Prepared for

SCE&G, VC Summer Station
Highway 215 and Bradham Blvd
Jenkinsville, South Carolina 29065

ENTRAINMENT PERFORMANCE STUDIES V.C. SUMMER NUCLEAR STATION UNIT 1 40 CFR § 122.21(r)(7)

SOUTH CAROLINA ELECTRIC & GAS COMPANY JENKINSVILLE, SOUTH CAROLINA

Prepared by

Geosyntec consultants

engineers | scientists | innovators

1255 Roberts Boulevard, Suite 200
Kennesaw, Georgia 30144

Project Number GK5356

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LIST OF ACRONYMS

CFR	Code of Federal Regulations
CWA	Clean Water Act
CWIS	cooling water intake structure
EPA	U.S. Environmental Protection Agency
FPSF	Fairfield Pumped Storage Facility
ft	feet
Geosyntec	Geosyntec Consultants, Inc.
m	meters
m^3	cubic meters
MGD	million gallons per day
MSL	mean sea level
NOAA	National Oceanic and Atmospheric Administration
Normandeau	Normandeau Associates, Inc.
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric and Gas
VCSNS	Virgil C. Summer Nuclear Station

1. INTRODUCTION

This report provides entrainment performance studies previously conducted for and in the vicinity of South Carolina Electric & Gas Company's (SCE&G's) Virgil C. Summer Nuclear Station (VCSNS) Unit 1. VCSNS Unit 1 is an existing nuclear-powered generating facility located on Monticello Reservoir in the Broad River basin near Jenkinsville, Fairfield County, South Carolina. SCE&G operates VCSNS Unit 1 under National Pollutant Discharge Elimination System (NPDES) Permit Number SC0030856. The information provided in this report supports the facility's compliance with section 316(b) of the Clean Water Act (CWA).

The U.S. Environmental Protection Agency (EPA) published 316(b) regulations for cooling water intake structures (CWISs) at existing power generating and manufacturing facilities that became effective October 14, 2014. The final 316(b) rule requires the submittal of applicable CWIS information under 40 CFR §122.21(r) to the South Carolina Department of Health and Environmental Control (SCDHEC), the NPDES permitting agency in South Carolina.

As provided in the NPDES permit application requirements at 40 CFR §122.21(r)(7), existing facilities with CWISs must submit previously conducted entrainment performance studies, as applicable, to include the following:

> *The owner or operator of an existing facility must submit any previously conducted studies or studies obtained from other facilities addressing technology efficacy, through-facility entrainment survival, and other entrainment studies. Any such submittals must include a description of each study, together with underlying data, and a summary of any conclusions or results. Any studies conducted at other locations must include an explanation as to why the data from other locations are relevant and representative of conditions at your facility. In the case of studies more than 10 years old, the applicant must explain why the data are still relevant and representative of conditions at the facility and explain how the data should be interpreted using the definition of entrainment at 40 CFR 125.92(h).*

This report describes entrainment studies conducted previously in Monticello Reservoir for the existing VCSNS Unit 1 CWIS.

2. BACKGROUND

2.1 Facility Description

VCSNS Unit 1 is a 972.7-megawatt, nuclear-fueled, base-load generating facility located at the southern end of Monticello Reservoir, a freshwater impoundment (Figure 1). VCSNS Unit 1 operates using a single CWIS located along the shoreline (Figure 2). The CWIS is part of a once-through cooling water system. It has a design intake capacity of approximately 533,122 gallons per minute or 768 million gallons per day. Although the cooling system operates in a "once-through" mode, Monticello Reservoir was constructed for the purpose of serving as part of the cooling water system (U.S. Nuclear Regulatory Commission [NRC], 2004). Thus, the use of Monticello Reservoir as a cooling impoundment for VCSNS Unit 1 has been determined by SCDHEC and EPA to be a closed-cycle recirculating system under 40 CFR, Part 125, Subpart J, §125.92(c)(2).

The VCSNS Unit 1 CWIS begins as an inlet bay on the south shore of Monticello Reservoir with a depth of 30 to 40 feet (ft) (Figure 2). The circulating pump house intake structure within the inlet bay is 93-ft wide and has six intake bays. Parallel concrete retainer walls on either side of the pump house and a skimmer wall extending 9.5 ft below the full-pool elevation direct the withdrawal of cooling water from the deeper, seasonally cooler mid depths of the reservoir. At normal high water, the CWIS is designed to withdraw water between elevations 415.5 ft and 390 ft mean sea level (MSL; NGVD29); or from depths of 9.5 ft to 35 ft. Six vertical 3/8-inch mesh traveling water screens strain out debris and any impinged organisms, which are then conveyed by the screen-was system to a trash sump for disposal. Three circulating water pumps convey the screened intake flow to the condensers. After leaving the condensers, the heated cooling water discharges to Monticello Reservoir via a discharge basin and a 1,000-ft-long discharge canal located east of the CWIS beyond the service water pond and jetty (Figure 2.)

2.2 Source Waterbody

Monticello Reservoir is a 6,500-acre freshwater lake with 51 miles of shoreline and a total storage volume of approximately 400,000 acre-feet. The reservoir has an average depth of 59 ft, a maximum depth of 125 ft, and a watershed area of 17.4 square miles in the Frees Creek valley, a tributary to the Broad River. Monticello Reservoir serves as the upper reservoir for the Fairfield Pumped Storage Facility (FPSF) and exchanges water daily with Parr Reservoir (the lower reservoir). FPSF is part of the Parr Hydroelectric

Project operated by SCE&G and licensed by the Federal Energy Regulatory Commission. Monticello Reservoir fluctuates up to 4.5 ft daily as a result of pumped storage operations within an operating band of 420.5 to 425.0 ft MSL. Monticello Reservoir is hydraulically connected to a 300-acre sub-impoundment at the northern end of the reservoir that is minimally influenced by pumped storage operations and is managed for fishing and recreation.

