Claiborne Reservoir Report 2018 & 2020

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Rivers and Reservoirs Unit
June 2023

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2018 & 2020

Claiborne Reservoir

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LIST OF ACRONYMS

A&I	Agriculture and Industry
ADEM	Alabama Department of Environmental Management
CHL *a*	Chlorophyll *a*
DO	Dissolved Oxygen
F&W	Fish and Wildlife
MAX	Maximum
MDL	Method Detection Limit
MIN	Minimum
MSC	Mean Standing Crop
NTU	Nephelometric Turbidity Units
OAW	Outstanding Alabama Waters
ONRW	Outstanding National Resource Water
PWS	Public Water Supply
QAPP	Quality Assurance Project Plan
RRMP	Rivers and Reservoirs Monitoring Program
S	Swimming and Other Whole Body Water-Contact Sports
SD	Standard Deviation
SOP	Standard Operating Procedures
TEMP	Temperature
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
COE	United States Army Corp of Engineers

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INTRODUCTION

Claiborne Reservoir was created with the construction of Claiborne Lock and Dam in 1971 by the United States Army Corps of Engineers (COE). The reservoir covers approximately 5,900 acres and stretches through three counties in southwest Alabama. Claiborne was primarily created for navigation, but the reservoir also provides a number of recreational opportunities, such as camping, hiking, fishing, and hunting.

Claiborne Reservoir was placed on Alabama's 1998 Clean Water Act (CWA) §303(d) list of impaired waters for not meeting its Public Water Supply/Swimming/Fish & Wildlife (PWS/S/F&W) water use classification. The reservoir was listed for impairments caused by organic enrichment (OE) due to dam construction, modifications/regulations to the flow regime of the Alabama River, and industrial sources. It was also listed for nutrient impairment caused by non-irrigated crop production and pasture grazing. The reservoir was delisted for nutrients in 2004 because historical chlorophyll *a* data indicated that values were meeting the chlorophyll *a* criterion of 15 µg/L proposed for the dam forebay of Claiborne Reservoir. In 2006, the Alabama Department of Public Health issued a fish consumption advisory due to mercury found in fish tissue. As a result, Claiborne Reservoir was placed on Alabama's 2008 CWA §303(d) list of impaired waters for not meeting its Swimming/Fish & Wildlife (S/F&W) water use classification for mercury caused by atmospheric deposition. Segments listed of OE were removed from the 2020 CWA §303(d) list as recent data indicated that an OE impairment did not currently exist in the reservoir.

The Alabama Department of Environmental Management (ADEM) monitored Claiborne Reservoir as part of the 2018 and 2020 assessments of the Alabama River basin under the Rivers and Reservoirs Monitoring Program (RRMP). ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program (now known as RRMP) was initiated by ADEM. The current objectives of this program are to provide data that can be used to assess current water quality conditions, to identify trends in water quality conditions, and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2017 Monitoring Strategy (ADEM 2017).

A specific water quality criterion for nutrient management was implemented in 2004 at the dam forebay or lower end sampling location (CLAM-1) on Claiborne Reservoir. This criterion represents a growing season mean (April-October) chlorophyll *a* (chl *a*) concentration that is protective of Claiborne Reservoir's Public Water Supply/Swimming/F&W (PWS/S/F&W) use classifications.

The purpose of this report is to summarize data collected at Claiborne Reservoir during the 2018 and 2020 growing seasons and to evaluate trends in mean lake trophic status and nutrient concentrations using ADEM's historic dataset. Monthly and mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chl *a*; algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's historical data and the established criteria.

METHODS

Sampling stations were selected using historical data and previous assessments (Figure 1). Specific station location information can be found in Table 1. Claiborne Reservoir was sampled in the dam forebay and upper reservoir in 2018 and 2020. Three tributary embayments stations were also monitored: Beaver Creek, Pursley Creek, and Tallatchee Creek. However, Tallatchee Creek (CLAM-5) was dropped from the sampling rotation after the 2018 sampling season due to difficulty accessing the embayment station by boat.

In 2018, water quality sampling was conducted at monthly intervals, April-October. The 2020 sampling schedule was modified to accommodate Departmental precautions related to COVID-19 that occurred early in the sampling season. As a result, no water quality samples were collected in April, and two samples were collected in October to account for the missed sampling event. These modifications are noted in related graphs. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2020), Surface Water Quality Assurance Project Plan (ADEM 2018a), and Quality Management Plan (ADEM 2018b).

Mean growing season TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. Monthly concentrations of these parameters were graphed with the closest

available USGS flow data and ADEM's previously collected data to help interpret the 2018 and 2020 results.

Figure 1. Claiborne Reservoir with sampling locations. A description of each sampling location for 2018 and 2020 is provided in Table 1.

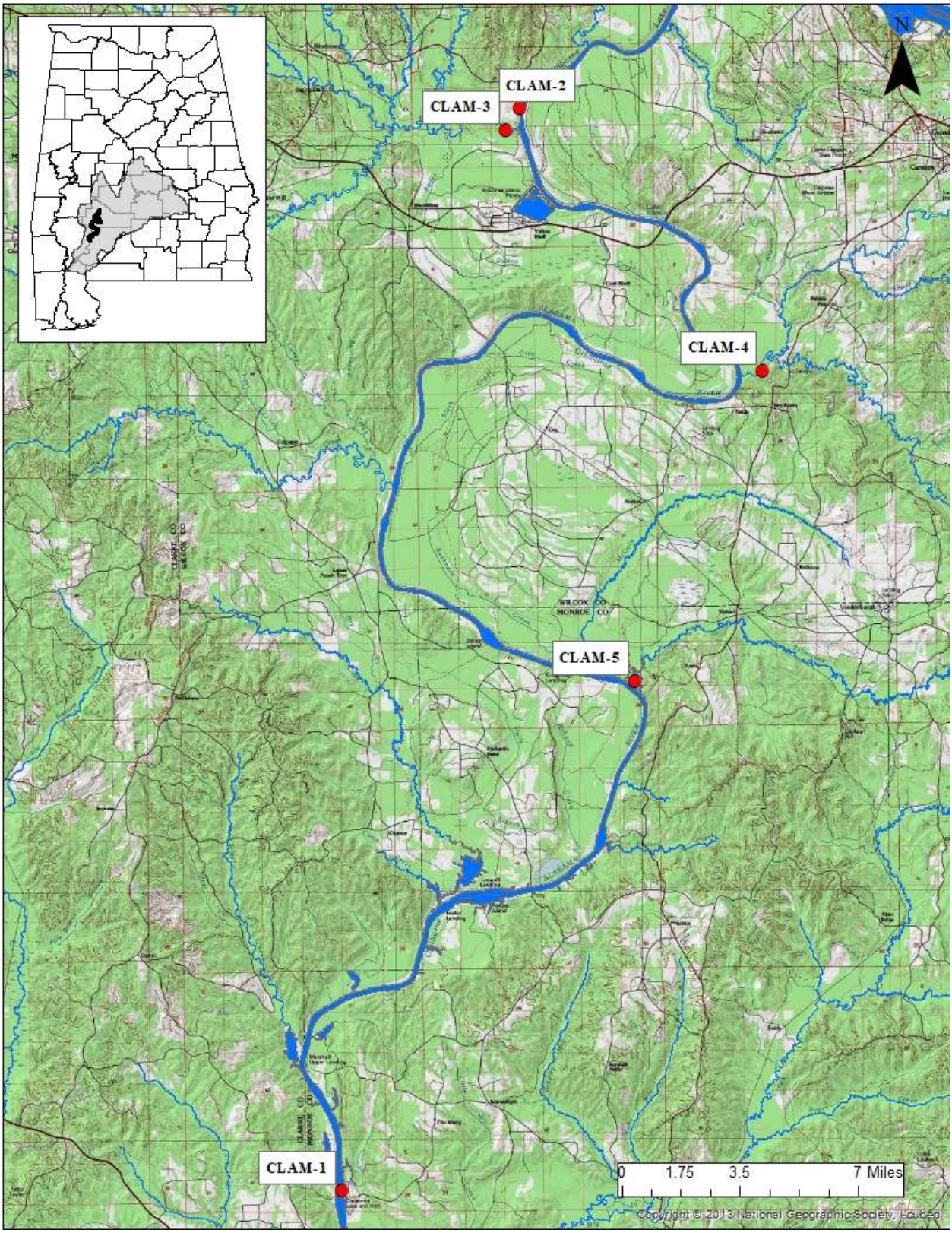


Table 1. Descriptions of the 2018 and 2020 monitoring stations in Claiborne Reservoir. Due to accessibility issues involving the boat ramp (CLAM-5) was not sampled in 2020.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criterion	Latitude	Longitude
Claiborne Reservoir								
031502030105	Monroe	CLAM-1**	Lower	Alabama R	Deepest point, main river channel, dam fore bay.	15 µg/L	31.6174	-87.5506
031502030703	Wilcox	CLAM-2	Upper	Alabama R	Deepest point, main river channel, approximately 0.5 miles upstream of Beaver Creek confluence.		32.0106	-87.4744
031502030604	Wilcox	CLAM-3	Beaver Cr	Beaver Cr	Deepest point, main creek channel, Beaver Creek embayment, approximately 0.5 miles upstream of lake confluence.		32.0028	-87.4806
031502030802	Wilcox	CLAM-4	Pursley Cr	Pursley Cr	Deepest point, main creek channel, Pursley Creek embayment, approximately 0.5 miles upstream of lake confluence.		31.9155	-87.3705
031502040101	Monroe	CLAM-5	Tallatchee Cr	Tallatchee Cr	Deepest point, main creek channel, Tallatchee Creek embayment, approximately 0.5 miles upstream of lake confluence.		31.8029	-87.4253

**Growing season mean Chl a criterion implemented at this station in 2004

RESULTS

Growing season mean graphs for TN, TP, chl *a*, and TSS are provided in this section (Figures 2 & 3). Monthly graphs for TN, TP, chl *a*, TSS, DO, and TSI are also provided (Figures 4-9, & 12-13). Mean monthly discharge is included in monthly graphs as an indicator of flow and retention time in the months sampled. Depth profile graphs of temperature, DO, and conductivity appear in Figures 10-11. Algal growth potential test (AGPT) results appear in Table 2. Summary statistics of all data collected during 2018 are presented in Appendix Table 1. Summary statistics of all data collected during 2020 are presented in Appendix Table 2. These tables contain the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

Stations with the highest concentrations of nutrients, chlorophyll *a*, and TSS are noted in the paragraphs to follow. Though stations with lowest concentrations may not always be mentioned, review of the graphs that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2018, the highest mean growing season TN value was in Tallatchee Creek. In 2020, the highest mean growing season TN concentration was measured at the upper reservoir station, although concentrations were similar reservoir-wide (Figure 2). Monthly TN concentrations at the upper and lower stations were at or below historic means throughout the 2018 and 2020 growing seasons with the exception of August 2020 (Figure 4). A historic low concentration was measured at the lower station in June 2020.

