Modeling and Regulatory Support Workgroup Meeting

Hybrid Meeting, August 2, 2022

Remote Access Options

Equipment Type	Access Information	Notes
Computers with microphones and speakers	Join Microsoft Teams Meeting **Please mute your microphone** unless you want to provide input.	Press control and click on this link to bring up Microsoft Teams through the internet. You can view the screen share and communicate through your computer's speakers and microphone
Computers without audio capabilities, or audio that is not working	Join Microsoft Teams Meeting (888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Follow instructions above **Turn down your computer speakers, mute your computer microphone,** and dial the toll-free number through your phone and enter the passcode
Phone only	(888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Dial the toll-free number and enter the passcode

Remote Access Guidelines

- This meeting will open 30 minutes prior to the official meeting start time to allow users to test equipment and ensure communication methods are working
- If you dial in through your phone, mute your microphone and turn down your speakers to avoid feedback
- Unless you are speaking, please mute your computer or device microphone and phone microphone to minimize background noise

Agenda

- Opening Comments, Agenda Review/Revisions
- Watershed Model Report Status
- WARMF Lake Modeling Status
- Potential WARMF Sensitivity Analyses
- EFDC Lake Modeling Status
- Lake Reporting Status
- Statistical Model Development and Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal
- Communications Outreach and Preparation

Watershed Model Report Status

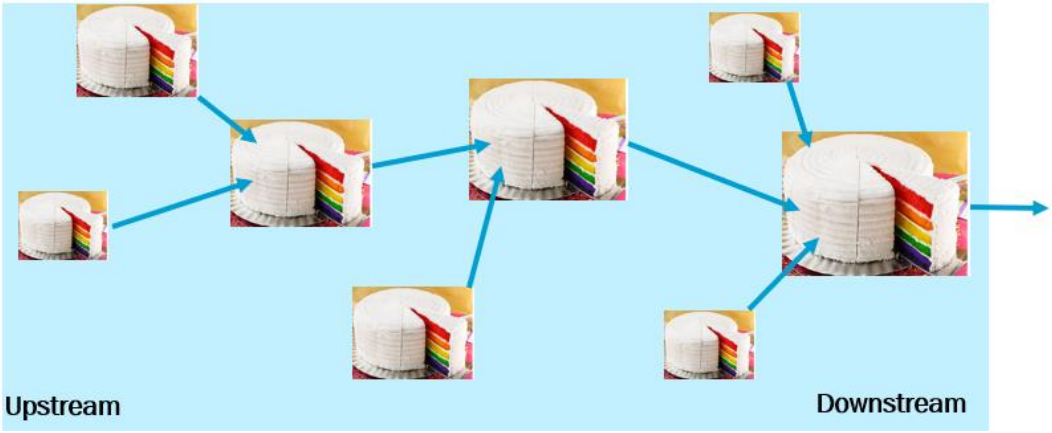
Watershed Model Report Status

- The draft WARMF watershed modeling report was distributed to the MRSW on June 30, 2022
- We have received comments from some MRSW members and expect comments to continue to be submitted
- DWR indicates they will provide comments by August 31, 2022.
- Modeling team will compile and address comments in a revised report to be submitted to the PFC
- Following PFC review and input, the report will be finalized for submittal to DWR for their formal review
- Delivery of the watershed model files has not yet occurred:
  - The WARMF Lake model is part of the complete package and is not yet calibrated
  - The new GUI (underdevelopment) will be needed to run the full model with all functionality
  - Plan to schedule a workshop with DWR and others interested in running the model once the new GUI is ready and the lake model is calibrated (September/October)

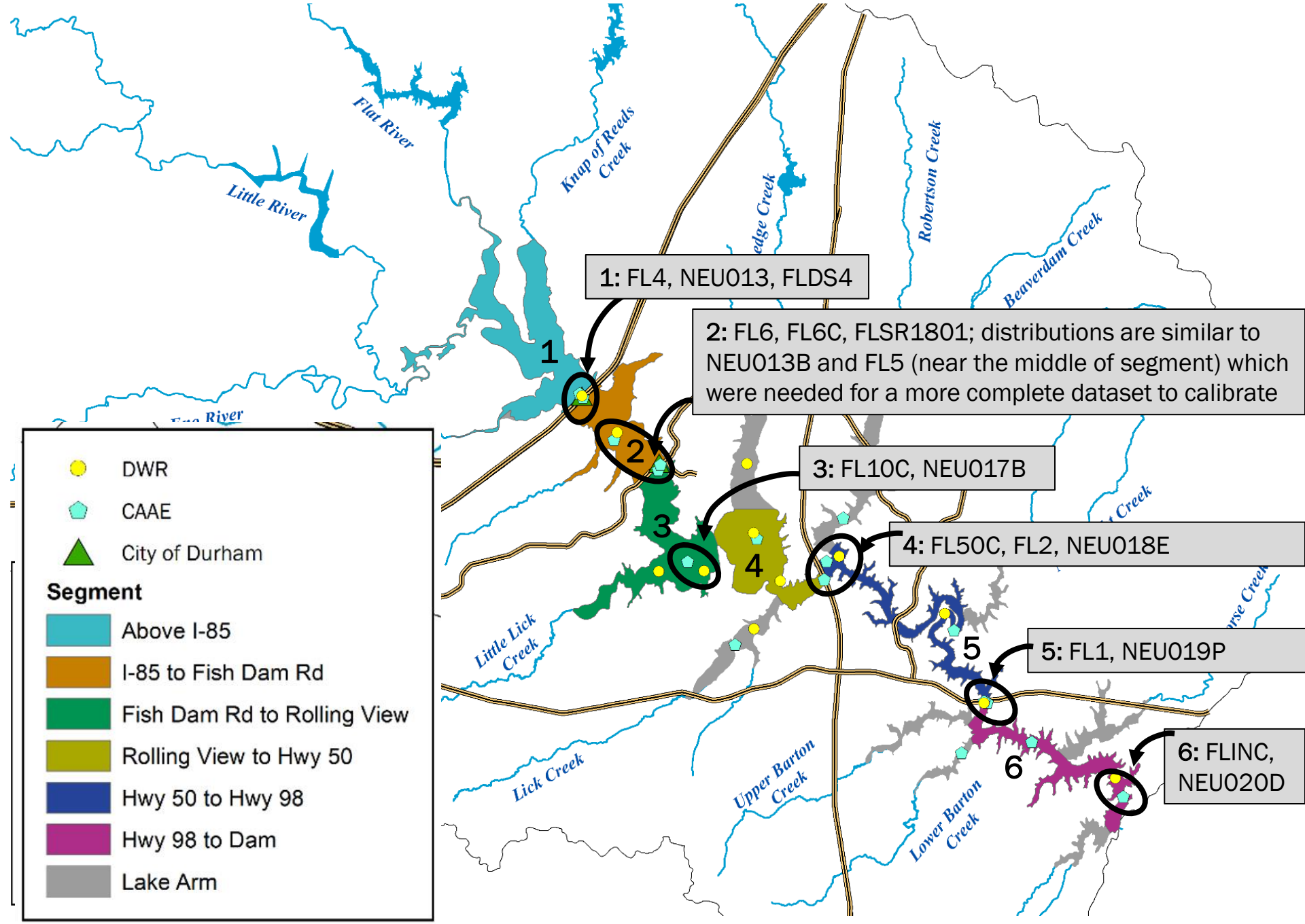
WARMF Lake Development and Calibration Status

