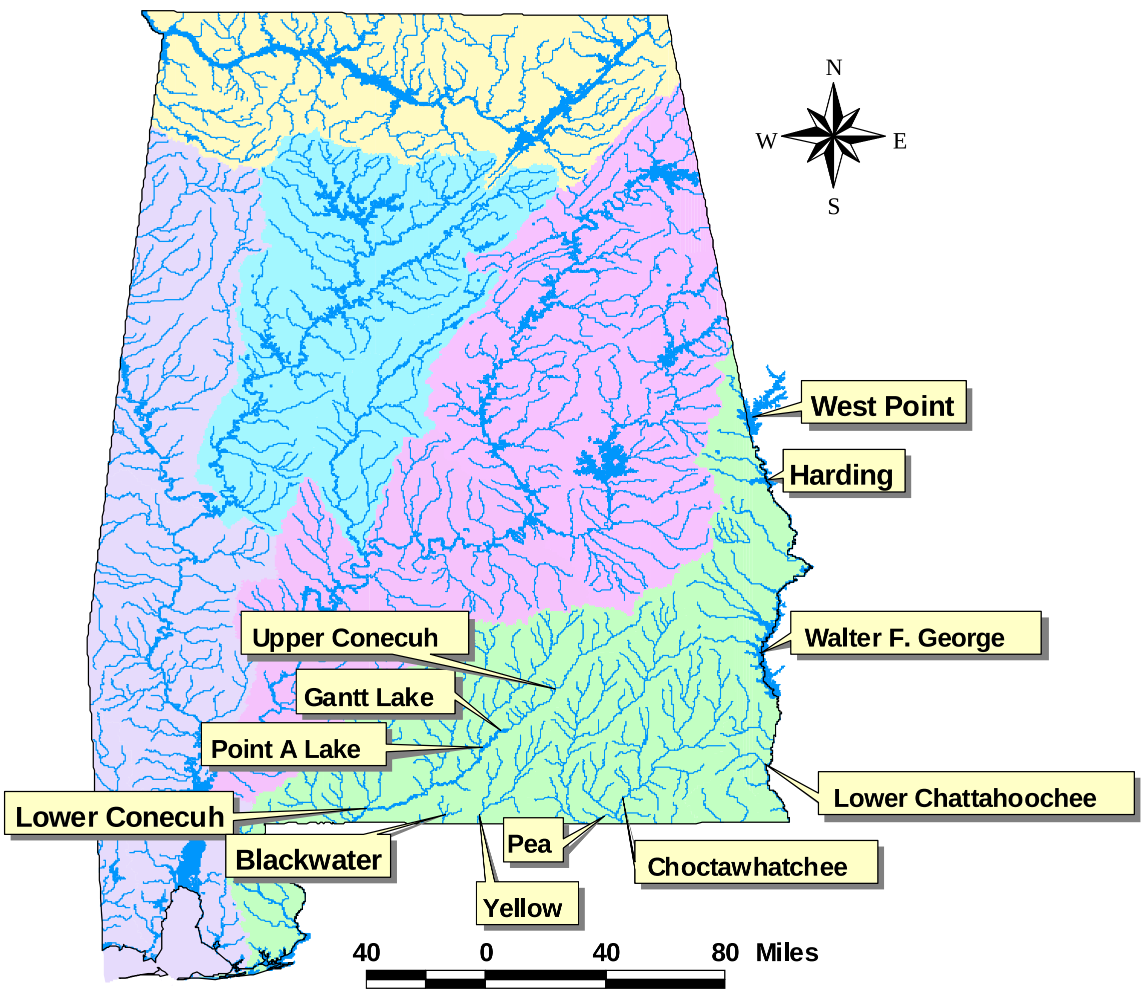
Surface Water Quality Screening Assessment of Southeast Alabama River Basins-2004

Part II: Rivers, Reservoirs, and Tributaries



Environmental Indicators Section – Field Operations Division
Alabama Department of Environmental Management

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Report Date: September 25, 2006

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FINAL REPORT

Preface

This project was funded or partially funded by the Alabama Department of Environmental Management utilizing a Clean Water Act Section 319(h) nonpoint source demonstration grant provided by the U.S. Environmental Protection Agency - Region 4.

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EXECUTIVE SUMMARY

In 2004, intensive monitoring of rivers and reservoirs in Southeast Alabama was conducted in an effort to address nutrient effects and to assist in development of total maximum daily loads as required by Section 303(d) of the Clean Water Act. Objectives of this survey were to:

a) assess the water quality of rivers, reservoirs, and tributary embayments in Southeast Alabama;
b) identify rivers, reservoirs, and tributary embayments most impacted by point and nonpoint source (NPS) pollution; and,
c) assist the Nonpoint Source Unit of the ADEM in prioritization of subwatersheds by determining the water quality of rivers and reservoirs.

Tributary embayment locations were targeted because embayments usually exhibit water quality characteristics that are more indicative of the tributary than of the mainstem reservoir. Selecting mainstem reservoir stations upstream and downstream of the tributary confluence allows a determination of the effects of the tributary inflows on the main body of the reservoir.

Sampling stations were determined using historical data and a previous assessment of the Chattahoochee River conducted in 1999. Water quality assessments were conducted at 32 locations throughout Southeast Alabama at monthly intervals April-October.

Chemical, physical, and biological variables were measured at each location to determine water quality and trophic state. Water quality data selected for further discussion consist of the following:

a) total nitrogen (TN) and total phosphorus (TP), used as indicators of nutrient content in the waterbody;
b) algal growth potential tests (AGPT), used as a determinant of the total quantity of algal biomass supportable by test waters and of the limiting nutrient;
c) corrected chlorophyll *a* (chl. a), used as an indicator of algal biomass;
d) Carlson Trophic State Index (TSI), calculated from corrected chlorophyll *a* concentrations as a means of trophic state classification of a reservoir or embayment;

e) total suspended solids (TSS), used as an indicator of sediment inflow; and,

f) dissolved oxygen (DO) concentrations, used as a more direct indicator of water quality.

These variables were selected because of their relationship to the process of eutrophication and their interest to the regulatory and scientific communities that stems from this relationship.

In September of 2004, southeast Alabama was significantly affected by the category III storm-Hurricane Ivan. The entire area received heavy rainfall with the effects to water quality of the Southeast Alabama river basins apparent in many September values. Rainfall totals can be seen in Figure 10.

Chattahoochee River Basin

West Point Reservoir

Mean TN in upper West Point Reservior was higher than any other location in the Chattahoochee River basin (Fig. 11). Mean TN in lower West Point was third highest of Chattahoochee basin mainstem locations. Mean TN concentrations at all three West Point stations were lower in 2004 than in 1999 (Fig. 12). Mean TP concentrations for West Point mainstem stations were similar to those of Harding and WF George (Fig. 13). Mean TP concentrations for all West Point stations in 2004 were more than three times any TP concentrations for 1999 (Fig. 14).

Mean chlorophyll *a* concentration in upper West Point was highest of all Chattahoochee Basin locations (Fig. 15). However, chlorophyll *a* in upper West Point was well below the criteria limit of 27 ug/l adopted by the ADEM in 2001. Wehadkee Creek embayment had the third highest mean chlorophyll *a* concentration of all Chattahoochee River tributary embayments sampled in 2004 (Fig. 15). Mean chlorophyll *a* concentrations for all West Point stations were higher in 2004 than in 1999 (Fig. 16).

AGPT results indicated that all West Point locations were phosphorus limited, with mean maximum standing crop (MSC) values well below the maximum 5.0 mg/l level suggested to assure protection from nuisance algal blooms and fish-kills in southeastern lakes (Table 5).

Trophic status (TSI) for all West Point locations remained in the eutrophic range throughout the sampling season (Fig. 21).

Mean TSS concentration for upper West Point was lower than upper reservoir stations at Harding and WF George (Fig. 17). West Point mean TSS concentrations for mainstem stations in 2004 were lower or similar to 1999.

Dissolved oxygen concentrations were above the ADEM Water Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/l for all stations in all months (Fig. 21). A strong chemocline existed in Upper West Point and Lower West Point from May – August with more than 60% of the water column deoxygenated during that period (Figs. 22 and 23). For Wehadkee Creek embayment, deoxygenation occurred in more than 50% of the water column from May to August (Fig. 24). A thermocline existed in lower West Point and Wehadkee Creek embayment from April to June (Figs. 23 and 24).

Harding Reservoir

Mean TN concentration in upper Harding Reservoir was second highest of the Chattahoochee River basin mainstem locations (Fig. 11). Monthly TN concentration in upper Harding was consistently higher than in other Harding Reservoir locations (Fig. 25). Mean TN concentrations for Harding Reservoir were slightly higher in 2004 than 1999 at all locations except Halawakee Creek embayment (Fig. 12). Mean TP concentrations in Harding were similar to other Chattahoochee River basin locations (Fig 13). Mean TP concentrations at all Harding stations in 2004 were higher than previous years of sampling (Fig. 14).

AGPT results indicated that phosphorus was the limiting nutrient at all three Harding stations. The mean maximum standing crop (MSC) value at upper Harding was above the maximum 5.0 mg/l level suggested to assure protection from nuisance algal blooms and fish-kills in southeastern lakes (Table 5).

Mean chlorophyll *a* concentration for lower Harding was the lowest of any mainstem reservoir station in the Chattahoochee basin (Fig. 15). Mean chlorophyll *a* concentration for lower Harding was well below the criteria limit of 15 mg/l (Fig. 15). Mean chlorophyll *a* concentrations for Harding locations in 2004 were similar to 1999 (Fig. 16). Chlorophyll *a* concentrations at Halawakee Creek embayment and lower Harding were higher in 2002 than any other years of sampling.

The TSI for upper Harding maintained oligotrophic status for most of the sampling season (Fig. 27). All other Harding locations ranged from mesotrophic to eutrophic April – October.

Mean TSS in Halawakee Creek was the lowest of any tributary embayment in the basin (Fig 17). Mean TSS concentrations for Harding Reservoir locations in 2004 were similar to or higher than TSS concentrations in 1999 (Figure 18).

Dissolved oxygen concentrations were above the ADEM Water Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/l for all stations in all months (Fig. 27). Dissolved oxygen and temperature profiles in lower Harding indicated that the lower half of the water column was essentially deoxygenated in June and August (Fig. 29). A thermocline existed in the upper portion of the water column at lower Harding from April – June and in the lower portion of the water column from June – October (Fig. 29). In Halawakee Creek embayment, deoxygenation occurred near the bottom from June to August (Fig. 31).

WF George Reservoir

Mean TN concentrations in lower WF George Reservoir were the lowest of Chattahoochee river or mainstem reservoir stations (Fig. 11). Mean TN concentrations for WF George tributaries were among the lowest of all Chattahoochee River basin tributary embayments sampled in 2004. Mean TN concentrations at all three WF George mainstem stations were higher in 2004 than 1999 (Fig. 12). Mean TP concentration for upper WF George was second highest of Chattahoochee basin mainstem locations (Fig. 13). Mean TP concentrations were higher in 2004 than in 1999 (Fig. 14). TN and TP concentrations in mid WF George were highest during June (Fig. 32).

Although the limiting nutrient for upper WF George was not determined in AGPT tests, the maximum standing crop (MSC) value exceeded the 5.0 mg/l level suggested to assure protection from nuisance algal blooms and fish-kills in southeastern lakes (Table 5). Mid WF George was phosphorus limited with nitrogen and phosphorus co-limiting in lower WF George. MSC values for both mid and lower reservoir were below 5.0 mg/l.

Mean chlorophyll *a* concentrations for mid WF George and lower WF George were below the ADEM's criteria limits of 18.00 ug/l and 15.00 ug/l respectively (Fig. 15). Mean chlorophyll *a* concentrations for WF George tributaries were among the highest of the Chattahoochee River basin tributary embayments sampled (Fig. 15). Mean chlorophyll *a* in Cowikee Creek was highest and Hatchechubee Creek second highest of all tributaries sampled. Mean chlorophyll *a* concentrations for WF George locations were higher in 2004 than 1999 with the exception of mid reservoir (Fig. 16). Trophic status remained between the mesotrophic and lower eutrophic range for all WF George locations (Fig. 34).

Mean TSS concentrations for upper WF George and lower WF George were higher than other mainstem locations in the Chattahoochee River basin (Figure 17). Mean TSS concentration for Uchee Creek was highest of all WF George tributaries and third highest of all Chattahoochee tributaries sampled (Fig. 17). TSS concentration for mid WF George in September was nearly three times higher than any other month of the sampling period (Fig 33). Approximately 3-5 inches of rain fell in the WF George watershed following landfall of Hurricane Ivan and prior to the September sampling event (Fig. 10).

DO concentrations for all WF George mainstem locations remained above the ADEM criterion limit of 5.0 mg/l for the entire sampling season (Fig. 34). Dissolved oxygen profiles indicated that more than 50% of the water column was deoxygenated from May to August at mid WF George (Fig. 36). During July, mid WF George water temperature exceeded 30 degrees C to more than 6 meters depth (Fig. 36). In Cowikee Creek embayment, over 50% of the water column was deoxygenated May to August (Fig. 40). Thermoclines rarely developed for the WF George locations sampled in 2004 (Figs. 35-42).

Lower Chattahoochee River

Mean TN concentrations for the lower Chattahoochee River locations were among the lowest of any Chattahoochee mainstem locations (Fig. 11). However, mean TN values for Abbie and Omussee creeks were the highest of all Chattahoochee River basin tributary embayments. TN concentration for Omussee creek was nearly two times higher than any other tributary embayment (Fig. 11). Mean TP concentration in the Chattahoochee River at Hwy 52 was the lowest, with Chattahoochee River at the Stateline the highest, of mainstem locations in the Chattahoochee basin (Fig. 13). Mean TP concentrations in Omussee Creek and Abbie Creek were the highest of Chattahoochee tributary embayments sampled.

AGPT results indicated that both Chattahoochee River mainstem locations were phosphorus limited (Table 5). Mean MSC values for both lower Chattahoochee River locations were below the suggested protection limit of 20 mg/l for streams or rivers (Raschke *et al.* 1996).

Mean chlorophyll *a* concentrations for the Lower Chattahoochee River locations were well below those of most upstream locations on the Chattahoochee River (Fig. 15). Mean chlorophyll *a* concentrations in Abbie and Omussee tributary embayments were the lowest of Chattahoochee tributaries (Fig. 15). The Lower Chattahoochee River stations were oligotrophic throughout most of the year (Fig. 44).

Mean TSS concentrations for Lower Chattahoochee River stations were lower than any WF George locations (Fig. 17). Mean TSS concentrations in Abbie and Omussee were the highest of any Chattahoochee tributary embayment sampled (Fig. 17).

DO concentrations in the Lower Chattahoochee River at Hwy 52 were below the criterion limit of 5.0 mg/l for the majority of the sampling season (Fig. 44). With the exception of July, DO concentrations at other Lower Chattahoochee River stations remained above 5.0 mg/l. Dissolved oxygen and temperature profiles indicated the water column remained well-mixed in all Lower Chattahoochee River locations throughout the sampling season (Figs. 45-48).

Perdido/Escambia/Choctawhatchee River Basin

Conecuh River at Hwy 331

The mean TN concentration for the Hwy 331 location was higher than any other Conecuh River location (Fig. 49). Mean TP concentration for Conecuh River at the Stateline was highest of the Conecuh River locations (Fig. 49).

AGPT results indicated that the Conecuh River at Hwy 331 was phosphorus limited (Table 6). MSC concentration was below the suggested 20 ug/l protection limit suggested for streams and rivers.

Mean chlorophyll *a* concentration for the Hwy 331 location was the lowest of the Conecuh River stations sampled in 2004 (Fig. 52). With exception of June, Conecuh River at Hwy 331 remained oligotrophic throughout the sampling season (Fig. 56).

Mean TSS concentration for the Conecuh River at Hwy 331 was higher than Gantt or Point A reservoirs and lower than Conecuh River at Hwy 41 or Conecuh River at the Stateline (Fig. 52).

Dissolved oxygen concentrations remained above the criteria limit of 5.0 mg/l throughout the sampling season (Fig. 56). The water column was well-mixed throughout the sampling season (Fig. 57).

Gantt Reservoir

Mean TN and mean TP concentrations in Gantt Reservoir were similar to or lower than most Perdido, Escambia, Choctawhatchee (PEC) basin locations (Fig. 49). Mean TN concentration for lower Gantt Reservoir was higher in 2004 than 1999 (Fig. 50). Mean TP concentration for lower Gantt Reservoir was higher each year sampled 1999-2003, then decreased slightly in 2004 (Fig. 51).

AGPT tests conducted for Gantt Reservoir indicated that nitrogen and phosphorus were co-limiting in the upper reservoir with lower Gantt phosphorus limited (Table 6). Mean MSC values were well below the 5.0 mg/l limit suggested to assure protection from nuisance algal blooms and fish kills in southeastern lakes.

Mean chlorophyll *a* concentration in lower Gantt was less than half of the criteria limit of 11.00 mg/l established by the ADEM (Fig. 52). Mean chlorophyll *a* concentrations for both

Gantt Reservoir locations were lower in 2004 than in previous years sampled (Fig. 53). TSI values for upper Gantt and lower Gantt ranged from oligotrophic in April to slightly eutrophic in July (Fig. 60). TSI for upper Gantt returned to oligotrophic status in September. TSI for lower Gantt remained in the lower mesotrophic range for September and October.

Mean TSS concentrations in both Gantt Reservoir locations were among the lowest of PEC basin locations (Fig. 52). Mean TSS concentrations for both Gantt reservoir stations increased from 1999 to 2004 (Fig. 54).

Dissolved oxygen profiles from both locations in Gantt Reservoir indicated that the lower half of the water column was deoxygenated from May to August (Fig. 61 and 62). No distinct thermocline developed in the Gantt Reservoir locations during the sampling period (Figs. 61 and 62).

Point A Reservoir

Mean TN concentrations in Point A Reservoir were similar to or lower than most Perdido, Escambia, Choctawhatchee (PEC) basin locations (Fig. 49). Mean TN concentration in Patsaliga Creek embayment was lower than any other station sampled in the PEC basins (Fig. 49). Mean TN concentration for Patsaliga Creek embayment in 2004 was less than half of the 1999 mean TN concentration (Fig. 50). Mean TP concentration for lower Point A was similar to Gantt Reservoir mainstem locations (Fig. 49). Mean TP concentration for lower Point A increased each year of sampling from 1999-2003 (Fig. 49). Mean TP for lower Point A was slightly lower in 2004 than in 2003. Mean TP concentration for Patsaliga Creek embayment in 2004 was nearly three times higher than in 1999 (Fig. 51).

AGPT results indicate that both stations in Point A Reservoir were phosphorus limited and had mean MSC values well below the 5.0 mg/l level suggested to assure protection from nuisance algal blooms and fish kills in southeastern lakes (Table 6).

Mean chlorophyll *a* concentration for lower Point A was higher than the mainstem Conecuh River locations and slightly lower than Gantt Reservoir locations (Fig. 52). Mean chlorophyll *a* concentration for lower Point A was less than half the criteria value adopted by the ADEM (Fig. 52). Mean chlorophyll *a* concentration for lower Point A decreased steadily from 1999 to 2003 and then increased slightly from 2003 to 2004 (Fig. 53). TSI values indicated mostly mesotrophic conditions existed at lower Point A (Fig. 65). Dissolved oxygen concentrations were above criterion limits throughout the sampling season (Fig. 65).

Mean TSS concentration for lower Point A was second lowest of all PEC basin locations (Fig. 52). Mean TSS for lower Point A increased each year sampled 1999-2003, then decreased in 2004 (Fig. 54). Mean TSS for Patsaliga creek embayment was higher in 2004 than in 1999. Mean TSS decreased slightly at lower Point A from 2003 to 2004.

Depth profiles of oxygen and temperature in lower Point A indicated that the water column was chemically and thermally stratified during July (Fig. 66). Deoxygenation occurred near the bottom May – June, with more than 50% of the water column essentially deoxygenated in July. A thermocline existed in Patsaliga Creek embayment during May, July, and August (Fig. 67). Dissolved oxygen concentrations fell below 5.0 mg/l just below mid-depth in Patsaliga Creek during July.

Lower Conecuh River

Mean TN concentration for the Conecuh River at Hwy 41 and the Conecuh River at the Stateline were similar to Gantt and Point A Reservoirs but lower than the Conecuh River at Hwy 331 (Fig. 49). Mean TP concentration in the Conecuh River at the Stateline was the highest of the locations within the Perdido-Escambia basin and lower than any location in the Choctawhatchee basin (Fig. 49).

AGPT results indicate that both the Stateline location and Hwy 41 location were phosphorus limited (Table 6). Mean MSC values for both lower Conecuh River locations were higher than other Perdido-Escambia locations, but lower than the suggested protection limit of 20 mg/l for streams or rivers.

Mean chlorophyll *a* concentration for Conecuh River at the Stateline was lower than Gantt or Point A Reservoir but higher than other riverine sampling location within the Perdido, Escambia, Choctawhatchee (PEC) basin (Fig. 52). TSI values for both lower Conecuh River locations ranged from mesotrophic to oligotrophic during the sampling season (Fig. 69).

Mean TSS concentrations in the Hwy 41 location and the Stateline location were second and third highest respectively of all PEC basin locations (Fig. 52).

The water column in the lower Conecuh River locations was well-mixed and had dissolved oxygen concentrations above 5.0 mg/l throughout the sampling season (Fig. 70 and 71).

Blackwater River

Mean TN concentration in the Blackwater River was similar to or lower than other locations in the Perdido-Escambia basin and considerably lower than Choctawhatchee basin locations (Fig. 49). Mean TP concentration in Blackwater River was among the lowest of all PEC basin locations sampled (Fig. 49).

AGPT results for Blackwater River indicate there was no limiting nutrient and the mean MSC value was the lowest of all PEC locations (Table 6).

Mean chlorophyll *a* concentration and TSS concentration in Blackwater River were among the lowest of the PEC basin (Fig. 52). TSI values for Blackwater River remained in the oligotrophic range throughout the sampling season (Fig. 73).

The water column for the Blackwater River was well-mixed throughout the sampling season (Fig. 74). Dissolved oxygen concentrations remained above 5.0 mg/l throughout the sampling season (Fig. 73).

Yellow River

Mean TN, TP and chlorophyll *a* concentrations in the Yellow River were among the lowest of all mainstem locations sampled in the PEC basin (Figs. 49 and 52).

AGPT results indicated that the Yellow River was phosphorus limited (Table 6). The mean MSC value was well below the suggested 20 mg/l protection limit.

Mean chlorophyll *a* concentration in the Yellow River was the lowest of the PEC basin locations (Fig. 52). TSI values were in the oligotrophic range through most of the sampling season (Fig 76).

Mean TSS concentration for the Yellow River was among the lowest of the river locations in the PEC basin (Fig. 52).

Dissolved oxygen concentrations were adequate throughout the sampling season (Figs. 76 and 77).

Pea River

Mean TN and TP concentrations in the lower Pea River and upper Pea River were third and fourth highest respectively of the PEC basin locations (Fig. 49).

AGPT tests indicated that both Pea River locations were phosphorus limited (Table 6). Mean MSC values for the Pea River locations were below the 20 mg/l protection limit for streams and rivers.

Mean chlorophyll *a* concentrations for Pea River locations were similar to values from the Choctawhatchee River locations and similar to or lower than Conecuh River locations (Fig. 52). TSI values for both Pea River locations remained primarily in the oligotrophic range throughout the sampling season (Fig. 79).

Mean TSS concentration in lower Pea was nearly two times higher than upper Pea (Fig. 52). TSS increased sharply in June at lower Pea, with a higher value recorded in October (Fig. 78).

Dissolved oxygen concentrations in both Pea River locations remained above the ADEM criterion limit of 5.0 mg/l throughout the sampling season (Fig. 79). Dissolved oxygen and temperature profiles indicate that the water column was well mixed from April to October (Figs. 80 and 81).

Choctawhatchee River

Mean TN concentration in both upper Choctawhatchee and lower Choctawhatchee were higher than any other PEC basin location (Fig. 49). Mean TP concentrations for both Choctawhatchee locations were also highest of the PEC basin locations (Fig. 49).

AGPT results indicated that nitrogen and phosphorus were co-limiting in the lower Choctawhatchee River (Table 6). Mean MSC values for both locations were much higher than other PEC basin locations, but remained below the 20 mg/l protection limit for streams and rivers.

Mean chlorophyll *a* concentration for lower Choctawhatchee was second highest of the river locations from the PEC basin (Fig. 52). TSI values were in the mesotrophic to oligotrophic range throughout the sampling season (Fig 83).

Mean TSS concentration in lower Choctawhatchee was higher than any other location in the PEC basin (Fig. 52). In upper Choctawhatchee, TSS concentration and discharge were much higher in June than other months (Fig. 82). TSS concentration at lower Choctawhatchee increased sharply from September to October.

Dissolved oxygen concentrations remained above the 5.0 mg/l criterion limit throughout the sampling season (Fig. 83).

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INTRODUCTION

ADEM Reservoir Water Quality Monitoring Program

Section 314 of the Water Quality Act of 1987 requires states to conduct assessments of the water quality of publicly-owned lakes and report the findings as part of their biennial 305(b) Water Quality Report To Congress. Prior to 1997, funding for the assessments was provided by Lake Water Quality Assessment (LWQA) grants administered through the Clean Lakes Program of the United States Environmental Protection Agency (EPA). Submittal to the EPA of approved lakes assessment information from states ensured continued eligibility for financial assistance under the Clean Lakes Program. With the discontinuance of Clean Lakes Program funding, water quality assessments are currently conducted using funding from a variety of sources, including Clean Water Act Section 319 funds.

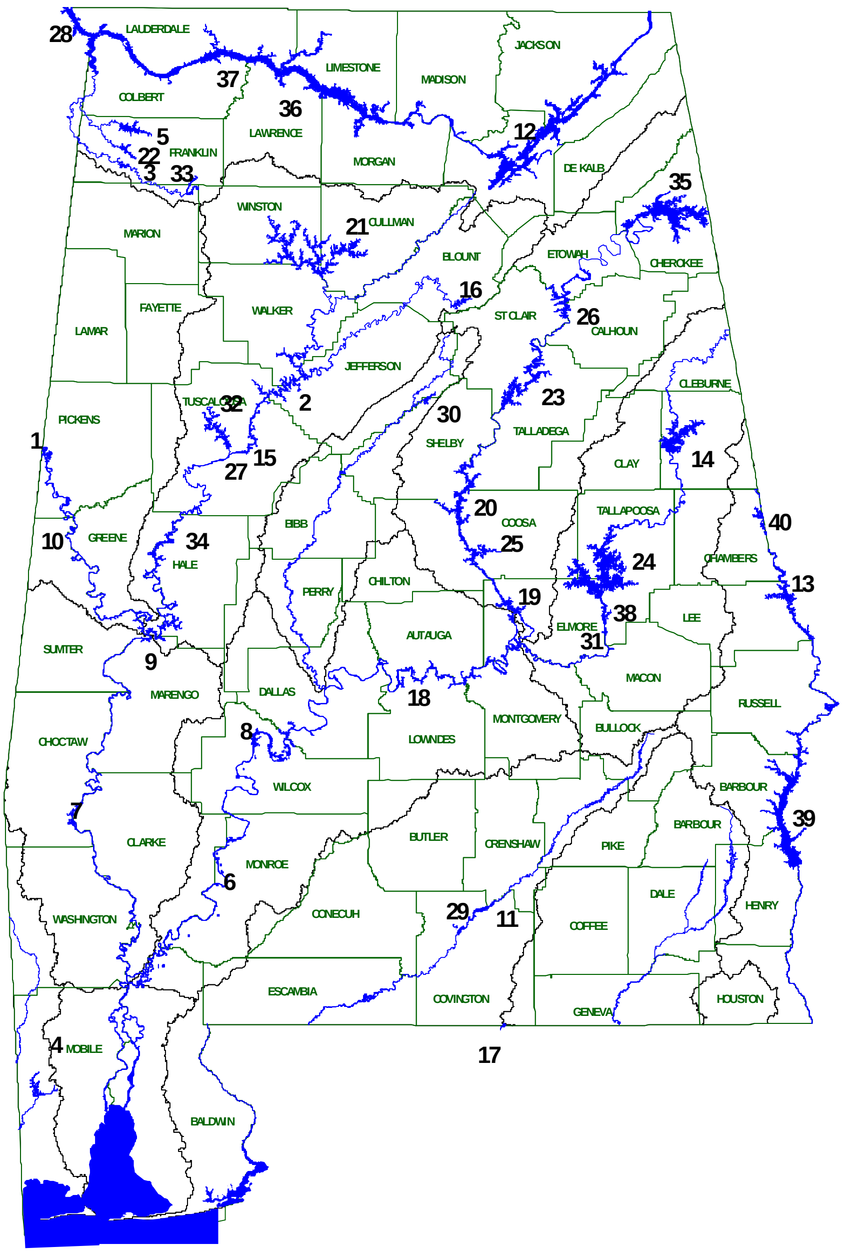
The Alabama Department of Environmental Management (ADEM) has defined publicly-owned lakes/reservoirs as those that are of a multiple-use nature, publicly-accessible, and exhibit physical/chemical characteristics typical of impounded waters. Lakes designated strictly for water supply, privately owned lakes, or lakes managed by the Alabama Department of Conservation and Natural Resources (ADCNR) strictly for fish production are not included in this definition. Lakes meeting the above definition are listed in Figure 1.

In 1985, the need for information on the trophic state of Alabama's publicly-owned lakes led to an initial survey conducted by ADEM with the assistance of the Environmental Protection Agency (EPA), Region IV. The survey established limited baseline information on the lakes and was used to rank them according to trophic condition.

In 1989, LWQA funds enabled the ADEM to conduct required water quality assessments of thirty-four publicly-owned lakes in the state and submit the collected information as part of the 1990 305(b) Water Quality Report to Congress (ADEM 1989). Trophic state index (TSI) values calculated from data gathered for the water quality assessments indicated potentially significant increases when compared to TSI values from the study conducted in 1985.

Figure 1.

Alabama Publicly Accessible Reservoirs



1) Aliceville
2) Bankhead
3) Bear Creek
4) Big Creek
5) Cedar Creek
6) Claiborne
7) Coffeeville
8) Dannelly
9) Demopolis
10) Gainesville
11) Gantt
12) Guntersville
13) Harding
14) Harris
15) Holt
16) Inland
17) Jackson
18) Jones Bluff
19) Jordan
20) Lay
21) Lewis Smith
22) Little Bear Creek
23) Logan-Martin
24) Martin
25) Mitchell
26) Neely Henry
27) Oliver
28) Pickwick
29) Point A
30) Purdy
31) Thurlow
32) Tuscaloosa
33) Upper Bear Creek
34) Warrior
35) Weiss
36) Wheeler
37) Wilson
38) Yates
39) W. F. George
40) West Point

In 1990, the Reservoir Water Quality Monitoring (RWQM) Program was initiated by the Special Studies Section of the Field Operations Division of ADEM. Objectives of the program are as follows:

a) to develop an adequate water quality database for all publicly-owned lakes in the state;

b) to establish trends in lake trophic status that can only be established through long-term monitoring efforts; and,

c) to satisfy the requirement of Section 314(a)(1) of the Water Quality Act of 1987 that states conduct assessments of the water quality of publicly-owned lakes and report the findings as part of their biennial Water Quality Report to Congress.

Acquiring this information enables the ADEM to determine lake water quality and identify those in which water quality may be deteriorating. Should deterioration in lake water quality be indicated by collected data, more intensive study of the lake can be instituted to establish causes and extent of the deterioration.

Thirty-one publicly-owned lakes in the state were monitored at least once during the three-year period 1990-1992. In 1991, additional funding received through the Clean Lakes Program enabled the expansion of the RWQM Program to include all of the 31 publicly-owned lakes in the state, with the exception of those in the Tennessee River system. Expansion of the program allowed more extensive monitoring of certain lakes for which water quality concerns were greatest and the inclusion of Alabama/Georgia border lakes that were not included in earlier water quality assessments.

Beginning in 1994, the frequency of reservoir monitoring in the RWQM Program was increased to a minimum of once every two years so that the water quality database and trends in trophic status could be developed more rapidly. Lakes indicated to be use-threatened or impaired from previously collected data continued to be monitored annually. Realignment of the reservoir sampling schedule was also begun in 1994 so that reservoir sampling by basin could be instituted.

In 1996, the Nonpoint Source Unit (NPSU) of the Office of Education and Outreach of ADEM adopted a watershed assessment strategy. The intent of the watershed management approach is to synchronize water quality monitoring, assessment, and implementation of control activities on a geographic basis. In Alabama, the major drainage basins are monitored on a 5-year rotation basis. Concentrating monitoring efforts within one basin provides the NPSU with a framework for more centralized management and implementation of control efforts and provides consistent and integrated decision making for awarding Clean Water Act Section 319 NPS funds.

During 1997, intensive monitoring of reservoirs by basin was initiated with Coosa and Tallapoosa reservoirs sampled to gather water quality data prior to proposed water diversions in Georgia. Intensive monitoring consists of monthly sampling of mainstem and tributary embayment sites through the algal growing season (April through October). Basins sampled to date are as follows:

a) 1997 - Coosa and Tallapoosa basins;
b) 1998 - Warrior basin;
c) 1999 - Chattahoochee and Conecuh basins;
d) 2000 - Coosa, Tallapoosa, Alabama basins;
e) 2001 - Escatawpa, Tombigbee basins;
f) 2002 - Warrior basin; and,
g) 2003 – Tennessee basin tributary embayments.

During 2004, reservoirs and main rivers of the Chattahoochee, Perdido/Escambia, and Choctawhatchee river basins were intensively monitored. The Lower Chattahoochee, Lower Conecuh, Blackwater, Yellow, Choctawhatchee, and Pea rivers were sampled along with the following reservoirs: West Point, Harding, Walter F. George, Gantt, and Point A. Data collected through these monitoring efforts will be used to develop lake-specific nutrient criteria, and to assist in development of total maximum daily loads as required by Section 303(d) of the Clean Water Act.

MATERIALS AND METHODS

Sampling Locations. Reservoirs sampled during 2004 appear in Table 1. Main rivers sampled appear in Table 2. Locations of all sampling sites appear in Table 3. Water quality measurements and water sample collections were conducted from boats positioned at the deepest point of the channel at each sampling site.

Sample Collection. Intensive monitoring consisted of monthly sampling of all Southeast Alabama stations from April through October. All stations were sampled within a one-week period to reduce weather-related variability in water quality conditions.

Monitoring and analyses were conducted in accordance with appropriate standard operating procedures. Water quality variables measured during 2004 appear in Table 4.

At each sampling site temperature, dissolved oxygen, specific conductance, and pH were measured in situ at multiple depths in the water column with Hydrolab Surveyor III and 4a instruments.

A standard, 20 cm diameter Secchi disk with attenuating black and white quadrants was used to measure visibility. Photic zone depth determinations were made by measuring the vertical illumination of the water column using an underwater photometer. The depth at which one percent of the surface illumination was measured by the photometer was considered the photic zone depth. A composite water sample of twenty liters was collected from the photic zone. The sample was collected by raising and lowering a plastic submersible pump and hose apparatus repeatedly through the photic zone while collecting the sample in a plastic container. Withdrawal of individual samples from the composite water sample occurred in the order presented in the following paragraphs.

Chlorophyll *a* samples were collected by filtering a minimum of 500 ml of the composite photic zone sample through glass fiber filters immediately after collection of the composite sample. Immediately after filtering, each filter was folded once and placed in a 50 mm petri dish. Each petri dish was wrapped in aluminum foil, sealed in a ziploc bag, and placed on ice for shipment to the Field Operations Division to be frozen until analyzed. Corrected chlorophyll *a* concentrations were used in calculating Carlson's trophic state index (TSI) for lakes. A more detailed discussion of Carlson's TSI appears later in this section.

Table 1. Reservoirs sampled during the Surface Water Quality Screening Assessment of Southeast Alabama River Basins-2004.

River	Reservoir	Surface Area (acres)	Drainage Area (mi^2)
Chattahoochee			
	West Point	25,299	5,440
	Harding	5,580	4,240
	WF George	45,200	7,460
Perdido/Escambia			
	Gantt	2,767	658
	Point A	900	1,277

Table 2. Rivers sampled during the Surface Water Quality Screening Assessment of Southeast Alabama River Basins-2004.

River	Drainage Area (mi^2)
Choctawhatchee	1,677
Pea	1,452
Yellow	507
Blackwater	148
Lower Conecuh	996
Lower Chattahoochee	586

Table 3. Monitoring sites for the Surface Water Quality Screening Assessment of Southeast Alabama Rivers, Reservoirs and Tributaries-2004.

Basin	Reservoir	Station #	Latitude	Longitude	Description
Chattahoochee					
	West Point	1	32.93429618	-85.19174807	Lower Reservoir, deepest point, main river channel, dam forebay.
		2	32.99830432	-85.19835901	Mid Reservoir, deepest point, main river channel, immediately downstream of Wehadkee/Veasey/Stroud Creeks confluence.
		3	33.0286539	-85.16482981	Upper Reservoir, deepest point, main river channel, at GA Hwy. 109 bridge.
	Harding	1	32.66763142	-85.09190375	Lower Reservoir, deepest point, main river channel, dam forebay.
		2	32.68877518	-85.12679394	Halawakee Creek embayment, Deepest point, main creek channel, approximately 0.6 miles upstream of Chattahoochee River confluence.
		3	32.72071972	-85.12865955	Osanippa Creek embayment, Deepest point, main creek channel.
		4	32.76598843	-85.13878641	Upper Reservoir, deepest point, main river channel, immediately downstream of Johnson Island.
	WF George	1	31.65699823	-85.082906	Lower Reservoir, deepest point, main river channel, dam forebay.
		4	31.8929329	-85.11961994	Mid Reservoir, deepest point, main river channel, approximately 0.25 miles upstream of U.S. Highway 82 causeway.
		6	32.08178507	-85.05161126	Upper Reservoir, deepest point, main river channel, immediately downstream of Florence Marina State Park.
		9	32.14187703	-85.06783988	Hatchechubee Creek embayment, Deepest point, main creek channel.
		10	31.97426673	-85.10962971	Cowikee Creek embayment , deepest point, main creek channel.
		12	31.86283272	-85.160539	Barbour Creek embayment, deepest point, main creek channel.
		13	31.83000218	-85.16759349	Cheneyhatchee Creek embayment, deepest point, main creek channel.
		16	32.30436131	-84.95452439	Uchee Creek embayment, deepest point, main creek channel.
	Lower Chattahoochee River	1	31.03839187	-85.00861655	At Alabama/Florida Stateline, deepest point, main river channel.
		2	31.28195597	-85.10928333	At State Hwy 52 crossing, deepest point, main river channel, just upstream of Omussee Creek/Chattahoochee River confluence.
		3	31.41156042	-85.08046349	Abbie Creek embayment, deepest point, main creek channel.

Table 3 cont. Monitoring sites for the Surface Water Quality Screening Assessment of Southeast Alabama Rivers, Reservoirs and Tributaries-2004.

Basin	Reservoir	Station #	Latitude	Longitude	Description
Chattahoochee	Lower Chattahoochee River	4	31.28101534	-85.11941081	Omussee Creek embayment, deepest point, main creek channel.
Choctawhatchee	Choctawhatchee River	1	31.02690	-85.85630	Lower Choctawhatchee River, deepest point, main river channel, approximately 0.5 miles upstream of the confluence with Pea River.
		2	31.23340	-85.68940	Upper Choctawhatchee River, deepest point, main river channel, approximately 0.5 miles downstream of Little Choctawhatchee confluence, near State Hwy 92.
	Pea River	1	31.0246	-85.876	Deepest point, main river channel, approximately 0.5 miles upstream of the confluence with Choctawhatchee River.
		2	31.4038	-86.069	Deepest point, main river channel, approximately 0.5 miles downstream of Beaverdam Creek/Pea River confluence, south of Elba, AL.
Perdido/Escambia	Gantt	1	31.404445	-86.479182	Lower Reservoir, deepest point, main river channel, dam forebay.
		2	31.440409	-86.451514	Upper Reservoir, deepest point, main river channel, approximately one mile upstream of Covington County Rd. 86 bridge.
	Point A	1	31.362136	-86.516374	Lower Reservoir, deepest point, main river channel, dam forebay.
		2	31.378554	-86.523245	Patsiliga Creek embayment, deepest point, main creek channel.
	Yellow River	1	31.01070	-86.53750	Yellow River, deepest point, main river channel, approximately 0.25 miles upstream of County Rd. 4 bridge.
	Conecuh River	1	30.99865	-87.163	At Alabama/Florida Stateline, deepest point, main river channel.
		2	31.06827	-87.0584	Deepest point, main river channel, approximately 0.5 miles upstream of State Hwy. 41, near East Brewton.
		3	31.575197	-86.252264	Deepest point, main river channel, approximately 0.5 miles upstream of US Hwy 331, south of Brantley, AL.

Figure 2. West Point Reservoir with 2004 sampling locations.

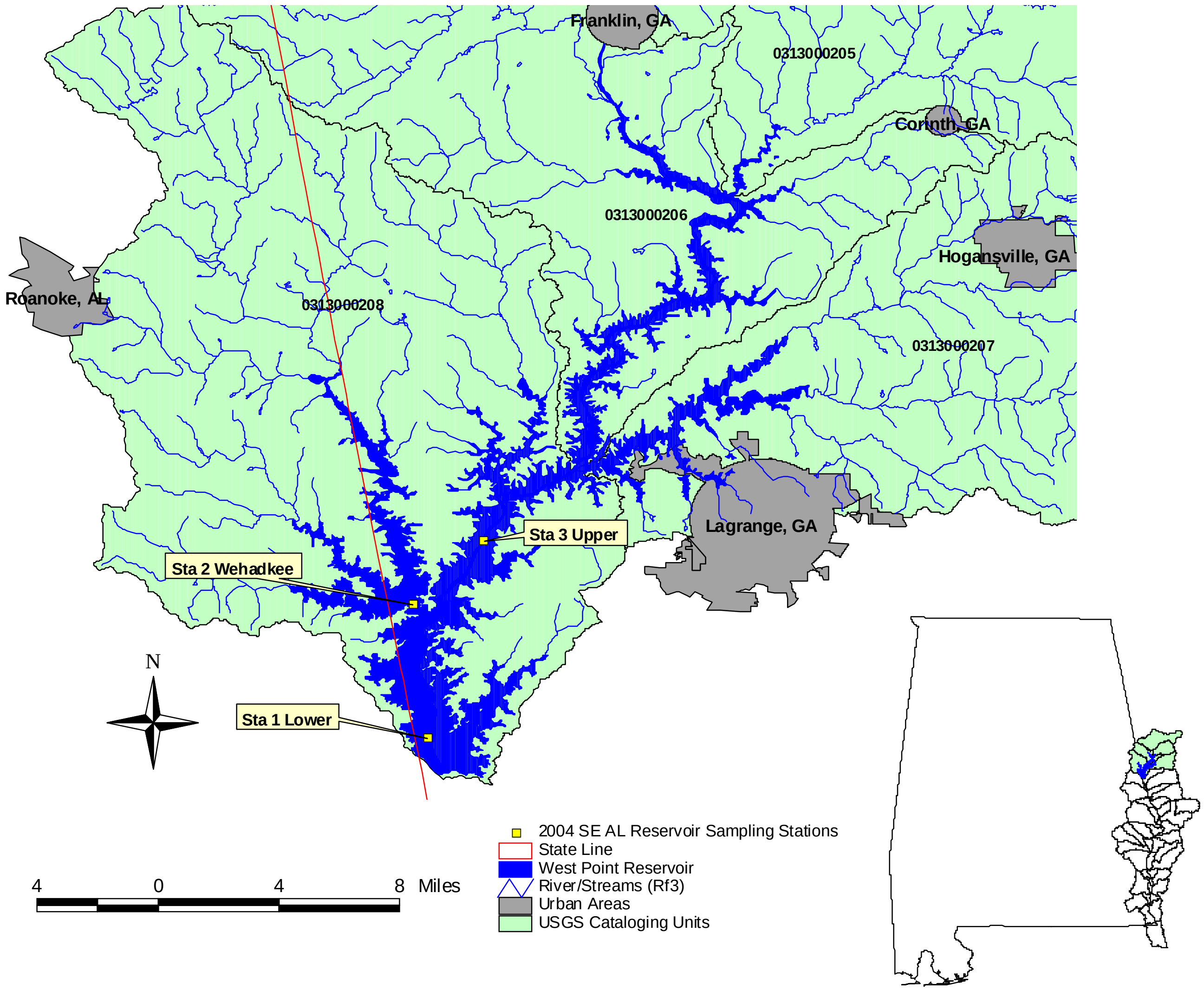


Figure 3. Harding Reservoir with 2004 sampling locations.

