BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

AMEREN ENERGY GENERATING CO.,	)	
	)	
Petitioner,	)	
	)	
v.	)	PCB No. 09-38
	)	(Thermal Demonstration-Water)
ILLINOIS ENVIRONMENTAL	)	
PROTECTION AGENCY	)	
	)	
Respondent.	)	

NOTICE OF FILING

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PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the **MOTION FOR LEAVE TO FILE INSTANER** and **RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY**, a copy of which is herewith served upon you.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

By: [signature]

Joey Logan-Wilkey
Assistant Counsel
Division of Legal Counsel

Dated: April 24, 2009

Illinois EPA
1021 North Grand Avenue East
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THIS FILING PRINTED ON RECYCLED PAPER

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

AMEREN ENERGY GENERATING CO.,	)	
	)	
Petitioner,	)	
	)	
v.	)	PCB No. 09-38
	)	(Thermal Demonstration-Water)
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY	)	
	)	
Respondent.	)	

MOTION FOR LEAVE TO FILE INSTANTER THE RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

NOW COMES the Respondent, ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, by and through Joey Logan-Wilkey, one of its attorneys, and pursuant to 35 Ill. Adm. Code 101.500, moves that the Illinois Pollution Control Board grant the Illinois EPA leave to file instanter the Recommendation of the Illinois EPA ("Recommendation") in response to the Petition filed by Ameren Energy Generating Co. in this matter. In support of its motion, the Illinois EPA states as follows:

1. The Petition in this matter was filed with the Illinois Pollution Control Board on December 15, 2008.
2. A Hearing Officer Order dated March 5, 2009, directed the Respondent to file the Recommendation by April 6, 2009.
3. On April 7, 2009, the Illinois EPA filed a motion for an extension of the deadline to file the Recommendation.
4. On April 8, 2009, a Hearing Officer Order was issued granting the Illinois EPA an extension to file the Recommendation of the Illinois EPA by April 17, 2009.

5. The Illinois EPA regrets that the Recommendation was not submitted in a timely fashion, and asks that the Board grant the Illinois EPA leave to file instanter the Recommendation.

WHEREFORE, for the reasons set forth above, Respondent ILLINOIS ENVIRONMENTAL PROTECTION AGENCY respectfully requests that the Board grant it leave to file instanter the Recommendation of the Illinois EPA.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

By: Joey Logan-Wilkey

Joey Logan-Wilkey
Assistant Counsel
Division of Legal Counsel

Dated: April 24, 2009

Illinois Environmental Protection Agency
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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

AMEREN ENERGY GENERATING CO.,	)	
	)	
Petitioner,	)	
	)	
v.	)	PCB No. 09-38
	)	(Thermal Demonstration-Water)
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY	)	
	)	
Respondent.	)	

RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

NOW COMES the Respondent, ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, by and through Joey Logan-Wilkey, one of its attorneys, in response to the Petition to Modify Specific Thermal Standard ("Petition") of Ameren Energy Generating Company ("Ameren" or "Petitioner") pursuant to Section 28.1 of the Illinois Environmental Protection Act ("Act"), 415 ILCS 5/28.1 (2008), 35 Ill. Adm. Code 106.200 *et seq*., and 35 Ill. Adm. Code 302.211(j)(5), and hereby recommends that the Illinois Pollution Control Board ("Board") **DENY** Ameren's request. Specifically, the Agency recommends that the Board deny Ameren's request because the Petition fails to address the impact of the proposed thermal limits on temperature and dissolved oxygen, measured at varying depths, throughout Coffeen Lake; the impact of the proposed thermal limits on total phosphorus and mercury levels in Coffeen Lake; and the resulting impacts on Lake habitat, and has therefore not met its burden under Section 28.1(c) of the

Act, 35 Ill. Adm. Code 106.200(a), and 35 Ill. Adm. Code 302.211(j)(5). In support of its Recommendation, the Agency states as follows:

I. INTRODUCTION

On December 15, 2008, Ameren filed a petition to modify the site specific thermal limits granted by the Board pursuant to 35 Ill. Adm. Code 302.211(j)(5) on March 19, 1982, which requires that the discharge from the Coffeen Power Station in Montgomery County to its artificial cooling lake known as Coffeen Lake shall not result in a temperature, measured at the outside edge of the mixing zone, that exceeds 105 degrees Fahrenheit as a monthly average from June through September, and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; and exceeds 89 degrees Fahrenheit as a monthly average from October through May, and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during that same period. These thermal limits were incorporated into Ameren's NPDES Permit as Special Condition No. 5.

In the petition, Ameren requests to modify the specific thermal standard for its discharge to Coffeen Lake to state that the thermal discharge shall not result in a temperature, measured at the outside edge of the mixing zone, which exceeds 105 degrees Fahrenheit as a monthly average, from June through September, and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; exceeds 89 degrees Fahrenheit as a monthly average, from November through April, and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during that same period; and exceeds 96 degrees Fahrenheit as a monthly average, in each of the months May and October, and 102 degrees Fahrenheit as a maximum for more than two percent of the hours in each of those same months.

Pursuant to 35 Ill. Adm. Code 106.208(b), the Agency is required to file its recommendation within 60 days of filing of the petition. In a March 5, 2009 order, the Hearing Officer stated that the Agency must file its recommendation by April 6, 2009.

On April 7, 2009, the Illinois EPA filed a Motion for Extension of Time to File Recommendation, requesting that its deadline to file the recommendation be extended to April 17, 2009. In an order dated April 8, 2009, the Hearing Officer granted the motion for extension, with the condition that the Agency file the recommendation electronically or in a manner allowing the Petitioner to receive the recommendation no later than April 17, 2009.

II. STATEMENT OF STANDARD OF GENERAL APPLICABILITY AND SITE SPECIFIC STANDARD FROM WHICH PETITIONER SEEKS A MODIFICATION

Petitioner has requested a modification to its site specific thermal standard previously granted by the Board pursuant to 35 Ill. Adm. Code 302.211(j)(5). The previously granted site specific standard provided Ameren relief from the general temperature limits found at 35 Ill. Adm. Code 302.211(b) through (e). The temperature requirements contained in Section 302.211 provide as follows:

Section 302.211 Temperature

a) Temperature has STORET number (F^o) 00011 and (C^o) 00010.

b) There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions.

c) The normal daily and seasonal temperature fluctuations which existed before the addition of heat due to other than natural causes shall be maintained.

d) The maximum temperature rise above natural temperatures shall not exceed 2.8° C (5° F).

e) In addition, the water temperature at representative locations in the main river shall not exceed the maximum limits in the following table during more than one percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the following table by more than 1.7° C (3° F).

	° C	° F		° C	° F
JAN.	16	60	JUL.	32	90
FEB.	16	60	AUG.	32	90
MAR.	16	60	SEPT.	32	90
APR.	32	90	OCT.	32	90
MAY	32	90	NOV.	32	90
JUNE	32	90	DEC.	16	60

On March 19, 1982, the Board granted a site specific thermal standard to the then-owner and operator of the Coffeen Power Station, CIPS. This standard required discharges not resulting in a temperature, measured at the outside edge of the mixing zone, which exceeds 105 degrees Fahrenheit as a monthly average from June through September, and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; and exceeds 89 degrees Fahrenheit as a monthly average from October through May, and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during that same period.

On June 5, 1997, the Board granted a variance from the from the original May and October thermal limits, allowing the June through September temperatures to apply in May and October. The Board made the variance conditional upon the completion of studies on the effect of the thermal discharges on the lake's fishery, and required that it be terminated if a fish kill should occur. The variance terminated due to a fish kill in 1999.

III. IMPLEMENTATION OF FEDERAL LAW

Section 316 of the Clean Water Act ("CWA"), 33 U.S.C. 1326, authorizes the Board to adopt alternative thermal limits. The Board adopted 35 Ill. Adm. Code 106.200(a)(2) and 302.211 in order to establish alternative thermal limits for artificial cooling lakes.

Pursuant to Sections 301 and 402 of the CWA, 33 U.S.C. 1311 and 1342, respectively, specific thermal limits are incorporated into the discharger's NPDES permit. The current specific thermal limits for Ameren's discharges into Coffeen Lake have been incorporated into Ameren's NPDES permit as Special Condition No. 5.

IV. NATURE OF PETITIONER'S ACTIVITY

Ameren operates the Coffeen Power Station ("Station"), located near Coffeen, Illinois, that was formerly owned and operated by CIPS. The Station is a two-unit 950 megawatt coal-fired steam generating station. *Petition at 6.* CIPS transferred the Station to Ameren on May 1, 2000. *Petition at 1.* Ameren's discharge of cooling water into Coffeen Lake is permitted pursuant to the National Pollutant Discharge Elimination System ("NPDES") permit No. IL0000108. The current specific thermal standard, established by the Board in 1982, states that the discharges to the Lake shall not result in a temperature, measured at the outside edge of the mixing zone, that exceeds 105 degrees Fahrenheit as a monthly average from June through September, and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; and exceeds 89 degrees Fahrenheit as a monthly average from October through May, and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during that same period.[1] These thermal limits were incorporated into Ameren's NPDES Permit as Special Condition No. 5.

The Coffeen Station was constructed from 1962 through 1965. The second unit was constructed and began operating in 1972. According to the Petitioner, in 2007, the Station's mean hourly generation was 694 gross MWh. Ameren's average annual net generation was 66 percent of its capacity in 2002 through 2006, and is expected to increase to up to 90 percent capacity by 2011. *Petition at 17.*

The 1,100-acre Coffeen Lake was constructed in 1963 to provide cooling water for the Station, and is now also used for recreational purposes and as a municipal water supply. CIPS and the Illinois Department of Natural Resources ("IDNR") entered into a lease agreement for the Lake to be used for conservation and recreation in 1986. *Petition at 7.*

Coffeen Lake was constructed by damming the McDavid Branch of the East Fork of Shoal Creek, two miles south of Coffeen. The Lake has a watershed of 18 square miles, and discharges into the East Fork of Shoal Creek, a general use water body. Most recent discharges to Shoal Creek were in May 2005 and April 2008. *Petition at 8.*

Cooling water is obtained from the western arm of the Lake, and then heated waste water is discharged back into the Lake through a discharge pipe into the eastern

[1] <u>CIPS v. IEPA</u>, PCB 77-158, PCB 78-100 (consolidated) (March 18, 1982).

arm of the Lake. *Petition at 11-12.* The Petitioner details a list of capital projects that have been completed to enhance the cooling capacity since 2000. Ameren constructed a 70-acre cooling basin at a cost of $20,734,000 and a 48-cell helper cooling tower at a cost of $6,833,000 in order to meet the mixing zone limits. *Petition at 12.* In addition, Ameren installed solar-powered aerators in the Lake to provide circulation of the water at a cost of $120,000. *Petition at 27.*

According to the Petitioner, average daily water temperatures at the edge of the mixing zone have been between 80 to 90 degrees Fahrenheit and have rarely exceeded 96 degrees Fahrenheit in May and October. Ameren states that maximum daily water temperatures have typically been in the 90s in May and October and have never exceeded 102 degrees Fahrenheit during those months. *Petition at 13.* Petitioner states that vertical stratification of temperatures and dissolved oxygen occurs during the summer months. *Petition at 13-14.*

V. SPECIFIC LEVEL OF JUSTIFICATION REQUIRED

Section 13 of the Act, 415 ILCS 5/13 (2008), provides the Board with the authority to adopt water quality standards. Section 28.1 of the Act, 415 ILCS 5/28.1 (2008), provides the Board with the authority to grant adjusted standards for those who meet the required level of justification for the adjusted standard in question.

The Board regulations provide the required level of justification for a specific thermal standard for a discharge to an artificial cooling lake. In order to make a demonstration for a specific thermal standard, Section 106.200(a), 35 Ill. Adm. Code 106.200(a), provides:

2) Artificial Cooling Lake Demonstration

A) If a discharger wishes to have the Board establish specific thermal standards for its discharge to an artificial cooling lake pursuant to 35 Ill. Adm. Code 302.211(j)(5) that would apply to the discharge in lieu of the applicable provisions of the thermal water quality standards set forth in 35 Ill. Adm. Code 302.211 and 303, the discharger must demonstrate in an adjudicatory proceeding before the Board, pursuant to 35 Ill. Adm. Code 302.211(j)(3), that the artificial cooling lake receiving the heated effluent will be environmentally acceptable and within the intent of the Act.

B) If the Board finds that the proof of the discharger under subsection (a)(2)(A) of this Section is adequate, the Board will establish, pursuant to 35 Ill. Adm. Code 302.211(j)(5), specific thermal standards to be applied to the discharge to the artificial cooling lake in lieu of the applicable provisions of the thermal water quality standards set forth in 35 Ill. Adm. Code 302.211 and 303.

C) A Board order providing alternate thermal standards under subsection (a)(2)(B) of this Section will include, but not be limited to, the following conditions:

i) Pursuant to 35 Ill. Adm. Code 302.211(j)(1), all discharges from the artificial cooling lake to other waters of the State must comply with the applicable provisions of 35 Ill. Adm. Code 302.211(b) through (e); and

ii) Pursuant to 35 Ill. Adm. Code 302.211(j)(2), the heated effluent discharged to the artificial cooling lake must comply with all applicable provisions of 35 Ill. Adm. Code Subtitle C, Chapter I, except 35 Ill. Adm. Code 302.211(b) through (e).

Section 106.202(b) of the Board regulations, 35 Ill. Adm. 106.202(b) requires that a petition for a specific thermal standard for an artificial cooling lake contain the following:

1) A demonstration that the artificial cooling lake receiving the heated effluent will be environmentally acceptable and within the intent of the Act, including:

A) Provision of conditions capable of supporting shellfish, fish and wildlife, and recreational uses consistent with good management practices; and

B) Control of the thermal component of the discharger's effluent by a technologically feasible and economically reasonable method.

2) The demonstration required under subsection (b)(1) of this Section may take the form of any of the following:

A) A final environmental impact statement;

B) Pertinent provisions of environmental assessments used to prepare the final environmental impact statement; or

C) A showing pursuant to Section 316(a) of the Clean Water Act (33 USC 1326).

3) A citation to any prior proceedings, in which the petitioner was a party, brought pursuant to 35 Ill. Adm. Code 302.211(f) or (j)(3).

For the reasons outlined below, the Petitioner has failed to meet the required level of justification for the proposed modification to the specific thermal limits for the discharge to Coffeen Lake.

A. Petitioner has not demonstrated that the proposed modification to the specific thermal standard for the discharge to Coffeen Lake will be environmentally acceptable and within the intent of the Act, in accordance with 35 Ill. Adm. Code 106.202(b)(1) and 302.211(j)(3).

1. Petitioner has not demonstrated that the proposed modification to the specific thermal standard for the discharge to Coffeen Lake will provide conditions capable of supporting shellfish, fish and wildlife, in accordance with 35 Ill. Adm. Code 106.202(b)(1)(A) and 302.211(j)(3)(A).

In order to obtain the proposed modification to the specific thermal standard, Ameren must demonstrate that discharges resulting in the proposed temperatures will provide conditions "capable of supporting shellfish, fish, and wildlife" (35 Ill. Adm. Code 106.202(b)(1) and 302.211(j)(3)(A)). Petitioner has failed to demonstrate that the proposed temperatures will provide conditions capable of supporting shellfish, fish and wildlife.

The 1997 variance required that CIPS conduct studies on the effects of its thermal discharges on the fishery in Coffeen Lake. Southern-Illinois University-Carbondale (SIUC) conducted studies of the effects of the thermal discharges and resulting temperatures on Newton Lake and Coffeen Lake from 1997 to 2006. SIUC studied fish species (largemouth bass, bluegill, and channel catfish) and habitat (dissolved oxygen and temperature profiles). Ameren retained ASA Analysis & Communication, Inc. to prepare a report ("ASA Report") on the possible impacts of the proposed modification to the thermal limits for the Lake, and has attached the report as an Exhibit 11 in support of the petition. According to Petitioner, the ASA Report is compiled of a Retrospective Assessment and Prospective Assessment based on data collected by IDNR, SIUC, and Ameren.

The Agency has reviewed the ASA Report and SIUC studies, and disagrees with Petitioner's statement that the data and ASA Report "demonstrate that Coffeen Lake is supporting a healthy fishery and that it would continue to do so under anticipated and worst-case operating conditions even with Ameren's requested relief." *Petition at 25*. SIUC states that fish kills occurred in 1999, 2001, 2002, and 2005, and that the fish kills were likely attributable to two types of critical conditions: first, ambient conditions such as hot air temperatures combining with high discharge water temperatures and low levels of dissolved oxygen, and second, habitat erosion wherein small fish were trapped in a thermal refuge near the mixing zones and the refuge was eroded by prolonged periods of heated discharge.[2]

The SIUC studies state that the effect of discharge temperatures on fish habitat depends greatly on weather patterns, and air temperatures in particular. SIUC notes that mean monthly mixing zone surface water temperatures were higher in 2003 through 2006, due to the stable increase in power production, when compared to 1999, the year of the fish kill that caused the May and October limits to revert back to the November through April limits.[3] Based on monitoring of water temperature, dissolved oxygen, and water depth profiles, SIUC concluded that potentially critical periods existed for fish between June and mid-September.[4] During periods of high ambient temperatures, the Lake is heated to depths where oxygen levels are too low to support aquatic life and fish kills occur. SIUC does not indicate a link between average surface temperatures and fish kills, but does state that fish kills have occurred during periods of maximum water temperatures.

In 1999, hourly surface temperatures at the outer edge of the mixing zone exceeded 112 degrees Fahrenheit during 83 hours, with most of the exceedances occurring between July 23 and 31.[5] The fish kill occurred during this period. SIUC states that the 1999 fish kill involved 242 largemouth bass and six channel catfish, and the fish were larger among the larger in the Lake. SIUC states that:

> The 1999 fish kills were likely induced by a combination of elevated, discharge water temperatures, prolonged periods of relatively hot air temperatures (which reduced the cooling capacity of the lakes and increased water

[2] Exhibit 1, pp. 9-13.
[3] Exhibit 1, pp. 13-14.
[4] Exhibit 2, p. 3.
[5] Exhibit 1, Table 4.

> temperatures at most depths throughout the lakes), and low levels of dissolved oxygen due to atmospheric conditions (which also induced fish kills in local ambient lakes). Habitat availability was extremely low for extended periods during late July 1999 in both lakes (Heidinger et al. 2000).[6]

The SIUC study links habitat erosion resulting from high mean water temperatures, at or over 100 degrees Fahrenheit, with fish kills, such as occurred in August 2001. SIU stated that "the prolonged high temperatures most likely caused fish mortality in a relatively small cove where the fish's thermal refuge was broken down."[7] SIUC cites two fish kills in Coffeen Lake, one in June/July 2002 and one in August 2005, that were "likely a result of eroding habitat."[8] The 2002 fish kill involved 42 largemouth bass, 64 striped bass, and small numbers of other fish species, while the 2005 fish kill involved 19 channel catfish.[9]

SIUC noted that smaller fish kills, such as occurred in July 2001, are more likely associated with water mixing zone temperatures.[10] In July 2001, 546 channel catfish and 65 largemouth bass were estimated to have died. According to SIUC, minimum water temperatures were close to 100 degrees Fahrenheit for several days leading up to the fish kill. SIUC noted that mean temperatures were at least 100 degrees Fahrenheit, and were "high to a depth of 3m which was the depth at which dissolved oxygen was also limited at the time."[11]

Data shows that mean monthly mixing zone surface water temperatures were lower in 1999 than in 2003 through 2006. SIUC states that these temperatures were

[6] Exhibit 1, p. 9.
[7] Exhibit 1, p. 11.
[8] Id.
[9] Id.
[10] Exhibit 1, p. 9.
[11] Exhibit 1, p. 10.

likely higher due to the increase in power production at the Station.[12] The maximum hourly surface water temperatures were, however, higher in 1999 than in subsequent years.[13] SIUC stated that the habitat conditions observed on August 2, 2005 "were the most critical" during all the years of the study, but only nineteen channel catfish were counted.[14] SIUC states that it is likely that cooler weather following extremely hot weather, a lack of cloud cover, and heavy rain events prevented a larger fish kill from occurring during August 2005, as well as the other years following the 1999 fish kill.[15] According to SIUC, "adequate habitat in Coffeen Lake was very nearly exhausted during several periods in 2005 and on at least one date in 2006."[16] SIUC attributes the fact that large fish kills did not occur from 2000 to 2006 to favorable weather conditions.

The ASA Report provided by Ameren in support of the proposed thermal standard examined the biological data collected by SIUC during its studies from 1997 to 2006, evaluating the effect of the thermal conditions on the fish. The ASA Report states that there is no "evidence of detrimental effects of water temperatures on fish recruitment, growth, and condition" in the fish under the current limits. *ASA at 5-2*. ASA predicts that a slow increase in water temperatures in May will provide a more natural thermal environment, and that an increased May standard will not cause warmer temperatures throughout the summer months. ASA also states that the warmer temperatures will allow for a longer growing season and improved winter survival of fish, and that the eastern and western arms of the Lake will have water temperatures that will provide a nursery and refuge for young and old fish. *ASA at ES-2*. The ASA Report focuses on the fact that

[12] Exhibit 1, p. 14.
[13] Exhibit 1, p. 3.
[14] Exhibit 1, p. VII.
[15] Exhibit 1, p. 14.
[16] Id.

fish kills have not occurred in May and October, and states that the proposed limits for those months will not cause fish kills, as water temperatures and dissolved oxygen levels associated with fish kills do not occur during those two months. That may be correct, but higher temperatures in May and October will likely increase the heat load to the Lake earlier in the summer, causing the water to reach higher temperatures throughout the rest of the season. Petitioner has not demonstrated that higher temperatures in May and October will not prolong the period of stratification and lower dissolved oxygen levels for the fish.

The SIUC studies and subsequent ASA Report have a key difference in that the SIUC studies evaluate temperature and dissolved oxygen related to depth to measure habitat conditions, while the ASA Report evaluated cumulative temperature based on degree days, which is based on surface temperatures at the edge of the mixing zone. SIUC notes that mixing zone surface temperatures indicate effluent temperatures rather than indicating water temperatures throughout the Lake and at different depths. The ASA Report states that "the vertical distribution of temperatures and DO during the months of May and October" is of greatest concern (*ASA at 2-3*), while the SIUC study states that the four months of June through September potentially encompass the most critical period when warm water temperatures may be lethal to fish species.[17] The ASA Report would consider the conditions during May and October in isolation, while it is unknown how increasing heat inputs in May could exacerbate environmental conditions during the summer months that lead to fish kills. Moreover, the prospective assessment provided by ASA reflected surface temperatures only. It predicts the May surface temperature at the edge of the mixing zone to be 95 degrees. *ASA at 4-3*. Suitable habitat

[17] Exhibit 2, p. 3.

for largemouth bass decrease when temperatures reach over 86 degrees, and oxygen concentration declines with depth, so available habitat may decline. The SIUC studies note the decline of dissolved oxygen with depth and the resulting effect on fish habitat, and stated that critical habitat existed on certain days. The Petitioner has failed to address the varying temperatures and levels of dissolved oxygen at different depths throughout the Lake and resulting impacts on fish.[18]

From 1997 through 2006, SIUC monitored water temperature, dissolved oxygen, and water depth profiles during the summer months, and prepared studies of the data collected. High temperatures and low dissolved oxygen can have negative impacts on fish growth, and can even be lethal at certain levels. SIUC estimated the amount of the lake that was available to fish for habitat as a percentage of the depth of the water below various temperatures, ranging from 87 to 96 degrees Fahrenheit, and above various dissolved oxygen concentrations, ranging from one to four parts per million.[19] Results indicated that potentially critical periods for fish existed in the Lake between June and mid-September.[20] According to the SIUC study, the effect that cooling plants' water discharge temperatures have on lake habitat availability is more dependent upon whether or not there are persistently high air temperatures.[21] On July 23, 1999, four days prior to the fish kill that caused the termination of the 1997 variance, SIUC researchers estimated the habitat available at or below 94 degrees Fahrenheit and with at least four ppm dissolved oxygen was ten percent in segment one of the lake and five percent in segment

[18] The Board has asked whether Ameren measured the water temperature and dissolved oxygen during May and October 2007 and 2008, and has requested information regarding the temperature monitoring locations and depths.

[19] Exhibit 1, p. 4.
[20] Exhibit 1, pp. 5-6.
[21] Exhibit 1, pp. 8-9.

two.[22] During the course of the study, SIUC estimated habitat conditions to be the most critical on August 8, 2001, July 6 and 8, 2002, August 20, 2003, June 28, 2005, July 27, 2005, August 2, 2005, and August 3, 2006.[23] Based on the water quality and the fact that dead fish were observed, SIUC stated that it is likely that adequate habitat was nearly exhausted during several periods in 2005 and at least one in 2006.[24] The SIUC study states that the dissolved oxygen/temperature profiles demonstrated that certain areas of the Lake could serve as refuges for fish during heavy thermal loading and low oxygen events, but that during the critical period of June through September, even those areas would likely have critically low quality habitat.[25] Increased thermal loading during May and October would likely exacerbate the lack of suitable fish habitat during critical periods.

The Illinois EPA's 2008 Integrated Water Quality Report listed Coffeen Lake as fully supporting aquatic life use, but not supporting fish consumption and aesthetic quality uses. The causes for aesthetic quality uses are aquatic plants, total phosphorus, and total suspended solids. The cause for fish consumption use was mercury. Increasing the water temperatures may also increase the phosphorus levels of the Lake. Dissolved oxygen and temperature profiles for Coffeen Lake showed evidence that segment one of the Lake begins to stratify in late April to May, and remains stratified until September. Increased temperatures in October may prolong the period of stratification. Stratification periods affect water quality because under anoxic conditions phosphorus is released into

[22] Exhibit 3, pp. 1-15.
[23] Exhibit 1, pp. 5-6, Table 7.
[24] Exhibit 1, p. 14.
[25] Id.

the water from the sediments. Phosphorus is the limiting nutrient in the Lake and is responsible for algal growth.

The Illinois EPA approved a Total Maximum Daily Load ("TMDL") for phosphorus for Coffeen Lake in August 2007. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. The TMDL endpoint for total phosphorus was set at 0.05 mg/L (the general use water quality standard for lakes with a surface area greater than 20 acres). Stratification periods affect water quality because under anoxic conditions at the lake sediment-water interface, phosphorus is released into overlying waters. Phosphorus continues to accumulate in the hypolimnion during stratification and is mixed in the water column during fall turnover. The amount of phosphorus released from the sediments is directly related to the period of anoxia during stratification. The longer the period of stratification and anoxia, the greater the phosphorus concentration. This process is called internal loading of phosphorus because the source of the phosphorus is the lake sediments.

The TMDL determined that a 64 percent reduction in tributary and internal phosphorus loading was necessary in order to meet the water quality target. This calculation of loading capacity in the TMDL report was based on a three foot increase in the level of the Lake, as Ameren had indicated plans to raise the dam to increase the level of the Lake in order to meet increasing productions needs. To date there has been no increase in the level of the Lake. Given current levels, a higher phosphorus reduction would be necessary to meet the water quality target.[26] Petitioner has not addressed the impact of the proposed thermal limits on phosphorus levels in the Lake.

As noted above, the Lake is also currently on the Agency's 303(d) List of impaired waters for mercury. During periods of stratification and low dissolved oxygen, more methylmercury is produced. Methylmercury bioaccumulates and is typically found in predatory fish. If the temperature of the Lake is higher in May and October, and the period of stratification is lengthened, the levels of mercury in the fish may also increase. Petitioner has not addressed the possible effects of the proposed thermal limits on the Lake's mercury levels.

A key difference between the ASA Report and the SIUC studies is the evaluation of temperature and dissolved oxygen. While SIUC evaluated temperature and dissolved oxygen profiles related to depth in order to estimate habitat conditions, ASA evaluated cumulative temperature based on degree days. Degree days are based on surface temperatures at the edge of the mixing zone. Mixing zone temperatures do not necessarily predict temperatures in other parts of the lake or with depth. According to the SIUC studies, the critical factor is habitat as defined by temperature and dissolved oxygen concentrations rather than degree days based on surface temperatures.

ASA used a one-dimensional thermal model to predict lake temperatures expected to occur as a result of increases in power produced and the resulting heat loading. The model predicted mean hourly water temperatures along the cooling loop from the mixing zone boundary to the intake at 1,000-foot intervals. This analysis only reflects surface temperatures. The model predicted a median temperature at the edge of the mixing zone

[26] Ameren has not raised the level of the dam, but has applied for 401 certification to pump water from Shoal Creek into the Lake to meet the water requirements of air pollution control equipment that will be installed at the Station.

to be 95 degrees Fahrenheit in May, which is seven degrees higher than the current limits allow. When considering available habitat for fish, it is important to take into consideration how far down the heat is transferred into the water column. If surface temperatures start seven degrees higher than the current temperatures in May, estimates of available habitat may also decline proportionally compared to estimates made under the current standard.

ASA briefly discussed dissolved oxygen and vertical stratification, but very little data was presented. Only vertical profiles for May and September of 2006 and October of 2000 were presented. ASA states that "of greatest concern is the vertical distribution of temperatures and DO during the months of May and October." *ASA at 2-3.* The time of greatest concern for the quality of the Lake is the period of lake stratification. The ASA Report emphasized conditions during May and October only, without considering that those two months are not isolated. Abiotic conditions in May and October are not independent, but reflect conditions occurring prior to and affect conditions occurring after those months. While it is true that the fish kills that have occurred in the Lake did not occur in May and October, the Petitioner has not demonstrated that increasing heat inputs in May will not exacerbate conditions during the summer months and cause fish kills, especially during certain weather conditions, such as prolonged high air temperatures, cloud cover, and lack of rainfall. Petitioner also has not demonstrated that increased loading in October will not prolong the stratification period in the Lake.

Petitioner has failed to demonstrate what impacts the proposed thermal limits for May and October will have on the critical period of June through September. Will the proposed limits increase the heat loading and have negative impacts on habitat during the summer months, and increase the period of stratification in the fall? SIUC has stated that air temperature has a significant impact on the effects of cooling plant discharges on fish habitat in the Lake. During past fish kills, a combination of high air temperatures, cloud cover, and high water temperatures have eroded fish habitat in the Lake. Petitioner has not demonstrated whether another fish kill would occur under the proposed limits if those factors were to occur simultaneously.

Further, IDNR's March 23, 2007 Lake Management Status Report states the largemouth bass population has declined in relative weight, and numbers of large fish have declined. According to IDNR, "this seems to be occurring with all species in this water body." *Petition, Exhibit 12 at 3.* Similarly, according to IDNR, the bluegill and channel catfish are also declining in relative weights. The conditions of the fish population in the Lake as noted by IDNR show the Petitioner has not demonstrated that the proposed thermal limits would provide conditions capable of supporting shellfish, fish and wildlife, as required by 35 Ill. Adm. Code 106.202(b)(1)(A) and 302.211(j)(3)(A).

1. Petitioner has not demonstrated that the alternatives to the proposed modification to the specific thermal standard for the discharge to Coffeen Lake are not technically feasible and economically reasonable, in accordance with 35 Ill. Adm. Code 106.202(b)(1)(B) and 302.211(j)(3)(B).

Ameren has not demonstrated that the alternatives to the proposed modification to the specific thermal standard for Coffeen Lake are not technically feasible and economically reasonable. Ameren has stated that alternatives to raising the May and October thermal limits, (including constructing additional cooling basins, cooling towers, and de-rating) are not economically reasonable, estimating the cost of a helper cooling tower at $13,000,000 to $18,000,000. Since 2000, Ameren has spent $27,687,000 on enhancements to the plant's cooling system. *Petition at 27.* According to the Petition, the Coffeen Cooling System Thermal Study prepared by Ameren's consultant, Sargent and Lundy, found four options to be technically feasible: construction of a new 175,000 gpm helper tower; construction of a new 130,000 gpm helper tower; construction of a new 100,000 gpm helper tower; and operation of the existing system with continued unit de-rating. *Petition at 30-32.* At an estimated cost of $18,000,000, the 175,000 gpm helper tower would allow the Petitioner to maintain compliance with the current thermal limits without de-rating. Petitioner estimates that it would recover the costs of this alternative 11.5 years after commissioning the new helper tower.

B. Prior proceedings pursuant to 35 Ill. Adm. Code 302.211(j)(3) in which Petitioner was a party (35 Ill. Adm. Code 106.202(b)(3)).

CIPS initially filed a petition with the Board requesting a specific thermal standard for Coffeen Lake on May 31, 1977.[27] The Board then set an interim thermal standard for Coffeen Lake requiring that the temperature at the edge of the mixing zone not exceed 98 degrees Fahrenheit for more than 8.2 percent of the hours in a twelve-month period, and at no time exceed 108 degrees Fahrenheit. On March 19, 1982, the Board granted the site specific thermal limits for Coffeen Lake.[28] The limits required discharges not resulting in a temperature, measured at the outside edge of the mixing zone, which exceeds 105 degrees Fahrenheit as a monthly average from June through September, and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; and exceeds 89 degrees Fahrenheit as a monthly average

[27] CIPS v. IEPA, PCB 77-158, PCB 78-100 (consolidated) (March 18, 1982).
[28] Id.

from October through May, and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during that same period.

On June 5, 1997, the Board granted a variance from the original May and October thermal limits, allowing the June through September temperatures to apply in May and October.[29] The Board made the variance conditional upon the completion of studies on the effect of the thermal discharges on the lake's fishery, and required that it be terminated if a fish kill should occur. A fish kill occurred in July 1999, causing termination of the variance. Upon termination of the variance, the May and October thermal standard reverted to the non-summer standard.

VI. CONSISTENCY WITH FEDERAL LAW

Pursuant to Sections 301 and 402 of the CWA, 33 U.S.C. 1311 and 1342, respectively, thermal discharges are permitted under the NPDES permit requirements, and specific thermal limits are then incorporated into the NPDES permit. Section 316 of the CWA allows states to develop alternative thermal limits so long as the alternative limits will "assure protection and propagation of "shellfish, fish, and wildlife."[30] The Board has set this standard in 35 Ill. Adm. Code 302.211(j)(3)(A). Petitioner has failed to demonstrate that the proposed modification to the specific thermal standard for Coffeen Lake will "assure protection and propagation" of shellfish, fish, and wildlife, in accordance with the CWA and Board regulations.

[29] CIPS v. IEPA, PCB 97-131 (June 5, 1997).
[30] 33 U.S.C. 1326(a).

VII. HEARING

Ameren states that the Board's rules do not require a hearing in this matter, and has agreed to waive hearing on the petition. *Petition at 37.* The Board has scheduled a hearing for May 19, 2009.

VIII. RECOMMENDATION AND CONCLUSION

In order to obtain a specific thermal standard for an artificial cooling lake, the discharger must demonstrate, pursuant to 35 Ill. Adm. Code 106.200(a)(2)(A), that "the artificial cooling lake receiving the heated effluent will be environmentally acceptable and within the intent of the Act," and must meet the requirements of 35 Ill. Adm. Code 302.211(j)(3). Pursuant to 35 Ill. Adm. Code 106.200(a) and consistent with 35 Ill. Adm. Code 106.202(b) and 302.211(j)(3), the Agency recommends that the Petitioner's request for the proposed modification to the specific thermal standard for Coffeen Lake be DENIED.

Petitioner has failed to demonstrate that the proposed modification will allow it to provide conditions capable of supporting shellfish, fish and wildlife. Petitioner has failed to demonstrate that the alternatives to the proposed modification to the thermal standard are technically infeasible and economically unreasonable. Consequently, Ameren has not met the requirements of S. 28.1 of the Act, 415 ILCS 5/28.1 (2008), and 35 Ill. Adm. Code 106.200(a), 106.202(b), and 302.211(j). Therefore, the Agency recommends that the Board deny the Petitioner's request to modify the specific thermal limits for Coffeen Lake.

WHEREFORE, for the reasons stated herein, the Illinois EPA recommends that the Board **DENY** Ameren's Petition.

Respectfully submitted,

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

By:_____________________________

Joey Logan-Wilkey
Assistant Counsel
Division of Legal Counsel

Dated: April 24, 2009

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THIS FILING PRINTED ON RECYCLED PAPER

EXHIBIT LIST

1. Ameren Newton and Coffeen Lakes Research and Monitoring Project Annual Report, Southern Illinois University at Carbondale, March 2007.

2. Ameren Newton and Coffeen Lakes Research and Monitoring Project Draft Report, Southern Illinois University at Carbondale, February 2004.

3. Ameren Newton and Coffeen Lakes Research and Monitoring Project Status Report, Southern Illinois University at Carbondale, November 2000.

CERTIFICATE OF SERVICE

I, Joey Logan-Wilkey, certify that I have served electronically the attached MOTION FOR LEAVE TO FILE INSTANTER and RECOMMENDATION OF THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, upon the following persons:

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Joey Logan-Wilkey
Assistant Counsel
Division of Legal Counsel
Illinois Environmental Protection Agency

THIS FILING PRINTED ON RECYCLED PAPER

EXHIBIT 1

Ameren Newton and Coffeen Lakes Research and Monitoring Project

Annual Report

Principal Investigators
Ronald C. Brooks
Roy C. Heidinger

Fisheries & Illinois Aquaculture Center
Southern Illinois University at Carbondale

March 2007
DRAFT

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ABSTRACT

Water temperatures in power-cooling reservoirs are often elevated to the point where summer habitat is limited for most fishes. Occasionally, increases in water temperatures may be responsible for stress-related fish kills. Since 1997, three types of critical conditions that resulted in fish kills have been recognized in Newton and Coffeen Lakes. The first type was associated with severe summer ambient conditions, and lead to the most severe fish kills. The largest fish kill of mature largemouth bass in both Newton Lake and Coffeen Lake occurred in 1999 when elevated water temperatures associated with an experimental mixing zone surface water temperature variance combined with summer weather conditions that caused particularly low levels of dissolved oxygen. Weather conditions that promoted a dissolved oxygen reduction in the power-cooling reservoirs also caused fish kills in local ambient lakes.

Another type of fish kill that likely occurred was habitat erosion, and we believe it accounted for three smaller fish kills since 1997. In 2001 there was a temperature-related fish kill on July 10 in Coffeen Lake and August 24 in Newton Lake. A small fish kill (124 fish) was observed by SIU personnel and estimated by IDNR between 24 June and 4 July, 2002 in Coffeen Lake. In these cases, the small fish were probably trapped in a thermal refuge near or in the discharge mixing zones. Prolonged periods of heated discharge eventually eroded away the refuge. The third type of fish kill is angler related. During 2003, 2004 and 2006, few dead fish were observed either lake, and the deaths appeared to be angler related, it accounted for the most frequent occurrences, but the least number of deaths. The dead or moribund fish are often in proximity of boat ramps or popular fishing areas. The bass probably succumbed to angling related stress. Such events were occasionally witnessed by SIU personnel during the warmest

periods. The deaths are usually delayed, and most anglers are not aware of the problem. The same sporadic fish mortality was true in Newton Lake during 2005, but in Coffeen Lake, 19 channel catfish were observed on 2 August, 2005, and habitat conditions were the most critcal we observed throught the eight years of this study. Fish were not collected for biological data following 2004. The preponderance of the data collected during 2000 through 2004 suggests that there were no long-term negative effects of the fish kills in either of these lakes.

INTRODUCTION

This report includes 2006 water temperature and dissolved oxygen data collected in Newton Lake and Coffeen Lake in Illinois. The data was collected using the same methods employed annually since fall 1997 (Heidinger et al. 2000) to facilitate comparison among years. Habitat availability was determined by combining water temperature, dissolved oxygen, and depth; the limiting factors being water temperature tolerances in conjunction with dissolved oxygen available to the fish.

The original project, which encompassed fall 1997 through fall 1999, monitored biotic communities ranging from phytoplankton through major sportfish. The goal was to determine conditions of the biotic communities prior to a water temperature "Variance" initiated in 1999 and compare those evaluations to the same parameters during and after the "Variance". A fish kill occurred during July, 1999 in both lakes while the power plants were operating under the new "Variance" (Heidinger et al. 2000). As a result of the fish kills and other economic considerations, the corporate decision was made to add additional cooling capacity to the Newton Lake and Coffeen Lake electrical generating stations. After summer 1999, the impetus of the study was to determine if the 1999 fish kill and subsequent smaller fish kills in either lake adversely affected three major sportfish populations in the lakes - channel catfish, largemouth bass, and bluegill. Data presented in this 2006 report will be used in conjunction with the previous years' water quality data primarily to examine trends of the abiotic parameters during potentially stressful summer periods.

For sampling purposes, Newton Lake was divided into four segments (Figure 1). From 1997 to 1999, Coffeen Lake was divided into two sampling segments. Beginning in 2000, temperature/oxygen/depth profiles were taken in two additional Segments (3 and 4) in Coffeen Lake (Figure 2). The basic sampling regime for data collected concurrently from 1997-2006 is outlined in

Table 1. A full description of the methods can be found in Appendix A. The 2006 study was approved and initiated at Newton Lake and Coffeen Lake during May.

PLANT OPERATION IN RELATION TO DISCHARGE STANDARDS

Four months (June-September) potentially encompass the critical period when extremely warm water temperatures may be lethal to fish species, and extremely warm ambient temperatures were prevalent throughout summer 2006. Mean monthly water temperatures were not excessively high in Newton Lake during 2006 (Table 2). Water discharge temperatures throughout the study period were greater than 106.0°F on only 11 occasions (19 July) and were never higher than 106.2. These water discharge temperatures were not conducive of critical consequences to the biota present in Newton lake. In fact, since 1999, neither mean monthly nor hourly temperatures have approached the old "Variance" levels of 102°F and 111°F, respectively. The highest monthly average temperature (104.1°F) during this study was recorded during July 1999, and hourly temperatures were consistently the highest recorded during this study exceeding 111°F on 100 occasions (Table 3).

Coffeen Lake mixing zone water temperatures were recorded hourly at the edge of the mixing zone in Segment 1 (Figure 2) either by Ameren or SIU-C for the past eight years. SIU-C's temperature logger placement was located in direct proximity to the station used by Ameren for measuring surface water temperatures in the mixing zone. However, the SIU-C temperature loggers were within 6 inches of the surface, and the biostations used by AMEREN have sensors located near the bottom of the buoys (approximately 28 inches below the surface). Therefore, mean monthly mixing zone water temperatures determined from SIU-C temperature loggers for 2001, July 2003, July-August 2004, and in 2006 are higher than would have been indicated for the deeper sensors on the biostations. This is especially true in Coffeen Lake where there can be a distinct drop in temperature throughout the upper three meters of water in that area of the lake (Figure 5). Hence, the discharge water temperatures reported using SIU-C's were the highest among the eight years studied in Coffeen Lake (Table 2).

Given the corrections likely required for the previous two-years' data, it is likely that June - September 2005 and 2006 water discharge temperatures averaged higher than the previous years, and they were certainly higher than in 1999 - year of the fish kill (Table 2). However, the maximum water discharge temperature recorded in 2006 was 111.9°F, and there were only 5 records where hourly temperatures exceeded 111°F. Those temperatures occurred during 30 and 31 July. Although these water discharge temperatures were high, they were apparently infrequent enough that the biota in Coffeen Lake did not succumb enmass to excessive thermal stress. When fish kills occurred in 1999, the maximum hourly surface water temperatures were higher (115.4°F) and more frequent than in 2005 or 2006 (Table 4). Additional weather-related factors in 1999 prolonged conditions that limited the cooling capacity of the lake water and resulted in temperatures that were elevated at all depths and in all segments of the lake (Appendix B). It should also be noted that in 2006, water temperatures cooled considerably as the distance increased from the discharge mixing zone (Figure 6).

HABITAT

Temperature/Oxygen/Depth Profiles

Seasonal temperature/oxygen /depth profiles were taken in Newton Lake and Coffeen Lake from 1997 through 2006 (Appendix A). Exact periods of data collection varied somewhat by grant time lines, but the historically, most stressful periods for the fish were usually encompassed. We estimated how much of the lake or lake segments were available to the fish as a percentage of the depth of the water that was below various temperatures (87-96° F) and above various dissolved oxygen levels (1-4ppm) (Heidinger et al. 2000). The mean percentage difference in habitat was calculated at 1.0° F intervals from 87-97° F at dissolved oxygen levels from 1-4ppm at 1ppm intervals. A detailed explanation of the methods used for habitat analyses can be found in Appendix A.

During 2000-2006, we added two additional lake segments (Segments 3 and 4) to our original two segments (Segments 1 and 2) in Coffeen Lake. Segment 3 is the large arm on the west side of Coffeen Lake known as cemetery bay, and segment 4 is the area between the intake canal and the railroad bridge. Both segment 3 and segment 4 are outside of the normal cooling loop.

Habitat availability was recorded year around during the initial three years of study. The results indicated that potentially critical periods for fish existed in the power-cooling lakes between June and mid-September. Therefore, since 2000, water temperature, dissolved oxygen, and depth profiles were monitored only during the summer periods when the grant time lines permitted.

Initially in the study period, habitat availability was compared between morning and afternoon samples. It appeared that afternoon temperature/oxygen/depth profiles gave a reasonable estimate of when the amounts of habitat available to the fish at various temperature and oxygen levels were at a minimum (Heidinger et al. 2001). Thus, since 2001, habitat profiles were taken in the afternoon periods when possible. To facilitate comparing profiles, data used in this report were taken from the latest possible times recorded within a date for each year prior to 2002.

Habitat data (2006) complete with all temperature ranges (87 - 96°F), dissolved oxygen levels (1 - 4), segments (1 - 4) and sample dates are presented in Appendix A. Ancillary versions of that appendix are given in Table 5 (Coffeen Lake) and Table 6 (Newton Lake). We also determined the three days per year that had the smallest amount of habitat from our samples from 1998 through 2006 for Coffeen Lake (Table 7) and Newton Lake (Table 8). In 2002, because of the contract time line, habitat monitoring formally started August 1. However, since there was a particularly warm period in July, we took temperature, oxygen, and depth profiles in Coffeen Lake on 6 and 8 July. For Chapter 1, habitat tables (2006) were condensed to include only four temperatures (87, 90, 93, and 96°F), and tables with data providing dates with the most critical habitat conditions during 1998-2006 were compiled using 3-ppm dissolved oxygen as a minimum criterion for the biotic communities at the same four temperatures. Habitat percentages represent means across all four segments in Newton Lake (Figure 1) and only segments one and two in Coffeen Lake (Figure 2).

During 2006 in Coffeen Lake, 22 June, 19 July, and 3 August were the three days when water quality was measured and conditions appeared to be most critical (Table 7). Those were days when habitat availability in the cooling loop (segments 1 and 2) was less than 10% at 90°F. Although the temperature and available dissolved oxygen were above the largemouth bass preferred temperatures, only on 3 August did the profiles indicate extremely stressful conditions. Adequate levels of dissolved oxygen were not present throughout the lake until water temperatures were greater than 93°F. At 93°F and 3 ppm dissolved oxygen, fish would be compelled to locate some type of thermal refugia to avoid short-term thermal stress. The fact that no fish kill occurred underscores the resilience and adaptability of fishes to extreme environmental conditions over time. However, if conditions eroded further than were witnessed on 3 August, it is most likely that a large-scale fish kill could have occured.

Similar critical habitat conditions have been apparent on seven other dates during the eight years of data collection (Table 7). Two of the seven dates occurred in 2005 (Brooks et al. 2006). No significant fish kills occurred on any of the other dates following the 1999 fish kill despite the fact that suitable habitat was extremely limited. It is possible that in 1999, habitat conditions were worst after the sample dates when fish kills were reported. Habitat conditions were as critical on 8 August, 2001, 6 July and 8 July, 2001, 20 August, 2003 and in all three of the dates in 2005 as they were on 23 July, 1999 - just four days before the major portion of the fish kill occured.

Based on the few numbers of fish kills that occurred during this study despite apparrently stressful conditions, average, lake wide habitat values do not necessarily give a complete indication of how stressful the habitat really is to fish in specific sections of the lake. For example, most habitat values in Coffeen Lake indicate more limited quality habitat in Segment 1 than when both segments are averaged. Extremely limited habitat was available to fish in Coffeen Lake on the eight dates previously indicated (Table 7). Interestingly, and perhaps indicating more serious conditions, these low levels usually occurred in both the cooling loop (Segments 1 and 2) and outside of the cooling loop (Segments 3 and 4) in 2005 and 2006 (Table 5).

In Newton Lake, the most critical periods ooccured prior to 2006 . This was particularly true on 24 July, 1999, 25 July and 7 August 2001, and 2 August 2002 (Tables 8). On two dates in 2005 dates (28 June and 26 July), water quality was worst than all other dates sampled during the eight-year sampling period except 24 July, 1999. At 90° F, 0% habitat with 3-ppm oxygen occurred on 24 July 1999 and on 26 July 2005; but on 25 July 2001 and 28 June 2005, only 2% habitat was available to fish (Table 8). To put this in perspective, if the lake depth averaged 5 m, 2% of that depth would mean only 0.1 m of water was available to the fish on that date. Fish kills occurred within three days of the 1999 and 2001 sampling dates. All four segments are in the cooling loop in Newton Lake.. Segments 1 and 2 (discharge arm) tend to have less desirable habitat during the summer months than Segments 3 and 4 (intake arm) (Table 6). It is likely that most of the fish killed during the periods of critical habitat were located well inside the discharge arm when the potentially fatal conditions began. If this were not true, then the fish kills would have involved much higher numbers of fish within and among species. Despite the very critical conditions prevalent in summer 2005, no fish kills were detected in Newton Lake.. Conditions in 2006 were never critical on the dates sampled.

Water Levels

Water levels in power-cooling reservoirs are typically lower than pool. Effects of lower water levels on fish species are dependent on the extent of aquatic macrophyte habitats lost. In Newton Lake, six of the seven worst habitat conditions occurred when water levels were at least 1.5 feet below pool level (Figures 7 - 9). The seventh occurred in 1999, just prior to the water levels dropping to 2.0 feet below pool. However, since there have been several summer periods when water levels were similar to the aforementioned dates (including 2005), effects of low water levels on fish stress are unclear at this time. Water levels occasionally are greater than pool over extended periods. No attempt has been made to determine the extent of spillway mortality in Newton or Coffeen lakes. Given the amount of movement of largemouth bass exhibit throughout all seasons, it is likely that some do escape over the spillway.

In Coffeen Lake, water levels fluctuate more than in Newton Lake. The levels have dipped to over 3 feet below pool during four extended periods over the last eight years (Figures 10-12). Examination of the most severe habitat conditions does not show any indication that low water levels promote the poor habitat conditions. As one would expect, those periods when water levels were over pool level often occurred during late spring or early summer. Since the higher water levels were infrequent, spillway mortality was not considered to be a threat to sport species in the lake.

FACTORS ASSOCIATED WITH FISH KILLS

In every reservoir or body of water where fish exist, one can find dead fish over the course of a summer or year. The deaths may have been natural or induced by extraordinary events. As we have discussed in this and previous reports, excessive water temperatures alone rarely cause massive fish kills. In most instances, there are other factors acting in concert with water temperatures to cause fish kills. In reservoirs, prolonged calm, cloudy weather patterns during warm periods can cause oxygen depletions that result in fish kills of a larger magnitude. Characteristically, few fish species are spared, but mortality among the species is dependent upon their tolerance to low levels of dissolved oxygen. Such a weather pattern occurred during July, 1999 when fish kills occurred in Newton and Coffeen lakes - as well as in ambient lakes such as East Fork Lake near Olney, Illinois. Personnel from SIU-C observed 121 largemouth bass and 8 dead or morbid channel catfish in Coffeen Lake (Table 9). In Newton Lake, 227 largemouth bass and 70 channel catfish were observed dead or dying (Table 10).

Under the high thermal loading parameters in Newton Lake, no differences in net primary productivity or chlorophyll were observed in July and August (1999) as compared to July and August (1998). Some of the fauna such as zooplankton, benthos number, benthos weight, and phytomacrobenthos actually increased (Heidinger et al. 2000). Thus, the data did not suggest long-term perturbation of the primary biota in the lakes. Examination of the fish indices resulted in similar conclusions.

The number of largemouth bass that died in Coffeen Lake and Newton Lake in 1999, relative to their abundance in the two lakes, indicated no significant long-term negative effects on the two bass populations were likely. In Coffeen Lake, assuming that only 50% of the largemouth bass that died were counted, then 242 bass died (0.22 per acre). If there were 20 bass per acre in Coffeen

Lake (1100 acres), then the death of 242 bass represented only 1% of the population. Although we have no recent creel data for Coffeen Lake, 242 bass is probably well below what is removed by anglers each year. Also, to place the 1% mortality due to the fish kill in perspective, the average total annual mortality rate for largemouth bass in Coffeen Lake from 1997-2004 is approximately 42% (Brooks and Heidinger 2005). In Newton Lake, assuming 20 largemouth bass per acre (1,750 acres), there were 35,000 bass in the lake before the kill. If anything, this was an underestimate, considering that from 02/16/98 through 12/31/98 the creel indicated that 60,187 bass were caught (Heidinger et al. 2002). In other words, if there were 35,000 bass in the lake, each bass on average was caught 1.7 times. Based on an estimate of 454 bass killed during the 1999 event and a population of 35,000 bass, the death of 454 (0.26 per acre) bass in Newton Lake would equal only 1% of the population. Again, to place the 1% of dead bass in perspective, average total annual mortality for bass in Newton Lake from 1997-2004 is approximately 57% .

The 1999 fish kills were likely induced by a combination of elevated, discharge water temperatures, prolonged periods of relatively hot air temperatures (which reduced the cooling capacity of the lakes and increased water temperatures at most depths throughout the lakes), and low levels of dissolved oxygen due to atmospheric conditions (which also induced fish kills in local ambient lakes). Habitat availability was extremely low for extended periods during late July 1999 in both lakes (Heidinger et al. 2000). A combination of factors caused the 1999 fish kills; but the kills were relatively insignificant to the sportfish populations.

Fish kills of smaller magnitudes also occurred in the two reservoirs during the study. Those kills were likely more directly associated with water mixing zone temperatures. Water currents associated with power-cooling discharges cause the biota behavior to be more characteristic of slow-moving rivers than of reservoirs. As a result, fish movement increases over that of ambient reservoirs. The movement is, in large part, dictated by forage abundance and locality. In power-cooling reservoirs, forage species often inhabits water temperatures near their thermal maximums because their food supply is more abundant there. If a sudden pulse of lethally hot water is pushed through, and some fish happen to be located in a cove away from the main water flow, the fish can be forced to stay in the cove until the slug of hot water passes. If lethally hot water temperatures persist in the main channel long enough, water temperatures in the coves will increase until they are similar to those in the main channel. This phenomenon, described as eroded fish habitats, results in smaller but more frequent fish kills such as occurred in 2001, 2002, and perhaps in Coffeen Lake in August 2005.

On July 10, 2001, in Coffeen Lake, 546 channel catfish (2-7 in TL), 513 Lepomis spp. (2-6 in TL) and 65 largemouth bass (2-7 in TL) were estimated to have died (Table 11). Mixing zone surface water temperatures began a prolonged increase where mean temperatures were at least 100°F on July 7 in 2001 (Heidinger and Brooks 2002). Prior to that date, although maximum water temperatures had increased to over 100°F, minimum temperatures were low enough to provide the fish with relief within a several-hour period. Minimum water temperatures increased to nearly 100°F after July 7 and did not decrease until mid-August. As postulated earlier, the prolonged nature of the high water temperatures after July 7 likely caused an eroding of cove habitat in the discharge mixing zone which resulted in the July 10 fish kill. Mean water temperatures were also high to a depth of 3 m which was the depth at which dissolved oxygen was limiting at that time.

In Newton Lake on August 28, 2001, we estimated that 10,765 three-inch gizzard shad were killed (Table 11). Again, maximum temperatures in the mixing zone prior to that time had been at least as high as on the day of the fish kill; but as in Coffeen Lake, Newton Lake mid-August water temperatures were increasing from summer lows, and by August 28, the temperatures stabilized at mean at over 100°F for several days. The prolonged high temperatures most likely caused fish mortality in a relatively small cove where the fish's thermal refuge was broken down..

Two additional fish kills detected during this study; that were likely a result of eroding habitat. One occurred in Coffeen Lake during late June and early July 2002, and the other just prior to 2 August 2005. In 2002, Forty two largemouth bass, 64 striped bass, and small amounts of five other species were found dead by SIU-C Personnel during the period (Table 12). In 2005, 19 channel catfish were discovered near the water intake. The fish were too decomposed to takes measurements, but were estimated to be about 12 to 15 inches TL. The abiotic circumstances in both years were very similar to the previous two fish kills in that water temperatures were increasing from summer lows, and the temperatures increased until late June (Heidinger and Brooks 2003).

It is likely these fish kills were associated with eroding of thermal refuge areas because, in Newton Lake, one particular area near the discharge mixing zone that draws many fish is the cove that receives spillage from the small ash pond. Water pouring in from the ash pond is generally cooler than the surrounding lake, and this cove typically is "stacked" with fish. This could be an area of concern if the water coming into the cove from the ash pond is warm and has relatively little oxygen at the same time when the surrounding lake water suddenly becomes very hot with low dissolved oxygen. Alternatively, if water discharge temperatures are not excessive, there are many small coves in the upper portion of Segment 1 that fish could use and eventually get trapped if the discharge water became suddenly hot and remained hot for extended periods. Coffeen Lake also has cove habitats in the discharge area where fish could be trapped. In particular, there is a cove located immediately adjacent to the discharge area where fish could easily congregate during less severe discharge temperatures and get trapped during a sudden increase of temperatures.

The magnitude of kills associated with habitat erosion should be relatively small. Identification of particularly suspect areas may be possible, but we are not certain at this time of whether the problem can be eradicated. We would need more information concerning fish use of the habitat at various water temperatures to further address this issue.

Beyond the previously described kills, very small numbers of dead fish have been observed by SIU-C personnel each year. The causes of death for these fish may be natural or associated with angling. In waters where fishing is popular, fish can be lethally hooked and released or stressed from capture and subsequent handling beyond their ability to recover. Stress-induced fish mortality from angling is primarily dependent upon water temperatures that, when relatively high, will increase the likelihood of stress-induced death. The extent of these fish kills are further dependent upon fish species, the number of fish hooked, where the fish were hooked, depth the fish were residing when hooked, and handling time. Fishing tournaments can cause higher numbers of stress related deaths not only because of the sheer numbers of fish caught, but also because of the additional stress the fish must endure from time spent in anglers' live wells and the extra handling during the weigh-in process. Fish killed by angling do not usually die at the time of capture or release; the mortality is delayed. The amount of delay is dependent upon the intensity of trauma inflicted on the fish during capture, time in captivity, or conditions of release.

In 2000, only four largemouth bass and two channel catfish were observed dead or dying in Coffeen Lake. In Newton Lake only two dead largemouth bass and two dead gizzard shad were observed in 2000. During 2001 in Coffeen Lake, except for the kill on July 7, 2001, only one dead striped bass, two white crappie, one largemouth bass and two channel catfish were observed by SIU personnel. In Newton Lake during 2001, only 10 dead fish were observed except for the kill of shad on August 28, 2001. Anglers reported several dead largemouth bass on August 21, 2002, but an exploratory visit to Newton Lake on the following day did not confirm this. We observed only two other dead channel catfish and three largemouth bass during 2002. However, due to the timing of the funding, we did not begin regular monitoring of the lakes until August. Throughout 2003, we only observed ten dead or dying fish in Newton Lake; and only two were observed in 2004. In both cases in 2004, the dead largemouth bass were observed at the west boat ramp. Only seven fish were observed dead or dying in Coffeen Lake during 2003, and three channel catfish were found dead in 2004. Since None of the deaths in 2004 were suspected to have resulted from water temperatures or dissolved oxygen. Dead or moribund fish observed during 2005 and 2006 were rarely observed during 2005 and 2006.

SUMMARY

The data collected since 2000 represents a small, but specific portion of the data collected during 1997 through 1999. The high cost of field data collection, laboratory work, and data analyses is often prohibitive to researchers attempting to answer field-related questions concerning fish populations and the interaction between abiotic and biotic entities. In order to circumvent the problem of costs, biologists attempt to examine trends in conjunction with traditional indices. Water quality data collected since 2000 was used as a continuation of the data previously collected to examine habitat quality.

Mean monthly water temperatures in Newton Lake during the annual study periods were , for the most part, cooler following 1999. In Coffeen Lake, the temperatures were actually warmer in 2003, 2004, 2005, and 2006 than in 1999. However, weather patterns (and not water temperatures) in 2000 - 2006 likely were responsible the lack of fish kills versus 1999. In 1999, temperatures remained very hot for a number of weeks. In most instances following 1999, very hot weather was followed for a few days by cooler weather, and in some cases, heavy rain events. These rain events are reflected in the summer water levels of Newton Lake through 2004. Weather patterns were mild through most of summer 2003 and 2004, and at least in Newton Lake, water temperatures were somewhat indicative of the weather. During 2005, the lack of extended periods of cloud cover most likely spared the lakes of fish kills despite the high water temperatures. It is likely that an extended period of cloud cover would have reduced the already critically limited habitat and caused fish kill as was witnessed in 1999.

The higher 2003 - 2006 mean mixing zone, surface water temperatures in Coffeen Lake reflected the stable increase in power production in that power plant. During 2005, the same habitat quality that persisted in Newton Lake due to ambient conditions were present in Coffeen Lake, except water temperatures were warmer in Coffeen Lake. Based on the water quality and the fact that a few fish succumbed to the water conditions, it is likely that adequate habitat in Coffeen Lake was very nearly exhausted during several periods in 2005 and on at least one date in 2006. Based on water quality data, a timely period of cloud cover would most likely have induced one or more fish kills. However, given the very warm summer ambient temperatures, It is just as likely that the same could have been reported for unheated lakes in the region since there was very little precipitation. In Coffeen Lake, temperature /oxygen profiles have indicated that cemetery cove and the area between the railroad bridge and the intake canal could serve as refuges for at least part of the fish community during heavy thermal loading and/or low oxygen events. However, during extremely critical periods, even those areas would likely have critically low quality habitat.

In power-cooling ponds, a second condition that can contribute to fish kills is an eroding refuge. A sudden increase of power output and concurring increase in water discharge temperatures can cause some fish to move to an immediate, nearby cove for refuge. If that refuge becomes secluded from inhabitable water by a significant distance (such as is likely if it would occur nearer the discharge mixing zone in either lake), then the refuge can be depleted over time from continuously high discharge temperatures. Fish inhabiting the cove will eventually succumb to heat if they must travel too far in find cooler water. In such instances, the fish kill would likely be relatively small since not all fish would react to the sudden increase in temperatures in the same manner (i.e. some would move to the cooler end of the lakes at the time increased temperatures were initially perceived). Based on information collected since 1997, this entrapment likely occurred on three occasions in the two lakes; the second highest frequency in terms of fish kills since 1997.

Low-level angler mortality is likely the most frequently cited kill factor. When epilimnion temperatures are very hot, detrimental effects of stress induced from increased activity and consequential increase in lactic acid from hooking and handling by anglers is compounded and likely causes incidental mortality that is witnessed every year in both lakes. The number of dead or moribund fish observed at specific areas frequented or recently vacated by anglers is usually small, but witnessed or not, this type of mortality most certainly occurs throughout summer. During the once-per-week sampling effort completed during summer 2000, 2003, 2004, 2005 and 2006 very few dead or dying fish were observed in either Newton Lake or Coffeen Lake. The few largemouth bass observed were usually found near boat docks and popular angler fishing areas. Since, in 2000, a number of boats were present at the dock when bass were observed, the bass may have been caught in a club tournament and released at the dock.

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Table 1. Ameren Project's basic sampling schedule for data collected concurrently from 1997 through 2006.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Newton Lake													
Temp/DO	0	0	0	0	4	4	4	4	4	0	0	0	**4 samples per date:** midway between segment borders; 1/2 meter intervals to bottom.
Coffeen Lake													
Temp/DO	0	0	0	0	4	4	4	4	4	0	0	0	**4 samples per date:** midway between segment borders; 1/2 meter intervals to bottom

[1]/ Starting dates for sampling were contingent upon grant approval.

Table 2. Comparison of summer and fall mean monthly temperatures (°F) at the outer edge of the discharge mixing zones.[a]

Month	1997	1998	1999	2000	2001[a]	2002	2003	2004	2005	2006
					Newton Lake					
May	---	89.8	88.4	82.5	91.7	84.8	84.6	93.2	91.4	80.3
June	95.9	96.3	97.0	94.2	94.5	97.4	90.8	96.7	99.0	94.2
July	101.7	101.7	104.1	98.0	100.1	99.1	96.9	96.8	99.3	99.4
August	96.2	102.3	99.7	97.5	99.4	96.6	98.3	95.3	99.3	99.8
September	94.9	94.6	93.1	92.8	92.9	94.0	92.7	93.3	97.7	93.7
October	86.3	87.5	85.4	84.9	84.8	86.3	84.8	84.2	86.9	---
					Coffeen Lake					
May	77.7	90.8	86.4	88.0	84.7	83.5	86.3	88.4	83.7	88.7[a]
June	87.9	94.9	90.5	93.9	86.6	82.2	96.7	100.8	99.9	101.5[a]
July	100.8	102.4	103.9	99.2	101.3	96.9	104.3[a]	105.0[a]	104.2	105.2[a]
August	98.7	100.1	101.5	99.2	102.4	100.4	102.2	105.6[a]	102.6	103.4[a]
September	88.7	96.1	94.8	93.5	93.2	100.4	97.2	102.9	100.5	95.5[a]
October	81.6	79.9	83.6	83.4	64.2	99.1	81.8	85.3	84.2	87.4[a]

[a]/ Hourly temperature data was provided by Ameren except for Coffeen Lake in 2001 and temperatures with superscripts in 2003, 2004, and 2006 which were obtained from SIU temperature recorders.

Table 3. Hourly surface temperatures in 1999 that exceeded 111°F at the outer edge of Newton Lake discharge mixing zone. Within a year total hours above 111°F were not to exceed 110°F (3% of total number of hours during the period June-October, 3,672 hours).

Date	Time	Surface temp.	Date	Time	Surface temp.	Date	Time	Surface temp.
7/22/1999	13:34:28	111.22	7/24/1999	20:34:28	111.47	7/28/1999	0:34:28	111.36
7/22/1999	14:34:28	111.39	7/24/1999	21:34:28	111.18	7/29/1999	12:34:28	111.33
7/22/1999	15:34:28	111.48	7/24/1999	22:34:28	111.01	7/29/1999	13:34:28	111.79
7/22/1999	16:34:28	111.65	7/25/1999	13:34:28	111.53	7/29/1999	14:34:28	111.99
7/22/1999	17:34:28	111.84	7/25/1999	14:34:28	111.5	7/29/1999	15:34:28	111.87
7/22/1999	18:34:28	112.03	7/25/1999	15:34:28	111.71	7/29/1999	16:34:28	111.99
7/22/1999	19:34:28	112.09	7/25/1999	16:34:29	111.77	7/29/1999	17:34:28	112.31
7/22/1999	20:34:29	112.06	7/25/1999	17:34:28	112.03	7/29/1999	18:34:28	111.43
7/22/1999	21:34:28	111.93	7/25/1999	18:34:28	112.13	7/29/1999	19:34:28	112.61
7/22/1999	22:34:28	111.85	7/25/1999	19:34:28	112.06	7/29/1999	20:34:28	112.85
7/22/1999	23:34:28	111.74	7/25/1999	20:34:28	112.11	7/29/1999	21:34:28	113
7/23/1999	0:34:28	111.48	7/25/1999	21:34:28	112.44	7/29/1999	22:34:28	112.39
7/23/1999	10:34:28	111.59	7/25/1999	22:34:28	112.53	7/29/1999	23:34:28	112.85
7/23/1999	11:34:29	112.01	7/25/1999	23:34:28	112.32	7/30/1999	0:34:28	112.79
7/23/1999	12:34:28	112.32	7/26/1999	11:34:28	111.15	7/30/1999	11:34:28	111.81
7/23/1999	13:34:28	112.53	7/26/1999	12:18:32	111.28	7/30/1999	12:34:28	111.85
7/23/1999	14:34:28	111.93	7/26/1999	16:34:28	111.35	7/30/1999	14:34:28	112.99
7/23/1999	15:34:28	112.06	7/26/1999	17:34:28	112.57	7/30/1999	15:34:28	113.31
7/23/1999	16:34:28	112.05	7/26/1999	18:34:28	112.46	7/30/1999	16:34:28	113.27
7/23/1999	17:34:28	111.98	7/26/1999	19:34:28	112.47	7/30/1999	17:34:28	113.35
7/23/1999	18:34:28	111.84	7/26/1999	20:34:29	112.34	7/30/1999	18:34:28	113.37
7/23/1999	19:34:28	111.77	7/26/1999	21:34:28	112.31	7/30/1999	19:34:28	113.51
7/23/1999	20:34:28	111.73	7/26/1999	22:34:28	112.33	7/30/1999	20:34:28	113.56
7/23/1999	21:34:28	111.79	7/26/1999	23:34:29	112.29	7/30/1999	21:34:28	113.63
7/23/1999	22:34:28	111.75	7/27/1999	0:34:28	112.23	7/30/1999	22:34:28	113.66
7/23/1999	23:34:28	111.49	7/27/1999	14:34:28	111.37	7/30/1999	23:34:28	113.64
7/24/1999	11:34:28	111.54	7/27/1999	15:34:28	111.54	7/31/1999	0:34:28	113.48
7/24/1999	12:34:28	111.96	7/27/1999	16:34:28	111.71	7/31/1999	1:34:28	111.98
7/24/1999	13:34:28	112.18	7/27/1999	17:34:28	111.82	7/31/1999	2:34:28	112.8
7/24/1999	14:34:28	112.27	7/27/1999	18:34:28	111.78	7/31/1999	3:34:28	112.67
7/24/1999	15:34:28	112.09	7/27/1999	19:34:28	111.57			
7/24/1999	16:34:28	112.05	7/27/1999	20:34:29	111.59			
7/24/1999	17:34:28	111.77	7/27/1999	21:34:28	111.7			
7/24/1999	18:34:28	111.7	7/27/1999	22:34:28	111.71			
7/24/1999	19:34:28	111.75	7/27/1999	23:34:28	111.6			
						TOTAL HOURS		100

Table 4. Hourly surface temperatures in 1999 that exceeded 112°F at the outer edge of Coffeen Lake discharge mixing zone. Within a year total hours above 112°F were not to exceed 132 (3% of total number of hours during the period May – October, 4,416 hours).

