

# In Situ Observational Study of Water Circulation and Associated Properties in Falls Lake, North Carolina

Rick Luettich, Tony Whipple, Crystal Fulcher

UNC-CH Institute of Marine Sciences

Harvey Seim

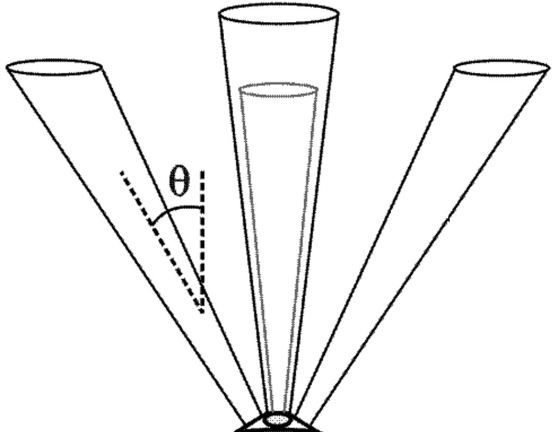
UNC-CH Department of Earth, Marine and Environmental Sciences

# Research Questions

- What are the primary circulation pattern(s) in Falls lake?
  - time-scales shorter than long-term averages and longer than a few hours
- How does along lake circulation vary (Years 1-2)
  - Inflows / Outflows
  - Physical Properties
  - Seasons
- What circulations connect the large tributary arms upstream of Highway 50 (Little Lick, Ledge and Lick Creeks) to the main channel of the lake? (Year 3)
- Implications for Water Quality
  - Localized velocities may affect localized water quality

# Instrumentation

- Year 1-2: November 2019 – February 2021
- Year 3: September 2021 – October 2022

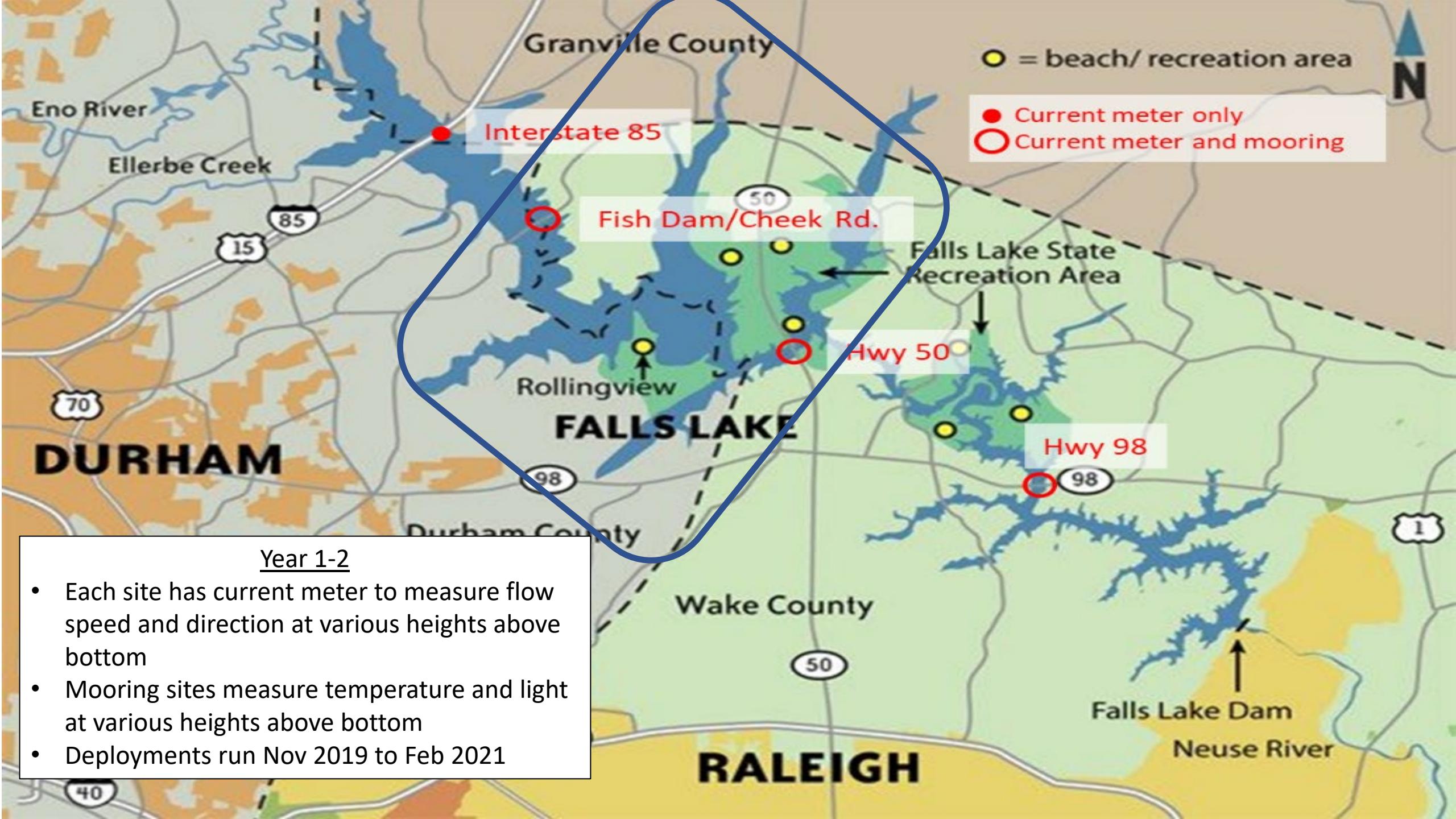


- Water Temperature & light moorings @ 0.5 m vertical spacing – every 6 min

- Water velocity @ 0.5 m vertical resolution – every 10 min







Year 1-2

- Each site has current meter to measure flow speed and direction at various heights above bottom
- Mooring sites measure temperature and light at various heights above bottom
- Deployments run Nov 2019 to Feb 2021