Segments and Calibration Approach (Past Discussions)

- WARMF Lake is a segment-based model
  - Each segment has up to 40 layers
  - Each layer is approximately 0.75 meter thick
- Water quality calibration stations were selected to represent the downstream end of each segment (DWR, City of Durham, and Center for Applied Aquatic Ecology)
  - Provides accurate inputs to the next downstream segment
  - Evaluates water quality near the City of Raleigh intake
- Falls Lake segmentation and calibration approach were approved by email vote November 3, 2020



WARMF Lake Calibration Stations (approved 10/5/2021)



Development and Layering Approach (Past Discussions)

- The model is directly connected to the watershed model
  - 6-hour time step
  - Calibration period (2015 to 2016)
  - Validation period (2017 to 2018)
- WARMF Lake layers are ~ 0.75 meters deep
- GUI shows output for top layer compared to observations
  - This was used to guide preliminary calibration
  - How we will view results today
- For comparison to the performance statistics, the MRSW approved this layer-averaging approach (October 5, 2021)

Segment	Typical Secchi Depth (m)	Typical Photic Zone (m)	Top Layers to Average
1	0.4	0.8	1
2	0.6	1.2	1, 2
3	0.75	1.5	1, 2
4	1	2	1, 2, 3
5	1.1	2.2	1, 2, 3
6	1.25	2.5	1, 2, 3

Performance Criteria (Past Discussions)

- WARMF Lake uses the same performance criteria as the watershed model for water quality evaluations
- Measurements in Falls Lake at each station selected for calibration are compared to the segment output for the 6-hour time step that contains the observation

General Watershed Model Calibration Guidance

Parameter	Percent Bias Criteria		
	Very Good	Good	Fair
Sediment	< ± 20	± 20-30	± 30-45
Water Temperature	< ± 7	± 8-12	± 13-18
Water Quality/Nutrients	< ± 15	± 15-25	± 25-35

Initial Conditions – Sediment Depth by Segment

Segment	Segment Type	Average Sediment Depth (cm)
Above I-85	Main	1.43
I-85 to Fish Dam Rd	Main	2.75
Fish Dam Rd to Rolling View	Main	3.40
Rollingview to Hwy 50	Main	6.77
Hwy 50 to Hwy 98	Main	6.76
Hwy 98 to Dam	Main	13.55
Beaverdam Impoundment	Arm	8.82
Honeycutt Arm	Arm	12.37
Horse Creek Arm	Arm	6.30
Ledge Creek Arm	Arm	3.04
Lick Creek Arm	Arm	3.52
Lower Barton Creek Arm	Arm	5.99
New Light Creek Arm	Arm	5.68
Upper Barton Creek Arm	Arm	6.65

Based on UNRBA Sediment Depth Special Study

Adsorption Isotherms and Initial Sediment Bed Conditions – All Segments

N & P sediment adsorption isotherms set using sediment core and pore water concentration data:	
Phosphate	25000 L/kg
Ammonia	60 L/kg
N & P initial sediment concentrations set using sediment core data:	
Ammonia	0.7 mg/g N
Phosphate	0.9 mg/g P
Organic Carbon	25.6 mg/g
Initial concentration of detritus (provides a pool of organic matter to break down into N, P, Org. C, etc.)	
Detritus	3.7 mg/g C

Based on UNRBA Sediment Quality Special Study

Sediment Bed Reaction and Diffusion Rates

Rate (segments)	Value
BOD Decay, 1/d (all segments)	0.5
Denitrification, 1/d (all segments)	0.5
Sulfate Reduction, 1/d (all segments)	0.05
Organic Carbon Decay, 1/d (segments 1-3)*	0.01
Organic Carbon Decay, 1/d (segments 4-6)*	0.005
Nitrification, 1/d (all segments)*	0.01
Detritus Decay, 1/d (all segments)*	0.01
Settled Detritus Decay, 1/d (segments 1-5) *	0
Settled Detritus Decay, 1/d (segment 6) *	0.05
Bed Diffusion Rate (m^2/d) (segments 1-3) *	8E-07
Bed Diffusion Rate (m^2/d) (segment 4) *	4E-06
Bed Diffusion Rate (m^2/d) (segment 5) *	3.5E-05
Bed Diffusion Rate (m^2/d) (segment 6) *	1.0E-04

Based on current model calibration; further refinement may occur
Parameters marked with a "" indicate these were adjusted for model calibration.*

