2017 Harding Reservoir Report
Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Rivers & Reservoirs Unit
April 2021

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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
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
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USACE	United States Geological Survey

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INTRODUCTION

Originally constructed by Columbus Electric and Power Company in 1926, Harding Reservoir, also known as Bartlett's Ferry, was acquired by Georgia Power in 1930 and operated for hydropower ever since. The reservoir stretches from just north of Columbus, GA to Valley, AL, and covers 5,850 acres along the Alabama/Georgia state line. Most of Harding's flow comes from upstream West Point Reservoir and three large tributaries, two in Alabama (Osanippa and Halawakee Creeks) and one in Georgia (Mountain Oak Creek).

The Alabama Department of Environmental Management (ADEM) monitored Harding Reservoir as part of the 2017 assessment of the Chattahoochee River Basin 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, to identify trends in water quality conditions, and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2017 Monitoring Strategy (ADEM 2017).

In 2004, the ADEM implemented a specific water quality criterion for nutrient management at the forebay station of Harding Reservoir, which has been monitored by ADEM since 1990. This criterion represents a growing season mean (April-October) chlorophyll *a* (chl *a*) concentration that is protective of Harding Reservoir's Public Water Supply, Swimming, and Fish & Wildlife (PWS/S/F&W) use classifications (Table 1).

The purpose of this report is to summarize data collected at three stations in Harding Reservoir during the 2017 growing season and to evaluate growing season trends in lake trophic status and nutrient concentrations using ADEM's historic dataset. Monthly and/or 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 (Figure 1). Specific location information can be found in Table 1. Harding Reservoir was sampled in the dam forebay and upper reservoir along with one tributary station—Osanippa Creek. The Halawakee Creek station (HARL-2) was not sampled during the 2017 season.

Water quality sampling was conducted at monthly intervals through the growing season, April-October. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures #2000 (ADEM 2017), Surface Water Quality Assurance Project Plan (ADEM 2017), and Quality Management Plan (ADEM 2013).

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 2017 results.

Figure 1. Harding Reservoir with 2017 sampling locations.

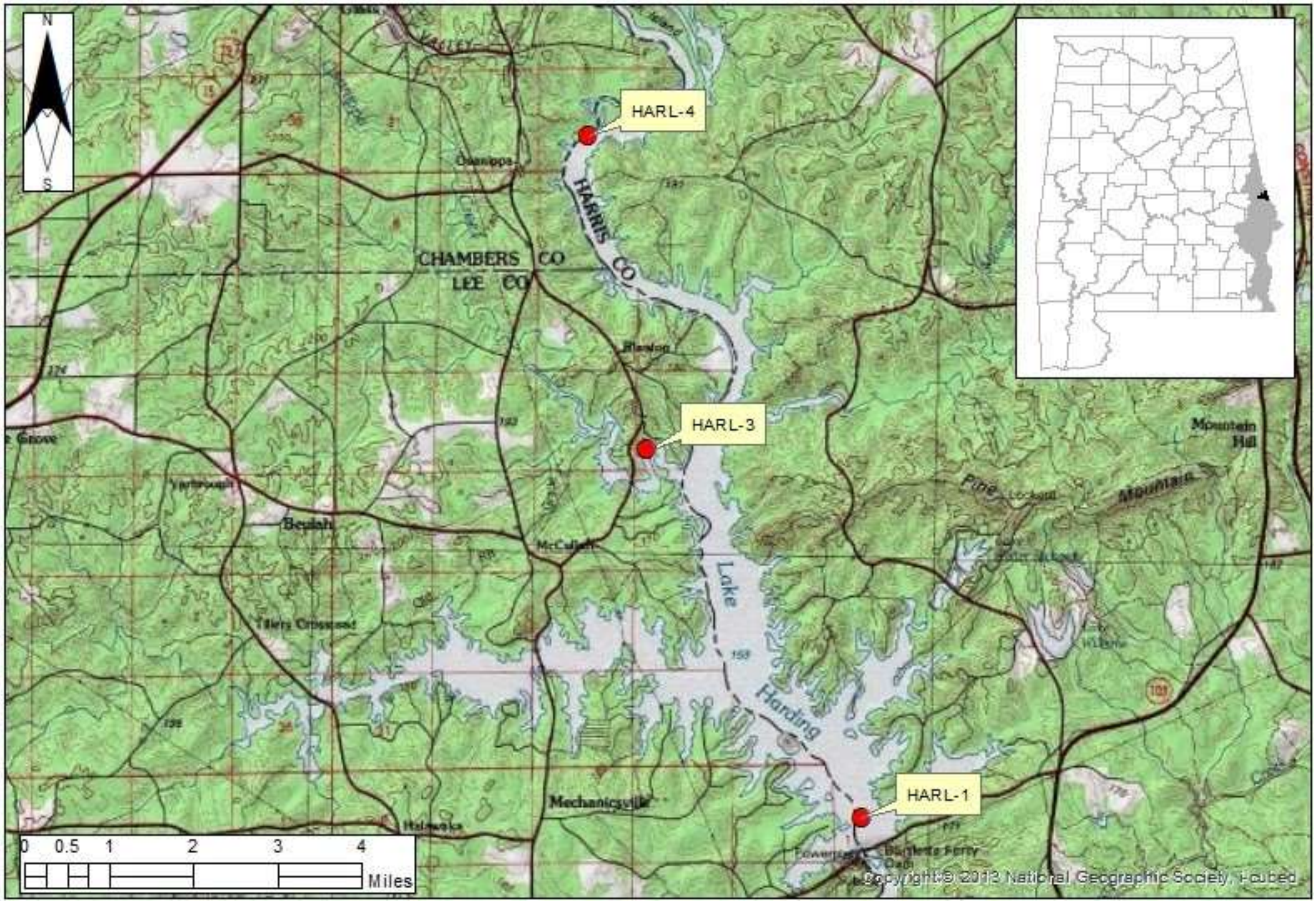


Table 1. Descriptions for the monitoring stations in Harding Reservoir.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criteria	Latitude	Longitude
031300021109	Lee	HARL-1*	Lower	Chattahoochee R	Deepest point, main river channel, dam forebay.	15 µg/l	32.66763	-85.09190
031300021105	Lee	HARL-3	Osanippa Ck	Osanippa Ck	Deepest point, main channel, Osanippa Ck embayment		32.72072	-85.12866
031300021109	Chambers	HARL-4	Upper	Chattahoochee R	Deepest point, main river channel, immediately downstream of Johnson Island.		32.76599	-85.13879

*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 (Figures 2 and 3). Monthly graphs for TN, TP, chl *a*, TSS, DO, and TSI are also provided (Figures 4-7 and 8). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, TSS, and TSI as an indicator of flow and retention time in the months sampled. AGPT results appear in Table 2. Depth profile graphs of temperature, DO, and conductivity appear in Figures 9 and 10. Summary statistics of all data collected during 2017 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, and TSS are noted in the paragraphs to follow. Though stations with lowest concentrations may not always be mentioned, review of the graphs that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2017, the highest mean growing season TN value calculated among Harding Reservoir stations was in the upper station, which is consistent with data collected 1999-2014 (Figure 2). Mean TN was higher in 2017 than the previous growing season at all stations sampled. Monthly TN concentrations were at or above historic means at all stations for most of the growing season (Figure 4). Historic high monthly TN concentrations were measured in the upper station in April. Osanippa Creek recorded a historic high in May, but also reached a historic low in October. The lower station measured historic high TN concentrations in April, July, and September.