Date	Time	Surface temp.	Date	Time	Surface temp.	Date	Time	Surface temp.
7/23/1999	16:00:00	112	7/28/1999	16:00:00	112.95	7/31/1999	14:00:00	113.02
7/23/1999	17:00:00	112.5	7/28/1999	17:00:00	113.17	7/31/1999	15:00:00	112.88
7/23/1999	18:00:00	112.21	7/28/1999	18:00:00	113.86	7/31/1999	18:00:00	113.29
7/23/1999	19:00:00	112.59	7/28/1999	19:00:00	113.91	7/31/1999	19:00:00	113.83
7/23/1999	20:00:00	112.16	7/28/1999	20:00:00	113.58	7/31/1999	20:00:00	114.09
7/25/1999	14:00:00	112.09	7/28/2002	21:00:00	113.37	7/31/1999	21:00:00	114.2
7/25/1999	15:00:00	112.72	7/28/2002	22:00:00	112.17	7/31/1999	22:00:00	113.68
7/25/1999	16:00:00	112.72	7/29/1999	13:00:00	112.89	7/31/1999	23:00:00	112.83
7/25/1999	17:00:00	112.43	7/29/1999	14:00:00	114.24	9/7/1999	14:00:00	120.27
7/25/1999	18:00:00	113.34	7/29/1999	15:00:00	114.04	9/7/1999	15:00:00	120.08
7/25/1999	19:00:00	112.95	7/29/1999	16:00:00	114.14	9/7/1999	16:00:00	122.49
7/25/1999	20:00:00	112.2	7/29/1999	17:00:00	114.56			
7/25/1999	23:00:00	112.8	7/29/1999	18:00:00	114.67			
7/26/1999	12:00:00	113.01	7/29/1999	19:00:00	114.19			
7/26/1999	13:00:00	113.48	7/29/1999	20:00:00	114.21			
7/26/1999	14:00:00	113.75	7/29/1999	21:00:00	113.6			
7/26/1999	15:00:00	113.87	7/29/1999	22:00:00	114			
7/26/1999	16:00:00	112.19	7/29/1999	23:00:00	113.89			
7/26/1999	18:00:00	112.36	7/30/1999	1:00:00	113.24			
7/26/1999	19:00:00	113.4	7/30/1999	2:00:00	113.9			
7/26/1999	20:00:00	114.35	7/30/1999	3:00:00	113.11			
7/26/1999	21:00:00	112.96	7/30/1999	4:00:00	112.34			
7/26/1999	22:00:00	114.17	7/30/1999	12:00:00	112.74			
7/26/1999	23:00:00	113.93	7/30/1999	13:00:00	114.2			
7/27/1999	0:00:00	112.9	7/30/1999	14:00:00	114.3			
7/27/1999	14:00:00	113.62	7/30/1999	15:00:00	114.65			
7/27/1999	15:00:00	113.22	7/30/1999	16:00:00	114.88			
7/27/1999	16:00:00	113.81	7/30/1999	17:00:00	115.05			
7/27/1999	17:00:00	113.31	7/30/1999	18:00:00	115.39			
7/27/1999	18:00:00	113.68	7/30/1999	19:00:00	114.06			
7/27/1999	19:00:00	113.43	7/30/1999	20:00:00	113.44			
7/27/1999	20:00:00	113.81	7/30/1999	21:00:00	113.52			
7/27/1999	21:00:00	114	7/30/1999	22:00:00	112.95			
7/27/1999	22:00:00	113.29	7/30/1999	23:00:00	113.64			
7/27/1999	23:00:00	112.91	7/31/1999	1:00:00	112.54			
7/28/1999	15:00:00	112.41	7/31/1999	2:00:00	112.31			

Total Hours 83

Table 5. Percent habitat among segments at various temperatures and oxygen ranges in Coffeen Lake during May-September 2006. Profiles were taken from 10:00 a.m. to 7:00 p.m.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
05/04/06	87	92	72	100	100	86	63	100	100	69	63	96	100	58	59	96	96
05/04/06	90	92	72	100	100	86	63	100	100	69	63	96	100	58	59	96	96
05/04/06	93	92	72	100	100	86	63	100	100	69	63	96	100	58	59	96	96
05/04/06	96	92	72	100	100	86	63	100	100	69	63	96	100	58	59	96	96
05/11/06	87	76	76	97	96	71	66	83	88	66	61	83	81	66	55	77	81
05/11/06	90	76	76	97	96	71	66	83	88	66	61	83	81	66	55	77	81
05/11/06	93	76	76	97	96	71	66	83	88	66	61	83	81	66	55	77	81
05/11/06	96	76	76	97	96	71	66	83	88	66	61	83	81	66	55	77	81
05/18/06	87	82	84	100	100	66	84	100	100	45	84	100	100	45	84	100	100
05/18/06	90	82	84	100	100	66	84	100	100	45	84	100	100	45	84	100	100
05/18/06	93	82	84	100	100	66	84	100	100	45	84	100	100	45	84	100	100
05/18/06	96	82	84	100	100	66	84	100	100	45	84	100	100	45	84	100	100
05/25/06	87	47	83	100	100	42	74	100	100	37	64	96	100	32	60	96	100
05/25/06	90	53	83	100	100	47	74	100	100	42	64	96	100	37	60	96	100
05/25/06	93	63	83	100	100	58	74	100	100	53	64	96	100	47	60	96	100
05/25/06	96	76	83	100	100	71	74	100	100	66	64	96	100	61	60	96	100
06/01/06	87	56	64	96	93	56	55	96	93	56	50	88	86	56	45	81	86
06/01/06	90	69	64	96	93	69	55	96	93	69	50	88	86	69	45	81	86
06/01/06	93	88	64	96	93	88	55	96	93	88	50	88	86	88	45	81	86
06/01/06	96	100	64	96	93	100	55	96	93	100	50	88	86	100	45	81	86

Table 5. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
06/09/06	87	33	32	68	46	22	32	64	36	17	32	57	29	11	23	36	21
06/09/06	90	39	41	100	100	28	41	96	89	22	41	89	82	17	32	68	75
06/09/06	93	39	66	100	100	28	66	96	89	22	66	89	82	17	57	68	75
06/09/06	96	39	66	100	100	28	66	96	89	22	66	89	82	17	57	68	75
06/15/06	87	32	40	12	29	16	25	12	29	11	15	12	21	11	10	12	7
06/15/06	90	42	50	19	57	26	35	19	57	21	25	19	50	21	20	19	36
06/15/06	93	42	55	100	96	26	40	100	96	21	30	100	89	21	25	100	75
06/15/06	96	42	78	100	96	26	63	100	96	21	53	100	89	21	48	100	75
06/22/06	87	0	10	12	4	0	0	8	4	0	0	0	0	0	0	0	0
06/22/06	90	17	25	42	38	11	10	38	38	6	5	8	17	0	5	0	0
06/22/06	93	33	40	50	54	28	25	46	54	22	20	15	33	17	20	8	17
06/22/06	96	39	50	100	100	33	35	96	100	28	30	65	79	22	30	58	63
06/29/06	87	0	29	4	0	0	14	4	0	0	14	4	0	0	5	4	0
06/29/06	90	17	57	65	73	0	43	65	73	0	43	65	73	0	33	65	73
06/29/06	93	33	76	100	100	17	62	100	100	11	62	100	100	11	52	100	100
06/29/06	96	39	88	100	100	22	74	100	100	17	74	100	100	17	64	100	100
07/06/06	87	0	5	18	4	0	0	18	4	0	0	14	4	0	0	14	4
07/06/06	90	18	27	79	100	6	23	79	100	0	18	75	100	0	14	75	100
07/06/06	93	29	45	100	100	18	41	100	100	12	36	96	100	0	32	96	100
07/06/06	96	29	57	100	100	18	52	100	100	12	48	96	100	0	43	96	100

Table 5. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
07/13/06	87	0	15	4	0	0	15	4	0	0	0	4	0	0	0	0	0
07/13/06	90	22	50	35	65	17	50	35	65	6	35	35	65	0	30	31	65
07/13/06	93	28	55	100	88	22	55	100	88	11	40	100	88	6	35	96	88
07/13/06	96	28	60	100	100	22	60	100	100	11	45	100	100	6	40	96	100
07/19/06	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07/19/06	90	0	5	4	4	0	0	4	4	0	0	4	0	0	0	4	0
07/19/06	93	28	24	12	27	22	19	12	27	22	14	12	23	17	14	12	23
07/19/06	96	39	38	100	73	33	33	100	73	33	29	100	69	28	29	100	69
07/27/06	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07/27/06	90	6	20	19	38	0	20	19	38	0	20	19	38	0	5	19	38
07/27/06	93	28	45	100	100	22	45	100	100	17	45	100	100	6	30	100	100
07/27/06	96	33	68	100	100	28	68	100	100	22	68	100	100	11	53	100	100
08/03/06	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08/03/06	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08/03/06	93	6	15	33	21	0	5	25	21	0	0	8	21	0	0	8	17
08/03/06	96	29	63	96	100	18	53	88	100	18	48	71	100	12	43	71	96
08/10/06	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08/10/06	90	0	5	4	0	0	5	4	0	0	0	4	0	0	0	4	0
08/10/06	93	28	45	100	100	0	45	100	100	0	40	100	100	0	30	100	100
08/10/06	96	28	73	100	100	0	73	100	100	0	68	100	100	0	58	100	100

Table 5. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
08/18/06	87	0	10	4	0	0	10	4	0	0	0	4	0	0	0	4	0
08/18/06	90	28	60	100	100	28	60	100	100	11	50	100	100	0	45	100	100
08/18/06	93	33	83	100	100	33	83	100	100	17	73	100	100	0	68	100	100
08/18/06	96	33	83	100	100	33	83	100	100	17	73	100	100	0	68	100	100
08/24/06	87	0	0	4	4	0	0	4	0	0	0	4	0	0	0	4	0
08/24/06	90	24	26	8	46	24	26	8	42	24	16	8	42	24	5	8	42
08/24/06	93	29	37	100	100	24	37	100	96	24	26	100	96	24	16	100	96
08/24/06	96	35	66	100	100	29	66	100	96	29	55	100	96	29	45	100	96
08/30/06	87	0	15	13	13	0	15	13	13	0	15	13	13	0	10	13	13
08/30/06	90	13	45	100	100	6	45	100	100	0	45	100	100	0	30	100	100
08/30/06	93	25	55	100	100	19	55	100	100	13	55	100	100	6	40	100	100
08/30/06	96	25	78	100	100	19	78	100	100	13	78	100	100	6	63	100	100
09/06/06	87	12	55	46	58	6	50	46	58	0	45	46	58	0	40	46	58
09/06/06	90	29	60	79	83	24	55	79	83	18	50	79	83	18	45	79	83
09/06/06	93	29	70	100	96	24	65	100	96	18	60	100	96	18	55	100	96
09/06/06	96	29	83	100	96	24	78	100	96	18	73	100	96	18	68	100	96
09/12/06	87	0	5	21	13	0	5	21	13	0	0	21	13	0	0	21	13
09/12/06	90	24	42	100	75	24	42	100	75	18	37	100	75	12	37	100	75
09/12/06	93	29	71	100	100	29	71	100	100	24	66	100	100	18	66	100	100
09/12/06	96	35	71	100	100	35	71	100	100	29	66	100	100	24	66	100	100

Table 5. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
09/19/06	87	25	68	100	100	13	68	100	100	6	63	100	100	0	63	100	100
09/19/06	90	31	68	100	100	19	68	100	100	13	63	100	100	0	63	100	100
09/19/06	93	31	68	100	100	19	68	100	100	13	63	100	100	0	63	100	100
09/19/06	96	44	68	100	100	31	68	100	100	25	63	100	100	13	63	100	100
09/28/06	87	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
09/28/06	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
09/28/06	93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
09/28/06	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 6. Percent habitat among segments at various temperatures and oxygen ranges in Newton Lake during May-September 2006. Profiles were taken from 10:00 a.m. to 6:30 p.m.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
05/04/06	87	100	97	100	100	94	90	97	100	69	83	85	100	56	70	79	100
05/04/06	90	100	97	100	100	94	90	97	100	69	83	85	100	56	70	79	100
05/04/06	93	100	97	100	100	94	90	97	100	69	83	85	100	56	70	79	100
05/04/06	96	100	97	100	100	94	90	97	100	69	83	85	100	56	70	79	100
05/11/06	87	100	97	97	95	100	97	97	95	100	77	91	86	100	70	84	86
05/11/06	90	100	97	97	95	100	97	97	95	100	77	91	86	100	70	84	86
05/11/06	93	100	97	97	95	100	97	97	95	100	77	91	86	100	70	84	86
05/11/06	96	100	97	97	95	100	97	97	95	100	77	91	86	100	70	84	86
05/17/06	87	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
05/17/06	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
05/17/06	93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
05/17/06	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
05/25/06	87	100	90	97	100	100	70	85	100	100	63	85	100	94	57	79	100
05/25/06	90	100	90	97	100	100	70	85	100	100	63	85	100	94	57	79	100
05/25/06	93	100	90	97	100	100	70	85	100	100	63	85	100	94	57	79	100
05/25/06	96	100	90	97	100	100	70	85	100	100	63	85	100	94	57	79	100
06/01/06	87	88	47	62	100	88	35	56	94	81	35	44	83	81	24	44	72
06/01/06	90	100	62	62	100	100	50	56	94	94	50	44	83	94	38	44	72
06/01/06	93	100	62	62	100	100	50	56	94	94	50	44	83	94	38	44	72
06/01/06	96	100	62	62	100	100	50	56	94	94	50	44	83	94	38	44	72

Table 6. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
06/09/06	87	44	33	74	100	25	20	56	95	13	13	50	85	13	13	50	75
06/09/06	90	69	63	74	100	50	50	56	95	38	43	50	85	38	43	50	75
06/09/06	93	69	63	74	100	50	50	56	95	38	43	50	85	38	43	50	75
06/09/06	96	100	63	74	100	81	50	56	95	69	43	50	85	69	43	50	75
06/15/06	87	31	67	100	100	25	33	62	100	25	27	62	100	25	27	56	100
06/15/06	90	44	97	100	100	38	63	62	100	38	57	62	100	38	57	56	100
06/15/06	93	81	97	100	100	75	63	62	100	75	57	62	100	75	57	56	100
06/15/06	96	100	97	100	100	94	63	62	100	94	57	62	100	94	57	56	100
06/22/06	87	19	53	47	0	13	27	18	0	0	13	18	0	0	0	6	0
06/22/06	90	19	53	65	100	13	27	35	100	0	13	35	100	0	0	24	100
06/22/06	93	31	60	85	100	25	33	56	100	13	20	56	100	0	7	44	100
06/22/06	96	31	60	85	100	25	33	56	100	13	20	56	100	0	7	44	100
06/29/06	87	19	50	50	50	13	20	24	50	0	0	6	50	0	0	6	44
06/29/06	90	31	63	74	100	25	33	47	100	13	13	29	100	0	13	29	94
06/29/06	93	44	70	100	100	38	40	74	100	25	20	56	100	13	20	56	94
06/29/06	96	44	77	100	100	38	47	74	100	25	27	56	100	13	27	56	94
07/06/06	87	0	13	68	100	0	7	68	100	0	7	68	100	0	0	68	100
07/06/06	90	31	33	68	100	25	27	68	100	25	27	68	100	13	20	68	100
07/06/06	93	44	70	68	100	38	63	68	100	38	63	68	100	25	57	68	100
07/06/06	96	69	70	68	100	63	63	68	100	63	63	68	100	50	57	68	100

Table 6. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
07/13/06	87	0	19	47	72	0	13	41	72	0	0	41	72	0	0	35	67
07/13/06	90	19	31	53	83	19	25	47	83	19	13	47	83	13	6	41	78
07/13/06	93	44	38	65	100	44	31	59	100	44	19	59	100	38	13	53	94
07/13/06	96	69	44	74	100	69	38	68	100	69	25	68	100	63	19	62	94
07/19/06	87	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
07/19/06	90	7	13	18	11	0	13	12	11	0	6	12	11	0	6	6	11
07/19/06	93	21	19	29	44	14	19	24	44	14	13	24	44	0	13	18	44
07/19/06	96	21	25	41	72	14	25	35	72	14	19	35	72	0	19	29	72
07/27/06	87	0	0	6	100	0	0	6	100	0	0	6	100	0	0	6	100
07/27/06	90	0	0	79	100	0	0	79	100	0	0	79	100	0	0	79	100
07/27/06	93	0	13	79	100	0	13	79	100	0	13	79	100	0	13	79	100
07/27/06	96	6	53	79	100	6	53	79	100	6	53	79	100	6	53	79	100
08/03/06	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08/03/06	90	0	0	6	65	0	0	6	65	0	0	6	65	0	0	0	65
08/03/06	93	0	6	56	100	0	0	56	100	0	0	56	100	0	0	50	100
08/03/06	96	13	13	56	100	13	6	56	100	0	6	56	100	0	0	50	100
08/11/06	87	0	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0
08/11/06	90	0	7	68	100	0	0	68	100	0	0	62	95	0	0	62	65
08/11/06	93	13	47	68	100	13	40	68	100	13	40	62	95	0	33	62	65
08/11/06	96	50	63	68	100	50	57	68	100	50	57	62	95	38	50	62	65

Table 6. Continued

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
08/19/06	87	0	0	18	17	0	0	6	17	0	0	0	17	0	0	0	11
08/19/06	90	0	0	47	39	0	0	35	39	0	0	29	39	0	0	18	33
08/19/06	93	13	7	74	100	13	0	62	100	0	0	56	100	0	0	44	94
08/19/06	96	13	27	74	100	13	20	62	100	0	20	56	100	0	20	44	94
08/24/06	87	0	0	12	20	0	0	12	20	0	0	6	15	0	0	0	5
08/24/06	90	0	0	35	70	0	0	35	70	0	0	29	65	0	0	24	55
08/24/06	93	13	7	68	100	0	7	68	100	0	7	62	95	0	0	56	85
08/24/06	96	25	43	68	100	13	43	68	100	13	43	62	95	0	37	56	85
08/30/06	87	0	0	32	100	0	0	32	100	0	0	32	100	0	0	21	100
08/30/06	90	0	13	74	100	0	7	74	100	0	7	74	100	0	0	62	100
08/30/06	93	13	50	74	100	13	43	74	100	0	43	74	100	0	37	62	100
08/30/06	96	81	50	74	100	81	43	74	100	69	43	74	100	69	37	62	100
09/06/06	87	0	40	85	100	0	27	79	100	0	20	79	95	0	7	74	95
09/06/06	90	25	53	85	100	25	40	79	100	13	33	79	95	13	20	74	95
09/06/06	93	69	70	85	100	69	57	79	100	56	50	79	95	56	37	74	95
09/06/06	96	69	70	85	100	69	57	79	100	56	50	79	95	56	37	74	95
09/12/06	87	13	7	68	100	0	7	68	100	0	0	68	100	0	0	62	100
09/12/06	90	25	27	68	100	13	27	68	100	0	20	68	100	0	20	62	100
09/12/06	93	25	43	68	100	13	43	68	100	0	37	68	100	0	37	62	100
09/12/06	96	94	50	68	100	81	50	68	100	69	43	68	100	69	43	62	100

Table 6. Continued.

		Dissolved Oxygen															
		1 ppm				2 ppm				3 ppm				4 ppm			
	Temperature	Segment				Segment				Segment				Segment			
Date	(°F)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
09/20/06	87	14	68	100	100	14	54	100	100	14	39	100	100	14	39	94	100
09/20/06	90	57	68	100	100	57	54	100	100	57	39	100	100	57	39	94	100
09/20/06	93	79	68	100	100	79	54	100	100	79	39	100	100	79	39	94	100
09/20/06	96	79	68	100	100	79	54	100	100	79	39	100	100	79	39	94	100
09/28/06	87	100	89	100	100	79	82	100	100	79	75	100	100	79	61	100	100
09/28/06	90	100	89	100	100	79	82	100	100	79	75	100	100	79	61	100	100
09/28/06	93	100	89	100	100	79	82	100	100	79	75	100	100	79	61	100	100
09/28/06	96	100	89	100	100	79	82	100	100	79	75	100	100	79	61	100	100

Table 7. Comparison of the three days in Coffeen Lake during 1998 through 2006 that had the worst habitat conditions. Comparisons are made at 3 ppm dissolved for 4 temperatures. Percent habitats were averaged for Segments 1and 2. Percentages for Segments 3 and 4 are given in parentheses when the segments were sampled from 2000 through 2006.

Temperature	1998			1999			2000		
(°F)	3-Jul	24-Jul	28-Aug	23-Jul	6-Aug	19-Aug	18-Jul	15-Aug	4-Sep
87	0	0	0	0	0	0	0 (0)	3 (9)	0 (0)
90	2	0	5	0	0	33	5 (15)	39 (78)	3 (4)
93	14	16	24	10	21	42	30 (100)	44 (99)	24 (83)
96	34	41	36	27	25	47	42 (100)	50 (99)	43 (83)
	2001			2002[a]			2003		
	10-Jul	24-Jul	8-Aug	6-Jul	8-Jul	1-Aug	8-Jul	20-Aug	27-Aug
87	0 (14)	0 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (4)
90	17 (21)	2 (20)	0 (0)	0 (0)	0 (0)	3 (13)	0 (4)	0 (11)	3 (15)
93	29 (59)	18 (44)	0 (7)	3 (10)	0 (24)	24 (52)	12 (54)	7 (84)	21 (54)
96	33 (62)	25 (90)	21 (40)	42 (83)	17 (80)	31 (82)	25 (88)	30 (96)	29 (96)

Table 7. Continued.

Temperature (°F)	2004 16-Jun	2004 30-Jun	2004 7-Jul	2005 28-Jun	2005 27-Jul	2005 2-Aug	2006 22-Jun	2006 19-Jul	2006 3-Aug
87	0 (4)	2 (11)	0 (24)	0 (0)	0 (0)	0 (0)	0 (0.0)	0 (0)	0 (0)
90	9 (69)	10 (38)	33 (85)	0 (2)	0 (0)	0 (2)	6 (13)	0 (2)	0 (0)
93	27 (87)	14 (77)	35 (85)	3 (2)	0 (27)	0 (5)	21 (24)	18 (18)	0 (15)
96	31 (87)	21 (87)	42 (85)	10 (16)	13 (27)	6 (22)	29 (72)	31 (85)	33 (86)

[a]/ In 2002, due to the timing of funding, temperature, oxygen and depth profiles were not formally started until August. However, profiles were taken on July 6 and July 8, 2002.

Table 8. Comparison of the three days in Newton Lake during 1998 through 2006 that had the worst habitat conditions. Comparisons are made at 3 ppm dissolved for 4 temperatures. Percent habitats were averaged in all four segments.

Temperature	1998			1999			2000		
(°F)	26-Jun	11-Jul	24-Aug	24-Jul	5-Aug	18-Aug	13-Jul	28-Jul	1-Sep
87	0	0	0	0	1	31	2	31	4
90	18	22	29	0	21	41	15	41	21
93	29	29	40	7	44	42	30	46	35
96	33	29	43	32	48	52	40	57	44

Temperature	2001			2002[a]			2003		
(°F)	18-Jun	25-Jul	7-Aug	2-Aug	21-Aug	29-Aug	2-Jul	9-Jul	28-Aug
87	3	0	0	0	34	47	15	0	2
90	37	2	9	9	53	57	26	31	28
93	44	24	26	27	72	69	39	41	40
96	56	32	39	34	79	85	50	53	45

Table 8. Continued.

Temperature (°F)	2004			2005			2006		
	15-Jun	13-Jul	3-Aug	28-Jun	26-Jul	2-Aug	19-Jul	3-Aug	19-Aug
87	11	0	9	0	0	0	0	0	4
90	34	7	22	2	0	5	7	18	17
93	34	26	32	10	14	10	24	39	39
96	42	30	39	12	14	15	35	41	44

[a]/ In 2002, due to the timing of funding, temperature, oxygen and depth profiles were not formally started until August.

Table 9. Numbers of dead and morbid fishes observed by SIU personnel in Coffeen Lake in 1999.

Date	Largemouth bass	*Lepomis*	Channel catfish	*Morone*	Crappie	Carp	Shad
4/9/1999	0	0	2	0	0	1	0
6/2/1999	0	0	0	0	0	0	0
6/3/1999	0	0	0	0	0	0	0
6/8/1999	0	0	0	0	0	0	0
6/15/1999	0	0	0	0	0	0	0
6/16/1999	0	0	0	0	0	0	0
6/29/1999	0	0	0	0	0	0	0
6/29/1999	0	0	0	0	0	0	0
6/30/1999	0	0	0	0	0	0	0
7/8/1999	1	0	0	0	0	0	0
7/9/1999	0	0	0	0	0	0	0
7/13/1999	0	0	0	0	0	0	0
7/16/1999	0	0	0	0	0	0	0
7/21/1999	0	0	0	1	1	0	0
7/23/1999	0	0	0	0	0	0	0
7/27/1999	15	31	0	0	0	0	5
7/28/1999	105	0	5	11	0	0	7
8/1/1999	0	0	0	0	0	0	0
8/2/1999	0	0	0	0	0	0	0
8/6/1999	0	0	0	0	0	0	0
8/10/1999	0	0	1	0	1	0	0
8/11/1999	0	0	0	0	0	0	0
8/19/1999	0	0	0	0	0	0	0
8/20/1999	0	0	0	0	0	0	0
8/24/1999	0	0	0	0	0	0	0
8/25/1999	0	0	0	0	0	0	0
8/26/1999	0	0	0	0	0	0	0
8/27/1999	0	0	0	0	0	0	0
Total	121	31	8	12	2	1	12

Table 10. Number of dead and morbid fishes observed by SIU personnel in Newton Lake in 1999.

Date	Largemouth bass	*Lepomis*	Channel catfish	*Morone*	Carp	Shad
3/23/1999	1	0	0	0	0	0
5/20/1999	1	0	0	0	0	1
6/1/1999	0	0	0	0	0	0
6/2/1999	0	0	0	0	0	0
6/3/1999	0	0	0	0	0	0
6/4/1999	0	0	0	0	0	0
6/8/1999	0	0	0	0	0	0
6/9/1999	27	0	0	0	0	0
6/14/1999	0	0	0	0	0	0
6/15/1999	0	0	0	0	0	0
6/19/1999	0	0	0	0	0	0
6/22/1999	4	0	0	0	0	0
6/23/1999	0	0	0	0	0	0
6/24/1999	0	0	0	0	0	0
6/29/1999	0	0	0	0	0	0
7/6/1999	0	0	0	0	0	0
7/7/1999	1	0	0	0	0	0
7/8/1999	0	0	0	0	0	0
7/14/1999	0	0	0	0	0	0
7/15/1999	0	0	0	0	0	0
7/16/1999	0	0	0	0	0	0
7/20/1999	1	0	0	1	0	0
7/21/1999	0	0	0	0	0	0
7/23/1999	0	0	0	0	0	0
7/24/1999	0	0	0	0	0	0
7/27/1999	18	1	22	1	1	8
7/29/1999	60	4	36	1	0	15
7/30/1999	5	0	0	0	0	0
7/31/1999	0	0	0	0	0	0
8/5/1999	3	0	9	0	0	2
8/9/1999	3	0	2	0	0	0
8/10/1999	0	0	0	0	0	0
8/11/1999	20	0	0	0	0	35
8/18/1999	24	0	1	2	0	0
8/19/1999	18	0	0	0	0	0
8/24/1999	6	0	0	0	0	0
8/25/1999	9	0	0	0	0	0
8/26/1999	14	0	0	0	0	0
8/27/1999	11	0	0	0	0	0
8/31/1999	1	0	0	0	0	0
Total	227	5	70	5	1	59

Table 11. Number and total length of dead and morbid fish observed by SIU personnel in Coffeen Lake and Newton Lake in 2000 and 2001.

Date	Species[a]	Number	Length (in.)	Status	Location/ Segment
		Coffeen Lake			
7/18/2000	LMB	1	18	Dying	Boat Ramp
	LMB	1	16	Dying	Boat Ramp
	LMB	1	21	Dying	Boat Ramp
	CCF	1	16	Dead	Boat Ramp
7/25/2000	CCF	1	14	Dead	Boat Ramp
7/10/2001	CCF	2 (11)[b]	2	Dead	1
	CCF	15 (85)	3	Dead	1
	CCF	37 (210)	4	Dead	1
	CCF	20 (114)	5	Dead	1
	CCF	14 (80)	6	Dead	1
	CCF	8 (46)	7	Dead	1
	Lepomis spp.	20 (113)	2	Dead	1
	Lepomis spp.	47 (265)	3	Dead	1
	Lepomis spp.	22 (124)	4	Dead	1
	Lepomis spp.	1 (7)	5	Dead	1
	Lepomis spp.	1 (7)	6	Dead	1
	LMB	5 (36)	2	Dead	1
	LMB	4 (29)	3	Dead	1
	LMB	1 (7)	7	Dead	1
7/12/2001	STPB	1	26.5	Dead	3
	WC	1	7	Dead	1
8/2/2001	CCF	1	15	Dead	4
	CCF	1	14.5	Dead	4
	LMB	1	16	Dead	3
	WC	1	9	Dead	1

Table 11. Continued.

Date	Species[a]	Number	Length (in.)	Status	Location/ Segment
		Newton Lake			
7/21/2000	LMB	1	19	Dead	3
	LMB	1	16	Dead	3
8/17/2000	GS	1	8	Dead	
	GS	1	8	Dead	
7/20/2001	BC	1	12	Dead	4
	WHB	1	17	Dying	3
7/25/2001	GZ	1	12.5	Dying	4
	Lepomis spp.	1	7	Dead	2
	WHB	1	13	Dead	4
8/1/2001	WHB	1	15	Dead	4
8/7/2001	LMB	1	20.5	Dead	4
8/14/2001	CCF	1		Dead	3
	GZ	1	12.5	Dead	2
8/22/2001	LMB	1	12	Dead	1
	LMB	1	16.5	Dead	4
	WC	1	11.5	Dead	4
8/28/2001	GZ	175 (10,765)[b]	3	Dead	1

[a]/ LMB = Largemouth bass; CCF = channel catfish; GZ = gizzard shad; WC = white crappic; BC = black crappie; HSB = hybrid striped bass; STPB = striped bass; WHB = white bass

[b]/ The number in parenthesis represents the prorated number of fish killed in each size group based on the extrapolated estimate. See appendix G and H for the extrapolation procedure.

Table12. Number and total length of dead and moribund fish estimated by IDNR personnel in Coffeen Lake from 24 June through 4 July, 2002.

Species	Number	Length (in.)
Largemouth bass	1	8
	2	12
	6	14
	10	15
	8	16
	6	17
	9	18
	42	
Bluegill	2	7
	2	8
	4	
White crappie	2	7
	1	8
	3	
Channel catfish	2	14
	1	16
	3	
Gizzard shad	1	4
	3	6
	3	9
	7	
Threadfin shad	1	2
Striped bass	5	17
	6	18
	8	19
	11	24
	19	25
	15	26
	64	
Total	124	

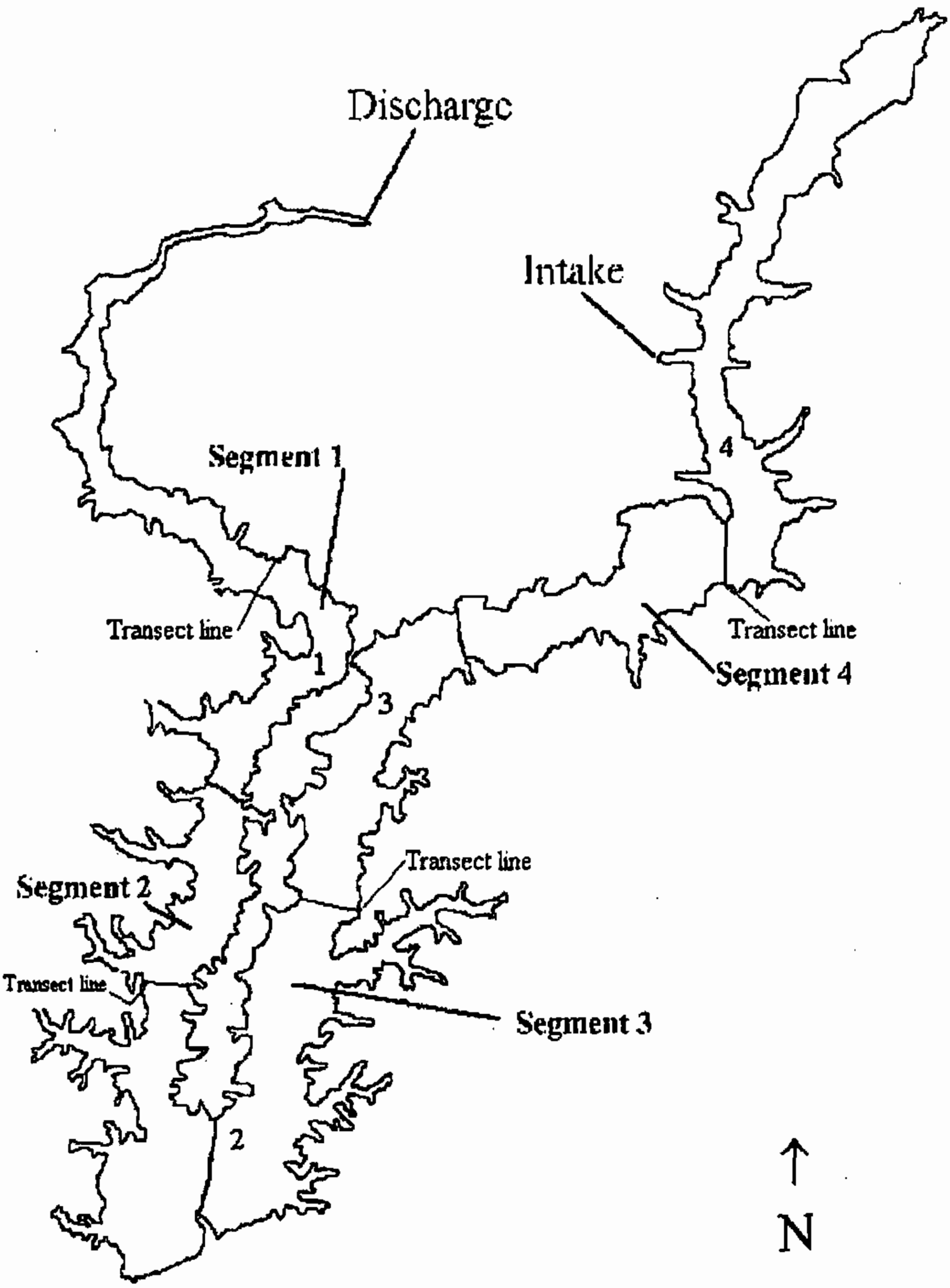


Figure 1. Newton Lake with four segments where sampling was conducted. Water temperature and dissolved oxygen were sampled at each transect line from August 1997 through 2006. Numbers represent locations of continuous temperature recorders.

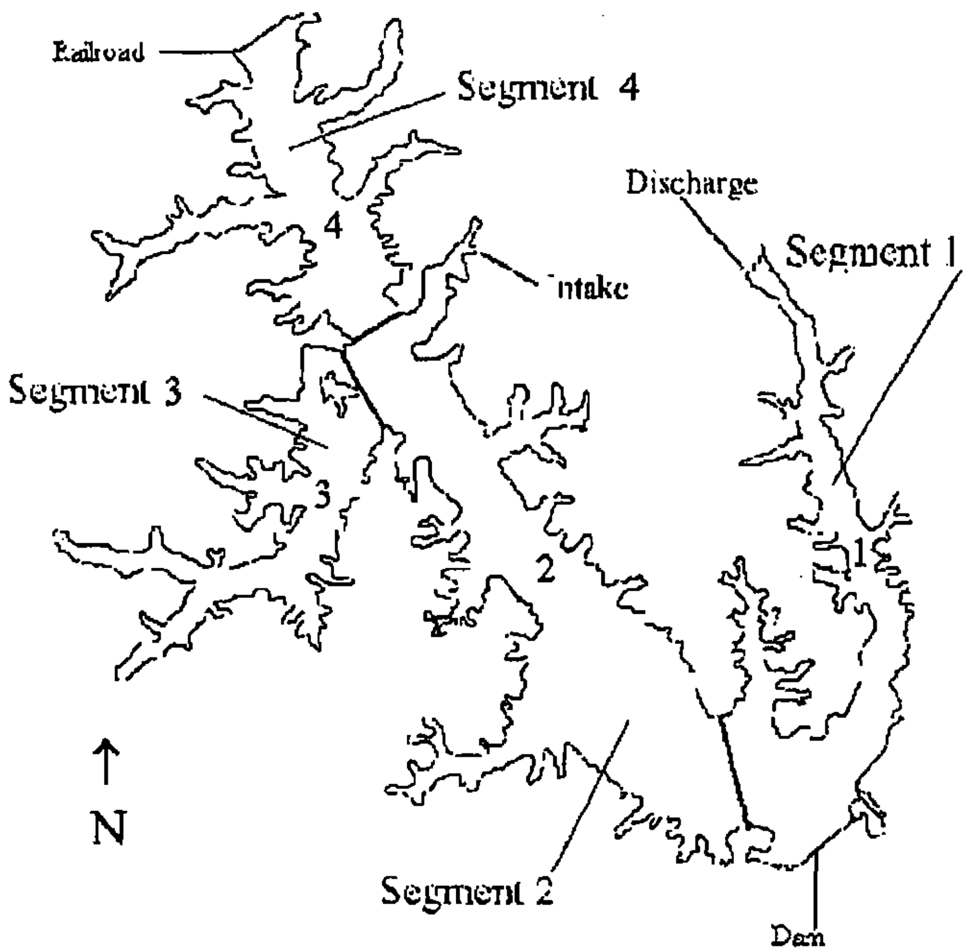


Figure 2. Coffeen Lake with two segments where sampling was conducted for water temperature and dissolved oxygen from August 1997 through 2006. Segments 3 and 4 were added in 2000. Sampling sites are represented by numbers inside lake borders.

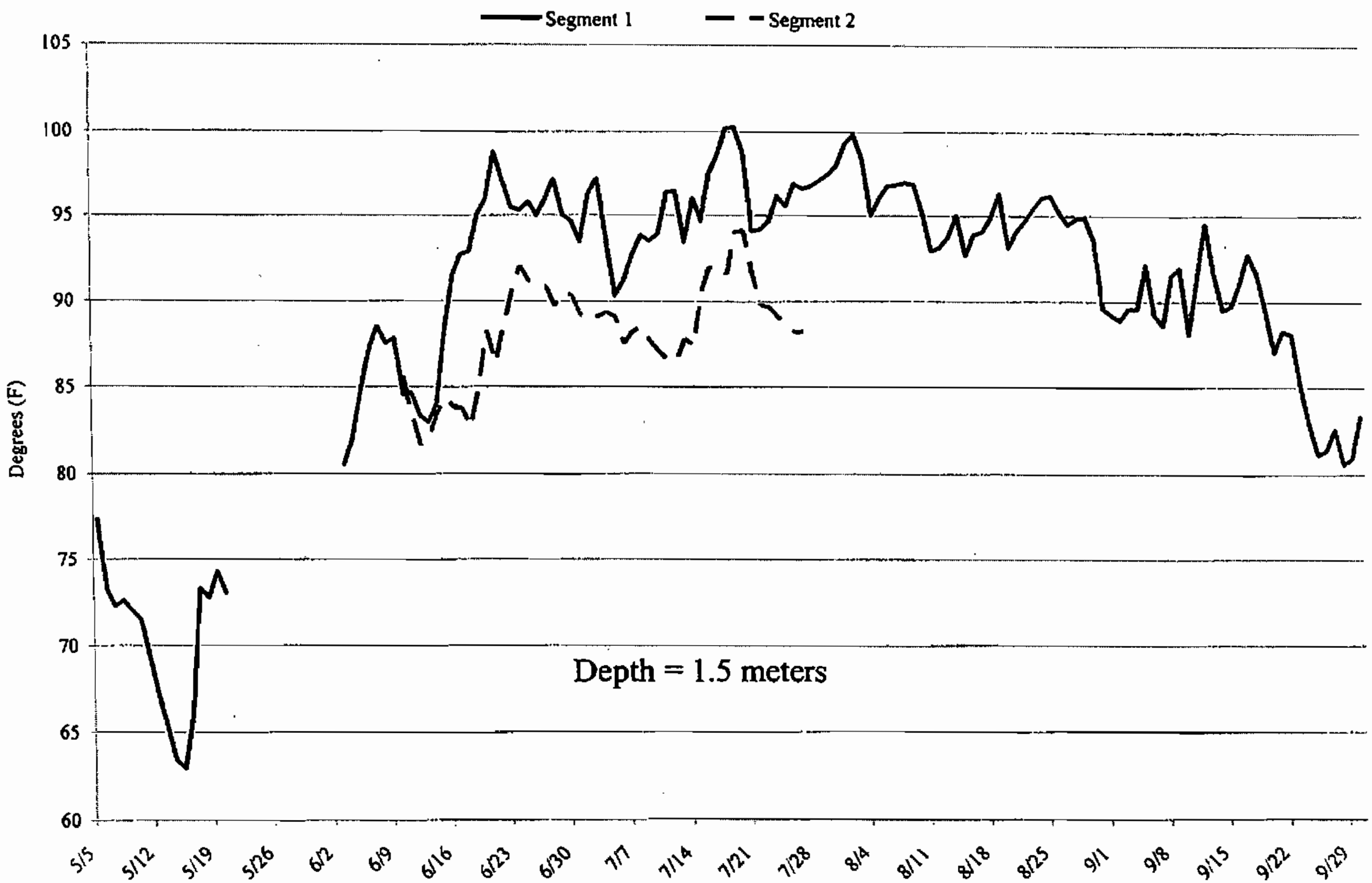


Figure 3. Mean daily temperatures during 2006 at two monitoring stations in Newton Lake at a depth of 1.5 meters. Segment one represents discharge mixng area, and for stations a spaced throughout the lake to Segment 4 which is near the water intake area.

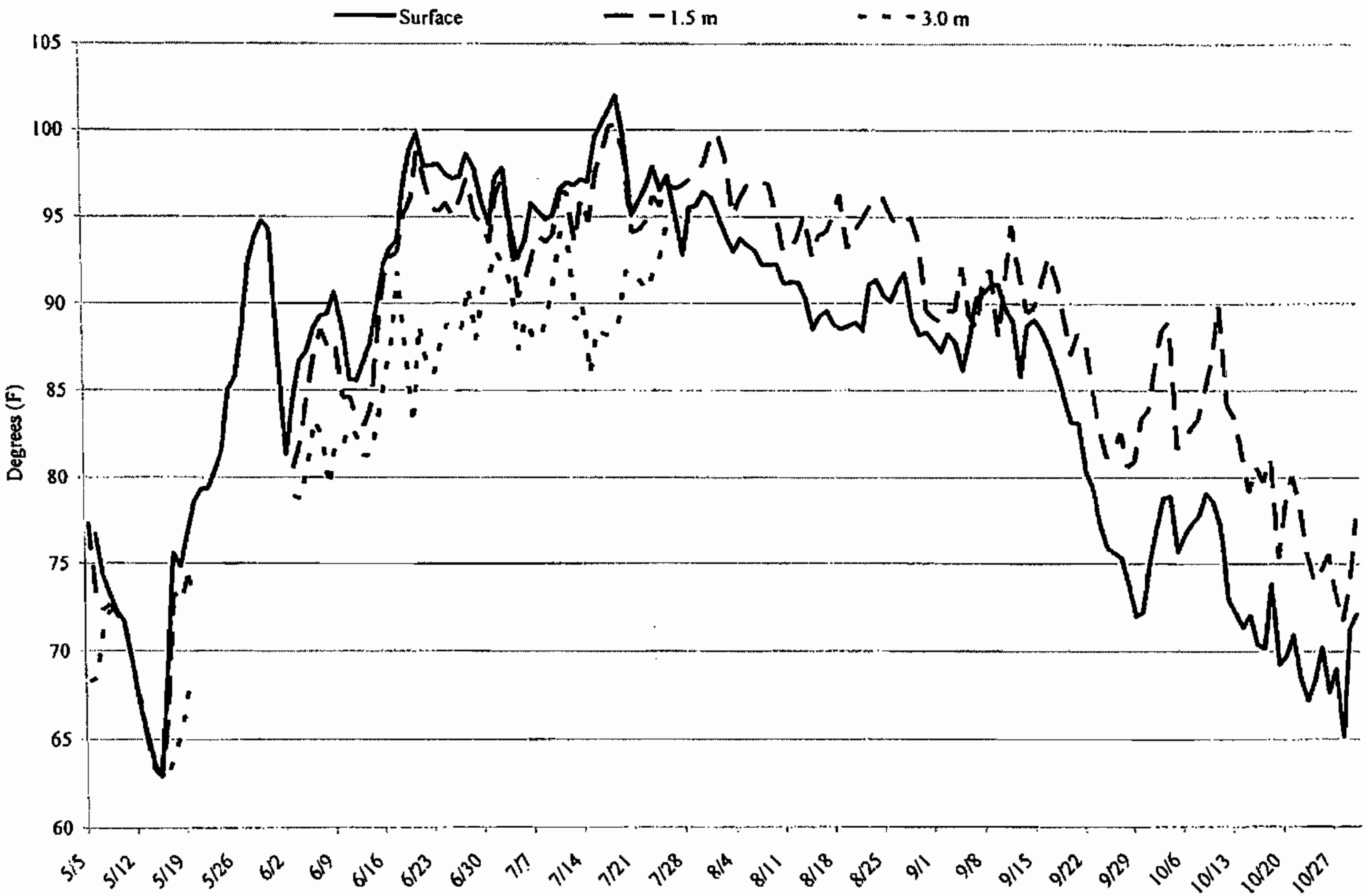


Figure 4. Mean daily temperatures during 2006 in Newton Lake Segment 1. Lake bottom is approximately 16.4 feet.

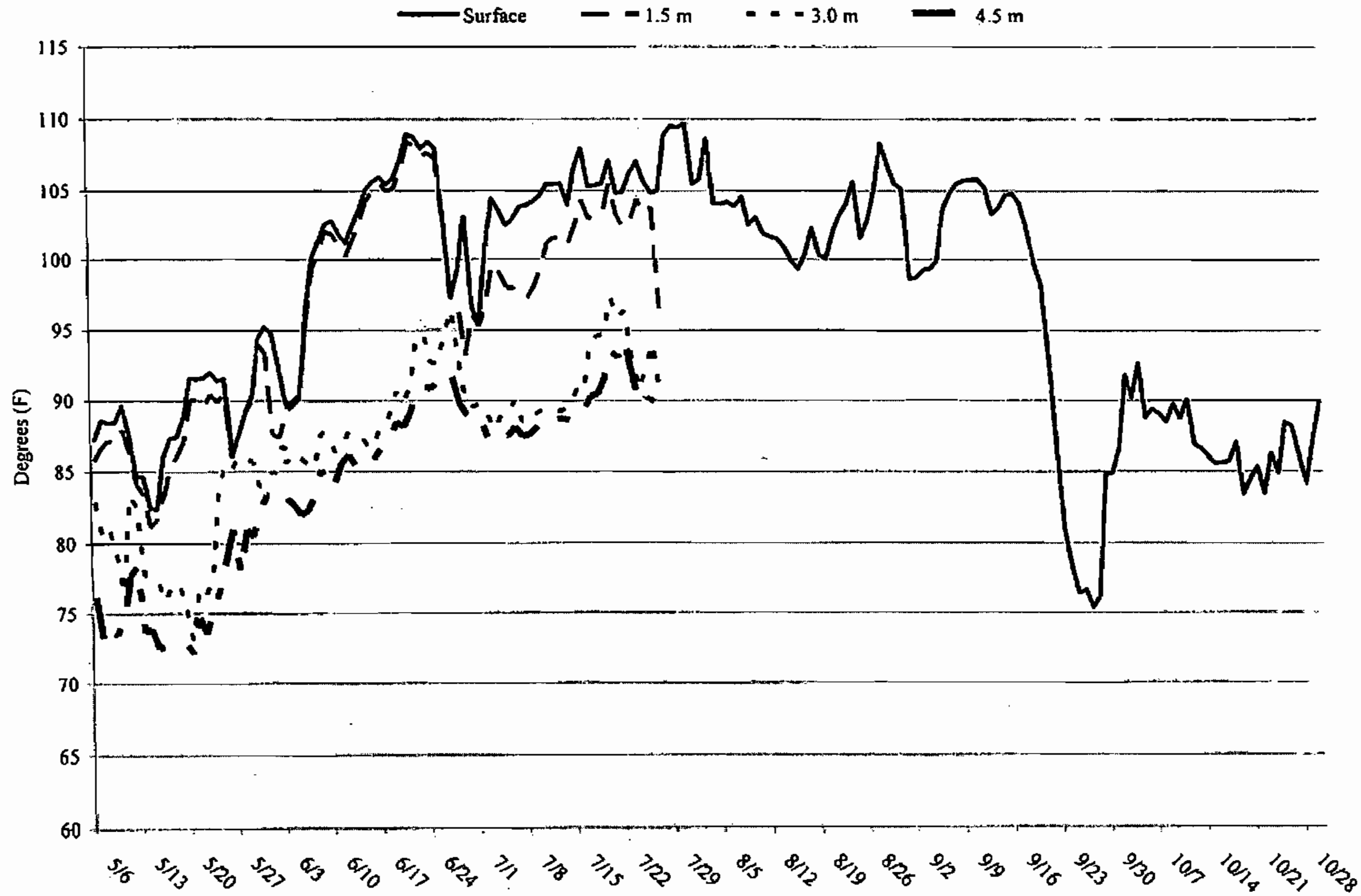


Figure 5. Mean daily temperatures in Segment 1 (mixing zone) during 2006 in Coffeen Lake. Lake bottom is approximately 18.0 feet.

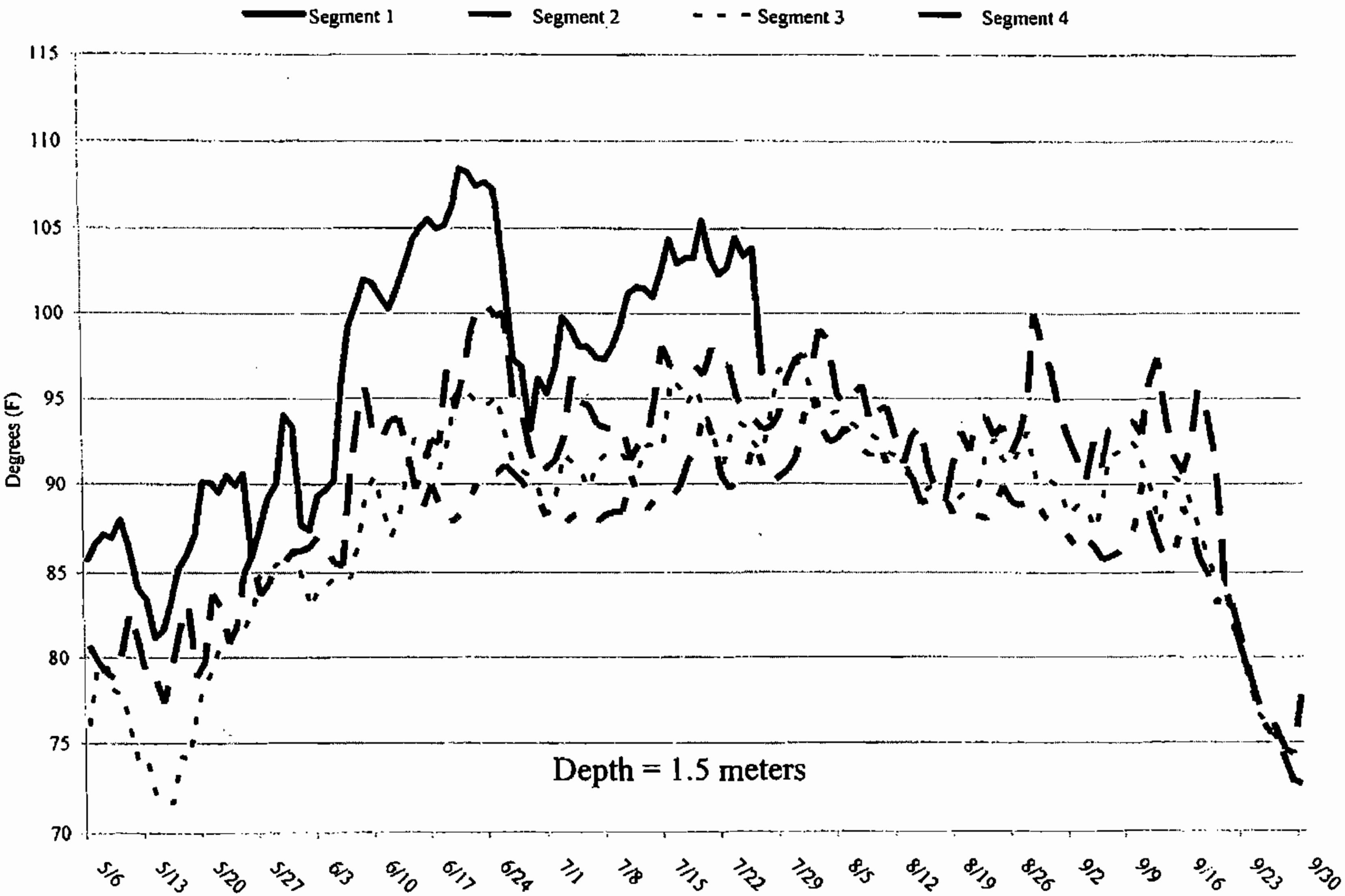


Figure 6. Mean daily temperatures during 2006 at four monitoring stations in Coffeen Lake at a depth of 1.5 meters. Segment one represcnts discharge mixng area, and the stations a spaced throughout the lake to Segment 4 which is near the water intake area.

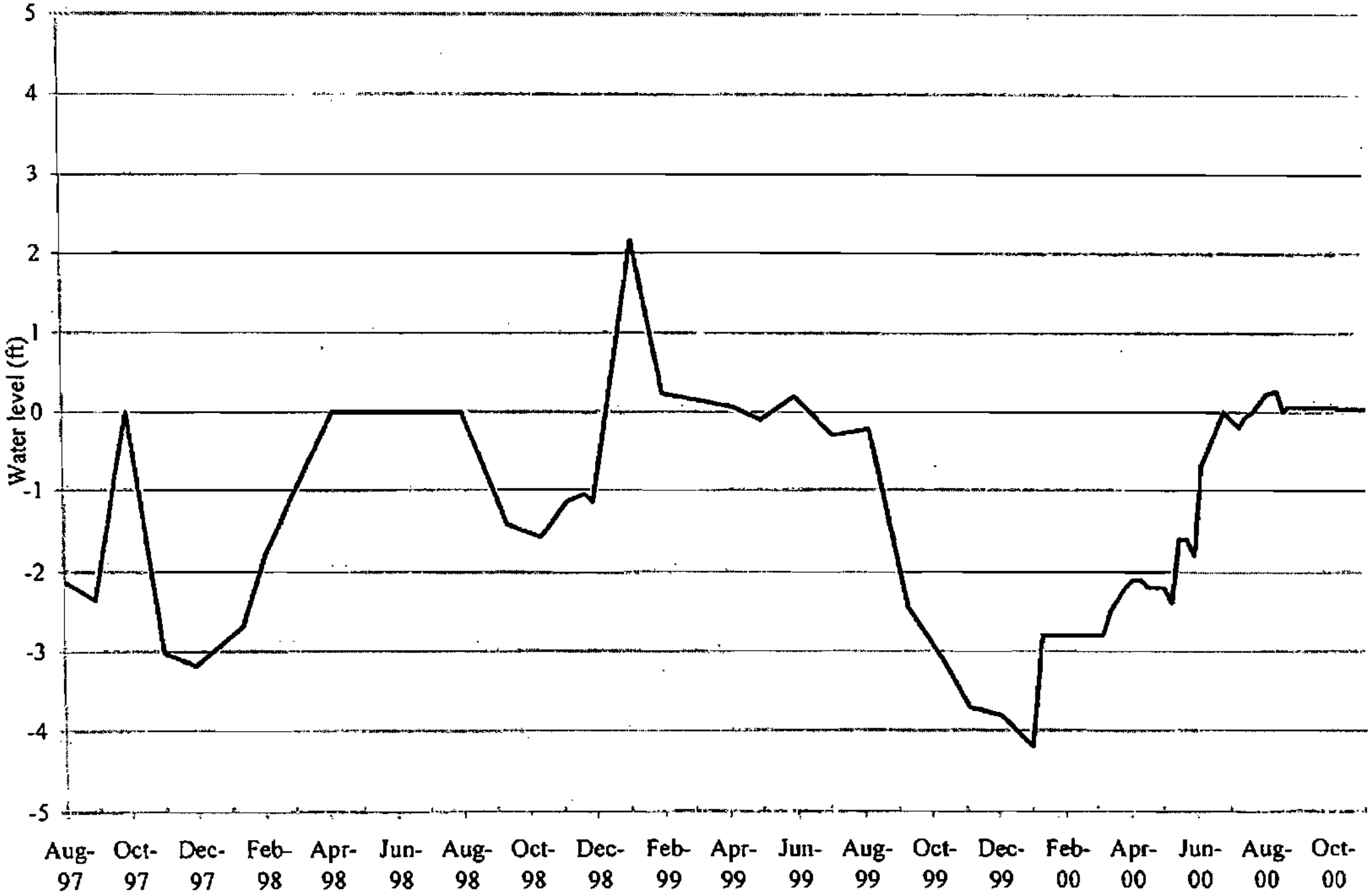


Figure 7. Water levels (feet) in relation to pool level in Newton Lake during 1997-2000.

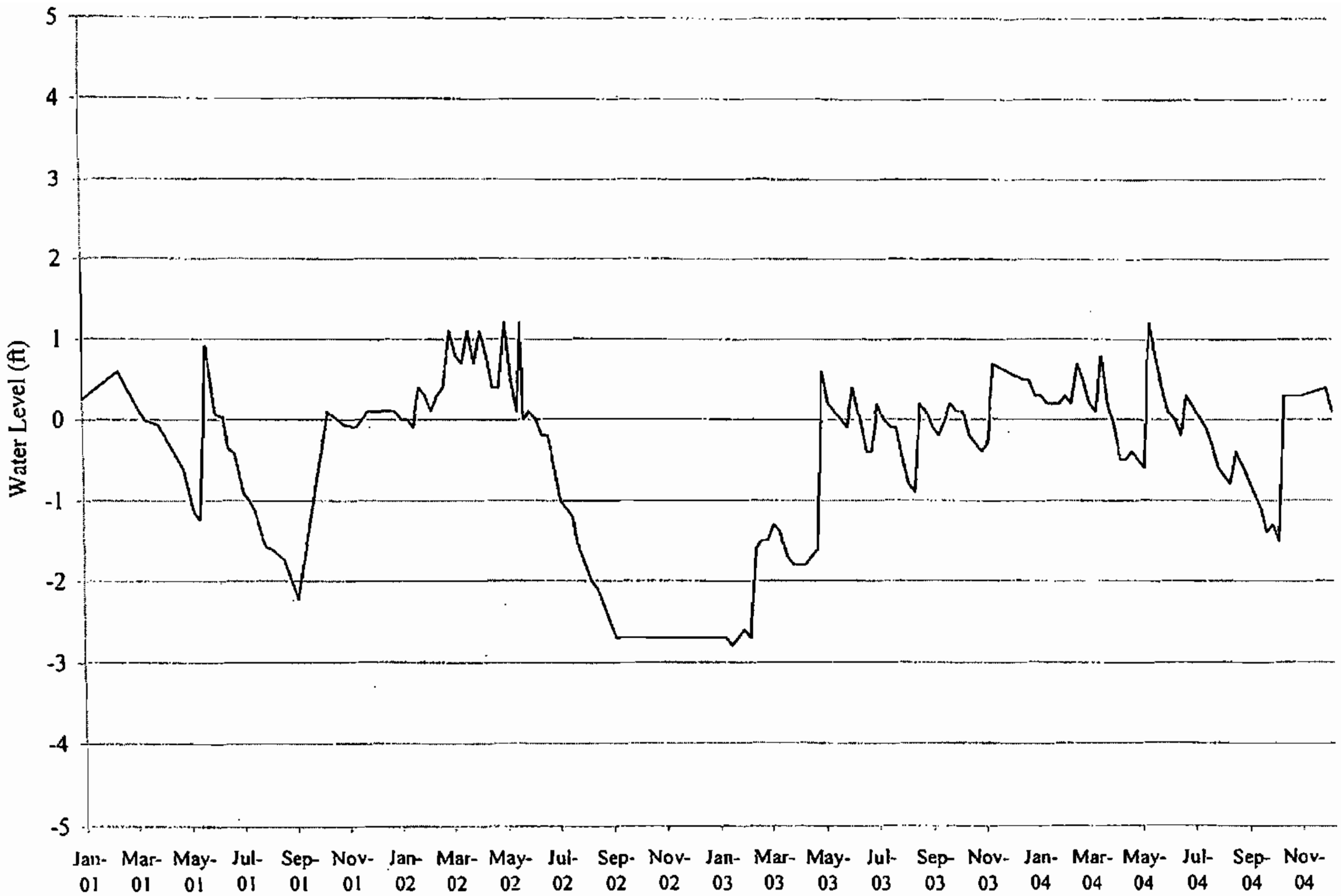


Figure 8. Water levels (feet) in relation to pool level in Newton Lake during 2001-2004.

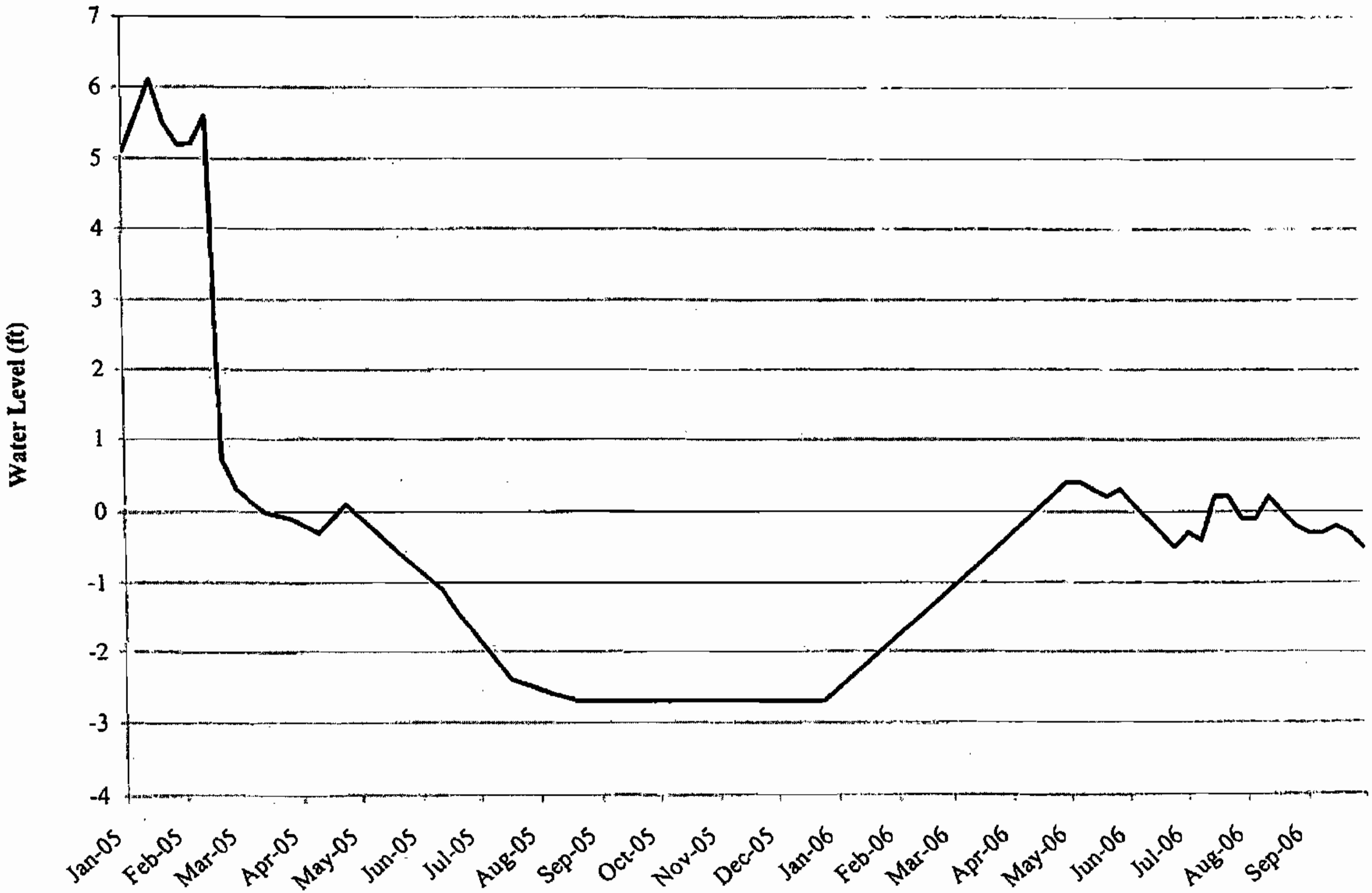


Figure 9. Water levels (feet) in relation to pool level in Newton Lake during 2005 - 2006.

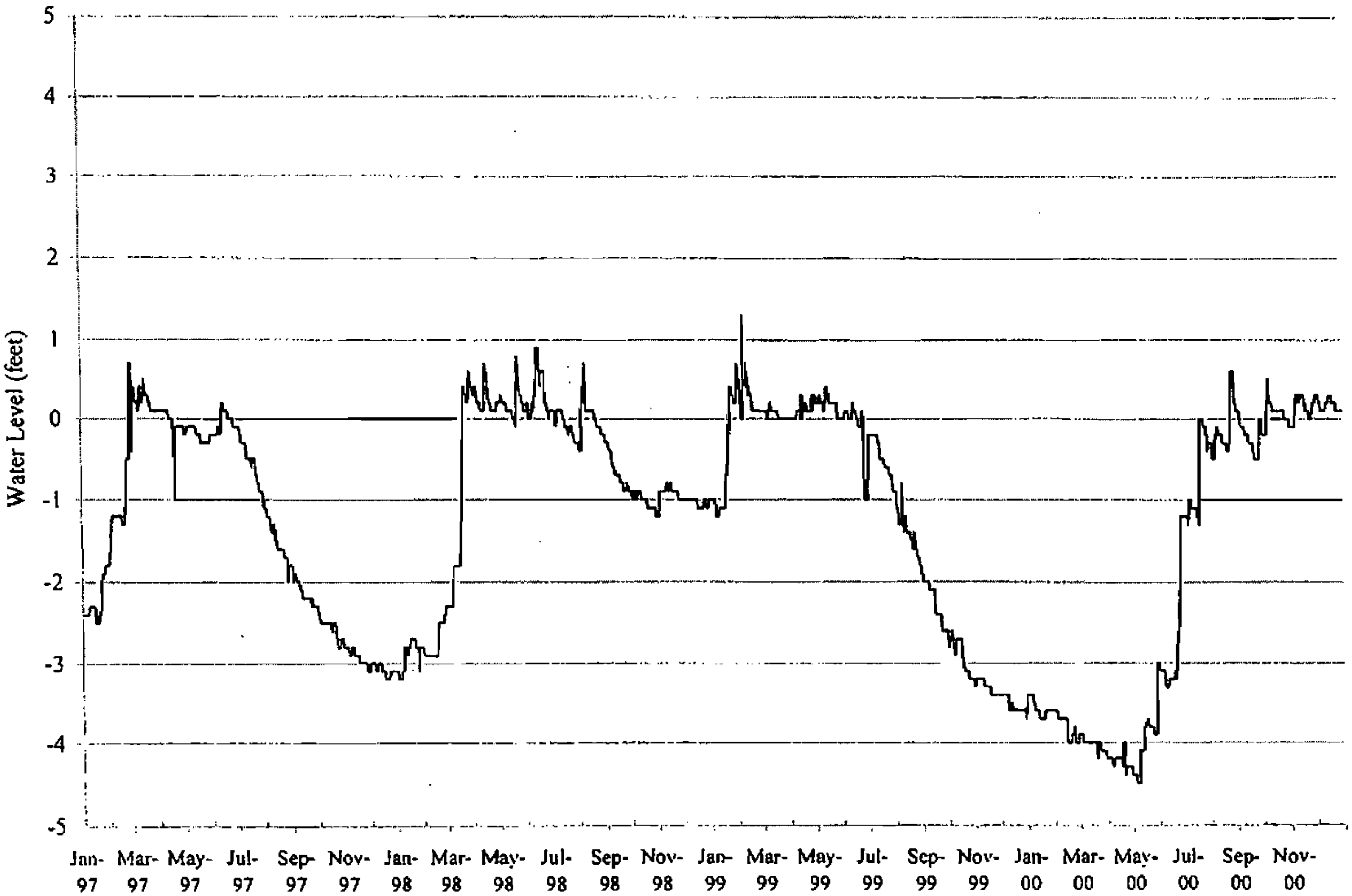


Figure10. Water levels (feet) in relation to pool level in Coffeen Lake during 1997-2000.

