2012 Bankhead Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
June 2015

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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

Bankhead Reservoir's 9,200 acre water body was established in 1915 by the US Army Corp of Engineers (COE) with the completion of John Hollis Bankhead Dam, and is the second largest reservoir in the Black Warrior system. While the COE maintains dam operations, Alabama Power owns and operates the generating plant. This allows Bankhead to fulfill multiple purposes, like fishing, recreation, and power supply.

The Alabama Department of Environmental Management (ADEM) monitored Warrior Reservoir as part of the 2012 assessment of the Black Warrior and Cahaba River Basins under the Rivers and Reservoirs Monitoring Program (RRMP). ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program, (now known as RRMP) was initiated by ADEM. The current objectives of this program are to provide data that can be used to assess current water quality conditions, 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 (ADEM 2012).

In 2004, the ADEM implemented a specific water quality criterion for nutrient management at one location on Bankhead Reservoir, which has been intensively monitored by ADEM. This criterion represents the maximum growing season mean (April-October) 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 eight stations in Bankhead Reservoir during the 2012 growing season and to evaluate growing season trends in mean lake trophic status and nutrient concentrations using ADEM's historic dataset. Monthly and growing season 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. Bankhead was sampled in the dam forebay, mid reservoir and in both Mulberry and Locusts Forks of the upper reservoir. Monitoring sites were also established in the Lost Creek, Village Creek, Valley Creek, and Big Yellow Creek 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 2012), Surface Water Quality Assurance Project Plan (ADEM 2013), and Quality Management Plan (ADEM 2008).

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 USGS flow data and ADEM's previously collected data to help interpret the 2012 results.

Figure 1. Bankhead Reservoir with 2012 sampling locations. A description of each sampling location is provided in Table 1.

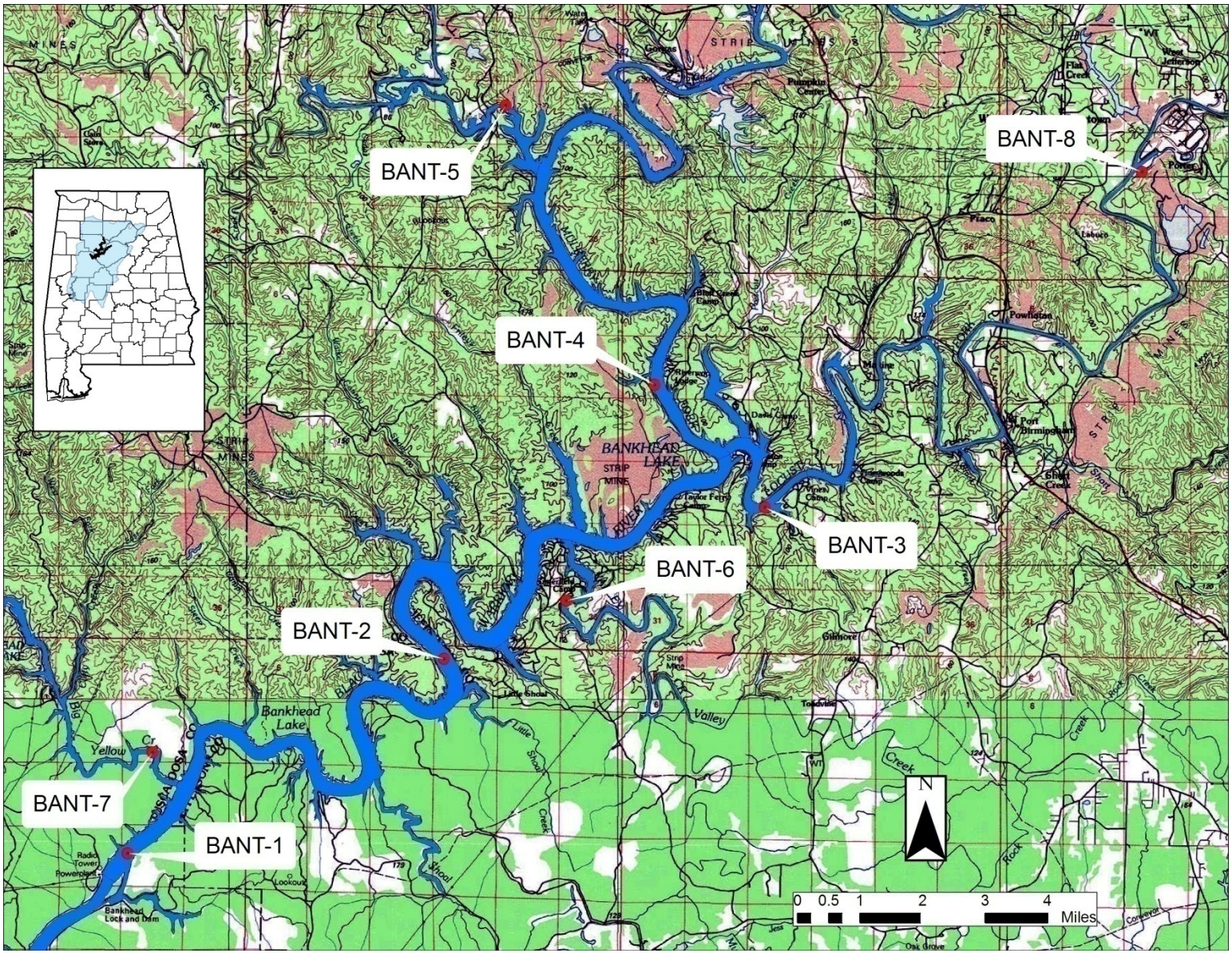


Table 1. Descriptions of the 2012 monitoring stations in Bankhead Reservoir.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criteria	Latitude	Longitude
Bankhead Reservoir								
031601120203	Tuscaloosa	BANT-1*	Lower	Black Warrior R	Deepest point, main river channel, dam forebay.	16 µg/l	33.4642	-87.3511
031601120203	Jefferson	BANT-2	Mid	Black Warrior R	Deepest point, main river channel, mid-reservoir. Approx. 0.5 mi. upstream of Little Shoal Creek confluence.		33.5095	-87.2637
031601110413	Jefferson	BANT-3	Locust Fk	Black Warrior R	Deepest point, main river channel, Locust Fork. Approx. 1.5 mi. upstream of Mulberry, Locust confluence.		33.5448	-87.1750
031601090604	Walker	BANT-4	Mulberry Fk	Black Warrior R	Deepest point, main river channel, Mulberry Fork. Approx. 1.5 mi. upstream of Mulberry, Locust confluence.		33.5732	-87.2055
031601090604	Walker	BANT-5	Lost Ck	Lost Ck	Deepest point, main creek channel, Lost Creek embayment. Approx. 0.5 mi. downstream of Walker Co. Rd. 53 bridge.		33.6380	-87.2470
031601120106	Jefferson	BANT-6	Valley Ck	Valley Ck	Deepest point, main creek channel, Valley Creek embayment. Approx. 1 mile upstream of confluence with Warrior River.		33.5231	-87.2299
031601120202	Tuscaloosa	BANT-7	Big Yellow Ck	Big Yellow Ck	Deepest point, main creek channel, Big Yellow Creek embayment. Approx. 1 mile upstream of confluence with Warrior River.		33.4876	-87.3443
031601110409	Jefferson	BANT-8	Village Ck	Village Ck	Deepest point, main creek channel, Village Creek embayment. Approx. 0.5 mile upstream of confluence with Black Warrior River.		33.6228	-87.0706

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

RESULTS

Growing season mean graphs for TN, TP, chl *a*, and TSS are provided in this section (Figs. 2, 3). Monthly graphs for TN, TP, chl *a*, TSS, DO and TSI are also provided (Figs. 4-8, and 11). 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. 9-10. Summary statistics of all data collected during 2012 are presented in Appendix Table 1. 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 are not always mentioned, review of the graphs will indicate stations that may be potential candidates for reference waterbodies and watersheds.

In 2012, the highest mean growing season TN value was calculated for the Village Ck station (Fig. 2). Mean growing season TN concentrations at each mainstem were variable since 1998, though 2012 concentrations were lower compared to 2011. Mean TN concentrations have decreased at the Village Ck station, 2007-2012, while values at the Valley Ck station have increased since 1998. Monthly TN concentrations were highest in May for Locust Fork and mid stations, July for the Mulberry Fork station, and August for the lower station.

In 2012, the highest mean growing season TP value was calculated for the Village Ck station (Fig. 2). Similar to mean growing season TN concentration trends, mean growing season TP concentrations were variable each year sampled in the mainstem stations, but decreased at Lost, Village and Big Yellow Ck embayment stations from the previous growing season. Valley Ck station mean growing season concentrations have increased since 1998. Monthly TP concentrations were below historic means in most months at each station with historic lows measured at the mid station in April and October (Fig. 5).

In 2012, the highest growing season mean chl *a* value was calculated for the mid station (Fig. 3). Mean growing season chl *a* concentrations have increased at all mainstem stations from

2011-2012. Mean concentrations at all embayment stations have decreased since 2007. A specific water quality criterion for nutrient management has been established on Bankhead at the lower station. The 2012 mean chl *a* concentration measured at the lower station continues to be in compliance with the criteria limit. Monthly chl *a* concentrations were at or below historic means a majority of months (Fig. 6). Monthly TN concentrations were highest in June for the Mulberry Fork station, July for the Locust Fork station, and August for the mid and lower stations.