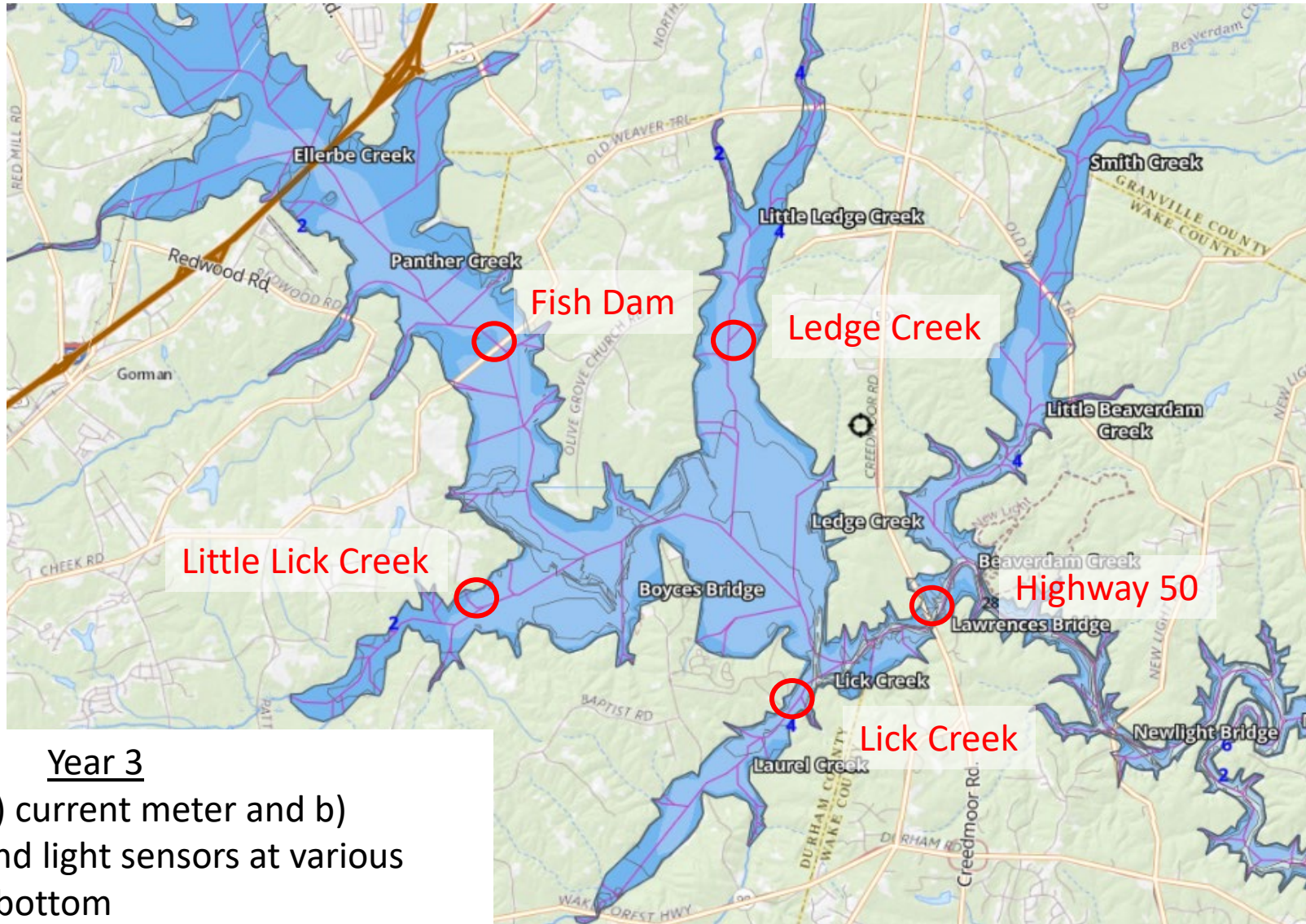
# Key Findings – Year 1-2

Much more complete picture of circulation in Falls Lake

- Median residence time ~11 months
- Along lake flow responds to inflows, dam operation, wind
  - Upper lake flows respond most strongly to inflows
  - Lower lake flows respond most strongly to dam outflow
  - A 5.5hr oscillation frequently occurs along the lake
  - Two-layer flow in lower lake ~40% of the time, occurs when temperature stratified



# Year 3 – Central Lake and Side-arms

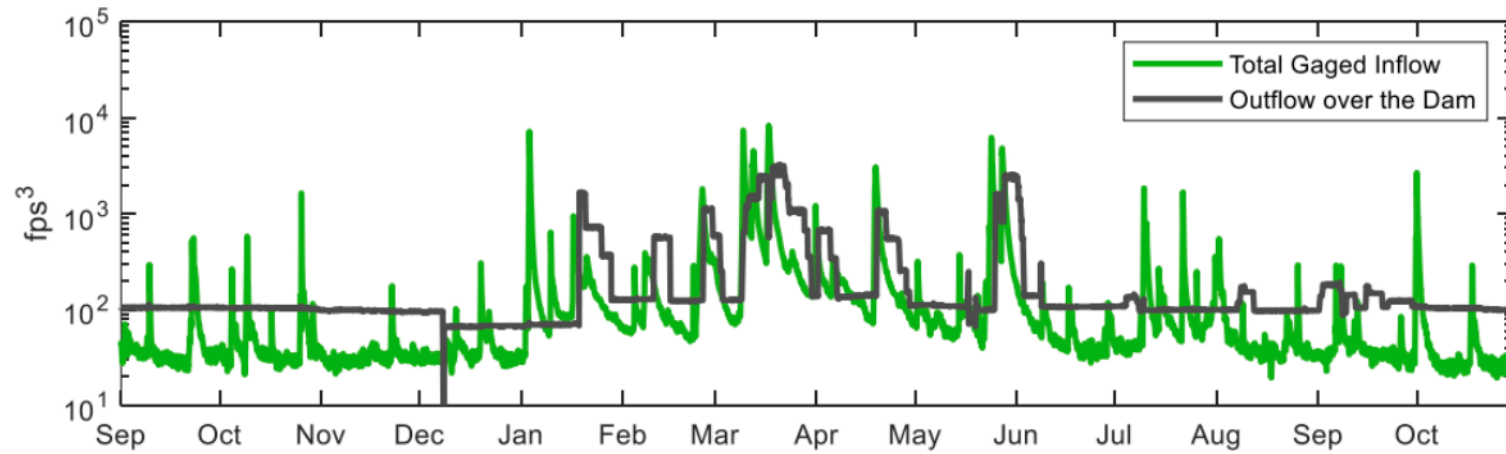


## Year 3

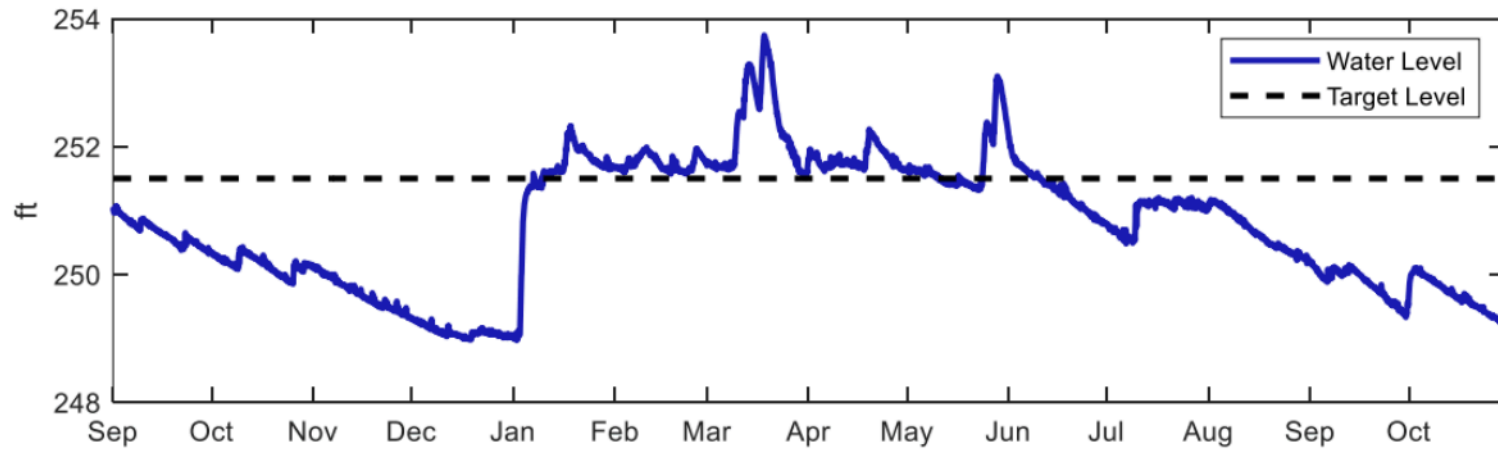
- Each site has a) current meter and b) temperature and light sensors at various heights above bottom
- Deployments run Sep 2021 to Oct 2022

Conditions during year 3 sampling – no extreme discharge events, rather dry (lake level below target)

