Modeling and Regulatory Support Workgroup Meeting

Remote Access, October 5, 2021

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
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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
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Agenda

- Opening Comments, Agenda Review/Revisions
- Falls Lake Research Presentation
- Modeling and Regulatory Support Status
- MRSW Workgroup Reports
- Plan for Statistical Model Development and Regulatory Options for the Chlorophyll-a Water Quality Standard

Falls Lake Research Presentation

Falls Lake Research Presentation

- Dr. Michael O'Driscoll will present his research on estimating the influence of onsite wastewater treatment systems on nutrient loading to Falls Lake Watershed
- This work is important to the UNRBA lake modeling efforts that are currently underway.
- The presentation from the May 19, 2021 joint symposium and the interim report are available online at https://nutrients.web.unc.edu/2021-falls-lake-symposium/ and https://nutrients.web.unc.edu/resources/

Modeling and Regulatory Support Status

WARMF Watershed Model

- The WARMF watershed model has been calibrated and approved for developing the WARMF and EFDC lake models
  - MRSW approved on August 27, 2021
  - PFC approved on September 7, 2021
- Watershed modeling report is being drafted
- Sources of loading to Falls Lake are being identified by processing the model output

Coordination with Dr. Rick Luettich

- Dr. Rick Luettich presented his research on water movement in Falls Lake at the July 6, 2021, MRSW meeting
- The lake modelers met virtually with Dr. Rick Luettich and third-party reviewer Dr. Daniel Obenour on September 21, 2021, to simulation of water movement in Falls Lake
  - The EFDC hydrodynamic model is simulating the magnitude of bi-directional flows observed by Dr. Luettich
  - WARMF Lake is a simplified, segment-based model and water within a segment cannot move in different directions; modifying WARMF Lake to simulate bi-directional flow within a segment is not in the scope of the project and would be costly in terms of schedule and budget

EFDC and WARMF Lake Modeling

- Both models are transitioning to water quality calibration where the model parameters will be adjusted to provide a good fit to observed data
- Both models separate the water column into layers
- The depths of the layers within each model are consistent; to simulate deeper water, more layers are added
- Modeling team would like to review recommended approaches for comparing model simulations to water quality observations

DWR Ambient Lakes Monitoring Program (ALMP) Quality Assurance Project Plan

- Stations are established at lake center or main-stem to capture whole-lake water quality and at the mouths of tributaries suspected of contributing to water quality concerns in the lake
- Lake monitoring data generally show high variation due to natural conditions and management of the water level
- In the event of volume loss due to drought or significant drawdown for dam repair, at least one year for stabilization of the system is required following the return to normal pool levels before sampling is resumed

DWR Ambient Lakes Monitoring Program (ALMP) Quality Assurance Project Plan

- A Secchi disk is lowered into the water to the depth at which the disk is no longer visible, then raised to where it just becomes visible.
  - The average of these two depths is recorded as the Secchi depth.
- Algae can utilize light at lower levels than our eyes can detect
- The photic-zone is assumed the depth over which algae can grow and it is approximated as twice the Secchi depth.
- DWR collects photic-zone composites for chlorophyll-a, nutrients, total solids, suspended solids, turbidity, and phytoplankton measurements

