2005 Woodruff Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
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2005

Woodruff Reservoir

Alabama River Basin

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INTRODUCTION

The Alabama Department of Environmental Management (ADEM) monitored Woodruff Reservoir as part of the 2005 assessment of the Alabama, Coosa, and Tallapoosa (ACT) River basins under the Rivers and Reservoirs Monitoring Program (RRMP). Implemented in 1990, the objectives of this program were 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. Woodruff Reservoir has been monitored by ADEM since 1989.

The purpose of this report is to summarize data collected at seven stations in Woodruff Reservoir during the 2005 growing season 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 (chlorophyll *a* (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.

METHODS

Sample sites were determined using historical data and previous assessments (Fig. 1). Woodruff Reservoir was sampled in the dam forebay, mid reservoir, and upper reservoir. Four tributary embayments representing a range of watershed conditions and landuse patterns were also monitored. Specific station location information is listed in Table 1.

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 (SOP), Surface Water Quality Assurance Project Plan (QAPP), and Quality Management Plan (QMP).

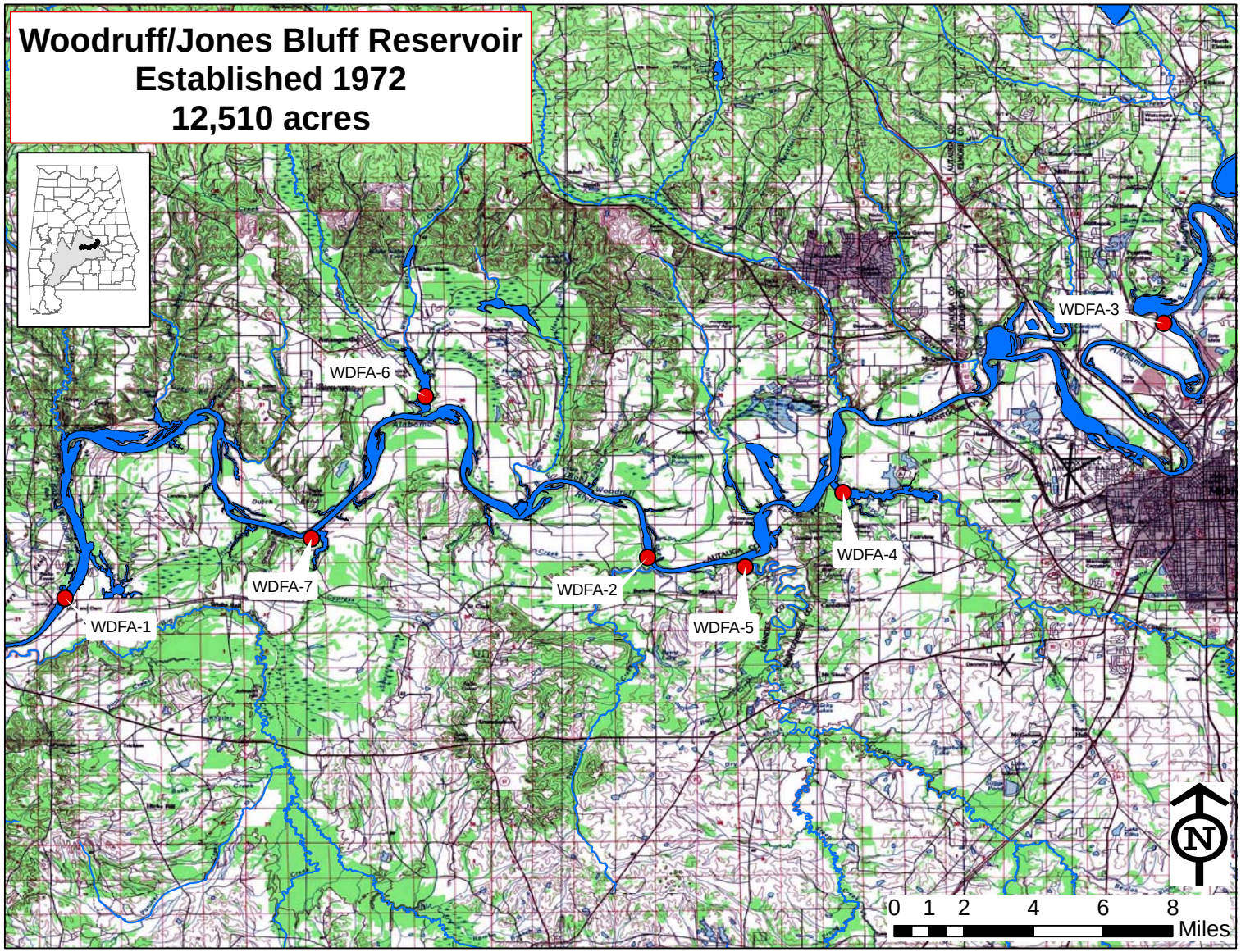


Figure 1. Woodruff Reservoir sampling locations, 2005.

Table 1. Descriptions for the monitoring stations in 2005 for Woodruff Reservoir.

Sub-watershed	County	Station Number	Report Designation	Waterbody Name	Station Description	Latitude	Longitude
Woodruff Reservoir							
Upper Alabama (0315-0201)							
0706	Autauga	WDFA-1	Lower	Alabama R	Lower reservoir. Deepest point, main river channel, dam forebay.	32.3273	-86.7820
0503	Lowndes	WDFA-2	Mid	Alabama R	Mid reservoir. Deepest point, main river channel, immediately. downstream of Tallawassee Creek confluence.	32.3443	-86.5397
0106	Montgomery	WDFA-3	Upper	Alabama R	Upper reservoir. Deepest point, main river channel, immediately. downstream of Jackson Lake.	32.4414	-86.3251
0309	Montgomery	WDFA-4	Catoma Cr	Catoma Cr	Deepest point, main creek channel, Catoma Creek embayment, approximately 0.5 miles upstream of lake confluence.	32.3711	-86.4584
0407	Montgomery	WDFA-5	Pintlalla Cr	Pintlalla Cr	Deepest point, main creek channel, Pintlalla Creek embayment, approximately 0.5 miles upstream of lake confluence.	32.3402	-86.4992
0603	Autauga	WDFA-6	Swift Cr	Swift Cr	Deepest point, main creek channel, Swift Creek embayment, approximately.0.5 miles upstream of lake confluence.	32.4111	-86.6321
0702	Lowndes	WDFA-7	Cypress Cr	Cypress Cr	Deepest point, main creek channel, Cypress Creek embayment, approximately 0.5 miles upstream of lake confluence.	32.3521	-86.6796

RESULTS

Summary statistics of all data collected during 2005 are presented in Appendix Table 1. The table contains the min, max, median, average, and standard deviation of each parameter analyzed.