Inflow to the lake  
Outflow over the dam



Lake water level



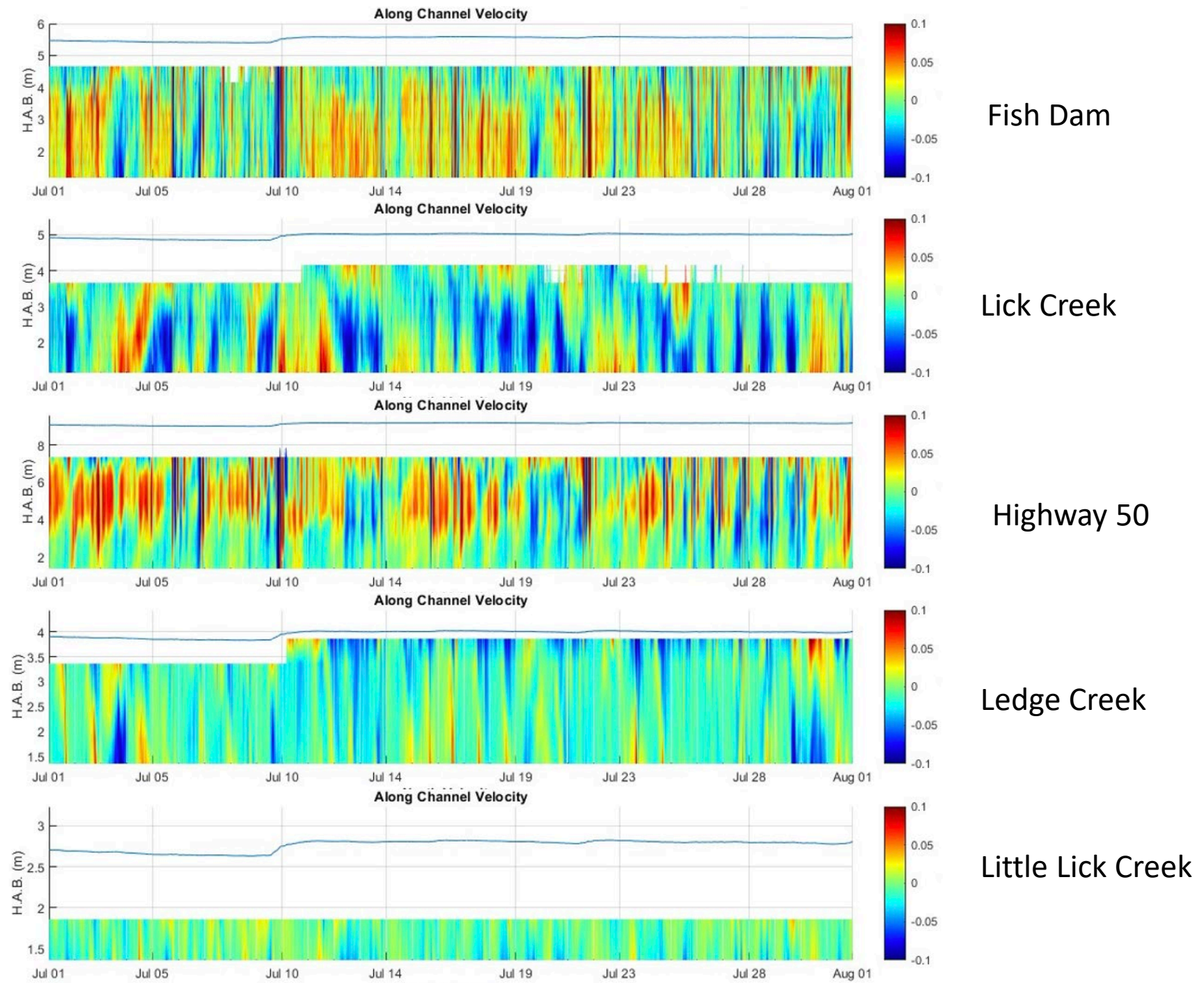


**Along-channel currents** (**positive** values toward the dam) during July 2022 when lake is stratified.

Note: Fish Dam and H50 records similar (dominantly downstream, few hour and daily fluctuations).

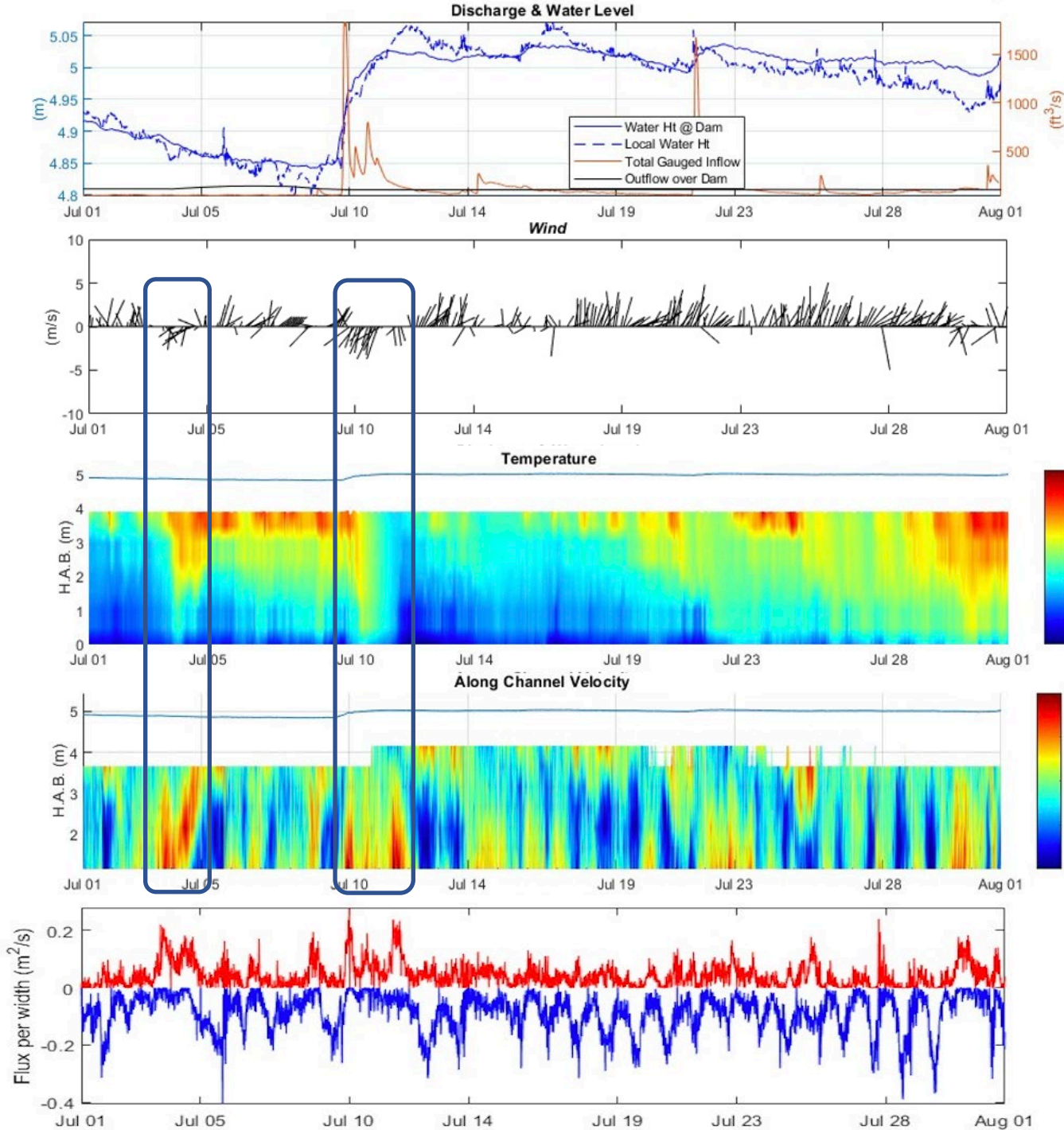
Lick, Ledge and Little Lick different from each other and main channel records.

Lick daily fluctuation clear, less pronounced at Ledge and Little Lick





Relationship of currents to wind and discharge in **Lick Creek** during stratified conditions. The winds appear to explain the strongest flows. There is little response to the discharge events.