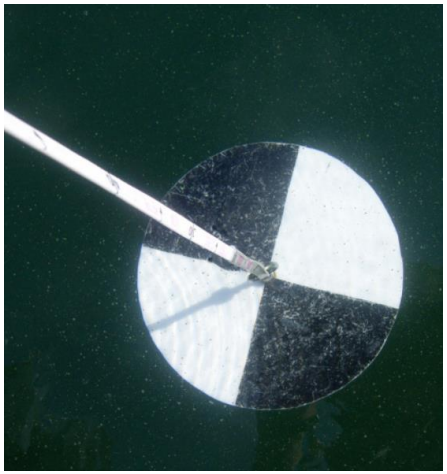
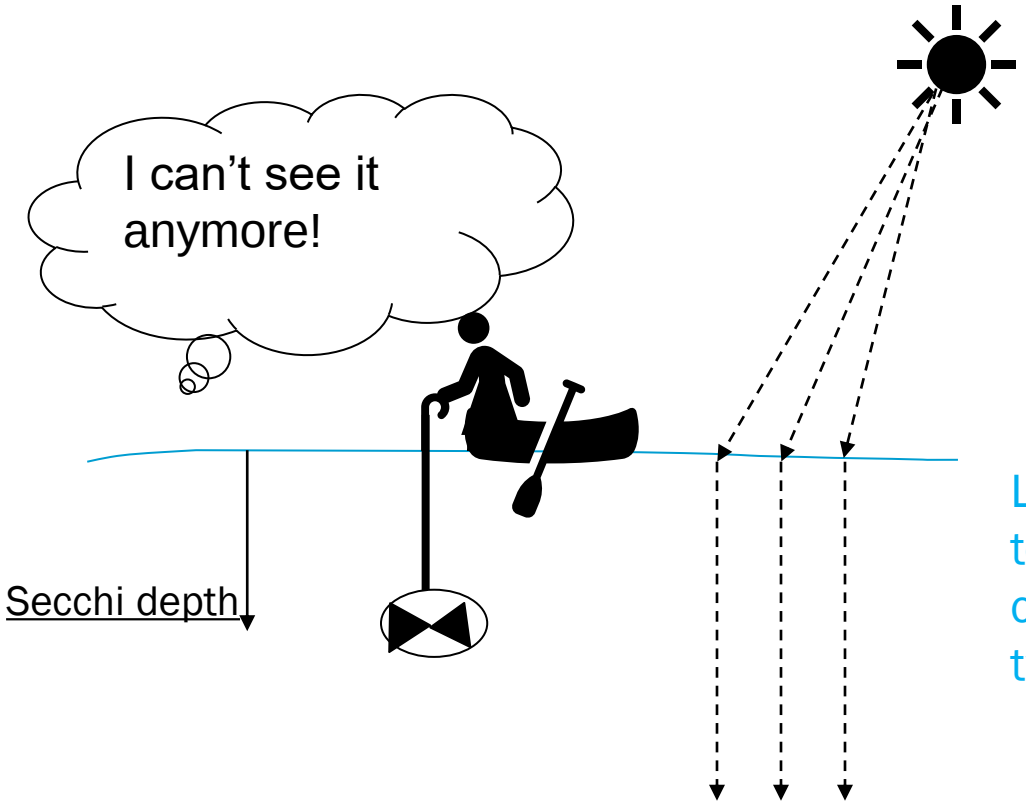
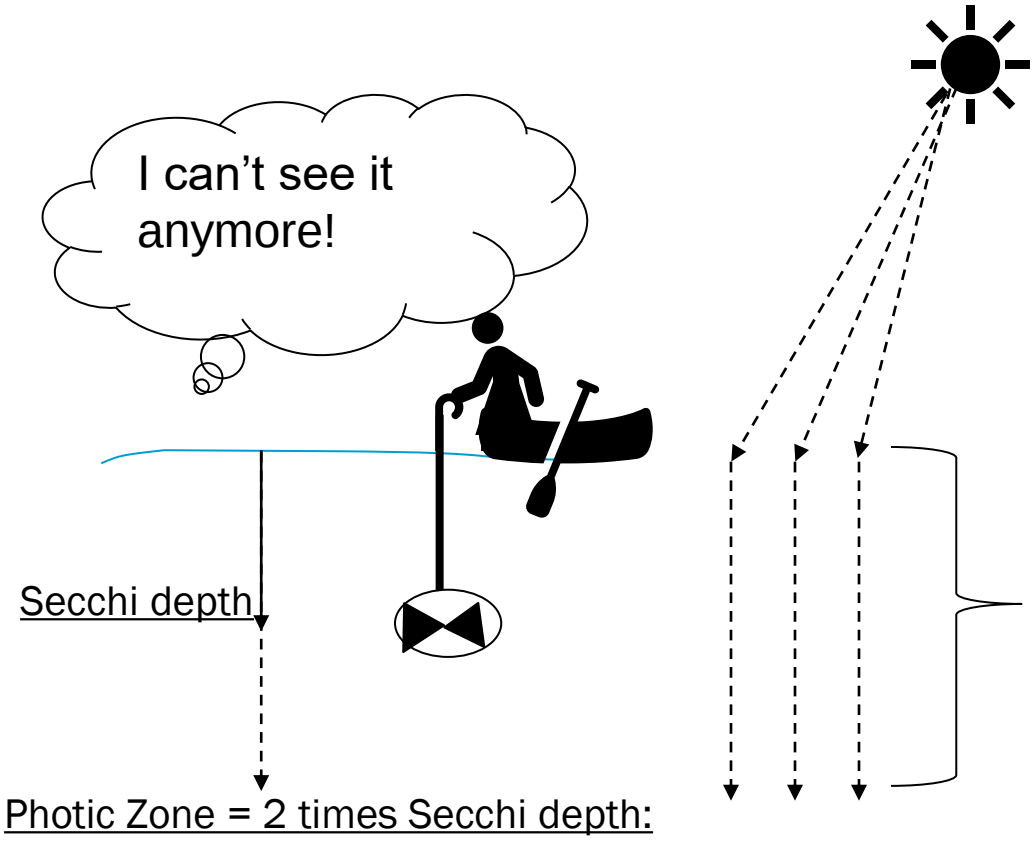


Illustration of Secchi Depth and Photic Zone



Light penetration sufficient to support photosynthesis can be approximated as twice Secchi Depth.