The mean TN concentrations measured at Woodruff Reservoir stations ranged from 0.58 mg/l at the upper and mid stations to 0.78 mg/l at the Catoma Cr embayment station (Fig. 2). Monthly TN concentrations measured at the upper and mid Woodruff Reservoir mainstem stations ranged from 0.37 mg/l and 0.34 mg/l in August, to 1.16 mg/l and 0.70 mg/l in May respectively (Fig. 3 & 4). Monthly TN concentrations at the lower station ranged from 0.46 mg/l in June to 1.08 mg/l in October (Fig. 5). Monthly TN concentrations measured at the upper mainstem station in April were the lowest measured in ADEM's dataset, while concentrations measured in May were the highest in ADEM's dataset, at this station for these months.

The mean TP concentrations ranged from 0.032 mg/l at the upper and lower mainstem stations to 0.061 mg/l at the Catoma Cr embayment station (Fig. 2). TP concentrations over 0.025 mg/l can indicate eutrophic conditions within a lake or reservoir. Monthly TP concentrations measured at the upper station ranged from <0.004 mg/l in October to 0.071 mg/l in April (Fig. 3). The mid mainstem station TP concentrations ranged from <0.004 mg/l in August and October to 0.064 mg/l in May, while concentrations measured at the lower station ranged from <0.004 mg/l in October to 0.049 mg/l in May (Fig. 4 & 5). Monthly TP concentrations measured in April at the upper station and May at the mid stations were the highest in ADEM's dataset at these stations for these months. Monthly TP concentrations measured in May at the upper station, August at the mid station, and April at the lower station were the lowest in ADEM's dataset at these stations for these months.

The highest mean chl *a* concentrations were measured in the Woodruff Reservoir tributaries (Fig. 2). Of the tributaries, the highest mean chl *a* concentration measured was 25.89 ug/l at the Cypress Cr embayment station while the lowest was 13.42 ug/l at the Swift Cr embayment. Mean chl *a* concentrations at the mainstem reservoir stations ranged from 7.12 ug/l at the upper station to 12.83 ug/l at the mid station. Monthly chl *a* concentrations measured at the upper

station ranged from 4.27 ug/l in April to 9.61 ug/l in May and September (Fig. 3). Monthly chl *a* concentrations at the mid station ranged from 8.9 ug/l in September to 19.22 ug/l in June, while the lower station ranged from 3.56 ug/l in August to 15.66 ug/l in July (Fig. 4 & 5). Monthly chl *a* concentrations measured at the upper station in April and August were the lowest in ADEM's dataset, while concentrations in May were the highest in ADEM's dataset, at this station for these months. Monthly chl *a* concentrations measured in April at the mid reservoir station were the highest in ADEM's dataset while concentrations measured in August at the lower station were the lowest in ADEM's dataset at these stations for these months. Mean chl *a* concentrations at all mainstem Woodruff Reservoir stations were lower in 2005 than in 2000 (Fig. 6).

Mean TSS concentrations at embayment stations ranged from 7.71 mg/l at the Cypress Cr embayment station to 17.29 mg/l at the Catoma Cr embayment (Fig. 2). Mean TSS concentrations at mainstem Woodruff Reservoir stations ranged from 9.43 mg/l at the mid station to 12.86 mg/l at the upper reservoir station. Monthly TSS concentrations measured at the upper station ranged from 5 mg/l in May and October to 26 mg/l in September (Fig. 3). The mid and lower stations TSS concentrations ranged from a low of 5 mg/l and 6 mg/l in May to 16 mg/l and 25 mg/l in April respectively (Fig. 4 & 5). Monthly TSS concentrations measured at all mainstem Woodruff Reservoir stations were the lowest in ADEM's dataset during May at these stations. The TSS concentrations at the mid and lower stations in April, and the lower station in August were the highest recorded in ADEM's dataset at these stations for these months.

AGPT results indicated the upper and lower stations were phosphorus limited while the mid station was co-limited (Table 2). Results obtained in 2000 are the same with respect to the upper station. However the mid and lower stations were nitrogen limited in 2000. Mean standing crop (MSC) values ranged from 5.33 mg/l at the lower station, to 8.63 mg/l at the mid station, and declined to 6.11 mg/l at the upper station. This pattern was also observed in 2000. Five mg/l MSC has been defined as protective of reservoir and lake systems (Raschke and Schultz 1987), with 20 mg/l MSC defined as protective of flowing streams and rivers (Raschke et al. 1996).

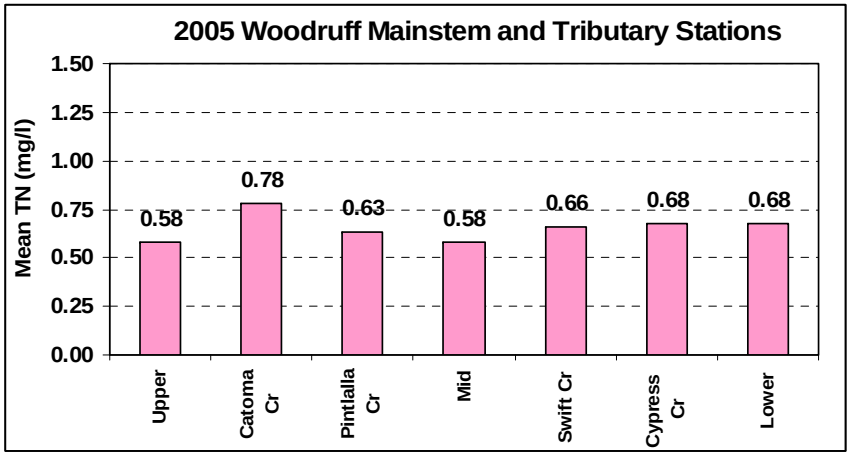
The dissolved oxygen concentration at the Cypress Cr embayment station was <5.0 mg/l at a depth of 5.0 feet during August (Fig. 8). All other measurements of dissolved oxygen

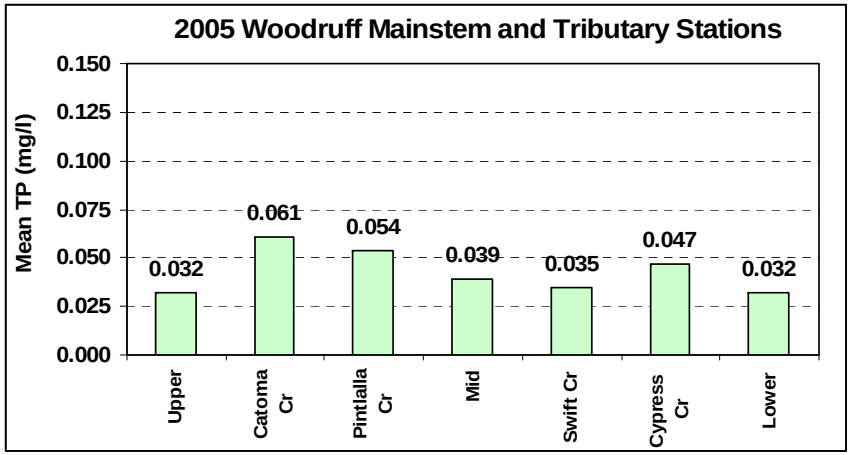
concentrations were above the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/l (Fig. 7 & 8) at this depth. Dissolved oxygen profiles of the Woodruff Reservoir mainstem stations show no thermal stratification, June-September (Fig. 7). Warmest water temperatures were reached in July at the upper station and August at the mid and lower stations.

