to 35 degrees Celsius. Raleigh said that is an interesting perspective but noted that most academic models use the Eppley curve and predict global species composition of growth rates continuing to increase past 40 degrees Celsius, assuming community composition will change. Gary said it is his understanding that the condition of each year is the determining factor of that year's species assemblage, since the species are everywhere, and the previous year's conditions do not matter. Regardless of if that is the case, a continuous adjustment, not a step change, is needed for the model based on the TMDL calibration. Clifton said his opinion is that Eppley curve is just the left-hand side of the graph, and that given the chlorophyll a drop off above certain temperatures it seems to indicate there is a relevant maximum. Raleigh said he does think there is a thermal maximum, but he thinks it would be a bad assumption to assume algal populations would crash in the Bay in the future.

Samuel Canfield followed up on Raleigh's question asking are most tropical algae assemblages temperature growth curves represented in the literature and could there be exceptions that do not follow the presented curve that aren't currently represented? This question was not answered due to a lack of time.

Richard asked about what temperature Clifton thinks is ideal for Chesapeake Bay. Clifton said he thinks it depends on the goal of the exercise. Given the interest in a single curve for all conditions, Clifton said it would depend on the combination of parameters. Richard then shared a graph of a continuous monitoring station in the Corsica which showed a decrease in chlorophyll above a specific temperature. Richard asked if this trend was because of the decrease in growth rate or an increase in the respiration rate. Richard explained how they are currently looking at different stations and comparing across datasets.

Carl Cerco said fluorescence peaks at 32 or 33 degrees Celsius. Carl said this data is based on historical data, not projecting forward, so there is a lot of uncertainty about how to determine this.

Dave asked if the STAC workshop will be happening and if this topic will be covered. Gary said the workshop will be happening and this question can be asked. Lew said the STAC workshop will be on climate change guidance in general for CBP models. Lew said by the time this conversation wraps up, there will have been time to examine shallow water processes related to this question.

Lew said there are a lot of dots to connect here, but in a small sample of the observed data we see temperatures of 35 degrees Celsius and we may see higher temperatures with a more exhaustive search. So, we need to think about the whole array of observations (including shallow water monitoring), a literature review, and what is being represented in the model. Thankfully, the MWG has a few quarters to explore this. Dave said what he understands is the STAC workshop will help address these concerns. Lew said this will be brought up at the next few quarterlies and then the results will be brought to the STAC workshop to get other perspectives.

Richard shared his screen again with figures that showed temperature relationships and growth rates from a paper he wrote.

Jian Shen said Mark Broesch reviewed the literature in multiple models with the Eppley curve. There is not just one curve applied to all. Jian said another challenge is dealing with calibration for temperature and nutrient limitation, which will require additional investigation.

Carl Cerco said he has looked at the data and literature, and he is not sure if anything will be definitively proven. It might need to be a consensus-based decision.

11:50 Progress on MTMs in the Potomac and Choptank Rivers – Nicole Cai, EPA ORISE, and Richard Tian, UMCES-CBPO

Richard and Nicole discussed initial progress on the set up of the Choptank, Potomac, and other MTMs.

Summary for Nicole's presentation

Nicole began with a review of the improvements in salinity and tidal range that are a result of grid refinements in the Potomac. The majority of Nicole's presentation focused on a generic

tracer study to identify interactions between each tributary. The motivations for the tracer work include having a fine grid covering all the tributaries and shallow regions and to quantitatively synthesize the interactions between each sub-tributary. Nicole walked through initial results for elevation, tide, salinity, and temperature and highlighted the distribution and role of each tributary. Nicole visualized this data in a source-sink connectivity matrix.

Nicole emphasized the initial grid prepared for the Potomac Model will be helpful for other MTMs and a fully coupled MTM shows reasonable preliminary calibrations.

Summary for Richard's presentation

Richard began his presentation with a discussion of how he defined the domain and developed the grid for the Choptank MTM, including notes about data sources and refinements. Richard then walked through preliminary results of surface simulation for surface current, temperature, salinity, dissolved oxygen, and chlorophyll for the Choptank.

