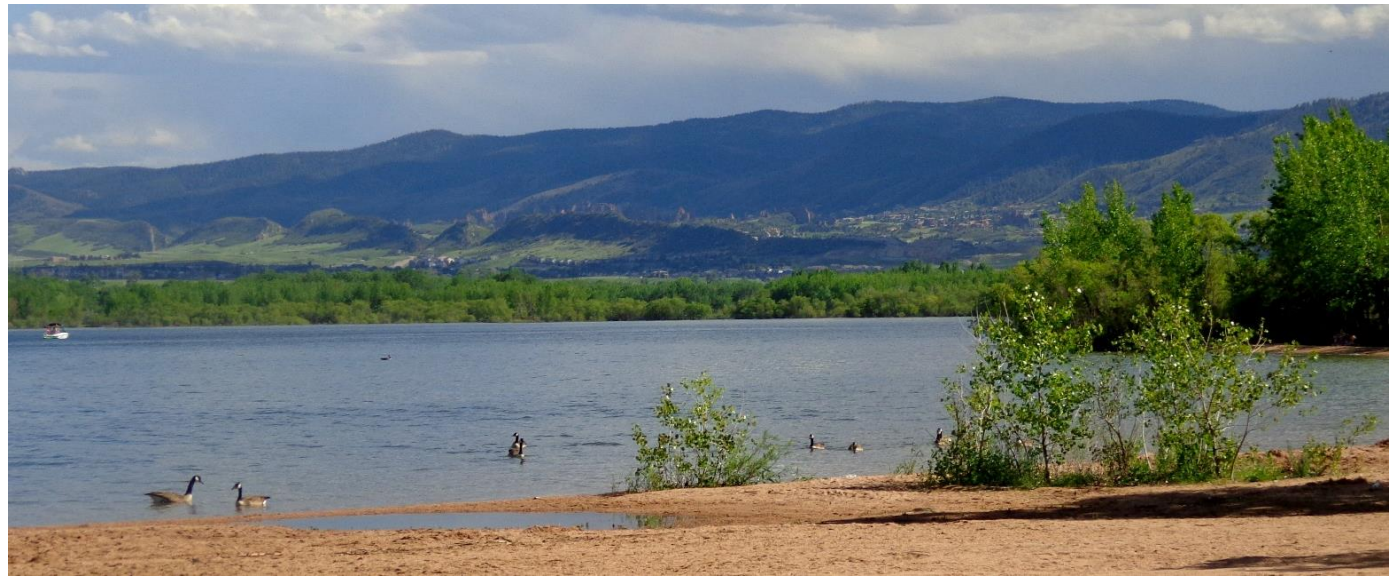


Chatfield Reservoir Water-Quality Model: 2022 Model Update and Extension

July 17, 2023

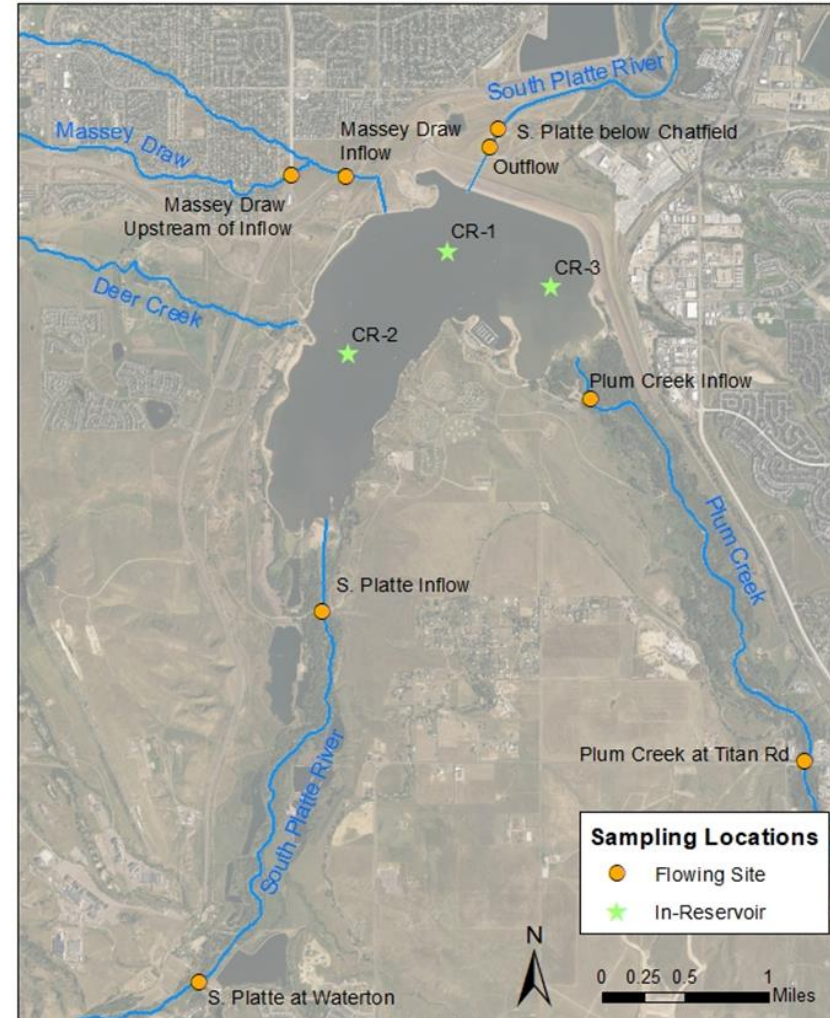


Outline

- Review of 2022 Data Highlights
 - Meteorology
 - Hydrology
 - Water Quality
- 2022 Model Extension
 - Project Effects on Water Quality