Reservoir Wide Parameters

Water Column Diffusion Parameters:			
Density Gradient Max (m^2/sec)	0.0005		
Wind Diffusion Max (m^2/sec)	0.0005		
Algae Growth Parameters:			
Parameter	**Blue-Green Algae**	**Diatoms**	**Other Algae (Greens, Prym., Eugl., etc.)**
Nitrogen Half-Saturation, mg/L	0.005	0.005	0.005
Phosphorus Half-Saturation, mg/L	0.005	0.005	0.005
Silica Half-Saturation, mg/L	0.005	0.005	0.005
Light Half-Saturation, W/m^2 *	200	55	150
Lower Growth Temperature, C *	10	0	5
Upper Growth Temperature, C *	40	30	40
Optimum Growth Temperature, C *	31	8	17

Based on current model calibration; further refinement may occur
Parameters marked with a "" indicate these were adjusted for model calibration.*

Water Column Reaction Rates – All Segments

Reaction Rate	Value
BOD Decay, 1/d	0.5
Denitrification, 1/d	0.5
Sulfate Reduction, 1/d	0.05
Periphyton Mortality, 1/d	0.05
Net Sand Settling/Resuspension, m/d *	1036.8
Blue-green Respiration, 1/d *	0.01
Diatom Respiration, 1/d *	0.01
Other Algae Respiration, 1/d *	0.01
Blue-green Mortality, 1/d *	0.02
Diatom Mortality, 1/d *	0.1
Other Algae Mortality, 1/d *	0.02
Detritus Decay, 1/d *	0.01

Based on current model calibration; further refinement may occur
Parameters marked with a "" indicate these were adjusted for model calibration.*

Water Column Reaction Rates – By Segment

Reaction Rate	Seg1	Seg2	Seg3	Seg4	Seg5	Seg6
Blue-green Settling, m/d	0.02	0.02	0.02	0.018	0.018	0.018
Diatom Settling, m/d	0.2	0.2	0.2	0.18	0.18	0.18
Other Algae Settling, m/d	0.06	0.06	0.06	0.054	0.054	0.054
Detritus Settling, m/d	0.25	0.25	0.25	0.25	0.5	0.5
Organic Carbon Decay, 1/d	0.01	0.01	0.01	0.005	0.005	0.005
Nitrification, 1/d	0.01	0.01	0.01	0.01	0.03	0.03
Blue-green Growth, 1/d	0.8	0.8	0.9	0.9	0.9	0.6
Other Algae Growth, 1/d	0.8	0.8	0.9	0.9	0.9	0.6
Diatom Growth, 1/d	1.5	1.82	2	2	2	1.5
Net Clay Settling/Resuspension, m/d	0.01	0.1	0.21	0.3	0.8	1
Net Silt Settling/Resuspension, m/d	0.01	3	3	3	3	3

Based on current model calibration; further refinement may occur
Each of these parameters were adjusted for model calibration.

Preliminary Draft Performance Criteria, 1/2, August 1st run

Average of pBias: August 1, 2022 Model Run								Average of ObsMean						
Segment:	**1**	**2**	**3**	**4**	**5**	**6**	**All**	**1**	**2**	**3**	**4**	**5**	**6**	**All**
Water Temperature, C								0%	0%	0%	0%	0%	0%	0%
Full	5	9	8	10	13	12	10	22.0	22.4	17.8	17.8	17.7	17.5	17.5
Calibration Per	5	8	6	10	15	13	10	21.5	22.2	17.4	17.4	16.9	17.0	17.0
Validation Peri	6	10	10	9	11	10	9	22.6	22.8	18.5	18.6	19.2	18.3	18.3
Ammonia Nitrogen as N, mg/l								64%	65%	11%	47%	23%	27%	49%
Full	55	34	20	9	-18	-22	21	0.029	0.031	0.019	0.019	0.045	0.060	0.034
Calibration Per	42	20	-11	-16	-20	-13	7	0.029	0.030	0.022	0.022	0.046	0.051	0.033
Validation Peri	68	47	105	41	-16	-28	44	0.029	0.033	0.013	0.015	0.043	0.069	0.034
Nitrate-Nitrite as N, mg/l								35%	37%	7%	46%	17%	28%	40%
Full	54	-19	-47	-28	-16	21	6	0.08	0.08	0.06	0.03	0.05	0.06	0.06
Calibration Per	96	0	-79	-72	-28	23	3	0.06	0.06	0.08	0.05	0.07	0.07	0.07
Validation Peri	24	-23	103	102	12	18	53	0.09	0.10	0.03	0.01	0.03	0.05	0.05
Total Kjeldahl Nitrogen as N, mg/l								0%	0%	0%	0%	0%	0%	0%
Full	-11	-2	12	10	33	31	10	0.96	0.83	0.76	0.72	0.67	0.62	0.76
Calibration Per	-8	-3	16	16	40	41	14	0.94	0.81	0.73	0.68	0.65	0.58	0.73
Validation Peri	-14	0	6	6	25	22	6	0.98	0.85	0.80	0.76	0.68	0.65	0.79
Total N - calculated, mg/l								Calculated parameter; percent less than RL not provided						
Full	-6	-4	7	8	29	30	10	1.03	0.90	0.82	0.75	0.72	0.68	0.82
Calibration Per	-3	-6	6	9	33	39	12	1.01	0.87	0.81	0.73	0.72	0.65	0.80
Validation Peri	-10	-3	8	8	24	22	8	1.06	0.94	0.83	0.77	0.71	0.71	0.84

Meeting the performance criteria is more difficult when concentrations are very low because a 35% pbias may be a difference of 0.01 mg-N/L (ammonia for example). Values in blue font are the percent of samples less than the reporting limit for the full period; note different organizations collected data in different segments.