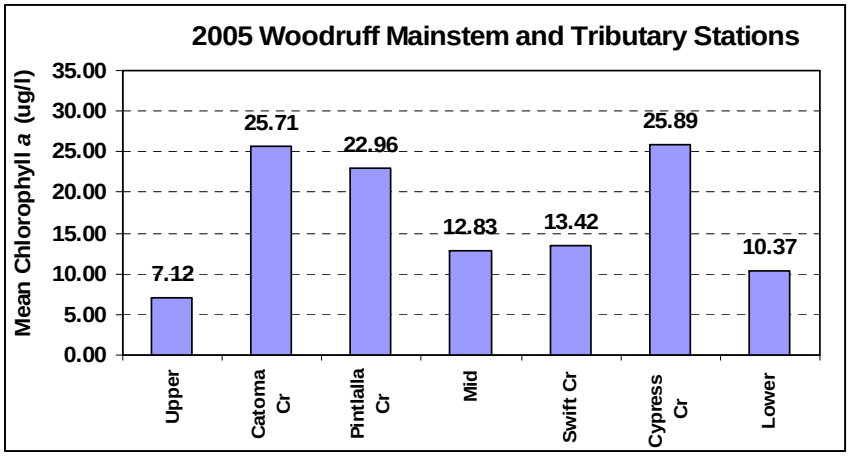
Carlson's TSI was calculated from the corrected chl *a* concentrations. At the upper station, TSI values were mesotrophic in April, July, and August, and eutrophic all other months monitored (Fig.9). The mid and lower reservoir stations were eutrophic all months monitored except August and October when the lower station was mesotrophic. The Catoma Cr and Swift Cr embayments were mesotrophic in May and June, respectively. Cypress Cr was hypereutrophic in August. Other monthly TSI values in embayment stations were eutrophic April-October

Except for mesotrophic conditions at the upper and lower stations during 2005, August TSI values calculated at the upper, mid, and lower mainstem stations were eutrophic through the entire historic record, 1985-2005 (Fig. 10).

Figure 2. Mean total nitrogen (TN), mean total phosphorus (TP), mean chlorophyll *a* (Chl *a*), and mean total suspended solids (TSS) measured throughout Woodruff Reservoir, April-October 2005. Bar graphs consist of multiple stations, illustrated from upstream to downstream as the graph is read from left to right.







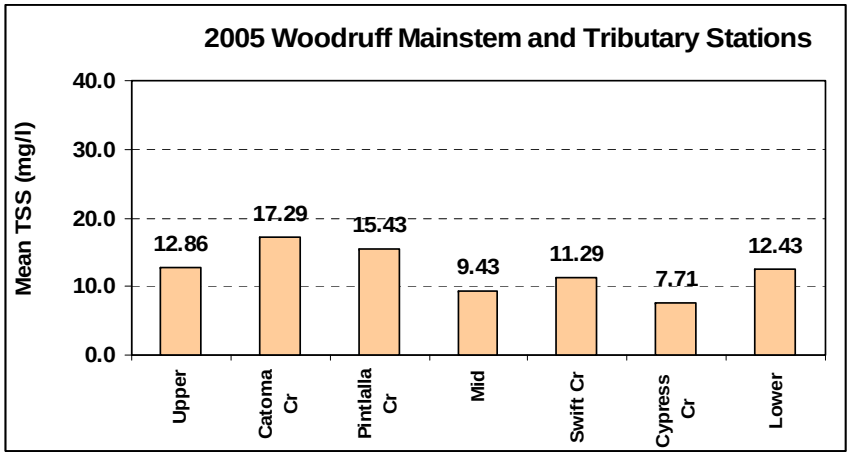
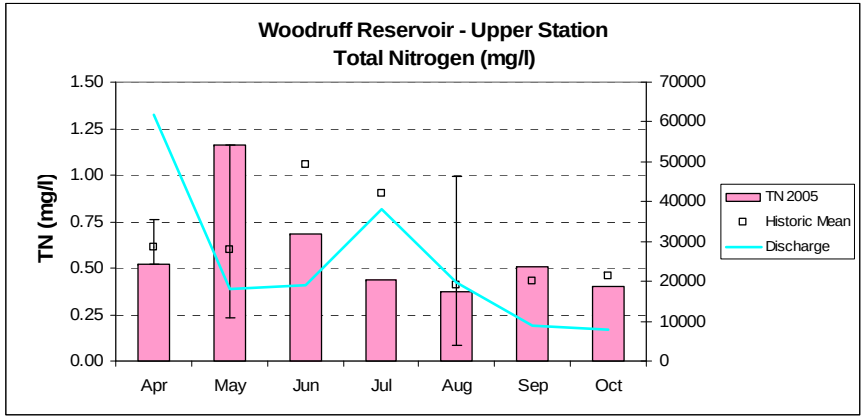
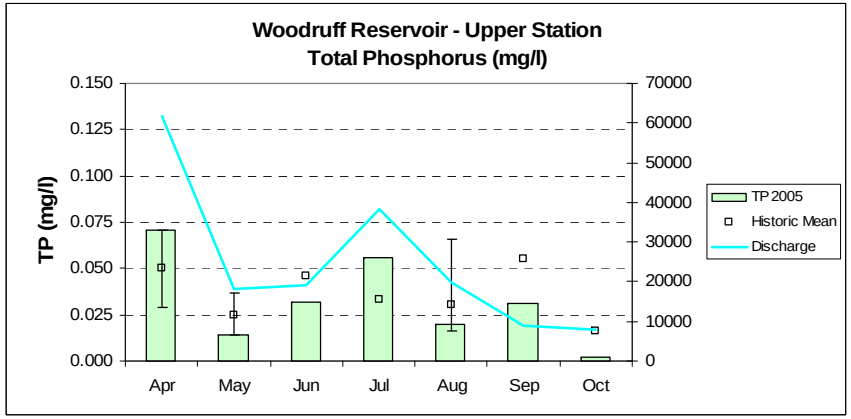
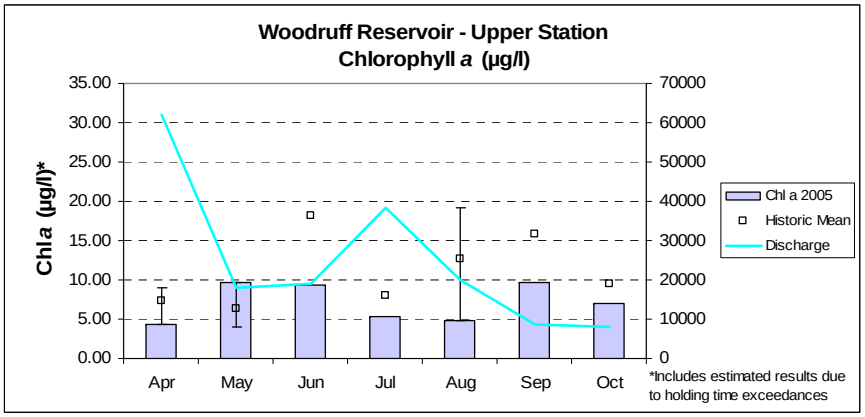


Figure 3. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a* (Chl *a*), and total suspended solids (TSS) of the upper station in Woodruff Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the upper station. The historic mean and min/max range are also displayed for comparison when there was at least 3 data points. Nutrients and TSS were plotted vs. discharge (USACE Mobile District gauge data, Woodruff/Jones Bluff Reservoir).







