Status of Water Quality and Point & Non-Point Source Pollution in the Southeastern United States

by

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EXECUTIVE SUMMARY

A review of the water quality in estuaries, public lakes, and streams in nine Southeastern states was undertaken, with somewhat more emphasis placed on lakes than estuaries and streams. The states studied were: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. In general, the presentations for estuaries and streams were restricted to a review of information presented in each state's 1984 Section 305(b) report and and its submission to the Association of Interstate Water Pollution Control Administrators' "State's Evaluation of Progress" (STEP) program. In addition to these data, municipal wastewater treatment plant (WWTP) total phosphorus load estimates were calculated for lakes. The terms "assessed" estuaries and streams will be used to refer to those waters evaluated by the states in the 1984 Section 305(b) reports, whereas the term "assessed" lakes will refer to the set of lakes considered in this report's WWTP phosphorus load analysis; at a minimum, assessed lakes included all lakes covered in the states' Clean Lakes Program Reports. The results of this project are summarized below.

<u>Trophic States of Lakes (Table A, col. 1 and 2)</u>

- By Number of Lakes: In 5 of 8 states the majority (>50%) of assessed lakes were eutrophic.

- By Surface Area of Lakes: A similar trend was apparent when the states' assessed lake surface areas were considered.

<u>Population Growth</u>

- Since 1970, the population growth was 7 to 63% in SE states.

- Increases of 9 to 41% are anticipated between 1985 and 2000.

<u>Wastewater Treatment Systems</u>

- WWTP's served from 41 to 81% of the states' populations, while most of the remaining population used septic tanks.

- WWTP's using phosphorus removal (chemical or biological): FL and VA had 10 each, GA had 7, SC had 1, and AL, KY, MS, NC, and TN had none. Eight of the 10 VA plants were in the Chesapeake Bay Basin.

- Only VA had major combined sewer overflow problems (particularly Richmond discharging into the James River / Chesapeake Bay Estuary).

WWTP's Potentially Impacting Lakes

An analysis was performed to identify those lakes which were potentially impacted by WWTP phosphorus loads. For this purpose, WWTP's located within approximately 50 miles upstream of assessed lakes were identified, and the total phosphorus loads from the WWTP's and non-point sources were estimated. This procedure indicated:

- 14 to 63% of each state's WWTP's may impact assessed lakes (Table A, col. 3).
- Less than 1/3 of each state's assessed lakes had WWTP's upstream, except NC (75%) and SC (53%) (Table A, col. 4).
- The majority of the assessed lake surface area in all SE states was potentially impacted by WWTP's (Table A, col. 5).

Table A: Ranking of Southeastern States According to Lake Trophic States and Municipal Wastewater Treatment Plants Which Potentially Impact Lakes.

(1)			(2)			(3)			(4)			(5)				
Number Of Assessed Lakes Which Are Eutrophic (As % Of Total)			Assessed Lake Surface Area Which Is Eutrophic (As Percent Of Total)			Percent Of WWTP's Upstream Of Lakes[1]			Percent Of Assessed Lakes With WWTP's Upstream)[1]			Assessed Lake Surface Area With WWTP's Upstream (As % Of Total)[1]			Avg. Rank	
	%	Rank[1]		%	Rank[1]		%	Rank		%	Rank		%	Rank		
MS	100	9	MS	100	9	TN	63	9	NC	75	9	KY	100	9	MS	7.2
GA	64	8	TN	60	8	SC	40	8	SC	53	8	MS	94	8	SC	7.0
VA	59	7	AL	>54[2]	7	GA	29	7	MS	29	7	GA	93	7	TN	6.6
SC	55	6	SC	52	6	NC	27	6	TN	23	6	SC	92	6	GA	6.2
TN	52	5	GA	48	5	KY	21	5	VA	20	5	TN	90	5	NC	5.2
KY	52	4	NC	35	4	VA	16	4	KY	17	4	VA	82	4	KY	5.0
NC	42	3	VA	32	3	MS	15	3	GA	14	3	NC	60	3	VA	4.8
AL	>24[2]	2	KY	21	2	FL	14	2	FL	4	2	FL	59	2	FL	2.0
FL[3]	9	1	FL	nd	1	AL	nd	nd	AL	nd	nd	AL	nd	nd	AL	1.0

nd = No data.
1: Nicholas L. Clesceri and Associates ranking.
2: Data were from U.S. EPA-NES Working Paper #475.
3: Not all lakes with WWTP's upstream could be identified.

Support of Designated Uses and Causes for Less Than Full Support
[Data as presented by the states' in their 1984 Section 305(b) reports]

The states' evaluations of the degree to which their waterbodies supported the designated uses (e.g. recreational or potable water supply), and the description of factors which might have been responsible for less than full support of the designated uses (e.g. industry, WWTP's, or non-point sources) were provided in the 1984 305(b) Reports. These permitted an analysis of the extent to which the various pollution sources in each state were responsible for the degradation of water quality.

1. Support of Designated Uses

- Estuaries: Less than 16% of assessed estuarine areas did not fully support their designated uses (except SC 36%) (Table B, col. 1).

- Lakes: 25% or less of the assessed lake areas in each state did not fully support their designated uses (except NC and TN 38%) (Table B, col. 2).

- Streams: Less than 50% of assessed stream miles did not fully support their designated uses (except KY 59% and VA 69%) (Table B, col. 3).

2. Causes for Less Than Full Support

- Non-point sources were the most frequently cited causes for failure to support designated uses for all types of surface waters.

- WWTP's were cited nearly as often as non-point sources.

- Industry was not considered to be a major factor except in NC (lakes), TN (lakes), and SC (estuaries).

3. Primary Factors Impairing Designated Uses

Individual nutrients (e.g. phosphorus, nitrogen), heavy metals (e.g. copper, lead), and toxic substances were not specified by the states and, therefore, could not be identified for the following summary.

- WWTP Discharges: Dissolved oxygen, fecal coliforms, and nutrients were the most commonly referenced problems. Heavy metals, pH, and toxic substances were less frequently noted.

- Non-Point Sources: Fecal coliforms, nutrients, and water clarity were the most commonly referenced problems. Dissolved oxygen, pH, and toxic substances were cited less frequently.

- Industrial Discharges: Dissolved oxygen and toxic substances were the parameters most often cited; nutrients, pH, and temperature were also common factors. Heavy metals and water clarity were noted in only one instance each.

- Other Sources: Iron, manganese, pH, temperature, and toxic substances were the problems noted.

Table B: Ranking of Southeastern States According to the Failure of Estuaries, Lakes, and Streams to Support Their Designated Uses.

Percent of Surface Water Area Providing Less Than Full Support of Designated Uses

Estuaries			Lakes			Streams			Average Rank[1]	
	%	Rank[1]		%	Rank[1]		%	Rank[1]		
VA	nd	9	NC	38	9	VA	69	8	VA	8.7
SC	36	8	TN	38	8	KY	59	9	TN	8.3
NC	16	7	SC	25	7	SC	49	5	NC	6.3
MS	11	6	FL	18	6	FL	45	7	SC	6.3
AL	5	5	GA	14	4	TN	19	6	KY	5.0
FL	3	4	VA	13	5	NC	18	4	FL	4.3
GA	2	3	KY	9	3	MS	10	3	MS	3.0
TN	NA	2	MS	4	2	AL	6	2	AL	2.0
KY	NA	1	AL	0	1	GA	5	1	GA	1.0

nd = No data.
NA = Not applicable.
1: Nicholas L. Clesceri and Associates ranking.

I. INTRODUCTION

A. Background

For the past few decades, the major focus of state water quality pesonnels' attention has been on the control of pollution from both point and non-point sources. Traditionally, greater emphasis has been placed on point source discharges, particularly municipal wastewater treatment plant effluents, as compared to non-point source pollution. This is due to the fact that nutrients such as phosphorus and nitrogen often stimulate unwanted algal growths, contributing to the highly visible and detrimental eutrophication of lakes, and because of the generally held tenet that point sources are more readily controllable than non-point sources. However, non-point sources often produce the same, or similar, deleterious effects on surface waters as point sources (e.g. increased nutrient loads, harmful microorganisms, and the depletion of dissolved oxygen). Currently, there are signs of a shift in attitude, a trend marked by recognition of the necessity to identify and control non-point source pollution if the standard of fishable/swimmable water quality for all publicly-owned surface waters is to be met. In evidence of this movement, non-point sources are now being ranked by water quality managers as an equal, if not greater, problem than point sources. The state reports published by the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA, 1983) indicate non-point sources are ranked as the greatest problem by 26 states and second by another 13. On the other hand, municipal point sources (generally wastewater treatment plants) are ranked as the greatest problem by 19 states and second by 20, with industrial point sources ranked first in only three states and third in 24.

Through continued and heightened awareness of the importance of non-point source pollution, as well as point source pollution, and through action on controlling any pollution source when found to be excessive and cost-effectively controllable, immense improvements in our nation's surface water quality can be realized.

B. Analysis of Water Quality in the Southeastern U.S.

The present report provides a state-by-state assessment of surface water quality in the Southeastern U.S. The study's primary goals were to provide a summary of the most current information describing the status of surface water quality in the region, and to examine the relative impact of municipal wastewater treatment plant and non-point source total phosphorus loads on lakes and streams in the Southeastern U.S.

The review was based on information and data obtained from Section 314 Clean Lakes Program reports, Section 305(b) State Water Quality Summaries, the Association of State and Interstate Water Pollution Control Administration's "America's Clean Waters" report (ASIWPCA; 1983a,b), and miscellaneous state data bases.

The analysis of phosphorus loads to Southeastern U.S lakes used the Clean Lakes Program reports as a starting point. The Clean Lakes Program state reports presented rankings of lakes prioritized according to the need of restoration, thereby providing a suitable point from which to initiate further investigations. The lakes in each state's Clean Lakes Program were selected because they were recognized by a state to be their most important lakes which may be experiencing deteriorations in water quality. These were, therefore, the most logical lakes on which to conduct additional analyses to provide insights into the relative importance of municipal point source versus non-point source phosphorus loads to water quality.

However, the Clean Lakes Program reports lacked crucial information required for a full assessment of phosphorus loads to the lakes; in particular, no data concerning actual nutrient loads were provided. As a result, additional information sources had to be utilized in conjunction with the Clean Lakes Program reports. Nevertheless, the wealth of other information contained in the reports, describing the characteristics of each lake (e.g. surface area, depth, volume) and its drainage basin (e.g. area, land use), were an invaluable asset without which further investigations concerning phosphorus loads and their affect on water quality would have been severly hampered. The following sections present this general approach for phosphorus load analysis which is capable of identifying the principle point and non-point sources and of prioritizing their importance to the water quality of the Clean Lakes Program lakes. The methodology is applicable to all states having conducted a Clean Lakes Program project or a similar program.

The states included in this report are from the Southeastern U.S.: Virginia, North Carolina, South Carolina, Kentucky, Tennessee, Alabama, Mississippi, Georgia, and Florida. For each state, the overview of water quality in the state's estuaries, lakes, and streams are presented first; these are the materials extracted from the Section 305(b) state reports and the ASIWPCA's summaries of state information (ASIWPCA, 1983a,b). The analysis of phosphorus loads to each state's Clean Lakes Program lakes follows the review section.

II. GENERAL PROCEDURES

A. Data Sources

The initial step in the analysis was to obtain data relating to lakes, their drainage basins, and the municipal wastewater treatment plants in the states of interest (see Figure 1, following page). A relatively large data base has been compiled during state and federally funded reviews of existing data and/or the establishment of new sampling programs to investigate the quality of surface waters. Therefore, state agencies were contacted to acquire the raw data and the reports generated from these studies. In general, the reports most useful for the present analysis originated from programs mandated by the Federal Water Pollution Control Amendments Act of 1972 (Public Law 92-500), particularly the Section 314 Clean Lakes Program and the biennial Section 305(b) State Water Quality Summary. A recent survey of state water pollution control administrators (ASIWPCA, 1984) provided information similar to the Section 305(b) reports, but in a convenient summary form. Data from these reports were supplemented with municipal wastewater treatment plant inventories maintained by the states in accordance with the National Pollution Discharge Elimination System (NPDES) and related state programs. The U.S. 1980 Census and U.S. Geological Survey (USGS) Water Year Data Reports for the individual states were also very useful. Brief descriptions of the Section 314, Section 305(b), and ASIWPCA STEP programs are provided in Appendix E.

B. Identification of Lakes With Municipal Wastewater Treatment Plants Upstream

The major objectives of the Clean Lakes Program were to evaluate the water quality of a state's publicly owned lakes, to provide a trophic state assessment for the lakes, and to establish a priority ranking of the lakes based on factors such as water quality and impediments to the designated uses of the lakes. Beginning with the set of lakes studied during a Clean Lakes Program, the present study isolated those lakes which had municipal wastewater discharges upstream. Each state's Clean Lakes Program Report provided some form of listing of point source discharges located upstream of the study lakes, allowing the municipal wastewater treatment plants to be readily identified. The Clean Lakes Program report for some states did not contain a complete listing of all municipal municipal wastewater treatment plants within a lake's drainage basin. For example, Florida listed only those plants discharging directly to a lake, and Georgia frequently stated "Numerous in Basin" without identifying the actual discharges. In such cases, USGS 1:500,000 scale state base maps and statewide inventories of municipal wastewater treatment plants were used to locate the facilities within 50 miles upstream of each lake. For the purposes of this report, only municipal plants were enumerated. Industrial and commercial

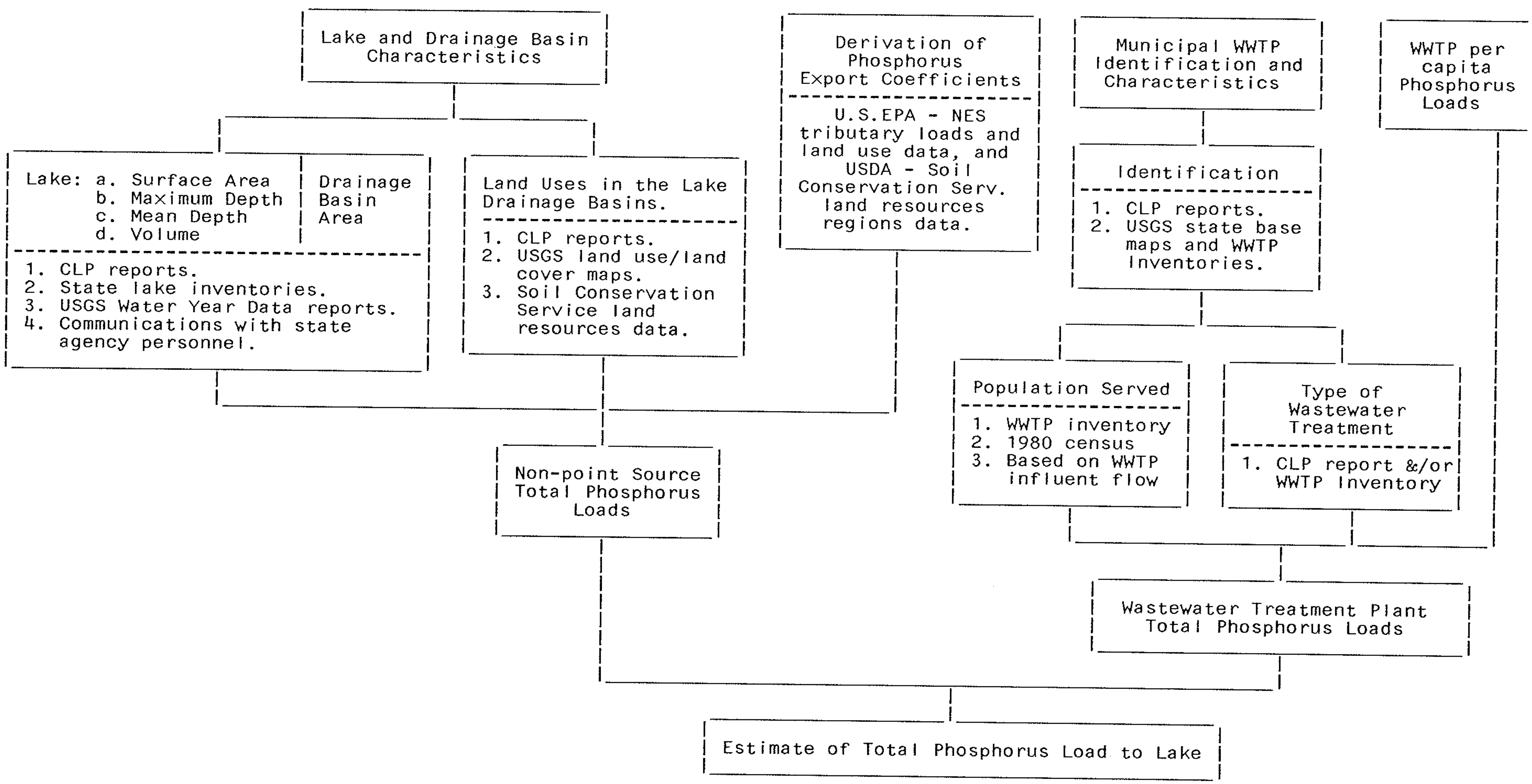

Figure 1: Schematic Diagram of Procedures and Hierarchies for Data Sources.

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waste treatment facilities were considered to be non-municipal discharges, as were facilities serving institutions such as schools and hospitals.

C. Lake and Drainage Basin Characteristics

Lake surface areas, mean and maximum depths, volumes, drainage basin areas, and land uses within the immediate drainage basins were obtained from the Clean Lakes Program reports whenever available. Land uses in a lake's total drainage basin were estimated by combining the data for a lake's immediate drainage basin with the data for any upstream lakes, after taking each basin's area into account. If any of these data were omitted, attempts were made to locate the values in other state reports and USGS Water Year Data reports. Occasionally, when no source for required data could be found, personnel of an appropriate state agency were contacted directly. If land use data were still unavailable, drainage basins were classified into the appropriate land use category with the aid of 1:250,000 scale USGS land use/land cover maps.

D. Municipal Wastewater Treatment Plant Total Phosphorus Loads

Total phosphorus load estimates were calculated only for lakes which had municipal point source discharges upstream. Municipal wastewater treatment plant total phosphorus loads were calculated using per capita loads [kg P/capita/year] and the population served by the facility. Untreated municipal wastewater containing some industrial/commercial contributions was assumed to contain 1.26 kg P/capita/yr (Clesceri, unpublished data; Soap and Detergent Association, unpublished data). Factors used for the removal of phosphorus during wastewater treatment were based on the type of wastewater treatment provided. Processes corresponding to conventional primary wastewater treatment were considered to be capable of removing only 10 percent of the phosphorus in untreated wastewater, conventional secondary processes to remove 20 percent, tertiary treatment plants to remove 30 percent, and facilities practicing chemical phosphorus removal were assumed to maintain a 1 mg P/L effluent concentration; flows of 150 gallons/capita/day were assumed for this calculation. The population served by each municipal wastewater treatment plant was obtained from the 1980 U.S. Census for all facilities whose name included the associated city or town. For those plants which were recognized as not serving a discrete census region, populations served were estimated using the facility's "Design Flow" and an assumed discharge rate of 150 gallons/capita/day. Thus, for example, the total phosphorus load for a conventional secondary facility serving 1000 persons would be calculated as:

TP Load [kg P/yr] = (1000 persons) X (1.26 kg P/cap/yr) X (1.0 - 0.2)
= 1008.0 kg P/yr

For the purposes of this report, land disposal was considered to achieve complete removal of phosphorus; therefore, such facilities were not included in the municipal wastewater treatment plant listings or in the load calculations.

E. Non-point Source Total Phosphorus Loads

Non-point source total phosphorus loads were calculated using export coefficients, expressed as kilograms of phosphorus per square kilometer per year [kg P/km^2/yr], and total drainage basin areas, expressed as square kilometers [km^2]. A summary of the methodology used to derive a set of appropriate export coefficients applicable to each lake's drainage basin is described in the Appendices. The basic procedure involved calculating average export coefficients for sets of Major Land Resource Areas (USDA, 1981) using data from the U.S. Environmental Protection Agency-National Eutrophication Survey [EPA-NES] (Omernik, 1977). The Major Land Resource Areas for the Southeast were grouped according to similar physico-graphic characteristics (e.g. topography, climate, soil types) provided by the U.S. Department of Agriculture (USDA, 1981). Each lake for which non-point source nutrient loads were to be calculated was placed into the applicable group (based on its geographical location) and classified with the appropriate land use category (based on the predominant land use within its watershed). Non-point source (NPS) total phosphorus loads were then calculated using the lake's total drainage basin area (BA) and the appropriate export coefficient (EC) from Table A in Appendix A:

$$\text{NPS TP [kg/yr]} = \text{BA [km}^2\text{] X EC [kg P/km}^2\text{/yr]}$$

III. ALABAMA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

Information concerning stream water quality and pollutant discharge sources is available for the State of Alabama [ASIWPCA, 1983a,b; Alabama Department of Environmental Management (Alabama DEM), 1984]; however, data concerning lakes is relatively scarce.

Extent and Nature of Water Quality Concerns

Alabama's assessment of water quality in estuaries, public lakes, and streams indicated that Alabama has experienced minor water quality problems associated with estuaries and streams, but the lakes assessed had no serious water quality problems (Table AL-1).

Streams

Of the 12,100 miles of streams assessed by Alabama, 94 percent support their designated uses (Table AL-1). For the 6 percent not wholly supporting their designated uses, the main cause appears to be discharges from municipal wastewater treatment plants (67 percent), with industrial sources (20 percent) and non-point sources (13 percent) accounting for the remaining cases.

Of the 57 ambient monitoring stations in Alabama's 14 major river basins, eight did not meet the 1983 goal of Fishable/Swimmable. Although not meeting the Fishable/Swimmable goal, some of these eight stations did support their present designated uses.

Estuaries

All but 5 percent of the state's 625 square miles of estuarine environment fully supported their designated uses, with nonsupport mainly attributable to industrial sources (94 percent), and the remainder caused by municipal and non-point sources (Table AL-1).

Lakes

One hundred percent of Alabama's 41 lakes fully supported their designated uses (Table AL-1). This is not to say that all the lakes in the state are in perfect condition; there are site specific problems with some of the impoundments. For example, Bear Creek Reservoir had a low pH and high concentrations of iron and manganese due to abandoned coal mining sites in the area.

Alabama's Stream Monitoring Program

The Alabama Department of Environmental Management maintains a network of approximately 57 ambient monitoring stations. The water quality at each station is evaluated by the four parameters for which specific numerical limits are established in the state's stream classification criteria: dissolved oxygen, pH, water temperature, and turbidity. The evaluation of other data collected at the stations is based on site specific judgements of the department staff.

Alabama's Clean Lakes Program

Alabama has not conducted a Clean Lakes Program as of this date. Communications with the state indicate that a program is in the planning stages.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table AL-2 provides an overview of the factors contributing to the water quality problems associated with Alabama's public lakes and streams as reported in the 1984 Alabama 305(b) Report (Alabama ADEM, 1984); the water quality of all lakes is presently considered to be adequate for their designated uses.

Municipal Wastewater Treatment Plants

Low dissolved oxygen levels and high fecal coliform counts were the most significant problems attributed to municipal wastewater treatment plant effluents, although nutrients were also listed as a concern.

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table AL-3).

These data indicate that 2,180,000 (56 percent) of the state's total population of 3,894,000 persons are served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tank systems. Alabama has no municipal wastewater treatment plants employing chemical phosphorus removal to reduce the effluent phosphorus concentration. No communities in Alabama are served by combined sewer systems.

Non-Point Sources

Non-point sources also contributed to nutrient and dissolved oxygen problems, as well as to high sediment loads, with nutrients the most significant problem.

Agricultural runoff has the potential to be a major problem because of its wide geographical extent, and urban stormwater and construction runoff have been found to be potential major problems in the large metropolitan areas of the state. Sediment loads from mining activities are also a concern.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of Alabama's water quality depends on the state's ability to establish and manage adequate programs in response to their problems. "Surface water quality maintenance; groundwater resource quality protection; identification and control of toxic pollutants from industrial sources; and municipal wastewater plant operation and maintenance are issues of concern in Alabama" (ASIWPCA, 1983a,b). The issue of decreased federal funding for municipal wastewater treatment plant construction is a major problem that must be resolved if Alabama is to maintain it's water quality. This problem is compounded by the Alabama's 13 percent population increase between 1970 and 1980 (U.S. 1980 Census). Alabama's population rose an additional 3 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 15 percent by the year 2000 (U.S. News & World Report, 1985).

Toxic pollutants are presently being addressed by the state's inclusion of biomonitoring requirements in industrial permits. A nonregulatory policy has been adopted in response to non-point pollution from agricultural runoff. The policy involves educational programs for the agricultural community and the implementation of best management practices to control agricultural runoff. Non-point source pollution from residual waste and mining sites have been controlled by regulatory programs for many years.

B. Analysis of Phosphorus Loads to the Alabama Study Lakes

An analysis of nutrient loads to Alabama's public lakes was not presented in this report since Alabama has not conducted a Clean Lakes Program and data from other sources are sparse and not readily available. This paucity of data is understandable, considering the state has only 41 publicly owned lakes, and all are supporting their designated uses.

C. Tables For Alabama

Table AL-1: Alabama's Estuaries, Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern as presented in ASIWPCA (1983b).

	Total Stream Miles or Acres of Estuaries or Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	40,600	12,101	30	94	2	4	0	20	67	13	0
Lakes	348,826 (41)	348,708	99	100	0	0	0	0	0	0	0
Estuaries	400,000	32,000	8	95	0	5	0	94	5	1	0
				Major Parameter(s) of Concern				DO* FC pH Tem Tox* WC	FC* Nut DO*	pH WC Nut*	--

*Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Fe : Iron concentration.
Mn : Manganese concentration.
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tem: Temperature.
Tox: Toxic substances.
WC : Turbidity (water clarity).

Table AL-2: Water Quality Problems in Alabama and the Factors Attributed to Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	S		S			S
b) Industrial				S		E[2]
Non-Point						
a) Agric.	S					S
b) Mining		S				
c) Other						

1. Municipal wastewater treatment plants.

2. There are probably other problems attributable to industrial sources, however, the only specific reference was to dissolved oxygen concentrations.

KEY: E=Estuaries, S=Streams.

Table AL-3: Wastewater Systems and State Statistics. [Data obtained from ASIWPCA (1983b)]

State Surface Area	= 50,767 mi^2
Lake Surface Area Percentage	= 1.1 %
Total State Population[1] (1980)	= 3,893,888
(1970)	= 3,444,165
Population Served by Municipal Wastewater Treatment Plants	= 2,180,000 (56%)
Year Round Housing Units[1]	
- With a Public Sewer	= 53.2 %
- With a Septic Tank or Cesspool	= 41.9 %
- Other Means	= 4.9 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 0 (0)
Compliance by Significant Municipal Wastewater Treatment Plants	= 89.0 %

1. Data obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	70,000	1.8
Biological[1]	600,000	15.4
Secondary	1,040,000	26.7
Tertiary	470,000	12.1
No System But Required[2]	none	none
System Not Required	1,713,888	44.0

1. Alabama defines biological treatment as those biological plants achieving only 80 to 85 percent removal of biochemical oxygen demand.
2. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

IV. FLORIDA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Florida Clean Lakes Program (Huber et al., 1983a,b), the Florida 1984 Section 305(b) Report [Florida Department of Environmental Resources (Florida DER), 1984], and the ASIWPCA STEP Program (ASIWPCA, 1983a,b), an extensive surface water quality data base and pollutant discharge inventories have been compiled for the State of Florida. Many of these data were previously accessible only through the acquistion of numerous reports published by a variety of state, federal, and university departments. These data are now stored in computerized form and can be retrieved readily.

Extent and Nature of Water Quality Concerns

Florida's assessment of water quality in estuaries, public lakes, and streams indicated that most problems were associated with streams, while estuaries and public lakes were affected to a lesser degree (Florida DER, 1984) (Table FL-1).

Streams

Only 46 percent of Florida's 12,659 stream miles demonstrated full support of their designated uses. Failure to meet water quality standards was attributed primarily to non-point sources (50 percent), with 20 percent of the cases due to municipal pollutants (Table FL-1).

Estuaries

All but 3 percent of the state's 4,277 square miles of estuarine environment assessed fully supported their designated uses, with nonsupport attributed to municipal pollutant sources (70 percent) and non-point source discharges (30 percent) (Table FL-1).

Lakes

Florida's assessment of public lakes indicated more than 90 percent fully or partially supported their designated uses (Table FL-1). Failure to support designated uses was attributed equally to municipal and non-point sources (both 48 percent) with the remaining 4 percent caused by industrial sources.

Florida's Stream Monitoring Program

The emphasis of this report is on lakes, therefore, only a brief description of Florida's stream monitoring program will be provided. The Florida Fixed Station Monitoring Program includes 58 sites (mainly stream sites) that are sampled six times a year for nutrients, coliform counts, dissolved oxygen, and a number of other water quality parameters, and once per year for heavy metals. A complete description of the program is available in the 1984 Florida 305(b) Report (Florida DER, 1984).

Florida's Clean Lakes Program

Researchers at the University of Florida compiled data from numerous prior studies to provide an analysis of 788 Florida lakes in a report to the Florida Department of Environmental Regulation (Huber et al., 1983a,b). This report serves as the state's Clean Lakes Program report. The available data permitted the evaluation of water quality in about 575 lakes, including trophic state assessments and nitrogen and phosphorus point and non-point source loads. A summary of the lakes' trophic states is provided in Table FL-2. Due to the extensive analysis presented in the Huber et al. report, it is not appropriate to attempt to provide any more detail here.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources, As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table FL-3 provides an overview of the water quality problems associated with Florida's estuaries, lakes, and streams and the corresponding factor(s) contributing to these problems. Pollutant sources responsible for water quality problems include phosphate mining and fertilizer production, domestic wastes, agricultural runoff, dairy and hog farms, and urban runoff. Municipal and non-point source pollutants have been designated as the primary offenders, each contributing to nearly half of the cases for less than full support of designated uses (Table FL-1).

In the 1984 Florida 305(b) report (Florida DER, 1984), the state made a number of observations pertaining to the factors causing water quality degradation. Some examples of these are presented in the following paragraphs, with additional basins being discussed in the 305(b) report.

a. North Central Florida: Several tributaries to the Suwanee River drain an extensive phosphate mining area. These tributaries have high specific conductivitances, high nutrient concentrations, and high counts of coliform bacteria.

b. East Coast of Florida: There are localized areas of water quality standards violations, some severe, due to rapid urban growth. Sykes Creek is an exemplary problem area with water quality problems resulting from treated wastewater effluent and urban growth. The north prong of the Alafia River, the Philippi Creek, and the Whitaker Bayou show very poor water quality, including high concentrations of nutrients and coliform bacteria, low dissolved oxygen concentrations, and low biological diversity. Phosphate mining, chemical plants, urban runoff, and municipal wasterwater effluents contribute to these problems.

c. Central Florida: The problems with the lakes and streams in this area of Florida are related to pump discharge from agricultural areas, and include low dissolved oxygen concentrations and high nutrient concentrations. Several streams are eutrophic due to municipal wastewater treatment plant effluents.

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table FL-4). These data indicate that 6,100,000 (63 percent) of the state's total population of 9,746,000 persons are served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tank systems. Only one community has a combined sewer system.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of Florida's water quality depends on the state's ability to establish and manage adequate programs in response to its extremely high population growth in recent years. Florida experienced a 44 percent population increase between 1970 and 1980 (U.S. 1980 census). Florida's population rose an additional 14 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 41 percent by the year 2000 (U.S. News & World Report, 1985). The continued flux of people into the "sun belt" region will place even more severe pressures on Florida's natural resources: "Adequate treatment of municipal and industrial waste continues to be a major concern because of continuing rapid population growth, environmentally sensitive receiving waters which require high treatment levels, and the state's dependence on ground water which limits land application of waste" (ASIWPCA, 1983b). To address these problems, the Florida Legislature in 1983 passed the $117 million Water Quality Assurance Act, which provided $100 million for sewage treatment plant construction and established major new programs, or strengthened old programs, for monitoring, inspection, and data collection.

Non-point source pollution is also a major problem, as estimates indicate that more than half of the pollutants entering Florida's surface waters are directly related to non-point sources. The state's non-point source pollution control strategies include best management practices encouraged through the State Administrative Code and local ordinances regulating urban stormwater control. Thus, a nonregulatory approach has been followed for control of pollution from silvicultural and agricultural sources. The state Stormwater Rule, state Dredge and Fill Rule, and state reclamation regulations are addressing the problems resulting from new mining.

B. Analysis of Phosphorus Loads to the Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

Huber et al. [1983a (Table 4-5)] identified 70 municipal wastewater treatment plants which discharged into 41 Florida lakes. However, all the facilities which discharged into streams flowing into the lakes were not included in the analysis. Perhaps this can be explained by the abundance of wetlands and interconnected lakes, which precludes the accurate determination of the direction of flow and ultimate destination for many discharges. Recognizing these obstacles to the present study, an attempt was made to provide at least a general picture of the magnitude of municipal wastewater treatment plant phosphorus loads to Florida lakes. Some modifications have been made to the generalized approach to avoid these quandaries. Beginning with the set of 41 lakes from Huber et al., 22 lakes were eliminated on the basis that their associated dischargers did not meet the study requirements. That is, either the facility was not considered strictly municipal (e.g. it served a country club, mobile home park, airport, etc.); the facility had been upgraded and the current level of treatment was considered to provide nearly the maximum rate of phosphorus removal which could be expected short of diversion of the effluents around the lakes (i.e. the utilization of chemical phosphorus removal or percolation ponds); the facility employed special land application technologies or the facility was not included in the most recently available inventory of Florida permitted wastewater dischargers (Florida DER, 1985). The 16 lakes remaining were located on a USGS 1:500,000 scale state base map, and municipal wastewater treatment plants within approximately 50 miles upstream were identified with the aid of the state's wastewater treatment plant inventory (Florida DER, 1985). During the visual inspection of the USGS base map, three additional lakes (Cypress, Kissimmee, and Rousseau) were observed to be situated downstream of two of the 16 lakes already targeted for analysis; therefore, these three lakes were included in the analysis. Thus, the phosphorus load analysis was performed on a total of 19 lakes (Table FL-A in Appendix B).

Morphological data for the study lakes (Table FL-A in Appendix B) and land use data for their basins (Table FL-B in Appendix B) were obtained from Tables 4-11 and 4-2 of Huber et al. (1983a), respectively. Table FL-C in Appendix B provides a listing of the municipal wasterwater treatment plants upstream of the 19 study lakes, along with the corresponding populations served by each facility. Although Huber et al. (1983a) calculated phosphorus loads for 14 of the 19 study lakes, the loads had to be recalculated because:

a. Huber et al. employed per capita load values based on the phosphorus content of wastewater during the early 1970's. The phosphorus content of typical domestic wastewater has declined appreciably during the intervening years, from around 12 percent in the late 1960's to the level of from 4 to 5 percent (Clesceri et ., unpublished data; Soap and Detergent Association, unpublished data).

b. Huber et al. did not include phosphorus loads from all municipal facilities discharging upstream.

Results and Discussion of Total Phosphorus Loads

Using the present study's approach, municipal wastewater treatment plant total phosphorus (TP) loads to the study lakes ranged from 1 to 76 percent of the total loads; the total loads were calculated as the sum of the non-point source and municipal wastewater treatment plant loads. Table FL-5 contains a complete listing of these figures along with relevant excerpts from the 1984 Florida 305(b) Report (Florida DER, 1984) concerning the 19 lakes potentially impacted by municipal wastewater treatment plant discharges. Table FL-6 provides an overview of the numbers of study lakes and municipal wastewater treatment plants and populations served by these plants as compared to the values for the entire state. The study lakes' water quality data from the Clean Lakes Program is presented in Table FL-7a and the trophic states in Table FL-7b.

The following paragraphs consist of observations made concerning some of the lakes studied in this report along with relevant comments from the Clean Lakes Program Study:

a. Cypress, Hatchineha, Kissimmee, Russell, and Tohopekaliga Lakes: These lakes are located downstream of the Orlando metropolitan area. Shingle Creek and Reedy Creek are the receiving streams for the Orlando-Mcleod Road, Orlando-Sand Lake Road, and Orlando-Reedy Creek Improvement District municipal wastewater treatment plants and empty into Tohopekaliga and Cypress Lakes which flow into Lake Hatchineha and then Lake Kissimmee. Lake Russell receives discharges via Reedy Creek from the Orlando-Reedy Creek Improvement District. According to the 1984 Florida 305(b) report, a number of steps have been taken to reduce sewage loads from these plants as well as urban and agricultural runoff. The Florida DER is presently completing a wasteload allocations study of Reedy Creek in an attempt to identify sewage plant discharge nutrient limitations to protect Lake Russell. Lake Tohopekaliga also receives effluent from the city of St. Cloud STP, which contributes to the historic dissolved oxygen concentrations, bacteria, and nutrient problems below the plant's discharge point. Although Lakes Hatchineha and Kissimmee are located downstream of Lake Cypress, and therefore receive wastewater treatment plant effluents from the same point sources, both currently meet their use designations.

b. Lake Thonotosassa: Problems in Lake Thonotosassa which included fish kills during warm weather, are caused by a combination of industrial and domestic point source pollutants and agricultural and rangeland non-point sources. The river basin has a very large percentage of agriculture, rangeland, and urban land use and the in-stream quality reflects high areal phosphorus loads (Florida DER, 1984).

c. Lake Rowell: This lake has a relatively small drainage basin area. The City of Starke STP is the only municipal facility upstream of the lake.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic states of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicated the state of eutrophy was not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table FL-8). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tended to show a high degree of eutrophy (6 of 7 lakes were eutrophic), some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic (2 of 5 lakes were eutrophic). This is as expected, because non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For Florida

Table FL-1: Florida's Estuaries, Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern as presented in ASIWPCA (1983b).

	Total Stream Miles or Acres of Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	12659	12659	100	46	32	13	9	4	20	50	26
Lakes	2085120 (7712)	741337	36	82	10	8	0	4	48	48	0
Estuaries	2751000	2737000	99	97	0	3	<1	0	70	30	0
				Major Parameter(s) of Concern				DO Nut*	FC Nut DO*	DO WC Nut	--

* Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
WC : Turbidity (water clarity).

Table FL-2: The 573 Florida Lakes for Which Huber et al. (1983a) had Sufficient Data to Calculate the Trophic States.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Oligotrophic	233	41	*	*
Mesotrophic	288	50	*	*
Eutrophic	52	9	*	*

* These values could not be readily calculated.

Table FL-3: Water Quality Problems in Florida and the Factors Attributed To Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	L S		E			E S
b) Industrial	S		S			E
Non-Point						
a) Agric.	L S					L S
b) Mining	E S		S			
c) Other	E[2]					E[2]

1. Municipal wastewater treatment plants.

2. Due to urban runoff.

KEY: E=Estuaries, L=Lakes, S=Streams.

Table FL-4: Wastewater System and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 57,261 mi^2
Lake Surface Area Percentage	= 5.7 %
Total State Population[1] (1980)	= 9,746,324
(1970)	= 6,791,000
Population Served by Municipal Wastewater Treatment Plants	= 6,100,000 (63%)
Year Round Housing Units[1]	
- With a Public Sewer	= 71.9 %
- With a Septic Tank or Cesspool	= 27.3 %
- Other Means	= 0.8 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 1 (4,370)
Compliance by Significant Municipal Wastewater Treatment Plants	= 93.6 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	none	0.0
Secondary	4,800,000	47.1
Tertiary	1,300,000	12.7
No System But Required[1]	3,200,000	31.4
System Not Required	900,000	8.8

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

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Table FL-5: Non-Point Source and Municipal Wastewater Treatment Plant [see (1)] Total Phosphorus Loads To Florida Study Lakes.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km²]	Land[3] Use Cat.	Est. TP Loads [10³ kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Crescent	7061	LO SJ	1401	--	53.00	2.71	5	
Cypress	1653	KISME	3010	--	171.00	325.00	66	
Dead	2711	CHPLA	3124	--	133.00	0.53	1	
E. Tohopekaliga	4836	KISME	798	--	46.90	13.60	23	
George	18932	UP SJ	9638	--	480.00	57.00	11	
Griffin	4314	OKLAW	2007	--	114.00	11.10	9	Shows problems due to Lake Apopka pollution sources, local point inputs, and urban runoff. Efforts underway to curb pollution loads.
Harney	2452	UP SJ	5028	--	265.00	63.00	20	
Hatchineha	2686	KISME	3010	--	171.00	325.00	66	
Kissimmee	14067	KISME	4162	--	235.00	325.00	59	Occasional low DO and high nutrient levels.
Monroe	3550	UP SJ	6268	--	325.00	81.00	20	Eutrophic lake receives STP effluents from Sanford and via St. John's River.
Okeechobee	176447	LK OK	14634	--	830.00	36.50	5	Receives agricultural runoff from upstream sources and backpumping of agricultural runoff from the area surrounding south end of lake.
Pointsett	1737	UP SJ	3295	--	185.00	1.26	1	
Rousseau	1686	WTHLA	5184	--	260.00	5.30	2	
Rowell	147	SANTA	51	--	2.12	6.60	76	
Russell	296	KISME	1065	--	58.00	71.00	55	Historic and recent DO and nutrient problem due to swamp drainage.
Talquin	2772	OCHLO	4455	--	181.00	18.10	10	Upstream point sources include stripmine.
Thonotosassa	334	HILLS	155	--	10.20	17.00	63	Receives pollution load from Baker Creek, shows severe eutrophication problems.
Tohopekaliga	7604	KISME	1606	--	94.00	255.00	73	Historic and recent eutrophication problems due to sewage loads, urban and agricultural runoff.
Tsala Apopka	5237	WTHLA	414	--	17.80	4.13	19	

[See footnotes on next page]

Table FL-5, continued.

1. Municipal wastewater treatment plant is appreviated as MWTP in the Table.

2. Key to lake river basin codes:

Code	Major River Basin
KISME	Kissimmee River
HILLS	Hillsborough
LK OK	Lake Okeechobee
OCHLO	Ochlockonee
OKLAW	Oklawaha
SANTA	Santa Fe
LO SJ	Lower St. Johns
UP SJ	Upper St. Johns
WTHLA	Withlacoochee

3. Land use categories are equivalent to those assigned to each lake's drainage basin as presented in Table FL-B in Appendix B.

Table FL-6: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers Presented by Huber et al. (1983a) and the State as a Whole.

		{A} Study	{B} Huber et al.	{C} State	Study (col A) as % of Huber (col B)	Study (col A) as % of State (col C)
Lakes	Number	22	573	7,712	4	<1
	Surface Area [km^2]	2,587	4,422	8,438	59	31
MWTP's[1]	Number	35	--[1]	244	--[1]	14
	Pop. Served (x10^3 persons)	567	--[1]	6,100	--[1]	9

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Huber et al. (1983a), except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

Table FL-7a: Water Quality Parameter Values for Those Study Lakes for Which Data Were Available. Values are in ug/L as P, N, and Chlorophyll-a, with Secchi Disk Depths in meters.

Lake Name	Data Sample Period [years]	TP		TN		Mean Secchi Disk Depth	Mean Chl-a Conc.	Troph. State	Macro-phyte [Pct. Cov.]
		No.	Mean	No.	Mean				
Crescent	71-80	20	26	18	1294	0.65	29.4	M	0.4
Cypress	54-81	63	112	64	1734	0.49	87.0	E	2.4
Dead	65-80	18	18	17	410	1.89	4.2	M	5.6
East Tohopekaiga	54-81	41	49	38	768	1.39	6.2	M	2.1
George	62-80	20	98	22	1454	0.76	38.5	E	1.2
Griffin	65-81	274	122	275	2702	0.51	64.4	E	0.4
Harney	68-80	9	131	22	1931	4.88	14.8	M	1.6
Hatchineha	54-81	37	91	38	1554	0.58	30.8	E	2.0
Howell	66-75	13	1538	30	1673	1.82	54.1	E	nd
Kissimmee	54-81	86	59	91	1460	1.22	23.3	M	4.8
Monroe	68-80	21	195	69	2804	2.73	44.7	M	0.2
Okeechobee	68-81	621	115	303	1645	0.68	16.1	E	10.0
Pointsett	54-80	28	62	43	1518	0.74	16.6	E	6.7
Rousseau	66-80	57	39	57	468	3.13	2.3	M	82.3
Rowell	66-81	13	139	12	873	0.74	21.0	E	1.9
Russell	78-81	5	50	5	1644	0.56	9.9	E	nd
Talquin	65-80	41	130	21	676	0.92	11.0	E	nd
Thonotasassa	65-81	119	687	102	963	0.60	54.8	E	1.2
Tohopekaliga	54-81	162	361	165	1809	1.24	85.3	E	14.4
Tsala Apopka	71-81	82	89	85	1085	0.88	3.1	M	69.1

Key to trophic states: M = Mesotrophic, E = Eutrophic

Table FL-7b: Trophic State Index and Trophic States for the Florida Study Lakes.