Illustration of Secchi Depth and Photic Zone

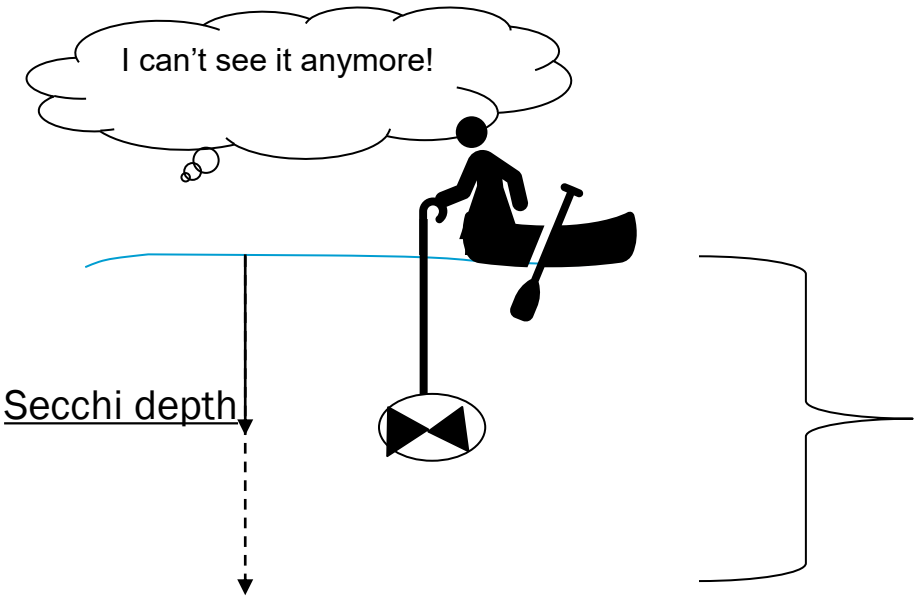


Nutrient, TSS, and chlorophyll-a samples are collected as composites from near the surface over the entire photic zone (i.e., photic-zone composites).

They do not represent water quality at a specific water depth so we may need to compare to more than one simulated layer.

Secchi depth can change at each location and on each sampling day.

Illustration of Secchi Depth and Photic Zone



Photic Zone = 2 times Secchi depth:
The sample is a composite from near the surface over the entire photic zone, it does not represent a specific water depth.

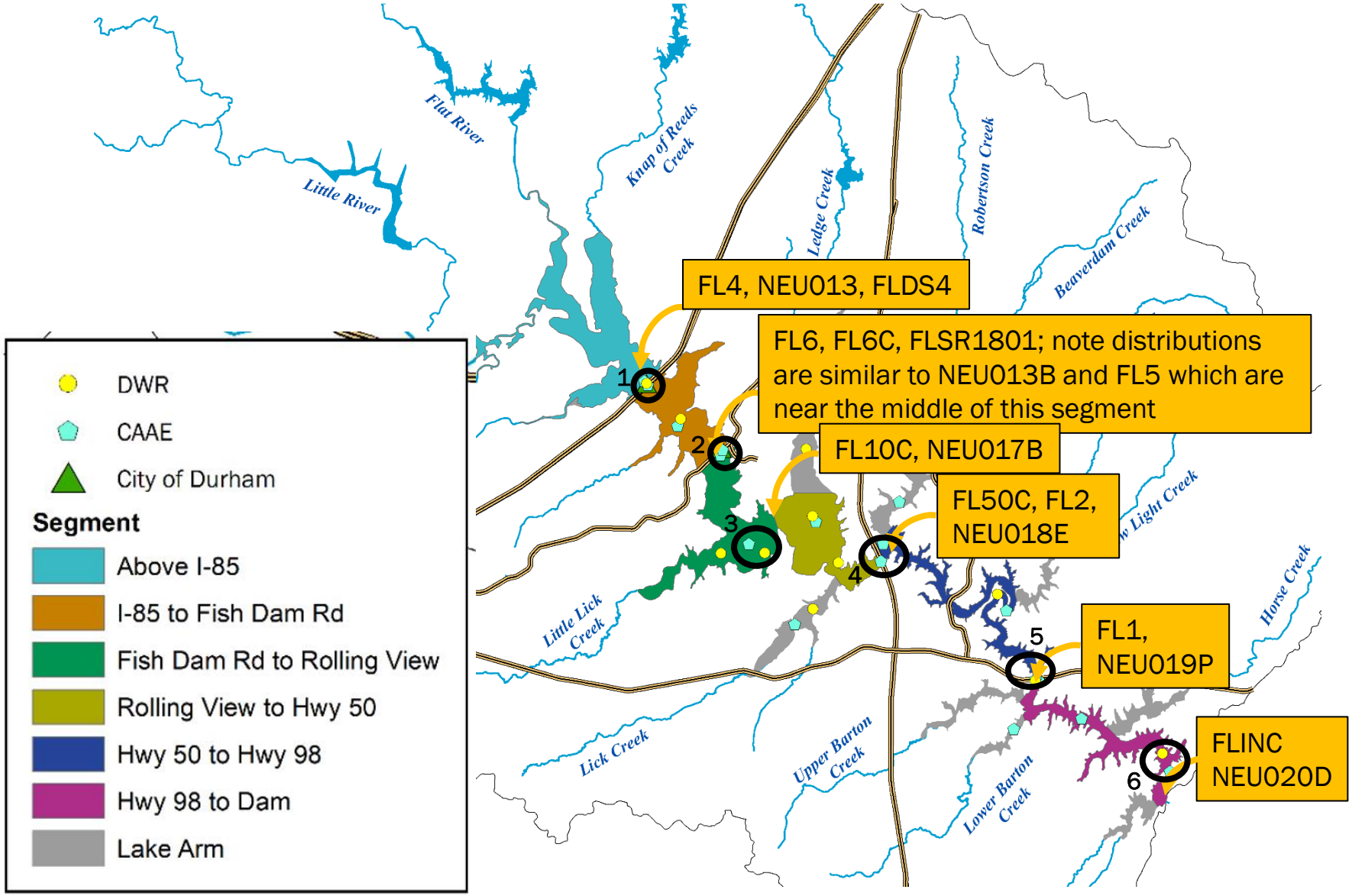
WARMF Lake and EFDC simulate the water column as several layers.