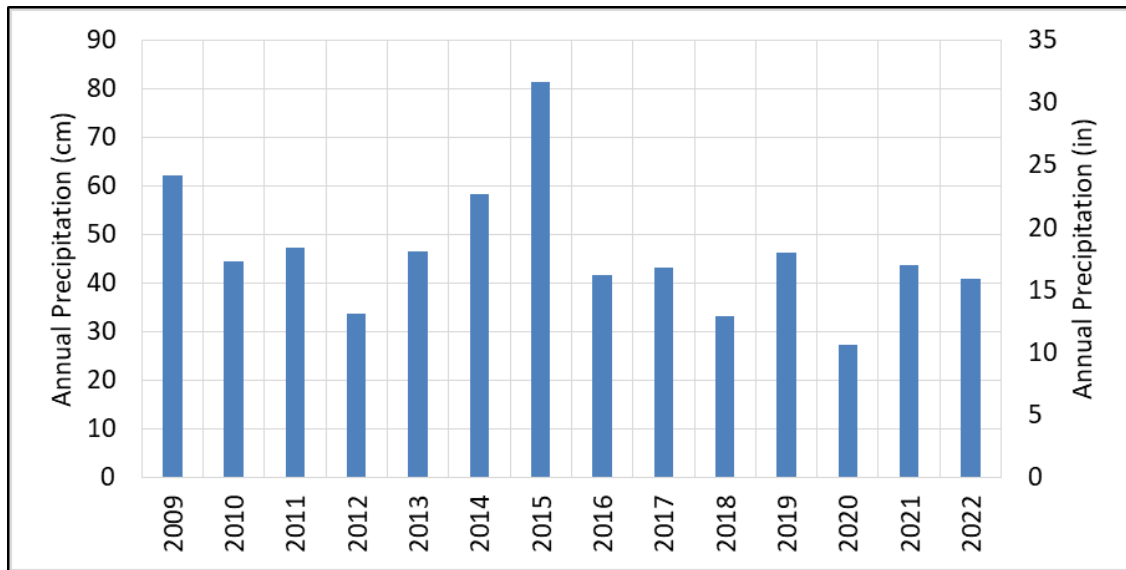
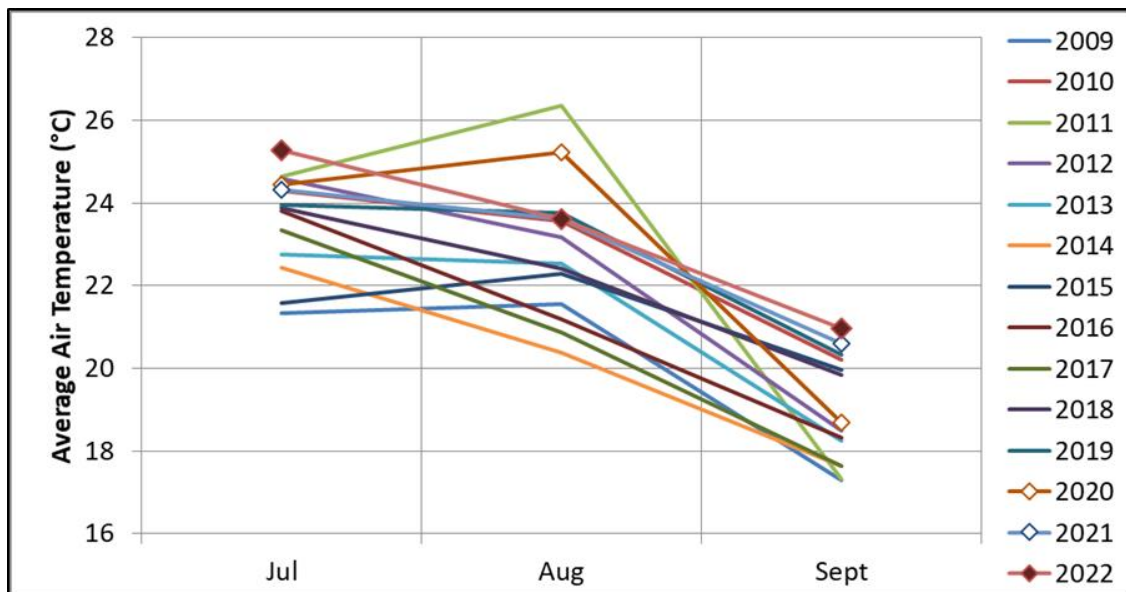
Review of 2022 Data

- Goals of Data Review:
 - Understand Water Quality in 2022
 - Determine What Drove that Response
 - Compare to Previous Years
- Focus is on 2022, With Comparisons to 2009 – 2021 for Context
- Best Data in Chatfield Reservoir from 2014 – Present



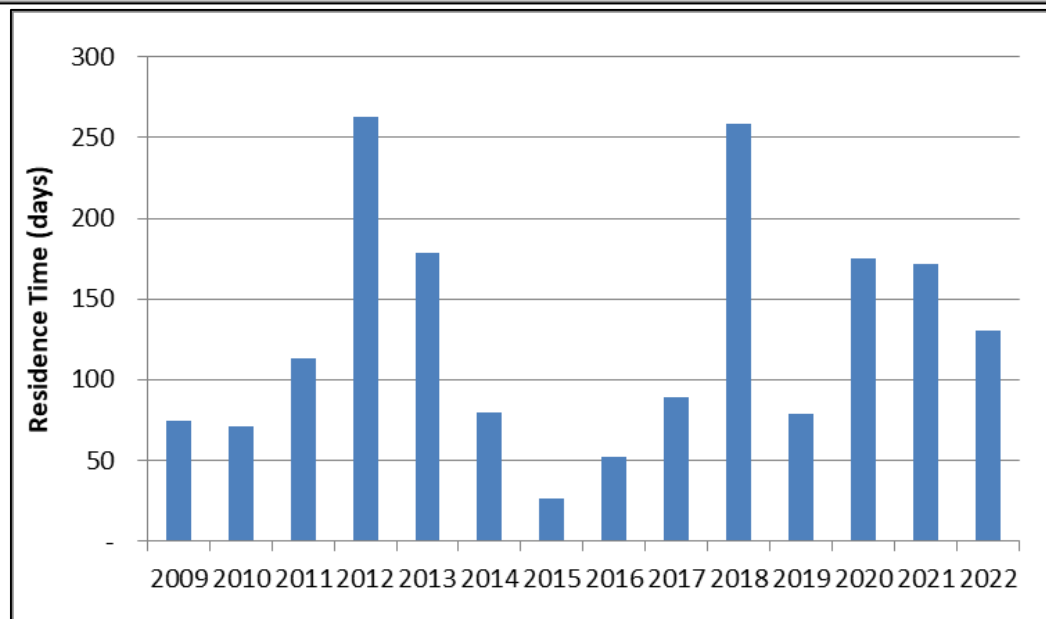
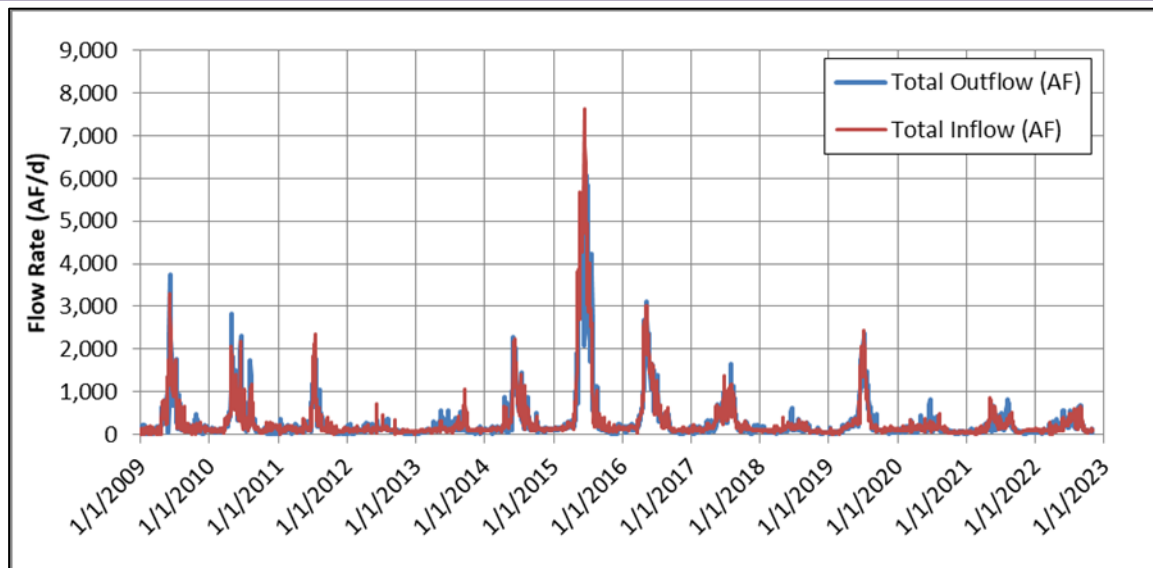
2022 Meteorology