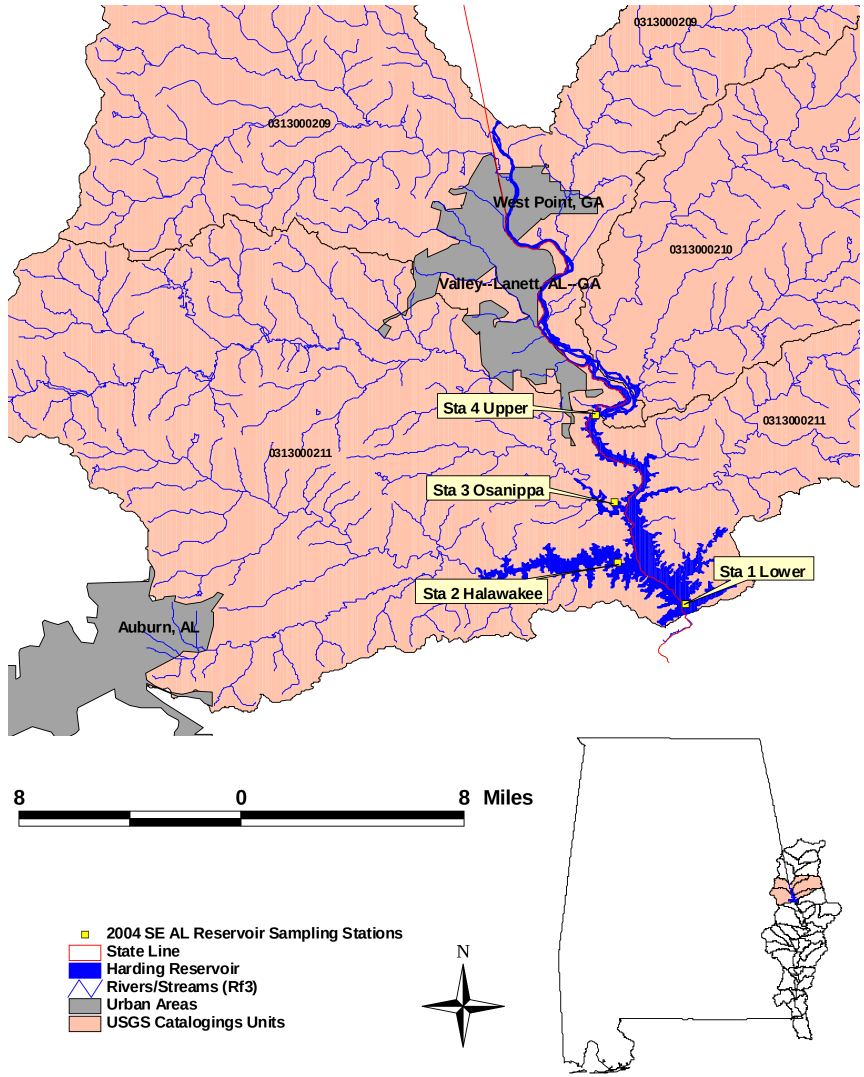


Figure 4. W.F. George Reservoir with 2004 sampling locations.

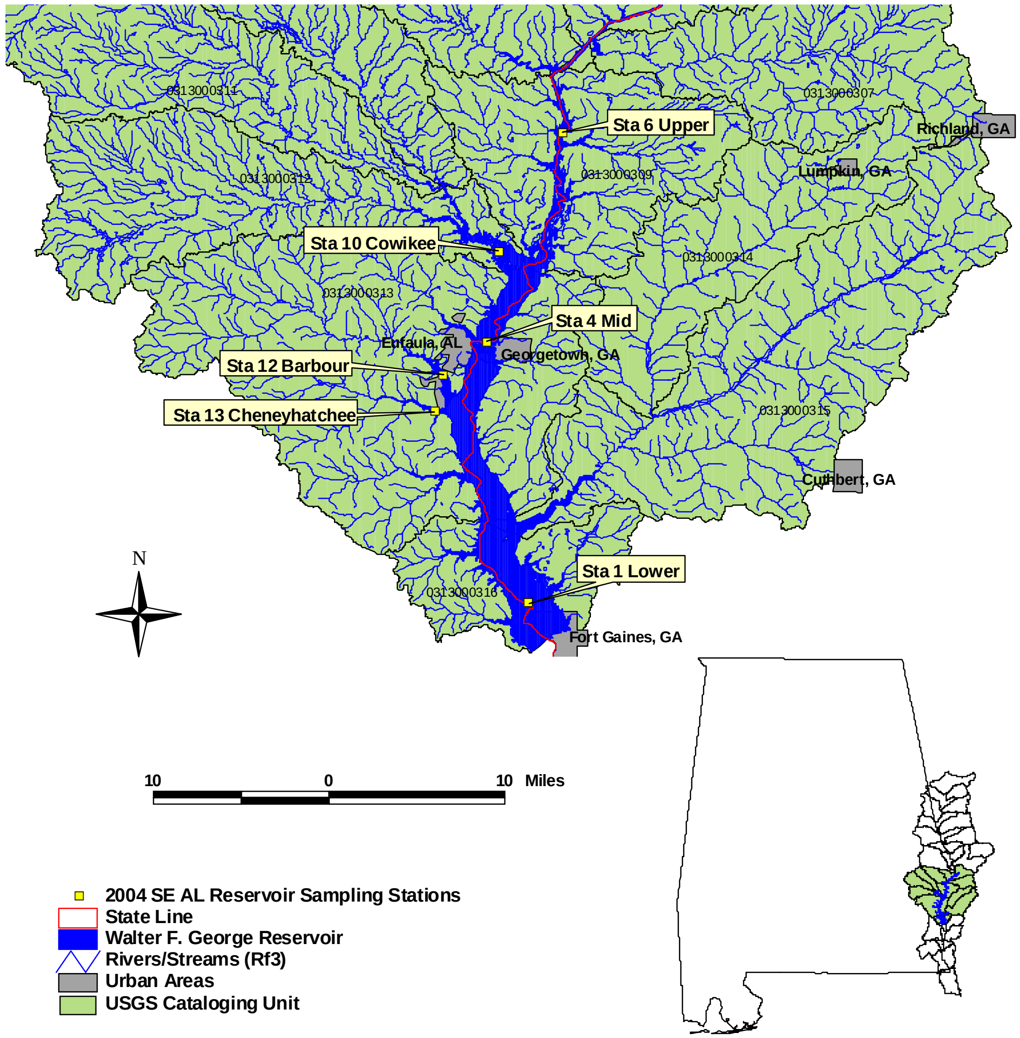


Figure 5. Lower Chattahoochee River with 2004 sampling locations.

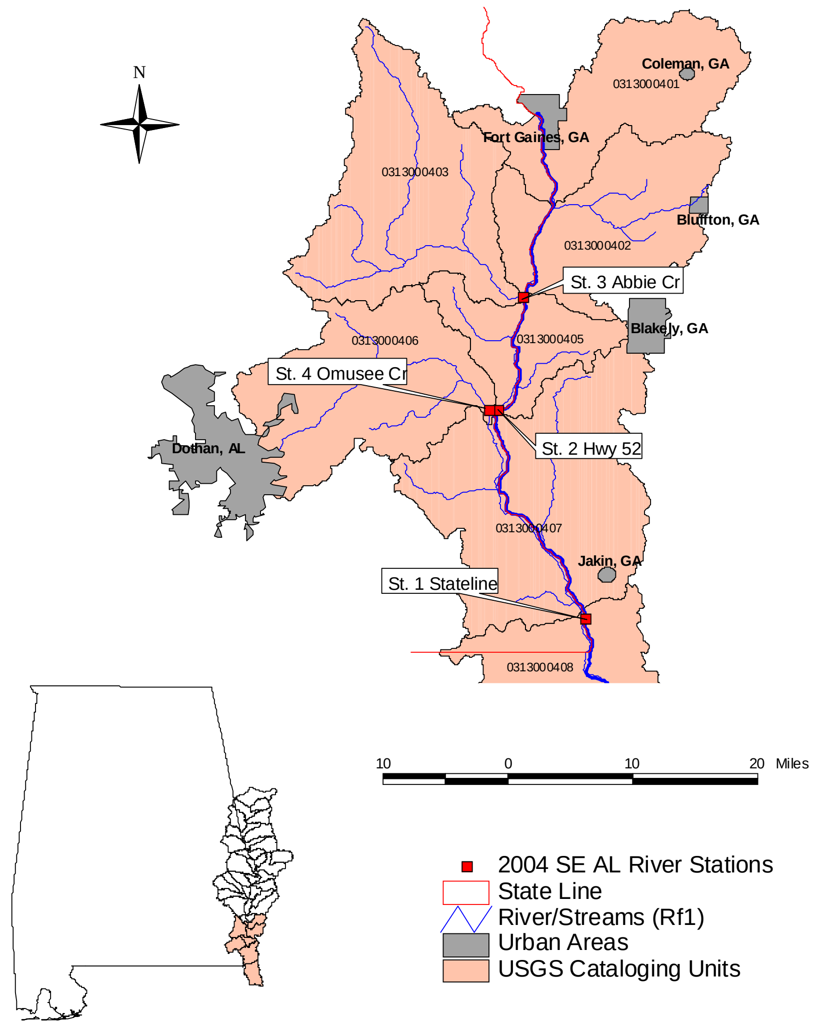


Figure 6. Gantt Reservoir with 2004 sampling locations.

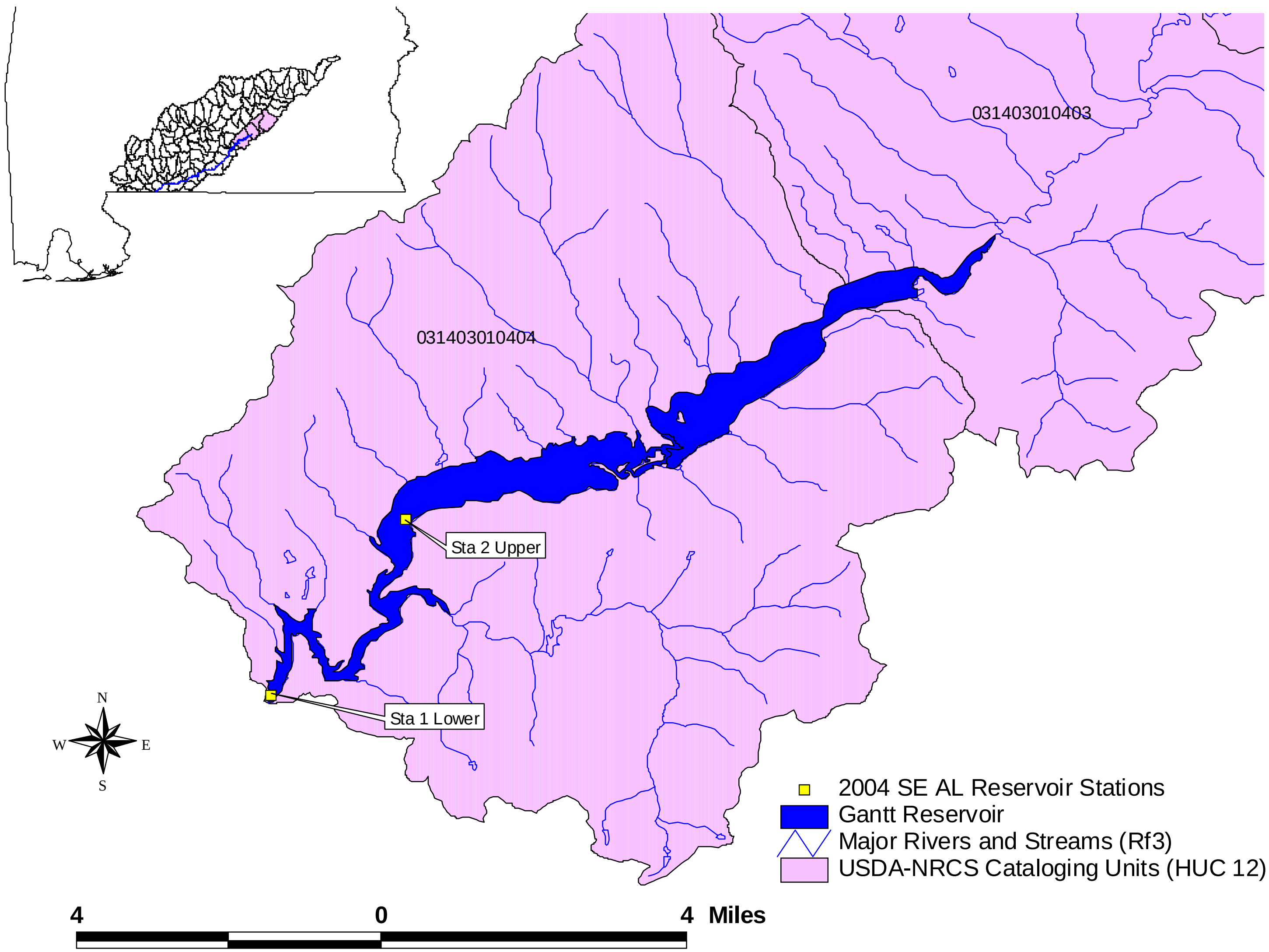


Figure 7. Point A Reservoir with 2004 sampling locations.

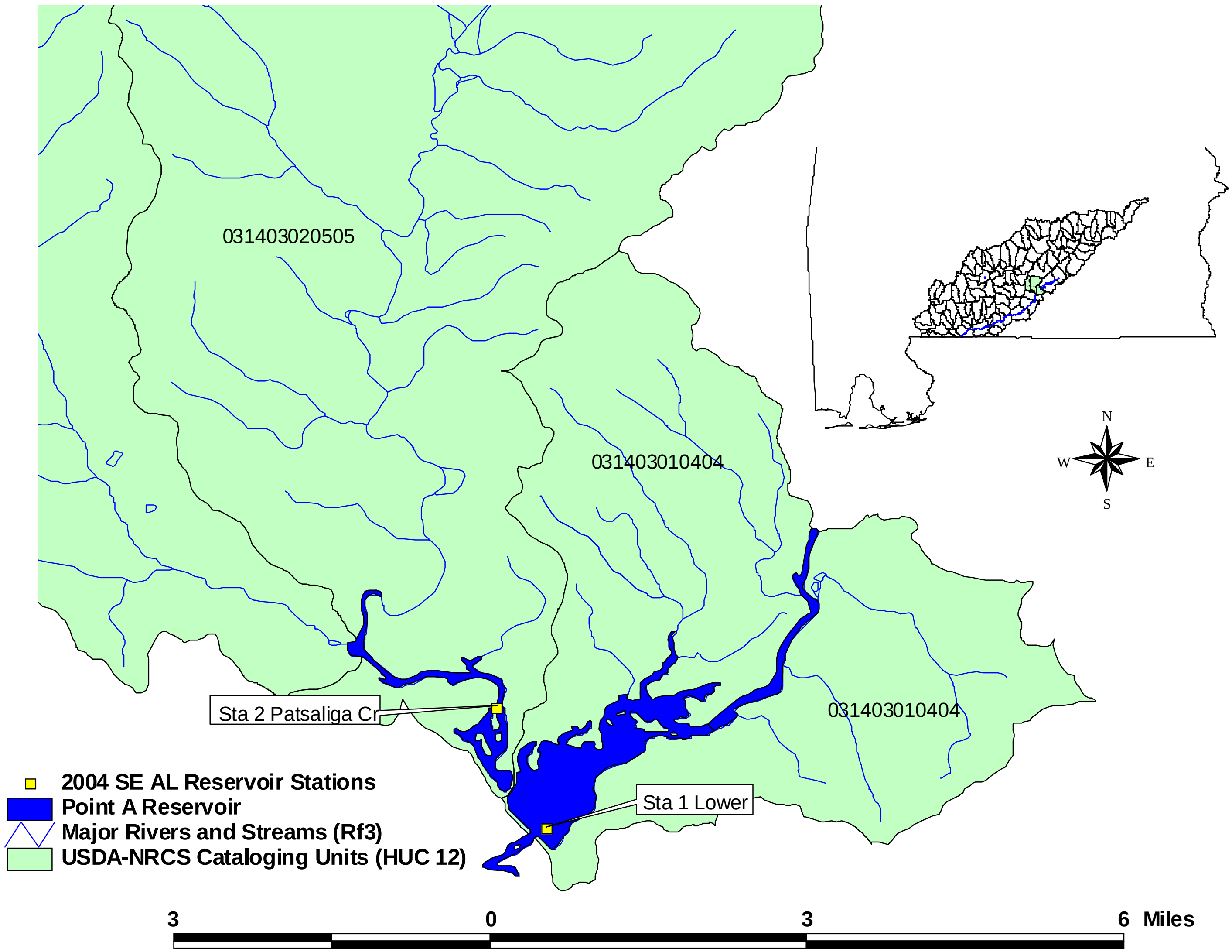


Figure 8. Perdido/Escambia River basins with 2004 sampling locations.

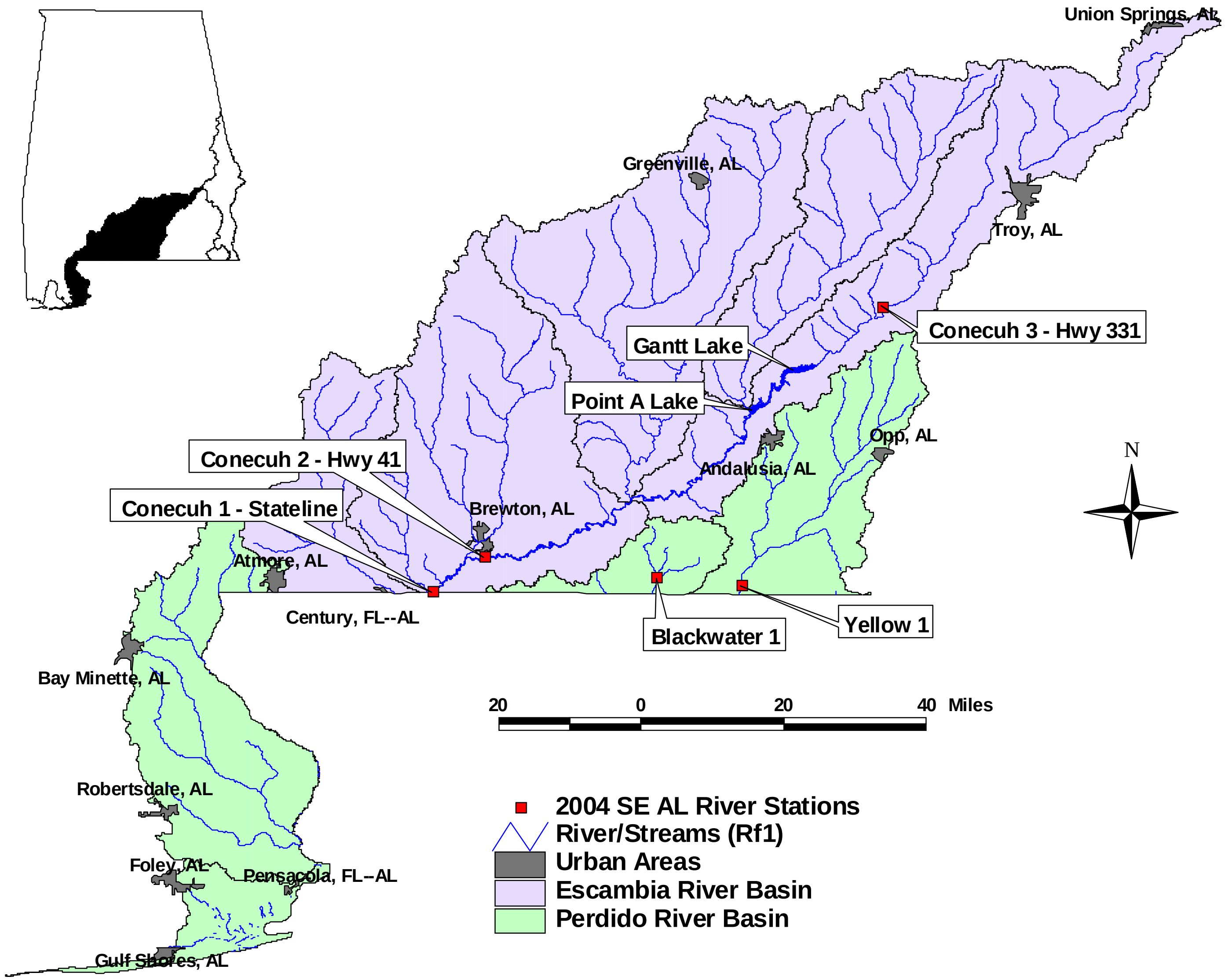


Figure 9. Choctawhatchee River basin with 2004 sampling locations.

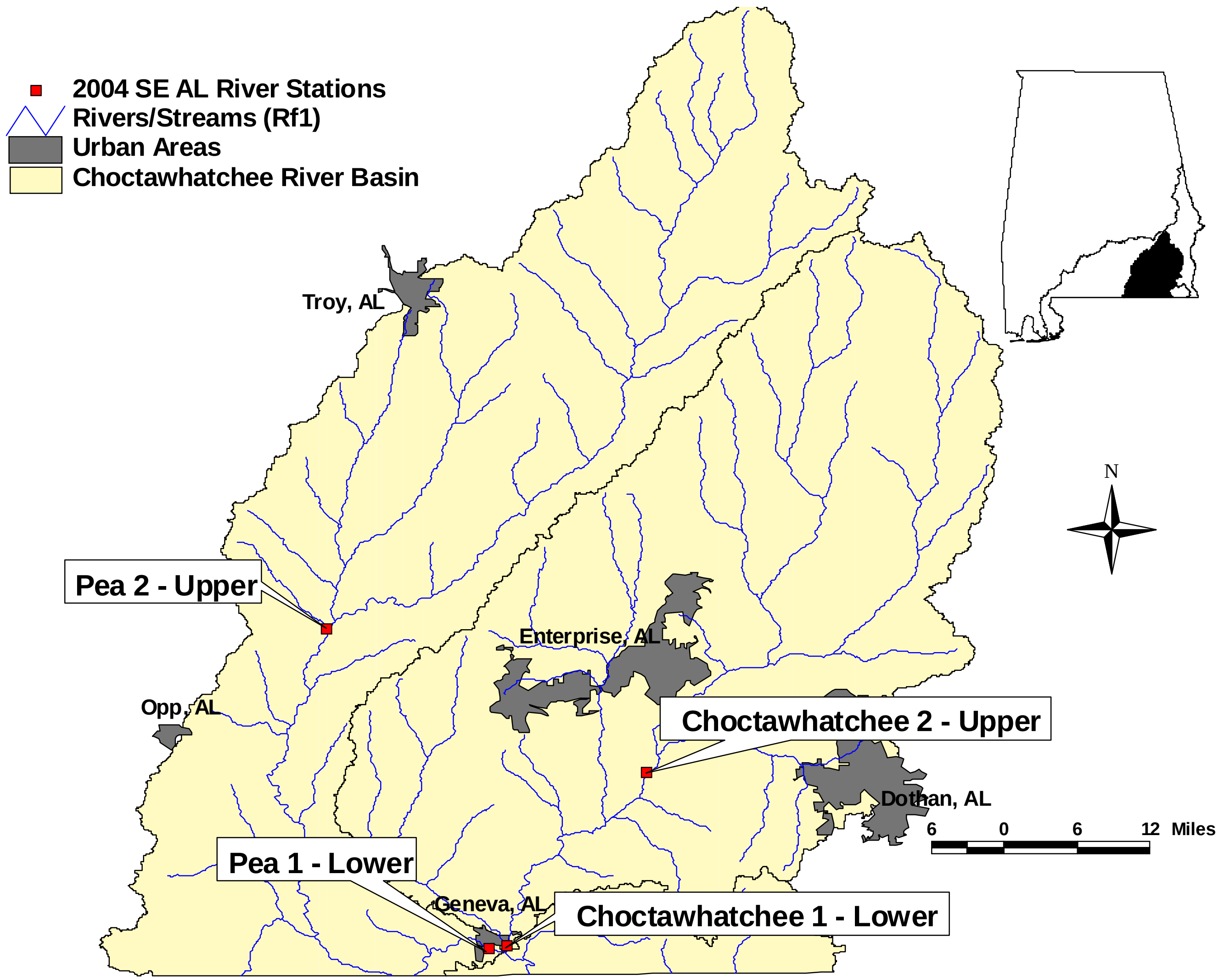


Table 4. Water quality variables measured during the Surface Water Quality Screening Assessment of Southeast Alabama Rivers and Reservoirs-2004.

Variable	Method	Reference	Detection Limit
Physical			
Vertical illumination	Photometer, Secchi disk	Lind, 1979	---
Temperature	Thermistor	APHA et al. 1998	---
Turbidity	Nephelometer	APHA et al. 1998	---
Total dissolved solids	Filtration, drying	EPA-600/4-79-020	1 mg/l
Total suspended solids	Filtration, drying	EPA-600/4-79-020	1 mg/l
Specific conductance	Wheatstone bridge	APHA et al. 1998	---
Hardness	Hardness (calc.)	SM2340B	1 mg/l
Alkalinity	Potentiometric titration	EPA-600/4-79-020	1 mg/l
Chemical			
Dissolved oxygen	Membrane electrode	APHA et al. 1998	---
pH	Glass electrode	APHA et al. 1998	---
Ammonia	Automated phenate	EPA-600/4-79-020	0.015 mg/l
Nitrate + Nitrite	Cadmium reduction	EPA-600/4-79-020	0.003 mg/l
Total Kjeldahl Nitrogen	Automated colorimetric	EPA-600/4-79-020	0.15 mg/l
Dissolved reactive phosphorus	Automated single reagent	EPA-600/4-79-020	0.004 mg/l
Total phosphorus	Persulfate digestion	EPA-600/4-79-020	0.004 mg/l
Total organic carbon	Persulfate-ultraviolet	EPA-600/4-79-020	0.50 mg/l
Biological			
Chlorophyll *a*	Spectrophotometeric	APHA et al. 1998	0.1 μg/l
Algal growth potential test *	Printz Algal Assay Test	ADEM 1993	---
Fecal coliform *	Membrane filter	APHA et al. 1998	---

* August only.

Dissolved reactive phosphorus samples were collected by vacuum filtering approximately 125 ml of the composite sample through a disposable filtering apparatus containing a 0.45 micron membrane filter. The detachable base flask containing collected filtrate served as the sample container.

Finally, two half-gallon portions of the composite sample were collected in plastic containers and properly preserved for laboratory analysis of water quality variables.

During August, subsurface grab samples were collected in properly prepared containers at each sampling site for fecal analysis. Samples for Algal Growth Potential Tests (AGPT) were also collected from the composite photic zone sample by filling a properly prepared plastic container and preserving on ice. A more detailed discussion of AGPT appears later in this section.

All samples were preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures and Quality Control Assurance Manual Volume I Physical/Chemical (2000).

Quality Control / Quality Assurance. For quality control/quality assurance purposes, field duplicates of each sample type were collected at five percent of the sampling sites. Field duplicates were true duplicates of the complete collection process. Blanks were collected at the same frequency as duplicates by processing distilled water through the collection and filtration equipment in the same manner as regular samples. Measurements of water temperature, dissolved oxygen, specific conductance, and pH were replicated at sampling sites where duplicate samples were collected.

Trophic State Index. Corrected chlorophyll *a* concentrations were used in calculating Carlson's trophic state index (TSI) for lakes (Carlson 1977). Carlson's TSI provides limnologists and the public with a single number that serves as an indicator of a lake's trophic status. Corrected chlorophyll *a* is the parameter used in the RWQM Program to calculate TSI because it is considered to give the best estimate of the biotic response of lakes to nutrient enrichment when algae is the dominant plant community. The trophic state classification scale used is as follows:

Oligotrophic:	TSI < 40
Mesotrophic:	TSI 40 – 49
Eutrophic:	TSI 50 - 69

Hypereutrophic: TSI $\geq$ 70

Algal Growth Potential Tests. The Algal Growth Potential Test (AGPT) determines the total quantity of algal biomass supportable by the test waters and provides a reliable estimate of the bioavailable and limiting nutrients (Raschke and Schultz 1987). In control samples, maximum algal standing crop (MSC) dry weights below 5.0 mg/l are thought to assure protection from nuisance algal blooms and fish-kills in southeastern lakes, with the exception of lakes in Florida (Raschke and Schultz 1987). Since physical and chemical characteristics of streams vary from lakes and tributary embayments, different protective MSC limits have been suggested for streams. Streams that have a MSC value equal to or less than 20 mg/l are considered to be in good condition (Raschke *et al.* 1996). Rivers sampled in 2004 were more comparable to streams than reservoirs and tributary embayments. Therefore, the AGPT results for rivers were evaluated using the 20 mg/l MSC limit.

In most freshwater lakes, phosphorus is the essential plant nutrient that limits growth and productivity of plankton algae (Wetzel 1983). Nitrogen usually becomes the limiting nutrient when bioavailable phosphorus increases relative to nitrogen, as in the case of waters receiving quantities of treated municipal waste (Raschke and Schultz 1987). The AGPT is helpful in identifying these common growth limiting nutrients.

RESULTS

Data Selection. Material in this section is by reservoir or by basin for main rivers. Water quality data presented for further discussion consist of the following:

a) total nitrogen (TN) and total phosphorus (TP), used as indicators of nutrient content in the waterbody;
b) algal growth potential tests (AGPT), used as a determinant of the total quantity of algal biomass supportable by test waters and of the limiting nutrient;
c) corrected chlorophyll a (chl. a), used as an indicator of algal biomass;
d) total suspended solids (TSS) concentrations, used as an indicator of water clarity;
e) Carlson Trophic State Index (TSI), calculated from corrected chlorophyll a concentrations as a means of trophic state classification of the reservoir; and,
f) dissolved oxygen (DO) concentrations, used as a more direct indicator of water quality because severe depletion can damage aquatic vertebrate and macroinvertebrate communities and interfere with water supply and recreational uses;

These data were selected because of their relationship to the process of eutrophication and their interest to the regulatory and scientific communities that stems from this relationship. The process of eutrophication and the effects on water quality will be discussed more fully in following paragraphs. Topics not selected for further discussion in this report were done so in the interests of time, space, or data availability. Stream water quality assessments, land-use information, point sources, and potential non-point sources can be found in *Surface Water Quality Screening Assessment of the SE AL River Basins-2004 Part I (2006).*

Graphs. Bar graphs consist of means of the variables for all months depicted in the line graphs. Bar graphs for growing season mean chlorophyll *a* concentrations include nutrient criteria values adopted by the ADEM thus far. Line graphs depict the monthly changes in the variables. Nutrients were plotted vs. discharge when available. This area was significantly affected by the Category III storm-Hurricane Ivan which made US landfall on September 16, 2004. Rainfall totals from the storm can be seen in Figure 10. The entire area received heavy rainfall with effects to water quality of the SE AL River basins apparent in many September values.

Line graphs of DO concentrations consist of measurements conducted at a depth of five feet, unless otherwise noted, because ADEM Water Quality Criteria pertaining to non-wadeable river and reservoir waters require a DO concentration of 5.0 mg/l at this depth (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.

Eutrophication. For those unfamiliar with the process of eutrophication, it may be useful to discuss the relationship of the topics to the process and how the process affects the water quality of lakes and embayments. Eutrophication is the process by which water bodies become more productive through increased input of nutrients, primarily nitrogen and phosphorus (Welch 1992). Normally, increased plant (algae and/or macrophyte) productivity and biomass are considered part of the eutrophication process though nutrients can increase without an increase in plant growth if available light in the water column is limited by high concentrations of suspended solids.

The classical trophic succession sequence that occurs in natural lakes is as follows:

Oligotrophic: nutrient-poor, biologically unproductive;

Mesotrophic: intermediate nutrient availability and productivity;

Eutrophic: nutrient-rich, highly productive;

Hypereutrophic: the extreme end of the eutrophic stage.

Depending on the nature of the watershed however, eutrophication of natural lakes may take thousands of years or they may never become eutrophic.

All waterbodies monitored during the intensive survey are reservoirs rather than natural lakes. Trophic succession in reservoirs does not occur in the classical form as in natural lakes. After filling of the reservoir basin, trophic upsurge occurs, resulting in high productivity of algae and fish. The trophic upsurge is fueled by nutrient inputs from the watershed, leaching of nutrients from the flooded soils of the basin, and decomposition of terrestrial vegetation and litter. Eventually a trophic depression takes place with a decline in the productivity of algae and fish as these initially available nutrient sources decline. In time, a less productive but more stable trophic state is established. The trophic state that the reservoir eventually settles into (oligotrophic, mesotrophic, or eutrophic) is determined by the combination of the natural fertility of the watershed and the effects of the point and nonpoint sources of pollution within the watershed.

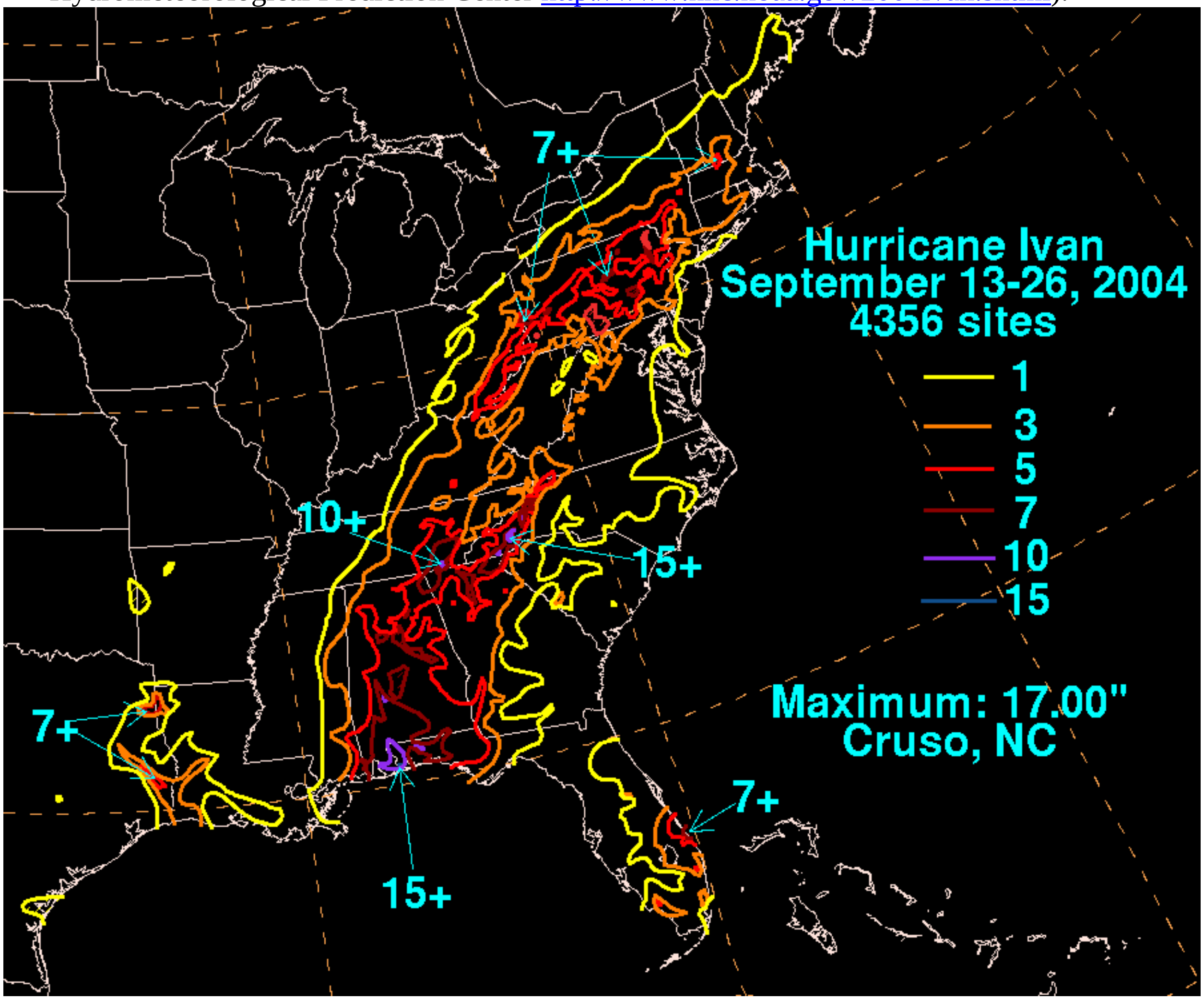
The concern about eutrophication from a water quality standpoint is more likely due to cultural eutrophication. Cultural eutrophication can be defined as eutrophication brought about by the increase of nutrient, soil, and /or organic matter loads to a lake or reservoir as a result of anthropogenic activities (EPA 1990). Activities that contribute to cultural eutrophication include wastewater treatment discharges, agricultural and silvicultural activities, residential and urban development, and road building. Increased eutrophication in a waterbody occurring over a period of 10 to 50 years usually indicates cultural eutrophication (Welch 1992).

The effects of cultural eutrophication to a reservoir that is highly productive, or eutrophic, can lead to hypereutrophic conditions. Hypereutrophic conditions are characterized by the following:

a) dense algal populations;
b) low dissolved oxygen concentrations;
c) increased likelihood of fish kills; and,
d) interference with public water supply and recreational uses.

Regardless of whether a reservoir is oligotrophic, mesotrophic, or eutrophic, however, cultural eutrophication negatively affects biological communities of these waterbodies through sedimentation and changes in water quality variables such as dissolved oxygen, pH, water temperature, and light availability.

Figure 10. United States rainfall totals for Hurricane Ivan (image courtesy of NOAA Hydrometeorological Prediction Center http://www.nhc.noaa.gov/2004ivan.shtml).



Chattahoochee River Basin

Figure 11. Mean total nitrogen (TN) concentrations of Chattahoochee River mainstem stations and tributary embayments, April-October 2004.

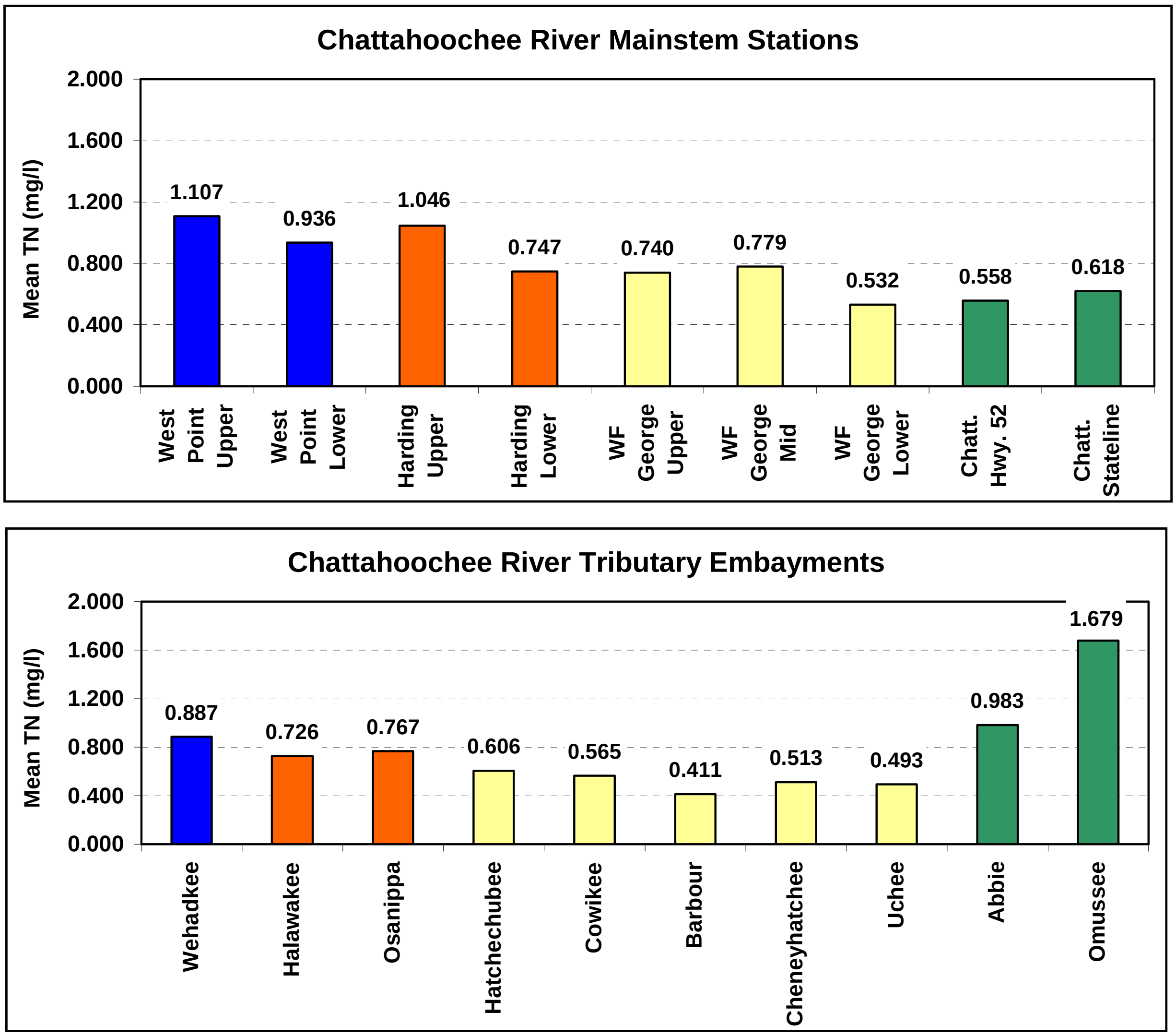
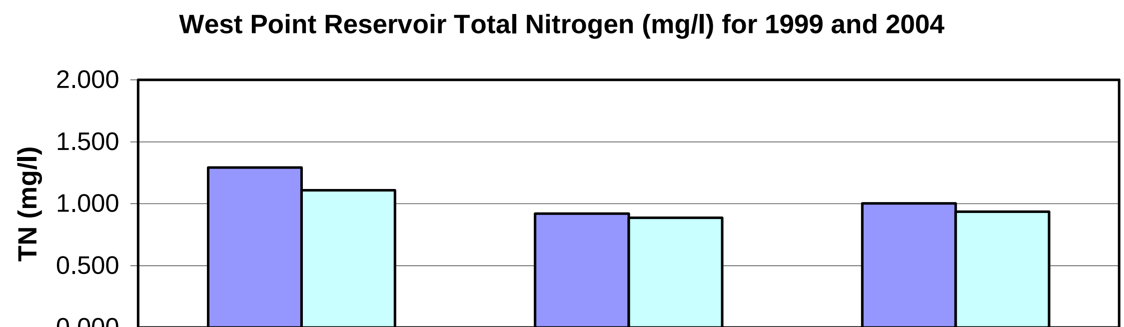
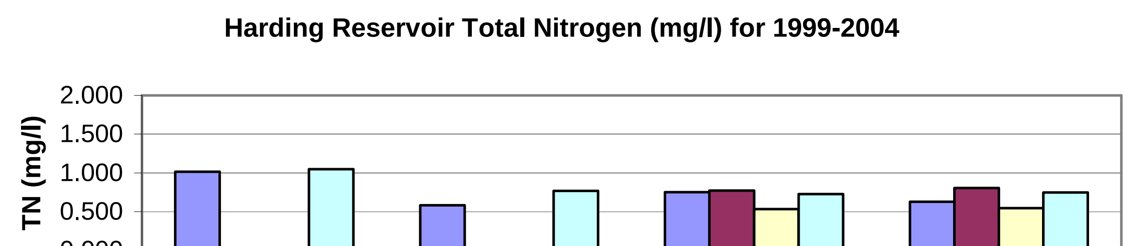


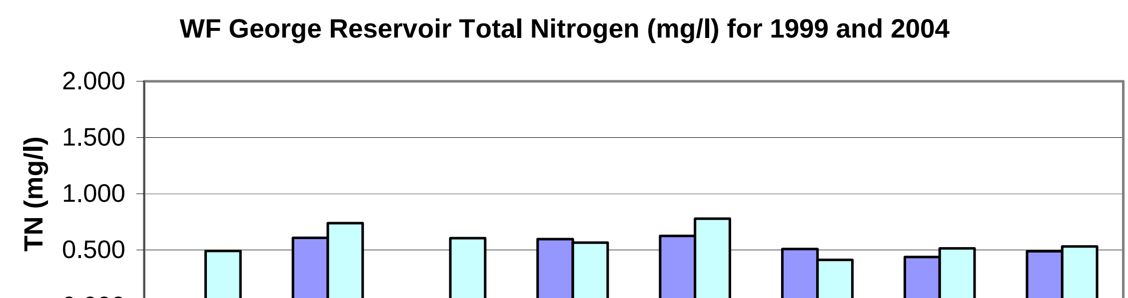
Figure 12. Mean total nitrogen (TN) concentrations of West Point Reservoir 1999 and 2004, Harding Reservoir 1999, 2002-2004, and WF George Reservoir 1999 and 2004.