The highest mean growing season TP value calculated in Harding Reservoir in 2017 was in Osanippa Creek, but mean TP values were very similar across stations. In general, mean TP concentrations have decreased at all stations 2004-2017 (Figure 2). Monthly TP concentrations in all Harding Reservoir monitoring locations were below historic means at all stations throughout the growing season (Figure 5). Historic low monthly TP values were measured in the upper station in June, September, and October and in Osanippa Creek in September and October.

Specific water quality criterion for nutrient management has been established for the lower station in Harding Reservoir. The growing season mean chl *a* concentration measured in 2017 was in compliance with the criteria limit (Figure 3). The highest mean growing season chl *a* value measured in 2017 was at the lower station, while the lowest value was in the upper station. Mean chl *a* concentrations in the upper station and Osanippa Creek were lower in 2017 than in 2014. However, the lower station recorded its highest mean chl *a* concentration since 2007. Monthly chl *a* concentrations in the riverine upper station were relatively low (≤1.60 µg/l) most months monitored; however, historic high monthly concentrations were measured there in August (Figure 6). Monthly chl *a* concentrations in Osanippa Creek reached a historic high in April, but remained below historic means for the remainder of the growing season. A historic high was also measured at the lower station in June.

In 2017, the highest mean TSS value was measured in Osanippa Creek (Figure 3). The mean TSS value did not change at the upper station from 2014 to 2017, but in general, mean TSS decreased at all stations since 2003. Monthly TSS concentrations were below historic means at all stations during all months monitored (Figure 7). Historic low monthly concentrations were measured numerous months at all stations during the growing season.

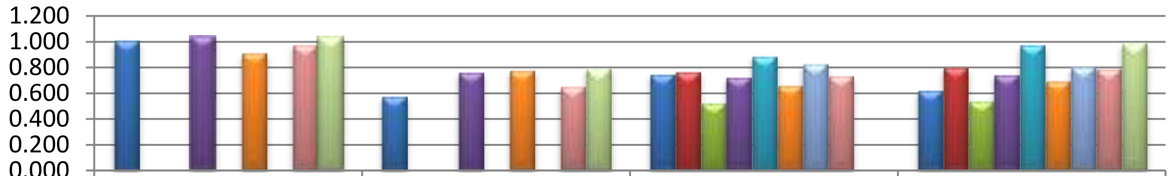
AGPT results at all stations in Harding Reservoir have remained phosphorus limited since monitoring began in 1999 (Table 2). Osanippa Creek was the only station sampled for AGPT during the 2017 season. MSC results were below 5 mg/L, the value that Raschke et al. (1987) defined as protective of reservoir and lake systems.

Dissolved oxygen (DO) measurements at all 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) for all months sampled (Figure 8). Based on monthly DO profiles, the reservoir was stratified at the lower station April through October, reaching anoxic conditions by 12 m in depth some months. The reservoir remained well-mixed in the upper station (Figures 9 & 10). Highest water temperatures were measured in August.

Monthly TSI values were calculated using chl *a* concentrations and Carlson's Trophic State Index. TSI conditions in the lower station began as oligotrophic in April, but then fluctuated between mesotrophic and eutrophic for the remainder of the sampling season (Figure 11). The upper station was oligotrophic most months, with the exception of a spike in August resulting in borderline eutrophic conditions. TSI values in Osanippa Creek also spiked in August causing temporary eutrophic conditions; however, the station remained mesotrophic/borderline eutrophic all other months sampled.

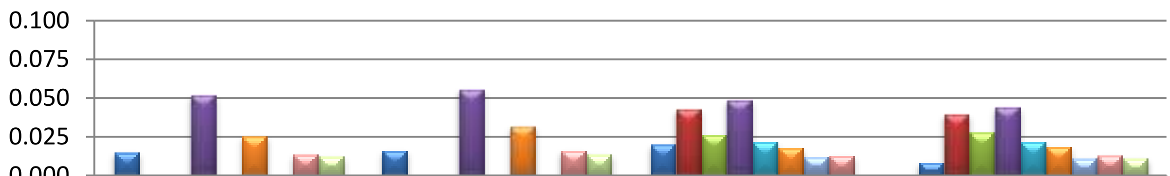
Figure 2. Mean growing season TN and TP measured in Harding Reservoir, April-October, 1999-2017. Stations are illustrated from upstream to downstream as the graph is read from left to right.

Harding Reservoir: Seasonal Mean TN (mg/L) 1999-2017



	Upper	Osanippa Ck	Halawakee Ck	Lower
1999	1.015	0.580	0.752	0.627
2002			0.773	0.804
2003			0.530	0.544
2004	1.046	0.767	0.726	0.747
2007			0.894	0.980
2008	0.918	0.783	0.666	0.701
2012			0.832	0.811
2014	0.982	0.657	0.741	0.794
2017	1.041	0.799		0.995

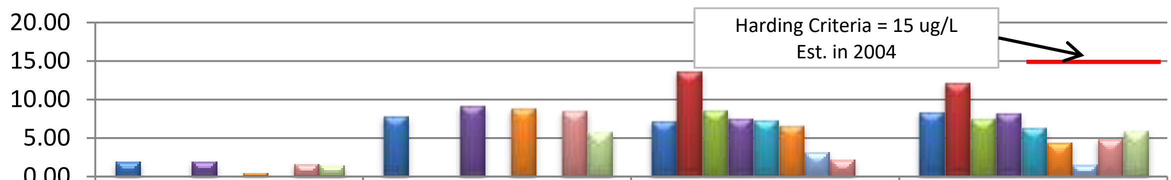
Harding Reservoir: Seasonal Mean TP (mg/L) 1999-2017



	Upper	Osanippa Ck	Halawakee Ck	Lower
1999	0.016	0.017	0.021	0.009
2002			0.044	0.040
2003			0.027	0.028
2004	0.052	0.056	0.049	0.045
2007			0.022	0.022
2008	0.026	0.032	0.018	0.019
2012			0.013	0.012
2014	0.014	0.017	0.013	0.014
2017	0.013	0.014		0.012

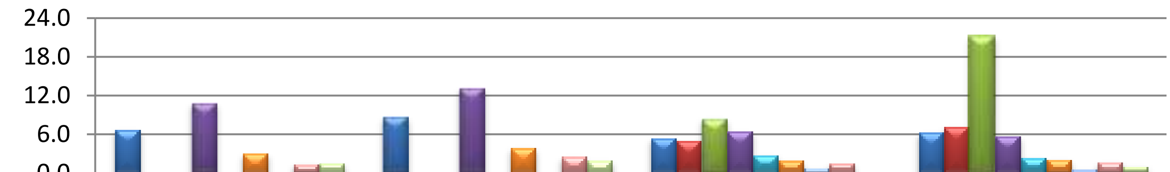
Figure 3. Mean growing season chl *a* and TSS measured in Harding Reservoir, April-October, 1999-2017. Stations are illustrated from upstream to downstream as the graph is read from left to right. Chl *a* criteria applies to the growing season mean of the lower station only.

