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Tennessee Valley Authority

Water Management

AQUATIC ECOLOGICAL HEALTH DETERMINATIONS FOR TVA RESERVOIRS--1995

An Informal Summary of 1995 Vital Signs Monitoring Results
and Ecological Health Determination Methods

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Section 1. Reservoir Monitoring -- Overview of Approach, Methods, and 1995 Results

Introduction

The Tennessee Valley Authority (TVA) began a program to systematically monitor the ecological condition of its reservoirs in 1990 to complement a Stream Monitoring Program begun in 1986. Previously, reservoir studies had been confined to reservoir specific assessments to meet specific needs as they arose. These two monitoring programs were combined with TVA's fish tissue and bacteriological studies to form an integrated program (Vital Signs Monitoring) that is part of TVA's comprehensive Clean Water Initiative.

Objectives of TVA's monitoring efforts are to provide information on the "health" or integrity of the aquatic ecosystem in major Tennessee River tributaries and reservoirs and to provide screening level information for describing how well these water resources meet the "fishable" and "swimmable" goals of the Clean Water Act. Ecological monitoring activities provide the necessary information from key physical, chemical, and biological indicators to evaluate conditions in streams and reservoirs and to target detailed assessment studies if significant problems are found. In addition, this information establishes a baseline for comparing future water quality conditions. Periodic monitoring of toxic contaminants in fish and bacteriological sampling at recreation areas provides information for evaluating whether Tennessee Valley waters are fishable and swimmable.

This document focuses on how TVA performs the overall ecological health rating for reservoirs. It summarizes 1995 data as an example of the mechanics and index values resulting from the rating system.

Each year, the evaulation system is reviewed and improvements are made as opportunities are recognized. These are described in appropriate sections of this document. Two major changes in the monitoring program also were made in 1995. One was a change in monitoring frequency from annual to every other year for those reservoirs which had been monitored for five consecutive years thereby providing a sound baseline evaluation. The other was to discontinue the toxicity testing component of sediment quality evaluation in response to budget restrictions.

Study Design Considerations

Study design was based on several fundamental premises or assumptions. These included:

1. Ecological health evaluations must be based on information on physical, chemical, and biological components of the ecosystem;

2. Monitoring program design must be considered dynamic and flexible, rather than rigid and static, and must allow adoption of new environmental monitoring techniques as they develop to meet specific needs;
3. Monitoring methods must provide current, useful information to resource managers;
4. Monitoring must be sustained for several years to document the status of the river/reservoir system, determine its year-to-year variability, and track results of water quality improvement efforts; and
5. Addressing specific cause/effect mechanisms is not the primary purpose of monitoring. While monitoring may provide information to identify cause/effect relationships, more detailed assessment investigations usually are required.

With these premises in mind, TVA's challenge has been to develop a sustainable monitoring effort that collects the right kinds of physical, chemical, and biological data to provide enough information to reliably characterize ecological health. Study design must carefully consider selection of important **ecological indicators, representative sampling locations, and frequency of sampling**, all in light of available resources. Following are some the basic study design decisions TVA made in developing this program. Vital signs monitoring activities focus on (1)physical/chemical characteristics of water; (2) physical/chemical characteristics of sediment; (3)benthic macroinvertebrate community sampling; and (4) fish assemblage sampling.

Ecological Indicators-- Physical, chemical, and biological indicators were selected to provide information from various habitats or ecological compartments on the health of that particular habitat or compartment. For example, in reservoirs the open water or pelagic area was represented by physical and chemical characteristics of water (including chlorophyll) in midchannel. The shoreline or littoral area was evaluated by sampling the fish community. The bottom or benthic compartment was evaluated using two indicators: quality of surface sediments in midchannel (determined by chemical analysis of sediments) and examination of benthic macroinvertebrates from a transect across the full width of the sample area (including overbanks if present).

Sampling Locations--Three areas were selected for monitoring: <u>the inflow area</u>, generally riverine in nature; the <u>transition zone</u> or <u>mid-reservoir area</u> where water velocity decreases due to increased cross-sectional area, suspended materials begin to settle, and algal productivity increases due to increased water clarity; and <u>the forebay</u>, the lacustrine area near the dam. Overbanks, basically the floodplain which was inundated when the dam was built, were included in transition zone and forebay areas. Embayments, another important type of reservoir area, also were considered. Previous studies (Meinert, Butkus, and McDonough, 1992) have shown that ecosystem interactions within an embayment are mostly controlled by activities and characteristics within the embayment watershed, usually with little influence from the main body of the reservoir. Although these are important areas, monitoring the ecological health of hundreds of embayments is beyond the scope of this program. As a result, only four, large embayments (all with drainage areas greater than 500 square miles and surface areas greater than 4500 acres) were included in the Vital Signs Monitoring Program.

Sampling Frequency--Sampling frequencies (indexing periods) must consider the expected temporal variation for each indicator. Physical and chemical components vary significantly in the short term so they are monitored monthly from spring to fall. Biological indicators better integrate long-term variations and are sampled once each year. Fish assemblage sampling is conducted in autumn (September-November). From 1990 through 1994 benthic macroinvertebrate sampling was conducted in early spring (February-April) to avoid aquatic insect emergence. Beginning in 1995, sampling was conducted in late autumn/early winter (November and December). The problem with spring benthos sampling is that results were reflective of conditions from the previous year. This caused evaluations for this indicator to be out of synch with those from the other indicators. This change is more thoroughly discussed in Section 5 "Benthic Macroinvertebrate Community."

Data Evaluation Considerations

Selection of data evaluation techniques is also of primary importance in study design considerations. Like most evaluations, results for ecological integrity studies must be compared to some reference or yard stick to determine if monitoring results are indicative of good, fair, or poor conditions. In streams this is usually accomplished by studying a site that has had little or preferably no alterations due to human activities. Observations at that site provide the **reference conditions** or expectations of what represents a site with good/excellent ecological health. Given that reservoirs are not natural systems, this approach is not possible. Developing reference conditions for reservoirs represents a more difficult task requiring special attention. Tied closely to development of reference conditions is the issue of **classification**--grouping only those waterbodies which are expected to have similar characteristics and thus correctly allow an "apples to apples" comparison. In streams, important considerations include comparable stream size, gradient, ecoregion, etc. Similar considerations apply to reservoirs but the list is longer because reservoirs are managed systems and those objectives must considered.

Reference Conditions--In absence of using reference sites to determine characteristics or expectations representative of good-fair-poor conditions, other approaches must be used. These include historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. Preimpoundment conditions are inappropriate because of significant habitat alterations. For the most part, models are of limited value for many indicators because of spatial and temporal variations within and among reservoirs. Spatial variation exists within in the multiple zones (e.g., forebay, transition zone, inflow, and embayments) of a reservoir. Further, each zone responds differently to different stimuli. Temporal variations are introduced because reservoirs are controlled systems with planned annual drawdowns in elevations ranging from only a few feet to close to a hundred feet. This leaves best observed conditions or professional judgment as the most viable alternatives for establishing appropriate reference conditions or expectations for reservoirs. Initially, TVA's approach was to use best observed conditions to define good, fair, and poor ranges for each ecological indicator's metrics. This is still the basic approach used but experience has shown the best results can be obtained by adjusting scoring for selected metrics using professional judgment. Two requites for this approach are an extensive database to determine reference conditions for each metric and substantial experience with both the environmental indicators and the types of reservoirs under consideration. Details of this approach to developing reference conditions are provided latter in this document.

Reservoir Classification -- Another important consideration in developing reference conditions is that care must be taken to compare only those reservoirs for which comparison is appropriate. That is, only reservoirs for which similar communities would be expected should be compared--those in the same ecoregion with comparable physical characteristics. Hence, separation of reservoirs into appropriate classes is a critical step. This was accomplished by examining the following fundamental question separately for each indicator--Should reservoir ecological health evaluations be based on:

(1) ideal conditions (for example, a very low DO concentration is an unacceptable ecological condition); or

(2) the best conditions expected for a reservoir given the environmental and operational characteristics of the dam/reservoir (for example, very low DO concentrations are acceptable in many tributary reservoirs because of water management practices, withdrawal schemes, stratification, etc.)?

The answer to this question was the same for some indicators but differed for others. For DO and Sediment Quality, ideal conditions should be expected. That is, poor DO is unacceptable regardless of type of reservoir or dam operation. Sediments should not have high concentrations of metals, should have no or at most very low concentrations of pesticides, and should not pose a toxic threat to biota. In this situation, there is no need for classification because the same conditions are desired for all reservoirs.

For chlorophyll, benthos, and fish the "best expected conditions" approach was used. As such, reservoirs must be grouped or stratified because the same conditions do not exist for all reservoirs. The classification scheme that has evolved for chlorophyll is actually a combination of the two approaches--examination of the "natural" nutrient level in the watershed and then a conceptual/subjective decision made as to the concentrations indicative of good, fair, and poor conditions. Two classes of reservoirs were developed -- reservoirs in watersheds draining nutrient poor soils, primarily those in the Blue Ridge Ecoregion (i.e., expected oligotrophic reservoirs); and reservoirs in watersheds draining soils which are not nutrient poor (i.e., expected mesotrophic reservoirs).

For the benthic macroinvertebrate and fish communities, reservoirs were divided into four classes. The reservoirs on the Tennessee River plus two navigable reservoirs on tributaries to the Tennessee River. This group of reservoirs has relatively short retention times and little winter drawdown. The remaining tributary reservoirs were separated by ecoregion into three classes: those in the Blue Ridge Ecoregion, those in the Ridge and Valley Ecoregion, and those on the Interior Plateau Ecoregion.

Reservoir classification issues are further discussed in subsequent sections as they apply to specific environmental indicators.

Ecological Health Rating Methods

There are no official or universally accepted guidelines or criteria upon which to base an evaluation of the health or integrity of the aquatic ecosystem within reservoirs. Consequently, an evaluation methodology had to be developed to assess overall ecological health or condition of reservoirs included in TVA's Vital Signs program. The ecological health evaluation system combines both biological and physical/chemical information to examine reservoir health. Five aquatic ecosystem indicators are used: **dissolved oxygen**, **chlorophyll-a**, **sediment quality**, **benthic macroinvertebrates**, and **fish community**.

Detailed descriptions of scoring criteria for each environmental indicator are provided in other sections. A brief overview is provided here to assist in understanding how individual ratings contribute to the overall ecological health score for a reservoir.

Dissolved oxygen scoring criteria attempt a multidimensional approach that includes considering dissolved oxygen levels both in the water column and near the bottom of the reservoir. The DO scoring criteria necessarily are complicated because of the combined effects of flow regulation and the potential for oxygen depletion in the hypolimnion. See Section 2 for details.

Chlorophyll scoring criteria were developed separately for each of the two classes of reservoirs based on geologic and soil characteristics and professional experience with reservoirs in the TVA region. Reservoirs expected to be oligotrophic received highest ratings at low chlorophyll concentrations. Reservoirs expected to be mesotrophic received highest ratings for an intermediate range of concentrations. Experience has shown that below a threshold level of chlorophyll (about 2-3 ug/l), primary production may be insufficient to support an active, biologically healthy food chain. In addition, chlorophyll concentrations above a higher threshold (about 10 ug/l) can result in undesirable eutrophic conditions. Minimum and maximum chlorophyll concentrations were selected based on this experience and professional judgment. Sec Section 3 for details.

Prior to 1995, the **sediment quality** scoring criteria used a combination of two characteristics: sediment toxicity tests and sediment chemical analyses for ammonia, heavy metals, pesticides, and PCBs. In 1995, only sediment analyses for metals, pesticides, and PCBs were used. Sediment toxicity tests were discontinued primarily because of budget reductions, but also because frequent changes in toxicity testing methods made year-to-year comparisons difficult. See Section 4 for details.

For the **benthic macroinvertebrate** and **fish** communities, scoring criteria were developed from the existing data base on TVA reservoirs as described above and in Sections 5 and 6. Seven metrics or characteristics were used to evaluate the benthic macroinvertebrate community (see Section 5) and 12 were used for the fish assemblage (see Section 6).

The ecological health scoring process is designed such that four of the indicators (DO, chlorophyll-a, benthos, and fish) are given equal weights and assigned a rating ranging from 1 (poor) to 5 (excellent). The other indicator, sediment quality, is given only half the weight of the other indicators and assigned a rating ranging from 0.5 (poor) to 2.5 (excellent). (Note: Prior to 1995, sediment quality had been rated on the full 1 to 5 range, same as the other indicators. But, discontinuance of sediment toxicity testing, which had contributed half the sediment quality rating, resulted in the rating for this indicator being reduced by one half). Ratings for the five indicators are summed for each site. Thus, the maximum total rating for a sample site would be 22.5 (all indicators excellent) and the minimum 4.5 (all indicators poor).

To arrive at an overall health evaluation for a reservoir, the sum of the ratings from all sites are totaled, divided by the maximum potential ratings for that reservoir, and expressed as a percentage. It is necessary to use a percentage basis because the number of sites monitored varies according to reservoir size and configuration. Only one site, the forebay, is sampled in small tributary reservoirs, and up to four sites (forebay, transition zone, inflow, and embayment) are sampled in selected run-of-the-river reservoirs. Also, the number of indicators varies from three at run-of-river inflow sites to five at the other types of sites. Chlorophyll and sediment quality are excluded at the inflows on run-of-the-river reservoirs because in situ plankton production of chlorophyll does not occur significantly in that part of a reservoir and because sediments do not accumulate there. As a result, the number of scoring possibilities may be as few as 5 indicator ratings for a small reservoir sampled only at the forebay. Or, as many as 18 indicator ratings for a large reservoir sampled at the forebay, transition zone, inflow, and embayment. The total score for the small reservoir would be 22.5 if all indicators rated excellent, whereas, the total score for the large reservoir would be 82.5 if all indicators rated excellent. Hence, using a percentage basis allows easier comparison among reservoirs. Specific information for each reservoir (number of locations and indicators monitored) is in Table 1.

This approach provides a potential range of scores from 20 to 100 percent and applies to all reservoirs regardless of the number of indicators or sample sites. To complete the ecological health scoring process, the 20-100 percent scoring range must be divided into categories representing good, fair, and poor ecological health conditions. This has been achieved as follows:

1. Results for each year are plotted, examined for apparent groupings, and compared to previous years.
2. Next, the groupings are compared to a trisection of the overall scoring range and to known, a priori conditions for each reservoir, focusing on reservoirs with known poor conditions.
3. Ranges representing good, fair, and poor conditions are then established. A final fine-tuning of scoring ranges is occasionally needed (adjusted either up or down a few percentage points) to ensure a reservoir with known conditions falls within the appropriate category. This is done only in circumstances where a nominal adjustment is necessary.

This ecological health scoring process has been in use for five years. Each year, slight modifications were made in the original evaluation process and the numerical rating criteria for each of the five ecological health indicators based on experience gained from working with this process, review of the evaluation scheme by other state and federal professionals, and results of another year of monitoring. As a result, scoring ranges changed slightly over the years as outlined below:

	Run-of-the-river reservoirs			Tributary, storage reservoirs		
	Poor	Fair	Good	Poor	Fair	Good
1991	<53	53-72	>72	<57	57-72	>72
1992	<53	53-72	>72	<57	57-72	>72
1993	<52	52-71	>71	<57	57-71	>71
1994	<52	52-72	>72	<57	57-72	>72
1995	<52	52-72	>72	<57	57-72	>72

The difference in the poor scoring range between the two types of reservoirs is due to the fact that two storage reservoirs with known poor conditions rated slightly higher than the boundary for the lower (poor) grouping on the run-of-the-river reservoirs. Hence, the high end of the lower scoring range for storage reservoirs was shifted upward from 52 to 56 percent to accommodate these reservoirs with known poor conditions.

An example that illustrates the overall reservoir health evaluation methodology is presented in Table 2. Fort Loudoun Reservoir, the example used, has five aquatic health indicators at two locations and two indicators at another location.

Ecological Health Ratings--1995 Results

Experience has shown rainfall and runoff have a significant impact on the ecological conditions in TVA reservoirs. Conditions in 1995 compared to the long-term average for the Tennessee Valley are shown in Figures 1 and 2, respectively. Figure 3 shows the relative contribution of each of the major tributary rivers to flow rates in Tennessee River reservoirs.

Physical and operational characteristics of reservoirs and the dams that control them are also important in evaluating ecological condition. Table 3 summarizes a number of attributes of the reservoirs included in the Vital Signs Monitoring program.

A brief summary of Vital Signs Monitoring results for each reservoir in 1995 is provided in Appendix A. Differences between 1995 and results for previous years are discussed and explained to the extent possible. Appendix A also includes ecological health scores for all years for which Vital Signs Monitoring data exist. Scores are provided as reported (calculated based on the methods in use at that time) and based on the 1994 scoring methods. These scores are also listed for each reservoir in Table 4.

The ecological score for each reservoir in 1995 is presented by classification unit in Figure 4. Run-of-river reservoirs clearly scored higher than any other class. Three of six reservoirs monitored fell in the "good" category, two in the "fair" range, and one in the "poor" range. For the tributary reservoirs, scores tended to be higher for reservoirs in the Blue Ridge Ecoregion--three were "good", two "fair", and one "poor". Tributary reservoirs in the Ridge and Valley Ecoregion had no "good" scores--three were in the "fair" range and four in the "poor" range. None of the reservoirs in the Interior Plateau Ecoregion rated "good", three were "fair", and four "poor".

Conditions for aquatic life in the Tennessee River system were adversely impacted by low rainfall and low stream flow during the spring and early summer of 1995. Of twenty-one reservoirs monitored and evaluated in 1995, sixteen had lower reservoir health scores than in 1994. Overall, health scores in 1995 were lower than in any of the previous five years. Nine reservoirs had poor health conditions for aquatic life in 1995, compared with four in 1994. Valley-wide, most of the aquatic indicators (oxygen, chlorophyll-a, benthos, and fish) used to determine the health scores had lower ratings in 1995. Sediment quality in 1995 was about the same as it had been in previous years. The low rainfall and low stream flow through the river/reservoir system during the spring and summer (April-September) of 1995 is the main reason for the depressed reservoir health conditions.

For example, in each of the last five years (1991-1995) spring-summer rainfall (April-September) in the Tennessee River basin has been below the long term (100 year) average, with generally less rainfall in the eastern part of the Valley (i.e. drainage area above Chattanooga) than in the western part of the Valley. For the summer of 1995 and the immediate preceding nine months (i.e. July 1994 through September 1995 -- a fifteen month period), only two months (October 1994 and January 1995) had rainfall amounts above normal, (see Figure 1). The rainfall deficit for the Tennessee River basin during this fifteen month period was 10.7 inches (a 17% deficit). Even more, the rainfall deficit for the eastern half of the Valley was 13.3 inches (a 21% deficit) during the same period.

This antecedent rainfall deficit resulted in runoff and stream flows in the early summer of 1995 to be the lowest of any April through June period in the last five years, lower even than the summer of 1993. Runoff in the Tennessee Valley from April through June 1995 was 36% below the long term average. These low runoffs and stream flows were particularly problematic in the eastern part of the Valley because they occurred at the same time TVA begins filling tributary storage reservoirs to summer levels. This lack of normal rainfall and runoff hampered TVA's efforts to fill tributary reservoirs, with the result that many of the tributary reservoirs did not reach their full pool, summer recreation levels in 1995 (e.g. Cherokee, Hiwassee, Chatuge, Nottely, Blue Ridge, Fontana, etc.). In addition, TVA's efforts to fill these tributary reservoirs to summer recreation levels resulted in little water being released from the tributary dams to provide downstream flows and supplement flows in the Tennessee River. For example, in April at Chickamauga dam (through which flows all the drainage in the eastern part of the Tennessee Valley), daily discharges averaged only about 10,000 cfs, compared with the long term average daily discharge for April of 26,600 (a decrease of over 60%).

The low stream flows Valley wide in the early summer of 1995 resulted in longer holding times and had a negative effect on the ecological condition of many reservoirs. A case in point was Fort Loudoun Reservoir. For the first time since Vital Signs monitoring began in 1990, oxygen concentrations rated poor in the forebay of Ft Loudoun in 1995. In early June, the majority of the water in the forebay of Ft Loudoun was found to have DOs less than 2 mg/l. In addition, near zero concentrations of DO extended 30 feet above the bottom of the reservoir. In May, the month preceding this onset of anoxia, discharges from Ft Loudoun dam averaged only 5500 cfs a day (the long term average for May is 11,600 cfs). Also, there were several days in May (May 24-28) when daily discharges averaged less than 1500 cfs. This situation developed because very little water was being released to Fort Loudoun from upstream Cherokee, Douglas, and Fontana reservoirs. As soon as it was realized the effect the low flows were having on the oxygen regime of the reservoir, discharges from Ft Loudoun dam were intermittently pulsed to eliminate extended periods of low, or no flow. In addition, an air injection system in the forebay of Ft Loudoun, which was just completed was quickly put into operation. These two reservoir management operations helped to eliminate the establishment of stagnant conditions and quickly resulted in greatly improved DO conditions in the forebay of Fort Loudoun reservoir. Water quality surveys in July found no oxygen concentrations below 3.5 mg/l, with the majority of measurements above 5.0 mg/l, in the forebay of Ft Loudoun.

In similar but less dramatic fashion, many reservoirs Valley wide experienced generally lower oxygen concentrations during the summer of 1995 -- largely due to the lower stream flows which allowed the progressive development of near bottom reservoir anoxia in those reservoirs with longer holding times.

With the exception of sediment quality, poorer average ratings were generally found for all ecological health indicators (e.g. lower DO, higher chlorophyll-a, and less abundant and diverse benthos and fish communities) in tributary reservoirs in 1995. Overall, average ratings were generally lower for only DO (which was lower) and chlorophyll (which was higher) in the Tennessee River reservoirs in 1995. The good news is that the stressed reservoir health conditions found in 1995 were flow related and only a temporary phenomena with little long-term effect. As spring and summer rainfall and stream flow return to a more historically normal seasonal pattern, the reservoir health conditions should improve significantly.

References

Meinert, DL., S.R. Butkus, and T.A. McDonough. 1992. Chickamauga Reservoir Embayment Study - 1990. TVA/WR-92/28

Figure 1

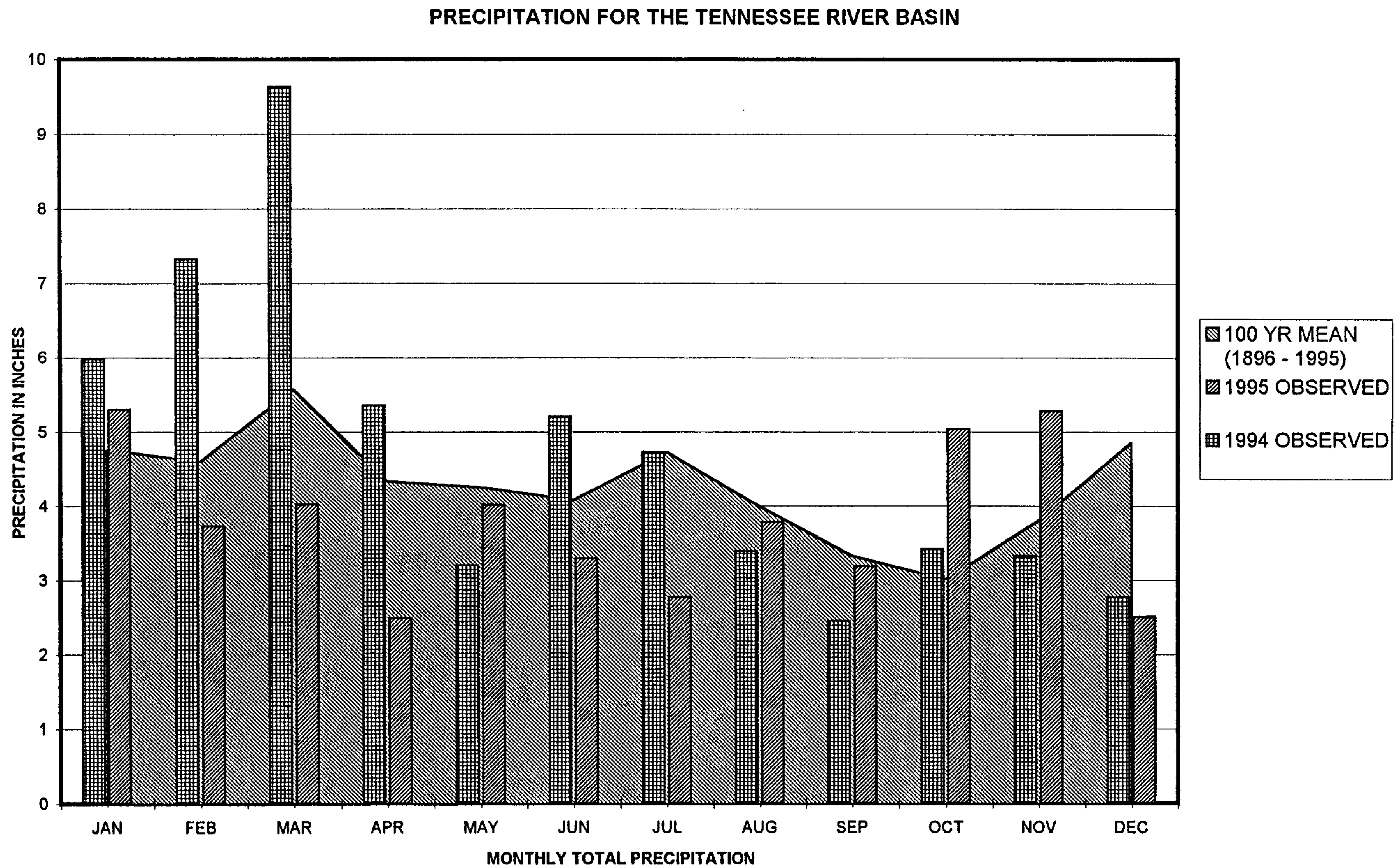
PRECIPITATION FOR THE TENNESSEE RIVER BASIN
PRECIPITATION IN INCHES
0
1
2
3
4
5
6
7
8
9
10
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHLY TOTAL PRECIPITATION
100 YR MEAN (1896 - 1995)
1995 OBSERVED
1994 OBSERVED

Figure 2

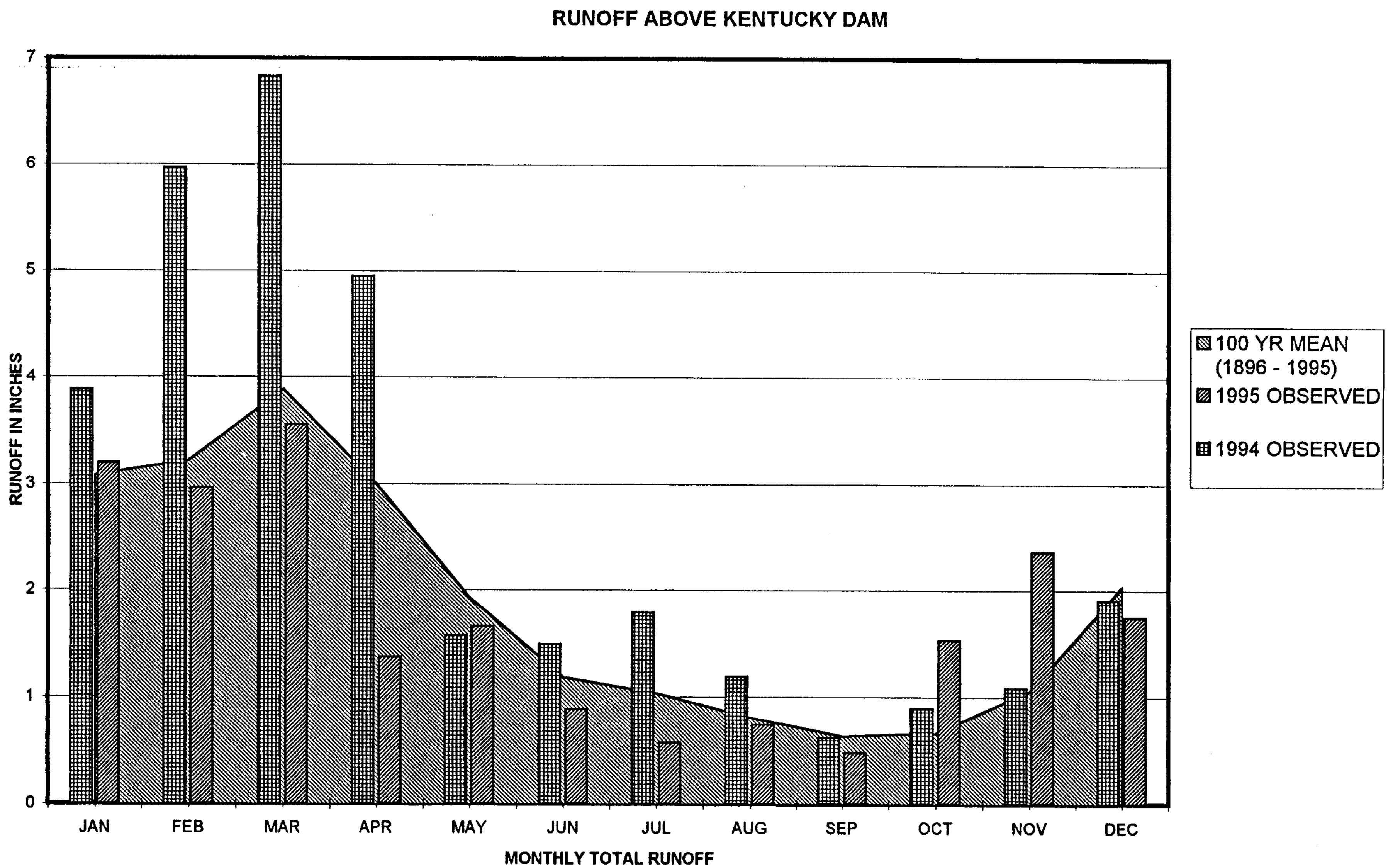
RUNOFF ABOVE KENTUCKY DAM
RUNOFF IN INCHES
0
1
2
3
4
5
6
7
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHLY TOTAL RUNOFF
100 YR MEAN (1896 - 1995)
1995 OBSERVED
1994 OBSERVED

Figure 3. Average Annual Tennessee River Flows Showing Contributions of Major Tributaries and Local Inflows.

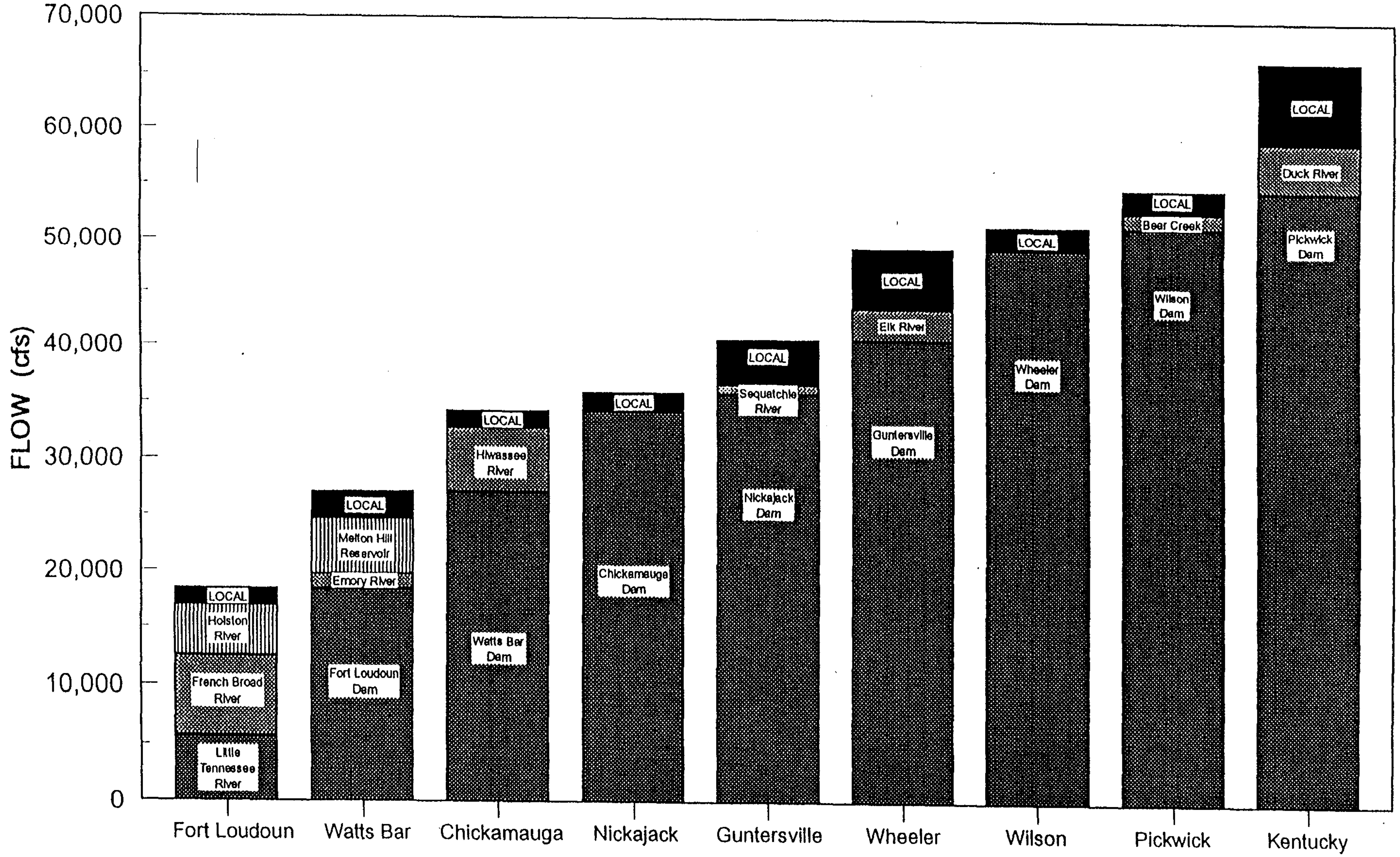

Figure 4. 1994/5 Ecological Health Summary

Reservoirs were sampled in the year in parenthesis

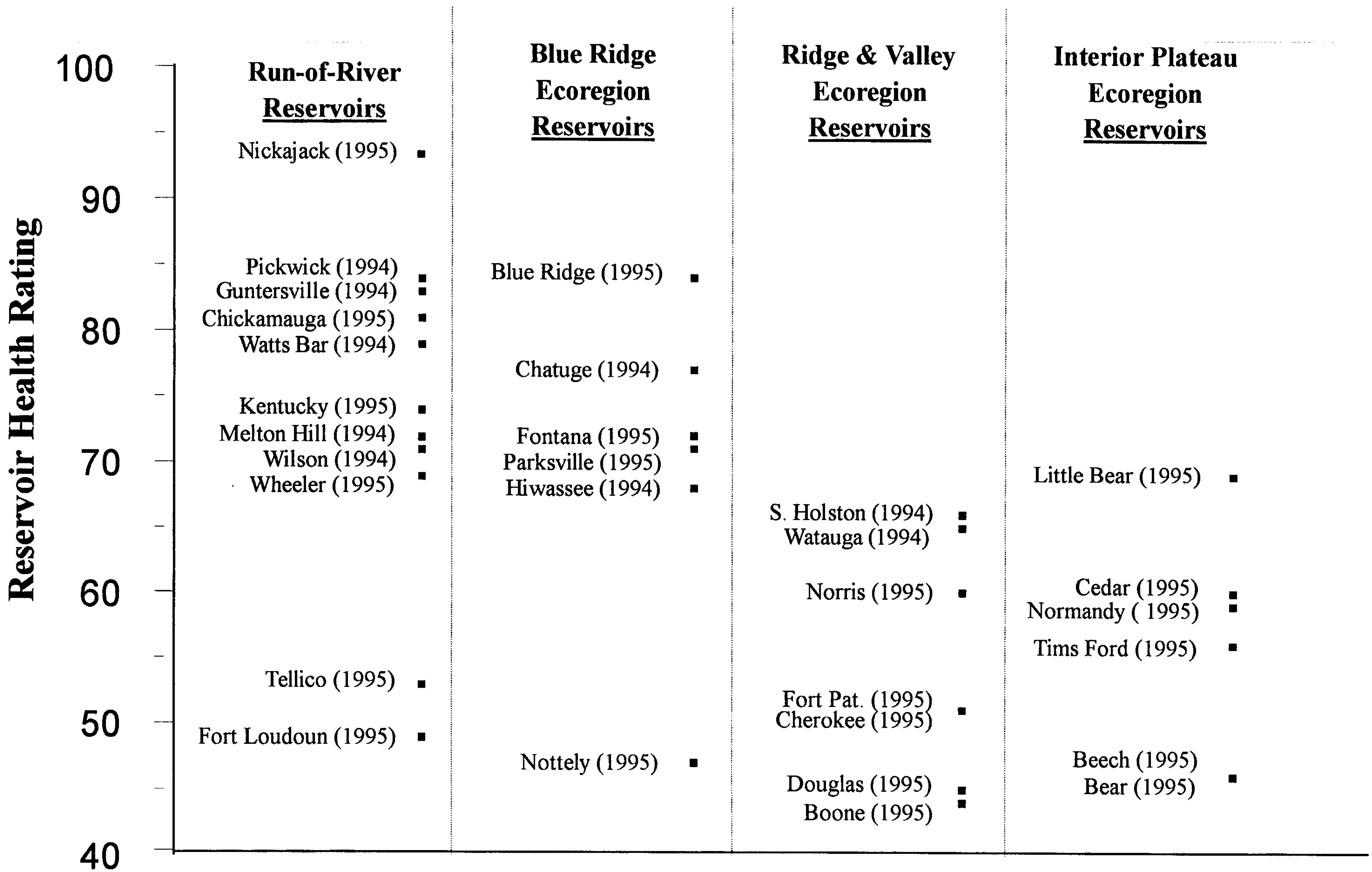

Table 1

Reservoir Vital Signs Monitoring Activities, 1995

Reservoir	River Mile	Sampling Schedule (Monthly or Annual)				
		Water Chemistry	Sediment Quality: Toxicity	Sediment Quality: Chemistry	Benthos	Fish
Kentucky	TRM 23.0	M	A	A	A	A
	TRM 85.0	M	A	A	A	A
	TRM 200-206	-	-	-	A	A
	Big Sandy 7.4	M	A	A	A	A
Pickwick	TRM 207.3	M	A	A	A	A
	TRM 230.0	M	A	A	A	A
	TRM 253-259	-	-	-	A	A
	Bear Creek 8.4	M	A	A	A	A
Wilson	TRM 260.8	M	A	A	A	A
	TRM 273-274	-	-	-	A	A
Wheeler	TRM 277.0	M	A	A	A	A
	TRM 295.9	M	A	A	A	A
	TRM 347-348	-	-	-	A	A
	Elk River 6.0	M	A	A	A	A
Guntersville	TRM 350.0	M	A	A	A	A
	TRM 375.2	M	A	A	A	A
	TRM 420-424	-	-	-	A	A
Nickajack	TRM 425.5	M	A	A	A	A
	TRM 469-470	-	-	-	A	A
Chickamuaga	TRM 472.3	M	A	A	A	A
	TRM 490.5	M	A	A	A	A
	TRM 518-529	-	-	-	A	A
	Hiwassee 8.5	M	A	A	A	A
Watts Bar	TRM 531.0	M	A	A	A	A
	TRM 560.8	M	A	A	A	A
	TRM 600-601	-	-	-	A	A
	CRM 19-22	-	-	-	A	A
Fort Loudoun	TRM 605.5	M	A	A	A	A
	TRM 624.6	M	A	A	A	A
	TRM 652	-	-	-	A	A
Tellico	LTRM 1.0	M	A	A	A	A
	LTRM 15.0	M	A	A	A	A
Melton Hill	CRM 24.0	M	A	A	A	A
	CRM 45.0	M	A	A	A	A
	CRM 59-66	-	-	-	A	A
Norris	CRM 80.0	M	A	A	A	A
	CRM 125.0	M	A	A	A	A
	PRM 30.0	M	A	A	A	A

Reservoir	River Mile	Sampling Schedule (Monthly or Annual)				
		Water Chemistry	Sediment Quality: Toxicity	Sediment Quality: Chemistry	Benthos	Fish
Cherokee	HRM 55.0	M	A	A	A	A
	HRM 77.0	M	A	A	-	A
Douglas	FBRM 33.0	M	A	A	A	A
	FBRM 50.0	M	A	A	A	A
Ft.Pat Henry	SFHR 8.7	M	A	A	A	A
Boone	SFHR 19.0	M	A	A	A	A
	SFHR 27.0	M	A	A	A	A
	WRM 6.5	M	A	A	A	A
South Holston	SFHR 51.0	M	A	A	A	A
	SFHR 62.5	M	A	A	A	A
Watauga	WRM 37.4	M	A	A	A	A
	WRM 45.5	M	A	A	A	A
Fontana	LTRM 62.0	M	A	A	-	A
	LTRM 81.5	M	A	A	A	A
	TkRM 3.0	M	A	A	A	A
Hiwassee	HiRM 77.0	M	A	A	A	A
	HiRM 85.0	M	A	A	A	A
	HiRM 90	-	-	-	A	-
Chatuge	HiRM 122.0	M	A	A	A	A
	Shooting Cr 1.5	M	A	A	A	A
Nottely	NRM 23.5	M	A	A	A	A
	NRM 31.0	M	A	A	A	A
Blue Ridge	ToRM 54.1	M	A	A	A	A
Ocoee No.1	ORM 12.5	M	A	A	A	A
Tims Ford	ERM 135.0	M	A	A	A	A
	ERM 150.0	M	A	A	A	A
Bear Creek	BCM 75.0	M	A	A	A	A
L. Bear Creek	LBCM 12.5	M	A	A	A	A
Cedar Creek	CCM 25.2	M	A	A	A	A
Normandy	DRM 249.5	M	A	A	A	A
Beech	BRM 36.0	M	A	A	A	A

Monthly (M) -- actually once every 6 weeks ; Annual (A) -- once per year

Shadded areas were not sampled in 1995

(vsigns95.xls-5/17/96)

Table 2

Fort Loudoun Reservoir -- 1995 (Run-of-the-River Reservoir)

Aquatic Health Indicators	Observations			Ratings		
	Forebay	Transition	Inflow	Forebay	Transition	Inflow
Chlorophyll-a			No Sample			
Summer Average, ug/l	15.8	17.4	--			
Maximum Concentration	24	25	--			
				1.1 (poor)	1.0 (poor)	No Rating
Dissolved Oxygen			No Sample			
Percent less than 2 mg/l :						
X-Sectional Area	9.8 (3)	0 (5)	--			
Bottom X-Sectional Length	14.5*(2)	0 (5)	--			
	*Bottom - 0 mg/l			2.5 (poor)	5 (good)	No Rating
Sediment Quality			No Sample			
Metals/Pesticides/PCBs	chlordane/PCB	Zn/chlordane/PCB	--			
				1.5 (fair)	1.0 (poor)	No Rating
Benthic Community						
Total Score - Seven Metrics	13	29	9			
				2 (poor)	4 (good)	1 (poor)
Fish Community						
Total Score - Twelve Metrics	36	27	32			
				3 (fair)	2 (poor)	3 (fair)
	Sampling Location Sum			10.1 of 22.5	13 of 22.5	4 of 10
	Reservoir Sum			27.1 of 55 (49%)		
	Overall Reservoir Evaluation			"poor"		

Overall Reservoir Evaluation Key:

Less than 52 % -- poor (red)
52 % to 72 % -- fair (yellow)
Greater than 72 % -- good (green)

exp-rate.xls (5/17/96)

Table 3

CHARACTERISTICS OF VITAL SIGNS RESERVOIRS

Reservoir Name	Drainage Area (sq. miles)	Reservoir Length[a] (miles)	Surface Area[a] (acres) 1000's	Depth at Dam[a] (ft)	Volume[a] (ac-ft) 1000's	Average Annual Drawdown[b] (ft)	Average Reservoir Flow--POR Thru-1995 (cfs)	Average Hydraulic Residence Time-1995[a] (days)	Average CY 1995 Reservoir Flow (cfs)
Run-of-the-River Reservoirs									
Kentucky	40,200	184.3	160.3	88	2,839	5	66,729	26.8	53,465
Pickwick	32,820	52.7	43.1	84	924	6	55,258	9.1	51,400
Wilson	30,750	15.5	15.5	108	634	3	51,823	6.4	50,087
Wheeler	29,590	74.1	67.1	66	1,050	6	49,783	10.8	48,855
Guntersville	24,450	75.7	67.9	65	1,018	2	41,076	12.5	41,077
Nickajack	21,870	46.3	10.7	60	241	0	36,429	3.5	34,663
Chickamauga	20,790	58.9	35.4	83	628	7	34,472	9.6	32,957
Watts Bar	17,300	72.0/24.0[c]	39.0	105	1,010	6	27,327	19.5	26,079
Fort Loudoun	9,550	50.0	14.6	94	363	6	18,607	9.3	19,648
Melton Hill	3,343	44.0	5.7	69	120	0	4,970	15.0	4,034
Tellico	2,627	33.2	16.5	80	415	6	6,406[d]	31.3	6,694[d]
Tributary River Reservoirs									
Norris	2,912	73.0/53.0[c]	34.2	202	2,040	32	4,211	299.4	3,345
Douglas	4,541	43.1	30.4	127	1,408	48	6,781	97.7	7,266
Cherokee	3,428	54.0	30.3	163	1,481	28	4,540	179.1	4,168
Ft Patrick Henry	1,903	10.4	0.9	81	27	0	2,658	5.5	2,473
Boone	1,840	17.4/15.3[c]	4.3	129	189	25	2,561	39.3	2,424
South Holston	703	23.7	7.6	239	658	33	980	358.7	860
Watauga	468	16.3	6.4	274	569	26	720	330.9	867
Fontana	1,571	29.0	10.6	460	1,420	64	3,884	161.1	4,445
Hiwassee	968	22.2	6.1	255	422	45	2,036	101.5	2,097
Chatuge	189	13.0	7.1	124	234	10	461	254.8	463
Nottely	214	20.2	4.2	167	170	24	417	213.7	401
Ocoee #1 (Parksville)	595	7.5	1.9	115	85	7	1,421	32.7	1,310
Blue Ridge	232	11.0	3.3	156	193	36	612	180.5	539
Tims Ford	529	34.2	10.6	143	530	12	950	352.1	759
Bear Creek	232	16.0	0.7	74	10	11[e]	387	11.4	441
Cedar Creek	179	9.0	4.2	79	94	14[e]	289	156.9	302
Little Bear Creek	61	7.1	1.6	82	45	12[e]	103	204.4	111
Normandy	195	17.0	3.2	83	110	11	326	200.2	277
Beech	16	5.3	0.9	32	11	1[e]	14(est)	--	--

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a. Estimates based on normal maximum summer pool.
b. ***Tennessee River and Reservoir System Operation and Planning Review,*** Final EIS, TVA/RDG/EQS--91/1, 1990.
c. Major/minor arms of reservoir.
d. Estimated flow based on releases from Chilhowee Dam (POR avg.= 4770cfs), and adjusted based on the additional drainage area between Chilhowee Dam (1977 sq miles) and Tellico Dam (2627 sq miles).
e. Estimated based on difference between normal maximum summer pool and average minimum winter pool elevations.

Data Source: Hydrologic Data Management (Knoxville, TN), Systems Engineering, TVA, 1995.

(vsres-ch.tbl)

Table 4. Reservoir Ecological Health Scores 1991 - 1995

Watershed/	Area	Res. Eco. Health Rating, as reported					Res. Eco. Health on 1995 Criteria					1992-94
Reservoir	(Acres)	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995	Average
Kentucky Res. Watershed												
Kentucky Reservoir	160,300	77	88	75	71	74	69	87	81	75	74	79
Beech Reservoir	900	N/A	N/A	65	56	46	N/A	N/A	69	54	46	56
Duck River Watershed												
Normandy Reservoir	3,200	N/A	N/A	56	68	59	N/A	N/A	62	64	59	62
Pickwick/Wilson Watershed												
Pickwick Reservoir	43,100	77	75	73	84	N/A	77	80	70	81	N/A	77
Wilson Reservoir	15,500	60	68	71	71	N/A	58	67	76	73	N/A	72
Bear Creek Resrvoir	700	N/A	N/A	60	56	46	N/A	N/A	64	60	46	57
Little Bear Creek Res.	1,600	N/A	N/A	64	64	69	N/A	N/A	68	69	69	69
Cedar Creek Reservoir	4,200	N/A	N/A	56	80	60	N/A	N/A	64	68	60	64
Wheeler/Elk Watershed												
Wheeler Reservoir	67,100	89	80	72	75	69	70	76	72	74	69	73
Tims Ford Reservoir	10,600	N/A	60	58	58	56	N/A	63	60	58	56	59
Guntersville/Sequatchie WS												
Guntersville Reservoir	67,900	66	83	78	83	N/A	84	85	79	83	N/A	82
Nickajack/Chickamauga												
Nickajack Reservoir	10,400	89	83	88	90	92	87	81	87	91	92	88
Chickamauga Res.	35,400	90	73	83	87	81	83	88	86	86	81	85
Hiwassee River Watershed												
Hiwassee Reservoir	6,100	82	69	58	68	N/A	72	71	69	62	N/A	67
Chatuge Reservoir	7,100	60	56	67	77	N/A	59	79	79	72	N/A	77
Nottely Reservoir	4,200	60	60	64	56	47	60	61	62	54	47	56
Blue Ridge Reservoir	3,300	87	73	72	86	84	87	83	91	80	84	85
Ocoee No. 1 Reservoir	1,900	47	53	52	60	71	74	74	67	67	71	70

Table 4. cont. Reservoir Ecological Health Score 1991 - 1995

Watershed	Area	Res. Eco Health Rating, as reported					Res. Eco. Health on 1995 Criteria					1992-94
Reservoir	(Acres)	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995	Average
Watts Bar/Ft. Loud./Mel. Hill												
Watts Bar Reservoir	39,000	69	71	68	79	N/A	72	79	76	74	N/A	76
Fort Loudoun Reservoir	14600	60	53	58	61	49	63	63	56	64	49	58
Melton Hill Reserovir	5700	80	67	68	72	N/A	67	65	66	73	N/A	68
Clinch/Powell Watershed												
Norris Reservoir	34200	57	67	67	69	60	71	72	69	65	60	67
L' Tenn. River Watershed												
Tellico Reservoir	15,900	48	48	63	71	53	61	57	63	74	53	62
Fontana Reservoir	10,600	N/A	N/A	64	67	72	N/A	N/A	71	75	72	73
French Broad River WS												
Douglas Reservoir	30,400	42	56	58	64	45	60	54	60	62	45	55
Holston River Watershed												
Cherokee Reservoir	30300	50	53	64	53	51	57	57	66	48	51	56
Fort Pat. Henry Res.	900	N/A	N/A	72	60	51	N/A	N/A	86	56	51	64
Boone Reservior	4300	51	64	59	59	49	53	63	58	56	49	57
South Holston Res.	7600	60	57	65	66	N/A	63	59	66	64	N/A	63
Watauga Reservor	6,400	80	57	61	65	N/A	75	72	63	61	N/A	65

Section 2. Dissolved Oxygen (DO)

Philosophical Approach/Background

Oxygen is vital for life. In situations where funding is limited and only one indicator of reservoir health could be measured, DO would likely be the indicator of choice. Hutchinson (1975) states that probably more can be learned about the nature of a lake from a series of oxygen measurements than from any other kind of chemical data. The presence, absence, and levels of DO in a lake or reservoir both control and are controlled by many physical, chemical, and biological processes (e.g., photosynthesis, respiration, oxidation-reduction reactions, bacterial decomposition, temperature). DO measurements coupled with observations of water clarity (Secchi depth), temperature, nutrients, and some basic hydrologic and morphometric information provide meaningful insight into the ecological health of a reservoir.

Ideally, a reservoir has near-saturation concentrations of DO throughout the water column available to fish, insects, and zooplankton for respiration. This is usually the case during winter and spring, when most reservoirs are well mixed. However, in summer (characterized by more available sunlight, warmer water temperatures, and lower flows) both thermal stratification and increased biological activity may combine to produce a greater biochemical demand for oxygen than is available, particularly in the deeper portions of the reservoir. As a result, summer levels of DO often are below saturation in the metalimnion and hypolimnion of a reservoir or lake. This hypolimnetic and metalimnetic oxygen depletion is a common, but undesirable, occurrence in many reservoirs, especially storage impoundments. Not only do lower concentrations of DO in the water column affect the assimilative capacity of a reservoir, but if they are low enough and/or sustained long enough, they adversely affect the health and diversity of the fish and benthic communities. Sustained near-bottom anoxia not only promotes the biochemical release of phosphorus which affects trophic conditions, but also promotes the release of ammonia, sulfide, and dissolved metals into the interstitial pore and near-bottom waters. If this phenomenon persists long enough, many of these reduced chemicals can cause chronic or acute toxicity to benthos.

A dissolved oxygen concentration of 2 mg/L was selected as a level below which undesirable ecological conditions exist. Values below this level primarily cause adverse impacts on benthic macroinvertebrate organisms and loss of quality habitat for fish. Historic information for reservoirs in the Tennessee Valley has shown that the burrowing mayfly (Hexagenia sp.) disappears from the benthic community at DO concentrations of 2 mg/L and below (Masters and McDonough, 1993). Most fish species avoid areas with DO concentrations below 2.0 mg/L (loss of habitat); fish health, growth, and reproduction is reduced at these levels, and many highly desirable species such as sauger and walleye simply cannot survive at such low levels of DO.

A question fundamental to reservoir ecological health evaluation as well as reservoir classification issues is -- should reservoir ecological health evaluations be based on (1) ideal conditions, for example, low DO concentrations represent an unacceptable ecological condition; or (2) the best conditions expected for a reservoir given the environmental and operational characteristics of the dam/reservoir, for example, very low DO concentrations are acceptable in many tributary reservoirs because of withdrawal schemes, stratification, etc. The approach selected for this program is -- poor DO is unacceptable regardless of type of reservoir or dam operation. Hence, reservoirs were not separated into classes for DO evaluations/expectations because the expectation was the same for all reservoirs.

Data Collection Methods

DO data were collected concurrently with chlorophyll and other physical/chemical samples. In 1995, physical/chemical water quality variables (Table 2) were measured at 39 locations on 21 reservoirs (Table 1, Section 1.0). Water quality surveys were conducted from April through October on an approximate six week recurring interval. Water quality sampling included in situ water column measurements of temperature, dissolved oxygen, pH, and conductivity; Secchi depth measurements; and photic zone (defined as twice the Secchi depth or 4-meters, whichever is greater) composite chlorophyll-a samples. In addition, on three occasions during the summer (beginning-, mid-, and end- of the summer growing season), photic zone composite samples for nutrient analyses (total phosphorus, ammonia-nitrogen, nitrate+nitrite-nitrogen, and organic nitrogen) were also collected. Water quality profiles and sampling was conducted over the original river channel at the reservoir's maximum depth at each location. Physical/chemical water quality sampling was not conducted at most reservoir inflow locations because many of these locations are free flowing (or tailwater areas of upstream dams) and are more representative of riverine processes (and the upstream reservoir), rather than conditions in the reservoir being assessed.

Two specific QA/QC activities were incorporated into the reservoir physical/chemical water sampling. These were: (1) collection and analysis of triplicate sets of water samples once during the year at five locations to assess sample collection, laboratory analysis, and natural sample variability; and (2) preparation and analysis of fifteen sets of sample container bottle blanks (five on each of the three surveys when the nutrient samples were collected) to assess the degree of contamination associated with the sample bottles and/or the sample handling processes.

DO Rating Scheme

A conceptual model was developed for dissolved oxygen rating criteria. The rating criteria represent a multidimensional approach that includes dissolved oxygen levels both throughout the water column (WC_{DO}) and near the bottom (B_{DO}) of the reservoir. The DO rating at each sampling location (ranging from 1 "poor" to 5 "good") is based on monthly summer water column and bottom water DO measurements. (Summer is defined as a six-month period when maximum thermal stratification and maximum hypolimnetic anoxia is expected to occur: April through September for the run-of-the-river reservoirs and May through October for the tributary reservoirs.)

The final DO rating is the average of the water column DO (WC_{DO}) rating and the bottom DO rating (B_{DO}):

DO Rating = 0.5 (WC_{DO} rating + B_{DO} rating), where:

WC_{DO} (Water Column DO) Rating--a six-month average of the percent of the reservoir cross-sectional area (at the location where the sampling was conducted) that has a dissolved oxygen (DO) concentration less than 2.0 mg/L. (See Figure 1).

Average Cross-Sectional Area (DO less than 2 mg/L)	WC_{DO} Rating for Sampling Location*
<5%	5 (good);
≥5% but ≤10%	3 (fair);
>10%	1 (poor).

*Because most state DO water quality criteria for fish and aquatic life specify a minimum of 5.0 mg/L DO at the 1.5 meter (5 foot) depth, the WC_{DO} rating was lowered if the measured DO at the 1.5 meter depth at a sampling location was below 5.0 mg/L at any time. These adjustments were as follows.

Minimum DO at 1.5 meter depth	Sampling Location WC_{DO} Rating Change
<5.0 mg/L	Decreased one unit (e.g., 5 to 4);
<4.0 mg/L	Decreased two units (e.g., 5 to 3);
<3.0 mg/L	Decreased three units (e.g., 5 to 2);
etc.	etc.

B_{DO} (Bottom DO) Rating--a six month average of the percent of the reservoir cross-sectional bottom length (at the location where sampling was conducted) that has a DO concentration less than 2.0 mg/L, as follows:

Average Cross-Sectional Length* (DO less than 2 mg/L)	B_{DO} Rating for Sampling Location
0%	5 (good);
0 to 10%	4
10 to 20%	3 (fair);
20 to 30%	2
>30%	1 (poor).

*The average percent cross-sectional bottom length was computed based on the total cross-sectional bottom length at average minimum winter pool elevation. In addition, if anoxic bottom conditions (i.e., 0 mg/L) were observed at a location, the B_{DO} rating was lowered one unit, with a minimum rating of 1.

Results from 1995 Monitoring

Table 1 summarizes DO results for each location monitored in 1995. The summary of DO results includes information on water column and bottom DO measurements and the final DO rating.

Isopleths for dissolved oxygen and temperature are provided in Appendix B for each sample location during the 1995 sampling season.

References

Hutchinson, G. Evelyn, 1975. A Treatise on Limnology, Volume 1, Part 2 - Chemistry of Lakes, J. Wiley and Sons, New York.

Masters, A., and T.A. McDonough, April 1993. TVA Water Management, Chattanooga, Tennessee, Personal Communication.

Table 1
1995 Dissolved Oxygen Results -- Vital Signs Monitoring Data
(using average minimum winter pool elevations)

	+---Dissolved Oxygen---						
	+----Water Column DO----+			+-------Bottom DO-------+			
Reservoir	Less than 5.0 mg/l ? (@ 1.5 meters)	Percent of X-Section <2.0 mg/l	Rating	Bottom DO 0 mg/l ?	Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
			RUN-OF-THE-RIVER RESERVOIRS				
Kentucky							
Forebay(TRM 23.0)	No	trace	5	No	trace	5	**5**
T-Zone(TRM 85.0)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 200-206	Yes 4.7	-	4	-	-	-	**4**
Embay(BSRM 7.4)	No	2.0	5	Yes	7.5	3	**4**
Pickwick							
Forebay(TRM 207.3)							
T-Zone(TRM 230.0)							
Inflow(TRM 253-259)							
Embay(BCM 8.4)							
Wilson							
Forebay(TRM 260.8)							
Inflow(TRM 273-274)							
Wheeler							
Forebay(TRM 277.0)	No	0.0	5	No	0.0	5	**5**
T-Zone(TRM 295.9)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 347-348	No	-	5	-	-	-	**5**
Embay(ERM 6.0)	No	12.3	1	Yes	39.0	1	**1**
Guntersville							
Forebay(TRM 350.0)							
T-Zone(TRM 375.2)							
Inflow(TRM 420-424)							
Nickajack							
Forebay(TRM 425.5)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 469-470	Yes 4.7	-	4	-	-	-	**4**
Chickamauga							
Forebay(TRM 472.3)	No	0.8	5	No	4.7	4	**4.5**
T-Zone(TRM 490.5)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 518-529	Yes 1.1	-	1	-	-	-	**1**
Embay(HRM 8.5)	No	0.0	5	No	0.0	5	**5**
Watts Bar							
Forebay(TRM 531.0)							
T-Zone(TRM 560.8)							
Inflow(TRM 600-601)							
Inflow(CRM 19-22)							

Table 1
1995 Dissolved Oxygen Results -- Vital Signs Monitoring Data
(using average minimum winter pool elevations)

Reservoir	Dissolved Oxygen: Water Column DO: Less than 5.0 mg/l ? (@ 1.5 meters)	Water Column DO: Percent of X-Section <2.0 mg/l	Rating	Bottom DO: Bottom DO 0 mg/l ?	Bottom DO: Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
Fort Loudoun							
Forebay(TRM 605.5)	No	9.8	3	Yes	14.5	2	**2.5**
T-Zone(TRM 624.6)	No	trace	5	No	trace	5	**5**
Tellico							
Forebay(LTRM 1.0)	No	10.5	1	Yes	26.2	1	**1**
T-Zone(LTRM 15.0)	No	1.0	5	No	3.0	4	**4.5**
Melton Hill							
Forebay(CRM 24.0)							
T-Zone(CRM 45.0)							
TRIBUTARY RESERVOIRS							
Norris							
Forebay(CRM 80.0)	No	19.0	1	Yes	27.9	1	**1**
CRM 125.0	No	22.4	1	Yes	61.0	1	**1**
PRM 30.0	No	20.2	1	Yes	44.6	1	**1**
Cherokee							
Forebay(HRM 55.0)	No	29.1	1	Yes	49.6	1	**1**
HRM 77.0	No	33.0	1	Yes	76.1	1	**1**
Douglas							
Forebay(FBRM 33.0)	No	35.4	1	Yes	70.1	1	**1**
FBRM 50.0	No	41.0	1	Yes	304.2	1	**1**
Ft. Patrick Henry							
Forebay(SFHRM 8.7)	No	0.0	5	No	0.0	5	**5**
Boone							
Forebay(SFHRM 19.0	No	0.4	5	No	5.4	4	**4.5**
SFHRM 27.0	No	17.2	1	No	13.6	3	**2**
WRM 6.5	No	trace	5	No	trace	5	**5**
South Holston							
Forebay(SFHRM 51.0)							
SFHRM 62.5							
Watauga							
Forebay(WRM 37.4)							
WRM 45.5							

Table 1
1995 Dissolved Oxygen Results -- Vital Signs Monitoring Data
(using average minimum winter pool elevations)

	Dissolved Oxygen						
	Water Column DO			Bottom DO			
Reservoir	Less than 5.0 mg/l ? (@ 1.5 meters)	Percent of X-Section <2.0 mg/l	Rating	Bottom DO 0 mg/l ?	Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
Fontana							
Forebay(LTRM 62.0)	No	0.1	5	No	0.1	4	**4.5**
LTRM 81.5	No	1.6	5	No	13.5	3	**4**
TkRM 3.0	No	3.3	5	Yes	13.6	2	**3.5**
Blue Ridge							
Forebay(ToRM 54.1)	No	1.4	5	No	14.1	3	**4**
Hiwassee							
Forebay(HiRM 77.0)							
HIRM 85.0							
Nottely							
Forebay(NRM 23.5)	No	16.4	1	Yes	29.9	1	**1**
NRM 31.0	No	10.1	1	Yes	40.9	1	**1**
Chatuge							
Forebay(HiRM 122.0)							
Shooting Cr 1.5							
Ocoee #1							
Forebay(ORM12.5)	No	0.0	5	No	0.0	5	**5**
Tims Ford							
Forebay(ERM 135.0)	No	16.3	1	Yes	35.6	1	**1**
ERM 150.0	No	37.8	1	Yes	67.4	1	**1**
Normandy							
Forebay(DRM 249.5)	No	46.4	1	Yes	64.5	1	**1**
Bear Creek							
Forebay(BCM 75.0)	No	28.4	1	Yes	70.0	1	**1**
Little Bear Creek							
Forebay(LBCM 12.5)	No	50.4	1	Yes	86.8	1	**1**
Cedar Creek							
Forebay(25.2)	No	31.7	1	Yes	83.1	1	**1**
Beech							
Forebay(BRM 36.0)	No	26.2	1	Yes	46.3	1	**1**

Shaded monitoring locations were not sampled in 1995.

Table 2

RESERVOIR "VITAL SIGNS" WATER QUALITY MONITORING WATER QUALITY MEASUREMENTS -- 1995

Samples/ Measurements	Depths(s)[a] (meters)	Container	Preservation/Handling
		FIELD - each survey	
Secchi disc	(record depth)	--	--
Temp, pH, DO, cond	0.3, 1.5, 4, etc.	in situ[b]	--
Chlorophyll[c]	S_c	1-L cubitainer	Immediately add 1 mL of $MgCO_3$ suspension, place on ice, filter within three hours
		LABORATORY - first, third, and fifth surveys[d]	
Nutrients -- (phosphorus, ammonia, nitrate + nitrite, and organic nitrogen)	S_c	250-mL	Add 1 mL of 1 + 4 H_2SO_4, place on ice
Blanks[e] and Triplicates[f]			
		AQUATIC BIOLOGICAL - each survey	
Algal Assemblage	S_c	125-mL, dark bottle	Add 2-mL of Lugol's solution
Zooplankton Tow[g]	Bottom to Surface tow	250-mL	Add approx. 20mL buffered formalin per 250 mL of sample
		SEDIMENT - annual survey	
Sediment[h] (metals, PCBs, and organochlorine pesticides)	Top 3 cm composite	1 - 1 liter glass wide mouth bottle	Immediately place on ice

a. S_c - indicates a surface composite sample.

b. Hydrolab measurements of temperature, pH, DO, and conductivity will be made at the depths shown and at 2-meter intervals (4-meter intervals on tributary reservoirs) to the bottom of the reservoir. Measurements will be made at intermediate depths any time the temperature changes by more than 2°C or the DO changes by more than 1 mg/L from the previous measurement.

c. Recommended chlorophyll filters -- Whatman GF/C, 47 mm, 1.2 µm pore size, MFR No.1822-047.

d. First survey -- April 1 to May 5; Second survey -- June 19 to July 28; Third survey -- September 11 to October 20.

e. Fifteen sets of sample container bottle blanks will be prepared -- five on each of the three surveys when nutrient samples are collected.

f. Triplicate samples - Three separate and distinct samples, each collected individually, will be collected at five locations.

g. Zooplankton net should be retrieved at a constant rate of 0.5 to 0.7 meters per second. (Duplicate samples collected from all forebay locations in August.)

h. Duplicate sediment samples will be collected at six locations.

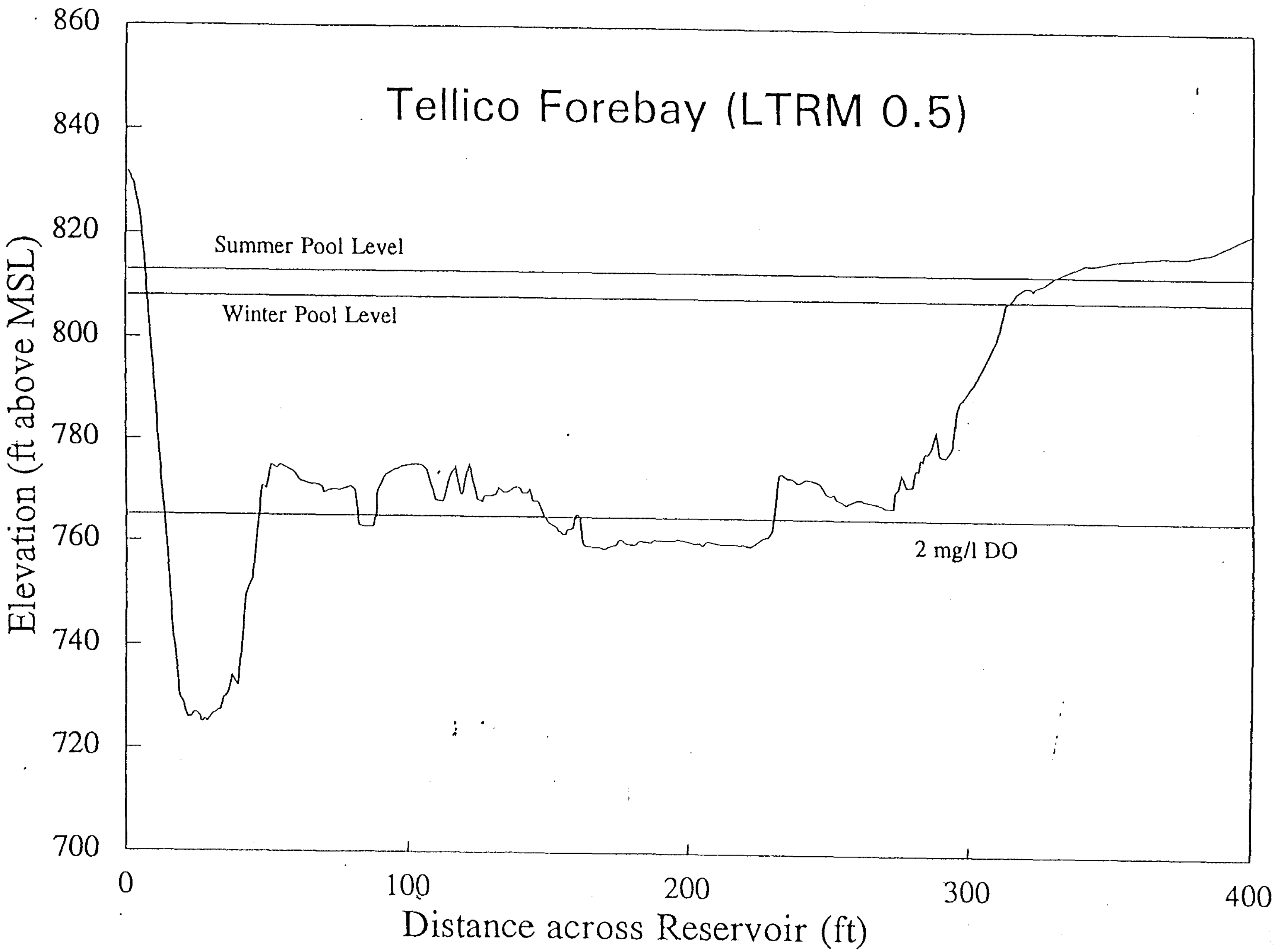


Figure 1. Cross-sectional Area of Tellico Reservoir Forebay Showing the Area with DO Less Than 2.0 mg/l.

Section 3. Chlorophyll

Philosophical Approach/Background

Algae are the base of the aquatic food chain; consequently, measuring algal biomass or primary productivity is important in evaluating ecological health. Without algae converting sunlight energy, carbon dioxide, and nutrients into oxygen and new plant material, a lake or reservoir could not support other aquatic life. Chlorophyll-a is a simple, long-standing, and well-accepted measurement for estimating algal biomass, algal productivity, and trophic condition of a lake or reservoir (Carlson, 1977).

Generally, lower chlorophyll concentrations in the oligotrophic range are thought of being indicative of good water quality conditions. Conversely, high chlorophyll concentrations are usually considered indicative of cultural eutrophication. However, care must be taken not to over generalize. For example, it would be inappropriate to expect all reservoirs in the Tennessee Valley to have low chlorophyll concentrations because some reservoirs are in watersheds which have nutrient rich, easily erodable soils. Most watersheds in the Tennessee Valley provide sufficient nutrients to expect chlorophyll concentrations in the mesotrophic range, even in absence of anthropogenic sources and cultural etrophication. However, two watersheds in the Tennessee Valley have soils (and consequently waters) with naturally low nutrient levels--the Little Tennessee and Hiwassee. The streams and rivers in these watersheds drain the Blue Ridge Ecoregion which is largely characterized by thin soils and is underlain mostly with hard crystalline and metasedimentary rocks.

Obviously, development of appropriate expectations is a critical step in evaluating implications of chlorophyll concentrations on the ecological health of a reservoir. The range of concentrations which are considered indicative of good, fair, and poor conditions must be tailored to reservoirs within each watershed based on knowledge of background or natural conditions. This leads to separating reservoirs into classes based upon these conditions.

The classification scheme used to develop expectations for chlorophyll in Tennessee Valley reservoirs was based on the "natural" nutrient level in a watershed. Professional judgment was used to select concentrations considered indicative of good, fair, and poor conditions. Based on this approach, reservoirs were placed into one of two classes for chlorophyll expectations -- those expected to be oligotrophic because they are in watersheds with naturally low nutrient concentrations and those expected to be mesotrophic because the are in watersheds which naturally have greater nutrient availability. The reservoirs expected to be ologotrophic are those in the Blue Ridge Ecoregion. Included in this group are those in the Hiwassee River drainage--Hiwassee, Chatuge, Nottely, Blue Ridge, and Parksville reservoirs and those in the Little Tennessee River drainage--Tellico and Fontana. The remaining reservoirs, both mainstream reservoirs and tributary reservoirs, are expected to be mesotrophic.

The range of concentrations selected to represent good, fair, and poor conditions obviously will be much lower for reservoirs in nutrient-poor watersheds. In reservoirs with naturally low nutrient levels, the primary concern is early identification of cultural eutrophication so appropriate actions can be taken to prevent a shift to a higher trophic state. For reservoirs expected to be mesotrophic, the concern is that chlorophyll levels not become too great because of the associated undesirable conditions--occasional dense algal blooms, poor water clarity, low DOs, and the predominance of noxious bluegreen algae. In mesotrophic reservoirs where sufficient nutrients are available but chlorophyll concentrations remain low, there is likely something inhibiting this natural process, such as excessive turbidity, toxicity, etc. Consequently, the rating for chlorophyll-a is lowered when such conditions are found.

Data Collection Methods

Chlorophyll samples were collected concurrently with DO and other physical/chemical samples. In 1995, physical/chemical water quality variables (Table 2, Section 2) were measured at 39 locations on 21 reservoirs (Table 1, Section 1). Additional details on collection methods are given in Data Collection Methods, Section 2.

Chlorophyll Rating Scheme

Chlorophyll ratings at each sampling location were based on the average summer concentration of monthly, composite photic zone samples collected from April through September (or October), using the criteria shown in Figure 1.

Results from 1995 Monitoring

Table 1 summarizes chlorophyll results for each location monitored in 1995. The summary of chlorophyll results includes the average chlorophyll concentration for the monitoring season, the maximum observed chlorophyll concentration, and the Final Chlorophyll-a Rating.

References

Carlson, R.E., 1977. "A Trophic State Index for Lakes." Limnology and Oceanography, 22:361-369.

