2007 Lewis Smith Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
May 2012

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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

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INTRODUCTION

Lewis Smith Reservoir's (Smith Reservoir) 21,200 acre water body was established in 1961 by Alabama Power with the completion of Lewis Smith Dam as the first and largest reservoir in the Black Warrior system. Alabama Power still owns and operates the generating plant. This allows Smith Reservoir to fulfill multiple purposes like fishing, recreation, drinking water and power supply.

The Alabama Department of Environmental Management (ADEM) monitored Smith 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 20012 Monitoring Strategy.

In 2004, the ADEM implemented a specific water quality criterion for nutrient management at three locations in Smith Reservoir, which has been intensively monitored by ADEM since 1998. This criterion represents the maximum growing season mean (Apr-Oct) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting the 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 eleven stations in Smith 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. Smith Reservoir was sampled in the dam forebay with additional stations in mid and upper reservoir. Monitoring sites were also established in the Ryan Creek, Rock Creek, Brushy Creek, Clear Creek, Dismal Creek, Crooked Creek, and Sipsey Fork embayments.

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. For mainstem stations, 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. Lewis Smith Reservoir with 2007 sampling locations. A description of each sampling location is provided in Table 1.

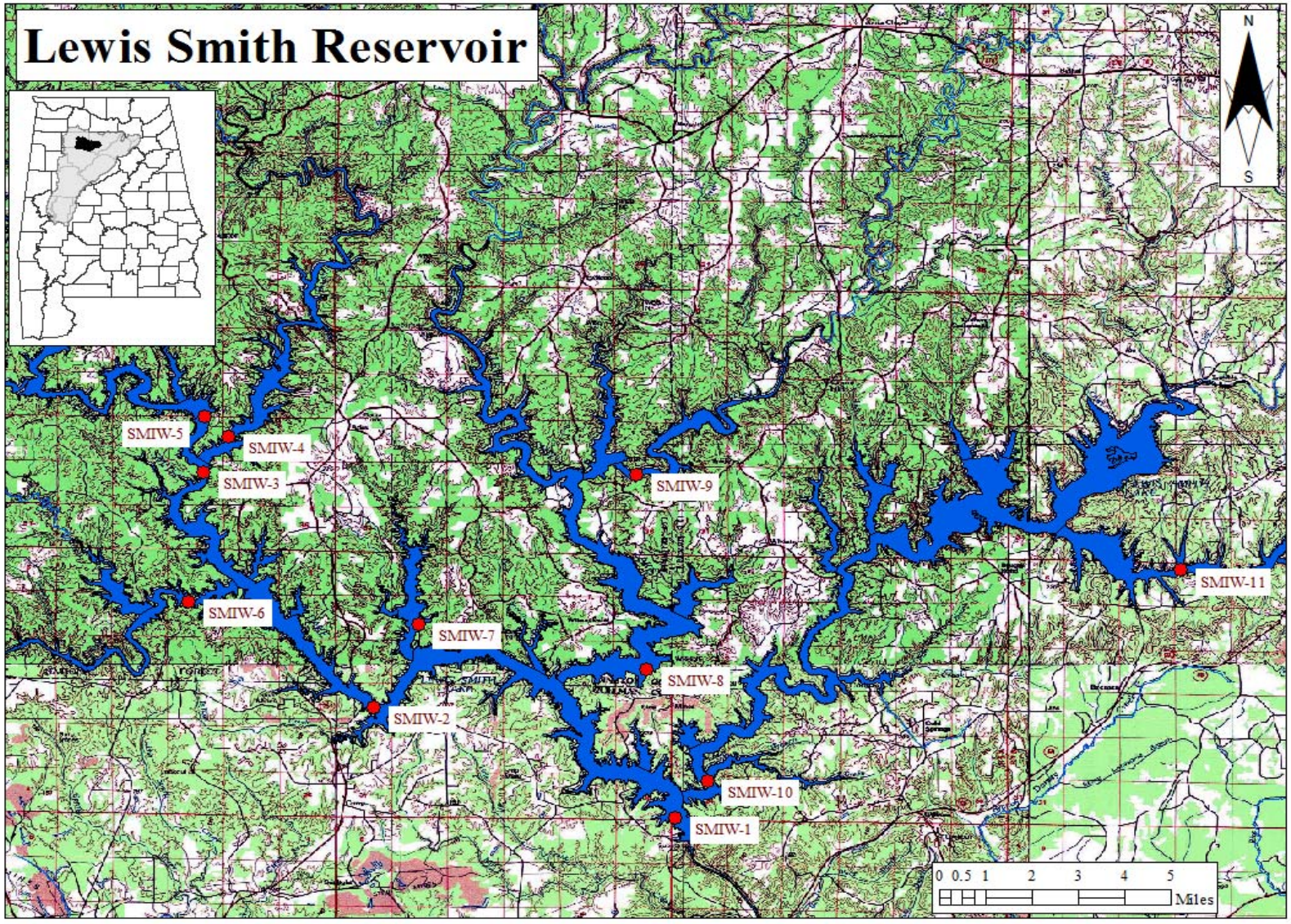


Table 1. Descriptions of the 2007 monitoring stations in Smith Reservoir.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criteria	Latitude	Longitude
Smith Reservoir								
031601100507	Cullman	SMIW-1	Lower	Black Warrior R	Deepest point, main river channel, dam forebay.	5 µg/l*	33.9495	-87.1108
031601100306	Winston	SMIW-2	Mid	Black Warrior R	Deepest point, main river channel, at Duncan Creek/Sipsey River confluence. Downstream of Alabama Hwy 257 bridge.	5 µg/l*	33.9860	-87.2052
031601100203	Winston	SMIW-3	Upper	Black Warrior R	Deepest point, main river channel, immed. downstream of Brushy Creek confluence.	5 µg/l*	34.0635	-87.2584
031601100203	Winston	SMIW-4	Brushy Ck	Brushy Ck	Deepest point, main creek channel, Brushy Creek embayment.		34.0754	-87.2505
031601100105	Winston	SMIW-5	Sipsey	Sipsey R	Deepest point, main river channel, approx. 0.5 miles downstream of the Sipsey Fork, Yellow Creek confluence.		34.0821	-87.2580
031601100305	Winston	SMIW-6	Clear Ck	Clear Ck	Deepest point, main creek channel, Clear Creek embayment.		34.0210	-87.2630
031601100306	Winston	SMIW-7	Dismal Ck	Dismal Ck	Deepest point, main creek channel, Dismal Creek embayment.		34.0135	-87.1912
031601100408	Winston	SMIW-8	Rock Ck	Rock Ck	Deepest point, main creek channel, Rock Creek embayment.		33.9987	-87.1197
031601100407	Winston	SMIW-9	Crooked Ck	Crooked Ck	Deepest point, main creek channel, Crooked Creek embayment. Approx. 1.5 miles upstream of Winston Co. Rd. 22 bridge.		34.0627	-87.1230
031601100505	Cullman	SMIW-10	Lower Ryan Ck	Ryan Ck	Deepest point, main creek channel, Ryan Creek embayment.		33.9619	-87.1008
031601100504	Cullman	SMIW-11	Upper Ryan Ck	Simpson Ck	Deepest point, main creek channel, Simpson Creek embayment, approx. 2.5 mi upstream of Ryan Creek.		34.0313	-86.9527

*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. 4-7). 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 appears in Table 2. Depth profile graphs of temperature and DO appear in Figs. 9-10. 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 not mentioned in the paragraphs below, review of the graphs that follow will also indicate those stations with lowest concentrations for these parameters. These stations may be potential candidates for reference waterbodies and watersheds.

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.

Highest mainstem growing season mean TN in 2007 was observed at the lower station and Clear Creek, Crooked Creek, and Ryan Creek for the tributaries (Fig. 2). Growing season mean TN concentrations were generally lower in 2007 than in previous years with the notable exception of Upper Ryan Creek (Fig. 2). Monthly TN concentrations were highest in May and September, and well below historic means June-August at all mainstem stations (Fig. 4). Lower Smith recorded record high TN means for May, September, and October (Fig. 4).

The highest growing season mean TP for mainstems in 2007 was observed at the mid station and Crooked Creek for the tributaries, though mean concentrations were similar at all tributary embayment locations (Fig. 2). Similar to mean TN concentration trends, growing season mean TP concentrations were generally lower in 2007 than in previous years (Fig. 2). All tributaries had a decrease in concentrations from 2002 (Fig. 2). Monthly TP concentrations for mainstem stations were relatively stable across the growing season and were at or below historic means in most months with the exception of lower Smith in October (Fig. 5). Although this value was at the top of historic ranges, it was the lowest measured of the year (Fig. 5).