Preliminary Draft Performance Criteria, 2/2, August 1st run

Average of pBias: August 1, 2022 Model Run								Average of ObsMean						
Segment:	**1**	**2**	**3**	**4**	**5**	**6**	**All**	**1**	**2**	**3**	**4**	**5**	**6**	**All**
Total Organic Carbon, mg/l								0%	0%	0%	0%	0%	0%	0%
Full	0	-3	8	3	17	11	3	8.1	8.1	7.6	7.8	7.5	7.2	7.7
Calibration Per	-2	-6	7	6	23	16	4	8.5	8.3	7.8	7.6	7.5	7.0	7.8
Validation Peri	2	0	10	2	11	7	2	7.8	7.8	7.3	7.9	7.6	7.3	7.6
Total Phosphorus as P, mg/l								30%	47%	0%	0%	0%	0%	20%
Full	-7	23	4	-3	-3	8	11	0.10	0.05	0.06	0.05	0.04	0.03	0.05
Calibration Per	-7	27	-3	-12	4	9	12	0.10	0.05	0.06	0.05	0.04	0.03	0.06
Validation Peri	-7	20	18	6	-10	6	13	0.09	0.06	0.05	0.05	0.04	0.03	0.05
Total Suspended Solids, mg/l								Calculated (TSS minus VSS) to correspond to simulation						
Full	-13	-37	2	-17	-8	-5	-8	19.5	13.9	6.2	5.0	3.1	2.2	8.3
Calibration Per	21	-30	0	-31	-17	-9	-7	16.7	12.6	6.2	5.5	3.2	2.2	7.7
Validation Peri	-32	-42	5	-4	-1	-3	-7	21.6	14.9	6.2	4.6	3.1	2.2	8.8
Chlorophyll-a, ug/l								0%	0%	0%	0%	0%	0%	0%
Full	-4	0	1	-18	-9	-4	-4	42.2	36.5	35.3	32.3	27.0	20.6	32.3
Calibration Per	12	22	15	-6	20	11	15	39.6	31.2	31.4	28.6	21.3	18.2	28.4
Validation Peri	-24	-18	-16	-31	-29	-23	-22	45.8	42.4	41.1	37.6	33.4	24.5	37.5

Values in blue font are the percent of samples less than the reporting limit for the full period; note different organizations collected data in different segments.

Review WARMF Modeling Results in the GUI Followed by MRSW Discussion

Note this calibration is not final.
We expect further refinements based on our discussion today

Potential WARMF Sensitivity Analyses

FY2023 Scope of Work

- “Following calibration of the models, sensitivity analyses will be conducted on a subset of global lake model parameters to evaluate the impact of variability or uncertainty in model inputs on the degree of calibration of the lake models and their results and conclusions.
- The modeling team will work with the UNRBA management team, PFC, Subject Matter Experts, and DWR to determine the parameters and ranges for evaluation with sensitivity analyses.
- The budget assumes that no more than $20,000 per model (WARMF or EFDC) will be expended for sensitivity analyses in FY2023.
- As the regulatory driver for the project is chlorophyll-a, this output parameter in Falls Lake will be the focus of the sensitivity analyses.”

Potential WARMF Sensitivity Analyses

- Scaling precipitation by 0.85 (all 78 stations) to see how sensitivity the model is to a dry to average hydrologic condition (compared to the calibration period that was average to wet) (can also test an increase)
- Scaling atmospheric deposition of nitrogen by a common factor to test the potential reductions due to increased air quality controls (can also test increases)
- Increasing or decreasing the sediment bed diffusion rate for each WARMF lake segment by a common percentage (high and low)
- Others?
  - Picking the mid-point or average of the segment specific rates not dealing with net settling/resuspension
  - Address concerns of local government with using the model to make decisions (assumptions, etc.)
  - Addressing other urban sources like pet waste or sewer exfiltration
- Will need to establish priority order to ensure we stay within the budget