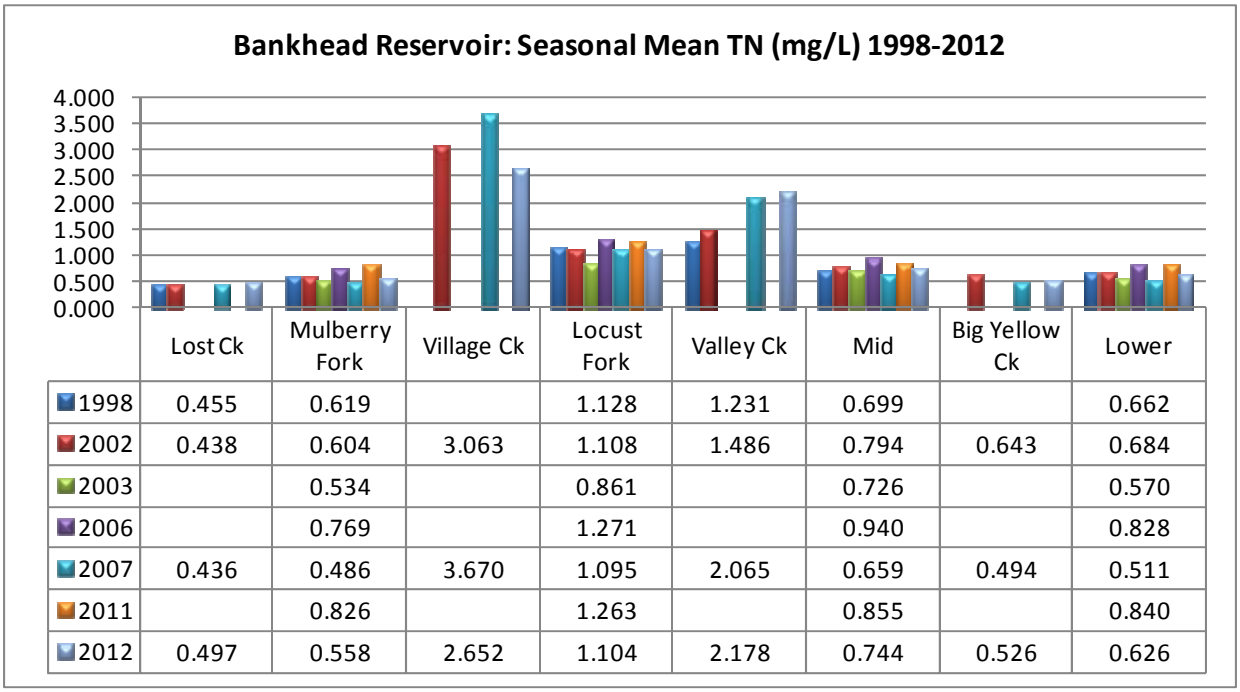
In 2012, the highest mean growing season TSS value was calculated for the Village Ck station (Fig. 3). Except for Village Ck stations, mean TSS concentrations have generally decreased since 2002. Monthly TSS concentrations were generally below historic means, reaching historic lows in most months, at all stations (Fig. 7). Highest concentrations were measured in August at all stations.

In 2012, AGPT results indicated Locust Fork and Mulberry Fork to be phosphorus limited, the mid station to be nitrogen limited and co-limited at the lower station (Table 2). The MSC values were well above 5 mg/L at all stations, the value defined as protective of reservoir and lake systems (Rashke and Schultz 1987).

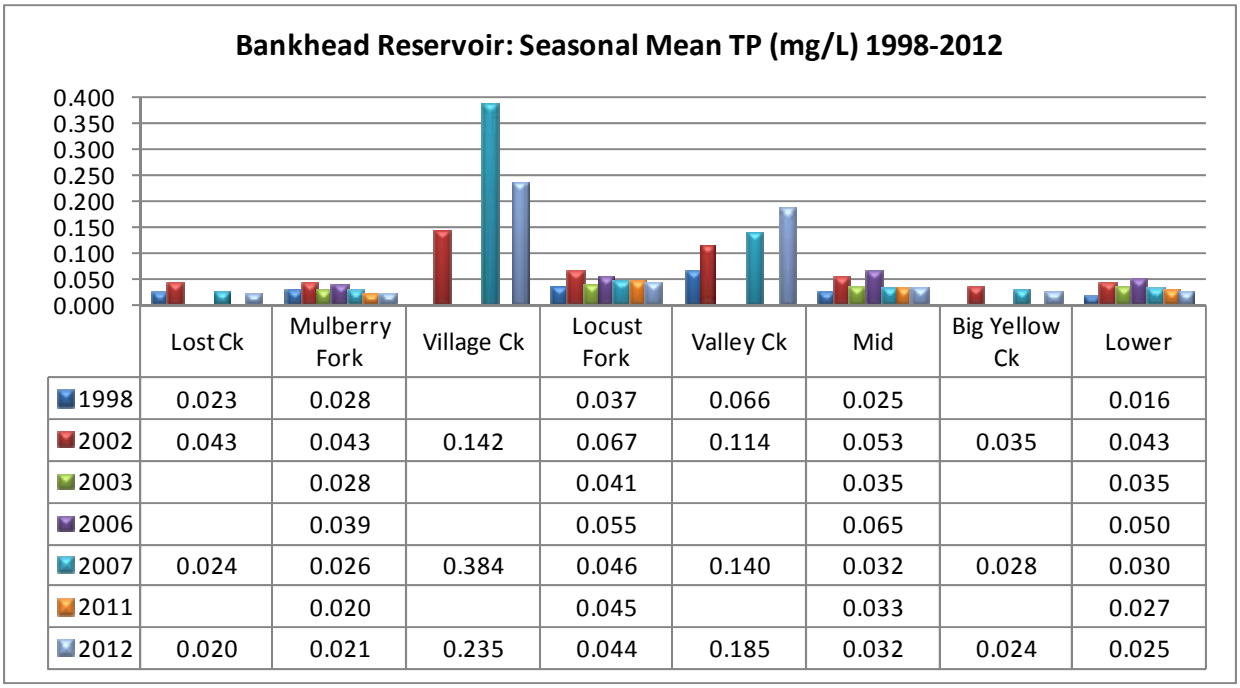
In September, the DO concentration at Big Yellow Ck was below the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) and the concentration was near the limit in the lower station (Fig. 8). All other measurements of DO were above criteria limits. Profiles of DO show the mid and lower stations were stratified in all months (Fig. 9 & 10). In June and July, conditions were essentially deoxygenated in half the water column at both stations. Profiles of temperature at both the lower and mid stations show highest temperatures were reached in July.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. Mainstem stations were mostly eutrophic for a majority of the growing season (Fig. 11). Big Yellow Ck, Valley Ck and Village Ck were eutrophic most months with the highest TSI tributary value calculated at the Valley Ck embayment in July. Values for Lost Ck were variable between mesotrophic and eutrophic.

Figure 2. Growing season mean TN and TP measured in Bankhead Reservoir, April-October 1998-2012. Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right.

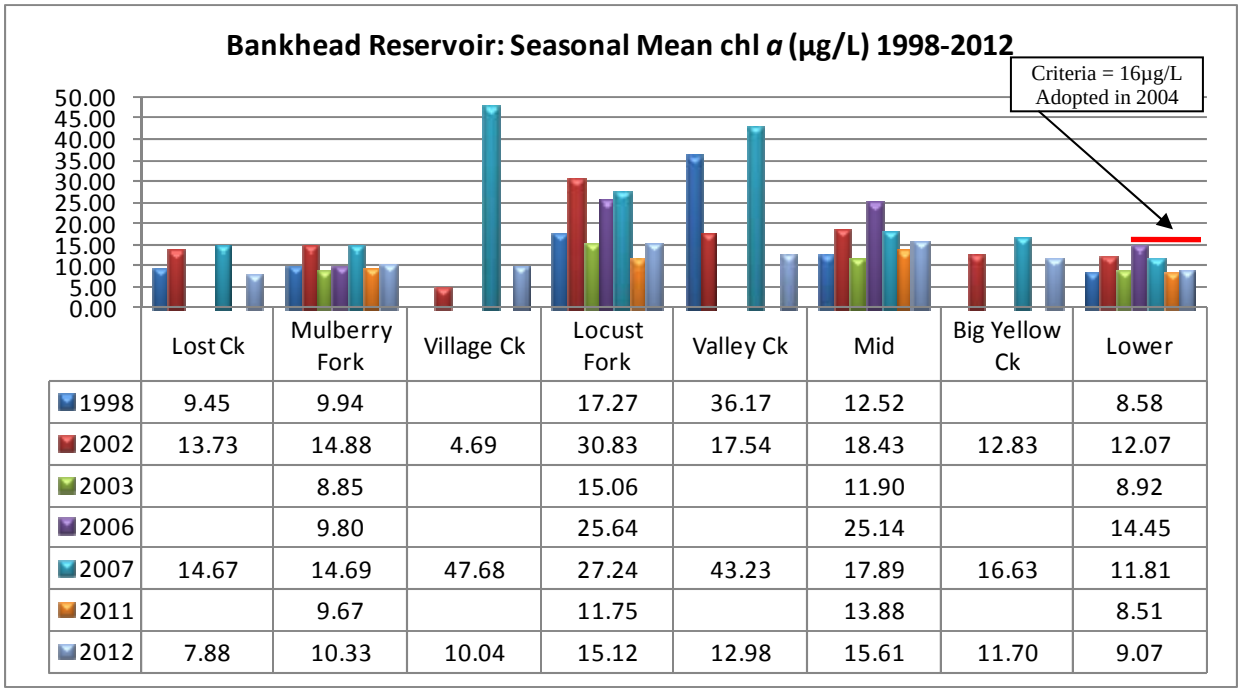


	Lost Ck	Mulberry Fork	Village Ck	Locust Fork	Valley Ck	Mid	Big Yellow Ck	Lower
1998	0.455	0.619		1.128	1.231	0.699		0.662
2002	0.438	0.604	3.063	1.108	1.486	0.794	0.643	0.684
2003		0.534		0.861		0.726		0.570
2006		0.769		1.271		0.940		0.828
2007	0.436	0.486	3.670	1.095	2.065	0.659	0.494	0.511
2011		0.826		1.263		0.855		0.840
2012	0.497	0.558	2.652	1.104	2.178	0.744	0.526	0.626