Water level, inflow

Winds

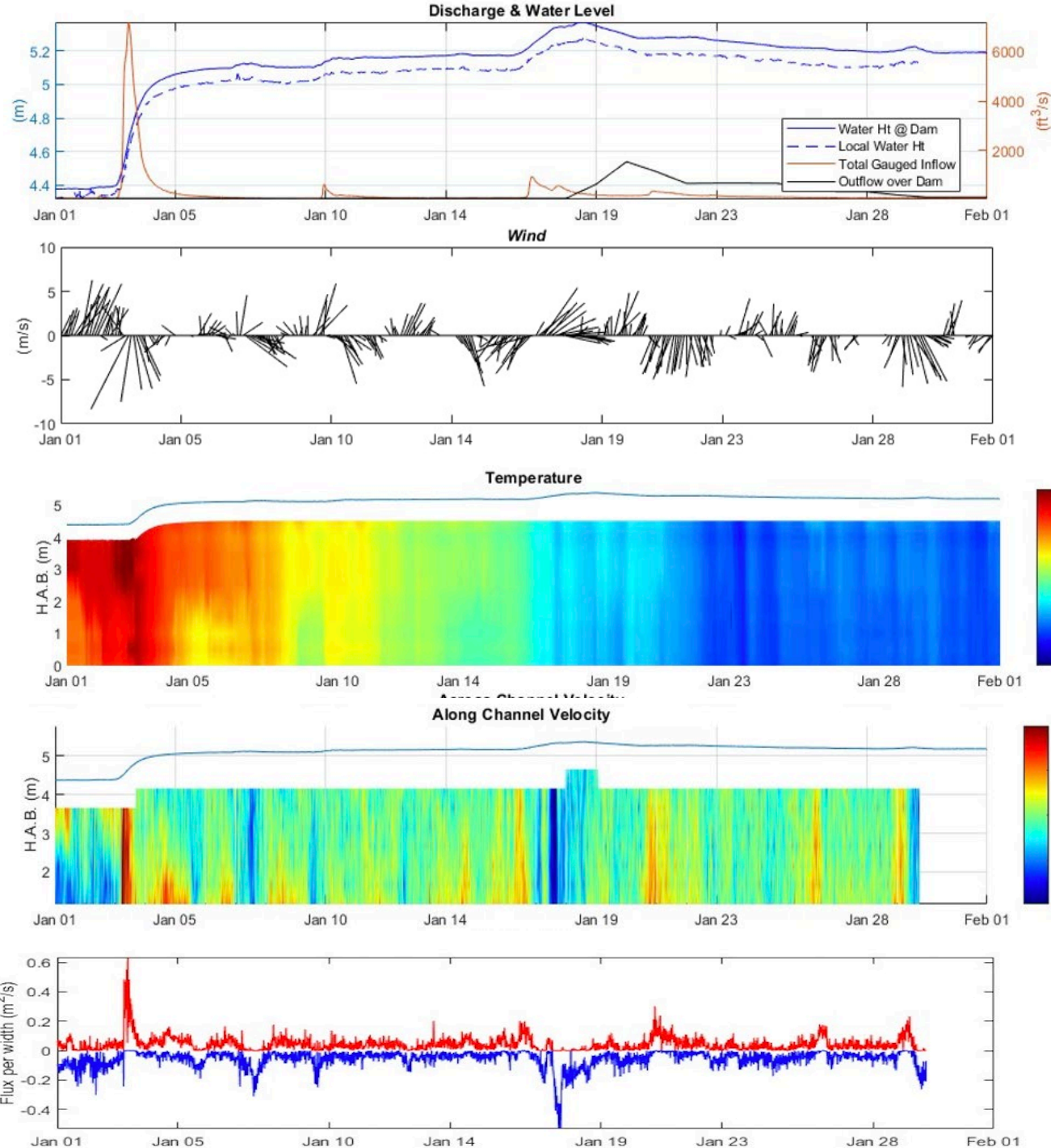
Water temperature vs. depth

Along-channel current vs depth

Transport/unit width  
 Toward main channel  
 Away from main channel

Relationship of currents to winds and discharge in **Lick Creek** during unstratified conditions. Currents are noticeably weaker, with the strongest events occurring during a discharge event and a strong wind event.

Total export in July (last slide) is roughly **twice** what occurred in January (this slide), indicating more exchange during stratified conditions than during unstratified conditions



Water level, inflow

Winds

Water temperature vs. depth

Along-channel current vs depth

Transport/unit width  
 Toward main channel  
 Away from main channel

# Key Findings – Year 3

- During stratified conditions winds drive exchange between the tributaries and the main channel. Circulation is strongest in Lick Creek, intermediate in Ledge Creek and weakest in Little Lick Creek. All exhibit daily period fluctuations
- During unstratified conditions less exchange occurs (half as much?), and strong exchange events are more episodic and associated with strong wind or discharge
- The tributaries do not participate in the 5.5 hour along-channel seiche

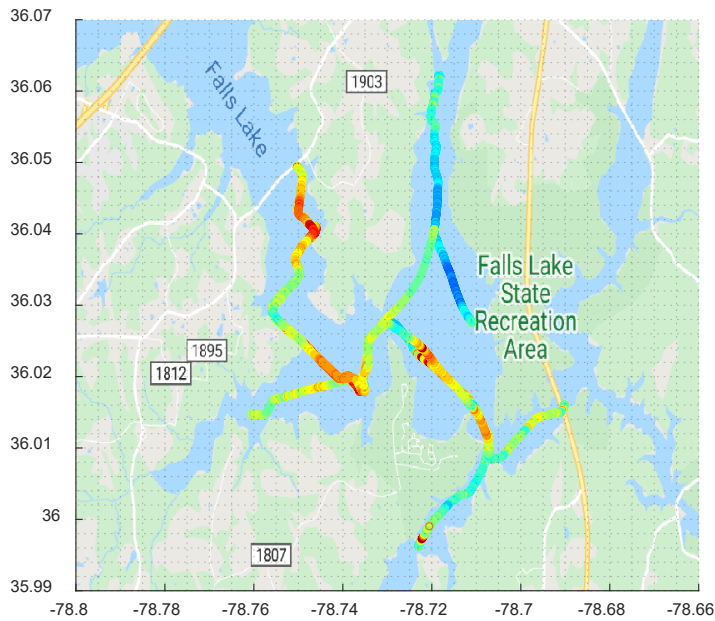


# Summary Statement

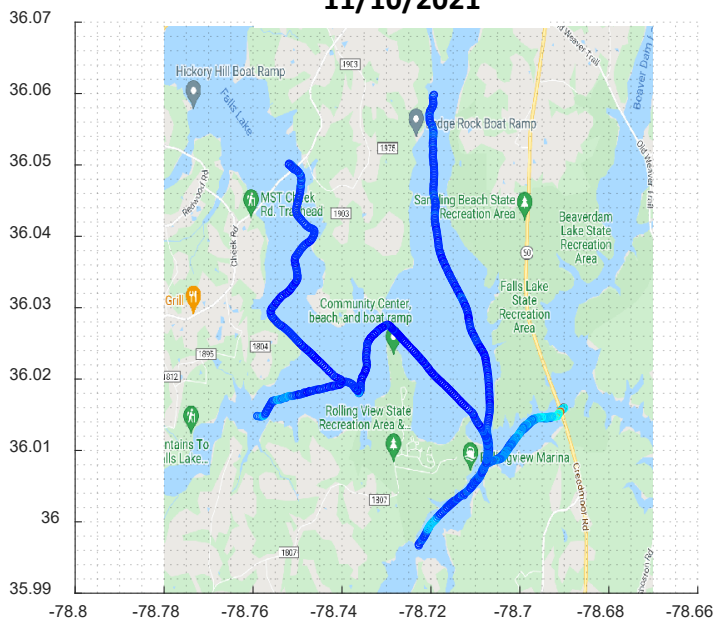
This study has provided a more complete picture of the circulation in Falls Lake than has previously been available. Along-lake flow responds to inflows and discharge over the dam; long-term median residence time in the lake is a bit less than a year, although this can vary substantially depending on the size of inflows and discharge. A lake-wide 5.5hr along-lake oscillation and two-layer flow in the lower lake (surface water moving down wind and bottom water flowing in reverse) are often present and may be dominant when the along lake flow is small. Exchange between the largest side-arms and the main channel is largely wind-driven. During stratified conditions daily period fluctuations are common and most energetic in Lick Creek. Exchange is weaker and more episodic during unstratified conditions.