A survey of the area of influence attributable to the VCSNS Unit 1 CWIS was conducted at three different reservoir elevations in April 2005 using acoustic Doppler current profiling technology (Geosyntec Consultants, Inc. [Geosyntec], 2005). Boundaries of the area of influence were conservatively estimated based on the detection of flow vectors oriented towards the CWIS regardless of the associated velocity (ichthyoplankton may be susceptible to entrainment even at low intake velocities). The survey delineated a maximum composited area of influence of 2.92 surface acres. The area of influence extends approximately 550 ft into the reservoir with a width of about 250 ft (Figure 3).

2.3 Source Water Biological Community

The fish community in Monticello Reservoir includes about 42 freshwater species in 10 families, mostly sunfishes (11 species), catfishes (6 species), and suckers (4 species). The families represented by the most species were sunfishes (11), suckers (8), catfishes (7), and minnows (6). Two species of crustaceans have also been documented in the reservoir. A 2007 fish community assessment found Monticello Reservoir to be dominated by three species: bluegill (*Lepomis macrochirus* [32.6 percent]), gizzard shad (*Dorosoma cepedianum* [(19.6 percent)], and blue catfish (*Ictalurus furcatus* [11 percent]) (Normandeau Associates, Inc. [Normandeau], 2007). Relative abundance data from another recent community assessment (Normandeau, 2009a) included the following species ranked in descending order of abundance: bluegill (33.4 percent), gizzard shad (6.7 percent), white perch (*Morone americana* [21.5 percent]), largemouth bass (*Micropterus salmoides* [7.6 percent]), and channel catfish (*Ictalurus punctatus* [5.6 percent]).

Data from previous impingement studies at VCSNS Unit 1 indicate similar species composition in Monticello Reservoir. The dominant species from an impingement study performed in 2005-2006 included: threadfin shad (*Dorosoma petenense* [50.2 percent]), blue catfish (12.2 percent), channel catfish (11.8 percent), white perch (9.4 percent),

yellow perch (*Perca flavescens* [6.1 percent]), and gizzard shad (4.4 percent) (Geosyntec, 2007). Other fish included species from the minnow and sucker families.

The greatest numbers of fish species inhabiting Monticello Reservoir spawn during the period April through June, although there is substantial temporal overlap of spawning periods from as early as March to as late as July and August (Rohde et al., 2009). Early spring spawners include black crappie, gizzard shad, and yellow perch. Mid-spring to early summer spawners include threadfin shad, minnows, suckers, catfishes, and most sunfishes. Gizzard shad and bluegill spawn through the summer.

Crustacean taxa collected in impingement samples included freshwater grass shrimp (*Palaemonetes* sp.) and unidentified crayfish (Geosyntec, 2007). No commercially important species of shellfish are known to inhabit Monticello Reservoir.

There are no known occurrences of federally protected threatened or endangered fish or shellfish species, or designated critical habitat for these species, in Monticello Reservoir (South Carolina Department of Natural Resources [SCDNR], 2014; U.S. Fish and Wildlife Service, 2016). The National Oceanic and Atmospheric Administration (NOAA, 2016) has proposed designating unoccupied critical habitat for the federally endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the Broad River extending upstream to Parr Dam (NOAA, 2016), but the designation would not include Parr Reservoir or Monticello Reservoir.

In March 2008, two specimens of robust redhorse (*Moxostoma robustum*), a species of conservation concern, were collected in Monticello Reservoir during a largemouth bass survey (SCDNR, 2013). The fish were believed to have been entrained into the reservoir through pump-back operations at FPSF, after having been stocked as juveniles upstream in the Broad River. The robust redhorse inhabits mainstem rivers and occurs in the Broad River primarily downstream of the Neal Shoals Hydro near Carlisle, South Carolina. The species is not listed as protected in South Carolina.

3. PREVIOUS ENTRAINMENT STUDIES

Entrainment performance studies previously conducted at VCSNS include the following two ichthyoplankton surveys:

- Ichthyoplankton sampling conducted at seven stations in Monticello Reservoir in 1983-1984 as part of the original CWA section 316(b) demonstration study for the newly constructed VCSNS Unit 1 (Dames & Moore, 1985). The sampling included one station in the vicinity of the Unit 1 CWIS.

- Ichthyoplankton sampling conducted along the southern shoreline of Monticello Reservoir in 2008-2009 to assess the potential for entrainment for previously planned VCSNS expansion (Normandeau, 2009b).

- Ichthyoplankton sampling was conducted in from March through August 2016 within the area of influence of the Unit 1 CWIS. Ichthyoplankton samples were collected from transects parallel to the shoreline within the area of influence of at both the surface and mid-depth. Day and night ichthyoplankton samples were collected twice per month for a total of 48 samples (Normandeau, 2017).

The following sections describe these two studies. Each section explains why the data are relevant and representative of conditions at VCSNS Unit 1, describes the study and underlying data, and summarizes any conclusions or results. Although neither study addressed technology efficacy or through-facility entrainment survival, together they characterize the ichthyoplankton assemblage in Monticello Reservoir that may be susceptible to entrainment at VCSNS Unit 1.

3.1 <u>CWA Section 316(b) Demonstration Study, 1983-1984</u>

The ichthyoplankton sampling for the original 316(b) demonstration study for VCSNS was conducted in 1983-1984 (Dames & Moore, 1985), prior to the introduction of blue catfish and white perch into the Monticello Reservoir fishery in (NRC, 2004). Blue catfish and white perch were collected from the reservoir for the first time in 1989 and 1995, respectively, and they have since become two of the numerically dominant species in the reservoir. Although the historical ichthyoplankton data reflect the overall composition of the fish community at the time of sampling, they remain relevant and representative of conditions at VCSNS Unit 1 in that they characterize seasonal and

spatial variation in the occurrence of larvae of fish species that have remained numerically abundant in the reservoir, including gizzard shad and white bass.