Lake	Index[1]	Trophic State[2]	TN:TP Ratio[3]	Limiting Nutrient[4]
Crescent	67	E	17	nd
Cypress	77	E	16	Balanced
Dead	38	M	22	Balanced
E. Tohopekaliga	48	M	16	Balanced
George	67	E	15	Balanced
Griffin	77	E	22	Balanced
Harney	46	M	15	Balanced
Hatcheneha	69	E	17	Balanced
Howell	62	E	1	N Limited
Kissimmee	59	E	25	Balanced
Monroe	60	E	14	Balanced
Okeechobee	65	E	14	Balanced
Pointsett	62	E	24	Balanced
Rousseau	33	M	12	Balanced
Rowell	62	E	6	N Limited
Russell	65	E	33	P Limited
Talquin	55	M-E	5	N Limited
Thonotassa	69	E	1	N Limited
Tohopekaliga	69	E	5	N Limited
Tsala Apopka	41	M	12	Balanced

1. This is the Huber et al. (1983a) chlorophyll-a trophic state index.

2. Utilizing the literature review in Table 27 of the Wisconsin DNR (1983) to relate chlorophyll-a concentrations to trophic states, and Table 3-1 in Huber et al. (1983a) which compares the chlorophyll-a trophic state index to chlorophyll-a concentrations, the following relationships were derived:

Index	Trophic State
>55	Eutrophic
30-55	Mesotrophic
<30	Oligotrophic

3. Refer to the glossary for explanation.

4. Balanced = nutrient balanced.
   N Limited = nitrogen limited.
   P Limited = phosphorus limited.
   Also, refer to the glossary.

Table FL-8: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)		
	Oligotrophic	Mesotrophic	Eutrophic
Less Than 1 To 5	0	3	2
5 To 25	0	4	3
25 To 50	0	0	0
Greater Than 50	0	1	6

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

V. GEORGIA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Georgia Clean Lakes Program [Georgia Department of Natural Resources (Georgia DNR), 1982], the Georgia 1984 Section 305(b) Report (Georgia DNR, 1984a), and the ASIWPCA STEP Program (ASIWPCA, 1983a,b), information has become available concerning surface water quality and pollutant discharge sources in the State of Georgia.

Extent and Nature of Water Quality Concerns

Georgia's assessment of water quality in streams, public lakes, and estuaries indicated that all three types of water bodies are in good condition in Georgia, either fully or partiy supporting all their designated uses (Table GA-1). The parameters of greatest concern were coliform bacteria, dissolved oxygen concentrations, and nutrient concentrations.

Streams

The principal cause of nonsupport for the 5 percent of the state's assessed stream miles exhibiting less than full support was municipal wastewater treatment plant discharges, which accounted for 98 percent of the cases (Table GA-1).

Estuaries

Ninety-eight percent of Georgia's assessed estuarine areas fully supported their designated uses. The cause for less than full support was attributed to natural sources in 80 percent of the cases (Table GA-1).

Lakes

The principal pollutant source identified as an impediment to full support of the designated uses of assessed lakes (14 percent not fully supportive) was municipal wastewater treatment plant discharges (96 percent of the cases). Industrial and non-point sources contributed equally to the remaining 4 percent (Table GA-1).

Georgia's Stream Monitoring Program

The emphasis of this report is on lakes; therefore, only a brief description of Georgia's stream monitoring program will be provided. For example, during 1982 and 1983, the state monitored 109 fixed site stations, with samples collected monthly at most sites. In addition, intensive surveys were conducted on 41 streams during 1982 and 1983.

Georgia's Clean Lakes Program

The Georgia Clean Lakes Program (Georgia DNR, 1982), collected data on 175 public freshwater lakes. Sampling was conducted on 153 of the 175 lakes in the summer of 1980. Based on these results, some of the lakes were selected for additional sampling during the summer of 1981. A summary of the trophic states of the lakes assessed during the Clean Lakes Program is provided in Table GA-2.

Three water quality classification categories were established to prioritize the lakes according to their need for restorative actions. Eight lakes were placed into Category A, representing the high priority lakes which were the primary candidates for restoration. The 28 lakes placed in Category B were moderate priority lakes having most of the problematic characteristics of Category A lakes, but to a lesser extent. The remaining 139 lakes were placed in Category C, thereby designating them as having no immediate need for restorative action.

Municipal Wastewater Treatment Plants Industrial Discharges, and Non-Point Sources As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table GA-3 provides an overview of the factors contributing to the water quality problems associated with Georgia's estuaries, public lakes, and streams. In the 1984a Georgia 305(b) Report (Georgia DNR, 1984), the state made several general observations pertaining to the sources of these water quality problems. These are covered in the following paragraphs.

Industrial Discharges

Industrial point sources contribute significantly to a low dissolved oxygen problem in lakes and streams.

Non-Point Sources

Turbidity due to sediments is the most severe problem attributed to non-point sources, which include agriculture, urban runoff, and construction. Excessive nutrients from non-point sources are also a large problem.

Municipal Wastewater Treatment Plants

The two most significant use impairments resulting from municipal wastewater treatment plant discharges were nutrient loads and low dissolved oxygen concentrations. The State of Georgia has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table GA-4). These data indicated that 3,280,000 (60 percent) of the state's total population of 5,463,000 persons were served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tanks. Seven municipal wastewater treatment plants employ chemical phosphorus removal technologies to reduce the phosphorus concentration in their effluents. Eight treatment plants serving 330,000 people have combined sewer systems.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of Georgia's water quality depends on the state's ability to set up and manage adequate programs in response to their water quality problems. For example, "Historically, the major environmental problem in Georgia has been water pollution from publicly owned wastewater treatment works (POTW), and this remains Georgia's major environmental problem in 1982. The problem with municipal discharges has not been the absence of technology but the insufficiency of funds for the construction of the required facilities" (ASIWPCA, 1983). This problem has been compounded by the state's 19 percent population increase from 1970 to 1980 (U.S. 1980 Census). Georgia's population rose an additional 8 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 17 percent by the year 2000 (U.S. News & World Report, 1985).

Georgia is working to identify and control the discharge of toxics from industrial facilities by incorporating biomonitoring provisions into industrial National Pollution Discharge Elimination System (NPDES) permit requirements.

The existing regulatory programs for the control of mining, construction, and other non-agricultural, non-point sources are considered adequate by the state. The nonregulatory approach to controlling non-point source pollution from agricultural and silvicultural practices and urban stormwater runoff consists of public education and training, monitoring of management practices, and planned refinement of nonregulatory programs. A three year assessment study to evaluate th magnitude of water quality problems related to non-point sources was scheduled for completion in 1984, after which the state intends to formulate appropriate responses.

B. Analysis of Phosphorus Loads to the Georgia Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

The Information Summary Sheets in the Clean Lakes Program report appendix (Georgia DNR, 1982) contained complete listings of wastewater discharges upstream of some lakes studied during the Georgia Clean Lakes Program. However, for other lakes, references were made to NES Working Papers or the report simply stated there were numerous discharges upstream. Whenever available, the discharger data from the Clean Lakes Program Report appendix were used to identify lakes having municipal wastewater treatment plants upstream. For the other lakes, the alternate method using a USGS 1:500,000 scale state base map and an inventory of Municipal Water Pollution Control Plants for the state of Georgia (Georgia DNR, 1984b) was used to identify the municipal facilities upstream.

Following these procedures, 24 of the 175 lakes assessed during the Georgia Clean Lakes Program were found to meet the criterion of having at least one municipal wastewater treatment plant discharging within approximately 50 miles upstream.

Morphological data for the study lakes (Table GA-A in Appendix B) were obtained from the Clean Lakes Program report. Land use data (Table GA-B in Appendix B) for the drainage basins were obtained from a number of sources. Data were available in the North Carolina and South Carolina Clean Lakes Program reports for the immediate drainage basins of those lakes on the state borders (North Carolina DEM, 1983 and 1984; South Carolina DHEC, 1982). For lakes having extremely large basins, such as those on the Chatahoochee River, land use data presented in USDA-Soil Conservation Service's National Resources Inventory for Georgia (USDA, 1982) were used to place the lake basin in the appropriate land use category. A list of the municipal wastewater treatment plants upstream of each study lake, along with the corresponding population served by each facility, is given in Table GA-C in Appendix B.

Results and Discussion of Phosphorus Loads

The present analysis of phosphorus loads to the 24 study lakes represents a comprehensive analysis of the lakes considered to be most important to the state of Georgia. Table GA-5 provides an overview of the numbers of study lakes and municipal wastewater treatment plants and the populations served by these plants compared to their values for the entire state. Municipal wastewater treatment plant total phosphorus (TP) loads to the study lakes ranged from 1 to 82 percent of the total TP loads; the total loads were calculated as the sum of the non-point source and municipal wastewater treatment plant loads. Table GA-6 contains these results along with relevant excerpts from the 1984 Georgia 305(b) Report (Georgia DNR, 1984a) concerning the 24 lakes potentially impacted by municipal wastewater treatment plant discharges. The Clean Lakes Program water quality sampling data for the study lakes are presented in Table GA-7.

A number of observations are worth noting in regard to some of the lakes' phosphorus loads attributable to municipal wastewater treatment plants.

a. Three of the largest lakes in the state have considerable phosphorus loads attributable to municipal wastewater treatment plants. These lakes are located downstream of major treatment facilities:

   1) Lake Allatoona: Receives approximately 75 percent of its municipal load from the recently upgraded Cobb County-Noonday Creek plant.

   2) Lake Jackson: The diversion of the Atlanta municipal wastewater treatment plant discharges to the Chattahoochee River, scheduled for 1985, will remove about 48 percent of the current municipal wastewater treatment plant phosphorus loads. The load was recently reduced by one-half through the upgrading of the Dekalb County-Snapfinger Creek plant and four Gwinnett County plants to chemical phosphorus removal. Furthermore, non-point source studies in progress should result in additional load reductions.

   3) Lake Oconee: Although the present phosphorus load analysis indicated 65 percent of the lake's total phosphorus load is attributable to municipal wastewater treatment plants, the lake is not experiencing any water quality problems. Perhaps this is due to the large distance the effluent must travel in reaching the lake.

b. Three relatively small lakes with substantial total phosphorus loads from municipal wastewater treatment plants are each impacted by a single facility (4-5 MGD).

   1) Coffee State Park Lake: Downstream of the Douglas wastewater treatment plant.

   2) Harry Williams: The municipal phosphorus load is primarily from the Cordele wastewater treatment plant.

3) High Falls: Is impacted primarily by the Griffin-Cabin Creek facility; one other very small facility is upstream (Locust Grove West).

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table GA-8). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy, some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic. This is as expected, since non-point source loads and industrial discharges can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For Georgia

Table GA-1: Georgia's Estuaries, Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern, as presented by ASIWPCA (1983a).

	Total Stream Miles or Acres of Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	20,000	17,000	85	95	2	3	0	1	98	1	0
Lakes	387,373 (175)	387,373	100	86	13	1	0	2	96	2	0
Estuaries	380,000	304,000	80	98	0	2	0	15	5	0	80[1]
				Major Parameter(s) of Concern				DO Tox	FC Nut* DO*	FC* Nut*	--

1. Natural sources.

* Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
Tox: Toxic substances.

Table GA-2: Trophic States of the 163 Public Lakes Assessed During Georgia's Clean Lakes Program for Which Data were Available.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Oligotrophic	16	10	56,888	36
Mesotrophic	42	26	24,501	16
Eutrophic	85	52	74,230	48
Hypereutrophic	20	12	360	<1

Table GA-3: Water Quality Problems in Georgia and the Factors Attributed to Them[1].

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
<u>Point</u>						
a) Municipal[2]	L S					L S
b) Industrial						L S
<u>Non-Point</u>						
a) Agric.	L S	L S				
b) Mining						
c) Other						

1. Georgia did not report they were experiencing any problems with estuaries.

2. Municipal wastewater treatment plants.

KEY: L=Lakes, S=Streams.

Table GA-4: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 60,000 mi^2
Lake Surface Area Percentage	= 1.0 %
Total State Population[1] (1980)	= 5,463,105
(1970)	= 4,589,575
Population Served by Municipal Wastewater Treatment Plants	= 3,280,000 (60 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 60.3 %
- With a Septic Tank or Cesspool	= 36.6 %
- Other Means	= 3.1 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 8 (330,240)
Compliance by Significant Municipal Wastewater Treatment Plants	= 91 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	none	none
Secondary	2,720,000	49.8
Tertiary	560,000	10.3
No System But Required[1]	330,000	6.0
System Not Required	1,950,000	35.7

1. System required: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

Table GA-5: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	24	175	nd	14	nd
	Surface Area [km^2]	1,460	1,568	nd	93	nd
MWTP's[1]	Number	123	--[1]	403	--[1]	31
	Pop. Served ($x10^3$ persons)	1,057	--[1]	3,280	--[1]	32

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Georgia's Clean Lakes Program, except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

Table GA-6: Non-point Source and Municipal Wastewater Treatment Plant [see (1)] Total Phosphorus Loads To Georgia Study Lakes.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km²]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Allatoona	4800	COOSA	2900	EMIX	48.10	66.00	58	Occas. algal blooms; fluctuating water level.
Blackshear	3446	FLINT	8780	FMIX	197.00	21.30	10	High trophic condition for a major impoundment; concern over industrial discharges to lake; some aquatic macrophyte problems.
Bull Sluice	235	CHATT	3630	EMIX	60.00	15.60	21	Receives inflow of sediment and surface-born garbage from banks.
Carters	1300	COOSA	970	GMIX	28.80	1.52	5	
Chatuge	2894	TENNE	490	GMIX	14.60	0.67	5	Garbage present on some adjacent land; alleged problems possibly due to lake pH fluctuations.
Clarks Hill	28329	SAVAN	15930	EMIX	265.00	24.60	9	
Coffee SP	2	SATIL	490	FMIX	11.00	11.10	51	New lake (fewer than two years old).
G.W. Andrews	623	CHATT	21260	FMIX	475.00	1.27	<1	
Goat Rock	381	CHATT	11540	EMIX	192.00	32.40	15	
Harding	2367	CHATT	10980	EMIX	182.00	33.10	16	Listed as highly eutrophic in previous studies.
Harry Williams	11	FLINT	175	FMIX	3.92	9.60	72	See footnote 4.
Hartwell	22643	SAVAN	5410	EMIX	90.00	18.00	17	Some problems reported concerning toxic concentration levels in fish.
High Falls	243	LO OC	490	EMIX	8.10	21.70	73	Alleged problems due to dye from Dundee Dye Plant, causing discoloration; submerged and emergent vegetation, fish kills, algal blooms, severe DO stratification and depletion, deposition of sediments.
Jackson	1923	UP OC	3630	EMIX	60.00	250.00	82	Algal blooms related to nutrient input from tributaries; siltation in upper lake; relatively severe DO stratification; history of fish kills and floating garbage.
Nottely	1736	TENNE	550	GNIX	16.30	0.53	4	
Oconee	7692	OCONE	4710	EMIX	78.00	141.00	65	
Oliver	870	CHATT	12100	EMIX	201.00	4.61	3	
Seminole	15182	APALA	44290	FMIX	990.00	24.90	3	Aquatic weed problem (many species).

Table GA-6, continued.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km^2]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Sidney Lanier	15394	CHATT	2690	EMIX	44.70	17.90	29	Infrequent problems with water levels, microorganism populations; some localized areas impacted by wastewater inputs.
Sinclair	6217	OCONE	7510	EMIX	125.00	13.30	10	
Stevens Creek	174	SAVAN	18000	EMIX	300.00	29.50	9	This is a run of the river impoundment with primarily riverine characteristics.
Tobesofkee	708	LO OC	470	EMIX	7.80	9.40	55	Some erosion-related problems.
Walter F. George	18300	CHATT	19320	FMIX	435.00	195.00	31	Point and non-point wastewater discharge from the City of Columbus; fish kills several years past; solid waste disposal leachate problems upstream.
West Point	10486	CHATT	13750	FMIX	310.00	20.10	7	Low water levels restrict recreation uses.

1. Municipal wastewater treatment plant is appreviated as MWTP in the Table.

2. Key to lake river basin codes:

Code	Major River Basin
SAVAN	Savannnah River
OCONE	Oconee
UP OC	Upper Ocmulgee
LO OC	Lower Ocmulgee
SATIL	Satilla
FLINT	Flint
CHATT	Chattahoochee
COOSA	Coosa
TENNE	Tennessee
APALA	Apalachicola

3. Land use categories are equivalent to those assigned to each lake's drainage basin as presented in Table GA-B of Appendix B.

4. "Harry Williams PFA Lake exhibited highly eutrophic conditions throughout 1980-1981. The lake was impacted by the Cordele wastewater treatment plant which discharged into the headwaters of the lake. Due to construction at the plant, occasionally in 1980 and 1981 only partially treated wastewater was discharged to the lake. As a result the lake exhibited consistently high total trophic state indices, elevated NO2 + NO3 and NH3 concentrations, severe dissolved oxygen concentration fluctuations, and recurrent fish kills. These conditions forced closure of the lake to public fishing and closure of a lake side campground. The lake was repeatedly drained and refilled in 1980-81 in an effort to correct the conditions. The lake was included in the 1981 Quarterly Sampling Project." [Georgia DNR, no date (1984 305b Report)]

Table GA-7: Water Quality Parameter Values and Trophic Conditions for Those Study Lakes[1] for Which Data was Available from the Georgia Clean Lakes Program Information Summary Sheets (Georgia DNR, 1983). TP and Chl-*a* are in ug/L as P and Chl-*a*, and Secchi Disk Depth is in meters.

Lake	Sampling Date(s)	TP Conc.	Chl-*a* Conc.	Secchi Disk Depth	Trophic State[2]	Macrophytes and/or Algae[3]
Allatoona	80 7 29	20	8.1	2.4	M	A
	81 7 16	40	9.5	1.2	E	
Blackshear	80 7 2	110	7.1	1.3	E	M
	81 7 7	1070	8.6	0.9	E	
Bull Sluice	80 6 25	90	2.8	0.3	H	N
Carters	80 8 13	20	6.2	3.0	M	N
	81 7 17	20	2.5	3.3	M	
Chatuge	80 7 22	20	5.4	2.3	M	N
	81 8 19	20	5.4	2.0	M	
Clarks Hill	80 7 26	20	6.3	2.7	M	N
	81 9 10	20	1.9	4.7	O	
Coffee SP	80 9 4	90	73.3	0.3	H	N
	81 7 22	20	33.8	0.4	H	
G.W. Andrews	81 8 6	30	38.6	1.1	E	N
Goat Rock	81 7 7	30	6.1	1.2	E	N
Harding	80 7 29	20	20.4	1.5	E	N
	81 7 22	30	18.9	1.6	E	
Harry Williams	80 7 2	600	156.9	0.6	E	B
	80 9 8	1040	13.8	0.5	H	
	81 7 8	630	190.8	0.5	H	
Hartwell	80 7 24	20	4.7	3.0	M	N
	81 8 26	20	1.9	5.0	O	
High Falls	80 9 9	50	38.5	1.0	E	N
	80 6 19	30	43.5	0.8	E	
	81 7 14	30	9.4	2.1	M	

Table GA-7, continued.

Lake	Sampling Date(s)	TP Conc.	Chl-a Conc.	Secchi Disk Depth	Trophic State[2]	Macro-phytes and/or Algae[3]
Jackson	80 6 17	50	26.6	1.5	E	A
	81 9 2	40	38.8	1.0	E	
Nottely	81 8 19	20	2.5	3.9	O	N
Oconee	80 9 10	40	9.6	0.7	E	N
	80 7 1	40	15	1.5	E	
	81 7 14	20	15.4	1.5	E	
Oliver	80 8 7	20	5	1.3	E	N
	81 7 22	20	12.1	1.4	E	
Seminole	80 8 1	20	46.4	1.2	-	M
	81 8 5	60	32.8	1.0	E	
Sidney Lanier	81 9 1	20	4.6	3.0	M	N
Sinclair	80 7 7	40	12.2	1.7	E	N
	80 9 10	20	7.2	2.9	E	
	81 6 25	20	8	2.0	M	
Stevens Creek	81 9 11	20	0.7	2.1	M	N
Tobesofkee	80 7 1	80	11.5	1.2	E	N
	81 7 9	140	9.9	1.6	E	
W.F.George	80 7 29	20	18.9	1.7	E	N
	81 7 21	20	17.2	1.3	E	
West Point	80 6 25	70	17.7	2.1	M	N
	81 7 21	20	15.9	1.5	E	

1. Study lakes were the lakes for which phosphorus loads were calculated.

2. Key to trophic states:
   H = Hypereutrophic
   E = Eutrophic
   M = Mesotrophic
   O = Oligotrophic

3. Key to presence of algae and/or macrophyte problems:
   A = Algae
   M = Macrophytes
   B = Both
   N = Not mentioned

Table GA-8: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)						
	Oligo.	Oligo-Meso.	Meso.	Meso-Eutro.	Eutro.	Eutro-Hyper.	Hyper-Eutro.
Less Than 1 To 5	1	0	2	0	3	0	0
5 To 25	0	2	1	2	3	0	0
25 To 50	0	0	1	0	1	0	1
Greater Than 50	0	0	0	2	3	1	1

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

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VI. KENTUCKY

A. Overview Of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Kentucky Clean Lakes Program [Kentucky Natural Resources and Environmental Protection Cabinet (Kentucky NREPC), 1984a), the Kentucky 1984 Section 305(b) Report (Kentucky NREPC, 1984b), and the ASIWPCA STEP Program (ASIWPCA, 1983a,b), information has become available concerning surface water quality and pollutant discharge sources in the State of Kentucky.

Extent and Nature of Water Quality Concerns

Kentucky's assessment of water quality in streams and public lakes suggests that more extensive problems are associated with streams than with lakes (Table KY-1). Ninety-one percent (82 of the 90) public lakes fully supported their designated uses, whereas only 10 percent of the 4,820 stream miles assessed supported their designated uses. However, it should be noted that only 12 percent of the stream miles in the state have been assessed.

Streams

Less than full support of stream usage has been attributed equally to municipal wastewater treatment plants, industrial discharges, non-point sources, and "other" sources (Table KY-1). During 1983, 37 fishkills were attributed to pollution, with approximately 51 miles of streams being affected. The resulting mortality was estimated to be 76,187 fish. The most frequent causes of kills were oil and chemical spills, wastes from oil drilling or mining operations, and contamination by wastewater of unspecified origin. A more extensive summary of the surface water quality for each of Kentucky's ten major river basins is provided in Table KY-2. Excessive phosphorus was identified as a problem parameter in three basins and excessive nitrogen in four basins. Nutrients have been improving in three of the ten basins and no trend was observable in the other seven.

Lakes

The failure of lakes to meet the required water quality standards has been largely attributed to non-point and "other" sources (26 and 68 percent, respectively), and only occasionally to municipal wastewater treatment plant discharges (Table KY-1). Industry has not been identified as causing water quality problems in Kentucky's public lakes.

Kentucky's Stream Monitoring Program

The emphasis of this report is on lakes; therefore, only a brief description of Kentucky's stream monitoring program will be provided. The Kentucky ambient monitoring program operates a fixed-station network of primary water quality monitoring sites, of which 69 were active during 1982-1983. Including the program activities which were coordinated with other agencies (EPA, Ohio River Valley Water Sanitation Commission, U.S. Geological Survey, U.S. Army Corps of Engineers, among others), this monitoring network generates data which are used to characterize approximately 1350 stream miles within the state. The fixed-station parameter coverage is extensive, with monthly water samples analyzed for pH, turbidity, and concentrations of bacteria, nutrients, solids, minerals, and metals.

Kentucky's Clean Lakes Program

Kentucky's Clean Lakes Program involved the trophic state assessment of 90 public lakes, a figure representing 17 "major" and 73 "minor" lakes. The scope of the project was intended to cover all public lakes deemed significant by the Kentucky NREPC. The 90 lakes studied were selected on the basis of public ownership, size (generally greater than 50 acres in surface area), and public interest and use. Three water quality categories were established based on the degree of water quality impairments. Five lakes which had documented severe use impairments were classified as Category I lakes, and 35 lakes having somewhat lesser, although serious, water quality problems were classified as Category II lakes. The remaining 50 lakes were considered to have no use impairments or water quality problems and were classified as Category III lakes. A summary of the trophic status of the lakes assessed during the Kentucky Clean Lakes Program is provided in Table KY-3.

Municipal Wastewater Treatment Plants and Non-Point Sources As Factors Causing Water Quality Degradation in Lakes and Streams

Table KY-4 contains an overview of the water quality problems associated with Kentucky's lakes and streams, and the corresponding factor(s) contributing to these problems.

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table KY-5). These data indicate that 1,485,000 (41 percent) of the state's total population of 3,661,000 persons are served by a municipal wastewater treatment system, with the remaining population (59 percent) being served primarily by septic systems. No municipal wastewater treatment plants are required by their NPDES permits to employ phosphorus removal. Seventeen treatment plants serving 769,000 people have combined sewer systems.

The primary impact of municipal wastewater facilities on lakes results from nutrients in the wastewater effluents. Streams are primarily affected by bacterial contamination (coliform) as well as increased nutrient loads, and have experienced fish kills due to municipal wastewater discharges. Toxic pollutants discharged to surface waters are also of concern.

Non-Point Sources

Kentucky's surface waters are adversely affected in a greater variety of ways by non-point sources than by municipal wastewater treatment plants. A summary of the extent and severity of non-point source pollutants in Kentucky is given in Table KY-6.

Agricultural runoff is a widespread problem, with one-half or more of the state's waters being affected. Agricultural activities cause problems associated with low dissolved oxygen concentrations, high bacterial counts (coliform), decreases in water clarity, and heightened concentrations of heavy metals, nutrients (phosphorus and nitrogen), and suspended solids.

Mining operations also seriously impact Kentucky's surface waters through land disturbances which result in runoff containing high levels of suspended solids and heavy metals.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Pollution

The future of Kentucky's surface water quality depends on the state's ability to establish adequately effective programs in response to their problems. Kentucky experienced a growth rate of 14 percent (1980 U.S. Census) in the 1970's and this continuing growth in population will necessitate the funding of additional pollution control technologies. Kentucky's population rose an additional 2 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 9 percent by the year 2000 (U.S. News & World Report, 1985). Kentucky has expressed concern about what were, at that time, proposed changes in the federal construction grants program for municipal wastewater treatment plants, which have now been enacted: "Reduction in funding for sewage treatment plant construction will seriously affect the progress made towards abating pollution from these [municipal wastewater treatment plants] sources. At the present Kentucky is near the halfway point in controlling pollution from municipalities. Assured funding with the retaining of the 75 percent federal participation will continue this progress."

(ASIWPCA, 1983b).

Kentucky is addressing the problem of pollution from mining practices through regulatory programs [e.g. NPDES and the Surface Mining Control and Reclamation Act (Public Law 95-87)]. To deal with agricultural, forestry, and construction-related pollution, the state has adopted a nonregulatory approach, including technical assistance, education, and economic incentives. Kentucky has also developed regulatory options in the form of a Model Sediment Control Ordinance, a Farm Lease Agreement, and a Timber Sale Contract, which will be implemented if the nonregulatory approach does not achieve the desired results.

B. Analysis of Phosphorus Loads to the Kentucky Study Lakes

Identification of Study Lakes And Municipal Wastewater Treatment Plants

The water quality of 90 publicly owned Kentucky lakes was assessed during the Kentucky Clean Lakes Program (Kentucky NREPC, 1984a). Of the 90 lakes assessed, 15 were selected for study according to the criteria given in the General Procedures section; that is, the study lakes are those which were identified as having at least one municipal wastewater treatment plant discharging within approximately 50 miles upstream. Two of the 15 lakes were Category I lakes, three were Category II lakes, and 10 were Category III lakes; these categories were previously described in the section on the Kentucky Clean Lakes Program. Thirteen of these lakes were identified using the listing of major point source discharges for each lake presented in Appendix B of the Clean Lakes Program report (Kentucky NREPC, 1984a). A review of Kentucky's "major" lakes listed in Table 2 of the Clean Lakes report indicated Barren River Reservoir and Lake Herrington also had municipal wastewater treatment plants upstream. These lakes were added to the set of study lakes to ensure complete coverage of the most important lakes in Kentucky.

Morphological data for the 15 lakes (Table KY-A in Appendix B), and land uses within their basins (Table KY-B in Appendix B), were obtained from the lake data summary sheets in the Clean Lakes Program report. A listing of the municipal wastewater treatment plants upstream of the study lakes, along with an estimate of the number of persons served by each plant, is given in Table KY-C in Appendix B.

Table KY-7 provides an overview of the numbers of study lakes and municipal wastewater treatment plants upstream, and the populations served by these plants, as compared to the values for the entire state. The 15 lakes chosen for study comprise almost 100 percent (347,529 acres) of Kentucky's 348,569 acres of publicly owned lakes assessed during the Kentucky Clean Lakes Program. Thus, the determination of estimated annual TP loads to the study lakes represents a comprehensive analysis of phosphorus loading for those lakes considered most important to the state of Kentucky.

Results and Discussion of Total Phosphorus Load Calculations

Municipal wastewater treatment plant total phosphorus loads to the 15 study lakes ranged from less than 1 to 91 percent of the total loads (Table KY-8). Table KY-8 also contains relevant excerpts from the 1984 Kentucky 305(b) Report (Kentucky NREPC, 1984b). The Clean Lakes Program water quality sampling data for the study lakes are presented in Table KY-9a, and the trophic states and limiting nutrients in Table KY-9b.

Although the total phosphorus load analysis indicated potential problems attributable to municipal wastewater treatment plant phosphorus loads could occur in Corbin, McNeely, Laurel River, and Nolin Lakes, special circumstances exist preventing this potential from being realized, or actions are already being taken to alleviate the problems.

a. Lakes Corbin and McNeely are small lakes (<60 acres) with relatively small drainage basin areas; thus, it would be unreasonable to expect them to be capable of assimilating the discharge from a municipal wastewater facility. Apparently, the state has recognized this as it has already recommended sewage diversion as a means of restoration.

   Lake Corbin was eligible for Phase I project funding under the Clean Lakes Program, facilitating an investigation of the causes for its water quality problems. The only Kentucky Clean Lakes Program lake eligible for Phase II project funding was McNeely Lake, making it a candidate for the implementation of methods necessary to bring about recommended improvements.

b. Laurel River Lake has been the subject of intensive monitoring. The Kentucky Clean Lakes Program report stated, "A preliminary investigation based on loading of phosphorus to the lake indicated that the lake would be eutrophic even if the point source loading from Corbin and London was eliminated. The impacted area of the lake represents about 5 percent of the total lake area."

c. Nolin Lake has been classified as mesotrophic and the Kentucky Clean Lakes Program report stated that lake protection and restoration measures were not required.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table KY-10). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy, some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic This is as expected, because non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For Kentucky

Table KY-1: Kentucky Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern [as presented by ASIWPCA (1983b)].

	Total Stream Miles or Acres of Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	40,000	4,820	12	10	59	0	31	25	25	25	25[1]
Lakes	358,203 (90)	358,203	100	91	9	<1	<1	0	6	26	68[1]
				Major Parameter(s) of Concern				Tox	FC DO Nut* Tox*	FC pH Tox Nut* WC*	Fe Mn

*Identified by the state as the most significant problems.

1 : Largely due to hypolimnetic iron and manganese release from impoundments affecting downstream community's water supply

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Fe : Iron concentration.
Mn : Manganese concentration.
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tox: Toxic substances.
WC : Turbidity (water clarity).

Table KY-2: Water Quality in Kentucky's River Basins (from Kentucky NREPC, 1984b).

	DO	pH	Aes.	Nut.	Tox.	Bact.	Bio.	Avg.	# Of Sites	Miles Assess.	Problem Parameters		
<u>Big Sandy River</u>													
WQI	G	G	F	G	F	P	F	F	8	805	Cu	FC	Fe
Trend	N	N	N	N	I	U	U						
<u>Licking River</u>													
WQI	G	G	F	P	F	F	G	F	5	1161	Cu	FC	Fe
Trend	N	N	N	N	N	U	U	-			NO_3	P	
<u>Upper Cumberland River</u>													
WQI	G	G	G	G	F	F	G	G	5	1348	Cu	FC	Fe
Trend	N	N	N	N	N	U	U	-			SS		
<u>Kentucky River</u>													
WQI	G	G	F	F	G	F	G	F	11	2343	Cu	FC	Fe
Trend	N	D	N	N	N	U	I	-			NO_3	P	Zn
<u>Salt River</u>													
WQI	G	G	F	P	F	F	F	F	7	994	Cu	FC	Fe
Trend	N	I	I	I	N	U	N	-			P	SS	Zn
<u>Green River</u>													
WQI	G	G	F	F	F	F	F	F	12	2681	Cu	Fe	NO_3
Trend	N	N	N	N	I	U	U	-			Zn		
<u>Tradewater River</u>													
WQI	G	G	U	F	F	P	U	F	1	383	Cu	FC	Fe
Trend	U	N	N	N	N	U	U	-					

Table KY-2, continued.

	DO	pH	Aes.	Nut.	Tox.	Bact.	Bio.	Avg.	# Of Sites	Miles Assess.	Problem Parameters
Lower Cumberland River											
WQI	G	G	G	G	U	U	U	G	2	109	NO_3
Trend	U	D	N	I	I	U	U	-			
Tennessee River											
WQI	G	F	G	F	F	F	U	F	2	44	None Listed
Trend	U	N	N	N	N	U	U	-			
Mississippi River											
WQI	G	G	U	F	G	F	U	F	1	136	Cu Fe
Trend	U	N	U	N	I	U	U	-			

Table Headings:
DO = Dissolved oxygen.
pH = pH.
Aes. = Aesthetics.
Nut. = Nutrients.
Tox. = Toxic substances.
Bact. = Bacteria.
Biol. = Biological.
Avg. = Average for site.

Problem Parameters:
Cu = Copper.
FC = Fecal coliform bacteria.
Fe = Iron.
NO_3 = Nitrates.
P = Total phosphorus.
SS = Suspended solids.
Zn = Zinc.

Water Quality Index (WQI):
G = Good
F = Fair
P = Poor
U = Unknown

Trend:
I = Improving quality.
N = No detectable trend.
D = Decreasing quality.
U = Unknown.

Table KY-3: Trophic State of Kentucky's 90 Public Lakes.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Oligotrophic	17	19	98,564	28
Mesotrophic	26	29	184,466	51
Eutrophic	45	50	75,079	21
Hypereutrophic	2	2	105	<1

Table KY-4: Water Quality Problems in Kentucky and the Factors Attributed to Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
<u>Point</u>						
a) Municipal[1]	L S		S		S	
b) Industrial		S			S	
<u>Non-Point</u>						
a) Agric.	N	L S	S	S		N
b) Mining		L S		S	S	
c) Other					S	

1. Municipal wastewater treatment plants.

Key: L = Lakes.
S = Streams.
N = Freshwater lakes and/or streams, not specified.

Table KY-5: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 40,598 mi^2
Lake Surface Area Percentage	= 1.4 %
Total State Population[1] (1980)	= 3,660,777
(1970)	= 3,220,771
Population Served by Municipal Wastewater Treatment Plants	= 1,485,000 (41 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 54.3 %
- With a Septic Tank or Cesspool	= 37.7 %
- Other Means	= 8.0 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 17 (768,560)
Compliance by Significant Municipal Wastewater Treatment Plants	= 70 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	16,000	0.4
Secondary	1,273,000	34.8
Tertiary	196,000	5.4
No System But Required[1]	No Data	No Data
System Not Required	No Data	No Data

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

Table KY-6: Severity and Extent of Non-Point Source Contributions (from Kentucky NREPC, 1984b).

Source	Extent	Severity	Primary Parameters
Urban	L	M	SS,M,T,C
Agriculture (irrigated)	nd	nd	nd
Agriculture (nonirrigated)	W	M	N,OD,P,SS,T
Animal Wastes	M	M	N,OD,C
Silviculture	L	I	SS,T
Mining	L[1]	S	M,SS,T,O
Construction	L	M	SS,T
Hydrologic Modification	nd	nd	nd
Residual Waste/Landfill	nd	nd	nd

1. Localized to two regions of state, but in those regions the problem is widespread.

Extent	Severity
W = Widespread (50% or more of the State's waters are affected).	S = Severe (designated use is impaired).
M = Moderate (25 to 50% of the State's waters are affected).	M = Moderate (designated use is not precluded, partial support).
L = Localized (less than 25% of the State's waters are affected).	I = Minor (designated use is almost always supported).

Primary Parameters

C = coliforms	P = pesticides/herbicides
LF = low flow	S = salinity
M = metals	SS = suspended solids
N = nutrients	T = turbidity
OD = oxygen demand	O = other: acid mine drainage-pH

Table KY-7: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	15	90	nd	17	nd
	Surface Area [km^2]	1,406	1,411	nd	100	nd
MWTP's[1]	Number	56	56	271	100	21
	Pop. Served ($x10^3$ persons)	184	184	1,485	100	12

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Kentucky's Clean Lakes Program, except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

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Table KY-8: Non-point Source and Municipal Wastewater Treatment Plant [see (1)] Total Phosphorus Loads To Kentucky Study Lakes.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km^2]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Barkley	23440	LO CU	45579	BMIX	645.00	42.10	7	
Barren River	4047	GREEN	2440	BMIX	34.40	7.60	18	Iron and manganese releases cause occasional water supply treatment problems downstream.
Buckhorn	498	KNTKY	1057	BFOR	8.20	0.49	6	Sediments and turbidity from surface mining.
Cave Run	3347	LCKNG	2139	BMIX	30.20	3.31	10	Iron and manganese releases cause occasional water supply treatment problems downstream.
Corbin	56	UP CU	409	BMIX	5.80	4.03	42	Nutrients from point and NP sources cause (taste and odor producing) algal blooms.
Cumberland	20336	UP CU	14792	BMIX	209.00	63.00	24	
Dale Hollow	12100	UP CU	2316	BMIX	32.70	2.36	7	
Grayson	612	L SAN	508	BMIX	7.20	0.55	8	
Green River	3322	GREEN	1766	BFOR	13.80	2.22	14	
Herrington	1190	KNTKY	1137	BMIX	16.00	20.80	57	
Kentucky	64872	TENNE	104120	FMIX	2330.00	22.60	1	
Laurel River	2452	UP CU	730	BMIX	10.30	12.50	55	Nutrients from point and NP sources causing nuisance algal blooms.
McNeely	21	SALTR	13	BURB	0.39	3.76	91	Nutrient inflows from package sewage treatment plants causing nuisance algal blooms and low dissolved oxygen concentrations.
Nolin	2343	GREEN	1821	BMIX	25.70	18.10	42	
Rough River	2064	GREEN	1176	BMIX	16.60	2.23	12	Manganese release from anoxic hyperlimnion causing downstream water treatment problems.

1. Municipal wastewater treatment plant is appreviated as MWTP in the Table.
2. Key to lake river basin codes:

Code	Major River Basin
SALTR	Salt River
TENNE	Tennessee
GREEN	Green
UP CU	Upper Cumberland
KNTKY	Kentucky
LCKNG	Licking
L SAN	Little Sandy

3. Land use categories are equivalent to those assigned to each lake's drainage basin as presented in Table KY-B of Appendix B.

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Table KY-9a: Water Quality Sampling Data for Those Study Lakes[1] With Relevant Information Available From the Clean Lakes Program (Kentucky NREPC, 1984a). All values are in ug/L as N, P, or Chl-*a*.

Lake	Date	NH_3 + NH_4	NO_2 + NO_3	TKN	TN	OP	DP	TP	Chl-*a*
Corbin S1	82 7 27	210	300	810	1110	7	12	46	12.6
	82 8 19	170	30	1210	1240	7	13	49	29.1
Corbin S2	82 8 19	200	260	1340	1600	32	42	276	148.0
Mean Values:		193	197	1120	1317	15	22	124	63.2
Herrington S2	83 8 23	50	30	400	430	1	7	10	9.7
Herrington S2	83 8 23	50	5	430	435	1	4	14	7.9
Mean Values:		50	18	415	433	1	6	12	8.8
Kentucky[2]	82 (mean)	nd	nd	nd	nd	nd	nd	60	6.1

1. The study lakes are those for which total phosphorus load estimates were calculated.

2. Data obtained from Carriker and Cox (1984).

Table KY-9b: Water Quality Indicators of Kentucky Study Lakes. [Mean and yearly trophic state indices are Carlson TSI (Chlorophyll-a) values].

Lake	Year	Mean TSI	1975-81 Average	Trophic State[1]	TN:TP Ratio[2]	Limiting Nutrient[3]	Macro-phytes and/or Algae[4]
Barkley	1979	58	nd	E	5-11:1	N-NP	N
Barren River	1981	50	43	E-M	nd	P	N
Buckhorn	1981	41	38	O	nd	nd	N
Cave Run	1981	34	35	O	nd	nd	N
Corbin	1982	55	nd	E	nd	P-NP	A
Cumberland	1979	37	nd	O	>30:1	P	N
Dale Hollow	1979	33	nd	O	>37:1	P	N
Grayson	1981	41	37	O	nd	nd	N
Green River	1981	53	43	M	nd	nd	N
Herrington	1983	56	nd	E	21-85:1	P	A
Kentucky	1982	48	nd	M	6-52:1	P-NP	N
Laurel River	1979	41	42[5]	O-M-E	nd	P	A
McNeely	1982	70	nd	H	<5:1	N	B
Nolin	1981	44	44	M	nd	nd	N
Rough River	1981	57	45	M	nd	nd	N

1. Key to trophic states:
   H = Hypereutrophic   M = Mesotrophic
   E = Eutrophic   O = Oligotrophic
2. Total nitrogen to total phosphorus ratio (see glossary).
3. See glossary for explanation.
4. The presence of macrophytes and/or algae is noted whenever mentioned in the Kentucky Clean Lakes report (Kentucky NREPC, 1984) as degrading water quality to the point where the lake's public use is impaired.
   A=Algae, B=Both, M=Macrophyte N=Not mentioned as a problem.
5. This value is the yearly mean for the period of 1977-79.

nd = No data.

Table KY-10: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)						
	Oligo.	Oligo-Meso.	Meso.	Meso-Eutro.	Eutro.	Eutro-Hyper.	Hyper-Eutro.
Less Than 1 To 5	0	0	1	0	0	0	0
5 To 25	5	0	2	1	1	0	0
25 To 50	0	0	1	0	1	0	0
Greater Than 50	0	1	0	0	1	0	1

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

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VII. MISSISSIPPI

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Mississippi Clean Lakes Program [Mississippi Department of Natural Resources (Mississippi DNR), 1984b], the 1984 Section 305(b) Report (Mississippi DNR, 1984a), and the ASIWPCA STEP Program (ASIWPCA, 1983a,b) information has become available concerning surface water quality and pollutant discharge sources for the state of Mississippi.

Extent and Nature of Water Quality Concerns

Mississippi's assessment of water quality in estuaries, lakes, and streams indicated slightly fewer pollution problems were associated with lakes than with streams and estuaries (Table MS-1). Overall, the state's surface water quality is apparently sound, with about 90 percent of its streams and estuaries fully supporting their designated uses, and 10 percent demonstrating partial support. Ninety-six percent of the lake surface area supported the designated uses.