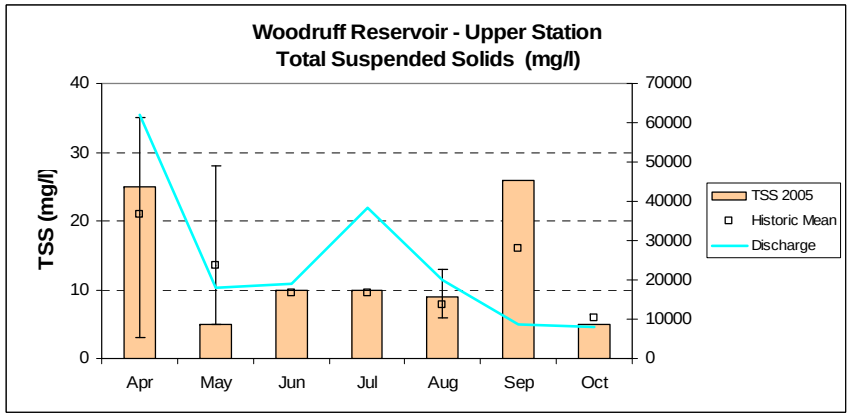


Figure 4. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a* (Chl *a*), and total suspended solids (TSS) of the mid station in Woodruff Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the mid-reservoir station. The historic mean and min/max range are also displayed for comparison when there was at least 3 data points. Nutrients and TSS were plotted vs. discharge (USACE Mobile District gauge data, Woodruff/Jones Bluff Reservoir).

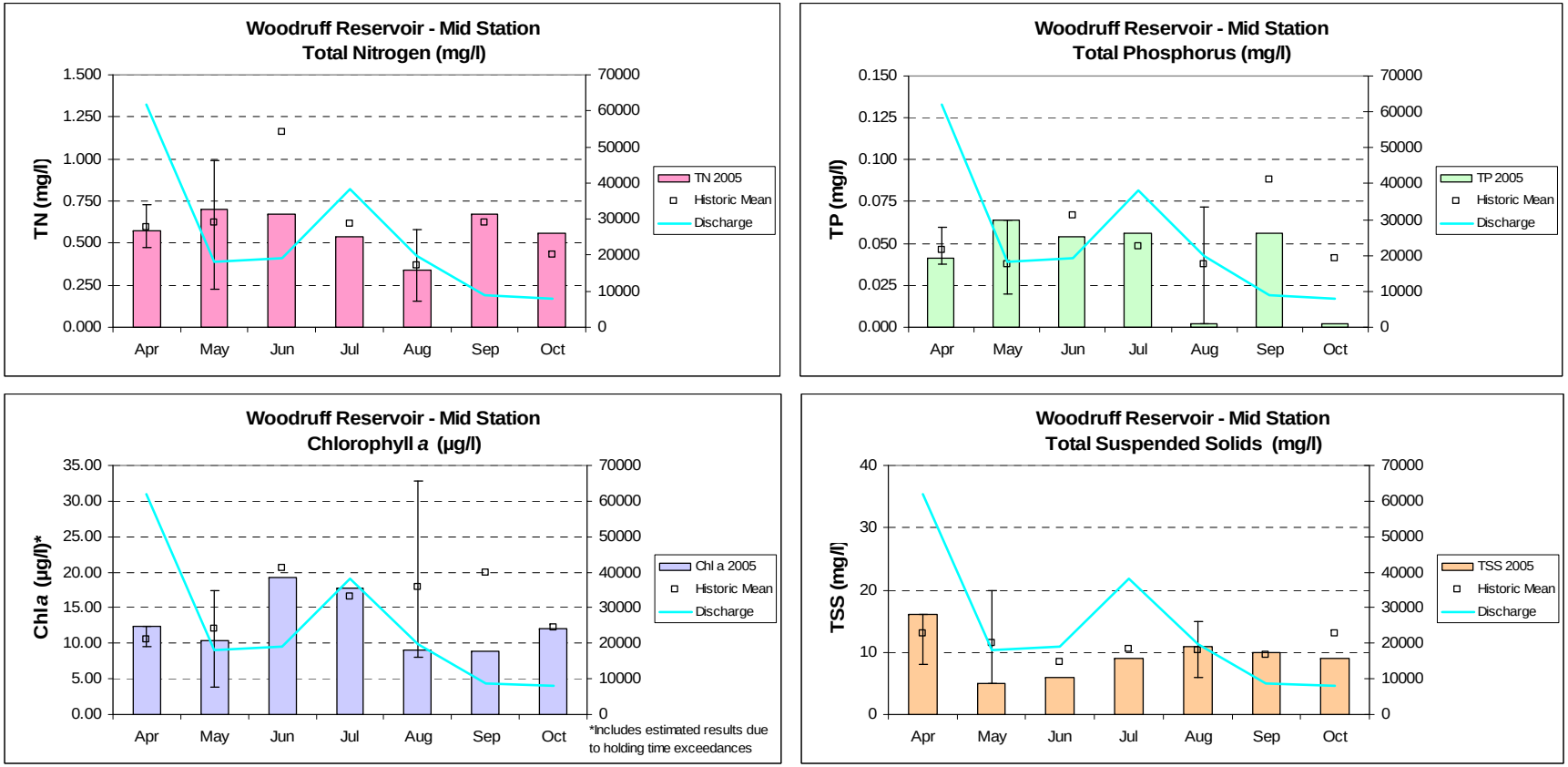
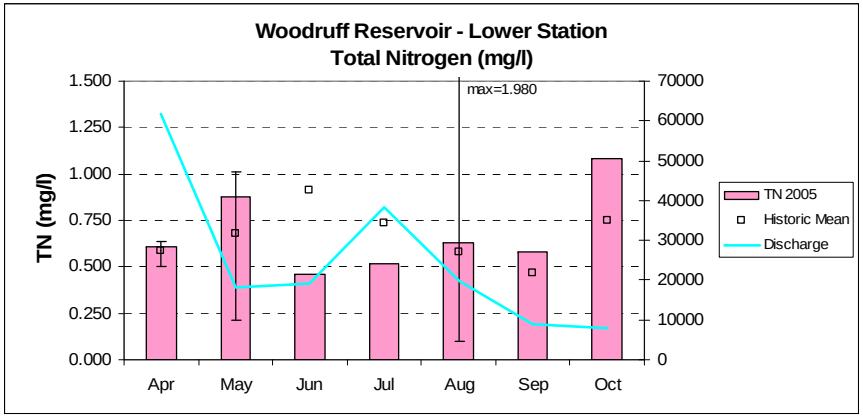
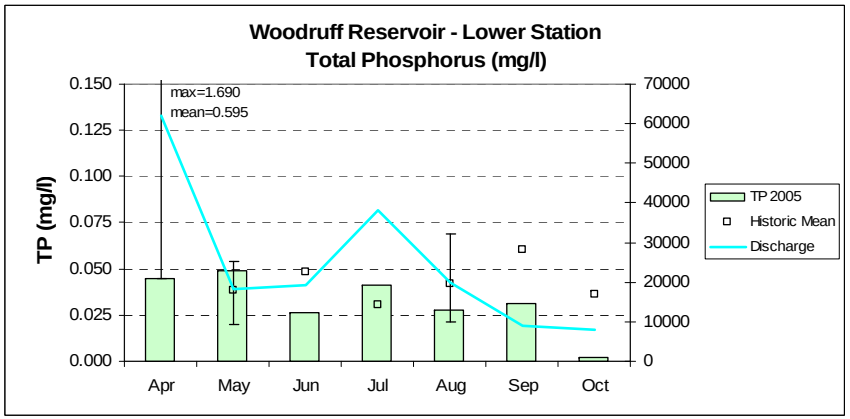
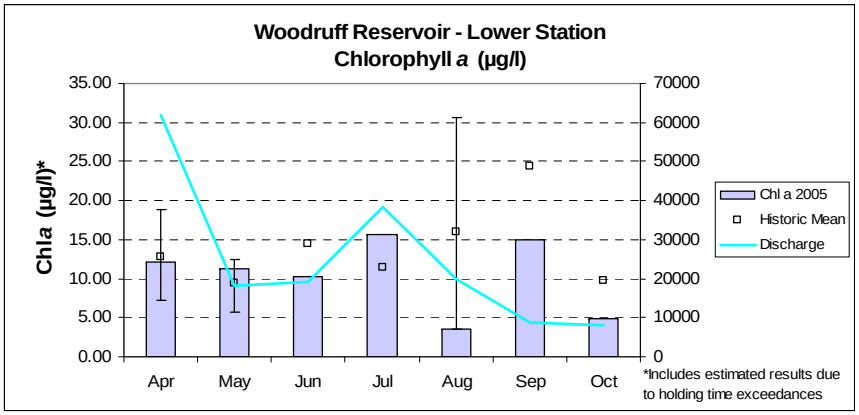


