HARRIS NUCLEAR POWER PLANT
1992 ANNUAL ENVIRONMENTAL MONITORING REPORT

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Metric-English Conversion and Units of Measure

Length

1 micron (m) = 4.0 x 10^{-5} inch
1 millimeter (mm) = 1000 m = 0.04 inch
1 centimeter (cm) = 10 mm = 0.4 inch
1 meter (m) = 100 cm = 3.28 feet
1 kilometer (km) = 1000 m = 0.62 mile

Area

1 square meter (m^2) = 10.76 square feet
1 hectare (ha) = 10,000 m^2 = 2.47 acres

Weight

1 microgram (g) = 10^{-3} mg or 10^{-6} g = 3.5 x 10^{-8} ounce
1 milligram (mg) = 3.5 x 10^{-5} ounce
1 gram (g) = 1000 mg = 0.035 ounce
1 kilogram (kg) = 1000 g = 2.2 pounds
1 metric ton = 1000 kg = 1.1 tons
1 kg/hectare = 0.89 pound/acre

Volume

1 milliliter (ml) = 0.034 fluid ounce
1 liter = 1000 ml = 0.26 gallon
1 cubic meter = 35.3 cubic feet

Temperature

Degrees Celsius (°C) = 5/9 (°F-32)

Specific Conductance

Microsiemens/centimeter = μS/cm = μmhos/cm

Turbidity

NTU = Nephelometric Turbidity Unit

Water Chemistry Abbreviations

Cl^-	Chloride	TOC	Total organic carbon	Cu	Total copper
SO_4^{2-}	Sulfate	TS	Total solids	Hg	Total mercury
Ca^{2+}	Total calcium	TDS	Total dissolved solids	Ni	Total nickel
Mg^{2+}	Total magnesium	TSS	Total suspended solids	Pb	Total lead
Na^+	Total sodium	Al	Total aluminum	Se	Total selenium
TN	Total nitrogen	As	Total arsenic	Zn	Total zinc
NH_3-N	Ammonia nitrogen	Cd	Total cadmium		
TP	Total phosphorus	Cr	Total chromium		

Executive Summary

Harris Lake was constructed by Carolina Power & Light Company to supply cooling tower makeup and auxiliary reservoir makeup water to the Harris Nuclear Power Plant. Prior to commercial operation of the Harris Plant in May 1987, the reservoir was moderately productive. However, the reservoir became more biologically productive when the Harris Plant began discharging, under the auspices of the plant's National Pollutant Discharge Elimination System permit, primarily cooling tower blowdown along with low volume waste discharges into the reservoir near the main dam.

The aquatic monitoring program conducted in 1992 continued to support the Environmental Protection Plan for the Harris Plant and provided an assessment of the effects of plant operation on the various components of the aquatic environment. Water quality assessments in 1992 determined that nutrient concentrations, as measured by total phosphorus and total nitrogen, seemed to have stabilized but at a level greater than the concentrations observed when the reservoir was first created and prior to power plant operations. Algal blooms, although not uncommon in piedmont reservoirs, now occur at least several times each year. However, the blooms have not been of the undesirable, noxious blue-green algal types and have not resulted in any fish kills.

The major ions increased in 1992 as compared with their concentrations in previous years. Such increases reflected the prolonged retention time of water in the reservoir and the infrequent discharge of water over the spillway. Seventy-eight percent of the 300 metal and metalloid samples analyzed in 1992 were less than their respective laboratory reporting limit concentrations.

Biofouling by introduced nonnative organisms--the Asiatic clam and the aquatic plant hydrilla--did not affect Harris Plant operations. The distributions of both species continued to expand throughout much of the shallow-water zone. No Asiatic clams were collected in samples taken from the auxiliary intake canal, the intake structures, or the fire protection system. No zebra mussels were found in the main or the auxiliary reservoirs.

During 1992 the fishery was dominated by largemouth bass and several species of sunfish. An increasing proportion of the largemouth bass fishery was represented by quality-length fish which presented the recreational fisherman and bass tournament participants with excellent sportfishing opportunities.

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Reservoir Description

The main body of Harris Lake has a surface area of 1680 ha; the auxiliary reservoir has a surface area of 130 ha (Appendix 1). The main reservoir has a maximum depth of 18 m, a mean depth of 5.29 m, a volume of 8.88 x 10^7 m^3, a full-pool elevation of 67.1 m (220 ft) National Geodetic Vertical Datum (formerly called mean sea level by the U.S. Geological Survey), and an average residence time of 28 months. The reservoir began filling in December 1980, and full-pool elevation was reached in February 1983. The 64.5-km shoreline is mostly wooded, and the 183.89-km^2 drainage area is mostly rolling hills with land used primarily for forestry and agriculture.

Historical Overview

Harris Lake was constructed to supply cooling tower makeup and auxiliary reservoir makeup water to the 900-MW, single-unit Harris Nuclear Power Plant which began commercial operation in May 1987. In 1986 the bottom waters of the reservoir began receiving NPDES-permitted wastewater discharges near the main dam. In 1987 macronutrients (as estimated by total phosphorus and total nitrogen concentrations) and ions (as estimated by total chloride and total sulfate concentrations) increased above the previous years' concentrations in the reservoir, particularly at the monitoring station closest to the dam (CP&L 1990a). Concomitantly, an increase in algal biomass (as estimated by chlorophyll *a* concentrations) was also observed throughout much of the reservoir. In May 1989 an algal bloom was observed throughout the reservoir for the first time, and chlorophyll *a* concentrations were measured above the North Carolina water quality standard (40 µg/liter) at each of the four monitoring stations. In 1990 chlorophyll *a* concentrations approached or exceeded the water quality standard on three separate occasions and in 1991 on two separate occasions.

The increased nutrient loadings from all point and nonpoint sources accelerated the primary productivity of Harris Lake from low/moderate productivity to moderate/high productivity within the period 1986-1989. The nutrient and chlorophyll *a* concentrations between

1989 and 1991 have remained stable but were at greater concentrations than what they were when the reservoir was first created and prior to operation of the plant.

The shift in productivity has also resulted in a greater volume of the hypolimnion being oxygen-depleted during the summer months, diurnal fluctuations in the dissolved oxygen concentration in the shallow-water zone during the summer months, and reduced water clarity. In June 1991 a die-off of freshwater mussels occurred, primarily in the Buckhorn Creek and White Oak Creek arms. This die-off was the first reported incident of this type in Harris Lake, and low dissolved oxygen concentrations in the shallow-water zone may have caused the die-off.

