Dannelly 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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Table of Contents

LIST OF ACRONYMS

A&I	Agriculture and Industry
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
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

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Dannelly Reservoir was created with the construction of Millers Ferry Lock and Dam. Construction of the reservoir began in 1963 and was completed in 1974 by the United States Army Corps of Engineers (COE). The reservoir covers approximately 17,200 acres and stretches from Benton, Alabama, to just northwest of Camden, Alabama. Dannelly provides hydroelectricity to the area and also provides a number of recreational opportunities such as camping, hiking, fishing, and hunting.

The Alabama Department of Environmental Management (ADEM) monitored Dannelly 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 the Field Operations Division of the 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 one location on Dannelly Reservoir (Table 1). This criterion represents a growing season mean (April-October) chlorophyll *a* (chl *a*) concentration that is protective of Dannelly Reservoir's Swimming and Fish & Wildlife (S/F&W) use classifications.

The purpose of this report is to summarize data collected at seven stations in Dannelly 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 location information can be found in Table 1. Dannelly Reservoir was sampled in the dam forebay, mid reservoir, upper reservoir, and at Alabama River mile 220. Three tributary embayments were also monitored: Cahaba River, Bogue Chitto Creek, and Pine Barren Creek.

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).

Growing season mean TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. For mainstem stations, monthly concentrations of these parameters were graphed with the closest available COE flow data and ADEM's previously collected data to help interpret the 2018 and 2020 results.

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

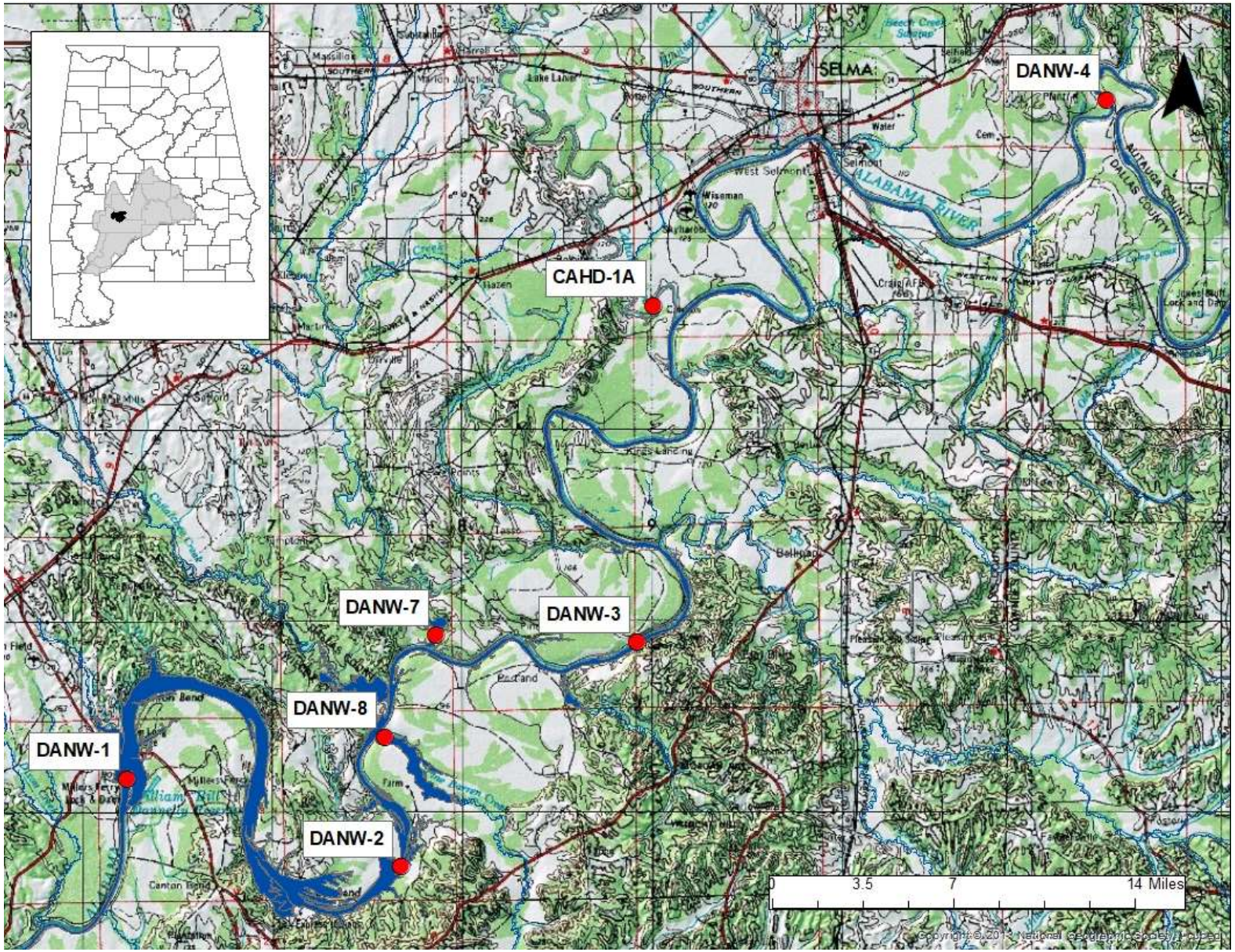


Table 1. Descriptions of the 2018 and 2020 monitoring stations in Dannelly Reservoir.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criteria	Latitude	Longitude
Dannelly Reservoir								
031502030701	Wilcox	**DANW-1	Lower	Alabama R	Deepest point, main river channel, dam forebay.	17 μg/L	32.1035	-87.3986
031502030701	Wilcox	DANW-2	Mid	Alabama R	Deepest point, main river channel, immediately. upstream of Roland Cooper State Park.		32.0619	-87.2457
031502030203	Dallas	DANW-3	Upper	Alabama R	Deepest point, main river channel, immediately upstream of Elm Bluff Park.		32.1680	-87.1136
031502011204	Dallas	DANW-4	ARM 220	Alabama R	Deepest point, main river channel, upstream of paper mill discharge.		32.4240	-86.8514
031502020902	Dallas	CAHD-1A	Cahaba R	Cahaba R	Deepest point, main river channel, Cahaba River approximately 2.3 miles upstream from confluence with Alabama River.		32.3268	-87.1046
031502030308	Dallas	DANW-7	Bogue Chitto Ck	Bogue Chitto Ck	Deepest point, main creek channel of Bogue Chitto Creek embayment, approximately 0.5 miles upstream of lake confluence.		32.1713	-87.2257
031502030506	Dallas	DANW-8	Pine Barren Ck	Pine Barren Ck	Deepest point, main creek channel, Pine Barrens Creek embayment, approximately 0.5 miles upstream of lake confluence.		32.1231	-87.2548

**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 and 14-15). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, TSS, and TSI as an indicator of flow and retention time in the months sampled. Depth profile graphs of temperature, DO, and conductivity appear in Figures 10-13. Summary statistics of all data collected during 2018 and 2020 are presented in Appendix Table 1 and Appendix Table 2. The table contains 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 growing season mean TN value was calculated for the Bogue Chitto Creek station (Figure 2). In 2020, Pine Barren Creek had the highest mean TN concentration. With the exception of Bogue Chitto Creek, stations generally showed a downward trend in mean TN concentrations since 2015. In 2018, monthly TN values reached historic high concentrations at Alabama River Mile (ARM) 220 in May, at the lower and upper stations in October, and at the mid station in April and May (Figure 4). Most other monthly values were at or below historic mean concentrations throughout the growing season. In 2020, the station at ARM 220 reached a historic high monthly TN concentration in September.

Bogue Chitto Creek had the highest growing season mean TP value in both 2018 and 2020 (Figure 2). In general, mean growing season TP concentrations in the four mainstem stations decreased from the early 2000s to 2018. Mean TP concentrations were higher in 2020 than in 2018 at all stations except the Cahaba River and the upper reservoir station. In 2018, a historic monthly high TP concentration was observed in the upper reservoir station (Figure 5). Mean monthly TP concentrations were below historic means during all months sampled in both 2018 and 2020 at the lower reservoir station.

A specific water quality criterion for nutrient management has been established for the lower station in Dannelly Reservoir. The growing season mean chl *a* value calculated for the lower station was below the criteria limit of 17 µg/L in both 2018 and 2020 (Figure 3). While the highest mean growing season chl *a* concentrations were calculated for Bogue Chitto Creek in both 2018 and 2020, mean chl *a* values have decreased throughout the reservoir since 2000. In 2018, a historic high monthly chl *a* concentration was observed at the ARM 220 station in April (Figure 6). In 2020, monthly chl *a* concentrations were at or below historic mean values at all stations for all months sampled except for the lower station in early October.

In both 2018 and 2020, the highest growing season mean TSS value was calculated for the Cahaba River station (Figure 3). The 2018 mean concentration of 61 mg/L was the highest mean recorded at that station since 2000. An extremely high monthly TSS value of 303 mg/L was observed at the Cahaba River station in May 2018, contributing to the high growing season mean. The May samples were collected during flood stage conditions, and turbidity during the sampling event was 432 NTU. In 2018, historic high monthly TSS concentrations were observed at ARM 220 in September and October, at the upper station in May, June, and September, and at the lower station in May (Figure 7). In 2020, a historic high monthly TSS concentration was recorded in June at ARM 220.

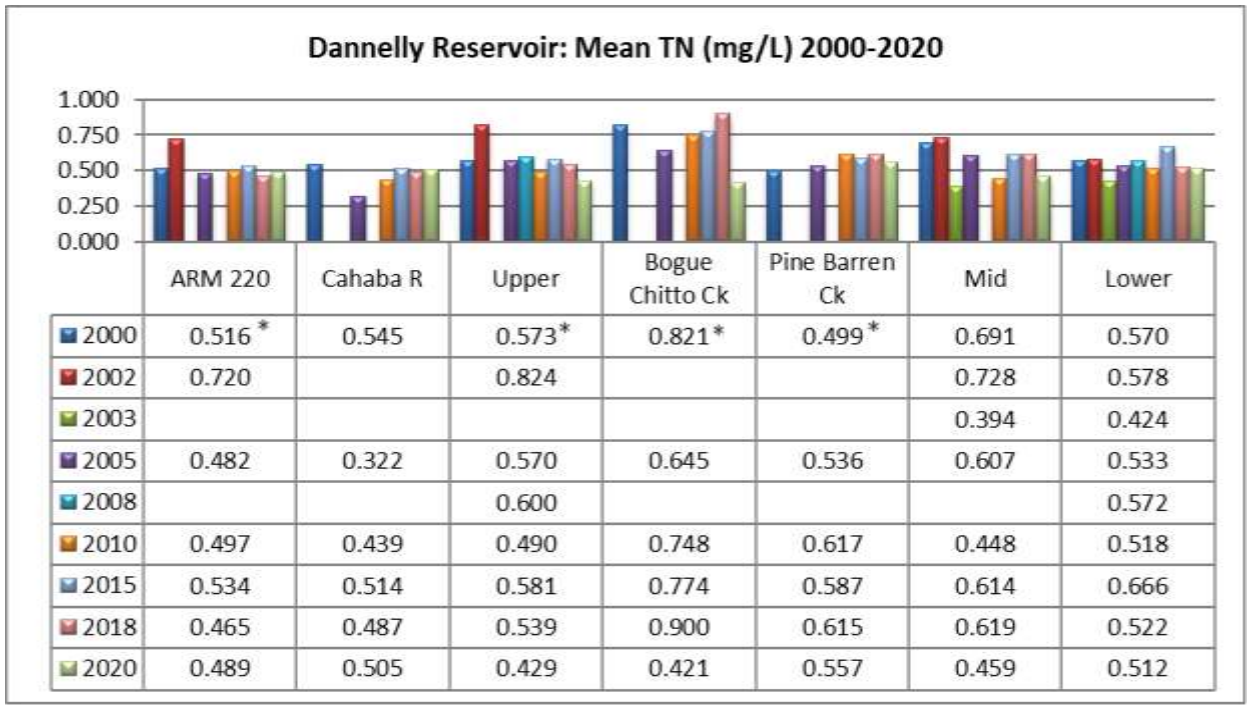
AGPT results for Dannelly Reservoir have varied between nitrogen-limited, phosphorus-limited, and co-limiting at the mainstem reservoir stations in the years monitored (Table 2). Raschke and Schultz (1987) found that maximum standing crop (MSC) values below 5.0 mg/L are considered to be protective of reservoir and lake systems. While MSC values at all stations were less than 5.0 mg/L MSC in 2000, values have increased at all stations over time, with 2018 values the highest observed at all three stations. 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 Dannelly Reservoir in 2020.