Table 1
1995 Chlorophyll-a Results – Vital Signs Monitoring Data

			Chlorophyll-a			
Date		Location	Results		Average	Rating
April	12	Bear-FB	5	5		
May	16	Bear-FB	10	10		
June	20	Bear-FB	13	13		
July	25	Bear-FB	49	*		
August	30	Bear-FB	22	22		
October	17	Bear-FB	11	11		
					12.20 *	1.9
April	11	Beech-FB	15	15		
May	17	Beech-FB	9	9		
June	27	Beech-FB	12	12		
August	8	Beech-FB	11	11		
September	13	Beech-FB	13	13		
October	18	Beech-FB	14	14		
					12.33	2.8
May	2	Boon-FB	9	9		
June	13	Boon-FB	14	14		
July	18	Boon-FB	12	12		
August	23	Boon-FB	9	9		
October	4	Boon-FB	12	12		
October	31	Boon-FB	8	8		
					10.67	3.7
May	2	BoonSF-MR	9	9		
June	13	BoonSF-MR	21	21		
July	18	BoonSF-MR	19	19		
August	23	BoonSF-MR	11	11		
October	4	BoonSF-MR	13	13		
October	31	BoonSF-MR	9	9		
					13.67	2.2
May	2	BoonW-MR	14	14		
June	13	BoonW-MR	19	19		
July	18	BoonW-MR	19	19		
August	23	BoonW-MR	17	17		
October	4	BoonW-MR	18	18		
October	31	BoonW-MR	10	10		
					16.17	1.0
April	18	BRdge-FB	2	2		
May	23	BRdge-FB	2	2		
July	12	BRdge-FB	2	2		
August	16	BRdge-FB	1	1		
September	20	BRdge-FB	2	2		
October	25	BRdge-FB	3	3		
					2.00	5.0
April	12	Cedar-FB	15	15		
May	16	Cedar-FB	11	11		
June	20	Cedar-FB	5	5		
July	25	Cedar-FB	2	2		
August	30	Cedar-FB	2	2		
October	17	Cedar-FB	3	3		
					6.33	5.0
April	24	Cher-FB	6	6		
May	16	Cher-FB	4	4		
June	13	Cher-FB	13	13		
July	17	Cher-FB	7	7		
August	14	Cher-FB	3	3		
September	18	Cher-FB	7	7		
October	24	Cher-FB	7	7		
					6.71	5.0

Table 1
1995 Chlorophyll-a Results – Vital Signs Monitoring Data

Date		Location	Chlorophyll-a Results		Average	Rating
April	24	Cher-MR	25	25		
May	17	Cher-MR	28	28		
June	15	Cher-MR	15	15		
July	19	Cher-MR	13	13		
August	16	Cher-MR	12	12		
September	20	Cher-MR	24	24		
November	25	Cher-MR	14	14		
					18.71	1.0
April	17	Chic-Emb	2	2		
May	22	Chic-Emb	8	8		
July	10	Chic-Emb	6	6		
August	17	Chic-Emb	3	3		
September	18	Chic-Emb	6	6		
					5.00	5.0
April	17	Chic-FB	7	7		
May	22	Chic-FB	21	21		
July	10	Chic-FB	18	18		
August	17	Chic-FB	14	14		
September	18	Chic-FB	6	6		
					13.20	2.4
April	17	Chic-TZ	14	14		
May	22	Chic-TZ	14	14		
July	10	Chic-TZ	19	19		
August	17	Chic-TZ	12	12		
September	18	Chic-TZ	5	5		
					12.80	2.6
May	2	Doug-FB	13	13		
June	5	Doug-FB	15	15		
July	10	Doug-FB	10	10		
August	7	Doug-FB	10	10		
September	11	Doug-FB	6	6		
October	31	Doug-FB	2	2		
					9.33	4.3
May	4	Doug-MR	16	16		
June	7	Doug-MR	20	20		
July	13	Doug-MR	16	16		
August	10	Doug-MR	43	*		
September	13	Doug-MR	7	7		
October	31	Doug-MR	15	15		
					14.80 *	1.0
April	26	Font-FB	1	1		
June	6	Font-FB	1	1		
July	12	Font-FB	2	2		
August	15	Font-FB	2	2		
September	19	Font-FB	3	3		
October	23	Font-FB	2	2		
					1.83	5.0
April	26	FontLT-MR	5	5		
June	6	FontLT-MR	5	5		
July	11	FontLT-MR	6	6		
August	14	FontLT-MR	4	4		
					5.00	3.4
April	26	FontTk-MR	3	3		
June	6	FontTk-MR	7	7		
July	11	FontTk-MR	4	4		
August	14	FontTk-MR	4	4		
					4.50	3.8

Table 1
1995 Chlorophyll-a Results -- Vital Signs Monitoring Data

Date		Location	Chlorophyll-a Results		Average	Rating
April	25	FtLd-FB	10	10		
June	7	FtLd-FB	24	24		
July	19	FtLd-FB	22	22		
August	24	FtLd-FB	17	17		
October	19	FtLd-FB	6	6		
					15.80	1.1
April	25	FtLd-TZ	18	18		
June	7	FtLd-TZ	21	21		
July	19	FtLd-TZ	25	25		
August	24	FtLd-TZ	16	16		
October	19	FtLd-TZ	7	7		
					17.40	1.0
May	3	FtPt-FB	7	7		
June	12	FtPt-FB	15	15		
July	18	FtPt-FB/T1	21	21		
July	18	FtPt-FB/T2	20	triplicate		
July	18	FtPt-FB/T3	21	triplicate		
August	23	FtPt-FB	21	21		
October	4	FtPt-FB	18	18		
October	30	FtPt-FB	2	2		
					14.00	2.0
April	11	Kent-Emb	5	5		
May	17	Kent-Emb	9	9		
June	27	Kent-Emb/T1	20	20		
June	27	Kent-Emb/T2	20	triplicate		
June	27	Kent-Emb/T3	21	triplicate		
August	9	Kent-Emb	41	*		
September	13	Kent-Emb	52	*		
					11.33 *	1.3
April	10	Kent-FB	14	14		
May	17	Kent-FB	28	28		
June	27	Kent-FB	18	18		
August	8	Kent-FB	17	17		
September	13	Kent-FB	4	4		
					16.20	1.0
May	17	Kent-TZ	8	8		
June	27	Kent-TZ	7	7		
August	8	Kent-TZ	4	4		
September	14	Kent-TZ	4	4		
					5.75	5.0
April	12	L.Bear-FB	4	4		
May	16	L.Bear-FB	5	5		
June	20	L.Bear-FB	7	7		
July	25	L.Bear-FB	3	3		
August	30	L.Bear-FB	3	3		
October	17	L.Bear-FB	3	3		
					4.17	5.0
April	3	Nick-FB	5	5		
May	9	Nick-FB	11	11		
June	19	Nick-FB	13	13		
July	24	Nick-FB	5	5		
August	31	Nick-FB	4	4		
					7.60	5.0
April	6	Norm-FB	11	11		
May	10	Norm-FB	12	12		
June	14	Norm-FB	12	12		
July	12	Norm-FB	6	6		

Table 1
1995 Chlorophyll-a Results -- Vital Signs Monitoring Data

Date		Location	Chlorophyll-a Results		Average	Rating
August	16	Norm-FB	3	3		
September	13	Norm-FB	7	7		
November	2	Norm-FB	8	8		
					8.43	4.8
May	4	Norr-FB	4	4		
June	13	Norr-FB	Lost Sample			
July	17	Norr-FB	3	3		
July	17	Norr-FB(dup)	3	duplicate		
August	21	Norr-FB	2	2		
August	21	Norr-FB(dup)	2	duplicate		
October	3	Norr-FB	5	5		
November	1	Norr-FB	2	2		
					3.20	4.2
May	4	NorrC-MR	6	6		
June	14	NorrC-MR	5	5		
June	14	NorrC-MR(dup)	4	duplicate		
July	17	NorrC-MR	4	4		
August	22	NorrC-MR	3	3		
August	22	NorrC-MR(dup)	3	duplicate		
October	3	NorrC-MR	2	2		
November	1	NorrC-MR	9	9		
					4.83	5.0
May	3	NorrP-MR	5	5		
June	14	NorrP-MR	6	6		
June	14	NorrP-MR(dup)	6	duplicate		
July	17	NorrP-MR	5	5		
July	17	NorrP-MR(dup)	5	duplicate		
August	22	NorrP-MR	4	4		
August	22	NorrP-MR(dup)	3	duplicate		
October	3	NorrP-MR	3	3		
November	1	NorrP-MR	4	4		
					4.50	5.0
April	20	Nott-FB	6	6		
May	24	Nott-FB	5	5		
July	12	Nott-FB	2	2		
August	16	Nott-FB	3	3		
September	20	Nott-FB	5	5		
October	25	Nott-FB	4	4		
					4.17	4.1
April	20	Nott-MR	5	5		
May	24	Nott-MR	8	8		
July	12	Nott-MR/T1	5	5		
July	12	Nott-MR/T2	5	triplicate		
July	12	Nott-MR/T3	5	triplicate		
August	16	Nott-MR	7	7		
September	20	Nott-MR	8	8		
October	25	Nott-MR	12	12		
					7.50	1.4
April	18	Ocoee-FB	4	4		
May	23	Ocoee-FB	1	1		
July	13	Ocoee-FB	3	3		
August	15	Ocoee-FB	1	1		
September	21	Ocoee-FB	1	1		
October	23	Ocoee-FB	2	2		
					2.00	5.0
April	25	Tellico-FB	2	2		
June	7	Tellico-FB	9	9		

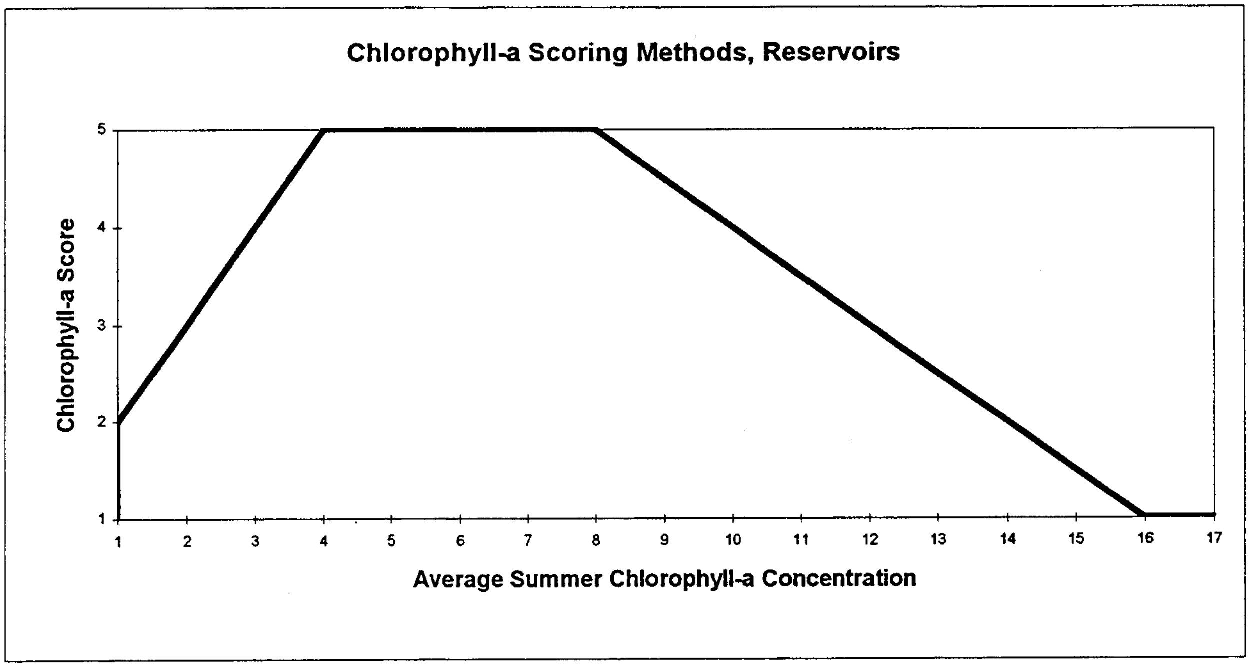
Table 1
1995 Chlorophyll-a Results -- Vital Signs Monitoring Data

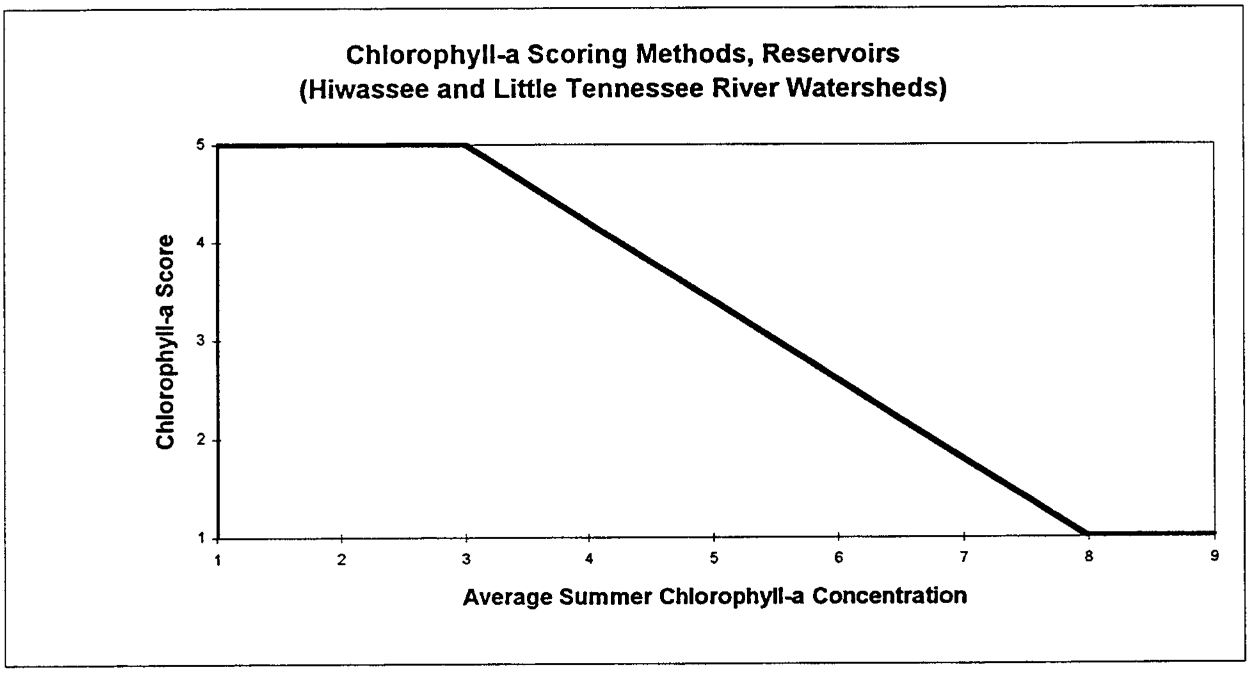
			Chlorophyll-a			
Date		Location	Results		Average	Rating
July	19	Tellico-FB	10	10		
August	24	Tellico-FB	10	10		
October	19	Tellico-FB	6	6		
					7.40	1.5
April	25	Tellico-TZ	5	5		
June	7	Tellico-TZ	3	3		
July	19	Tellico-TZ	4	4		
August	24	Tellico-TZ	4	4		
October	19	Tellico-TZ	5	5		
					4.20	4.0
April	6	TFord-FB	2	2		
May	10	TFord-FB	6	6		
June	26	TFord-FB	4	4		
August	7	TFord-FB	5	5		
September	12	TFord-FB	7	7		
November	2	TFord-FB	4	4		
					4.67	5.0
April	6	TFord-MR	5	5		
May	10	TFord-MR	10	10		
June	26	TFord-MR	5	5		
August	7	TFord-MR	7	7		
September	12	TFord-MR	6	6		
November	2	TFord-MR	7	7		
					6.67	5.0
April	4	Whel-Emb	24	24		
May	8	Whel-Emb	36	*		
June	19	Whel-Emb	18	18		
July	24	Whel-Emb	25	25		
August	29	Whel-Emb/T1	27	triplicate		
August	29	Whel-Emb/T2	28	triplicate		
August	29	Whel-Emb/T3	28	28		
					23.75 *	1.0
April	3	Whel-FB	10	10		
May	8	Whel-FB	30	*		
June	20	Whel-FB	4	4		
July	25	Whel-FB	10	10		
August	29	Whel-FB	8	8		
					8.00 *	4.0
April	4	Whel-TZ	2	2		
May	8	Whel-TZ	20	20		
June	19	Whel-TZ	25	25		
July	24	Whel-TZ	10	10		
August	29	Whel-TZ	5	5		
					12.40	2.8

* -- Indicates one (or more) chlorophyll-a results equaled or exceeded 30 ug/L

Shading indicates ratings for samples collected in a nutrient limited watershed

Figure 1





Chlorophyll-a Rating – The chlorophyll-a rating at each sampling location is based on the average summer concentration (of monthly photic zone composite samples). If triplicate samples are collected at a sampling location, only the median value of the triplicate is used in the calculation of the summer average and the maximum. If a monthly chlorophyll-a sample has a concentration that exceeds 30 ug/l, the value is not included in the calculation of the summer average, however, the final chlorophyll-a rating is decreased one unit, (i.e. 5 to 4, or 4 to 3, etc.) for each sample that exceeds 30 ug/l.

* If nutrients are present (e.g. total phosphorus greater than about 0.01 mg/L and nitrate+nitrite-nitrogen greater than about 0.05 mg/L) but chlorophyll-a concentrations are generally low (e.g. < 3ug/L), other limiting or inhibiting factors (e.g., high streamflows, turbidity, toxicity, etc.) must be considered. When these conditions exist, the chlorophyll-a rating is decreased one unit.

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Section 4.0. Sediment Quality

Philosophical Approach/Background

Contaminated bottom sediments can have direct adverse impacts on bottom fauna and can often be long-term sources of toxic substances to the aquatic environment. They may impact wildlife and humans through the consumption of contaminated food or water or through direct contact. These impacts may occur even though the water above the sediments meets water quality criteria. There are many sediment assessment methods, but there is no single method that measures all contaminated sediment impacts at all times and to all biological organisms (EPA, 1992). Prior to 1995, TVA's approach used two sediment assessment methods--one biological (toxicity tests), the other chemical (direct chemcial analysis of sediments)--to evaluate sediment quality. In 1995 only sediment chemical analysis of heavy metals, pesticides, and PCBs was used. The primary reason for excluding toxicity tests in 1995 was budget reductions. Another important reason was that toxicity testing protocols had changed often during the four years they had been part of this monitoring program. Test media had changed from sediment elutriate to sediment pore water. Test procedures/organisms had changed from Microtox®, to Microtox® plus Rototox®, and later to Rototox® plus 24-hour acute test using Ceriodaphnia. Protocols were to change again in 1995 to the newly approved EPA methods using whole sediments and amphipods and midge larvae.

A fundamental question concerning implications of sediment quality on overall reservoir ecological health is essentially a classification issue -- should reservoir ecological health evaluations be based on: (1) ideal conditions; for example, sediments should not have high concentrations of metals compared to background, should have no or at most very low concentrations of pesticides, and should not pose a toxic threat to biota; or (2) the best conditions expected for a reservoir given the environmental and operational characteristics of the dam/reservoir; for example, high concentrations of reduced metals are acceptable in tributary reservoirs due to anoxic conditions resulting from long retention times and thermal stratification. The approach taken for these studies accepts only ideal conditions. That is, metal concentrations should not be elevated and pesticides should not be present. In this situation, there is no need for classification because the same conditions are desired for all reservoirs.

Sediment Collection Methods

Sediment samples were collected during the summer of 1995 from 39 locations, i.e., the forebays and transition zones (or mid-reservoir) of 6 run-of-river reservoirs and 15 tributary reservoirs as shown in Table 1 of Section 1. In addition, 6 of the 39 locations were randomly selected for replicate QA/QC sampling. Sampling efforts were repeated at each of the 6 sites. Replicate samples were handled and processed independently. Results from these 6 sets of replicates were used to assess field methods consistency, variations in laboratory physical/chemical analyses, and spatial homogeneity of the sediment. Eckman dredge samplers were used to collect the top three centimeters of sediment. Each sediment sample was a composite of at least three subsamples independently collected at each sampling location from the original stream channel bed. At each sampling site, the subsamples were composited, thoroughly mixed to uniform color and consistency. Samples were placed on ice immediately after collection, compositing, and splitting, and were shipped or carried to the laboratory where they were analyzed for 13 metals and 26 selected trace organics (organochlorine pesticides and PCBs, Table 1).

Sediment Rating Scheme

Prior to 1995, the rating scheme was based on both results of toxicity tests (S_{TOX}) and chemcial analysis (S_{CHM}). The final for 1990 -1994 was the average of these two:

$$\textbf{Sediment Quality Rating} = \mathbf{0.5\ (S_{TOX}\ rating + S_{CHM}\ rating).}$$

This resulted in a sediment quality rating ranging from 1 (poor quality) to 5 (excellent quality) for a sample site. This rating was combined with ratings from the other four indicators (each with a rating ranging from 1 to 5) to arrive at an overall ecologial health score for a reservoir as described in Section 1.

Begining in 1995, only the rating from sediment chemical analysis was available. As a result, a decision had to be made regarding the sediment quality rating in relation to the other four indicaotrs. The decison is most easily underestood by examining the sediment quality rating equation. The two possibilities for 1995 were:

$$\textbf{Sediment Quality Rating} = \mathbf{S_{CHM}\ rating,}$$

or

$$\textbf{Sediment Quality Rating} = \mathbf{0.5\ (S_{CHM}\ rating).}$$

If the former were adopted, the end result would be for sediment chemistry alone to carry the same weight (i.e., contribute up to 5 points to the overall reservoir health score) as the other four indicators. If the latter were adopted, sediment quality would carry half the weight (i.e., contribute a maximum of 2.5 points) as the other indictors to the overall reservoir health score. The latter apporach was accepted because it was felt inappropriate for sediment chemistry alone to be equally weighted as DO, chlorophyll, benthos, and fish.

The rating for sediment chemistry was developed as follows:

S_{CHM} (Sediment Chemistry) Rating--Sediment samples were analyzed for heavy metals, organochlorine pesticides, and PCBs. Sediment chemistry ratings were based on: (a) concentrations of heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn) that exceed freshwater sediment guidelines (Table 1) and (b) detectable amounts of PCBs or pesticides. Each sampling location was rated as follows:

Sampling Location S_{CHM} Rating	Sediment Chemistry*
5 (good)	No analytes exceed guidelines;
3 (fair)	One or two analytes exceed guidelines;
1 (poor)	Three or more exceed guidelines.

* Analytes (i.e., heavy metals, pesticides, and PCBs) and guidelines are listed in Table 1.

Results from 1995 Monitoring

Table 2 provides sediment chemistry rating, Final Sediment Quality Rating, and comments for each location examined in 1995. Table 3 presents the sediment chemistry data which resulted in the sediment chemistry rating for each location.

References

Environmental Protection Agency, 1992. Sediment Classification Methods Compendium. EPA 823-R-92-006, USEPA, Washington, D.C.

Environmental Protection Agency, 1977. "Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments." USEPA, Region V, Chicago.

Table 1
Physical/Chemical Measurements of Sediment, Reservoir Vital Signs Monitoring, 1995

Description, units	Detection Limits (dry weight)	Sediment Quality Guidelines[a]
Metals		
Aluminum, mg/kg	5 mg/kg	--
Arsenic, mg/kg	0.5 mg/kg	15 mg/kg
Cadmium, mg/kg	0.5 mg/kg	6 mg/kg[b]
Calcium, mg/kg	10 mg/kg	--
Chromium, mg/kg	5 mg/kg	75 mg/kg[b]
Copper, mg/kg	1 mg/kg	50 mg/kg[b]
Iron, mg/kg	1 mg/kg	--
Lead, mg/kg	5 mg/kg	60 mg/kg[b]
Magnesium, mg/kg	1 mg/kg	--
Manganese, mg/kg	0.5 mg/kg	--
Mercury, mg/kg	0.1 mg/kg	1 mg/kg[b]
Nickel, mg/kg	5 mg/kg	50 mg/kg[b]
Zinc, mg/kg	1 mg/kg	300 mg/kg
Organochlorine Pesticides and PCB's		
Aldrin, μg/kg	10 μg/kg	10 μg/kg
α-Benzene Hexachloride (BHC), μg/kg	10 μg/kg	10 μg/kg
β-Benzene Hexachloride (BHC), μg/kg	10 μg/kg	10 μg/kg
γ-Benzene Hexachloride (Lindane), μg/kg	10 μg/kg	10 μg/kg
δ-Benzene Hexachloride (BHC), μg/kg	10 μg/kg	10 μg/kg
Chlordane, μg/kg	10 μg/kg	10 μg/kg
Dieldrin, μg/kg	10 μg/kg	10 μg/kg
ρ,ρ DDT, μg/kg	10 μg/kg	10 μg/kg
ρ,ρ DDD, μg/kg	10 μg/kg	10 μg/kg
ρ,ρ DDE, μg/kg	10 μg/kg	10 μg/kg
α-Endosulfan, μg/kg	10 μg/kg	10 μg/kg
β-Endosulfan, μg/kg	10 μg/kg	10 μg/kg
Endosulfan Sulfate, μg/kg	10 μg/kg	10 μg/kg
Endrin, μg/kg	10 μg/kg	10 μg/kg
Endrin Aldehyde, μg/kg	10 μg/kg	10 μg/kg
Heptachlor, μg/kg	10 μg/kg	10 μg/kg
Heptachlor Epoxide, μg/kg	10 μg/kg	10 μg/kg
Methoxychlor, μg/kg	10 μg/kg	10 μg/kg
PCB-1221, μg/kg	25 μg/kg	25 μg/kg
PCB-1232, μg/kg	25 μg/kg	25 μg/kg
PCB-1242, μg/kg	25 μg/kg	25 μg/kg
PCB-1248, μg/kg	25 μg/kg	25 μg/kg
PCB-1254, μg/kg	25 μg/kg	25 μg/kg
PCB-1260, μg/kg	25 μg/kg	25 μg/kg
PCB-1016, μg/kg	25 μg/kg	25 μg/kg
PCB's, Total, μg/kg	25 μg/kg	25 μg/kg
Toxaphene, μg/kg	500 μg/kg	500 μg/kg

[a] Unless otherwise noted, guidelines are suggested TVA Sediment Quality Guidelines.
[b] EPA Region V Guidelines for polluted freshwater sediment (EPA, 1977).

(sedanl95.tbl)

Table 2
1995 Sediment Ratings -- Vital Signs Reservoir Monitoring

Chemistry
5 - no analytes
3 - 1 or 2 analytes
1 - 3 or more analytes

Toxicity
5 - no toxicity
3 - some toxicity
1 - significant toxicity

No Toxicity Testing in 1995

0.5 (SED chm) + (SED tox) = Sediment Quality Rating

Reservoir	Mile	Comment	Collection Date yy	mm	dd	# Pest.	# Metals	SED-CHM RATING	SED-TOX RATING	SEDIMENT QUALITY RATING	COMMENTS
Kentucky	TRM 23.0		95	8	13	0	0	5		2.5	
Kentucky	TRM 85.0		95	9	14	0	0	5		2.5	
Kentucky	BSRM 7.4		95	9	13	0	0	5		2.5	
Wheeler	TRM 277.0		95	8	29	0	0	5		2.5	
Wheeler	TRM 295.9		95	8	29	1	0	3 (4)		1.5 (2.0)	DL conc of DDD
Wheeler	ERM 6.0	Dup-1	95	8	29	0	0	5		2.5	
		Dup-2	95	8	29	0	0	5		2.5	
		Precision				0	0	5		2.5	
Nickajack	TRM 425.5	Dup-1	95	8	31	1	0	3		1.5	PCB
		Dup-2	95	8	31	1	0	3		1.5	PCB
Chickamauga	TRM 472.3		95	8	17	0	2	3		1.5	Cu, Zn
Chickamauga	TRM 490.5		95	8	17	0	0	5		2.5	
Chickamauga	HiRM 8.5		95	8	17	0	0	5		2.5	
Fort Loudoun	TRM 605.5		95	8	24	2	0	3		1.5	Chlordane, PCB
Fort Loudoun	TRM 624.6		95	8	24	2	0	3		1.5	Chlordane, PCB
		Precision				2	1	1		0.5	Chlordane, PCB, Zn
Tellico	LTRM 1.0		95	10	19	2	0	3		1.5	Aldrin, Dieldrin
Tellico	LTRM 15.0	Dup-1	95	8	24	0	0	5		2.5	
		Dup-2	95	10	19	0	0	5		2.5	
Norris	CRM 80.0	Dup-1	95	8	21	0	2	3		1.5	As, Pb
		Dup-2	95	10	3	0	2	3		1.5	As, Pb
Norris	CRM 125.0		95	8	22	0	0	5		2.5	
Norris	PRM 30.0		95	8	22	1	0	3 (4)		1.5 (2.0)	DL conc of β-endosulfan
Douglas	FBRM 33.0		95	9	11	0	0	5		2.5	
Douglas	FBRM 50.0		95	9	13	2	0	3		1.5	
Cherokee	HRM 55.0		95	9	18	0	0	5		2.5	
Cherokee	HRM 77.0		95	9	20	0	1	3 (4)		1.5 (2.0)	Copper, 50ug/g

Table 2
1995 Sediment Ratings -- Vital Signs Reservoir Monitoring

Chemistry
5 - no analytes
3 - 1 or 2 analytes
1 - 3 or more analytes

Toxicity	
5 - no toxicity	No Toxicity Testing in 1995
3 - some toxicity	
1 - significant toxicity	

0.5 (SED chm) + (SED tox) = Sediment Quality Rating

Reservoir	Mile	Comment	Collection Date yy	mm	dd	# Pest.	# Metals	SED-CHM RATING	SED-TOX RATING	SEDIMENT QUALITY RATING	COMMENTS
Ft Pat Henry	SFHRM 8.7		95	8	23	1	0	3		1.5	Chlordane
Boone	SFHRM 19.0		95	8	23	1	0	3		1.5	Chlordane
Boone	SFHRM 27.0		95	8	23	2	0	3		1.5	Chlordane, PCB
Boone	WRM 6.5		95	8	23	2	2	1		0.5	Chlordane, PCB, Cu, Zn
Fontana	LTRM 62.0		95	8	15	0	0	5		2.5	
Fontana	LTRM 81.5		95	8	14	1	0	3		1.5	Chlordane
Fontana	TkRM 3.0		95	8	14	0	0	5		2.5	
Nottely	NRM 23.5		95	8	16	0	0	5		2.5	
Nottely	NRM 31.0		95	8	16	1	0	3 (4)		1.5 (2.0)	DL conc of DDE
Ocoee #1	ORM 12.5	Dup-1	95	8	15	1	4	1		0.5	PCB, As, Cu, Pb, Zn
		Dup-2	95	9	21	1	4	1		0.5	PCB, As, Cu, Pb, Zn
		Precision				1	4	1		0.5	PCB, As, Cu, Pb, Zn
Blue Ridge	ToRM 54.1		95	8	16	1	0	3 (4)		1.5 (2.0)	DL conc of DDE
Tims Ford	ERM 135.0		95	9	12	0	1	3		1.5	Ni
Tims Ford	ERM 150.0		95	9	12	0	0	5		2.5	
Normandy	DRM 249.5	Dup-1	95	8	16	0	0	5		2.5	
		Dup-2	95	11	2	0	0	5		2.5	
Bear Creek	BCM 75.0		95	8	30	0	0	5		2.5	
L. Bear Creek	LBCM 12.5		95	8	30	0	0	5		2.5	
Cedar Creek	CCM 25.2		95	8	30	0	0	5		2.5	
Beech	BRM 36.0		95	9	13	1	0	3		1.5	DDE
(sed95a.xls)											

Table 3

Vital Signs Reservoir Monitoring 1995 - Sediment

Reservoir	Mile	Comment	Collection Date yy	mm	dd	Metals, mg/kg (dry weight) ALUMINUM	ARSENIC	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	ZINC
Kentucky	TRM 23.0		95	8	13	28000	4.5	0.5 K	3200	32	20	33000	22	3000	3000	0.13	30	120
Kentucky	TRM 85.0		95	9	14	17000	3.7	0.5 K	2700	20	12	21000	14	2300	2100	0.10 K	17	72
Kentucky	BSRM 7.4		95	9	13	810	0.5 K	0.5 K	70	5 K	1 K	1200	5 K	68	230	0.10 K	5 K	1 K
Wheeler	TRM 277.0		95	8	29	30000	9.0	0.5 K	3000	31	24	37000	25	2400	2400	0.16	27	140
Wheeler	TRM 295.9		95	8	29	18000	2.2	0.5 K	1500	17	14	24000	16	1800	1500	0.13	14	83
Wheeler	ERM 6.0	Dup-1	95	8	29	23000	4.0	0.5 K	8000	22	10	28000	24	2600	2300	0.10	27	72
		Dup-2	95	8	29	24000	4.2	0.5 K	7000	23	10	26000	20	2900	2300	0.10	28	79
		Precision				23000	3.8	0.5 K	7000	20	10	26000	20	2600	2100	0.10	25	69
Nickajack	TRM 425.5	Dup-1	95	8	31	21000	5.2	0.5 K	2800	30	38	29000	42	2700	2900	0.27	25	230
		Dup-2	95	8	31	23000	5.2	0.5 K	3500	30	43	32000	46	2800	3200	0.27	29	250
Chickamauga	TRM 472.3		95	8	17	30000	7.9	0.5 K	2500	31	63	40000	47	3100	5200	0.37	32	300
Chickamauga	TRM 490.5		95	8	17	26000	5.8	0.5 K	2600	30	32	37000	43	3300	3800	0.31	30	240
Chickamauga	HiRM 8.5		95	8	17	7500	0.5 K	0.5 K	560	12	18	12000	13	1300	440	0.13	8	180
Fort Loudoun	TRM 605.5		95	8	24	31000	9.1	0.5 K	5000	33	31	47000	46	4000	3000	0.15	30	260
Fort Loudoun	TRM 624.6		95	8	24	26000	6.4	0.9	7200	32	32	39000	39	5200	2700	0.14	26	290
		Precision				29000	6.6	1.0	7000	32	32	38000	38	5200	2700	0.15	28	300

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

			Collection Date			Metals, mg/kg (dry weight)												
Reservoir	Mile	Comment	yy	mm	dd	ALUMINUM	ARSENIC	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	ZINC
Tellico	LTRM 1.0		95	10	19	29000	4.8	0.5 K	1700	29	20	34000	22	4300	2000	0.10	26	110
Tellico	LTRM 15.0	Dup-1	95	8	24	40000	6.4	0.5 K	1700	26	24	48000	32	3100	3800	0.13	24	100
		Dup-2	95	10	19	32000	6.4	0.5 K	2000	27	23	45000	32	3200	3800	0.12	25	100
Norris	CRM 80.0	Dup-1	95	8	21	25000	22.0	0.5 K	3900	22	24	39000	80	2300	5000	0.13	30	120
		Dup-2	95	10	3	31000	24.0	0.5 K	4600	27	29	41000	89	2800	5300	0.14	38	150
Norris	CRM 125.0		95	8	22	16000	3.8	0.5 K	5900	19	15	25000	22	3000	670	0.10 K	24	85
Norris	PRM 30.0		95	8	22	23000	8.0	0.5 K	6400	21	24	35000	44	3800	1200	0.10 K	34	160
Douglas	FBRM 33.0		95	9	11	41000	6.6	0.5 K	2600	44	31	51000	36	4400	1100	0.10 K	31	190
Douglas	FBRM 50.0		95	9	13	36000	0.5 K	0.5 K	2800	42	32	42000	34	5000	840	0.10 K	30	200
Cherokee	HRM 55.0		95	9	18	30000	9.3	0.5 K	4300	34	39	37000	34	2600	840	0.19	28	130
Cherokee	HRM 77.0		95	9	20	29000	9.6	0.5 K	11000	32	50	36000	28	3600	1100	0.35	30	150
Ft Pat Henry	SFHRM 8.7		95	8	23	27000	6.0	0.5 K	5200	30	41	34000	34	4100	1400	0.13	25	210
Boone	SFHRM 19.0		95	8	23	31000	7.2	0.5 K	4000	33	30	40000	36	3800	1300	0.10	28	160
Boone	SFHRM 27.0		95	8	23	22000	4.5	0.5 K	31000	27	27	28000	31	3900	1200	0.14	26	31
Boone	WRM 6.5		95	8	23	30000	5.2	0.5 K	4800	31	53	40000	46	5000	1000	0.17	26	310
Fontana	LTRM 62.0		95	8	15	64000	3.7	0.5 K	570	35	37	60000	28	5400	1700	0.10	30	130
Fontana	LTRM 81.5		95	8	14	49000	1.6	0.5 K	1400	41	35	46000	18	7100	750	0.10 K	26	120
Fontana	TkRM 3.0		95	8	14	30000	1.2	0.5 K	1000	32	19	36000	12	8600	440	0.10 K	23	100

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Reservoir	Mile	Comment	yy	mm	dd	ALUMINUM	ARSENIC	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	ZINC
			Collection Date			Metals, mg/kg (dry weight)												
Nottely	NRM 23.5		95	8	16	68000	2.2	0.5 K	810	36	32	52000	25	2800	490	0.10 K	22	92
Nottely	NRM 31.0		95	8	16	43000	1.2	0.5 K	980	34	29	35000	16	4000	400	0.10 K	18	94
Ocoee #1	ORM 12.5	Dup-1	95	8	15	64000	49.0	2.2	1500	38	1300	100000	810	2900	1600	0.25	22	1200
		Dup-2	95	9	21	60000	43.0	2.0	1400	36	1300	96000	920	2300	1700	0.21	24	1200
		Precision				58000	42.0	2.2	1400	35	1200	96000	920	2800	1700	0.23	24	1200
Blue Ridge	ToRM 54.1		95	8	16	55000	2.2	0.5 K	390	34	30	50000	26	3000	330	0.10 K	21	95
Tims Ford	ERM 135.0		95	9	12	24000	11.0	0.5 K	9800	20	17	34000	20	3000	2300	0.10 K	65	86
Tims Ford	ERM 150.0		95	9	12	25000	7.3	0.5 K	2300	26	12	24000	24	1800	1100	0.10 K	28	82
Normandy	DRM 249.5	Dup-1	95	8	16	28000	8.4	0.5 K	2200	21	21	30000	22	2000	1300	0.10 K	31	84
		Dup-2	95	11	2	24000	6.4	0.5 K	2100	19	2	29000	21	1700	1600	0.10 K	30	74
Bear Creek	BCM 75.0		95	8	30	23000	5.0	0.5 K	1300	27	13	30000	16	2000	1300	0.10 K	24	78
L. Bear Creek	LBCM 12.5		95	8	30	29000	9.8	0.5 K	2700	41	14	41000	24	2000	1200	0.10 K	32	150
Cedar Creek	CCM 25.2		95	8	30	28000	8.2	0.5 K	6600	33	10	36000	18	2300	1400	0.10 K	25	88
Beech	BRM 36.0		95	9	13	33000	14.0	0.5 K	1200	28	18	43000	29	2300	930	0.10 K	24	76
			Number			50	50	50	50	50	50	50	50	50	50	50	50	50
			Max			64000	24.0	1.0	31000	44	63	60000	89	8600	5300	0.37	38	310
			Min			810	0.5 K	0.5 K	70	5 K	1 K	1200	5 K	68	230	0.10 K	5 K	1 K
			Mean			25992	5.8	0.5 K	4443	27	27	33148	32	3331	2264	0.16 K	25	159

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	ALDRIN	Benzene Hexachloride (BHC) ALPHA	BETA	GAMMA	DELTA	CHLORDANE	DIELDRIN	DDT's p,p DDT	p,p DDD	p,p DDE	Endosulfan ALPHA	BETA	SULFATE	ENDRIN
Kentucky	TRM 23.0		95	8	13	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Kentucky	TRM 85.0		95	9	14	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Kentucky	BSRM 7.4		95	9	13	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Wheeler	TRM 277.0		95	8	29	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Wheeler	TRM 295.9		95	8	29	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10	10 K	10 K	10 K	10 K	10 K
Wheeler	ERM 6.0	Dup-1	95	8	29	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	8	29	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Precision				10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Nickajack	TRM 425.5	Dup-1	95	8	31	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	8	31	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Chickamauga	TRM 472.3		95	8	17	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Chickamauga	TRM 490.5		95	8	17	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Chickamauga	HiRM 8.5		95	8	17	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Fort Loudoun	TRM 605.5		95	8	24	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Fort Loudoun	TRM 624.6		95	8	24	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Precision				10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	ALDRIN	Benzene Hexachloride (BHC) ALPHA	BETA	GAMMA	DELTA	CHLORDANE	DIELDRIN	DDTs p,p DDT	p,p DDD	p,p DDE	Endosulfan ALPHA	BETA	SULFATE	ENDRIN
Tellico	LTRM 1.0		95	10	19	10	10 K	10 K	10 K	10 K	10 K	70	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Tellico	LTRM 15.0	Dup-1	95	8	24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	10	19	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Norris	CRM 80.0	Dup-1	95	8	21	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	10	3	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Norris	CRM 125.0		95	8	22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Norris	PRM 30.0		95	8	22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10	10 K	10 K
Douglas	FBRM 33.0		95	9	11	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Douglas	FBRM 50.0		95	9	13	10 K	10 K	10 K	10 K	10 K	10	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K
Cherokee	HRM 55.0		95	9	18	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Cherokee	HRM 77.0		95	9	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Ft Pat Henry	SFHRM 8.7		95	8	23	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Boone	SFHRM 19.0		95	8	23	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Boone	SFHRM 27.0		95	8	23	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Boone	WRM 6.5		95	8	23	10 K	10 K	10 K	10 K	10 K	30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Fontana	LTRM 62.0		95	8	15	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Fontana	LTRM 81.5		95	8	14	10 K	10 K	10 K	10 K	10 K	30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Fontana	TkRM 3.0		95	8	14	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	ALDRIN	Benzene Hexachloride (BHC) ALPHA	BETA	GAMMA	DELTA	CHLORDANE	DIELDRIN	DDT's p,p DDT	p,p DDD	p,p DDE	Endosulfan ALPHA	BETA	SULFATE	ENDRIN
Nottely	NRM 23.5		95	8	16	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Nottely	NRM 31.0		95	8	16	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10	10 K	10 K	10 K	10 K
Ococe #1	ORM 12.5	Dup-1	95	8	15	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	9	21	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Precision				10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Blue Ridge	ToRM 54.1		95	8	16	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10	10 K	10 K	10 K	10 K
Tims Ford	ERM 135.0		95	9	12	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Tims Ford	ERM 150.0		95	9	12	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Normandy	DRM 249.5	Dup-1	95	8	16	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
		Dup-2	95	11	2	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Bear Creek	BCM 75.0		95	8	30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
L. Bear Creek	LBCM 12.5		95	8	30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Cedar Creek	CCM 25.2		95	8	30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
Beech	BRM 36.0		95	9	13	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	20	10 K	10 K	10 K	10 K

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	ENDRIN	ALDEHYDE	HEPTACHLOR	HEPTACHLOR EPOXIDE	PCB 1221	PCB 1232	PCB 1242	PCB 1248	PCB 1254	PCB 1260	PCB 1016	PCB TOTAL	METHOXYCHLOR	TOXAPENE
Kentucky	TRM 23.0		95	8	13	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Kentucky	TRM 85.0		95	9	14	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Kentucky	BSRM 7.4		95	9	13	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Wheeler	TRM 277.0		95	8	29	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Wheeler	TRM 295.9		95	8	29	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Wheeler	ERM 6.0	Dup-1	95	8	29	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
		Dup-2	95	8	29	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
		Precision				10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Nickajack	TRM 425.5	Dup-1	95	8	31	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	30	25 K	30	10 K	500 K
		Dup-2	95	8	31	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	50	25 K	50	10 K	500 K
Chickamauga	TRM 472.3		95	8	17	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Chickamauga	TRM 490.5		95	8	17	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Chickamauga	HiRM 8.5		95	8	17	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Fort Loudoun	TRM 605.5		95	8	24	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	50	25 K	50	10 K	500 K
Fort Loudoun	TRM 624.6		95	8	24	10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	50	25 K	50	10 K	500 K
		Precision				10 K		10 K	10 K	25 K	25 K	25 K	25 K	25 K	60	25 K	60	10 K	500 K

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	ENDRIN ALDEHYDE	HEPTACHLOR	HEPTACHLOR EPOXIDE	Polychlorinated Biphenyls (PCB's) 1221	1232	1242	1248	1254	1260	1016	TOTAL	METHOXYCHLOR	TOXAPENE
Tellico	LTRM 1.0		95	10	19	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Tellico	LTRM 15.0	Dup-1	95	8	24	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
		Dup-2	95	10	19	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Norris	CRM 80.0	Dup-1	95	8	21	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
		Dup-2	95	10	3	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Norris	CRM 125.0		95	8	22	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Norris	PRM 30.0		95	8	22	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Douglas	FBRM 33.0		95	9	11	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Douglas	FBRM 50.0		95	9	13	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Cherokee	HRM 55.0		95	9	18	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Cherokee	HRM 77.0		95	9	20	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Ft Pat Henry	SFHRM 8.7		95	8	23	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Boone	SFHRM 19.0		95	8	23	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Boone	SFHRM 27.0		95	8	23	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	120	25 K	120	10 K	500 K
Boone	WRM 6.5		95	8	23	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	50	25 K	50	10 K	500 K
Fontana	LTRM 62.0		95	8	15	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Fontana	LTRM 81.5		95	8	14	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Fontana	TkRM 3.0		95	8	14	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K

Table 3 (continued)

Vital Signs Reservoir Monitoring 1995 - Sediment

Organochlorine Pesticides and PCB's (ug/kg dry weight)

Reservoir	Mile	Comment	Collection Date yy	mm	dd	Endrin Aldehyde	Heptachlor	Heptachlor Epoxide	Polychlorinated Biphenyls (PCB's) 1221	1232	1242	1248	1254	1260	1016	Total	Methoxychlor	Toxaphene
Nottely	NRM 23.5		95	8	16	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Nottely	NRM 31.0		95	8	16	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Ocoee #1	ORM 12.5	Dup-1	95	8	15	10 K	10 K	10 K	25 K	25 K	25 K	25 K	320	25 K	25 K	320	10 K	500 K
		Dup-2	95	9	21	10 K	10 K	10 K	25 K	25 K	25 K	25 K	310	25 K	25 K	310	10 K	500 K
		Precision				10 K	10 K	10 K	25 K	25 K	25 K	25 K	330	25 K	25 K	330	10 K	500 K
Blue Ridge	ToRM 54.1		95	8	16	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Tims Ford	ERM 135.0		95	9	12	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Tims Ford	ERM 150.0		95	9	12	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Normandy	DRM 249.5	Dup-1	95	8	16	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
		Dup-2	95	11	2	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Bear Creek	BCM 75.0		95	8	30	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
L. Bear Creek	LBCM 12.5		95	8	30	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Cedar Creek	CCM 25.2		95	8	30	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K
Beech	BRM 36.0		95	9	13	10 K	10 K	10 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	25 K	10 K	500 K

Section 5. Benthic Macroinvertebrate Community

Philosophical Approach/Background

Benthic macroinvertebrates are usually included in aquatic monitoring programs because they are important to the aquatic foodweb and because they have limited capability of movement thereby preventing them from avoiding undesirable conditions. The macroinvertebrate community in a reservoir is expected to be vastly different from that in a free-flowing river. Also, substantial differences are expected along a longitudinal gradient with a more riverine community expected at the upper end or inflow of a reservoir and a more lake like community expected in the pool near the dam. Other factors to consider in evaluating this community in reservoirs include reservoir operational characteristics (e.g., depth of withdrawal for discharge, water depth, depth of drawdown for flood control, retention time, stratification, bottom anoxia, substrate type and stability) and physical/chemical features owing to geological characteristics of different ecoregions.

All these factors, plus the fact that a reservoir is an artificial system, must be considered in selecting community characteristics or expectations that will be used to represent good, fair, and poor conditions. Given that reservoirs are artificial systems, it is not possible to use the well accepted Index of Biotic Integrity (IBI) approach of using reference sites to determine characteristics or expectations of a reservoir unaffected by human impacts. Other approaches must be used such as: historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. As stated above, preimpoundment conditions are inappropriate due to significant habitat alterations. The state of the science of benthic macroinvertebrate communities in reservoirs is insufficient for predictive models to be effective. This leaves the latter two as the most viable alternatives for establishing appropriate reference conditions or expectations for this community in reservoirs. TVA's experience has found use of best observed conditions adjusted using professional judgment is the best approach. Use of best observed conditions requires an extensive database to determine metric expectations, and use of professional judgment to adjust scoring ranges requires substantial experience with the group of reservoirs under consideration. To use this concept, results in the data base which approach desired conditions for a given community characteristic are considered representative of best observed condition. Monitoring results falling within that range would be considered "good". Details of this approach to developing reference conditions are provided later in this section.

Another important consideration in developing reference conditions is that care must be taken to compare only those reservoirs for which comparison is appropriate. That is, only reservoirs for which similar communities would be expected should be compared--those in the same ecoregion with comparable physical characteristics. Hence, separation of reservoirs into appropriate classes is a critical step.

TVA's monitoring program includes 30 reservoirs. For classification purposes these have been divided into two major groups : "run-of-the-river" reservoirs (those with short retention times and winter drawdown of only a few feet) and tributary reservoirs (those with long retention times and substantial winter drawdowns). The tributary reservoirs have been further divided into three groups by ecoregion and reservoir physical characteristics.

Run-of-the-River <u>Reservoirs</u>
- Kentucky
- Pickwick
- Wilson
- Wheeler
- Guntersville
- Nickajack
- Chickamauga
- Watts Bar
- Melton Hill
- Tellico
- Fort Loudon

Tributary Reservoirs: <u>Interior Plateau Ecoregion</u>
- Bear Creek
- Cedar Creek
- Little Bear
- Normandy
- Beech

Tributary Reservoirs: <u>Ridge and Valley Ecoregion</u>
- Cherokee
- Fort Patrick Henry*
- Boone
- South Holston
- Norris
- Douglas
- Tims Ford**

Tributary Reservoirs: <u>Blue Ridge Ecoregion</u>
- Fontana
- Hiwassee
- Chatuge
- Nottely
- Parksville***
- Blue Ridge
- Watauga

* Fort Patrick Henry Reservoir was included in this class because it is in the Ridge and Valley Ecoregion, but its results were excluded in developing scoring ranges for this class because its shallow drawdown and short retention are uncharacteristic of the other reservoirs in this class.
** Tims Ford is in the Interior Plateau ecoregion but due to operational and morphological characteristics was considered more similar to and classified with Ridge and Valley reservoirs.
***Results for Parksville Reservoir were excluded from developing reference conditions because of known poor sediments conditions (very high metal concentrations), which would be expected to cause a degraded benthic macroinvertebrate community.

Once reservoirs have been appropriately classified, scoring criteria (i.e., those values for each metric which will be considered good, fair, or poor) must be developed. When using best observed conditions, a data base must exist and decisions made as to how best to separate data for each metric into the three scoring ranges of good, fair, and poor. The approach taken by TVA is, for each metric, to first omit outliners (defined as more than three standard deviations from the mean), then trisect the range of the remaining values. Cutoff points are examined closely and adjusted if appropriate based on professional judgment. These three ranges represent good, fair, and poor conditions and form the reference conditions or expectations for each metric. More details of TVA's approach to developing scoring ranges are provided under the Benthic Community Scoring Scheme below.

Sample Collection Methods

Benthic macroinvertebrate samples were collected in the late fall/early winter (November-December) at 44 locations on 21 TVA reservoirs in 1995 (Table 1, Section 1). This is a change from the late winter/early spring (February-March) sampling seasons of the previous five years. Vital Signs monitoring results are summarized and reported on a calendar year cycle. The problem with using late winter/early spring benthic macroinvertebrate information is that they are an indication of the conditions which existed during the summer and autumn of the previous year. This has the undesirable effect of causing results for benthic macroinvertebrates to be out of synch with the rest of the monitoring data for a particular year. Benthos sampling was initially conducted in late autumn/early winter because the required reporting date of mid-January did not allow sample processing time in the laboratory. Also, there was concern that insect instars would be so small that they could pass through the collection screen and/or be difficult to identify. Thorough evaluation of the 1993 - 1994 results showed late fall/early winter collection and use of field identification to the Family and Order levels would negate most of the problems resulting from late winter/early spring sampling and would improve the contribution of this important community to the overall reservoir evaluation. The basis for these changes are documented in Appendix C of Dycus 1995. Actual implications of implementing the changes are discussed later in this section.

At each sample location, a line-of-sight transect was established across the width of the reservoir, and one Ponar grab sample collected at 10 equally-spaced locations along this transect. When rocky substrates were encountered, a Peterson dredge was used. Care was taken to collect samples only from the permanently wetted bottom portion of the reservoir (i.e., below the elevation of the minimum winter pool level). Samples were washed in the field, counted, and identified to either family or order level as appropriate (i.e., the lowest practical in the field). Samples were then transferred to a labeled collection jar, and fixed with 10 percent buffered formalin solution.

The Quality Control (QC) element of the benthic macroinvertebrate evaluation includes two components. One examines how the final benthic score is affected by the change from full laboratory processing to field processing. The other examines the reproducibility of benthic macroinvertebrate sampling results. To fulfill the first component, samples from 8 sites (about 20% of the sampling locations) were processed in the field (described above) and later sent to the benthic laboratory for full processing as in previous years (sorted and quantified at the lowest practical taxon). Benthic scores were developed for both sets of sample results and compared. To examine the reproducibility of the collection and analysis procedure, the same 8 sites selected above were resampled. This was achieved by collecting the first set of 10 samples, leaving the sampling location, and then returning as near as possible to the original transect site (on the same day) and repeating the collection of a second (replicate) set of 10 samples. In this effort, both sets of samples were field processed and benthic scores developed and compared for each set of samples. All classes of reservoirs and types of locations (i.e., forebay, transition zone, embayment, and inflow) were included in the QC effort. Benthic macroinvertebrate data are available in computer-readable form from TVA upon request.

Benthic Community Rating Scheme

Seven community characteristics (or metrics), were selected to evaluate the benthic community in 1995. This is a change from previous years when 8 were used. The Percent Chironomid metric was dropped, because it "penalized" a site if there was an abundance of chironomids, which may or may not be tolerant of pollution depending on the species.

1. **Taxa richness**—The average total number of taxa per sample at each site. An increase taxa richness indicates better conditions than low taxa richness.
2. **EPT**—The average total number of Ephemeroptera, Plecoptera, and Trichoptera per sample at each site. Higher diversity of these taxa indicate good water quality and other habitat conditions in streams. A similar use is incorporated here despite expected lower numbers in reservoirs than in streams.
3. **Long-lived species**—The proportion of samples with at least one long-lived organism (Corbicula, Hexagenia, mussels, and snails) present. The presence of long-lived taxa is indicative of conditions which allow long-term survival.
4. **Percentage as Tubificidae**—The average percentage of tubificids in each sample at each site. A higher proportion indicates poor water quality.
5. **Percentage as dominant taxa**—The average percentage of the two dominant families in each sample even if the dominant taxon differed among the samples at a site. This allows more discretion to identify imbalances at a site than developing an average for a single

dominant taxon for all samples a site. This metric is used as an evenness indicator. Dominance of one or two families indicates poor conditions.

6. **Total abundance excluding Chironomidae and Tubificidae**—The average number of organisms excluding chironomids and tubificids per sample at each site. This metric examines the community excluding families which often dominate under adverse conditions. A higher abundance of non-chironomids and tubificids indicates good water quality conditions.
7. **Proportion of samples with no organisms present**—Proportion of samples with no organisms present. "Zero-samples" indicate living conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). Any site having one or more empty samples was assigned a score of one. Sites with no empty samples were assigned a score of five.

Scoring Criteria for each of the seven metrics were developed using the five years of Vital Signs monitoring data (1990 - 1995). Scoring ranges were developed as follows:

- Individual criteria were developed for each type of sampling location (forebay, transition zone/mid-reservoir, embayment and inflow) for each of the four classes of reservoirs.
- Results from the 10 samples along a transect for each sample year were combined (averaged for most metrics) and outliers deleted.
- The range of average values was then trisected with the third of the range representing desirable conditions assigned a value of 5 (good), the middle one-third assigned a 3 (fair), and the third representing undesirable conditions was assigned a 1 (poor).

Professional judgment and observations on the entire data base were used to adjust the cutoffs for the range of each metric. Scoring criteria resulting from these efforts are detailed for each metric in Table 1. Separate tables are provided for each class of reservoir. It is important to note ranges reported here for 1995 differ from those listed in the informal report for 1994 because the 1995 ranges were established for field processed samples as described above and the 1994 ranges were for lab processed samples. Scoring criteria for results from lab processed samples can be found in the 1994 report covering Vital Signs methods and results (Dycus, 1995).

Sample results at each site were compared with these criteria for each metric and assigned the rating described above -- 5 (good), 3 (fair), or 1 (poor) if they fell in the top, middle, or bottom group, respectively. Numerical ratings for the seven metrics were then summed. This resulted in a minimum score of 7 if all metrics at a site were poor, and a maximum score of 35 if all metrics were excellent.

One use of the benthic macroinvertebrate score is to help establish the overall ecological health score for a reservoir as described in Section 1. The benthic macroinvertebrate community is one of five indicators which are summed to arrive at an overall Ecological Health Index for a reservoir.

To arrive at an evaluation of the condition of the benthic macroinvertebrate community at a sample location, scores were evaluated as follows:

Benthic Community Score	7-12	13-18	19-23	24-29	30-35
Community Condition	Very Poor	Poor	Fair	Good	Excellent
Contribution to Reservoir Ecological Health Score	1	2	3	4	5

Benthic community results along with results from the other four indicators and overall ecological health scores for each reservoir are used to keep the public informed on the conditions of Tennessee Valley reservoirs. In publications intended for the public, results for each of the five environmental indicators at each sample site are presented using one of three colors -- green (good), yellow (fair), or red (poor). This necessitates dividing scores for each indicator into three ranges. The benthic macroinvertebrate scores are categorized as follows:

Benthic Community Score	7-16	17-26	27-35
Color	Poor (Red)	Fair (Yellow)	Good (Green)

Results from 1995 Monitoring

Results and Scores

Results from 1995 monitoring activities are summarized for each sample location by reservoir class and reservoir section in Table 2. This table includes the final benthic score and results plus ratings for each of the seven metrics. Results for 1994 are also included in Table 2. All results in Table 2 are from field-processed samples. Appendix C provides mean density for each taxon at each location in 1995; first for field-processed samples, followed by lab-processed samples. Scores based on lab-processed samples for 1995 are in Table 3.

Table 4 provides benthic community scores for all years and locations for which monitoring has been conducted. The primary purpose of this table is to examine implications of the two changes in protocols implemented in 1995 -- one was a change to autumn rather than spring sampling and the other was a change to field processing of samples rather than complete processing and enumeration in the laboratory (further discussion of lab versus field processing is provided below in Evaluation of QC Results). To allow apples-to-apples comparisons, results for all years were scored using 1995 protocols (new scoring ranges for each metric and one less metric compared to previous years). To allow evaluation of field versus lab processing, scores in Table 4 for 1991 - 1994 were based on results from lab-processed samples, whereas, scores for 1995 were based on results from field-processed samples. The basic assumption for this examination is that if the final benthic community scores for 1995 were similar to the benthic scores for previous years, then changes implemented in 1995 had little effect on benthic macroinvertebrate evaluations. Table 4 shows that many scores for 1995 fell within the range of scores for previous years, and most others were only two to four points outside the range. Scores for only five locations (about 12%) changed more than 6 points (the significance of this magnitude of change is discussed below). It appears that the changes implemented in 1995 had only inconsequential effects.

Evaluation of QC Results

As described earlier, QC efforts for benthic macroinvertebrates included two components -- one was aimed at evaluating implications of the change in 1995 to scoring the benthic community based on field processed samples rather than lab processed samples as in previous years. (Note: In 1994 samples had been processed in both the field and lab but reported only for the lab, and in 1995 the protocol changed to all field processing with only a subset set to the lab for verification.) Results (scores and metric ratings) from lab processed samples for this QC component are in Table 3. They are not reported in Table 2 because different scoring criteria (i.e., different expectations) are used for lab processed samples, as discussed above.

The other QC component deals with how well the benthic scores can be repeated and was accomplished by collecting a second set of samples at selected locations. Results of this component for both 1994 and 1995 are provided in Table 2 and identified with a "Q".

Determination of acceptable differences for QC results is an important issue and must consider study design and planned use of results. Given that the primary use of these results is to help evaluate the overall condition of a reservoir, the acceptable difference was defined in terms of impact on the Reservoir Ecological Health Score. As explained above, the benthic community at each sample location can contribute from 1 to 5 points depending upon where the score falls within five scoring ranges. For reservoirs with only one sample location, a 1 point shift in the benthic contribution (or the contribution by any of the five indicators) changes the Reservoir Ecological Health Score 4.4 percent and a 2 point shift changes it 8.8 percent. For evaluation of QA results the former was deemed acceptable and the latter unacceptable. Therefore, for both components of the QC effort, the difference in contribution between the original sample and the QC sample should be no more than one point (i.e., one scoring category).

In terms of the benthic score itself, the score for the original sample and the QC sample should be no more than 6 points apart. Differences greater than this could cause the benthic rating to change two scoring categories.

QC Results: Comparison of scores -- field-processed samples versus lab processed samples in 1995.

Run-of-the-River Reservoirs	Benthic Community Scores		
	Field Score	Lab Score	Difference
Chickamauga Inflow	31 (Excellent)	29 (Good)	2
Nickajack Forebay	33 (Excellent)	29 (Good)	4
Wheeler Embayment	13 (Poor)	15 (Poor)	2
Tellico Transition	17 (Poor)	17 (Poor)	0
Tributary Reservoirs			
	Field Score	Lab Score	Difference
Blue Ridge Ecoregion			
Parksville Forebay	19 (Fair)	13 (Poor)	6
Nottely Mid-reservoir	11 (Very Poor)	27 (Good)	16
Ridge and Valley Ecoregion			
Norris Forebay	23 (Fair)	21 (Fair)	2
Interior Plateau Ecoregion			
Normandy Forebay	7 (Very Poor)	7 (Very Poor)	0

The maximum observed difference between scores from field identified and lab identified samples was 16 (1 set) and the minimum was 0 (2 sets). The difference of 16 was much greater than desired. Close examination of those results indicates differences in three metrics were responsible for 12 points: EPT - none were seen in the field and a few small individuals found in the lab (4 points); Proportion as dominant taxa - both field and laboratory processed samples were dominated by tubificids and chronomids but only these two taxa were found in the field, whereas, additional taxa were found in the lab (4 points); and Percentage of samples with no organisms present - field examination failed to find any organisms in one of the 10 samples, but laboratory found at least a few organisms in all samples (4 points).

Scores from field versus lab processed samples were tested using a t-test for paired comparisons at $\alpha = 0.05$ with the null hypothesis that the mean difference between each pair of scores did not exceed 6. Tests were run on actual scores and on simulated scores (described below). Actual scores were tested by reservoir section, by reservoir class, by combined sections within each class, by reservoir sections across classes, and all locations combined. All tests failed to detect a significant difference; therefore, the null hypothesis could not be rejected (Table 5). A total of 88 pairs of actual scores were tested, and only 6 pairs (7 percent) had a difference of more than six points. Although a significant difference was detected in only a few tests, there appeared to be positive bias in scores from laboratory processed samples -- 42 (47%) of the pairs had higher scores for laboratory samples, 22 (25%) had higher scores for field processed samples, and the remaining 23 (27%) had identical scores. (Note: Most of these results are for 1994 because all samples for that year were processed in both the field and the lab, whereas, in 1995 all samples were processed in the field and only QC samples were processed in the lab.)

To further test results from this QC component, t-tests for paired comparisons also were run using simulated scores from field and lab processed samples. For each sample location, 100 simulated field and lab scores were developed by using the boot strap method (randomly selecting 10 samples, with replacement, 100 times). From each set of 10 samples, scores were developed for field processed results and compared to scores from lab results on the same 10 samples. Simulated paired scores were tested by location, by reservoir section, by reservoir class, by combined sections within each class, by reservoir sections across classes, and all locations combined. Only 4 of the 76 location simulations (5%) had a mean difference significantly greater than 6 (Table 6). None of the section, class, or combined tests were significant. Therefore, the null hypothesis can be rejected in only a small percentage of the location specific tests and none of the other tests. There was a slight positive bias; slightly more lab simulated scores were higher than the field simulated scores, 58% compared to 42%.

These results provide strong evidence that field processing of samples is acceptable and in only a few cases (7% for actual scores and 5% for simulated scores) would result in a score for the benthic macroinvertebrate community of 6 points or more different than the score from lab processed samples.

QC Results: Scores for original samples compared to scores for repeat sampling in 1995.

Run-of-the-River Reservoirs	Benthic Community Scores		
	Original Field Score	QA/QC Field Score	Difference
Chickamauga Inflow	31 (Excellent)	25 (Good)	6
Nickajack Forebay	33 (Excellent)	29 (Good)	4
Wheeler Embayment	13 (Poor)	15 (Poor)	2
Tellico Transition	17 (Poor)	9 (Very Poor)	8
Tributary Reservoirs			
Blue Ridge Ecoregion			
Parksville Forebay	19 (Fair)	13 (Poor)	6
Nottely Mid-reservoir	11 (Very Poor)	15 (Poor)	4

Tributary Reservoirs cont.'

	Original Field Score	QA/QC Field Score	Difference
Ridge and Valley Ecoregion			
Norris Forebay	23 (Fair)	21 (Fair)	2
Interior Plateau Ecoregion			
Normandy Forebay	7 (Very Poor)	7 (Very Poor)	0

The maximum observed difference between scores from regular samples and scores from repeat samples in 1995 was 8 (1 sample) and the minimum was 0 (1 sample); two other sample sets had a difference of 6. The single sample set to have a difference greater than 6 was from Tellico transition zone. The metric which contributed the most to this difference was Percentage of samples with no organisms present. The first sampling event (or regular samples) found at least a few organisms in all samples, whereas, the second set of samples had one of the 10 sample with no organisms present. The rating from this metric is either a 5 (all samples contained at least one organism) or 1 (one or more samples were void of any organisms). So 4 of the 8 point difference was due to the chance occurrence of collecting such a sample in one set but not the other.

Scores from this QC component were tested using a t-test for paired comparisons similar to the tests described above with the same null hypothesis. Scores from field processed samples for 1994 and 1995 were tested by reservoir section, by reservoir class, by combined sections within each class, by reservoir sections across classes, and all locations combined. All tests failed to detect a significant difference; therefore, the null hypothesis could not be rejected (Table 7). This testing indicates good reproducibility of benthic community scores.

In addition to the above QA/QC evaluations, results were used to evaluate the efficacy of the currently used sample size (10 per location). The boot strap process described above was used to develop simulation for sample sizes varying from 5 up to 20 for both field and lab processed results. Standard deviations were developed by randomly selecting 5 samples, with replacement, 100 times. The process was repeated for 6 samples and so on. Figure 1 plots these results. As expected, mean standard deviation decreased with sample size. However, a change in the rate of decrease clearly occurred at a sample size of 10. Mean standard deviation decreased steadily between 5 and 10 samples, then the rate of decrease flattened substantially at a sample size of 10 and above. These results indicate 10 is the appropriate sample size. There is little to be gained by increasing sample size above 10, but greater variation would be encountered if sample size were decreased.

Reference

Dycus, D.L., 1995. "Aquatic Ecological Health Determinations for TVA Reservoirs--1994. An Informal Summary of 1994 Vital Signs Monitoring Results and Ecological Health Determination Methods." April 1995.

Table 1. Scoring Criteria for Benthic Macroinvertebrate Community
1995 Reservoir Vital Signs Monitoring

Run-of-the-River Reservoirs

Benthic Community Metrics	Forebay			Transition			Inflow		
	1	3	5	1	3	5	1	3	5
Taxa Richness	<2	2-11	>11	<2.3	2.3-4.6	.4.6	<2.3	2.3-4.6	>4.6
EPT	<.3	.3-.6	>.6	<.3	.3-.6	>.6	<.7	.7-1.3	>1.3
Long-lived	<.3	.3-.6	>.6	<.3	.3-.6	>.6	<.3	.3-.6	>.6
Percent Tubificids	>34	17-34	<17	>34	17-34	<17	>34	17-34	<17
Dominance	>93	84-93	>84	>93	84-93	>84	>93	84-93	>84
Non Chi. and Tub. Density	<100	100-200	>200	<166	166-333	>333	<233	233-466	>466
Zero Samples	≥1	-	0	≥1	-	0	≥1	-	0

Blue Ridge Tributary Reservoirs

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	<1	1-3	>3	-	-	-	<.8	.8-1.6	>1.6
EPT	<.1	.1-.2	>.2	-	-	-	<.1	.1	>.1
Long-lived	<.1	.1	>.1	-	-	-	<.1	.1	>.1
Percent Tubificids	>66	33-66	<33	-	-	-	>56	28-56	<28
Dominance	>96.6	93.3-96.6	<93.3	-	-	-	>96.6	93.3-96.6	<93.3
Non Chi. and Tub. Density	<5.5	5.5-11.3	>11.3	-	-	-	<3	3-6	>6
Zero Samples	≥1	-	0	-	-	-	≥1	-	0

Table 1. Cont', Scoring Criteria for Benthic Macroinvertebrate Community
1995 Reservoir Vital Signs Monitoring

Interior Plateau Tributary Reservoirs

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	<1.3	1.3-2.6	>2.6	-	-	-	-	-	-
EPT	<.1	.1-.2	>.2	-	-	-	-	-	-
Long-lived	<.1	.1	>.1	-	-	-	-	-	-
Percent Tubificids	>66	33-66	<33	-	-	-	-	-	-
Dominance	>96.6	93.3-96.6	<93.3	-	-	-	-	-	-
Non Chi. and Tub. Density	<10	10-20	>20	-	-	-	-	-	-
Zero Samples	≥1	-	0	-	-	-	-	-	-

Ridge and Valley Tributary Reservoirs

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	<.8	.8-1.6	>1.6	-	-	-	<1.2	1.2-2.3	>2.3
EPT	<.1	.1	>.1	-	-	-	<.1	.1	>.1
Long-lived	<.1	.1	>.1	-	-	-	<.1	.1	>.1
Percent Tubificids	>66	33-66	<33	-	-	-	>56	28-56	<28
Dominance	>96.6	93.3-96.6	<93.3	-	-	-	>96.6	93.3-96.6	<93.3
Non Chi. and Tub. Density	<21	21-43	>43	-	-	-	<8	8-16	>16
Zero Samples	≥1	-	0	-	-	-	≥1	-	0

Table 2. Results and Ratings for Individual Metrics and Final Benthos Score. Separated by Reservoir Class and Type of Sample Location

Run-of-River Reservoirs--Forebays

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
BEAR CREEK		8.4 #	94	17	5.0 5	0.0 1	0.0 1	20.5 3	99.6 1	3.3 1	0.0 5
CHICKAMAUGA		472.3	94	33	5.3 5	1.0 5	1.0 5	13.8 5	82.3 5	151.7 3	0.0 5
CHICKAMAUGA	Q*	472.3	94	31	5.9 5	1.0 5	0.5 3	26.3 3	78.6 5	298.3 5	0.0 5
CHICKAMAUGA		472.3	95	31	4.3 5	0.9 5	0.4 3	14.9 5	85.3 3	310.0 5	0.0 5
FORT LOUDOUN		605.5	94	13	3.0 3	0.1 1	0.1 1	34.6 1	99.3 1	7.6 1	0.0 5
FORT LOUDOUN		605.5	95	13	3.2 3	0.1 1	0.1 1	43.1 1	96.5 1	11.7 1	0.0 5
GUNTERSVILLE		350	94	27	4.9 5	1.0 5	0.6 3	20.0 3	86.6 3	143.3 3	0.0 5
KENTUCKY		7.4 #	94	19	6.2 5	0.2 1	0.0 1	5.9 5	94.1 1	60.0 1	0.0 5
KENTUCKY		7.4 #	95	19	4.9 5	0.1 1	0.0 1	8.7 5	93.5 1	78.3 1	0.0 5
KENTUCKY		23	94	27	6.0 5	0.9 5	0.2 1	25.6 3	81.0 5	173.3 3	0.0 5
KENTUCKY		23	95	27	4.4 5	0.7 5	0.2 1	17.4 3	85.4 3	521.1 5	0.0 5
MELTON HILL		24	94	15	3.5 3	0.4 3	0.5 3	23.5 3	94.6 1	18.3 1	0.1 1
NICKAJACK		425.5	94	33	4.8 5	0.8 5	1.5 5	4.6 5	82.8 5	138.3 3	0.0 5
NICKAJACK	Q	425.5	94	33	4.8 5	0.9 5	1.1 5	11.3 5	82.4 5	151.7 3	0.0 5
NICKAJACK		425.5	95	33	4.2 5	0.9 5	0.8 5	16.5 5	75.9 5	171.7 3	0.0 5
NICKAJACK	Q	425.5	95	29	3.9 3	0.9 5	0.6 3	14.9 5	82.8 5	196.7 3	0.0 5
PICKWICK		207.3	94	31	4.9 5	0.5 3	0.5 3	12.2 5	78.8 5	213.3 5	0.0 5
TELLICO		1	94	7	0.8 1	0.0 1	0.0 1	73.3 1	100.0 1	0.0 1	0.4 1
TELLICO		1	95	7	0.9 1	0.0 1	0.0 1	73.3 1	100.0 1	1.7 1	0.3 1
WATTS BAR		531	94	15	3.8 3	0.2 1	0.3 3	31.6 3	92.8 3	20.0 1	0.1 1
WHEELER		277	94	19	4.8 5	0.4 3	0.0 1	19.1 3	93.1 1	41.7 1	0.0 5
WHEELER		277	95	17	3.0 3	0.2 1	0.0 1	16.5 5	94.2 1	21.7 1	0.0 5
WILSON		260.8	94	19	4.6 5	0.0 1	0.0 1	9.1 5	94.1 1	78.3 1	0.0 5

*Q = Identifies results from a replicate set of samples for QA purposes.

= Identifies an embayment sample location; included with forebays because habitat (sediment substrate and reservoir flow) in these embayments was similar to forebay habitat.

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Table 2. (Cont'd)

Run-of-River Reservoirs--Transition Zones

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
CHICKAMAUGA		8.5 #	94	19	2.9 3	0.5 3	0.6 3	29.5 3	90.5 3	203.3 3	0.1 1
CHICKAMAUGA	Q*	8.5 #	94	15	2.6 3	0.4 3	0.4 3	45.3 1	86.7 3	61.7 1	0.1 1
CHICKAMAUGA		8.5 #	95	31	5.5 5	0.9 5	0.9 5	33.8 3	75.9 5	166.7 3	0.0 5
CHICKAMAUGA		490.5	94	35	5.7 5	0.9 5	1.0 5	10.8 5	70.8 5	373.3 5	0.0 5
CHICKAMAUGA	Q	490.5	94	35	5.5 5	1.0 5	1.0 5	5.0 5	73.7 5	480.0 5	0.0 5
CHICKAMAUGA		490.5	95	31	5.4 5	0.9 5	0.9 5	23.0 3	74.6 5	170.0 3	0.0 5
FORT LOUDOUN		1.5 #	95	15	2.6 3	0.0 1	0.0 1	29.4 3	95.5 1	5.0 1	0.0 5
FORT LOUDOUN		624.6	94	21	3.9 3	0.4 3	0.4 3	28.6 3	92.8 3	21.7 1	0.0 5
FORT LOUDOUN		624.6	95	29	4.9 5	0.7 5	0.7 5	15.3 5	86.2 3	76.7 1	0.0 5
GUNTERSVILLE		375.2	94	35	6.3 5	1.0 5	1.0 5	7.4 5	78.8 5	610.0 5	0.0 5
KENTUCKY		85	94	33	5.3 5	1.0 5	0.8 5	10.0 5	81.0 5	255.0 3	0.0 5
KENTUCKY	Q	85	94	33	5.8 5	0.9 5	0.8 5	14.7 5	79.7 5	253.3 3	0.0 5
KENTUCKY		85	95	31	3.9 3	1.0 5	0.9 5	1.6 5	85.8 3	433.3 5	0.0 5
MELTON HILL		45	94	19	3.2 3	0.3 3	0.3 3	26.0 3	96.7 1	8.3 1	0.0 5
PICKWICK		230	94	31	6.0 5	1.0 5	0.8 5	18.4 3	74.6 5	294.9 3	0.0 5
TELLICO		15	94	13	1.5 1	0.3 3	0.3 3	29.0 3	100.0 1	6.7 1	0.2 1
TELLICO		15	95	17	2.0 1	0.4 3	0.4 3	33.8 3	99.0 1	10.0 1	0.0 5
TELLICO	Q	15	95	9	1.3 1	0.2 1	0.2 1	17.5 3	100.0 1	3.3 1	0.1 1
WATTS BAR		560.8	94	31	4.5 3	0.9 5	1.0 5	2.7 5	90.2 3	356.7 5	0.0 5
WHEELER		6 #	94	15	4.6 3	0.1 1	0.0 1	28.4 3	98.9 1	8.3 1	0.0 5
WHEELER		6 #	95	13	2.8 3	0.0 1	0.0 1	54.5 1	95.2 1	10.0 1	0.0 5
WHEELER	Q	6 #	95	15	3.5 3	0.0 1	0.0 1	45.2 1	90.4 3	25.0 1	0.0 5
WHEELER		295.9	94	33	5.6 5	1.0 5	0.8 5	10.4 5	77.3 5	316.7 3	0.0 5
WHEELER		295.9	95	27	3.3 3	1.0 5	0.6 3	6.6 5	82.2 5	131.7 1	0.0 5

*Q = Identifies results from a replicate set of samples for QA purposes.

Table 2. (Cont'd)

Run-of-River Reservoirs--Inflows

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA		LONGLIVE		EPT		%TUBI		DOMN		TOTNONC		ZEROS	
CHICKAMAUGA		518	94	23	2.6	3	1.0	5	0.0	1	5.3	5	95.7	1	411.7	3	0.0	5
CHICKAMAUGA		518	95	31	6.4	5	0.9	5	1.0	3	3.5	5	68.1	5	249.1	3	0.0	5
CHICKAMAUGA	Q*	518	95	25	4.5	3	0.9	5	0.3	1	2.9	5	79.5	5	155.5	1	0.0	5
FORT LOUDOUN		652	94	7	1.2	1	0.1	1	0.0	1	58.4	1	99.5	1	10.9	1	0.3	1
FORT LOUDOUN		652	95	9	1.7	1	0.0	1	0.0	1	32.5	3	95.2	1	19.1	1	0.1	1
GUNTERSVILLE		420	94	25	3.3	3	0.9	5	0.1	1	2.0	5	87.3	3	281.8	3	0.0	5
KENTUCKY		15	94	25	5.4	5	1.0	5	0.7	3	18.1	3	86.4	3	214.6	1	0.0	5
KENTUCKY		200	94	27	5.2	5	0.9	5	0.4	1	12.7	5	75.8	5	80.9	1	0.0	5
KENTUCKY		200	95	23	3.1	3	0.8	5	0.0	1	0.6	5	88.3	3	92.7	1	0.0	5
MELTON HILL		58.8	94	9	1.2	1	0.0	1	0.0	1	27.2	3	100.0	1	0.0	1	0.2	1
NICKAJACK		469	94	35	7.6	5	1.0	5	2.4	5	0.5	5	82.2	5	693.6	5	0.0	5
NICKAJACK	Q	469	94	31	5.8	5	1.0	5	2.1	5	0.0	5	85.3	3	457.3	3	0.0	5
NICKAJACK		469	95	35	8.5	5	1.0	5	2.2	5	2.1	5	79.7	5	1086.4	5	0.0	5
PICKWICK		253.2	94	25	4.2	3	0.4	3	1.0	3	5.4	5	79.7	5	95.5	1	0.0	5
PICKWICK	Q	253.2	94	21	3.6	3	0.6	3	0.5	1	10.4	5	91.4	3	183.6	1	0.0	5
WATTS BAR		19	94	13	1.8	1	0.3	3	0.2	1	10.0	5	96.5	1	38.2	1	0.1	1
WATTS BAR		600	94	19	2.9	3	0.2	1	0.2	1	4.3	5	89.9	3	65.5	1	0.0	5
WHEELER		347	94	31	6.1	5	0.9	5	1.0	3	0.9	5	68.7	5	308.2	3	0.0	5
WHEELER		347	95	25	4.5	3	1.0	5	0.1	1	0.4	5	86.0	3	407.3	3	0.0	5
WILSON		273	94	29	5.5	5	1.0	5	0.6	1	1.9	5	80.4	5	359.7	3	0.0	5

*Q = Identifies results from a replicate set of samples for QA purposes.

Table 2. (Cont'd)

Blue Ridge Ecoregion Tributary Results--Forebays and Upper Reservoir

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
FOREBAY											
BLUE RIDGE		54.1	94	13	1.5 3	0.0 1	0.0 1	70.2 1	97.4 1	15.0 5	0.5 1
BLUE RIDGE	Q*	54.1	94	29	2.7 5	0.2 5	0.4 5	51.0 3	92.4 5	105.0 5	0.2 1
BLUE RIDGE		54.1	95	29	3.5 5	0.3 5	0.3 5	52.7 3	86.2 5	161.7 5	0.1 1
CHATUGE		1.5	94	15	1.9 3	0.1 3	0.1 3	38.7 3	98.9 1	4.2 1	0.2 1
CHATUGE		122	94	17	1.5 3	0.0 1	0.2 3	45.1 3	100.0 1	5.0 1	0.0 5
FONTANA		62	95	7	0.6 1	0.0 1	0.0 1	94.7 1	100.0 1	3.3 1	0.6 1
HIWASSEE		77	94	7	0.3 1	0.0 1	0.0 1	90.0 1	100.0 1	0.0 1	0.7 1
NOTTELY		23.5	94	11	1.7 3	0.0 1	0.0 1	47.4 3	100.0 1	0.0 1	0.1 1
NOTTELY		23.5	95	13	2.6 5	0.0 1	0.0 1	46.4 3	100.0 1	0.0 1	0.1 1
PARKSVILLE - OCOEE NO 1		12.5	94	7	0.8 1	0.0 1	0.0 1	87.8 1	100.0 1	3.3 1	0.3 1
PARKSVILLE - OCOEE NO 1	Q	12.5	94	7	0.4 1	0.0 1	0.0 1	100.0 1	100.0 1	0.0 1	0.6 1
PARKSVILLE - OCOEE NO 1		12.5	95	19	1.5 3	0.0 1	0.0 1	63.4 3	96.7 1	18.3 5	0.0 5
PARKSVILLE - OCOEE NO 1	Q	12.5	95	13	1.0 3	0.0 1	0.0 1	78.4 1	98.6 1	15.0 5	0.3 1
WATAUGA		37.4	94	9	0.5 1	0.1 3	0.0 1	80.0 1	100.0 1	1.8 1	0.5 1
UPPER											
FONTANA		3	94	13	1.9 5	0.0 1	0.0 1	51.3 3	100.0 1	0.0 1	0.2 1
FONTANA		81.5	94	13	2.0 5	0.0 1	0.0 1	35.4 3	100.0 1	0.0 1	0.1 1
HIWASSEE		85	94	9	1.0 3	0.0 1	0.0 1	81.5 1	100.0 1	0.0 1	0.5 1
HIWASSEE		90	94	17	1.8 5	0.1 3	0.1 3	29.4 3	99.4 1	1.7 1	0.1 1
HIWASSEE	Q	85	94	9	1.3 3	0.0 1	0.0 1	96.2 1	100.0 1	0.0 1	0.4 1
NOTTELY		31	94	29	2.6 5	0.2 5	0.2 5	8.2 5	99.0 1	5.5 3	0.0 5
NOTTELY	Q	31	94	31	2.2 5	0.3 5	0.4 5	2.9 5	99.3 1	9.1 5	0.0 5
NOTTELY		31	95	11	1.2 3	0.0 1	0.0 1	43.7 3	100.0 1	1.7 1	0.1 1
NOTTELY	Q	31	95	15	1.3 3	0.1 3	0.1 3	39.5 3	96.7 1	1.7 1	0.2 1
WATAUGA		45.5	94	17	1.6 3	0.0 1	0.0 1	25.1 5	98.8 1	151.7 5	0.1 1
WATAUGA	Q	45.5	94	13	1.3 3	0.0 1	0.0 1	16.5 5	100.0 1	1.7 1	0.1 1

*Q = Identifies results from a replicate set of samples for QA purposes.

Table 2. (Cont'd)

Ridge and Valley Ecoregion Tributary Results--Forebays and Upper Reservoir

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
FOREBAY											
BOONE		19	94	15	2.4 5	0.0 1	0.0 1	86.4 1	98.6 1	1.7 1	0.0 5
BOONE		19	95	9	1.1 3	0.0 1	0.0 1	99.7 1	100.0 1	1.7 1	0.1 1
CHEROKEE		53	94	21	2.4 5	0.1 3	0.1 3	43.7 3	99.6 1	3.3 1	0.0 5
CHEROKEE		53	95	13	2.2 5	0.0 1	0.0 1	56.3 3	100.0 1	0.0 1	0.1 1
DOUGLAS		33	94	13	2.2 5	0.0 1	0.0 1	61.0 3	100.0 1	0.0 1	0.1 1
DOUGLAS		33	95	9	1.5 3	0.0 1	0.0 1	85.2 1	100.0 1	0.0 1	0.2 1
FORT PATRICK HENRY		8.7	94	17	2.3 5	0.0 1	0.0 1	54.8 3	99.6 1	1.7 1	0.0 5
FORT PATRICK HENRY		8.7	95	15	1.9 5	0.0 1	0.0 1	72.6 1	100.0 1	0.0 1	0.0 5
NORRIS		80.4	94	19	1.3 3	0.2 5	0.0 1	77.4 1	99.0 1	40.9 3	0.0 5
NORRIS		80.4	95	23	1.2 3	0.3 5	0.1 3	73.0 1	100.0 1	65.0 5	0.0 5
NORRIS	Q*	80.4	95	21	1.1 3	0.2 5	0.0 1	78.9 1	100.0 1	101.7 5	0.0 5
SOUTH HOLSTON		51	94	15	1.3 3	0.2 5	0.1 3	81.4 1	97.6 1	4.6 1	0.3 1
TIMS FORD		135	94	9	0.8 3	0.0 1	0.0 1	95.5 1	100.0 1	0.0 1	0.4 1
TIMS FORD		135	95	9	0.9 3	0.0 1	0.0 1	85.0 1	100.0 1	0.0 1	0.2 1
UPPER											
BOONE		27	94	15	2.2 3	0.0 1	0.0 1	47.6 3	99.7 1	0.9 1	0.0 5
BOONE		6.5	94	13	2.0 3	0.0 1	0.0 1	76.7 1	100.0 1	0.0 1	0.0 5
BOONE		27	95	9	1.7 3	0.0 1	0.0 1	64.4 1	100.0 1	0.0 1	0.1 1
BOONE		6.5	95	11	1.3 3	0.1 3	0.0 1	85.5 1	100.0 1	1.7 1	0.1 1
DOUGLAS		51	94	17	2.1 3	0.0 1	0.0 1	28.0 5	100.0 1	0.0 1	0.0 5
DOUGLAS		51	95	15	1.9 3	0.0 1	0.0 1	36.1 3	100.0 1	0.0 1	0.0 5
NORRIS		30	94	27	3.9 5	0.1 3	0.1 3	40.3 3	95.7 3	28.3 5	0.0 5
NORRIS		125	94	29	3.1 5	0.2 5	0.2 5	22.9 5	98.8 1	11.7 3	0.0 5
NORRIS		30	95	19	1.9 3	0.0 1	0.0 1	51.8 3	92.6 5	23.3 5	0.2 1
NORRIS		125	95	17	3.0 5	0.0 1	0.0 1	37.8 3	96.5 3	13.3 3	0.1 1
SOUTH HOLSTON		62.5	94	17	2.7 5	0.0 1	0.0 1	30.9 3	99.3 1	1.8 1	0.0 5
TIMS FORD		150	94	9	0.7 1	0.0 1	0.0 1	55.0 3	100.0 1	0.0 1	0.4 1
TIMS FORD		150	95	7	0.6 1	0.0 1	0.0 1	80.0 1	100.0 1	0.0 1	0.4 1

QA*= Identifies results from a replicate set of samples for QA purposes.

Table 2. (Cont'd)

Interior Plateau Tributary Reservoir--Forebays

RESERVOIR NAME		MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
BEAR CREEK		75	94	19	1.8 3	0.0 1	0.1 3	4.1 5	100.0 1	3.3 1	0.0 5
BEAR CREEK		75	95	17	1.8 3	0.0 1	0.0 1	14.6 5	100.0 1	0.0 1	0.0 5
BEECH LAKE		36	94	31	4.3 5	0.1 3	0.3 5	11.9 5	96.5 3	23.3 5	0.0 5
BEECH LAKE		36	95	23	3.1 5	0.1 3	0.1 3	11.0 5	98.7 1	6.7 1	0.0 5
CEDAR CREEK		25.2	94	23	2.4 3	0.2 5	0.3 5	33.2 3	96.9 1	31.7 5	0.1 1
CEDAR CREEK		25.2	95	9	1.2 1	0.0 1	0.0 1	34.0 3	100.0 1	0.0 1	0.3 1
LITTLE BEAR CREEK		12.5	94	21	2.2 3	0.1 3	0.2 3	65.7 3	99.3 1	10.0 3	0.0 5
LITTLE BEAR CREEK	Q*	12.5	94	21	1.9 3	0.1 3	0.1 3	76.7 1	99.7 1	30.0 5	0.0 5
LITTLE BEAR CREEK		12.5	95	21	3.6 5	0.1 3	0.1 3	40.0 3	100.0 1	28.3 5	0.4 1
NORMANDY		249.5	94	15	1.4 3	0.0 1	0.0 1	47.1 3	100.0 1	0.0 1	0.0 5
NORMANDY		249.5	95	7	0.9 1	0.0 1	0.0 1	81.4 1	100.0 1	0.0 1	0.3 1
NORMANDY	Q	249.5	95	7	0.7 1	0.0 1	0.0 1	89.1 1	100.0 1	0.0 1	0.4 1

*Q = Identifies results from a replicate set of samples for QA purposes.

Table 3. Results and Ratings for Individual Metrics and Final Benthos Score for Samples Collected for QA/QC from Lab Processed Samples.