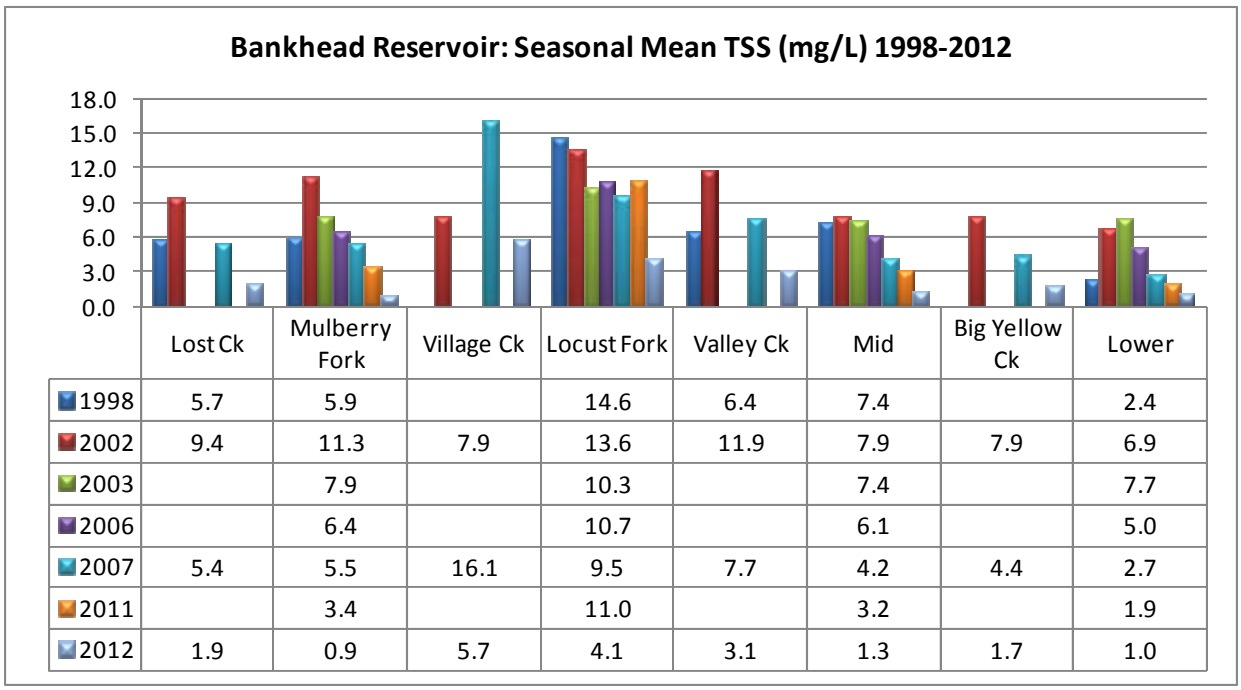


	Lost Ck	Mulberry Fork	Village Ck	Locust Fork	Valley Ck	Mid	Big Yellow Ck	Lower
1998	0.023	0.028		0.037	0.066	0.025		0.016
2002	0.043	0.043	0.142	0.067	0.114	0.053	0.035	0.043
2003		0.028		0.041		0.035		0.035
2006		0.039		0.055		0.065		0.050
2007	0.024	0.026	0.384	0.046	0.140	0.032	0.028	0.030
2011		0.020		0.045		0.033		0.027
2012	0.020	0.021	0.235	0.044	0.185	0.032	0.024	0.025

Figure 3. Growing season mean chl *a* and TSS measured in Bankhead Reservoir, April-October 1998-2012. 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.



	Lost Ck	Mulberry Fork	Village Ck	Locust Fork	Valley Ck	Mid	Big Yellow Ck	Lower
1998	9.45	9.94		17.27	36.17	12.52		8.58
2002	13.73	14.88	4.69	30.83	17.54	18.43	12.83	12.07
2003		8.85		15.06		11.90		8.92
2006		9.80		25.64		25.14		14.45
2007	14.67	14.69	47.68	27.24	43.23	17.89	16.63	11.81
2011		9.67		11.75		13.88		8.51
2012	7.88	10.33	10.04	15.12	12.98	15.61	11.70	9.07



	Lost Ck	Mulberry Fork	Village Ck	Locust Fork	Valley Ck	Mid	Big Yellow Ck	Lower
1998	5.7	5.9		14.6	6.4	7.4		2.4
2002	9.4	11.3	7.9	13.6	11.9	7.9	7.9	6.9
2003		7.9		10.3		7.4		7.7
2006		6.4		10.7		6.1		5.0
2007	5.4	5.5	16.1	9.5	7.7	4.2	4.4	2.7
2011		3.4		11.0		3.2		1.9
2012	1.9	0.9	5.7	4.1	3.1	1.3	1.7	1.0

Figure 4. Monthly TN concentrations of the mainstem stations in Bankhead Reservoir, April-October 2012. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and the min/max range is also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. TN was plotted vs. the closest discharge (lower and mid stations: USGS 02462500 Black Warrior R at Bankhead L&D near Bessemer AL; Locust Fork: USGS 02456500 Locust Fork at Sayre, AL; Mulberry Fork: USGS 02453500 Mulberry Fork near Cordova, AL).

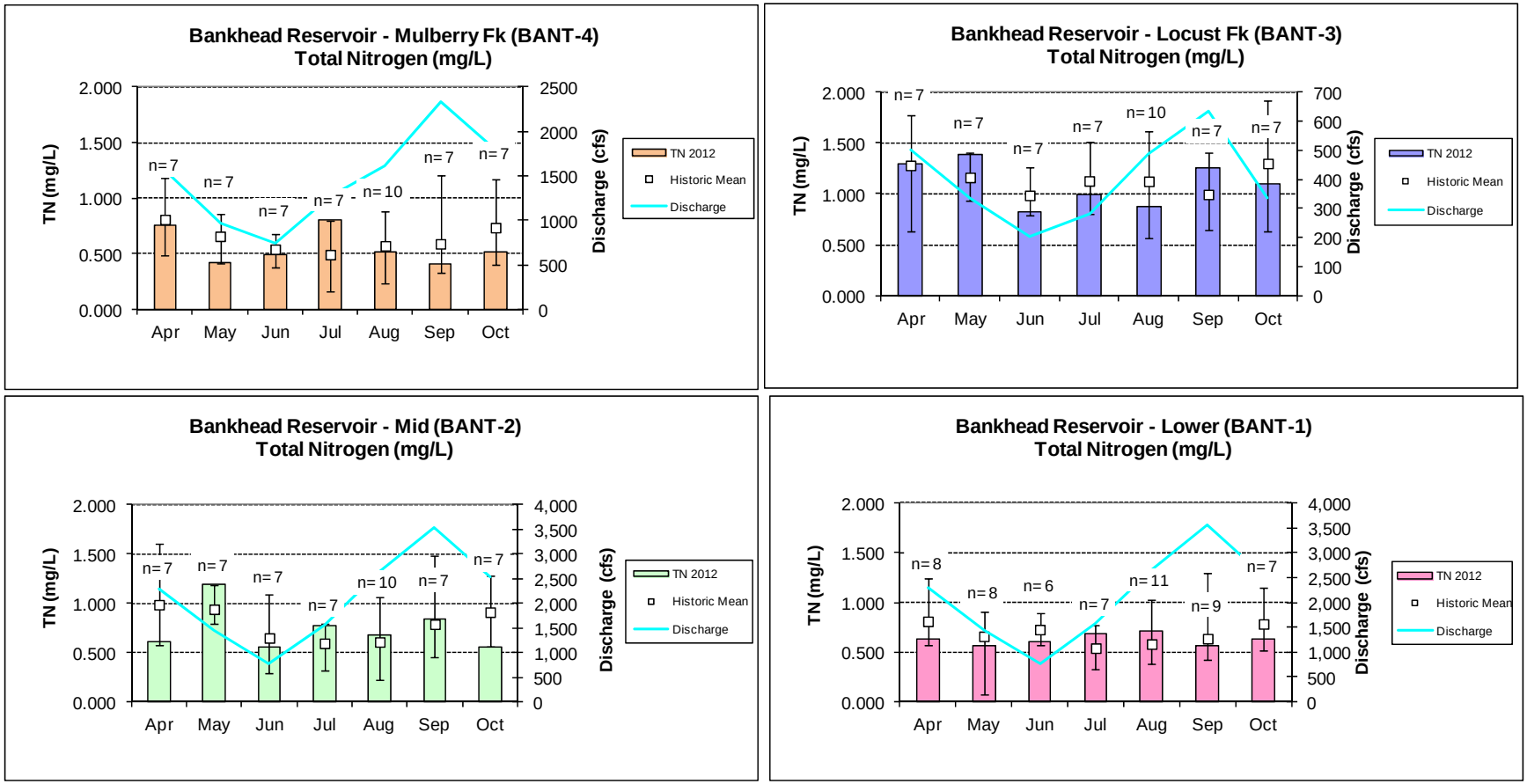


Figure 5. Monthly TP concentrations of the mainstem stations in Bankhead Reservoir, April-October 2012. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and the min/max range is also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. TP was plotted vs. the closest discharge (lower and mid stations: USGS 02462500 Black Warrior R at Bankhead L&D near Bessemer AL; Locust Fork: USGS 02456500 Locust Fork at Sayre, AL; Mulberry Fork: USGS 02453500 Mulberry Fork near Cordova, AL).