- 2022 was Another Very Warm Year
- Highest July-Sept. Avg. Air Temp. from 2009 – 2022
 - 23.3 °C (74 °F)
- Below-Average Precip.
 - 16.1” (41 cm)
 - Avg: 18.5” (47 cm)



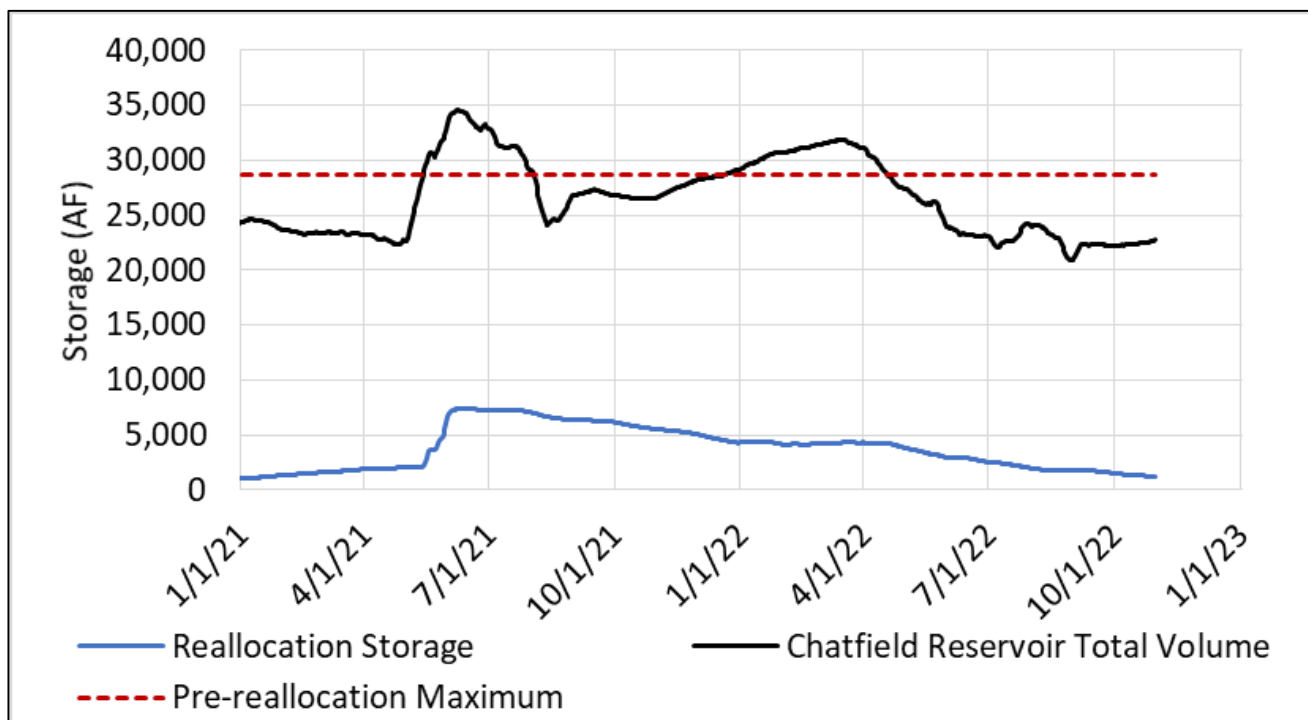
2022 Hydrology

- Below-Average Inflow and Outflow Volumes
- Above-Average Annual Residence Time



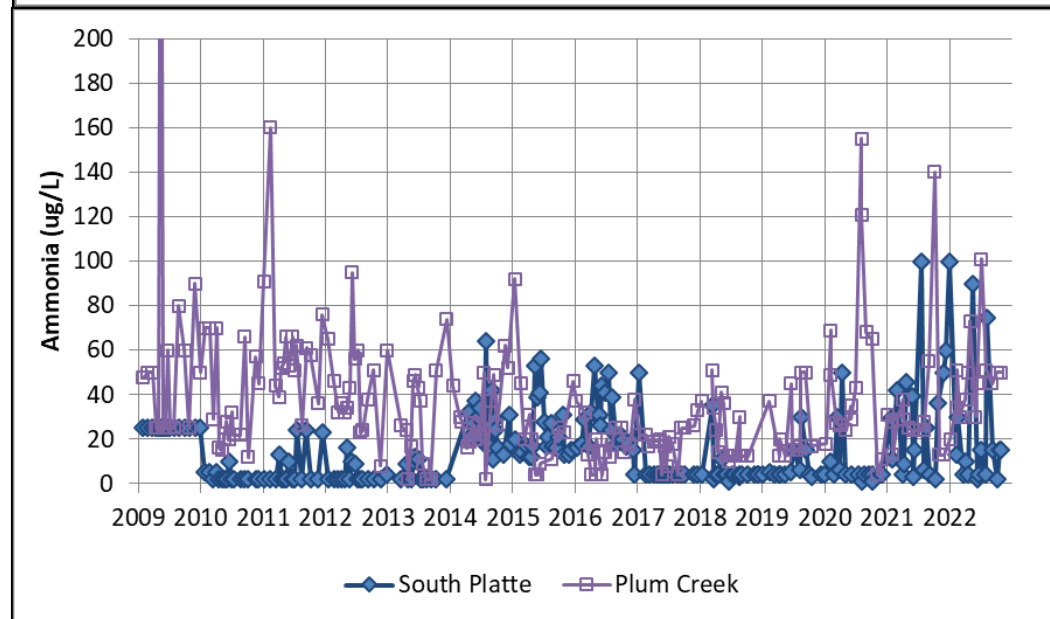
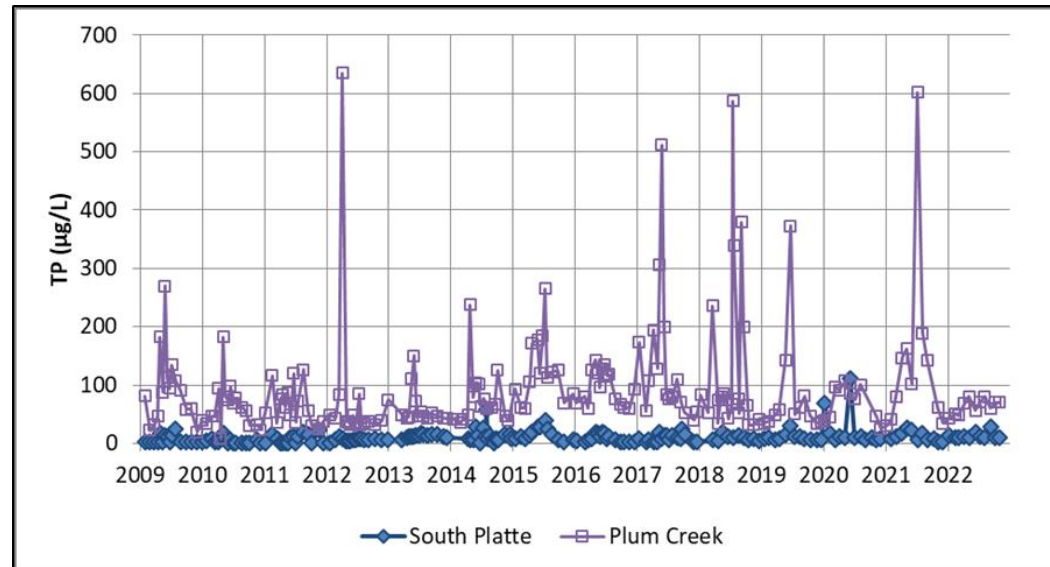
2022 Storage