RESERVOIR NAME	MILE	YEAR	SCOR	TAXA	LONGLIVE	EPT	%TUBI	DOMN	TOTNONC	ZEROS
NICKAJACK - Forebay	425	95	29	6.9 5	1.0 5	1.5 5	29.4 3	73.1 5	191.7 1	0.0 5
CHICKAMAUGA - Inflow	518	95	29	7.3 5	0.9 5	1.2 3	11.8 5	65.8 5	266.1 1	0.0 5
TELLICO - Transition	15	95	17	4.2 3	0.4 3	0.4 1	24.2 3	95.5 1	36.7 1	0.0 5
WHEELER - Embayment (Elk R.)	6	95	15	4.9 3	0.4 3	0.0 1	47.9 1	93.1 1	33.3 1	0.0 5
PARKSVILLE - Forebay	12	95	13	1.8 3	0.0 1	0.0 1	74.2 1	97.8 1	25.0 1	0.0 5
NOTTELY - Midreservoir	31	95	27	5.2 5	0.0 1	0.6 5	35.0 3	93.2 5	31.7 3	0.0 5
NORRIS - Forebay	80	95	21	2.0 3	0.5 5	0.2 3	80.2 1	99.3 1	113.3 3	0.0 5
NORMANDY - Forebay	250	95	7	1.5 1	0.0 1	0.0 1	73.3 1	99.1 1	6.7 1	0.1 1

Table 4. Benthic Community Scores for All Years of Vital Signs Monitoring; Samples for 1991-1994 Collected in Late Winter/Early Spring with Scores Based on Lab Processed Samples and Samples for 1995 Collected in Late Autumn and Scores Based on Field Processed Samples

Run-of-the-River Reservoirs

Reservoir		Mile	1991*	1992*	1993*	1994*	1995
Chickamauga	Forebay	472.3	25	31	27	29	31
Chickamauga	Inflow	518	15	19	21	19	31
Chickamauga	Embayment	8.5	.	.	25	25	31
Chickamauga	Transition	490.5	27	27	27	35	31
Fort Loudoun	Forebay	603.2	13	15	.	.	.
Fort Loudoun	Forebay	605.5	.	9	15	15	13
Fort Loudoun	Inflow	652	9	15	11	7	9
Fort Loudoun	Inflow	649.5	.	.	19	.	.
Fort Loudoun	Transition	624.6	13	15	19	17	29
Guntersville	Forebay	350	29	27	27	31	.
Guntersville	Inflow	420	19	27	21	25	.
Guntersville	Transition	375.2	.	25	31	33	.
Kentucky	Embayment	7.4	.	.	25	23	19
Kentucky	Forebay	23	23	23	27	27	27
Kentucky	Inflow	200	11	23	21	27	23
Kentucky	Transition	85	.	29	27	33	31
Melton Hill	Forebay	24	17	21	17	19	.
Melton Hill	Inflow	58.8	9	15	15	13	.
Melton Hill	Transition	45	17	15	15	17	.
Nickajack	Forebay	425.5	27	29	29	33	33
Nickajack	Inflow	469	25	27	31	35	35
Pickwick	Embayment	8.4	.	.	17	17	.
Pickwick	Forebay	207.3	19	27	27	33	.
Pickwick	Inflow	253.2	9	19	29	23	.
Pickwick	Transition	230	21	27	27	31	.
Tellico	Forebay	1	7	13	15	13	7
Tellico	Transition	15	.	.	13	15	17
Watts Bar	Forebay	531	17	19	23	23	.
Watts Bar	Inflow	19	17	17	15	13	.
Watts Bar	Inflow	600	13	17	17	23	.
Watts Bar	Transition	560.8	23	25	27	35	.
Wheeler	Forebay	277	17	15	17	25	17
Wheeler	Inflow	347	23	29	29	31	25
Wheeler	Embayment	6	.	.	15	15	13
Wheeler	Transition	295.9	.	.	29	33	27
Wilson	Forebay	260.8	15	15	21	17	.
Wilson	Inflow	273	25	25	29	31	.

* Note: Results for all years are scored on 1995 scoring protocols. This means scores for 1991 - 1994 in this table are different than scores for these years presented elsewhere; that is, this table is the only place lab processed results for 1991 - 1994 are scored on 1995 protocols; scores for the 1991 - 1994 results are presented in earlier reports based on earlier scoring protocols and elsewhere in this report based on results from field-processing of these samples.

Table 4. Cont.'

Blue Ridge Ecoregion

Reservoir		Mile	1991*	1992*	1993*	1994*	1995*
Blue Ridge	Forebay	54.1	.	.	23	19	29
Chatuge	Forebay	1.5	.	.	27	25	.
Chatuge	Forebay	122	.	.	25	19	.
Fontana	Forebay	62	.	.	7	.	7
Fontana	Mid-reservoir	3	.	.	15	9	.
Fontana	Mid-reservoir	81.5	.	.	21	15	.
Hiwassee	Forebay	77	.	.	7	13	.
Hiwassee	Mid-reservoir	85	.	.	15	15	.
Nottely	Forebay	23.5	.	.	17	15	13
Nottely	Mid-reservoir	31	.	.	25	31	11
Parksville - Ocoee No 1	Forebay	12.5	.	.	15	7	19
Watauga	Forebay	37.4	.	.	7	11	.
Watauga	Mid-reservoir	45.5	.	.	13	21	.

Interior Plateau Ecoregion

Reservoir		Mile	1991*	1992*	1993*	1994*	1995*
Bear Creek	Forebay	75		.	27	25	17
Beech Lake	Forebay	36	.	.	27	31	23
Cedar Creek	Forebay	25		.	.	.	.
Cedar Creek	Forebay	25.2	.	.	19	35	9
Little Bear Creek	Forebay	12.3		.	.	.	.
Little Bear Creek	Forebay	12.5	.	.	15	23	15
Normandy	Forebay	249.5	.	.	7	13	7

Ridge and Valley Ecoregion

Reservoir		Mile	1991*	1992*	1993*	1994*	1995*
Boone	Forebay	19	.	.	15	15	9
Boone	Mid-reservoir	27	.	.	13	13	9
Boone	Mid-reservoir	6.5	.	.	13	19	11
Cherokee	Forebay	53	7	19	21	21	13
Cherokee	Mid-reservoir	85	.	.	.	.	.
Douglas	Forebay	33	11	17	15	15	9
Douglas	Mid-reservoir	51	.	.	.	17	15
Fort Patrick Henry	Forebay	8.7	.	.	15	15	15
Norris	Forebay	80.4	21	31	21	17	23
Norris	Mid-reservoir	30	27	23	25	27	19
Norris	Mid-reservoir	125	25	27	17	31	15
South Holston	Forebay	51	.	.	7	17	.
South Holston	Mid-reservoir	62.5	.	.	17	13	.
Tims Ford	Forebay	135	.	.	.	7	9
Tims Ford	Mid-reservoir	150	.	.	11	11	7

* Note: Results for all years are scored on 1995 scoring protocols. This means scores for 1991 - 1994 in this table are different than scores for these years presented elsewhere; that is, this table is the only place lab processed results for 1991 - 1994 are scored on 1995 protocols; scores for the 1991 - 1994 results are presented in earlier reports based on earlier scoring protocols and elsewhere in this report based on results from field-processing of these samples.

Table 5. Results of Paired-t Test on Actual Benthic Community Scores Developed from Field Processed and Lab Processed Samples. (Note: a "+" difference indicates the lab score was higher and a "-" difference indicates the field score was higher.)

PAIRED-COMPARISON T TEST

RESTYPE	WBDSECNA	SITE	YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
			.	88	1.4545	0.40982	0.00063	1.00000	1.00000
	FOREBAY		.	40	1.5500	0.62629	0.01778	0.99982	1.00000
	INFLOW		.	15	0.6667	0.77254	0.40271	0.99963	1.00000
	TRANSITION		.	33	1.6970	0.71309	0.02345	0.99857	1.00000
BR			.	20	3.3000	1.09808	0.00728	0.73429	0.98815
BR	FOREBAY		.	10	2.4000	1.39204	0.11878	0.85934	0.98520
		BLUE_FORE_ 54.1	94	1	6.0000	.	.	.	.
		BLUE_FOREQ 54.1	94	1	0.0000	.	.	.	.
		CHAT_FORE_ 1.5	94	1	10.0000	.	.	.	.
		CHAT_FORE_ 122	94	1	2.0000	.	.	.	.
		HIWA_FORE_ 77	94	1	6.0000	.	.	.	.
		NOTT_FORE_ 23.5	94	1	4.0000	.	.	.	.
		PARK_FORE_ 12.5	94	1	0.0000	.	.	.	.
		PARK_FORE_ 12.5	95	1	-6.0000	.	.	.	.
		PARK_FOREQ 12.5	94	1	0.0000	.	.	.	.
		WATA_FORE_ 37.4	94	1	2.0000	.	.	.	.
BR	TRANSITION		.	10	4.2000	1.72434	0.03763	0.45459	0.83800
		FONT_INFL_ 3	94	1	-4.0000	.	.	.	.
		FONT_INFL_ 81.5	94	1	2.0000	.	.	.	.
		HIWA_INFL_ 85	94	1	6.0000	.	.	.	.
		HIWA_INFL_ 90	94	1	2.0000	.	.	.	.
		HIWA_INFLQ 85	94	1	10.0000	.	.	.	.
		NOTT_INFL_ 31	94	1	2.0000	.	.	.	.
		NOTT_INFLQ 31	94	1	2.0000	.	.	.	.
		NOTT_TRAN_ 31	95	1	16.0000	.	.	.	.
		WATA_INFL_ 45.5	94	1	4.0000	.	.	.	.
		WATA_INFLQ 45.5	94	1	2.0000	.	.	.	.
IP			.	7	3.1429	1.79189	0.12998	0.67172	0.91792
IP	FOREBAY		.	7	3.1429	1.79189	0.12998	0.67172	0.91792
		BEAR_FORE_ 75	94	1	6.0000	.	.	.	.
		BEEC_FORE_ 36	94	1	0.0000	.	.	.	.
		CEDA_FORE_ 25.2	94	1	12.0000	.	.	.	.
		LITT_FORE_ 12.5	94	1	2.0000	.	.	.	.
		LITT_FOREQ 12.5	94	1	4.0000	.	.	.	.
		NORM_FORE_ 249.5	94	1	-2.0000	.	.	.	.
		NORM_FORE_ 249.5	95	1	0.0000	.	.	.	.
MAIN			.	46	0.8696	0.47610	0.07443	1.00000	1.00000
MAIN	FOREBAY		.	15	1.3333	1.02663	0.21502	0.98939	0.99977
		CHIC_FORE_ 472.3	94	1	-4.0000	.	.	.	.
		CHIC_FOREQ 472.3	94	1	-4.0000	.	.	.	.
		FORT_FORE_ 605.5	94	1	2.0000	.	.	.	.

Table 5. Cont.'

PAIRED-COMPARISON T TEST

RESTYPE	WBOSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
MAIN	FOREBAY	GUNT_FORE_	350	94	1	4.0000	.	.	.	.
		KENT_EMBA_	7.4	94	1	4.0000	.	.	.	.
		KENT_FORE_	23	94	1	0.0000	.	.	.	.
		MELT_FORE_	24	94	1	4.0000	.	.	.	.
		NICK_FORE_	425.5	94	1	0.0000	.	.	.	.
		NICK_FORE_	425.5	95	1	-4.0000	.	.	.	.
		NICK_FOREQ	425.5	94	1	-2.0000	.	.	.	.
		PICK_FORE_	207.3	94	1	2.0000	.	.	.	.
		TELL_FORE_	1	94	1	6.0000	.	.	.	.
		WATT_FORE_	531	94	1	8.0000	.	.	.	.
		WHEE_FORE_	277	94	1	6.0000	.	.	.	.
		WILS_FORE_	260.8	94	1	-2.0000	.	.	.	.
MAIN	INFLOW			.	15	0.6667	0.77254	0.40271	0.99963	1.00000
		CHIC_INFL_	518	94	1	-4.0000	.	.	.	.
		CHIC_INFL_	518	95	1	-2.0000	.	.	.	.
		FORT_INFL_	652	94	1	0.0000	.	.	.	.
		GUNT_INFL_	420	94	1	0.0000	.	.	.	.
		KENT_INFL_	15	94	1	-2.0000	.	.	.	.
		KENT_INFL_	200	94	1	0.0000	.	.	.	.
		MELT_INFL_	58.8	94	1	4.0000	.	.	.	.
		NICK_INFL_	469	94	1	0.0000	.	.	.	.
		NICK_INFLQ	469	94	1	2.0000	.	.	.	.
		PICK_INFL_	253.2	94	1	-2.0000	.	.	.	.
		PICK_INFLQ	253.2	94	1	8.0000	.	.	.	.
		WATT_INFL_	19	94	1	0.0000	.	.	.	.
		WATT_INFL_	600	94	1	4.0000	.	.	.	.
		WHEE_INFL_	347	94	1	0.0000	.	.	.	.
		WILS_INFL_	273	94	1	2.0000	.	.	.	.
MAIN	TRANSITION			.	16	0.6250	0.70045	0.38633	0.99988	1.00000
		CHIC_EMBA_	8.5	94	1	6.0000	.	.	.	.
		CHIC_EMBAQ	8.5	94	1	6.0000	.	.	.	.
		CHIC_TRAN_	490.5	94	1	0.0000	.	.	.	.
		CHIC_TRANQ	490.5	94	1	0.0000	.	.	.	.
		FORT_TRAN_	624.6	94	1	-4.0000	.	.	.	.
		GUNT_TRAN_	375.2	94	1	-2.0000	.	.	.	.
		KENT_TRAN_	85	94	1	0.0000	.	.	.	.
		KENT_TRANQ	85	94	1	-2.0000	.	.	.	.
		MELT_TRAN_	45	94	1	-2.0000	.	.	.	.
		PICK_TRAN_	230	94	1	0.0000	.	.	.	.
		TELL_TRAN_	15	94	1	2.0000	.	.	.	.
		TELL_TRAN_	15	95	1	0.0000	.	.	.	.
		WATT_TRAN_	560.8	94	1	4.0000	.	.	.	.
		WHEE_EMBA_	6	94	1	0.0000	.	.	.	.
		WHEE_EMBA_	6	95	1	2.0000	.	.	.	.
		WHEE_TRAN_	295.9	94	1	0.0000	.	.	.	.
RV				.	15	0.0000	0.64734	1.00000	0.99998	1.00000
RV	FOREBAY			.	8	-0.5000	0.62678	0.45124	0.99949	0.99997

Table 5. Cont.'

PAIRED-COMPARISON T TEST

RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
RV	FOREBAY	BOON_FORE_	19	94	1	0.0000	.	.	.	.
		CHER_FORE_	53	94	1	0.0000	.	.	.	.
		DOUG_FORE_	33	94	1	2.0000	.	.	.	.
		FORT_FORE_	8.7	94	1	-2.0000	.	.	.	.
		NORR_FORE_	80.4	94	1	-2.0000	.	.	.	.
		NORR_FORE_	80.4	95	1	-2.0000	.	.	.	.
		SOUT_FORE_	51	94	1	2.0000	.	.	.	.
		TIMS_FORE_	135	94	1	-2.0000	.	.	.	.
RV	TRANSITION			. .	7	0.5714	1.21218	0.65400	0.98035	0.99708
		BOON_INFL_	27	94	1	-2.0000	.	.	.	.
		BOON_INFL_	6.5	94	1	6.0000	.	.	.	.
		DOUG_TRAN_	51	94	1	0.0000	.	.	.	.
		NORR_TRAN_	30	94	1	0.0000	.	.	.	.
		NORR_TRAN_	125	94	1	2.0000	.	.	.	.
		SOUT_INFL_	62.5	94	1	-4.0000	.	.	.	.
		TIMS_TRAN_	150	94	1	2.0000	.	.	.	.

Table 6. Results of Paired-t Test on Simulated Benthic Community Scores Developed from Field Processed and Lab Processed Samples (Note: a "+" difference indicates the lab score was higher and a "-" indicates the field score was higher.)

PAIRED-COMPARISON T TEST

RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
				.	7500	1.1040	0.04458	0.00000	1.00000	1.00000
	EMBAYMENT			.	400	2.3550	0.16637	0.00000	1.00000	1.00000
	FOREBAY			.	3400	1.2471	0.06641	0.00000	1.00000	1.00000
	INFLOW			.	1300	0.4662	0.08475	0.00000	1.00000	1.00000
	TRANSITION			.	2400	1.0383	0.08644	0.00000	1.00000	1.00000
BR				.	1500	2.3613	0.13472	0.00000	1.00000	1.00000
BR	FOREBAY			.	800	1.9575	0.16842	0.00000	1.00000	1.00000
		BLUE_FORE_	54.1	94	100	2.5000	0.36223	0.00000	0.99996	1.00000
		CHAT_FORE_	1.5	94	100	7.7200	0.33031	0.00000	0.00000	0.00000
		CHAT_FORE_	122	94	100	-0.5200	0.16483	0.00213	1.00000	1.00000
		HIWA_FORE_	77	94	100	4.7400	0.44281	0.00000	0.04893	0.99730
		NOTT_FORE_	23.5	94	100	3.4200	0.29719	0.00000	0.97310	1.00000
		PARK_FORE_	12.5	94	100	0.3000	0.17145	0.08325	1.00000	1.00000
		PARK_FORE_	12.5	95	100	-5.7200	0.20893	0.00000	0.00000	0.90837
		WATA_FORE_	37.4	94	100	3.2200	0.25882	0.00000	0.99836	1.00000
BR	TRANSITION			.	700	2.8229	0.21395	0.00000	1.00000	1.00000
		FONT_INFL_	3	94	100	-2.9600	0.14628	0.00000	1.00000	1.00000
		FONT_INFL_	81.5	94	100	0.7000	0.26723	0.01019	1.00000	1.00000
		HIWA_INFL_	85	94	100	7.9400	0.29740	0.00000	0.00000	0.00000
		HIWA_INFL_	90	94	100	-0.0200	0.40251	0.96047	1.00000	1.00000
		NOTT_INFL_	31	94	100	1.3000	0.27907	0.00001	1.00000	1.00000
		NOTT_TRAN_	31	95	100	11.8000	0.38612	0.00000	0.00000	0.00000
		WATA_INFL_	45.5	94	100	1.0000	0.30285	0.00134	1.00000	1.00000
IP				.	600	3.0267	0.16404	0.00000	1.00000	1.00000
IP	FOREBAY			.	600	3.0267	0.16404	0.00000	1.00000	1.00000
		BEAR_FORE_	75	94	100	4.7200	0.23702	0.00000	0.00152	1.00000
		BEEC_FORE_	36	94	100	2.0400	0.27704	0.00000	1.00000	1.00000
		CEDA_FORE_	25.2	94	100	8.1400	0.43508	0.00000	0.00000	0.00000
		LITT_FORE_	12.5	94	100	2.8400	0.26081	0.00000	0.99999	1.00000
		NORM_FORE_	249.5	94	100	-1.3400	0.11030	0.00000	1.00000	1.00000
		NORM_FORE_	249.5	95	100	1.7600	0.24990	0.00000	1.00000	1.00000
MAIN				.	3900	0.7262	0.05165	0.00000	1.00000	1.00000
MAIN	EMBAYMENT			.	400	2.3550	0.16637	0.00000	1.00000	1.00000
		CHIC_EMBA_	8.5	94	100	4.9400	0.39127	0.00000	0.00908	0.99602
		KENT_EMBA_	7.4	94	100	3.5000	0.29319	0.00000	0.95437	1.00000
		WHEE_EMBA_	6	94	100	-0.2000	0.14907	0.18278	1.00000	1.00000
		WHEE_EMBA_	6	95	100	1.1800	0.15595	0.00000	1.00000	1.00000
MAIN	FOREBAY			.	1200	0.9900	0.09827	0.00000	1.00000	1.00000
		CHIC_FORE_	472.3	94	100	-1.3800	0.19425	0.00000	1.00000	1.00000

Table 6. Cont.'

PAIRED-COMPARISON T TEST

RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB HO: MEAN = 0	PROB HO: |MEAN| < 4	PROB HO: |MEAN| < 6
MAIN	FOREBAY	FORT_FORE_	605.5	94	100	1.1800	0.15852	0.00000	1.00000	1.00000
		GUNT_FORE_	350	94	100	2.1600	0.21776	0.00000	1.00000	1.00000
		KENT_FORE_	23	94	100	-0.8000	0.22918	0.00072	1.00000	1.00000
		MELT_FORE_	24	94	100	0.3200	0.37896	0.40048	1.00000	1.00000
		NICK_FORE_	425.5	94	100	-0.3200	0.15497	0.04155	1.00000	1.00000
		NICK_FORE_	425.5	95	100	-2.0200	0.16936	0.00000	1.00000	1.00000
		PICK_FORE_	207.3	94	100	0.7600	0.23403	0.00159	1.00000	1.00000
		TELL_FORE_	1	94	100	5.4800	0.11235	0.00000	0.00000	0.99999
		WATT_FORE_	531	94	100	5.4400	0.36744	0.00000	0.00008	0.93466
		WHEE_FORE_	277	94	100	3.2200	0.23250	0.00000	0.99944	1.00000
		WILS_FORE_	260.8	94	100	-2.1600	0.12927	0.00000	1.00000	1.00000
MAIN	INFLOW			.	1300	0.4662	0.08475	0.00000	1.00000	1.00000
		CHIC_INFL_	518	94	100	-4.2000	0.12227	0.00000	0.05253	1.00000
		CHIC_INFL_	518	95	100	-2.1000	0.14320	0.00000	1.00000	1.00000
		FORT_INFL_	652	94	100	1.5200	0.25917	0.00000	1.00000	1.00000
		GUNT_INFL_	420	94	100	1.1000	0.19771	0.00000	1.00000	1.00000
		KENT_INFL_	15	94	100	-2.2000	0.28213	0.00000	1.00000	1.00000
		KENT_INFL_	200	94	100	0.1400	0.13106	0.28801	1.00000	1.00000
		MELT_INFL_	58.8	94	100	3.1600	0.25926	0.00000	0.99919	1.00000
		NICK_INFL_	469	94	100	-0.5000	0.16175	0.00259	1.00000	1.00000
		PICK_INFL_	253.2	94	100	2.4600	0.28120	0.00000	1.00000	1.00000
		WATT_INFL_	19	94	100	0.6000	0.23181	0.01110	1.00000	1.00000
		WATT_INFL_	600	94	100	3.8600	0.20939	0.00000	0.74735	1.00000
		WHEE_INFL_	347	94	100	0.0600	0.12857	0.64175	1.00000	1.00000
		WILS_INFL_	273	94	100	2.1600	0.23558	0.00000	1.00000	1.00000
MAIN	TRANSITION			.	1000	0.0960	0.09217	0.29787	1.00000	1.00000
		CHIC_TRAN_	490.5	94	100	-0.9000	0.11849	0.00000	1.00000	1.00000
		FORT_TRAN_	624.6	94	100	-2.4400	0.17884	0.00000	1.00000	1.00000
		GUNT_TRAN_	375.2	94	100	-1.6200	0.09296	0.00000	1.00000	1.00000
		KENT_TRAN_	85	94	100	-0.5800	0.22616	0.01183	1.00000	1.00000
		MELT_TRAN_	45	94	100	-0.7000	0.26572	0.00978	1.00000	1.00000
		PICK_TRAN_	230	94	100	-0.4800	0.18882	0.01257	1.00000	1.00000
		TELL_TRAN_	15	94	100	5.2600	0.26155	0.00000	0.00000	0.99718
		TELL_TRAN_	15	95	100	0.5000	0.16422	0.00298	1.00000	1.00000
		WATT_TRAN_	560.8	94	100	3.1200	0.17825	0.00000	1.00000	1.00000
		WHEE_TRAN_	295.9	94	100	-1.2000	0.13633	0.00000	1.00000	1.00000
RV				.	1500	0.0600	0.07877	0.44634	1.00000	1.00000
RV	FOREBAY			.	800	-0.4125	0.08560	0.00000	1.00000	1.00000
		BOON_FORE_	19	94	100	-0.5600	0.09462	0.00000	1.00000	1.00000
		CHER_FORE_	53	94	100	-1.8400	0.19834	0.00000	1.00000	1.00000
		DOUG_FORE_	33	94	100	2.1000	0.21532	0.00000	1.00000	1.00000
		FORT_FORE_	8.7	94	100	-1.7800	0.07464	0.00000	1.00000	1.00000
		NORR_FORE_	80.4	94	100	-2.1400	0.18259	0.00000	1.00000	1.00000
		NORR_FORE_	80.4	95	100	-1.0200	0.22292	0.00001	1.00000	1.00000
		SOUT_FORE_	51	94	100	2.9600	0.15434	0.00000	1.00000	1.00000
		TIMS_FORE_	135	94	100	-1.0200	0.10048	0.00000	1.00000	1.00000

Table 6. Cont.'

PAIRED-COMPARISON T TEST

RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
RV	TRANSITION			.	700	0.6000	0.13475	0.00001	1.00000	1.00000
		BOON_INFL_	27	94	100	-1.2400	0.12643	0.00000	1.00000	1.00000
		BOON_INFL_	6.5	94	100	4.2600	0.42035	0.00000	0.26882	0.99996
		DOUG_TRAN_	51	94	100	-0.0800	0.13002	0.53977	1.00000	1.00000
		NORR_TRAN_	30	94	100	-0.0600	0.38503	0.87648	1.00000	1.00000
		NORR_TRAN_	125	94	100	3.1200	0.21143	0.00000	0.99997	1.00000
		SOUT_INFL_	62.5	94	100	-3.7600	0.13716	0.00000	0.95838	1.00000
		TIMS_TRAN_	150	94	100	1.9600	0.15037	0.00000	1.00000	1.00000

Table 7. Results of Paired-t Tests on Benthic Community Scores Developed from the Original Sample Set and Repeat Sample Set. (Note: a "+" difference indicates the original sample set score was higher and a "-" difference indicates the repeat sample set score was higher.)

S[illegible]E	RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
FIELD					.	22	0.8182	1.03329	0.43732	0.99709	0.99997
FIELD		FOREBAY			.	9	-0.2222	2.09349	0.91808	0.90638	0.97875
FIELD		INFLOW			.	3	4.6667	0.66667	0.01980	0.20839	0.90631
FIELD		TRANSITION			.	5	2.0000	1.78885	0.32616	0.82269	0.94997
FIELD		UPPER			.	5	-0.8000	1.35647	0.58705	0.94911	0.98701
FIELD	BR				.	7	-1.7143	2.70550	0.54970	0.74513	0.90330
FIELD	BR	FOREBAY			.	3	-3.3333	6.56591	0.66213	0.34570	0.49247
			BLUE_FORE_	54.1	94	1	-16.0000	.	.	.	.
			PARK_FORE_	12.5	94	1	0.0000	.	.	.	.
			PARK_FORE_	12.5	95	1	6.0000	.	.	.	.
FIELD	BR	UPPER			.	4	-0.5000	1.70783	0.78878	0.89458	0.95978
			HIWA_INFL_	85	94	1	0.0000	.	.	.	.
			NOTT_INFL_	31	94	1	-2.0000	.	.	.	.
			NOTT_TRAN_	31	95	1	-4.0000	.	.	.	.
			WATA_INFL_	45.5	94	1	4.0000	.	.	.	.
F[illegible]	IP				.	2	0.0000	0.00000	.	.	.
FIELD	IP	FOREBAY			.	2	0.0000	0.00000	.	.	.
			LITT_FORE_	12.5	94	1	0.0000	.	.	.	.
			NORM_FORE_	249.5	95	1	0.0000	.	.	.	.
FIELD	MAIN				.	11	2.7273	0.90545	0.01307	0.90492	0.99763
FIELD	MAIN	FOREBAY			.	3	2.0000	1.15470	0.22540	0.86975	0.95281
			CHIC_FORE_	472.3	94	1	2.0000	.	.	.	.
			NICK_FORE_	425.5	94	1	0.0000	.	.	.	.
			NICK_FORE_	425.5	95	1	4.0000	.	.	.	.
FIELD	MAIN	INFLOW			.	3	4.6667	0.66667	0.01980	0.20839	0.90631
			CHIC_INFL_	518	95	1	6.0000	.	.	.	.
			NICK_INFL_	469	94	1	4.0000	.	.	.	.
			PICK_INFL_	253.2	94	1	4.0000	.	.	.	.
FIELD	MAIN	TRANSITION			.	5	2.0000	1.78885	0.32616	0.82269	0.94997
			CHIC_EMBA_	8.5	94	1	4.0000	.	.	.	.
			CHIC_TRAN_	490.5	94	1	0.0000	.	.	.	.
			KENT_TRAN_	85	94	1	0.0000	.	.	.	.
			TELL_TRAN_	15	95	1	8.0000	.	.	.	.
			WHEE_EMBA_	6	95	1	-2.0000	.	.	.	.
F[illegible]	RV				.	2	0.0000	2.00000	1.00000	0.70483	0.79517
FIELD	RV	FOREBAY			.	1	2.0000	.	.	.	.

Table 7. Cont.'

PAIRED-COMPARISON T TEST

SOURCE	RESTYPE	WBDSECNA	SITE		YEAR	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
FIELD	RV	FOREBAY	NORR_FORE_	80.4	95	1	2.0000	.	.	.	.
FIELD	RV	UPPER			.	1	-2.0000	.	.	.	.
			CHER_TRAN_	91	95	1	-2.0000	.	.	.	.

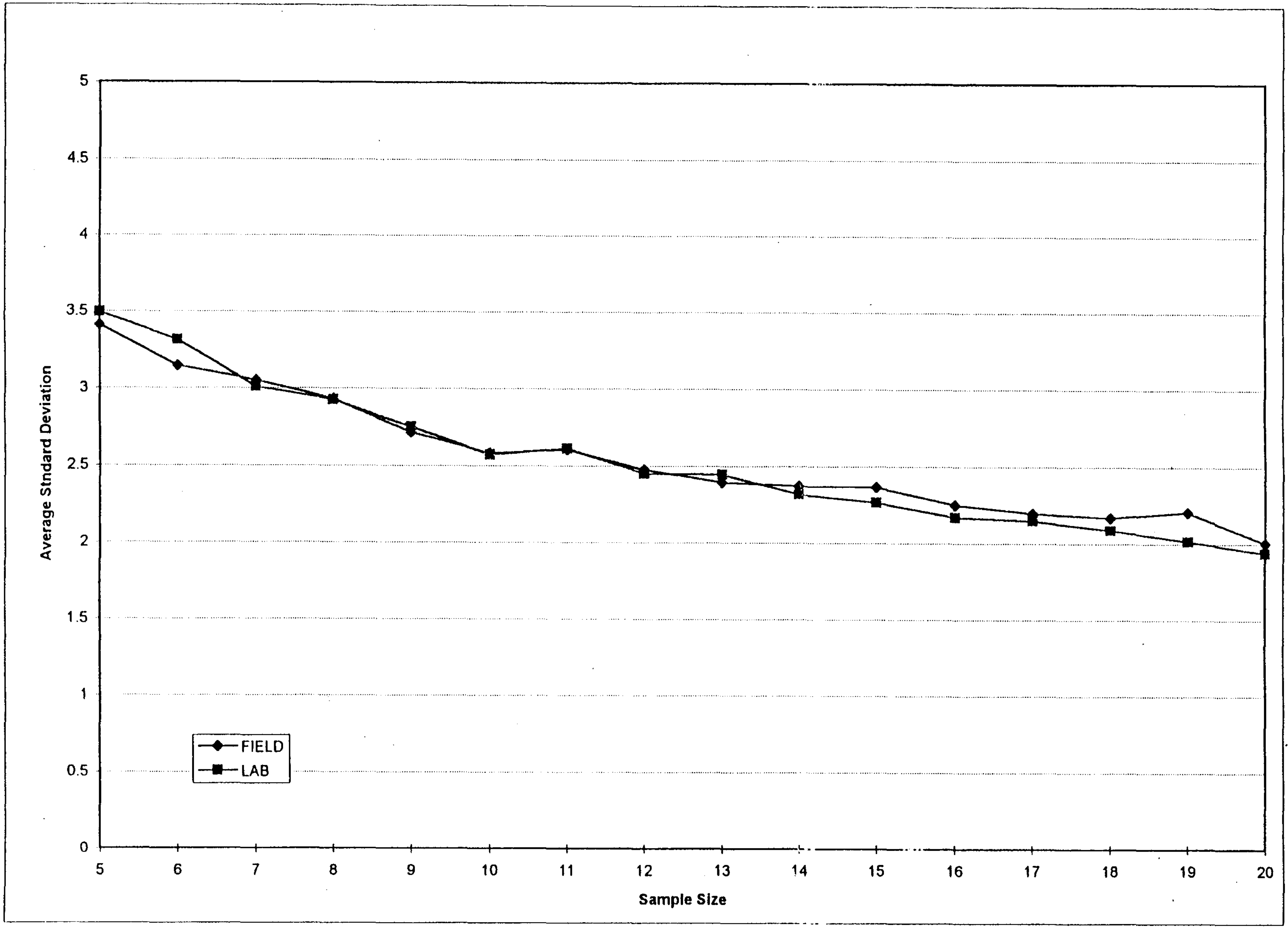

Figure 1. Average Standard Deviation of Simulated Benthic Community Scores Plotted Against Sample Sizes Ranging from 5 to 20

Section 6. Fish Community

Philosophical Approach/Background

Many of the same considerations discussed for the benthic macroinvertebrate community (Section 5) also apply for the fish community. These are repeated here, as appropriate, in case the reader does not have access to that information.

Fish are usually included in aquatic monitoring programs because they are important to the aquatic foodweb and because they have long a life cycle which allows them to integrate conditions over time. In streams, fish community monitoring often has found environmental degradation when physical and chemical monitoring have failed to do so. Fish are also important to the public for aesthetic, recreational, and commercial reasons.

Reservoir fish communities are vastly different from that in the river prior to impoundment due to significant habitat alterations. Also, substantial differences are expected along a longitudinal gradient with a more riverine community expected at the upper end or inflow of a reservoir and a more lacustrine community expected in the pool near the dam. Other factors to consider in evaluating biotic communities in reservoirs include reservoir operational characteristics (e.g., water depth, water level fluctuation, depth of drawdown for flood control, retention time, stratification, bottom anoxia, substrate type and stability, and depth of withdrawal for discharge) and physical/chemical features owing to geological characteristics of different ecoregions.

All these factors, plus the fact that a reservoir is an artificial system, must be considered in selecting community characteristics or expectations that will be used to evaluate aquatic resource conditions. Given that reservoirs are artificial systems, it is not possible to use the well accepted Index of Biotic Integrity (IBI) approach of using reference sites to determine characteristics or expectations of a reservoir unaffected by human impacts. By definition, IBI specifies reference conditions should be developed from natural, unaltered habitats (Karr and Dudley, 1981 after Frey 1975). Therefore, other approaches must be used; such as, using historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. As stated above, preimpoundment conditions are inappropriate due to significant habitat alterations. Like benthic macroinvertebrates, the state of the understanding of fish communities in reservoirs simply is insufficient for models to effectively predict species composition and relative abundance. This leaves the latter two as the most viable alternatives for establishing appropriate reference conditions or expectations for reservoirs. TVA's experience has found use of best observed conditions adjusted using professional judgment as the best approach. Use of best observed conditions requires an extensive database to determine expectations for each metric, and use of professional judgment to adjust scoring ranges requires substantial experience with the group of reservoirs under consideration. To use this concept, results in the data base which approach desired conditions for a given community characteristic are considered representative of best observed conditions. Monitoring results falling within that range would be considered "good". Details of this approach to developing reference conditions are provided later in this document.

Another important consideration in developing reference conditions is that care must be taken to compare only those reservoirs for which comparison is appropriate. That is, only reservoirs for which similar communities would be expected should be compared, i.e., those in the same ecoregion and comparable physical characteristics. Hence, separation of reservoirs into appropriate classes is a critical step.

TVA's monitoring program includes 30 reservoirs. For classification purposes these have been divided into two major groups : run-of-the-river reservoirs (those with short retention times and winter drawdown of only a few feet) and tributary reservoirs (those with long retention times and substantial winter drawdowns). The tributary reservoirs have been further divided into three groups by ecoregion and reservoir physical characteristics. Fish assemblage expectations for each metric (discussed later) have been developed for each of these four reservoir categories.

Run-of-the-River
<u>Reservoirs</u>
- Kentucky
- Pickwick
- Wilson
- Wheeler
- Guntersville
- Nickajack
- Chickamauga
- Watts Bar
- Melton Hill
- Tellico
- Fort Loudon

Tributary Reservoirs:
<u>Interior Plateau Ecoregion</u>
- Bear Creek
- Cedar Creek
- Little Bear
- Normandy
- Beech
- Tims Ford

Tributary Reservoirs:
<u>Ridge and Valley Ecoregion</u>
- Cherokee
- Fort Patrick Henry
- Boone
- South Holston
- Norris
- Douglas

Tributary Reservoirs:
<u>Blue Ridge Ecoregion</u>
- Fontana
- Hiwassee
- Chatuge
- Nottely
- Parksville
- Blue Ridge
- Watauga

Sample Collection Methods

Shoreline electrofishing samples were collected during daylight hours from inflow, transition, and forebay zones of most reservoirs during autumn (September to mid-November 1995). Only one or two zones were sampled on reservoirs where zones were indistinguishable. No inflow zones were sampled in tributary reservoirs during 1995 because environmental quality of major inflow streams was addressed using Index of Biotic Integrity (IBI) techniques in the free flowing portion upstream of the impoundment. Location of collection sites in 1995 are identified in Section 1, Table 1.

A total of 15 electrofishing transects, each covering 300m of shoreline, was collected from each of the sampled zones. All habitats were sampled in proportion to their occurrence in the zone. Twelve experimental gill nets with five 6.1m panels (mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm) were set for one overnight period in forebay and transition zones. Excessive current prevented use of gill nets in mainstream inflow areas limiting sampling to only electrofishing in these locations. Nets were set in all habitat types, alternating mesh sizes toward the shoreline between sets.

Total length (mm) and weight (g) were obtained for all sport species and channel catfish. Remaining species captured were enumerated prior to release. During electrofishing, fish observed but not captured were included if positive identification could be made and counts were estimated when high densities of identifiable fish were encountered. Young-of-year fish were counted separately and, as in stream IBI calculations (Karr 1981), were excluded from proportional and abundance metrics due to sampling inefficiencies. Only fish examined closely as a result of obtaining length and weight measurements were inspected externally for signs of disease, parasites, and anomalies. Other species groups often included several individuals which were observed, but not captured, thus the ratio of diseased, etc. was not obtainable for these groups. Natural hybrids (i.e., those known not to be part of a fisheries management program) were included as an anomaly. Field data loggers were used to record all sampling results.

Reservoir Fish Assemblage Index (RFAI)

The current RFAI uses 12 fish community metrics from five general categories (Hickman and McDonough, 1995). The 12 metrics include:

Species Richness and Composition

1. **Total number of species**--Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at a site decline.

2. **Number of piscivore species**--Higher diversity of piscivores is indicative of better quality environment.

3. **Number of sunfish species**--Lepomid sunfish (excludes black basses, crappies, and rock bass) are basically insectivores, and high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

4. **Number of sucker species**--Suckers are also insectivores but inhabit the pelagic and more riverine sections of reservoirs.

5. **Number of intolerant species**--This group is made up of species that are particularly intolerant of habitat degradation. Higher densities of intolerant individuals represent better environmental quality.

6. **Percentage of tolerant individuals** (excluding Young-of-Year)--This metric signifies poorer quality with increasing proportions of individuals tolerant of degraded conditions.

7. **Percentage dominance by one species**--Ecological quality is considered reduced if one species dominates the resident fish community.

Trophic Composition

8. **Percentage of individuals as omnivores**--Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

9. **Percentage of individuals as insectivores**--Due to the special dietary requirements of this group of species and the limitations of their food source in degraded environments, proportion of insectivores increases with environmental quality.

Reproductive Composition

10. **Number of lithophilic spawning species**--Lithophilic broadcast spawners spawn over rocky substrate and do not provide parental care. This guild is expected to be sensitive to siltation. Numbers of lithophilic spawning species increase in reservoirs providing suitable conditions reflective of good environmental quality.

Abundance

11. **Total catch per unit effort** (number of individuals)--This metric is based upon the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

12. **Percentage individuals with anomalies**--Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization are noted for all fish measured, with higher incidence indicating poor environmental conditions.

Establishing scoring criteria (i.e., expectations or reference conditions) requires a substantial data base for each class of reservoir and assumes the data base contains reservoirs with conditions ranging from poor to good for each metric. The smaller the number of reservoirs within a class, the less likely these assumptions can be met and the greater the need for sound professional judgment based on extensive knowledge of reservoir communities being studied. One way to help alleviate this problem is to use several years of results from reservoirs within a class. This not only helps establish baseline conditions for each reservoir, but also has the desirable effect of increasing the data base from which scoring criteria can developed. However, care must be taken to keep this time period as short as possible; otherwise, constantly changing criteria will prevent recognition of improvements or degradation if they occur. This potential problem was realized as this monitoring program was being conceived. As a result, it was decided that the maximum desired period to establish baseline conditions and provide the data base to develop scoring criteria would be five years, assuming variations of low, normal, and high flows were experienced in that time frame. This proved to be the case. In practice, scoring criteria for RAFI metrics were reevaluated each year from 1990 through 1994 as new data were added. Scoring criteria have not been adjusted since 1994.

In developing scoring criteria, a slightly different approach was used for species richness metrics than for abundance and proportional metrics. For species richness metrics, a list was made of all species collected from comparable locations within a reservoir class from 1990 - 1994. This species list was adjusted using inferences of experienced biologists knowledgeable of the reservoir system, resident fish species, susceptibility of each species to collection methods being used, and effects of human-induced impacts on these species. This effort resulted in a list of the maximum number of species expected to occur at a sampling location and be captured by collection devices in use. Given that only one collection effort is exerted each year, this maximum number of species would not be expected to be represented in that one collection. Therefore, the range from zero to 95% of the maximum was trisected to provide the three scoring ranges (good, fair, and poor). Although even 95% of the maximum number of species at a site would not be expected to be collected in one sampling event, this "high" expectation was adopted to keep these metrics conservative in light of potential uncertainties introduced by relying heavily on professional judgment.

Scoring criteria for proportional metrics and the abundance metric were determined by trisecting observed ranges after omitting outliers. Next, cutoff points between the three ranges were adjusted based on examination of frequency distributions of observed data for each metric along with professional judgment. In some cases, the narrow range of observed conditions required further adjustment based on knowledge of metric responses to human-induced impacts observed in other reservoir classes. Scoring criteria for the fish health metric are those described by Karr et.al. (1986). Scoring criteria are detailed in Table 1.

Scoring criteria are used to separate results for each metric into three categories assumed to represent relative degrees of condition of the fish assemblage ranging from good to poor. Each category has a corresponding value: good = 5; fair = 3; and poor = 1. The sum of the 12 metrics constitutes the RFAI score.

Scoring criteria were applied differently to results from the two collections methods (electrofishing and experimental gill netting) depending on the type metric. For the taxa richness, reproductive composition, and fish health metrics, sampling results were pooled prior to scoring. For abundance and proportional metrics, electrofishing and gill netting results were scored separately, then the two scores averaged to arrive at a final metric value.

To arrive at an evaluation of the condition of the fish assemblage at a sample location, scores were evaluated as follows:

RFAI Score	12-21	22-31	32-40	41-50	51-60
Community Condition	Very Poor	Poor	Fair	Good	Excellent

The contribution of the fish community results for each sample site to the overall reservoir Ecological Health Index was as follows:

RFAI Score	12-21	22-31	32-40	41-50	51-60
Contribution to Reservoir Ecological Health Index	1	2	3	4	5

Fish assemblage results along with results from the other four indicators and overall the ecological health score for each reservoir are used to keep the public informed on the conditions of Tennessee Valley reservoirs. In publications intended for the public, results for each of the five environmental indicators at each sample site are presented using one of three colors -- green (good), yellow (fair), or red (poor). This necessitated dividing the RFAI scores into three ranges as follows:

RFAI Score	12-28	29-44	45-60
Color	Poor (Red)	Fair (Yellow)	Good (Green)

Results from 1995 Monitoring

RFAI scores for 1990 through 1995 are summarized by reservoir class and type of location in Table 2. (Note: 10 electrofishing runs were used in 1990 - 1992 and 15 were used in 1993 - 1995.) Appendix D summarizes results and ratings for individual metrics and final RFAI scores for each sample location based on 1995 data. Appendix E provides mean catch per effort by species for electrofishing and gill netting efforts at each location in 1995.

Approximately 20 percent of the locations (9 randomly selected sites) were revisited for Quality Control purposes. These sites were revisited by a second sample crew several days or weeks after the initial sampling to collect a second set of samples. A RFAI score was developed separately for each of the two sample sets. The desired maximum difference between the RFAI score from the original sample and the QC sample set was 10. A difference greater than this could cause the RAFI to change two categories (e.g., very poor-1 point to fair-3 points or fair-3 points to good-5 points). A shift of two categories in the RFAI could cause a change of 2 points contributed to the overall Reservoir Ecological Health Score. For reservoirs with only one sample location, a 2 point change translates into a change of 8.8 percent change in the Ecological Health Score, which was deemed unacceptable.

Results from the Second QC Component: Scores derived from repeat sampling compared to scores from the original samples in 1995.

	Original Score	QC Score	Difference
Run-of-the-River Reservoirs			
Chickamauga Inflow	44 (Good)	48 (Good)	4
Nickajack Forebay	44 (Good)	45 (Good)	1
Wheeler Embayment	39 (Fair)	43 (Good)	4
Tellico Transition	37 (Fair)	32 (Fair)	5
Tributary Reservoirs			
Blue Ridge Ecoregion			
Parksville Forebay	37 (Fair)	37 (Fair)	0
Nottely Forebay	36 (Fair)	34 (Fair)	2
Ridge and Valley Ecoregion			
Norris Forebay	31 (Poor)	37 (Fair)	6
Cherokee Mid-reservoir	32 (Fair)	32 (Fair)	0
Interior Plateau Ecoregion			
Normandy Forebay	45 (Good)	51 (Excellent)	6

The maximum observed difference was 6 (2 sets of samples) and the minimum was 0 (2 sets of samples). The mean difference for all reservoirs was 3.1. The 95% confidence interval around the mean would be 1.7 to 7.9, below the desired level of 10.

Scores from the two sample sets from each QC location in 1995 were tested using a t-test for paired comparisons at $\alpha = 0.05$ with the null hypothesis that the mean difference between each pair of scores did not exceed 6. The test failed to detect a significant difference; therefore, the null hypothesis could not rejected (Table 4).

These results indicate acceptable reproducibility for fish assemblage sampling.

References

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Table 1. Scoring Criteria for Individual Metrics for Each Class of Reservoir

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
all	all	all	12. Percent anomalies	combined	< 0.02	0.02 - 0.05	> 0.05
BLUE RIDGE	all	forbay	1. Number of species	combined	< 8	8 - 15	> 15
BLUE RIDGE	all	forbay	2. Piscivore species	combined	< 3	3 - 5	> 5
BLUE RIDGE	all	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
BLUE RIDGE	all	forbay	4. Sucker species	combined	< 2	2 - 3	> 3
BLUE RIDGE	all	forbay	5. Intolerant species	combined	< 2	2 - 2	> 2
BLUE RIDGE	all	forbay	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15
BLUE RIDGE	all	forbay	6. Percent tolerant species	Gill netting	> .20	.10 - .20	< .10
BLUE RIDGE	all	forbay	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
BLUE RIDGE	all	forbay	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
BLUE RIDGE	all	forbay	8. Percent omnivores	Electrofishing	> .10	.05 - .10	< .05
BLUE RIDGE	all	forbay	8. Percent omnivores	Gill netting	> .30	.15 - .30	< .15
BLUE RIDGE	all	forbay	9. Percent insectivores	Electrofishing	< .75	.75 - .85	> .85
BLUE RIDGE	all	forbay	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
BLUE RIDGE	all	forbay	10. Lithophilic spawning species	combined	< 3	3 - 4	> 4
BLUE RIDGE	all	forbay	11. Average number of individuals	Electrofishing	< 30	30 - 60	> 60
BLUE RIDGE	all	forbay	11. Average number of individuals	Gill netting	< 10	10 - 18	> 18
BLUE RIDGE	all	transition	1. Number of species	combined	< 8	8 - 15	> 15
BLUE RIDGE	all	transition	2. Piscivore species	combined	< 3	3 - 5	> 5
BLUE RIDGE	all	transition	3. Sunfish species	combined	< 2	2 - 3	> 3
BLUE RIDGE	all	transition	4. Sucker species	combined	< 2	2 - 3	> 3
BLUE RIDGE	all	transition	5. Intolerant species	combined	< 2	2 - 2	> 2
BLUE RIDGE	all	transition	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15
BLUE RIDGE	all	transition	6. Percent tolerant species	Gill netting	> .20	.10 - .20	< .10
BLUE RIDGE	all	transition	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
BLUE RIDGE	all	transition	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
BLUE RIDGE	all	transition	8. Percent omnivores	Electrofishing	> .10	.05 - .10	< .05
BLUE RIDGE	all	transition	8. Percent omnivores	Gill netting	> .30	.15 - .30	< .15
BLUE RIDGE	all	transition	9. Percent insectivores	Electrofishing	< .75	.75 - .85	> .85
BLUE RIDGE	all	transition	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
BLUE RIDGE	all	transition	10. Lithophilic spawning species	combined	< 3	3 - 4	> 4
BLUE RIDGE	all	transition	11. Average number of individuals	Electrofishing	< 30	30 - 60	> 60
BLUE RIDGE	all	transition	11. Average number of individuals	Gill netting	< 10	10 - 18	> 18
INTER PLAT	BEAR SYS.	forbay	1. Number of species	combined	< 10	10 - 19	> 19
INTER PLAT	NORMANDY	forbay	1. Number of species	combined	< 8	8 - 17	> 17
INTER PLAT	TIMS FORD	forbay	1. Number of species	combined	< 10	10 - 20	> 20

Table 1 (Cont'd)

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
INTER PLAT	BEAR SYS.	forbay	2. Piscivore species	combined	< 3	3 - 6	> 6
INTER PLAT	NORMANDY	forbay	2. Piscivore species	combined	< 3	3 - 6	> 6
INTER PLAT	TIMS FORD	forbay	2. Piscivore species	combined	< 4	4 - 6	> 6
INTER PLAT	BEAR SYS.	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
INTER PLAT	NORMANDY	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
INTER PLAT	TIMS FORD	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
INTER PLAT	BEAR SYS.	forbay	4. Sucker species	combined	< 3	3 - 5	> 5
INTER PLAT	NORMANDY	forbay	4. Sucker species	combined	< 3	3 - 4	> 4
INTER PLAT	TIMS FORD	forbay	4. Sucker species	combined	< 4	4 - 6	> 6
INTER PLAT	BEAR SYS.	forbay	5. Intolerant species	combined	< 2	2 - 2	> 2
INTER PLAT	NORMANDY	forbay	5. Intolerant species	combined	< 2	2 - 2	> 2
INTER PLAT	TIMS FORD	forbay	5. Intolerant species	combined	< 2	2 - 2	> 2
INTER PLAT	all	forbay	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15
INTER PLAT	all	forbay	6. Percent tolerant species	Gill netting	> .35	.20 - .35	< .20
INTER PLAT	all	forbay	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
INTER PLAT	all	forbay	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
INTER PLAT	all	forbay	8. Percent omnivores	Electrofishing	> .25	.10 - .25	< .10
INTER PLAT	all	forbay	8. Percent omnivores	Gill netting	> .60	.40 - .60	< .40
INTER PLAT	all	forbay	9. Percent insectivores	Electrofishing	< .60	.60 - .80	> .80
INTER PLAT	all	forbay	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
INTER PLAT	BEAR SYS.	forbay	10. Lithophilic spawning species	combined	< 3	3 - 6	> 6
INTER PLAT	NORMANDY	forbay	10. Lithophilic spawning species	combined	< 3	3 - 6	> 6
INTER PLAT	TIMS FORD	forbay	10. Lithophilic spawning species	combined	< 4	4 - 6	> 6
INTER PLAT	all	forbay	11. Average number of individuals	Electrofishing	< 40	40 - 80	> 80
INTER PLAT	all	forbay	11. Average number of individuals	Gill netting	< 10	10 - 18	> 18
INTER PLAT	NORMANDY	transition	1. Number of species	combined	< 8	8 - 17	> 17
INTER PLAT	TIMS FORD	transition	1. Number of species	combined	< 11	11 - 20	> 20
INTER PLAT	NORMANDY	transition	2. Piscivore species	combined	< 3	3 - 6	> 6
INTER PLAT	TIMS FORD	transition	2. Piscivore species	combined	< 4	4 - 6	> 6
INTER PLAT	NORMANDY	transition	3. Sunfish species	combined	< 2	2 - 3	> 3
INTER PLAT	TIMS FORD	transition	3. Sunfish species	combined	< 2	2 - 3	> 3
INTER PLAT	NORMANDY	transition	4. Sucker species	combined	< 2	2 - 2	> 2
INTER PLAT	TIMS FORD	transition	4. Sucker species	combined	< 4	4 - 6	> 6
INTER PLAT	NORMANDY	transition	5. Intolerant species	combined	< 2	2 - 2	> 2
INTER PLAT	TIMS FORD	transition	5. Intolerant species	combined	< 2	2 - 2	> 2
INTER PLAT	all	transition	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15

Tab... 1 (Cont'd)

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
INTER PLAT	all	transition	6. Percent tolerant species	Gill netting	> .35	.20 - .35	< .20
INTER PLAT	all	transition	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
INTER PLAT	all	transition	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
INTER PLAT	all	transition	8. Percent omnivores	Electrofishing	> .25	.10 - .25	< .10
INTER PLAT	all	transition	8. Percent omnivores	Gill netting	> .60	.40 - .60	< .40
INTER PLAT	all	transition	9. Percent insectivores	Electrofishing	< .50	.50 - .70	> .70
INTER PLAT	all	transition	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
INTER PLAT	NORMANDY	transition	10. Lithophilic spawning species	combined	< 3	3 - 6	> 6
INTER PLAT	TIMS FORD	transition	10. Lithophilic spawning species	combined	< 4	4 - 6	> 6
INTER PLAT	all	transition	11. Average number of individuals	Electrofishing	< 40	40 - 80	> 80
INTER PLAT	all	transition	11. Average number of individuals	Gill netting	< 10	10 - 18	> 18
MAINSTREAM	LOWER MS	forbay	1. Number of species	combined	< 14	14 - 27	> 27
MAINSTREAM	MELTON H	forbay	1. Number of species	combined	< 13	13 - 24	> 24
MAINSTREAM	TELLICO	forbay	1. Number of species	combined	< 13	13 - 24	> 24
MAINSTREAM	UPPER MS	forbay	1. Number of species	combined	< 14	14 - 27	> 27
MAINSTREAM	LOWER MS	forbay	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	forbay	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	TELLICO	forbay	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	UPPER MS	forbay	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	LOWER MS	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
MAINSTREAM	MELTON H	forbay	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	TELLICO	forbay	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	UPPER MS	forbay	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	LOWER MS	forbay	4. Sucker species	combined	< 4	4 - 6	> 6
MAINSTREAM	MELTON H	forbay	4. Sucker species	combined	< 4	4 - 6	> 6
MAINSTREAM	TELLICO	forbay	4. Sucker species	combined	< 4	4 - 6	> 6
MAINSTREAM	UPPER MS	forbay	4. Sucker species	combined	< 4	4 - 7	> 7
MAINSTREAM	LOWER MS	forbay	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	MELTON H	forbay	5. Intolerant species	combined	< 2	2 - 3	> 3
MAINSTREAM	TELLICO	forbay	5. Intolerant species	combined	< 2	2 - 3	> 3
MAINSTREAM	UPPER MS	forbay	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	all	forbay	6. Percent tolerant species	Electrofishing	> .45	.20 - .45	< .20
MAINSTREAM	all	forbay	6. Percent tolerant species	Gill netting	> .40	.20 - .40	< .20
MAINSTREAM	all	forbay	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
MAINSTREAM	all	forbay	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
MAINSTREAM	all	forbay	8. Percent omnivores	Electrofishing	> .45	.20 - .45	< .20

Table 1 (Cont'd)

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
MAINSTREAM	all	forbay	8. Percent omnivores	Gill netting	> .45	.30 - .45	< .30
MAINSTREAM	all	forbay	9. Percent insectivores	Electrofishing	< .35	.35 - .70	> .70
MAINSTREAM	all	forbay	9. Percent insectivores	Gill netting	< .05	.05 - .15	> .15
MAINSTREAM	LOWER MS	forbay	10. Lithophilic spawning species	combined	< 4	4 - 6	> 6
MAINSTREAM	MELTON H	forbay	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	TELLICO	forbay	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	UPPER MS	forbay	10. Lithophilic spawning species	combined	< 3	3 - 6	> 6
MAINSTREAM	all	forbay	11. Average number of individuals	Electrofishing	< 50	50 - 100	> 100
MAINSTREAM	all	forbay	11. Average number of individuals	Gill netting	< 15	15 - 35	> 35
MAINSTREAM	LOWER MS	inflow	1. Number of species	combined	< 14	14 - 27	> 27
MAINSTREAM	MELTON H	inflow	1. Number of species	combined	< 13	13 - 24	> 24
MAINSTREAM	UPPER MS	inflow	1. Number of species	combined	< 14	14 - 27	> 27
MAINSTREAM	LOWER MS	inflow	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	inflow	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	UPPER MS	inflow	2. Piscivore species	combined	< 3	3 - 6	> 6
MAINSTREAM	LOWER MS	inflow	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	MELTON H	inflow	3. Sunfish species	combined	< 3	3 - 4	> 4
MAINSTREAM	UPPER MS	inflow	3. Sunfish species	combined	< 3	3 - 4	> 4
MAINSTREAM	LOWER MS	inflow	4. Sucker species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	inflow	4. Sucker species	combined	< 3	3 - 6	> 6
MAINSTREAM	UPPER MS	inflow	4. Sucker species	combined	< 3	3 - 6	> 6
MAINSTREAM	LOWER MS	inflow	5. Intolerant species	combined	< 3	3 - 6	> 6
MAINSTREAM	MELTON H	inflow	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	UPPER MS	inflow	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	all	inflow	6. Percent tolerant species	Electrofishing	> .55	.30 - .55	< .30
MAINSTREAM	all	inflow	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
MAINSTREAM	all	inflow	8. Percent omnivores	Electrofishing	> .55	.30 - .55	< .30
MAINSTREAM	all	inflow	9. Percent insectivores	Electrofishing	< .25	.25 - .50	> .50
MAINSTREAM	LOWER MS	inflow	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	inflow	10. Lithophilic spawning species	combined	< 3	3 - 5	> 5
MAINSTREAM	UPPER MS	inflow	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	all	inflow	11. Average number of individuals	Electrofishing	< 50	50 - 100	> 100
MAINSTREAM	LOWER MS	transition	1. Number of species	combined	< 16	16 - 30	> 30
MAINSTREAM	MELTON H	transition	1. Number of species	combined	< 13	13 - 26	> 26
MAINSTREAM	TELLICO	transition	1. Number of species	combined	< 13	13 - 26	> 26
MAINSTREAM	UPPER MS	transition	1. Number of species	combined	< 15	15 - 29	> 29

ble 1 (Cont'd)

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
MAINSTREAM	LOWER MS	transition	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	transition	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	TELLICO	transition	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	UPPER MS	transition	2. Piscivore species	combined	< 4	4 - 7	> 7
MAINSTREAM	LOWER MS	transition	3. Sunfish species	combined	< 2	2 - 3	> 3
MAINSTREAM	MELTON H	transition	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	TELLICO	transition	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	UPPER MS	transition	3. Sunfish species	combined	< 2	2 - 4	> 4
MAINSTREAM	LOWER MS	transition	4. Sucker species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	transition	4. Sucker species	combined	< 4	4 - 6	> 6
MAINSTREAM	TELLICO	transition	4. Sucker species	combined	< 4	4 - 6	> 6
MAINSTREAM	UPPER MS	transition	4. Sucker species	combined	< 4	4 - 7	> 7
MAINSTREAM	LOWER MS	transition	5. Intolerant species	combined	< 3	3 - 4	> 4
MAINSTREAM	MELTON H	transition	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	TELLICO	transition	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	UPPER MS	transition	5. Intolerant species	combined	< 2	2 - 4	> 4
MAINSTREAM	all	transition	6. Percent tolerant species	Electrofishing	> .50	.25 - .50	< .25
MAINSTREAM	all	transition	6. Percent tolerant species	Gill netting	> .40	.20 - .40	< .20
MAINSTREAM	all	transition	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
MAINSTREAM	all	transition	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
MAINSTREAM	all	transition	8. Percent omnivores	Electrofishing	> .50	.25 - .50	< .25
MAINSTREAM	all	transition	8. Percent omnivores	Gill netting	> .45	.30 - .45	< .30
MAINSTREAM	all	transition	9. Percent insectivores	Electrofishing	< .30	.30 - .60	> .60
MAINSTREAM	all	transition	9. Percent insectivores	Gill netting	< .07	.07 - .15	> .15
MAINSTREAM	LOWER MS	transition	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	MELTON H	transition	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	TELLICO	transition	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	UPPER MS	transition	10. Lithophilic spawning species	combined	< 4	4 - 7	> 7
MAINSTREAM	all	transition	11. Average number of individuals	Electrofishing	< 50	50 - 100	> 100
MAINSTREAM	all	transition	11. Average number of individuals	Gill netting	< 15	15 - 35	> 35
RID & VALL	all	forbay	1. Number of species	combined	< 10	10 - 19	> 19
RID & VALL	all	forbay	2. Piscivore species	combined	< 3	3 - 6	> 6
RID & VALL	all	forbay	3. Sunfish species	combined	< 2	2 - 3	> 3
RID & VALL	all	forbay	4. Sucker species	combined	< 3	3 - 5	> 5
RID & VALL	all	forbay	5. Intolerant species	combined	< 2	2 - 2	> 2
RID & VALL	all	forbay	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15

Table 1 (Cont'd)

Reservoir Group	Reservoir Subgroup	STATION	METRIC	GEAR	ONE	THREE	FIVE
RID & VALL	all	forbay	6. Percent tolerant species	Gill netting	> .50	.30 - .50	< .30
RID & VALL	all	forbay	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
RID & VALL	all	forbay	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
RID & VALL	all	forbay	8. Percent omnivores	Electrofishing	> .25	.10 - .25	< .10
RID & VALL	all	forbay	8. Percent omnivores	Gill netting	> .60	.40 - .60	< .40
RID & VALL	all	forbay	9. Percent insectivores	Electrofishing	< .60	.60 - .80	> .80
RID & VALL	all	forbay	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
RID & VALL	all	forbay	10. Lithophilic spawning species	combined	< 2	2 - 4	> 4
RID & VALL	all	forbay	11. Average number of individuals	Electrofishing	< 40	40 - 80	> 80
RID & VALL	all	forbay	11. Average number of individuals	Gill netting	< 15	15 - 30	> 30
RID & VALL	all	transition	1. Number of species	combined	< 11	11 - 20	> 20
RID & VALL	all	transition	2. Piscivore species	combined	< 4	4 - 6	> 6
RID & VALL	all	transition	3. Sunfish species	combined	< 2	2 - 3	> 3
RID & VALL	all	transition	4. Sucker species	combined	< 3	3 - 6	> 6
RID & VALL	all	transition	5. Intolerant species	combined	< 2	2 - 2	> 2
RID & VALL	all	transition	6. Percent tolerant species	Electrofishing	> .30	.15 - .30	< .15
RID & VALL	all	transition	6. Percent tolerant species	Gill netting	> .50	.30 - .50	< .30
RID & VALL	all	transition	7. Dominance(% composition of most abundant species)	Electrofishing	> 60	40 - 60	< 40
RID & VALL	all	transition	7. Dominance(% composition of most abundant species)	Gill netting	> 50	30 - 50	< 30
RID & VALL	all	transition	8. Percent omnivores	Electrofishing	> .25	.10 - .25	< .10
RID & VALL	all	transition	8. Percent omnivores	Gill netting	> .60	.40 - .60	< .40
RID & VALL	all	transition	9. Percent insectivores	Electrofishing	< .50	.50 - .70	> .70
RID & VALL	all	transition	9. Percent insectivores	Gill netting	< .03	.03 - .06	> .06
RID & VALL	all	transition	10. Lithophilic spawning species	combined	< 3	3 - 6	> 6
RID & VALL	all	transition	11. Average number of individuals	Electrofishing	< 40	40 - 80	> 80
RID & VALL	all	transition	11. Average number of individuals	Gill netting	< 15	15 - 30	> 30

Table 2. Summary of RFAI Scores for 1991-1995 Based on 1994 Scoring Methods.

		1991	1992	1993	1994	1995
Beach Lake	Forebay	.	.	.	29	27
Bear Creek	Forebay	.	47	45	44	38
Blue Ridge	Forebay	40	37	39	42	44
Boone	Forebay	30	35	24	34	35
	Transition South Fork of The Holston	41	30	36	36	27
	Transition Watauga	34	34	34	37	39
Cedar Creek	Forebay	.	42	41	50	44
Chatuge	Forebay	35	43	40	43	.
	Shooting Creek	.	.	40	39	.
Cherokee	Forebay	42	35	42	38	37
	Inflow	.	.	.	.	.
	Transition	36	34	38	38	32
Chickamauga	Embayment	.	.	48	42	39
	Forebay	44	46	45	41	47
	Inflow	48	42	56	52	44
	Transition	45	41	51	41	50
Douglas	Forebay	33	39	40	42	36
	Inflow	.	.	.	.	.
	Transition	42	38	43	44	37
Fontana	Forebay	.	.	42	43	.
	Transition Little Tennessee	.	.	44	42	37
	Transition Tuckasegee	.	.	40	40	33
Fort Loudoun	Embayment	.	.	.	.	35
	Forebay	35	41	41	37	36
	Inflow	32	24	34	36	32
	Transition	33	33	34	38	27
Fort Patrick Henry	Forebay	.	.	46	33	20
Guntersville	Forebay	46	39	46	30	.
	Inflow	46	40	38	42	.
	Transition	33	40	38	35	.
Hiwassee	Forebay	42	39	48	52	.
	Inflow	.	.	.	.	.
	Transition	49	40	47	43	.
Kentucky	Embayment	.	.	31	31	28
	Forebay	44	38	42	38	41
	Inflow	46	36	38	34	36
	Transition	44	49	44	43	42
Little Bear Creek	Forebay	.	42	45	46	42

Table 2, Cont.'

Melton Hill	Forebay	42	31	40	49	.
	Inflow	20	18	22	28	.
	Transition	36	30	43	43	.
Nickajack	Forebay	45	36	49	45	44
	Inflow	48	48	58	50	54
	Transition	40	.	.	.	.
Normandy	Forebay	.	41	53	48	45
	Transition	.	51	.	.	.
Norris	Forebay	34	34	34	43	31
	Transition Clinch	40	43	47	51	39
	Transition Powell	48	44	48	52	41
Nottely	Forebay	37	35	37	38	36
	Transition	.	.	40	37	37
Parksville - Ocoee 1	Forebay	32	36	34	42	37
Pickwick	Embayment	.	.	42	44	.
	Forebay	40	34	50	43	.
	Inflow	44	42	50	46	.
	Transition	45	40	47	47	.
South Holston	Forebay	34	39	51	43	.
	Transition	41	40	44	44	.
Tellico	Forebay	38	36	36	47	37
	Transition	31	31	41	44	37
Tims Ford	Forebay	.	40	46	50	33
	Transition	.	48	51	47	49
Upper Bear Creek	Forebay	.	31	34	.	.
Watauga	Forebay	33	29	30	31	.
	Transition	32	31	42	35	.
Watts Bar	Forebay	42	35	39	43	.
	Inflow Clinch	40	34	44	40	.
	Inflow Tennessee	40	42	38	46	.
	Transition	46	44	53	46	.
Wheeler	Embayment	.	.	41	50	39
	Forebay	43	40	49	41	50
	Inflow	44	40	44	48	42
	Transition	36	31	47	43	37
Wilson	Forebay	44	39	44	45	.
	Inflow	38	46	54	40	.

Table 3
Vital Signs Monitoring

Core fish species list with trophic tolerance, and reproductive designations (*) for use in Reservoir Fish Assemblage Index (RFAI) for TVA reservoirs

Species	Trophic Guild	Tolerance	Lithophilic Spawner
Chestnut lamprey	PS		L
Spotted gar	PI		
Longnose gar	PI	TOL	
Shortnose gar	PI	TOL	
Bowfin	PI		
American eel	PI		
Skipjack herring	PI	INT	
Gizzard shad	OM	TOL	
Threadfin shad	PL		
Mooneye	IN		L
Chain pickerel	PI		
Central stoneroller	HB		
Common carp	OM	TOL	
Goldfish	OM	TOL	
Silver chub	IN	INT	
Golden shiner	OM	TOL	
Emerald shiner	IN		
Ghost shiner	IN		
Spotfin shiner	IN		
Mimic shiner	IN	INT	
Steelcolor shiner	IN		
Pugnose minnow	IN		
Bluntnose minnow	OM		
Fathead minnow	OM		
Bullhead minnow	IN		
River carpsucker	OM		
Quillback	OM		
Northern hog sucker	IN	INT	L
Smallmouth buffalo	OM		
Bigmouth buffalo	PL		
Black buffalo	OM		
Spotted sucker	IN	INT	L
Silver redhorse	IN		L
Shorthead redhorse	IN		L
River redhorse	IN	INT	L
Black redhorse	IN	INT	L
Golden redhorse	IN		L

Table 3 (continued)
Vital Signs Monitoring

Core fish species list with trophic tolerance, and reproductive designations (*) for use in Reservoir Fish Assemblage Index (RFAI) for TVA reservoirs

Species	Trophic Guild	Tolerance	Lithophilic Spawner
Blue catfish	OM		
Black bullhead	OM	TOL	
Yellow bullhead	OM	TOL	
Brown bullhead	OM	TOL	
Channel catfish	OM		
Flathead catfish	PI		
Blackstripe topminnow	IN		
Blackspotted topminnow	IN		
Mosquitofish	IN	TOL	
Brook Silverside	IN		
White bass	PI		L
Yellow bass	PI		L
Rock bass	PI	INT	
Redbreast sunfish	IN	TOL	
Green sunfish	IN	TOL	
Warmouth	IN		
Orangespotted sunfish	IN		
Bluegill	IN		
Longear sunfish	IN	INT	
Redear sunfish	IN		
Spotted sunfish	IN		
Smallmouth bass	PI		
Spotted bass	PI		
Largemouth bass	PI		
White crappie	PI		
Black crappie	PI		
Yellow perch	IN		
Logperch	IN		L
Sauger	PI		L
Walleye	PI		L
Freshwater drum	IN		

*Designations:
Trophic: herbivore (HB), parasitic (PS), planktivore (PL), omnivore (OM), insectivore (IN), piscivore (PI)
Tolerance: tolerant (TOL), intolerant (INT)
Lithophilic spawning species (L)

Table 4. Results of T-Test for Paired Comparisions Run on RFAI Scores from QC Repeat Sampling in 1995

The SAS System

OBS	RESERVOR	YEAR	SITE	RFAI	QA	DIFF
1	Cherokee	1995	Transition	32	32	0
2	Chickamauga	1995	Inflow	44	48	-4
3	Nickajack	1995	Forebay	44	45	-1
4	Normandy	1995	Forebay	45	51	-6
5	Norris	1995	Forebay	31	37	-6
6	Nottely	1995	Forebay	36	34	2
7	Parksville - ocoee no 1	1995	Forebay	37	37	0
8	Tellico	1995	Transition	37	32	5
9	Wheeler	1995	Embayment	39	43	-4

PAIRED-COMPARISON T TEST

OBS	N	MEAN	SE	PROB H0: MEAN = 0	PROB H0: |MEAN| < 4	PROB H0: |MEAN| < 6
1	9	-1.55556	1.24846	0.24802	0.95597	0.99615

Appendix A.

Watershed and Reservoir Physical Description Including Summary of Ecological Health Results for Each Reservoir in 1995

Kentucky Reservoir Watershed

Duck River Watershed

Pickwick Reservoir - Wilson Reservoir Watershed

Wheeler Reservoir - Elk River Watershed

Guntersville Reservoir - Sequatchie River Watershed

Nickajack Reservoir - Chickamauga Reservoir Watershed

Hiwassee River Watershed

Watts Bar Reservoir, Fort Loudoun Reservoir, and Melton Hill Reservoir Watershed

Clinch River and Powell River Watershed

Little Tennessee River Watershed

French Broad River Watershed

Holston River Watershed

Table 1. List of Vital Signs Monitoring Reservoirs and Years When Vital Signs Monitoring Activities Have Occurred and Are Planned for The Future.

Reservoir	Numer of Sites	CY 1990	CY 1991	CY 1992	CY 1993	CY 1994	CY 1995	CY 1996	CY 1997	CY 1998
RUN-OF-THE-RIVER RES.										
KY Tailrace	1	X	X	X	X	X				
Kentucky	4	X	X	X	X	X	X		X	
Pickwick	4	X	X	X	X	X		X		X
Wilson	2	X	X	X	X	X		X		X
Wheeler	4	X	X	X	X	X	X		X	
Guntersville	3	X	X	X	X	X		X		X
Nickajack	2	X	X	X	X	X	X		X	
Chickamauga	4	X	X	X	X	X	X		X	
Watts Bar	4	X	X	X	X	X		X		X
Fort Loudoun	3	X	X	X	X	X	X	X	X	X
Tellico	2		X	X	X	X	X		X	
Melton Hill	3		X	X	X	X		X		X
HIWASSEE WATERSHED										
Hiwassee	2		X*	X*	X	X		X		X
Chatuge	2		X*	X*	X	X		X		X
Nottely	2		X*	X*	X	X	X		X	
Blue Ridge	1		X*	X*	X	X	X		X	
Parksville	1		X*	X*	X	X	X		X	
HOLSTON WATERSHED										
Cherokee	2	X	X	X	X	X	X	X**		X
Fort Patrick Henry	1		X*	X*	X	X	X	X**	X	
Boone	3		X*	X*	X	X	X		X	
South Holston	2		X*	X*	X	X		X		X
Watauga	2		X*	X*	X	X		X		X
CLINCH/POWELL WS										
Norris	3	X	X	X	X	X	X		X	
LITTLE TENNESSEE WS										
Fontana	3				X	X	X	X		X
FRENCH BROAD WS										
Douglas	2	X	X	X	X	X	X		X	
OTHER WATERSHEDS										
Tims Ford	2			X*	X	X	X	X		X
Normandy	1				X	X	X	X		X
Bear	1				X	X	X	X	X	
Little Bear	1				X	X	X	X	X	
Cedar	1				X	X	X	X	X	
Beech	1		X*		X	X	X	X		X
Total Sites	69									

* Limited VS Monitoring in Tribs (DO,Chlorophyll, and Fish)

** Cooperative Efforts

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KENTUCKY RESERVOIR WATERSHED

The Kentucky Reservoir watershed area includes all streams flowing into the Tennessee River downstream of Pickwick Landing Dam at Tennessee River mile (TRM) 206.7 to the confluence of the Tennessee River with the Ohio River. The one exception is the Duck River which is considered a separate watershed. The Kentucky Reservoir watershed area is relatively large (4590 square miles) and has an average annual discharge of about 66,600 cfs. Of that, about 82 percent (54,000 cfs) comes into Kentucky Reservoir from Pickwick Landing Dam. The Duck River supplies about 6 percent (4075 cfs), with the remaining 11 percent coming from local inflows.

Kentucky Reservoir is the dominant feature of this watershed. There are four monitoring sites on Kentucky Reservoir--forebay, transition zone, inflow, and Big Sandy River embayment

The watershed also includes the seven small reservoirs on the Beech River. The largest, Beech Reservoir, is the only one included in Vital Signs monitoring. Given its small size, the forebay is the only site monitored.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Kentucky Reservoir

Kentucky Reservoir is the largest reservoir on the Tennessee River. The dam is located at Tennessee River Mile (TRM) 22.4, and the reservoir extends 184 miles upstream to Pickwick Dam at TRM 206.7. At full pool the surface area is 160,300 acres, and the shoreline is 2280 miles. Average annual discharge is about 66,600 cfs, which provides an average hydraulic retention time of about 22 days.

The Duck River, a major tributary to the Tennessee River (and Kentucky Reservoir), provides about 6 percent of the total flow through Kentucky Reservoir. The confluence of the Duck River with the Tennessee River is at TRM 110.7.

The transition zone sample location was moved prior to the 1992 sample season from TRM 112.0 to TRM 85.0. Results for 1990 and 1991 at TRM 112.0 indicated that location was more representative of a riverine environment than a transition environment. The 1992, 1993 and 1994 results indicate the new transition zone site is correctly located.

Vital Signs monitoring was expanded in 1993 to include a sample site in four of the largest embayments in the Tennessee Valley. One, the Big Sandy River embayment on Kentucky Reservoir, is the largest embayment in the Tennessee Valley. It covers 15,238 surface acres and has over 93 miles of shoreline. Because its watershed is only 629 square miles, there is very little water exchange.

Beech Reservoir

Beech Reservoir, the largest of seven small flood control projects on the Beech River system in western Tennessee, is formed by Beech Dam at Beech River mile 35.0. Beech Reservoir is only 5.3 miles long and averages only about 12 feet deep. It has no hydropower generating facilities, but is the primary source of water for the city of Lexington. The reservoir is an urban lake with considerable residential lakefront development. Consequently, it receives a large amount of recreational use relative to its small size (about 900 acres). Discharge from Beech Dam averages only about 14 cfs per day, resulting in a long hydraulic residence times of 300 to 400 days.

Reservoir: **Kentucky** **1995 Score:** 74%

	Previous Scores		
	Reported	1995 Criteria	
1991	77	69	(no embayment/no transition)
1992	88	87	(no embayment)
1993	75	81	(85 if Big Sandy were excluded)
1994	71	75	(85 if Big Sandy were excluded)
1995	74%	74	(80 if Big Sandy were excluded)

Kentucky	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	1.0	5.0	1.3		7.3		-2.8	0.0	0.3		-2.5
DO	5.0	5.0	4.0	4.0	18.0		0.5	0.0	2.0	-1.0	1.5
Sediment	2.5	2.5	2.5		7.5		0.0	0.0	0.0		0.0
Benthos	4.0	5.0	3.0	3.0	15.0		0.0	0.0	0.0	-1.0	-1.0
Fish	4.0	4.0	2.0	3.0	13.0		1.0	0.0	0.0	0.0	1.0
Total	16.5	21.5	12.8	10.0	60.8		-1.3	0.0	2.3	-2.0	-1.0

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Kentucky Reservoir was good in 1995, although conditions were not quite as good as in previous years. The primary concerns were high levels of chlorophyll at the forebay and in Big Sandy embayment and a poor fish assemblage in Big Sandy. Chlorophyll levels at Big Sandy were high throughout most of the summer with blooms in August and September. Forebay chlorophyll levels were also high throughout summer due to lower flows and longer residence times than usual. The poor rating for the fish assemblage in Big Sandy was due to presence of a high percentage of tolerant species, a high percentage omnivores, and a relatively high incidence of anomalies in the fish captured. Of the four locations monitored on Kentucky Reservoir, the mid-reservoir/transition zone had the best ecological condition and the Big Sandy embayment location had the poorest.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition was similar to but slightly lower than most previous years. Poor (high) concentrations of chlorophyll, a poor fish assemblage, and lowered DOs in Big Sandy have been found in previous years, indicating stressed conditions in that very large embayment. One note of good news for Big Sandy was that poor DO conditions found in 1994 were not found in 1995. Chlorophyll levels at the forebay of Kentucky were the highest found since monitoring began in 1990. Based on past experience, high chlorophyll levels were expected given the low reservoir flow which existed in 1995.

Aquatic Macrophytes in 1995: Areal coverage of macrophytes in 1995 (900-1400 acres) were higher than 1994 (about 400 acres) but substantially lower than 6000-7000 acres found in the 1980's.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Kentucky Reservoir. Channel catfish and largemouth bass were collected from all four Vital Signs monitoring sites during autumn 1995.

Status of Swimming Advisories in 1995: There are no swimming advisories on Kentucky Reservoir. Bacteriological sampling was not conducted on Kentucky in 1995.

Reservoir: **Beech** **1995 Score:** 46%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	65	69 (no fish)
1994	56	54
1995	46%	46

Beech	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	2.8				2.8		1.2				1.2
DO	1.0				1.0		0.0				0.0
Sediment	1.5				1.5		-1.0				-1.0
Benthos	3.0				3.0		-2.0				-2.0
Fish	2.0				2.0		0.0				0.0
Total	10.3				10.3		-1.8				-1.8

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Beech Reservoir was poor again in 1995, with a score even lower than in 1994. All five indicators rated either fair or poor. Chlorophyll levels were high throughout the summer, but no major blooms were found on any sample dates. Bottom DO was <2ppm for more than three months (June - August) with extended periods of anoxia. The fish assemblage rated poor due to finding relatively few fish, mostly tolerant species, and mostly omnivores. The sediment rating was fair because DDE (a breakdown product of DDT) was found for the first time at a level slightly above the detection limit.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: Beech Reservoir had a poor ecological condition in 1995, as in 1994, but the score was even lower in 1995. The lower score in 1995 was due to lower ratings for benthos and sediment. Chlorophyll and DO rated poor both years. The benthos rated fair in 1995 compared to good in 1994 due to a decrease in EPT taxa (intolerant animals), a decrease in number of intolerant animals collected, and a less balanced community as indicated by the dominance metric. The fish assemblage rated poor in 1995 compared to fair in 1994, but there was little actual difference -- the 1994 score was at the lower end of the fair range and the 1995 score was at the upper end of the poor range.

Aquatic Macrophytes in 1995: Not an issue in Beech Reservoir.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Beech Reservoir. Channel catfish and largemouth bass were collected from the forebay in autumn 1995.

Status of Swimming Advisories in 1995: There are no water contact advisories on Beech Reservoir. No bacteriological samples were collected in 1995.

DUCK RIVER WATERSHED

The Duck River Watershed includes all streams flowing into the Duck River. It has an area of 3500 square miles and an average annual discharge of 4075 cfs to Kentucky Reservoir on the Tennessee River. The Duck River basin is underlain almost entirely by limestone, or phosphatic limestone; consequently, waters in the streams draining this basin are fairly hard and contain large concentrations of minerals. Large deposits of phosphate ores permit phosphate mining and refining operations in the basin. Phosphate concentrations in surface and groundwater are significantly higher than in most of the Tennessee Valley. The soils are thin with limestone outcrops at the surface in many places, and sinkholes are common throughout the watershed.

Normandy Reservoir is the only reservoir in this watershed. This is a relatively small reservoir and only the forebay is included in the Vital Signs monitoring program.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on Normandy Reservoir. It also provides planned activites in the future .

Normandy Reservoir

Normandy Reservoir is formed by Normandy Dam at Duck River mile (DRM) 248.6. Normandy Reservoir, constructed primarily for flood control and water supply, has a drainage area of 195 square miles and no electric power generation capacity. One of TVA's smaller reservoirs, Normandy at full pool elevation has about 3200 surface acres, 73 miles of shoreline, and about 17 miles of impounded backwater. The reservoir has an average depth of about 35 feet and an average annual drawdown of about 11 feet. The average annual discharge from Normandy Dam is about 320 cfs, providing an average annual retention time of about 175 days.