	Upper	Wehadkee Cr.	Lower
1999	1.29	0.92	1.00
2004	1.107	0.887	0.936



	Upper	Osanippa Cr.	Halawakee Cr.	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



	Uchee	Upper	Hatchechubee	Cowikee	Mid	Barbour	Cheneyhatchee	Lower
1999		0.61		0.60	0.63	0.51	0.44	0.49
2004	0.493	0.740	0.606	0.565	0.779	0.411	0.513	0.532

Figure 13. Mean total phosphorus (TP) concentrations of Chattahoochee River mainstem stations and tributary embayments, April-October 2004.

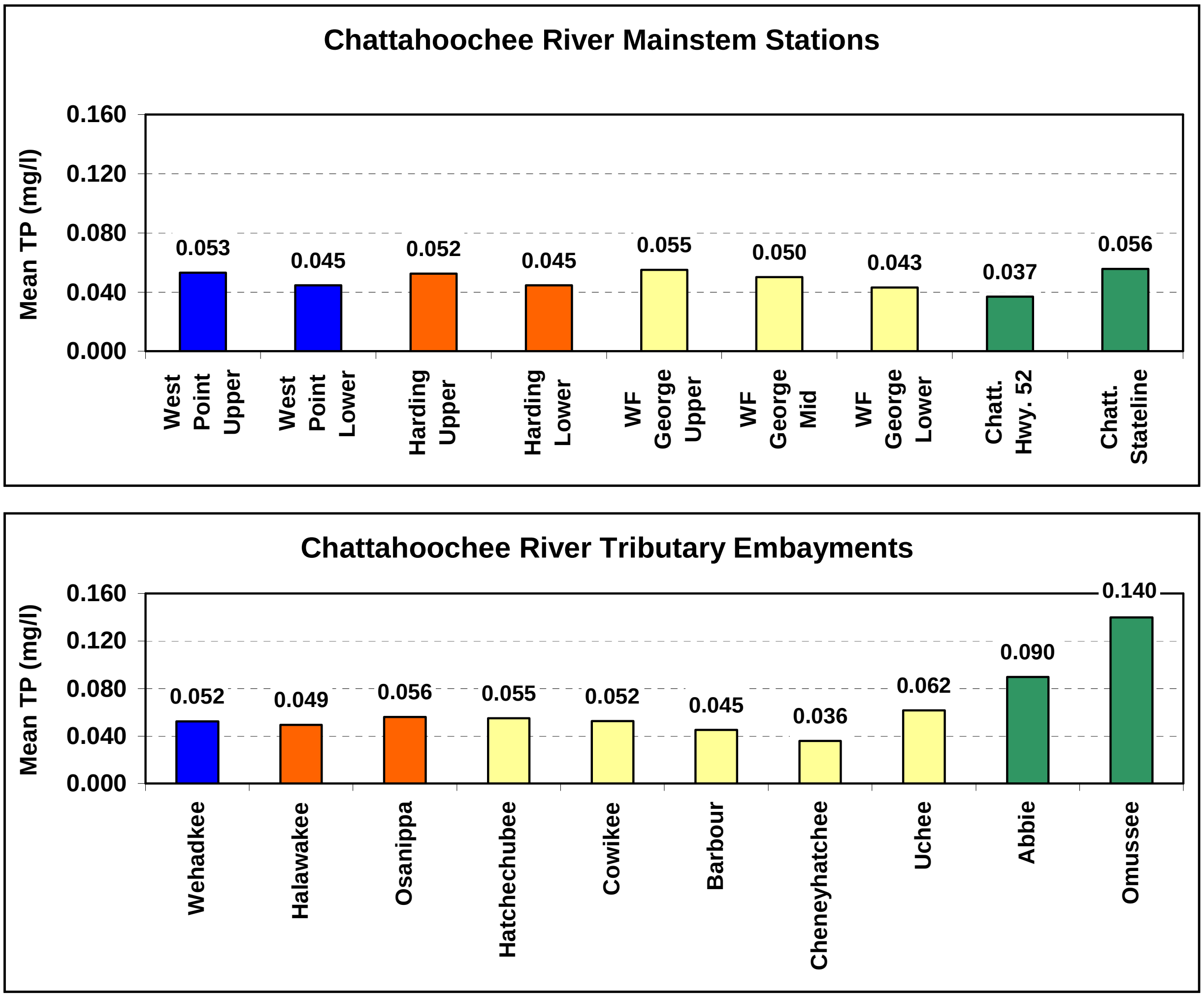
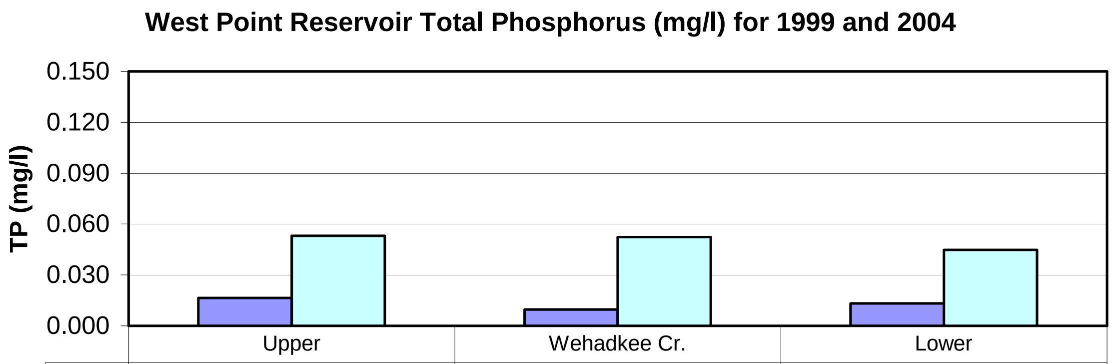
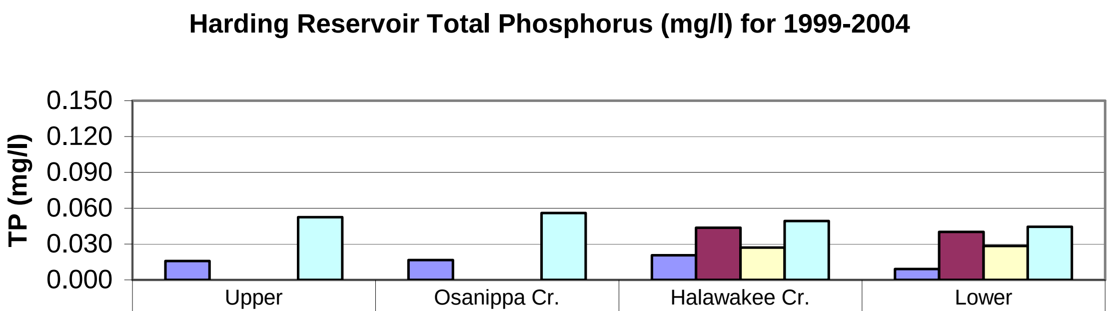


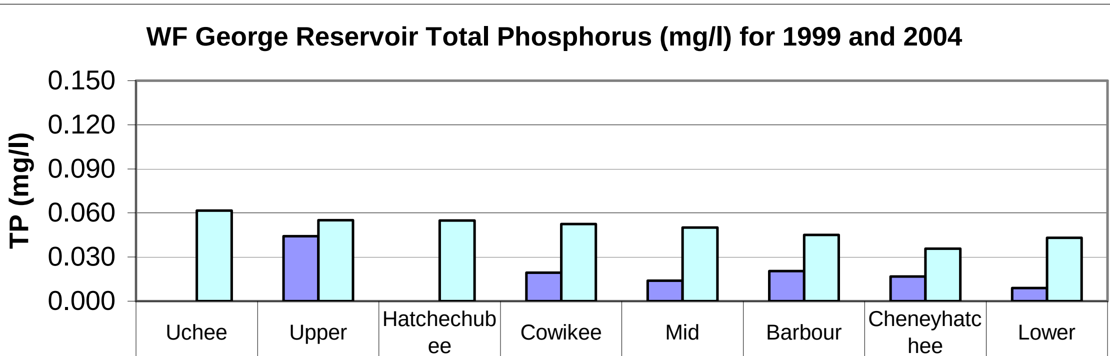
Figure 14. Mean total phosphorus (TP) concentrations of West Point Reservoir 1999 and 2004, Harding Reservoir 1999, 2002-2004, and WF George Reservoir 1999 and 2004.



	Upper	Wehadkee Cr.	Lower
1999	0.016	0.010	0.013
2004	0.053	0.052	0.045



	Upper	Osanippa Cr.	Halawakee Cr.	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



	Uchee	Upper	Hatchechubee	Cowikee	Mid	Barbour	Cheneyhatchee	Lower
1999		0.044		0.019	0.014	0.021	0.017	0.009
2004	0.062	0.055	0.055	0.052	0.050	0.045	0.036	0.043

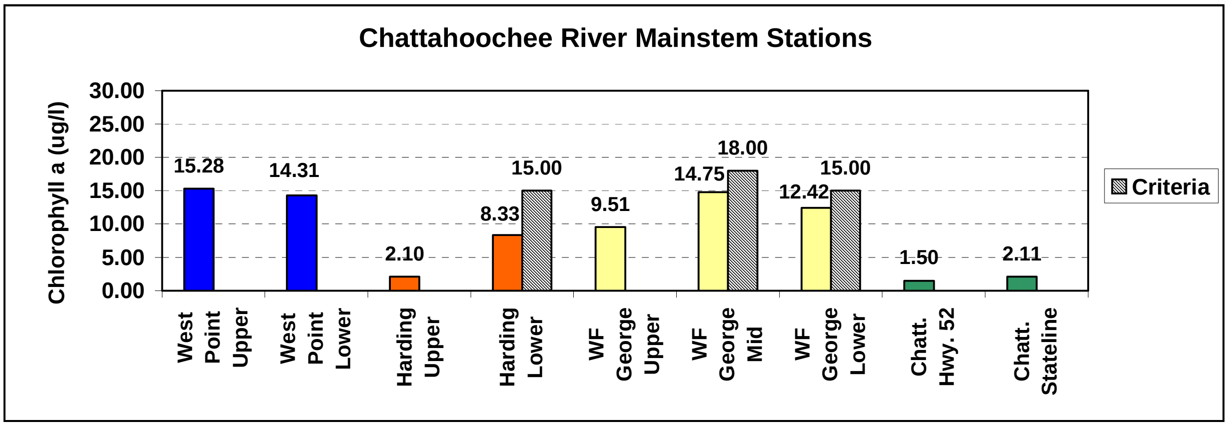
Table 5. Algal growth potential testing for the Chattahoochee River Basin-2004**.**

Station Identification	Control mean MSC	Limiting Nutrient
West Point 3 (Upper)	2.65	Phosphorus
West Point 2 (Mid)	2.25*	Phosphorus
West Point 1 (Lower)	2.36*	Phosphorus
Harding 4 (Upper)	5.27	Phosphorus
Harding 2 (Mid)	2.47*	Phosphorus
Harding 1 (Lower)	2.36*	Phosphorus
WF George 6 (Upper)	6.46	**
WF George 4 (Mid)	3.29	Phosphorus
WF George 1 (Lower)	2.16	Co-Limiting
Chattahoochee 2 (Hwy 52)	4.13	Phosphorus
Chattahoochee 1 (Stateline)	4.91	Phosphorus

* These results are an average of the original test data (which was ended on day 6 due to unexpected circumstances) and an abbreviated repeat test that was conducted using one flask per treatment and ended on day 7 as per the standard operating procedures. No considerable differences were observed in the data from the original and the repeat test.

** Results for Phosphorus test flasks ranged from 9.54 to 25.91. Results are reported as the average of six flasks (test was repeated to obtain the additional data points). The accuracy of these results is less than is typical for this test method and therefore the limiting nutrient status can not accurately be determined.

Figure 15. Mean chlorophyll *a* concentrations of Chattahoochee River mainstem stations and tributary embayments, April-October 2004.



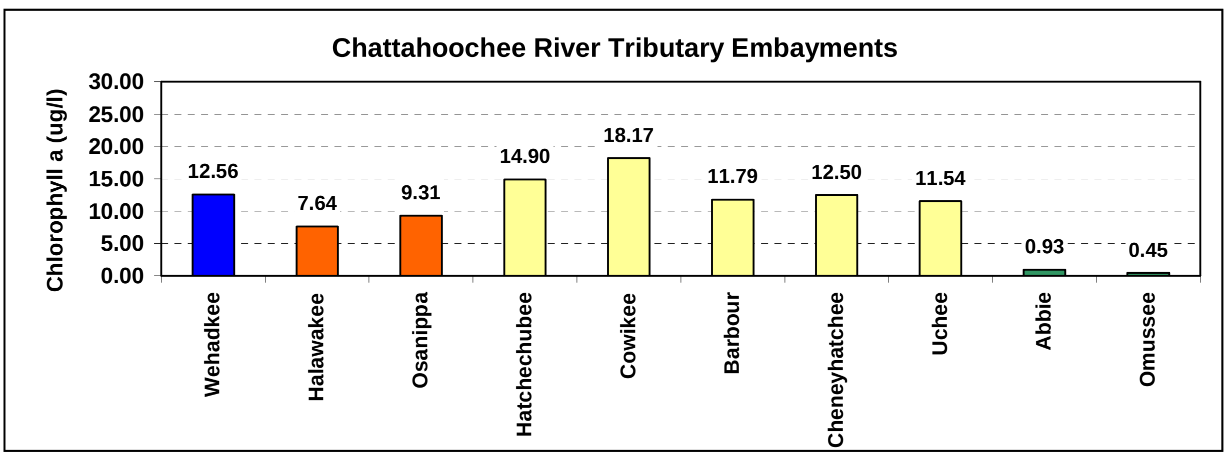
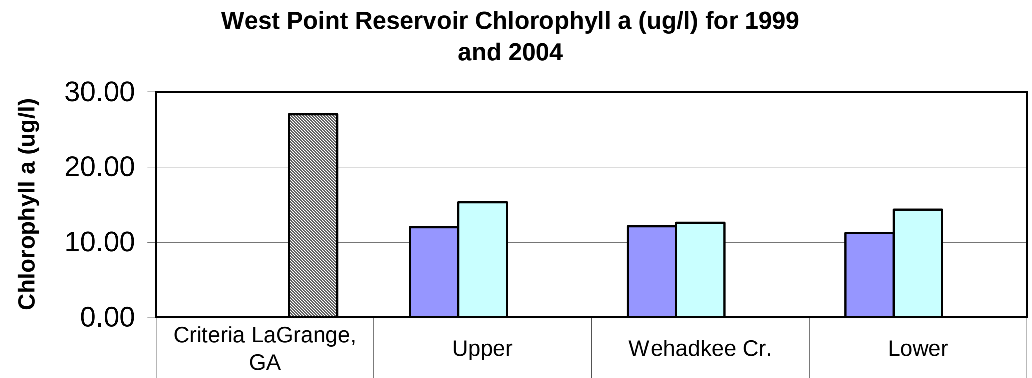
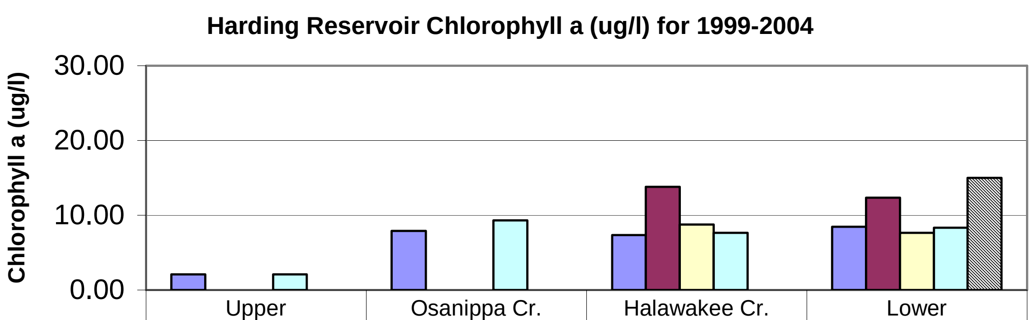


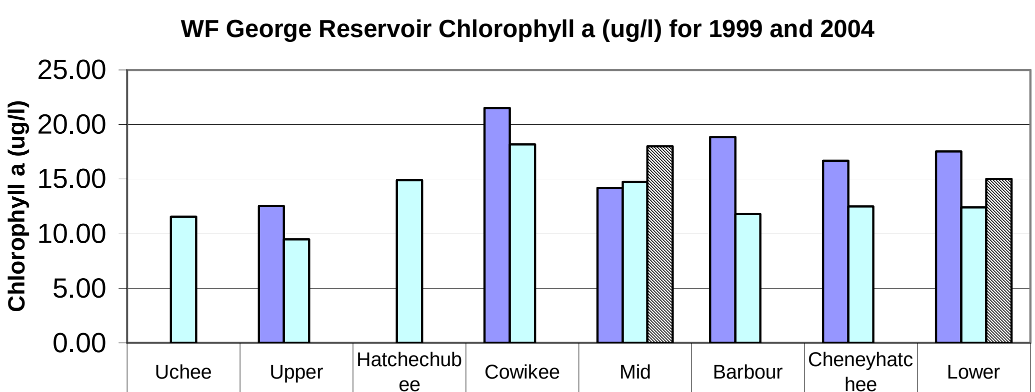
Figure 16. Mean chlorophyll *a* concentrations of West Point Reservoir 1999 and 2004, Harding Reservoir 1999, 2002-2004, and WF George Reservoir 1999 and 2004.



	Criteria LaGrange, GA	Upper	Wehadkee Cr.	Lower
1999		12.0	12.1	11.2
2004		15.28	12.56	14.31
Criteria	27.0			



	Upper	Osanippa Cr.	Halawakee Cr.	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
Criteria				15



	Uchee	Upper	Hatchechubee	Cowikee	Mid	Barbour	Cheneyhatchee	Lower
1999		12.5		21.5	14.2	18.8	16.7	17.5
2004	11.54	9.51	14.90	18.17	14.75	11.79	12.50	12.42
Criteria					18.0			15.0

Figure 17. Mean total suspended solids (TSS) concentrations of Chattahoochee River mainstem stations and tributary embayments, April-October 2004.

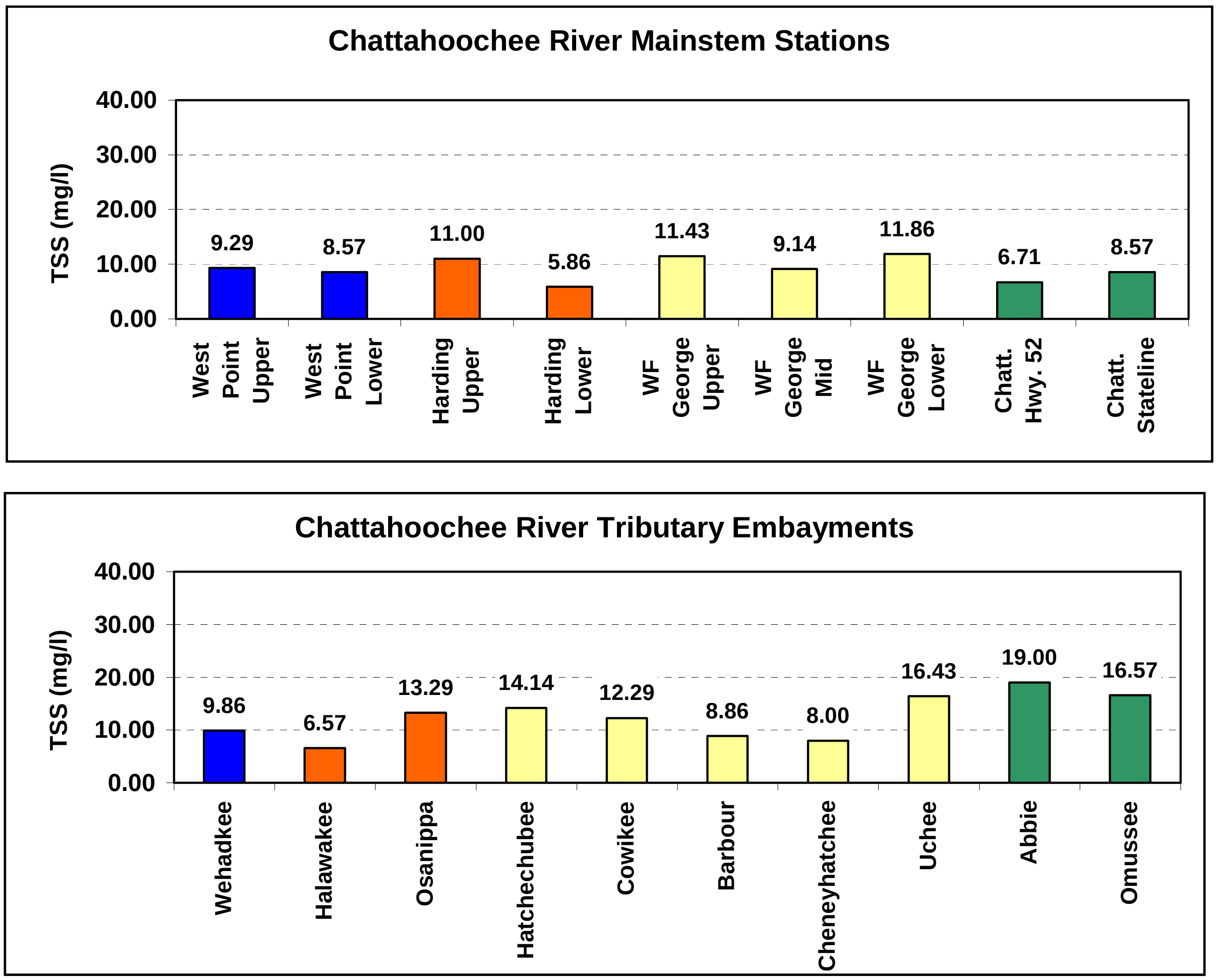
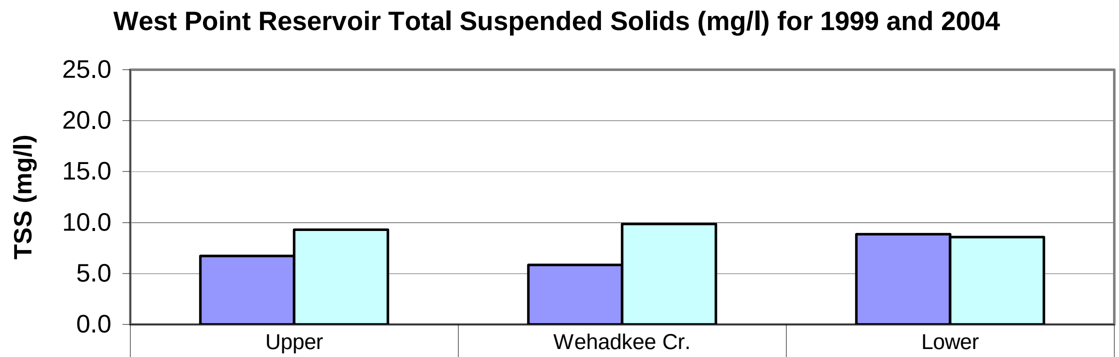
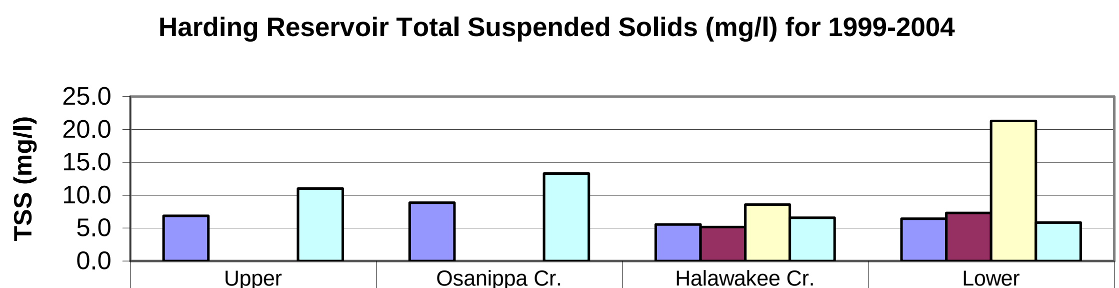


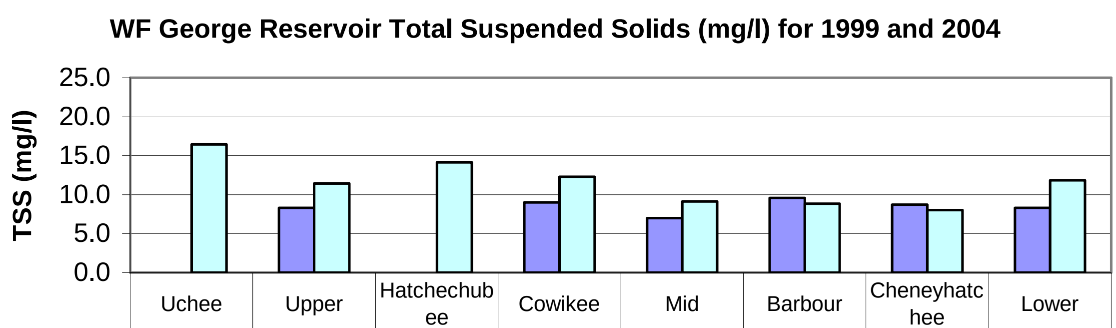
Figure 18. Mean total suspended solids (TSS) concentrations of West Point Reservoir 1999 and 2004, Harding Reservoir 1999, 2002-2004, and WF George Reservoir 1999 and 2004.



	Upper	Wehadkee Cr.	Lower
1999	6.7	5.9	8.9
2004	9.3	9.9	8.6



	Upper	Osanippa Cr.	Halawakee Cr.	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



	Uchee	Upper	Hatchechubee	Cowikee	Mid	Barbour	Cheneyhatchee	Lower
1999		8.3		9.0	7.0	9.6	8.7	8.3
2004	16.4	11.4	14.1	12.3	9.1	8.9	8.0	11.9

West Point Reservoir

Figure 19. Total nitrogen (TN) and total phosphorus (TP) in West Point Reservoir, April-October 2004.

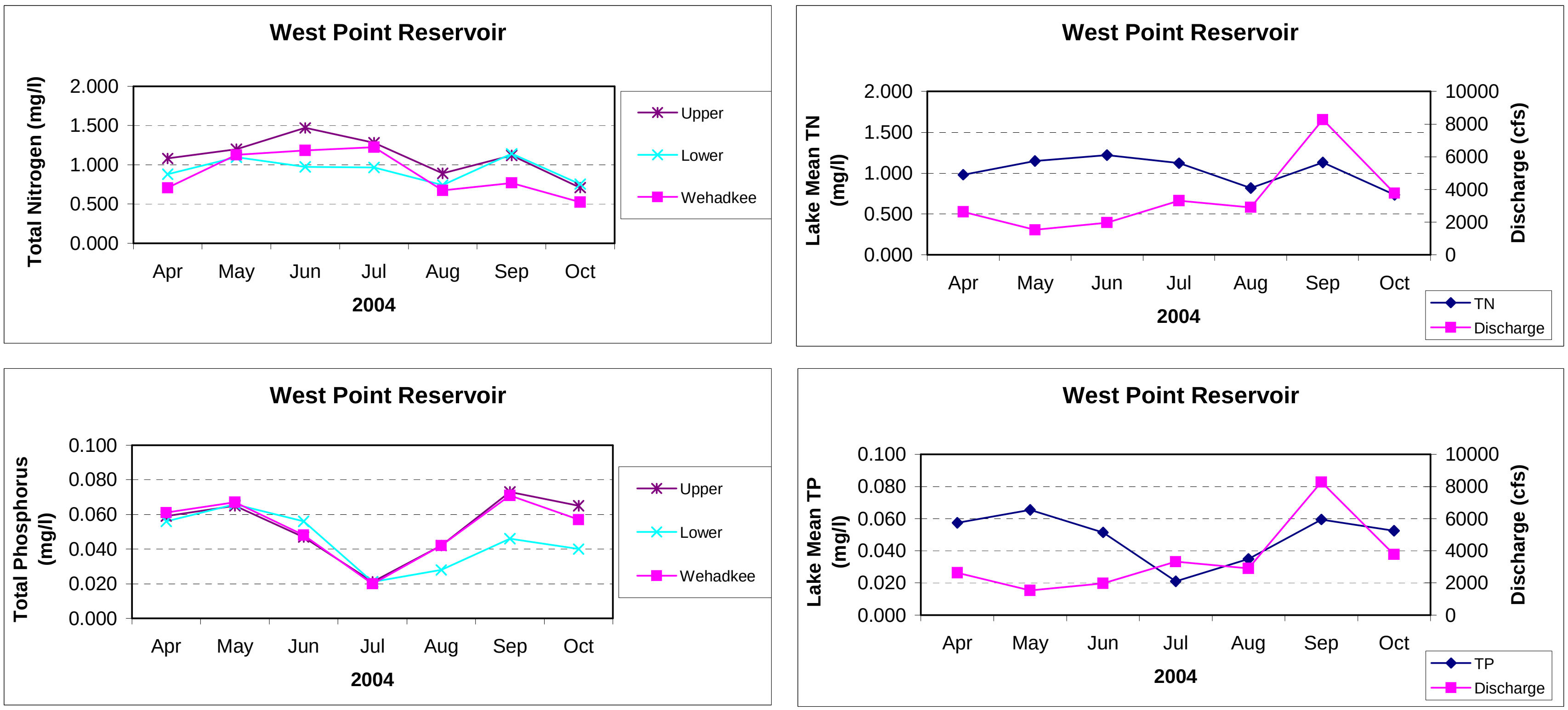


Figure 20. Chloropyll *a* and total suspended solids (TSS) in West Point Reservoir, April-October 2004.

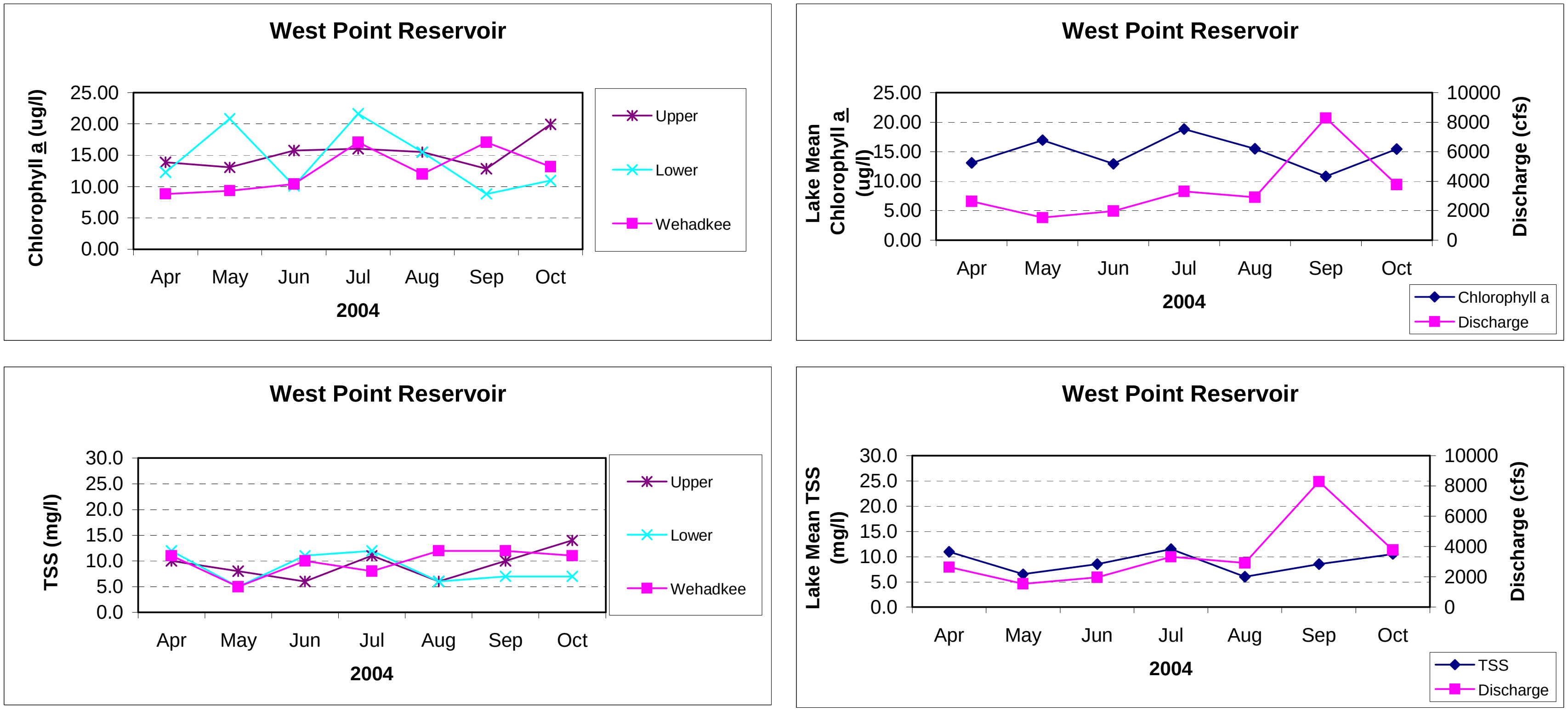
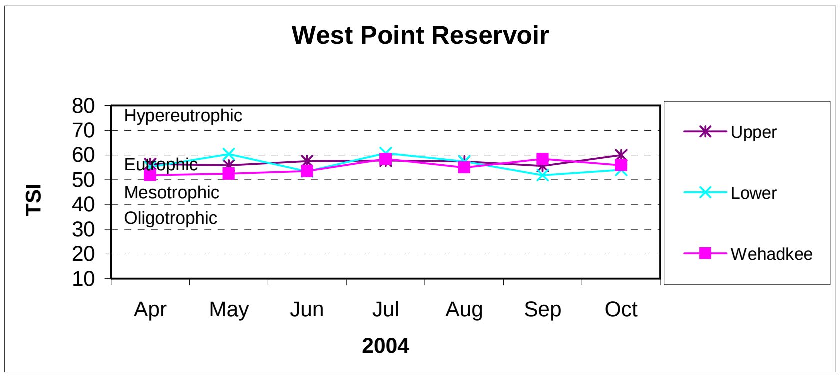


Figure 21. Trophic State Index (TSI) and dissolved oxygen (DO) in West Point Reservoir, April-October 2004.



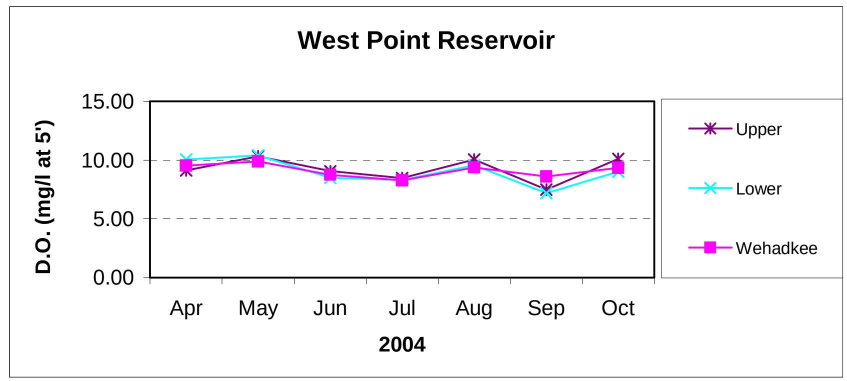


Figure 22. Depth profiles of dissolved oxygen (DO) and temperature (Temp) of upper West Point Reservoir, April-October 2004.

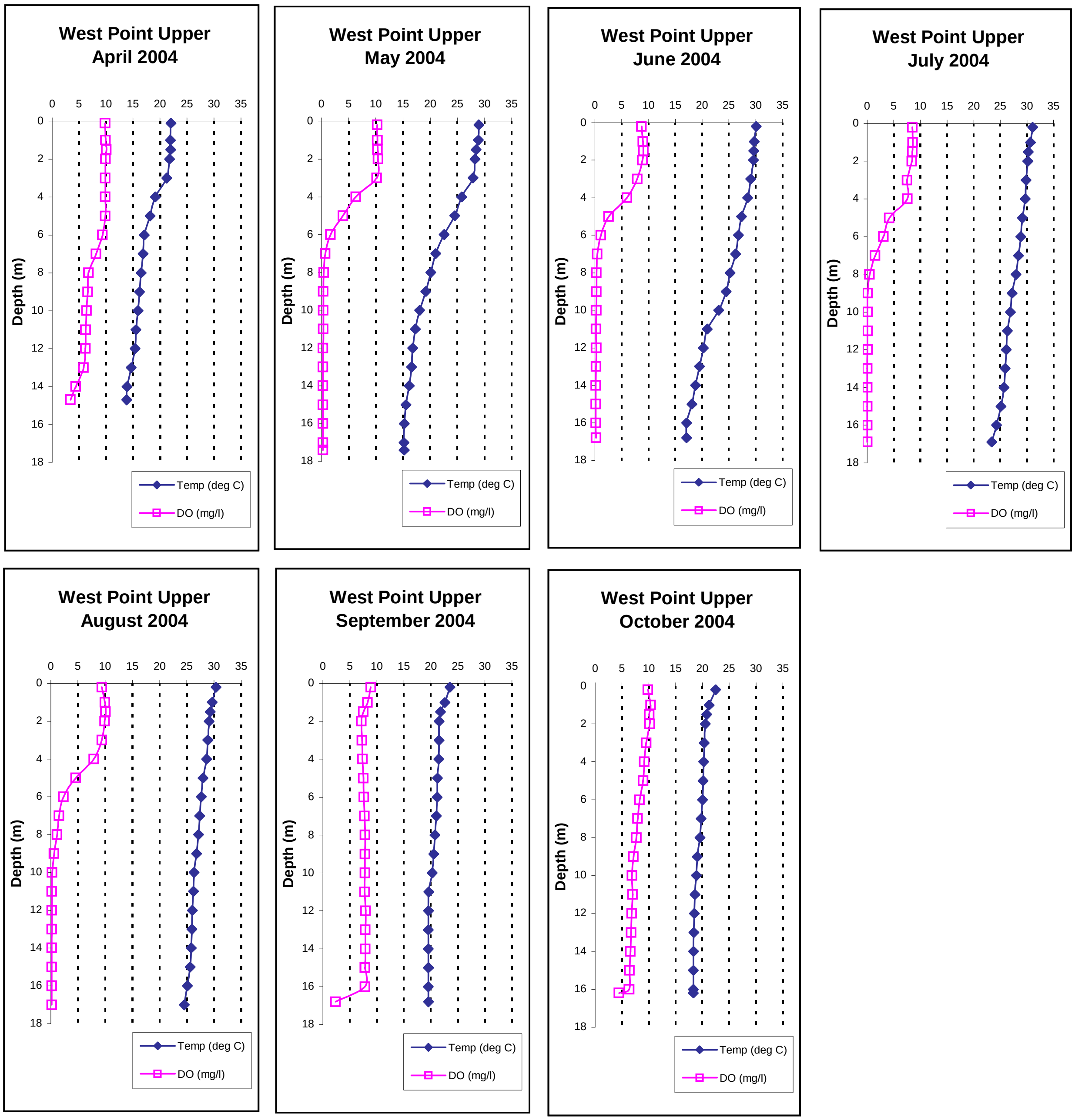


Figure 23. Depth profiles of dissolved oxygen (DO) and temperature (Temp) of Lower West Point Reservoir, April-October 2004.