Harding Reservoir: Seasonal Mean chl *a* (ug/L) 1999-2017



	Upper	Osanippa Ck	Halawakee Ck	Lower
1999	2.10	7.94	7.35	8.49
2002			13.81	12.34
2003			8.74	7.63
2004	2.10	9.31	7.64	8.33
2007			7.44	6.46
2008	0.65	8.98	6.72	4.50
2012			3.29	1.66
2014	1.78	8.67	2.33	5.00
2017	1.58	5.91		6.07

Harding Reservoir: Seasonal Mean TSS (mg/L) 1999-2017



	Upper	Osanippa Ck	Halawakee Ck	Lower
1999	6.9	8.9	5.6	6.4
2002			5.1	7.3
2003			8.6	21.3
2004	11.0	13.3	6.6	5.9
2007			2.9	2.5
2008	3.2	4.1	2.1	2.2
2012			0.9	0.7
2014	1.6	2.7	1.6	1.9
2017	1.6	2.1		1.1

Figure 4. Monthly TN concentrations measured in Harding Reservoir, April-October 2017 vs. average monthly discharge. Monthly discharge acquired from USACE at West Point Dam. Each bar graph depicts monthly changes in each station. The historic mean (1990-2017) and min/max ranges are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations.

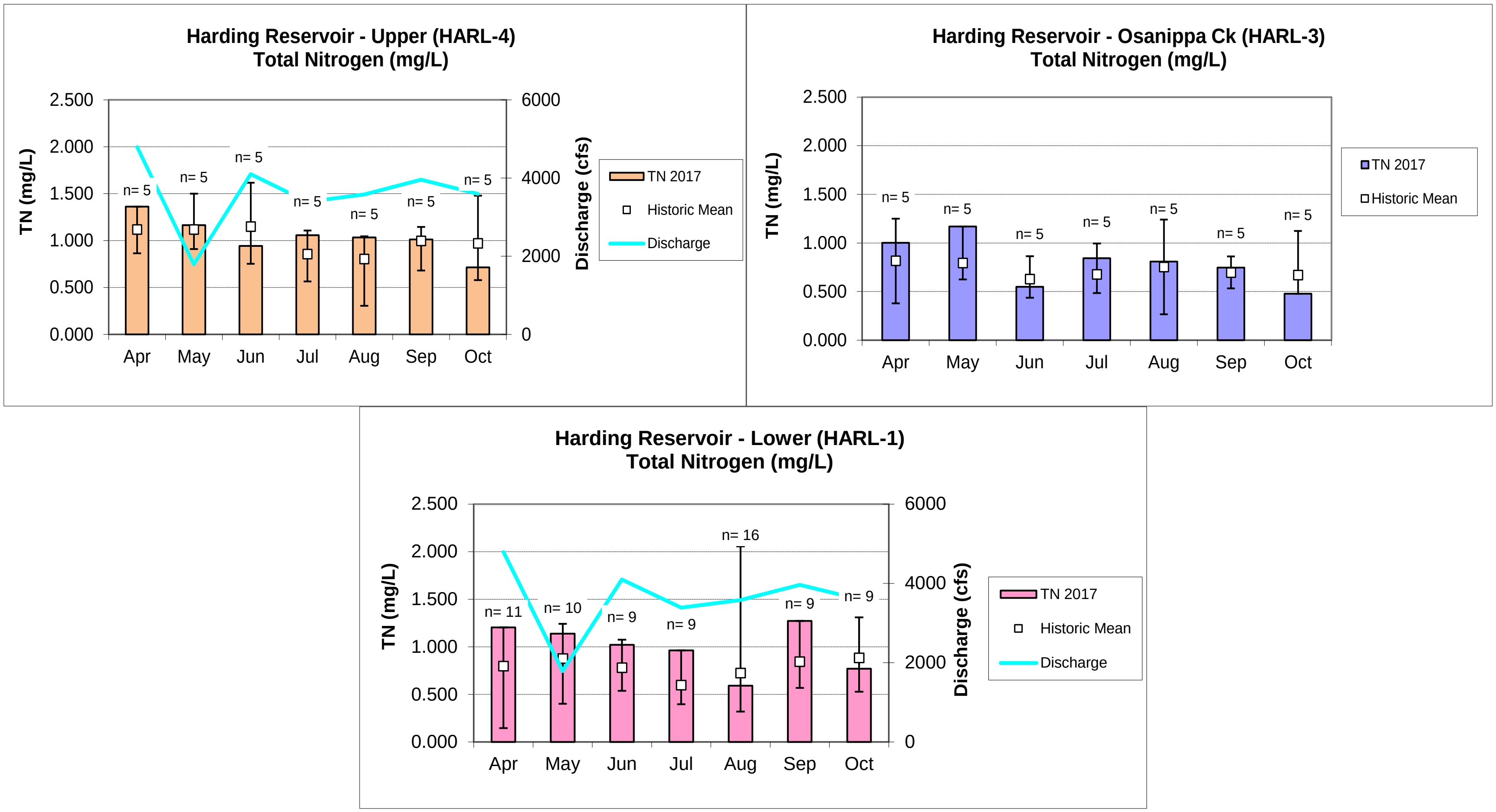
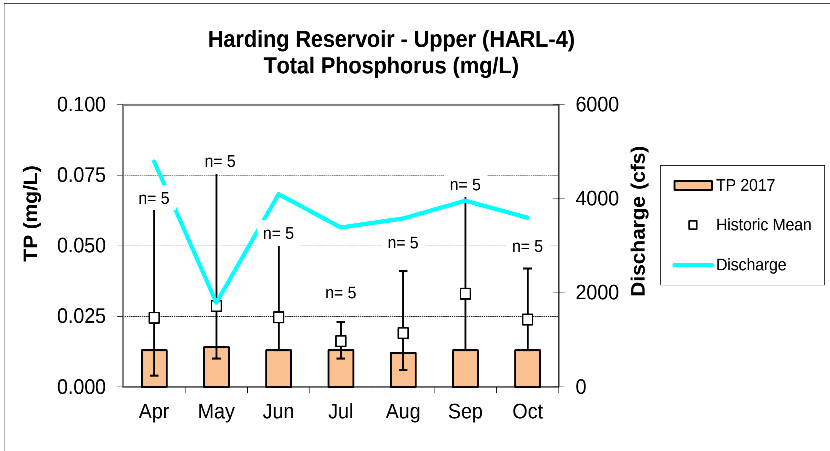
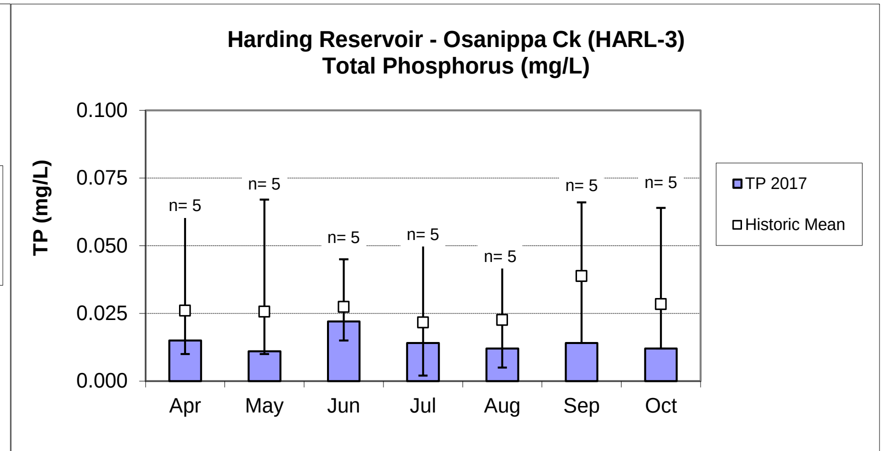