Streams

Failure of Mississippi's streams to meet required water quality standards was attributed primarily to non-point sources (72 percent), while municipal and industrial pollutant sources accounted for 23 percent and 5 percent of the cases, respectively (Table MS-1). A more extensive summary of the surface water quality for each of Mississippi's major river basins is provided in Table MS-2; the water quality, in respect to nutrients, was categorized as good or excellent at all sites.

Estuaries

Non-point source pollutants were targeted as being the prime offenders to estuaries, representing 56 percent of the cases for nonsupport; 31 percent and 13 percent of the water quality problems were attributed to municipal and industrial sources, respectively. One example of these problems is along the Mississippi Gulf Coast. Extensive planning has been conducted in this area to develop a management strategy for providing effective wastewater collection and treatment: "studies indicate that along with improved wastewater treatment, an intensive effort will be needed to locate and correct sources of bacterial contamination in runoff into the Mississippi Sound" (ASIWPCA, 1983).

Lakes

Only 4 percent of Mississippi's lakes demonstrated less than full support of their designated uses, a condition attributed solely to non-point source pollutants (Table MS-1). Although 96 percent of the 34 lakes presently support their designated uses, 29 were classified as eutrophic and the remaining five as mesotrophic. The Mississippi DNR anticipates that the implementation of Best Management Practices for non-point sources would improve the water quality of all 34 Clean Lakes Program lakes such that the goal of fishable/swimmable use would be met.

Mississippi's Stream Monitoring Program

The emphasis of this report is on lakes; therefore, only a brief description of Mississippi's stream monitoring program will be provided. Their program is composed of fixed station monitoring (including the EPA core stations), intensive surveys, and compliance monitoring. Mississippi's 30 primary fixed stations are sampled once every other month and the EPA's core and chemical stations are sampled every month for a variety of parameters (e.g. nutrients, dissolved oxygen, bacteria, Secchi disk depth).

Mississippi's Clean Lakes Program

Mississippi's Clean Lakes Program (Mississippi DNR, 1983) selected 34 lakes to be included in the trophic state classification and ranking phase of the program. These lakes included the six major reservoirs within the state, 18 oxbow lakes, and 10 smaller reservoirs. Emphasis was placed on lakes having surface areas exceeding 100 hectares (250 acres). To establish the trophic states of these lakes sampling was conducted from June 15 through July 14, 1982. A table of trophic states is not presented for Mississippi because the Clean Lakes Program Report indicated all 34 lakes were eutrophic. However, the 1984 Mississippi 305(b) Report stated the water quality in five of the lakes had improved to a mesotrophic state; the five lakes were not specified.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table MS-3 provides an overview of the water quality problems associated with Mississippi's estuaries, public lakes, and streams, and the corresponding factor(s) contributing to these problems.

Municipal Wastewater Treatment Plants

The major parameters of concern from municipal wastewater treatment plant effluents are coliform bacteria, dissolved oxygen, and nutrients. Of these, bacteria and dissolved oxygen are considered to be the most serious problem areas at this time.

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table MS-4). These data indicate that 1,600,000 (63 percent) of the state's total population of 2,520,000 persons are served by a municipal wastewater treatment system, with the remaining population (37 percent) being served primarily by septic systems. Mississippi has no wasterwater treatment plants practicing chemical removal of phosphorus, and has no communities served by a combined sewer system.

Industrial Discharges

Parameters causing concern from industrial sources are dissolved oxygen, nutrients, temperature, and toxics. At present, dissolved oxygen and nutrients are considered to be the two parameters of most serious concern.

Non-Point Sources

The impact of non-point source discharges has resulted in higher levels of coliform bacteria, nutrients, toxics, and turbidity, with coliform bacteria and toxics considered to be the most serious. A summary of the extent and severity of non-point source pollutants in Mississippi is given in Table MS-5.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of Mississippi's surface water quality depends on the state's ability to establish and manage adequate programs in response to their problems. Construction of new wastewater treatment plants began to alleviate the historically bad municipal and industrial pollution problems on the Gulf Coast, but this trend is being hampered by insufficient funds to construct the facilities still needed. This problem is being compounded by the state's population growth, which was 14 percent from 1970 to 1980 (U.S. 1980 Census). Mississippi's population rose an additional 4 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 11 percent by the year 2000 (U.S. News & World Report, 1985). However, the State of Mississippi recognizes that emphasis can not be placed on municipal wastewater treatment plants alone if high water quality is to be achieved: "Non-point source pollution appears to be our greatest challenge in the future. Once the remaining needs for publicly owned treatment works are addressed, control of non-point sources will be required to attain additional water quality improvements" (ASIWPCA, 1983). Mississippi is utilizing educational programs to promote the use of Best Management Practices to control non-point pollution from agricultural runoff. Additional planning, though, will be necessary to develop implementation strategies for more non-point source pollution control.

B. Analysis of Phosphorus Loads to the Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

Appendix 2 of Mississippi's Clean Lakes Program report (Mississippi DNR, 1984b) contained complete listings of municipal wastewater discharges in each lake's drainage basin. Following the methods previously described in the General Procedures section, 10 of the 34 lakes were found to have municipal wastewater discharges upstream (Table MS-A in Appendix B). This 10 lake study group encompassed the entire range of water quality found in the 34 Clean Lakes Program lakes, representing the highest priority lake (Tchula) to one of the lowest priority lakes (Enid).

Morphological data for the 10 lakes (Table MS-B in Appendix B), and land uses in their drainage basins (Table MS-C in Appendix B), were obtained from the data summary sheets in the Mississippi Clean Lakes Program report (Mississippi DNR, 1983).

Results and Discussion of Phosphorus Loads

Table MS-6 provides an overview of the numbers of study lakes and municipal wastewater treatment plants, and the populations served by these plants, as compared to the values for the entire state. Municipal wastewater treatment plant total phosphorus (TP) loads to the study lakes ranged from less than 1 to 99 percent of the total TP loads; the total loads were calculated as the sum of the non-point source and municipal wastewater treatment plant loads. Table MS-7 contains all of the calculated loads along with relevant excerpts from the 1984 Mississippi 305(b) Report (Mississippi DNR, 1984a) concerning the 10 lakes potentially impacted by municipal wastewater treatment plant discharges. The water quality sampling data from the Clean Lakes Program for the study lakes is presented in Table MS-8. The following are pertinent observations concerning some of the lakes in the study.

a. Lake Mary: The small drainage basin area of the lake and its relatively small size precludes municipal wastewater treatment plant discharges without a concomitant degradation of water quality.

b. Lake Ferguson: This lake serves as a harbor for the City of Greenville, and all but the uppermost portions of the lake are severely impacted by port activities. The lake's level is controlled by inflow from the Mississippi River. Therefore, although the municipal wastewater treatment plant phosphorus load is relatively large, other problems most likely mask any impact it would otherwise have.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table MS-9). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy, some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic. This is as expected, since non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For Mississippi

Table MS-1: Mississippi's Estuaries, Public Lakes, and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern as presented by ASIWPCA (1983b).

	Total Stream Miles or Acres of Estuaries or Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	10,274	10,274	100	90	10	0	0	5	23	72	0
Lakes	495,191 (nd)	495,191	100	96	4	0	0	0	0	100	0
Estuaries	85,120	85,120	100	89	10	1	0	13	31	56	0
				Major Parameter(s) of Concern				DO* Tox Nut* Tem	FC* Nut DO*	FC* Nut* Tox* WC	--

* Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
Tem: Temperature.
Tox: Toxic substances.

Table MS-2: Water Quality in Mississippi's River Basins (from Mississippi DNR, 1984a). A Key to Codes Is Provided at the End of the Table.

	Temp.	DO	pH	Solids	Nut.	Bact.	H. Met.	Pest.	Bio.	Overall Water Quality and Trend
1. Big Black River Basin										
Canton										
WQI	E	E	E	G	G	G	-	-	-	G-E
Trend	U	U	U	U	I	U	-	-	-	I
Bovina										
WQI	E	E	E	G	G	E	-	-	-	G-E
Trend	U	U	U	U	U	U	-	-	-	
2. Coastal Streams Basin										
Back Bay of Biloxi										
WQI	E	E	E	E	E	E	G	G	F	G
Trend	U	U	U	D	U	I	S	S	S	S
Jourdan River Bay, St. Louis										
WQI	E	E	F	E	E	G	E	E	E	G-E
Trend	U	D	U	U	D	U	S	S	S	S
St. Louis Bay, Highway 90										
WQI	E	E	E	E	E	G	E	E	-	E
Trend	U	D	S	U	U	U	I	I	-	I
Wolf River										
WQI	E	E	G	-	E	E	-	-	-	E
Trend	U	U	U	-	U	U	-	-	-	U
3. Mississippi River Basin										
Mississippi River, Vicksburg										
WQI	E	E	E	F	G	E	-	-	-	G
Trend	U	U	U	U	U	U	-	-	-	U
4. Pascagoula River Basin										
Black Creek, Purvis										
WQI	E	E	G	E	E	E	E	E	U	E
Trend	U	D	U	U	D	U	S	S	U	D
Chickasawhay River / Enterprise										
WQI	-	-	-	-	-	-	-	E	G	G
Trend	-	-	-	-	-	-	-	U	U	U

Table MS-2, continued.

	Temp.	DO	pH	Solids	Nut.	Bact.	H. Met.	Pest.	Bio.	Overall Water Quality and Trend
Cypress Creek, Janice										
WQI	E	E	P	-	E	E	-	-	-	E
Trend	U	U	D	-	U	U	-	-	-	U
Escatawpa River, Moss Point										
WQI	E	G	F	E	E	E	G	G	F	F-G
Trend	D	D	U	U	U	U	S	S	S	S
Leaf River, McClain										
WQI	E	E	G	E	G	G	E	E	-	G-E
Trend	U	U	U	U	U	U	I	I	-	I
Okatibbee Creek, Arundel										
WQI	E	E	F	E	G	G	U	U	F	F-G
Trend	U	U	U	U	U	U	U	U	I	I
Okatibbee Creek, Meridian										
WQI	-	-	-	-	-	-	-	-	G	G
Trend	-	-	-	-	-	-	-	-	D	D
Okatoma Creek, Seminary										
WQI	E	E	G	E	E	E	G	G	E	E
Trend	U	U	U	U	U	U	S	S	S	S
Pascagoula River, Benndale										
WQI	E	-	E	-	E	-	-	-	-	U
Trend	U	-	U	-	U	-	-	-	-	U
Tallahala Creek, Runnelstown										
WQI	E	E	G	E	G	E	E	E	F	G
Trend	U	U	U	U	U	U	I	I	D	U
W. Pascagoula River, Highway 90										
WQI	E	E	G	E	E	E	E	E	G	G-E
Trend	D	U	U	U	D	U	S	S	S	S
5. South Independent Streams										
Bayou Pierre, Willows										
WQI	E	E	G	G	G	E	-	-	-	G
Trend	U	U	U	U	U	U	-	-	-	U

Table MS-2, continued.

	Temp.	DO	pH	Solids	Nut.	Bact.	H. Met.	Pest.	Bio.	Overall Water Quality and Trend
Homochitto River, Rosetta										
WQI	G	E	E	-	E	E	-	-	-	G-E
Trend	U	U	U	-	U	U	-	-	-	U
6. Tombigbee River Basin										
Luxapalila Creek, Steens										
WQI	E	E	G	E	G	E	G	E	-	G-E
Trend	U	U	U	D	U	U	S	S	-	S
7. Yazoo River Basin										
Coldwater River, Prichard										
WQI	E	E	E	F	G	F	G	G	-	G
Trend	U	U	U	U	U	U	I	I	-	I
L. Tallahatchie River, Etta										
WQI	E	E	E	G	G	E	-	-	-	G-E
Trend	U	U	U	U	U	U	-	-	-	U
Sunflower River, Clarksdale										
WQI	E	G	G	G	G	G	-	-	-	G
Trend	U	D	U	U	U	U	-	-	-	U
Sunflower River, Sunflower										
WQI	E	G	E	G	G	G	G	P	P	F-G
Trend	U	U	U	U	I	U	U	I	D	U
Tallahatchie River, Swan Lake										
WQI	E	E	G	G	G	G	F	F	-	G
Trend	U	U	U	U	U	U	U	U	-	U
Yalobusha River, Grenada										
WQI	E	E	E	G	G	G	-	-	-	G
Trend	U	U	D	U	D	U	-	-	-	D
Yazoo River, Redwood										
WQI	E	E	E	-	G	E	-	-	-	U
Trend	U	U	U	-	U	U	-	-	-	U

Table MS-2, continued.

	Temp.	DO	pH	Solids	Nut.	Bact.	H. Met.	Pest.	Bio.	Overall Water Quality and Trend
Yazoo River, Shell Bluff										
WQI	E	E	E	G	G	E	G	F	P	F-G
Trend	U	U	U	U	U	U	U	D	S	U
8. Pearl River Basin										
Bogue Chitto River, Lehr										
WQI	E	E	G	E	E	E	G	E	G	G-E
Trend	U	U	U	U	U	I	S	S	S	S
Pearl River, Barnett River										
WQI	E	E	G	E	G	G	E	G	-	G
Trend	U	D	U	U	U	U	S	D	-	D
Pearl River, Byram										
WQI	E	E	G	G	G	G	E	G	F	G
Trend	U	U	U	U	U	I	S	S	S	S
Pearl River, Columbia										
WQI	E	E	G	G	G	E	G	G	G	G
Trend	U	U	U	U	U	U	S	S	S	S
Pearl River, Highway 90										
WQI	-	-	-	-	-	-	E	E	-	U
Trend	-	-	-	-	-	-	U	U	-	U

Key To Table MS-2:

Parameters:

Temp.: Temperature.
DO: Dissolved oxygen.
Nut.: Nutrients (e.g. nitrogen, phosphorus).
Bact.: Bacteria (coliform).
H. Met.: Heavy Metals.
Pest.: Pesticides.
Bio.: Biological.

Chemical Evaluation

a. Quality.

- P - Poor - Frequent severe standards violations or other major effects.
- F - Fair - Occasional severe standards violations or other effects.
- G - Good - Some minor violations but generally not impaired.
- E - Excellent - No standards violations or effects.
- U - Unknown - Insufficient data.

b. Trend.

- D - Degrading.
- S - Stable.
- I - Improving.
- U - Unknown.

Key To Table MS-2, Continued:

Biological Evaluation:

a. Quality.

P - Poor - Unhealthy communities of aquatic organisms, low diversity, dominant species pollution tolerant.
F - Fair - Generally unhealthy communities, low diversity, some impacts of pollution.
G - Good - Moderately healthy, indigenous and diversified communities, slight pollution impacts.
E - Excellent - Healthy, indigenous communities of aquatic organisms with high diversity and no apparent impacts of pollution.

b. Trend.

D - Degrading.
S - Stable.
I - Improving.
U - Unknown.

Table MS-3: Water Quality Problems in Mississippi and the Factors Attributed to Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	S		E S			E S
b) Industrial	S					S
Non-Point						
a) Agric.	L E S	L S	L S			L S
b) Mining						
c) Other	E[2]					

1. Municipal wastewater treatment plants.

2. Toxics and pesticides from unspecified sources were also listed as problems.

KEY: E=Estuaries, L=Lakes, S=Streams.

Table MS-4: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 47,700 mi^2
Lake Surface Area Percentage	= 1.6 %
Total State Population[1] (1980)	= 2,520,638
(1970)	= 2,216,912
Population Served by Municipal Wastewater Treatment Plants	= 1,600,000 (63 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 56.5 %
- With a Septic Tank or Cesspool	= 35.3 %
- Other Means	= 8.2 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 0 (0)
Compliance by Significant Municipal Wastewater Treatment Plants	= 85 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
No Treatment	50,000	2.0
Primary	300,000	11.9
Secondary	700,000	27.8
Tertiary	600,000	23.8
No System But Required[1]	150,000	6.0
System Not Required	700,000	27.8

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

Table MS-5: Severity and Extent of Non-Point Source Contributions (from Mississippl DNR, 1984a).

Source	Extent	Severity	Primary Parameters
Urban	L	M	C
Agriculture (irrigated)	L	S	N,P,SS,T
Agriculture (nonirrigated)	L	S	N,P,SS,T
Animal Wastes	L	I	N,C
Silviculture	L	I	SS
Mining	L	I	SS
Construction	L	I	SS
Hydrologic Modification	L	M	OD,SS
Saltwater Intrusion	na	na	na
Residual Waste/Landfill	L	I	M,N

Extent

W = Widespread (50% or more of the State's waters are affected).

M = Moderate (25 to 50% of the State's waters are affected).

L = Localized (less than 25% of the State's waters are affected).

Severity

S = Severe (designated use is impaired).

M = Moderate (designated use is not precluded, partial support).

I = Minor (designated use is almost always supported).

Primary Parameters

C = coliforms	P = pesticides/herbicides
LF = low flow	S = salinity
M = metals	SS = suspended solids
N = nutrients	T = turbidity
OD = oxygen demand	O = other

na : Not available.

Table MS-6: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	10	34	nd	29	nd
	Surface Area [km^2]	1,887	2,005	nd	94	nd
MWTP's[1]	Number	54	--[1]	359	--[1]	15
	Pop. Served ($x10^3$ persons)	141	--[1]	1,600	--[1]	9

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Mississippi's Clean Lakes Program, except for those added or deleted due to special circumstances as described in Part B of the General Methods section.

Table MS-7: Non-point Source and Municipal Wastewater Treatment Plant Total Phosphorus Loads To Mississippi Study Lakes.

Lake Name	Surface Area [ha]	Basin Code[1]	Basin Area [km²]	Land Use Cat.[2]	Est. TP Loads [x1000 kg/yr] Non-Point	Point (MWTP)[3]	% of Total TP Loads Attributed to MWTP's[3]
Arkabutla	4804	YAZOO	2590	DMIX	70.00	11.30	14
Bogue Homa	486	PASCA	303	FMIX	6.80	1.91	22
Enid	5249	YAZOO	1450	FMIX	32.50	30.30	49
Ferguson	582	MISSI	39	DURB	0.75	40.90	99
Grenada	9838	YAZOO	3419	FMIX	77.00	6.40	8
Mary	911	S IND	41	DFOR	0.25	2.63	92
Pickwick	18940	TENNE	85003	FMIX	1900.00	2.87	1
Ross Barnett	135171	PEARL	7690	FMIX	172.00	35.90	18
Sardis	12546	YAZOO	4002	FMIX	90.00	8.00	9
Tchula	188	YAZOO	366	DMIX	9.90	1.95	17

1. Key to lake river basin codes:

Code	Major River Basin
MISSI	Mississippi River
TENNE	Tennessee
YAZOO	Yazoo
PEARL	Pearl
PASCA	Pascagoula

2. Land use categories are equivalent to those assigned to each lake's drainage basin as presented in Table MS-B of Appendix B.

3. MWTP: Municipal wastewater treatment plants.

Table MS-8: Water Quality Sampling Data and Trophic Conditions for Those Study Lakes[1] for Which Data Were Available in the Mississippi Clean Lakes Program (Mississippi DNR, 1983); the Analyses Were Performed on Samples Collected from June 15 Through September 14, 1982. TP, TN, and Chl-*a* are in ug/L as P, N, and Chl-*a*; Dissolved oxygen is in mg/L and Secchi Disk Depth is in Meters.

Lake Name	TP	TN	Chl-*a*	D.O.	Secchi Disk Depth	Limit. Nut.[2]	TN:TP[3]	Trophic State[4]	Macro-phytes and/or Algae[5]
Arkabutla	205	1000	7.7	7.5	0.4	P	5	E	N
Bogue Homa	10	710	7.1	7.5	1.4	P	71	E	M
Enid	55	900	8.2	6.9	1.3	P	16	E	N
Ferguson	12	1000	24.4	7.2	1.5	P	83	E	N
Grenada	49	800	6.7	8.7	0.6	P	16	E	N
Mary	30	5200	18.0	11.5	1.0	P	173	E	N
Pickwick	75	800	6.7	6.4	1.7	P	11	E	M
Ross Barnett	75	1140	29.2	8.5	0.4	P	15	E	M
Sardis	13	800	4.5	8.2	1.8	P	62	E	N
Tchula	35	130	38.2	6.?	0.2	nd	4	E	N

1. The Study Lakes are lakes for which phosphorus loads were calculated.

2. See glossary for explanation.

3. Total nitrogen to total phosphorus ratio, see glossary.

4. Key to trophic states:
   H = Hypereutrophic
   E = Eutrophic
   M = Mesotrophic
   O = Oligotrophic

5. Key to presence of algae and/or macrophyte problems:
   A = Algae
   M = Macrophytes
   B = Both
   N = Not mentioned

Table MS-9: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)		
	Oligotrophic	Mesotrophic	Eutrophic
Less Than 1 To 5	0	0	1
5 To 25	0	0	6
25 To 50	0	0	1
Greater Than 50	0	0	2

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

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VIII. NORTH CAROLINA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the North Carolina Clean Lakes Program [North Carolina Department of Natural Resources and Community Development (North Carolina DNR&CD), 1983], the North Carolina 1984 Section 305(b) Report (North Carolina DNR&CD, 1984), and the ASIWPCA STEP Program (ASIWPCA, 1983a,b), information has become available concerning surface water quality in the State of North Carolina. Numerous other state studies have provided additional information (North Carolina DNR&CD, 1984a, 1984b, 1983, and 1982, among others).

Water Quality Status of Estuaries, Lakes, and Streams

North Carolina's assessment of water quality in estuaries, public lakes, and streams indicated all three types of water bodies supported or partially supported their designated uses in greater than 90 percent of the cases (Table NC-1).

Streams

Only 4 percent of North Carolina's stream miles did not support their designated uses. Failure to meet water quality standards was attributed primarily to non-point sources (55 percent) and municipal point sources (30 percent) (Table NC-1).

Estuaries

Although only 0.3 percent of North Carolina's estuaries were not supporting their designated uses, these coastal waters were exhibiting severe signs of eutrophication, organic pollution, bacterial contamination, and excessive freshwater inflow (Table NC-1). "Developing and implementating appropriate management strategies for point and non-point source pollution to these waters is a high priority. Separate standards for primary nursery areas are being considered as one approach to the coastal problems" (ASIWPCA, 1983). The state feels eutrophication problems may necessitate additional regulations for point source dischargers, such as the implementation of phosphorus removal technologies.

Lakes

North Carolina's assessment of its public lakes indicated that 100 percent of the lakes fully supported or partially supported their designated uses (Table NC-1).

The State's Stream Monitoring Program

The emphasis of this report is on lakes; therefore, only a brief description of North Carolina's stream monitoring program will be provided. The program consists of 346 stations that are sampled either monthly, quarterly or semi-annually for a wide range of water quality parameters. Thirty-seven of these stations are part of the national Basic Water Monitoring Program and are sampled monthly for all water quality parameters.

The State's Clean Lakes Program

During the North Carolina Clean Lakes Program (North Carolina DNR, 1983), 65 of North Carolina's 88 public lakes were sampled during 1981, and sampling was conducted again on 31 of these lake in the summer of 1982. It is noteworthy that North Carolina continued its lake sampling program in 1983 using its own funds to provide additional data (North Carolina DNR&CD, 1984c). The 65 lakes were classified according to their trophic state and a priority list for restoration was formulated. A summary of the trophic states is provided in Table NC-2.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources, As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table NC-3 provides an overview of the water quality problems associated with North Carolina's estuaries, public lakes, and streams and the corresponding factor(s) contributing to these problems. Municipal, industrial, and non-point sources were estimated to contribute equally to causing nonsupport of uses in streams. Eutrophication problems in lakes was attributed to non-point sources 55 percent of the time and municipal sources accounted for 40 percent of the problems. Coastal waters were impacted primarily by non-point sources, although municipal and industrial discharges may have localized impacts. Major parameters of concern impacting the most stream mileage include fecal coliforms, oxygen demand, nutrients, and heavy metals. Sediment loads were considered to impact more miles than all the other sources.

In the 1984 North Carolina 305(b) report (North Carolina DNR&CD, 1984), the state made a number of observations pertaining to the surface water quality in the state:

a. The 1985 fiscal year program objectives emphasize coastal water quality issues, toxic substance programs, "nutrient sensitive waters", implememtation of non-point source controls, as well as continuing efforts in permitting, pretreatment, compliance, and monitoring of municipal and industrial wastewater treatment plants.

b. There were approximately 130 fishkills reported from 1982 to 1983. The majority of these fishkills were caused by: chemical and toxic spills (23 percent), agriculture and urban runoff (10 percent), natural conditions (12 percent), low dissloved oxygen concentrations (8 percent), and unidentified causes accounted for about 23 percent of the fishkills.

c. Eutrophication problems are most evident in the North Carolina coastal plain and piedmont regions (Catawba, Yadkin/Pee-Dee, upper Cape Fear, Roanoke, Neuse, Tar-Pamlico, and Chowan/Albermarle River Basins). Approximately 55 percent of the land area of North Carolina drains to these waters and 71 percent of the state's population lives in this area.

d. The entire Chowan river basin and portions of the Cape Fear and Neuse basins in the Jordan and Falls lake watersheds have been classified as "nutrient sensitive waters". This supplemental stream classification provides the authority to limit nutrient inputs from dischargers. The state has been utilizing an approach of reducing nutrient inputs from all sources, point and non-point, in attempting to protect "nutrient sensitive waters". Presently, point dischargers in the Chowan basin have been issued limits of 3 mg N/L for total nitrogen and 1 mg P/L for total phosphorus, and all new permitted dischargers to the Falls and Jordan Lake watersheds have a 1 mg P/L limit.

e. The Water Quality Management Plan for North Carolina identified suspended sediments as the most widespread water quality problem. Sediment has severe physical, biological and chemical impacts on most waters of North Carolina. A large portion of the nutrients entering waters via runoff are transported as suspended sediment, particularly phosphorus.

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table NC-4). These data indicate that 2,930,000 (50 percent) of the state's 1980 total population of 5,882,000 persons are served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tank systems. Presently, no facilities employ chemical phosphorus removal, however, numerous plants in the regions designated as "nutrient sensitive waters" (Chowan Basin, and Falls of the Neuse and B. Everett Jordan Reservoirs watersheds), it may be required in the near future to achieve the 1 mg P/L effluent limit. One treatment plant serving 38,350 people has a combined sewer system.

Non-Point Sources

A summary of the extent and severity of non-point source pollution in North Carolina is given in Table NC-5.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of North Carolina's water quality depends on the state's ability to establish and manage adequate programs in response to their problems. During the 1970's emphasis was placed on point source dischargers and 1.3 billion dollars was used to improve the effluent quality of municipal wastewater treatment plants. There are still problems with many small municipal facilities and funds for upgrading these plants are required. The major plants serving the metropolitan areas are also a concern (e.g. Durham and Raleigh). This problem has also been compounded by the state's 16 percent increase in population from 1970 to 1980. North Carolina's population rose an additional 5 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 23 percent by the year 2000 (U.S. News & World Report, 1985).

Control of non-point source pollution has been and will continue to be a major focus of water quality programs in upcoming years. "Since 1977 non-point source pollution problems have been a particular concern, particularly erosion problems throughout the state and eutrophication of coastal waters. Programs have been developed to deal with various non-point sources of pollution; however, implementation of these programs requires additional effort (ASIWPCA, 1983). Erosion control is considered by the state as the cornerstone of an effective non-point source control program.

The entry of toxic materials to the state's waters is also an important problem that is being addressed through the use of a mobile bioassay laboratory.

B. Analysis of Nutrient Loads to the Study Lakes

For the phosphorus load analysis, refer to Curran et al. (1985).

C. Tables For North Carolina

Table NC-1: North Carolina's Estuaries, Public Lakes, and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern as presented by ASIWPCA (1983b).

	Total Stream Miles or Acres of Estuaries or Public Lakes In State (# Lakes)	Streams And Lakes Assessed		Support of Designated Uses (Percent)				Cause For Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	39,150	39,150	100	82	14	4	--	15	30	55	--
Lakes	320,000 (88)	310,300	97	87	13	0	--	30	35	35	--
Estuaries	2048000	2048000	100	84	16	<1	--	10	25	65	--
				Major Parameter(s) of Concern				Tox* DO* Nut Tem	FC DO* Nut* Tox	FC WC* Tox Nut*	Tox*

*Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Fe : Iron concentration.
Mn : Manganese concentration.
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tox: Toxic substances.
WC : Turbidity (water clarity).

Table NC-2: Trophic States for the 59 North Carolina Clean Lakes Program Lakes for Which Sampling Data were Available.

Trophic Classification	Number of Lakes	Percent of Total	Surface[1] Area [ac]	Percent of Total
Oligotrophic	9	15	49,178	20
Oligo-Meso.	10	17	55,630	23
Mesotrophic	15	25	46,954	19
Alpha-Eutrophic	15	25	65,525	27
Beta-Eutrophic	8	14	20,680	9
Hypereutrophic	2	3	3,126	1

1. Lake area totals are incomplete, as not all 59 lakes had values for surface area provided.

Table NC-3: Water Quality Problems in North Carolina and the Factors Attributed to Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	L E S		E S		S	S
b) Industrial				L		
Non-Point	E[2]					
a) Agric.	F	F	F			
b) Mining		F				
c) Urban Runoff	F	F	F	F		
d) Other		F				

1. Municipal wastewater treatment plants.
2. A major estuary problem is dilution by increased freshwater runoff due to agricultural, silvicultural, and urban activities.

Key: E = Estuaries, L = Lakes, S = Streams,
F = Freshwater lakes and/or streams, not specified.

Table NC-4: State Characteristics and Wastewater System Information Summary for North Carolina.

State Surface Area	= 52,712 mi^2
Lake Surface Area Percentage	= 1.0 %
Total State Population[1] (1980)	= 5,881,766
(1970)	= 5,082,059
Population Served by Municipal Wastewater Treatment Plants	= 2,930,000 (50 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 46.8 %
- With a Septic Tank or Cesspool	= 48.8 %
- Other Means	= 4.4 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 1 (38,350)
Compliance by Significant Municipal Wastewater Treatment Plants	= 85 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	1982 Population	Percent of Total State Population
Primary	30,000	0.5
Secondary[1]	590,000	9.8
Advanced[2]	1,500,000	24.8
Tertiary[3]	810,000	13.4
No System But Required[4]	250,000	4.1
System Not Required	2,860,000	47.4

(Footnotes are provided on following page.)

Table NC-4: Continued.

Footnotes:

1. Secondary: The State of North Carolina defines secondary as biological treatment and settling capable of achieving BOD's of 30 to 45 mg/L (trickling filters, some lagoons, extended aeration, etc.).

2. Advanced: The State of North Carolina defines advanced as biological treatment capable of achieving BOD's less than 28 mg/L (activated sludge).

3. Tertiary: The State of North Carolina defines Tertiary as two stage biological treatment or a combination of biological/chemical treatment capable of achieving advanced levels (activated sludge plus chemical precipitation.

4. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and who therefore need a sewer system.

Table NC-5: Severity and Extent of Non-Point Source Contributions (from Kentucky NREPC, 1984b).

Source	Extent	Severity	Primary Parameters
Urban	L	S	C,M,N,SS,T,P,SOC
Agriculture (irrigated)	W	M	SS,N,P,C
Agriculture (nonirrigated)	W	M	SS,N,P,C
Animal Wastes	L	M	C,OD,SS,N
Silviculture	W	I	SS,N
Mining	L	S	SS,T
Construction	nd	nd	nd
Hydrologic Modification	M	I	SS,S,LF
Saltwater Intrusion	nd	nd	nd
On-Site Wastewater Disp.	L	M	C,N,OD
Residual Waste/Landfill	L	I	SS,M,SOC

Extent

W = Widespread (50% or more of the State's waters are affected).

M = Moderate (25 to 50% of the State's waters are affected).

L = Localized (less than 25% of the State's waters are affected).

Severity

S = Severe (designated use is impaired).

M = Moderate (designated use is not precluded, partial support).

I = Minor (designated use is almost always supported).

Primary Parameters

C = coliforms
LF = low flow
M = metals
N = nutrients
OD = oxygen demand
SOC = synthetic organic chemicals
P = pesticides/herbicides
S = salinity
SS = suspended solids
T = turbidity
O = other

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IX. SOUTH CAROLINA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the South Carolina Clean Lakes Program [South Carolina Department of Health and Environmental Control (South Carolina DH&EC), 1982], the South Carolina 1984 Section 305(b) Report (South Carolina DH&EC, 1984), and the ASIWPCA STEP Program (ASIWPCA, 1983a,b) information has become available concerning surface water quality in the State of South Carolina.

Extent and Nature of Water Quality Concerns

South Carolina's assessment of water quality in streams and public lakes (South Carolina DH&EC, 1982) indicated the state's pollution problems were associated somewhat more with streams and estuaries than with lakes (Table SC-1).

Streams

Extensive pollution problems were indicated for South Carolina's streams, with half of them assessed as not fully supporting their designated uses (Table SC-1). Failure of South Carolina's streams to meet required water quality standards was attributed to non-point sources (37 percent), municipal discharges (23 percent), industrial sources (16 percent), and the remaining 24 percent to other unidentified sources.

Estuaries

Less than full support of designated uses was attributed to non-point sources (40 percent), other unidentified sources (34 percent), and municipal point sources (24 percent) (Table SC-1). The state is especially concerned with urban runoff and has designated Myrtle Beach as a "National Urban Runoff Project Demonstration Area" for the purposes of studying the impact of stormwater runoff upon surf water quality. Marina development along coastal South Carolina has also raised concerns regarding water quality and the state is presently assessing these impacts.

Lakes

Seventy-five percent of South Carolina's 40 public lakes fully supported their designated uses (Table SC-1). Municipal discharges and non-point sources were targeted as being responsible for 37 percent and 34 percent of the cases of less than full support of designated lake uses, with industrial discharges, mixed point (industrial and municipal point sources), and other unidentified sources accounting for the remaining 29 percent

South Carolina's Stream Monitoring Program

The water quality monitoring program planned for fiscal year 1985 is described in a special South Carolina DH&EC report (South Carolina DH&EC, 1985). South Carolina's monitoring program has a fixed monitoring network consisting of 181 primary stations that are sampled once per month (26 of these stations are included in the National Basic Ambient Monitoring Program). A secondary network of 404 strategically located stations (known and potential problem areas) are sampled six times per year during the period of May through October.

South Carolina's Clean Lakes Program

The South Carolina Clean Lakes Program report (South Carolina DH&EC, 1982) was intended to provide an overview of the water quality in the state's publicly owned lakes. Specific problem areas were to be investigated in subsequent Clean Lakes projects (Phases I and II). The program designated 40 lakes as comprising the significant publicly-owned freshwater lakes or reservoirs of the State of South Carolina. Inclusion of a lake in this list was restricted to those publicly owned lakes listed in the South Carolina Water Resources Commission's "Inventory of Lakes in South Carolina Ten Acres or More in Surface Area" (Coleman and Dennis, 1974), and whose restoration would have "an impact on the people of South Carolina and the United States." In accordance with the Federal Water Pollution Control Act Ammendments of 1972 (Public Law 92-500), the Clean Lakes Program report prioritized the 40 lakes according to trophic state and certain social factors. Table SC-2 contains a summary of the trophic states for the 40 lakes.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources As Factors Causing Water Quality Concerns in Estuaries, Lakes, and Streams

Table SC-3 provides an overview of the water quality problems associated with South Carolina's estuaries, public lakes, and streams, and the corresponding factor(s) contributing to these problems.

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table SC-4). These data indicate that 1,421,000 (46 percent) of the state's total population of 3,122,000 persons are served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tank systems. One facility employs chemical phosphorus removal, and no communities are served by combined sewer systems.

Non-Point Sources

In the 1984 South Carolina 305(b) report, the state identified agriculture and construction as the non-point source problems of greatest concern to the state. Both sources were described as creating localized problems of moderate severity where designated uses were not totally precluded but were only partially supported. A summary of the extent and severity of non-point source pollutants is given in Table SC-5.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The State of South Carolina continues to be concerned about municipal wastewater treatment plants, with the 1982 Needs Survey stating that 871 million dollars are still needed for municipal facilities."The matter of future funding to meet this critical need is a serious concern to the State" (ASIWPCA, 1983b). This problem is being compounded by the state's population growth, which was 21 percent from 1970 to 1980 (U.S. 1980 Census). South Carolina's population rose an additional 7 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 20 percent by the year 2000 (U.S. News & World Report, 1985). South Carolina's non-point Source Control Strategy incorporates both regulatory and voluntary approaches to compliance. Existing regulatory programs for mining, residual waste disposal, and hydrologic modifications are considered to be adequate, but programs of voluntary compliance have been recommended by the Statewide 208 Non-point Source Management plan for agricultural and silvicultural activities. Technical, financial, and educational assistance have been advised to encourage the implementation of best management practices by these industries.

B. Analysis of Phosphorus Loads to the Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

Section VII of the South Carolina Clean Lakes Classification Survey listed the point source dischargers in each lake's immediate watershed area. Of the 40 lakes listed in the report, 17 have municipal wastewater treatment plants discharging upstream within their immediate watersheds, and therefore were included in this study. Another four lakes, listed as having no municipal dischargers in their immediate basins, were added to the set of study lakes because they are located immediately downstream of one of the original 17 lakes.

Morphological data for these 21 lakes (Table SC-A in Appendix B) and land uses in their drainage basins (Table SC-B in Appendix B) were obtained from Tables 4.1, 5.2, and 5.3 of the South Carolina's Clean Lakes Program report (South Carolina DH&EC, 1982). A listing of the municipal wastewater treatment plants located upstream of each of the study lakes, along with the population served by each facility, is given in Table SC-C in Appendix B.

Results and Discussion of Phosphorus Loads

The analysis of phosphorus loads to the 21 study lakes represents a comprehensive analysis of the lakes considered to be most important to the state of South Carolina. Table SC-6 provides an overview of the number of study lakes and municipal wastewater treatment plants, along with the populations served by these plants, as compared to the corresponding values for the entire state. Municipal wastewater treatment plant total phosphorus loads to the study lakes, ranged from 3 percent to 90 percent of the total TP loads Table SC-7. Water quality information (sampling data from Clean Lakes Program) concerning the study lakes is presented in Table SC-8.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table SC-9). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy (6 of 8 lakes eutrophic), some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic. This is as expected, since non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For South Carolina

Table SC-1: South Carolina's Estuaries, Public Lakes, and Streams, Their Support of Designated Uses, Causes for Less Than, Full Support, and the Major Water Quality Parameters of Concern, as presented by ASIWPCA (1983b).

	Total Stream Miles or Acres of Estuaries or Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Not Det.
Streams	9,679	2,765	29	51	24	25	0	12	32	25	31
Lakes[1]	447,984 (40)	447,984	100	75	18	7	0	6	37	34	23
Estuar-ies	242,000	nd	nd	56	24	11	8	2	24	40	34
				Major Parameter(s) of Concern				DO* Tox pH	FC* Nut DO* Tox pH	FC* WC Nut*	--

* Identified by the state as the most significant problems.

1. Information for some of these parameters was obtained from the state 305(b) report.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tox: Toxic Substances.
WC : Turbidity (water clarity).

Table SC-2: Trophic State of South Carolina's 40 Public Lakes Based on the Clean Lakes Program's Chlorophyll-<u>a</u> sampling data.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Oligotrophic	5	12.5	1,763	1
Mesotrophic	13	32.5	85,831	47
Eutrophic	21	52.5	93,632	52
Hypereutrophic	1	2.5	74	< 1

Table SC-3: Water Quality Problems in South Carolina and The Factors Attributed to Them.

	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
<u>Point</u>						
a) Municipal[1]	L		L S		N	L E S
b) Industrial			L S			L S
<u>Non-Point</u>						
a) Agric.	N	N	N			E[2]
b) Mining						
c) Constr.		N				
c) Other			E[3]			

1. Municipal wastewater treatment plants.

2. Other problems may also occur as a result of agricultural activities but were not mentioned.

3. Discharges of wastes at marinas.

KEY: E = Estuaries.
L = Lakes.
S = Streams.
N = Freshwater lakes and/or streams, not specified.

Table SC-4: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 33,055 mi^2
Lake Surface Area Percentage	= 2.1 %
Total State Population[1] (1980)	= 3,121,820
(1970)	= 2,590,713
Population Served by Municipal Wastewater Treatment Plants	= 1,421,223 (46%)
Year Round Housing Units[1]	
- With a Public Sewer	= 53.1 %
- With a Septic Tank or Cesspool	= 42.8 %
- Other Means	= 4.1 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 0 (0)
Compliance by Significant Municipal Wastewater Treatment Plants	= 76 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	58,925	1.9
Secondary	1,362,298	42.2
Tertiary	none	none
No System But Required[1]	642,298	19.9
System Not Required	1,160,918	36.0

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

Table SC-5: Severity and Extent of Non-Point Source Contributions (from South Carolina DH&EC, 1984a).

Source	Severity	Extent	Primary Parameters
Urban	I	L	C,M,OD,O-1
Agriculture (irrigated)	M	L	C,N,P,SS,T
Agriculture (nonirrigated)	M	L	C,N,P,SS,T
Animal Wastes	I	L	C,OD
Silviculture	I	L	SS,T
Mining	I	L	SS
Construction	M	L	SS,T
Hydrologic Modification	I	L	SS,T
Saltwater Intrusion	I	L	S,O-2
Residual Waste/Landfill	I	L	M,OD,O-2

Extent

W = Widespread (50% or more of the State's waters are affected).

M = Moderate (25 to 50% of the State's waters are affected).

L = Localized (less than 25% of the State's waters are affected).

Severity

S = Severe (designated use is impaired).

M = Moderate (designated use is not precluded, partial support).

I = Minor (designated use is almost always supported).

Primary Parameters

C = coliforms
LF = low flow
M = metals
N = nutrients
OD = oxygen demand
P = pesticides/herbicides
S = salinity
SS = suspended solids
T = turbidity
O = other: O-1 = oil & grease; O-2 = toxic materials

Table SC-6: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	21	40	1,400[2]	53	<2
	Surface Area [km^2]	1,663	1,813	1,990[2]	92	84
MWTP's[1]	Number	130	--[1]	296	--[1]	44
	Pop. Served ($x10^3$ persons)	871	--[1]	1,421	--[1]	61

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in South Carolina's Clean Lakes Program, except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

2. Inventory of lakes in South Carolina ten acres or more in surface area (South Carolina WRC, 1974).

Table SC-7: Non-point Source and Municipal Wastewater Treatment Plant Total Phosphorus Loads To South Carolina Study Lakes.

Lake Name	Surface Area [ha]	Basin Code[1]	Basin Area [km^2]	Land Use Cat.[2]	Est. TP Loads [x1000 kg/yr] Non-Point	Point (MWTP)[3]	% of Total TP Loads Attributed to MWTP's[3]
Boyd Mill Pond	74	SNTCP	630	EURB	18.00	162.00	90
Broadway	121	SAVAN	75	EURB	1.30	1.18	48
Edgar A. Brown	54	EDICO	60	FMIX	1.34	5.60	81
Clarks Hill	31769	SAVAN	15900	EMIX	265.00	84.00	24
Cunningham	101	SNTCP	120	EMIX	1.99	7.10	78
Fishing Cr.	1364	SNTCP	9870	EMIX	164.00	47.00	23
Greenwood	4614	SNTCP	3030	EURB	43.50	204.00	83
Hartwell	24828	SAVAN	5410	EMIX	90.00	39.80	31
Marion	44759	SNTCP	38100	FMIX	855.00	255.00	24
Moultrie	24444	SNTCP	38850	FMIX	870.00	255.00	23
Murray	20639	SNTCP	6270	EMIX	104.00	246.00	71
Parr	749	SNTCP	7770	EURB	102.00	187.00	65
Prestwood	121	PEDEE	500	EURB	12.10	1.83	14
Reynolds	51	EDICO	140	EMIX	2.32	2.89	56
Robinson	911	PEDEE	450	EMIX	7.50	1.83	20
Rock & Cedar Cr.	324	SNTCP	10710	EMIX	178.00	58.00	25
Saluda	202	SNTCP	750	EFOR	9.10	2.52	22
Secession	356	SAVAN	500	EURB	6.30	17.10	74
Warren	243	EDICO	180	FMIX	4.03	2.33	37
Wateree	5548	SNTCP	13100	FMIX	295.00	58.00	17
Wylie	5041	SNTCP	7820	EMIX	130.00	3.48	3

1. Key to lake river basin codes: EDICO: Edisto-Combahee
   PEE DEE: Pee Dee SAVAN: Savannah SNTCP: Santee-Cooper
2. From Table SC-B in Appendix B.
3. MWTP: Municipal wastewater treatment plants.