In 2018 and 2020, the highest mean growing season TP value was calculated for the lower reservoir station (Figure 2). While the upper and lower stations both show a decreasing trend in mean TP concentrations from 2003 to 2015, concentrations appeared to increase in 2018 and 2020. Monthly TP concentrations at the upper reservoir station were at or below historic means during all months sampled in 2018 and in 2020 (Figure 5). Historic low TP concentrations occurred at the upper station in April and September in 2018. Monthly TP concentrations in the lower station were at historic lows in August and in late October of 2020. There was one historical high TP value observed in September of 2020 at the lower station.

A specific water quality criterion for nutrient management has been established for the lower station in Claiborne Reservoir. The growing season mean chl *a* value calculated for the lower station was below the criteria limit of 15 µg/L in both 2018 and 2020 (Figure 3). At the mainstem stations, mean chl *a* concentrations calculated since 2008 have been lower than those calculated in years prior. In 2018, mean growing season chl *a* concentrations at Pursley Creek, Tallatchee Creek, and the lower station were the lowest values calculated in those waterbodies since 2000. Monthly chl *a* concentrations at the lower station were higher in 2020 than in 2018 for all months sampled (Figure 6). In 2018, historic low chl *a* concentrations were observed at the upper station in September and at the lower station in July-October. In 2020, a historic low monthly concentration was measured at the upper station in early October and a historic high monthly concentration was measured at the lower station in July.

In both 2018 and 2020, the highest mean growing season TSS value calculated was in Pursley Creek and the lowest mean growing season TSS value calculated was at the lower station (Figure 3). The mean TSS values were higher in 2018 than in 2020 at all sampling locations. All monthly TSS concentrations were near or below historic mean values at the upper station except for May 2018, which was a historic high monthly concentration (Figure 7). At the lower station, monthly growing season TSS concentrations were above historic means in April and September of 2018 and in July and late October of 2020.

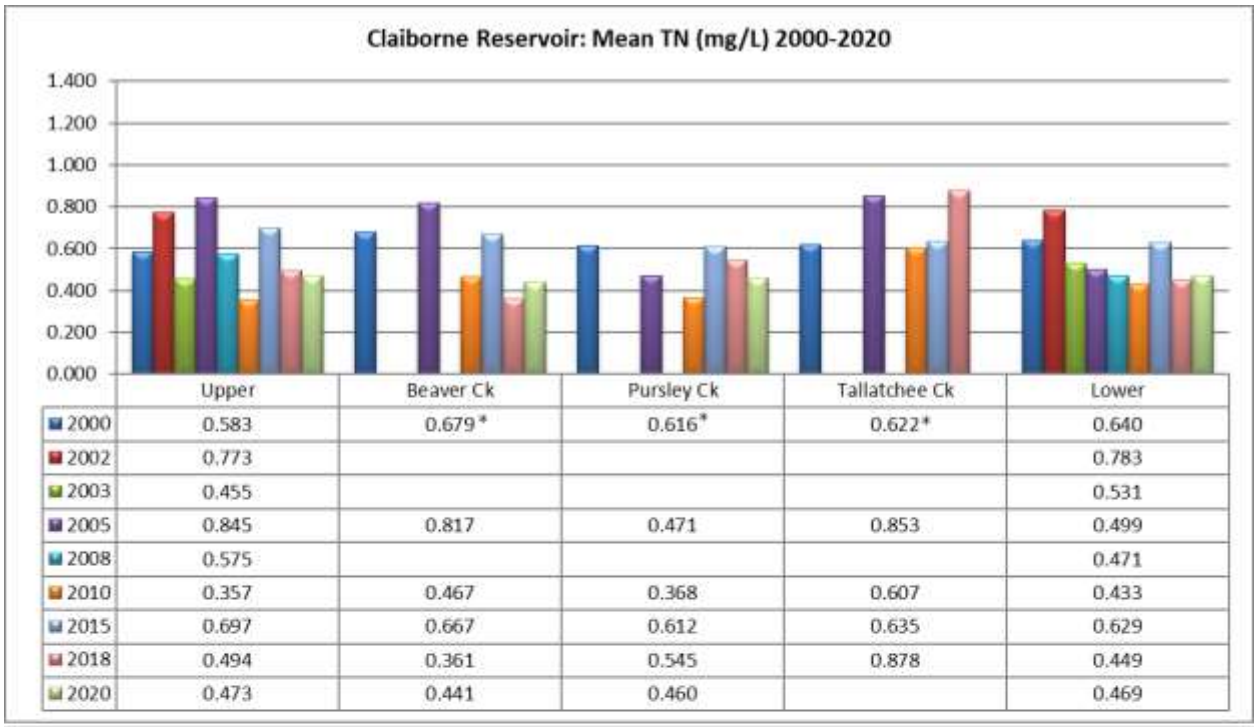
AGPT results for Claiborne Reservoir have varied between nitrogen-limited, phosphorus-limited, and co-limiting at the upper and lower reservoir stations in the years monitored (Table 2). However, all samples collected in 2018, including the embayment stations, were nitrogen-limited. Raschke and Schultz (1987) found that maximum standing crop (MSC) values below 5.0 mg/L are considered to be protective of reservoir and lake systems. While all historic AGPT samples collected in 2000 and 2005 were less than 5.0 mg/L MSC, samples collected in 2010 and 2018 were above 5.0 mg/L MSC. However, all samples collected were below 20.0 mg/L MSC, the value that Raschke and Schultz (1987) defined as protective of flowing stream and river systems. No AGPT samples were collected at Claiborne Reservoir in 2020.

In 2018, both mainstem stations on Claiborne Reservoir were above ADEM's DO criteria limit of 5.0 mg/L at 5.0 ft (1.5 m) in all months sampled during the growing season (Figure 8). DO

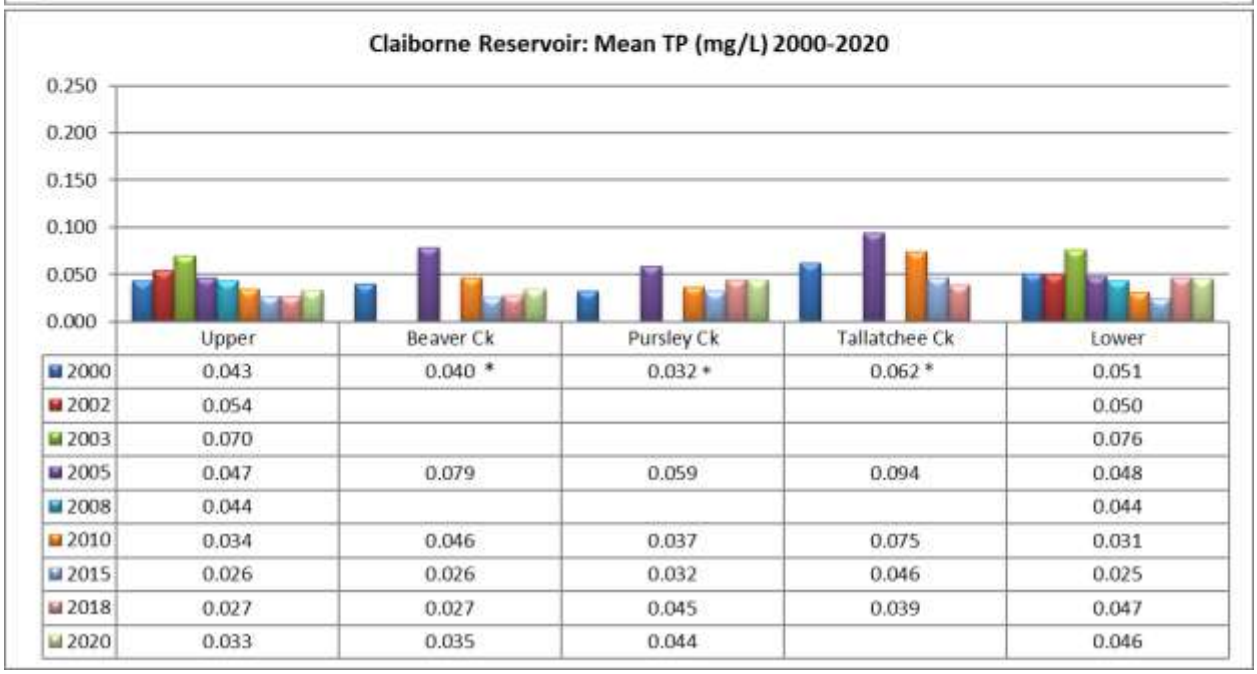
concentrations at Tallatchee Creek dropped below criteria in June and August in 2018. In 2020, all stations sampled were at or above the criteria limit during all sampling events (Figure 9). Based on monthly DO profiles, the water column at the lower station was mixed most of the sampling season in 2018 with slight stratification occurring in June (Figure 10). In 2020, the lower station was stratified from June until early October (Figure 11). The highest water temperatures were observed in July of the 2018 growing season and in July and August of the 2020 growing season.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. The highest TSI value was calculated in Beaver Creek, which reached upper eutrophic conditions in April of 2018 (Figure 12). The upper mainstem station reached eutrophic conditions in June, August, and October of 2018, while the lower station was mesotrophic all months sampled except August and October, which were oligotrophic. In 2020, both the upper and lower mainstem stations remained eutrophic for the majority of the growing season (Figure 13). Beaver Creek maintained eutrophic to upper mesotrophic conditions throughout the growing season, while Pursley Creek fluctuated between oligotrophic and mesotrophic most of the year, reaching eutrophic conditions only in August.

Figure 2. Growing season mean TN and TP concentrations measured in Claiborne Reservoir, April-October 2000-2020. Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right.