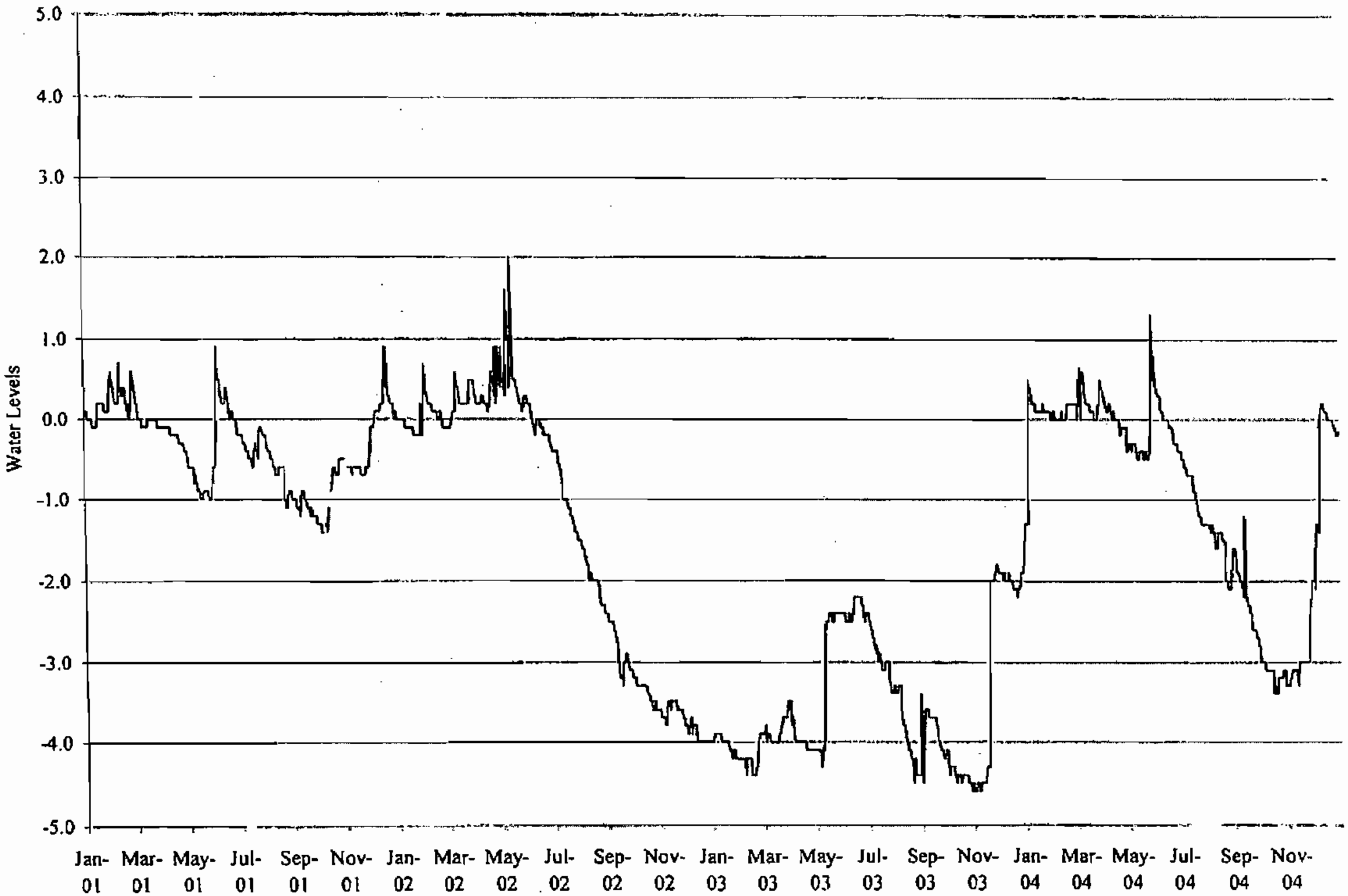


Figure 11. Water levels (feet) in relation to pool level in Coffeen Lake during 2001-2004.

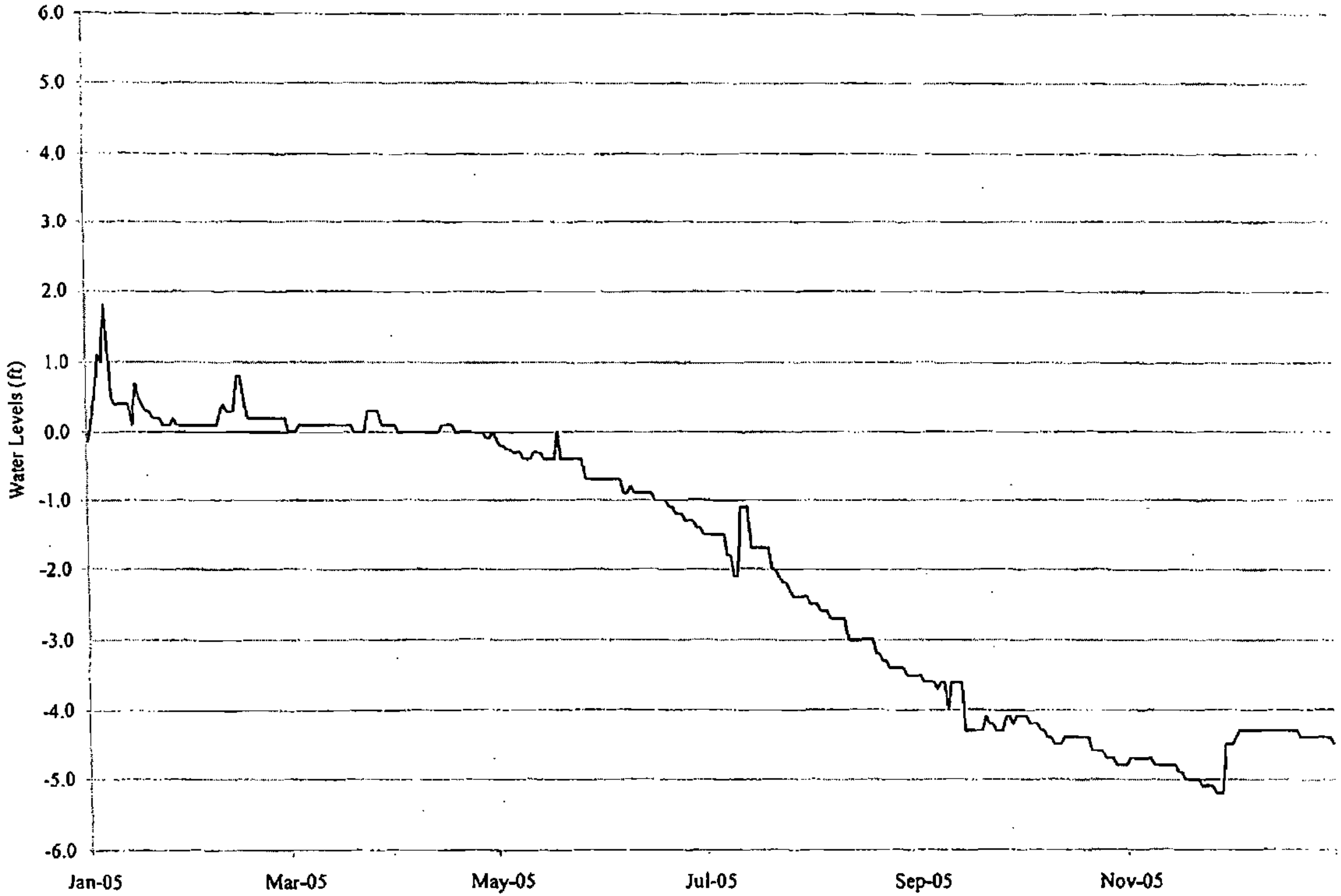


Figure 12. Water levels (feet) in relation to pool level in Coffeen Lake during 2005. No data was available for 2006.

Appendix A. Depth, Temperature, Oxygen Profile

Materials and Methods:

Methods used in 2006 to determine temperature and temperature, oxygen and depth profiles were the same as methods used during previous years of this study (1997-2005). The timeline was slightly different among the years due to the grant confirmations in each year. Temperature and oxygen were sampled in weekly during 2006 beginning in May Newton and Coffeen lakes, and sampling continued through September 2006. In order to compare the eight years of data, temperature, oxygen, and depth profiles were taken in the same four stations Newton Lake (Figure A-1) and Coffeen Lake (Figures A-2) during 2006 as in the previous years. Two probes from YSI Model 550A temperature/oxygen meters were used in tandem for sampling. Measurements were taken at 0.5-m intervals from the surface to the bottom; therefore, the final reading taken each sample date is within 0.5 – m of the bottom of the lake. Measurements were taken at the midpoint of each of four segments of each lake. Oxygen membranes were changed frequently. Graphs depicting the temperature and depth profiles taken are given in this appendix.

In Newton Lake, temperature loggers were set for continuous readings (1-hr intervals) at three of Ameren' biostations in Newton Lake (Figure A-1) beginning in June. The temperature loggers were programmed to measure temperature every 2 minutes, and the mean of these measurements was recorded every 1 hour to determine the hourly temperature. We had an additional station on the buoy line near the intake. Loggers were set at the surface and at 1.5-m intervals to a maximum of 4.5 m at each station. Thus, temperature loggers were set at the surface, 1.5 m (4.9 ft.), 3.0 m (9.8 ft.), and 4.5 m (14.8 ft.) in Segments 1 – 4 of Newton Lake. AMEREN provided water temperature data for mean monthly temperatures in the Newton Lake mixing zone (discharge area).

In Coffeen Lake, temperature loggers were set at the same depth intervals as described for Newton Lake in four stations located on either Ameren's biostations or IDNR buoys. The loggers were set at biostations at the mixing zone, near the dam, and near the intake (Figure A-2). Additional loggers were set outside of the immediate cooling loop on a buoy provided by IDNR near the railroad bridge. Mean monthly temperatures for the discharge areas during 2006 were determined using SIU-C temperature loggers set at the surface. No data was provided by AMEREN prior to this report.

In both lakes, mean daily temperature and maximum daily temperature was determined from the hourly readings. Monthly mean temperature was determined by averaging the mean daily temperatures each month. Table A-1 gives mean monthly temperatures recorded in the mixing zones of Newton Lake during 1997 through 2006. Similar data is given for Coffeen Lake mixing zone temperatures in Table A-2. Aditionally in both lakes, there were numerous instnaces where the VEMCO temperature loggers malfunctioned during 2006. VEMCO recently changed the materials with which their loggers were manufactured. The new plastic casings often cracked at some point during the year. As a result, despite sending the units in for data recovery, 30% of the data was not recoverable. Finally, in Newton Lake, loggers set at station three were evidently stolen. This is the second occassion where SIU-C loggers have been pilfered - the first occassion occurred in Coffeen Lake several years earlier.

Weekly temperature, oxygen, and depth profiles were used to estimate the amount of habitat available to the fish during the study periods. Combinations of temperature (range 87 to 97° F) and oxygen (range from 1 to 4 ppm) were used to determine percent of habitat available. For any combination of temperature and oxygen, each 0.5 – m stratum was examined to determine if that stratum had water warmer than the given temperature provided in the tables or oxygen levels lower than the given oxygen provided in the tables. If either of these criteria were met, the stratum was considered unavailable as habitat for fish. Summing all unavailable strata for a given sampling date in a given segment and then dividing by the depth of the segment gave an estimate of the percent of habitat that was unavailable to the fish. Subtraction from 100% gave the percent habitat which was available. For example, if the water were 10 – m deep in a particular segment on a sampling date, and for a given set of temperature and oxygen criteria only 2.5 m was available as fish habitat; the percent habitat available would have been 25%.

The above method was calculated in two dimensions to provide an estimate of percent available habitat based upon assumptions of rectangular basin shape. Preliminary investigations suggest that even extreme changes in basin shape have little effect on the value calculated for percent available habitat.

Table A-1. Mean monthly water surface temperatures at the outer edge of the Newton Lake mixing zone. Mean temperatures were calculated from hourly temperature data provided by Ameren.

Year	Month	Number of days	Surface temperature monthly average
1997	June	27	95.9
1997	July	31	101.7
1997	August	31	96.2
1997	September	30	94.9
1997	October	31	86.3
1997	November	21	69.5
1997	December	31	71.3
1998	January	31	62.6
1998	February	28	63.8
1998	March	31	67
1998	April	30	79.7
1998	May	31	89.8
1998	June	30	96.3
1998	July	31	101.7
1998	August	31	102.3
1998	September	30	94.6
1998	October	31	87.5
1998	November	30	72.4
1998	December	31	69.8
1999	January	31	54
1999	February	28	67
1999	March	31	72.3
1999	April	30	77.3
1999	May	31	88.4
1999	June	30	97
1999	July	31	104.1
1999	August	31	99.7
1999	September	30	93.1
1999	October	31	85.4
1999	November	16	80.9
1999	December	24	72.7

Table A-1. Continued.

Year	Month	Number of days	Surface temperature monthly average
2000	January	27	67.7
2000	February	19	74.9
2000	March	31	76.7
2000	April	30	71.6
2000	May	19	82.5
2000	June	29	94.2
2000	July	31	98
2000	August	31	97.5
2000	September	30	92.8
2000	October	31	84.9
2000	November	30	75.8
2000	December	31	65.9
2001	January	—[a]	—[a]
2001	February	20	70.7
2001	March	17	73.6
2001	April	2	78.2
2001	May	31	91.7
2001	June	30	94.5
2001	July	31	100.1
2001	August	31	99.4
2001	September	30	92.9
2001	October	31	84.8
2001	November	30	75.0
2001	December	31	70.1
2002	January	30	70.9
2002	February	28	73.5
2002	March	31	72.5
2002	April	30	82.9
2002	May	31	84.8
2002	June	30	97.4
2002	July	31	99.1
2002	August	31	96.6
2002	September	30	94.0
2002	October	31	86.3
2002	November	30	79.2
2002	December	31	69.5

Table A-1. Continued.

Year	Month	Number of days	Surface temperature monthly average
2003	January	31	68.9
2003	February	28	68.8
2003	March	31	76.3
2003	April	30	75.3
2003	May	31	84.6
2003	June	30	90.8
2003	July	31	96.9
2003	August	31	98.3
2003	September	24	92.7
2003	October	23	84.8
2003	November	30	77.8
2003	December	31	69.3
2004	January	31	68.0
2004	February	28	72.6
2004	March	31	--[a]
2004	April	30	81.5
2004	May	31	93.2
2004	June	30	96.7
2004	July	31	96.8
2004	August	31	95.3
2004	September	24	93.3
2004	October	23	84.2
2004	November	30	75.3
2004	December	31	67.2
2005	January	31	66.9
2005	February	28	73.2
2005	March	31	74.2
2005	April	30	82.5
2005	May	31	91.4
2005	June	30	99.0
2005	July	31	99.3
2005	August	31	99.3
2005	September	30	97.7
2005	October	31	86.9
2005	November	30	77.6
2005	December	31	70.9

Table A-1. Continued.

Year	Month	Number of days	Surface temperature monthly average
2006	January	31	--[a]
2006	February	28	--[a]
2006	March	31	--[a]
2006	April	30	--[a]
2006	May	31	80.3
2006	June	30	94.2
2006	July	31	99.4
2006	August	31	99.8
2006	September	24	93.7
2006	October	23	--[a]
2006	November	30	--[a]
2006	December	31	--[a]

[a]/ No data available.

Table A-2. Mean monthly water surface temperatures at the outer edge of the Coffeen Lake mixing zone. Mean temperatures were calculated from hourly temperature data provided by Ameren.

Year	Month	Number of days	Surface temperature monthly average
1996	September	6	92.4
1996	October	19	83.2
1996	November	30	80.5
1996	December	31	76.6
1997	January	31	71.6
1997	February	28	69.6
1997	March	26	76.1
1997	April	15	70.2
1997	May	31	77.7
1997	June	30	87.9
1997	July	31	100.8
1997	August	31	98.7
1997	September	30	88.7
1997	October	31	81.6
1997	November	30	76
1997	December	31	73.3
1998	January	23	68.2
1998	February	--[a]	--[a]
1998	March	--[a]	--[a]
1998	April	15	82.8
1998	May	31	90.8
1998	June	30	94.9
1998	July	31	102.4
1998	August	31	100.1
1998	September	28	96.1
1998	October	31	79.9
1998	November	30	68.1
1998	December	25	66.4
1999	January	26	67.8
1999	February	24	64.9
1999	March	31	73.1
1999	April	18	85.5
1999	May	31	86.4
1999	June	30	90.5
1999	July	31	103.9
1999	August	31	101.5
1999	September	30	94.8
1999	October	31	83.6
1999	November	30	75.3
1999	December	12	70.8

Table A-2. Continued.

Year	Month	Number of days	Surface temperature monthly average
2000	January	31	65.2
2000	February	29	76.3
2000	March	31	79.9
2000	April	30	81.2
2000	May	31	88
2000	June	30	93.9
2000	July	31	99.2
2000	August	31	99.2
2000	September	30	93.5
2000	October	6	83.4
2000	November	24	70.7
2000	December	31	70.3
2001	January	31	67.0
2001	February	28	71.1
2001	March	31	68.7
2001	April	30	82.4
2001	May	31	84.7
2001	June	30	86.6
2001	July	31	101.3
2001	August	31	102.4
2001	September	30	93.2
2001	October	31	64.2
2001	November	30	62.4
2001	December	31	71.0
2002	January	31	71.0
2002	February	12	75.9
2002	March	24	75.3
2002	April	30	81.8
2002	May	31	82.2
2002	June	30	96.9
2002	July	31	100.4
2002	August	31	100.4
2002	September	30	99.2
2002	October	31	80.8
2002	November	30	76.6
2002	December	31	68.4

Table A-2. Continued.

Year	Month	Number of days	Surface temperature monthly average
2003	January	31	72.9
2003	February	28	74.6
2003	March	31	62.4
2003	April	30	84.0
2003	May	31	86.3
2003	June	30	96.7
2003	July	31	--[a]
2003	August	31	102.2
2003	September	24	97.2
2003	October	23	81.8
2003	November	30	78.2
2003	December	31	72.5
2004	January	31	75.0
2004	February	28	75.3
2004	March	31	72.1
2004	April	30	81.5
2004	May	31	88.4
2004	June	30	100.8
2004	July	31	--[a]
2004	August	31	--[a]
2004	September	24	102.9
2004	October	23	85.3
2004	November	30	--[a]
2004	December	31	--[a]
2005	January	31	63.1
2005	February	28	48.4
2005	March	31	57.9
2005	April	30	74.2
2005	May	31	83.7
2005	June	30	99.9
2005	July	31	104.2
2005	August	31	102.6
2005	September	30	100.5
2005	October	31	84.2
2005	November	30	77.8
2005	December	31	71.6

Table A-2. Continued.

Year	Month	Number of days	Surface temperature monthly average
2006	January	31	--[a]
2006	February	28	--[a]
2006	March	31	--[a]
2006	April	30	--[a]
2006	May	31	88.7
2006	June	30	101.5
2006	July	31	105.2
2006	August	31	103.4
2006	September	24	95.5
2006	October	23	87.4
2006	November	30	--[a]
2006	December	31	--[a]

[a]/ No data available.

Table A-3. Estimated percent habitat available in Newton Lake at 1700 hours on 4 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	56	70	79	100	76
4	88	56	70	79	100	76
4	89	56	70	79	100	76
4	90	56	70	79	100	76
4	91	56	70	79	100	76
4	92	56	70	79	100	76
4	93	56	70	79	100	76
4	94	56	70	79	100	76
4	95	56	70	79	100	76
4	96	56	70	79	100	76
4	97	56	70	79	100	76
3	87	69	83	85	100	84
3	88	69	83	85	100	84
3	89	69	83	85	100	84
3	90	69	83	85	100	84
3	91	69	83	85	100	84
3	92	69	83	85	100	84
3	93	69	83	85	100	84
3	94	69	83	85	100	84
3	95	69	83	85	100	84
3	96	69	83	85	100	84
3	97	69	83	85	100	84
2	87	94	90	97	100	95
2	88	94	90	97	100	95
2	89	94	90	97	100	95
2	90	94	90	97	100	95
2	91	94	90	97	100	95
2	92	94	90	97	100	95
2	93	94	90	97	100	95
2	94	94	90	97	100	95
2	95	94	90	97	100	95
2	96	94	90	97	100	95
2	97	94	90	97	100	95
1	87	100	97	100	100	99
1	88	100	97	100	100	99
1	89	100	97	100	100	99
1	90	100	97	100	100	99
1	91	100	97	100	100	99
1	92	100	97	100	100	99
1	93	100	97	100	100	99
1	94	100	97	100	100	99
1	95	100	97	100	100	99
1	96	100	97	100	100	99
1	97	100	97	100	100	99

Table A-4. Estimated percent habitat available in Newton Lake at 1100 hours on 11 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	100	70	84	86	85
4	88	100	70	84	86	85
4	89	100	70	84	86	85
4	90	100	70	84	86	85
4	91	100	70	84	86	85
4	92	100	70	84	86	85
4	93	100	70	84	86	85
4	94	100	70	84	86	85
4	95	100	70	84	86	85
4	96	100	70	84	86	85
4	97	100	70	84	86	85
3	87	100	77	91	86	89
3	88	100	77	91	86	89
3	89	100	77	91	86	89
3	90	100	77	91	86	89
3	91	100	77	91	86	89
3	92	100	77	91	86	89
3	93	100	77	91	86	89
3	94	100	77	91	86	89
3	95	100	77	91	86	89
3	96	100	77	91	86	89
3	97	100	77	91	86	89
2	87	100	97	97	95	97
2	88	100	97	97	95	97
2	89	100	97	97	95	97
2	90	100	97	97	95	97
2	91	100	97	97	95	97
2	92	100	97	97	95	97
2	93	100	97	97	95	97
2	94	100	97	97	95	97
2	95	100	97	97	95	97
2	96	100	97	97	95	97
2	97	100	97	97	95	97
1	87	100	97	97	95	97
1	88	100	97	97	95	97
1	89	100	97	97	95	97
1	90	100	97	97	95	97
1	91	100	97	97	95	97
1	92	100	97	97	95	97
1	93	100	97	97	95	97
1	94	100	97	97	95	97
1	95	100	97	97	95	97
1	96	100	97	97	95	97
1	97	100	97	97	95	97

Table A-5. Estimated percent habitat available in Newton Lake at 1800 hours on 17 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	100	100	100	100	100
4	88	100	100	100	100	100
4	89	100	100	100	100	100
4	90	100	100	100	100	100
4	91	100	100	100	100	100
4	92	100	100	100	100	100
4	93	100	100	100	100	100
4	94	100	100	100	100	100
4	95	100	100	100	100	100
4	96	100	100	100	100	100
4	97	100	100	100	100	100
3	87	100	100	100	100	100
3	88	100	100	100	100	100
3	89	100	100	100	100	100
3	90	100	100	100	100	100
3	91	100	100	100	100	100
3	92	100	100	100	100	100
3	93	100	100	100	100	100
3	94	100	100	100	100	100
3	95	100	100	100	100	100
3	96	100	100	100	100	100
3	97	100	100	100	100	100
2	87	100	100	100	100	100
2	88	100	100	100	100	100
2	89	100	100	100	100	100
2	90	100	100	100	100	100
2	91	100	100	100	100	100
2	92	100	100	100	100	100
2	93	100	100	100	100	100
2	94	100	100	100	100	100
2	95	100	100	100	100	100
2	96	100	100	100	100	100
2	97	100	100	100	100	100
1	87	100	100	100	100	100
1	88	100	100	100	100	100
1	89	100	100	100	100	100
1	90	100	100	100	100	100
1	91	100	100	100	100	100
1	92	100	100	100	100	100
1	93	100	100	100	100	100
1	94	100	100	100	100	100
1	95	100	100	100	100	100
1	96	100	100	100	100	100
1	97	100	100	100	100	100

Table A-6. Estimated percent habitat available in Newton Lake at 1800 hours on 25 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	94	57	79	100	83
4	88	94	57	79	100	83
4	89	94	57	79	100	83
4	90	94	57	79	100	83
4	91	94	57	79	100	83
4	92	94	57	79	100	83
4	93	94	57	79	100	83
4	94	94	57	79	100	83
4	95	94	57	79	100	83
4	96	94	57	79	100	83
4	97	94	57	79	100	83
3	87	100	63	85	100	87
3	88	100	63	85	100	87
3	89	100	63	85	100	87
3	90	100	63	85	100	87
3	91	100	63	85	100	87
3	92	100	63	85	100	87
3	93	100	63	85	100	87
3	94	100	63	85	100	87
3	95	100	63	85	100	87
3	96	100	63	85	100	87
3	97	100	63	85	100	87
2	87	100	70	85	100	89
2	88	100	70	85	100	89
2	89	100	70	85	100	89
2	90	100	70	85	100	89
2	91	100	70	85	100	89
2	92	100	70	85	100	89
2	93	100	70	85	100	89
2	94	100	70	85	100	89
2	95	100	70	85	100	89
2	96	100	70	85	100	89
2	97	100	70	85	100	89
1	87	100	90	97	100	97
1	88	100	90	97	100	97
1	89	100	90	97	100	97
1	90	100	90	97	100	97
1	91	100	90	97	100	97
1	92	100	90	97	100	97
1	93	100	90	97	100	97
1	94	100	90	97	100	97
1	95	100	90	97	100	97
1	96	100	90	97	100	97
1	97	100	90	97	100	97

Table A-7. Estimated percent habitat available in Newton Lake at 1600 hours on 1 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	81	24	44	72	55
4	88	94	38	44	72	62
4	89	94	38	44	72	62
4	90	94	38	44	72	62
4	91	94	38	44	72	62
4	92	94	38	44	72	62
4	93	94	38	44	72	62
4	94	94	38	44	72	62
4	95	94	38	44	72	62
4	96	94	38	44	72	62
4	97	94	38	44	72	62
3	87	81	35	44	83	61
3	88	94	50	44	83	68
3	89	94	50	44	83	68
3	90	94	50	44	83	68
3	91	94	50	44	83	68
3	92	94	50	44	83	68
3	93	94	50	44	83	68
3	94	94	50	44	83	68
3	95	94	50	44	83	68
3	96	94	50	44	83	68
3	97	94	50	44	83	68
2	87	88	35	56	94	68
2	88	100	50	56	94	75
2	89	100	50	56	94	75
2	90	100	50	56	94	75
2	91	100	50	56	94	75
2	92	100	50	56	94	75
2	93	100	50	56	94	75
2	94	100	50	56	94	75
2	95	100	50	56	94	75
2	96	100	50	56	94	75
2	97	100	50	56	94	75
1	87	88	47	62	100	74
1	88	100	62	62	100	81
1	89	100	62	62	100	81
1	90	100	62	62	100	81
1	91	100	62	62	100	81
1	92	100	62	62	100	81
1	93	100	62	62	100	81
1	94	100	62	62	100	81
1	95	100	62	62	100	81
1	96	100	62	62	100	81
1	97	100	62	62	100	81

Table A-8. Estimated percent habitat available in Newton Lake at 1700 hours on 9 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available: Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	13	13	50	75	38
4	88	13	13	50	75	38
4	89	25	20	50	75	43
4	90	38	43	50	75	52
4	91	38	43	50	75	52
4	92	38	43	50	75	52
4	93	38	43	50	75	52
4	94	69	43	50	75	59
4	95	69	43	50	75	59
4	96	69	43	50	75	59
4	97	69	43	50	75	59
3	87	13	13	50	85	40
3	88	13	13	50	85	40
3	89	25	20	50	85	45
3	90	38	43	50	85	54
3	91	38	43	50	85	54
3	92	38	43	50	85	54
3	93	38	43	50	85	54
3	94	69	43	50	85	62
3	95	69	43	50	85	62
3	96	69	43	50	85	62
3	97	69	43	50	85	62
2	87	25	20	56	95	49
2	88	25	20	56	95	49
2	89	38	27	56	95	54
2	90	50	50	56	95	63
2	91	50	50	56	95	63
2	92	50	50	56	95	63
2	93	50	50	56	95	63
2	94	81	50	56	95	71
2	95	81	50	56	95	71
2	96	81	50	56	95	71
2	97	81	50	56	95	71
1	87	44	33	74	100	63
1	88	44	33	74	100	63
1	89	56	40	74	100	68
1	90	69	63	74	100	77
1	91	69	63	74	100	77
1	92	69	63	74	100	77
1	93	69	63	74	100	77
1	94	100	63	74	100	84
1	95	100	63	74	100	84
1	96	100	63	74	100	84
1	97	100	63	74	100	84

Table A-9. Estimated percent habitat available in Newton Lake at 1800 hours on 15 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	25	27	56	100	52
4	88	25	27	56	100	52
4	89	25	57	56	100	60
4	90	38	57	56	100	63
4	91	38	57	56	100	63
4	92	63	57	56	100	69
4	93	75	57	56	100	72
4	94	94	57	56	100	77
4	95	94	57	56	100	77
4	96	94	57	56	100	77
4	97	94	57	56	100	77
3	87	25	27	62	100	54
3	88	25	27	62	100	54
3	89	25	57	62	100	61
3	90	38	57	62	100	64
3	91	38	57	62	100	64
3	92	63	57	62	100	71
3	93	75	57	62	100	74
3	94	94	57	62	100	78
3	95	94	57	62	100	78
3	96	94	57	62	100	78
3	97	94	57	62	100	78
2	87	25	33	62	100	55
2	88	25	33	62	100	55
2	89	25	63	62	100	63
2	90	38	63	62	100	66
2	91	38	63	62	100	66
2	92	63	63	62	100	72
2	93	75	63	62	100	75
2	94	94	63	62	100	80
2	95	94	63	62	100	80
2	96	94	63	62	100	80
2	97	94	63	62	100	80
1	87	31	67	100	100	75
1	88	31	67	100	100	75
1	89	31	97	100	100	82
1	90	44	97	100	100	85
1	91	44	97	100	100	85
1	92	69	97	100	100	92
1	93	81	97	100	100	95
1	94	100	97	100	100	99
1	95	100	97	100	100	99
1	96	100	97	100	100	99
1	97	100	97	100	100	99

Table A-10. Estimated percent habitat available in Newton Lake at 1400 hours on 22 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	6	0	2
4	88	0	0	12	28	10
4	89	0	0	18	100	30
4	90	0	0	24	100	31
4	91	0	0	44	100	36
4	92	0	7	44	100	38
4	93	0	7	44	100	38
4	94	0	7	44	100	38
4	95	0	7	44	100	38
4	96	0	7	44	100	38
4	97	0	37	44	100	45
3	87	0	13	18	0	8
3	88	0	13	24	28	16
3	89	0	13	29	100	36
3	90	0	13	35	100	37
3	91	0	13	56	100	42
3	92	13	20	56	100	47
3	93	13	20	56	100	47
3	94	13	20	56	100	47
3	95	13	20	56	100	47
3	96	13	20	56	100	47
3	97	13	50	56	100	55
2	87	13	27	18	0	15
2	88	13	27	24	28	23
2	89	13	27	29	100	42
2	90	13	27	35	100	44
2	91	13	27	56	100	49
2	92	25	33	56	100	54
2	93	25	33	56	100	54
2	94	25	33	56	100	54
2	95	25	33	56	100	54
2	96	25	33	56	100	54
2	97	25	63	56	100	61
1	87	19	53	47	0	30
1	88	19	53	53	28	38
1	89	19	53	59	100	58
1	90	19	53	65	100	59
1	91	19	53	85	100	64
1	92	31	60	85	100	69
1	93	31	60	85	100	69
1	94	31	60	85	100	69
1	95	31	60	85	100	69
1	96	31	60	85	100	69
1	97	31	90	85	100	77

Table A-11. Estimated percent habitat available in Newton Lake at 1800 hours on 29 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	6	44	13
4	88	0	7	12	56	19
4	89	0	7	24	61	23
4	90	0	13	29	94	34
4	91	0	13	35	94	36
4	92	0	13	56	94	41
4	93	13	20	56	94	46
4	94	13	20	56	94	46
4	95	13	27	56	94	48
4	96	13	27	56	94	48
4	97	25	50	56	94	56
3	87	0	0	6	50	14
3	88	0	7	12	61	20
3	89	13	7	24	67	28
3	90	13	13	29	100	39
3	91	13	13	35	100	40
3	92	13	13	56	100	46
3	93	25	20	56	100	50
3	94	25	20	56	100	50
3	95	25	27	56	100	52
3	96	25	27	56	100	52
3	97	38	50	56	100	61
2	87	13	20	24	50	27
2	88	13	27	29	61	33
2	89	25	27	41	67	40
2	90	25	33	47	100	51
2	91	25	33	53	100	53
2	92	25	33	74	100	58
2	93	38	40	74	100	63
2	94	38	40	74	100	63
2	95	38	47	74	100	65
2	96	38	47	74	100	65
2	97	50	70	74	100	74
1	87	19	50	50	50	42
1	88	19	57	56	61	48
1	89	31	57	68	67	56
1	90	31	63	74	100	67
1	91	31	63	79	100	68
1	92	31	63	100	100	74
1	93	44	70	100	100	79
1	94	44	70	100	100	79
1	95	44	77	100	100	80
1	96	44	77	100	100	80
1	97	56	100	100	100	89

Table A-12. Estimated percent habitat available in Newton Lake at 1900 hours on 6 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	68	100	42
4	88	0	7	68	100	44
4	89	0	13	68	100	45
4	90	13	20	68	100	50
4	91	13	50	68	100	58
4	92	13	57	68	100	60
4	93	25	57	68	100	63
4	94	25	57	68	100	63
4	95	38	57	68	100	66
4	96	50	57	68	100	69
4	97	50	57	68	100	69
3	87	0	7	68	100	44
3	88	0	13	68	100	45
3	89	13	20	68	100	50
3	90	25	27	68	100	55
3	91	25	57	68	100	63
3	92	25	63	68	100	64
3	93	38	63	68	100	67
3	94	38	63	68	100	67
3	95	50	63	68	100	70
3	96	63	63	68	100	74
3	97	63	63	68	100	74
2	87	0	7	68	100	44
2	88	0	13	68	100	45
2	89	13	20	68	100	50
2	90	25	27	68	100	55
2	91	25	57	68	100	63
2	92	25	63	68	100	64
2	93	38	63	68	100	67
2	94	38	63	68	100	67
2	95	50	63	68	100	70
2	96	63	63	68	100	74
2	97	63	63	68	100	74
1	87	0	13	68	100	45
1	88	6	20	68	100	49
1	89	19	27	68	100	54
1	90	31	33	68	100	58
1	91	31	63	68	100	66
1	92	31	70	68	100	67
1	93	44	70	68	100	71
1	94	44	70	68	100	71
1	95	56	70	68	100	74
1	96	69	70	68	100	77
1	97	69	70	68	100	77

Table A-13. Estimated percent habitat available in Newton Lake at 1700 hours on 13 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	35	67	26
4	88	0	0	41	67	27
4	89	0	0	41	78	30
4	90	13	6	41	78	35
4	91	25	6	41	78	38
4	92	25	13	47	94	45
4	93	38	13	53	94	50
4	94	50	13	62	94	55
4	95	63	19	62	94	60
4	96	63	19	62	94	60
4	97	63	25	62	94	61
3	87	0	0	41	72	28
3	88	0	6	47	72	31
3	89	6	6	47	83	36
3	90	19	13	47	83	41
3	91	31	13	47	83	44
3	92	31	19	53	100	51
3	93	44	19	59	100	56
3	94	56	19	68	100	61
3	95	69	25	68	100	66
3	96	69	25	68	100	66
3	97	69	31	68	100	67
2	87	0	13	41	72	32
2	88	0	19	47	72	35
2	89	6	19	47	83	39
2	90	19	25	47	83	44
2	91	31	25	47	83	47
2	92	31	31	53	100	54
2	93	44	31	59	100	59
2	94	56	31	68	100	64
2	95	69	38	68	100	69
2	96	69	38	68	100	69
2	97	69	44	68	100	70
1	87	0	19	47	72	35
1	88	0	25	53	72	38
1	89	6	25	53	83	42
1	90	19	31	53	83	47
1	91	31	31	53	83	50
1	92	31	38	59	100	57
1	93	44	38	65	100	62
1	94	56	38	74	100	67
1	95	69	44	74	100	72
1	96	69	44	74	100	72
1	97	69	50	74	100	73

Table A-14. Estimated percent habitat available in Newton Lake at 1400 hours on 19 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available: Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	0	11	3
4	90	0	6	6	11	6
4	91	0	6	12	22	10
4	92	0	6	12	22	10
4	93	0	13	18	44	19
4	94	0	13	24	56	23
4	95	0	13	29	72	29
4	96	0	19	29	72	30
4	97	0	19	35	72	32
3	87	0	0	0	0	0
3	88	0	0	6	0	2
3	89	0	0	6	11	4
3	90	0	6	12	11	7
3	91	14	6	18	22	15
3	92	14	6	18	22	15
3	93	14	13	24	44	24
3	94	14	13	29	56	28
3	95	14	13	35	72	34
3	96	14	19	35	72	35
3	97	14	19	41	72	37
2	87	0	0	0	0	0
2	88	0	6	6	0	3
2	89	0	6	6	11	6
2	90	0	13	12	11	9
2	91	14	13	18	22	17
2	92	14	13	18	22	17
2	93	14	19	24	44	25
2	94	14	19	29	56	30
2	95	14	19	35	72	35
2	96	14	25	35	72	37
2	97	14	25	41	72	38
1	87	0	0	6	0	2
1	88	0	6	12	0	5
1	89	7	6	12	11	9
1	90	7	13	18	11	12
1	91	21	13	24	22	20
1	92	21	13	24	22	20
1	93	21	19	29	44	28
1	94	21	19	35	56	33
1	95	21	19	41	72	38
1	96	21	25	41	72	40
1	97	21	25	47	72	41

Table A-15. Estimated percent habitat available in Newton Lake at 1700 hours on 27 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	6	100	27
4	88	0	0	29	100	32
4	89	0	0	79	100	45
4	90	0	0	79	100	45
4	91	0	0	79	100	45
4	92	0	0	79	100	45
4	93	0	13	79	100	48
4	94	0	53	79	100	58
4	95	0	53	79	100	58
4	96	6	53	79	100	60
4	97	19	53	79	100	63
3	87	0	0	6	100	27
3	88	0	0	29	100	32
3	89	0	0	79	100	45
3	90	0	0	79	100	45
3	91	0	0	79	100	45
3	92	0	0	79	100	45
3	93	0	13	79	100	48
3	94	0	53	79	100	58
3	95	0	53	79	100	58
3	96	6	53	79	100	60
3	97	19	53	79	100	63
2	87	0	0	6	100	27
2	88	0	0	29	100	32
2	89	0	0	79	100	45
2	90	0	0	79	100	45
2	91	0	0	79	100	45
2	92	0	0	79	100	45
2	93	0	13	79	100	48
2	94	0	53	79	100	58
2	95	0	53	79	100	58
2	96	6	53	79	100	60
2	97	19	53	79	100	63
1	87	0	0	6	100	27
1	88	0	0	29	100	32
1	89	0	0	79	100	45
1	90	0	0	79	100	45
1	91	0	0	79	100	45
1	92	0	0	79	100	45
1	93	0	13	79	100	48
1	94	0	53	79	100	58
1	95	0	53	79	100	58
1	96	6	53	79	100	60
1	97	19	53	79	100	63

Table A-16. Estimated percent habitat available in Newton Lake at 1300 hours on 3 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	0	0	0
4	90	0	0	0	65	16
4	91	0	0	29	100	32
4	92	0	0	50	100	38
4	93	0	0	50	100	38
4	94	0	0	50	100	38
4	95	0	0	50	100	38
4	96	0	0	50	100	38
4	97	0	13	50	100	41
3	87	0	0	0	0	0
3	88	0	0	0	0	0
3	89	0	0	0	0	0
3	90	0	0	6	65	18
3	91	0	0	35	100	34
3	92	0	0	56	100	39
3	93	0	0	56	100	39
3	94	0	6	56	100	41
3	95	0	6	56	100	41
3	96	0	6	56	100	41
3	97	0	19	56	100	44
2	87	0	0	0	0	0
2	88	0	0	0	0	0
2	89	0	0	0	0	0
2	90	0	0	6	65	18
2	91	0	0	35	100	34
2	92	0	0	56	100	39
2	93	0	0	56	100	39
2	94	0	6	56	100	41
2	95	13	6	56	100	44
2	96	13	6	56	100	44
2	97	13	19	56	100	47
1	87	0	0	0	0	0
1	88	0	0	0	0	0
1	89	0	0	0	0	0
1	90	0	0	6	65	18
1	91	0	6	35	100	35
1	92	0	6	56	100	41
1	93	0	6	56	100	41
1	94	0	13	56	100	42
1	95	13	13	56	100	46
1	96	13	13	56	100	46
1	97	13	25	56	100	49

Table A-17. Estimated percent habitat available in Newton Lake at 1400 hours on 11 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	60	15
4	89	0	0	41	65	27
4	90	0	0	62	65	32
4	91	0	0	62	65	32
4	92	0	20	62	65	37
4	93	0	33	62	65	40
4	94	13	50	62	65	48
4	95	13	50	62	65	48
4	96	38	50	62	65	54
4	97	63	50	62	65	60
3	87	0	0	0	0	0
3	88	0	0	0	90	23
3	89	0	0	41	95	34
3	90	0	0	62	95	39
3	91	0	7	62	95	41
3	92	13	27	62	95	49
3	93	13	40	62	95	53
3	94	25	57	62	95	60
3	95	25	57	62	95	60
3	96	50	57	62	95	66
3	97	75	57	62	95	72
2	87	0	0	0	5	1
2	88	0	0	6	95	25
2	89	0	0	47	100	37
2	90	0	0	68	100	42
2	91	0	7	68	100	44
2	92	13	27	68	100	52
2	93	13	40	68	100	55
2	94	25	57	68	100	63
2	95	25	57	68	100	63
2	96	50	57	68	100	69
2	97	75	57	68	100	75
1	87	0	0	0	5	1
1	88	0	0	6	95	25
1	89	0	7	47	100	39
1	90	0	7	68	100	44
1	91	0	13	68	100	45
1	92	13	33	68	100	54
1	93	13	47	68	100	57
1	94	25	63	68	100	64
1	95	25	63	68	100	64
1	96	50	63	68	100	70
1	97	75	63	68	100	77

Table A-18. Estimated percent habitat available in Newton Lake at 1600 hours on 19 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available: Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	11	3
4	88	0	0	0	11	3
4	89	0	0	12	22	9
4	90	0	0	18	33	13
4	91	0	0	24	94	30
4	92	0	0	35	94	32
4	93	0	0	44	94	35
4	94	0	7	44	94	36
4	95	0	7	44	94	36
4	96	0	20	44	94	40
4	97	13	27	44	94	45
3	87	0	0	0	17	4
3	88	0	0	12	17	7
3	89	0	0	24	28	13
3	90	0	0	29	39	17
3	91	0	0	35	100	34
3	92	0	0	47	100	37
3	93	0	0	56	100	39
3	94	0	7	56	100	41
3	95	0	7	56	100	41
3	96	0	20	56	100	44
3	97	13	27	56	100	49
2	87	0	0	6	17	6
2	88	0	0	18	17	9
2	89	0	0	29	28	14
2	90	0	0	35	39	19
2	91	0	0	41	100	35
2	92	0	0	53	100	38
2	93	13	0	62	100	44
2	94	13	7	62	100	46
2	95	13	7	62	100	46
2	96	13	20	62	100	49
2	97	25	27	62	100	54
1	87	0	0	18	17	9
1	88	0	0	29	17	12
1	89	0	0	41	28	17
1	90	0	0	47	39	22
1	91	0	7	53	100	40
1	92	0	7	65	100	43
1	93	13	7	74	100	49
1	94	13	13	74	100	50
1	95	13	13	74	100	50
1	96	13	27	74	100	54
1	97	25	33	74	100	58

Table A-19. Estimated percent habitat available in Newton Lake at 1800 hours on 24 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	5	1
4	88	0	0	12	15	7
4	89	0	0	18	35	13
4	90	0	0	24	55	20
4	91	0	0	24	85	27
4	92	0	0	56	85	35
4	93	0	0	56	85	35
4	94	0	0	56	85	35
4	95	0	17	56	85	40
4	96	0	37	56	85	45
4	97	0	37	56	85	45
3	87	0	0	6	15	5
3	88	0	0	18	25	11
3	89	0	0	24	45	17
3	90	0	0	29	65	24
3	91	0	0	29	95	31
3	92	0	7	62	95	41
3	93	0	7	62	95	41
3	94	0	7	62	95	41
3	95	13	23	62	95	48
3	96	13	43	62	95	53
3	97	13	43	62	95	53
2	87	0	0	12	20	8
2	88	0	0	24	30	14
2	89	0	0	29	50	20
2	90	0	0	35	70	26
2	91	0	0	35	100	34
2	92	0	7	68	100	44
2	93	0	7	68	100	44
2	94	0	7	68	100	44
2	95	13	23	68	100	51
2	96	13	43	68	100	56
2	97	13	43	68	100	56
1	87	0	0	12	20	8
1	88	0	0	24	30	14
1	89	0	0	29	50	20
1	90	0	0	35	70	26
1	91	0	0	35	100	34
1	92	13	7	68	100	47
1	93	13	7	68	100	47
1	94	13	7	68	100	47
1	95	25	23	68	100	54
1	96	25	43	68	100	59
1	97	25	43	68	100	59

Table A-20. Estimated percent habitat available in Newton Lake at 1100 hours on 30 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	21	100	30
4	88	0	0	62	100	41
4	89	0	0	62	100	41
4	90	0	0	62	100	41
4	91	0	0	62	100	41
4	92	0	37	62	100	50
4	93	0	37	62	100	50
4	94	0	37	62	100	50
4	95	13	37	62	100	53
4	96	69	37	62	100	67
4	97	69	37	62	100	67
3	87	0	0	32	100	33
3	88	0	0	74	100	44
3	89	0	0	74	100	44
3	90	0	7	74	100	45
3	91	0	7	74	100	45
3	92	0	43	74	100	54
3	93	0	43	74	100	54
3	94	0	43	74	100	54
3	95	13	43	74	100	58
3	96	69	43	74	100	72
3	97	69	43	74	100	72
2	87	0	0	32	100	33
2	88	0	0	74	100	44
2	89	0	0	74	100	44
2	90	0	7	74	100	45
2	91	13	7	74	100	49
2	92	13	43	74	100	58
2	93	13	43	74	100	58
2	94	13	43	74	100	58
2	95	25	43	74	100	61
2	96	81	43	74	100	75
2	97	81	43	74	100	75
1	87	0	0	32	100	33
1	88	0	0	74	100	44
1	89	0	7	74	100	45
1	90	0	13	74	100	47
1	91	13	13	74	100	50
1	92	13	50	74	100	59
1	93	13	50	74	100	59
1	94	13	50	74	100	59
1	95	25	50	74	100	62
1	96	81	50	74	100	76
1	97	81	50	74	100	76

Table A-21. Estimated percent habitat available in Newton Lake at 1200 hours on 6 September 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	7	74	95	44
4	88	0	13	74	95	46
4	89	13	13	74	95	49
4	90	13	20	74	95	51
4	91	38	27	74	95	59
4	92	56	37	74	95	66
4	93	56	37	74	95	66
4	94	56	37	74	95	66
4	95	56	37	74	95	66
4	96	56	37	74	95	66
4	97	56	37	74	95	66
3	87	0	20	79	95	49
3	88	0	27	79	95	50
3	89	13	27	79	95	54
3	90	13	33	79	95	55
3	91	38	40	79	95	63
3	92	56	50	79	95	70
3	93	56	50	79	95	70
3	94	56	50	79	95	70
3	95	56	50	79	95	70
3	96	56	50	79	95	70
3	97	56	50	79	95	70
2	87	0	27	79	100	52
2	88	13	33	79	100	56
2	89	25	33	79	100	59
2	90	25	40	79	100	61
2	91	50	47	79	100	69
2	92	69	57	79	100	76
2	93	69	57	79	100	76
2	94	69	57	79	100	76
2	95	69	57	79	100	76
2	96	69	57	79	100	76
2	97	69	57	79	100	76
1	87	0	40	85	100	56
1	88	13	47	85	100	61
1	89	25	47	85	100	64
1	90	25	53	85	100	66
1	91	50	60	85	100	74
1	92	69	70	85	100	81
1	93	69	70	85	100	81
1	94	69	70	85	100	81
1	95	69	70	85	100	81
1	96	69	70	85	100	81
1	97	69	70	85	100	81

Table A-22. Estimated percent habitat available in Newton Lake at 1200 hours on 12 September 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available: Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	62	100	41
4	88	0	7	62	100	42
4	89	0	13	62	100	44
4	90	0	20	62	100	46
4	91	0	20	62	100	46
4	92	0	27	62	100	47
4	93	0	37	62	100	50
4	94	0	43	62	100	51
4	95	31	43	62	100	59
4	96	69	43	62	100	69
4	97	69	43	62	100	69
3	87	0	0	68	100	42
3	88	0	7	68	100	44
3	89	0	13	68	100	45
3	90	0	20	68	100	47
3	91	0	20	68	100	47
3	92	0	27	68	100	49
3	93	0	37	68	100	51
3	94	0	43	68	100	53
3	95	31	43	68	100	61
3	96	69	43	68	100	70
3	97	69	43	68	100	70
2	87	0	7	68	100	44
2	88	0	13	68	100	45
2	89	13	20	68	100	50
2	90	13	27	68	100	52
2	91	13	27	68	100	52
2	92	13	33	68	100	54
2	93	13	43	68	100	56
2	94	13	50	68	100	58
2	95	44	50	68	100	66
2	96	81	50	68	100	75
2	97	81	50	68	100	75
1	87	13	7	68	100	47
1	88	13	13	68	100	49
1	89	25	20	68	100	53
1	90	25	27	68	100	55
1	91	25	27	68	100	55
1	92	25	33	68	100	57
1	93	25	43	68	100	59
1	94	25	50	68	100	61
1	95	56	50	68	100	69
1	96	94	50	68	100	78
1	97	94	50	68	100	78

Table A-23. Estimated percent habitat available in Newton Lake at 1700 hours on 20 September 2006. Habitat was considered available if it contained no less than the minimum oxygen o no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	14	39	94	100	62
4	88	29	39	94	100	66
4	89	43	39	94	100	69
4	90	57	39	94	100	73
4	91	57	39	94	100	73
4	92	79	39	94	100	78
4	93	79	39	94	100	78
4	94	79	39	94	100	78
4	95	79	39	94	100	78
4	96	79	39	94	100	78
4	97	79	39	94	100	78
3	87	14	39	100	100	63
3	88	29	39	100	100	67
3	89	43	39	100	100	71
3	90	57	39	100	100	74
3	91	57	39	100	100	74
3	92	79	39	100	100	80
3	93	79	39	100	100	80
3	94	79	39	100	100	80
3	95	79	39	100	100	80
3	96	79	39	100	100	80
3	97	79	39	100	100	80
2	87	14	54	100	100	67
2	88	29	54	100	100	71
2	89	43	54	100	100	74
2	90	57	54	100	100	78
2	91	57	54	100	100	78
2	92	79	54	100	100	83
2	93	79	54	100	100	83
2	94	79	54	100	100	83
2	95	79	54	100	100	83
2	96	79	54	100	100	83
2	97	79	54	100	100	83
1	87	14	68	100	100	71
1	88	29	68	100	100	74
1	89	43	68	100	100	78
1	90	57	68	100	100	81
1	91	57	68	100	100	81
1	92	79	68	100	100	87
1	93	79	68	100	100	87
1	94	79	68	100	100	87
1	95	79	68	100	100	87
1	96	79	68	100	100	87
1	97	79	68	100	100	87

Table A-24. Estimated percent habitat available in Newton Lake at 1500 hours on 28 September 2006. Habitat as considered available if it contained no less than the minimum oxygen o no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	79	61	100	100	85
4	88	79	61	100	100	85
4	89	79	61	100	100	85
4	90	79	61	100	100	85
4	91	79	61	100	100	85
4	92	79	61	100	100	85
4	93	79	61	100	100	85
4	94	79	61	100	100	85
4	95	79	61	100	100	85
4	96	79	61	100	100	85
4	97	79	61	100	100	85
3	87	79	75	100	100	89
3	88	79	75	100	100	89
3	89	79	75	100	100	89
3	90	79	75	100	100	89
3	91	79	75	100	100	89
3	92	79	75	100	100	89
3	93	79	75	100	100	89
3	94	79	75	100	100	89
3	95	79	75	100	100	89
3	96	79	75	100	100	89
3	97	79	75	100	100	89
2	87	79	82	100	100	90
2	88	79	82	100	100	90
2	89	79	82	100	100	90
2	90	79	82	100	100	90
2	91	79	82	100	100	90
2	92	79	82	100	100	90
2	93	79	82	100	100	90
2	94	79	82	100	100	90
2	95	79	82	100	100	90
2	96	79	82	100	100	90
2	97	79	82	100	100	90
1	87	100	89	100	100	97
1	88	100	89	100	100	97
1	89	100	89	100	100	97
1	90	100	89	100	100	97
1	91	100	89	100	100	97
1	92	100	89	100	100	97
1	93	100	89	100	100	97
1	94	100	89	100	100	97
1	95	100	89	100	100	97
1	96	100	89	100	100	97
1	97	100	89	100	100	97

Table A-25. Estimated percent habitat available in Coffeen Lake at 1300 hours on 4 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	58	59	96	96	77
4	88	58	59	96	96	77
4	89	58	59	96	96	77
4	90	58	59	96	96	77
4	91	58	59	96	96	77
4	92	58	59	96	96	77
4	93	58	59	96	96	77
4	94	58	59	96	96	77
4	95	58	59	96	96	77
4	96	58	59	96	96	77
4	97	58	59	96	96	77
3	87	69	63	96	100	82
3	88	69	63	96	100	82
3	89	69	63	96	100	82
3	90	69	63	96	100	82
3	91	69	63	96	100	82
3	92	69	63	96	100	82
3	93	69	63	96	100	82
3	94	69	63	96	100	82
3	95	69	63	96	100	82
3	96	69	63	96	100	82
3	97	69	63	96	100	82
2	87	86	63	100	100	87
2	88	86	63	100	100	87
2	89	86	63	100	100	87
2	90	86	63	100	100	87
2	91	86	63	100	100	87
2	92	86	63	100	100	87
2	93	86	63	100	100	87
2	94	86	63	100	100	87
2	95	86	63	100	100	87
2	96	86	63	100	100	87
2	97	86	63	100	100	87
1	87	92	72	100	100	91
1	88	92	72	100	100	91
1	89	92	72	100	100	91
1	90	92	72	100	100	91
1	91	92	72	100	100	91
1	92	92	72	100	100	91
1	93	92	72	100	100	91
1	94	92	72	100	100	91
1	95	92	72	100	100	91
1	96	92	72	100	100	91
1	97	92	72	100	100	91

Table A-26. Estimated percent habitat available in Coffeen Lake at 1500 hours on 11 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	66	55	77	81	70
4	88	66	55	77	81	70
4	89	66	55	77	81	70
4	90	66	55	77	81	70
4	91	66	55	77	81	70
4	92	66	55	77	81	70
4	93	66	55	77	81	70
4	94	66	55	77	81	70
4	95	66	55	77	81	70
4	96	66	55	77	81	70
4	97	66	55	77	81	70
3	87	66	61	83	81	73
3	88	66	61	83	81	73
3	89	66	61	83	81	73
3	90	66	61	83	81	73
3	91	66	61	83	81	73
3	92	66	61	83	81	73
3	93	66	61	83	81	73
3	94	66	61	83	81	73
3	95	66	61	83	81	73
3	96	66	61	83	81	73
3	97	66	61	83	81	73
2	87	71	66	83	88	77
2	88	71	66	83	88	77
2	89	71	66	83	88	77
2	90	71	66	83	88	77
2	91	71	66	83	88	77
2	92	71	66	83	88	77
2	93	71	66	83	88	77
2	94	71	66	83	88	77
2	95	71	66	83	88	77
2	96	71	66	83	88	77
2	97	71	66	83	88	77
1	87	76	76	97	96	86
1	88	76	76	97	96	86
1	89	76	76	97	96	86
1	90	76	76	97	96	86
1	91	76	76	97	96	86
1	92	76	76	97	96	86
1	93	76	76	97	96	86
1	94	76	76	97	96	86
1	95	76	76	97	96	86
1	96	76	76	97	96	86
1	97	76	76	97	96	86

Table A-27. Estimated percent habitat available in Coffeen Lake at 1100 hours on 18 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	45	84	100	100	82
4	88	45	84	100	100	82
4	89	45	84	100	100	82
4	90	45	84	100	100	82
4	91	45	84	100	100	82
4	92	45	84	100	100	82
4	93	45	84	100	100	82
4	94	45	84	100	100	82
4	95	45	84	100	100	82
4	96	45	84	100	100	82
4	97	45	84	100	100	82
3	87	45	84	100	100	82
3	88	45	84	100	100	82
3	89	45	84	100	100	82
3	90	45	84	100	100	82
3	91	45	84	100	100	82
3	92	45	84	100	100	82
3	93	45	84	100	100	82
3	94	45	84	100	100	82
3	95	45	84	100	100	82
3	96	45	84	100	100	82
3	97	45	84	100	100	82
2	87	66	84	100	100	88
2	88	66	84	100	100	88
2	89	66	84	100	100	88
2	90	66	84	100	100	88
2	91	66	84	100	100	88
2	92	66	84	100	100	88
2	93	66	84	100	100	88
2	94	66	84	100	100	88
2	95	66	84	100	100	88
2	96	66	84	100	100	88
2	97	66	84	100	100	88
1	87	82	84	100	100	92
1	88	82	84	100	100	92
1	89	82	84	100	100	92
1	90	82	84	100	100	92
1	91	82	84	100	100	92
1	92	82	84	100	100	92
1	93	82	84	100	100	92
1	94	82	84	100	100	92
1	95	82	84	100	100	92
1	96	82	84	100	100	92
1	97	82	84	100	100	92

Table A-28. Estimated percent habitat available in Coffeen Lake at 1400 hours on 25 May 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	32	60	96	100	72
4	88	32	60	96	100	72
4	89	32	60	96	100	72
4	90	37	60	96	100	73
4	91	42	60	96	100	75
4	92	47	60	96	100	76
4	93	47	60	96	100	76
4	94	61	60	96	100	79
4	95	61	60	96	100	79
4	96	61	60	96	100	79
4	97	61	60	96	100	79
3	87	37	64	96	100	74
3	88	37	64	96	100	74
3	89	37	64	96	100	74
3	90	42	64	96	100	76
3	91	47	64	96	100	77
3	92	53	64	96	100	78
3	93	53	64	96	100	78
3	94	66	64	96	100	82
3	95	66	64	96	100	82
3	96	66	64	96	100	82
3	97	66	64	96	100	82
2	87	42	74	100	100	79
2	88	42	74	100	100	79
2	89	42	74	100	100	79
2	90	47	74	100	100	80
2	91	53	74	100	100	82
2	92	58	74	100	100	83
2	93	58	74	100	100	83
2	94	71	74	100	100	86
2	95	71	74	100	100	86
2	96	71	74	100	100	86
2	97	71	74	100	100	86
1	87	47	83	100	100	83
1	88	47	83	100	100	83
1	89	47	83	100	100	83
1	90	53	83	100	100	84
1	91	58	83	100	100	85
1	92	63	83	100	100	87
1	93	63	83	100	100	87
1	94	76	83	100	100	90
1	95	76	83	100	100	90
1	96	76	83	100	100	90
1	97	76	83	100	100	90

Table A-29. Estimated percent habitat available in Coffeen Lake at 1300 hours on 1 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	56	45	81	86	67
4	88	56	45	81	86	67
4	89	56	45	81	86	67
4	90	69	45	81	86	70
4	91	69	45	81	86	70
4	92	81	45	81	86	73
4	93	88	45	81	86	75
4	94	100	45	81	86	78
4	95	100	45	81	86	78
4	96	100	45	81	86	78
4	97	100	45	81	86	78
3	87	56	50	88	86	70
3	88	56	50	88	86	70
3	89	56	50	88	86	70
3	90	69	50	88	86	73
3	91	69	50	88	86	73
3	92	81	50	88	86	76
3	93	88	50	88	86	78
3	94	100	50	88	86	81
3	95	100	50	88	86	81
3	96	100	50	88	86	81
3	97	100	50	88	86	81
2	87	56	55	96	93	75
2	88	56	55	96	93	75
2	89	56	55	96	93	75
2	90	69	55	96	93	78
2	91	69	55	96	93	78
2	92	81	55	96	93	81
2	93	88	55	96	93	83
2	94	100	55	96	93	86
2	95	100	55	96	93	86
2	96	100	55	96	93	86
2	97	100	55	96	93	86
1	87	56	64	96	93	77
1	88	56	64	96	93	77
1	89	56	64	96	93	77
1	90	69	64	96	93	81
1	91	69	64	96	93	81
1	92	81	64	96	93	84
1	93	88	64	96	93	85
1	94	100	64	96	93	88
1	95	100	64	96	93	88
1	96	100	64	96	93	88
1	97	100	64	96	93	88

Table A-30. Estimated percent habitat available in Coffeen Lake at 1400 hours on 9 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	11	23	36	21	23
4	88	11	23	50	36	30
4	89	11	32	68	43	39
4	90	17	32	68	75	48
4	91	17	36	68	75	49
4	92	17	48	68	75	52
4	93	17	57	68	75	54
4	94	17	57	68	75	54
4	95	17	57	68	75	54
4	96	17	57	68	75	54
4	97	17	57	68	75	54
3	87	17	32	57	29	34
3	88	17	32	71	43	41
3	89	17	41	89	50	49
3	90	22	41	89	82	59
3	91	22	45	89	82	60
3	92	22	57	89	82	63
3	93	22	66	89	82	65
3	94	22	66	89	82	65
3	95	22	66	89	82	65
3	96	22	66	89	82	65
3	97	22	66	89	82	65
2	87	22	32	64	36	39
2	88	22	32	79	50	46
2	89	22	41	96	57	54
2	90	28	41	96	89	64
2	91	28	45	96	89	65
2	92	28	57	96	89	68
2	93	28	66	96	89	70
2	94	28	66	96	89	70
2	95	28	66	96	89	70
2	96	28	66	96	89	70
2	97	28	66	96	89	70
1	87	33	32	68	46	45
1	88	33	32	82	61	52
1	89	33	41	100	68	61
1	90	39	41	100	100	70
1	91	39	45	100	100	71
1	92	39	57	100	100	74
1	93	39	66	100	100	76
1	94	39	66	100	100	76
1	95	39	66	100	100	76
1	96	39	66	100	100	76
1	97	39	66	100	100	76

Table A-31. Estimated percent habitat available in Coffeen Lake at 1400 hours on 15 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	11	10	12	7	10
4	88	16	15	12	14	14
4	89	16	15	19	21	18
4	90	21	20	19	36	24
4	91	21	20	27	43	28
4	92	21	20	85	64	48
4	93	21	25	100	75	55
4	94	21	25	100	75	55
4	95	21	43	100	75	60
4	96	21	48	100	75	61
4	97	26	48	100	75	62
3	87	11	15	12	21	15
3	88	16	20	12	29	19
3	89	16	20	19	36	23
3	90	21	25	19	50	29
3	91	21	25	27	57	33
3	92	21	25	85	79	53
3	93	21	30	100	89	60
3	94	21	30	100	89	60
3	95	21	48	100	89	65
3	96	21	53	100	89	66
3	97	26	53	100	89	67
2	87	16	25	12	29	21
2	88	21	30	12	36	25
2	89	21	30	19	43	28
2	90	26	35	19	57	34
2	91	26	35	27	64	38
2	92	26	35	85	86	58
2	93	26	40	100	96	66
2	94	26	40	100	96	66
2	95	26	58	100	96	70
2	96	26	63	100	96	71
2	97	32	63	100	96	73
1	87	32	40	12	29	28
1	88	37	45	12	36	33
1	89	37	45	19	43	36
1	90	42	50	19	57	42
1	91	42	50	27	64	46
1	92	42	50	85	86	66
1	93	42	55	100	96	73
1	94	42	55	100	96	73
1	95	42	73	100	96	78
1	96	42	78	100	96	79
1	97	47	78	100	96	80

Table A-32. Estimated percent habitat available in Coffeen Lake at 1800 hours on 22 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	0	0	0
4	90	0	5	0	0	1
4	91	6	10	0	0	4
4	92	11	15	8	8	11
4	93	17	20	8	17	16
4	94	17	25	58	63	41
4	95	17	25	58	63	41
4	96	22	30	58	63	43
4	97	22	30	58	63	43
3	87	0	0	0	0	0
3	88	0	0	0	0	0
3	89	0	0	0	0	0
3	90	6	5	8	17	9
3	91	11	10	8	17	12
3	92	17	15	15	25	18
3	93	22	20	15	33	23
3	94	22	25	65	79	48
3	95	22	25	65	79	48
3	96	28	30	65	79	51
3	97	28	30	65	79	51
2	87	0	0	8	4	3
2	88	0	0	15	13	7
2	89	0	5	23	21	12
2	90	11	10	38	38	24
2	91	17	15	38	38	27
2	92	22	20	46	46	34
2	93	28	25	46	54	38
2	94	28	30	96	100	64
2	95	28	30	96	100	64
2	96	33	35	96	100	66
2	97	33	35	96	100	66
1	87	0	10	12	4	7
1	88	6	15	19	13	13
1	89	6	20	27	21	19
1	90	17	25	42	38	31
1	91	22	30	42	38	33
1	92	28	35	50	46	40
1	93	33	40	50	54	44
1	94	33	45	100	100	70
1	95	33	45	100	100	70
1	96	39	50	100	100	72
1	97	39	50	100	100	72

Table A-33. Estimated percent habitat available in Coffeen Lake at 1500 hours on 29 June 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	5	4	0	2
4	88	0	14	4	12	8
4	89	0	19	19	35	18
4	90	0	33	65	73	43
4	91	0	48	73	81	51
4	92	11	52	88	88	60
4	93	11	52	100	100	66
4	94	17	57	100	100	69
4	95	17	62	100	100	70
4	96	17	64	100	100	70
4	97	17	64	100	100	70
3	87	0	14	4	0	5
3	88	0	24	4	12	10
3	89	0	29	19	35	21
3	90	0	43	65	73	45
3	91	0	57	73	81	53
3	92	11	62	88	88	62
3	93	11	62	100	100	68
3	94	17	67	100	100	71
3	95	17	71	100	100	72
3	96	17	74	100	100	73
3	97	17	74	100	100	73
2	87	0	14	4	0	5
2	88	0	24	4	12	10
2	89	0	29	19	35	21
2	90	0	43	65	73	45
2	91	6	57	73	81	54
2	92	17	62	88	88	64
2	93	17	62	100	100	70
2	94	22	67	100	100	72
2	95	22	71	100	100	73
2	96	22	74	100	100	74
2	97	22	74	100	100	74
1	87	0	29	4	0	8
1	88	0	38	4	12	14
1	89	0	43	19	35	24
1	90	17	57	65	73	53
1	91	22	71	73	81	62
1	92	33	76	88	88	71
1	93	33	76	100	100	77
1	94	39	81	100	100	80
1	95	39	86	100	100	81
1	96	39	88	100	100	82
1	97	39	88	100	100	82