Another significant change to the reservoir's benthic invertebrate community since impoundment was the colonization of the reservoir by the Asiatic clam *Corbicula fluminea* during 1988-1989. This nonnative organism has the potential to block power plant pipes and tubes in raw water systems. Until 1990 no clams had been collected from the intake structures or the auxiliary reservoir. In 1990 one individual was collected in the main intake canal. Although densities remained at low levels during 1991 and the reservoirwide monitoring program has not shown a rapid population increase, the presence of shells along the shoreline in many areas has indicated that the clam has continued to spread throughout the reservoir. No incidences of biofouling within the Harris Plant have occurred from the clams and operations have not been affected.

The fishery has been dominated by the sport fishes bluegill, pumpkinseed, largemouth bass, redear sunfish, black crappie, and by gizzard shad. Monitoring of fish populations through 1987 and a study of largemouth bass age and growth in 1985 documented slow growth rates for this species. However, during 1988 and 1989, the size distributions shifted towards larger-size bass. This shift was probably the result of the increased primary productivity, the availability of suitable-size forage fish due to the introduction of threadfin shad by the North Carolina Wildlife Resources Commission (NCWRC) in 1987, and an increased abundance of suitable-size gizzard shad. This shift towards intermediate- to large-size largemouth bass has presented anglers the opportunity for greater fishing success. No detrimental impacts on the fish community from plant operations have been observed since the Harris Plant became operational.

The aquatic plant hydrilla *Hydrilla verticillata* was initially found in 1988 growing in the White Oak Creek arm of the reservoir. Within a two-year period, this nonnative macrophyte had displaced the native species and had become the dominant littoral plant species. Since 1990 creeping water primrose *Ludwigia uruguayensis* has also increased its littoral zone coverage in the main reservoir. The auxiliary reservoir, however, has remained relatively free of aquatic vegetation since its impoundment. Despite these shifts in the structure of the aquatic macrophyte community, the community has not impacted Harris Plant operations.

Objectives

The primary objective of the nonradiological environmental monitoring program for 1992 was to continue to support the Environmental Protection Plan for the Harris Nuclear Power Plant. Secondary objectives were to provide an assessment of the effects of plant operations on the various components of the aquatic environment in Harris Lake, to document any natural changes or changes induced by sources other than the power plant, and to assess the impact of any introduced nonnative species. These objectives have also been addressed in previous reports (e.g., CP&L 1990a, 1990b, and 1991, 1992).

The 1992 environmental program included monitoring the limnology (water quality and chemistry and phytoplankton [algae]); Asiatic clam, zebra mussel, and fish populations; and the distribution of aquatic vegetation (Appendices 2 and 3). Sampling methods in 1992 were similar to those used in previous years (Appendix 4), except the electrofishing sampling was conducted biannually (May and November) rather than quarterly. Supporting data summaries, statistical analyses (Appendix 5), and key environmental indicators were used to describe and interpret the environmental quality of the reservoir. These indicators were included when a significant change or abnormal event occurred, an important trend was observed, or the potential for any of these was present. Other data were included as key indicators when there was environmental, public, or regulatory interest.

The accuracy and precision of laboratory analyses of water chemistry data were determined with analytical standards, spikes, and replicates (Appendix 6). In this report where concentrations were less than the laboratory reporting limit, the concentrations were assumed to be at one-half the reporting limit for the calculation of the mean.

Key Indicators of Environmental Quality During 1992

Limnology

(Appendices 7-18)

Reservoir Elevations

- Reservoir water surface elevations ranged from 218 to 221 ft (66.5-67.4 m) in 1992 (Appendix 7). Water spillage occurred from mid-June to mid-July and from early November to the end of the year. There was no spillage from the reservoir between early July 1991 until mid-June 1992--a period of approximately 350 days.

Temperature

- Harris Lake is a warm-water, monomictic reservoir. [A monomictic reservoir is defined as a reservoir whose water temperature is not less than 4°C and whose waters circulate freely in the winter but thermally stratify during the summer.] During 1992 surface water minimum temperatures ranged from 7.2° to 9.2°C and maximum temperatures ranged from 29.6° to 31.6°C (Appendix 8). The waters at the deeper stations (E2, H2, and P2) were stratified from April (except Station P2) through September and were freely circulating from January through March (except Station H2) and October through December (Appendix 9).

Specific Conductance

- Specific conductance (an estimate of the concentration of the dissolved ions) ranged from 51 to 198 μS/cm throughout the water column during 1992 (Appendix 8). Specific conductance increased with depth during the summer months as the reservoir became thermally stratified. When the bottom waters became increasingly devoid of oxygen during stratification, conditions were favorable for chemical reduction to occur and subsequent dissolution of ions.

Dissolved Oxygen

- A clinograde oxygen curve was observed for all stations from May through September and during November (Appendices 8 and 10). [A clinograde oxygen curve is defined as an abrupt depletion and undersaturation of oxygen with a concomitant increase in depth.] As water temperature increased and a well-defined thermocline developed during the summer, dissolved oxygen concentrations in the hypolimnion (bottom waters) typically decreased to anoxic (where dissolved oxygen concentrations were < 1 mg/liter) conditions (Appendices 8 and 10).

- The depressed percent oxygen saturation levels observed in January 1991 (CP&L 1992) were not repeated in 1992. Surface water percent saturation levels remained above 65% in 1992 (CP&L unpublished data), except for slightly lower levels during the fall turnover in October when oxygen-depleted bottom waters circulated to the surface.

Solids, Turbidity, and Water Clarity

- During 1992 there was no consistent spatial trend among the surface waters for all indicators and measurements of the optical clarity of the water--solids (total, total dissolved, and total suspended), turbidity, and Secchi disk transparency depth data (Appendices 11-13). However, the annual mean turbidity value at Station S2 (the upper reservoir station) was significantly greater than the values from the middle and lower reservoir stations (Stations E2, H2, and P2) (Appendix 13). Conversely, the mean Secchi disk transparency depth value at Station S2 was significantly less than at the other stations. This relationship was expected due to the tributary inflow and subsequent sediment transport from White Oak Creek and the negative relationship between two variables.

- There were no significant spatial trends for solids, turbidity, and Secchi disk transparency depth data during the period 1987-1992 (Appendix 14). Secchi disk transparency depth data was not inversely related to the temporal trend of decreasing annual mean turbidity values from 1987 to 1992, except for the peak turbidity mean in 1989 which corresponded to a peak chlorophyll *a* mean (Appendix 15). There were no significant temporal differences among the solids data for the period 1987-1992.