Reservoir: **Normandy** **1995 Score:** 59%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	56	62
1994	68	64
1995	59%	59

Normandy	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	4.8				4.8		-0.2				-0.2
DO	1.0				1.0		0.0				0.0
Sediment	2.5				2.5		0.0				0.0
Benthos	1.0				1.0		-1.0				-1.0
Fish	4.0				4.0		0.0				0.0
Total	13.3				13.3		-1.2				-1.2

<u>Summary/Key Ecological Health Finding for 1995</u>: The overall ecological condition of Normandy Reservoir was fair again in 1995. DO and benthos rated poor and the other three indicators rated good. DO rated poor because a large proportion of the water column had DO <2ppm for most of the summer and near bottom oxygen concentrations were zero during July, August, and September. The benthos received the lowest possible score -- essentially the only type of animal collected was the very tolerant tubificid worms and several samples had no animals at all. The poor benthos is probably related to the very poor DO conditions, which are characteristic of this type of reservoir with a long holding time (more than 200 days in 1995) resulting in stagnant bottom waters.

<u>Explanation of Differences in Ecological Health Scores in 1995 and Previous Years</u>: Normandy Reservoir has had a fair ecological condition each year sampled and the poor ratings for DO and benthos have been found each year.

<u>Aquatic Macrophytes in 1995</u>: Not an issue on Normandy Reservoir.

<u>Status of Fish Consumption Advisories in 1995</u>: There are no fish consumption advisories on Normandy Reservoir. Channel catfish and largemouth bass were collected from the forebay in autumn 1995.

<u>Status of Swimming Advisories in 1995</u>: There are no water contact advisories on Normandy Reservoir, although the Duck River and Little Duck River upstream of Normandy at Old Stone Fort State Park are included in an advisory by the State of Tennessee. The Duck River at four access locations downstream of Normandy Dam failed to meet criteria in TVA tests in 1993. Bacteriological studies were not conducted by TVA on Normandy or nearby streams in 1995.

PICKWICK RESERVOIR - WILSON RESERVOIR WATERSHED

Pickwick Reservoir and Wilson Reservoir on the Tennessee River are the most notable features of this drainage area. Only a small part of the flow leaving this watershed actually originates within the watershed itself. The average annual discharge from Pickwick Dam is 54,900 cfs. Of that, 49,500 cfs (90 percent) is the discharge from Wheeler Dam into Wilson Reservoir. About 2100 cfs enters Wilson Reservoir through local tributaries and about 3400 cfs originates in tributaries to Pickwick Reservoir. The streams within this watershed drain an area of about 3230 square miles. The largest tributaries are Bear Creek, a tributary to Pickwick Reservoir with a drainage area of about 945 square miles, and Shoal Creek, a tributary to Wilson Reservoir, with a drainage area of about 445 square miles.

Four small reservoirs were built on Bear Creek in the late 1970s and early 1980s for flood control and recreation. These are Bear Creek, Little Bear Creek, Cedar Creek, and Upper Bear Creek Reservoirs.

Reservoir monitoring activities occur at the forebay, transition zone, and inflow on Pickwick Reservoir and at the forebay and inflow on Wilson Reservoir. Wilson is relatively short and has no definable transition zone. Because of their smaller size, only the forebays of Bear Creek, Little Bear Creek, and Cedar Creek Reservoirs are monitored. No monitoring activities are conducted on Upper Bear Creek because of TVA's program to destratify and oxygenate water in the forebay.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Pickwick Reservoir

Pickwick Reservoir is immediately upstream of Kentucky Reservoir on the Tennessee River. Pickwick Dam is located at TRM 206.7. Like the rest of the mainstream, run-of-the-river reservoirs, Pickwick is much shorter (53 miles long) and smaller (43,100 acres and shoreline of 496 miles) than Kentucky Reservoir. Average annual discharge is about 55,000 cfs, which provides an average hydraulic retention time of about eight days.

A major tributary, Bear Creek, joins the Tennessee River in Pickwick Reservoir at about mile 225. Bear Creek provides, on the average, about 2.5 percent of the flow through Pickwick Reservoir.

Reservoir Monitoring activities were expanded on Pickwick Reservoir in 1993 to include a Vital Signs monitoring site in Bear Creek embayment. This rather large embayment (7200 acres) extends from the mouth of Bear Creek upstream about 17 miles to the point where flow is not affected by backwater from Pickwick Dam.

Wilson Reservoir

Wilson Reservoir is quite different from other mainstream Tennessee River reservoirs in both length and depth. Wilson Dam is located at TRM 259.4 and Wheeler Dam is at TRM 274.9, providing a length of only 15.5 miles, a shoreline of 154 miles, and surface area of 15,500 acres. Water depth in the forebay is slightly over 100 feet. This short, deep pool, coupled with the largest hydroelectric generating plant in the TVA system, provides for short hydraulic retention times (six days). Average annual discharge from Wilson is 51,500 cfs. Because of the physical characteristics, design, and operation of Wilson Dam (primarily upper strata withdrawal for hydropower generation), low DO conditions develop in deeper strata of the forebay during summer months.

Bear Creek Reservoir

With a surface of only 700 acres, Bear Creek is one of the smallest reservoirs in the TVA system. It is relatively long (16 miles), narrow, and deep (74 feet at the dam). The average annual discharge is 380 cfs providing an average hydraulic retention time of about 13 days. Average annual drawdown is about 11 feet. Bear Creek Reservoir stratifies in the summer and develops hypolimnetic anoxia. Another water quality concern is abandoned strip mines in the watershed.

Little Bear Creek Reservoir

Little Bear Creek Reservoir is relatively short (7.1 miles long) and deep (84 feet at the dam). It has a surface area of 1600 acres. With an average annual discharge of 101 cfs, the hydraulic retention time is 225 days. Compared to Bear Creek Reservoir, the lower flow into the reservoir and larger reservoir volume make the retention time much longer in Little Bear Creek Reservoir. Average annual drawdown is about 12 feet.

Cedar Creek Reservoir

Like the other reservoirs in the Bear Creek watershed, Cedar Creek Reservoir is small (only nine miles long and 4200 acres surface area) and deep (79 feet at the dam). The low average annual discharge from the dam (282 cfs) creates a relatively long average retention time (168 days). This combination of physical features lead to thermal stratification and hypolimnetic anoxia in the summer. Average annual drawdown is about 14 feet.

Reservoir: **Bear Creek** **1995 Score:** 46%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	60	64
1994	56	60
1995	46%	46

Bear Cr	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	1.9				1.9		-1.1				-1.1
DO	1.0				1.0		0.0				0.0
Sediment	2.5				2.5		0.0				0.0
Benthos	2.0				2.0		-1.0				-1.0
Fish	3.0				3.0		-1.0				-1.0
Total	10.4				10.4		-3.1				-3.1

<u>Summary/Key Ecological Health Finding for 1995</u>: The overall ecological condition of Bear Creek was poor again in 1995 with a score lower than in any previous year. Chlorophyll and DO both rated poor, benthos and fish rated fair, and sediment rated good. Chlorophyll levels were high throughout most of the summer with a very high level in July (49ug/L). Much of the water column had little DO (<2ppm) during the summer months with extended periods (June - September) of no DO near bottom. Both the benthos and fish were represented by animals tolerant of poor conditions, and the number of animals collected was low for both groups.

<u>Explanation of Differences in Ecological Health Scores in 1995 and Previous Years</u>: Bear Creek Reservoir has had poor or fair overall ecological conditions during all years sampled (1993, 1994, and 1995). The biggest problems generally found each year are low DO and high chlorophyll (algal productivity), which contributes to the poor DO conditions as algal cells die, settle to bottom, and decompose. Both benthos and fish received a slightly lower score in 1995 compared to 1994, but both were still in the fair category. Sediments rated fair in 1994 and good in 1995, which may or may not represent improved conditions. The fair rating in 1994 was due to occurrence of toxicity to test animals. These tests were not conducted in 1995 due to budget constraints. The good news is that there were no chemicals (metals, pesticides, or PCBs) found in sediments in elevated concentrations in 1994 or 1995.

<u>Aquatic Macrophytes in 1995</u>: Not an issue in Bear Creek Reservoir.

<u>Status of Fish Consumption Advisories in 1995</u>: There are no fish consumption advisories on Bear Creek Reservoir. Fish were collected in 1992 and all analytes except mercury were low. The slightly elevated levels of mercury were further examined in 1993 and the Alabama Public Health Dept. did not consider the levels sufficiently high to represent a health concern.

<u>Status of Swimming Advisories in 1995</u>: There are no water contact advisories on Bear Creek Reservoir. No bacterioloical samples were collected from Bear Creek in 1995.

Reservoir: **Cedar Creek** **1995 Score:** 60%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	56	64
1994	80	68
1995	60%	60

Cedar	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0				5.0		0.3				0.3
DO	1.0				1.0		0.0				0.0
Sediment	2.5				2.5		0.0				0.0
Benthos	1.0				1.0		-2.0				-2.0
Fish	4.0				4.0		0.0				0.0
Total	13.5				13.5		-1.7				-1.7

Summary/Key Ecological Health Finding for 1995: Cedar Creek Reservoir had a fair overall ecological condition in 1995. DO and benthos both rated poor, fish fair, and chlorophyll and sediment good. DO rated poor due to much of the water column having low DOs (<2ppm) during the summer with no DO near bottom from June through September. Very few benthic animals were found and those which were found were tolerant animals such as tubificid worms. The score for fish was in the high end of the fair range -- only two of the 12 metrics were poor, the number of fish collected was too low and too many of the fish collected were omnivores.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The ecological condition of Cedar Creek Reservoir was reported as poor in 1993, good in 1994, and now fair for 1995. These large year-to-year fluctuations are mostly due to changes in the methods used to evaluate results, with only slight changes in the overall condition. These changes have resulted from improvements made in the scoring system as more has been learned about the reservoir. Other methods have changed as a result of budget constraints causing some types of data collection efforts to be discontinued (e.g., toxicity testing of sediments). When data for all three years are evaluated on the current methods (a true apples to apples comparison), results for all three years fall in the fair category. Like the other reservoirs in the Bear Creek watershed, Cedar Creek's most significant chronic problem continues to be poor DO conditions during the summer.

Aquatic Macrophytes in 1995: Not an issue on Cedar Creek Reservoir.

Status of Fish Consumption Advisories in 1995: These are no fish consumption advisories on Cedar Creek Reservoir. The most recent collection of fish for tissue analysis was in 1992; concentrations of all analytes were either nondetectable or very low.

Status of Swimming Advisories in 1995: There are no water contact advisories on Cedar Creek Reservoir. TVA did not conduct bacteriological sampling on this reservoir in 1995.

Reservoir: **Little Bear** **1995 Score:** 69%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	64	68
1994	64	69
1995	69%	69

L. Bear	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0				5.0		0.0				0.0
DO	1.0				1.0		0.0				0.0
Sediment	2.5				2.5		0.0				0.0
Benthos	3.0				3.0		0.0				0.0
Fish	4.0				4.0		0.0				0.0
Total	15.5				15.5		0.0				0.0

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Little Bear Creek Reservoir was fair in 1995, same as the previous two years. The only poor rating was for DO -- a large part of the water column had DO levels <2ppm throughout most of the summer with extended periods of no DO near bottom. Of the three Bear Creek lakes (Bear, Little Bear, and Cedar) Little Bear continues to exhibit the poorest DO conditions. Both chlorophyll and sediment rated good. Chlorophyll levels were within acceptable ranges on all sample dates and sediment chemical concentrations (metals, pesticides, and PCBs) were not elevated. Although both the benthos and fish rated fair, both were in the high end of the fair range. This might be unexpected, especially for the benthos given the very poor DO conditions. But it is important to remember that, in absence of an accepted standard, reservoirs are compared only to other reservoirs within their class. The Bear Creek reservoirs, Beech, Normandy, and Tims Ford all fall within the Interior Plateau Ecoregion and form one set for comparison. All these reservoirs have very poor DO conditions which impact benthos. A fair or good rating for benthos in one of these reservoirs means it is not as severely impacted as the other reservoirs with which it is being compared.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition rating of fair for Little Bear Creek Reservoir in 1995 was also found the previous two years (1993 and 1994). In all years chlorophyll has rated good; DO poor (among the lowest in the TVA system); and benthos, fish, and sediment either good or fair.

Aquatic Macrophytes in 1995: Not as issue in Little Bear Creek.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on this reservoir. Fish were collected in 1992 and all analytes except mercury were low. The slightly elevated levels of mercury were further examined in 1993 and the Alabama Department of Public Health did not consider the levels sufficiently high to represent a health concern.

Status of Swimming Advisories in 1995: There are no water contact advisories on Little Bear Creek Reservoir. TVA did not conduct bacteriological studies on this reservoir in 1995.

WHEELER RESERVOIR - ELK RIVER WATERSHED

The Wheeler Reservoir - Elk River watershed drains about 5140 square miles in north central Alabama and south central Tennessee. Wheeler Reservoir is the fourth of nine reservoirs on the Tennessee River. About 24,500 square miles of the Tennessee Valley are upstream of this watershed. Wheeler Reservoir receives an average annual inflow of 40,700 cfs from Guntersville Dam. Discharges from Wheeler Dam average 49,400 cfs on an annual basis leaving 8700 cfs which originate within the watershed.

The largest tributary to Wheeler Reservoir is the Elk River, which has a drainage area of about 2250 square miles and contributes about 3000 cfs. The remaining flow enters from tributaries directly to Wheeler Reservoir.

Wheeler Reservoir is the largest reservoir within this watershed followed by Tims Ford Reservoir on the Elk River. There are four Vital Signs monitoring sites on Wheeler Reservoir--forebay, transition zone, inflow, and the Elk River embayment. Two sites are monitored for Vital Signs on Tims Ford Reservoir--forebay and mid-reservoir. Woods Reservoir on the Elk River is not included in this monitoring program because it is property of the Arnold Engineering Development Center, Arnold Air Force Base.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Wheeler Reservoir

Wheeler Reservoir has the third-largest surface area (67,100 acres) of all reservoirs in the TVA system. It is 74 miles long (dam at TRM 274.9) and has 1063 miles of shoreline. Average annual discharge is about 49,400 cfs which provides an average hydraulic retention time of about 11 days. Information collected in 1990 and 1991 indicated a more riverine than transition environment at TRM 307.5; consequently, in 1992 the transition zone sampling location was relocated further downstream to TRM 295.9. Results for 1992 and 1993 are being evaluated to determine if this new site is suitably located or if it needs to be moved further downstream.

The Elk River joins the Tennessee River in the downstream portion of Wheeler Reservoir at about mile 284 and provides, on the average, about 6 percent of the flow through Wheeler Reservoir.

Vital Signs monitoring activities were expanded in 1993 to include a site in the Elk River embayment. The Elk River embayment covers about 4900 acres. Given the relatively high flows in the Elk River (about 3000 cfs annual average), there is substantial water exchange in this embayment.

Tims Ford Reservoir

Tims Ford Reservoir in middle Tennessee is formed by Tims Ford Dam at Elk River mile (ERM) 133.3. The reservoir is 34 miles long at full pool and has a surface area of 10,600 acres. The depth at the dam is 143 feet and the average depth is about 50 feet. Average annual discharges from Tims Ford Dam are about 940 cfs, resulting in a hydraulic residence time of about 280 days. Tims Ford Reservoir is designed for a useful controlled drawdown of 30 feet (895-865 feet MSL) for flood protection; however, annual drawdowns average about 18 feet.

Reservoir: **Wheeler** **1995 Score:** 69%

	Previous Scores		
	Reported	1995 Criteria	
1991	89	70	(no embayment, no transition)
1992	80	76	(no embayment)
1993	72	72	(80 if Elk River were excluded)
1994	75	74	(81 if Elk River were excluded)
1995	69%	69	(79 if Elk River were excluded)

Wheeler	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	4.0	2.8	1.0		7.8		2.4	-0.4	0.0		2.0
DO	5.0	5.0	1.0	5.0	16.0		0.0	0.0	-2.0	0.0	-2.0
Sediment	2.5	2.0	2.5		7.0		0.0	0.5	0.0		0.5
Benthos	2.0	4.0	2.0	4.0	12.0		-1.0	-1.0	0.0	-1.0	-3.0
Fish	4.0	3.0	3.0	4.0	14.0		0.0	-1.0	-1.0	0.0	-2.0
Total	17.5	16.8	9.5	13.0	56.8		1.4	-1.9	-3.0	-1.0	-4.5

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Wheeler Reservoir was fair in 1995, with conditions in the Elk River embayment being very poor. If results for the Elk River embayment station were excluded, Wheeler would rate good. At the Elk River station chlorophyll, DO, and benthos rated poor and fish fair. Only sediment quality rated good. DO levels in deeper strata at Elk River were low (<2ppm) and even down to zero during much of the summer. Chlorophyll levels were quite high on all sample dates because algal growth was being stimulated by naturally high nutrient levels in the Elk River watershed. The poor rating for benthos resulted from few animals being collected; most of which were tolerant forms like tubificid worms which may be a result of the poor DO conditions. Other than Elk River, the only poor rating on Wheeler Reservoir was for chlorophyll at the transition zone, which rated poor due to high concentrations in May and June.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition of Wheeler Reservoir was fair in 1995 with a score slightly lower than in previous years, which had rated good overall. Results for 1995 were similar to past years in that conditions at the Elk River site were much worse than any other sample site. If results for Elk River were excluded from results for all years, Wheeler would rate good for all years with very little variation among years.

Aquatic Macrophytes in 1995: Macrophyte coverage was about the same in 1995 (range of 5,500 to 7,500 acres) as in 1994 (estimated coverage of about 6,500 acres).

Status of Fish Consumption Advisories in 1995: There is an advisory not to eat certain fish species from Indian Creek and the nearby section of the Tennessee River due to DDT contamination. Results from a 1995 TVA study were being reviewed by the Alabama Department of Public Health at the time this description was written. Lower concentrations in this study may allow the State to remove or alter the current advisory. Fish were also collected from the four Vital Signs monitoring sites in 1995.

Status of Swimming Advisories in 1995: There are no water contact advisories on Wheeler Reservoir. TVA did not conduct bacteriological sampling on Wheeler in 1995.

Reservoir: **Tims Ford** **1995 Score**: 56%

	Previous Scores	
	Reported	1995 Criteria
1991		60 (no benthos, no fish & no sediment)
1992	60	63 (no benthos & no sediment)
1993	58	60
1994	58	58
1995	56%	56

Tims Ford	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0	5.0			10.0		0.0	0.0			0.0
DO	1.0	1.0			2.0		0.0	0.0			0.0
Sediment	1.5	2.5			4.0		0.0	0.0			0.0
Benthos	1.0	1.0			2.0		0.0	0.0			0.0
Fish	3.0	4.0			7.0		-1.0	0.0			-1.0
Total	11.5	13.5			25.0		-1.0	0.0			-1.0

<u>**Summary/Key Ecological Health Finding for 1995**</u>: The overall ecological condition of Tims Ford Reservoir was poor in 1995, with a score just below the cutoff for fair. DO and benthos rated poor at both sample sites. The only good rating at the forebay was for chlorophyll, whereas, chlorophyll, sediment, and fish rated good at the mid-reservoir site. DO concentrations in mid and lower strata at both locations were <2ppm during much of the summer with periods of no DO near bottom during late summer. The very long water retention time in Tims Ford (352 days in 1995) allows water to stagnate and become devoid of DO near the lake bottom. The benthos was represented by few animals and those present were primarily tubificid worms, a type of animal very tolerant of low DOs. The sediment quality rated fair at the forebay due to elevated levels of nickel, which have been observed consistently.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition of Tims Ford Reservoir has been quite consistent for the last four years -- on the borderline between fair and poor. Reservoir scores have varied very little, with the 1995 score just below the fair range and scores for the previous years just above the lower end of the fair range. The primary ecological concerns for Tims Ford are low DO and poor benthos.

Aquatic Macrophytes in 1995: Not an issue in Tims Ford Reservoir.

Status of Fish Consumption Advisories in 1995: There are no fish consumption on Tims Ford Reservoir. The most recent data from 1992 did not indicate elevated concentrations of any analytes. Channel catfish and largemouth bass were collected from the forebay and mid-reservoir site in autumn 1995.

Status of Swimming Advisories in 1995: There are no water contact advisories on Tims Ford Reservoir. TVA did not conduct bacteriological studies on Tims Ford in 1995, but in 1994 five of seven access sites on the Elk River downstream of Tims Ford Dam failed state criteria.

GUNTERSVILLE RESERVOIR - SEQUATCHIE RIVER WATERSHED

This watershed includes Guntersville Reservoir and all tributaries draining directly to Guntersville Reservoir. As with the other watershed areas on the mainstem of the Tennessee River, most of the water leaving the watershed through Guntersville Dam enters the watershed area through discharges from the upstream dam (Nickajack). About 35,900 cfs enter from Nickajack Dam and about 40,700 cfs is discharged from Guntersville Dam on an annual average basis. The remaining 4800 cfs originates with the Guntersville Reservoir-Sequatchie River watershed area. The largest contributor of this flow is the Sequatchie River (about 800 cfs). The total watershed area is 2669 square miles. The area drained by the Sequatchie River is about 600 square miles.

Guntersville Reservoir is the dominant characteristic of this watershed. There are three Vital Signs monitoring site on Guntersville Reservoir: forebay, transition zone, and inflow.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on Guntersville Reservoir. It also provides planned activites in the future .

Guntersville Reservoir

Guntersville Dam, located at TRM 349.0, creates a 76 mile long reservoir with a surface area of 67,900 acres and a shoreline of 949 miles at full pool. Average annual discharge is about 40,700 cfs, corresponding to an average hydraulic retention time of about 13 days.

Guntersville Reservoir is similar to Wheeler Reservoir in several size characteristics, but it differs in one important feature. The average controlled storage volume of Guntersville is about half that of Wheeler. This is due to the shallow nature of Guntersville Reservoir at the inflow area and extensive shallow overbank areas. As a result, winter drawdown on Guntersville Reservoir is nominal to maintain navigation. The shallow drawdown allows the large overbank areas to be permanently wetted creating good habitat for aquatic macrophytes. Guntersville has the greatest area coverage of aquatic plants of any TVA reservoir.

The Sequatchie River joins the Tennessee River at about TRM 423, in the upstream portion of Guntersville Reservoir, just downstream from Nickajack Dam. On the average the Sequatchie River contributes less than 2 percent to the total flow of the Tennessee River through Guntersville Reservoir.

Data collected in 1990 and 1991, indicated a more riverine than transition environment at TRM 396.8. Consequently, in 1992 the transition zone sampling location was relocated further downstream to TRM 375.2.

NICKAJACK RESERVOIR - CHICKAMAUGA RESERVOIR WATERSHED

Nickajack and Chickamauga Reservoirs are primary features of this watershed. The Hiwassee River is the only sizeable tributary which merges with the Tennessee River within the watershed area. The drainage basin of the Hiwassee River is large enough to be designated a separate watershed. The remaining area drained by tributaries to these two reservoirs is 1780 square miles. On an annual average basis, about 3200 cfs is contributed to the Tennessee River from streams within this watershed. This compares to 27,100 cfs entering the upper end of Chickamauga Reservoir from Watts Bar Dam and 5600 cfs from the Hiwassee River, for a total average annual discharge from Nickajack Dam of 35,900 cfs.

There are two Vital Signs monitoring sites on Nickajack Reservoir, one at the forebay and one at the inflow. There is no transition zone site on Nickajack because the reservoir is short and water exchange is quite rapid. This causes conditions at the location that might be considered the transition zone to be similar to those at the forebay. Chickamauga Reservoir has four Vital Signs monitoring sites--the forebay, the transition zone, the inflow, and a new site established in 1993 in the Hiwassee River embayment.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Nickajack Reservoir

Nickajack Reservoir is one of the smallest reservoirs on the mainstem of the Tennessee River. With the dam at TRM 424.7, Nickajack has a length of 46 miles, surface area of 10,370 acres, and a shoreline of 192 miles at full pool. Average annual discharge from Nickajack is approximately 35,900 cfs which provides an average hydraulic retention time of only about three or four days, the shortest retention time among the reservoirs monitored in this program.

Results from the 1990 and 1991 monitoring indicated that both the forebay and transition zone sampling sites had quite similar water quality. This was expected since the two sites are relatively close together (separated by only 7.5 river miles), and Nickajack is a well-mixed, run-of-the-river reservoir. Therefore, sampling at the transition zone in Nickajack Reservoir was discontinued in 1992.

Chickamauga Reservoir

Chickamauga Dam is located at TRM 471.0. The reservoir is 59 miles long, has 810 miles of shoreline, and has a surface area of 35,400 acres at full pool. The average annual discharge is approximately 34,200 cfs which provides an average hydraulic retention of nine to ten days.

The Hiwassee River, a major tributary to the Tennessee River, flows into the middle portion of Chickamauga Reservoir at about TRM 499. The flow from the entire Hiwassee River watershed contributes approximately 16.5 percent of the flow through Chickamauga Reservoir. About 10 percent of the 16.5 percent is from the Ocoee River and tributaries in the lower end of the Hiwassee watershed (i.e., downstream of Apalachia Dam).

Vital Signs monitoring activities were expanded in 1993 to include a site in the Hiwassee River embayment, which covers about 6500 acres. Given the relatively high flows in the Hiwassee River (about 5600 cfs annual average), there is substantial water exchange in this embayment, much greater than in any of the other three embayments monitored.

Reservoir: **Nickajack** **1995 Score:** 92%

	Previous Scores	
	Reported	1995 Criteria
1991	89	87
1992	83	81
1993	88	87
1994	90	91
1995	92%	92

Nickajack	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0				5.0		1.3				1.3
DO	5.0			4.0	9.0		0.0			-1.0	-1.0
Sediment	1.5				1.5		-1.0				-1.0
Benthos	5.0			5.0	10.0		0.0			0.0	0.0
Fish	4.0			5.0	9.0		0.0			1.0	1.0
Total	20.5			14.0	34.5		0.3			0.0	0.3

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Nickajack Reservoir was good in 1995, same as all four previous years monitored. All environmental indicators rated good except DO which rated fair at the inflow (dropped slightly below 5ppm for brief period in early summer); sediment quality which rated fair at the forebay (PCBs found in low concentrations); and fish which rated fair at the forebay (relatively few fish were collected and the number of sucker species was lower than expected).

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: Nickajack Reservoir has had a good ecological condition since evaluations began in 1991. Ratings for individual indicators have varied from good to fair through time, but none indicate a consistent problem. The only indicator to have ever received a poor rating is DO at the inflow sampling location just downstream of Chickamauga Dam. This occurred in 1992 and 1993, which, like 1995, had low flows in summer. Consistent fair to good ratings for benthos and fish at the inflow location indicate these communities are able to withstand the stress of short term low DOs and/or are able to recover relatively quickly.

Aquatic Macrophytes in 1995: Aquatic macrophytes covered about 500-800 acres of Nickajack Reservoir in 1995, generally the same as the estimated 500 - 1000 acres in previous years.

Status of Fish Consumption Advisories in 1995: The state of Tennessee has issued a precautionary advisory for channel catfish on Nickajack Reservoir due to PCB contamination. Children, nursing mothers, and pregnant women should not eat any catfish. All other people should limit the amount eaten to 1.2 pounds per month or less. They also warn that no fish from Chattanooga Creek should not be eaten due to elevated PCB and chlordane levels. TVA collected additional fish from Nickajack Reservoir in autumn 1995.

Status of Swimming Advisories in 1995: The state of Tennessee warns there should be no contact with the water in Chattanooga Creek or in the lower five miles of Stringer's Branch. TVA checked bacterial levels at four beaches on Nickajack Lake in 1995 and all met criteria for safe swimming.

Reservoir: **Chickamauga** **1995 Score**: 81%

	Previous Scores		
	Reported	1995 Criteria	
1991	90	83	(no embayment)
1992	73	88	(no embayment)
1993	83	86	
1994	87	86	
1995	81%	81	

Chickamauga	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	2.4	2.6	5.0		10.0		-2.5	-2.4	0.8		-4.1
DO	4.5	5.0	5.0	1.0	15.5		-0.5	0.0	0.0	-2.0	-2.5
Sediment	1.5	2.5	2.5		6.5		0.5	0.0	0.0		0.5
Benthos	5.0	5.0	5.0	5.0	20.0		0.0	0.0	2.0	2.0	4.0
Fish	4.0	4.0	3.0	4.0	15.0		0.0	0.0	-1.0	-1.0	-2.0
Total	17.4	19.1	20.5	10.0	67.0		-2.5	-2.4	1.8	-1.0	-4.1

<u>Summary/Key Ecological Health Finding for 1995</u>: The overall ecological condition of Chickamauga Reservoir was good again in 1995. All indicators rated fair or good at all locations except chlorophyll which rated poor at the forebay and transition zone and DO which rated poor at the inflow. The poor ratings for chlorophyll were due to high levels during most of the summer. Chlorophyll levels of this magnitude had not been found on Chickamuaga since monitoring began in 1990. These high chlorophyll levels were most likely due to the very low flows which also existed in the summer, especially in early summer (April-June) when discharges from Chickamauga Dam were the lowest they have been in the last five years. The poor rating for DO at the inflow (just downstream of Watts Bar Dam) was caused by DO concentrations as low 1 to 2 ppm during June and July. Low DO concentrations were also found further upstream in discharges from Fort Loudoun Dam. Similarly low DO levels have occurred previously when flows in the reservoir system were low such as in summer of 1993.

<u>Explanation of Differences in Ecological Health Scores in 1995 and Previous Years</u>: Chickamauga Reservoir had a good overall ecological condition rating in 1995 for the fifth straight year. As noted above, chlorophyll levels were much higher in 1995 than any previous year. DO ratings at the inflow have been either fair or poor each year with poor ratings occurring during years with low summer flows such 1993 and 1995. The fair rating for sediments at the forebay in 1995 is typical of ratings for previous years due to elevated levels of zinc and copper, probably associated with past mining activities in the Copper Basin. An interesting note is the change in benthos at the Hiwassee River site and at the inflow; both rated fair in 1994 and good in 1995. Improvements were found in most meterics used to evaluate the benthos.

<u>Aquatic Macrophytes in 1995</u>: Areal coverage of macrophytes was about 500-900 acres in 1995, similar to that observed since 1991 but much lower than the 5000 - 7500 acres found in the 1980's.

<u>Status of Fish Consumption Advisories in 1995</u>: There are no advisories on Chickamauga Reservoir. Channel catfish and largemouth bass were collected for tissue analysis from all Vital Signs monitoring stations in autumn 1995.

<u>Status of Swimming Advisories in 1995</u>: There are no water contact advisories on Chickamauga Reservoir. TVA checked bacterial levels at four beaches and two informal swimming areas in 1995. All areas met criteria except the informal swimming area at the Harrison Bay Campground.

HIWASSEE RIVER WATERSHED

The headwaters of the Hiwassee River extend into the Blue Ridge Mountains in Tennessee, North Carolina, and Georgia. Streams in this watershed have naturally low concentrations of nutrients and dissolved minerals. These streams change from steep gradient, cold water trout streams in the mountains to lower gradient warm water streams in the valley.

The Hiwassee River Watershed has an area of 2700 square miles and an average annual discharge to the Tennessee River of 5640 cfs. The confluence of the Hiwassee River with the Tennessee River is in Chickamauga Reservoir at Tennessee River Mile 499.4. The lower portion of the Hiwassee River is impounded by backwater from Chickamauga Dam. The impounded portion of the Hiwassee River forms a large embayment (about 6500 surface acres) which extends over 20 miles up the Hiwassee River.

The largest tributary to the Hiwassee River is the Ocoee River, with a drainage area of about 640 square miles. Due to past copper mining and industrial activities in the Copperhill area, several streams and reservoirs in the Ocoee River basin have degraded water quality.

There are eight TVA reservoirs in the Hiwassee River. Vital Signs monitoring activities are conducted on the five largest reservoirs: Hiwassee Reservoir (forebay, mid-reservoir, and inflow); Chatuge Reservoir (forebay sites on the Hiwassee River and Shooting Creek arms); Nottely Reservoir (forebay and mid-reservoir); Ocoee Reservoir No. 1 (forebay only); and Blue Ridge Reservoir (forebay only). Apalachia, Ocoee No. 2, and Ocoee No. 3 Reservoirs are not included in this monitoring because of their small size.

Vital Signs monitoring also includes a site on the Hiwassee River embayment (at HiRM 10) of Chickamauga Reservoir with results reported with the Chickamauga/Nickajack Watershed.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Hiwassee Reservoir

Hiwassee Reservoir, in the southwestern corner of North Carolina, is the second-largest of the five reservoirs in the Hiwassee River watershed included in the Vital Signs monitoring program. Hiwassee Reservoir is impounded by Hiwassee Dam at river mile 75.8. At full pool level, its backwater storage pool is about 22 miles long, 6100 acres in surface area, and has a mean depth of about 69 feet (with a maximum depth of about 255 feet at the dam). It has an average annual discharge of about 2020 cfs and average residence time of about 105 days. Hiwassee Reservoir has an average annual drawdown of 45 feet.

Chatuge Reservoir

Chatuge Reservoir is located on the Georgia-North Carolina state line in northeastern Georgia and is formed by Chatuge Dam at Hiwassee River mile (HiRM) 121.0. At full pool elevation, the reservoir is 13 miles long and has a surface area of about 7000 acres. Its maximum depth at the dam is 124 feet, and it has a mean depth of 33 feet. An average annual discharge of 459 cfs results in an average hydraulic residence time of about 260 days. Chatuge Reservoir has a potential useful controlled storage of 23 feet (1928-1905 feet MSL), however, the annual drawdown averages only ten feet.

Only the forebay of Chatuge Reservoir was monitored prior to 1993. A new monitoring site was added in 1993 in the Shooting Creek arm to further evaluate this rather large part of the lake. Because of its physical features, the Shooting Creek site would be expected to be representative of forebay conditions.

Nottely Reservoir

Nottely Reservoir is formed by Nottely Dam at Nottely River mile 21.0 in northern Georgia. At full pool elevation, the reservoir is 20 miles long, covers 4200 acres, and has a mean depth of 40 feet, with a maximum depth of about 165 feet at the dam. Long-term flows from Nottely Dam average about 415 cfs which result in an average hydraulic retention time of about 206 days. The annual drawdown averages about 24 feet on Nottely Reservoir.

Blue Ridge Reservoir

Blue Ridge Dam impounds the Toccoa River at mile 53.0 in rural northwest Georgia. The watershed is mountainous and forested, with a significant portion of the basin lying within the Chattahoochee National Forest. At full pool, Blue Ridge Reservoir is about 11 miles long, 3300 acres in surface area, and 155 feet deep at the dam, with a average depth of 59 feet. The rate of discharge of water from Blue Ridge Reservoir averages about 610 cfs, which results in an average theoretical residence time of about 159 days. The annual drawdown of Blue Ridge Reservoir averages 36 feet.

Ocoee Reservoir No. 1 (Parksville Reservoir)

Ocoee No. 1 Reservoir, also known as Parksville Reservoir, is formed by Ocoee No. 1 Dam at Ocoee River mile 11.9. At full pool elevation, the reservoir has a surface area of about 1900 acres and length of 7.5 miles. Ocoee No. 1 Reservoir is located downstream from the Copper Basin, and decades of erosion have caused significant filling of the reservoir. Ocoee No. 1 Reservoir has lost about 25 percent of its original volume, has an average depth of 45 feet and is about 115 feet deep at the dam. An average annual discharge of about 1400 cfs from Ocoee No. 1 Dam results in a reservoir retention time of approximately 30 days. Although Ocoee No. 1 Reservoir is not operated for flood control (only for peaking power generation), its annual drawdown averages about seven feet.

Reservoir: **Nottely** **1995 Score:** 47%

	Previous Scores	
	Reported	1995 Criteria
1991	60	60 (only forebay-no benthos & no sediment)
1992	60	61 (only forebay-no benthos & no sediment)
1993	64	62
1994	56	54
1995	47%	47

Nottley	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	4.1	1.4			5.5		1.0	-0.6			0.3
DO	1.0	1.0			2.0		0.0	-1.0			-1.0
Sediment	2.5	2.0			4.5		0.0	-0.5			-0.5
Benthos	2.0	1.0			3.0		1.0	-3.0			-2.0
Fish	3.0	3.0			6.0		0.0	0.0			0.0
Total	12.6	8.4			21.0		2.0	-5.1			-3.2

Summary/Key Ecological Health Finding for 1995: Nottely Reservoir had a poor overall ecological condition in 1995. The only indicators which rated good were sediment and chlorophyll, both at the forebay. DO conditions rated poor at both the forebay and the mid-reservoir locations because near bottom concentrations of DO were zero from mid June to mid September. Benthos also rated poor at both locations in 1995. Chlorophyll rated poor at the mid-reservoir station. Concentrations were high during most of the summer relative to the expected low concentrations characteristic of reservoirs in nutrient poor watersheds, thus indicating nutrient enrichment. Sediment quality rated fair at the mid-reservoir site due to presence of DDE (a degradation product of DDT) which was found at the detection limit of 0.01mg/kg. Benthos communities showed poor diversity and balance, being completely dominated by only two kinds of animals, tubificids and chironomids, generally considered tolerant. The fish assemblage rated fair at both locations. There were few intolerant fish species, few sucker species, and a large proportion of fish with anomalies at both places negatively affecting the fish assemblage rating.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: Nottely again rated poor in 1995 like in 1994. In the last five years Nottely has rated either poor or fair, just above the level considered poor. DO has consistently rated poor year after year. This is most likely related to the long reservoir holding time (over 200 days in 1995) combined with the high algal growth which is stimulated by nutrient enrichment, primarily phosphorus from the Nottely River. As these algal cells dye and settle to bottom, oxygen is depleted by bacteria in the decompose process. The benthos at the mid-reservoir site have shown substantial variation over the three years in which they have been monitored -- good in 1993, fair in 1994, and poor in 1995. At the forebay the ratings were fair, poor, and poor, respectively. It would appear that the consistency of the fair to poor ratings are probably more indicative of true conditions than the single good rating in 1993.

Aquatic Macrophytes in 1995: Not an issue on Nottely Reservoir

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Nottely Reservoir. TVA last collected fish from the forebay in 1993 and did not find elevated levels of pesticides, PCBs, or metals.

Status of Swimming Advisories in 1995: There are no water contact advisories on Nottely Reservoir. The state of Georgia lists the Nottely River from US highway 19 to Nottely Lake as not supporting recreation due to fecal coliform bacteria. TVA did not conduct bacteriological sampling on Nottely Lake in 1995.

Reservoir: **Blue Ridge** **1995 Score**: 84%

	Previous Scores	
	Reported	1995 Criteria
1991	87	87 (no benthos & no sediment)
1992	73	83 (no benthos & no sediment)
1993	72	91
1994	86	80
1995	84%	84

BRidge	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0				5.0		0.0				0.0
DO	4.0				4.0		-0.5				-0.5
Sediment	2.0				2.0		-0.5				-0.5
Benthos	4.0				4.0		2.0				2.0
Fish	4.0				4.0		0.0				0.0
Total	19.0				19.0		1.0				1.0

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Blue Ridge Reservoir was good in 1995. All indicators rated good or fair. DO rated fair because concentrations near bottom dropped below 2ppm along about 14% of the width of the bottom at the forebay during July and August. This is a much smaller percentage than most other tributary reservoirs and therefore received a "high" fair rating. Sediment quality rated fair due to presence of DDE (a degradation product of DDT) which was found at the detection limit of 0.01mg/kg. The score for the fish assemblage was at the extreme upper boundary of the fair range; one additional point would have put the score in the good range. Of the 12 metrics used to evaluate the fish assemblage, all were rated fair to excellent except one (number of species) which rated poor due to collection of fewer than expected species.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The good overall ecological condition for Blue Ridge Reservoir in 1995 was the same as in all previous years. The low chlorophyll concentrations found in Blue Ridge are expected in this nutrient poor watershed and therefore rate good. DO levels in Blue Ridge are usually quite good and have always rated good in previous years. The fair rating in 1995 was caused by a relatively small percentage of the bottom having low summer DO concentrations. These conditions developed in 1995 because of greatly reduced discharges from the dam in most of June and July owing to the dry spring and summer that year. The DO rating is expected to be good again in 1996 assuming more normal rainfall occurs. The benthos improved from fair in 1994 to good in 1995, with improvements found in all seven metrics use to evaluate benthos results.

Aquatic Macrophytes in 1995: Not an issue on Blue Ridge.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Blue Ridge Reservoir. Fish for tissue analysis were last collected from there in 1993 and did not show concentrations of any analyte (pesticides, PCBs, and metals) to be sufficiently high to have human health implications.

Status of Swimming Advisories in 1995: There are no water contact advisories on Blue Ridge Lake. TVA did not conduct bacteriological sampling on Blue Ridge in 1995.

Reservoir: **Ocoee (Parksville)** **1995 Score:** 71%

	Previous Scores	
	Reported	1995 Criteria
1991	47	74 (no benthos & no sediment[= 0])
1992	53	74 (no benthos & no sediment[= 0])
1993	52	67
1994	60	67
1995	71%	71

Ocoee	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	5.0				5.0		0.0				0.0
DO	5.0				5.0		0.0				0.0
Sediment	0.0				0.0		0.0				0.0
Benthos	3.0				3.0		2.0				2.0
Fish	3.0				3.0		-1.0				-1.0
Total	16.0				16.0		1.0				1.0

Summary/Key Ecological Health Finding for 1995: Parksville had a fair ecological condition in 1995 with a score close to the good range. Chlorophyll and DO rated good. Sediment quality, the most obvious problem on this reservoir, rated poor due to very high concentrations of several metals and PCBs. These metals had concentrations much higher than anywhere else in the Tennessee Valley -- arsenic, cadmium, copper, iron, lead, and zinc (a legacy of past mining activities in the Copper Hill basin). Both benthos and fish rated fair, mostly because few intolerant species were found. Low numbers of fish were again found in Parksville lake in 1995.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The fair overall ecological condition of Parksville Reservoir in 1995 was the same as in 1994, although the score was higher in 1995 than in 1994. In earlier years (1991, 1992, and 1993) different criteria were used to evaluate results, especially for chlorophyll, and the overall lake rating was reported as poor for each of those years. When those results are evaluated on current criteria, all years would rate fair (1993, 1994, and 1995) or good (1991 and 1992). The only indicator to exhibit much of a change between 1994 and 1995 was benthos. In 1994 all seven metrics used to evaluate benthos results rated poor, whereas in 1995 three rated poor, two fair, and two good.

Aquatic Macrophytes in 1995: Not as issue on Parksville.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Parksville; however, TVA studies have found elevated PCB concentrations in catfish fillets consistently for several years. The state of Tennessee collected fish from there in 1994 and did not find elevated PCB levels. TVA and the state worked together to resolve these differences but were not successful for a variety of reasons. In a continuing effort TVA collected additional fish in autumn 1995 and sent samples to the Tennessee lab and to the EPA Region IV lab. Those results are expected later in 1996.

Status of Swimming Advisories in 1995: There are no water contact advisories on Parksville Reservoir. TVA did not conduct bacteriological sampling on this reservoir in 1995.

WATTS BAR RESERVOIR, FORT LOUDOUN RESERVOIR, AND MELTON HILL RESERVOIR WATERSHED

This watershed area is relatively small (1370 square miles) and includes three reservoirs: Fort Loudoun and Watts Bar Reservoirs on the Tennessee River and Melton Hill Reservoir on the Clinch River. All three are run-of-the-river reservoirs with relatively short retention times and annual pool drawdowns of only a few feet. The inflow of Fort Loudoun Reservoir is actually the origin of the Tennessee River. The Holston and French Broad Rivers merge at that point to form the Tennessee River. The Little Tennessee River, another major tributary to the Tennessee River, enters Fort Loudoun Reservoir near the forebay. Watts Bar Reservoir is immediately downstream of Fort Loudoun. The Clinch River, another major tributary, merges with the Tennessee River upstream of the transition zone on Watts Bar Reservoir. Melton Hill Dam bounds the upper end of Watts Bar Reservoir on the Clinch River and Fort Loudoun Reservoir bounds it on the Tennessee River.

Like the other watershed areas formed around one or more of the reservoirs on the mainstream of the Tennessee River, very little of the water leaving this watershed area originates from within. The average annual discharge through Watts Bar Reservoir is about 27,000 cfs. Of this, about 25 percent (6800 cfs) enters from the French Broad River, 16 percent (4500 cfs) from the Holston River, 21 percent (5700 cfs) from the Little Tennessee River, and 15 percent (4200 cfs) from the Melton Hill Dam on the Clinch River. Another five percent (1400 cfs) is contributed by the Emory River, a tributary to the Clinch River near the confluence with the Tennessee River. The remaining 18 percent (4800 cfs) originates from streams which drain directly to one of these reservoirs.

Vital Signs monitoring activities are conducted at the forebays, transition zones, and inflows of all three of these reservoirs. Watt Bar Reservoir has two inflow sites, one near Fort Loudoun Dam and one near Melton Hill Dam.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Watts Bar Reservoir

Watts Bar Reservoir impounds water from both the Tennessee River and one of the major tributaries to the Tennessee River, the Clinch River. The three dams which bound Watts Bar Reservoir are: Watts Bar Dam located at Tennessee River Mile (TRM) 529.9, Fort Loudoun Dam located at TRM 602.3, and Melton Hill Dam located at Clinch River mile (CRM) 23.1. The total length of Watts Bar Reservoir, including the Clinch River arm is 96 miles, the shoreline length is 783 miles, and the surface area is 39,000 acres. The average annual discharge from Watts Bar is approximately 27,000 cfs, providing an average hydraulic retention time of about 19 days.

The confluence of the Clinch and Tennessee Rivers is upstream of the transition zone sampling location in Watts Bar, so biological sampling was conducted at the forebay, transition zone, and both the Tennessee River and Clinch River inflows. Water entering Watts Bar from Melton Hill Reservoir is quite cool due to the hypolimnetic withdrawal from Norris Reservoir (a deep storage impoundment) upstream from Melton Hill. Water entering Watts Bar Reservoir from Fort Loudoun Dam is usually warmer and lower in DO during summer months than water entering from Melton Hill Dam.

The Emory River is a major tributary to the Clinch River arm of Watts Bar Reservoir and supplies about 5 percent of the average annual flow through Watts Bar Reservoir. The Tennessee and Little Tennessee Rivers (i.e., discharge from Fort Loudoun Dam) account for about 75 percent of the flow, and the Clinch River (i.e., discharge from Melton Hill Dam) accounts for about 15 percent through Watts Bar Reservoir.

Fort Loudoun Reservoir

Fort Loudoun Reservoir is the ninth and uppermost reservoir on the Tennessee River with the dam located at TRM 602.3. The surface area and shoreline are relatively small (14,600 acres and 360 miles, respectively) considering the length (61 miles), indicating it is mostly a run-of-the-river reservoir. The average annual discharge from Fort Loudoun Dam is 18,400 cfs which provides an average hydraulic retention time of about ten days.

Fort Loudoun Reservoir (and the Tennessee River) is formed by the confluence of the French Broad and Holston Rivers, with both of these rivers having a major reservoir upstream. Douglas Dam, 32.3 miles up the French Broad River, and Cherokee Dam, 52.3 miles up the Holston River, form deep storage impoundments, each having long retention times. Both of these deep storage impoundments become strongly stratified during summer months resulting in the release of cool, low DO, hypolimnetic water during operation of the hydroelectric units. Some warming and reaeration of the water occurs downstream from Cherokee and Douglas Dams, but both temperature and DO levels are sometimes low when the water reaches Fort Loudoun Reservoir.

Fort Loudoun Reservoir also receives surface waters from the Little Tennessee River, via the Tellico Reservoir canal, which connects the forebays of the two reservoirs. (Since Tellico Dam has no outlet, under most normal conditions, water flows into Fort Loudoun Reservoir from Tellico Reservoir.) Water from Tellico Reservoir (Little Tennessee River) is often cooler and higher in DO, and has a much lower conductivity than water in Fort Loudoun Reservoir (Tennessee River). In 1992, the forebay sampling location on Fort Loudoun Reservoir (originally located at TRM 603.2) was moved upstream to TRM 605.5. This resulted in a better assessment of the water quality conditions of the Tennessee River in the forebay portion of Fort Loudoun Reservoir by minimizing the effects of the Little Tennessee River and Tellico Reservoir on the data gathered in the forebay of Fort Loudoun Reservoir.

Although Fort Loudoun Reservoir is a mainstream reservoir, its complex set of hydrologic conditions (cool water inflows from the Holston, French Broad, and Little Tennessee Rivers) often causes it to exhibit several characteristics that are more typical of a storage impoundment. In fact, analysis of historical fisheries data for the Tennessee Valley indicates the fish community of Fort Loudoun Reservoir is more similar to that in Valley storage impoundments than in other mainstream reservoirs.

Melton Hill Reservoir

Melton Hill Dam is located at mile 23.1 on the Clinch River and is 56.7 miles downstream of Norris Dam. Impounded water extends upstream from Melton Hill Dam about 44 miles. Melton Hill Reservoir has about 170 miles of shoreline and 5690 surface acres at full pool. Average flow through Melton Hill is about 4900 cfs resulting in an average retention time of approximately 12 days. Melton Hill is TVA's only tributary dam with a navigation lock.

The predominant factor influencing the aquatic resources of Melton Hill Reservoir, especially the inflow and mid-reservoir areas, is the cold water entering from Norris Dam discharges. During summer, water discharged from Norris is cold and low in oxygen content. Oxygen concentrations are improved by a re-regulation weir downstream of Norris Dam and by atmospheric reaeration in the river reach between Norris Dam and upper Melton Hill Reservoir. However, water is warmed little and is still quite cool when it enters upper Melton Hill Reservoir. Bull Run Steam Plant, located at about CRM 47, warms the water some, but water temperatures are still too cool to support warm water biota and too warm to support cold water biota.

Reservoir: **Fort Loudoun** **1995 Score:** 49%

	Previous Scores	
	Reported	1995 Criteria
1991	60	63
1992	53	63
1993	58	56
1994	61	64
1995	49%	49

Ft. Loudou	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	1.1	1.0			2.1		-2.5	-2.9			-5.4
DO	2.5	5.0			7.5		-2.0	0.0		0.0	-2.0
Sediment	1.5	1.0			2.5		0.0	-0.5			-0.5
Benthos	2.0	4.0		1.0	7.0		0.0	1.0		0.0	1.0
Fish	3.0	2.0		3.0	8.0		0.0	-1.0		0.0	-1.0
Total	10.1	13.0		4.0	27.1		-4.5	-3.4		0.0	-7.9

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Fort Loudoun Reservoir was poor in 1995 compared to a consistent fair rating for the previous four years. Only the DO and benthos at the transition zone rated good. All other ratings were either fair or poor. Chlorophyll rated poor at both sample sites due to quite high levels throughout the summer. DO rated poor at the forebay due to very low concentrations (near zero) in the lower strata of the reservoir in early June when only nominal amounts of water were being released from the dam. Sediments at the transition zone rated poor due to the occurrence of PCBs, chlordane, and zinc. These same chemicals were found at the forebay but, a slightly lower concentration of zinc allowed the sediment ratings to be fair there. The benthos rated poor at the forebay and inflow and good at the transition zone. The sites with benthos poor ratings had mostly tolerant, short-lived animals and few individuals collected. Fish rated poor at the transition zone due to collection of only a few fish. Fish collected were generally tolerant omnivores with few intolerant species present.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition of Fort Loudoun Reservoir was poor for the first time in 1995. Previously, overall conditions had always rated fair, although the rating for some previous years was just above the breakpoint between fair and poor. All indicators rated poor at at least one location in 1995. Chlorophyll concentrations usually had been relatively high in previous years resulting in mostly fair rating. However, concentrations in 1995 were even higher at both locations resulting in the poor ratings. DO at the forebay rated poor in 1995 for the first time since monitoring began (in 1990). Discharging only small amounts of water from the dam during June resulted in a much longer than normal holding time which allowed DO near the bottom of the reservoir to be consumed by natural processes. The poor ratings for sediments resulted from three chemicals (PCBs, chlordane, and zinc); all of which have been found in past years. Benthos have typically rated poor in this reservoir. The good rating at the transition zone is the exception. Most metrics used to evaluate the benthos were improved at that site in 1995. Ratings for fish have also been poor in most previous years for the reasons named above.

Aquatic Macrophytes in 1995: Not an issue on Fort Loudoun.

Status of Fish Consumption Advisories in 1995: Catfish from Fort Loudoun Reservoir should not be eaten due to PCBs. Also, largemouth bass should not be eaten if they weigh more than two pounds or are caught in Little River Embayment. Catfish and largemouth bass were collected from the three Vital Signs monitoring sites in autumn 1995.

Status of Swimming Advisories in 1995: The state of Tennessee advise against water contact in First, Second, Third, and Goose Creeks, and the head of Sinking Creek embayment. TVA did not conduct bacteriological sampling on Fort Loudoun Lake in 1995. The Blount County boat ramp was sampled in 1994 and failed to meet state criteria.

CLINCH RIVER AND POWELL RIVER WATERSHED

This long, narrow watershed lies in southwest Virginia and northeast Tennessee. Streams in the watershed have high concentrations of dissolved minerals and generally low concentrations of nutrients.

For management purposes, an artificial ending point of the watershed has been established at Norris Dam, which is near Clinch River mile 80. The remainder of the Clinch River is associated with the Watts Bar, Fort Loudoun, and Melton Hill Reservoir Watershed area. As defined, this watershed drains an area of 2912 square miles and has an average annual discharge of about 4200 cfs. The Clinch and Powell Rivers contribute about 80 percent of this flow.

Norris Reservoir is the only major reservoir in the watershed; essentially all streams upstream from Norris are free flowing. There are three Vital Signs monitoring sites in Norris Reservoir (forebay and mid-reservoir sites on the Clinch and Powell arms).

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on Norris Reservoir. It also provides planned activites in the future .

Norris Reservoir

Norris Reservoir is formed by Norris Dam at Clinch River mile (CRM) 79.8. It is a large, dendritic, tributary storage impoundment of the Clinch and Powell Rivers which flow together about nine miles upstream of the dam. Norris is one of the deeper TVA tributary reservoirs, with depths over 200 feet. Annual drawdown averages about 32 feet. At full pool, the surface area of the reservoir is 34,200 acres, the shoreline is about 800 miles in length, and water is impounded 73 miles upstream on the Clinch River and 53 miles upstream on the Powell River. Norris Reservoir has a long average retention time (about 245 days) and an average annual discharge of approximately 4200 cfs. Due to the great depth and long retention time of Norris Reservoir, significant vertical stratification is expected.

Because of the confluence of the Clinch and Powell Rivers relatively close to the dam, three reservoir sampling locations were established: one forebay site; and two mid-reservoir sites--one on the Clinch River and one on the Powell River.

Reservoir: **Norris** **1995 Score:** 60%

	Previous Scores	
	Reported	1995 Criteria
1991	57	71
1992	67	72
1993	67	69
1994	69	65
1995	60%	60

Norris	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ-C	TZ-P	Inf	Total		FB	TZ-C	TZ-P	Inf	Total
Cholorophyll	4.2	5.0	5.0		14.2		0.9	1.3	0.7		2.9
DO	1.0	1.0	1.0		3.0		0.0	0.0	0.0		0.0
Sediment	1.5	2.5	2.0		6.0		0.0	0.0	0.5		0.5
Benthos	3.0	3.0	2.0		8.0		0.0	-1.0	-2.0		-3.0
Fish	2.0	3.0	4.0		9.0		-2.0	-1.0	-1.0		-4.0
Total	11.7	14.5	14.0		40.2		-1.1	-0.7	-1.8		-3.6

Summary/Key Ecological Health Finding for 1995: Norris rated fair again in 1995, like it has each of the last five years. With the exception of DO, all indicators rated either good or fair at all three locations. Poor ratings for DO at the three monitoring locations resulted from much of the water column having DO concentrations <2pm during summer with periods of near zero DO near bottom. Typically chlorophyll has rated fair in Norris because of lower than expected concentrations. This was not the case in 1995 -- concentrations were within the expected range and rated good.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The fair ecological condition for Norris in 1995 was consistent with previous years. Like in past years, the biggest problem was low DO in summer. Norris is a typical deep tributary lake in which the water separates into layers in summer and the oxygen in the cold, bottom layer is gradually used up. Also, elevated concentrations of lead and arsenic have been routinely found in the forebay. Although Norris had a fair rating for the overall ecological condition in 1995, the ecological health score was lower than in previous years. The primary contributors to the reduced score in 1995 was lower ratings for benthos at both mid-reservoir locations and for the fish assemblage at all three locations. Lowered ratings for benthos were due to collecting fewer long-lived taxa and fewer EPT taxa than in previous years. Differences in the fish assemblage were mostly related to the tolerant/intolerant metrics and trophic composition meterics.

Aquatic Macrophytes in 1995: Not an issue on Norris Reservoir.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Norris. TVA last collected fish from Norris for tissue analysis in 1993. Concentrations of all pesticides and PCBs were either low or nondectable. Mercury was the only metal which was slightly elevated but not sufficiently high to pose a human health concern.

Status of Swimming Advisories in 1995: There are no water contact advisories on Norris Lake. TVA did not conduct bacteriological sampling on Norris in 1995.

LITTLE TENNESSEE RIVER WATERSHED

The Little Tennessee River Watershed encompasses 2672 square miles, mostly in Tennessee and North Carolina with a small area in Georgia. Much of the watershed is forested, with the headwaters in the Blue Ridge Mountains. The basin is underlain mostly by crystalline and metasedimentary rocks of the Blue Ridge province. This watershed is home to a large variety of federally listed threatened and endangered species.

Most of the streams in the watershed are steep gradient and generally have low concentrations of both dissolved minerals and nutrients. The two largest tributaries to the Little Tennessee River are the Tuckasegee River which merges with the Little Tennessee in Fontana Reservoir and the Tellico River which merges with the Little Tennessee in Tellico Reservoir.

There are several reservoirs in the watershed but only Fontana Reservoir in the mountainous area and Tellico Reservoir at the lower end of the watershed are monitored. TVA does not monitor the other reservoirs either because of their small size or because they are owned by the Aluminum Company of America (ALCOA).

Two sites are monitored on Tellico Reservoir (the forebay and transition zone) and three sites on Fontana Reservoir (the forebay and mid-reservoir sites on the Little Tennessee River and Tuckasegee River).

Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Tellico Reservoir

Tellico Dam is located on the Little Tennessee River just upstream of the confluence of the Little Tennessee and Tennessee Rivers. It is the last dam completed in the TVA system with dam closure in 1979. Tellico Reservoir is 33 miles long, has a shoreline of 373 miles, and has a surface area of about 16,000 acres at full pool. The average estimated flow through Tellico Reservoir is approximately 5700 cfs which provides an average retention time of about 37 days. Very little of this water is discharged through Tellico Dam. Rather, it is diverted through a navigation canal to Fort Loudoun Reservoir near the dam for hydroelectric power production. Water characteristics in these two reservoirs differ considerably. The hydrodynamics and exchange of water via the inter-connecting canal significantly affect water quality within Tellico Reservoir (and Fort Loudoun Reservoir). The canal is only 20-25 feet deep, but the depth of Tellico Reservoir at the forebay is about 80 feet. Thus, water at strata below about 25 feet is essentially trapped and becomes anoxic during much of the summer in the forebay of Tellico Reservoir.

The impounded water of Tellico Reservoir extends upstream of the confluence of the Little Tennessee and Tellico Rivers. The transition zone site selected for sample collection in 1990, 1991, and 1992 was in the Little Tennessee River, just upstream of the confluence with the Tellico River at Little Tennessee River Mile (LTRM) 21.0. Water conditions at that site are largely controlled by discharges from Chilhowee Dam at LTRM 33.6. This water is cold, nutrient poor, and has a low mineral content, conditions that are not conducive to establishing a diverse, abundant aquatic community. In 1993, the transition zone sampling location in Tellico Reservoir was moved six miles downstream to LTRM 15.0, just below the confluence of the Tellico River--a site more characteristic of a transition environment rather than riverine conditions.

Fontana Reservoir

Fontana Reservoir is located in the Blue Ridge Mountains of western North Carolina. Fontana is the deepest reservoir in the TVA system. At full pool it has a maximum depth of 460 feet, a length of 29 miles, a shoreline of 248 miles, and a surface area of 10,640 acres. Fontana Reservoir has a relatively large drawdown, which averages about 64 feet annually. Every fifth year Fontana is drawn even deeper to allow sluice gate access for maintenance.

Fontana Dam is located at Little Tennessee River Mile 61.0. Average annual discharge is 3840 cfs which provides an average hydraulic retention time in the reservoir of 186 days.

Water in Fontana Reservoir is quite clear due to limited photosynthetic activity and a mostly forested watershed. Water entering the reservoir is low in nutrients and dissolved minerals.

Reservoir: **Tellico** **1995 Score:** 53%

	Previous Scores	
	Reported	1995 Criteria
1991	48	61 (only forebay)
1992	48	57 (only forebay)
1993	63	63
1994	71	74
1995	53%	53

Tellico	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	1.5	4.0			5.5		-1.9	-0.3			-2.2
DO	1.0	4.5			5.5		-3.5	-0.5			-4.0
Sediment	1.5	2.5			4.0		-1.0	0.0			-1.0
Benthos	1.0	2.0			3.0		0.0	0.0			0.0
Fish	3.0	3.0			6.0		-1.0	-1.0			-2.0
Total	8.0	16.0			24.0		-7.4	-1.8			-9.2

Summary/Key Ecological Health Finding for 1995: The overall ecological condition in Tellico Reservoir was again fair in 1995, but several indicators, particularly at the forebay, were much lower than in previous years. The summer of 1995 was quite different due to very limited flows through the reservoir system which were the result of an extremely dry spring and early summer. In fact, there were extended periods from mid-April through early July when flows through Tellico were greatly below normal caused by low rainfall and low runoff and by efforts to fill Fontana Reservoir upstream. Conditions were much worse at the forebay than the middle of the reservoir where chlorophyll, DO, and benthos all rated poor and sediment quality and fish rated fair. The poor rating for high chlorophyll was related to the lower streamflows resulting in longer residence times and to chlorophyll rich water entering Tellico forebay from Fort Loudoun forebay via the canal which connects the two reservoirs. Poor DO conditions during summer resulted from the lack of flow through the reservoir which allowed stagnant conditions to develop behind Tellico Dam. Benthos usually rate poor in Tellico probably due to a combination of factors such as low DO and cold bottom waters. All indicators at the transition zone rated either good or fair.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: Although Tellico had a fair ecological condition in 1995 (same as the previous two years) the score was at the low end of the fair range. The biggest difference between 1995 and the previous years was much worse conditions at the forebay, especially for DO. DOs during the summer were the lowest observed at the forebay since monitoring began in 1990. These very low DOs and other results cited above for 1995 were tied to the unusually low flows throughout the summer. Quite low rainfall in spring and summer and the desire to fill tributary reservoirs (e.g., Fontana) severely limited flows into and through Tellico.

Aquatic Macrophytes in 1995: Macrophytes were not surveyed on Tellico in 1995. Only nominal amounts have been found previously (e.g., about 250 acres in 1994).

Status of Fish Consumption Advisories in 1995: The state of Tennessee advises people not to eat catfish from Tellico Reservoir due to PCB contamination. Channel catfish were collected from the forebay and transition zone in autumn in 1995.

Status of Swimming Advisories in 1995: There are no water contact advisories on Tellico Lake. TVA did not conduct bacteriological sampling on Tellico Lake in 1995.

Reservoir: **Fontana** **1995 Score:** 72%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	64	71
1994	67	75
1995	72%	72

Fontana	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ-LT	TZ-TK	Inf	Total		FB	TZ-LT	TZ-TK	Inf	Total
Cholorophyll	5.0	3.4	3.8		12.2		0.0	-1.1	-1.2		-2.3
DO	4.5	4.0	3.5		12.0		0.0	-1.0	0.0		-1.0
Sediment	2.5	1.5	2.5		6.5		1.0	0.0	1.0		2.0
Benthos	1.0	????	????		1.0		????	????	????		0.0
Fish	????	3.0	3.0		6.0		????	-1.0	0.0		-1.0
Total	13.0	11.9	12.8		37.7		1.0	-3.1	-0.2		-2.3

<u>Summary/Key Ecological Health Finding for 1995</u>: Fontana Reservoir had a good ecological condition rating in 1995. Only one indicator had a poor rating -- benthos at the forebay due to occurrence of very few animals and those present were mostly tolerant types such as tubificid worms. (Note: Benthos samples could not be collected from the two mid-reservoir sites because of the special reservoir drawdown in autumn 1995). All other indicators rated fair or good. Chlorophyll rated fair at the two mid-reservoir locations due to concentrations being slightly higher that expected. (Fontana is expected to have only low chlorophyll concentrations because it is in a nutrient poor watershed.) Good/fair ratings for sediment quality in 1995 are notable because they were poor at all locations in 1994. (See further explanation below for differences in sediment rating between years.)

Hydrologically, 1995 was an unusual year for Fontana. Very low rainfall in spring and summer prevented reservoir filling to normal pool levels and resulted in much lower releases from Fontana Dam from early April through the end of July. Beginning in early August, releases from the dam were increased substantially above normal to draw the reservoir elevation down for maintenance and safety inspections on the dam. This special operation occurs every five years.

<u>Explanation of Differences in Ecological Health Scores in 1995 and Previous Years</u>: The overall ecological condition for Fontana Reservoir in 1995 was good, with a score slightly better than in previous years when the overall condition rated fair. Sediment quality ratings were much better in 1995 (rated good at two locations and fair one - due to presence of chlordane) compared to 1994 when significant toxicity to test animals and chlordane resulted in poor ratings at all locations. Toxicity tests were not conducted in 1995 due to budget constraints. Had toxicity tests been performed in 1995 and comparable results found, one site would have rated poor (due to presence of both toxicity and chlordane) and the two other would have rated fair (due to presence of toxicity).

<u>Aquatic Macrophytes in 1995</u>: Not an issue on Fontana Reservoir.

<u>Status of Fish Consumption Advisories in 1995</u>: There are no fish consumption advisories on Fontana. Fish for tissue analysis were last collected in 1993 and analyzed for pesticides, PCBs and selected metals. Only mercury was elevated but not significantly so.

<u>Status of Swimming Advisories in 1995</u>: There are no water contact advisories on Fontana Lake. TVA did not conduct bacteriological studies on Fontana in 1995.

FRENCH BROAD RIVER WATERSHED

The French Broad River watershed is one of the largest (5124 square miles) watersheds in the Tennessee Valley. About half the watershed is in Tennessee and half is in North Carolina. The French Broad River and its two large tributaries (Nolichucky and Pigeon Rivers) originate in the Blue Ridge Mountains. All three of these rivers merge at the upper end of Douglas Reservoir, the only sizable reservoir in the watershed. The water in the French Broad River is moderately hard and relatively high in nutrients.

There are two reservoir Vital Signs monitoring sites on Douglas. Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on Dougla Reservoirs. It also provides planned activites in the future .

Douglas Reservoir

Douglas Reservoir is a deep storage impoundment (tributary reservoir) on the French Broad River. Douglas Dam is located 32.3 miles upstream of the confluence of the French Broad and Holston Rivers which form the Tennessee River. Reservoir drawdown during late summer and autumn is rather large, with an annual average of about 48 feet. The large annual fluctuation in surface water elevation causes other physical characteristics such as surface area, reservoir length, and retention time to vary greatly during the year. At full pool, maximum depth at the dam is 127 feet, surface area is 30,400 acres, the shoreline is 555 miles, and the length is 43 miles. Average annual discharge is approximately 6780 cfs, which provides an average hydraulic retention time of about 105 days.

Lengthy retention times and lack of mixing due to their deep nature tend to cause storage impoundments to have strong thermal stratification during summer months. Undesirable conditions often develop in the hypolimnion due to anoxia, which in most cases extends from the forebay to the mid-reservoir sampling location.

Reservoir: **Douglas** **1995 Score:** 45%

	Previous Scores	
	Reported	1995 Criteria
1991	42	60 (only Forebay)
1992	56	54 (only Forebay)
1993	58	60
1994	64	62
1995	45%	45

Douglas	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Cholorophyll	4.3	1.0			5.3		-0.7	-3.1			-3.7
DO	1.0	1.0			2.0		0.0	-1.0			-1.0
Sediment	2.5	1.5			4.0		0.0	0.0			0.0
Benthos	1.0	2.0			3.0		-1.0	0.0			-1.0
Fish	3.0	3.0			6.0		-1.0	-1.0			-2.0
Total	11.8	8.5			20.3		-2.7	-5.1			-7.7

Summary/Key Ecological Health Finding for 1995: The overall ecological condition of Douglas Reservoir was poor in 1995 with the lowest score ever recorded for this reservoir (typically rated fair in past years). There are several problems usually found at one or both sample locations on Douglas such as very low DOs in summer in mid and lower strata, poor benthos, and often high chlorophyll levels. The lower overall score for Douglas in 1995 was due to occurrence of all these common problems, plus slightly lower scores for fish, which, although still within the fair range, contributed to lowering the overall score. Although the DO rated poor in 1995 at both locations as expected, lower DO concentrations were measured at the mid-reservoir station during the summer of 1995 than in any previous year. There were only two indicators which rated good in 1995 on Douglas Reservoir -- chlorophyll and sediment, both at the forebay.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The ecological condition for Douglas Reservoir has been fair or poor in previous years. The rating for 1995 was lower than in any previous year. The consistent problems are very low DO levels and poor benthos, generally found at both locations on Douglas since monitoring began in 1990. Also, chlorophyll concentrations are frequently too high, particularly at the mid-reservoir location. TVA is working to improve poor DO conditions in Douglas and other, similarly large storage reservoirs.

Aquatic Macrophytes in 1995: Not as issue on Douglas Reservoir.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Douglas Reservoir. TVA last collected fish for tissue analysis from Douglas in 1994. All pesticides, metals, and PCBs were either below detection limits or found in only low concentrations.

Status of Swimming Advisories in 1995: The state of Tennessee advises against water contact in the lower end of Leadvale Creek near Douglas Lake. There are no other water contact advisories for the lake. The swimming beach near Douglas Dam was tested in 1995 and met state criteria.

HOLSTON RIVER WATERSHED

The Holston River Watershed encompasses 3776 square miles, mostly in upper east Tennessee and southwest Virginia and a small area in North Carolina. The area is relatively highly populated with substantial industrial development.

Much of the area is underlain with limestone and dolomite which results in high concentrations of dissolved minerals in the streams. There is also substantial zinc mining in the watershed.

There are several reservoirs in the watershed with varying size, depth, flow, and water quality characteristics. The largest is Cherokee Reservoir on the Holston River near the lower end of the watershed. The uppermost reservoirs are Watauga Reservoir on the Watauga River and South Holston Reservoir on the South Fork Holston River. Downstream from these reservoirs, the Watauga and South Holston Rivers merge in Boone Reservoir. Immediately downstream from Boone Dam is Fort Patrick Henry Reservoir, the smallest of the five reservoirs in this watershed included in the Vital Signs Monitoring Program. A few miles downstream from Fort Patrick Henry Dam the South Fork and North Fork Holston Rivers merge to form the Holston River.

The average annual discharge from Cherokee Dam is 4460 cfs. The Holston River merges with the French Broad River at Knoxville to form the Tennessee River.

Vital Signs monitoring activities are conducted at one, two, or three locations depending on reservoir size and characteristics. Table 1 of this appendix identifies the years when Vital Signs Monitoring activites have occurred on reservoirs in this watershed. It also provides planned activites in the future .

Cherokee Reservoir

Cherokee Reservoir is formed by Cherokee Dam at Holston River mile (HRM) 52.3. Like Norris and Douglas Reservoirs, it is a large, relatively deep, tributary storage impoundment with a substantial drawdown which begins in late summer. When the water surface is at full pool, maximum depth at the dam is 163 feet and winter drawdown is 53 feet. However, full pool is not reached most years, and the long-term average drawdown is about 28 feet. At full pool, Cherokee Reservoir is 54 miles long, has a surface area of 30,300 acres, and a shoreline of 393 miles. Average annual discharge is about 4500 cfs which provides an average hydraulic retention time (at full pool) of approximately 165 days.

Like other deep storage impoundments with long retention times, Cherokee Reservoir exhibits strong vertical stratification during summer months. The hypolimnetic oxygen deficit on Cherokee is one of the worst of all Vital Signs monitoring reservoirs and has been well documented in numerous past studies (Iwanski, 1978; Iwanski et al., 1980; Hauser et al., 1987).

Fort Patrick Henry Reservoir

Fort Patrick Henry Reservoir is one of the smaller reservoirs included in the Vital Signs Monitoring Program. It is only ten miles long, has a surface area of about 870 acres, and has a shoreline of 37 miles. Although it is a tributary reservoir, it has characteristics of a run-of-river reservoir, rather than a storage reservoir. Annual fluctuation in elevation is only five feet. Also, retention time is short; with an average discharge of 2650 cfs, the hydraulic retention time is only about five days. Maximum depth is about 80 feet. Fort Patrick Henry Dam is located at South Fork Holston River mile 8.2.

This reservoir had not been sampled as part of this monitoring effort prior to 1993. Because of its small size, only the forebay is monitored for Vital Signs.

Boone Reservoir

Boone Dam is located at South Fork Holston River mile (SFHRM) 18.6, approximately 1.4 miles downstream of the confluence of the South Fork Holston and the Watauga Rivers. At normal maximum pool (1384 feet MSL), Boone Reservoir extends upstream approximately 17.4 miles on the South Fork Holston River and 15.3 miles on the Watauga River for a total reservoir length of approximately 32.7 miles. Boone Reservoir has a surface area of 4300 acres, a shoreline length of approximately 122 miles, an average depth of 44 feet, and a maximum depth of 129 feet near the dam. Annual average discharge from Boone Dam is about 2500 cfs, which results in an average hydraulic residence time of about 38 days. Annual drawdowns of Boone Reservoir usually average about 25 feet.

Three locations were selected for ecological health monitoring in Boone Reservoir, one at the forebay and two mid-reservoir sampling locations, one on the Watauga River arm and one on the South Fork Holston River arm. Sediment and benthic macroinvertebrate sampling were added for the first time in 1993.

South Holston Reservoir

South Holston Reservoir in northeastern Tennessee and southwestern Virginia is created by South Holston Dam, located on the South Fork of the Holston River at mile 49.8. The dam creates a storage pool approximately 24 miles long, over 230 feet deep near the dam, with an average depth of 86.5 feet and approximately 7600 acres in surface area. With an average annual discharge of about 980 cfs from the dam, the average hydraulic residence time is almost one year (340 days)--one of the longest residence times of any TVA reservoir. Average annual drawdown of South Holston Reservoir is about 33 feet.

Two locations are monitored for Vital Signs--the forebay and mid-reservoir. Sediment and benthic macroinvertebrate sampling were added for the first time in 1993.

Watauga Reservoir

Watauga Dam in the northeastern corner of Tennessee impounds the Watauga River at mile 36.7. It forms a pool 16 miles in length, approximately 6400 acres in surface area, about 274 feet deep at the dam, and an average depth of about 89 feet, making it the second-deepest reservoir sampled as part of TVA's Vital Signs Monitoring Program. With an annual average discharge of about 700 cfs, Watauga Reservoir also has the longest hydraulic residence time of any of the Vital Signs reservoirs (about 400 days). Average annual drawdown of Watauga Reservoir is about 26 feet.

Two locations are monitored on Watauga Reservoir, the forebay and mid-reservoir. Sediment quality and benthic macroinvertebrates were examined for the first time in 1993.

Reservoir: **Cherokee** **1995 Score:** 51%

	Previous Scores	
	Reported	1995 Criteria
1991	50	57
1992	53	57
1993	64	66
1994	53	48
1995	51%	51

Cherokee	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Chol**o**rophyll	5.0	1.0			6.0		1.8	0.0			1.8
DO	1.0	1.0			2.0		0.0	0.0			0.0
Sediment	2.5	2.0			4.5		0.0	0.5			0.5
Benthos	2.0	????			2.0		-1.0	????			-1.0
Fish	3.0	3.0			6.0		0.0	0.0			0.0
Total	13.5	7.0			20.5		0.8	0.5			1.3

Summary/Key Ecological Health Finding for 1995: Cherokee Reservoir had a poor overall ecological condition in 1995. DO rated poor at both sites because much of the water column had DO <2ppm for most of the summer with extended periods (June through September) of no DO near bottom. Chlorophyll rated good at the forebay but poor at the mid-reservoir site. Chlorophyll concentrations were quite high at the mid-reservoir site throughout the summer (second highest average found in all sites monitored in 1995) and indicative of the high nutrient levels of the Holston River flowing into Cherokee. Sediment quality rated good at the forebay and fair at mid-reservoir due to slightly elevated concentrations of copper. Benthos rated poor at the forebay (samples not collected at the mid-reservoir site in 1995). The benthic animals collected were all tubificid worms and chironomids. The fish assemblage rated fair at both sites. The rating was poor because collections included too few intolerant species, too few insectivores, and relatively few individuals.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition for Cherokee Reservoir has been poor in most years. Problems generally found each year include very low DOs, poor benthos, and elevated chlorophyll concentrations at mid-reservoir. Results for 1995 were similar to past years. TVA is working to improve poor DO conditions in Cherokee and other reservoirs.

Aquatic Macrophytes in 1995: Not an issue in Cherokee.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories on Cherokee Reservoir. TVA collected catfish from Cherokee in 1993 and found only low levels of metals and pesticides, but PCB concentrations were slightly elevated. TVA collected additional catfish in 1994 and found essentially the same results. Catfish were again collected in 1995 to be sure PCB concentrations had not changed.

Status of Swimming Advisories in 1995: The state of Tennessee advises against water contact recreation in the lower five miles of Turkey Creek, which flows into Cherokee Reservoir. The swimming beach at Cherokee Dam was tested in 1995 and met state criteria.

Reservoir: **Ft Patrick Henry** **1995 Score**: 51%

	Previous Scores	
	Reported	1995 Criteria
1991		
1992		
1993	72	86
1994	60	56
1995	51%	51

Ft. Pat	1995 Results					Differences between 1994 and 1995-same criteria					
	FB	TZ	Emb	Inf	Total		FB	TZ	Emb	Inf	Total
Chlorophyll	2.0				2.0		1.0				1.0
DO	5.0				5.0		0.0				0.0
Sediment	1.5				1.5		0.0				0.0
Benthos	2.0				2.0		0.0				0.0
Fish	1.0				1.0		-2.0				-2.0
Total	11.5				11.5		-1.1				-1.1

<u>**Summary/Key Ecological Health Finding for 1995**</u>: The overall ecological condition of Ft. Patrick Henry Reservoir was poor in 1995. DO was the only indicator which rated good. Sediment quality rated fair due to presence of chlordane. The other three indicators (chlorophyll, benthos, and fish) rated poor. Chlorophyll concentrations were too high throughout the summer and were rated poor. (Nutrient concentrations were also high, fueling this high algal productivity.) The benthos rated poor because only tolerant animals such as tubificids and chironomids were collected. Fish assemblage also rated poor. Seven of the 12 metrics used to evaluate the fish assemblage received the lowest possible rating. Generally, only a few fish were collected representing mostly tolerant species.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: The overall ecological condition of Ft. Patrick Henry Reservoir has dropped from good in 1993 to fair in 1994 to poor in 1995. Most indicators rated fair in 1993, but more importantly, none rated poor allowing the overall score to be just within the good range. Generally the same results were found in 1994 except chlorophyll rated poor compared to fair in 1993 and caused the overall ratings to drop into fair range. In 1995 chlorophyll, benthos, and fish all rated poor with sediment fair and DO good. Lower flows (longer residence time) in spring and summer 1995 most likely contributed to higher chlorophyll levels. It is not clear from the data at hand what would have caused worsened conditions for benthos and fish. The large year-to-year variation in overall ecological condition in Ft. Pat indicates a need to continue monitoring this reservoir to determine its true condition and to better understand the cause of the variation.

Aquatic Macrophytes in 1995: Not an issue in this reservoir.

Status of Fish Consumption Advisories in 1995: There are no fish consumption advisories for Ft. Pat. TVA collected channel catfish and largemouth bass from the forebay in 1995 for analysis of pesticides, PCBs, and metals.

Status of Swimming Advisories in 1995: There are no water contact advisories on FT. Pat. The only area tested in 1995 was the swimming beach at Warrior Path State Park which met state criteria.

Reservoir: **Boone** **1995 Score:** 49%

	Previous Scores	
	Reported	1995 Criteria
1991	51	53 (no benthos & no sediment)
1992	64	63 (no benthos & no sediment)
1993	59	58
1994	59	56
1995	49%	49

Boone	1995 Results						Differences between 1994 and 1995-same criteria				
	FB	TZ-SFH	TZ-WR	Inf	Total		FB	TZ-SFH	TZ-WR	Inf	Total
Cholorophyll	3.7	2.2	1.0		6.8		-1.0	1.2	-1.4		-1.2
DO	4.5	2.0	5.0		11.5		0.0	0.0	0.0		0.0
Sediment	1.5	1.5	0.5		3.5		0.0	0.0	0.0		0.0
Benthos	1.0	1.0	1.0		3.0		-1.0	-1.0	-1.0		-3.0
Fish	3.0	2.0	3.0		8.0		0.0	-1.0	0.0		-1.0
Total	13.7	8.7	10.5		32.8		-2.0	-0.9	-2.4		-5.2

Summary/Key Ecological Health Finding for 1995: The overall ecological condition for Boone Reservoir was poor in 1995. The only indicator to rate good was DO at the forebay and the Watauga River mid-reservoir sites. All other indicators rated fair or poor. DO at the South Fork Holston River mid-reservoir site rated poor due to low DOs (<2ppm) for most of the summer at mid-water column strata. Upper and lower strata had ample DO. Chlorophyll concentrations were too high at all locations but especially so at the two mid-reservoir sites which had poor ratings due to high levels throughout the summer stimulated by high nutrient levels in water entering the lake. The fair sediment quality rating at the forebay was due to presence of chlordane; whereas the fair rating at the South Fork Holston mid-reservoir site was due to presence of both PCBs and chlordane. At the Watauga mid-reservoir site, presence of PCBs, chlordane, and elevated zinc and copper resulted in a poor rating. The benthos rated poor at all three sites with the common problem of having only tolerant animals present such as tubificid worms. For example, this group comprised 99.7% of the animals collected at the forebay. The fish assemblage at the South Fork Holston mid-reservoir site rated poor with 6 of the 12 metrics used to evaluate the fish assemblage receiving the lowest possible score (generally few fish collected representing mostly tolerant species). Ratings for the fish assemblage at the other two sites were fair with few of the meterics being particularly low and few being particularly high. Ecological conditions were poorest on the South Fork Holston arm of the lake where all but one of the indicators (sediment) rated poor and best at the forebay where only one indicator (benthos) rated poor.