Figure 5. Monthly TP concentrations measured in Harding Reservoir, April-October 2017 vs. average monthly discharge. Monthly discharge acquired from USACE at West Point Dam. Each bar graph depicts monthly changes in each station. The historic mean (1990-2017) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





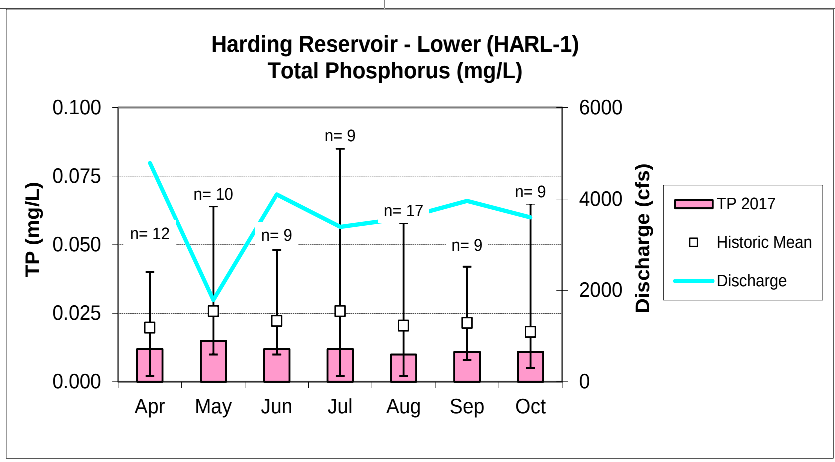


Figure 6. Monthly chl *a* concentrations measured in Harding Reservoir, April-October 2017 vs. average monthly discharge. Monthly discharge acquired from USACE at West Point Dam. Each bar graph depicts monthly changes in each station. The historic mean (1990-2017) and min/max ranges are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations. The scale of the vertical axis of the upper station is smaller than the other two stations to allow visibility of the results.

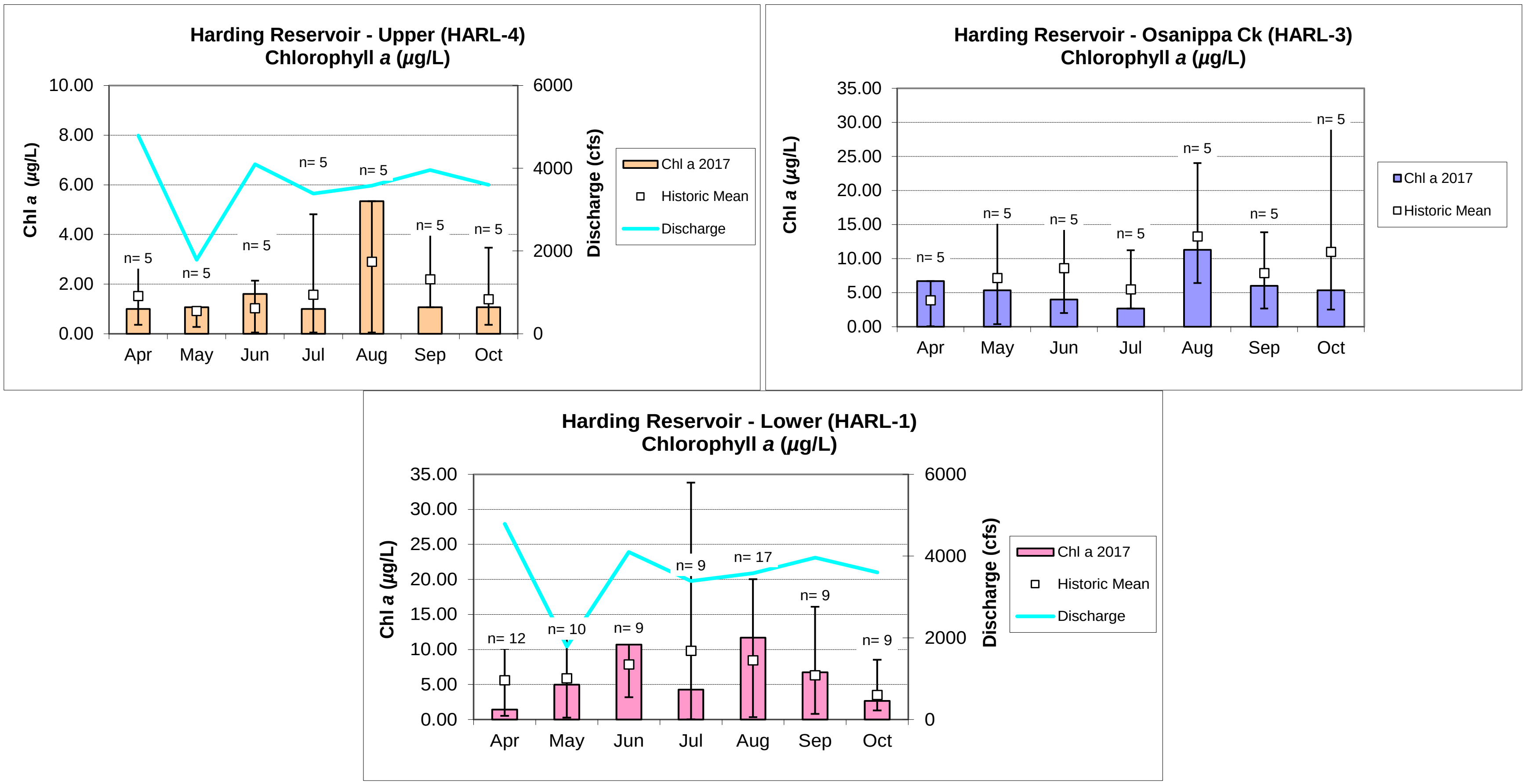
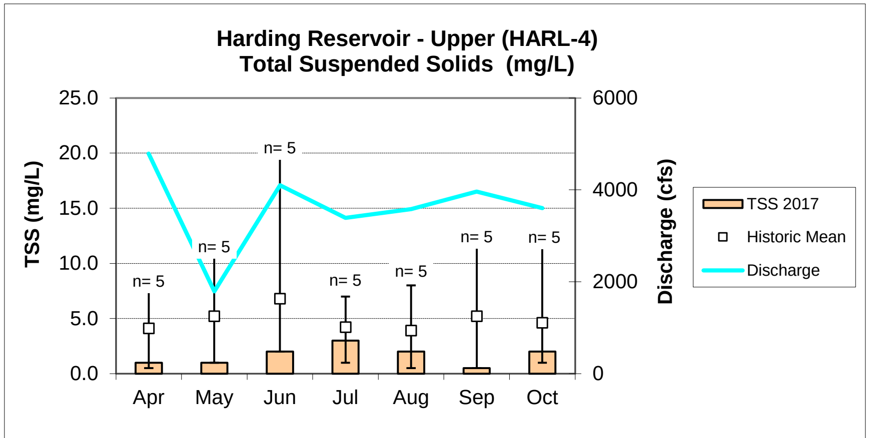
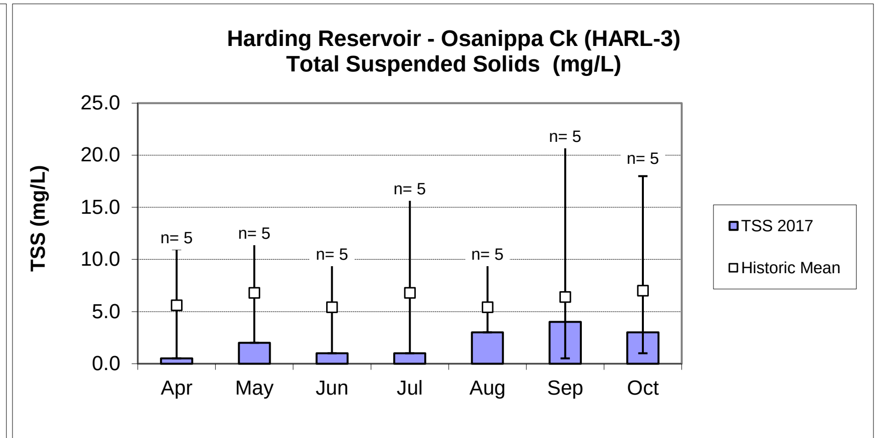


Figure 7. Monthly TSS concentrations measured in Harding Reservoir, April-October 2017 vs. average monthly discharge. Monthly discharge acquired from USACE at West Point Dam. Each bar graph depicts monthly changes in each station. The historic mean (1990-2017) and min/max range are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations.





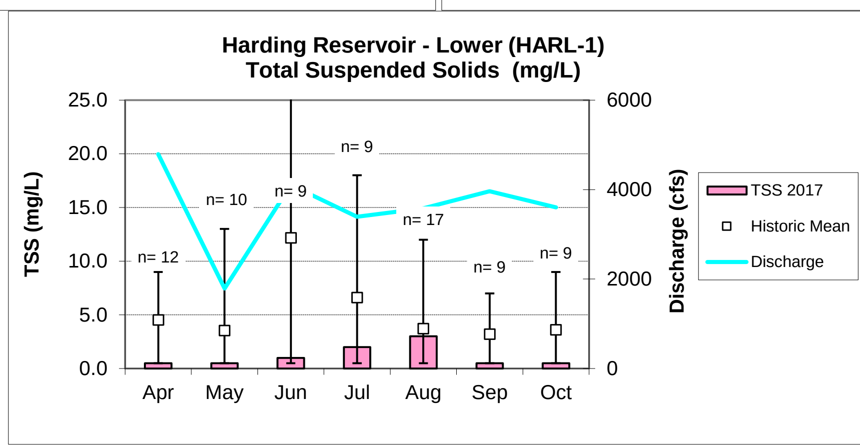


Table 2. Algal growth potential test results, Harding Reservoir, 1999-2017 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers (Raschke and Schultz 1987).

	Upper		**Osanippa Creek**		**Halawakee Creek**		**Lower**	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
June 1999	5.18	Phosphorus	6.99	Phosphorus	1.57	Phosphorus	1.34	Phosphorus
July 1999	6.14	Phosphorus	2.74	Phosphorus	3.43	Phosphorus	2.48	Phosphorus
August 1999	2.62	Phosphorus	1.74	Phosphorus	1.51	Phosphorus	1.84	Phosphorus
August 2004	5.27	Phosphorus	*	*	2.47	Phosphorus	2.36	Phosphorus
August 2008	*	*	*	*	3.93	Phosphorus	3.59	Phosphorus
August 2014	*	*	*	*	5.53	Phosphorus	4.39	Phosphorus
August 2017	*	*	3.8	Phosphorus	*	*	*	*

* No AGPT sample collected at this location.

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Harding Reservoir stations collected April-October 2017. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2010).

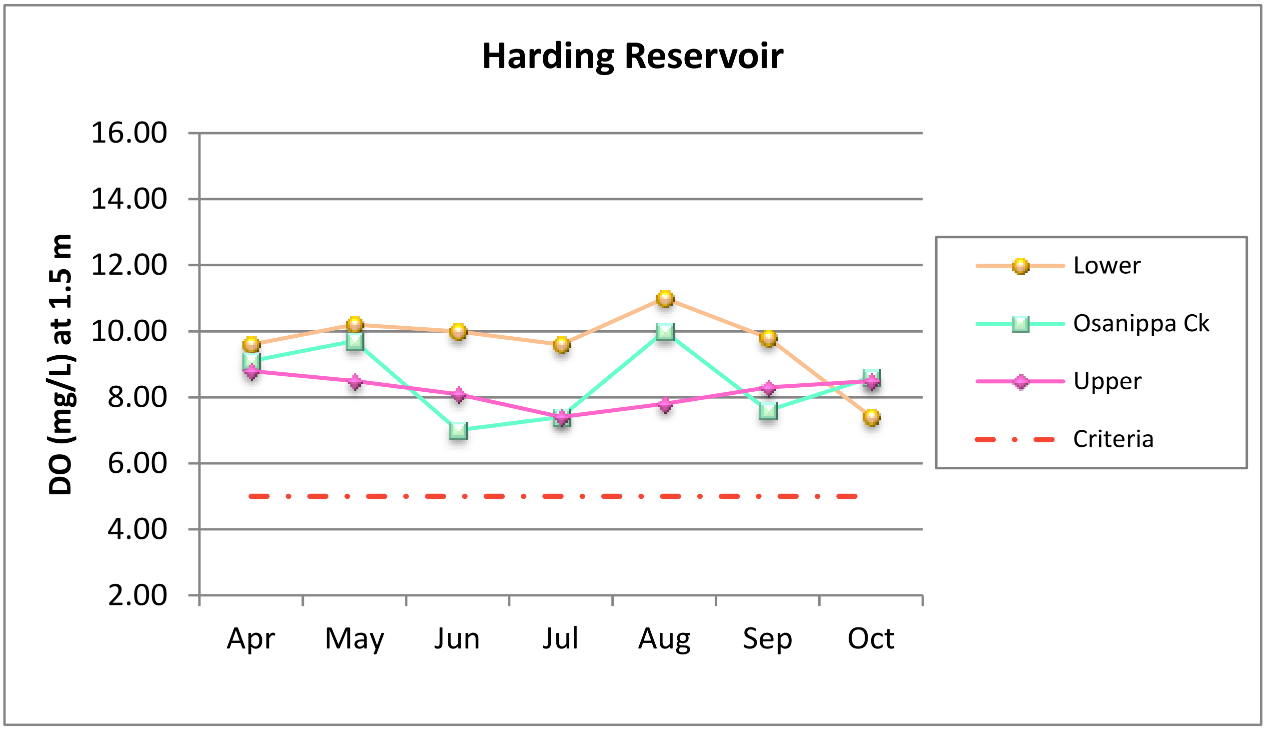


Figure 9. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the lower Harding Reservoir station, April-October 2017.

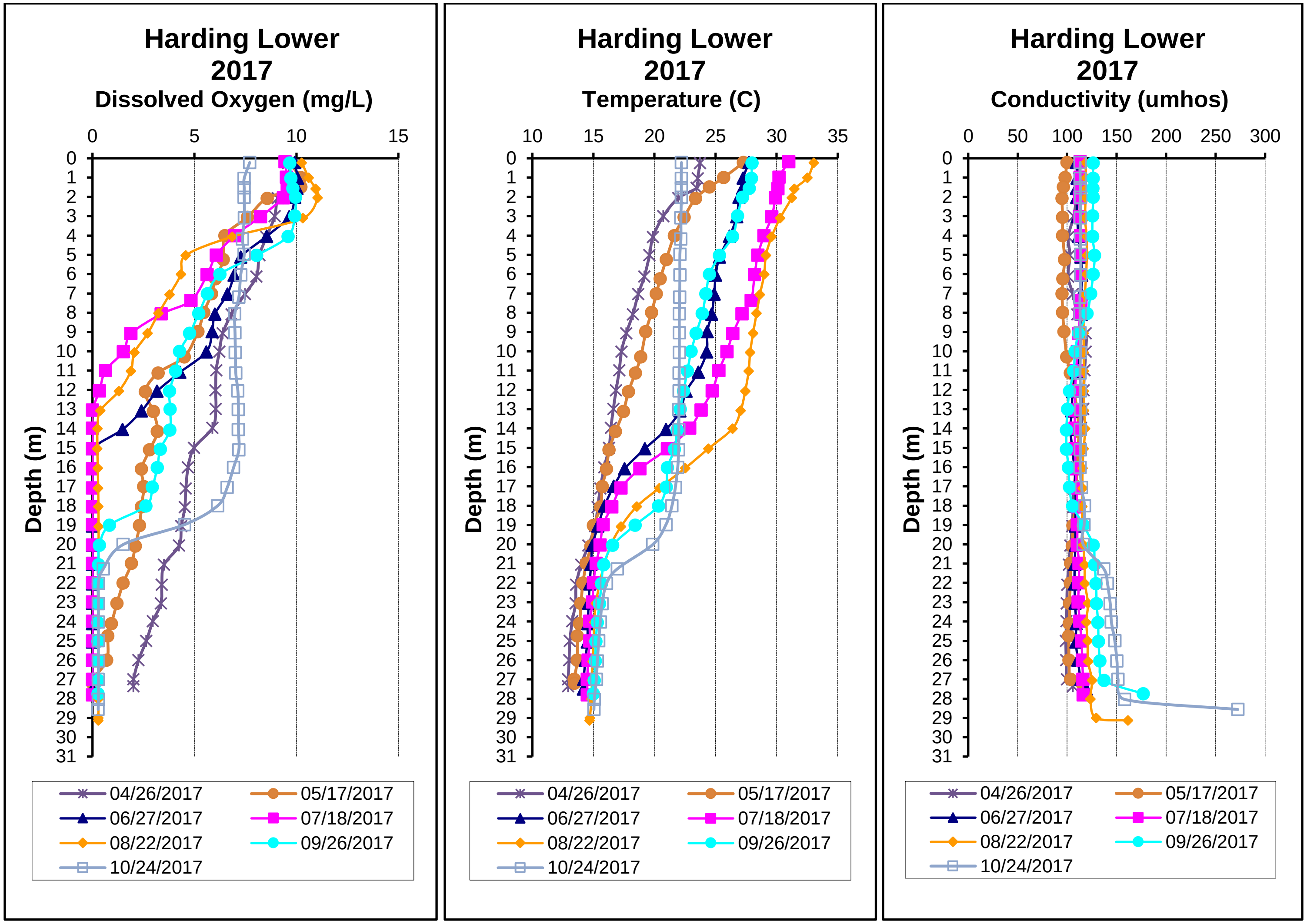


Figure 10. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the upper Harding Reservoir station, April-October 2017.