11:40 Discussion of the Potomac, Choptank, and Other MTMs Set Up Progress

Summary for Nicole's presentation

Lew asked if surface tracer cells were used on slide 12. Nicole said both surface and bottom cells were used in the runs, but only the depth average is being displayed on slide 12. Lew said in the Potomac the depth average is throwing a lot out of the surface and a lot in on the bottom, demonstrating a classical circulation pattern with a skew to the southern portion of the river. This is visible for the James as well.

Regarding the matrix on slide 17, Lew asked what end products Nicole was envisioning. Nicole said she plans to communicate the matrix in a manuscript where she will explain the importance of the Potomac, considering its outsized impact on this generic tracer run. Lew added the Susquehanna also plays a big role.

Gary said this work is important for the new model in TMDL considerations, especially geographic isolation runs. The primary interest of the TMDL and trading is in the oxygen effect of one tributary on another, or the main Bay. Gary suggested having a future Ad Hoc on this topic because he has a lot of questions. Nicole and Lew agreed to set aside time at the weekly meeting on April 11th to discuss this further.

Lew clarified what is being presented is pure dissolved, unreactive tracer.

Richard said on top of the geographic isolation run, he did a tracer analysis for Virginia DEQ for the James River and found it had an influence on upper portions of the Bay. Richard asked Nicole where she place the tracer – was it at the fall line or everywhere. Nicole said it was put wherever watershed loading existed.

Jian said there is a coupling effect with the Potomac, which is not present in the James. Jian suggested considering the coupling effect on the boundary condition of the Potomac. Nicole said the Potomac grid domain is much larger and the computer was struggling with the run. Jian said the one-way coupling information should inform setting the open boundary.

Neil Ganju noted the possibility of parameterizing the influence of tidal marshes using newly published geospatial data, i.e., using vegetated fraction and marsh plain elevation to possibly make volumetric or roughness corrections. Neil recommended checking out two datasets: https://www.sciencebase.gov/catalog/item/630f73acd34e36012efa0842 and the marsh lifespan

under SLR scenarios, which could be useful for future planning: https://www.sciencebase.gov/catalog/item/63a32f2bd34e176674f520ee. Nicole said this is helpful and said her work is still preliminary, so these datasets can be considered. The York River is a strong demonstration of the importance of tidal wetlands.

Summary for Richard's presentation

Joseph said the MBM team has digital charts that can be rasterized and shared with Richard. Richard said he will utilize that dataset in the future.

Joseph suggested the areas of high bottom chlorophyll Richard is interested in are caused by benthic algae. Lew said there were instances where chlorophyll bottom observations are quite high in the Main Bay. The rate of chlorophyll decay and accumulation here is the key question for benthic algae considerations.

Carl said when looking at the Corsica, the fluorescence was extraordinarily high at low temperatures. Carl said Jeremy Testa shared a paper with a new name for spring freshwater algae. Carl said perhaps it is time to introduce a new spring freshwater algae group seen in the eastern shore tributaries, given the figure for ET5.1 on slide 14. Carl suggested adding a new voting group for the currently open group in these eastern shore systems. Richard said if we add another group that behaves as demonstrated in the paper (Millette, 2023), it would be helpful for simulating the Corsica. Richard said he thinks Carl is right. Lew asked Carl if he is suggesting substituting for the blue-greens in the Choptank or completely adding a new group. Carl said he thinks it can be substituted since the blue-greens are turned off and are only used in the tidal fresh Potomac. Richard said there is more and more evidence to support substituting a new group.

Raleigh Hood asked if the diffuse light attenuation coefficient is turned off, because otherwise the bloom might be happening in a different part of the river and could really throw off the results. Richard agreed this is important and said he has not run the sediment model yet, although it is included, so that makes it hard to understand light attenuation. Richard said light attenuation is key, especially in shallow waters. Raleigh recommended focusing on light attenuation first before looking at phytoplankton groups, as that can affect calibration. Raleigh said Elizabeth North has a great dataset that is worth considering, which includes chlorophyll and diffuse light attenuation coefficient. Richard said he has been using salinity to tune the growth rate in the meantime while diffuse light attenuation is still being worked on.

Lew asked about the bay boundary condition on slide 3. Lew suggested one option might be extending the boundary from shore to shore, which could be helpful for multiple tributaries in the Bay. Lew asked what an appropriate boundary condition would be. Richard said this is an important question and it is the right time to discuss this. Richard said he has two grids: one for the wave, sediment, and shoreline erosion that have a finer resolution grid that fully includes the coastline; another that includes the tidal wetlands. Richard said this is an opportunity to test out boundary conditions. Richard added the larger domain allows for capturing more wave energy and improved simulation.