Mean chl *a* concentrations for 2007 were the lowest recorded means at all locations with the highest growing season mean observed at the upper station for mainstems and Crooked Creek for tributaries (Fig. 3). Monthly chl *a* consistently demonstrates this with averages below or near historic means in all months sampled (Fig. 6). Discharge values did not show a strong relationship to chl *a* values in April-October (Fig. 6).

Growing season mean TSS concentrations are near or lower than previous years sampled at all stations with the highest observed at the lower station for mainstems and Clear Creek for the tributary stations (Fig. 3). Monthly TSS concentrations were variable month to month, independent of discharge (Fig. 7). With the exception of the lower station in May and September, which were at the top of historic ranges, all other stations were at or below historical means (Fig. 7).

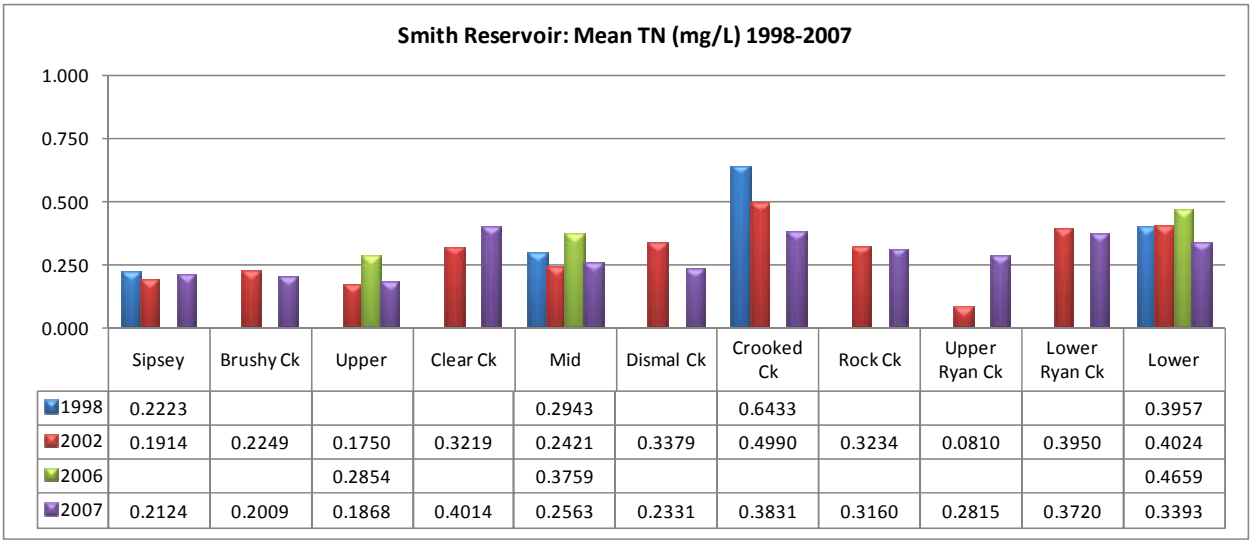
AGPT results show all stations except the upper station in 2002 have remained phosphorus limited since testing was initiated in 1998 (Table 2). All the 2007 mean standing crop (MSC) values were below 5 mg/L, the value that Raschke et al. (1996) defined as protective of reservoir and lake systems, but the values were nearly double the previous studies (Table 2).

All measurements of dissolved oxygen concentrations in Smith Reservoir 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). The lower and mid reservoir stations showed stratification April-Oct with more variability at the mid station Sept-Oct (Fig. 9-10). The water column at the lower station was completely

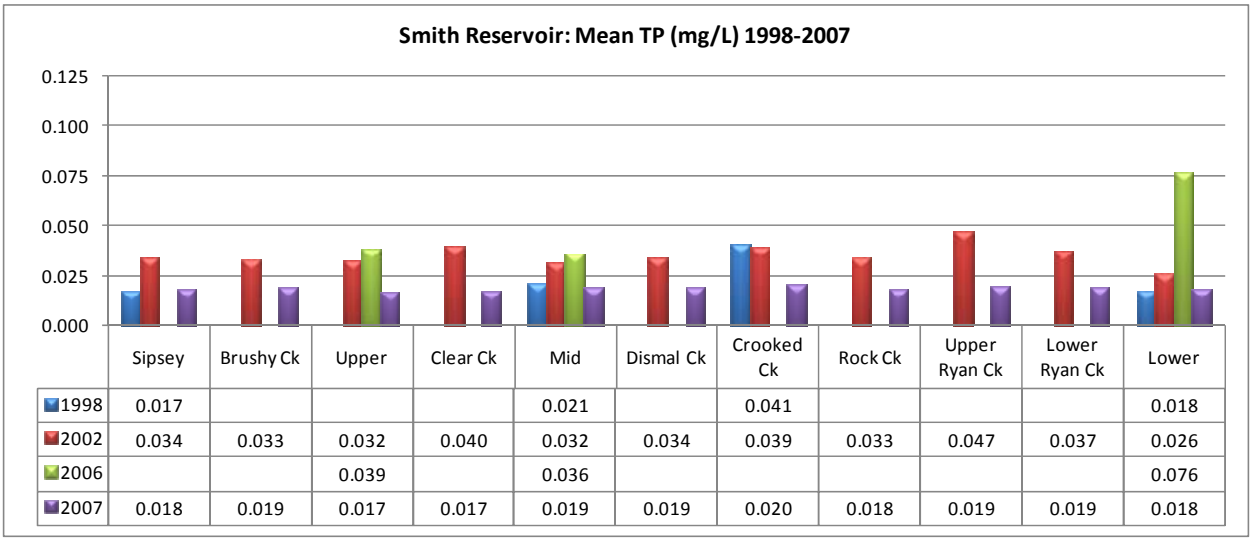
deoxygenated below 25m from April-October, while the conductivity varied little throughout the water column (Fig. 9). Highest temperatures were recorded in August (Fig. 9).

Mean growing season TSI values were calculated using season mean chl *a* concentrations and Carlson's Trophic State Index. TSI values for all mainstem locations indicate the reservoir was oligotrophic in 2007. These stations indicated mesotrophic conditions since 1998 (Fig. 11).

Figure 2. Growing season mean TN and TP concentrations measured in Smith Reservoir, April-October 1998-2007. Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right.

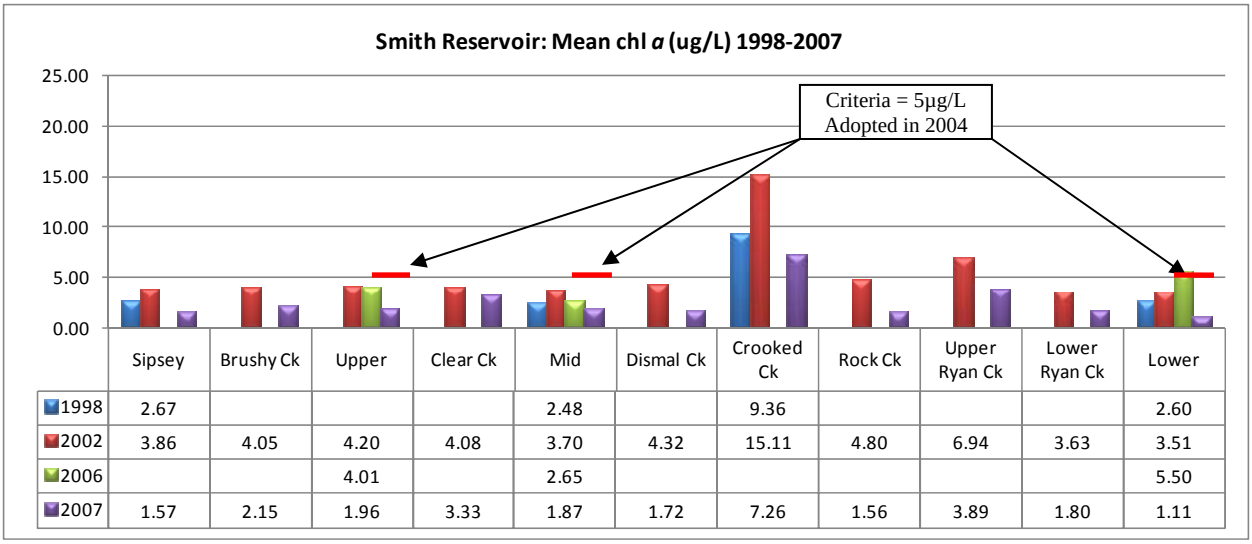


	Sipsey	Brushy Ck	Upper	Clear Ck	Mid	Dismal Ck	Crooked Ck	Rock Ck	Upper Ryan Ck	Lower Ryan Ck	Lower
1998	0.2223				0.2943		0.6433				0.3957
2002	0.1914	0.2249	0.1750	0.3219	0.2421	0.3379	0.4990	0.3234	0.0810	0.3950	0.4024
2006			0.2854		0.3759						0.4659
2007	0.2124	0.2009	0.1868	0.4014	0.2563	0.2331	0.3831	0.3160	0.2815	0.3720	0.3393