Each layer represents the average condition over the thickness of the layer.

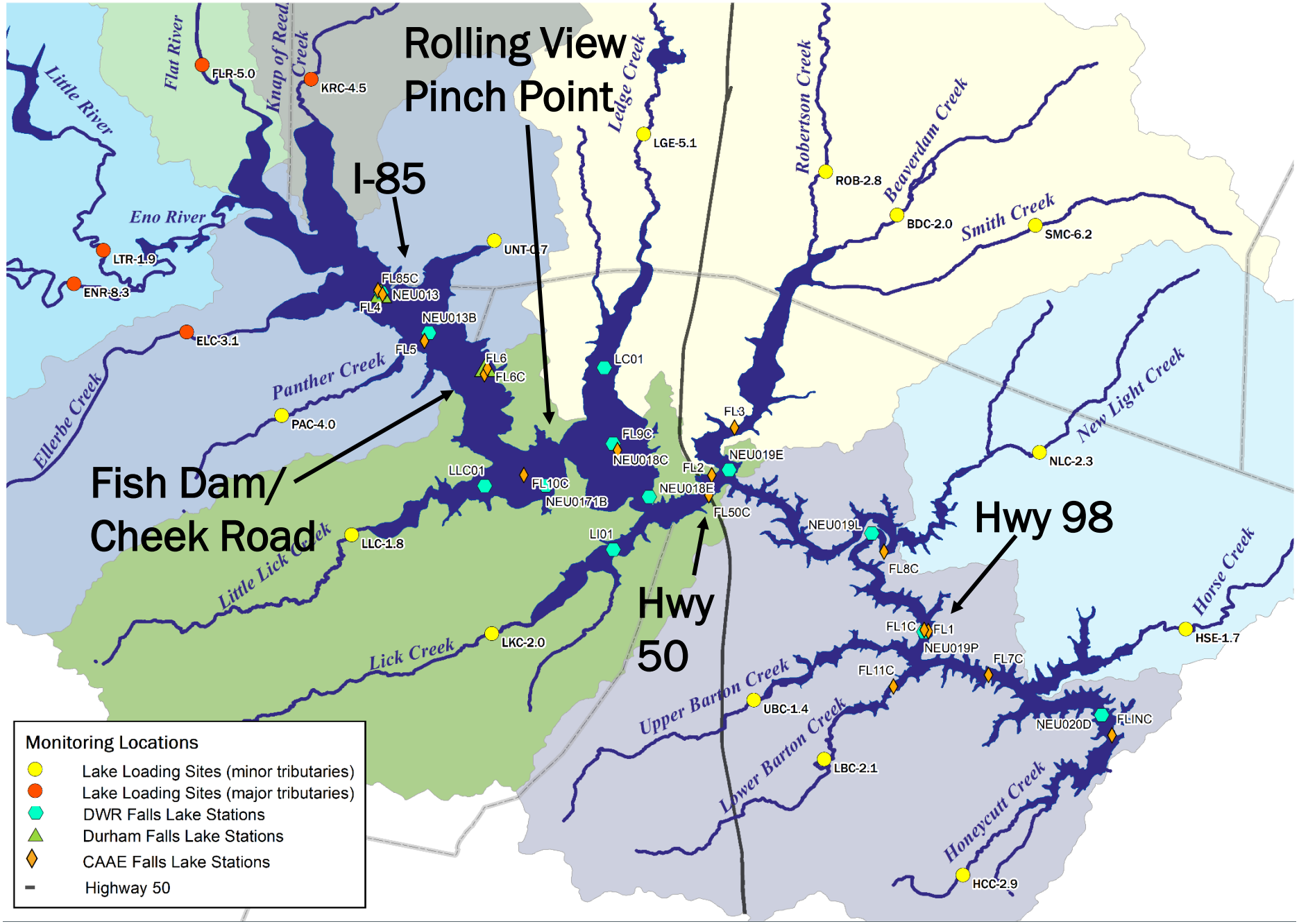
We need to compare the appropriate layer(s) to the water quality observation to calibrate the models.