Figure 5. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a* (Chl *a*), and total suspended solids (TSS) of the lower station in Woodruff Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the lower reservoir station. The historic mean and min/max range are also displayed for comparison when there was at least 3 data points. Nutrients and TSS were plotted vs. discharge (USACE Mobile District gauge data, Woodruff/Jones Bluff Reservoir).







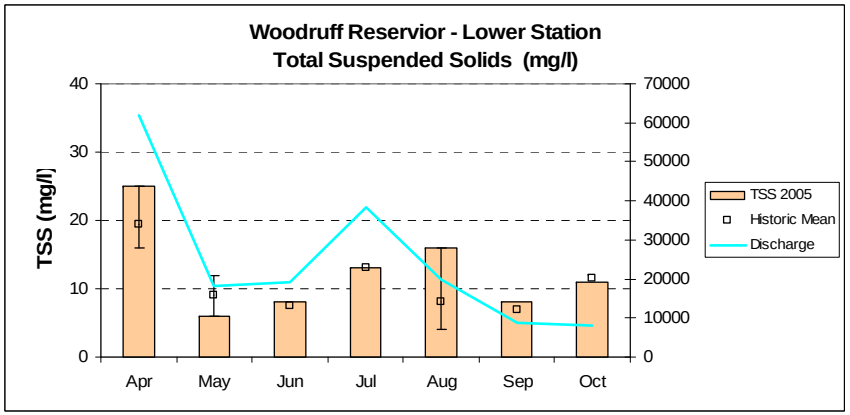


Figure 6. Mean chlorophyll *a* concentrations of mainstem Woodruff Reservoir, 2000 and 2005.

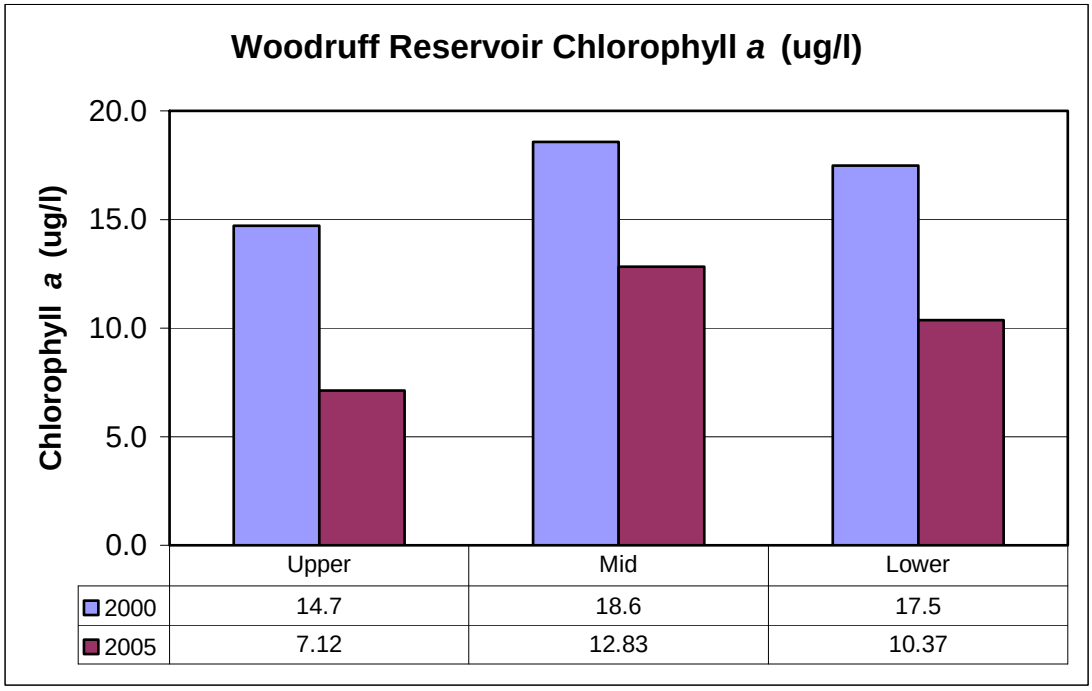


Table 2. Algal growth potential test results for mainstem Woodruff Reservoir stations, 2000 and 2005 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status.