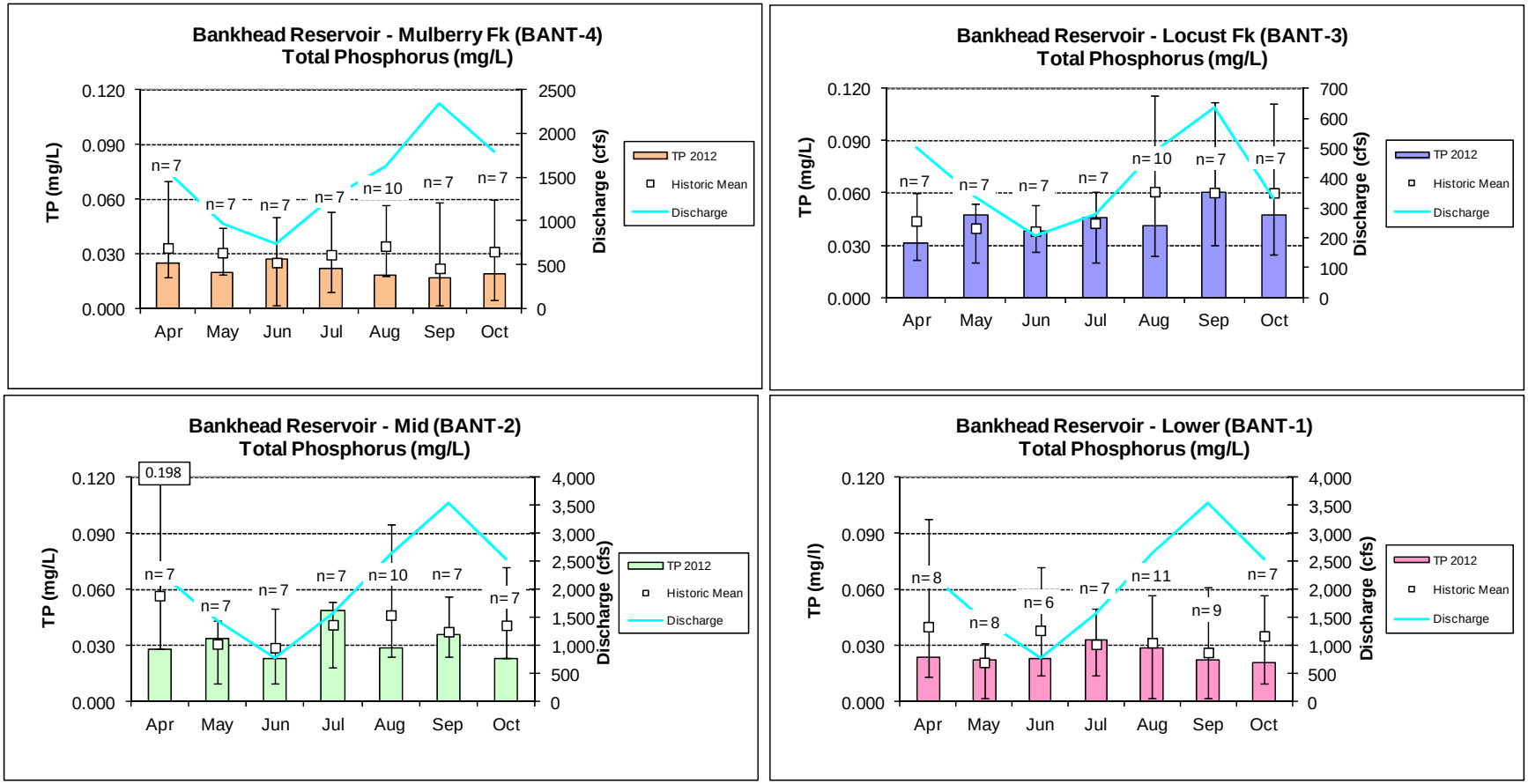


Figure 6. Monthly chl *a* concentrations of the mainstem stations in Bankhead Reservoir, April-October 2012. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and the min/max range is also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. Chl *a* was plotted vs. the closest discharge (lower and mid stations: USGS 02462500 Black Warrior R at Bankhead L&D near Bessemer AL; Locust Fork: USGS 02456500 Locust Fork at Sayre, AL; Mulberry Fork: USGS 02453500 Mulberry Fork near Cordova, AL).

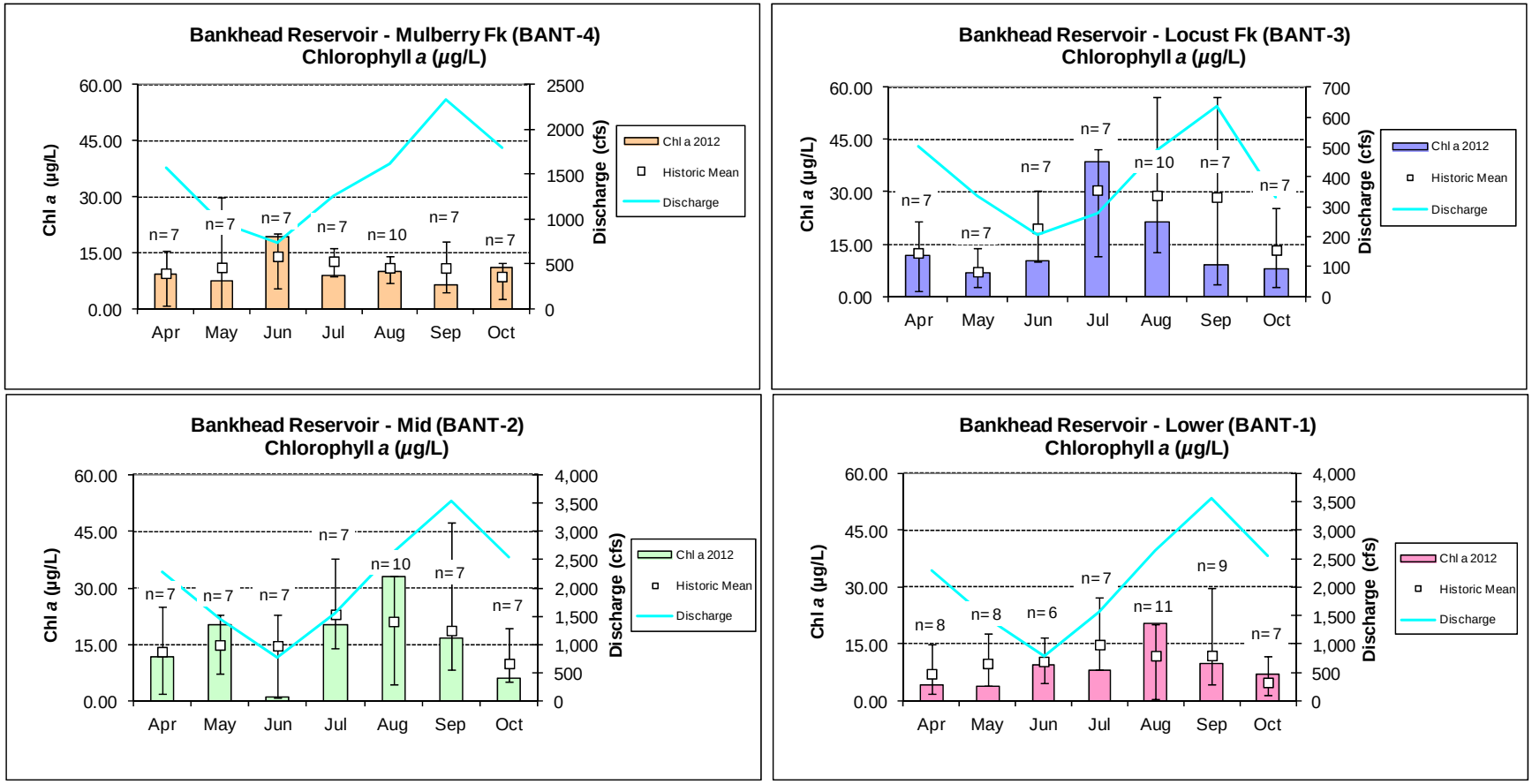


Figure 7. Monthly TSS concentrations of the mainstem stations in Bankhead Reservoir, April-October 2012. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and the min/max range is also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations. TSS was plotted vs. the closest discharge (lower and mid stations: USGS 02462500 Black Warrior R at Bankhead L&D near Bessemer AL; Locust Fork: USGS 02456500 Locust Fork at Sayre, AL; Mulberry Fork: USGS 02453500 Mulberry Fork near Cordova, AL).

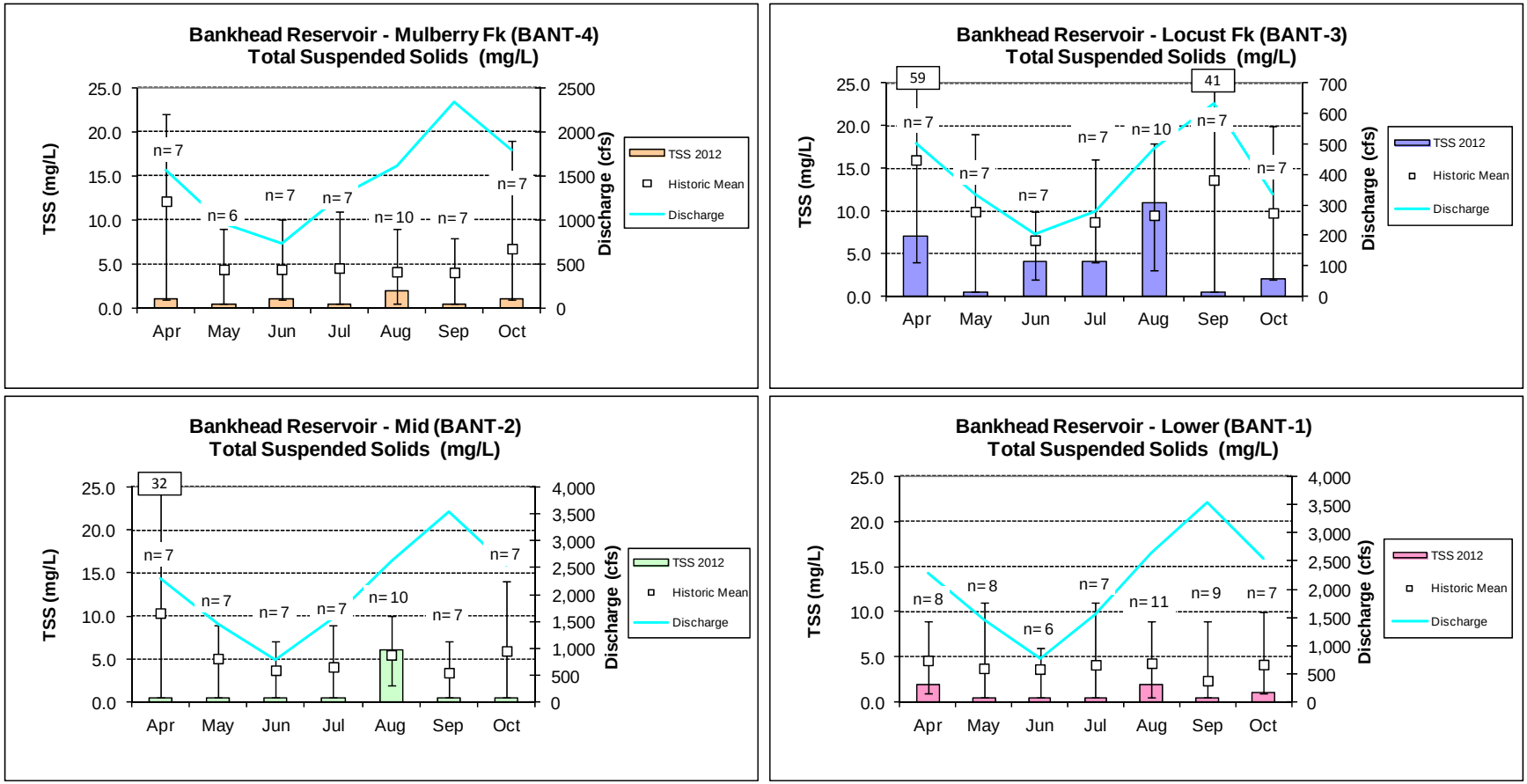
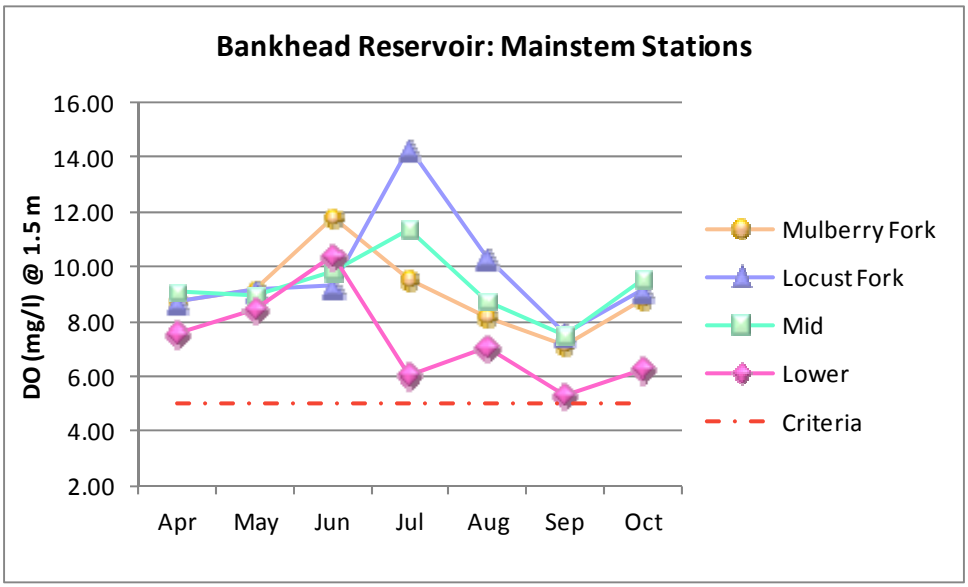


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective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

Station	Mulberry Fork		Locust Fork		Mid		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 1998	2.31	Phosphorus	24.74	Phosphorus	4.52	Phosphorus	2.65	Phosphorus
August 2002	6.95	Phosphorus	15.91	Phosphorus	9.61	Co-limiting	3.56	Co-limiting
June 2007	2.05	Phosphorus	2.34	Phosphorus	2.11	Phosphorus	2.23	Phosphorus
July 2007	2.91	Phosphorus	3.44	Phosphorus	3.42	Nitrogen	2.29	Nitrogen
August 2007	2.91	Phosphorus	9.53	Nitrogen	2.41	Nitrogen	2.40	Nitrogen
August 2012	9.25	Phosphorus	39.24	Phosphorus	22.24	Nitrogen	17.43	Co-limiting

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Bankhead Reservoir stations collected April-October 2012. 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.



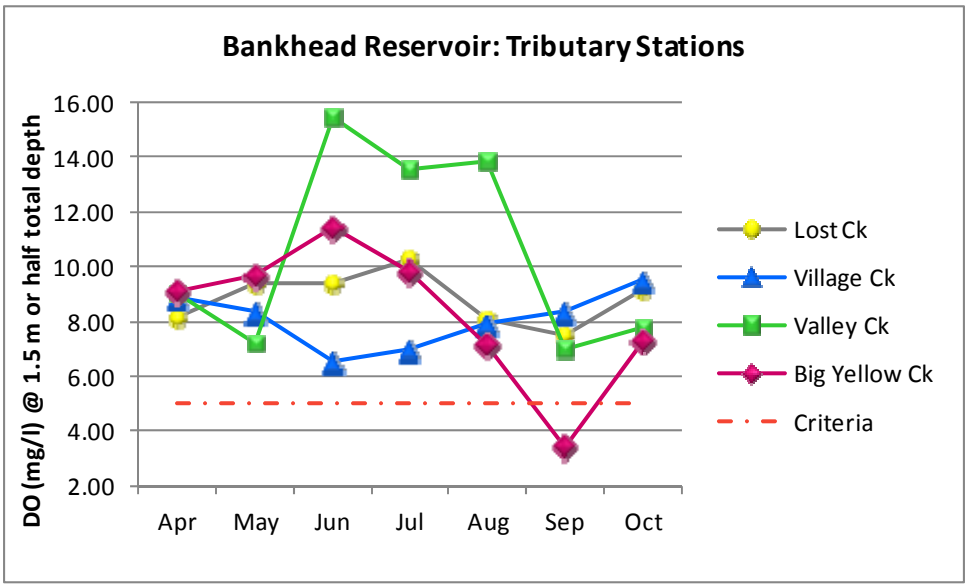


Figure 9. Monthly depth profiles of dissolved oxygen, temperature and conductivity in lower Bankhead Reservoir, April-October 2012.

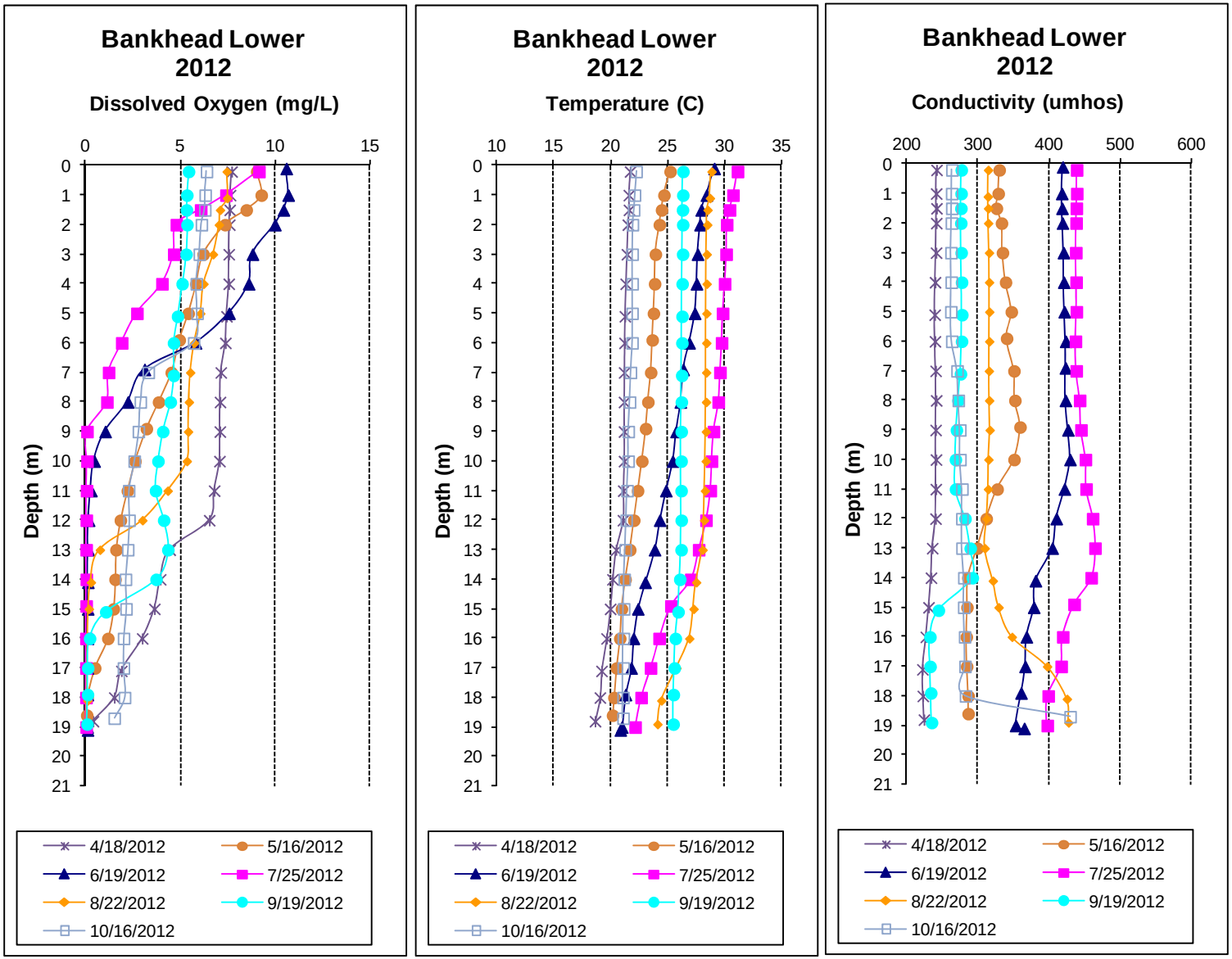


Figure 10. Monthly depth profiles of dissolved oxygen, temperature and conductivity in mid Bankhead Reservoir, April-October 2012.

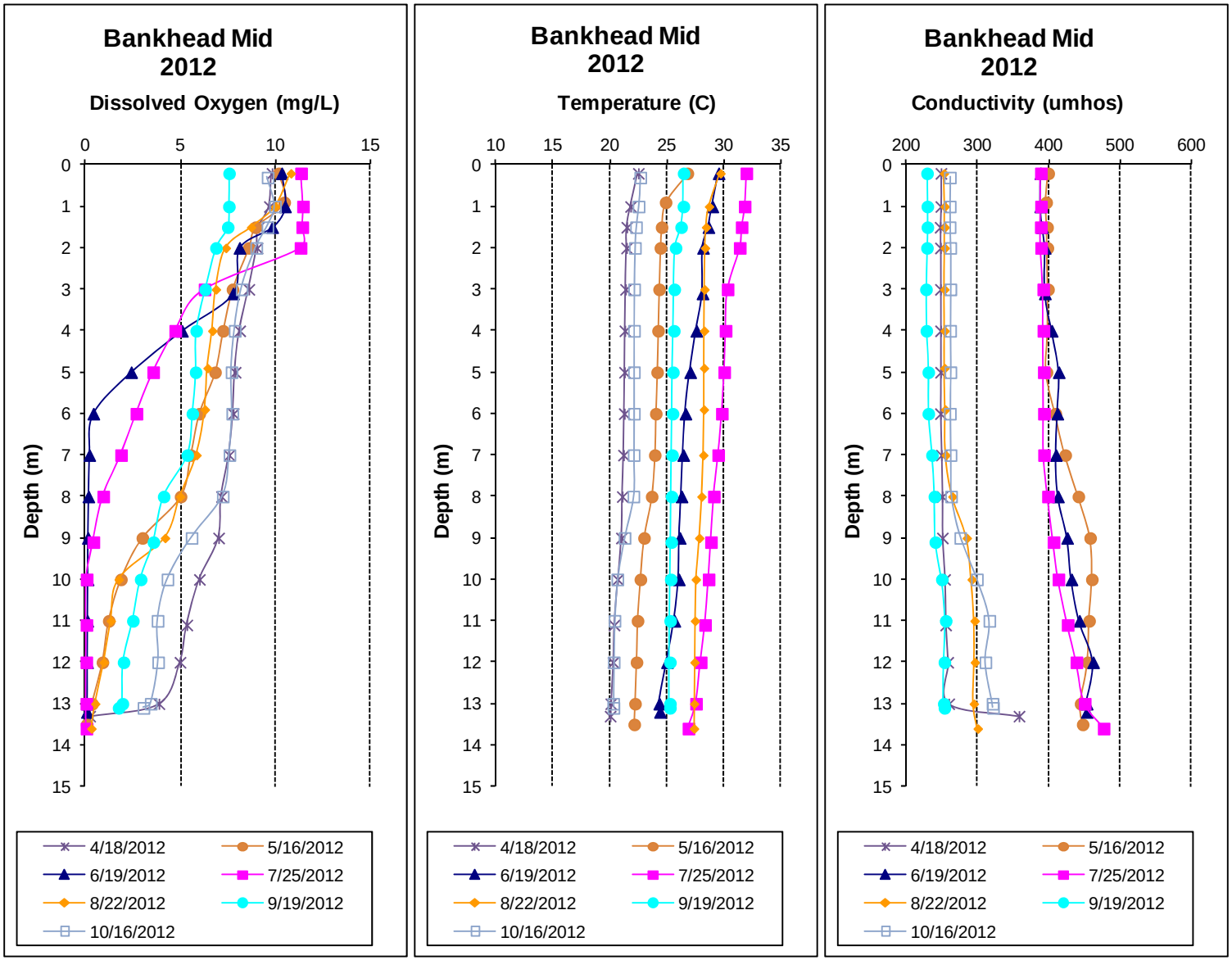
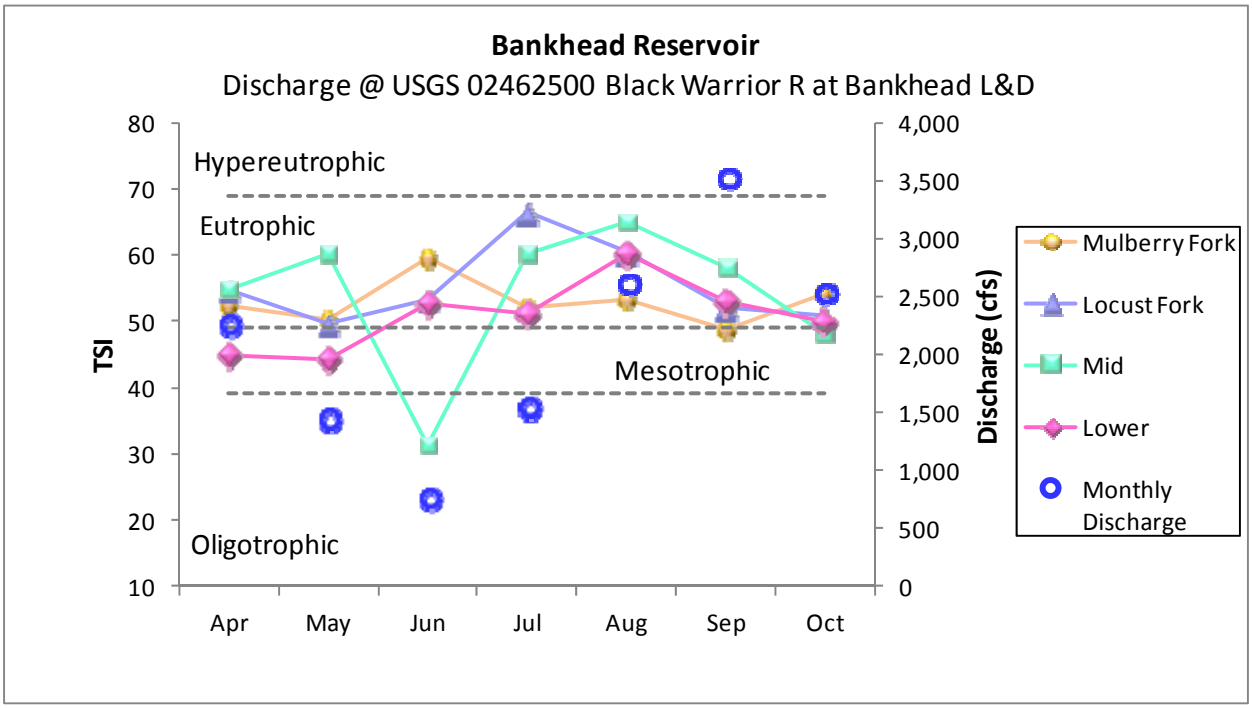
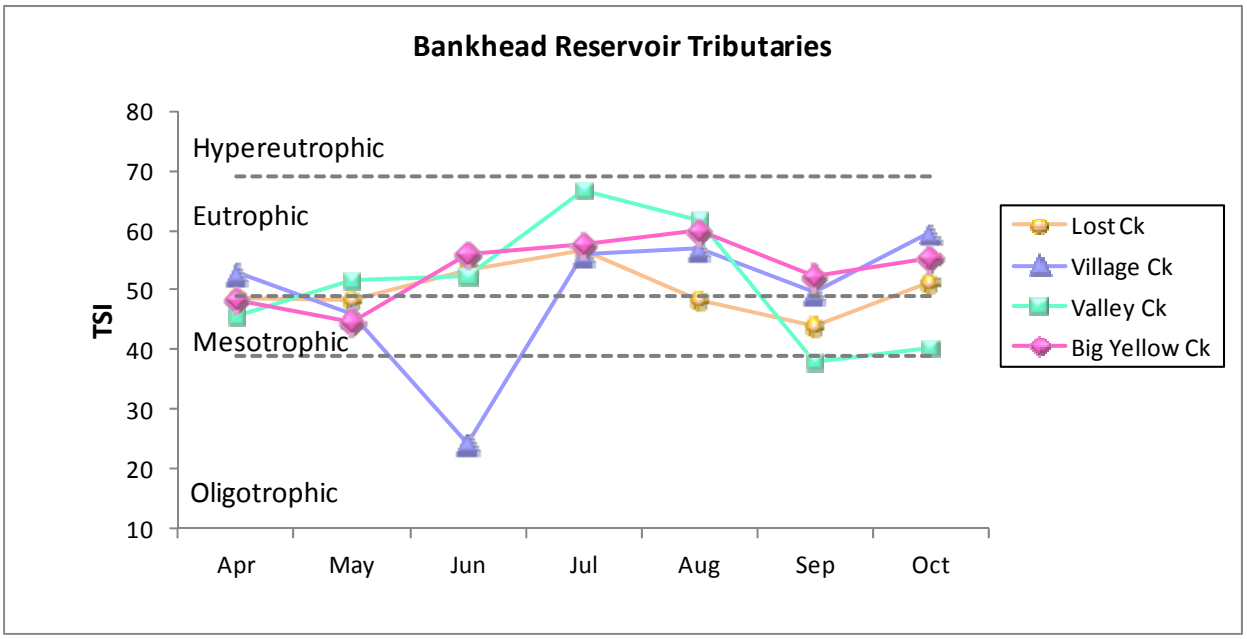