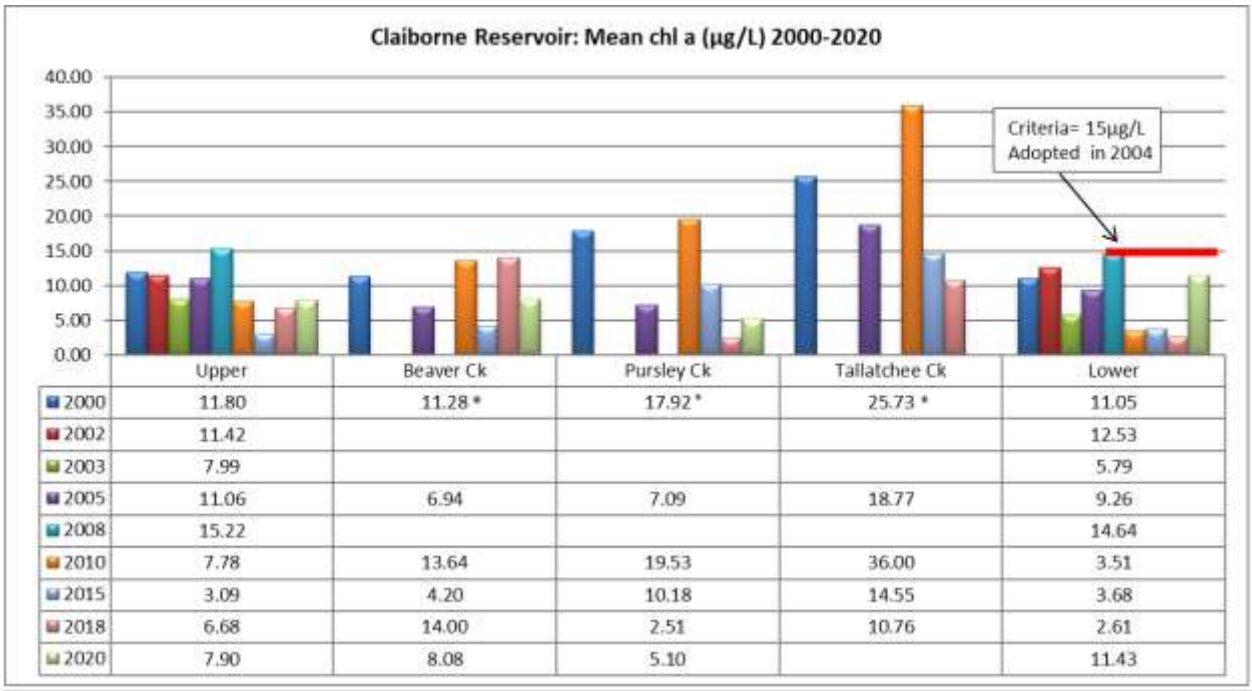
	Upper	Beaver Ck	Pursley Ck	Tallatchee Ck	Lower
2000	0.583	0.679*	0.616*	0.622*	0.640
2002	0.773				0.783
2003	0.455				0.531
2005	0.845	0.817	0.471	0.853	0.499
2008	0.575				0.471
2010	0.357	0.467	0.368	0.607	0.433
2015	0.697	0.667	0.612	0.635	0.629
2018	0.494	0.361	0.545	0.878	0.449
2020	0.473	0.441	0.460		0.469



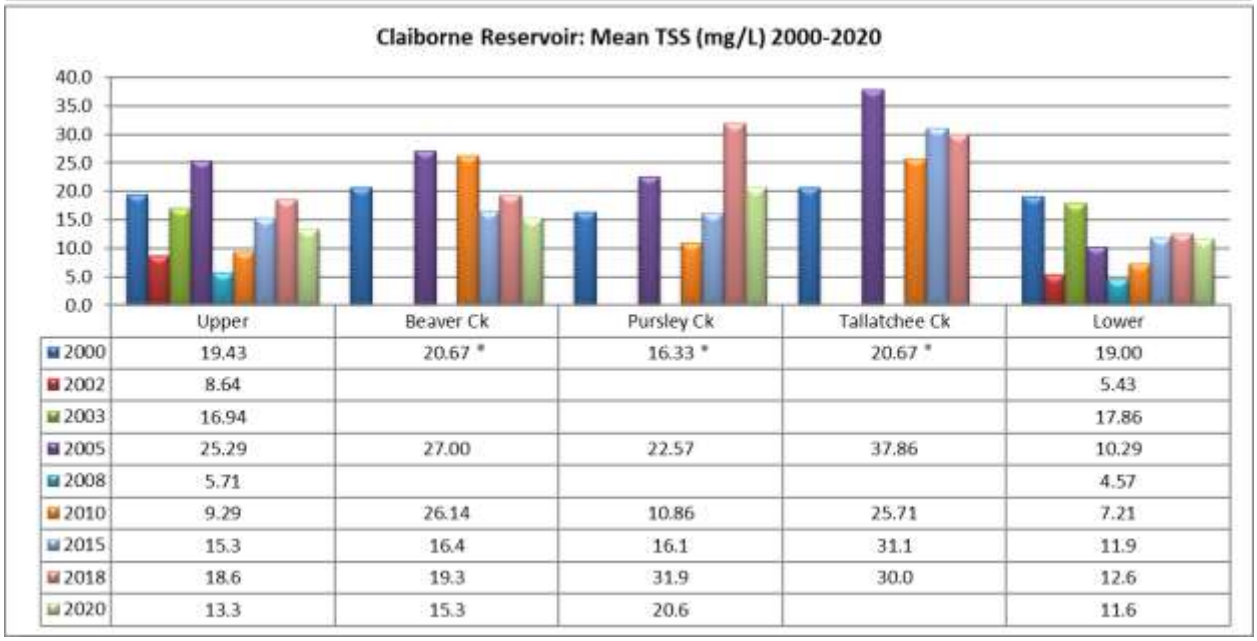
	Upper	Beaver Ck	Pursley Ck	Tallatchee Ck	Lower
2000	0.043	0.040 *	0.032 *	0.062 *	0.051
2002	0.054				0.050
2003	0.070				0.076
2005	0.047	0.079	0.059	0.094	0.048
2008	0.044				0.044
2010	0.034	0.046	0.037	0.075	0.031
2015	0.026	0.026	0.032	0.046	0.025
2018	0.027	0.027	0.045	0.039	0.047
2020	0.033	0.035	0.044		0.046

*Mean of April/June/August only.

Figure 3. Growing season mean chl *a* and TSS concentrations measured in Claiborne Reservoir, April-October 2000-2020. Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right. Chl *a* criteria applies to the growing season mean of the lower station only.



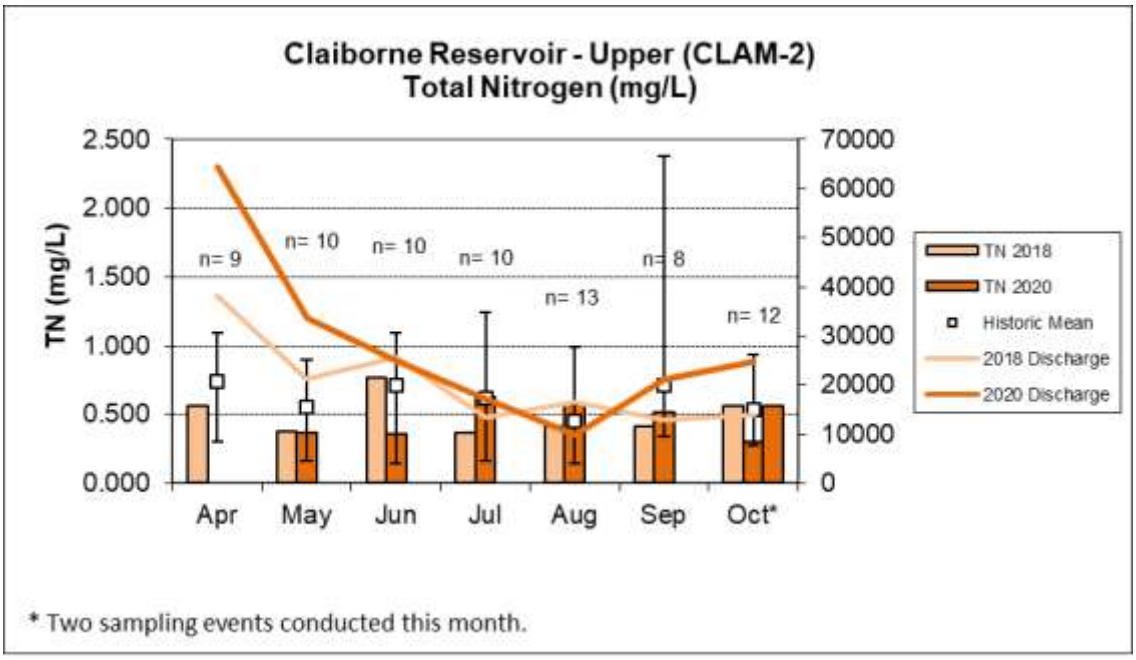
	Upper	Beaver Ck	Pursley Ck	Tallatchee Ck	Lower
2000	11.80	11.28 *	17.92 *	25.73 *	11.05
2002	11.42				12.53
2003	7.99				5.79
2005	11.06	6.94	7.09	18.77	9.26
2008	15.22				14.64
2010	7.78	13.64	19.53	36.00	3.51
2015	3.09	4.20	10.18	14.55	3.68
2018	6.68	14.00	2.51	10.76	2.61
2020	7.90	8.08	5.10		11.43



	Upper	Beaver Ck	Pursley Ck	Tallatchee Ck	Lower
2000	19.43	20.67 *	16.33 *	20.67 *	19.00
2002	8.64				5.43
2003	16.94				17.86
2005	25.29	27.00	22.57	37.86	10.29
2008	5.71				4.57
2010	9.29	26.14	10.86	25.71	7.21
2015	15.3	16.4	16.1	31.1	11.9
2018	18.6	19.3	31.9	30.0	12.6
2020	13.3	15.3	20.6		11.6

*Mean of April/June/August only.

Figure 4. Monthly TN concentrations of mainstem stations measured in Claiborne Reservoir, April-October 2018 and 2020**.** Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TN was plotted vs. the closest discharge (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).