3.1.1 Study Approach

Dames & Moore (1985) collected ichthyoplankton samples at seven stations located throughout Monticello Reservoir from October 1983 through September 1984. One station (Station M) was located in the vicinity of the VCSNS Unit 1 CWIS (Figure 3) but it was not located within the area of influence delineated in April 2005 (Geosyntec, 2005). The other stations were used to assess the distribution of larval fish near the FPSF intake (Station L), the extreme northern end of the reservoir (Station I), and at various other locations in the reservoir (Stations J, K, N, O). Samples were collected at the surface and at mid-depth using net tows. Specimens were identified to the lowest practical taxonomic level with the densities calculated as number per 100 cubic meters (m^3) and reported separately for surface and mid-water samples.

3.1.2 Results and Conclusions

Appendix A reproduces the tables of ichthyoplankton sampling results from Dames & Moore (1985) (tables 3 through 5). Nine taxa of larval fish from six families were collected from the reservoir in 1983-1984 but no fish eggs or shellfish were collected. Larval fish were collected at Station M in the vicinity of the VCSNS Unit 1 intake in the months February through August. The numerically dominant taxon collected at all stations in the reservoir (surface and mid-depth) was shad (Clupeidae), mostly gizzard shad. Gizzard shad dominated the Station M samples at both depths, comprising 94 percent of the samples. White bass represented about 5 percent of the samples. The overall surface density at Station M for the study period was 53.9 larval fish per 100 m^3 of water, and the overall mid-depth density was 11.8 fish per 100 m^3. Ichthyoplankton densities in Station M surface samples were over 4.5 times greater than those in mid-depth samples. Other taxa collected at Station M in low numbers were minnows, suckers, sunfish, and perch. Catfish eggs and larvae were not collected.

Larval fish first appeared in ichthyoplankton samples in February, consisting entirely of white bass. Shad and perch larvae began appearing in March. By April, six taxa were represented among the sampling stations. Pronounced peaks in larval density occurred in May and June, with eight and six taxa represented in the reservoir, respectively. At Station M, the mean total density of larval fish in surface and mid-depth samples was

48.4 fish per 100 m^3 in May and 169.7 fish per 100 m^3 in June. Shad dominated the samples collected at Station M in May and June, comprising 97 percent and greater of the surface samples and 94 percent and greater of the mid-depth samples. Shad also dominated the samples collected at other stations throughout the reservoir in May and June. In general, larval shad occurred in similar densities between surface and mid-depth samples, with the exception of June at Station M, when shad densities were over ten times greater in the surface samples. In contrast, ichthyoplankton samples from July, August, and September yielded very low densities of larval fish and few taxa. No larval fish were detected in samples from October through January.

Entrainment of ichthyoplankton is directly related to the seasonal distribution of reproduction of individual species. Entrainment tends to peak following spawning seasons and declines upon larval recruitment to the juvenile life stage, when young fish become capable of escaping intake velocities and/or too large to pass through the traveling screens. Dames & Moore (1985) found that ichthyoplankton densities near the VCSNS Unit 1 intake exhibited a seasonal pattern with the highest densities occurring during the months of April through June. The dominant species in the samples shifted over time as spawning periods for each species initiated at different times. White bass larvae were a major component of the ichthyoplankton samples from February through May. Shad larvae began appearing in April and peaked in density in May and June. Shad were collected in ichthyoplankton samples from April through August and occurred at the highest densities, indicating that clupeids (gizzard shad and threadfin shad) were the primary species potentially susceptible to entrainment at the VCSNS Unit 1 CWIS.

The highest densities of larval fish were found to occur in the southern end of Monticello Reservoir near Station M, in the vicinity of the VCSNS Unit 1 intake. Dames & Moore (1985) attributed this pattern of distribution to the pump-back operations at FPSF, which may replenish this area of the reservoir with nutrients and also transport larvae into the reservoir from Parr Reservoir. Dames & Moore (1985) concluded that the operation of the VCSNS Unit 1 CWIS did not cause a reduction in optimum sustained yield to sport and/or commercial fisheries of Monticello Reservoir and that ecological functioning of Monticello Reservoir was not impaired as a result of CWIS operations.

3.2 Ichthyoplankton Survey, 2008-2009

An ichthyoplankton survey was conducted along the southern shoreline of Monticello Reservoir from September 2008 through August 2009 to assess potential entrainment at

the previously proposed VCSNS expansion (Normandeau, 2009b) located about 1,250 ft west of the Unit 1 CWIS (Figure 2). The 2008-2009 ichthyoplankton survey represents the current species composition of the Monticello Reservoir as well as the overall physical characteristics and aquatic habitats available in the vicinity of the Unit 1 CWIS. Therefore, the entrainment study results for this study are relevant and representative of conditions at the Unit 1 CWIS.

3.2.1 Study Approach

Normandeau (2009b) collected ichthyoplankton samples from two transects oriented parallel to the shoreline near the proposed location for the previously planned expansion (Figure 3). Samples were collected at mid-depth along the offshore transect and at the surface along the nearshore transect using paired (i.e. bongo) 0.5 meter (m)-diameter, 0.300 millimeter-mesh nets. The sample nets were fitted with calibrated flow meters and each side filtered a minimum of 50 m^3 of water along a tow length of 250 m. Samples were collected once per month from August through February and twice per month from March through July. Day and night samples were collected during each event. A total of 68 samples were collected during the study. Organisms were identified to the lowest practical taxon and enumerated as to life stage, either eggs, yolk-sac larvae, post yolk-sac larvae, young-of-year, or juvenile (age 1). Ichthyoplankton density data were normalized to number of organisms per 100 m^3 of water sampled.