WARMF Lake Layers

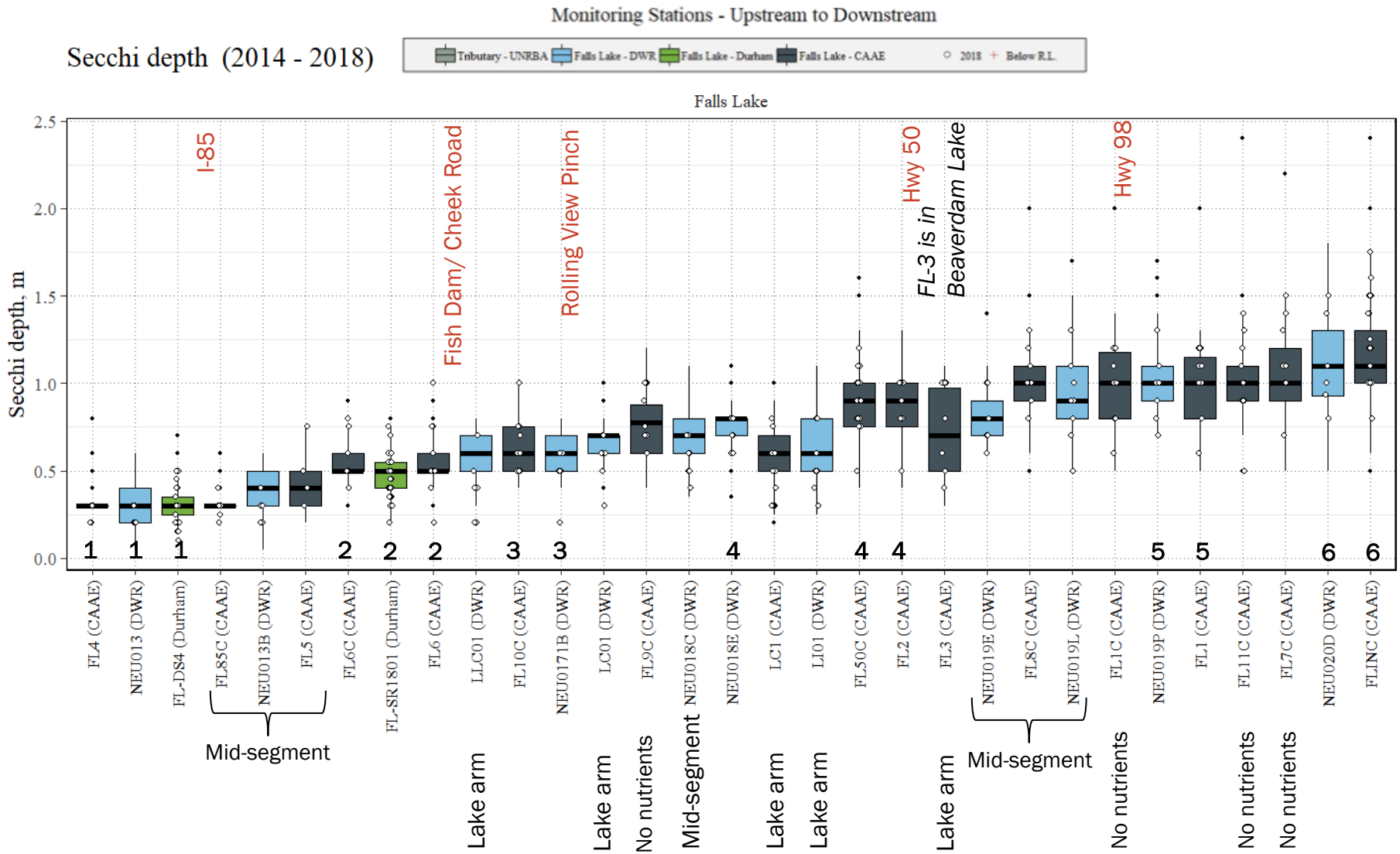
Water Quality Stations to Include in WARMF Lake Calibration (Mainstem, with QAPP)



Falls Lake Water Quality Monitoring Stations



The MRSW approved calibrating WARMF Lake segments to stations near the downstream end of each segment. Numbers above identify which stations correspond to which segments. Only stations along the mainstem with data collected under an approved QAPP where both nutrient and chlorophyll-a data were collected are used for calibration.