Lew said it looks like the red points on slide 8 are coastline loading points, but the grid is expanded to consider sea level rise. Richard said he expanded to grid to include the influence of tidal wetlands, so the average sea level rise from the literature is captured. Lew replied we need to be consistent everywhere and should consider the Phase 6 method here. This would involve

checking with Andy Fitch where the boundary is and where the tidal wetlands are. Lew said this approach is non-conventional and is concerned it might exceed runtimes when scaled up to the entire Bay. Richard replied this is only a test case and would likely not be possible in the mainstem Bay. Lew asked if this would be helpful for shoreline erosion. Richard said there is a separate grid for shoreline erosion. Lew suggested bringing this to an *Ad Hoc* meeting to discuss the open boundaries. Lew said it may be easier to take information from the main Bay. Richard said if the shoreline is extended to the west bank, there may be issues with the tide because the boundary is so large. Lew said ultimately this is an operational question, so we need to consider tradeoffs. Richard said this question is very relevant for the Patapsco. Joseph replied for Patapsco it makes sense to have one large open boundary and include the entire upper Bay. Larry said a focused Ad Hoc meeting would be ideal for resolving this question. Larry said if there is wind wave input across an open boundary, he is not sure how the matching is done. If the MBM transfers wave development well to the MTM, then the boundary does not matter that much, but if the transfer is not smooth, it can be a problem. Joseph replied the wave model in the MBM should allow for continuing the wave model.

Samuel asked if this would mean duplicating previously created MTMs. Nicole said she is creating Standard Operating Procedures for ensuring standardization across tributaries, which should minimize work. However, the MTMs are going to each be different so there is no gold standard. Gary said he thought the purpose of the MTMs was to have a different approach in each tributary so they can be compared to learn what works best and then implement them in the MBM. Lew replied there needs to be some form of consistency for parameterization and boundaries so results can be compared between tributaries and the Bay as jurisdictions may need this option for smaller scale management. One example might be the shared TMDL between MD and DC for the Potomac and Anacostia.

1:40 **Integrated Watershed-Wide Indicator of the TMDL-Required Reduction of Nitrogen and Phosphorus – Gary Shenk, USGS-CBPO, and Qian Zhang, UMCES**

An Integrated Watershed-Wide Indicator of the TMDL-Required Reduction of Nitrogen and Phosphorus was presented. The indicator separates the TN and TP loads into elements of 1) implemented and realized load reductions; 2) implemented load reductions but lagged; 3) future implementation of load reductions; and 4) other categories**.** The indicator will provide CBP with greater insight into the guidance given from monitoring and modeling estimates of loads.

Summary

Gary began with some context on the current indicators available for the WIPs and TMDL. Gary emphasized the purpose is to build an indicator that is relevant to the TMDL, based on monitored changes in load to the extent possible, and bridges monitoring and modeling by assessing lag time and other effects. The indicator seeks to answer the TMDL question: “what level of load reduction from 1995 will be necessary to meet water quality standards?”

Gary then walked through the target decreases, expected decreases (implemented), and measured decreases in nitrogen loads by the four categories: River Input Monitoring (RIM) Nonpoint source (NPS), RIM Point Source (PS), Below RIM NPS, and Below RIM PS.

Gary discussed the question "Why are monitoring and modeling not showing the same thing?" Answers to this question include uncertainty in CAST (BMPs implemented, BMP effectiveness, nutrient applications, and watershed response), uncertainty in "monitored" loads, lag time, and competing factors (e.g., climate change and Conowingo infill). Gary spent some additional time explaining the lag time and Conowingo infill effects.

Gary shared the WQGIT has given approval to make this an annually updated indicator on ChesapeakeProgress under the 2025 WIP Outcome. Gary walked through the components of the indicator and explained the story they tell. Gary described how the indicator has been vetted by the partnership through many different venues with much feedback that has shaped the indicator.

Related data products will be available to the partnership on the data dashboard. A complementary product is a station-level dashboard product Qian created which allows for interactive visualizations of the data. Gary then did a live demonstration of the station-level dashboard product.