Table A-34. Estimated percent habitat available in Coffeen Lake at 1500 hours on 6 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	14	4	5
4	88	0	5	43	19	17
4	89	0	14	57	35	27
4	90	0	14	75	100	47
4	91	0	23	96	100	55
4	92	0	27	96	100	56
4	93	0	32	96	100	57
4	94	0	43	96	100	60
4	95	0	43	96	100	60
4	96	0	43	96	100	60
4	97	6	43	96	100	61
3	87	0	0	14	4	5
3	88	0	9	43	19	18
3	89	0	18	57	35	28
3	90	0	18	75	100	48
3	91	6	27	96	100	57
3	92	12	32	96	100	60
3	93	12	36	96	100	61
3	94	12	48	96	100	64
3	95	12	48	96	100	64
3	96	12	48	96	100	64
3	97	18	48	96	100	66
2	87	0	0	18	4	6
2	88	0	14	46	19	20
2	89	0	23	61	35	30
2	90	6	23	79	100	52
2	91	12	32	100	100	61
2	92	18	36	100	100	64
2	93	18	41	100	100	65
2	94	18	52	100	100	68
2	95	18	52	100	100	68
2	96	18	52	100	100	68
2	97	24	52	100	100	69
1	87	0	5	18	4	7
1	88	0	18	46	19	21
1	89	12	27	61	35	34
1	90	18	27	79	100	56
1	91	24	36	100	100	65
1	92	29	41	100	100	68
1	93	29	45	100	100	69
1	94	29	57	100	100	72
1	95	29	57	100	100	72
1	96	29	57	100	100	72
1	97	35	57	100	100	73

Table A-35. Estimated percent habitat available in Coffeen Lake at 1400 hours on 13 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available: Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	5	0	12	4
4	89	0	20	8	35	16
4	90	0	30	31	65	32
4	91	0	35	54	73	41
4	92	6	35	62	81	46
4	93	6	35	96	88	56
4	94	6	40	96	100	61
4	95	6	40	96	100	61
4	96	6	40	96	100	61
4	97	11	53	96	100	65
3	87	0	0	4	0	1
3	88	0	10	4	12	7
3	89	0	25	12	35	18
3	90	6	35	35	65	35
3	91	6	40	58	73	44
3	92	11	40	65	81	49
3	93	11	40	100	88	60
3	94	11	45	100	100	64
3	95	11	45	100	100	64
3	96	11	45	100	100	64
3	97	17	58	100	100	69
2	87	0	15	4	0	5
2	88	0	25	4	12	10
2	89	11	40	12	35	25
2	90	17	50	35	65	42
2	91	17	55	58	73	51
2	92	22	55	65	81	56
2	93	22	55	100	88	66
2	94	22	60	100	100	71
2	95	22	60	100	100	71
2	96	22	60	100	100	71
2	97	28	73	100	100	75
1	87	0	15	4	0	5
1	88	0	25	4	12	10
1	89	17	40	12	35	26
1	90	22	50	35	65	43
1	91	22	55	58	73	52
1	92	28	55	65	81	57
1	93	28	55	100	88	68
1	94	28	60	100	100	72
1	95	28	60	100	100	72
1	96	28	60	100	100	72
1	97	33	73	100	100	77

Table A-36. Estimated percent habitat available in Coffeen Lake at 1800 hours on 19 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	0	0	0
4	90	0	0	4	0	1
4	91	0	5	4	8	4
4	92	6	10	4	15	9
4	93	17	14	12	23	17
4	94	22	19	12	54	27
4	95	28	24	35	62	37
4	96	28	29	100	69	57
4	97	28	29	100	96	63
3	87	0	0	0	0	0
3	88	0	0	0	0	0
3	89	0	0	0	0	0
3	90	0	0	4	0	1
3	91	6	5	4	8	6
3	92	11	10	4	15	10
3	93	22	14	12	23	18
3	94	28	19	12	54	28
3	95	33	24	35	62	39
3	96	33	29	100	69	58
3	97	33	29	100	96	65
2	87	0	0	0	0	0
2	88	0	0	0	0	0
2	89	0	0	0	0	0
2	90	0	0	4	4	2
2	91	6	10	4	12	8
2	92	11	14	4	19	12
2	93	22	19	12	27	20
2	94	28	24	12	58	31
2	95	33	29	35	65	41
2	96	33	33	100	73	60
2	97	33	33	100	100	67
1	87	0	0	0	0	0
1	88	0	0	0	0	0
1	89	0	0	0	0	0
1	90	0	5	4	4	3
1	91	11	14	4	12	10
1	92	17	19	4	19	15
1	93	28	24	12	27	23
1	94	33	29	12	58	33
1	95	39	33	35	65	43
1	96	39	38	100	73	63
1	97	39	38	100	100	69

Table A-37. Estimated percent habitat available in Coffeen Lake at 1300 hours on 27 July 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	4	0	1
4	89	0	0	12	13	6
4	90	0	5	19	38	16
4	91	0	10	100	100	53
4	92	6	25	100	100	58
4	93	6	30	100	100	59
4	94	11	35	100	100	62
4	95	11	53	100	100	66
4	96	11	53	100	100	66
4	97	11	53	100	100	66
3	87	0	0	0	0	0
3	88	0	0	4	0	1
3	89	0	5	12	13	8
3	90	0	20	19	38	19
3	91	11	25	100	100	59
3	92	17	40	100	100	64
3	93	17	45	100	100	66
3	94	22	50	100	100	68
3	95	22	68	100	100	73
3	96	22	68	100	100	73
3	97	22	68	100	100	73
2	87	0	0	0	0	0
2	88	0	0	4	0	1
2	89	0	5	12	13	8
2	90	0	20	19	38	19
2	91	17	25	100	100	61
2	92	22	40	100	100	66
2	93	22	45	100	100	67
2	94	28	50	100	100	70
2	95	28	68	100	100	74
2	96	28	68	100	100	74
2	97	28	68	100	100	74
1	87	0	0	0	0	0
1	88	0	0	4	0	1
1	89	0	5	12	13	8
1	90	6	20	19	38	21
1	91	22	25	100	100	62
1	92	28	40	100	100	67
1	93	28	45	100	100	68
1	94	33	50	100	100	71
1	95	33	68	100	100	75
1	96	33	68	100	100	75
1	97	33	68	100	100	75

Table A-38. Estimated percent habitat available in Coffeen Lake at 1700 hours on 3 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	0	0	0
4	90	0	0	0	0	0
4	91	0	0	0	0	0
4	92	0	0	0	8	2
4	93	0	0	8	17	6
4	94	0	0	71	33	26
4	95	6	15	71	79	43
4	96	12	43	71	96	56
4	97	12	43	71	96	56
3	87	0	0	0	0	0
3	88	0	0	0	0	0
3	89	0	0	0	0	0
3	90	0	0	0	0	0
3	91	0	0	0	0	0
3	92	0	0	0	13	3
3	93	0	0	8	21	7
3	94	0	5	71	38	29
3	95	12	20	71	83	47
3	96	18	48	71	100	59
3	97	18	48	71	100	59
2	87	0	0	0	0	0
2	88	0	0	0	0	0
2	89	0	0	0	0	0
2	90	0	0	0	0	0
2	91	0	0	0	0	0
2	92	0	0	17	13	8
2	93	0	5	25	21	13
2	94	0	10	88	38	34
2	95	12	25	88	83	52
2	96	18	53	88	100	65
2	97	18	53	88	100	65
1	87	0	0	0	0	0
1	88	0	0	0	0	0
1	89	0	0	0	0	0
1	90	0	0	0	0	0
1	91	0	0	0	0	0
1	92	0	5	25	13	11
1	93	6	15	33	21	19
1	94	12	20	96	38	42
1	95	24	35	96	83	60
1	96	29	63	96	100	72
1	97	29	63	96	100	72

Table A-39. Estimated percent habitat available in Coffeen Lake at 1300 hours on 10 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	0	0	0
4	88	0	0	0	0	0
4	89	0	0	4	0	1
4	90	0	0	4	0	1
4	91	0	10	4	0	4
4	92	0	15	25	100	35
4	93	0	30	100	100	58
4	94	0	58	100	100	65
4	95	0	58	100	100	65
4	96	0	58	100	100	65
4	97	0	58	100	100	65
3	87	0	0	0	0	0
3	88	0	0	0	0	0
3	89	0	0	4	0	1
3	90	0	0	4	0	1
3	91	0	20	4	0	6
3	92	0	25	25	100	38
3	93	0	40	100	100	60
3	94	0	68	100	100	67
3	95	0	68	100	100	67
3	96	0	68	100	100	67
3	97	6	68	100	100	69
2	87	0	0	0	0	0
2	88	0	0	0	0	0
2	89	0	0	4	0	1
2	90	0	5	4	0	2
2	91	0	25	4	0	7
2	92	0	30	25	100	39
2	93	0	45	100	100	61
2	94	0	73	100	100	68
2	95	0	73	100	100	68
2	96	0	73	100	100	68
2	97	6	73	100	100	70
1	87	0	0	0	0	0
1	88	0	0	0	0	0
1	89	0	0	4	0	1
1	90	0	5	4	0	2
1	91	0	25	4	0	7
1	92	22	30	25	100	44
1	93	28	45	100	100	68
1	94	28	73	100	100	75
1	95	28	73	100	100	75
1	96	28	73	100	100	75
1	97	33	73	100	100	77

Table A-40. Estimated percent habitat available in Coffeen Lake at 1600 hours on 18 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	4	0	1
4	88	0	10	4	13	7
4	89	0	15	100	71	47
4	90	0	45	100	100	61
4	91	0	68	100	100	67
4	92	0	68	100	100	67
4	93	0	68	100	100	67
4	94	0	68	100	100	67
4	95	0	68	100	100	67
4	96	0	68	100	100	67
4	97	6	68	100	100	69
3	87	0	0	4	0	1
3	88	0	15	4	13	8
3	89	6	20	100	71	49
3	90	11	50	100	100	65
3	91	11	73	100	100	71
3	92	17	73	100	100	73
3	93	17	73	100	100	73
3	94	17	73	100	100	73
3	95	17	73	100	100	73
3	96	17	73	100	100	73
3	97	22	73	100	100	74
2	87	0	10	4	0	4
2	88	0	25	4	13	11
2	89	22	30	100	71	56
2	90	28	60	100	100	72
2	91	28	83	100	100	78
2	92	33	83	100	100	79
2	93	33	83	100	100	79
2	94	33	83	100	100	79
2	95	33	83	100	100	79
2	96	33	83	100	100	79
2	97	39	83	100	100	81
1	87	0	10	4	0	4
1	88	0	25	4	13	11
1	89	22	30	100	71	56
1	90	28	60	100	100	72
1	91	28	83	100	100	78
1	92	33	83	100	100	79
1	93	33	83	100	100	79
1	94	33	83	100	100	79
1	95	33	83	100	100	79
1	96	33	83	100	100	79
1	97	39	83	100	100	81

Table A-41. Estimated percent habitat available in Coffeen Lake at 1500 hours on 24 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	4	0	1
4	88	0	0	4	8	3
4	89	12	0	4	17	8
4	90	24	5	8	42	20
4	91	24	11	25	58	30
4	92	24	16	100	96	59
4	93	24	16	100	96	59
4	94	29	16	100	96	60
4	95	29	21	100	96	62
4	96	29	45	100	96	68
4	97	29	45	100	96	68
3	87	0	0	4	0	1
3	88	0	5	4	8	4
3	89	12	11	4	17	11
3	90	24	16	8	42	23
3	91	24	21	25	58	32
3	92	24	26	100	96	62
3	93	24	26	100	96	62
3	94	29	26	100	96	63
3	95	29	32	100	96	64
3	96	29	55	100	96	70
3	97	29	55	100	96	70
2	87	0	0	4	0	1
2	88	0	16	4	8	7
2	89	12	21	4	17	14
2	90	24	26	8	42	25
2	91	24	32	25	58	35
2	92	24	37	100	96	64
2	93	24	37	100	96	64
2	94	29	37	100	96	66
2	95	29	42	100	96	67
2	96	29	66	100	96	73
2	97	29	66	100	96	73
1	87	0	0	4	4	2
1	88	0	16	4	13	8
1	89	12	21	4	21	15
1	90	24	26	8	46	26
1	91	29	32	25	63	37
1	92	29	37	100	100	67
1	93	29	37	100	100	67
1	94	35	37	100	100	68
1	95	35	42	100	100	69
1	96	35	66	100	100	75
1	97	35	66	100	100	75

Table A-42. Estimated percent habitat available in Coffeen Lake at 1900 hours on 30 August 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	10	13	13	9
4	88	0	25	67	21	28
4	89	0	30	100	38	42
4	90	0	30	100	100	58
4	91	0	30	100	100	58
4	92	6	35	100	100	60
4	93	6	40	100	100	62
4	94	6	63	100	100	67
4	95	6	63	100	100	67
4	96	6	63	100	100	67
4	97	6	63	100	100	67
3	87	0	15	13	13	10
3	88	0	30	67	21	30
3	89	0	35	100	38	43
3	90	0	45	100	100	61
3	91	6	45	100	100	63
3	92	13	50	100	100	66
3	93	13	55	100	100	67
3	94	13	78	100	100	73
3	95	13	78	100	100	73
3	96	13	78	100	100	73
3	97	13	78	100	100	73
2	87	0	15	13	13	10
2	88	0	30	67	21	30
2	89	0	35	100	38	43
2	90	6	45	100	100	63
2	91	13	45	100	100	65
2	92	19	50	100	100	67
2	93	19	55	100	100	69
2	94	19	78	100	100	74
2	95	19	78	100	100	74
2	96	19	78	100	100	74
2	97	19	78	100	100	74
1	87	0	15	13	13	10
1	88	0	30	67	21	30
1	89	0	35	100	38	43
1	90	13	45	100	100	65
1	91	19	45	100	100	66
1	92	25	50	100	100	69
1	93	25	55	100	100	70
1	94	25	78	100	100	76
1	95	25	78	100	100	76
1	96	25	78	100	100	76
1	97	25	78	100	100	76

Table A-43. Estimated percent habitat available in Coffeen Lake at 1500 hours on 6 September 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

Minimum oxygen (ppm)	Maximum temperature (°F)	Percent habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	40	46	58	36
4	88	12	45	54	75	47
4	89	12	45	71	83	53
4	90	18	45	79	83	56
4	91	18	50	88	96	63
4	92	18	55	96	96	66
4	93	18	55	100	96	67
4	94	18	55	100	96	67
4	95	18	55	100	96	67
4	96	18	68	100	96	71
4	97	24	68	100	96	72
3	87	0	45	46	58	37
3	88	12	50	54	75	48
3	89	12	50	71	83	54
3	90	18	50	79	83	58
3	91	18	55	88	96	64
3	92	18	60	96	96	68
3	93	18	60	100	96	69
3	94	18	60	100	96	69
3	95	18	60	100	96	69
3	96	18	73	100	96	72
3	97	24	73	100	96	73
2	87	6	50	46	58	40
2	88	18	55	54	75	51
2	89	18	55	71	83	57
2	90	24	55	79	83	60
2	91	24	60	88	96	67
2	92	24	65	96	96	70
2	93	24	65	100	96	71
2	94	24	65	100	96	71
2	95	24	65	100	96	71
2	96	24	78	100	96	75
2	97	29	78	100	96	76
1	87	12	55	46	58	43
1	88	24	60	54	75	53
1	89	24	60	71	83	60
1	90	29	60	79	83	63
1	91	29	65	88	96	70
1	92	29	70	96	96	73
1	93	29	70	100	96	74
1	94	29	70	100	96	74
1	95	29	70	100	96	74
1	96	29	83	100	96	77
1	97	35	83	100	96	79

Table A-44. Estimated percent habitat available in Coffeen Lake at 1500 hours on 12 September 2006. Habitat was considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	0	21	13	9
4	88	0	16	21	21	15
4	89	6	21	50	38	29
4	90	12	37	100	75	56
4	91	18	37	100	100	64
4	92	18	37	100	100	64
4	93	18	66	100	100	71
4	94	18	66	100	100	71
4	95	24	66	100	100	73
4	96	24	66	100	100	73
4	97	24	66	100	100	73
3	87	0	0	21	13	9
3	88	0	16	21	21	15
3	89	12	21	50	38	30
3	90	18	37	100	75	58
3	91	24	37	100	100	65
3	92	24	37	100	100	65
3	93	24	66	100	100	73
3	94	24	66	100	100	73
3	95	29	66	100	100	74
3	96	29	66	100	100	74
3	97	29	66	100	100	74
2	87	0	5	21	13	10
2	88	6	21	21	21	17
2	89	18	26	50	38	33
2	90	24	42	100	75	60
2	91	29	42	100	100	68
2	92	29	42	100	100	68
2	93	29	71	100	100	75
2	94	29	71	100	100	75
2	95	35	71	100	100	77
2	96	35	71	100	100	77
2	97	35	71	100	100	77
1	87	0	5	21	13	10
1	88	6	21	21	21	17
1	89	18	26	50	38	33
1	90	24	42	100	75	60
1	91	29	42	100	100	68
1	92	29	42	100	100	68
1	93	29	71	100	100	75
1	94	29	71	100	100	75
1	95	35	71	100	100	77
1	96	35	71	100	100	77
1	97	35	71	100	100	77

Table A-45. Estimated percent habitat available in Coffeen Lake at 1700 hours on 19 September 2006. Habitat was considered available if it contained no less than the minimum oxygen o no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	0	63	100	100	66
4	88	0	63	100	100	66
4	89	0	63	100	100	66
4	90	0	63	100	100	66
4	91	0	63	100	100	66
4	92	0	63	100	100	66
4	93	0	63	100	100	66
4	94	0	63	100	100	66
4	95	6	63	100	100	67
4	96	13	63	100	100	69
4	97	13	63	100	100	69
3	87	6	63	100	100	67
3	88	6	63	100	100	67
3	89	13	63	100	100	69
3	90	13	63	100	100	69
3	91	13	63	100	100	69
3	92	13	63	100	100	69
3	93	13	63	100	100	69
3	94	13	63	100	100	69
3	95	19	63	100	100	71
3	96	25	63	100	100	72
3	97	25	63	100	100	72
2	87	13	68	100	100	70
2	88	13	68	100	100	70
2	89	19	68	100	100	72
2	90	19	68	100	100	72
2	91	19	68	100	100	72
2	92	19	68	100	100	72
2	93	19	68	100	100	72
2	94	19	68	100	100	72
2	95	25	68	100	100	73
2	96	31	68	100	100	75
2	97	31	68	100	100	75
1	87	25	68	100	100	73
1	88	25	68	100	100	73
1	89	31	68	100	100	75
1	90	31	68	100	100	75
1	91	31	68	100	100	75
1	92	31	68	100	100	75
1	93	31	68	100	100	75
1	94	31	68	100	100	75
1	95	38	68	100	100	77
1	96	44	68	100	100	78
1	97	44	68	100	100	78

Table A-46. Estimated percent habitat available in Coffeen Lake at 1800 hours on 28 September 2006. Habitat as considered available if it contained no less than the minimum oxygen o no more than the maximum temperature indicated. Segment numbers correspond to areas sampled immediately outside discharge mixung zone (1) to intake area (4).

		Percent habitat available				
Minimum oxygen (ppm)	Maximum temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	Mean
4	87	100	100	100	100	100
4	88	100	100	100	100	100
4	89	100	100	100	100	100
4	90	100	100	100	100	100
4	91	100	100	100	100	100
4	92	100	100	100	100	100
4	93	100	100	100	100	100
4	94	100	100	100	100	100
4	95	100	100	100	100	100
4	96	100	100	100	100	100
4	97	100	100	100	100	100
3	87	100	100	100	100	100
3	88	100	100	100	100	100
3	89	100	100	100	100	100
3	90	100	100	100	100	100
3	91	100	100	100	100	100
3	92	100	100	100	100	100
3	93	100	100	100	100	100
3	94	100	100	100	100	100
3	95	100	100	100	100	100
3	96	100	100	100	100	100
3	97	100	100	100	100	100
2	87	100	100	100	100	100
2	88	100	100	100	100	100
2	89	100	100	100	100	100
2	90	100	100	100	100	100
2	91	100	100	100	100	100
2	92	100	100	100	100	100
2	93	100	100	100	100	100
2	94	100	100	100	100	100
2	95	100	100	100	100	100
2	96	100	100	100	100	100
2	97	100	100	100	100	100
1	87	100	100	100	100	100
1	88	100	100	100	100	100
1	89	100	100	100	100	100
1	90	100	100	100	100	100
1	91	100	100	100	100	100
1	92	100	100	100	100	100
1	93	100	100	100	100	100
1	94	100	100	100	100	100
1	95	100	100	100	100	100
1	96	100	100	100	100	100
1	97	100	100	100	100	100

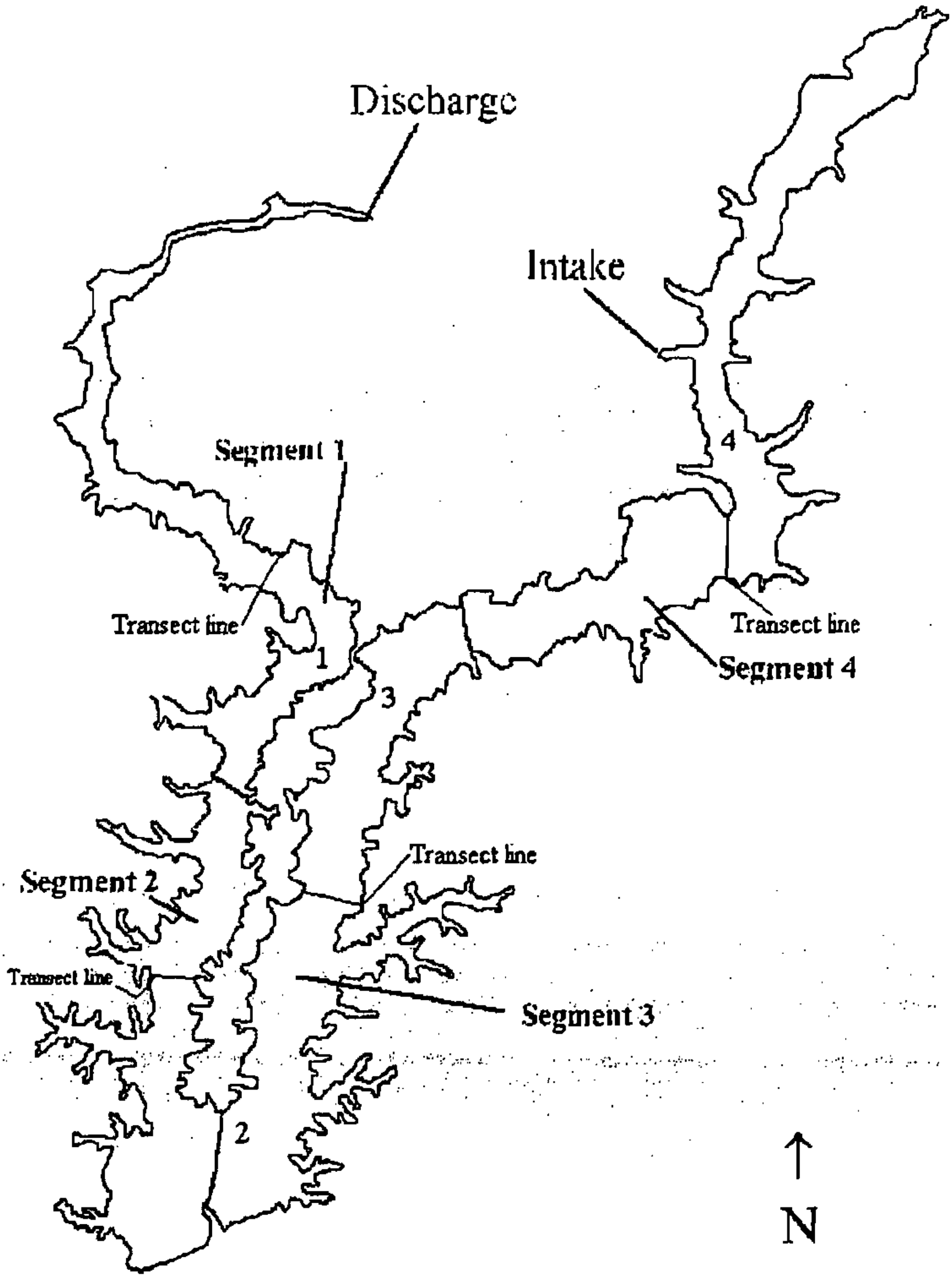


Figure A-1. Four segments in Newton Lake where water temperature and dissolved oxygen were sampled. Data were collected weekly at each transect line from May 2006 through September 200. Numbers in lake boundaries represent locations of continuous temperature recorders set during same periods.

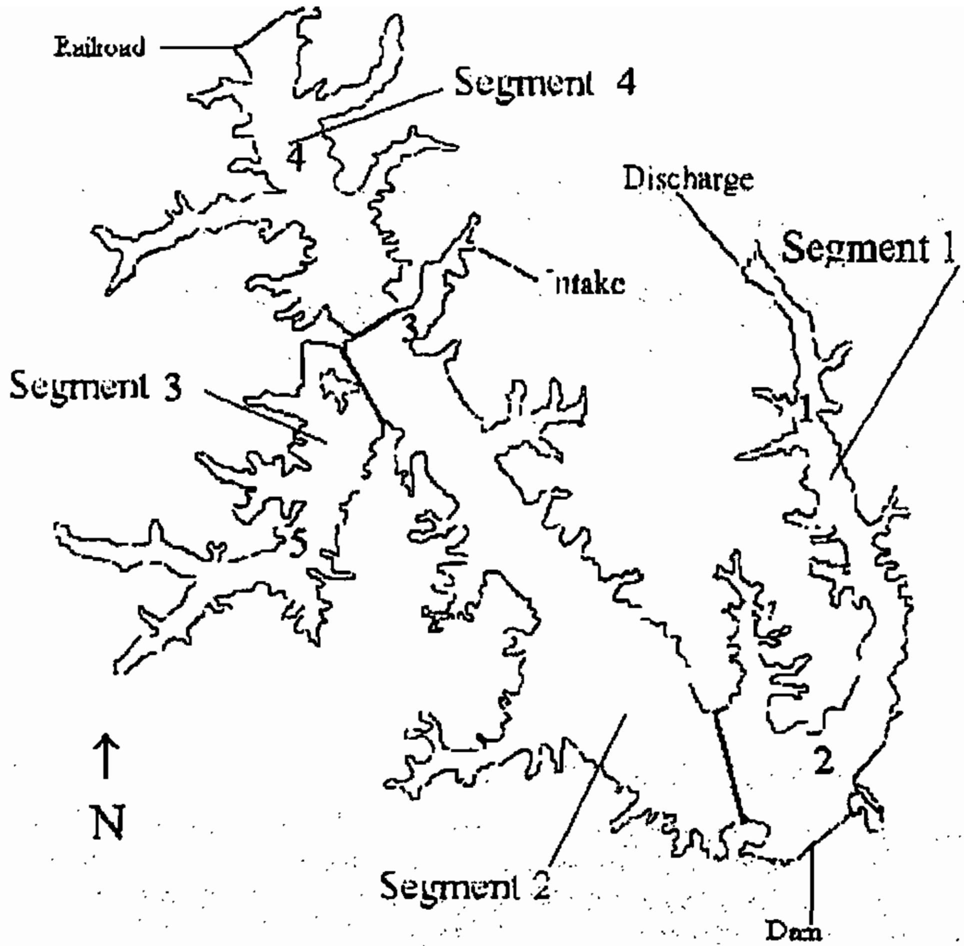


Figure A-2. Four segments in Coffeen Lake where water temperature and dissolved oxygen were sampled. Data were collected weekly at each segment number from May 2006 through September 2006. Numbers in lake boundaries represent locations of continuous temperature recorders set during same periods.

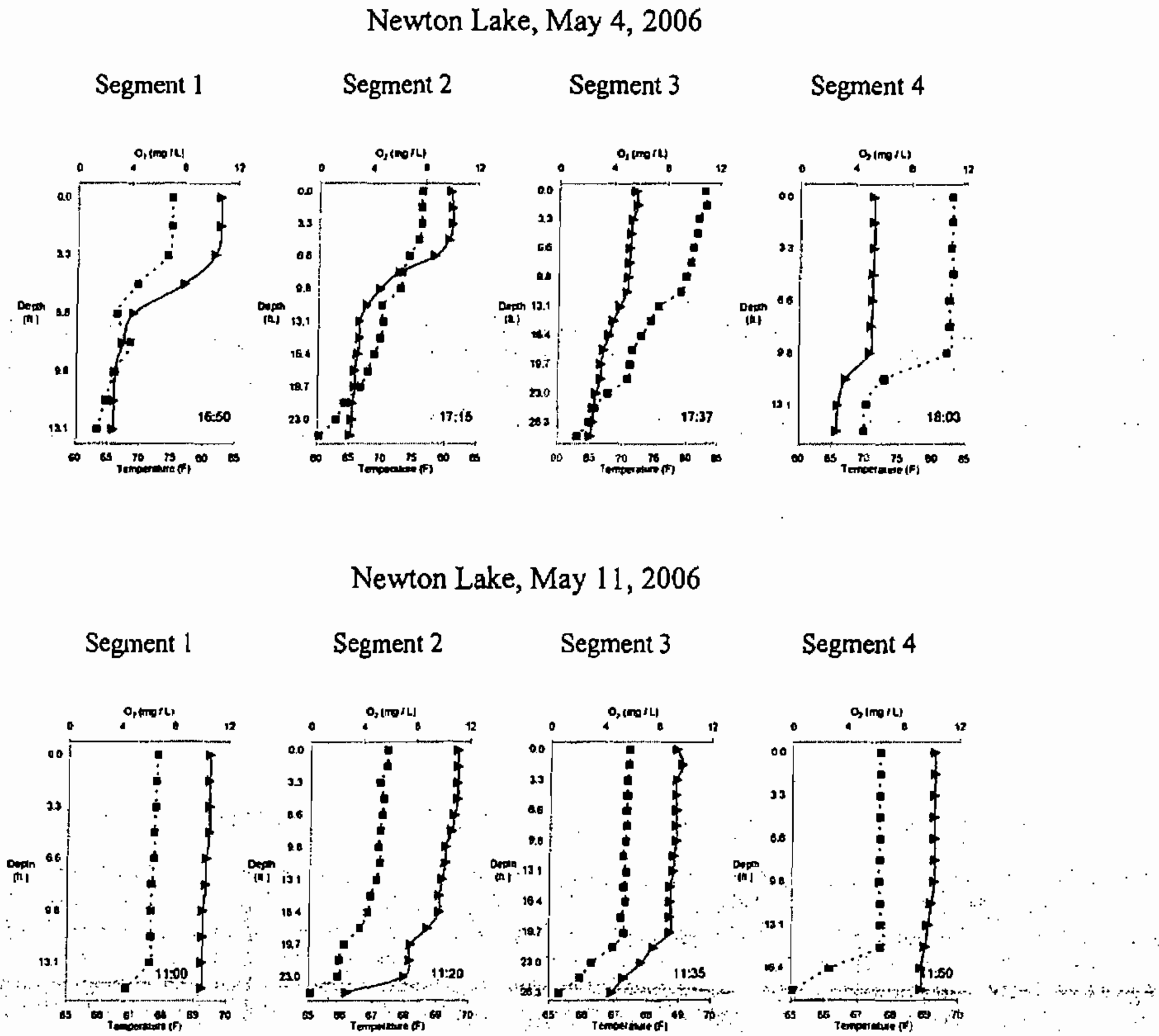


Figure A-3. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

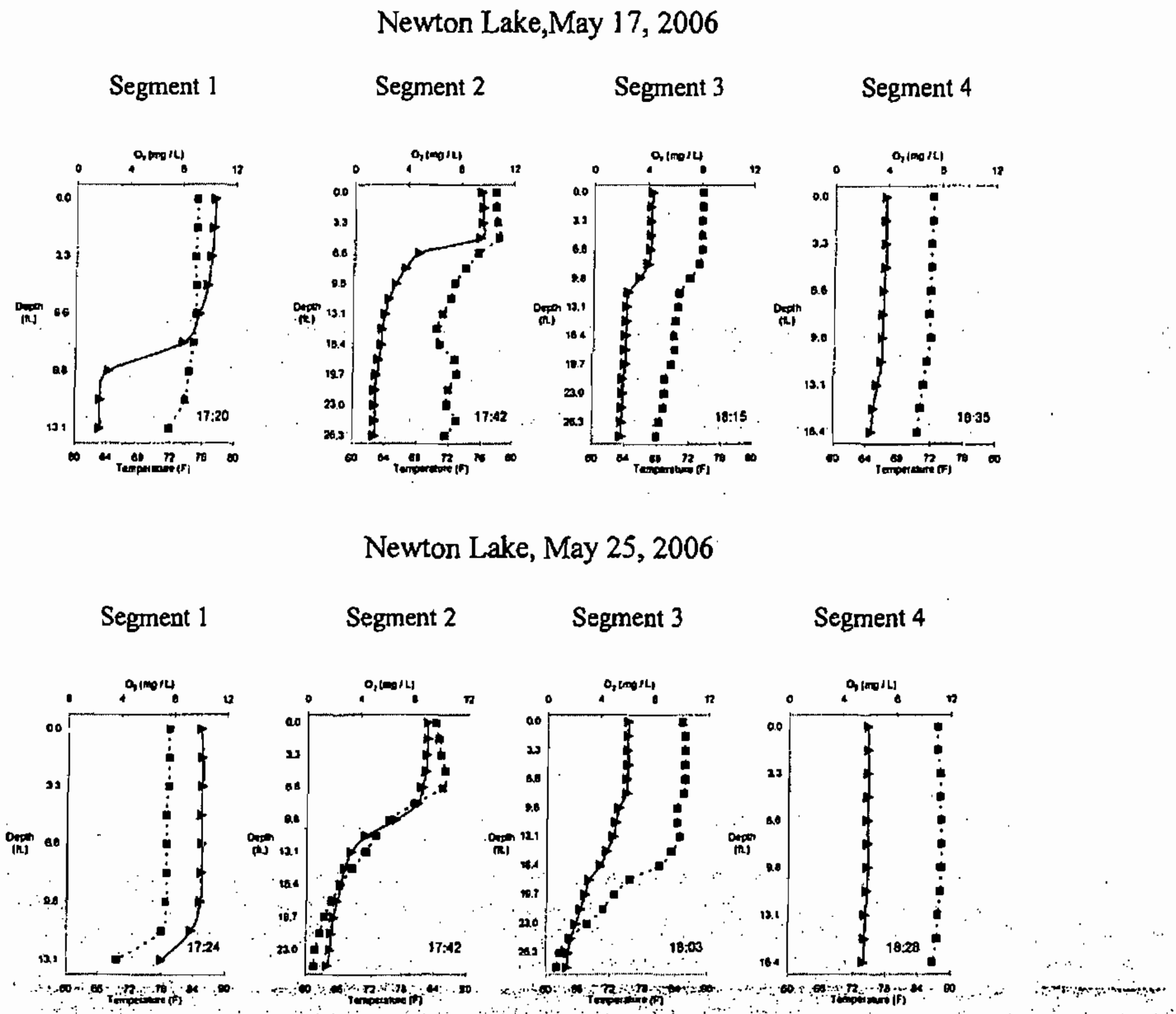


Figure A-3. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

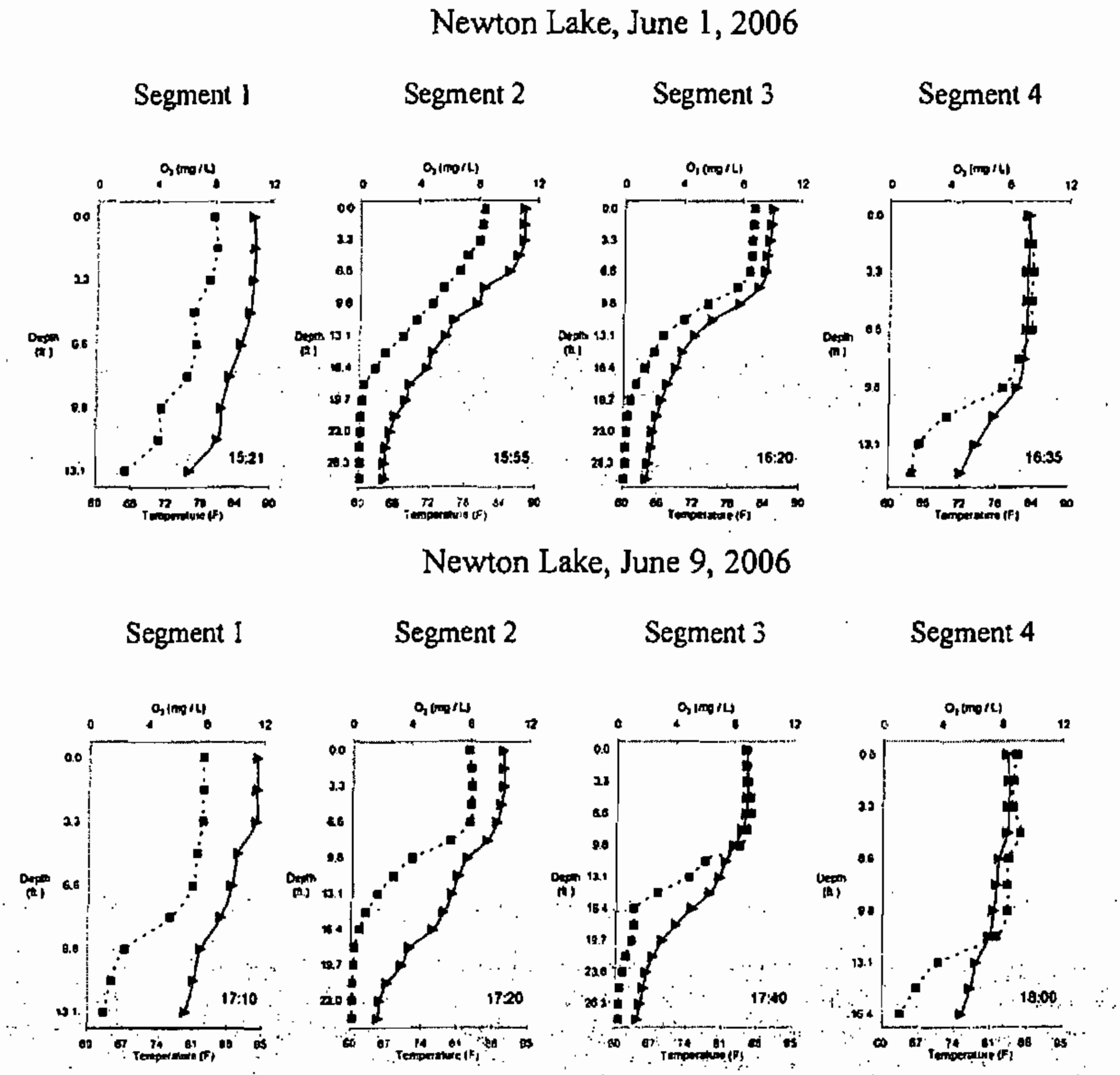
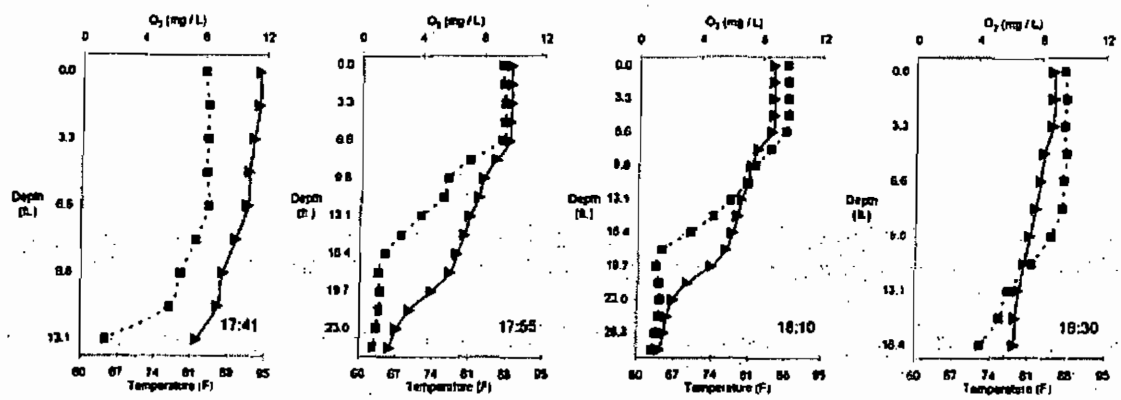


Figure A-3. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Newton Lake, June 15, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Newton Lake, June 22, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

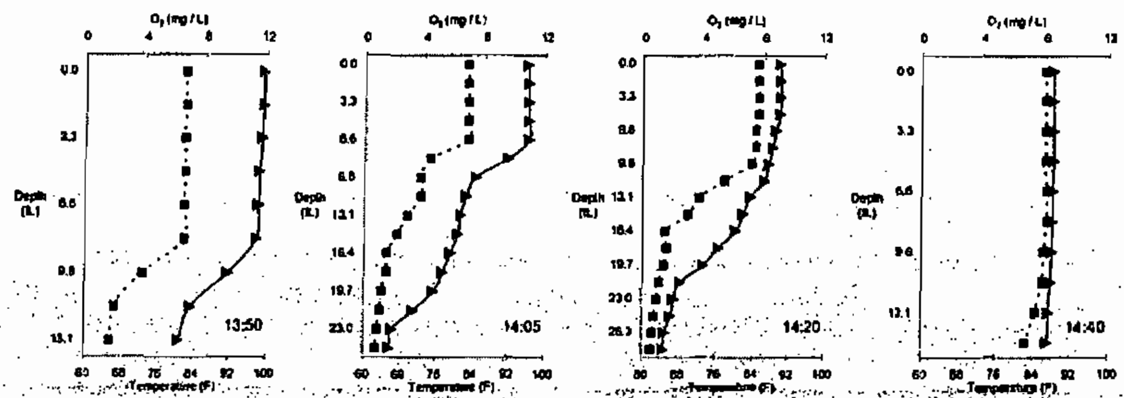


Figure A-4. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

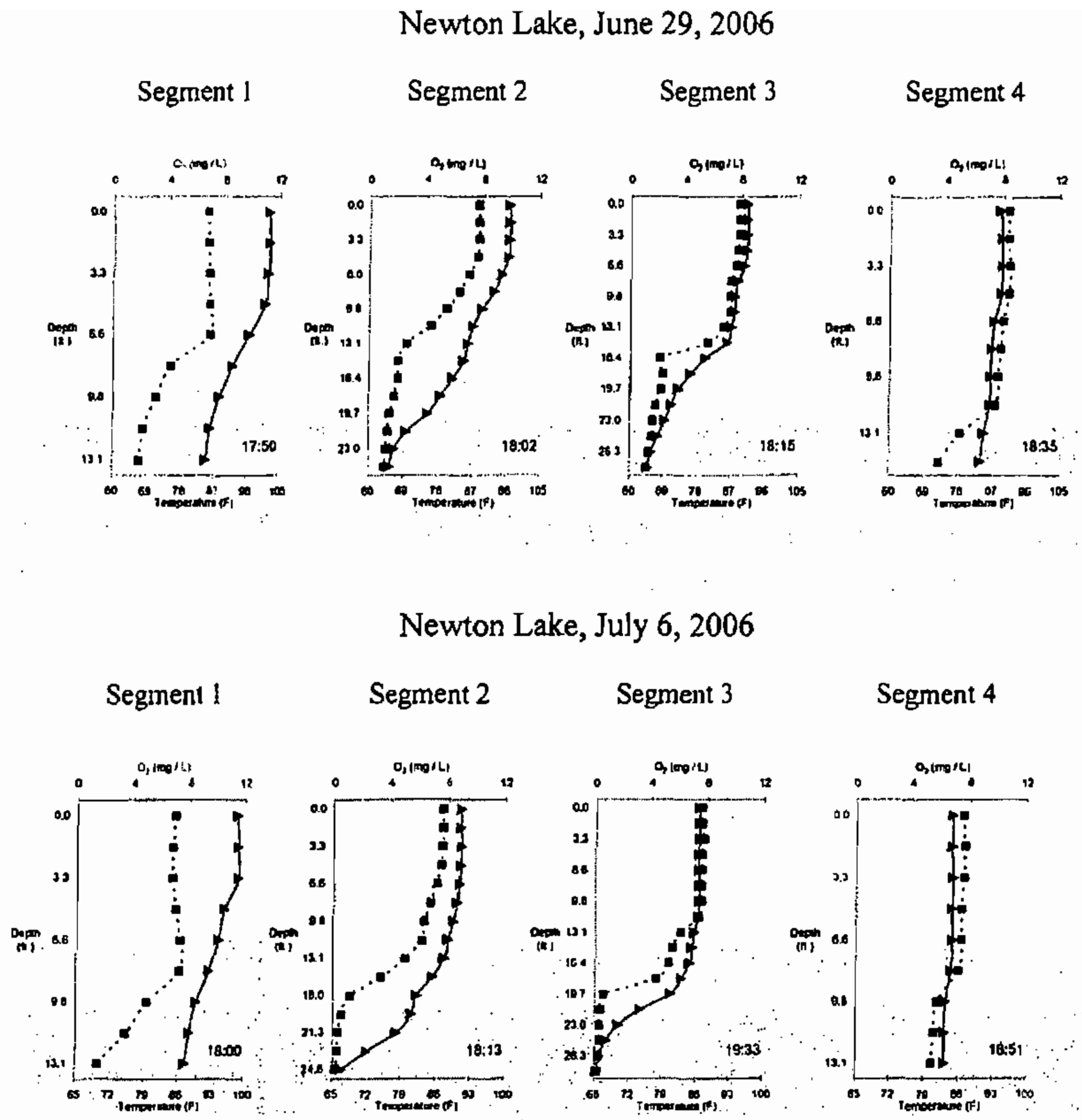


Figure A-5. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

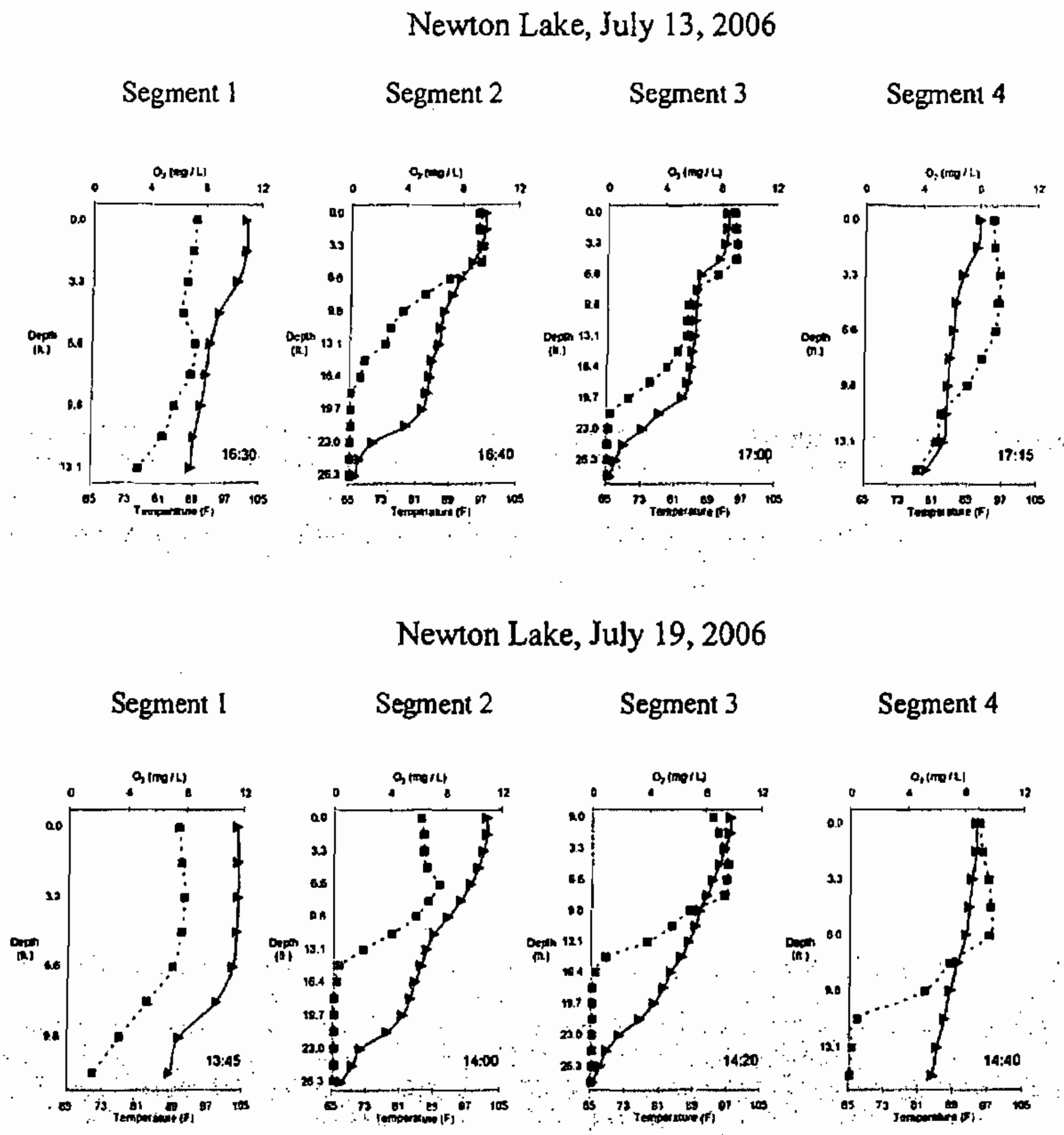


Figure A-6. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

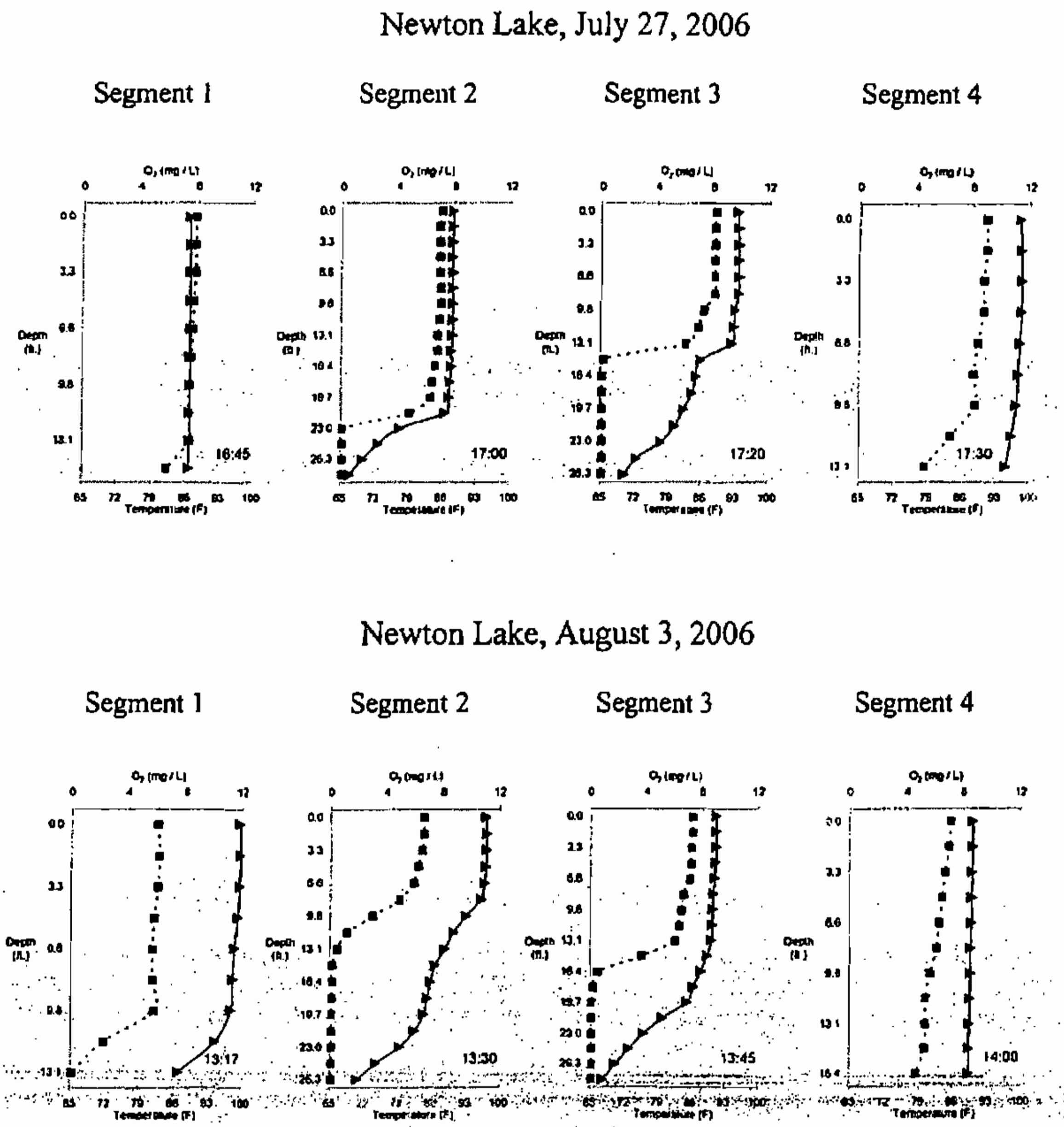
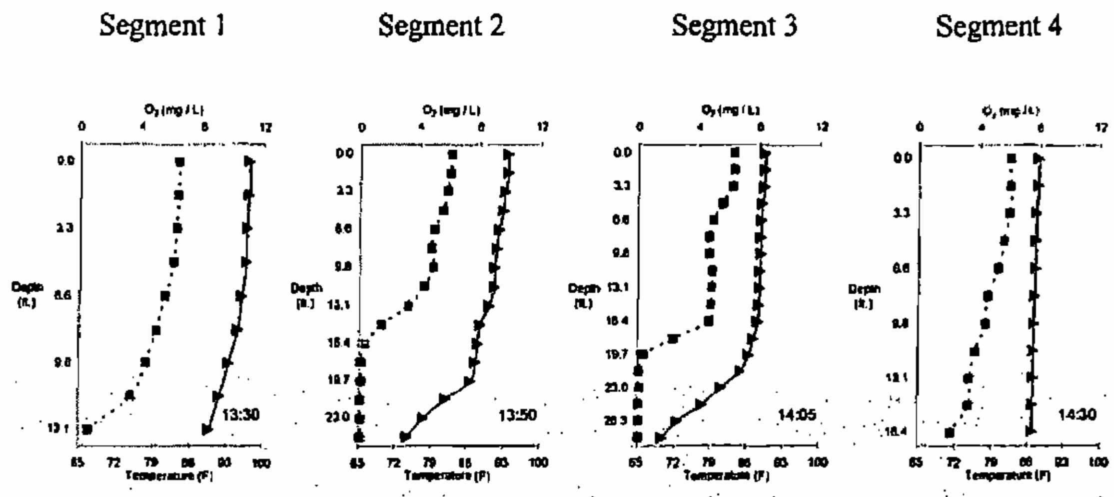


Figure A-7. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Newton Lake, August 11, 2006



Newton Lake, August 19, 2006

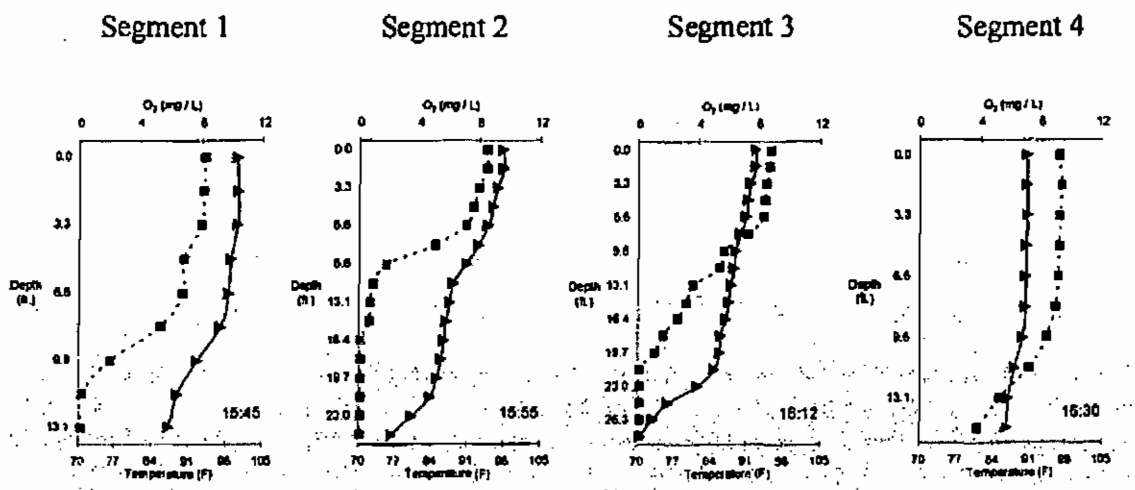


Figure A-8. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

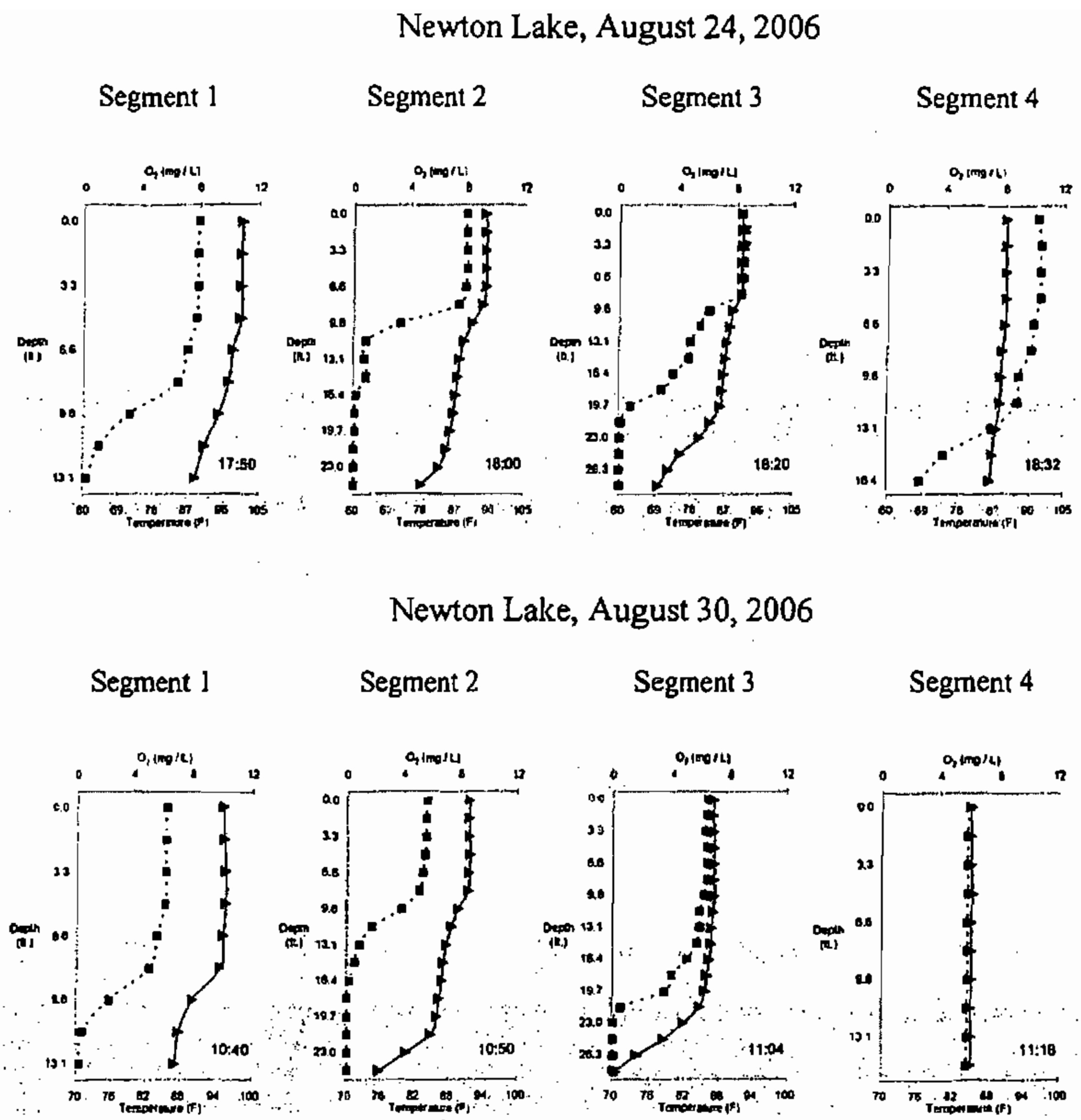


Figure A-9. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

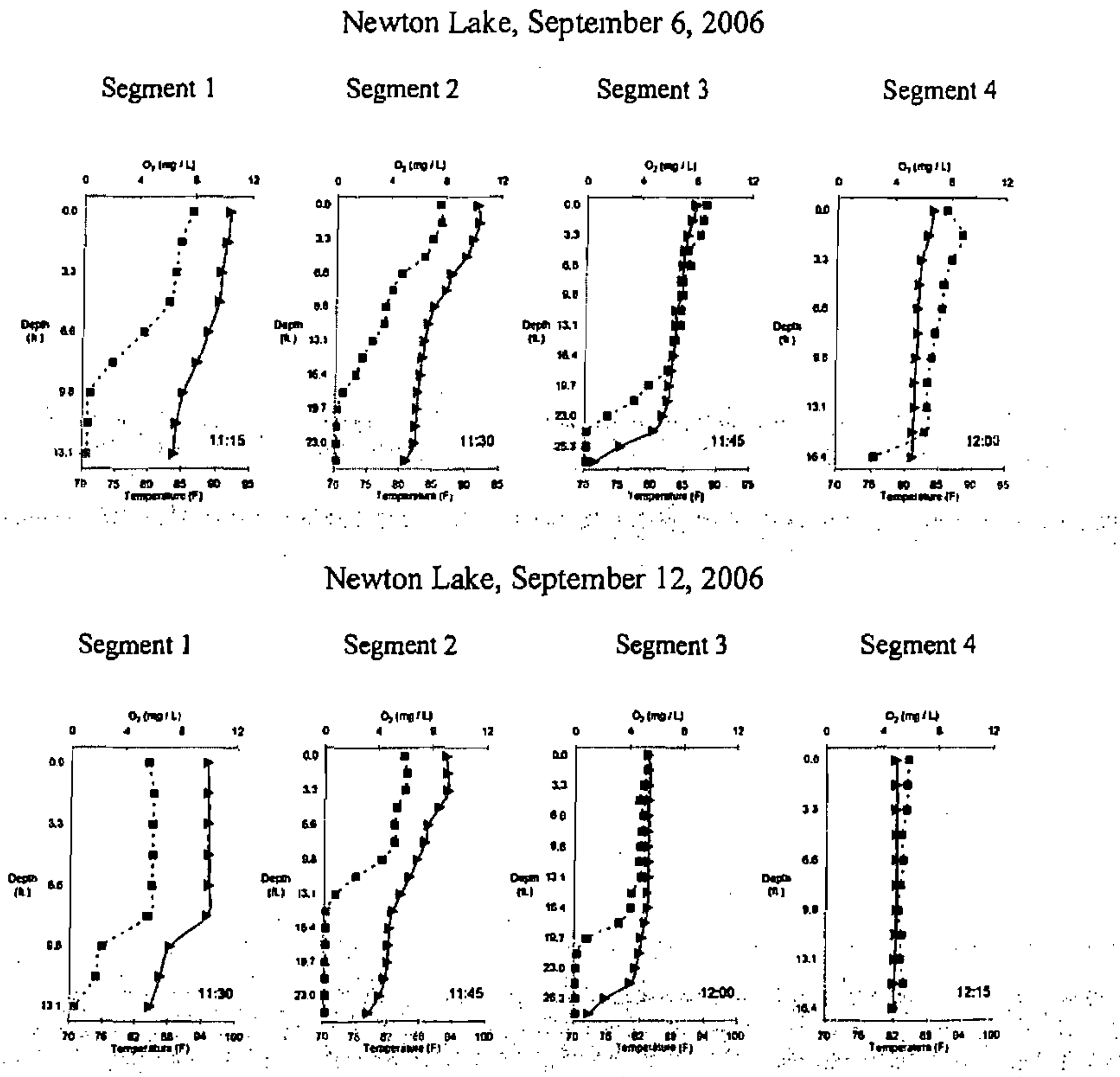


Figure A-10. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

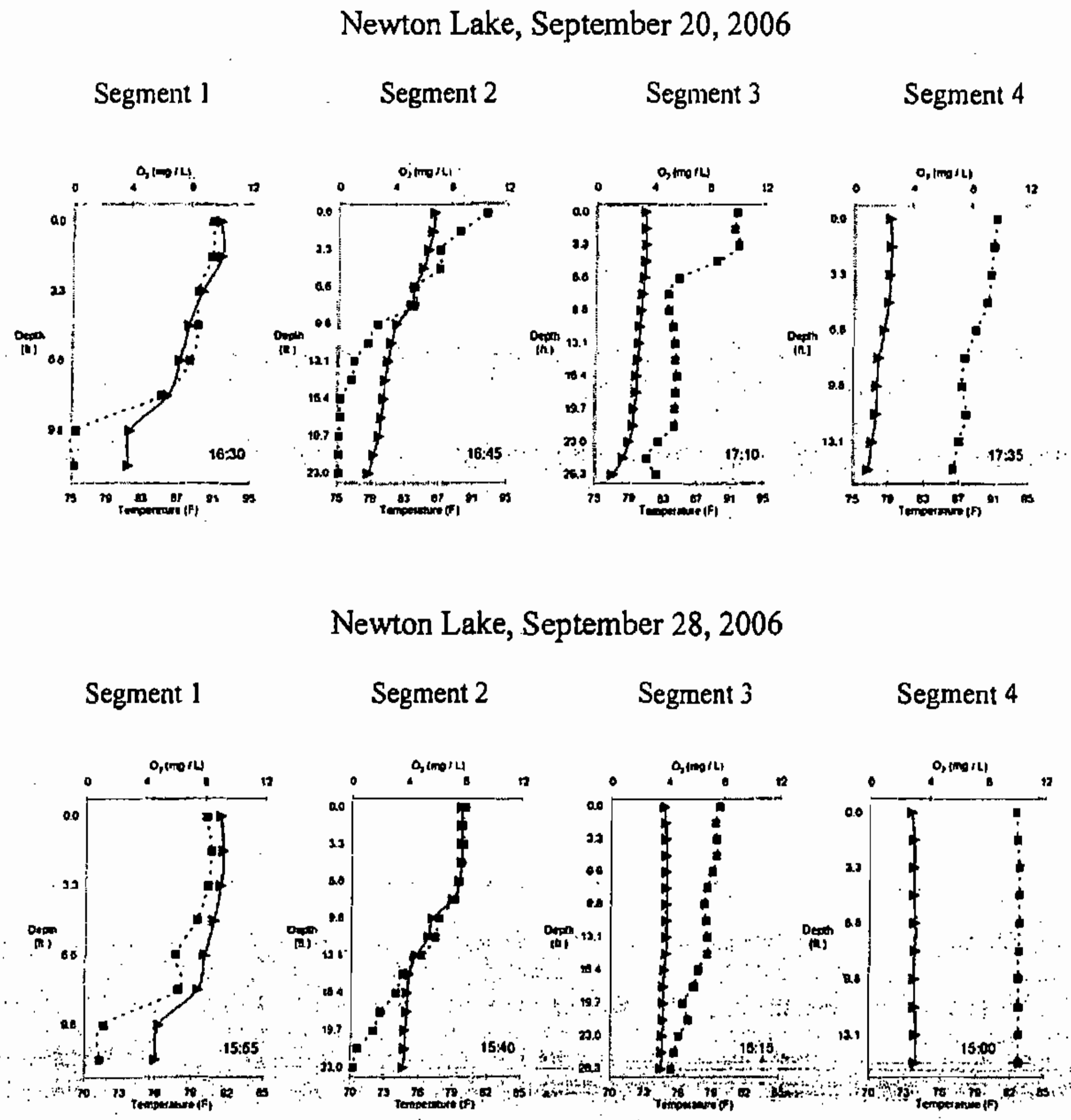


Figure A-11. Temperature and dissolved oxygen profiles in 4 segments of Newton Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