Table SC-8: Water Quality Parameter Sampling Data and Trophic Conditions for Those Study Lakes[1] for Which Information was Available from the South Carolina Clean Lakes Program (South Carolina DH&EC, 1982). [All values represent analysis of samples taken during the period 6/24/81 to 8/11/81; concentrations are in ug/L as P, N or Chl-*a* and Secchi disk depth is in meters].

Lake Name	NH_3 + NH_4	NO_2 + NO_3	TKN	TN	TOP	DOP	TP	Chl-a	SD	Troph. State[2]	Macro-phytes &/or Algae[3]
Boyd Mill S1	410	1060	1600	2660	700	680	940	48.3	0.3		
Boyd Mill S2	50	900	1540	2440	600	550	880	67.7	0.3		
Mean:	230	980	1570	2550	650	615	910	58.0	0.3	H	A
Broadway S1	130	20	1300	1320	20	<20	100	19.9	0.3		
Broadway S2	250	<20	1120	1120	30	20	80	13.6	0.5		
Broadway S3	670	<20	1840	1840	40	20	50	18.4	0.6		
Mean:	350	<20	1420	1427	30	<20	77	17.3	0.4	E	
Brown, Edgar A.	800	20	2500	2520	50	30	170	38.6	0.3	E	B
Clarks S1	720	20	860	880	80	30	80	9.6	1.0		
Clarks S2	90	50	800	850	<20	<20	60	6.3	1.4		
Clarks S3	150	120	310	430	<20	<20	40	3.1	2.4		
Mean:	320	63	657	720	<80	<30	60	6.3	1.6	M	
Cunning. S1	140	210	560	770	20	20	70	1.3	0.1		
Cunning. S2	1000	40	1940	1980	<20	<20	60	6.5	1.0		
Mean:	570	125	1250	917	<20	<20	65	3.9	0.6	M	M
Fishing S1	700	430	1080	1510	100	100	180	22.5	0.6		
Fishing S2	230	490	900	1390	160	120	250	20.1	0.6		
Mean:	465	460	990	1450	130	110	215	21.3	0.6	E	N
Greenwood S1	150	240	1760	2000	40	20	240	48.3	0.6		
Greenwood S2	110	360	1440	1800	320	250	740	57.2	0.6		
Greenwood S3	550	100	1120	1220	<20	<20	140	30.9	0.9		
Greenwood S4	600	140	780	920	<20	<20	80	5.4	1.8		
Mean:	353	210	1275	1980	<18	<13	300	35.5	1.0	E	

Table SC-8, continued.

Lake Name	NH_3 + NH_4	NO_2 + NO_3	TKN	TN	TOP	DOP	TP	Chl-a	SD	Troph. State[2]	Macro-phytes &/or Algae[3]
Hartwell S1	400	40	610	650	<20	<20	60	15.8	1.0		
Hartwell S2	120	60	780	840	<20	<20	70	20.7	0.6		
Hartwell S3	900	60	1460	1520	<20	<20	80	29.3	0.5		
Hartwell S4	510	140	1640	1780	<20	<20	50	3.4	4.0		
Mean:	483	75	1123	1198	<20	<20	65	17.3	1.5	E	N
Marion S1	650	<20	780	780	<20	<20	70	7.2	1.5		
Marion S2	340	300	570	870	30	30	50	1.9	0.3		
Marion S3	400	30	1500	1530	40	<20	90	13.3	0.6		
Marion S4	540	<20	910	910	<20	<20	110	8.6	1.5		
Mean:	733	<165	940	1023	<35	<30	80	7.8	0.9	E	B
Moultrie S1	140	<20	1120	1120	<20	<20	60	4.1	1.0		
Moultrie S2	670	<20	720	720	<20	<20	60	5.8	0.3		
Moultrie S3	120	60	340	400	<20	<20	50	3.8	2.0		
Mean:	310	<30	727	747	<20	<20	57	4.6	1.1	M	B
Murray S1	60	30	450	480	20	<20	60	6.8	0.9		
Murray S2	990	30	1400	1430	40	30	120	10.0	0.9		
Murray S3	70	30	680	710	<20	<20	80	4.1	1.8		
Murray S4	110	140	1040	1180	<20	90	70	2.6	3.0		
Mean:	150	120	310	950	<30	<60	40	3.1	2.4	E	N
Parr S2	170	240	560	800	<20	100	70	3.4	0.5		
Parr S2	150	340	490	830	20	50	100	3.2	0.8		
Mean:	160	290	525	815	<20	75	85	3.3	0.7	M	N
Prstwd. S1	1300	60	1640	1700	<20	<20	40	2.1	2.0		
Prstwd. S2	1400	50	1790	1840	<20	<20	40	1.5	1.4		
Mean:	1350	55	1715	1770	<20	<20	40	1.8	1.7	O	M
Reynolds S1	600	120	1700	1820	20	<20	60	2.7	0.5		
Reynolds S2	2000	40	2400	2440	<20	<20	60	16.9	1.5		
Mean:	1300	80	2050	2130	<20	<20	60	9.8	1.0	E	M
Robinson S1	410	30	860	890	<20	<20	50	4.3	2.0		
Robinson S2	400	60	7800	7860	<20	<20	40	0.4	1.0		
Mean:	405	45	4330	4375	<20	<20	45	2.4	1.5	O	N

Table SC-8, continued.

Lake Name	NH_3 + NH_4	NO_2 + NO_3	TKN	TN	TOP	DOP	TP	Chl-a	SD	Troph. State[2]	Macro-phytes &/or Algae[3]
Rck & Cdr S1	490	360	1280	1640	100	70	180	34.6	0.6		
Rck & Cdr S2	180	90	940	1030	60	<20	140	33.5	0.4		
Mean:	335	225	1110	1335	80	<70	160	34.1	0.5	E	N
Saluda S1	710	90	3400	3490	20	20	70	5.6	0.1		
Saluda S2	480	30	720	750	20	<20	100	5.0	1.0		
Mean:	595	60	2060	2120	20	<20	85	5.3	0.6	M	N
Secession S1	290	30	750	780	20	20	90	27.8	0.3		
Secession S2	310	<20	550	550	<20	<20	40	5.9	1.5		
Mean:	300	<30	650	665	<20	<20	65	16.9	0.9	E	A
Warren S1	700	20	1500	1520	40	30	190	30.6	0.5		
Warren S2	850	20	1500	1520	30	20	160	29.3	0.5		
Mean:	775	20	1500	1520	35	25	175	30.0	0.5	E	B
Wateree S1	560	50	940	990	<20	<20	150	8.5	1.0		
Wateree S2	270	270	1120	1390	80	80	170	7.7	0.8		
Wateree S3	120	40	1480	1520	<20	<20	100	12.1	0.5		
Mean:	317	120	1180	1300	<40	<40	140	9.4	0.8	E	N
Wylie S1	110	40	1120	1160	40	<20	180	14.8	0.4		
Wylie S2	740	30	2400	2430	<20	<20	90	5.2	0.5		
Wylie S3	200	50	500	550	<20	<20	60	4.7	1.5		
Mean:	350	40	1340	1380	<40	<20	110	8.2	0.8	E	A

1. Study lakes were the lakes for which phosphorus loads were calculated.

2. Key to trophic states:
   H = Hypereutrophic
   E = Eutrophic
   M = Mesotrophic
   O = Oligotrophic

3. Key to presence of algae and/or macrophyte problems:
   A = Algae
   M = Macrophytes
   B = Both
   N = Not mentioned

Table SC-9: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)		
	Oligotrophic	Mesotrophic	Eutrophic
Less Than 1 To 5	0	0	1
5 To 25	2	3	4
25 To 50	0	0	3
Greater Than 50	0	2	6

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

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X. TENNESSEE

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Tennessee Clean Lakes Program [Tennessee Department of Health and Environment (Tennessee DH&E), 1980], the Tennessee 1984 Section 305(b) Report (Tennessee DH&E, 1984), the ASIWPCA STEP Program (ASIWPCA, 1983a,b), and sampling programs of the Tennessee Valley Authority (Carriker and Cox, 1984; Higgins and Kim, 1981; Placke, 1983, among others), information has become available concerning surface water quality in the State of Tennessee.

Extent and Nature of Water Quality Concerns

Tennessee's assessment of water quality in streams and public lakes (Tennessee DH&E, 1984) indicated the state's pollution problems are associated with both streams and lakes (Table TN-1).

Streams

The failure of 50 percent of Tennessee's assessed stream miles to support their designated uses was attributed primarily to non-point sources (55 percent). Municipal and industrial pollutant sources accounted for 33 percent and 15 percent of nonsupport cases, respectively (Table TN-1). A more extensive summary of the surface water quality for each of Tennessee's 13 major river basins is given in Table TN-2.

Lakes

Sixty-two percent of Tennessee's 115 public lakes fully supported their designated uses (Table TN-1). Industrial discharges were targeted as the primary cause for less than full support of designated lake uses (51 percent), with municipal and non-point source discharges being responsible for 33 percent and 15 percent, respectively.

Tennessee's Stream Monitoring Program

Tennessee's primary program of ambient water quality monitoring consists of approximately 90 fixed sampling sites sampled on a quarterly basis with some special stations sampled on a monthly basis. A secondary monitoring network of water treatment plants collects monthly composite samples of untreated surface water. The third integral part of the state's monitoring is an intensive survey program.

Tennessee's Clean Lakes Program

The Tennessee Clean Lakes Program (Tennessee DH&E, 1980). designated 112 lakes as comprising the significant publicly-owned freshwater lakes of the State of Tennessee. Inclusion of a lake in this group was restricted to publicly-owned lakes (state or federal jurisdiction) with a surface area of at least 2 hectares (5 acres) which had been identified by the state as having substantial public interest and use. In accordance with the Federal Water Pollution Control Act Ammendments of 1972 (Public Law 92-500), the Survey prioritized the 112 lakes according to trophic state and certain social factors. A summary of the trophic states of the lakes assessed during the Tennessee Clean Lakes Program is provided in Table TN-3. Lake sampling during the program was limited to samples taken during the period of July 15 through September 15, 1979, as this was determined to be the time of peak seasonal productivity. However, the Tennessee Valley Authority has analyzed all the major reservoirs under its jurisdiction thereby significantly enhancing the available surface water quality data base (Higgins and Kim, 1981; Placke, 1983; among others).

Municipal Wastewater Treatment Plants and Non-Point Sources As Factors Causing Water Quality Degradation in Lakes and Streams

Table TN-4 provides an overview of the water quality problems associated with Tennessee's lakes and streams and the corresponding factor(s) contributing to these problems.

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table TN-5). These data indicate that 2,982,000 (65 percent) of the state's total population of 4,591,000 persons are served by a municipal wastewater treatment system, with the remaining population being served primarily by septic tank systems. Five treatment plants serving 150,500 people have combined sewer systems. No municipal wastewater treatment plants in Tennessee are required by their NPDES permits to practice phosphorus removal, although there may be a few very small municipalities which remove phosphorus.

Non-Point Sources

A summary of the extent and severity of non-point source pollutants in Tennessee is given in Table TN-6. In the 1984 Tennessee 305(b) report, the state made several general observations pertaining to non-point sources causing water quality problems in lakes and streams (Tennessee DH&E, 1984).

a. West Tennessee has the worst water quality in the state, a situation which is largely due to agricultural activities. The major rivers in this region are impacted by poor agricultural practices on highly erodible soils and by the channelization of the waterways. Agricultural runoff adds appreciably to the sediment loads, nutrients, and organic chemicals in the waterways.

b. Mining runoff from coal, phosphate, and mineral mines, in addition to agricultural related runoff, affect an estimated 808 miles of streams in middle and eastern Tennessee.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The State of Tennessee continues to be concerned about municipal wastewater treatment plants, stating, "More municipal plants must be brought up to standard or face continual problems with downstream water users and run the risk of health problems and loss of recreational uses." (ASIWPCA, 1983b). This problem is being compounded by the state's population growth, which was 17 percent from 1970 to 1980. Tennessee's population rose an additional 3 percent between 1980 and 1985 (N.Y. Times, 1985), and is projected to increase another 16 percent by the year 2000 (U.S. News & World Report, 1985). The Tennessee Division of Water Management, in cooperation with the State Rural Clean Water Coordinating Committee and other agriculture related committees, is seeking to develop a comprehensive and implementable nonregulatory program to control agricultural non-point source pollution, including a system for ranking priority areas in the state.

B. Analysis of Phosphorus Loads to the Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

Appendices A and B of the Tennessee Clean Lakes Program report consisted of data summary sheets for each lake studied, including municipal wastewater discharges. However, for the purposes of this study, the discharge listings were found to be incomplete. Therefore, identification of municipal wastewater discharges upstream of the lakes was performed by following the alternate method. Using a 1:500,000 scale USGS state base map and the State of Tennessee's municipal wastewater treatment plant inventory (Tennessee DH&E, 1985), 27 lakes were identified as having municipal wastewater dischargers within approximately 50 miles upstream.

Morphological data for these 27 lakes (Table TN-A in Appendix B) and land uses in their drainage basins (Table TN-B in Appendix B) were obtained from the data summary sheets in Appendices A and B of the Tennessee Clean Lakes Program report (Tennessee DH&E, no date). A listing of the municipal wastewater treatment plants located upstream of each of the study lakes, along with the population served by each facility, is given in Table TN-C in Appendix B.

An overview of the numbers of study lakes, municipal wastewater treatment plants, and the populations served by these plants, compared to the corresponding values for the entire state, is presented in Table TN-7. The 27 lakes chosen for study comprise about 90 percent (609,374 acres) of Tennessee's 675,550 acres of publicly owned lakes assessed during the Tennessee Clean Lakes Program. Thus, the analysis of phosphorus loads to the 27 study lakes represents a comprehensive analysis of the lakes considered to be most important to the state of Tennessee (Table TN-8).

Results and Discussion of Total Phosphorus Load Calculations

Municipal wastewater treatment plant total phosphorus loads to the 27 study lakes ranged from 2 percent to 98 percent of the total TP loads (Table TN-8). Table TN-8 also contains relevant excerpts from the 1984 Tennessee 305(b) Report (Tennessee DH&E, 1984).

It is clear from the comments in Table TN-8 that heavy metals, low pH, and high suspended solids concentrations are of primary concern in the State of Tennessee. However, Tennessee does recognize major problems with the eutrophication of many of its largest and most important reservoirs. The Tennessee DH&E stated in the 305(b) report that, "the problems associated with eutrophication are low dissolved oxygen [concentrations] (D.O.), elevated concentrations of iron and manganese in the [reservoir] release waters, and reduced waste assimilation capacity." They also reported, "the reservoir release problems resulting from low dissolved oxygen concentrations are generally associated with nutrient enriched stratified reservoirs." Municipal wastewater treatment plants have been shown by the present analysis to contribute significant phosphorus loads to some Tennessee lakes, however, of the 27 lakes identified in the municipal wastewater treatment plant phosphorus load analysis, only Boone has been specified by the state as having excessive nutrient loads from municipal discharges in the 1984 Tennessee 305(b) report (Tennessee DH&E, 1984). This may be due to the recent upgrading of several municipal facilities which were felt to have a deleterious affect on surface waters, the elimination of discharges from some facilities, and the construction of new plants for areas not previously sewered. This improvement strategy included the major Chattanooga and Knoxville plants, which were upgraded to secondary treatment levels. Furthermore, the Boone Reservoir watershed has recently been classified as a "nutrient sensitive waters" region.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

Table TN-9 provides a summary of the water quality parameter values and trophic conditions for those of the study lakes sampled during the Tennessee Clean Lakes Program. A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table TN-10). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy, some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic. This is as expected, because non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case. In fact, the only two lakes specified by the Tennessee DH&E (1984) as being adversely affected by municipal wastewater treatment plants were Boone and Fort Loudon (Table TN-8).

C. Tables For Tennessee

Table TN-1: Tennessee Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern [as presented by ASIWPCA (1983b)].

	Total Stream Miles or Acres of Public Lakes In State (# Lakes)	Streams And Lakes Assessed		Support of Designated Uses (Percent)				Cause For Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	19,236	19,236	100	50	16	3	31	15	30	55	0
Lakes	675,550 (115)	675,550	100	62	20	18	0	51	33	15	1
				Major Parameter(s) of Concern				Tox* pH Tem Met* DO	FC* DO Met	FC pH Tox* Nut WC* DO	--

*Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Met: Heavy Metals
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tem: Temperature.
Tox: Toxic substances.
WC : Turbidity (water clarity).

Table TN-2: Overview of Water Quality in Major Tennessee River Basins.

Region	Overall Water Quality	Water Quality Parameters	Violation of Water Quality Standards Attributed to:	Comments
<u>Northeast</u>				
(Clinch, French-Broad, Holston, and Upper Tennessee River Basins)	Very Good	Heavy Metals, Fecal Coli., Susp. Solids	Coal mining, oil and gas explorations, and agr. NPS	French-Broad R. is the worst in Tenn. due to very high susp. solids from urban and agr. NPS runoff in N.C.
<u>Southeast</u>				
(Hiwassee and Lower Tennessee River Basins)	Good	Heavy metals, Susp. Solids, Low pH	Copper Basin mining NPS runoff.	Fecal Coliform exceeded standard while Chattanooga Moccasin Bend WWTP was being upgraded
<u>Middle</u>				
(Tennessee R. Western Valley, Cumberland, Duck, and Elk River Basins)	Mod. Good Good	Occasionally Heavy Metals, Fecal Coli., Susp. Solids, Low pH	Agr. NPS run-off, phosphate mining, flow reductions and minor impact from indust. and municipal discharges.	Cumberland above Nashville best in state. Tenn. R. very high susp. solids and heavy metal violations more frequent. Flow reductions in Elk R. are problem along with PCB's.
<u>West</u>				
(Forked Deer, Obion, and Hatchie River Basins)	Mod. Good	Heavy Metals Fecal Coli., Susp. Solids, High pH, Chlordane	Atmospheric, urban, and agr. NPS, land use practices.	Heavy metals are from the NPS's, susp. solids are from land use, and pH is natural.

Table TN-3: Trophic State of Tennessee's 115 Public Lakes.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Ultra-Oligotrophic	3	3	12,542	5
Oligotrophic	19	17	23,932	9
Mesotrophic	29	26	69,864	25
Eutrophic	47	42	155,061	56
Hypereutrophic	8	7	3,817	1
No Data	6	5	10,877	4

Table TN-4: Water Quality Problems in Tennessee and the Factors Attributed to Them.

	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	L S					
b) Industrial				L S		
Non-Point						
a) Agric.	L S	S				S
b) Mining	S	S		S		
c) Other						

1. Municipal wastewater treatment plants.

KEY: L = Lakes, S = Streams.

Table TN-5: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 42,244 mi^2
Lake Surface Area Percentage	= 2.5 %
Total State Population[1] (1980)	= 4,591,120
(1970)	= 3,925,687
Population Served by Municipal Wastewater Treatment Plants	= 2,982,165 (65 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 56.4 %
- With a Septic Tank or Cesspool	= 39.6 %
- Other Means	= 4.0 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 5 (150,500)
Compliance by Significant Municipal Wastewater Treatment Plants	= 79 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	113,606	2.5
Secondary	2,557,513	55.7
Tertiary	311,046	6.8
No System But Required[1]	56,546	1.2
System Not Required	135,146	2.9
Unknown	1,417,269	30.9

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and therefore need a sewer system.

Table TN-6: Severity and Extent of Non-Point Source Contributions (from Tennessee DH&E, 1984).

Source	Extent	Severity	Primary Parameters
Urban	L	U	SS,M,C,N,OD,T,O-1
Agriculture (irrigated)	W	S	N,SS,P
Agriculture (nonirrigated)	M	M	N,SS,P
Animal Wastes	L	M	C,OD,SS,T,N
Silviculture	L	I	SS,E
Mining	L	M	M,O-2,SS
Construction	L	I	SS
Hydrologic Modification	L	M	O-3
Residual Waste/Landfill	L	M	M,O-1

Extent

W = Widespread (50% or more of the State's waters are affected).

M = Moderate (25 to 50% of the State's waters are affected).

L = Localized (less than 25% of the State's waters are affected).

Severity

S = Severe (designated use is impaired).

M = Moderate (designated use is not precluded, partial support).

I = Minor (designated use is almost always supported).

U = Unknown

Primary Parameters

C = coliforms	P = pesticides/herbicides
LF = low flow	S = salinity
M = metals	SS = suspended solids
N = nutrients	T = turbidity
OD = oxygen demand	O = other: O-1 = toxics
	O-2 = pH
	O-3 = low D.O.

Table TN-7: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	27	115	nd	23	nd
	Surface Area [km^2]	2,466	2,734	nd	90	nd
MWTP's[1]	Number	--[1]	107	--[1]	100	63
	Pop. Served ($x10^3$ persons)	2,461	--[1]	2,982	--[1]	83

1. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Georgia's Clean Lakes Program, except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

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Table TN-8: Non-point Source and Municipal Wastewater Treatment Plant [see (1)] Total Phosphorus Loads To Tennessee Study Lakes.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km^2]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Barkley	37799	LO CU	45579	BMIX	645.00	59.00	9	
Boone	1781	HOLST	4766	CMIX	104.00	147.00	59	Sludge build-up from sewage overflows, bacterial contamination, and eutrophication.
Burgess Falls	28	UP CU	39	BMIX	0.55	20.50	98	
Center Hill	9332	UP CU	5685	BAGR	105.00	47.70	32	
Cheatham	3015	LO CU	36674	BMIX	515.00	895.00	64	
Cherokee	12262	HOLST	8881	CMIX	194.00	125.00	39	Reservoir release problems; mercury contamination.
Chickamauga	14326	LO TN	53846	CURB	710.00	75.00	10	Shows impact of past industrial and municipal discharges.
Cordell Hull	5628	UP CU	20966	BMIX	295.00	7.00	3	
Dale Hollow	12542	UP CU	2422	BMIX	34.20	3.27	9	Lack of nutrients and fish food supply probably inhibits coldwater fishery.
Douglas	12303	FR BR	11761	CMIX	260.00	8.10	3	Siltation, thermal pollution, coloration from pulp mill, and reservoir release problems.
Ft. Pat Henry	353	HOLST	4929	CMIX	108.00	147.00	58	
Fort Loudon	5909	UP TN	24735	CURB	400.00	515.00	57	Polychlorinated biphenyls (PCB's); urban runoff and municipal wastes from city of Knoxville.
Great Falls	854	UP CU	4343	BAGR	80.00	20.70	21	
J. Percy Priest	9187	LO CU	3210	BURB	78.00	45.60	37	
Kentucky	64873	TN WV	104118	FMIX	2330.00	26.60	2	PCB's, high suspended solids, and heavy metals.
Melton Hill	2303	CLNCH	8658	CMIX	190.00	29.40	14	
Nickajack	4197	LO TN	56643	CURB	745.00	350.00	32	
Nolichucky	155	FR BR	3064	CAGR	57.00	19.60	26	Mineral mines causing high suspended solids and siltation.
Normandy	1279	DUCKR	505	BMIX	7.10	7.30	51	
Norris	13841	CLNCH	7542	CMIX	165.00	17.60	10	Coal mining producing low pH, high sulfates, coal fines, and elevated heavy metals in fish.

Table TN-8, continued.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km^2]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Ocoee #1	765	LO TN	1540	GMIX	45.70	0.42	1	For all three Ocoee reservoirs: heavy metals, low pH, and high suspended solids from mines.
Ocoee #2	nd	LO TN	1326	GMIX	39.40	0.42	1	See Ocoee #1.
Ocoee #3	194	LO TN	1274	GMIX	37.80	0.42	2	See Ocoee #1.
Old Hickory	11109	LO CU	30236	BMIX	425.00	39.70	9	
Tims Ford	4290	ELK R	1370	BMIX	19.30	25.80	58	
Watauga	2602	HOLST	1212	GURB	11.00	2.14	17	
Watts Bar	15783	UP TN	44833	CURB	410.00	610.00	60	

nd = No data available.

1. Municipal wastewater treatment plant is appreviated as MWTP in the Table.

2. Key to lake river basin codes:

Code	Major River Basin
CLNCH	Clinch River
TN WV	TN Western Valley
LO CU	Lower Cumberland
UP CU	Upper Cumberland
DUCKR	Duck River
ELK R	Elk River
HOLST	Holston
FR BR	French Broad
UP TN	Upper Tennessee
LO TN	Lower Tennessee

3. Land use categories are equivalent to those assigned to each lake's drainage basin as presented in Table TN-B of Appendix B.

Table TN-9: Water Quality Parameter Values and Trophic States for Those Study Lakes for Which Data Was Available in the Tennessee Clean Lakes Program Report (Tennessee DH&E, 1984). All concentrations are in units of ug/l and Secchi disk depth values are in meters.

Lake Name	Total Phosphorus	Chl-a	Secchi Depth	Trophic[2] State	Macro-phytes and/or Algae[2]
Barkley	90	9	0.45	E	N
Boone	20	14	1.50	E	N
Burgess Falls	80	13	0.40	E	A
Center Hill	10	0	4.30	O	N
Cheatham	100	18	0.50	E	N
Cherokee	10	12	3.50	E	N
Chickamauga	20	5	1.70	M	N
Cordell Hull	20	6	1.50	M	N
Dale Hollow	10	1	6.50	O	N
Douglas	10	6	2.20	M	N
Fort Loudon	30	16	1.50	E	N
Fort P. Henry	10	27	1.30	E	N
Great Falls	18	9	0.20	E	N
J. Percy Priest	10	5	1.80	M	A
Kentucky	40	10	1.50	E	N
Melton Hill	10	1	1.00	O	N
Nickajack	20	4	1.30	M	N
Nolichucky	40	3	1.00	M	N
Normandy	nd	nd	nd	nd	B
Norris	10	2	3.40	O	A
Ocoee#1	10	1	2.50	O	O
Ocoee#2	nd	nd	nd	nd	O
Ocoee#3	10	0	1.00	O	O
Old Hickory	60	27	0.80	E	N
Tims Ford	10	3	2.25	M	N
Watauga	10	2	4.00	M	B
Watts Bar	20	9	1.50	E	N

1. E = Eutrophic, M = Mesotrophic, O = Oligotrophic.

2. The presence of macrophytes and/or algae is noted whenever the Tennessee Lake Classification Report mentioned documented nuisance algae blooms or a macrophyte infestation within the last 5 years. (A = Algae, M = Macrophytes, B = Both, O = Abiotic conditions, N = Not mentioned).

Table TN-10: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)		
	Oligotrophic	Mesotrophic	Eutrophic
Less Than 1 To 5	2	1	2
5 To 25	0	2	3
25 To 50	1	4	0
Greater Than 50	0	1	6

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

XI. VIRGINIA

A. Overview of Surface Water Quality

Recent State Water Quality Investigations

As a result of the Virginia Clean Lakes Program [Virginia State Water Control Board (Virginia SWCB), 1982], the Virginia 1984 Section 305(b) Report (Virginia SWCB, 1984a,b), and the ASIWPCA STEP Program (ASIWPCA, 1983Aa,b), information concerning surface water quality and pollutant discharge sources is available for the State of Virginia.

Water Quality Status of Estuaries, Lakes, and Streams

Virginia's assessment of water quality in streams and public lakes indicated that more extensive problems were associated with streams than with lakes (Table VA-1).

Streams

Only 31 percent of the 4,500 stream miles assessed by Virginia supported their designated uses, while 25 percent partially supported them, and 44 percent did not support their designated uses (Table VA-1). Less than full support of stream usage was largely attributed to non-point source pollution (98 percent) with municipal and industrial sources accounting for the remaining 2 percent.

Estuaries

A seven year 27 million dollar study of the Chesapeake Bay has been completed. Recommendations for long-range management of the Bay are currently being formulated. This program is too important and complex to attempt a brief summary here.

Lakes

Eighty-six percent of Virginia's 161 public lakes fully supported their designated uses (Table VA-1). Failure to meet required water quality standards was attributed to municipal wastewater treatment plants (35 percent), industrial sources (20 percent), non-point sources (33 percent) and other unspecified problems (12 percent).

The State's Stream Monitoring Program

The State Water Control Board of Virginia maintains a statewide network of 307 ambient water quality monitoring stations that are sampled monthly. Forty of these 307 stations are part of EPA's National Core Monitoring Program and are sampled annually for metals and pesticides in water and sediments. These stations are also sampled biennially for metals and pesticides in fish tissues and for the health of bottom dwelling (benthic) invertabrates and periphyton (attached algae). In addition, the state maintains 175 biological monitoring stations that are sampled either annually or biannually in the spring and fall to evaluate the benthic macroinvertebrate community.

The State's Clean Lakes Program

The Virginia State Water Control Board (SWCB) conducted Virginia's Clean Lakes Program during 1980 and 1981. Of the 161 publicly owned lakes which met the criteria for inclusion in the Clean Lakes Program, 32 were determined to be the most significant, high priority lakes and were monitored at monthly intervals over a seven month period (April to October, 1980). An additional 19 lakes having insufficient or outdated data from past investigations were surveyed once during the summer of 1980. The 161 lakes were classified according to trophic state using the data collected on these sampling trips and information from previous state and federally funded lake studies (e.g. EPA-NES). For the purposes of ranking, these 161 lakes were classified into two classes, the 32 priority lakes being Class I lakes and the remaining lakes being Class II lakes. A summary of the trophic states of the lakes assessed during the Virginia Clean Lakes Program is provided in Table VA-2.

Municipal Wastewater Treatment Plants, Industrial Discharges, and Non-Point Sources As Factors Causing Water Quality Concerns In Estuaries, Lakes, and Streams

Table VA-3 provides an overview of the water quality problems associated with Virginia's estuaries, public lakes, and streams and the corresponding factor(s) contributing to these problems.

In the 1984 Virginia 305(b) report, the state made several observations pertaining to the factors causing water quality problems in lakes and streams:

a. Dissolved oxygen and pH problems in streams are mainly due to natural conditions.

b. Fecal coliform (bacterial) contamination, which affects 3,597 miles of streams, is attributed to municipal, animal waste, and agricultural pollution sources.

c. Over one-third (35 percent) of the publicly owned freshwater lakes were considered eutrophic. This can be attributed to their shallowness and non-point source nutrient contributions.

d. From 1981 to 1983, 50 fish kills were attributed to pollution, with the resulting mortality estimated to be 1,365,434 fish. However, 88 percent of this total came from two large fish kills, one attributed to a gasoline spill and the other to an industrial discharge.

Municipal Wastewater Treatment Plants and Non-Point Sources As Factors Causing Water Quality Degradation in Lakes and Streams

Municipal Wastewater Treatment Plants

The state has compiled data on municipal wastewater treatment plants, the type of treatment provided, and the populations served by each treatment type (Table VA-4). These data indicate that 4,328,000 (81 percent) of the state's total population of 5,347,000 persons are served by a municipal wastewater treatment system, with the majority of the remaining population having septic systems. Virginia is concerned about the 11 combined sewer systems in the state which serv 536,900 people. Of particular concern are the Richmond combined sewer overflows which are thought to impact the Upper James River estuary. There are ten municipal facilities employing chemical phosphorus removal; eight of these are located in the Chesapeake Bay drainage basin.

Non-Point Sources

Virginia has identified non-point sources as a major problem in the state and the following are some of the responses to this pollution. Additional projects have also been started using Federal 205(j) funds.

a. Virginia has published a management handbook and five technical handbooks containing plans and specifications for selected best management practices (BMP's) applicable to Virginia.

b. Detailed non-point source abatement and control plans and programs have been prepared by designated areawide planning agencies (Section 208) for the Hampton Roads area, the Fredericksburg area and Northern Virginia.

c. Eight cities, 20 towns and 17 counties (20 percent of all localities in the state) in the non-designated State planning area have passed formal resolutions affirming and supporting the state voluntary BMP implementation program.

d. Twenty-six priority agricultural watersheds covering over three million acres (12 percent of the state's area). were selected for targeting available resources to implement BMPs.

e. A two year program to create vegetative filter strips along waterways in the Chowan and Chesapeake Bay basins was started in the spring of 1983.

Trends in the Control and Management of Municipal Wastewater Treatment Plant and Non-Point Source Pollution

The future of Virginia's water quality situation depends on the state's ability to establish and manage adequate programs in response to their problems. These problems have been compounded by the 15 percent increase in population from 1970 to 1980 (U.S. 1980 Census).

Toxic pollutants, protection of the Chesapeake Bay, and the quality of interstate waters have been major concerns of the state of Virginia over the past decade. Toxic pollutants are presently being addressed by a program that will monitor complex effluents for both organic and inorganic substances.

The state was so concerned with non-point source pollution that the Secretary of Commerce formed a non-point source pollution committee. Due to the paucity of water quality data supporting definition of non-point problems, a non-regulatory approach was recommended. Best management practices handbooks, public education, and citizen's programs to monitor streams and activities causing land disturbances are some of the methods being used in this non-regulatory approach (See Nonpoint Source section of this report). Special non-point source studies are also being conducted on lakes and the Chesapeake Bay region to evaluate this problem more extensively.

B. Analysis of Phosphorus Loads to the Study Lakes

Identification of Study Lakes and Municipal Wastewater Treatment Plants

Thirty-two lakes were identified by the Virginia Clean Lakes Program as being significant, high priority lakes, but only three of these lakes were listed as having municipal wastewater treatment plants upstream of them. This is in agreement with the state's observation that 98 percent of the pollutant sources to lakes are non-point. However, these 32 lakes represent only 12 percent of the total acreage of lakes in the state. Therefore, further sources of information were used to identify additional lakes for a more complete and representative analysis.

Using Table 2 of the Virginia Clean Lakes Program report, all lakes greater than 100 hectares in surface area were located on USGS 1:500,000 state base maps, and municipal wastewater treatment plants within approximately 50 miles upstream were identified. NES working papers were also used for identifying municipal wastewater treatment plants for Rivanna, Occoquan, Claytor, Chesdin, and John W. Flannagan. After checking 54 of the 161 lakes (those greater than 100 hectares or listed as having point source problems), an additional eight lakes were added to the study. The remaining lakes were too small to be found on the USGS maps and therefore could not be checked for wastewater treatment plants.

Morphological data for the study lakes (Table VA-A in Appendix B) were obtained from the Clean Lakes Program report, EPA-NES working papers, and USGS reports. Land use data for the lake basins (Table VA-B) were obtained from the Virginia Clean Lakes Program for the three lakes listed as having municipal wastewater treatment plants upstream. The other eight lakes' watersheds were placed in the appropriate regional land use category through visual inspection of the 1:250,000 scale USGS land use and land cover maps. Table VA-C in Appendix B provides a listing of the municipal wasterwater treatment plants upstream of the 11 study lakes, along with the corresponding populations served by each facility.

Results and Discussion of Total Phosphorus Loads

Using the present study's approach, municipal wastewater treatment plant total phosphorus (TP) loads to the study lakes ranged from 9 to 59 percent of the total loads; the total loads were calculated as the sum of the non-point source and municipal wastewater treatment plant loads. Table VA-5 contains a complete listing of these figures along with relevant excerpts from the 1984 Virginia 305(b) Report (Virginia SWCB,1984a,b) concerning the 11 lakes potentially impacted by municipal wastewater treatment plant discharges. Table VA-6 provides an overview of the numbers of study lakes and municipal wastewater treatment plants and populations served by these plants as compared to the values for the entire state. The study lakes' water quality data from the Clean Lakes Program is presented in Table VA-7a and the trophic states in Table VA-7b.

Comparison of Clean Lakes Program Water Quality Data to the Results of the Total Phosphourus Load Analysis for Study Lakes

A comparison of the trophic state of the study lakes to the percent of the total phosphorus load attributable to municipal wastewater treatment plants indicates the state of eutrophy is not simply dependent on the percent contribution to the phosphorus load by the municipal wastewater treatment plants (Table VA-9). Although lakes with greater than 50 percent of their load attributable to municipal wastewater treatment plants tend to show a high degree of eutrophy, some lakes with minimal phosphorus contributions from municipal wastewater treatment plants were also eutrophic. This is as expected, since non-point source loads can also cause severe water quality degradation.

These observations are important, as all too often, people have equated wastewater treatment plants with eutrophic lake conditions; this is not always the case.

C. Tables For Virginia

Table VA-1: Virginia's Estuaries, Public Lakes and Streams, Their Support of Designated Uses, Causes for Less Than Full Support, and the Major Water Quality Parameters of Concern, as presented by ASIWPCA (1983b).

	Total Stream Miles or Acres of Estuaries or Public Lakes in State (# Lakes)	Streams and Lakes Assessed		Support of Designated Uses (Percent)				Cause for Less Than Full Support of Designated Uses (Percent)			
		Miles or Acres	Pct. of Total	Full	Part	None	Not Known	Ind	Mun	Non Pt.	Oth.
Streams	27,240	4,500	17	31	25	44	0	20	35	33	12
Lakes	67,912 (161)	67,912	100	86	13	0	1	1	1	98	0
Estuaries	1,524,480	na	na	na	na	na	na	na	na	na	na
				Major Parameter(s) of Concern				DO* FC Tox*	DO FC* Nut*	FC* Nut* Oth	pH* Tem*

na : Not available.
* Identified by the state as the most significant problems.

DO : Dissolved oxygen concentration.
FC : Coliform or fecal coliform counts (bacteria).
Nut: Nutrient concentrations (nitrogen and/or phosphorus).
pH : The pH of the water.
Tem: Temperature.
Tox: Toxic substances.

Table VA-2: Trophic State of Virginia's Public Lakes.

Trophic Classification	Number of Lakes	Percent of Total	Surface Area [ac]	Percent of Total
Oligotrophic	8	5	1,180	2
Oligo-Meso.	17	11	14,298	21
Mesotrophic	44	27	30,749	45
Eutrophic	56	35	21,228	31
Unknown	36	22	642	1

Table VA-3: Water Quality Problems in Virginia and the Factors Attributed to Them.

Source	Nutrient	Sediment	Coliform	Heavy Metals	Fish Kills	Dissolved Oxygen
Point						
a) Municipal[1]	L S		S			S
b) Industrial				E[2]		S
Non-Point	E[3]					
a) Agric.	L S		S			L S
b) Mining						
c) Other						

Key: E=Estuaries, L=Lakes, S=Streams.

1. Municipal wastewater treatment plants.

2. Pesticides and other toxics are also problems.

3. Nutrients are a general non-point source problem estuaries, but the sources were not specified.

Table VA-4: Wastewater Systems and State Statistics. Data were from ASIWPCA (1983b).

State Surface Area	= 40,815 mi^2
Lake Surface Area Percentage	= 0.3 %
Total State Population[1] (1980)	= 5,346,818
(1970)	= 4,651,487
Population Served by Municipal Wastewater Treatment Plants	= 4,328,000 (81 %)
Year Round Housing Units[1]	
- With a Public Sewer	= 65.8 %
- With a Septic Tank or Cesspool	= 29.7 %
- Other Means	= 4.5 %
Number of Combined Sewer Systems and (Pop. Served)[2]	= 11 (536,900)
Compliance by Significant Municipal Wastewater Treatment Plants	= 66.1 %

1. Figure obtained from the 1980 U.S. Census.
2. U.S. EPA (1985).

Wastewater System Type	Population	Percent of Total State Population
Primary	308,000	5.8
Secondary	2,210,000	41.3
Tertiary	1,810,000	33.9
No System But Required[1]	329,000	6.2
System Not Required	689,818	12.9

1. Requires system: State residents for whom septic systems are not an adequate method of wastewater discharge and who therefore need a sewer system.

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Table VA-5: Non-point Source and Municipal Wastewater Treatment Plant [see (1)] Total Phosphorus Loads To Virginia Study Lakes.

Lake Name	Surface Area [ha]	Basin[2] Code	Basin Area [km^2]	Land[3] Use Cat.	Est. TP Loads [10^3 kg/yr] Non-Point	Point (MWTP)	% of Total TP Loads Attributed to MWTP's	Comments/Considerations
Lake Anna	5262	YORKR	891	EMIX	14.80	2.69	16	Study [316(a)] being conducted to determine effect of heated water discharge on aqua. life.
Beaverdam Creek	257	POTOM	500	CAGR	9.20	1.03	10	High FC levels attributed to storm related runoff from agricultural land.
Chesdin	1295	JAMES	3445	EMIX	57.00	9.50	15	NPS pollutants (mostly from agricultural runoff) account for almost all the SS, TP, and TN loadings to lake; elevated Fe and Mn levels related to severity of DO depletion.
Claytor	1815	NEWRV	6138	GMIX	182.00	54.00	23	Problems with bacteria, DO, SS, and elevated pH in upper arm (Peak Creek).
Halifax	166	ROANK	1417	EMIX	23.50	2.84	11	Slight increase in FC violations downstream; critical erosion problems in watershed.
J. W. Flannagan	463	TENBS	572	BFOR	4.46	2.47	36	Upstream tributaries affected by active or discontinued coal mining activities.
Leesville	1376	ROANK	3899	EMIX	65.00	27.30	30	Fluctuating water levels, erratic flow patterns give upper portion highly riverine chars.
Moomaw	6005	JAMES	891	CFOR	8.30	11.50	59	New reservoir (full pool level reached 1982).
Occoquan R.	688	POTOM	1533	EMIX	25.40	22.90	48	With the Upper Occoquan Sewage Authority operating efficiently, the water quality problems in the watershed shift from STP effluent to NPS runoff from agricultural lands.
Rivanna	158	JAMES	671	CMIX	14.70	1.44	9	Restorative and protective activities, e.g. implementation of BMP's, initiated through "Clean Lakes Phase II" project funding.
Smith Mtn.	8094	ROANK	2653	CMIX	58.00	22.50	28	Depressed oxygen levels, high FC counts, algal blooms, and sedimentation problems in upper reaches; lake is on a long-range recovery cycle due to reduced nutrient concentrations. Section 208 Study strongly recommended that BMP's be implemented throughout entire lake watershed.

(Footnotes are on following page)

Table VA-5, continued.

Footnotes:

1. Municipal wastewater treatment plant is appreviated as MWTP in the Table.

2. Key to lake river basin codes:

Code	Major River Basin
POTOM	Potomac River
JAMES	James River
ROANK	Roanoke River
TENBS	Tennessee & Big Sandy
YORKR	York River
NEWRV	New River

3. Land use categories are equivalent to those assigned to each lake's drainage area as presented in Table VA-B of Appendix B.

Table VA-6: Comparison of the Number of Lakes and Municipal Wastewater Treatment Plants in the Phosphorus Load State Analysis to the Numbers in the State's Clean Lakes Program (CLP) and the State as a Whole.

		{A} Study	{B} CLP+NES[1]	{C} State	Study (col A) as % of CLP (col B)	Study (col A) as % of State (col C)
Lakes	Number	11	54	nd	20	nd
	Surface Area [km^2]	256	na	na	na	na
MWTP's[2]	Number	35	--[1]	244	--[1]	14
	Pop. Served ($x10^3$ persons)	297	--[1]	4,328	--[1]	7

na = Not available.

1. This group is comprised of all major (Category I) lakes, all minor (Category II) lakes with surface areas >100 ha, and all EPA-NES lakes. All of the 161 lakes in the Clean Lakes Program report (Virginia SWCB, 1982) and the 1984 305(b) report (Virginia SWCB, 1984) which were stated to have problems related to municipal discharges were included in this set of lakes.

2. Municipal Wastewater Treatment Plants. The municipal facilities identified in the present study were the same as those included in Virginia's Clean Lakes Program, except for those added or deleted due to special circumstances, as described in Part B of the General Procedures section.