In 2018 and 2020, all mainstem stations on Dannelly 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 (Figures 8 & 9). DO concentrations at Bogue Chitto Creek were below the criteria limit in July and September of 2018 and in May and June of 2020. All other embayments had DO concentrations

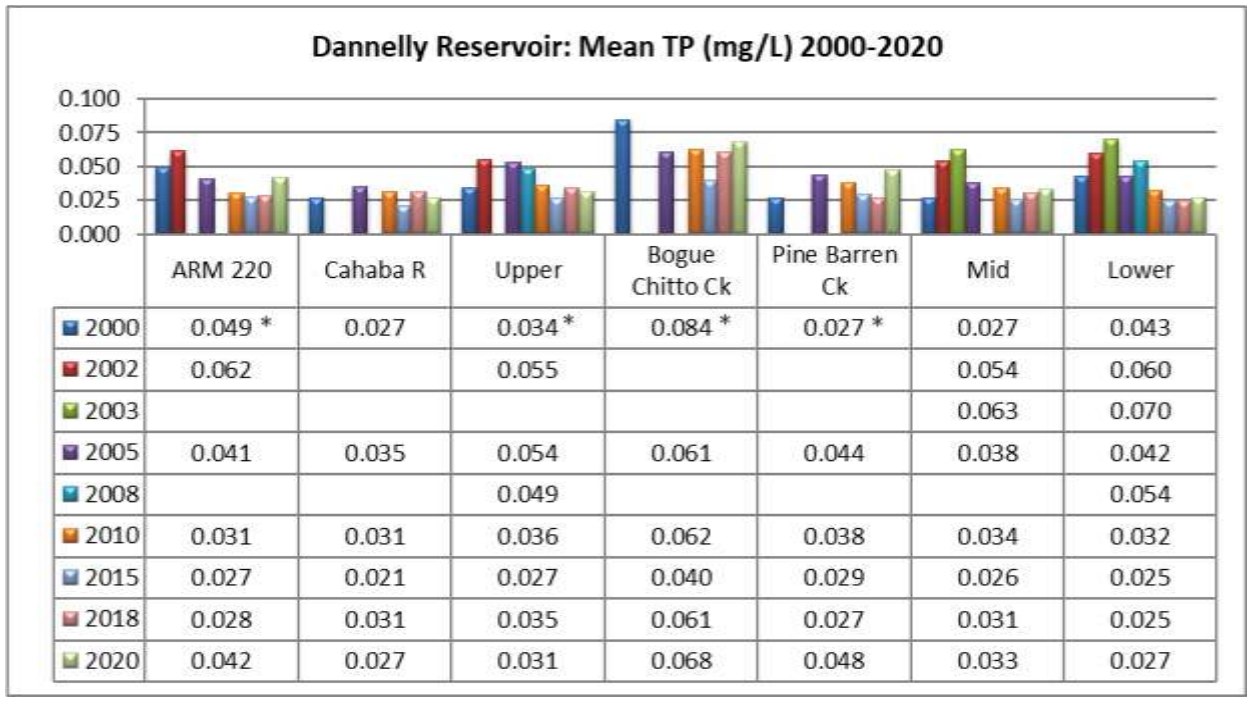
above the criteria limit in all months sampled. Based on monthly DO profiles, the water column at the lower and mid stations were mixed most of the sampling season in 2018 with slight stratification occurring June-September at the lower station and in June and August at the mid station (Figures 10 & 12). Highest water temperatures were reached in July at both stations. In 2020, the lower station showed slight stratification July-early October, while the mid station was well-mixed throughout the sampling season (Figures 11 & 13). Highest water temperatures were reached in August at both stations.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. Mainstem trophic state was highly variable during the 2018 sampling season, but most monthly values ranged from lower eutrophic to upper mesotrophic levels. (Figure 14). Tributary TSI values were also variable during the sampling period, but trophic state was mostly eutrophic at all stations. Mainstem stations were more stable during the 2020 sampling period, with TSI in a eutrophic state for much of the growing season (Figure 15). Tributary trophic state was eutrophic for most of the year, with Bogue Chitto Creek having the highest TSI values for most of the months sampled.

Figure 2. Growing season mean TN and TP measured in Dannelly 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.



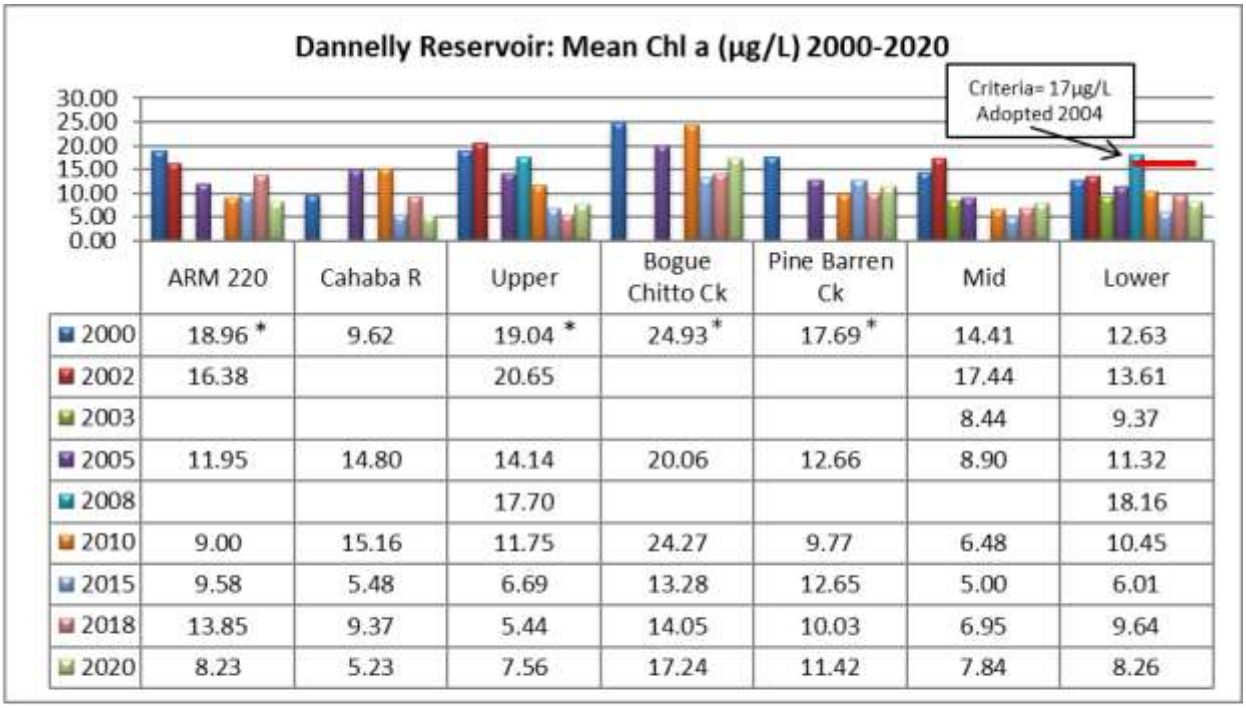
	ARM 220	Cahaba R	Upper	Bogue Chitto Ck	Pine Barren Ck	Mid	Lower
2000	0.516 *	0.545	0.573*	0.821*	0.499*	0.691	0.570
2002	0.720		0.824			0.728	0.578
2003						0.394	0.424
2005	0.482	0.322	0.570	0.645	0.536	0.607	0.533
2008			0.600				0.572
2010	0.497	0.439	0.490	0.748	0.617	0.448	0.518
2015	0.534	0.514	0.581	0.774	0.587	0.614	0.666
2018	0.465	0.487	0.539	0.900	0.615	0.619	0.522
2020	0.489	0.505	0.429	0.421	0.557	0.459	0.512



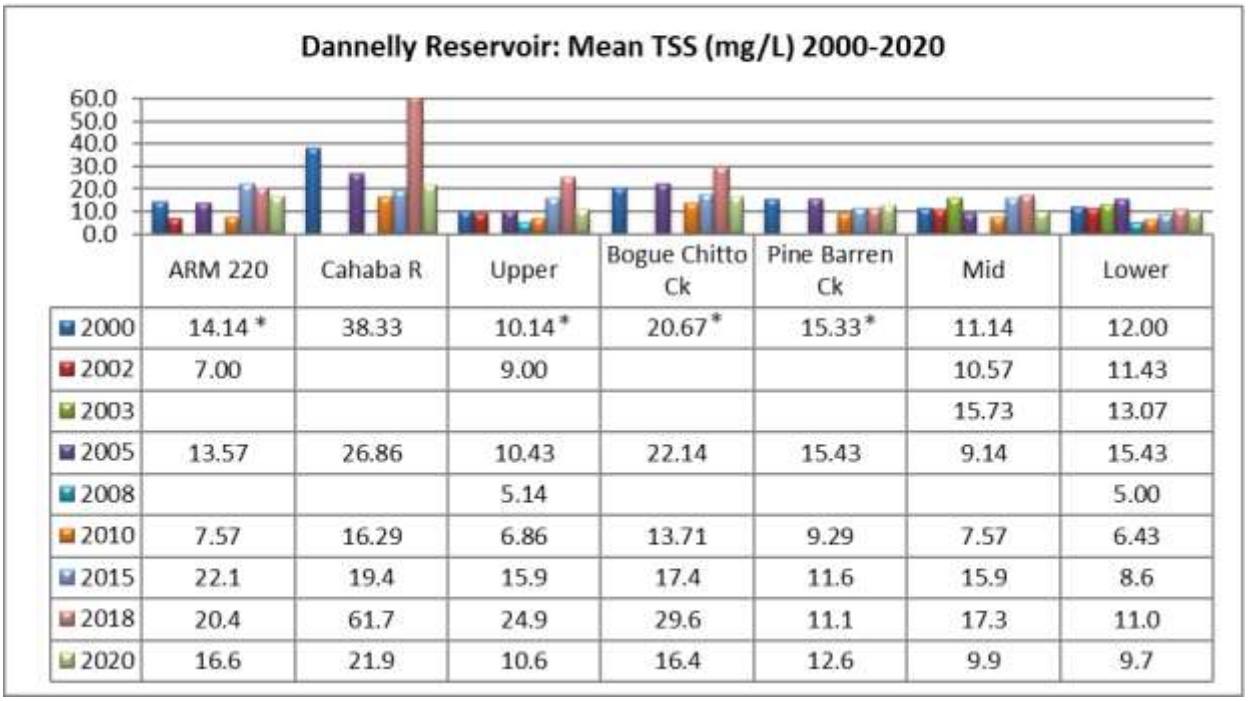
	ARM 220	Cahaba R	Upper	Bogue Chitto Ck	Pine Barren Ck	Mid	Lower
2000	0.049 *	0.027	0.034*	0.084 *	0.027 *	0.027	0.043
2002	0.062		0.055			0.054	0.060
2003						0.063	0.070
2005	0.041	0.035	0.054	0.061	0.044	0.038	0.042
2008			0.049				0.054
2010	0.031	0.031	0.036	0.062	0.038	0.034	0.032
2015	0.027	0.021	0.027	0.040	0.029	0.026	0.025
2018	0.028	0.031	0.035	0.061	0.027	0.031	0.025
2020	0.042	0.027	0.031	0.068	0.048	0.033	0.027

*Mean of April/June/August only.