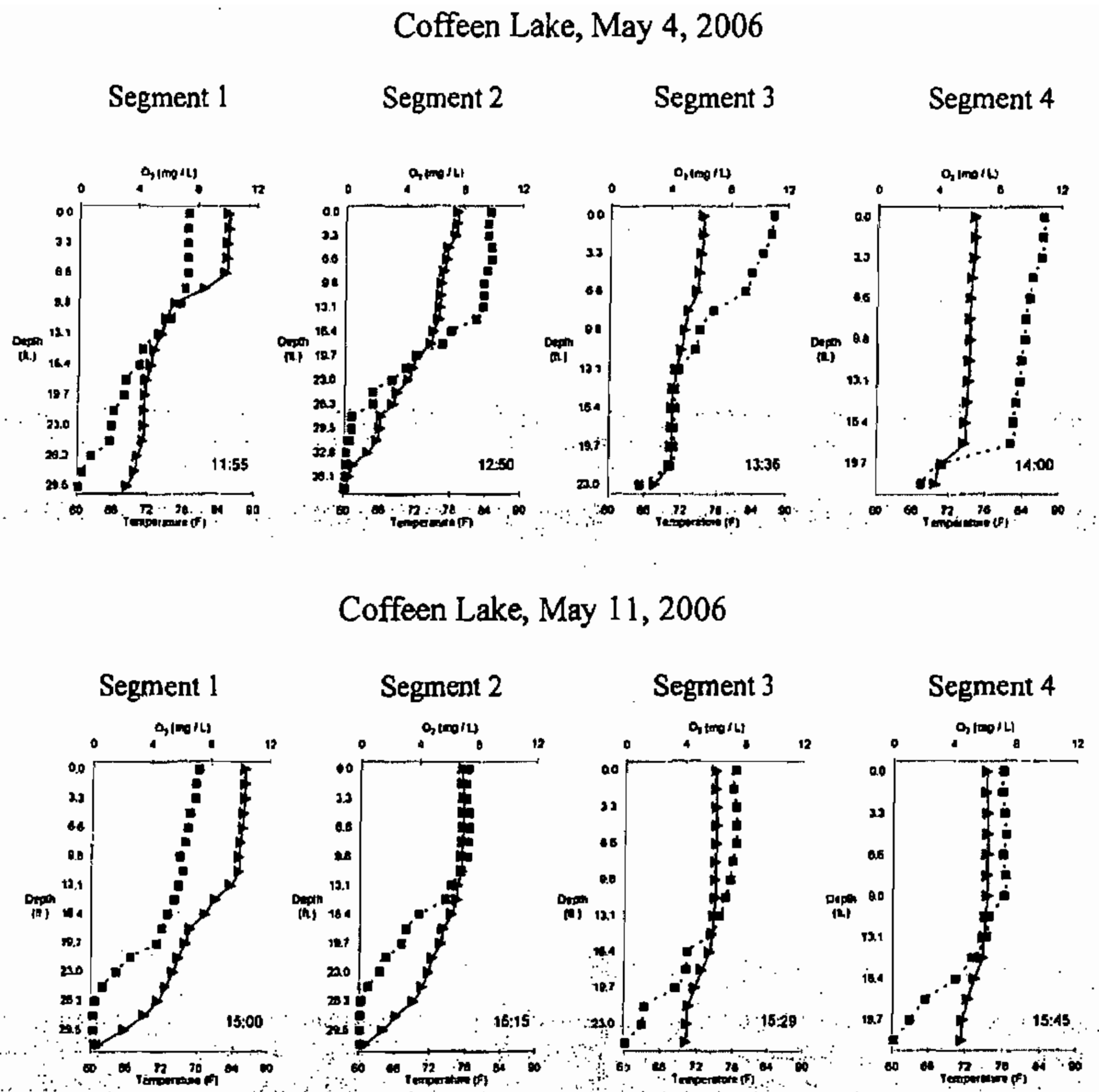


Figure A-12. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

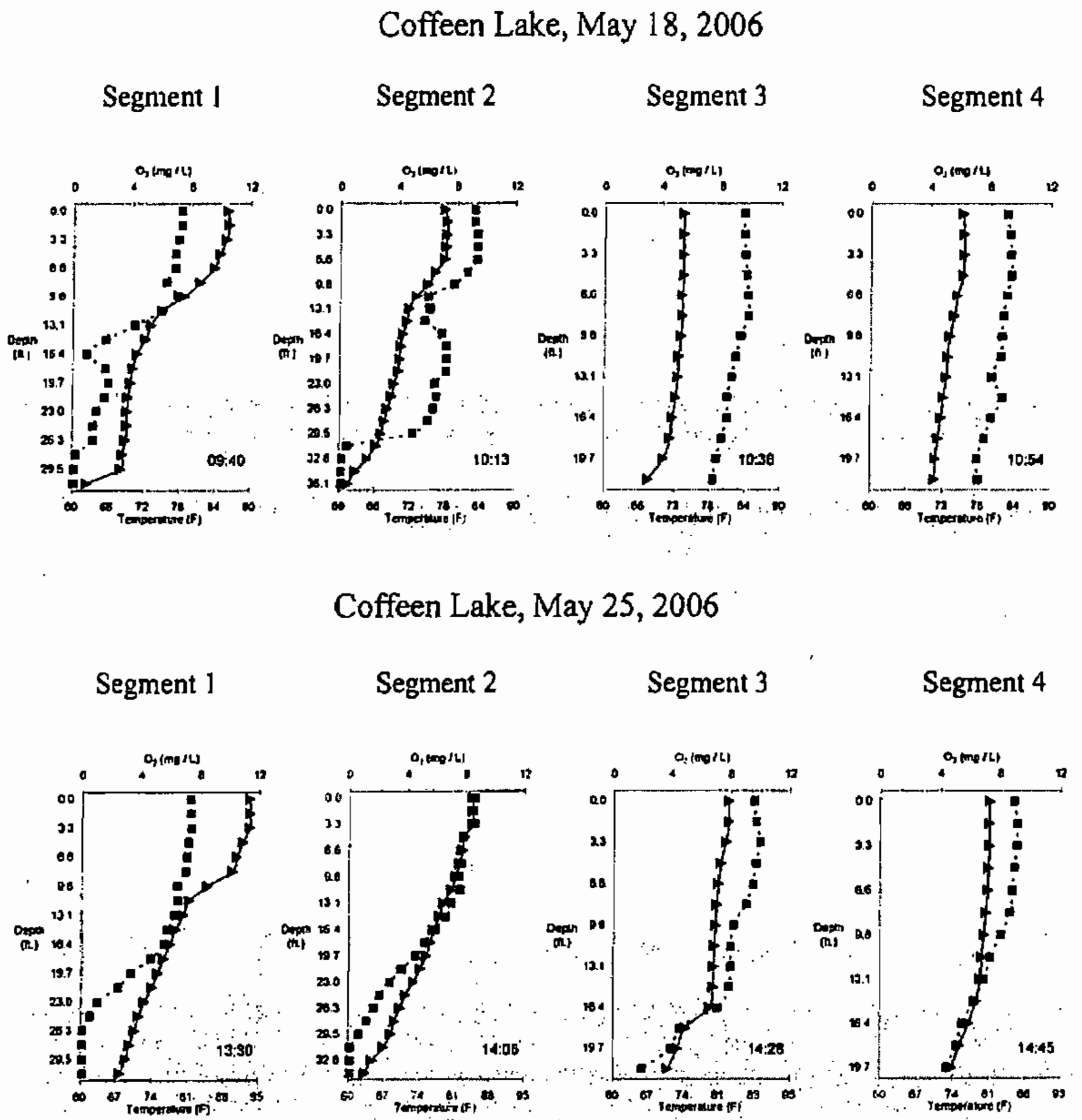


Figure A-12. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

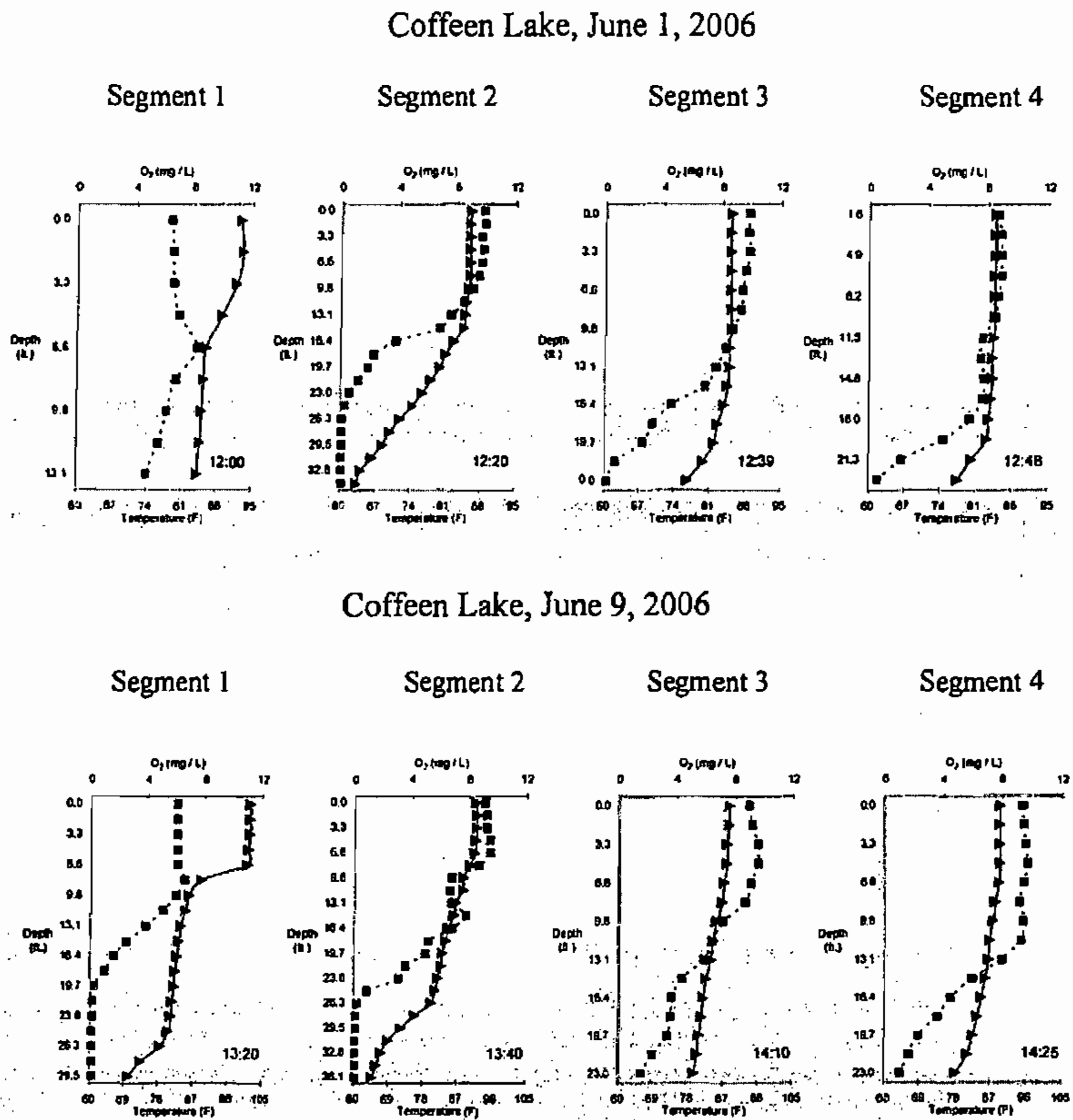
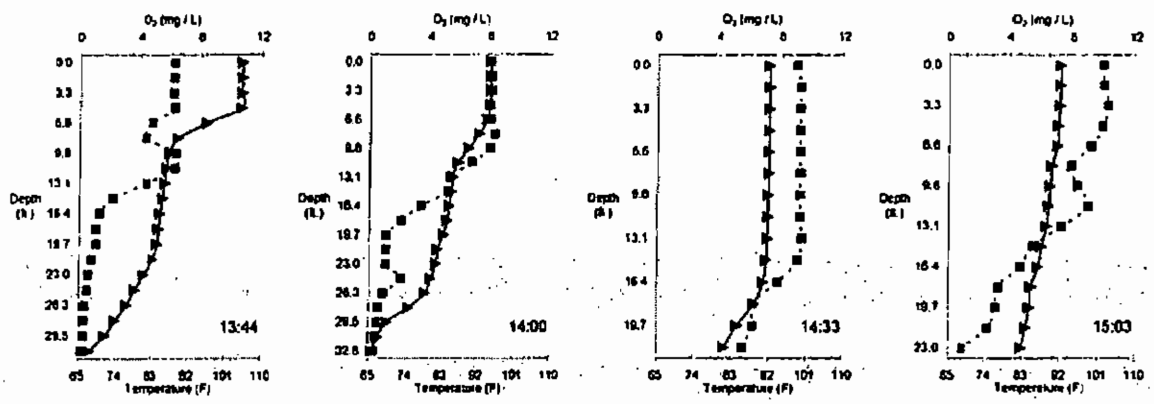


Figure A-12. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, June 15, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Coffeen Lake, June 22, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

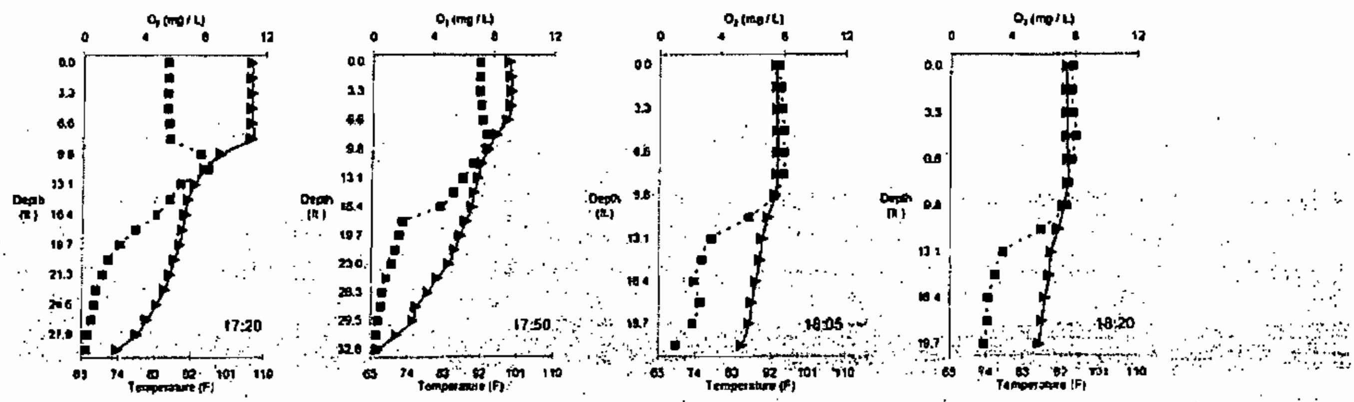


Figure A-13. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

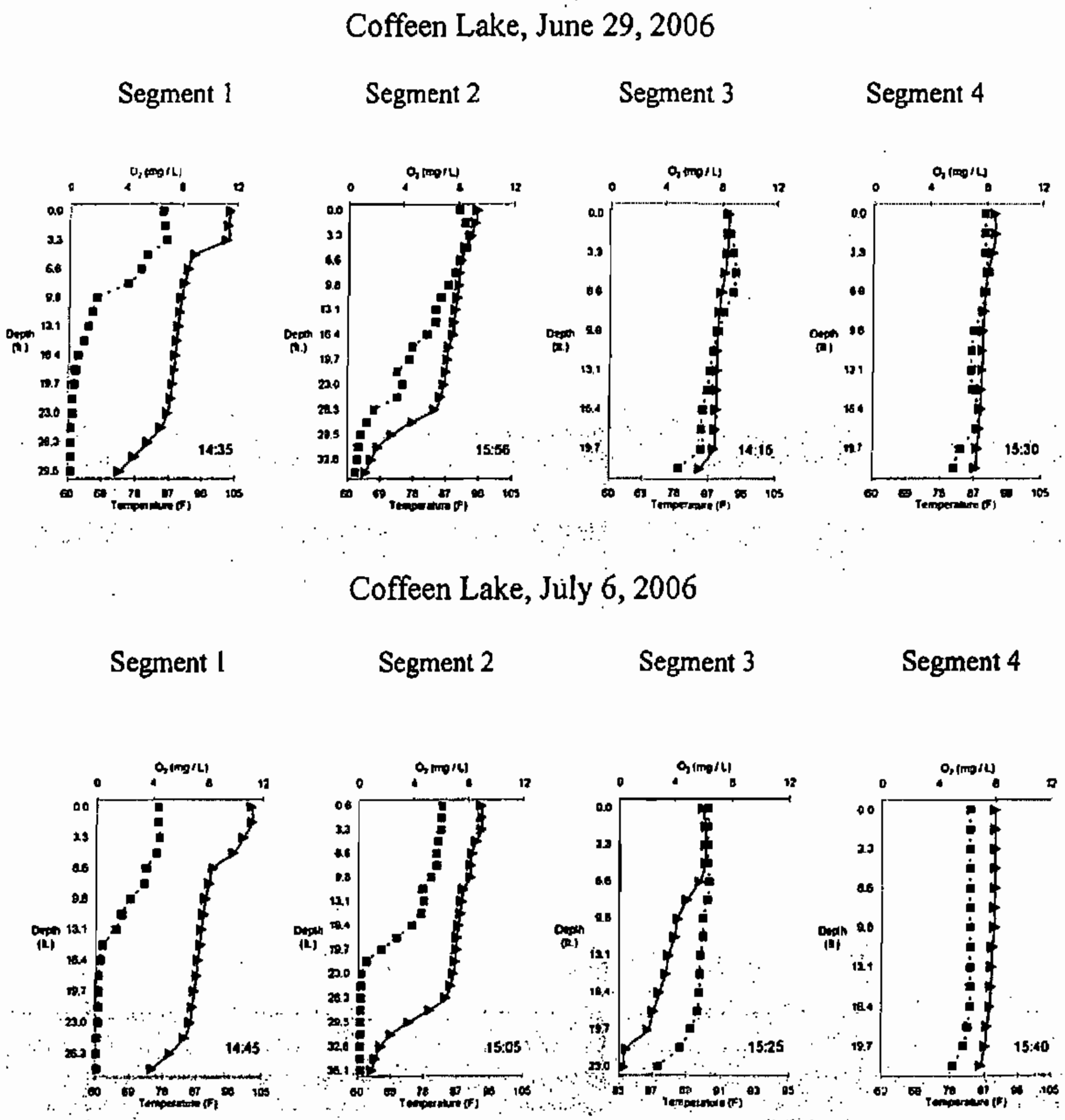
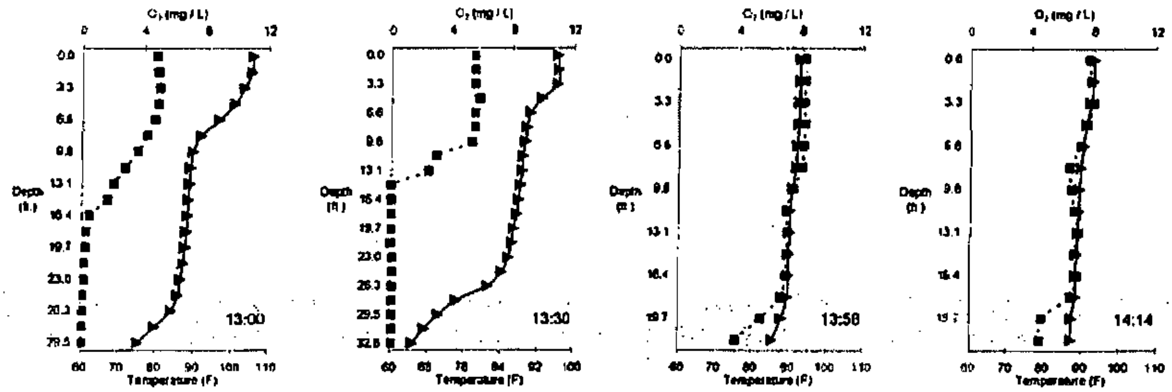


Figure A-14. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, July 13, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Coffeen Lake, July 19, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

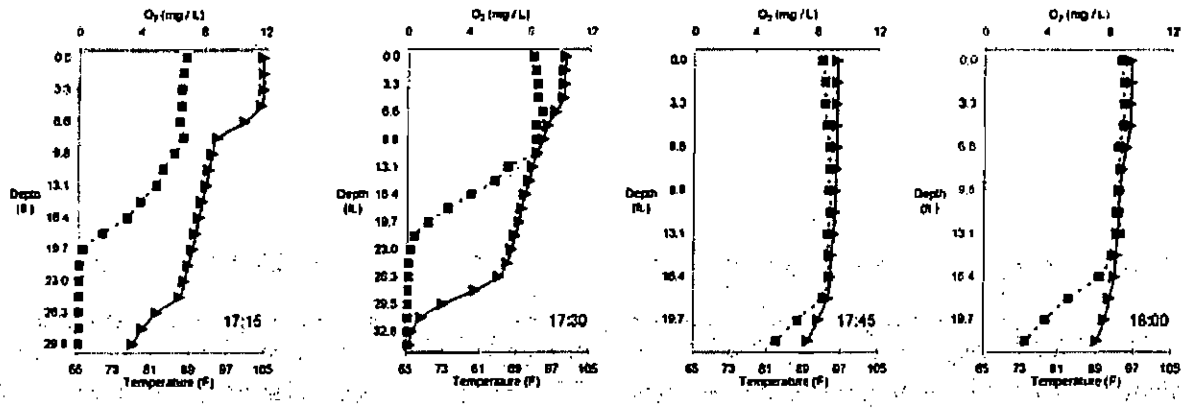
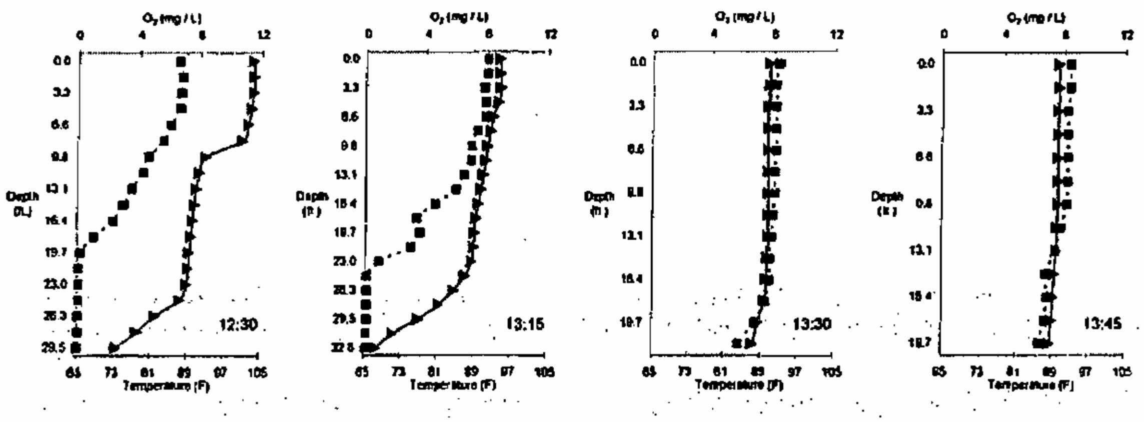


Figure A-15. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, July 27, 2006

Segment 1 Segment 2 Segment 3 Segment 4



Coffeen Lake, August 3, 2006

Segment 1 Segment 2 Segment 3 Segment 4

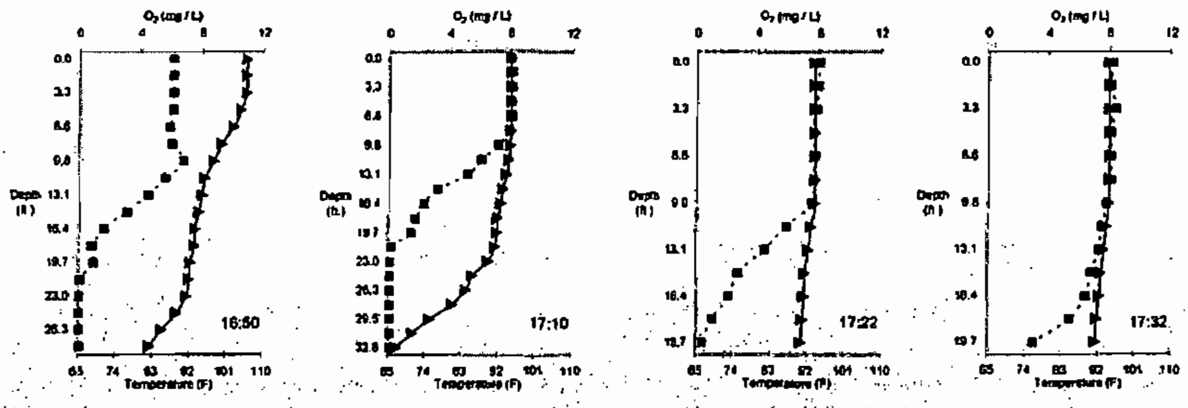
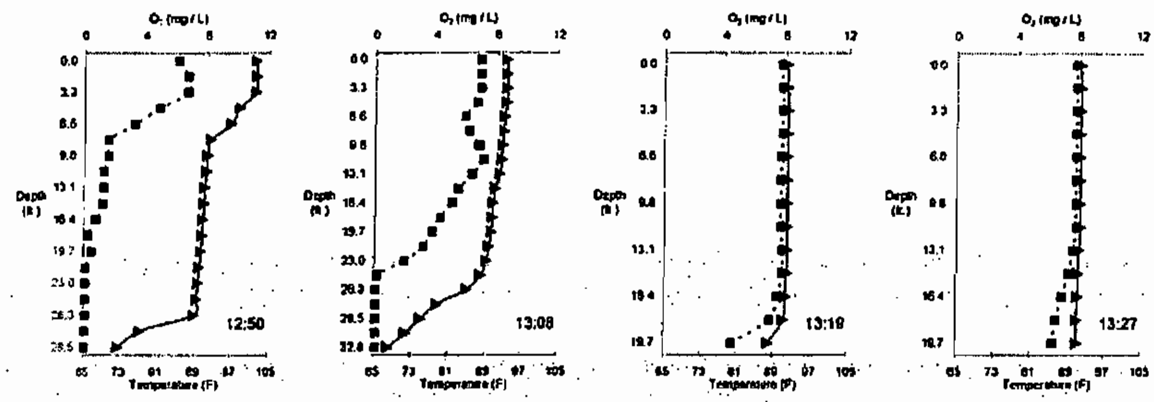


Figure A-16. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, August 10, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Coffeen Lake, August 18, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

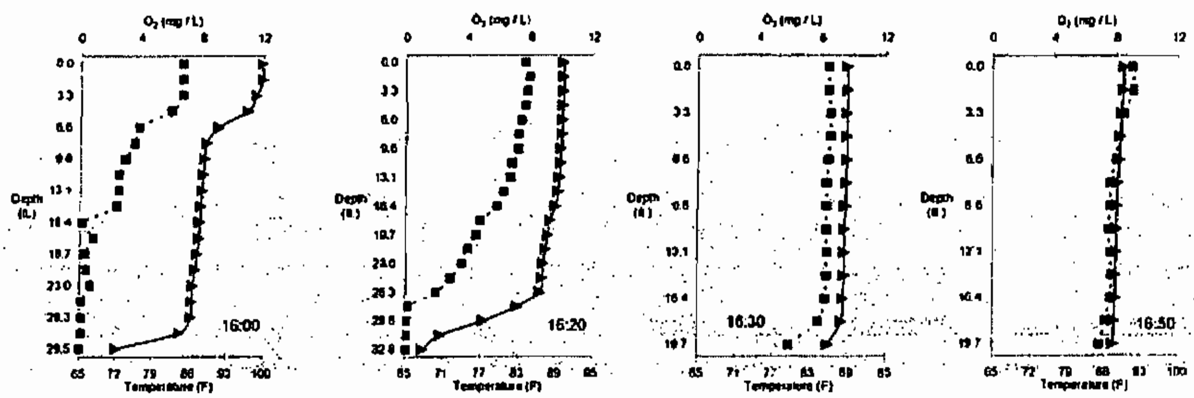
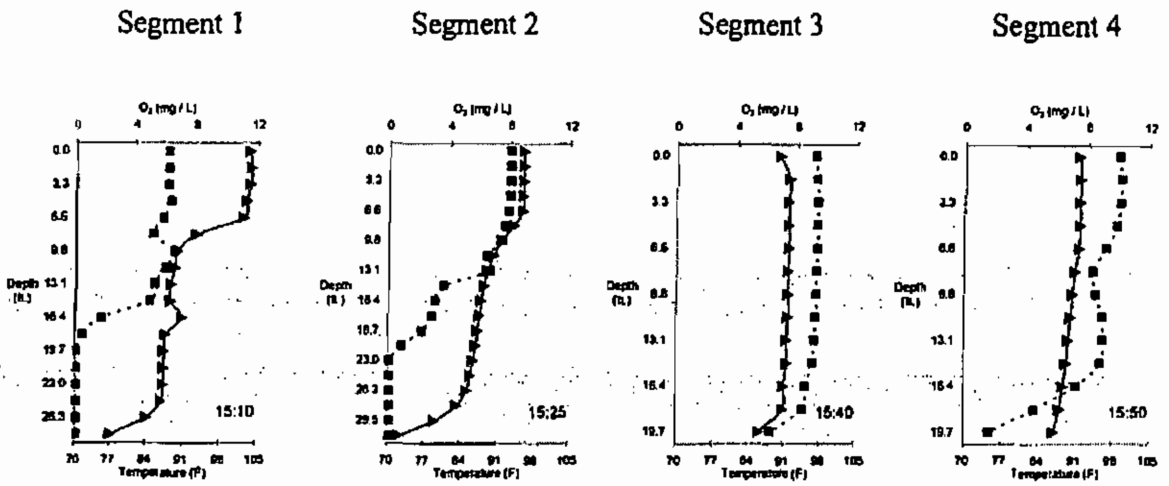


Figure A-17. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, August 24, 2006



Coffeen Lake, August 30, 2006

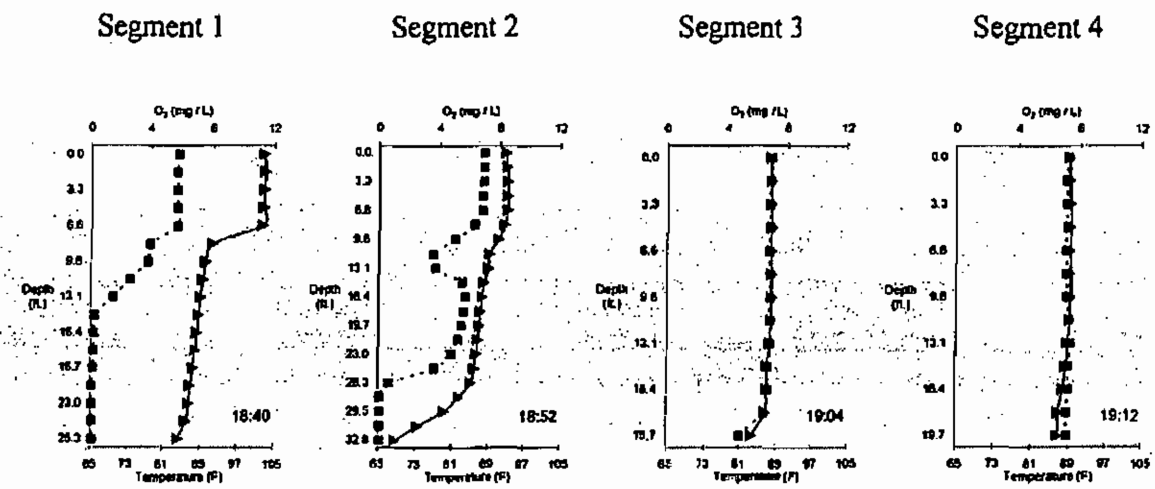
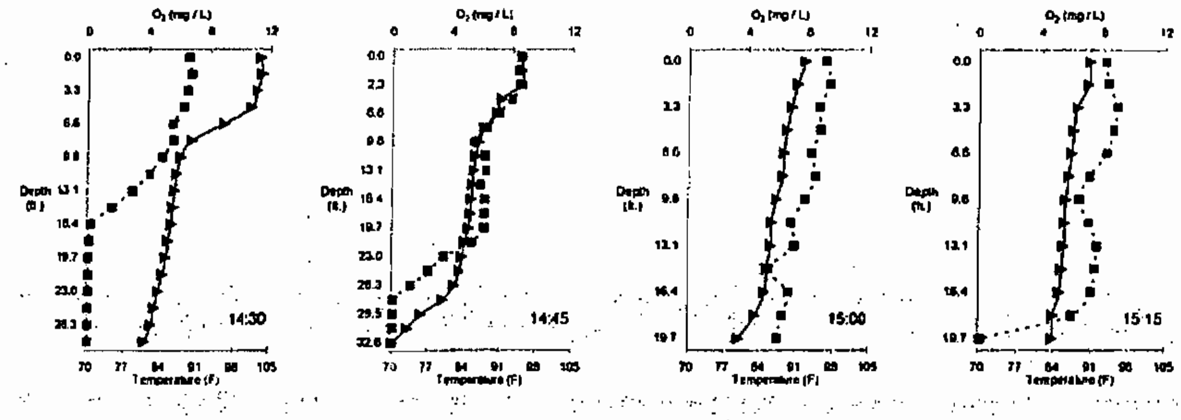


Figure A-18. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, September 6, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Coffeen Lake, September 12, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

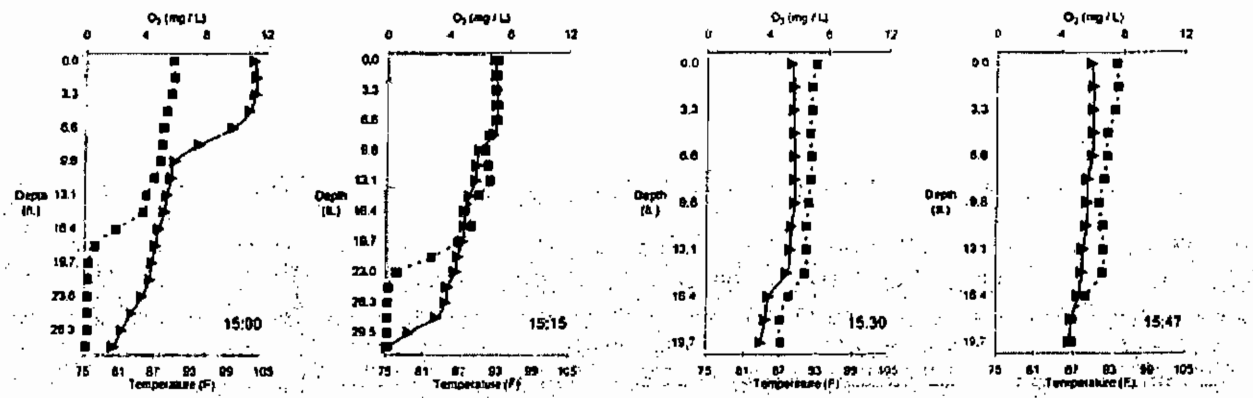
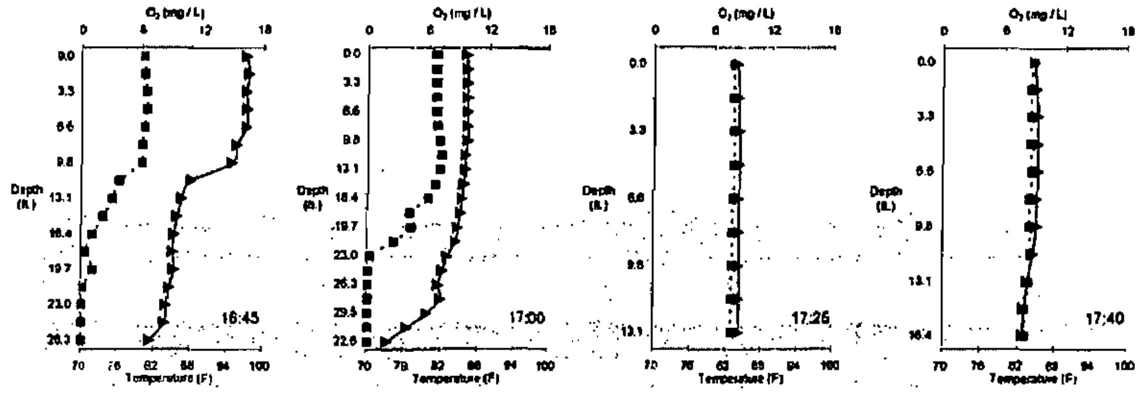


Figure A-19. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

Coffeen Lake, September 19, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4



Coffeen Lake, September 28, 2006

Segment 1 | Segment 2 | Segment 3 | Segment 4

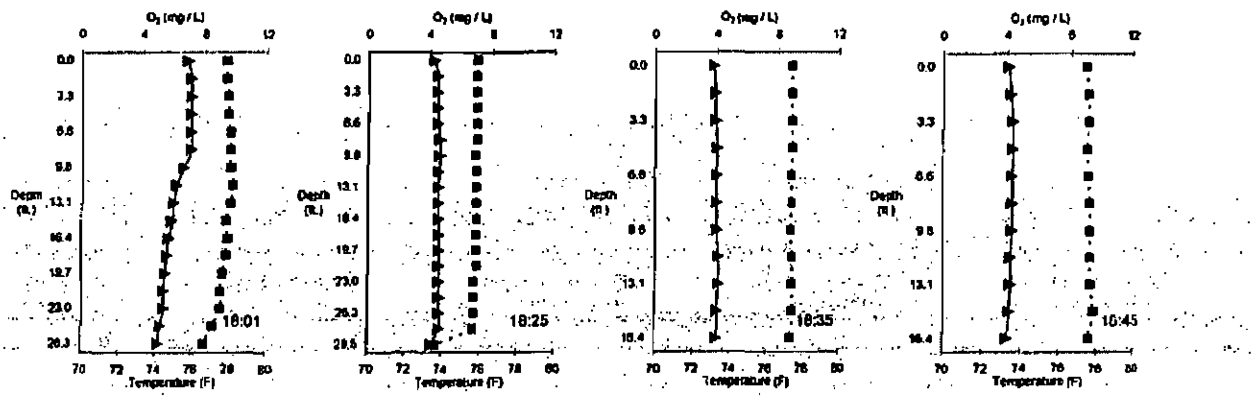


Figure A-20. Temperature and dissolved oxygen profiles in 4 segments of Coffeen Lake. Triangles represent temperature (F) and squares represent oxygen (mg / L).

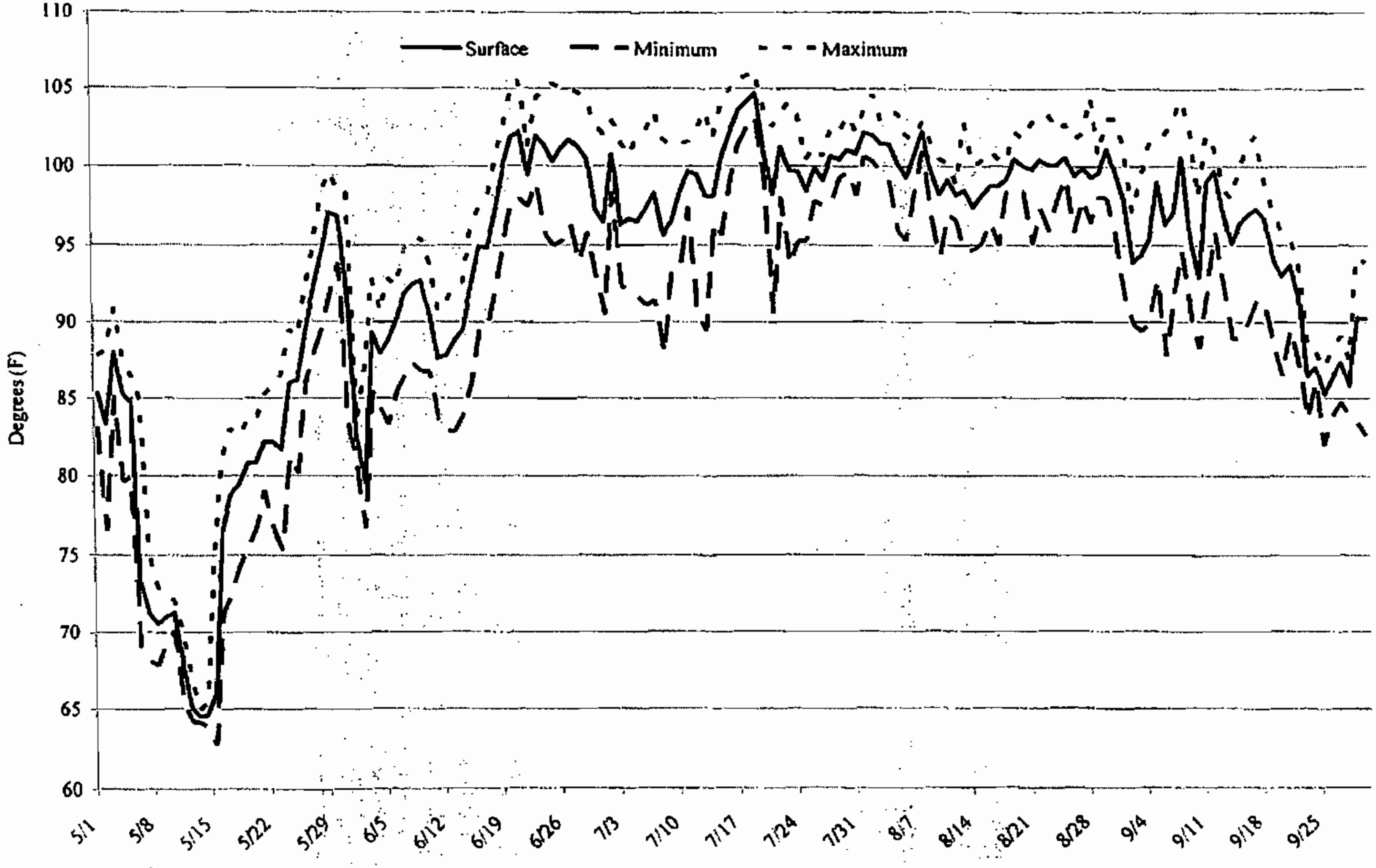


Figure A-21.Mean, minimum, and maximum daily surface temperatures during 2006 at the Newton Lake mixing zone. Temperatures were provided by AMEREN.

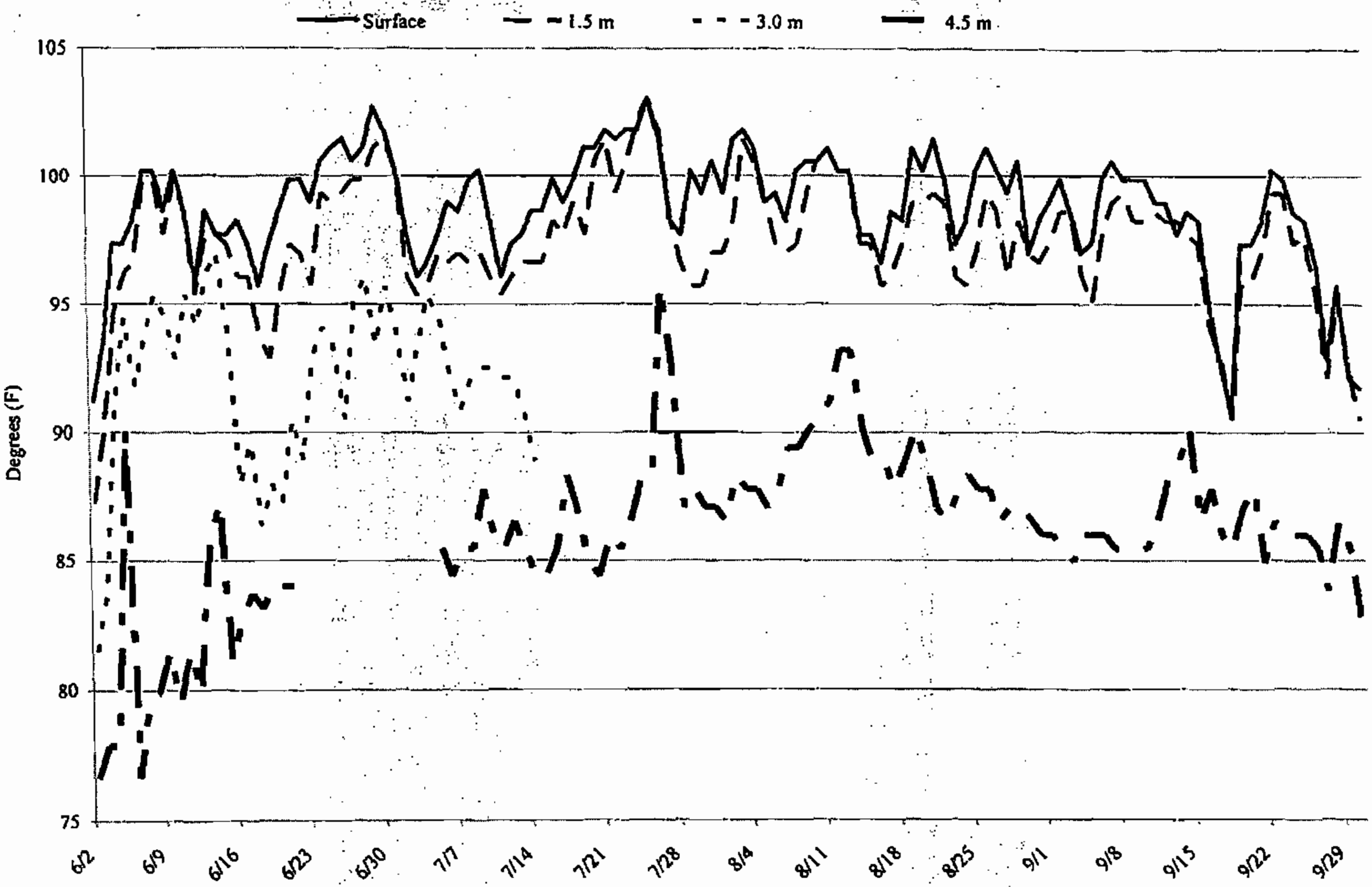


Figure A-22. Mean daily temperatures during 2006 in Newton Lake Segment 1. Lake bottom is approximately 16.4 feet.

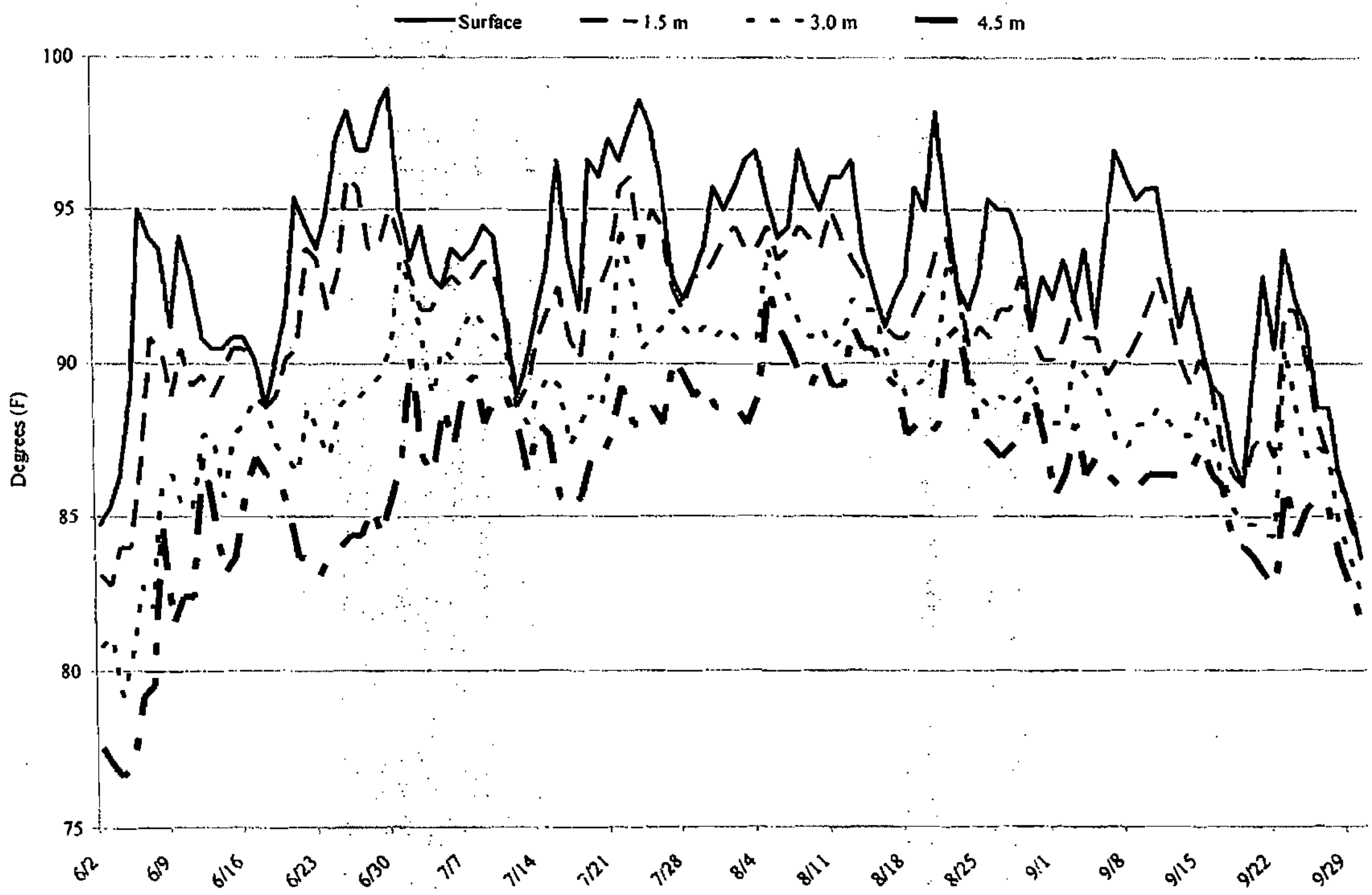


Figure A-23. Mean daily temperatures during 2006 in Newton Lake Segment 2. Lake bottom is approximately 32.8 feet.

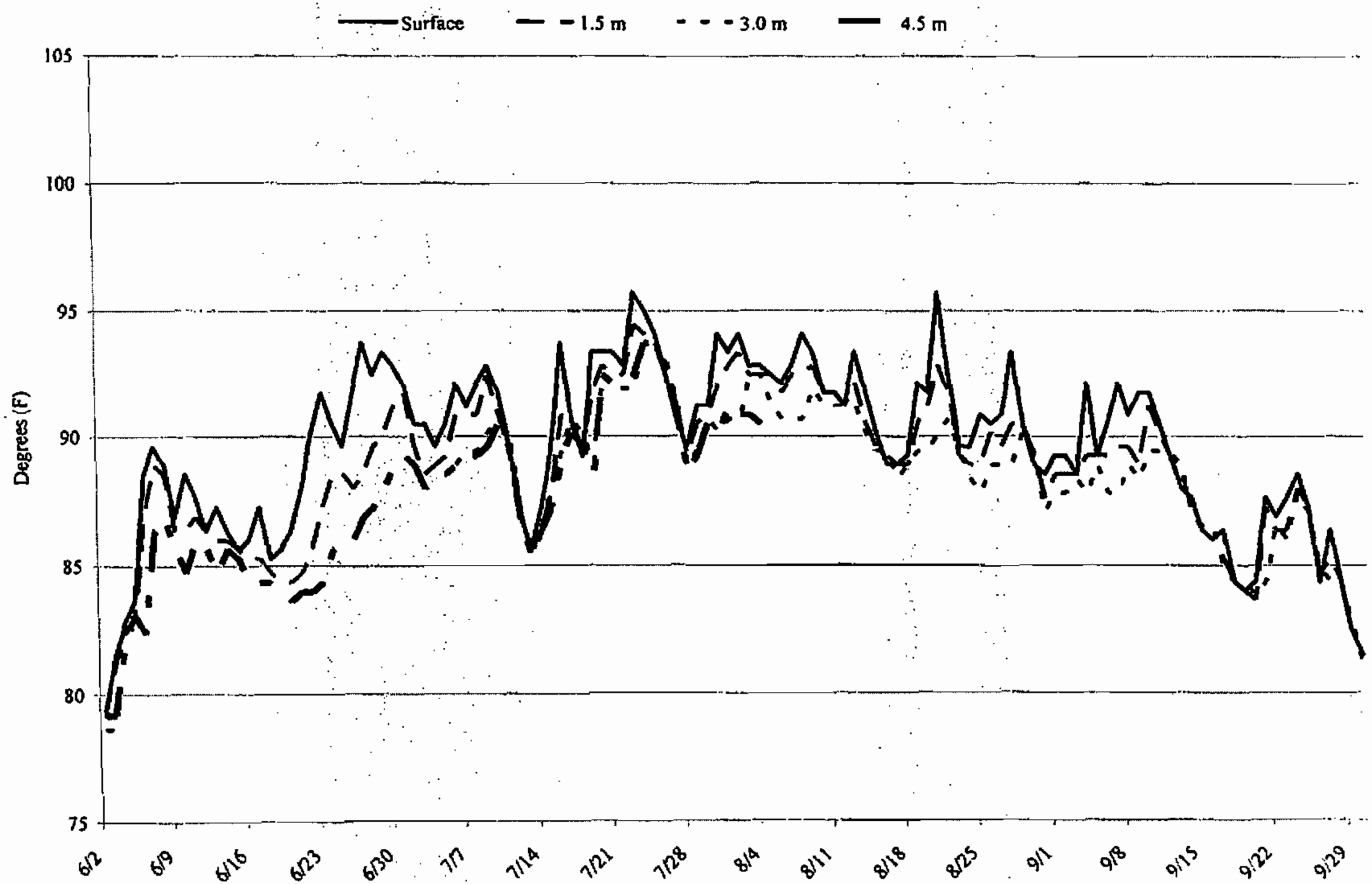


Figure A-24. Mean daily temperatures during 2006 in Newton Lake Segment 3. Lake bottom is approximately 32.8 feet.

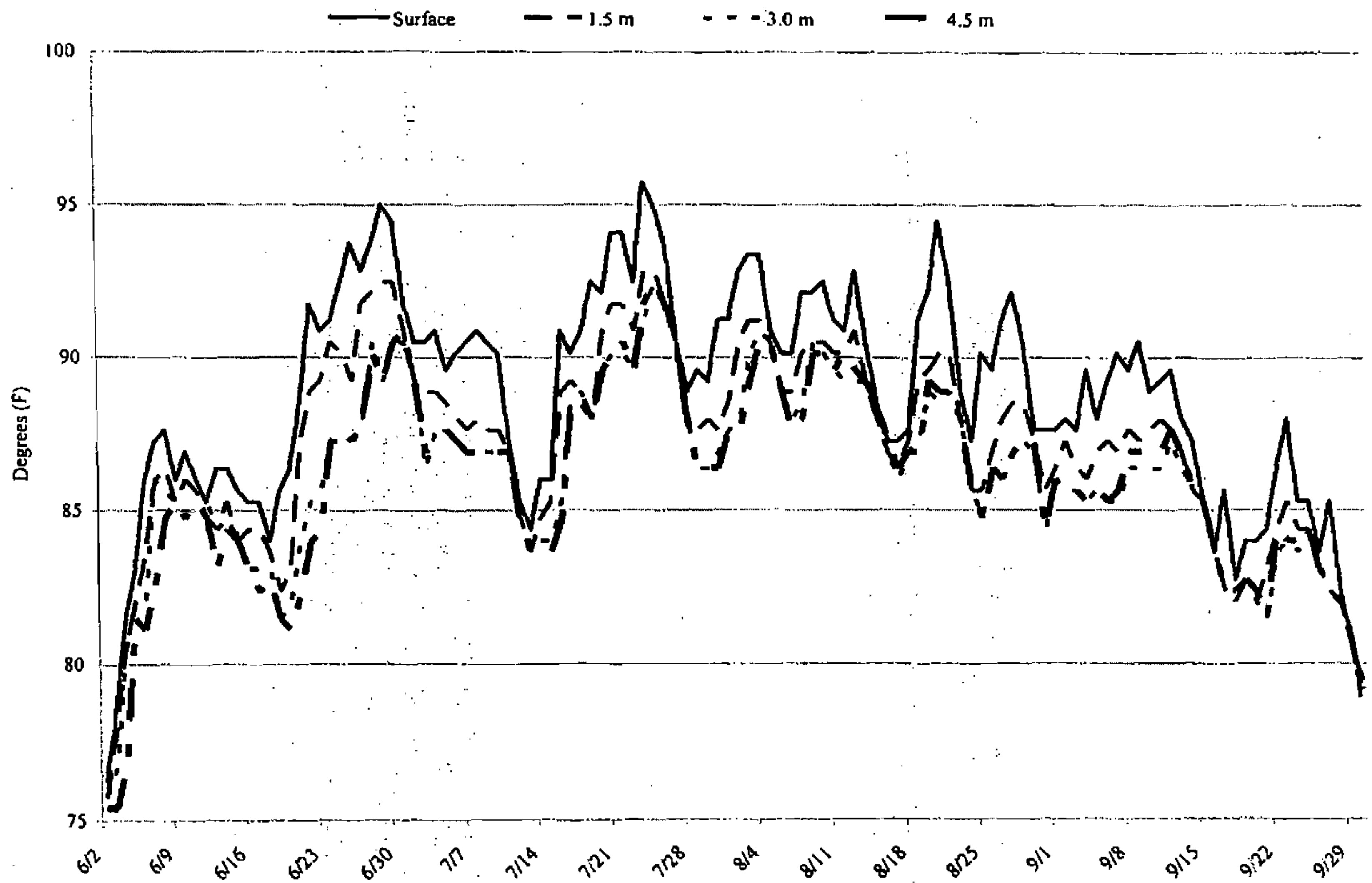


Figure A-25. Mean daily temperatures during 2006 in Newton Lake Segment 4. Lake bottom is approximately 29.5 feet.

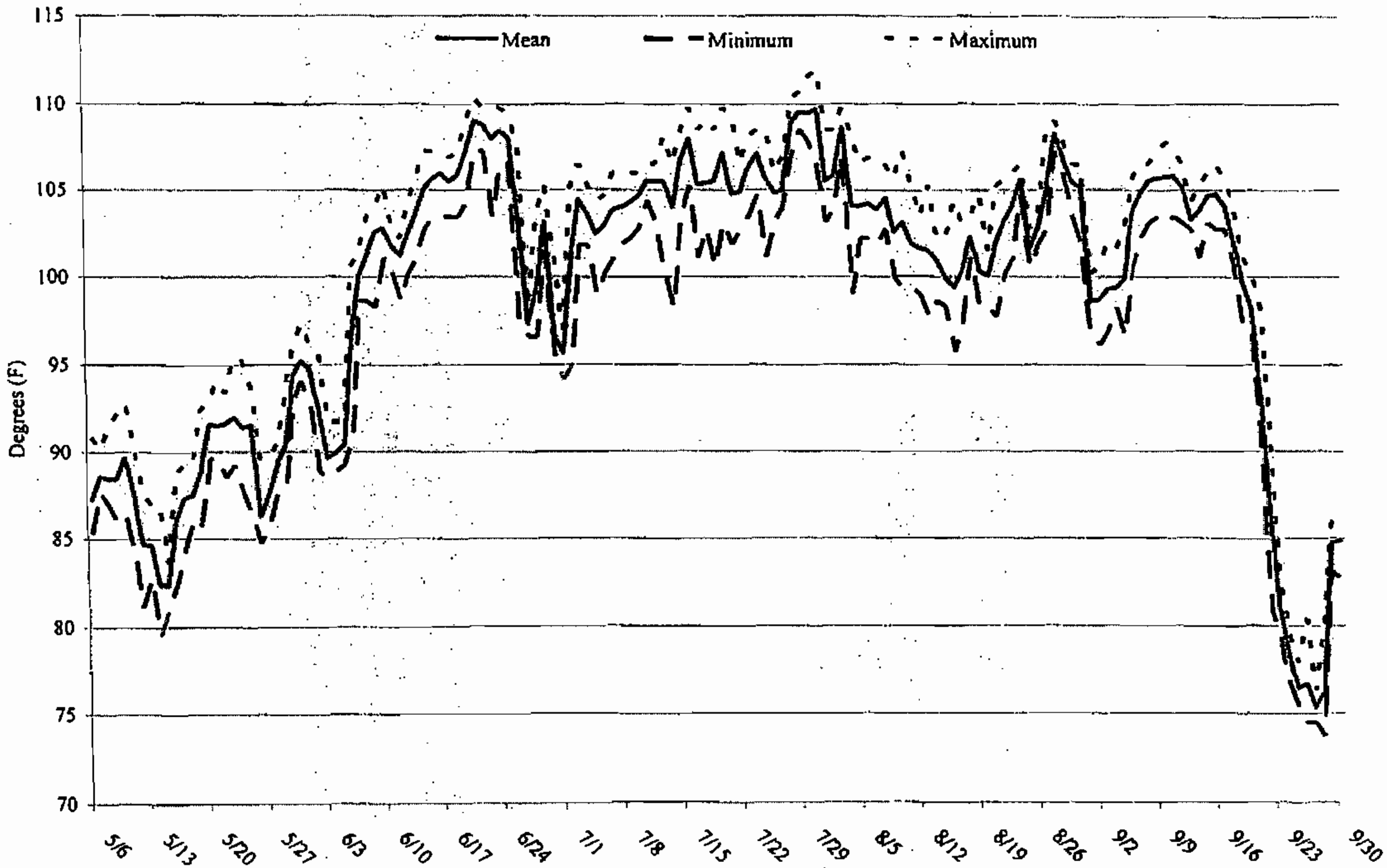


Figure A-26. Mean daily temperatures during 2006 in the Coffeen Lake discharge as determined by an SIU-C temperature logger located at the water's surface. Lake bottom is approximately 18.0 feet.

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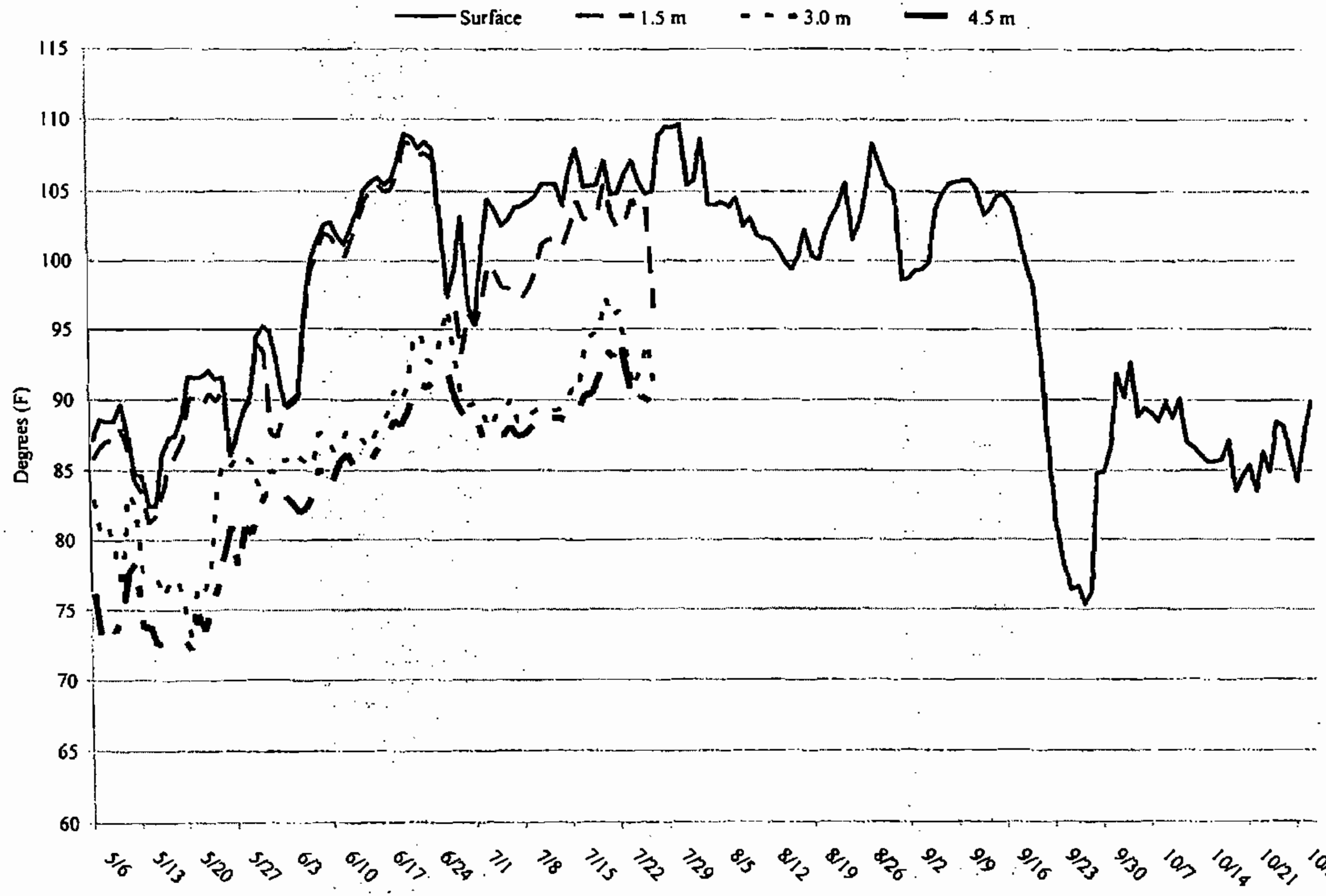

Figure A-27. Mean daily temperatures in Segment 1 (mixing zone) during 2006 in Coffeen Lake. Lake bottom is approximately 18.0 feet.

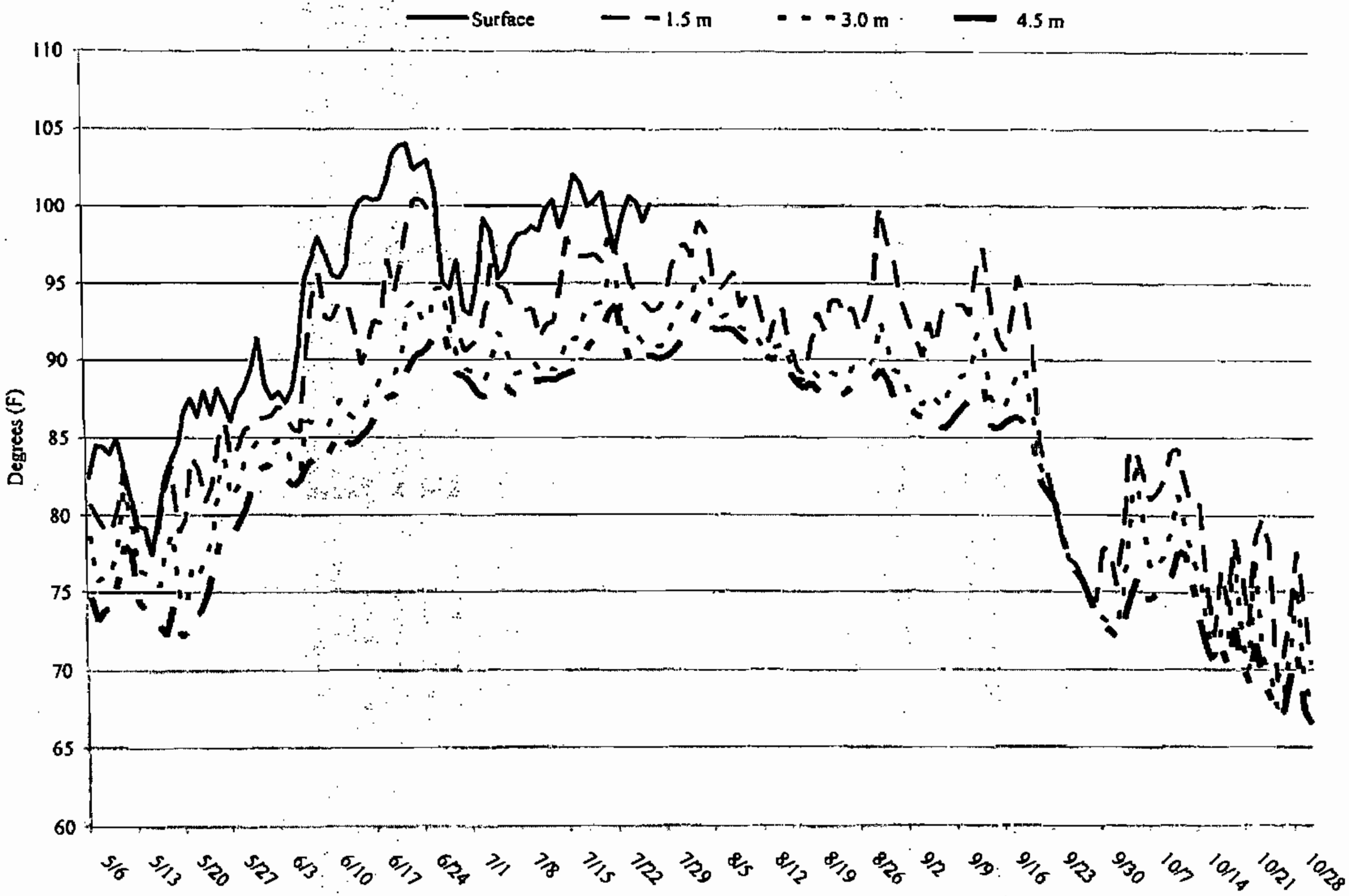

Figure A-28. Mean daily temperatures during 2006, Coffeen Lake at the dam. Lake bottom is approximately 42.6 feet.