*in vivo* fluorescence ( $\mu\text{g/l}$ ) from  
underway shipboard sampling

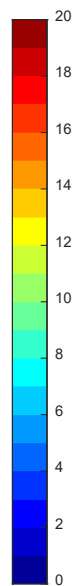
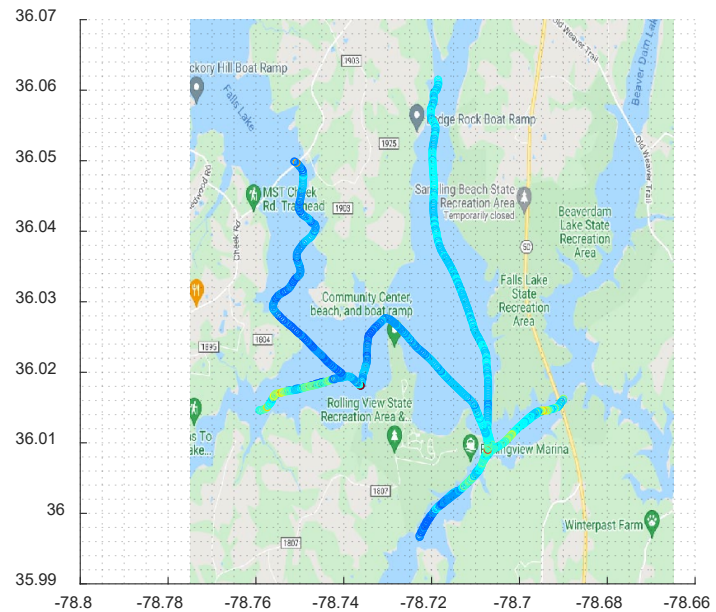
9/14/2021



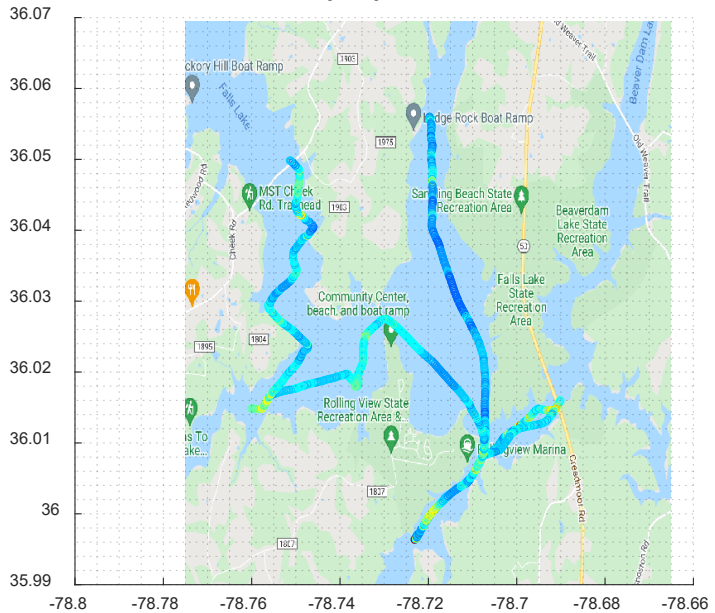
11/10/2021



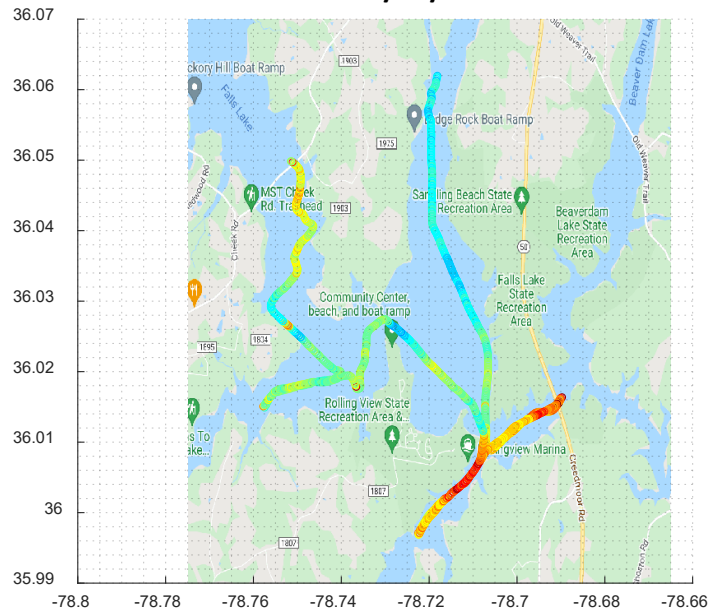
2/2/2022



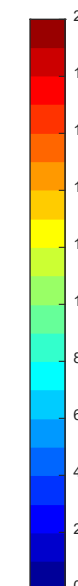
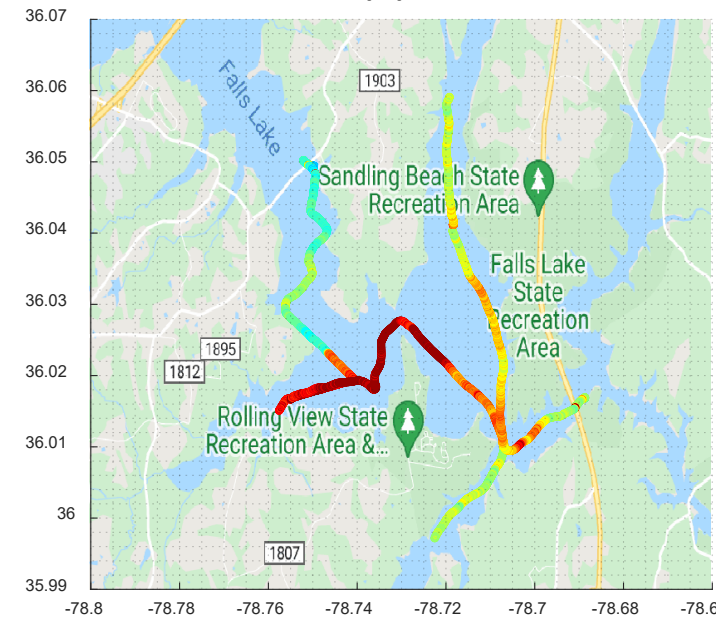
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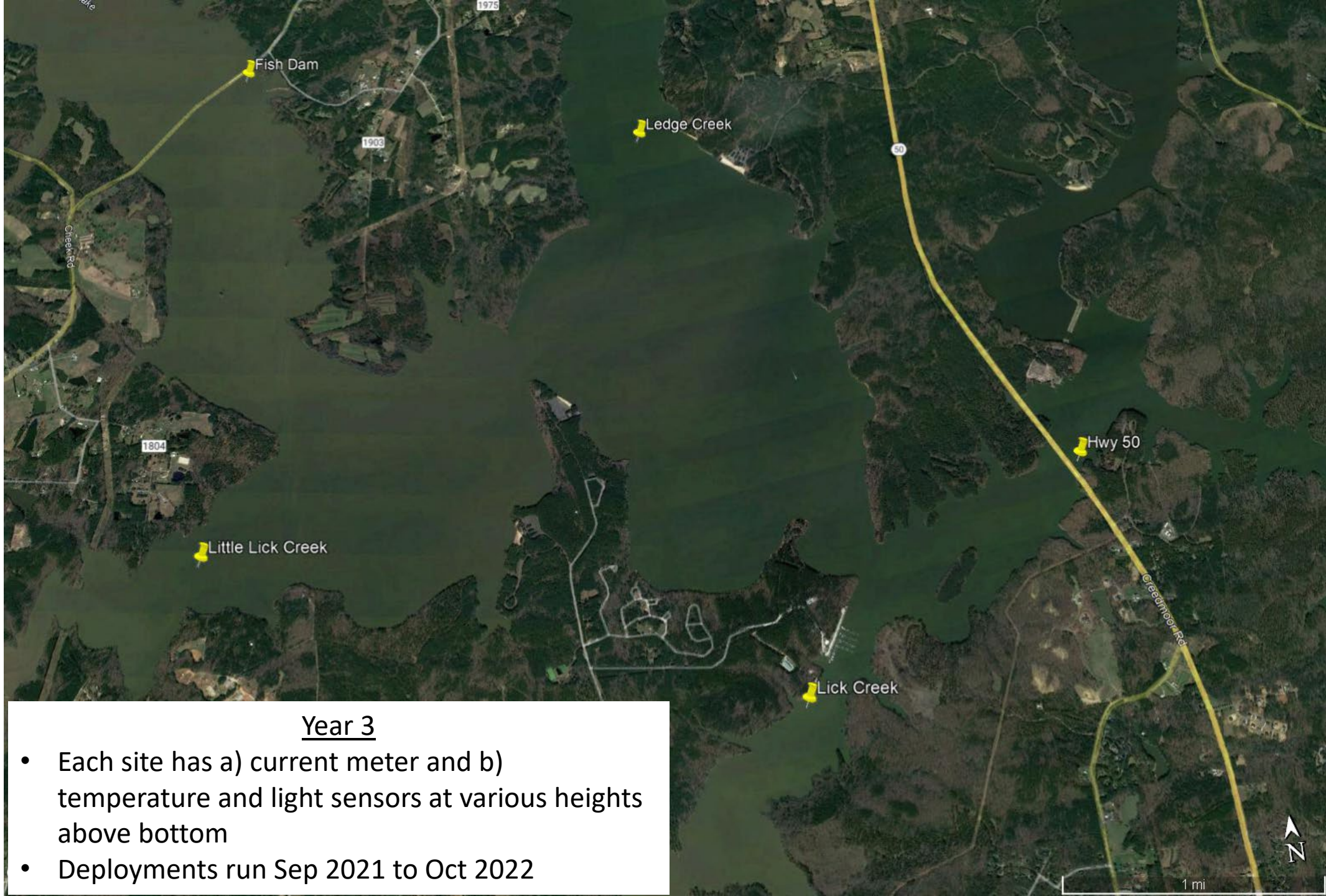
12/16/2021