Station	2000 Control mean MSC	2000 Limiting Nutrient	2005 Control mean MSC	2005 Limiting Nutrient
Upper	4.36	Phosphorus	6.11	Phosphorus
Mid	6.79	Nitrogen	8.63	Co-Limiting
Lower	5.22	Nitrogen	5.33	Phosphorus

Figure 7. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Woodruff Reservoir, June-September 2005. Although profiles were measured April-October, these select months were chosen as they represent the warmest water temperatures and most stratified dissolved oxygen concentrations. ADEM Water Quality Criteria pertaining to non-wadeable river and reservoir waters require a DO concentration of 5.0 mg/l at 5.0 ft (1.5 m) (ADEM Admin. Code R. 335-6-10-.09). Under extreme natural conditions such as drought, the DO concentration may be as low as 4.0 mg/l.

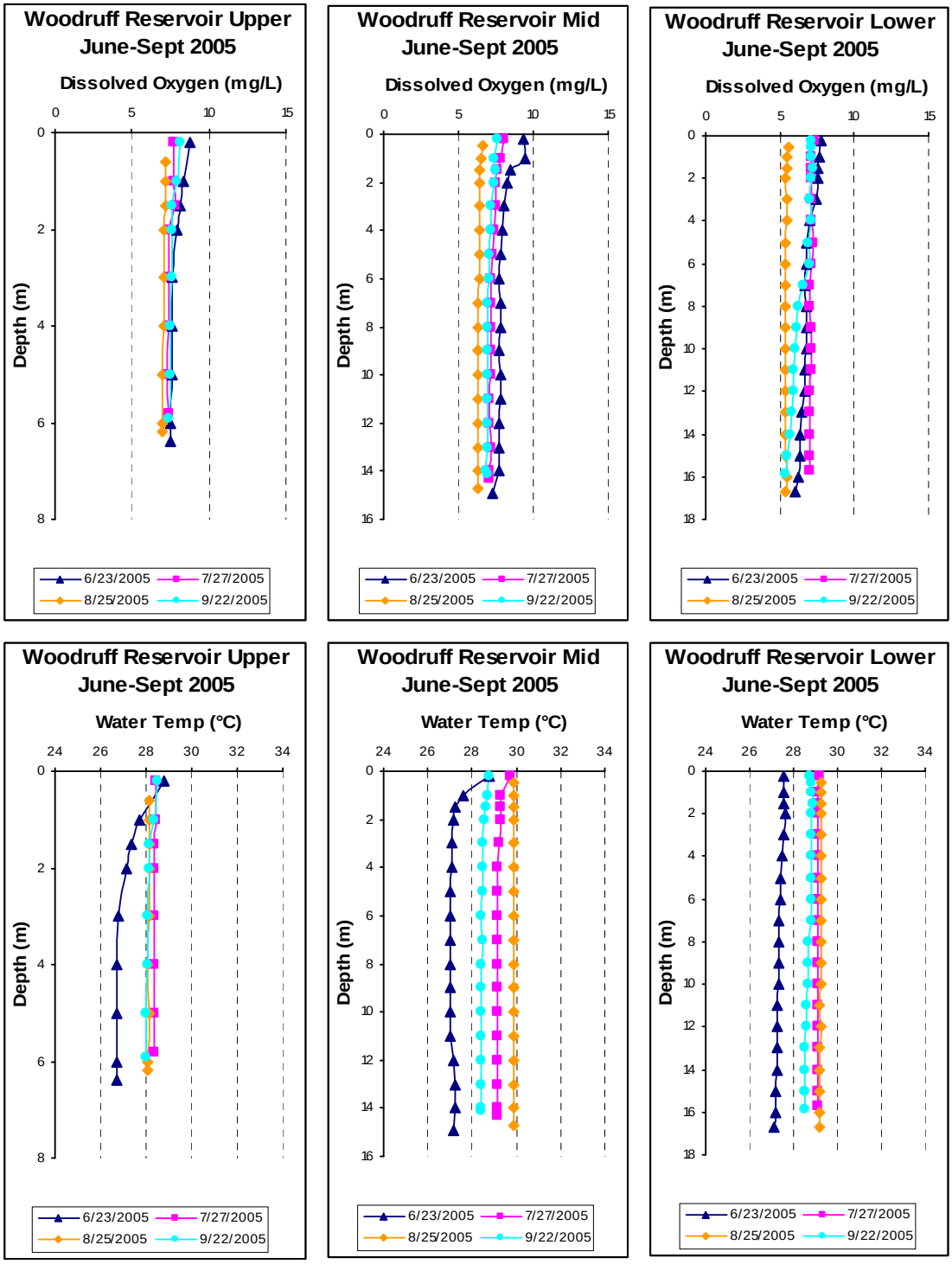


Figure 8. DO concentrations at 5 ft (1.5 m) for Woodruff reservoir tributaries collected April-October 2005. For tributary embayments, which are typically not as deep as mainstem stations and usually maintain a mixed water column throughout the season, profiles were collected but only the monthly DO concentrations at a depth of 5 ft (1.5 m) are graphed. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/l at this depth (ADEM 2005).

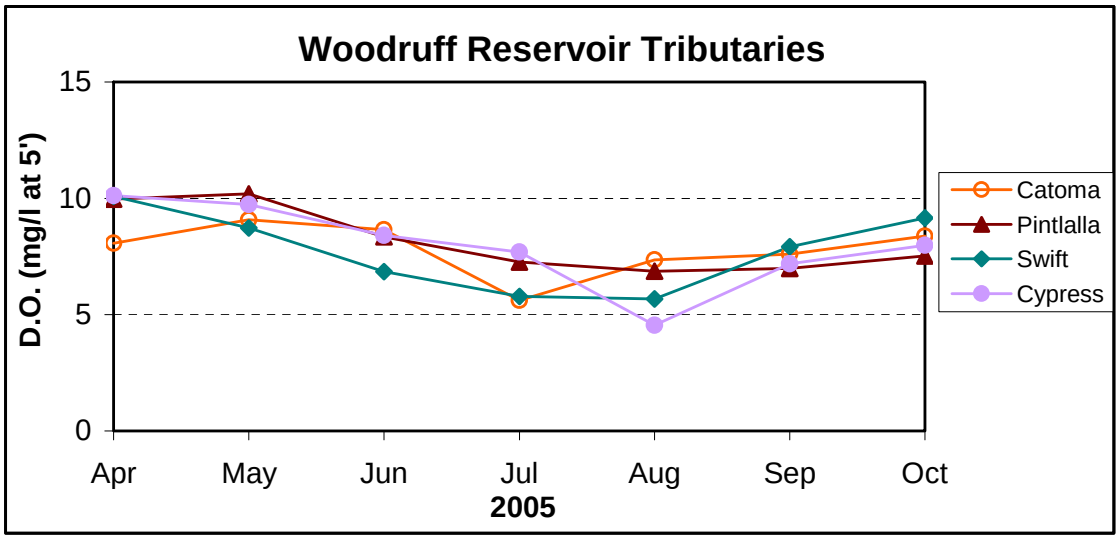


Figure 9. Monthly TSI values for Woodruff Reservoir mainstem and tributary stations using chlorophyll *a* concentrations and the Carlson's Trophic State Index calculation, April-October 2005.