- Second Year with Substantive Storage in Reallocation Pool
- Surface Elevations Above Pre-Reallocation Project Normal Maximum from Jan – Mid-April
- Small Amount of New Water Stored in Reallocation Pool
 - Reallocation Storage Decreased Through 2022



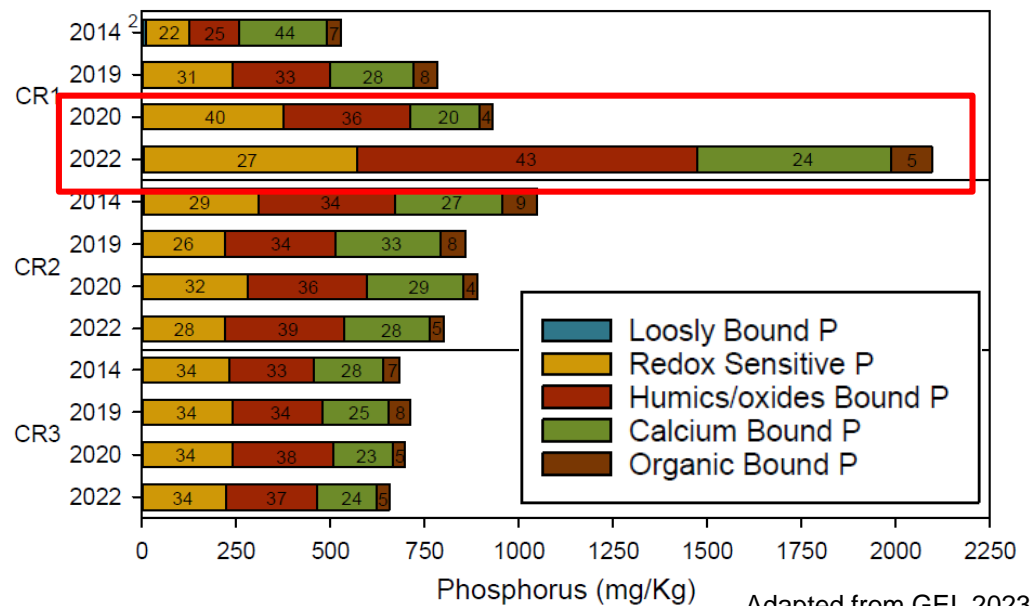
2022 Inflow Water Quality

- 2022 Concentrations Within Range of Historical Observations
- Some Elevated NH_3 Observations in Both Major Tributaries



2022 Sediment Sampling

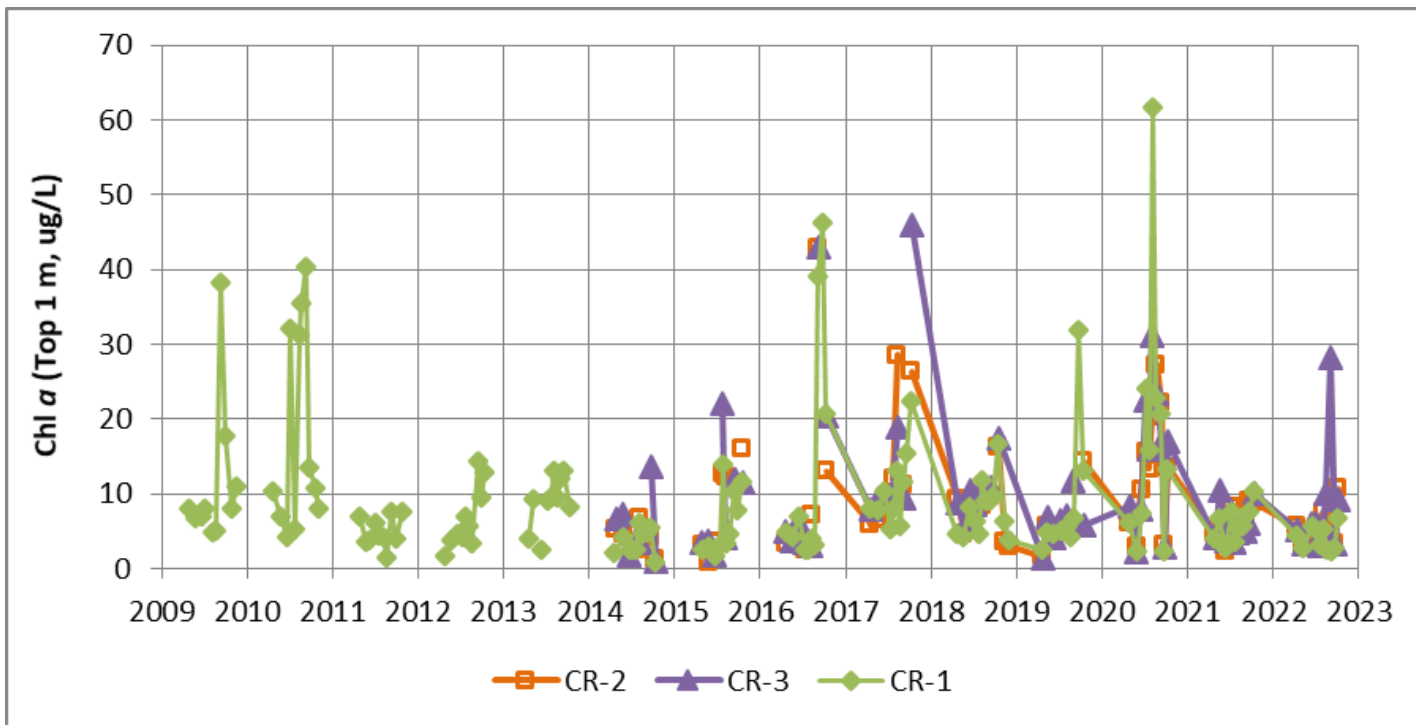
- Cores Collected at CR-1, CR-2, CR-3 in August
- Data Suggested:
 - Little Change Since 2020 at CR-2 and CR-3
 - Phosphorus Mass Increased ~2X at CR-1 Since 2020, but Relative Proportion in Each Form Similar to 2020
- May Reflect Differences in Stratification Timing/Redox in 2022 (GEI)
- May Also Reflect Spatial Variability of Sediment
- Note: Model Update Did Not Require Changes to Sediment Settings