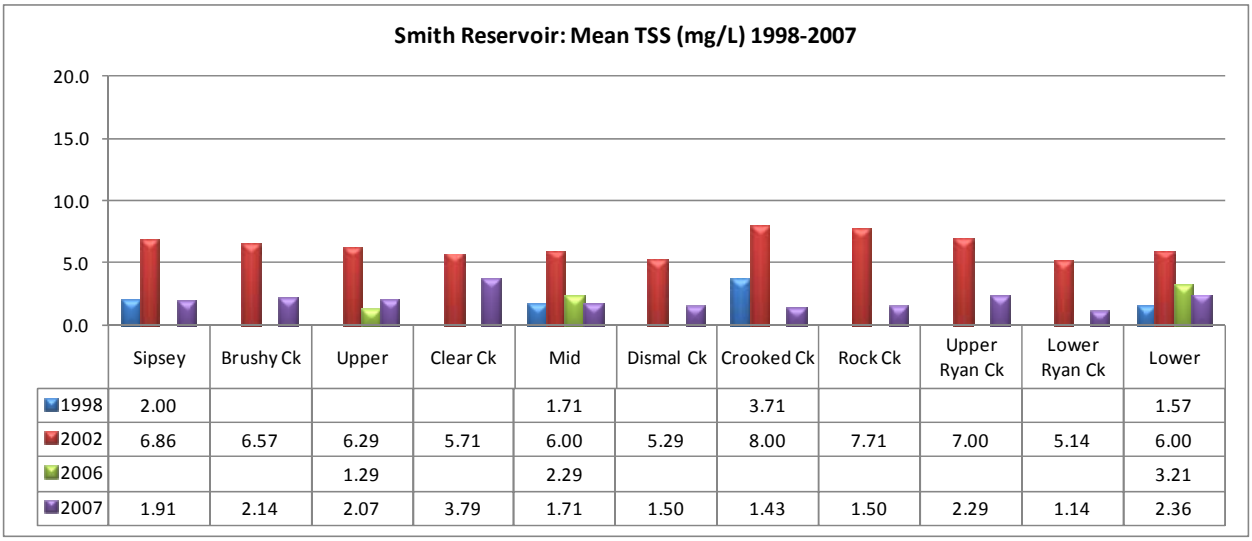


	Sipsey	Brushy Ck	Upper	Clear Ck	Mid	Dismal Ck	Crooked Ck	Rock Ck	Upper Ryan Ck	Lower Ryan Ck	Lower
1998	0.017				0.021		0.041				0.018
2002	0.034	0.033	0.032	0.040	0.032	0.034	0.039	0.033	0.047	0.037	0.026
2006			0.039		0.036						0.076
2007	0.018	0.019	0.017	0.017	0.019	0.019	0.020	0.018	0.019	0.019	0.018

Figure 3. Growing season mean chl *a* and TSS concentrations measured in Smith Reservoir, April-October 1998-2007. 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.



	Sipsey	Brushy Ck	Upper	Clear Ck	Mid	Dismal Ck	Crooked Ck	Rock Ck	Upper Ryan Ck	Lower Ryan Ck	Lower
1998	2.67				2.48		9.36				2.60
2002	3.86	4.05	4.20	4.08	3.70	4.32	15.11	4.80	6.94	3.63	3.51
2006			4.01		2.65						5.50
2007	1.57	2.15	1.96	3.33	1.87	1.72	7.26	1.56	3.89	1.80	1.11



	Sipsey	Brushy Ck	Upper	Clear Ck	Mid	Dismal Ck	Crooked Ck	Rock Ck	Upper Ryan Ck	Lower Ryan Ck	Lower
1998	2.00				1.71		3.71				1.57
2002	6.86	6.57	6.29	5.71	6.00	5.29	8.00	7.71	7.00	5.14	6.00
2006			1.29		2.29						3.21
2007	1.91	2.14	2.07	3.79	1.71	1.50	1.43	1.50	2.29	1.14	2.36

Figure 4. Monthly TN concentrations of the mainstem stations in Smith Reservoir, April-October 2007. 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 data points included in the monthly historic calculations. TN was plotted vs. the closest discharge (Smith Dam, information provided by Alabama Power).

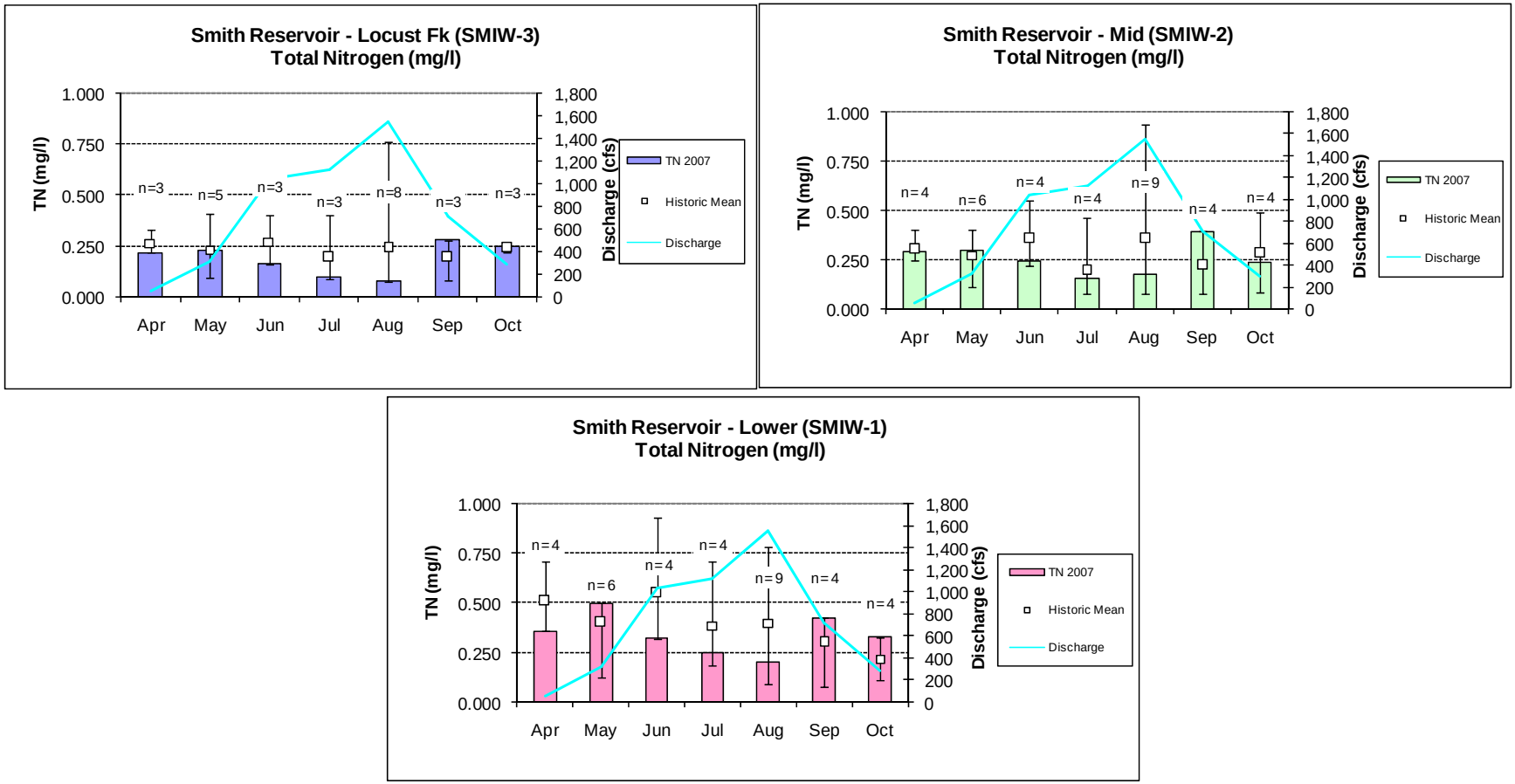


Figure 5. Monthly TP concentrations of the mainstem stations in Smith Reservoir, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. TP was plotted vs. the closest discharge (Smith Dam, information provided by Alabama Power).