Algal Biomass

- Reservoirwide mean chlorophyll *a* concentrations (an algal pigment that is used as an approximate measure of algal biomass) during 1992 ranged from 3.8 to 44.4 µg/liter (Appendices 11 and 13). There were no significant spatial differences in mean chlorophyll *a* concentrations during 1992 or from 1987 to 1992 (Appendices 13 and 14). The annual mean chlorophyll *a* concentration for 1992 was not significantly different than the annual means for the period 1987-1991, except for 1989 which had the greatest mean value for this period (Appendix 15).

- The mean chlorophyll *a* concentrations for January 1992 at Station H2 (40.2 µg/liter) and for August 1992 at Station E2 (44.4 µg/liter) were greater than the North Carolina water quality standard of 40 µg/liter (Appendices 11 and 16) which indicated the occurrences of algal blooms as defined by the NCDEM (1992). Occasional chlorophyll *a* concentrations greater than the water quality standard are not an uncommon occurrence in piedmont reservoirs and have occurred periodically in Harris Lake since 1989.

- When the mean chlorophyll *a* concentration at Station H2 was elevated in January, the total algal density was in the lower end (9969 units/ml) of the range of conditions defined as an algal bloom (i.e., total density ≥ 10,000 units/ml). The diatom *Melosira distans* and the flagellated cryptophyte *Chroomonas minuta* constituted approximately 45% of the total algal density. *Chroomonas minuta* was the taxon in greatest abundance (26% of the total density) during the bloom in August at Station E2. However, the total algal density for this month (5110 units/ml) was only in the moderate range (5-10,000 units/ml).

Nutrients

- There were no clear spatial differences in mean total phosphorus concentrations during 1992 (Appendix 13). Mean concentrations remained approximately 1.5-1.8 times greater at Station E2 than at either Station H2 or P2 during the 1987-1992 period (Appendix 14). The annual mean concentration for 1992 was not significantly different from the mean for 1991 and was significantly less than the mean for 1990 (Appendix 15). The annual mean concentrations in Harris Lake seemed to have stabilized at a level greater than the concentrations observed prior to the operation of the plant.

- During 1992 mean total nitrogen concentrations in the surface waters at Station E2 were greater than the concentrations at all other stations (Appendix 13). This pattern, however, was not evident from the long-term analyses during the period 1987-1992 (Appendix 14).

The annual mean concentration for 1992 was significantly less than the concentrations in 1990 and 1991 and returned to the lower levels that were observed during 1987-1989 (Appendix 15).

Ions

- Annual mean calcium concentrations in 1992 were significantly greater than the mean concentrations measured since 1989 but were within the range (3.3-3.8 mg/liter) of means for the 1987-1989 period (Appendix 15).

- Annual mean concentrations of magnesium, sodium, chloride, and sulfate in 1992 were significantly greater than mean concentrations of these ions measured for the 1987-1991 period and continued a general increasing trend each year (Appendix 15). This trend may be reflective of the increased retention time of the water in the reservoir and the infrequent discharge over the spillway during the 1990-1992 period (Appendix 7).

- There were no clear spatial trends in the sodium concentrations during 1992 (Appendix 13). However, concentrations were significantly greater at Station E2 compared to the concentrations at either Station H2 or P2 during the period 1987-1992 (Appendix 14).

Trace Metals and Metalloids

- Excluding mercury and copper, all metal and metalloid concentrations measured in 1992 were less than the respective North Carolina water quality standard or action level (Appendices 12 and 17).

- All mercury concentrations, except the sample collected from the bottom waters at Station E2 during November (0.11 µg/liter) and from the surface waters at Station E2 during March (0.05 µg/liter), were below the laboratory detection level of 0.05 µg/liter (Appendices 12 and 17). The North Carolina water quality standard for mercury is 0.012 µg/liter.

- All copper concentrations during 1992 were less than the North Carolina action level (7 µg/liter), except during January when the concentration in bottom waters at Station E2 was 7.5 µg/liter (Appendices 12 and 17). The 1992 annual mean concentration was similar to the values calculated for 1989 and 1991 and was less than the annual mean concentrations observed for the years 1987-1988 and 1990 (Appendix 15). There were no significant spatial differences during the period 1987-1992 (Appendix 14).

- The annual mean aluminum concentration measured at Station S2 during 1992 was significantly greater than at all other stations (Appendix 17). Elevated values during January (610 μg/liter) and March (1200 μg/liter) contributed to the elevated mean for this station (Appendix 12). There were no significant spatial differences in the concentrations in the surface waters for the period 1987-1992 and there was not a clear temporal trend during this period (Appendices 14 and 15).

Chemical Constituents from the Bottom Waters at Station E2

- There were no significant differences in measured chemical concentrations between the surface and bottom waters at Station E2 during 1992 (Appendix 13). Significant differences were unlikely due to the expected variability in the concentrations in the bottom waters between periods of stratification and of uniform mixing in the water column. Concentrations of most chemical constituents (i.e., total alkalinity, hardness, the solids, total phosphorus, total nitrogen, ammonia, total organic carbon, total calcium, and total magnesium) increased during stratification to a maximum concentration by September because of the movement of chemicals across the sediment-water interface under the reducing anoxic conditions found in the bottom waters during that time (Appendix 12). Sulfate concentrations decreased during the stratification period because the sulfate was reduced to hydrogen sulfide.

- There were no significant differences among years (1987-1992) for solids (total, dissolved, and suspended solids), turbidity, nutrients (total nitrogen, nitrate + nitrite-N, ammonia-N, and total phosphorus), and total organic carbon in the bottom water at Station E2 (Appendix 18).

- There were significant increases in the concentrations of the major ions--such as magnesium, sodium, chloride, and sulfate--in the bottom waters of Harris Lake at Station E2 during the period 1987-1992 (Appendix 18). There was no clear trend for total alkalinity and hardness concentrations for the period 1987-1992.

- Aluminum and copper concentrations for 1992 in the bottom waters at Station E2 remained relatively unchanged for the period 1987-1992 (Appendix 18).

Benthic Invertebrates

Freshwater Mussels

- There was no die-off of freshwater mussels in 1992 as there was in June 1991 in Harris Lake.

Asiatic Clam Surveys

- No Asiatic clams *Corbicula fluminea* were collected in either of the two intake canals during April 1992; however, during October one specimen was collected near the intake structure at Station MI (Appendix 1). The estimated density at this location decreased from 43 clams/m^2 in 1991 to 14 clams/m^2 in 1992. No Asiatic clams were collected in the auxiliary reservoir intake canal, in the intake structures, or in the fire protection system during 1992.