Adapted from GEI, 2023

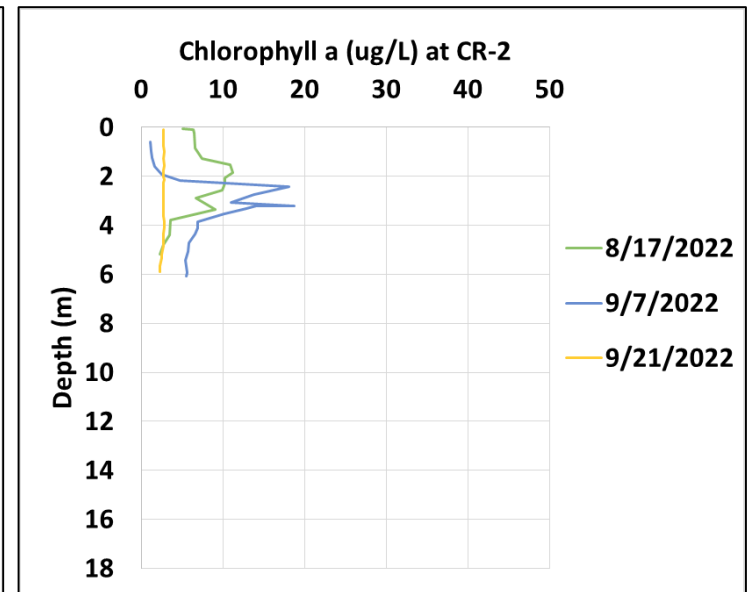
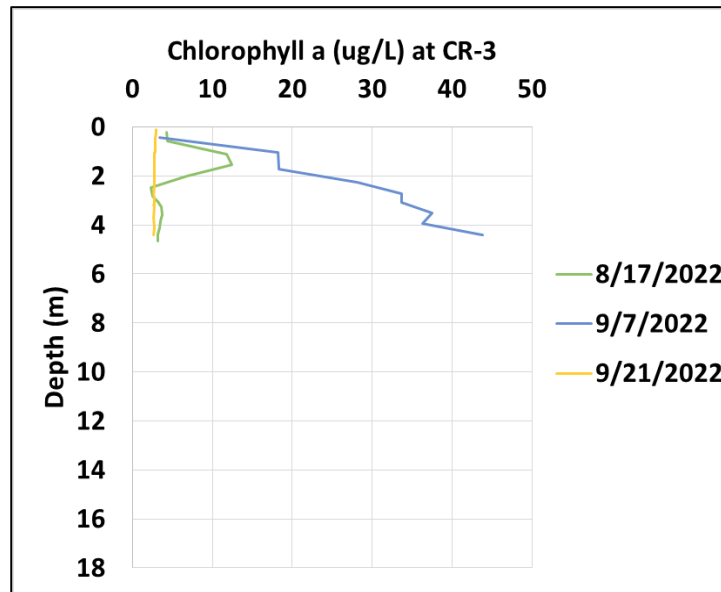
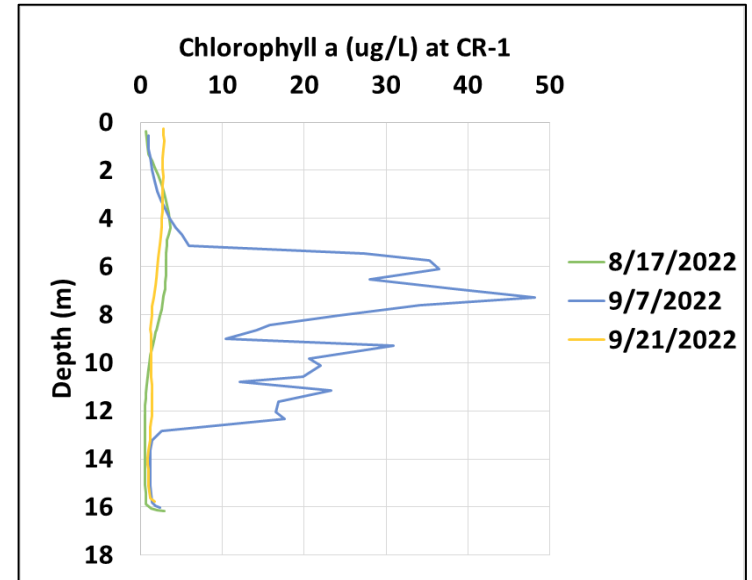
2022 Water Quality – Chlorophyll *a*

- Chlorophyll-*a* Generally Below 10 µg/L in 2022, Except
 - 28.1 µg/L at CR-3 in September
 - 10.7 µg/L at CR-2 in October
- Elevated Chl-*a* Likely in Response to Higher Nutrients in Sept