Figure 3. Growing season mean chl *a* and TSS measured in Dannelly 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.



	ARM 220	Cahaba R	Upper	Bogue Chitto Ck	Pine Barren Ck	Mid	Lower
2000	18.96 *	9.62	19.04 *	24.93 *	17.69 *	14.41	12.63
2002	16.38		20.65			17.44	13.61
2003						8.44	9.37
2005	11.95	14.80	14.14	20.06	12.66	8.90	11.32
2008			17.70				18.16
2010	9.00	15.16	11.75	24.27	9.77	6.48	10.45
2015	9.58	5.48	6.69	13.28	12.65	5.00	6.01
2018	13.85	9.37	5.44	14.05	10.03	6.95	9.64
2020	8.23	5.23	7.56	17.24	11.42	7.84	8.26



	ARM 220	Cahaba R	Upper	Bogue Chitto Ck	Pine Barren Ck	Mid	Lower
2000	14.14 *	38.33	10.14 *	20.67 *	15.33 *	11.14	12.00
2002	7.00		9.00			10.57	11.43
2003						15.73	13.07
2005	13.57	26.86	10.43	22.14	15.43	9.14	15.43
2008			5.14				5.00
2010	7.57	16.29	6.86	13.71	9.29	7.57	6.43
2015	22.1	19.4	15.9	17.4	11.6	15.9	8.6
2018	20.4	61.7	24.9	29.6	11.1	17.3	11.0
2020	16.6	21.9	10.6	16.4	12.6	9.9	9.7

*Mean of April/June/August only.

Figure 4. Monthly TN concentrations of the mainstem stations measured in Dannelly 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 (COE Alabama River at Millers Ferry L& D near Camden, AL).

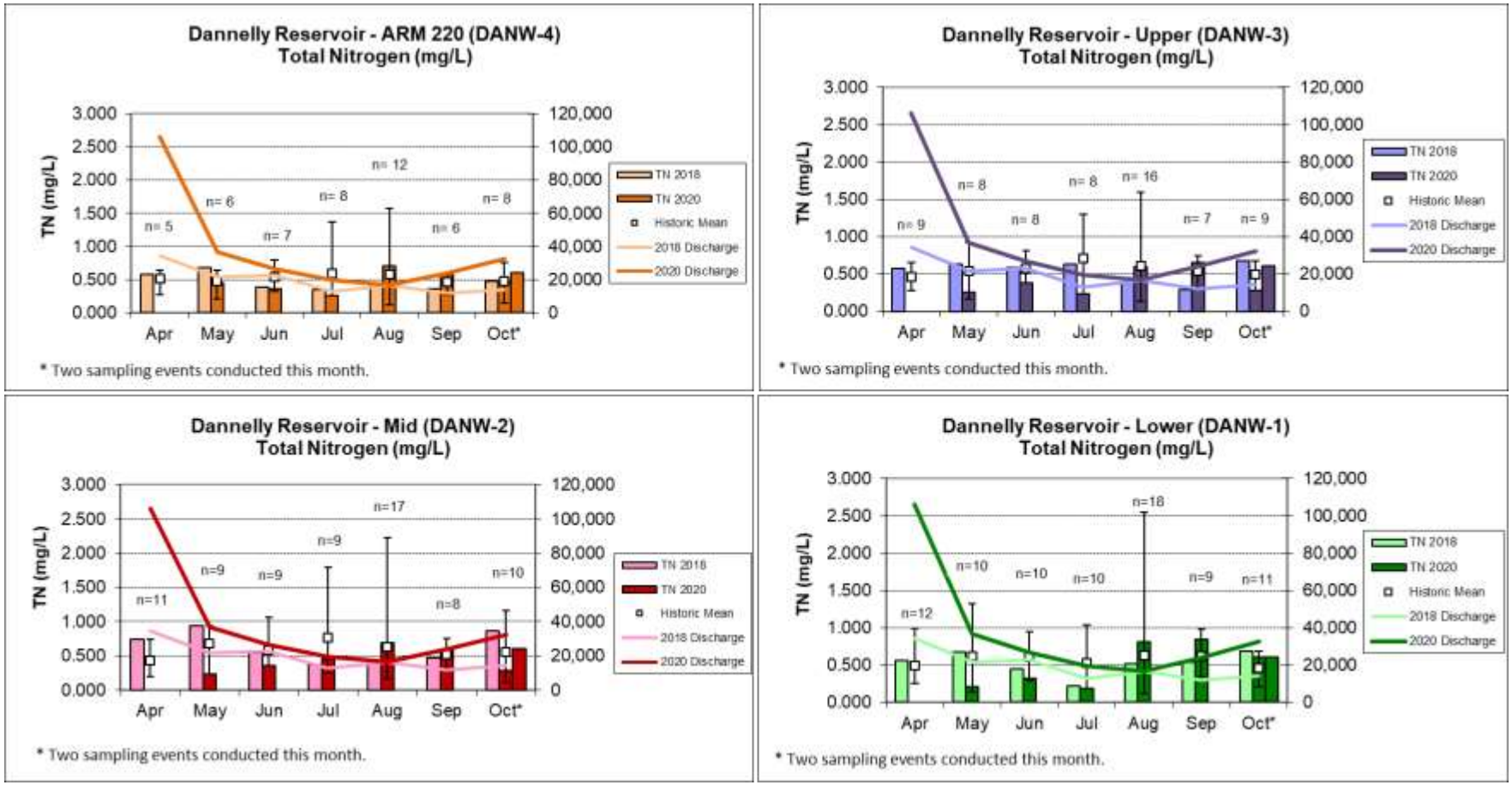


Figure 5. Monthly TP concentrations of the mainstem stations measured in Dannelly Reservoir, April-October 2018 and 2020**.** Each bar graph depicts monthly changes in each station**.** The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points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

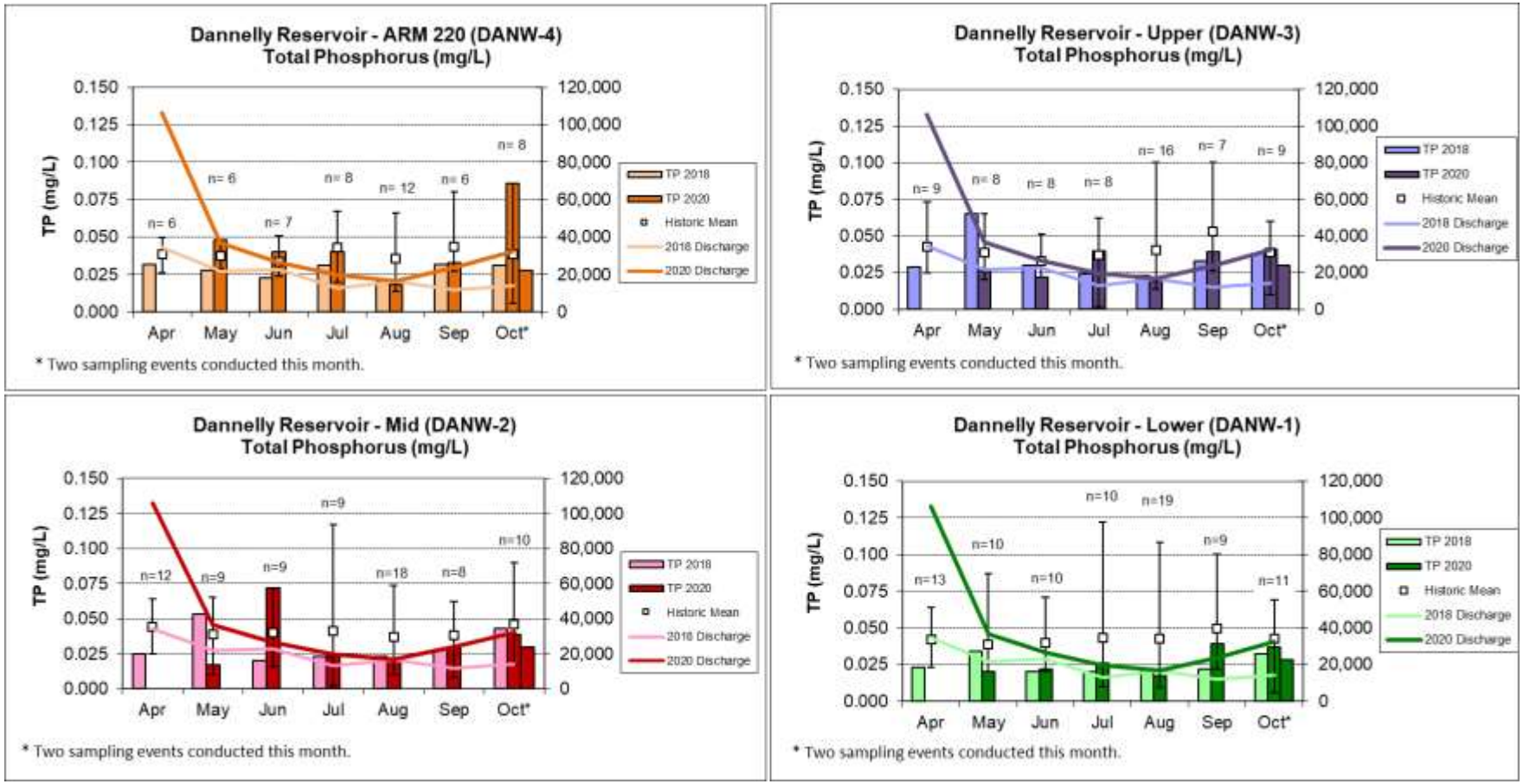


Figure 6. Monthly chl *a* concentrations of the mainstem stations measured in Dannelly Reservoir, April-October 2018 and 2020**.** Each bar graph depicts monthly changes in each station**.** The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data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