Figure 11. Monthly TSI values for all stations in Bankhead Reservoir using chl *a* concentrations and Carlson's Trophic State Index calculation. Monthly TSI for mainstem stations were plotted vs. the closest mean monthly discharge (USGS 02462500 Black Warrior R at Bankhead L&D near Bessemer AL).





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APPENDIX

Appendix Table 1. Summary of water quality data collected April-October, 2012. 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	N		Min	Max	Med	Mean	SD
BANT-1							
Physical							
Turbidity (NTU)	7		2.1	2.7	2.3	2.3	0.2
Total Dissolved Solids (mg/L)	7		102.0	260.0	220.0	198.3	53.9
Total Suspended Solids (mg/L)	7	<	1.0	2.0	0.5	1.0	0.7
Hardness (mg/L)	4		83.0	140.0	91.1	101.3	26.3
Alkalinity (mg/L)	7		53.9	106.0	75.6	76.3	18.6
Photic Zone (m)	7		4.10	6.83	5.12	5.37	0.95
Secchi (m)	7		1.33	2.63	1.70	1.82	0.40
Bottom Depth (m)	7		18.90	19.10	18.90	18.86	0.17
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.022	0.004	0.007	0.007
Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.002	0.468	0.346	0.277	0.174
Total Kjeldahl Nitrogen (mg/L)	7		0.159	0.686	0.212	0.349	0.207
Total Nitrogen (mg/L)	7	<	0.558	0.711	0.627	0.626	0.058
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.007	0.002	0.004	0.002
Total Phosphorus (mg/L)	7		0.021	0.033	0.023	0.025	0.004
CBOD-5 (mg/L)[J]	7	<	2.0	2.0	1.0	1.0	0.0
Chlorides (mg/L)	7		5.3	9.6	7.2	7.5	1.4
Biological							
Chlorophyll a (ug/L)	7		4.01	20.29	8.19	9.07	5.47
E. coli (col/100mL)[J]	3					<1	0
BANT-2							
Physical							
Turbidity (NTU)	7		3.0	4.3	3.7	3.6	0.4
Total Dissolved Solids (mg/L)	7		138.0	264.0	186.0	194.9	47.9
Total Suspended Solids (mg/L)	7	<	1.0	6.0	0.5	1.3	2.1
Hardness (mg/L)	4		84.5	146.0	88.4	101.8	29.5
Alkalinity (mg/L)	7		55.1	92.0	63.5	71.6	16.4
Photic Zone (m)	7		3.41	5.46	3.82	4.03	0.68
Secchi (m)	7		1.09	1.63	1.39	1.40	0.21
Bottom Depth (m)	7		13.00	13.60	13.30	13.34	0.22
Chemical							
Ammonia Nitrogen (mg/L)[J]	7	<	0.008	0.020	0.004	0.008	0.008
Nitrate+Nitrite Nitrogen (mg/L)[J]	7		0.007	0.380	0.309	0.226	0.156
Total Kjeldahl Nitrogen (mg/L)	7		0.215	0.811	0.532	0.518	0.223
Total Nitrogen (mg/L)[J]	7		0.554	1.191	0.674	0.744	0.224
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.006	0.002	0.003	0.002
Total Phosphorus (mg/L)	7		0.023	0.049	0.029	0.032	0.009
CBOD-5 (mg/L)[J]	7	<	2.0	3.3	1.0	1.3	0.9
Chlorides (mg/L)	7		4.1	7.7	6.0	5.9	1.4
Biological							
Chlorophyll a (ug/L)	7		1.07	33.11	16.73	15.61	10.56
E. coli (col/100mL)[J]	3					<1	0

Station	N		Min	Max	Med	Mean	SD
BANT-3							
Physical							
Turbidity (NTU)	7		5.8	11.1	7.2	7.3	1.9
Total Dissolved Solids (mg/L)	7		208.0	370.0	276.0	283.7	48.7
Total Suspended Solids (mg/L)	7	<	1.0	11.0	4.0	4.1	3.8
Hardness (mg/L)	4		137.0	199.0	154.5	161.2	26.7
Alkalinity (mg/L)	7		73.9	116.0	84.1	90.4	15.3
Photic Zone (m)	7		2.29	3.53	2.89	2.89	0.49
Secchi (m)	7		0.85	1.33	1.21	1.13	0.19
Bottom Depth (m)	7		6.00	6.40	6.30	6.23	0.19
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.121	0.004	0.029	0.046
Nitrate+Nitrite Nitrogen (mg/L)	7		0.153	0.936	0.595	0.570	0.316
Total Kjeldahl Nitrogen (mg/L)	7		0.172	0.844	0.553	0.533	0.229
Total Nitrogen (mg/L)	7		0.824	1.382	1.101	1.104	0.215
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.028	0.010	0.012	0.009
Total Phosphorus (mg/L)	7		0.031	0.060	0.046	0.044	0.009
CBOD-5 (mg/L)[J]	7	<	2.0	3.4	1.0	1.6	1.0
Chlorides (mg/L)	7		5.7	12.9	6.6	7.7	2.6
Biological							
Chlorophyll a (ug/L)	7		6.94	38.72	10.15	15.12	11.46
E. coli (col/100mL)[J]	3		1	4	3	3	2
BANT-4							
Physical							
Turbidity (NTU)	7		3.2	4.3	4.0	3.9	0.4
Total Dissolved Solids (mg/L)	7		118.0	242.0	140.0	160.3	49.6
Total Suspended Solids (mg/L)	7	<	1.0	2.0	1.0	0.9	0.5
Hardness (mg/L)	4		79.0	161.0	108.8	114.4	38.6
Alkalinity (mg/L)	7		34.4	88.4	55.2	56.1	18.5
Photic Zone (m)	7		3.45	4.70	4.16	4.11	0.37
Secchi (m)	7		1.12	1.62	1.50	1.42	0.18
Bottom Depth (m)	7		11.90	12.10	12.10	11.97	0.17
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.036	0.004	0.011	0.013
Nitrate+Nitrite Nitrogen (mg/L)	7		0.038	0.324	0.172	0.182	0.103
Total Kjeldahl Nitrogen (mg/L)	7		0.188	0.726	0.340	0.376	0.193
Total Nitrogen (mg/L)	7		0.413	0.803	0.512	0.558	0.159
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.006	0.002	0.003	0.001
Total Phosphorus (mg/L)	7		0.017	0.027	0.020	0.021	0.004
CBOD-5 (mg/L)[J]	7	<	2.0	2.6	1.0	1.2	0.6
Chlorides (mg/L)	7		3.1	6.4	3.6	4.1	1.2
Biological							
Chlorophyll a (ug/L)	7		6.41	19.22	9.26	10.33	4.21
E. coli (col/100mL)[J]	3	<	1	6	1	3	3