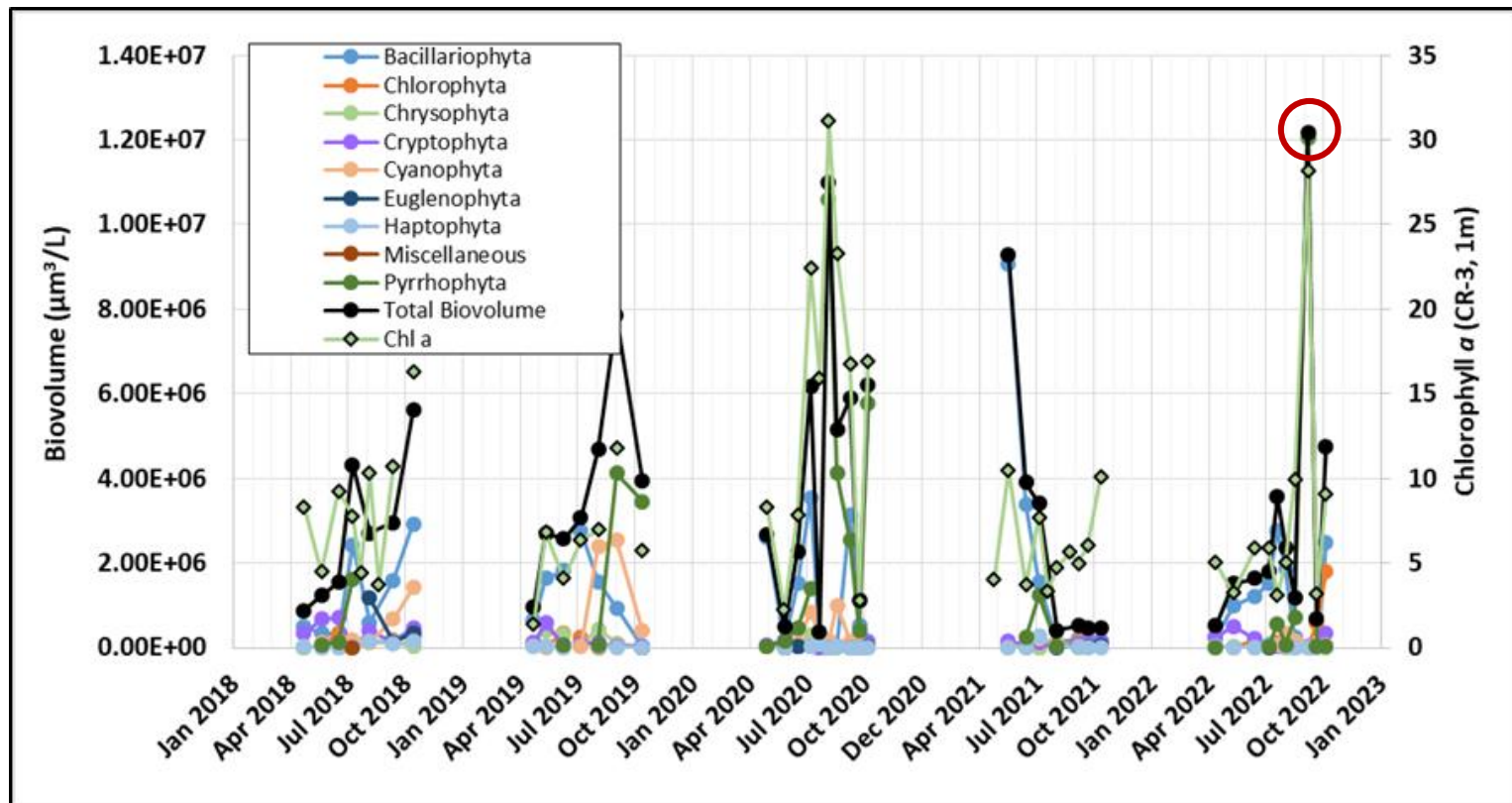
2022 Water Quality – Chlorophyll a

- Sonde Profile Data Show Higher Chl-a Deeper in Reservoir During September



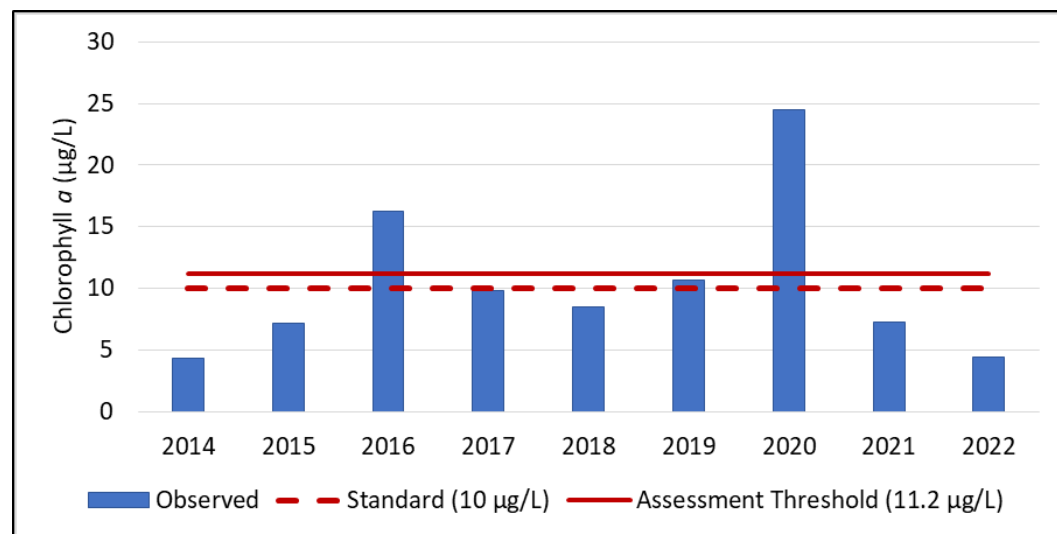
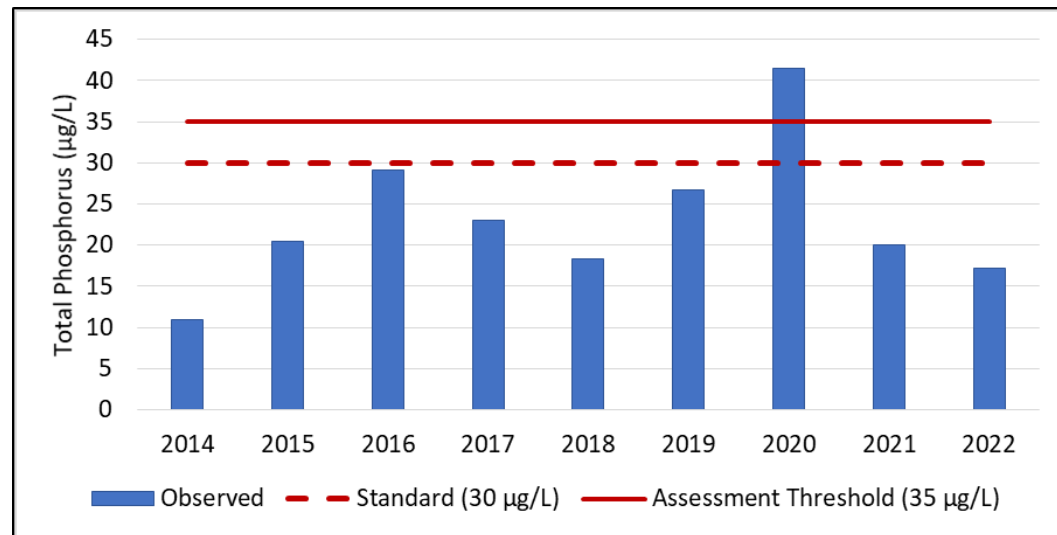
2022 Water Quality – Algae Biovolume

- Biovolume Data Suggest *Ceratium* Driver of Higher Chl-a in Sept/Oct
 - Commonly-Observed Algae in Chatfield
 - Can Move Up/Down in Water Column to Find Optimal Conditions
- Relatively Little Cyanobacteria



TP and Chl-a Standards

- TP and Chl-a Below Assessment Thresholds in 2022
 - TP: 17.2 $\mu\text{g/L}$
 - Chl-a: 4.4 $\mu\text{g/L}$
- Both Standards Attained



Other Standards

- Reviewed 33 Constituents Beyond TP and Chl-a
- Chatfield Reservoir Meeting All Other Standards Reviewed Except:
 - Total Arsenic
 - Dissolved Manganese
- Past Standards Comparisons Also Showed Arsenic and Manganese Concerns Relative to Standards, Prior to Reallocation Project

2022 Water Quality - Synthesis

- Second Year with Substantive Storage in Reallocation Pool
- Warmest Summer Air Temperatures in Period Considered
- Generally Low Summer Chlorophyll *a* Concentrations
 - *Ceratium* was Dominant Algae by Biovolume
 - Responsible for Higher Chl-*a* During September
- TP and Chl-*a* Below Assessment Thresholds in 2022
 - Reservoir is Attaining Both Standards
- Attaining Other WQ Standards, Except As_T and Mn_D
 - Similar to Years Before Reallocation Project

Chatfield Reservoir Water-Quality Model

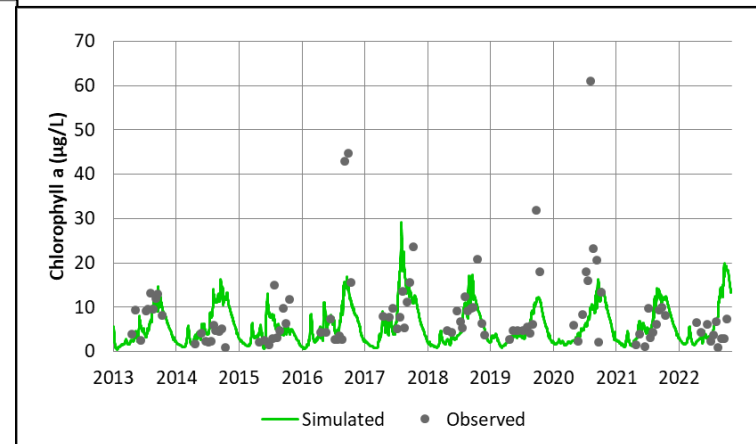
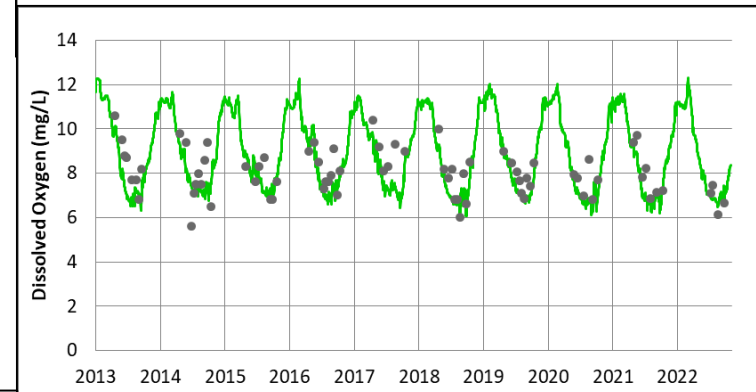
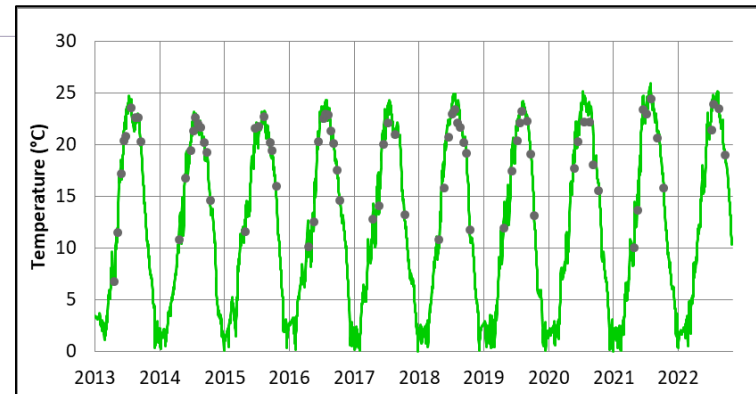
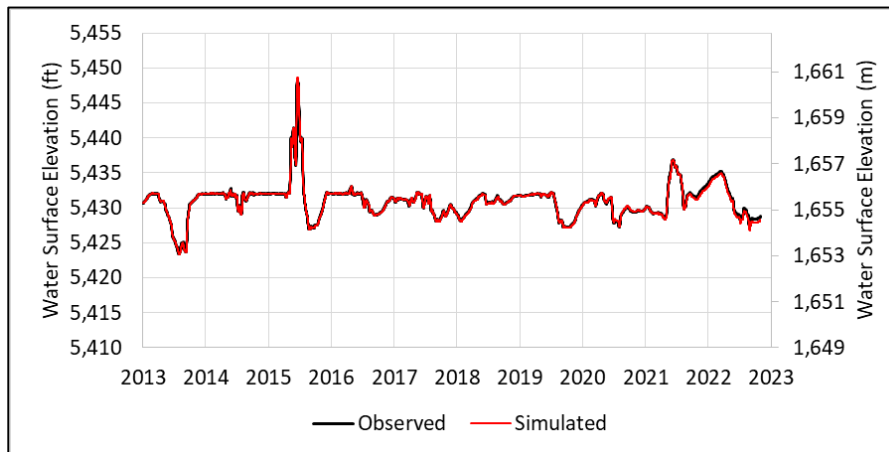
- ✓ Phase I: Initial Model Development (Completed in 2018)
 - Develop and Calibrate Model (2013 – 2016)

- ✓ Phase II: Model Update Prior to Storage (Completed in 2020)
 - Extend Model to Include 2017 – 2019
 - Update Model Calibration for Entire 2013 – 2019 Period