Explanation of Differences in Ecological Health Scores in 1995 and Previous Years: In previous years ecological conditions on Boone have been at best fair. But in 1995 conditions were poorer than in any previous year. Every indictor rated poor at one or more locations in 1995. At one point or another during the past five years all indicators have rated poor at at least one of the three locations on Boone. What made the overall ecological condition so poor in 1995 was the coexistence of so many poor ratings. The major contributor to these conditions was the lack of rainfall in spring and summer which resulted in very little flow through the reservoir causing stagnant conditions.

Aquatic Macrophytes in 1995: Not an issue on Boone.

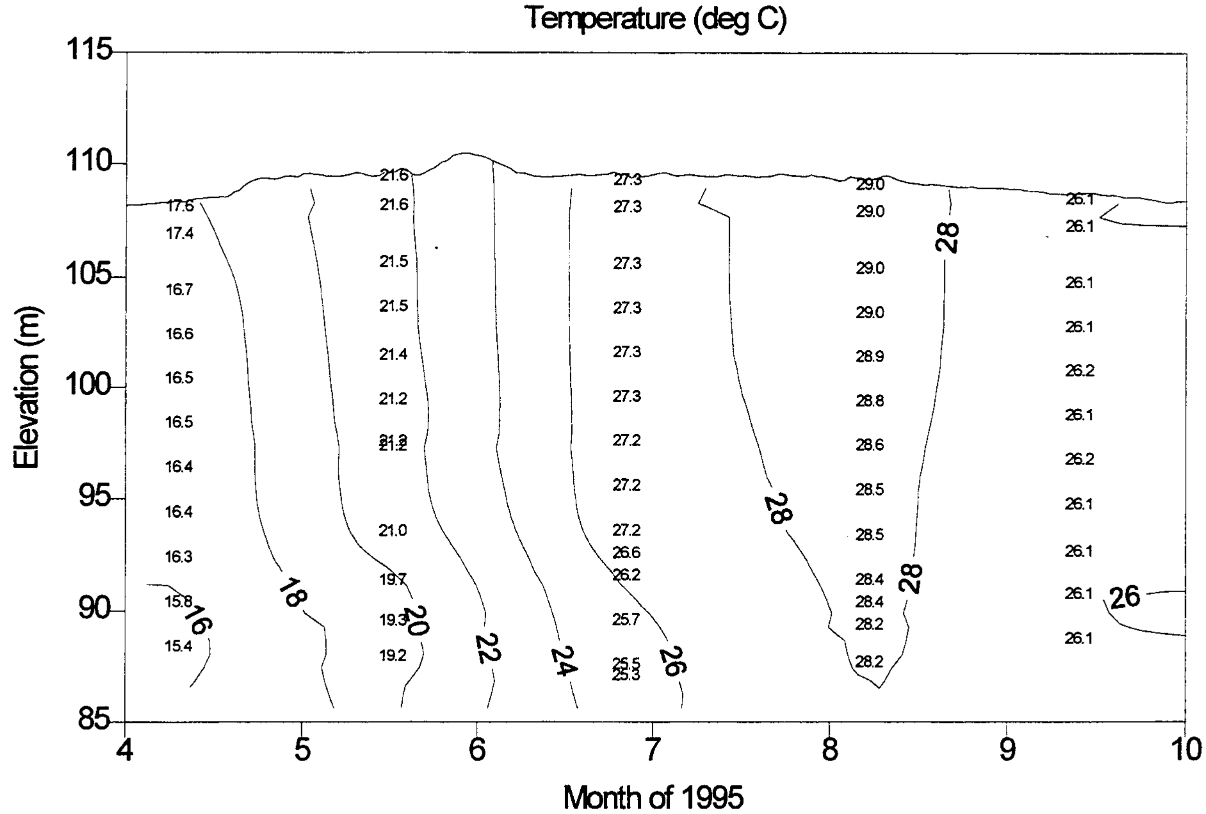
Status of Fish Consumption Advisories in 1995: The state of Tennessee has a precautionary advisory for catfish and carp from Boone Reservoir. Children, pregnant women, and nursing mothers should not eat contaminated fish. All others should eat no more than 1.2 pounds per month.

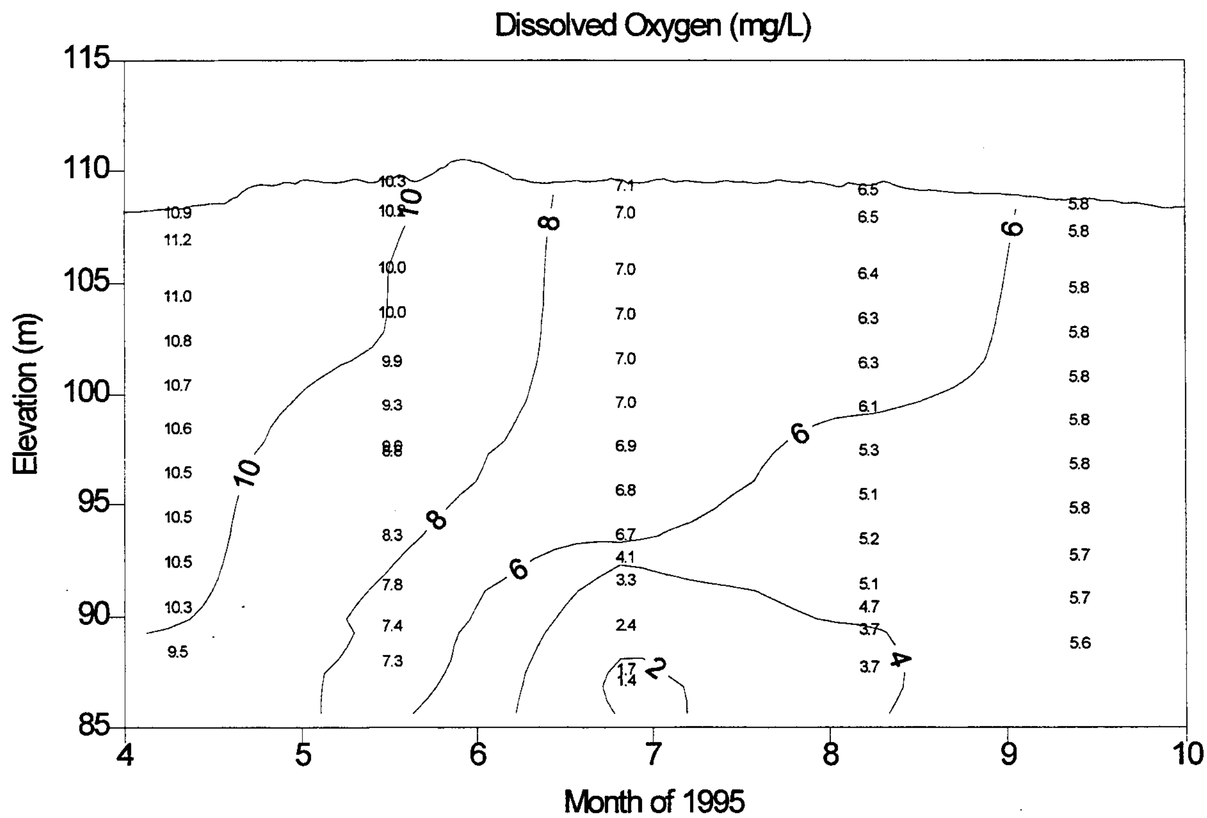
Status of Swimming Advisories in 1995: The state of Tennessee advises against water contact in the lower portions of Cash Hollow, Sinking, and Beaver Creeks, which flow into Boone Lake. The only area on Boone tested in 1995 was the swimming beach at the dam, which met state criteria.

Appendix B.

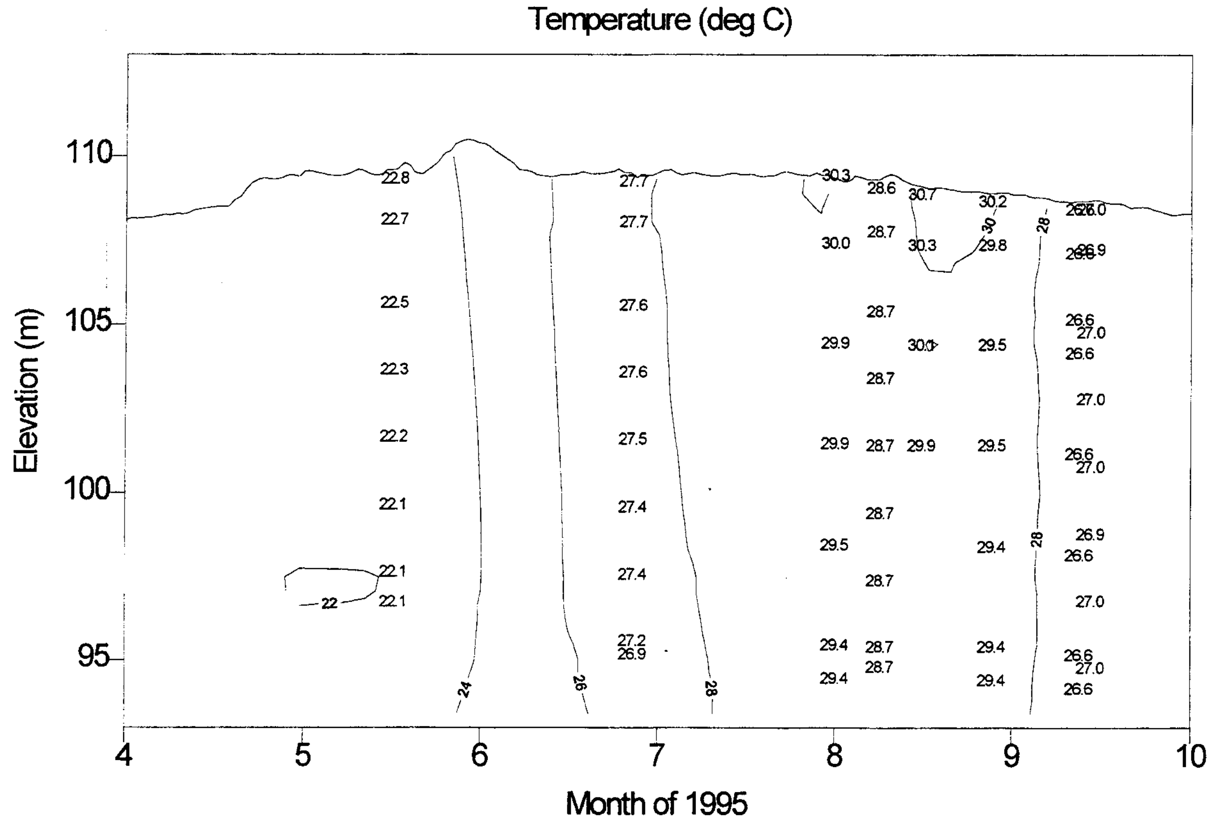
Temperature and Dissolved Oxygen Isopleths for Each Sample Location Throughout the 1995 Monitoring Period

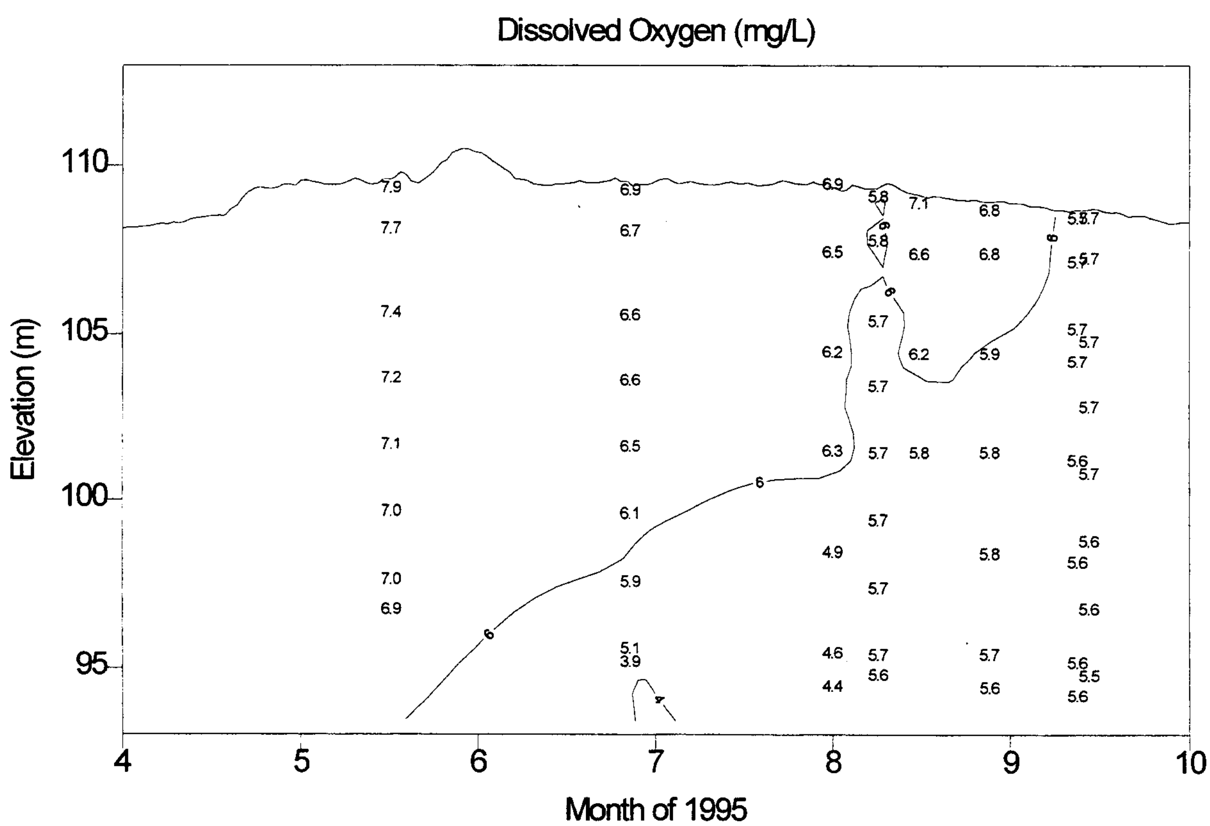
Kentucky Reservoir - TRM 23.0



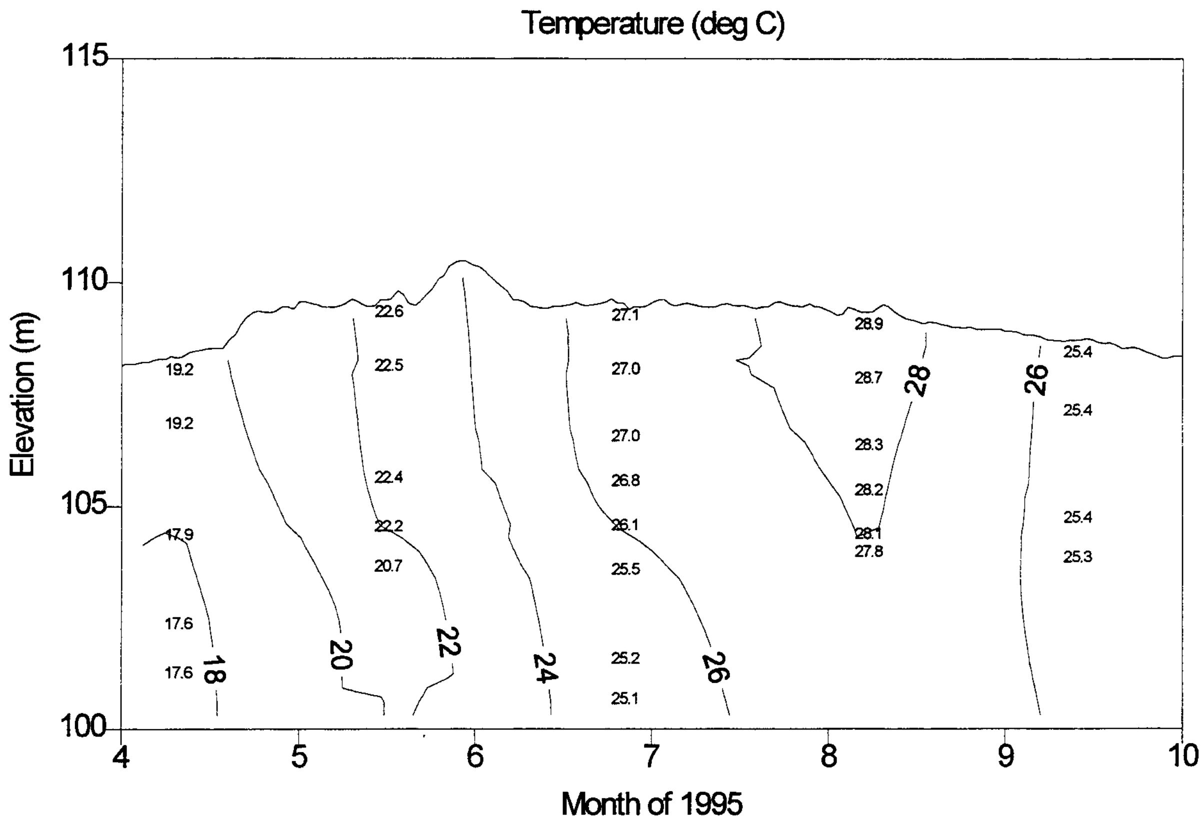


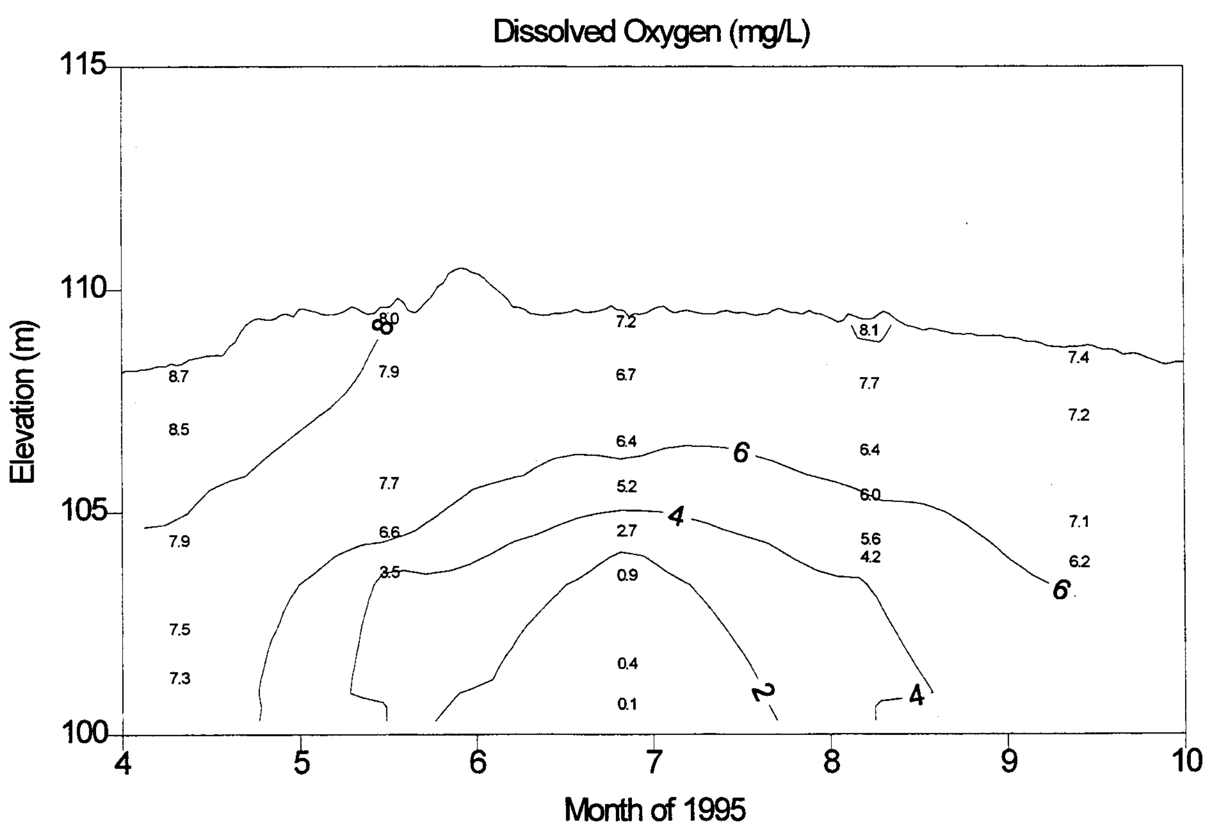
Kentucky Reservoir - TRM 85.0



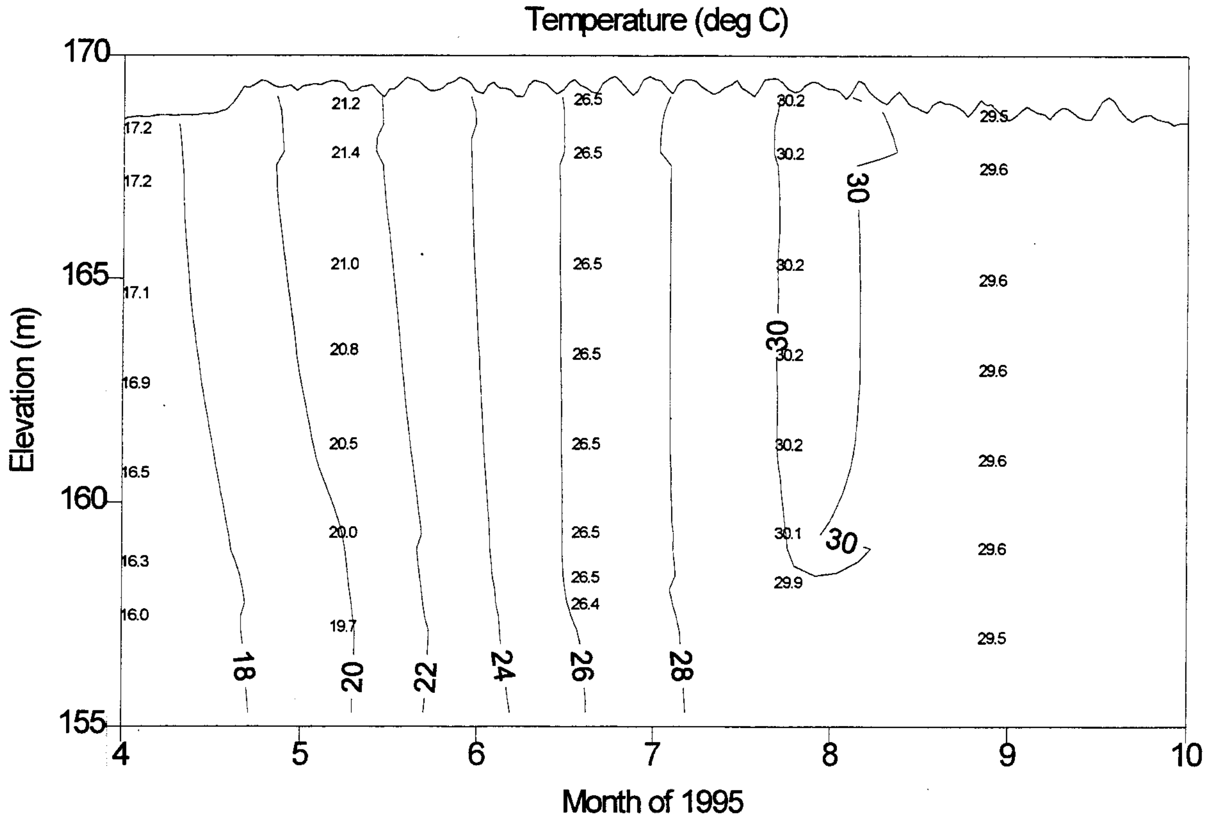


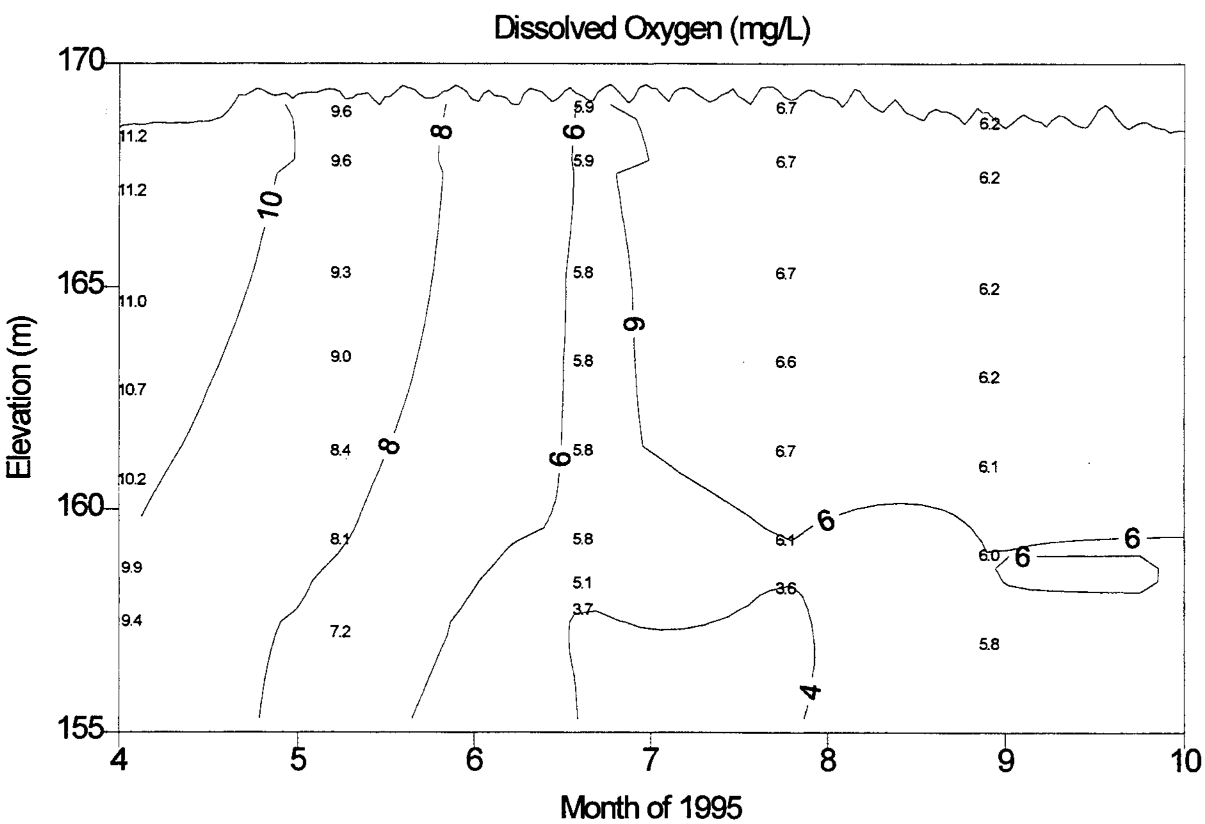
Kentucky Reservoir - Big Sandy River Mile 7.4





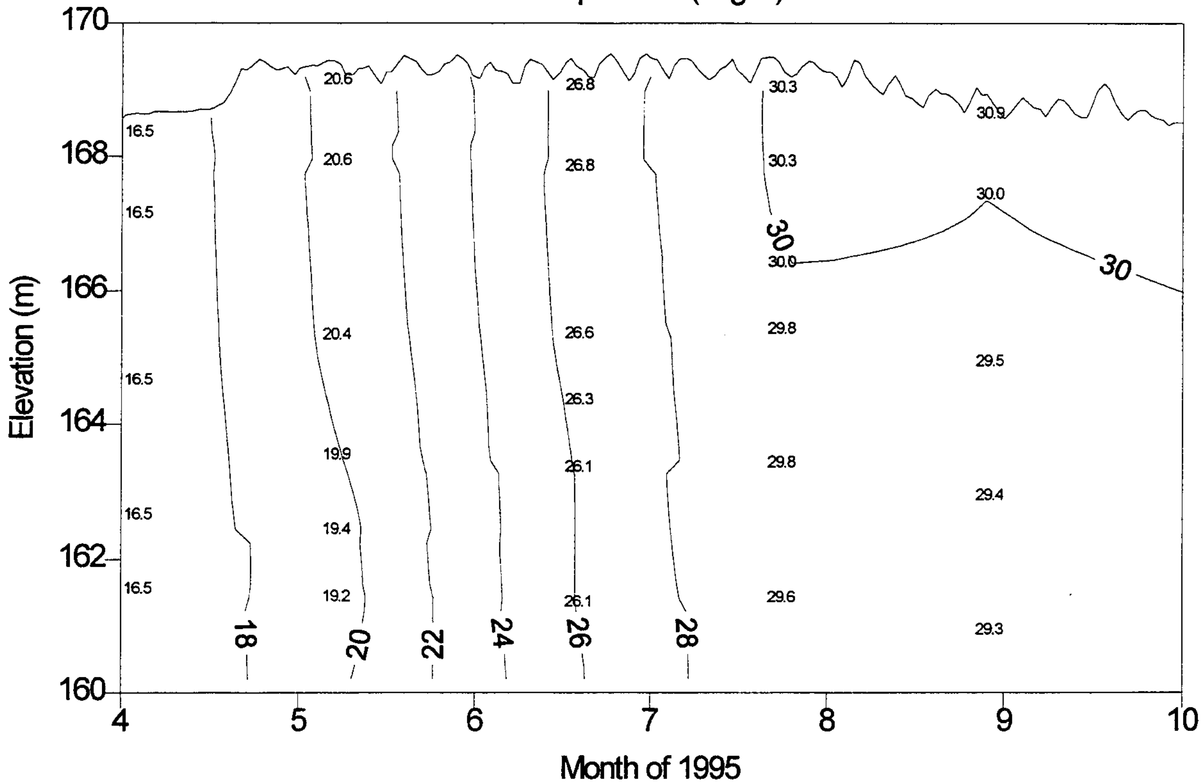
Wheeler Reservoir - TRM 277.0



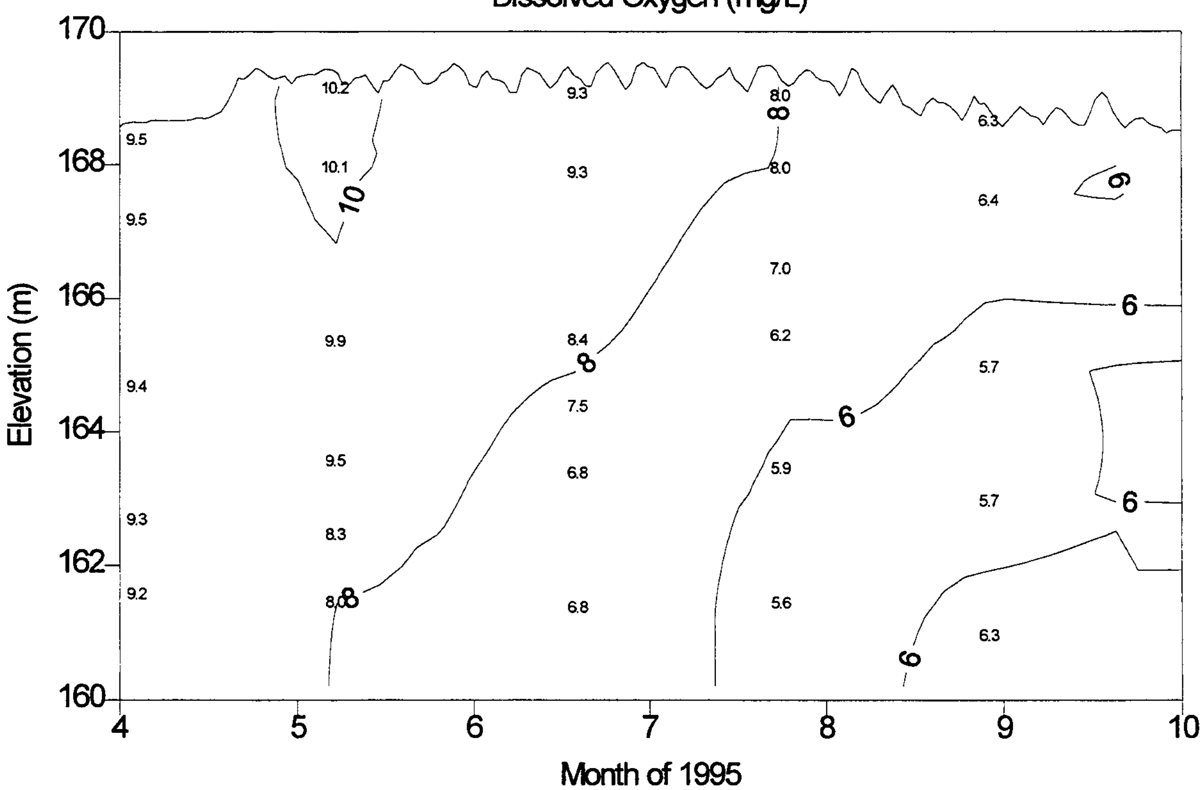


Wheeler Reservoir - TRM 295.87

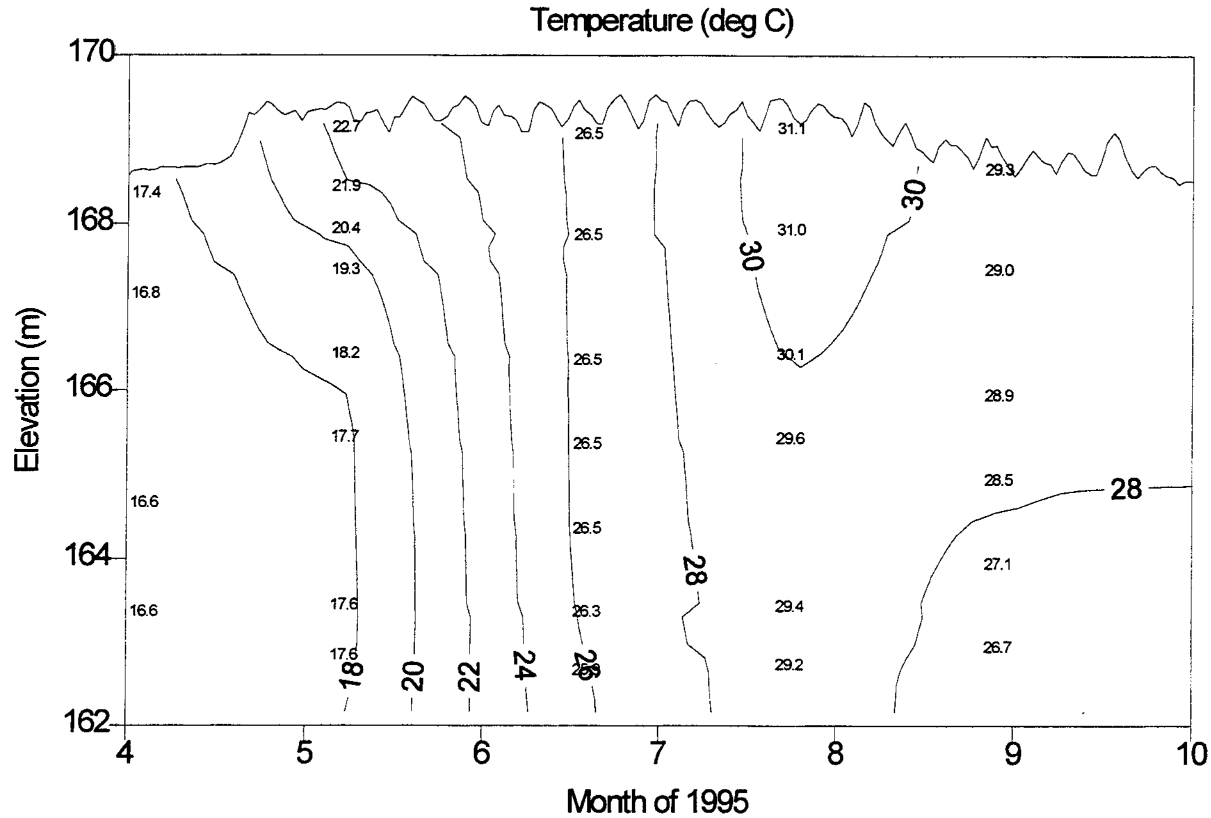
Temperature (deg C)

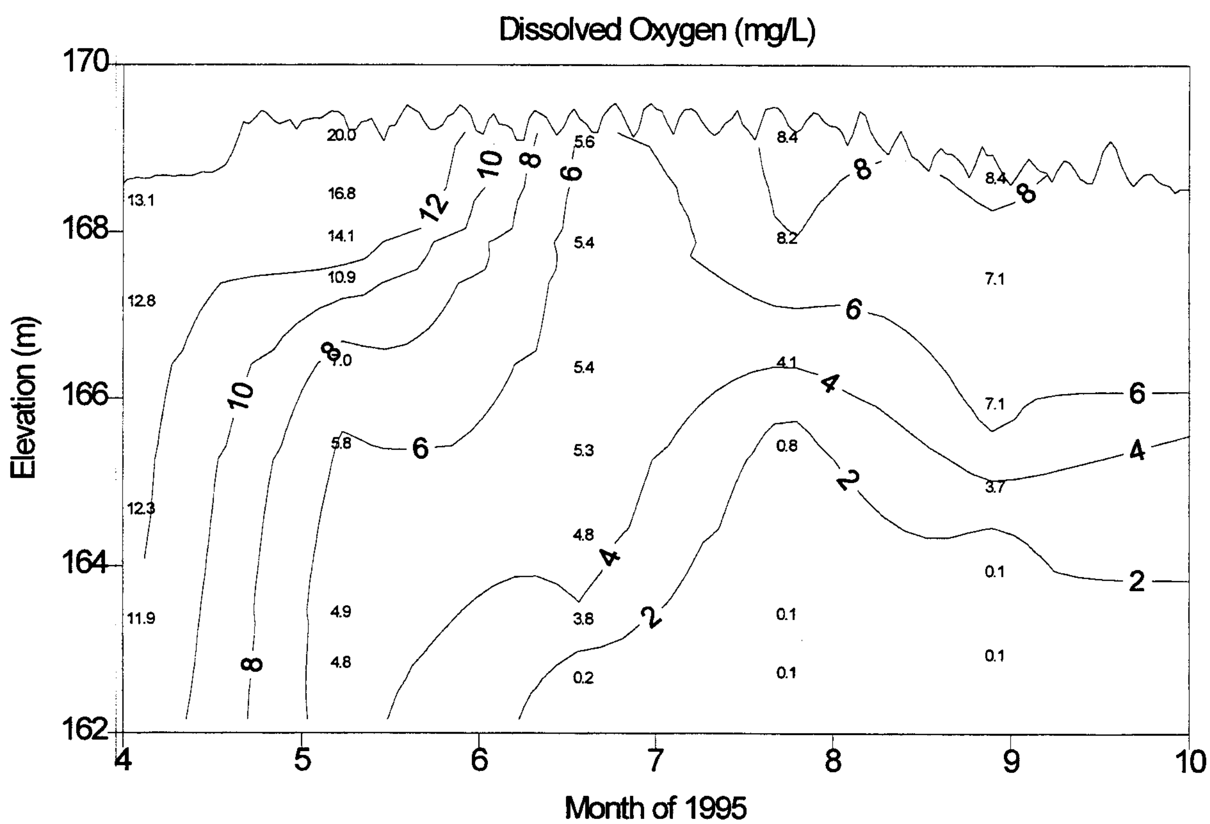


Dissolved Oxygen (mg/L)

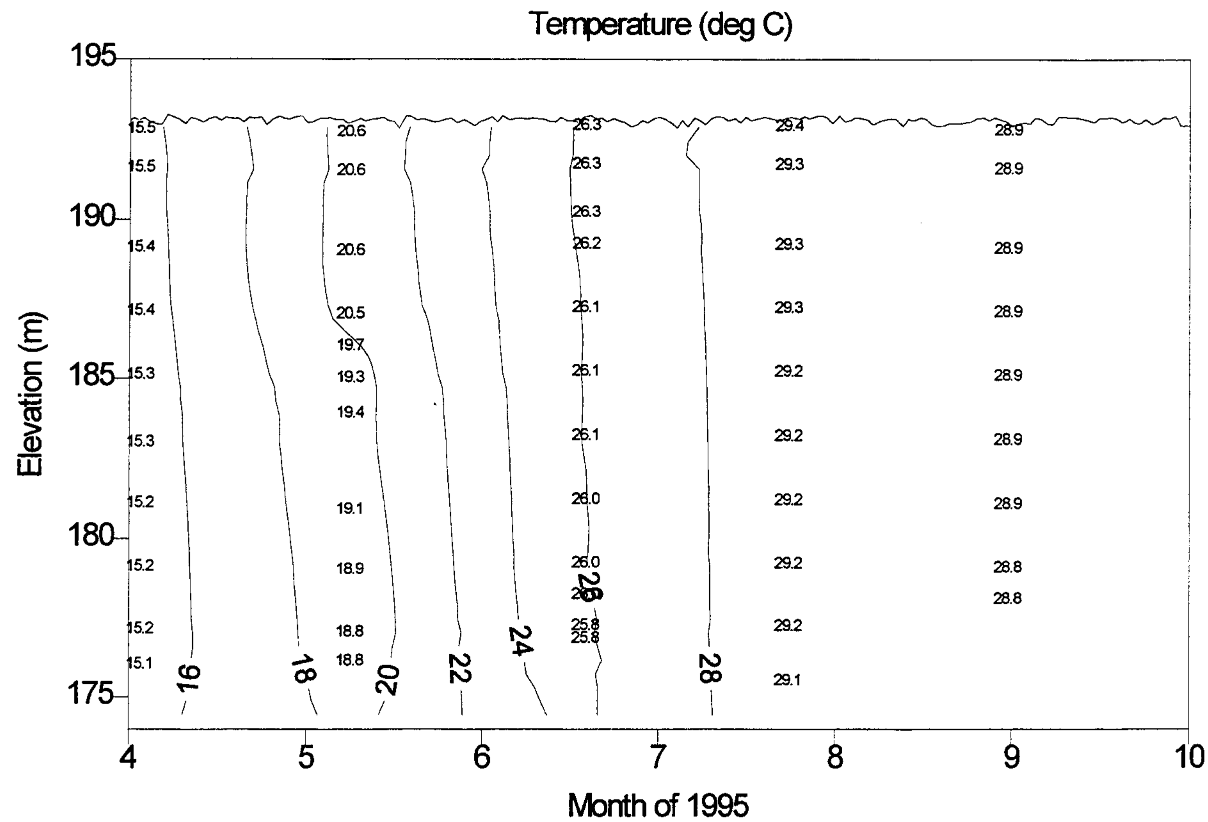


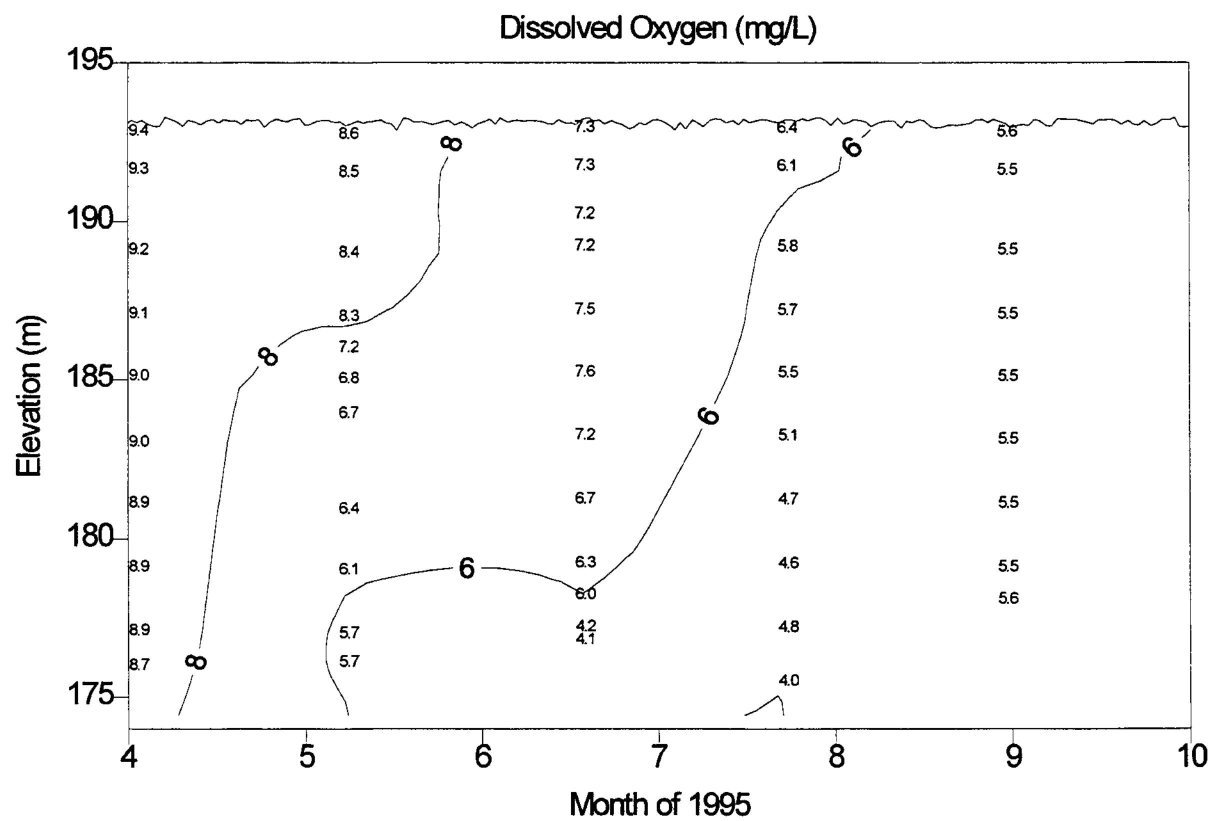
Wheeler Reservoir - Elk River Mile 6.0



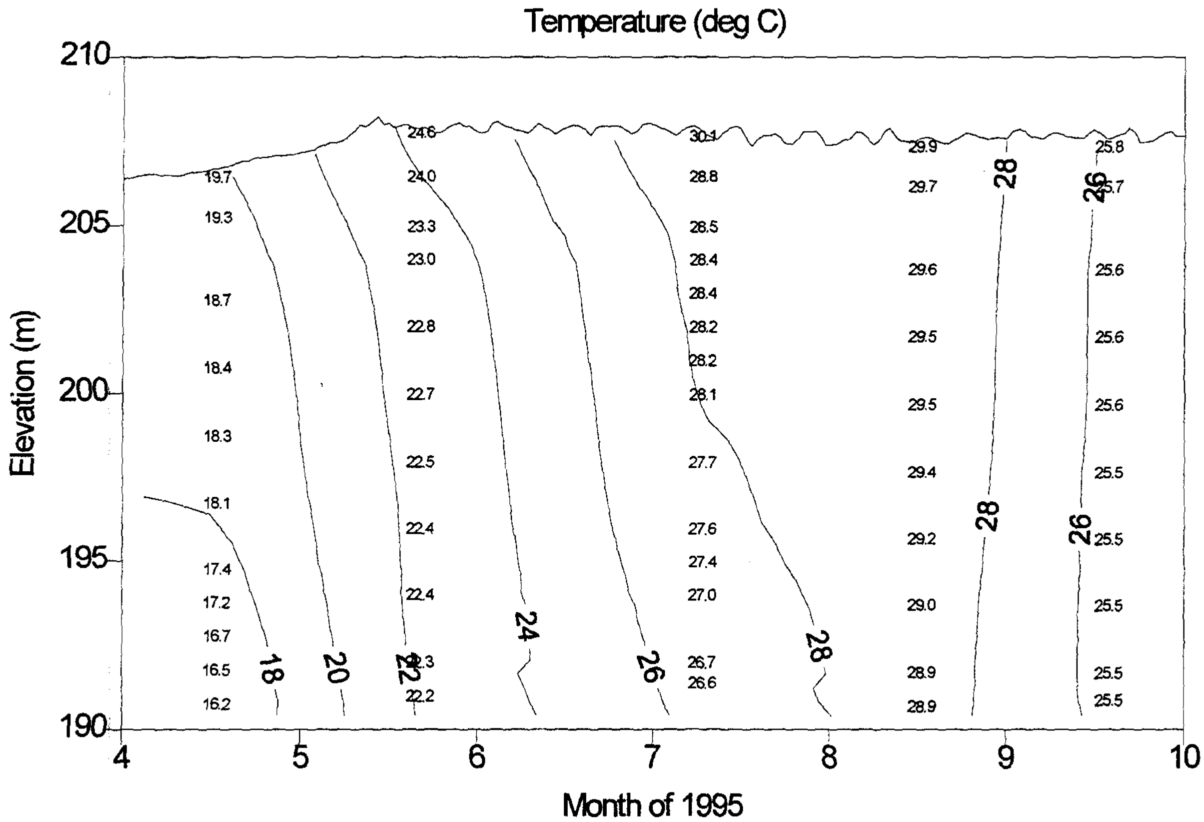


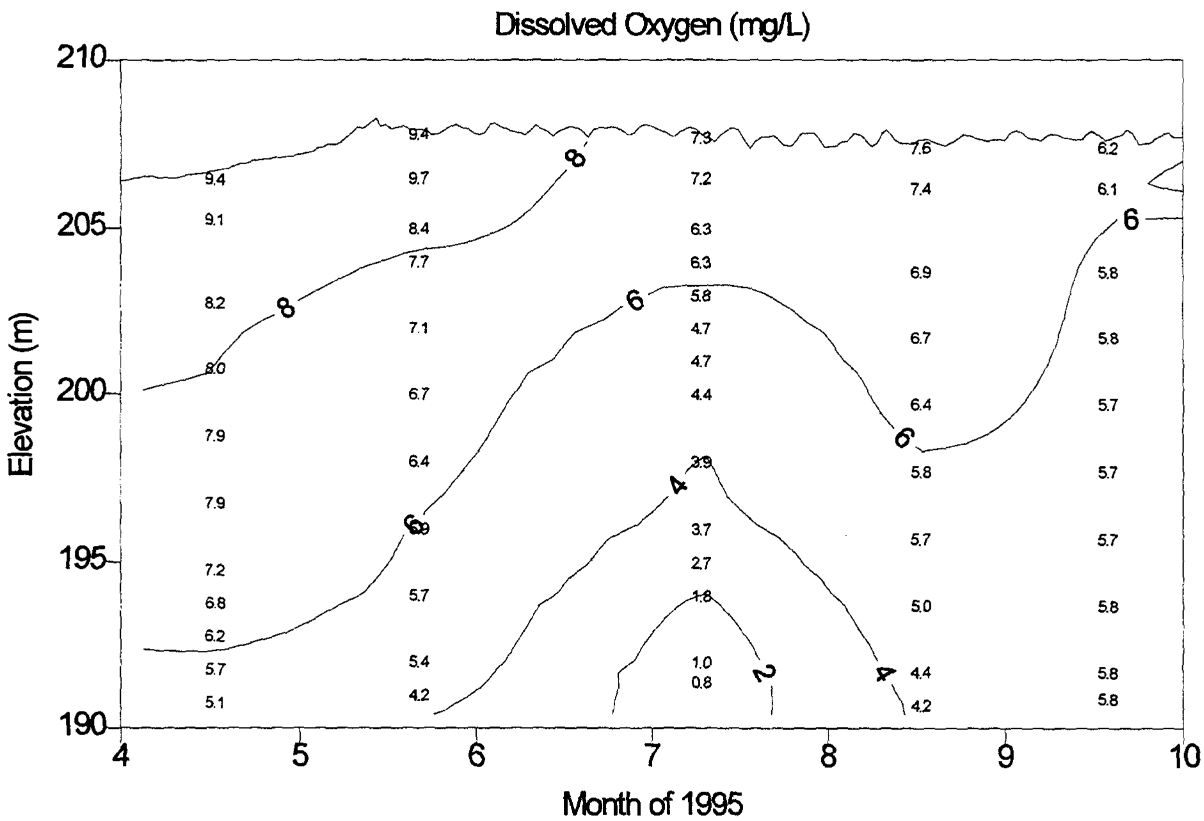
Nickajack Reservoir - TRM 425.5



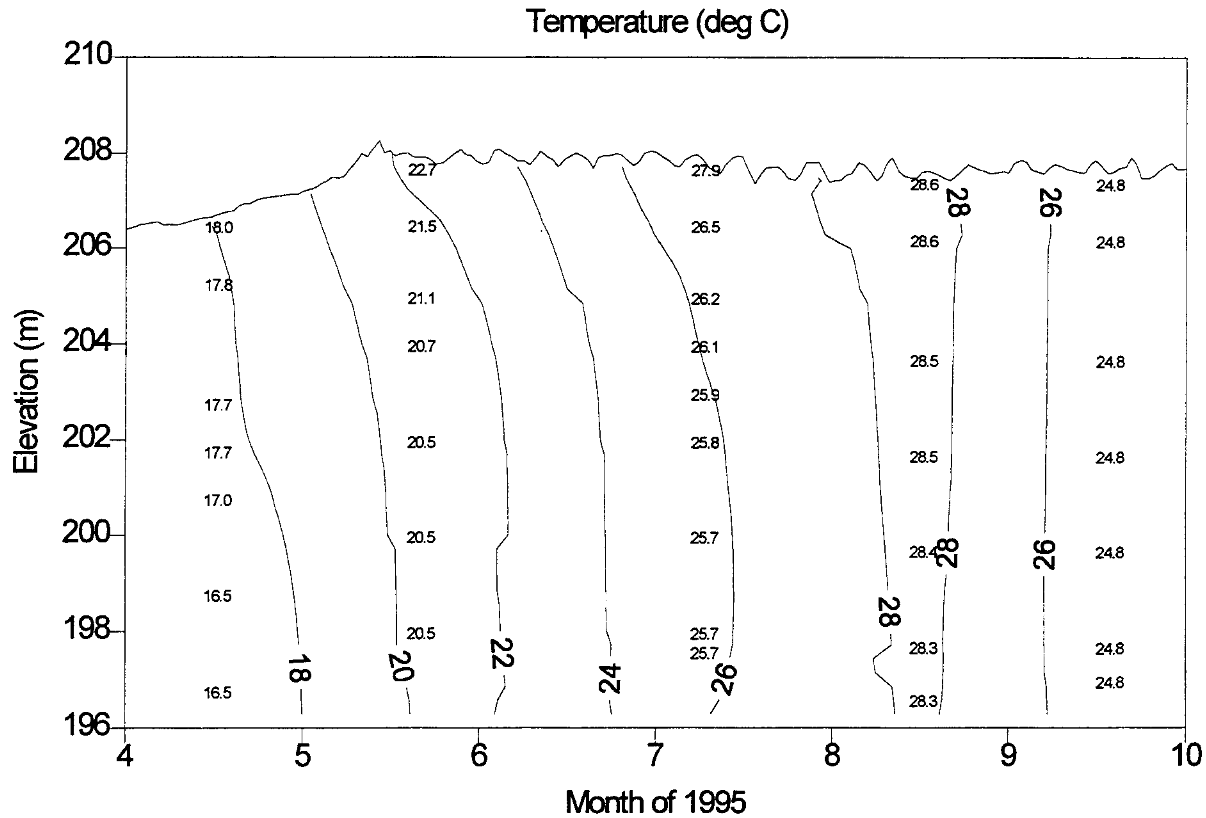


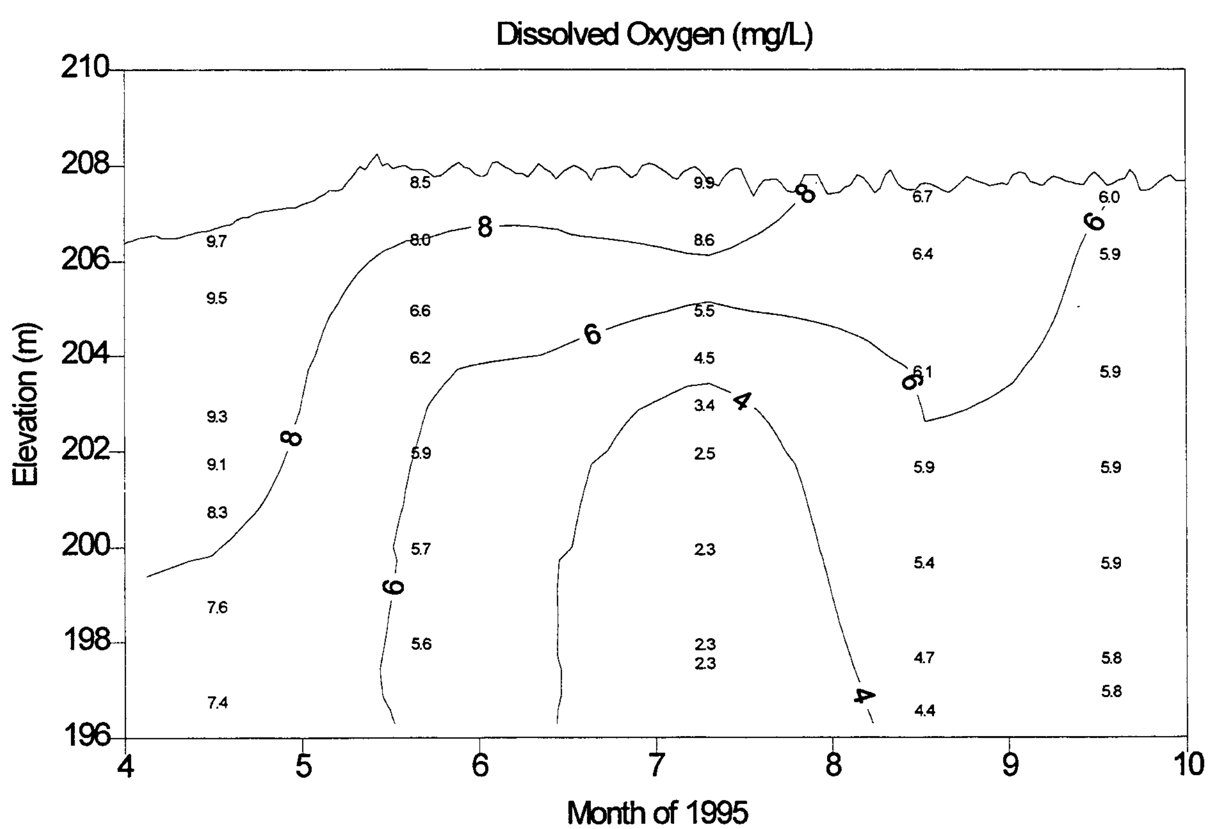
Chickamauga Reservoir - TRM 472.3



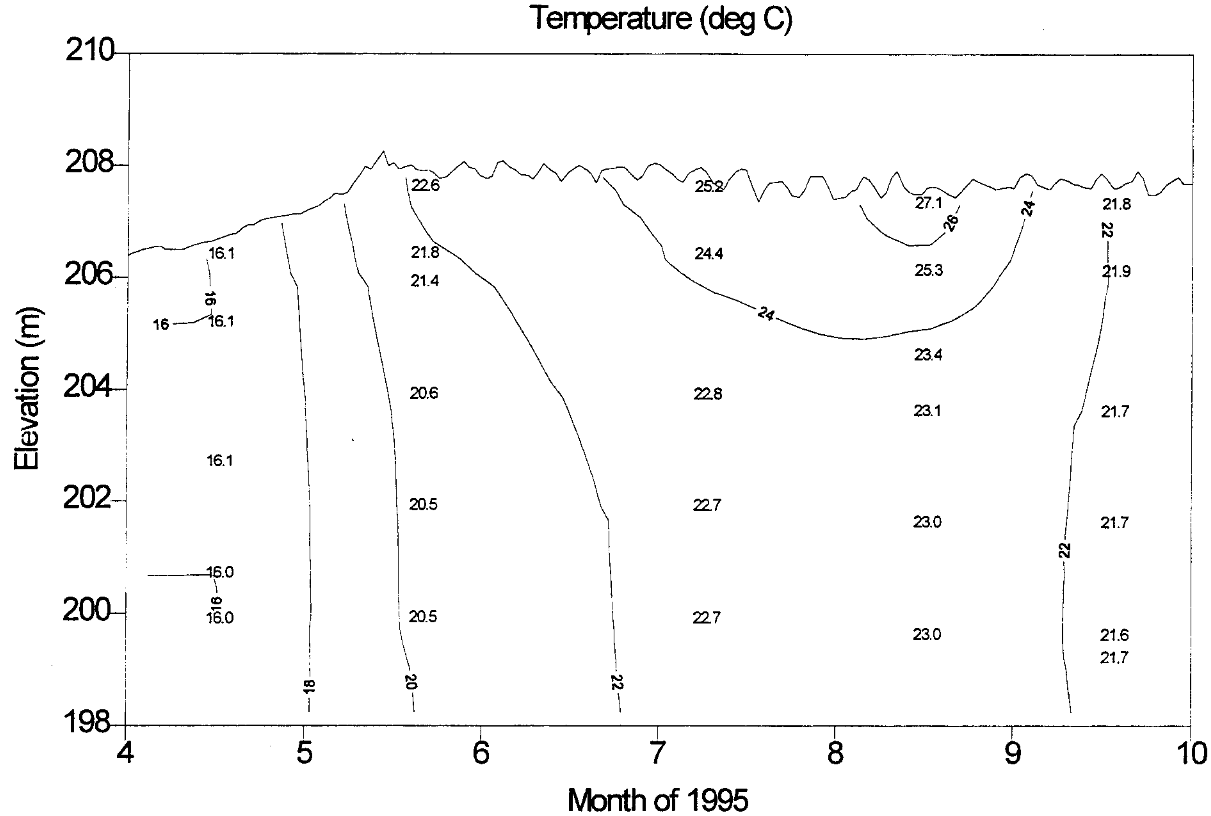


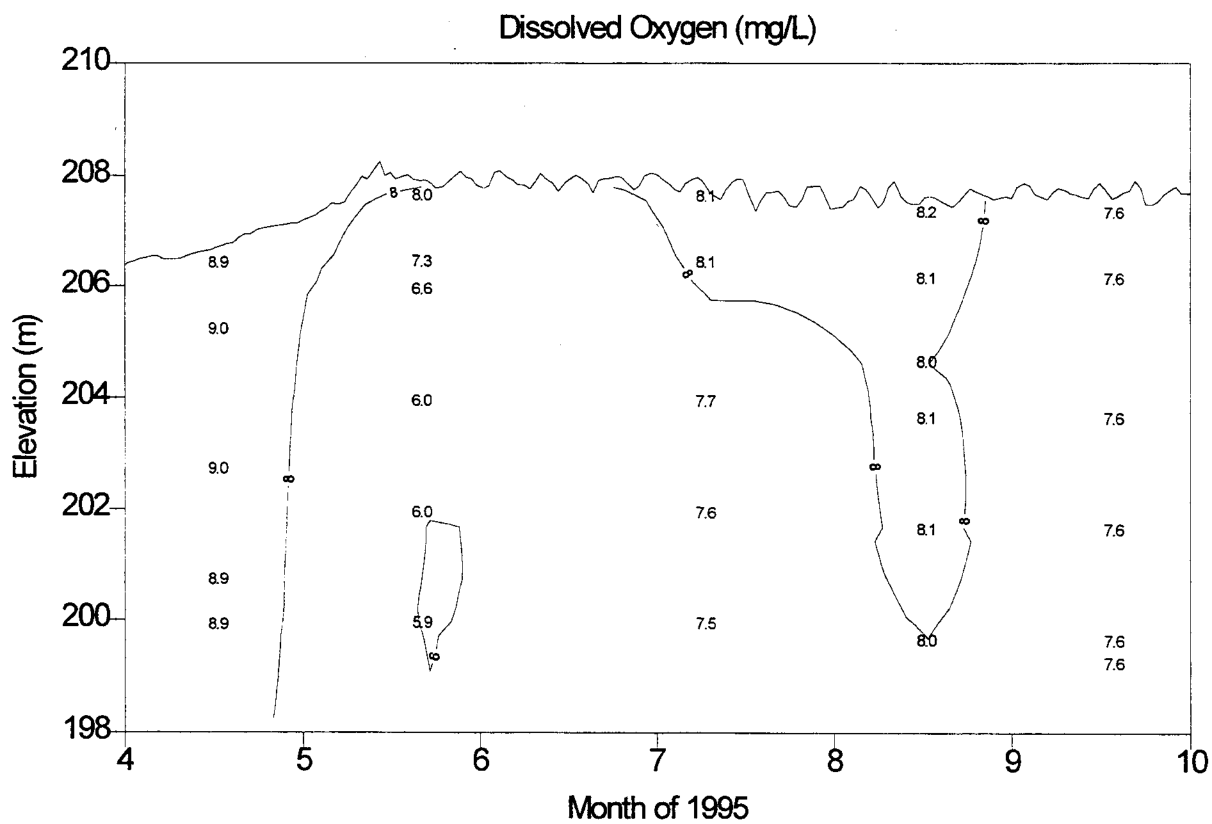
Chickamauga Reservoir - TRM 490.5



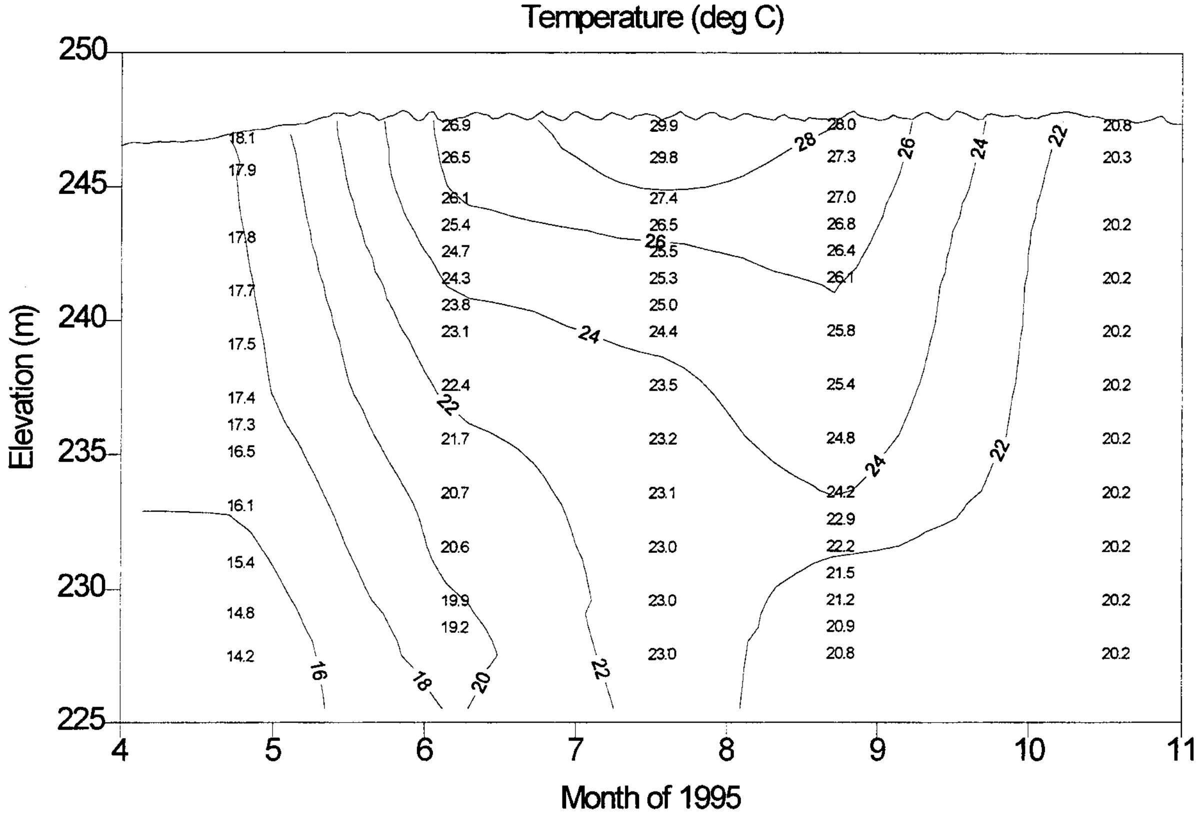


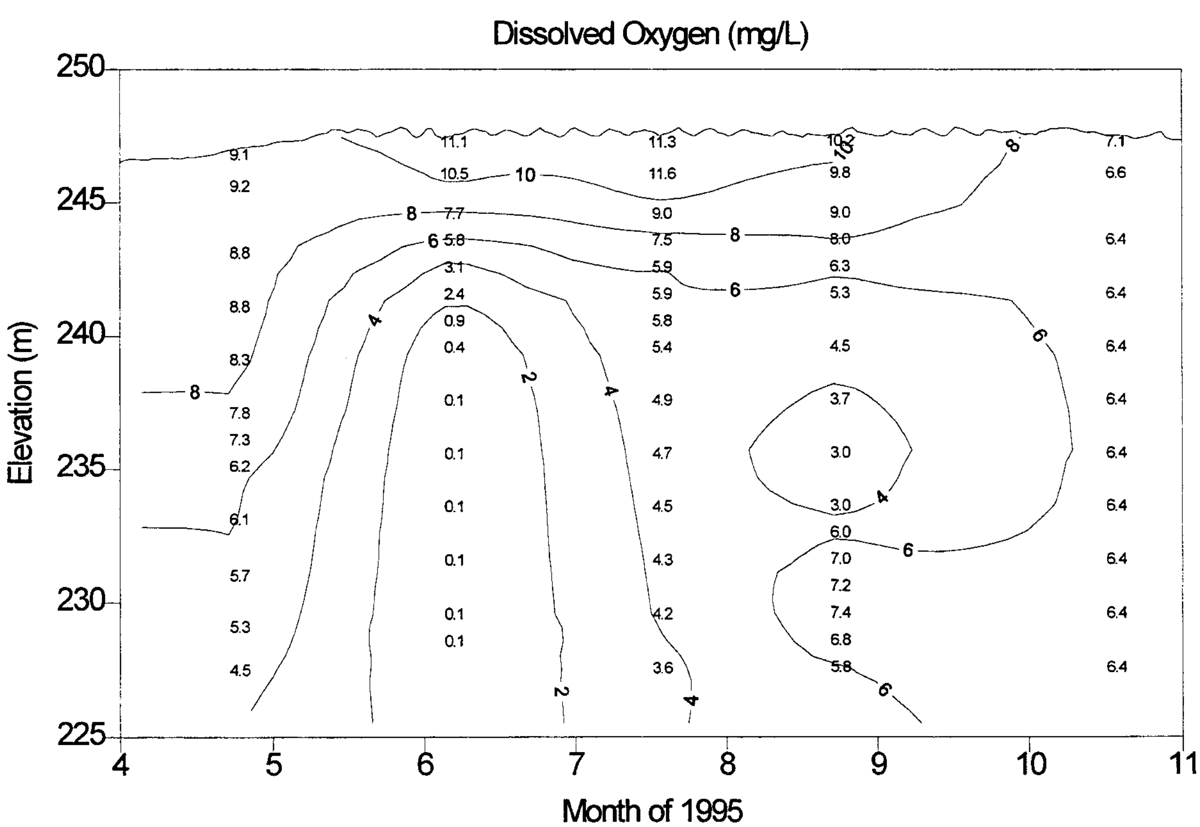
Chickamauga Reservoir - Hiwassee River Mile 8.5