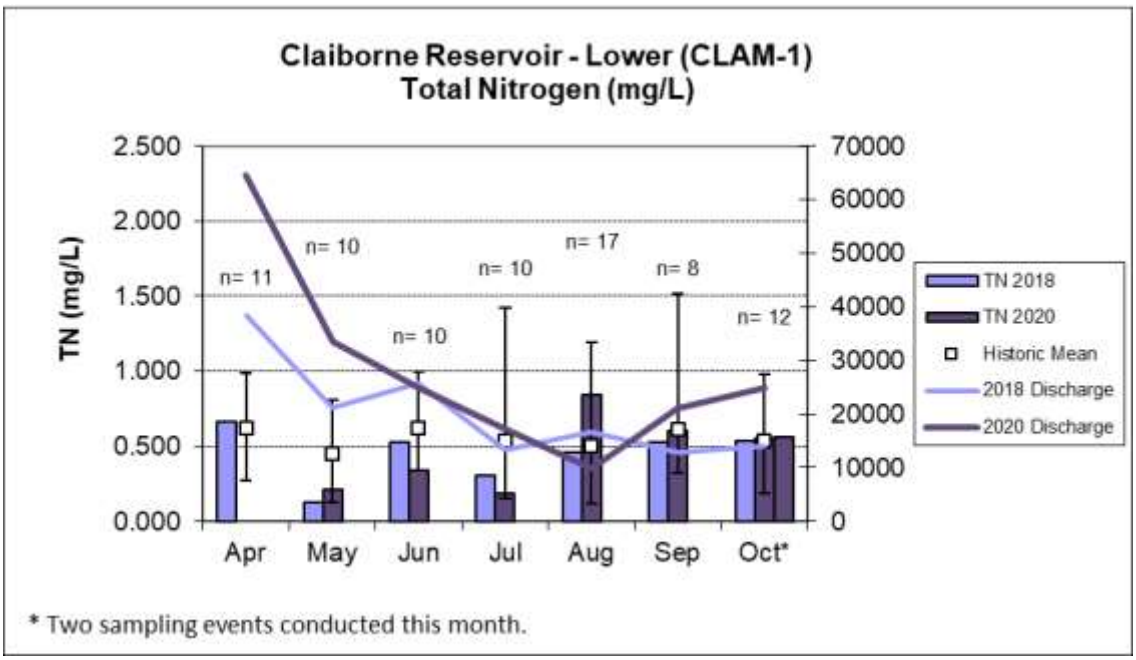
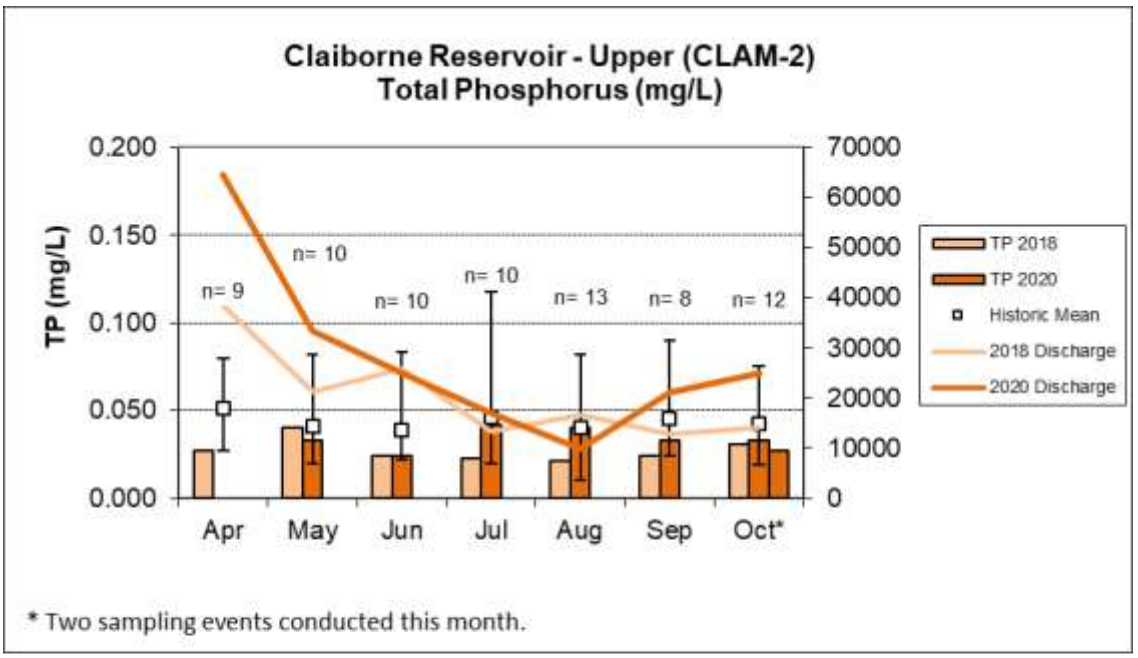


Figure 5. Monthly TP concentrations of mainstem stations measured in Claiborne Reservoir, April-October 2018 and 2020. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TP was plotted vs. the closest discharge (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).



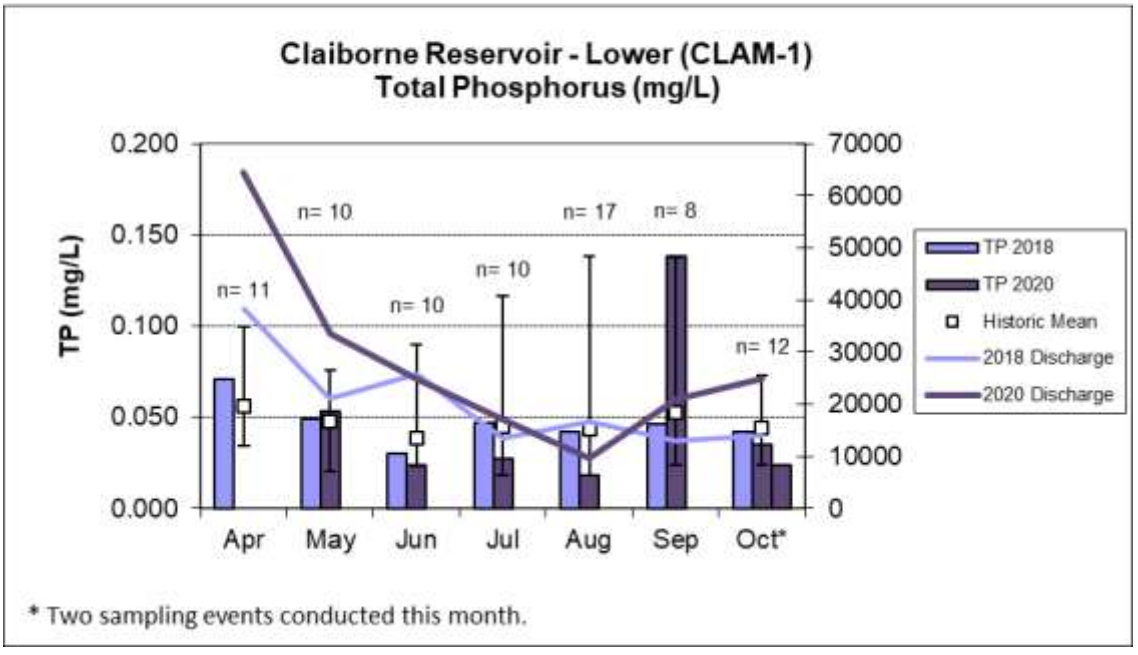
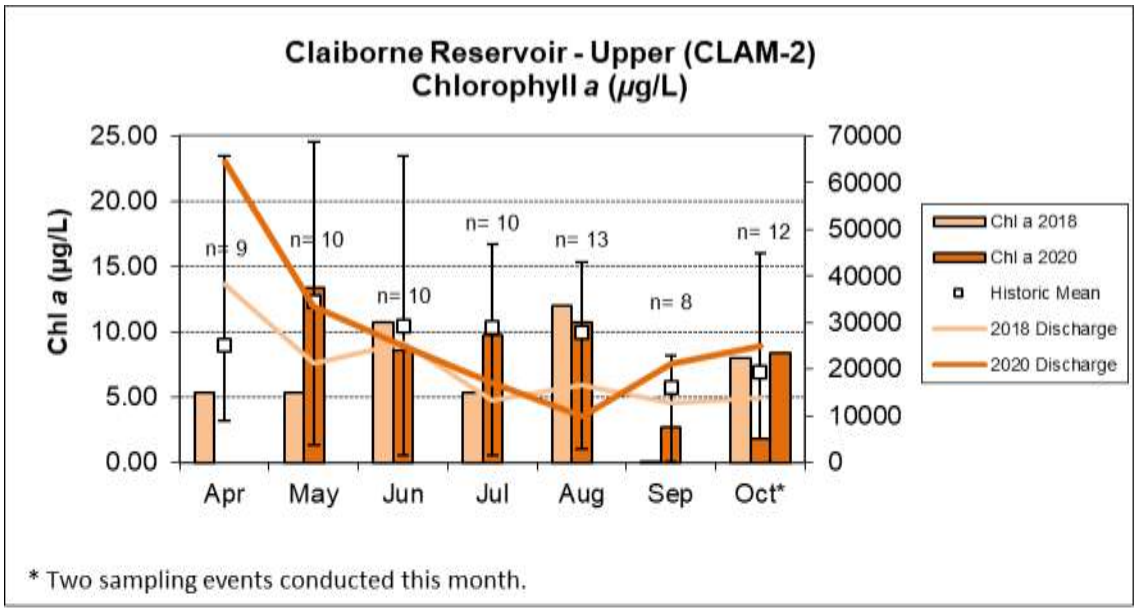


Figure 6. Monthly chl *a* concentrations of mainstem stations measured in Claiborne Reservoir, April-October 2018 and 2020. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. Chl *a* was plotted vs. the closest discharge (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).



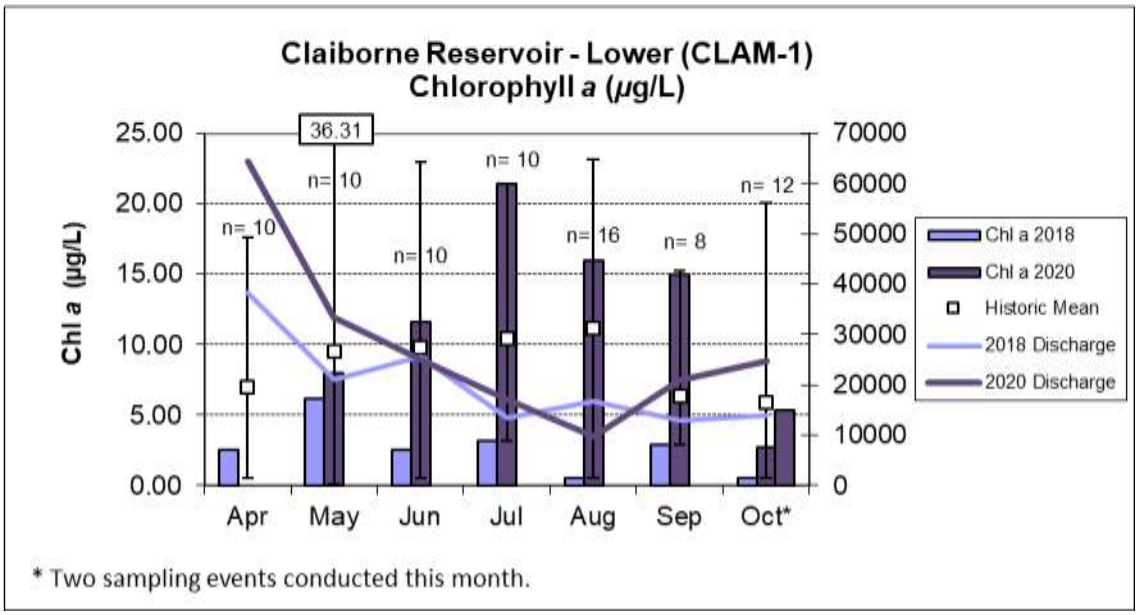
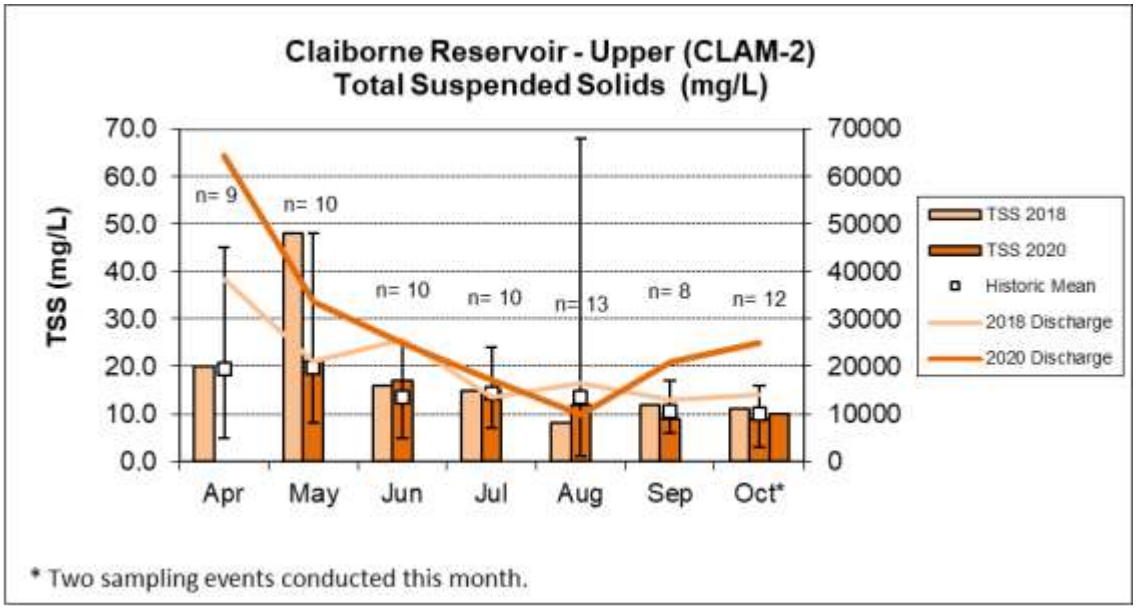


Figure 7. Monthly TSS concentrations of mainstem stations measured in Claiborne Reservoir, April-October 2018 and 2020. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TSS was plotted vs. the closest discharge (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).