- Asiatic clam shells were qualitatively observed at many locations along the shoreline which indicated that the species has continued to spread throughout the reservoir.

Zebra Mussel Surveys

- Zebra mussels *Dreissena polymorpha*, potentially serious biofouling organisms to power plant operations, were not found during special monitoring activities. Although the species has not yet been reported from North Carolina, it has the potential to colonize the state during the next few years.

Fisheries

(Appendices 19-35)

Fish Community Structure

- The species composition during 1992 (i.e., 17 species representing 7 families) was similar to that observed in previous years (Appendix 19), and, as in previous years, the fish community and sport fishery were dominated by bluegill, largemouth bass, redear sunfish, gizzard shad, and pumpkinseed (Appendices 20 and 21). Construction of beaver lodges at some stations provided increased cover which concentrated fish and made them more susceptible to electrofishing. There were, however, no significant spatial differences in the mean catch rate for any of these dominant species during 1992 (Appendix 20).

- Although no channel catfish were collected and the mean catch rate for black crappie was low during 1992 (Appendix 20), conversations with anglers indicated that these species were being caught in sufficient numbers to also be considered an important part of the sport fishery.

- The mean catch rate of total fish using electrofishing sampling has not changed significantly during the past ten years, except during 1989 when the catch rate was significantly greater at a rate of 309 fish/hour (Appendices 21 and 22). The mean catch rate of total fish during the period 1983-1992 was significantly greater at Area V than at all other areas (Appendix 22).

- The mean catch rates for bluegill have not changed significantly since 1988 (Appendices 21 and 22). During the past ten years, the mean catch rate at Area V was significantly greater than at all other areas (Appendix 22). The quality of the bluegill fishery was evaluated with a length-frequency index based on the concept of total lengths as a percentage of world record lengths (Gabelhouse 1984). The catch rates of stock- and quality-length fish have generally increased since 1985, while the catch rate of preferred-length fish has generally been constant at approximately 1-3 fish/hr since 1986 (Appendix 23).

- The mean catch rates for redear sunfish during 1990-1992 were significantly greater than the catch rates during all the other years (Appendices 21 and 22). There were no significant spatial differences in the mean catch rates for the period 1983-1992. The quality of the redear sunfish fishery was similarly evaluated with the length-frequency index based on world record lengths. The catch rates of stock- and quality-length fish have generally shown a steady increase since 1983 and the greatest rates were measured during 1992 (Appendix 24). The catch rate for preferred-length fish has fluctuated between 1-6 fish/hr since 1984, while the catch rate for memorable-length fish peaked in 1990 (Appendix 24).

- The mean catch rate for pumpkinseed during 1992 was significantly less than the catch rate in 1989 (Appendices 21 and 22). There were no significant spatial differences in the mean catch rates for the period 1983-1992.

- The mean catch rate of black crappie during 1992 was significantly lower than the catch rate in 1989 but not significantly different from any other year (Appendices 21 and 22). Black crappie were collected at significantly higher rates at Areas S and V than the other three areas during the same time period (Appendix 22). A study conducted by the North Carolina Wildlife Resources Commission (NCWRC) during 1992 concluded that the black crappie population in Harris Lake experienced "good" growth rates and size structure among the various age classes of fish (Mr. Wayne Jones, NCWRC, pers. comm.).

- As in 1991, greater numbers of intermediate- to large-size sport fishes were collected by electrofishing sampling during 1992 than in previous years based upon a comparison of the length-frequency distributions (Appendices 25-28). The length-frequency histograms for redear sunfish indicated adequate recruitment and size distributions during 1992 (Appendix 26). Recruitment for bluegill, pumpkinseed, and black crappie was as low or lower than observed in previous years as indicated by few fish < 60 mm (Appendices 26-28).

- The length-frequency histograms for gizzard shad and brown bullhead in 1992 indicated a greater proportion of larger fish was collected than what would have been expected (Appendices 29 and 30). This may have occurred because electrofishing sampling can be biased against the collection of small (i.e., < 65 mm) fish (Reynolds 1983). The small individuals of these two species are usually found in dense vegetation (brown bullhead) or in open deep water (gizzard shad)--areas not usually sampled efficiently with the boat electrofisher.

<u>Largemouth Bass Population Structure</u>

- The mean catch rate of largemouth bass during 1992 was not significantly different from catch rates during 1985-1988 and 1991 but was significantly less than the catch rates during the years 1983-1984 and 1989 (Appendices 21 and 22). The mean catch rate at Area S was significantly less than the catch rates at all other areas during the period 1983-1992

(Appendix 22). A study conducted by the NCWRC during 1992 concluded that the catch rate at Harris Lake (3.9 fish/100 m of shoreline) was slightly greater than the catch rates for Falls of the Neuse Reservoir and Lake Gaston (2.4 and 1.5 fish/100 m of shoreline, respectively) (Mr. Wayne Jones, NCWRC, pers. comm.).

- The length-frequency histogram indicated adequate recruitment and size distribution during 1992 (Appendix 31).

- The quality of the largemouth bass fishery was evaluated with the length-frequency index based on world record lengths as previously applied to the bluegill and redear sunfish fishery. The catch rate of stock-length fish has generally decreased since 1984 to a level of approximately 5-8 fish/hr (Appendix 32). Quality-length fish peaked in 1988 at a rate of 9 fish/hr and have gradually increased during the past two years as have preferred-length fish. Prior to 1991, no memorable-length fish had been collected in Harris Lake during the May and November electrofishing sampling. In 1992 the memorable-length fish catch rate was approximately 1 fish/hr.

- The quality of the largemouth bass fishery was further assessed with two correlated indicies--Proportional stock Density (PSD) and Relative Stock Density (RSD). The PSD is a measure of the proportion of quality-size fish (fish ≥ 300 mm) in the population (all fish collected ≥ 200 mm), and the RSD is the proportion of fish of any designated size group in a population (Anderson and Gutreuter 1983). For example, an RSD-380 (i.e., preferred-length) is the proportion of the population that was ≥ 380 mm.

- The PSD of largemouth bass in 1992 continued to be in the optimal range (Appendix 33), indicating that the population contained many quality-length fish and was balanced for a moderate density objective (Gabelhouse 1984). A moderate density objective is defined as where largemouth bass are one of several species of equal importance in a balanced community (Gabelhouse 1984). This was opposite the situation which occurred during the period 1983-1987, when the PSD was below the optimal level indicating that the population contained few quality-size fish.