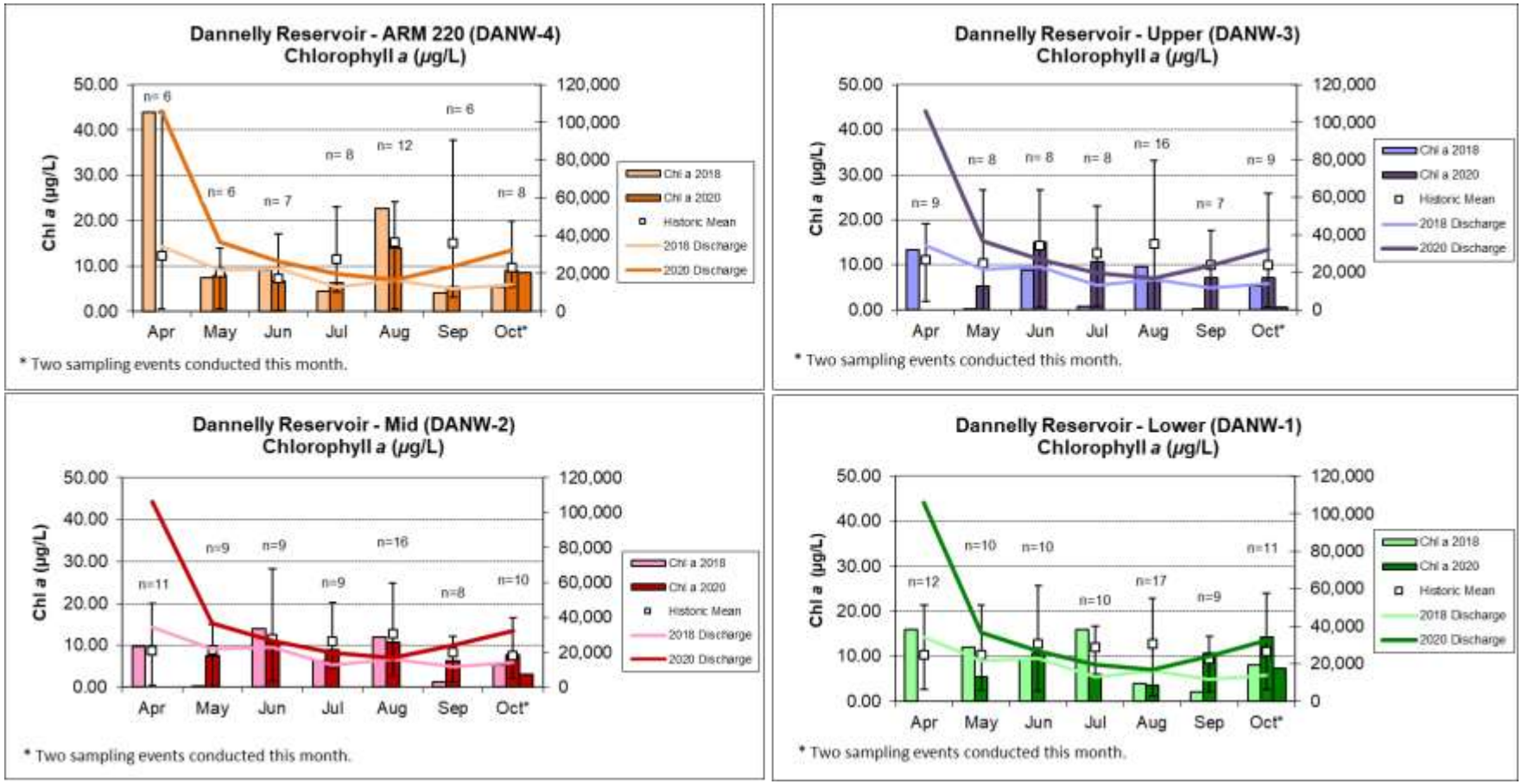


Figure 7. Monthly TSS concentrations of the mainstem stations measured in Dannelly Reservoir, April-October 2018 and 2020**.** Each bar graph depicts monthly changes in each station**.** The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points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

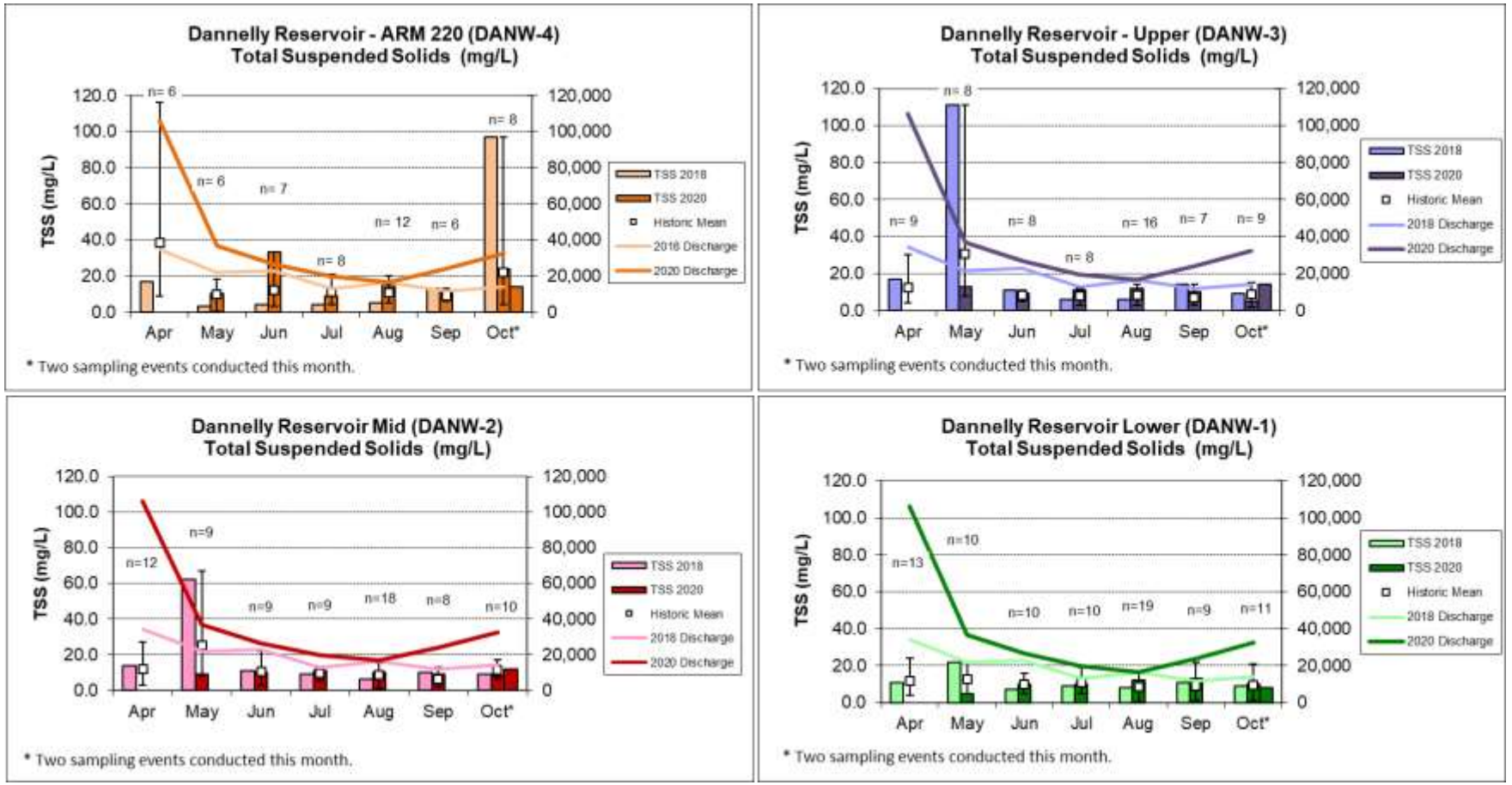
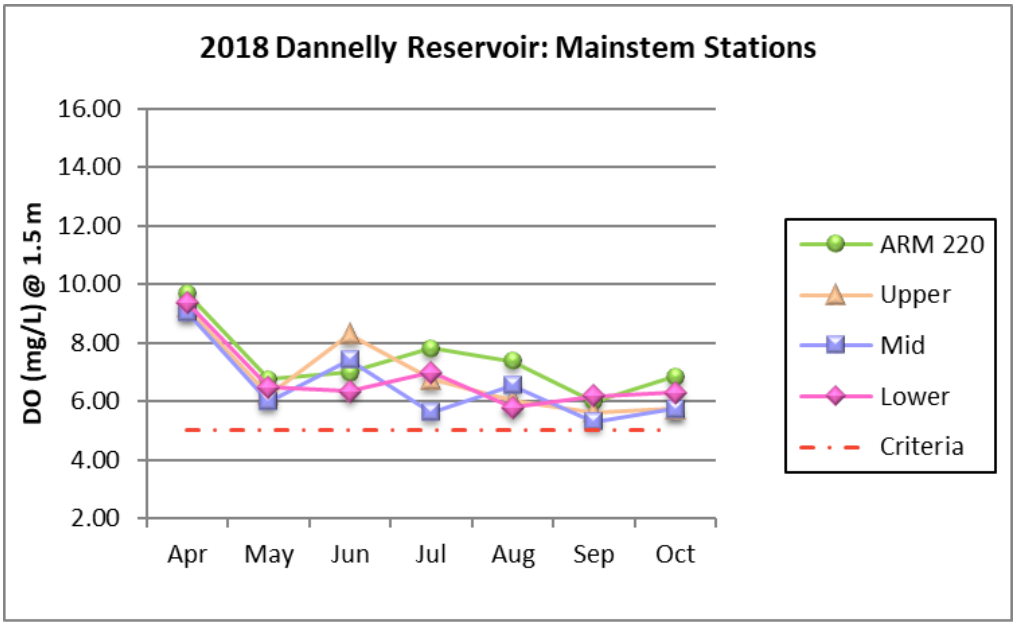


Table 2. Algal growth potential test results, Dannelly Reservoir, 2000-2018 (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20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

Station	DANW-1 (Lower)		DANW-2 (Mid)		DANW-3 (Upper)	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
2000	2.94	NITROGEN	4.34	NITROGEN	2.82	NITROGEN
2005	6.61	PHOSPHORUS	8.12	PHOSPHORUS	9.70	PHOSPHORUS
2010	---	---	---	---	8.91	CO-LIMITING
2018	8.31	NITROGEN	11.52	PHOSPHORUS	14.49	PHOSPHORUS

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Dannelly 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).



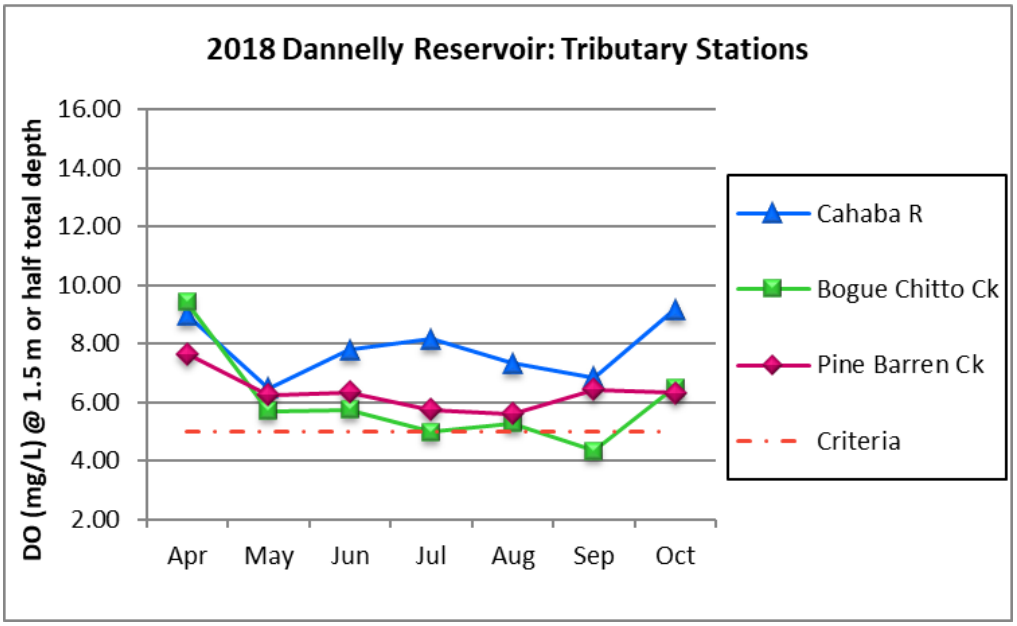


Figure 9. Monthly DO concentrations at 1.5 m (5 ft) for Dannelly Reservoir stations collected April-October 2020. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth (ADEM Admin. Code R. 335-6-10-.09).

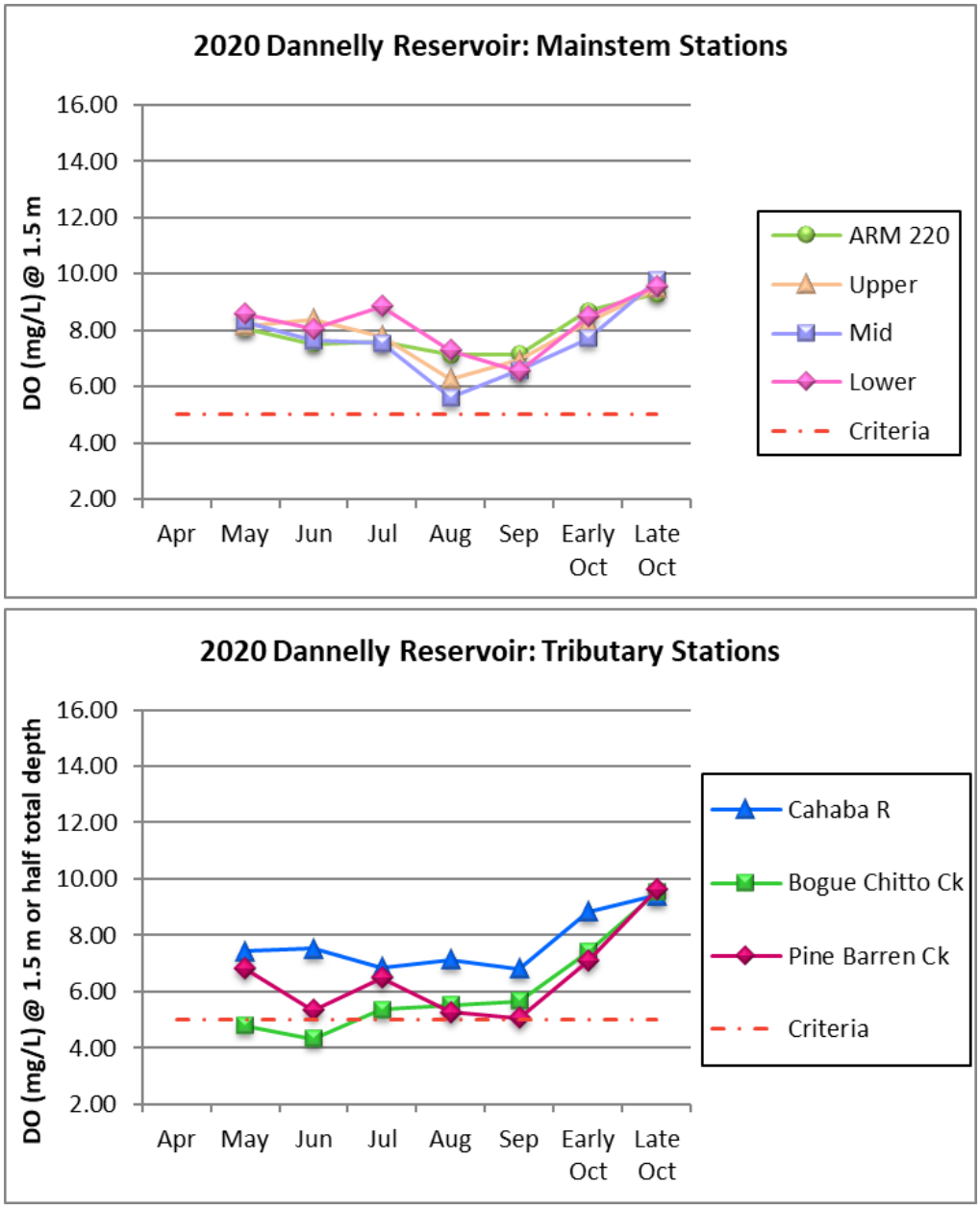


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Dannelly Reservoir station, April-October 2018.

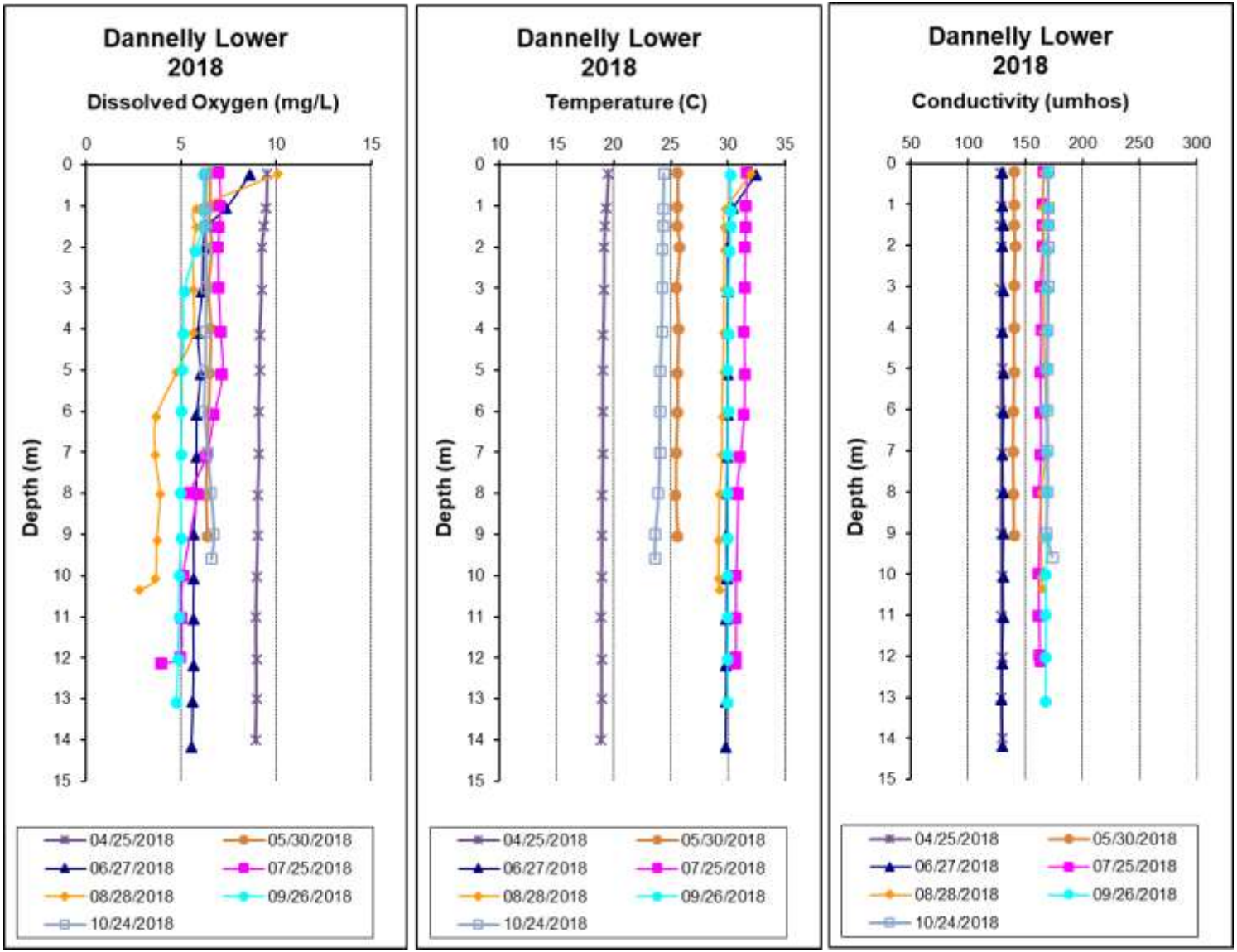


Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Dannelly Reservoir station, April-October 2020. No samples were collected in April, and two sampling events were conducted in October.

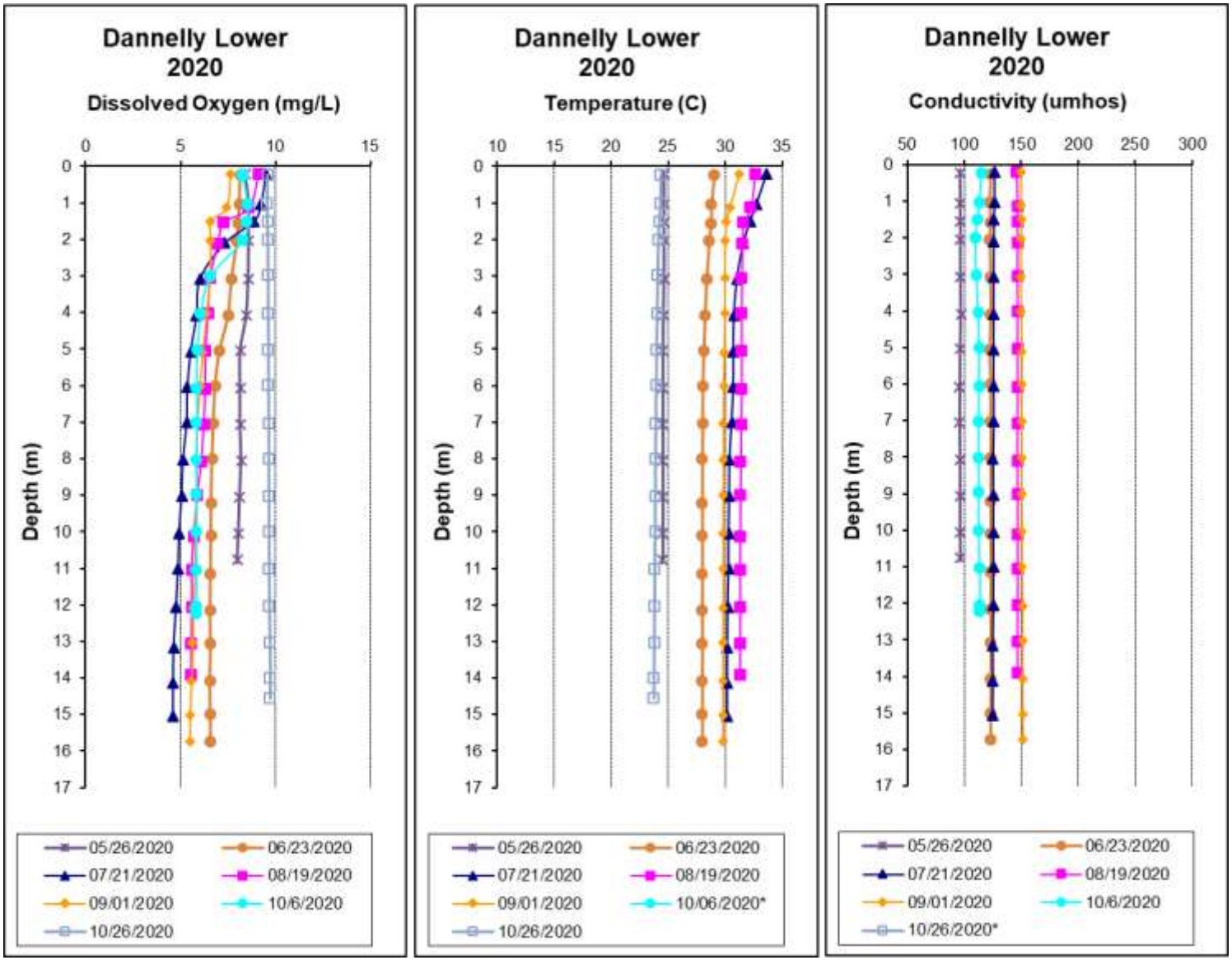


Figure 12. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the mid Dannelly Reservoir station, April-October 2018.