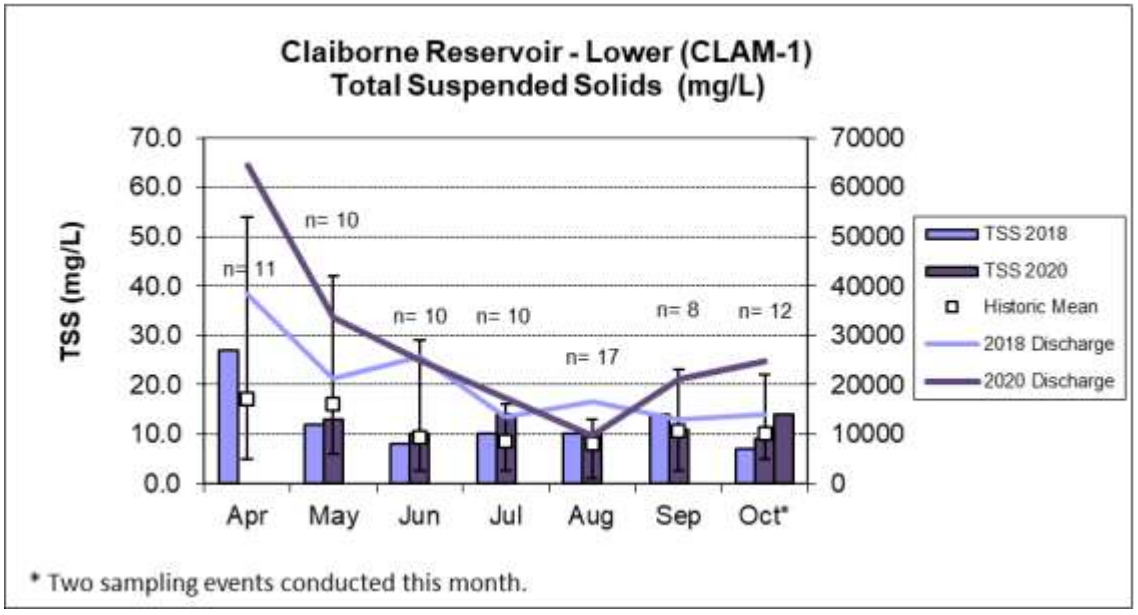


Table 2. Algal growth potential test results, Claiborne Reservoir, 2000-2018 (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	CLAM-1 (Lower)		CLAM-2 (Upper)		CLAM-3		CLAM-4		CLAM-5	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
2000	2.81	NITROGEN	3.30	PHOSPHORUS	---	---	---	---	---	---
2005	3.58	PHOSPHORUS	4.73	CO-LIMITING	---	---	---	---	---	---
2010	---	---	8.20	PHOSPHORUS	---	---	---	---	---	---
2018	11.20	NITROGEN	9.98	NITROGEN	12.56	NITROGEN	7.22	NITROGEN	25.38	NITROGEN

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Claiborne Reservoir stations collected April-October 2018. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth (ADEM Admin. Code R. 335-6-10-.09).

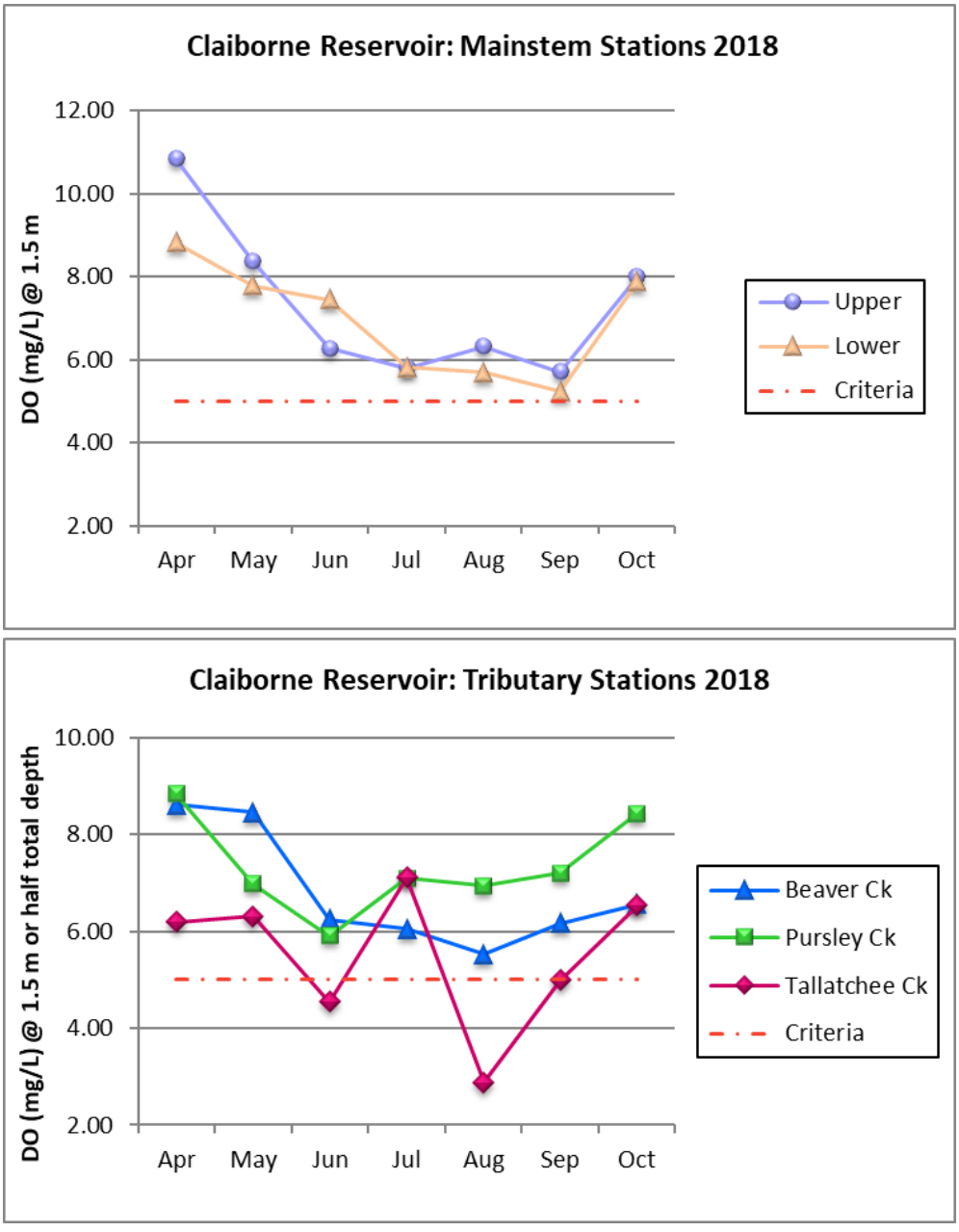


Figure 9. Monthly DO concentrations at 1.5 m (5 ft) for Claiborne Reservoir stations collected April-October 2020. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth (ADEM Admin. Code R. 335-6-10-.09).

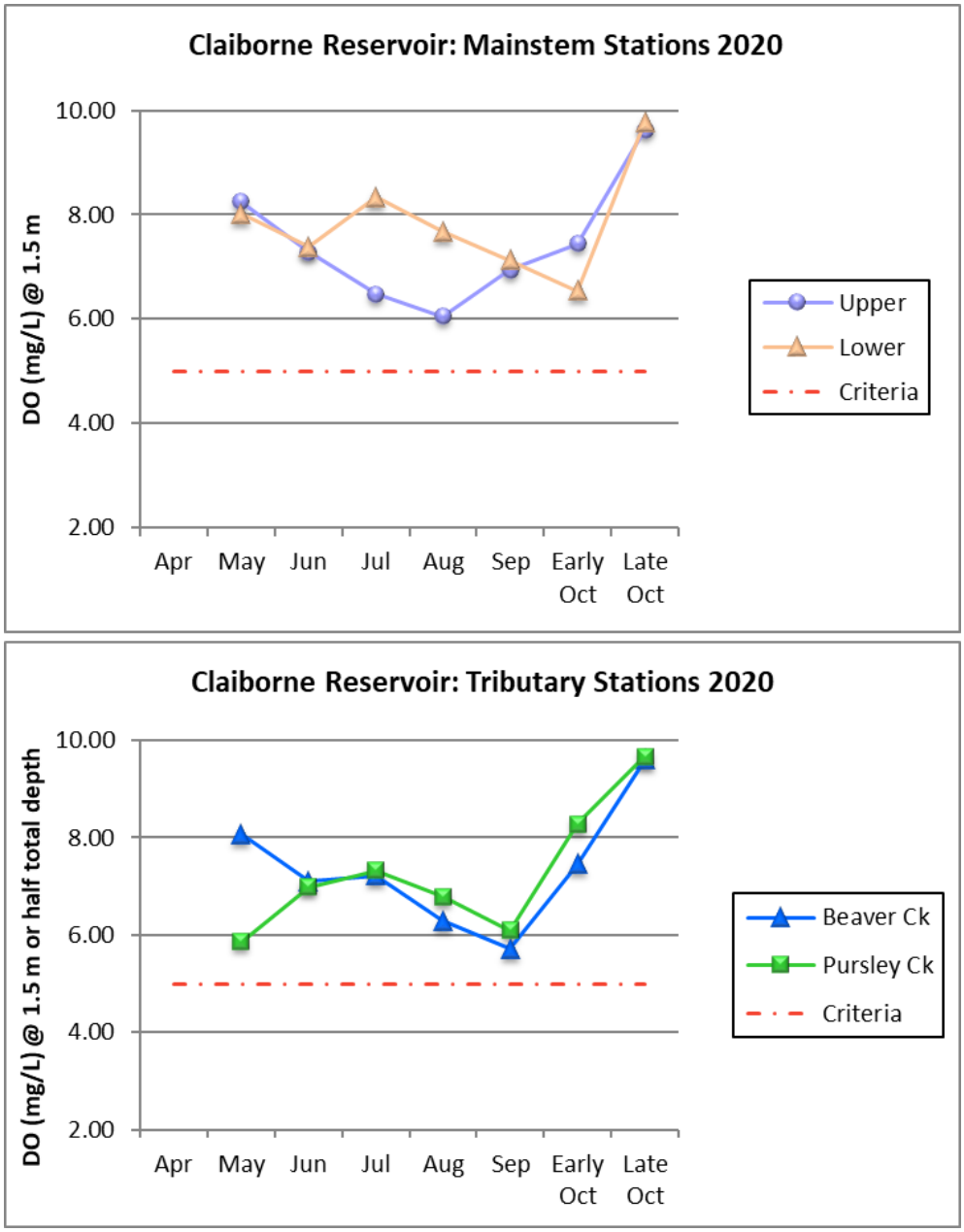


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (µmhos) in the lower Claiborne Reservoir station, April-October 2018.