- The RSD-380 of largemouth bass also showed continued improvement during 1992 (Appendix 33). The RSD-380 since 1989 has also remained in the optimal range for a moderate density objective (Gabelhouse 1984). This proportion of the total population was the greatest since impoundment, further supporting the observations that the largemouth bass sport fishery has continued to improve.

- During March 1992, 126 anglers participated in a largemouth bass tournament held at Harris Lake. The tournament rules allowed each team to "weigh-in" ten fish. Two of the fish were allowed to be between 12 and 14 inches (305-356 mm) and the eight other fish were required to be ≥ 14 inches. Two hundred sixteen fish were "weighed-in" during the tournament. This resulted in the greatest tournament weigh-in catch rate, 0.20 fish/angler-hour, since 1987 (Appendix 34). [Note: "tournament weigh-in catch rate" is not synonymous with the term "catch rate" used elsewhere in this report. This term is used by CP&L fishery biologists to conveniently measure the relative success of largemouth bass tournaments.]

- The length-frequency distribution of "weighed-in" fish during the tournament indicated that a greater number of fish ≥ 356 mm were caught in 1992 as compared with the distributions in either 1987 or 1990 (Appendix 35). The 1992 length-frequency distribution was similar to that from the 1991 tournament.

Aquatic Vegetation

(Appendix 36)

- During 1992, hydrilla *Hydrilla verticillata* continued to be the dominant species of aquatic vegetation in Harris Lake. This nonnative, submersed plant grew in homogeneous stands throughout the littoral zone (< 3 m deep) of the reservoir except for the Buckhorn Creek arm (Appendix 36). A previously observed small patch in that arm was not present in 1992. Also, the amount of hydrilla in a cove near the dam greatly decreased in surface area from that of 1991. The areal coverage of hydrilla in Harris Lake in 1992 was approximately 430 ha, an increase of only 5 ha since 1991. This species had no impact to the Harris Plant's operation.

- Only one species of submersed vegetation, naiad *Najas minor*, was observed growing in the auxiliary reservoir. This occurred in the shallow areas of the headwaters near U.S. Highway 1. One small patch of water shield *Brasenia schreberi* occurred near the auxiliary reservoir dam.

- Emergent vegetation grew along the shoreline of both the main and the auxiliary reservoirs. The dominant species were cat-tail *Typha latifolia*, rush *Juncus effusus*, bulrush *Scirpus cyperinus*, and the emergent form of creeping water primrose *Ludwigia uruguayensis* (which did not occur at the auxiliary reservoir). The littoral zone of the Buckhorn Creek arm supported three submersed native species; spike-rush *Eleocharis baldwinii*, naiad, and musk-grass *Chara* sp. Coverage varied from sparse to dense and most vegetation occurred in protected coves.

- Floating-leaf vegetation throughout Harris Lake was dominated by creeping water primrose and lotus *Nelumbo lutea*. Creeping water primrose grew along the shoreline of all major arms of the lake, primarily in the coves. Lotus was restricted to several stands in the headwater area of the White Oak Creek arm. Water shield and water-lily *Nymphaea odorata* also grew in small to moderate areas throughout the reservoir's littoral zone.

Conclusions

The primary objective of the 1992 nonradiological environmental monitoring program was to continue to support the Environmental Protection Plan for the Harris Nuclear Power Plant. Secondary objectives were to provide an assessment of the effects of plant operations on the various components of the aquatic environment, to document any natural changes or changes induced by sources other than the power plant, and to assess the impact of any introduced nonnative species.

The environmental monitoring programs that were conducted prior to commercial operation of the Harris Plant determined that Harris Lake was in many ways a typical southeastern, moderately productive reservoir. However, after the Harris Plant began discharging cooling tower blowdown and other NPDES-permitted wastewater discharges into the reservoir, the reservoir became more biologically productive. Environmental characteristics of a typical southeastern, biologically productive reservoir include the presence of oxygen-deficient subsurface waters, elevated nutrient and algal concentrations, reduced water clarity, an abundance of rooted shallow-water aquatic plants, and a productive sport fishery--all characteristics of Harris Lake.

Water quality assessments determined that nutrients, as measured by total phosphorus and total nitrogen, did not increase during 1992 and seemed to have stabilized but at a level greater than the concentrations observed prior to the operation of the Harris Plant. Algal blooms, although not uncommon in piedmont reservoirs, now occur several times per year in Harris Lake. The blooms, however, have not been composed of the noxious blue-green algal types and have not resulted in any fish kills.

The major ions (i.e., calcium, magnesium, sodium, chloride, and sulfate) continued to increase in 1992 as compared with concentrations in previous years. Such increases may reflect the reservoir's prolonged retention time and the infrequent spillage of water from the reservoir. Seventy-eight percent of the 300 metal and metalloid concentrations analyzed in 1992 were less than the laboratory reporting limit.

Biofouling by the Asiatic clam and the aquatic plant hydrilla did not impact Harris Plant operations. Each of these species continued to slowly expand its distribution throughout much of the littoral zone of the reservoir. No clams were collected in the auxiliary intake canal, in the intake structures, or in the fire protection system. The zebra mussel, another potentially biofouling organism, was not found in the main or the auxiliary reservoirs.

The recreational and sport fishery, as in previous years, was dominated by largemouth bass and several species of sunfish. During the past several years, an increasing proportion of the largemouth bass fishery has been represented by quality- or better-length fish which have provided the recreational fishermen with a greater opportunity for fishing success.