3.2.2 Results and Conclusions

Appendix 2 within Appendix B provides the Normandeau (2009b) study report, which includes tables and study results. Ichthyoplankton sampling in Monticello Reservoir from 2008-2009 resulted in the collection of 10 fish taxa from five families. Larval fish first appeared in ichthyoplankton samples in March, consisting of black crappie, white perch, yellow perch, darters, and threadfin shad, which dominated the samples. Gizzard shad, cyprinids (minnows), catostomids (suckers), and sunfish (*Lepomis* species) began appearing in samples in April. By May, seven taxa were represented among the total catch. The largest number of taxa collected in one month, 10 species, occurred in June. In contrast, ichthyoplankton samples from July and August resulted in the collection of only four and three taxa, respectively.

The largest peak in larval density occurred in May with 125.1 organisms/100 m^3, followed by a rapid decline to 0.41/100 m^3 in August. Density of threadfin shad in the

monthly samples followed the same pattern, exhibiting a sharp peak in May with a density of 116.2/100 m^3 and then rapidly declined to 0.09 organisms/100 m^3 in June. Although June sampling resulted in the largest number of taxa collected, the months of June through August exhibited sharp declines in total catch.

Larval fish were collected from March through July, peaking in April and May, with highest densities occurring in May. Clupeids comprised the majority of the total catch, with threadfin shad being the most abundant at 71.0 percent of all ichthyoplankton collected. White perch was the second most abundant, comprising 12.6 percent of the total catch. White bass, which were collected in the 1983-1984 ichthyoplankton survey (Dames & Moore, 1985), were not collected in 2008-2009. Gizzard shad, the dominant species from 1983-1984 at 94.2 percent of the samples, made up only 2.2 percent of the samples in 2008-2009. The remaining portion of the samples consisted of minnows, suckers, black crappie, and yellow perch, with each species representing less than one percent of all specimens collected. No fish eggs or shellfish were collected in 2008-2009.

Normandeau (2009b) speculated that the differences observed in population dynamics of the reservoir from 1983-1984 to 2008-2009 were likely a result of natural community turnover and progression, stabilization of reservoir water quality, changes in nutrient inputs, new species introductions, and density-dependent interactions between predator-prey fish species.

Normandeau (2009b) found that ichthyoplankton densities exhibited a seasonal pattern with the highest densities occurring from March to June and peaking in April and May. White perch larvae were a major component of the ichthyoplankton samples from March through June. Threadfin shad larvae began appearing in March and peaked in density in April and May. Gizzard shad began appearing in April and peaked in May. Shad were collected in ichthyoplankton samples from March through August and occurred at the highest densities, indicating that clupeids (gizzard shad and threadfin shad) were the primary species potentially susceptible to entrainment at the VCSNS Unit 1 CWIS.

Normandeau (2009b) applied monthly ichthyoplankton densities to typical withdrawal rates to derive annual entrainment estimates and their associated lower and upper 95-percent confidence limits. According to Normandeau (2009b), low ichthyoplankton diversity and natural system variability in Monticello Reservoir, coupled with potential future introductions of non-native species, could produce large inter-annual variation in ichthyoplankton density and potential entrainment.

3.3 Ichthyoplankton Survey, 2016

3.3.1 Study Approach

Normandeau (2017) conducted an ichthyplankton survey within the area of influence of the Unit 1 CWIS from March through August 2016. Ichthyoplankton samples were collected from transects orientated parallel to the shoreline within the area of influence of the Unit 1 CWIS at both the surface and mid-depth using paired 0.5 m-diameter, 0.300 mm-mesh nets. Day and night ichthyoplankton samples were collected twice per month. A total of 48 samples were collected during the study. Organisms were and enumerated as to life stage, either eggs, yolk-sac, post yolk-sac, larvae, young-of-year (YOY), or juvenile (age 1). In a few instances, larvae were identified as having an undetermined larval stage due to unambiguous size and the lack of distinguishing guts and/or yolk sac.

3.3.2 Results and Conclusions

Ichthyoplankton were collected in all samples from March through August 2016, though numbers collected in March and August were the lowest observed during the sampling period (Appendix A, Table 4-1 and 4-7). A total of 1,311 organisms comprising seven fish families were collected with over half (50.8%) occurring during the month of June. Larval fish dominated collections with only one egg (*Dorosoma* spp.) and five YOY catfish (blue and channel catfish) comprising other life stages. As expected, no federal or state protected species were identified in ichthyoplankton samples. Ichthyoplankton were dominated by members of the Clupeid family (*Dorosoma* genus), which comprised over 86% of all organisms collected (Appendix A, Table 4-6). Centrarchidae comprised 9.6%, Cyprinidae 1.6%, and the Catostomidae, Ictaluridae, Moronidae, and Percidae each comprised less than 1% of the total number collected.

No differences were found in larval density based on the sampling depth, however, density was typically higher during the day than the night. Ichthyoplankton densities were highest in June with *Dorosoma* genus dominating the numbers for April, May and June. Lepomid larval fish were the most abundant taxon in July and August, but with far few organisms.

4. SUMMARY AND CONCLUSIONS

Planktonic fish larvae occurring in the southern end of Monticello Reservoir are the life stages most susceptible to entrainment at the VCSNS Unit 1 CWIS because of their potential to enter the CWIS area of influence and their small size and lack of swimming ability. Based on entrainment studies previously conducted at VCSNS in 1983-1984 (Dames & Moore, 1985) and 2008-2009 (Normandeau), and 2016 (Normandeau) and the known life-stage habitats of resident fish species, the species most susceptible to entrainment at the VCSNS Unit 1 CWIS are threadfin shad, gizzard shad, and white perch. Each of these species is relatively abundant in Monticello Reservoir and highly fecund. Although their eggs are demersal and removed from the CWIS area of influence, as the larvae grow and move into the water column of nearshore waters, they become susceptible to entrainment upon drifting toward the inlet bay to the CWIS. Sunfishes and catfishes are relatively abundant in the reservoir fish community but are much less susceptible to entrainment because their larvae receive prolonged parental care and reside in sheltered littoral-zone habitats away from the generally deeper waters of the CWIS area of influence.