3/3/2022





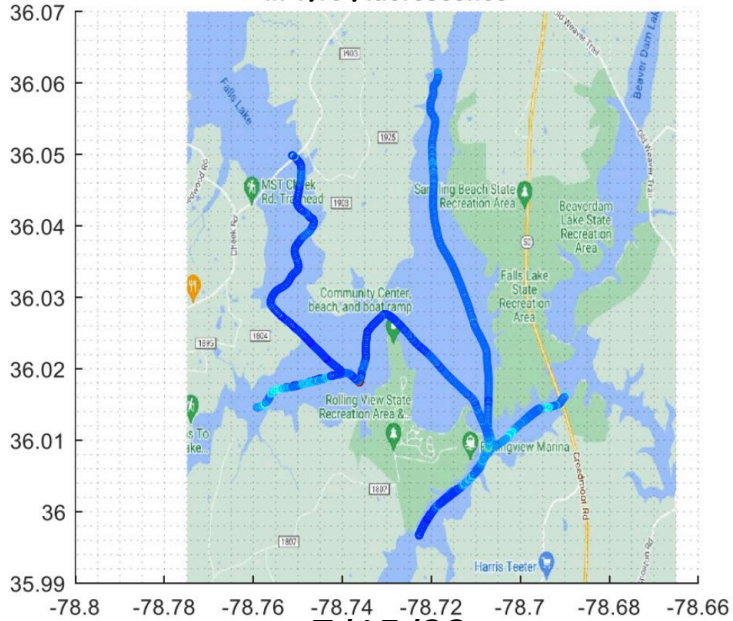


### Year 3

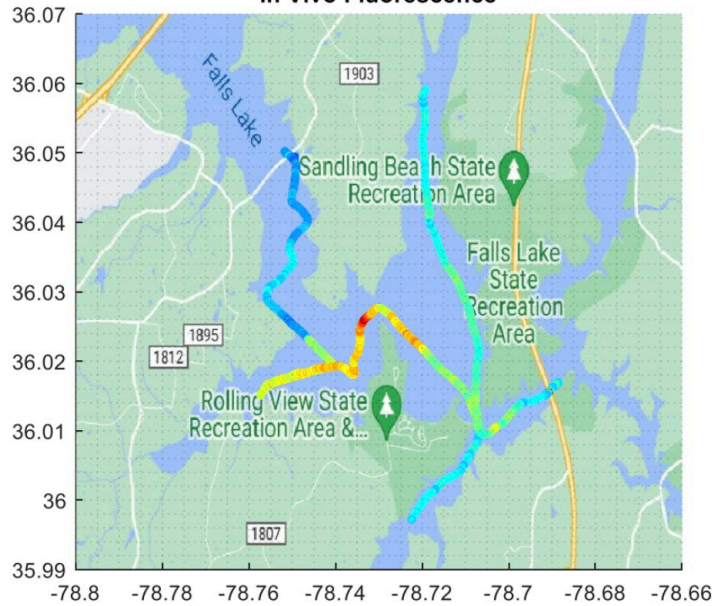
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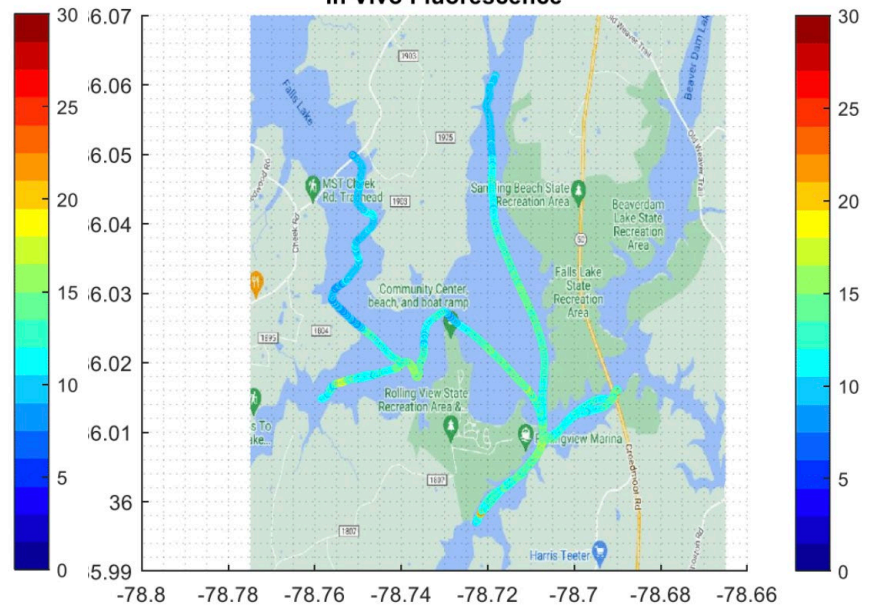
2/2/22  
In Vivo Fluorescence