- Phase III: Model Use Post-Storage (In Progress)
 - Extend Model on an Annual Basis
 - Use Model to Understand Causes of Observed Water-Quality Response

Extended Model Performance

- Extended Model Simulation Period
 - Jan 2013 – Oct 2022
- Model Continues to Perform Well



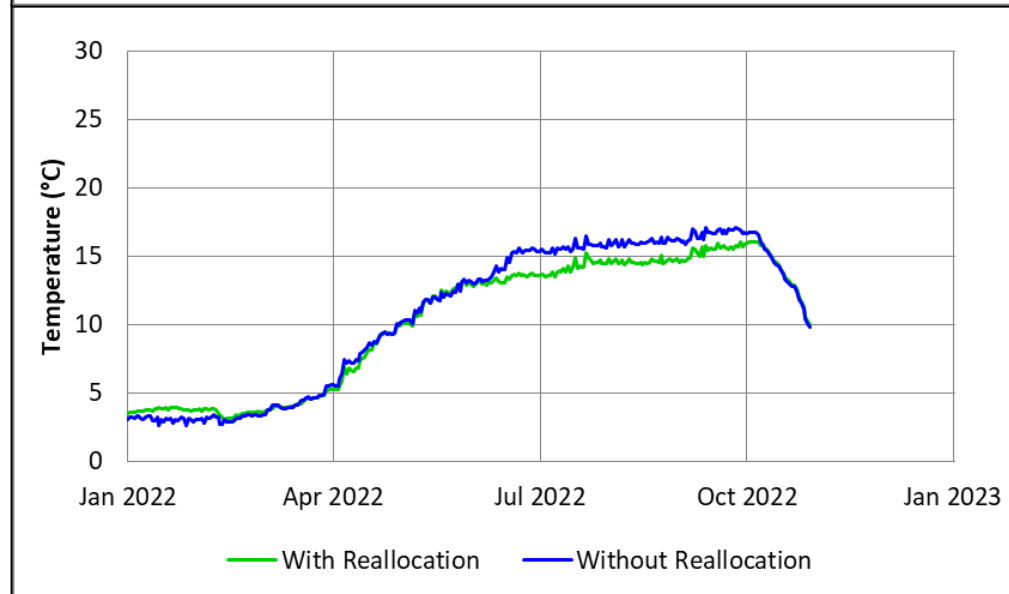
Reallocation Project Effects

- Developed Model Scenario Without Reallocation Project
 - Removed Storage from Reallocation Project and Denver Water Above 5,432' from Water Balance by Adjusting Outflows

- Compare Results With/Without Project
 - Temperature
 - DO
 - TP
 - Chlorophyll *a*

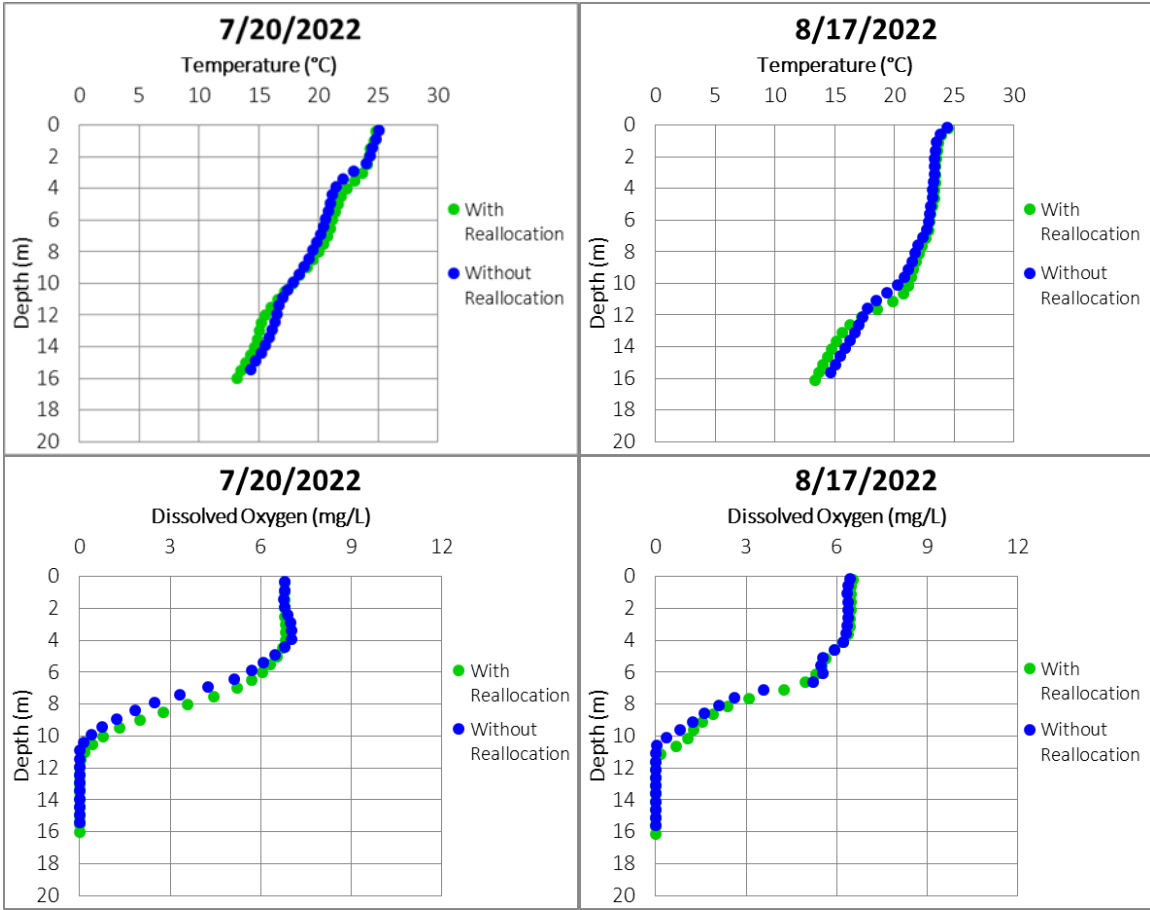
Project Effects – Temperature and DO

- Similar Temperatures and DO With/Without Project



Project Effects – Temperature and DO

- Similar Temperatures and DO With/Without Project



Project Effects – TP and Chlorophyll a

- Similar TP and Chlorophyll a With/Without Project
- Suggests Little Effect of Reallocation Project on Water Quality in 2022



Model Summary and Next Steps

- Extended Model Continues to Perform Well
- Model Scenario Comparisons Show the Reallocation Project Did Not Adversely Affect Water Quality in 2022
- Continue Annual Phase III Model Updates
 - Extension Through October 2023 to Begin in 2024
 - May Storms Leading to First Year of Full Storage Post-Reallocation
 - Use Model to Understand Reallocation Project Role in 2023 Water-Quality Response