The primary period of larval abundance in Monticello Reservoir from March through August with peak larval abundance occurring from April to June. This time period generally coincides with the spawning and larval rearing seasons for the greatest number of species inhabiting Monticello Reservoir.

Dames and Moore (1985) documented differences in the ichthyoplankton distribution in Monticello Reservoir, noting greater larval densities at the sample station at the southern end of the reservoir in the vicinity of the VCSNS Unit 1 CWIS. Differences were also observed in the species composition of entrainment samples between 1983-1984 and 2008-2009, which were attributed in part to the introduction of blue catfish and white perch by 1989 and 1995, respectively. Despite the observed shift in numerical dominance of ichthyoplankton from gizzard shad to threadfin shad, the results from the three ichthyoplankton studies indicate that the overall trends in larval seasonal occurrence and peak abundance were similar. The ichthyoplankton samples were numerically dominated in both studies by species of shad, either threadfin shad or gizzard shad.

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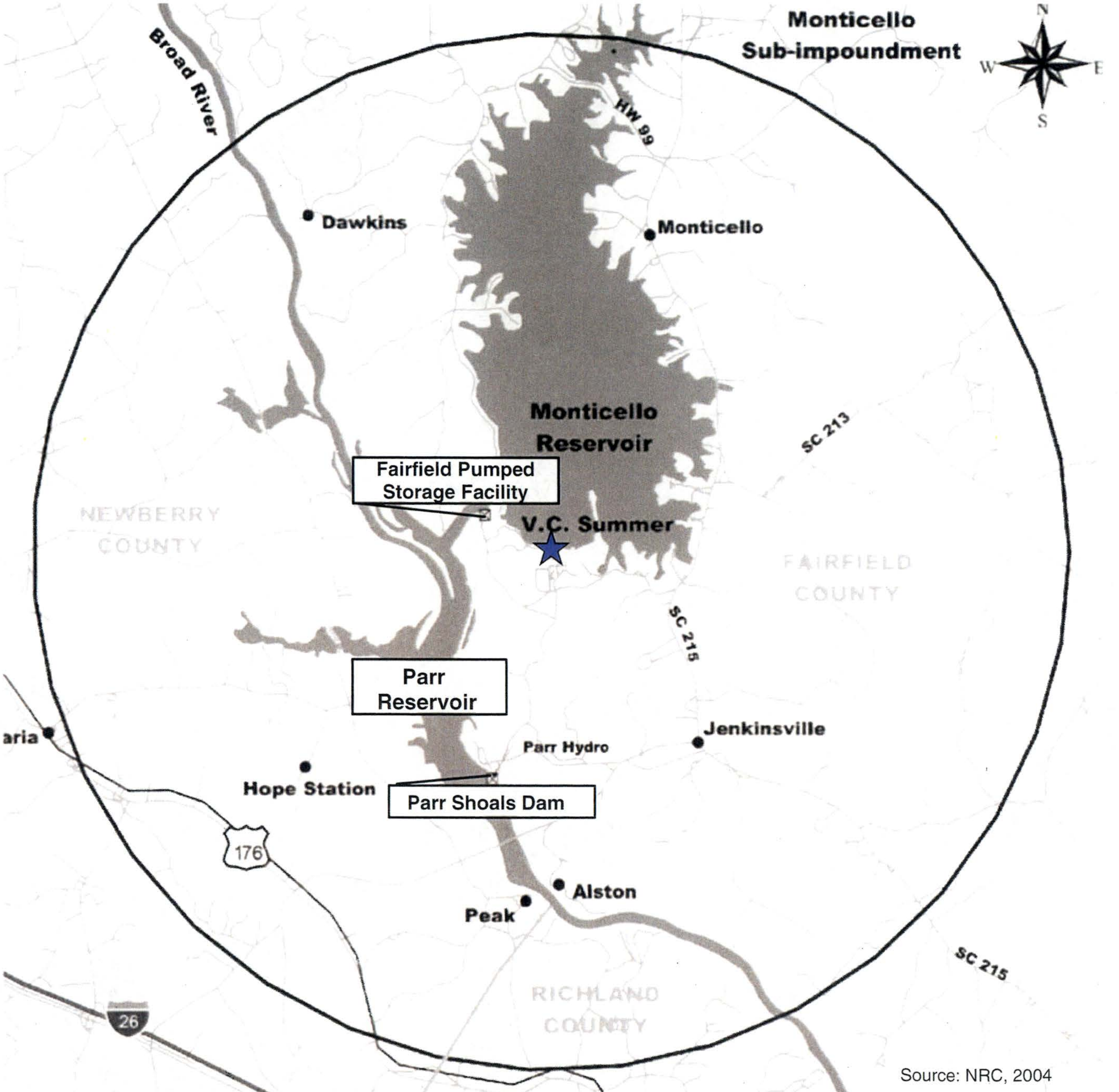
FIGURES