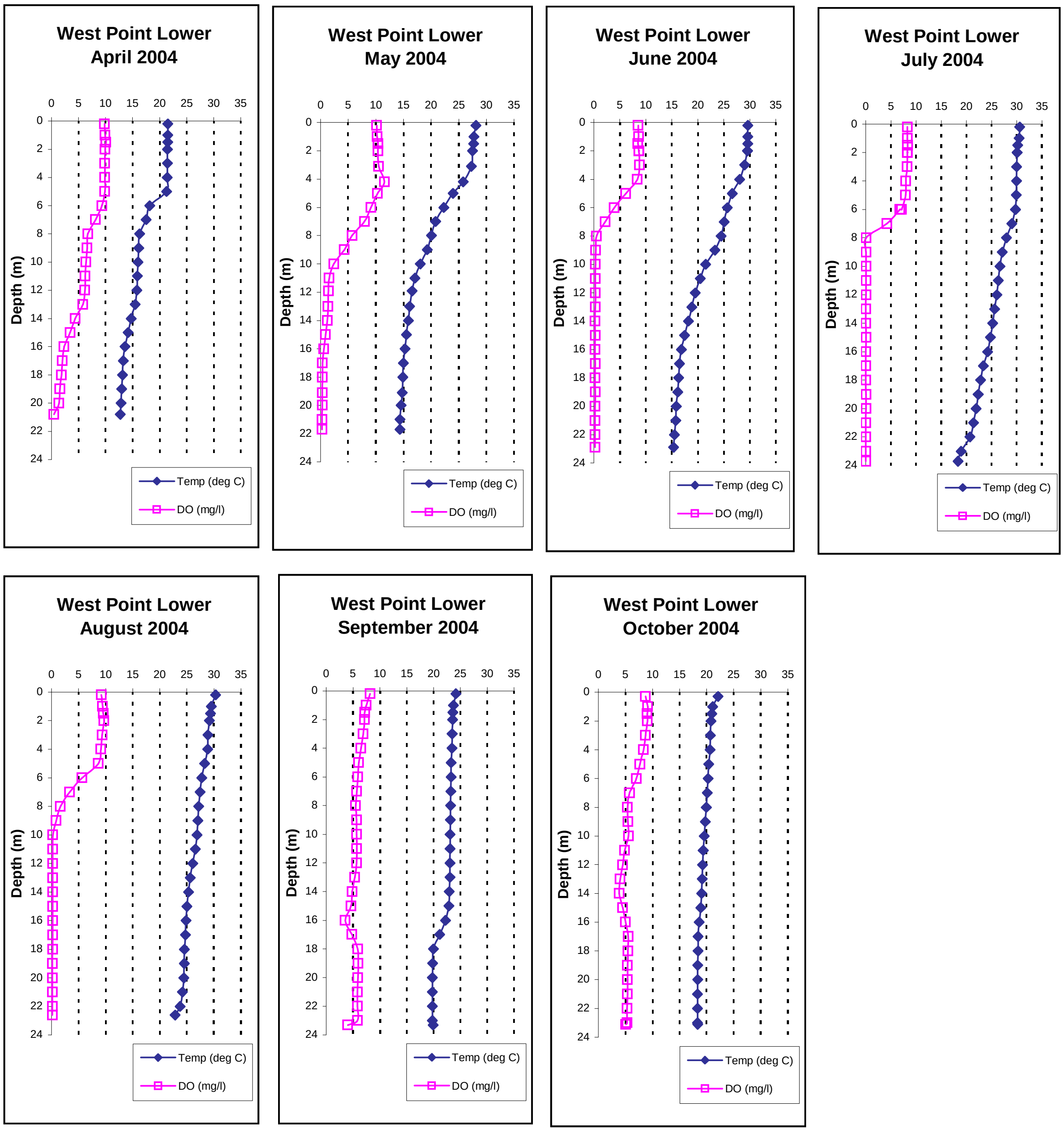
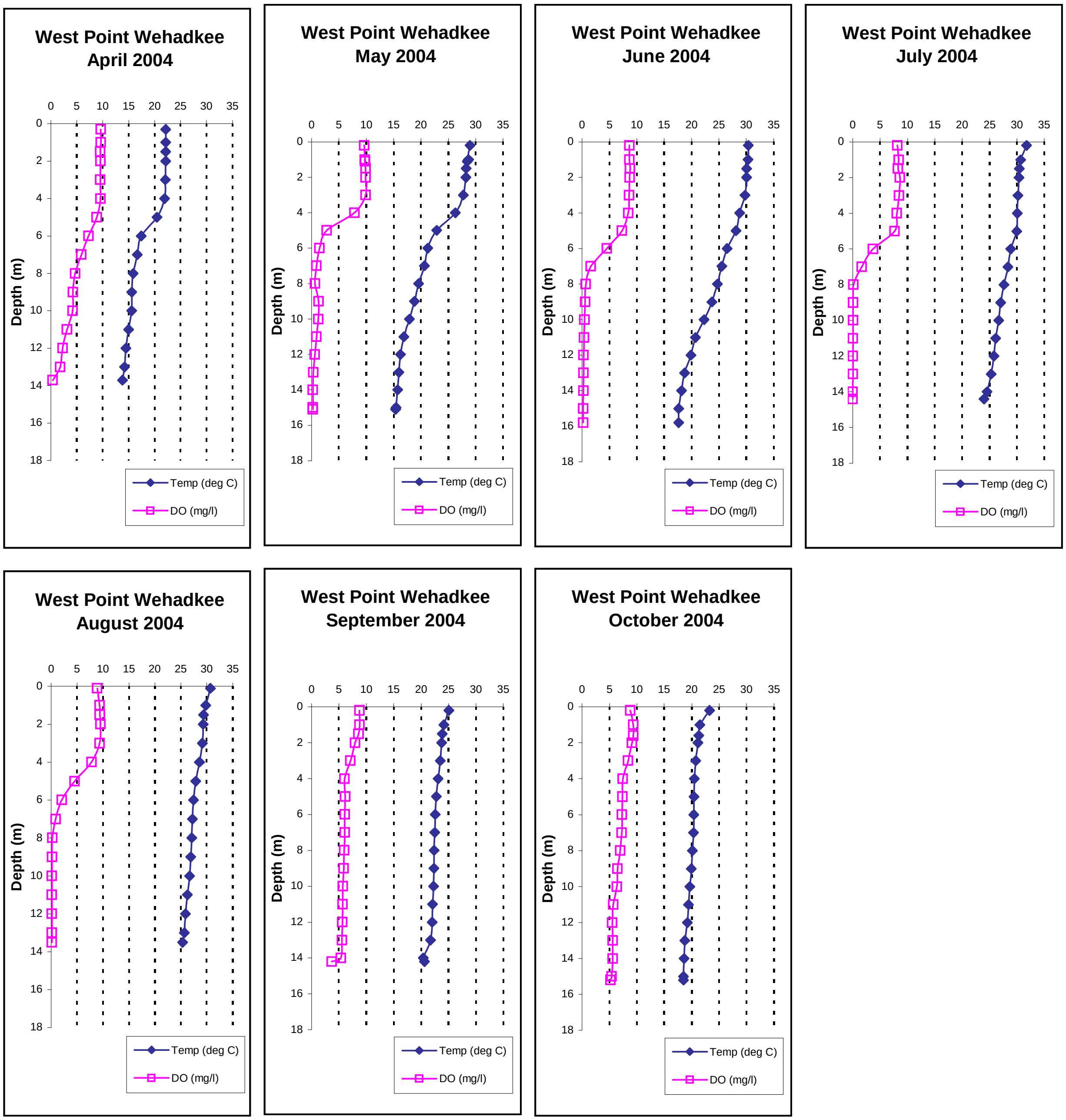


Figure 24. Depth profiles of dissolved oxygen (DO) and temperature (Temp) of Wehadkee Creek embayment, April-October 2004.



Harding Reservoir

Figure 25. Total nitrogen (TN) and total phosphorus (TP) in Harding Reservoir, April-October 2004.

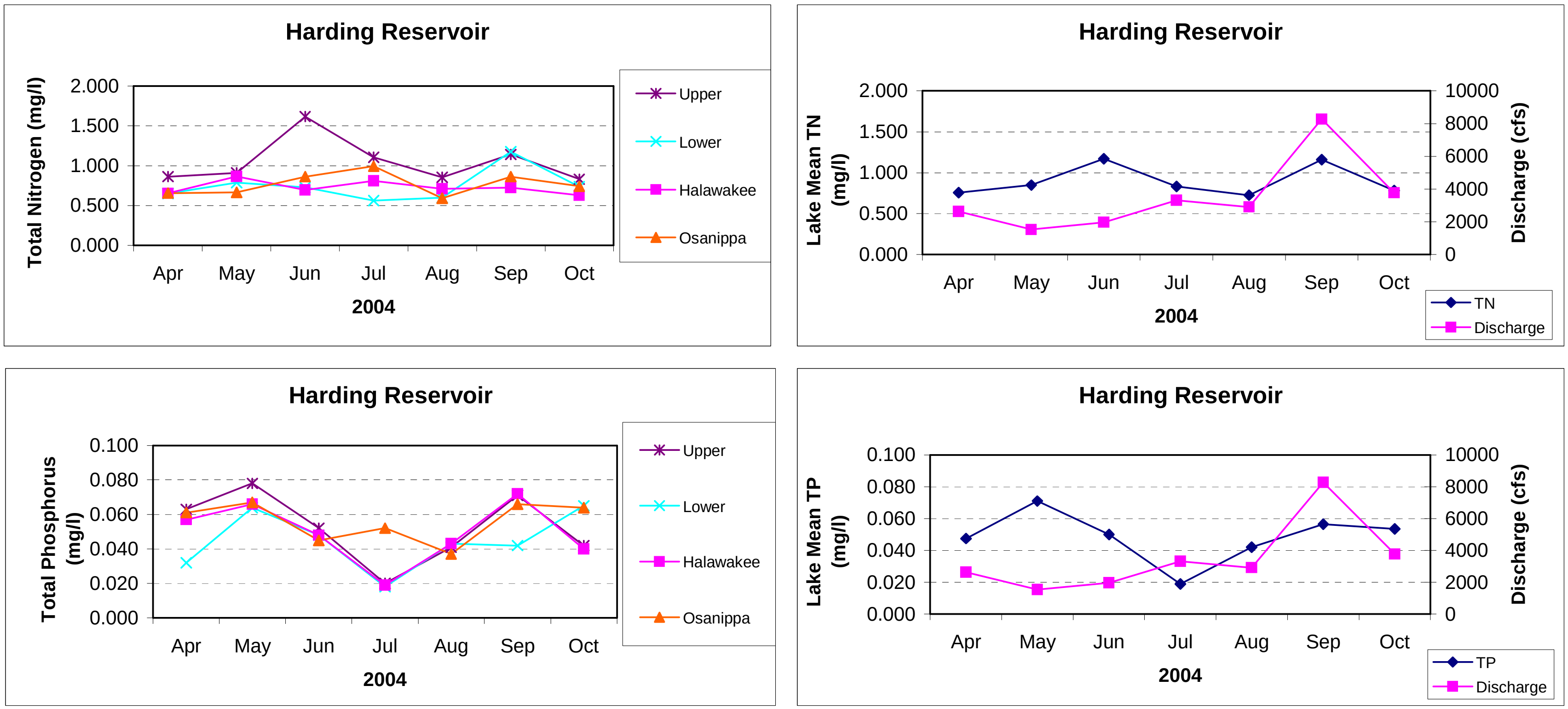


Figure 26. Chlorophyll *a* and total suspended solids (TSS) in Harding Reservoir, April-October 2004.

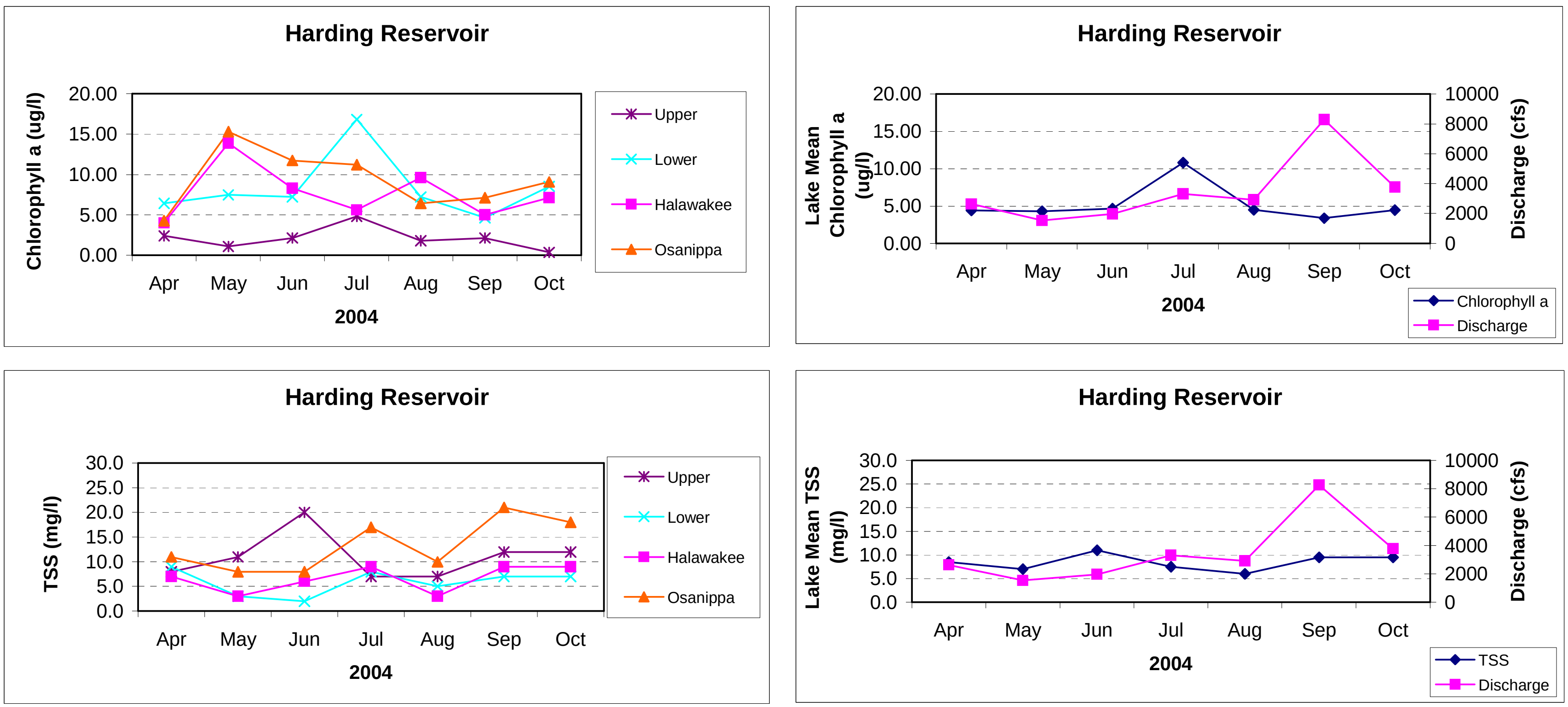
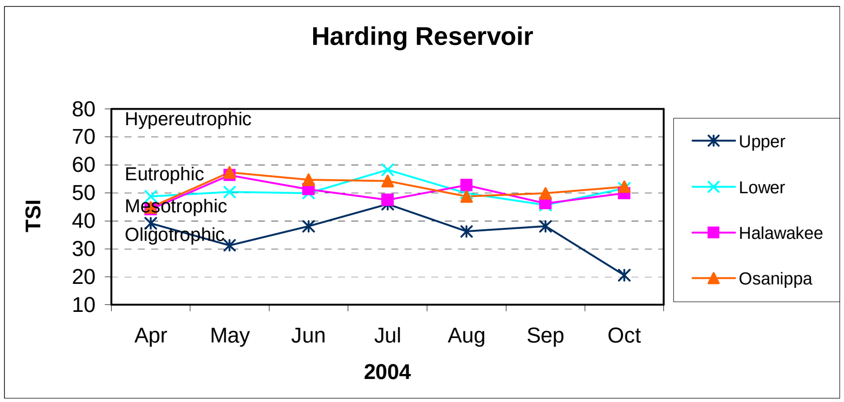


Figure 27. Trophic State Index (TSI) and dissolved oxygen (DO) in Harding Reservoir, April-October 2004.



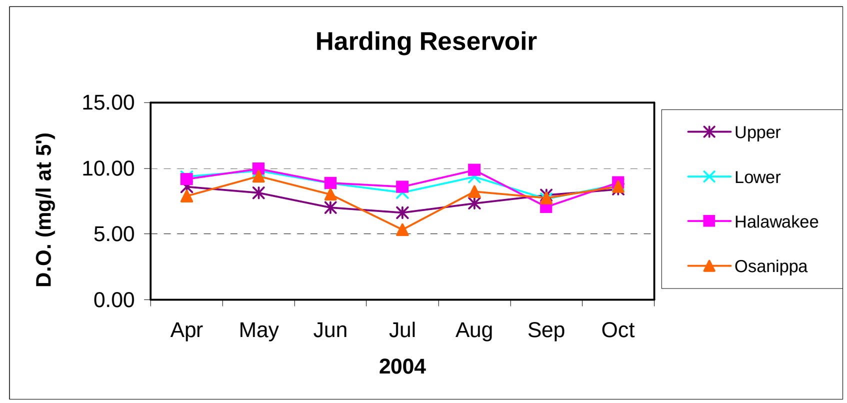


Figure 28. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in upper Harding Reservoir, April-October 2004.

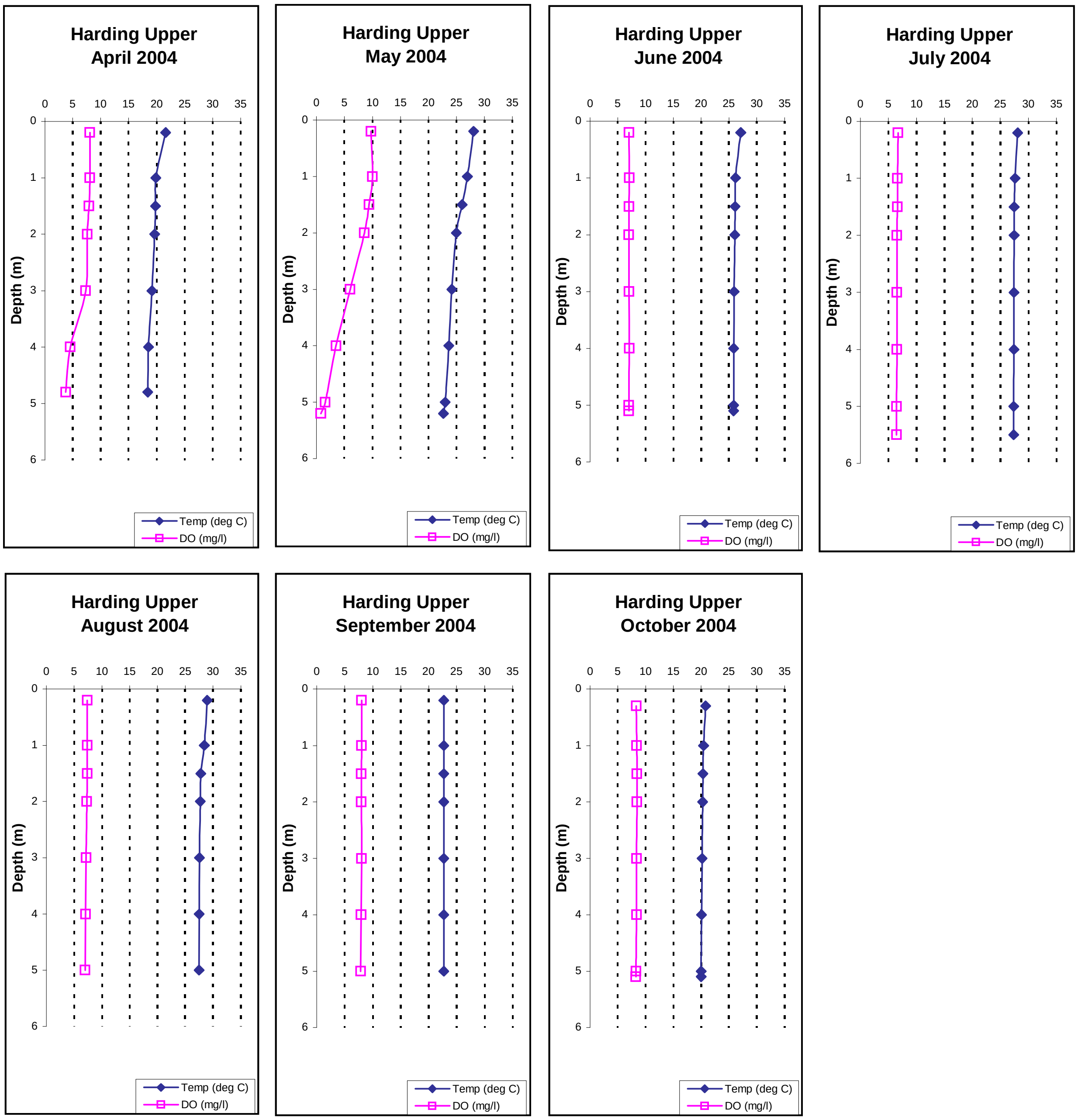


Figure 29. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in lower Harding Reservoir, April-October 2004.

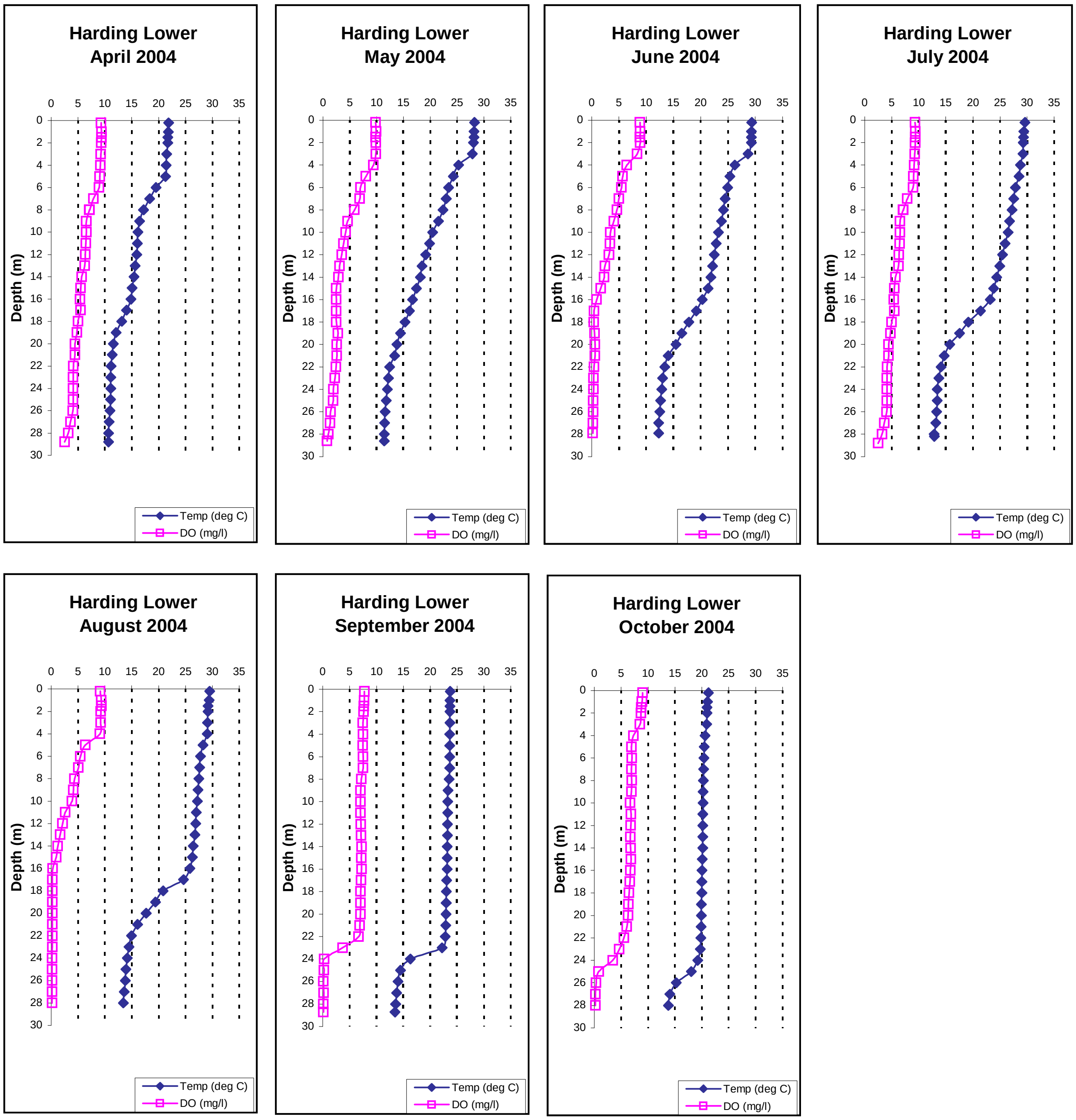


Figure 30. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Osanippa Creek embayment, April-October 2004.

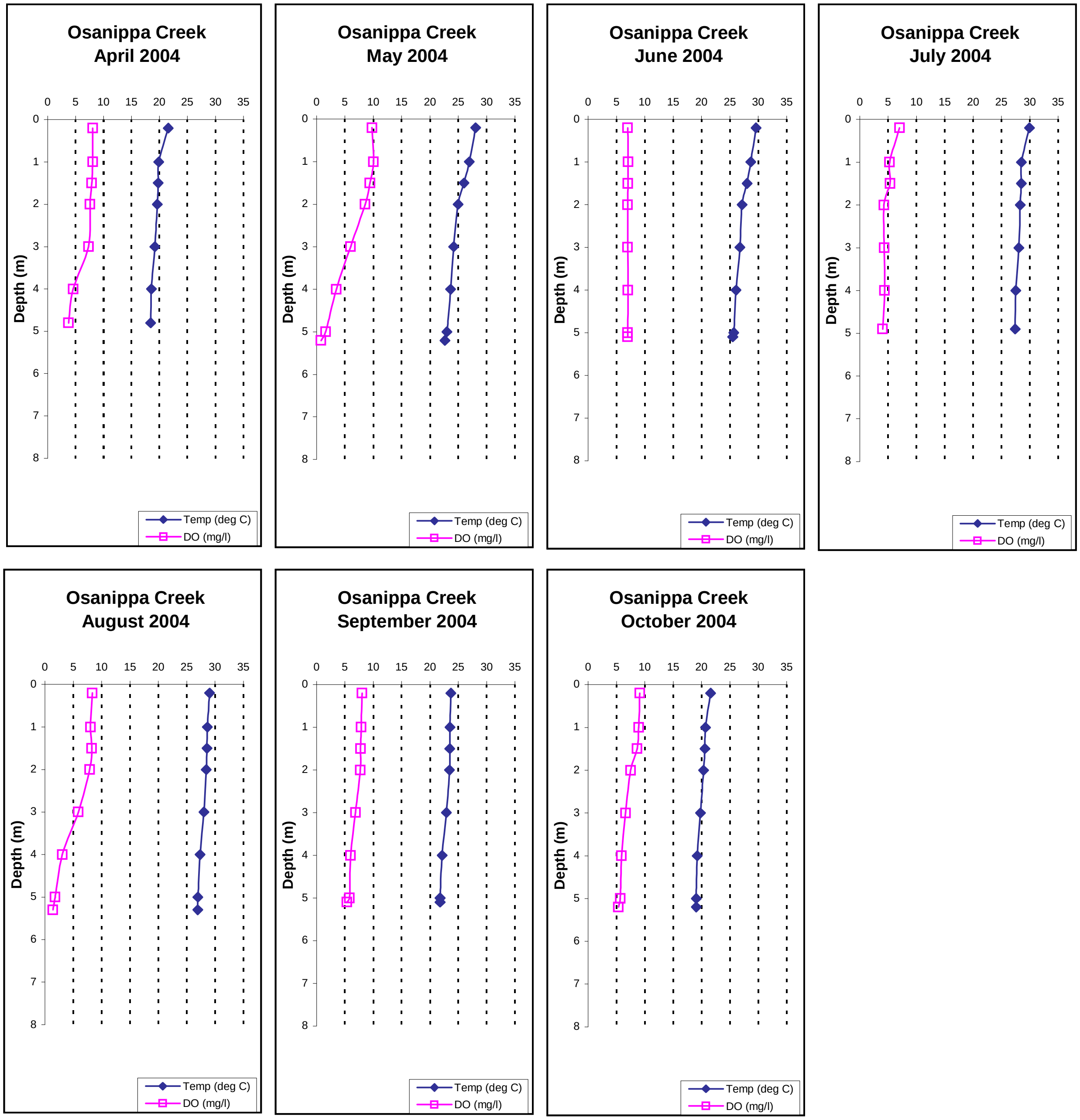
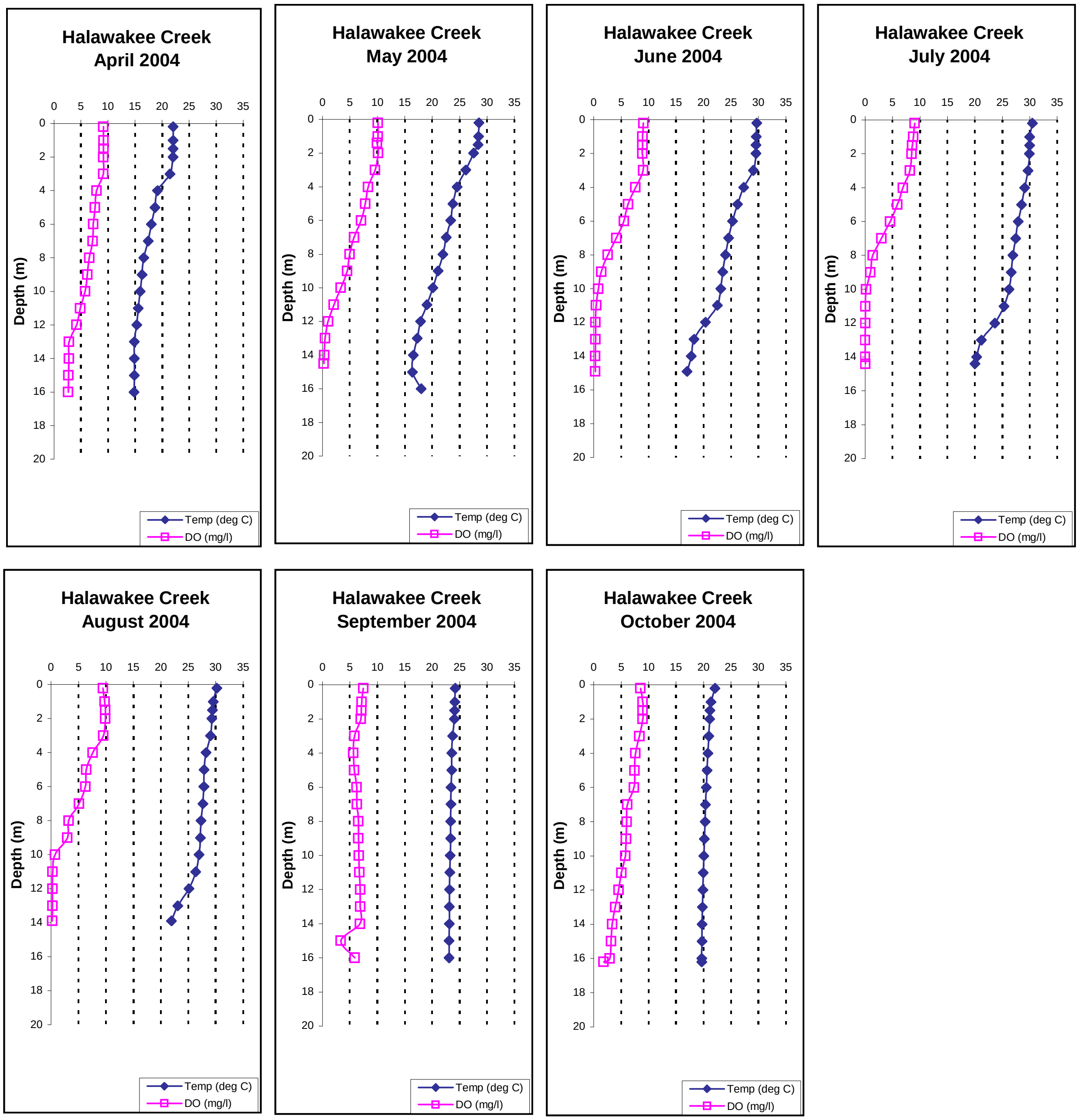


Figure 31. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Hallawakee Creek embayment, April-October 2004.



WF George Reservoir

Figure 32. Total nitrogen (TN) and total phosphorus (TP) of WF George Reservoir, April-October 2004.

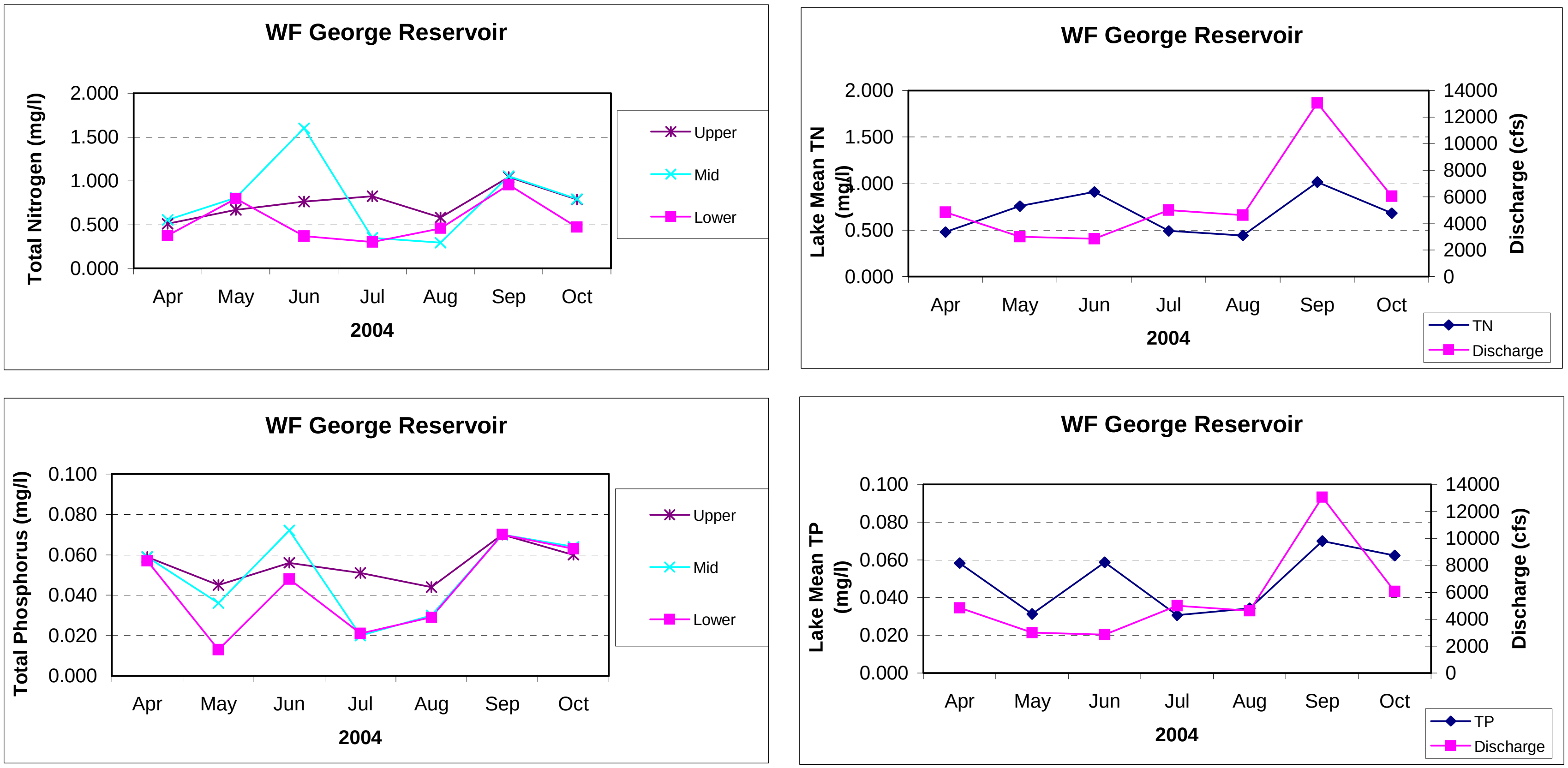


Figure 33. Chlorophyll *a* and total suspended solids (TSS) of WF George Reservoir, April-October 2004.

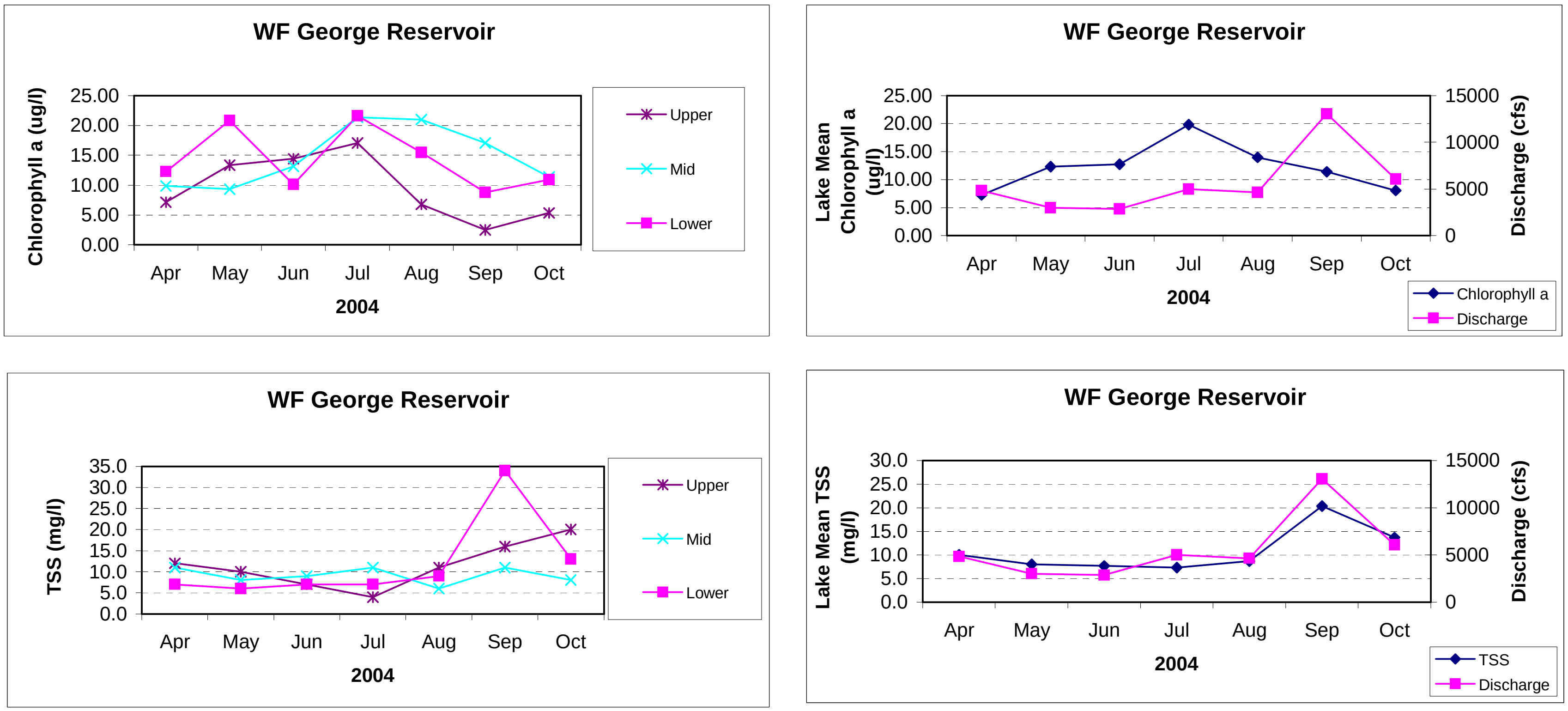
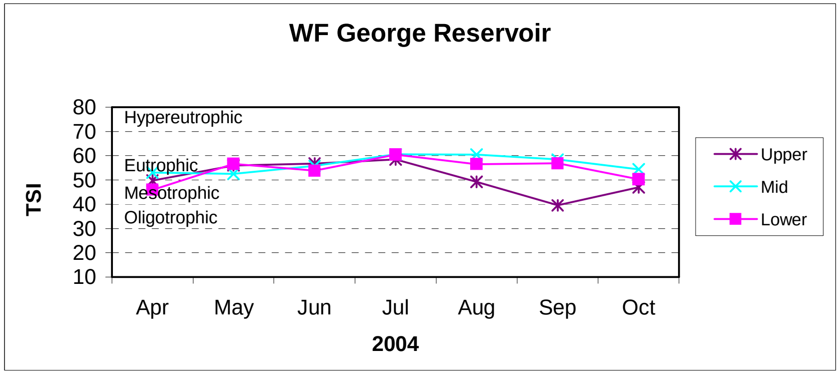


Figure 34. Trophic State Index (TSI) and dissolved oxygen (DO) of WF George Reservoir, April-October 2004.



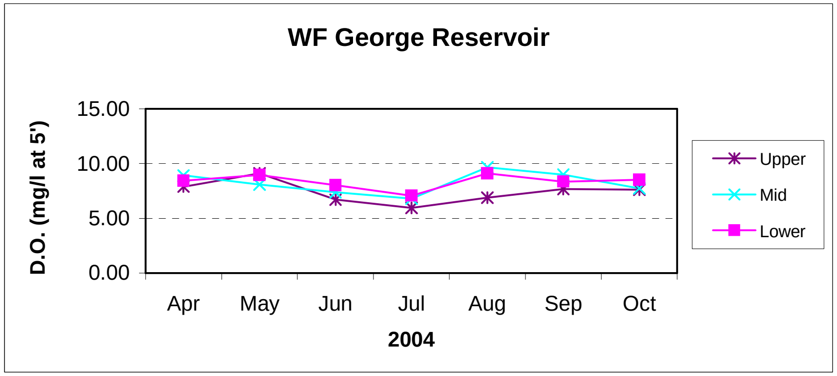


Figure 35. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in upper WF George Reservoir, April-October 2004.

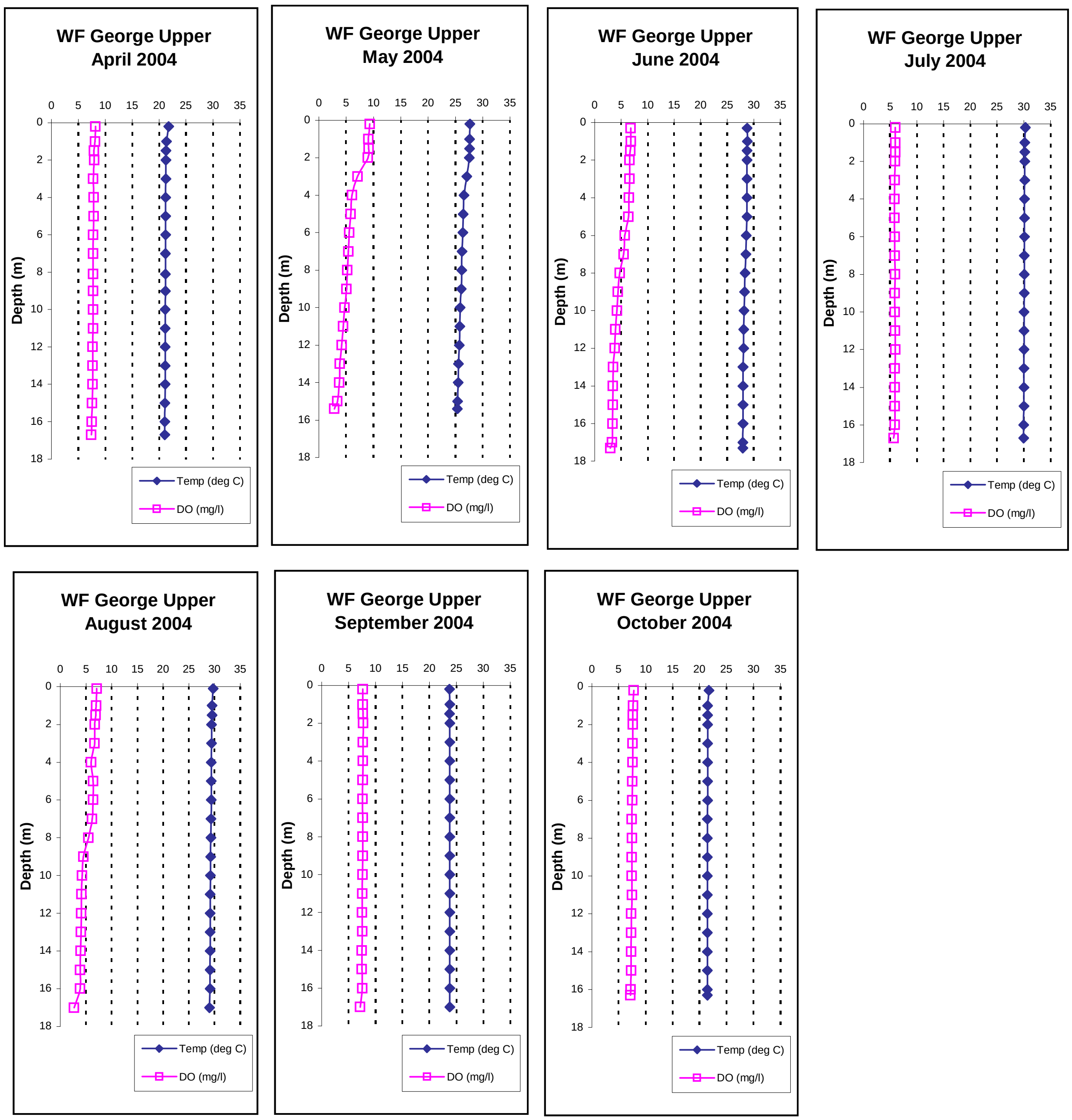


Figure 36. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in mid WF George Reservoir, April-October 2004.