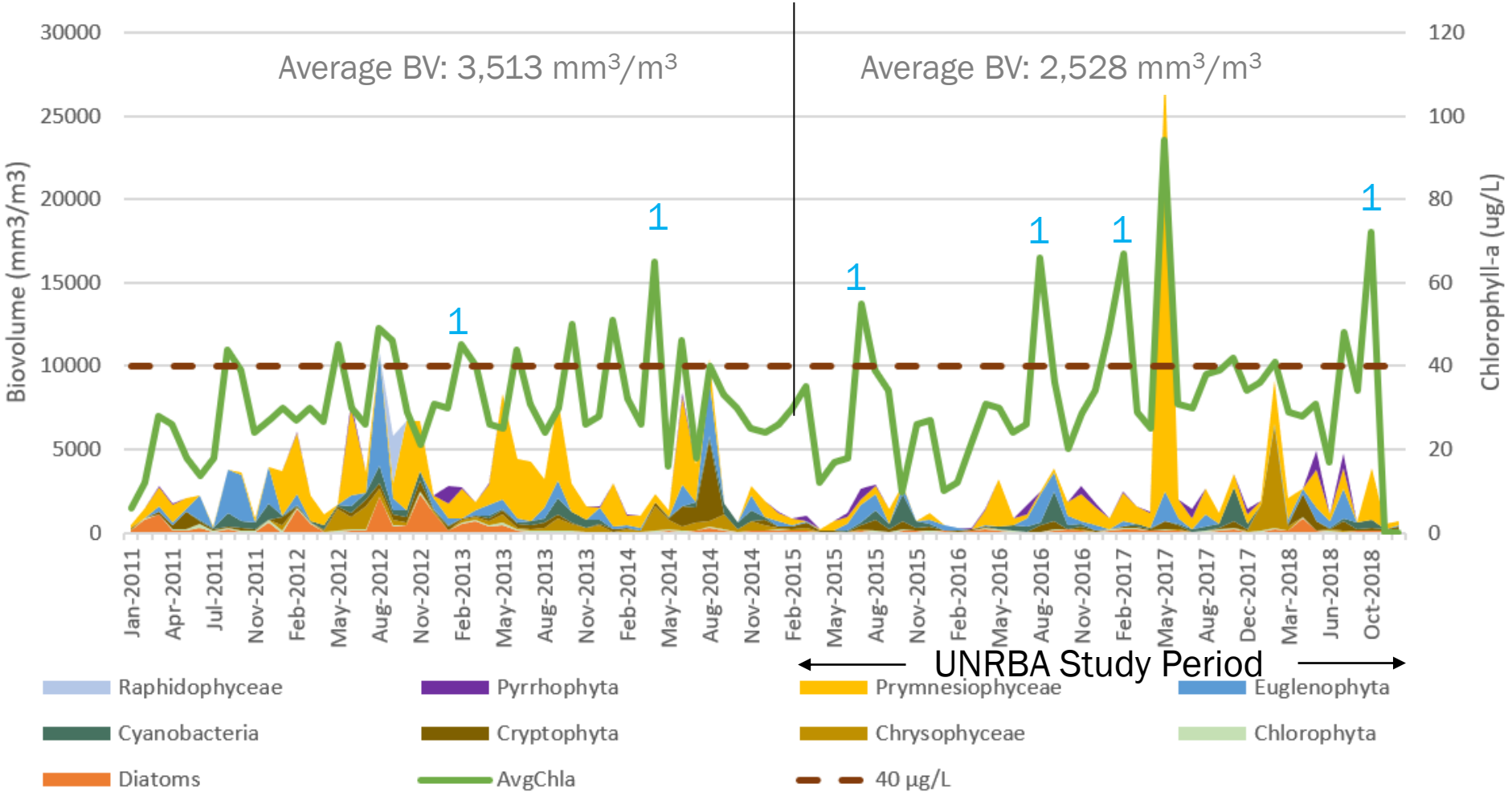
EFDC Lake Modeling Status

EFDC Lake Modeling Status

- During our last MRSW meeting, the modeling team described the challenges with the EFDC chlorophyll-a calibration with respect to the algal groups present in Falls Lake
- Discussed adding algal groups to the model to represent Prymnesiophytes and Euglenoids
- Consulted with local algal experts and the literature
- Sufficient data is not available to parameterize the models for these groups
- Modeling team has reverted back to the simulation of three algal groups and discussed the calibration challenges with the subject matter experts and DWR modeling staff
  - Both have requested additional information
  - Modeling team is compiling for review
  - Examples follow (additional information for the three stations with biovolume data will be provided to DWR and SMEs.)

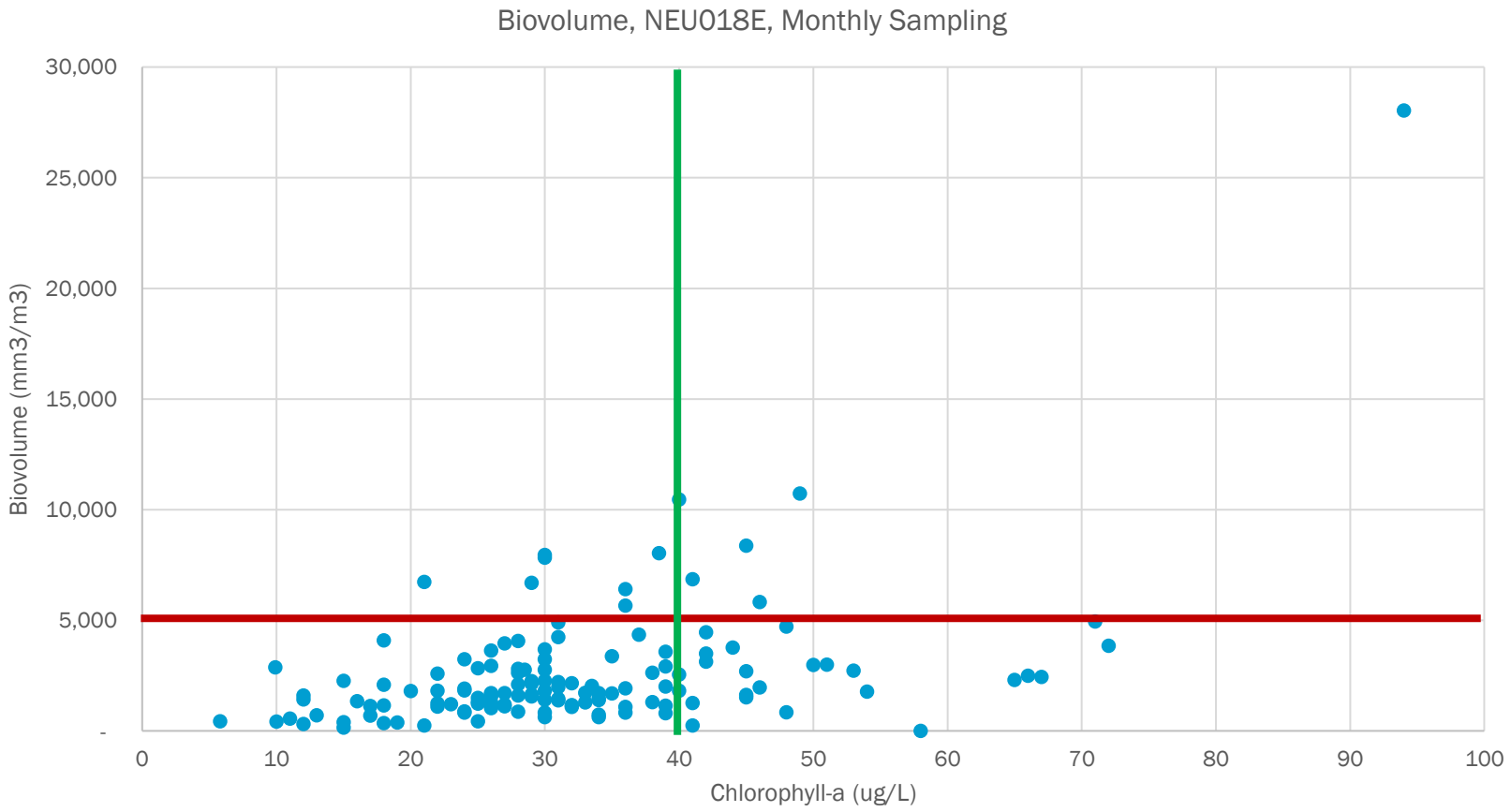
Time Series Comparison of Total Biovolume to Chlorophyll-a at NEU018E (midlake)

One of the items we've discussed with DWR and the SMEs is the comparison of total algal biovolume compared to chlorophyll-a. Sometimes high chlorophyll-a does not correspond to increased biovolume (1), and this situation is difficult to represent with a model.