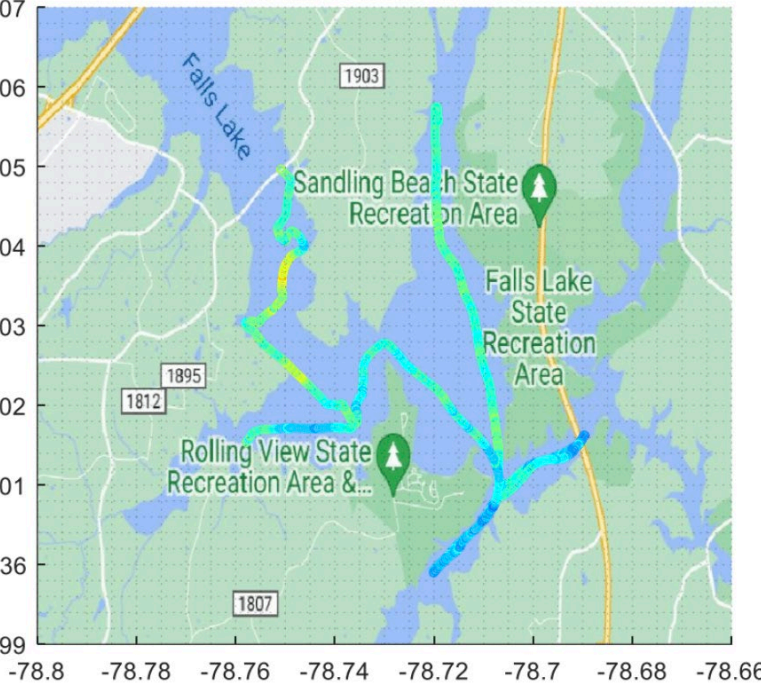
3/3/22  
In Vivo Fluorescence



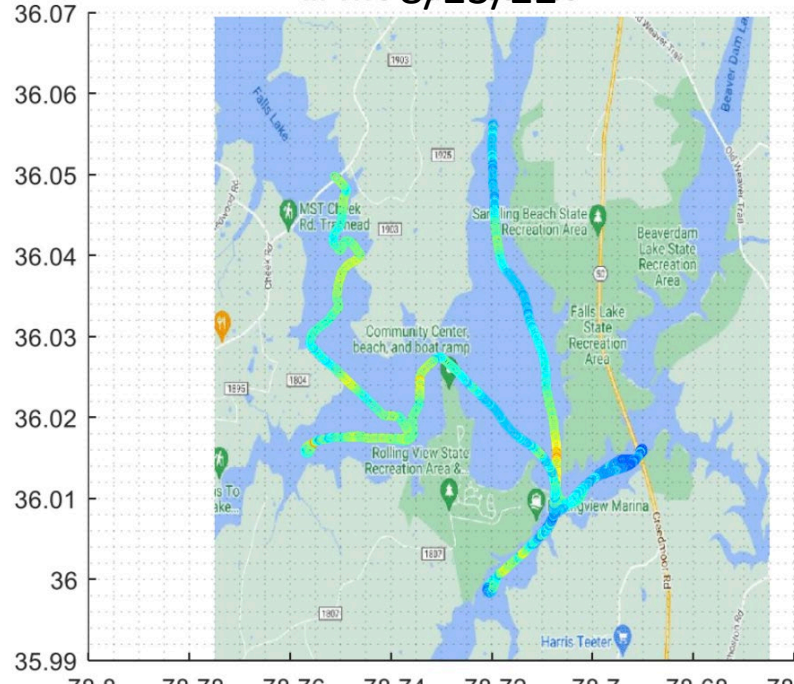
4/21/2022  
In Vivo Fluorescence



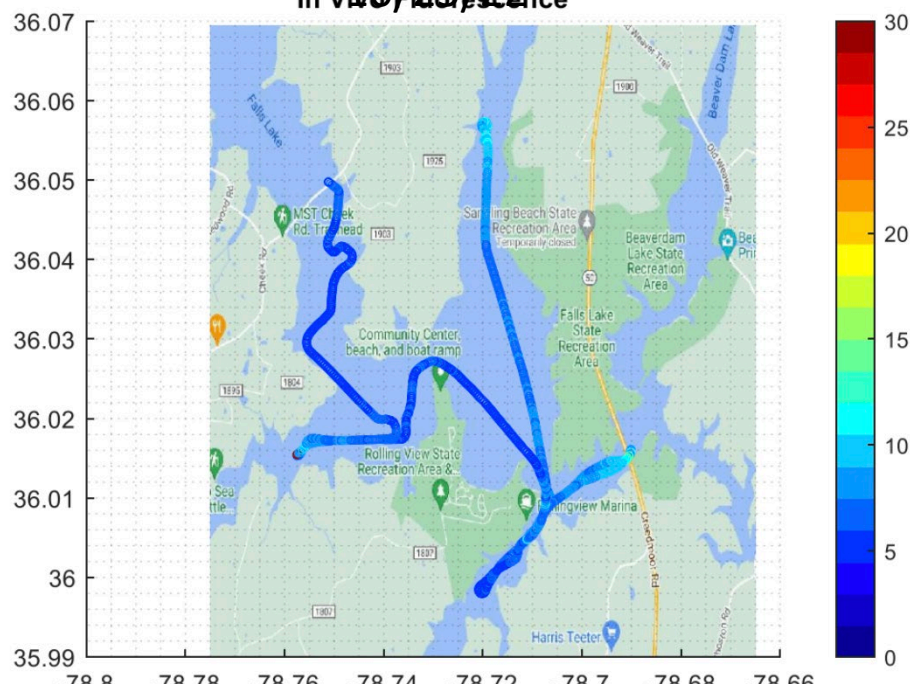
7/15/22  
In Vivo Fluorescence



8/23/22  
In Vivo Fluorescence

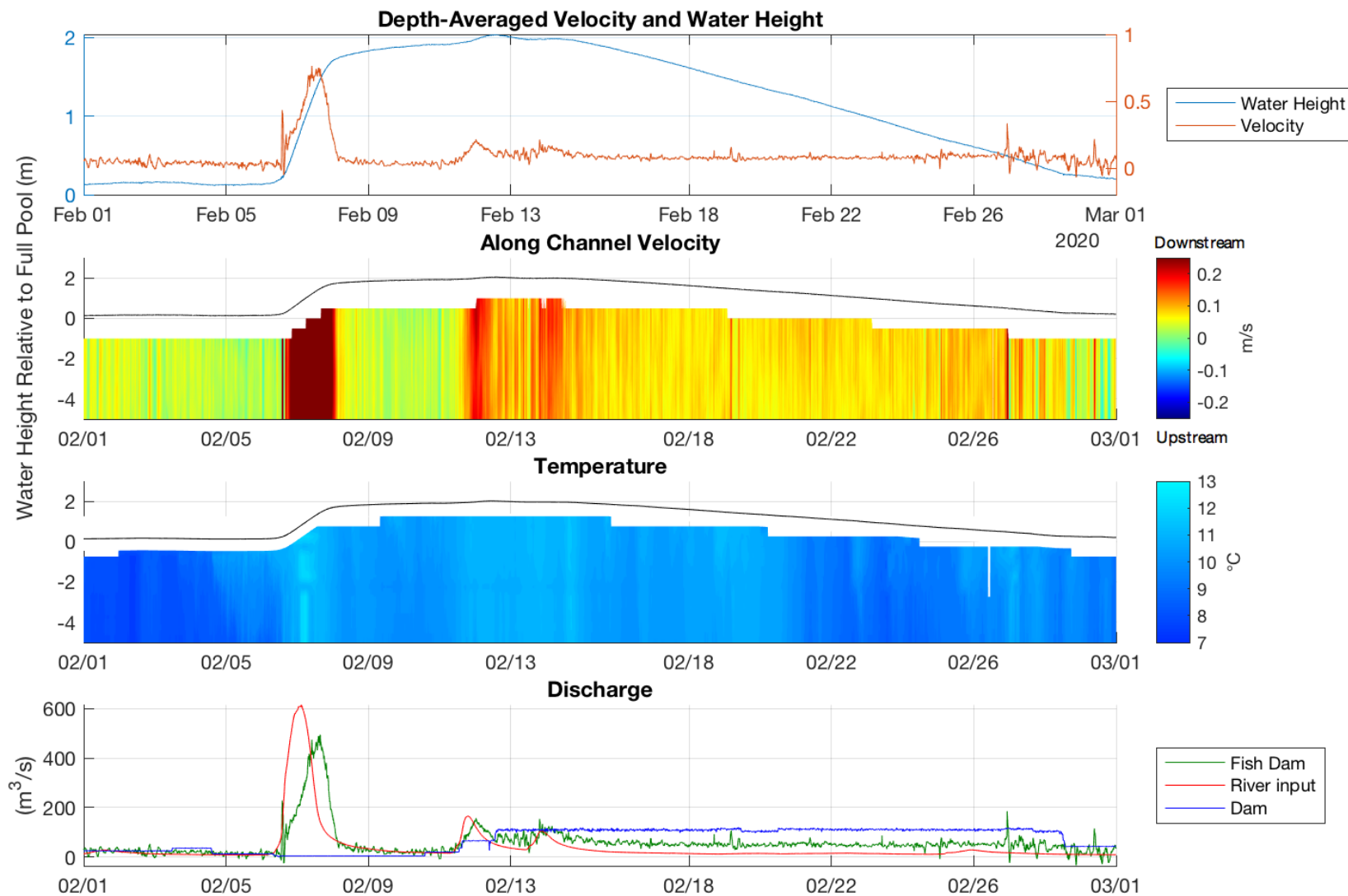
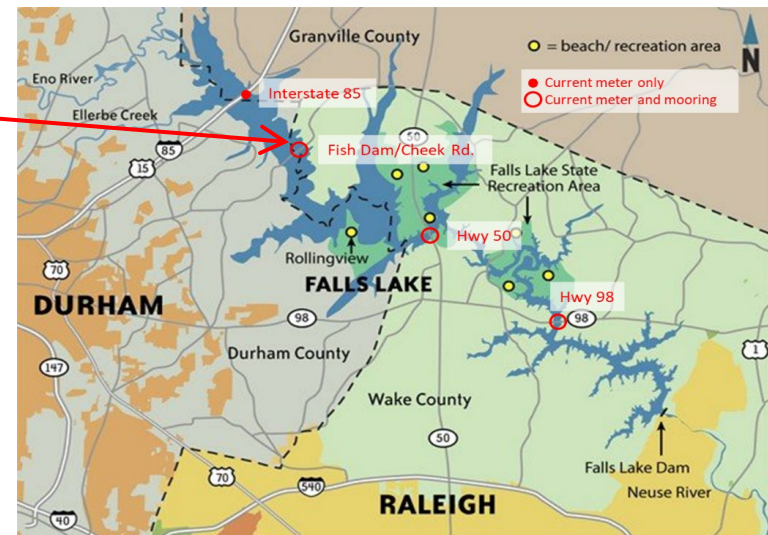