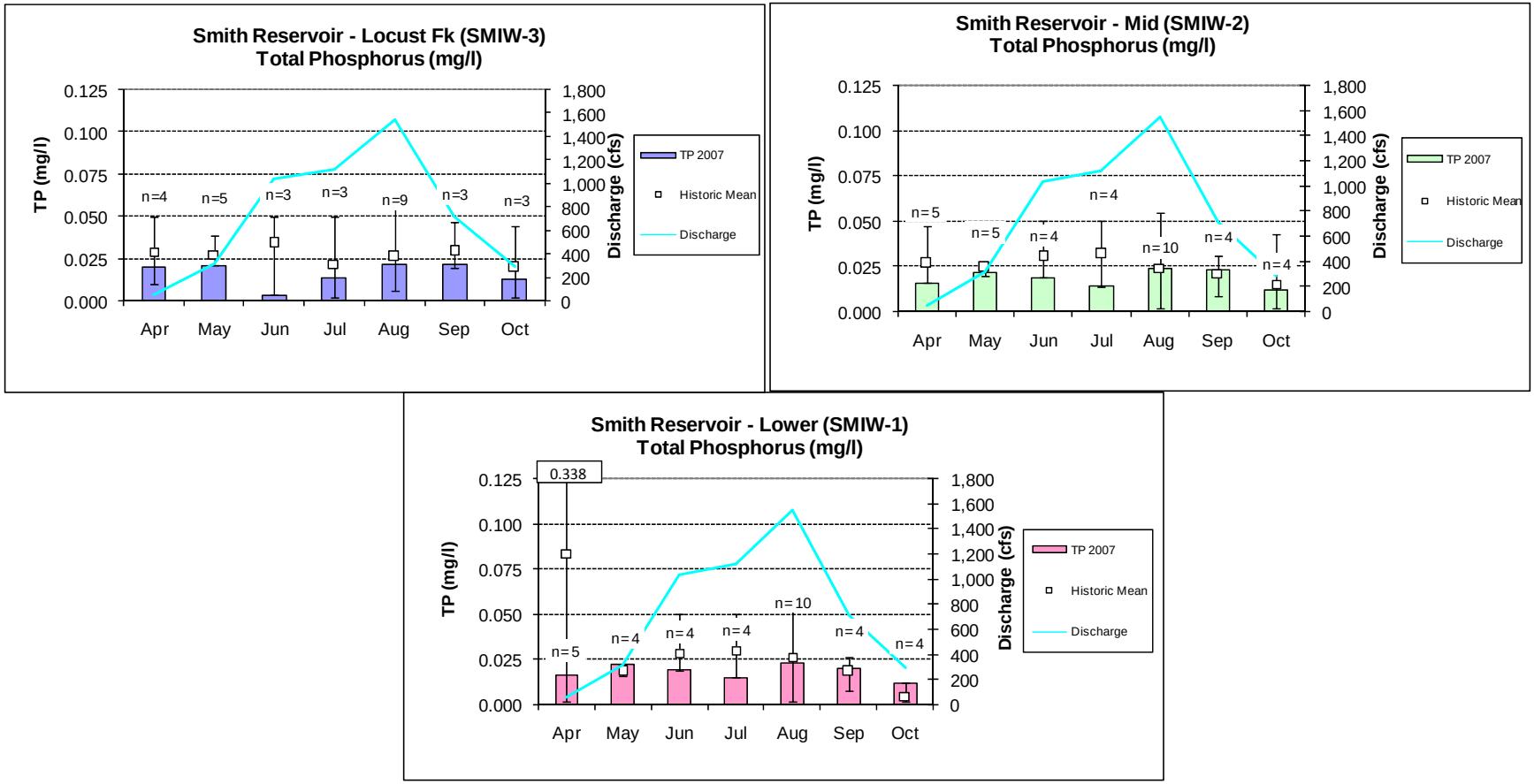


Figure 6. Monthly chl *a* concentrations of the mainstem stations in Smith Reservoir, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean (1990 -2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. Chl *a* was plotted vs. the closest discharge (Smith Dam, information provided by Alabama Power).

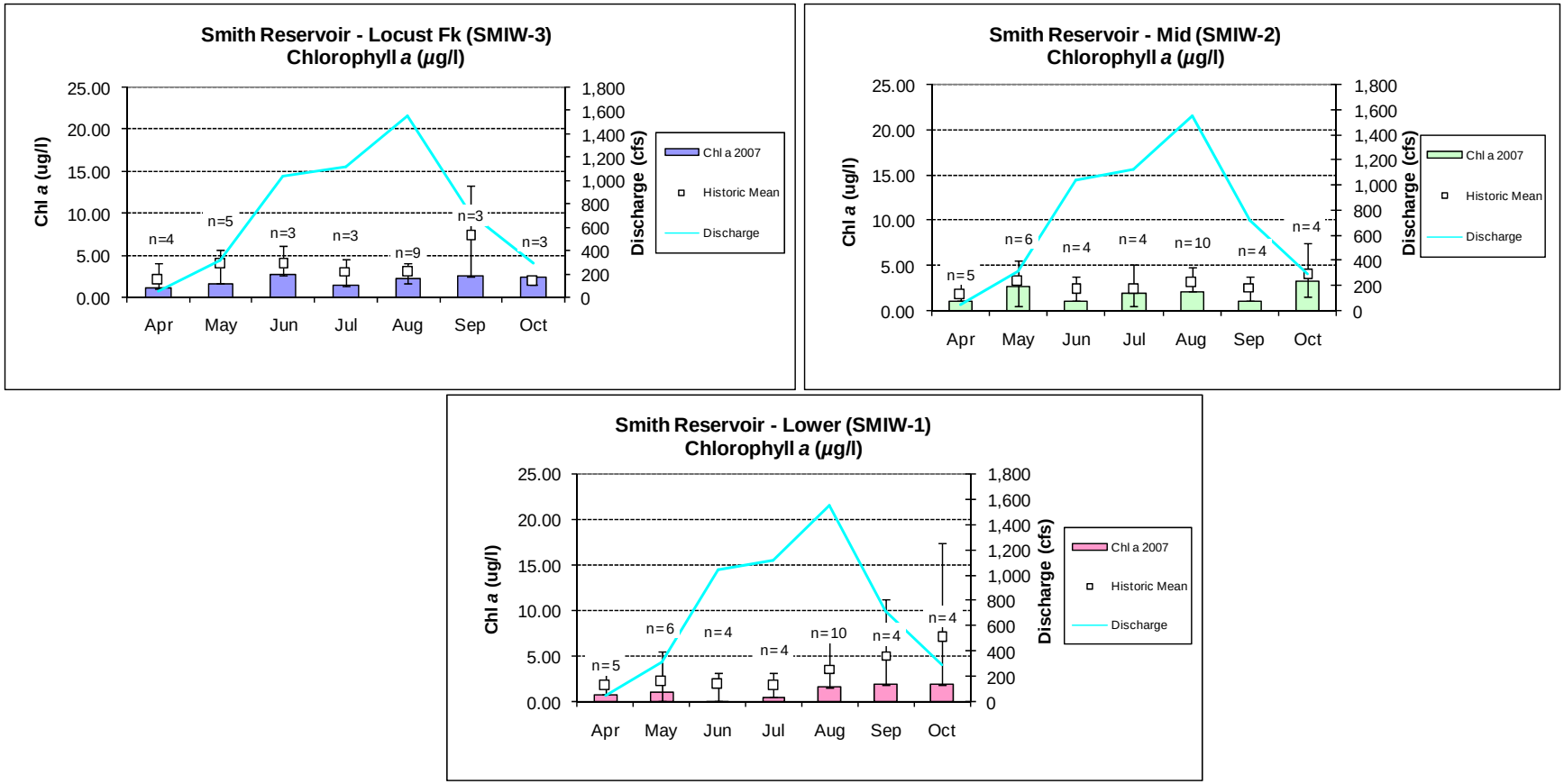


Figure 7. Monthly TSS of the mainstem stations in Smith Reservoir, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean (1990-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. TSS was plotted vs. the closest discharge (Smith Dam, information provided by Alabama Power).