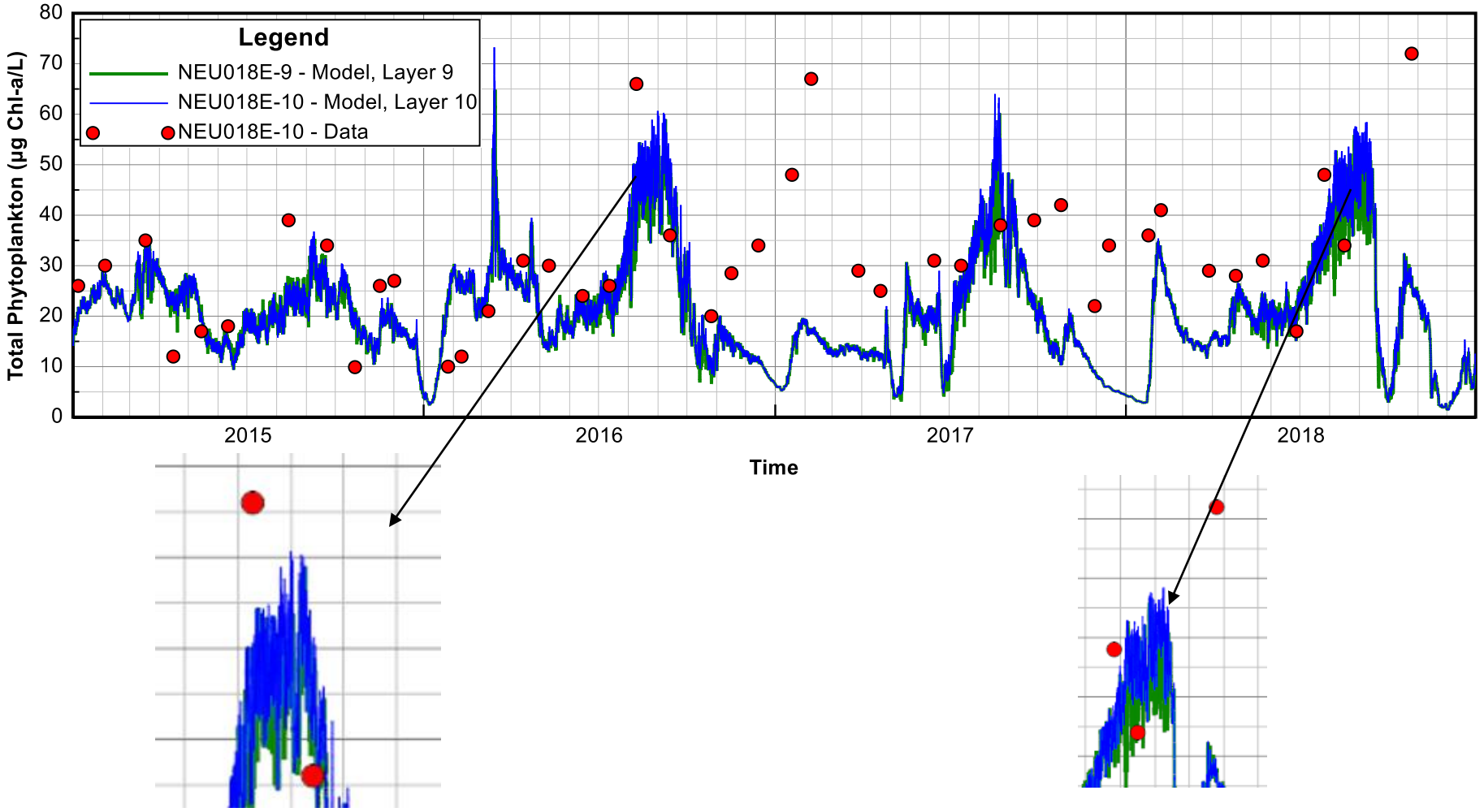
Scatter Plot Comparison of Total Biovolume to Chlorophyll-a at NEU018E (midlake)

DWR suggested we display this data as a scatter plot, shown below for this example station. A total biovolume of 5,000 mm^3/m^3 is the DWR threshold for a "bloom." 80 percent (22 of the 27) of the chlorophyll-a measurements over 40 µg/L occur when the biovolume is less than of 5,000 mm^3/m^3 .



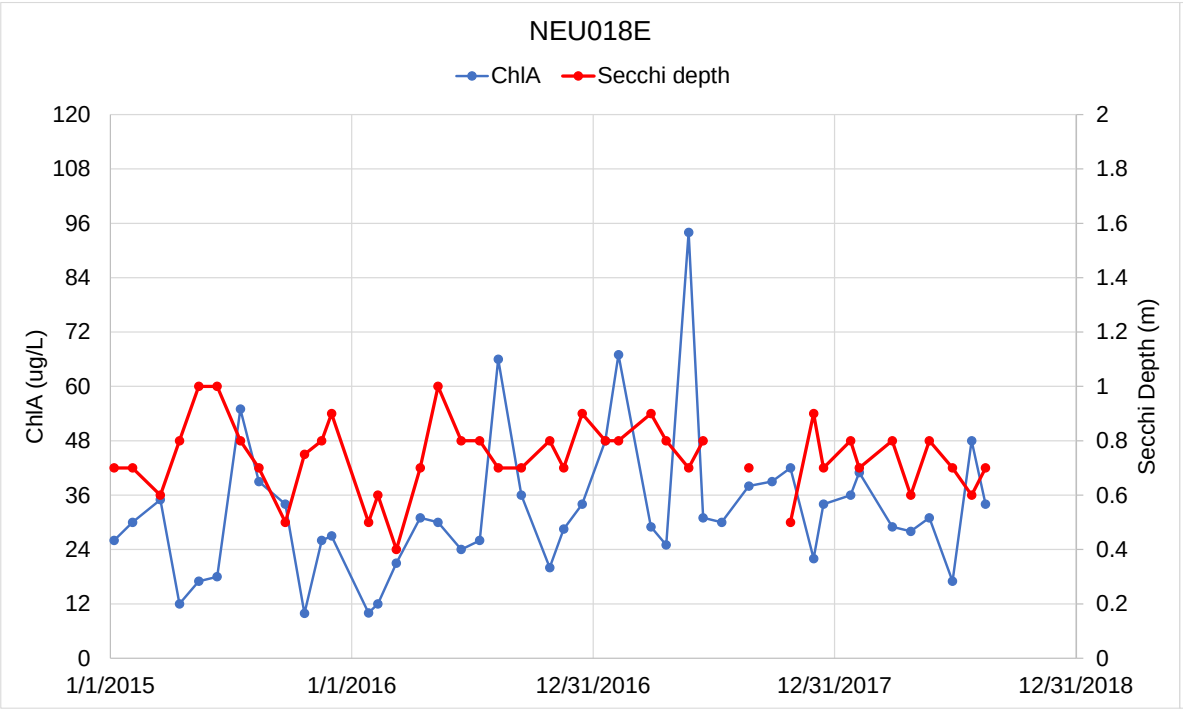
Preliminary Draft (June)– Model Simulation of Chlorophyll-a at NEU018E (midlake)