Station	N		Min	Max	Med	Mean	SD
BANT-5							
Physical							
Turbidity (NTU)	7		3.4	5.4	4.8	4.7	0.6
Total Dissolved Solids (mg/L)	7		200.0	420.0	234.0	282.0	86.4
Total Suspended Solids (mg/L)	7	<	1.0	7.0	0.5	1.9	2.4
Hardness (mg/L)	4		129.0	187.0	138.0	148.0	27.0
Alkalinity (mg/L)	7		77.4	154.0	94.3	102.7	27.4
Photic Zone (m)	7		3.15	4.24	3.68	3.63	0.36
Secchi (m)	7		1.27	1.84	1.36	1.47	0.22
Bottom Depth (m)	7		11.00	14.00	13.60	13.33	0.92
Chemical							
Ammonia Nitrogen (mg/L)[J]	7	<	0.008	0.036	0.004	0.010	0.012
Nitrate+Nitrite Nitrogen (mg/L)	7		0.051	0.407	0.249	0.200	0.145
Total Kjeldahl Nitrogen (mg/L)[J]	7	<	0.076	0.534	0.326	0.298	0.165
Total Nitrogen (mg/L)[J]	7	<	0.316	0.733	0.471	0.497	0.159
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.006	0.002	0.003	0.001
Total Phosphorus (mg/L)	7		0.015	0.028	0.019	0.020	0.004
CBOD-5 (mg/L)[J]	7	<	2.0	2.7	1.0	1.4	0.7
Chlorides (mg/L)	7		2.2	4.4	3.3	3.2	0.6
Biological							
Chlorophyll a (ug/L)	7		3.92	14.42	6.41	7.88	3.48
E. coli (col/100mL)[J]	3	<	1	2	2	2	1
BANT-6							
Physical							
Turbidity (NTU)	7		4.6	21.8	6.6	9.4	6.1
Total Dissolved Solids (mg/L)	7		242.0	434.0	302.0	320.9	75.1
Total Suspended Solids (mg/L)	7	<	1.0	7.0	3.0	3.1	2.7
Hardness (mg/L)	4		131.0	205.0	162.5	165.2	32.3
Alkalinity (mg/L)	7		90.8	163.0	125.0	126.3	29.7
Photic Zone (m)	7		1.68	4.27	2.81	2.86	0.84
Secchi (m)	7		0.78	1.44	1.03	1.04	0.26
Bottom Depth (m)	7		7.90	9.20	7.90	8.07	0.52
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.029	0.004	0.013	0.012
Nitrate+Nitrite Nitrogen (mg/L)	7		0.300	3.267	1.217	1.655	1.170
Total Kjeldahl Nitrogen (mg/L)[J]	7		0.183	1.050	0.499	0.523	0.356
Total Nitrogen (mg/L)[J]	7		1.256	3.454	1.780	2.178	0.861
Dissolved Reactive Phosphorus (mg/L)	7		0.034	0.270	0.079	0.123	0.101
Total Phosphorus (mg/L)	7		0.085	0.298	0.174	0.185	0.078
CBOD-5 (mg/L)	7	<	2.0	2.0	1.0	1.0	0.0
Chlorides (mg/L)	7		9.3	25.1	16.5	15.6	5.6
Biological							
Chlorophyll a (ug/L)	7		2.14	39.38	8.68	12.98	13.81
E. coli (col/100mL)[J]	3		1	102	12	38	55

Station	N		Min	Max	Med	Mean	SD
BANT-7							
Physical							
Turbidity (NTU)	7		2.1	2.6	2.5	2.4	0.2
Total Dissolved Solids (mg/L)	7		144.0	240.0	216.0	207.7	32.2
Total Suspended Solids (mg/L)	7	<	1.0	8.0	0.5	1.7	2.8
Hardness (mg/L)	7		79.1	143.0	109.0	111.3	23.6
Alkalinity (mg/L)	7		51.6	103.0	72.1	79.6	20.0
Photic Zone (m)	7		3.47	7.08	5.33	5.33	1.24
Secchi (m)	7		1.18	2.40	1.92	1.80	0.41
Bottom Depth (m)	7		17.90	18.60	18.30	18.29	0.24
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.044	0.004	0.013	0.016
Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.002	0.390	0.234	0.206	0.164
Total Kjeldahl Nitrogen (mg/L)[J]	7		0.115	0.462	0.365	0.320	0.142
Total Nitrogen (mg/L)[J]	7	<	0.433	0.648	0.494	0.526	0.084
Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.008	0.002	0.004	0.002
Total Phosphorus (mg/L)	7		0.020	0.030	0.022	0.024	0.004
CBOD-5 (mg/L)[J]	7	<	2.0	5.3	1.0	1.6	1.6
Chlorides (mg/L)	7		4.5	9.9	8.0	7.6	1.9
Total Metals							
Aluminum (mg/L)[J]	7	<	0.043	0.045	0.022	0.025	0.009
Iron (mg/L)[J]	7	<	0.019	0.062	0.010	0.026	0.021
Manganese (mg/L)[J]	7		0.014	0.161	0.027	0.048	0.051
Dissolved Metals							
Aluminum (mg/L)	7	<	0.043	0.043	0.022	0.022	0.000
Antimony (µg/L)	7	<	3.6	3.6	1.8	1.8	0.0
Arsenic (µg/L)[J]	7	<	1.8	3.3	0.9	1.4	1.0
Cadmium (µg/L)	7	<	0.022	0.046	0.023	0.020	0.006
Chromium (µg/L)	7	<	9.000	9.000	4.500	4.500	0.000
Copper (mg/L)	7	<	0.020	0.020	0.010	0.010	0.000
Iron (mg/L)[J]	7	<	0.019	0.020	0.010	0.011	0.004
Lead (µg/L)	7	<	0.9	0.9	0.4	0.4	0.0
Manganese (mg/L)	7	<	0.007	0.007	0.004	0.004	0.000
Mercury (µg/L)	6	<	0.035	0.035	0.018	0.018	0.000
Nickel (mg/L)	7	<	0.042	0.042	0.021	0.021	0.000
Selenium (µg/L)	7	<	2.5	2.5	1.2	1.2	0.0
Silver (µg/L)[J]	7	<	0.015	0.287	0.108	0.105	0.093
Thallium (µg/L)	7	<	1.4	1.4	0.7	0.7	0.0
Zinc (mg/L)	7	<	0.012	0.012	0.006	0.006	0.000
Biological							
Chlorophyll a (ug/L)	7		4.27	20.29	12.55	11.70	5.60
E. coli (col/100mL)[J]	3	<	1	2	1	1	1

Station	N		Min	Max	Med	Mean	SD
BANT-8							
Physical							
Turbidity (NTU)	7		3.8	12.7	6.6	7.2	2.9
Total Dissolved Solids (mg/L)	7		258.0	602.0	298.0	346.3	124.1
Total Suspended Solids (mg/L)	7	<	1.0	14.0	3.0	5.7	5.6
Hardness (mg/L)	4	<	0.0	209.0	189.5	147.0	98.5
Alkalinity (mg/L)	7		89.3	132.0	126.0	119.0	15.2
Photic Zone (m)	7		1.96	2.90	2.38	2.48	0.39
Secchi (m)	7		0.72	1.71	1.01	1.09	0.35
Bottom Depth (m)	7		2.00	2.90	2.70	2.57	0.33
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.008	0.038	0.004	0.012	0.015
Nitrate+Nitrite Nitrogen (mg/L)[J]	7		1.533	2.675	1.975	2.029	0.422
Total Kjeldahl Nitrogen (mg/L)	7		0.255	0.982	0.585	0.623	0.261
Total Nitrogen (mg/L)[J]	7		1.788	3.430	2.538	2.652	0.522
Dissolved Reactive Phosphorus (mg/L)	7		0.096	0.353	0.158	0.185	0.085
Total Phosphorus (mg/L)	7		0.172	0.404	0.199	0.235	0.079
CBOD-5 (mg/L)[J]	7	<	2.0	2.1	1.0	1.2	0.4
Chlorides (mg/L)	7		7.9	17.0	11.1	11.8	2.9
Biological							
Chlorophyll a (ug/L)	7		0.53	19.76	9.79	10.04	6.53
E. coli (col/100mL)[J]	3		9	219	55	94	110

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