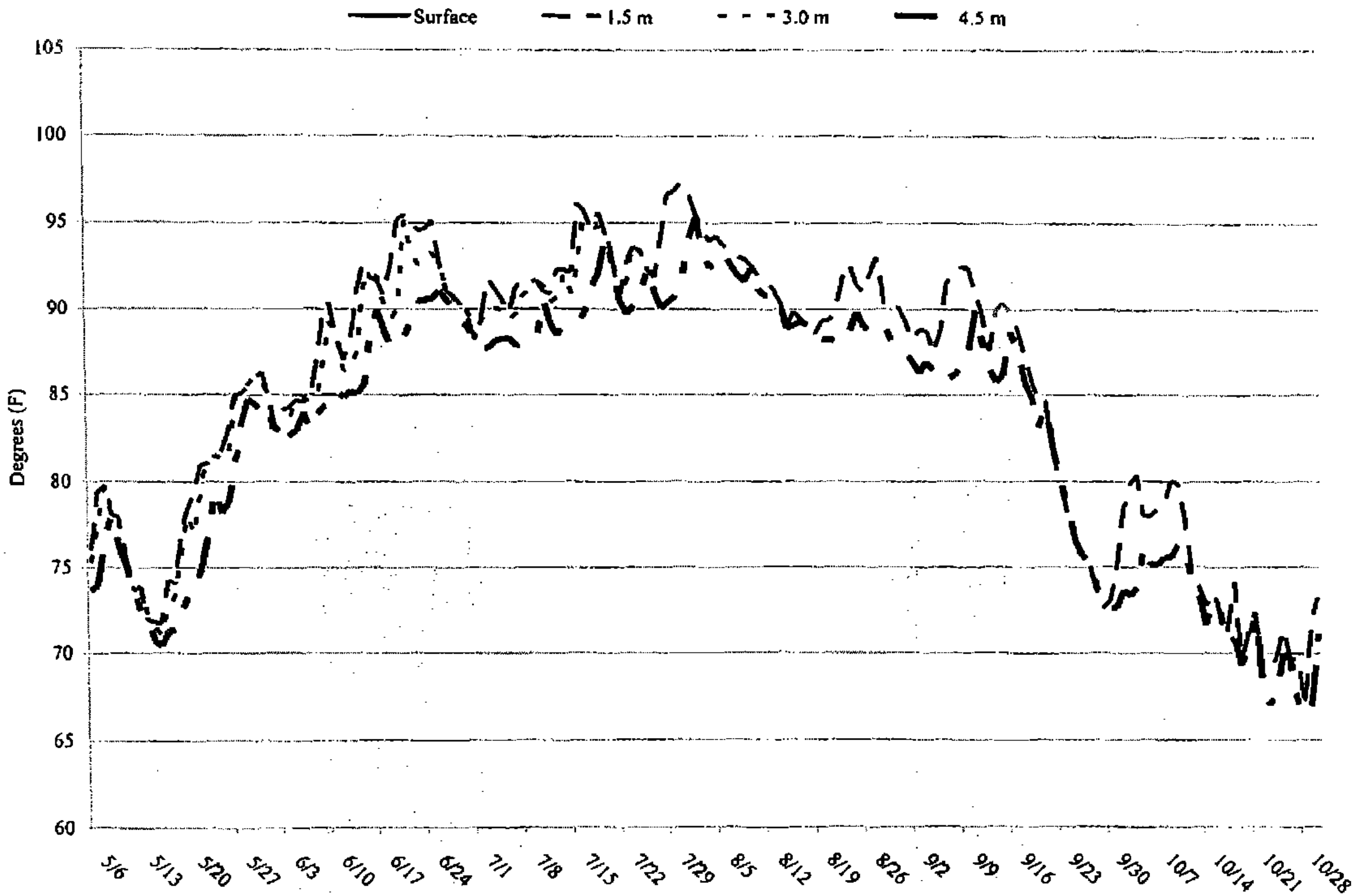

Figure A-29. Mean daily temperatures during 2006, Coffeen Lake at the intake. Lake bottom is approximately 26.2 feet.

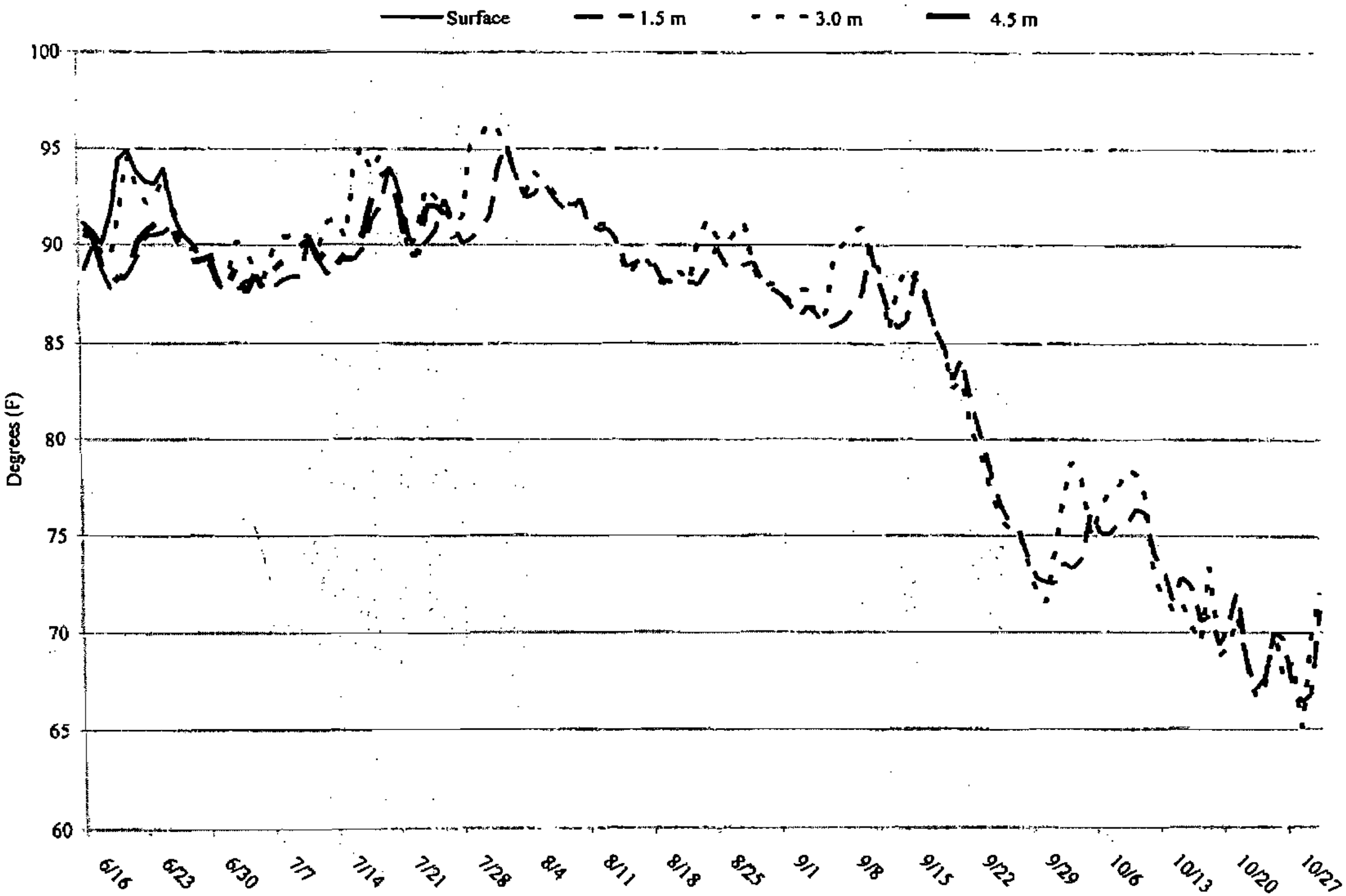

Figure A-30. Mean daily temperatures during 2006, Coffeen Lake located near the railroad bridge. Lake bottom is approximately 24.7 feet.

EXHIBIT 2

Ameren/CIPS Newton and Coffeen Lakes Research and Monitoring Project

Draft Report

Principal Investigator
Ronald Brooks

Fisheries & Illinois Aquaculture Center
Southern Illinois University at Carbondale

February 2004

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ERRATUM

Several errors were found in the June 2000 report. The discussion in Volume I, page1-7, last paragraph concerning catch-per-unit effort of age-1 bass and the CPU value for age-1 bass in Table 1.21 are not correct. In Table 1.31 the data for water depth was incorrectly converted from meters to feet. Due to an error in our computer program, a few fish were counted more than once when CPU's were calculated from SIU collected fish in Chapter 13. These errors have been corrected in the March 2001, March 2002, March 2003, and this report (March 2004). None of these errors seriously change the interpretation of the results of the largest kills to the population of largemouth bass in either Newton or Coffeen lakes that occurred in 1999. Data in the 2004 report supercedes data in the earlier reports.

ABSTRACT

During 1997-2003, the largest fish kill of mature largemouth bass in both Newton Lake and Coffeen Lake occurred in 1999. One of the major differences in 2000 versus 1999 was that no major fish kill occurred in either lake in 2000. In 2000 we saw only four largemouth bass and two channel catfish dead or dying in Coffeen Lake. In Newton Lake we observed only two dead largemouth bass and two dead gizzard shad. In both lakes all of the bass and channel catfish were observed near the boat docks. The bass probably succumbed to angling related stress. In 2001, 2002, and 2003, as one would expect, a few dead fish were observed in both lakes. However, in 2001 there was a temperature related fish kill on July 10 in Coffeen Lake and August 24 in Newton Lake. A major fish kill was not observed in Newton Lake in 2003. A small fish kill (124 fish) was observed by SIU personnel and estimated by IDNR between 24 June and 4 July, 2002 in Coffeen Lake. In these cases the small fish were probably trapped in a thermal refuge, which eventually eroded away. The

preponderance of the data collected in 2000, 2001, 2002, and 2003 suggests that there were no long-term negative effects of the 1999, 2001, or the 2002 fish kills in either of these lakes.

INTRODUCTION

In July of 1999, a fish kill occurred in Newton Lake while the power plant was operating under a new "Variance." A kill occurred essentially at the same time in Coffeen Lake while the plant was operating within the parameters of its old variance (Heidinger et al. 2000). As a result of the fish kills and other economic considerations, the corporate decision was made to add additional cooling capacity to the Newton Lake and Coffeen Lake electrical generating stations. The goal of this study is to determine if there are any long-term effects of the 1999 and subsequent fish kills in either Newton Lake or Coffeen Lake. Additionally, data presented in this 2003 report will be used in conjunction with the previous years' data to examined overall trends of temperature and oxygen during the potentially most stressful periods of the year to several biotic indices.

Under the high thermal loading conditions associated with the fish kill in Newton Lake in 1999, no difference in net primary productivity or chlorophyll occurred in July and August (1999) as compared to July and August (1998). Some of the fauna such as zooplankton, benthos number, benthos weight, and phytomacrobenthos actually increased (Heidinger et al. 2000).

The number of largemouth bass (*Micropterus salmoides*) that died in Coffeen Lake and Newton Lake in 1999, relative to their abundance in the two lakes, indicated no significant long-term negative effects on the two bass populations. In Coffeen Lake, assuming that only 50% of the largemouth bass that died were counted, then 242 bass died (0.22 per acre). If there were 20 bass per acre in Coffeen Lake (1100 acres), then the death of 242 bass represented only 1% of the population. Although we have no recent creel data for Coffeen Lake, 242 bass is probably well below what is removed by anglers each year. Also, to place the 1% mortality due to the fish kill in perspective, the average total annual mortality rate for largemouth bass in Coffeen Lake from 1997-2003 is approximately 42% (Table 1).

In Newton Lake, assuming 20 largemouth bass per acre (1750 acres), there were 35,000 bass in the lake before the kill. If anything, this is an underestimate, considering that from 02/16/98 through 12/31/98 the creel indicated that 60,187 bass were caught. In other words, if there were 35,000 bass in the lake, each bass on average was caught 1.7 times. Based on an estimate of 454 bass killed during the 1999 event and a population of 35,000 bass, the death of 454 (0.26 per acre) bass in Newton Lake would equal only 1% of the population. Again, to place the 1% of dead bass in perspective, average total annual mortality for bass in Newton Lake from 1997-2003 is approximately 57% (Table 1).

In order to verify the validity of the no long-term effect projections based on the above calculations, sampling primarily of the fish communities in Newton Lake and Coffeen Lake was continued in 2000, 2001, 2002, and 2003. In addition, the creel survey on Newton Lake was continued from April 9, 2000 – March 15, 2001. Newton Lake was closed to fishing in order to renovate the boat ramp from July 16, 2001 – November 2, 2001.

If negative effects from the kill did occur, they could be expected to manifest themselves in a reduced catch by anglers, a shift in size distributions, reduced recruitment, increased mortality rates and a decrease in electrofishing catch per unit effort. A fish kill may result in the surviving fish increasing their growth rate and relative weight if the stress is short term and more food is available to the surviving fish. Stress over a prolonged period would result in a reduced growth rate and a lower relative weight.

For sampling purposes, Newton Lake was divided into four segments (Figure 1). From 1997 to 1999 Coffeen Lake was divided into two sampling segments. Beginning in 2000, temperature/oxygen/depth profiles were taken in two additional Segments (3 and 4) in Coffeen Lake (Figure 2). Lake of Egypt was dropped from the study in 2000. The basic sampling regime is outlined for 2000-2002 in Table 2 and for 2003 in Table 3. In order to be able to compare the data collected from 1997 to 1999 with that collected during 2000 through 2003, the specific sampling methods used in 2000 through 2003 were the same as those used in 1997-1999 (Heidinger et al. 2000). A description of the methods and additional data can be found in the six appendixes (A-H).

The 2003 study was approved, and therefore initiated, at Newton Lake in May and Coffeen Lake during June. As in the previous years of study, largemouth bass, bluegill (*Lepomis macrochirus*), and channel catfish (*Ictalurus punctatus*) are the principal species evaluated.

PLANT OPERATION IN RELATION TO DISCHARGE STANDARDS

The four months including June-September potentially encompass the most critical period when extremely warm water temperatures may be lethal to fish species. During this period, Newton Lake average monthly water temperatures in the mixing zone in 2003 were relatively mild (90.8-98.3°F) and among the lowest during the seven years the data has been recorded (Table 4). The maximum hourly temperature recorded was 106° which occurred on 18 occasions during four dates in late August. Since 1999, neither mean monthly nor hourly temperatures approached the old "Variance" levels of 102°F and 111°F, respectively. In July 1999, the highest monthly average temperature (104.1°F) during this study was recorded, and the hourly temperatures were also the highest recorded during this study exceeding 111°F on 100 occasions (Table 5). Both average monthly temperatures and hours exceeding 111°F were lower than the limits detailed in the 1999 "Variance."

Coffeen Lake water discharge temperatures were not provided 2003. However, the biostation in Segment 1 used by SIU-C personnel was located in direct proximity to the station used in previous years by AmerenCIPS for measuring surface water temperatures in the mixing zone, and the data should be comparable to previous years. Mean monthly 2003 discharge water temperatures of the previously described four-month period (97.8-104.3°F) were the highest during the seven years studied in Coffeen Lake (Table 4). In fact, in 2003, July average temperatures were higher than in 1999, the year of the July fish kill. However, no significant fish kills were noted by SIU-C personnel or reported to the Illinois Department of Natural Resources (IDNR) during all of 2003. Maximum water temperatures are usually more indicative of lethality to fish than average water temperatures. In 1999, July temperatures exceeded 112°F on 83 occasions (Table 6). Interestingly, 2003 water hourly temperatures reached 111°F on only one occasion and were 110°F on only 32 others. Thus, despite the higher monthly average in 2003, maximum temperatures were lower throughout the 2003 critical period than they were in 1999. In fact, since 1999, neither the maximum mean monthly temperature (105°F) nor the 112°F hourly maximum water temperature limit described in the "Variance' has ever been attained.

DEAD FISH

In 1999, SIU personnel observed 121 largemouth bass and 8 dead or morbid channel catfish in Coffeen Lake (Table 7). In Newton Lake, 227 largemouth bass and 70 channel catfish were observed dead or dying (Table 8). In 2000, only four largemouth bass and two channel catfish were observed dead or dying in Coffeen Lake (Table 9). In Newton Lake only two dead largemouth bass and two dead gizzard shad were observed in 2000 (Table 9). In Coffeen Lake except for the kill on July 7, 2001, only one dead striped bass, two white crappie, one largemouth bass and two channel catfish were observed by SIU personnel in 2001 (Table 9). In Newton Lake during 2001, only 10 dead fish were observed except for the kill of shad on August 28, 2001.

On July 10, 2001, in Coffeen Lake, 546 2 to 7 inch long channel catfish, 513 2 to 6 inch Lepomis and 65 2 to 7 inch largemouth bass were estimated to have died (Table 9; Appendix G, Table G-1). Rounding accounts for the slight differences in the number of dead fish listed in these two tables. The highest mixing zone temperature occurred on August 7 and 9; therefore, the July 7 fish kill does not correlate with these temperatures.

On August 24, 2001, we estimated that 10,765 three-inch gizzard shad were killed in Newton Lake (Table 9; Appendix H). Again this kill did not correlate with the maximum temperatures that occurred in the mixing zone on July 31, 2001. It is likely that both kills were associated with eroding of thermal refuge areas.

Anglers reported several dead largemouth bass on August 21, 2002, but an exploratory visit to Newton Lake on the following day did not confirm this. In 2002, we observed (and the IDNR documented) a fish kill that occurred in Coffeen Lake between June 24 and July 4 (Table 10). There were 124 dead fish including 42 largemouth bass and 64 striped bass. Again, we believe that this kill was associated with the eroding of a thermal refuge area. The exact location of this area (or areas) has not been determined. We observed only two other dead channel catfish during 2002. However, due to the timing of the funding, we did not begin regular monitoring of the lakes until August 2002.

No Major fish kills occurred in Newton Lake in 2002 or 2003 or Coffeen Lake in 2003. In Newton Lake, we only observed three dead largemouth bass in 2002 and ten dead or dying fish in 2003 (Table 11). In two cases with largemouth bass, the fish were moribund and located in areas where anglers had been fishing. Only seven fish were observed dead or dying in Coffeen Lake during 2003.

CHARACTERISTICS OF THE FISH COMMUNITIES

Size Frequency and Electrofishing Catch Per Hour

From both Newton Lake and Coffeen Lake where fall electrofishing data are available, we compared, among years, the size frequency distributions and catch-per-unit efforts for bluegill, channel catfish and largemouth bass. IDNR fall 2003 electrofishing data are not available at this time from Coffeen Lake. Since the IDNR and SIU electrofishing data were not taken with exactly the same equipment and the sampling procedures were different, trend comparisons should be made only within the respective data sets and not between data sets.

Newton Lake

The fish community in Newton Lake has undergone many changes since 1976. Fishing started in 1980. Initially crappie were abundant and grew well in Newton Lake. Although they continue to grow well, recruitment was greatly reduced by 1987. Crappie, from a recently built nursery area on the lake, probably accounts for the slight increase in their electrofishing catch rates after 1998 (Table 12).

Historically, except for the first few years after filling, very few bluegill reached 7 inches in total length (Table 13). Since 1978, except for the 1998 spring sample, less than 5% of the bluegill have been larger than 7 inches. During the late 1970's and early 1980's, a significant number of channel catfish exceeded 20 inches in total length in Newton Lake. After the mid 1980's, fewer than 7 % of the sampled channel catfish exceeded 20 inches (Table 14). Largemouth bass are the most sought after sport-fish in Newton Lake. There has been an 18-inch minimum length limit and a 3 fish per day creel limit on the lake since it opened for fishing in 1980. The highest percentage of bass larger than 18 inches in total length tended to occur in the spring samples rather than in the fall samples (Table 15). Since 1992 the percentage of large bass appears to have decreased, although spring samples from 1997 to 2003 show 8-16 % of the bass sampled were over 18 inches in total length. Spring and fall IDNR electrofishing samples are collected essentially in a single day. Variability in sample numbers and fish sizes from single samples are subject to many abiotic factors including (but not limited to) weather, water temperature, and water clarity. Therefore, these length-frequency trends are useful only to identify possible major shifts. In 2001, a largemouth bass over ten pounds was caught in Newton Lake. From a bass fishery stand point this is still an excellent population.

Changes were not consistent in the size frequency distributions of largemouth bass in the fall of 1999 after the fish kill versus their distributions every fall since 1992 before the kill. There were fewer bass greater than 12.2 inches, more larger than 14.2 inches and fewer longer than 16.1 or 18.1 inches in fall 1999 as compared to fall 1998 (Table 16). All of the size frequency values found in 1999 fall within the range of values found over the past eight years. Catch-per-unit effort of largemouth bass by both IDNR and SIU was slightly lower in 1999 than in 1998 (Table 17). Both IDNR and SIU estimates of catch per hour, however, were higher in 1999 than in 1997. IDNR had a lower CPU in 2000 (35) but higher in 2001 (53), 2002 (55), and 2003 (53) than in 1999 (43). SIU's CPU for largemouth bass was higher in 2000 (76) than in 1999 (32), but similar in 2001 (33), 2002 (39), and 2003 (32). In 1993, SIU's CPU was equal to 1999's CPU. Therefore, no clear-cut trends are evident that indicate the bass population was negatively impacted by the 1999 kill.

In Newton Lake, the fall size frequency distributions of bluegill from 1999 through 2003 were similar to that found in 1998 (Table 18). Very few of the bluegill collected reached 6.3 inches in total length since the study began in 1997. Fall electrofishing catch-per-unit efforts by both IDNR and SIU were higher in 1999, 2001, and 2002 than in 1998 but were lower in 2003 (Table 17).

IDNR's bluegill CPU was slightly lower in 2000 (42) than in 1998 (44) while SIU had a higher CPU in 2000 (115) than in 1998 (51). In 2003, IDNR and SIU had the lowest bluegill CPU's since 1998.

IDNR collected a higher percentage of the channel catfish larger than 12.2 inches in Newton Lake during fall electrofishing from 1999-2003 (38%-64%) than in any year from 1993-1998 (4%-35%; Table 19). A lower percentage of 16.1 inch or larger channel catfish was collected in 1999 than in 1998 (1% versus 4%), but a higher percentage was collected in 2000, 2001, and 2003 (14%-21%) than in any year from 1993-1998 (4%-10%; Table 17). The size frequency distribution of channel catfish in 2003 showed that 21% were greater than 16.1 inches; which was the highest percentage observed since fall 1984 (23%; Table 14). Electrofishing catch-per-hour of channel catfish obtained by both IDNR and SIU were essentially the same from 1998 to 1999 (Table 17). IDNR had a slightly lower catch rate in 1999, 2000, 2002, and 2003 versus 1998, but a higher catch rate in 2001. SIU had the same catch rate in 1999, higher catch rates in 2000, 2001 and 2002, and a lower rate in 2003 (4) than in 1998.

Coffeen Lake

No 2003 CPU data was available for Coffeen Lake from IDNR. However, data from 2002 that was not previously available is included in this report. Based on IDNR fall electrofishing samples from Coffeen Lake, a higher percentage of largemouth bass were collected in each of the four size groups in 1999 than in 1998 (Table 16). Size frequencies collected in 1998 were similar to those in 2000 - 2003. Both IDNR and SIU collected more bass per hour in the fall of 1999 (67 and 25 respectively) than in the fall of 1998 (43 and 14 respectively; Table 20). SIU had CPUs that were lowest in 1998 (14) and 2000 (16), highest in 2002 (39), and similar in each of the other years (23-26). IDNR's CPU trends were similar in that the lowest CPU occurred in 1998 (43) and 2000 (20).

However, IDNR had the highest largemouth bass CPUs in 2001 (99) and 2002 (93). In Coffeen Lake there was no difference in size frequencies of bluegill from 1997 to 2002 (Table 18). Essentially, no bluegill longer than 6.3 inches in total length were collected in the IDNR fall electrofishing samples. Fall electrofishing catch-per-unit effort of bluegill by both IDNR and SIU in 1999 (127 and 163 respectively) after the fish kill was higher than in 1998 (99 and 49 respectively), the year before the fish kill (Table 20). SIU catch rates were higher in every year since 1997 than in 1998. IDNR catch rates of bluegill were lower in 2000 (89) and 2001 (86) than in 1998 but increased to its second highest level in 2002 (179).

Lower percentages of channel catfish 16.1 inches or longer were collected by IDNR in Coffeen Lake following the fall of 1998 (48; Table 19). Electrofishing catch-per-hour of channel catfish, however, by both IDNR and SIU was higher in 1999 than in 1998 (Table 20). Catch rates by IDNR were lower in 2000 and 2001 than in 1998, but similar in 2002 to 1998. SIU had higher catch rates each year since 1997 (3-13) than in 1998 (1).

Relative Weight

Many biologists assume that the desirable range for relative weights of largemouth bass, bluegill, and channel catfish is between 90 and 110. Largemouth bass collected in the fall of each year since 1997 from both Newton Lake and Coffeen Lake tend to be near the middle of the range (Table 21). Although a few statistically significant differences were found among years, no discernible trend occurred in either lake between 1997 and 2003. Mean relative weights average approximately 102 in Newton Lake and 103 in Coffeen Lake.

In both lakes, bluegill tended to be below or at the low end of the 90-110 range both before and after the fish kill. Over the past seven years, fall relative weight of bluegill collected by IDNR and SIU averaged approximately 89 in Newton Lake and 87 in Coffeen Lake (Table 21). The high relative weight (104) determined by SIU in 1998 was due to 32 very plump bluegill that were picked up right at the intake structure.

Channel catfish tended to have lower mean relative weights in Newton Lake (86) than in Coffeen Lake (92) (Table 21). Based on IDNR data, fall relative weight values for channel catfish were fairly similar from 1997 to 2003 in both lakes. SIU data indicates there may be an increase in mean relative weight of channel catfish in both lakes in 2001 and 2002. However, 2003 data indicated relative weights that were similar to other years and the overall means. On average, during the seven-year study, channel catfish collected from Newton Lake by SIU had higher mean relative weights that catfish collected by IDNR.

Mortality Rates

If a large part of the fish community was removed from a lake, one would expect a major increase in the total annual mortality rates. Mean total annual mortality rate for largemouth bass in Newton Lake was slightly higher (58%) in 1999 than in 1998 (45%). However, the 58% mortality rate in 1999 was lower than the 68% found in 1997 or the 64% in 2000 (Table 1). Total mortality of largemouth bass in 2003 (51%) was lower than every year but 1998 (45%). In fact the mean mortality rate during 1997-2003 was 57% which is essentially the same rate estimated in 1999 – the year of the largest fish kills. Total mortality rates for largemouth bass in Coffeen Lake averaged 42%. The rates were actually lower in 1999 than in every other year during this study except 1997. Mortality in both years was 39% (Table 1).

The mean annual mortality rate for bluegill was lower in Newton Lake in 1999 (78%) than in 1998 (83%) or 2000 (82%) but not in the remaining four years studied (67%-74%; Table 1).

Similarly in Coffeen Lake, the annual mortality rate was lower in 1999 (59%), the year of the kill, than the remaining six year of the study (65%-72%). From 1997 to 2003 bluegill mortality rates in Newton Lake averaged 75% while in Coffeen Lake they averaged 67%. These annual mortality rates are high.

Total mean annual mortality rate of channel catfish in Newton Lake during 1999 (36%) was lower than in 1997 (48%), 1998 (41%) or 2001 (45%) but not 2000 (29%), 2002 (26%), or 2003 (29%). In Coffeen Lake, the mortality rate of channel catfish was higher in 1999 (37%) than in 1997 (23%) or 1998 (26%), but mortality rates were higher than 1999 in 2000 (46%), 2001 (45%), 2002 (47%), and 2003 (44%). From 1997 through 2003, annual mean mortality rates averaged 36% in Newton Lake and 38% in Coffeen Lake. None of the annual mortality rates for channel catfish appear unusually excessive (Table 1).

Recruitment

A major fish kill could have had an effect on the recruitment of fishes produced, especially in the year of the kill. From 1998 to 2001 standard shoreline seine hauls were made in Newton Lake and Coffeen Lake. The scope of the study was changed in 2002, and shoreline seining was not included in the new protocol. We compared the mean catch-per-seine haul in July and August among years. Most of the fishes collected in the seine hauls were young-of-the-year or age-1. Mean total number of fish collected per seine haul in Newton Lake in 1998 was not statistically different from the mean total number collected in 1999 or 2001 (Table 22). More fish were collected per seine haul in 2000 than in either 1998 or 1999. There were no significant differences in the seine haul catch rate of largemouth bass in Newton Lake between 1998 and 1999. Catch rates were lower in 2000 and 2001 than in 1998.

In Coffeen Lake there was no difference in seining catch per unit effort of total fish from 1998 to 2000 (Table 22). More fish per seine haul were caught in 2001 than in either 1998 or 1999. Statistically, largemouth bass had the same catch rate in 1998 and 2000. Fewer largemouth bass were caught in 1999 than in 1998 or 2001, but more were caught in 2000 than in 1999.

It was also possible to look at trends in recruitment of age-0 and age-1 bass from IDNR and SIU fall electrofishing samples. Largemouth bass collected each fall by SIU were measured and aged using their otoliths. The bass collected by IDNR were measured but not aged. Thus, the catch per hour of age-0 and age-1 bass could be determined directly from the SIU fall samples but not from the IDNR fall collected fish. By looking at the length of the age-0 and age-1 bass each year in the SIU sample, it was possible to estimate the number of age-0 bass in the IDNR sample. The lengths of the largest age-0 bass aged in the SIU fall electrofishing samples were used as the cut off length between age-0 and age-1 bass collected by IDNR in their fall samples (Table 23). SIU did not spend as many hours quantitatively electrofishing for largemouth bass as did IDNR; thus, the IDNR database is larger. For example, from 1997 to 2002, the number of bass collected by IDNR each fall from Coffeen Lake ranged from 139 to 648 (Table 16) while the number that SIU collected each year from 1997 to 2003 ranged from 73 to 156 (Table 21). From 1997 to 2002 IDNR collected 316 to 705 (Table 16) largemouth bass each fall from Newton Lake while SIU collected only 99 to 208 fish (Table 21).

In Newton Lake, fall electrofishing catch per hour of age-0 largemouth bass was higher in 1999 after the fish kill than in 1998 in both the IDNR sample and the SIU sample (Table 24). IDNR and SIU catch rates of age-0 bass were also higher in 2000, 2001, 2003, and 2003 than in 1998. Because of the way the sample ages (and resultant numbers) were estimated, the data does not lend itself to statistical testing.

In Coffeen Lake catch-per-unit effort of age-0 bass in the IDNR sample in 1999 was lower (9.9) than in each year from 1997 through 2002 (12.6-32.0) except 2000 (5.1; Table 25). IDNR catch rate in 2000 (5.1) was the lowest since the study began in 1997 but moved back up to 30.0 in 2001. The SIU catch per hour of age-0 bass was higher in 1999 (8.9) was among the highest recorded during the seven-years of data collection. CPUs were marginally higher in 1997 (10.2), 1998 (3.4), and 2000 (5.0). In 1993, age-0 CPU determined for largemouth bass by SIU was 2.8 and the lowest observed during the study; but comparable to 3.4 recorded in 1998.

Many fishery biologists prefer to measure recruitment after the fish go through their first winter; in other words at age-1. In Newton Lake, fewer age-1 largemouth bass were collected by both IDNR and SIU in 1999 than in any other study year (Table 24). The lower catch rate in 1999 is probably not entirely due to the added thermal stress that occurred in 1999. In part, the high number of age-1 bass collected in 1998 reflects the very strong 1997 year-class. The low number of age-1 bass collected in 1999 when the fish kill occurred resulted from the relatively weak 1998-year class. Likewise, a strong 1999-year class is reflected in the very high catch per hour obtained for age-1 bass in 2000 (Table 24). In other words the high catch rates in 2000 are a result of the high survival of age-0 bass that were produced in 1999, the year of the fish kill. Relatively higher catch rates of age-1 bass were also obtained by both IDNR and SIU in 2001, 2002 and 2003.

For Coffeen Lake we do not have IDNR spring electrofishing data sets to estimate catch per hour of age-I largemouth bass. Based on the fall electrofishing samples by SIU where the bass were aged, more age-1 bass per hour were collected in 1999 (6.2) than in 1998 (5.8; Table 25). Fewer age-1 bass representing the 1999 year class were collected in 2000 (3.2) than those of the 1998 year-class collected in 1999 (6.2). The catch rate of the 2000 year-class collected in 2001 was 8.2. Catch rate of the 2001 year-class collected in 2002 (13.4) was the highest rate of age-1 bass obtained from

1997 to 2002 (Table 25). However, catch rates of age-1 largemouth bass in Coffeen Lake were again lower in 2003 (5.5).

Growth of Largemouth Bass

The total lengths of age-0 to age-4 largemouth bass at the time of capture in fall electrofishing samples by SIU were compared from 1997 to 2003 in both Newton Lake and Coffeen Lake. Too few age-5 and older largemouth bass were collected to statistically analyze growth rates among years (Table 26). Bass were aged from their sagittae otoliths.

Of all four age groups in Newton Lake, only age-1 bass were statistically smaller in the fall of 1999, after the kill, than in 1998 (Table 26; Figure 3). In each of the last four years of data, the growth rates of age-1 bass was among the highest observed in the study. This indicates that, if there was a negative effect on the growth of age-1 bass due to the heat loading in 1999, it was obviated by 2000. Excluding 1999, growth rates of age-0, age-2, age-3, or age-4 bass were very similar among the years. Though there were a few statistically significant differences among years and ages, there were no biologically significant differences in terms of notable reductions in growth (Table 26; Figure 3). In general, good growth rates in 1993 for age-1 through age-4 largemouth bass changed statistical significance slightly from previous years' analyses. Age-0 largemouth bass growth (167 mm TL) in 2003 was statistically equal to or above all years except 2001 (193 mm TL).

The growth rates of age-0 to age-4 largemouth bass in Coffeen Lake were interesting in that age-1 was the only year-class that indicated possible effects of the higher 1999 water temperatures. Slightly more interesting is the fact that age-0 through age-2 largemouth bass exhibited the significant increases in growth rates the year following the 1999 fish kill (Table 26; Figure 4). CPUs did not indicate that there was an extensive reduction in the largemouth bass population; thus it is likely that forage production and availability increased in 2000. Also, we know that 2003 mean water temperatures were fairly high relative to the other years of study. Good growth rates exhibited by largemouth bass in all age groups for 2003 present additional evidence that mean water temperatures in the ranges of this study have not been deleterious to growth rates.

Creel Catch and Harvest Data

Creels were not run on Coffeen Lake from 1997 to 2001. Data has been provided by IDNR for a creel survey conducted in 2002, but the information is incomplete to date. AmerenCIPS provided historical 12-month creel data for Newton Lake. Evidently, these historic creels were designed to yield harvest but not catch data. AmerenCIPS contracted with the Illinois Natural History Survey (INHS) to conduct a creel survey on Newton Lake in 1998, 1999, and 2000/2001. The 1998 creel survey was run from 02/16/98-12/31/98 (10.5 months). In 1999 the creel was run for 12 months. A creel was run from April 9, 2000 – March 15, 2001 (11.25 months).

Total catch and harvest data from 1998, 1999, and 2000/2001 are not ideally comparable because of the differences in the length of the creel period. We have asked INHS to recalculate all creel data on a 10.5 month basis and 2000 creel on both a 10.5 and 12 month basis. Based on the data we have at this time there was both a higher catch (97,785 versus 91,711) and harvest (18,607 versus 12,604) of fishes in 1999 (the year of the kill) than in the year before the kill (1998) (Table 27).

More largemouth bass were caught and harvested in 1999 than in 1998 (Table 28). The harvest of largemouth bass increased from 1,503 fish in 1998 to 2,100 fish in 1999 (Table 28). Fewer bluegill (548) were harvested in 1999 than in 1998 (953) (Table 29). More white crappie were harvested in 1999 than in 1998 (Table 29). As was the case with the largemouth bass, the harvest of channel catfish increased in 1999 over 1998 (Table 30). In fact, the total number of channel catfish harvested in 1999 (12,023) almost doubled the number harvested (6,427) in 1998 (Table 30).

Although more fish were caught and harvested in 1999 than in 1998, fewer fish were harvested in the second half of 1999 than in the second half of 1998 (Table 31). In 1998, 48% of the total number of fish and 46% of the largemouth bass were caught between 02/16/98 and 06/15/98. Fifty eight percent of the largemouth bass were harvested during this period. In 1999 63% of the total number of fish and 70% of the largemouth bass were caught between 01/01/99 and 06/15/99. Eighty two percent of the total harvest of largemouth bass occurred during the first six months of 1999 (Table 31).

During the April 9, 2000 – March 15, 2001 creel period, fish pressure (angling hours) was reduced by approximately 27% below that found in 1998 (102,179) and 1999 (106,027) (Table 27).

The 75,650 angling hours of pressure estimated for the 2000/2001 creel is similar to the number of angling hours from 1988 to 1992 which ranged from 70,330 to 84,022. Even with the 27% reduction in angling hours, due to an increase in fish caught per hour, almost as many fish were caught in 2000/2001 as in 1998 or 1999 and the number of fish harvested in 2000/2001 was considerably higher. The pounds of fish harvested were higher in 2000/2001 then in 1998 but not as high as 1999, the year of the kill (Table 27).

Fewer largemouth bass were caught or harvested during the 2000/2001 creel periods than in either 1998 or 1999 (Table 28). Essentially the same number of channel catfish and bluegill were caught and harvested in 2000/2001 as in 1998 and 1999 (Table 29; Table 30).

HABITAT

Macrophytes

Macrophytes were monitored in Newton Lake but not Coffeen Lake. In general macrophytes are not very abundant in Newton Lake. By far, water willow is the most dominant macrophyte in Newton Lake. The percent coverage of water willow during August tends to be inversely related to water levels. The number of acres of macrophytes in August was lower in 1999 than in 1998. However, the water level was at pool level in August of 1998 and 0.8 feet below pool in August of 1999. More surface area was covered with macrophytes in 2000 than in either 1997 or 1998 (Table 32). Over the period 1997-2001, macrophyte coverage was lowest in 2001. There was no difference between 1998 and 1999 in the weight of macrophytes per square meter. The weight of macrophytes per square meter was less in 2000 than in either 1998 or 1999. In 2002, due to low water levels, macrophytes were not present in Newton Lake.

Temperature/Oxygen/Depth Profiles

Seasonal temperature/oxygen /depth profiles were taken in Newton Lake and Coffeen Lake from 1997 through 2003. Exact periods of data collection varied somewhat by grant time lines, but the historically, most stressful periods for the fish were usually encompassed. We estimated how much of the lake or lake segments were available to the fish as a percentage of the depth of the water that was below various temperatures (87-97° F) and above various dissolved oxygen levels (1-4ppm) (Heidinger et al. 2000). All of the profiles were taken during the daytime hours (1-5 PM) during 1997 through 1999. Since photosynthesis does not occur at night, it seemed possible that we were over estimating the amount of available habitat in the lake.

In 2000 and 2002, we investigated how "time of day" affected habitat availability. In Newton Lake, during 12 different 24-hour periods from 07/13/00 to13/23/00, we took paired day (1-5 PM) and night (2-5 AM) temperature/oxygen/depth profiles in each of our four sampling segments (48 total) on each lake. During August 2002, on four dates we took paired morning (7-9 AM) and afternoon (3-7 PM) temperature/oxygen/depth profiles in each of four sampling segments on each lake (16 total) on each lake. Habitat was averaged for the 11 temperatures (87-97°F) for each of the four oxygen levels (1, 2, 3, 4) four lake segments (1, 2, 3, 4), and four August 2002 dates. Those means were used to compare analyze habitat percentage differences between morning and afternoon-evening habitats within each lake among dates, and overall mean habitat differences were used to compare differences between years.

During 2000-2003, we added two additional lake segments (segment 3 and 4) to our original two segments (segment 1 and 2) in Coffeen Lake. Segment 3 is the large arm on the west side of Coffeen Lake known as cemetery bay, and segment 4 is the area between the intake canal and the railroad bridge. Both segment 3 and segment 4 are outside of the normal cooling loop. The mean percentage difference in habitat was calculated at 1.0° F intervals from 87-97° F at dissolved oxygen levels from 1-4ppm at 1ppm intervals.

In Newton Lake during November and December 2000, there was 100% habitat at all stations. This means that all temperatures were below 87° F and all dissolved oxygen readings were above 4ppm (Heidinger et al. 2001). Disregarding the samples taken in November and December, where there were no differences, the mean absolute differences (disregarding the sign) in estimated habitat from paired day versus night samples from 07/13/00 to 10/12/00 was 7% (Heidinger et al. 2001). The range was 0 to 43%. On all 12 dates (07/13/00-12/23/00) in all four segments of the lake over the four oxygen levels (192 data points), day samples indicated larger habitats on 70 comparisons, no difference on 65 comparisons, and larger habitats at night on 57 comparisons (Table 33). In August 2002, mean absolute difference in Newton Lake (Heidinger et al. 2002) was 8% and ranged from 0% to 31%. In Newton Lake over all four August 2002 sampling days, mean habitats percentages were higher in the morning samples 81% of the time and lower for 19% of the comparisons. Therefore, in Newton Lake during 2002, habitat was usually better in the morning hours than in the late afternoon and early evening hours. In 2000, there was a greater tendency for the daytime readings to indicate larger available habitats than nighttime readings in Segment 1 than in Segments 2-4. In fact, in Segment 4, nighttime samples tended to show larger habitats than daytime samples.

Two processes affect the relative size of the habitats at night versus during the day. At night there is no photosynthesis; therefore, oxygen is being used up which tends to reduce the size of the habitat. But also at night there tends to be additional cooling of the water because there is a larger temperature differential between the surface water temperature and the air temperature. A larger volume of cooler water tends to increase the amount of the habitat. The relative strengths of photosynthesis, respiration, cooling and heating determine if there is more or less habitat during the day than at night.

In Coffeen Lake during November and December, there was 100% habitat at all stations. This means that all temperatures were below 87° F, and all dissolved readings were above 4ppm (Heidinger et al. 2001). Disregarding the samples taken in November and December where there were no differences, the mean absolute differences (disregards the sign) in estimated habitat from paired day versus night samples from 07/18/00 to 10/16/00 was 9% (Heidinger et al. 2001). The range was 0 to 36%. On all 12 dates (07/18/00-12/22/00) in all four segments of the lake over the four oxygen levels (192 data points), day samples indicated larger habitats on 46 comparisons, no difference on 52 comparisons and larger habitats at night on 94 comparisons (Table 34). There were no clear differences among segments. This was true even though Segments 1 and 2 were directly in the cooling loop and Segments 3 and 4 were adjacent to the direct cooling loop. During 2002 in Coffeen Lake, the mean absolute difference (Heidinger et al. 2002) was 1% and ranged from 0% to 56%. In all, 69% of the mean habitat comparisons in 2002 morning samples had higher percentages of habitat, and 31% of the times morning mean habitat percentages were lower than late afternoon or evening mean habitat percentages. Thus, in Coffeen Lake during 2002, habitat was usually better in the morning hours than in the late afternoon and early evening hours.

Interestingly, during 2000 in Coffeen Lake, a larger amount of habitat was also more frequently found at night than during the day (Table 34). The opposite was found in Newton Lake during 2000 but not in 2002 (Table 33). It appears that afternoon temperature/oxygen/depth profiles give a reasonable estimate of when the amounts of habitat available to the fish at various temperature and oxygen levels are at a minimum. Therefore, the afternoon samples would likely best indicate times when fish would likely be exposed to maximum stress periods.

Habitat Among Years

The effect power cooling plants' water discharge temperatures have on lake habitat availability is most dependent upon whether or not there are persistently high air temperatures that are usually associated with the summer season. The most potentially critical period for fish in central Illinois lakes includes June through the first two weeks in September. In Newton Lake, mean monthly water temperatures at the outer edge of the discharge mixing zone tended to be the same or lower in 2000 through 2003 than in 1998 or 1999 (Table 4). Conversely, June through September mean monthly discharge temperatures in Coffeen Lake during 2003 were higher than in all previous years. However, as earlier reported, maximum hourly temperatures in 2003 were lower than in 1999 and never reached "Variance" levels. In fact, maximum hourly temperatures at the outer edge of the mixing zone in each year have been lower those recorded in 1999 (See the section on Plant Operation in Relation to Discharge Standards).

We determined the three days per year that had the smallest amount of habitat from our samples in 1998 through 2003 for Coffeen Lake and Newton Lake (Table 35). In 2002, because of the contract time line, habitat monitoring formally started August 1. However, since there was a particularly warm period in July, we took temperature, oxygen, and depth profiles in Coffeen Lake on July 6 and July 8. For all years (1998-2003), in order to compare the amount of habitat among years, percent habitat was calculated using 3ppm dissolved oxygen as a minimum criterion combined with four temperatures from 87°F to 96°F. Habitat percentages reported represent means across all four segments in Newton Lake (Figure 1) and only segments one and two in Coffeen Lake (Figure 2).

In Coffeen Lake, at 87°F there was no suitable habitat during any of the 18 days (among all six years) under the worst conditions. At 90° F, there tended to be more habitat in 2000 and 2001 than in the remaining years (Table 35). At 93° F the smallest amount of habitat was found in 2001, 2002, and 2003. At 96° F and 3 ppm oxygen, the most limited habitat during all six years occurred July 8 2002 (17%) and 8 August 2001 (21%). Since segments 3 and 4 (which are outside the cooling loop) were not added until 2000, their habitats are not averaged into the data in Table 35. Segments 3 and 4 tend to serve as thermal refuge areas in Coffee Lake (see the following section) (Table 36; Table 37; Table 38; Table 39).

Average, whole-lake habitat values do not necessarily give a complete indication of how stressful the habitat really is to fish in specific sections of the lake. For example, the July 8, 2002 habitat values in Coffeen Lake indicate a more severe situation in Segment 1 (Table 38) than when both segments are averaged (Table 35). Extremely limited habitat was available to fish in Coffeen Lake on August 8, 2001, July 6, 2002 and July 8, 2002 (Table 35). This was primarily due to low oxygen levels. Interestingly, and perhaps indicating more serious conditions, these low levels occurred in both the cooling loop (segments 1 and 2) and outside of the cooling loop (segments 3 and 4; Table 37 and Table 38). Despite higher mean temperatures, such conditions were not detected during 2003.

The auxiliary cooling pond at Newton has in operation since summer in 2000. Considering the three least desirable temperature/oxygen events with 3ppm oxygen at 87° F, there was more habitat in 2000 and 2002 than in the remaining four years (Table 35). At 90° F, 0% habitat with 3-ppm oxygen occurred only in 1999. At 93° F and 96° F there were little clear cut trends in the amount of habitat from 1998 to 2003. All four segments are in the cooling loop at Newton Lake. Clearly segments 1 and 2 (discharge end) tend to have less desirable habitat during the summer months than segments 3 and 4 (intake end) (Table 40; Table 41; Table 42; Table 43).

Refuge Areas in Coffeen Lake

In 2000, temperature/oxygen/depth profiles were taken during the day and at night in the two segments of the lake in the cooling loop (1 and 2) and in the two segments of the lake outside the cooling loop (3 and 4) (Figure 2). In 2001, profiles were only taken during the day. It is clear that Segments 3 and 4, which are outside of the cooling loop, tended to have more habitat available to fish than Segments 1 and 2, which are in the cooling loop (Table 36; Table 37; Table 38; Table 39).

Water Level

In most years water did not go over the spillway at Newton Lake until late June (Figure 5). This is well after largemouth bass have spawned. In general, largemouth bass tend to go over the spillway primarily when overflow occurs around their spawning season. In Newton Lake, however, largemouth bass move much more than they do in other lakes (Heidinger et al. 2000). Evidently this movement occurs through the summer. It is not known if this movement leads to escapement of large numbers of largemouth bass over the spillway during summer overflow events. During 2002, water levels dipped below pool level on June 29 and did not return to pool. In fact, water levels decreased to 2.7 feet below pool in October and did not increase for the remainder of the year. In 2003, water levels returned to pool levels and stayed near pool level the remainder of the year.

In Coffeen Lake water levels were above the spillway during the largemouth bass spawning season in 1997, 1998, and 1999 but not in 2000 and 2001 (Figure 6). Water level data for 2002 and 2003 were not provided from Coffeen Lake.

SUMMARY

Differences between such parameter as catch per unit effort obtained by SIU and IDNR is probably due to sampling on different days. The same portion of the fish community is not vulnerable to electrofishing gear every day. Electrofishing methods were not consistent enough to average the IDNR and SIU CPUs for each year. IDNR data was collected annually at specific stations and with preset amounts of effort at each station, whereas SIU employed a more random method of data collection.

Mean monthly water temperatures in Newton Lake during the annual study periods were cooler following 1999. In Coffeen Lake, the temperatures were actually warmer in 2003 than in 1999. However, in both Newton Lake and Coffeen Lake, hourly water temperatures at the outer edge of the mixing zone in June, July and August were much cooler in 2000, 2001, 2002, and 2003 than in 1999. In part these lower discharge temperatures resulted from the use of the added cooling ponds and, in Coffeen Lake, cooling towers. Another factor was the weather patterns in 2000 - 2003 versus 1999. In 1999, temperatures remained very hot for a number of weeks. In 2000 - 2003, very hot weather was followed after a few days by cooler weather and in some cases heavy rain events. These rain events are reflected in the summer water levels of Newton Lake. Weather patterns were mild through most of summer 2003, and at least in Newton Lake, water temperatures were somewhat indicative of the weather. The higher 2003 mean water temperatures in Coffeen Lake reflected the stable increase in power production in that power plant.

Paired day and night oxygen/temperature/depth profiles indicated that habitat could be reasonably determined from daytime readings in both lakes. In Coffeen Lake, these profiles also demonstrated that cemetery cove and the area between the railroad bridge and the intake canal could serve as refuges for at least part of the fish community during heavy thermal loading and/or low oxygen events. On average, lower temperatures resulted in more available habitat in both Newton Lake and Coffeen Lake after 1999; however, averages can be somewhat misleading. Some of the most sever habitat conditions that we have observed occurred in Coffeen Lake on August 8, 2001, July 6, 2002, and July 8, 2002. Coffeen Lake's segments 3 and 4 can provide added refuge during some extremely stressful habitat periods, but habitat conditions on the same three dates indicated that these thermal refuge areas can be subjected to extremely low oxygen levels.

Shorter-term conditions or weather patterns that promote fish kills in ambient lakes (as witnessed in 1999) can also be deleterious to habitat quality in the power-cooling lakes. These conditions include very warm, cloudy periods when, in fact for power-cooling ponds, added power is required which may further deteriorate critical habitat. These types of weather patterns cause the largest fish kills in all lakes, and it is difficult to ascertain whether an additional heat load induced fish kills in the power-cooling reservoirs, or if the severe weather patterns (or a combination of both) induced the kills. For power-cooling ponds, a second condition that can contribute to fish kills is an eroding refuge. A sudden increase of power output and concurring increase in water discharge temperatures can cause some fish to move to an immediate, nearby cove for refuge. If that refuge becomes secluded from inhabitable water by a significant distance (such as is likely if it would occur nearer the discharge mixing zone in either lake), then the refuge can be depleted over time from continuously high discharge temperatures. Fish inhabiting the cove will eventually succumb to heat if they must travel too far in find cooler water. In such instances, the fish kill would likely be relatively small since not all fish would react to the sudden increase in temperatures in the same manner (i.e. some would move to the cooler end of the lakes at the time increased temperatures were initially perceived). Based on information collected since 1997, this entrapment likely occurs at the second highest frequency in terms of fish kills. Low-level angler mortality is likely the most frequently cited kill factor. When epilimnion temperatures are very hot, detrimental effects of stress induced from increased activity and consequential increase in lactic acid from hooking and handling by anglers is compounded and likely causes incidental mortality that is witnessed every year in both lakes. The number of dead or moribund fish observed at specific areas frequented or recently vacated by anglers is usually small, but witnessed or not, this type of mortality most certainly occurs throughout summer. During the once-per-week sampling effort completed during summer 2000 and

2003, very few dead or dying fish were observed in either Newton Lake or Coffeen Lake. The few largemouth bass observed were found near boat docks and popular angler fishing areas. Since, in 2000, a number of boats were present at the dock when bass were observed, the bass may have been caught in a club tournament and released at the dock.

A temperature related kill of approximately 10,000 three-inch gizzard shad was documented on August 24, 2001 in Newton Lake. A kill of approximately 1,200 two to seven inch channel catfish, Lepomis and largemouth bass was observed in Coffeen Lake on July 10, 2001. Both of these kills were in the discharge end of the lake. These kills were most likely associated with the eroding away of thermal refuge areas. In 2002, a kill of 124 fish (including 42 largemouth bass and 64 striped bass) was documented by IDNR in Coffeen Lake. It occurred during the period of June 24 to July 4, 2002.

Some of the variables were statistically tested to determine if they changed among years; however, many of the variables measured before and after the fish kill in 1999 did not lend themselves well to statistical comparisons. For example, it is possible to determine if the length frequency distributions of the sampled fish are different among years. Such a tool as the Kolmogorov-Smirnov test will indicate if there is a significant difference in the length frequency distributions of fish sampled between years. The problem is that fish kills are not the only reason why the length frequency distributions can differ among years. Hypothetically, if there is a statistical difference between the length frequency distributions of largemouth bass in Newton Lake in 1998 versus 1999, one possible reason could be the fish kill in 1999. Another possible reason could be due to unequal year-class strength. The largemouth bass population in Newton Lake, as in most lakes, exhibits unequal year-class strength. Thus as strong and weak year classes move through the population the shape of the length frequency distributions changes. A statistical test can indicate a difference in shape but it cannot assign a specific cause to the difference.

In many cases a more appropriate approach, especially if data are available for a number of years, is to determine if the variables associated with the health of a fish community fall within the range of historical data. When variables such as size frequency, electrofishing catch-per-unit effort, recruitment at age-0 and age-1, total annual mortality, growth rate of largemouth bass, relative weight, and angler catch and harvest are compared before and after the fish kill, they essentially all fall within historical levels. Such a finding strongly suggests that no substantial long-term detrimental effects occurred from the fish kill in either lake.

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EXHIBIT 3

File: WQ 3.15.8.2

Ameren/CIPS Newton and Coffeen Lakes Research and Monitoring Project

Status Report

Principal Investigators
Roy Heidinger
Ronald Brooks
Robert Sheehan

Fisheries & Illinois Aquaculture Center
Southern Illinois University at Carbondale

November 2000

Status

The goals of this study are to: (1) determine if there are any long-term effects of the 1999 fish kills that occurred in both Newton and Coffeen Lakes, (2) determine how much the physical changes that were made in cooling capacity to the Newton Lake and Coffeen Lake electrical generating stations change fish habitat, and (3) investigate other ways to improve fish habitat in Newton Lake.

Job 1. Structure and Dynamics of Fish Populations in Newton Lake and Coffeen Lake.

Job 1.1 Age and Growth and Total Mortality

Samples of largemouth bass, channel catfish, and bluegill were collected from both Newton and Coffeen Lake in October and November of 2000. The otoliths from these fish are being processed to determine their age. The age-frequency distribution will be used to determine total mortality.

Job 1.2 Young-of-the-Year Fish and Recruitment

Young-of-the-year fish were sampled by seining the shoreline of both lakes in April, May, June, July and August. Since we were under the impression that this project was not going to be continued some of the samples that ideally should have been taken in late May and June were not taken. All of the rest of the samples were collected.

Catch per seine haul of Age-0 largemouth bass from both Newton and Coffeen Lake was lower in 2000 than in any of the other three years (Table 1). Catch per unit effort of age-0 bluegill was lower from Coffeen Lake in 2000 than in 1997, 1998 or 1999 but the catch per unit effort of age-0 bluegill from Newton Lake was higher than in any of the previous three years (Table 1).

Fall electrofishing catch per hour of all ages of largemouth bass and channel catfish from Newton Lake was higher in 2000 than in any of the previous three years. CPUE of bluegill in 2000 was lower than in 1997 but higher than that obtained in either 1998 or 1999 (Table 2).

Fall electrofishing CPUE of largemouth bass from Coffeen Lake was lowest in 2000 while CPUE for bluegill and channel catfish from Coffeen Lake fell within the range of those found in the previous three years (Table 2).

IDNR has extensive spring and fall sampling data that we can use to determine trends in the fish communities in these two lakes. On October 10, 2000, I sent a registered letter to Dr. John Tranquilli requesting information that IDNR has that we need for this evaluation (see enclosure). I received a phone call from Mike Hooe whose district includes Newton Lake. He indicated that he would send me the requested information. I never received any direct response from Dr. Tranquilli or from Mr. Charley Merbut whose district includes Coffeen Lake. To date, I have not received any data from IDNR.

We have received the corrected 1998 and 1999 creel data for Newton Lake from INHS. Assuming we receive the 2000 creel data before March 2001, we will include it in our March 2001 annual report.

Job 2. Fish Habitat in Newton Lake

Job 2.1 Aquatic Vegetation

All of the samples specified in the scope of work for the aquatic vegetation portion of the project in Newton Lake were successfully obtained. In general the size of the vegetation beds were more extensive in 2000 than in any of the previous three years, and the diversity (number of species) of vegetation was greater.

Job 2.2 Depth, Temperature, Oxygen Profiles

In 1997, 1998 and 1999 we used a brand of temperature recorders at various locations and depths in both Newton and Coffeen Lake that proved very unreliable. In late summer of 2000 these temperature recorders were replaced with another brand. To date these recorders seem much more reliable.

Although we are just starting to analyze the data, it appears that there is little difference in the volume of Newton Lake available to the fish with respect to temperature and oxygen levels during July and August 2000 versus July and August 1999.

In December 2000 and January 2001, we will be discussing with IDNR various options for enhancing the fish habitat in Newton Lake

Summary

All work is on schedule. One of the major differences in 2000 versus 1999 is that no major fish kill occurred in either lake in 2000. We saw only four dead or dying bass and one dead channel catfish in Coffeen Lake in 2000. Only two dead bass were observed in Newton Lake. All of the bass were found around the boat docks and probably were the result of angling related stress.

Table 1. Largemouth bass and bluegill collected by seining in two Illinois power-cooling lakes during August 1997 and April through August 1998, 1999, and 2000. The lakes were seined twice per month. Ten seine hauls were made in each of four segments in Newton Lake and in two segments in Coffeen Lake. The number of age-0+ bluegill was extrapolated in relation to relative abundance of identifiable *Lepomis* species collected at each station.

Species	Lake	Year	Number per seine (Age-0)	Number per seine (Age-1)
Micropterus salmoides	Coffeen	1997	1.50	0.00
	Coffeen	1998	0.39	0.01
	Coffeen	1999	0.15	0.01
	Coffeen	2000	0.02	0.00
	Newton	1997	1.58	0.00
	Newton	1998	5.88	0.01
	Newton	1999	3.49	0.00
	Newton	2000	0.54	0.02
Lepomis macrochirus	Coffeen	1997	3.00	0.75
	Coffeen	1998	2.13	3.37
	Coffeen	1999	4.67	1.18
	Coffeen	2000	1.03	3.73
	Newton	1997	0.23	0.03
	Newton	1998	0.58	3.45
	Newton	1999	0.15	0.38
	Newton	2000	0.75	1.20

Table 2. Three phase AC electrofishing catch-per-unit effort (catch per hour) of largemouth bass, bluegill and channel catfish from Newton and Coffeen Lakes during the fall of 1997, 1998, 1999 and 2000.

	Newton Lake			
	1997	1998	1999	2000
Largemouth bass	37.1	50.6	36.7	76.6
Bluegill	130.1	78.8	97.6	114.6
Channel Catfish	3.1	7.3	7.3	13.2
	Coffeen Lake			
Largemouth bass	24.4	15.0	27.9	10.3
Bluegill	69.1	58.7	163.3	95.0
Channel catfish	5.7	2.2	6.6	2.9

SIU
SOUTHERN ILLINOIS UNIVERSITY
CARBONDALE

October 10, 2000

Dr. John Tranquilli
11731 State Highway 37
Route 4, Box 208
Benton, Illinois 62812

Dear John:

As you know Ameren CIPS has continued our grant to evaluate thermal loading on Newton and Coffeen Lake. Even though this work is funded at a reduced level, I still need the information from your biologist's spring and fall sampling surveys.

I have not received the spring 1999 data for Newton Lake. I understand that it was sent but I do not have it in my files. I have the fall 1999 data for Newton Lake.

I need the following:

Newton Lake: Spring 1999 and Spring 2000

Coffeen Lake: Fall 1999 and Spring 2000

Thanks.

Sincerely,

Roy Heidinger

Roy Heidinger
Email: royheid@siu.edu

sw

Fisheries and Illinois Aquaculture Center, Mailcode 6511, Carbondale, Illinois 62901-6511, Phone and Fax: 618/536-7761

CHAPTER 1. OVERVIEW OF RESULTS

Introduction:

The AmerenCIPS Newton Lake Project was initiated primarily to determine additional biological impacts, if any, on the biota of Newton Lake from increased thermal loading when Newton Power Station is operated under a new "Variance." The Variance allows increases of maximum thermal discharges to the extent that water temperatures during June-October will not exceed a monthly average of 106EF and a maximum of 111EF for no more than 3% of the hours. During the remaining months, discharge limits are to be similar to those prior to the Variance. Thus, average monthly water temperatures may not exceed 102EF and maximum temperatures will be no more than 111EF.

The thermal discharge on Coffeen Lake was also modified in 1997. The historic variance was as follows:

> "The thermal discharge to Coffeen Lake from Central Illinois Public Service's Coffeen Power Station shall not result in a temperature, measured at the outside edge of the mixing zone in Coffeen Lake, which: 1) exceeds 105 degrees Fahrenheit as a monthly average from June through September and 112 degrees Fahrenheit as a maximum for more than three percent of the hours during that same period; 2) exceeds 89 degrees Fahrenheit as a monthly average from October through May and 94 degrees Fahrenheit as a maximum for more than two percent of the hours during the same period."

This was changed so that the summer time frame of June through September was changed to May through October.

This study was designed to examine effects of the Variance thermal regime in Newton Lake at trophic levels encompassing primary producers to tertiary consumers. Ecological principles dictate that adverse effects on lower trophic levels will be manifested at higher trophic levels. Since fish tend to integrate thermal effects in aquatic systems and they are of particular importance to the public, considerable emphasis is placed on this taxon. In order to monitor changes in the lower trophic levels, phytoplankton, macrophytes, zooplankton, benthos, and phytomacrobenthos were monitored in Newton Lake.

Newton Lake has 1,750 acres to service two electrical generating units with a design capacity of 1,234 GMW. Coffeen Lake (1,100 acres) was chosen as a study lake because it has similar thermal loading from its two electrical generating units that have a total capacity of 1,005 GMW. Thermal loading affects Lake of Egypt much less. This 2,300-acre lake, located in southern Illinois, supports four units with a total design capacity of 272 GMW. All three power plants are coal fired.

A portion of this study compares the health and condition of Newton Lake fish species to those in Lake of Egypt and Coffeen Lake. Growth is an excellent indicator of health and condition of fish because it integrates all of the biotic and abiotic factors acting on them. Age and growth analysis is especially appropriate for this study because average growth rates for age classes within species can be determined via back-calculation for several years prior to plant operation under the new variance. With additional years of study a comparisons of growth rates before and after operation under the new variance would provide key information on how fishery resources is affected in the long term. Age and growth analysis also permits direct comparisons of growth among the three lakes for the various species. Even if fish are growing well, a desirable fishery will not exist unless recruitment is adequate. Ichthyoplankton as well as recruitment to age-1 was also monitored.

Fish health assessments were made not only by growth analysis but also with condition factors and stress indicators. The effects of stress depend upon the fishes' ability to acclimate not only to higher temperature extremes and lower oxygen but also to the wide temperature fluctuations that occur in cooling ponds.

If the fish require refuge from the potentially stressful temperatures, then it is important to determine if suitable habitat is available. Fish movement was monitored to determine habitat utilization. Since movement of largemouth bass (*Micropterus salmoides*) and to a much lesser degree channel catfish (*Ictalurus punctatus*) was monitored in all three lakes, habitat utilization can be compared among lakes as well as seasonally within each lake.

For sampling purposes Newton Lake was divided into four segments (Figure 1.1), and Coffeen Lake and Lake of Egypt into two segments (Figure 1.2; Figure 1.3). The basic sampling regime is outlined in Table 1.1.

This report is separated into sixteen chapters, and primarily includes an analysis of the data collected in August 1997 through August 31, 1999. An effort has been made to address the magnitude, cause, and significance of the fish kill that occurred in Newton Lake and Coffeen Lake in July of 1999.

Plant Operation in Relation to the Variance

Newton power plant discharge temperatures never exceeded the new variance criteria in 1997 or 1998. Thus, 1998 can be considered a pre-variance year. Newton power plant discharge temperatures in the summer of 1999 reached but did not exceed the new variance levels. The highest monthly average of 104°F occurred in July 1999 (Table 1.2) Mean daily temperatures exceeded 105°F in all three years (Figures 1.4, 1.5, 1.6). All of the 100 hours of discharge temperature equal to or above 111°F occurred between July 22, 1999 and July 31, 1999 (Table 1.3). The new variance allowed 110 hours.

July 1999 had the highest mean monthly temperature (103°F) in Coffeen Lake (Table 1.4). Thus mean month temperatures did not exceed the 105°F mean monthly maximum allowed by the variance. Only 83 of the allowable 132 hours above or equal to 112°F were used in 1999. All except 3 hours occurred between July 23, 1999 and July 31, 1999. Three hours associated with start up above 120°F occurred on September 7, 1999 (Table 1.5). Mean daily temperatures were above 105°F and peaked in July 1997, 1998, and 1999 (Figures 1.7, 1.8, 1.9).

Characteristics of the Fish Community

The fish community in Newton Lake has undergone many changes since 1976. Fishing started in 1980. Initially crappie were abundant and grew well in Newton Lake. Although they continue to grow well, recruitment was greatly reduced by 1987. Crappie from a recently built nursery area on the lake probably accounts for their slight increase in the 1999-electrofishing catch (Table 1.6). Historically, except for the first few years, very few bluegill reached 7 inches in total length (Table 1.7). Except for the 1998 spring sample, less than 5% of the bluegill were larger than 6 inches since 1994. During the late 1970's and early 1980's, a significant number of channel catfish exceeded 20 inches in total length. After the mid 1980's fewer than 7 percent of the sampled channel catfish exceeded 20 inches (Table 1.8). Largemouth bass are the most sought after sport-fish in Newton Lake. There has been an 18-inch minimum length limit and a 3 fish per day creel limit on the lake since it opened for fishing in 1980. The highest percentage of bass larger than 18 inches in total length tended to occur in the spring samples rather then in the fall samples (Table 1.9). Since 1990 the percentage of large bass appears to be decreasing, although spring samples in 1997 and 1998 show 14 and 15 percent of the bass sampled were over 18 inches in total length.

The growth rate of white crappie in Newton Lake was faster than in Coffeen Lake but slower than in Lake of Egypt (Table 1.10). Bluegill were growing slowly in all three lakes (Table 1.11). Channel catfish were growing very slowly in Newton Lake. Their weight (0.6 lb) at age-10 was only about half of a 10-year-old channel catfish (1.1 lb) in Coffeen Lake. Ten-year-old channel catfish in Lake of Egypt averaged 2.9 pounds (Table 1.12). Largemouth bass grew fairly fast for the first two or three years in Newton Lake and Coffeen Lake (Table 1.13). Their growth rate then slowed down; however, there are significant numbers of three to five pound bass in Newton Lake and three to four pound bass in Coffeen Lake. Bass larger than six pounds are relatively rare in both lakes. Noteworthy is the fact that growth rate of largemouth bass in the cooler Lake of Egypt is slower than in either Newton Lake or Coffeen Lake.