WARMF Model Simulation Layers

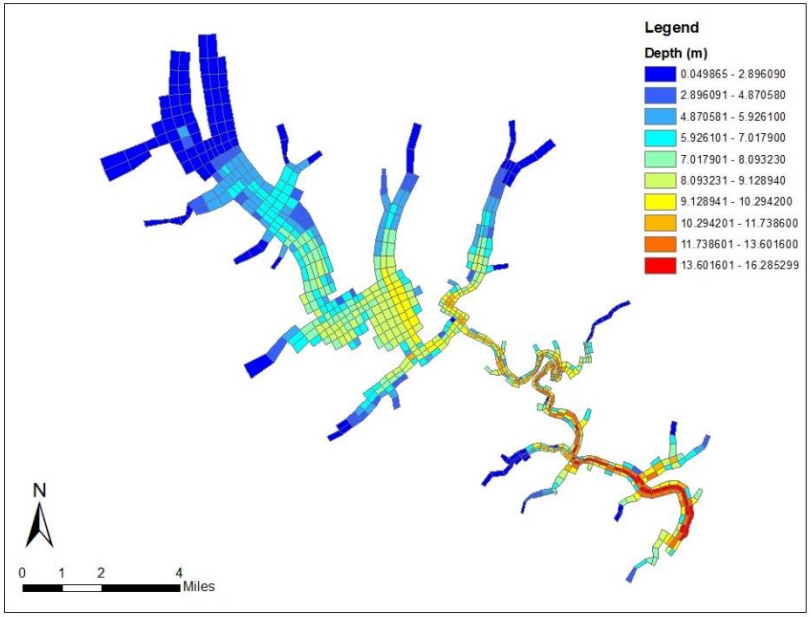
- Layers are ~ 0.75 meters deep
- The model shows output for **top layer** compared to observations (visual calibration) and this will be used to guide **preliminary calibration**
- Modelers recommends outputting simulated values for the top three layers (+1) and **averaging layers** according to the typical Secchi depth in that segment (75th percentile) for generating **performance criteria** and **finalizing calibration**
- MRSW discussion