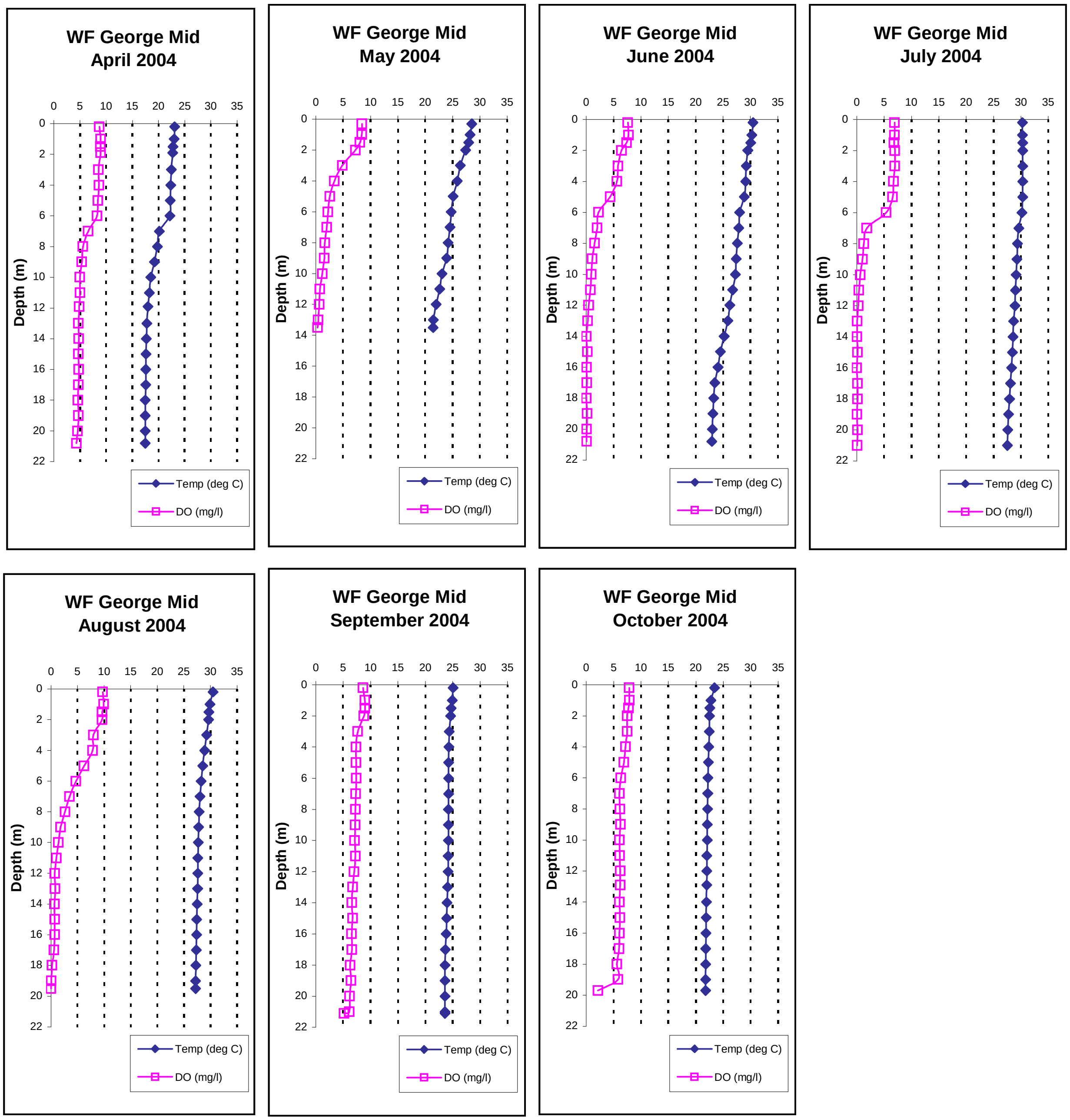


Figure 37. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in lower WF George Reservoir, April-October 2004.

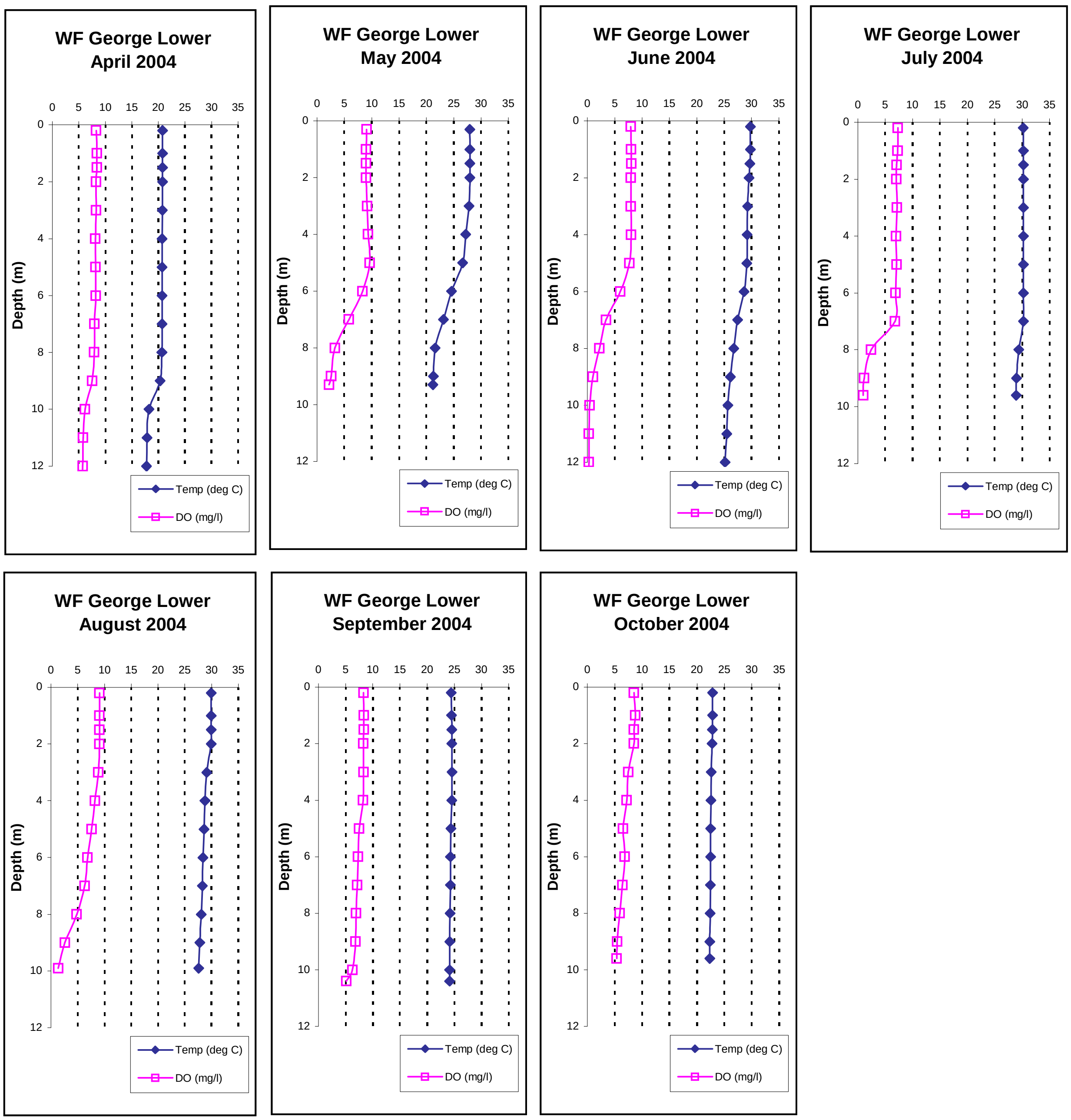


Figure 38. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Uchee Creek embayment, April-October 2004.

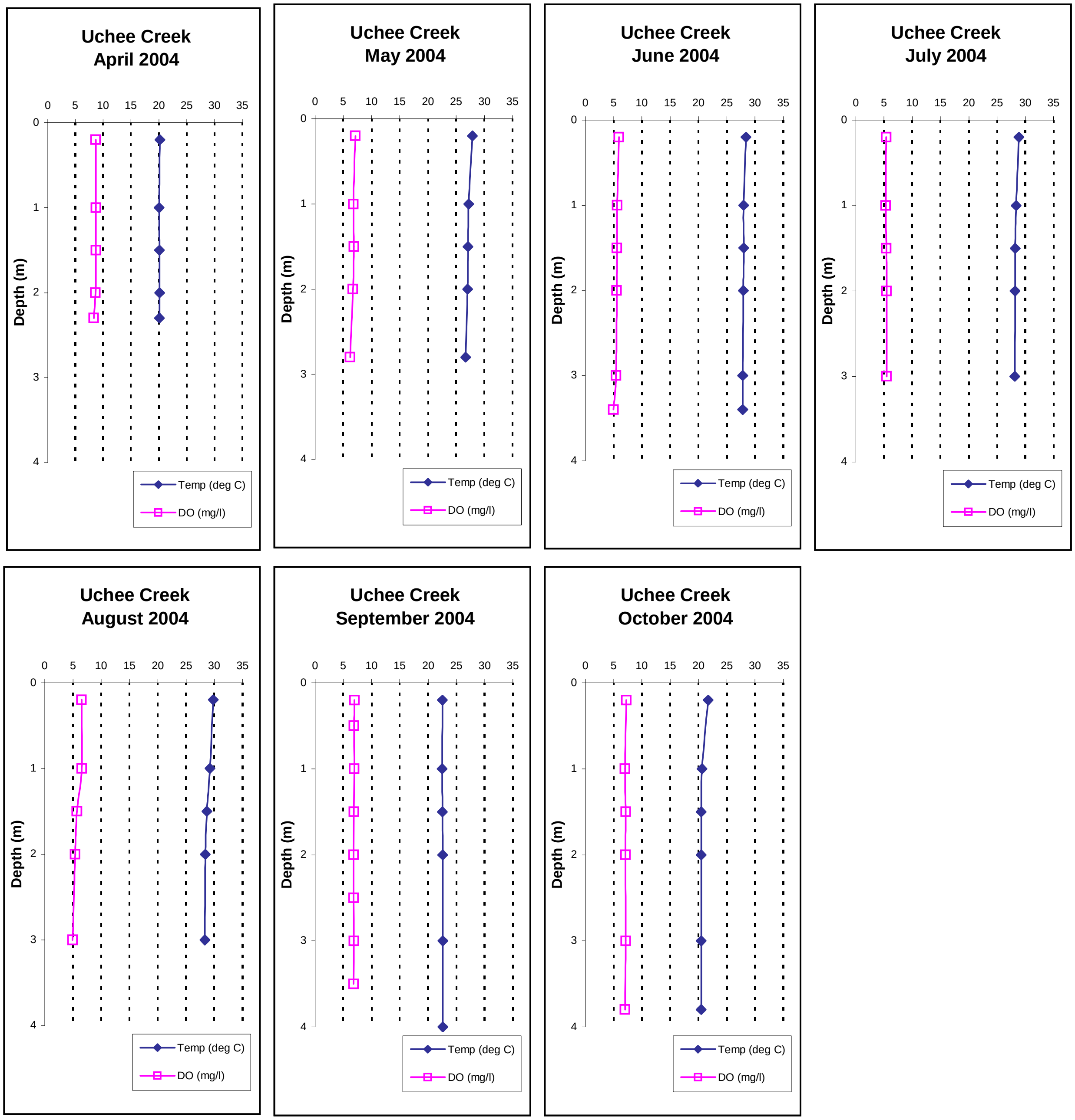


Figure 39. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Hatchechubee Creek embayment, April-October 2004.

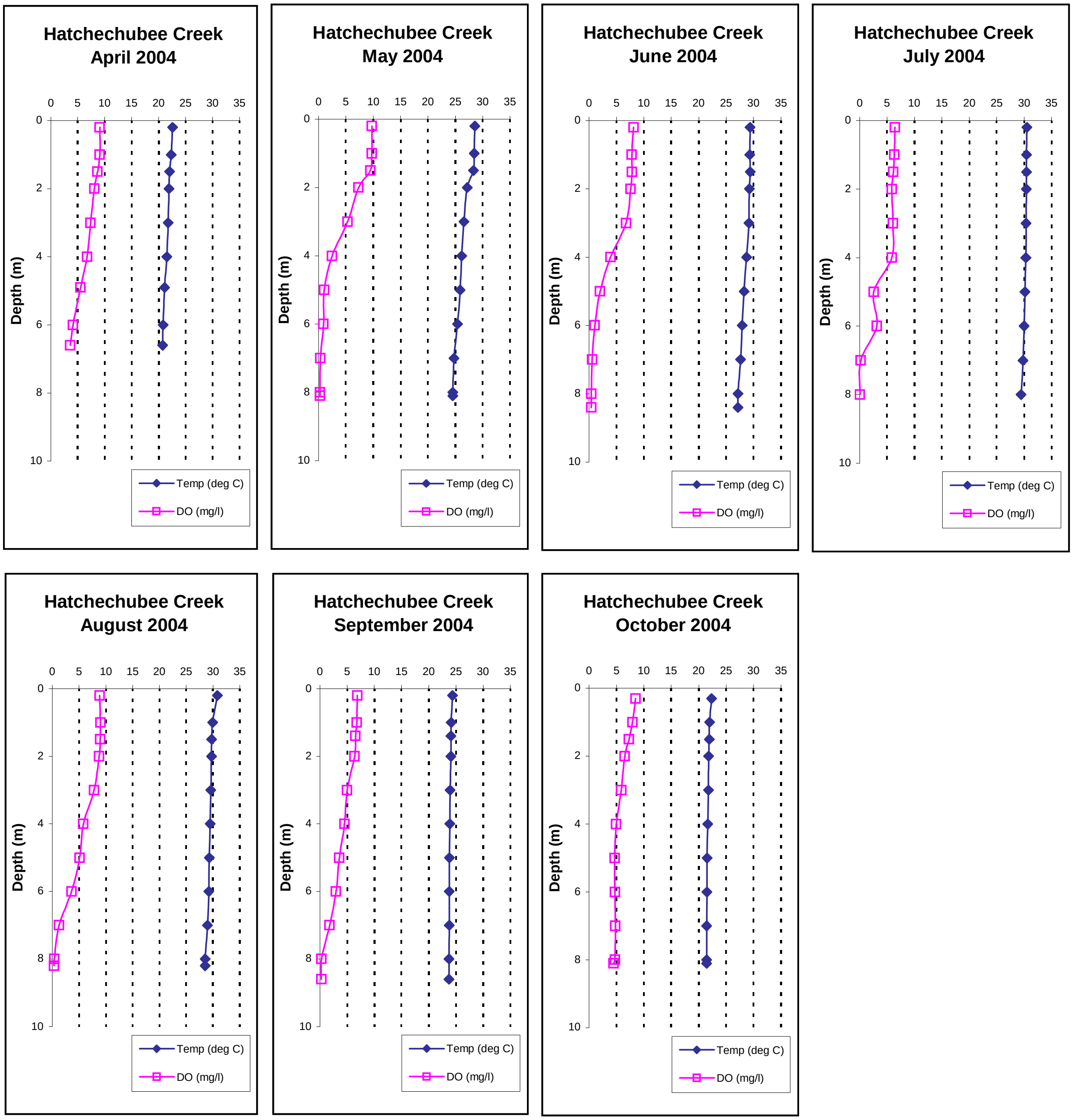


Figure 40. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Cowikee Creek embayment, April-October 2004.

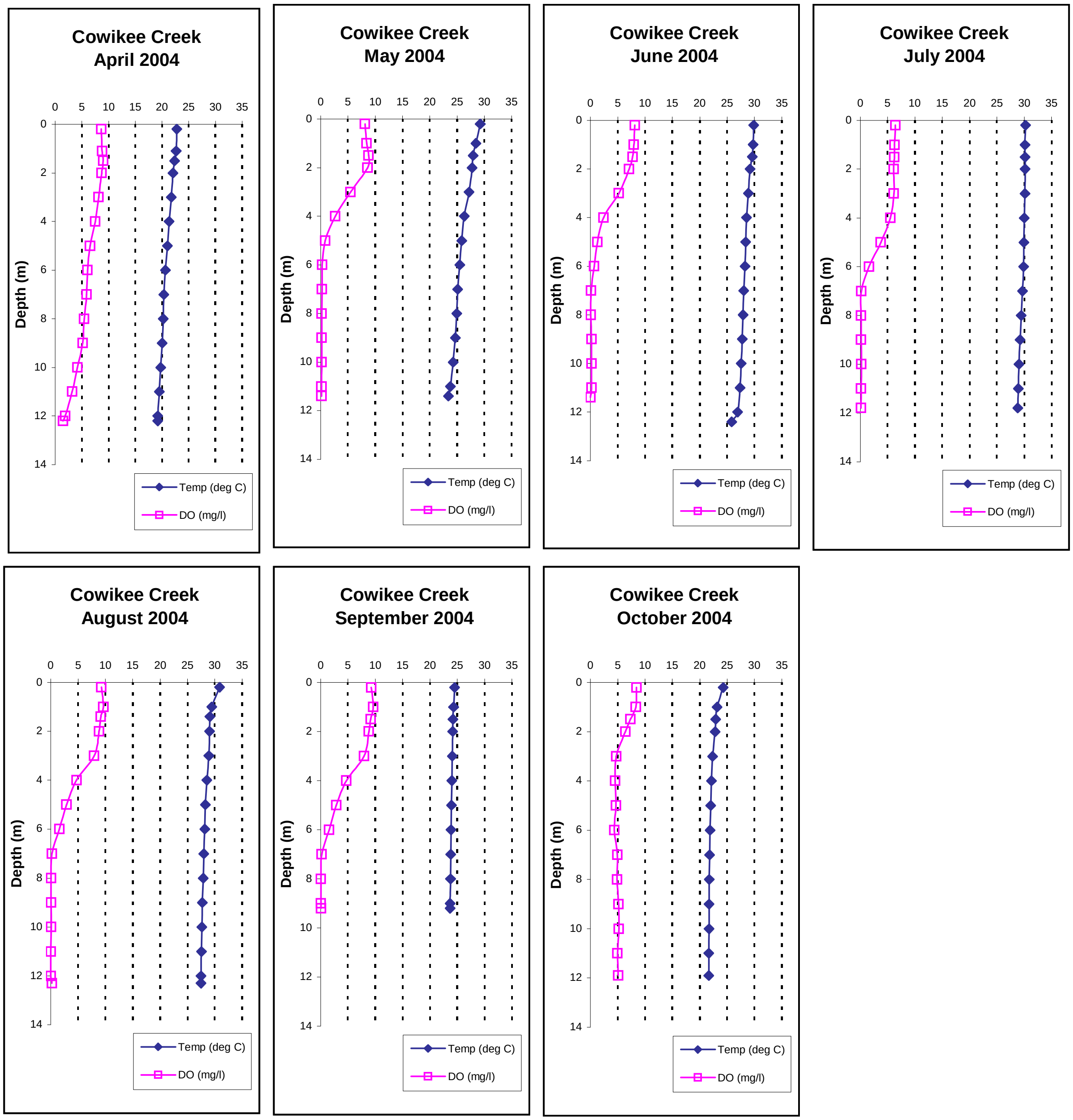


Figure 41. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Barbour Creek embayment, April-October 2004.

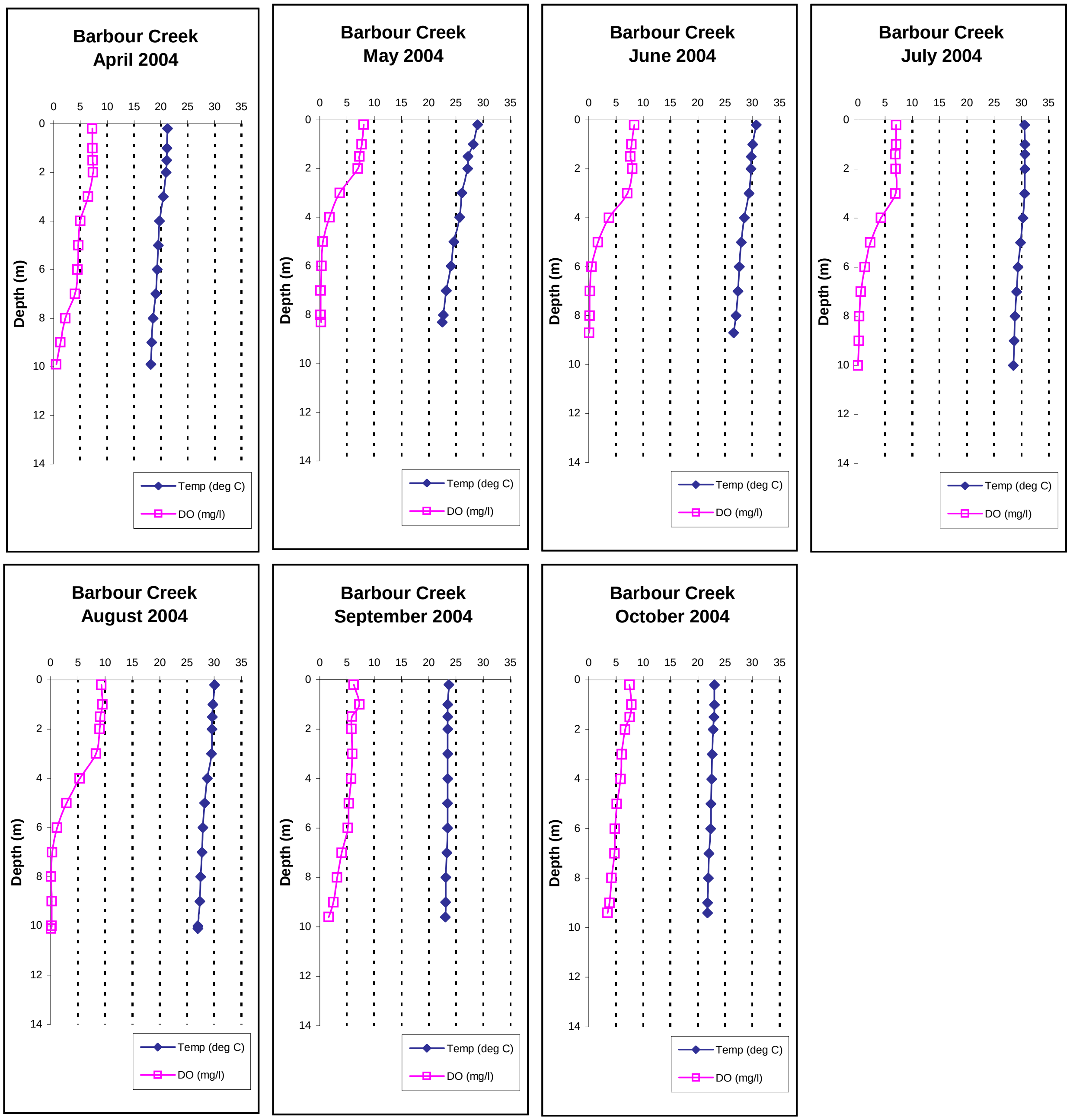
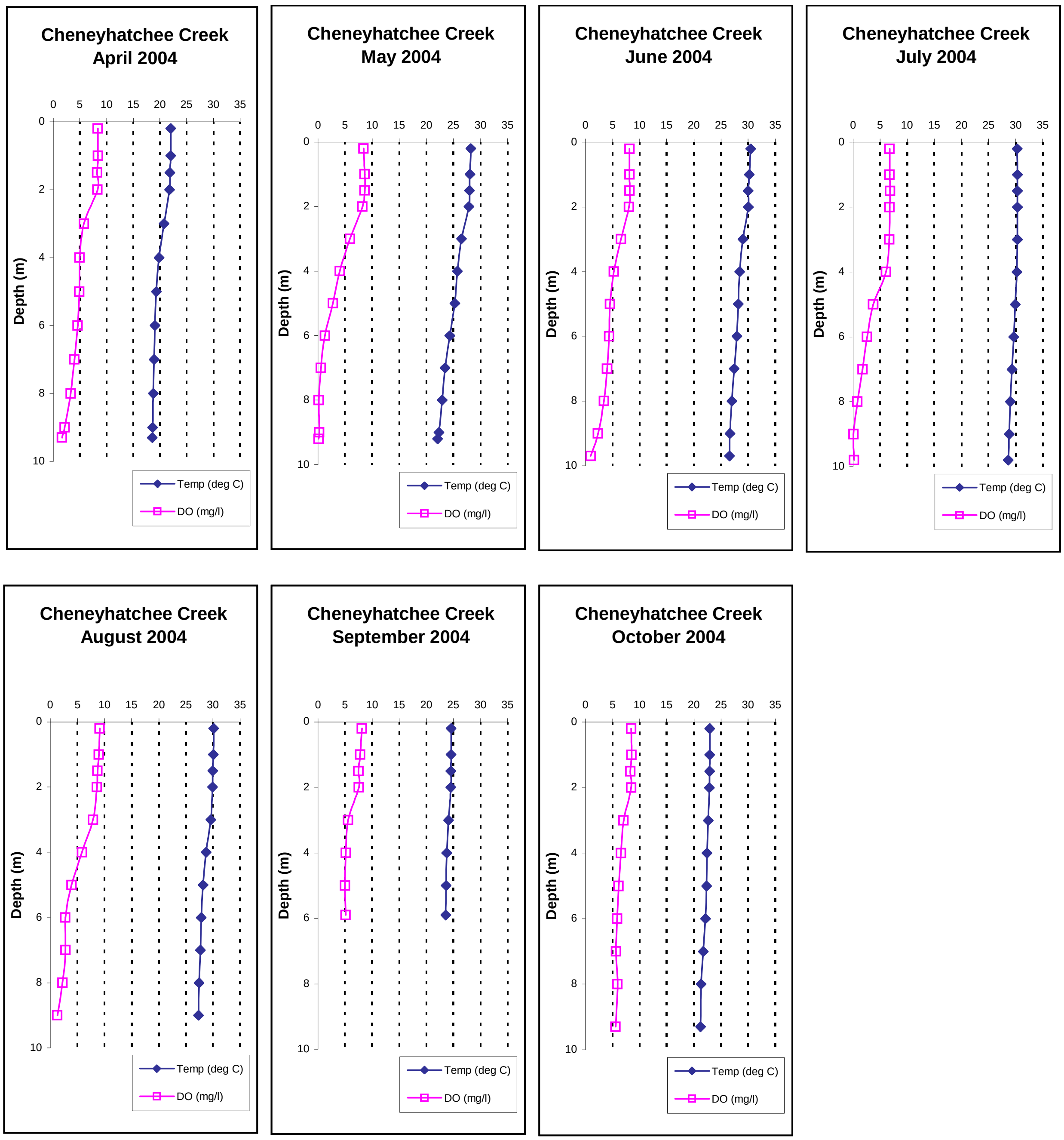


Figure 42. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Cheneyhatchee Creek embayment, April-October 2004.



Lower Chattahoochee River

Figure 43. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, total suspended solids (TSS) in the Lower Chattahoochee River, April-October 2004.

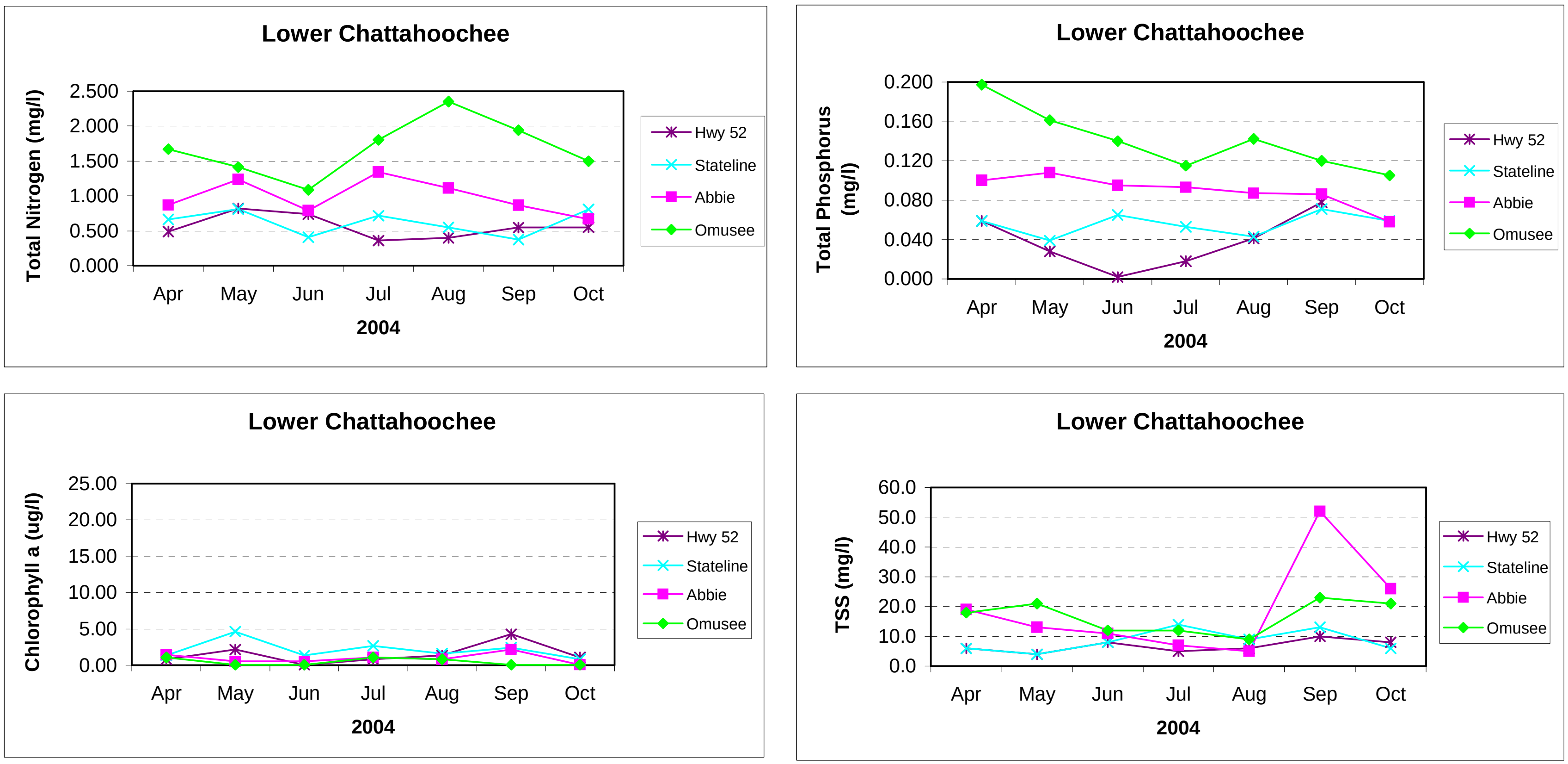
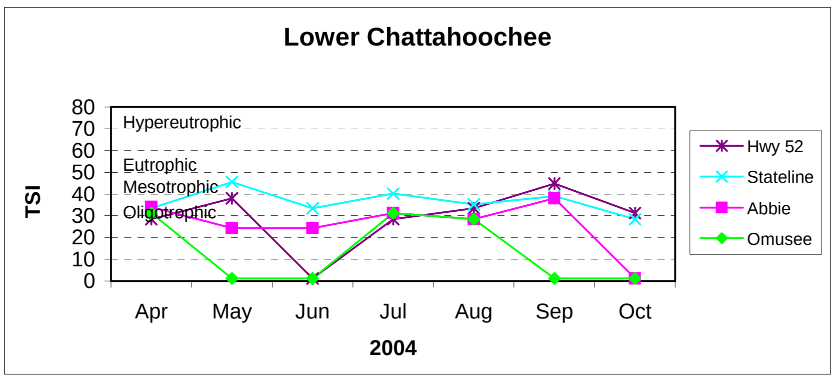


Figure 44. Trophic State Index (TSI) and dissolved oxygen (DO) in the Lower Chattahoochee River, April-October 2004.



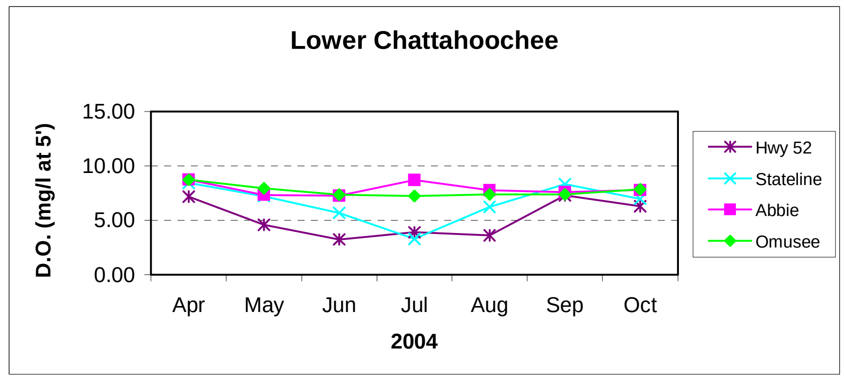


Figure 45. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Lower Chattahoochee River near AL Hwy 52, April-October 2004.

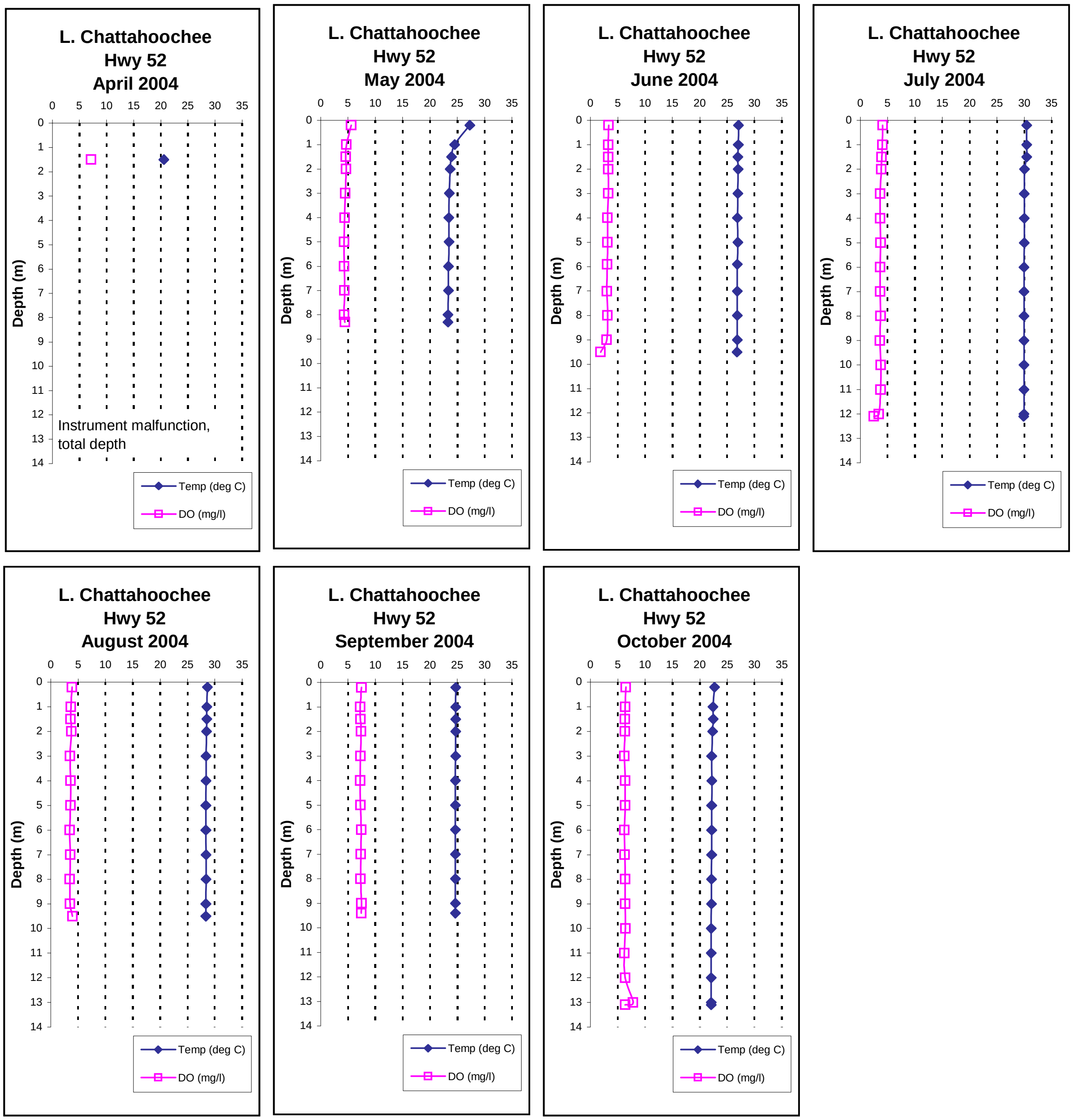


Figure 46. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Lower Chattahoochee River near AL/FL Stateline, April-October 2004.

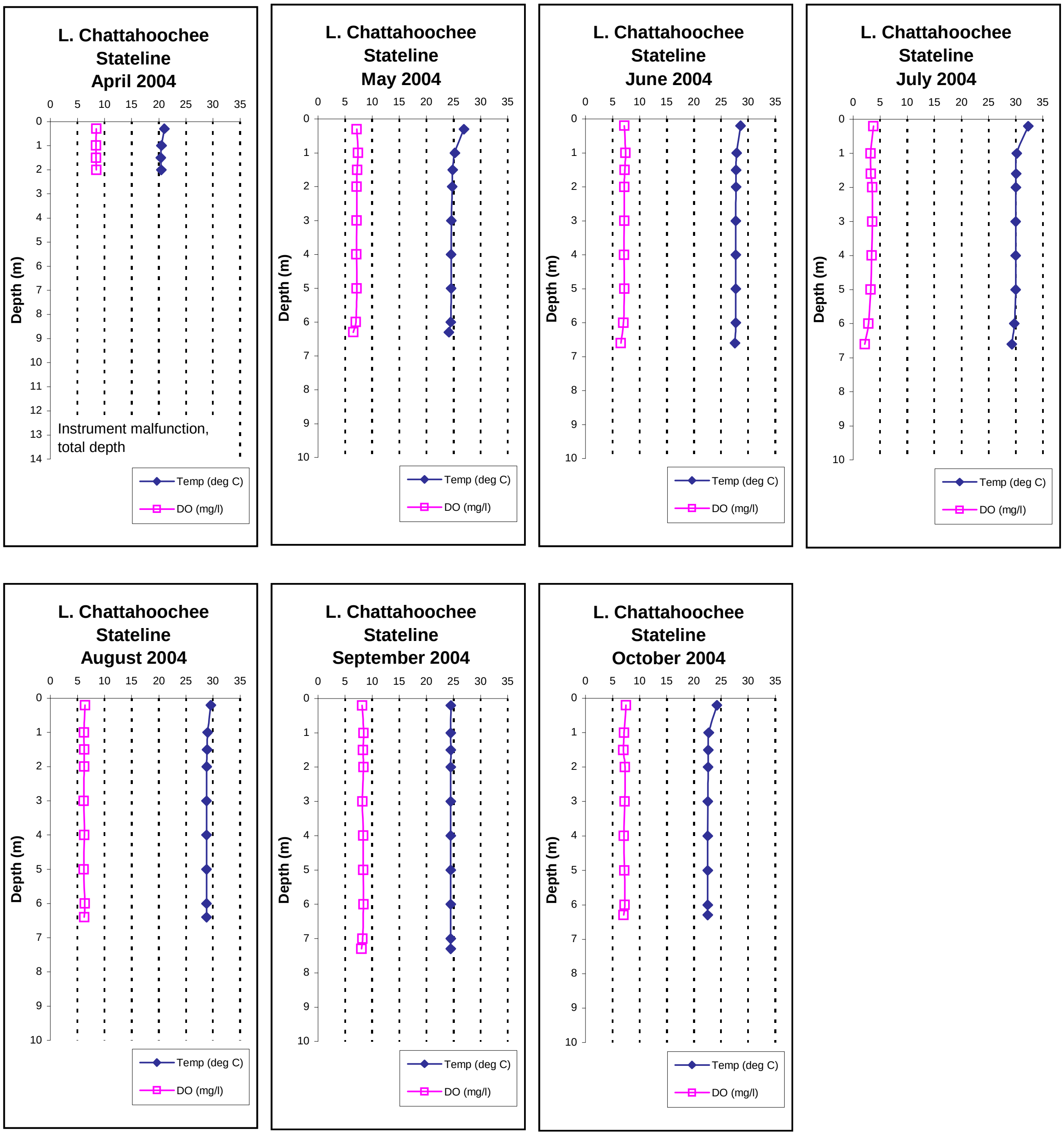


Figure 47. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Abbie Creek embayment, April-October 2004.