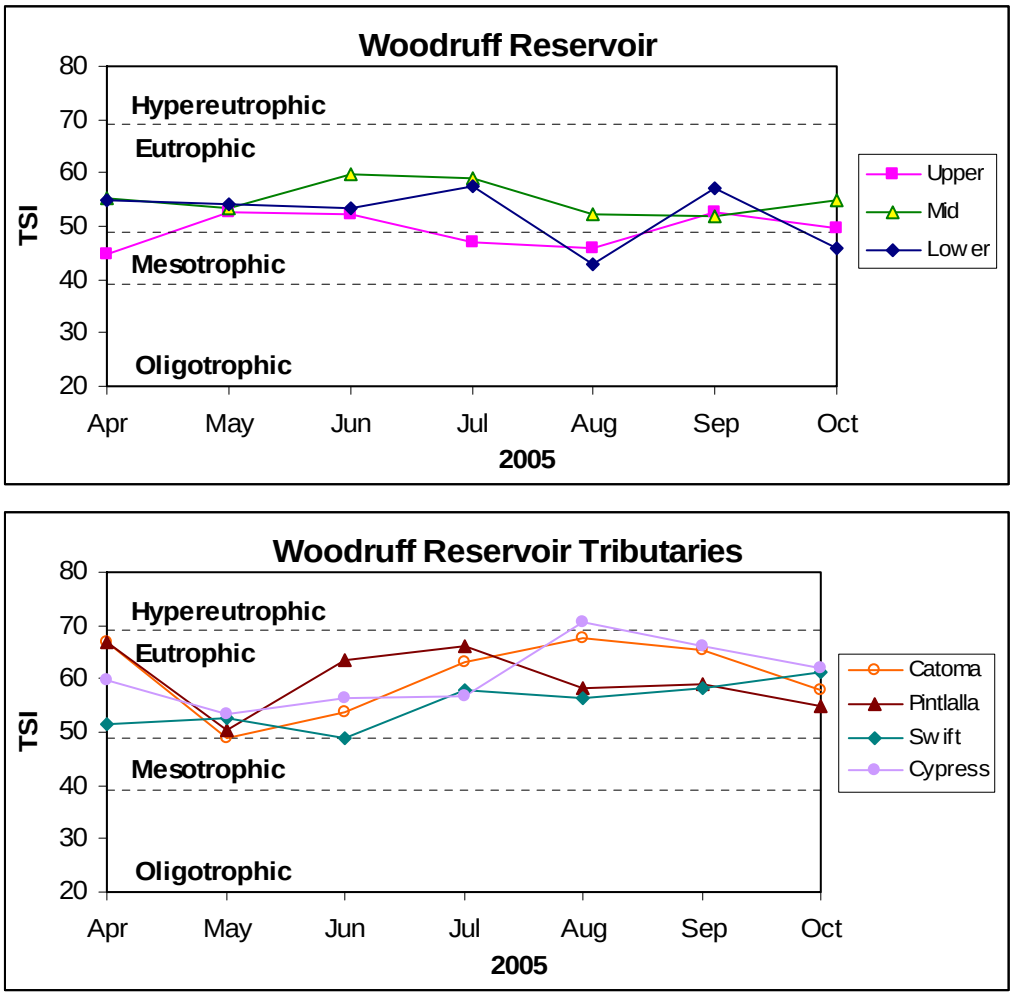
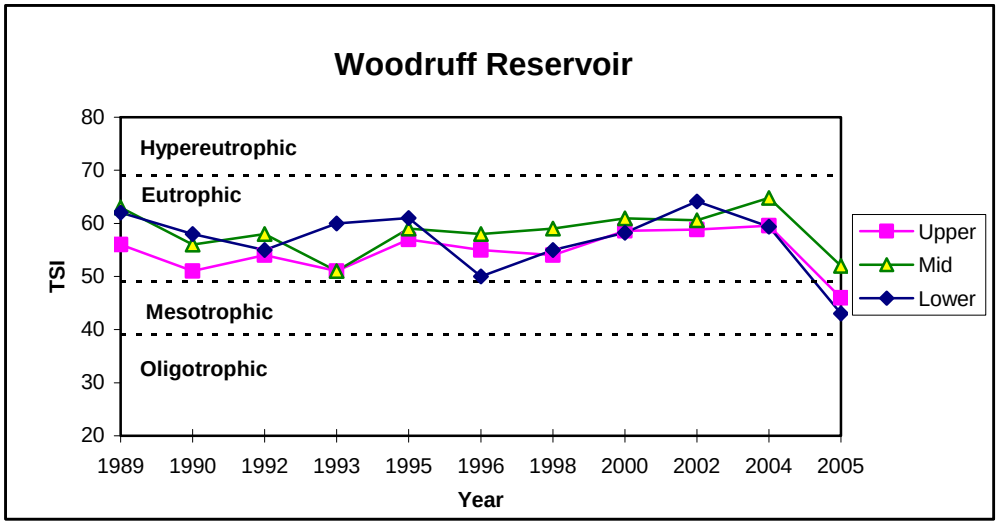


Figure 10. Trophic State Index values from critical period sampling of Woodruff Reservoir (August sampling only) from 1989 to 2005.