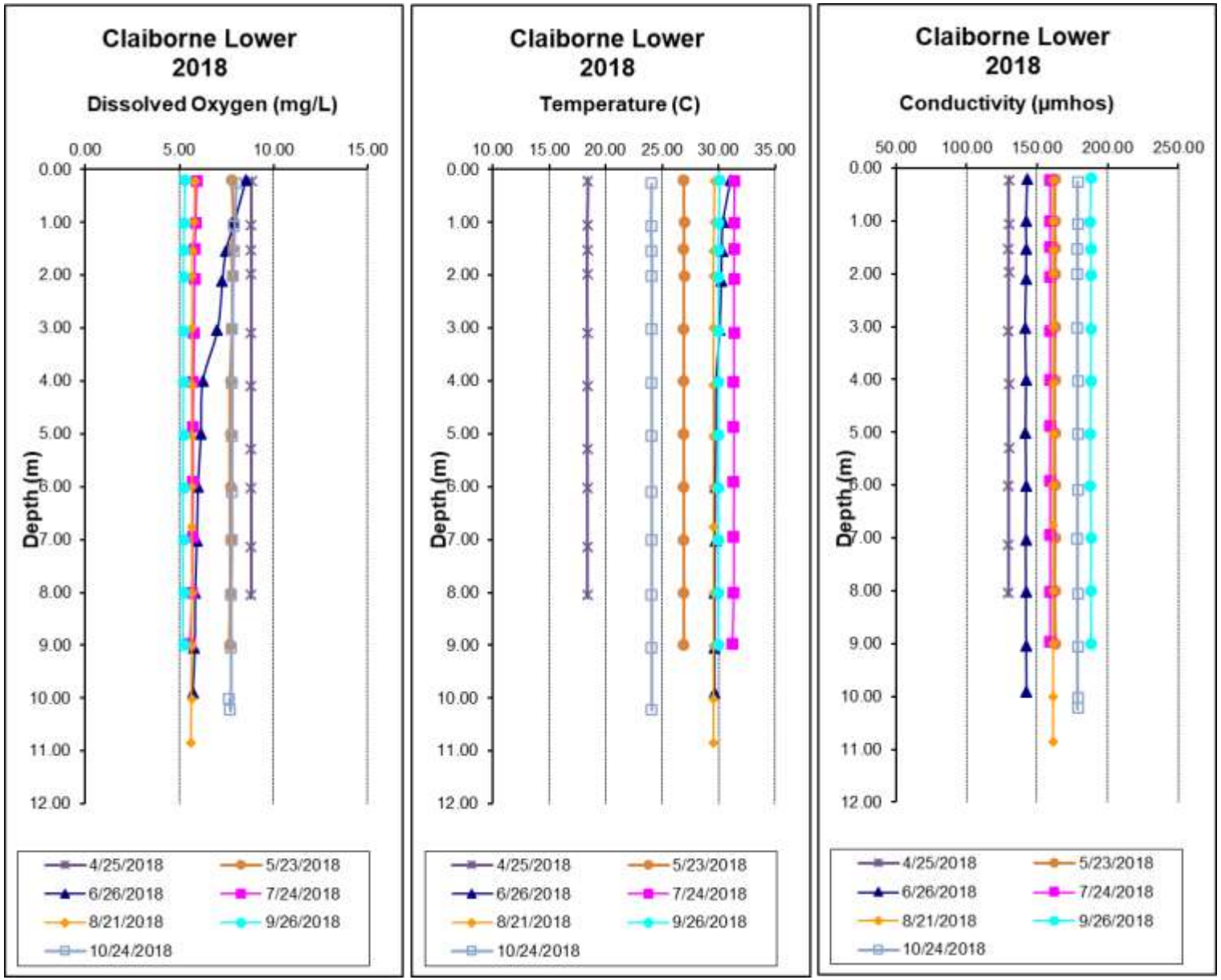


Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (µmhos) in the lower Claiborne Reservoir station, April-October 2020. No samples were collected in April, and two sampling events were conducted in October.

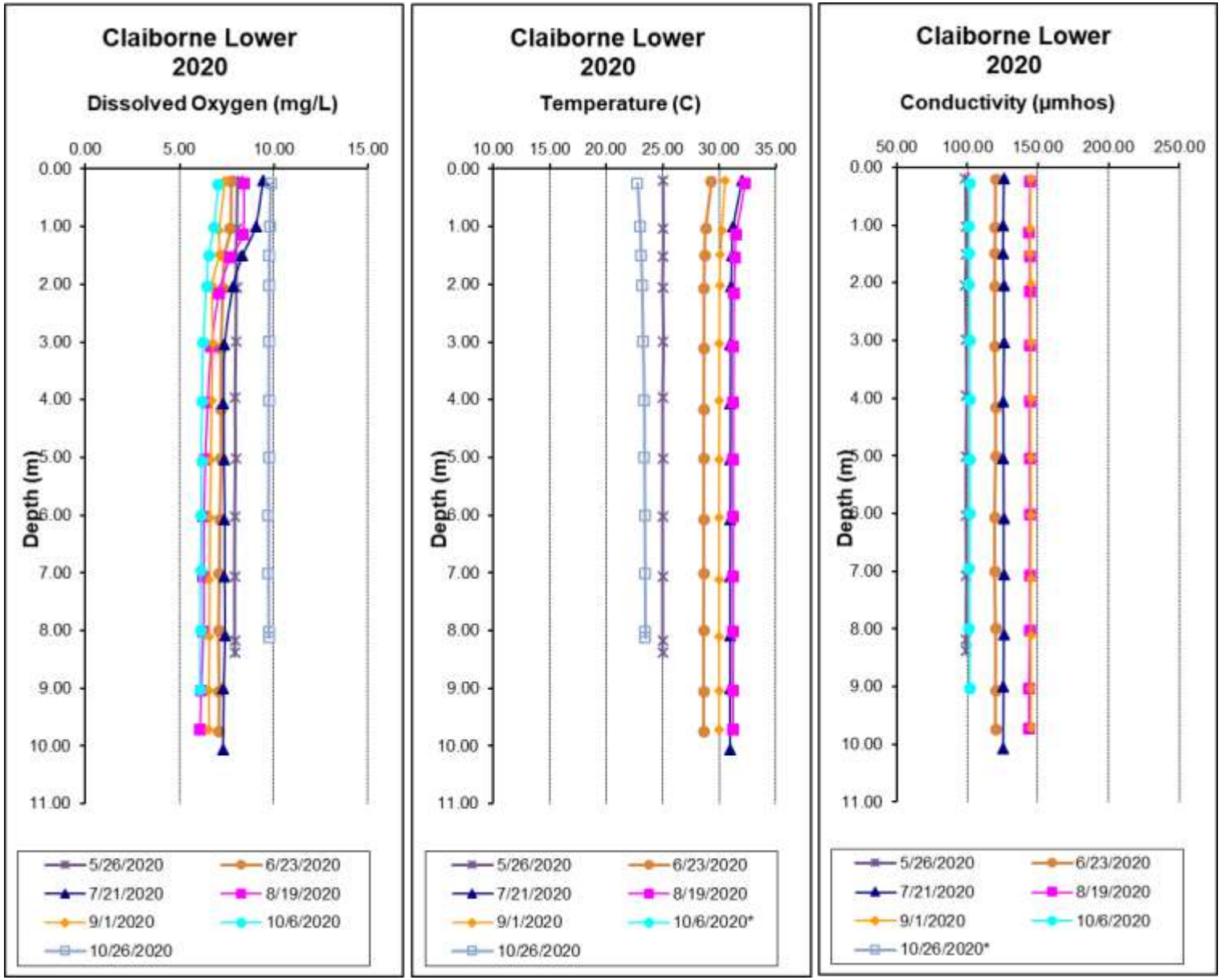


Figure 12. Monthly TSI values calculated for mainstem and tributary Claiborne Reservoir stations in 2018 using chl *a* concentrations and Carlson's Trophic Index calculation (Carlson 1977). Monthly discharge data from nearest gage station (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).