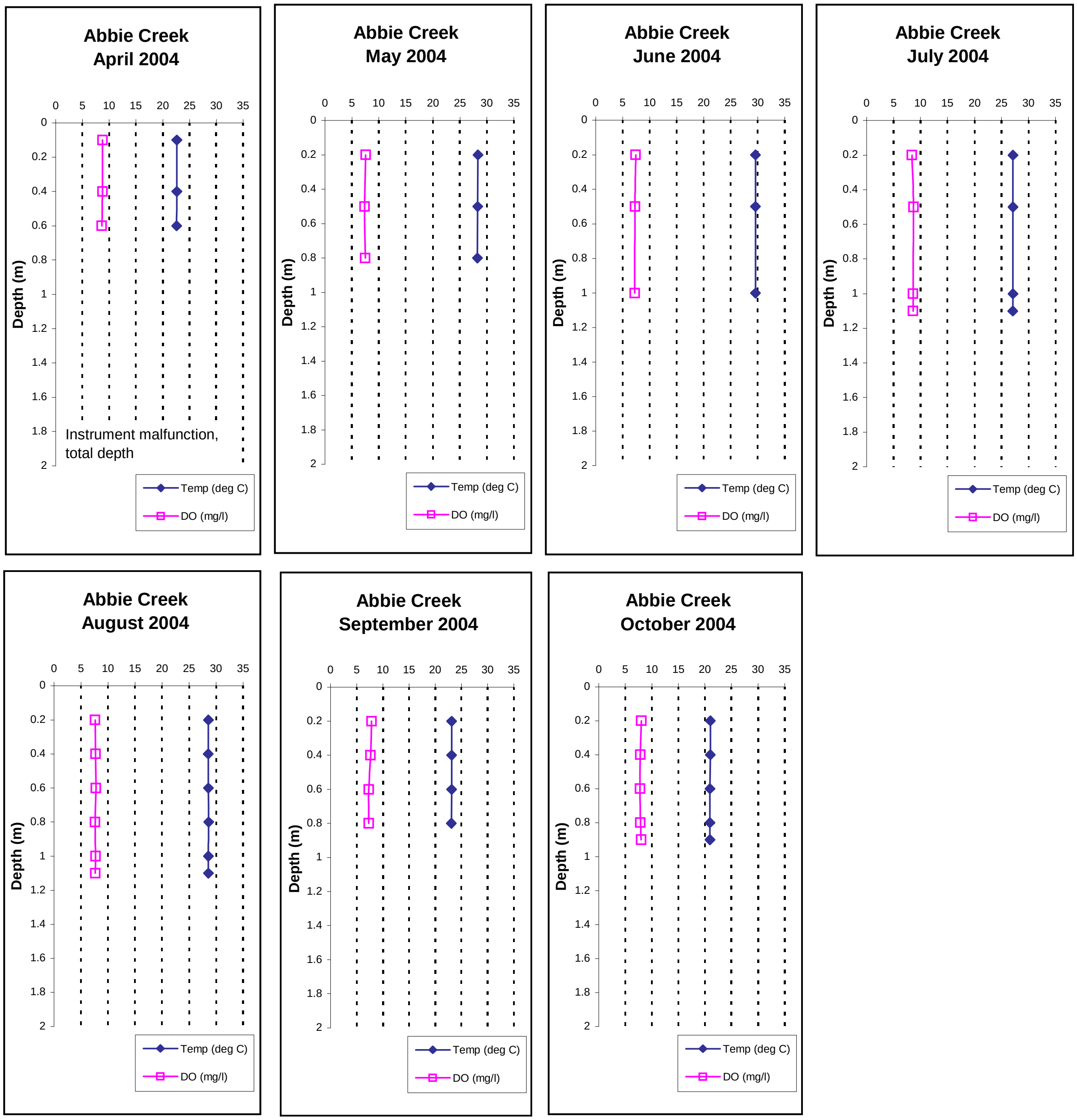
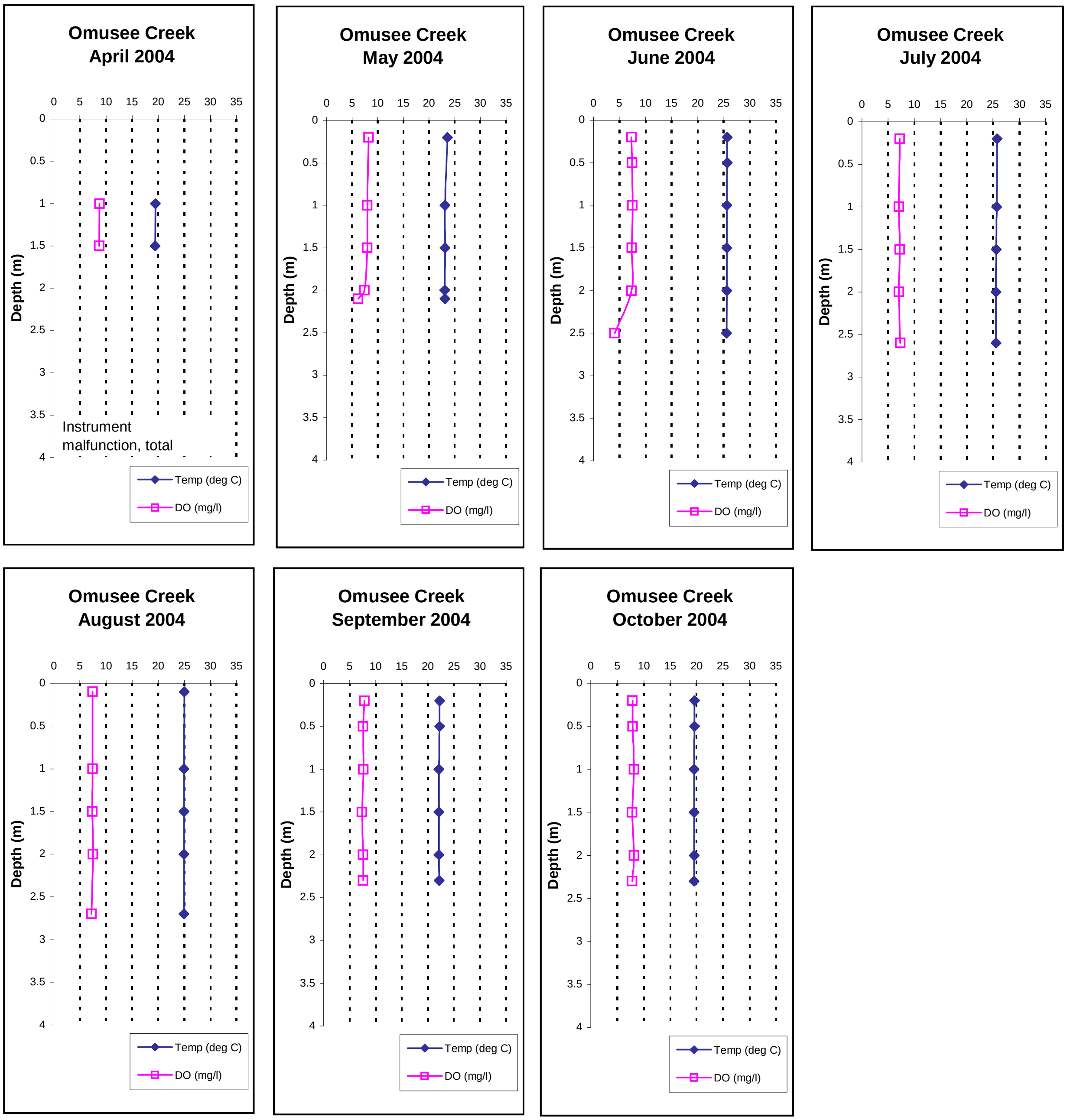
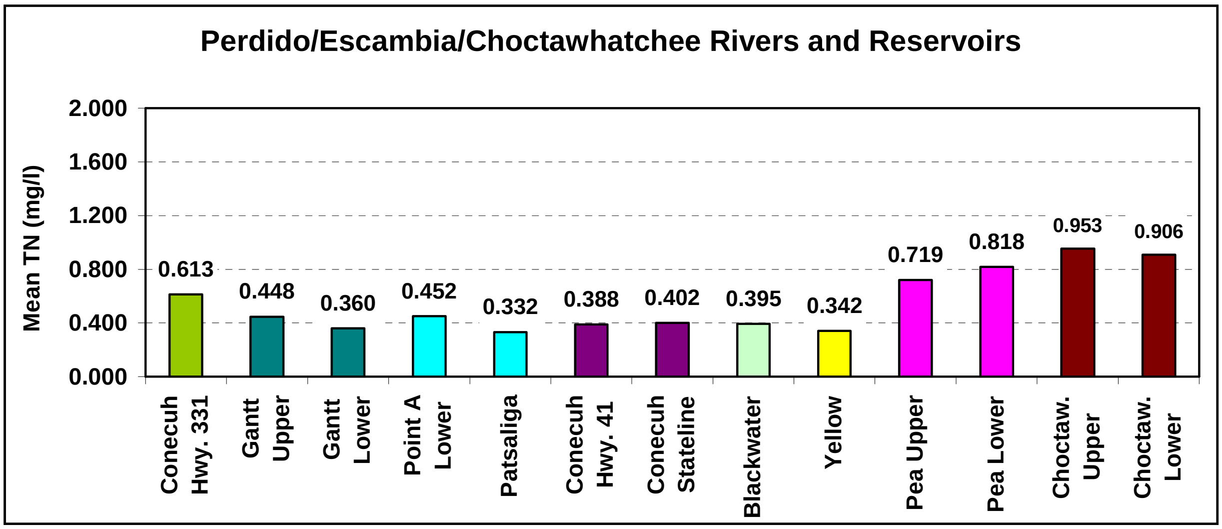


Figure 48. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Omusee Creek embayment, April-October 2004.



Perdido/Escambia/Choctawhatchee River Basin

Figure 49. Mean total nitrogen (TN) and total phosphorus (TP) concentrations of the Perdido/Escambia/Choctawhatchee River basin, April-October 2004.



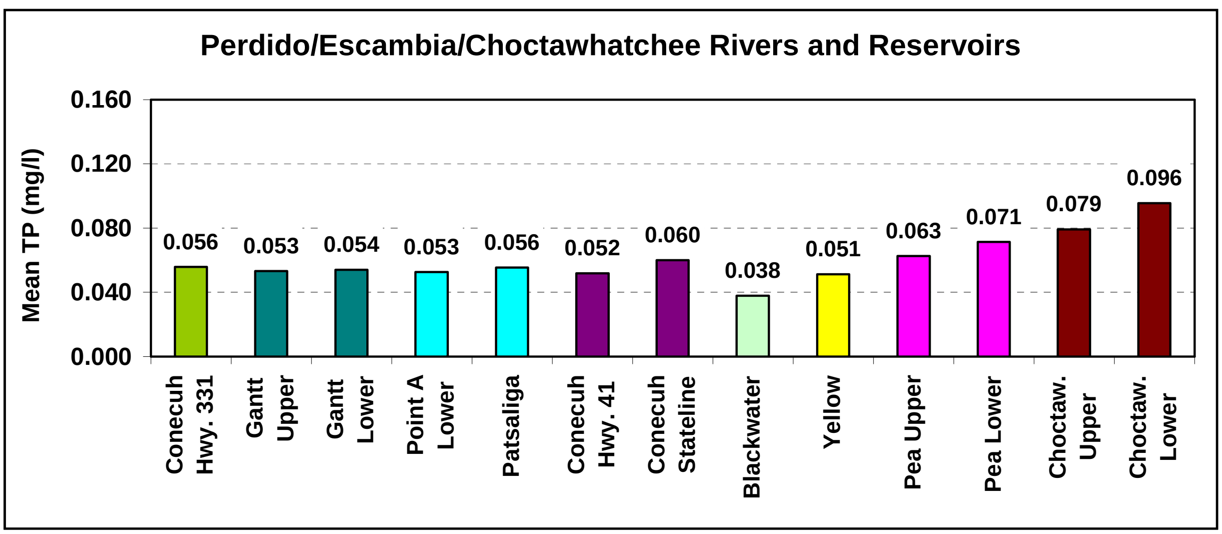
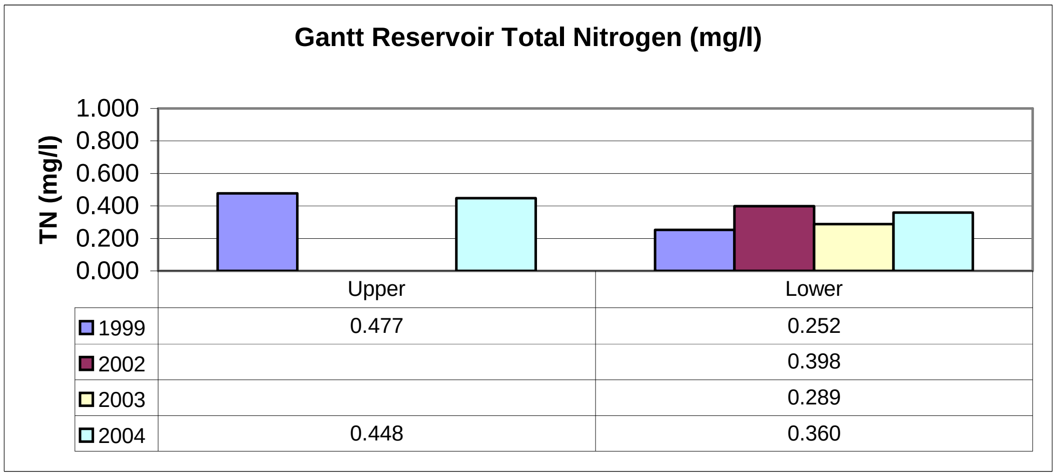


Figure 50. Mean total nitrogen (TN) concentrations of Gantt Reservoir and Point A Reservoir 1999 and 2002-2004.



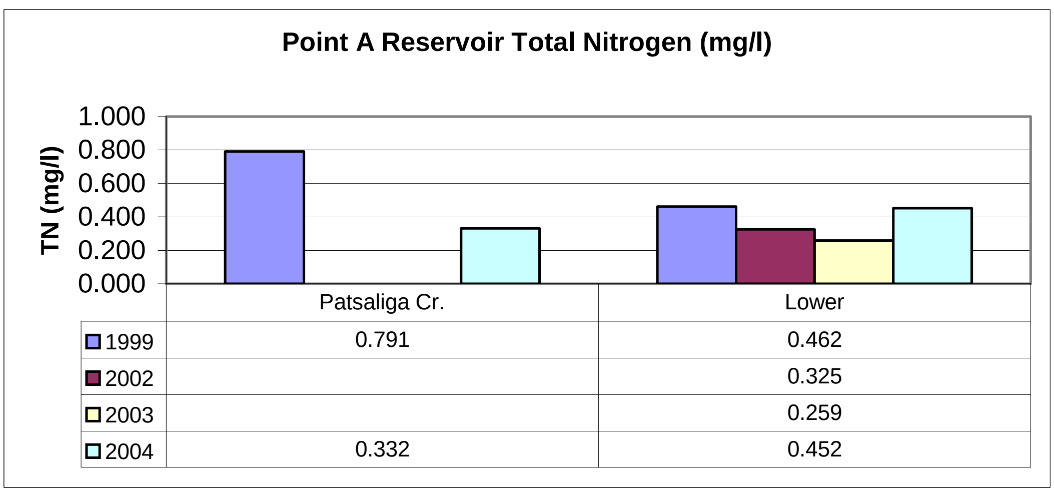
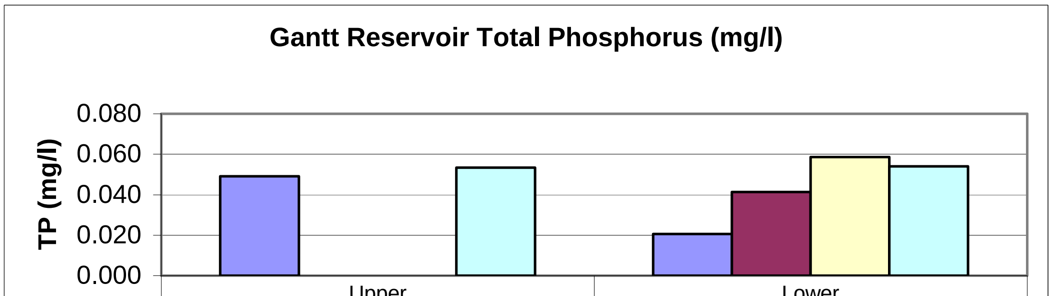
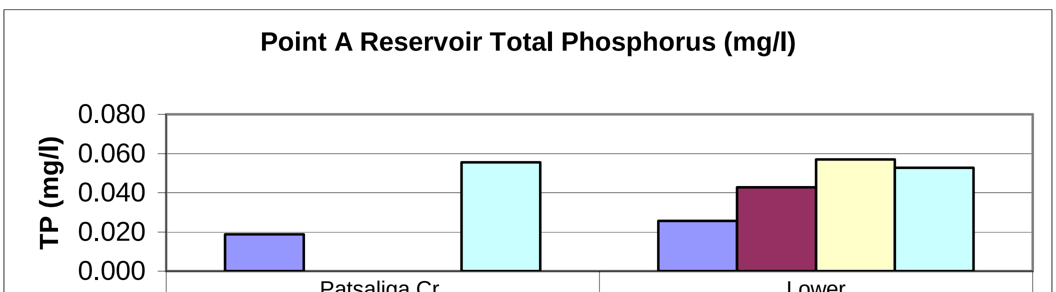


Figure 51. Mean total phosphorus (TP) concentrations of Gantt Reservoir and Point A Reservoir 1999 and 2002-2004.



	Upper	Lower
1999	0.049	0.021
2002		0.041
2003		0.059
2004	0.053	0.054



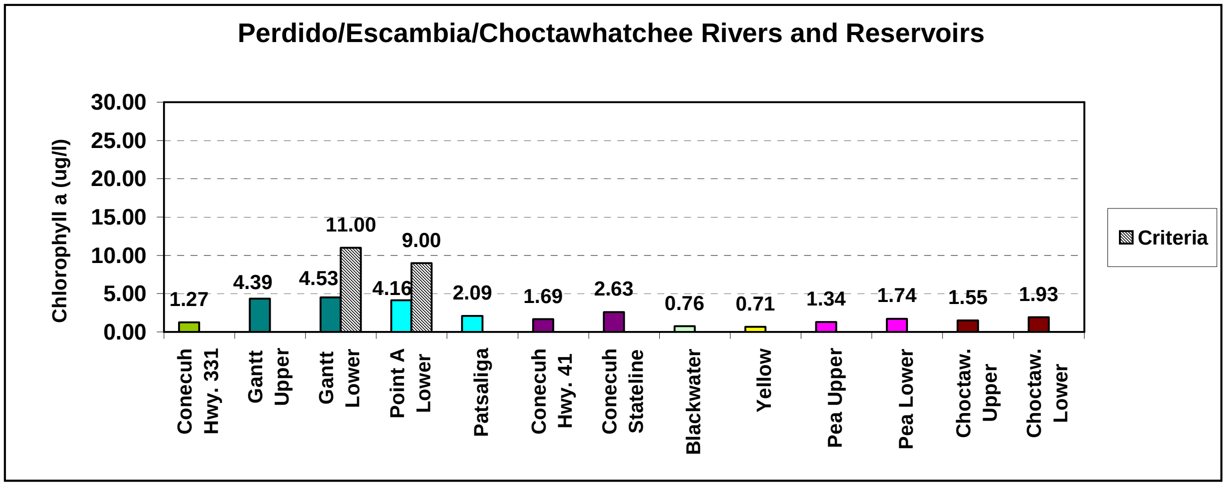
	Patsaliga Cr.	Lower
1999	0.019	0.026
2002		0.043
2003		0.057
2004	0.056	0.053

Table 6. Algal growth potential testing for the Perdido/Escambia/Choctawhatchee River Basin-2004**.**

Station Identification	Control mean MSC	Limiting Nutrient
Conecuh 3 (Hwy. 331)	4.08	Phosphorus
Gantt 2 (Upper)	2.44	Phosphorus
Gantt 1 (Lower)	2.08	Co-Limiting
Point A 2 (Upper)	3.79	Phosphorus
Point A 1 (Lower)	2.96	Phosphorus
Conecuh 2 (Hwy 41)	5.44	Phosphorus
Conecuh 1 (Stateline)	6.05	Phosphorus
Blackwater 1	0.83	Non-Limiting
Yellow 1	6.50	Phosphorus
PEA 2 (Upper)	8.53	Phosphorus
PEA 1 (Lower)	5.24	Phosphorus
Choctawhatchee 2 (Upper)	18.35***	***
Choctawhatchee 1 (Lower)	18.91	Co-Limiting

*** Results for test flasks ranged from 12.34 to 34.20 in the Control, 23.09 to 38.79 in the Nitrogen treatment, and 27.15 to 71.16 in the Phosphorus treatment. Results are reported as the average of twelve flasks for the Control and six flasks each for the Nitrogen and Phosphorus treatments (test was repeated to obtain the additional data points). The accuracy of these results is less than is typical for this test method and therefore the limiting nutrient status can not be accurately determined.

Figure 52. Mean chlorophyll *a* and total suspended solids (TSS) concentrations of the Perdido/Escambia/Choctawhatchee River Basin, April-October 2004.



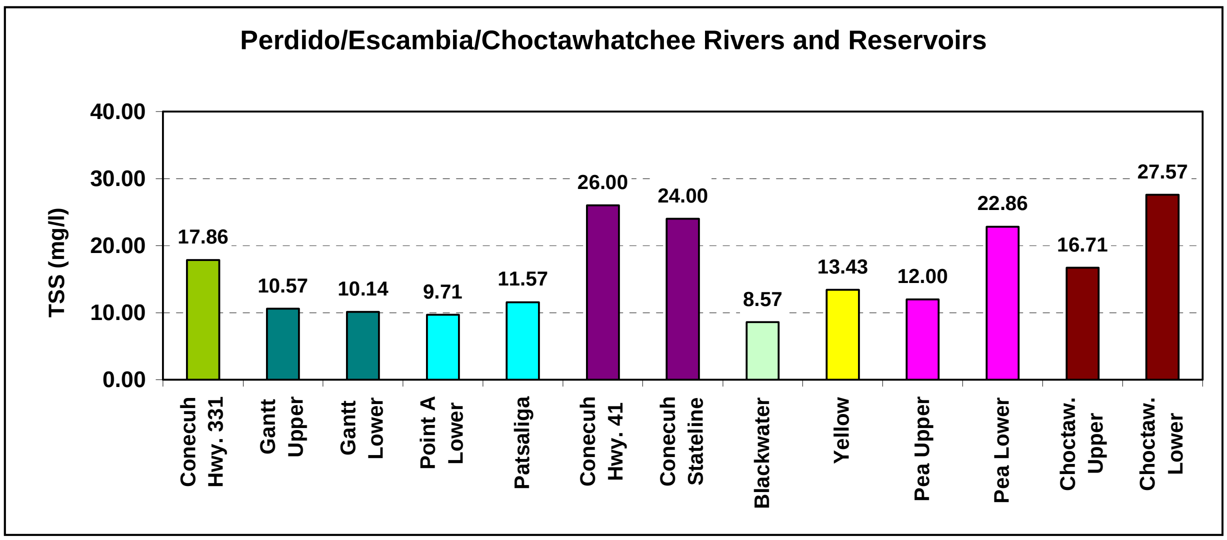
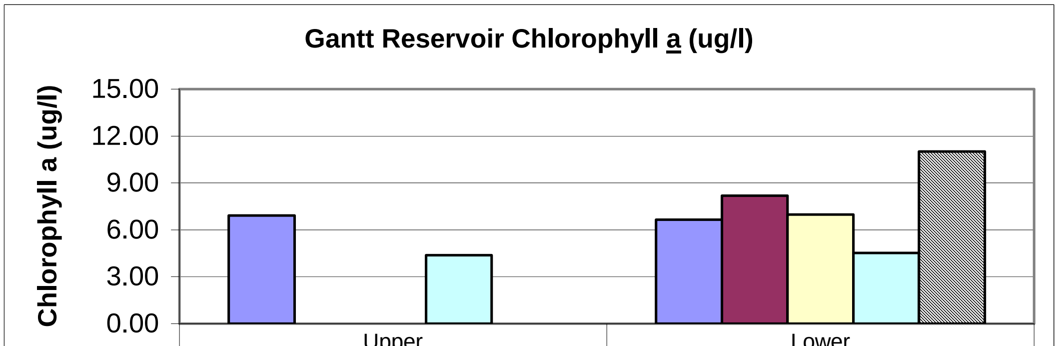
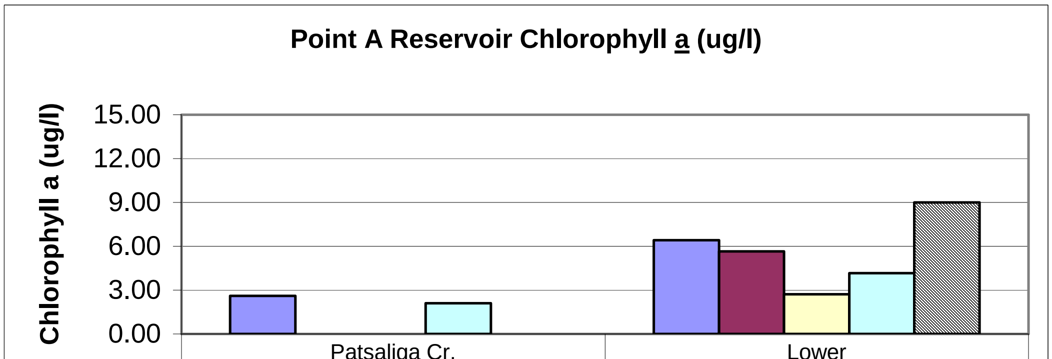


Figure 53. Mean chlorophyll *a* concentrations of Gantt Reservoir and Point A Reservoir 1999 and 2002-2004.

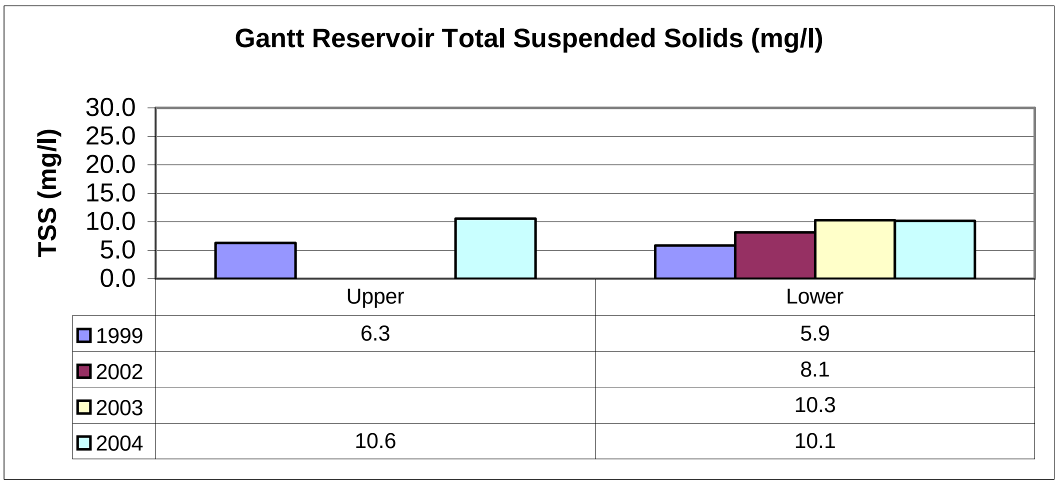


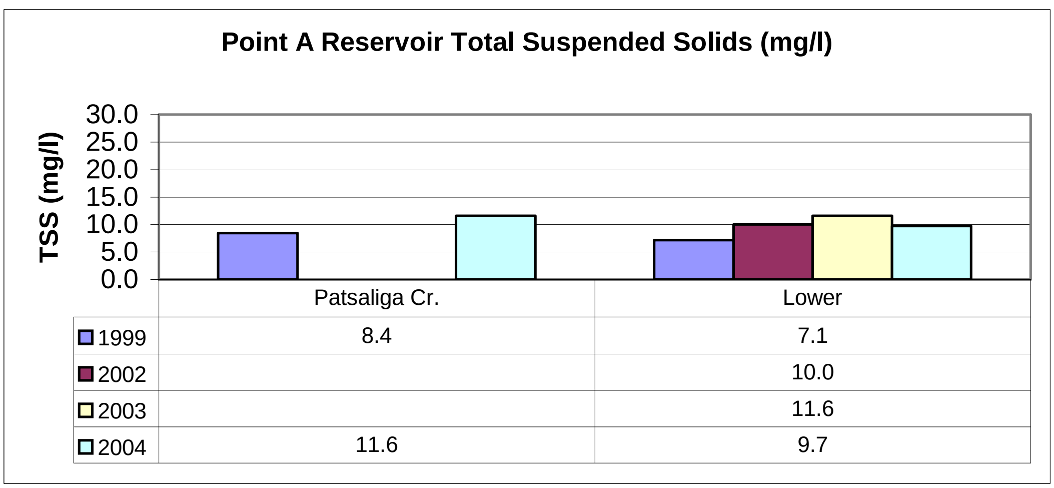
	Upper	Lower
1999	6.93	6.64
2002		8.19
2003		6.98
2004	4.39	4.53
Criteria		11.00



	Patsaliga Cr.	Lower
1999	2.60	6.41
2002		5.65
2003		2.72
2004	2.09	4.16
Criteria		9.00

Figure 54. Mean total suspended solids (TSS) concentrations of Gantt Reservoir and Point A Reservoir 1999 and 2002-2004.





Upper Conecuh River

Figure 55. Total nitrogen (TN), total phosphorus (TP), Chlorophyll *a*, and total suspended solids (TSS) in the Conecuh River at Hwy 331, April-October 2004.

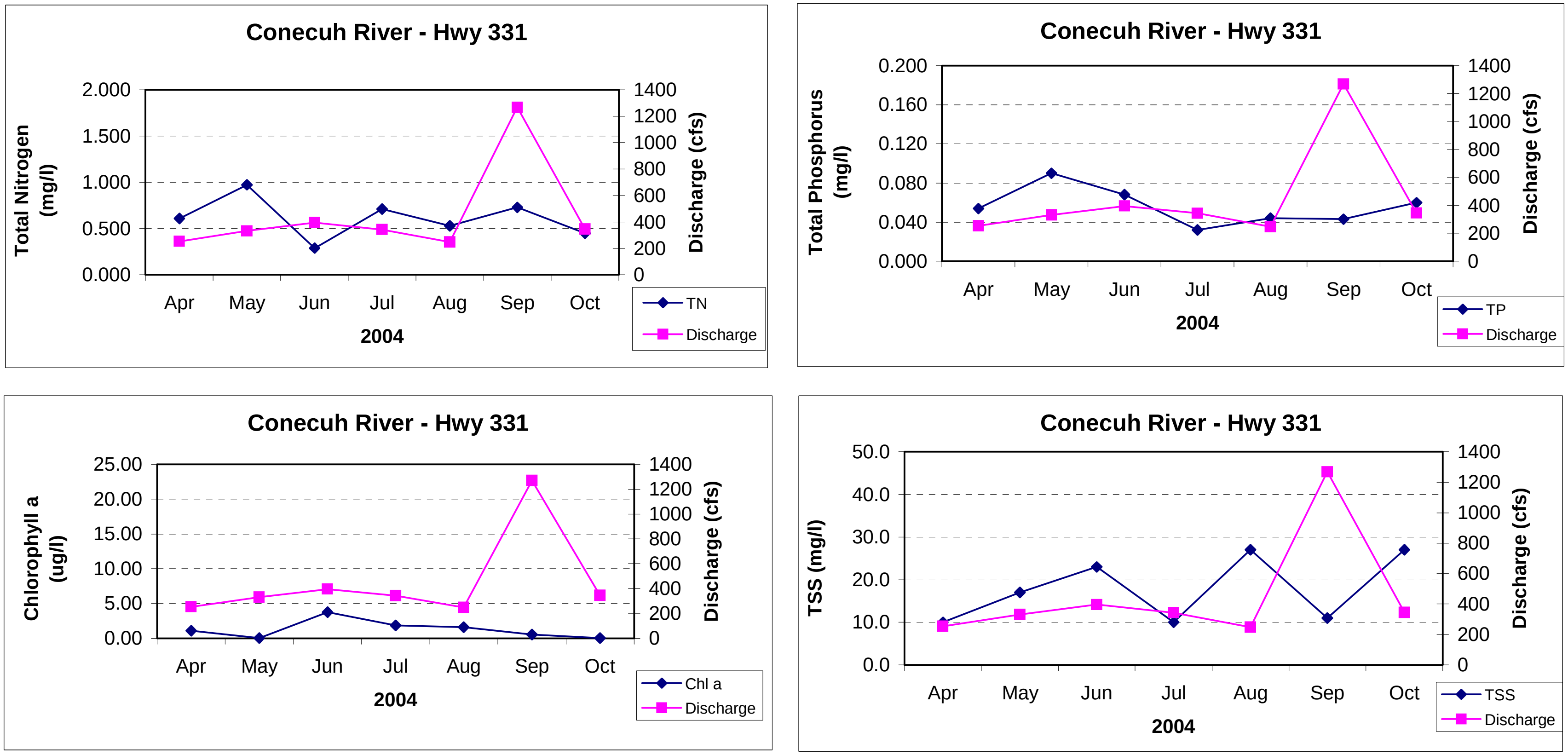
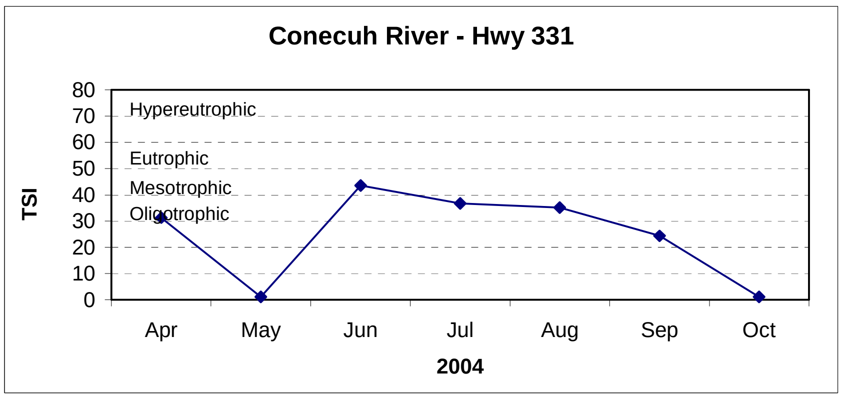


Figure 56. Trophic state index (TSI) and dissolved oxygen (DO) for the Conecuh River at Hwy 331, April-October 2004.



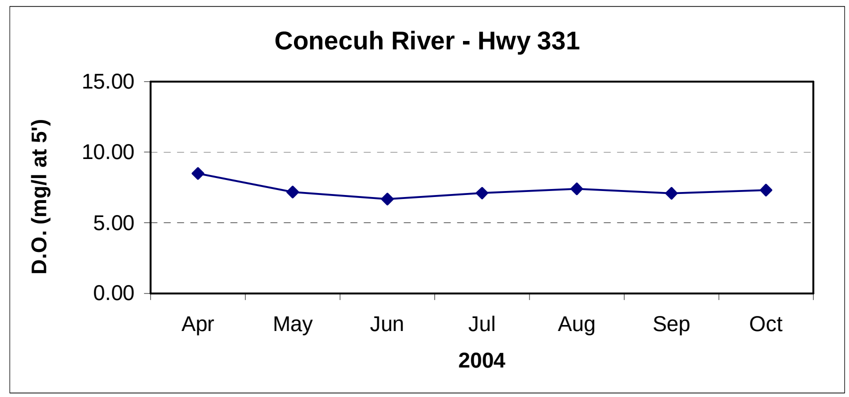
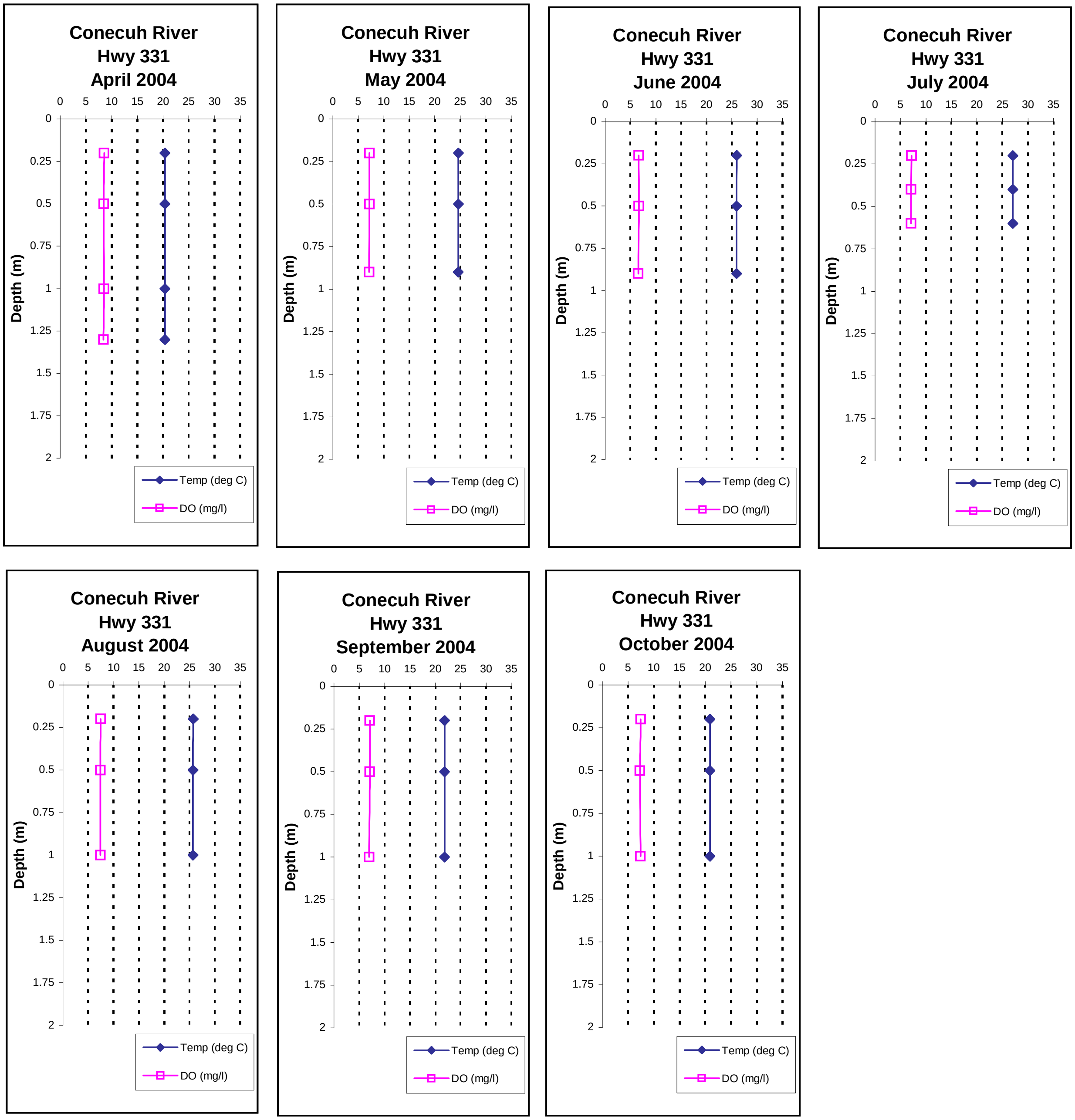


Figure 57. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Conecuh River at Hwy 331, April-October 2004.



Gantt Reservoir

Figure 58. Total nitrogen (TN) and total phosphorus (TP) in Gantt Reservoir, April-October 2004.

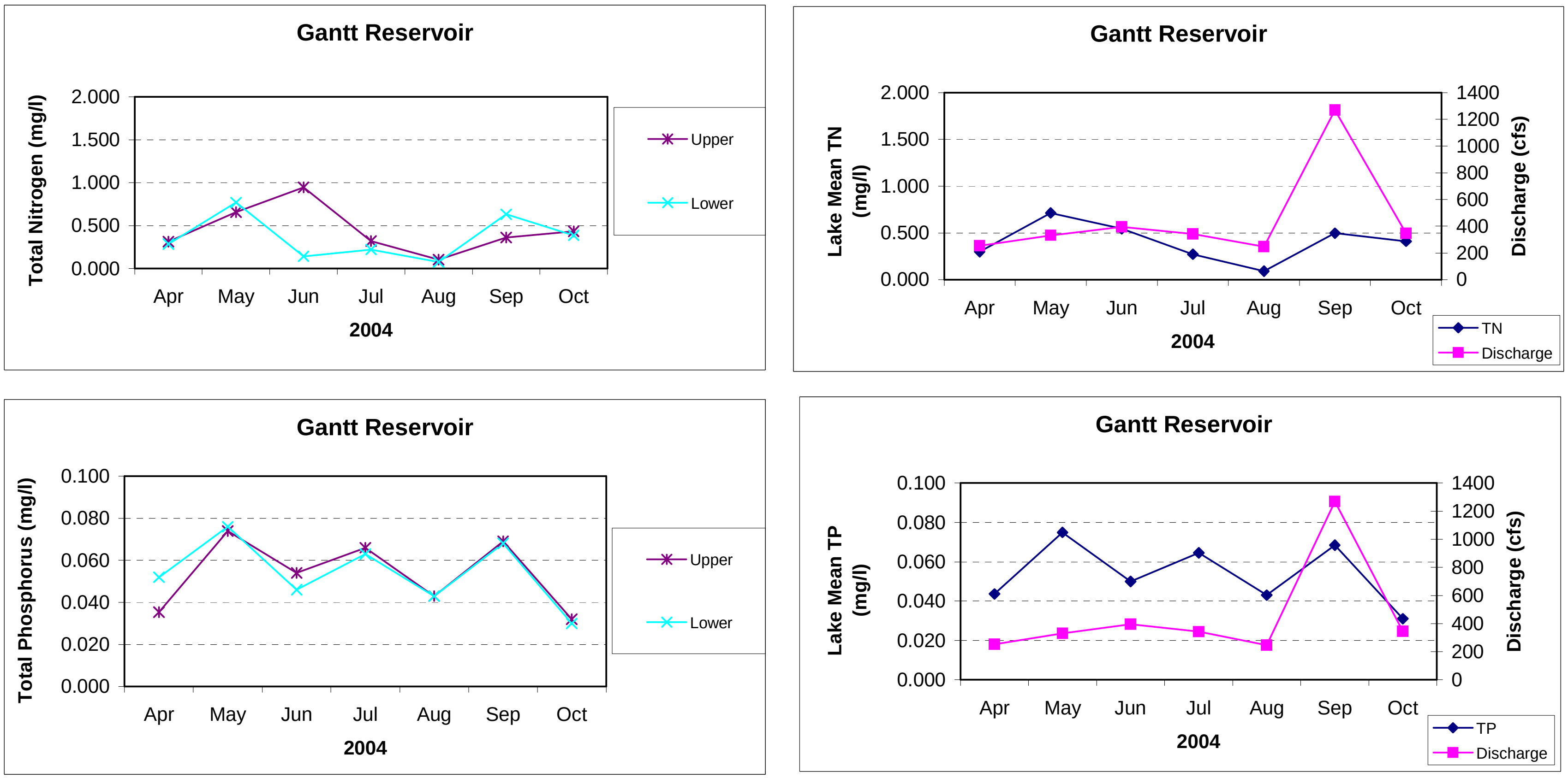


Figure 59. Chlorophyll *a* and total suspended solids (TSS) in Gantt Reservoir, April-October 2004.

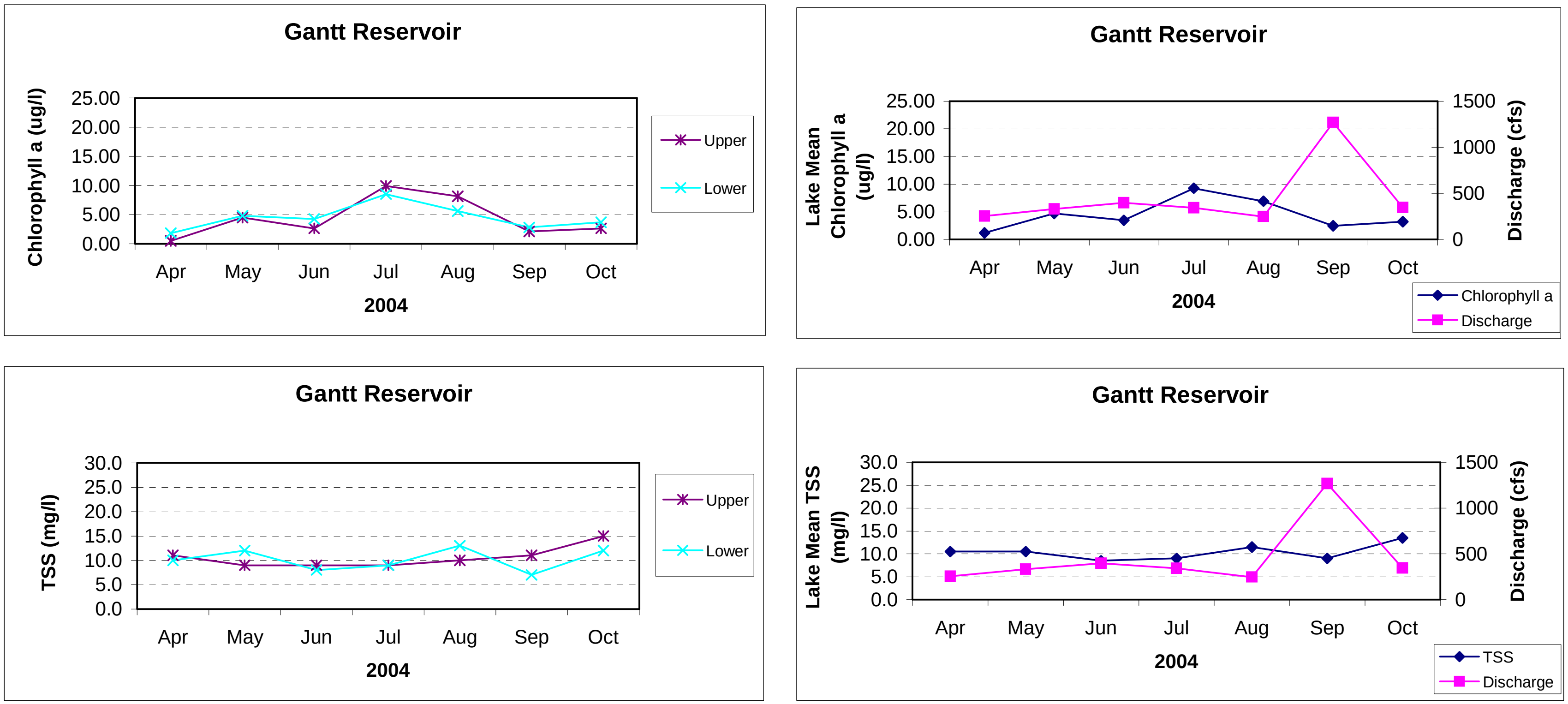
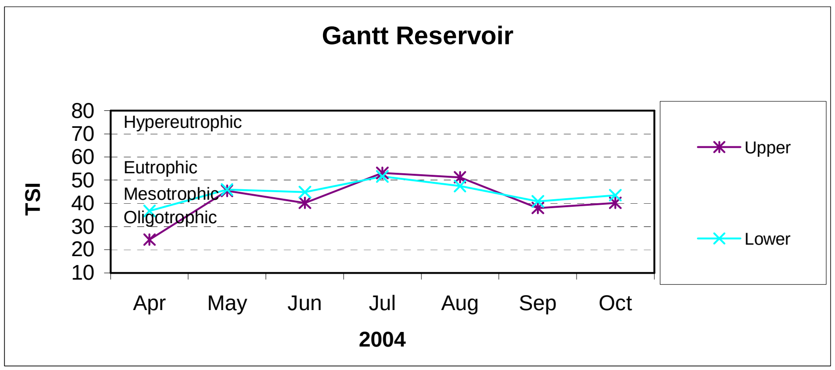


Figure 60. Trophic state index (TSI) and dissolved oxygen (DO) for Gantt Reservoir, April-October 2004.