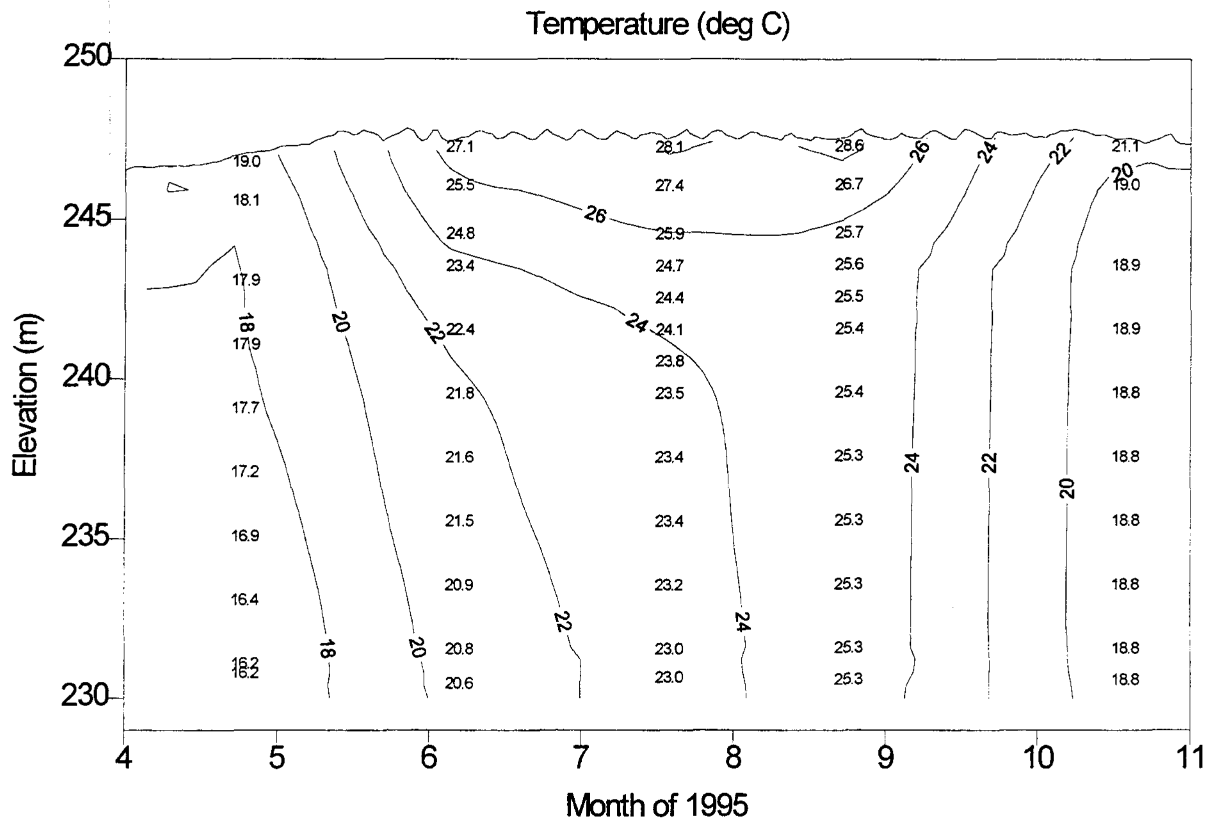


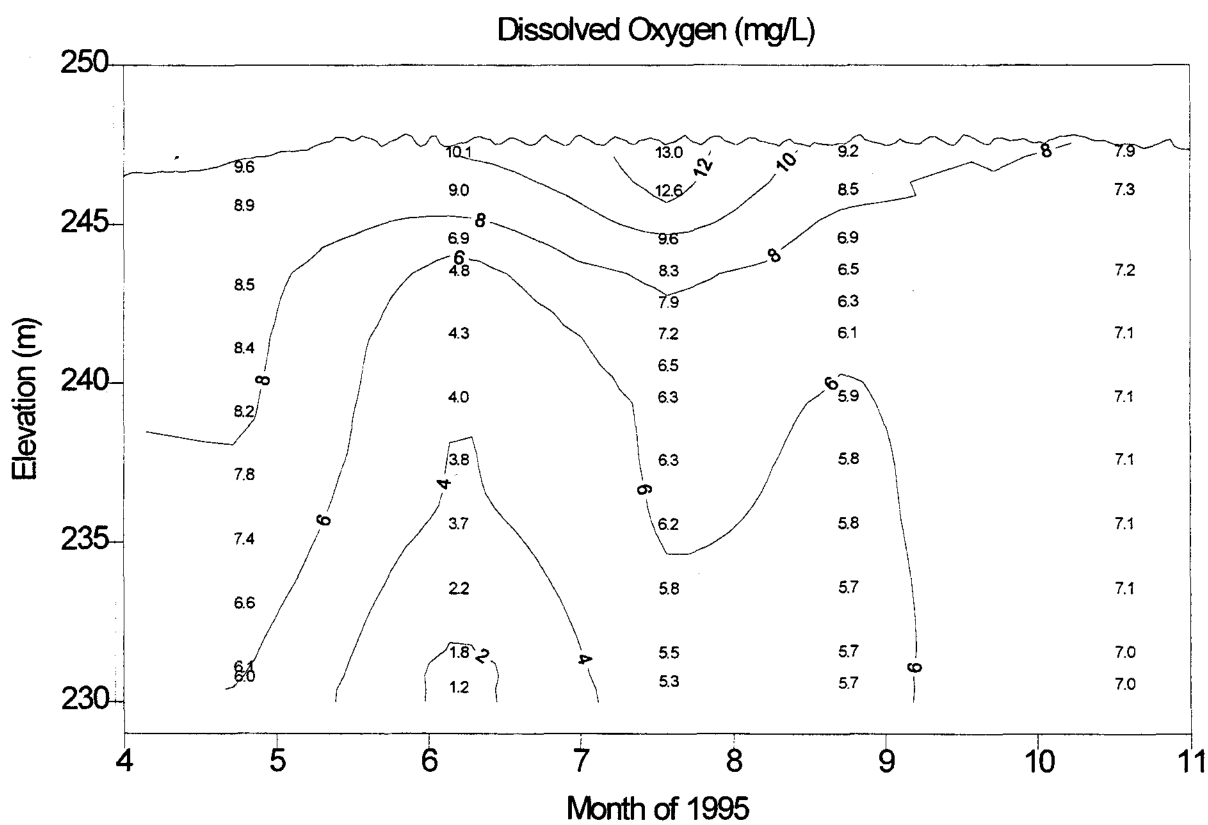
Fort Loudoun Reservoir - TRM 605.5



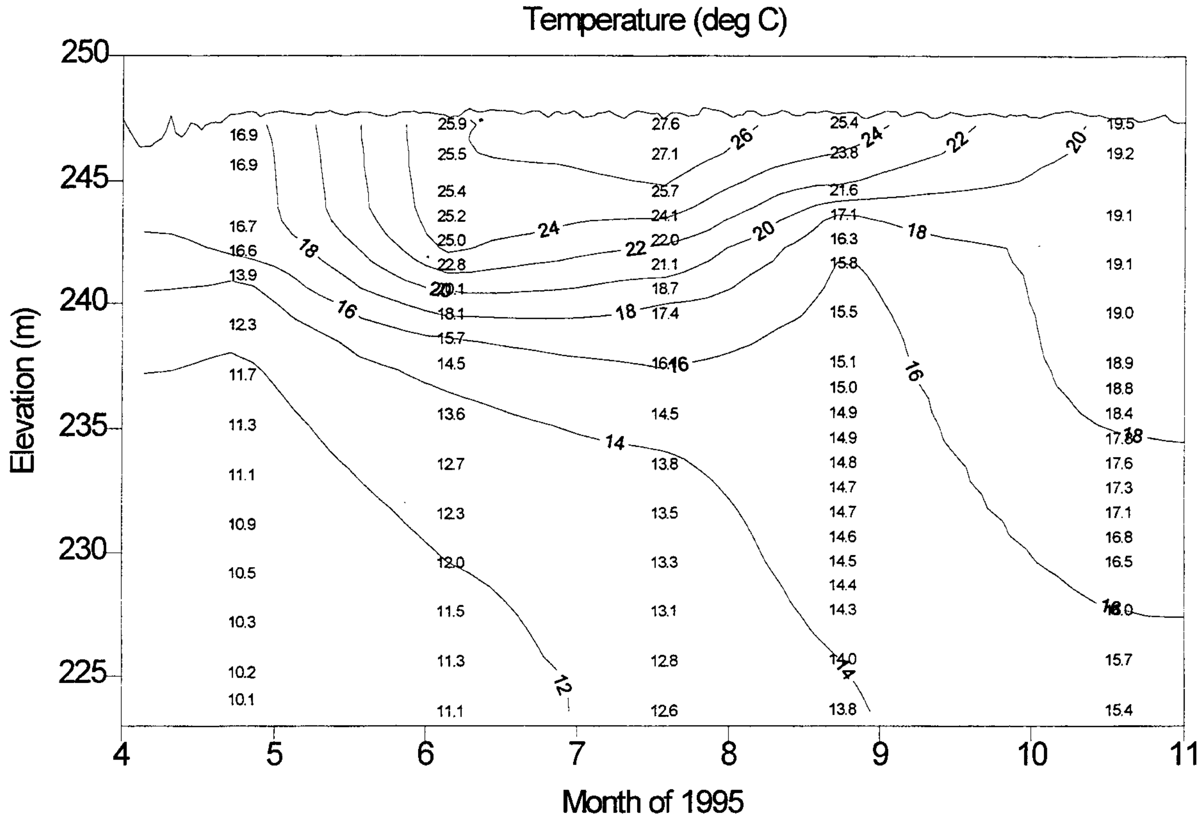


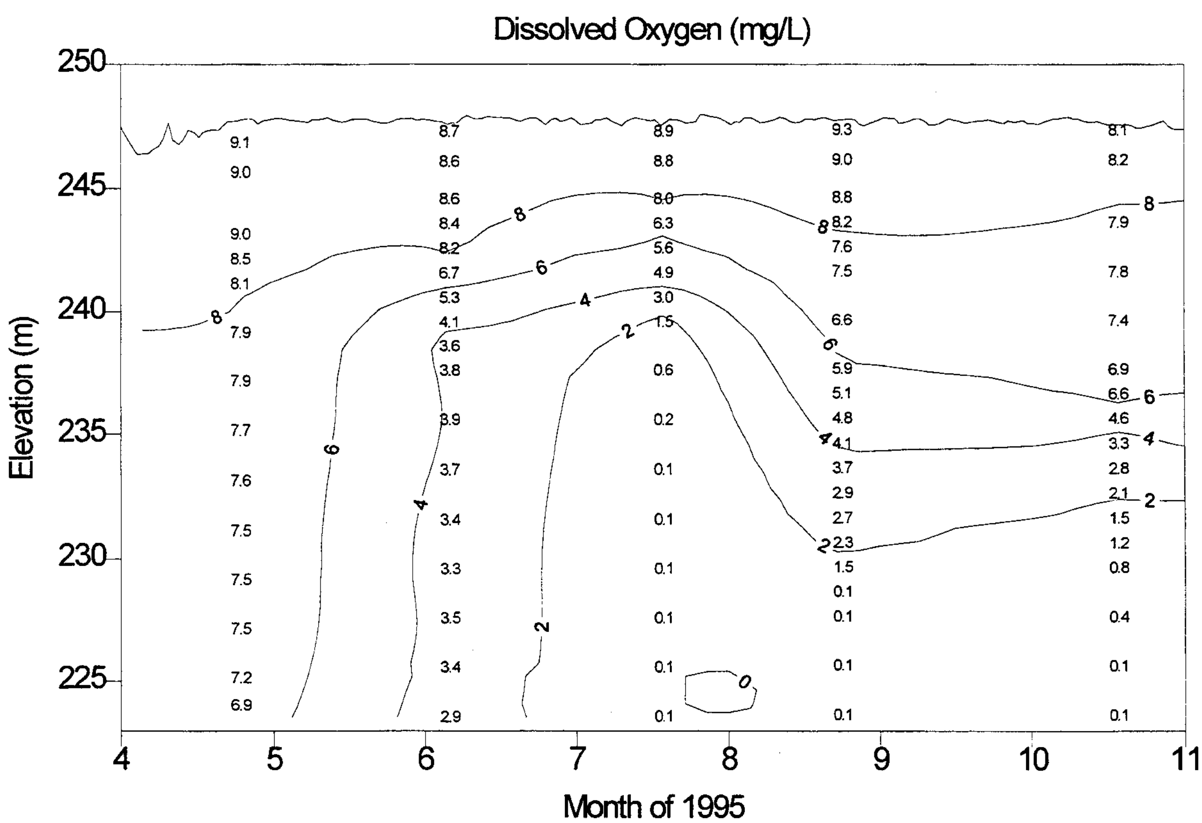
Fort Loudoun Reservoir - TRM 624.6



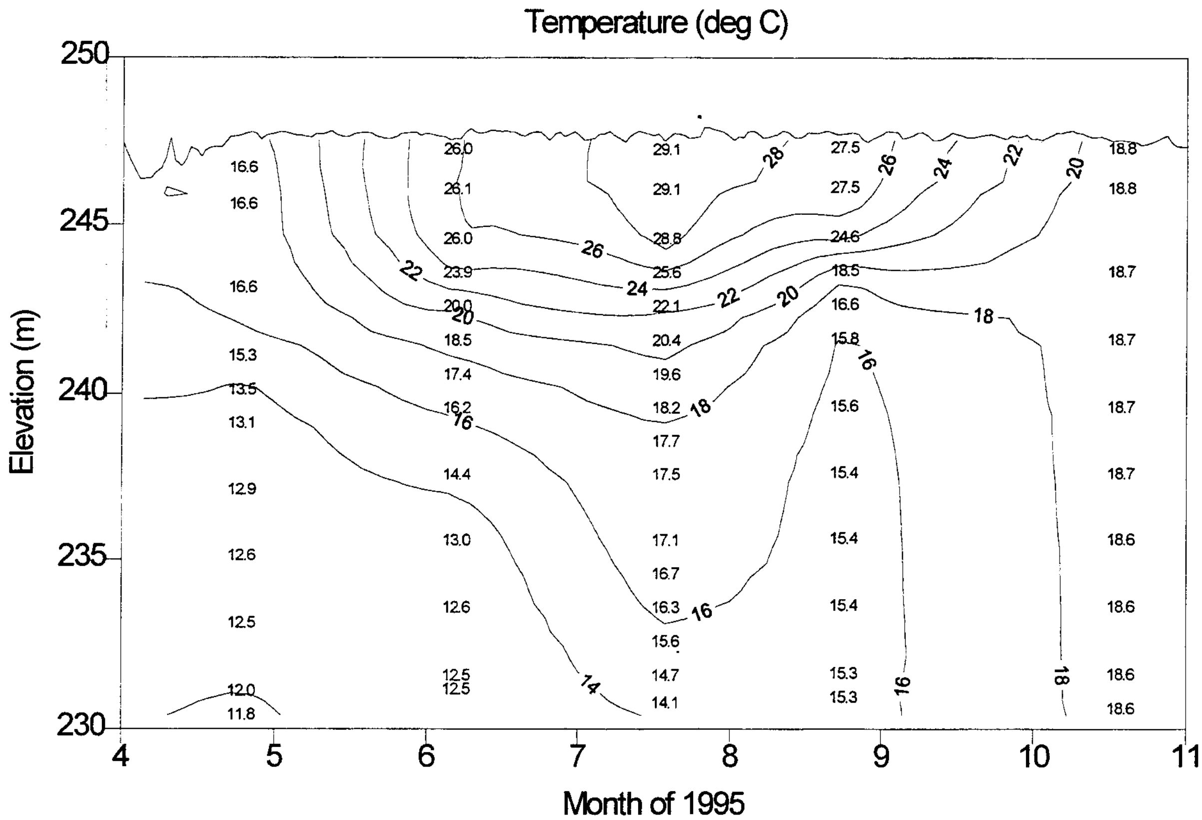


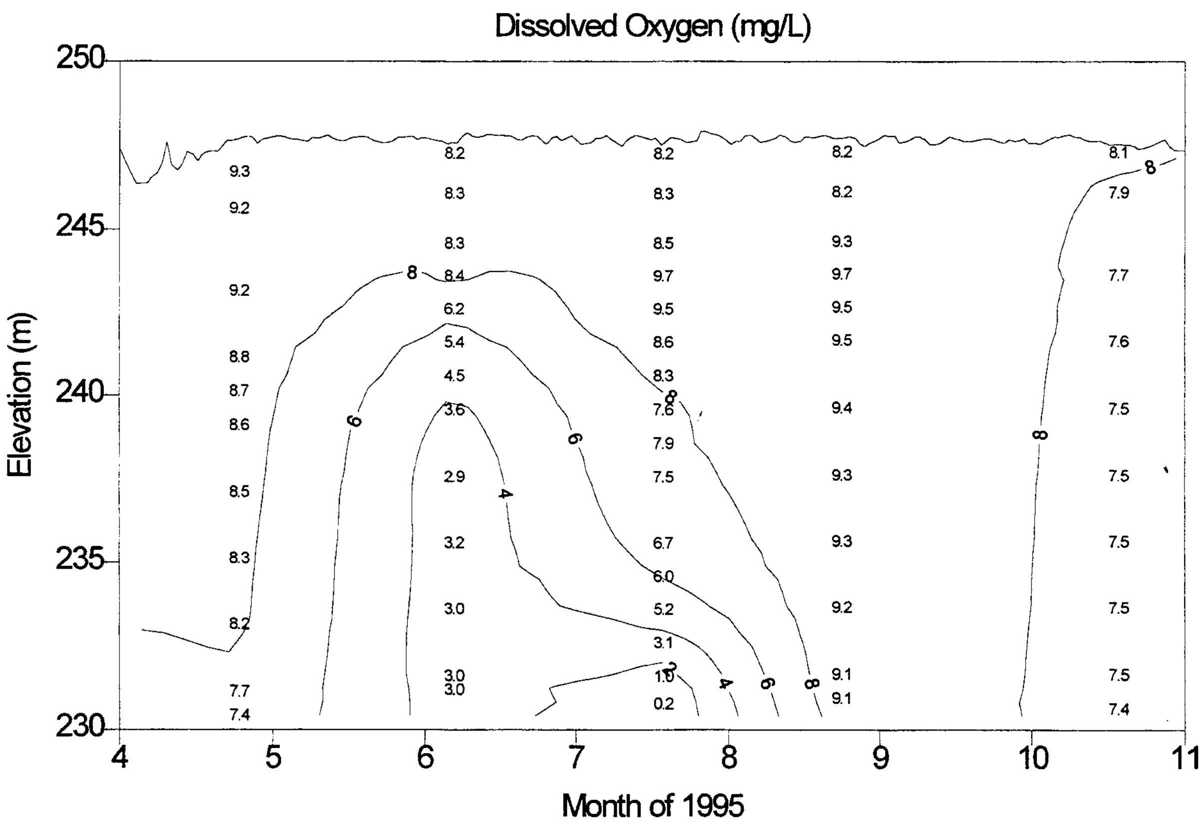
Tellico Reservoir - LTRM 1.0



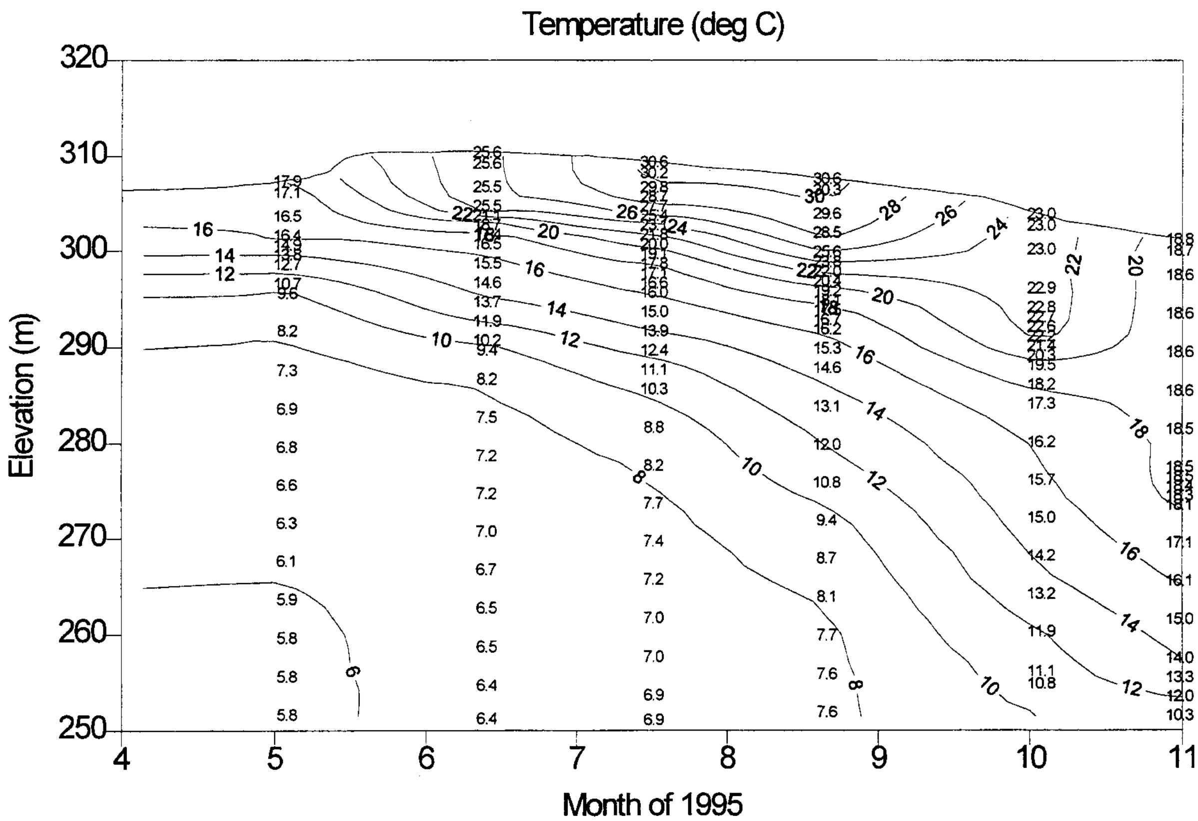


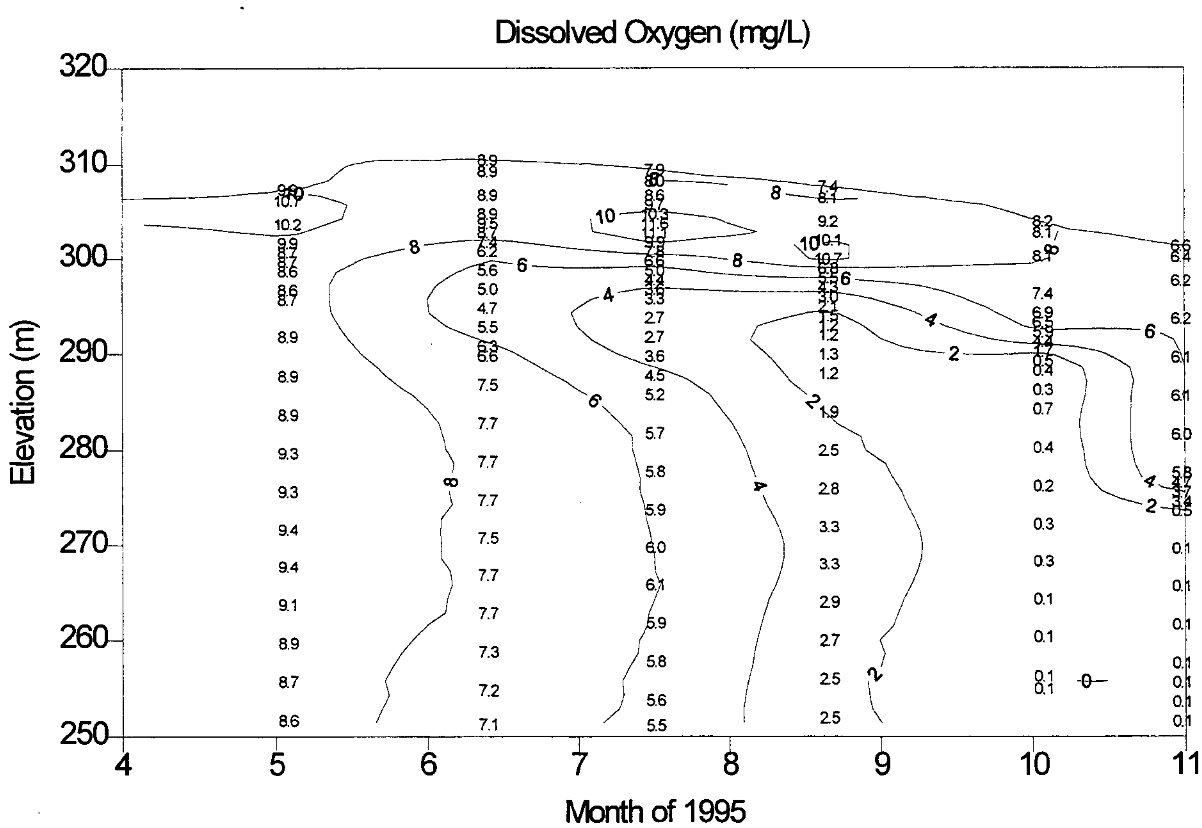
Tellico Reservoir - LTRM 15.0



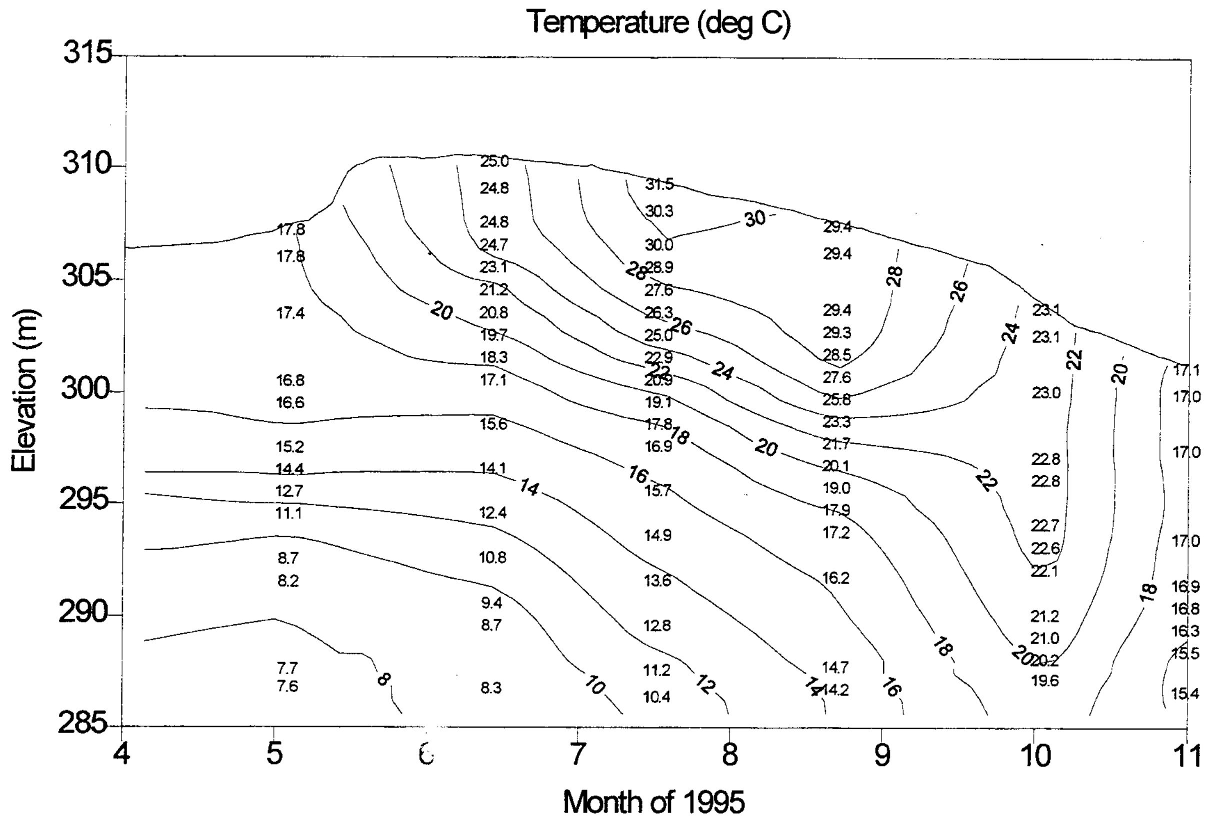


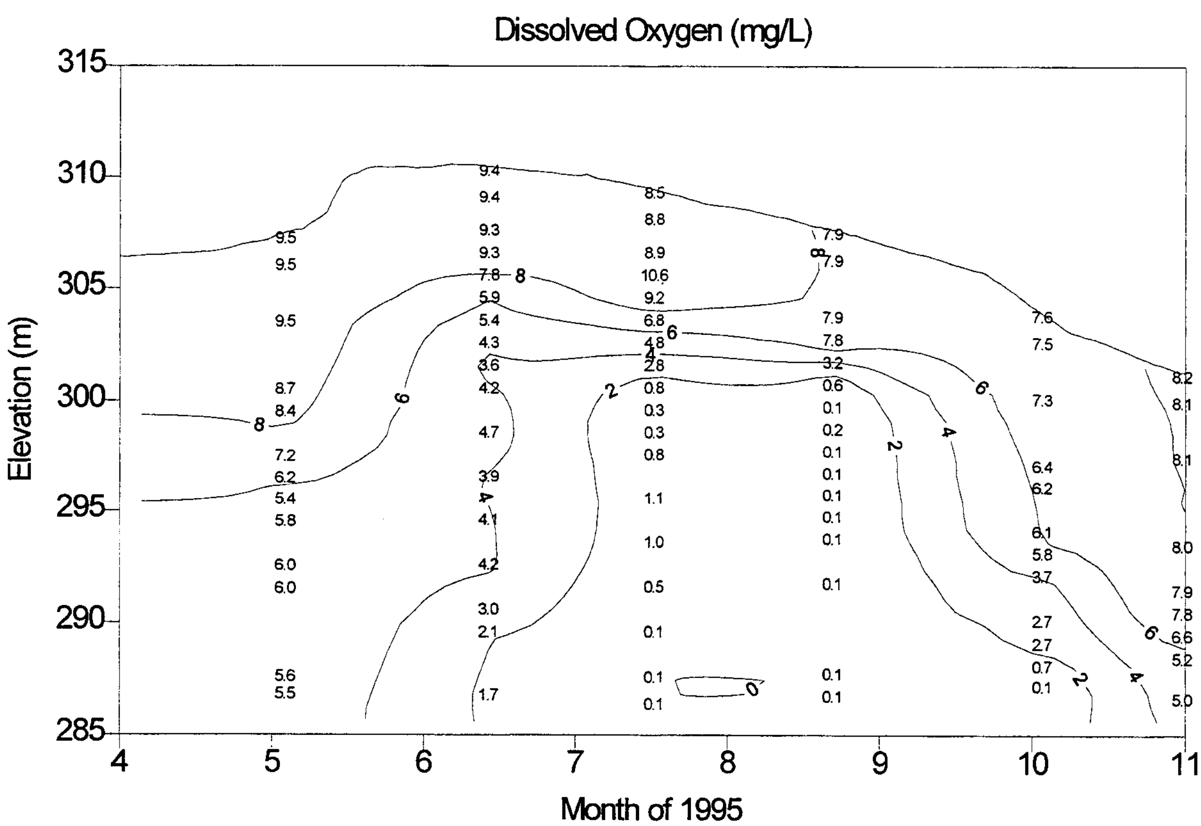
Norris Reservoir - CRM 80



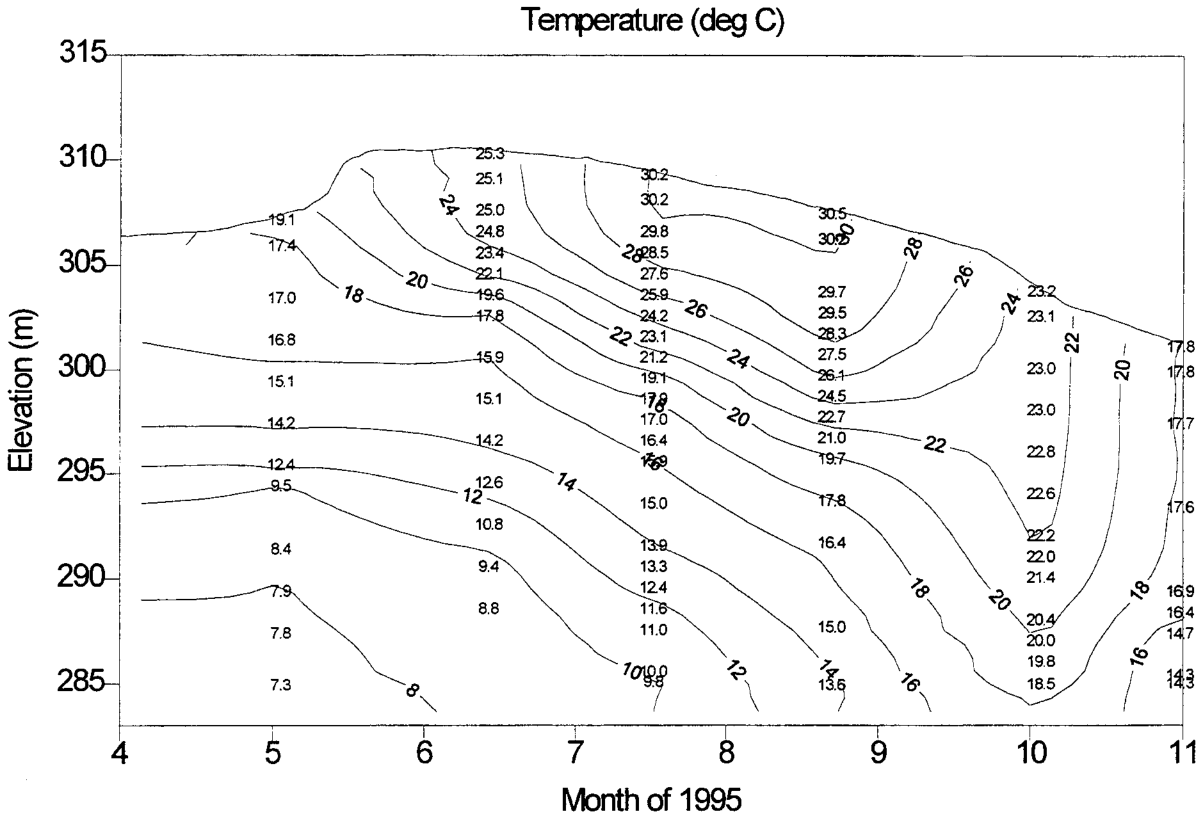


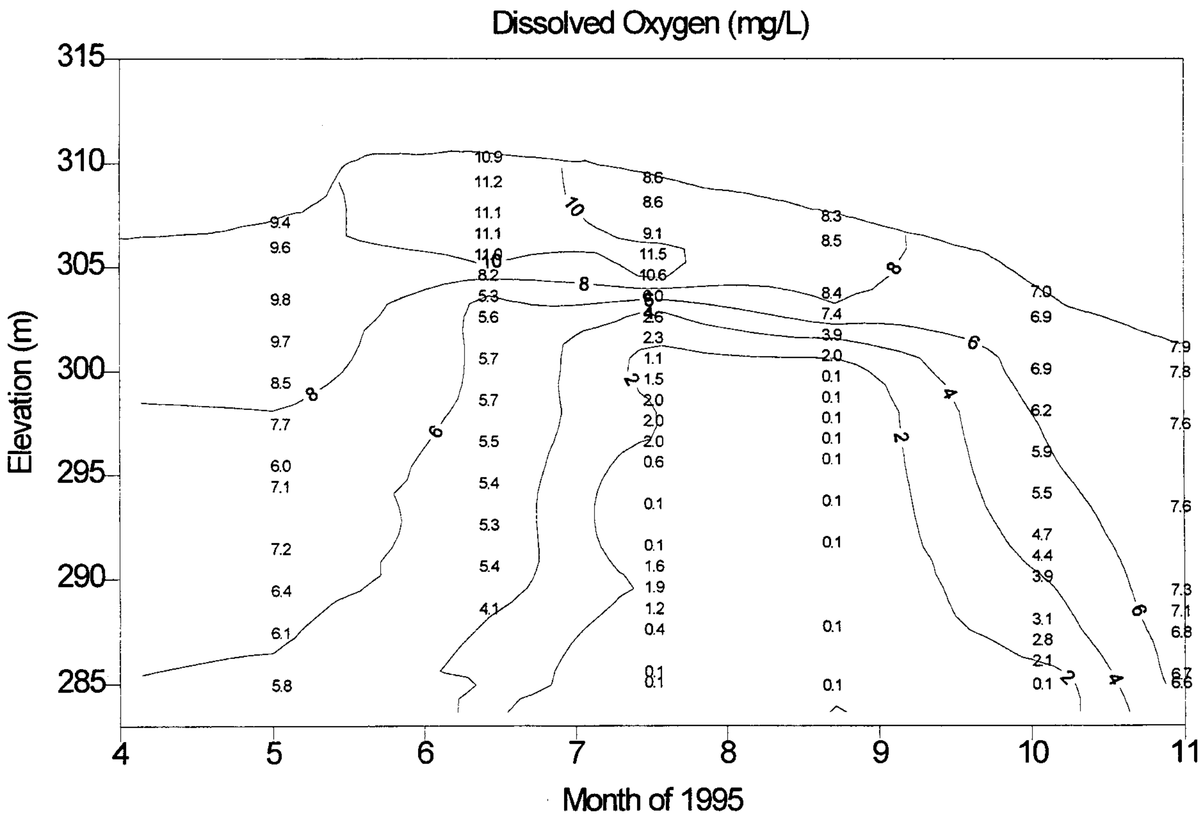
Norris Reservoir - CRM 125



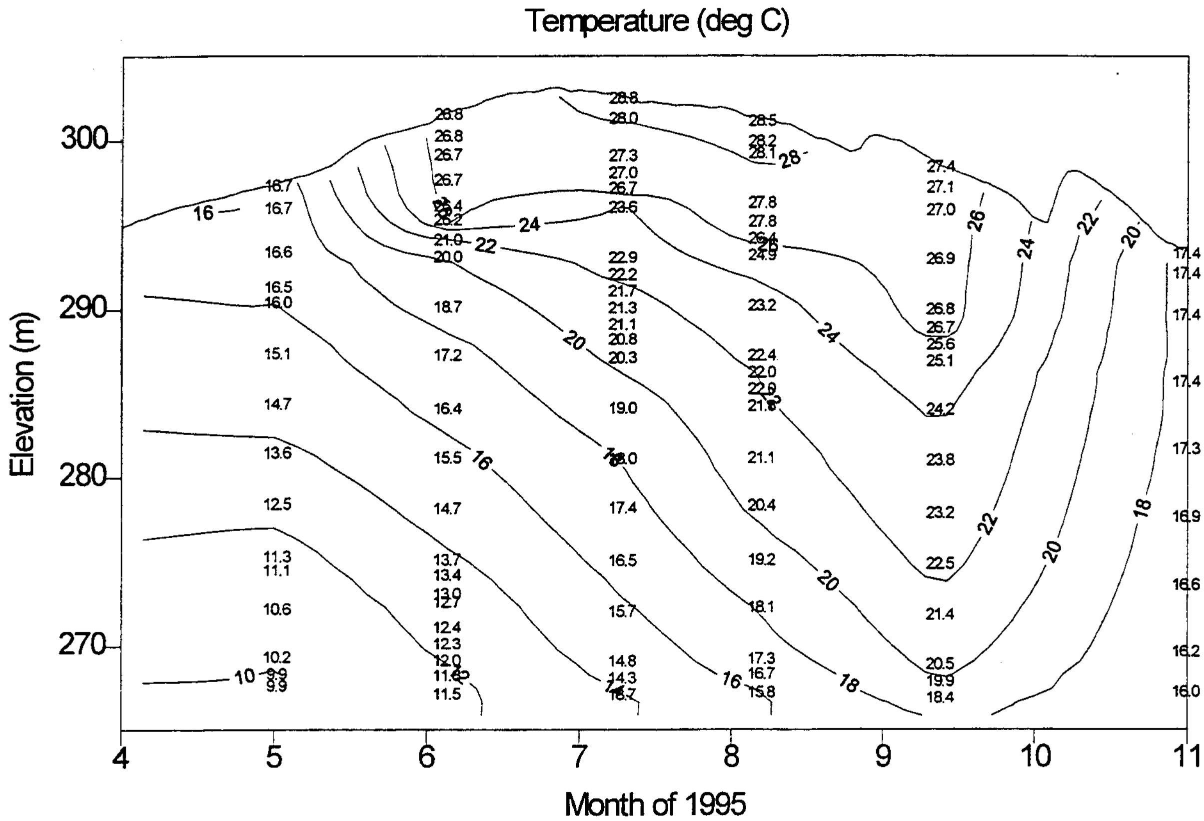


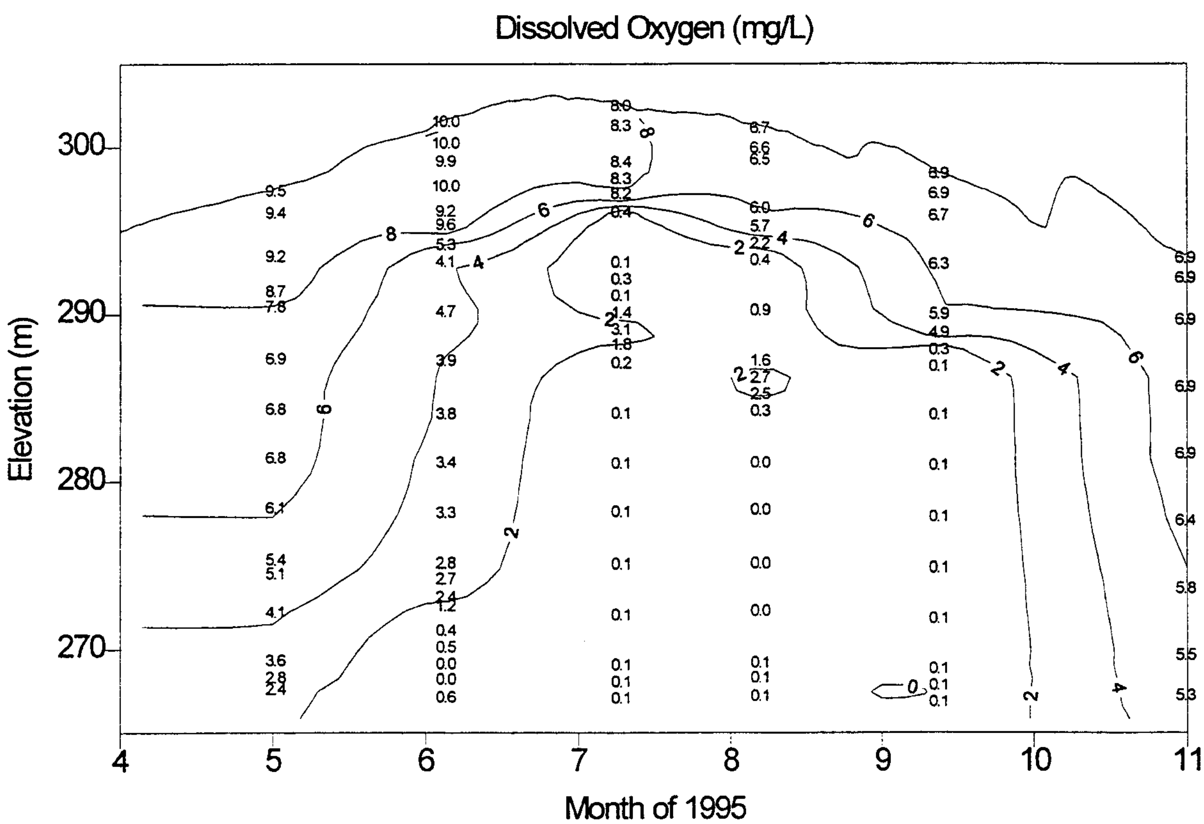
Norris Reservoir - PRM 30



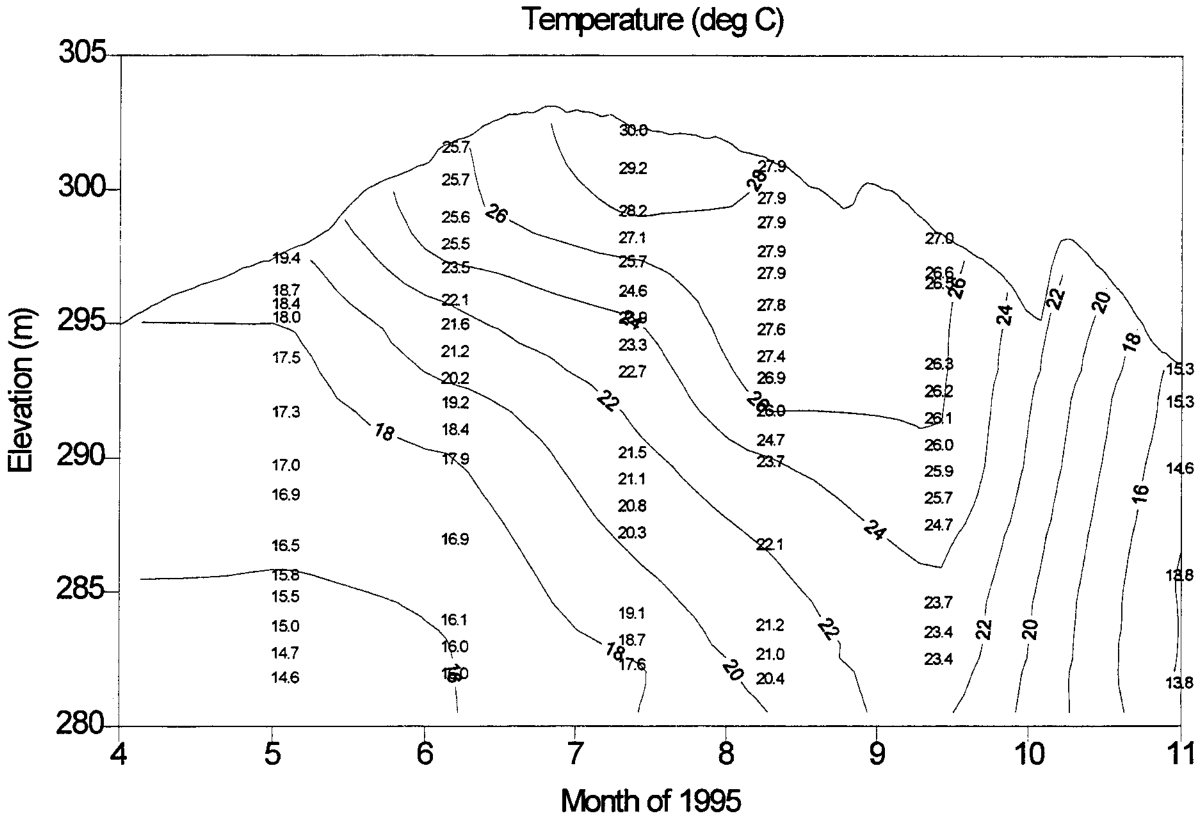


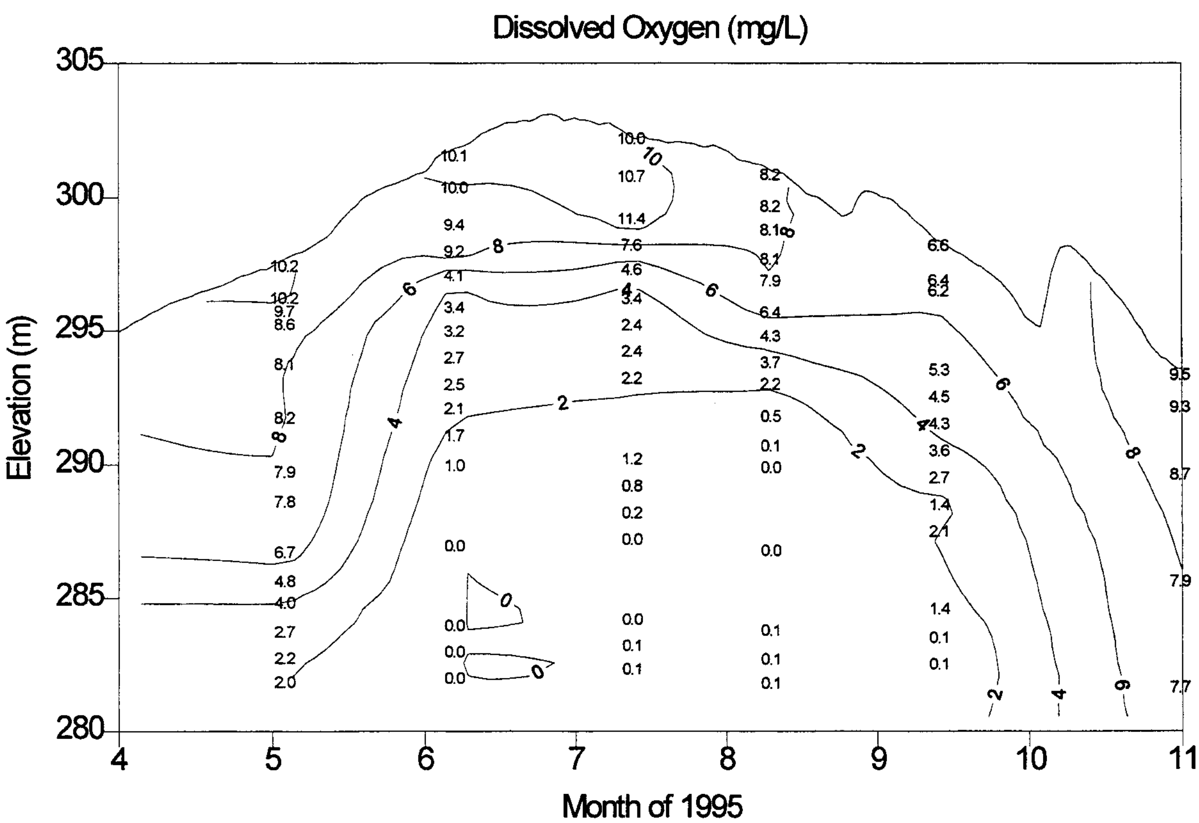
Douglas Reservoir - FBRM 33



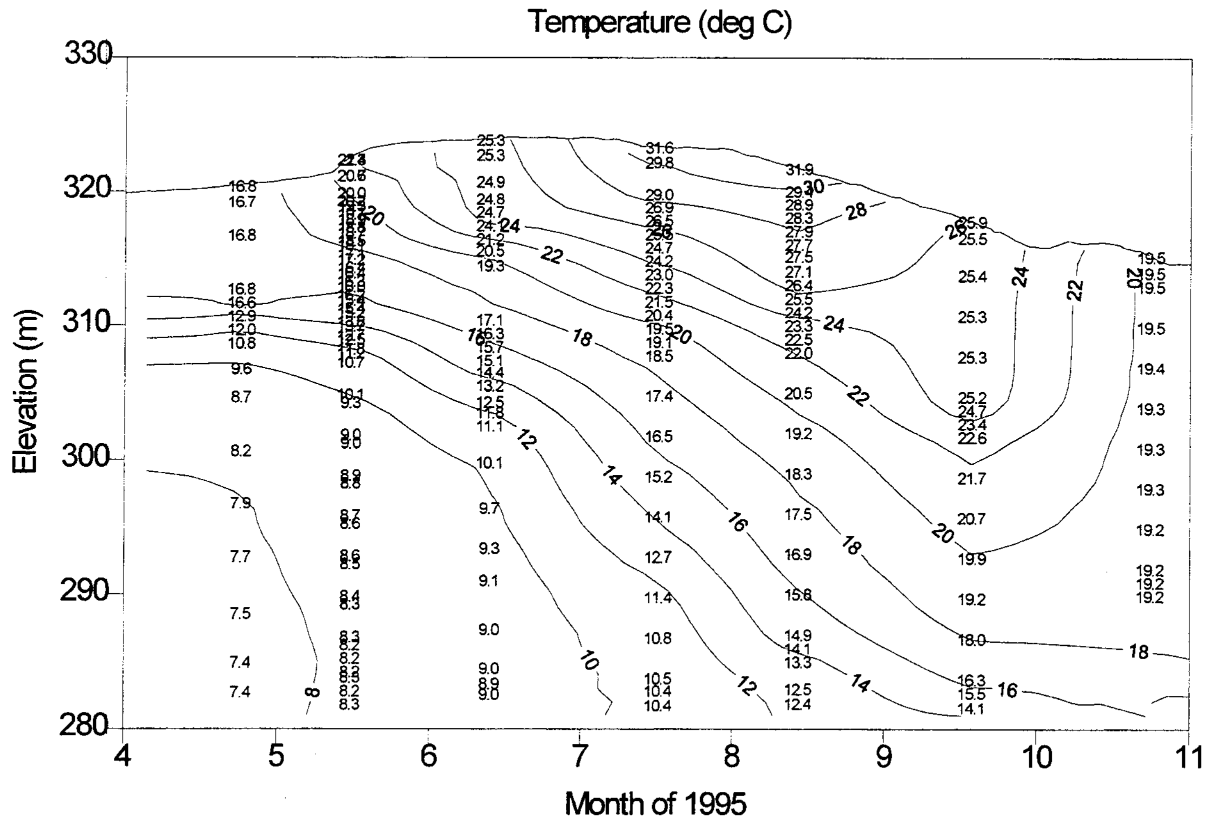


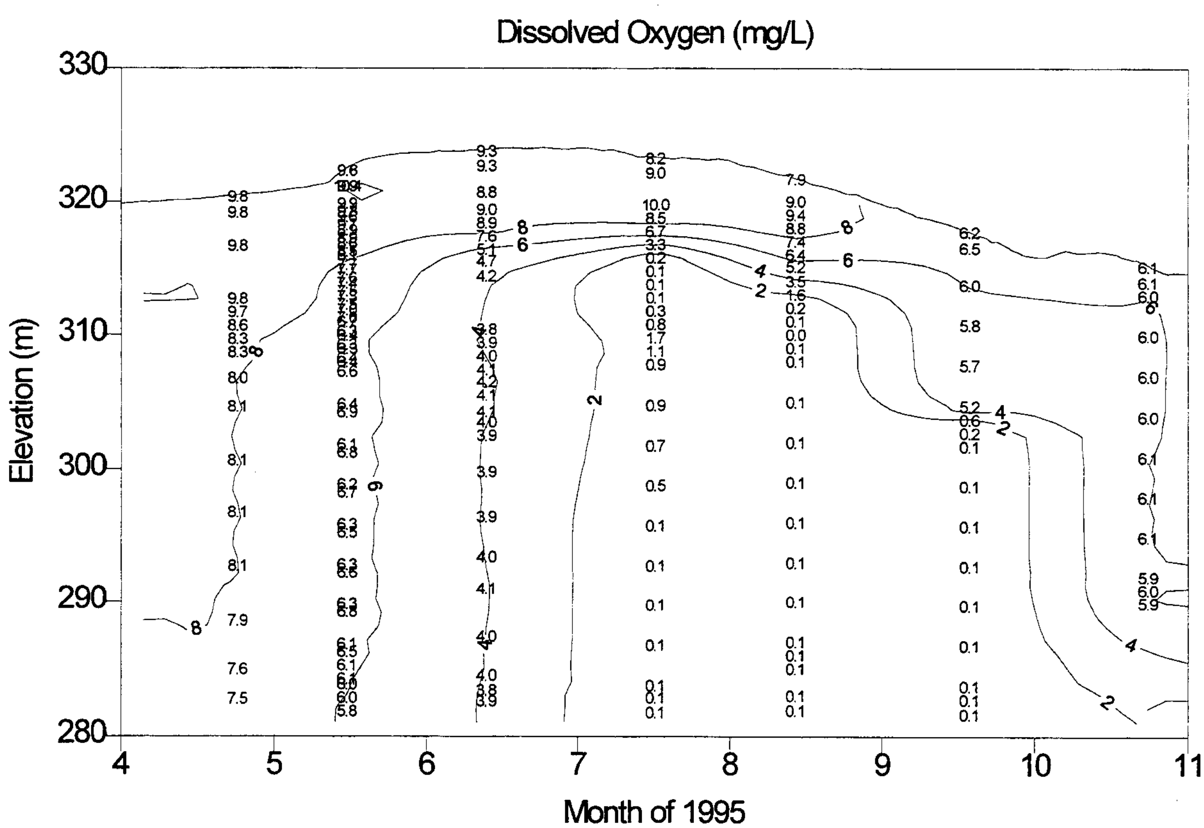
Douglas Reservoir - FBRM 50



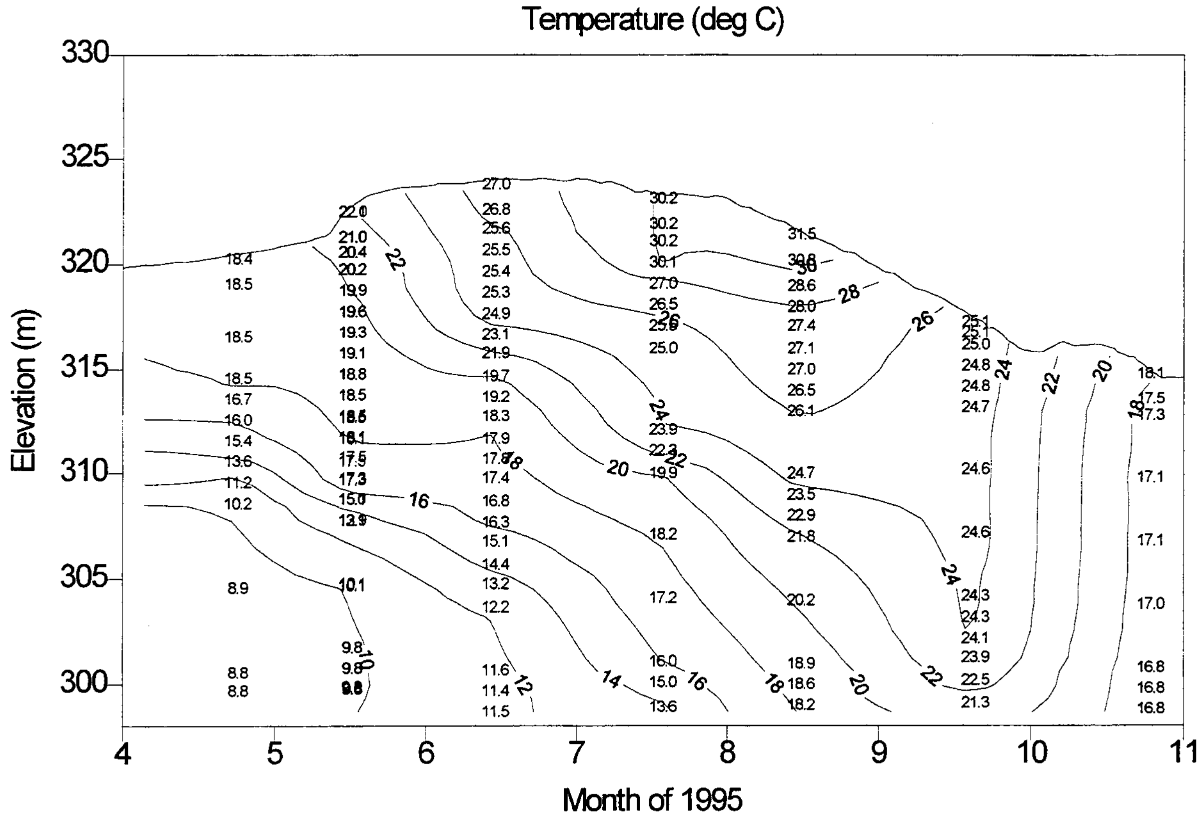


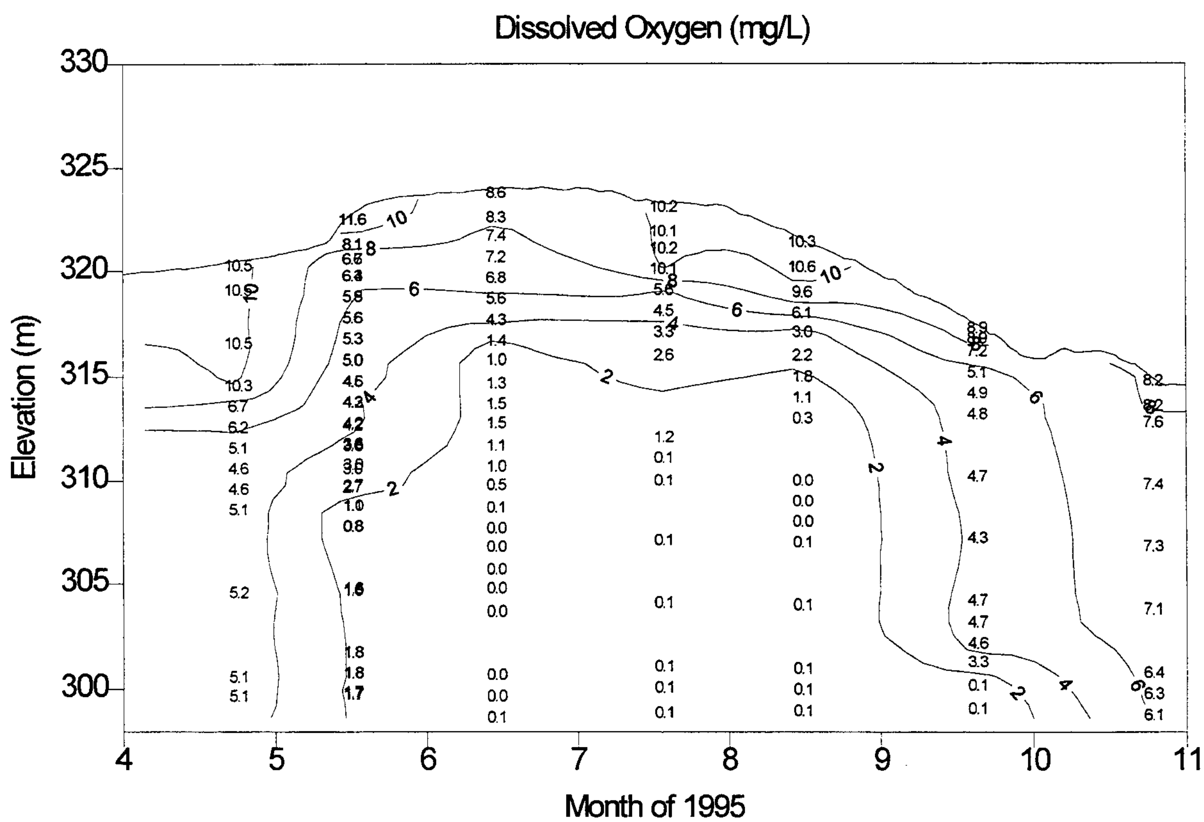
Cherokee Reservoir - HRM 55



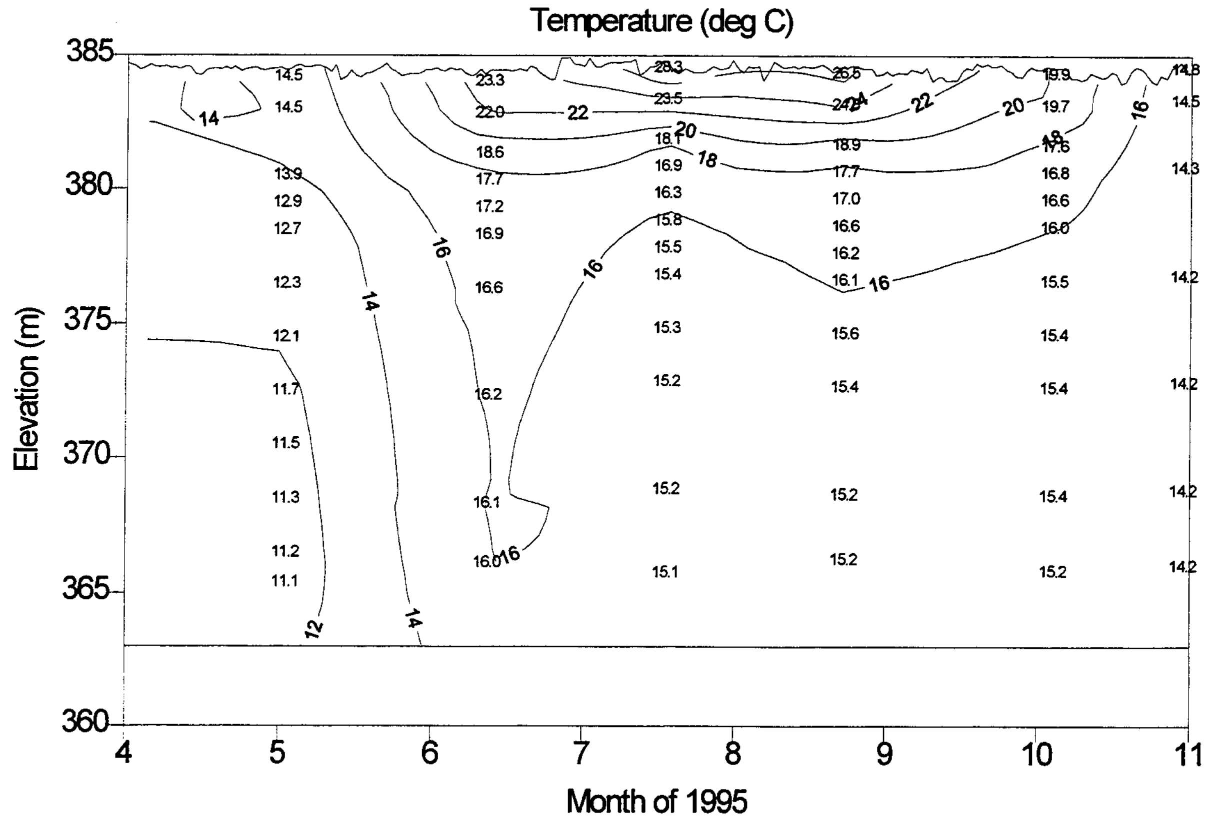


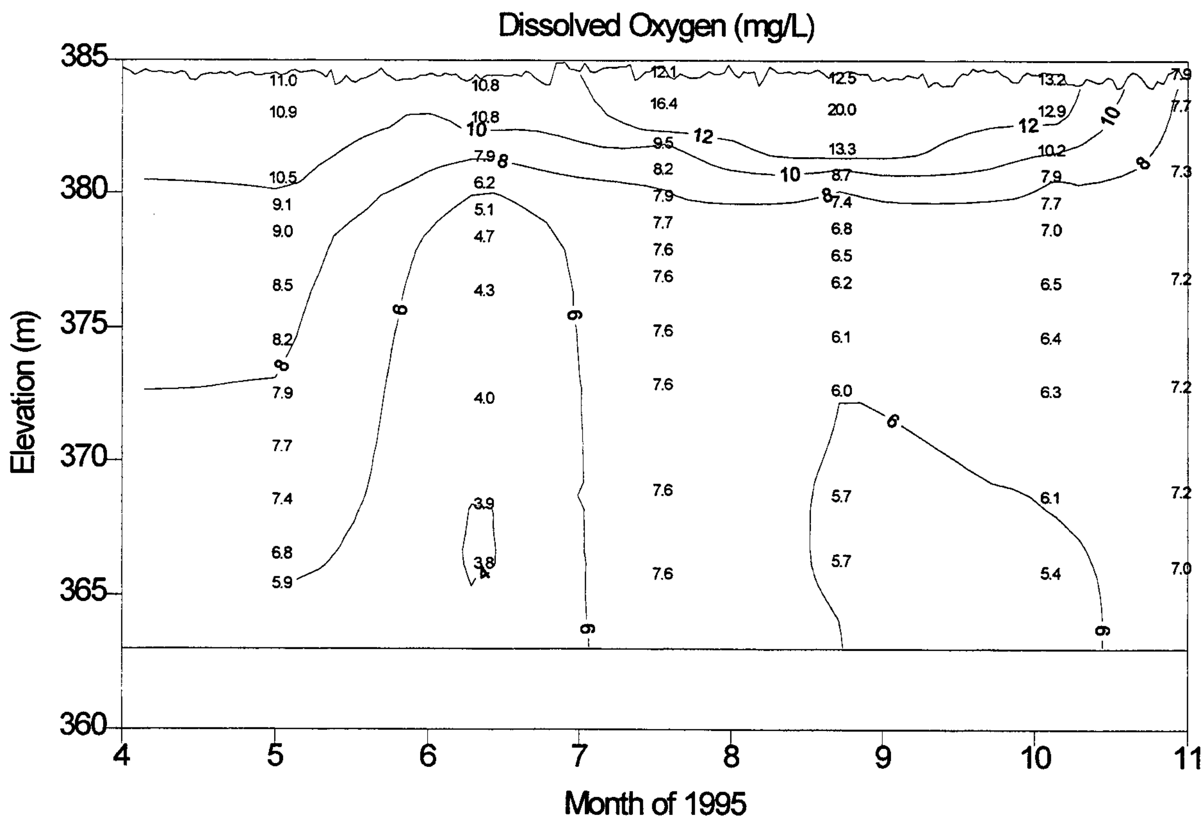
Cherokee Reservoir - HRM 77





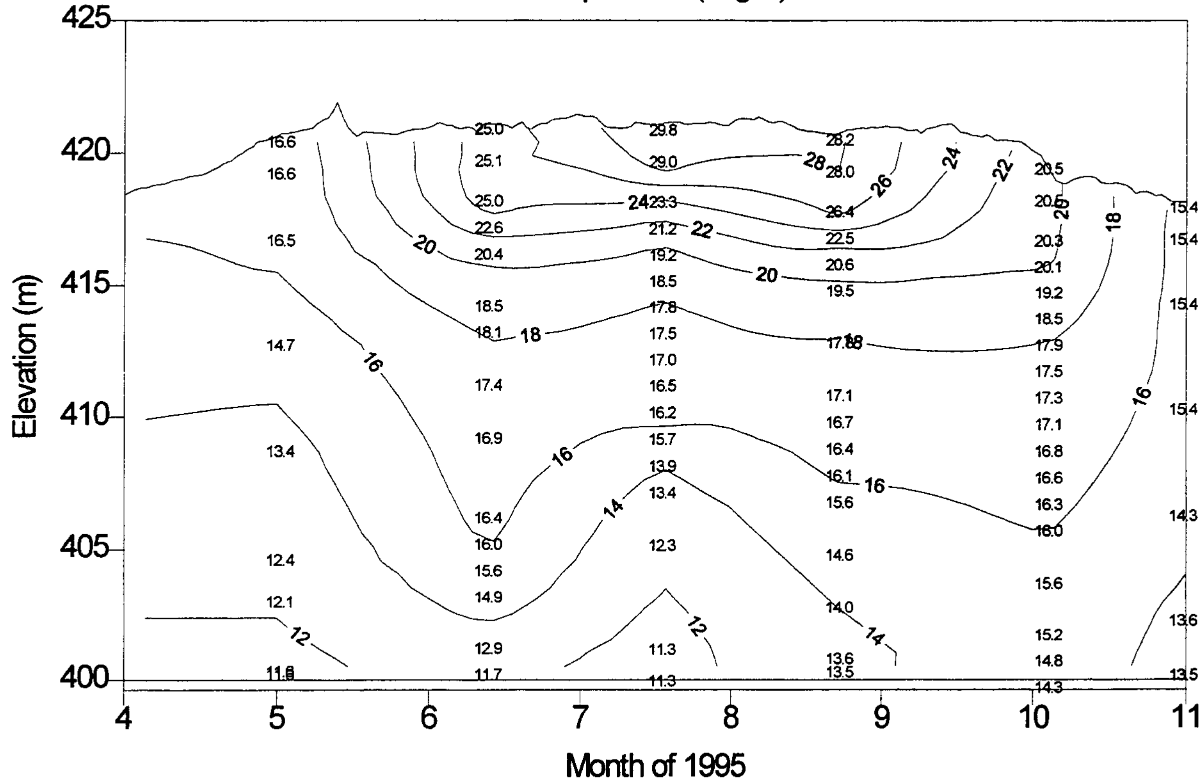
Fort Patrick Henry Reservoir - SFHRM 8.7



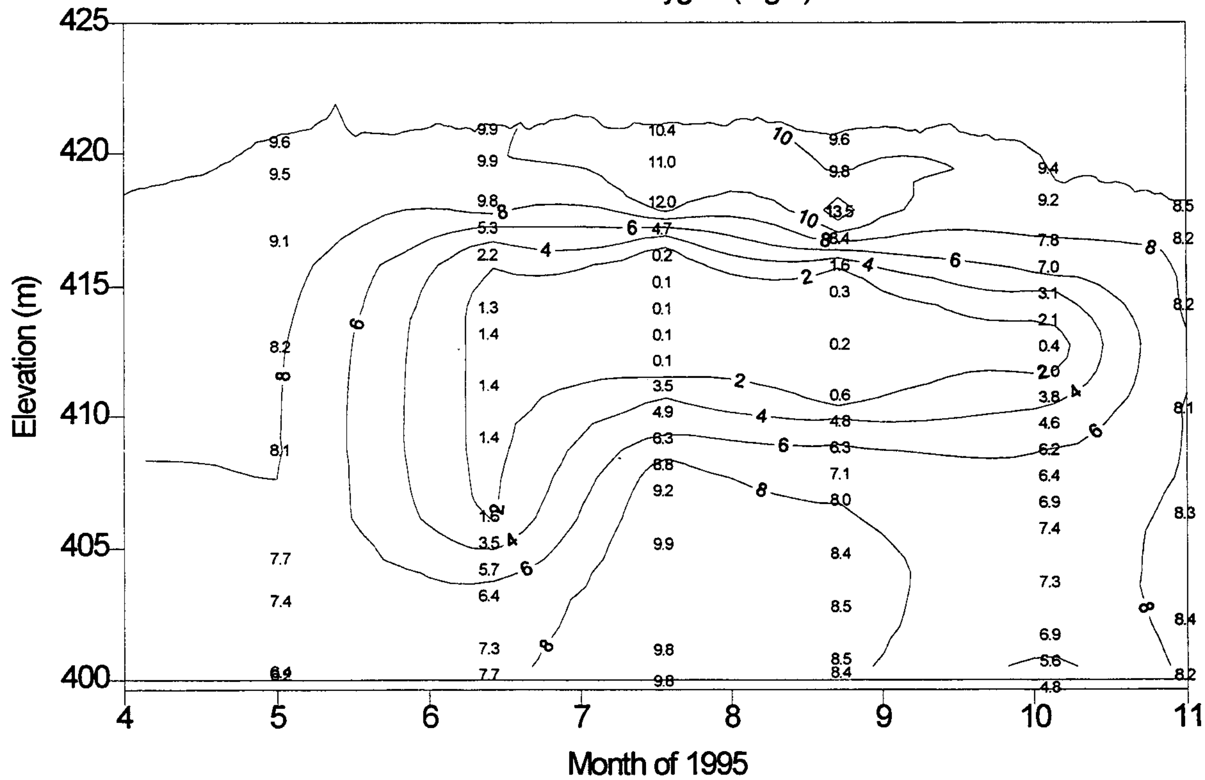


Boone Reservoir - SFHRM 27

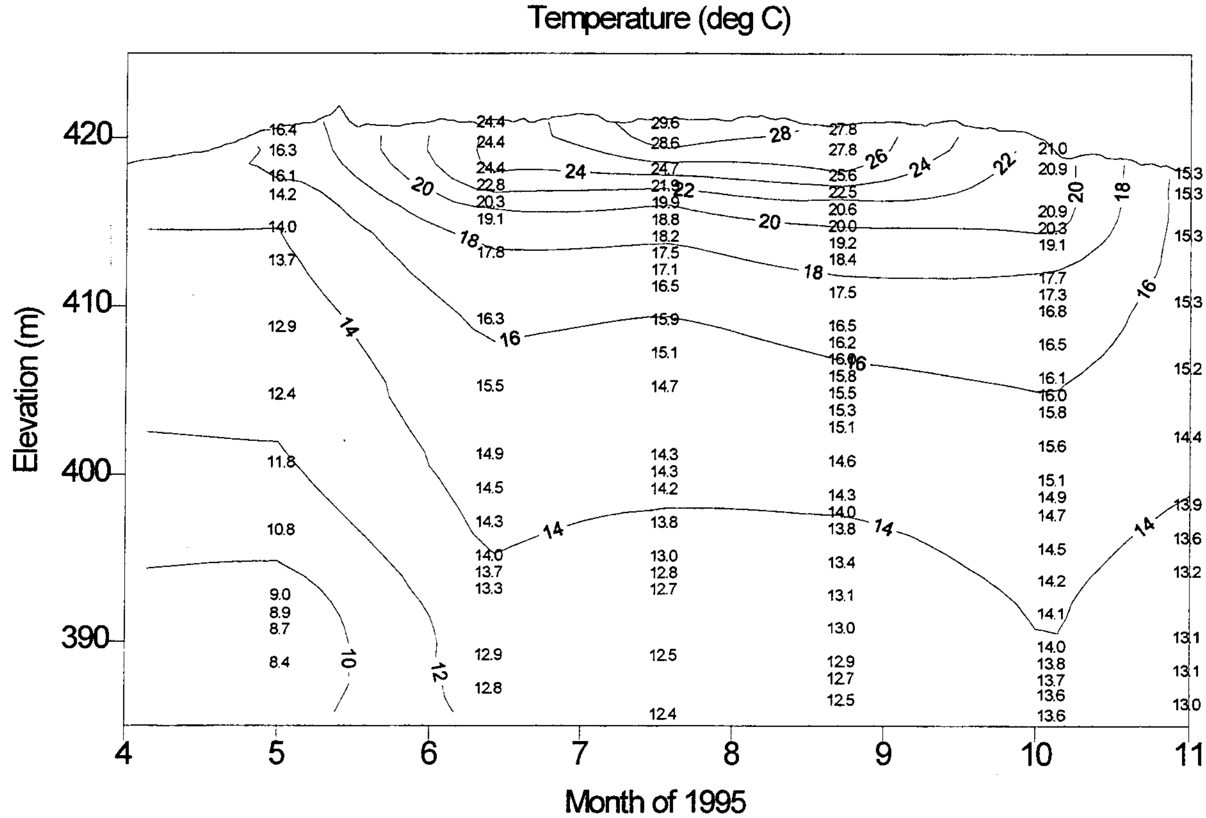
Temperature (deg C)

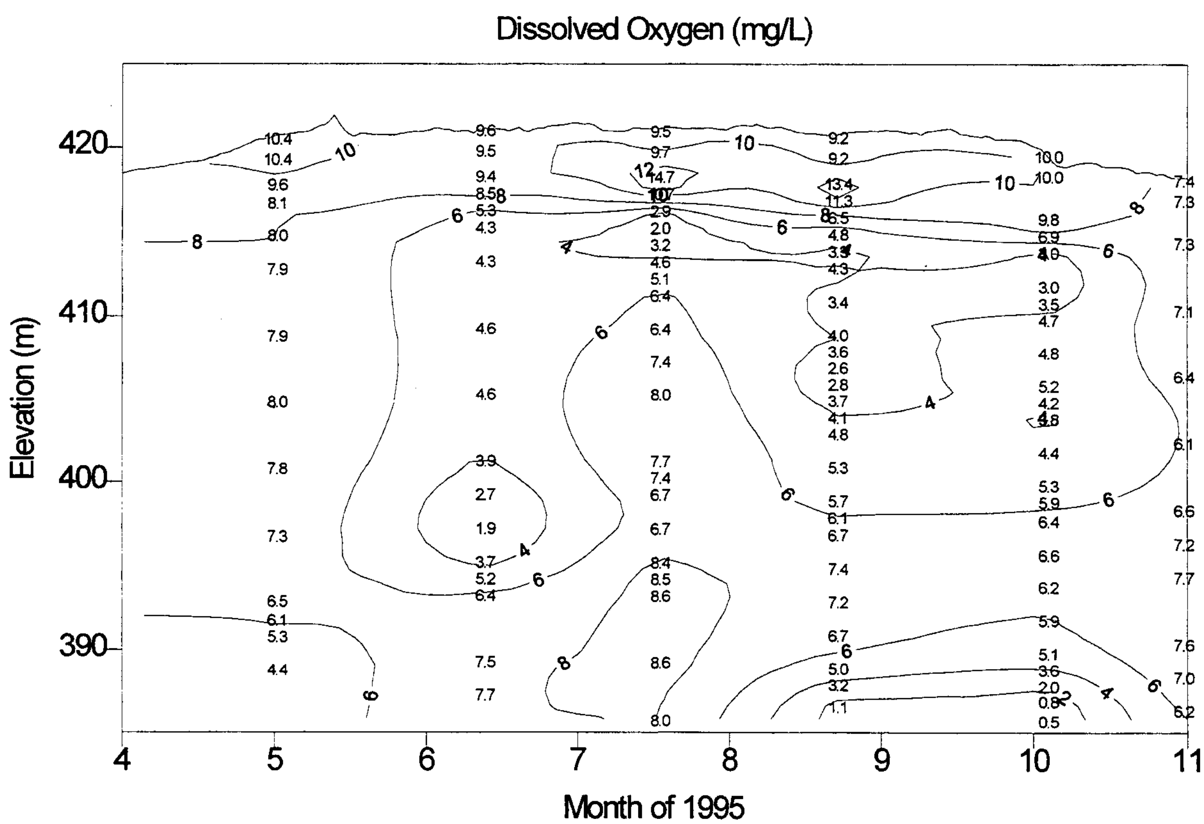


Dissolved Oxygen (mg/L)

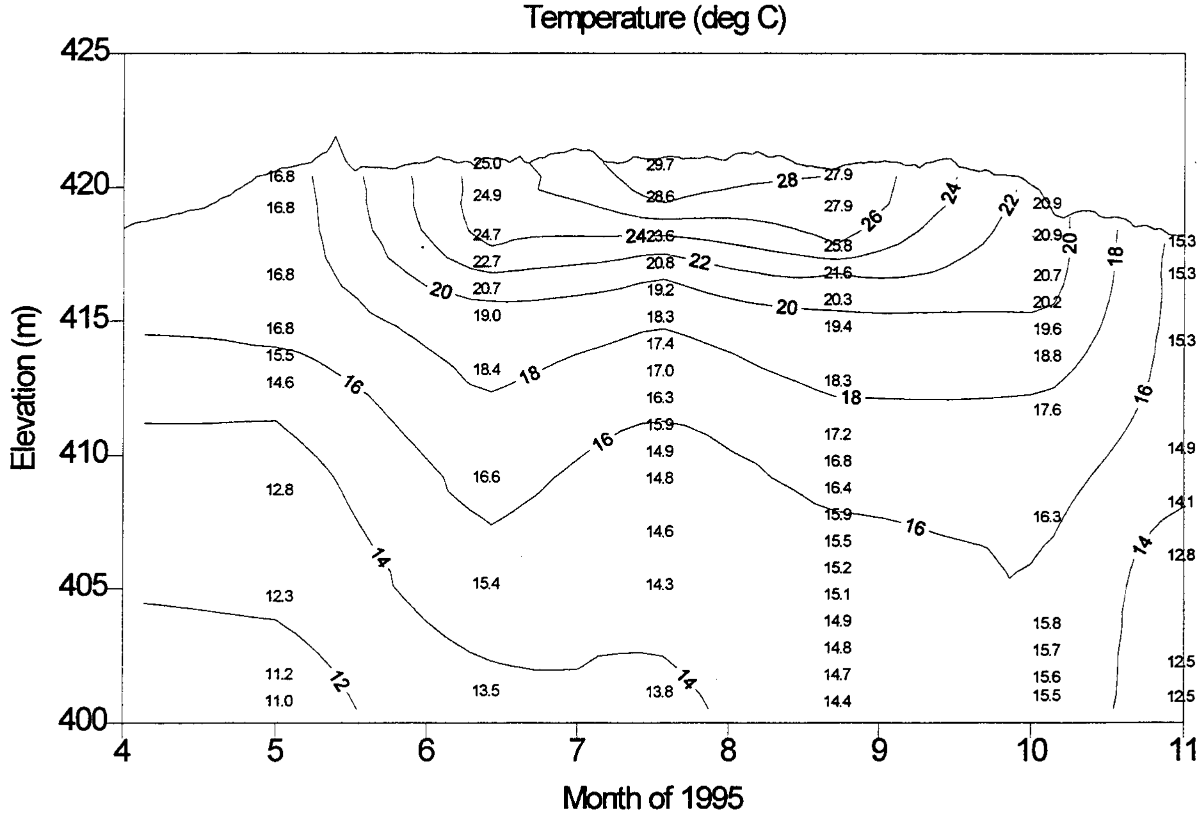


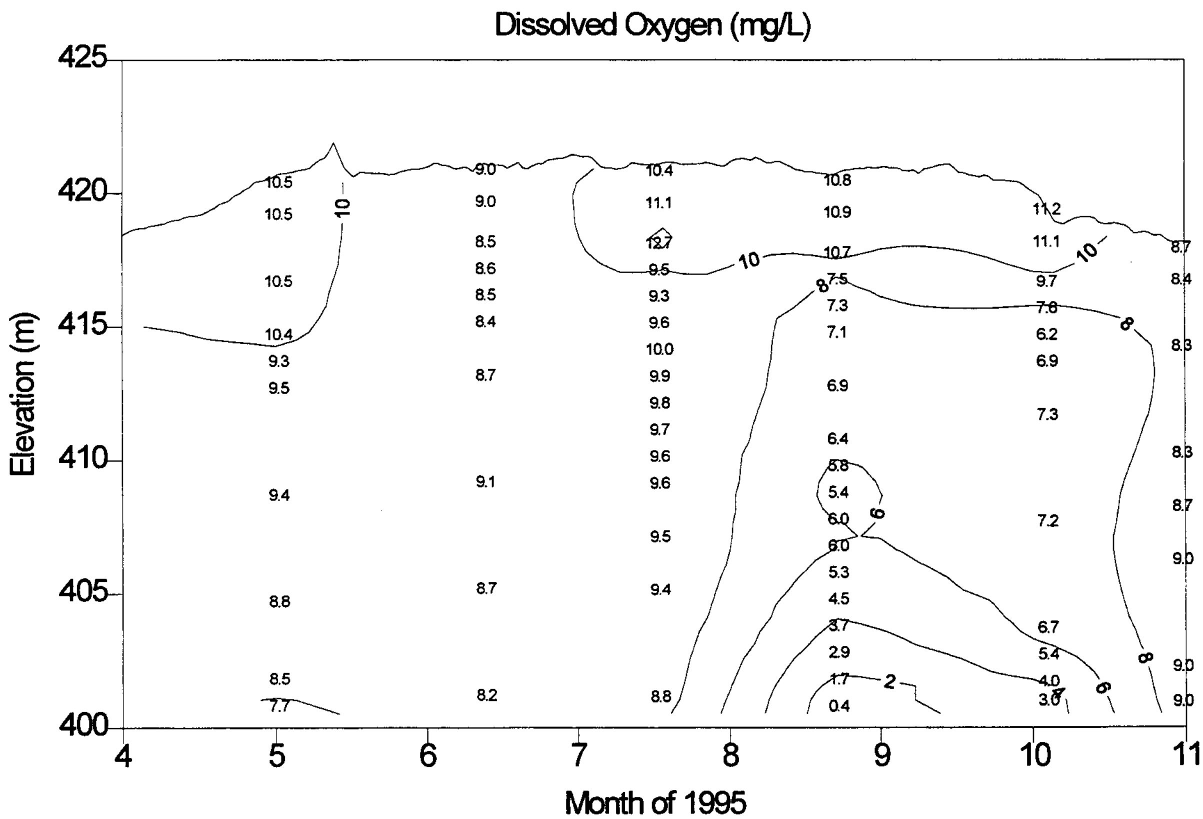
Boone Reservoir - SFHRM 19





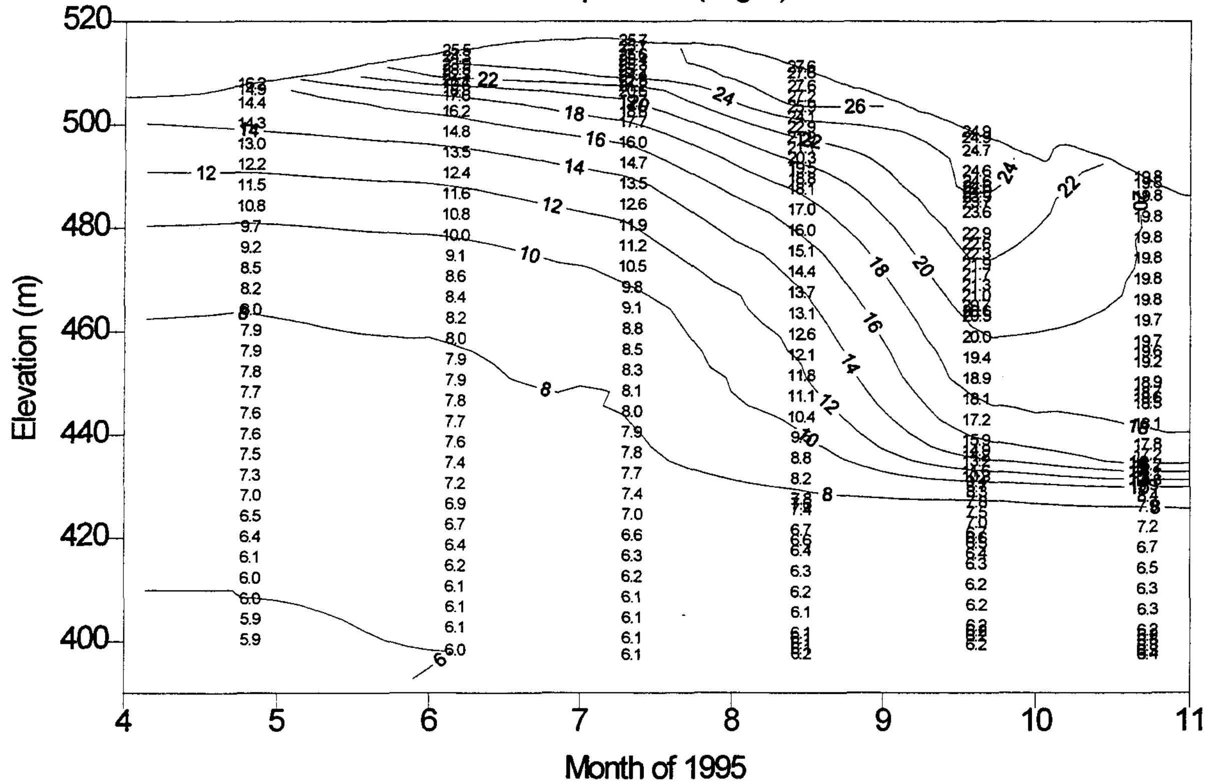
Boone Reservoir - WRM 6.5



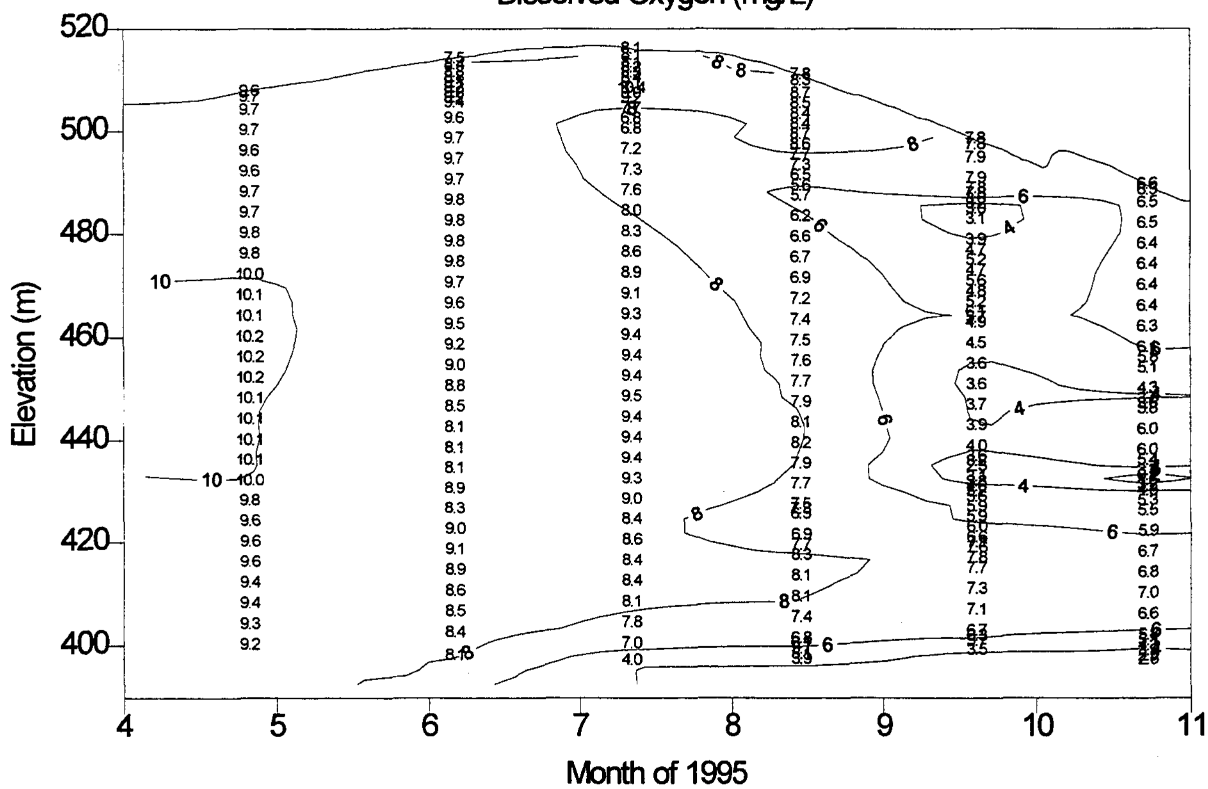


Fontana Reservoir - LTRM 62

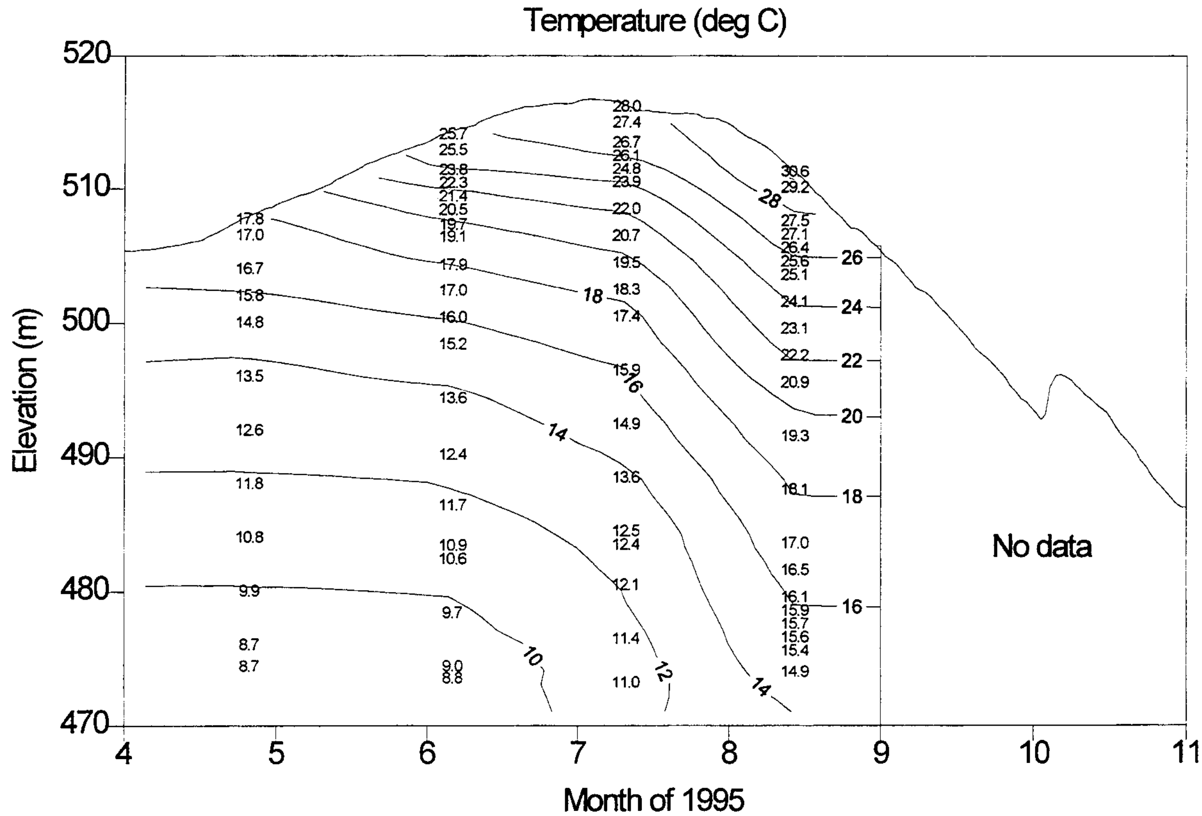
Temperature (deg C)