Next steps for the indicator include working with the CBP web and communications team, adding the annual finer category data to the nontidal data dashboard, and adding the station level app to the data dashboard.

2:15 Discussion of the Integrated Watershed-Wide Indicator of the TMDL-Required Reduction of Nitrogen and Phosphorus

Summary

Dave asked who is in charge of figuring out what is going on with phosphorus. Gary said it is on the entire partnership. The MWG is responsible for the spatial distribution of loads, with the exception of lag times, while the WQGIT is more responsible for the temporal distribution of loads. So, the WQGIT needs to be heavily involved. Additionally, this problem is happening in other regions, like the Great Lakes. Gary said the changes that need to be made are likely going to need to happen at the WQGIT, but the MWG will be heavily involved in figuring it out. Hopefully STAC will help with this effort. Dave asked if certain information can be gleaned from the Great Lakes region. Gary said he is not caught up on the most recent literature, but there is information to be learned. Dave and Isabella said land tile drainage has been discussed and it is a hot topic in this conversation.

Isabella noted phosphorus is associated with high uncertainty in the Weighted Regression on Time, Discharge, and Seasons (WRTDS) model and this needs to be remembered. Gary agreed this is important to remember, and said it is consistent across the watershed that phosphorus is going up despite our reports that it is going down. Qian said WRTDS is even more uncertain for sediment.

Norm asked if Gary sees any hint between differentiation between NPS developed and agriculture sectors. Gary said there are not a lot of watersheds that have a large, developed land use sector. One example is Lancaster County where phosphorus has been declining, but many other areas show phosphorus increasing. Gary suggested exploring the tool further to explore these trends. Gary mentioned a paper Qian and Robert Sabo wrote that discusses how nitrogen loads in forested watersheds in the western part of the Bay watershed are increasing and the trend has somewhat reversed itself.

Lew expressed how great of a communication tool this indicator will be in explaining progress and current conditions. Looking at slide 24, Lew said this represents the successes the CBP has been able to achieve. Lew emphasized this connects well to CESR and explaining the story of system response. Dave asked if the data will be tabulated including both the implemented and realized and implemented and unrealized, or if just one will be displayed. Lew said how you score is very important, so both should be represented.

Samuel asked if there is a summary of stations that have hit the mark for nutrient reductions and what has been done to achieve those reductions. Gary said you can download the data from Qian's tool but cautioned people from making conclusions from a few anecdotes. We need to use this tool to see what is going on in local watersheds to motivate a more rigorous analysis.

Karl Berger asked if the indicator has been broken out at the basin scale. Gary said no and there are not any plans to do it because there are concerns about putting together a summary for areas on the eastern shore where there is very little monitored load. Overall, about 83% of the loads are monitored, but that would change if looking at the eastern shore.

Lew asked when this will be available and ready. Gary said they are working with the web team to get it on CheaspeakeProgress, and it should be available in one to two months. The indicator will be in the form of a stacked bar plot instead of the area graph currently displayed.

Dave asked about the phosphorus chart on slide 27 and why the implemented and realized area has increased so dramatically. Gary said be careful not to read too closely into the difference in lag times since WRTDS is less reputable on phosphorus. However, Lew, Dave, and Gary noted this drop in phosphorus could make sense as there was a drop in fertilizer purchases and some improvements in manure management plans in the 1990s.

2:30 ADJOURN

Participants: Alex Gunnerson, Arianna Johns, Carl Cerco, Carl Friedrichs, Carlington Wallace, Challen Hyman, Clifton Bell, Dave Montali, Dave Parrish, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano-Pulido, Isabella Bertani, Jamileh Soueidan, Jesse Bash, Jian Shen, Joseph Zhang, Karl Berger, KC Filippino, Kevin McLean, Kimberly Dagen, Larry Sanford, Lew Linker, Lisa Beatty, Marc Hensel, Mark Bennett, Martha Shimkin, Mukhtar Ibrahim, Neil Ganju, Nicole Cai, Norm Goulet, Qian Zhang, Raleigh Hood, Rebecca Murphy, Richard Tian, Robert Burgholzer, Robert Sabo. Sam Merrill, Samuel Canfield, Sophia Grossweiler, Steve Beiber.