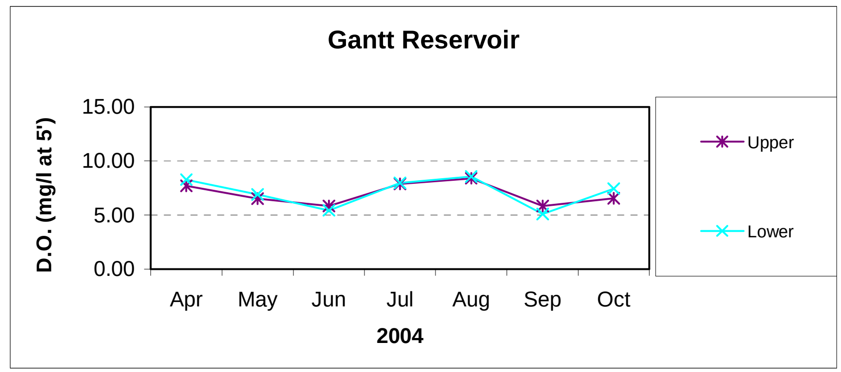


Figure 61. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in upper Gantt Reservoir, April-October 2004.

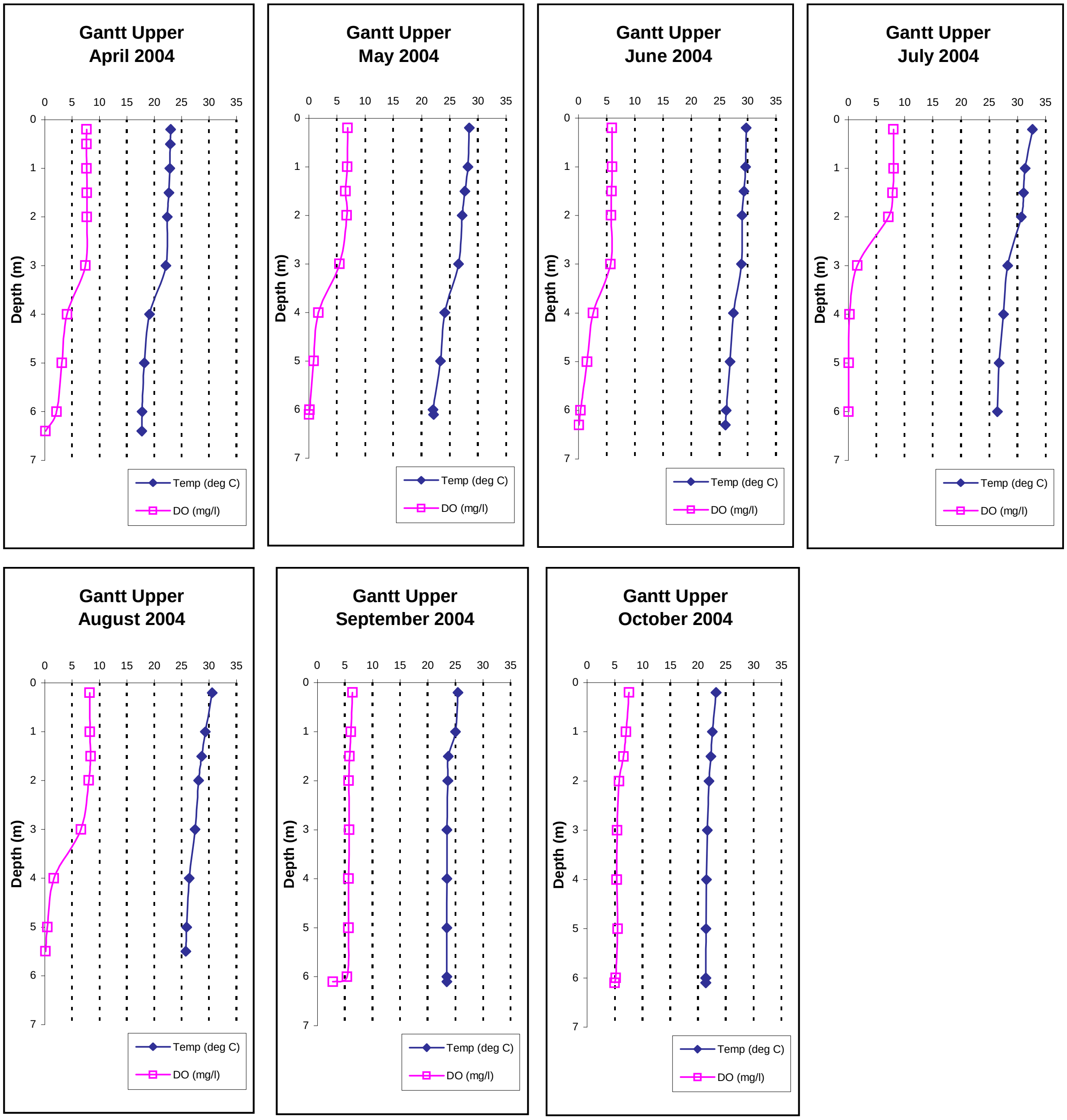
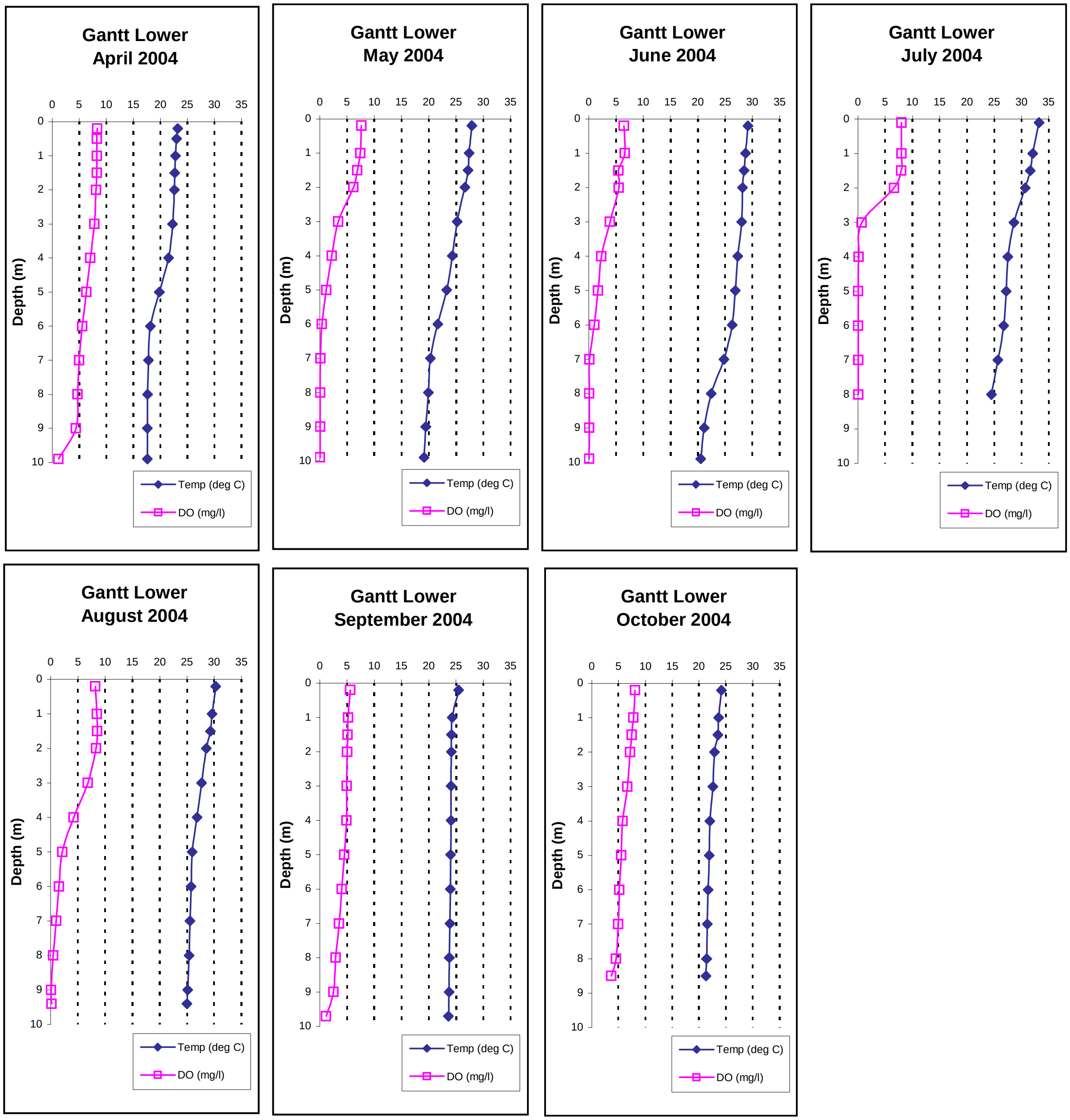


Figure 62. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in lower Gantt Reservoir, April-October 2004.



Point A Reservoir

Figure 63. Total nitrogen (TN) and total phosphorus (TP) in Point A Reservoir, April-October 2004.

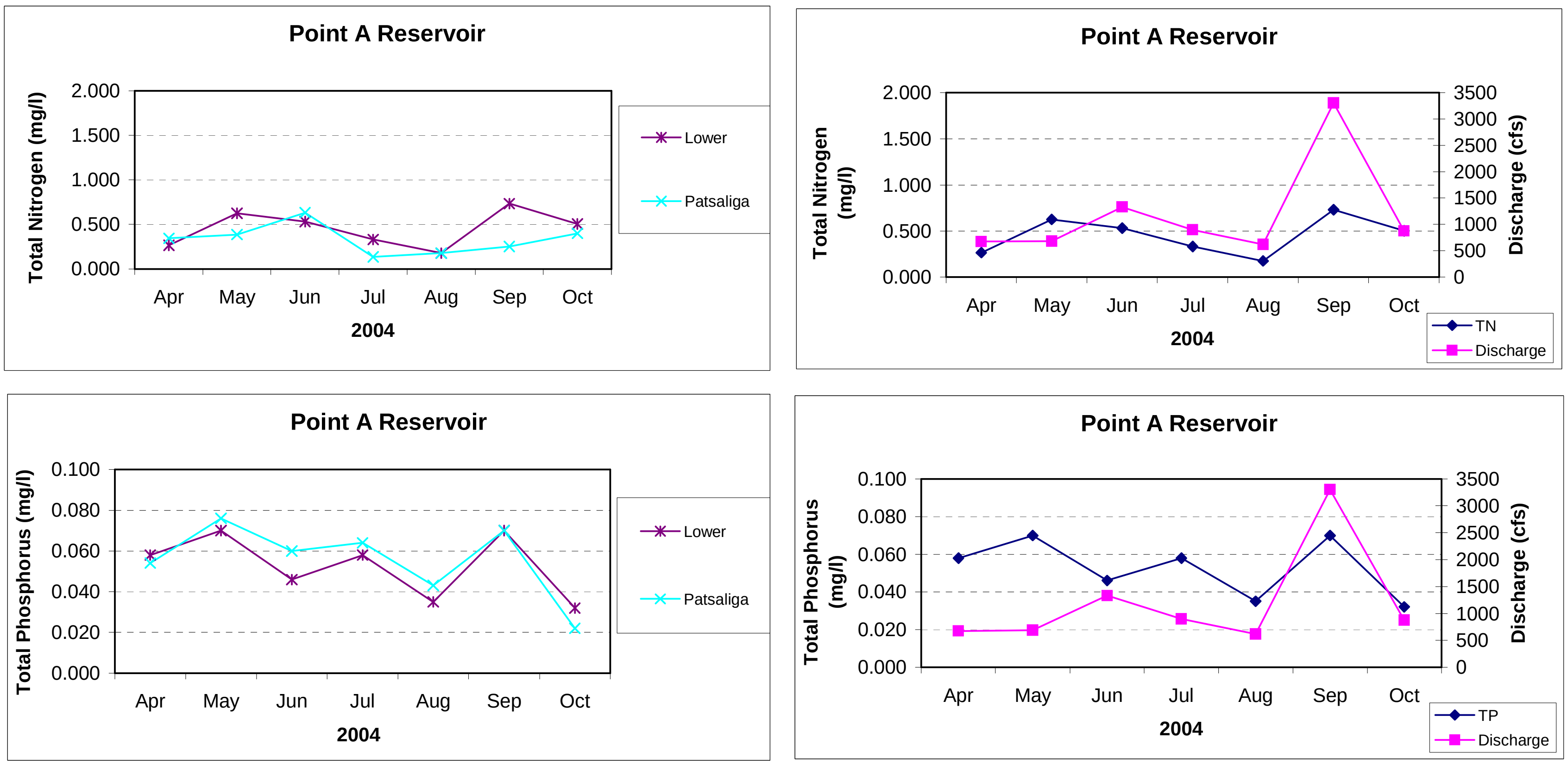


Figure 64. Chlorophyll *a* and total suspended solids (TSS) in Point A Reservoir, April-October 2004.

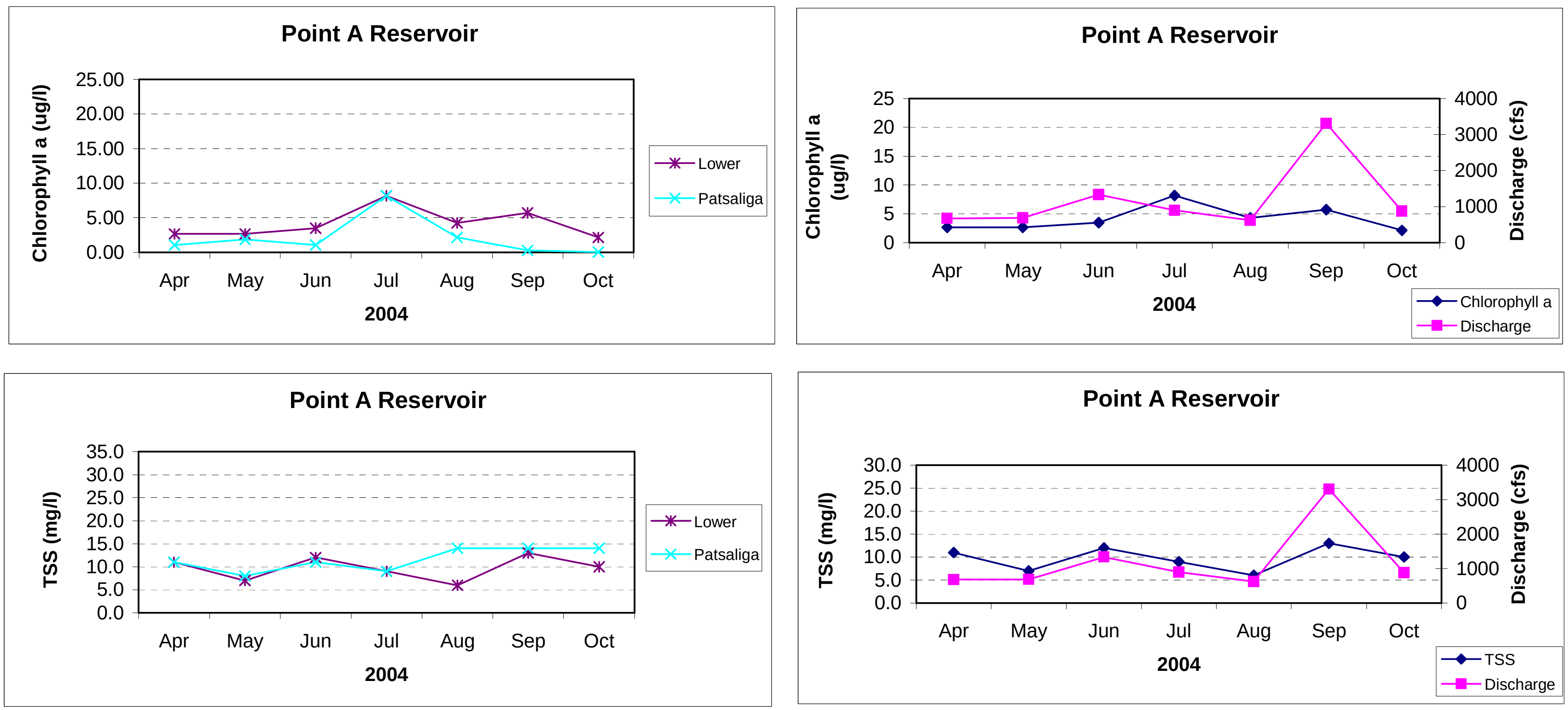
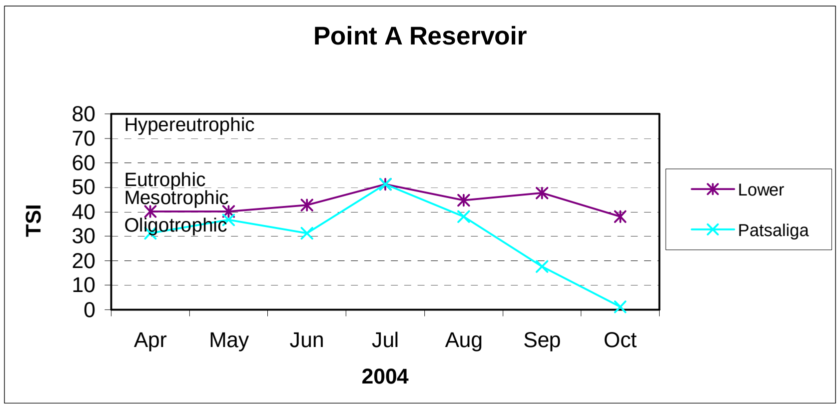


Figure 65. Trophic state index (TSI) and dissolved oxygen (DO) in Point A Reservoir, April-October 2004.



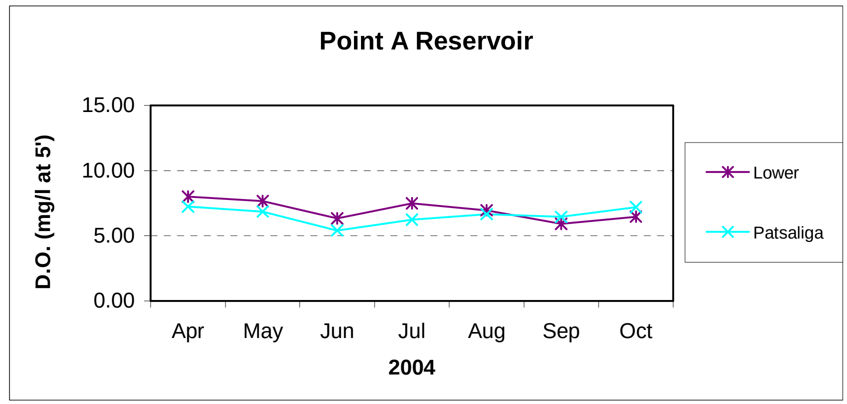


Figure 66. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in lower Point A Reservoir, April-October 2004.

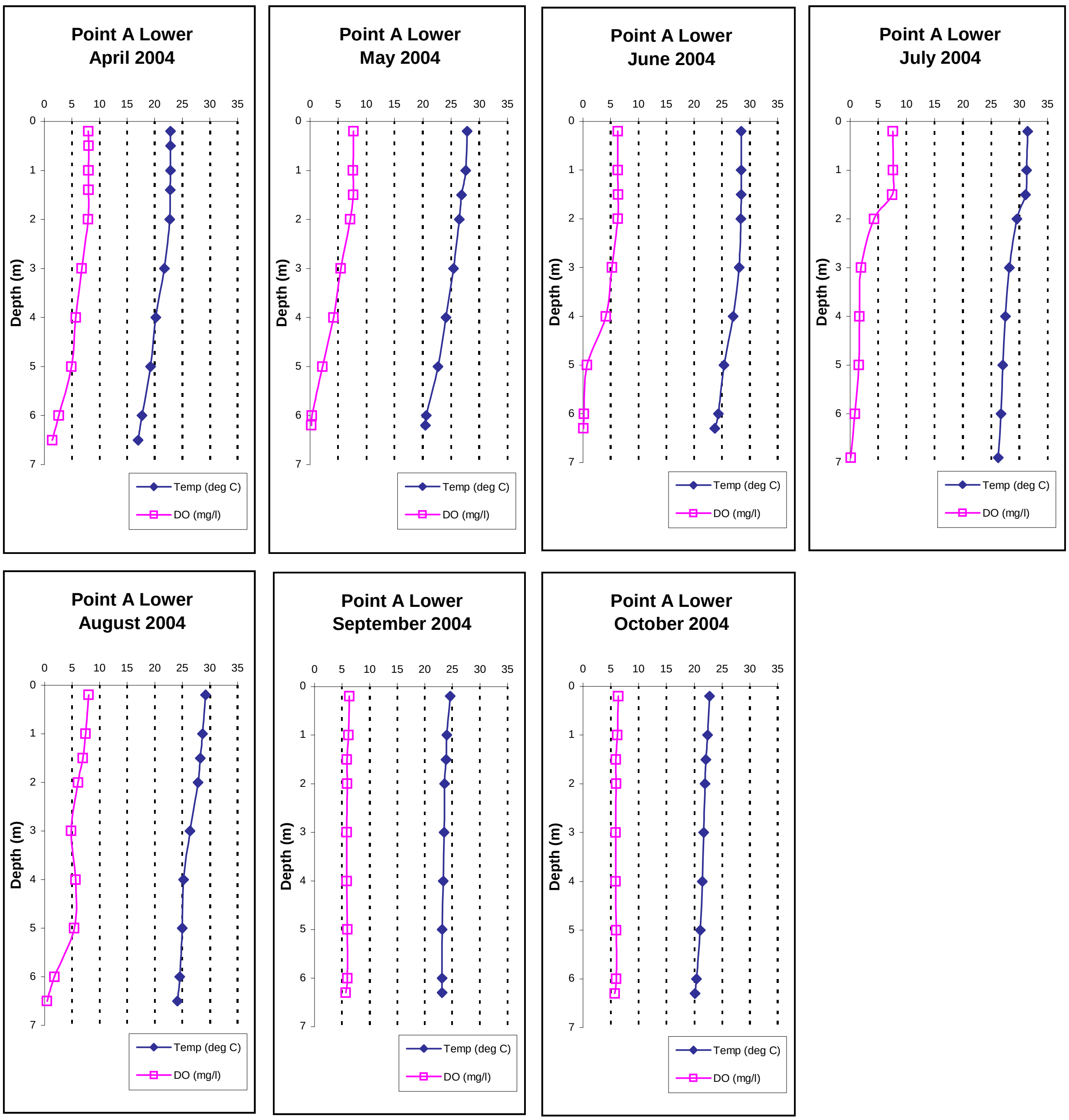
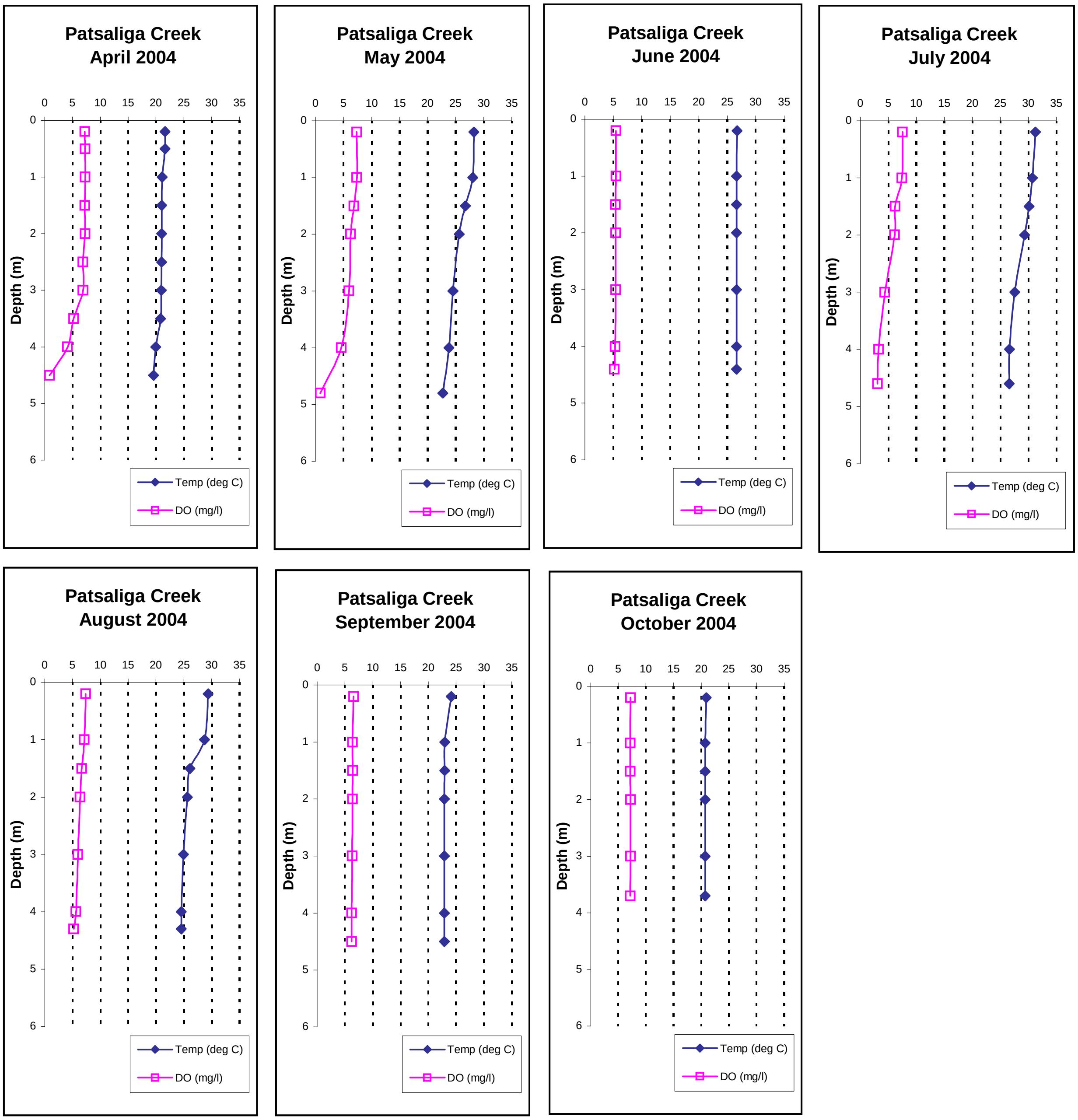


Figure 67. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Patsaliga Creek embayment, April-October 2004.



Lower Conecuh River

Figure 68. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and total suspended solids (TSS) in the Lower Conecuh River, April-October 2004.

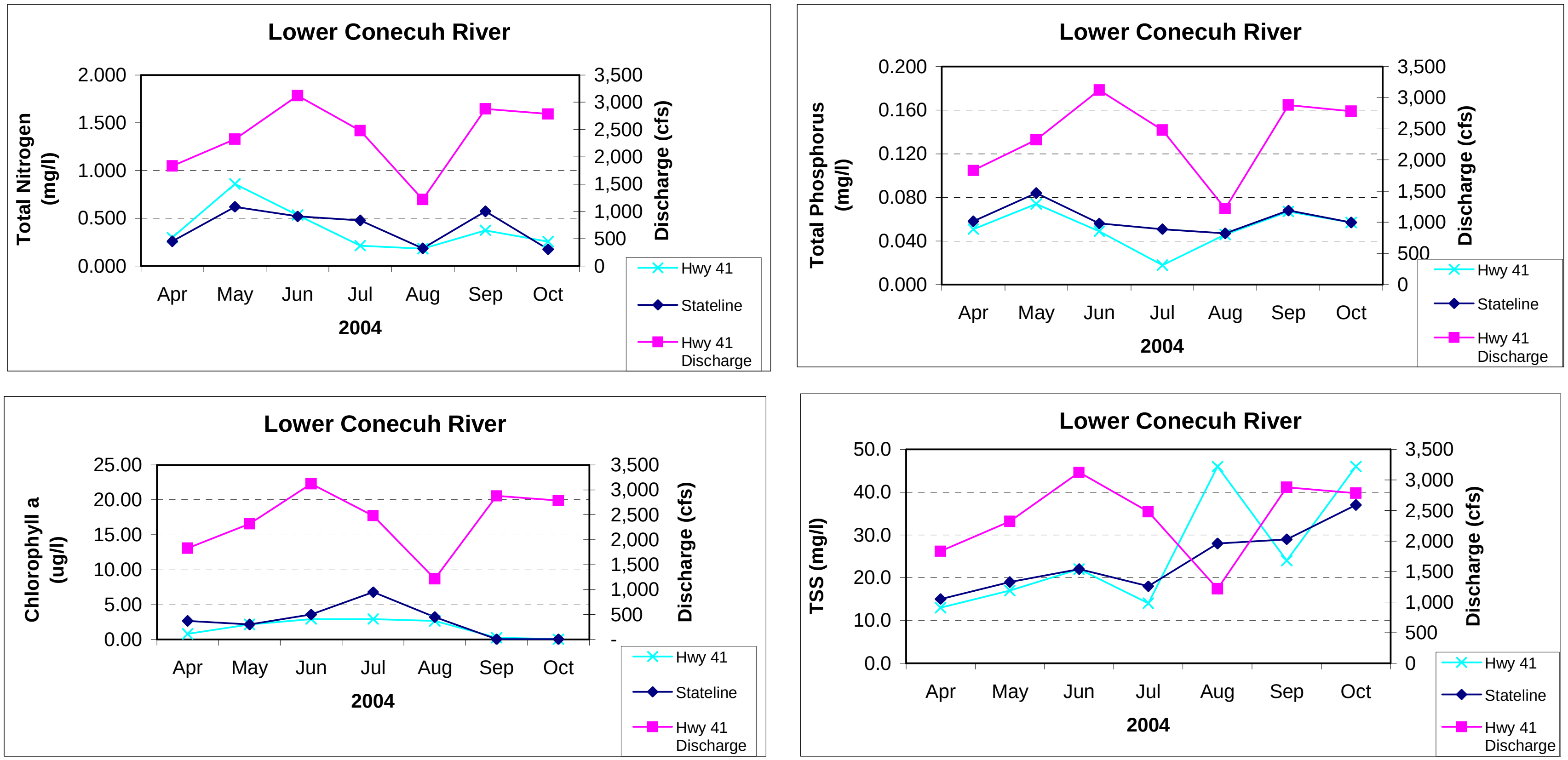
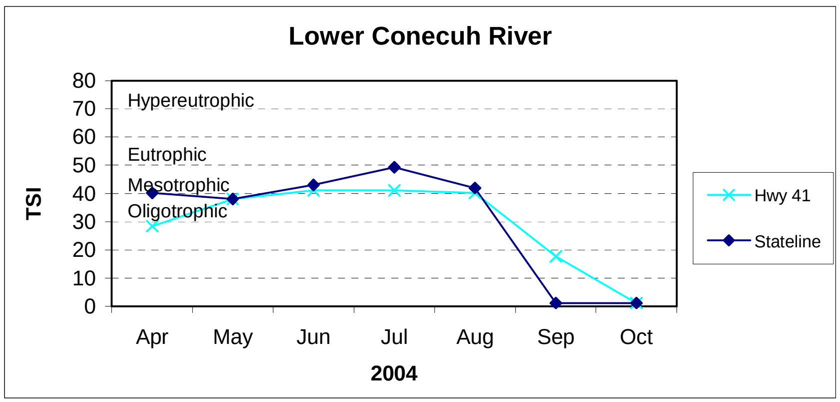


Figure 69. Trophic state index (TSI) and dissolved oxygen (DO) in the lower Conecuh River, April-October 2004.



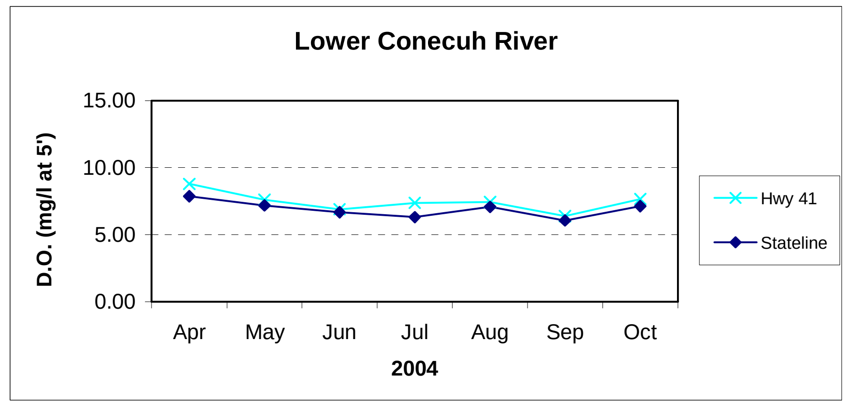


Figure 70. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Conecuh River at Hwy 41, April-October 2004.

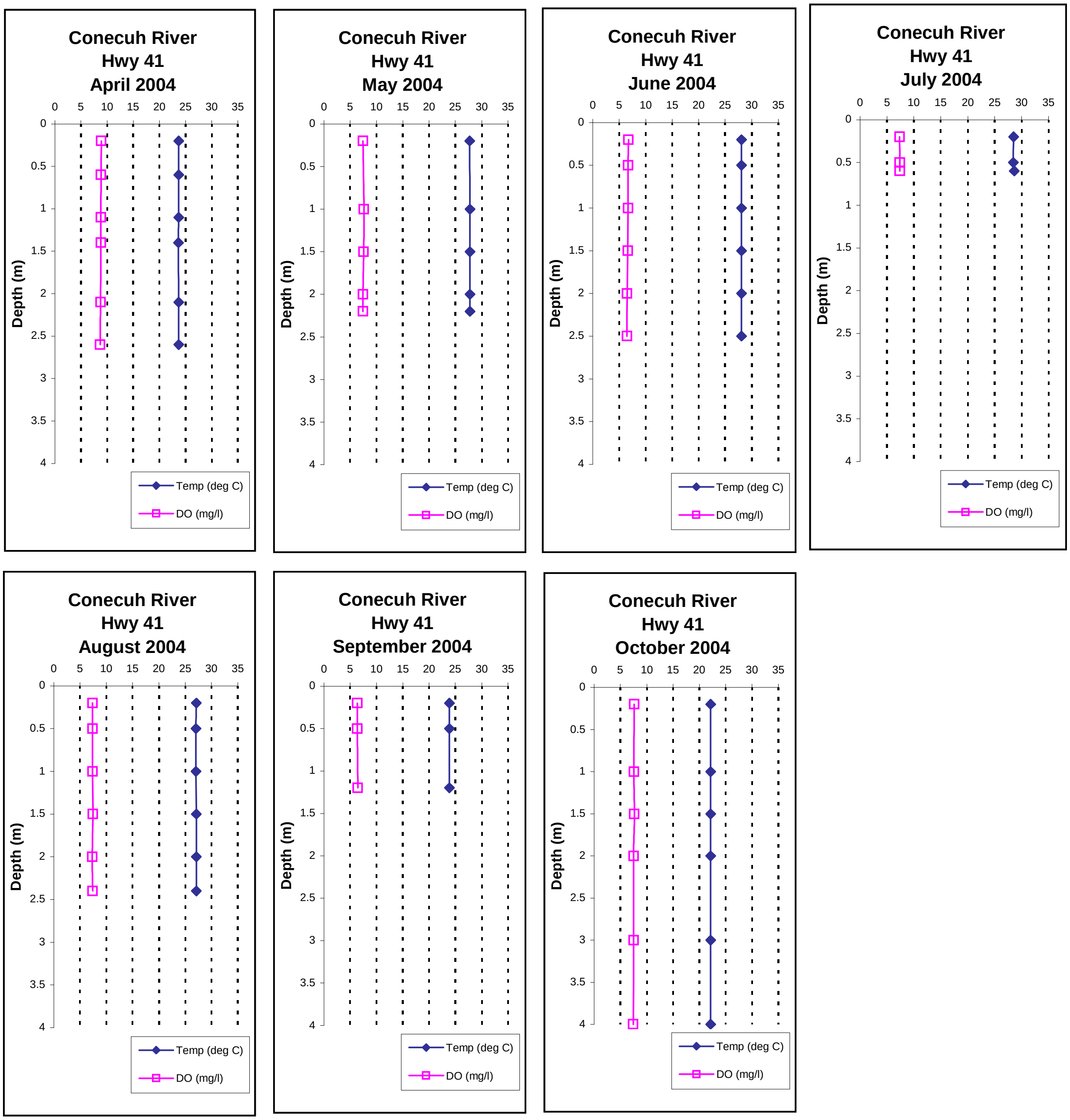
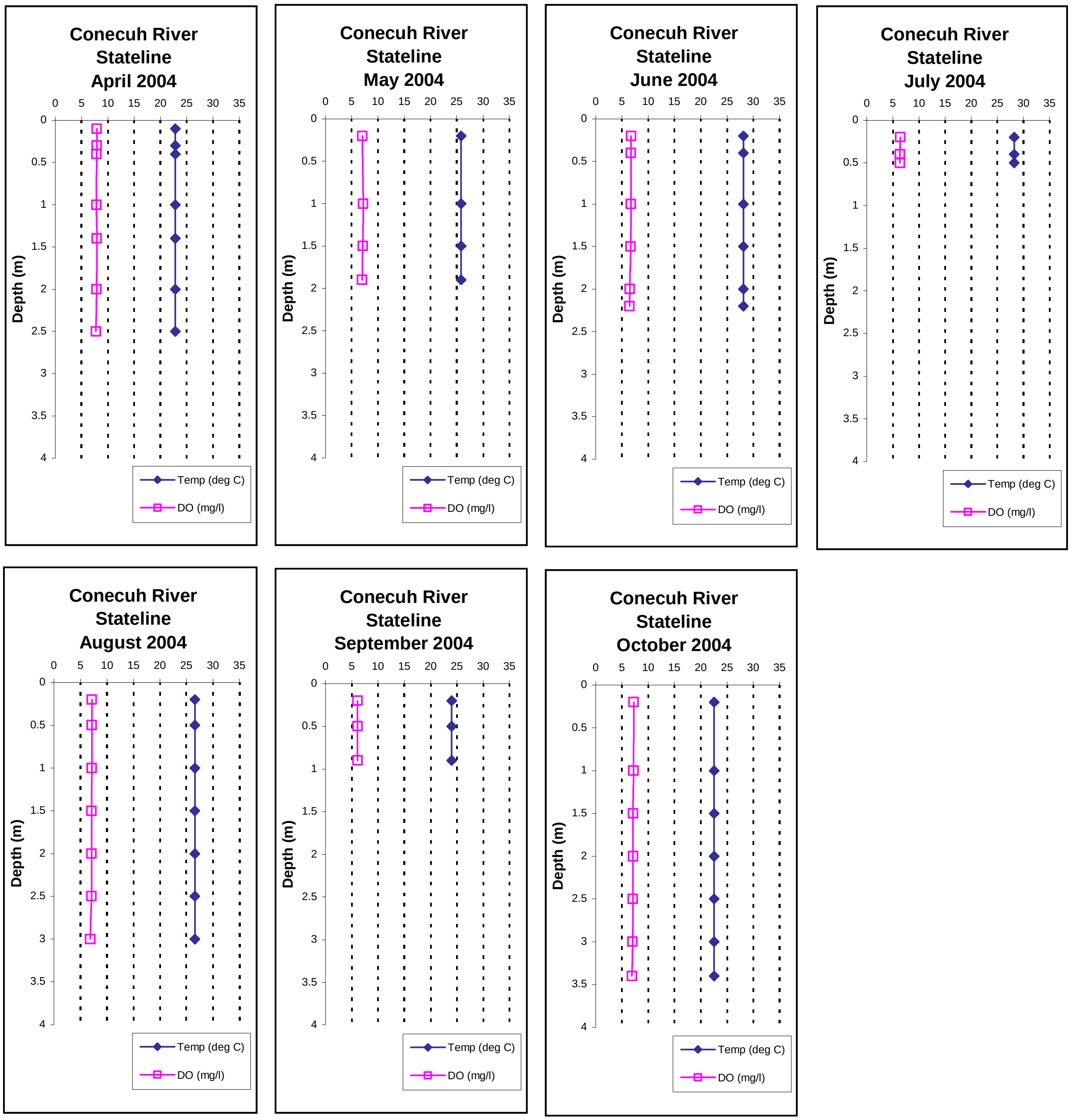


Figure 71. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Conecuh River at the Stateline, April-October 2004.



Blackwater River

Figure 72. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and total suspended solids (TSS) in the Blackwater River, April-October 2004.