Source: NRC, 2004

★ Virgil C. Summer Nuclear Station

Site Vicinity Map
Virgil C. Summer Nuclear Station
Jenkinsville, South Carolina

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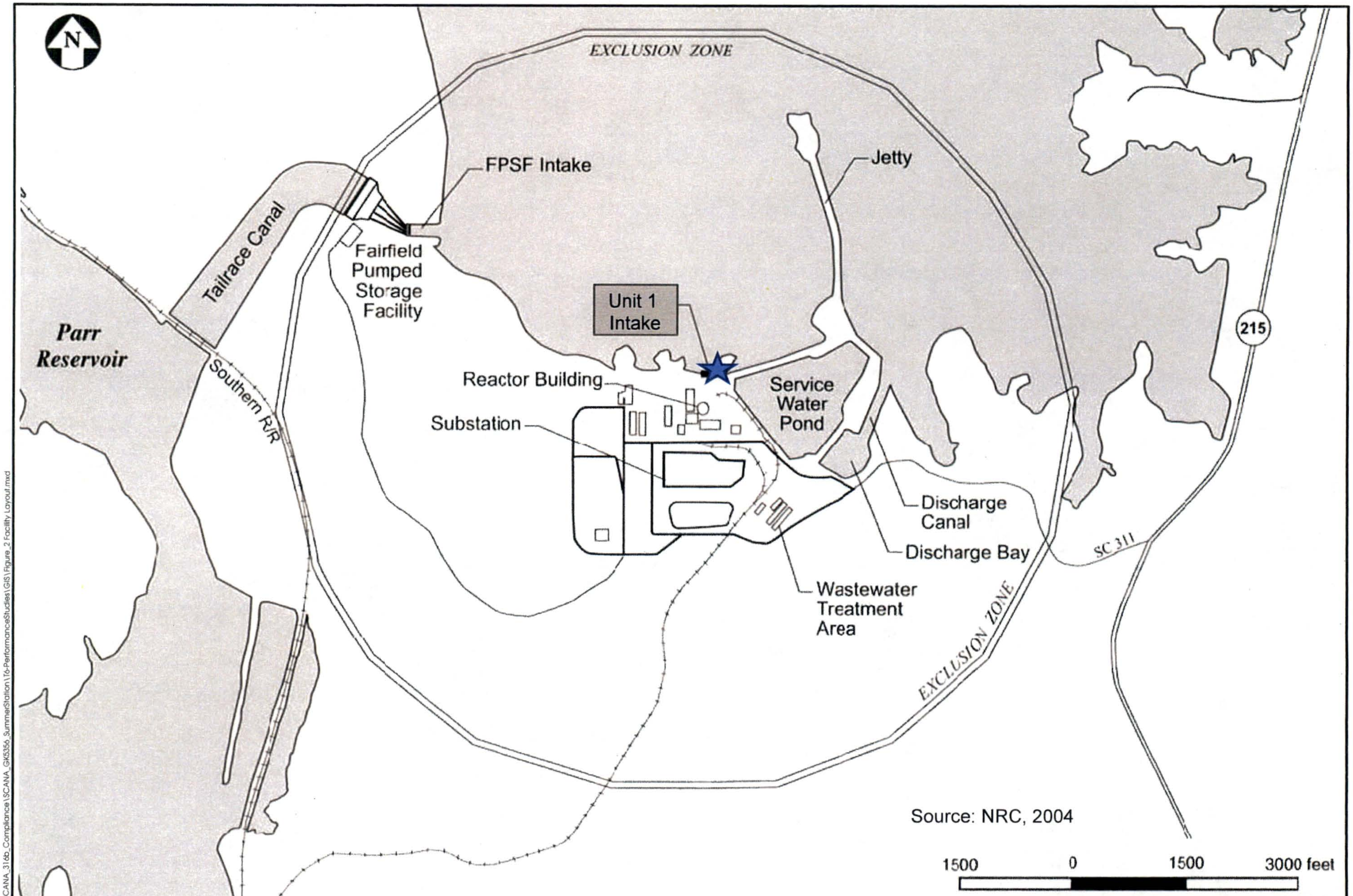
Atlanta, Georgia | February 2015

Figure **1**



Legend

★ Unit 1 Cooling Water Intake

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Site Layout
Virgil C. Summer Nuclear Station

Jenkinsville, South Carolina

Figure 2

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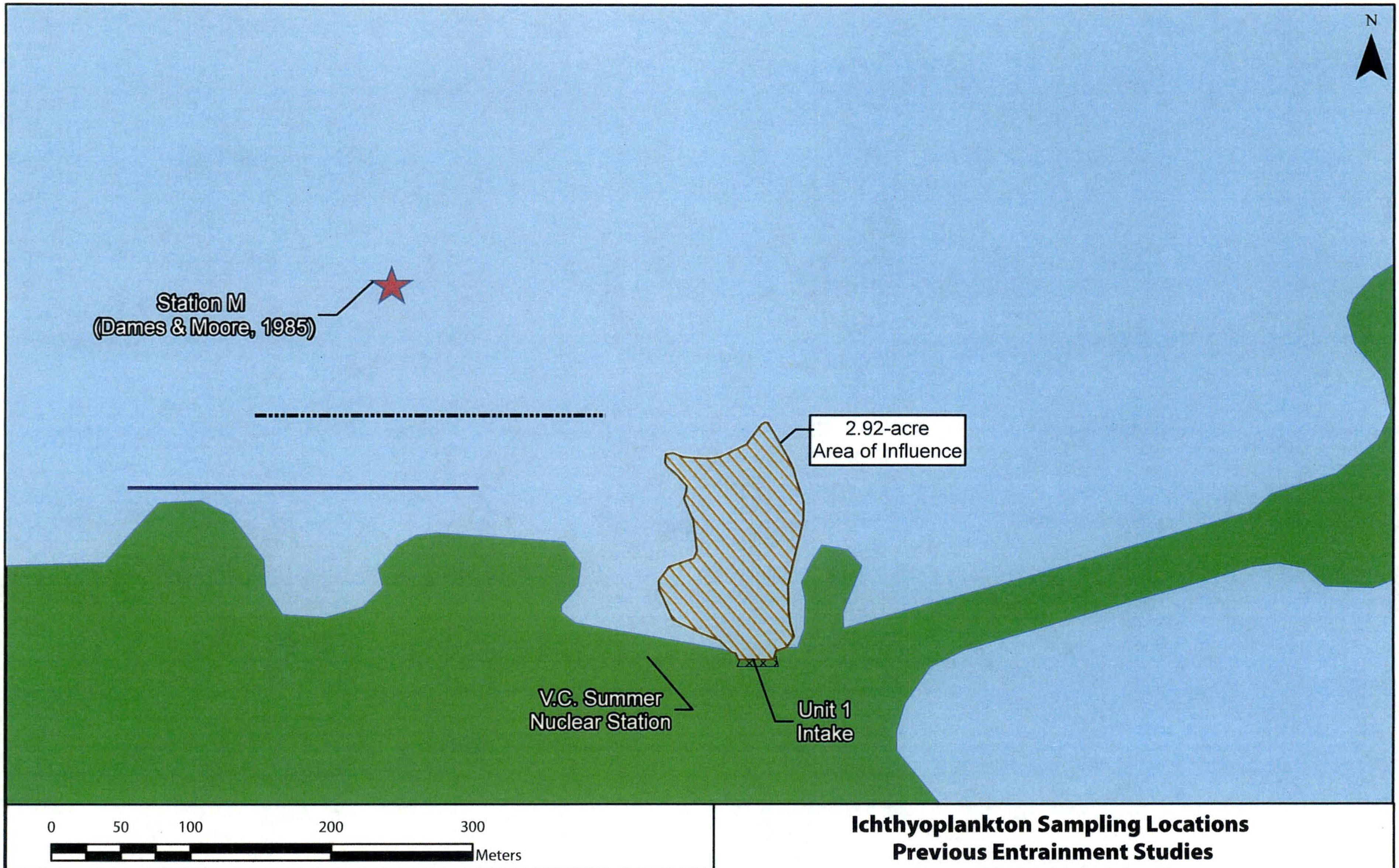