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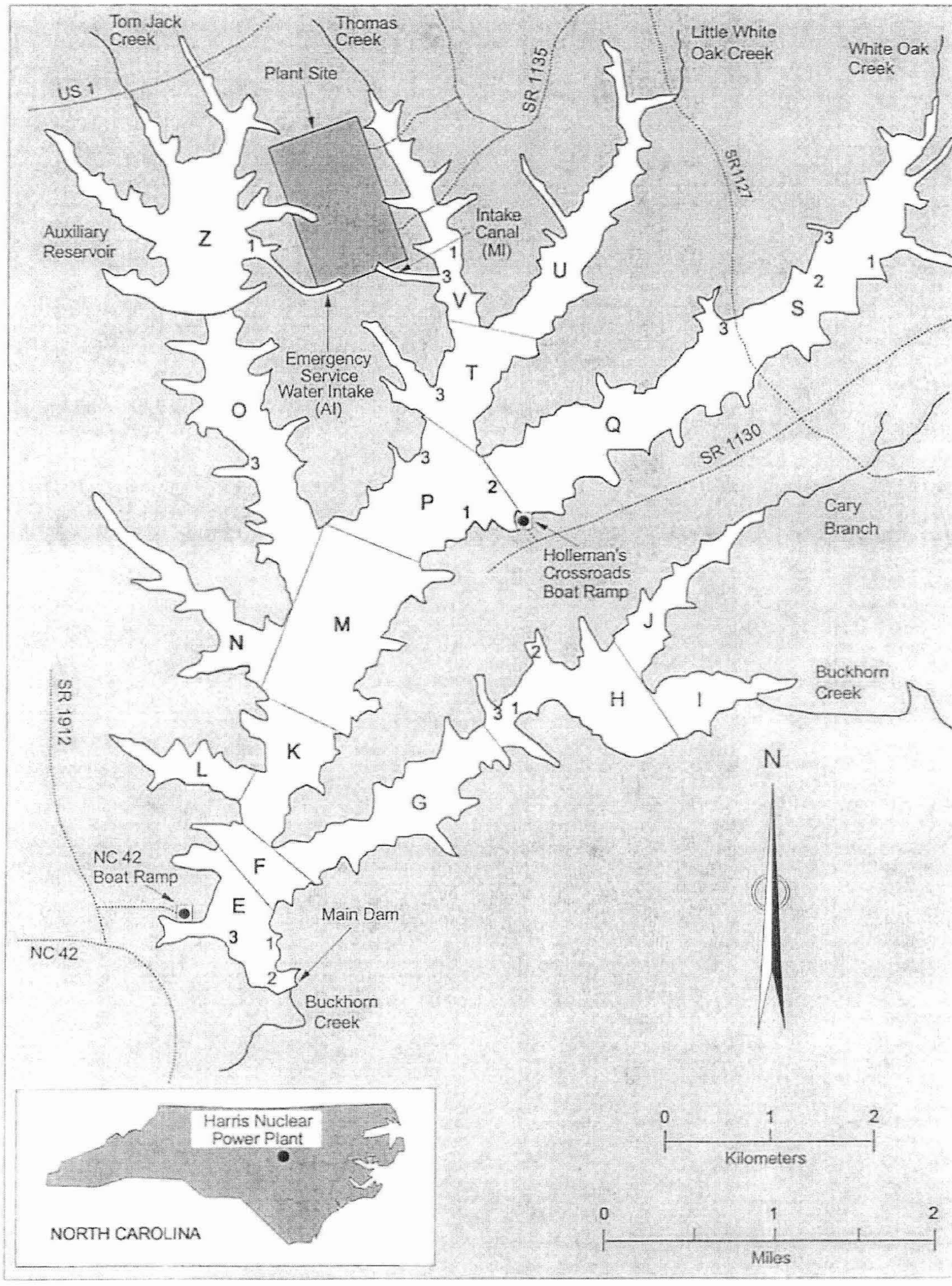


Appendix 1. Harris Lake sampling areas and stations during 1992.

Appendix 2. Harris Lake environmental monitoring program for 1992.

Program	Frequency	Location
Limnology		
Water quality (temperature, dissolved oxygen, pH, specific conductance, and Secchi disk transparency)	Once per calendar month	E2, H2, P2, and S2 (surface to bottom at 1-m intervals)
Water chemistry		
Monitoring	Alternate months (Jan, Mar, May, Jul, Sep, Nov)	E2 (surface and bottom); H2, P2, and S2 (surface)
Nutrients (turbidity, solids, total phosphorus, ammonia-nitrogen, nitrate + nitrite-nitrogen, and total nitrogen)	Once per calendar month	E2 (surface and bottom); H2, P2, and S2 (surface)
Plankton (phytoplankton[+] and chlorophyll *a*)	Once per calendar month	E2, H2, P2, and S2 (surface, Secchi disk transparency depth, and twice the Secchi disk transparency depth)
Benthic invertebrates		
Asiatic clam surveys	Twice per calendar year (April, October)	Emergency service water and cooling tower makeup system intake structures and Stations V3, Z1, MI, and AI
Zebra mussel surveys	Once per calendar month	Intake structure, water quality station buoys, or Holleman's boat ramp
Fisheries		
Fish community structure	Twice per calendar year (May, Nov)	E1, E3, H1, H3, P1, P3, S1, S3, V1, V3
Largemouth bass tournaments	March	Harris Lake boat ramps
Aquatic vegetation		
Survey	October	I, E, P, Q, S, V, Z

[+]Phytoplankton samples were collected and preserved but identified and enumerated only when the chlorophyll *a* concentrations at a station were > 40 μg/liter to assess bloom conditions.

Appendix 3. Harris Lake environmental monitoring program changes from 1991 to 1992.

Program	Change
Limnology	
Water quality, water chemistry (nutrients), and plankton	Increased sampling frequency from alternate months to monthly to model nutrient and chlorophyll *a* relationships and the eutrophication of Harris Lake.
Benthic invertebrates	
Asiatic clam surveys	Discontinued littoral zone survey because reservoir monitoring was not a Nuclear Regulatory Commission requirement (Generic Letter 89-13).
Zebra mussel surveys	Added to monitoring program as a Special Study to document possible introduction of the species into the reservoir.
Fisheries	
Fish community structure	Reduced sampling frequency from quarterly to biannually (spring and fall) to adequately monitor the general status of the fishery.
Aquatic vegetation	
Survey	Discontinued summer survey because hydrilla was well established and one fall survey was sufficient for documenting its distribution.

Appendix 4. **Field sampling and laboratory methods followed in the 1992 Harris Lake environmental monitoring program.**

Program	Method
Limnology	
Water quality	Temperature, dissolved oxygen, pH, and conductivity were measured with a calibrated Martek Mark XV® instrument and YSI® dissolved oxygen meter. Measurements were taken from surface to bottom at 1-m intervals. Water clarity was measured with a Secchi disk.
Water chemistry	Surface and bottom samples were collected with a nonmetallic Van Dorn sampler, transferred to appropriate containers, transported to the laboratory on ice, and analyzed according to USEPA (1979) and APHA (1986).
Plankton	
Phytoplankton	Equal amounts of water from the surface, the Secchi depth, and twice the Secchi depth were obtained with a Van Dorn sampler and mixed in a plastic container. A 250-ml subsample was taken and preserved with 5 ml of "M3" fixative. Subsamples were identified and enumerated in the laboratory.
Chlorophyll *a*	Three 1000-ml samples were collected from the surface, the Secchi depth, and twice the Secchi depth with a Van Dorn sampler, placed in dark bottles, and transported to the laboratory on ice. At the laboratory, two 250-ml subsamples were analyzed according to Strickland and Parsons (1972) and APHA (1986).
Benthic invertebrates	
Asiatic clam surveys	At Stations V3, Z1, MI, and AI, three replicate samples were collected with a petite Ponar at the 2-m depth. In the emergency service water and cooling tower makeup intake structures, seven samples were collected with a petite Ponar. Samples were preserved with 5% formalin and returned to the laboratory where they were elutriated through 1000-, 500-, and 300-μ mesh sieves. Asiatic clams were counted, measured, and preserved.