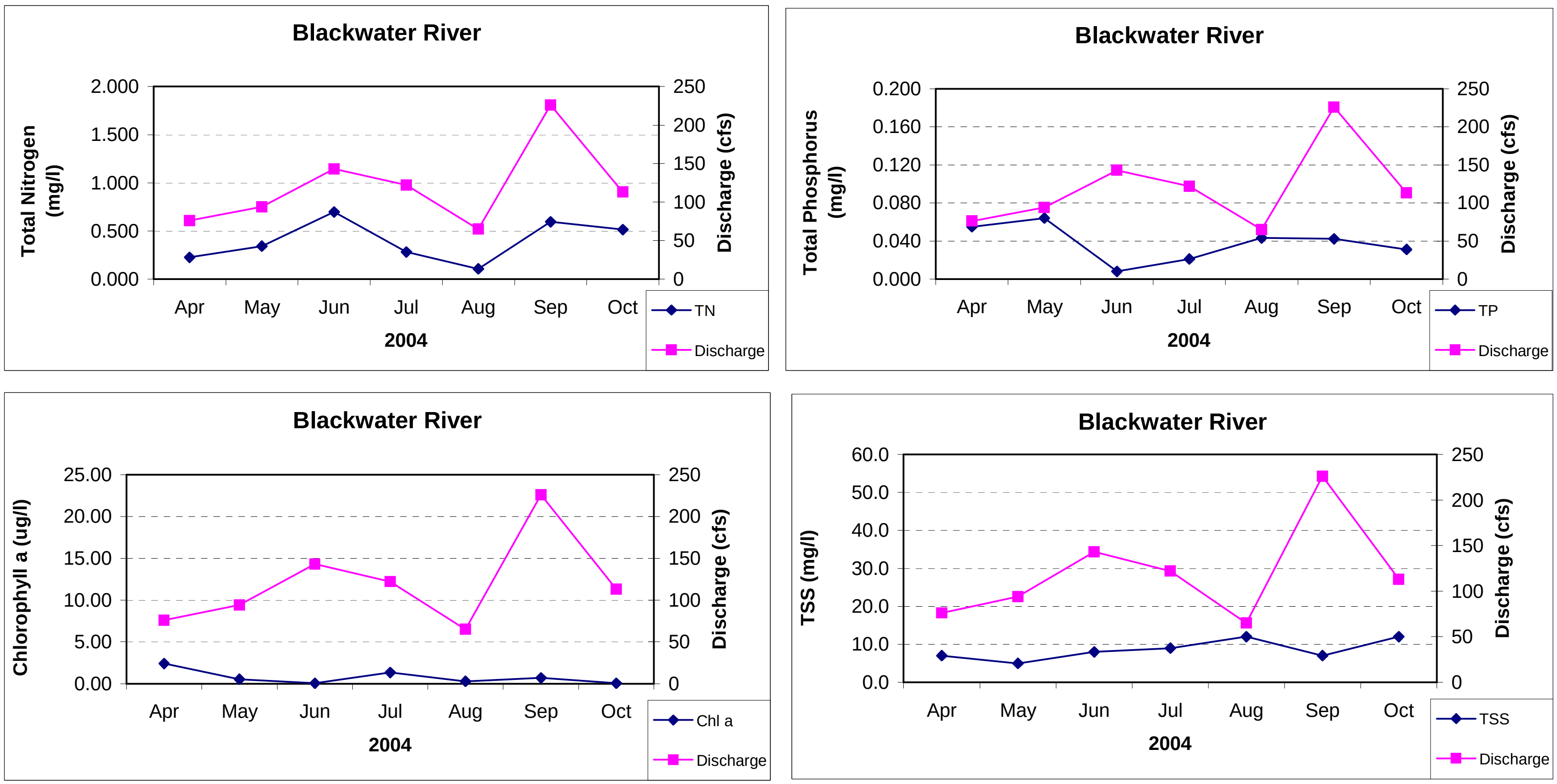
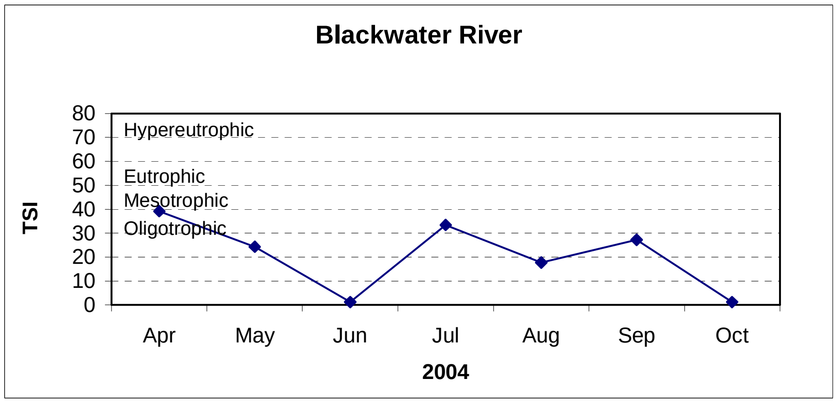


Figure 73. Trophic state index (TSI) and dissolved oxygen (DO) in the Blackwater River, April-October 2004.



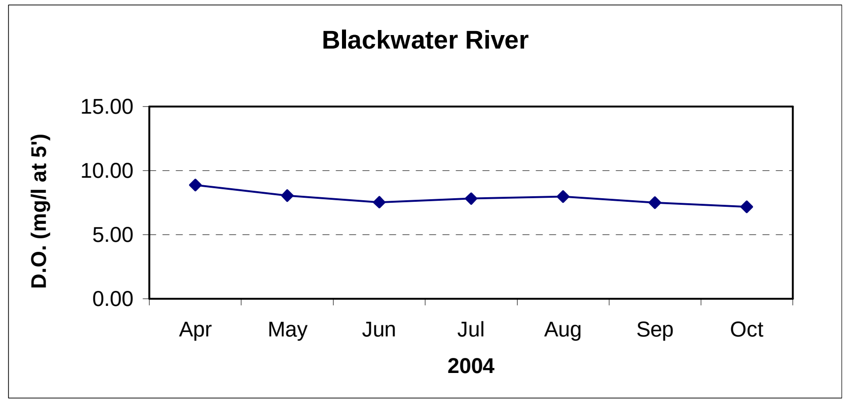
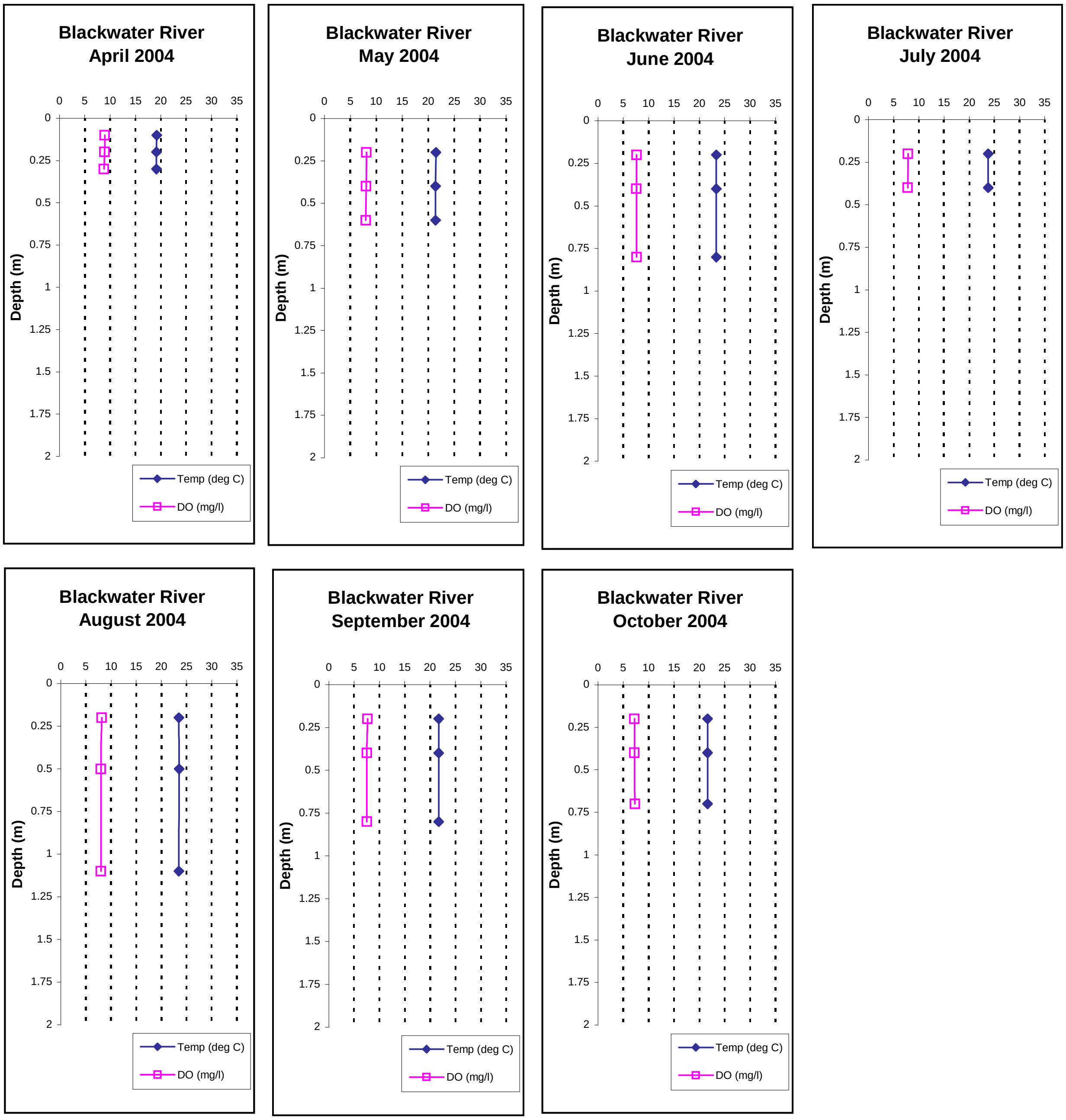


Figure 74. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Blackwater River, April-October 2004.



Yellow River

Figure 75. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and total suspended solids (TSS) in the Yellow River, April-October 2004.

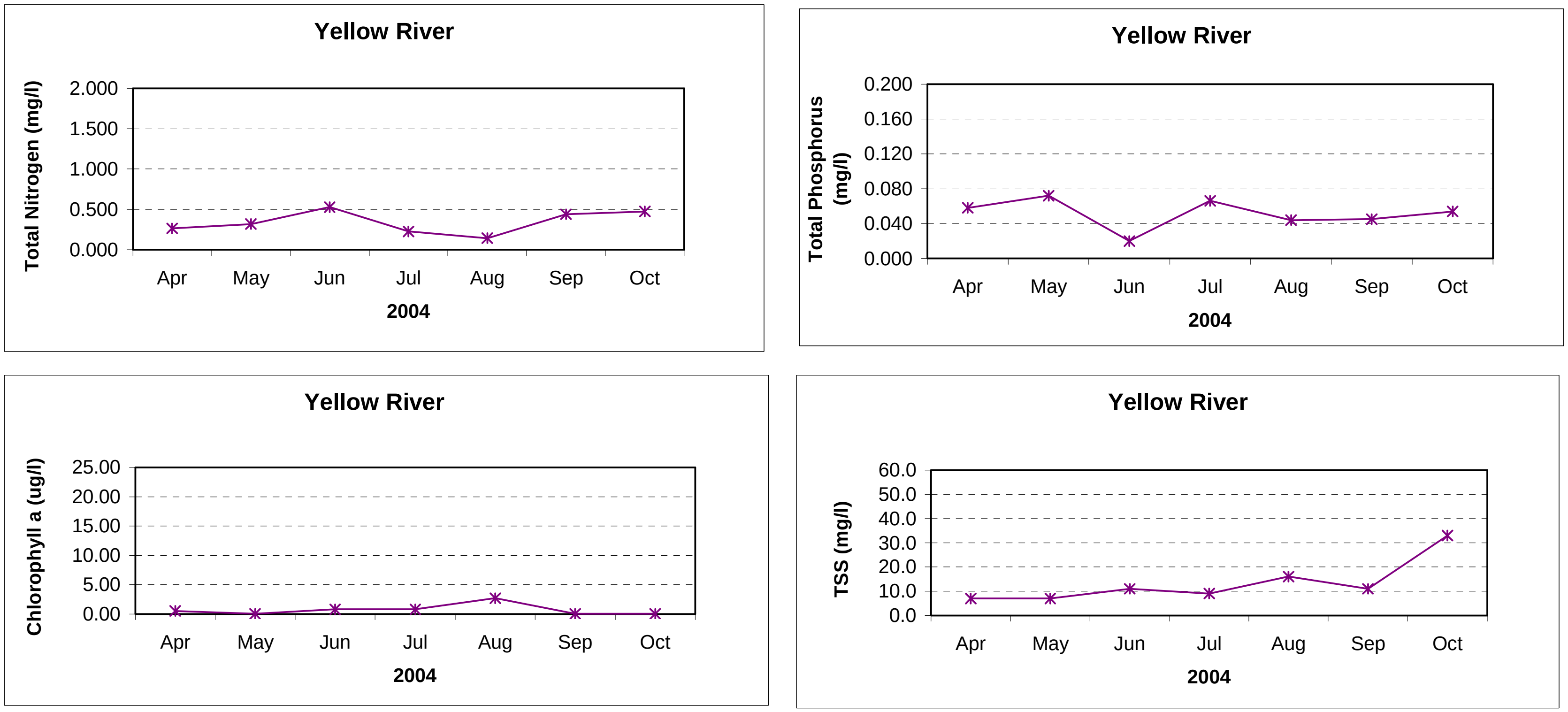


Figure 76. Trophic state index (TSI) and dissolved oxygen (DO) in the Yellow River, April-October 2004.

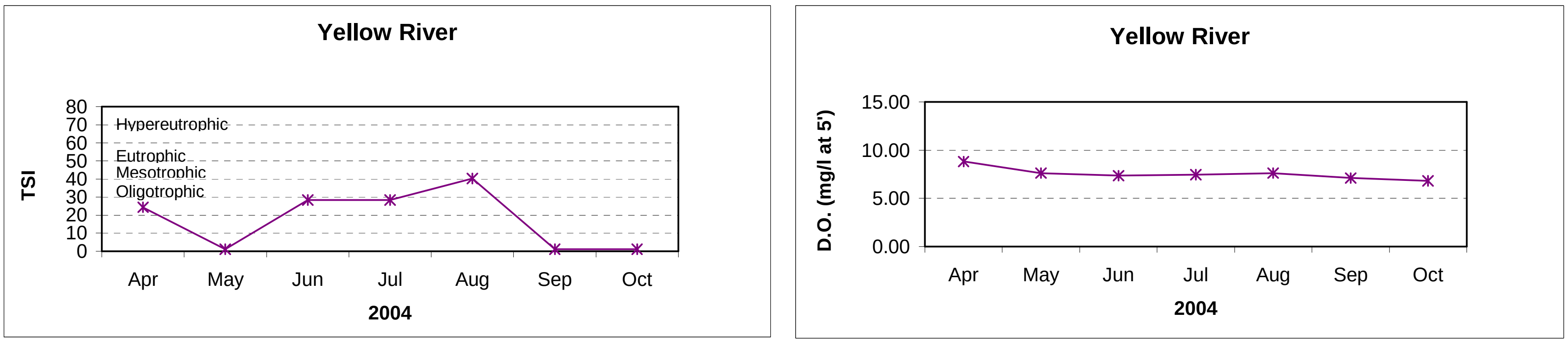
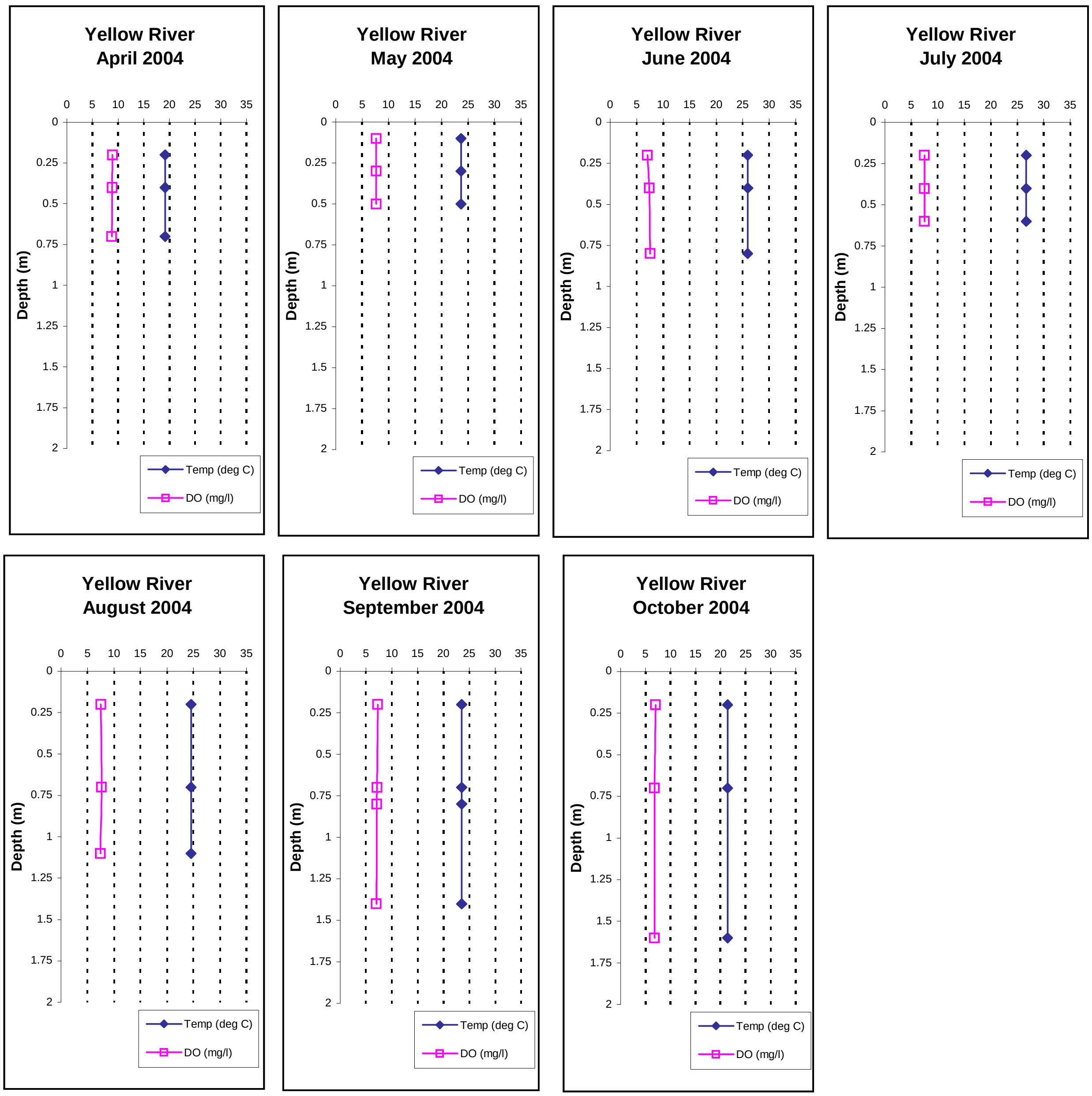


Figure 77. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in the Yellow River, April-October 2004.



Pea River

Figure 78. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and total suspended solids (TSS) in the Pea River, April-October 2004.

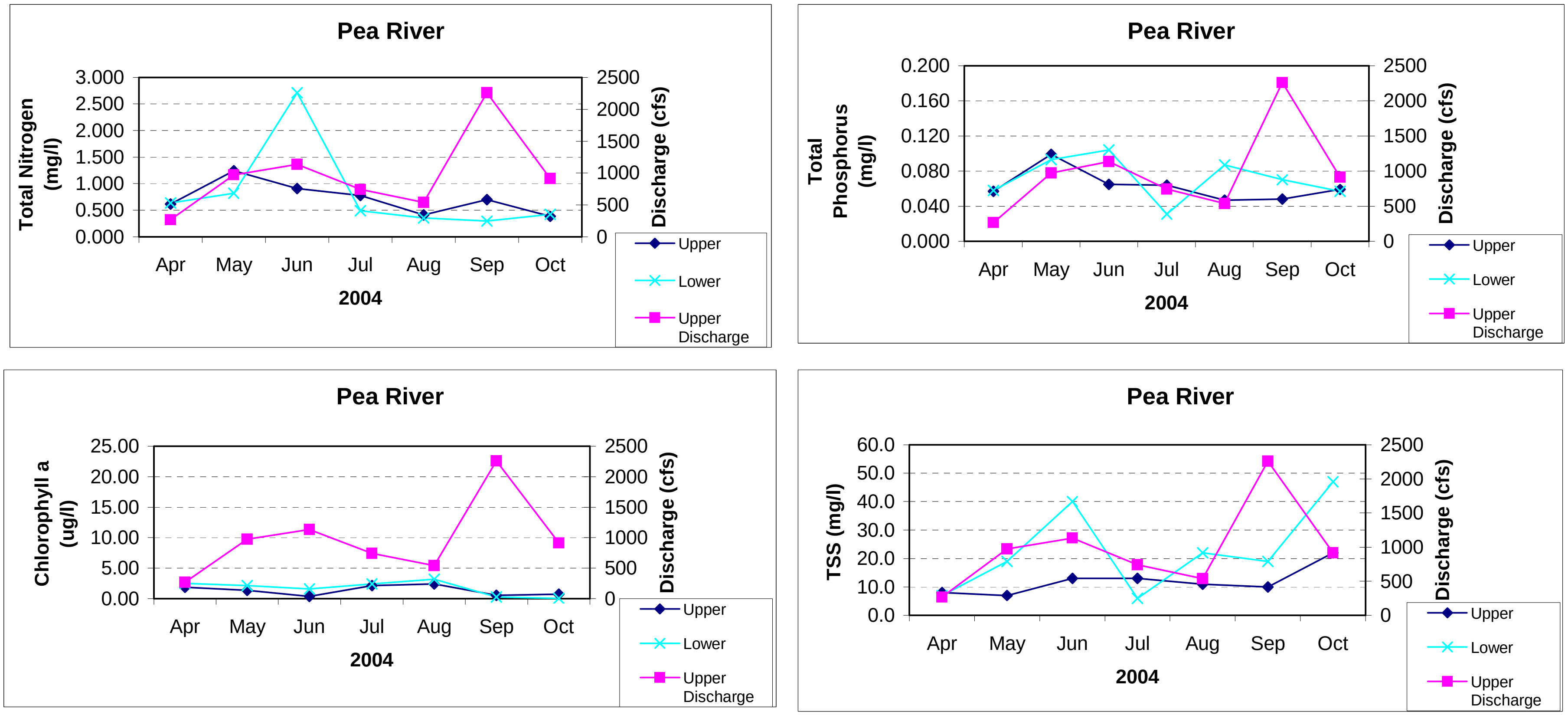


Figure 79. Trophic state index (TSI) and dissolved oxygen (DO) in the Pea River, April-October 2004.

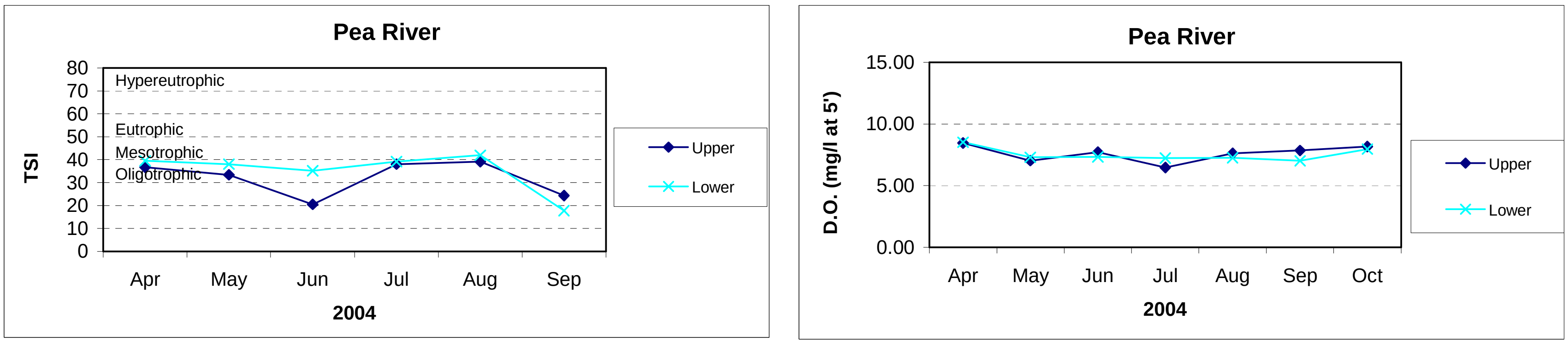


Figure 80. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in upper Pea River, April-October 2004.

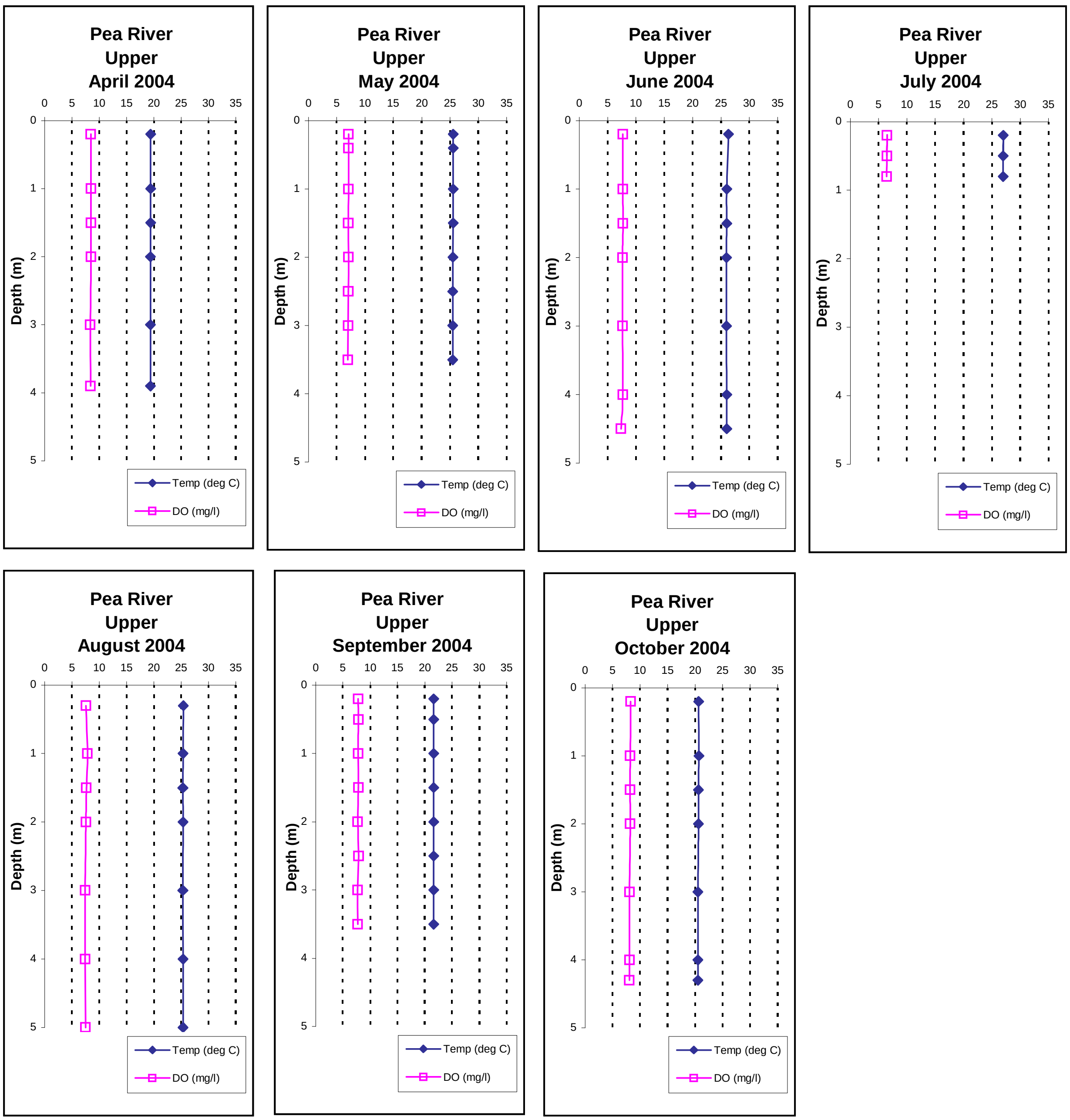
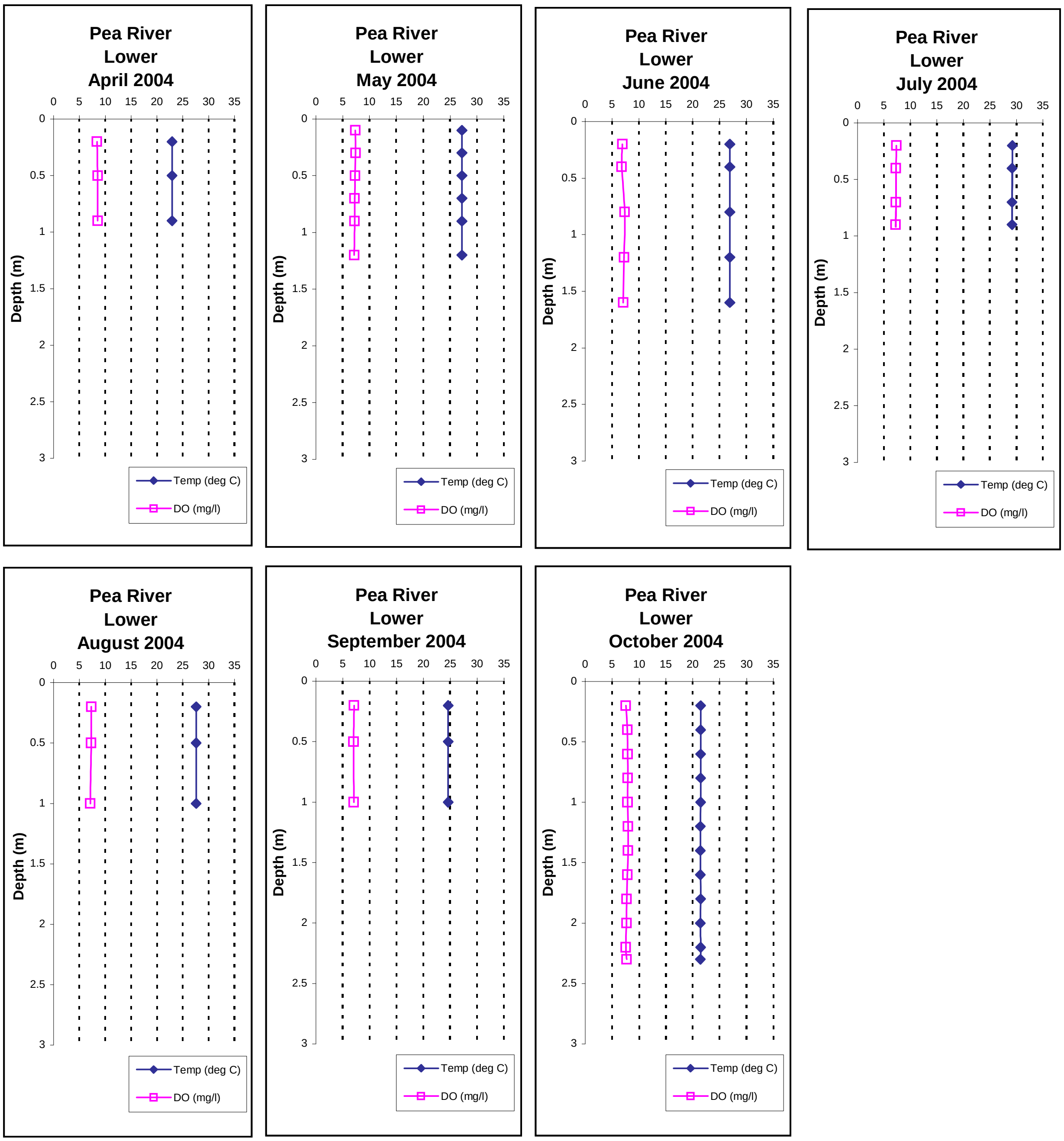


Figure 81. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in lower Pea River, April-October 2004.



Choctawhatchee River

Figure 82. Total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and total suspended solids (TSS) in the Choctawhatchee River, April-October 2004.

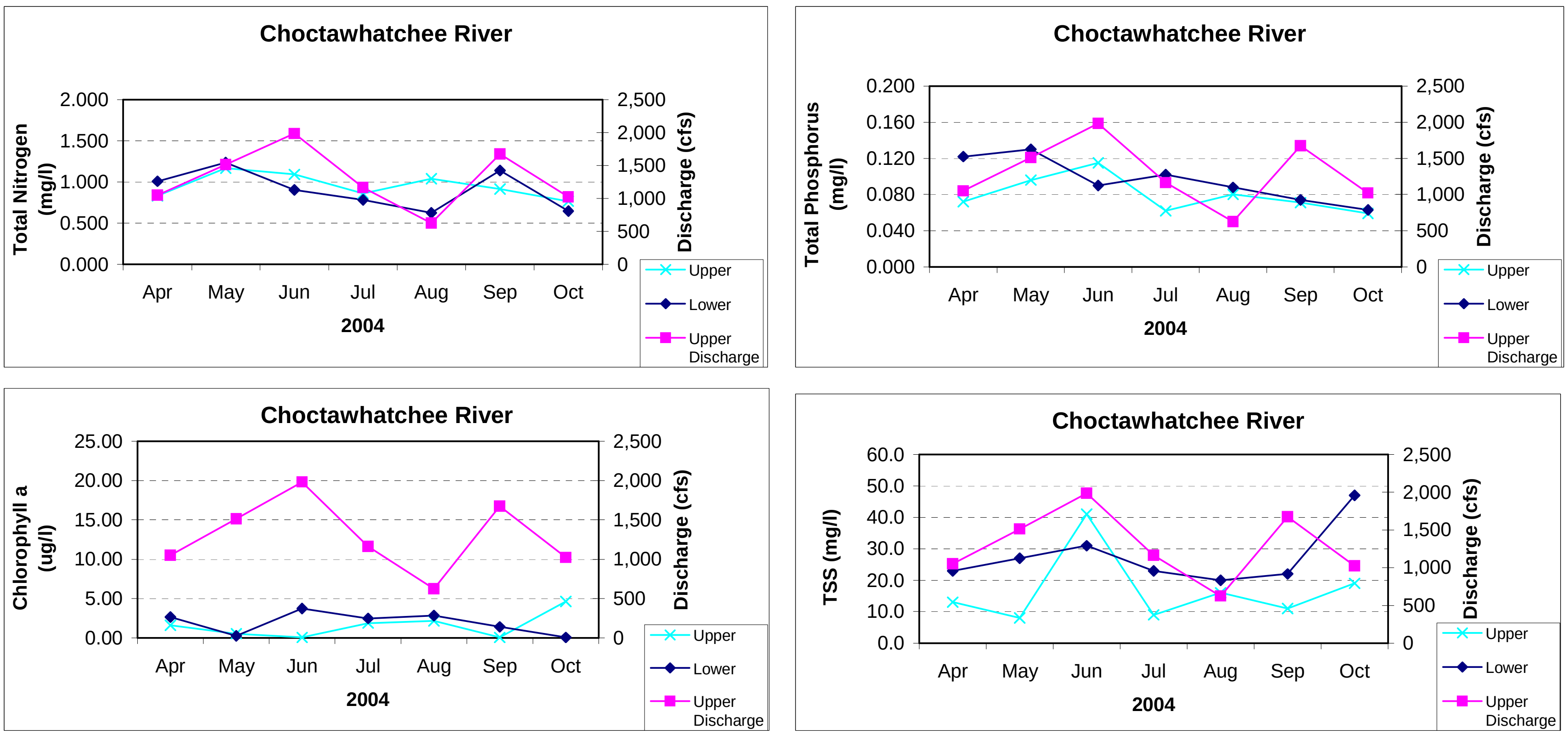
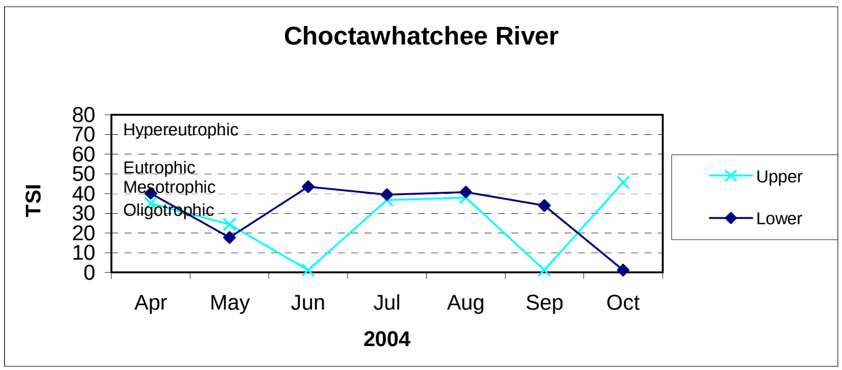


Figure 83. Trophic state index (TSI) and dissolved oxygen (DO) in the Choctawhatchee River, April-October 2004.



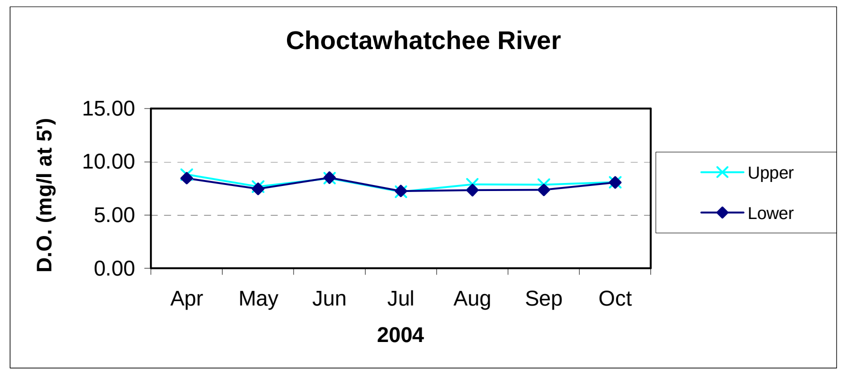


Figure 84. Depth profiles of dissolved oxygen and temperature in the upper Choctawhatchee River, April – October 2004.

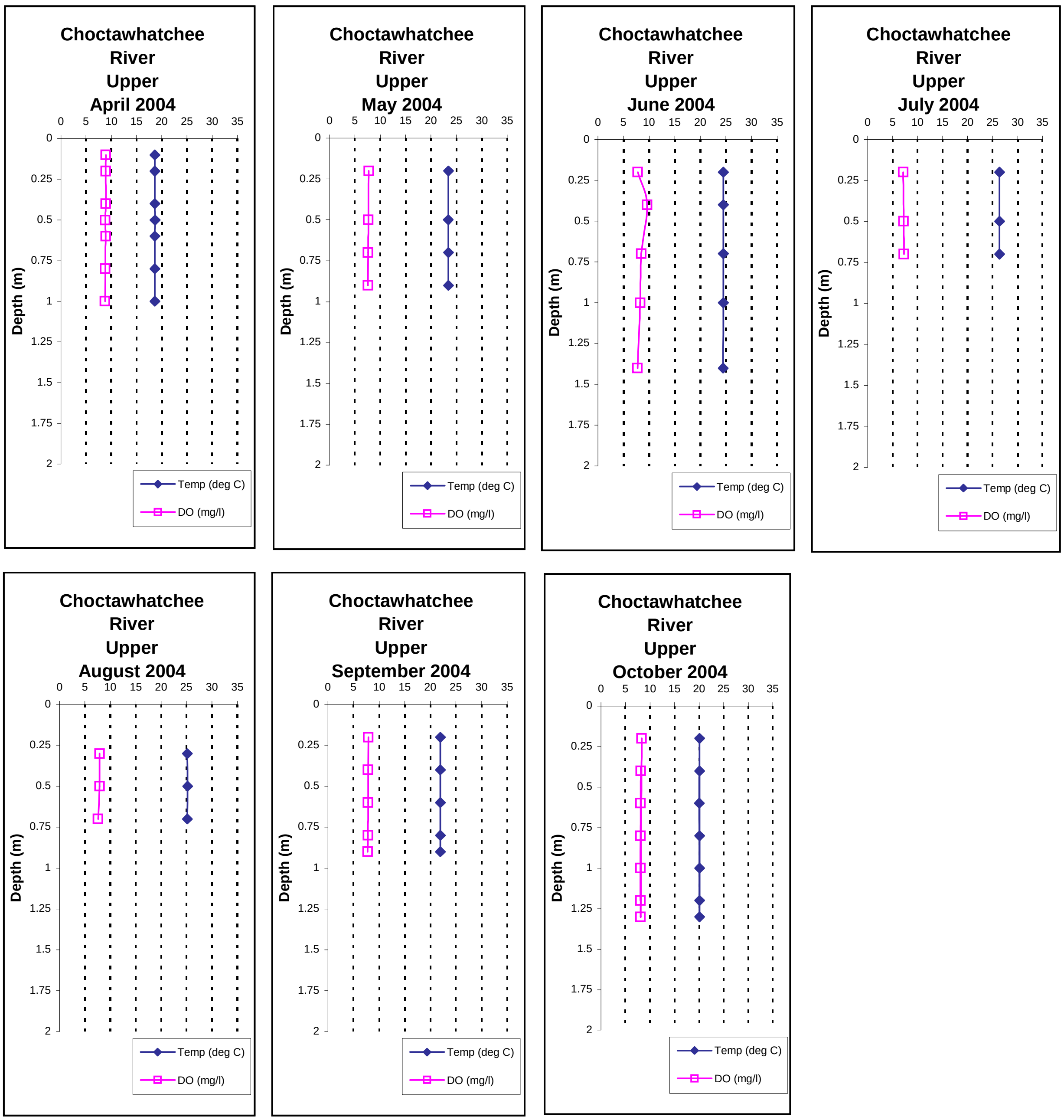
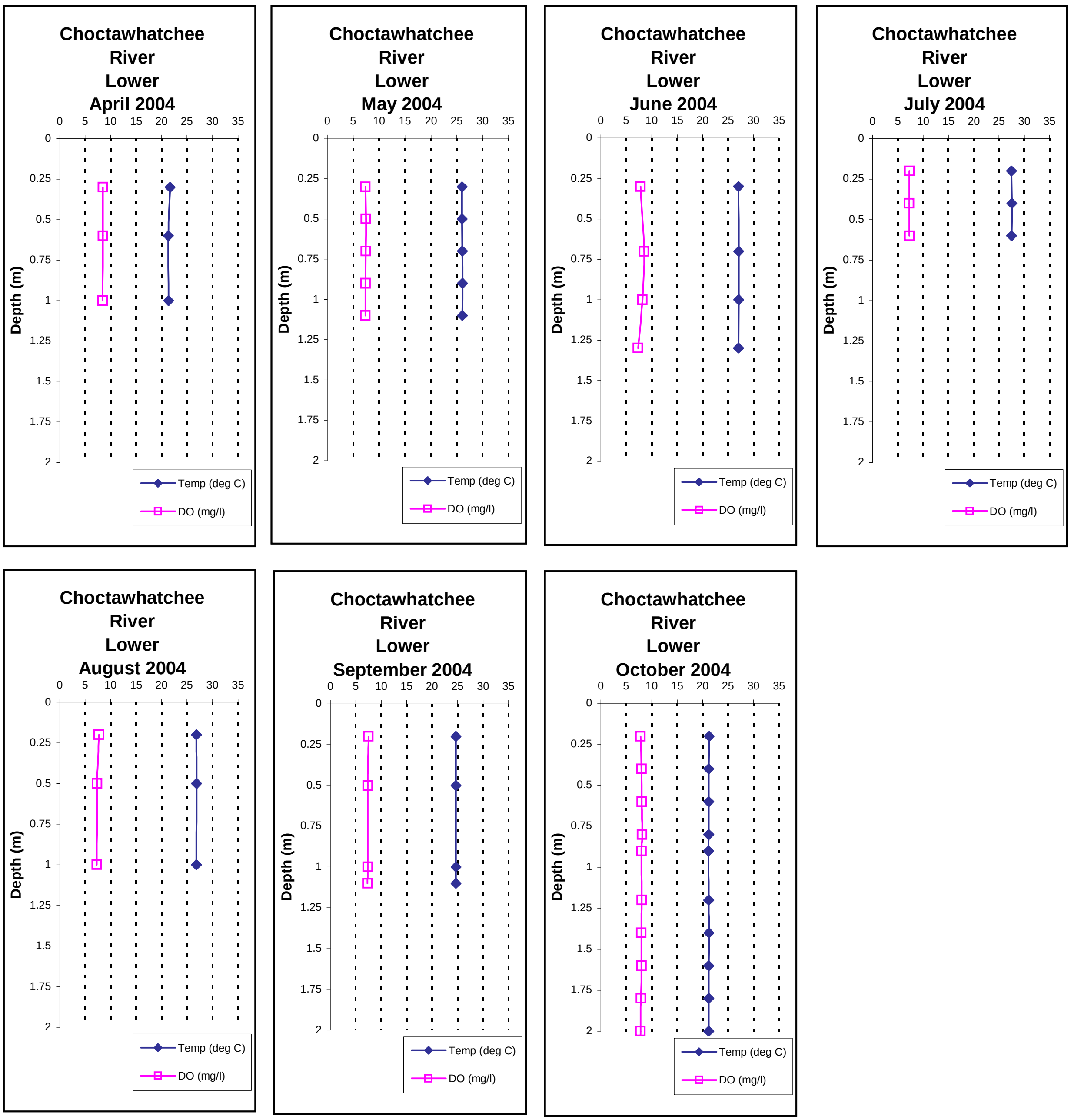


Figure 85. Depth profiles of dissolved oxygen and temperature in the lower Choctawhatchee River, April – October 2004.



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