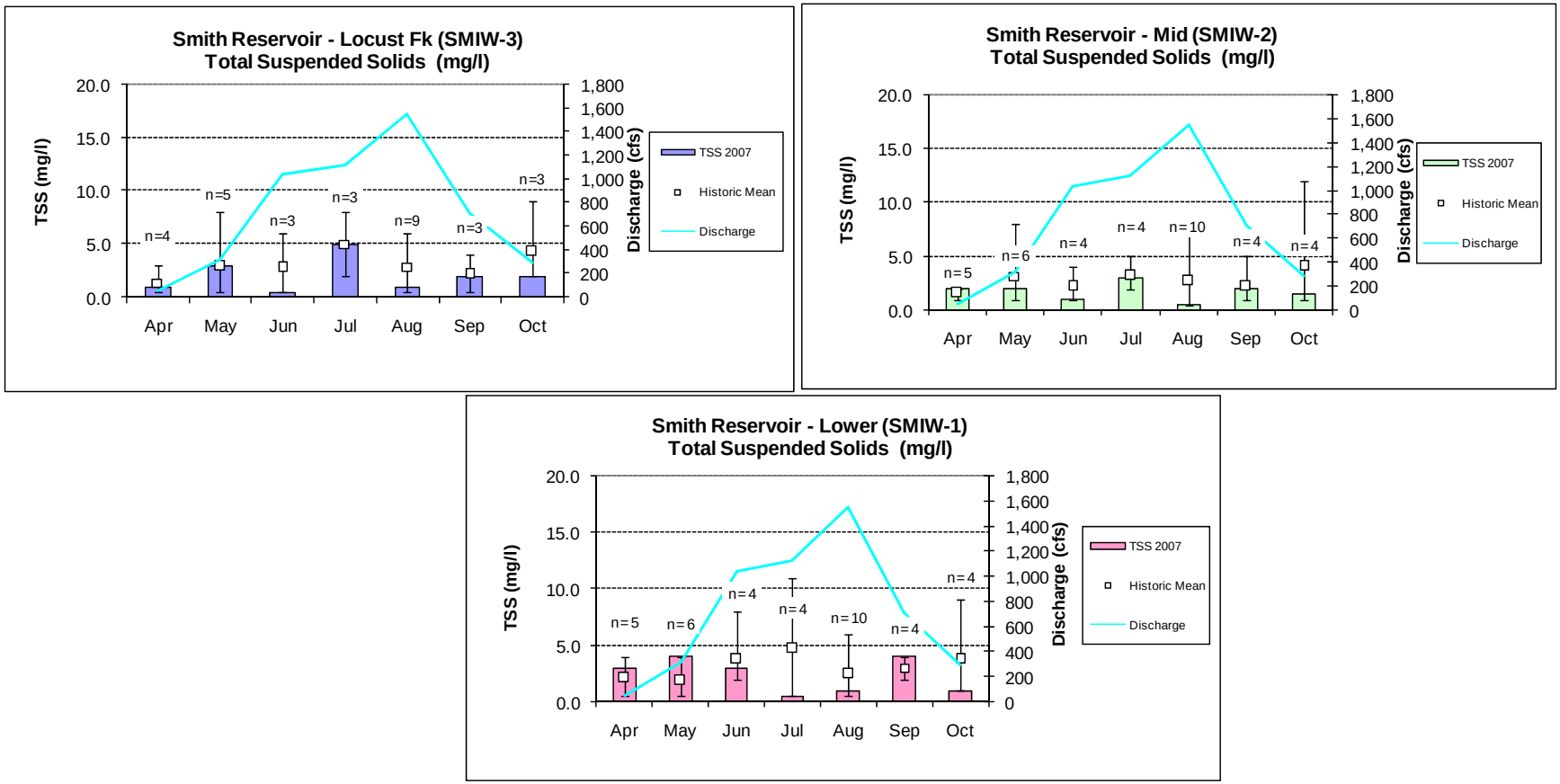
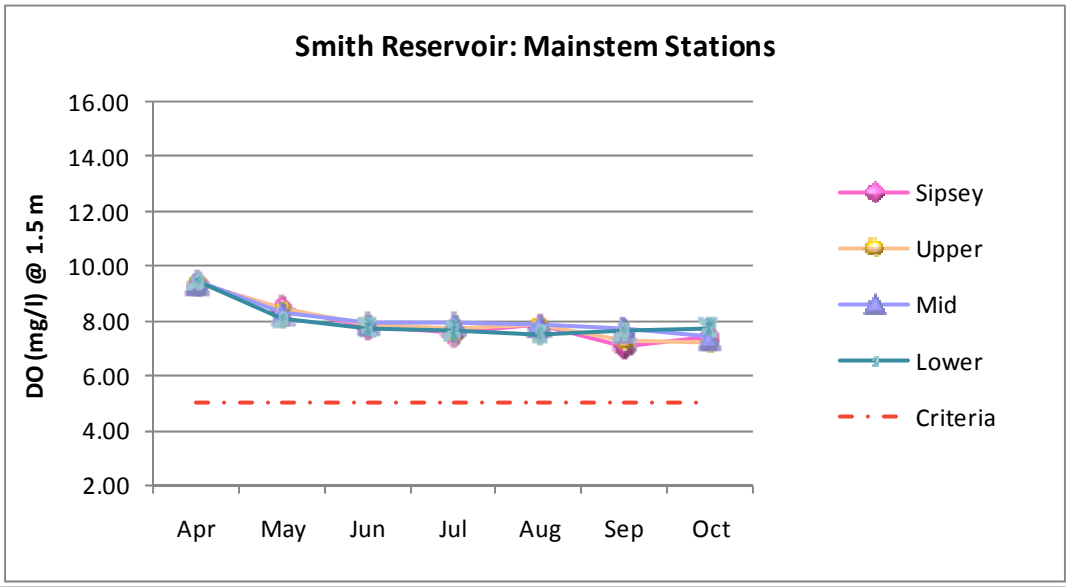


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/l are considered to be protective in reservoirs and lakes; values below 20 mg/l MSC are considered protective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

Station	Upper		Mid		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 1998			1.62	Phosphorus	1.29	Phosphorus
August 2002	1.69	Co-limiting	1.41	Phosphorus	1.44	Phosphorus
June 2007	3.13	Phosphorus	3.28	Phosphorus	3.36	Phosphorus
July 2007	3.24	Phosphorus	3.37	Phosphorus	3.77	Phosphorus
August 2007	2.70	Phosphorus	3.03	Phosphorus	2.79	Phosphorus

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Smith 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). In tributaries, when total depth was less than 3 m, criteria applies to the mid-depth reading.



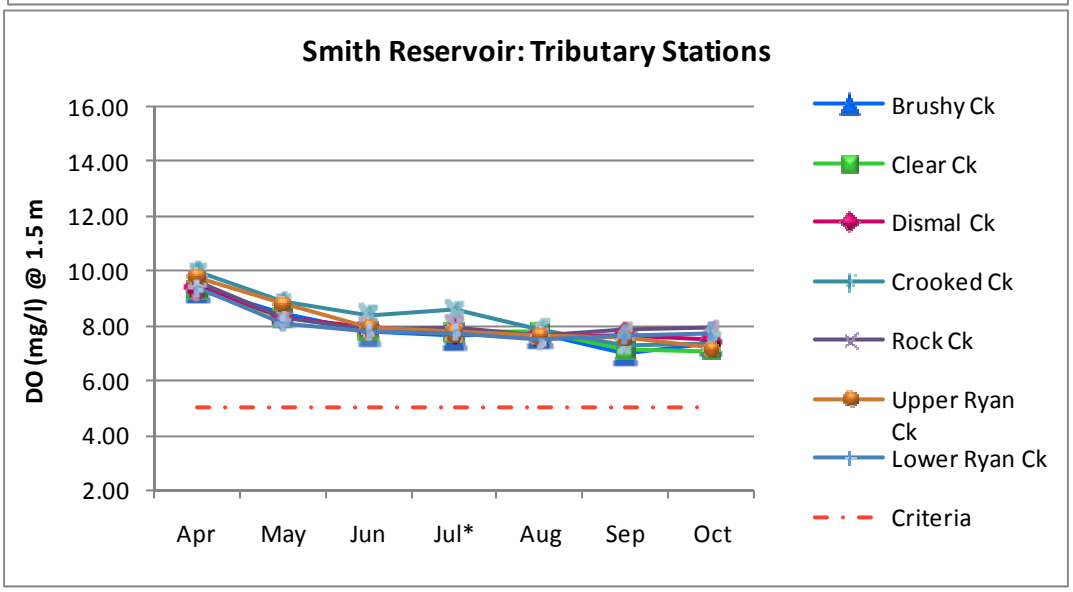


Figure 9. Monthly depth profiles of dissolved oxygen, temperature and conductivity in lower Smith Reservoir, April-October 2007.