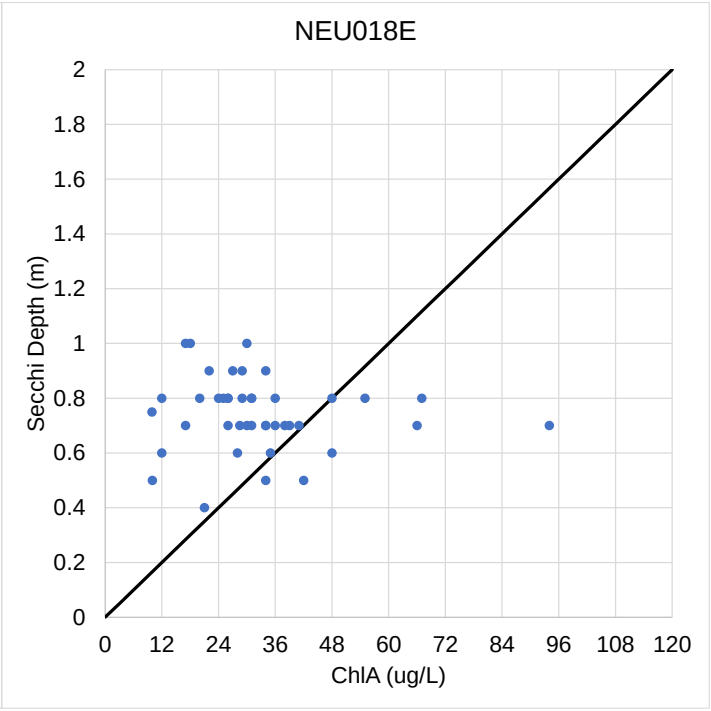
One suggestion was to display multiple layers on the simulation figure to determine if simulated concentrations were higher in the surface layer and would better match observations that may be affected by vertically mobile Prymnesiophytes. The top layer does sometimes have higher concentrations, but simulation challenges remain.



Comparison of Chlorophyll-a to Secchi Depth

There was also a suggestion to display chlorophyll-a and Secchi depth through time as a time series and scatter plot. Sometimes when chlorophyll-a is high, Secchi depth is low (as expected because more algae reduce light penetration). But this is not always the case. Secchi depth is affected by turbidity and background color as well.