Table VA-7a: Water Quality Sampling Data for Those Study Lakes[1] With Relevant Information Available From the Clean Lakes Program (Virginia SWCB, 1982). All values are in ug/L as N, P, or Chl-a, with Secchi Disk Depths in centimeters.

Lake	Depth[1]	Date	Secchi Depth	Chl-a	NH_3 + NH_4	NO_2 + NO_3	TKN	TP	OP
Beaverdam	Sb	80 05 21	100	10.3	<100	490	300	100	20
	Sb	80 06 23	175	8.7	<100	200	500	<100	<10
	2M	80 07 14	nd	4.3	<100	90	400	<100	<10
	Sb	80 08 11	nd	nd	100	250	800	100	30
	3M	80 08 11	150	5.3	<100	<50	300	<100	10
		80 09 25	130	nd	100	<50	400	<100	10
	Sb	80 10 29	100	6.5	300	80	700	<100	10
Chesdin A1	Sr	80 04 15	40	9.9	100	160	300	200	70
	1M	80 05 06	100	18.6	<100	900	300	<100	<10
	1M	80 06 09	80	12.1	<100	230	700	<100	30
	1M	80 07 01	100	nd	<100	80	400	<100	<10
	1M	80 08 25	150	13.1	<100	<50	300	<100	10
	1M	80 09 10	160	14.1	<100	<50	300	<100	10
	1M	80 10 09	100	16.0	<100	<50	400	100	20
Chesdin B1	1M	80 05 06	80	18.6	<100	270	300	<100	10
	1M	80 06 09	70	13.2	<100	180	200	400	20
	3M	80 07 01	120	nd	<100	200	400	<100	10
	1M	80 08 25	110	13.0	<100	<50	400	<100	20
	1M	80 09 10	100	18.0	<100	70	500	<100	20
	1M	80 10 09	90	24.2	<100	60	400	200	20
Rivanna A1	1M	80 04 24	84	10.9	<100	310	200	200	<10
	Sb	80 05 08	114	12.6	<100	150	300	100	<10
	Sb	80 06 24	130	7.8	100	100	500	<100	<10
	1M	80 07 15	90	11.9	<100	60	400	<100	<10
	.5M	80 08 13	95	19.8	200	100	500	<100	10
	Sb	80 09 16	123	12.6	400	50	400	<100	10
	Sb	80 10 15	85	9.8	400	80	600	<100	10
Rivanna B1	1M	80 04 24	84	16.1	<100	<300	100	<100	<10
	.5M	80 05 08	100	12.9	<100	110	200	100	<10
	Sb	80 06 24	204	6.9	<100	90	500	<100	<10
	1M	80 07 15	130	18.2	<100	<50	300	100	<10
	1M	80 08 13	99	50.4	<100	<50	600	<100	10
	.5M	80 09 16	nd	50.0	100	<50	400	<100	<10
	Sb	80 10 15	139	18.3	300	80	600	100	<10

Table VA-7a: Continued.

Lake	Depth[1]	Date	Secchi Depth	Chl-a	NH_3 + NH_4	NO_2 + NO_3	TKN	TP	OP
Rivanna C1	1M	80 04 24	72	14.5	<100	500	200	<100	<10
	.5M	80 05 08	100	9.7	<100	280	200	200	<10
	Sb	80 06 24	194	9.7	<100	70	400	<100	<10
	1M	80 07 15	134	24.3	<100	<50	300	<100	<10
	.5M	80 09 16	64	57.4	<100	<50	400	<100	10
	Sb	80 10 15	100	25.1	300	80	500	<100	10
Rivanna D1	1M	80 04 24	81	8.7	100	260	200	200	100
	.2M	80 05 08	75	10.1	<100	110	200	100	<10
	Sb	80 06 24	160	12.6	<100	70	400	<100	<10
	1M	80 07 15	131	15.2	<100	<50	400	<100	10
	1M	80 08 13	nd	45.2	<100	<50	500	<100	20
	.5M	80 09 16	73	79.6	<100	<50	600	<100	10
	Sb	80 10 15	116	16.4	300	90	500	<100	nd
Rivanna E1	1M	80 04 24	87	4.7	<100	270	200	200	<10
	.5M	80 05 08	120	5.7	nd	190	<100	100	200
	Sb	80 06 24	147	5.1	<100	130	200	<100	20
	1M	80 07 15	131	8.4	<100	210	100	200	120
	.5M	80 09 16	35	271.7	Int	<100	4200	300	40
	Sb	80 10 15	142	6.3	nd	<100	100	100	200

nd = No data.

1. Key to Depths:
    a. Sr = surface
    b. Sb = subsurface
    c. 1M, 2M etc. = 1 meter, 2 meters, etc.

Table VA-7b: Trophic Status and Water Quality Indicators for the Virginia Study Lakes.

Lake	Trophic[1] State	Macrophytes[2] and/or Algae
Anna	O-M	N
Beaverdam	M	N
Chesdin	E	B
Claytor	E	A
Halifax	M	N
John W. Flannagan	nd	N
Leesville	E	N
Moomaw	nd	N
Occoquan	E	A
Rivanna	E	A
Smith Mountain	M	A

1. See glossary for definitions of eutrophic, mesotrophic, and oligotrophic.

2. The presence of macrophytes and/or algae is noted whenever mentioned in the 1984 Virginia 305(b) report as degrading water quality (Virginia SWCB, 1984).

   (A=algae, M=macrophytes, B=both, N=not a problem)

Table VA-8: Comparison of Trophic State to the Percent of the Total Phosphorus Load Attributable to Municipal Wastewater Treatment Plants.

Percent Attributed to Municipal Plants	Trophic State[1] (Number of Study Lakes)		
	Oligotrophic	Mesotrophic	Eutrophic
Less Than 1 To 5	0	0	0
5 To 25	1	2	3
25 To 50	0	1	2
Greater Than 50	0	0	0

1. See glossary for descriptions of oligotrophic, mesotrophic, and eutrophic.

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XII. SUMMARY

A review of the water quality in estuaries, public lakes, and streams in nine Southeastern states was undertaken, with somewhat more emphasis placed on lakes than estuaries and streams. The states studied were: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. In general, the presentations for estuaries and streams were restricted to a review of information presented in each state's 1984 Section 305(b) report and and its submission to the Association of Interstate Water Pollution Control Administrators' "State's Evaluation of Progress" (STEP) program. In addition to these data, municipal wastewater treatment plant (WWTP) total phosphorus load estimates were calculated for lakes. The terms "assessed" estuaries and streams will be used to refer to those waters evaluated by the states in the 1984 Section 305(b) reports, whereas the term "assessed" lakes will refer to the set of lakes considered in this report's WWTP phosphorus load analysis; at a minimum, assessed lakes included all lakes covered in the states' Clean Lakes Program Reports. The results of this project are summarized below.

1. <u>Trophic States of Lakes</u>:

   a. Number of Lakes: In five of eight Southeastern states (Alabama had no data) the majority of public lakes are eutrophic, with a somewhat lesser number being mesotrophic and even fewer oligotrophic. This is illustrated by the bar graphs in Figure SUM-1 for individual states, the Southeast as a whole, and the average of the state percentages. The "regional" graph represents all Southeastern lakes as a single group rather than an average of state values, and is, therefore, heavily biased by the large number of oligotrophic and mesotrophic lakes in Florida.

   b. Surface Area of Lakes: When the surface areas of the lakes are considered, a similar trend is visible, although surface areas reveal predominantly mesotrophic conditions in Kentucky, North Carolina, and Virginia (Figure SUM-2). It should be noted that surface area data were not calculated for Florida, thus the regional graph is similar to the average of states graph.

2. <u>Population Growth</u>:

   a. Since 1970, the population has increased by 7 to 63 percent in every Southeastern state (Figures SUM-3 and SUM-4). Only slightly lower growth rates (9 to 41 percent) are anticipated between 1985 and 2000. Florida has experienced the greatest growth, 63 percent during 1970-1985, and another 41 percent is projected by 2000.

3. Municipal Wastewater Treatment Plants Potentially Impacting Lakes:

   a. On a regional basis, 27 percent of the municipal wastewater treatment plants potentially impact lakes assessed during the Clean Lakes Program, with the percentages for individual states ranging from 14 to 63 percent (Figure SUM-5). Tennessee had the highest percentage of treatment plants impacting lakes (63 percent) followed by South Carolina (40 percent). Less than 30 percent of the treatment plants impacted lakes in all other states, with the lowest percentage being Florida (14 percent). However, the Florida analysis was not as complete as that performed on the other states. The percentage in Florida may actually be higher.

   b. In all states, the majority of Clean Lakes Program lakes did not have a municipal wastewater treatment plant located upstream, and those which did tended to have less than 25 percent of their phosphorus load attributable to the municipal facilities (Figure SUM-6).

   c. In contrast to the numbers of lakes, when the surface area of public lakes are considered, it is found that most of the freshwater surface area is potentially impacted by municipal wastewater treatment plants (Figure SUM-7). The percentage of potentially impacted lake surface areas ranges from 60 percent in North Carolina to 97 percent in Kentucky. In general, municipal wastewater treatment plants represent less than 25 percent of the total phosphorus load. Virginia is a notable exception, having 29 percent of the surface area with municipal phosphorus loads accounting for from 1 to 25 percent of the total load, 34 percent of the area with 26 to 50 percent, and 19 percent with 51 percent or more.

4. Wastewater Treatment Systems:

   a. Presently, there are no municipal wastewater treatment plants employing chemical phosphorus removal in Alabama, Kentucky, Mississippi, North Carolina, or Tennessee; Florida and Virginia have ten facilities each, Georgia has seven, and South Carolina has one (Table SUM-1).

   b. As a regional average, about 60 percent of the population in the Southeastern U.S. is served by municipal wastewater treatment plants and 40 percent by septic tank systems (Figure SUM-8). The percentage of the population served by municipal facilities for individual states range from 41 percent in Kentucky to 81 percent in Virginia, with most of the remaining population using septic tanks to treat their wastewater.

c. Levels of Treatment: The largest number of persons connected to municipal wastewater treatment plants are served by facilities practicing secondary treatment, ranging from 28 to 60 percent of the total state population (Table SUM-2). Mississippi has 12 percent of its population served by primary treatment facilities, whereas all other states have less than 6 percent with primary treatment. Mississippi is the only Southeastern state with any of its population discharging without treatment (2 percent).

d. Combined sewer overflows were not stated to be a major problem except in Virginia which is particularly concerned about the City of Richmond combined sewer overflows.

5. <u>Support of Designated Uses and Causes for Non-Support</u>:

The extent to which surface waters in the Southeastern U.S. support their designated uses, and the causes for less than full support, are summarized in Figures SUM-9 through SUM-14 and Table SUM-3.

a. Support of Designated Uses:

1) Estuaries: At least 80 percent of assessed estuarine areas in all states having estuaries fully support their designated uses, with the exception of South Carolina which has only about 56 percent fully supporting the uses.

2) Lakes: With the exception of North Carolina (62 percent) and Tennessee (62 percent), 75 percent or more of the lakes fully support their designated uses. The average support for all states was 82 percent.

3) Streams: The majority of stream miles assessed by the states also fully support their designated uses, except in Florida (46 percent), Kentucky (10 percent), Tennessee (50 percent), and Virginia (31 percent).

b. <u>Causes for Less Than Full Support</u>: The causes for less than full support of designated uses in estuaries, public lakes, and streams were highly variable from state to state. Although non-point sources were the most frequently cited cause for failure to meet designated uses for all surface waters, municipal wastewater treatment plants were considered to be nearly as important. In general, industry was not the causative factor in as many cases as non-point sources or municipal wastewater treatment plants, except in North Carolina (lakes), Tennessee (lakes), and South Carolina (estuaries) where industry was the greatest problem. However, as an <u>average of all states</u>, less than full support of estuaries was attributed approximately equally to industry, municipal wastewater treatment plants, non-point sources, and unknown sources, while municipal wastewater treatment plants and non-point sources were the most common factors for less than full support in lakes and streams.

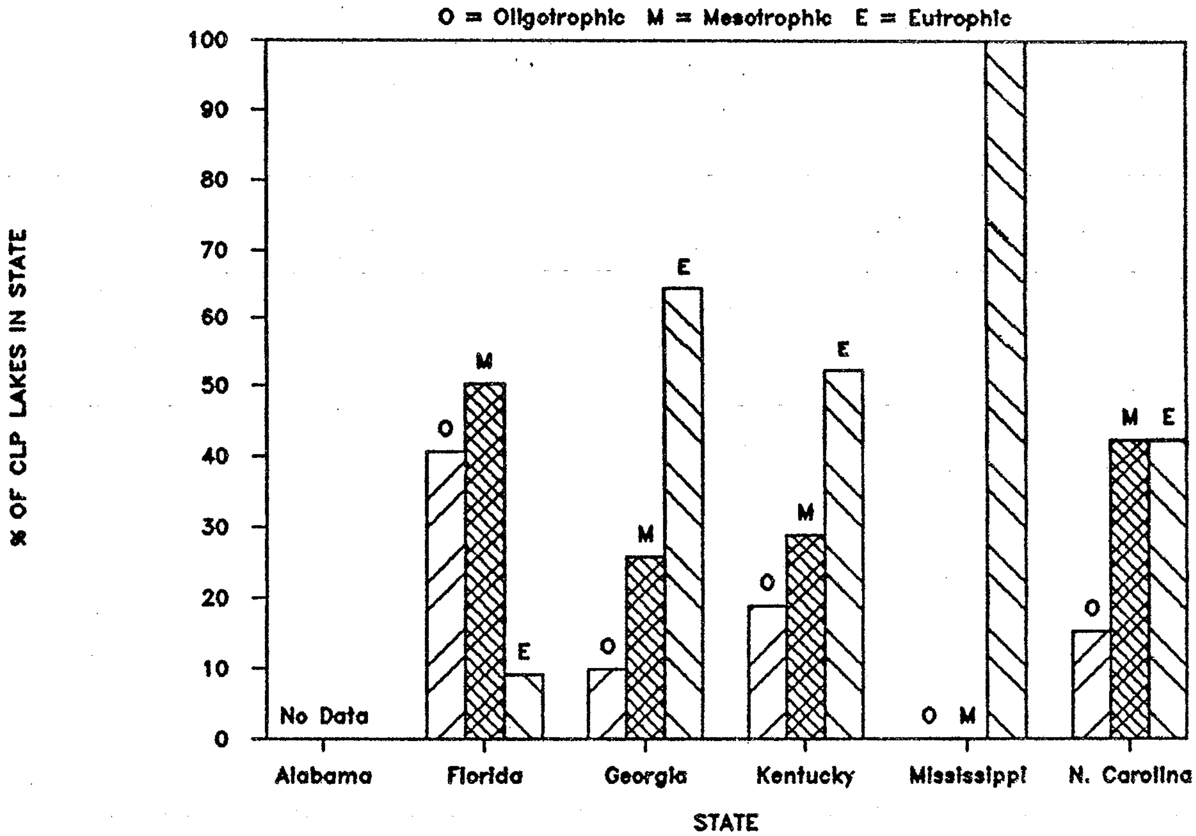
1) Municipal Wastewater Treatment Plant Discharges: Dissolved oxygen fecal coliform, and nutrient concentrations were the most commonly referenced problems attributed to municipal wastewater treatment plants (Figure SUM-15). Heavy metals, pH, and toxic substances were less frequently noted.

2) Non-Point Sources: Fecal coliform, nutrient concentrations, and water clarity were the most commonly referenced problems attributed to non-point sources (Figure SUM-16). Dissolved oxygen, pH, and toxic substances were mentioned, but less frequently.

3) Industrial Discharges: Dissolved oxygen concentrations and toxic substances were the parameters most often cited in regard to industrial discharges, although nutrients, pH, and temperature were also common factors (Figure SUM-17). Heavy metals and water clarity were noted in only one instance each.

4) Other Sources: Fe (iron) and Mn (manganese) from reservoir releases (anoxic hypolimnion), pH, temperature, and toxic substances were the only "other" sources referenced; each was cited only once (Figure SUM-18). Although the Fe and Mn problems were specifically attributed to natural causes, the ultimate causes are probably nutrients and BOD (biochemical oxygen demand from organic compounds) which can result in depletion of hypolimnetic dissolved oxygen.

Fig. SUM-1: Trophic States of Assessed Lakes - % of Lakes.



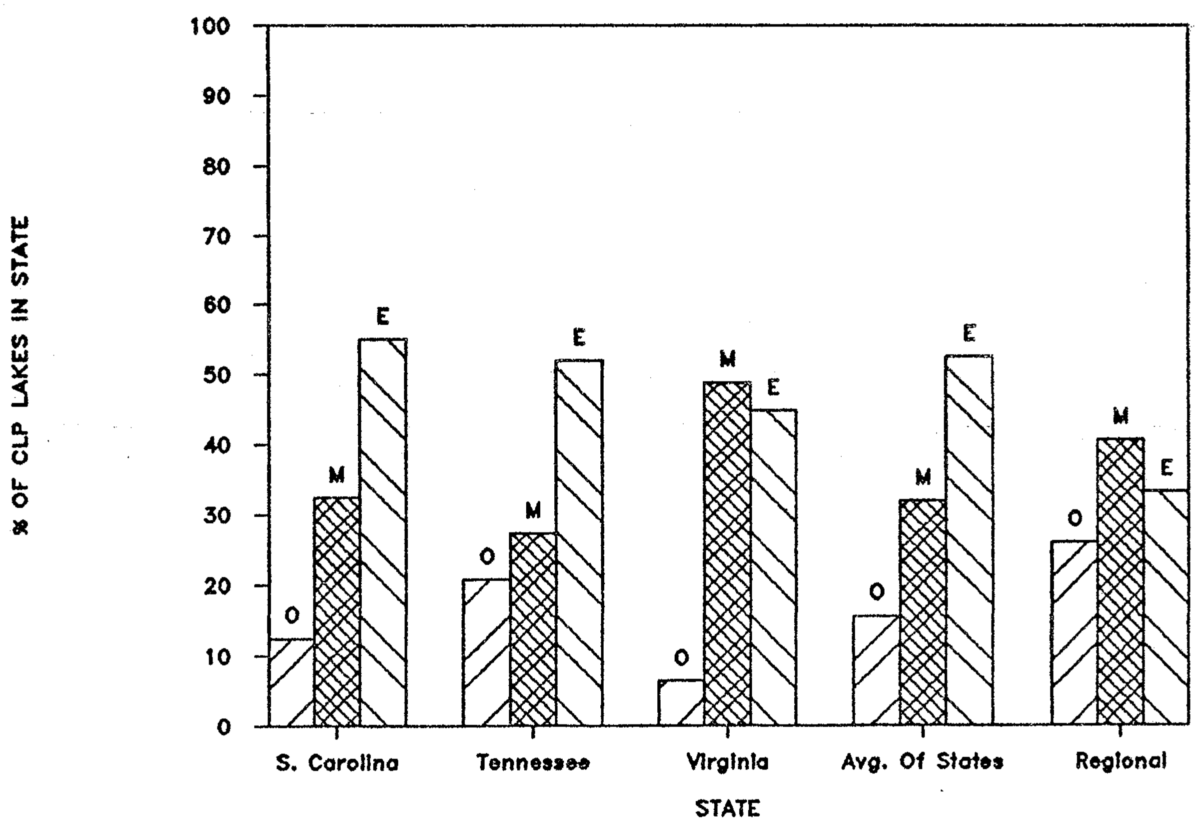


Fig. SUM-2: Trophic States of Assessed Lakes - % of Surface Area.

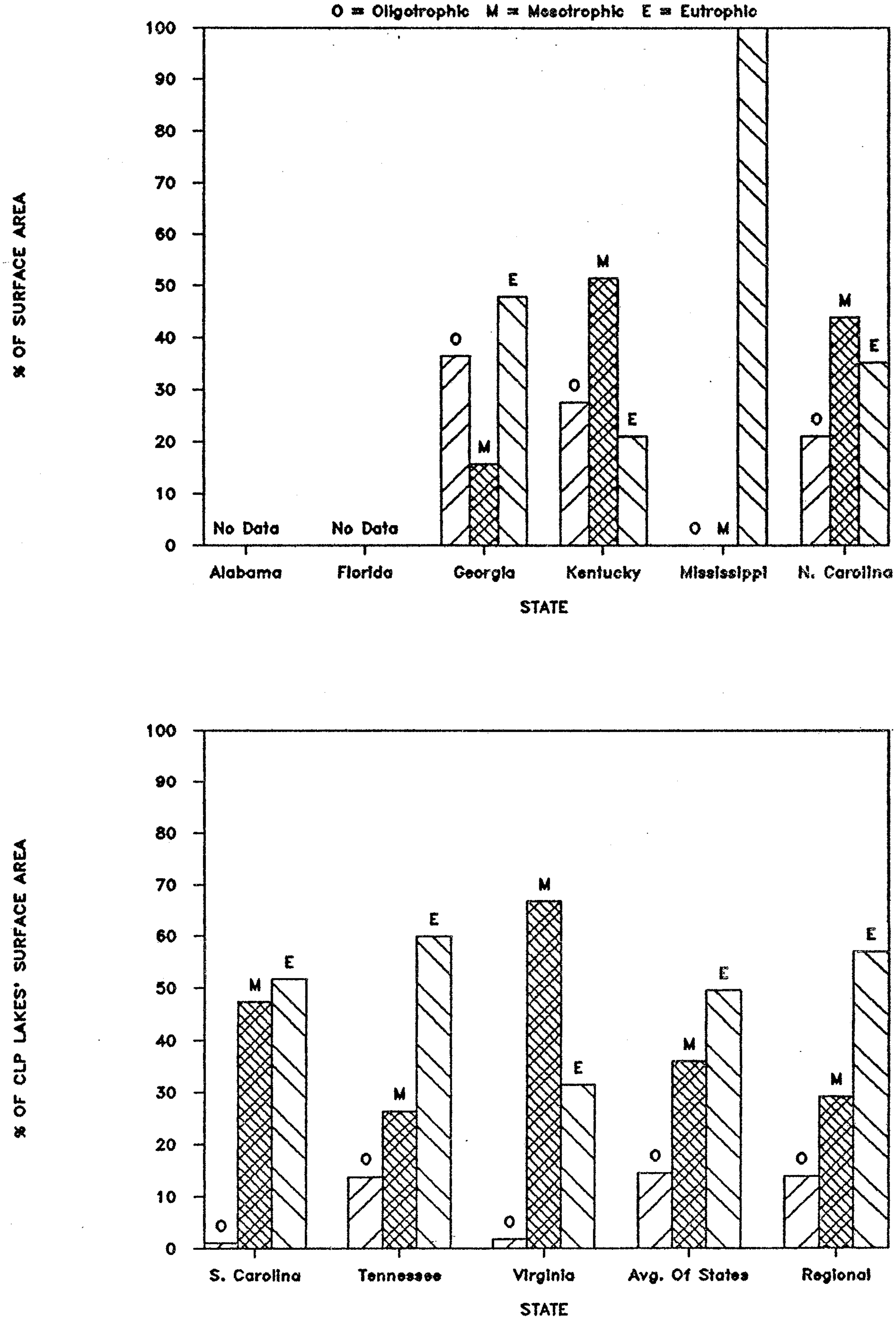


Fig. SUM-3: Populations in the Southeastern U.S.

1970, 1985, and 2000.

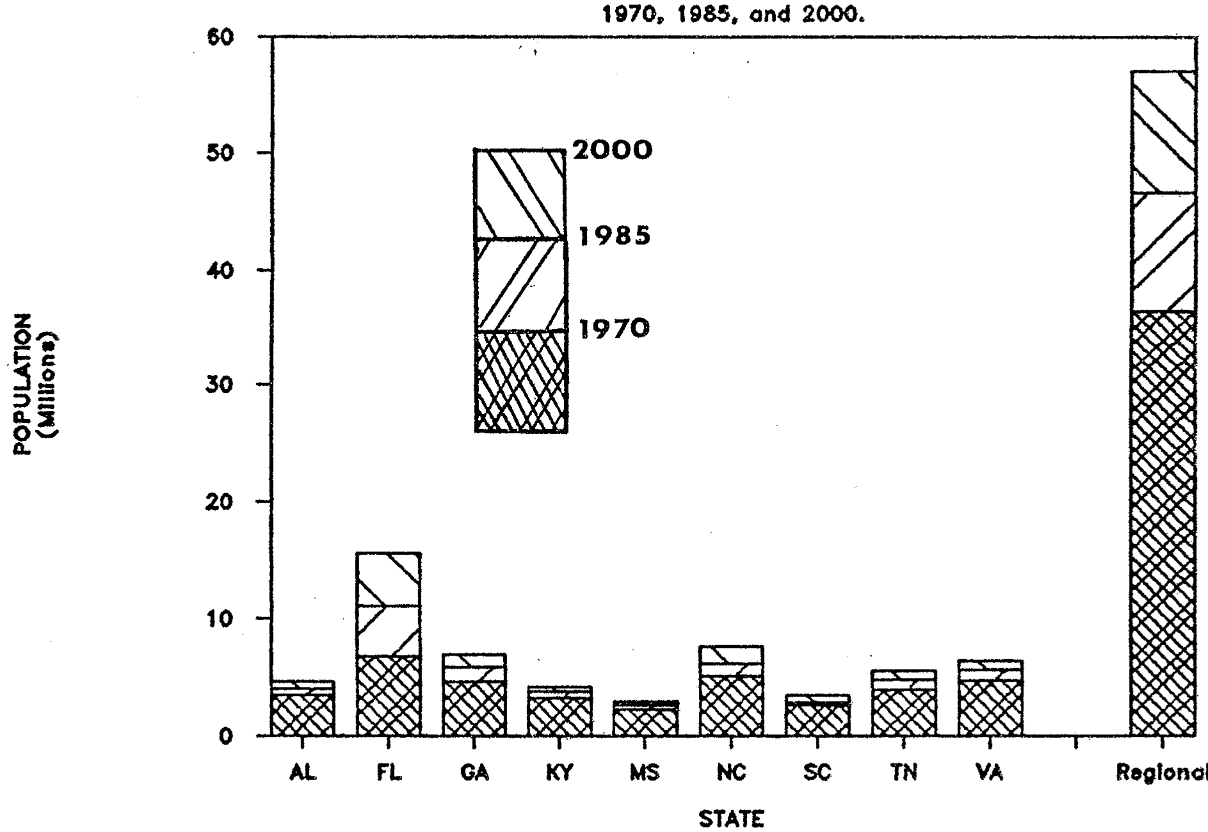


Fig. SUM-4: Population Increases in the Southeastern U.S.

A = 1970-1985 B = 1985-2000

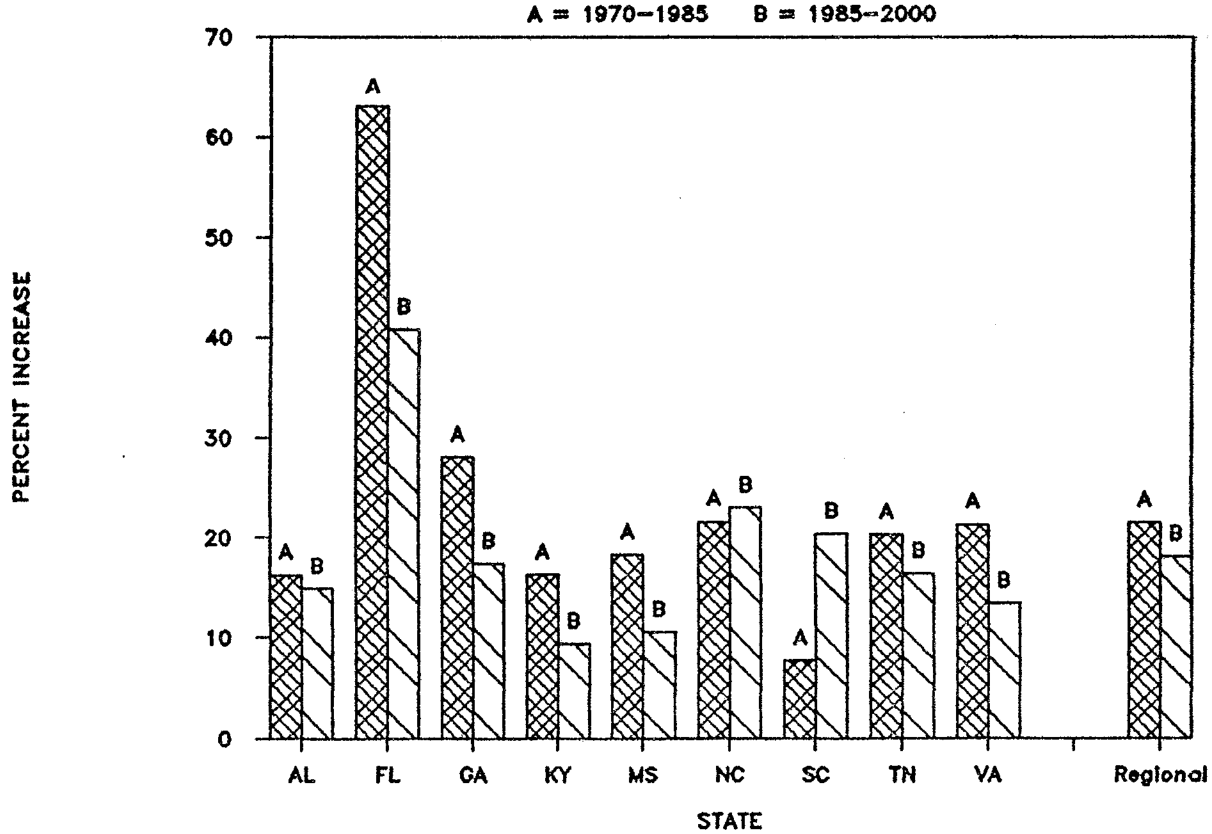


Fig. SUM−5: Number of Municipal WWTP's in Southeastern States.

(Number Represents % of WWTP's Upstream of Assessed Lakes)

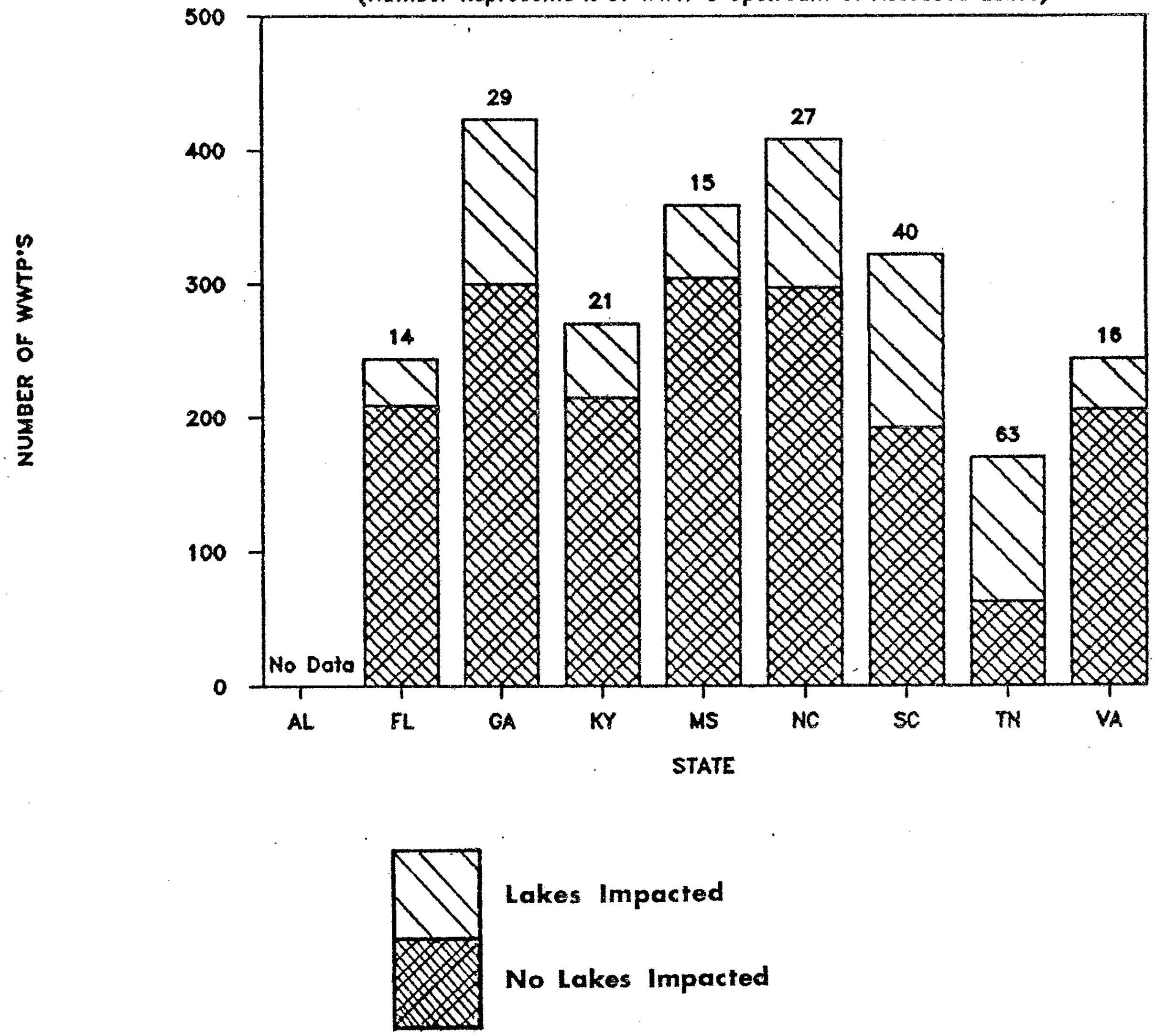


Fig. SUM-6: WWTP TP Loads to CLP Lakes As % of Total Loads.

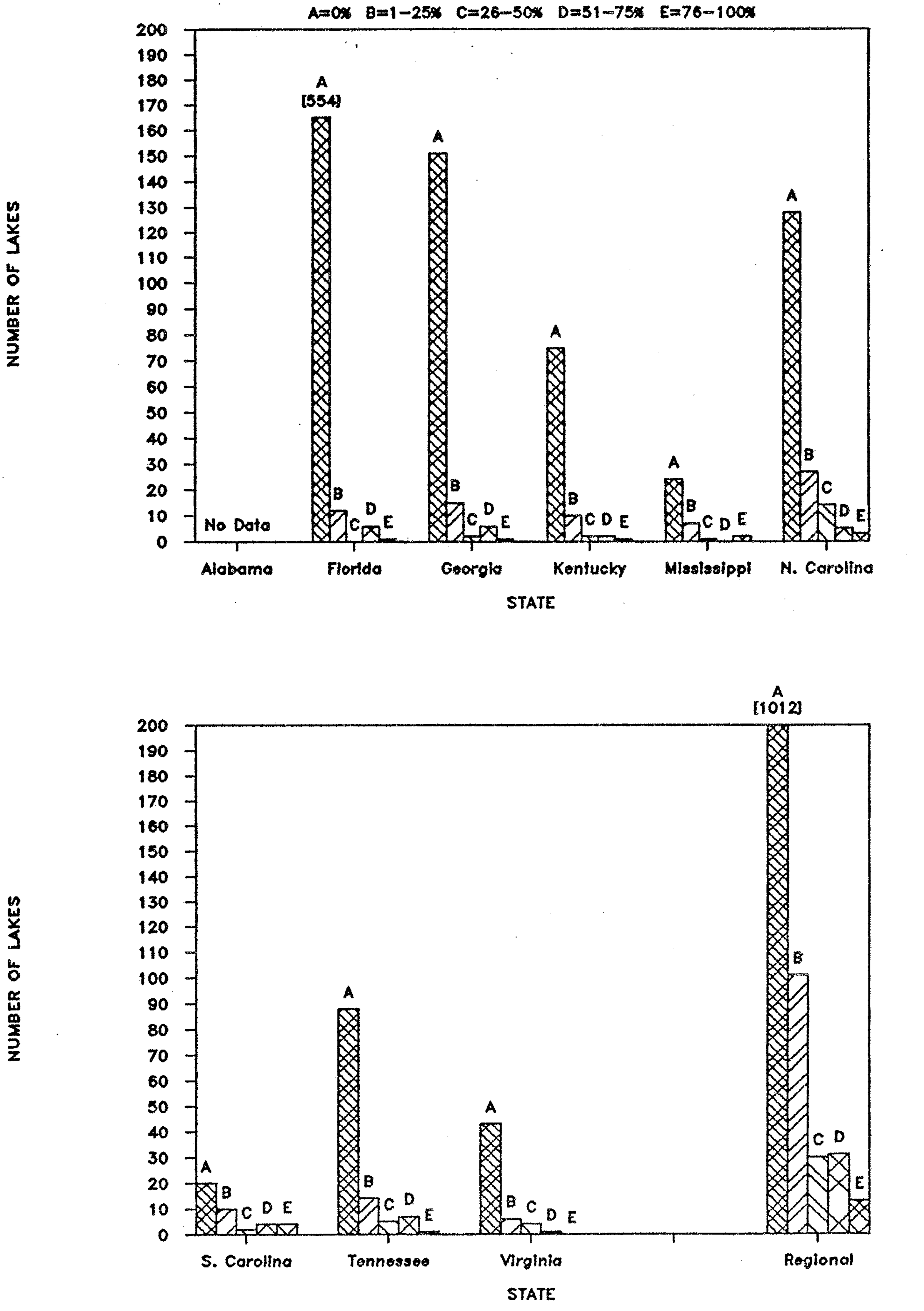


Fig. SUM-7: Lake Surface Area Impacted by WWTP TP Loads.

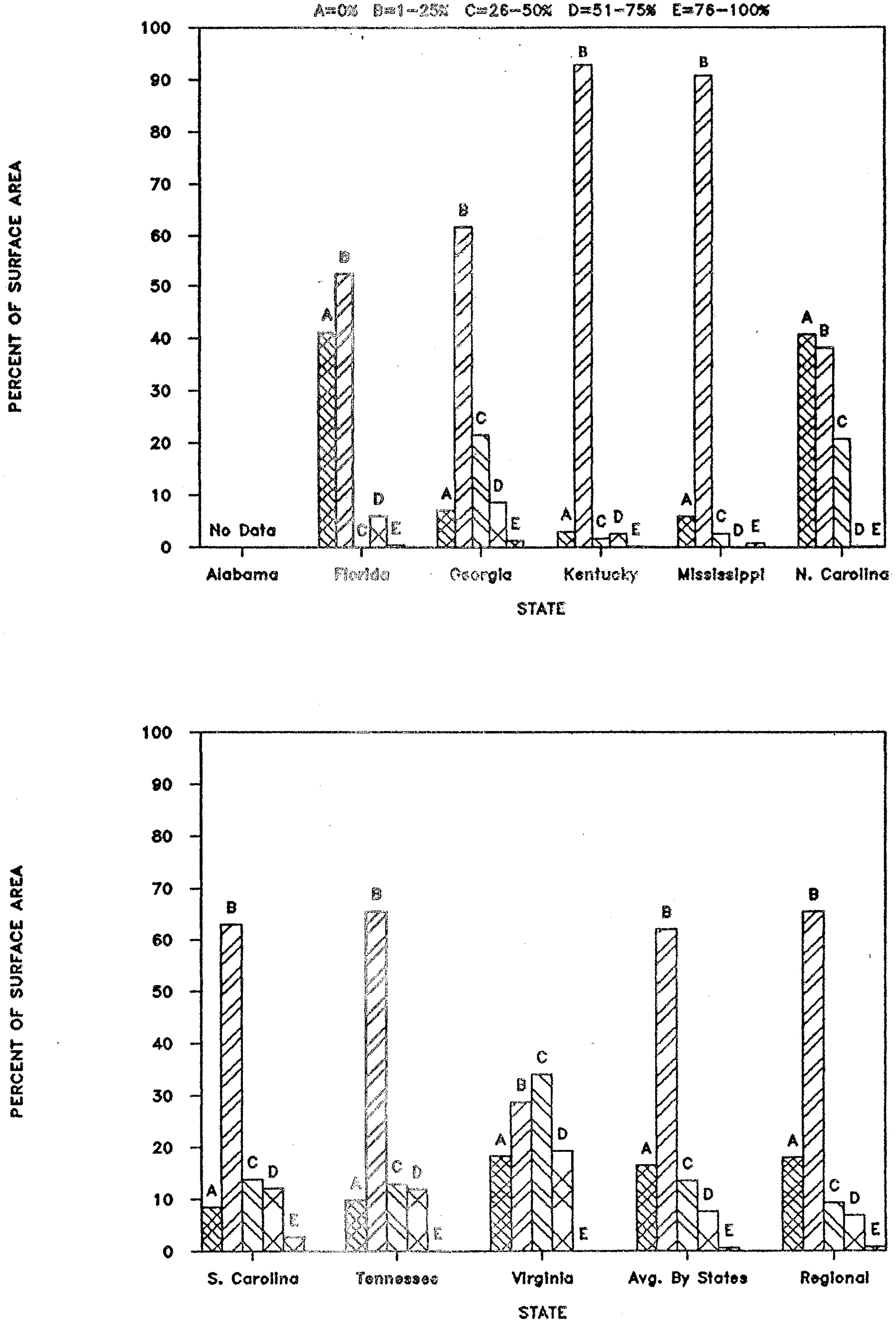


Fig. SUM-8: Municipal & On-Site Wastewater Treatment Systems.