Legend

- Unit 1 Intake
- Area of Influence (Hydraulic Zone of Influence)
- Dames & Moore (1985) (Approximate Location of Station M)
- Monticello Reservoir

Normandeau Study (2009)

- Mid-depth Transect
- Surface Transect

Ichthyoplankton Sampling Locations
Previous Entrainment Studies
Near VCSNS Unit 1 Intake
Jenkinsville, South Carolina

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Figure **3**

N:\S\SCANA_316b_Compliance\SCANA_GK5356_SummerStation\T6-PerformanceStudies\GIS\Figure_3 Ichthyoplankton Sample Locations Summer Station.mxd

APPENDIX A

Ichthyoplankton Sampling Study Data from Monticello Reservoir, 1983-1984

(Tables reproduced from Dames & Moore, 1985)

Table 3 Mean density of larval fish (number/100 m^3) for Stations I through O during October 1983 through September 1984.

Species	Scientific Name	Station	I	J	K	L	M	N	O
Gizzard shad	Dorosoma	Surface	16.37	6.77	12.96	10.84	51.57	8.95	9.88
		Mid-depth	17.38	6.86	11.96	1.71	10.33	9.05	3.13
Minnow	Cyprinidae	Surface	--	--	--	--	0.11	--	0.04
		Mid-depth	--	--	--	0.06	0.15	--	--
Sucker	Catostomidae	Surface	--	--	--	0.61	0.11	--	0.24
		Mid-depth	--	--	--	--	--	--	0.00
White bass	Morone chrysops	Surface	0.08	0.04	--	1.64	1.94	1.67	2.29
		Mid-depth	0.04	0.12	0.83	0.25	1.13	1.86	0.34
Sunfish	Centrarchidae	Surface	--	--	--	--	--	--	--
		Mid-depth	0.04	--	--	--	0.03	--	--
Sunfish	Lepomis spp.	Surface	0.09	--	--	0.04	0.04	--	0.20
		Mid-depth	--	--	--	--	--	--	--
Crappie	Pomoxis spp.	Surface	0.12	--	--	0.03	--	--	0.08
		Mid-depth	0.03	--	--	--	--	--	0.04
Yellow perch	Perca flavescens	Surface	0.10	--	--	--	--	--	--
		Mid-depth	--	--	0.01	--	--	--	--
Percid	Percidae	Surface	0.86	0.19	0.03	0.21	0.08	0.17	1.37
		Mid-depth	0.17	0.13	0.17	0.04	--	0.02	0.04
	Damaged Unid.	Surface	0.74	0.04	0.08	0.23	0.07	0.18	0.15
		Mid-depth	0.24	0.04	0.09	--	0.18	0.19	--
Total Surface			18.34	7.03	13.07	13.60	53.92	10.93	14.25
Total Mid-Depth			17.89	7.14	12.58	2.06	11.82	11.12	2.55

Table 4 Mean monthly densities of larval fish (number/100 m^3) collected in net tows, October 1983 through September 1984. (Larval fish first appeared in the February 1984 collections.)

FEBRUARY 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Morone chrysops	White bass	Sfc	—	—	—	10.13	11.53	3.99	—
		Mid	—	—	1.82	—	5.61	11.19	—
Total		Sfc	—	—	—	10.13	11.53	8.99	—
		Mid	—	—	1.82	—	5.61	11.19	—

MARCH 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	—	—	—	—	—	0.70	—
		Mid	—	—	0.12	—	—	0.45	—
Morone chrysops	White bass	Sfc	—	0.27	—	0.40	1.28	1.00	0.85
		Mid	0.13	0.29	0.29	0.32	0.92	0.57	—
Perca flavescens	Perch	Sfc	—	—	—	—	—	—	—
		Mid	—	—	0.09	—	—	—	—
Percidae	Perch	Sfc	—	0.27	0.11	—	—	—	1.99
		Mid	—	0.29	0.72	—	—	—	0.26
Total		Sfc	—	0.54	0.11	0.40	1.28	1.60	2.83
		Mid	0.13	0.58	1.22	0.32	0.92	1.02	0.26

Table 4 (Continued)