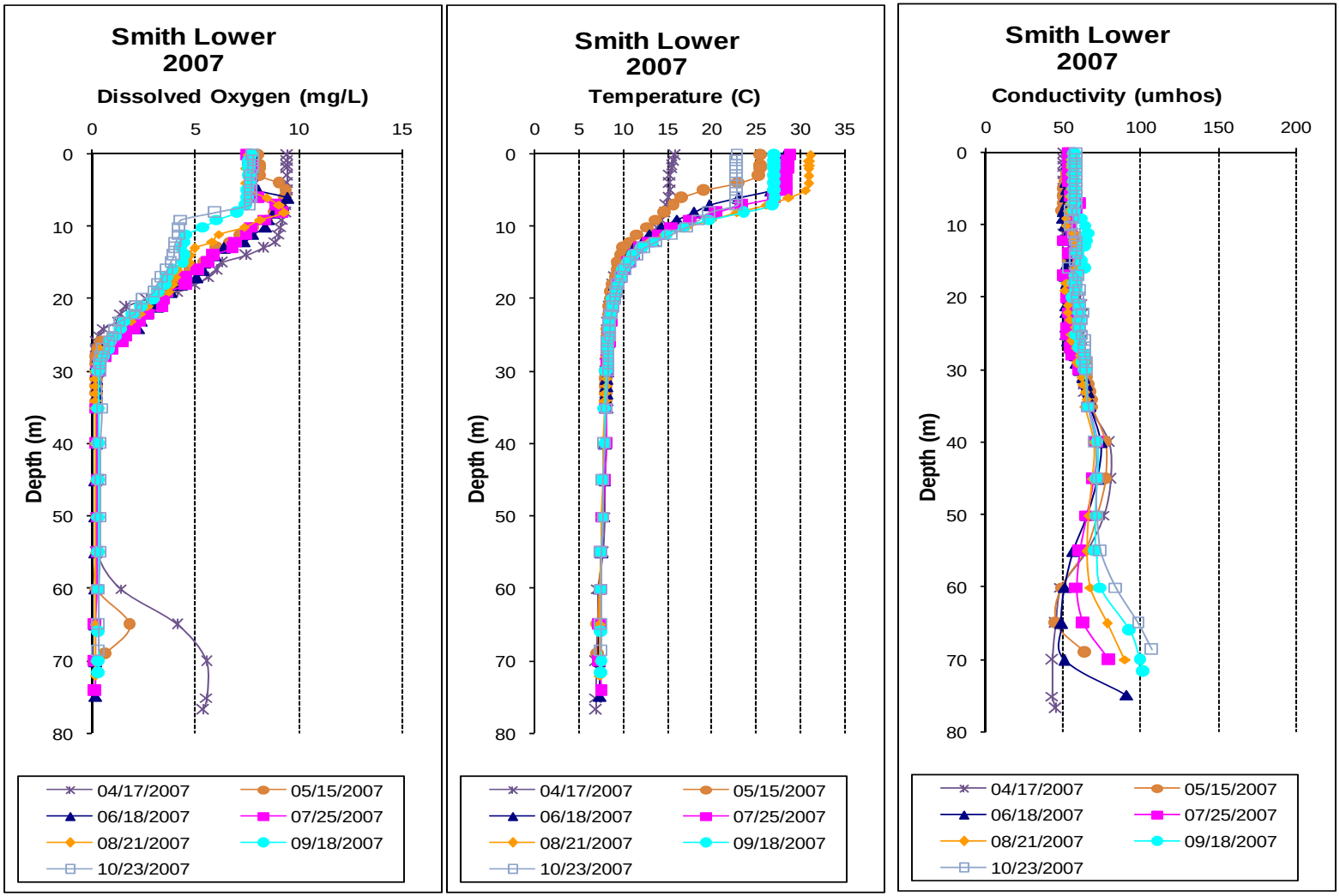


Figure 10. Monthly depth profiles of dissolved oxygen, temperature and conductivity in mid Smith Reservoir, April-October 2007.

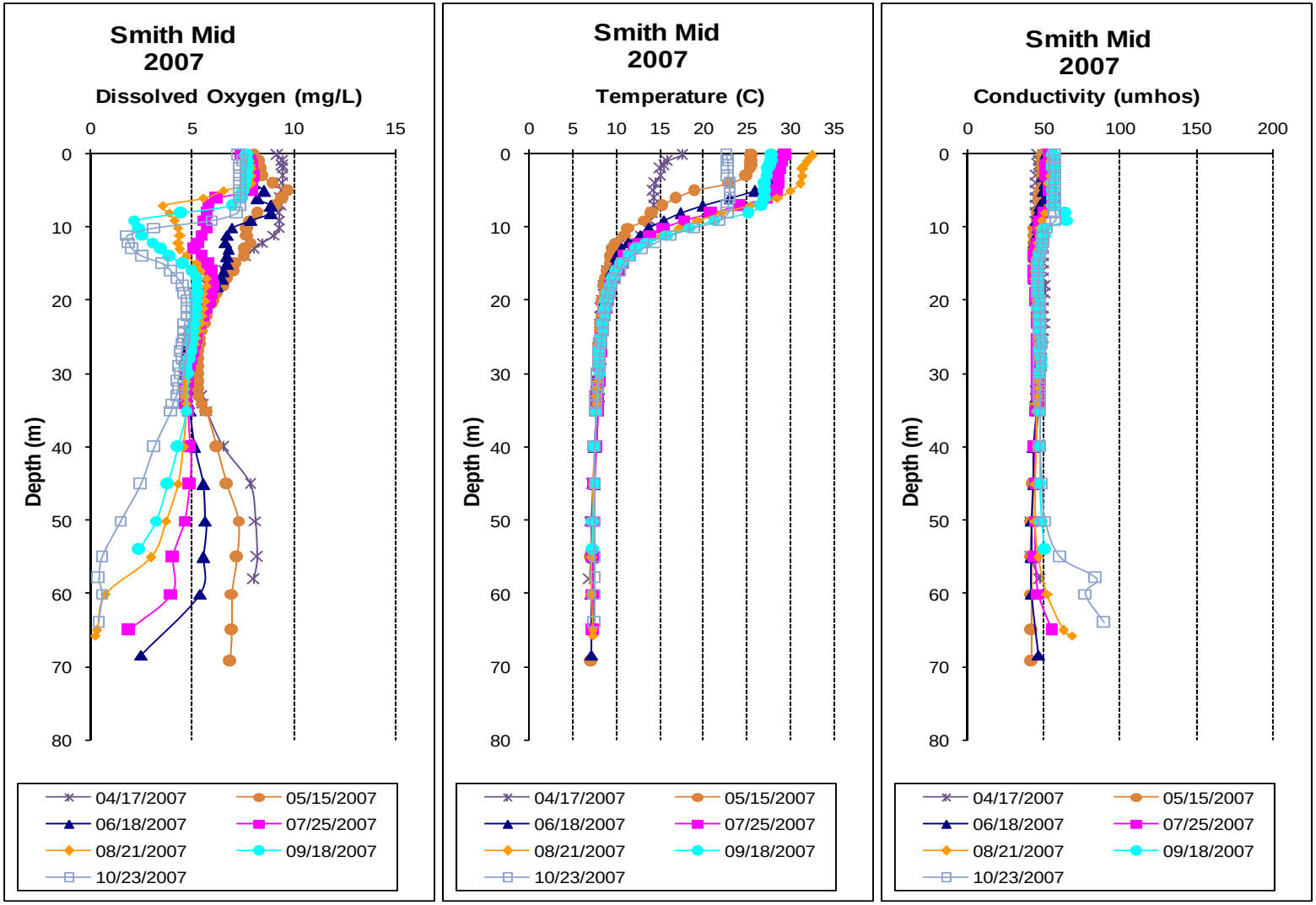
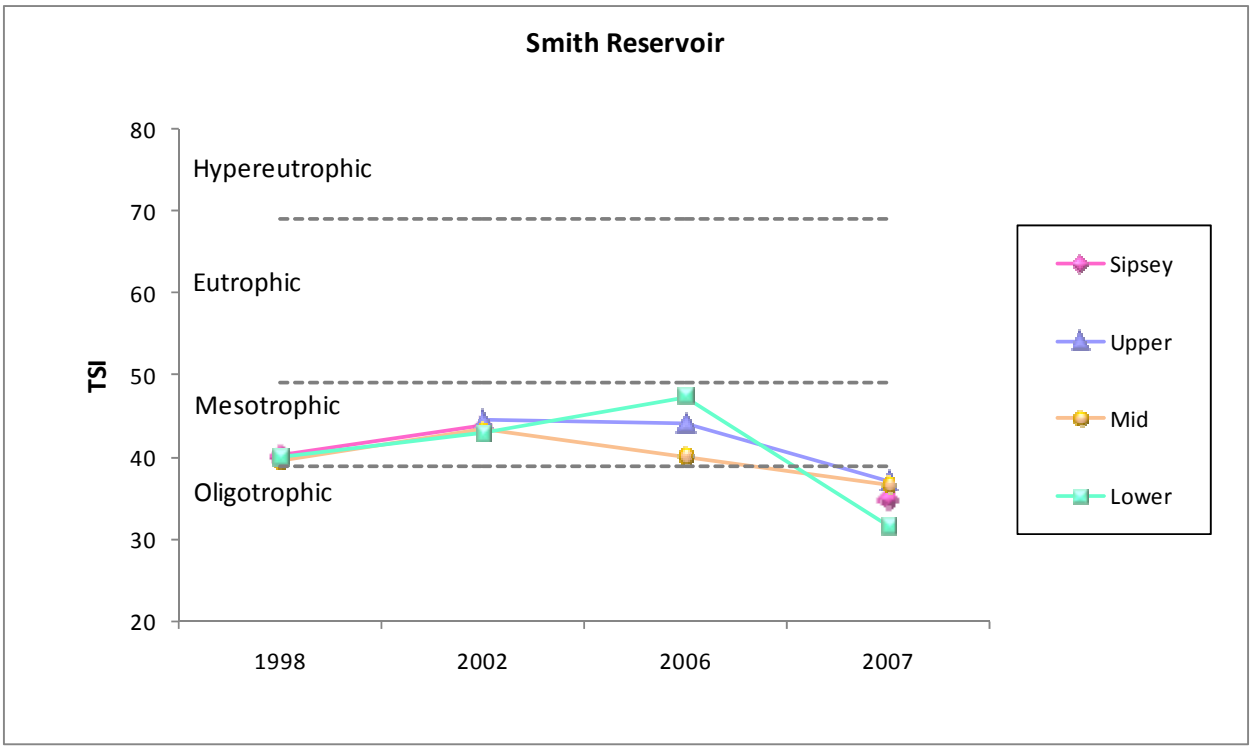