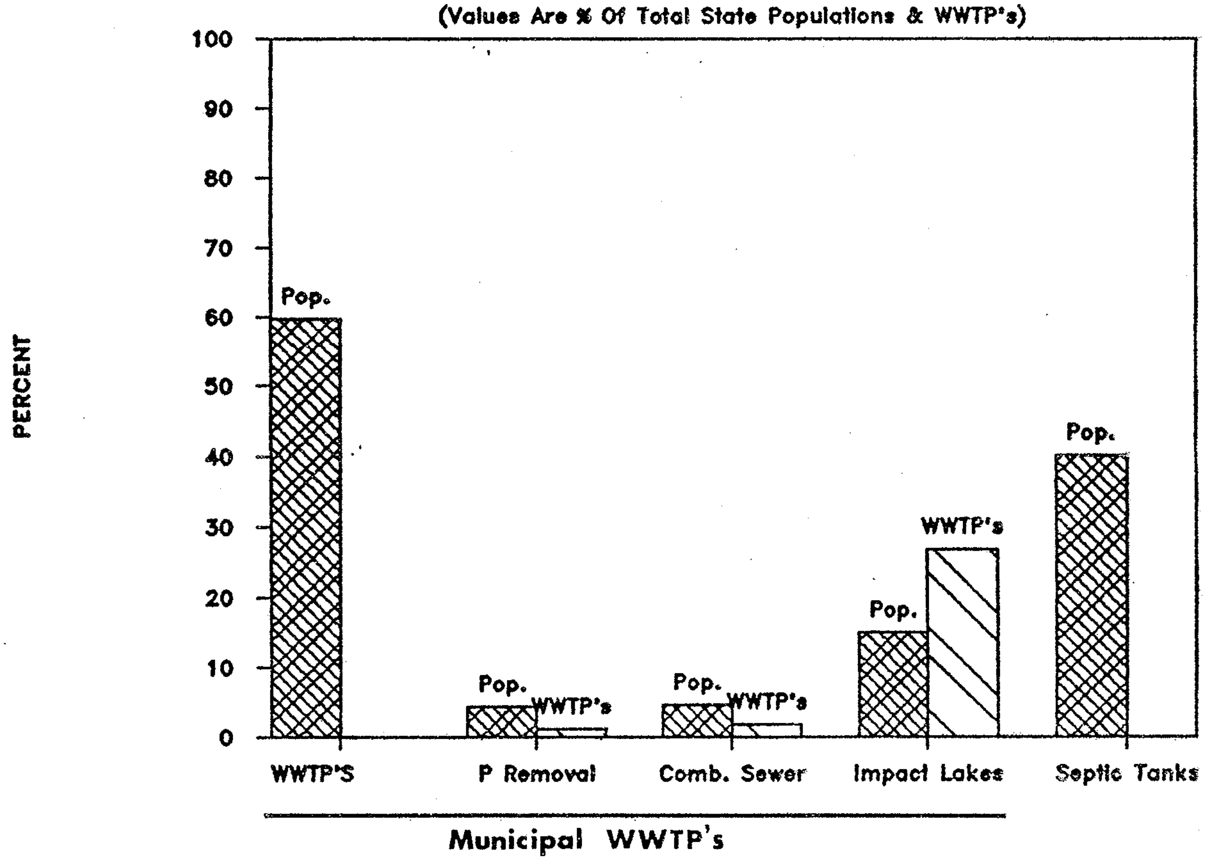
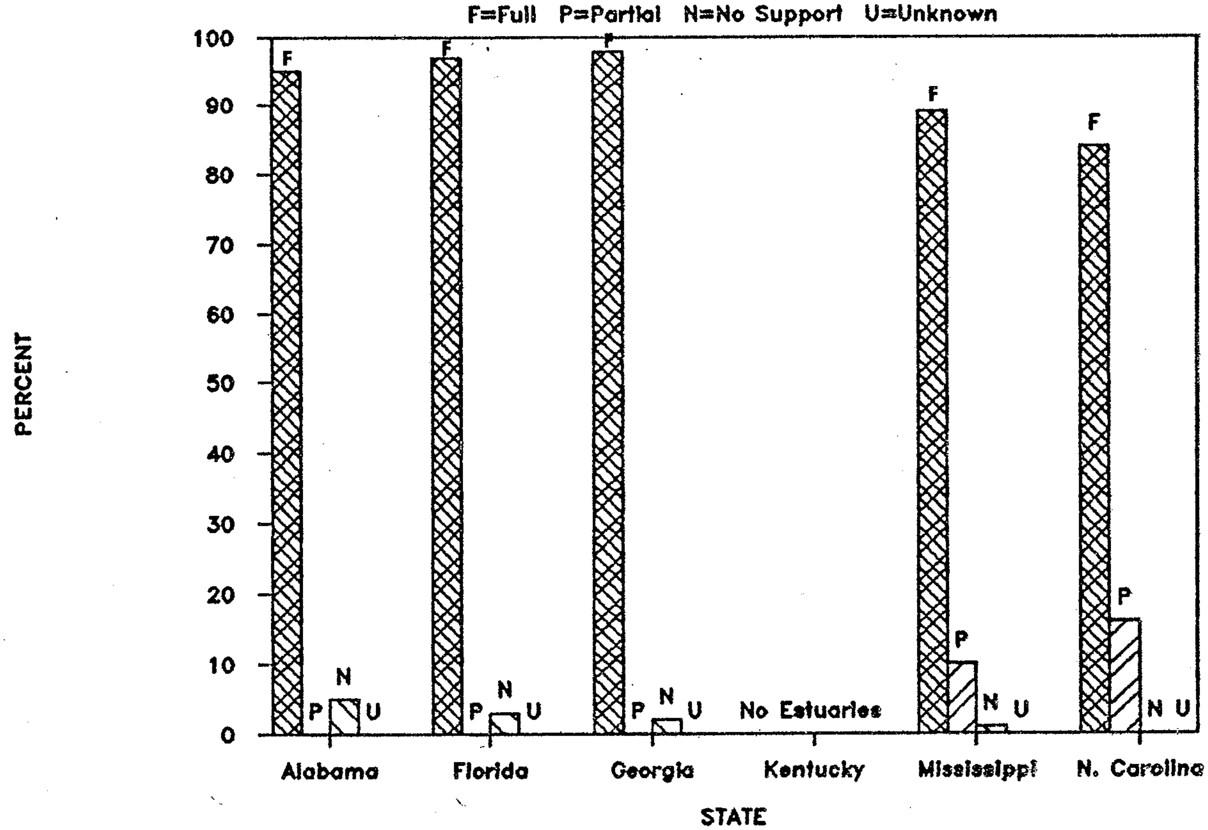


Fig. SUM-9: Support of Designated Uses - Esturaries.



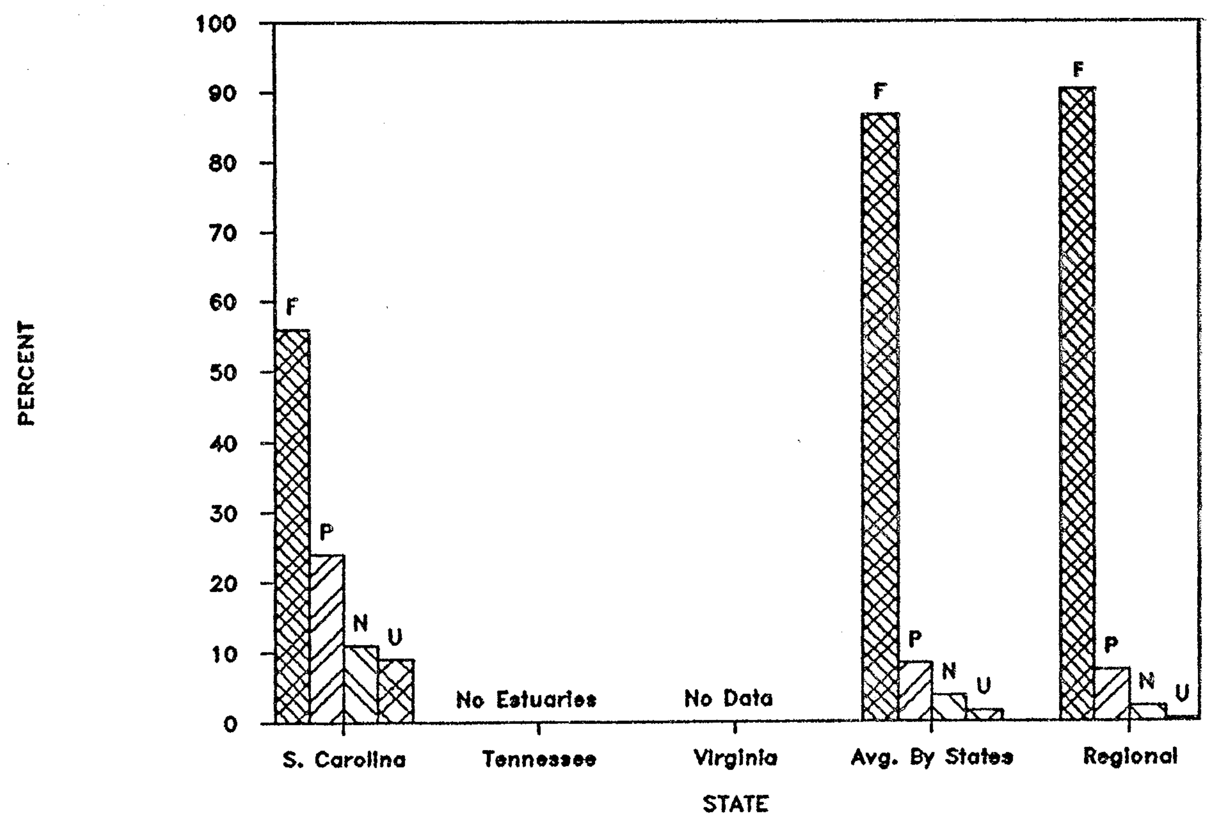


Table SUM-1: Southeastern States Having Municipal WWTP's Practicing Biological or Chemical Phosphorus Removal.

State	Number Of Plants	Population Served	Percent Of State Population
Alabama	0	0	0
Florida	10	864,000	9
Georgia	7	334,700	6
Kentucky	0	0	0
Mississippi	0	0	0
North Carolina	0	0	0
South Carolina	1	33,300	1
Tennessee	0	0	0
Virginia	10	>476,115[1]	>9
Regionally	28	1,708,115[1]	>4

1: Population data were available for only 4 of the 10 plants in Virginia.
NA: Not applicable, no facilities.
nd: No data.

Table SUM-2: Level of Treatment Provided by Municipal Facilities With the Percentage of the Total State Population Served.

	Percent of Total State Population			
	No Treatment	Primary	Secondary	Tertiary[1]
Alabama	0	2	42	12
Florida	0	0	47	13
Georgia	0	0	60	10
Kentucky	0	<1	35	5
Mississippi	2	12	28	24
North Carolina	0	<1	35	13
South Carolina	0	2	42	0
Tennessee	0	3	56	7
Virginia	0	6	41	34

1: Refer to glossary for definitions of level of treatments.

Table SUM-3: Support of Designated Uses and Causes for Less Than Full Support.

A. Estuaries

	Percent Of Total Area Assessed	Support Of Designated Uses (Percent)				Causes For Less Than Full Support (Percent)			
		Full	Part	None	Unk.	Ind.	Mun.	Non-Pt.	Oth.
Alabama	8	95	0	5	0	94	5	1	0
Florida	99	97	0	3	0	0	70	30	0
Georgia	80	98	0	2	0	15	5	0	80
Kentucky	na	na	na	na	na	na	na	na	na
Mississippi	100	89	10	1	0	13	31	56	0
North Carolina	100	84	16	0	0	10	25	65	0
South Carolina	100	56	24	11	9	2	24	40	34
Tennessee	na	na	na	na	na	na	na	na	na
Virginia	nd	nd	nd	nd	nd	nd	nd	nd	nd
Avg. Of States	92	87	8	4	2	22	27	32	19
Regional	92	90	7	2	0	nd	nd	nd	nd

na: Not applicable, no estuaries.
nd: No data.

B. Lakes

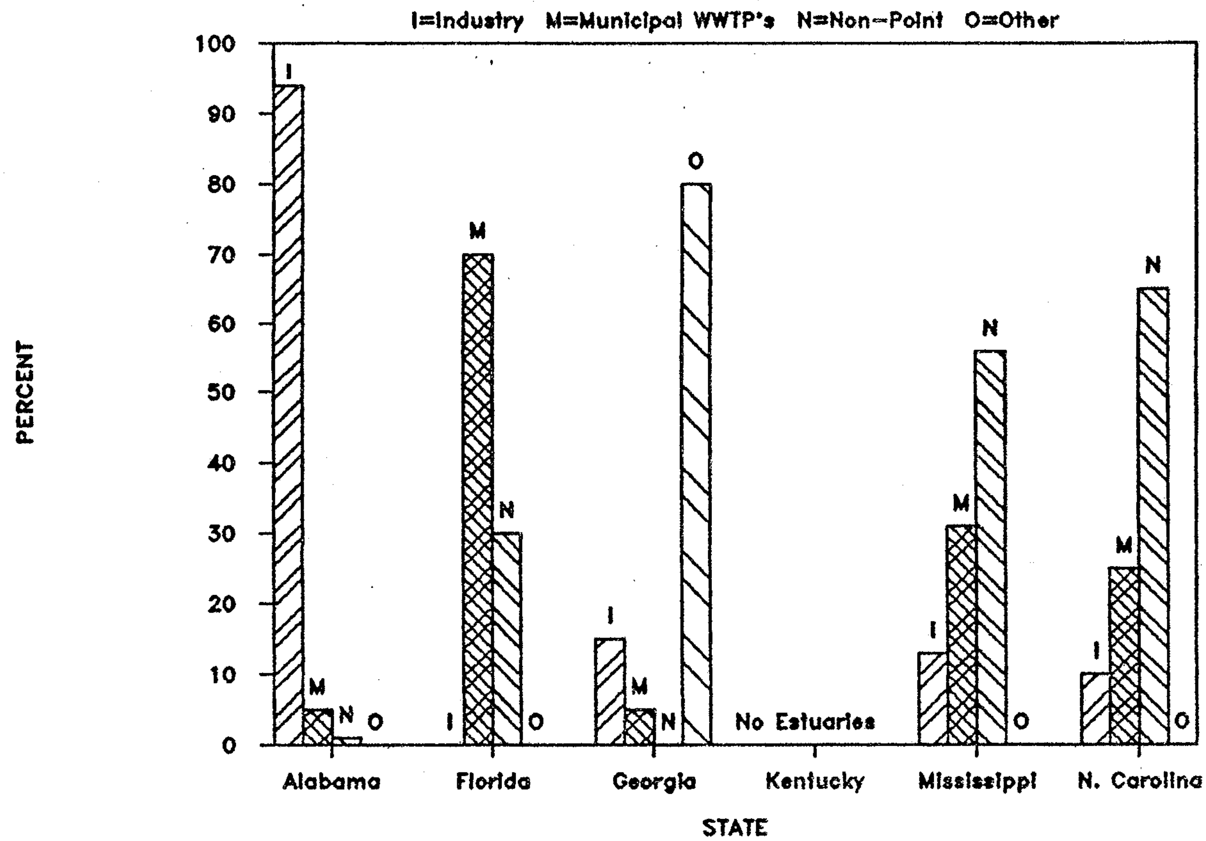
	Percent Of Total Area Assessed	Support Of Designated Uses (Percent)				Causes For Less Than Full Support (Percent)			
		Full	Part	None	Unk.	Ind.	Mun.	Non-Pt.	Oth.
Alabama	100	100	0	0	0	0	0	0	0
Florida	36	82	10	8	0	4	48	48	0
Georgia	100	86	13	1	0	2	96	2	0
Kentucky	100	91	9	0	0	0	6	26	68
Mississippi	100	96	4	0	0	0	0	100	0
North Carolina	97	62	20	18	0	51	33	15	1
South Carolina	100	75	18	7	0	6	37	34	23
Tennessee	100	62	20	18	0	51	33	15	1
Virginia	100	86	13	0	1	1	1	98	0
Avg. Of States	74	82	12	6	0	13	28	38	10
Regional	74	81	12	7	0	nd	nd	nd	nd

Tabl SUM-3, continued.

C. Streams

	Percent Of Total Area Assessed	Support Of Designated Uses (Percent)				Causes For Less Than Full Support (Percent)			
		Full	Part	None	Unk.	Ind.	Mun.	Non-Pt.	Oth.
Alabama	30	94	2	4	0	20	67	13	0
Florida	100	46	32	13	9	4	20	50	26
Georgia	85	95	2	3	0	1	98	1	0
Kentucky	12	10	59	0	31	25	25	25	25
Mississippi	100	90	10	0	0	5	23	72	0
North Carolina	100	82	14	4	0	15	30	55	0
South Carolina	29	51	24	25	0	12	32	25	31
Tennessee	100	50	16	3	31	15	30	55	0
Virginia	17	31	25	44	0	20	35	33	12
Avg. Of States	56	61	20	11	8	13	40	37	10
Regional	56	72	15	6	7	nd	nd	nd	nd

Fig. SUM-10: Causes For Less Than Full Support - Estuaries.



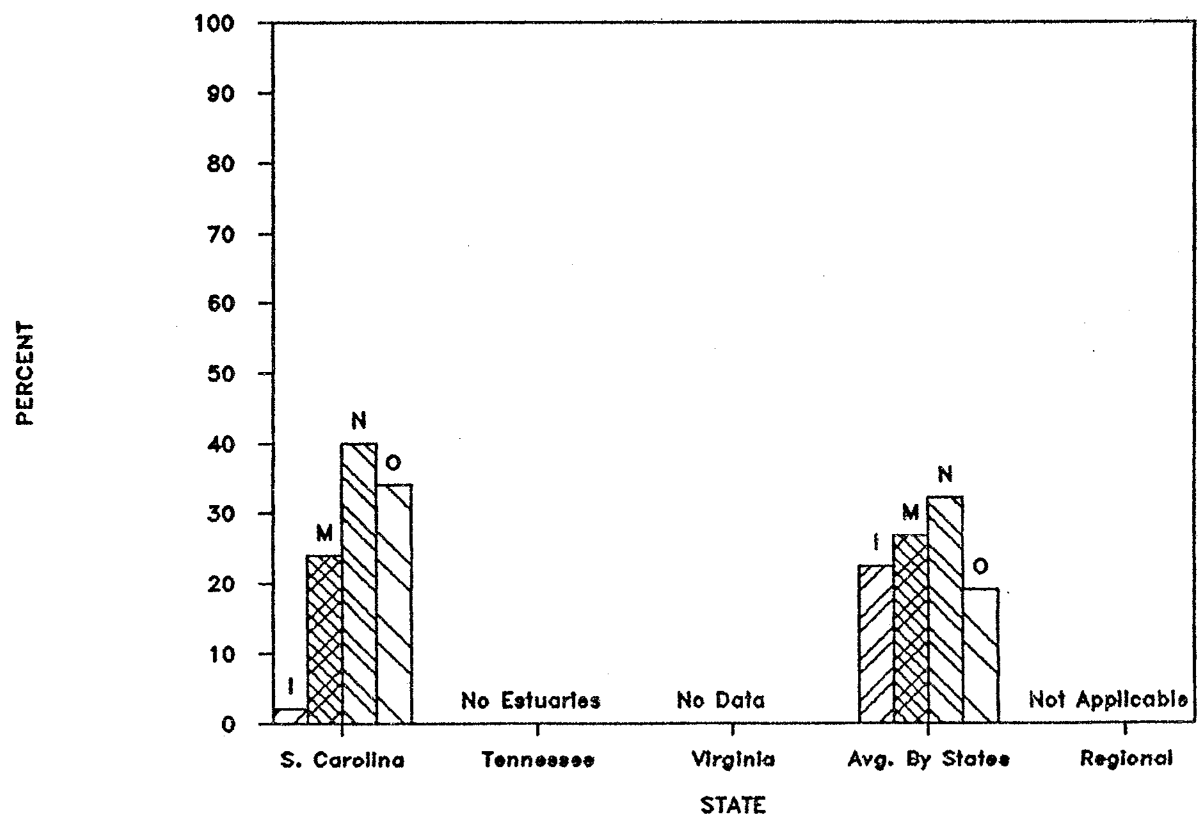


Fig. SUM-11: Support of Designated Uses - Lakes.

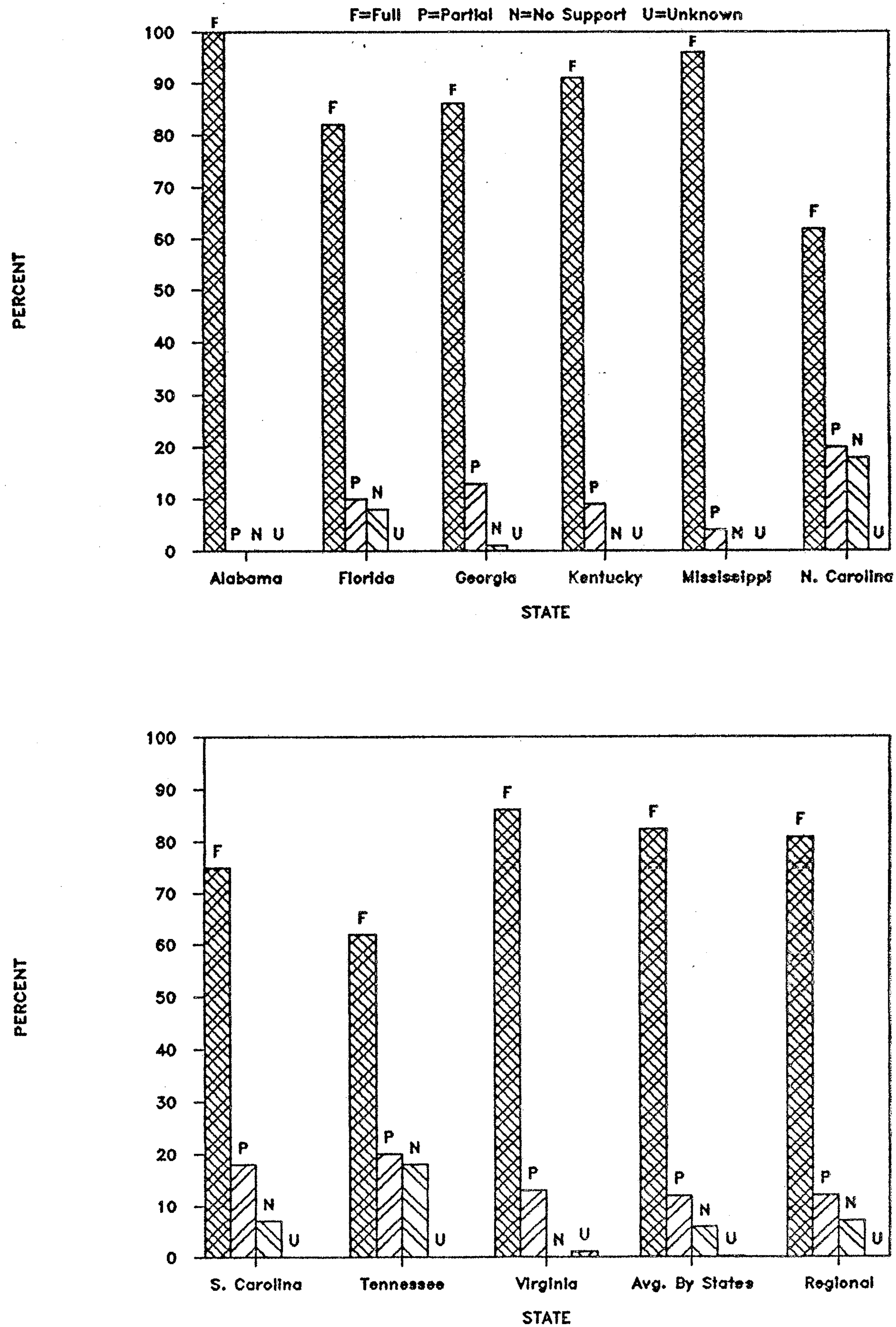
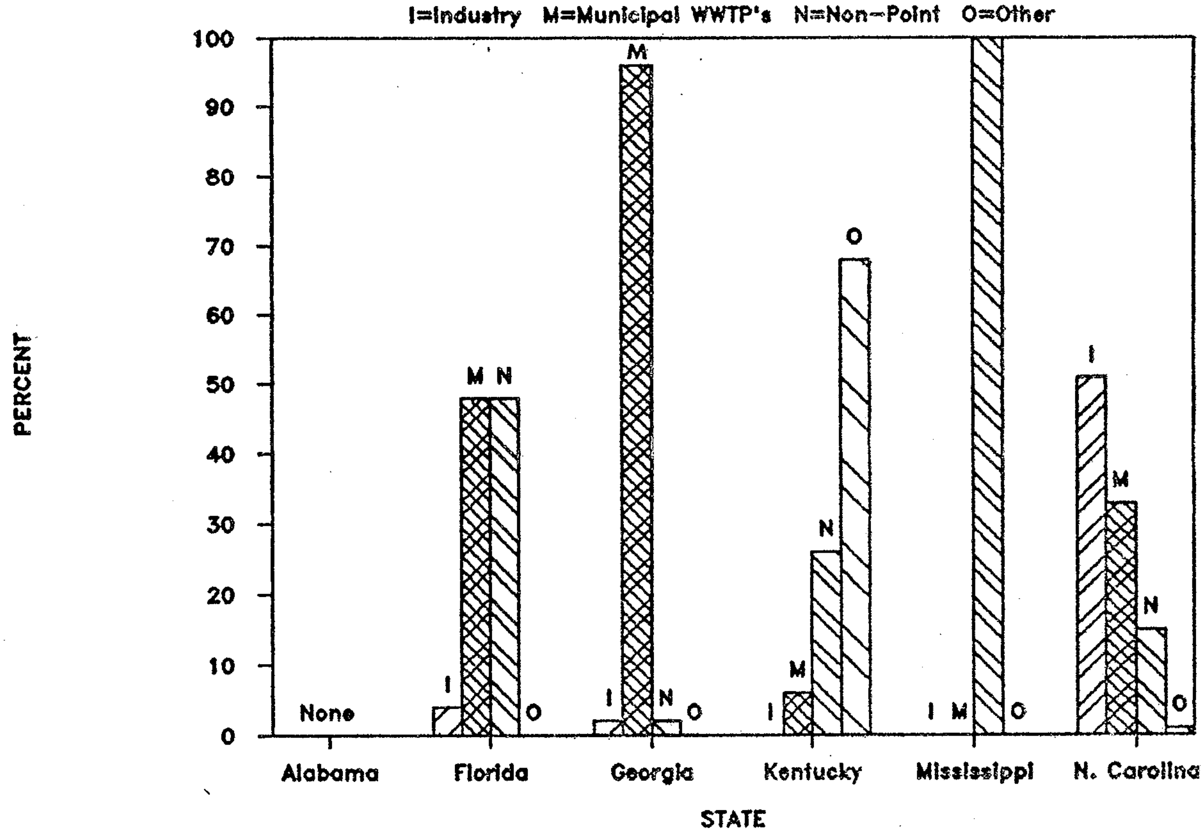


Fig. SUM-12: Causes For Less Than Full Support - Lakes.



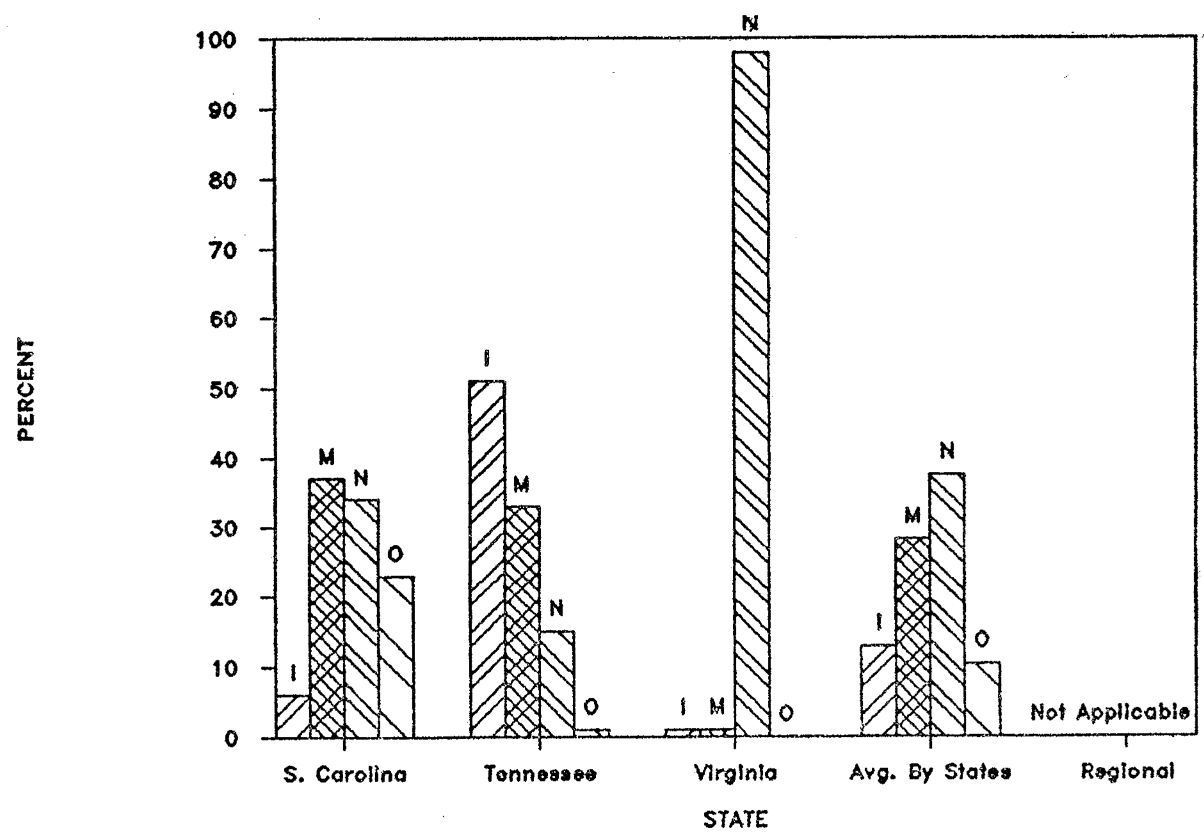


Fig. SUM-13: Support of Designated Uses - Streams.

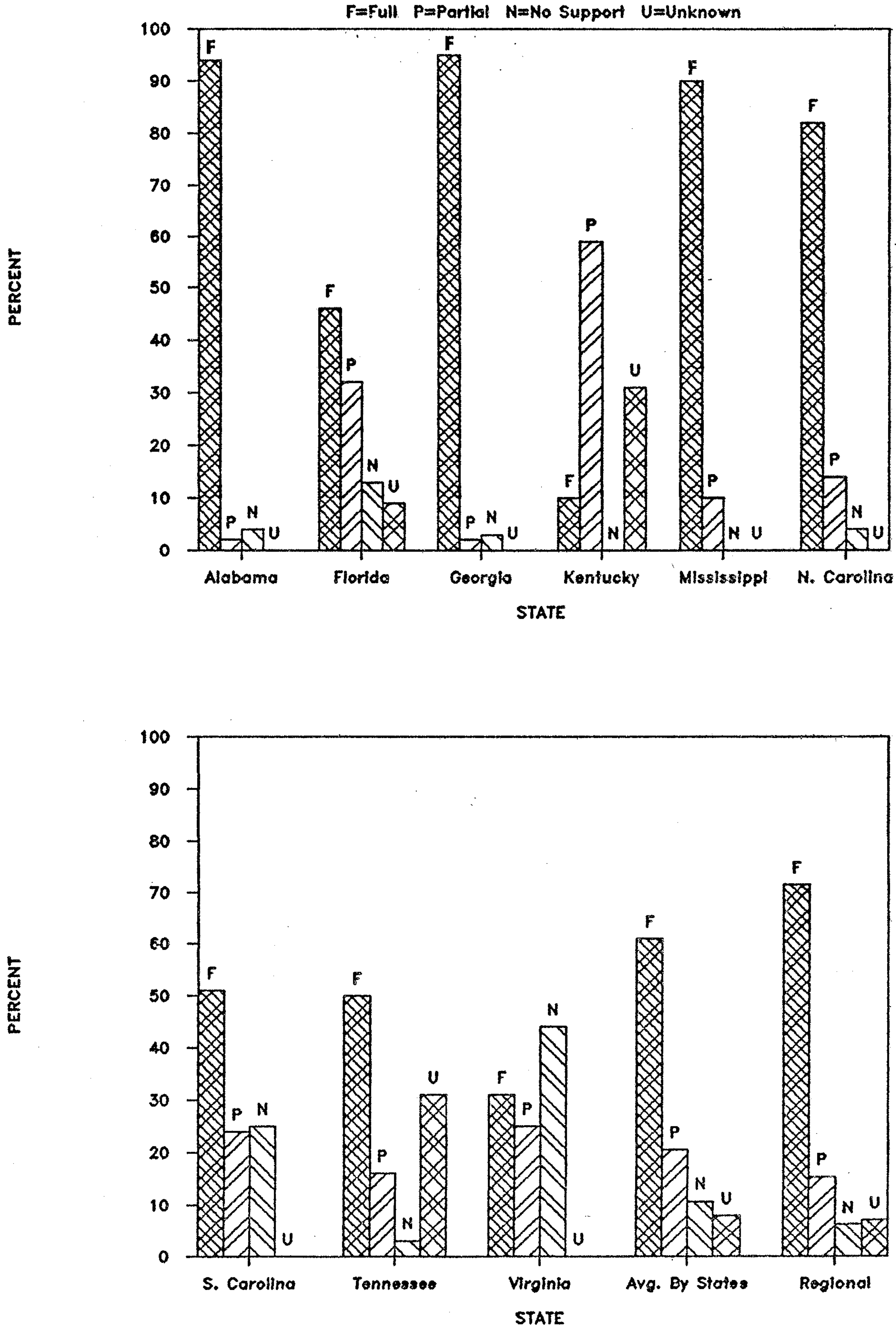
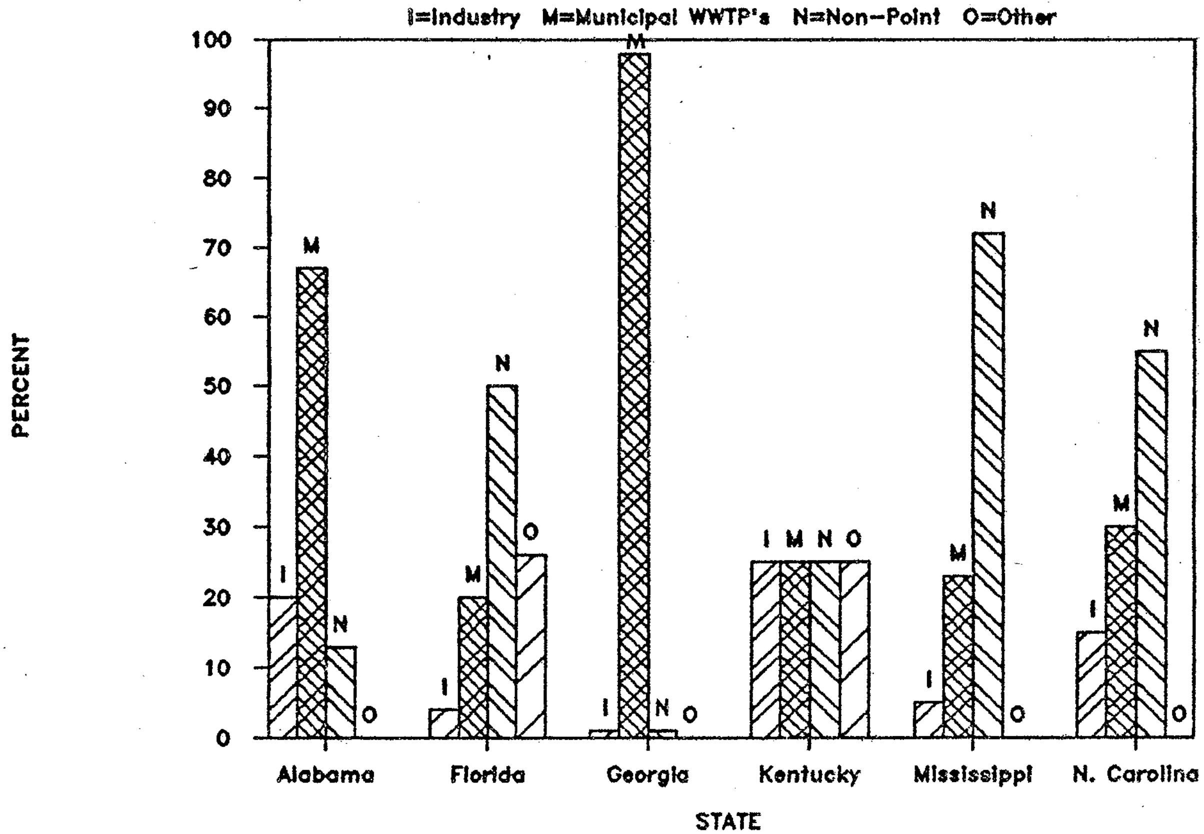


Fig. SUM-14: Causes For Less Than Full Support - Streams.



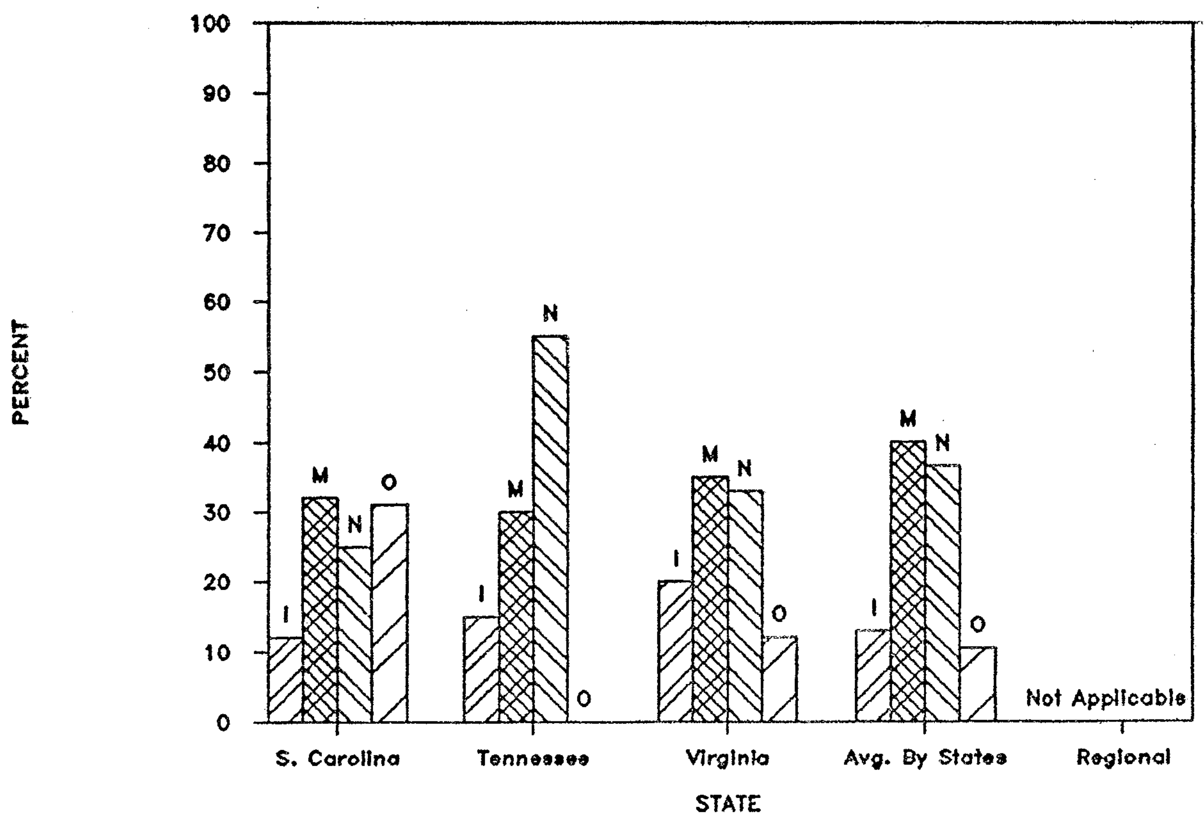


Fig. SUM–15: Concerns Relating to Munic. WWTP Discharges.

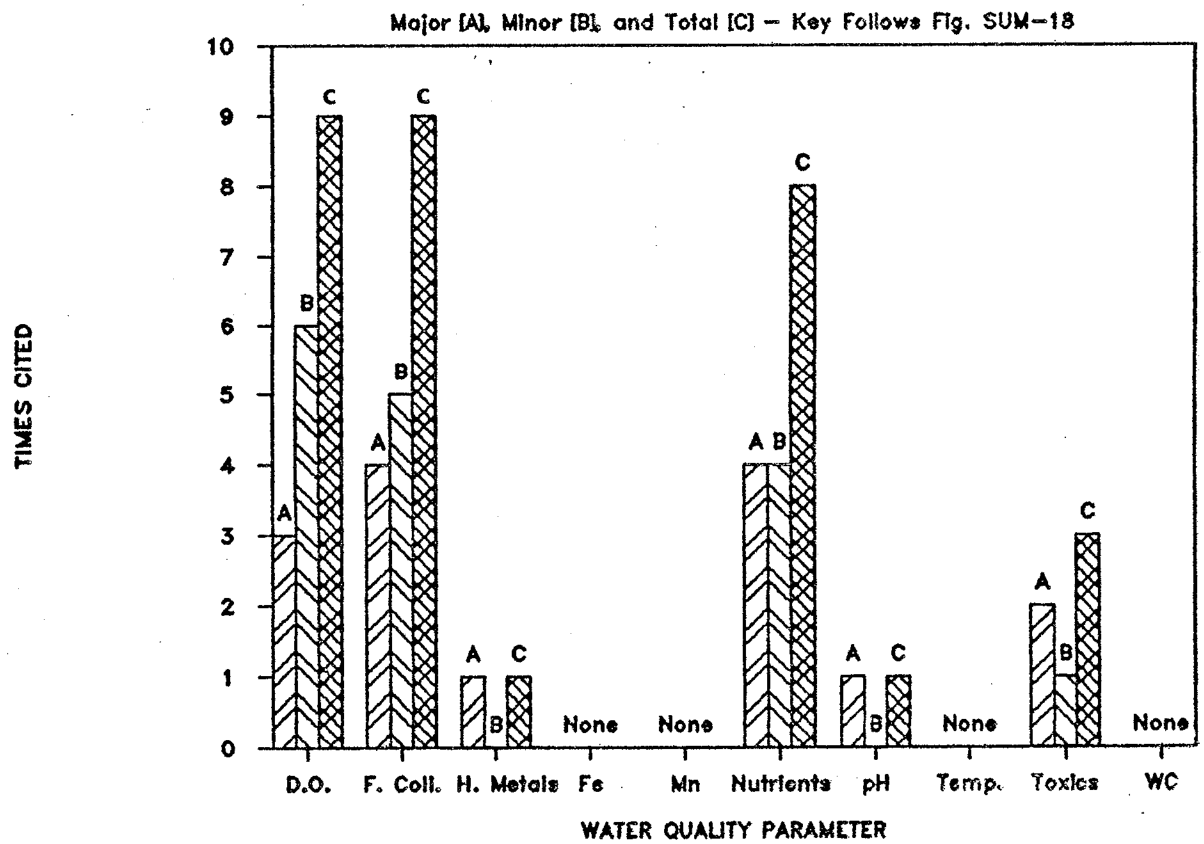


Fig. SUM–16: Concerns Relating to Non–Point Sources.

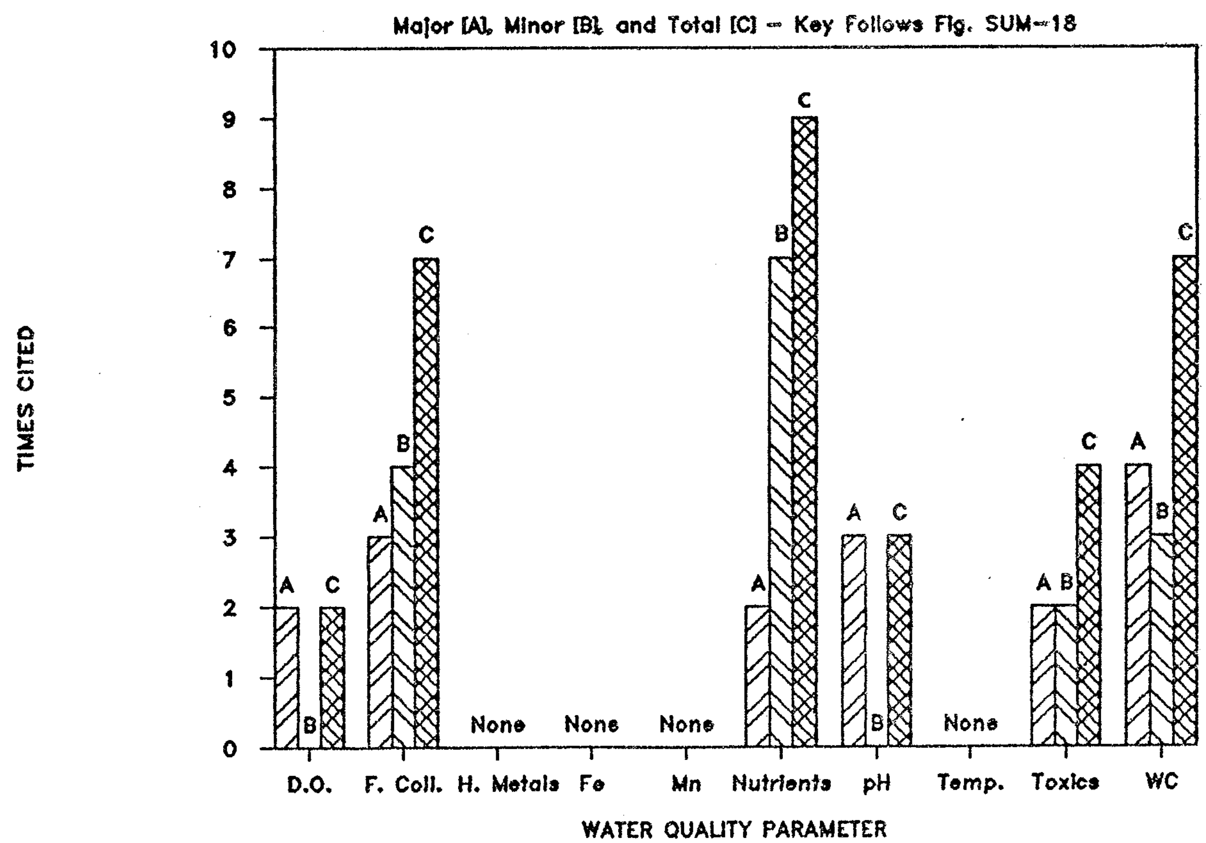


Fig. SUM-17: Concerns Relating to Industrial Discharges.