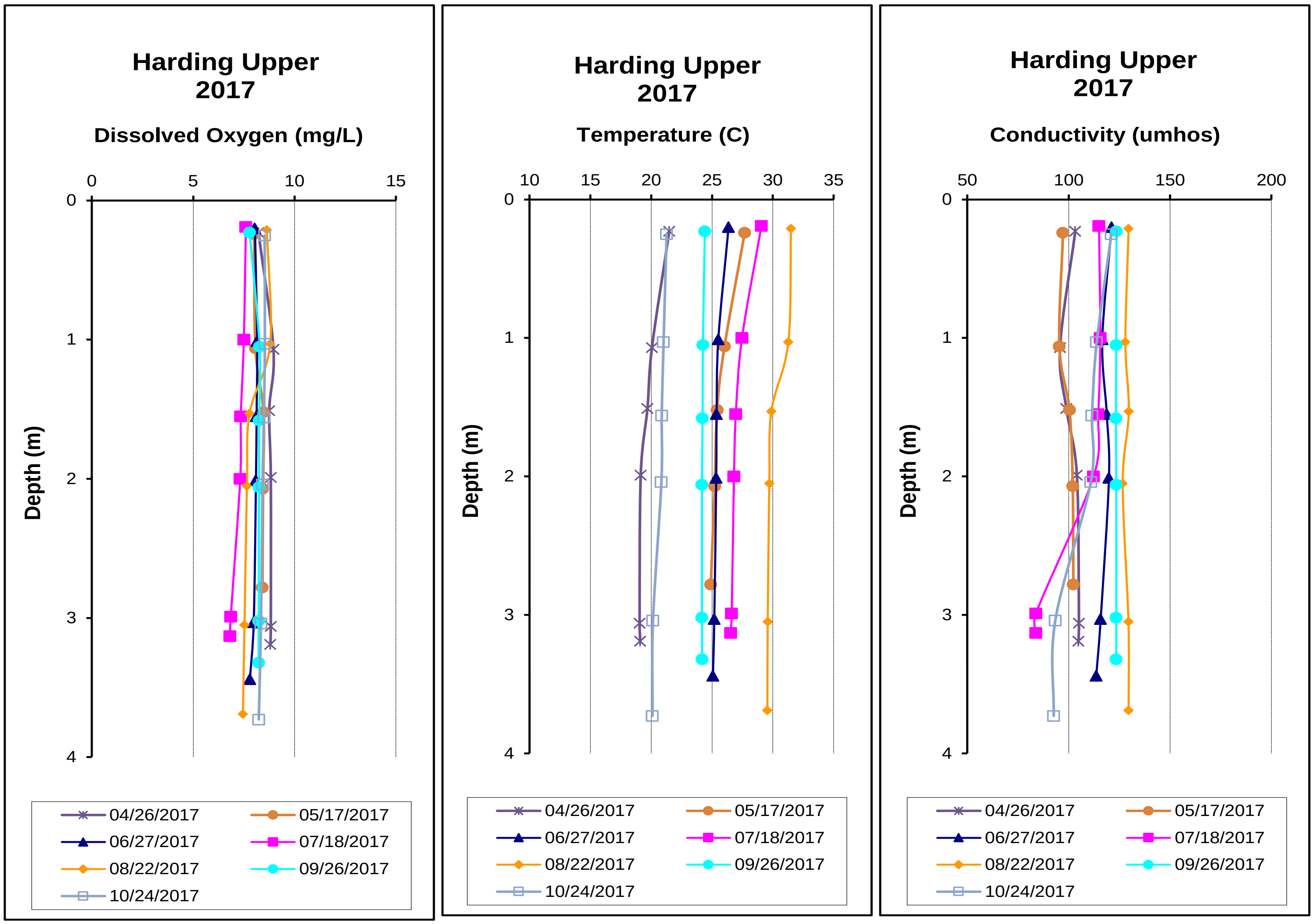
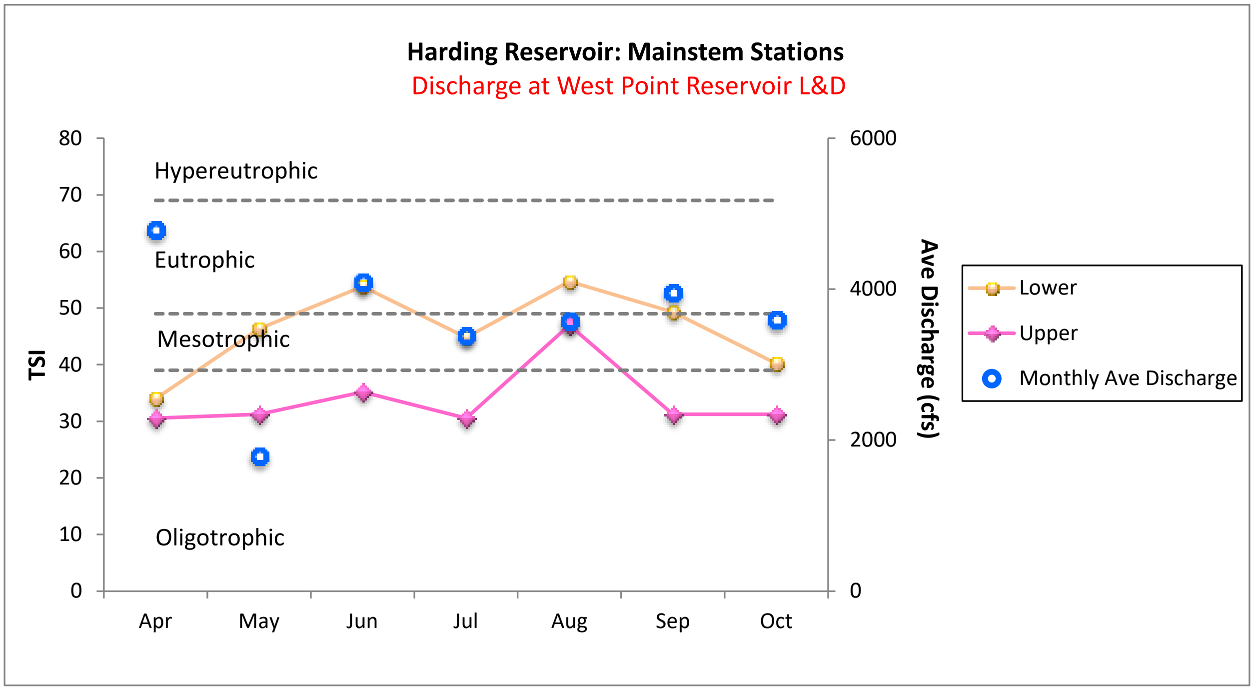
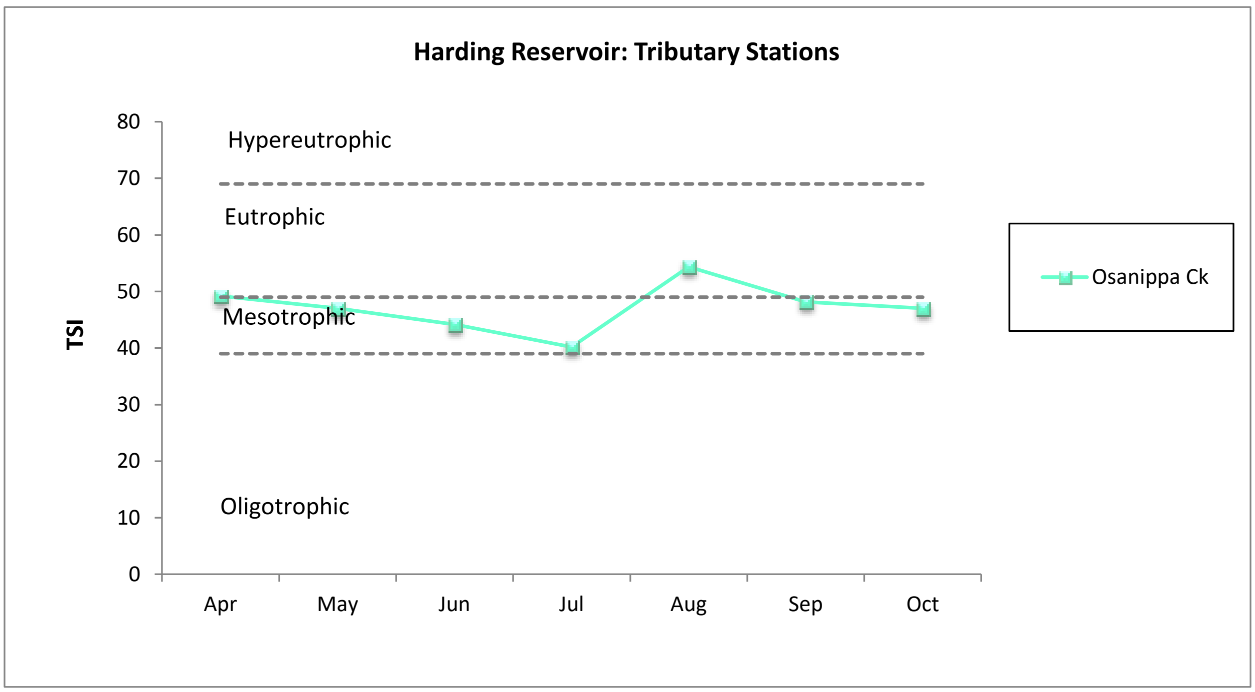


Figure 11. Monthly TSI values, April-October 2017, calculated for mainstem and tributary Harding Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation. Monthly discharge acquired from USACE at West Point Lock and Dam.