Figure 11. Mean growing season TSI values for mainstem stations using chl *a* concentrations and Carlson's Trophic State Index calculation.



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APPENDIX

Appendix Table 1. Summary of 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	Mean	SD
SMIW-1	**Physical**						
	Turbidity (NTU)	7	1.0	1.9	1.5	1.4	0.3
	Total Dissolved Solids (mg/L)	7	16.0	46.0	41.0	37.0	9.9
	Total Suspended Solids (mg/L)	7	< 1.0	4.0	3.0	2.4	1.5
	Hardness (mg/L)	4	11.3	20.4	15.6	15.7	4.6
	Alkalinity (mg/L)	7	13.3	20.6	14.1	15.0	2.5
	Photic Zone (m)	7	13.02	17.10	13.66	14.43	1.60
	Secchi (m)	7	3.17	8.95	4.40	4.77	1.94
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.035	0.008	0.011	0.010
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.118	0.282	0.172	0.194	0.071
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.307	0.075	0.145	0.094
	Total Nitrogen (mg/L)	7	< 0.203	0.494	0.328	0.339	0.099
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.006	0.009	0.009	0.008	0.001
	[J]Total Phosphorus (mg/L)	7	0.012	0.023	0.019	0.018	0.004
	CBOD-5 (mg/L)	7	< 1.0	2.5	0.5	0.9	0.8
	[J]Chlorides (mg/L)	7	1.9	2.5	2.4	2.3	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	< 0.10	1.87	1.07	1.11	0.70
	[J]Fecal Coliform (col/100 mL)	1				2	
SMIW-2	**Physical**						
	Turbidity (NTU)	7	1.1	2.9	1.9	1.9	0.6
	Total Dissolved Solids (mg/L)	7	3.0	39.0	29.0	25.7	14.4
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	2.0	1.7	0.8
	Hardness (mg/L)	4	11.3	22.3	14.8	15.8	5.3
	Alkalinity (mg/L)	7	11.6	14.4	13.4	13.1	1.0
	Photic Zone (m)	7	7.48	16.80	10.30	11.35	3.43
	Secchi (m)	7	2.12	5.53	3.82	3.66	1.14
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	[J]Nitrate+Nitrite Nitrogen (mg/L)	7	0.002	0.225	0.078	0.102	0.098
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.393	0.075	0.154	0.120
	[J]Total Nitrogen (mg/L)	7	< 0.153	0.395	0.244	0.256	0.081
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.007	0.011	0.009	0.009	0.001
	[J]Total Phosphorus (mg/L)	7	0.012	0.024	0.019	0.019	0.005
	CBOD-5 (mg/L)	7	< 1.0	4.5	1.5	1.7	1.4
	[J]Chlorides (mg/L)	7	1.0	2.3	2.1	1.9	0.5
	Biological						
	[J]Chlorophyll a (ug/L)	7	1.07	3.20	1.87	1.87	0.86
	[J]Fecal Coliform (col/100 mL)	1				3	

Station	Parameter	N	Min	Max	Med	Mean	SD
SMIW-3	**Physical**						
	Turbidity (NTU)	7	1.5	3.7	2.3	2.4	0.7
	Total Dissolved Solids (mg/L)	7	9.0	59.0	33.0	31.3	17.2
	Total Suspended Solids (mg/L)	7	< 1.0	5.0	2.0	2.1	1.5
	Hardness (mg/L)	4	11.3	19.0	14.2	14.7	3.9
	Alkalinity (mg/L)	7	11.1	14.2	13.2	12.9	1.0
	Photic Zone (m)	7	7.14	14.62	8.58	10.11	2.97
	Secchi (m)	7	1.92	3.80	2.38	2.66	0.71
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	[J]Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.202	0.021	0.067	0.083
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.016	0.279	0.075	0.120	0.099
	[J]Total Nitrogen (mg/L)	7	< 0.076	0.280	0.218	0.187	0.078
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.007	0.010	0.009	0.009	0.001
	[J]Total Phosphorus (mg/L)	7	< 0.007	0.022	0.020	0.016	0.007
	CBOD-5 (mg/L)	7	< 1.0	2.2	1.4	1.3	0.8
	[J]Chlorides (mg/L)	7	1.9	2.0	2.0	1.9	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	1.07	2.67	2.14	1.96	0.62
	[J]Fecal Coliform (col/100 mL)	1				1	
SMIW-4	**Physical**						
	Turbidity (NTU)	7	1.6	3.1	2.5	2.5	0.5
	Total Dissolved Solids (mg/L)	7	16.0	43.0	28.0	28.6	9.5
	Total Suspended Solids (mg/L)	7	1.0	4.0	2.0	2.1	1.1
	Hardness (mg/L)	4	11.1	20.6	13.6	14.7	4.5
	Alkalinity (mg/L)	7	11.2	13.9	13.0	12.8	0.1
	Photic Zone (m)	7	8.14	12.50	8.62	9.52	1.74
	Secchi (m)	7	1.78	3.51	2.68	2.61	0.64
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.047	0.008	0.013	0.015
	[J]Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.178	0.019	0.060	0.074
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.244	0.075	0.141	0.083
	[J]Total Nitrogen (mg/L)	7	< 0.076	0.422	0.153	0.201	0.139
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.007	0.010	0.009	0.009	0.001
	[J]Total Phosphorus (mg/L)	7	0.013	0.025	0.020	0.019	0.005
	CBOD-5 (mg/L)	7	< 1.0	2.2	1.1	1.2	0.8
	[J]Chlorides (mg/L)	7	1.9	2.1	1.9	1.9	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	1.07	2.94	2.40	2.15	0.79
	[J]Fecal Coliform (col/100 mL)	1				1	

Station	Parameter	N	Min	Max	Med	Mean	SD
SMIW-5	**Physical**						
	Turbidity (NTU)	7	1.2	3.6	2.7	2.4	0.8
	Total Dissolved Solids (mg/L)	7	5.0	36.0	31.0	23.3	13.1
	Total Suspended Solids (mg/L)	7	< 1.0	6.0	1.4	1.9	1.9
	Hardness (mg/L)	4	11.7	19.8	14.5	15.1	4.0
	Alkalinity (mg/L)	7	12.2	14.3	13.9	13.5	0.9
	Photic Zone (m)	7	7.46	15.29	8.50	10.28	3.15
	Secchi (m)	7	1.78	3.73	2.87	2.76	0.66
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.177	0.016	0.060	0.075
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.306	0.075	0.152	0.101
	Total Nitrogen (mg/L)	7	< 0.091	0.308	0.222	0.212	0.072
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.007	0.012	0.009	0.009	0.002
	[J]Total Phosphorus (mg/L)	7	0.012	0.023	0.017	0.018	0.004
	CBOD-5 (mg/L)	7	< 1.0	2.5	1.2	1.3	0.8
	[J]Chlorides (mg/L)	7	1.9	2.0	1.9	1.9	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	< 0.10	2.67	1.60	1.57	0.82
	[J]Fecal Coliform (col/100 mL)	1				1	
SMIW-6	**Physical**						
	Turbidity (NTU)	7	2.0	4.4	3.2	3.3	1.0
	Total Dissolved Solids (mg/L)	7	14.0	95.0	38.0	43.1	25.8
	Total Suspended Solids (mg/L)	7	3.0	6.0	3.0	3.8	1.2
	Hardness (mg/L)	4	10.8	23.5	14.6	15.9	6.0
	Alkalinity (mg/L)	7	11.5	14.3	13.6	13.3	1.0
	Photic Zone (m)	7	5.24	10.23	6.74	7.58	1.97
	Secchi (m)	7	1.44	2.36	1.89	1.86	0.33
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.179	0.010	0.061	0.076
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.929	0.271	0.340	0.277
	Total Nitrogen (mg/L)	7	< 0.080	1.016	0.363	0.401	0.299
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.007	0.011	0.009	0.009	0.001
	[J]Total Phosphorus (mg/L)	7	0.011	0.023	0.018	0.017	0.004
	CBOD-5 (mg/L)	7	< 1.0	2.3	0.5	1.1	0.7
	[J]Chlorides (mg/L)	7	1.9	2.3	2.0	2.0	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	2.40	5.87	2.67	3.33	1.25
	[J]Fecal Coliform (col/100 mL)	1				1	

Station	Parameter	N	Min	Max	Med	Mean	SD
SMIW-7	**Physical**						
	Turbidity (NTU)	7	1.4	2.3	1.5	1.8	0.4
	Total Dissolved Solids (mg/L)	7	< 1.0	49.0	32.0	27.4	18.8
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	2.0	1.5	0.6
	Hardness (mg/L)	4	10.6	20.2	14.6	15.0	4.8
	Alkalinity (mg/L)	7	11.9	13.7	13.1	12.9	0.6
	Photic Zone (m)	7	7.54	15.81	11.96	12.11	2.75
	Secchi (m)	7	2.45	4.53	3.66	3.51	0.67
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	[J]Nitrate+Nitrite Nitrogen (mg/L)	7	0.009	0.243	0.089	0.117	0.103
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.362	0.075	0.116	0.108
	[J]Total Nitrogen (mg/L)	7	< 0.084	0.371	0.258	0.233	0.110
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.006	0.010	0.008	0.008	0.001
	[J]Total Phosphorus (mg/L)	7	0.013	0.023	0.020	0.019	0.004
	CBOD-5 (mg/L)	7	< 1.0	2.6	0.5	1.0	0.8
	[J]Chlorides (mg/L)	7	1.9	2.3	2.2	2.1	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	1.07	3.20	1.60	1.72	0.70
	[J]Fecal Coliform (col/100 mL)	1				<1	
SMIW-8	**Physical**						
	Turbidity (NTU)	7	1.0	2.2	1.1	1.3	0.4
	Total Dissolved Solids (mg/L)	7	14.0	50.0	41.0	35.1	14.8
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	1.0	1.5	1.2
	Hardness (mg/L)	4	11.0	20.2	14.6	15.1	4.7
	Alkalinity (mg/L)	7	13.0	142.0	13.5	31.7	48.6
	Photic Zone (m)	7	11.94	16.99	13.89	14.56	1.81
	Secchi (m)	7	3.88	8.34	4.94	5.26	1.44
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.027	0.345	0.177	0.187	0.123
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.277	0.075	0.129	0.093
	Total Nitrogen (mg/L)	7	< 0.187	0.420	0.348	0.316	0.080
	[J]Dissolved Reactive Phosphorus (mg/L)	7	0.006	0.010	0.008	0.008	0.001
	[J]Total Phosphorus (mg/L)	7	0.012	0.022	0.018	0.018	0.003
	CBOD-5 (mg/L)	7	< 1.0	1.8	0.5	0.9	0.5
	[J]Chlorides (mg/L)	7	2.0	2.6	2.5	2.4	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	0.50	2.94	1.60	1.56	0.72
	[J]Fecal Coliform (col/100 mL)	1				<1	

Station	Parameter	N	Min	Max	Med	Mean	SD
SMIW-9	**Physical**						
	Turbidity (NTU)	7	2.1	3.5	2.8	2.7	0.5
	Total Dissolved Solids (mg/L)	7	3.0	50.0	36.0	28.9	18.4
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	2.0	1.4	0.7
	Hardness (mg/L)	4	11.3	19.7	14.8	15.2	4.3
	Alkalinity (mg/L)	7	13.2	15.3	14.9	14.6	0.8
	Photic Zone (m)	7	6.51	9.25	7.86	7.70	0.99
	Secchi (m)	7	1.44	2.91	2.00	2.14	0.50
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	[J]Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.473	0.010	0.132	0.188
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.315	0.287	0.251	0.091
	[J]Total Nitrogen (mg/L)	7	< 0.085	0.760	0.312	0.383	0.230
	[J]Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.009	0.007	0.007	0.002
	[J]Total Phosphorus (mg/L)	7	0.016	0.025	0.019	0.020	0.004
	CBOD-5 (mg/L)	7	< 1.0	3.3	1.1	1.2	0.1
	[J]Chlorides (mg/L)	7	2.9	3.0	2.9	2.9	0.1
	Biological						
	[J]Chlorophyll a (ug/L)	7	4.81	9.08	7.48	7.26	1.35
	[J]Fecal Coliform (col/100 mL)	1				<1	
SMIW-10	**Physical**						
	Turbidity (NTU)	7	1.1	2.3	1.4	1.4	0.4
	Total Dissolved Solids (mg/L)	7	12.0	43.0	38.0	32.3	11.7
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	1.0	1.1	0.6
	Hardness (mg/L)	4	11.1	23.7	15.4	16.4	6.1
	Alkalinity (mg/L)	7	13.6	15.4	14.4	14.5	0.7
	Photic Zone (m)	7	9.74	18.53	15.11	14.69	2.77
	Secchi (m)	7	3.34	5.78	4.05	4.45	1.05
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.055	0.283	0.173	0.174	0.089
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.591	0.159	0.198	0.184
	Total Nitrogen (mg/L)	7	< 0.248	0.679	0.307	0.372	0.150
	[J]Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.009	0.008	0.007	0.003
	[J]Total Phosphorus (mg/L)	7	0.013	0.023	0.020	0.019	0.004
	CBOD-5 (mg/L)	7	< 1.0	4.3	1.0	1.4	1.4
	[J]Chlorides (mg/L)	7	1.0	2.6	2.5	2.4	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	0.80	4.08	1.60	1.80	1.11
	[J]Fecal Coliform (col/100 mL)	1				<1	

Station	Parameter	N	Min	Max	Med	Mean	SD
SMIW-11	**Physical**						
	Turbidity (NTU)	7	1.5	2.7	2.0	2.1	0.3
	Total Dissolved Solids (mg/L)	7	1.0	56.0	43.0	32.6	21.4
	Total Suspended Solids (mg/L)	7	< 1.0	5.0	2.0	2.3	1.6
	Hardness (mg/L)	2	15.6	25.0	20.3	20.3	6.6
	Alkalinity (mg/L)	7	20.8	22.6	21.9	21.9	0.7
	Photic Zone (m)	7	7.42	11.41	9.95	9.51	1.32
	Secchi (m)	7	2.59	3.45	2.72	2.91	0.36
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.002	0.260	0.048	0.080	0.100
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.150	0.307	0.250	0.201	0.094
	Total Nitrogen (mg/L)	7	< 0.123	0.510	0.264	0.282	0.144
	[J]Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.007	0.006	0.005	0.002
	[J]Total Phosphorus (mg/L)	7	0.016	0.025	0.018	0.019	0.004
	CBOD-5 (mg/L)	7	< 1.0	4.9	0.5	1.8	1.8
	[J]Chlorides (mg/L)	7	2.9	3.5	3.3	3.2	0.2
	Biological						
	[J]Chlorophyll a (ug/L)	7	2.67	5.34	3.74	3.89	0.86
	[J]Fecal Coliform (col/100 mL)	1				<1	

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