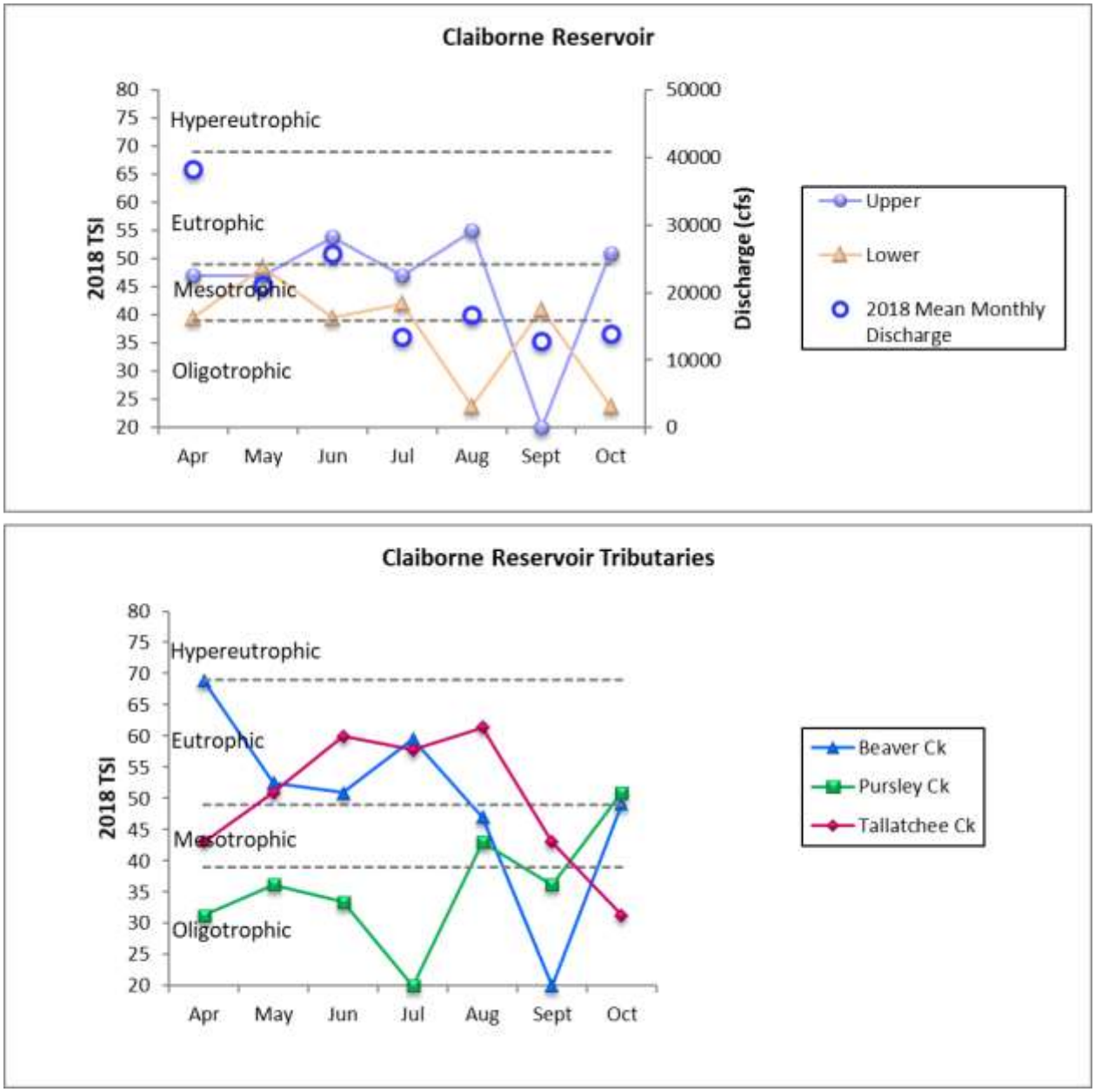
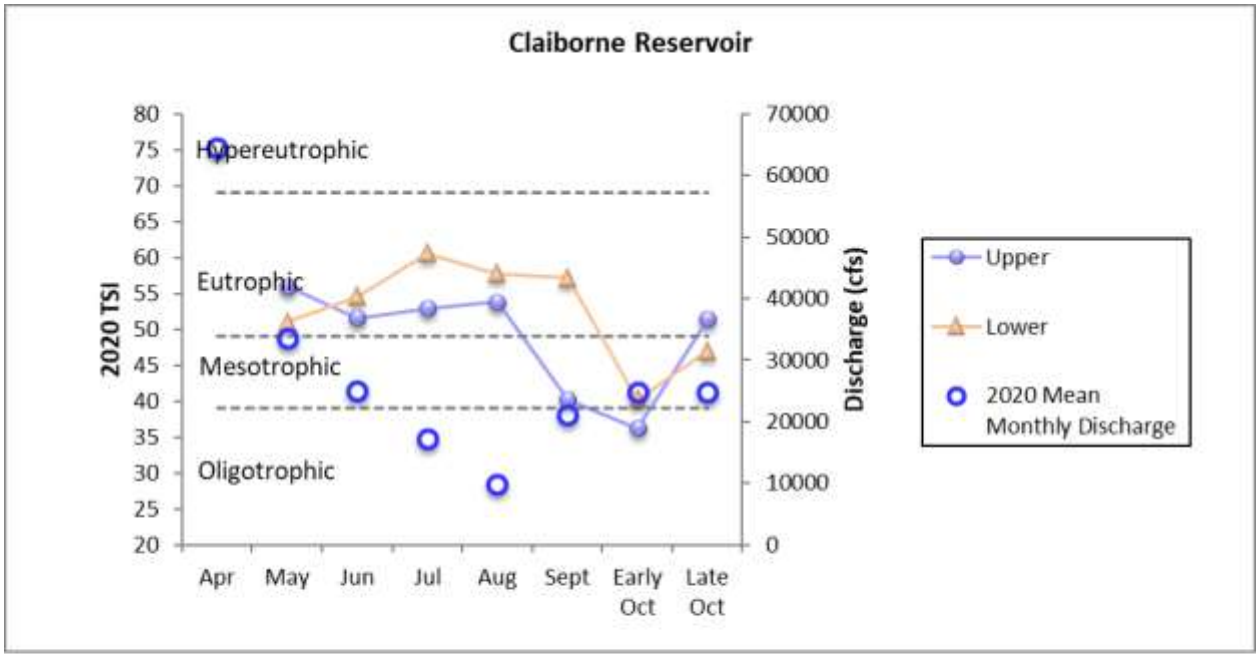
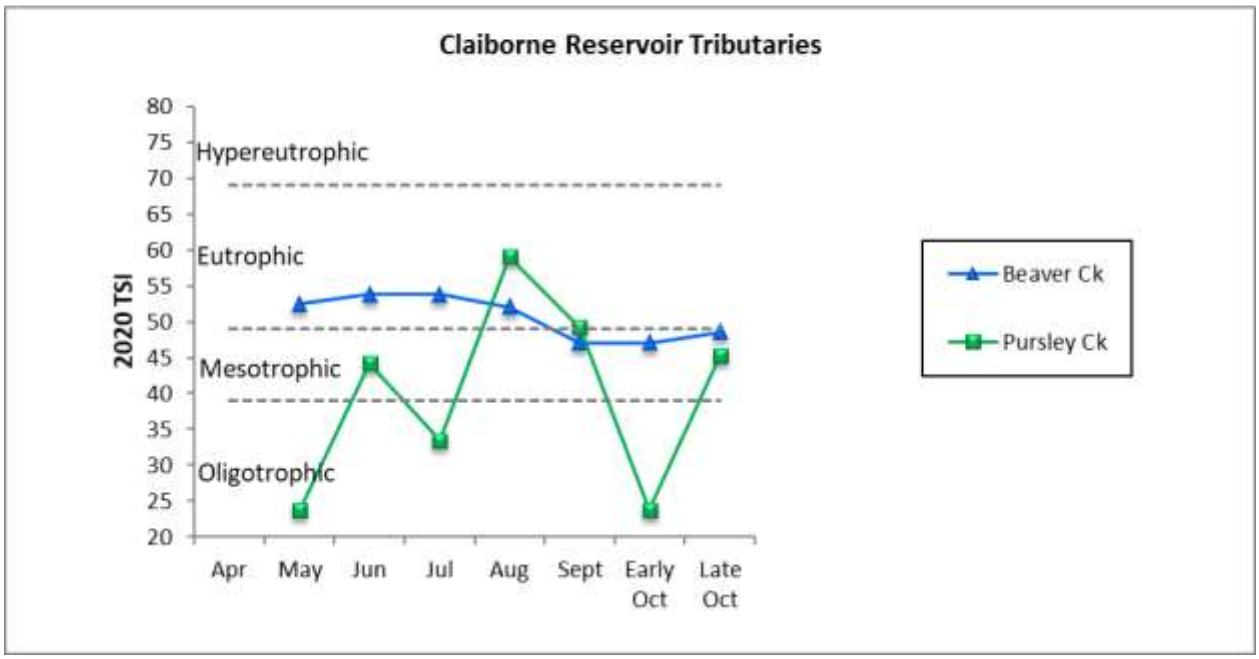


Figure 13. Monthly TSI values calculated for mainstem and tributary Claiborne Reservoir stations in 2020 using chl *a* concentrations and Carlson's Trophic Index calculation (Carlson 1977). Monthly discharge data from nearest gage station (USGS 02428400 Alabama River at Claiborne L&D near Monroeville, AL).





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APPENDIX

Table 1. Summary of water quality data collected April-October, 2018. Minimum (min) and maximum (max) values calculated using minimum detection limits when results were less than this value. Median (med), mean, and standard deviation (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Avg	SD
CLAM-1	**Physical**						
	Turbidity (NTU)	7	8.0	34.5	12.9	14.9	8.9
	Total Dissolved Solids (mg/L)	7	68.0	114.0	87.0	89.0	15.0
	Total Suspended Solids (mg/L)	7	7.0	27.0	10.0	12.6	6.8
	Hardness (mg/L)	4	45.6	61.0	53.0	53.1	6.6
	Alkalinity (mg/L)	7	46.9	60.5	54.8	54.8	5.2
	Photic Zone (m)	7	1.61	3.18	2.88	2.60	0.53
	Secchi (m)	7	0.58	0.97	0.85	0.81	0.14
	Bottom Depth (m)	7	8.2	11.0	9.5	9.6	0.9
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.028	0.050	0.014	0.022	0.014
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.055	0.218	0.121	0.129	0.065
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.140	0.470	0.340	0.320	0.147
	Total Nitrogen (mg/L)[J]	7	< 0.375	1.983	0.527	0.449	0.179
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.006	0.014	0.009	0.008	0.004
	Total Phosphorus (mg/L)[J]	7	0.030	0.071	0.046	0.047	0.012
	CBOD-5 (mg/L)[J]	7	< 2.0	< 2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7	3.9	9.0	6.1	6.2	1.8
	Biological						
	Chlorophyll a (mg/m³)	7	< 1.00	6.20	2.50	2.61	1.93
	E. coli (MPN/DL)[J]	4	1	24	3	8	11
CLAM-2	**Physical**						
	Turbidity (NTU)	7	10.2	28.5	16.0	16.8	6.4
	Total Dissolved Solids (mg/L)	7	53.0	96.0	90.0	84.3	14.9
	Total Suspended Solids (mg/L)	7	8.0	48.0	15.0	18.6	13.5
	Hardness (mg/L)	4	50.0	62.9	57.4	56.9	5.6
	Alkalinity (mg/L)	7	48.2	61.5	57.0	54.9	5.3
	Photic Zone (m)	7	1.46	3.90	1.92	2.10	0.81
	Secchi (m)	7	0.38	1.18	0.83	0.79	0.29
	Bottom Depth (m)	7	7.2	11.1	8.5	8.9	1.5
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.078	0.194	0.142	0.139	0.041
	Total Kjeldahl Nitrogen (mg/L)	7	0.219	0.667	0.331	0.355	0.151
	Total Nitrogen (mg/L)	7	1.104	2.292	0.417	0.494	0.144
	Dis Reactive Phosphorus (mg/L)[J]	7	0.004	0.012	0.006	0.007	0.003
	Total Phosphorus (mg/L)	7	0.021	0.040	0.024	0.027	0.006
	CBOD-5 (mg/L)[J]	7	< 2.0	< 2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	4.9	9.0	6.7	6.7	1.7
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.10	12.00	5.34	6.68	3.99
	E. coli (MPN/DL)[J]	4	1	6	3	3	2