APRIL 1984

Scientific or Family Name	Common Name		I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	—	—	—	—	1.30	2.17	0.76
		Mid	0.26	0.28	0.20	0.29	0.60	12.32	0.60
Cyprinidae	Minnows	Sfc	—	—	—	—	—	—	—
		Mid	—	—	—	0.28	—	—	—
Morone chrysops	White bass	Sfc	0.53	—	—	0.48	0.78	1.31	15.19
		Mid	—	0.56	—	—	0.60	0.21	2.38
Centrarchidae	Sunfish	Sfc	—	—	—	—	—	—	—
		Mid	0.26	—	—	—	—	—	—
Pomoxis spp.	Crappie	Sfc	0.47	—	—	—	—	—	—
		Mid	—	—	—	—	—	—	0.30
Percidae	Perch	Sfc	5.64	0.57	—	0.25	0.25	0.97	3.88
		Mid	0.81	0.58	0.43	0.26	—	—	—
Damaged Unid.		Sfc	—	—	—	—	—	—	0.51
		Mid	—	—	—	—	—	0.21	—
Total		Sfc	6.63	0.57	—	0.73	2.33	4.49	20.34
		Mid	1.32	1.43	0.63	0.84	1.20	12.73	3.27

MAY 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	89.22	44.73	48.28	18.60	49.75	38.16	43.69
		Mid	113.37	33.87	48.78	10.93	43.08	41.81	14.31
Cyprinidae	Minnows	Sfc	--	--	--	--	--	--	--
		Mid	--	--	--	0.15	0.38	--	--
Catostomidae	Sucker	Sfc	--	--	--	4.26	0.51	--	--
		Mid	--	--	--	--	--	--	--
Morone chrysops	White bass	Sfc	--	--	--	0.47	--	0.37	--
		Mid	0.17	--	0.21	1.41	0.75	1.03	--
Centrarchidae	Sunfish	Sfc	--	--	--	--	--	--	--
		Mid	--	--	--	--	0.19	--	--
Pomoxis spp.	Crappie	Sfc	0.35	--	--	0.24	--	--	0.59
		Mid	0.18	--	--	--	--	--	--
Perca flavescens	Perch	Sfc	0.69	--	--	--	--	--	--
		Mid	--	--	--	--	--	--	--
Percidae	Perch	Sfc	0.35	0.27	--	0.71	0.33	0.19	0.89
		Mid	0.38	--	0.21	--	--	--	--
Damaged Unid.		Sfc	3.08	0.27	0.56	--	0.50	1.29	0.26
		Mid	1.64	0.27	0.37	--	1.28	1.12	--
Total		Sfc	93.67	45.26	48.85	24.28	51.09	40.01	45.42
		Mid	115.73	34.14	49.55	12.48	45.69	43.96	14.31

JUNE 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	21.72	2.65	42.30	57.25	309.51	21.39	24.70
		Mid	7.26	13.57	34.62	0.78	28.03	8.78	6.98
Cyprinidae	Minnows	Sfc	—	—	—	—	0.76	—	0.28
		Mid	—	—	—	—	0.51	—	—
Catostomidae	Sucker	Sfc	—	—	—	—	0.25	—	1.69
		Mid	—	—	—	—	—	—	—
Morone chrysops	White bass	Sfc	—	—	—	—	—	—	—
		Mid	—	—	—	—	—	—	—
Lepomis spp.	Sunfish	Sfc	—	—	—	0.27	0.27	—	1.41
		Mid	—	—	—	—	—	—	—
Percidae	Perch	Sfc	—	0.22	0.13	0.53	—	—	2.81
		Mid	—	—	—	—	—	0.14	—
Damaged Unid.		Sfc	1.58	—	—	1.60	—	—	0.28
		Mid	—	—	0.19	—	—	—	—
Total		Sfc	23.30	2.86	42.12	59.65	310.79	21.39	31.17
		Mid	7.26	13.57	34.81	0.78	28.54	8.91	6.98

Table 4 (Continued)

JULY 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	3.20	—	—	—	0.27	—	—
		Mid	0.79	0.27	—	—	0.26	—	—
Damaged Unid.		Sfc	0.49	—	—	—	—	—	—
		Mid	—	—	—	—	—	—	—
Total		Sfc	3.69	—	—	—	0.27	—	—
		Mid	0.79	0.27	—	—	0.26	—	—

AUGUST 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	—	—	—	—	0.16	—	—
		Mid	—	—	—	—	0.32	—	—
Cyprinidae	Minnows	Sfc	—	—	—	—	—	—	—
		Mid	—	—	—	—	0.18	—	—
Lepomis spp.	Sunfish	Sfc	0.62	—	—	—	—	—	—
		Mid	—	—	—	—	—	—	—
Total		Sfc	0.62	—	—	—	0.16	—	—
		Mid	—	—	—	—	0.50	—	—

Table 4 (Continued)

SEPTEMBER 1984

Scientific or Family Name	Common Name	Station	I	J	K	L	M	N	O
Dorosoma spp.	Shad	Sfc	0.45	--	--	--	--	--	--
		Mid	--	--	--	--	--	--	--
Total		Sfc	0.45	--	--	--	--	--	--
		Mid	--	--	--	--	--	--	--

Table 5 A comparison of larval fish mean densities at Stations I, L, and M for the dates indicated.[a]

	Stations					
	I	L	I	M	L	M
April 1984	7.96	1.57	7.96	3.53	1.57	3.53
	$p<0.001$		$(0.02<p<0.05)$		$0.01<p.0.02$	
May 1984	209.40	36.76	209.40	96.78	36.76	96.78
	$p<0.001$		$p<0.001$		$p<0.001$	
June 1984	30.52	60.43	30.52	339.33	60.43	339.33
	$(0.01<p<0.05)$		$p<0.001$		$p<0.001$	

[a] Mean densities have been calculated by using combined surface and mid-depth samples, and are given in organisms/100 m^3.