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

EFDC Layers

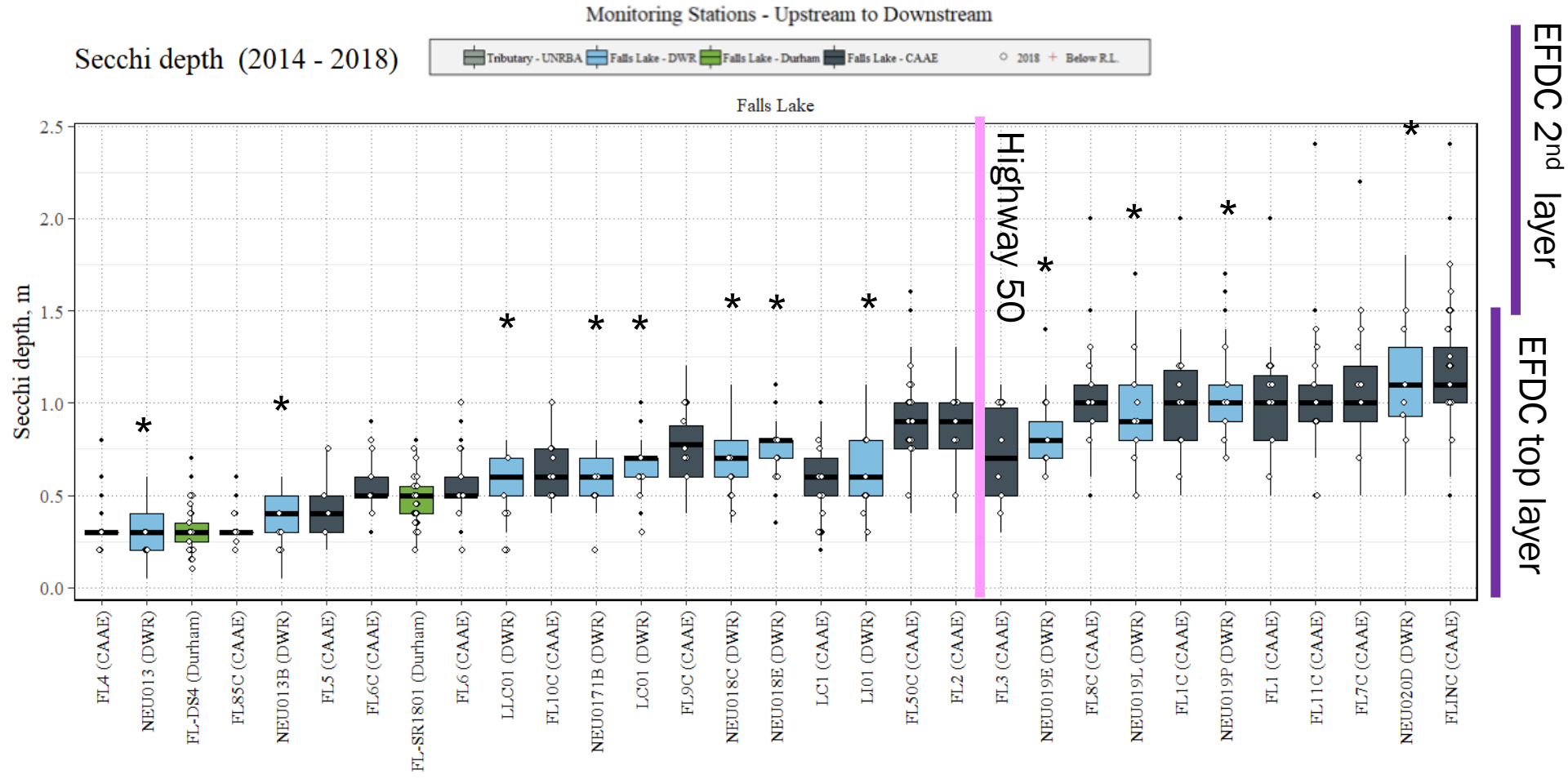
EFDC Model Simulation Layers

- The EFDC model grid contains 862 cells with 10 layers
- Layers are ~ 1.5 meters deep
- The model can be set to visualize output for multiple layers and show vertical profiles
- Observations can be displayed to aid visual calibration
- EFDC model will be calibrated to DWR monitoring locations per the UNRBA Modeling QAPP; other stations may be used for reference



Per the UNRBA Modeling QAPP, the EFDC model will be calibrated to the DWR lake monitoring stations. The "*" on the figure shows the approximate photic depth, twice the 75th percentile Secchi depth (i.e., two times the top of the box).

- Above Highway 50, the EFDC top layer contains the photic zone approximately 75 percent of the time.
- Below Highway 50, the photic zone is usually within the top two layers.



EFDC Recommendation

- For stations above Highway 50, compare observations to the model output for the top layer
- Below Highway 50, compare observations to an average of the top two layers
- MRSW discussion

MRSW Workgroup Reports

Status of Scenario Screening Workgroup

- Developing a selection process for choosing scenarios and a preliminary list of scenarios to evaluate
- The 7th meeting for workgroup was held September 20, 2021
- Two subgroups of this workgroup are working on scenario forms for scenarios preliminarily assigned a high priority

Plan for Statistical Model Development and Regulatory Options for the Chlorophyll-a Water Quality Standard

Statistical Modeling Framework

- Designed to incorporate many types of data, information, and expert knowledge
- Inform decision making using a structured tool
- Test management scenarios for impacts
  - Loading
  - Lake water quality
  - Designated uses
- Understand the relationships among parameters (e.g., if “this” goes up, what is the likelihood “that” will go up?)

Falls Lake Information Overview

Inputs to Falls Lake

- Inflow volume & timing
  - USGS flow gauge data
  - Wet vs. dry conditions
  - Storm events
- Concentrations (or loads) of nutrients, sediment, organic matter in inflows
  - Local watershed and lake data
  - Management scenarios based on WARMF watershed model
  - Empirical estimates using historic data
- Climate
- Atmospheric deposition
- Lake outflows and withdrawals
  - USGS flow gauge data below the dam
  - City of Raleigh withdrawal data

Water quality & processes in Falls Lake

- Organic Carbon
  - Particulate/Dissolved
  - Watershed/Algal
- Dissolved Oxygen
  - Surface/Hypolimnetic
  - Spatial extent of anoxia
  - Percent of time or percent of volume hypoxic, anoxic
- Nitrogen
  - Inorganic/Organic
  - Sediment release
  - N-fixation, denitrification
- Phosphorus
  - Particulate/Dissolved
  - Sediment release
- Algae
  - Chlorophyll-a
  - Species Composition
  - Biomass
  - Toxin release
- pH
- Clarity (Secchi Depth)
- Residence time
- Temperature

Water Quality Standards

Designated Uses

- Safe drinking water
  - Taste, Odor
  - DBPs
  - TOC removal
  - Filter clogging
- Aquatic Life
  - Dissolved Oxygen
  - Fish Kills
- Recreation
  - Fishing (DO stress, food)
  - Swimming (pH, algal mats, odor, clarity)
- Flood control