Station	Parameter	N		Min	Max	Med	Avg	SD
CLAM-3	**Physical**							
	Turbidity (NTU)	7		7.0	68.1	16.1	27.0	21.3
	Total Dissolved Solids (mg/L)	7		32.0	90.0	83.0	75.6	21.0
	Total Suspended Solids (mg/L)	7		9.0	47.0	16.0	19.3	13.4
	Hardness (mg/L)	4		49.3	60.1	56.9	55.8	4.6
	Alkalinity (mg/L)	7		34.0	58.5	55.8	51.9	8.6
	Photic Zone (m)	7		1.26	3.20	1.89	2.04	0.72
	Secchi (m)	7		0.49	1.02	0.73	0.74	0.21
	Bottom Depth (m)	7		2.9	8.6	4.7	5.2	2.1
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.020	0.004	0.006	0.006
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.052	0.191	0.107	0.112	0.045
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.107	0.331	0.255	0.249	0.075
	Total Nitrogen (mg/L)[J]	7		0.477	1.260	0.384	0.361	0.092
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.013	0.005	0.006	0.004
	Total Phosphorus (mg/L)	7		0.019	0.042	0.026	0.027	0.008
	CBOD-5 (mg/L)[J]	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		4.5	8.8	6.3	6.6	1.6
	Biological							
	Chlorophyll a (mg/m³)	7	<	0.10	49.40	8.01	14.00	16.64
	E. coli (MPN/DL)[J]	4		3	23	12	13	8
CLAM-4	**Physical**							
	Turbidity (NTU)	7		9.5	60.1	16.7	27.7	20.1
	Total Dissolved Solids (mg/L)	7		94.0	151.0	119.0	121.1	19.2
	Total Suspended Solids (mg/L)	7		6.0	75.0	30.0	31.9	26.0
	Hardness (mg/L)	4		48.3	95.4	76.0	74.0	20.3
	Alkalinity (mg/L)	7		36.4	81.6	58.0	58.4	15.0
	Photic Zone (m)	7		0.54	1.96	0.79	0.93	0.48
	Secchi (m)	7		0.20	1.02	0.58	0.57	0.28
	Bottom Depth (m)	7		0.6	3.0	1.0	1.3	0.9
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.044	0.008	0.017	0.017
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.032	0.198	0.101	0.103	0.058
	Total Kjeldahl Nitrogen (mg/L)	7		0.276	0.899	0.366	0.442	0.214
	Total Nitrogen (mg/L)	7		1.140	2.823	0.467	0.545	0.201
	Dis Reactive Phosphorus (mg/L)	7		0.010	0.022	0.013	0.015	0.004
	Total Phosphorus (mg/L)	7		0.028	0.078	0.038	0.045	0.018
	CBOD-5 (mg/L)	7	<	2.0	2.9	1.0	1.3	0.7
	Chlorides (mg/L)	7		3.9	9.0	5.0	5.6	1.8
	Biological							
	Chlorophyll a (mg/m³)	7	<	0.10	8.01	1.78	2.51	2.64
	E. coli (MPN/DL)	4		137	816	232	354	318

Station	Parameter	N		Min	Max	Med	Avg	SD
CLAM-5	**Physical**							
	Turbidity (NTU)	7		22.7	56.2	35.8	37.8	11.1
	Total Dissolved Solids (mg/L)	7		71.0	97.0	81.0	81.7	9.7
	Total Suspended Solids (mg/L)	7		11.0	65.0	25.0	30.0	17.6
	Hardness (mg/L)	4		29.2	54.2	42.3	42.0	11.8
	Alkalinity (mg/L)	7		24.4	55.5	31.5	38.1	13.4
	Photic Zone (m)	5		0.67	2.64	1.00	1.37	0.81
	Secchi (m)	5		0.26	0.66	0.39	0.45	0.18
	Bottom Depth (m)	7		0.6	2.8	1.7	1.7	0.8
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.113	0.038	0.045	0.039
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.058	0.187	0.077	0.095	0.046
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.109	2.740	0.511	0.783	0.890
	Total Nitrogen (mg/L)[J]	7		0.507	8.409	0.622	0.878	0.878
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.008	0.006	0.006	0.002
	Total Phosphorus (mg/L)	7		0.023	0.071	0.034	0.039	0.017
	CBOD-5 (mg/L)[J]	7	<	2.0	3.4	2.1	2.4	0.9
	Chlorides (mg/L)	7		4.6	7.8	6.5	6.4	1.1
	Biological							
	Chlorophyll a (mg/m³)	7		1.07	23.10	8.01	10.76	8.85
	E. coli (MPN/DL)[J]	4		32	148	87	89	59

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit.

Appendix Table 2. Summary of water quality data collected April-October, 2020. Minimum (min) and maximum (max) values calculated using minimum detection limits when results were less than this value. Median (med), mean, and standard deviation (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Avg	SD
CLAM-1	**Physical**						
	Turbidity (NTU)	7	9.7	14.7	10.1	10.9	1.8
	Total Dissolved Solids (mg/L)	7	59.0	84.0	71.0	69.6	8.2
	Total Suspended Solids (mg/L)	7	9.0	14.0	11.0	11.6	2.1
	Hardness (mg/L)	4	43.5	70.4	46.3	51.6	12.6
	Alkalinity (mg/L)	7	34.7	49.0	44.6	43.2	5.6
	Photic Zone (m)	7	2.20	2.83	2.62	2.51	0.26
	Secchi (m)	7	0.84	1.10	0.93	0.95	0.11
	Bottom Depth (m)	7	8.1	10.1	9.7	9.2	0.8
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.016	0.031	0.008	0.013	0.009
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.022	0.155	0.109	0.086	0.052
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.200	0.814	0.395	0.383	0.237
	Total Nitrogen (mg/L)[J]	7	< 0.552	2.532	0.550	0.469	0.238
	Dis Reactive Phosphorus (mg/L)[J]	6	< 0.004	0.015	0.004	0.006	0.005
	Total Phosphorus (mg/L)	7	0.018	0.138	0.027	0.046	0.042
	CBOD-5 (mg/L)	6	< 2.0	< 2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	3.9	6.2	5.1	4.9	0.8
	Biological						
	Chlorophyll a (mg/m³)	7	2.67	21.40	11.60	11.43	6.56
	E. coli (MPN/DL)[J]	4	1	5	2	2	1
CLAM-2	**Physical**						
	Turbidity (NTU)	7	9.0	15.6	12.8	12.4	2.1
	Total Dissolved Solids (mg/L)	7	65.0	93.0	77.0	78.4	10.0
	Total Suspended Solids (mg/L)	7	9.0	21.0	12.0	13.3	4.6
	Hardness (mg/L)	4	22.7	48.2	46.2	40.8	12.2
	Alkalinity (mg/L)	7	34.8	52.0	45.9	45.2	6.5
	Photic Zone (m)	7	2.10	2.96	2.60	2.56	0.30
	Secchi (m)	7	0.67	1.12	0.85	0.85	0.15
	Bottom Depth (m)	7	6.9	9.2	7.7	8.0	0.9
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.016	0.062	0.008	0.017	0.020
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.069	0.142	0.117	0.108	0.029
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.246	0.549	0.396	0.365	0.137
	Total Nitrogen (mg/L)[J]	7	< 0.912	1.872	0.513	0.473	0.127
	Dis Reactive Phosphorus (mg/L)[J]	6	< 0.004	0.010	0.004	0.005	0.003
	Total Phosphorus (mg/L)	7	0.024	0.042	0.033	0.033	0.006
	CBOD-5 (mg/L)	6	< 2.0	< 2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7	3.7	6.6	5.2	5.2	0.9
	Biological						
	Chlorophyll a (mg/m³)	7	1.78	13.40	8.54	7.90	4.22
	E. coli (MPN/DL)[J]	4	1	2	2	2	1

Station	Parameter	N	Min	Max	Med	Avg	SD
CLAM-3	**Physical**						
	Turbidity (NTU)	7	10.7	39.9	11.8	16.5	10.5
	Total Dissolved Solids (mg/L)	7	61.0	97.0	72.0	77.7	13.5
	Total Suspended Solids (mg/L)	7	7.0	35.0	13.0	15.3	9.2
	Hardness (mg/L)	4	< 0.4	47.7	41.1	32.5	22.0
	Alkalinity (mg/L)	7	33.3	51.5	44.4	42.8	7.4
	Photic Zone (m)	7	1.18	2.91	2.22	2.19	0.54
	Secchi (m)	7	0.49	1.11	0.78	0.78	0.18
	Bottom Depth (m)	7	2.2	3.8	3.0	3.1	0.5
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.016	0.063	0.024	0.026	0.021
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.069	0.136	0.092	0.100	0.027
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.200	0.499	0.400	0.341	0.160
	Total Nitrogen (mg/L)	7	< 0.636	1.773	0.530	0.441	0.164
	Dis Reactive Phosphorus (mg/L)[J]	6	< 0.004	0.009	0.006	0.006	0.003
	Total Phosphorus (mg/L)	7	0.018	0.062	0.025	0.035	0.016
	CBOD-5 (mg/L)	6	< 2.0	< 2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	3.9	6.6	4.9	5.1	0.9
	Biological						
	Chlorophyll a (mg/m³)	7	5.34	10.70	8.90	8.08	2.40
	E. coli (MPN/DL)[J]	4	4	144	58	66	71
CLAM-4	**Physical**						
	Turbidity (NTU)	7	7.6	33.4	16.6	20.7	10.8
	Total Dissolved Solids (mg/L)	7	67.0	159.0	109.0	114.0	29.6
	Total Suspended Solids (mg/L)	7	4.0	39.0	17.0	20.6	12.5
	Hardness (mg/L)	4	50.7	79.0	62.7	63.8	13.2
	Alkalinity (mg/L)	7	49.0	65.4	56.3	57.1	5.6
	Photic Zone (m)	7	0.72	1.65	1.23	1.20	0.29
	Secchi (m)	7	0.33	1.15	0.60	0.69	0.28
	Bottom Depth (m)	7	0.7	2.3	1.2	1.3	0.5
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.016	0.049	0.008	0.019	0.016
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.009	0.127	0.058	0.071	0.043
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.200	0.727	0.449	0.389	0.210
	Total Nitrogen (mg/L)[J]	7	< 0.582	2.562	0.463	0.460	0.228
	Dis Reactive Phosphorus (mg/L)[J]	6	< 0.004	0.015	0.010	0.009	0.004
	Total Phosphorus (mg/L)	7	0.021	0.064	0.042	0.044	0.014
	CBOD-5 (mg/L)	6	< 2.0	2.4	1.0	1.2	0.6
	Chlorides (mg/L)	7	4.1	7.3	5.4	5.8	1.1
	Biological						
	Chlorophyll a (mg/m³)	7	< 1.00	18.20	4.00	5.10	6.22
	E. coli (MPN/DL)[J]	4	3	435	222	220	190

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit.