2007 Tuscaloosa Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
May 2012

Rivers and Reservoirs Monitoring Program

2007

Tuscaloosa Reservoir

Black Warrior River Basin

Alabama Department of Environmental Management
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Table of Contents

LIST OF ACRONYMS **4**

LIST OF FIGURES **5**

LIST OF TABLES **6**

INTRODUCTION **7**

METHODS **8**

RESULTS **11**

APPENDIX **28**

LIST OF ACRONYMS

A&I	Agriculture and Industry water supply use classification
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
BW	Black Warrior
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

LIST OF FIGURES

Figure 1. Tuscaloosa Reservoir with 2007 sampling locations. 9

Figure 2. Mean growing season TN and TP measured in Tuscaloosa Reservoir, April-October, 1998-2007 14

Figure 3. Mean growing season chl *a* and TSS measured in Tuscaloosa Reservoir, April-October, 1998-2007. 15

Figure 4. Monthly TN concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. 16

Figure 5. Monthly TP concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. 17

Figure 6. Monthly chl *a* concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. 18

Figure 7. Monthly TSS concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. 19

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Tuscaloosa Reservoir stations collected April-October 2007. 21

Figure 9. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Tuscaloosa Reservoir station, April-October 2007 22

Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the mid Tuscaloosa Reservoir station, April-October 2007. 23

Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the upper Tuscaloosa Reservoir station, April-October 2007 24

Figure 12. Mean growing season TSI values for mainstem Tuscaloosa Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation. 25

LIST OF TABLES

Table 1. Descriptions of the 2007 monitoring stations in Tuscaloosa Reservoir..... 10

Table 2. Algal growth potential test results, Tuscaloosa Reservoir, 1998-2007 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status 20

Appendix Table 1. Summary of Tuscaloosa Reservoir water quality data collected April-October, 2007 29

INTRODUCTION

Lake Tuscaloosa is located 5 miles north of the cities of Tuscaloosa and Northport in west central Alabama. The 5,885 acre lake was impounded in 1971 to provide drinking and industrial water for the city of Tuscaloosa. The major waterbodies flowing into Lake Tuscaloosa include Binion Creek and the North River while the tailrace empties into the Black Warrior River east of Tuscaloosa.

The Alabama Department of Environmental Management (ADEM) monitored Tuscaloosa Reservoir as part of the 2007 assessment of the Black Warrior and Cahaba River (BWC) Basins under the Rivers and Reservoirs Monitoring Program (RRMP). Implemented in 1990, the objectives of this program are to provide data that can be used to assess current water quality conditions, 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 2012 Monitoring Strategy.

In 2004, the ADEM implemented a specific water quality criterion for nutrient management at the forebay of Tuscaloosa Reservoir, which has been monitored by ADEM since 1990. This criterion represents the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting Tuscaloosa Reservoir's Public Water Supply, Swimming, and Fish & Wildlife (PWS, S, F&W) use classifications.

The purpose of this report is to summarize data collected at five stations in Tuscaloosa Reservoir during the 2007 growing season and to evaluate growing season trends in mean lake trophic status and nutrient concentrations using ADEM's nine-year 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 established criteria.

METHODS

Sampling stations were selected using historical data and previous assessments (Fig. 1). Specific location information can be found in Table 1. Tuscaloosa Reservoir was sampled in the dam forebay, mid reservoir, and upper reservoir. Two tributary stations were also monitored, Binion Creek and the North River.

Water quality assessments were conducted at monthly intervals, April-October. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2007), Surface Water Quality Assurance Project Plan (ADEM 2005), and Quality Management Plan (ADEM 2003).

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 2007 results.

Figure 1. Tuscaloosa Reservoir with 2007 sampling locations. A description of each sampling location is provided in Table 1.

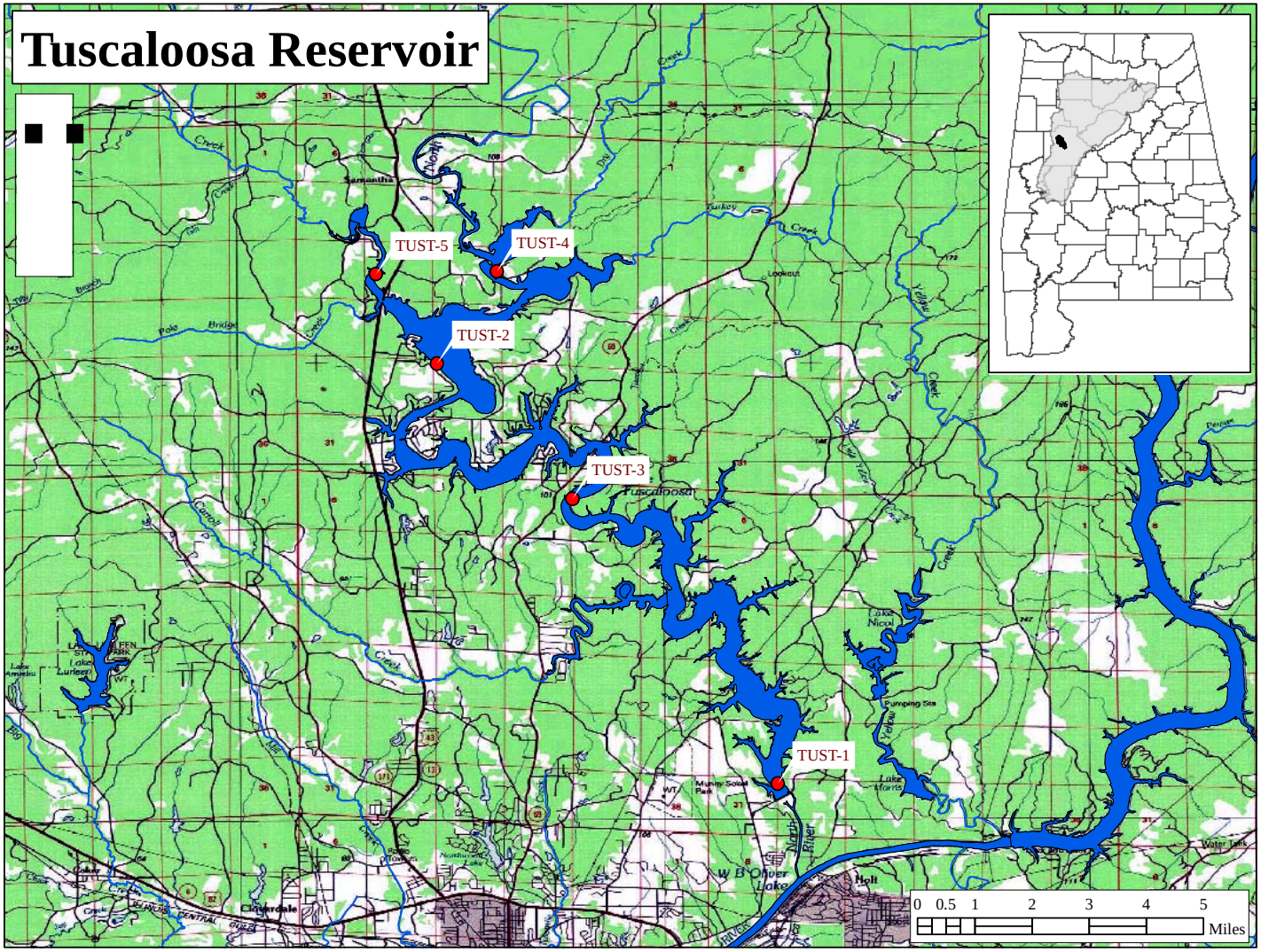


Table 1. Descriptions of the 2007 monitoring stations in Tuscaloosa Reservoir.

HUC	County	Station Number	Report Designation	Waterbody	Station Description	Chl *a* Criteria	Latitude	Longitude
Tuscaloosa Reservoir								
031601120413	Tuscaloosa	TUST-1*	Lower	North R	Deepest point, main river channel, dam forebay.	8 ug/L	33.2685	-87.5084
031601120413	Tuscaloosa	TUST-2	Upper	North R	Deepest point, main river channel, immediately downstream of Binion Creek confluence.		33.3747	-87.5946
031601120413	Tuscaloosa	TUST-3	Mid	North R	Deepest point, main river channel, approximately one mile downstream of Alabama Hwy. 69 bridge.		33.3405	-87.5604
031601120411	Tuscaloosa	TUST-4	North R	North R	North River immediately upstream of Bull Slough Road crossing, deepest point, main channel.		33.3979	-87.5795
031601120410	Tuscaloosa	TUST-5	Binion Ck	Binion Ck	Binion Creek, deepest point, main channel, immediately upstream of Hwy 43.		33.3972	-87.6101

*Growing season mean chl *a* criteria implemented at this station in 2004.

RESULTS

Growing season mean graphs for TN, TP, chl *a*, TSS, and TSI are provided in this section (Figs. 2, 3, and 11). Monthly graphs for TN, TP, chl *a*, TSS, and DO are also provided (Figs. 4-8). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, and TSS as an indicator of flow and retention time in the months sampled. Algal growth potential test (AGPT results appear in Table 2. Depth profile graphs of temperature, DO, and conductivity appear in Figs. 9-11. Summary statistics of all data collected during 2007 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

According to the National Weather Service, during 2007 Alabama recorded its driest January through August period in the past 100 years. The drought was intensified by a drier than normal preceding winter and spring. Though difficult to quantify, drought of this magnitude will affect water quality in a number of ways and is a likely factor in many of the results to follow.

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

In 2007 the highest mean growing season TN value calculated among Tuscaloosa Reservoir mainstem stations was in the upper station (Fig. 2). The highest mean growing season TN value among tributary stations was in the North River. Mean growing season TN values in the lower Tuscaloosa Reservoir station increased 1998-2003, then decreased through 2007 while concentrations in the mid and upper stations fluctuated each year sampled (Fig. 2). Mean growing season TN values measured in 2007 in the North River station were higher than concentrations measured in 2002 while concentrations measured in the Binion Ck station were lower. Monthly TN concentrations in mainstem locations were generally at or below historic means (Fig. 4). Historic high monthly TN concentrations were measured in all mainstem Tuscaloosa Reservoir stations in October (Fig. 4). Historic low TN concentrations were measured in August in the mid station and in April, July, and August in the upper station (Fig. 4).

In 2007 mean growing season TP values calculated among Tuscaloosa Reservoir mainstem stations were similar (Fig. 2). The highest mean growing season TP value among tributary stations was in the North River. The mean growing season TP values calculated in all Tuscaloosa Reservoir stations during 2007 were the lowest measured since 2002 (Fig. 2). Monthly TP concentrations measured in all Tuscaloosa Reservoir mainstem stations were at or below historic means May-October (Fig. 5). Historic low monthly TP concentrations were measured during June in the lower and mid stations, and during July in the upper Tuscaloosa Reservoir station (Fig. 5).

In 2007 the highest mean growing season chl *a* value calculated among Tuscaloosa Reservoir mainstem stations was in the upper station (Fig. 3). The highest mean growing season chl *a* value among tributary stations was in the North River. Specific water quality criterion for nutrient management has been established for the lower station on Tuscaloosa Reservoir. The growing season mean chl *a* concentration measured at the lower station in Tuscaloosa Reservoir during 2007 was in compliance with the criteria limits (Fig. 3). Mean growing season chl *a* values in the mainstem Tuscaloosa Reservoir stations were among the lowest recorded, 1998-2007. The mean growing season chl *a* value calculated for the Binion Ck station was also lower in 2007 than 2002. However, the value calculated for the North River station increased in 2007 compared to 2002. Historic low monthly chl *a* concentrations were recorded in the lower Tuscaloosa Reservoir station July, September, and October (Fig. 6). Historic low concentrations were also measured April-June and August in the mid station. A historic high monthly chl *a* concentration was measured in the upper Tuscaloosa Reservoir station during October, while the highest chl *a* concentration was measured in June (Fig. 6).

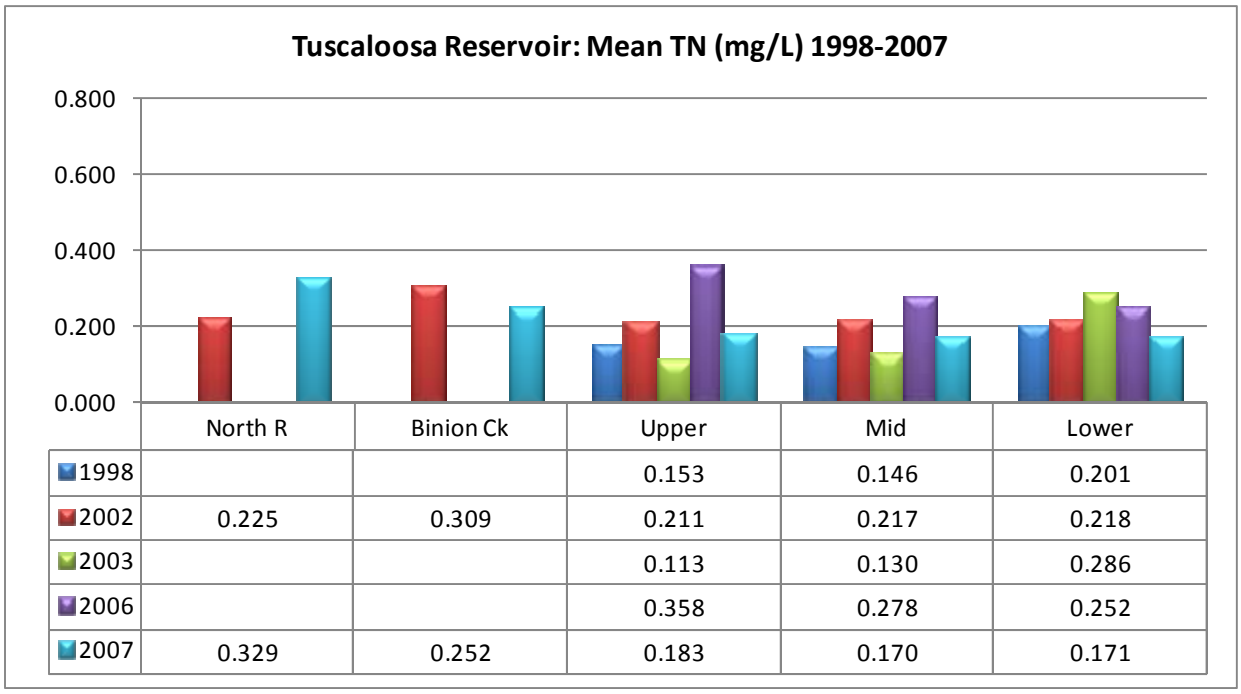
In 2007 the highest mean growing season TSS value calculated among Tuscaloosa Reservoir mainstem stations was in the upper station (Fig. 3). The highest mean growing season TSS value among tributary stations was in the North River. The mean growing season TSS values calculated in all Tuscaloosa Reservoir stations during 2007 were the lowest measured since monitoring began in 1998 (Fig. 3). Historic low monthly TSS concentrations were measured during April, June, and July in the lower station and April, June, and October in the upper station (Fig. 7). Historic low monthly TSS concentrations were also measured in the mid station all months monitored.

AGPT results for the mid and upper Tuscaloosa Reservoir stations have consistently changed between phosphorus limited, nitrogen limited, and co-limited since AGPT testing began in 1998 (Table 2). AGPT results from the lower station have been more consistent indicating phosphorus limited conditions since 2002. AGPT results indicate all mainstem Tuscaloosa Reservoir stations remained below 5 mg/L MSC (Table 2), the value that Raschke et al. (1996) defined as protective of reservoir and lake systems.

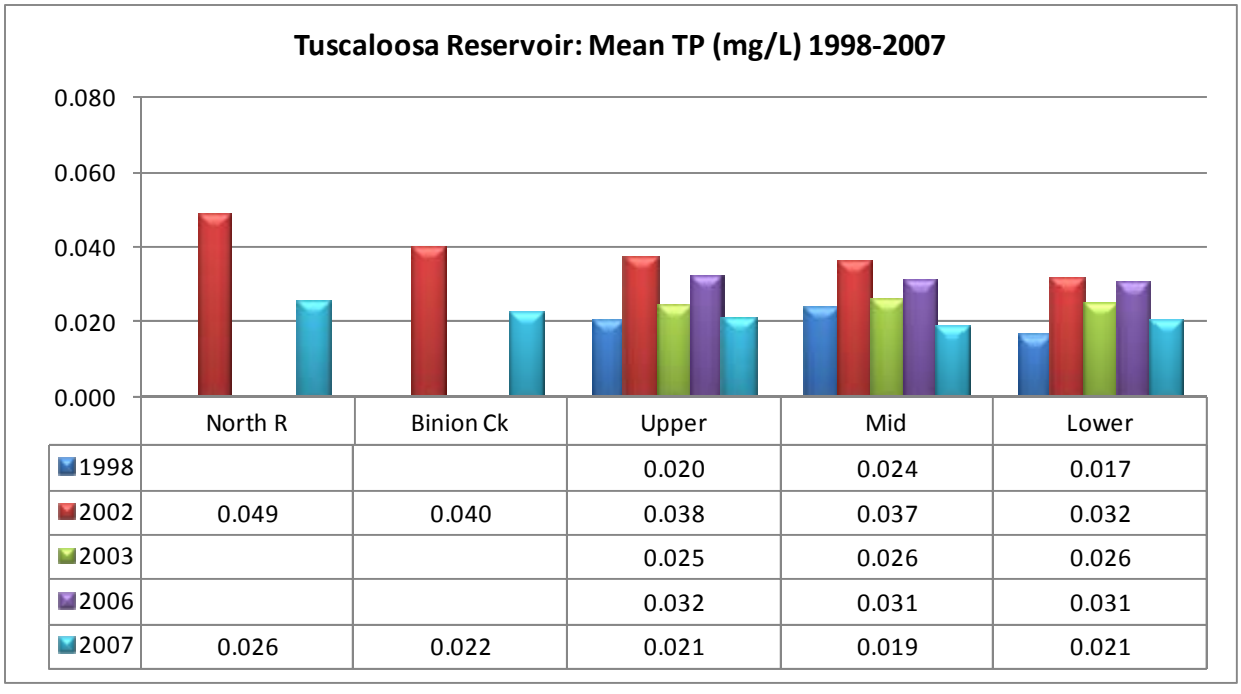
All measurements of dissolved oxygen (DO) concentrations in Tuscaloosa Reservoir mainstem and tributary stations met the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) (Fig. 8). Based on monthly DO profiles, the lower Tuscaloosa Reservoir station was thermally stratified all months monitored (Fig. 9). Based on conductivity profiles, chemoclines were also observed in the lower station from June-October. Monthly DO profiles at the mid Tuscaloosa Reservoir station indicate anoxic conditions below 6 m during June, July, August, and September (Fig. 10). Thermal stratification was observed April-October in the upper Tuscaloosa Reservoir station and anoxic conditions existed below 6 m during June, July, and August (Fig. 11). Based on conductivity measurements chemoclines were measured in the upper station all months monitored with the exception of April. Highest temperatures were measured in August in all Tuscaloosa Reservoir mainstem stations.

Mean growing season TSI values were calculated using season mean chl *a* concentrations and Carlson's Trophic State Index. TSI values calculated for the Tuscaloosa Reservoir mainstem stations have been highest in the upper station and lowest in the lower stations all years monitored, 1998-2007 (Fig. 11). The upper Tuscaloosa Reservoir station was mesotrophic in 2007 and the mid and lower stations were in the upper oligotrophic range (Fig. 11). The lower Tuscaloosa Reservoir station has varied between oligotrophic and mesotrophic while the mid station has remained mesotrophic, 1998-2007. The upper station has varied between mesotrophic and eutrophic 1998-2007 (Fig. 11).

Figure 2. Mean growing season TN and TP measured in Tuscaloosa Reservoir, April-October, 1998-2007. Stations are illustrated from upstream to downstream as the graph is read from left to right.

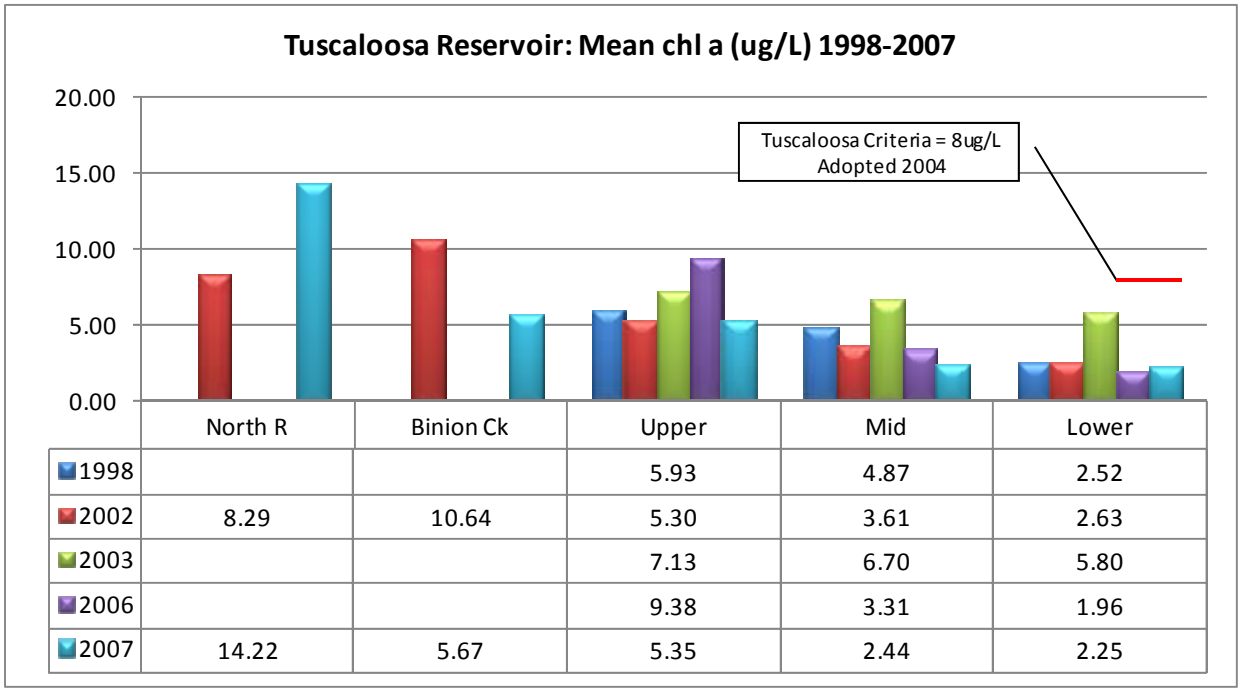


	North R	Binion Ck	Upper	Mid	Lower
1998			0.153	0.146	0.201
2002	0.225	0.309	0.211	0.217	0.218
2003			0.113	0.130	0.286
2006			0.358	0.278	0.252
2007	0.329	0.252	0.183	0.170	0.171

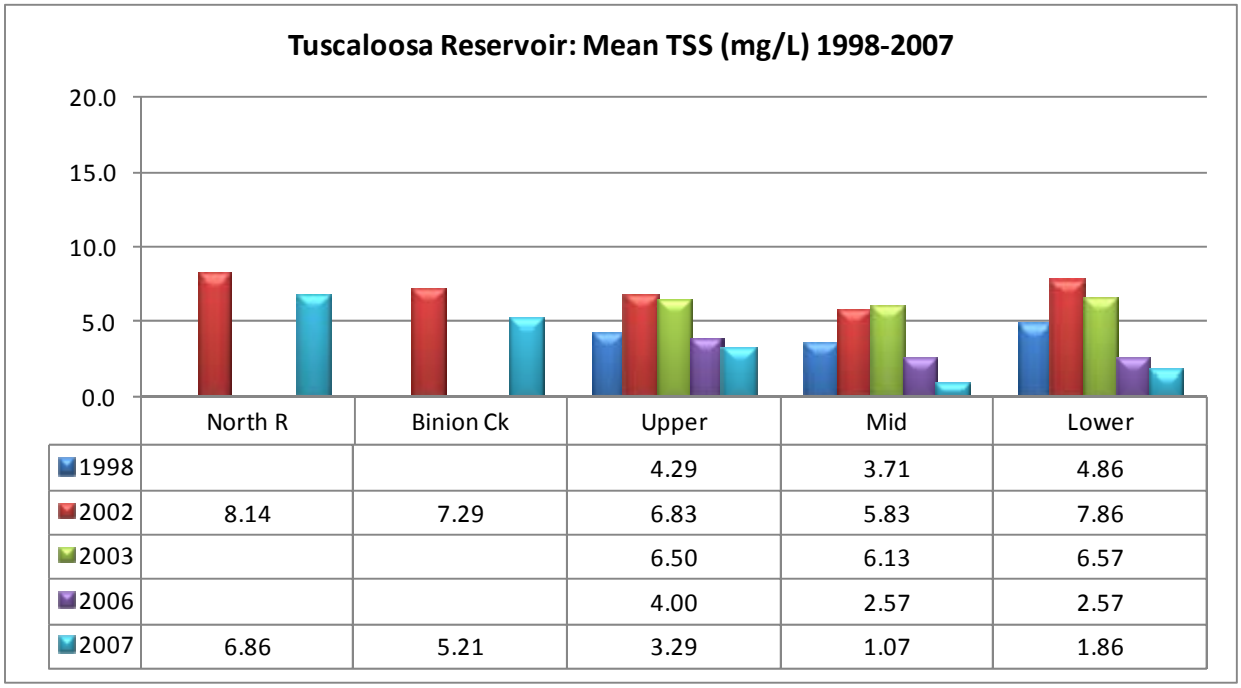


	North R	Binion Ck	Upper	Mid	Lower
1998			0.020	0.024	0.017
2002	0.049	0.040	0.038	0.037	0.032
2003			0.025	0.026	0.026
2006			0.032	0.031	0.031
2007	0.026	0.022	0.021	0.019	0.021

Figure 3. Mean growing season chl *a* and TSS measured in Tuscaloosa Reservoir, April-October, 1998-2007. Stations are 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.



	North R	Binion Ck	Upper	Mid	Lower
1998			5.93	4.87	2.52
2002	8.29	10.64	5.30	3.61	2.63
2003			7.13	6.70	5.80
2006			9.38	3.31	1.96
2007	14.22	5.67	5.35	2.44	2.25



	North R	Binion Ck	Upper	Mid	Lower
1998			4.29	3.71	4.86
2002	8.14	7.29	6.83	5.83	7.86
2003			6.50	6.13	6.57
2006			4.00	2.57	2.57
2007	6.86	5.21	3.29	1.07	1.86

Figure 4. Monthly TN concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

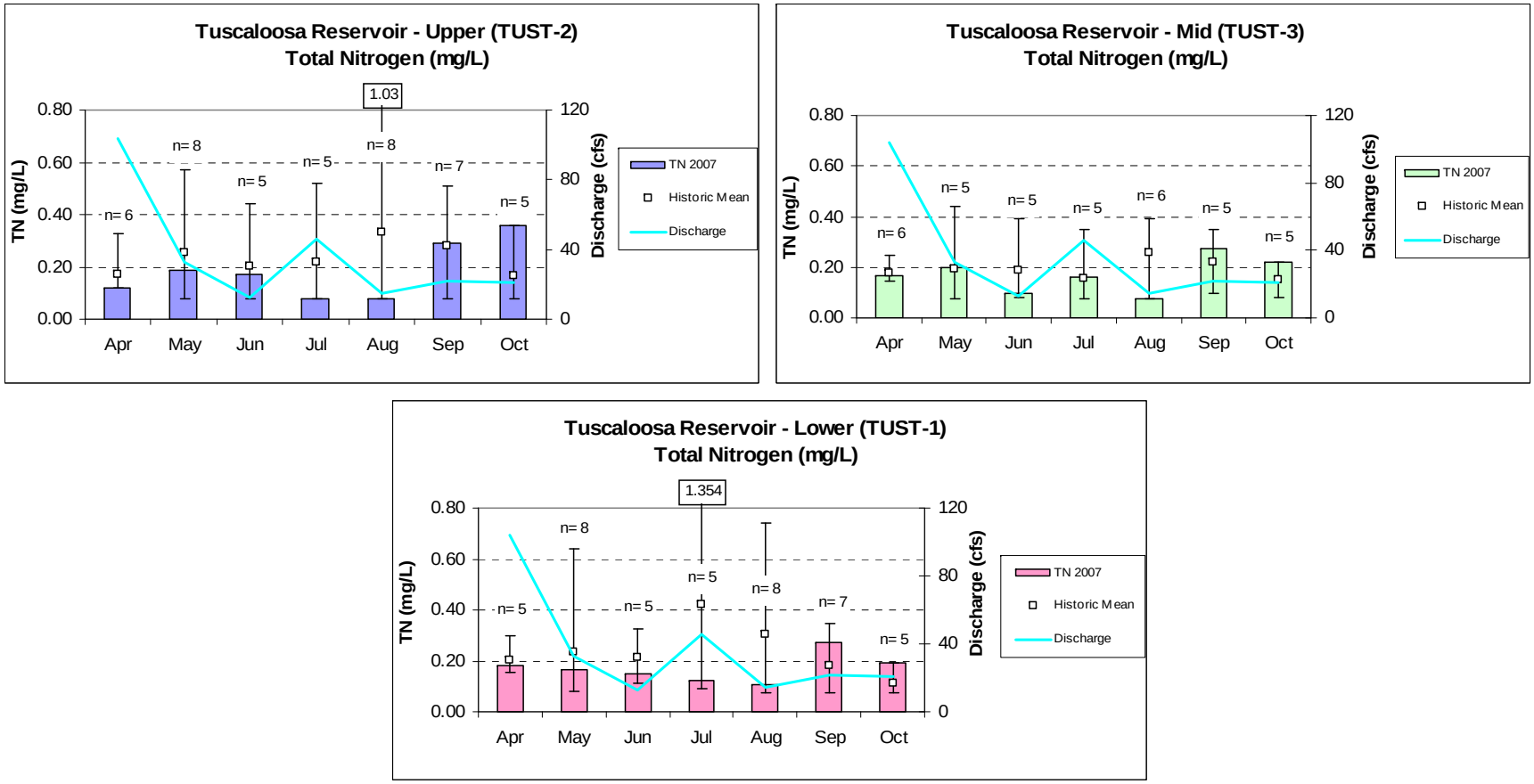


Figure 5. Monthly TP concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

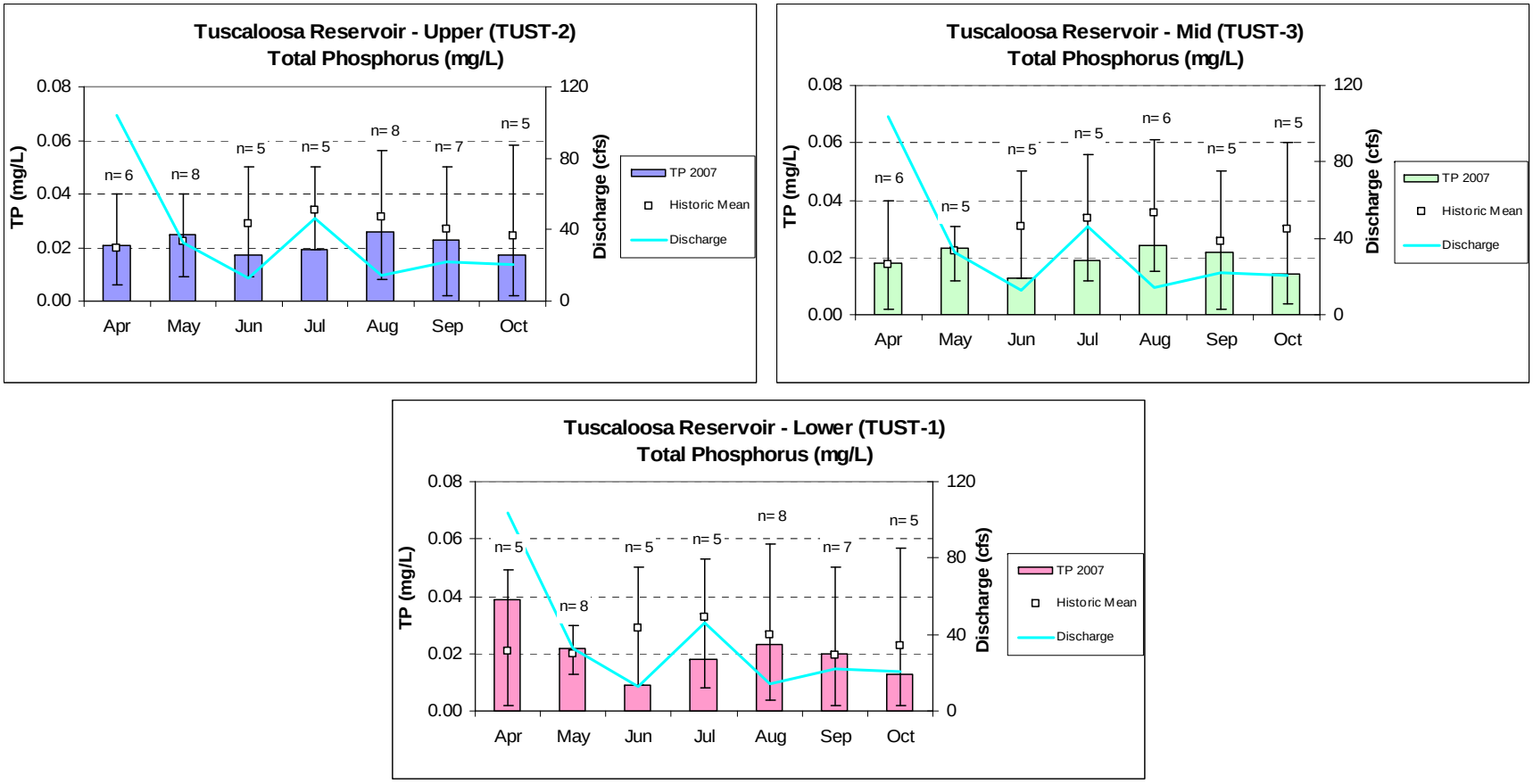
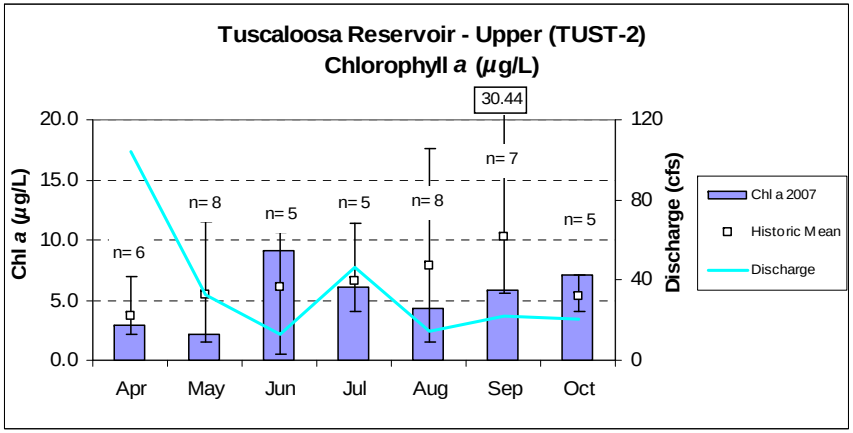
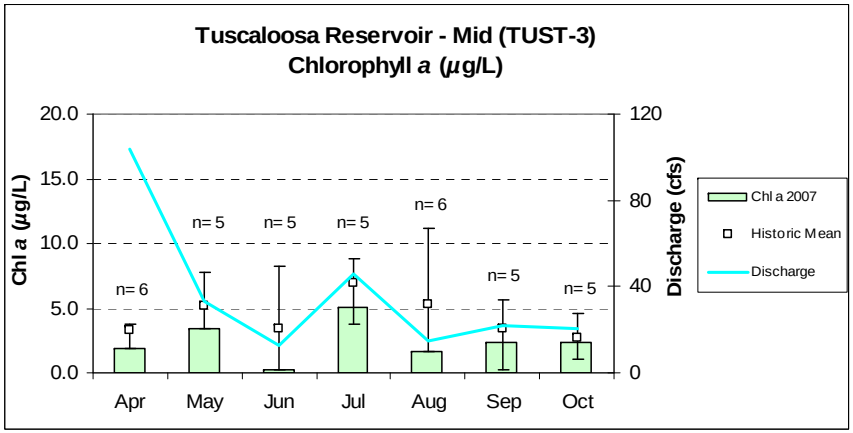


Figure 6. Monthly chl *a* concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





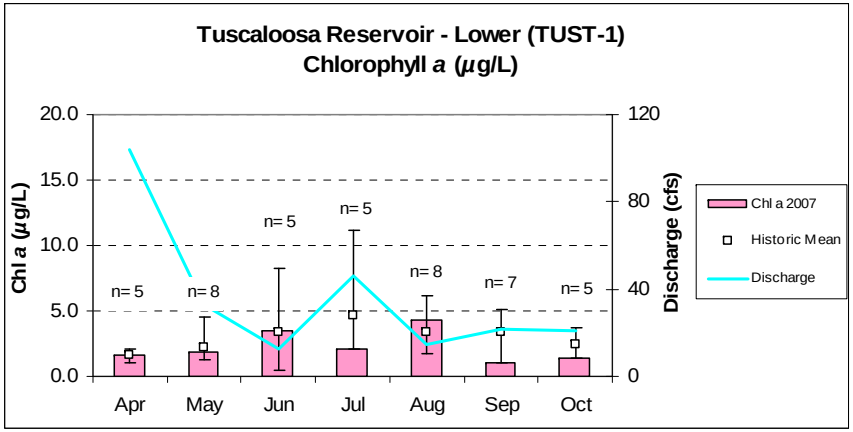
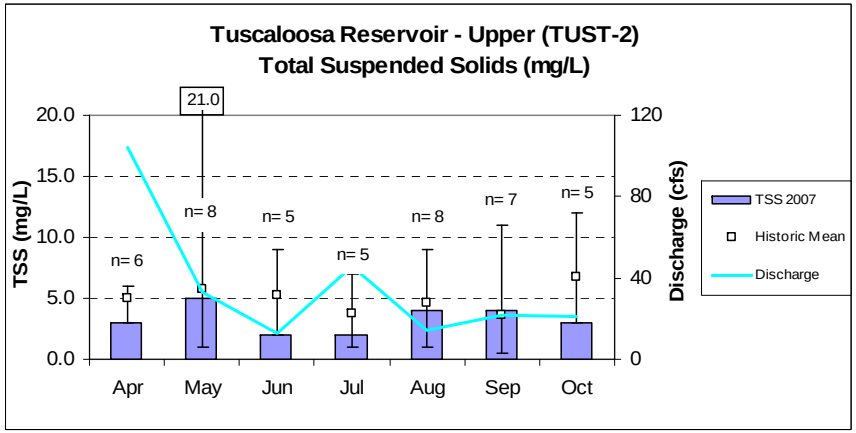
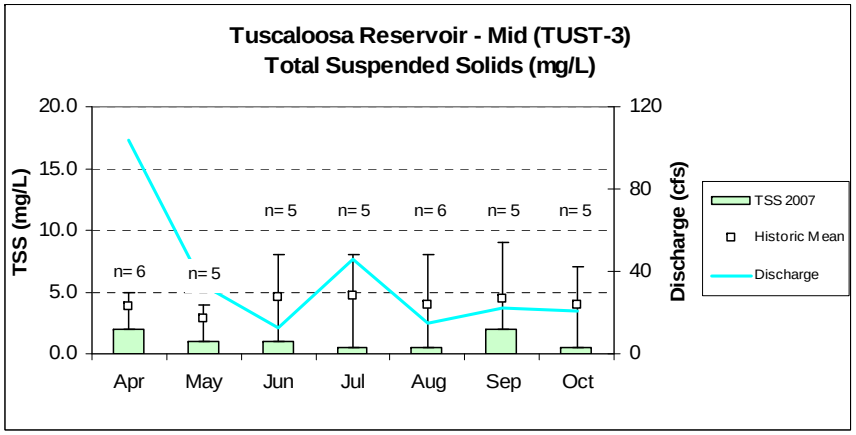


Figure 7. Monthly TSS concentrations measured in Tuscaloosa Reservoir, April-October 2007 vs. average monthly discharge. Discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





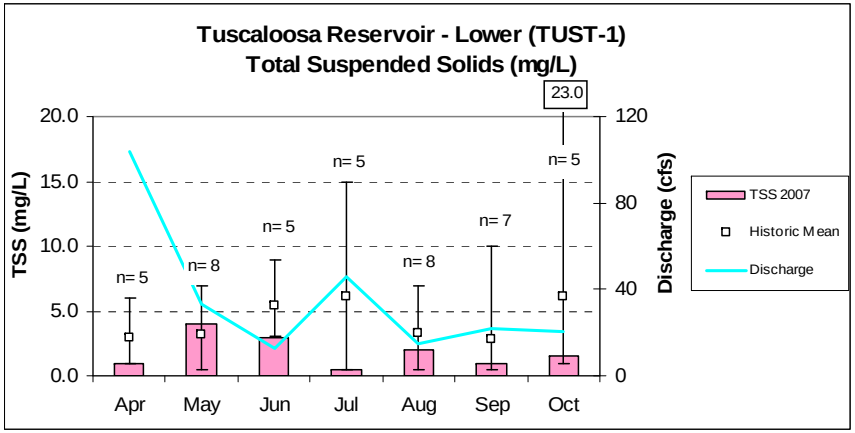
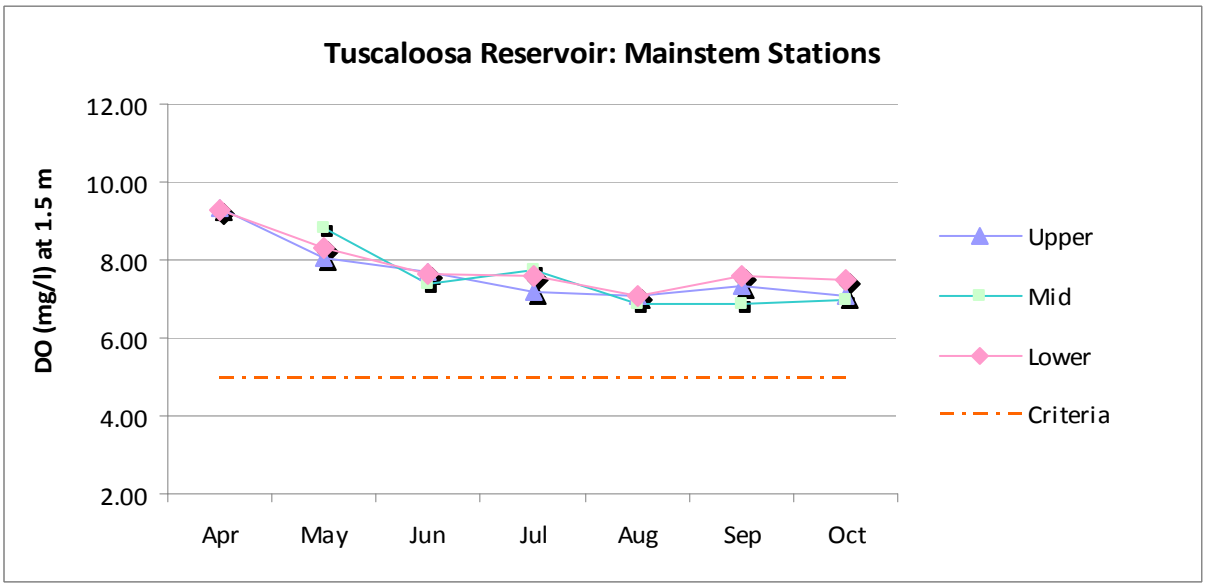


Table 2. Algal growth potential test results, Tuscaloosa Reservoir, 1998-2007 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	Upper		Mid		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 1998	2.49	Phosphorus	2.18	Phosphorus	2.31	Co-limiting
August 2002	1.80	Co-limiting	1.89	Nitrogen	1.82	Phosphorus
June 2007	2.05	Co-limiting	1.79	Phosphorus	2.13	Phosphorus
July 2007	1.80	Phosphorus	1.05	Co-limiting	1.28	Phosphorus
August 2007	2.21	Co-limiting	2.26	Phosphorus	2.32	Phosphorus

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Tuscaloosa Reservoir stations collected April-October 2007. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2005).



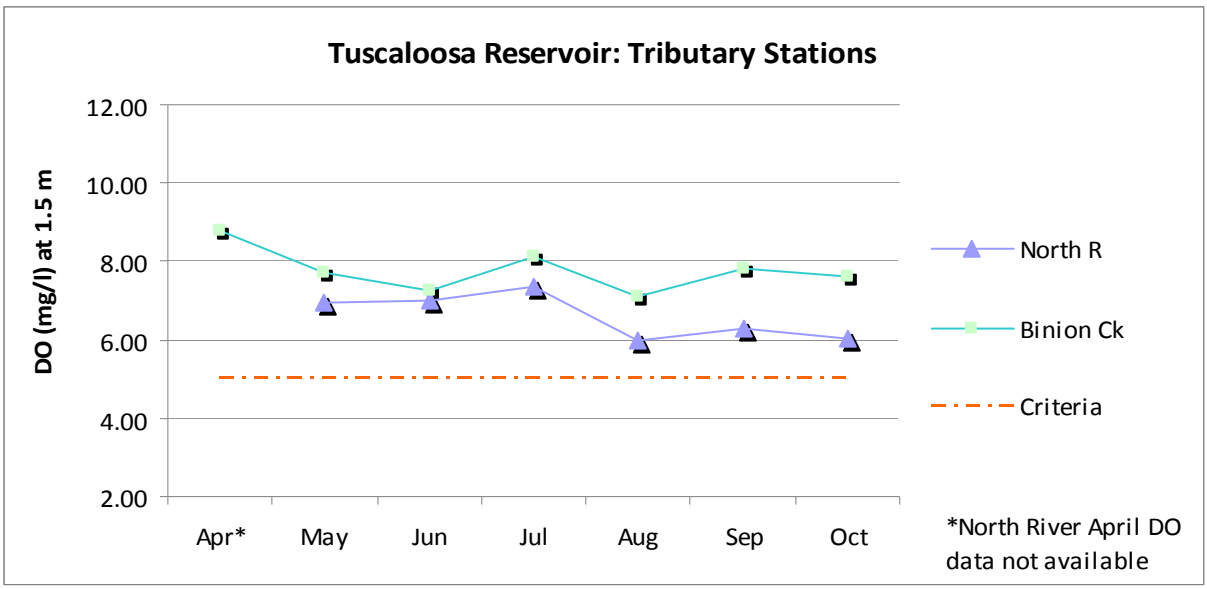


Figure 9. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Tuscaloosa Reservoir station, April-October 2007.

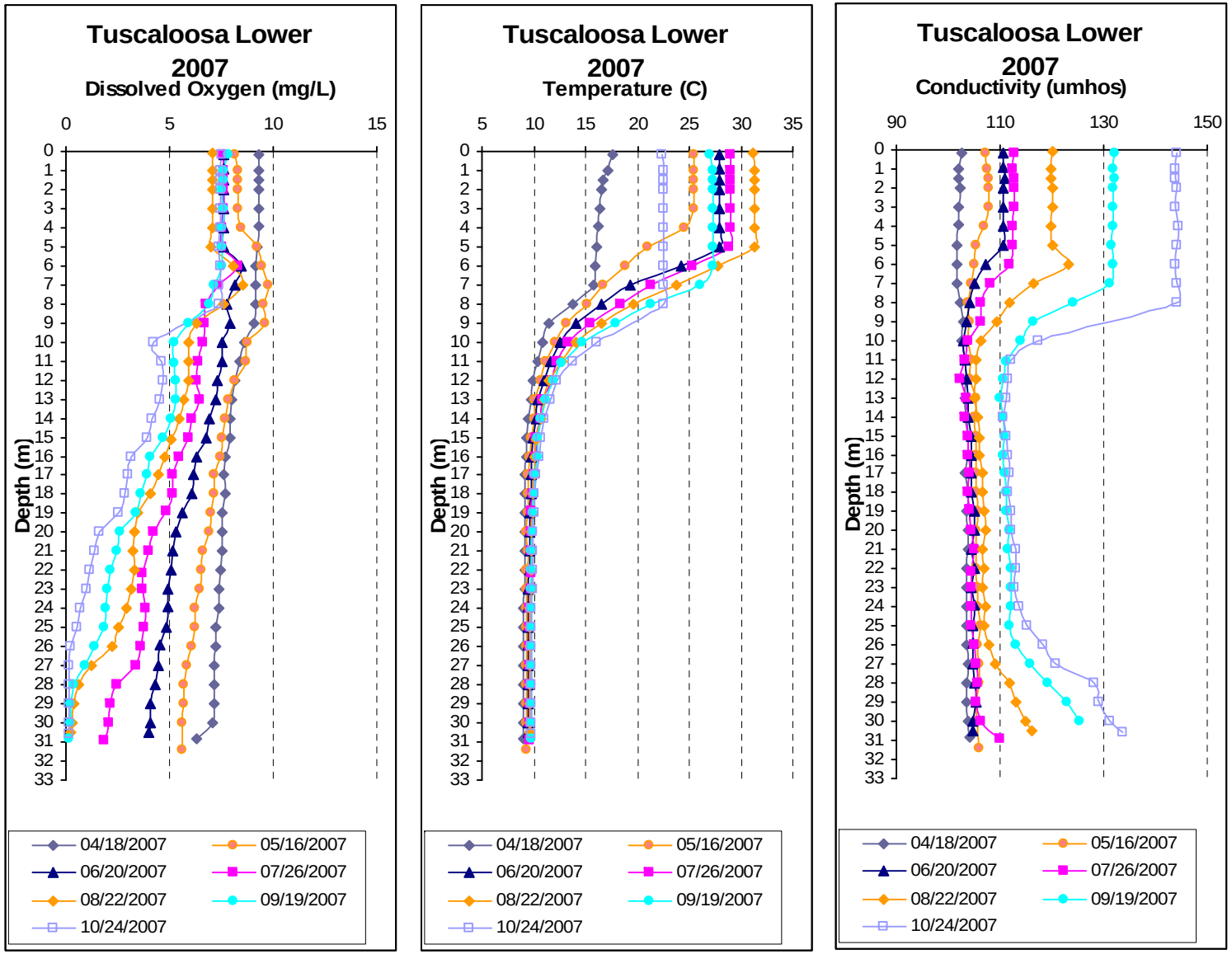


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the mid Tuscaloosa Reservoir station, April-October 2007.

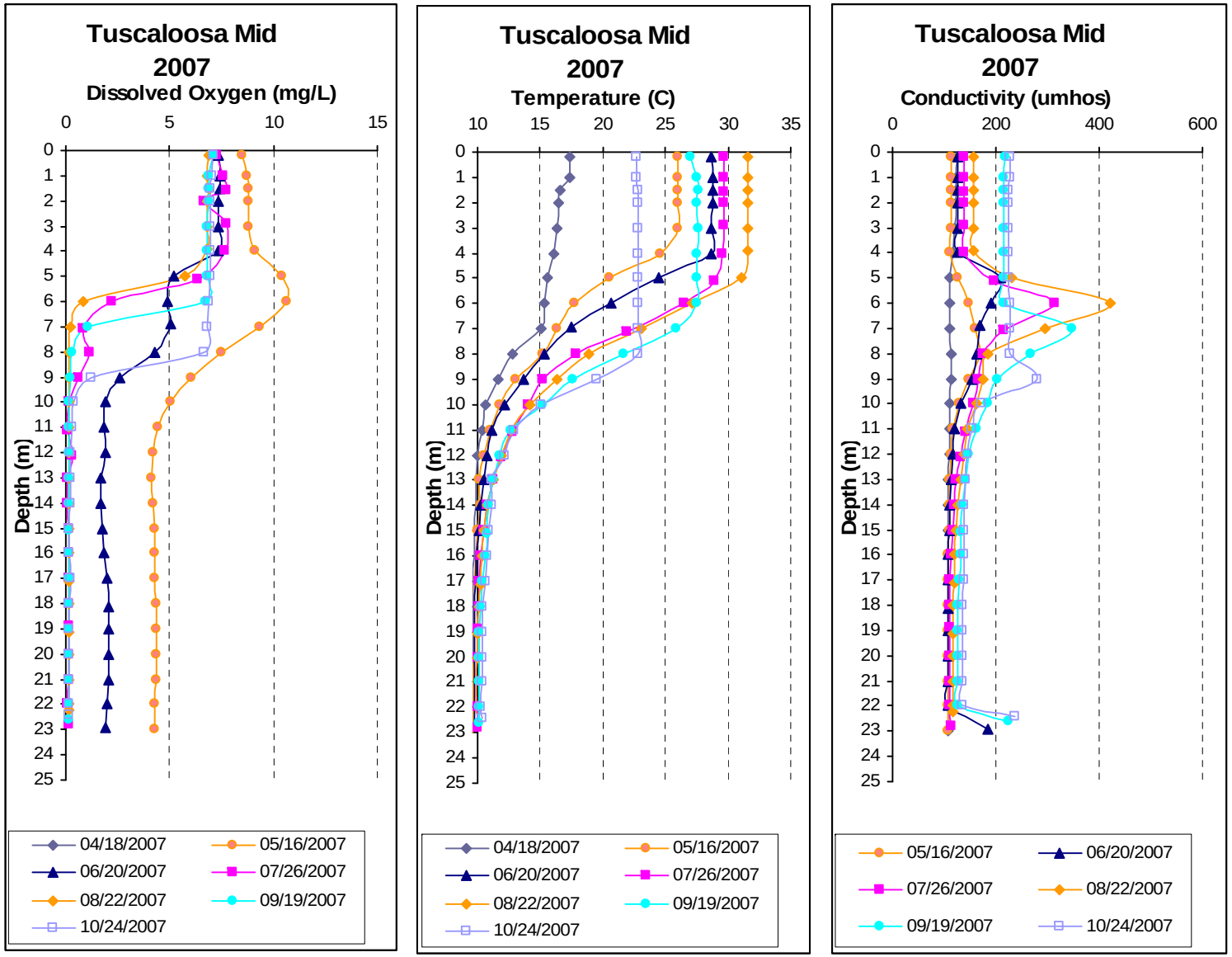


Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the upper Tuscaloosa Reservoir station, April-October 2007.

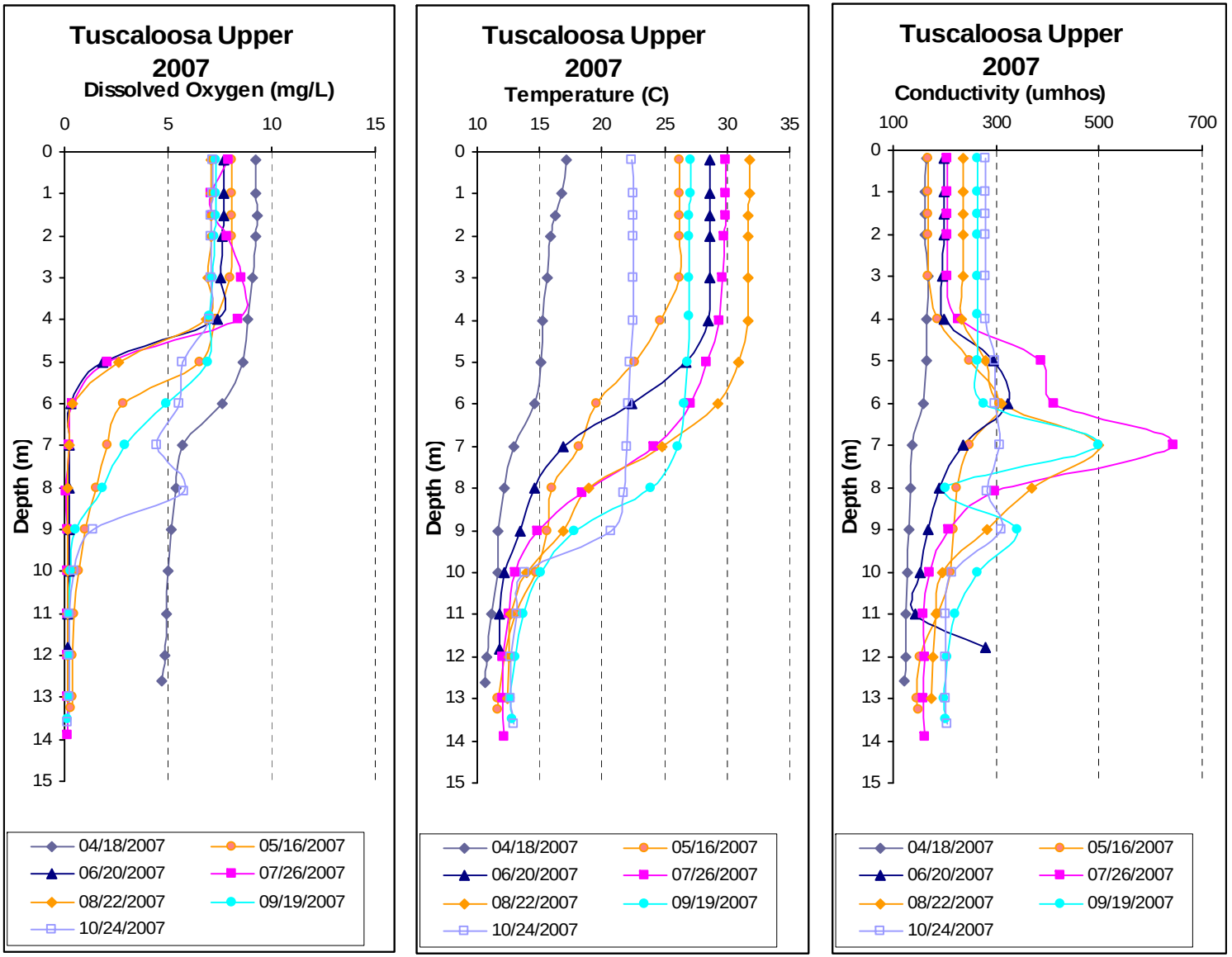
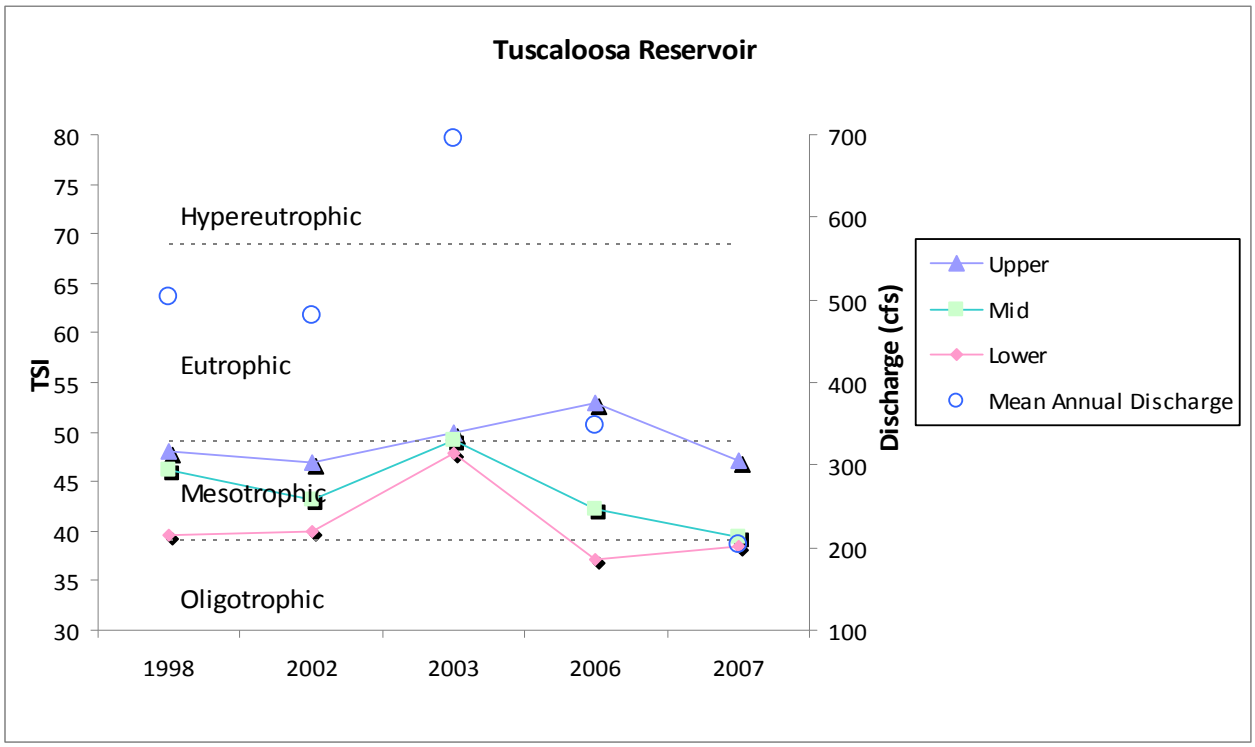


Figure 12. Mean growing season TSI values for mainstem Tuscaloosa Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation. Mean annual discharge calculated as the sum of USGS 02464000 North R near Samantha AL and 02464360 Binion Ck below Gin Ck near Samantha AL.



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APPENDIX

Appendix Table 1. Summary of Tuscaloosa Reservoir water quality data collected April-October, 2007. 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
TUST-1	**Physical**							
	Turbidity (NTU)	7		1.0	1.2	1.1	1.1	0.1
	Total Dissolved Solids (mg/L)	7		24.0	82.0	65.0	59.0	20.8
	Total Suspended Solids (mg/L)	7	<	1.0	4.0	1.5	1.9	1.2
	Hardness (mg/L)	4		11.0	27.5	17.2	18.2	8.3
	Alkalinity (mg/L)	7		16.5	23.4	17.9	18.6	2.6
	Photic Zone (m)	7		9.67	10.80	9.69	9.89	0.42
	Secchi (m)	7		4.55	6.39	4.72	5.10	0.72
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.020	0.107	0.048	0.058	0.032
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.239	0.075	0.113	0.067
	Total Nitrogen (mg/L)	7	<	0.108	0.274	0.163	0.171	0.055
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.009	0.011	0.010	0.010	0.001
	Total Phosphorus (mg/L)	7		0.009	0.039	0.020	0.021	0.010
	CBOD-5 (mg/L)	7	<	1.0	2.6	0.5	1.1	1.0
	Chlorides (mg/L) [J]	7		9.9	14.4	11.4	11.6	1.7
	Biological							
	Chlorophyll a (ug/L) [J]	7		1.07	4.27	1.87	2.25	1.18
	Fecal Coliform (col/100 mL) [J]	1					5	
TUST-2	**Physical**							
	Turbidity (NTU)	7		3.1	4.7	3.6	3.6	0.6
	Total Dissolved Solids (mg/L)	7		90.0	128.0	111.0	111.0	12.8
	Total Suspended Solids (mg/L)	7		2.0	5.0	3.0	3.3	1.1
	Hardness (mg/L)	4		13.0	29.8	21.0	21.2	8.9
	Alkalinity (mg/L)	7		27.7	48.7	42.4	39.5	7.4
	Photic Zone (m)	7		4.23	5.99	5.49	5.30	0.62
	Secchi (m)	7		1.39	2.60	2.20	2.11	0.46
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	<	0.002	0.043	0.004	0.009	0.015
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.355	0.162	0.173	0.112
	Total Nitrogen (mg/L) [J]	7	<	0.076	0.357	0.169	0.183	0.108
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.008	0.013	0.009	0.010	0.002
	Total Phosphorus (mg/L)	7		0.017	0.026	0.021	0.021	0.004
	CBOD-5 (mg/L)	7	<	1.0	3.1	1.7	1.5	0.9
	Chlorides (mg/L) [J]	7		1.9	35.1	23.1	23.1	11.4
	Biological							
	Chlorophyll a (ug/L) [J]	7		2.14	9.08	5.87	5.35	2.42
	Fecal Coliform (col/100 mL) [J]	1					2	

Station	Parameter	N		Min	Max	Med	Avg	SD
TUST-3	**Physical**							
	Turbidity (NTU)	7		1.5	2.0	1.6	1.7	0.2
	Total Dissolved Solids (mg/L)	7		69.0	113.0	86.0	90.0	15.3
	Total Suspended Solids (mg/L)	7	<	0.5	2.0	1.0	1.1	0.7
	Hardness (mg/L)	4		12.7	27.3	18.6	19.3	7.5
	Alkalinity (mg/L)	7		17.9	39.3	31.7	30.0	8.7
	Photic Zone (m)	7		6.63	9.72	7.11	7.73	1.20
	Secchi (m)	7		2.36	5.55	3.61	3.87	1.03
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.002	0.091	0.002	0.021	0.033
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.274	0.159	0.149	0.079
	Total Nitrogen (mg/L)	7	<	0.076	0.275	0.166	0.170	0.069
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.008	0.012	0.010	0.010	0.002
	Total Phosphorus (mg/L)	7		0.013	0.024	0.019	0.019	0.004
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	1.0	0.6
	Chlorides (mg/L) [J]	7		13.9	27.4	22.1	21.0	6.0
	Biological							
	Chlorophyll a (ug/L) [J]	7		0.27	5.07	2.40	2.44	1.51
	Fecal Coliform (col/100 mL) [J]	1					1	
TUST-4	**Physical**							
	Turbidity (NTU)	7		6.0	12.7	7.7	8.5	2.5
	Total Dissolved Solids (mg/L)	7		146.0	221.0	158.0	171.9	31.5
	Total Suspended Solids (mg/L)	7		4.0	10.0	6.0	6.9	2.4
	Hardness (mg/L)	4		14.7	38.0	24.2	25.3	11.9
	Alkalinity (mg/L)	7		42.4	80.6	62.3	61.2	13.8
	Photic Zone (m)	7		2.18	3.52	2.82	2.93	0.48
	Secchi (m)	7		0.77	1.22	0.89	0.95	0.18
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	<	0.002	0.040	0.002	0.009	0.014
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.473	0.349	0.321	0.149
	Total Nitrogen (mg/L) [J]	7	<	0.076	0.483	0.365	0.329	0.152
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.008	0.012	0.009	0.010	0.002
	Total Phosphorus (mg/L)	7		0.021	0.032	0.026	0.026	0.004
	CBOD-5 (mg/L)	7	<	1.0	4.3	1.7	1.6	1.4
	Chlorides (mg/L) [J]	7		2.0	58.8	32.3	35.5	18.4
	Biological							
	Chlorophyll a (ug/L) [J]	7		7.48	25.99	12.28	14.22	6.19
	Fecal Coliform (col/100 mL)	1					20	

Station	Parameter	N		Min	Max	Med	Avg	SD
TUST-5	**Physical**							
	Turbidity (NTU)	7		4.5	6.5	5.2	5.2	0.7
	Total Dissolved Solids (mg/L)	7		69.0	141.0	105.0	107.1	24.8
	Total Suspended Solids (mg/L)	7		4.0	7.0	5.5	5.2	1.2
	Hardness (mg/L)	4		13.1	29.0	17.6	19.4	7.7
	Alkalinity (mg/L)	7		21.8	44.5	36.4	35.0	9.1
	Photic Zone (m)	7		3.13	4.43	3.97	4.02	0.46
	Secchi (m)	7		1.14	1.77	1.48	1.44	0.22
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	<	0.002	0.062	0.004	0.012	0.022
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.355	0.300	0.240	0.120
	Total Nitrogen (mg/L) [J]	7	<	0.076	0.359	0.304	0.252	0.110
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.007	0.013	0.010	0.010	0.002
	Total Phosphorus (mg/L)	7		0.015	0.027	0.023	0.022	0.004
	CBOD-5 (mg/L)	7	<	1.0	3.2	0.5	1.1	1.0
	Chlorides (mg/L) [J]	7		12.0	32.2	26.6	24.6	7.6
	Biological							
	Chlorophyll a (ug/L) [J]	7		2.14	8.90	5.70	5.67	2.35
	Fecal Coliform (col/100 mL) [J]	1					1	

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