REFERENCES

ADEM. 2017 (as amended). Standard Operating Procedures Series #2000, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2013. Quality Management Plan (QMP) for the Alabama Department of Environmental Management (ADEM) Rev 4, Montgomery, AL. 58 pp.

ADEM. 2017. Quality Assurance Project Plan (QAPP) for Surface Water Quality Monitoring in Alabama Rev 1.3. Alabama Department of Environmental Management (ADEM), Montgomery, AL. 2/6/2017

ADEM. 2017 (draft). State of Alabama Water Quality Monitoring Strategy June 19, 2012. Alabama Department of Environmental Management (ADEM), Montgomery, AL. 108 pp. http://www.adem.alabama.gov/programs/water/wqsurvey/2012WQMonitoringStrategy.pdf

Alabama Department of Environmental Management Water Division (ADEM Admin. Code R. 335-6-10-.09). 2017. Specific Water Quality Criteria. Water Quality Program. Chapter 10. Volume 1. Division 335-6.

Alabama Department of Environmental Management Water Division (ADEM Admin. Code R. 335-6-10-.11). 2017. Water Quality Criteria Applicable to Specific Lakes. Water Quality Program. Chapter 10. Volume 1. Division 335-6.

Carlson, R.E. 1977. A trophic state index. Limnology and Oceanography. 22(2):361-369.

Raschke, R.L. and D.A. Schultz. 1987. The use of the algal growth potential test for data assessment. Journal of Water Pollution Control Federation 59(4):222-227.

APPENDIX

Appendix Table 1. Summary of Harding Reservoir water quality data collected April-October, 2017. 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
HARL-1	**Physical**							
	Turbidity (NTU)	7		2.6	6.1	3.9	4.1	1.2
	Total Dissolved Solids (mg/L)	7		32.0	75.0	61.0	60.1	14.1
	Total Suspended Solids (mg/L)	7	<	1.0	3.0	0.5	1.1	1.0
	Hardness (mg/L)	4		25.7	31.2	28.6	28.6	2.3
	Alkalinity (mg/L)	7		22.2	30.3	26.6	26.1	2.7
	Photic Zone (m)	7		3.33	5.48	4.55	4.51	0.81
	Secchi (m)	7		1.59	2.45	1.86	1.90	0.30
	Bottom Depth (m)	7		27.2	29.1	27.8	27.9	0.7
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.004	0.048	0.004	0.015	0.019
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.292	0.856	0.630	0.605	0.177
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.253	0.571	0.348	0.389	0.111
	Total Nitrogen (mg/L)[J]	7		0.593	1.273	1.021	0.995	0.244
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.002	0.005	0.003	0.003	0.001
	Total Phosphorus (mg/L)	7		0.010	0.015	0.012	0.012	0.002
	CBOD-5 (mg/L)	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		8.6	11.1	9.6	9.6	0.8
	Biological							
	Chlorophyll a (mg/m³)	7		1.42	11.70	4.98	6.07	3.90
	E. coli (MPN/DL)[J]	4		1	19	2	6	9
HARL-2	**Physical**							
	Turbidity (NTU)	7		5.3	15.1	7.0	9.4	4.2
	Total Dissolved Solids (mg/L)	7		41.0	65.0	59.0	54.9	9.1
	Total Suspended Solids (mg/L)	7	<	1.0	4.0	2.0	2.1	1.3
	Hardness (mg/L)	4		22.8	30.6	26.0	26.4	3.2
	Alkalinity (mg/L)	7		23.8	30.6	26.9	26.5	2.4
	Photic Zone (m)	7		2.01	3.65	2.97	2.80	0.61
	Secchi (m)	7		0.84	1.78	1.36	1.27	0.35
	Bottom Depth (m)	7		5.0	5.8	5.0	5.2	0.3
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.004	0.048	0.019	0.020	0.016
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.288	0.669	0.386	0.442	0.150
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.135	0.782	0.333	0.357	0.214
	Total Nitrogen (mg/L)[J]	7		0.476	1.168	0.808	0.799	0.241
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.002	0.004	0.003	0.003	0.001
	Total Phosphorus (mg/L)	7		0.011	0.022	0.014	0.014	0.004
	CBOD-5 (mg/L)	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		4.9	9.6	7.2	7.3	1.6
	Biological							
	Chlorophyll a (mg/m³)	7		2.67	11.30	5.34	5.91	2.72
	E. coli (MPN/DL)[J]	4		1	26	7	10	11

Station	Parameter	N		Min	Max	Med	Mean	SD
HARL-4	**Physical**							
	Turbidity (NTU)	7		3.0	11.8	5.0	5.9	3.3
	Total Dissolved Solids (mg/L)	7	<	1.0	88.0	65.0	60.1	27.6
	Total Suspended Solids (mg/L)	7	<	1.0	3.0	2.0	1.6	0.8
	Hardness (mg/L)	4		27.5	33.1	28.2	29.3	2.6
	Alkalinity (mg/L)	7		21.4	30.2	25.8	25.8	3.0
	Photic Zone (m)	7		2.81	3.69	3.20	3.22	0.30
	Secchi (m)	7		1.13	2.56	2.38	2.02	0.56
	Bottom Depth (m)	7		3.1	3.7	3.3	3.4	0.2
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.004	0.102	0.062	0.054	0.036
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.522	0.974	0.678	0.732	0.150
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.077	0.499	0.380	0.309	0.154
	Total Nitrogen (mg/L)	7	<	0.715	1.362	1.033	1.041	0.198
	Dis Reactive Phosphorus (mg/L)[J]	7	<	0.002	0.005	0.003	0.003	0.002
	Total Phosphorus (mg/L)	7		0.012	0.014	0.013	0.013	0.001
	CBOD-5 (mg/L)	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		9.2	11.0	9.7	9.9	0.7
	Biological							
	Chlorophyll a (mg/m³)	7		0.36	5.34	1.07	1.58	1.71
	E. coli (MPN/DL)[J]	4		1	76	27	33	32

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