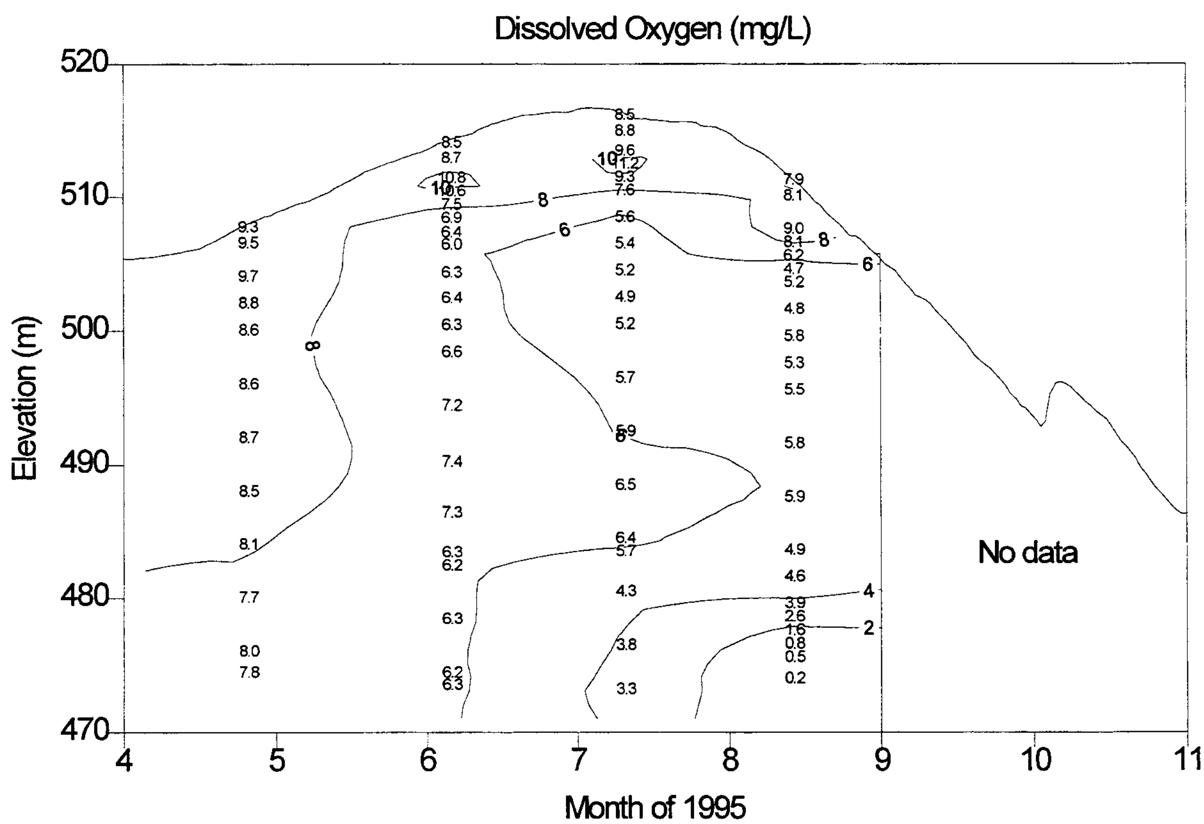


Dissolved Oxygen (mg/L)



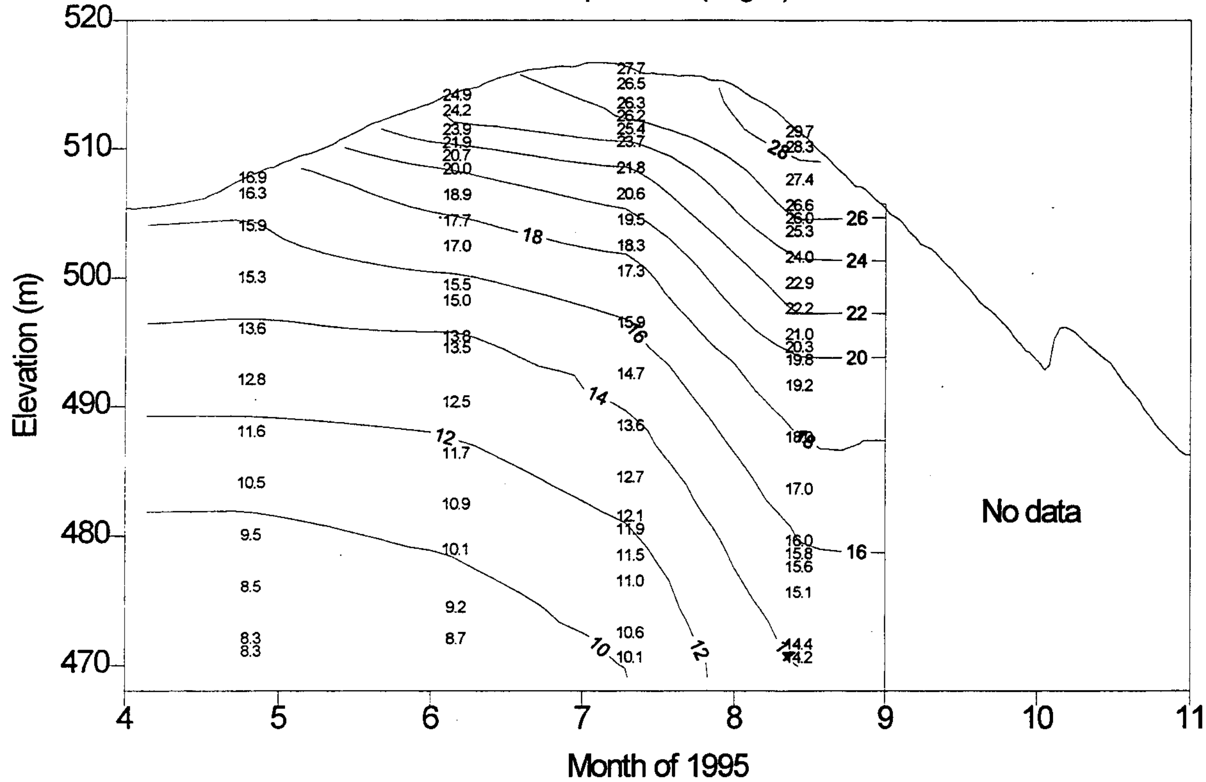
Fontana Reservoir - LTRM 81.5



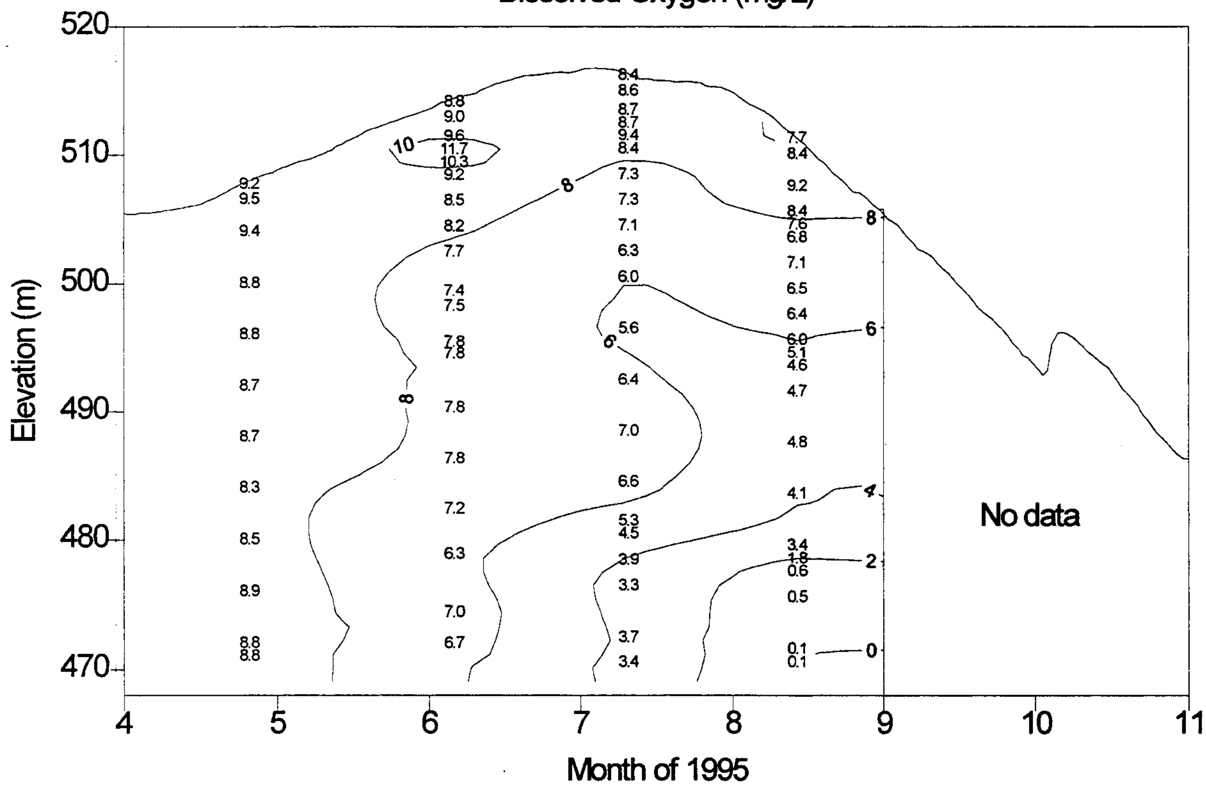


Fontana Reservoir -Tuckaseegee River Mile 3

Temperature (deg C)

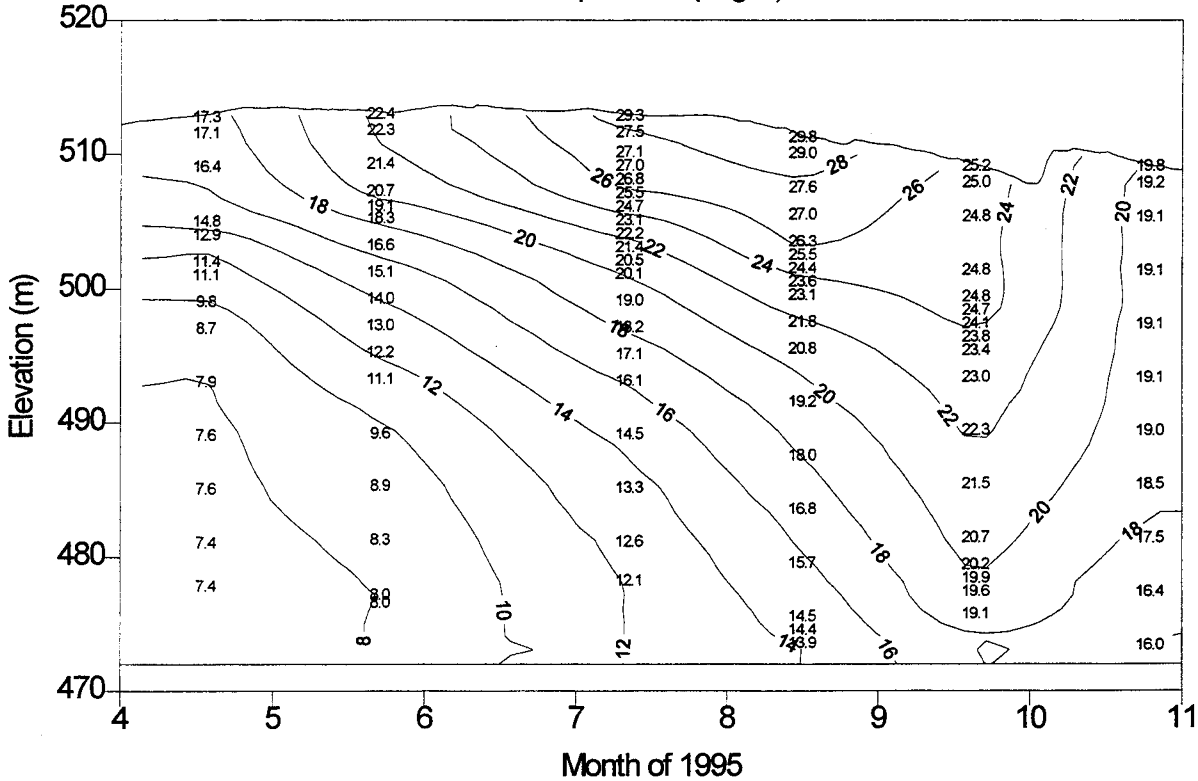


Dissolved Oxygen (mg/L)

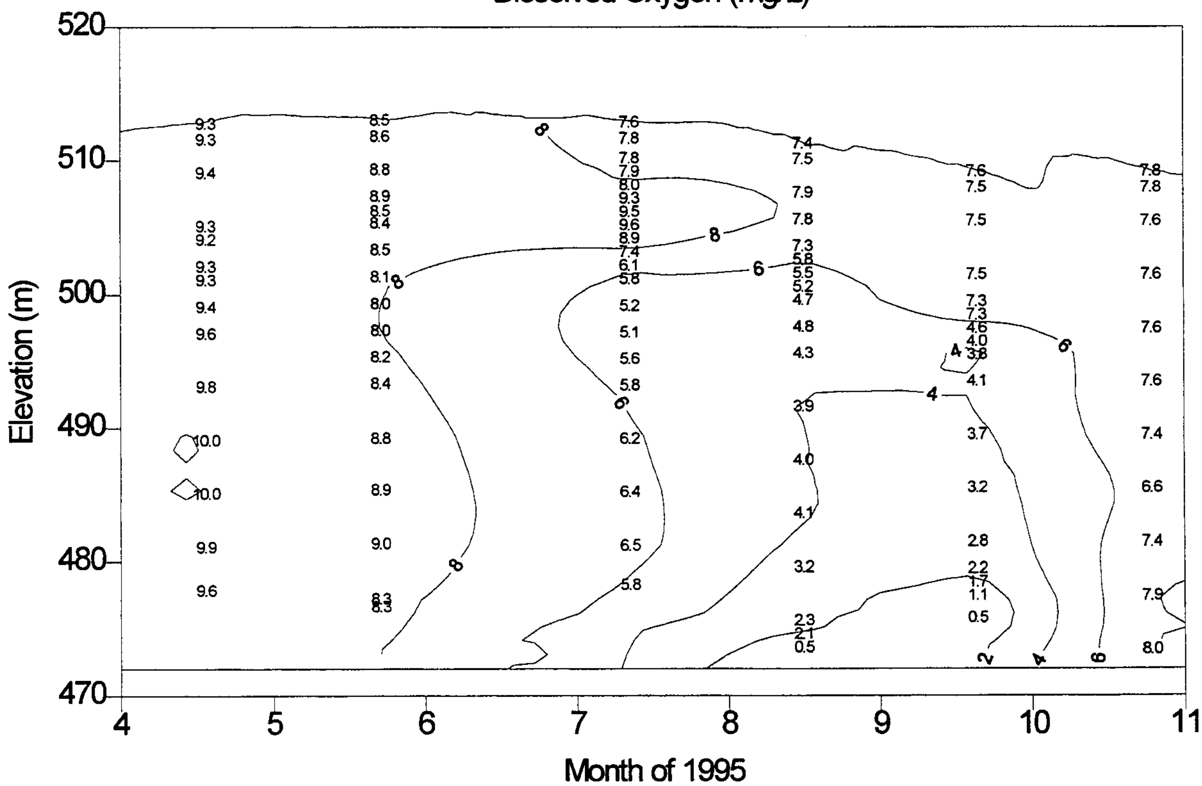


Blue Ridge Reservoir - ToRM 54.1

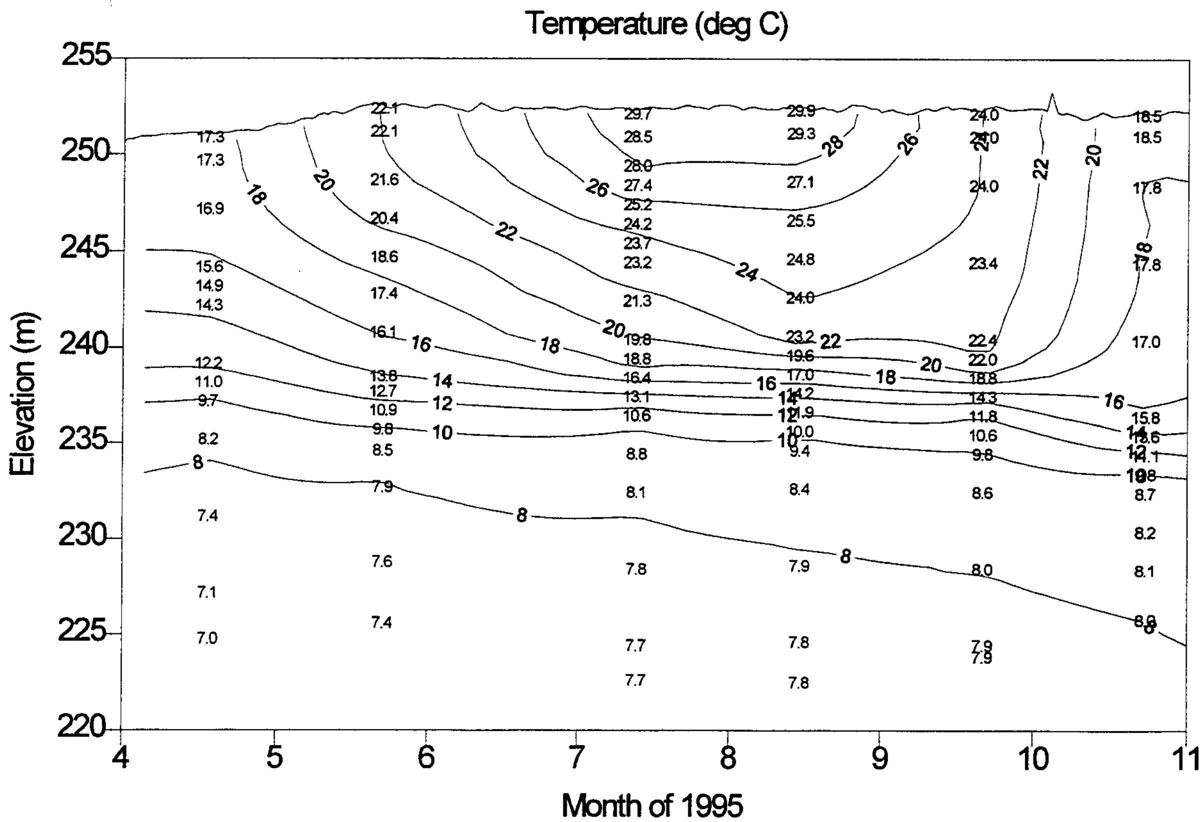
Temperature (deg C)

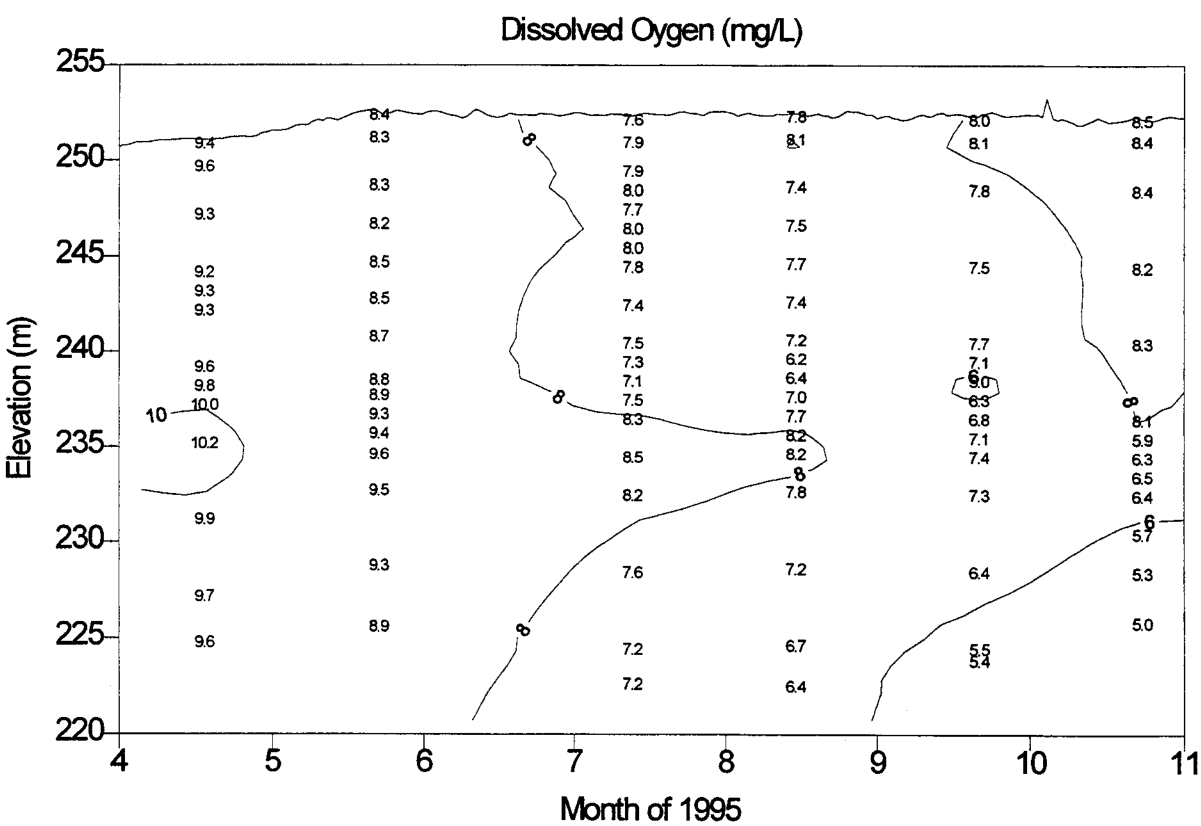


Dissolved Oxygen (mg/L)

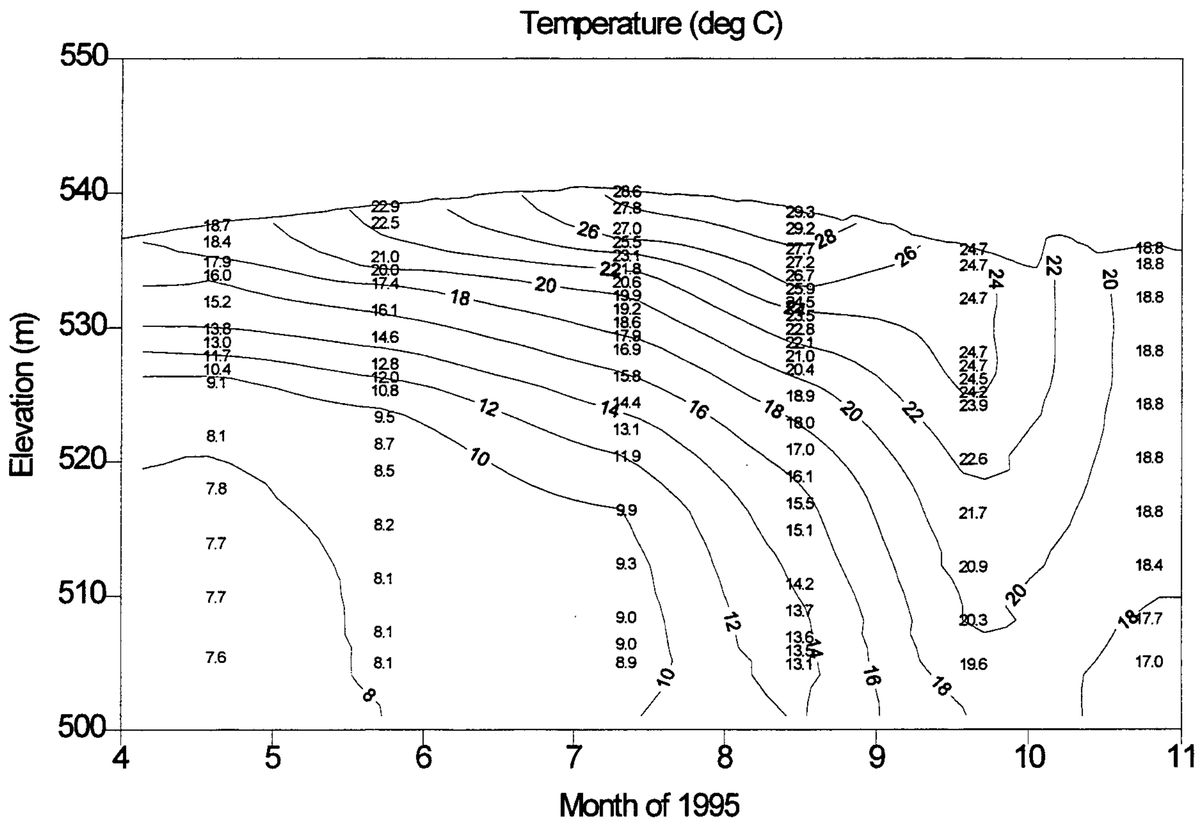


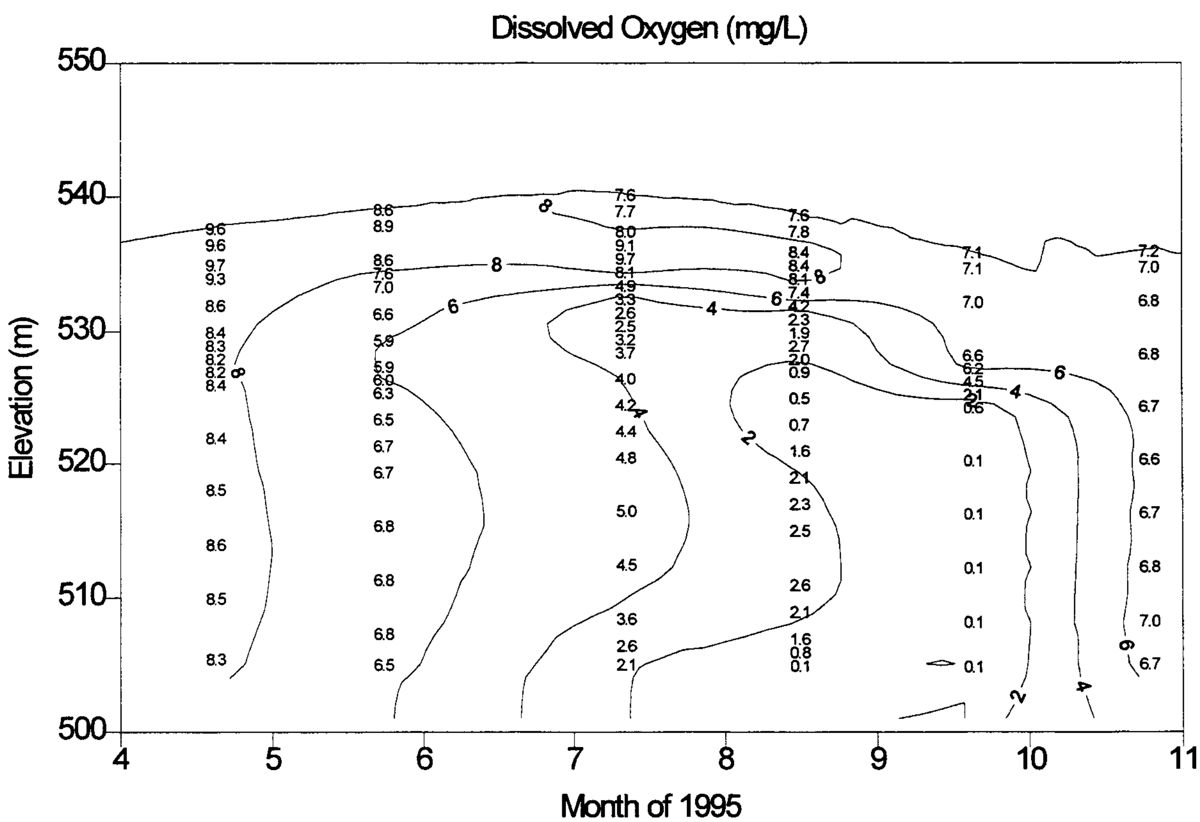
Ocoee #1 Reservoir - ORM 12.5





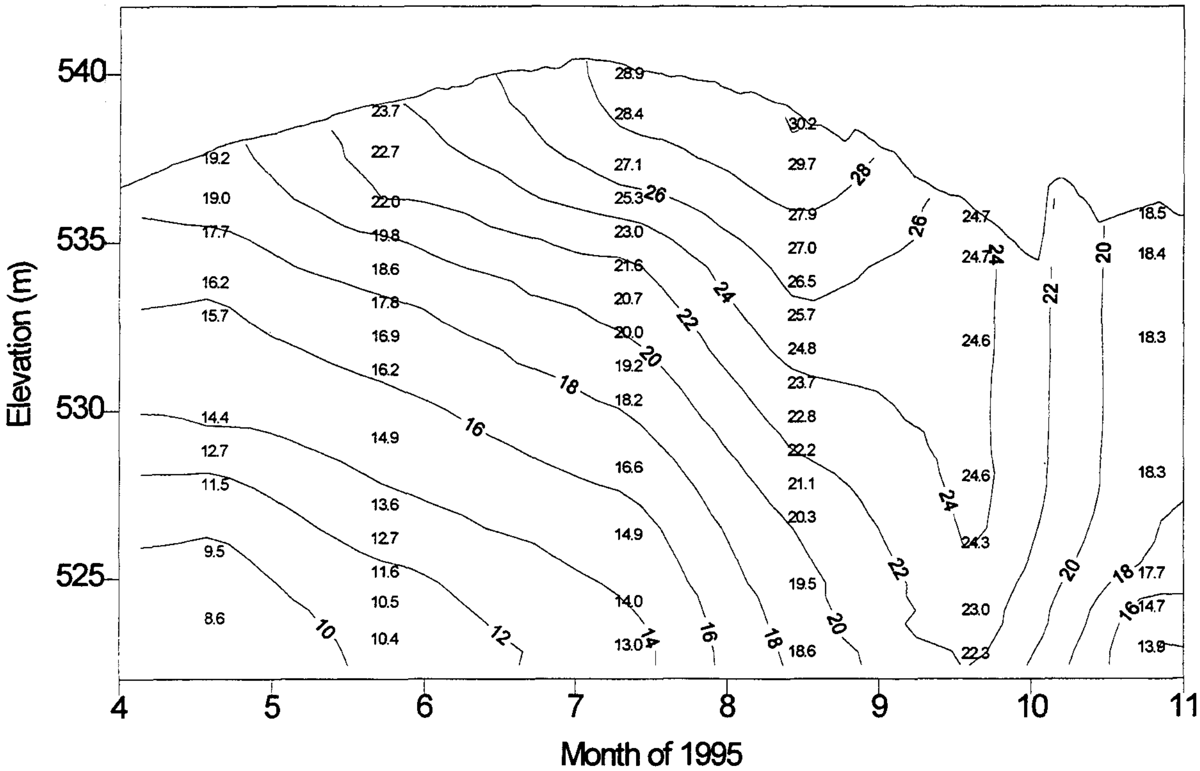
Nottely Reservoir - NRM 23.5



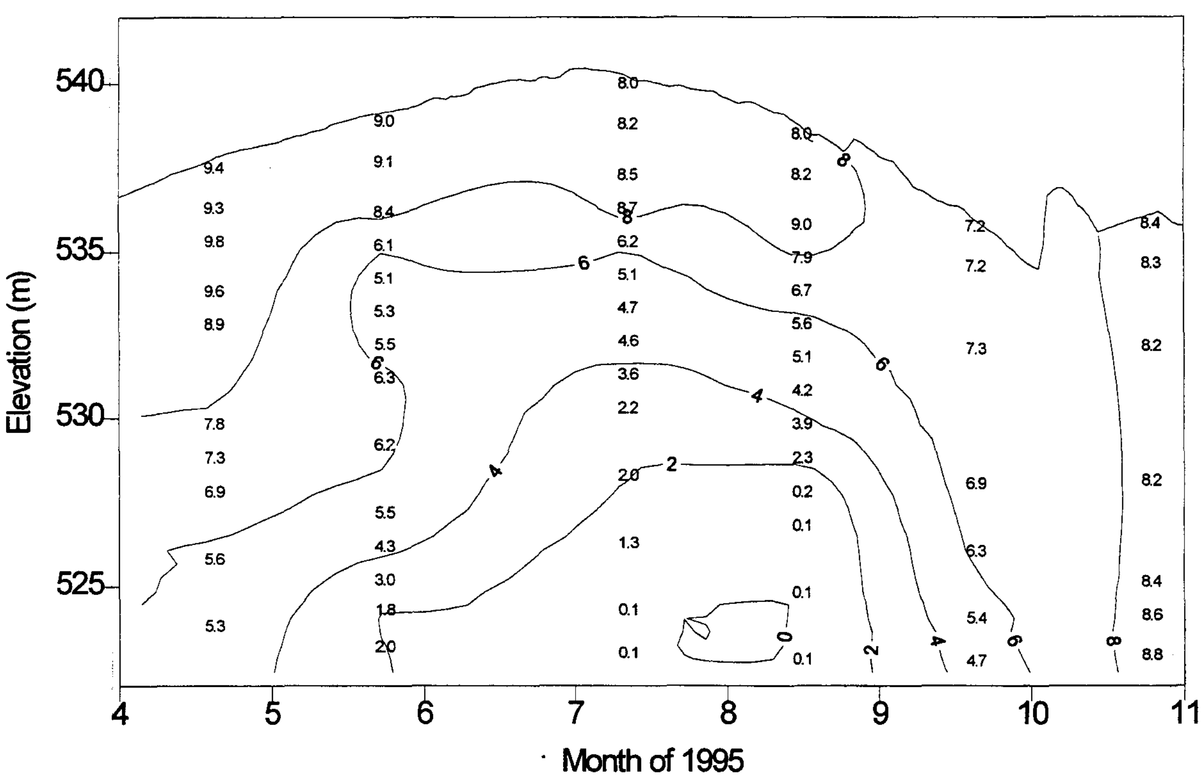


Nottely Reservoir - NRM 31

Temperature (deg C)

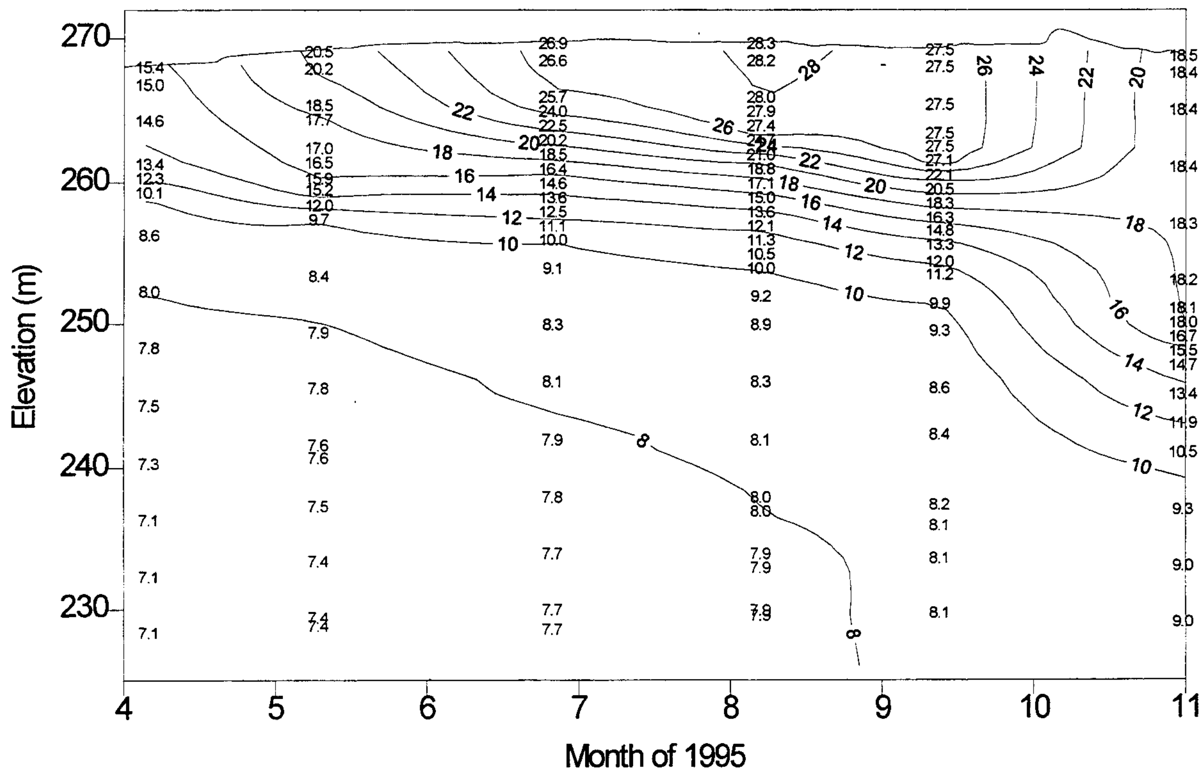


Dissolved Oxygen (mg/L)

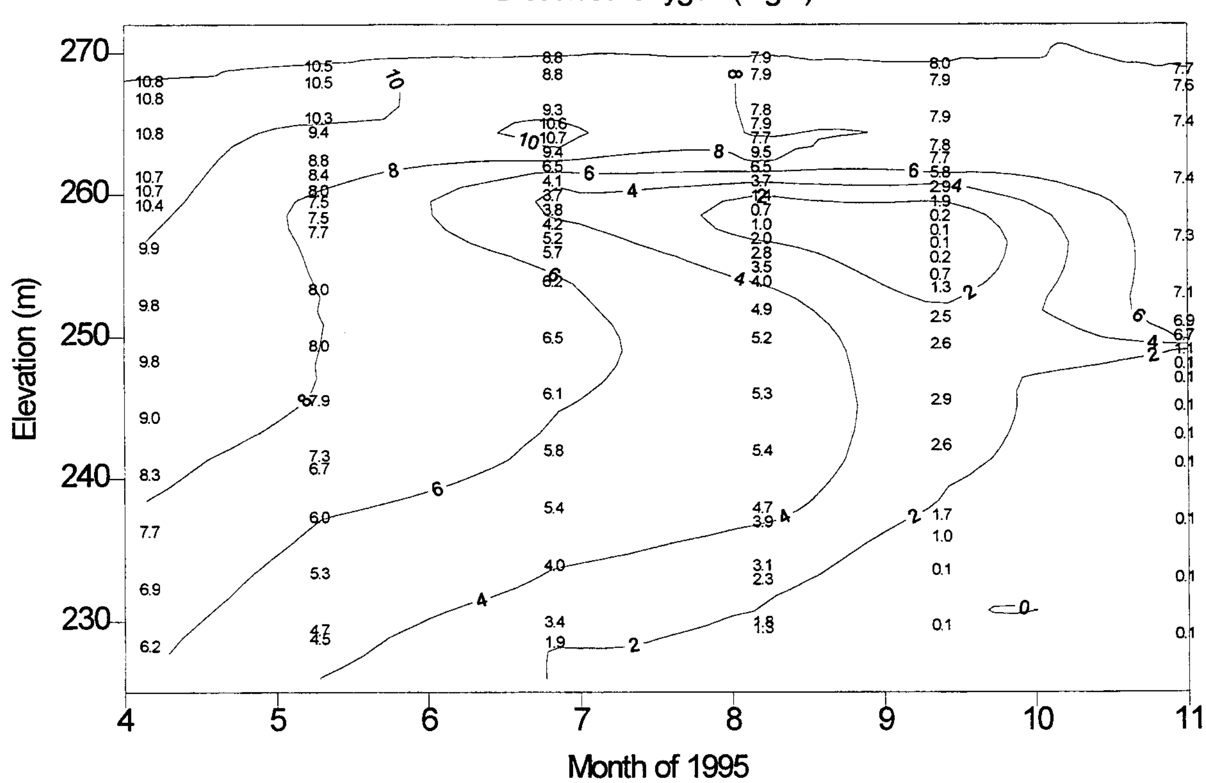


Tims Ford Reservoir - ERM 135

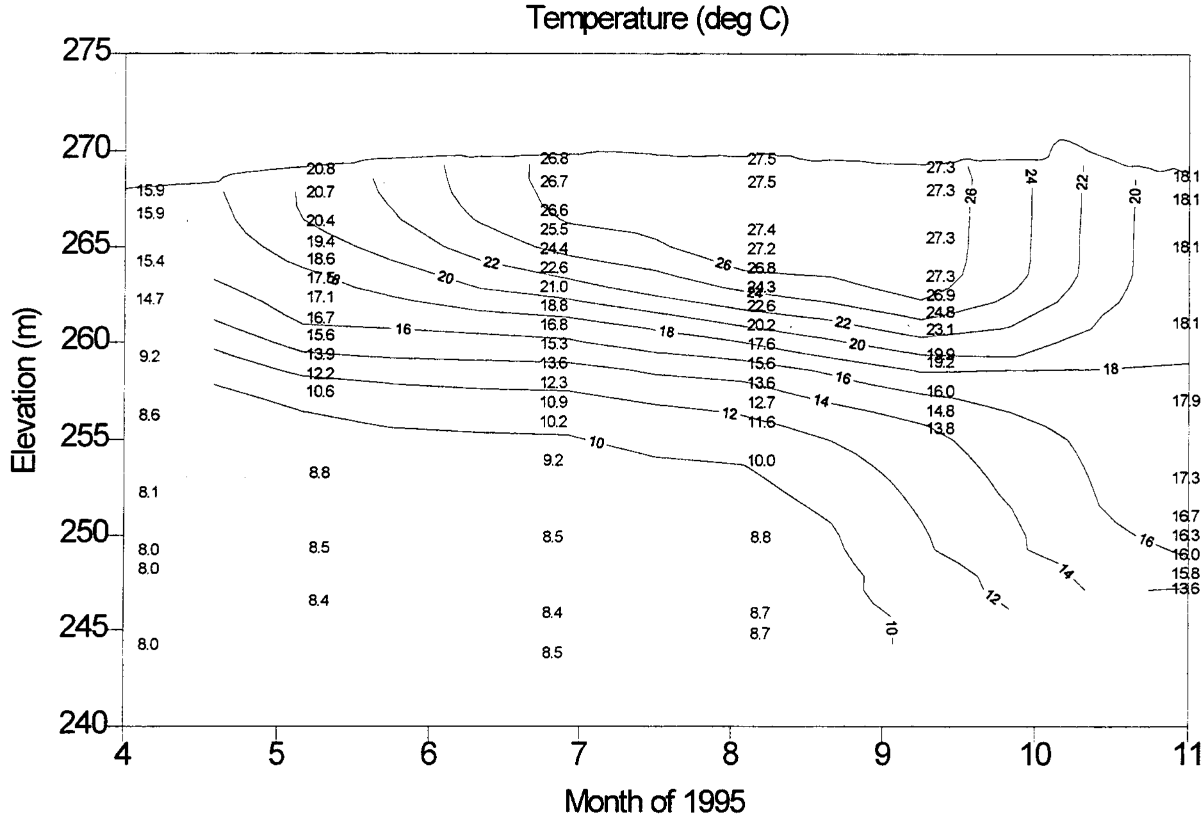
Temperature (deg C)

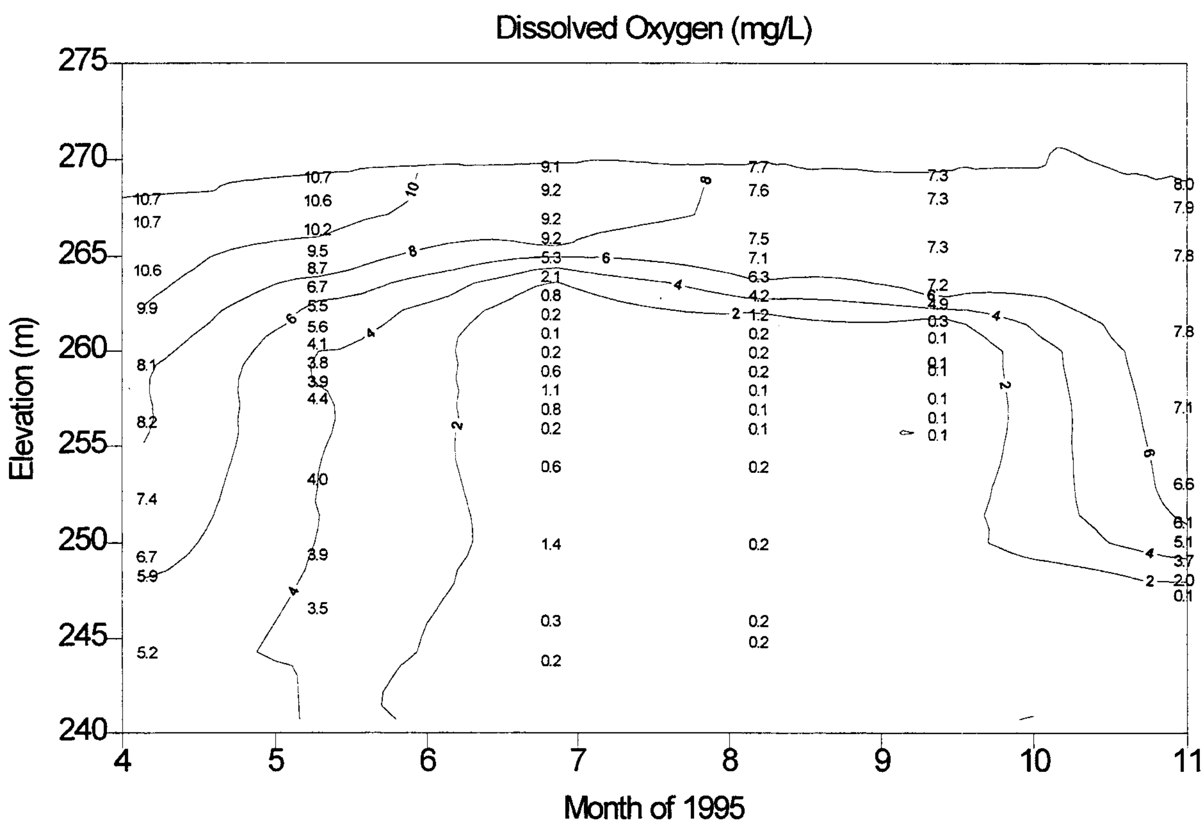


Dissolved Oxygen (mg/L)



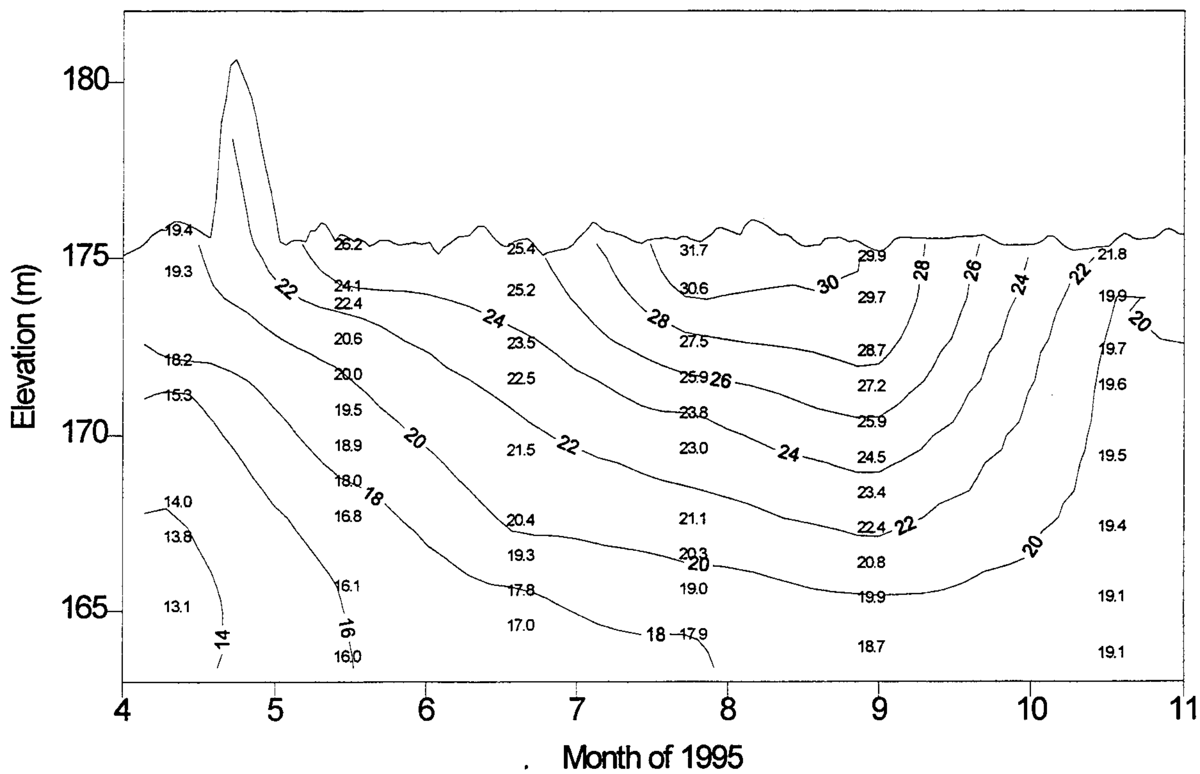
Tims Ford Reservoir - ERM 150



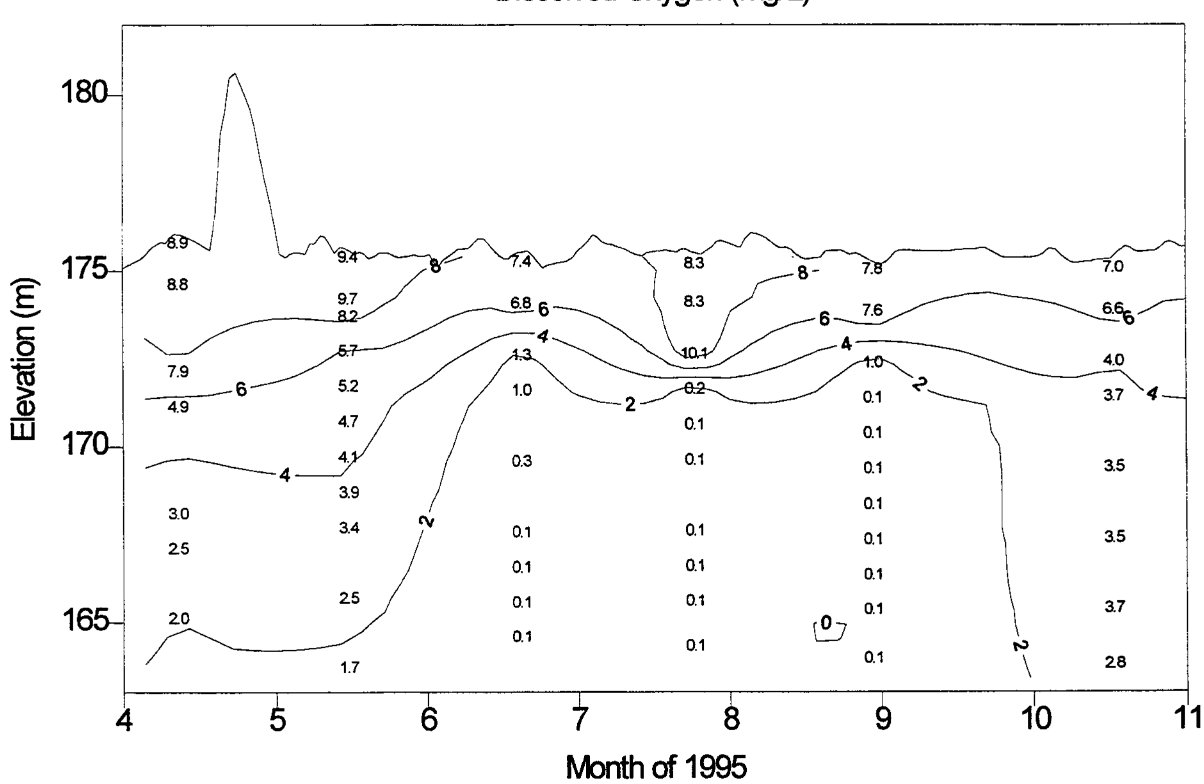


Bear Creek Reservoir - BCM 75.0

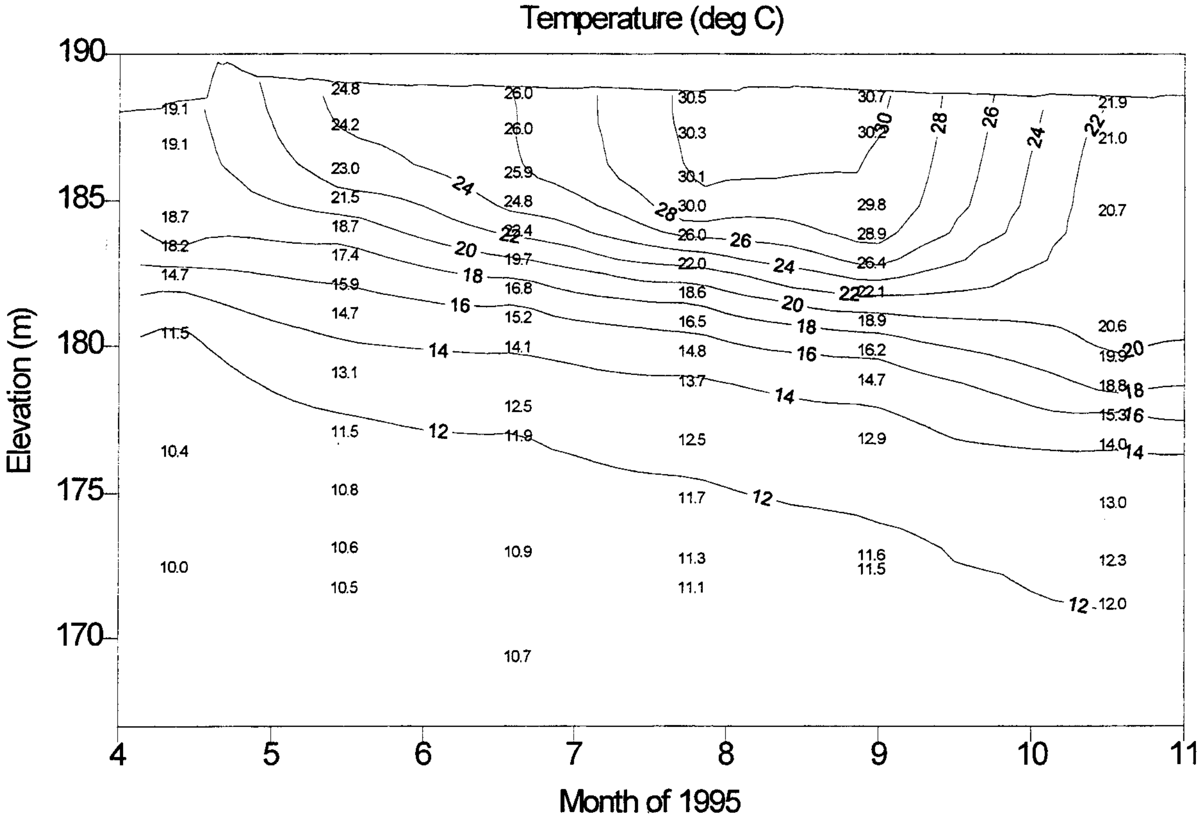
Temperature (deg C)

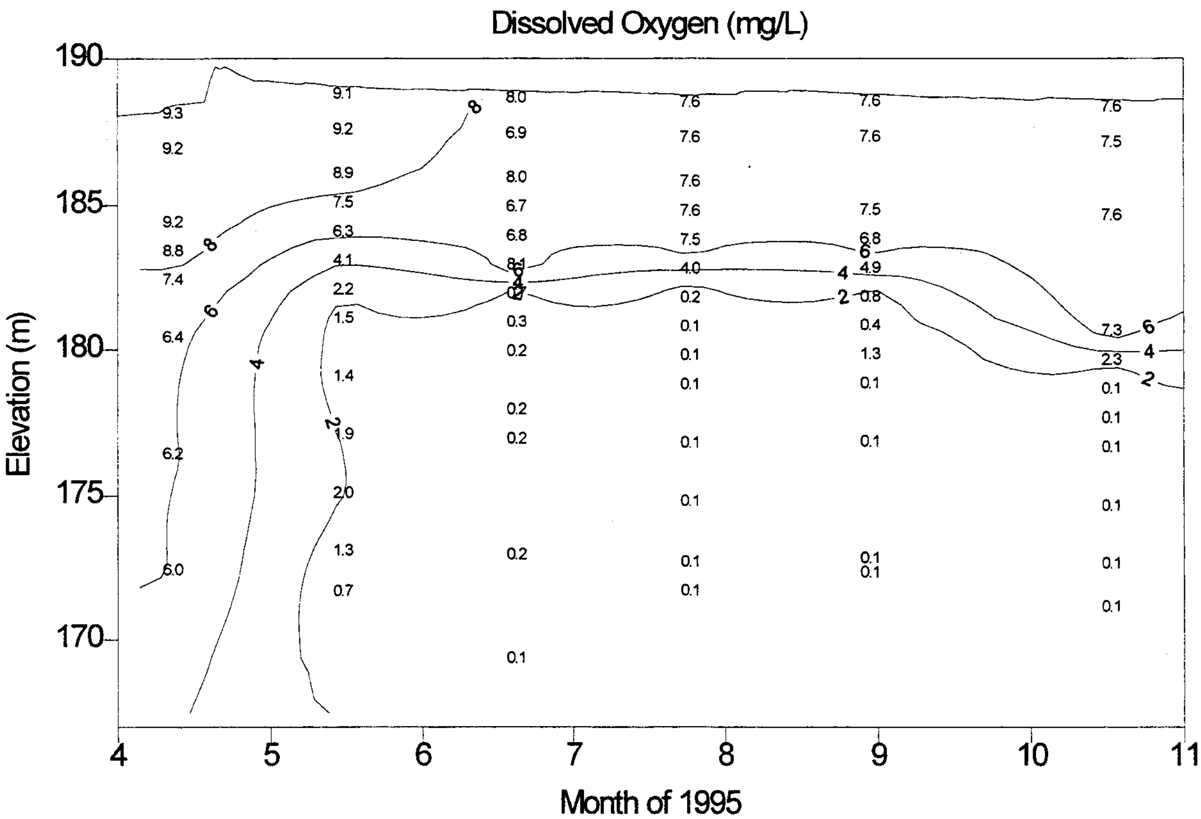


Dissolved Oxygen (mg/L)

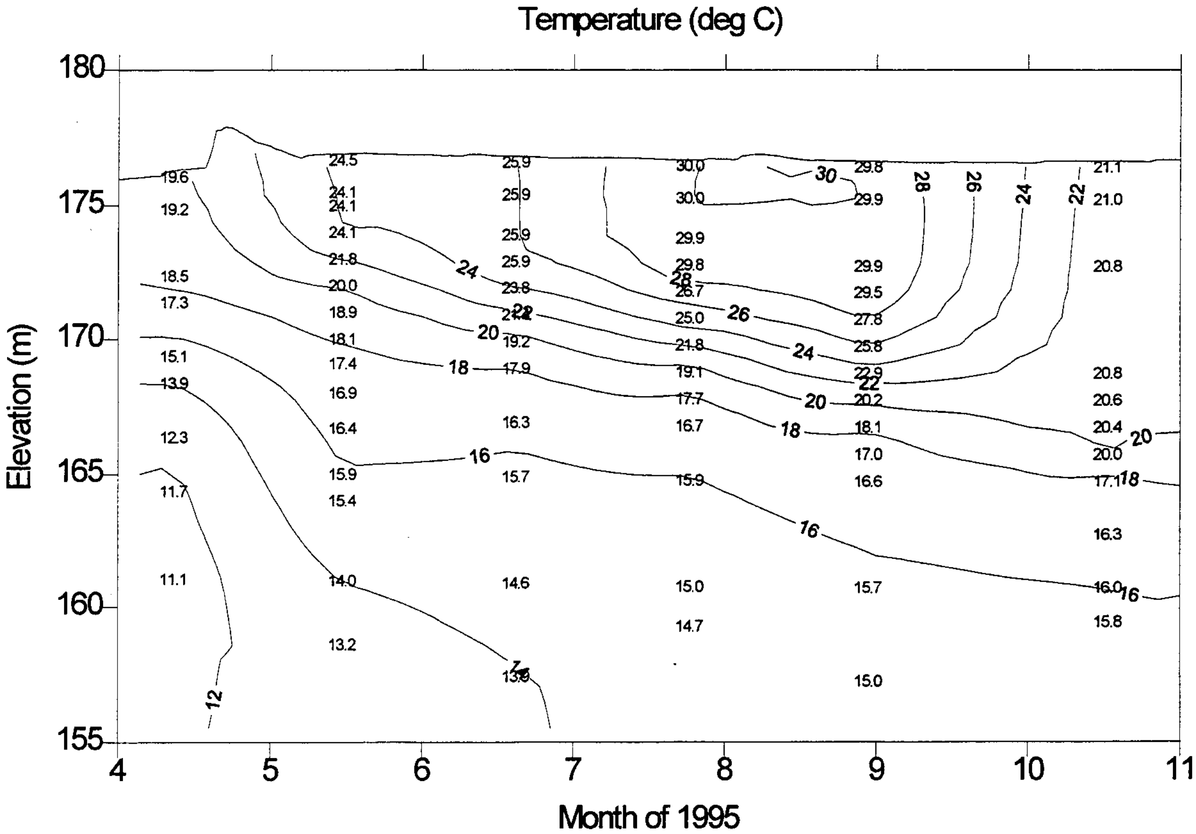


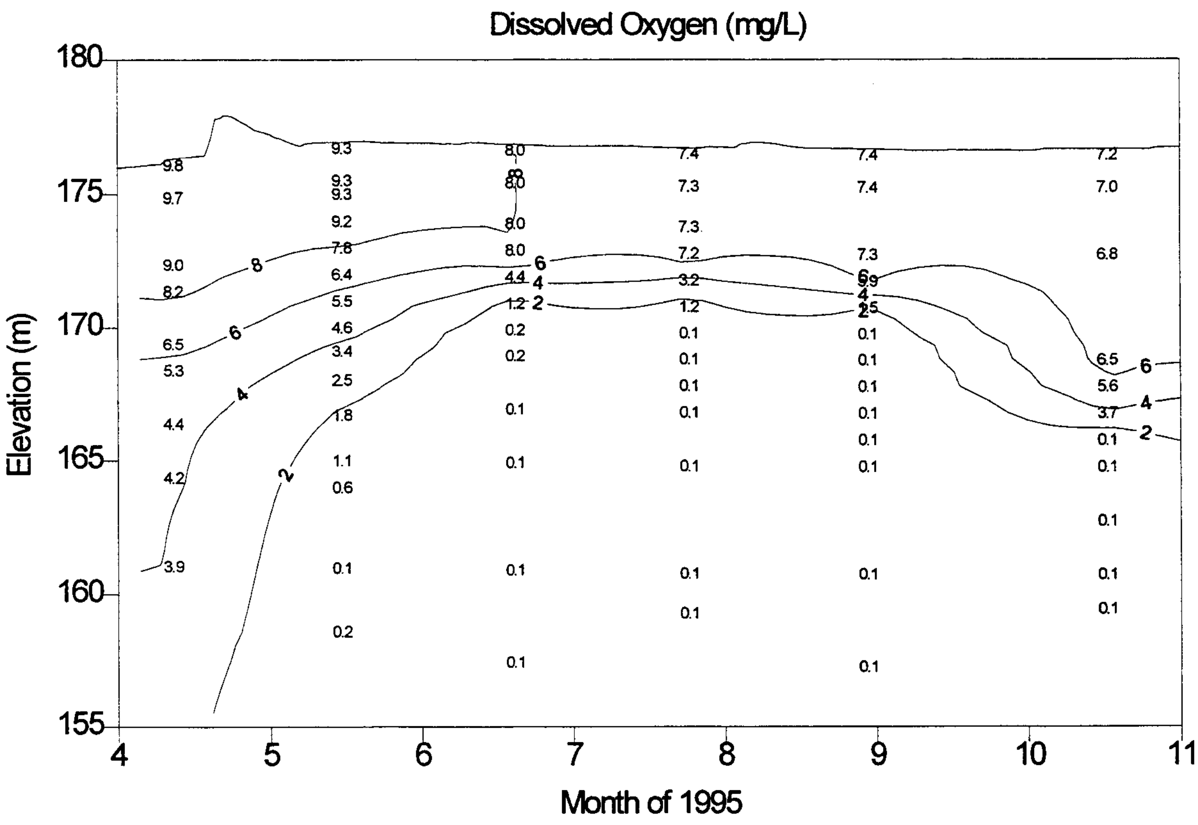
Little Bear Creek Reservoir - LBCM 12.5





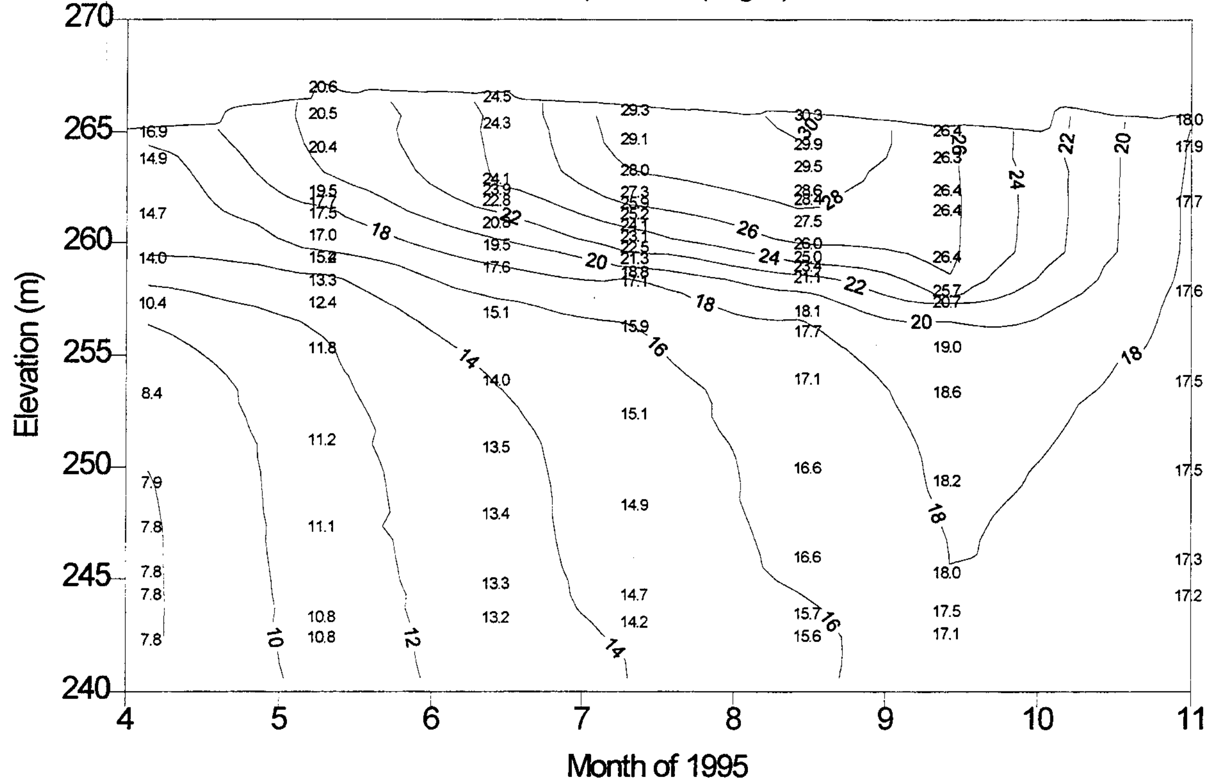
Cedar Creek Reservoir - CCM 25.2



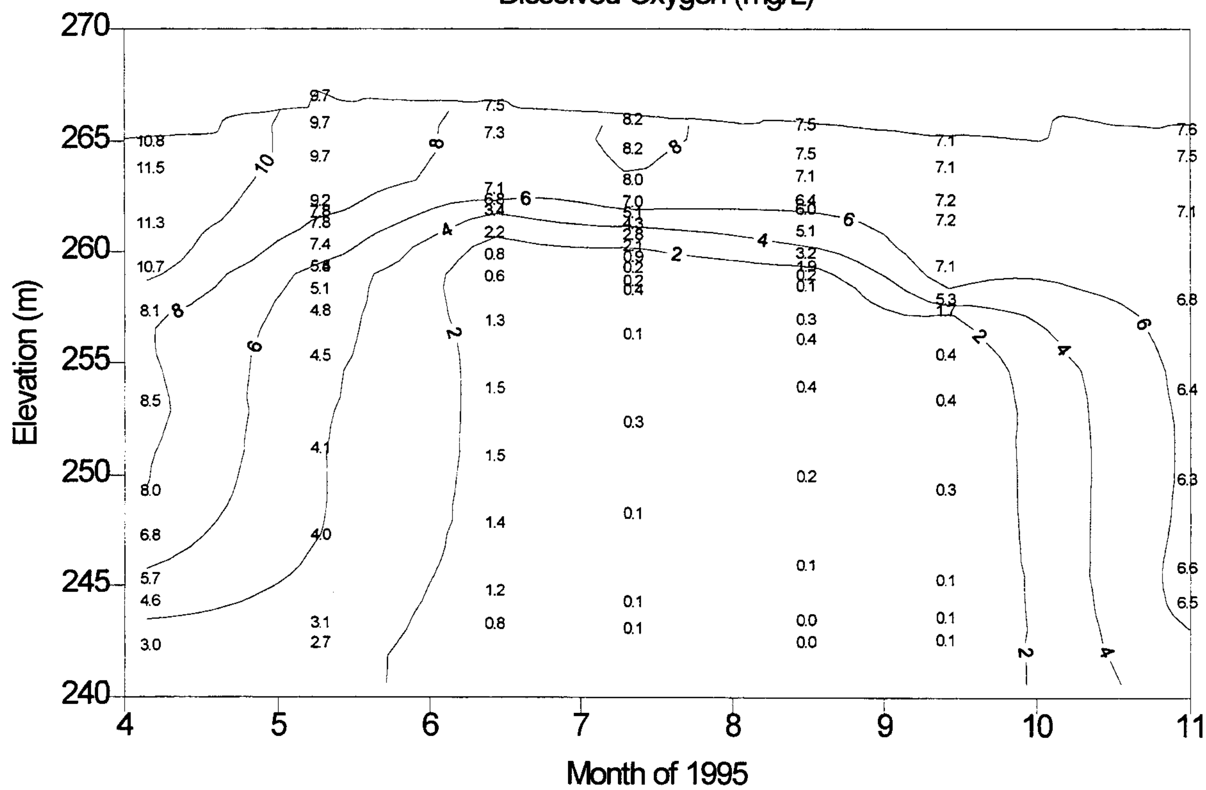


Normandy Reservoir - DRM 249.5

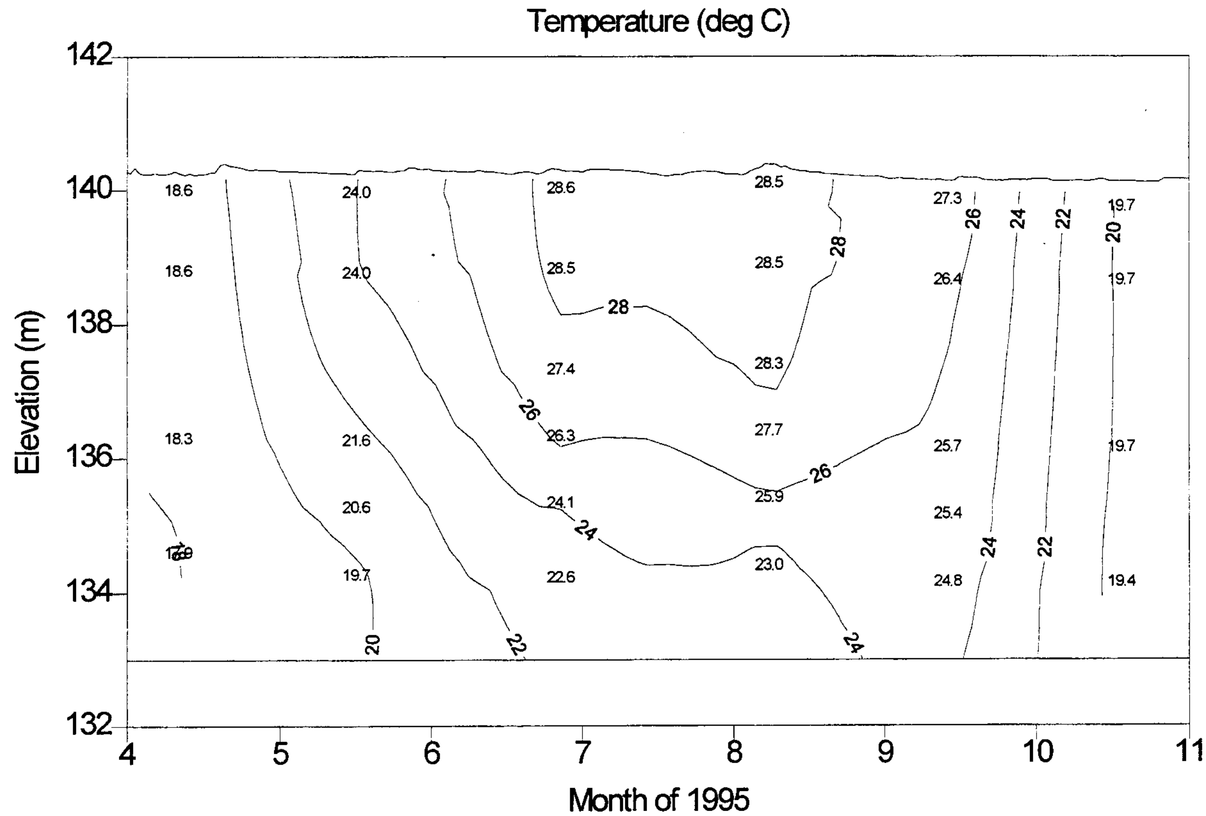
Temperature (deg C)

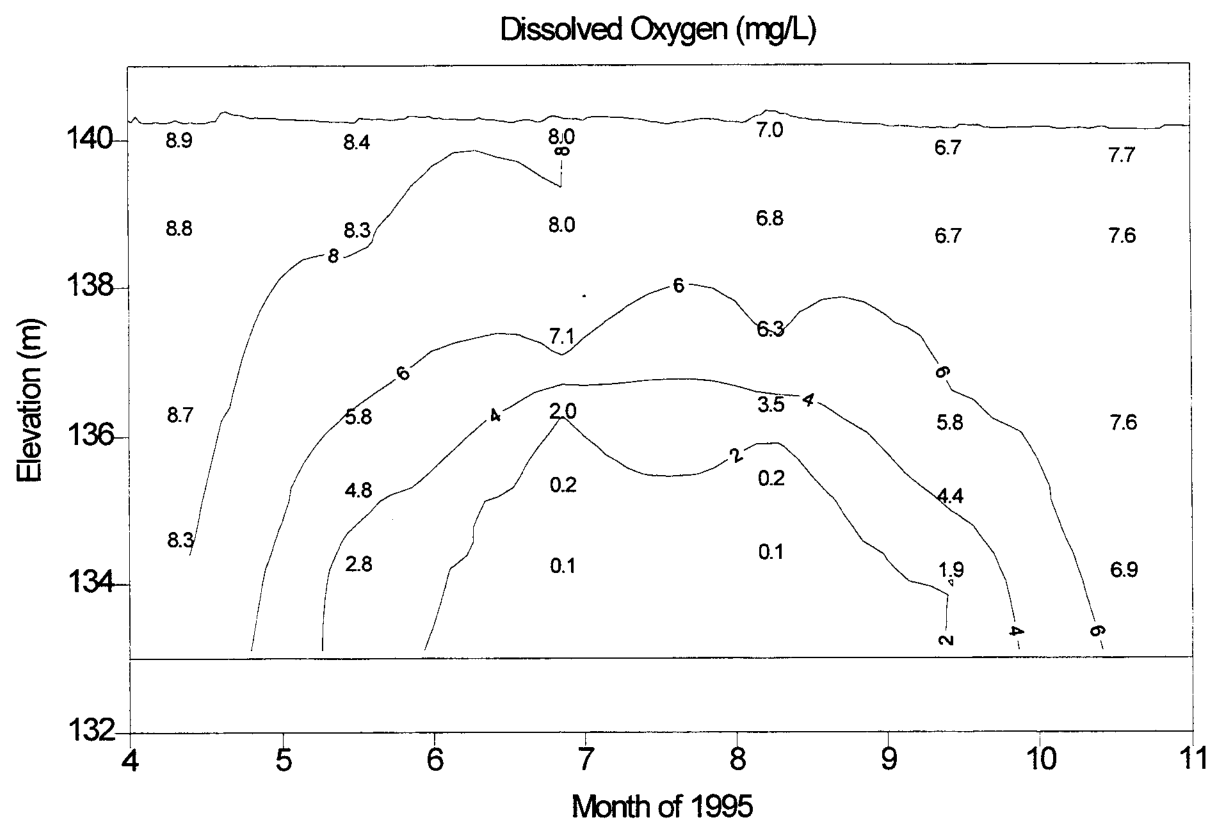


Dissolved Oxygen (mg/L)



Beech Reservoir - BCM 36





Appendix C.