Major [A], Minor [B], and Total [C] – Key Follows Fig. SUM-18

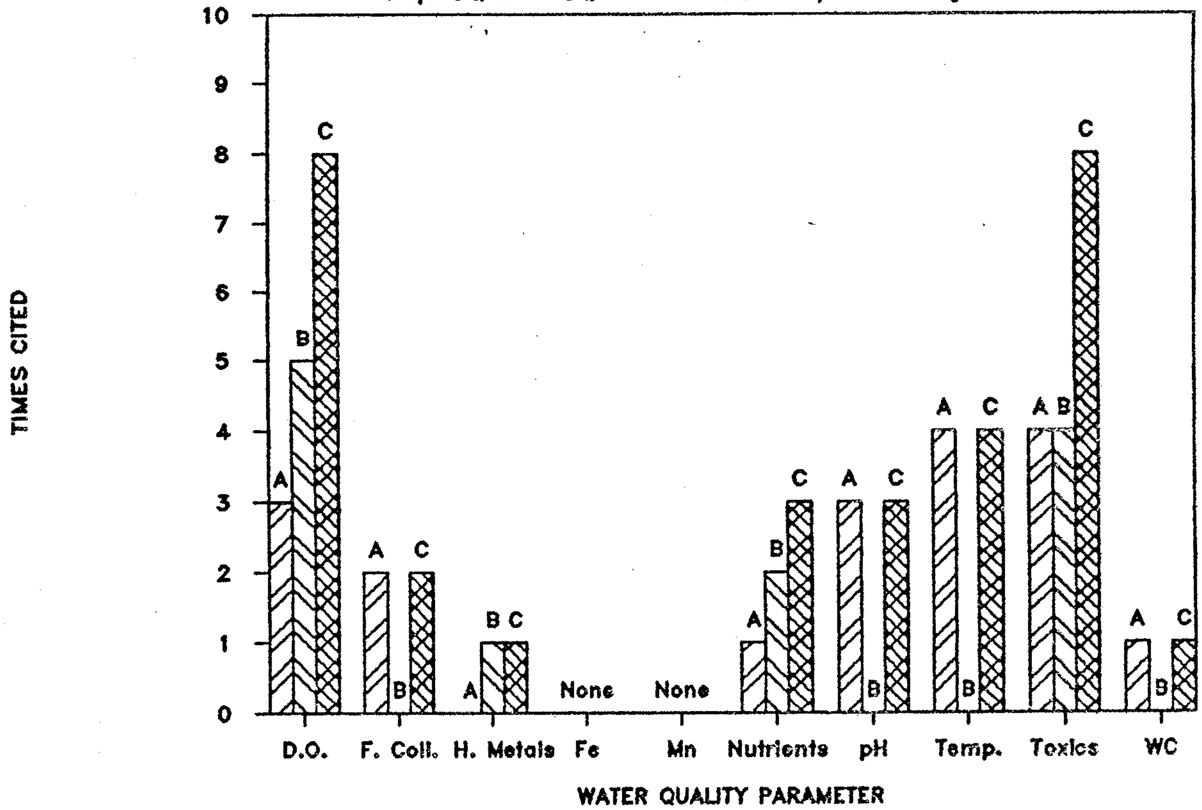
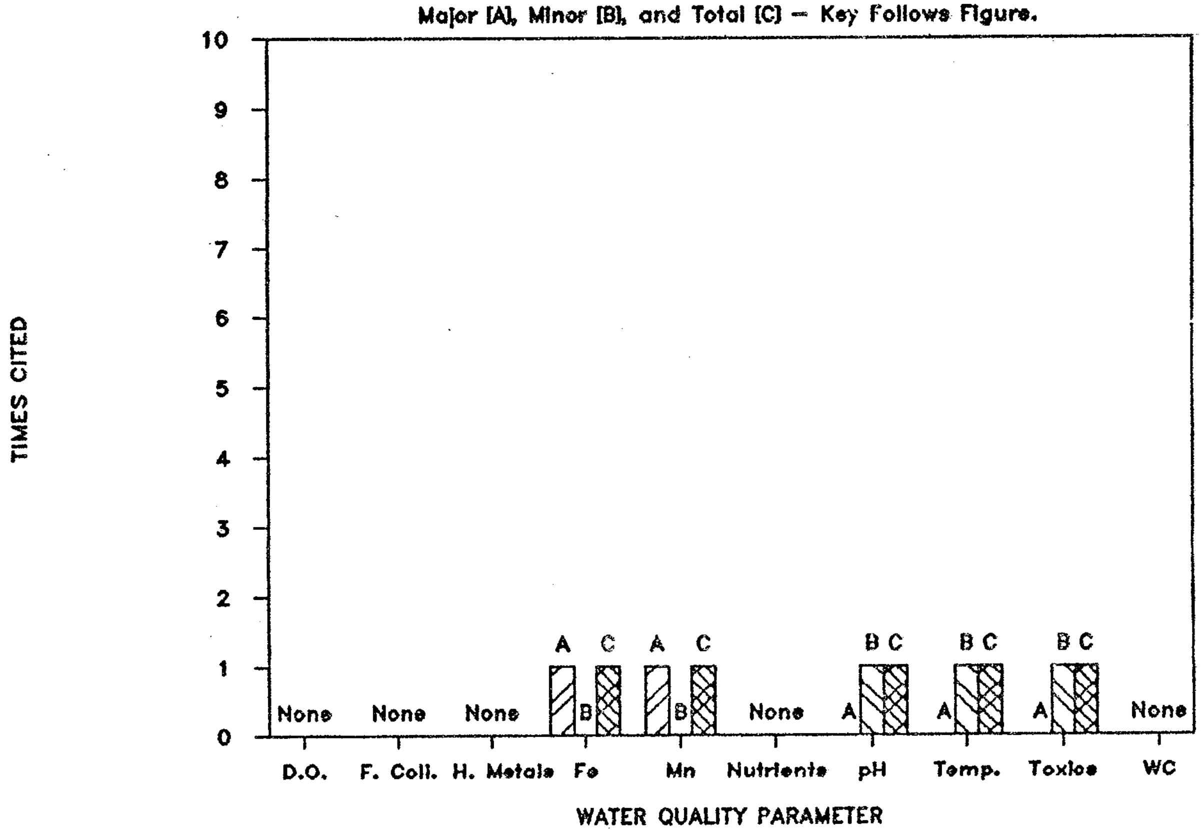


Fig. SUM-18: Concerns Relating to "Other" Causes.

Major [A], Minor [B], and Total [C] – Key Follows Figure.



Key To Tables SUM-15 Through SUM-18

D.O. = Dissolved oxygen.
F.Coli. = Fecal coliform.
H. Metals = Heavy metals.
Fe = Iron.
Mn = Manganese.
Temp. = Temperature.
WC = Water clarity.

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APPENDIX A

Derivation of Export Coefficients For Use In The Southeastern U.S.

Table 1: Regional Grouping of the Major Land Resource Areas in the Mideastern and Southeastern U.S.

Region Code	U.S.D.A. Category	Major Land Resource Area (MLRA) Description
A	116A	Ozark Highland
	117	Boston Mountains
	118	Arkansas Valley and Ridges
	119	Ouachita Mountains
B	120	KY & IN Sandstone and Shale Hills and Valleys
	121	Kentucky Bluegrass
	122	Highland Rim and Pennyroyal
	123	Nashville Basin
	125	Cumberland Plateau and Mountains
C	126	Central Allegheny Plateau
	127	Eastern Allegheny Plateau and Mountains
	128	Southern Appalachian Ridges and Valleys
	129	Sand Mountain
	147	Northern Appalachian Ridges and Valleys
	148	Northern Piedmont
D	131	Southern Mississippi Valley Alluvium
	134	Southern Mississippi Valley Silty Uplands
E	136	Southern Piedmont
	137	Carolina and Georgia Sand Hills
F	133A	Southern Coastal Plain
	135	AL, MS, and AR Blackland Prairie
	138	North-Central Florida Ridge
G	130	Blue Ridge

Table 2: Criteria Used to Categorize NES Subdrainage Areas According to Land Use Percentages.

Overall Land Use Category[2]	Land Use Code	Land Use Percentages[1]			
		Forest	Agriculture	Urban	Other
Forest	FOR	≥75	<25	<5	<10
Mixed	MIX	≥25	≥25	<10	<10
Agriculture	AGR	<25	≥75	<10	<10

1. The four land use percentage categories (i.e. "forest", "agriculture", "urban", and "other") are compilations of the land use parameters utilized by Omernick (1977). "Forest" is equivalent to forest plus wetlands, "agriculture" represents agriculture plus cleared unproductive land use, "urban" is equivalent to the urban land use percentage, and "other" is the sum of the other and rangeland percentages.

2. Any NES site which did not fit into one of the above categories were excluded from the analysis. Export coefficients for areas with significant urban influence were obtained from the literature (see text).

Table 3: Nutrient Export Coefficients Derived for Overall Land Use Categories Within Each Pre-defined "Major Land Resource Area" (MLRA) Region.

Regional Land Use Code (a)	Export Coefficients [kg/km²/yr] TP No. of Sites	TP Mean	TP S.D.	TN No. of Sites	TN Mean	TN S.D.
AFOR	24	5.8	3.0	24	170	74
AMIX	12	7.6	5.3	12	298	214
AAGR	0	nd	nd	0	nd	nd
BFOR	9	7.8	2.3	9	333	105
BMIX	11	14.1	7.9	13	472	140
BAGR	2	53.0[2]	62.1	2	616	169
CFOR	14	9.3	7.9	14	452	213
CMIX	28	21.9	13.7	28	670	273
CAGR	5	18.5	14.0	5	830	427
DFOR	6	6.0	2.8	6	331	141
DMIX	16	27.1	19.4	17	478	218
DAGR	1	48.7[2]	---	1	416	---
EFOR	10	12.2	4.1	10	239	106
EMIX	36	16.6	11.9	36	355	176
EAGR	0	nd	nd	0	nd	nd
FFOR	8	12.8	9.3	8	262	118
FMIX	7	22.4	13.9	8	680	1066
FAGR	0	nd	nd	0	nd	nd
GFOR	21	19.8	11.3	21	477	186
GMIX	2	29.7	10.4	2	518	206
GAGR	0	nd	nd	0	nd	nd

1. The regional land use codes consist of the three overall land use codes (i.e. FOR, MIX, and AGR), prefixed by a region code (A-G) to designate the group of MLRA's (see Table 1) which contains the sites used to derive each export coefficient.

2. Due to insufficient data, these values are presented for illustrative purposes only and were not used in the application of export coefficients to lake drainage basins.

APPENDIX B

Characteristics of the Study Lakes and Their Drainage Basins.

Table FL-A: Morphological Characteristics of the Florida Study Lakes.

	Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Lake Volume [10^6 m^3]	Hyd. Res. Time [days]
1	Crescent	Flagler, Putnam	7061	nd	2.0	141	116
2	Cypress	Osceola	1653	nd	1.7	28	13
3	Dead	Calhoun, Gulf	2711	nd	2.4	65	14
4	E. Tohopekaliga	Osceola	4836	nd	2.8	135	240
5	George	Putnam, Volusia	18932	nd	2.6	492	59
6	Griffin	Lake	4314	nd	2.2	95	55
7	Harney	Seminole, Volusia	2452	nd	nd	nd	nd
8	Hatchineha	Osceola	2686	nd	1.9	51	25
9	Kissimmee	Osceola	14067	nd	1.8	255	88
10	Monroe	Seminole, Volusia	3550	nd	1.8	64	12
11	Okeechobee	Glades, Hendry, Okeechobee, Martin, Palm Beach	176447	nd	3.0	5293	693
12	Pointsett	Brevard	1737	nd	0.8	14	4
13	Rousseau	Citrus, Marion, Levy	1686	nd	6.6	112	41
14	Rowell	Bradford	147	nd	1.6	2	30
15	Russell	Osceola	296	nd	nd	nd	nd
16	Talquin	Gadsden, Leon	2772	nd	5.3	147	27
17	Thonotosassa	Hillsborough	334	nd	3.1	10	77
18	Tohopekaliga	Osceola	7604	nd	2.4	183	164
19	Tsala Apopka	Citrus	5237	nd	0.2	11	37

nd: No data available.

Table FL-B: Land Uses Within the Florida Study Lake Basins. Values represent percentages of total drainage basin area.

Lake Name	Percent Land Use					Total Basin Area [km^2]
	Forest	Agric.	Urban	Wetland	Water	
Crescent	78	13	1	1	6	1401
Cypress	23	54	8	4	11	3010
Dead	70	27	2	<1	1	3124
E. Tohopekaliga	17	54	11	4	14	798
George	41	41	6	8	5	9638
Griffin	14	53	5	5	22	2007
Harney	30	54	3	10	3	5028
Hatchineha	23	54	8	4	11	3010
Kissimmee	22	55	6	4	13	4162
Monroe	33	48	5	9	5	6268
Okeechobee	15	58	3	6	18	14634
Pointsett	25	64	2	8	3	3295
Rousseau	44	45	4	5	3	5184
Rowell	77	11	11	0	1	51
Russell	31	49	9	3	7	1065
Talquin	71	18	4	2	4	4455
Thonotosassa	10	67	19	1	4	155
Tohopekaliga	23	50	14	3	11	1606
Tsala Apopka	57	24	5	10	4	414

Table FL-C: Municipal Wastewater Treatment Plants In The Florida Study Lake Basins.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat.	Pop.[2] Served
Crescent	Bunnell	AS	Ter	2500
	Crescent City	EA	Sec	500
Cypress	Kissimmee Martin St.	CS	Sec	17000
	Orlando McLeod Road	TF	Sec	62113[5]
	Orlando NTC Annex	TF	Sec	13500
	OCPU/Sand Lake Road	CS	Sec	150000
	Reedy Creek ID	AS	Sec	70000
	Saint Cloud	TF	Sec	10000
Dead	Cottondale	TFP	Ter	600
E. Tohopekaliga	Orlando NTC Annex	TF	Sec	13500
George	Altamonte Regional	AWT	Ter	22028[4]
	Deland Regional	AS	Sec	16000
	Lincoln Heights Subd.	AS	Sec	795
	Sanford	AS	Sec	18000
	Weathersfield Subd.	EAP	Ter	3206
Griffin	Leesburg	AS	Sec	11000
Harney	BCUD/Silver Pines	CS	Sec	900
	BCUD/West Coccoa	CS	Sec	1250
	OCPU/Univ. Highlands	EA	Sec	2310
	Orlando/Iron Bridge Rd.	RBC	Sec	49140[5]
	Orange Cnty, Orlando	nd	Sec[6]	3538[5]
	Park Manor Estates	EA	Sec	4900
Hatchineha	Kissimmee Martin St.	CS	Sec	17000
	OCPU/Sand Lake Road	CS	Sec	150000
	Orlando McLeod Road	TF	Sec	62113[5]
	Orlando NTC Annex	TF	Sec	13500
	Reedy Creek ID	AS	Sec	70000
	Saint Cloud	TF	Sec	10000
Kissimmee	Kissimmee Martin St.	CS	Sec	17000
	OCPU/Sand Lake Road	CS	Sec	150000
	Orlando McLeod Road	TF	Sec	62113[5]
	Orlando NTC Annex	TF	Sec	13500
	Reedy Creek ID	AS	Sec	70000
	Saint Cloud	TF	Sec	10000

Table FL-C, continued.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat.[2]	Pop. Served
Monroe	BCUD/Silver Pines	CS	Sec	900
	BCUD/West Coccoa	CS	Sec	1250
	OCPU/Univ. Highlands	EA	Sec	2310
	Orange Cnty, Orlando	nd	Sec[6]	3538[5]
	Orlando/Iron Bridge Rd.	BC	Sec	49140[5]
	Park Manor Estates	EA	Sec	4900
	Sanford	AS	Sec	18000
Okeechobee	Belle Glade	CS	Sec	20000
	Clewiston	CS	Sec	667[3]
	Okeech	nd	Sec[6]	4140
	Okeechobee	AS	Sec	1400
	Pahokee	nd	Sec[6]	10000
Pointsett	BCUD/West Coccoa	CS	Sec	1250
Rousseau	Dunnellon	TF+	Sec	1146
	Inverness	AS	Sec	4095[4]
Rowell	Starke	CS	Sec	6500
Russell	Reedy Creek ID	AS	Sec	70000
Talquin	Havana	TF	Sec	3000
	Quincy	CS	Sec	15000
Thonotosassa	Plant City	AS+	Ter	19270[4]
Tohopekaliga	Kissimmee Martin St.	CS	Sec	17000
	OCPU/Sand Lake Rd.	CS	Sec	150000
	Orlando McLeod Road	TF	Sec	62113[5]
	Orlando NTC Annex	TF	Sec	13500
	Saint Cloud	TF	Sec	10000
Tsala Apopka	Inverness	AS	Sec	4095[4]

(Footnotes are on Following Page)

Table FL-C, continued.

Footnotes:

nd: No data available.

1. Codes for Wastewater Treatment Type:

+:	Additional treatment of unspecified type.
AS:	Activated sludge.
AWT:	Advanced wastewater treatment.
BC:	Biological contactor.
CS:	Contact stabilization.
EA:	Extended aeration.
EAP:	Extended aeration with effluent to polishing pon4.
RBC:	Rotating biological contactor.
TF:	Trickling filter.
TFP:	Trickling filter with polishing pond.

2. Population served as listed in Florida DER (1985).

3. Estimated using the facility's "Design Flow" (Florida DER, 1985) and an assumed discharge rate of 150 gal/capita/day.

4. 1980 U.S. Census.

5. This value represents the population of the city served by the facility multiplied by the ratio of the facility's "Design Flow" to the sum of the "Design Flow" values of all municipal facilities serving the city.

6. No data, conventional secondary treatment was assumed.

Table GA-A: Morphological Characteristics of the Georgia Study Lakes.

Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Lake Volume [10^6 m^3]
Category A Lakes					
1 Harry Williams	Crisp	11	3.0	nd	nd
2 High Falls	Butts, Lamar, Monroe	243	7.3	3.7	9.0
3 Jackson	Butts, Jasper, Newton	1923	30.0	6.9	130.0
Category B Lakes					
4 Blackshear	Crisp, Dooly, Lee, Sumter, Worth	3446	14.0	5.3	180.0
5 Coffee SP Lower	Coffee	2	5.0	nd	nd
6 Seminole	Decatur, Seminole	15182	12.0	3.1	4600.0
7 Tobesofkee	Bibb	708	13.0	nd	nd
Category C Lakes					
8 Allatoona	Bartow, Cobb, Cherokee	4800	45.0	9.4	450.0
9 Bull Sluice	Fulton	235	6.5	nd	nd
10 Carters	Murray	1300	120.0	12.8	170.0
11 Chatuge	Towns	2894	37.0	10.6	310.0
12 Clarks Hill	Columbia, Elbert, Lincoln, McDuffie, Wilkes	28329	48.0	11.0	3100.0
13 G.W. Andrews	Early	623	9.3	3.6	22.0
14 Goat Rock	Harris	381	14.0	nd	nd
15 Harding	Harris	2367	33.8	9.4	220.0
16 Hartwell	Franklin, Hart, Stevens	22643	53.4	13.9	3100.0
17 Nottely	Union	1736	39.0	13.1	230.0
18 Oconee	Putnam	7692	32.0	5.7	440.0
19 Oliver	Muscogee	870	20.0	nd	nd
20 Sinclair	Baldwin, Hancock, Putnam	6217	28.0	6.6	410.0
21 Sidney Lanier	Dawson, Forsyth, Hall, Lumpkin	15394	55.0	19.5	3100.0
22 Stevens Creek	Columbia	174	2.1	nd	nd
23 Walter F. George	Clay, Quitman	18300	30.0	6.3	1150.0
24 West Point	Heard, Troup	10486	25.0	7.2	750.0

nd: No data available.

Table GA-B: Land Uses Within the Georgia Study Lake Basins.

Lake Name	Percent[1] Land Use	Regional[2] Land Use Category	Total[3] Basin Area [km^2]
Allatoona	--	EMIX	2900
Blackshear	--	FMIX	8780[4]
Bull Sluice	--	EMIX	3630[4]
Carters	--	GMIX	970[4]
Chatuge	--	GMIX	490
Clarks Hill	--	EMIX	15930
Coffee SP Lower	--	FMIX	490[5]
G.W. Andrews	--	FMIX	21260
Goat Rock	--	EMIX	11540[4]
Harding	--	EMIX	10980
Harry Williams	--	FMIX	175[5]
Hartwell	--	EMIX	5410
High Falls	--	EMIX	490[4]
Jackson[6]	--	EMIX	3630
Nottely	--	GMIX	550
Oconee	--	EMIX	4710
Oliver	--	EMIX	12100[4]
Seminole	--	FMIX	44290
Sinclair	--	EMIX	7510
Sidney Lanier	--	EMIX	2690
Stevens Creek	--	EMIX	18000[4]
Tobesofkee	--	EMIX	470[4]
Walter F. George	--	FMIX	19320[4]
West Point	--	EMIX	8910

1. No data were available in the Georgia Clean Lakes Program report (Georgia DNR, 1982).

2. Drainage basins were classified into the appropriate regional land use category using data available from Georgia DNR (1982) and USGS land use/land cover maps.

3. Unless otherwise noted, the total drainage area was obtained from the USGS Water Resources Data for Georgia: Water Year 1983 report.

4. Estimated using data obtained from the USGS Water Resources Data for Georgia: Water Year 1983 report for the gaging station located immediately downstream of the lake or reservoir of interest.

5. Estimated from 1:500,000 scale USGS state base map.

6. Listed as Lloyd Shoals Reservoir in the USGS Water Resources Data for Georgia: Water Year 1983.

Table GA-C: Municipal Wastewater Treatment Plants In Georgia Study Lake Basins.

Lake	Municipal Wastewater Treatment Plants	Treat.[1] Type	Level of Treat.	Pop. Served
Allatoona	Acworth	AS	Sec	3608
	Canton	AS	Sec	3601
	Cobb Cnty-Hunt. Woods	AS	Sec	247[2]
	Cobb Cnty-Noonday Cr.	RBC	Sec	53333[2]
	Dawsonville	WSP	Sec	400[2]
	Jasper-East Pond	WSP	Sec	1556
	Jasper-West Pond	WSP	Sec	"
	Woodstock	WSP	Sec	2699
Blackshear	Andersonville	AS	Sec	267[2]
	Byromville	WSP	Sec	733[2]
	Cordele	TF/AS	Ter	10914
	Oglethorpe	WSP	Sec	1305
	Marshallville	WSP/SF	Sec	1540
	Montezuma #1	AS	Sec	4830
	Montezuma #2	AS	Sec	"
	Vienna	WSP	Sec	2886
Bull Sluice	Buford-Southside	AS/MS	Sec	6697
	Buford-Westside	AS	Sec	"
	Cumming	AP/PP/SF	Ter	2094
	Flowery Branch	AS/SF	P	1333[2]
	Gainesville-Flat Cr.	CT/TF/AS	P	10586[3]
	Gainesville-Linwood	TF	Sec	4537[3]
	Gainesville-White Sulphur	AS/PP	Ter	151[3]
Carters	Ellijay	AS	Sec	1507
Chatuge	Hiawassee	AS	Sec	667[2]
Clarks Hill	Danielsville	AP/PP	Sec	800[2]
	Elberton-Falling Cr.	AS	Sec	5686
	Elberton-Fortson Cr.	AS	Sec	"
	Hartwell	TF	Sec	4855
	Lincolnton	AS/SF	Sec	1406
	Thomson	AS	Sec	7001
	Washington	AS	Sec	4662
Coffee SP	Douglas	AS	Sec	10980
G.W. Andrews	Fort Gaines	AS	Sec	1260

Table GA-C, continued.

Lake	Municipal WWTP Name	Treat.[1] Type	Level of Treat.	Pop. Served
Goat Rock	Hamilton	NT	Nil	567[2]
	Hogansville	AS	Sec	3362
	Hogansville Pond	WSP	Sec	"
	LaGrange Blue John Ind.	AS	Sec	24204
	LaGrange Blue John Mun.	TF	Sec	"
	LaGrange Hogansville Road	TF	Sec	"
	LaGrange Yellow Jacket Cr.	TF	Sec	"
	Pine Mountain	AS	Sec	984
	West Point	AS	Sec	4294
Harding	Hogansville	AS	Sec	3362
	Hogansville Pond	WSP	Sec	"
	LaGrange Blue John Ind.	AS	Sec	24204
	LaGrange Blue John Mun.	TF	Sec	"
	LaGrange Hogansville Road	TF	Sec	"
	LaGrange Yellow Jacket Cr.	TF	Sec	"
	Pine Mountain	AS	Sec	984
	West Point	AS	Sec	4294
Harry Williams	Cordele	TF/AS	Ter	10914
Hartwell	Clayton	AS	Sec	1838
	Hartwell	TF	Sec	4855
	Lavonia	TF	Sec	2024
	Toccoa-Eastanollee Cr.	AP/PP	Sec	9104
	Toccoa-Toccoa Cr.	AP/PP	Sec	"
High Falls	Griffin-Cabin Creek	TF	Sec	20728
	Locust Grove-West	WSP	Sec	754[3]
Jackson	Atlanta South River	AS/TF	Ter	120000[2]
	Conyers-Almond Branch	AS	Sec	8333[2]
	Conyers-Atl. Suburbia SD	AS/PP	Ter	1333[2]
	Conyers-Boar Tusk Cr.	AS	Sec	6667[2]
	Conyers-Honey Cr.	AS	Sec	3333[2]
	Conyers-Lakeridge Est. SD	AS/PP	Ter	600[2]
	Conyers-Scott Cr.	AS	Sec	2000[2]
	Conyers-Stanton Woods	AS	Sec	1000[2]
	Covington	TF/AS	Ter	10586
	Dekalb Cnty-Pole Bridge	AS	Sec	20000[2]
	Dekalb Cnty-Snapfinger Cr.	TF/AS	P	240000[2]
	Gwinnett Cnty-Beaver Ruin	AS/SF	P	24000[2]
	Gwinnett Cnty-Big Haynes	AS/SF	Sec	3333[2]
	Gwinnett Cnty-Castlewood	AS/PP	Ter	467[2]
	Gwinnett Cnty-Jackson Cr.	AS/SF	P	16000[2]
	Gwinnett Cnty-Lilburn Pond	WSP	Sec	347[2]

Table GA-C, continued.

Lake	Municipal WWTP Name	Treat.[1] Type	Level of Treat.	Pop. Served
Jackson (Cont.)	Gwinnett Cnty-Snellville	AS	P	6667[2]
	Gwinnett Cnty-Yellow R.	AS/SF	P	40000[2]
	Henry Cnty-Camp Cr.	AS/SF	Sec	3333[2]
	Henry Cnty-Hudson Bridge	AS/PP	Ter	2667[2]
	Henry Cnty-Panola Woods	AS/PP	Ter	833[2]
	Locust Grove-East	WSP	Sec	725[3]
	Loganville	RBC	Sec	1841
	McDonough	WSP	Sec	2778
	Monroe-Grubby Cr.	WSP	Sec	8854
	Monroe-Mill Cr.	WSP	Sec	"
	Monroe-Mountain Cr.	WSP	Sec	"
	Newton Cnty	AS	Sec	6667[2]
	Stockbridge	AS/SF	Sec	2103
Nottely	Blairsville	WSP	Sec	530
Oconee	Athens-Cedar Cr.	TF	Sec	130015[4]
	Athens-Doublegate	WSP	Sec	"
	Athens-Middle Oconee	TF	Sec	"
	Athens-North Oconee	TF	Sec	"
	Athens-Rivercliff SD	---	Sec[5]	"
	Athens-Weatherly Woods	WSP	Sec	"
	Greensboro-North	WSP	Sec	2985
	Greensboro-South	AS	Sec	"
	Jefferson	WSP	Sec	1820
	Madison-North	AS	Sec	2954
	Madison-South	AS	Sec	"
	Monroe-Jacks Cr.	WSP	Sec	2240[3]
	Statham	AS	Sec	1101
	Watkinsville	NT	Nil	1204
Oliver	Hamilton	NT	Nil	567[2]
	Pine Mountain	AS	Sec	984
	West Point	AS	Sec	4294
Seminole	Bainbridge	AS	Sec	10553
	Colquitt	AS	Sec	2065
	Camilla	AS	Sec	5414
	Decatur Cnty-Indian Air Pk	TF	Sec	3333[2]
	Donalsonville	AS	Sec	3320
Sidney Lanier	Clarksville	TF	Sec	1348
	Cleveland	AS	Sec	1578
	Cornelia	TF/AS	Ter	3203
	Dahlonega	AS	Sec	2844
	Demorest	AS	Sec	1130

Table GA-C, continued.

Lake	Municipal WWTP Name	Treat.[1] Type	Level of Treat.	Pop. Served
Sidney Lanier (Cont.)	Flowery Branch	AS/SF	P	1333[2]
	Gainesville-Flat Cr.	CT/TF/AS	P	10586[3]
	Gainesville-Linwood	TF	Sec	4537[3]
	Gainesville-White Sulphur	AS/PP	Ter	151[3]
	Helen	AS	Sec	265
	Lula	WSP	Sec	857
Sinclair	Eatonton WPCP #1 (East)	AS/PP	Ter	4833
	Eatonton WPCP #2 (West)	AS/PP	Ter	"
	Greensboro-North	WSP	Sec	2985
	Greensboro-South	AS	Sec	"
	Madison-North	AS	Sec	2954
	Madison-South	AS	Sec	"
	Monticello-Pearson Cr.	WSP	Sec	2382
	Monticello-White Oak Cr.	WSP	Sec	"
	Rutledge	WSP	Sec	694
Stevens Creek	Columbia Cnty-Crawford Cr.	AS	Sec	3333[2]
	Columbia Cnty-Reed Cr.	AS	Sec	11333[2]
	Harlem	AS	Sec	1485
	Lincolnton	AS/SF	Sec	1406
	Thomson	AS	Sec	7001
	Washington	AS	Sec	4662
Tobesofkee	Barnesville Gordon Road	AS	Sec	4887
	Forsyth-Northeast	AS	Sec	3303[3]
	Forsyth-South	AS/PP	Ter	1321[3]
W.F. George	Lumpkin	IT	Pri	1335
	Columbus-Battle Forest	AS	Sec	191840[4]
	Columbus-Heiferhorn Cr.	AS	Sec	"
	Columbus-South	AS	Sec	"
West Point	Franklin	AS	Sec	711
	Grantville Pond #1	WSP	Sec	1110
	Grantville Pond #2	WSP	Sec	"
	Grantville Pond #3	WSP	Sec	"
	Grantville Pond #4	WSP	Sec	"

Table GA-C, continued.

Lake	Municipal WWTP Name	Treat.[1] Type	Level of Treat.	Pop. Served
West Point (Cont.)	Hogansville	AS	Sec	3362
	Hogansville Pond	WSP	Sec	"
	LaGrange-Yellow Jacket Cr.	TF	Sec	3338[3]
	Newnan-Mineral Springs	AS	Sec	11449
	Newnan-Southside	AS	Sec	"
	Newnan-Snake Cr.	TF	Sec	"
	Newnan-Wahoo Cr.	AS	Sec	"

1. Codes for Wastewater Treatment Type:
   - AP: Aeration pond.
   - AS: Activated sludge.
   - NT: No treatment.
   - SF: Sand filter.
   - TF: Trickling filter.
   - PP: Polishing pond.
   - WSP: Waste stabilization ponds.
   - IT: Imhoff tank.
   - CT: Chemical Treatment
   - RBC: Rotating biological contactor.

2. Estimated using the facility's "Design Flow" (Georgia DNR, 1984b) and an assumed discharge rate of 150 gal/capita/day.

3. This value represents the population of the city served by the facility multiplied by the ratio of the facility's "Design Flow" to the sum of the "Design Flow" values of all facilities serving the city.

4. Population figure listed under the heading of "Standard Metropolitan Statistical Area" (SMSA) in the 1980 U.S. Census.

5. No data were available, therefore conventional secondary treatment was assumed.

Table KY-A: Morphological Characteristics of the Kentucky Study Lakes.

Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Lake Volume [10^6 m^3]
1 Barkley	Livingston, Lyon, Trigg	23440	22.7	4.6	1071.9
2 Barren River[1]	Allen, Barren	4047	24.4	7.8	316.2
3 Buckhorn	Leslie, Perry	498	20.0	7.9	39.6
4 Cave Run	Bath, Menifee, Rowan	3347	27.0	8.2	274.6
5 Corbin	Laurel	56	9.5	5.4	3.1
6 Cumberland	Clinton, McCreary, Pulaski, Russell, Wayne	20336	56.7	24.2	4927.8
7 Dale Hollow	Clinton, Cumberland	12100	49.0	14.9	1668.9
8 Grayson	Carter, Elliott	612	18.0	5.8	35.8
9 Green River	Adair, Taylor	3322	26.0	9.1	301.1
10 Herrington[1]	Boyle, Garrard, Mercer	1190	76.0	23.9	284.3
11 Kentucky	Calloway, Livingston, Lyon, Marshall, Trigg	64872	26.9	5.4	3501.9
12 Laurel River	Laurel, Whitley	2452	76.0	21.9	537.3
13 McNeely	Jefferson	21	9.1	3.0	0.5
14 Nolin	Edmonson, Grayson, Hart	2343	30.5	5.9	139.0
15 Rough River	Breckinridge, Grayson	2064	22.0	7.2	148.0

1. This lake was included in the Kentucky Clean Lakes Program report (Kentucky NREPC, 1984a), but was not listed in Appendix B of the report as having a major point source discharge facility.

Table KY-B: Land Uses Within the Kentucky Study Lake Basins.

Lake	Percent Land Use				Regional Land Use Category	Total Basin Area [km²]
	Forest[1]	Agric.	Urban	Other[2]		
Barkley	44	34	6	16	BMIX	45579
Barren River	40	42	3	15	BMIX	2440
Buckhorn	88	12	1	1	BFOR	1057
Cave Run	73	22	1	4	BMIX	2139
Corbin	65	35	0	1	BMIX	409
Cumberland	56	21	3	20	BMIX	14792
Dale Hollow	60	29	4	7	BMIX	2316
Grayson	62	36	1	0	BMIX	508
Green River	94	1	1	4	BFOR	1766
Herrington	26	71	3	0	BMIX	1137
Kentucky	83	17	0	0	FMIX	104120
Laurel River	71	26	2	1	BMIX	730
McNeely	16	37	31	16	BURB	13
Nolin	39	56	5	0	BMIX	1821
Rough River	40	60	1	0	BMIX	1176

1. The "forest" land use percentage is considered to be equivalent to the "silviculture" classification in the Kentucky Clean Lakes Program report (Kentucky NREPC, 1984a).

2. The "other" land use percentage represents the sum of the "other" and "mining-related" percentages in the Kentucky Clean Lakes Program report (Kentucky NREPC, 1984a).

Table KY-C: Municipal Wastewater Treatment Plants In Kentucky Study Lake Basins.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat.	Pop. Served
Barkley	Adairville		Sec	1105
	Cadiz		Sec	1661
	Eddyville		Sec	1949
	Elkton		Sec	1815
	Guthrie		Sec	1361
	Hopkinsville-STP		Sec	9618[2]
	Hopkinsville-S&WW Co.	LAG	Ter	17700[2]
	Kuttawa		Sec	560
	Pembroke		Sec	636
	Princeton		Sec	7073
	Smith Subdivision		Sec	13[2]
	Trenton		Sec	465
Barren River	Glasgow #1		Sec[3]	12958
	Glasgow #2	TF	Sec	"
	Tompkinsville		Sec	4366
	Tomp.-Mulkey Est. Subd.		Sec	"
Buckhorn	Hyden		Sec	488
Cave Run	Frenchburg		Sec	550
	Salyersville		Sec	1352
	West Liberty		Sec	1381
Corbin City	London		Sec	4002
Cumberland	Barbourville		Sec	3333
	Benham		Sec	936
	Corbin	TF/AS	Sec	8075
	Cumberland		Sec	3712
	Evarts		Sec[3]	1234
	Harlan		Sec	3024
	Jellico		P	nd
	Livingston		Sec	334
	Loyall		Sec	1210
	Lynch		Sec	1614
	McKee		Ter	255
	Middlesboro		Sec	12215
	Monticello		Sec	5677
	Mt. Vernon		Sec	2334
	Pineville		Sec	2599
	Russell Cnty-Jamestown		Ter	1441
	Somerset		Ter	10649
	Williamsburg		Sec	5560

Table KY-C, continued.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat.	Pop. Served
Dale Hollow	Albany		Pri	2083
Grayson	Sandy Hook		Ter	627
Green River	Liberty		Sec	2206
Herrington	Brodhead		Sec[3]	686
	Crab Orchard		Sec[3]	843
	Danville #2		Sec[3]	12942
	Stanford		Sec[3]	2764
	Lancaster		Sec[3]	3365
Kentucky	Marshall City S/D #1		Ter	1067[2]
Laurel River	Corbin		Sec	8075
	London		Sec	4002
	Northland Estates Subd.		Ter	333[2]
McNeely	Apple Valley Subd.		Ter	1333[2]
	Cogan Cnty-Maple Gr.#5		Ter	93[2]
	GHK Sewage Co.		Ter	1333[2]
	Pleasant Valley Subd.		Ter	1500[2]
Nolin	Elizabeth		Sec	15380
	Hodgenville		Sec	2531
Rough River	Hardinsburg		Sec[3]	2211

nd: No data available.

1. Codes for Wastewater Treatment Type:
   - AS: Activated sludge.
   - LAG: Wastewater lagoon.
   - TF: Trickling filter.

2. The population served by this facility was estimated using the municipal wastewater treatment plant's "Design Flow", obtained through communications with the Kentucky DNR, and an assumed discharge rate of 150 gal/cap/day.

3. No data available; therefore conventional secondary treatment was assumed.

Table MS-A. Morphological Characteristics of the Mississippi Study Lakes.

	Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Lake Volume [10^6 m^3
1	Arkabutla	DeSoto, Tate	4804	---	9.1	437.0
2	Bogue Homa	Jones	486	---	1.2	5.8
3	Enid	Panola, Yalobusha	5249	---	15.5	814.0
4	Ferguson	Washington	582	---	nd	nd
5	Grenada	Grenada, Yalobusha	9838	---	16.5	1623.0
6	Mary	Wilkinson	911	---	nd	nd
7	Pickwick	Tishomingo	18940	---	6.0	1136.0
8	Ross Barnett	Madison, Rankin	135171	---	3.7	5001.0
9	Sardis	Lafayette, Panola	12546	---	16.5	2055.0
10	Tchula	Holmes	188	---	3.0	5.6

Table MS-B: Land Uses Within the Mississippi Study Lake Basins.

Lake Name	Percent Land Use				Regional Land Use Category	Total[1] Basin Area [km^2]
	Forest	Agric.	Urban	Other		
Arkabutla	36	57	4	4	DMIX	2590
Bogue Homa	70	20	5	5	FMIX	303
Enid	67	26	3	4	FMIX	1450
Ferguson	60	10	20	10	DURB	39
Grenada	61	32	3	4	FMIX	3419
Mary	83	12	2	2	DFOR	41
Pickwick	71	20	6	4	FMIX	85003
Ross Barnett	65	29	4	2	FMIX	7690
Sardis	65	27	4	4	FMIX	4002
Tchula	27	71	2	<1	DMIX	366

1. Obtained through personal communication with the Mississippi DNR (April, 1985).

Table MS-C: Municipal Wastewater Treatment Plants In Mississippi Study Lake Basins.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat	Pop. Served
Arkabutla	Back Acres Subdivision	nd	Sec	467[2]
	Castle Park Subd.[3]	nd	Sec	927[2]
	Coldwater North	CL	Sec	1505
	Coldwater South	CL	Sec	"
	Hernado North	CL	Sec	2969
	Hernado South	AL	Sec	"
	Magnolia Hills Subd.	nd	Sec	100[2]
	Royal Heights Subd.	nd	Sec	200[2]
	Senatobia	AS	Sec	5013
Bogue Homa	Heidelberg	HCR	Sec	1098
	Sandersville	AL	Sec	800
Enid	Brittany Woods Subd.	nd	Sec	273[2]
	Busby Subd.	nd	Sec	267[2]
	Chickasaw Hill Subd.	nd	Sec	47[2]
	Oxford	AS	Sec	9882
	Univ. of Mississippi	AS	Sec	15467[2]
	Water Valley	AL	Sec	4147
Ferguson	Greenville	AS	Sec	40613
Grenada	Bruce East	CL	Sec	2208
	Bruce West	CL	Sec	"
	Calhoun City	CL	Sec	2033
	Calhoun City West	CL	Sec	"
	Coffeeville	AS	Sec	1129
	Vardaman	CL	Sec	1009
Mary	Bude	CL	Sec	1092
	Crosby	AL	Sec	349
	Meadville	CL	Sec	575
	Roxie	3C	Sec	591
Pickwick	Iuka	CL	Sec	2846
Ross Barnett	Ackerman	CL	Sec	1567
	Carthage	CL	Sec	3453
	Ethel	CL	Sec	486
	Forest North	AS	Sec	5229
	Forest South	nd	Sec[4]	"
	Kosciusko South	AS	Sec	7415
	Kosciusko Southeast(2)	CL	Sec	"
	Kosciusko Northeast	CL	Sec	"

Table MS-C, continued.

Lake Name	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level of Treat	Pop. Served
Ross Barnett (Cont.)	Lake	CL	Sec	524
	Louisville South	CL	Sec	7323
	Louisville Southeast	CL	Sec	"
	Noxapater North	CL	Sec	516
	Noxapater South	CL	Sec	"
	Pelahatchie East	CL	Sec	1445
	Pelahatchie West	CL	Sec	"
	Philadelphia North	CL	Sec	6434
	Philadelphia South	CL	Sec	"
	Sebastopol	nd	Sec[4]	268
	Walnut Grove	CL	Sec	439
	Weir	3C	Sec	553
Sardis	College Hills Subd.	nd	Sec	253[2]
	Myrtle	CL	Sec	402
	New Albany	AL	Sec	7072
	Western Hills Subd.	nd	Sec	160[2]
Tchula	Tchula	AL	Sec	1931

nd: No data available.

1. Codes for Wastewater Treatment Type:
   AL: Aerated Lagoon.
   AS: Activated Sludge.
   CL: Conventional Lagoon.
   HCR: Hydrograph Controlled Release.
   3C: 3-Cell conventional lagoon.

2. Estimated using the "Permitted Average Flow" obtained in Mississippi (1984c), and an assumed discharge rate of 150 gal/capita/day.

3. Renamed as Country Haven Subdivision.

4. No information was available in Mississippi DNR (1984c), therefore, conventional secondary treatment was assumed.

Table SC-A: Morphological Characteristics of the South Carolina Study Lakes.

	Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Volume million [10^6 m^3]
1	Boyd Mill Pond	Laurens	74	9.5	3.7	2.7
2	Broadway	Anderson	121	6.7	1.8	2.2
3	Edgar A. Brown	Barnwell	54	3.0	1.0	0.5
4	Clarks Hill	McCormick; GA	31769	43.0	11.3	3577.1
5	Cunningham	Greenville				
6	Fishing Cr.	Chester, Lancaster	1364	27.3	7.2	98.7
7	Greenwood	Greenwood, Laurens, Newberry	4614	21.0	7.0	320.7
8	Hartwell	Anderson, Oconee, Pickens; GA	24828	53.4	13.9	3503.1
9	Marion	Berkeley, Calhoun, Clarendon, Orangebury, Sumter	44759	23.4	3.9	1726.9
10	Moultrie	Berkeley	24444	23.0	6.1	1493.8
11	Murray	Lexington, Newberry, Richland, Saluda	20639	57.8	12.6	2607.6
12	Parr	Fairfield, Newberry	749	7.6	4.6	34.7
13	Prestwood	Darlington	121	4.3	1.8	2.2
14	Reynolds	Aiken	51	1.5	1.5	0.8
15	Robinson	Chesterfield, Darlington	911	9.4	4.2	38.2
16	Rock & Cedar Cr.	Chester, Faifield, Lancaster	324	10.7	8.8	28.4
17	Saluda	Greenville, Pickens	202	12.2	2.4	4.9
18	Secession	Abbeville, Anderson	356	55.0	6.7	23.9
19	Warren	Hampton	243	2.1	1.8	4.4
20	Wateree	Fairfield, Kershaw, Lancaster	5548	19.5	6.9	382.4
21	Wylie	York; NC	5041	28.4	6.9	347.7

Table SC-B: Land Uses Within the South Carolina Study Lakes' Basins (Upstream impoundments are in brackets).