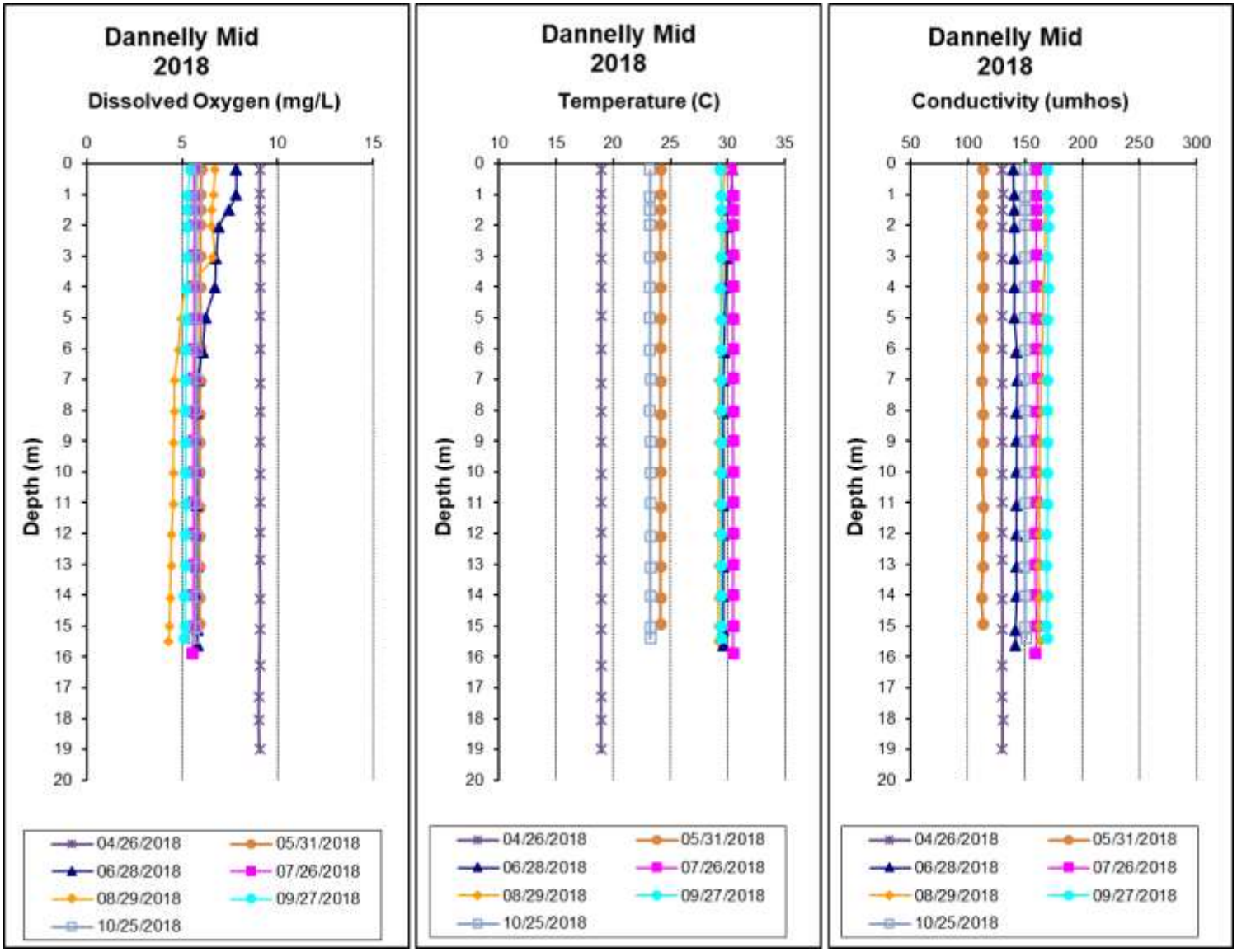


Figure 13. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the mid Dannelly Reservoir station, April-October 2020. No samples were collected in April, and two sampling events were conducted in October.

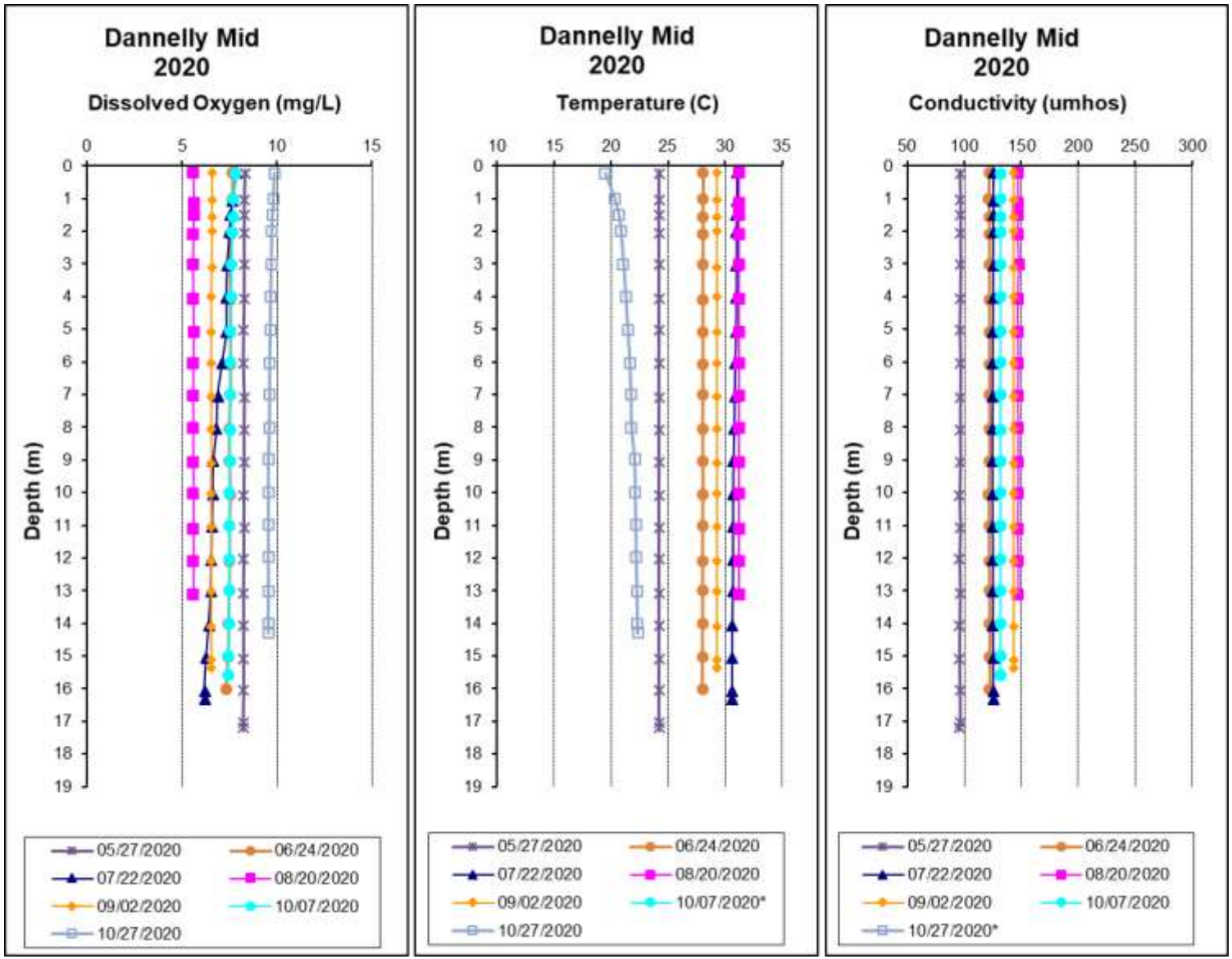


Figure 14. Monthly TSI values in 2018 calculated for mainstem and tributary Dannelly Reservoir stations in 2018 using chl *a* concentrations and Carlson's Trophic State Index calculation (Carlson 1977). TSI for mainstem stations were plotted vs. closest discharge (COE Alabama River at Millers Ferry L&D near Camden, AL).

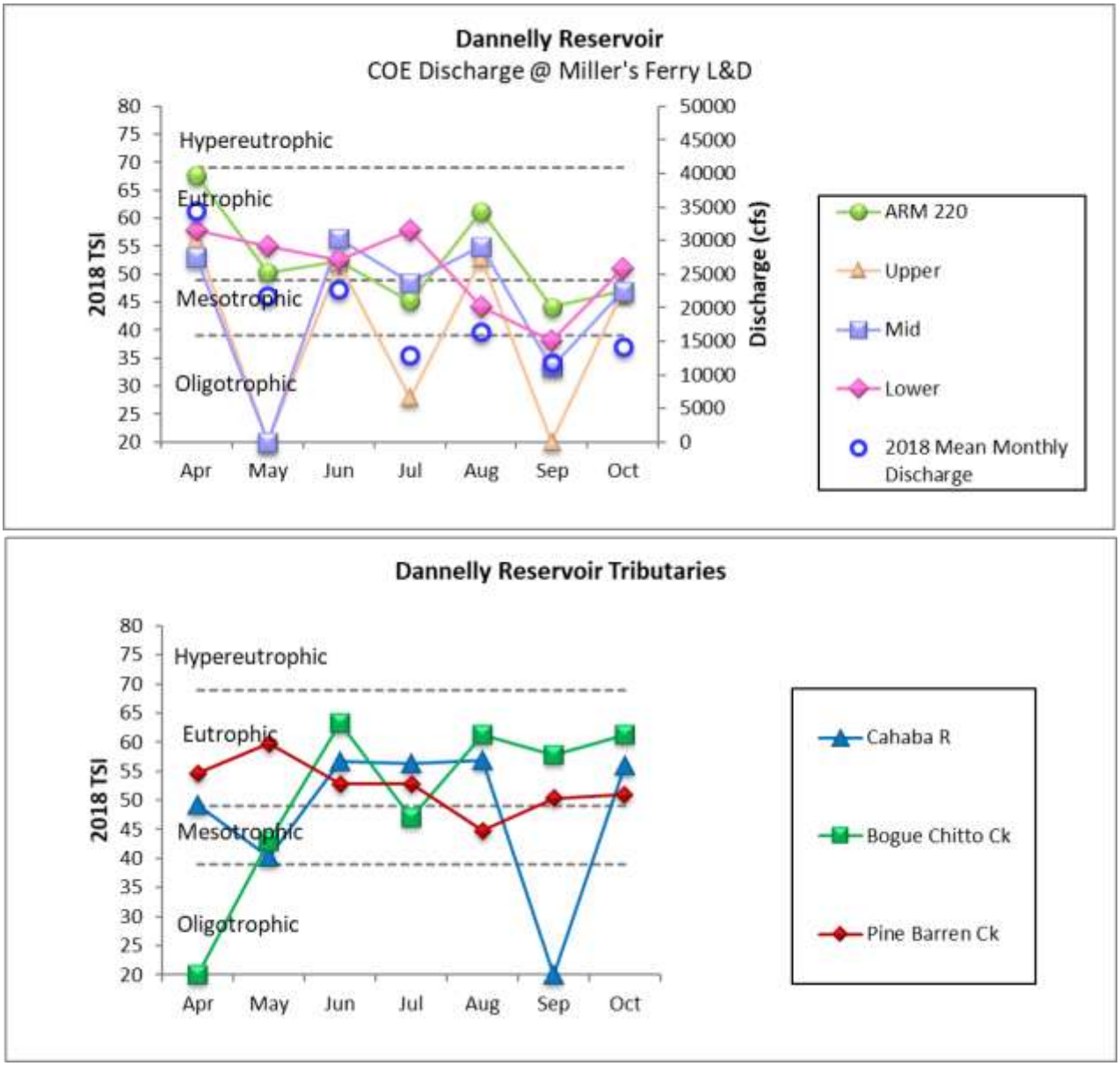
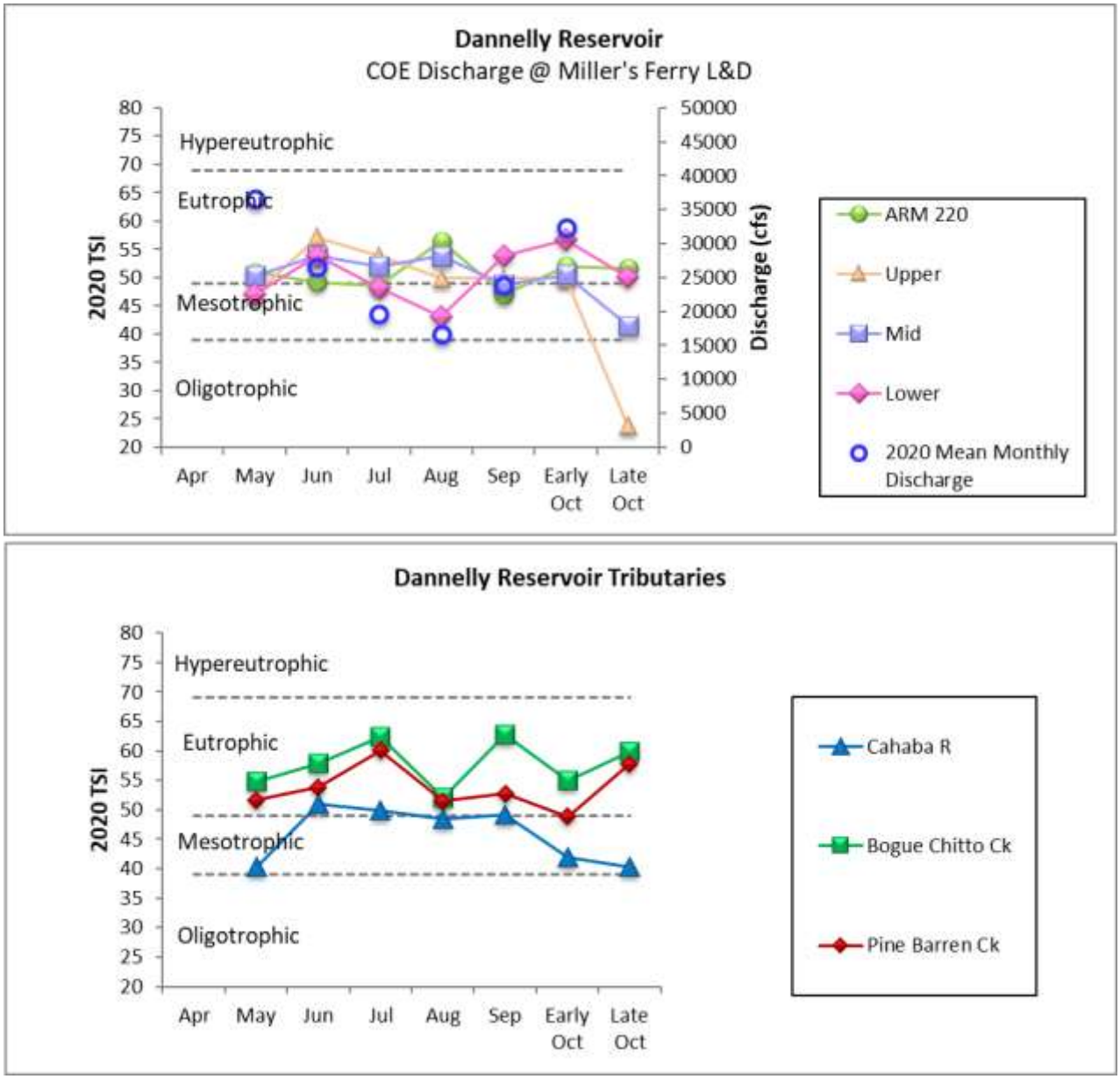


Figure 15. Monthly TSI values in 2018 calculated for mainstem and tributary Dannelly Reservoir stations in 2020 using chl *a* concentrations and Carlson's Trophic State Index calculation (Carlson 1977). TSI for mainstem stations were plotted vs. closest discharge (COE Alabama River at Millers Ferry L&D near Camden, AL).



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APPENDIX

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
DANW-1	**Physical**							
	Turbidity (NTU)	7		8.4	18.3	10.6	11.8	3.4
	Total Dissolved Solids (mg/L)	7		81.0	96.0	92.0	90.3	5.2
	Total Suspended Solids (mg/L)	7		7.0	22.0	9.0	11.0	5.1
	Hardness (mg/L)	4		49.7	64.2	58.3	57.6	6.0
	Alkalinity (mg/L)	7		48.1	62.3	56.5	55.2	5.4
	Photic Zone (m)	7		1.54	3.52	2.39	2.40	0.58
	Secchi (m)	7		0.58	1.10	0.81	0.81	0.18
	Bottom Depth (m)	7		9.2	14.2	12.1	11.8	2.1
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.036	0.204	0.141	0.134	0.063
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.096	0.487	0.399	0.388	0.136
	Total Nitrogen (mg/L)[J]	7		0.660	2.073	0.540	0.522	0.157
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.013	0.002	0.005	0.004
	Total Phosphorus (mg/L)	7		0.020	0.034	0.022	0.025	0.006
	CBOD-5 (mg/L)[J]	7	<	2.0	2.4	1.0	1.4	0.6
	Chlorides (mg/L)	7		5.1	8.8	6.9	6.8	1.6
	Biological							
	Chlorophyll a (mg/m³)	7		2.14	16.00	9.34	9.64	5.44
	E. coli (MPN/DL)[J]	4		1	1	1	1	0
DANW-2	**Physical**							
	Turbidity (NTU)	7		7.7	69.7	13.0	20.6	21.8
	Total Dissolved Solids (mg/L)	7		61.0	98.0	92.0	84.6	15.2
	Total Suspended Solids (mg/L)	7		6.0	62.0	10.0	17.3	19.9
	Hardness (mg/L)	4		49.0	59.2	56.1	55.1	4.7
	Alkalinity (mg/L)	7		43.1	59.7	52.1	52.3	5.7
	Photic Zone (m)	7		1.20	3.48	2.23	2.27	0.66
	Secchi (m)	7		0.30	1.10	0.76	0.73	0.24
	Bottom Depth (m)	7		15.0	19.0	15.5	16.0	1.4
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.007	0.032	0.013	0.013	0.010
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.088	0.237	0.181	0.171	0.057
	Total Kjeldahl Nitrogen (mg/L)	7		0.170	0.711	0.449	0.448	0.196
	Total Nitrogen (mg/L)	7		1.110	2.826	0.537	0.619	0.229
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.018	0.008	0.009	0.006
	Total Phosphorus (mg/L)	7		0.020	0.053	0.025	0.031	0.012
	CBOD-5 (mg/L)[J]	7	<	2.0	2.8	1.0	1.6	0.8
	Chlorides (mg/L)	7		3.6	8.1	7.2	6.5	1.7
	Biological							
	Chlorophyll a (mg/m³)	7	<	0.10	13.90	6.23	6.95	5.23
	E. coli (MPN/DL)[J]	4	<	1	18	2	5	8

Station	Parameter	N		Min	Max	Med	Avg	SD
DANW-3	**Physical**							
	Turbidity (NTU)	7		8.4	102.0	14.2	27.0	33.6
	Total Dissolved Solids (mg/L)	7		48.0	91.0	71.0	72.3	13.9
	Total Suspended Solids (mg/L)[J]	7		6.0	111.0	11.0	24.9	38.2
	Hardness (mg/L)	4		46.3	59.6	56.8	54.8	5.9
	Alkalinity (mg/L)	7		40.7	60.6	52.3	51.3	7.7
	Photic Zone (m)	7		0.96	3.80	2.46	2.35	0.87
	Secchi (m)	7		0.24	0.92	0.83	0.73	0.25
	Bottom Depth (m)	7		7.7	13.4	12.8	11.9	2.0
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.007	0.030	0.008	0.014	0.012
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.105	0.273	0.164	0.164	0.055
	Total Kjeldahl Nitrogen (mg/L)	7		0.155	0.478	0.404	0.375	0.120
	Total Nitrogen (mg/L)	7		0.882	2.031	0.583	0.539	0.141
	Dis Reactive Phosphorus (mg/L)[J]	7		0.004	0.018	0.008	0.009	0.005
	Total Phosphorus (mg/L)	7		0.023	0.065	0.030	0.035	0.014
	CBOD-5 (mg/L)[J]	7	<	2.0	2.0	1.0	1.2	0.4
	Chlorides (mg/L)	7		3.9	8.9	7.6	6.7	2.0
	Biological							
	Chlorophyll a (mg/m³)	7	<	0.10	13.40	5.34	5.44	5.36
	E. coli (MPN/DL)	4		1	108	3	29	53
DANW-4	**Physical**							
	Turbidity (NTU)	7		5.6	19.5	8.8	11.0	5.6
	Total Dissolved Solids (mg/L)	7		42.0	104.0	47.0	62.9	23.5
	Total Suspended Solids (mg/L)	7		3.0	97.0	5.0	20.4	34.2
	Hardness (mg/L)	4		43.0	52.9	49.7	48.8	4.4
	Alkalinity (mg/L)	7		37.1	53.4	46.9	47.0	5.3
	Photic Zone (m)	7		1.40	3.32	2.99	2.65	0.80
	Secchi (m)	7		0.64	1.15	0.83	0.88	0.19
	Bottom Depth (m)	7		3.0	6.0	4.0	4.0	1.1
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.007	0.037	0.004	0.010	0.012
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.096	0.189	0.145	0.145	0.033
	Total Kjeldahl Nitrogen (mg/L)	7		0.210	0.513	0.291	0.320	0.107
	Total Nitrogen (mg/L)	7		1.059	2.037	0.426	0.465	0.122
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.015	0.004	0.007	0.006
	Total Phosphorus (mg/L)	7		0.020	0.032	0.031	0.028	0.005
	CBOD-5 (mg/L)[J]	7	<	2.0	2.4	1.0	1.4	0.6
	Chlorides (mg/L)	7		4.3	8.5	6.3	6.3	1.6
	Biological							
	Chlorophyll a (mg/m³)	7		4.00	43.80	7.48	13.85	14.70
	E. coli (MPN/DL)	4		1	55	5	16	26