10/25/22  
In Vivo Fluorescence



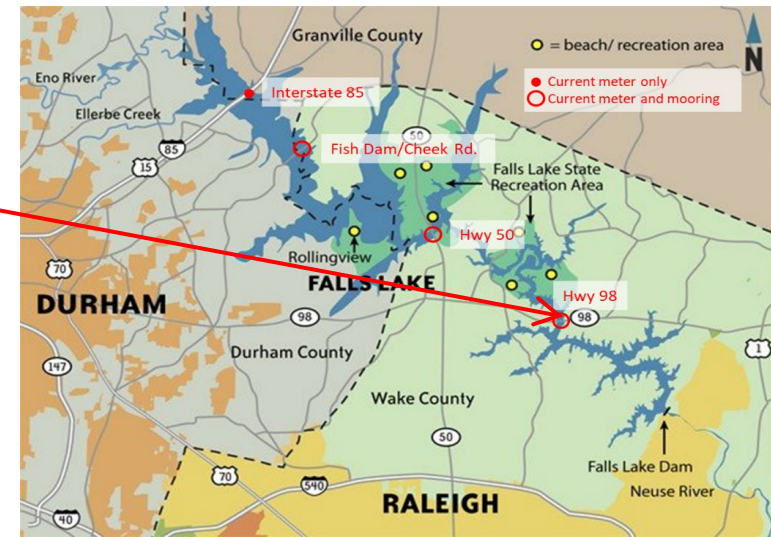
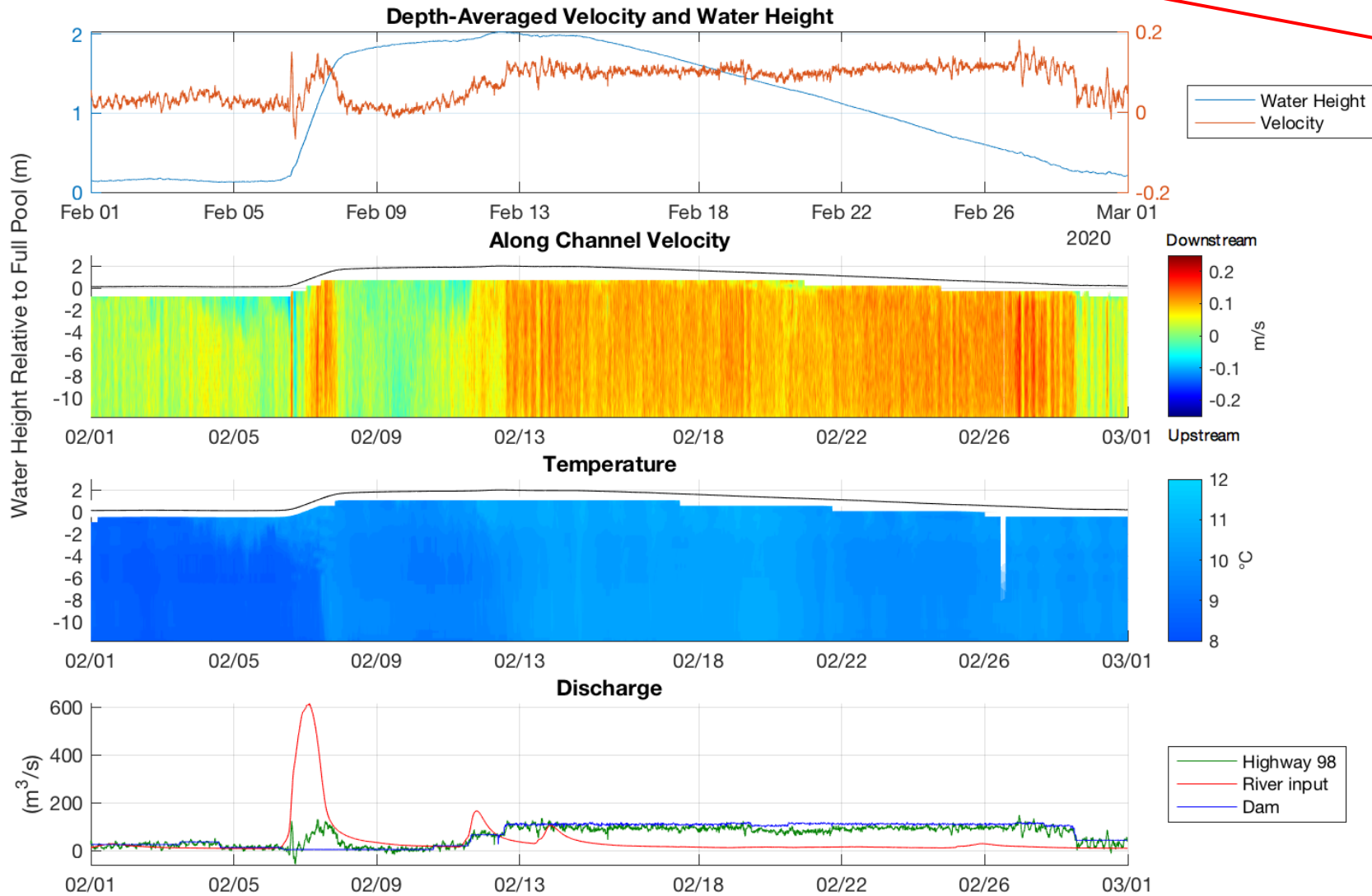


# Fish Dam Rd- February 2020





# Hwy 98 - February 2020



# Two-layer flow in Lower Lake