WQ Criteria

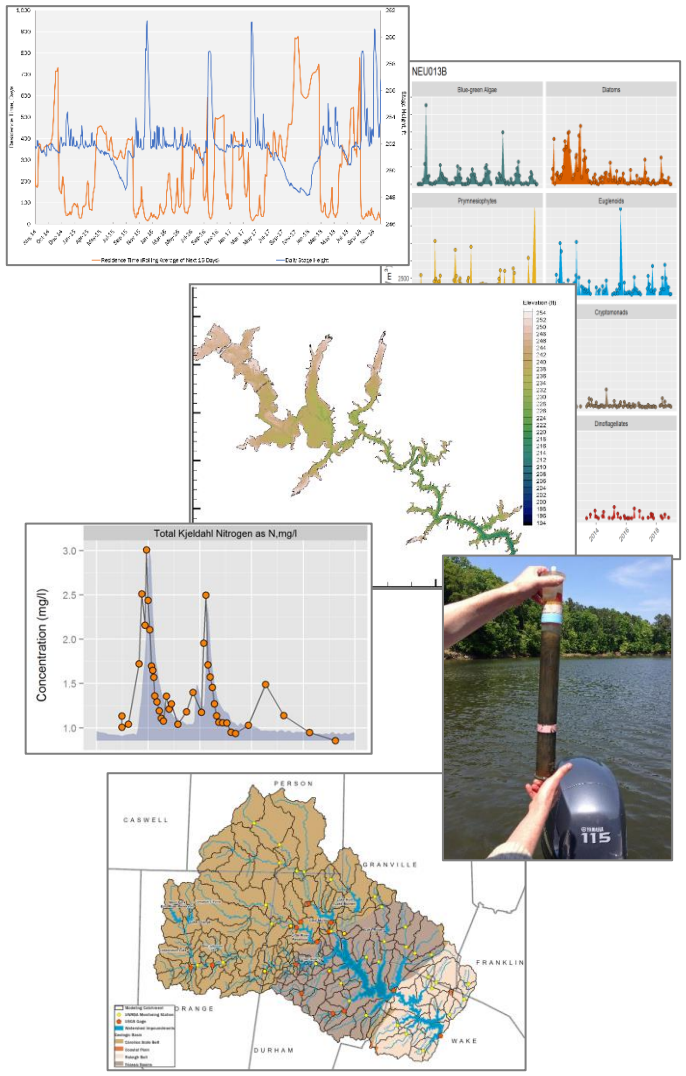
- Dissolved oxygen
- pH
- Chlorophyll-a
  - 90th percentile
  - Geomean
  - Arithmetic mean
- Total organic carbon (SDWA)

Data and WARMF/EFCD Model Driven

Probabilistic/Bayesian Predictions

Falls Lake is the Most Studied Reservoir in NC

- Watershed stream flow and water quality data and lake water quality data
  - UNRBA, USGS, DWR, local governments, CAAE
- Lake bathymetry, water movement, stage
  - UNRBA, UNC Collaboratory, USACE
- Lake sediments, special studies
  - UNRBA, UNC Collaboratory, EPA, DWR
- Loading estimates to the lake
  - WARMF, 2019 Monitoring Report (LOADEST and GAM)



USGS: U.S. Geological Survey, DWR: Division of Water Resources, CAAE: Center for Applied Aquatic Ecology, WARMF: Watershed Analysis Risk Management Framework GAM: general additive models

Local Data Sets Acquired

- Tributary water quality data
  - UNRBA monitoring data (2014 to 2020)
  - DWR and USGS data (1983 to 2020)
  - Other organizations (1999 to 2011 (Task 2 report))
- Tributary flow data
  - USGS
- Lake water quality data collected under an approved QAPP
  - UNRBA supplemental parameters (2014 to 2018)
  - DWR data (1983 to 2020)
  - CAAE (2016 to 2018)
  - City of Durham (2015 to 2018)
- Lake levels
  - USGS

National Data Sets Acquired

- National Aquatic Resource Surveys National Lakes Assessment (NARS-NLA) (2007, 2011, 2017)
  - Basin characteristics (land use, drainage area, elevation)
  - Lake origin (natural or man made)
  - Hydrologic characteristics (residence time, evaporation-inflow ratio)
  - Water chemistry and field parameters (pH, DO, nutrients, chlorophyll-a, dissolved organic carbon, color, etc.)
  - Mean dissolved oxygen in upper 2 meters
  - Zooplankton, benthic macroinvertebrates, algae counts by species, cyanobacteria density
  - Microcystin
- National Eutrophication Survey
  - Similar but less complete information
  - Data collected in the 1970s

National Data Sets Requested

- One Health Harmful Algal Bloom System (OHHABS)
  - Human illnesses caused by HABs (gastrointestinal, headache, fever, rashes, or itchy skin)
  - Animal illnesses caused by HABs (lack of energy, loss of appetite, weakness, gastrointestinal, neurologic
  - Environmental data about HABs
    - Confirmed or suspected event
    - Waterbody type
    - Toxin type and concentrations
    - Algal species
  - Contact type (swallowing, eating contaminated food, breathing in, or having skin contact)

Loading Models to Falls Lake

- General Additive Models developed for the 2019 Annual Monitoring Report for
  - Nutrient species, carbon, flow
  - 1980s to 2020
  - Ellerbe, Eno, Flat, and Knap of Reeds
- WARMF model simulations
  - Nutrient species, carbon, flow, chlorophyll-a
  - 2015 to 2018
  - All tributaries
- LOADEST models (may be incorporated)
  - Total nitrogen, total phosphorus, total organic carbon
  - 2015 to 2018
  - All tributaries

Next Steps

- Meet with CDC staff to discuss project purpose and hopefully obtain OHHABS data
- Meet with local experts to discuss available information on satisfaction with designated uses
  - Contact list has been finalized (can be expanded)
  - Small group meetings by designated use are being scheduled
- Continue compiling data and models to begin model building

Closing Comments
Additional Discussion