Station	Parameter	N		Min	Max	Med	Avg	SD
DANW-7	**Physical**							
	Turbidity (NTU)	7		13.8	123.0	21.4	36.3	38.6
	Total Dissolved Solids (mg/L)	7		68.0	102.0	91.0	90.4	11.4
	Total Suspended Solids (mg/L)	7		11.0	99.0	16.0	29.6	31.4
	Hardness (mg/L)	4		56.8	69.5	61.4	62.2	5.3
	Alkalinity (mg/L)	7		44.6	67.3	61.4	58.4	7.8
	Photic Zone (m)	7		1.12	2.18	1.60	1.63	0.41
	Secchi (m)	7		0.28	0.66	0.57	0.54	0.13
	Bottom Depth (m)	7		4.6	6.4	6.0	5.9	0.6
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.085	0.004	0.024	0.035
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7		0.019	1.010	0.060	0.194	0.362
	Total Kjeldahl Nitrogen (mg/L)	7		0.329	1.240	0.645	0.706	0.348
	Total Nitrogen (mg/L)[J]	7		1.179	6.210	0.790	0.900	0.599
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.075	0.007	0.017	0.026
	Total Phosphorus (mg/L)	7		0.030	0.157	0.049	0.061	0.044
	CBOD-5 (mg/L)[J]	7	<	2.0	3.8	2.3	2.3	1.3
	Chlorides (mg/L)	7		3.2	8.2	6.9	6.3	1.6
	Biological							
	Chlorophyll a (mg/m³)	7	<	0.10	28.00	16.00	14.05	11.03
	E. coli (MPN/DL)	4		1	114	3	30	56
DANW-7	**Physical**							
	Turbidity (NTU)	7		12.7	30.4	18.5	18.7	6.2
	Total Dissolved Solids (mg/L)	7		25.0	90.0	74.0	69.3	23.4
	Total Suspended Solids (mg/L)	7		7.0	19.0	9.0	11.1	5.2
	Hardness (mg/L)	4		51.1	54.2	52.5	52.6	1.4
	Alkalinity (mg/L)	7		49.1	60.7	53.2	54.1	4.6
	Photic Zone (m)	7		1.50	2.45	1.76	1.91	0.32
	Secchi (m)	7		0.43	0.94	0.67	0.65	0.18
	Bottom Depth (m)	7		5.3	7.0	6.9	6.5	0.7
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.007	0.034	0.004	0.011	0.012
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.004	0.158	0.058	0.069	0.061
	Total Kjeldahl Nitrogen (mg/L)	7		0.214	0.895	0.560	0.546	0.227
	Total Nitrogen (mg/L)[J]	7	<	1.077	3.159	0.565	0.615	0.243
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.011	0.005	0.006	0.003
	Total Phosphorus (mg/L)	7		0.023	0.032	0.026	0.027	0.004
	CBOD-5 (mg/L)[J]	7	<	2.0	3.3	1.0	1.7	0.9
	Chlorides (mg/L)	7		4.2	8.0	5.3	5.6	1.3
	Biological							
	Chlorophyll a (mg/m³)	7		4.27	19.60	9.61	10.03	4.80
	E. coli (MPN/DL)[J]	4	<	1	16	4	6	7

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
DANW-1	**Physical**							
	Turbidity (NTU)	7		7.9	12.0	11.0	10.3	1.7
	Total Dissolved Solids (mg/L)[J]	7		53.0	91.0	79.0	76.1	12.0
	Total Suspended Solids (mg/L)[J]	7		5.0	13.0	10.0	9.7	2.6
	Hardness (mg/L)	4		12.1	48.9	48.4	39.5	18.2
	Alkalinity (mg/L)	7		35.3	50.9	46.2	45.1	5.9
	Photic Zone (m)	7		1.86	3.16	2.90	2.71	0.44
	Secchi (m)	7		0.69	1.19	0.93	0.95	0.21
	Bottom Depth (m)	7		10.8	15.7	14.6	13.1	1.9
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.043	0.008	0.017	0.013
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.021	0.149	0.102	0.098	0.048
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.200	0.744	0.457	0.415	0.245
	Total Nitrogen (mg/L)	7	<	0.549	2.538	0.603	0.512	0.273
	Dis Reactive Phosphorus (mg/L)[J]	6	<	0.004	0.010	0.004	0.005	0.004
	Total Phosphorus (mg/L)	7		0.017	0.039	0.026	0.027	0.008
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		3.7	6.8	5.2	5.2	1.0
	Biological							
	Chlorophyll a (mg/m³)	7		3.56	14.20	7.34	8.26	3.74
	E. coli (MPN/DL)[J]	4		1	1	1	1	0
DANW-2	**Physical**							
	Turbidity (NTU)	7		6.8	12.4	8.9	9.6	2.0
	Total Dissolved Solids (mg/L)[J]	7		58.0	85.0	71.0	72.1	9.9
	Total Suspended Solids (mg/L)[J]	7		8.0	12.0	10.0	9.9	1.4
	Hardness (mg/L)	4		11.5	50.7	48.0	39.5	18.7
	Alkalinity (mg/L)	7		35.4	51.1	47.6	46.5	5.3
	Photic Zone (m)	7		2.60	4.24	2.94	3.19	0.61
	Secchi (m)	7		0.86	1.58	0.92	1.10	0.32
	Bottom Depth (m)	7		13.1	17.2	15.6	15.4	1.4
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.053	0.021	0.023	0.017
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.058	0.160	0.123	0.111	0.040
	Total Kjeldahl Nitrogen (mg/L)[J]	7	<	0.200	0.593	0.399	0.349	0.174
	Total Nitrogen (mg/L)[J]	7	<	0.690	2.055	0.457	0.459	0.176
	Dis Reactive Phosphorus (mg/L)[J]	6	<	0.004	0.012	0.006	0.006	0.004
	Total Phosphorus (mg/L)	7		0.017	0.072	0.029	0.033	0.019
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		3.8	6.6	5.2	5.0	0.9
	Biological							
	Chlorophyll a (mg/m³)	7		3.05	10.70	7.63	7.84	2.67
	E. coli (MPN/DL)[J]	4	<	1	2	2	2	1

Station	Parameter	N		Min	Max	Med	Avg	SD
DANW-3	**Physical**							
	Turbidity (NTU)	7		7.8	25.4	9.9	11.9	6.3
	Total Dissolved Solids (mg/L)[J]	7		57.0	115.0	82.0	79.7	19.2
	Total Suspended Solids (mg/L)[J]	7		5.0	14.0	11.0	10.6	3.0
	Hardness (mg/L)	4		46.1	66.6	47.9	52.1	9.7
	Alkalinity (mg/L)	7		36.0	56.9	45.2	46.0	6.7
	Photic Zone (m)	7		2.62	3.68	3.30	3.20	0.35
	Secchi (m)	7		0.84	1.43	1.02	1.09	0.22
	Bottom Depth (m)	7		11.0	12.8	11.5	11.8	0.6
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.044	0.018	0.021	0.014
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.069	0.158	0.114	0.112	0.036
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.200	0.524	0.294	0.316	0.182
	Total Nitrogen (mg/L)	7	<	0.693	1.962	0.375	0.429	0.187
	Dis Reactive Phosphorus (mg/L)[J]	6	<	0.004	0.010	0.005	0.005	0.003
	Total Phosphorus (mg/L)	7		0.019	0.041	0.030	0.031	0.009
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		3.9	6.5	5.1	5.3	1.0
	Biological							
	Chlorophyll a (mg/m³)	7	<	1.00	15.00	7.12	7.56	4.48
	E. coli (MPN/DL)[J]	4	<	1	7	3	4	3
DANW-4	**Physical**							
	Turbidity (NTU)	7		7.0	39.0	13.9	17.8	10.2
	Total Dissolved Solids (mg/L)	7		52.0	89.0	66.0	68.4	11.8
	Total Suspended Solids (mg/L)[J]	7		9.0	33.0	14.0	16.6	8.8
	Hardness (mg/L)	4		40.2	124.0	43.5	62.8	40.8
	Alkalinity (mg/L)	7		30.5	50.2	43.9	41.4	6.7
	Photic Zone (m)	7		1.10	3.83	2.77	2.59	1.02
	Secchi (m)	7		0.39	1.20	1.03	0.88	0.30
	Bottom Depth (m)	7		3.4	4.6	3.8	3.9	0.4
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.056	0.008	0.019	0.018
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.091	0.179	0.115	0.126	0.031
	Total Kjeldahl Nitrogen (mg/L)[J]	7	<	0.250	0.589	0.354	0.363	0.148
	Total Nitrogen (mg/L)[J]	7	<	0.759	2.100	0.462	0.489	0.154
	Dis Reactive Phosphorus (mg/L)[J]	6	<	0.004	0.009	0.004	0.005	0.003
	Total Phosphorus (mg/L)	7		0.018	0.086	0.040	0.042	0.022
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		4.0	5.7	4.7	4.8	0.6
	Biological							
	Chlorophyll a (mg/m³)	7		5.34	13.90	8.01	8.23	2.81
	E. coli (MPN/DL)	4		4	299	18	85	142

Station	Parameter	N		Min	Max	Med	Avg	SD
DANW-7	**Physical**							
	Turbidity (NTU)	7		11.4	35.2	17.3	20.1	8.7
	Total Dissolved Solids (mg/L)[J]	7		62.0	100.0	93.0	88.1	12.6
	Total Suspended Solids (mg/L)[J]	7		9.0	25.0	17.0	16.4	5.2
	Hardness (mg/L)	4		49.2	63.4	60.0	58.2	6.4
	Alkalinity (mg/L)	7		52.5	66.3	53.4	56.5	5.0
	Photic Zone (m)	7		1.30	2.56	1.93	1.94	0.37
	Secchi (m)	7		0.51	0.89	0.67	0.67	0.13
	Bottom Depth (m)	7		5.3	6.3	5.5	5.6	0.4
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.086	0.017	0.029	0.030
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.003	0.072	0.026	0.037	0.026
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.200	0.694	0.424	0.384	0.246
	Total Nitrogen (mg/L)[J]	7	<	0.378	2.154	0.496	0.421	0.244
	Dis Reactive Phosphorus (mg/L)[J]	6		0.004	0.014	0.006	0.007	0.004
	Total Phosphorus (mg/L)	7		0.031	0.138	0.062	0.068	0.036
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		5.2	7.6	5.7	6.0	0.9
	Biological							
	Chlorophyll a (mg/m³)	7		8.90	26.70	16.00	17.24	7.04
	E. coli (MPN/DL)[J]	4	<	1	10	3	4	4
DANW-8	**Physical**							
	Turbidity (NTU)	7		10.0	18.5	16.2	14.7	3.4
	Total Dissolved Solids (mg/L)	7		60.0	81.0	74.0	73.1	6.9
	Total Suspended Solids (mg/L)[J]	7		8.0	21.0	12.0	12.6	4.2
	Hardness (mg/L)	4		42.8	51.3	47.1	47.1	3.5
	Alkalinity (mg/L)	7		40.8	53.1	48.8	47.6	4.7
	Photic Zone (m)	7		1.60	2.58	2.00	2.04	0.40
	Secchi (m)	7		0.55	0.92	0.67	0.70	0.13
	Bottom Depth (m)	7		4.8	7.2	5.9	6.0	0.9
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.016	0.033	0.028	0.021	0.012
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.003	0.087	0.025	0.035	0.032
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.267	1.240	0.481	0.522	0.347
	Total Nitrogen (mg/L)[J]	7	<	0.561	3.750	0.538	0.557	0.346
	Dis Reactive Phosphorus (mg/L)[J]	6	<	0.004	0.005	0.002	0.003	0.001
	Total Phosphorus (mg/L)	7		0.025	0.098	0.036	0.048	0.027
	CBOD-5 (mg/L)	6	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)[J]	7		3.6	6.3	4.2	4.6	0.9
	Biological							
	Chlorophyll a (mg/m³)	7		6.41	20.30	9.61	11.42	4.94
	E. coli (MPN/DL)[J]	4	<	1	5	3	3	2

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