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APPENDIX

Appendix Table 1. Summary of Woodruff Reservoir water quality data, April-October, 2005. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median (Med), average (Ave), and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Median	Avg	SD
WDFA-1	Alkalinity (mg/L)	7	33.3	42.9	38.3	38.4	3.3
	Hardness (mg/L)	4	30.7	39.9	38.0	36.6	4.2
	Total Dissolved Solids (mg/L)	7	24.0	112.0	88.0	76.1	34.7
	Total Suspended Solids (mg/L)	7	6.0	25.0	11.0	12.4	6.5
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.057	0.008	0.016	0.018
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.099	0.331	0.165	0.186	0.077
	Total Kjeldahl Nitrogen (mg/L)	7	0.356	0.750	0.384	0.491	0.179
	Total Nitrogen (mg/L)	7	0.460	1.080	0.610	0.680	0.220
	Total Phosphorus (mg/L)	7	< 0.004	0.049	0.031	0.032	0.016
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.057	0.009	0.014	0.019
	Chlorophyll a (mg/L)[J]	7	3.56	15.66	11.21	10.37	4.65
	Turbidity (NTU)	7	8	14	9	10	2
	Secchi (m)	7	0.68	0.99	0.82	0.85	0.11
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	4	---
WDFA-2	Alkalinity (mg/L)	7	31.3	52.6	38.3	40.5	7.5
	Hardness (mg/L)	4	33.7	44.6	42.3	40.7	4.9
	Total Dissolved Solids (mg/L)	7	25.0	107.0	84.0	76.9	26.0
	Total Suspended Solids (mg/L)	7	5.0	16.0	9.0	9.4	3.6
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.045	0.008	0.020	0.016
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.111	0.323	0.188	0.212	0.079
	Total Kjeldahl Nitrogen (mg/L)	7	0.175	0.593	0.350	0.369	0.139
	Total Nitrogen (mg/L)	7	0.340	0.700	0.570	0.579	0.123
	Total Phosphorus (mg/L)	7	< 0.004	0.064	0.054	0.039	0.026
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.025	0.008	0.012	0.010
	Chlorophyll a (mg/L)[J]	7	8.90	19.22	12.02	12.83	4.13
	Turbidity (NTU)	7	6	15	9	9	3
	Secchi (m)	7	0.66	0.91	0.86	0.84	0.08
	Fecal Coliform (col/100 mL)	1	---	---	---	18	---
WDFA-3	Alkalinity (mg/L)	7	28.9	49.9	33.5	37.0	8.4
	Hardness (mg/L)	4	30.9	48.6	32.5	36.1	8.4
	Total Dissolved Solids (mg/L)	7	11.0	80.0	72.0	56.1	26.5
	Total Suspended Solids (mg/L)	7	5.0	26.0	10.0	12.9	8.9
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.048	0.008	0.015	0.015
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.132	0.239	0.177	0.181	0.045
	Total Kjeldahl Nitrogen (mg/L)	7	0.193	1.032	0.270	0.400	0.301
	Total Nitrogen (mg/L)	7	0.370	1.160	0.510	0.583	0.274
	Total Phosphorus (mg/L)	7	< 0.004	0.071	0.031	0.032	0.024
	Dissolved Reactive Phosphorus (mg/L)	6	< 0.004	0.012	0.004	0.005	0.004
	Chlorophyll a (mg/L)[J]	7	4.27	9.61	6.94	7.12	2.37
	Turbidity (NTU)	7	4	36	7	11	11
	Secchi (m)	7	0.39	1.27	1.14	0.99	0.32
	Fecal Coliform (col/100 mL)	1	---	---	---	110	---
WDFA-4	Alkalinity (mg/L)	7	37.9	82.3	50.4	55.2	17.5
	Hardness (mg/L)	4	31.1	105.0	64.9	66.5	35.1
	Total Dissolved Solids (mg/L)	7	64.0	152.0	90.0	97.3	28.6
	Total Suspended Solids (mg/L)	7	4.0	31.0	19.0	17.3	8.4
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.036	0.008	0.014	0.011
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.018	0.165	0.100	0.091	0.054

Station	Parameter	N	Min	Max	Median	Avg	SD
	Total Kjeldahl Nitrogen (mg/L)	7	0.341	1.109	0.640	0.686	0.241
	Total Nitrogen (mg/L)	7	0.510	1.130	0.740	0.777	0.204
	Total Phosphorus (mg/L)	7	< 0.004	0.101	0.066	0.061	0.035
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.024	0.010	0.011	0.009
	Chlorophyll a (mg/L)[J]	7	6.41	43.79	27.77	25.71	14.86
	Turbidity (NTU)	7	6	19	15	14	5
	Secchi (m)	7	0.49	0.83	0.58	0.63	0.14
	Fecal Coliform (col/100 mL)	1	---	---	---	77	---
WDFA-5	Alkalinity (mg/L)	7	39.8	87.4	46.9	56.0	18.0
	Hardness (mg/L)	4	39.6	112.0	52.5	64.1	33.3
	Total Dissolved Solids (mg/L)	7	81.0	287.0	94.0	123.0	73.9
	Total Suspended Solids (mg/L)	7	8.0	28.0	14.0	15.4	7.2
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.023	0.008	0.012	0.007
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.003	0.254	0.088	0.113	0.107
	Total Kjeldahl Nitrogen (mg/L)	7	0.245	0.803	0.472	0.521	0.199
	Total Nitrogen (mg/L)	7	0.420	0.890	0.630	0.634	0.155
	Total Phosphorus (mg/L)	7	0.004	0.090	0.061	0.055	0.028
	Dissolved Reactive Phosphorus (mg/L)	7	0.004	0.022	0.009	0.009	0.006
	Chlorophyll a (mg/L)[J]	7	7.48	40.05	18.16	22.96	12.69
	Turbidity (NTU)	6	8	23	11	11	7
	Secchi (m)	7	0.50	0.93	0.74	0.72	0.16
	Fecal Coliform (col/100 mL)	1	---	---	---	52	---
WDFA-6	Alkalinity (mg/L)	7	11.7	38.5	22.2	23.7	10.0
	Hardness (mg/L)	4	14.9	36.1	22.6	24.1	8.9
	Total Dissolved Solids (mg/L)	7	9.0	87.0	67.0	61.3	27.1
	Total Suspended Solids (mg/L)	7	4.0	17.0	12.0	11.3	4.5
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.040	0.008	0.015	0.014
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.069	0.247	0.140	0.157	0.064
	Total Kjeldahl Nitrogen (mg/L)	7	0.265	0.644	0.544	0.503	0.145
	Total Nitrogen (mg/L)	7	0.510	0.770	0.680	0.659	0.089
	Total Phosphorus (mg/L)	7	< 0.004	0.062	0.031	0.036	0.021
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.022	0.002	0.006	0.007
	Chlorophyll a (mg/L)[J]	7	6.41	22.96	13.88	13.42	5.70
	Turbidity (NTU)	7	6	15	11	11	3
	Secchi (m)	7	0.62	1.16	0.82	0.86	0.19
	Fecal Coliform (col/100 mL)	1	---	---	---	25	---
WDFA-7	Alkalinity (mg/L)	7	35.5	51.7	38.7	40.2	5.5
	Hardness (mg/L)	4	38.7	43.9	41.4	41.3	2.2
	Total Dissolved Solids (mg/L)	7	47.0	90.0	77.0	72.1	17.3
	Total Suspended Solids (mg/L)	7	5.0	12.0	6.0	7.7	2.8
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.028	0.008	0.013	0.009
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.018	0.167	0.076	0.091	0.053
	Total Kjeldahl Nitrogen (mg/L)	7	0.286	1.174	0.545	0.587	0.286
	Total Nitrogen (mg/L)	7	0.430	1.250	0.590	0.676	0.268
	Total Phosphorus (mg/L)	6	< 0.030	0.064	0.058	0.054	0.012
	Dissolved Reactive Phosphorus (mg/L)	6	< 0.004	0.018	0.004	0.007	0.007
	Chlorophyll a (mg/L)[J]	7	10.15	59.81	19.94	25.89	17.58
	Turbidity (NTU)	7	7	10	8	8	1
	Secchi (m)	7	0.73	1.25	0.81	0.91	0.20
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	5	---

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