Appendix 4 (continued)

Benthic invertebrates	
Zebra mussel surveys	An artificial substrate sampler, constructed of a PVC frame and fitted with removable PVC plates, was placed near the cooling tower makeup intake structure. This sampler, the dock at the Holleman's boat ramp, or the water quality station marker buoys were visually inspected for the presence of mussels during routine water quality or Asiatic clam survey monitoring.
Fisheries	
Fish community structure	Fifteen-minute samples were collected at each station using a Smith-Root equipped Wisconsin-design electrofishing boat with pulsed DC current. Fish were weighed, measured, and released.
Largemouth bass tournaments	After largemouth bass tournament officials had recorded their necessary measurements, fish were weighed, measured, tagged, and released.
Aquatic vegetation	Portions of the shoreline and/or littoral zone of the lake and auxiliary reservoir were systematically surveyed by boat for the presence of aquatic vegetation. The location and extent of observed species were recorded on maps and in field notes. Estimation of areal coverage of hydrilla was made by measuring the maximum depth of its growth at 49 transects throughout the lake and applying these data to topographic maps.

Appendix 5. Statistical analyses performed on data collected in the 1992 and 1983-1992 Harris Lake environmental monitoring programs.

Variable	Statistical test/model[+]	Main effect(s)	Interaction term
For 1992 data only			
Secchi disk transparency depth, specific conductance, selected chemical variables, and chlorophyll *a*[¶]	One-way ANOVA block on month	Station	
	Paired t-test at Station E2	Surface *vs.* bottom	
Catch rate of individual fish species[§]	One-way ANOVA	Area	
For 1983-1992 data			
Secchi disk transparency depth, specific conductance, selected chemical variables, and chlorophyll *a*[¶]	Multi-factor ANOVA, block on month	Station, year	Station-by-year
Catch rate of individual fish species[§]	One-way ANOVA	Area	
	One-way ANOVA	Year	

[+]A Type I error rate of 5% ($\alpha = 0.05$) was used to judge the significance of all tests. Fisher's protected least significant difference test was applied to determine where difference in means occurred if the overall F test from the analysis of variance (ANOVA) indicated that the main effect was significant.

[¶]Chlorophyll *a* ANOVA models were structured using the mean station-by-month concentration based on three paired replicate samples.

[§]Fisheries data were transformed using the $\log_e$ (number of fish/hour + 1) transformation. Because of the change in the sampling regime between 1992 and previous years (i.e., from quarterly to biannual [May and November] sampling), the ANOVA models were fitted with only the biannual data across all years.

Appendix 6. Mean percent recovery and sample size of water chemistry standards for the CP&L Chemistry Laboratory during 1992.

Variable	Standard[+]	Known value	Units	n	Mean	Standard deviation	Recovery (%)	RSD[1] (%)
Chloride	LQC	1.0	mg/L	15	0.9830	0.0146	98.3	1.49
	HQC	2.0	mg/L	15	1.9170	0.0295	95.9	1.54
	Low Spike	1.0	mg/L	3	0.9440	0.0510	94.4	5.35
	High Spike	2.0	mg/L	4	2.0300	0.0460	101.0	2.27
T. Phosphorus	LQC	0.005	mg/L	14	0.0058	0.0007	116.0	12.07
	HQC	0.05	mg/L	14	0.0498	0.0009	99.6	1.81
	Low Spike	0.00498	mg/L	5	0.00516	16.3000	103.2	4.7
	High Spike	0.0498	mg/L	6	0.0515	4.8600	103	4.7
T. Nitrogen	LQC	0.1	mg/L	10	0.0983	0.0048	98.3	4.88
	HQC	0.2	mg/L	10	0.2018	0.0055	100.9	2.73
	Spike	0.2	mg/L	6	0.2062	0.0149	103.1	7.23
Sulfate	LQC	2.0	mg/L	15	2.0250	0.0290	101.3	1.43
	HQC	5.0	mg/L	15	4.8840	0.0814	97.7	1.67
	Low Spike	2.0	mg/L	3	1.8100	0.0330	90.4	1.84
	High Spike	5.0	mg/L	5	4.8800	97.5000	0.1	2.26
TOC (1)[§]	LQC	4.1	mg/L	6	3.9600	0.1960	96.6	4.95
TOC (2)[§]	LQC	5.1	mg/L	7	4.7600	0.0620	93.3	1.30
TOC (3)[§]	LQC	6.8	mg/L	1	6.6500	0.0000	97.8	0.00
Aluminum	LQC	50.0	µg/L	2	52.1500	1.4849	104.3	2.85
	HQC	100.0	µg/L	9	104.7000	10.4898	104.7	10.02
	Spike	100.0	µg/L	5	92.3000	13.9000	92.3	15.10
Arsenic	LQC	5	µg/L	25	5.2000	0.1000	104.0	1.92
	Spike	500	µg/L	23	457.000	68.3000	91.4	14.95
Cadmium	LQC	0.2	µg/L	40	0.2133	0.0347	106.7	16.27
	HQC	0.5	µg/L	40	0.5038	0.0294	100.8	5.84
	Spike	0.5	µg/L	8	0.5100	0.0480	102.5	9.42
Calcium	LQC	1.0	mg/L	8	0.9659	0.0513	96.6	5.31
	MQC	5.0	mg/L	8	4.8075	0.203	96.15	4.22
	HQC	10.0	mg/L	8	9.8513	0.3013	98.5	3.06
	Spike	5.0	mg/L	10	4.5320	0.2954	90.6	6.52
Chromium	LQC	5.0	µg/L	31	5.6200	0.6120	112.4	10.89
	HQC	10.0	µg/L	31	10.0100	0.9280	100.1	9.27
	Spike	10.0	µg/L	5	10.3700	0.1901	103.7	1.83
Copper	LQC	5.0	µg/L	7	5.0600	0.2517	101.2	4.97
	HQC	10.0	µg/L	7	9.9600	0.4531	99.6	4.55
	Spike	5.0	µg/L	11	5.3791	0.3640	107.6	6.77
Lead	LQC	2.0	µg/L	40	2.1400	0.2810	107.0	13.13
	HQC	5.0	µg/L	40	5.1900	0.4270	103.8	8.23
	Spike	5.0	µg/L	8	4.6800	0.3210	93.6	6.85