Mean relative weights of largemouth bass were higher in Newton Lake and Coffeen Lake than in the cooler Lake of Egypt (Table 1.14). Except for their August average of 82 in Lake of Egypt, all mean relative weights were within the desirable range of 100 plus or minus 10. Except for the fall (November) values in Newton Lake (91) and Coffeen Lake (92), the mean relative weight of bluegill tended to be below the desirable range at all other times of the year and in all three lakes. Channel catfish in Lake of Egypt tended to have mean relative weights above 90; whereas, catfish in both Newton Lake and Coffeen Lake had relative weights less than 90.

During the three years of this study, largemouth bass in Newton Lake had a higher percentage of empty stomachs (59.1%) than either Coffeen Lake (40.6%) or Lake of Egypt (40.7%). Channel Catfish from Coffeen Lake had the highest percentage of empty stomachs (55.8%) and channel catfish from Lake of Egypt had the lowest (34.3%). Largemouth bass had a higher percentage of empty stomachs in 1999 than in 1998. Channel catfish also had a higher percentage of empty stomachs in Newton Lake and Coffeen Lake in 1999 than in 1998, but in Lake of Egypt channel catfish had a lower percentage of empty stomachs in 1999 (Table 1.15).

Based on the catch curve method, the mean annual mortality of largemouth bass in 1997-1999 was highest in Newton Lake (51%) and lowest in Lake of Egypt (28%) with Coffeen Lake falling in between (36%) the other two lakes (Table 1.16). Bluegill follow the same trend with a 72% annual mortality rate in Newton Lake, 45% in Lake of Egypt and 63% in Coffeen Lake (Table 1.16). Channel catfish, on the other hand, had the highest annual mortality rate in Lake of Egypt (50%) followed by Newton Lake with 37% and those in Coffeen Lake with 23%. The mortality rate calculations for channel catfish from Lake of Egypt were based on very few specimens. All of the values from all three lakes for all three species were well within the ranges reported in the literature.

Growth rates, mortality rates and recruitment rates determine the structure of a fish population. Larval fish densities were monitored in Newton Lake, Coffeen Lake, and Lake of Egypt. Most fish species in Illinois spawn in the spring when water temperatures reach a certain level. As water temperatures continue to increase, essentially, a temperature is reached where a given species stops spawning. It seems logical to assume that this "spawning window" may be narrowed by rapidly adding heat to a lake; however, the hatching date ranges were not restricted in Newton Lake or Coffeen Lake and were actually extended when compared to the cooler Lake of Egypt (Table 1.17). Except for *Pomoxis* in Lake of Egypt and *Lepomis* in Coffeen Lake, spawning took place over more days in 1999 than in 1998 in all three lakes (Table 1.17).

In Newton Lake and Coffeen Lake, the densities of larval *Lepomis* and *Dorosoma* in ichthyoplankton tows were the same in 1999 as they were in 1998 (Table 1.18). In Lake of Egypt, the density of *Dorosoma* in 1998 was the same as in 1999, but the density of *Lepomis* was greater in 1998 than in 1999 (Table 1.18). There was no difference in catch per hour for *Lepomis*, *Dorosoma* or *Micropterus* in light traps between 1998 and 1999 in any of the three lakes (Table 1.19).

Zooplankton, the initial food supply for larval fish was also relatively abundant. During the spawning of the various species of fish mean total zooplankton ranged from approximately 100 to 800 zooplankters per liter of lake water (see Chapter 8).

It is possible to have large numbers of larval fishes and still have a weak year class of fish. Shoreline seining captures larger, thus older fish, than ichthyoplankton net tows. In all three lakes, there was no difference in the catch per unit effort of all fish (primarily young of the year) collected by shoreline seining in 1998 versus 1999 (Table 1.20). Nor was there any difference in the shoreline seining catch per unit effort for young of the year largemouth bass between 1998 and 1999 in Newton Lake or Coffeen Lake. In Lake of Egypt more largemouth bass were captured in 1999 than in 1998.

Most biologists prefer to measure recruitment after the fish go through the first winter, in other words at age-1. In Newton Lake, our fall electrofishing samples indicated a drop in catch per hour of age-1+ largemouth bass in 1999 as compared to 1998 (Table 1.21). The information in Table 16 is based on a relatively small sample size. In 1998 and 1999, IDNR made a much larger fall electrofishing collection of largemouth bass in Newton Lake. These fish were not aged, but they were measured. If we assume that an age-1+ largemouth bass captured in the fall would have a total length up to 11.8 inches, then in 1998, out of the 705 largemouth bass collected there were 287 age-1+ bass. In 1999, out of the 514 largemouth bass sampled there were 255 age-1+ bass. This is equivalent to 23.9 age-1+ bass per hour in 1998 and 21.2 age-1+ bass per hour in 1999. Since we have not received the 1999 fall sampling data for Coffeen Lake from IDNR, we can not make the same calculations for this lake. Actually, the best estimate can be made only after the spring 2000 electrofishing data are obtained. These data will allow us to compare spring to spring recruitment for age-1+ largemouth bass.

Creel Harvest Data

Creels were not run on either Coffeen Lake or Lake of Egypt in 1997-1999. AmerenCIPS provided historical 12-month creel data for Newton Lake. Evidently, these historic creels were designed to yield harvest but not catch data. AmerenCIPS contracted with the Illinois Natural History Survey to conduct a creel survey on Newton Lake in 1998 and 1999. The April, 1998 creel survey report covered only nine months. The heavily fished November, December, and January months were not included.

Yearly angling effort dropped from a high of 150,814 hours in 1986 (12 months) to a 12 month low level of 70,330 hours in 1991 (Table 1.22). In 1998 fishing pressure was back up to 105,931 hours for the 9-month creel. The harvest of largemouth bass has remained remarkably consistent since 1986 ranging from 731 to 1,743 fish (Table 1.23). In 1998 a total of 1,287 largemouth bass was harvested. A size limit of 18 inches total length and a harvest limit of three fish per day has been in place since Newton Lake was opened to fishing in 1980.

Bluegill harvest has been very low throughout all creel years. The harvest of 947 bluegill in 1998 approaches the 1986 high of 1,009 fish (Table 16.24). Crappie harvest fell from a high of 89,499 in 1986 and 66,971 in 1987 to 69 in 1988. This drastic decrease in harvest reflects the classical significant reduction in recruitment of crappie, which is well documented but not understood, in older and warmer power cooling lakes. Since angler harvest of crappie tends to be dominated by 3 and 4-year-old fish, the reduction in recruitment probably started in 1985.

Channel catfish harvest in Newton Lake in 1998 was approximately one-half that of previous years (Table 1.25). The harvested fish average approximately one pound in weight, which reflects the relatively slow growth rate of the channel catfish in Newton Lake. Since a 10-year-old catfish in Newton Lake only averages approximately 0.6 pounds, the harvested fish are probably the faster growing portion of the population.

Significant changes in the structure and utilization by anglers of the fish community in Newton Lake have taken place, but as far as the data show, these changes occurred before the new variance was placed into effect.

In addition to describing the fish community and its utilization by anglers, other components of the flora and fauna were monitored in Newton Lake. Since the power plant did not operate within the new variance parameters until 1999, the 1997-1998 data can be viewed as base line information.

Primary Productivity/Phytoplankton

Primary productivity and phytoplankton densities were monitored only in Newton Lake. During both 1998 and 1999, net photosynthesis tended to be higher during the summer months (Figure 1.10). The values of net photosynthesis fall well within the range of values found for other lakes (Table 1.26). Since the highest temperatures occurred in Newton Lake in July of 1999, the effects of these temperatures on the flora and fauna were investigated, where possible, by comparing data from July and August 1998 to similar data collected in July and August 1999.

Phytoplankton cell counts peaked in June 1998 and in January 1999 (Figure 1.11). Even though there was a decrease in mean total phytoplankton densities in July and August 1999 over July and August 1998 (Table 1.27) there were no differences in net photosynthesis (Table 1.28) or chlorophyll a levels, probably due to a deeper euphotic zone (Table 1.29). There was a very slightly higher OD664/OD665 ratio in July and August 1998 than in 1999 (Table 1.30). The net photosynthetic rate and not the number of phytoplankters is the factor that ultimately determines the amount of oxygen in the euphotic zone of the lake.

Macrophytes

By producing shade, macrophytes reduce the temperatures in shallow water. Unfortunately, macrophytes cover a very small portion of Newton Lake. The dominant plant in Newton Lake is water willow (*Dianthera americana*). Water willow covered approximately 35 acres in August 1998, 22 acres in August 1999, and 15 acres in 1997 (Table 1.31). The lower coverage in 1999 over 1998 was a function of water level. In August 1998, Newton Lake was at pool level; whereas, in August 1999 it was 5.2 feet below pool. Within the vegetation beds, there was no difference in stem density per unit of surface area between 1998 (4.94 lb/m^2) and 1999 (4.00 lb/m^2) (Table 1.31). Since, in all three years, the area of macrophyte coverage was only 0.9-2% of the lake, it would be highly desirable to find a way to increase this coverage.

Zooplankton

As expected, zooplankton fluctuated widely throughout the year (Figure 1.12). Densities ranged from approximately 100 to 800 organisms per liter. Peak densities occurred in the winter and early spring. Zooplankton densities from April through August fell within the middle of the range for 12 other Illinois lakes (Figure 1.13). Mean zooplankton densities were actually higher by 40% in July and August 1999 (239/L) than in July and August 1998 (171/L) (Table 1.32).

Benthos

Diptera comprised 82% of the benthos numerically and 84% by weight. Tubificida made up 13% by numbers, but only 8% by weight; whereas Veneroida (clams) comprised only 2% of the benthos by number and 5% by weight. The highest mean number and weight of the benthos per meter squared occurred in the winter of 1998 (Figure 1.14). Benthos densities in Newton Lake from May through October tended to fall within the lower third of the densities found in 12 Illinois lakes (Figure 1.15). Both the density and weight of the benthos per meter squared were considerably higher in 1999 than in 1998 (Table 1.33).

Phytomacrobenthos

Phytomacrobenthos are the macroinvertebrates that are attached to the aquatic vegetation. In Newton Lake, the phytomacrobenthos are primarily found on water willow. The numbers of phytomacrobenthos peaked in August 1998 and 1999. Their weight peaked in August 1998 and in September 1999 (Figure 1.16). The mean number of phytomacrobenthos in July and August 1999 was 93% higher than their density in 1998 (Table 1.34). Likewise, the mean weight of phytomacrobenthos in July and August 1999 was 140% higher than in July and August 1998 (Table 1.34).

Fish Kill

Temperature related fish kills occurred in Coffeen Lake and Newton Lake in 1999. A fish kill did not occur in Lake of Egypt in 1999 nor did a kill occur in any of the three lakes in 1998. The following discussion concerning the fish kills emphasizes largemouth bass.

In Coffeen Lake, the fish kill probably started on July 27, 1999, peaked on July 28, 1999, with no other fish except for one gizzard shad and one white crappie found after July 28 (Table 1.35). SIUC personnel counted a total of 121 dead largemouth bass. In addition to the fish that died, large numbers of the exotic Asiatic clam (*Corbicula sp.*) were also killed. Unlike the fish, the number of clams that died was not quantified. In both lakes, fish that were not too decayed were measured for total length. The six dead channel catfish that were measured from Coffeen Lake were not among the larger individuals in the population (Figure 1.17), and many large individuals were present in the population in the fall of 1999 (Figure 1.18). The dead largemouth bass tended to be among the larger fish in the population (Figure 1.19). This is not unexpected since large bass are more susceptible to higher temperatures and low dissolved oxygen stress than are small bass; however, there was no discernible difference in their fall 1999 length frequency distribution from that of the fall of 1998 (Figure 1.20).

In Newton Lake, there were two distinct fish kills. The first occurred on June 9, 1999 when 27 largemouth bass were found (Table 1.36). No other species of fish were found at this time or over the next few weeks. Maximum hourly discharge temperatures were approximately 96°F for two hours on June 8, 1999, and temperatures approached 95°F on the afternoon of June 9, 1999, but by this time the fish were already dead. There was a considerable amount of oxygenated, deeper, cooler water in segment 1 on June 2 and June 8

(Figure 1.21). Since no other species were found, it is possible that these fish died as a result of an informal bass club tournament instead of a thermal kill.

A definite temperature related fish kill probably started on July 27, 1999, in Newton Lake. On this date, 18 largemouth bass and 33 other fish from 5 different taxa were found. Unlike the kill on Coffeen Lake, which lasted only a couple of days, fish died in Newton Lake from July 27, 1999--August 31, 1999. During the first couple of days, primarily dead bass and not moribund bass were found. Later, especially in August both dead and dying fish were observed. Externally, the dying fish were heavily infected with bacteria and fungus. Thus, it appears that the stress in late July made the fish vulnerable to bacteria and fungus infections in August. We collected both dying fish and apparently healthy fish by electrofishing in late July. The fish health assessment index proposed by Goede (1993, see chapter 9 for citation) was not sensitive enough to delineate between these two groups of bass (Table 1.37). Thus, this index is not suitable for monitoring short-term thermal stress events. The larger largemouth bass (Figure 1.22) and channel catfish (Figure 1.23) died in the kill, but no change could be detected in the 1999 versus 1998 fall length frequency distributions for either species (Figures 1.24-1.25).

Significance of Dead Largemouth Bass

A few calculations will show that the number of largemouth bass that died in Coffeen Lake and Newton Lake pose no significant long-term effect on the two bass populations. Assuming that we counted only 50% of the largemouth bass that died, then 242 bass died in Coffeen Lake (0.22 per acre) and 454 in Newton Lake (0.26 per acre). If there are 20 bass per acre in Coffeen Lake (1100 acres), then the death of 242 bass represents only 1% of the population. Although we have no recent creel data for Coffeen Lake, this is probably well below what is removed by anglers each year. Average total annual mortality for largemouth bass in Coffeen Lake is approximately 36% (Table 1.16).

Assuming 20 largemouth bass per acre in Newton Lake (1750 acres), there were 35,000 bass in the lake. If anything, this is an underestimate considering that from February through October of 1998 the creel results indicated that 56,339 bass were caught. In other words if there were 35,000 bass, each bass on average was caught 1.6 times. Based on a population of 35,000 bass, the death of 454 bass in Newton Lake would equal only 1% of the population. In both lakes, the fish that died were large fish in the population but based on the 1998 nine month creel, which does not include the heavily fished late fall and winter months, anglers removed 1,287 bass that were 18 inches or larger (Table 1.23). Also, to place the loss into perspective, average total annual mortality for bass in Newton Lake is 51% (Table 1.16).

Temperature/Depth/Oxygen Profiles

Temperature-depth-oxygen profiles were routinely taken every two weeks in each of the three lakes near the middle of each segment (Figures 1.1-1.3). Unfortunately, no profiles were scheduled for the day of the fish kills. Additional profiles were taken during the fish health and fish movement portions of the study. These profiles are given in Chapter 15.

It is difficult to interpret the full meaning of depth-temperature-oxygen profiles by inspection. Estimated percent habitat tables were constructed as an alternative approach (Table 1.38). Basically, the percent of depth is calculated at each sampling station where temperature is at or *below* a given value (from 87-97°F) and dissolved oxygen is at or *above* 1-4 ppm. This percent of depth is assumed to equal the percent by volume of the lake in that section of the lake where the sample was taken. The percent habitat value could be calculated more accurately if a good map with bottom contours of the lake was available. A current map does not exist for either lake. Modeling of this approach on graph paper with lakes of different basin shapes indicates that the habitat values are conservatively within plus or minus 20% of the true value. Thus a habitat value of 50% should be considered to have a range of 40% to 60%. By far the greatest error would occur if the sampling station is located on top of a sharply elevated underwater island or over a creek that is very deep relative to the average depth of the lake. We do not believe that either condition exists at any of our sampling stations.

Unfortunately, we do not have a depth-temperature-oxygen profile in any of the three lakes on July 27, 1999, when the fish kill probably started. In Lake of Egypt, on July 22, 1999 18% of the habitat (lake volume) in segment one (warm area) and 50% of the habitat in segment two (cool area) was 90°F or less and contained at least 4 ppm dissolved oxygen (Table 1.38).

In Coffeen Lake on July 23, 1999, the habitat available at or below 94°F and 4 ppm or more dissolved oxygen was 10% in segment 1 and 5% in segment 2 (Table 1.39). One of the few nighttime profiles that we have shows that by August 1, 1999, habitat conditions were even more restrictive in these areas (Table 1.40); however, we did not have a sampling station on the large cove or the area of the lake north of the plant's intake that are out of the cooling loop. These areas may have had much better water quality than that part of the lake that is in the cooling loop.

Habitat availability conditions on July 24, 1999, and July 18,1998, in Newton Lake are given in Table 1.41. Since the four sampling segments essentially cover the entire lake and they are approximately equal in size, the total habitat available can be estimated. By August 5, 1999, there was a considerable improvement in the amount of suitable habitat (Table 1.42).

Almost all of the depth-temperature-oxygen profiles that were used to construct the percent suitable habitat tables were taken during the day. Since photosynthesis only occurs during daylight hours, available habitat for the fish at night was almost certainly less than shown because of lower dissolved oxygen. Cooler water does exist in both Newton Lake (Table 1.43) and Coffeen Lake (Table 1.44) throughout the year. The problem is that this cooler water has 0-1 ppm dissolved oxygen during the summer.

Summer Habitat Utilization by Largemouth Bass

The fish movement portion of this study gives considerable insight on how largemouth bass react to high summer temperatures and relatively low dissolved oxygen concentrations. During the summer, largemouth bass in both Newton Lake and Coffeen Lake tended to move 1 to 1.5 miles in 24 hours (Figure 1.26). They also tended to use most of the lake, even in the summer (Figures 1.27-1.29).

Individually identifiable, temperature-sensitive sonic transmitters were placed in largemouth bass. These transmitters not only allowed us to locate individual fish but the internal body temperature of the bass could also be determined. By taking a depth/temperature/oxygen profile each time a bass was located, it was possible to determine the location, depth, temperature, and dissolved oxygen concentration where the bass was located. These determinations are not exact because it takes 30-60 minutes for the internal body temperature of a bass to equilibrate to the water temperature after a change of 18°F.

Mean summer internal body temperatures (IBT) of largemouth bass ranged from 79-90°F (Figure 1.30). In Coffeen Lake, the mean IBT ranged from 80-97°F (Figure 1.31) and in Newton Lake mean IBT range was from 75-92°F (Figure 1.32). In both Newton Lake and Coffeen Lake mean maximum internal temperatures occurred in July 1999.

By assuming internal body temperature equaled the external water temperature, it was possible to calculate the oxygen concentration at the fishes' location. In all three lakes, largemouth bass were found at the lowest mean dissolved oxygen concentrations in July 1999 (Figures 1.33-1.35). In Newton Lake for example, in July 1999 largemouth bass were primarily found at oxygen concentrations between 1.9-3.0 ppm (Figure 1.35).

Conclusions:

Since the fish kill on Coffeen Lake occurred with the plant operating at a level that existed under the old variance and the kill on Newton Lake occurred while operating under the new variance, the two cases need to be separated when considering variances. Clearly the habitat in which the fish were able to live was reduced in the summer of 1999 as compared to 1998, but except for the fish kill, there was no indication that the added heat loading in Newton Lake had any negative effect. The fish appeared to be sacrificing higher oxygen levels for lower temperatures. Unfortunately, we do not know where the fish that died were when they were exposed to the critical levels of heat. In both lakes, the kill took place approximately five or six days after the hourly temperatures in the discharge water of Coffeen Lake were exceeding 112°F and those in Newton Lake were exceeding 111°F. It is possible that the dead fish were trapped in an area where their livable habitat was finally eroded away.

To date, there is scant evidence that the fish kills in Newton and Coffeen Lake resulted in significant damage to the fisheries, due to the relatively low proportions of fish that died relative to the numbers of fish in these lakes; however, future creel and relative abundance data collected subsequent to the kills need to be examined to determine whether this view is correct. Other measures, such as fish health assessments, condition factors, relative weights, etc., did not indicate substantial long-term impacts on fish that survived the kill. It is possible that conditions in Newton and/or Coffeen Lakes during summer 1999 will diminish recruitment from 1999 year classes; spring 2000 sampling for relative abundance of age 1 fish needs to be completed before this question can be resolved.

On the other hand, habitat in which fish can survive, based on vertical temperature and dissolved oxygen profiles and the behavior of largemouth bass in the telemetry studies, appears to have been nearly completely lost towards the end of July in Newton Lake, based on our present knowledge of the tolerance of species such as largemouth bass, bluegill, and channel catfish to low dissolved oxygen and elevated temperature. Had habitat conditions been marginally better, there may not have been any kills at all. Conversely, had lake temperatures continued to rise and dissolved oxygen continued to degrade for a few more days, it is possible that the magnitude of the resulting fish kills would have had substantial impacts on the fisheries, especially in Newton Lake and possibly in Coffeen Lake. An apparent decline in electrical power demand, the concomitant reductions in thermal loading, and reduced air temperatures towards the end of July led to improving temperature and dissolved oxygen conditions in both Newton Lake and Coffeen Lake.

Table 1.1 Basic sampling schedule for AmerenCips Newton Lake Project.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
					Newton Lake								
Phytoplankton	0	1	1	2	2	2	2	2	2	1	0	1	24 samples per date: Sampled at 3 stations in each of 4 segments; 2 samples per station.
Zooplankton	0	1	1	2	2	2	2	2	2	1	0	1	Same as phytoplankton.
Primary productivity	1	1	1	1	1	1	1	1	1	1	1	1	Same as phytoplankton.
Chlorophyll a	1	1	1	1	1	1	1	1	1	1	1	1	Same as phytoplankton.
Benthos	1	1	1	2	2	2	2	2	2	1	1	1	24 samples per date: 6 stations per transect. Transects at midway between segment borders.
Phytomacrobenthos	0	0	0	0	1	1	1	1	1	0	0	0	40 samples per date: 5 stations per segment where vegetation present; 2 samples per station. Random in areas sampled that had vegetation.
Aquatic vegetation	0	0	0	0	0	0	0	1	0	0	0	0	80 random stations, 20 per segment
Ichthyoplankton	0	0	1	2	2	2	2	1	1	1	0	0	Tows 48 samples per date: 10-min per tow, 6 stations per segment, 2 samples per station. Light traps: 16 per date; 4 traps per segment, 2-hr sets. 1/2 pelagic - 1/2 littoral for both methods.
Health-stress	0	0	1	0	0	0	0	1	0	0	0	0	
Food habits	1	0	1	1	1	1	1	1	1	1	1	1	Until numbers satisfied. Sampling completed as necessary in each segment to satisfy number requirements.
Age and growth, mortality	0	0	0	0	0	0	0	0	0	1	1	1	October (1998 and 1999); November (1997) for mortality. Extra sampling in following months as necessary for age and growth requirements.
Seine / recruitment	0	0	0	2	2	2	2	2	0	0	0	0	40 samples per date. 10 stations per segment.
DC electrofishing	0	0	0	0	0	0	0	1	0	0	0	0	Six zones per ESE Report (1995).
Fish movement	1	1	1	4	4	4	4	4	4	1	1	1	Entire lakes per date; 24-hr sampling 3 seasons (spring, summer, winter), twice per season.
Temp/DO	2	2	2	2	2	2	2	2	2	2	2	2	4 samples per date: midway between segment borders; 1/2 meter intervals from surface to bottom.

Table 1.1. Continued.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
						Lake of Egypt							
Ichthyoplankton	0	0	1	2	2	2	2	1	1	0	0	0	Tows 24 samples per date. Light traps 8. samples per date.
Age and growth, mortality	0	0	0	0	0	0	0	0	0	1	1	1	Same as Newton.
Seine / recruitment	0	0	0	2	2	2	2	2	0	0	0	0	20 samples per date: Same as Newton - 2 segments.
AC Electrofishing CPUE	0	0	0	0	0	0	0	0	1	1	1	0	Sept - Oct 1997 and 1998.
Fish movement	1	1	1	4	4	4	4	4	4	1	1	1	Same as Newton - 2 segments.
Temp/DO	2	2	2	2	2	2	2	2	2	2	2	2	Same as Newton - 2 segments.
Food habits	0	0	1	0	0	0	0	1	1	1	1	0	Only taken during mortality and age/growth.
						Coffeen Lake							
Ichthyoplankton	0	0	1	2	2	2	2	1	1	0	0	0	Tows 24 samples per date. Light traps 8. samples per date.
Age and growth, mortality	0	0	0	0	0	0	0	0	0	1	1	1	Same as Newton.
Seine / recruitment	0	0	0	2	2	2	2	2	0	0	0	0	20 samples per date: Same as Newton - 2 segments.
Fish movement	1	1	1	4	4	4	4	4	4	1	1	1	Same as Newton - 2 segments.
Temp/DO	2	2	2	2	2	2	2	2	2	2	2	2	Same as Newton - 2 segments.
Food habits	0	0	1	0	0	0	0	1	0	1	1	1	Only taken during mortality and age/growth.

Table 1.2. Mean monthly water surface temperatures of the Newton Lake discharge.

Year	Month	Number	Surface temperature monthly average
1997	June	27	95.9
1997	July	31	101.7
1997	August	31	96.2
1997	September	30	94.9
1997	October	31	86.3
1997	November	21	69.5
1997	December	31	71.3
1998	January	31	62.6
1998	February	28	63.8
1998	March	31	67.0
1998	April	30	79.7
1998	May	31	89.8
1998	June	30	96.3
1998	July	31	101.7
1998	August	31	102.3
1998	September	30	94.6
1998	October	31	87.5
1998	November	30	72.4
1998	December	31	69.8
1999	January	31	54.0
1999	February	28	67.0
1999	March	31	72.3
1999	April	30	77.3
1999	May	31	88.4
1999	June	30	97.0
1999	July	31	104.1
1999	August	31	99.7
1999	September	30	93.1
1999	October	31	85.4
1999	November	16	80.9

Table 1.3. Hourly temperatures that exceeded 111 F, Newton Lake discharge, 1998 – 1999. Within a year total hours above 111 F were not to exceed 110 (3% of total number of hours during the period June – October, 3,672 hours).

Date	Time	Surface temp.	Date	Time	Surface temp.	Date	Time	Surface temp.
07/22/1999	13:34:28	111.22	07/24/1999	20:34:28	111.47	07/28/1999	0:34:28	111.36
07/22/1999	14:34:28	111.39	07/24/1999	21:34:28	111.18	07/29/1999	12:34:28	111.33
07/22/1999	15:34:28	111.48	07/24/1999	22:34:28	111.01	07/29/1999	13:34:28	111.79
07/22/1999	16:34:28	111.65	07/25/1999	13:34:28	111.53	07/29/1999	14:34:28	111.99
07/22/1999	17:34:28	111.84	07/25/1999	14:34:28	111.5	07/29/1999	15:34:28	111.87
07/22/1999	18:34:28	112.03	07/25/1999	15:34:28	111.71	07/29/1999	16:34:28	111.99
07/22/1999	19:34:28	112.09	07/25/1999	16:34:28	111.77	07/29/1999	17:34:28	112.31
07/22/1999	20:34:29	112.06	07/25/1999	17:34:28	112.03	07/29/1999	18:34:28	111.43
07/22/1999	21:34:28	111.93	07/25/1999	18:34:28	112.13	07/29/1999	19:34:28	112.61
07/22/1999	22:34:28	111.85	07/25/1999	19:34:28	112.06	07/29/1999	20:34:28	112.85
07/22/1999	23:34:28	111.74	07/25/1999	20:34:28	112.11	07/29/1999	21:34:28	113
07/23/1999	0:34:28	111.48	07/25/1999	21:34:28	112.44	07/29/1999	22:34:28	112.39
07/23/1999	10:34:28	111.59	07/25/1999	22:34:28	112.53	07/29/1999	23:34:28	112.85
07/23/1999	11:34:29	112.01	07/25/1999	23:34:28	112.32	07/30/1999	0:34:28	112.79
07/23/1999	12:34:28	112.32	07/26/1999	11:34:28	111.15	07/30/1999	11:34:28	111.81
07/23/1999	13:34:28	112.53	07/26/1999	12:18:32	111.28	07/30/1999	12:34:28	111.85
07/23/1999	14:34:28	111.93	07/26/1999	16:34:28	111.35	07/30/1999	14:34:28	112.99
07/23/1999	15:34:28	112.06	07/26/1999	17:34:28	112.57	07/30/1999	15:34:28	113.31
07/23/1999	16:34:28	112.05	07/26/1999	18:34:28	112.46	07/30/1999	16:34:28	113.27
07/23/1999	17:34:28	111.98	07/26/1999	19:34:28	112.47	07/30/1999	17:34:28	113.35
07/23/1999	18:34:28	111.84	07/26/1999	20:34:28	112.34	07/30/1999	18:34:28	113.37
07/23/1999	19:34:28	111.77	07/26/1999	21:34:28	112.31	07/30/1999	19:34:28	113.51
07/23/1999	20:34:28	111.73	07/26/1999	22:34:28	112.33	07/30/1999	20:34:28	113.56
07/23/1999	21:34:28	111.79	07/26/1999	23:34:29	112.29	07/30/1999	21:34:28	113.63
07/23/1999	22:34:28	111.75	07/27/1999	0:34:28	112.23	07/30/1999	22:34:28	113.66
07/23/1999	23:34:28	111.49	07/27/1999	14:34:28	111.37	07/30/1999	23:34:28	113.64
07/24/1999	11:34:28	111.54	07/27/1999	15:34:28	111.54	07/31/1999	0:34:28	113.48
07/24/1999	12:34:28	111.96	07/27/1999	16:34:28	111.71	07/31/1999	1:34:28	111.98
07/24/1999	13:34:28	112.18	07/27/1999	17:34:28	111.82	07/31/1999	2:34:28	112.8
07/24/1999	14:34:28	112.27	07/27/1999	18:34:28	111.78	07/31/1999	3:34:28	112.67
07/24/1999	15:34:28	112.09	07/27/1999	19:34:28	111.57			
07/24/1999	16:34:28	112.05	07/27/1999	20:34:29	111.59	TOTAL HOURS 100		
07/24/1999	17:34:28	111.77	07/27/1999	21:34:28	111.7			
07/24/1999	18:34:28	111.7	07/27/1999	22:34:28	111.71			
07/24/1999	19:34:28	111.75	07/27/1999	23:34:28	111.6			

Table 1.4. Mean monthly surface water temperatures in the Coffeen Lake discharge.

Year	Month	Number	Surface temperature monthly average
1996	September	6	92.4
1996	October	19	83.2
1996	November	30	80.5
1996	December	31	76.6
1997	January	31	71.6
1997	February	28	69.6
1997	March	26	76.1
1997	April	15	70.2
1997	May	31	77.7
1997	June	30	87.9
1997	July	31	100.8
1997	August	31	98.7
1997	September	30	88.7
1997	October	31	81.6
1997	November	30	76.0
1997	December	31	73.3
1998	January	23	68.2
1998	February	0	
1998	March	0	
1998	April	15	82.8
1998	May	31	90.8
1998	June	30	94.9
1998	July	31	102.4
1998	August	31	100.1
1998	September	28	96.1
1998	October	31	79.9
1998	November	30	68.1
1998	December	25	66.4
1999	January	26	67.8
1999	February	24	64.9
1999	March	31	73.1
1999	April	18	85.5
1999	May	31	86.4
1999	June	30	90.5
1999	July	31	103.9
1999	August	31	101.5
1999	September	30	94.8
1999	October	31	83.6
1999	November	30	75.3
1999	December	12	70.8

Table 1.5. Hourly temperatures that exceeded 112 F, Coffeen Lake discharge, 1998 – 1999. Within a year total hours above 112 F were not to exceed 132 (3% of total number of hours during the period May – October, 4,416 hours).

Date	Time	Surface temp.	Date	Time	Surface temp.
07/23/1999	16:00:00	112	07/29/1999	13:00:00	112.89
07/23/1999	17:00:00	112.5	07/29/1999	14:00:00	114.24
07/23/1999	18:00:00	112.21	07/29/1999	15:00:00	114.02
07/23/1999	19:00:00	112.59	07/29/1999	16:00:00	114.14
07/23/1999	20:00:00	112.16	07/29/1999	17:00:00	114.56
07/25/1999	14:00:00	112.09	07/29/1999	18:00:00	114.67
07/25/1999	15:00:00	112.72	07/29/1999	19:00:00	114.19
07/25/1999	16:00:00	112.72	07/29/1999	20:00:00	114.21
07/25/1999	17:00:00	112.43	07/29/1999	21:00:00	113.6
07/25/1999	18:00:00	113.34	07/29/1999	22:00:00	114
07/25/1999	19:00:00	112.95	07/29/1999	23:00:00	113.89
07/25/1999	20:00:00	112.2	07/30/1999	1:00:00	113.24
07/25/1999	23:00:00	112.8	07/30/1999	2:00:00	113.9
07/26/1999	12:00:00	113.01	07/30/1999	3:00:00	113.11
07/26/1999	13:00:00	113.48	07/30/1999	4:00:00	112.34
07/26/1999	14:00:00	113.75	07/30/1999	12:00:00	112.74
07/26/1999	15:00:00	113.87	07/30/1999	13:00:00	114.2
07/26/1999	16:00:00	112.19	07/30/1999	14:00:00	114.3
07/26/1999	18:00:00	112.36	07/30/1999	15:00:00	114.65
07/26/1999	19:00:00	113.4	07/30/1999	16:00:00	114.88
07/26/1999	20:00:00	114.35	07/30/1999	17:00:00	115.05
07/26/1999	21:00:00	112.96	07/30/1999	18:00:00	115.39
07/26/1999	22:00:00	114.17	07/30/1999	19:00:00	114.06
07/26/1999	23:00:00	113.93	07/30/1999	20:00:00	113.44
07/27/1999	0:00:00	112.9	07/30/1999	21:00:00	113.52
07/27/1999	14:00:00	113.62	07/30/1999	22:00:00	112.95
07/27/1999	15:00:00	113.22	07/30/1999	23:00:00	113.64
07/27/1999	16:00:00	113.81	07/31/1999	1:00:00	112.54
07/27/1999	17:00:00	113.31	07/31/1999	2:00:00	112.31
07/27/1999	18:00:00	113.68	07/31/1999	14:00:00	113.02
07/27/1999	19:00:00	113.43	07/31/1999	15:00:00	112.88
07/27/1999	20:00:00	113.81	07/31/1999	18:00:00	113.29
07/27/1999	21:00:00	114	07/31/1999	19:00:00	113.83
07/27/1999	22:00:00	113.29	07/31/1999	20:00:00	114.09
07/27/1999	23:00:00	112.91	07/31/1999	21:00:00	114.2
07/28/1999	15:00:00	112.41	07/31/1999	22:00:00	113.68
07/28/1999	16:00:00	112.95	07/31/1999	23:00:00	112.83
07/28/1999	17:00:00	113.17	09/07/1999	14:00:00	120.27
07/28/1999	18:00:00	113.86	09/07/1999	15:00:00	120.08
07/28/1999	19:00:00	113.91	09/07/1999	16:00:00	122.49
07/28/1999	20:00:00	113.58			
07/28/1999	21:00:00	113.37	TOTAL HOURS 83		
07/28/1999	22:00:00	112.17			

Table 1.6. Size frequency distributions for white crappie in Newton Lake based on IDNR fall and spring electrofishing samples from fall 1976 to fall 1999. The electrofishing effort was not constant over all sampling periods.

		Total length (inches)		
Year	Sample size	6	7	10
1976 Fall	6	33	33	33
1977 Spring	6	17	17	17
1977 Fall	6	100	83	83
1978 Spring	37	70	30	19
1978 Fall	11	100	64	18
1979 Spring	65	100	23	8
1979 Fall	0	33	33	33
1980 Spring	24	100	100	62
1980 Fall	57	100	96	17
1981 Spring	185	100	85	5
1981 Fall	78	100	100	44
1982 Spring	89	100	98	31
1982 Fall	140	100	96	36
1983 Spring	793	100	95	14
1983 Fall	No data	No data	No data	No data
1984 Spring	63	100	63	13
1984 Fall	178	100	97	26
1985 Spring	279	100	85	6
1985 Fall	188	100	95	28
1986 Spring	103	100	80	24
1986 Fall	104	100	100	62
1987 Spring	24	100	100	54
1987 Fall	38	100	100	76
1988 Spring	6	100	100	83
1988 Fall	7	100	100	100
1989 Spring	0	0	0	0
1989 Fall	9	100	100	56
1990 Spring	2	100	100	0
1990 Fall	3	100	100	33
1991 Spring	18	33	22	17
1991 Fall	0	0	0	0
1992 Spring	0	0	0	0
1992 Fall	0	0	0	0
1993 Spring	5	60	40	0
1993 Fall	3	100	0	0
1994 Spring	3	43	0	0
1994 Fall	3	100	100	100
1995 Spring	1	100	100	0

Table 1.6. Continued.

Year	Sample size	Total length (inches)		
		6	7	10
1995 Fall	2	100	100	50
1996 Spring	0	0	0	0
1996 Fall	1	0	0	0
1997 Spring	0	0	0	0
1997 Fall	2	100	100	0
1998 Spring	2	100	100	100
1998 Fall	1	100	100	100
1999 Spring	--	--	--	--
1999 Fall	22	100	100	5

Table 1.7. Size frequency distributions for bluegill in Newton Lake based on IDNR fall and spring electrofishing samples from fall 1976 to fall 1999.

		Total length (inches)		
Year	Sample size	6	7	8
1976 Fall	103	38	6	0
1977 Spring	200	45	5	0
1977 Fall	73	29	3	0
1978 Spring	548	43	9	0
1978 Fall	259	31	4	0
1979 Spring	466	24	3	0
1979 Fall	361	7	0.8	0
1980 Spring	113	15	0	0
1980 Fall	262	13	0.8	0
1981 Spring	379	15	2	0
1981 Fall	264	20	0	0
1982 Spring	1,026	13	0.2	0
1982 Fall	363	3	0.3	0
1983 Spring	534	25	3	0
1983 Fall	No data	No data	No data	No data
1984 Spring	399	29	1	0
1984 Fall	181	18	2	0
1985 Spring	367	13	0.5	0
1985 Fall	550	6	0	0
1986 Spring	312	10	0	0
1986 Fall	125	16	0	0
1987 Spring	472	6	0	0
1987 Fall	372	5	0	0
1988 Spring	150	5	0.7	0
1988 Fall	376	3	0	0
1989 Spring	120	9	0.8	0
1989 Fall	628	5	0	0
1990 Spring	95	17	4	2
1990 Fall	107	5	2	2
1991 Spring	512	5	0.8	0
1991 Fall	108	4	0	0
1992 Spring	108	14	1	0
1992 Fall	78	15	0	0
1993 Spring	112	21	3	0.9
1993 Fall	620	14	3	0
1994 Spring	106	0	0	0
1994 Fall	289	0	0	0
1995 Spring	133	0	0	0

Table 1.7. Continued.

Year	Sample size	Total length (inches)		
		6	7	8
1995 Fall	1,236	<1	0	0
1996 Spring	434	5	2	0.5
1996 Fall	618	0	0	0
1997 Spring	368	4	2	0
1997 Fall	542	2	1	0
1998 Spring	348	28	8	0
1998 Fall	522	2	1	0
1999 Spring	--	--	--	--
1999 Fall	832	1	0	0

Table 1.8. Size frequency distributions for channel catfish in Newton Lake based on IDNR fall and spring electrofishing samples from fall 1976 to fall 1999.

		Total length (inches)		
Year	Sample size	12	16	20
1976 Fall	0	0	0	0
1977 Spring	0	0	0	0
1977 Fall	0	0	0	0
1978 Spring	4	100	0	0
1978 Fall	0	0	0	0
1979 Spring	19	100	53	26
1979 Fall	22	82	77	27
1980 Spring	6	50	33	17
1980 Fall	51	12	6	2
1981 Spring	52	40	31	27
1981 Fall	87	90	23	7
1982 Spring	148	64	18	9
1982 Fall	80	72	28	8
1983 Spring	87	49	9	2
1983 Fall	No data	No data	No data	No data
1984 Spring	327	45	13	0.3
1984 Fall	115	62	23	6
1985 Spring	267	93	8	1
1985 Fall	381	50	17	4
1986 Spring	336	49	11	1
1986 Fall	105	48	15	5
1987 Spring	148	31	8	3
1987 Fall	85	27	12	5
1988 Spring	238	31	7	2
1988 Fall	227	44	12	4
1989 Spring	191	35	7	1
1989 Fall	221	24	10	1
1990 Spring	82	46	7	1
1990 Fall	114	60	19	4
1991 Spring	396	48	13	3
1991 Fall	186	58	13	3
1992 Spring	44	43	5	2
1992 Fall	139	40	18	7
1993 Spring	73	36	15	1
1993 Fall	193	4	0	0
1994 Spring	72	42	19	0
1994 Fall	137	28	8	1

Table 1.8. Continued.

Year	Sample size	Total length (inches)		
		12	16	20
1995 Spring	186	0.5	0	0
1995 Fall	528	9	2	1
1996 Spring	177	14	0	0
1996 Fall	149	13	2	0
1997 Spring	54	32	2	0
1997 Fall	49	35	10	2
1998 Spring	111	8	1	1
1998 Fall	161	33	4	0
1999 Spring	--	--	--	--
1999 Fall	142	37	1	0

Table 1.9. Size frequency distributions for largemouth bass in Newton Lake based on IDNR fall and spring electrofishing samples from fall 1976 to fall 1999.

		Total length (inches)			
Year	Sample size	12	14	16	18
1976 Fall	79	51	51	1	0
1977 Spring	137	59	51	2	0.5
1977 Fall	211	84	61	22	3
1978 Spring	342	92	73	46	4
1978 Fall	427	82	74	49	10
1979 Spring	364	95	86	71	21
1979 Fall	1,622	79	65	29	10
1980 Spring	273	90	79	57	21
1980 Fall	462	74	65	31	11
1981 Spring	471	84	73	47	18
1981 Fall	522	71	66	31	12
1982 Spring	592	86	71	42	19
1982 Fall	445	72	61	21	8
1983 Spring	1,006	82	64	27	13
1983 Fall	No data	No data	No data	No data	No data
1984 Spring	344	88	74	47	14
1984 Fall	356	70	66	30	13
1985 Spring	266	82	75	51	23
1985 Fall	310	59	56	12	6
1986 Spring	343	85	72	43	27
1986 Fall	363	71	62	25	10
1987 Spring	245	78	70	40	22
1987 Fall	469	70	60	20	8
1988 Spring	586	80	72	43	21
1988 Fall	377	82	69	38	15
1989 Spring	663	89	74	48	21
1989 Fall	623	66	62	24	9
1990 Spring	520	85	74	49	18
1990 Fall	518	69	60	20	7
1991 Spring	721	86	64	28	12
1991 Fall	534	70	66	31	13
1992 Spring	383	80	71	43	18
1992 Fall	642	62	57	14	5
1993 Spring	509	69	60	21	8
1993 Fall	637	69	56	11	6
1994 Spring	809	52	50	0	0
1994 Fall	1,126	79	53	6	2
1995 Spring	548	53	50	0	0
1995 Fall	840	44	32	14	2
1996 Spring	592	85	73	43	9

Table 1.9. Continued.

Year	Sample size	Total length (inches)			
		12	14	16	18
1996 Fall	1,000	58	47	27	7
1997 Spring	718	84	70	46	14
1997 Fall	357	24	19	12	5
1998 Spring	691	63	53	41	15
1998 Fall	705	53	41	31	6
1999 Spring	--	--	--	--	--
1999 Fall	514	50	38	13	4

Table 1.10. The numbers, mean back-calculated length (inches) and mean derived weight (pounds) for white crappie from Newton Lake, Coffeen Lake and Lake of Egypt collected from 1997 through 1999.

	Newton Lake			Coffeen Lake			Lake of Egypt		
Age	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)
1		4.26	0.04	1	4.45	0.03		4.46	0.10
2	21	8.38	0.30	13	6.70	0.10	56	8.80	0.40
3				88	8.02	0.20	82	10.97	0.70
4				30	9.04	0.30	20	11.74	0.80
5				2	11.77	0.90	10	12.04	0.90
6							4	12.83	1.10
7								14.99	1.60
8							1	15.55	1.80

Table 1.11. The numbers, mean back-calculated length (inches) and mean derived weight (pounds) for bluegill sunfish from Newton Lake, Coffeen Lake and Lake of Egypt collected from 1997 through 1999.

	Newton Lake			Coffeen Lake			Lake of Egypt		
Age	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)
1	71	2.45	0.01	95	2.64	0.01	5	2.61	0.01
2	202	3.87	0.03	214	3.76	0.03	78	4.10	0.04
3	76	4.88	0.07	125	4.50	0.05	85	5.38	0.10
4	29	5.70	0.11	17	5.03	0.08	98	6.20	0.14
5	10	6.06	0.14	3	5.47	0.10	34	6.51	0.17
6	1	6.10	0.14				22	6.76	0.20
7							1	7.99	0.33

Table 1.12. The numbers, mean back-calculated length (inches) and mean derived weight (pounds) for channel catfish from Newton Lake, Coffeen Lake and Lake of Egypt collected from 1997 through 1999.

	Newton Lake			Coffeen Lake			Lake of Egypt		
Age	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)
1		3.73	0.1		4.16	0.1		4.93	0.1
2	13	6.09	0.1	5	7.24	0.1	1	9.83	0.3
3	28	7.81	0.1	27	9.34	0.2	1	13.22	0.8
4	42	9.11	0.2	32	10.93	0.4	3	15.74	1.3
5	60	10.12	0.3	43	12.30	0.5	5	17.56	1.8
6	65	10.84	0.3	50	13.52	0.7	15	18.80	2.2
7	65	11.60	0.4	39	14.59	0.9	21	19.80	2.6
8	55	12.36	0.5	54	15.52	1.1	17	20.48	2.9
9	27	13.14	0.6	45	16.01	1.2	19	20.91	3.1
10	18	13.06	0.6	13	15.74	1.1	6	22.39	3.7
11	4	12.07	0.5	4	15.64	1.1	4	25.41	5.4
12	4	11.71	0.4	4	15.33	1.0			

Table 1.13. The numbers, mean back-calculated length (inches) and mean derived weight (pounds) for largemouth bass from Newton Lake, Coffeen Lake and Lake of Egypt collected from 1997 through 1999.

	Newton Lake			Coffeen Lake			Lake of Egypt		
Age	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)	Number	Length(in)	Weight(lb)
1	232	6.80	0.1	135	7.50	0.2	25	6.38	0.1
2	152	13.14	1.2	115	12.50	1.1	56	10.61	0.6
3	59	16.11	2.3	95	15.25	2.0	78	12.93	1.0
4	37	17.31	2.9	57	16.57	2.6	45	14.41	1.4
5	32	18.01	3.3	25	17.60	3.2	43	15.41	1.7
6	11	18.70	3.8	9	18.46	3.7	22	16.11	1.9
7	8	19.13	4.1	11	19.05	4.1	19	16.90	2.2
8	1	19.51	4.3	3	19.11	4.2	12	17.40	2.5
9		20.64	5.2	2	19.07	4.1	8	17.92	2.8
10	1	21.10	5.5	1	18.74	3.9	3	18.97	3.3
11							1	19.52	3.6
12							1	18.58	3.1
13							1	19.41	3.7

Table 1.14. Summary of mean relative weights for largemouth bass, bluegill, and channel catfish captured in each lake during November 1997, and March, August, and November of 1998 and 1999.

	Newton Lake			Lake of Egypt			Coffeen Lake		
Year	March	August	November	March	August	November	March	August	November
Largemouth Bass									
1997	--	--	105	--	--	89	--	--	99
1998	105	96	106	89	82	95	104	96	105
1999	108	97	105	98	82	--	110	93	105
Mean	107	97	105	93	82	92	107	95	103
Bluegill									
1997	--	--	85	--	--	81	--	--	82
1998	92	84	85	90	84	93	--	88	97
1999	78	89	98	82	82	--	83	90	96
Mean	81	87	91	86	83	87	83	88	92
Channel Catfish									
1997	--	--	82	--	--	87	--	--	82
1998	86	90	84	100	87	107	89	83	92
1999	86	82	84	96	94	--	79	95	91
Mean	86	86	83	98	89	103	84	88	89

Table 1.15. Mean percentage of largemouth bass, and channel catfish with empty stomachs from the three Illinois power-cooling reservoirs (Newton Lake, Coffeen Lake, and Lake of Egypt) during 1997, 1998, and 1999.

		Newton Lake		Coffeen Lake		Lake of Egypt	
Species	Year	% Empty	Months[a]	% Empty	Months[a]	% Empty	Months[a]
Largemouth	1997	49.9	4	33.6	2	36.4	1
Bass	1998	50.7	9	29.4	5	30.4	4
	1999	68.5	12	54.6	5	55.4	2
	Mean	59.1		40.6		38.4	
Channel	1997	38.0	4	46.3	2	25.0	1
Catfish	1998	38.2	9	43.1	6	39.4	4
	1999	39.5	11	87.5	3	28.6	2
	Mean	38.7		55.8		34.3	

[a]/ Number of months that samples were taken.

Table 1.16. Summary of Chapman-Robson (1960)(C-R) and catch curve estimates (C-C) of actual annual mortality rate (percent) for largemouth bass, bluegill, and channel catfish calculated from catch data of fish captured in each lake during fall 1997, 1998 and 1999 (-- indicates an undeterminable value).

	Newton Lake		Lake of Egypt		Coffeen Lake	
Year	C-R	C-C	C-R	C-C	C-R	C-C
			Largemouth Bass			
1997	73	63	30	28	40	37
1998	56	34	39	28	50	35
1999	61	55	--[1]	--[1]	40	38
Mean	63	51	35	28	43	36
			Bluegill			
1997	73	72	59	38	69	58
1998	88	78	36	52	70	69
1999	88	67	--[1]	--[1]	56	61
Mean	83	72	48	45	65	63
			Channel Catfish			
1997	54	41	67	50	32	13
1998	44	38	11	--	33	18
1999	40	32	--[1]	--[1]	36	38
Mean	46	37	39	50	34	23

1/ No sampling scheduled.

Table 1.17. Hatching date ranges for 1998-99 by taxa in three Illinois power cooling reservoirs. In 1998 and 1999, hatching dates were calculated using the 1998 aged larvae and their subsequent length-age linear regression prediction equations. The initial temperature is the lowest temperature at the beginning of the hatching range. The ending temperature is the highest temperature at the end of the hatching range.

Lake	Year	Taxa	Hatching date range	Days	Hatching temp. range (°F)	
					Initial	Ending
Newton Lake	1998	*Lepomis*	4/15-9/19	158	56	94
		Dorosoma	3/27-6/30	96	60	100
		Morone[2]	4/04-5/15[1]	42		
		Micropterus	4/05-5/09[1]	35		
	1999	*Lepomis*	3/31-10/01	185	70	87
		Dorosoma	3/11-7/01	113	52	92
		Morone[2]	3/14-5/03[1]	51		
		Micropterus	3/27-5/11[1]	44		
Coffeen Lake	1998	*Lepomis*	4/23-10/04	165	78	84
		Dorosoma	3/29-6/27	81	62	97
		Morone[2]	4/04-4/28[1]	25		
		Pomoxis	4/08-5/14[1]	37		
	1999	*Lepomis*	5/02-9/10	132	80	103
		Dorosoma	3/21-7/09	111	67	100
Lake of Egypt	1998	*Lepomis*	5/09-9/05	120	67	91
		Dorosoma	4/03-6/29	88	63	92
		Pomoxis	4/01-5/05[1]	35		
		Micropterus[2]	4/26-5/20[1]	25		
	1999	*Lepomis*	5/01-9/08	131	74	87
		Dorosoma	4/08-7/16	100	63	89
		Pomoxis	4/04-5/06[1]	33		
		Micropterus[2]	4/19-5/24[1]	36		

[1] Hatching range temperatures fall within the ranges for those of *Dorosoma* for that year.

[2] Hatching range was calculated from a length-age linear regression equation developed from a small sample size of fish and having relatively low R^2 values.

Table 1.18. Mean densities (n/m^3) for larval fish (all segments combined) in three Illinois power cooling lakes. Superscripts with different letters are significantly different between years, within taxa, at $\alpha = 0.05$. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Year	Taxa	Density	Range	Std.dev.
Newton Lake	1998	*Lepomis*	0.0129[a]	0-0.0842	0.0174
	1999	*Lepomis*	0.0146[a]	0-0.0970	0.0244
	1998	*Dorosoma*	0.7992[a]	0-4.6318	1.1534
	1999	*Dorosoma*	0.9326[a]	0-5.5988	1.5106
Coffeen Lake	1998	*Lepomis*	0.0067[a]	0-0.0441	0.0106
	1999	*Lepomis*	0.0015[a]	0-0.0075	0.0024
	1998	*Dorosoma*	0.1123[a]	0-0.6234	0.1931
	1999	*Dorosoma*	0.1038[a]	0-0.8778	0.2312
Lake of Egypt	1998	*Lepomis*	0.0946[a]	0-0.4197	0.1266
	1999	*Lepomis*	0.0245[b]	0-0.1107	0.0326
	1998	*Dorosoma*	0.3407[a]	0-3.9256	1.0363
	1999	*Dorosoma*	0.3691[a]	0-1.833	0.6348

Table 1.19. Mean CPUE (n/hr) for larval fish (all segments combined) collected with light traps in three Illinois power cooling lakes. Superscripts with different letters are significantly different between segments, within taxa, at $\alpha = 0.05$. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Year	Taxa	CPUE	Range	Std.dev.
Newton Lake	1998	*Lepomis*	5.18[a]	0-30.35	8.01
	1999	*Lepomis*	26.75[a]	0-383.37	68.26
	1998	*Dorosoma*	2.45[a]	0-32.00	6.74
	1999	*Dorosoma*	6.26[a]	0-49.94	12.77
	1998	*Micropterus*	1.27[a]	0-4.53	1.81
	1999	*Micropterus*	2.72[a]	0-40.72	9.29
Coffeen Lake	1998	*Lepomis*	2.4[a]	0-14.94	3.56
	1999	*Lepomis*	17.01[a]	0-152.57	37.38
	1998	*Dorosoma*	0.64[a]	0-2.69	0.98
	1999	*Dorosoma*	1.48[a]	0-9.68	2.76
	1998	*Micropterus*	0.04[a]	0-.12	0.06
	1999	*Micropterus*	0.31[a]	0-1.00	0.47
Lake of Egypt	1998	*Lepomis*	2.84[a]	0-15.47	4.43
	1999	*Lepomis*	5.44[a]	0-46.09	12.35
	1998	*Dorosoma*	6.96[a]	0-56.64	14.96
	1999	*Dorosoma*	3.74[a]	0-36.29	9.36
	1998	*Micropterus*	0.8[a]	0-2.12	0.91
	1999	*Micropterus*	1.35[a]	0-7.75	3.13

Table 1.20. Mean number[1] of all fish collected in seine hauls in August 1997 and April through August 1998 and 1999. Number of largemouth bass are in parenthesis.

Lake	Year		
	1997	1998	1999
Newton	[a]2.98 (1.58)[a]	[a]16.38 (5.90)[a]	[a]7.89 (3.49)[a]
Coffeen	[a]8.80 (1.50)[a]	[a]11.96 (0.40)[b]	[a]8.83 (0.17)[b]
Lake of Egypt	[a]28.85 (1.25)[b]	[a]12.44 (1.29)[b]	[a]30.56 (2.64)[b]

[1]/ Numbers with same superscript are not significantly different at the $\alpha = 0.05$ level.

Table 1.21. Electrofishing catch per hour for age-1+ largemouth bass collected by Southern Illinois University personnel during fall of each year. Largemouth bass ages were determined by examining their saggittae otoliths.

	1997			1998			1999		
Lake	Effort (hrs)	Sample[a] size	Catch per hour	Effort (hrs)	Sample[a] size	Catch per hour	Effort (hrs)	Sample[a] size	Catch per hour
Newton	9.3	132	1.94	6.3	111	9.84	9	187	3.11
Coffeen	4.8	106	3.33	7.3	109	6.03	5.1	141	7.06
Lake of Egypt	12.6	98	1.83	10.2	105	2.25	---	---	---

[a]/ Total number of all aged largemouth bass examined for age-1+ fish.

Table 1.22. Summary of fishing and harvest effort on Newton Lake (1,750 acres) from 1986-1993 and 1998. Creel data for 1986-1993 were taken from Merle Price's report to AmerenCIPS (Table 50). Creel data for 1998 was taken from INHS April 12, 1999, report to AmerenCIPS.

	Angling	Total No. Fish		Fish/acre		Fish/hr.	Total pounds		Pounds/acre		Pounds/hr	
Year	hours	Caught	Harvested	Caught	Harvested	caught	Caught	Harvested	Caught	Harvested	Caught	Harvested
1986	150,814		125,746		72			76,368		43.6		0.51
1987	119,609		90,018		51			64,448		36.8		0.54
1988	73,395		25,537		15			26,630		15.2		0.36
1989	84,022		24,942		14			29,146		16.6		0.35
1990	82,351		32,102		18			44,356		25.3		0.34
1991	70,330		21,029		12			23,142		16.1		0.33
1992	78,531		24,320		14			30,514		17.4		0.39
1993	51,152		10,495		6			14,991		8.6		0.29
1998	105,931	89,726	12,432	127	7	1	114,902	11,937	66	6.8	0.68	0.08

[a] Lake was closed 5/20/93 – 8/31/93.

[b] Creel was only run from 2/01/98 through 10/31/98 (9 months).

Table 1.23. Summary of largemouth bass catch and harvest on Newton Lake (1,750 acres) from 1986-1993 and 1998. Creel data for 1986-1993 were taken from Merle Price's report to AmerenCIPS (Table 50). Creel data for 1998 was summarized from INHS April 12, 1999 report to AmerenCIPS.

	Total no. fish		Fish/acre		No. fish/hr.		Total pounds		Pounds/acre		Pounds/hr.	
Year	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested
1986		1,743		1.0		0.01		7,033		4.0		0.05
1987		1,278		0.7		0.01		5,409		3.0		0.04
1988		1,231		0.7		0.02		5,322		3.0		0.07
1989		1,141		0.6		0.01		5,160		3.0		0.06
1990		1,216		0.7		0.01		5,248		3.0		0.06
1991		1,143		0.7		0.02		4,883		2.8		0.07
1992		1,441		0.8		0.02		6,351		3.6		0.08
1993		731		0.4		0.01		3,465		2.0		0.07
1998	56,339	1,287	32	0.7	0.35	0.01	103,364	4,752	59	2.7	0.60	0.03

[a] Lake was closed 5/20/93 – 8/31/93.

[b] Creel was only run from 2/01/98 through 10/31/98 (9 months).

Table 1.24. Summary of bluegill and white crappie harvest, on Newton Lake (1,750 acres), from 1986-1993 and 1998. Creel data for 1986-1993 were taken from Merle Price's report to AmerenCIPS (Table 50). Creel data for 1998 was summarized from INHS April 12, 1999 report to AmerenCIPS.

	Number of bluegill		
Year	Harvested	Caught	Number of harvested white crappie
1986	1,009		89,499
1987	619		66,971
1988	90		69
1989	283		141
1990	281		199
1991	112		3
1992	29		0
1993[a]	91		0
1998[b]	947	4,482	?[c]

a Lake was closed 5/20/93 - 8/31/93

b In 1998 creel was only run from 2/01/98 through 10/31/98 (9 months).

c Some of the miscellaneous category that contains 61 fish may be crappie.

Table 1.25. Summary of channel catfish catch and harvest on Newton Lake (1,750 acres) from 1986-1993 and 1998. Creel data for 1986-1993 were taken from Merle Price's report to AmerenCIPS (Table 50). Creel data for 1998 was summarized from INHS April 12, 1999 report to AmerenCIPS.

	Total no. fish		Fish/acre		No. fish/hr.		Total pounds		Pounds/acre		Pounds/hr.	
Year	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested	Caught	Harvested
1986		32,280		18.0		0.21		35,231		20.0		0.23
1987		20,691		12.0		0.17		21,398		12.0		0.18
1988		23,939		14.0		0.33		21,070		12.0		0.29
1989		22,887		13.0		0.27		23,605		13.0		0.28
1990		30,133		17.0		0.37		38,824		22.0		0.47
1991		19,500		11.0		0.28		23,154		13.0		0.33
1992		22,755		13.0		0.29		24,058		14.0		0.31
1993		9,642		6.0		0.19		11,486		7.0		0.22
1998		9,720		5.6		0.19		6,984		4.0		0.05

[a] Lake was closed 5/20/93 – 8/31/93.

[b] Creel was only run from 2/01/98 through 10/31/98 (9 months).

Table 1.26. Primary production values from several studies (after Kimmel et al. 1990)[a].

Reservoir, Location	Year	Production	Units	Comments	Reference
Francis Case, SD	1968	260	mg C m^{-2} d^{-1}	Net O_2 change, summer estimates	Martin and Novotny (1975)
Lewis and Clark, NB	1968	530	mg C m^{-2} d^{-1}	Net O_2 change, summer estimates	Martin and Novotny (1975)
Hebgen, MT	1965	658	mg C m^{-2} d^{-1}	Net O_2 change, summer estimates	Martin and Arneson (1978)
Canyon Ferry, MT	1958	1125	mg C m^{-2} d^{-1}	Net O_2 change, April – September	Wright (1958, 1959, 1960)
Ashtabula, ND	1966 - 68	1828	mg C m^{-2} d^{-1}	Net O_2 change	Peterka and Reid (1966), Knuston (1970), cited in Soltero et al. (1975)
Newton Lake, IL	1997 – 98	944	mg C m^{-2} d^{-1}	Net O_2 change	this study

[a]/ See Chapter 4 for citations.

Table 1.27. Mean total phytoplankton cells per L (Coccoid singles excluded) and confidence interval (C. I.) from Newton Lake for July and August combined, and with all segments combined. Means with different superscripts are significantly different at the α = 0.05 level.

Year	95% C. I.			n	R^2	p value
1998	41,873,674[a]	±	5,124,984	48	16.6%	0.0001
1999	26,722,723[b]	±	2,867,211	48		

Table 1.28 Mean net photosynthesis (mg C m^{-2} day^{-1}) and confidence interval (C. I.) from Newton Lake for July and August combined, and with all segments combined. Means with different superscripts are significantly different at the α = 0.05 level.

Year	95% C. I.			n	R^2	p value
1998	1340.7[a]	±	381.1	16	0.0 %	0.8379
1999	1392.5[a]	±	219.6	16		

Table 1.29. Mean chlorophyll *a* (μg / L) and confidence interval (C. I.) from Newton Lake for July and August combined, and with all segments combined. Means with different superscripts are significantly different at the α = 0.05 level.

Year	95% C. I.			n	R^2	p value
1998	14.6[a]	±	0.8	70	0.6 %	0.3623
1999	13.8[a]	±	1.2	72		

Table 1.30. Mean OD 664 / OD 665 ratio (range 1.0 – 1.7) and confidence interval (C. I.) from Newton Lake for July and August combined, and with all segments combined. Means with different superscripts are significantly different at the α = 0.05 level.

Year	95% C. I.			n	R^2	p value
1998	1.37[a]	±	0.01	70	9.6 %	0.0002
1999	1.32[b]	±	0.01	72		

Table 1.31. Density of macrophytes, primarily water willow, in Newton Lake. Superscripts indicate statistical differences between weights ($p = 0.0001$).

Date	Pool elevation (ft)	Macrophyte area in acres (%[a])	Pounds per m^2	Mean maximum depth (ft)
August 1997	-2.1	15.1 (0.9)	1.00[b]	3.15
August 1998	0	34.8 (2.0)	4.94[a]	5.27
August 1999	-5.2	21.9 (1.2)	4.00[a]	3.45

[a]/ Percent of lake based on a lake area of 1,750 acres.

Table 1.32. Mean zooplankton densities in Newton Lake with all four sampling segments combined.

Date	Number per L
August 1997	146[a]
July – August 1998	171[b]
July – August 1999	239[c]

[a] / Means with different superscripts are different at α=0.05.

Table 1.33. Mean July and August benthos densities for all four segments combined. Superscripts indicate statistical differences between years at $\alpha = 0.05$.

Date	Density (n per m^2)	Weight (g per m^2)
1998	966[b]	0.9733[b]
1999	1,683[a]	1.418[a]

Table 1.34. Densities of phytomacrobenthos over time in Newton Lake with all four segments combined.

Date	Mean number (m^2)	Mean weight g/m^2
July 1997	1,628[a]	0.369[a]
July – August 1998	4,519[b]	1.337[b]
July – August 1999	8,729[c]	3.220[c]

Means with different superscripts are different at the $\alpha = 0.05$ level.

Table 1.35. Numbers of dead and morbid fishes observed by SIU personnel in Coffeen Lake in 1999.

Date	Largemouth bass	*Lepomis*	Channel catfish	*Morone*	White crappie	Carp	Shad
4/9/99	0	0	2	0	0	1	0
6/2/99	0	0	0	0	0	0	0
6/3/99	0	0	0	0	0	0	0
6/8/99	0	0	0	0	0	0	0
6/15/99	0	0	0	0	0	0	0
6/16/99	0	0	0	0	0	0	0
6/29/99	0	0	0	0	0	0	0
6/30/99	0	0	0	0	0	0	0
7/8/99	1	0	0	0	0	0	0
7/9/99	0	0	0	0	0	0	0
7/13/99	0	0	0	0	0	0	0
7/16/99	0	0	0	0	0	0	0
7/21/99	0	0	0	1	1	0	0
7/23/99	0	0	0	0	0	0	0
7/27/99	15	31	0	0	0	0	5
7/28/99	105	0	5	11	0	0	7
8/1/99	0	0	0	0	0	0	0
8/2/99	0	0	0	0	0	0	0
8/6/99	0	0	0	0	0	0	0
8/10/99	0	0	1	0	1	0	0
8/11/99	0	0	0	0	0	0	0
8/19/99	0	0	0	0	0	0	0
8/20/99	0	0	0	0	0	0	0
8/24/99	0	0	0	0	0	0	0
8/25/99	0	0	0	0	0	0	0
8/26/99	0	0	0	0	0	0	0
8/27/99	0	0	0	0	0	0	0
Total	121	31	8	12	2	1	12

Table 1.36. Numbers of dead and morbid fishes observed by SIU personnel in Newton Lake in 1999.

Date	Largemouth bass	Lepomis	Channel catfish	Morone	Carp	Shad
3/23/99	1	0	0	0	0	0
5/20/99	1	0	0	0	0	1
6/1/99	0	0	0	0	0	0
6/2/99	0	0	0	0	0	0
6/3/99	0	0	0	0	0	0
6/4/99	0	0	0	0	0	0
6/8/99	0	0	0	0	0	0
6/9/99	27	0	0	0	0	0
6/14/99	0	0	0	0	0	0
6/15/99	0	0	0	0	0	0
6/19/99	0	0	0	0	0	0
6/22/99	4	0	0	0	0	0
6/23/99	0	0	0	0	0	0
6/24/99	0	0	0	0	0	0
6/29/99	0	0	0	0	0	0
7/6/99	0	0	0	0	0	0
7/7/99	1	0	0	0	0	0
7/8/99	0	0	0	0	0	0
7/14/99	0	0	0	0	0	0
7/15/99	0	0	0	0	0	0
7/16/99	0	0	0	0	0	0
7/20/99	1	0	0	1	0	0
7/21/99	0	0	0	0	0	0
7/23/99	0	0	0	0	0	0
7/24/99	0	0	0	0	0	0
7/27/99	18	1	22	1	1	8
7/29/99	60	4	36	1	0	15
7/30/99	5	0	0	0	0	0
7/31/99	0	0	0	0	0	0
8/5/99	3	0	9	0	0	2
8/9/99	3	0	2	0	0	0
8/10/99	0	0	0	0	0	0
8/11/99	20	0	0	0	0	35
8/18/99	24	0	1	2	0	0
8/19/99	18	0	0	0	0	0
8/24/99	6	0	0	0	0	0
8/25/99	9	0	0	0	0	0
8/26/99	14	0	0	0	0	0
8/27/99	11	0	0	0	0	0
8/31/99	1	0	0	0	0	0
Total	227	5	70	5	1	59

Table 1.37. Fish Health Assessment Index (FHAI) scores for largemouth bass, 1998-1999. No differences occurred among the lakes within a season. Asterisks indicate differences between seasons at the $\alpha = 0.05$ level.

Year	Season	Lake	N	FHAI	Std. err.
1998	Spring	Newton*	36	103	5.12
		Coffeen*	30	100	5.79
		Egypt*	31	97	4.79
	Summer	Newton	26	59	5.65
		Coffeen	30	71	4.38
		Egypt	30	53	6.15
1999	Spring	Newton	31	81	5.91
		Coffeen	30	90	6.04
		Egypt	32	91	8.65
	Summer	Newton	17	70	6.52
		Coffeen	31	76	6.50
		Egypt	28	74	7.92
		Newton Moribund	10	102	7.29
		Non-power cooling lakes	23	71	5.66

Table 1.38. Estimated percent habitat available in Lake of Egypt, July 22, 1999 (Segment 1 = 5:26 PM, Segment 2 = 4:20 PM). Habitat is considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated.

Minimum oxygen (ppm)	Maximum temperature (°F)	% Habitat available Segment 1	Segment 2
4	87	5	29
4	88	14	43
4	89	18	43
4	90	18	50
4	91	23	61
4	92	23	61
4	93	23	61
4	94	23	61
4	95	23	61
4	96	23	61
4	97	23	61
3	87	14	36
3	88	23	50
3	89	27	50
3	90	27	57
3	91	32	68
3	92	32	68
3	93	32	68
3	94	36	68
3	95	36	68
3	96	36	68
3	97	36	68
2	87	18	36
2	88	27	50
2	89	32	50
2	90	32	57
2	91	36	68
2	92	36	68
2	93	36	68
2	94	41	68
2	95	45	68
2	96	45	68
2	97	45	68
1	87	23	50
1	88	32	64
1	89	36	64
1	90	36	71
1	91	41	82
1	92	41	82
1	93	41	82
1	94	45	82
1	95	50	82
1	96	52	82
1	97	52	82

Table 1.39. Estimated percent habitat available in Coffeen Lake, July 23, 1999 (Segment 1 = 3:10 PM, Segment 2 = 2:50 PM). Habitat is considered available if it contained no less than the minimum oxygen or no more than the maximum temperature indicated.

Minimum oxygen (ppm)	Maximum temperature (°F)	% Habitat available[a] Segment 1	Segment 2
4	87	0	0
4	88	0	0
4	89	0	0
4	90	0	0
4	91	0	0
4	92	0	0
4	93	5	0
4	94	10	5
4	95	14	10
4	96	19	20
4	97	24	25
3	87	0	0
3	88	0	0
3	89	0	0
3	90	0	0
3	91	0	5
3	92	5	5
3	93	10	10
3	94	14	15
3	95	19	20
3	96	24	30
3	97	29	35
2	87	0	0
2	88	0	0
2	89	0	0
2	90	0	10
2	91	5	15
2	92	10	15
2	93	14	20
2	94	19	25
2	95	24	30
2	96	29	40
2	97	33	45
1	87	0	0
1	88	0	5
1	89	5	5
1	90	10	15
1	91	14	20
1	92	19	20
1	93	24	25
1	94	29	30
1	95	33	35
1	96	38	45
1	97	43	50

[a]/ Habitat at the sampling station. Coffeen Lake has a large cove and an area north of the intake that may have had better conditions.

Table 1.40. Estimated percent habitat available in Coffeen Lake, August 1, 1999, at the discharge (upstream from segment 1 midpoint) and dam (border of segments 1 and 2) temperature monitor buoys (Discharge = 1:45 AM, Dam = 2:00 AM). Habitat is considered available if it contains no less than the minimum oxygen or no more than the maximum temperature indicated.

Minimum	Maximum	% Habitat available	
oxygen (ppm)	temperature (°F)	Segment 1	Segment 2
4	87	0	0
4	88	0	0
4	89	0	0
4	90	0	0
4	91	0	0
4	92	0	0
4	93	0	0
4	94	0	0
4	95	0	0
4	96	0	14
4	97	0	29
3	87	0	0
3	88	0	0
3	89	0	0
3	90	0	0
3	91	0	0
3	92	0	0
3	93	0	0
3	94	0	0
3	95	0	0
3	96	0	21
3	97	10	36
2	87	0	0
2	88	0	0
2	89	0	0
2	90	0	0
2	91	0	0
2	92	0	0
2	93	0	0
2	94	0	0
2	95	0	14
2	96	0	36
2	97	10	50
1	87	0	0
1	88	0	0
1	89	0	0
1	90	0	0
1	91	0	0
1	92	0	0
1	93	0	0
1	94	0	0
1	95	0	14
1	96	0	36
1	97	10	50

Table 1.41. Estimated percent habitat available in Newton Lake, July 24, 1999 (Segment 1 = 9:20 AM, Segment 2 = 10:33AM, Segment 3 = 12:12 PM, Segment 4 = 1:36 PM). Habitat is considered available if it contains no less than the minimum oxygen or no more than the maximum temperature indicated.

Minimum	Maximum	% Habitat available				Total habitat	
oxygen (ppm)	temperature (°F)	Segment 1	Segment 2	Segment 3	Segment 4	1999	1998[a]
4	87	0	0	0	0	0	2
4	88	0	0	0	0	0	7
4	89	0	0	0	0	0	12
4	90	0	0	0	0	0	16
4	91	0	0	0	0	0	27
4	92	0	0	0	10	3	34
4	93	0	0	6	20	7	37
4	94	0	0	18	50	17	39
4	95	0	0	24	80	26	42
4	96	0	0	38	85	31	44
4	97	0	0	38	85	31	44
3	87	0	0	0	0	0	2
3	88	0	0	0	0	0	7
3	89	0	0	0	0	0	12
3	90	0	0	0	0	0	16
3	91	0	0	0	0	0	27
3	92	0	0	0	10	3	36
3	93	0	0	6	20	7	39
3	94	0	0	18	50	17	41
3	95	0	0	24	80	26	47
3	96	0	6	38	85	32	48
3	97	0	6	38	85	32	48
2	87	0	0	0	0	0	2
2	88	0	0	0	0	0	7
2	89	0	0	0	0	0	12
2	90	0	0	0	0	0	16
2	91	0	0	0	0	0	27
2	92	0	0	0	10	3	36
2	93	0	6	6	20	8	39
2	94	0	6	18	50	19	41
2	95	0	6	24	80	28	47
2	96	0	13	38	85	34	48
2	97	0	13	38	85	34	48
1	87	0	0	0	0	0	6
1	88	0	0	0	0	0	13
1	89	0	0	0	0	0	18
1	90	0	0	0	0	0	22
1	91	13	0	6	0	5	33
1	92	13	0	6	10	7	42
1	93	13	6	12	20	13	44
1	94	25	6	24	50	26	47
1	95	25	6	29	80	35	52
1	96	25	13	44	85	42	54
1	97	25	13	44	85	42	54

[a]/ July 18, 1998.

Table 1.42. Estimated percent habitat available in Newton Lake, August 5, 1999 (Segment 1 = 3:50 PM, Segment 2 = 4:05 PM, Segment 3 = 4:20 PM, Segment 4 = 4:40 PM). Habitat is considered available if it contains no less than the minimum oxygen or no more than the maximum temperature indicated.

Minimum oxygen (ppm)	Maximum temperature (°F)	% Habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Total habitat
4	87	0	0	0	5	1
4	88	0	0	0	25	6
4	89	0	0	11	55	17
4	90	0	0	11	65	19
4	91	0	6	33	100	35
4	92	0	6	58	100	41
4	93	0	13	58	100	43
4	94	0	13	58	100	43
4	95	0	13	58	100	43
4	96	0	13	58	100	43
4	97	0	25	58	100	46
3	87	0	0	0	5	1
3	88	0	0	0	25	6
3	89	0	6	11	55	18
3	90	0	6	11	65	21
3	91	0	13	33	100	37
3	92	0	13	58	100	43
3	93	0	19	58	100	44
3	94	0	19	58	100	44
3	95	0	19	58	100	44
3	96	13	19	58	100	48
3	97	13	31	58	100	51
2	87	0	0	0	5	1
2	88	0	0	0	25	6
2	89	0	13	11	55	20
2	90	0	13	11	65	22
2	91	0	19	33	100	38
2	92	0	19	58	100	44
2	93	0	25	58	100	46
2	94	0	25	58	100	46
2	95	0	25	58	100	46
2	96	13	25	58	100	49
2	97	13	38	58	100	52
1	87	0	0	6	5	3
1	88	0	6	6	25	9
1	89	0	19	17	55	23
1	90	0	19	17	65	25
1	91	13	25	39	100	44
1	92	13	25	64	100	51
1	93	13	31	64	100	52
1	94	13	31	64	100	52
1	95	13	31	64	100	52
1	96	25	31	64	100	55
1	97	25	44	64	100	58

Table 1.43. Estimated percent habitat available in Newton Lake based upon temperature only. Habitat is considered available if it contains no more than the maximum temperature indicated.

Date	Maximum temperature	% Habitat available				
		Segment 1	Segment 2	Segment 3	Segment 4	Mean
06/02/99	70	0	31	26	0	14
06/02/99	75	17	47	32	0	24
06/02/99	80	28	69	100	100	74
06/02/99	85	28	75	100	100	76
06/18/99	70	0	10	21	0	8
06/18/99	75	0	17	26	0	11
06/18/99	80	0	30	50	77	39
06/18/99	85	17	57	100	100	68
07/02/99	70	0	9	25	0	8
07/02/99	75	0	21	31	0	13
07/02/99	80	0	38	42	0	20
07/02/99	85	6	62	75	86	57
07/13/99	70	0	15	15	0	7
07/13/99	75	0	21	21	0	10
07/13/99	80	0	32	32	0	16
07/13/99	85	0	38	50	75	41
07/24/99	70	0	9	15	0	6
07/24/99	75	0	16	21	0	9
07/24/99	80	0	28	32	0	15
07/24/99	85	0	41	44	5	22
08/05/99	70	0	9	19	0	7
08/05/99	75	0	16	25	0	10
08/05/99	80	0	22	31	0	13
08/05/99	85	0	28	36	0	16
08/18/99	70	0	9	9	0	4
08/18/99	75	0	15	15	0	7
08/18/99	80	0	21	21	0	10
08/18/99	85	19	50	44	35	37
08/31/99	70	0	0	0	0	0
08/31/99	75	0	9	3	0	3
08/31/99	80	0	16	9	0	6
08/31/99	85	0	53	84	100	59

Table 1.44. Estimated percent habitat available in Coffeen Lake based upon temperature only. Habitat is considered available if it contains no more than the maximum temperature indicated.

Date	Maximum temperature	% Habitat available		
		Segment 1	Segment 2	Mean
06/02/1999	70	3	23	13
06/02/1999	75	18	35	27
06/02/1999	80	39	56	48
06/02/1999	85	71	100	86
06/16/1999	70	0	11	6
06/16/1999	75	3	16	9
06/16/1999	80	13	30	21
06/16/1999	85	61	100	80
07/08/1999	70	0	7	3
07/08/1999	75	0	11	6
07/08/1999	80	8	20	14
07/08/1999	85	34	39	36
07/23/1999	70	7	0	4
07/23/1999	75	12	3	7
07/23/1999	80	17	8	12
07/23/1999	85	21	18	19
08/06/1999	70	0	7	3
08/06/1999	75	0	11	6
08/06/1999	80	0	16	8
08/06/1999	85	0	20	10
08/19/1999	70	0	7	3
08/19/1999	75	0	7	3
08/19/1999	80	0	11	6
08/19/1999	85	0	25	13

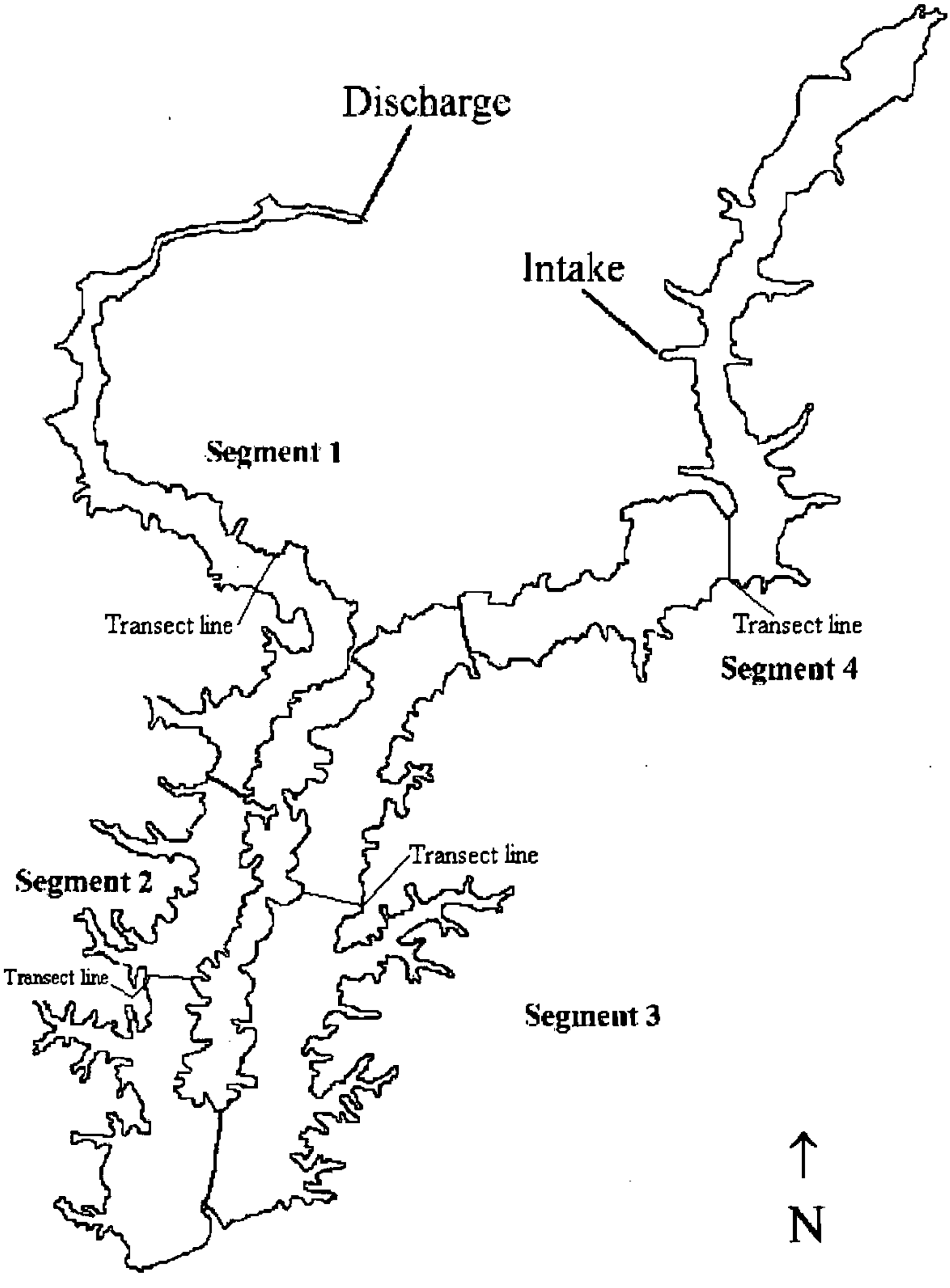

Figure 1. Newton Lake with four segments and transect lines where sampling was conducted for water quality, benthos, and zooplankton from August 1997 through 1999.

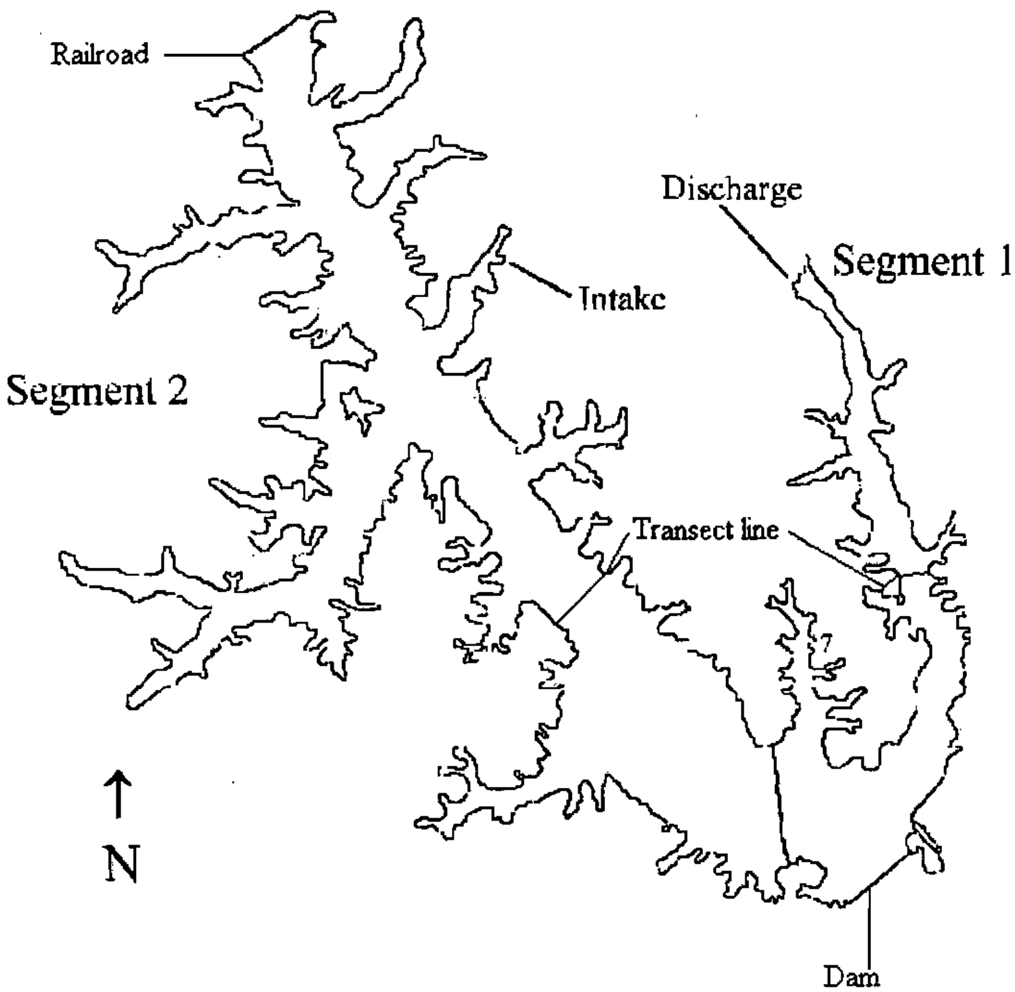

Figure 2. Coffeen Lake with two segments and transect lines where sampling was conducted for water temperature and dissolved oxygen from August 1997 through 1999.

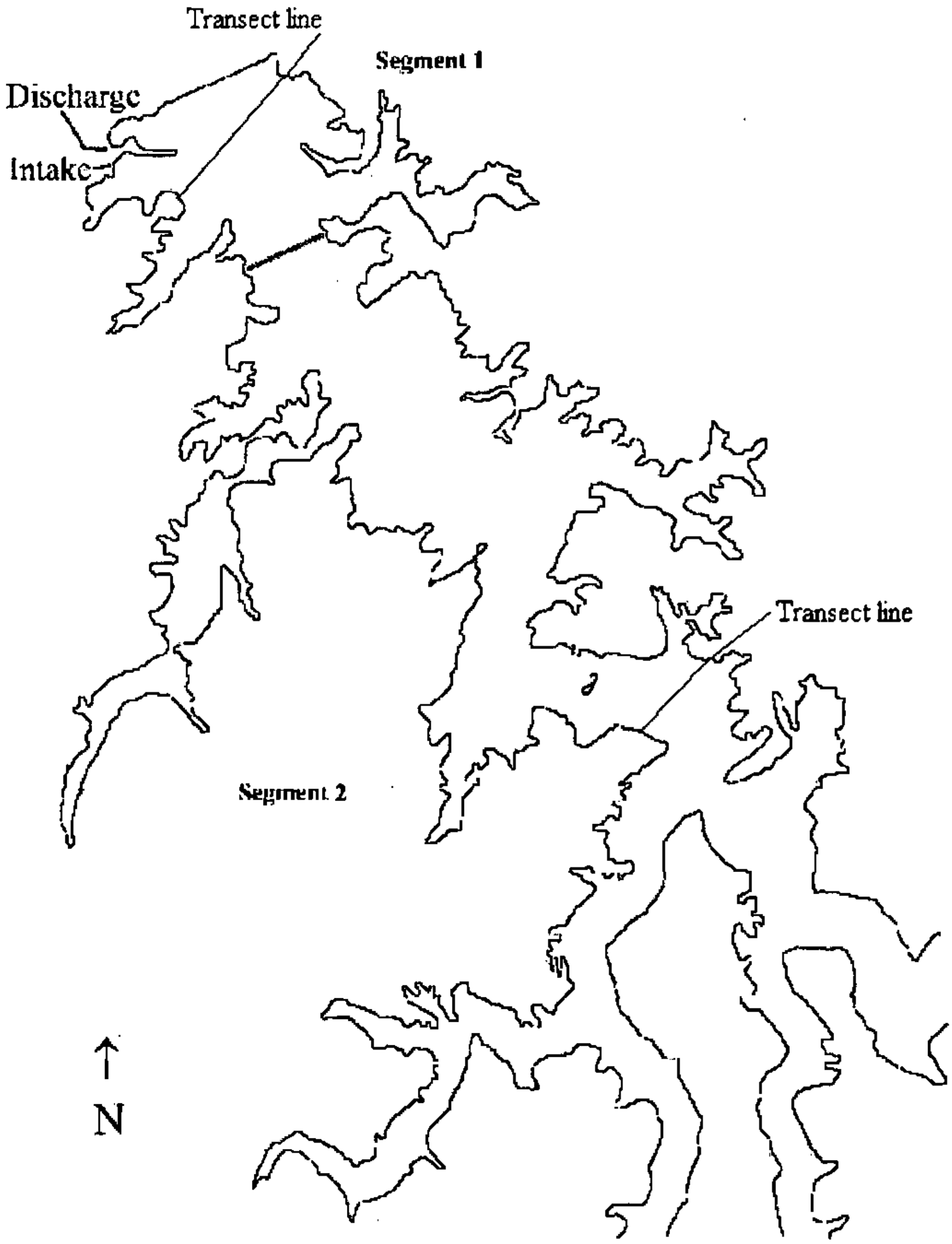

Figure 1.3. Lake of Egypt with two segments and transect lines where sampling was conducted for water temperature and dissolved oxygen from August 1997 through August 1999.

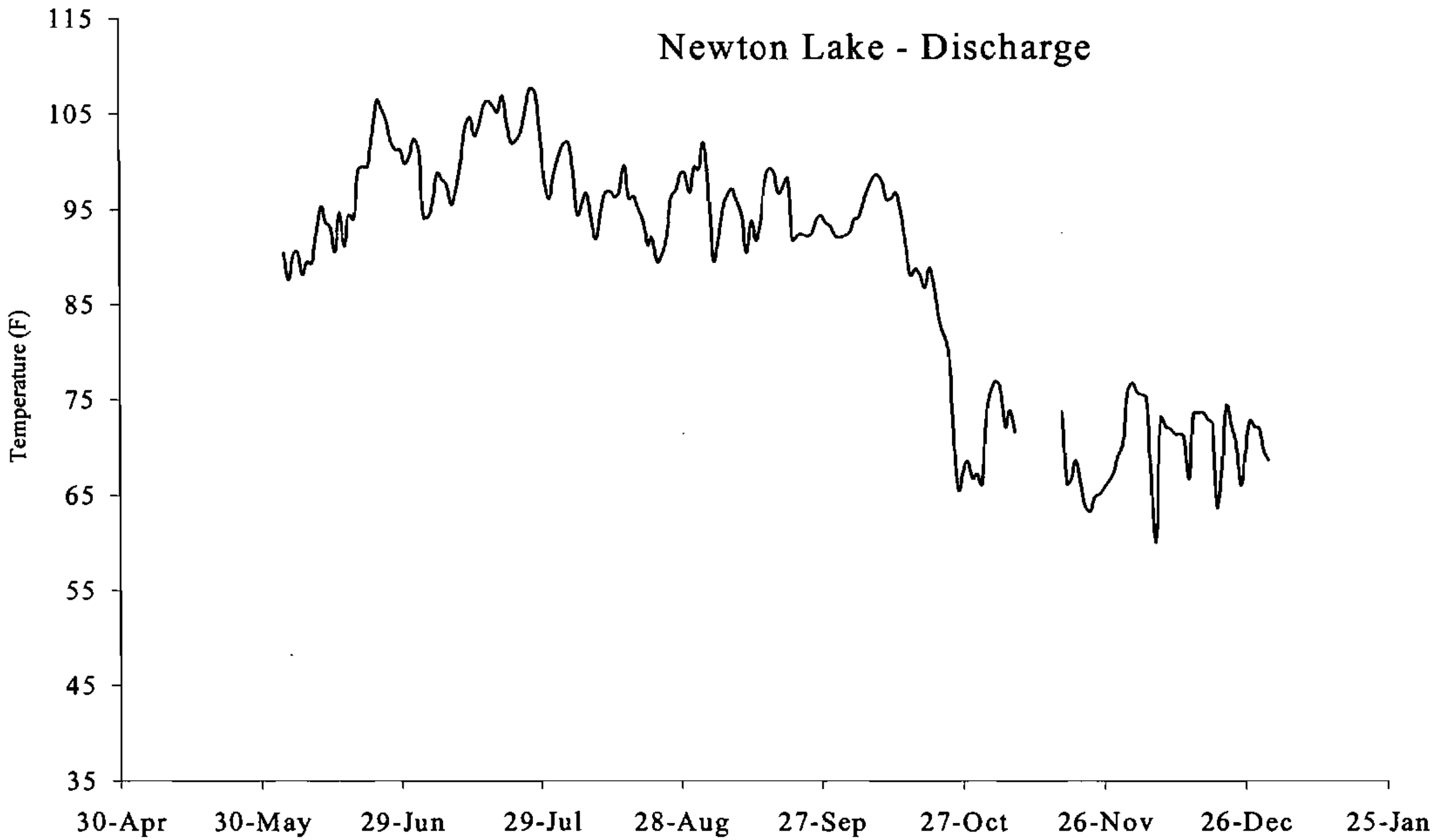

Figure 1.4. Mean daily surface temperatures during 1997 at the Newton Lake discharge.

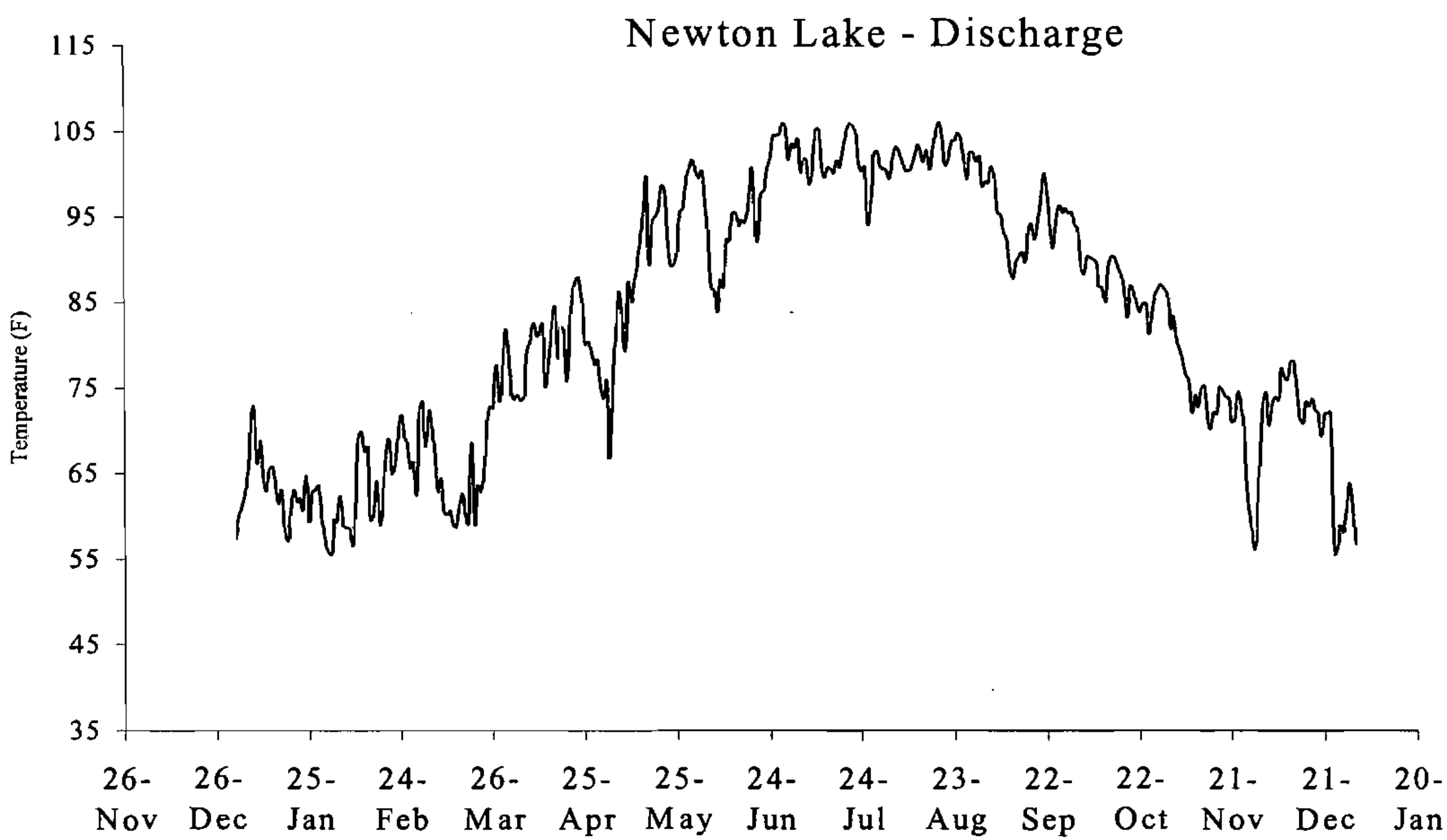

Figure 1.5. Mean daily surface temperatures during 1998 at the Newton Lake discharge.

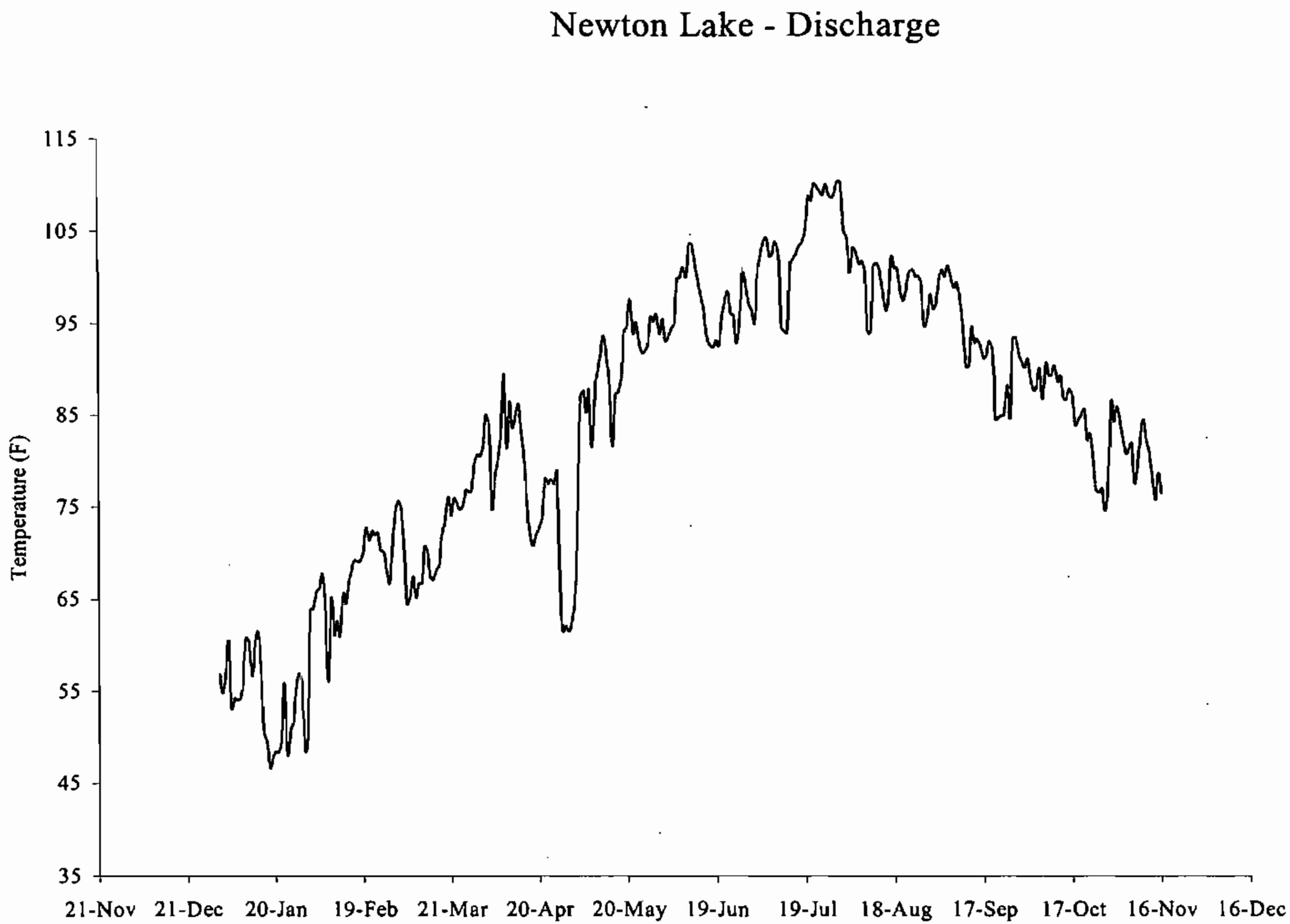

Figure 1.6. Mean daily surface temperatures during 1999 at the Newton Lake discharge.

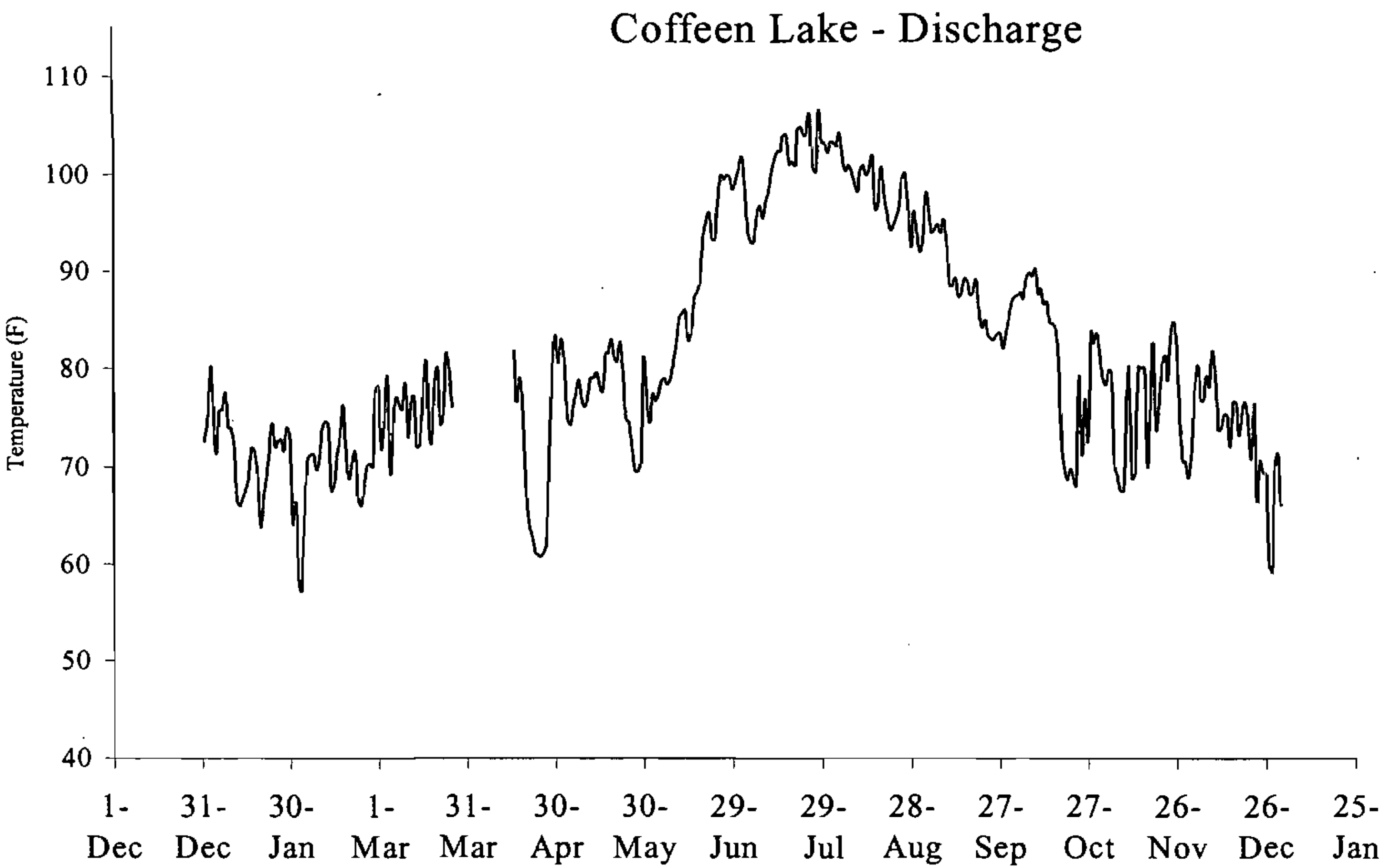

Figure 1.7. Mean daily surface temperatures during 1997 at the Coffeen Lake discharge. Lake bottom is approximately 18.0 feet.

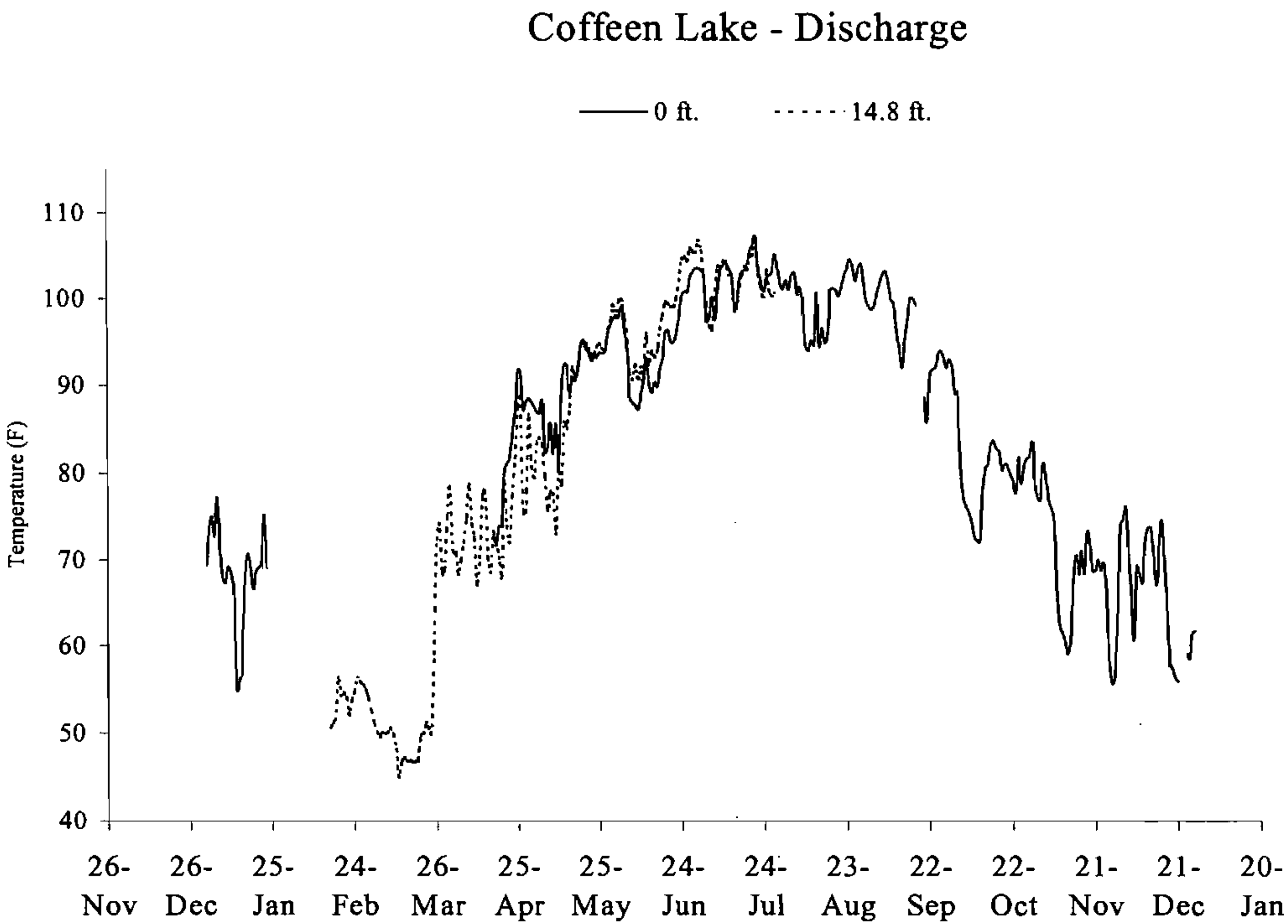

Figure 1.8. Mean daily temperatures during 1998 at the Coffeen Lake discharge. Lake bottom is approximately 18.0 feet.

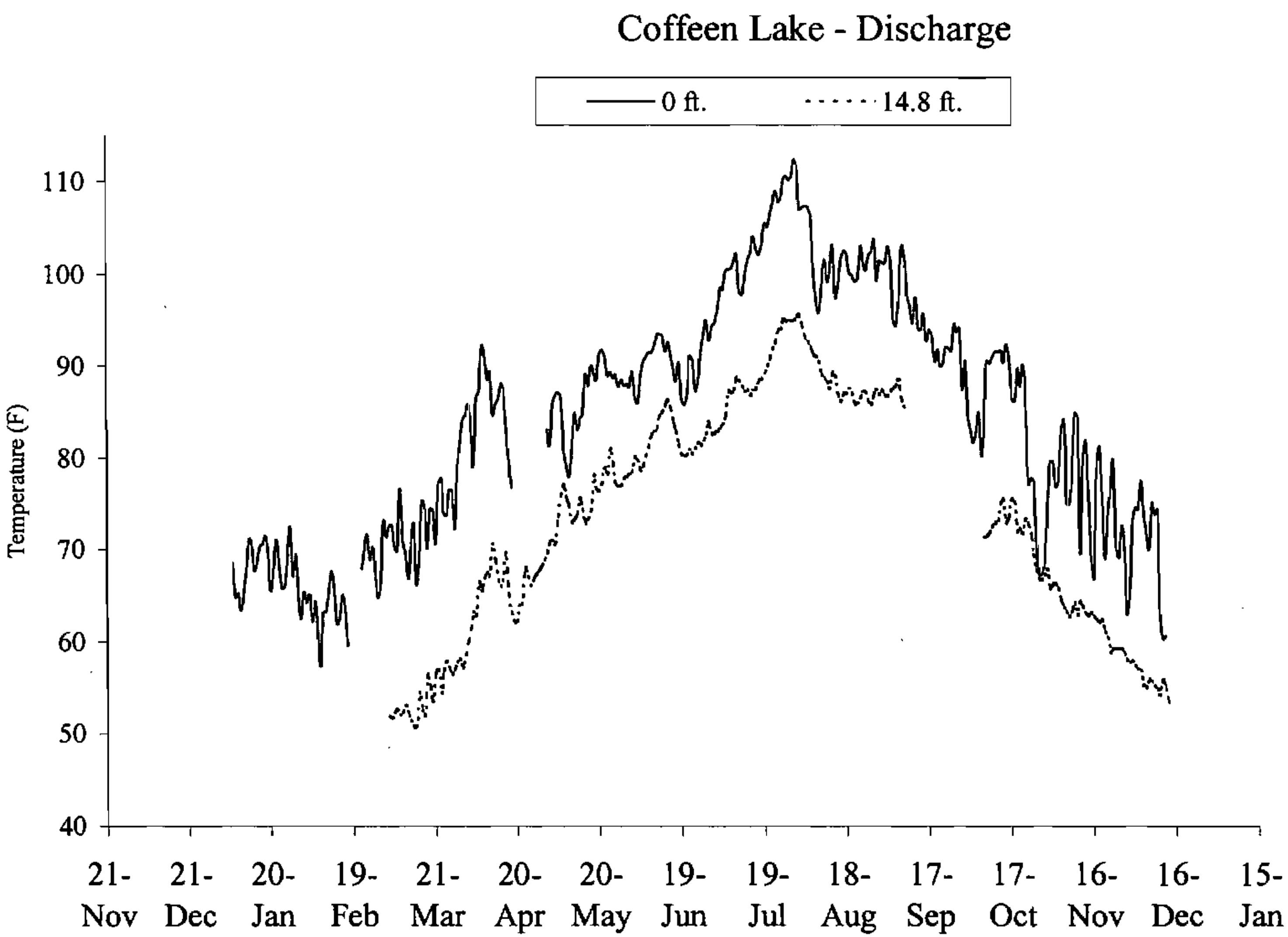

Figure 1.9. Mean daily temperatures during 1999 at the Coffeen Lake discharge. Lake bottom is approximately 18.0 feet.

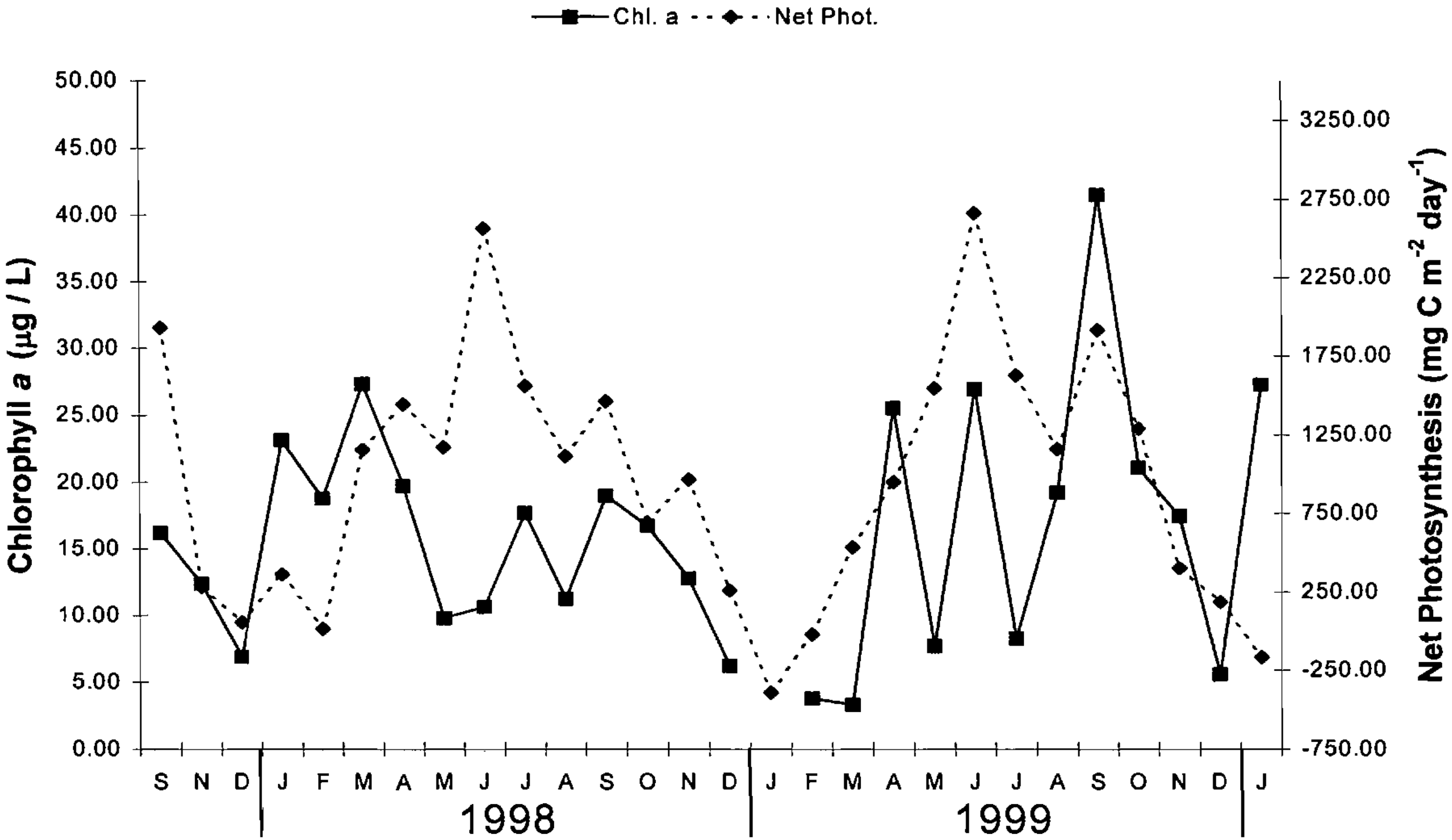

Figure 1.10. Mean chlorophyll *a* (µg / L) and mean net photosynthesis (mg C m^{-2} day^{-1}), Newton Lake, all segments combined. Note that during the winter months some negative photosynthesis occurred and the date axis does not intersect the net photosynthesis axis at 0.

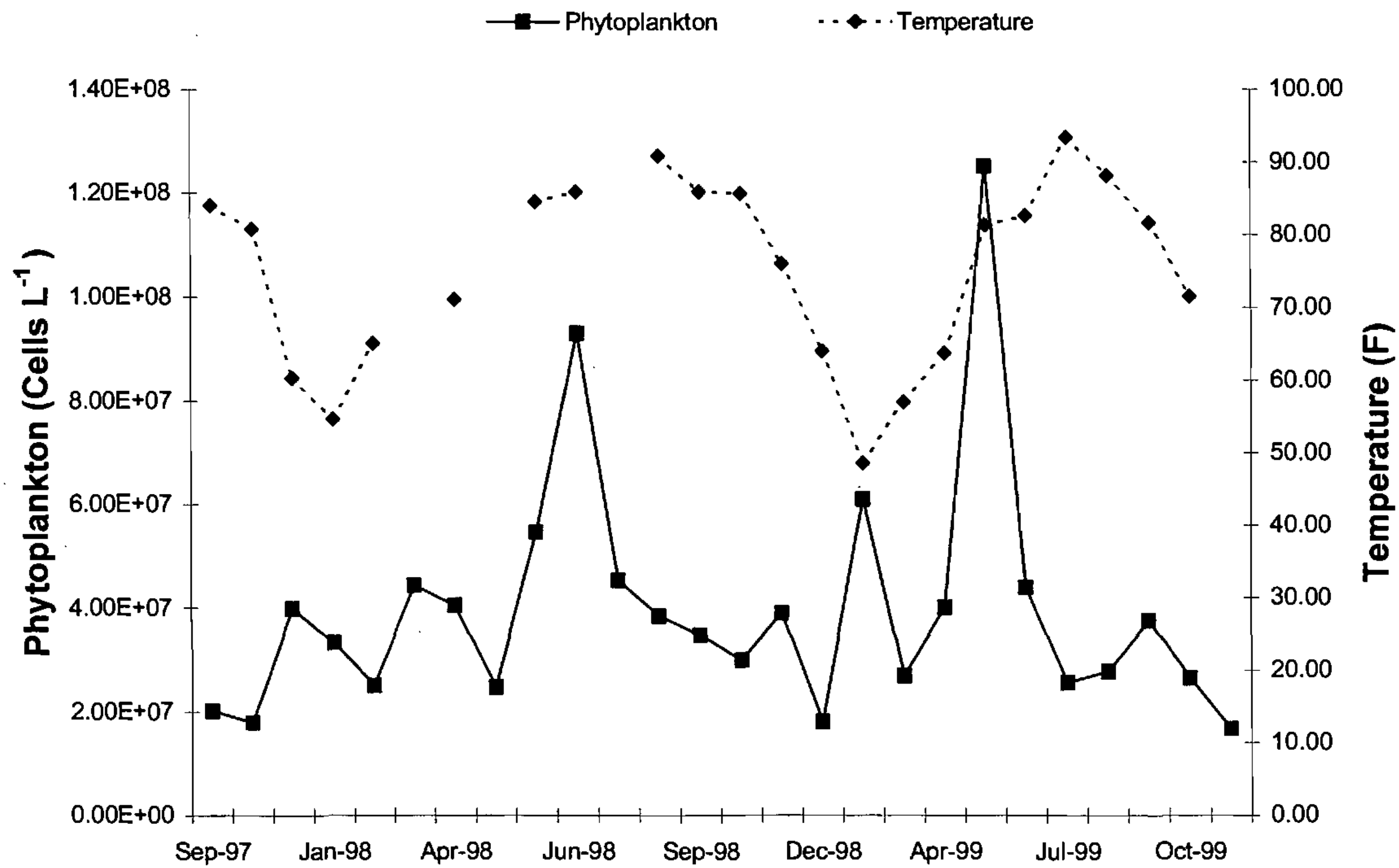

Figure 1.11. Mean total cell count L^{-1} (Coccoid singles included) and mean euphotic temperature (F) for Newton Lake, all segments combined, 1997 – 1999.

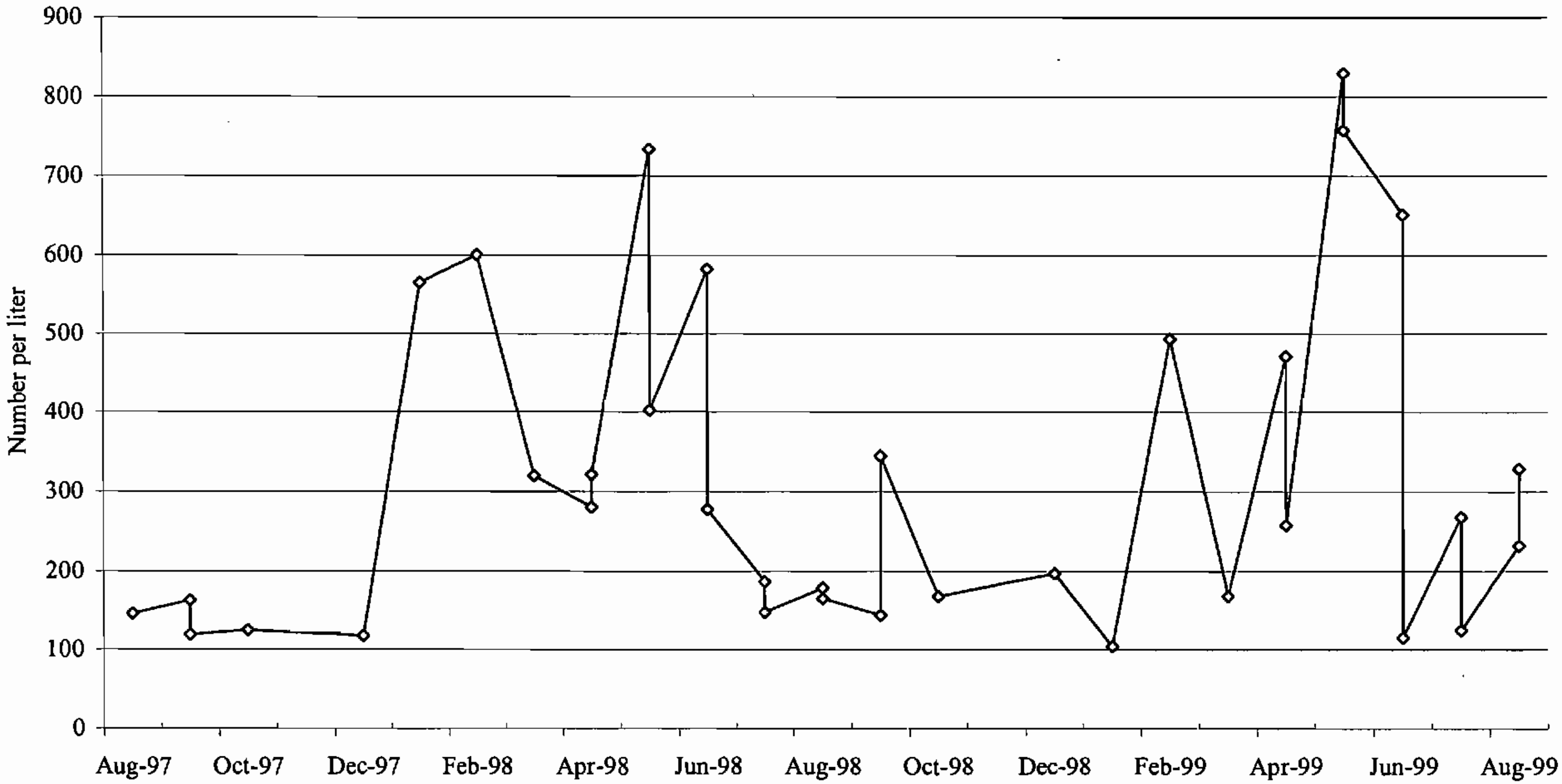

Figure 1.12. Mean densities of zooplankton by date collected in Newton Lake (12 stations, all segments combined) from August 1997 through August 1999.

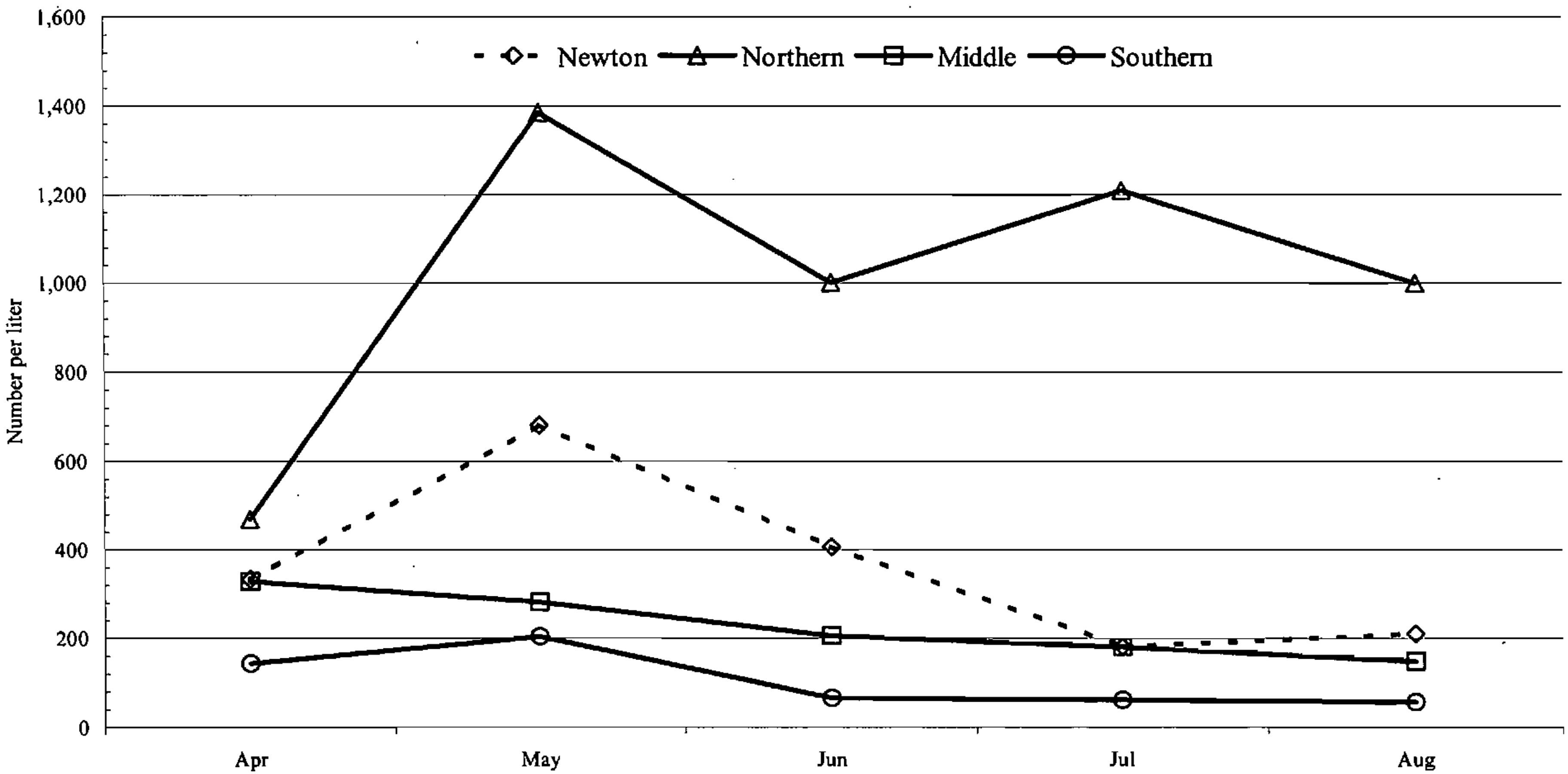

Figure 1.13. Mean monthly densities of zooplankton collected in Newton Lake compared to 12 lakes grouped into three regions of Illinois. Zooplankton was collected from the Illinois lakes during April through August of 1993 through 1997. Five lakes were sampled in the northern zone, six in the middle zone, and four in the southern zone. Four to six samples were taken from the Illinois lakes each month for five years.

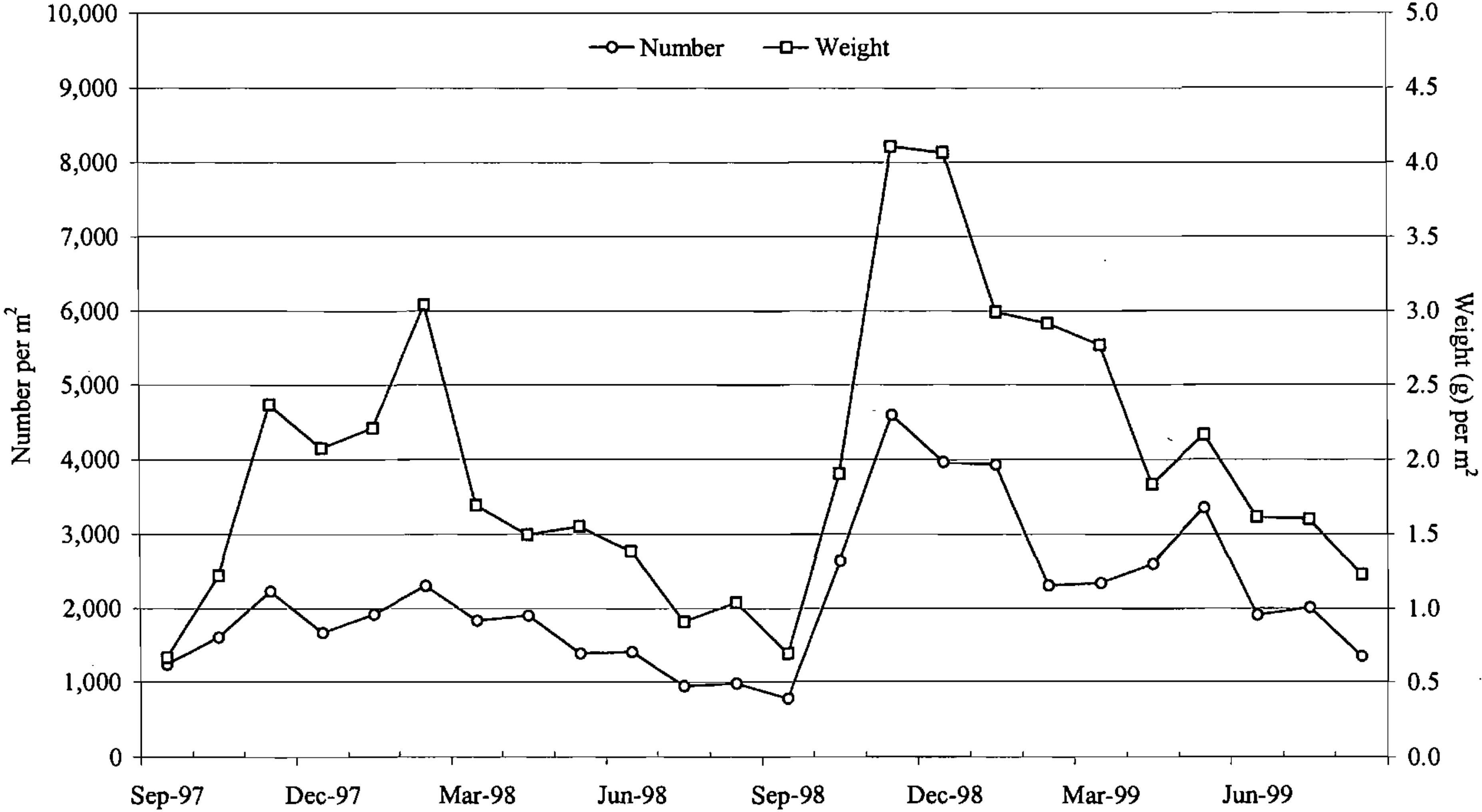

Figure 1.14. Mean monthly densities and weights of benthos collected in Newton Lake (24 stations for all segments combined) from September 1997 through August 1999. Benthos was collected using a ponar dredge.

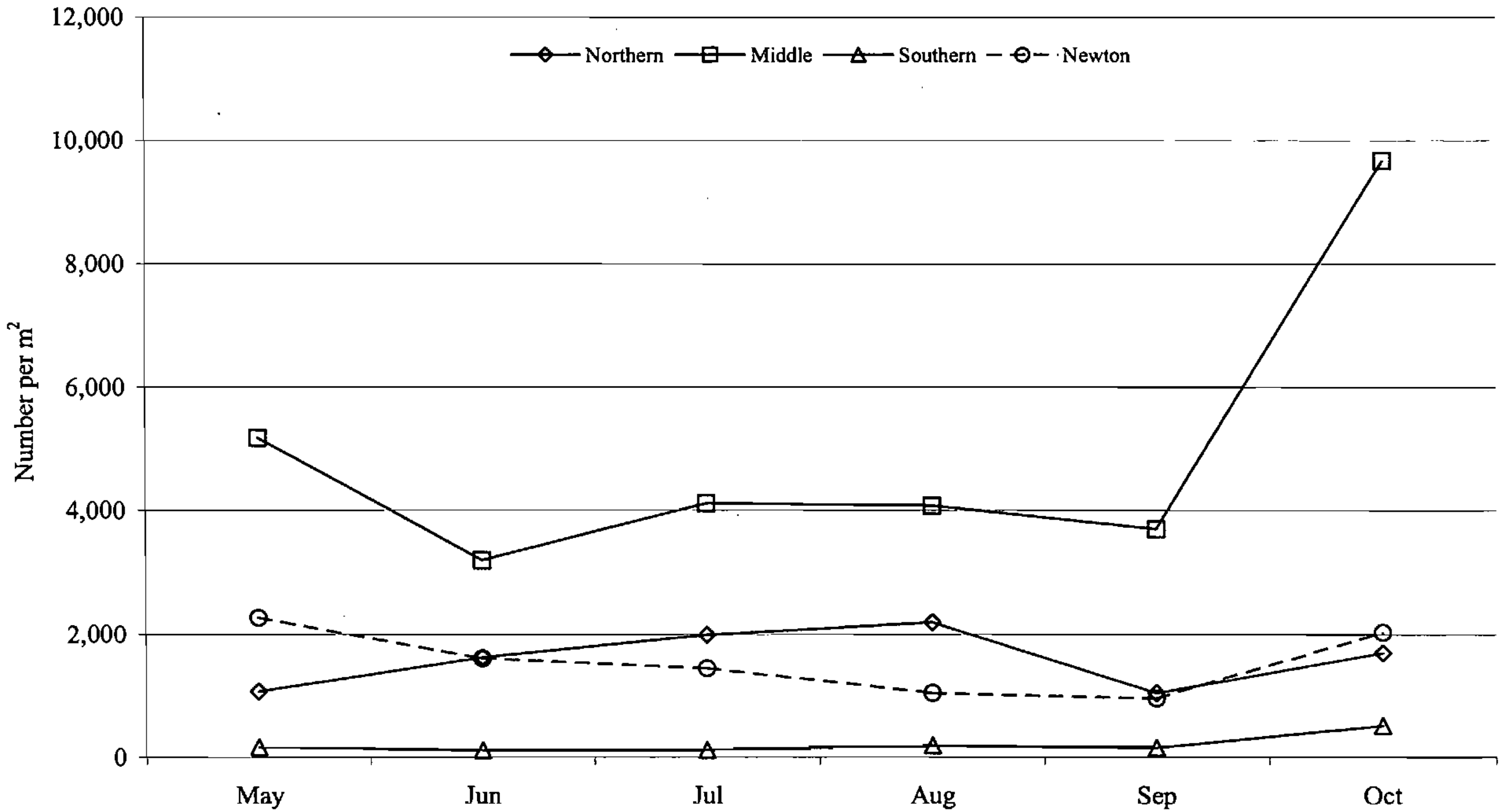

Figure 1.15. Mean benthos densities in 12 lakes located in three regions of Illinois compared to densities in Newton Lake from May through October. Benthos was collected each year during 1993 through 1997 from the 12 Illinois lakes and in 1998 and 1999 in Newton Lake. Four to six samples were taken each month from each of the 12 lakes for five years. Five lakes were sampled in the northern zone, six in the middle zone, and four in the southern zone.