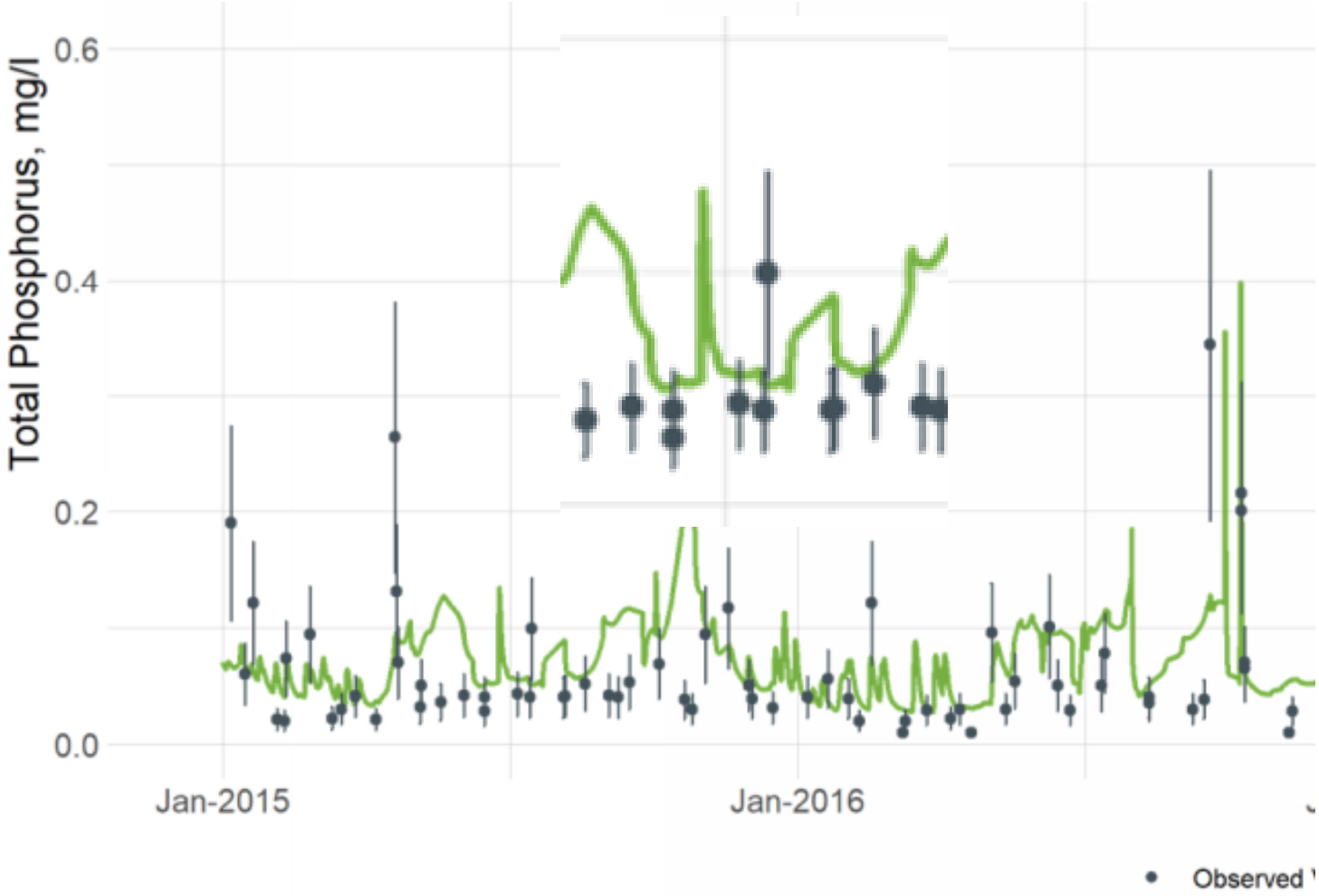
Lake Reporting Status

Lake Reporting Status

- The modeling team is continuing to draft sections and appendices of the lake modeling report.
- One of the questions that has come up regards the display of error bars around observations as shown in the watershed modeling report.
- While the UNRBA monitoring program collected the data that allowed us to add error bars specific to each water quality parameter, the sources of lake data (primarily DWR and CAAE) indicate they do not have the ability to evaluate this uncertainty.
- The lake data also includes data from multiple organizations at the same station which adds complexity.
- Options for addressing this issue will be discussed in terms of assumptions and level of effort

Example from the watershed modeling report

- Total phosphorus at the Eno River lake loading station



DWR and CAAE QAPP's

- These are the two largest sources of lake data, so these were evaluated first
  - DWR data is the calibration dataset for EFDC
  - WARMF Lake uses both datasets as well as City of Durham
- The DWR quality assurance project plan (QAPP) provides "example" targets for relative percent difference
  - Most nutrients <=10 percent
  - TKN, TSS and TOC <=20 percent
  - Chlorophyll-a was not listed
- CAAE QAPP listed a target RDP of 15 percent for all parameters
- The UNRBA Monitoring report estimated 95th percentile confidence intervals that were approximately twice the percent differences from the duplicates and these were used to visualize the uncertainty in the watershed model report

Options for Visualizing Uncertainty in the Lab Data

- Purpose is to illustrate that there is uncertainty around laboratory measurements; i.e., we are not comparing to exact numbers
- Simple options (modeling team recommends one of these)
  - Apply a single +- value like 30% to all parameters and all organizations
  - Apply a single +- value like 30% to all organizations but vary by parameter (20 to 40% depending in the parameter)
- Intensive option
  - Obtain the duplicate data for DWR, CAEE, and City of Durham
  - Evaluate uncertainty and 95th confidence intervals for each organization and parameter
  - Apply to each parameter/organization separately

MRSW Discussion

Statistical Model Development and Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal

Statistical/Bayesian Decision Tool Status

- The modeling team is continuing to compile data for use in the statistical/Bayesian/decision support tool
- The Technical Advisors Workgroup met on July 8, 2022, to review some of the data compiled and to discuss potential categories to classify data and evaluate changes
- We will summarize this discussion at the September 6, 2022, PFC meeting
- The modeling team will take this input and discuss with the topic experts to continue building the model

Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal

- The Executive Director met with the DWR Director on June 17th
- The Executive Director and UNRBA subject matter experts met with the DWR Director and the leadership team on July 25th
- Both meetings discussed a collaborative approach to
  - Finalize the models
  - Develop a revised nutrient management strategy
  - Develop a petition for site specific criteria
- The UNRBA will continue to work with other stakeholders on these items as well
- The subject matter experts continue to evaluate other State's site-specific standards for chlorophyll-a and nutrient-related standards
- Continue to coordinate with Dr. Marty Lebo to integrate his work into the statistical modeling and regulatory support efforts

Communications Outreach and Preparation

Communications Outreach and Preparation

- Continued engagement with DWR
- UNRBA Technical Stakeholder Workshop (see next slides)
  - Fall
- Workshop with DWR and UNRBA on how to run the revised WARMF Model with the new model GUI and functionality
  - Fall (perhaps the same week as the technical stakeholder workshop)
- Workshop with local government communications staff
  - Winter
- Workshop with DWR/NC Policy Collaboratory/NGOs
  - Spring
- Joint symposium with NC Policy Collaboratory
  - Summer

Planning for the UNRBA Technical Stakeholder Workshop (Fall 2022) – Part 1

- Watershed model
  - Overview of development
  - Model performance (summary table)
  - Nutrient loading summaries to Falls Lake by source
- Lake models
  - Overview of development
  - Model performance (summary table)
  - Water quality trends
- Scenario Evaluation
  - Scenario selection process and status
  - Results of “all forest/unmanaged land uses”
- Preliminary concepts for revised nutrient management strategy including input from the joint symposium with the NC Policy Collaboratory (April 2022)

Planning for the UNRBA Technical Stakeholder Workshop (Fall 2022) – Part 2

- Small group discussions and stakeholder feedback
  - Did anything you hear today surprise you?
  - How should new findings be incorporated into a revised nutrient management strategy for Falls Lake?
  - What preliminary concepts for a revised strategy do you like? Which concepts would you change and how?
  - What additional concepts for the revised strategy should be considered?
  - What level of engagement, if any, would you like to have in the development of the strategy? Please include your name, organization, and email address:
    - Active participant (attends work sessions, reviews draft products)
    - End-product reviewer (reviews near-final products)
    - Other (please describe other levels of engagement you are interested in)

Future Meeting Protocols

Future Meeting Protocols

- Based on feedback from the MRSW, PFC, and UNRBA Board, meetings will continue to be offered with a hybrid format.
- The Executive Director will continue to track conditions and coordinate changes as needed.

Closing Comments
Additional Discussion