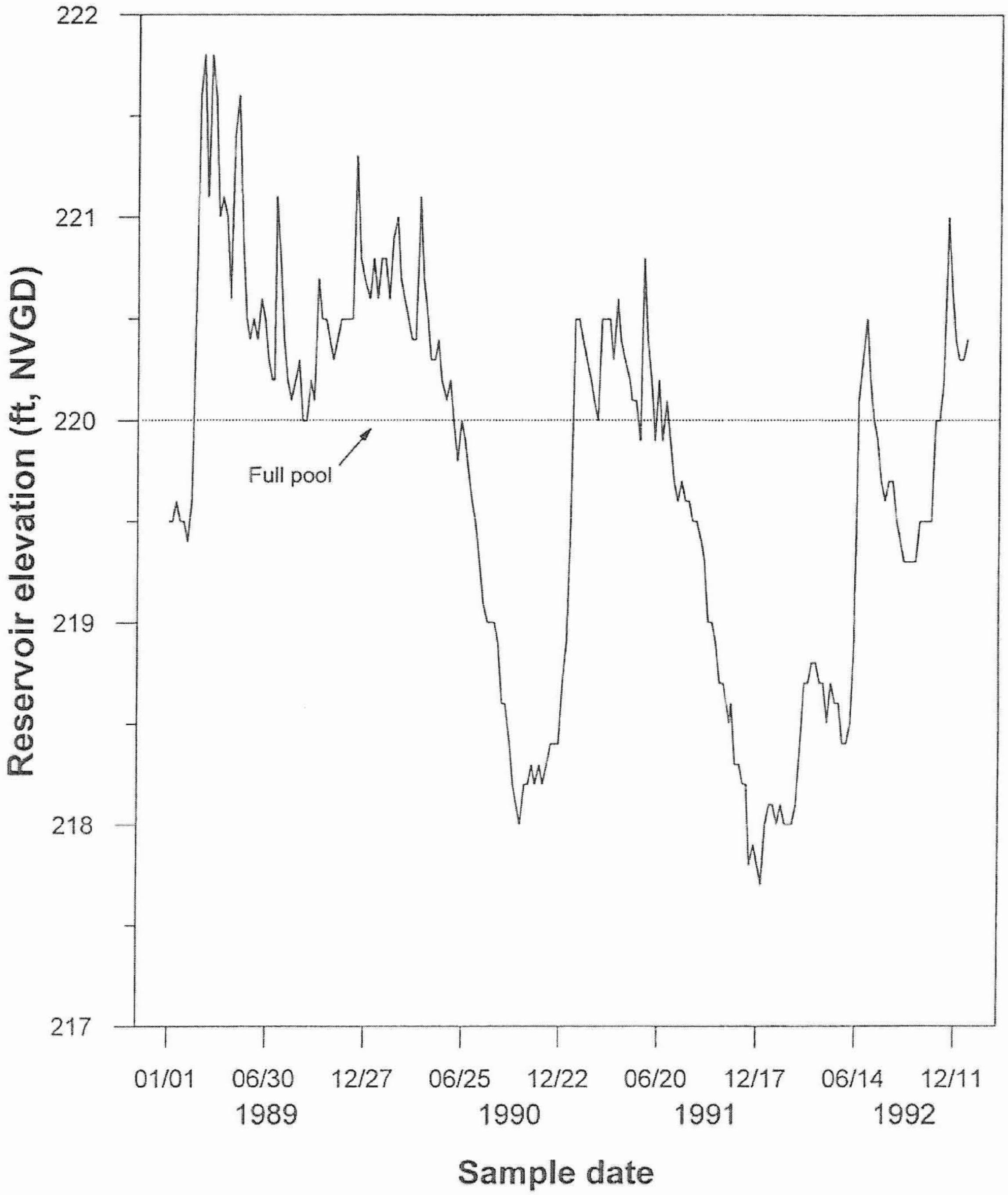
Appendix 6 (continued)

Variable	Standard+	Known value	Units	n	Mean	Standard deviation	Recovery (%)	RSD (%)
Magnesium	LQC	1.0	mg/L	8	0.9956	0.0242	99.6	2.43
	MQC	5.0	mg/L	8	5.0213	0.1761	100.4	3.51
	HQC	10.0	mg/L	7	10.1329	0.2654	101.3	2.62
	Spike	5.0	mg/L	10	4.9000	0.1441	98.0	2.94
Mercury	LQC	0.10	µg/L	22	0.0850	0.0330	85.0	38.82
	HQC	0.30	µg/L	23	0.2740	0.0406	91.3	14.82
Nickel	LQC	10.0	µg/L	31	10.4300	0.9190	104.3	8.81
	HQC	20.0	µg/L	30	19.8500	1.3120	99.3	6.61
	Spike	20.0	µg/L	5	20.8000	0.8820	104.2	4.24
Selenium	LQC	5	µg/L	33	5.1000	0.1000	102.0	1.96
	Spike	500	µg/L	70	493.0000	86.2000	98.6	17.50
Sodium	LQC	1.0	mg/L	11	1.0075	0.0348	100.8	3.45
	HQC	2.0	mg/L	11	2.0375	0.0628	101.9	3.08
	Spike	2	mg/L	10	1.9800	0.0610	99.0	3.06
Zinc	LQC	50	µg/L	8	50.3000	4.3000	100.6	8.55
	MQC	100	µg/L	8	98.6000	8.7000	98.6	8.82
	HQC	500	µg/L	8	502.6000	10.6000	100.5	2.11
	Spike	50	µg/L	10	52.2000	3.7000	104.4	7.09

+LQC = low-range quality control standard, MQC = mid-range quality control standard, HQC = high-range quality control standard, Spike = sample matrix spike.

¶RSD = Relative standard deviation = standard deviation ÷ mean x 100.

§There were three different concentrations used for the known values of total organic carbon in the laboratory analyses.



Appendix 7. Water surface elevations at Harris Lake, 1989-1992. NVGD = National Geodetic Vertical Datum (formerly called mean sea level by the U.S. Geological Survey).