Lake Name	Percent Land Use[1] Forest[2]	Agric.[3]	Urban[4]	Other	Regional[5] Land Use Category	Total Basin Area [km²]
Boyd Mill Pond	44	27	29	<1	EURB	630
Broadway	42	40	18	<1	EURB	75
Edgar A. Brown	63	36	<1	<1	FMIX	60
Clarks Hill [Hartwell, Secession]	57	29	6	8	EMIX	15900*
Cunningham	65	30	3	2	EMIX	120
Fishing Cr. [Wylie]	51	23	25	1	EMIX	9870[6]
Greenwood [Boyd Mill Pond]	48	32	15	5	EURB	3030*
Hartwell	47	31	14	8	EMIX	5410*
Marion	60	25	11	4	FMIX	38100*
Moultrie [Marion]	23	5	2	70	FMIX	38850[6]
Murray [Greenwood]	52	35	8	5	EMIX	6270*
Parr	60	25	14	1	EURB	7770
Prestwood [Robinson]	40	30	25	5	EURB	500+
Reynolds	34	62	4	0	EMIX	140
Robinson	55	43	<1	<2	EMIX	450
Rock & Cedar Cr. [Fishing Cr.]	56	20	23	1	EMIX	10710+
Saluda	80	15	4	1	EFOR	750
Secession [Broadway]	40	42	13	5	EURB	500[6]

Table SC-B, continued.

Lake Name	Percent Land Use[1] Forest[2]	Agric.[3]	Urban[4]	Other	Regional[5] Land Use Category	Total Basin Area [km^2
Warren	37	57	3	3	FMIX	180
Wateree [Rock & Cedar Cr.]	60	18	19	3	FMIX	13100*
Wylie	39	22	31	8	EMIX	7820

1. These values represent the land use (by percent of total) for the immediate watershed, as listed in Table 5.3 in the South Carolina Clean Lakes Program report (South Carolina DH&EC, 1984a).

2. The "Forest" land use percentage represents the sum of the values given under the "forest" and "wetlands" headings in Table 5.3 in the South Carolina Clean Lakes report (South Carolina DH&EC, 1984a).

3. The "Urban" land use percentage is considered to be equivalent to the "built-up" classification in Table 5.3 of the South Carolina Clean Lakes Program report (South Carolina DH&EC, 1984a).

4. The "Other" land use percentage figure represents the sum of the values given under the "water" and "other" headings in Table 5.3 of the South Carolina Clean Lakes Program report (South Carolina DH&EC, 1984a).

5. For those lakes which have no upstream impoundments listed, the associated drainage basin was placed into the appropriate land use category according to the given land use distribution. The watersheds of lakes with upstream impoundments were categorized as mixed unless the entire basin, characterized as the weighted sum of the sub-basin land use distributions, was predominantly agricultural or forested.

6. Total drainage area obtained from a compendium of lake and reservoir data collected by the EPA-NES in the eastern, north-central, and southeastern United States (U.S. EPA-NES Working Paper #475).

* Total drainage area was obtained from the USGS Water Resources Data for South Carolina: Water Year 1982 report.

\+ The total drainage area value represents the sum of the lake's immediate drainage basin area and the drainage area of the lake located just upstream.

Table SC-C: Municipal Wastewater Treatment Plants in the South Carolina Study Lake Basins.

Lake	Municipal Wastewater Treatment Plants	Estimated Population Served
Boyd Mill Pond	WCRSA/Idlewild Trust Subd.	350[1]
	/Lower Reedy Creek	25000[1]
	/Lynndale Subd.	200[1]
	/Mauldin Road	135000[1]
	/Pinebrook Forest	280[1]
Broadway	Belton/Breazale	1169[2]
Brown, E. A.	Barnwell City	5572
Clarks Hill	Abbeville	5863
	Anderson	27313
	Belton/Breazeale	3273[2]
	/Marshall	"
	Calhoun Falls	2491
	Central	1914
	Due West	1366
	Easley/(four in Hartwell)	6166[2]
	Honea Path/Corner Lagoon	2611[2]
	Iva	1369
	Liberty	3167
	Oconee Cnty Sewer Comm.	25000
	Pickens/Town Cr.	2381[2]
Cunningham	Duncan	1259
	Greer/South Tyger R.	5741[2]
Fishing Cr.	Clover	3451
	Fort Mill	4162
	Lancaster	9603
	Rock Hill/Manchester Cr.	29453[2]
Greenwood	Belton/Ducworth	2039[2]
	Easley/Brushy Cr.	8098[2]
	/Burdine Spring	"
	/Georges Cr.	"
	/Glenwood	"
	Honea Path/Clatworthy	458[2]
	/Still Branch	"
	Pelzer	2100

Table SC-C, continued.

Lake	Municipal Wastewater Treatment Plants	Estimated Population Served
	WCRSA/Avice Dale	175[1]
	/Fountain Inn A	3440[1]
	/Grove Cr.	10000[1]
	/Holmesview	30[1]
	/Parker	1000[1]
	/Piedmont	6000[1]
	/Piedmont Industrial	50[1]
	/Saluda River	2500[1]
	/(five in Boyd Mill Pond)	160830[1]
	West Pelzer	944
	Williamston	4310
Hartwell	Central	1914
	Easley/Arial Mill Village	6166[2]
	/Eighteen Mile Cr.	"
	/Golden Cr. Lagoon	"
	/Golden Cr. Overland	"
	Liberty	3167
	Oconee Cnty Sewer Comm.	25000[1]
	Pickens/Town Cr.	3199[2]
Marion	Camden	7462
	Cayce City	11701
	Columbia/Broad River	1800[1]
	/Challedon Oxid. Lag.	1170[1]
	/Challedon West Lag.	655[1]
	/Coatsworth	610[1]
	/Coldstream	2000[1]
	/Friarsgate	1550[1]
	/Gardendale	1150[1]
	/Hallmark	220[1]
	/Metro Plant	200000[1]
	/Pineglen	285[1]
	/Quail Valley Subd.	1050[1]
	/Whitehall 1	4000[1]
	/Whitehall 2	1845[1]
	/Whitehall 3	550[1]
	East Richland Cnty PSD	10000[1]
	Lexington	2131
	Ridgeway	600[1]
	Springdale/Springdale Subd.	50[1]
	St. Matthews	2496
	Winnsboro/Jackson Cr.	2919

Table SC-C, continued.

Lake	Municipal Wastewater Treatment Plants	Estimated Population Served
Moultrie	BCW&SA/Land-O'-Pines Subd.	150[1]
	Camden	7462
	Cayce City	11701
	Columbia/(14 in Marion)	216885[1]
	East Richland Cnty PSD	10000[1]
	Lexington	2131
	Ridgeway	600[1]
	Springdale/Springdale Subd.	50[1]
	St. Matthews	2496
	Winnsboro/Jackson Cr.	2919
Murray	Belton/Ducworth	2039[2]
	Easley/(four in Greenwood)	8098[2]
	Greenwood/Wilson Cr.	14313[2]
	Honea Path/(two in Greenwood)	458[2]
	Laurens Town	10587
	Newberry	9218
	Newberry Cnty W&SA/Plant 1	1700[1]
	Newberry Cnty W&SA/Plant 2	75[1]
	Ninety-Six	2249
	Pelzer	2100
	Prosperity	672
	Ridge Spring/N	204[2]
	Saluda	2752
	WCRSA/(13 in Greenwood)	184025[1]
	West Pelzer	944
	Williamston	4310
Parr Reservoir	Blacksburg	1873
	Carlisle	503
	Chesnee	1069
	Chester/Sandy R.	4161[2]
	Cowpens	2023
	Duncan	1259
	Gaffney	13453
	Greer/Maple Cr.	10525
	/South Tyger R.	"
	Inman Mills Water District	1811
	Inman Town	1554
	Jonesville	1188

Table SC-C, continued.

Lake	Municipal Wastewater Treatment Plants	Estimated Population Served
Parr Reservoir (Cont.)	Landrum/Page Cr.	535[2]
	Lyman	50000[1]
	Pacolet Mills	686
	Prosperity/East	286[2]
	Riverdale Mills	450[1]
	SSSD/Bondale Subd.	265[1]
	/Cinder Branch	nd[1]
	/Compark	125[1]
	/Hickory Hill	193[1]
	/Hillbrook Forest	770[1]
	/Lawson Fork	30000[1]
	/Oak For. 1	500[1]
	/Oak For. 2	625[1]
	/Old Furnace	300[1]
	/Roebuck MS	110[1]
	/Salem Est.	500[1]
	/Shoresbrook	1000[1]
	/Southern Pines	350[1]
	/Springfield	4500[1]
	/Standing Stone	75[1]
	/Twin Lakes	110[1]
	Union/Meng Cr.	1432[2]
	WCRSA/Coachman Estates	125[1]
	/Evergreen	160[1]
	/Fountain B	2000[1]
	/Fountain C	2550[1]
	/Fountain D	2055[1]
	/Howard Court	47[1]
	/Mauldin A	6500[1]
	/River Downs	300[1]
	/Rocky Cr.	3750[1]
	/Simpsonville B	870[1]
	/Simpsonville C	1300[1]
	/Taylors	37500[1]
	/Travelers Rest-East	3000[1]
	/Wade Hampton	20000[1]
	Wellford	100[1]
	Whitmire	2038
	Woodruff	5171

Table SC-C, continued.

Lake	Municipal Wastewater Treatment Plants	Estimated Population Served
Prestwood	Pageland/SE Oxid. Pond	1813[2]
Reynolds	Aiken/Airport Industrial Park	2500[1]
	ECW&SA/Trenton City Lag.	365[1]
Robinson	Pageland/SE Oxid. Pond	1813[2]
Rock&Cedar	Chester/Rocky Cr.	2659[2]
	Clover	3451
	Fort Mill	4162
	Great Falls	2601
	Lancaster	9603
	Rock Hill	35344
Saluda	WCRSA/Slater & Marietta	2500
Secession	Anderson/Rocky R.	13657[2]
	Belton/Breazale	3273[2]
	/Marshall	"
Warren	Estill Town	2308
Wateree	Chester/Rocky Cr.	2659[2]
	Clover	3451
	Fort Mill	4162
	Great Falls	2601
	Lancaster	9603
	Rock Hill	35344
Wylie	Clover	3451

1. Estimated using the facility's "WLAFLO" obtained from the South Carolina DHEC (1984c), and an assumed discharge rate of 150 gal/cap/day.

2. This value represents the population of the city served by the facility multiplied by the ratio of the facility's "WLAFLO" to the sum of the "WLAFLO" values of all municipal facilities serving the city.

Table TN-A: Morphological Characteristics of the Tennessee Study Lakes.

	Lake Name	County	Surface[1] Area [ha]	Max.[1] Depth [m]	Mean[2] Depth [m]	Lake Volume [10^6 m^3]
1	Barkley	Montgomery, Stewart	37799	21.0	6.8	2568.0
2	Boone	Carter, Sullivan, Washington	1781	39.7	13.4	239.0
3	Burgess Falls	Putnam	28	1.9	1.0[1]	0.3[1]
4	Center Hill	DeKalb, Putnam, White	9332	54.8	27.7	2581.0
5	Cheatham	Cheatham, Davidson	3015	13.0	4.2	128.0
6	Cherokee	Grainger, Hawkins, Hamblein, Jefferson	12262	49.7	15.5	1904.0
7	Chickamauga	Hamilton, McMinn, Meigs, Rhea	14326	20.0	6.4	912.0
8	Cordell Hull	Jackson, Smith	5628	25.9	6.8	383.0
9	Dale Hollow	Clay, Pickett	12542	36.0	16.8	2104.0
10	Douglas	Cocke, Jefferson, Sevier	12303	38.7	14.8	1820.0
11	Ft. Patrick Henry	Sullivan	353	27.4	9.3	33.0
12	Ft. Loudon	Blount, Loudon, Knox	5909	25.3	17.5	1037.0
13	Great Falls	VanBuren, White, Warren	854	21.9	7.4	63.0
14	J. Percy Priest	Davidson, Rutherford, Wilson	9187	30.5	8.8	804.0
15	Kentucky	Benton, Henry, Houston, Humphreys, Stewart	64873	26.9	11.7	7561.0
16	Melton Hill	Anderson, Knox, Loudon, Roane	2303	21.0	6.7	155.0
17	Nickajack	Marion	4197	39.3	7.4	311.0
18	Nolichucky[3]	Greene	155	19.0	2.0	3.2
19	Normandy	Bedford	1279	26.8	12.3	157.0
20	Norris	Campbell	13841	61.6	22.7	3148.0
21	Ocoee #1	Polk	765	32.8	14.0[1]	107.0[1]
22	Ocoee #2	Polk	nd	nd	nd	nd
23	Ocoee #3	Polk	194	32.6	2.0	4.1
24	Old Hickory	Davidson, Sumner, Wilson	11109	17.6	6.0	672.0
25	Tims Ford	Franklin, Moore	4290	43.6	17.5	750.0
26	Watauga	Carter, Johnson	2602	83.5	32.1	835.0
27	Watts Bar	Loudon, Meigs, Rhea, Roane	15783	32.0	9.2	1450.0

(See footnotes on following page).

TN-A, continued.

Footnotes:

nd: No data available.

1. All surface area and maximum depth values for the study lakes were obtained from the the appendix of the Tennessee Clean Lakes Report (Tennessee DH&E, 1980), as were the mean depths and lake volumes footnoted by an '1'.

2. Unless otherwise noted, these data were calculated from data in the USGS Water Resources Data for Tennessee: Water Year 1983. Lake volumes represent the total reservoir capacity.

3. Nolichucky Reservoir is listed in the USGS Water Resources Data for Tennessee: Water Year 1983 as Davy Crockett Reservoir.

Table TN-B: Land Uses Within the Tennessee Study Lake Basins.

Lake Name	Percent Land Use: Forest	Agric.	Urban[1]	Other[2]	Regional Land Use Category	Total Basin Area [km²]
Barkley	89[3]	10	1	--	BMIX	45579
Boone	15	84	1	--	CMIX	4766
Burgess Falls	40	60	--	--	BMIX	39
Center Hill	40	54	5	1	BAGR	5685
Cheatham	50	45	5	--	BMIX	36674
Cordell Hull	44	55	1	--	BMIX	20966
Cherokee	29	60	10	1	CMIX	8881
Chickamauga	30	28	40	1	CURB	53846
Dale Hollow	55	40	5	--	BMIX	2422
Douglas	35	60	5	--	CMIX	11761
Ft. Pat Henry	9	85	5	1	CMIX	4929
Fort Loudon	5	15	75	5	CURB	24735
Great Falls	9	90	--	1	BAGR	4343
J. Percy Priest	35	35	25	5	BURB	3210
Kentucky	68[3]	30	2	--	FMIX	104118
Melton	54	45	1	--	CMIX	8658
Nickajack	55	40	4	1	CURB	56643
Nolichucky	4	95	--	1	CAGR	3064
Normandy	50	50	--	--	BMIX	505
Norris	56	39	2	2	CMIX	7542
Ocoee #1	70	20	--	10[4]	GMIX	1540
Ocoee #2	99	--	--	1	GMIX	1326
Ocoee #3	75	15	--	10[4]	GMIX	1274
Old Hickory	45	35	15	5	BMIX	30236
Tims Ford	55	45	--	--	BMIX	1370
Watauga	50	40	10	--	GURB	1212
Watts Bar	52	45	3	--	CURB	44833

1. The "urban" land use category is equivalent to the urban and built-up classification given in the appendix of the Tennessee Clean Lakes Report (Tennessee DH&E, 1980).

2. The "other" land use category represents the sum of the open space and mining land use percentages given in the appendix of the Tennessee Clean Lakes Report (Tennessee DH&E, 1980).

3. Includes a significant percentage of wetland (≥5% of total).

4. Includes a significant percentage of land use devoted to mining activity (≥5% of total).

Table TN-C: Municipal Wastewater Treatment Plants In Tennessee Study Lake Basins.

Lake Name	Municipal Wastewater Treatment Plants	Treat.[1] Type	Level of Treat.	Pop. Served
Barkley	Clarksville	OAS	Sec	54777
	Cumberland City	LAG	Sec	567[2]
	Dover	CS	Sec	1197
	Erin	CS	Sec	1614
Boone	Bluff City	PRI	Pri	1121
	Bristol Regional	CAS	Sec	53537[3]
	Elizabethton	CAS	Sec	12431
	Johnson City-Brush Cr.	CAS	Sec	78473[3]
	Johnson City-Knob Cr.	CAS	Sec	"
	Johnson City-Regional	CAS	Sec	"
Burgess Falls	Cookeville	TF	Sec	20350
Center Hill	Cookeville	TF	Sec	20350
	McMinnville	CAS	Sec	10683
	Monterey	TF	Sec	2610
	Smithville	CAS	Sec	3839
	Sparta	TF	Sec	4864
	West Warren UD	TF	Sec	5000[2]
Cheatham	Ashland City	CS	Sec	2329
	Dickson	CAS	Sec	7040
	Franklin	EA	Sec	12407
	La Vergne	CS	Sec	5495
	Nashville-Central	CAS	Sec	850505[4]
	Nashville-Dry Cr.	CAS	Sec	"
	Nashville-Hurricane Cr.	CAS	Sec	"
	Nashville-Lincoya Bay	CS	Sec	"
	Nashville-Whites Cr.	CAS	Sec	"
	Nash.-Old Hickory UD	TF	Sec	"
	Smyrna	OXD	Sec	8839
Cordell Hull	Byrdstown	CS	Sec	884
	Celina	CAS	Sec	1580
	Gainesboro	CS	Sec	1119
	Livingston	CAS	Sec	3372
Cherokee	Church Hill	CS	Sec	4110
	Jefferson City	TF	Sec	5612
	Kingsport	RF/AS	Sec	89760[3]
	Morristown	RF/AS	Sec	19683
	Rogersville	CAS	Sec	4368

Table TN-C, continued.

Lake Name	Municipal Wastewater Treatment Plants	Treat.[1] Type	Level of Treat.	Pop. Served
Chickamauga	Athens #1	RF/AS	Sec	12080
	Cleveland	TF	Sec	26415
	Dayton	CAS	Sec	5913
	Decatur	EA	Sec	1069
	Etowah	TF	Sec	3758
	Harriman	PRI	Pri	8303
	Kingston #1	PRI	Pri	4441
	Kingston #2	PRI	Pri	"
	Loudon	OXD	Sec	3943
	Niota	EA	Sec	765
	Rockwood	TF	Sec	5767
Dale Hollow	Byrdstown	CS	Sec	884
	Jamestown	CS	Sec	2364
Douglas	Dandridge	EA	Sec	1383
	Newport	2AS	Ter	7580
Ft. Pat Henry	Bluff City	PRI	Pri	1121
	Bristol Regional	CAS	Sec	53537[3]
	Elizabethton	CAS	Sec	12431
	Johnson City-Brush Cr.	CAS	Sec	78473[3]
	Johnson City-Knob Cr.	CAS	Sec	"
	Johnson City-Regional	CAS	Sec	"
Fort Loudon	Dandridge	EA	Sec	1383
	Gatlinburg	2AS	Ter	3210
	Jefferson City	TF	Sec	5612
	Knoxville-E. Knox Forks	CAS	Sec	8818[5]
	Knoxville-1UD Turkey Cr.	CS	Sec	8818[5]
	Knoxville-Fourth Cr.	CAS	Sec	68074[5]
	Knoxville-Kuwahee	2AS	Ter	352714[5]
	Knoxville-Loves Cr.	TF	Sec	29275[5]
	Maryville Regional	CAS	Sec	17480
	Pigeon Forge	2AS	Ter	1822
	Sevierville	CAS	Sec	4556
Great Falls	McMinnville	CAS	Sec	10683
	Sparta	TF	Sec	4864
	West Warren UD	TF	Sec	5000[2]
J. Percy Priest	La Vergne	CS	Sec	5495
	Murfreesboro-Sinking Cr.	2AS	Ter	32845
	Smyrna	OXD	Sec	8839
	Woodbury	OXD	Sec	2160

Table TN-C, continued.

Lake Name	Municipal Wastewater Treatment Plants	Treat.[1] Type	Level of Treat.	Pop. Served
Kentucky	Camden	TF	Sec	3279
	Centerville	CS	Sec	2824
	Hohenwald	TF	Sec	3922
	Linden	CS	Sec	1087
	Lobelville	LAG	Sec	993
	McEwen	2AS	Ter	1352
	Paris Utilities Main	CAS	Sec	10728
	Parsons	TF	Sec	2422
Melton Hill	Clinton Utilities #1	TF	Sec	5245
	Hallsdale Powell	OXD	Sec	14000[2]
	Knoxville-W. Knox UD	EA	Sec	8818[5]
	Lake City	TF	Sec	2335
	Maynardville	EA	Sec	924
Nickajack	Chattanooga-Moccasin B.	OAS	Sec	301515[3]
	Dayton	CAS	Sec	5913
	East Ridge	RF/AS	Sec	21236
	Red Bank	TF	Sec	13297
	Signal Mountain	CS	Sec	5818
Nolichucky	Erwin	PRI	Pri	4739
	Greenville	TF	Sec	14097
Normandy	Manchester	EA	Sec	7250
Norris	Caryville-Jacksboro	CS	Sec	3659
	Claiborne City	EA	Sec	4333[2]
	La Follette	TF	Sec	8198
	Sneedville	PRI	Pri	1110
Ocoee #1	Copperhill	OXD	Sec	418
Ocoee #2	Copperhill	OXD	Sec	418
Ocoee #3	Copperhill	OXD	Sec	418
Old Hickory	Carthage	CAS	Sec	2672
	Gainesboro	CS	Sec	1119
	Gallatin	CAS	Sec	17191
	Hartsville	CAS	Sec	2674
	Lafayette	RF/AS	Sec	3808
	Lebanon	TF	Sec	11872

Table TN-C, continued.

Lake Name	Municipal Wastewater Treatment Plants	Treat.[1] Type	Level of Treat.	Pop. Served
Tims Ford	Cowan	TF	Sec	1790
	Decherd	TF	Sec	2233
	Tullahoma (Utility Bd.)	TF	Sec	15800
	Winchester	TF	Sec	5821
Watauga	Mountain City	OXD	Sec	2125
Watts Bar	Clinton Utilities #1	TF	Sec	5245
	Crossville	2AS	Ter	6394
	Cumberland UD-Scotts H.	TF	Sec	12000[2]
	Cumberland UD-Dodson C.	TF	Sec	"
	Hallsdale Powell	OXD	Sec	14000[2]
	Harriman	PRI	Pri	8303
	Kingston #1	PRI	Pri	4441
	Kingston #2	PRI	Pri	"
	Knoxville-E. Knox Forks	CAS	Sec	8818[5]
	Knoxville-1UD Turkey Cr.	CS	Sec	8818[5]
	Knoxville-Fourth Cr.	CAS	Sec	68074[5]
	Knoxville-Kuwahee	2AS	Ter	352714[5]
	Knoxville-Loves Cr.	TF	Sec	29275[5]
	Knoxville-W. Knox UD	EA	Sec	8818[5]
	Lake City	TF	Sec	2335
	Lenoir City	TF	Sec	5446
	Loudon	OXD	Sec	3943
	Madisonville	TF	Sec	2884
	Maryville Regional	CAS	Sec	17480
	Oak Ridge	CAS	Sec	27662
	Oliver Springs	CS	Sec	3659
	Rockwood	TF	Sec	5767
	Spring City	OXD	Sec	1951
	Sweetwater	TF	Sec	4725
	Wartburg	CS	Sec	761

1. Codes for Wastewater Treatment Type:
   - CAS: Conventional Activated Sludge.
   - CS: Contact Stabilization.
   - EA: Extended Aeration.
   - LAG: Lagoon.
   - OXD: Oxidation Ditch.
   - PRI: Primary.
   - OAS: (Pure) Oxygen Activated Sludge.
   - RF/AS: Roughing Filter/Activated Sludge.
   - TF: Trickling Filter.
   - 2AS: 2-stage Activated Sludge.

(Foototes continued on following page)

Table TN-C, continued.

Footnotes Continued:

2. The population served by this plant was estimated using the "Design Flow" in Tennessee DH&E (1985), and an assumed discharge rate of 150 gal/capita/day.

3. Population for the "Urbanized Area" in the 1980 U.S. Census.

4. Population for the "Standard Metropolitan Statistical Area" (SMSA) in the 1980 U.S. Census.

5. This figure represents the population of the city served by the given facility multiplied by the ratio of the facility's "Design Flow" to the sum of the "Design Flow" values for all facilities serving that city.

Table VA-A: Morphological Characteristics of the Virginia Study Lakes.

	Lake Name	County	Surface Area [ha]	Max. Depth [m]	Mean Depth [m]	Lake Volume [10^6 m^3]
1	Anna	Spotsylvania,	5262	nd	nd	nd
2	Beaverdam	Loudon	257	14.0	8.5	21.8
3	Chesdin	Chesterfield New Kent	1295	14.0	3.7	90.7
5	Claytor	Pulaski	1815	35.0	29.0	527.5
6	Halifax	Halifax	166	nd	nd	nd
7	John W. Flannagan	Dickenson	463	46.0	18.0	83.3
8	Leesville	Pittsylvania,	1376	nd	nd	nd
8	Moomaw	Alleghany Bedford, Campbell	6005	nd	nd	nd
9	Occoquan	Prince William, Fairfax	688	nd	4.9	33.7
10	Rivanna	Albemarle	158	12.6	6.1	9.6
11	Smith Mountain	Pittsylvania, Franklin, Bedford	8094	61.0	35.1	2841.0

Table VA-B: Land Uses Within the Virginia Study Lake Basins.

	Percent Land Use[1]			Regional	Total Basin
Lake Name	Forest	Agric.	Urban	Land Use Category	Area [km^2]
Anna	nd	nd	nd	EMIX	891
Beaverdam	30	50	20	CAGR	500[2]
Chesdin	70-80	15-25	<5	EMIX	3445
Claytor	nd	nd	nd	GMIX	6138
Halifax	nd	nd	nd	EMIX	1417
John W. Flannagan	nd	nd	nd	BFOR	572
Leesville	nd	nd	nd	EMIX	3899
Moomaw	nd	nd	nd	CFOR	891
Occoquan	nd	nd	nd	EMIX	1533
Rivanna	61	35	4	CMIX	671
Smith Mtn.	nd	nd	nd	CMIX	2653

1. Estimated from USGS Land Use/Land Cover maps.

2. Estimated from 1:500,000 scale base map of Virginia.

Table VA-C: Municipal Wastewater Treatment Plants in Virginia Study Lakes' Basins.

Lake	Municipal Wastewater Treatment Plant	Treat.[1] Type	Level Level Of Trmt.	Pop. Served
Anna	Louisa	TF	Sec	932
	Louisa Cnty SB-Minerales	ST	Sec	33[2]
	Louisa Regional STP	nd	Sec[3]	1300[2]
	Mineral	LAG	Sec	399
Beaverdam	Loudon Cnty SA-St. Louis	AL	Sec	573[2]
	Round Hill	EA/CF	Ter	510
Chesdin	Amelia Cnty SD	LAG	Sec	1000[2]
	Crewe	TF	Sec	2325
	Farmville	LAG	Sec	6067
Claytor	Galax	TF	Sec	6524
	Hillsville	AL/TF	Sec	2123
	Independence	AL/TF	Sec	1112
	Pulaski	TF	Sec	35229
	Rural Retreat	TF	Sec	1083
	Wyetheville	CAS	Sec	7135
Halifax	Chatham	nd	Pri	1390
	Gretna	CAS/LAG	Sec	1255
Flannagan	Clintwood	TF	Sec	1369
	Pound	EA	Sec	1086
Leesville	Ferrum	SE	Sec	500
	Roanoke	CAS/NR/CF	P	100220
	Rocky Mount	TF	Sec	4198
	Shawsville	EA/CCS	P	667[2]
	Starkey	EAS	Sec	3333[2]
Moomaw	Ashwood	EA	Sec	4640
	Bath Cnty SA	TF	Sec	5860
	Hot Springs	SE	Sec	300
	Monterey	nd	Pri	223
	Warm Springs	nd	Sec[3]	350
Occoquan	Upper Occoquan Regional	CA/EA/CS/OD	P	100000[2]
	Warrenton	TF/RBC/CCS	Sec	3907
Rivanna	Brownsville	TF/PP	Sec	nd
	Crozet	EA	Sec	1433
Smith Mtn.	Roanoke	CAS/NR/CF	P	100220
	Shawsville	EA/CCS	P	667[2]
	Starkey	EAS	Sec	3333[2]

(See footnotes on following page)

Table VA-C, continued.

Footnotes.

nd: No data available

1. Codes for Wastewater Treatment Type:
   - AL=Aerated Lagoon
   - CA=Contact Aerators
   - CAS=Conventional Activated Sludge
   - CCS=Chemical Coagulation and Sedimentation
   - CF=Chemical-Filtration
   - CS=Contact Stabilization
   - EA=Extended Aeration
   - LAG=Lagoon
   - NR=Nitrogen Removal
   - OD=Oxidation Ditch
   - PP=Polishing (Holding) Pond
   - RBC=Rotating Biological Contactors
   - ST=Septic Tank-Sand Filter
   - TF=Trickling Filter

2. [illegible] using the facility's Design Flow [illegible] through personal communication with the [illegible] discharge rate of 150 gal/cap/da.

3. No information was available in [illegible] of municipal facilities (1982) [illegible] secondary treatment was assumed.

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APPENDIX C

Glossary of Terms

Activated Sludge: A biological wastewater treatment system utilizing aerobic microorganisms (bacteria, protozoa, and rotifers) in a tank containing wastewater to stabilize (purify) the wastewater.

Advanced Treatment: Tertiary Treatment and Advanced Treatment are sometimes used as synonyms, but they are not precisely the same. Advanced treatment means any process or system which is used after conventional treatment, or to modify or replace one or more steps, to remove refractory contaminants. (See Tertiary Treatment)

Assimilative Capacity: Ability of a body of water to purify itself of pollutants.

Biochemical Oxygen Demand (BOD): Bacteria placed in contact with organic material will utilize it as a food source, consuming oxygen to oxidize the organic material to stable end products such as carbon dioxide and water. The amount of oxygen used in this process is called the biochemical oxygen demand (BOD) and is considered to be a measure of the organic content of the wastewater.

Chlorophyll a: Green pigment in plants and algae necessary for photosynthesis.

Coliform bacteria: Nonpathogenic organisms considered a good indicator of pathogenic bacterial pollution.

Combined Sewer: A sewer receiving both stormwater runoff and sewage.

Combined Sewer Overflow (CSO): A discharge of a mixture of stormwater and domestic wastes which occurs when the flow capacity of a combined sewer system is exceeded during a rainstorm.

Conventional Secondary Wastewater Treatment: These are conventional treatment processes which achieve secondary treatment levels of pollutant removal. Activated sludge, extended aeration, trickling filters, stabilization ponds, and rotating biological contactors (to name just a few) are generally considered to be conventional secondary treatment processes.

Conventional Wastewater Treatment: In the general sense, conventional wastewater treatment is the treatment of wastewater by means which have become well extablished and which are now in widespread use. Conventional treatment generally includes a primary treatment step and a conventional secondary treatment step. (Also see Conventional Secondary Wastewater Treatment).

Designated Use: A system of classifying water utilization in natural waterways that is identified in State water quality standards. Uses can include cold water fisheries, public water supply, fish and wildlife, and recreation.

Dissolved Oxygen (DO): The quantity of oxygen present in water in a dissolved state, usually expressed as milligrams per liter of water. Adequate levels of dissolved oxygen are needed to support aquatic life.

Effluent: Liquid that is discharged to the environment from a treatment plant after completion of the treatment process.

Epilimnion: The upper circulating layer of a thermally stratified lake.

Estuaries: Regions of interaction between rivers and nearshore ocean waters, where tidal action and stream flow create a mixing of fresh and salt water.

Eutrophication: A natural enrichment process of a lake, which may be accelerated by man's activities. Usually manifested by one or more of the following characteristics: (a) excessive biomass accumulations of primary producers where surface runoff from streams and other natural watercourses is carried by a single drainage system to a common outlet.

Effluent: Liquid that is discharged to the environment from a treatment plant after completion of the treatment process.

Epilimnion: The upper circulating layer of a thermally stratified lake.

Estuaries: Regions of interaction between rivers and nearshore ocean waters, where tidal action and stream flow create a mixing of fresh and salt water.

Eutrophication: A natural enrichment process of a lake, which may be accelerated by man's activities. Usually manifested by one or more of the following characteristics: (a) excessive biomass accumulations of primary producers (e.g. algae). (b) rapid organic and/or inorganic sedimentation and shallowing of the water. (c) seasonal and/or diurnal dissolved oxygen deficiencies.

Extended Aeration: An activated sludge wastewater treatment process that has a much longer hydraulic retention time than conventional activated sludge (24 hours versus 6-8 hours, respectively). (Also see activated sludge)

Fecal Coliform Bacteria: A group of organisms common to the intestinal tracts of man and of animals. The presence of fecal coliforms in water is an indicator of pollution and of potentially dangerous bacterial contamination.

Heavy Metals: Metals of high specific gravity, including, cadmium, chromium, cobalt, copper, lead, and mercury. They are toxic to many organisms even in extremely low concentrations.

Hypolimnion: The lower, non-circulating layer of a thermally stratified lake.

Lagoon: A shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater. Lagoons are widely used by small communities to provide wastewater treatment.

Limiting Nutrient: As stated by Justus Liebig in 1840: "[the] growth of a plant is dependent on the amount of foodstuff which is presented to it in minimum quantity [in relation to its needs]." Thus, a limiting nutrient can be considered to be a nutrient which stimulates plant growth (e.g. algae and macrophytes) when its concentration in a waterbody increases. Phosphorus is considered to be the most common limiting nutrient, however nitrogen is also often limiting, and phosphorus and nitrogen commonly are co-limiting.

Macrophytes: Large vascular, aquatic plants which are either rooted or floating.

Mesotrophic Lake: A trophic condition between an oligotrophic and a eutrophic water body.

Municipal Watewater Treatment Plant: A publicly owned wastewater treatment facility. Generally, the wastewater contains both domestic (household) wastes and some industrial/commercial wastes.

Nitrogen: An essential plant nutrient present in high concentrations in wastewater. Some commonly measured forms of nitrogen are:

- Ammonia (NH_3).
- Ammonium ion (NH_4).
- Nitrite ion (NO_2).
- Nitrate ion (NO_3).
- Total Kjeldahl Nitrogen (TKN), orgainc nitrogen plus ammonia nitrogen.
- Total Nitrogen, includes all forms of nitrogen and is generally calculated as the sum of the nitrite, nitrate, and total Kjeldahl nitrogen concentrations.

Non-point Source: non-point source pollutants are not traceable to a discrete origin, but generally result from land runoff, precipitation, drainage, or seepage. These pollution sources are diffuse rather than discreet in origin. The commonly used categories for such sources are agriculture, forestry, urban areas, mining, construction, and saltwater intrusion.

Oligotrophic Lake: A lake with a small supply of nutrients, and consequently a low level of primary production. Oligotrophic lakes are often characterized by a high level of species diversification.

Phosphorus, Available: Phosphorus which is readily available for plant growth. Usually in the form of soluble orthophosphates. Phosphorus, Total (TP): All of the phosphorus present in a sample regardless of form.

Photosynthesis: The process occurring in green plants in which light energy is used to convert inorganic compounds to carbohydrates. In this process, carbon dioxide is consumed and oxygen is released.

Point Source: A discreet pollutant discharge such as a pipe, ditch, channel, or concentrated animal feeding operation.

Polishing Ponds: Aerobic or facultative ponds that polish the effluent from conventional treatment plants by further reducing the settleable solids, biochemical oxygen demand, fecal bacteria, and ammonia (NH_3). (See Ponds)

Pollution: A condition created by the presence of harmful or objectionable material in water.

Ponds (Wastewater Treatment): An earthen basin open to the sun and air that depends on biological, chemical, and physical processes to stabilize (purify) wastewater. These processes include sedimentation, digestion, oxidation, synthesis, photosynthesis, endogenous respiration, gas exchange, aeration, evaporation, thermal currents, and seepage.

Primary Treatment: Primary treatment is the removal of the larger particulate material in wastewater generally through allowing the particles to settle out of the water column to the bottom of a tank where they can be collected (i.e. sedimentation). It may also be used to describe a treatment process that does not achieve secondary treatment effluent standards.

Rotating Biological Contactor (RBC): This system of wastewater treatment, like the trickling filter, is a fixed growth reactor. The process involves the rotating of partially submerged disks in wastewater, allowing wastewater to flow over a fixed biomass film (composed of microorganisms) on the disk and absorbing oxygen from the air. The microorganisms remove dissolved oxygen and organic material from the wastewater.

Sand Filters: Granular media filtration used as an effluent polishing technique in treatment plants to increase biochemical oxygen demand, and suspended solids removal.

Secchi Disk Depth: A measure of optical water clarity as determined by lowering a weighted Secchi disk into a water body to the point where it is no longer visible.

Secondary Treatment: A treatment process that achieves a level of effluent quality established by the EPA in 1973. Acceptable secondary treatment must have the following minimum water quality parameters:

- A 30 mg/l concentration (30 day arithmetic mean) for biochemical oxygen demand and Suspended Solids. Removal efficiencies shall not be less than 85 percent.
- A geometric mean (30 consecutive days) of 200 per 100 ml for fecal coloform counts.
- Effluent pH shall remain in the 6.0-9.0 range.

Septic Tank: The most popular on-site wastewater treatment technique which relies on a collection tank which receives waste from the home and provides a period of settling, during which a significant portion of suspended solids settle out and are gradually decomposed by bacterial action at the bottom of the tank. The remaining sewage is discharged into a drain field composed of lengths of porous or perforated pipe placed at shallow depths. A well designed and maintained system will provide ecologically sound treatment.

Suspended Solids: Refers to the particulate matter in a sample of water, including the material that settles readily as well as the material that remains dispersed.

Tertiary Treatment: Advanced Treatment and Tertiary Treatment are sometimes used as synonyms, but they are not precisely the same. Tertiary treatment suggests additional step applied only after conventional primary and secondary waste processing. Upgrading treatment to increase biochemical oxygen demand, and suspended solids removal and/or nutrient removal can be accomplished through tertiary treatment. Examples of Advanced and Tertiary treatments are:

- Adsorption on granular activated carbon.
- Microscreening.
- Chemical coagulation and clarification.
- Extended biological oxidation.
- Biological nitrification-denitrification.
- Irrigation of cropland.

Total Nitrogen: (See Nitrogen).

Total Nitrogen to Total Phosphorus Ratio (TN:TP): The ratio of the total nitrogen concentration to the total phosphorus concentration in water serves as a yardstick with which to evaluate whether nitrogen or phosphorus is the limiting nutrient (see limiting nutrient). In general, nitrogen is considered to be the limiting nutrient if the ratio is less than 10, and phosphorus is limiting if it is greater than about 15. When the ratio is between 10 and 15 the limiting nutrient can not be predicted, and the two may be co-limiting. Numerous studies have used slightly different values than those presented here.

Treatment Plant: A structure constructed to purify wastewater prior to discharging it to the environment. The purification, or treatment, is accomplished by subjecting the wastewater to a combination of physical, chemical, and biological processes which reduce the concentration of contaminants present in the wastewater.

Trickling Filter: A biological treatment process where wastewater is purified by trickling wastewater over rocks on which colonies of bacteria are growing. The bacteria remove the organic impurities from the wastewater and utilize it as a food source. The name trickling filter is a misnomer since no filtering action in a physical sense occurs.

Trophic Condition: A relative description of a lake's biological productivity. The range of trophic conditions is characterized by the terms oligotrophic for the least biologically productive, to eutrophic for the most biologically productive. Turbidity: A measure of the cloudiness of a liquid. Turbidity provides an indirect measure of the suspended solids concentration in water. Water Quality: A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular use or purpose.

Water Quality Standards: Requirements authorized by State law that consist of designated uses for all waters and minimum acceptable levels of water quality that will permit achievement of these uses. The criteria can be numerical or narrative.

APPENDIX D

Table of Conversions and Definition of Units

cfs = cubic feet per second = 7.48 gallons per second
= 28.32 liters per second = 35.31 cubic meters per second

ha = hectare = 2.47 acres

km = kilometer = 1000 meters = 0.62 miles = 3281 feet

km^2 = square kilometer = 100 hectares
= 247.11 acres = 0.39 square miles

kg = kilogram = 2.20 pounds

kg P/cap/yr = kilograms phosphorus per capita per year
= 2.20 pounds phosphorus per capita per year

kg P/km^2/yr = kilograms phosphorus per square kilometer per year
= 5.70 pounds phosphorus per square mile per year

L = liter = 1.06 quarts

lb = pound = 0.45 kilograms

m = meter = 1.09 yards = 3.28 feet

mgd = million gallons per day = 11.57 gallons per second
1.55 cubic feet per second

mg/l = milligrams per liter = ppm = parts per million

mi^2 = square mile = 640 acres
= 259 hectares = 2.59 square kilometers

ml = milliliter = 1/1000 of a liter

ug = microgram = 1/1000 of a milligram

APPENDIX E

Descriptions of Data Sources

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), which arose from the recognized need to "maintain the integrity of the Nation's waters", conferred to the states the responsibility of preventing, reducing, and eliminating pollution.

To aid the states in achieving this goal, two provisions of the Public Law 92-500 were instituted: Section 305(b) State Water Quality Summary and Section 314 Clean Lakes Programs. These measures were intended to provide economic support and standardized approaches for the states to use in evaluating and reporting on the condition of their surface waters. One aspect of these programs was to encourage each state to develop a trophic state (water quality) ranking for its publicly-owned lakes. In addition, a prioritized ranking of the state's streams and publicly owned lakes was to be established based on the support of designated uses and need for restoration. The biennial state water quality reports mandated by Section 305(b) provide a standardized means of reporting a state's water quality assessments to the U.S. Environmental Protection Agency (EPA). It is then the EPA's responsibility to provide Congress with a biennial update on the nation's water quality.

In contrast, the Section 314 Clean Lakes Program is an optional investigative vehicle through which state funds for the analysis of publicly-owned lakes are matched by federal funds. Conclusions were to be made concerning the overall water quality by combining the results from short-term sampling conducted during the Clean Lakes Program with previous studies and professional judgements. Lakes chosen for analysis under the Program have generally been those directly affected by human activities or those having significant public interest and use. Thus, the result of the Clean Lakes Program has been a sound information base upon which intelligent, cost-effective water quality management decisions can be founded.

In 1982, the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) and the EPA cooperated in the development of a comprehensive program to evaluate the progress made by the states in meeting the requirements set down by the Public Law 92-500 (ASIWPCA, 1983a,b). The ASIWPCA sent a questionaire to the appropriate personnel in each state's water quality agency and compiled the responses, which paralleled the data generated by the states' 305(b) and Clean Lakes Program reports. The resulting publication, consisting of state-by-state water quality summaries, has provided an excellent, standardized basis from which a general assessment of water quality on the national level can be made. The report has targeted point sources (e.g. municipal and industrial waste discharges), non-point sources (e.g. diffuse runoff, including agricultural runoff), and toxic pollutants as significant problem areas.