Reservoir Benthic Macroinvertebrate --Mean Density of Each Taxon at Each Sample Location in 1995

Results from Field-Processed Samples - 1995

OBS	STREAM	STREAMMI	STREAMMI	SAMCNT	SITECNT	SUMAREA	LATD	LATM	LATS	LONGD	LONGM
1	BEAR CR	75.0	75.0	10	1	0.60	34	23	56	87	58
2	BEECH R	36.0	36.0	10	2	0.60	35	40	31	88	25
3	TOCCOA R	54.1	54.1	10	3	0.60	34	52	12	84	16
4	S FK HOLSTON R	19.0	19.0	10	4	0.60	36	26	18	82	26
5	S FK HOLSTON R	27.0	27.0	10	5	0.60	36	28	9	82	20
6	WATAUGA R	6.5	6.5	10	6	0.60	36	24	48	82	22
7	CEDAR CR	25.2	25.2	10	7	0.60	34	32	14	87	57
8	HOLSTON R	53.0	53.0	10	8	0.60	36	10	1	83	29
9	HOLSTON R	91.0	91.0	20	9	1.20	36	21	29	83	10
10	TENNESSEE	472.3	472.3	10	10	0.60	35	6	13	85	12
11	TENNESSEE	490.5	490.5	10	11	0.60	35	17	55	85	4
12	TENNESSEE	518.0	518.0	20	12	2.15	35	32	16	84	52
13	HIWASSEE R	8.5	8.5	10	13	0.60	35	21	38	84	53
14	FRENCH BROAD R	33.0	33.0	10	14	0.60	35	57	52	83	31
15	FRENCH BROAD R	51.0	51.0	10	15	0.60	35	59	49	83	15
16	LITTLE TENNESSEE R	62.0	62.0	10	16	0.60	35	27	2	83	47
17	TENNESSEE	605.5	605.5	10	17	0.60	35	45	46	84	12
18	TENNESSEE	624.6	624.6	10	18	0.60	35	49	49	84	3
19	TENNESSEE	652.0	652.0	10	19	1.10	35	57	31	83	51
20	LITTLE R	1.5	1.5	10	20	0.60	.	.	.	.	.
21	S FK HOLSTON R	8.7	8.7	10	21	0.60	36	30	10	82	30
22	TENNESSEE	23.0	23.0	10	22	0.60	37	0	12	88	15
23	TENNESSEE	85.0	85.0	10	23	0.60	36	12	33	87	56
24	TENNESSEE	200.0	200.0	10	24	1.10	35	7	39	88	18
25	BIG SANDY R	7.4	7.4	10	25	0.60	36	20	31	88	5
26	LITTLE BEAR CR	12.5	12.5	10	26	0.60	34	27	14	87	58
27	TENNESSEE	425.5	425.5	20	27	1.20	35	0	3	85	36
28	TENNESSEE	469.0	469.0	10	28	1.10	35	5	46	85	15
29	DUCK R	249.5	249.5	20	29	1.20	35	28	21	86	14
30	CLINCH R	80.4	80.4	20	30	1.20	36	13	46	84	5
31	CLINCH R	125.0	125.0	10	31	0.60	36	21	37	83	41
32	POWELL R	30.0	30.0	10	32	0.60	36	24	36	83	50
33	NOTTELY R	23.5	23.5	10	33	0.60	34	56	17	84	5
34	NOTTELY R	31.0	31.0	20	34	1.20	34	54	31	84	2
35	OCOEE R	12.5	12.5	20	35	1.20	35	5	54	84	38
36	LITTLE TENNESSEE R	1.0	1.0	10	36	0.60	35	46	21	84	15
37	LITTLE TENNESSEE R	15.0	15.0	20	37	1.20	35	38	0	84	15
38	ELK R	135.0	135.0	10	38	0.60	35	13	4	86	16
39	ELK R	150.0	150.0	10	39	0.60	35	12	58	86	11
40	TENNESSEE	277.0	277.0	10	40	0.60	34	48	42	87	20
41	TENNESSEE	295.9	295.9	10	41	0.60	34	40	58	87	6
42	TENNESSEE	347.0	347.0	10	42	1.10	34	26	24	86	25
43	ELK R	6.0	6.0	20	43	1.20	34	48	53	87	12

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	BEAR C
STREAM	BEAR C
STREAMMI	75.0
SPECIES	
Oligochaeta	
Oligochaetes	13
Insecta	
Diptera	
Chironomidae	
Chironomids	213
Number of samples	10
Sum	226
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	BEECH
STREAM	BEECH
STREAMMI	36.0
SPECIES	
Oligochaeta	
Oligochaetes	35
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia (>10mm)	3
Megaloptera	
Sialidae	
Sialis sp.	3
Diptera	
Chironomidae	
Chironomids	535
Number of samples	10
Sum	576
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	BLUE R
STREAM	TOCCOA
STREAMMI	54.1
SPECIES	
Oligochaeta	
Oligochaetes	285
Crustacea	
Amphipoda	8
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia (<=10mm)	10
Hexagenia (>10mm)	38
Diptera	
Chironomidae	
Chironomids	95
Coleoptera	7
Bivalvia	
Veneroida	
Sphaeriidae	
Fingernail clams	98
Number of samples	10
Sum	541
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA STREAM STREAMMI	BOONE S FK H 19.0	BOONE S FK H 27.0	BOONE WATAUG 6.5
SPECIES			
Oligochaeta			
Oligochaetes	425	195	178
Hirudinea	2	.	.
Insecta			
Diptera			
Chironomidae			
Chironomids	2	70	8
Bivalvia			
Veneroida			
Corbiculidae			
Corbicula (>10mm)	.	.	2
Number of samples	10	10	10
Sum	429	265	188
Sum of area	0.60	0.60	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	CEDAR
STREAM	CEDAR
STREAMMI	25.2
SPECIES	
Oligochaeta	
Oligochaetes	3
Insecta	
Diptera	
Chironomidae	
Chironomids	72
Number of samples	10
Sum	75
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	CHEROK
STREAM	HOLSTO
STREAMMI	53.0
SPECIES	
Oligochaeta	
Oligochaetes	193
Insecta	
Diptera	
Chironomidae	
Chironomids	290
Number of samples	10
Sum	483
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

SPECIES		CHICKA	CHICKA	CHICKA	CHICKA
	RESVORNA	CHICKA	CHICKA	CHICKA	CHICKA
	STREAM	TENNE	TENNE	TENNE	HIWASS
	STREAMMI	472.3	490.5	518.0	8.5
Turbellaria					
Tricladida					
Planariidae		.	.	23	.
Oligochaeta					
Oligochaetes		83	117	5	158
Crustacea					
Amphipoda		.	.	77	.
Insecta					
Odonata					
Aeshnidae		.	2	.	.
Ephemeroptera					
Mayflies		.	.	1	.
Ephemeridae					
Hexagenia (<=10mm)		5	5	.	38
Hexagenia (>10mm)		7	48	.	52
Trichoptera					
Caddisflies		.	.	26	.
Diptera					
Chironomidae					
Chironomids		177	158	4	157
Gastropoda					
Snails		13	.	23	3
Bivalvia					
Unionoida					
Unionidae					
Fusconaia ebena		.	.	.	.
Leptodea fragilis		.	.	.	2
Veneroida					
Corbiculidae					
Corbicula (<=10mm)		2	18	13	23
Corbicula (>10mm)		272	63	30	.
Sphaeriidae					
Fingernail clams		12	33	9	48
Number of samples		10	10	20	10
Sum		571	444	211	481
Sum of area		0.60	0.60	2.15	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA / STREAM / STREAMMI	DOUGLA FRENCH 33.0	DOUGLA FRENCH 51.0
SPECIES		
Oligochaeta		
Oligochaetes	130	50
Insecta		
Diptera		
Chironomidae		
Chironomids	48	118
Number of samples	10	10
Sum	178	168
Sum of area	0.60	0.60

VS 95 DENSITY/SQ.METER BY SITE

	FONTAN
RESVORNA	FONTAN
STREAM	LITTLE
STREAMMI	62.0
SPECIES	
Oligochaeta	
Oligochaetes	17
Crustacea	
Amphipoda	3
Number of samples	10
Sum	20
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA STREAM STREAMMI	FORT L TENNE 605.5	FORT L TENNE 624.6	FORT L TENNE 652.0	FORT L LITTLE 1.5
SPECIES				
Oligochaeta				
Oligochaetes	112	62	38	32
Hirudinea	.	2	.	.
Crustacea				
Amphipoda	.	.	5	.
Insecta				
Ephemeroptera				
Ephemeridae				
Hexagenia (>10mm)	2	47	.	.
Diptera				
Chironomidae				
Chironomids	167	228	27	187
Coleoptera	.	.	1	.
Gastropoda				
Basommatophora				
Ancylidae	.	.	1	.
Bivalvia				
Veneroida				
Corbiculidae				
Corbicula (<=10mm)	10	18	13	5
Sphaeriidae				
Fingernail clams	.	10	.	.
Number of samples	10	10	10	10
Sum	291	367	85	224
Sum of area	0.60	0.60	1.10	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	FORT P
STREAM	S FK H
STREAMMI	8.7
SPECIES	
Oligochaeta	
Oligochaetes	108
Insecta	
Diptera	
Chironomidae	
Chironomids	33
Number of samples	10
Sum	141
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA / STREAM / STREAMMI	KENTUC TENNE 23.0	KENTUC TENNE 85.0	KENTUC TENNE 200.0	KENTUC BIG SA 7.4
SPECIES				
Oligochaeta				
Oligochaetes	65	10	1	72
Hirudinea	.	2	.	2
Insecta				
Ephemeroptera				
Ephemeridae				
Hexagenia (<=10mm)	.	2	.	.
Hexagenia (>10mm)	3	123	.	.
Diptera				
Ceratopogonidae	5	.	.	7
Chironomidae				
Chironomids	165	67	.	710
Gastropoda				
Snails	52	7	25	2
Bivalvia				
Mussels	.	.	1	.
Unionoida				
Unionidae				
Cyclonaias tuberculata	.	.	2	.
Fusconaia ebena	.	2	7	.
Quadrula pustulosa pustulo	.	.	2	.
Truncilla donaciformis	.	.	1	.
Veneroida				
Corbiculidae				
Corbicula (<=10mm)	12	265	53	.
Corbicula (>10mm)	397	15	1	.
Dreissenidae				
Dreissena polymorpha	.	.	1	.
Sphaeriidae				
Fingernail clams	55	18	.	68
Number of samples	10	10	10	10
Sum	754	511	94	861
Sum of area	0.60	0.60	1.10	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	LITTLE
STREAM	LITTLE
STREAMMI	12.5
SPECIES	
Oligochaeta	
Oligochaetes	88
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia (>10mm)	2
Diptera	
Chironomidae	
Chironomids	42
Number of samples	10
Sum	132
Sum of area	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA STREAM STREAMMI	NICKAJ TENNE 425.5	NICKAJ TENNE 469.0
SPECIES		
Turbellaria		
Tricladida		
Planariidae	.	66
Oligochaeta		
Oligochaetes	59	21
Hirudinea	1	8
Crustacea		
Amphipoda	3	12
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia (<=10mm)	16	.
Hexagenia (>10mm)	68	.
Trichoptera		
Caddisflies	.	490
Diptera		
Chironomidae		
Chironomids	126	4
Gastropoda		
Snails	.	118
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula (<=10mm)	7	305
Corbicula (>10mm)	69	48
Sphaeriidae		
Fingernail clams	22	38
Number of samples	20	10
Sum	371	1110
Sum of area	1.20	1.10

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	NORMAN
STREAM	DUCK R
STREAMMI	249.5
SPECIES	
Oligochaeta	
Oligochaetes	57
Insecta	
Diptera	
Chironomidae	
Chironomids	9
Number of samples	20
Sum	66
Sum of area	1.20

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	NORRIS	NORRIS	NORRIS
STREAM	CLINCH	CLINCH	POWELL
STREAMMI	80.4	125.0	30.0
SPECIES			
Oligochaeta			
Oligochaetes	304	47	52
Insecta			
Ephemeroptera			
Ephemeridae			
Hexagenia (>10mm)	1	.	.
Diptera			
Chironomidae			
Chironomids	.	143	40
Bivalvia			
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	8	.	.
Corbicula (>10mm)	71	.	.
Sphaeriidae			
Fingernail clams	3	13	23
Number of samples	20	10	10
Sum	387	203	115
Sum of area	1.20	0.60	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	NOTTEL	NOTTEL
STREAM	NOTTEL	NOTTEL
STREAMMI	23.5	31.0
SPECIES		
Oligochaeta		
Oligochaetes	102	17
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia (>10mm)	.	1
Megaloptera		
Sialidae		
Sialis sp.	.	1
Diptera		
Chironomidae		
Chironomids	127	215
Number of samples	10	20
Sum	229	234
Sum of area	0.60	1.20

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	PARKSV
STREAM	OCOEE
STREAMMI	12.5
SPECIES	
Oligochaeta	
Oligochaetes	66
Crustacea	
Amphipoda	16
Insecta	
Megaloptera	
Sialidae	
Sialis sp.	1
Diptera	
Chironomidae	
Chironomids	3
Number of samples	20
Sum	86
Sum of area	1.20

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA STREAM STREAMMI	TELLIC LITTLE 1.0	TELLIC LITTLE 15.0
SPECIES		
Oligochaeta		
Oligochaetes	52	21
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia (>10mm)	.	6
Megaloptera		
Sialidae		
Sialis sp.	.	1
Diptera		
Chironomidae		
Chironomids	10	42
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula (<=10mm)	2	.
Number of samples	10	20
Sum	64	70
Sum of area	0.60	1.20

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA	TIMS F	TIMS F
STREAM	ELK R	ELK R
STREAMMI	135.0	150.0
SPECIES		
Oligochaeta		
Oligochaetes	145	22
Insecta		
Diptera		
Chironomidae		
Chironomids	3	8
Number of samples	10	10
Sum	148	30
Sum of area	0.60	0.60

VS 95 DENSITY/SQ.METER BY SITE

RESVORNA STREAM STREAMMI	WHEELE TENNE 277.0	WHEELE TENNE 295.9	WHEELE TENNE 347.0	WHEELE ELK R 6.0
SPECIES				
Oligochaeta				
Oligochaetes	37	13	3	103
Hirudinea	5	2	5	1
Crustacea				
Amphipoda	.	3	.	.
Insecta				
Ephemeroptera				
Mayflies	.	.	1	.
Ephemeridae				
Hexagenia (<=10mm)	.	7	.	.
Hexagenia (>10mm)	.	47	.	.
Diptera				
Ceratopogonidae	.	.	.	11
Chironomidae				
Chironomids	180	37	.	108
Gastropoda				
Snails	.	17	65	.
Basommatophora				
Ancylidae				
Ferrissia sp.	.	.	35	.
Bivalvia				
Unionoida				
Unionidae				
Cyclonaias tuberculata	.	.	1	.
Obliquaria reflexa	.	.	1	.
Quadrula pustulosa pustulo	.	.	1	.
Veneroida				
Corbiculidae				
Corbicula (<=10mm)	.	7	227	.
Corbicula (>10mm)	10	47	69	.
Sphaeriidae				
Fingernail clams	7	3	3	6
Number of samples	10	10	10	20
Sum	239	183	411	229
Sum of area	0.60	0.60	1.10	1.20

Results from Lab-Processed Sampl

The SAS System 10:44 We

OBS	STREAM	STREAMMI	STREAMMI	SAMCNT	SITECNT	SUMAREA	LATD	LATM
1	HOLSTON R	91.0	91.0	10	1	0.60	36	21
2	TENNESSEE	518.0	518.0	10	2	1.05	35	32
3	TENNESSEE	425.5	425.5	10	3	0.60	35	0
4	DUCK R	249.5	249.5	10	4	0.60	35	28
5	CLINCH R	80.4	80.4	10	5	0.60	36	13
6	NOTTELY R	31.0	31.0	10	6	0.60	34	54
7	OCOEE R	12.5	12.5	10	7	0.60	35	5
8	LITTLE TENNESSEE R	15.0	15.0	10	8	0.60	35	38
9	ELK R	6.0	6.0	10	9	0.60	34	48

VS 95 NUMBERS COLLECTED/SITE

RESVORNA	CHEROK
STREAM	HOLSTO
STREAMMI	91.0
SPECIES	
Nematoda	1
Oligochaeta	
Haplotaxida	
Tubificidae	48
Branchiura sowerbyi	3
Limnodrilus hoffmeisteri	20
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia limbata	1
Diptera	
Chironomidae	1
Ablabesmyia annulata	2
Chironomus sp.	163
Coelotanypus sp.	1
Cryptochironomus fulvus	6
Procladius sp.	3
Arachnoidea	
Hydrachnellae	
Limnesiidae	
Limnesia sp.	2
Bivalvia	
Veneroida	
Sphaeriidae	1
Number of samples	10
Sum	252
Number of species	13
Number of ept taxa	1
Sum of area	0.60

VS 95 NUMBERS COLLECTED/SITE

	RESVORNA STREAM STREAMMI	CHICKA TENNE 518.0
SPECIES		
Hydrozoa		
Hydroida		
Hydridae		
Hydra americana		6
Turbellaria		
Tricladida		
Planariidae		
Dugesia tigrina		26
Oligochaeta		
Haplotaxida		
Tubificidae		31
Limnodrilus hoffmeisteri		1
Hirudinea		1
Crustacea		
Amphipoda		
Crangonyctidae		
Crangonyx sp.		4
Gammaridae		
Gammarus sp.		10
Gammarus minus		104
Insecta		
Ephemeroptera		
Heptageniidae		
Stenacron sp.		2
Trichoptera		
Leptoceridae		
Oecetis sp.		2
Polycentropodidae		
Cyrnellus fraternus		51
Diptera		
Chironomidae		2
Coelotanypus sp.		1
Coelotanypus tricolor		6
Cryptochironomus fulvus		2
Dicrotendipes sp.		3
Nanocladius sp.		1
Parachironomus sp.		1
Xenochironomus sp.		1
Gastropoda		
Mesogastropoda		
Pleuroceridae		
Pleurocera sp.		3
Pleurocera canaliculata		9
Basommatophora		
Ancylidae		
Ferrissia rivularis		5
Planorbidae		5
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea		52
Sphaeriidae		
Musculium transversum		7
Number of samples		10
Sum		336
Number of species		25
Number of ept taxa		3
Sum of area		1.05

VS 95 NUMBERS COLLECTED/SITE

SPECIES	RESVORNA STREAM STREAMMI	NICKAJ TENNE 425.5
Oligochaeta		
Haplotaxida		
Tubificidae		98
Branchiura sowerbyi		4
Limnodrilus hoffmeisteri		13
Hirudinea		
Rhynchobdellida		
Glossiphoniidae		
Helobdella sp.		3
Crustacea		
Amphipoda		
Gammaridae		
Gammarus sp.		2
Talitridae		
Hyalella azteca		1
Insecta		
Ephemeroptera		
Caenidae		
Caenis sp.		1
Ephemeridae		
Hexagenia limbata		42
Heptageniidae		
Stenacron interpunctatum		1
Trichoptera		
Hydropsychidae		
Cheumatopsyche sp.		1
Diptera		
Chironomidae		4
Ablabesmyia annulata		25
Ablabesmyia mallochi		1
Chironomus sp.		21
Coelotanypus tricolor		88
Cryptochironomus fulvus		2
Procladius sp.		1
Gastropoda		
Basommatophora		
Planorbidae		2
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea		43
Sphaeriidae		3
Musculium sp.		4
Musculium transversum		12
Number of samples		10
Sum		372
Number of species		22
Number of ept taxa		4
Sum of area		0.60

VS 95 NUMBERS COLLECTED/SITE

RESVORNA	NORMAN
STREAM	DUCK R
STREAMMI	249.5
SPECIES	
Nematoda	4
Oligochaeta	
Haplotaxida	
Tubificidae	157
Limnodrilus hoffmeisteri	5
Insecta	
Diptera	
Chironomidae	
Chironomus sp.	16
Number of samples	10
Sum	182
Number of species	4
Number of ept taxa	0
Sum of area	0.60

VS 95 NUMBERS COLLECTED/SITE

	RESVORNA STREAM STREAMMI	NORRIS CLINCH 80.4
SPECIES		
Nematoda		1
Oligochaeta		
Haplotaxida		
Tubificidae		295
Limnodrilus hoffmeisteri		105
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata		2
Diptera		
Chironomidae		
Chironomus sp.		2
Cryptochironomus fulvus		2
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea		61
Sphaeriidae		
Pisidium sp.		4
Number of samples		10
Sum		472
Number of species		8
Number of ept taxa		1
Sum of area		0.60

VS 95 NUMBERS COLLECTED/SITE

RESVORNA	NOTTEL
STREAM	NOTTEL
STREAMMI	31.0
SPECIES	
Oligochaeta	
Haplotaxida	
Naididae	
Nais sp.	6
Tubificidae	90
Limnodrilus hoffmeisteri	17
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia sp.	4
Heptageniidae	
Stenacron sp.	1
Trichoptera	
Leptoceridae	
Oecetis sp.	1
Megaloptera	
Sialidae	
Sialis sp.	1
Diptera	
Ceratopogonidae	
Bezzia sp.	4
Chironomidae	4
Chironomus sp.	234
Cricotopus bicinctus	2
Cryptochironomus fulvus	9
Cryptotendipes sp.	1
Microtendipes sp.	1
Polypedilum illinoense	3
Procladius sp.	11
Stempellina sp.	1
Stictochironomus sp.	1
Stictochironomus devinctus	11
Tanytarsus sp.	3
Bivalvia	
Veneroida	
Corbiculidae	
Corbicula fluminea	2
Number of samples	10
Sum	407
Number of species	21
Number of ept taxa	3
Sum of area	0.60

VS 95 NUMBERS COLLECTED/SITE

	PARKSV
RESVORNA	PARKSV
STREAM	OCOEE
STREAMMI	12.5
SPECIES	
Oligochaeta	
Haplotaxida	
Naididae	1
Tubificidae	61
Limnodrilus hoffmeisteri	30
Crustacea	
Amphipoda	
Crangonyctidae	
Crangonyx sp.	13
Insecta	
Megaloptera	
Sialidae	
Sialis sp.	1
Diptera	
Chironomidae	
Polypedilum halterale	1
Procladius sp.	4
Number of samples	10
Sum	111
Number of species	7
Number of ept taxa	0
Sum of area	0.60

VS 95 NUMBERS COLLECTED/SITE

RESVORNA	TELLIC
STREAM	LITTLE
STREAMMI	15.0
SPECIES	
Nematoda	2
Oligochaeta	
Haplotaxida	
Naididae	
Dero sp.	5
Tubificidae	66
Branchiura sowerbyi	5
Limnodrilus hoffmeisteri	3
Crustacea	
Amphipoda	
Crangonyctidae	
Crangonyx sp.	7
Insecta	
Ephemeroptera	
Ephemeridae	
Hexagenia limbata	6
Megaloptera	
Sialidae	
Sialis sp.	1
Diptera	
Ceratopogonidae	
Bezzia sp.	1
Chironomidae	1
Ablabesmyia annulata	8
Ablabesmyia sp.	2
Chironomus sp.	55
Procladius sp.	10
Pseudochironomus sp.	1
Stictochironomus sp.	1
Zalutschia zalutschicola	14
Number of samples	10
Sum	188
Number of species	17
Number of ept taxa	1
Sum of area	0.60

VS 95 NUMBERS COLLECTED/SITE

RESVORNA	WHEELE
STREAM	ELK R
STREAMMI	6.0
SPECIES	
Oligochaeta	
Haplotaxida	
Tubificidae	179
Branchiura sowerbyi	14
Limnodrilus hoffmeisteri	25
Lumbriculida	
Lumbriculidae	1
Insecta	
Diptera	
Ceratopogonidae	
Bezzia sp.	10
Chironomidae	
Chironomus sp.	73
Coelotanypus sp.	38
Coelotanypus tricolor	29
Cryptochironomus fulvus	7
Microtendipes sp.	1
Procladius sp.	14
Gastropoda	
Mesogastropoda	
Pleuroceridae	
Pleurocera sp.	2
Pleurocera canaliculata	4
Viviparidae	
Viviparus georgianus	1
Bivalvia	
Veneroida	
Sphaeriidae	
Musculium sp.	1
Musculium transversum	1
Number of samples	10
Sum	400
Number of species	16
Number of ept taxa	0
Sum of area	0.60

Appendix D.

Results and Ratings for Individual Metrics and Final RFAI Score for Each Sample Location in 1995

Table 1. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Beech Lake Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		14	3
2. Piscivore species		5	3
3. Sunfish species		4	5
4. Sucker species		0	1
5. Intolerant species		1	1
6. Percent tolerant species	electrofishing	32.3%	0.5
	gill netting	50.0%	0.5
7. Dominance *	electrofishing	34.5%	2.5
	gill netting	45.8%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	32.3%	0.5
	gill netting	60.2%	0.5
9. Percent insectivores	electrofishing	32.6%	0.5
	gill netting	5.9%	1.5
C. Reproductive composition			
10. Lithophilic spawning species		1	1
D. Fish abundance and health			
11. Average number of individuals		21.9	0.5
	gill netting	11.8	1.5
12. Percent anomalies		2.3%	3
RFAI			27 poor

* Percent composition of most abundant species.

Table 2. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Bear Creek Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		22	5
2. Piscivore species		6	3
3. Sunfish species		4	5
4. Sucker species		8	5
5. Intolerant species		2	3
6. Percent tolerant species	electrofishing	43.4%	0.5
	gill netting	51.7%	0.5
7. Dominance *	electrofishing	40.7%	1.5
	gill netting	51.7%	0.5
B. Trophic composition			
8. Percent omnivores	electrofishing	42.5%	0.5
	gill netting	79.3%	0.5
9. Percent insectivores	electrofishing	35.3%	0.5
	gill netting	7.8%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		6	3
D. Fish abundance and health			
11. Average number of individuals		14.7	0.5
	gill netting	11.6	1.5
12. Percent anomalies		0.5%	5
RFAI			38 fair

* Percent composition of most abundant species.

Table 3. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Blue Ridge Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		19	5
2. Piscivore species		7	5
3. Sunfish species		4	5
4. Sucker species		3	3
5. Intolerant species		2	3
6. Percent tolerant species	electrofishing	15.9%	1.5
	gill netting	14.3%	1.5
7. Dominance *	electrofishing	46.8%	1.5
	gill netting	31.4%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	0.0%	2.5
	gill netting	25.7%	1.5
9. Percent insectivores	electrofishing	65.1%	0.5
	gill netting	11.4%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		5	5
D. Fish abundance and health			
11. Average number of individuals		30.2	1.5
	gill netting	3.5	0.5
12. Percent anomalies		2.1%	3
RFAI			44 good

* Percent composition of most abundant species.

Table 4. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Boone Reservoir.

Metric		Transition South Fork of The Holston		Transition Watauga		Forebay	
		Obs.	Score	Obs.	Score	Obs.	Score
A. Species richness and composition							
1. Number of species		16	3	16	3	18	3
2. Piscivore species		7	5	7	5	8	5
3. Sunfish species		1	1	3	3	4	5
4. Sucker species		2	1	3	3	2	1
5. Intolerant species		0	1	2	3	2	3
6. Percent tolerant species	electrofishing	55.4%	0.5	22.5%	1.5	79.5%	0.5
	gill netting	46.8%	1.5	47.7%	1.5	31.6%	1.5
7. Dominance *	electrofishing	45.3%	1.5	52.2%	1.5	77.0%	0.5
	gill netting	20.1%	2.5	40.7%	1.5	21.1%	2.5
B. Trophic composition							
8. Percent omnivores	electrofishing	55.6%	0.5	22.8%	1.5	79.2%	0.5
	gill netting	48.2%	1.5	66.3%	0.5	56.8%	1.5
9. Percent insectivores	electrofishing	28.7%	0.5	53.8%	1.5	8.7%	0.5
	gill netting	0.0%	0.5	9.3%	2.5	1.1%	0.5
C. Reproductive composition							
10. Lithophilic spawning species		2	1	3	3	2	3
D. Fish abundance and health							
11. Average number of individuals		27.2	0.5	43.5	1.5	42.3	1.5
	gill netting	13.9	0.5	8.6	0.5	9.5	0.5
12. Percent anomalies		1.3%	5	0.8%	5	1.0%	5
RFAI			27 poor		39 fair		35 fair

* Percent composition of most abundant species.

Table 5. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Cedar Creek Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		25	5
2. Piscivore species		10	5
3. Sunfish species		4	5
4. Sucker species		4	3
5. Intolerant species		3	5
6. Percent tolerant species	electrofishing	26.5%	1.5
	gill netting	25.7%	1.5
7. Dominance *	electrofishing	46.3%	1.5
	gill netting	33.3%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	27.5%	0.5
	gill netting	43.8%	1.5
9. Percent insectivores	electrofishing	57.7%	0.5
	gill netting	35.2%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		6	3
D. Fish abundance and health			
11. Average number of individuals		19.9	0.5
	gill netting	10.5	1.5
12. Percent anomalies		1.3%	5
RFAI			44 good

* Percent composition of most abundant species.

Table 6. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Cherokee Reservoir.

Metric		Transition Obs.	Transition Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		24	5	22	5
2. Piscivore species		10	5	10	5
3. Sunfish species		1	1	2	3
4. Sucker species		4	3	4	3
5. Intolerant species		1	1	1	1
6. Percent tolerant species	electrofishing	51.1%	0.5	15.4%	1.5
	gill netting	35.4%	1.5	26.6%	2.5
7. Dominance *	electrofishing	49.6%	1.5	53.4%	1.5
	gill netting	27.1%	2.5	42.5%	1.5
B. Trophic composition					
8. Percent omnivores	electrofishing	51.7%	0.5	15.4%	1.5
	gill netting	70.3%	0.5	73.4%	0.5
9. Percent insectivores	electrofishing	38.3%	0.5	58.1%	0.5
	gill netting	2.6%	0.5	0.9%	0.5
C. Reproductive composition					
10. Lithophilic spawning species		4	3	5	5
D. Fish abundance and health					
11. Average number of individuals		67.7	1.5	19.9	0.5
	gill netting	19.2	1.5	21.4	1.5
12. Percent anomalies		2.8%	3	2.4%	3
RFAI			32 fair		37 fair

* Percent composition of most abundant species.

Table 7. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Chickamauga Reservoir.

Metric		Inflow Obs.	Inflow Score	Transition Obs.	Transition Score	Forebay Obs.	Forebay Score	Embayment Obs.	Embayment Score
A. Species richness and composition									
1. Number of species		29	5	31	5	28	5	29	3
2. Piscivore species		11	5	11	5	10	5	11	5
3. Sunfish species		5	5	6	5	5	5	2	3
4. Sucker species		4	3	2	1	3	1	4	3
5. Intolerant species		3	3	3	3	3	3	2	3
6. Percent tolerant species	electrofishing	51.1%	3	15.8%	2.5	4.5%	2.5	58.1%	0.5
	gill netting	.	.	19.9%	2.5	9.8%	2.5	21.5%	1.5
7. Dominance *	electrofishing	49.8%	3	39.5%	2.5	70.9%	0.5	55.3%	1.5
	gill netting	.	.	28.0%	2.5	18.6%	2.5	23.5%	2.5
B. Trophic composition									
8. Percent omnivores	electrofishing	52.7%	3	15.9%	2.5	5.2%	2.5	58.5%	0.5
	gill netting	.	.	25.7%	2.5	19.7%	2.5	30.2%	1.5
9. Percent insectivores	electrofishing	31.8%	3	80.2%	2.5	88.5%	2.5	38.1%	1.5
	gill netting	.	.	10.5%	1.5	10.9%	1.5	26.8%	2.5
C. Reproductive composition									
10. Lithophilic spawning species		8	5	6	3	7	5	10	5
D. Fish abundance and health									
11. Average number of individuals		105.7	5	146.4	2.5	66.3	1.5	99.9	1.5
	gill netting	.	.	29.6	1.5	18.3	1.5	14.9	0.5
12. Percent anomalies		5.5%	1	1.9%	5	3.7%	3	3.8%	3
RFAI			44 good		50 good		47 good		39 fair

* Percent composition of most abundant species.

Table 8. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Douglas Reservoir.

Metric		Transition Obs.	Transition Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		23	5	23	5
2. Piscivore species		9	5	10	5
3. Sunfish species		3	3	3	3
4. Sucker species		4	3	6	5
5. Intolerant species		0	1	1	1
6. Percent tolerant species	electrofishing	25.5%	1.5	28.4%	1.5
	gill netting	41.3%	1.5	44.0%	1.5
7. Dominance *	electrofishing	32.0%	2.5	42.5%	1.5
	gill netting	37.3%	1.5	43.3%	1.5
B. Trophic composition					
8. Percent omnivores	electrofishing	26.2%	0.5	27.4%	0.5
	gill netting	69.3%	0.5	57.5%	1.5
9. Percent insectivores	electrofishing	21.7%	0.5	55.2%	0.5
	gill netting	14.2%	2.5	5.2%	1.5
C. Reproductive composition					
10. Lithophilic spawning species		5	3	7	5
D. Fish abundance and health					
11. Average number of individuals		52.7	1.5	38.7	0.5
	gill netting	22.5	1.5	13.4	0.5
12. Percent anomalies		3.8%	3	12.6%	1
RFAI			37 fair		36 fair

* Percent composition of most abundant species.

Table 9. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Fontana Reservoir.

Metric		Transition Little Tennessee Obs.	Transition Little Tennessee Score	Transition Tuckasegee Obs.	Transition Tuckasegee Score	Forebay Obs.	Forebay Score
A. Species richness and composition							
1. Number of species		16	5	15	3	12	3
2. Piscivore species		6	5	7	5	6	5
3. Sunfish species		2	3	2	3	1	1
4. Sucker species		3	3	1	1	1	1
5. Intolerant species		1	1	1	1	2	3
6. Percent tolerant species	electrofishing	38.8%	0.5	91.9%	0.5	.	.
	gill netting	28.7%	0.5	50.7%	0.5	6.5%	2.5
7. Dominance *	electrofishing	21.2%	2.5	91.0%	0.5	.	.
	gill netting	24.3%	2.5	32.4%	1.5	44.5%	1.5
B. Trophic composition							
8. Percent omnivores	electrofishing	18.8%	0.5	0.9%	2.5	.	.
	gill netting	29.8%	1.5	54.9%	0.5	7.7%	2.5
9. Percent insectivores	electrofishing	48.8%	0.5	92.2%	2.5	.	.
	gill netting	1.1%	0.5	0.0%	0.5	2.6%	0.5
C. Reproductive composition							
10. Lithophilic spawning species		5	5	3	3	3	3
D. Fish abundance and health							
11. Average number of individuals		5.3	0.5	68.1	2.5	.	.
	gill netting	18.1	2.5	7.1	0.5	15.5	1.5
12. Percent anomalies		2.8%	3	0.9%	5	0.6%	5
RFAI			37 fair		33 fair		. MISSING

* Percent composition of most abundant species.

Table 10. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Fort Loudoun Reservoir.

Metric		Inflow Obs.	Inflow Score	Transition Obs.	Transition Score	Forebay Obs.	Forebay Score	Embayment Obs.	Embayment Score
A. Species richness and composition									
1. Number of species		27	3	25	3	30	5	23	3
2. Piscivore species		8	5	10	5	10	5	9	5
3. Sunfish species		3	3	4	3	4	3	2	3
4. Sucker species		7	5	2	1	6	3	4	3
5. Intolerant species		4	3	1	1	2	3	2	3
6. Percent tolerant species	electrofishing	68.6%	1	64.0%	0.5	78.1%	0.5	68.8%	0.5
	gill netting	.	.	43.3%	0.5	37.0%	1.5	26.9%	1.5
7. Dominance *	electrofishing	40.8%	3	57.3%	1.5	73.4%	0.5	65.3%	0.5
	gill netting	.	.	30.9%	1.5	31.0%	1.5	14.8%	2.5
B. Trophic composition									
8. Percent omnivores	electrofishing	68.6%	1	68.2%	0.5	78.9%	0.5	73.2%	0.5
	gill netting	.	.	61.9%	0.5	55.0%	0.5	48.1%	0.5
9. Percent insectivores	electrofishing	21.3%	1	26.5%	0.5	14.2%	0.5	19.6%	0.5
	gill netting	.	.	10.3%	1.5	9.5%	1.5	8.3%	1.5
C. Reproductive composition									
10. Lithophilic spawning species		9	5	5	3	9	5	7	3
D. Fish abundance and health									
11. Average number of individuals		18.5	1	41.5	0.5	45.4	0.5	75.9	1.5
	gill netting	.	.	9.7	0.5	20.0	1.5	10.8	0.5
12. Percent anomalies		5.3%	1	2.7%	3	3.2%	3	1.3%	5
RFAI			32 fair		27 poor		36 fair		35 fair

* Percent composition of most abundant species.

Table 11. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Fort Patrick Henry Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		12	3
2. Piscivore species		5	3
3. Sunfish species		1	1
4. Sucker species		2	1
5. Intolerant species		1	1
6. Percent tolerant species	electrofishing	91.6%	0.5
	gill netting	69.2%	0.5
7. Dominance *	electrofishing	85.8%	0.5
	gill netting	35.9%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	91.6%	0.5
	gill netting	74.4%	0.5
9. Percent insectivores	electrofishing	0.6%	0.5
	gill netting	5.1%	1.5
C. Reproductive composition			
10. Lithophilic spawning species		2	3
D. Fish abundance and health			
11. Average number of individuals		30.9	0.5
	gill netting	3.9	0.5
12. Percent anomalies		5.6%	1
RFAI			20 very poor

* Percent composition of most abundant species.

Table 12. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Kentucky Reservoir.

Metric		Inflow Obs.	Inflow Score	Transition Obs.	Transition Score	Forebay Obs.	Forebay Score	Embayment Obs.	Embayment Score
A. Species richness and composition									
1. Number of species		33	5	31	5	33	5	24	3
2. Piscivore species		13	5	11	5	12	5	11	5
3. Sunfish species		4	3	3	3	4	5	3	3
4. Sucker species		7	3	3	1	5	3	2	1
5. Intolerant species		4	3	5	5	4	3	3	3
6. Percent tolerant species	electrofishing	77.4%	1	85.7%	0.5	93.0%	0.5	74.3%	0.5
	gill netting	.	.	30.4%	1.5	64.1%	0.5	55.3%	0.5
7. Dominance *	electrofishing	76.4%	1	85.1%	0.5	92.5%	0.5	74.3%	0.5
	gill netting	.	.	29.2%	2.5	63.1%	0.5	55.3%	0.5
B. Trophic composition									
8. Percent omnivores	electrofishing	77.9%	1	85.8%	0.5	93.0%	0.5	74.4%	0.5
	gill netting	. . .	.	40.7%	1.5	76.3%	0.5	62.8%	0.5
9. Percent insectivores	electrofishing	11.6%	1	12.4%	0.5	5.3%	0.5	10.2%	0.5
	gill netting	.	.	10.6%	1.5	6.5%	1.5	14.2%	1.5
C. Reproductive composition									
10. Lithophilic spawning species		8	5	8	5	8	5	5	3
D. Fish abundance and health									
11. Average number of individuals		87.5	3	121.2	2.5	198.1	2.5	191.0	2.5
	gill netting	.	.	32.9	1.5	58.2	2.5	25.3	1.5
12. Percent anomalies		0.0%	5	0.0%	5	0.6%	5	5.8%	1
RFAI			36 fair		42 good		41 good		28 poor

* Percent composition of most abundant species.

Table 13. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Little Bear Creek Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		19	3
2. Piscivore species		5	3
3. Sunfish species		4	5
4. Sucker species		5	3
5. Intolerant species		3	5
6. Percent tolerant species	electrofishing	11.6%	2.5
	gill netting	4.2%	2.5
7. Dominance *	electrofishing	32.6%	2.5
	gill netting	43.7%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	14.0%	1.5
	gill netting	16.7%	2.5
9. Percent insectivores	electrofishing	37.2%	0.5
	gill netting	63.5%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		6	3
D. Fish abundance and health			
11. Average number of individuals		5.7	0.5
	gill netting	9.6	0.5
12. Percent anomalies		2.6%	3
RFAI			42 good

* Percent composition of most abundant species.

Table 14. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Nickajack Reservoir.

Metric		Inflow Obs.	Inflow Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		35	5	28	5
2. Piscivore species		11	5	9	5
3. Sunfish species		6	5	6	5
4. Sucker species		6	3	1	1
5. Intolerant species		6	5	3	3
6. Percent tolerant species	electrofishing	22.5%	5	25.2%	1.5
	gill netting	.	.	14.2%	2.5
7. Dominance *	electrofishing	20.4%	5	41.7%	1.5
	gill netting	.	.	17.5%	2.5
B. Trophic composition					
8. Percent omnivores	electrofishing	25.9%	5	13.8%	2.5
	gill netting	.	.	17.5%	2.5
9. Percent insectivores	electrofishing	40.7%	3	74.2%	2.5
	gill netting	.	.	10.8%	1.5
C. Reproductive composition					
10. Lithophilic spawning species		10	5	6	3
D. Fish abundance and health					
11. Average number of individuals		153.1	5	96.0	1.5
	gill netting	.	.	12.0	0.5
12. Percent anomalies		2.6%	3	4.3%	3
RFAI			54 excellent		44 good

* Percent composition of most abundant species.

Table 15. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Normandy Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		26	5
2. Piscivore species		12	5
3. Sunfish species		4	5
4. Sucker species		5	5
5. Intolerant species		5	5
6. Percent tolerant species	electrofishing	41.1%	0.5
	gill netting	27.7%	1.5
7. Dominance *	electrofishing	42.5%	1.5
	gill netting	32.1%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	40.5%	0.5
	gill netting	32.1%	2.5
9. Percent insectivores	electrofishing	55.4%	0.5
	gill netting	8.0%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		9	5
D. Fish abundance and health			
11. Average number of individuals		53.1	1.5
	gill netting	11.2	1.5
12. Percent anomalies		5.9%	1
RFAI			45 good

* Percent composition of most abundant species.

Table 16. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Norris Reservoir.

Metric		Transition Clinch Obs.	Transition Clinch Score	Transition Powell Obs.	Transition Powell Score	Forebay Obs.	Forebay Score
A. Species richness and composition							
1. Number of species		23	5	26	5	17	3
2. Piscivore species		10	5	11	5	6	3
3. Sunfish species		1	1	1	1	2	3
4. Sucker species		5	3	6	3	2	1
5. Intolerant species		1	1	1	1	1	1
6. Percent tolerant species	electrofishing	31.8%	0.5	58.2%	0.5	12.3%	2.5
	gill netting	22.5%	2.5	22.9%	2.5	16.0%	2.5
7. Dominance *	electrofishing	42.0%	1.5	58.2%	1.5	30.8%	2.5
	gill netting	30.0%	2.5	19.4%	2.5	60.0%	0.5
B. Trophic composition							
8. Percent omnivores	electrofishing	31.8%	0.5	58.2%	0.5	31.9%	0.5
	gill netting	30.8%	2.5	22.4%	2.5	16.0%	2.5
9. Percent insectivores	electrofishing	52.7%	1.5	25.7%	0.5	56.0%	0.5
	gill netting	4.2%	1.5	14.7%	2.5	4.0%	1.5
C. Reproductive composition							
10. Lithophilic spawning species		7	5	9	5	3	3
D. Fish abundance and health							
11. Average number of individuals		36.1	0.5	48.9	1.5	24.9	0.5
	gill netting	12.0	0.5	17.0	1.5	5.0	0.5
12. Percent anomalies		1.3%	5	0.6%	5	2.6%	3
RFAI			39 fair		41 good		31 poor

* Percent composition of most abundant species.

Table 17. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Nottely Reservoir.

Metric		Transition Obs.	Transition Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		19	5	18	5
2. Piscivore species		8	5	8	5
3. Sunfish species		4	5	4	5
4. Sucker species		1	1	1	1
5. Intolerant species		1	1	0	1
6. Percent tolerant species	electrofishing	17.1%	1.5	16.5%	1.5
	gill netting	16.6%	1.5	13.6%	1.5
7. Dominance *	electrofishing	56.8%	1.5	70.6%	0.5
	gill netting	25.4%	2.5	55.2%	0.5
B. Trophic composition					
8. Percent omnivores	electrofishing	3.5%	2.5	2.1%	2.5
	gill netting	21.5%	1.5	14.3%	2.5
9. Percent insectivores	electrofishing	71.0%	0.5	85.5%	2.5
	gill netting	1.7%	0.5	0.6%	0.5
C. Reproductive composition					
10. Lithophilic spawning species		3	3	3	3
D. Fish abundance and health					
11. Average number of individuals		52.0	1.5	56.9	1.5
	gill netting	18.1	2.5	15.4	1.5
12. Percent anomalies		9.8%	1	14.0%	1
RFAI			37 fair		36 fair

* Percent composition of most abundant species.

Table 18. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Parksville - Ocoee no 1 Reservoir.

Metric		Forebay Obs.	Forebay Score
A. Species richness and composition			
1. Number of species		17	5
2. Piscivore species		4	3
3. Sunfish species		5	5
4. Sucker species		0	1
5. Intolerant species		1	1
6. Percent tolerant species	electrofishing	6.8%	2.5
	gill netting	6.9%	2.5
7. Dominance *	electrofishing	63.3%	0.5
	gill netting	37.9%	1.5
B. Trophic composition			
8. Percent omnivores	electrofishing	3.4%	2.5
	gill netting	31.0%	0.5
9. Percent insectivores	electrofishing	88.5%	2.5
	gill netting	20.7%	2.5
C. Reproductive composition			
10. Lithophilic spawning species		0	1
D. Fish abundance and health			
11. Average number of individuals		25.6	0.5
	gill netting	2.9	0.5
12. Percent anomalies		1.3%	5
RFAI			37 fair

* Percent composition of most abundant species.

Table 19. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Tellico Reservoir.

Metric		Transition Obs.	Transition Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		20	3	28	5
2. Piscivore species		8	5	10	5
3. Sunfish species		4	3	3	3
4. Sucker species		3	1	3	1
5. Intolerant species		2	3	3	3
6. Percent tolerant species	electrofishing	48.9%	1.5	45.5%	0.5
	gill netting	27.3%	1.5	28.6%	1.5
7. Dominance *	electrofishing	39.7%	2.5	41.4%	1.5
	gill netting	24.2%	2.5	48.8%	1.5
B. Trophic composition					
8. Percent omnivores	electrofishing	46.6%	1.5	44.4%	1.5
	gill netting	51.5%	0.5	38.5%	1.5
9. Percent insectivores	electrofishing	32.8%	1.5	41.4%	1.5
	gill netting	9.1%	1.5	1.4%	0.5
C. Reproductive composition					
10. Lithophilic spawning species		4	3	9	5
D. Fish abundance and health					
11. Average number of individuals		8.7	0.5	29.1	0.5
	gill netting	3.3	0.5	21.3	1.5
12. Percent anomalies		1.5%	5	3.0%	3
RFAI			37 fair		37 fair

* Percent composition of most abundant species.

Table 20. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Tims Ford Reservoir.

Metric		Transition Obs.	Transition Score	Forebay Obs.	Forebay Score
A. Species richness and composition					
1. Number of species		26	5	17	3
2. Piscivore species		11	5	7	5
3. Sunfish species		3	3	3	3
4. Sucker species		7	5	2	1
5. Intolerant species		3	5	1	1
6. Percent tolerant species	electrofishing	5.1%	2.5	5.5%	2.5
	gill netting	26.3%	1.5	10.3%	2.5
7. Dominance *	electrofishing	52.2%	1.5	58.6%	1.5
	gill netting	14.5%	2.5	41.0%	1.5
B. Trophic composition					
8. Percent omnivores	electrofishing	6.9%	2.5	2.2%	2.5
	gill netting	46.1%	1.5	59.0%	1.5
9. Percent insectivores	electrofishing	85.5%	2.5	94.2%	2.5
	gill netting	3.9%	1.5	0.0%	0.5
C. Reproductive composition					
10. Lithophilic spawning species		6	3	2	1
D. Fish abundance and health					
11. Average number of individuals		27.2	0.5	108.9	2.5
	gill netting	15.2	1.5	3.9	0.5
12. Percent anomalies		0.9%	5	5.3%	1
RFAI			49 good		33 fair

* Percent composition of most abundant species.

Table 21. 1995 scoring results for the twelve metrics and overall Reservoir Fish Assemblage Index (RFAI) for Wheeler Reservoir.

Metric		Inflow		Transition		Forebay		Embayment	
		Obs.	Score	Obs.	Score	Obs.	Score	Obs.	Score
A. Species richness and composition									
1. Number of species		19	3	25	3	32	5	27	3
2. Piscivore species		9	5	10	5	12	5	11	5
3. Sunfish species		3	3	4	5	4	5	5	5
4. Sucker species		0	1	4	3	6	3	4	3
5. Intolerant species		2	1	3	3	4	3	3	3
6. Percent tolerant species	electrofishing	18.6%	5	73.7%	0.5	17.6%	2.5	91.1%	0.5
	gill netting	.	.	23.9%	1.5	18.2%	2.5	47.6%	0.5
7. Dominance *	electrofishing	30.5%	5	72.8%	0.5	42.6%	1.5	91.0%	0.5
	gill netting	.	.	21.7%	2.5	60.7%	0.5	47.6%	1.5
B. Trophic composition									
8. Percent omnivores	electrofishing	18.3%	5	73.9%	0.5	18.2%	2.5	91.3%	0.5
	gill netting	.	.	37.0%	1.5	20.7%	2.5	50.8%	0.5
9. Percent insectivores	electrofishing	25.1%	3	17.8%	0.5	67.2%	1.5	6.3%	0.5
	gill netting	.	.	4.3%	0.5	5.5%	1.5	17.7%	2.5
C. Reproductive composition									
10. Lithophilic spawning species		5	3	6	3	9	5	6	3
D. Fish abundance and health									
11. Average number of individuals		64.1	3	51.0	1.5	149.8	2.5	1056.1	2.5
	gill netting	.	.	4.6	0.5	27.5	1.5	37.2	2.5
12. Percent anomalies		1.5%	5	0.0%	5	0.9%	5	0.0%	5
RFAI			42 good		37 fair		50 good		39 fair

* Percent composition of most abundant species.

Appendix E.

Mean Catch Per Effort by Species for Electrofishing and Gill Netting Efforts at Each Location in 1995

Table 1. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Bear Creek, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	7.7	6.0
Threadfin shad	17.8	.
Common carp	0.1	.
Quillback carpsucker	.	2.7
Northern hogsucker	0.1	.
Smallmouth buffalo	0.1	0.2
Black buffalo	.	0.1
Spotted sucker	0.2	0.6
Silver redhorse	0.5	.
Black redhorse	0.1	0.2
Golden redhorse	0.5	.
Channel catfish	.	0.2
Flathead catfish	.	0.1
Yellow bass	0.1	.
Warmouth	.	0.1
Green sunfish	0.3	.
Bluegill	3.9	.
Redear sunfish	0.1	.
Spotted bass	2.7	0.1
Largemouth bass	0.5	0.1
White crappie	0.7	.
Black crappie	.	1.2
Total	35.3	11.6
Number of samples	15	10
Number collected	529	116
Species collected	16	12

Table 2. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Beech lake, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	6.9	5.4
Common carp	0.1	0.3
Golden shiner	.	0.1
Yellow bullhead	0.1	0.1
Channel catfish	.	1.2
Flathead catfish	0.1	.
Yellow bass	.	3.5
Warmouth	0.1	.
Bluegill	351.9	0.7
Longear sunfish	1.6	.
Redear sunfish	1.3	.
Largemouth bass	8.7	0.1
White crappie	0.3	0.1
Black crappie	.	0.3
Total	371.1	11.8
Number of samples	15	10
Number collected	5567	118
Species collected	10	10

Table 3. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Blue Ridge, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	.	0.3
Common carp	.	0.2
Whitetail shiner	0.3	.
Northern hogsucker	0.1	.
River redhorse	.	0.3
Black redhorse	.	0.1
Channel catfish	0.5	0.4
Flathead catfish	.	0.4
White bass	0.6	1.1
Warmouth	0.2	.
Redbreast sunfish	1.8	.
Green sunfish	5.0	.
Bluegill	120.0	.
Smallmouth bass	15.5	0.5
Spotted bass	0.5	.
Largemouth bass	2.1	.
Black crappie	0.1	0.1
Tangerine darter	0.1	.
Walleye	.	0.1
Total	147.0	3.5
Number of samples	15	10
Number collected	2205	35
Species collected	13	10

Table 4. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Boone, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition Watauga	Electrofishing TRANSITION SOUTH FORK OF THE HOLSTON	Electrofishing Forebay	Gill Netting Transition Watauga	Gill Netting TRANSITION SOUTH FORK OF THE HOLSTON	Gill Netting Forebay
Longnose gar	.	.	.	.	1.6	.
Alewife	.	.	.	.	0.1	.
Gizzard shad	6.3	12.3	45.9	0.6	2.5	1.2
Threadfin shad	.	8.6	.	.	.	.
Brown trout	.	.	.	.	.	0.1
Common carp	3.9	2.7	0.9	3.5	2.4	1.8
Spotfin shiner	0.1	3.3	.	.	.	.
Quillback carpsucker	0.1	.	.	0.5	.	2.0
Northern hogsucker	.	0.1	0.1	.	.	.
Black redhorse	0.1	.	.	0.1	.	.
Golden redhorse	0.1	1.0	.	.	.	.
Blue catfish	.	.	.	.	0.5	.
Channel catfish	0.2	0.1	.	1.1	1.3	0.4
Flathead catfish	0.1	.	0.1	0.2	0.5	0.1
White bass	.	.	.	0.1	.	0.1
Striped bass	.	.	.	.	1.6	1.1
Striped x white bass	0.1	.	.	0.6	2.8	0.8
Rock bass	0.1	.	0.1	.	.	.
Warmouth	0.3	.	0.1	.	.	.
Redbreast sunfish	.	.	0.1	.	.	.
Green sunfish	0.1	.	0.1	.	.	.
Bluegill	23.1	3.5	3.3	0.7	.	.
Hybrid sunfish	.	.	0.1	.	.	.
Smallmouth bass	2.9	0.7	1.1	.	0.4	1.9
Largemouth bass	6.8	3.5	3.9	0.3	0.1	.
White crappie	.	.	0.1	.	.	.
Black crappie	0.8	0.1	.	0.9	0.1	.
Banded sculpin	.	.	0.3	.	.	.
Total	45.1	35.8	56.0	8.6	13.9	9.5
Number of samples	15	15	15	10	10	10
Number collected	676	537	840	86	139	95
Species collected	16	11	14	11	12	10

Table 5. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Cedar Creek, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Longnose gar	.	0.2
Gizzard shad	4.5	2.2
Threadfin shad	.	0.1
Common carp	0.7	0.3
Bigeye chub	0.1	.
Bluntnose minnow	0.1	.
Quillback carpsucker	.	1.5
Spotted sucker	0.3	3.5
Black redhorse	0.1	0.1
Golden redhorse	0.1	.
Channel catfish	0.2	0.6
Flathead catfish	0.1	.
White bass	.	0.1
Yellow bass	.	0.8
Striped bass	.	0.2
Striped x white bass	.	0.1
Green sunfish	0.1	.
Bluegill	9.3	.
Longear sunfish	1.1	.
Redear sunfish	0.5	.
Smallmouth bass	0.2	.
Spotted bass	2.1	.
Largemouth bass	0.8	0.7
White crappie	.	0.1
Logperch	0.1	.
Freshwater drum	.	0.1
Total	20.2	10.6
Number of samples	15	10
Number collected	303	106
Species collected	17	15

Table 6. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Cherokee, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition	Electrofishing Forebay	Gill Netting Transition	Gill Netting Forebay
Longnose gar	.	.	0.1	0.1
Gizzard shad	180.2	2.7	5.2	5.1
Threadfin shad	26.7	.	.	.
Hybrid shad	.	.	0.1	.
Common carp	1.1	0.3	1.5	0.5
Spotfin shiner	21.0	0.3	.	.
River carpsucker	0.2	.	1.6	.
Quillback carpsucker	0.1	.	3.5	9.1
Smallmouth buffalo	0.1	.	0.4	0.4
Black redhorse	0.1	0.1	.	0.1
Golden redhorse	.	0.1	.	.
Blue catfish	.	.	0.1	.
Channel catfish	0.1	.	1.2	0.6
Flathead catfish	0.1	0.2	1.8	0.5
White bass	1.7	0.2	0.2	0.4
Striped bass	.	.	0.6	1.8
Warmouth	.	0.2	.	.
Bluegill	4.3	10.8	0.1	.
Smallmouth bass	1.1	0.5	.	0.4
Spotted bass	0.1	.	.	.
Largemouth bass	3.1	2.9	0.4	0.1
White crappie	.	.	0.1	0.2
Black crappie	0.5	1.5	0.1	0.4
Logperch	0.1	0.1	.	.
Walleye	0.1	.	1.8	1.5
Hybrid walleye x sauger	.	.	.	0.1
Freshwater drum	0.4	.	0.4	0.1
Brook silverside	0.1	0.1	.	.
Total	241.0	20.1	19.2	21.4
Number of samples	15	15	10	10
Number collected	3615	301	192	214
Species collected	20	14	18	17

Table 7. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Chickamauga, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Inflow	Electrofishing Transition	Electrofishing Forebay	Electrofishing Embayment	Gill Netting Transition	Gill Netting Forebay	Gill Netting Embayment
ChesTennesseeut lamprey	.	.	.	0.1	.	.	.
Spotted gar	.	.	.	0.3	0.1	.	.
Longnose gar	.	.	.	0.1	.	.	.
Skipjack herring	0.1	.	.	.	8.1	3.4	1.0
Gizzard shad	56.3	22.0	2.1	55.3	5.8	1.8	3.0
Threadfin shad	26.1	4130.8	120.2	32.3	.	.	.
Common carp	0.5	0.5	0.3	2.0	.	.	0.2
Golden shiner	0.7	0.3	.	0.7	0.1	.	.
Emerald shiner	.	57.9	47.0	23.5	.	.	.
Spotfin shiner	0.3	3.5	.	0.1	.	.	.
Steelcolor shiner	0.5	.	.	.	.	.	.
Bluntnose minnow	.	.	0.1	.	.	.	.
Grass carp	.	.	.	0.1	.	.	.
Northern hogsucker	0.1	.	0.1	.	.	.	.
Smallmouth buffalo	.	0.2	.	0.5	0.2	0.1	0.6
Spotted sucker	1.9	1.1	0.9	4.3	0.1	0.5	0.4
Silver redhorse	.	.	.	.	.	.	0.1
Black redhorse	0.3	.	.	.	.	.	.
Golden redhorse	0.7	.	.	0.1	.	.	.
Blue catfish	.	.	.	0.1	0.6	0.9	0.7
Channel catfish	1.9	0.3	1.0	.	0.9	0.8	.
Flathead catfish	0.3	0.5	0.1	.	0.2	0.2	0.1
White bass	4.1	0.6	0.1	0.1	0.4	0.7	0.2
Yellow bass	1.5	0.1	.	0.5	8.3	3.3	3.5
Striped bass	0.1	.	.	.	.	.	.
Warmouth	0.1	0.2	.	.	.	.	.
Redbreast sunfish	0.1	0.2	0.5	.	.	.	.
Green sunfish	0.1	0.1	0.1	.	.	.	.
Bluegill	28.6	25.5	9.3	12.3	0.2	0.4	0.2
Longear sunfish	.	0.5	0.2	.	.	.	.
Redear sunfish	9.3	1.3	2.9	2.3	1.9	1.0	1.7
Hybrid sunfish	.	.	0.1	.	.	.	.
Smallmouth bass	0.7	0.4	1.3	.	.	0.4	.
Spotted bass	4.9	2.7	1.6	0.3	0.1	1.5	0.4
Largemouth bass	7.9	1.0	1.1	2.1	0.1	0.2	.
White crappie	0.2	.	.	.	0.1	0.2	.
Black crappie	0.4	0.7	0.5	0.1	0.1	1.6	0.1
Yellow perch	.	0.2	.	0.3	0.3	.	.
Logperch	0.5	0.8	0.8	0.3	.	.	.
Sauger	0.3	.	.	0.1	1.4	1.2	0.7
Walleye	.	.	.	.	.	.	0.4
Freshwater drum	0.3	0.3	0.5	0.4	0.6	0.1	1.6
Brook silverside	.	41.6	0.1	.	.	.	.
Total	148.9	4293.2	190.9	138.0	29.6	18.3	14.9
Number of samples	15	15	15	15	10	10	10
Number collected	2233	64398	2864	2070	296	183	149
Species collected	29	26	23	25	20	18	17

Table 8. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Douglas, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition	Electrofishing Forebay	Gill Netting Transition	Gill Netting Forebay
Gizzard shad	106.6	10.6	8.4	5.8
Hybrid shad	.	.	0.3	.
Goldfish	0.1	.	0.1	.
Common carp	0.1	0.1	0.7	0.1
Golden shiner	.	.	0.1	.
Spotfin shiner	0.9	2.6	.	.
River carpsucker	.	.	1.5	0.1
Quillback carpsucker	.	.	2.4	0.3
Northern hogsucker	.	0.1	.	.
Smallmouth buffalo	0.2	.	2.0	1.4
Shorthead redhorse	0.2	0.1	.	.
River redhorse	.	0.1	.	.
Channel catfish	0.1	.	0.4	.
Flathead catfish	.	0.3	0.4	0.2
White bass	8.9	3.3	0.5	1.8
Striped bass	0.1	.	.	.
Warmouth	0.3	0.6	.	.
Green sunfish	.	0.4	.	.
Bluegill	7.5	17.3	.	0.4
Redear sunfish	0.1	.	.	.
Smallmouth bass	.	0.9	.	.
Spotted bass	.	.	.	0.1
Largemouth bass	21.1	3.3	0.3	1.1
White crappie	0.3	0.1	0.6	0.4
Black crappie	1.1	.	.	0.3
Logperch	1.9	1.1	.	.
Sauger	0.2	.	1.2	0.9
Walleye	.	.	0.4	0.1
Hybrid walleye x sauger	0.1	.	.	0.1
Freshwater drum	0.6	0.1	3.2	0.3
Total	150.3	40.8	22.5	13.4
Number of samples	15	15	10	10
Number collected	2255	612	225	134
Species collected	19	16	16	16

Table 9. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Fontana, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition Little TENNESSEE	Electrofishing Transition Tuckasegee	Gill Netting Transition Little TENNESSEE	Gill Netting Transition Tuckasegee	Gill Netting Forebay
Gizzard shad	1.0	0.7	4.4	2.3	0.6
Threadfin shad	.	7.3	.	.	.
Rainbow trout	.	.	.	.	0.1
Muskellunge	.	0.1	.	.	.
Common carp	.	.	0.8	1.3	0.4
Silver redhorse	0.1	.	0.2	.	.
River redhorse	0.1	.	.	.	0.1
Black redhorse	.	0.2	.	.	.
Golden redhorse	0.1	.	.	.	.
Channel catfish	0.1	.	0.2	0.3	0.2
Flathead catfish	0.3	2.3	1.3	0.6	1.4
White bass	.	.	1.1	0.3	0.3
Green sunfish	1.1	61.9	.	.	.
Bluegill	8.2	3.2	.	.	0.2
Hybrid sunfish	0.1	.	.	.	.
Smallmouth bass	2.1	5.1	1.6	0.8	6.9
Largemouth bass	0.7	1.5	0.8	0.1	0.9
Black crappie	.	.	4.2	0.4	0.1
Tangerine darter	0.1	0.1	.	.	.
Olive darter	0.1	.	.	.	.
Walleye	.	.	3.5	1.0	4.3
Total	13.9	82.3	18.1	7.1	15.5
Number of samples	15	15	10	10	10
Number collected	209	1235	181	71	155
Species collected	13	10	10	9	12

Table 10. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Fort Loudoun, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Inflow	Electrofishing Transition	Electrofishing Forebay	Electrofishing Embayment	Gill Netting Transition	Gill Netting Forebay	Gill Netting Embayment
Longnose gar	0.1	.	.	.	.	.	.
Skipjack herring	0.1	0.1	.	.	0.8	1.8	1.1
Gizzard shad	7.5	23.8	33.3	49.6	3.0	6.2	1.6
Threadfin shad	.	2.1	6.7	38.7	0.4	2.2	0.8
Hybrid shad	.	0.1	.	0.4	0.1	0.3	.
Common carp	3.7	2.5	1.7	2.7	1.2	1.2	1.3
Golden shiner	0.1	.	.	.	.	.	.
Emerald shiner	0.1	0.1	.	.	.	.	.
Spotfin shiner	0.1	0.9	0.9	.	.	.	.
Northern hogsucker	0.1	.	0.2	.	.	.	.
Smallmouth buffalo	0.5	1.5	0.5	3.3	0.7	1.0	0.4
Black buffalo	0.3	0.2	0.3	0.1	.	0.1	0.1
Spotted sucker	0.1	.	.	2.5	.	.	0.4
Silver redhorse	0.3	.	.	.	.	0.1	.
River redhorse	.	.	0.1	.	.	.	.
Black redhorse	0.1	.	.	.	.	.	.
Golden redhorse	0.5	.	0.2	0.4	.	.	.
Blue catfish	.	.	.	.	0.6	1.9	0.7
Channel catfish	0.5	0.3	.	.	0.5	0.6	1.1
Flathead catfish	.	0.1	0.1	0.2	0.5	0.7	1.5
White bass	0.1	0.1	0.7	0.3	0.1	0.6	.
Yellow bass	0.1	.	.	0.1	0.2	1.5	1.2
Striped bass	.	.	.	.	0.1	.	.
Rock bass	0.1	.	.	.	.	.	.
Redbreast sunfish	1.3	0.2	0.1	.	.	.	.
Green sunfish	.	0.1	0.3	.	.	.	.
Bluegill	0.3	8.5	3.8	12.8	0.2	0.3	0.2
Redear sunfish	0.1	0.1	0.1	0.2	.	.	.
Smallmouth bass	0.3	0.8	0.9	.	.	.	.
Spotted bass	0.9	.	0.1	.	.	.	.
Largemouth bass	0.3	0.9	1.3	3.4	0.1	0.1	.
White crappie	.	0.1	.	0.9	.	0.4	0.5
Black crappie	.	0.1	.	0.3	.	.	.
Yellow perch	0.1	.	0.1	0.1	.	.	.
Logperch	0.5	0.1	0.1	0.1	.	.	.
Sauger	.	0.1	0.1	0.1	0.8	1.6	0.3
Walleye	.	.	.	.	.	0.1	0.1
Freshwater drum	0.3	1.1	0.5	0.7	0.8	1.5	0.3
Brook silverside	.	.	1.1	.	.	.	.
Total	18.5	43.9	53.2	116.7	10.1	22.2	11.6
Number of samples	15	15	15	15	10	10	10
Number collected	278	658	798	1750	101	222	116
Species collected	27	23	23	20	16	19	16

Table 11. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Fort Patrick Henry, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	26.5	0.7
Common carp	1.7	1.4
White sucker	0.1	0.5
Northern hogsucker	0.1	0.1
Yellow bullhead	.	0.1
Channel catfish	.	0.2
Flathead catfish	.	0.1
Striped bass	.	0.1
Rock bass	.	0.1
Bluegill	0.1	0.1
Smallmouth bass	.	0.4
Largemouth bass	2.5	0.1
Total	31.0	3.9
Number of samples	15	10
Number collected	465	39
Species collected	6	12

Table 12. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Kentucky, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Inflow	Electrofishing Transition	Electrofishing Forebay	Electrofishing Embayment	Gill Netting Transition	Gill Netting Forebay	Gill Netting Embayment
Spotted gar	0.4	.	.	.	0.2	.	.
Longnose gar	0.1	.	.	.	.	.	.
ShorTennesseeose gar	.	.	.	.	.	0.1	.
Bowfin	0.3	.	.	.	.	.	.
Skipjack herring	0.3	.	.	1.6	7.1	5.4	1.2
Gizzard shad	66.9	1386.5	183.1	220.7	9.6	36.7	14.0
Threadfin shad	3983.3	609.0	.	30.7	0.1	.	.
Hybrid shad	.	.	.	.	.	.	2.7
Goldeye	.	.	.	.	.	0.1	.
Mooneye	.	.	.	.	0.7	1.2	.
Central stoneroller	.	0.1	.	.	.	.	.
Common carp	0.8	0.7	1.0	.	0.1	0.5	.
Golden shiner	.	.	.	.	0.3	.	.
Emerald shiner	0.4	3.3	0.4	.	.	.	.
Whitetail shiner	0.1	.	.	.	.	.	.
Spotfin shiner	.	0.1	.	0.1	.	.	.
River carpsucker	0.1	.	.	.	.	0.8	.
Quillback carpsucker	.	.	.	.	.	0.3	.
Highfin carpsucker	0.1	.	.	.	.	.	.
Smallmouth buffalo	0.3	.	0.1	0.1	0.4	1.0	0.2
Bigmouth buffalo	.	.	.	.	.	0.4	.
Spotted sucker	0.1	1.3	0.9	0.1	0.8	0.6	.
Shorthead redhorse	0.1	.	.	.	.	.	.
Black redhorse	0.2	0.1	.	.	.	.	.
Golden redhorse	0.2	.	.	.	.	.	.
Blue catfish	.	.	.	.	0.4	1.6	0.7
Channel catfish	0.1	0.1	.	0.1	2.6	3.5	1.0
Flathead catfish	0.1	.	0.3	0.1	.	0.4	0.1
American eel	.	.	.	0.1	.	.	.
White bass	0.5	.	0.3	0.6	0.4	.	.
Yellow bass	0.9	1.5	0.7	25.1	6.1	2.0	1.2
Striped bass	0.1	.	.	.	0.1	0.1	.
Warmouth	0.1	.	.	.	.	0.1	.
Bluegill	4.1	9.7	3.6	11.1	0.2	0.2	0.1
Longear sunfish	2.1	2.6	2.7	0.5	.	0.1	.
Redear sunfish	1.6	2.8	0.5	0.5	0.8	0.1	.
Smallmouth bass	0.7	0.5	0.6	0.1	.	.	.
Spotted bass	0.4	.	.	1.2	0.5	0.4	.
Largemouth bass	5.1	0.3	1.6	0.7	.	0.2	.
White crappie	0.3	0.1	0.1	.	0.1	.	0.5
Black crappie	.	.	.	0.1	0.2	0.4	0.1
Yellow perch	.	0.1	0.1	2.2	.	.	.
Logperch	.	0.5	0.3	0.1	.	.	.
Sauger	0.1	0.2	0.1	0.7	1.3	0.6	.
Freshwater drum	0.3	3.1	2.1	6.2	1.0	1.4	3.5
Brook silverside	1.1	0.1	0.6	.	.	.	.
Inland silverside	0.2	.	0.1	.	.	.	.
Total	4071.1	2022.6	199.1	302.5	33.0	58.2	25.3
Number of samples	15	15	15	15	10	10	10
Number collected	61067	30339	2987	4538	330	582	253
Species collected	33	21	20	22	21	25	12

Table 13. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Little Bear Creek, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	0.5	0.4
Threadfin shad	0.7	.
Common carp	0.1	.
Whitetail shiner	0.2	.
Northern hogsucker	0.1	.
Spotted sucker	0.1	4.2
Silver redhorse	.	1.6
Black redhorse	0.3	0.1
Golden redhorse	0.3	0.2
Channel catfish	0.2	1.2
Flathead catfish	.	0.1
White bass	.	0.9
Green sunfish	0.3	.
Bluegill	0.5	.
Longear sunfish	1.0	.
Redear sunfish	0.7	.
Smallmouth bass	0.7	0.1
Spotted bass	0.2	0.2
Largemouth bass	1.9	0.6
Total	7.8	9.6
Number of samples	15	10
Number collected	117	96
Species collected	16	11

Table 14. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Nickajack, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Inflow	Electrofishing Forebay	Gill Netting Forebay
ChesTennesseeut lamprey	0.1	.	.
Spotted gar	0.2	0.3	0.7
Longnose gar	0.3	.	.
Skipjack herring	0.1	.	2.0
Gizzard shad	30.7	12.6	1.7
Threadfin shad	1.4	599.1	.
Mooneye	0.1	.	.
Common carp	2.1	0.5	.
Emerald shiner	2.7	12.9	.
Spotfin shiner	3.9	0.1	.
Steelcolor shiner	0.4	.	.
Bullhead minnow	.	0.1	.
Smallmouth buffalo	0.5	.	.
Bigmouth buffalo	0.3	.	.
Spotted sucker	0.3	1.2	0.3
Shorthead redhorse	0.1	.	.
Black redhorse	0.3	.	.
Golden redhorse	0.4	.	.
Blue catfish	.	.	0.2
Channel catfish	6.3	0.1	0.2
Flat bullhead	.	.	0.1
Flathead catfish	.	1.1	0.1
White bass	0.9	.	0.6
Yellow bass	25.9	0.3	2.1
Rock bass	2.0	.	.
Warmouth	0.1	0.4	.
Redbreast sunfish	1.1	15.9	.
Green sunfish	0.6	0.5	.
Bluegill	35.9	141.6	0.3
Longear sunfish	0.5	2.7	.
Redear sunfish	15.7	17.1	0.4
Hybrid sunfish	.	.	0.1
Smallmouth bass	10.9	.	.
Spotted bass	9.9	2.7	1.5
Largemouth bass	4.3	9.3	0.3
White crappie	0.1	.	.
Black crappie	0.8	0.1	0.3
Logperch	2.5	0.3	.
Sauger	.	.	1.0
Freshwater drum	1.4	0.2	0.1
Brook silverside	1.6	0.7	.
Total	164.5	819.9	12.0
Number of samples	15	15	10
Number collected	2467	12298	120
Species collected	35	23	18

Table 15. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Normandy, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Longnose gar	.	0.1
Gizzard shad	20.2	1.0
Common carp	0.8	2.0
Spotfin shiner	1.7	.
Striped shiner	0.1	.
Spotted sucker	0.1	0.3
Silver redhorse	.	0.5
River redhorse	0.1	.
Black redhorse	0.1	0.1
Golden redhorse	0.1	.
Channel catfish	0.3	0.6
Flathead catfish	0.1	0.9
White bass	.	0.3
Rock bass	0.1	.
Green sunfish	1.7	.
Bluegill	65.5	.
Longear sunfish	4.2	.
Redear sunfish	0.1	.
Smallmouth bass	1.7	0.2
Spotted bass	0.7	3.6
Largemouth bass	0.6	.
White crappie	.	0.2
Black crappie	.	0.2
Logperch	1.9	.
Sauger	.	0.1
Walleye	.	0.2
Hybrid walleye x sauger	.	0.9
Total	100.0	11.2
Number of samples	15	10
Number collected	1500	112
Species collected	19	16

Table 16. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Norris, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition Clinch	Electrofishing Transition Powell	Electrofishing Forebay	Gill Netting Transition Clinch	Gill Netting Transition Powell	Gill Netting Forebay
Longnose gar	.	.	.	.	0.4	0.1
Gizzard shad	11.3	31.8	0.9	1.5	3.0	0.4
Threadfin shad	.	452.1	.	.	.	.
Muskellunge	0.1	.	.	.	.	.
Common carp	0.1	.	0.1	1.2	0.5	0.3
Silver shiner	0.1	0.1	.	.	.	.
Spotfin shiner	0.1	0.3	7.7	.	.	.
Bluntnose minnow	.	.	6.9	.	.	.
Quillback carpsucker	.	.	.	0.6	0.3	.
Northern hogsucker	.	0.1	.	.	.	.
Silver redhorse	.	0.1	.	0.2	1.7	.
Shorthead redhorse	0.4	0.6	.	0.1	.	0.1
River redhorse	.	.	.	.	.	0.1
Black redhorse	0.1	1.7	.	.	0.2	.
Golden redhorse	0.8	1.0	.	0.1	0.5	.
Channel catfish	.	.	.	0.4	.	0.1
Flathead catfish	.	0.1	.	0.1	0.1	.
White bass	0.1	.	.	1.2	1.0	.
Striped bass	.	0.1	.	1.0	2.6	0.4
Green sunfish	.	.	2.0	.	.	.
Bluegill	2.3	5.5	4.4	.	.	.
Smallmouth bass	1.2	2.1	0.6	0.1	.	0.4
Spotted bass	0.5	1.8	1.5	.	0.1	0.1
Largemouth bass	1.5	2.2	0.7	0.1	0.9	.
White crappie	.	.	.	.	0.2	.
Black crappie	1.0	0.5	.	0.2	0.3	.
Logperch	.	2.9	.	.	.	.
Sauger	.	0.1	.	1.5	1.8	.
Walleye	1.4	1.2	0.5	3.6	3.3	3.0
Freshwater drum	0.1	0.3	0.1	0.1	0.1	.
Brook silverside	15.1	3.4	0.2	.	.	.
Total	36.1	507.8	25.5	12.0	17.0	5.0
Number of samples	15	15	15	10	10	10
Number collected	542	7617	383	120	170	50
Species collected	17	21	12	16	17	10

Table 17. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Nottely, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition	Electrofishing Forebay	Gill Netting Transition	Gill Netting Forebay
Alewife	.	.	.	0.2
Gizzard shad	.	.	0.6	1.5
Hybrid shad	0.1	.	2.2	.
Common carp	1.7	1.1	2.4	0.6
Silver redhorse	.	.	.	0.1
Black redhorse	.	.	0.1	.
White catfish	.	.	0.2	.
Channel catfish	0.1	0.1	0.7	0.1
Snail bullhead	.	0.1	0.1	.
Flathead catfish	0.1	0.1	0.4	.
White bass	.	0.1	2.6	1.2
Striped bass	.	.	1.6	8.5
Warmouth	0.1	0.1	.	.
Redbreast sunfish	0.8	0.4	.	.
Green sunfish	8.8	13.0	.	.
Bluegill	40.9	85.1	0.1	.
Smallmouth bass	0.2	1.3	0.2	0.2
Spotted bass	5.8	5.3	1.7	2.3
Largemouth bass	3.9	2.3	.	.
Black crappie	4.5	.	4.6	0.1
Yellow perch	0.1	.	.	.
Walleye	.	.	0.6	0.6
Total	67.2	108.9	18.1	15.4
Number of samples	15	15	10	10
Number collected	1008	1634	181	154
Species collected	13	12	15	11

Table 18. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Parksville - Ocoee no 1, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Forebay	Gill Netting Forebay
Gizzard shad	0.5	0.1
Rainbow trout	0.1	.
Common carp	0.1	.
Yellow bullhead	0.1	.
Brown bullhead	.	0.1
Channel catfish	0.2	0.7
Warmouth	0.3	.
Redbreast sunfish	0.1	.
Green sunfish	1.0	.
Bluegill	16.7	0.2
Redear sunfish	0.8	.
Smallmouth bass	0.1	.
Largemouth bass	2.5	1.1
White crappie	.	0.2
Black crappie	.	0.1
Yellow perch	2.3	0.4
Brook silverside	2.0	.
Total	26.5	2.9
Number of samples	15	10
Number collected	398	29
Species collected	14	8

Table 19. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Tellico, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition	Electrofishing Forebay	Gill Netting Transition	Gill Netting Forebay
Skipjack herring	0.1	0.1	0.8	10.4
Gizzard shad	3.5	12.1	0.3	5.6
Threadfin shad	.	.	.	1.7
Hybrid shad	.	.	.	0.1
Goldeye	.	.	.	0.1
Mooneye	.	.	.	0.1
Common carp	0.4	0.9	0.6	0.5
Emerald shiner	.	0.1	.	.
Spotfin shiner	.	2.2	.	.
Northern hogsucker	.	0.1	.	.
Smallmouth buffalo	0.1	.	0.5	0.4
Black buffalo	0.1	.	.	.
Spotted sucker	.	0.1	0.2	0.1
Blue catfish	.	.	.	0.3
Channel catfish	.	.	0.3	1.4
Flathead catfish	.	0.1	.	0.3
White bass	.	.	0.1	0.2
Yellow bass	.	.	0.1	0.7
Striped bass	.	.	.	0.3
Warmouth	.	0.8	.	.
Redbreast sunfish	0.2	0.3	.	.
Green sunfish	0.2	.	.	.
Bluegill	1.0	7.9	.	.
Redear sunfish	0.1	.	.	.
Smallmouth bass	0.7	1.8	.	.
Spotted bass	0.4	0.1	.	.
Largemouth bass	0.9	2.1	.	.
Yellow perch	0.4	0.5	.	.
Sauger	.	0.1	.	0.3
Walleye	.	.	0.2	0.5
Hybrid walleye x sauger	.	.	0.1	.
Freshwater drum	.	0.3	0.1	.
Brook silverside	1.7	0.1	.	.
Total	9.7	29.5	3.3	23.0
Number of samples	15	15	10	10
Number collected	145	443	33	230
Species collected	14	18	11	17

Table 20. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Tims Ford, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Transition	Electrofishing Forebay	Gill Netting Transition	Gill Netting Forebay
Longnose gar	.	.	0.6	.
Gizzard shad	0.5	.	2.2	0.1
Threadfin shad	0.1	0.1	.	.
Common carp	0.9	2.4	1.2	0.3
Spotfin shiner	8.7	63.8	.	.
River carpsucker	.	.	1.7	0.2
Smallmouth buffalo	0.4	.	1.5	1.6
Black buffalo	.	.	0.1	.
Spotted sucker	0.1	.	.	.
Silver redhorse	.	.	0.4	.
Black redhorse	0.1	.	0.1	.
Golden redhorse	0.1	.	.	.
Channel catfish	0.1	.	0.3	0.1
Flathead catfish	0.1	0.6	0.4	.
White bass	.	.	1.0	.
Yellow bass	.	0.1	2.2	.
Striped bass	.	.	1.6	0.5
Green sunfish	0.2	4.2	.	.
Bluegill	25.9	75.2	.	.
Longear sunfish	0.1	0.3	.	.
Smallmouth bass	1.2	2.7	0.2	0.1
Spotted bass	0.1	0.2	.	.
Largemouth bass	0.9	0.9	.	.
White crappie	0.1	.	0.1	.
Black crappie	0.1	.	.	.
Logperch	.	0.3	.	.
Hybrid walleye x sauger	.	.	1.5	1.0
Freshwater drum	.	.	0.1	.
Total	39.5	150.7	15.2	3.9
Number of samples	15	15	10	10
Number collected	592	2260	152	39
Species collected	18	12	17	8

Table 21. Species listing and catch per unit effort at the transition during fall electrofishing and gill netting on Wheeler, 1995 (electrofishing effort = 300 meters of shoreline and gill netting effort = net-nights).

Common name	Electrofishing Inflow	Electrofishing Transition	Electrofishing Forebay	Electrofishing Embayment	Gill Netting Transition	Gill Netting Forebay	Gill Netting Embayment
Spotted gar	.	0.1	0.4	4.2	.	.	0.2
Longnose gar	0.3	.	.	0.4	.	.	.
Skipjack herring	0.1	0.1	0.7	0.4	0.9	15.7	8.0
Gizzard shad	11.4	41.1	25.9	11185	1.0	5.8	19.1
Threadfin shad	2.4	224.0	1540.0	7990.6	.	.	0.6
Common carp	.	0.4	.	0.5	0.1	.	.
Golden shiner	0.3	.	0.5	.	.	.	.
Emerald shiner	0.2	0.3	63.8	0.1	.	.	.
Spotfin shiner	.	.	0.1	.	.	.	.
Striped shiner	.	.	0.1	.	.	.	.
Northern hogsucker	.	.	0.1	.	.	.	.
Smallmouth buffalo	.	0.1	0.3	3.0	0.4	.	0.8
Bigmouth buffalo	.	0.1	.	.	.	.	.
Spotted sucker	.	0.8	0.3	1.6	.	0.2	3.7
Silver redhorse	.	.	0.1	.	.	.	.
Black redhorse	.	.	0.1	.	.	.	.
Golden redhorse	.	0.1	0.1	0.9	.	.	.
Blue catfish	.	.	.	0.2	.	0.1	0.3
Channel catfish	0.1	.	0.5	0.1	0.2	0.6	0.3
Flathead catfish	.	0.1	0.2	0.2	.	0.2	0.1
White bass	3.5	0.9	0.1	0.4	0.2	0.9	0.1
Yellow bass	19.5	0.6	0.1	0.1	0.4	0.6	1.0
Striped bass	.	.	.	.	.	0.1	.
Striped x white bass	.	.	.	.	.	0.5	.
Warmouth	.	.	.	0.1	.	.	.
Green sunfish	.	0.1	0.1	0.1	.	.	.
Bluegill	13.9	3.9	26.8	68.3	.	.	.
Longear sunfish	0.3	0.3	0.9	0.4	.	.	.
Redear sunfish	0.3	3.4	1.2	0.3	0.1	0.1	.
Hybrid sunfish	0.1	.	.	.	.	.	.
Smallmouth bass	0.1	0.5	16.9	0.5	.	.	.
Spotted bass	12.1	0.2	0.1	0.1	0.3	.	.
Largemouth bass	0.3	1.5	3.7	18.8	.	0.3	.
White crappie	.	0.1	.	0.4	.	0.1	.
Black crappie	0.2	.	.	.	.	.	.
Logperch	1.0	.	.	.	.	.	.
Sauger	0.5	0.3	.	0.1	0.9	0.1	0.4
Freshwater drum	0.7	2.1	5.1	2.3	0.1	1.2	3.4
Brook silverside	.	.	2.7	.	.	.	.
Inland silverside	.	0.4	0.2	.	.	.	.
Total	67.1	281.4	1690.9	19279	4.6	26.5	38.0
Number of samples	15	15	15	16	10	10	10
Number collected	1007	4221	25363	308459	46	265	380
Species collected	20	24	28	26	11	15	13